

executed

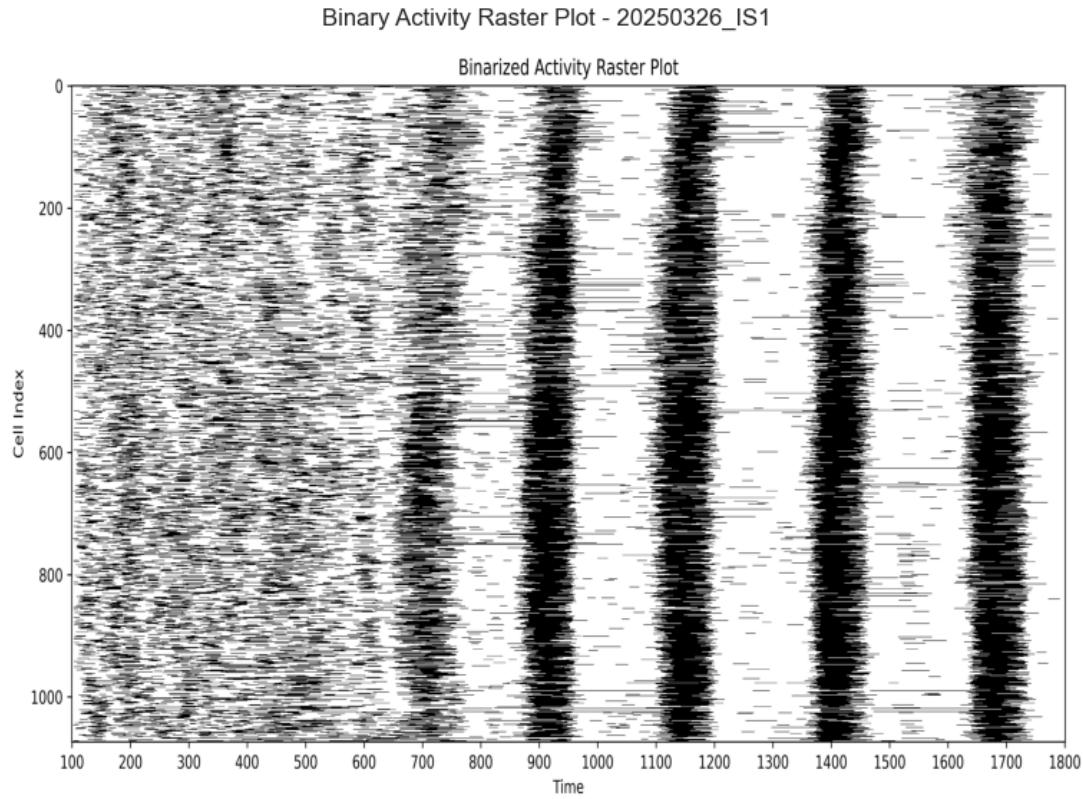
August 13, 2025

1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

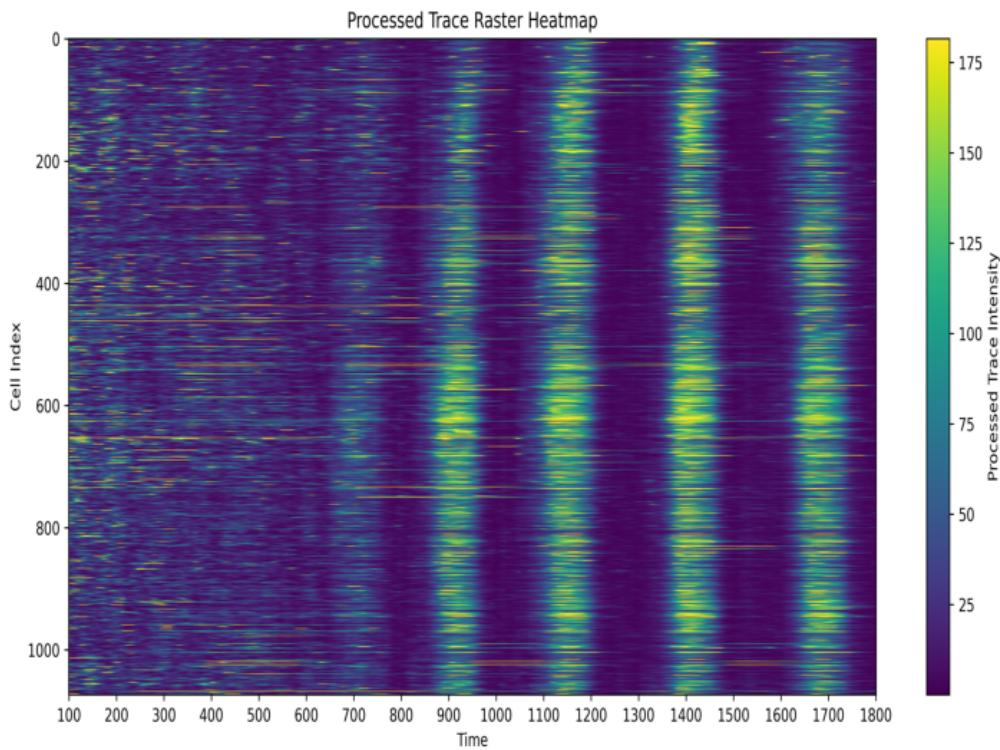
1.0.1 Initialization

1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot



Heatmap Activity Raster Plot - 20250326_IS1



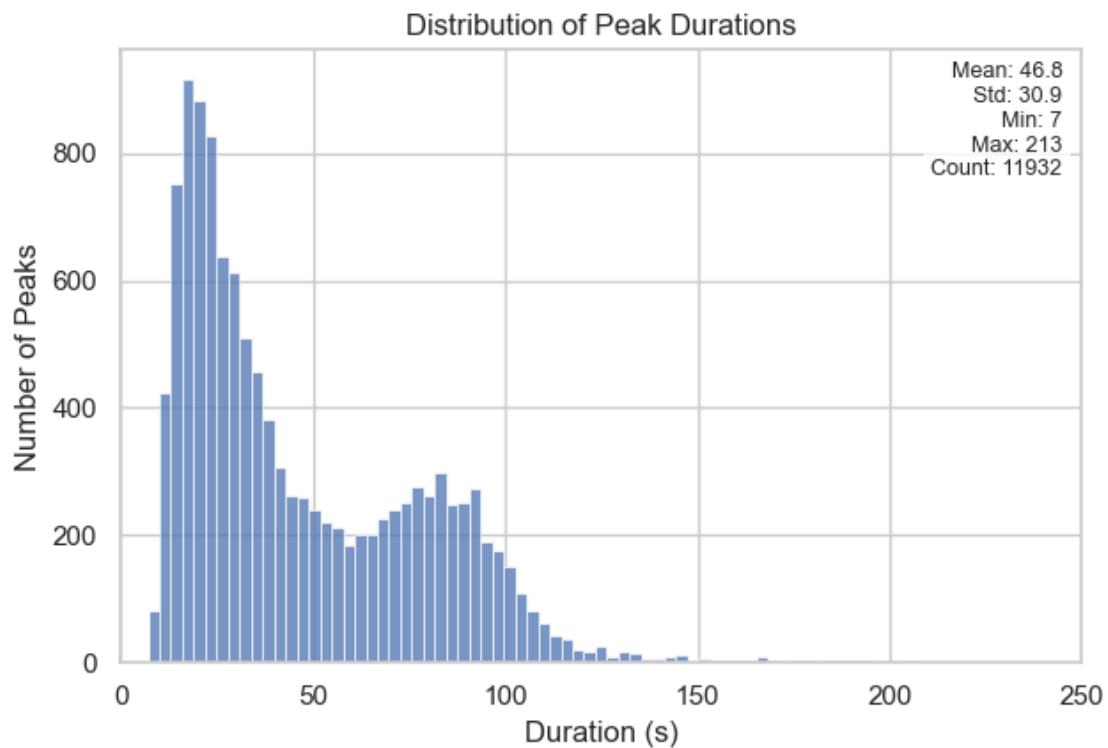
1.1.2 Peaks population

Total number of peaks: 11955

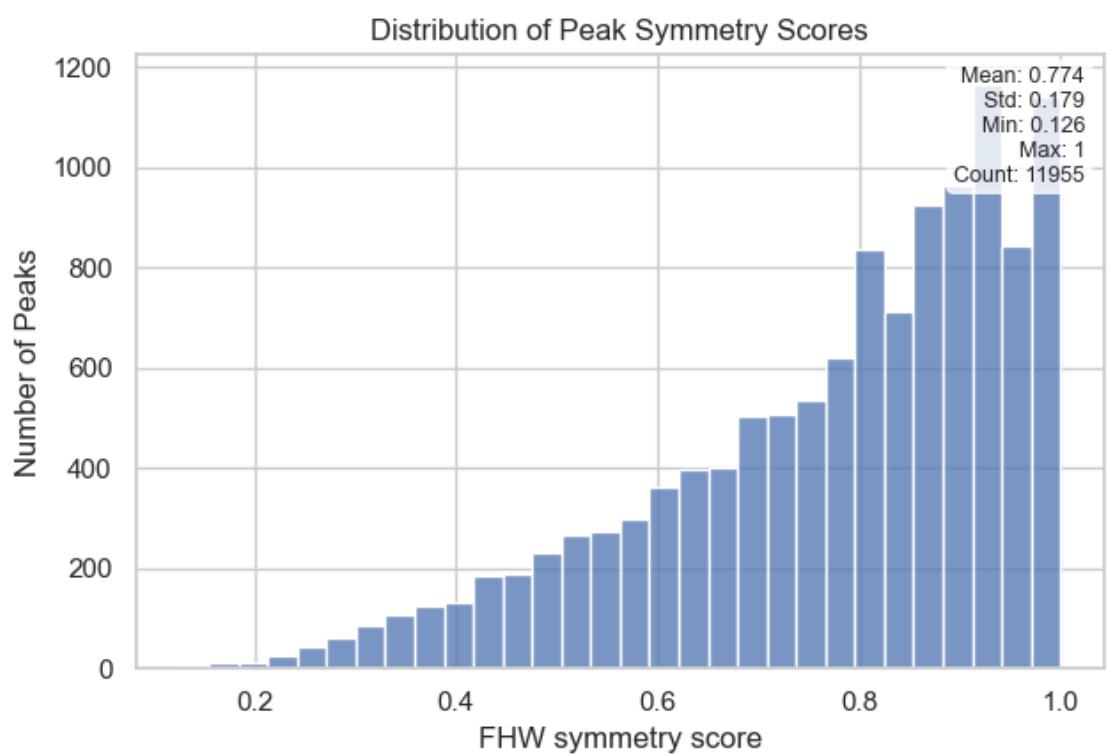
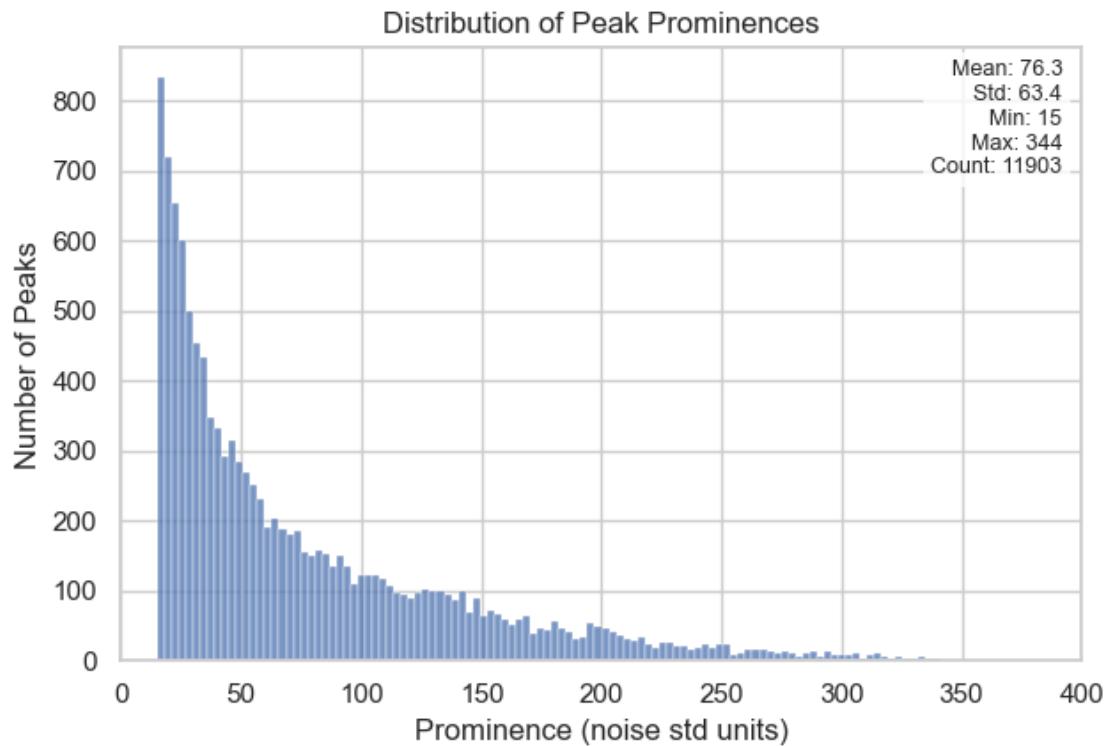
Total number of cells: 1074

1.1.3 Peaks statistics

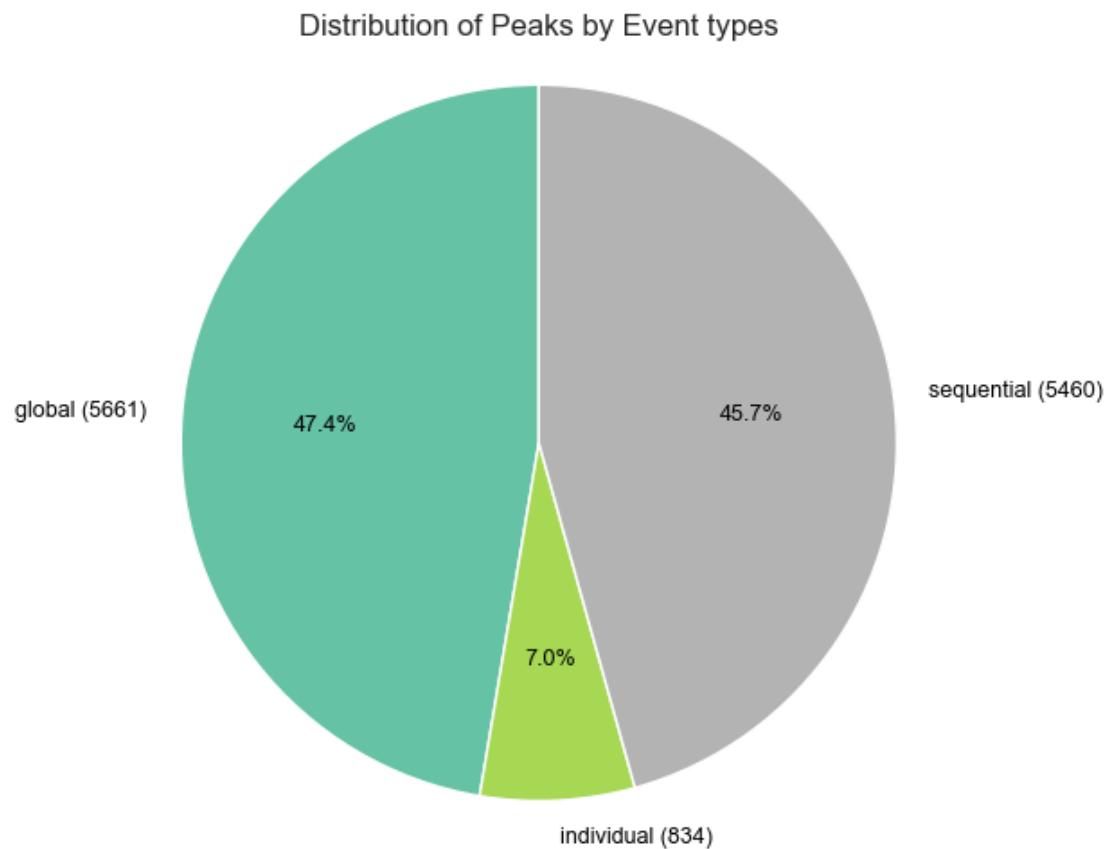
```
[2025-08-13 11:23:07] [INFO] calcium: plot_histogram: removed 23 outliers out of  
11955 on 'Duration (s)' (lower=-132, upper=225)
```



```
[2025-08-13 11:23:07] [INFO] calcium: plot_histogram: removed 52 outliers out of  
11955 on 'Prominence (noise std units)' (lower=-210.35, upper=345.8)
```

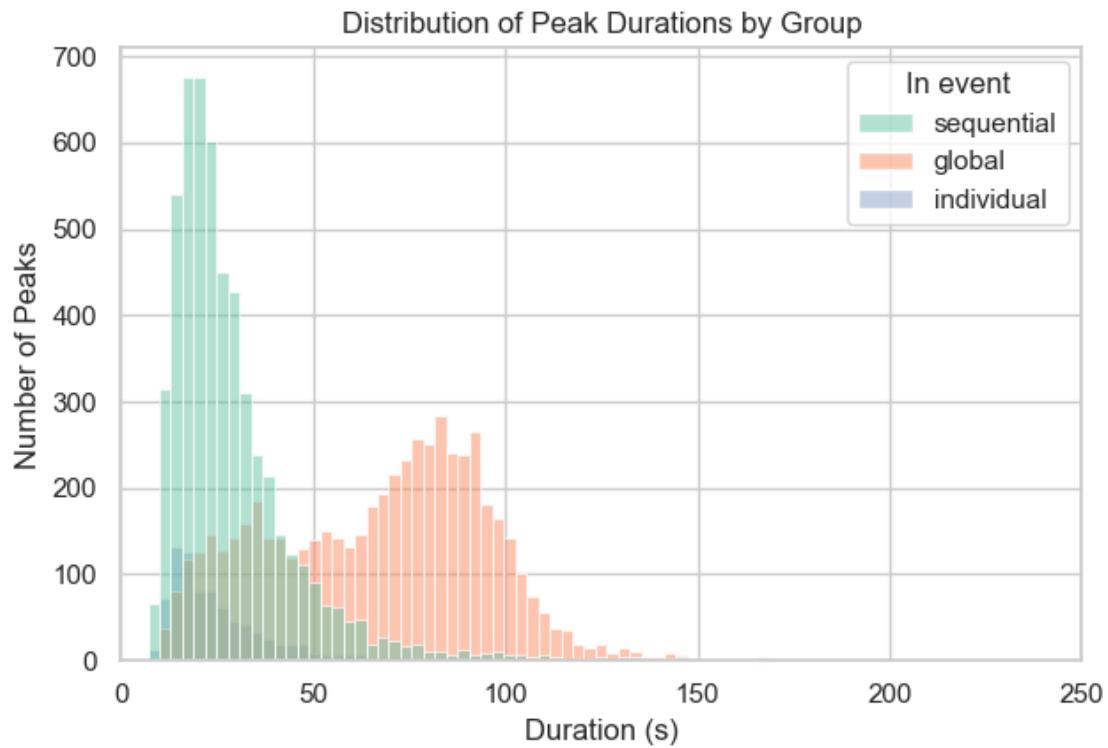


1.1.4 Distribution of peaks per event types



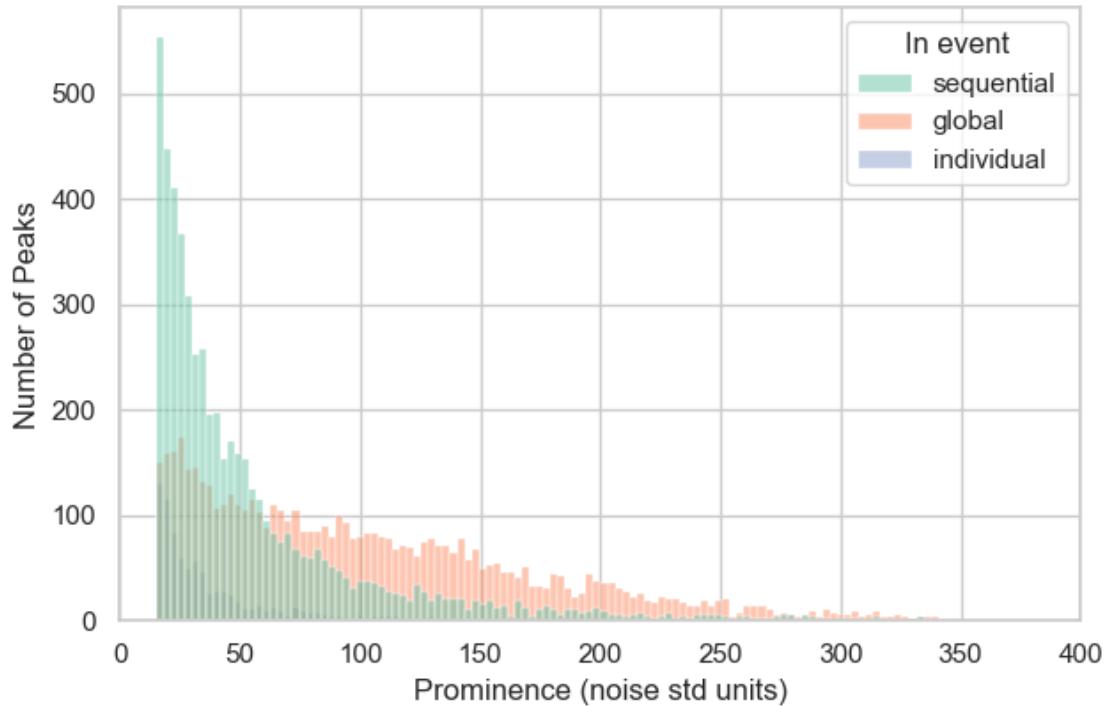
1.1.5 Peaks statistics per event types

```
[2025-08-13 11:23:08] [INFO] calcium: plot_histogram_by_group: removed 23 outliers out of 11955 on 'Duration (s)' (lower=-132, upper=225)
```

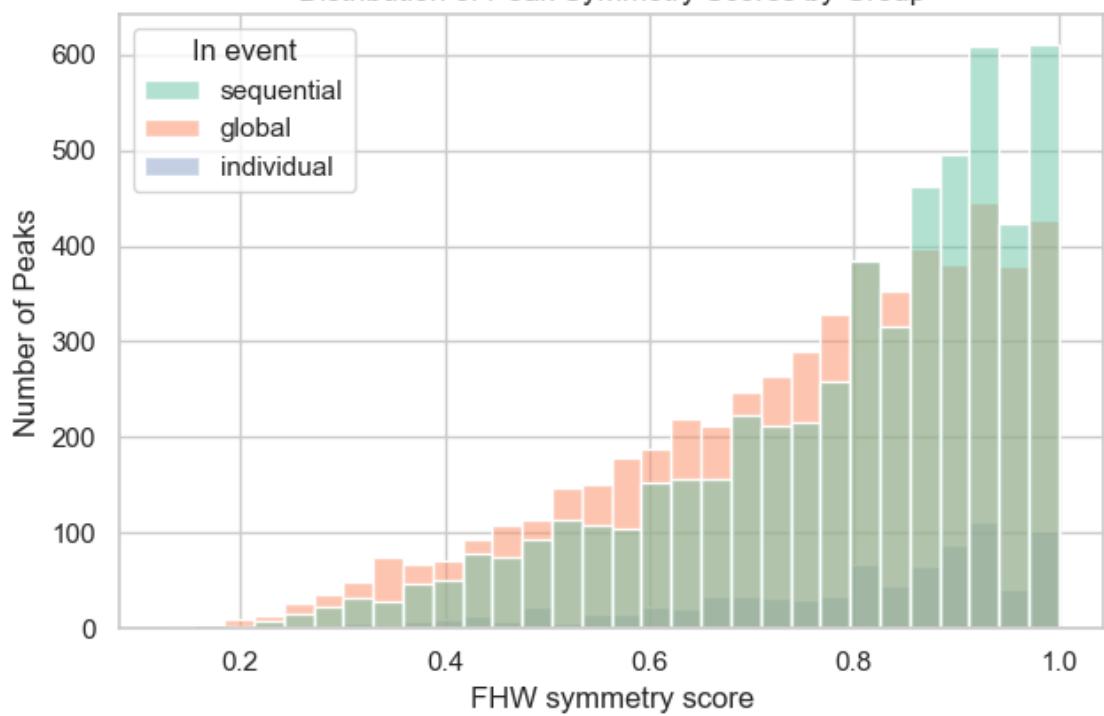


```
[2025-08-13 11:23:08] [INFO] calcium: plot_histogram_by_group: removed 52 outliers out of 11955 on 'Prominence (noise std units)' (lower=-210.35, upper=345.8)
```

Distribution of Peak Prominences by Group



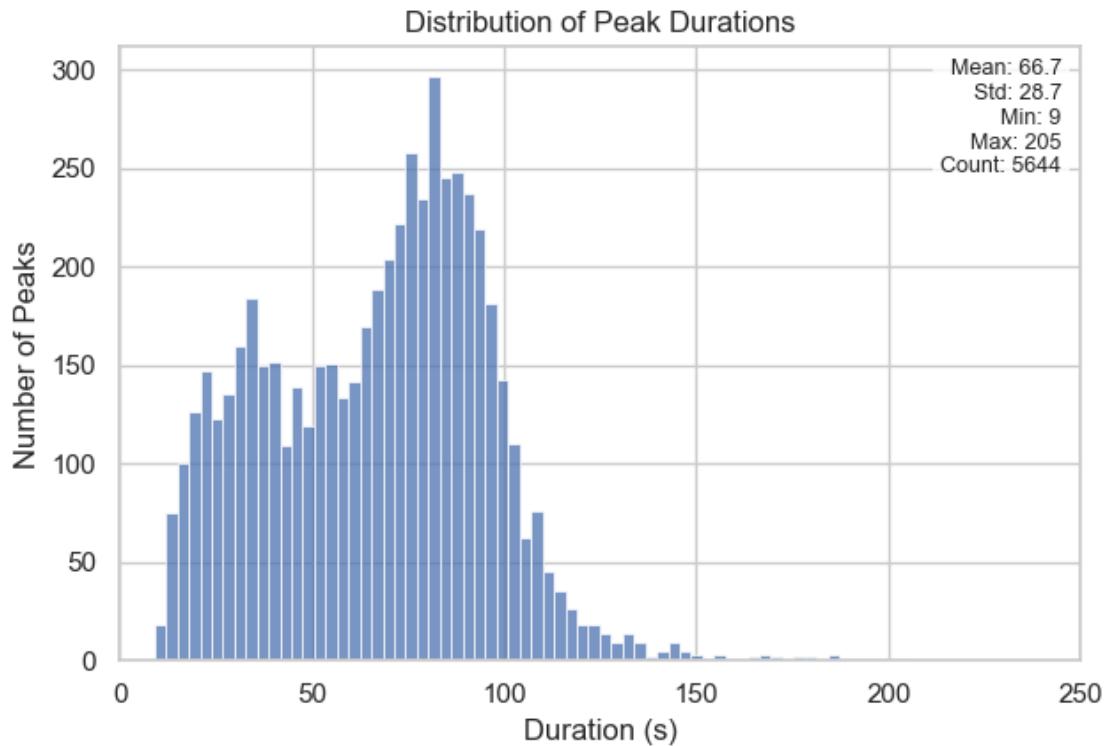
Distribution of Peak Symmetry Scores by Group



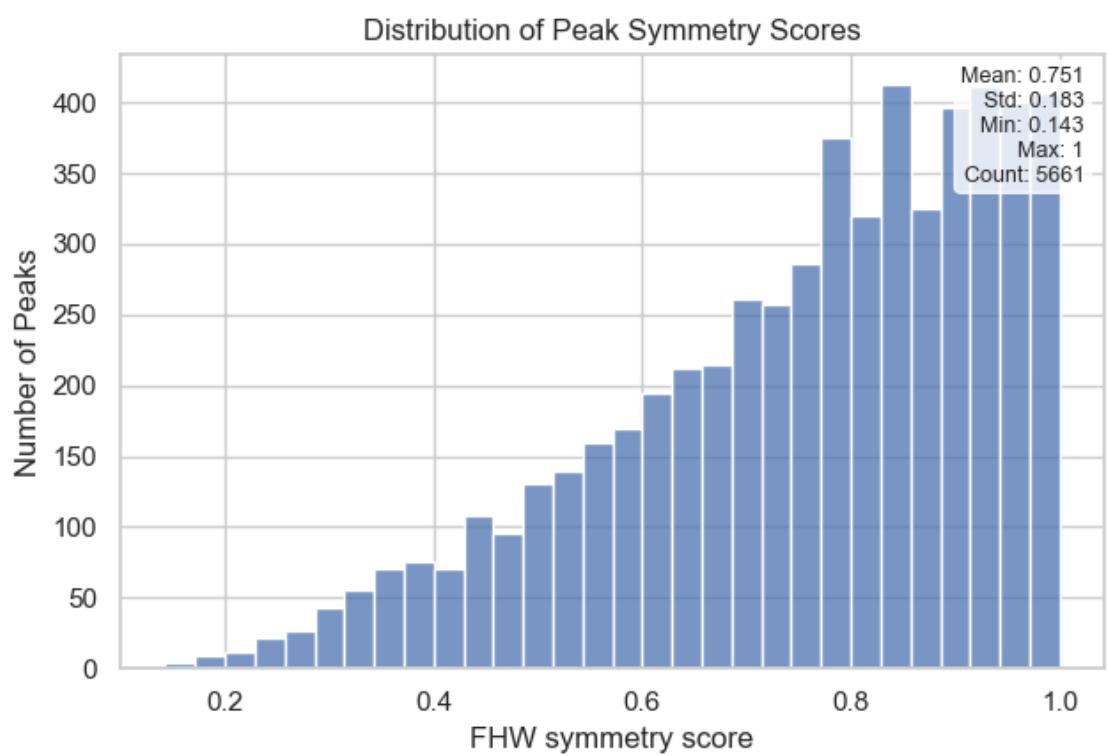
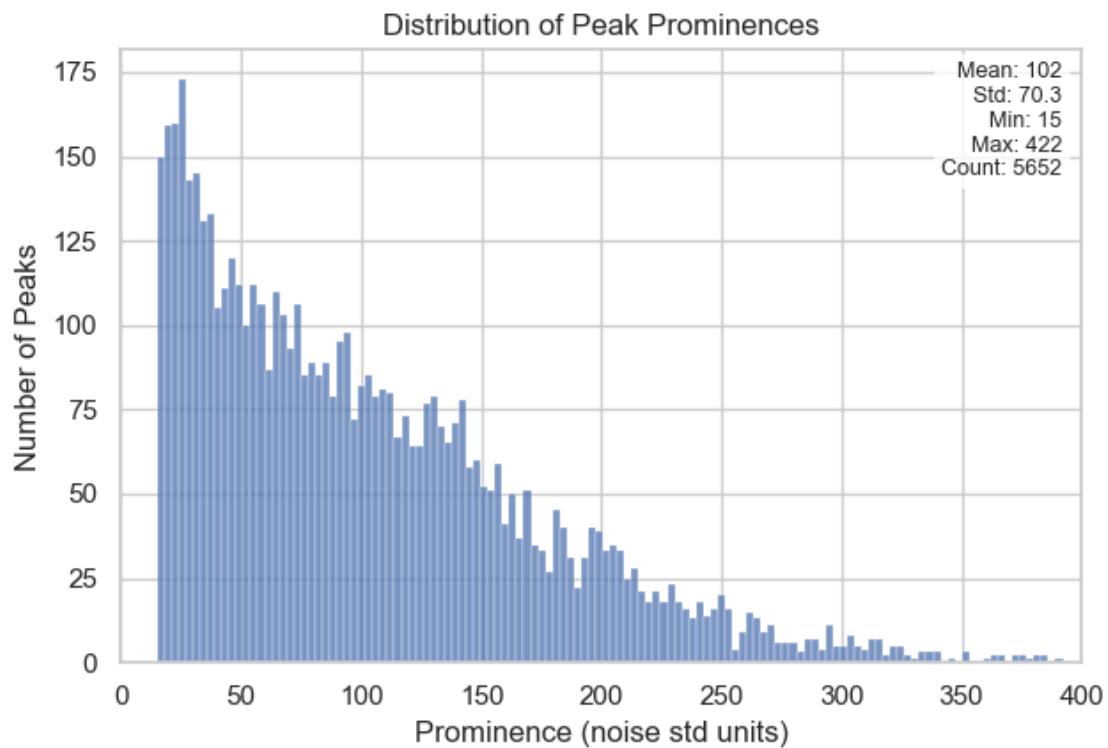
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

[2025-08-13 11:23:09] [INFO] calcium: plot_histogram: removed 17 outliers out of 5661 on 'Duration (s)' (lower=-92, upper=223)

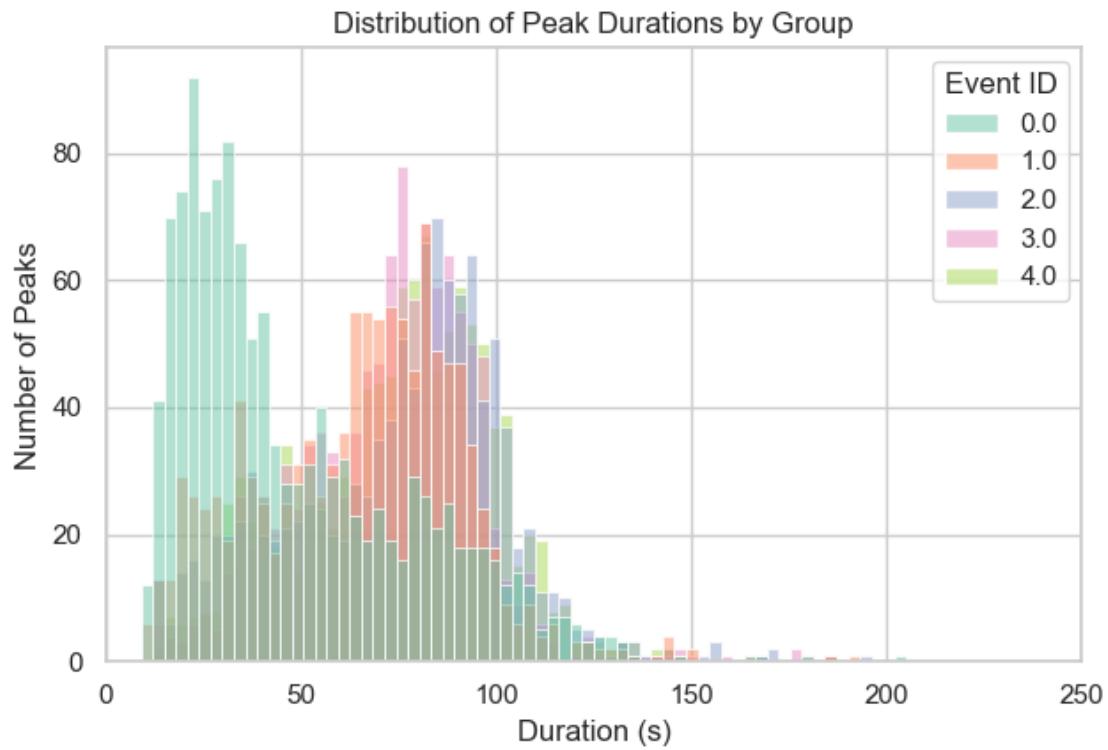


[2025-08-13 11:23:09] [INFO] calcium: plot_histogram: removed 9 outliers out of 5661 on 'Prominence (noise std units)' (lower=-248, upper=435.9)



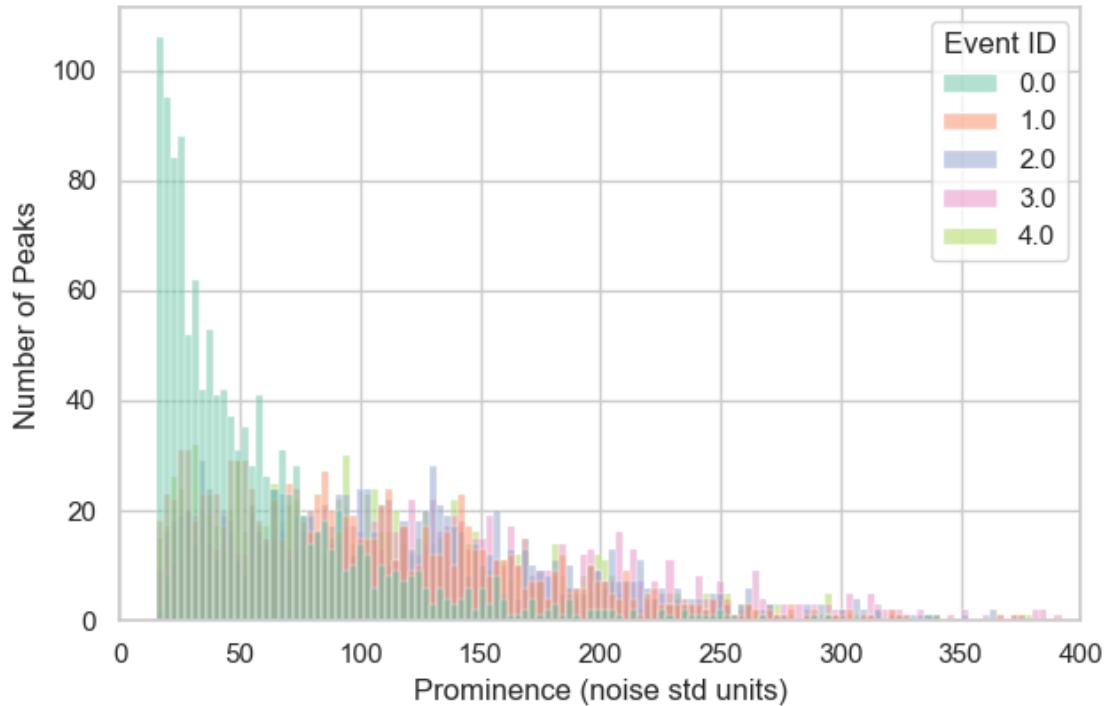
1.2.2 Peak statistics in global event per event ID

[2025-08-13 11:23:09] [INFO] calcium: plot_histogram_by_group: removed 17 outliers out of 5661 on 'Duration (s)' (lower=-92, upper=223)

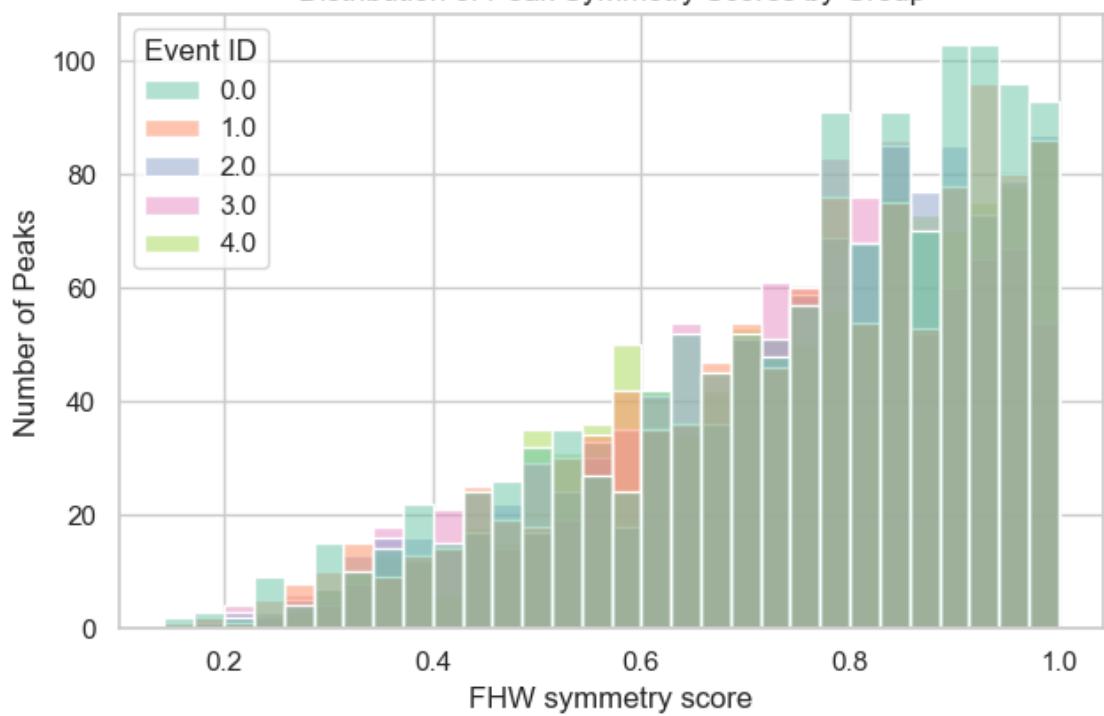


[2025-08-13 11:23:10] [INFO] calcium: plot_histogram_by_group: removed 9 outliers out of 5661 on 'Prominence (noise std units)' (lower=-248, upper=435.9)

Distribution of Peak Prominences by Group

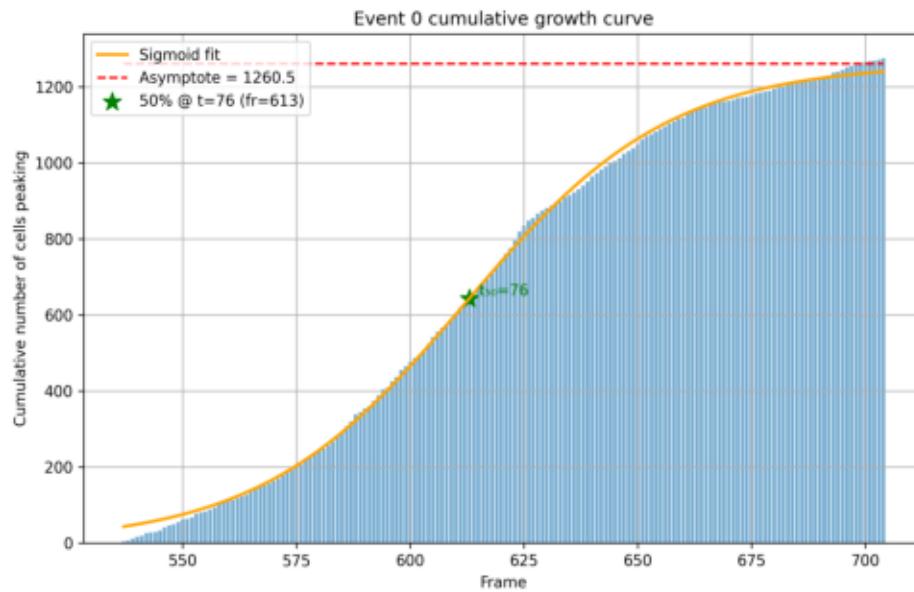


Distribution of Peak Symmetry Scores by Group

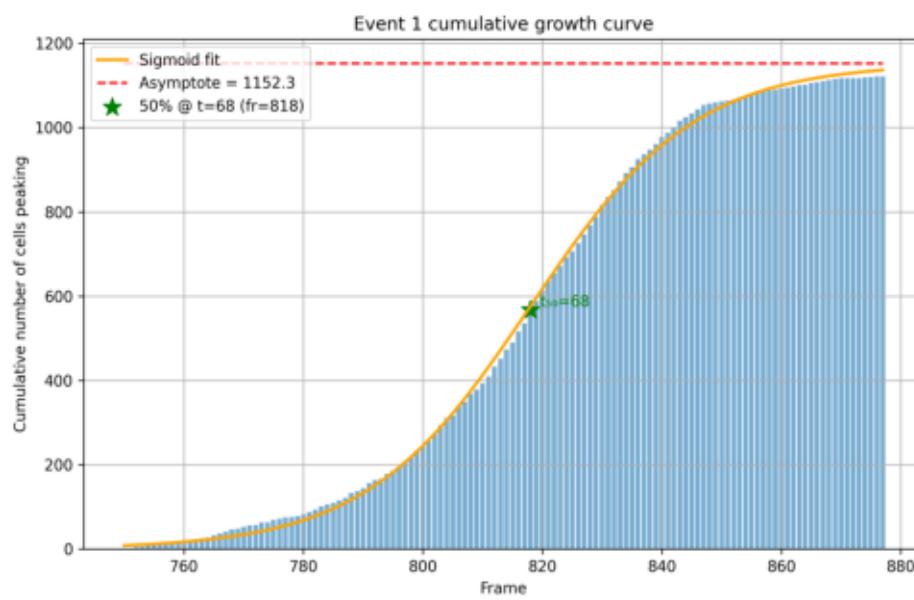


1.2.3 Kinetics of global events

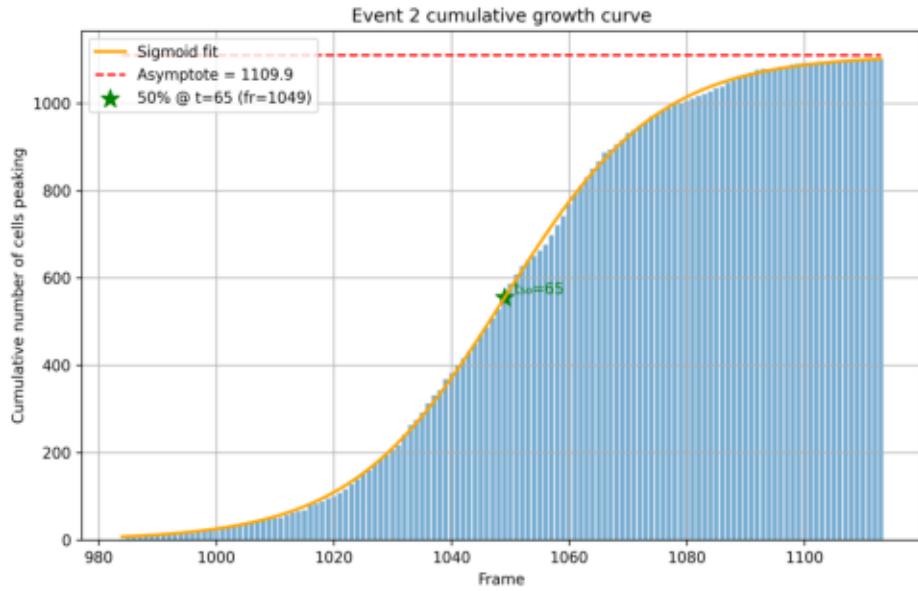
Event Activity Overlay (Event ID: 0) - 20250326_IS1



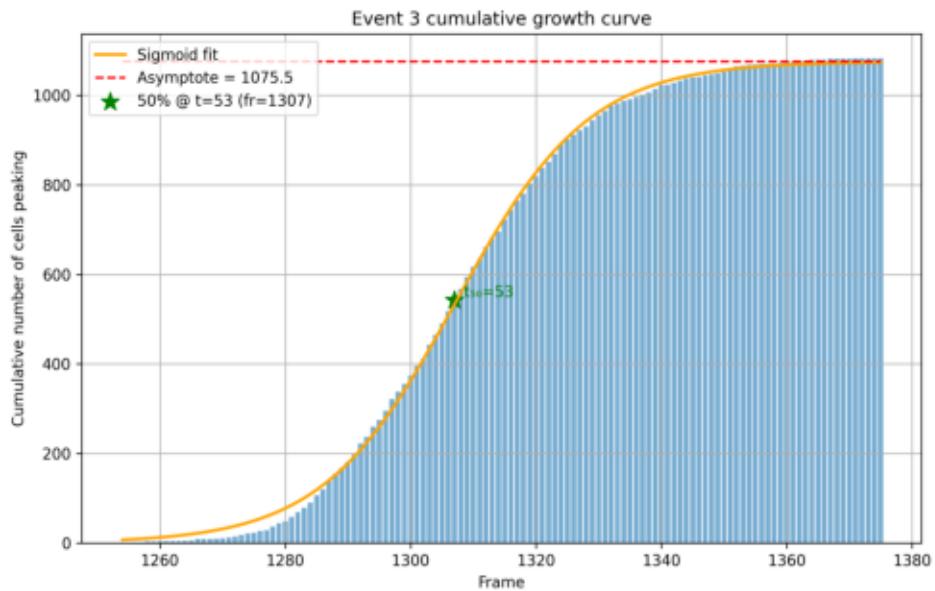
Event Activity Overlay (Event ID: 1) - 20250326_IS1



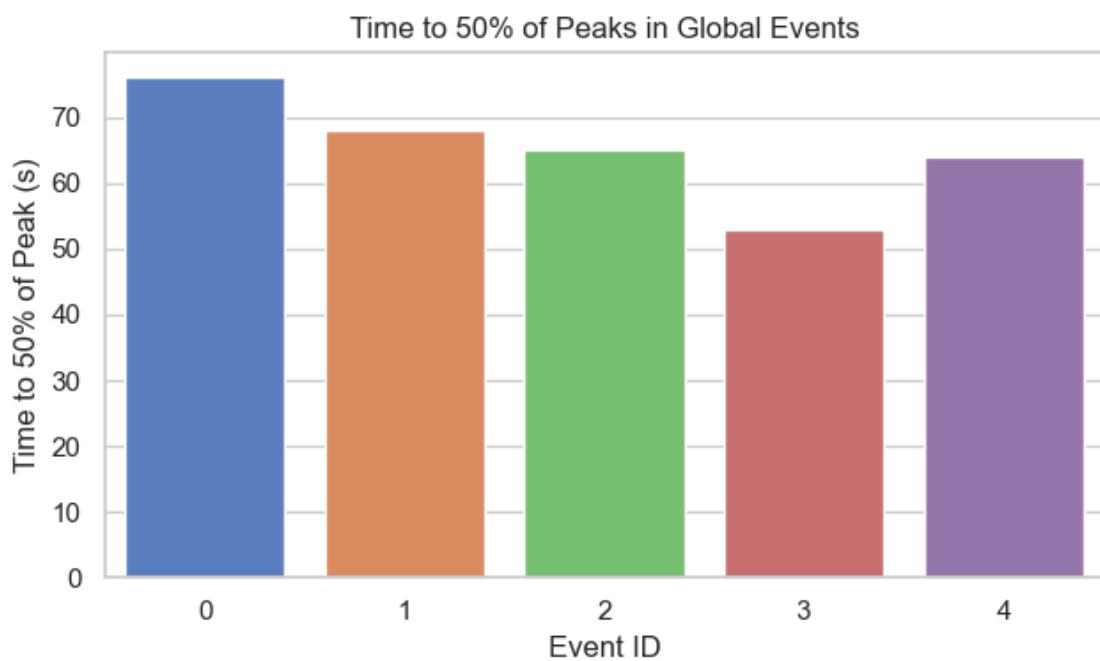
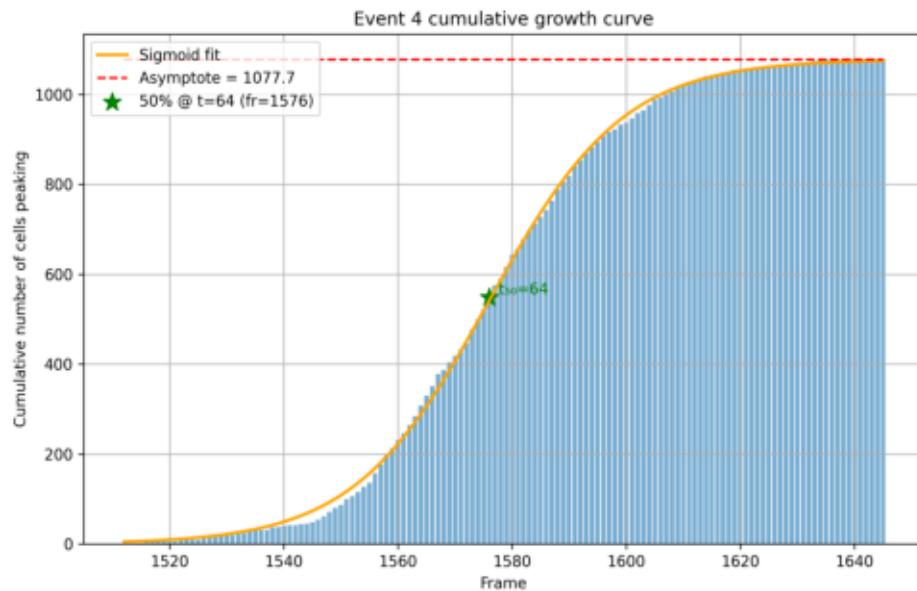
Event Activity Overlay (Event ID: 2) - 20250326_IS1

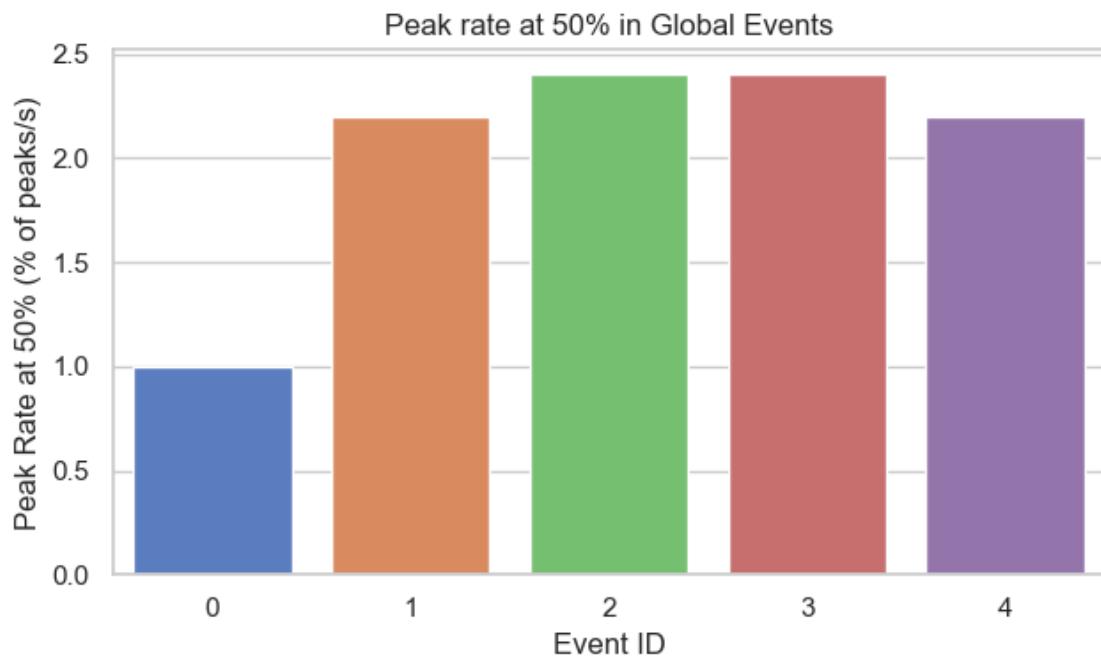


Event Activity Overlay (Event ID: 3) - 20250326_IS1

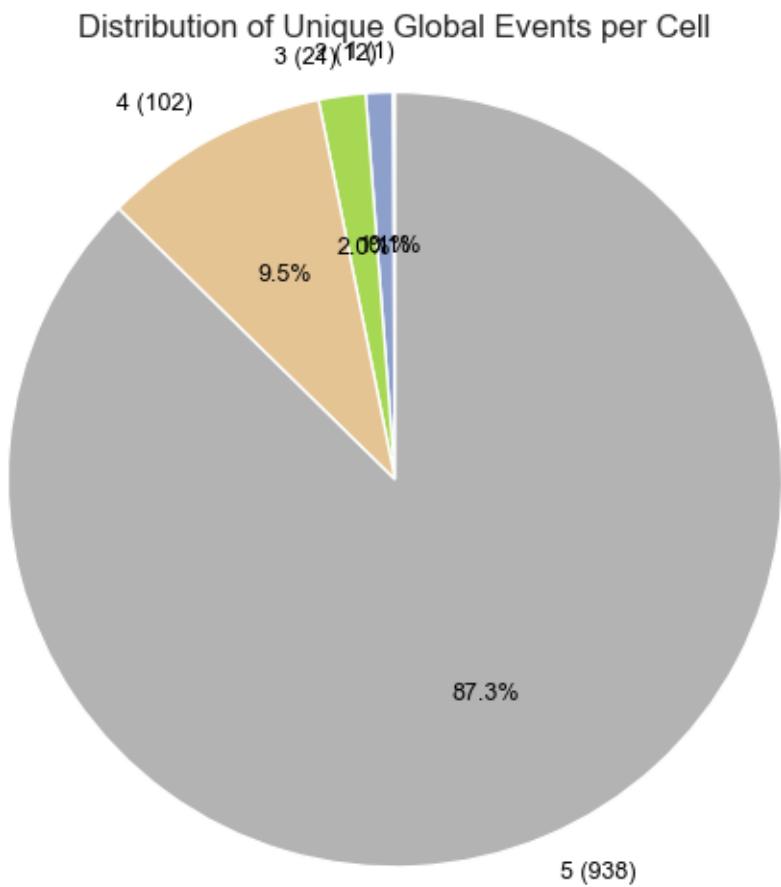


Event Activity Overlay (Event ID: 4) - 20250326_IS1

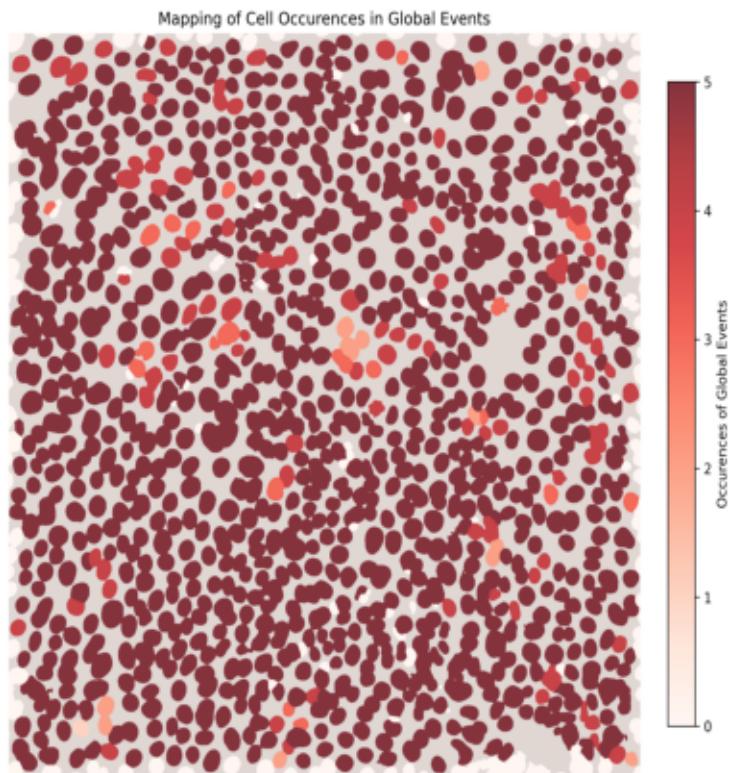


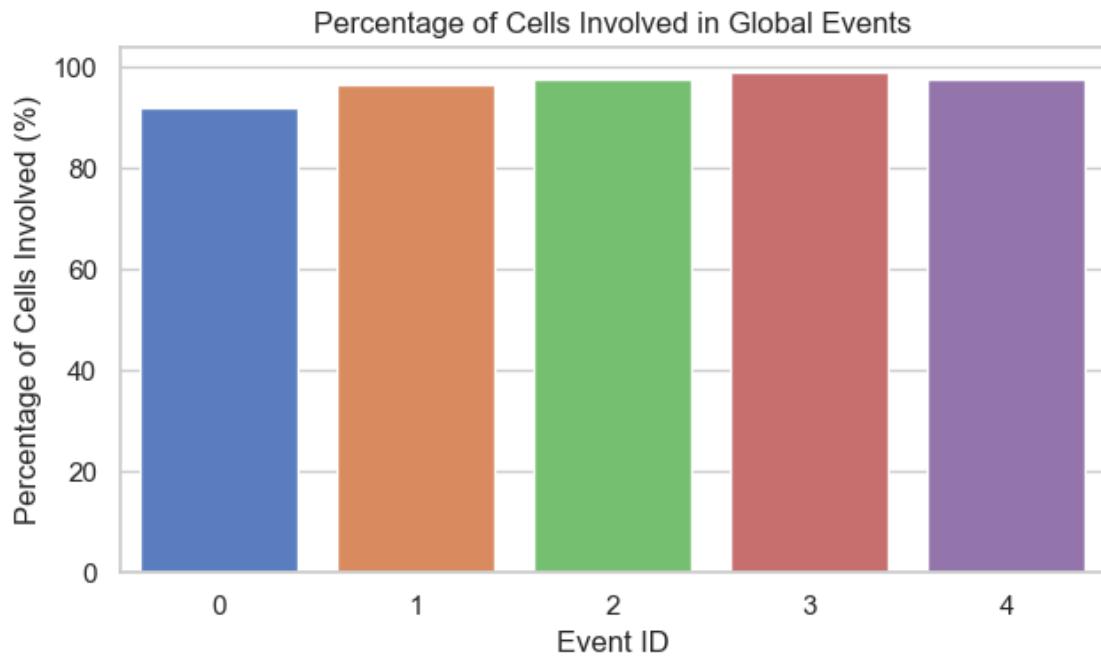


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250326_IS1





1.2.5 Inter-event interval analysis

Intervals between global event peaks: [210.0, 227.0, 260.0, 267.0]

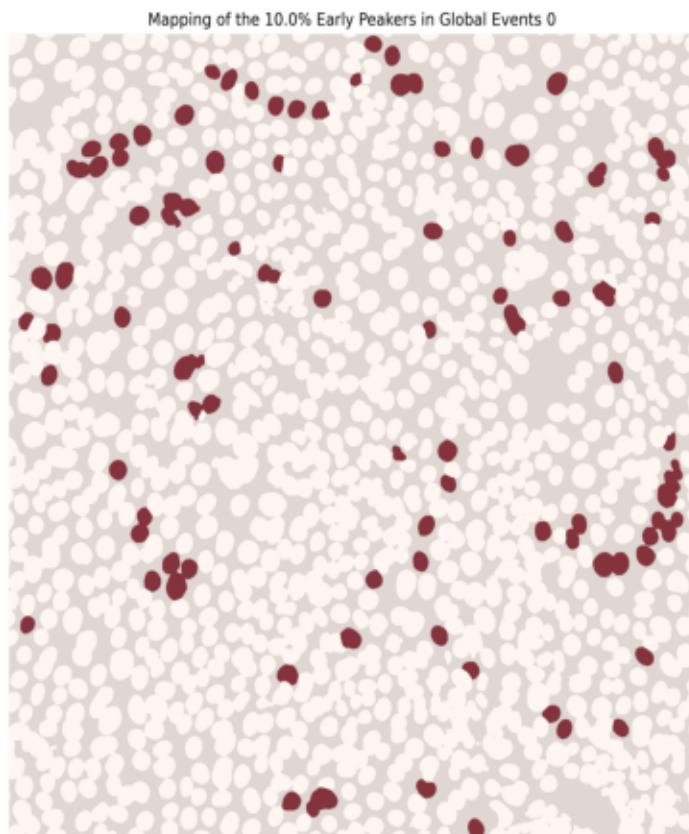
Estimated periodicity: 0.911

The global events exhibit a regular periodic pattern.

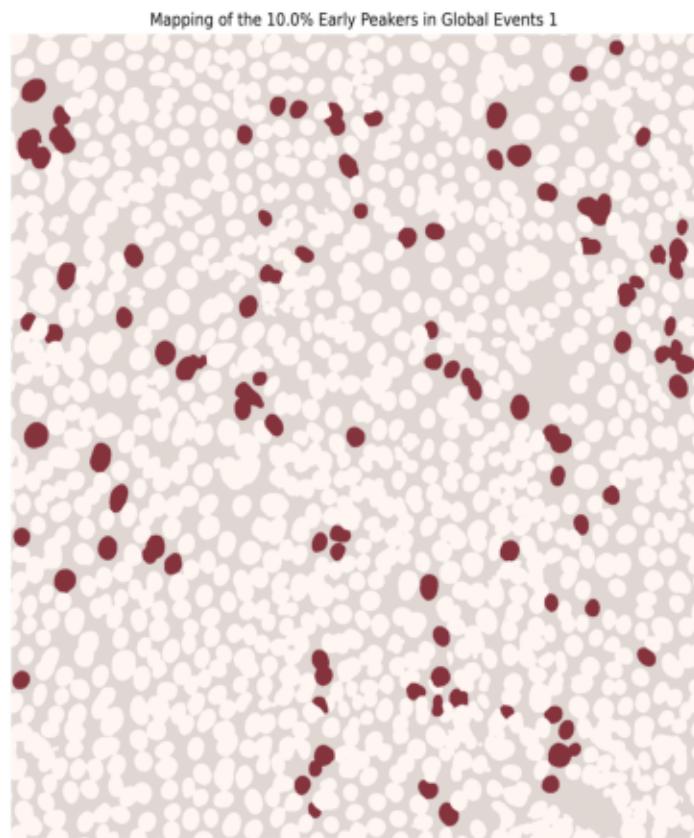
Estimated frequency (1/mean interval): 0.004 Hz

1.2.6 Early peakers in the events

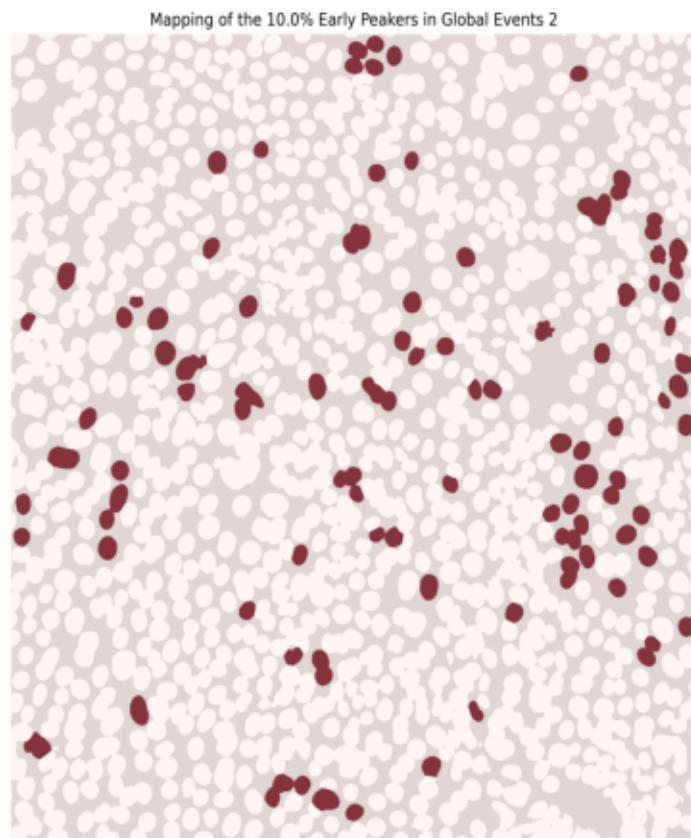
Cell Mapping with Early Peakers Overlay for event 0 - 20250326_IS1



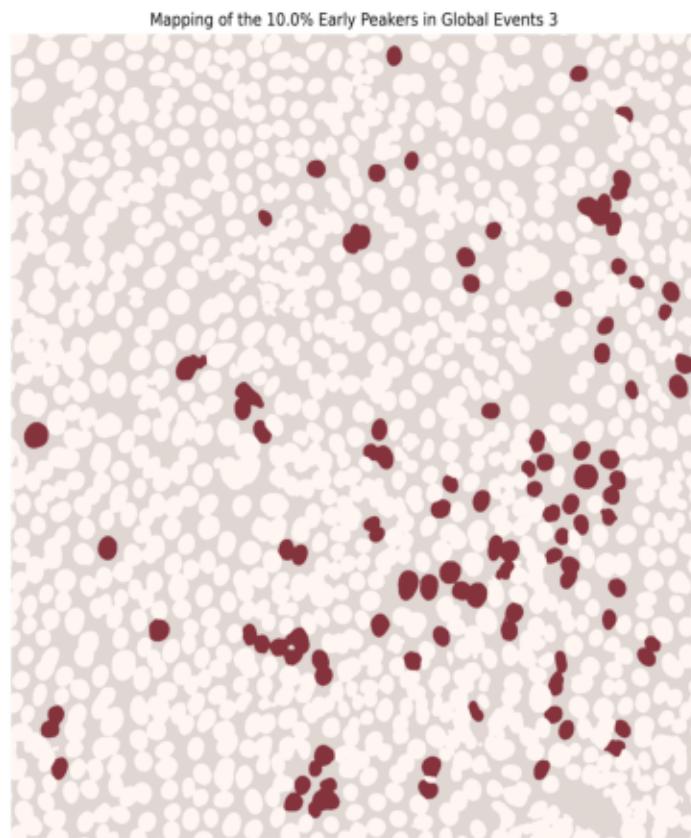
Cell Mapping with Early Peakers Overlay for event 1 - 20250326_IS1



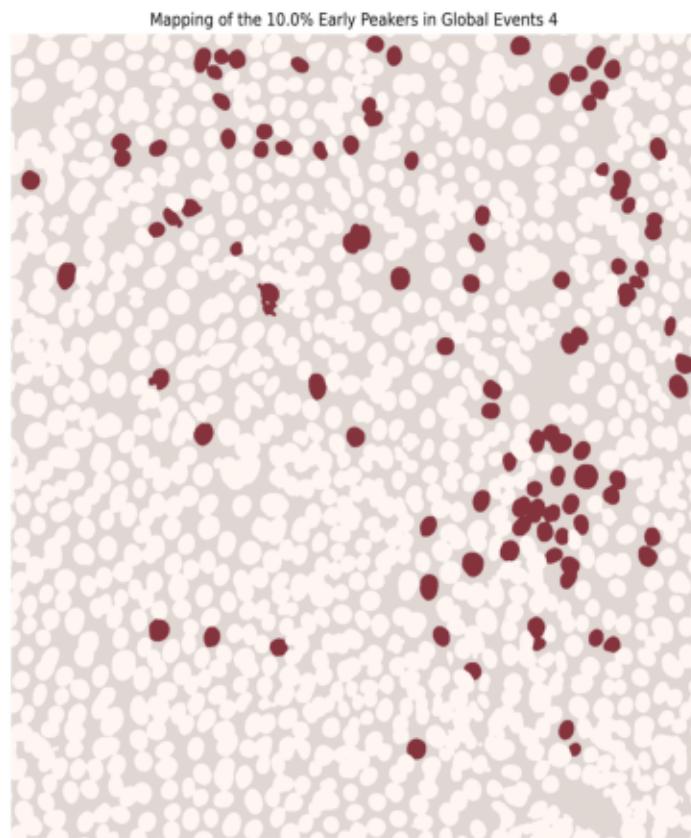
Cell Mapping with Early Peakers Overlay for event 2 - 20250326_IS1



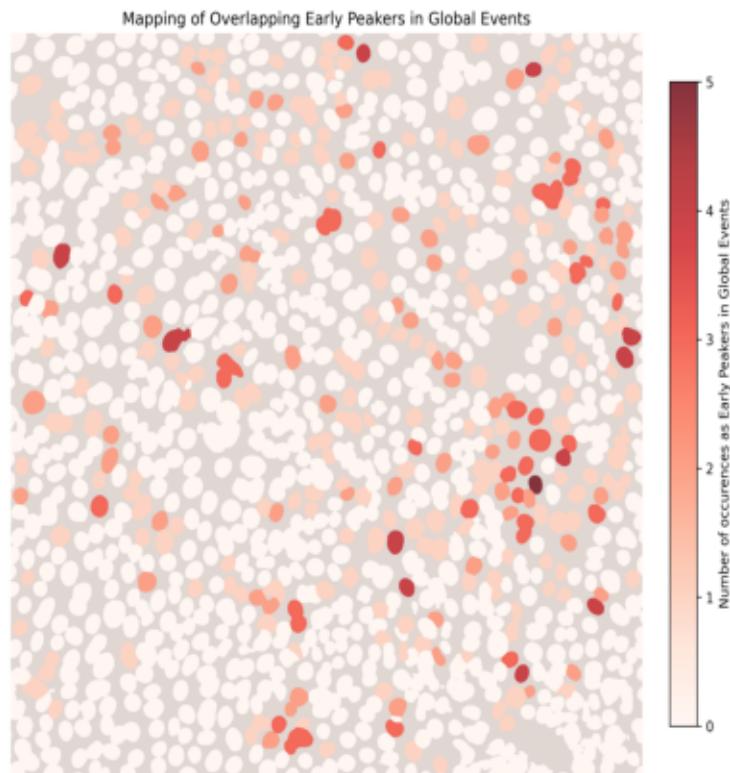
Cell Mapping with Early Peakers Overlay for event 3 - 20250326_IS1



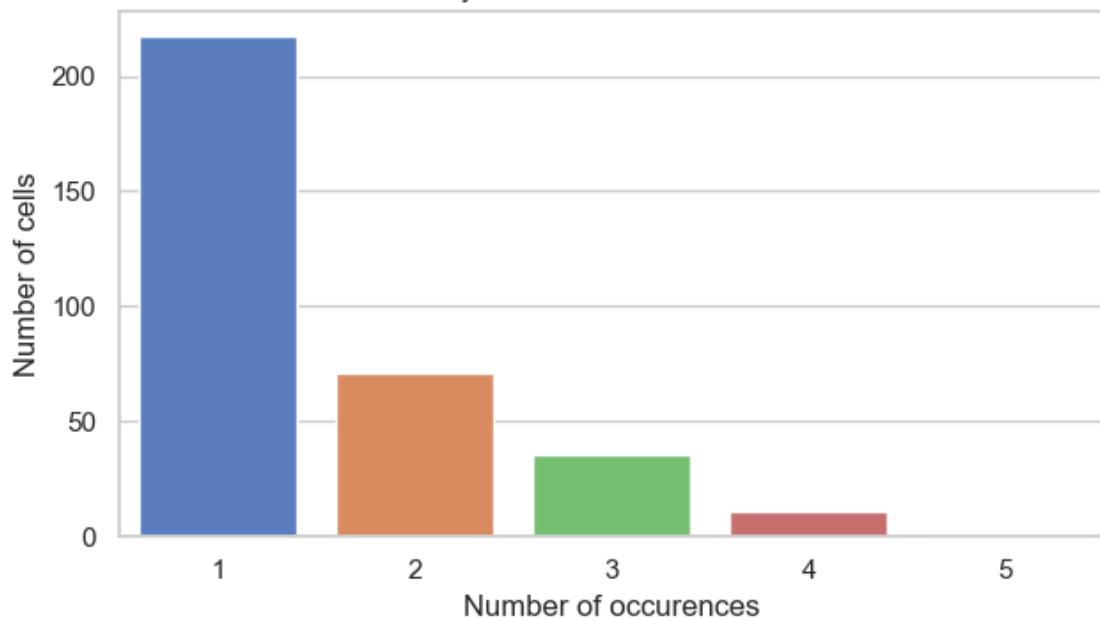
Cell Mapping with Early Peakers Overlay for event 4 - 20250326_IS1



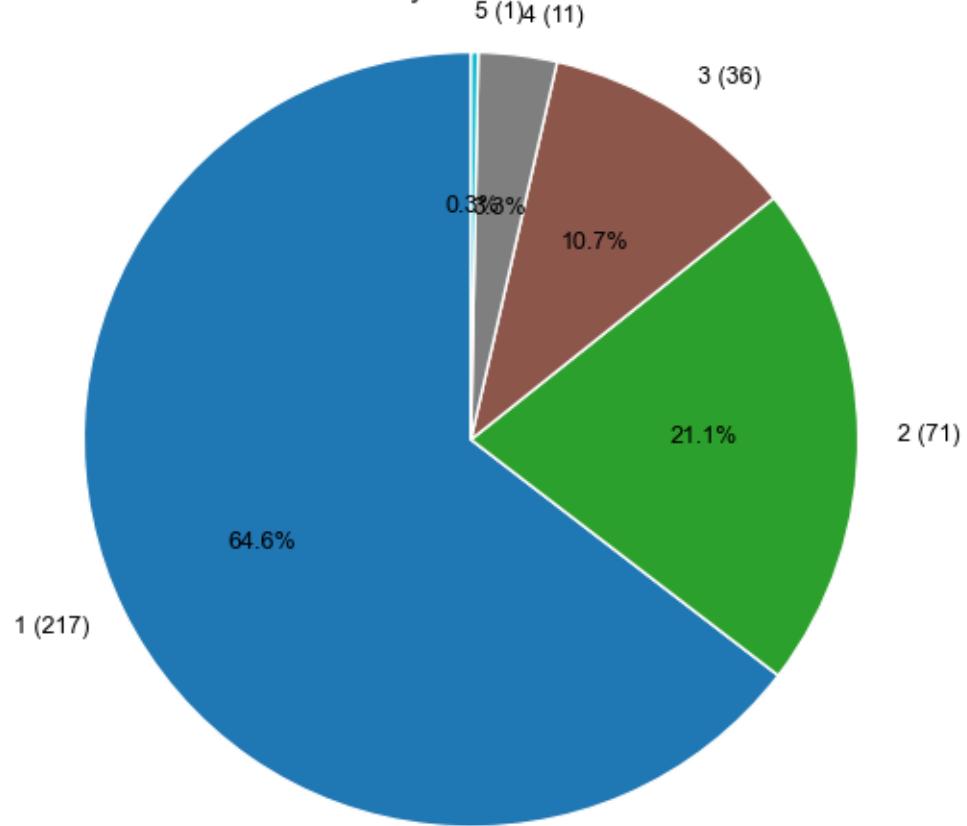
Cell Mapping with Occurrences in Global Events Overlay - 20250326_IS1



Early Peakers in Global Events

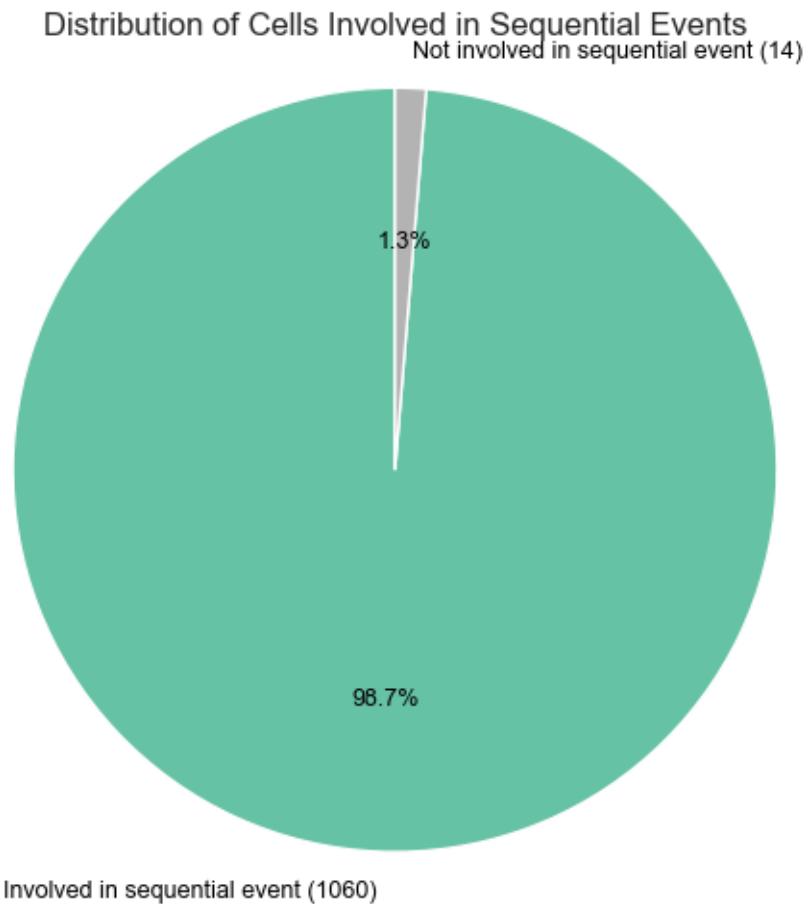


Distribution of Early Peakers in Global Events

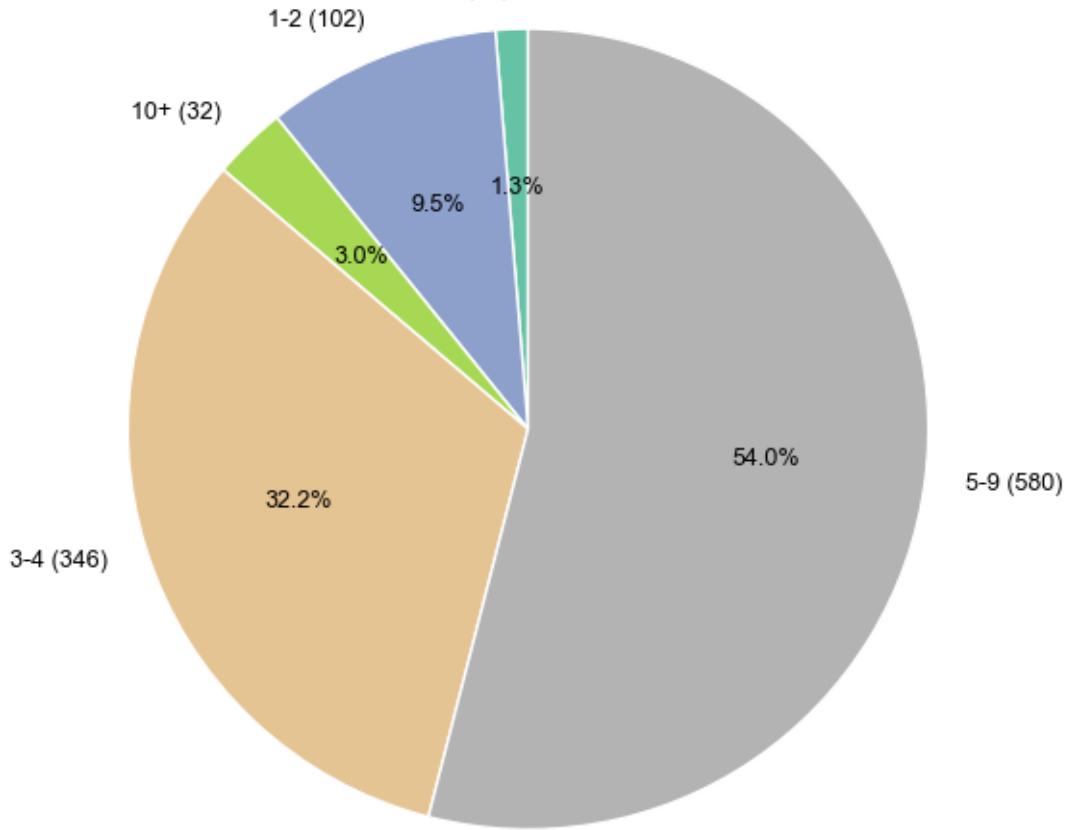


1.3 SEQUENTIAL EVENTS

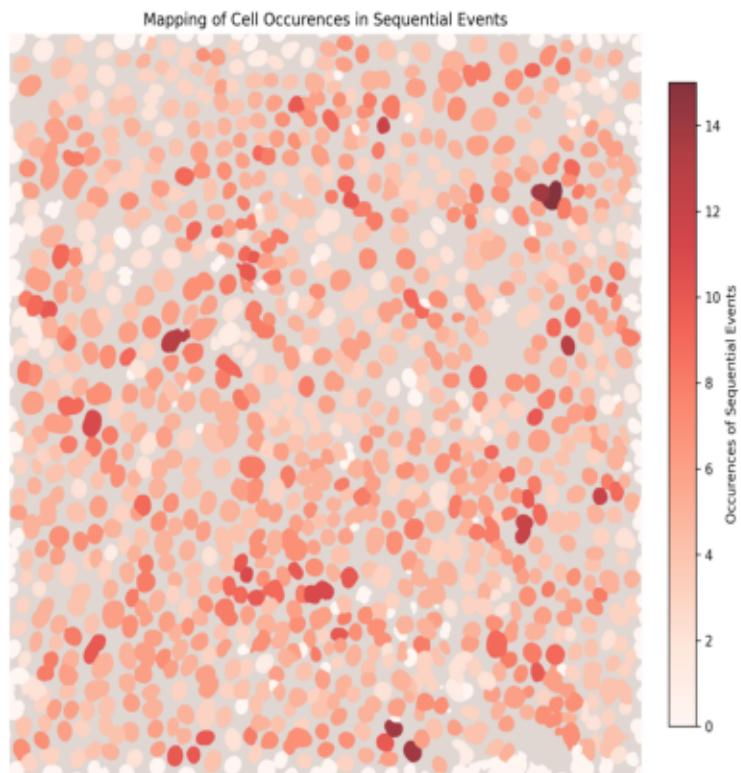
1.3.1 Cells occurrences in sequential events



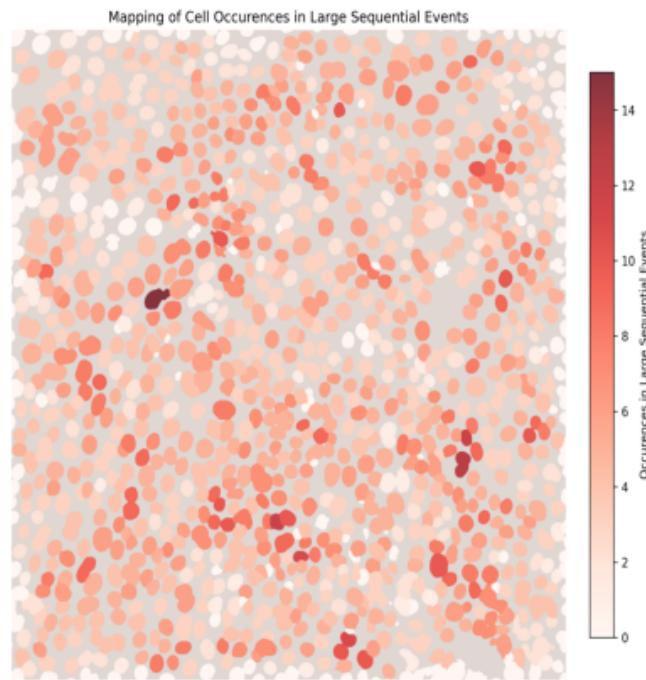
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250326_IS1

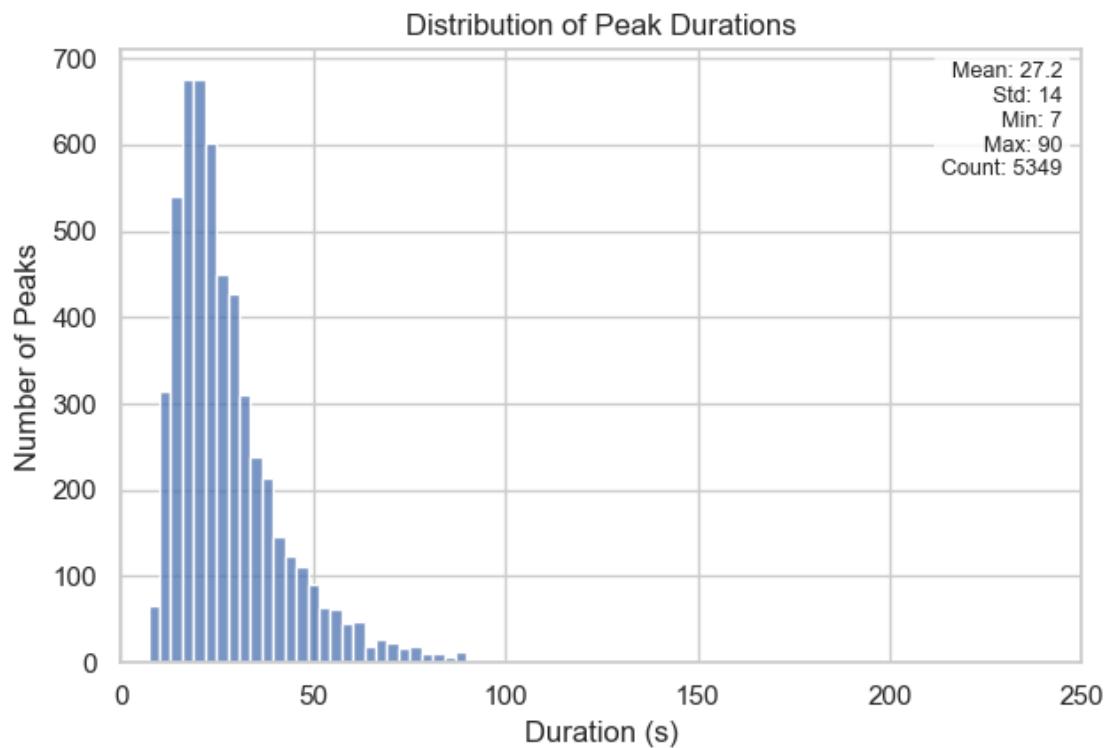


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250326_IS1

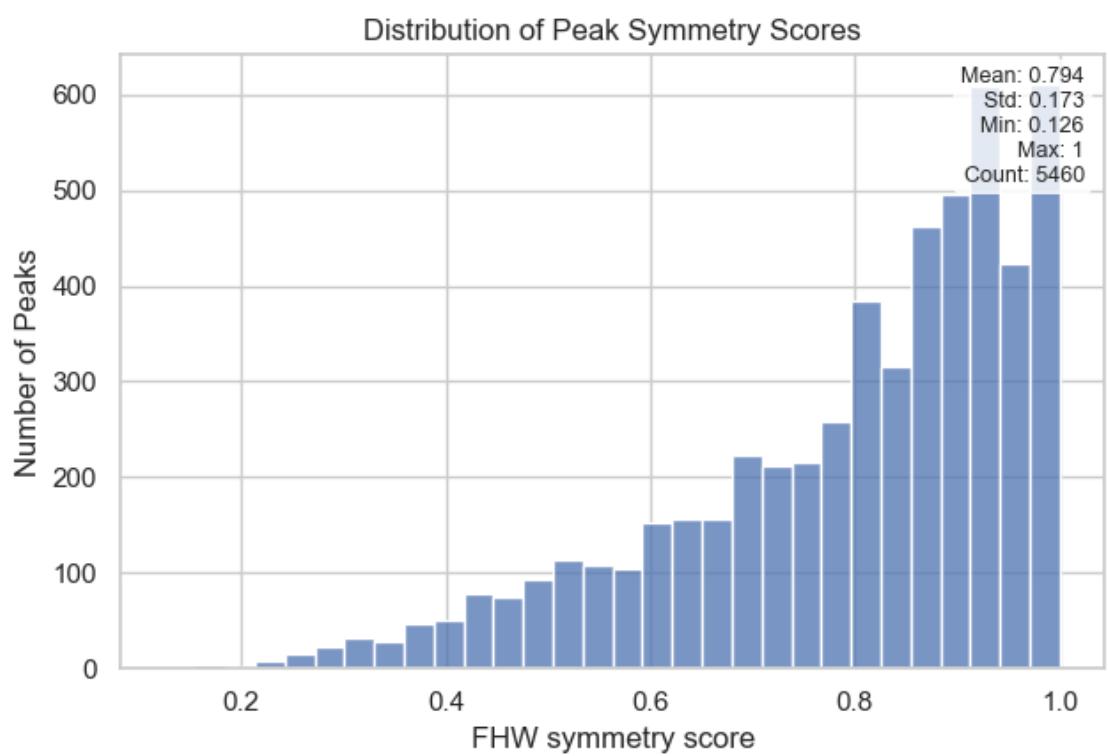
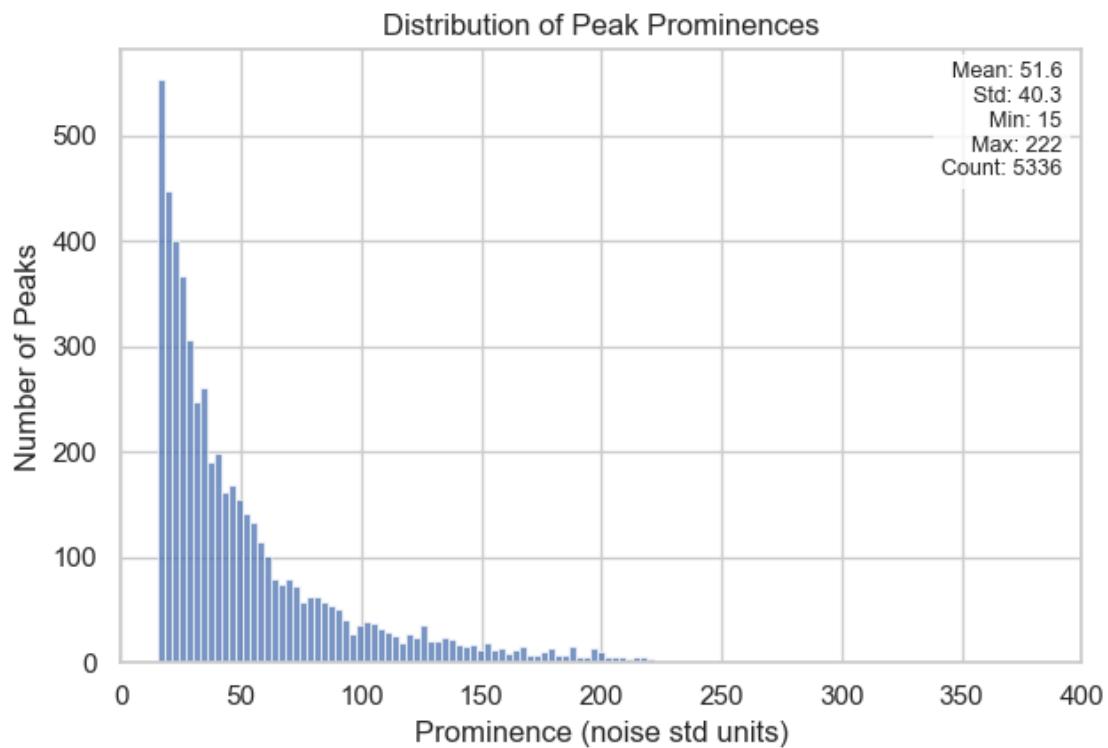


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 11:23:26] [INFO] calcium: plot_histogram: removed 111 outliers out  
of 5460 on 'Duration (s)' (lower=-6, upper=90)
```

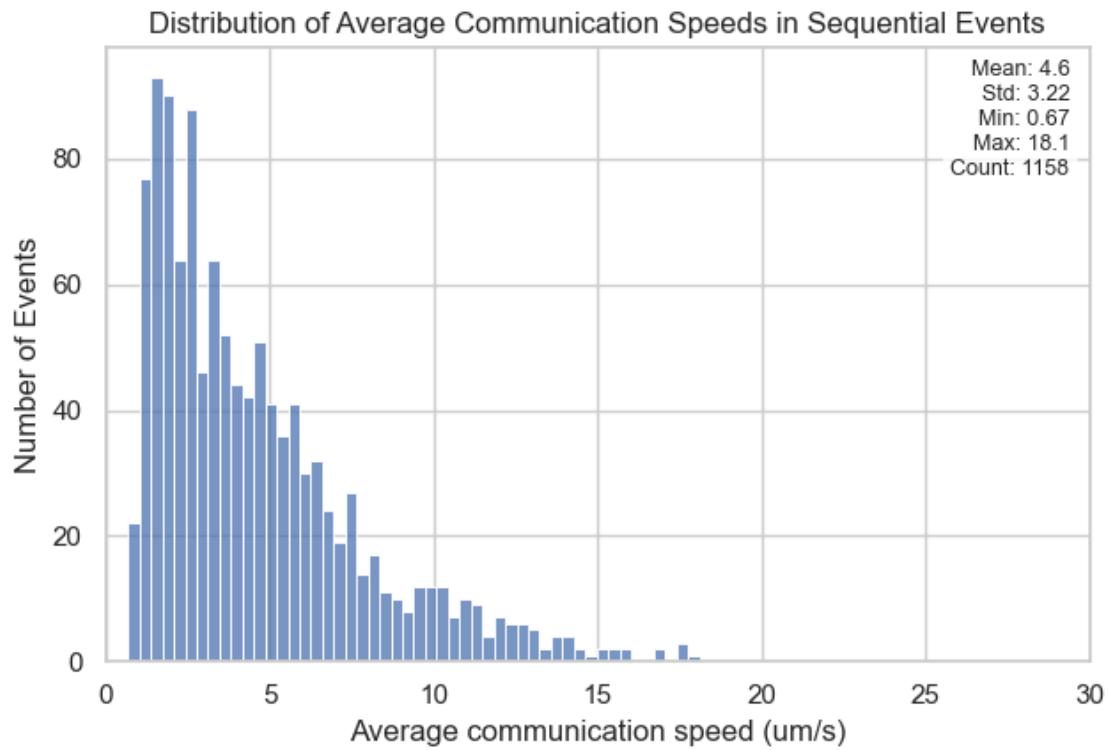


[2025-08-13 11:23:26] [INFO] calcium: plot_histogram: removed 124 outliers out of 5460 on 'Prominence (noise std units)' (lower=-43, upper=223.4)

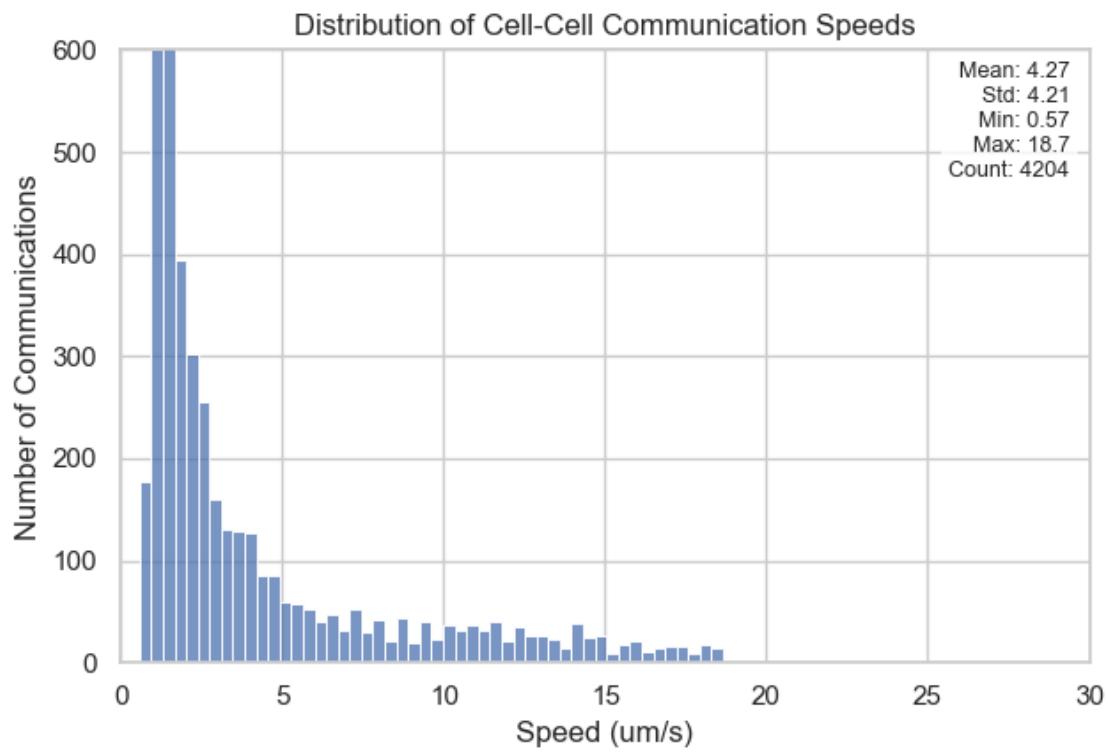


1.3.3 Cell-cell communication speed

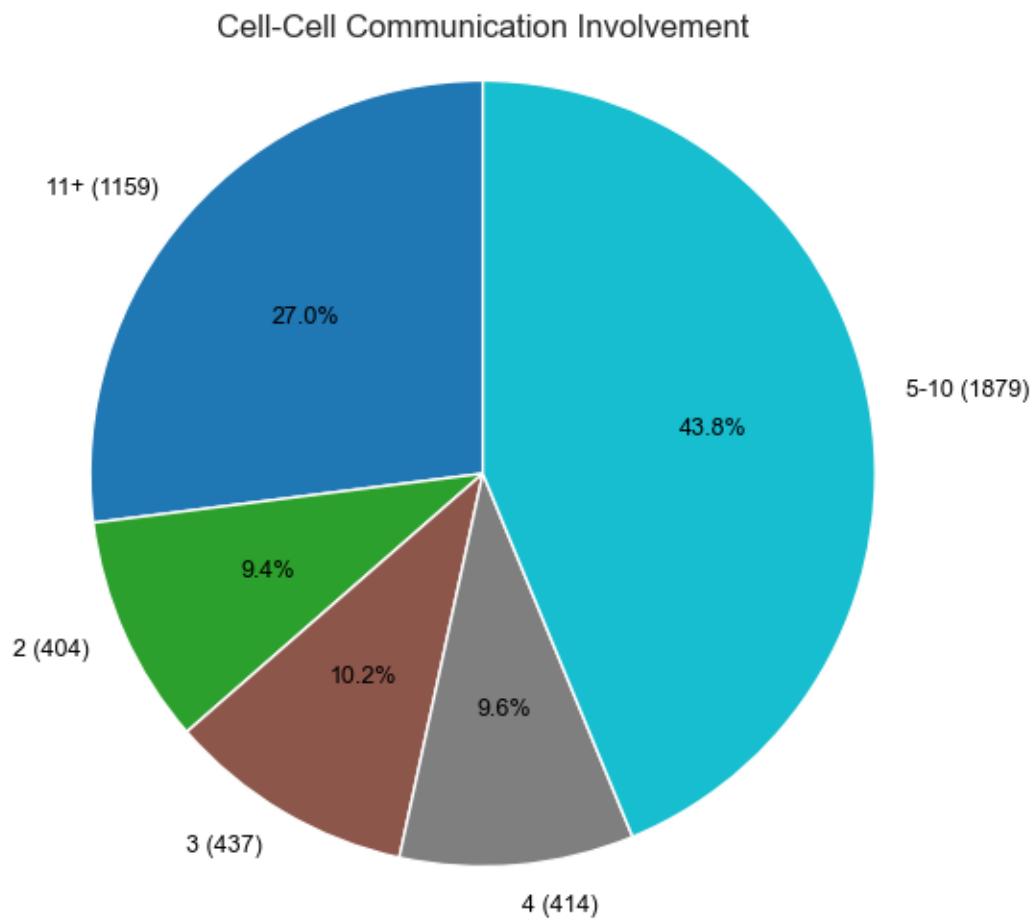
[2025-08-13 11:23:27] [INFO] calcium: plot_histogram: removed 9 outliers out of 1167 on 'Average communication speed (um/s)' (lower=-10.06, upper=18.36)



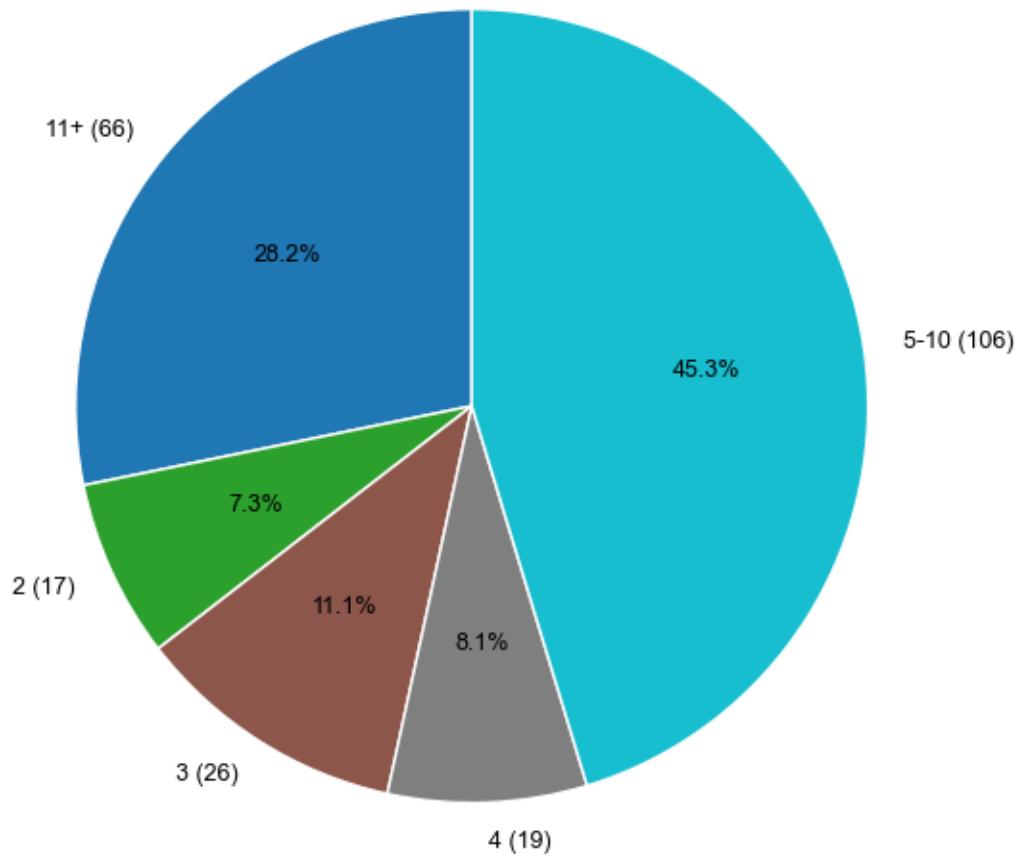
[2025-08-13 11:23:27] [INFO] calcium: plot_histogram: removed 89 outliers out of 4293 on 'Speed (um/s)' (lower=-11.52, upper=18.72)



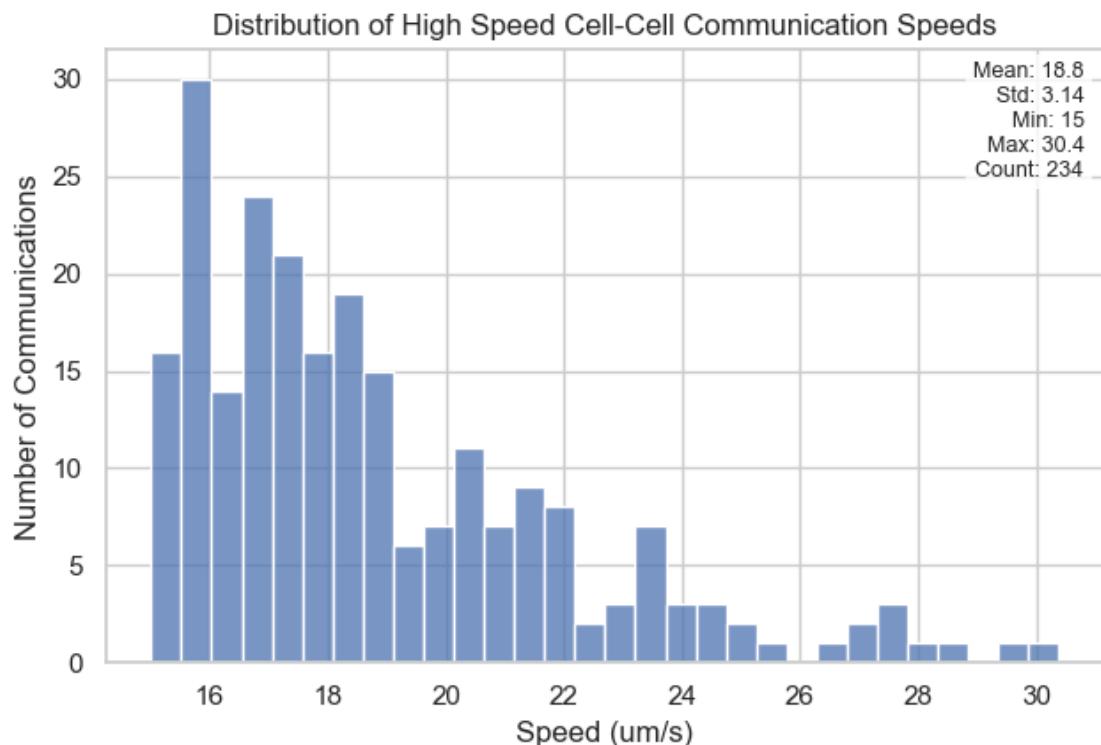
1.3.4 Double distribution in cell-cell communication speeds



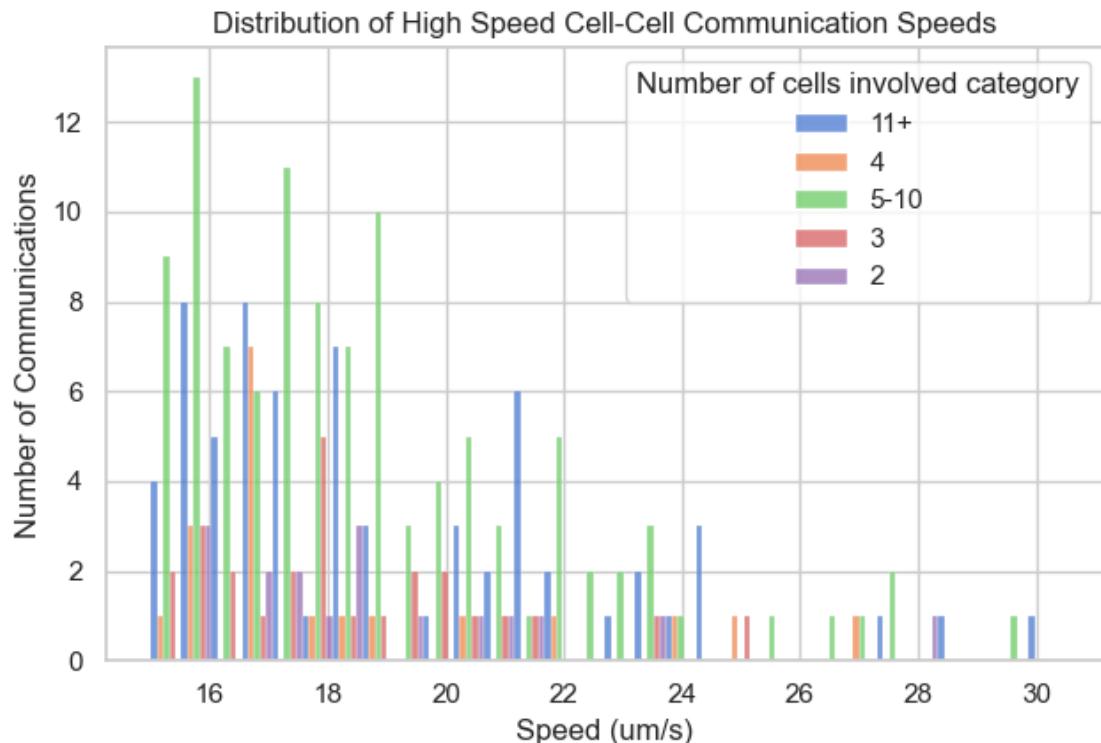
High Speed Cell-Cell Communication Involvement



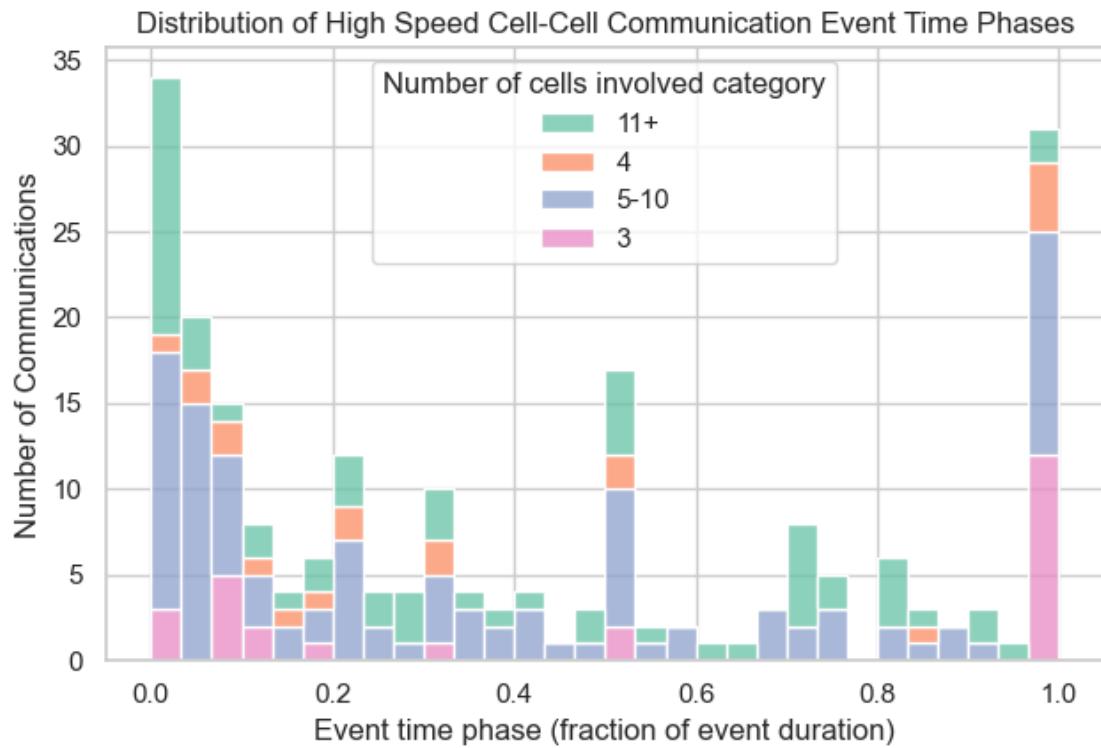
[2025-08-13 11:23:28] [INFO] calcium: plot_histogram: removed 0 outliers out of 234 on 'Speed (um/s)' (lower=4.24, upper=32.782)



```
[2025-08-13 11:23:28] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 234 on 'Speed (um/s)' (lower=4.24, upper=32.782)
```

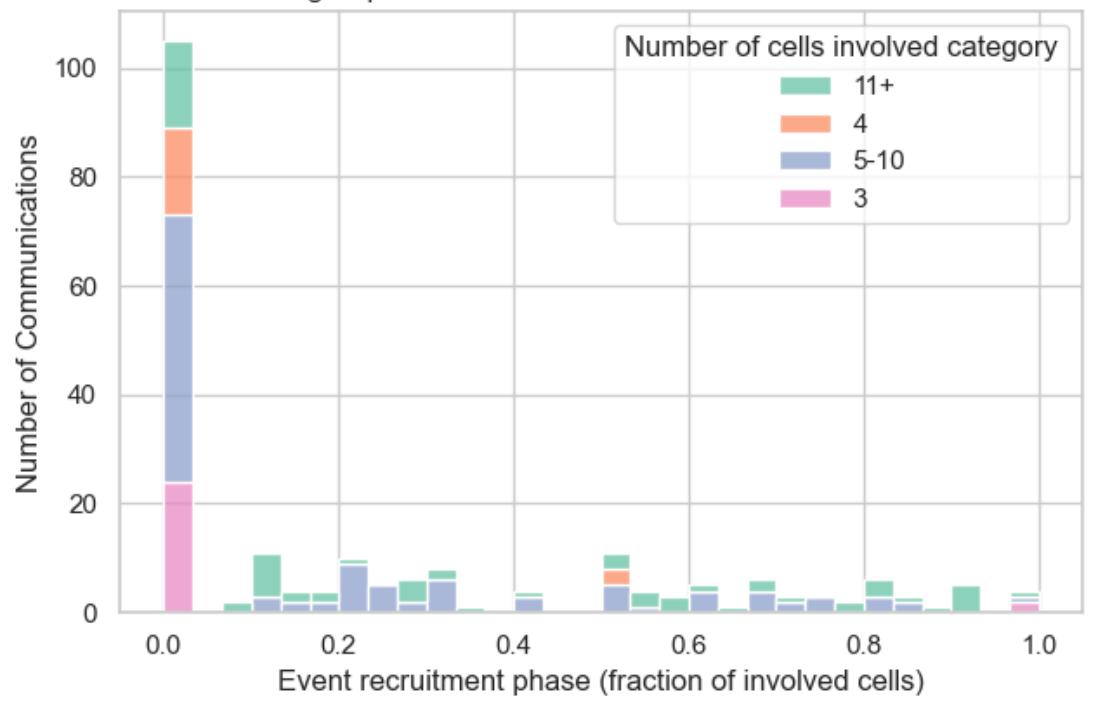


```
[2025-08-13 11:23:28] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 217 on 'Event time phase (fraction of event duration)' (lower=-1.85, upper=2.63)
```

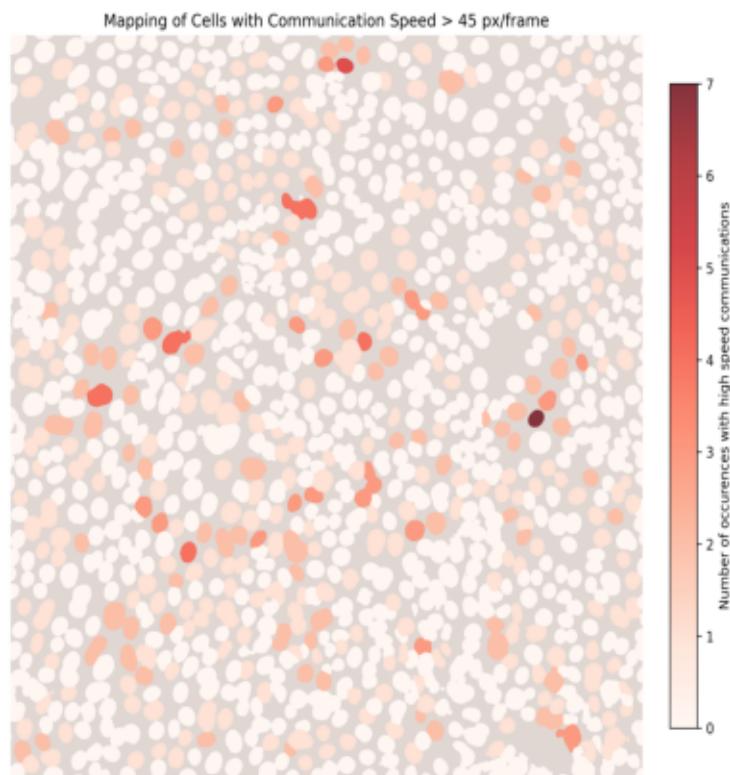


```
[2025-08-13 11:23:28] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 217 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.5, upper=2)
```

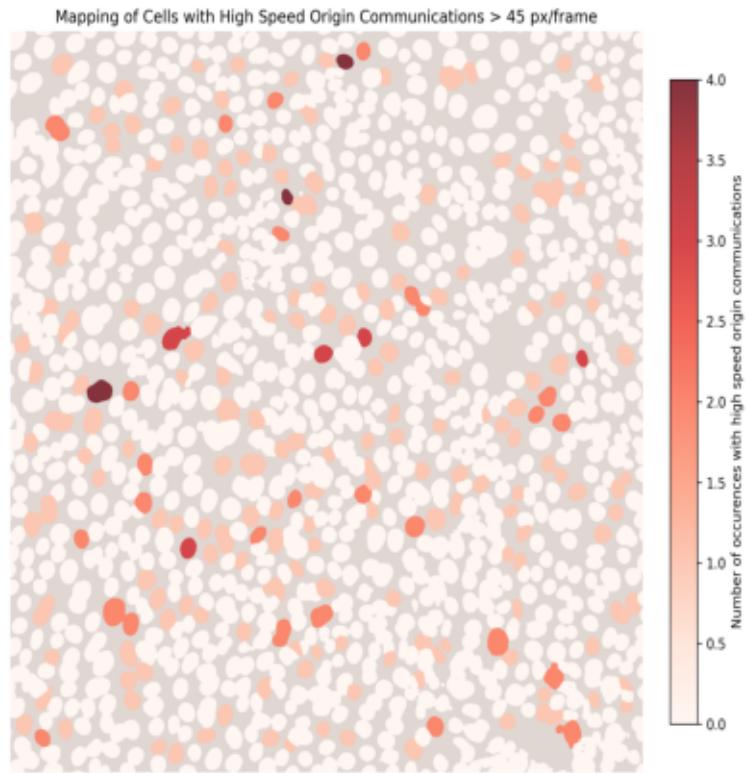
Distribution of High Speed Cell-Cell Communication Event Recruitment Phases



Cell Mapping with High Speed Cells Overlay - 20250326_IS1



Cell Mapping with High Speed Origin Cells Overlay - 20250326_IS1



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
3	1759529141344	5	1088		2
26	1759496109072	6	1208		2
35	1759496108976	9	817		0
42	1759496109552	10	309		2
52	1759496109456	13	408		5
...	
4187	1759438969808	1110	1713		10
4190	1759438978928	1111	1713		1
4208	1759396316880	1117	1727		1
4232	1759438973744	1129	1749		17
4246	1759438975520	1139	1757		3

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
3	1144	2	80.0	80.0	
26	1245	3	169.0	169.0	
35	786	2	85.0	85.0	
42	330	2	220.0	220.0	
52	360	3	533.0	534.0	
...	
4187	1673	11	938.0	939.0	
4190	1738	1	91.0	92.0	
4208	1771	0	48.0	49.0	
4232	1703	17	1154.0	1155.0	
4246	1717	2	184.0	185.0	
	Duration (s)	Distance (um)	Speed (um/s)	\	
3	0.0	17.47	17.47		
26	0.0	16.82	16.82		
35	0.0	19.63	19.63		
42	0.0	25.38	25.38		
52	1.0	16.51	16.51		
...	
4187	1.0	20.55	20.55		
4190	1.0	17.67	17.67		
4208	1.0	17.95	17.95		
4232	1.0	21.37	21.37		
4246	1.0	15.12	15.12		
	Event time phase (fraction of event duration)	\			
3		0.15			
26		1.00			
35		0.71			
42		0.41			
52		0.50			
...		...			
4187		0.33			
4190		0.11			
4208		0.08			
4232		NaN			
4246		0.09			
	Event recruitment phase (fraction of involved cells)	dataset	\		
3		0.11	20250326_IS1		
26		0.00	20250326_IS1		
35		0.00	20250326_IS1		
42		0.25	20250326_IS1		
52		0.00	20250326_IS1		
...			
4187		0.00	20250326_IS1		
4190		0.00	20250326_IS1		

4208		0.00	20250326_IS1
4232		NaN	20250326_IS1
4246		0.00	20250326_IS1

	Number of cells involved	category	Speed category
3		11+	High speed
26		4	High speed
35		5-10	High speed
42		5-10	High speed
52		5-10	High speed
...
4187		3	High speed
4190		3	High speed
4208		5-10	High speed
4232		2	High speed
4246		3	High speed

[234 rows x 16 columns]

Origin cell ID	Speed category	High speed	Low speed
240		0	2
241		0	4
243		0	3
244		0	1
245		0	3
...
1767		0	2
1768		0	2
1771		0	1
1774		0	4
1775		0	7

[993 rows x 2 columns]

	Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
0	240	264.55		5.85
1	241	111.15		6.17
2	243	370.18		6.83
3	244	51.02		7.80
4	245	440.05		8.12
...
1069	1767	232.38		489.78
1070	1768	160.22		489.78
1071	1771	15.60		490.75
1072	1774	265.20		491.07
1073	1775	339.30		492.38

Number of peaks Is active Occurences in global events \

0	15	True	5
1	14	True	5
2	13	True	5
3	9	True	5
4	16	True	5
...
1069	12	True	5
1070	10	True	5
1071	10	True	5
1072	11	True	5
1073	12	True	5

Occurrences in global events as early peaker \

0	3
1	0
2	1
3	0
4	1
...	...
1069	0
1070	0
1071	0
1072	0
1073	1

Occurrences in sequential events \

0	7
1	4
2	4
3	3
4	5
...	...
1069	3
1070	4
1071	3
1072	3
1073	5

Occurrences in sequential events as origin \

0	0
1	1
2	2
3	1
4	1
...	...
1069	2
1070	2
1071	0

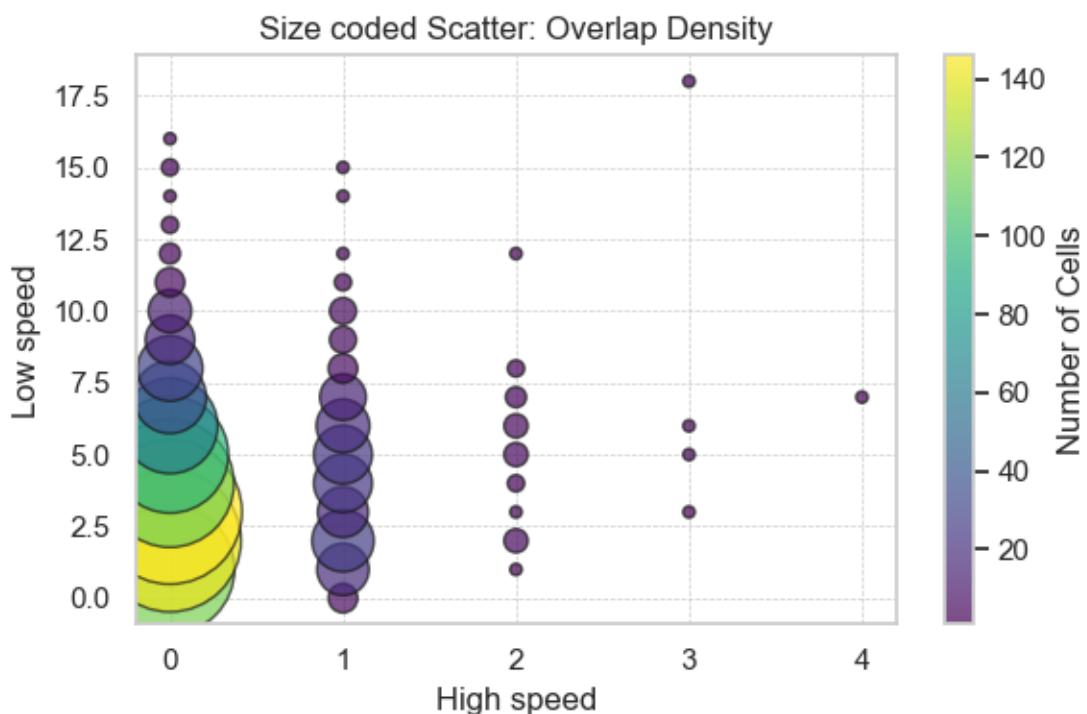
1072		3		
1073		3		
	Occurrences in individual events	Peak frequency (Hz)	Periodicity score	\
0	0	0.0088	0.60	
1	5	0.0082	0.58	
2	2	0.0076	0.67	
3	1	0.0053	0.70	
4	4	0.0094	0.56	
...
1069	3	0.0071	0.65	
1070	1	0.0059	0.73	
1071	2	0.0059	0.71	
1072	3	0.0065	0.76	
1073	0	0.0071	0.64	
	Neighbor count	Neighbors (labels)	dataset	\
0	3	[248, 260, 280]	20250326_IS1	
1	3	[247, 274, 285]	20250326_IS1	
2	4	[257, 272, 293, 299]	20250326_IS1	
3	4	[250, 251, 288, 296]	20250326_IS1	
4	3	[263, 264, 284]	20250326_IS1	
...
1069	4	[1722, 1740, 1744, 1765]	20250326_IS1	
1070	3	[1721, 1723, 1751]	20250326_IS1	
1071	3	[1727, 1743, 1756]	20250326_IS1	
1072	3	[1728, 1744, 1752]	20250326_IS1	
1073	5	[1699, 1704, 1725, 1734, 1749]	20250326_IS1	
	Involved in sequential event	Occurrences in sequential events	category	\
0	Involved in sequential event		5-9	
1	Involved in sequential event		3-4	
2	Involved in sequential event		3-4	
3	Involved in sequential event		3-4	
4	Involved in sequential event		5-9	
...
1069	Involved in sequential event		3-4	
1070	Involved in sequential event		3-4	
1071	Involved in sequential event		3-4	
1072	Involved in sequential event		3-4	
1073	Involved in sequential event		5-9	
	High speed	Low speed		
0	0.0	2.0		
1	0.0	4.0		
2	0.0	3.0		
3	0.0	1.0		
4	0.0	3.0		

```

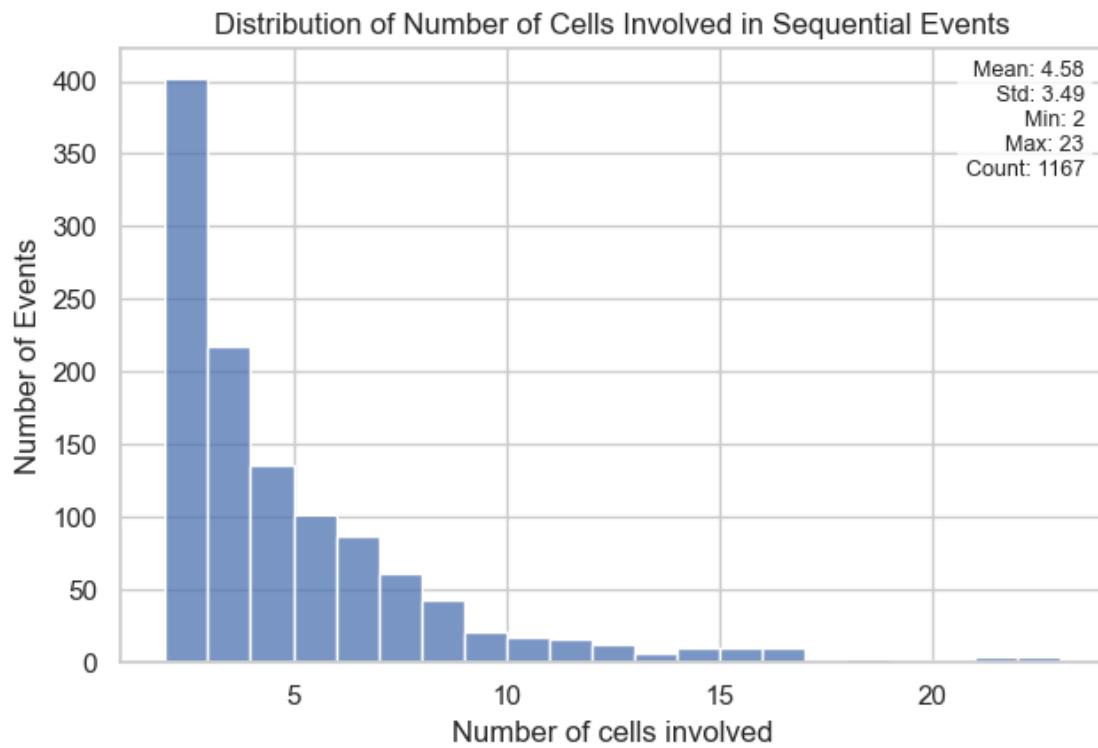
...
1069      0.0      2.0
1070      0.0      2.0
1071      0.0      1.0
1072      0.0      4.0
1073      0.0      7.0

```

[993 rows x 19 columns]



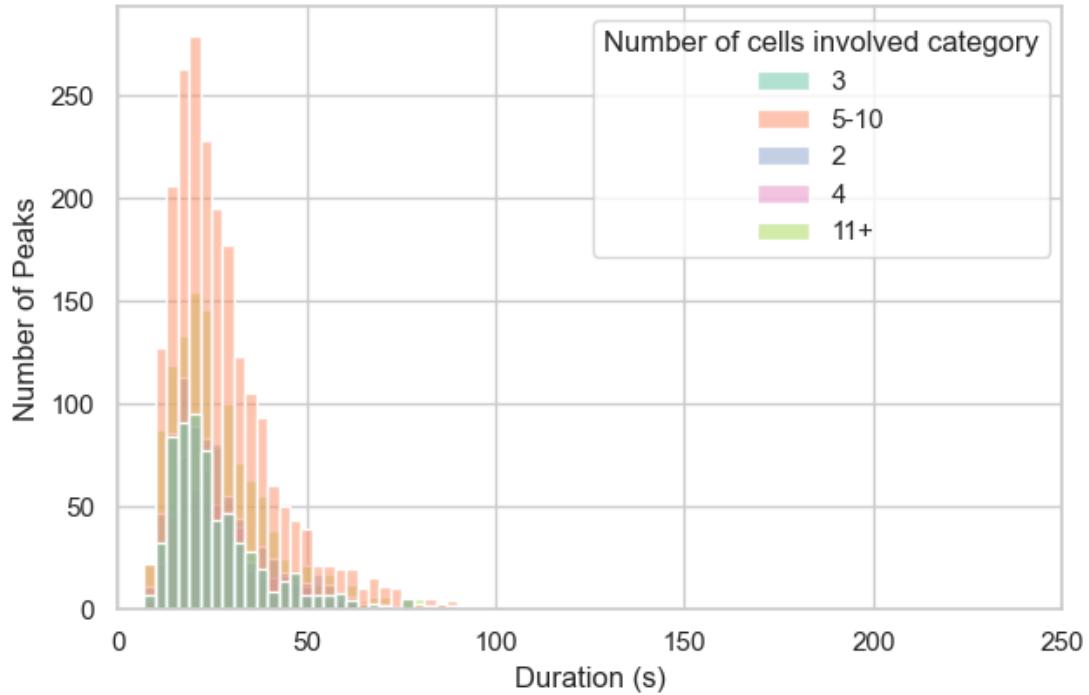
1.3.5 Number of cells involved per sequential events



1.3.6 Influence of cell count per event on statistics

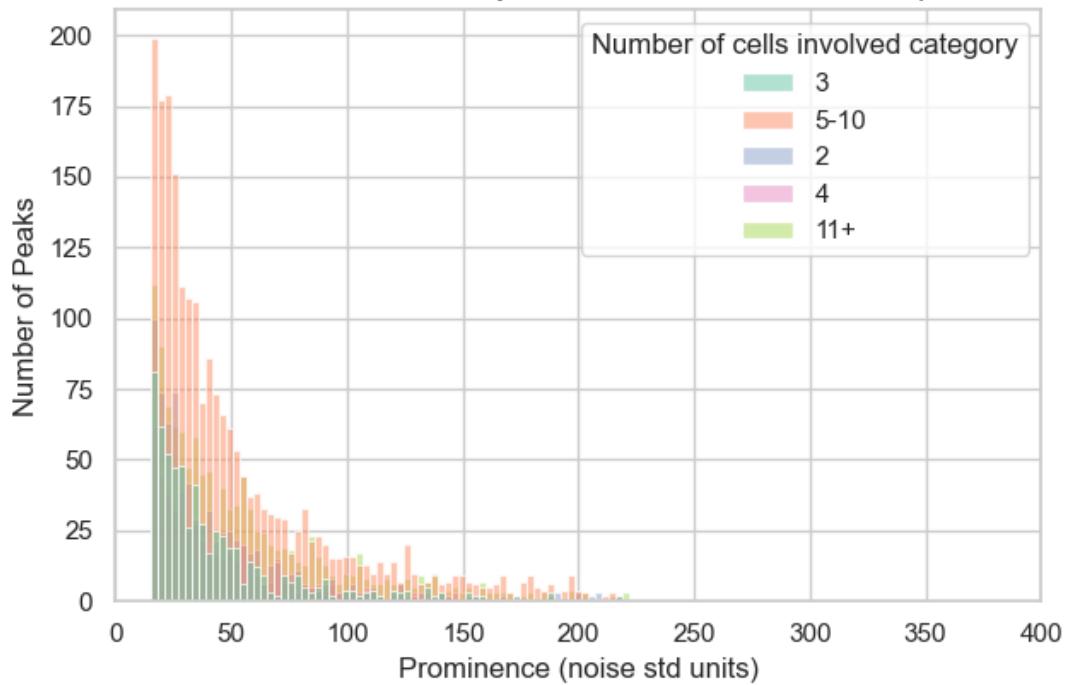
```
[2025-08-13 11:23:32] [INFO] calcium: plot_histogram_by_group: removed 111 outliers out of 5460 on 'Duration (s)' (lower=-6, upper=90)
```

Distribution of Peak Durations by Number of Cells Involved in Sequential Events

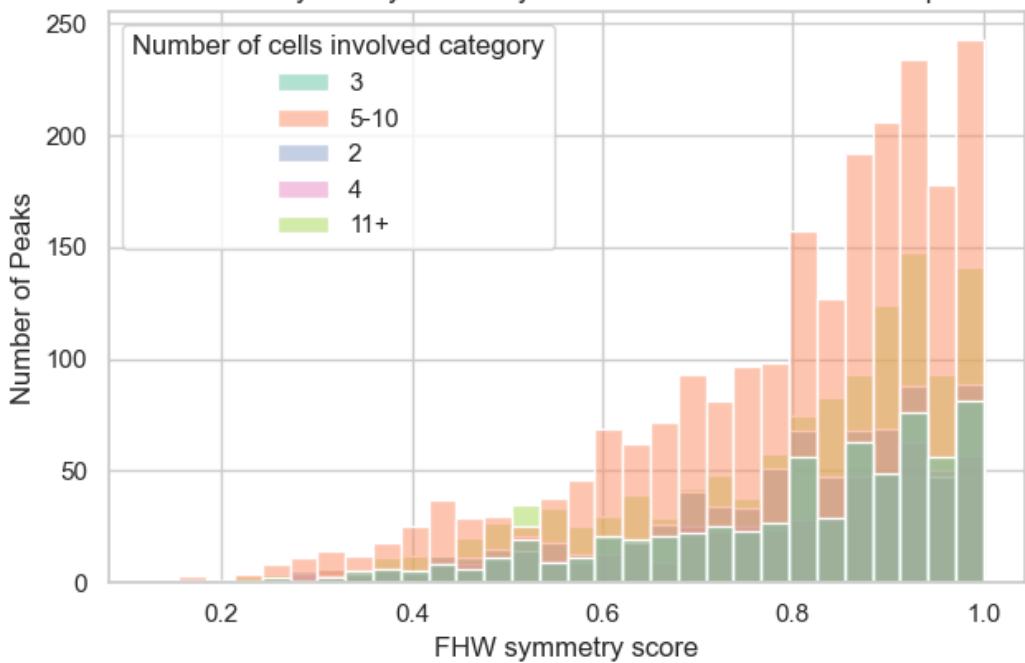


```
[2025-08-13 11:23:32] [INFO] calcium: plot_histogram_by_group: removed 124 outliers out of 5460 on 'Prominence (noise std units)' (lower=-43, upper=223.4)
```

Distribution of Peak Prominences by Number of Cells Involved in Sequential Events

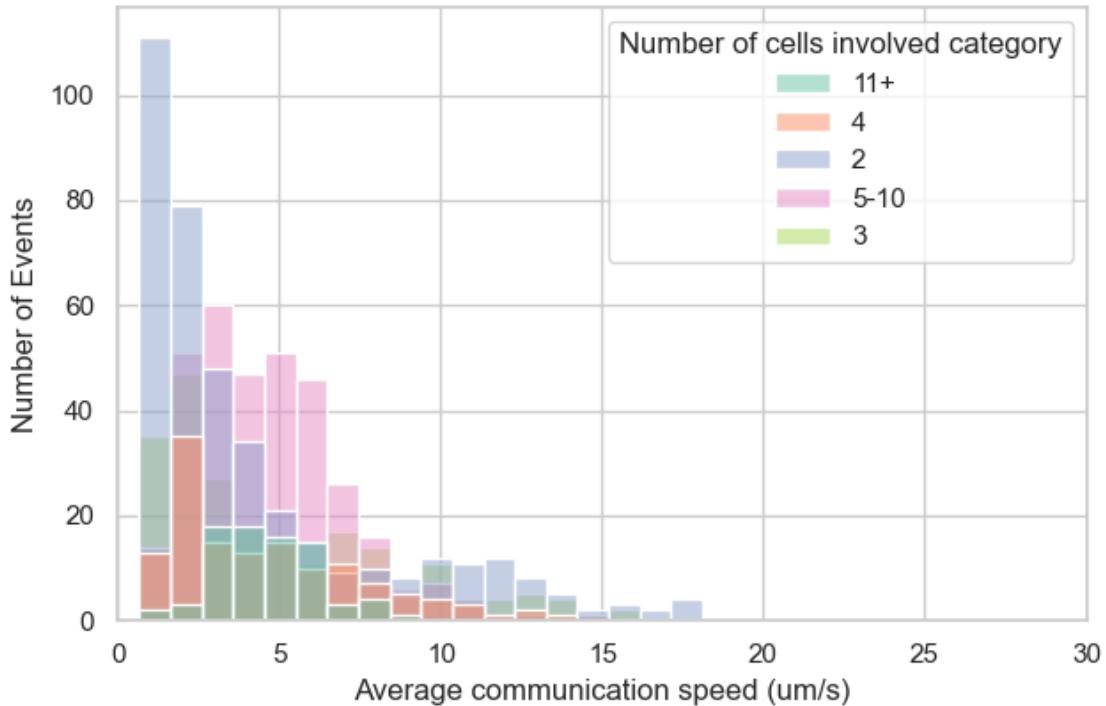


Distribution of Peak Symmetry Scores by Number of Cells Involved in Sequential Events



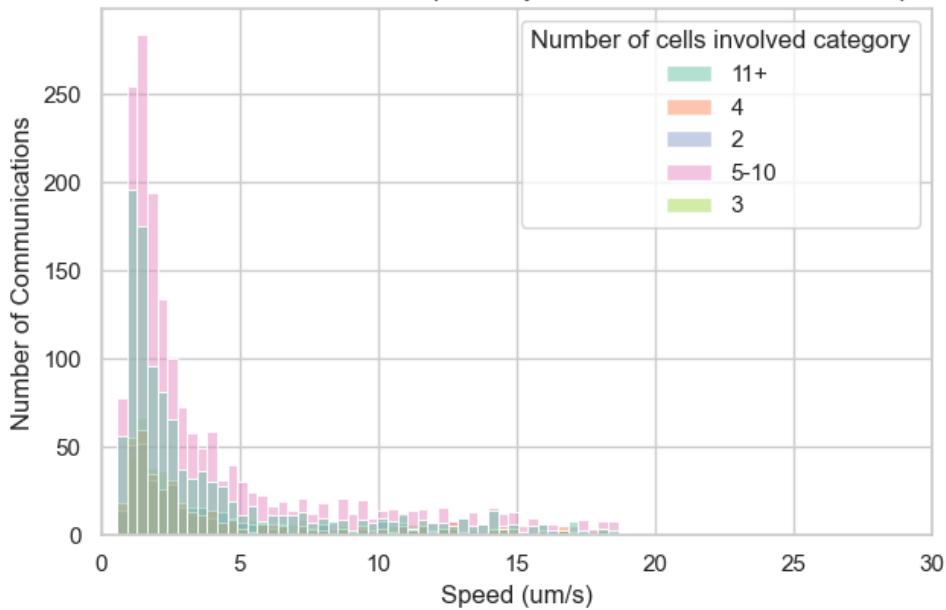
```
[2025-08-13 11:23:33] [INFO] calcium: plot_histogram_by_group: removed 9 outliers out of 1167 on 'Average communication speed (um/s)' (lower=-10.06, upper=18.36)
```

Distribution of Average Communication Speeds by Number of Cells Involved



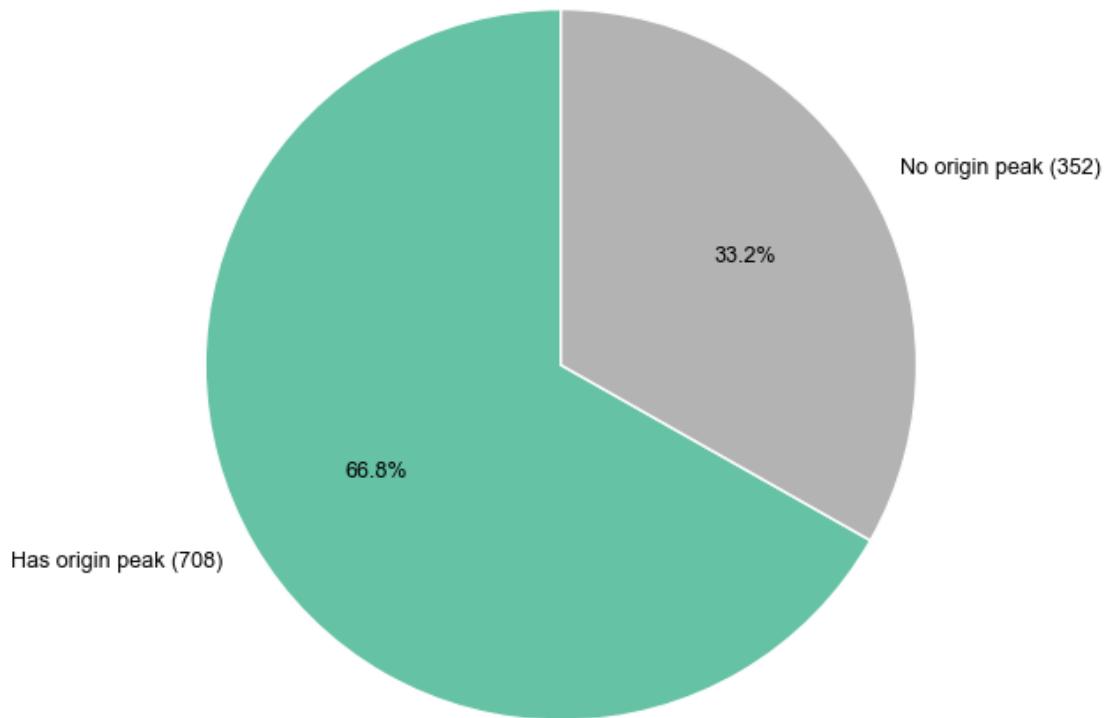
[2025-08-13 11:23:33] [INFO] calcium: plot_histogram_by_group: removed 89 outliers out of 4293 on 'Speed (um/s)' (lower=-11.52, upper=18.72)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events

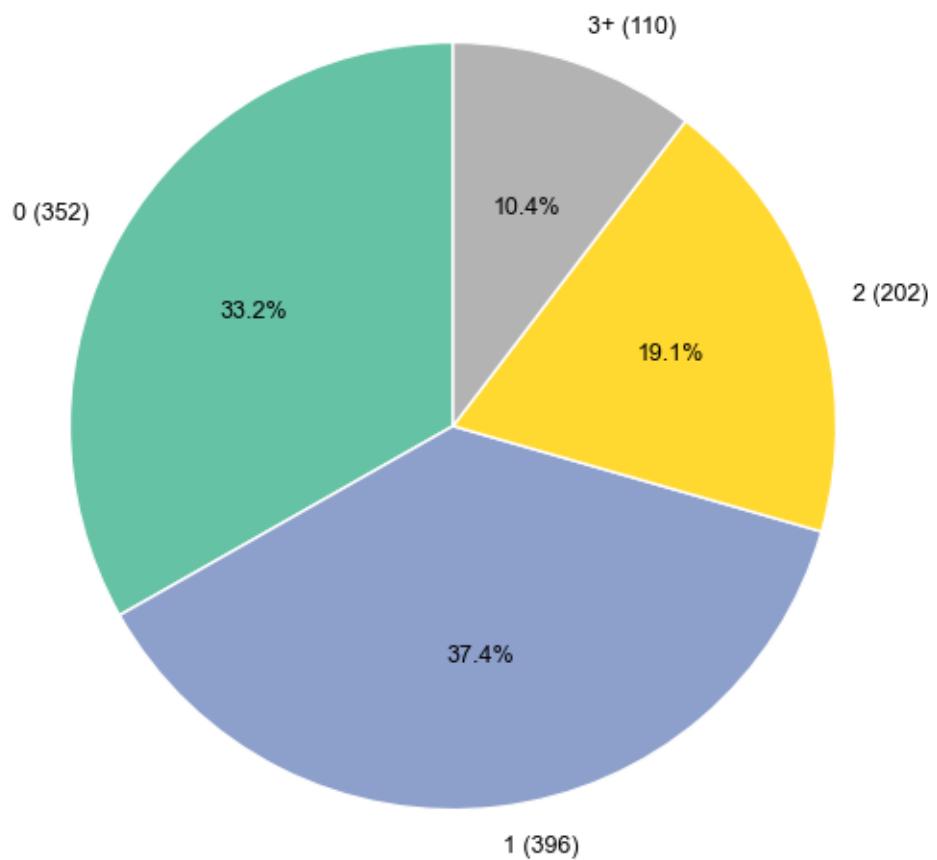


1.3.7 Cells occurrences as origin in sequential events

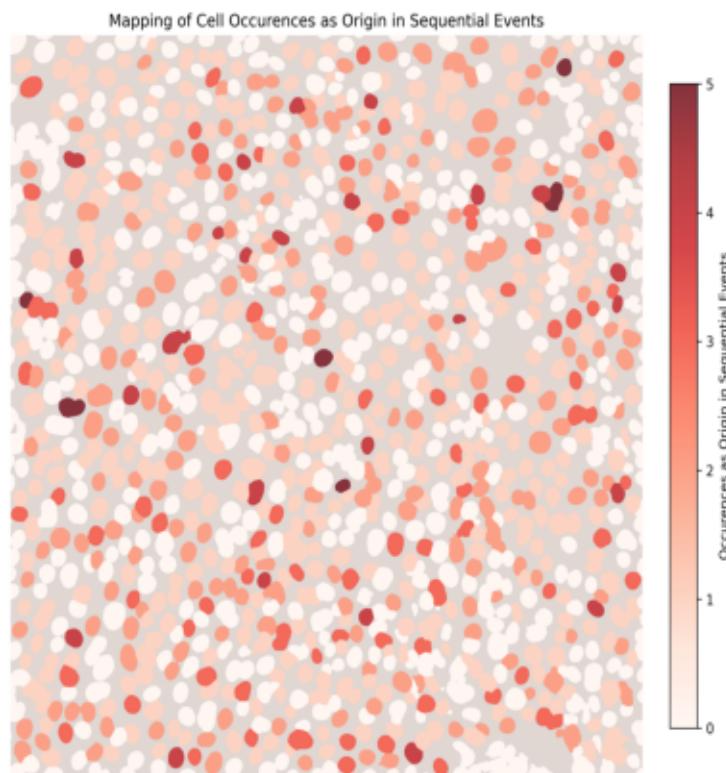
Distribution of Number of Sequential Event Origin Peaks per Cell

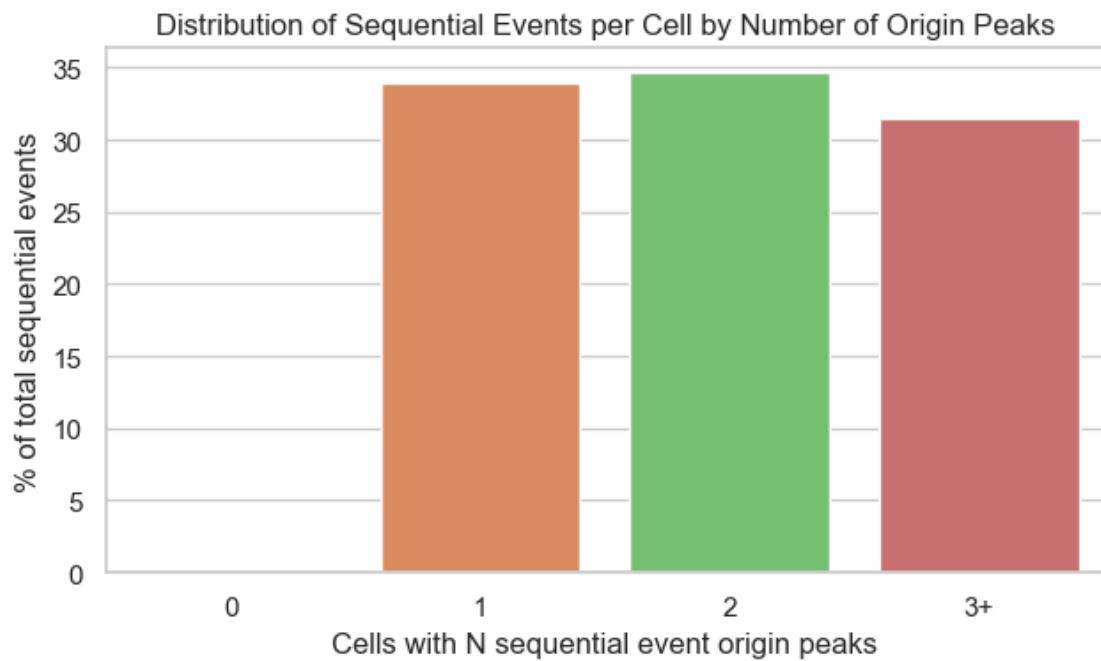


Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)



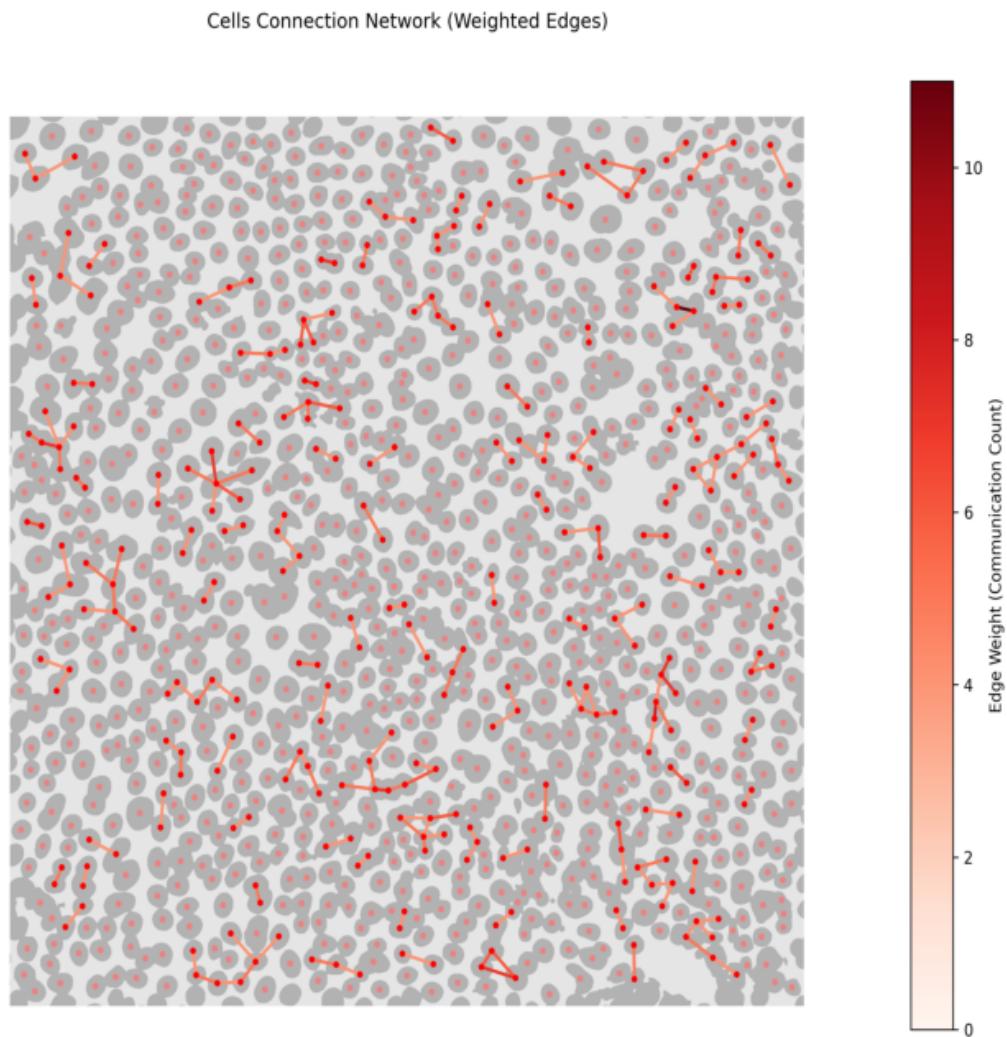
Cell Mapping with Origin Peaks Overlay - 20250326_IS1

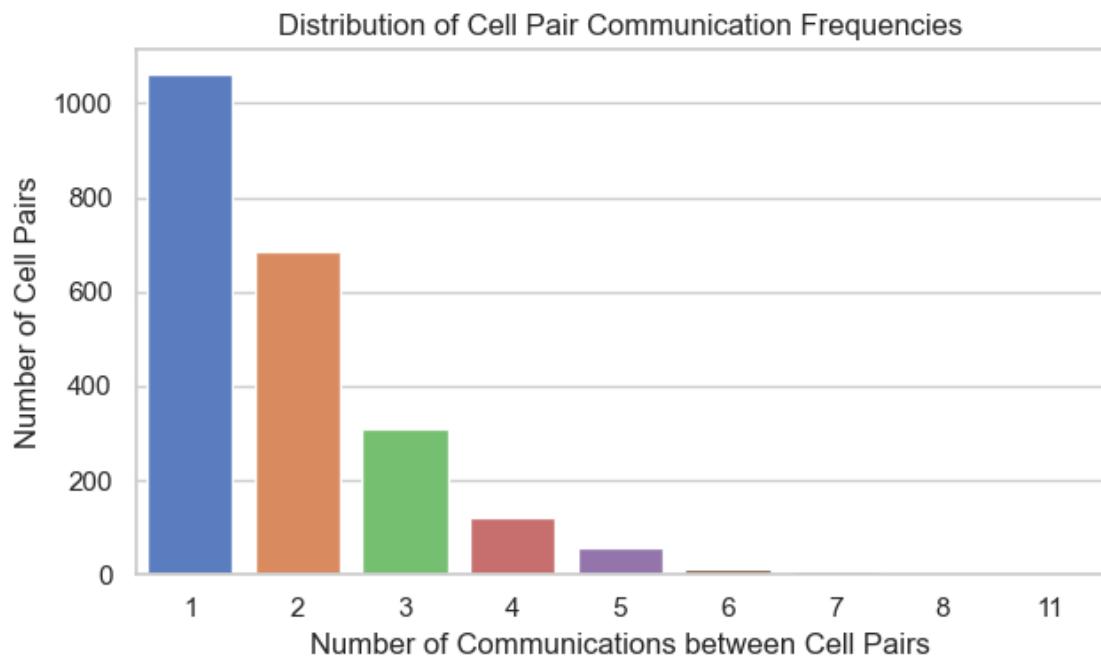




1.3.8 Connection network between cells

Cell Connection Network Graph - 20250326_IS1

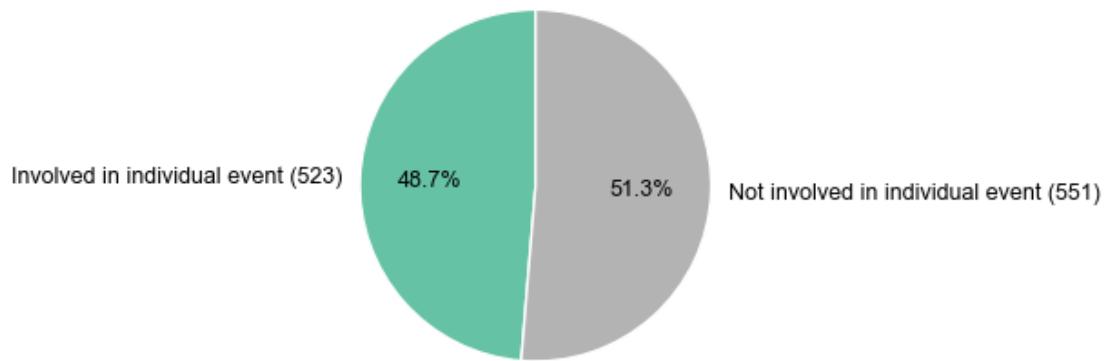




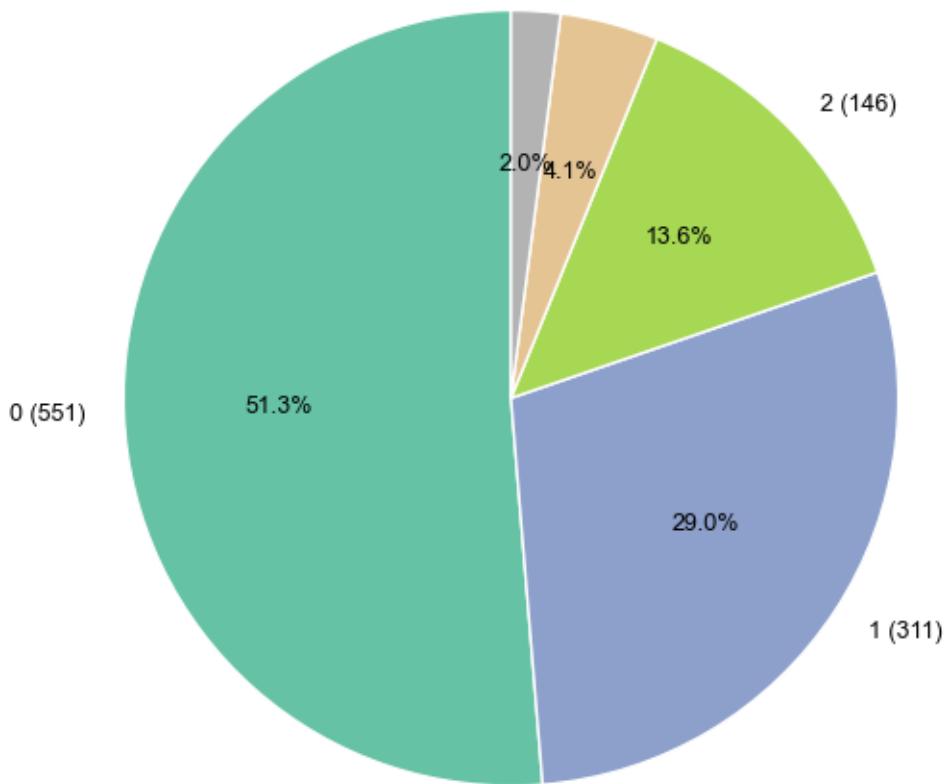
1.4 INDIVIDUAL EVENTS

1.4.1 Cells occurrences in individual events

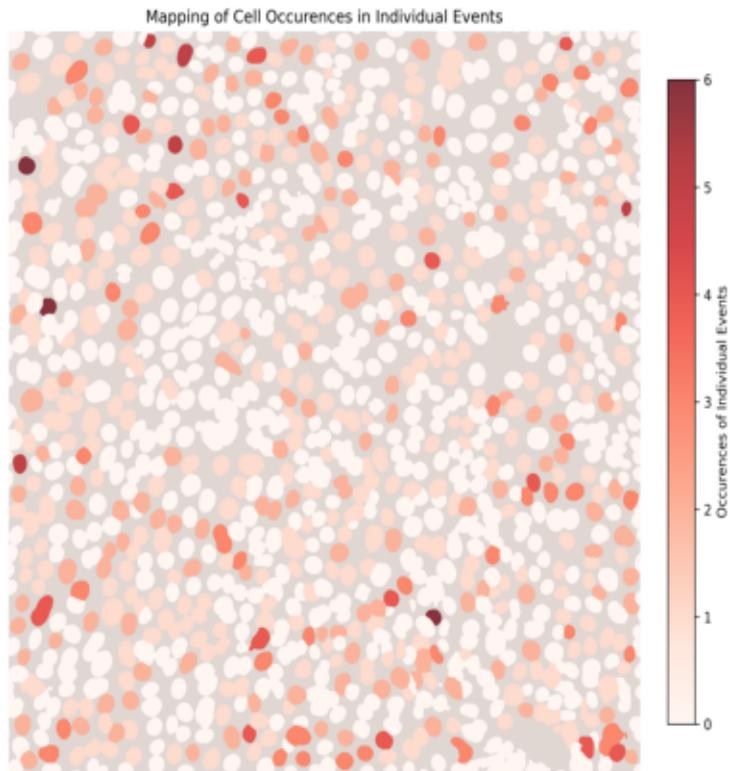
Distribution of Cells Involved in Individual Events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

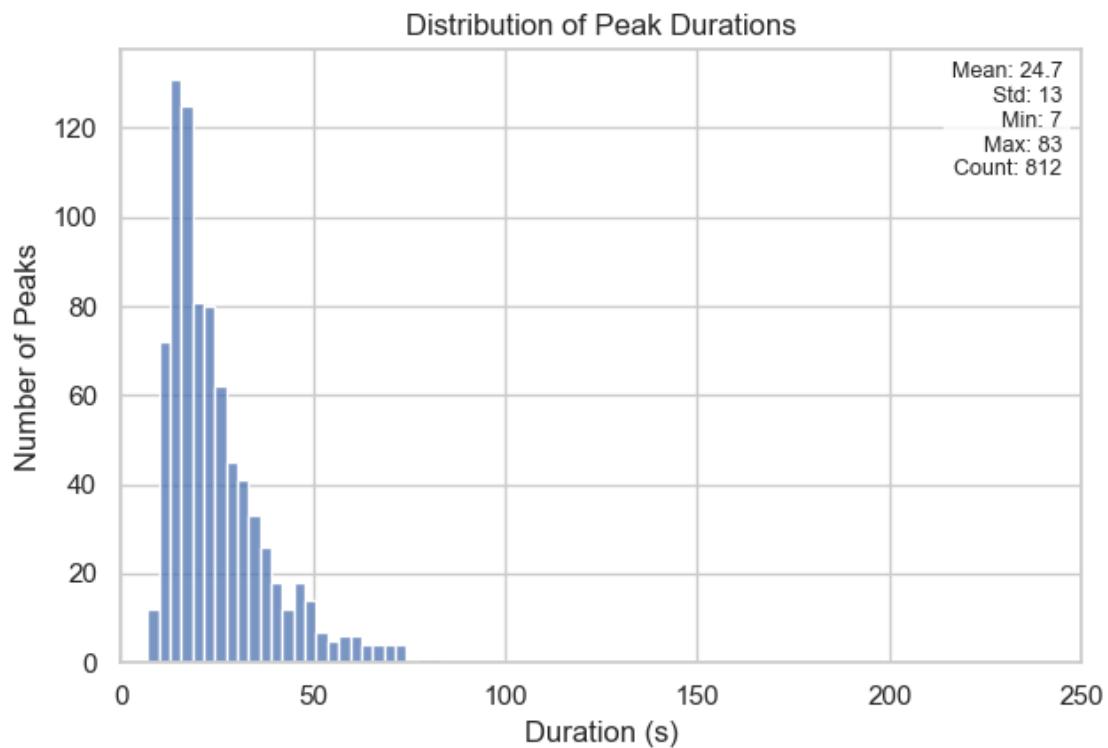


Cell Mapping with Occurrences in Individual Events Overlay - 20250326_IS1

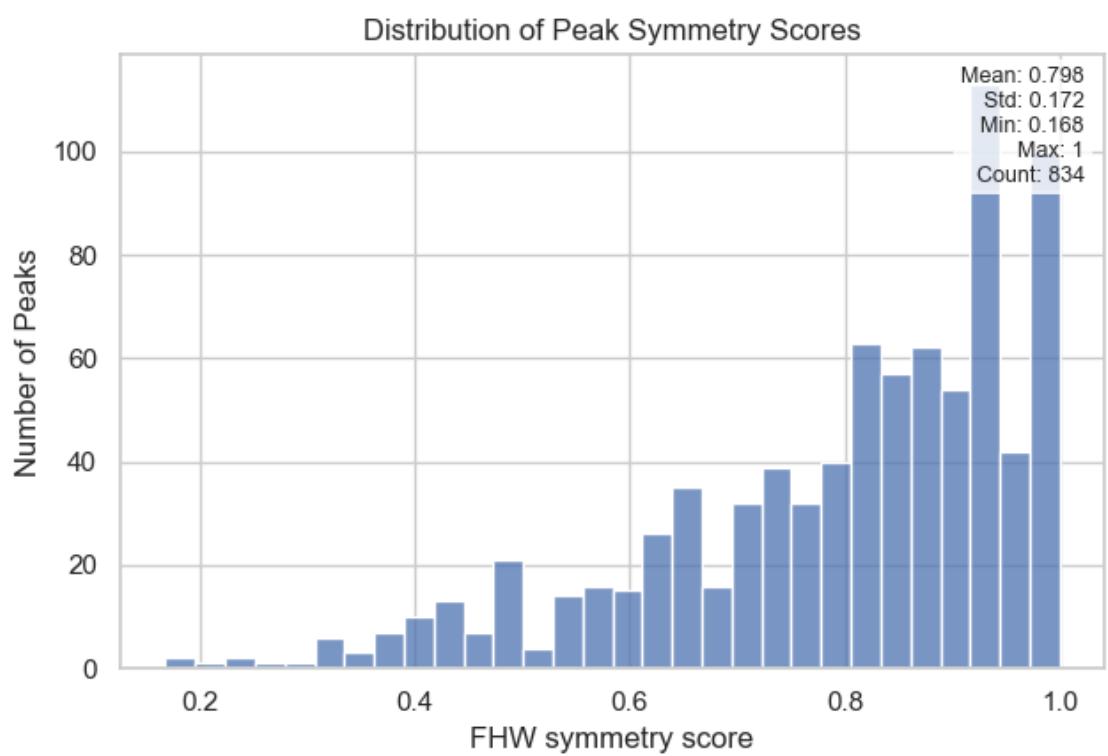
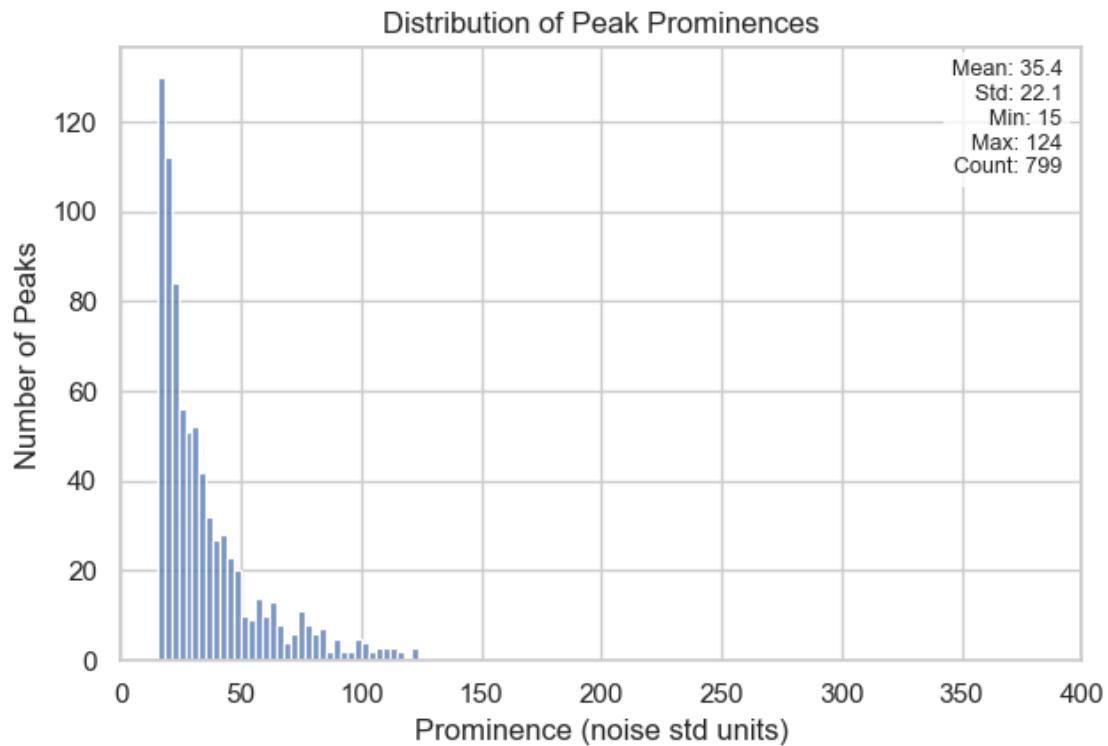


1.4.2 Peaks statistics in individual events

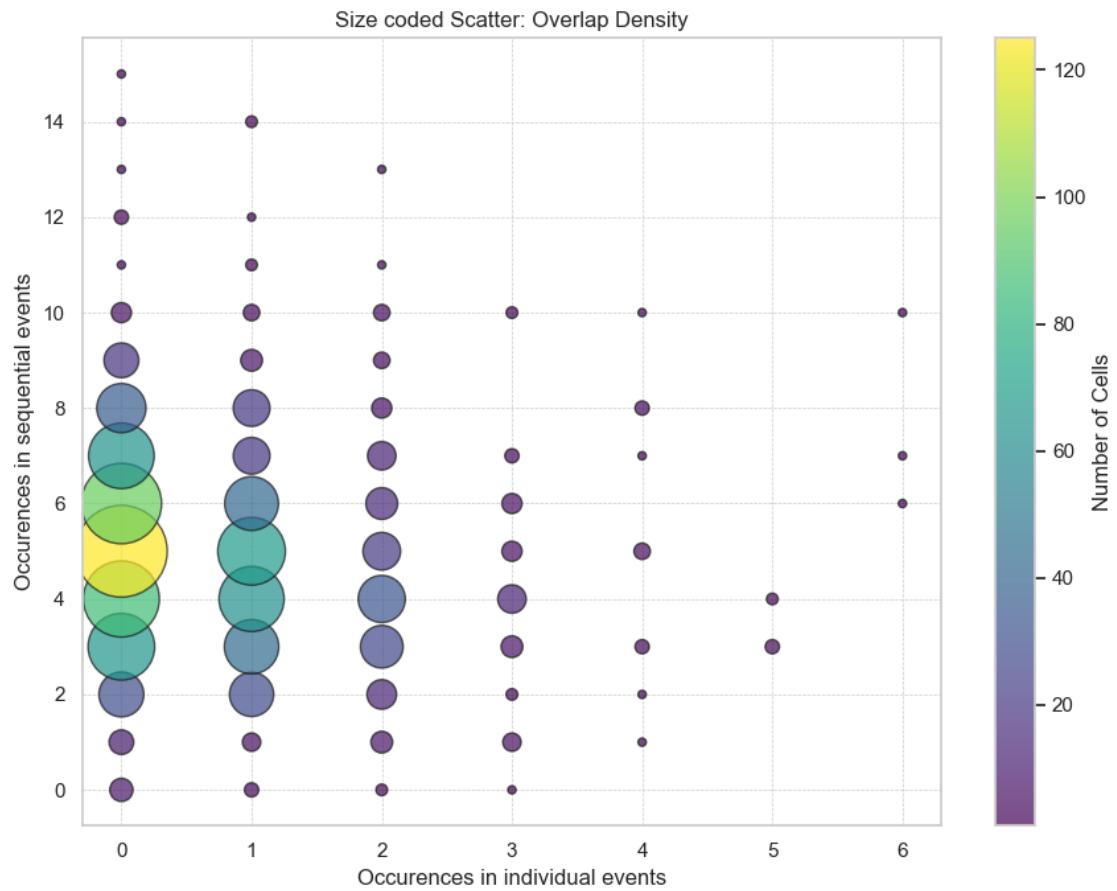
```
[2025-08-13 11:23:39] [INFO] calcium: plot_histogram: removed 22 outliers out of  
834 on 'Duration (s)' (lower=-36, upper=83)
```



```
[2025-08-13 11:23:39] [INFO] calcium: plot_histogram: removed 35 outliers out of 834 on 'Prominence (noise std units)' (lower=-58.5, upper=124.2)
```

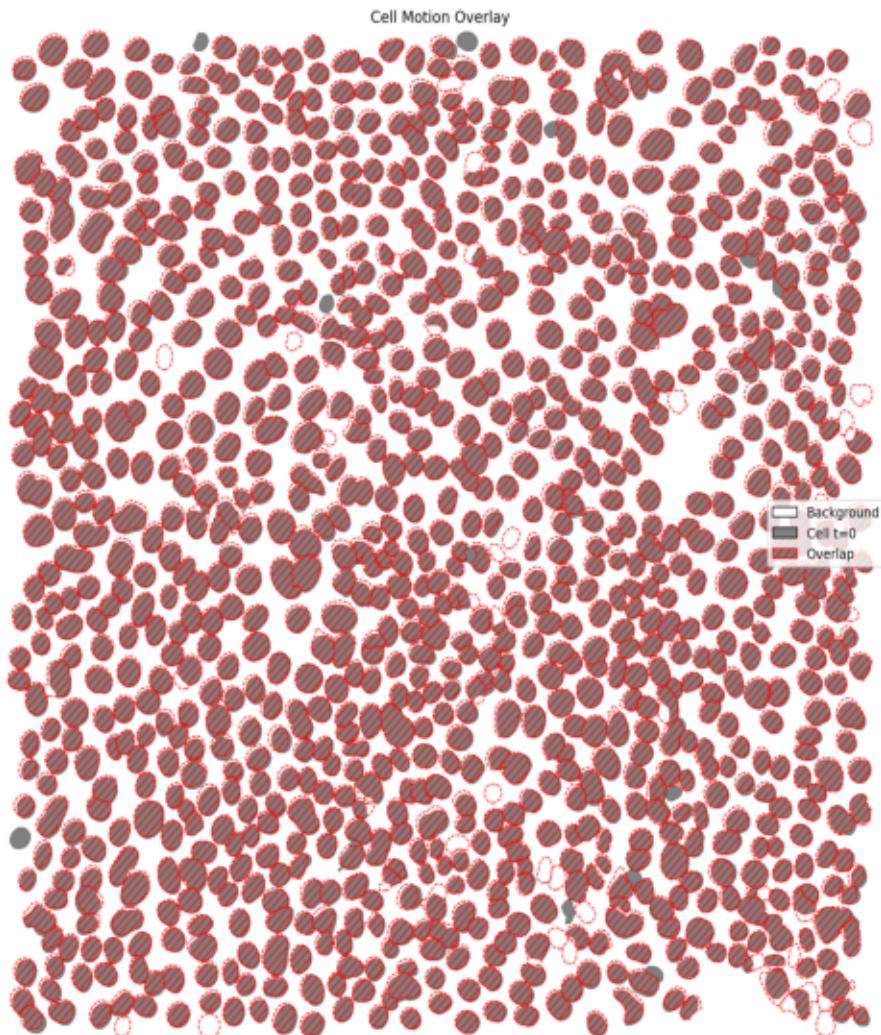


1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250326_IS1



Number of cells:

- Hoechst image taken at t=0: 1057
- Hoechst image taken at t=1801: 1054
- Number of cells difference: absolute 3, relative 0.28%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 1118572
- Pixels segmented as cell at t=1801: 1144633
- Overlapping pixels between t=0 and t=1801: 985731 (87.11% of total)
- Pixels exclusive to t=0: 132841 (11.88% of total)
- Pixels exclusive to t=1801: 158902 (13.88% of total)

executed

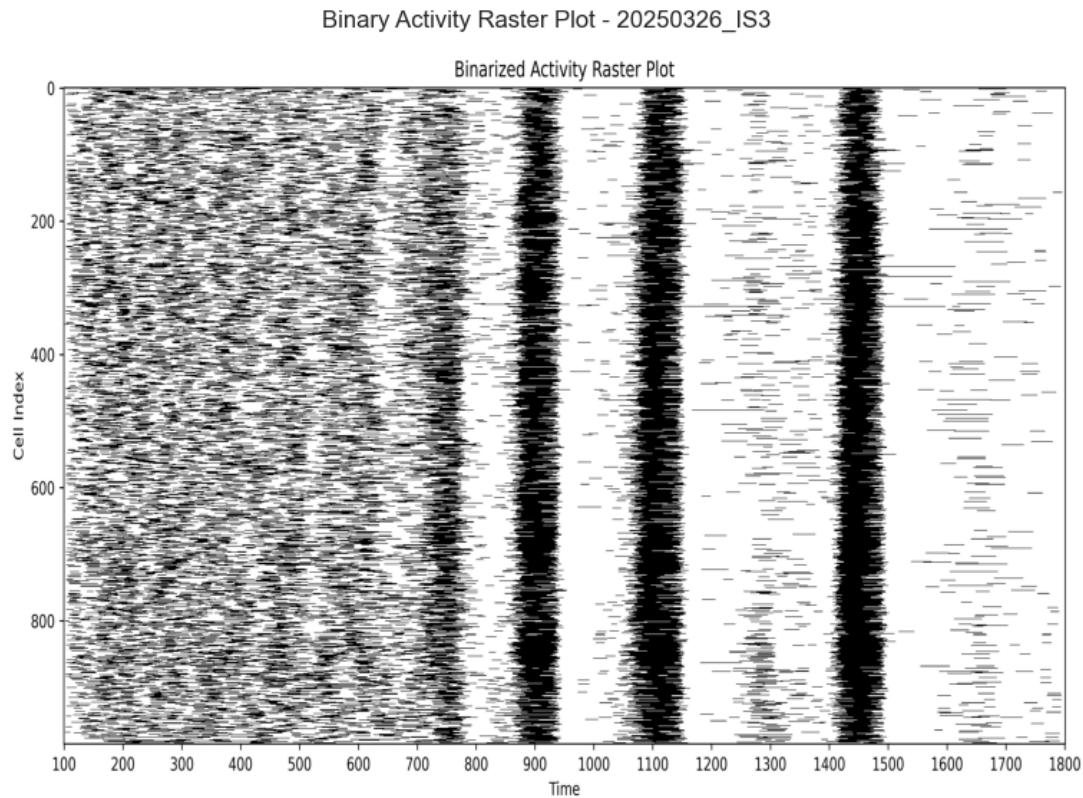
August 13, 2025

1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

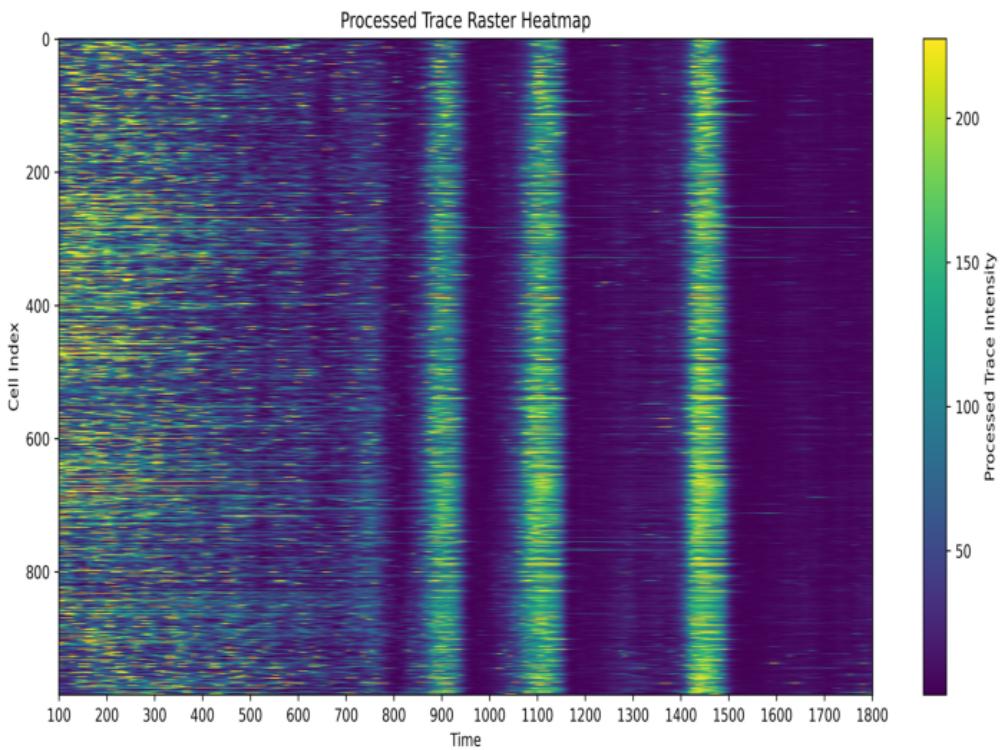
1.0.1 Initialization

1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot



Heatmap Activity Raster Plot - 20250326_IS3



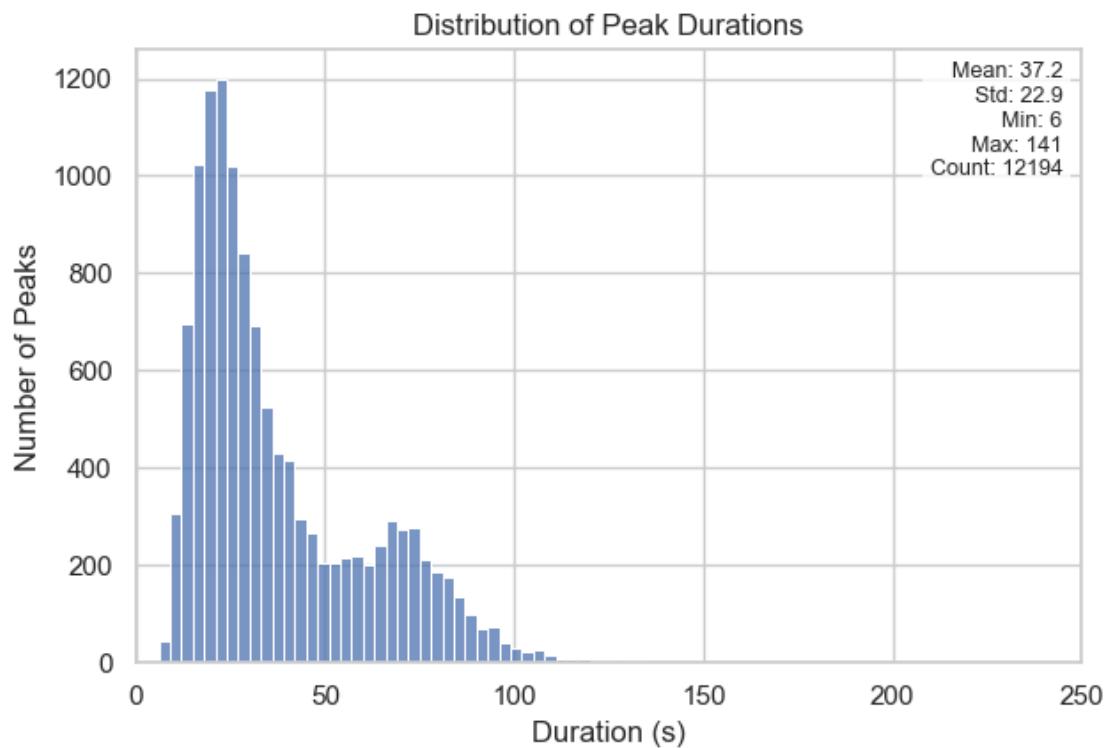
1.1.2 Peaks population

Total number of peaks: 12215

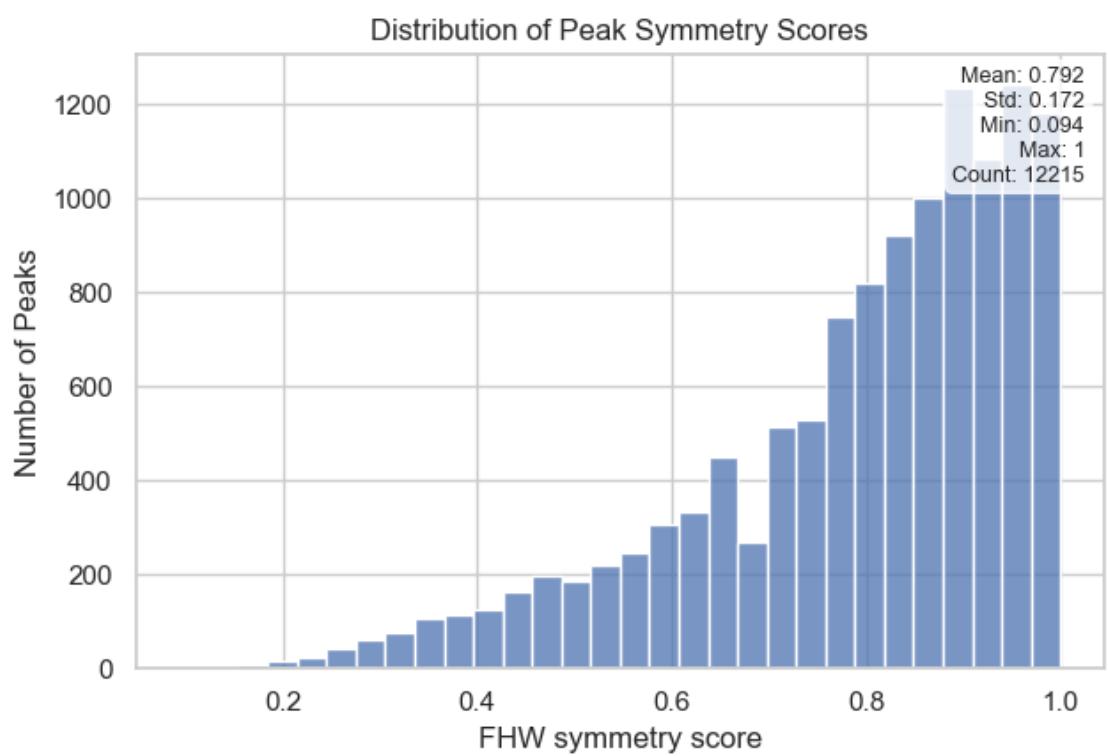
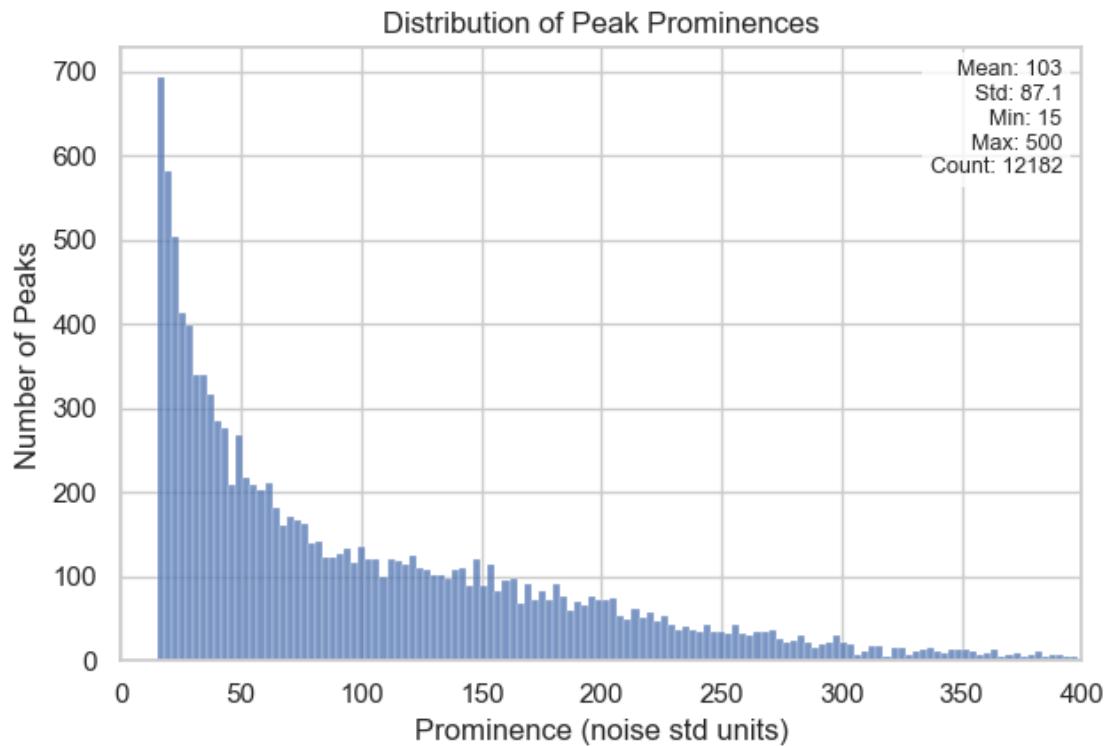
Total number of cells: 985

1.1.3 Peaks statistics

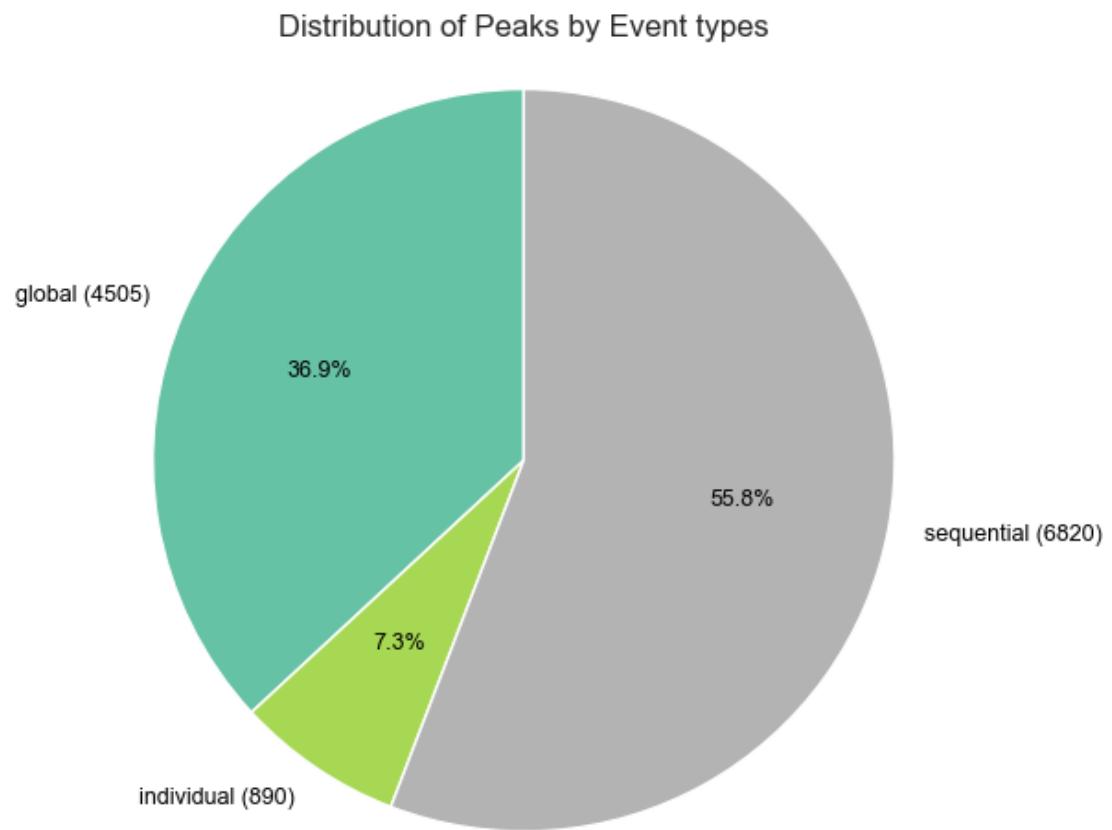
```
[2025-08-13 11:25:09] [INFO] calcium: plot_histogram: removed 21 outliers out of  
12215 on 'Duration (s)' (lower=-73, upper=144)
```



```
[2025-08-13 11:25:09] [INFO] calcium: plot_histogram: removed 33 outliers out of  
12215 on 'Prominence (noise std units)' (lower=-318.8, upper=504.4)
```

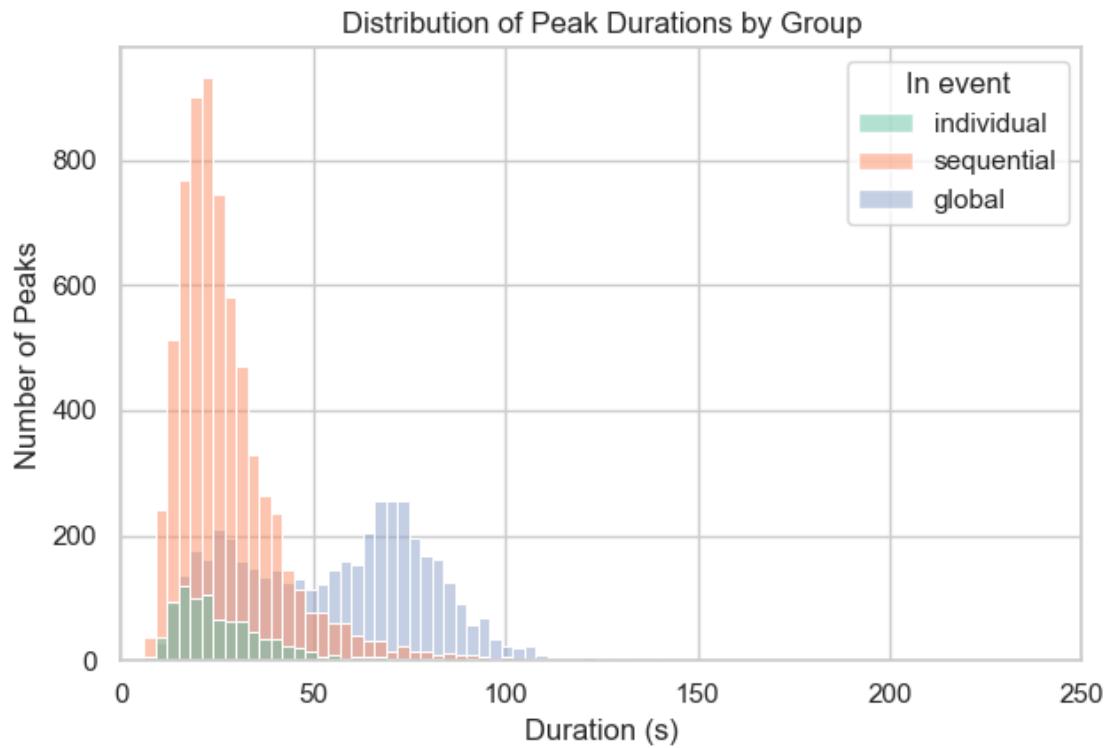


1.1.4 Distribution of peaks per event types



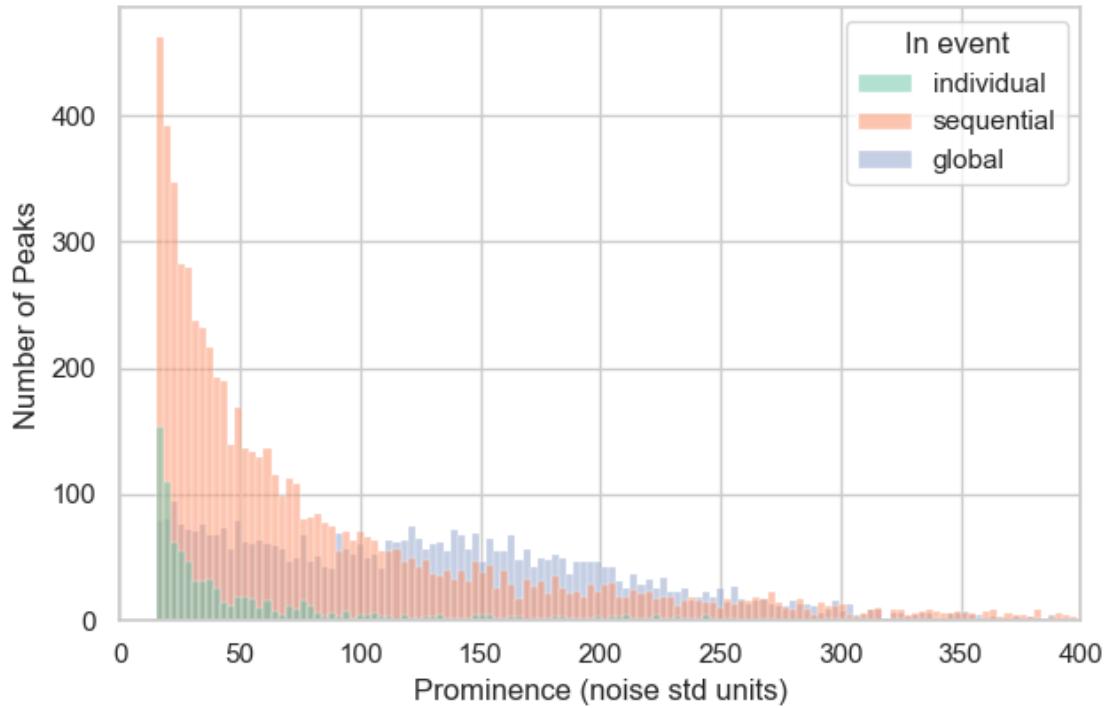
1.1.5 Peaks statistics per event types

```
[2025-08-13 11:25:10] [INFO] calcium: plot_histogram_by_group: removed 21
outliers out of 12215 on 'Duration (s)' (lower=-73, upper=144)
```

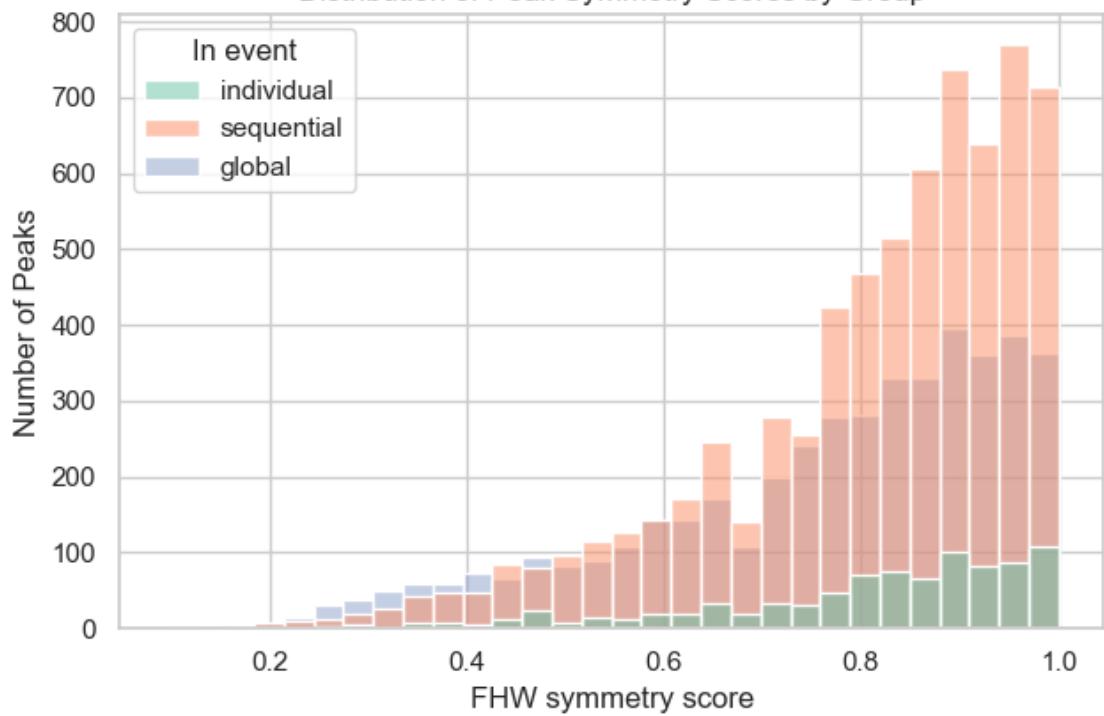


```
[2025-08-13 11:25:10] [INFO] calcium: plot_histogram_by_group: removed 33
outliers out of 12215 on 'Prominence (noise std units)' (lower=-318.8,
upper=504.4)
```

Distribution of Peak Prominences by Group



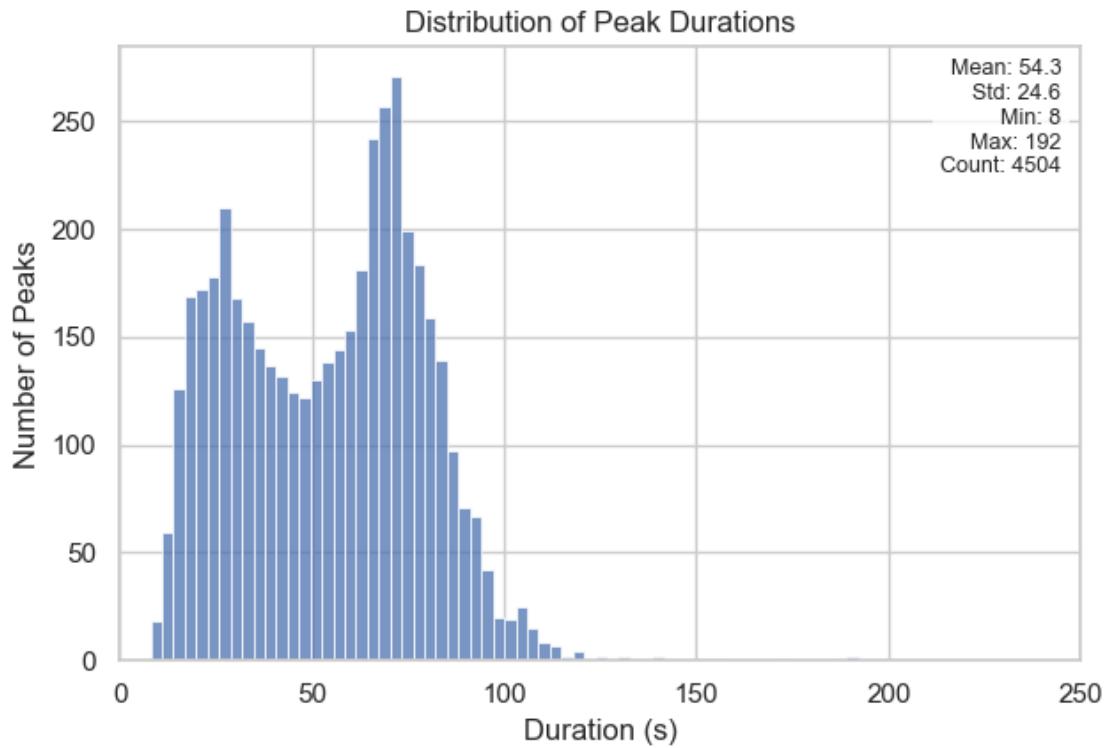
Distribution of Peak Symmetry Scores by Group



1.2 GLOBAL EVENTS

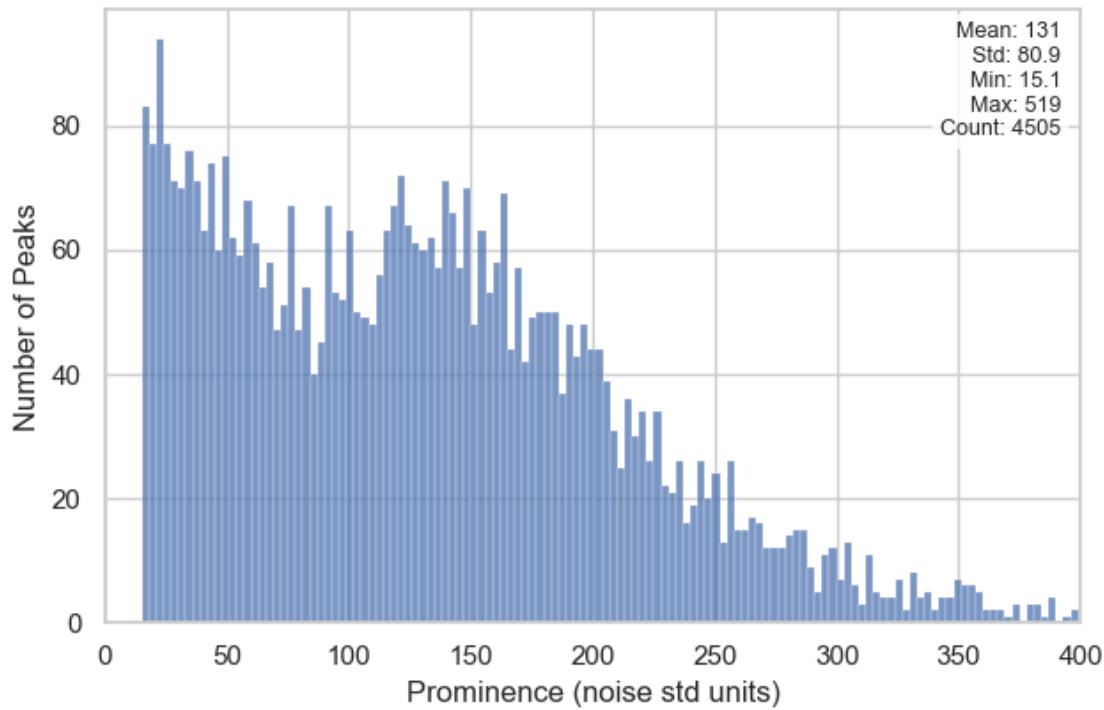
1.2.1 Peak statistics in global events

[2025-08-13 11:25:11] [INFO] calcium: plot_histogram: removed 1 outliers out of 4505 on 'Duration (s)' (lower=-91, upper=196)

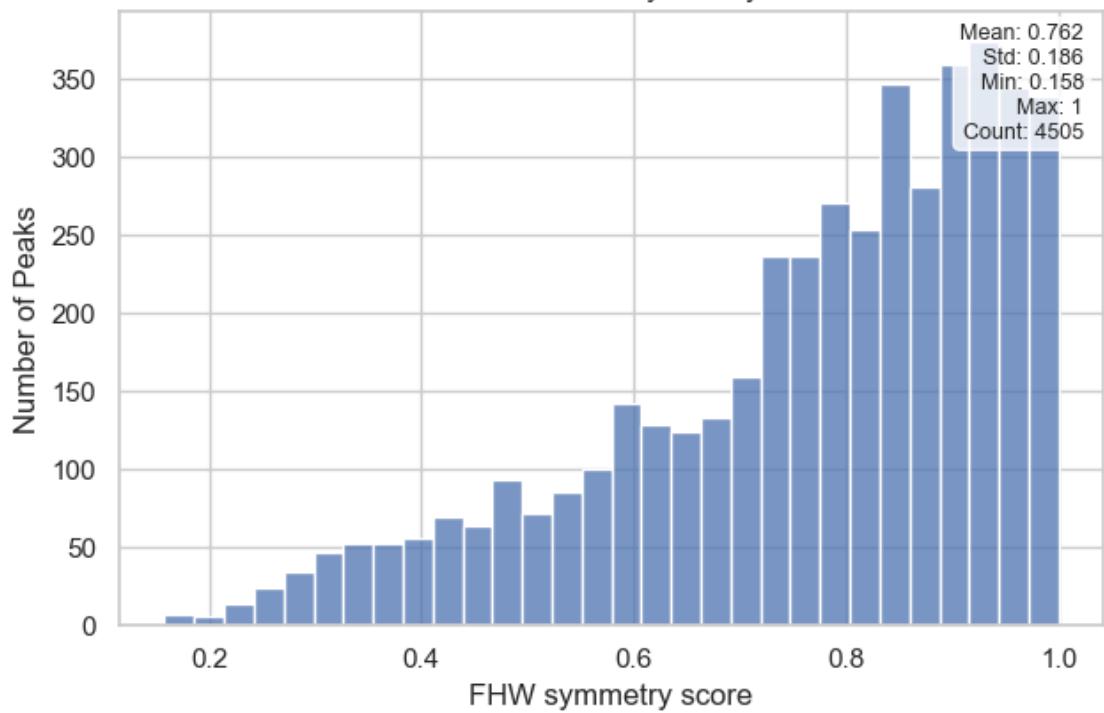


[2025-08-13 11:25:11] [INFO] calcium: plot_histogram: removed 0 outliers out of 4505 on 'Prominence (noise std units)' (lower=-297.8, upper=542.2)

Distribution of Peak Prominences

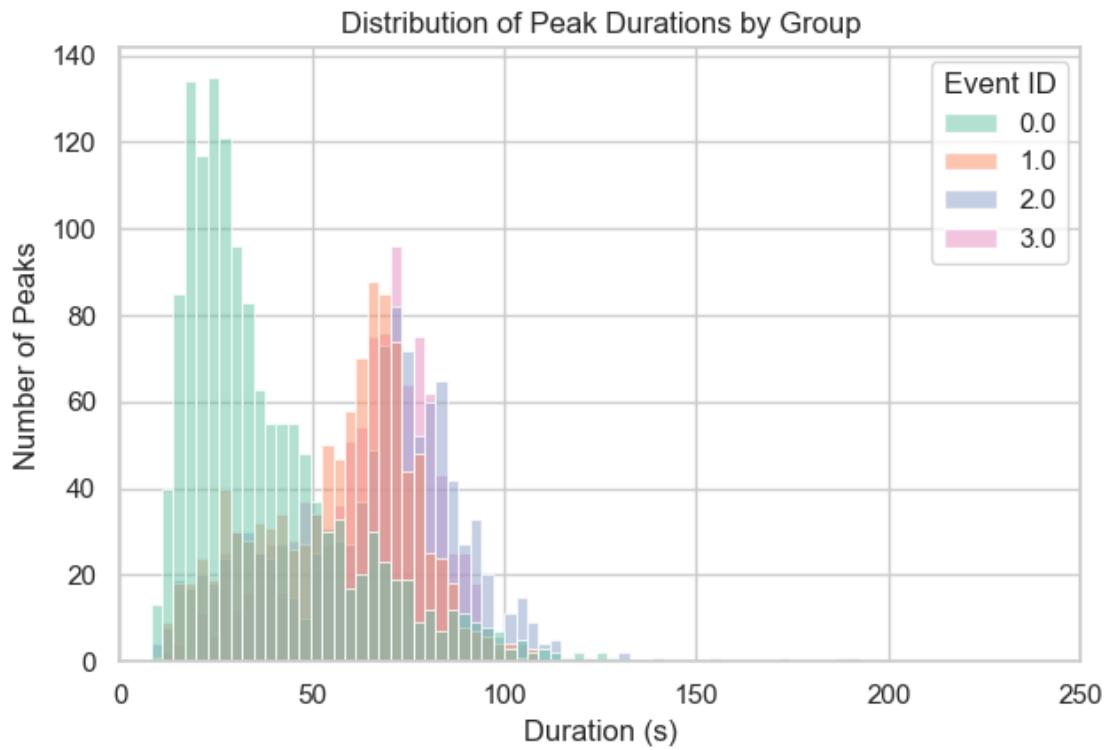


Distribution of Peak Symmetry Scores

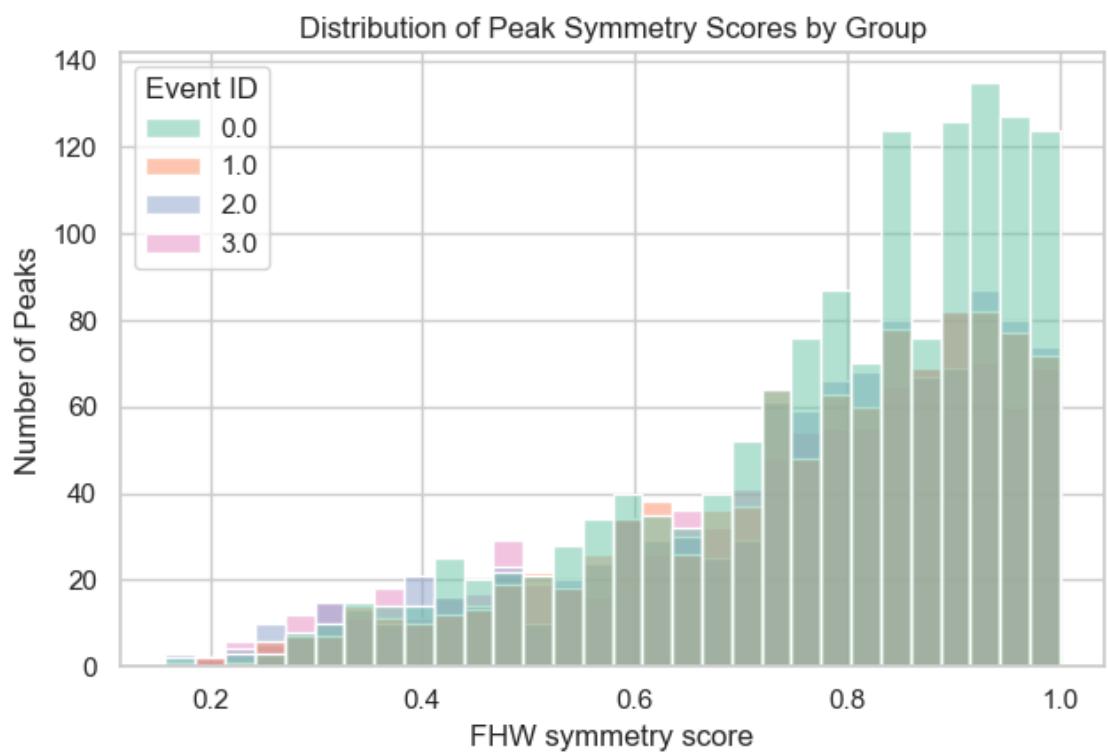
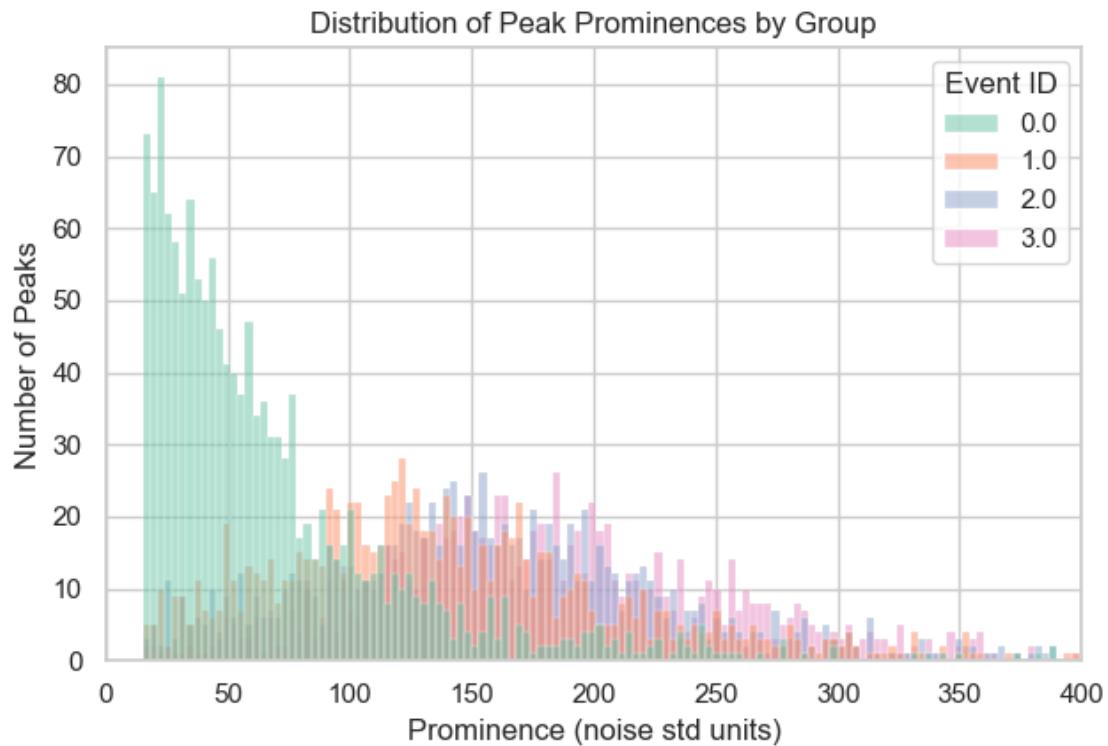


1.2.2 Peak statistics in global event per event ID

```
[2025-08-13 11:25:12] [INFO] calcium: plot_histogram_by_group: removed 1 outliers out of 4505 on 'Duration (s)' (lower=-91, upper=196)
```

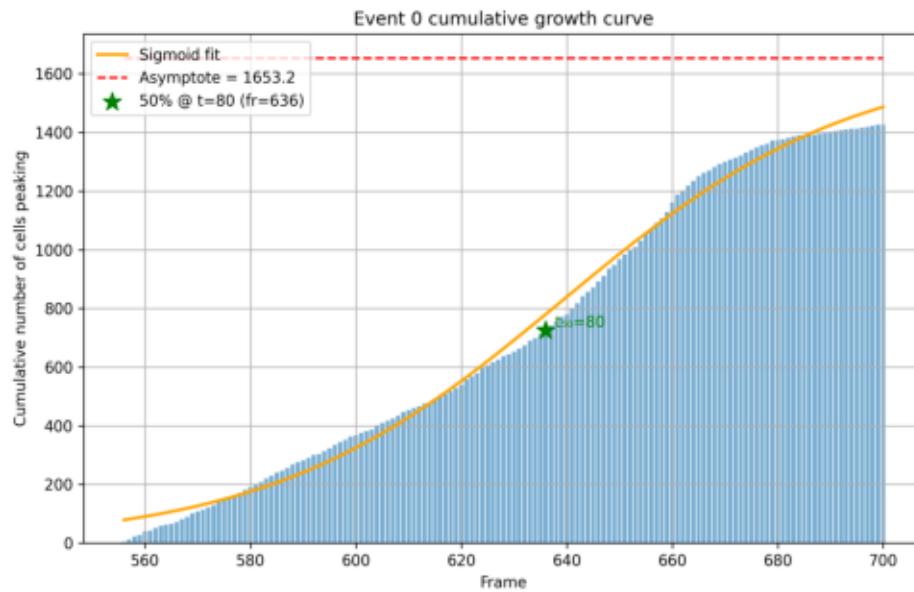


```
[2025-08-13 11:25:12] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 4505 on 'Prominence (noise std units)' (lower=-297.8, upper=542.2)
```

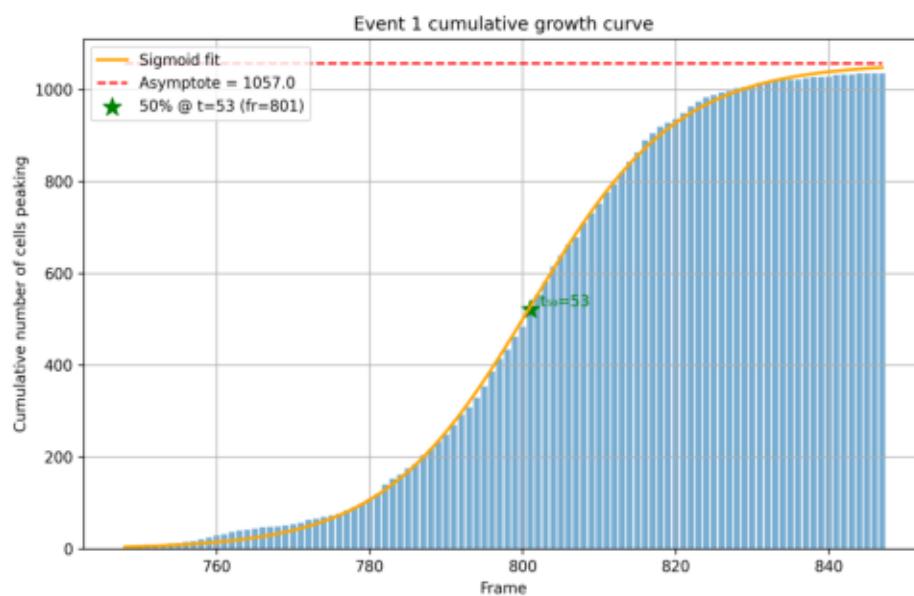


1.2.3 Kinetics of global events

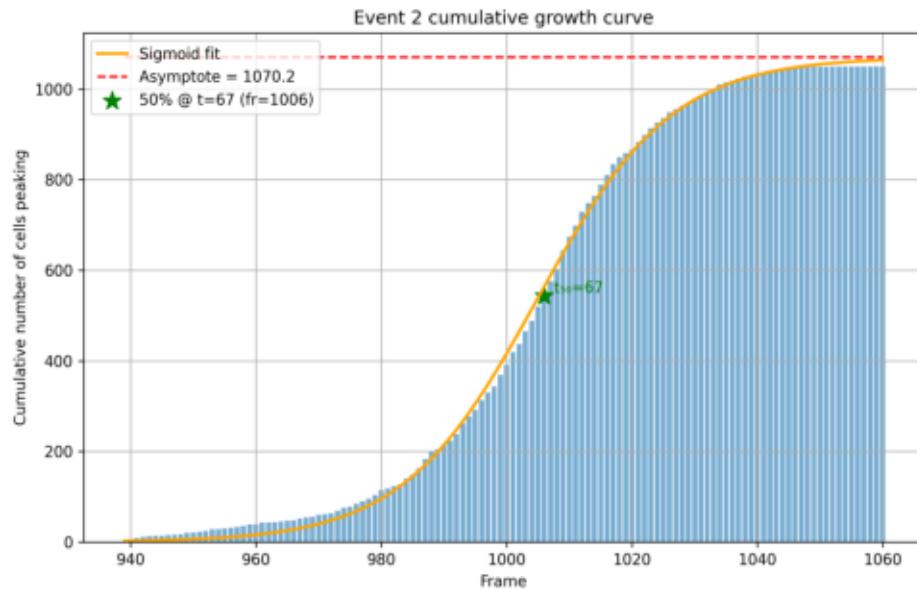
Event Activity Overlay (Event ID: 0) - 20250326_IS3



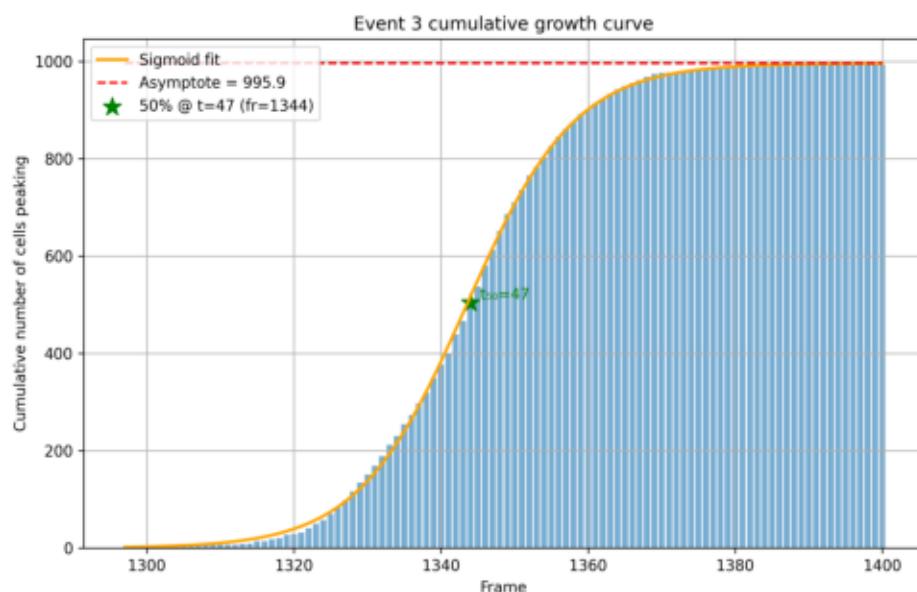
Event Activity Overlay (Event ID: 1) - 20250326_IS3



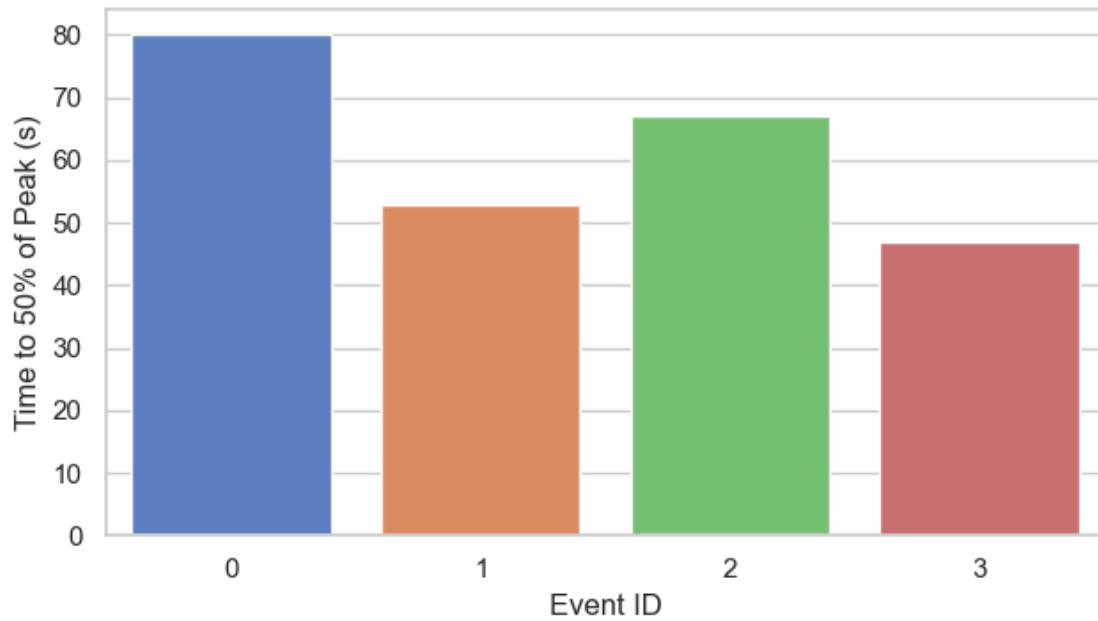
Event Activity Overlay (Event ID: 2) - 20250326_IS3



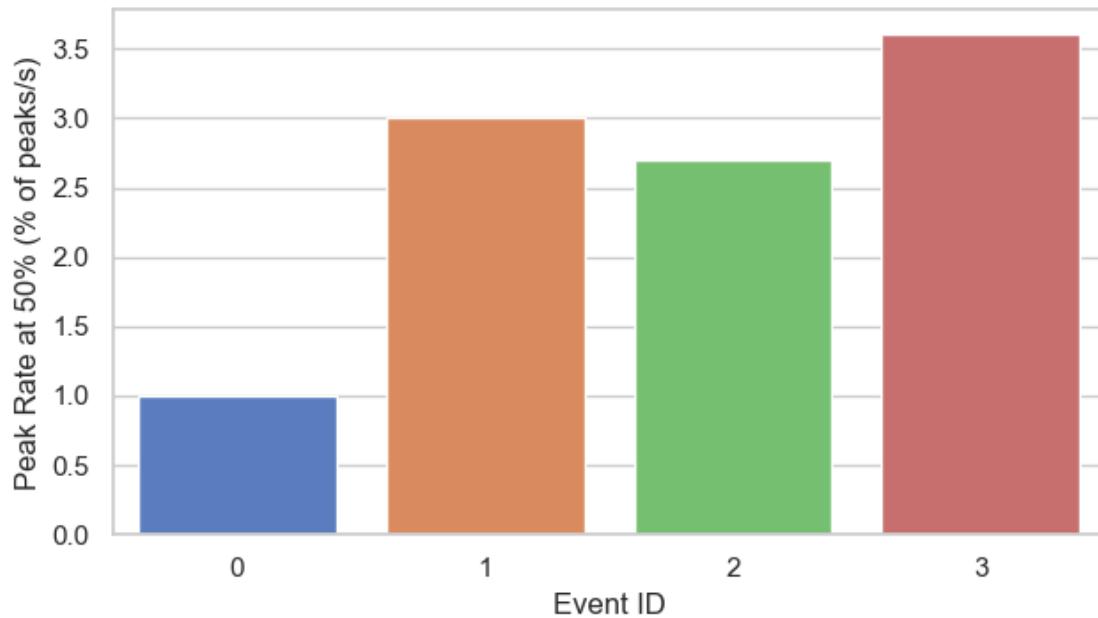
Event Activity Overlay (Event ID: 3) - 20250326_IS3



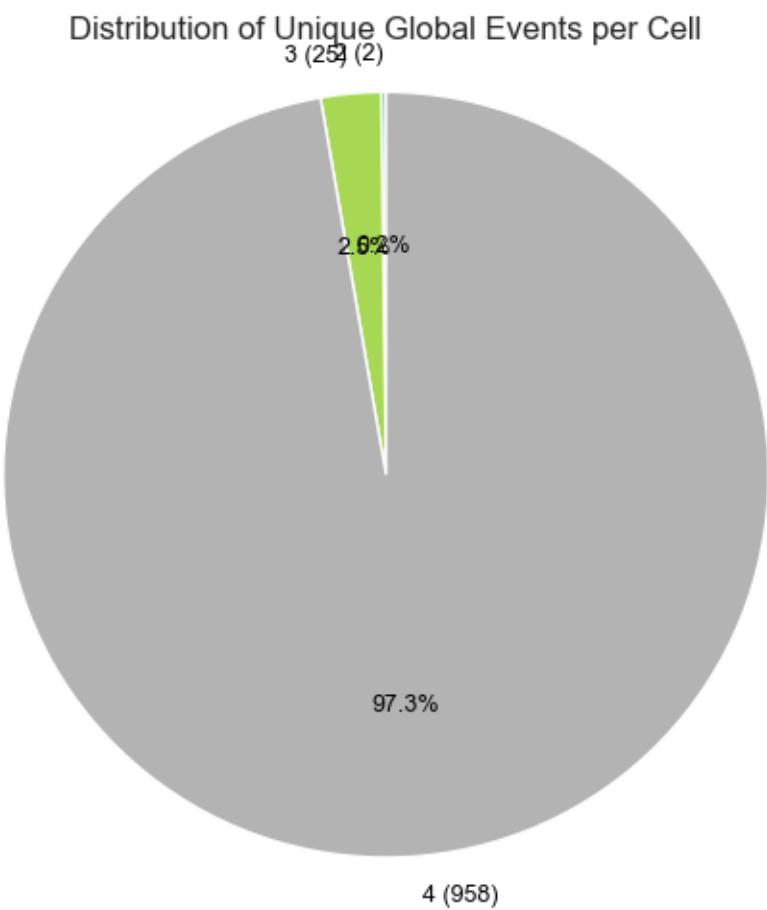
Time to 50% of Peaks in Global Events



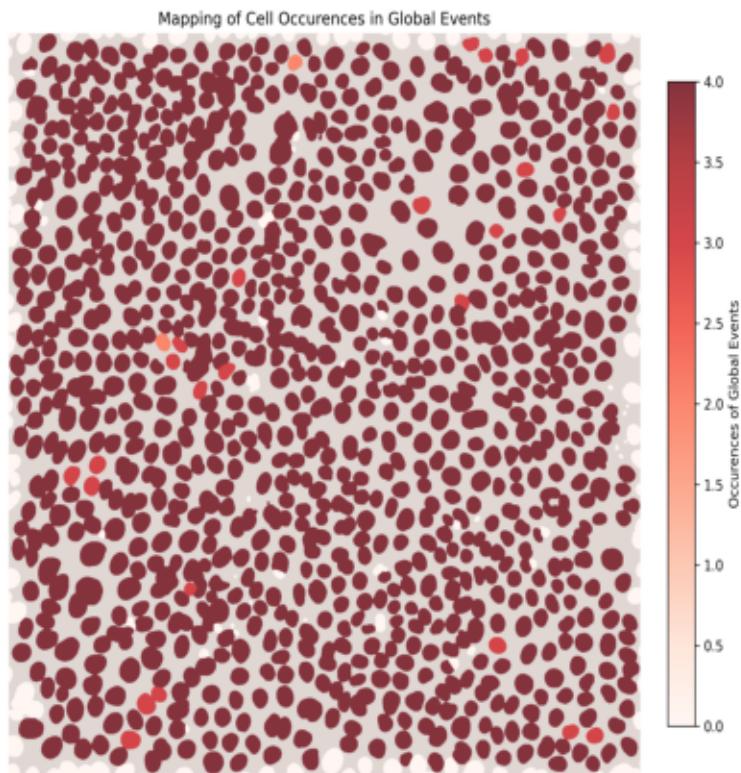
Peak rate at 50% in Global Events

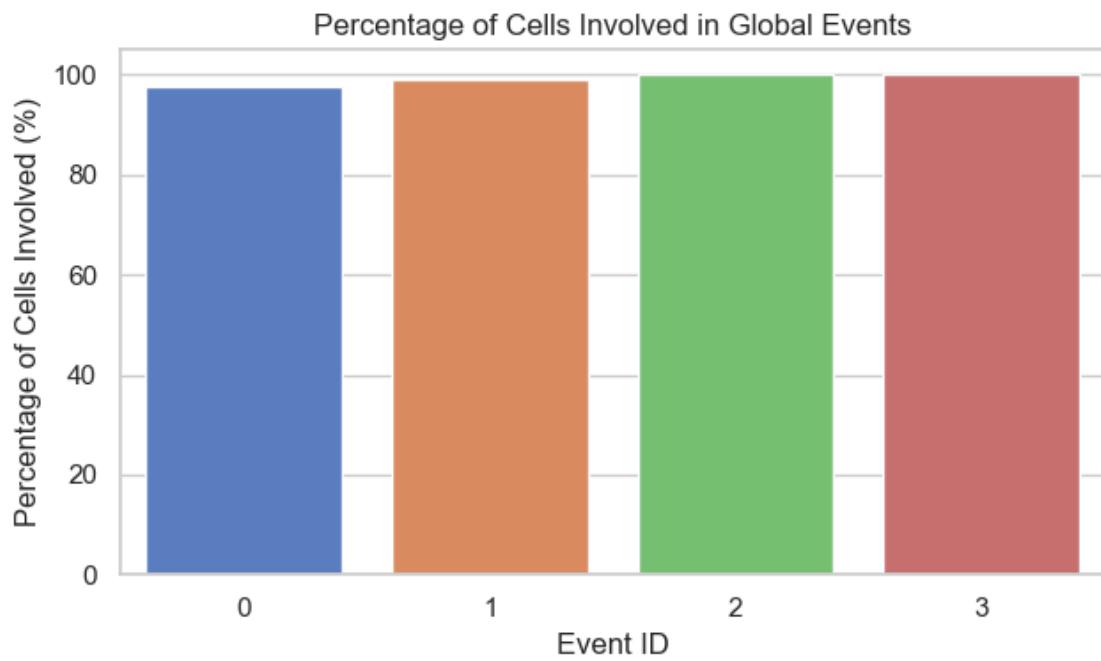


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250326_IS3





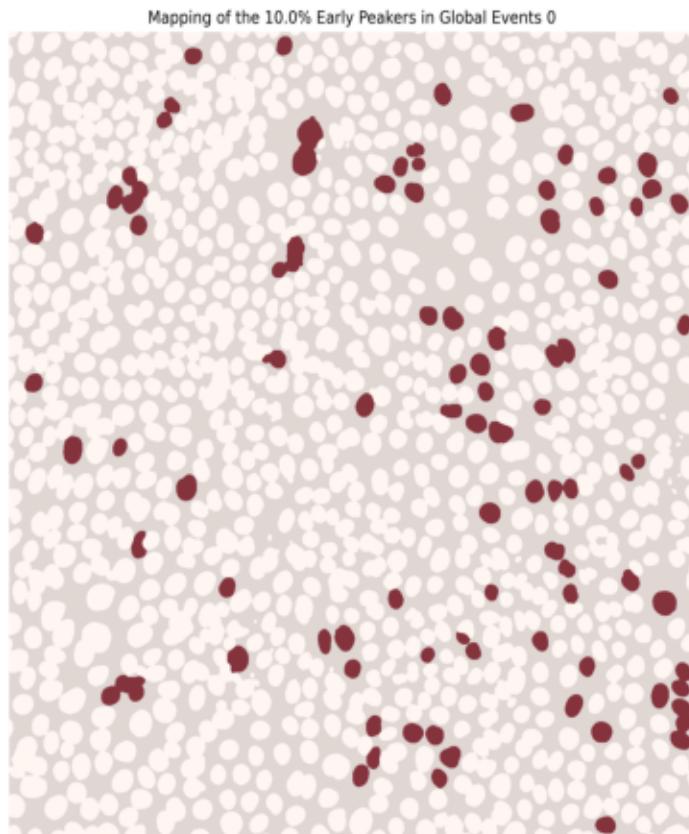
1.2.5 Inter-event interval analysis

Intervals between global event peaks: [149.0, 205.0, 343.0]

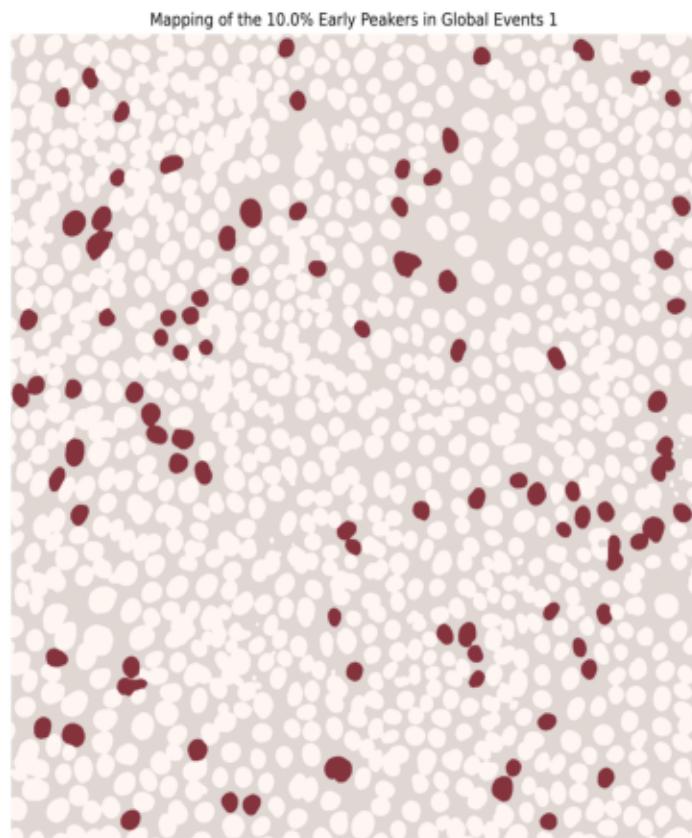
Estimated periodicity: 0.740

1.2.6 Early peakers in the events

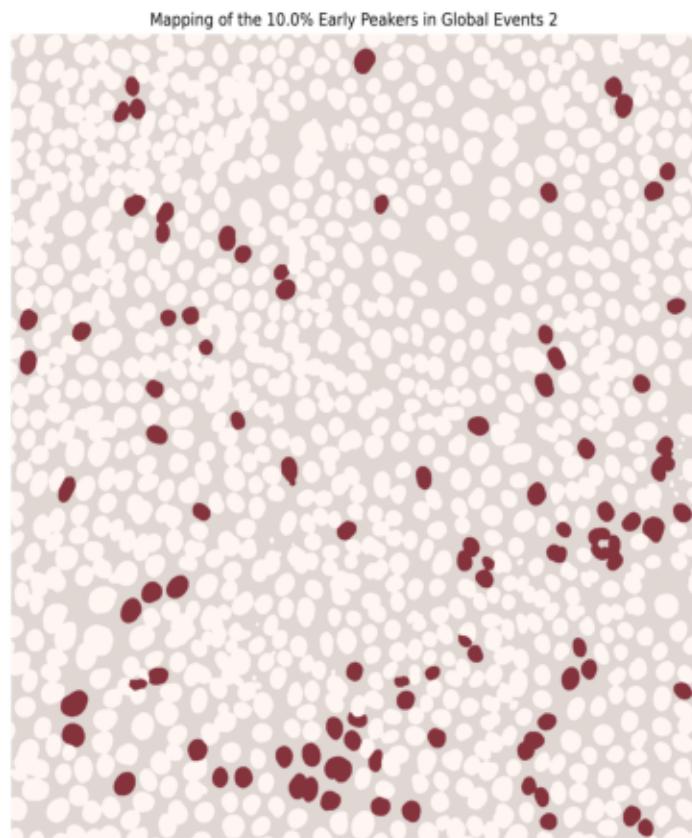
Cell Mapping with Early Peakers Overlay for event 0 - 20250326_IS3



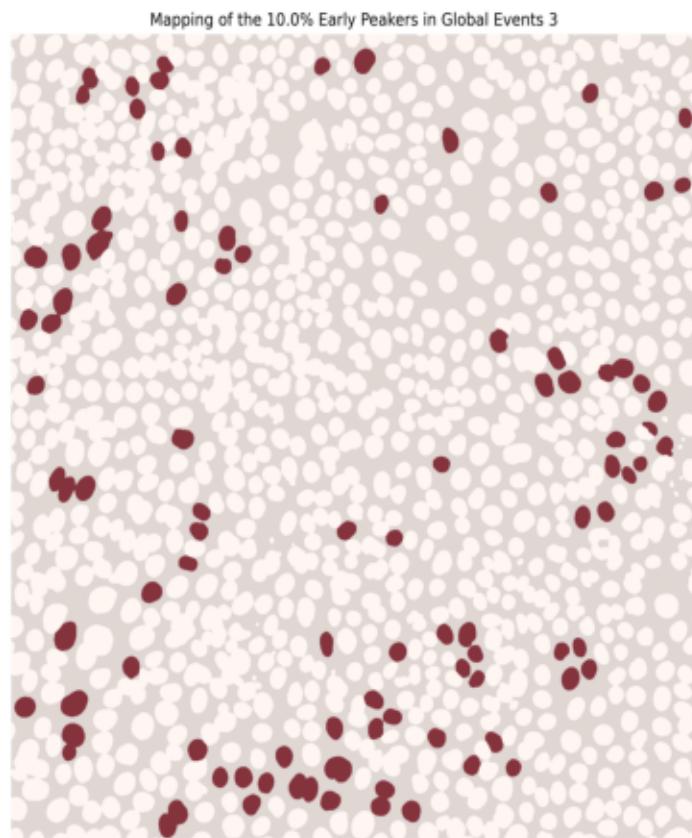
Cell Mapping with Early Peakers Overlay for event 1 - 20250326_IS3



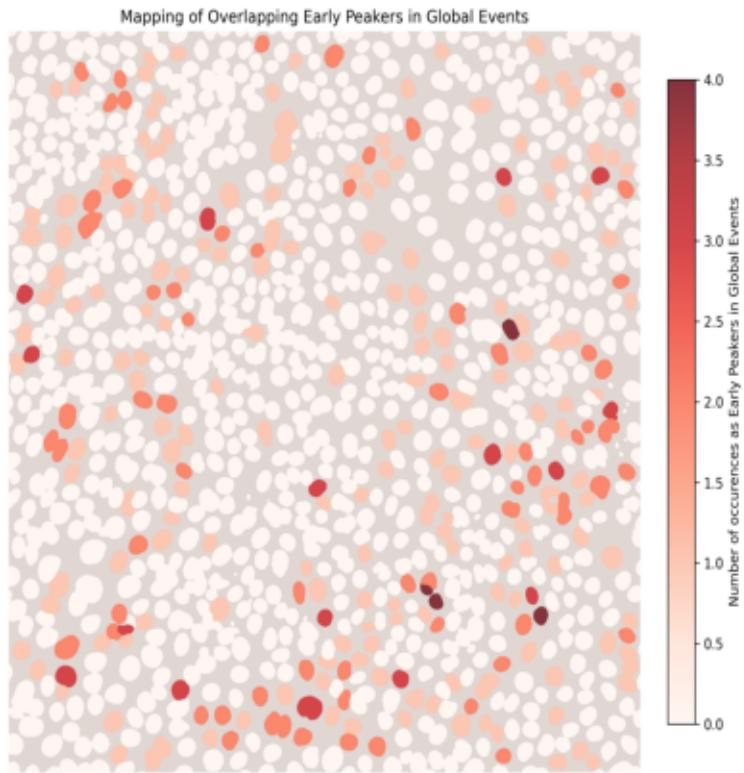
Cell Mapping with Early Peakers Overlay for event 2 - 20250326_IS3

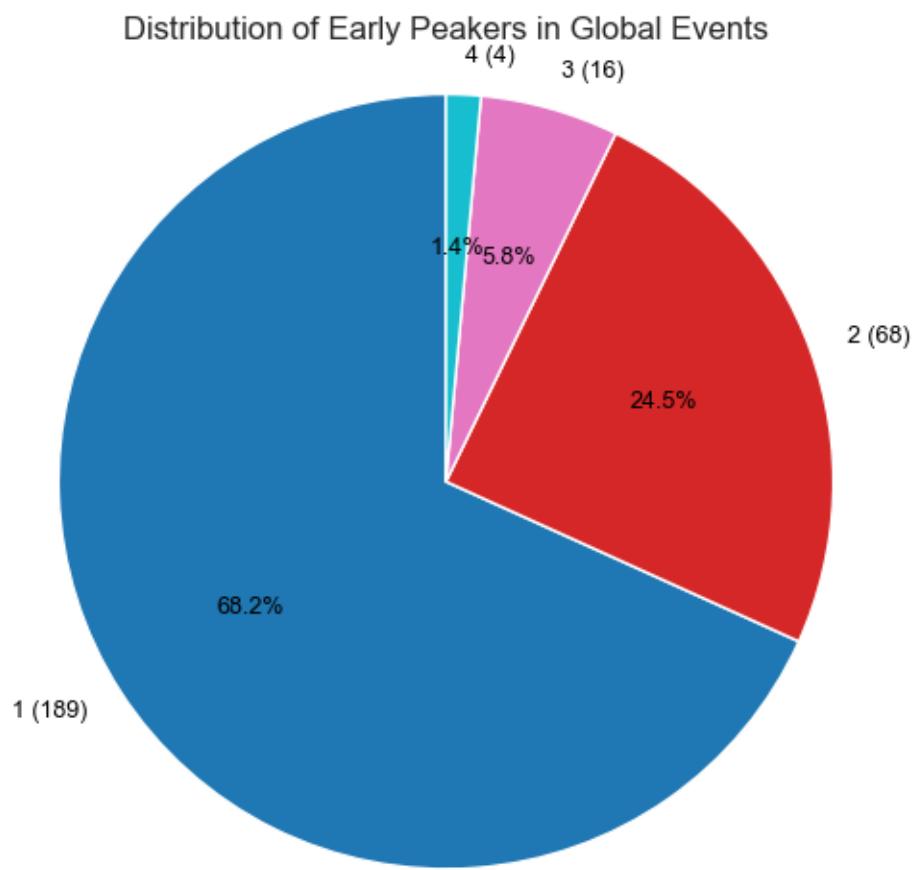
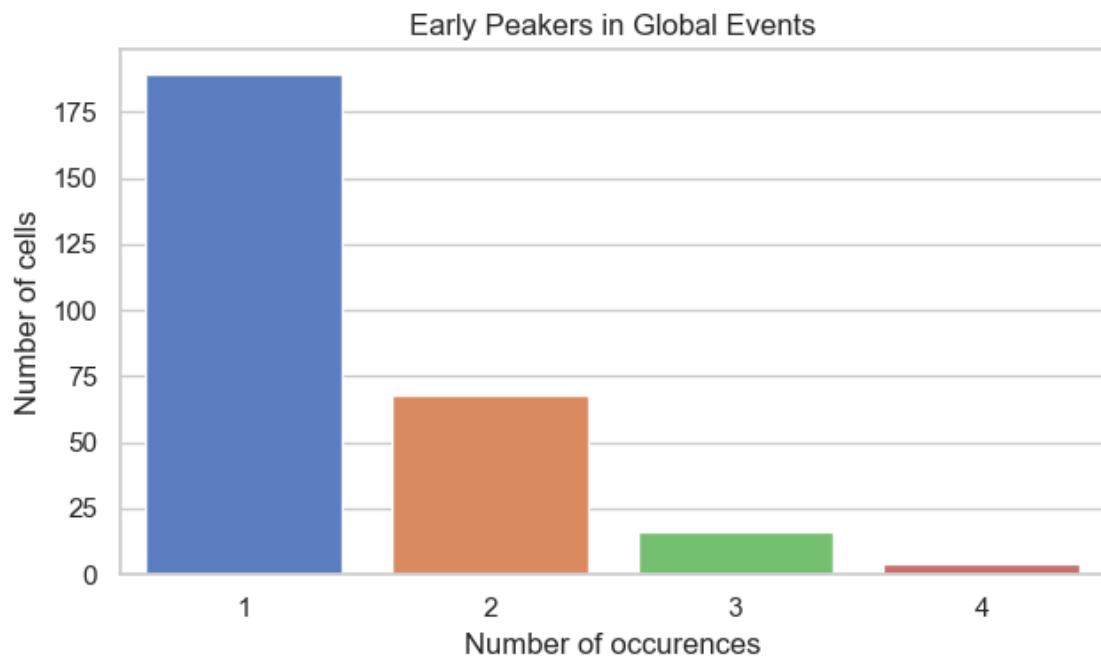


Cell Mapping with Early Peakers Overlay for event 3 - 20250326_IS3



Cell Mapping with Occurrences in Global Events Overlay - 20250326_IS3

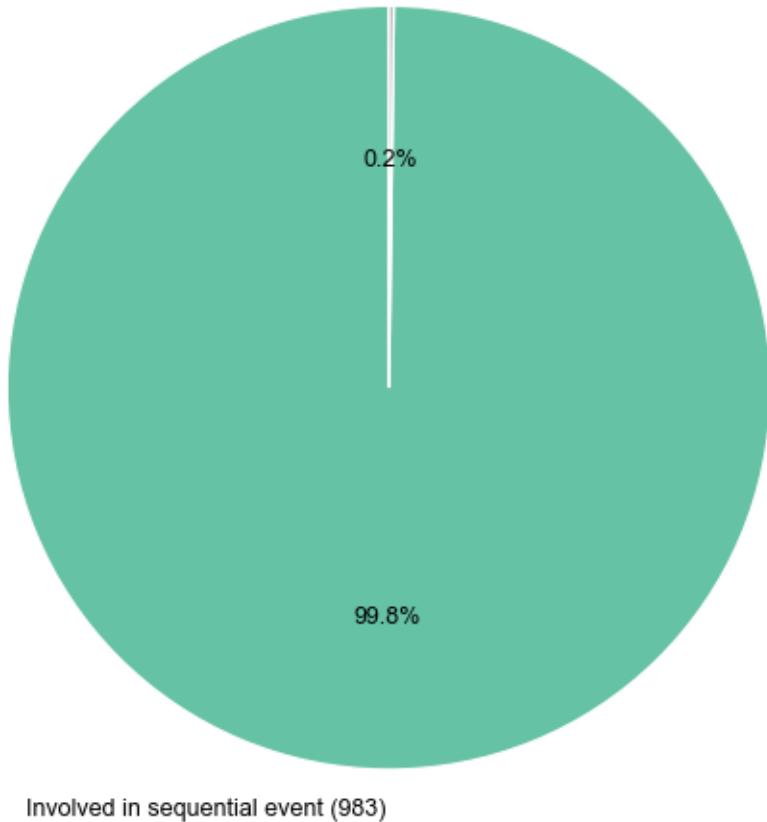




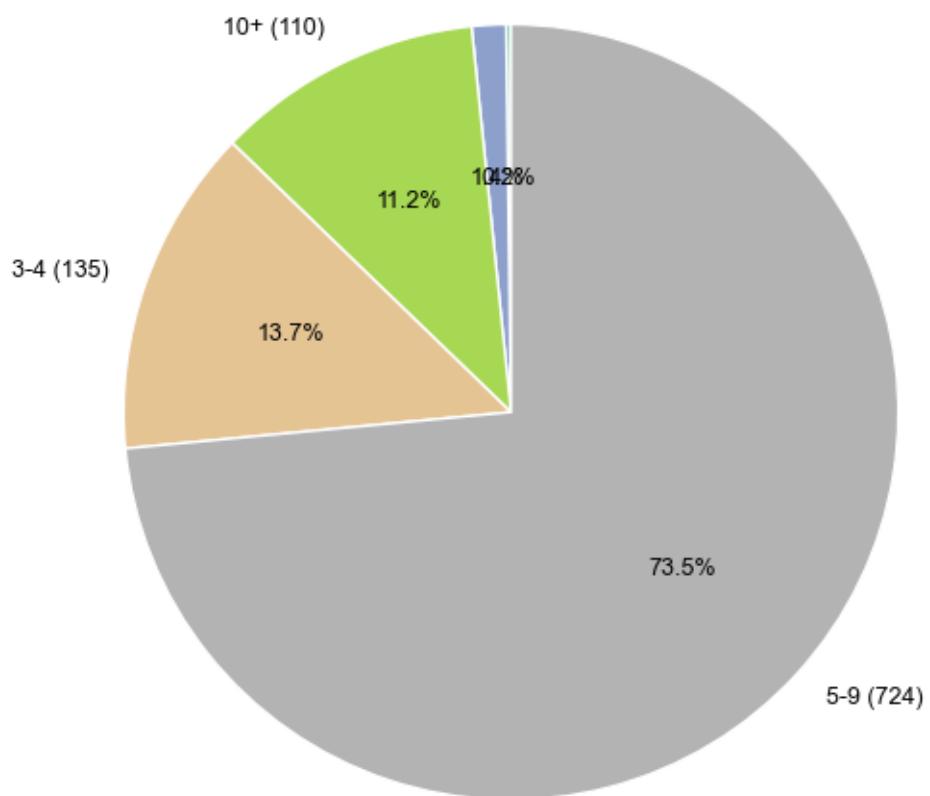
1.3 SEQUENTIAL EVENTS

1.3.1 Cells occurrences in sequential events

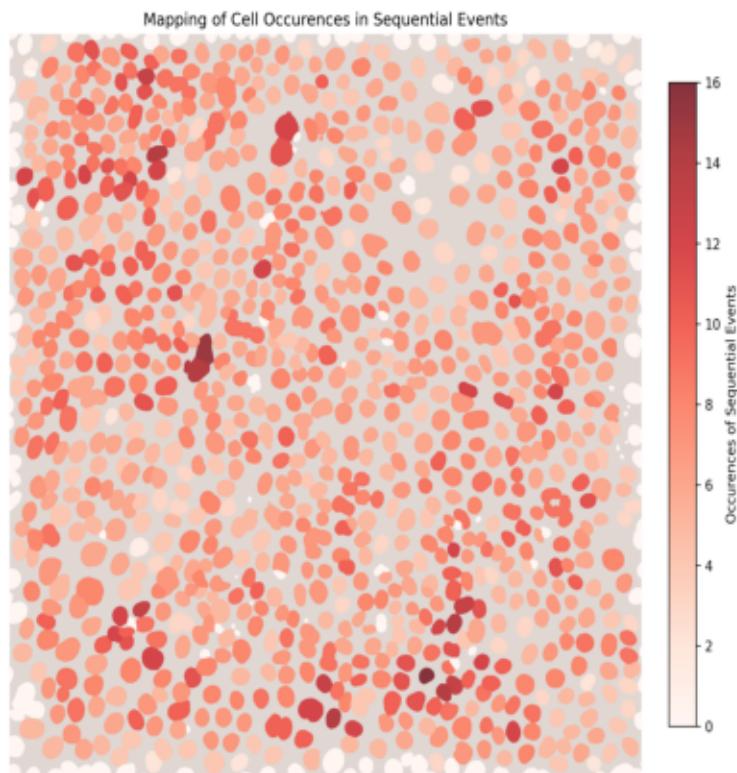
Distribution of Cells Involved in Sequential Events
Not involved in sequential event (2)



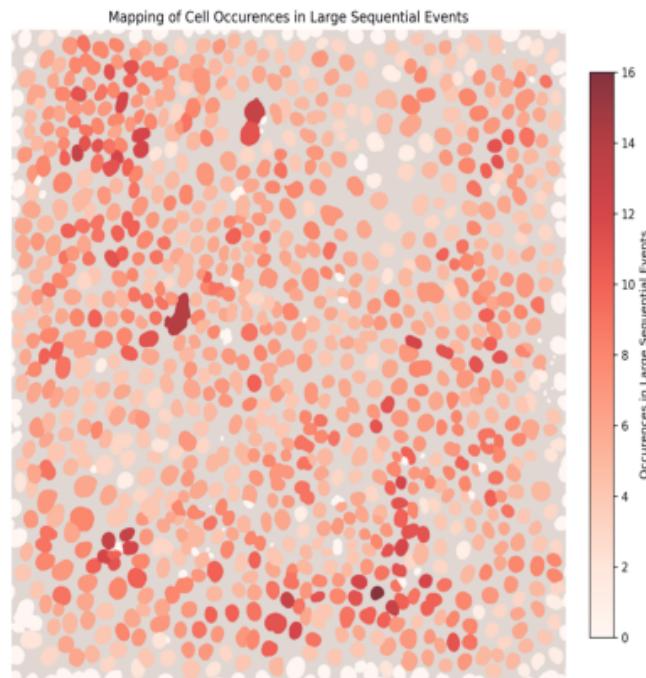
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)
1-2 (14) 2



Cell Mapping with Occurrences in Sequential Events Overlay - 20250326_IS3

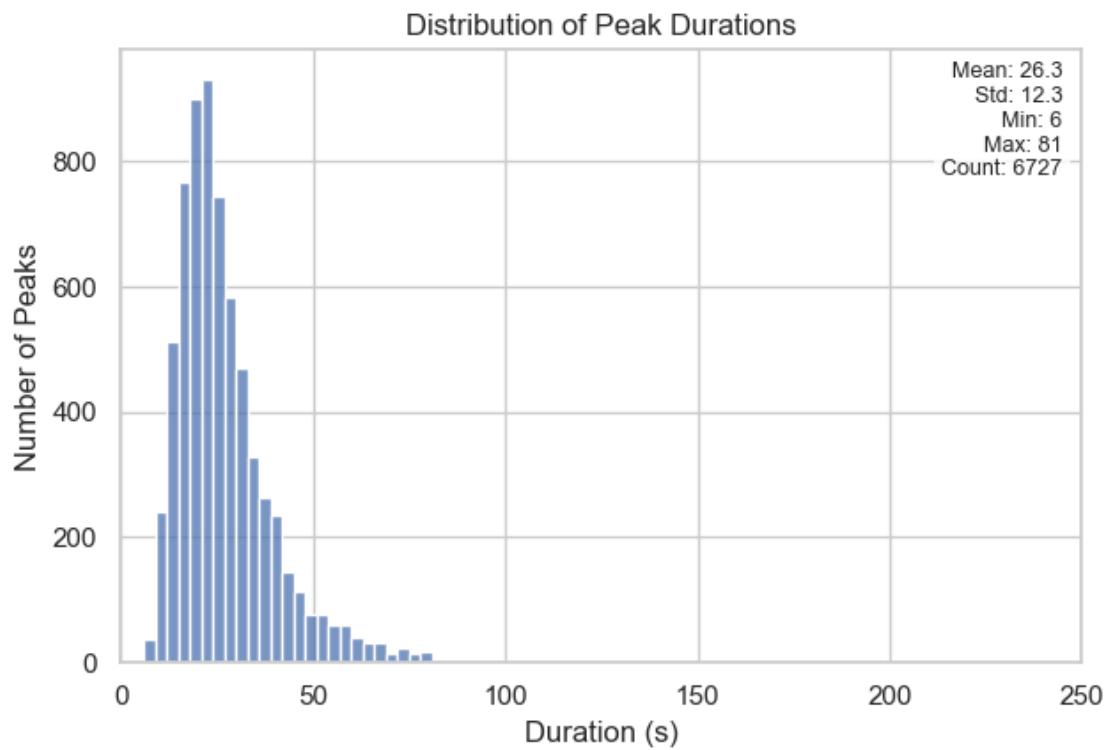


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250326_IS3

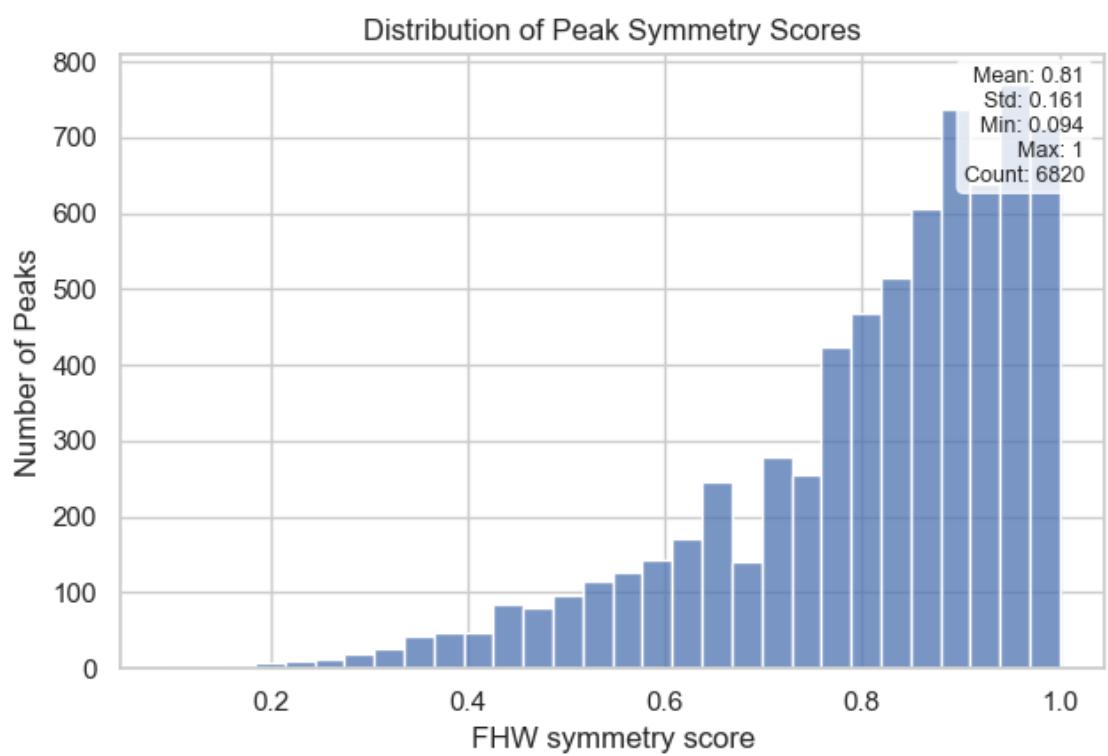
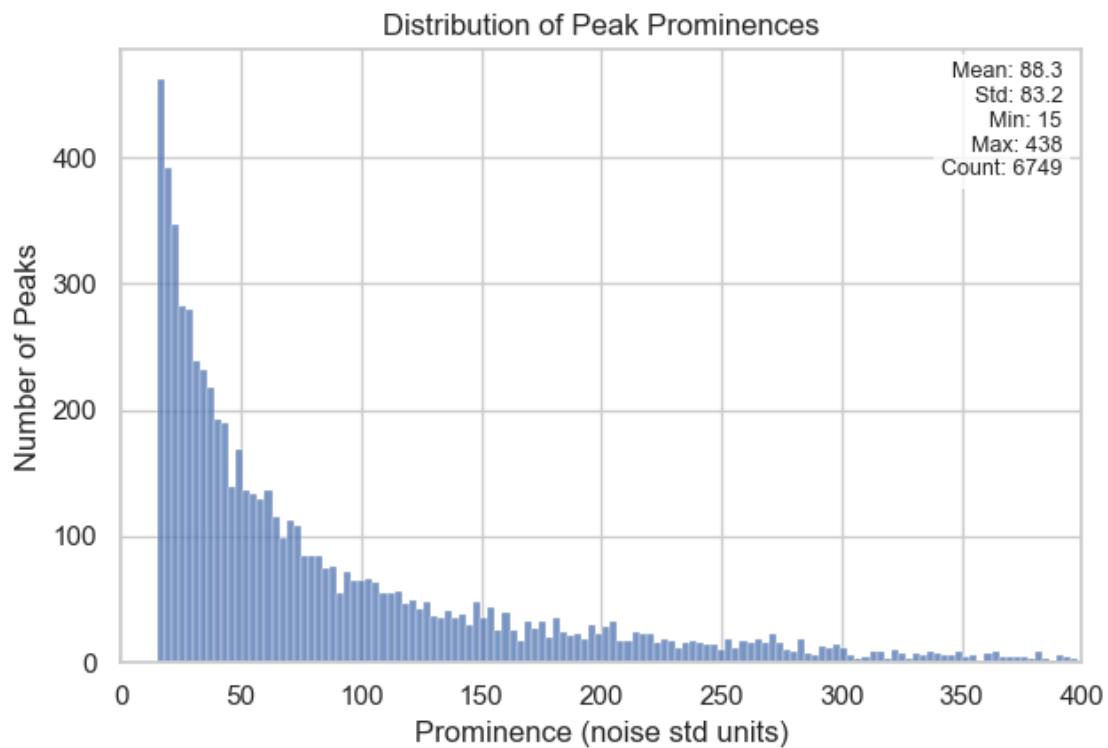


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 11:25:25] [INFO] calcium: plot_histogram: removed 93 outliers out of 6820 on 'Duration (s)' (lower=-3, upper=81)
```

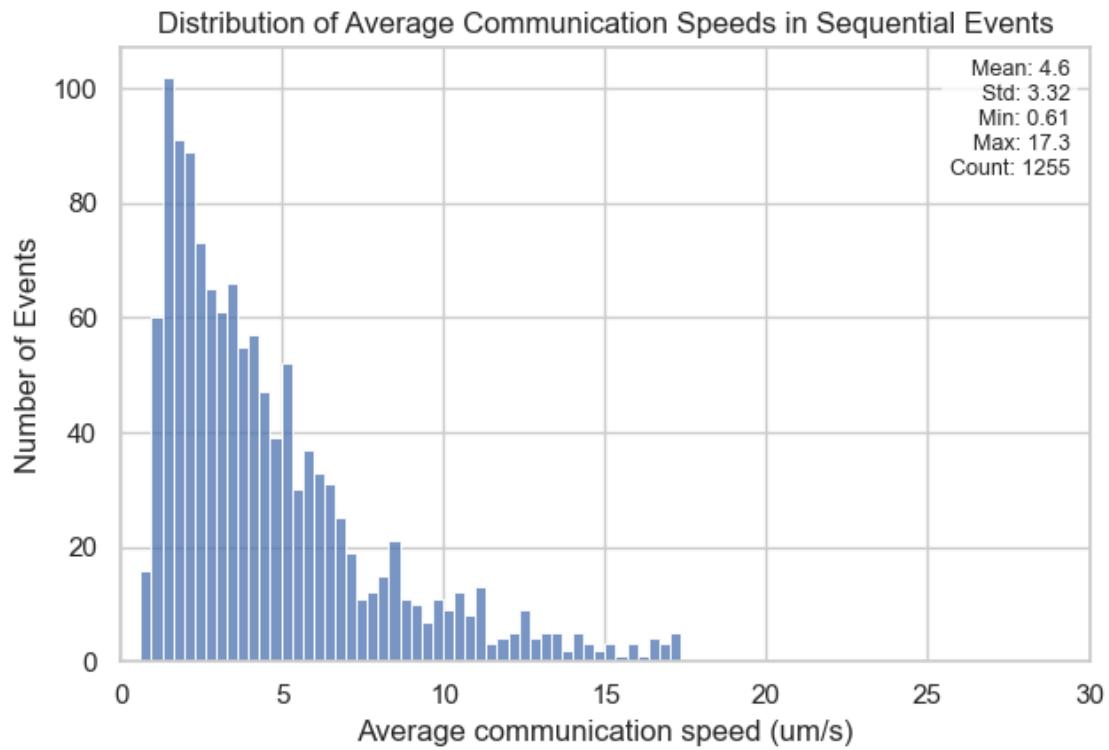


```
[2025-08-13 11:25:25] [INFO] calcium: plot_histogram: removed 71 outliers out of  
6820 on 'Prominence (noise std units)' (lower=-106.9, upper=437.9)
```

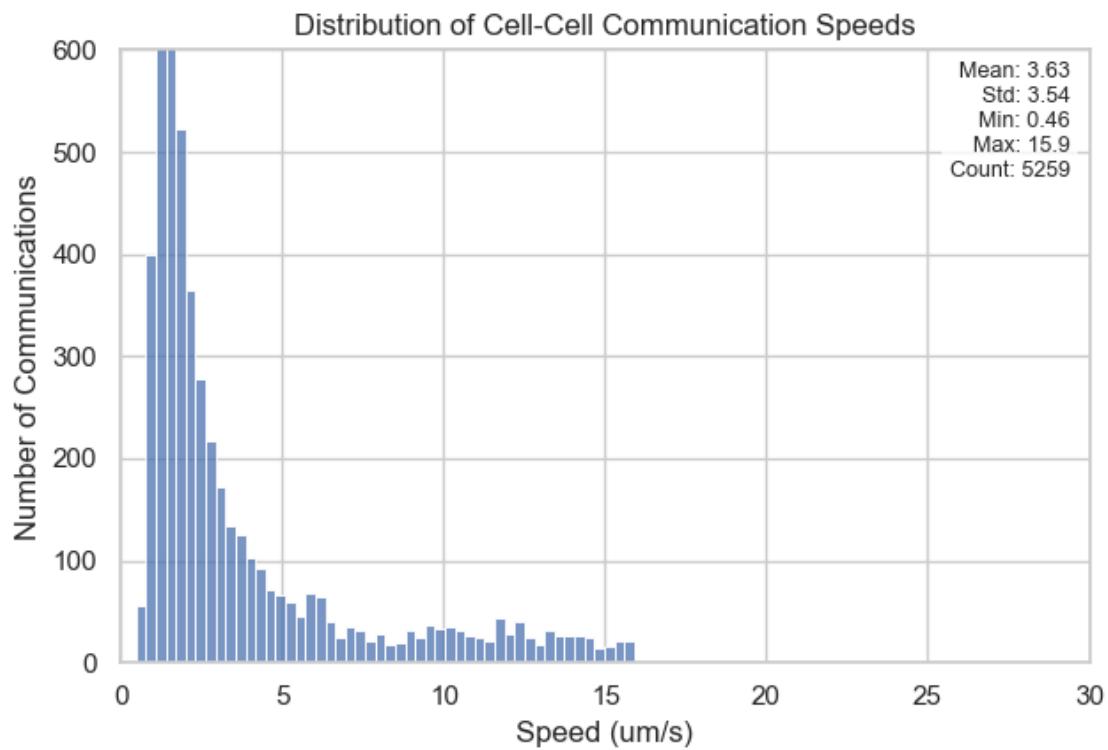


1.3.3 Cell-cell communication speed

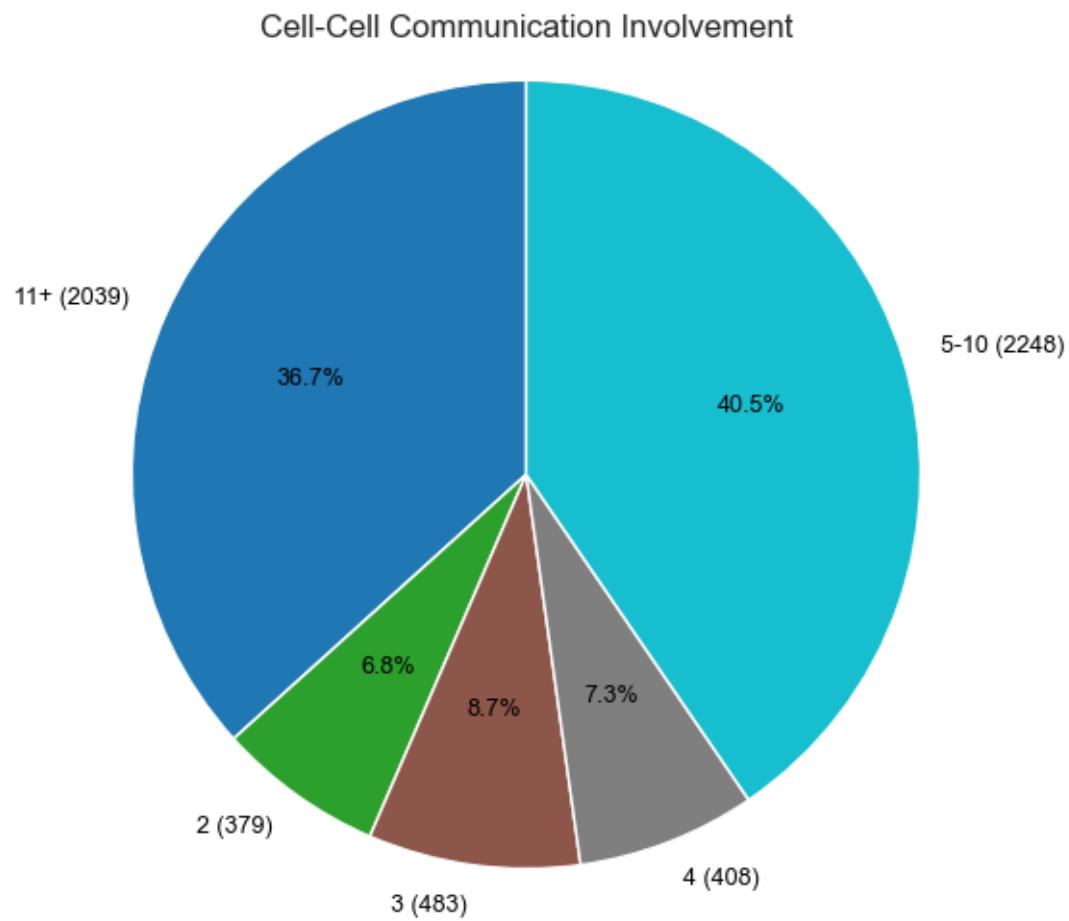
[2025-08-13 11:25:26] [INFO] calcium: plot_histogram: removed 8 outliers out of 1263 on 'Average communication speed (um/s)' (lower=-9.65, upper=17.79)



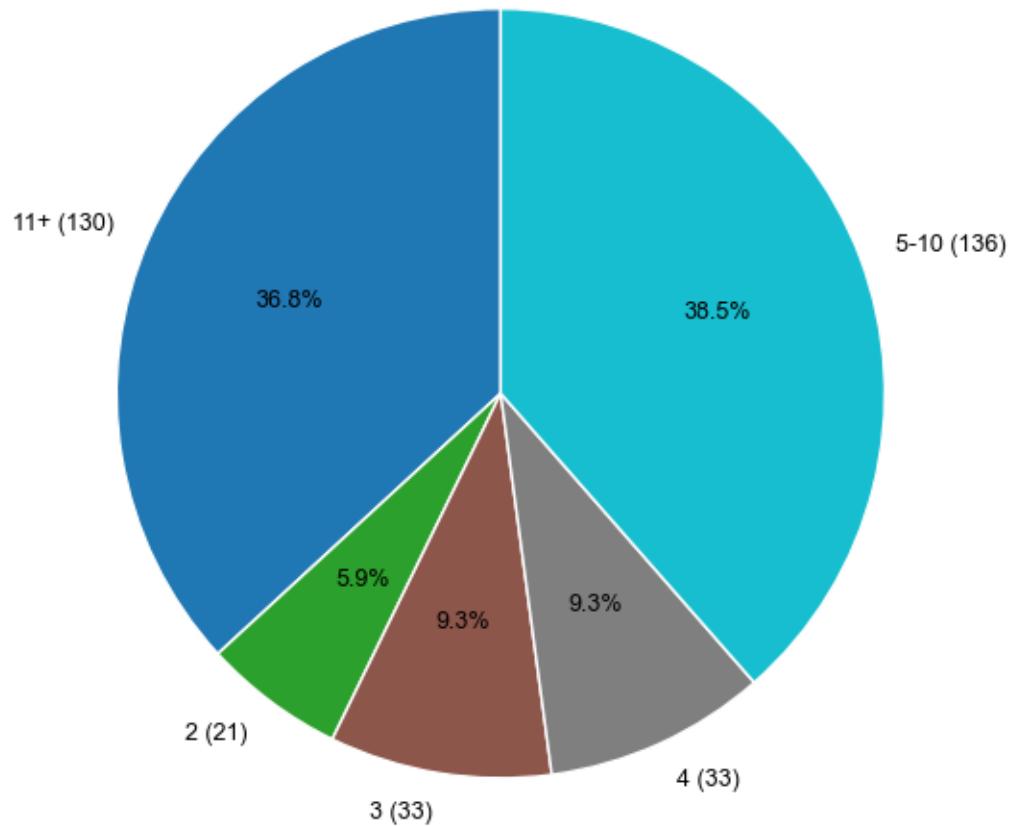
[2025-08-13 11:25:26] [INFO] calcium: plot_histogram: removed 298 outliers out of 5557 on 'Speed (um/s)' (lower=-9.43, upper=15.91)



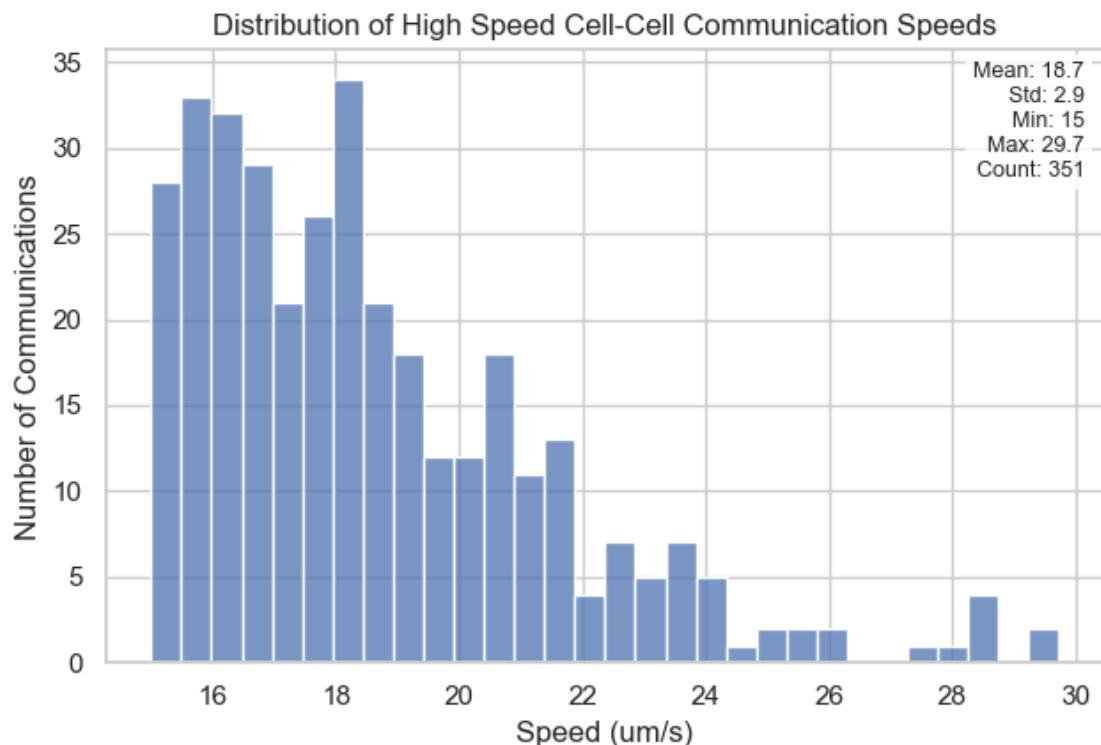
1.3.4 Double distribution in cell-cell communication speeds



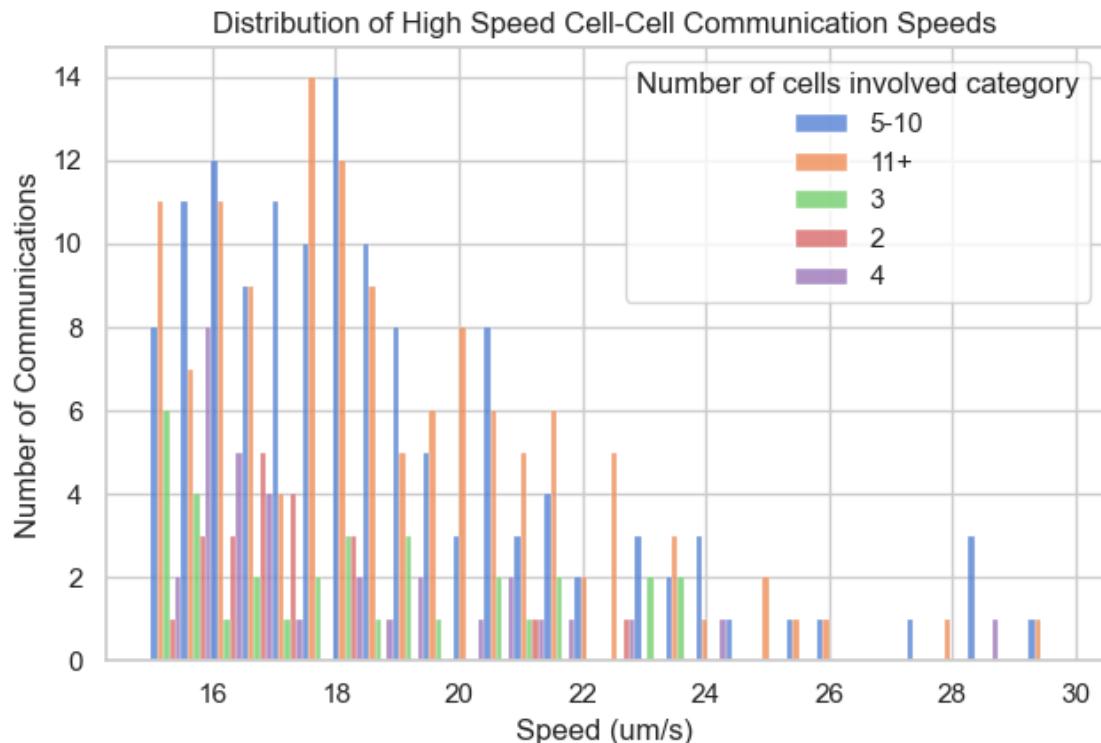
High Speed Cell-Cell Communication Involvement



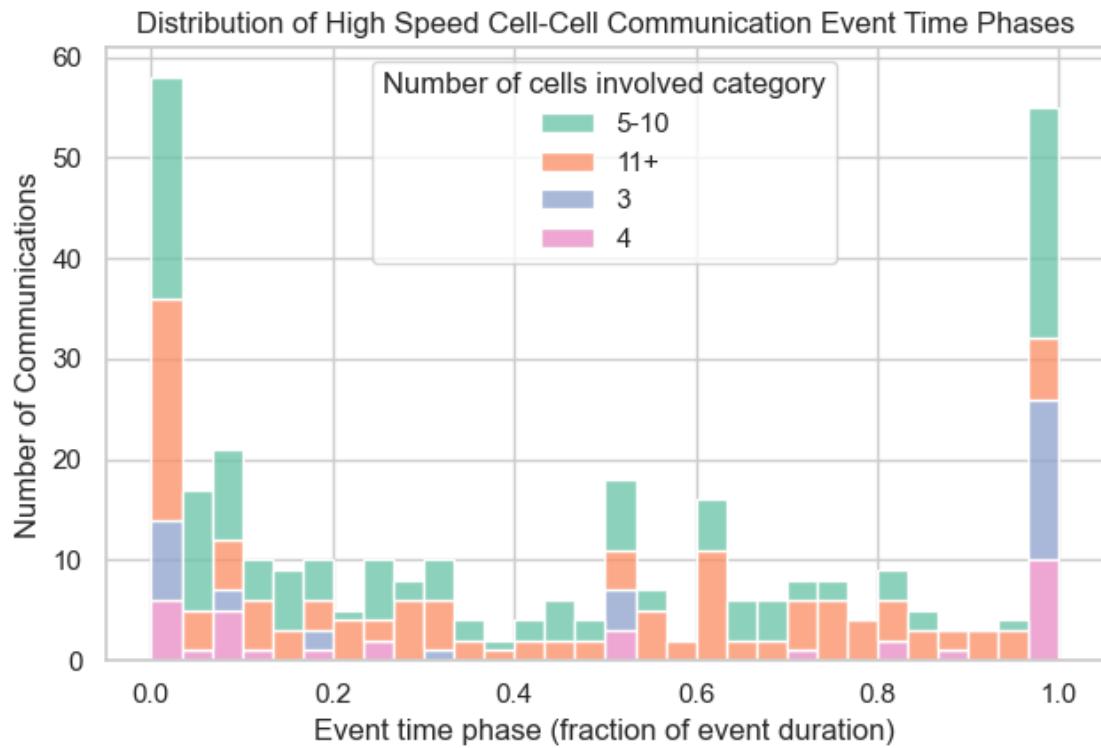
[2025-08-13 11:25:26] [INFO] calcium: plot_histogram: removed 2 outliers out of 353 on 'Speed (um/s)' (lower=4.52, upper=32.24)



```
[2025-08-13 11:25:26] [INFO] calcium: plot_histogram_by_group: removed 2 outliers out of 353 on 'Speed (um/s)' (lower=4.52, upper=32.24)
```

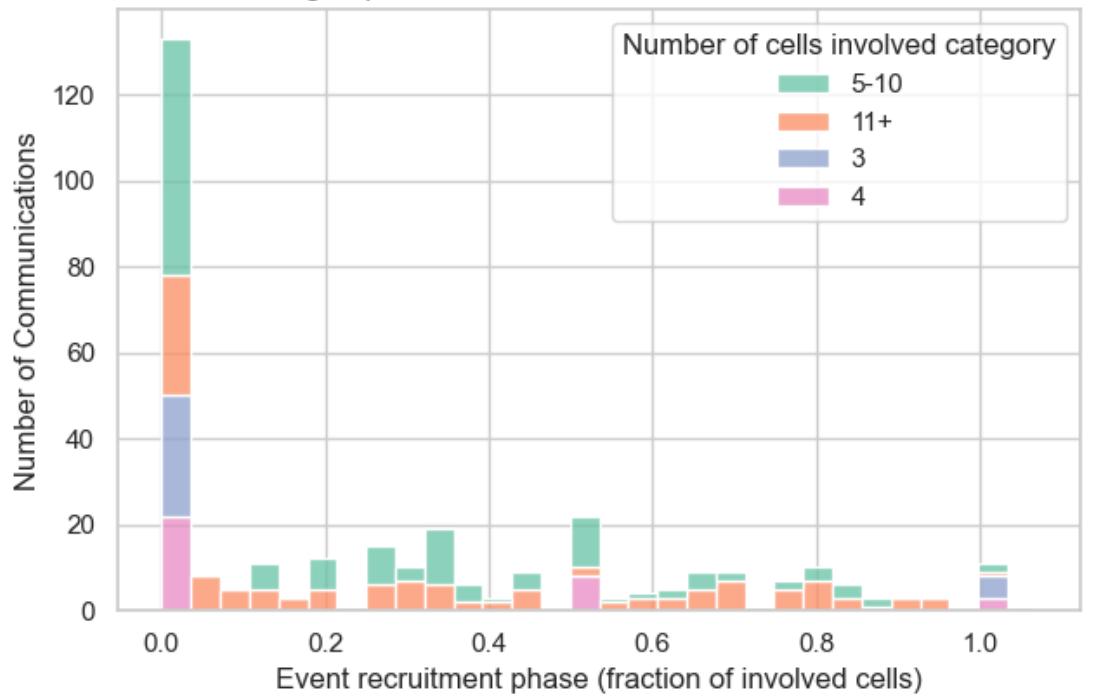


```
[2025-08-13 11:25:27] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 332 on 'Event time phase (fraction of event duration)' (lower=-1.9675, upper=2.81)
```

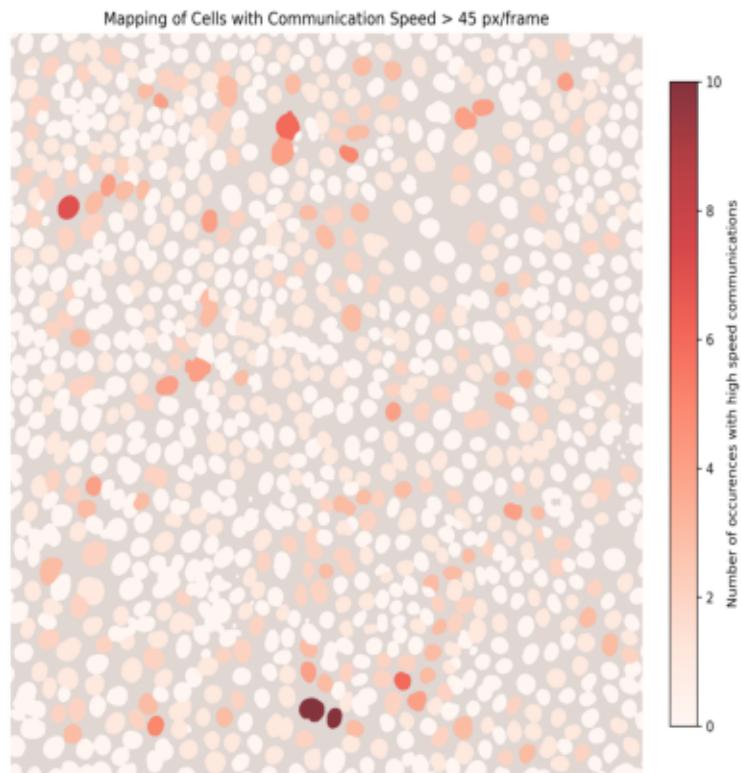


```
[2025-08-13 11:25:27] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 332 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.5, upper=2)
```

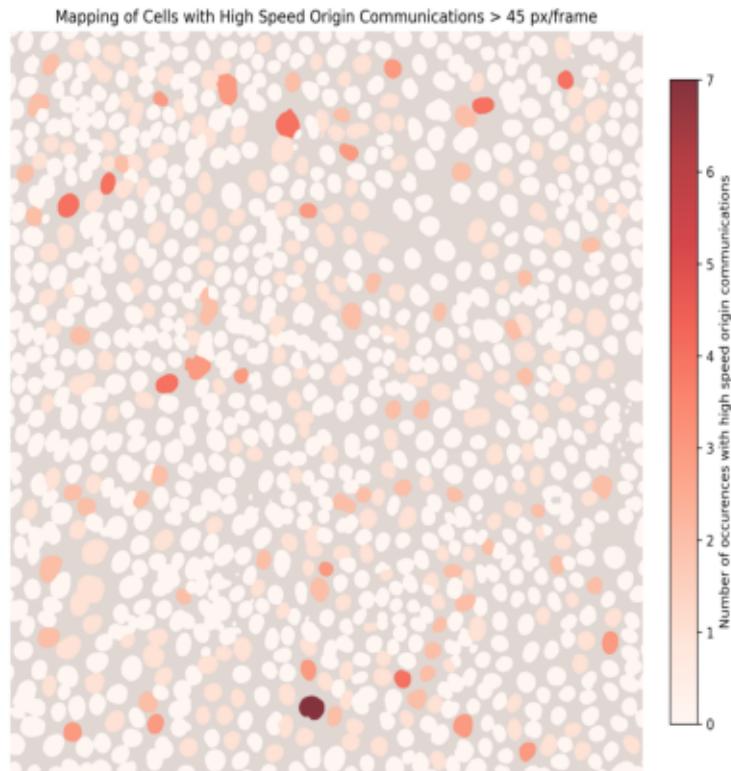
Distribution of High Speed Cell-Cell Communication Event Recruitment Phases



Cell Mapping with High Speed Cells Overlay - 20250326_IS3



Cell Mapping with High Speed Origin Cells Overlay - 20250326_IS3



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
0	1759456165648	4	928		1
5	1759456165024	5	1436		3
6	1759456160368	5	1436		3
25	1759508166592	9	558		5
41	1759364411312	10	908		7
...
5488	1759523234688	1221	1555		11
5494	1759456359616	1222	1631		4
5506	1759523232912	1232	1617		1
5522	1759523226048	1242	1631		2
5539	1759523230848	1252	1642		0

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
0	927	1	181.0	182.0	
5	1425	5	309.0	310.0	
6	1463	3	309.0	310.0	
25	599	3	304.0	304.0	
41	861	6	419.0	419.0	
...	
5488	1570	13	932.0	933.0	
5494	1636	3	343.0	344.0	
5506	1585	1	154.0	155.0	
5522	1596	3	181.0	182.0	
5539	1603	1	134.0	135.0	
	Duration (s)	Distance (um)	Speed (um/s)	\	
0	1.0	18.53	18.53		
5	1.0	16.03	16.03		
6	1.0	17.16	17.16		
25	0.0	17.76	17.76		
41	0.0	20.41	20.41		
...	
5488	1.0	18.40	18.40		
5494	1.0	17.53	17.53		
5506	1.0	17.31	17.31		
5522	1.0	15.32	15.32		
5539	1.0	17.34	17.34		
	Event time phase (fraction of event duration)	\			
0		0.04			
5		0.25			
6		0.25			
25		0.05			
41		0.76			
...		...			
5488		NaN			
5494		0.53			
5506		NaN			
5522		0.50			
5539		NaN			
	Event recruitment phase (fraction of involved cells)	dataset	\		
0		0.00	20250326_IS3		
5		0.00	20250326_IS3		
6		0.00	20250326_IS3		
25		0.00	20250326_IS3		
41		0.71	20250326_IS3		
...			
5488		NaN	20250326_IS3		
5494		0.40	20250326_IS3		

5506		NaN	20250326_IS3
5522		0.00	20250326_IS3
5539		NaN	20250326_IS3

	Number of cells involved	category	Speed category
0		5-10	High speed
5		5-10	High speed
6		5-10	High speed
25		11+	High speed
41		11+	High speed
...	
5488		2	High speed
5494		5-10	High speed
5506		2	High speed
5522		3	High speed
5539		2	High speed

[353 rows x 16 columns]

Origin cell ID	Speed category	High speed	Low speed
263		0	1
266		0	3
267		1	5
269		0	2
270		0	1
...
1643		0	1
1644		0	1
1645		0	1
1649		0	1
1650		0	2

[955 rows x 2 columns]

	Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
0	263	30.23		6.17
1	266	364.98		6.83
2	267	199.88		8.45
3	269	233.35		9.10
4	270	279.50		10.08
..
980	1643	113.10		490.43
981	1644	161.53		490.75
982	1645	181.35		490.75
983	1649	461.50		491.40
984	1650	433.88		491.73

Number of peaks	Is active	Occurrences in global events	\
-----------------	-----------	------------------------------	---

0	11	True	4
1	11	True	3
2	13	True	4
3	9	True	4
4	11	True	4
..
980	6	True	4
981	17	True	4
982	9	True	4
983	11	True	4
984	14	True	4

Occurrences in global events as early peaker \

0	0
1	0
2	2
3	0
4	0
..	...
980	1
981	0
982	0
983	1
984	1

Occurrences in sequential events \

0	3
1	6
2	6
3	3
4	4
..	...
980	2
981	4
982	2
983	2
984	4

Occurrences in sequential events as origin \

0	1
1	2
2	1
3	0
4	1
..	...
980	1
981	0
982	1

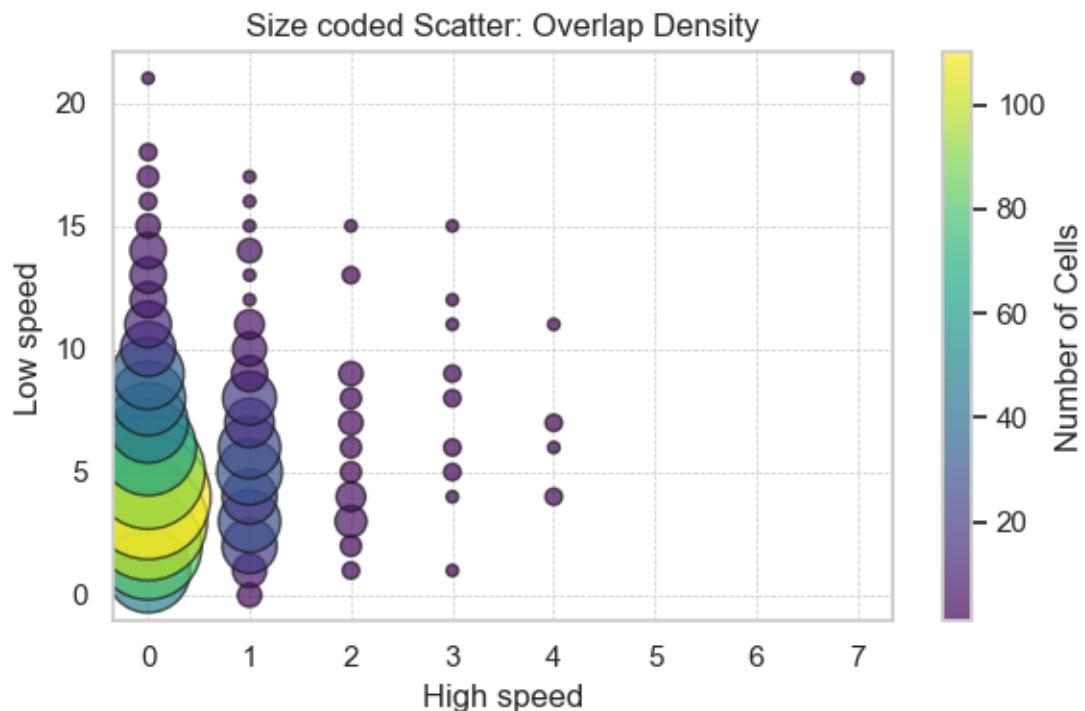
983		0	
984		1	
Occurrences in individual events Peak frequency (Hz) Periodicity score \			
0	4	0.0065	0.67
1	2	0.0065	0.57
2	2	0.0076	0.62
3	2	0.0053	0.65
4	3	0.0065	0.71
..
980	0	0.0035	0.72
981	7	0.0100	0.62
982	2	0.0053	0.74
983	4	0.0065	0.63
984	5	0.0082	0.63
Neighbor count Neighbors (labels) dataset \			
0	3	[278,305,310]	20250326_IS3
1	3	[294,308,327]	20250326_IS3
2	4	[283,289,306,315]	20250326_IS3
3	3	[289,301,307]	20250326_IS3
4	3	[280,297,309]	20250326_IS3
..
980	2	[1606,1626]	20250326_IS3
981	4	[1607,1612,1624,1645]	20250326_IS3
982	3	[1612,1613,1644]	20250326_IS3
983	3	[1601,1630,1632]	20250326_IS3
984	3	[1616,1619,1630]	20250326_IS3
Involved in sequential event Occurrences in sequential events category \			
0	Involved in sequential event		3-4
1	Involved in sequential event		5-9
2	Involved in sequential event		5-9
3	Involved in sequential event		3-4
4	Involved in sequential event		3-4
..
980	Involved in sequential event		1-2
981	Involved in sequential event		3-4
982	Involved in sequential event		1-2
983	Involved in sequential event		1-2
984	Involved in sequential event		3-4
High speed Low speed			
0	0.0	1.0	
1	0.0	3.0	
2	1.0	5.0	
3	0.0	2.0	
4	0.0	1.0	

```

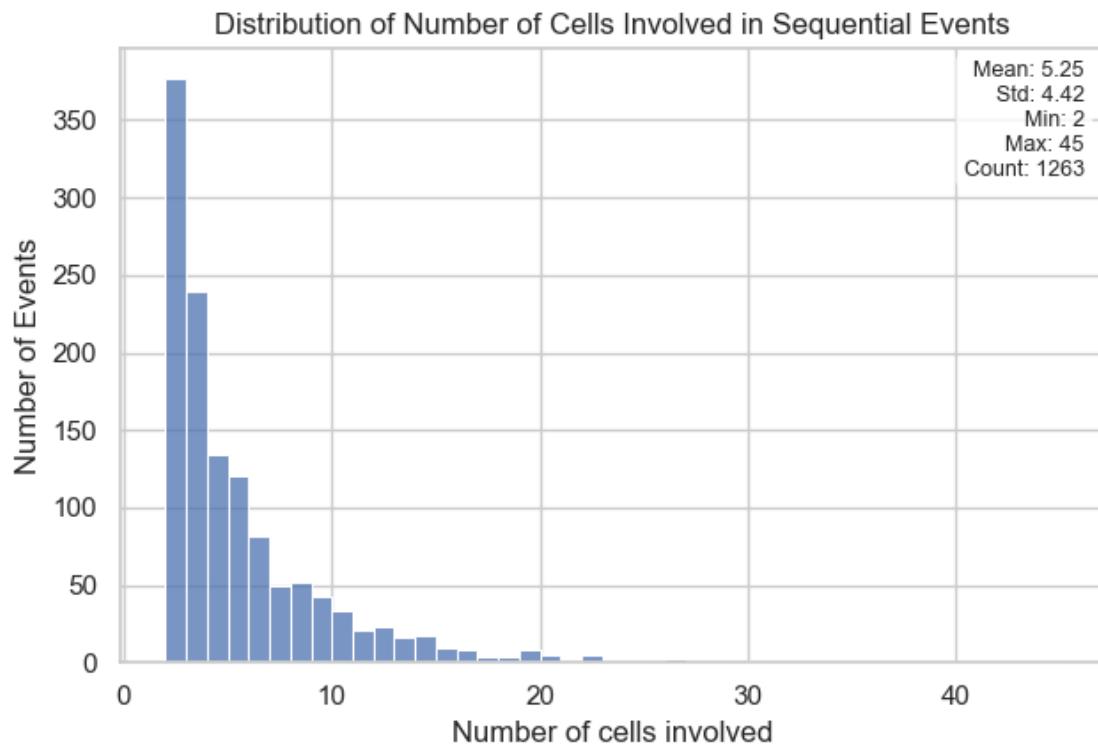
...
980      0.0      1.0
981      0.0      1.0
982      0.0      1.0
983      0.0      1.0
984      0.0      2.0

```

[955 rows x 19 columns]

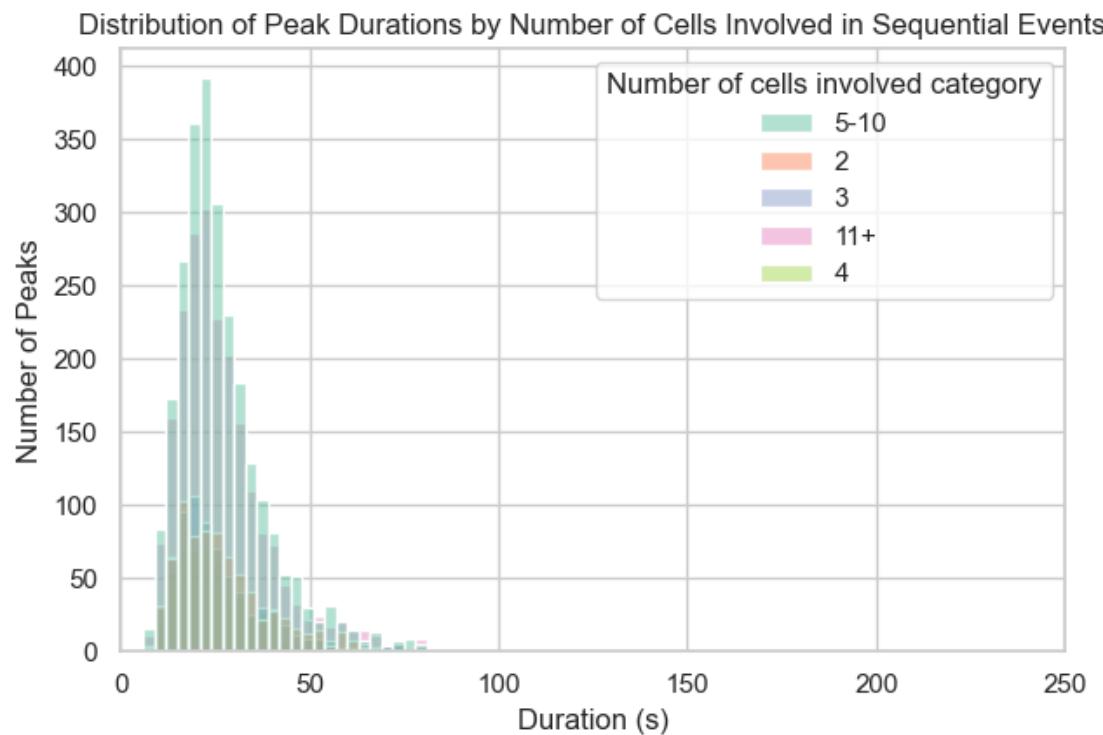


1.3.5 Number of cells involved per sequential events



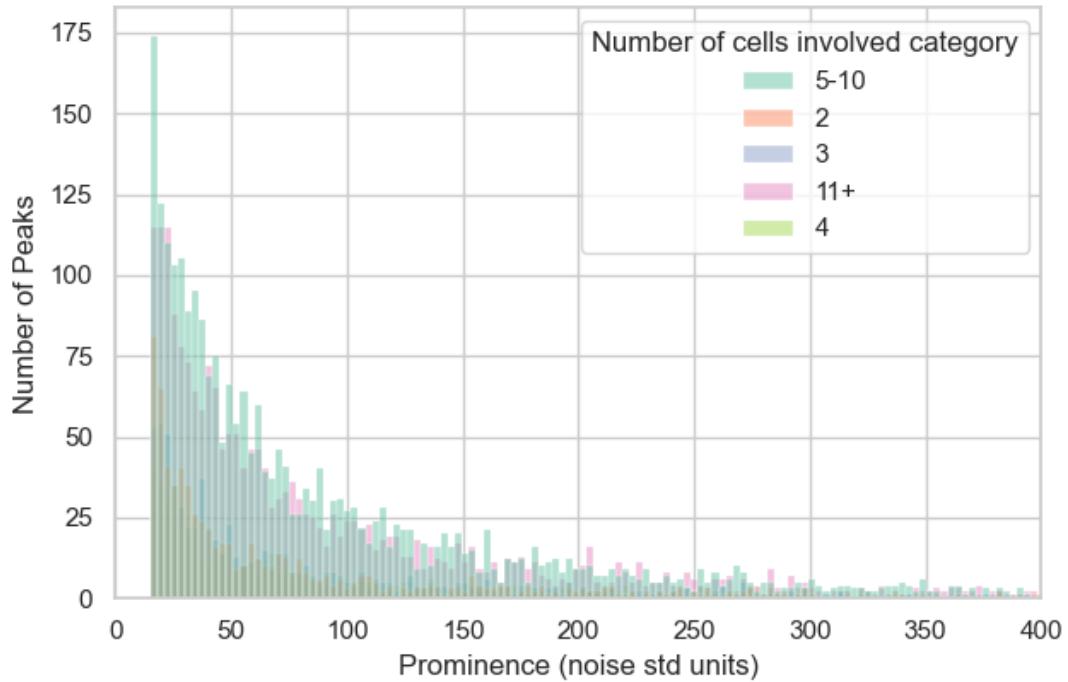
1.3.6 Influence of cell count per event on statistics

```
[2025-08-13 11:25:30] [INFO] calcium: plot_histogram_by_group: removed 93 outliers out of 6820 on 'Duration (s)' (lower=-3, upper=81)
```

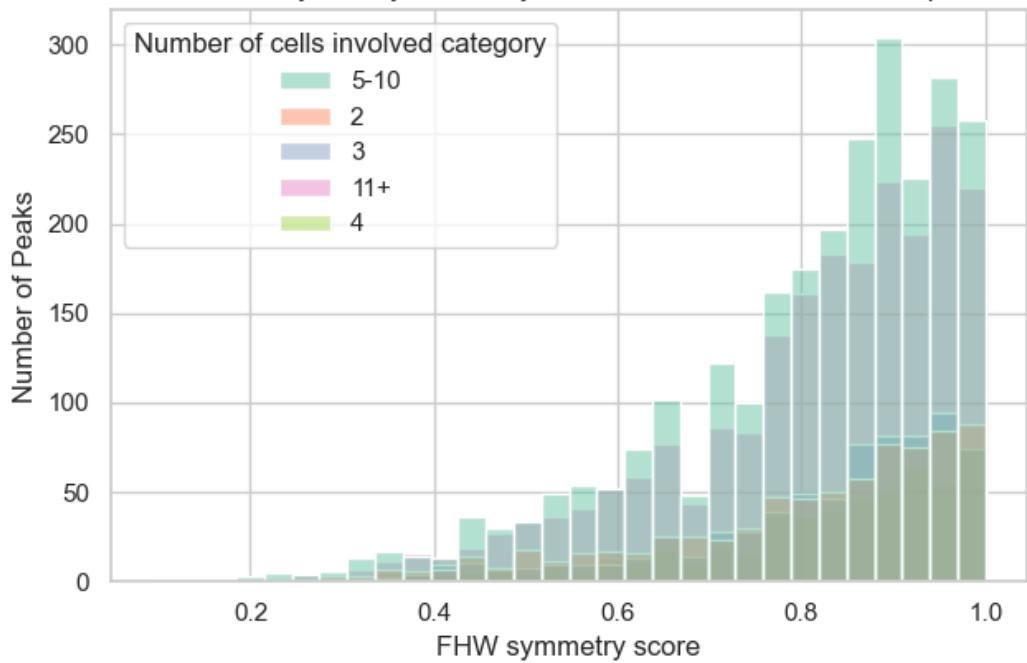


```
[2025-08-13 11:25:31] [INFO] calcium: plot_histogram_by_group: removed 71 outliers out of 6820 on 'Prominence (noise std units)' (lower=-106.9, upper=437.9)
```

Distribution of Peak Prominences by Number of Cells Involved in Sequential Events

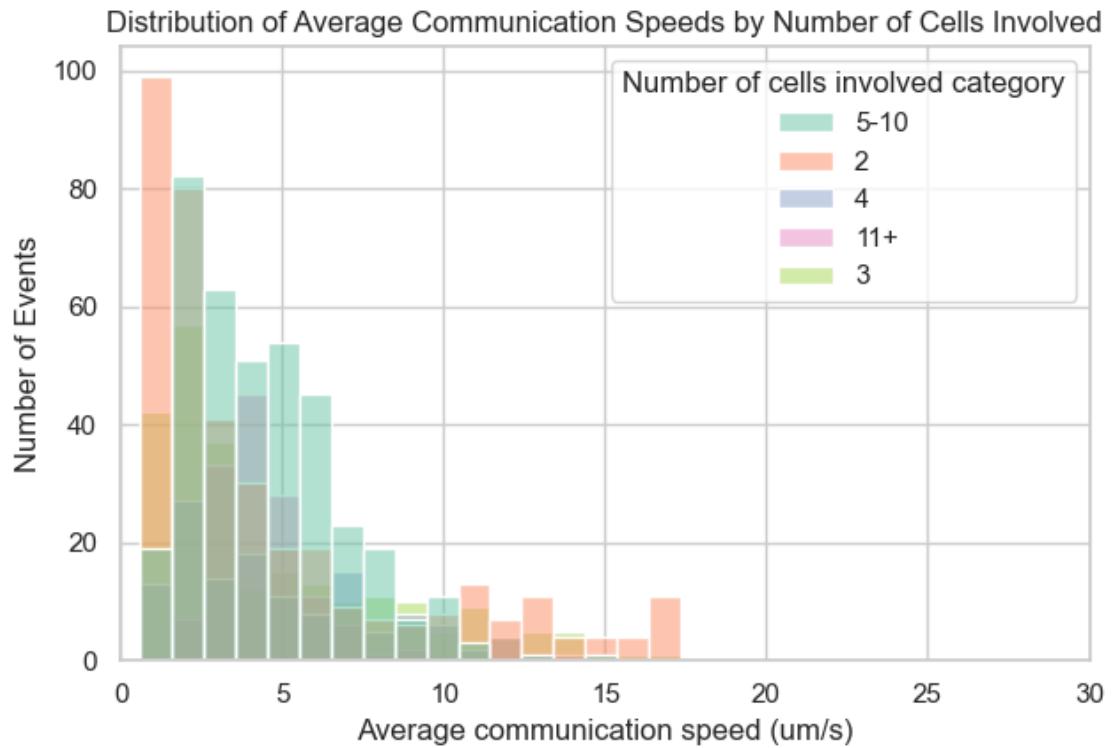


Distribution of Peak Symmetry Scores by Number of Cells Involved in Sequential Events



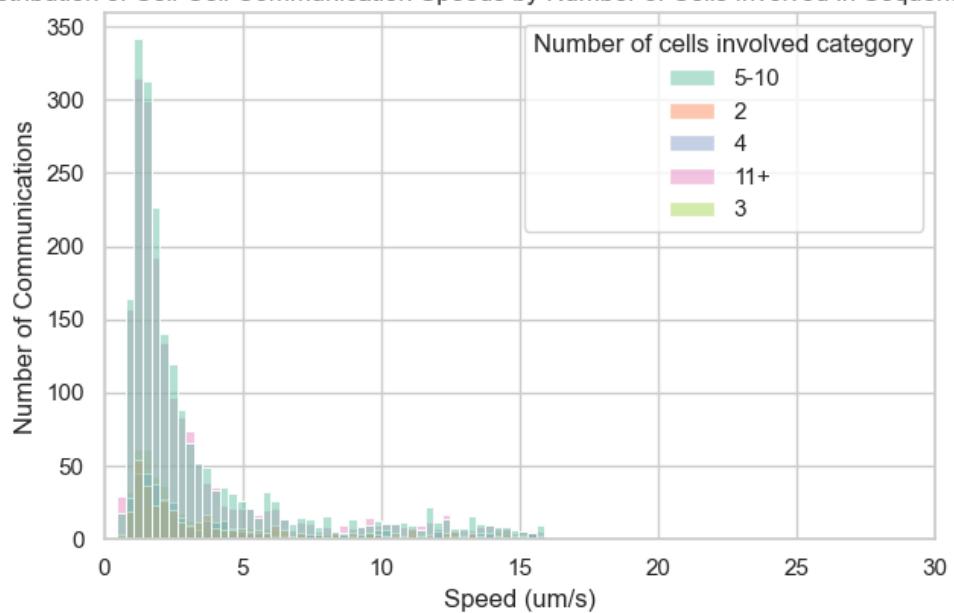
[2025-08-13 11:25:32] [INFO] calcium: plot_histogram_by_group: removed 8

outliers out of 1263 on 'Average communication speed (um/s)' (lower=-9.65, upper=17.79)



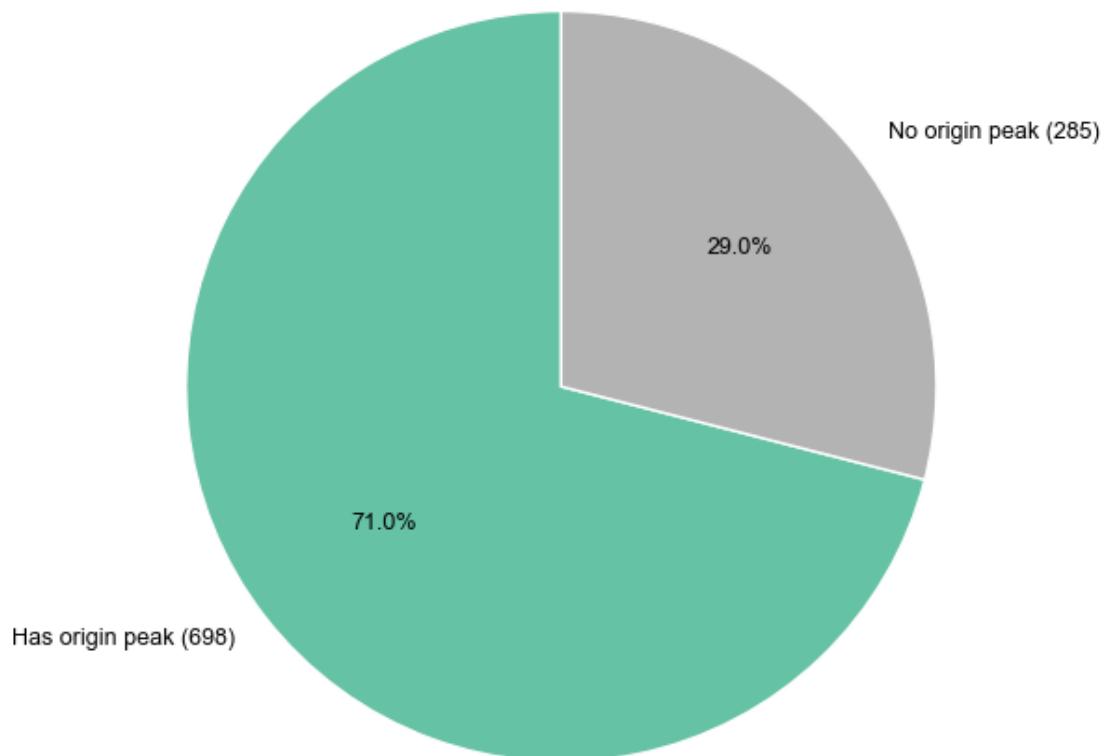
[2025-08-13 11:25:32] [INFO] calcium: plot_histogram_by_group: removed 298 outliers out of 5557 on 'Speed (um/s)' (lower=-9.43, upper=15.91)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events

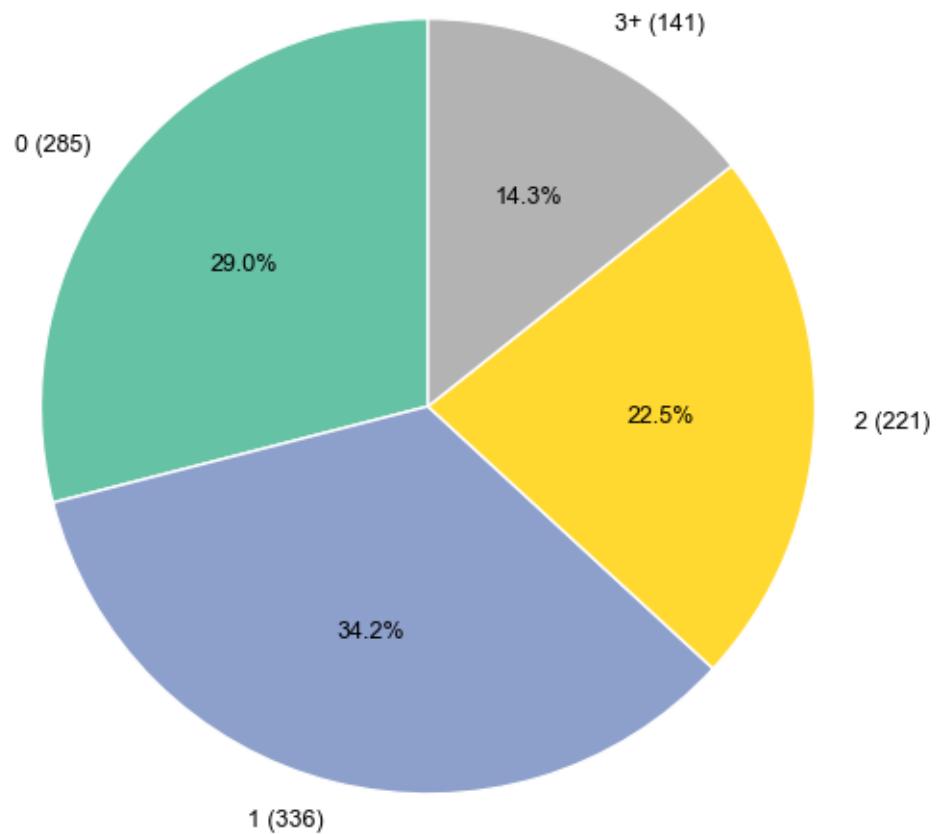


1.3.7 Cells occurrences as origin in sequential events

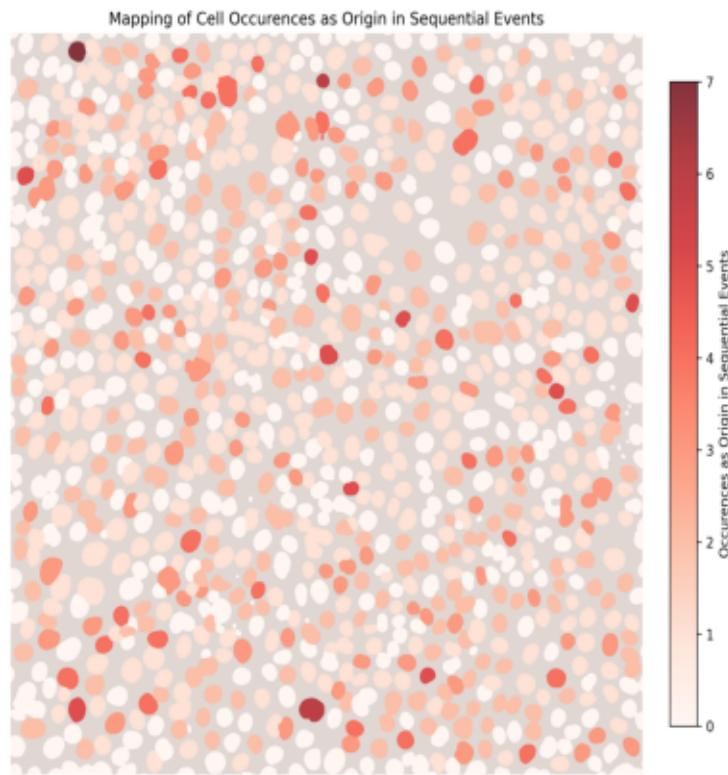
Distribution of Number of Sequential Event Origin Peaks per Cell

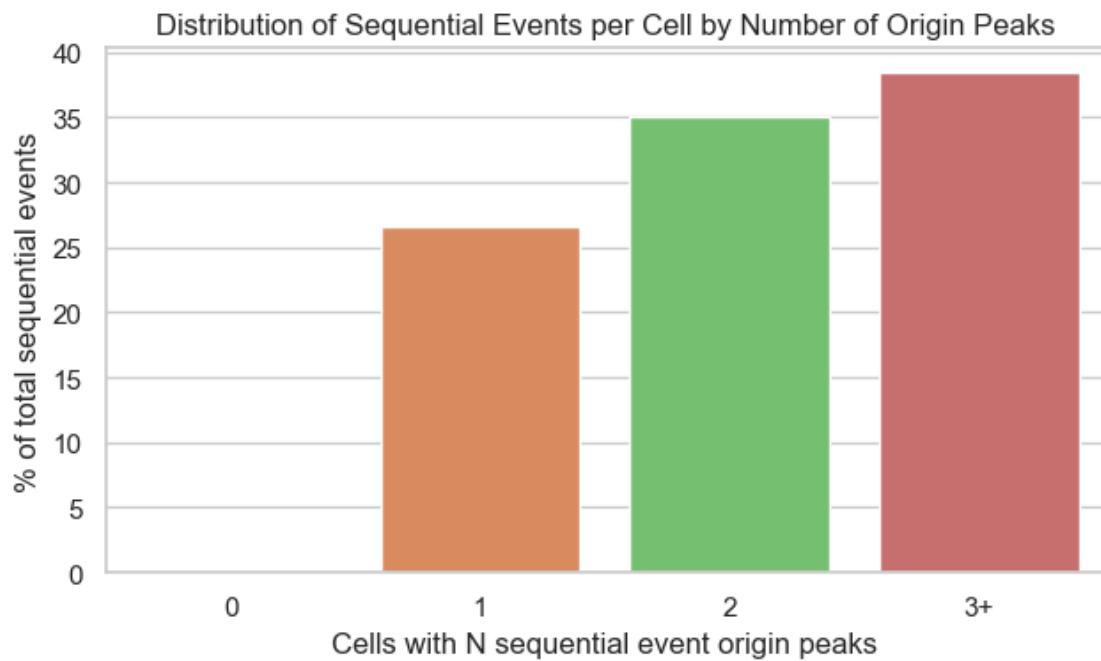


Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)



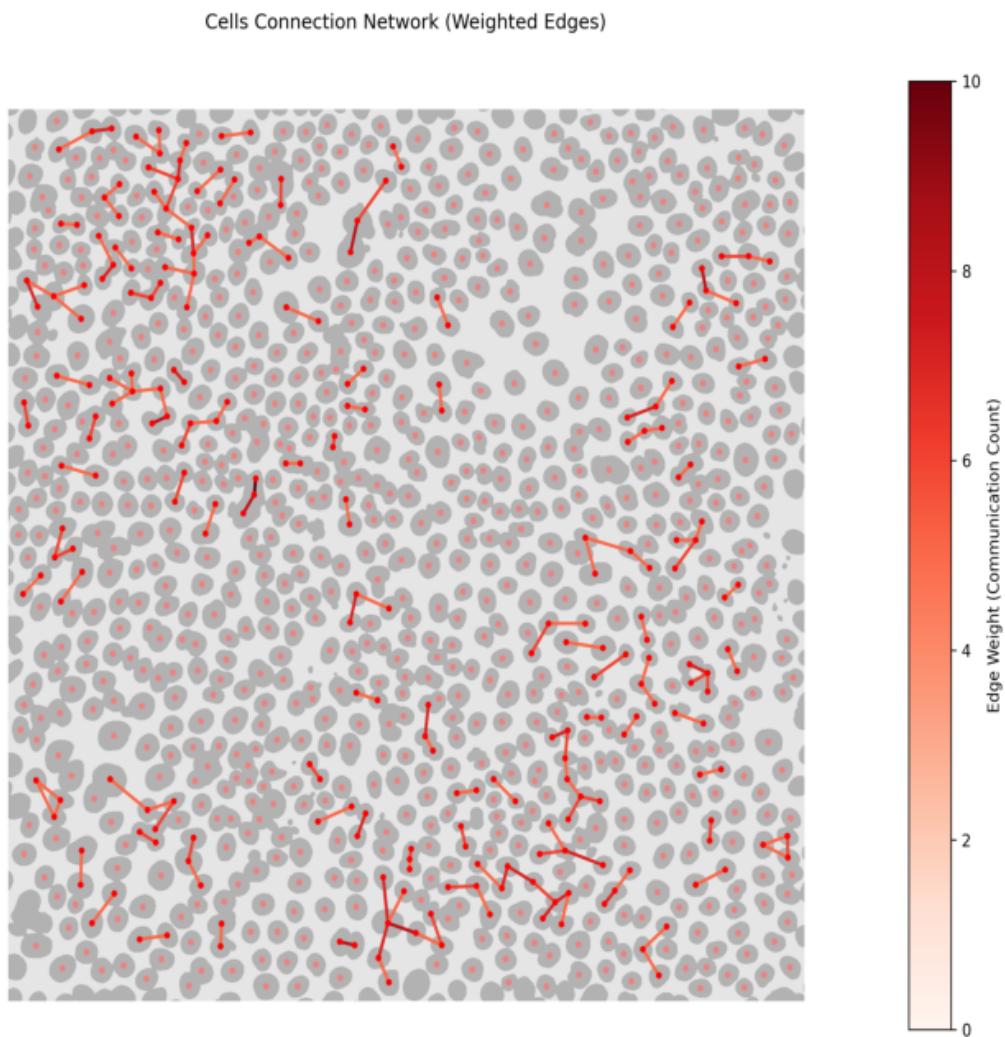
Cell Mapping with Origin Peaks Overlay - 20250326_IS3

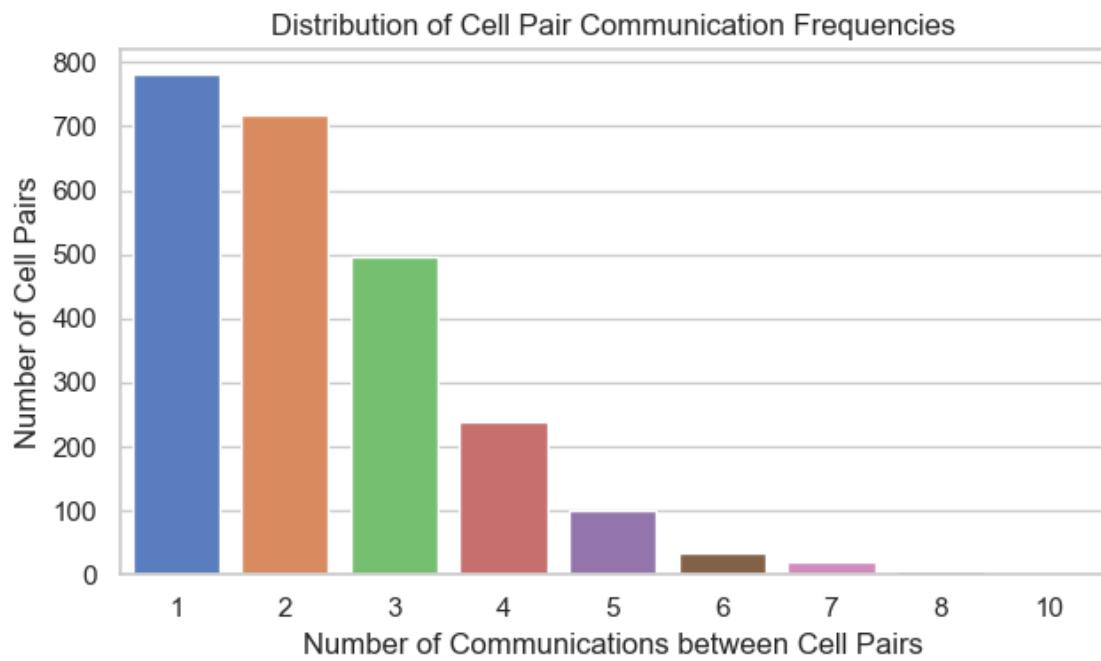




1.3.8 Connection network between cells

Cell Connection Network Graph - 20250326_IS3

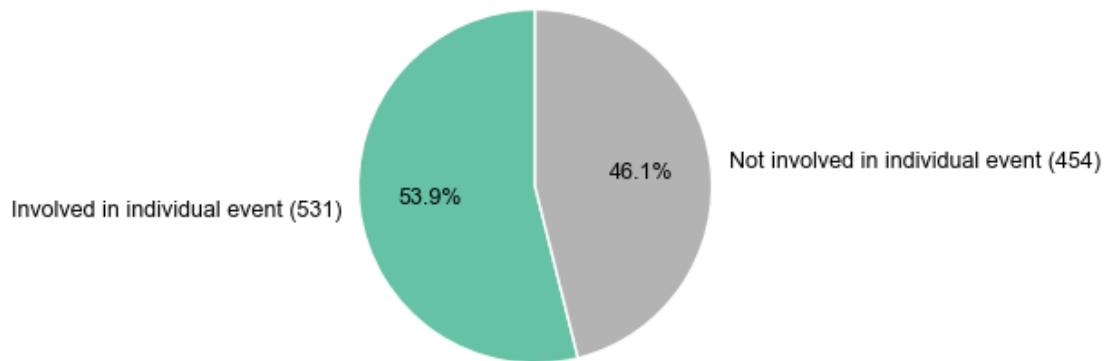




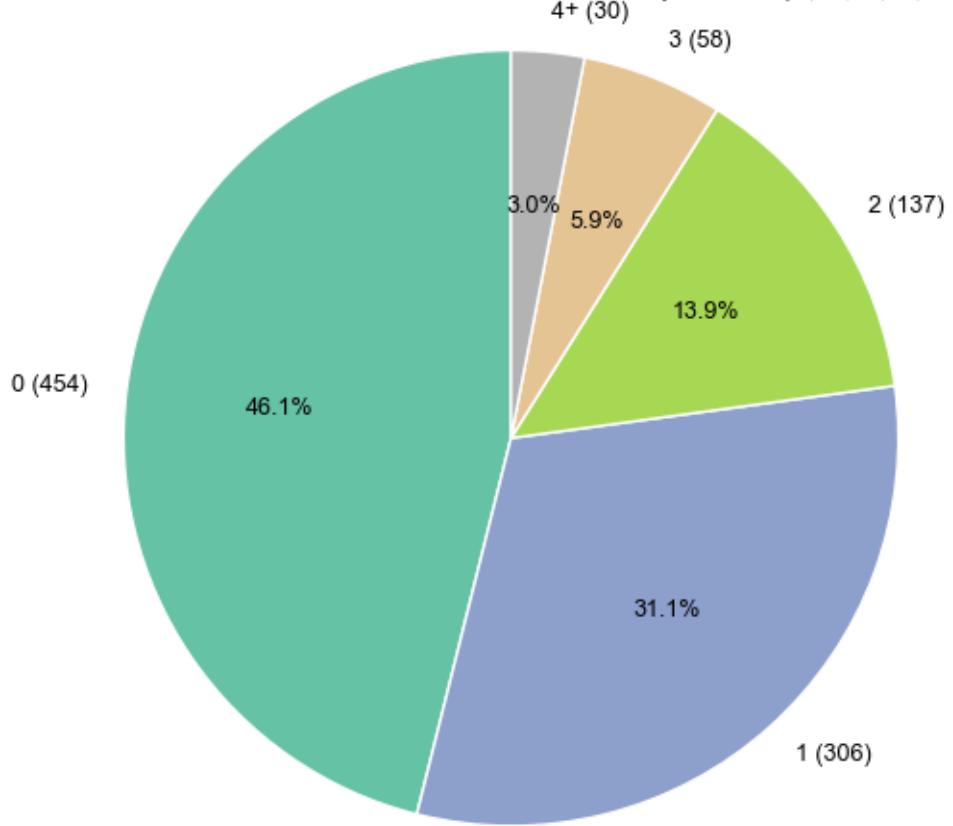
1.4 INDIVIDUAL EVENTS

1.4.1 Cells occurrences in individual events

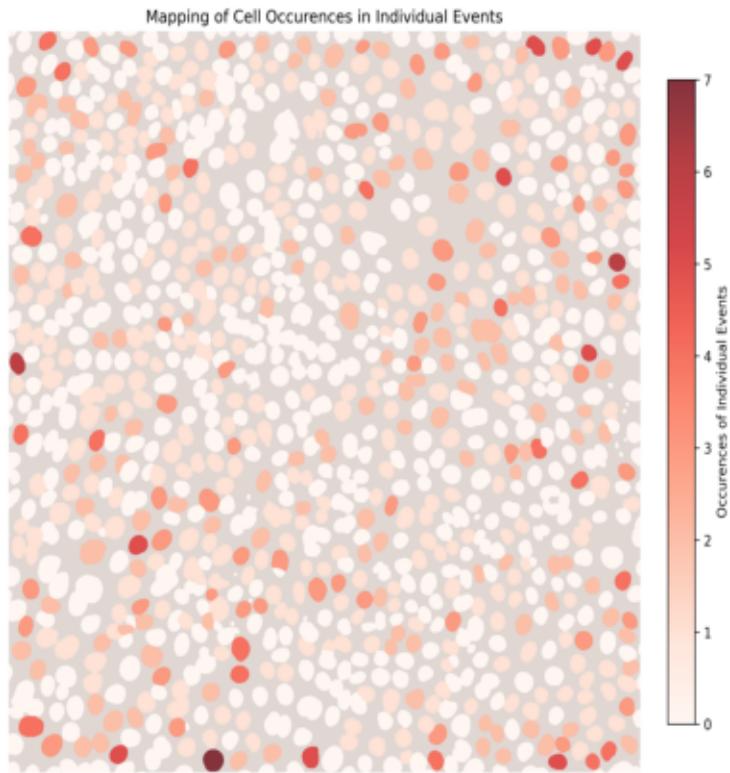
Distribution of Cells Involved in Individual Events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

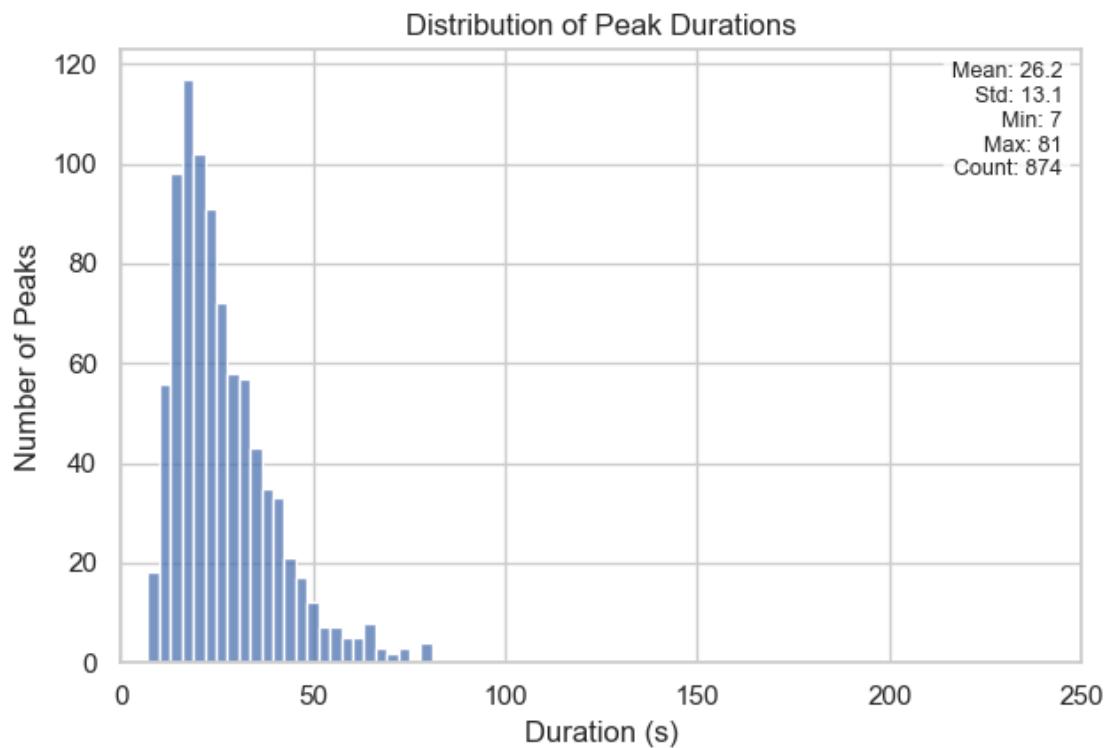


Cell Mapping with Occurrences in Individual Events Overlay - 20250326_IS3

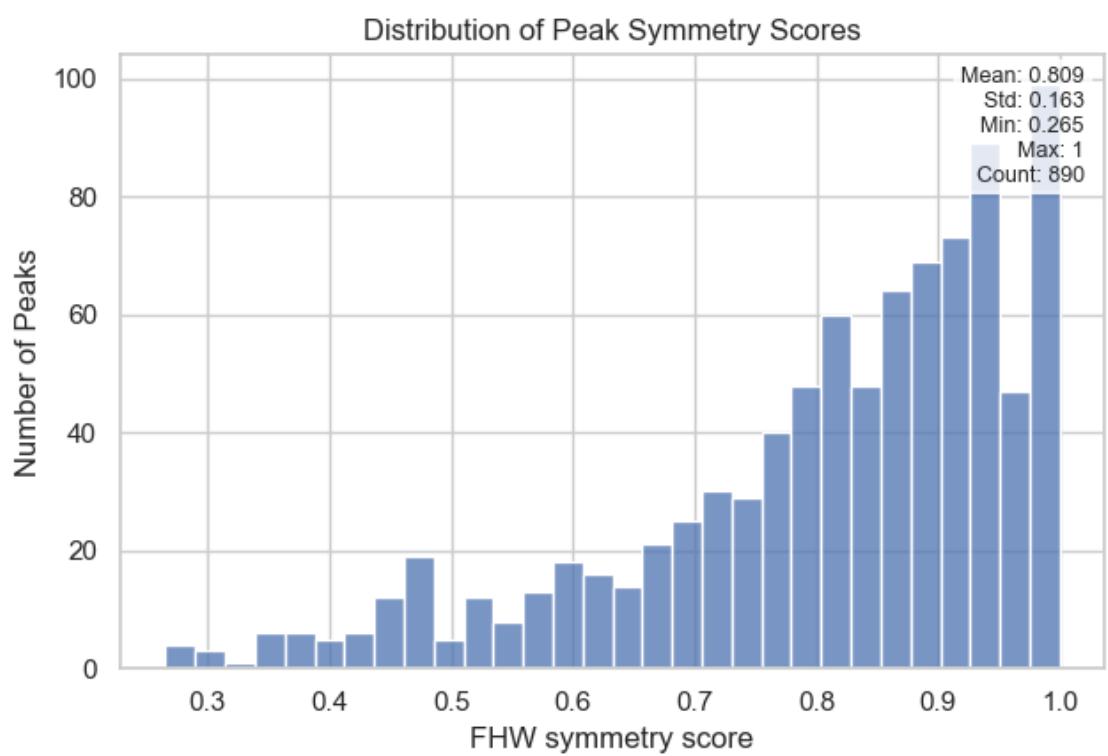
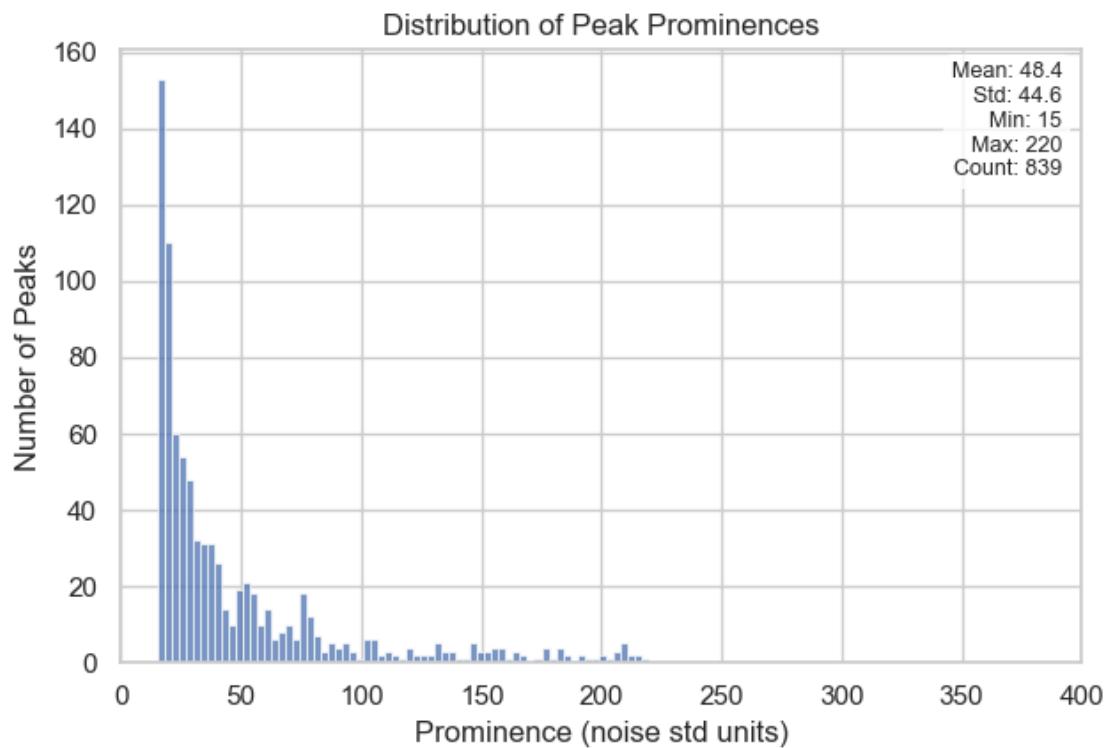


1.4.2 Peaks statistics in individual events

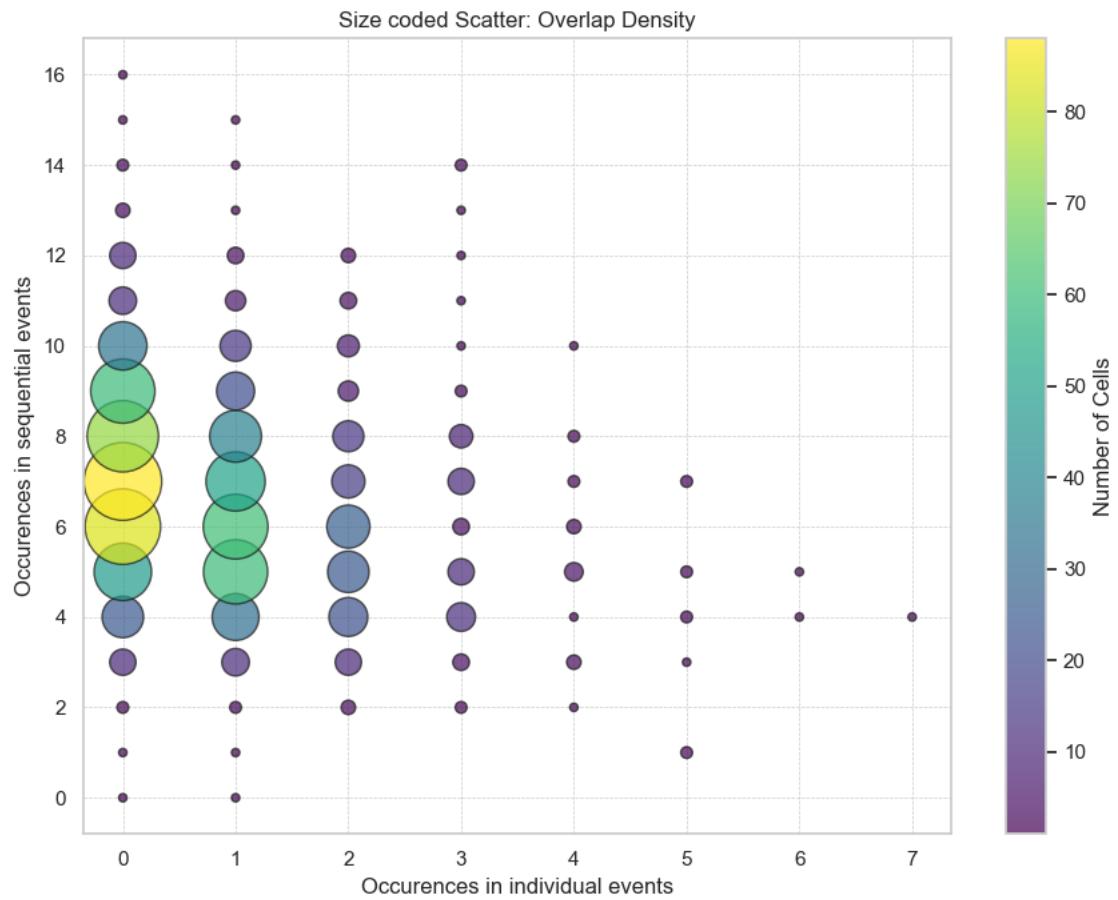
```
[2025-08-13 11:25:37] [INFO] calcium: plot_histogram: removed 16 outliers out of  
890 on 'Duration (s)' (lower=-31, upper=81)
```



[2025-08-13 11:25:37] [INFO] calcium: plot_histogram: removed 51 outliers out of 890 on 'Prominence (noise std units)' (lower=-130.28, upper=219.9)

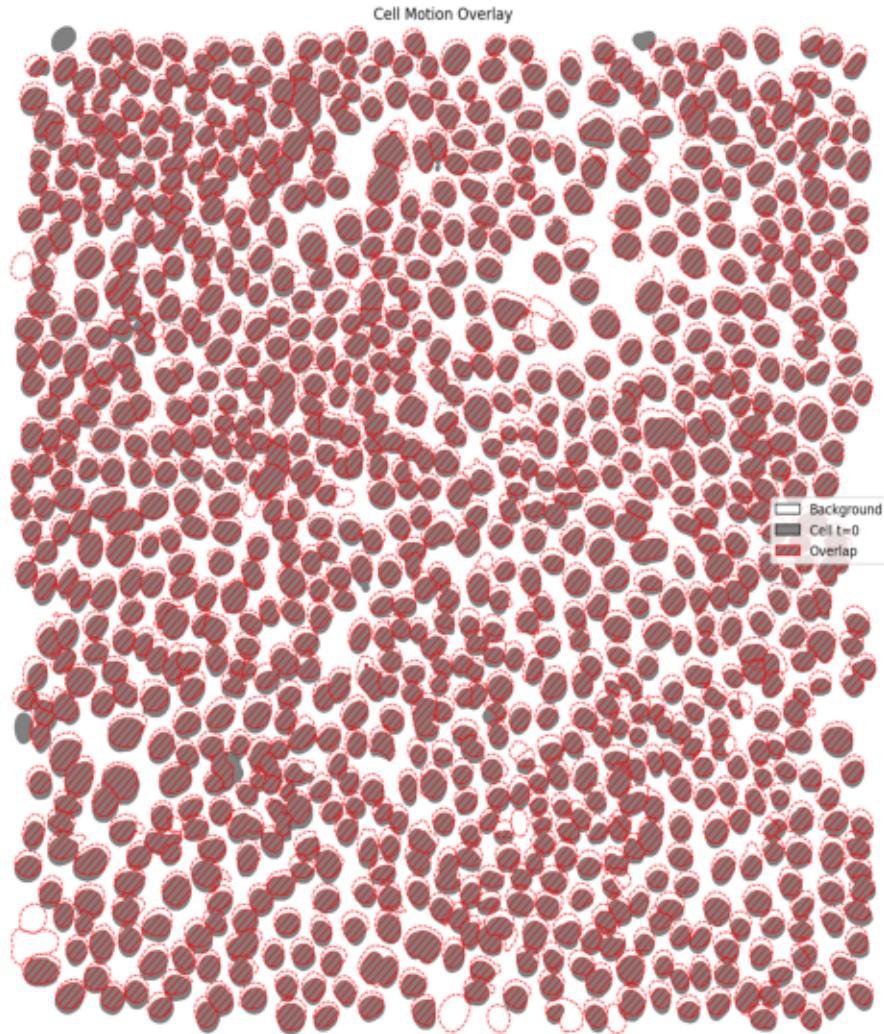


1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250326_IS3



Number of cells:

- Hoechst image taken at t=0: 985
- Hoechst image taken at t=1801: 999
- Number of cells difference: absolute 14, relative 1.41%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 1166809
- Pixels segmented as cell at t=1801: 1288137
- Overlapping pixels between t=0 and t=1801: 937179 (76.35% of total)
- Pixels exclusive to t=0: 229630 (19.68% of total)
- Pixels exclusive to t=1801: 350958 (27.25% of total)

executed

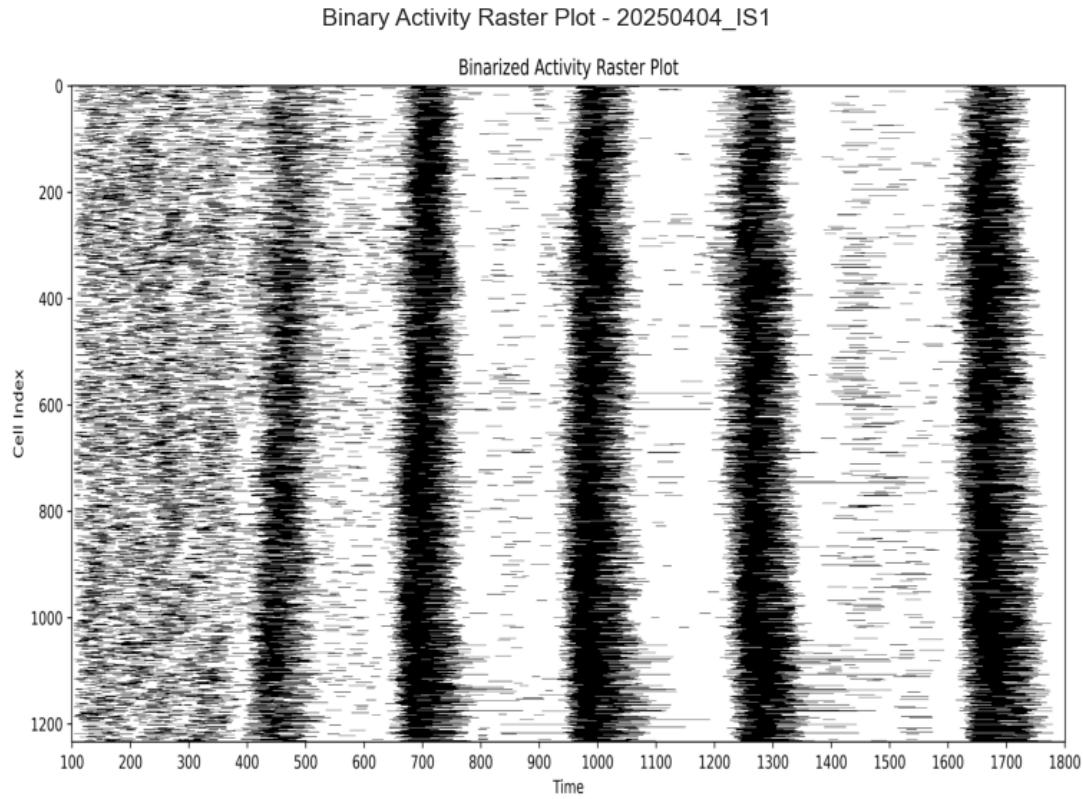
August 13, 2025

1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

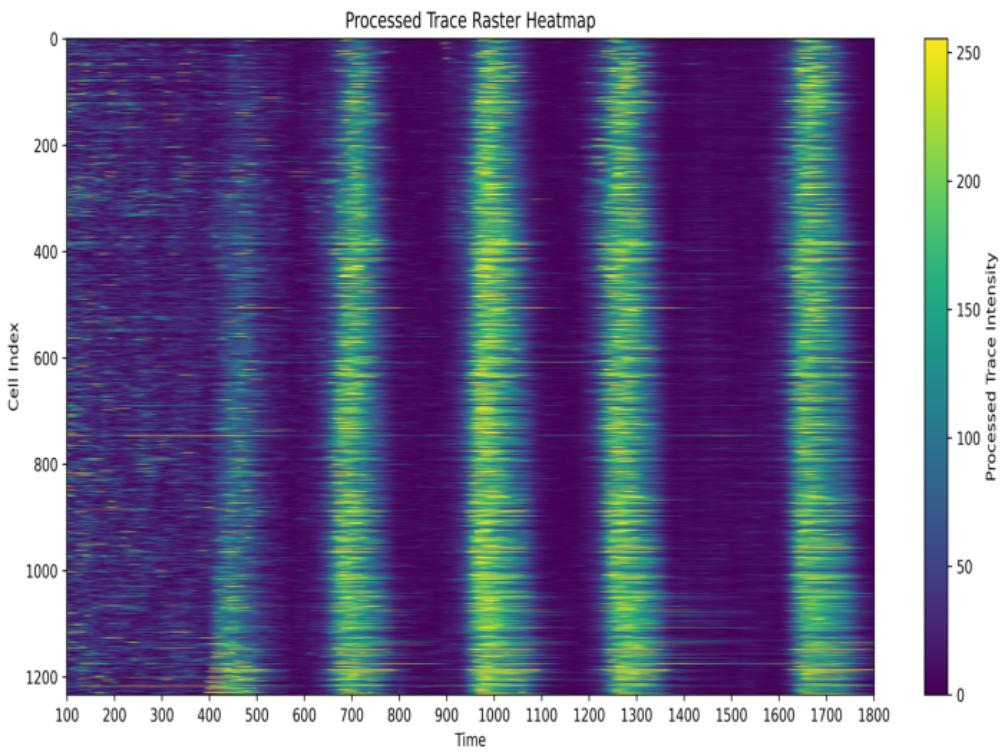
1.0.1 Initialization

1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot



Heatmap Activity Raster Plot - 20250404_IS1



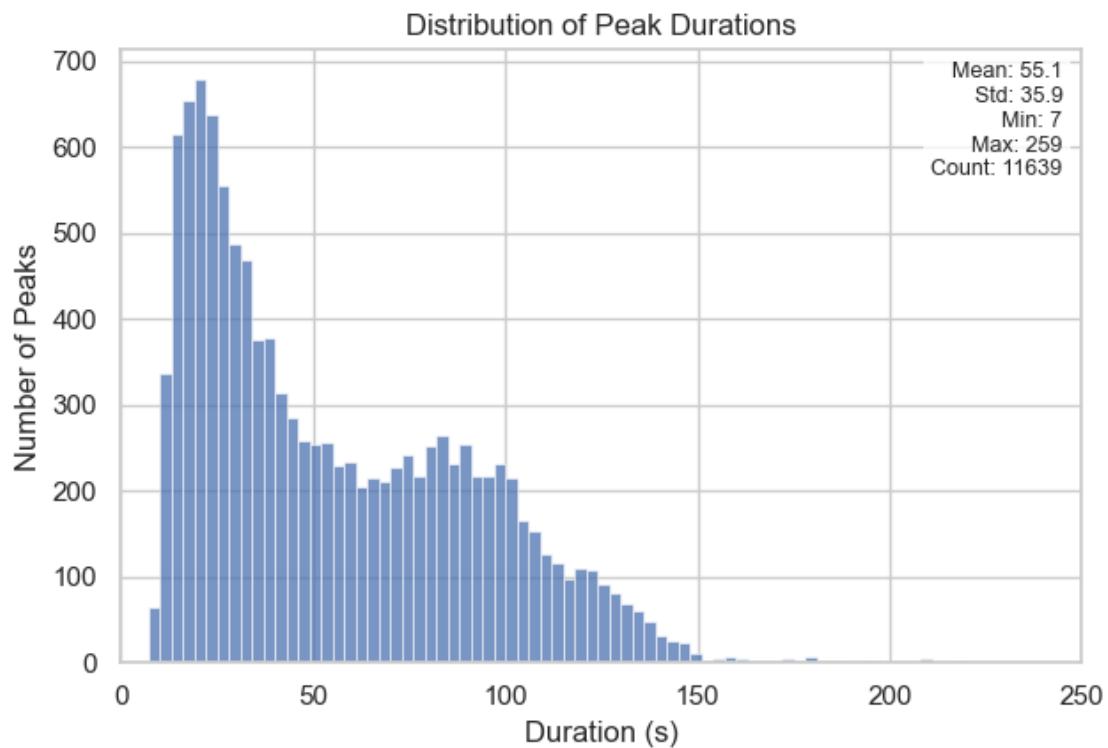
1.1.2 Peaks population

Total number of peaks: 11644

Total number of cells: 1234

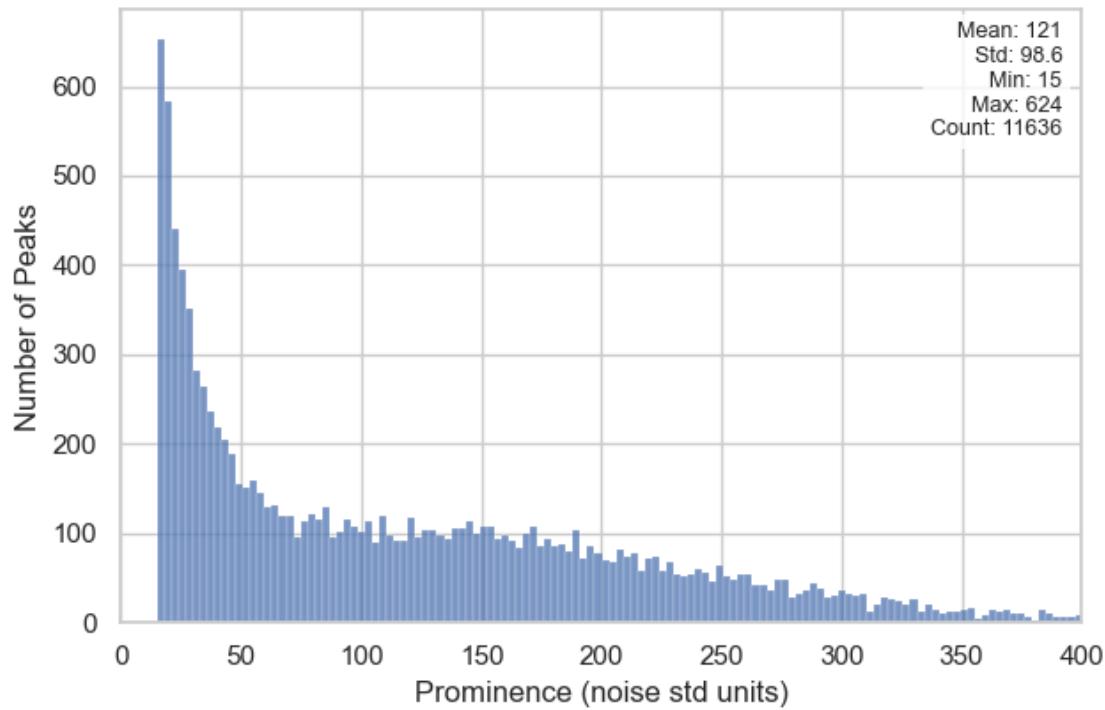
1.1.3 Peaks statistics

```
[2025-08-13 11:27:01] [INFO] calcium: plot_histogram: removed 5 outliers out of  
11644 on 'Duration (s)' (lower=-153, upper=260)
```

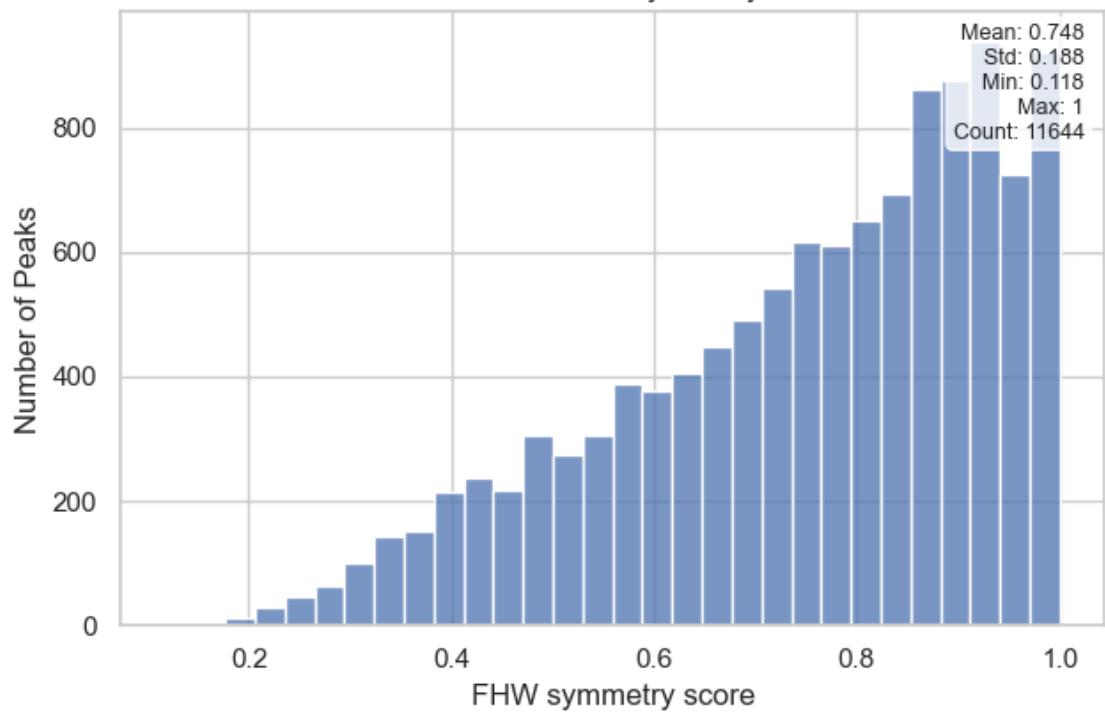


```
[2025-08-13 11:27:01] [INFO] calcium: plot_histogram: removed 8 outliers out of  
11644 on 'Prominence (noise std units)' (lower=-407.2, upper=625.3)
```

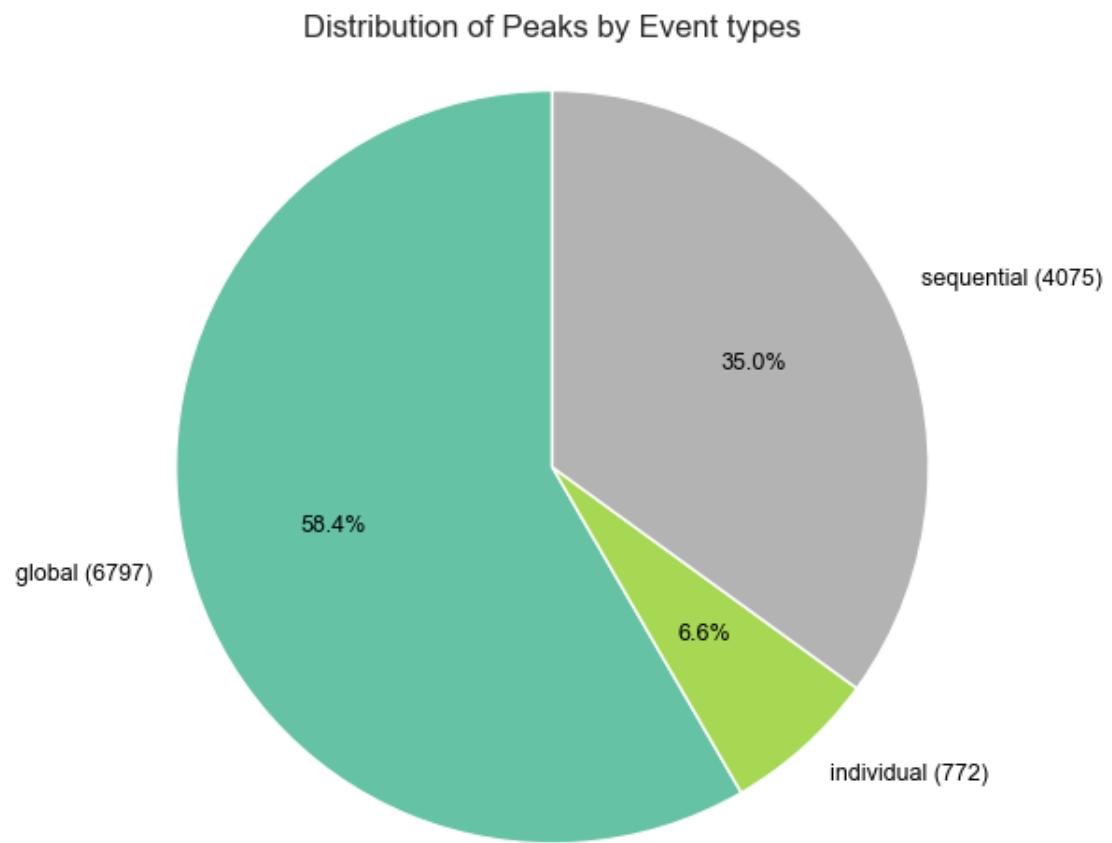
Distribution of Peak Prominences



Distribution of Peak Symmetry Scores

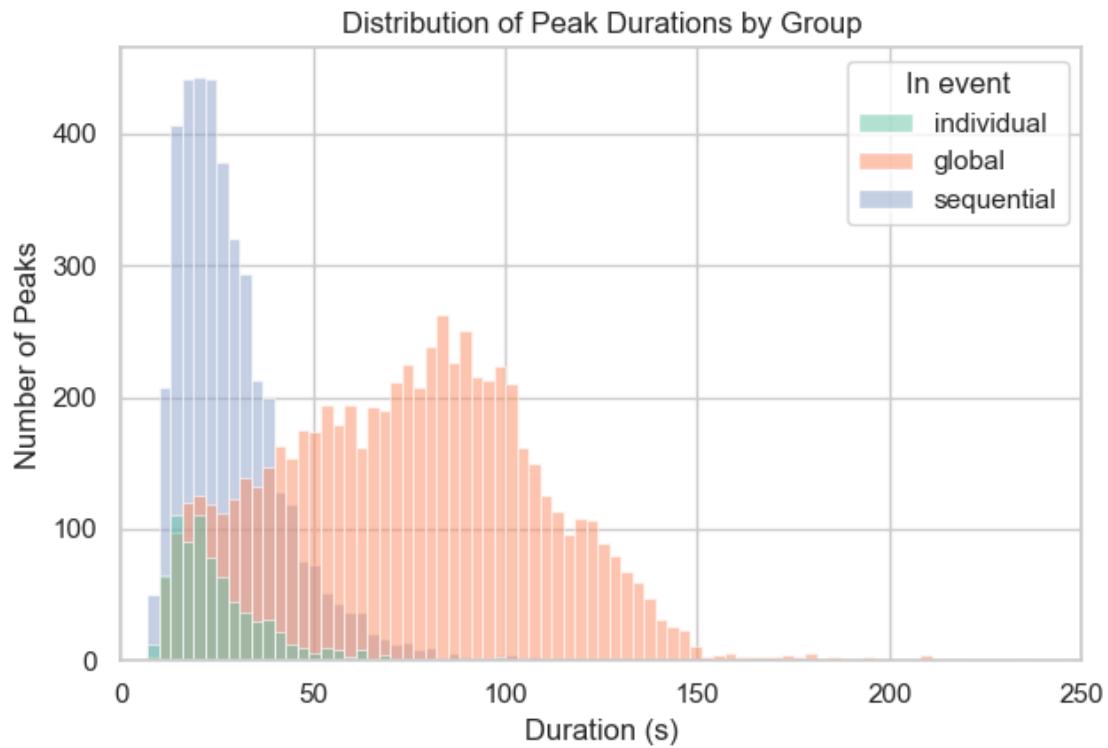


1.1.4 Distribution of peaks per event types



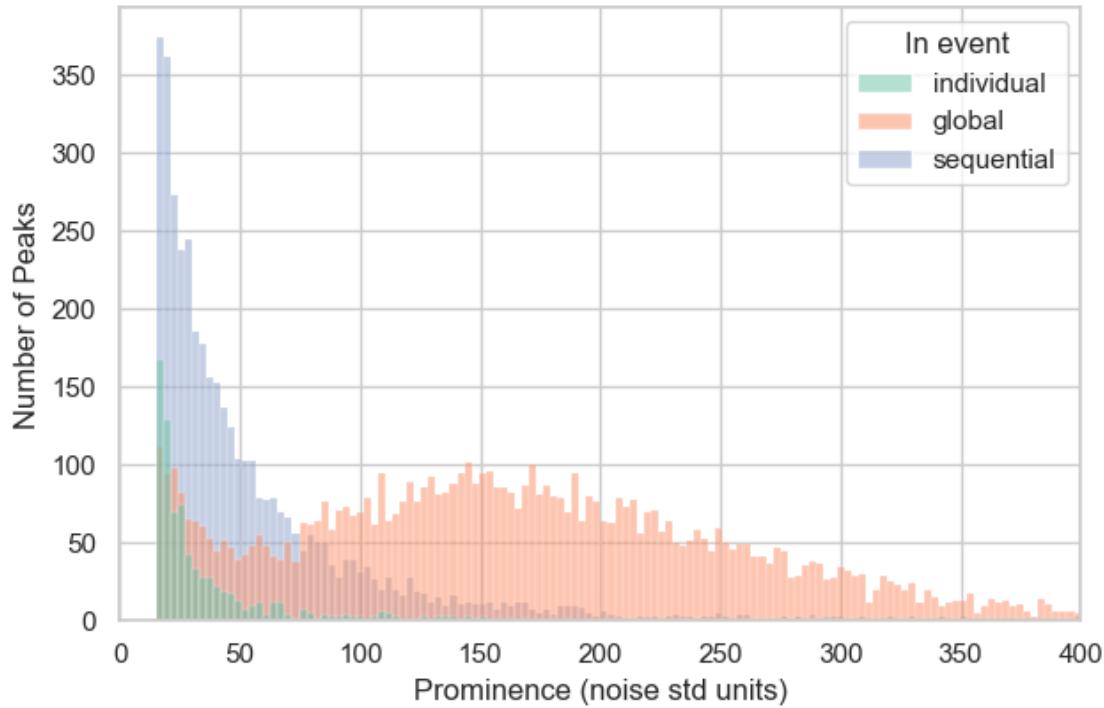
1.1.5 Peaks statistics per event types

```
[2025-08-13 11:27:02] [INFO] calcium: plot_histogram_by_group: removed 5 outliers out of 11644 on 'Duration (s)' (lower=-153, upper=260)
```

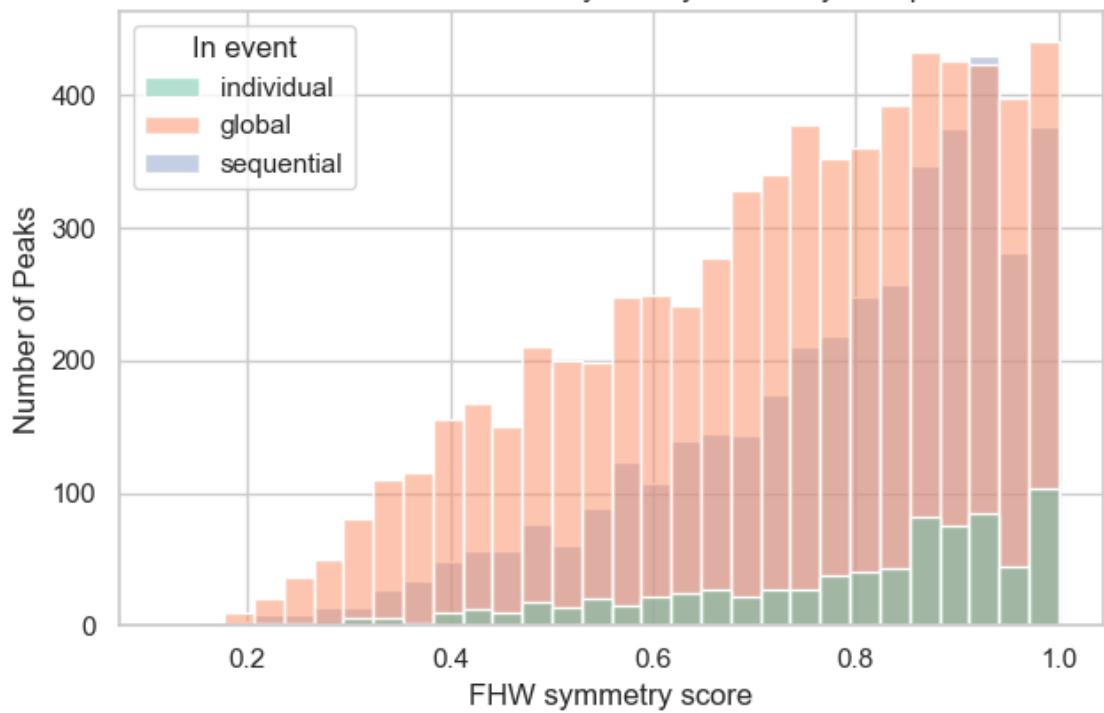


```
[2025-08-13 11:27:02] [INFO] calcium: plot_histogram_by_group: removed 8 outliers out of 11644 on 'Prominence (noise std units)' (lower=-407.2, upper=625.3)
```

Distribution of Peak Prominences by Group



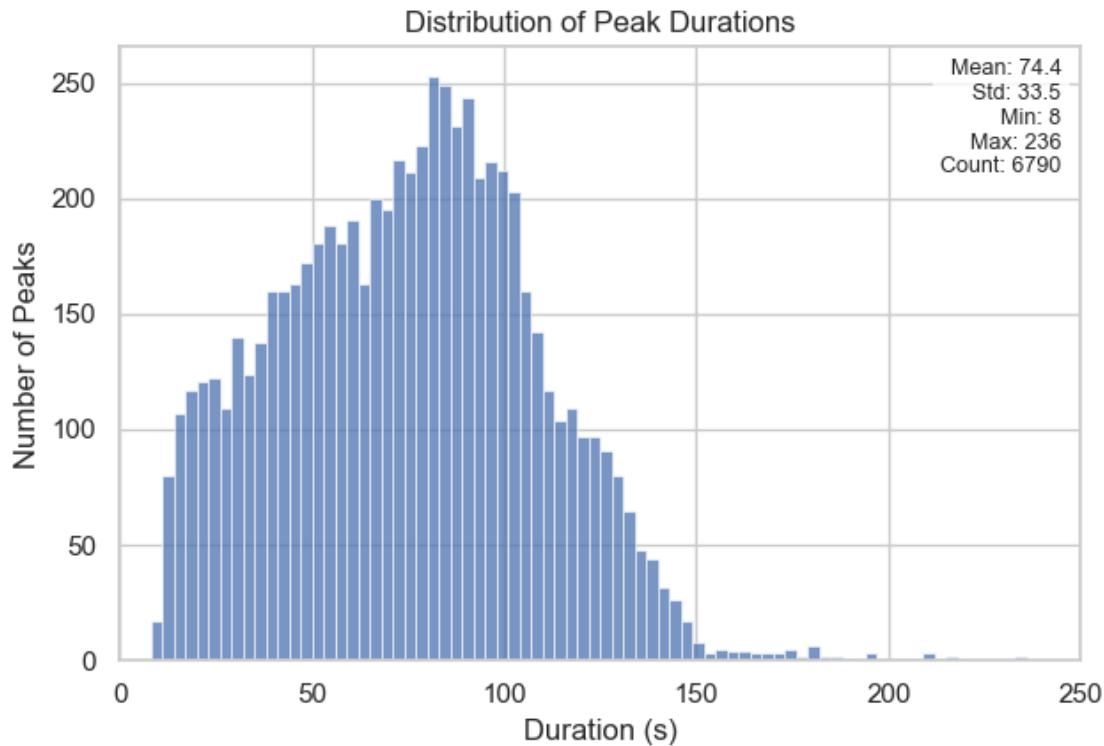
Distribution of Peak Symmetry Scores by Group



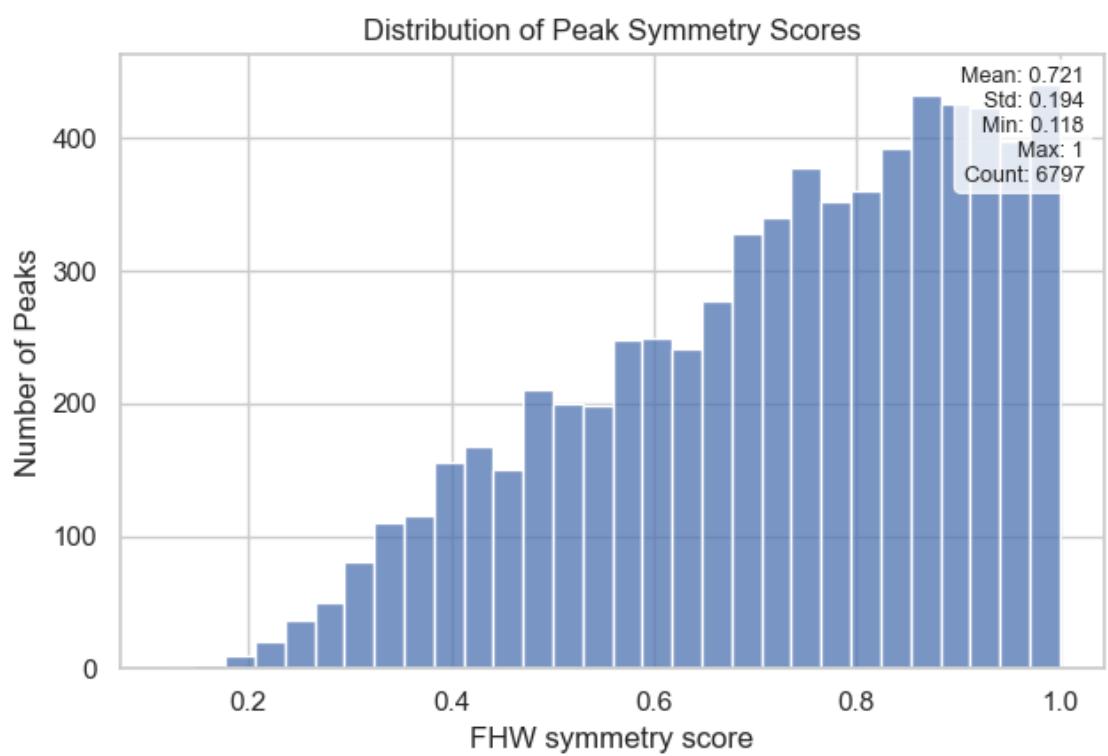
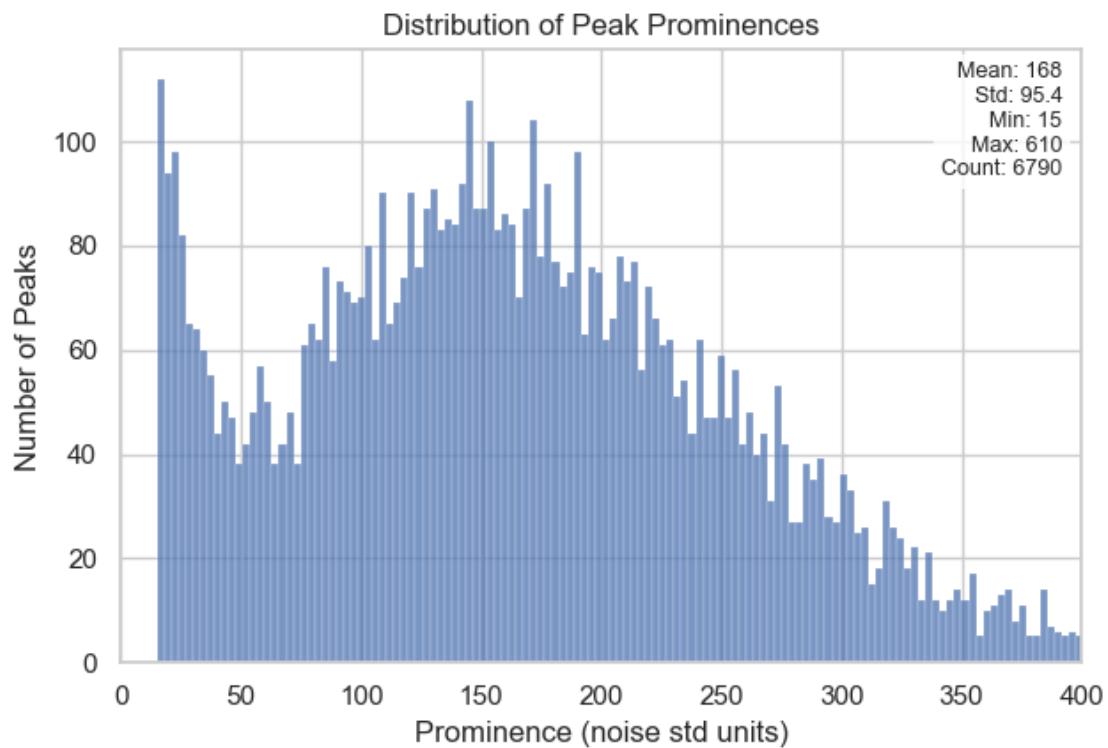
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

[2025-08-13 11:27:03] [INFO] calcium: plot_histogram: removed 7 outliers out of 6797 on 'Duration (s)' (lower=-98, upper=245)

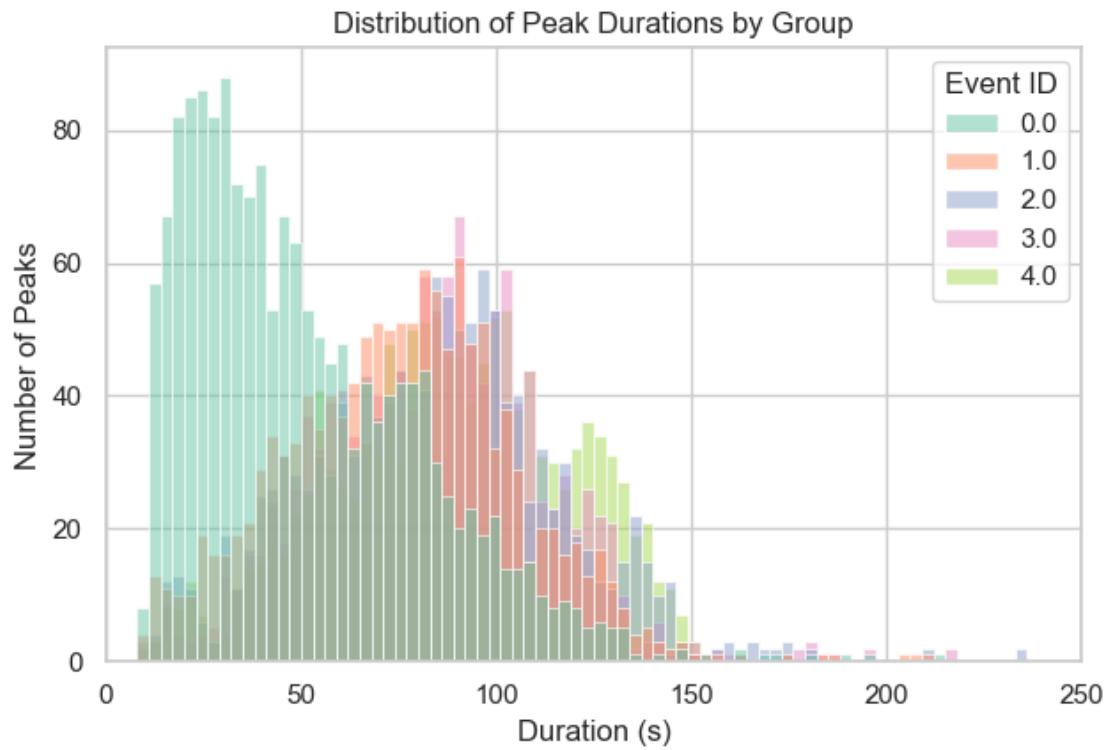


[2025-08-13 11:27:03] [INFO] calcium: plot_histogram: removed 7 outliers out of 6797 on 'Prominence (noise std units)' (lower=-286.2, upper=611.2)



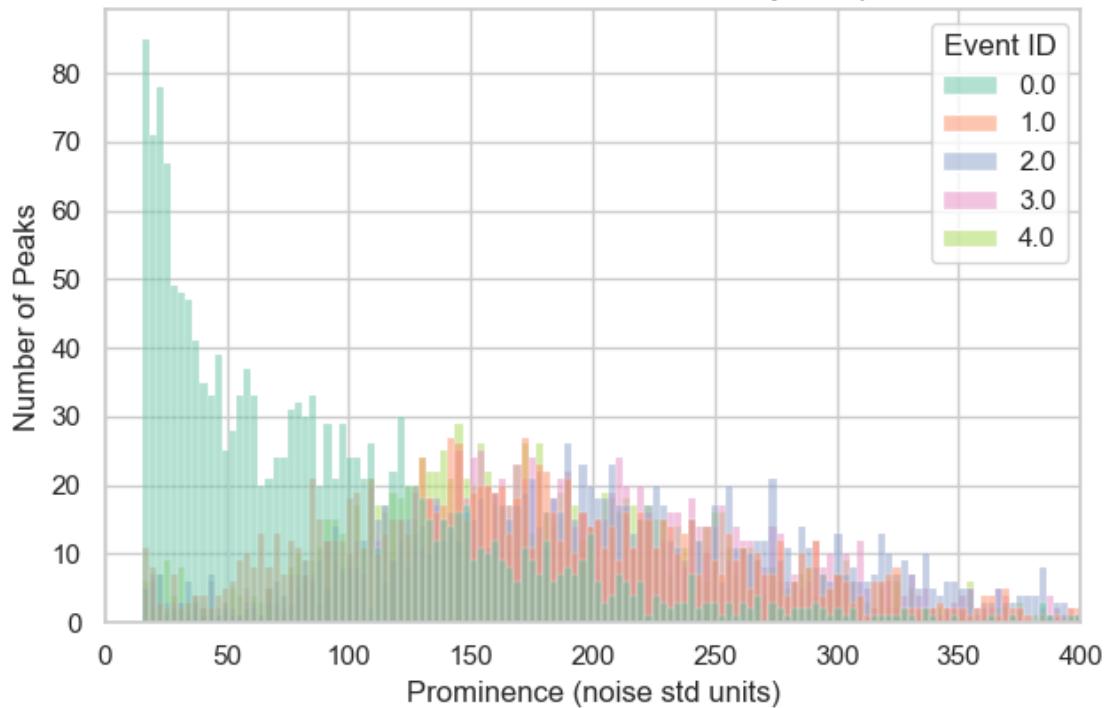
1.2.2 Peak statistics in global event per event ID

[2025-08-13 11:27:04] [INFO] calcium: plot_histogram_by_group: removed 7 outliers out of 6797 on 'Duration (s)' (lower=-98, upper=245)

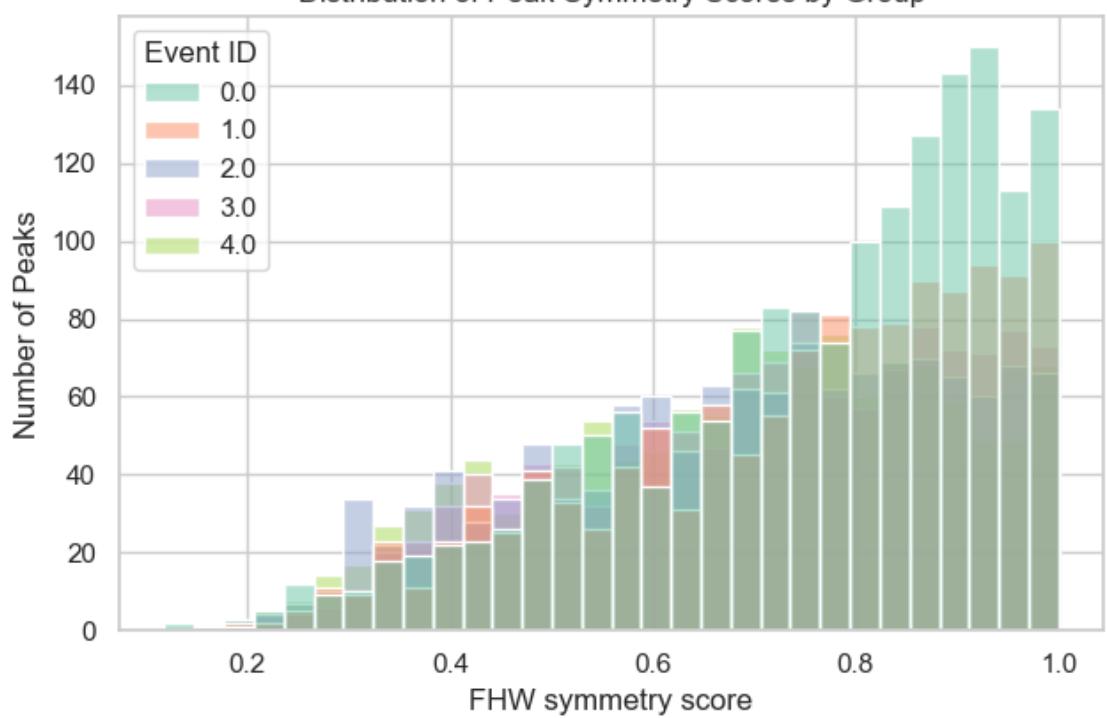


[2025-08-13 11:27:04] [INFO] calcium: plot_histogram_by_group: removed 7 outliers out of 6797 on 'Prominence (noise std units)' (lower=-286.2, upper=611.2)

Distribution of Peak Prominences by Group

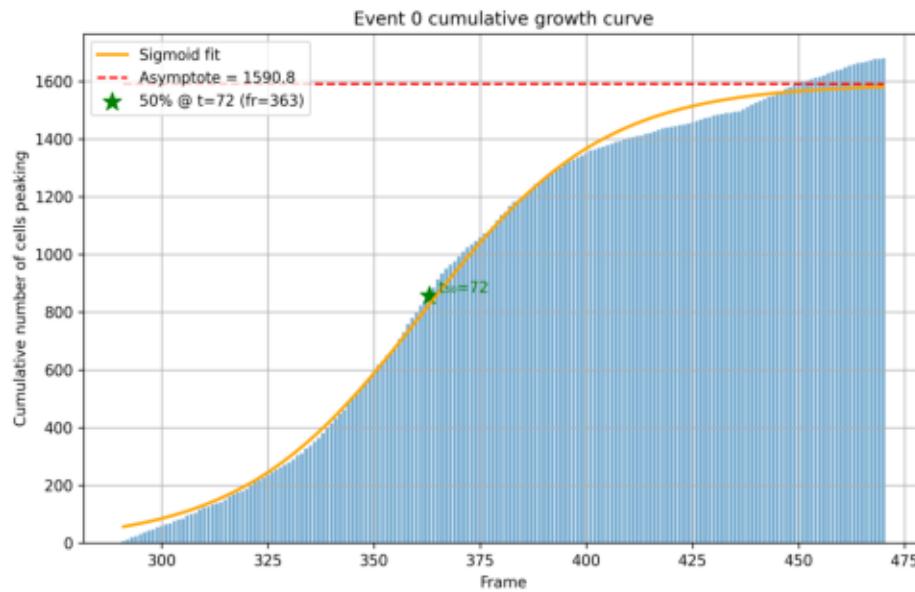


Distribution of Peak Symmetry Scores by Group

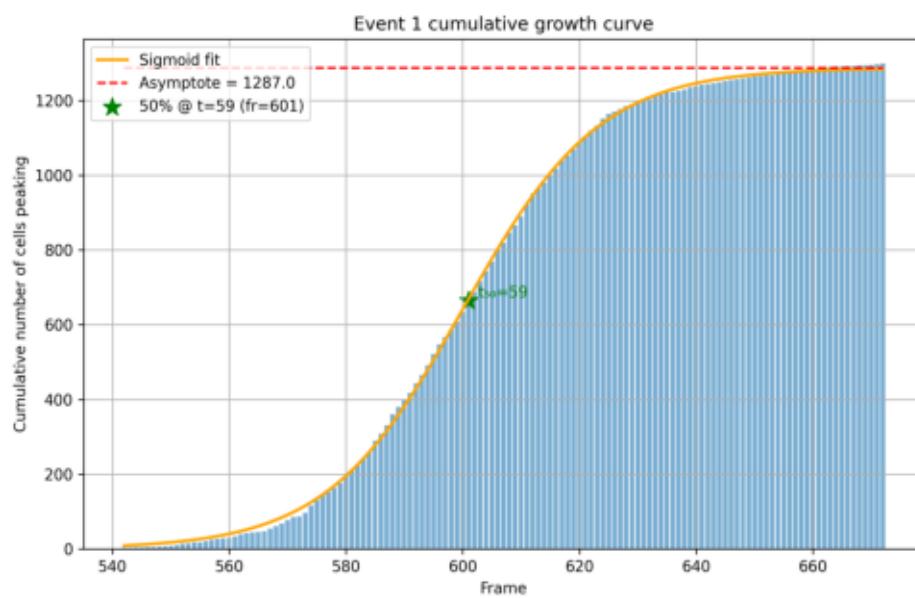


1.2.3 Kinetics of global events

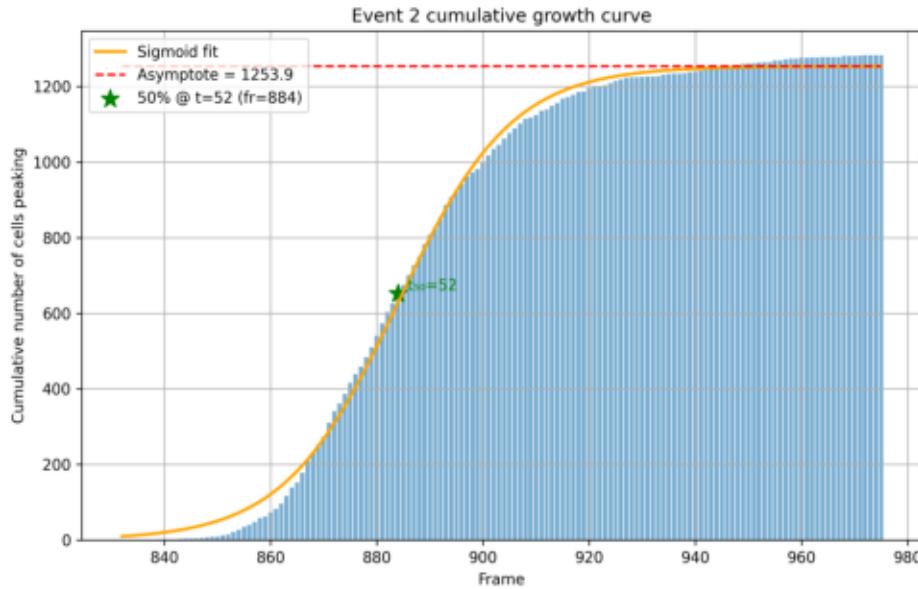
Event Activity Overlay (Event ID: 0) - 20250404_IS1



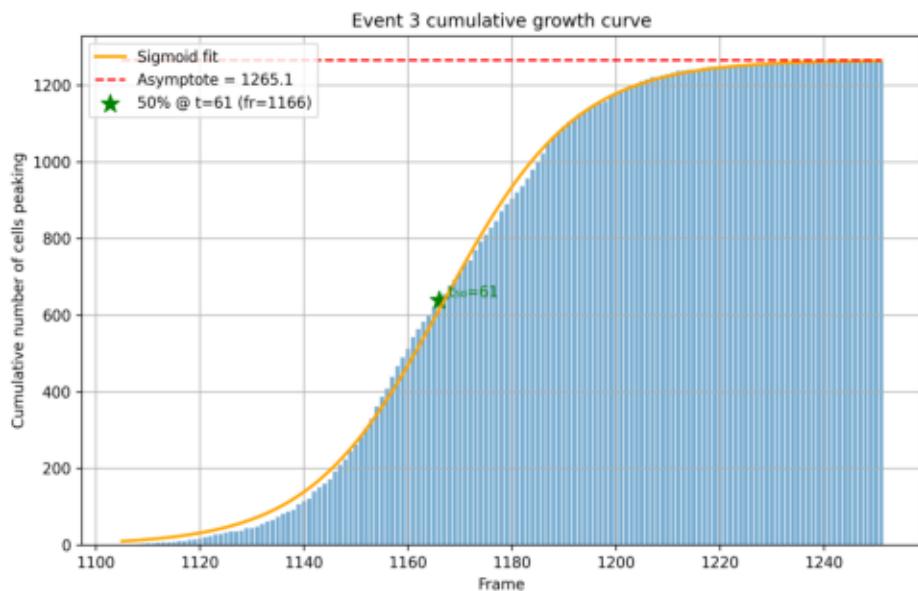
Event Activity Overlay (Event ID: 1) - 20250404_IS1



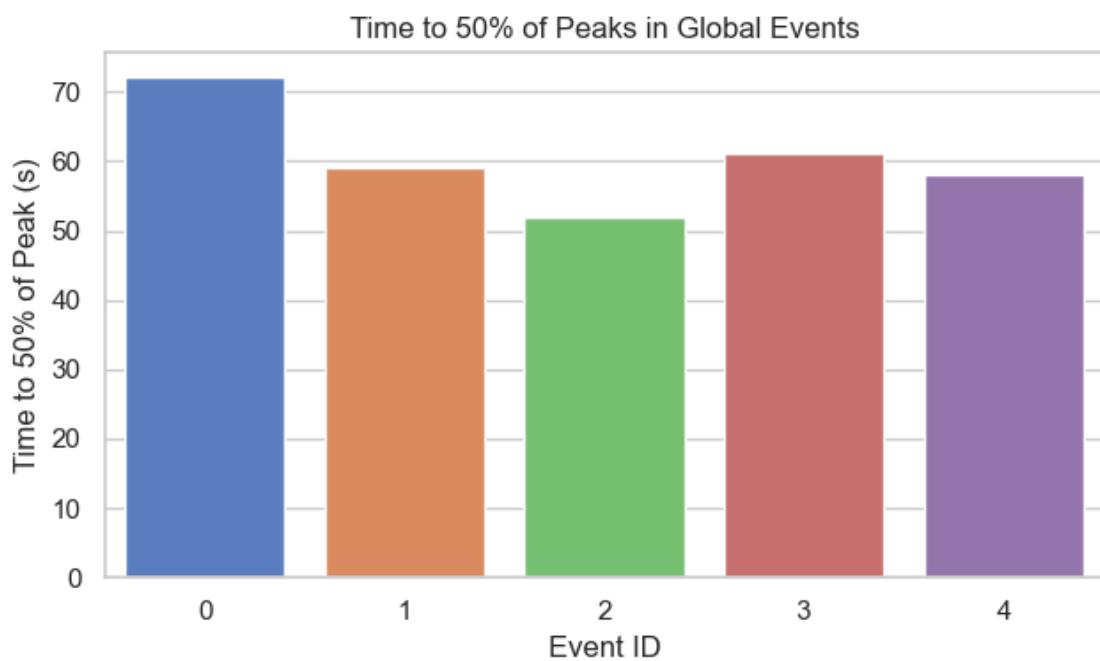
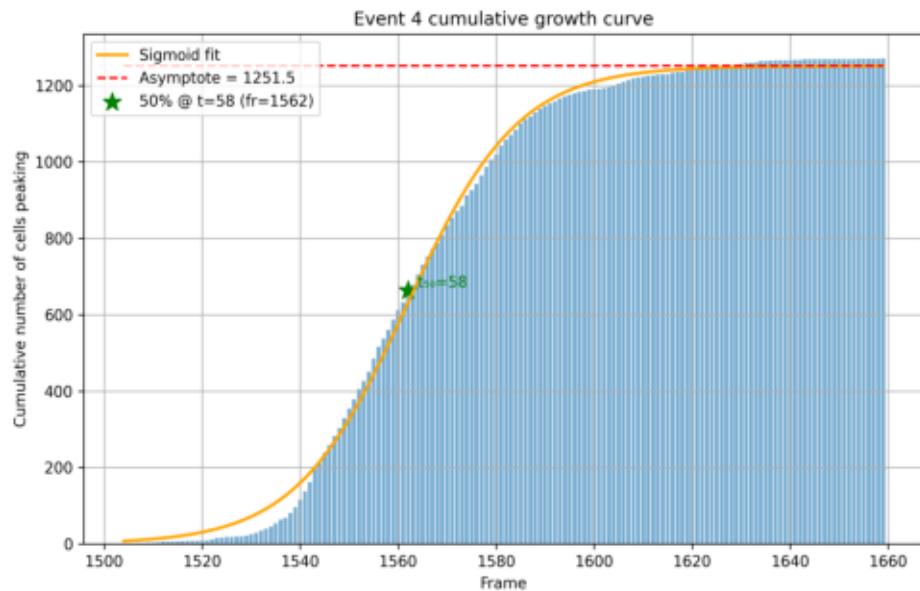
Event Activity Overlay (Event ID: 2) - 20250404_IS1

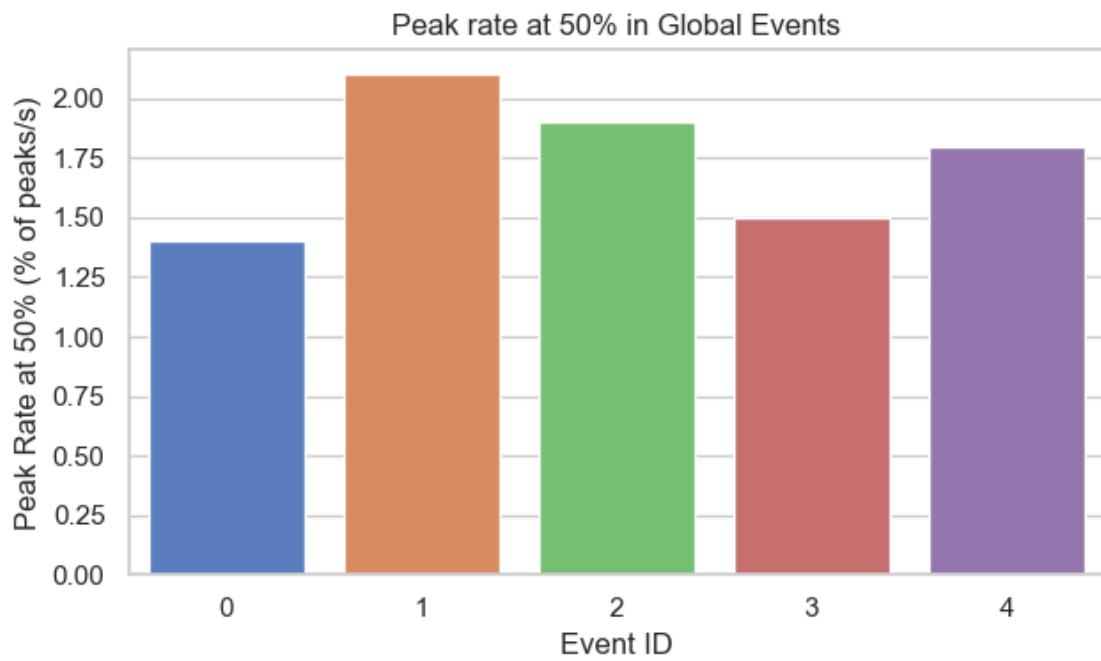


Event Activity Overlay (Event ID: 3) - 20250404_IS1

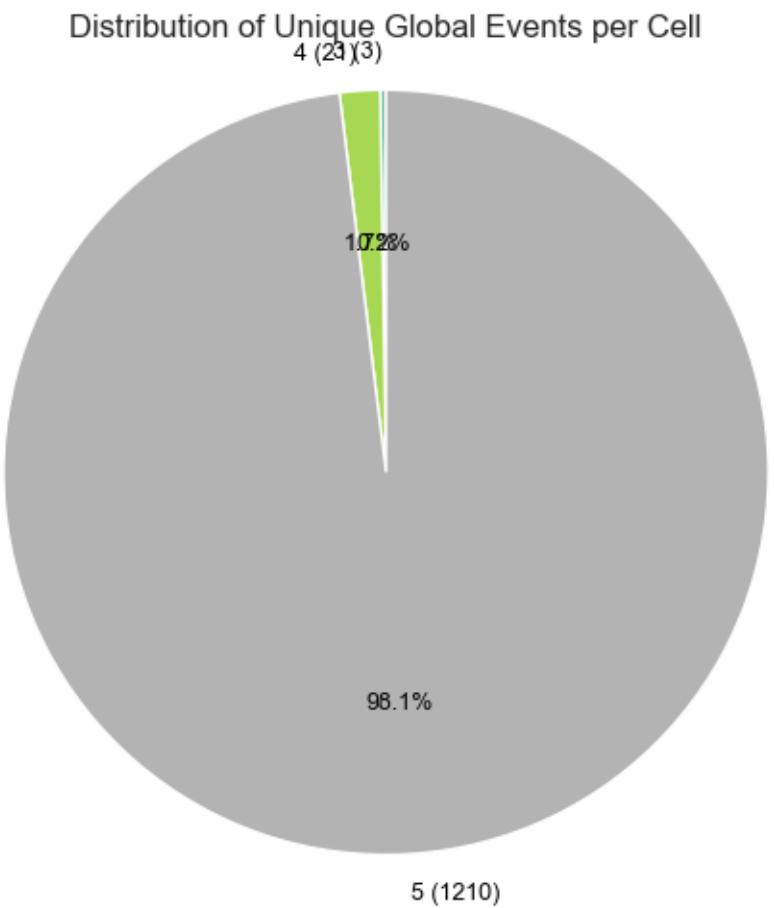


Event Activity Overlay (Event ID: 4) - 20250404_IS1

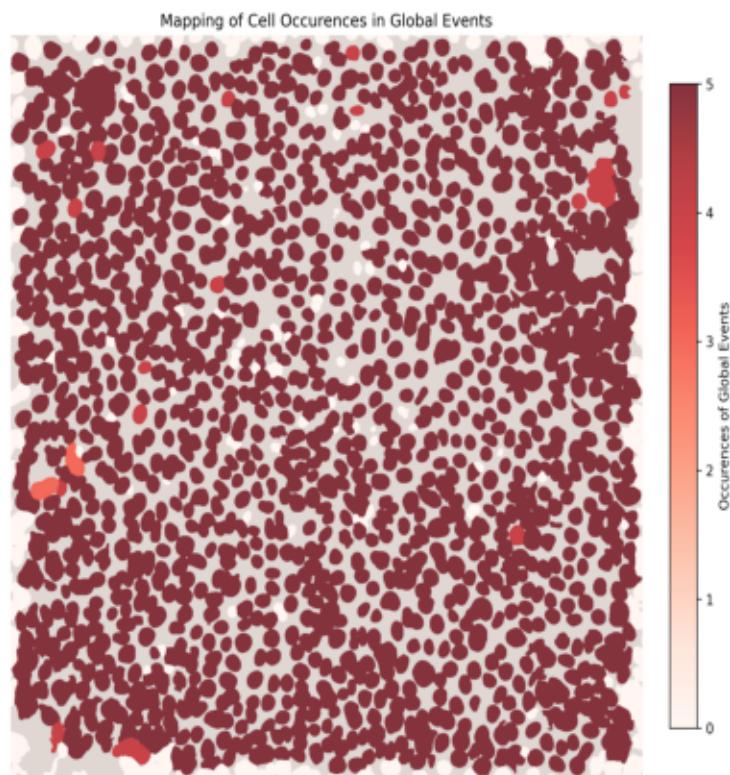


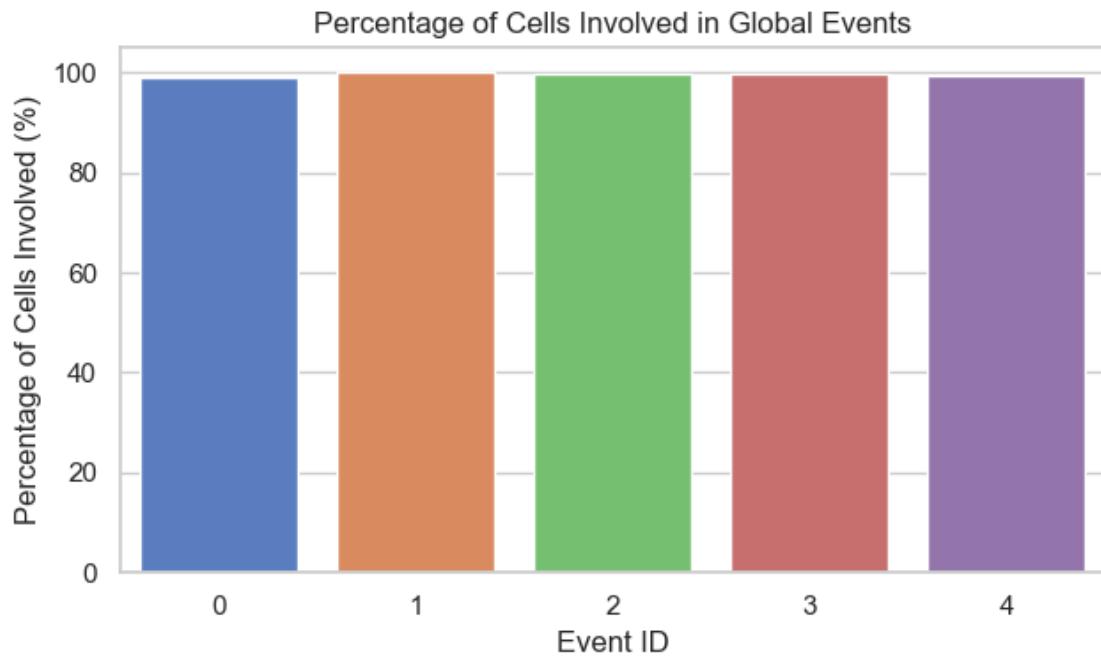


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250404_IS1





1.2.5 Inter-event interval analysis

Intervals between global event peaks: [241.0, 286.0, 281.0, 396.0]

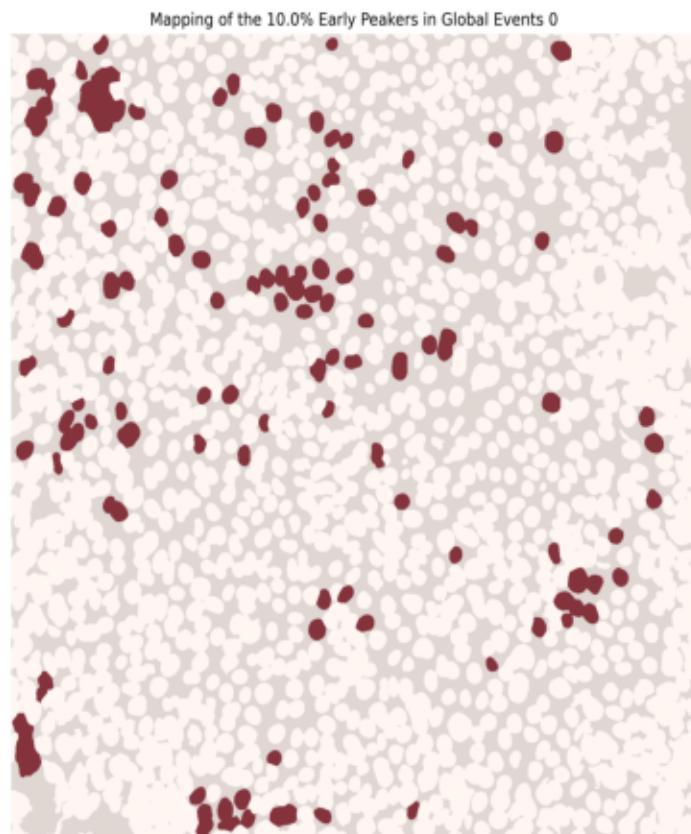
Estimated periodicity: 0.839

The global events exhibit a regular periodic pattern.

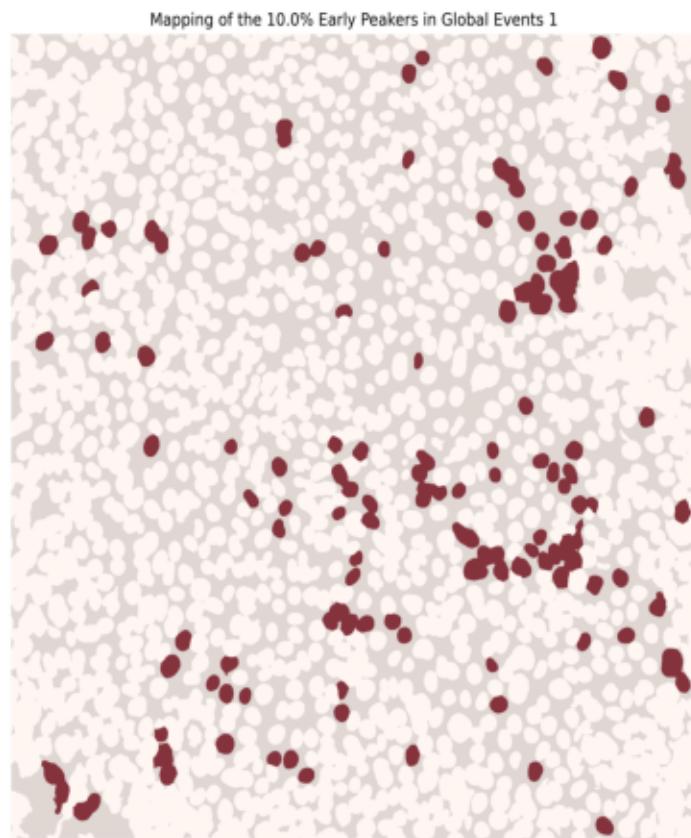
Estimated frequency (1/mean interval): 0.003 Hz

1.2.6 Early peakers in the events

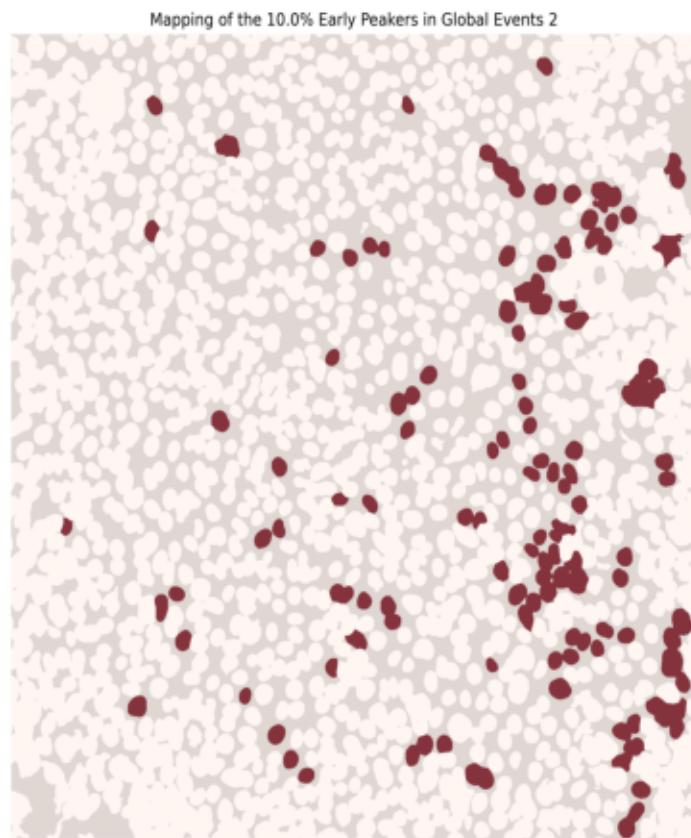
Cell Mapping with Early Peakers Overlay for event 0 - 20250404_IS1



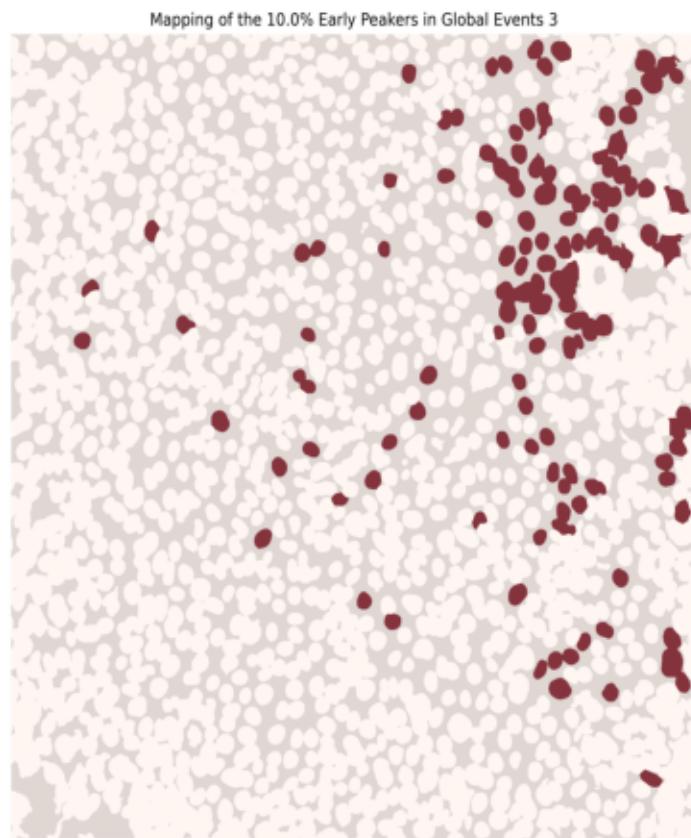
Cell Mapping with Early Peakers Overlay for event 1 - 20250404_IS1



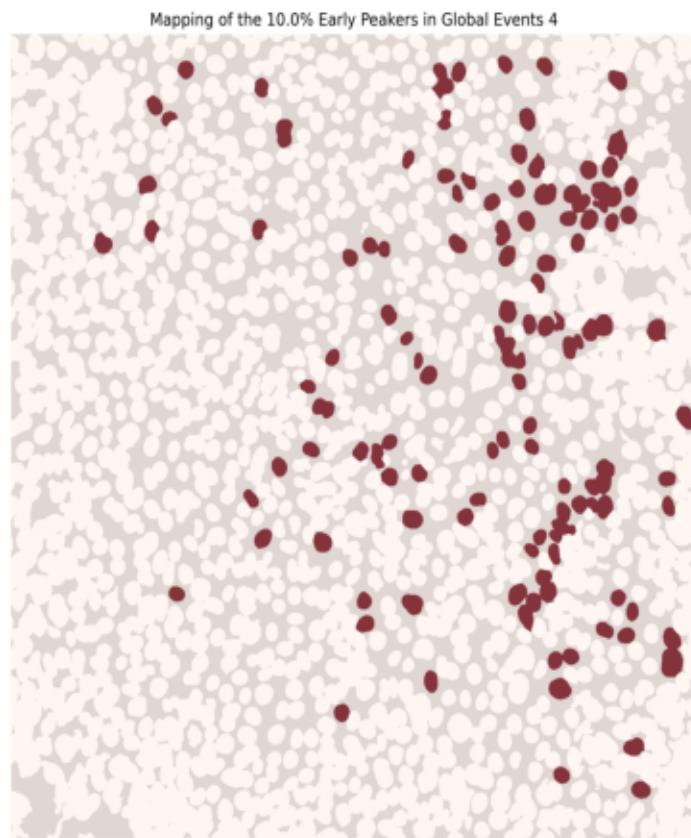
Cell Mapping with Early Peakers Overlay for event 2 - 20250404_IS1



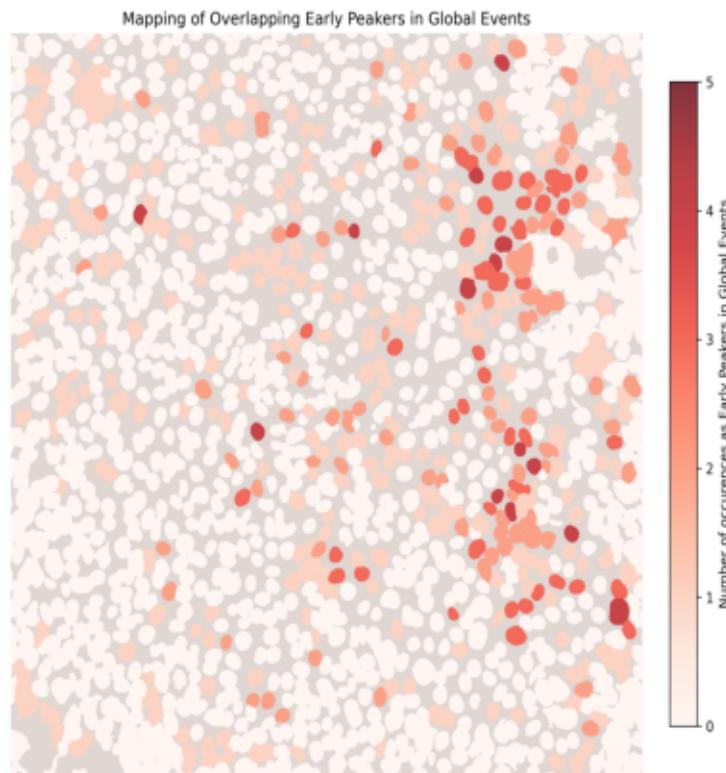
Cell Mapping with Early Peakers Overlay for event 3 - 20250404_IS1

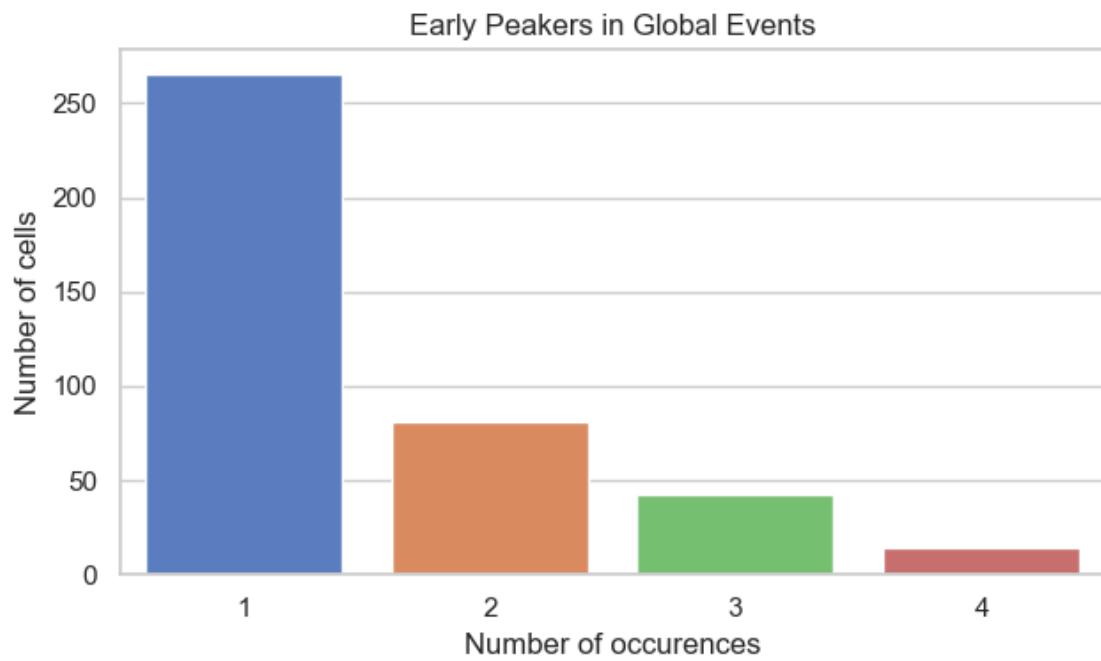


Cell Mapping with Early Peakers Overlay for event 4 - 20250404_IS1

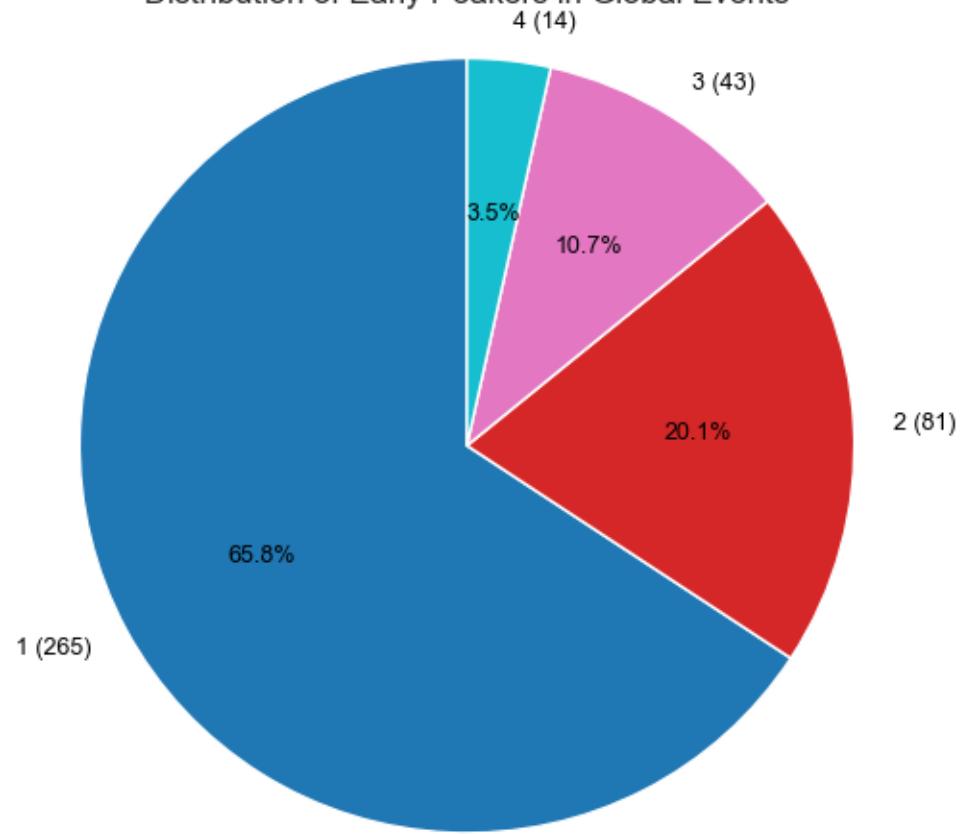


Cell Mapping with Occurrences in Global Events Overlay - 20250404_IS1



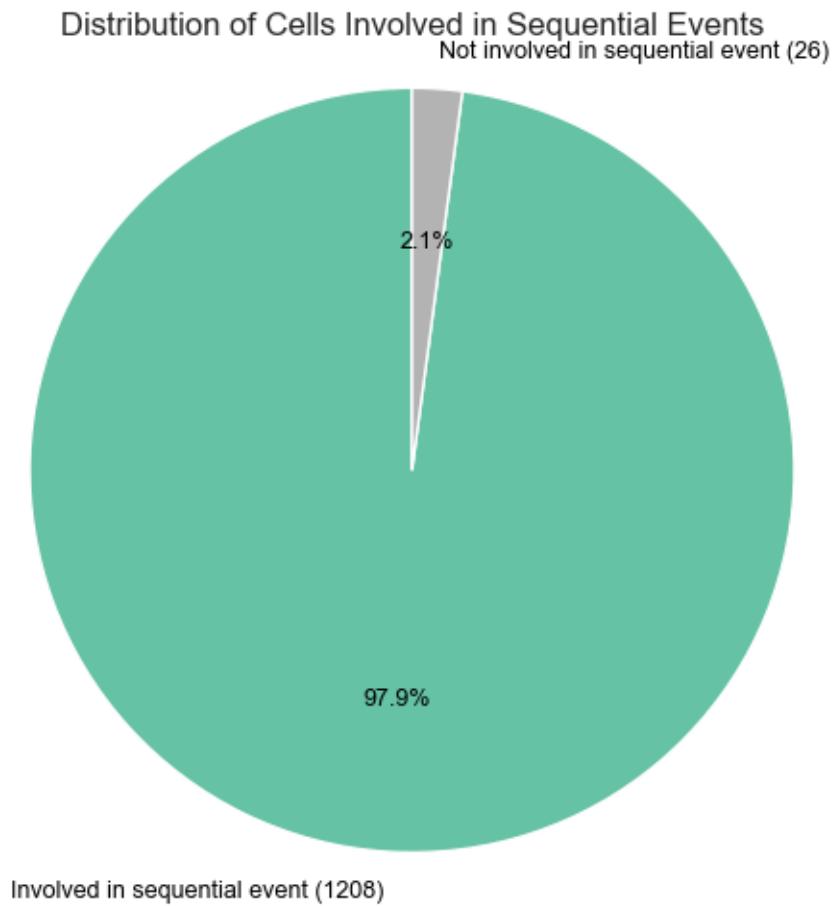


Distribution of Early Peakers in Global Events

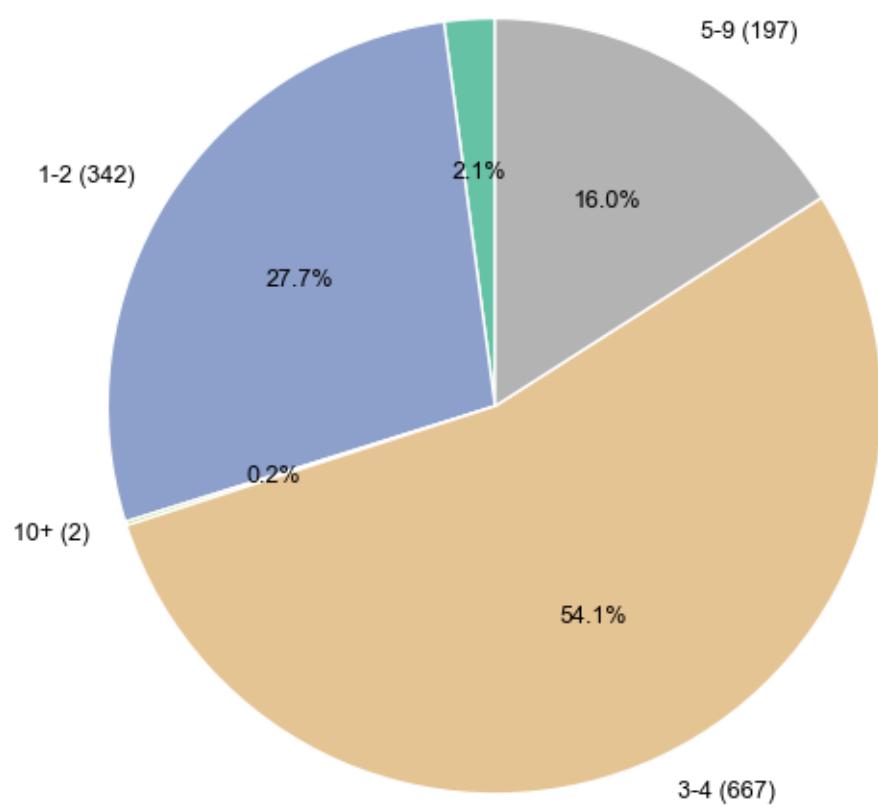


1.3 SEQUENTIAL EVENTS

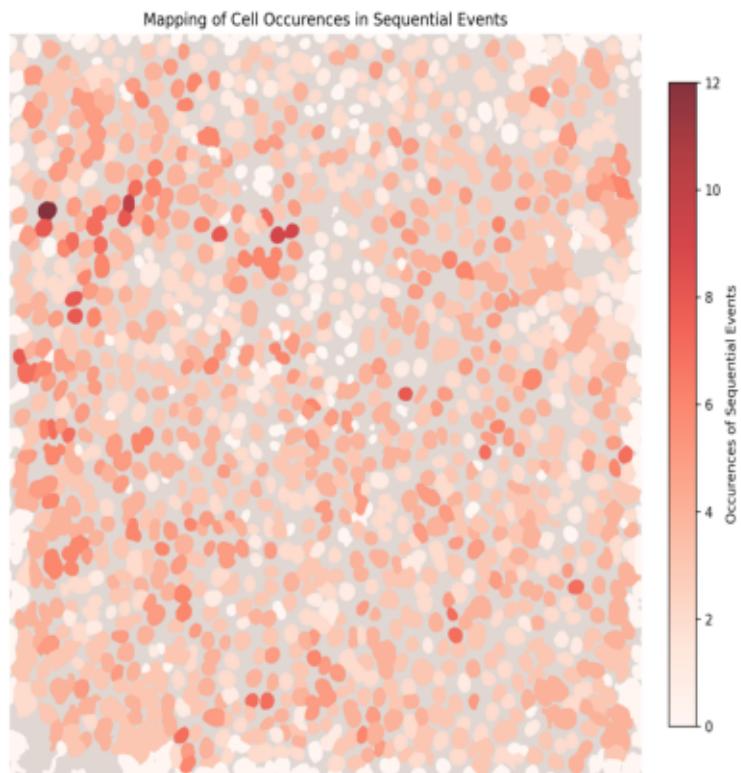
1.3.1 Cells occurrences in sequential events



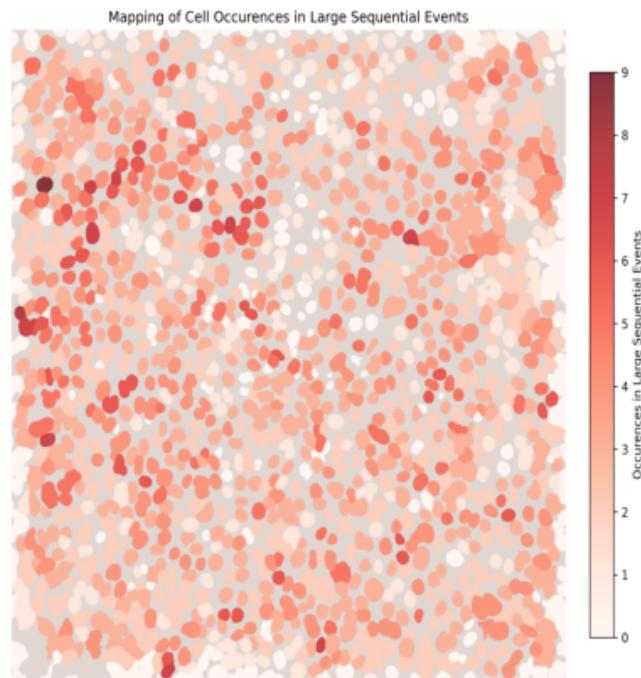
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250404_IS1

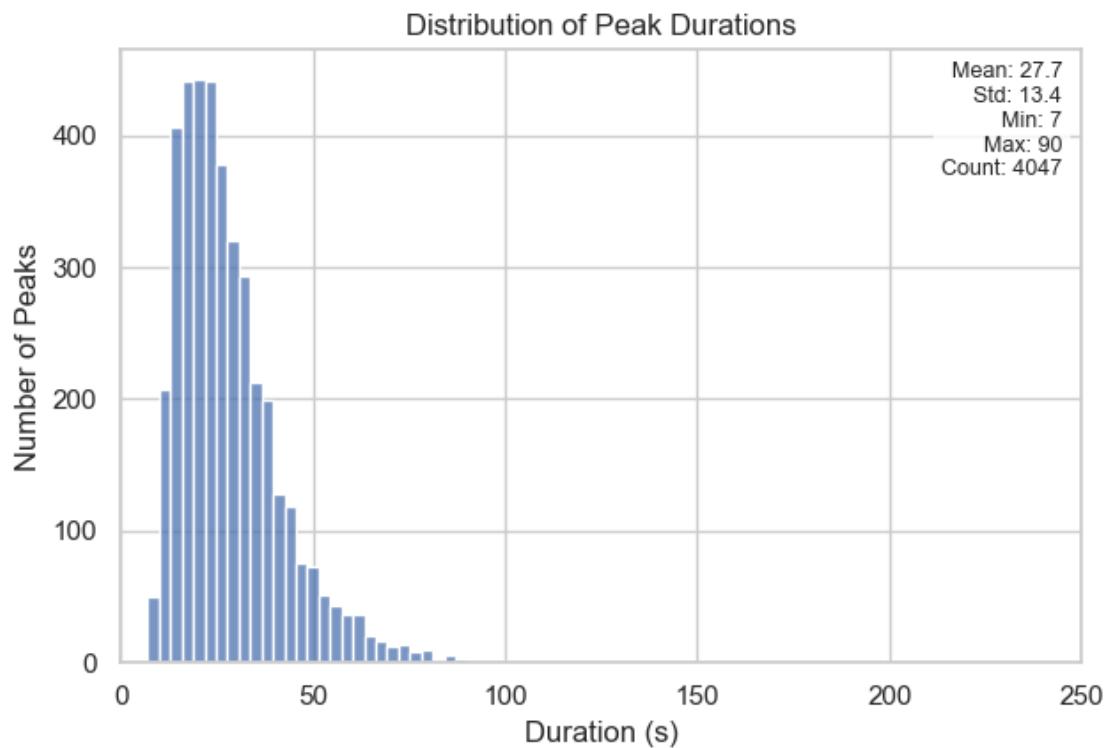


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250404_IS1

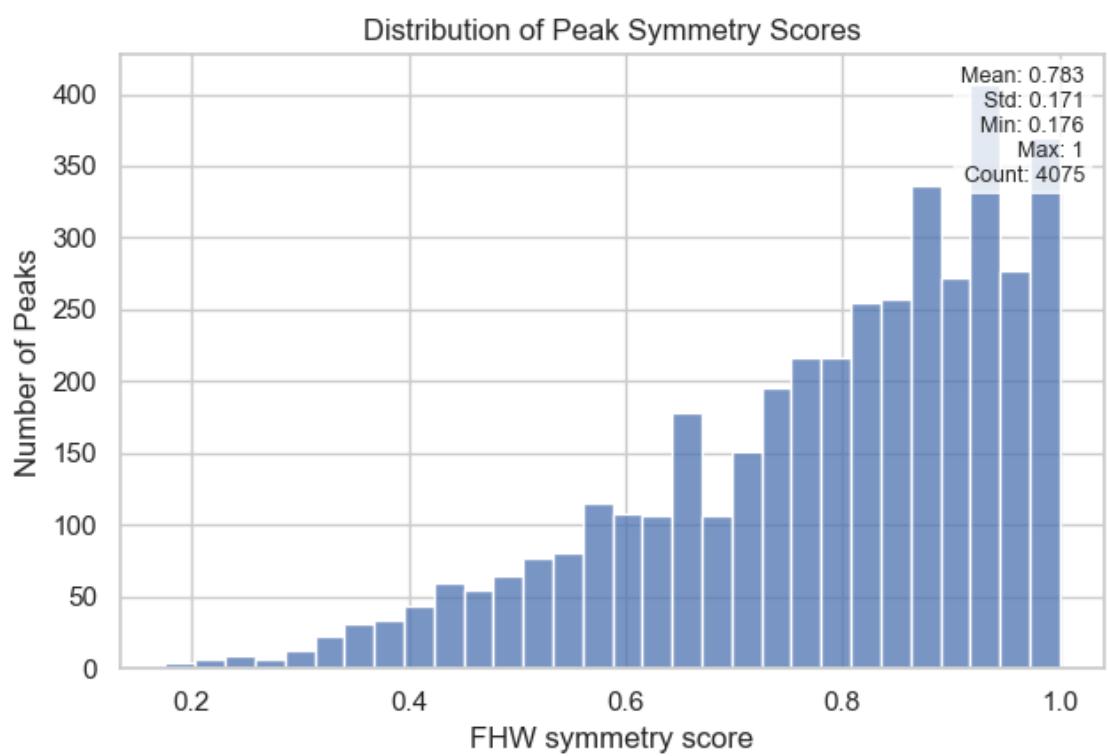
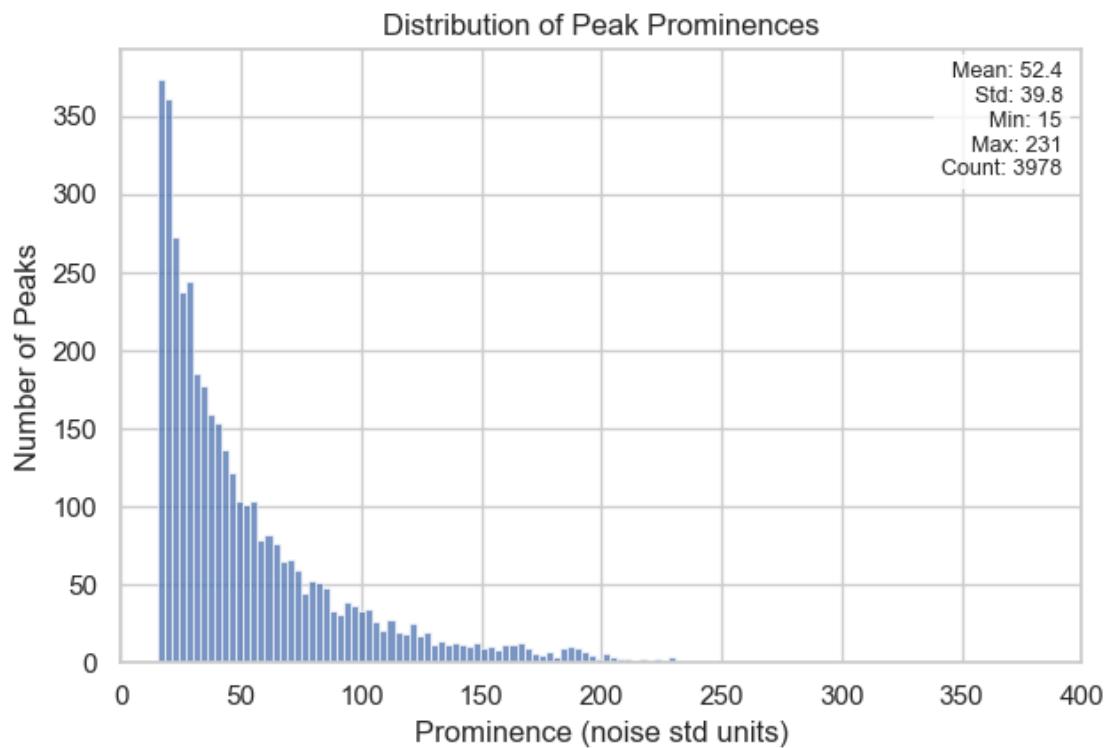


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 11:27:22] [INFO] calcium: plot_histogram: removed 28 outliers out of 4075 on 'Duration (s)' (lower=-6, upper=90)
```

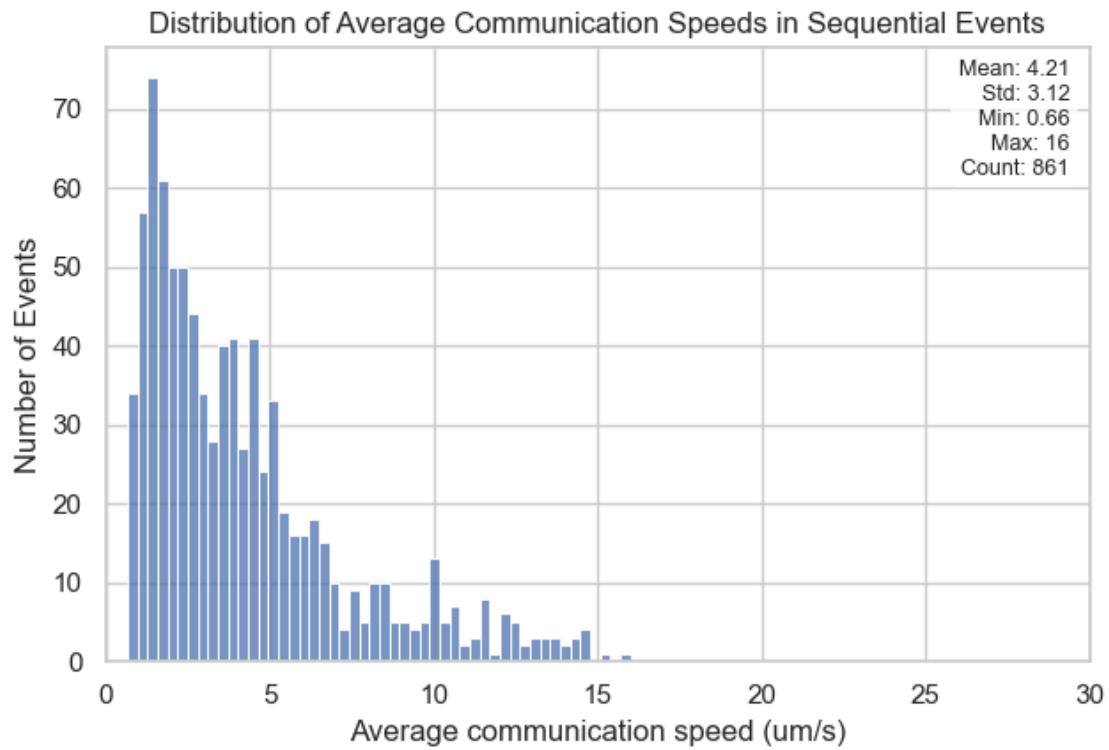


```
[2025-08-13 11:27:22] [INFO] calcium: plot_histogram: removed 97 outliers out of 4075 on 'Prominence (noise std units)' (lower=-44.825, upper=230.88)
```

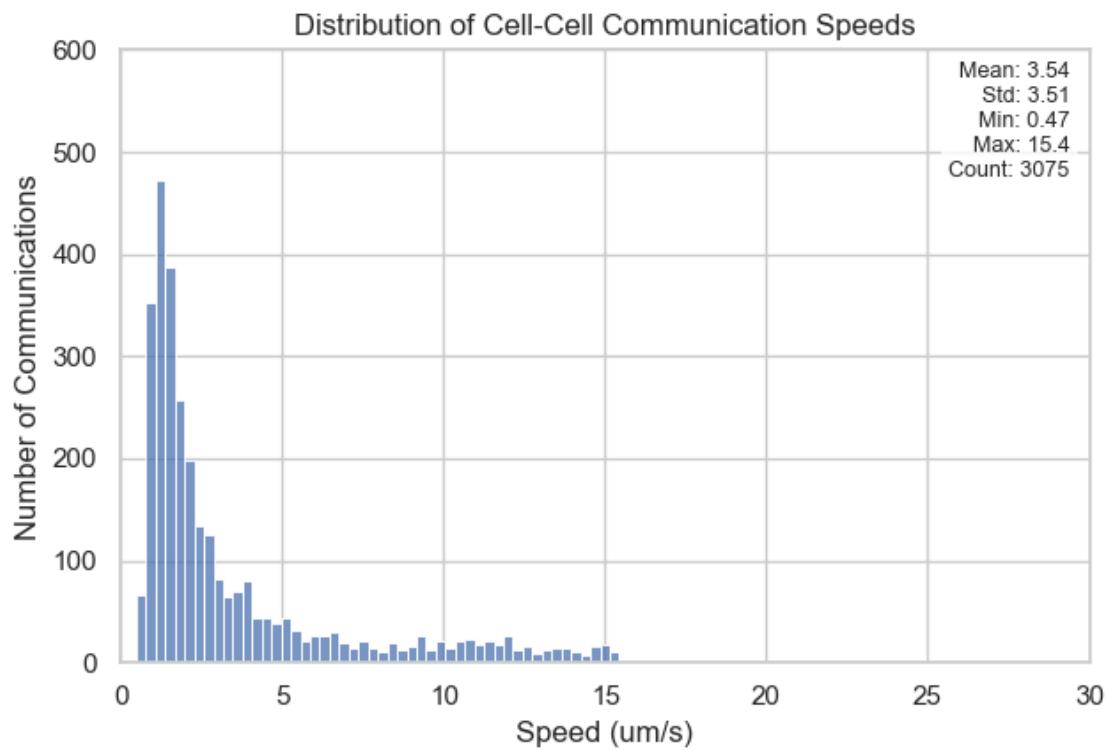


1.3.3 Cell-cell communication speed

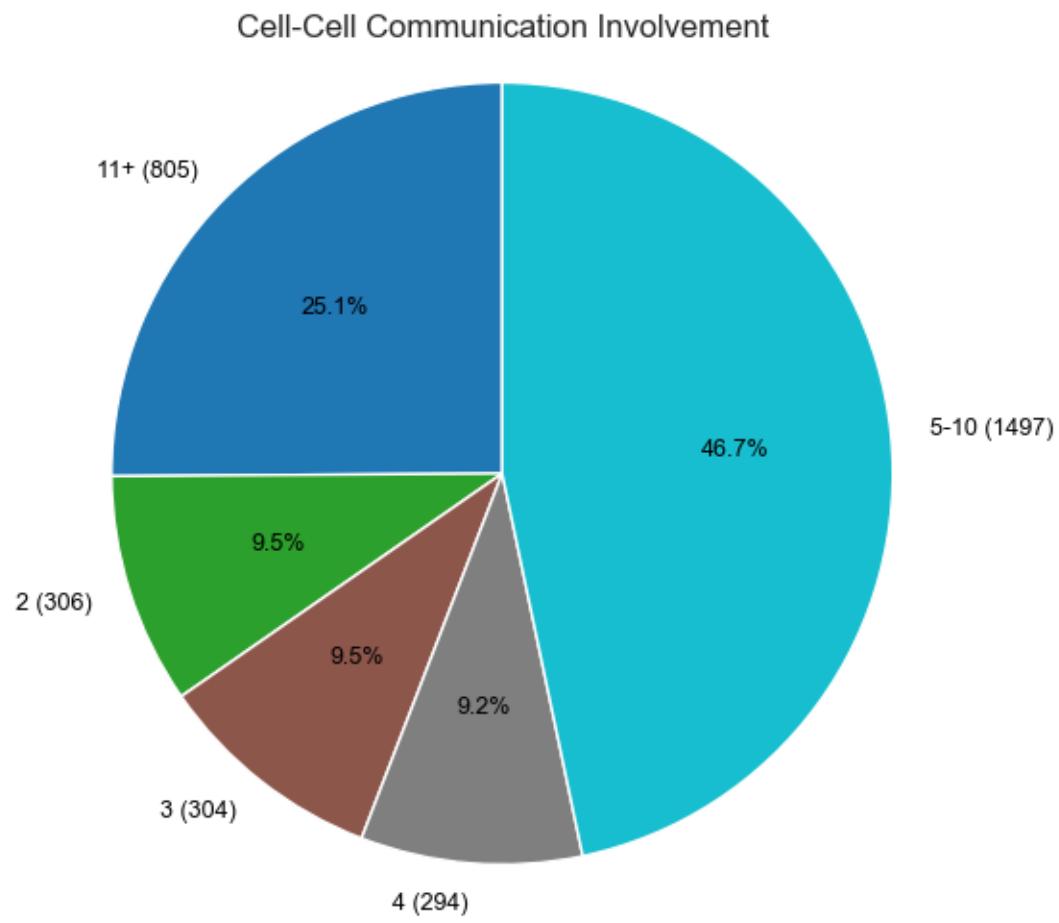
[2025-08-13 11:27:23] [INFO] calcium: plot_histogram: removed 8 outliers out of 869 on 'Average communication speed (um/s)' (lower=-9.01, upper=16.33)



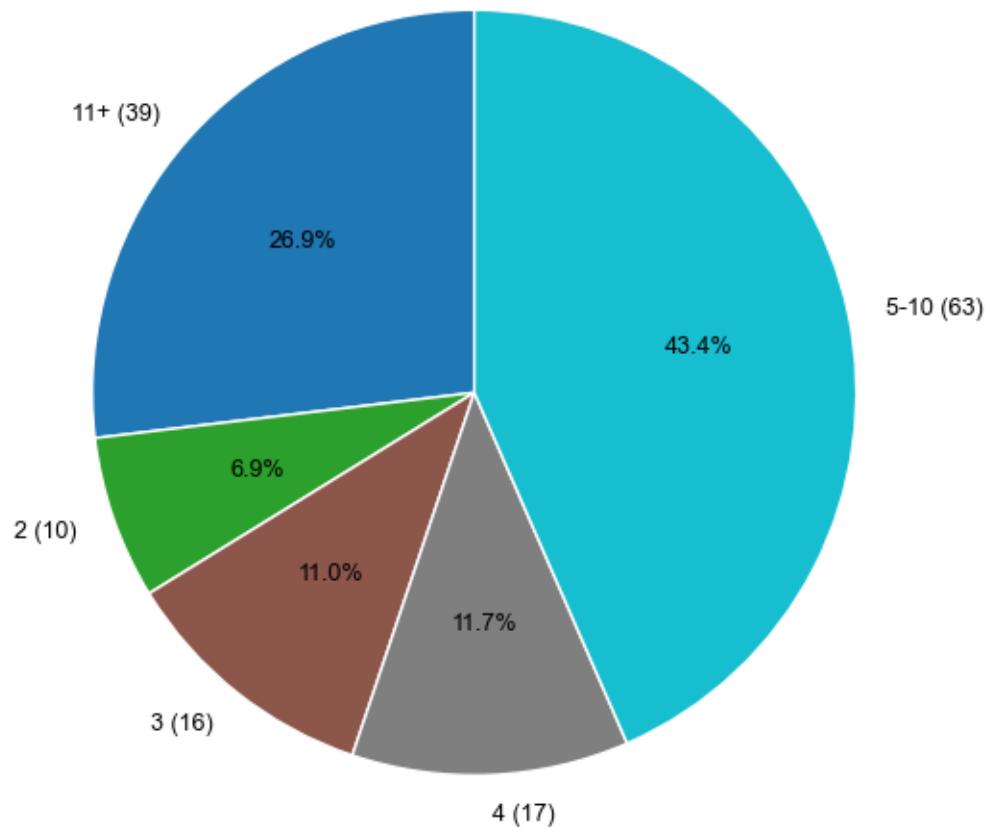
[2025-08-13 11:27:23] [INFO] calcium: plot_histogram: removed 131 outliers out of 3206 on 'Speed (um/s)' (lower=-9.34, upper=15.51)



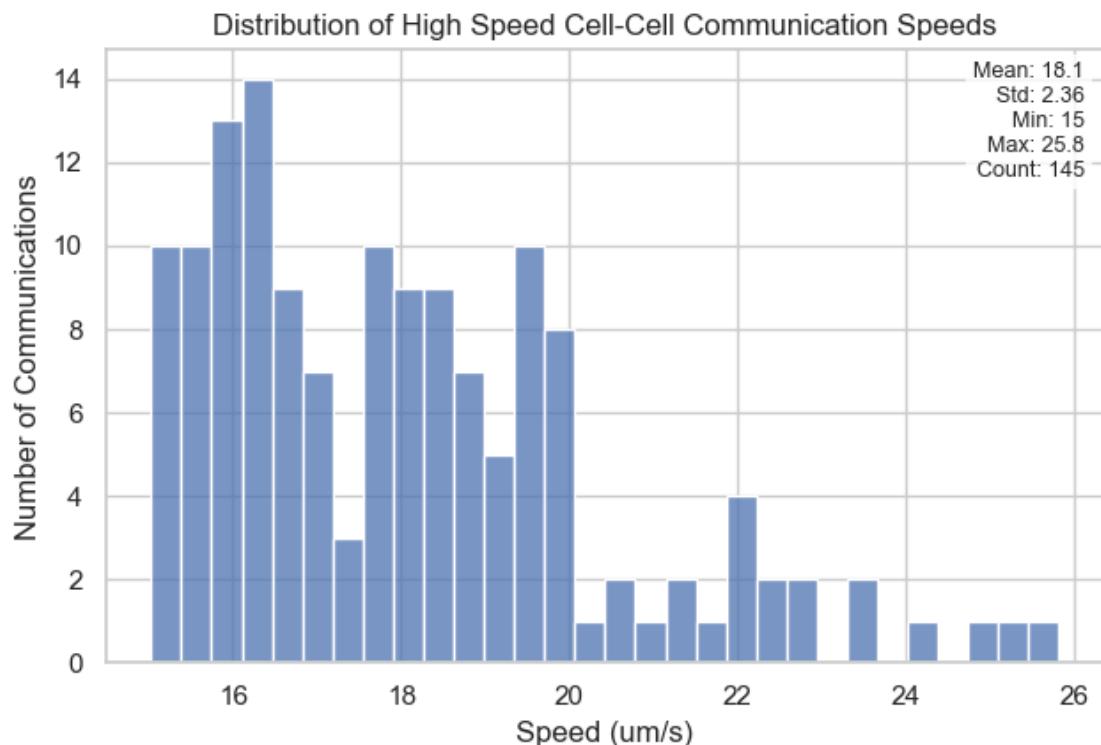
1.3.4 Double distribution in cell-cell communication speeds



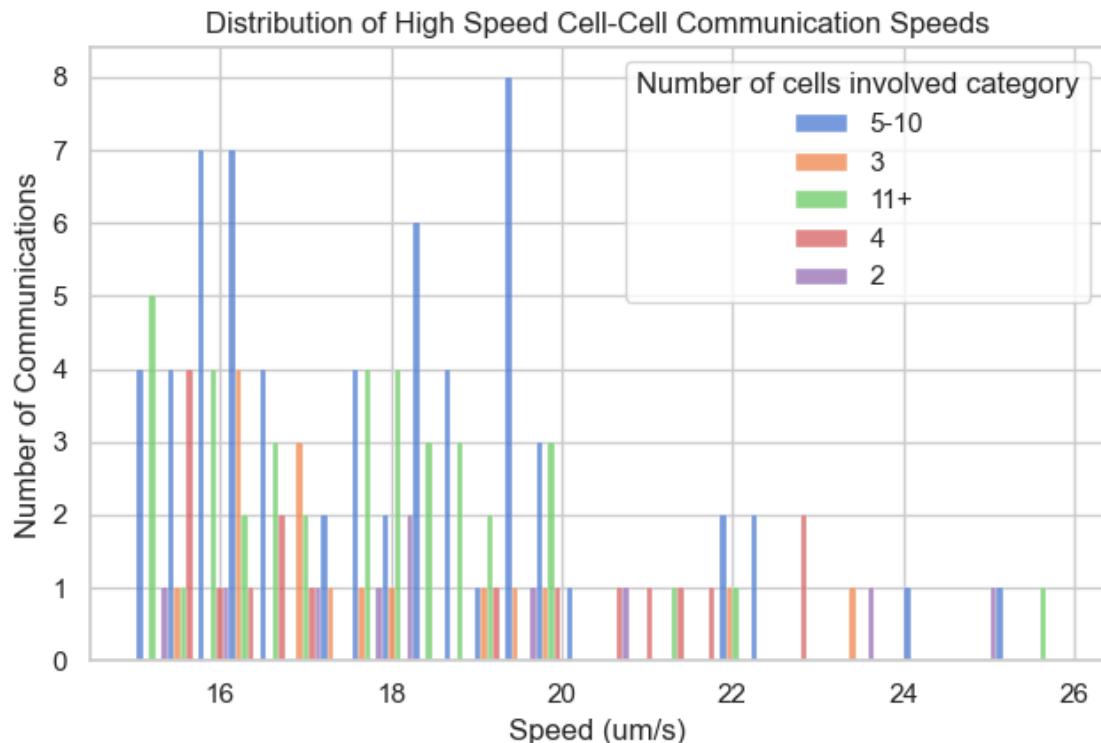
High Speed Cell-Cell Communication Involvement



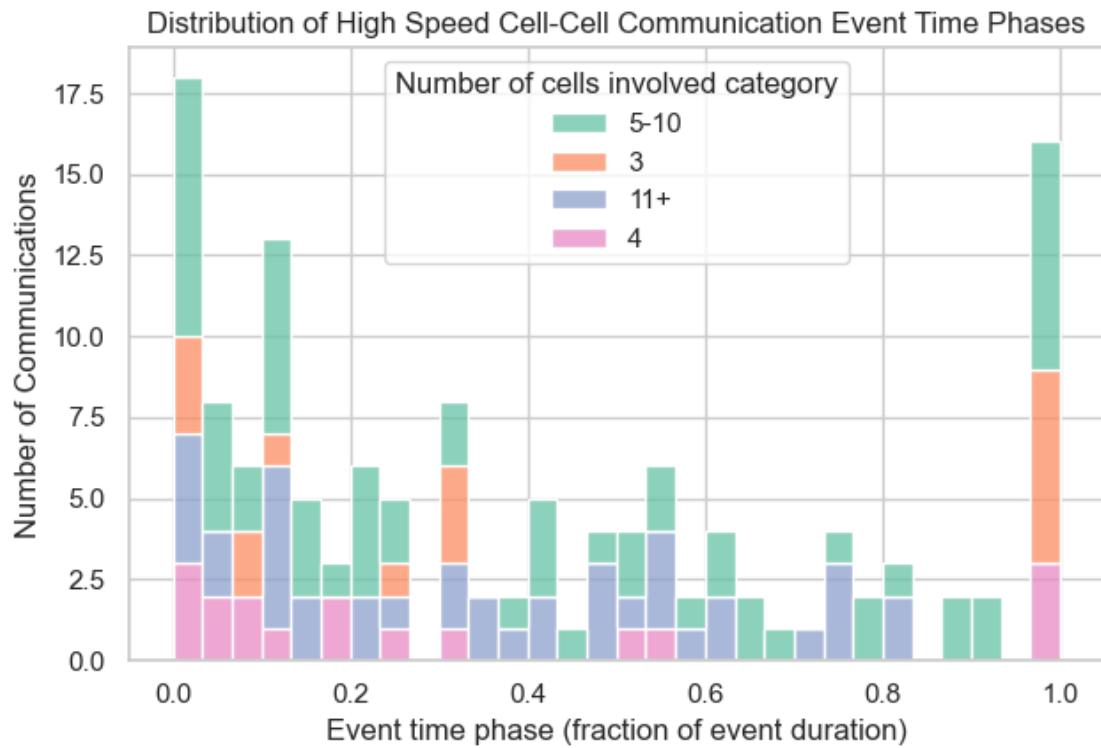
[2025-08-13 11:27:24] [INFO] calcium: plot_histogram: removed 0 outliers out of 145 on 'Speed (um/s)' (lower=6.59, upper=28.92)



```
[2025-08-13 11:27:24] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 145 on 'Speed (um/s)' (lower=6.59, upper=28.92)
```

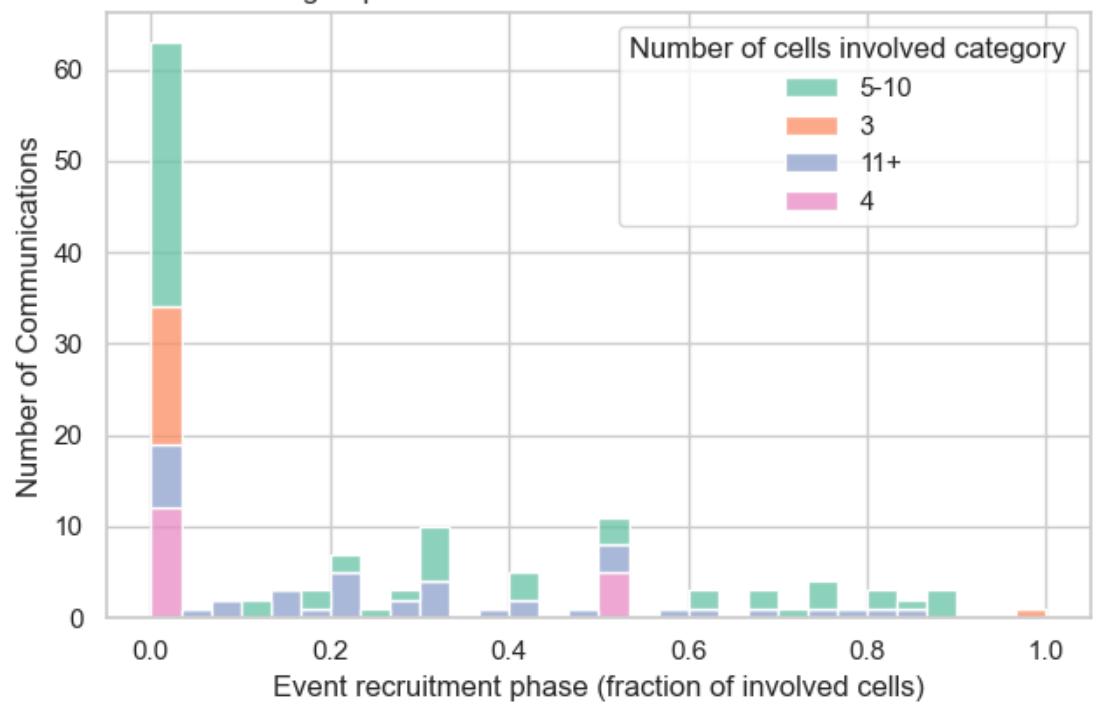


```
[2025-08-13 11:27:24] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 135 on 'Event time phase (fraction of event duration)' (lower=-1.475, upper=2.2)
```

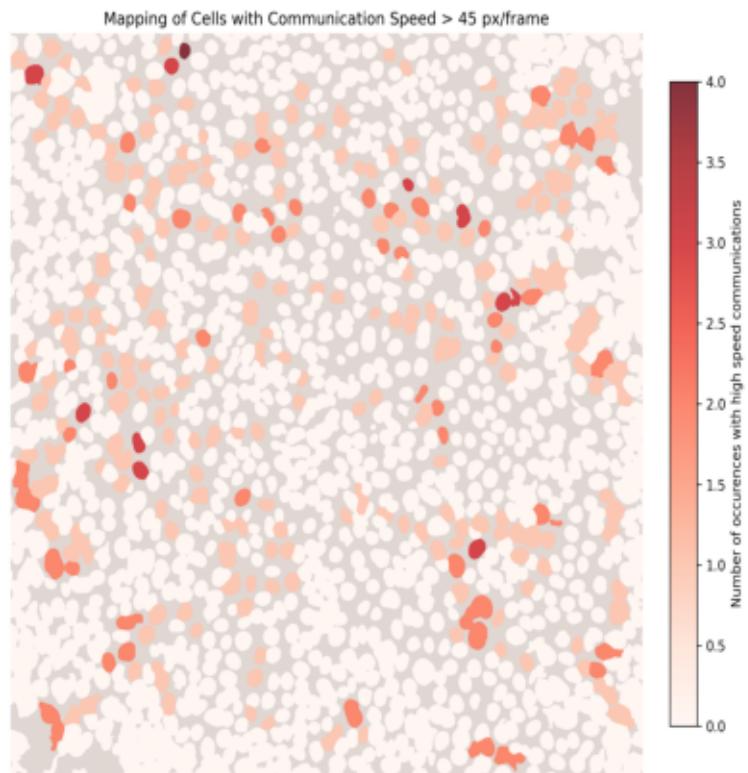


```
[2025-08-13 11:27:25] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 135 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.35, upper=1.8)
```

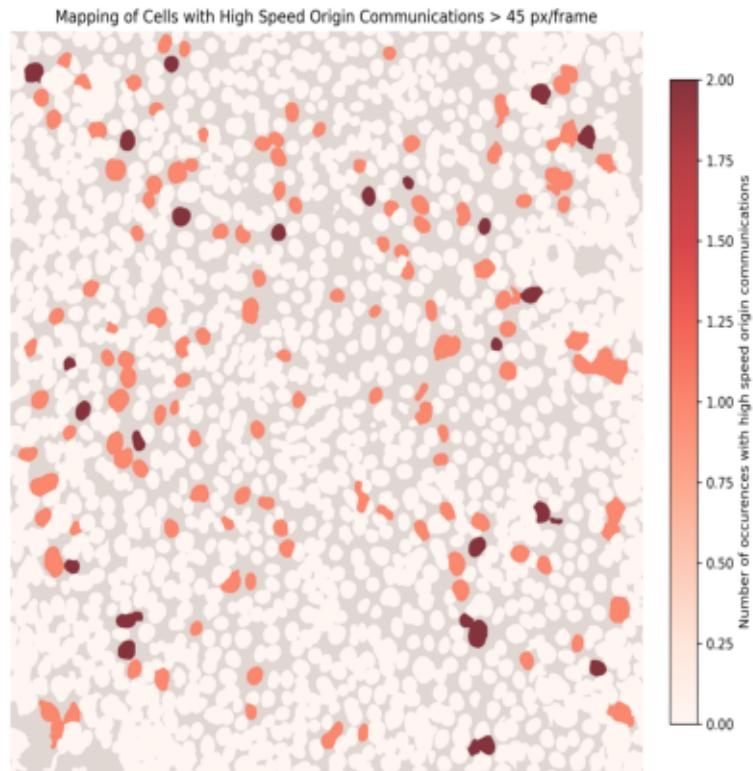
Distribution of High Speed Cell-Cell Communication Event Recruitment Phases



Cell Mapping with High Speed Cells Overlay - 20250404_IS1



Cell Mapping with High Speed Origin Cells Overlay - 20250404_IS1



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
1	1759389736320	5	646	0	
21	1759389740016	8	958	0	
42	1759389739728	12	559	0	
73	1759389740496	16	458	1	
118	1759389744000	22	1817	2	
...	
2911	1759381963152	748	1610	5	
2920	1759410235200	752	1648	0	
3014	1759410234816	791	1706	5	
3043	1759529974704	802	1872	0	
3086	1759529969424	816	1801	1	

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
1	612	0	41.0	41.0	
21	1008	1	50.0	50.0	
42	529	0	19.0	19.0	
73	417	1	72.0	72.0	
118	1785	2	181.0	181.0	
...	
2911	1571	6	492.0	493.0	
2920	1694	1	155.0	156.0	
3014	1692	4	484.0	485.0	
3043	1895	0	29.0	30.0	
3086	1823	2	95.0	96.0	
	Duration (s)	Distance (um)	Speed (um/s)	\	
1	0.0	18.75	18.75		
21	0.0	17.03	17.03		
42	0.0	17.76	17.76		
73	0.0	16.09	16.09		
118	0.0	15.28	15.28		
...	
2911	1.0	15.34	15.34		
2920	1.0	15.83	15.83		
3014	1.0	18.17	18.17		
3043	1.0	21.48	21.48		
3086	1.0	15.41	15.41		
	Event time phase (fraction of event duration)	\			
1		0.77			
21		1.00			
42		0.42			
73		0.41			
118		0.80			
...		...			
2911		NaN			
2920		0.10			
3014		NaN			
3043		0.54			
3086		0.06			
	Event recruitment phase (fraction of involved cells)	dataset	\		
1	0.60	20250404_IS1			
21	0.00	20250404_IS1			
42	0.17	20250404_IS1			
73	0.18	20250404_IS1			
118	0.33	20250404_IS1			
...			
2911	NaN	20250404_IS1			
2920	0.00	20250404_IS1			

3014		NaN	20250404_IS1
3043		0.40	20250404_IS1
3086		0.00	20250404_IS1

	Number of cells involved	category	Speed category
1		5-10	High speed
21		3	High speed
42		5-10	High speed
73		11+	High speed
118		5-10	High speed
...	
2911		2	High speed
2920		5-10	High speed
3014		2	High speed
3043		11+	High speed
3086		4	High speed

[145 rows x 16 columns]

Origin cell ID	Speed category	High speed	Low speed
255		0	3
256		0	1
257		0	1
258		0	1
259		1	3
...
1899		0	1
1902		0	3
1905		0	1
1907		0	1
1909		0	1

[1055 rows x 2 columns]

	Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
3	255	204.10		8.12
4	256	325.32		8.12
5	257	429.32		8.12
6	258	476.12		8.12
7	259	121.88		8.12
...
1227	1899	431.28		490.43
1229	1902	140.40		492.05
1230	1905	273.00		491.07
1232	1907	372.45		492.05
1233	1909	447.53		491.73

Number of peaks	Is active	Occurrences in global events	\
-----------------	-----------	------------------------------	---

3	12	True	5
4	8	True	5
5	8	True	5
6	7	True	5
7	12	True	5
...
1227	9	True	5
1229	19	True	5
1230	8	True	5
1232	9	True	5
1233	10	True	5

Occurrences in global events as early peaker \

3	0
4	0
5	1
6	0
7	0
...	...
1227	1
1229	1
1230	0
1232	0
1233	1

Occurrences in sequential events \

3	2
4	2
5	1
6	2
7	2
...	...
1227	3
1229	6
1230	3
1232	3
1233	4

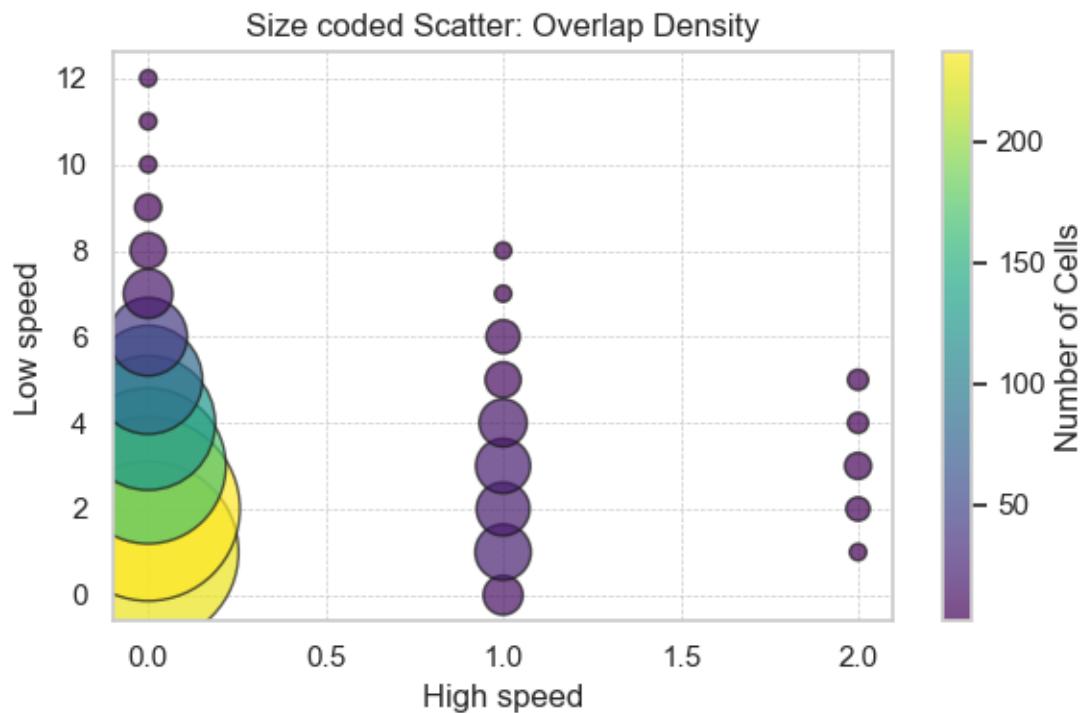
Occurrences in sequential events as origin \

3	1
4	0
5	1
6	1
7	2
...	...
1227	1
1229	3
1230	0

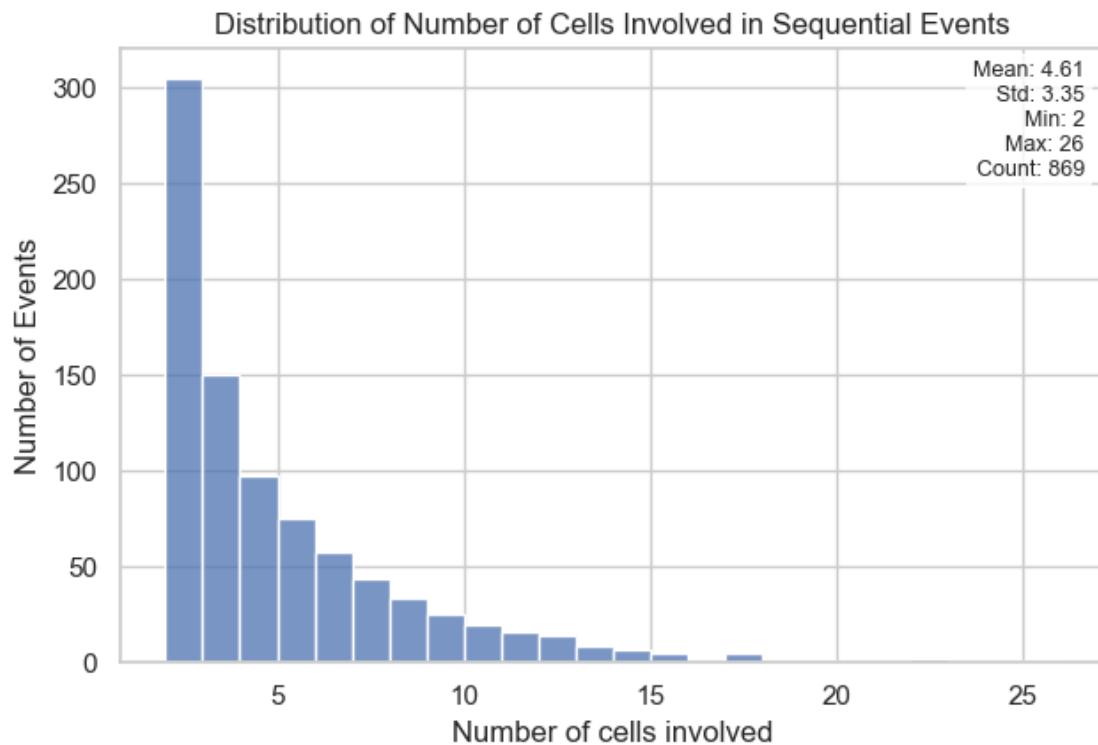
1232		1	
1233		0	
Occurrences in individual events Peak frequency (Hz) Periodicity score \			
3	3	0.0071	0.56
4	0	0.0047	0.67
5	1	0.0047	0.63
6	0	0.0041	0.70
7	5	0.0071	0.59
...
1227	1	0.0053	0.60
1229	5	0.0110	0.58
1230	0	0.0047	0.65
1232	1	0.0053	0.61
1233	1	0.0059	0.63
Neighbor count Neighbors (labels) dataset \			
3	3	[272,277,293]	20250404_IS1
4	4	[254,276,305,308]	20250404_IS1
5	2	[284,321]	20250404_IS1
6	2	[282,295]	20250404_IS1
7	4	[273,274,302,314]	20250404_IS1
...
1227	4	[1861,1870,1892,1909]	20250404_IS1
1229	3	[1875,1879,1893]	20250404_IS1
1230	4	[1855,1873,1889,1906]	20250404_IS1
1232	3	[1872,1894,1895]	20250404_IS1
1233	4	[1862,1870,1876,1899]	20250404_IS1
Involved in sequential event Occurrences in sequential events category \			
3	Involved in sequential event		1-2
4	Involved in sequential event		1-2
5	Involved in sequential event		1-2
6	Involved in sequential event		1-2
7	Involved in sequential event		1-2
...
1227	Involved in sequential event		3-4
1229	Involved in sequential event		5-9
1230	Involved in sequential event		3-4
1232	Involved in sequential event		3-4
1233	Involved in sequential event		3-4
High speed		Low speed	
3	0.0	3.0	
4	0.0	1.0	
5	0.0	1.0	
6	0.0	1.0	
7	1.0	3.0	

```
...      ...      ...
1227    0.0     1.0
1229    0.0     3.0
1230    0.0     1.0
1232    0.0     1.0
1233    0.0     1.0
```

[1055 rows x 19 columns]



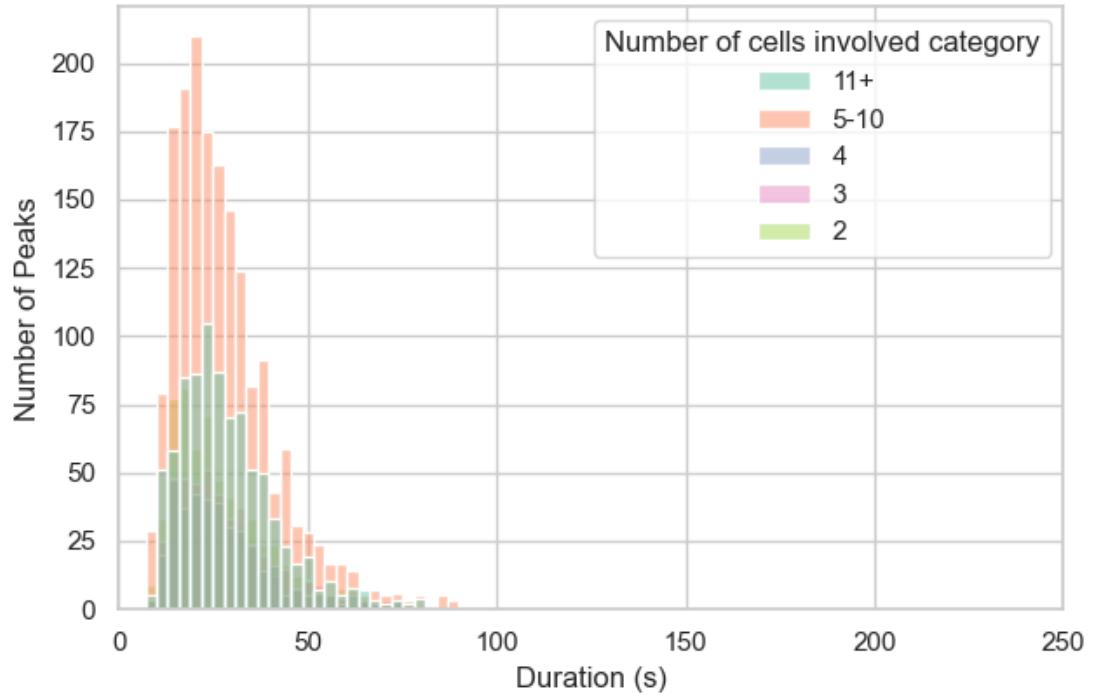
1.3.5 Number of cells involved per sequential events



1.3.6 Influence of cell count per event on statistics

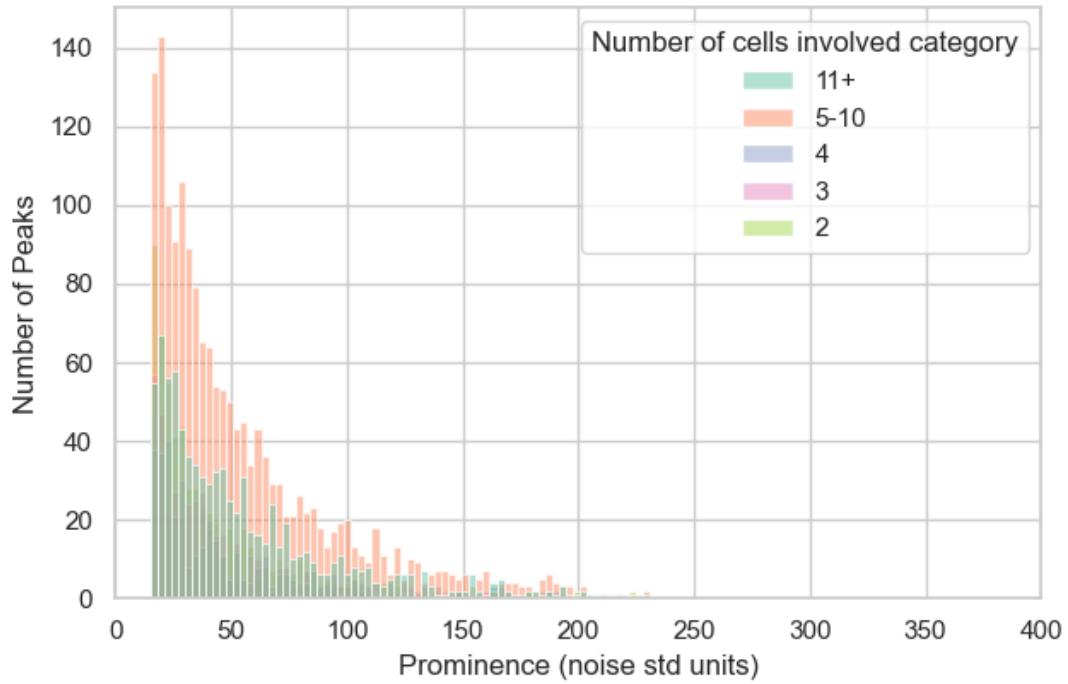
```
[2025-08-13 11:27:28] [INFO] calcium: plot_histogram_by_group: removed 28 outliers out of 4075 on 'Duration (s)' (lower=-6, upper=90)
```

Distribution of Peak Durations by Number of Cells Involved in Sequential Events

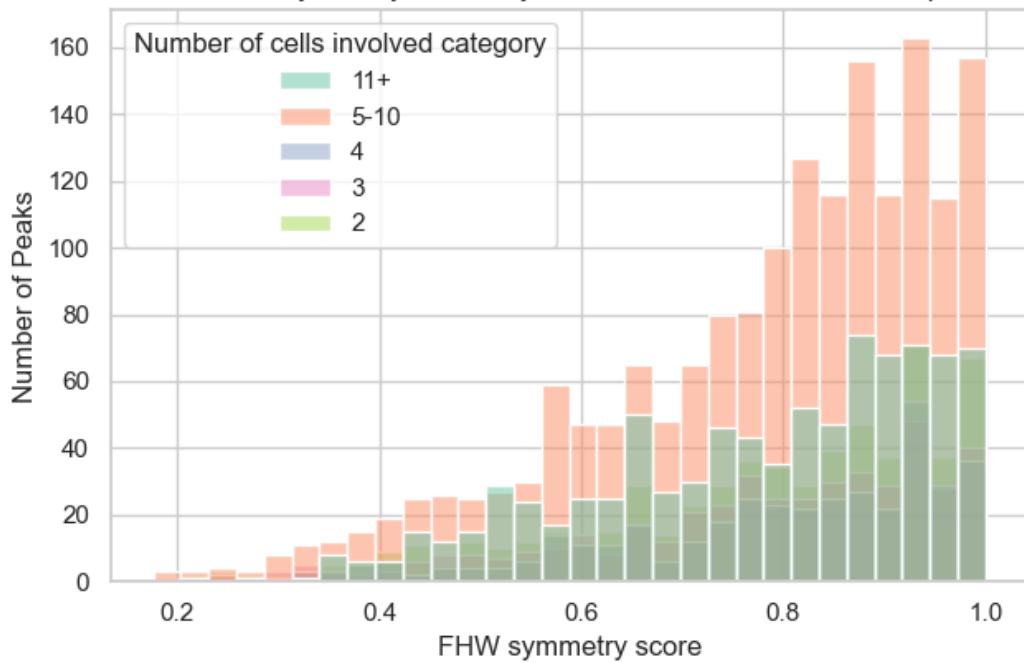


```
[2025-08-13 11:27:29] [INFO] calcium: plot_histogram_by_group: removed 97 outliers out of 4075 on 'Prominence (noise std units)' (lower=-44.825, upper=230.88)
```

Distribution of Peak Prominences by Number of Cells Involved in Sequential Events

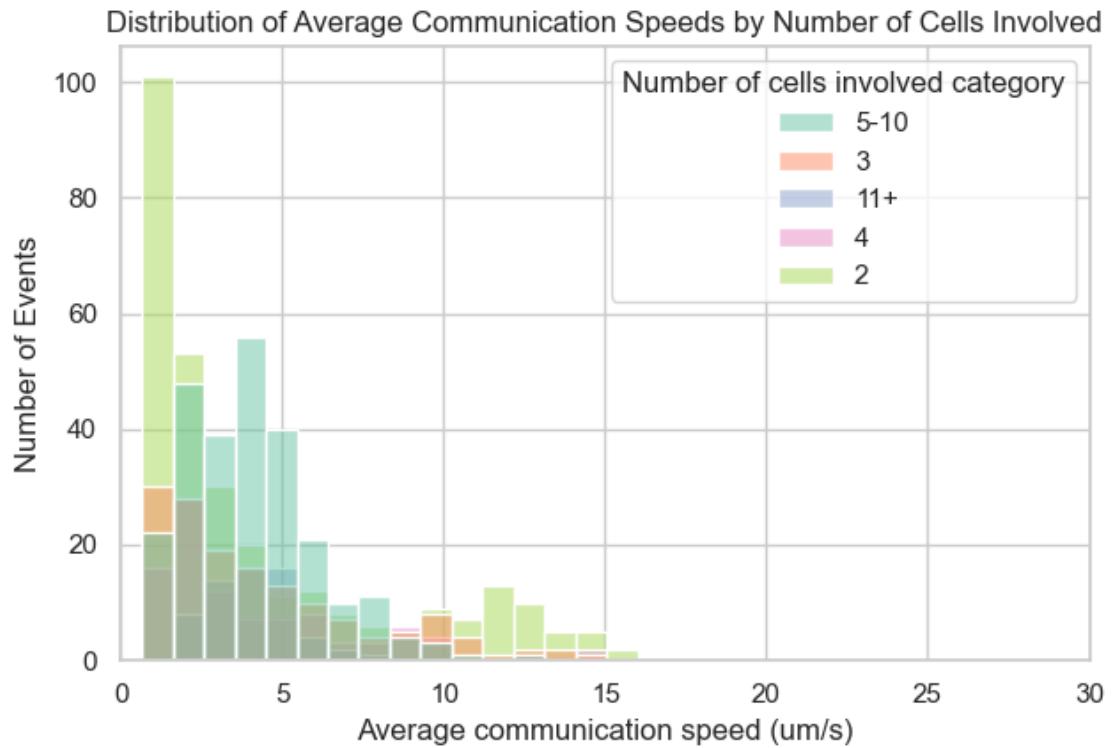


Distribution of Peak Symmetry Scores by Number of Cells Involved in Sequential Events



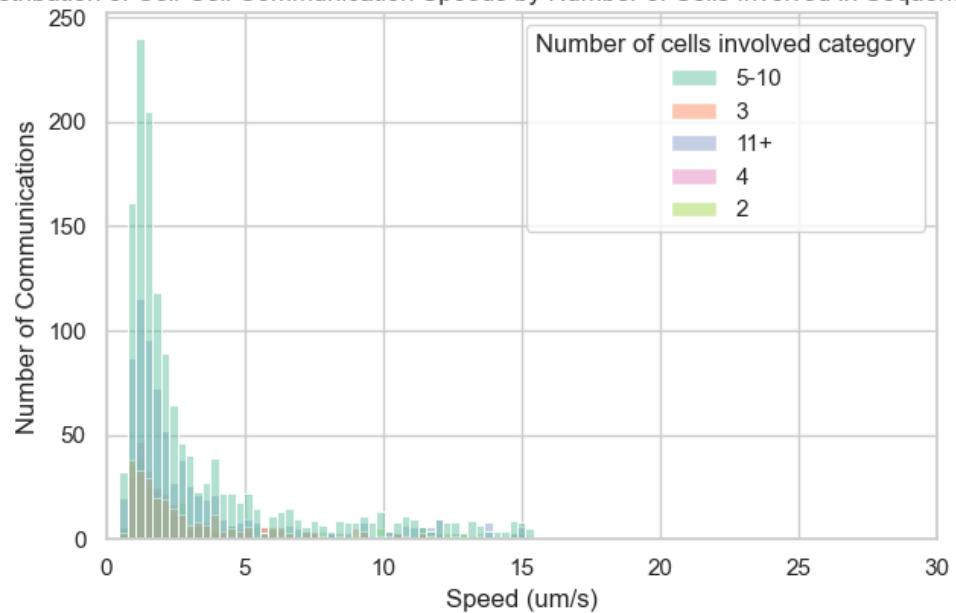
[2025-08-13 11:27:30] [INFO] calcium: plot_histogram_by_group: removed 8

outliers out of 869 on 'Average communication speed (um/s)' (lower=-9.01, upper=16.33)



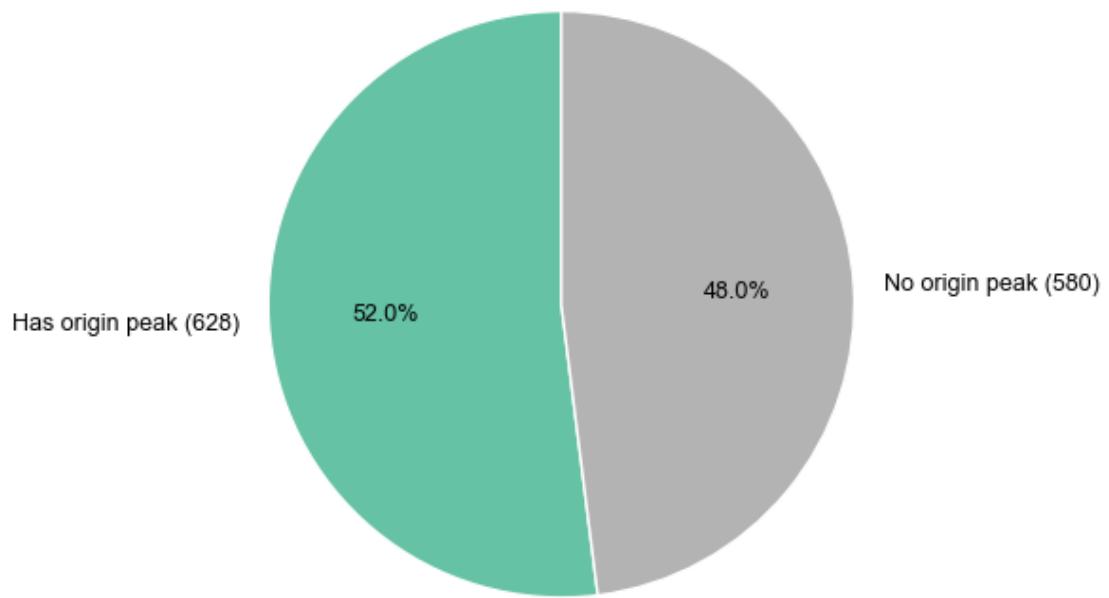
[2025-08-13 11:27:30] [INFO] calcium: plot_histogram_by_group: removed 131 outliers out of 3206 on 'Speed (um/s)' (lower=-9.34, upper=15.51)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events

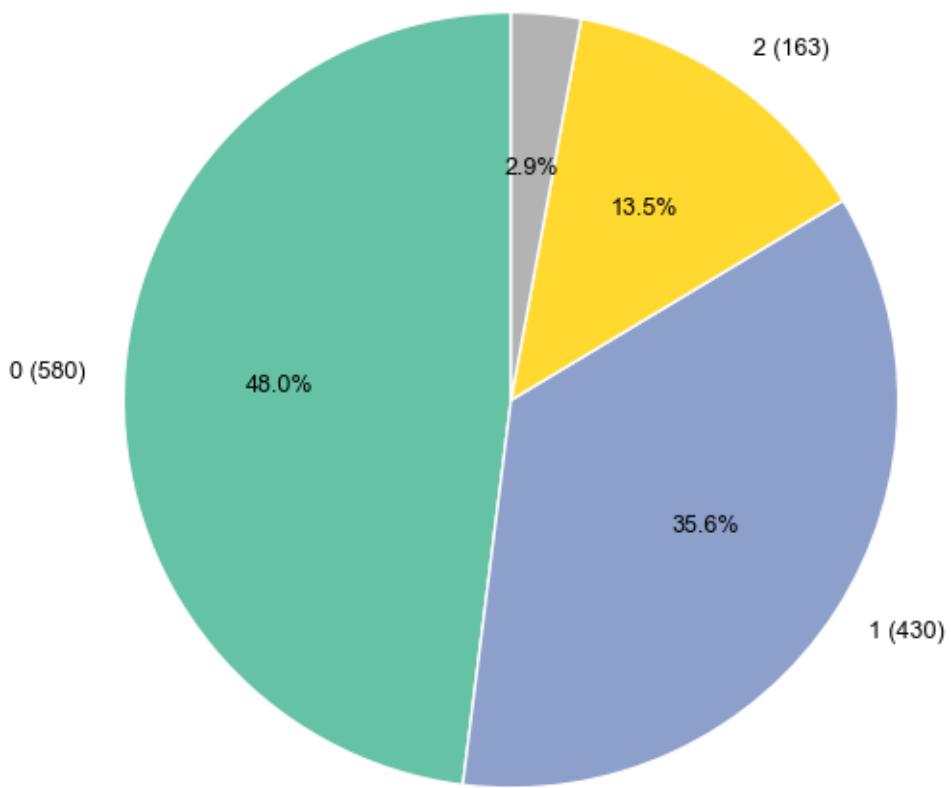


1.3.7 Cells occurrences as origin in sequential events

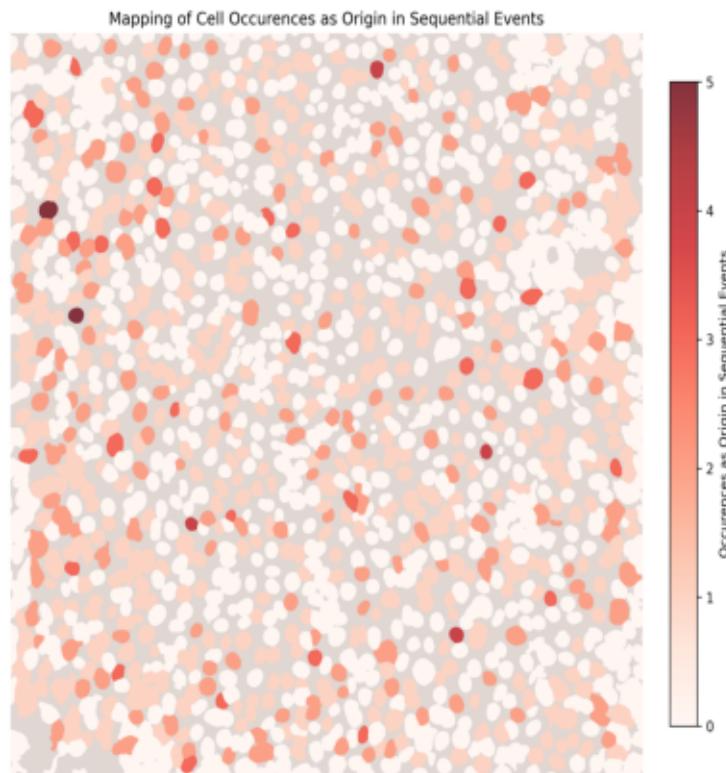
Distribution of Number of Sequential Event Origin Peaks per Cell

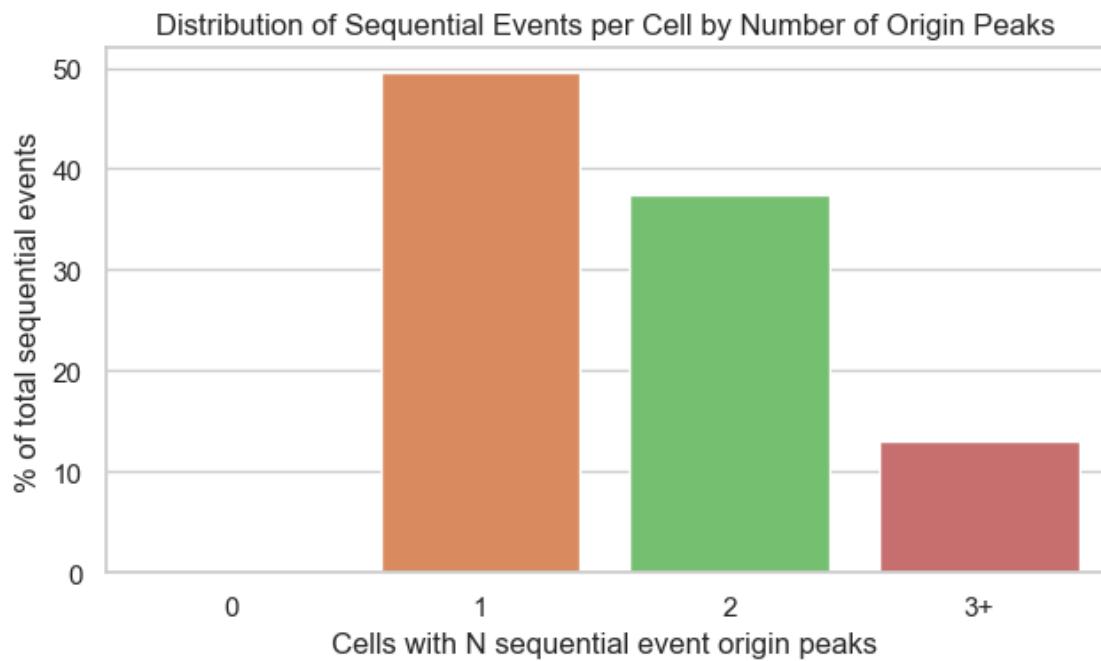


Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)



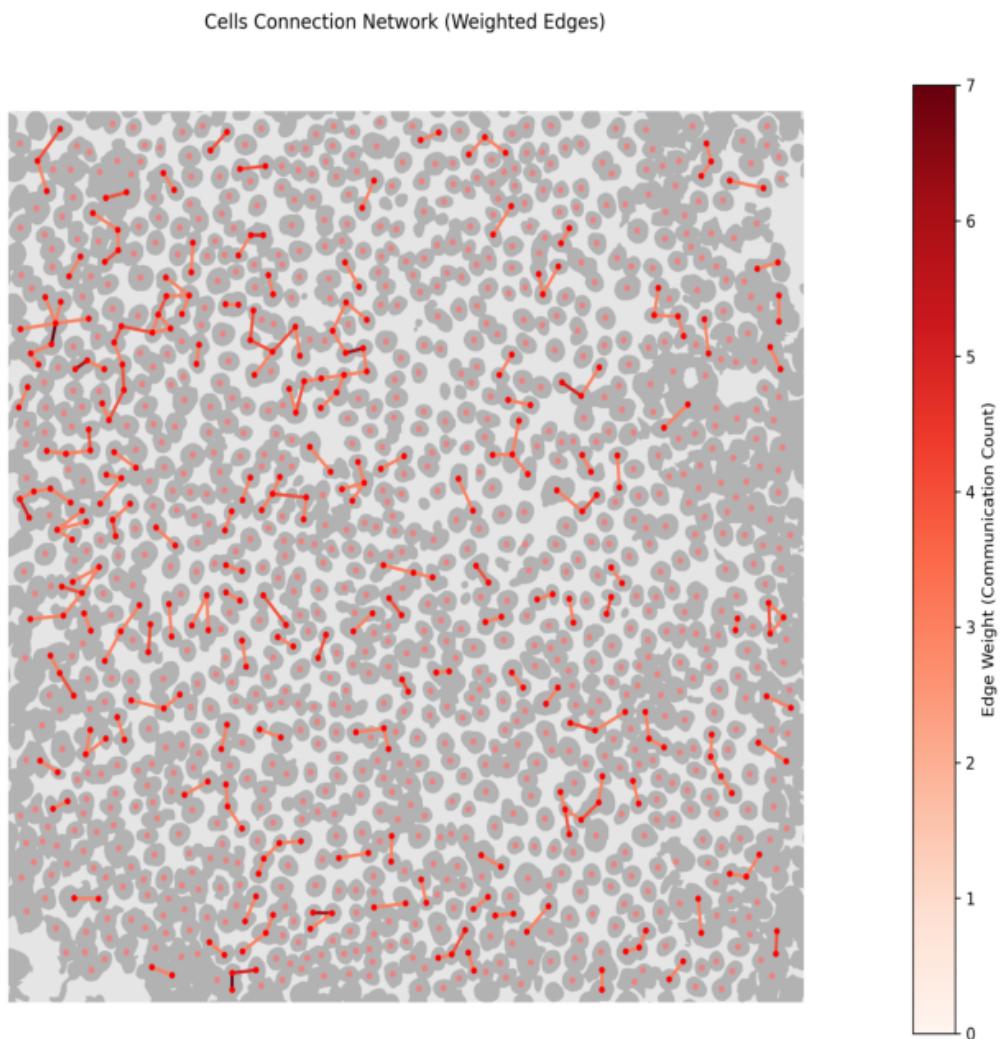
Cell Mapping with Origin Peaks Overlay - 20250404_IS1

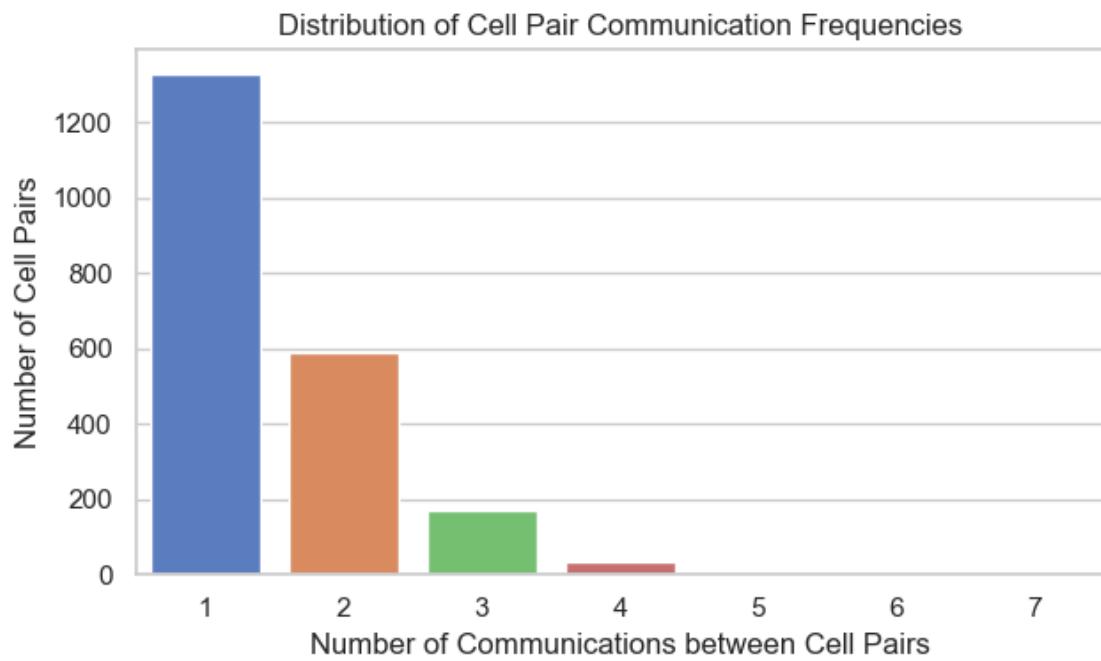




1.3.8 Connection network between cells

Cell Connection Network Graph - 20250404_IS1

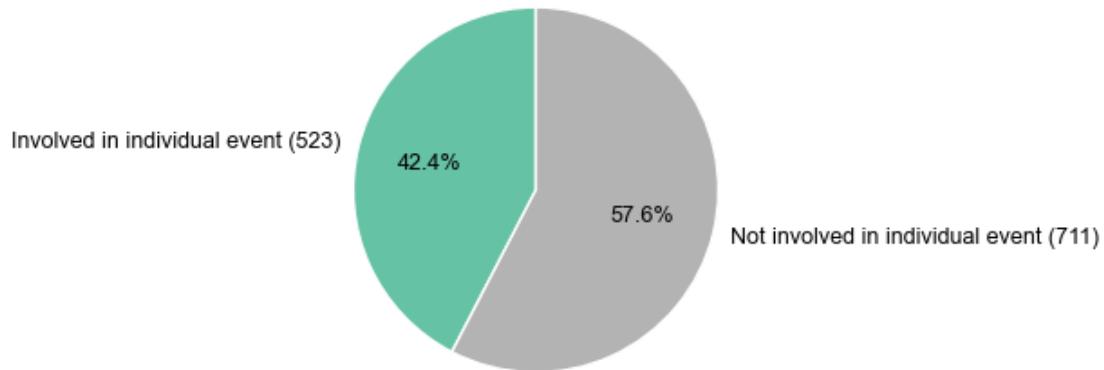




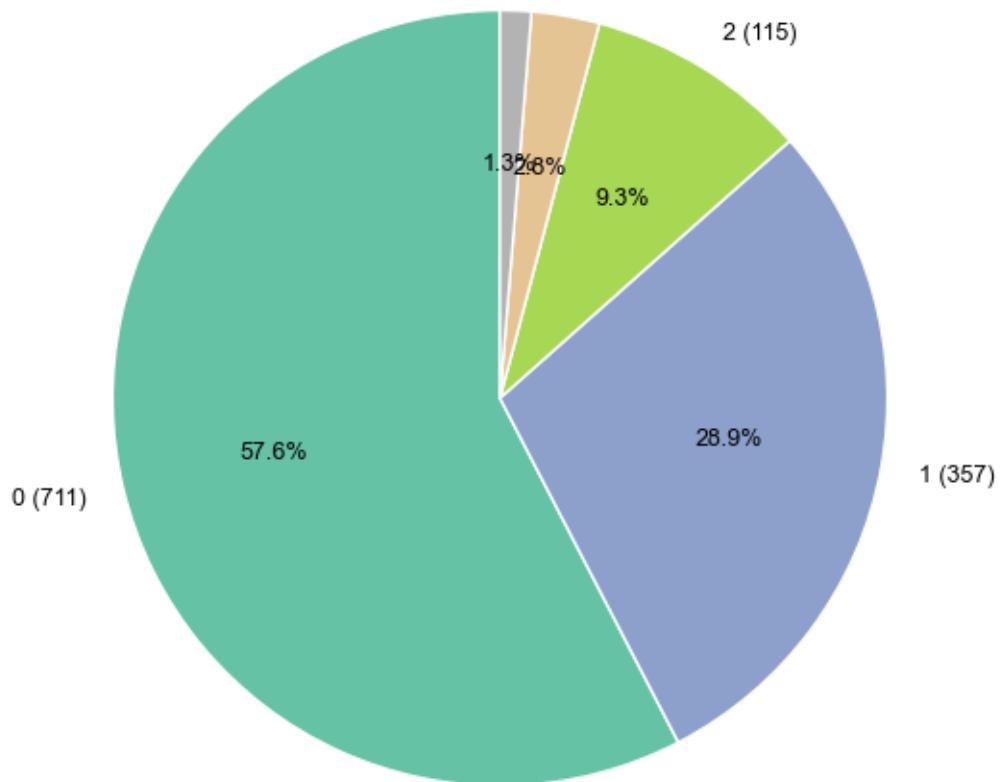
1.4 INDIVIDUAL EVENTS

1.4.1 Cells occurrences in individual events

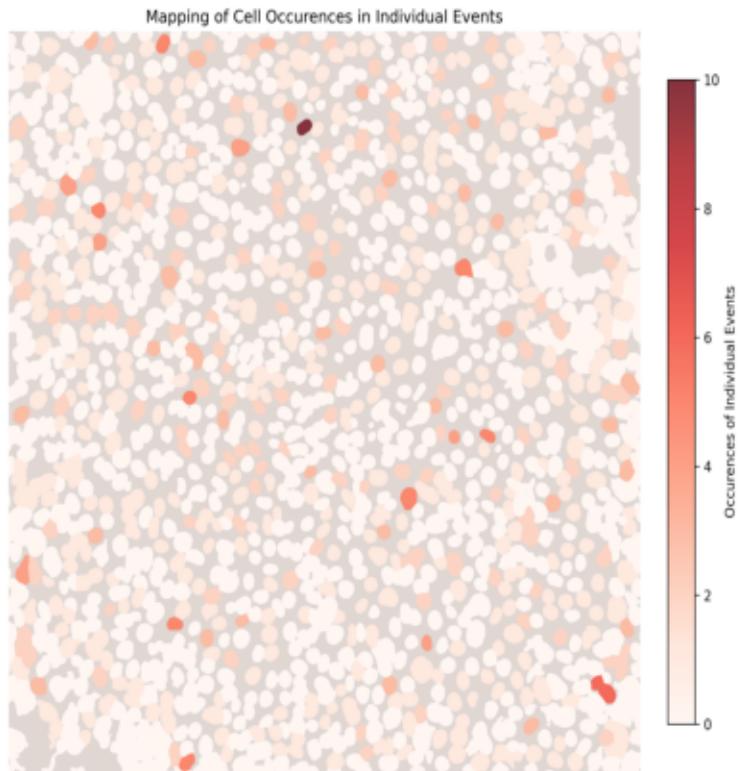
Distribution of Cells Involved in Individual Events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)
4+ (19)(35)

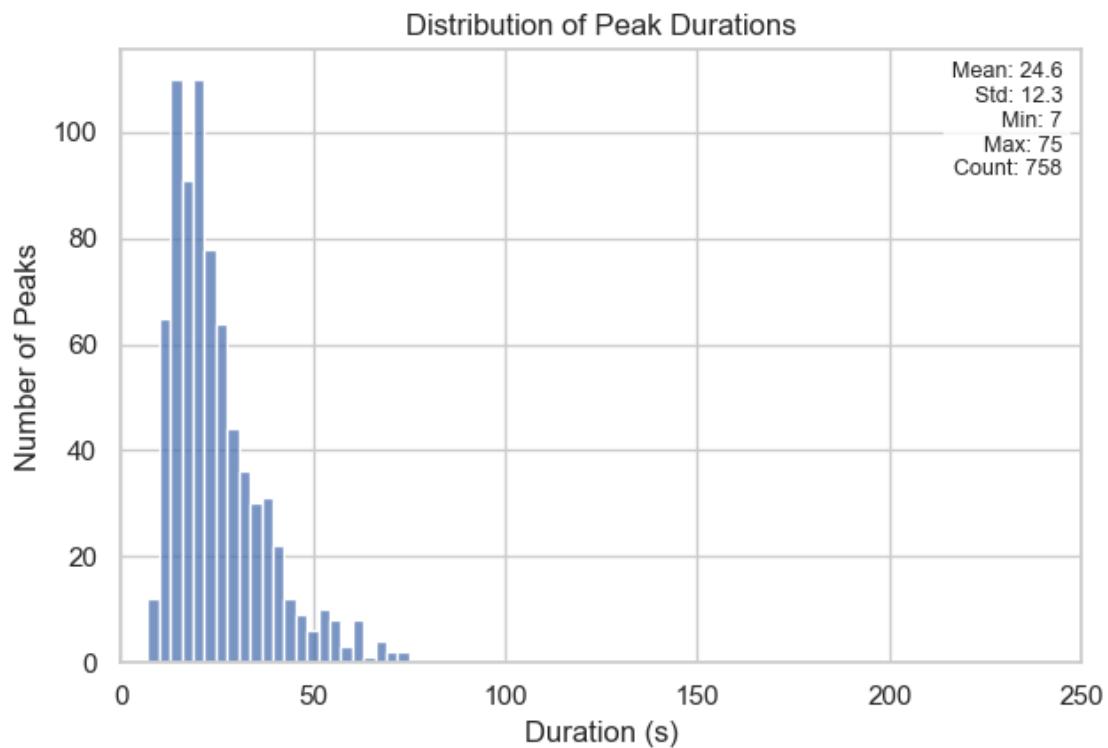


Cell Mapping with Occurrences in Individual Events Overlay - 20250404_IS1

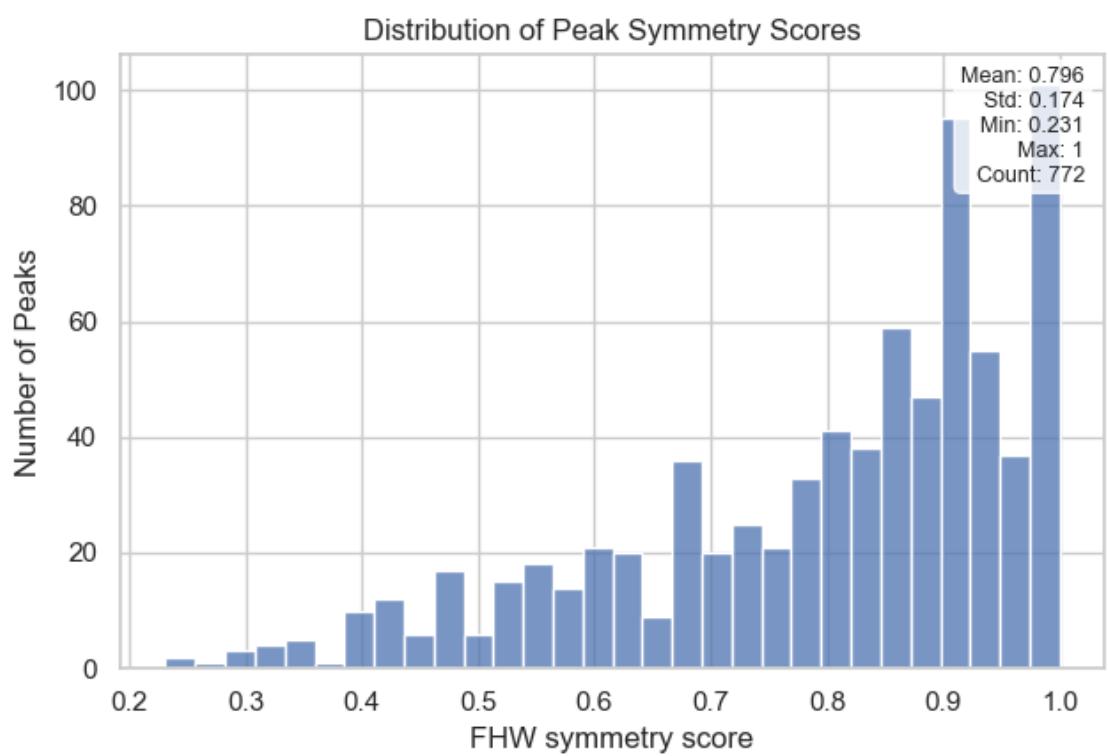
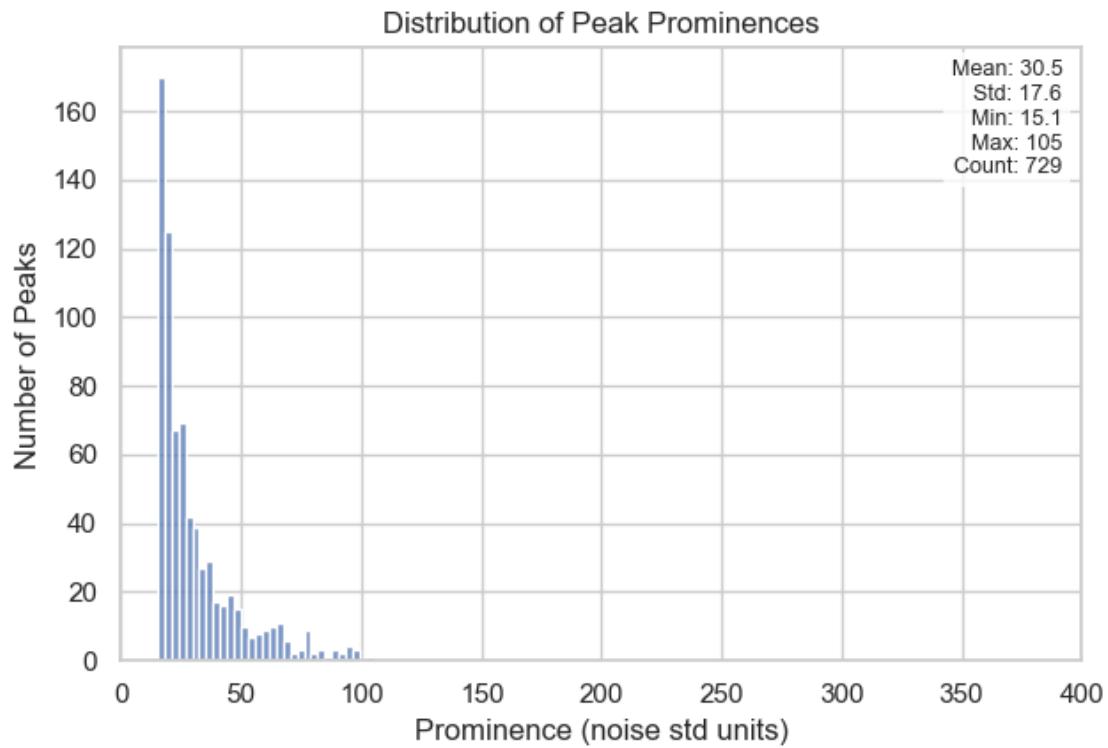


1.4.2 Peaks statistics in individual events

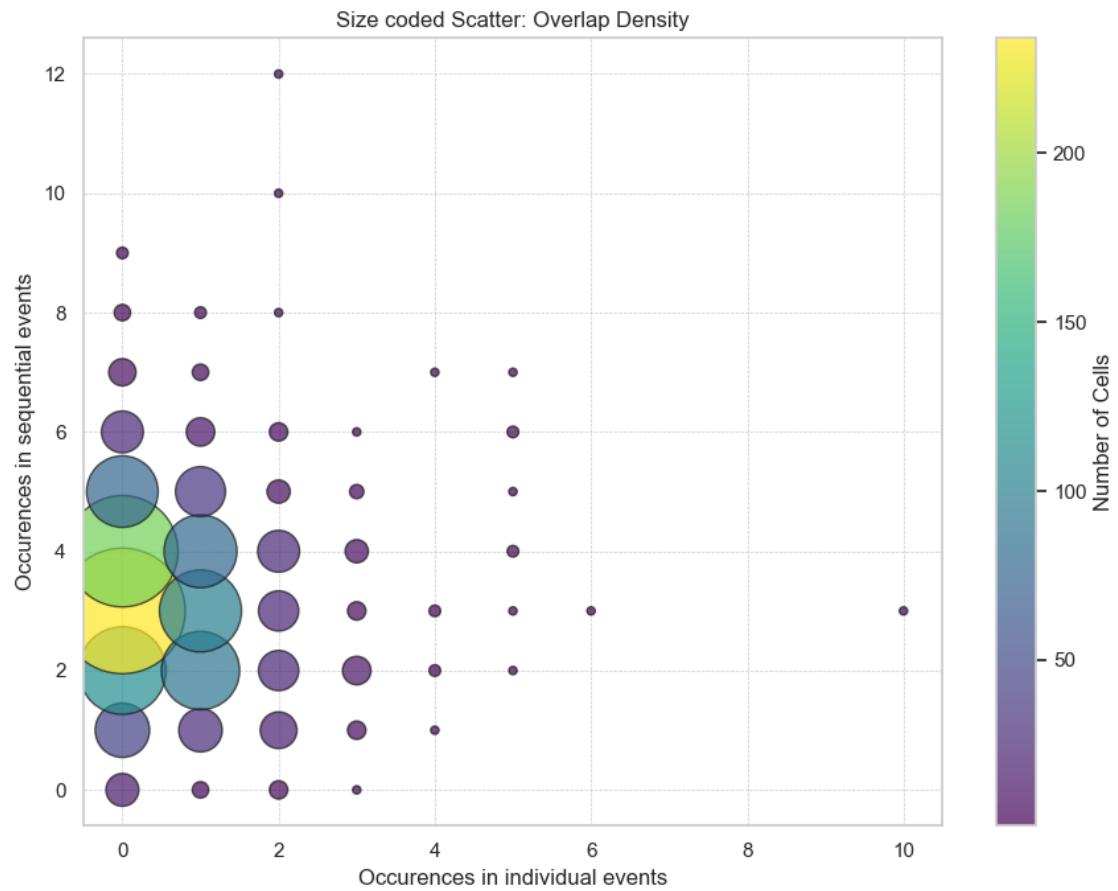
```
[2025-08-13 11:27:36] [INFO] calcium: plot_histogram: removed 14 outliers out of  
772 on 'Duration (s)' (lower=-29, upper=76)
```



[2025-08-13 11:27:36] [INFO] calcium: plot_histogram: removed 43 outliers out of 772 on 'Prominence (noise std units)' (lower=-46.975, upper=105.8)

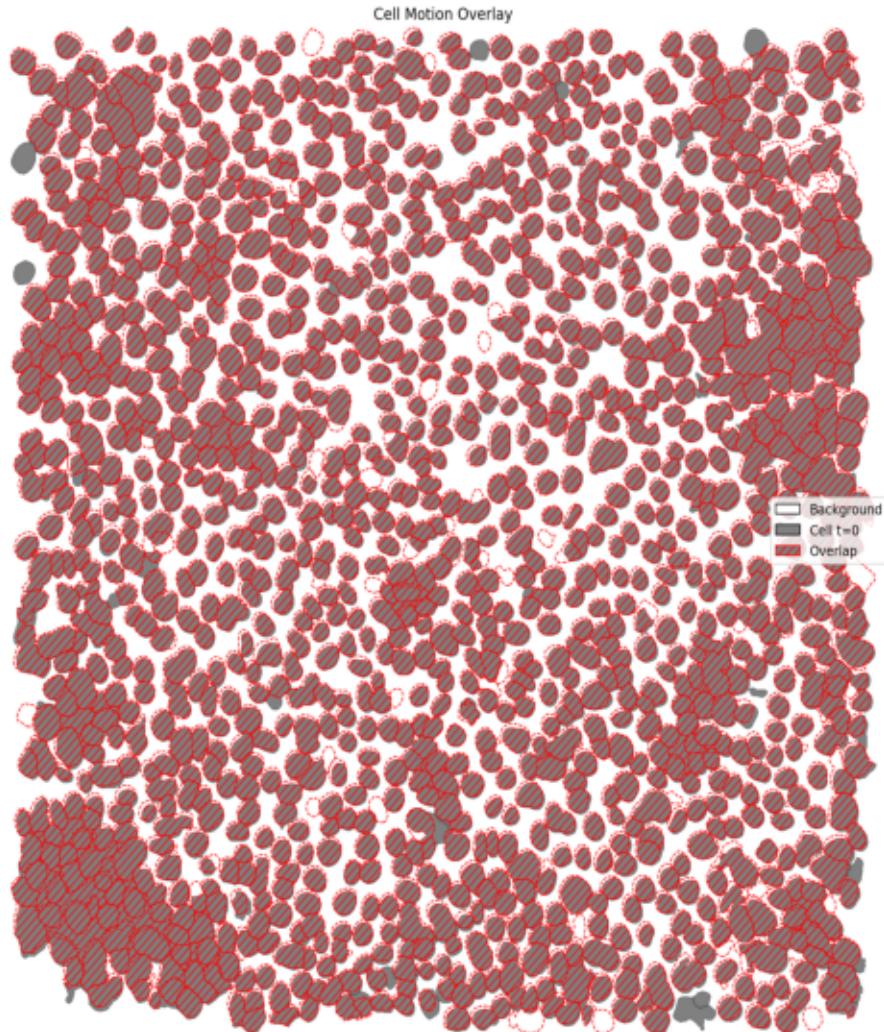


1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250404_IS1



Number of cells:

- Hoechst image taken at t=0: 1234
- Hoechst image taken at t=1801: 1238
- Number of cells difference: absolute 4, relative 0.32%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 1369674
- Pixels segmented as cell at t=1801: 1414102
- Overlapping pixels between t=0 and t=1801: 1219514 (87.62% of total)
- Pixels exclusive to t=0: 150160 (10.96% of total)
- Pixels exclusive to t=1801: 194588 (13.76% of total)

executed

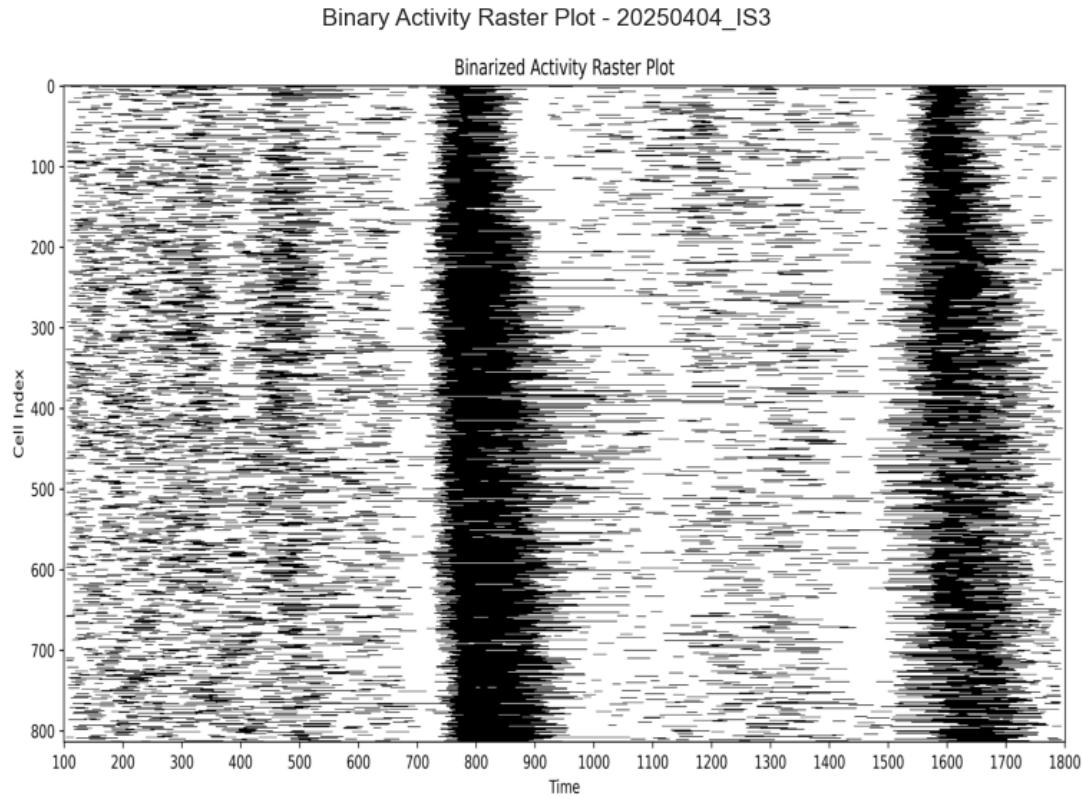
August 13, 2025

1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

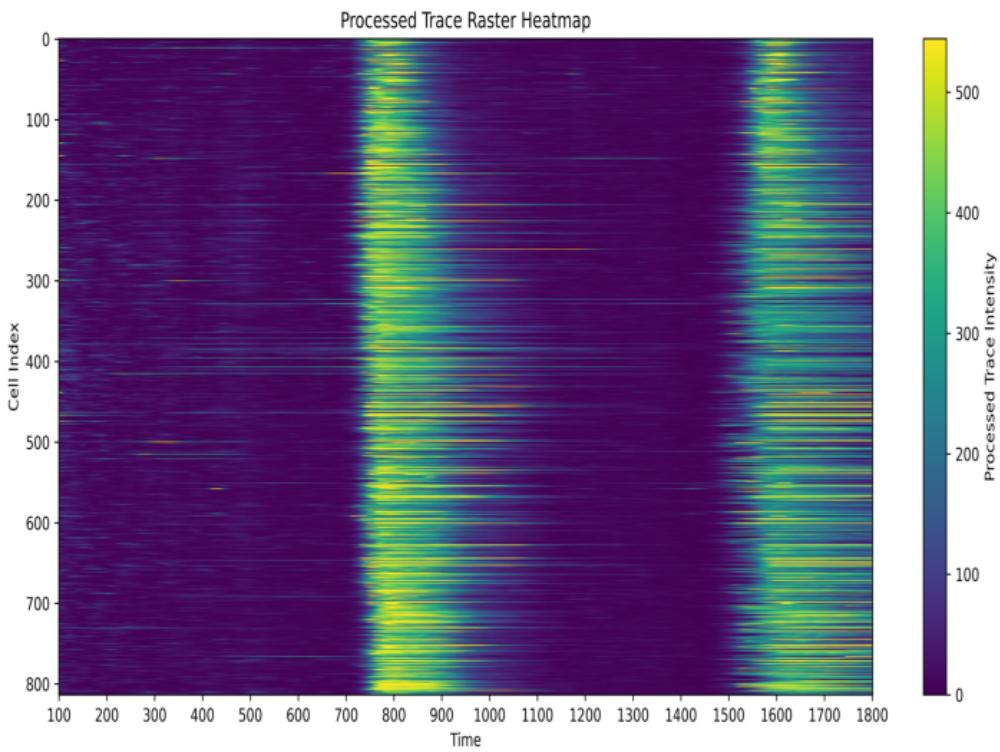
1.0.1 Initialization

1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot



Heatmap Activity Raster Plot - 20250404_IS3



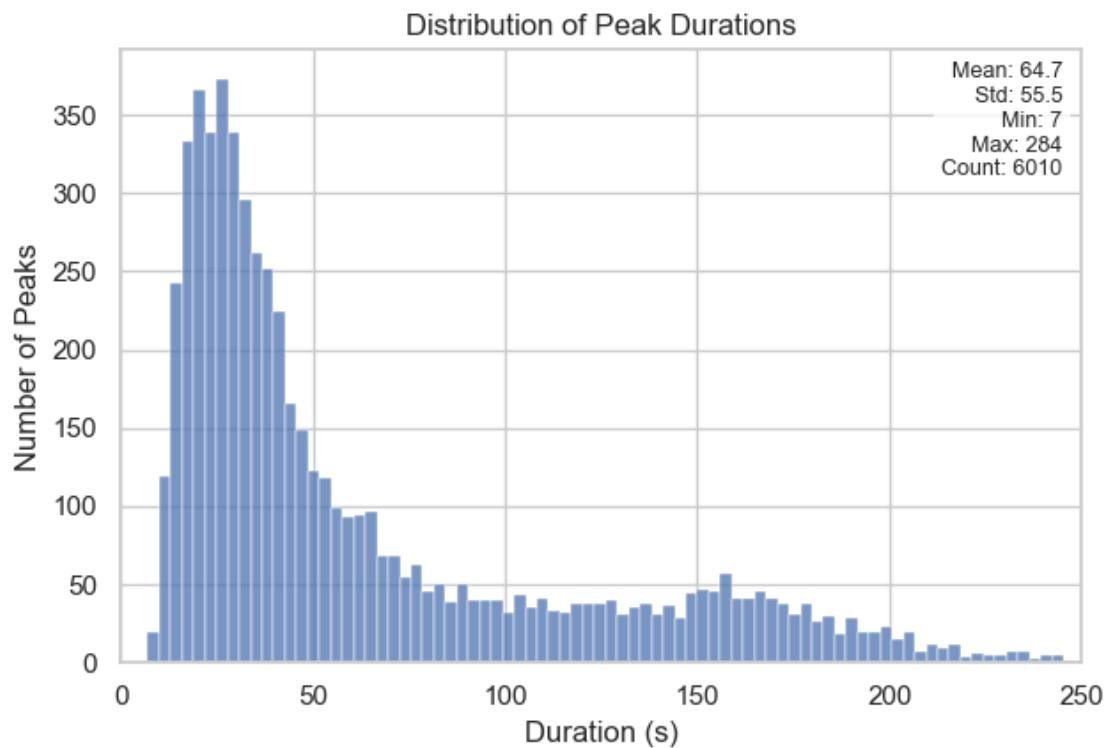
1.1.2 Peaks population

Total number of peaks: 6049

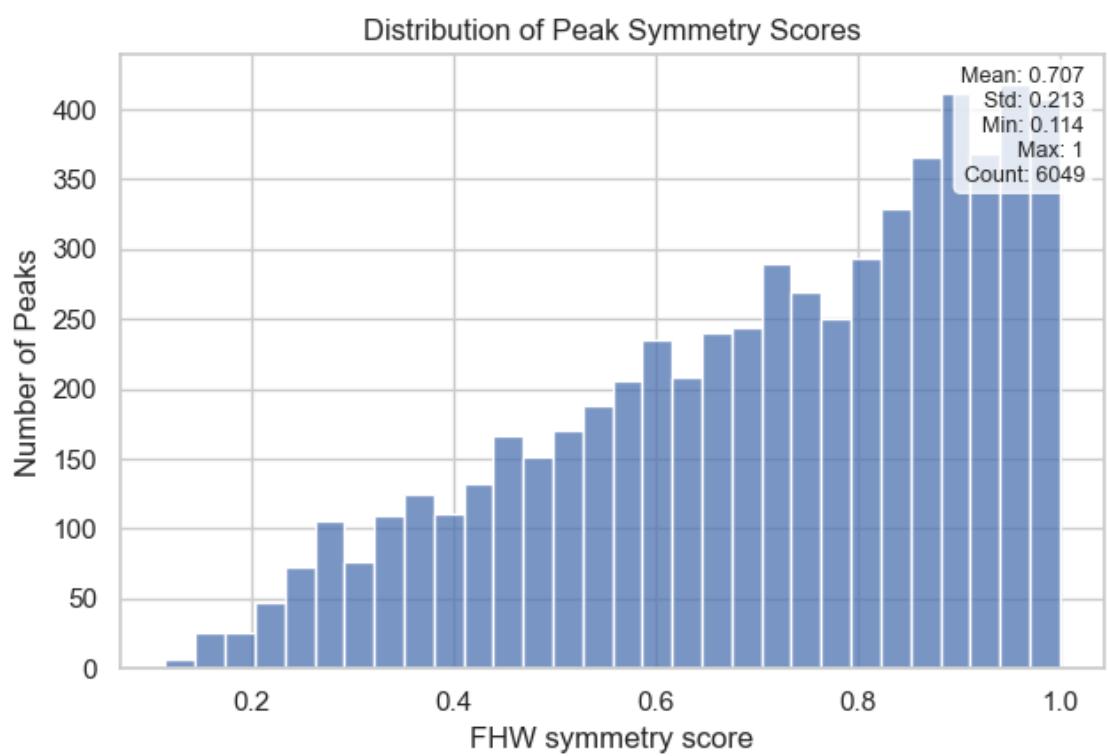
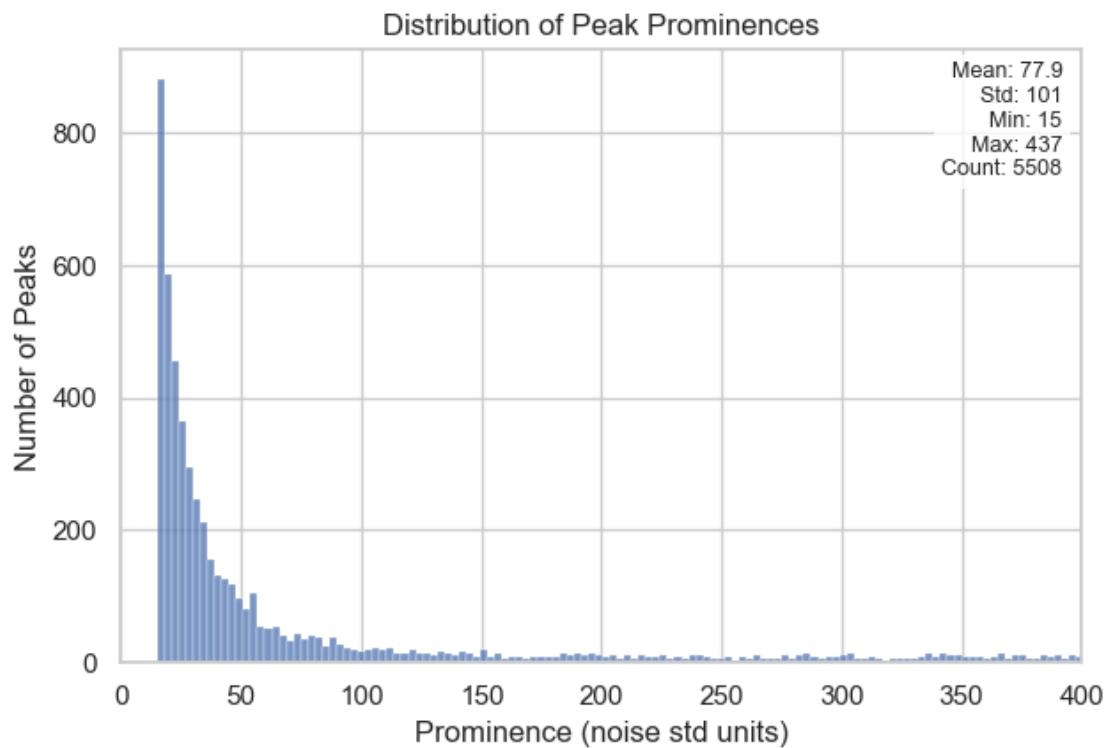
Total number of cells: 814

1.1.3 Peaks statistics

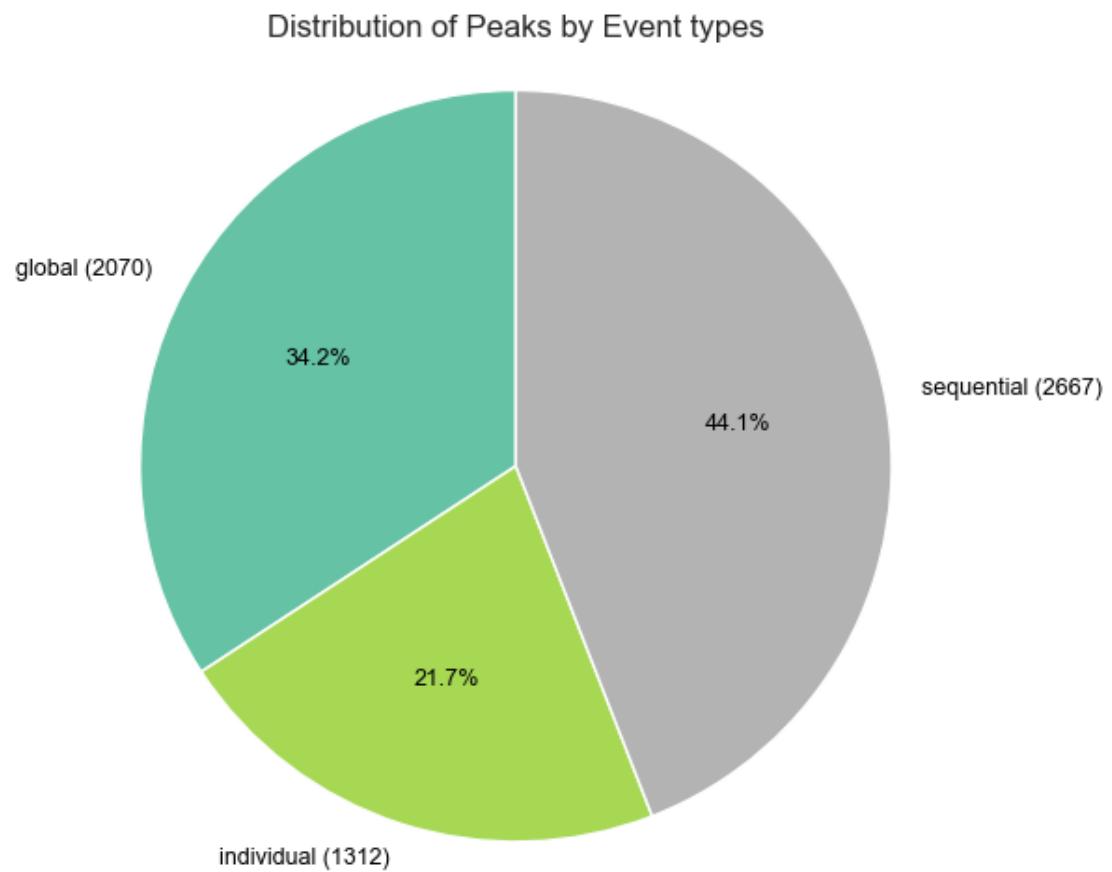
```
[2025-08-13 11:29:11] [INFO] calcium: plot_histogram: removed 39 outliers out of  
6049 on 'Duration (s)' (lower=-170, upper=285)
```



```
[2025-08-13 11:29:11] [INFO] calcium: plot_histogram: removed 541 outliers out  
of 6049 on 'Prominence (noise std units)' (lower=-290.8, upper=437.2)
```

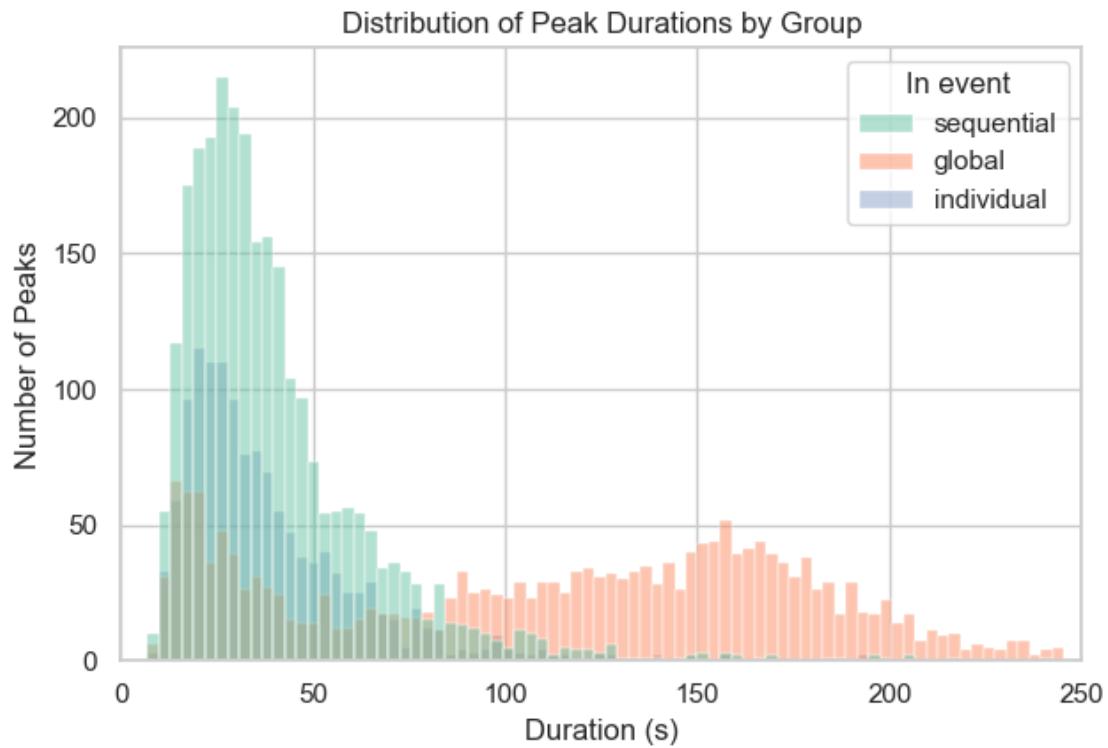


1.1.4 Distribution of peaks per event types



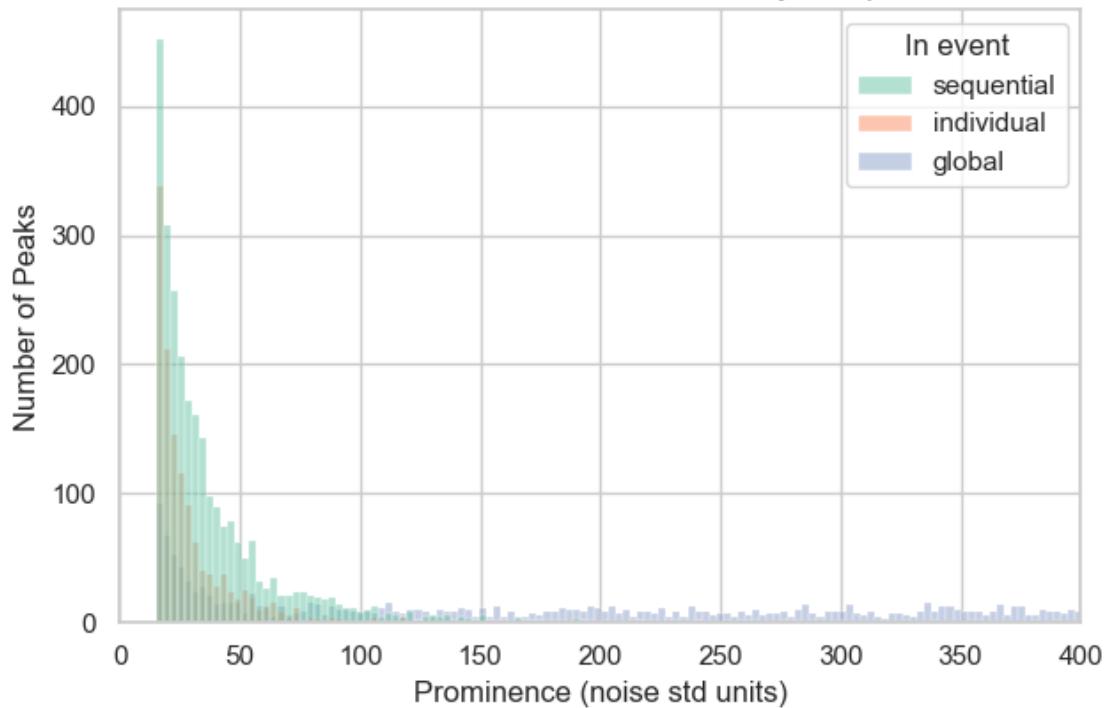
1.1.5 Peaks statistics per event types

```
[2025-08-13 11:29:12] [INFO] calcium: plot_histogram_by_group: removed 39
outliers out of 6049 on 'Duration (s)' (lower=-170, upper=285)
```

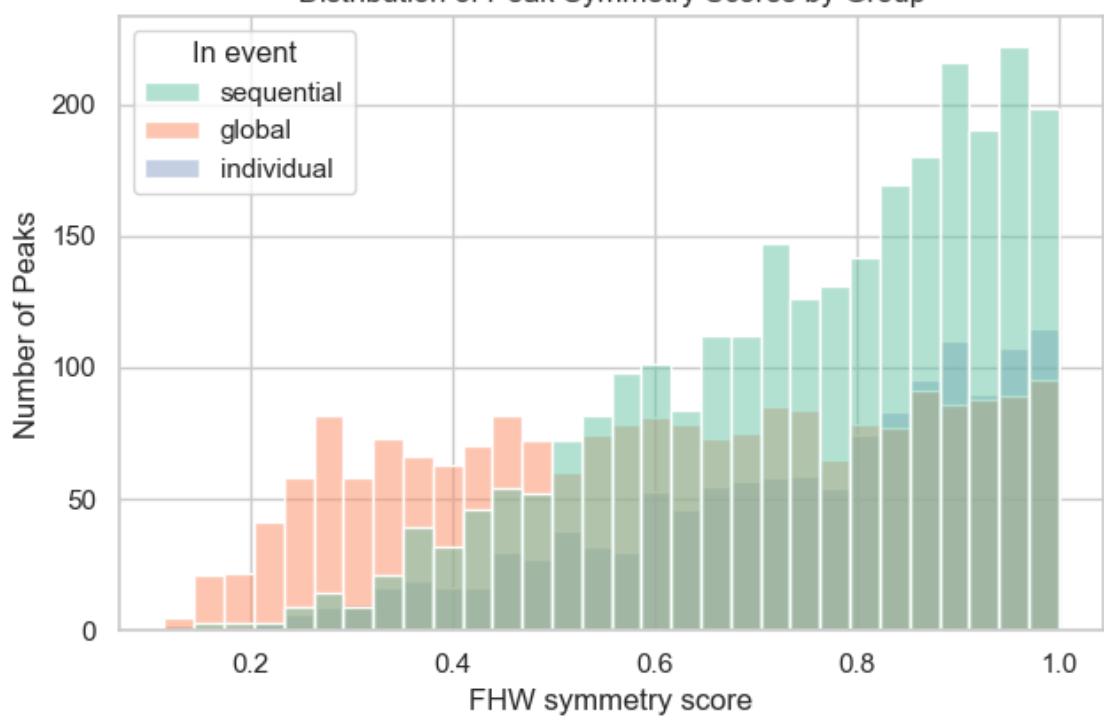


```
[2025-08-13 11:29:12] [INFO] calcium: plot_histogram_by_group: removed 541 outliers out of 6049 on 'Prominence (noise std units)' (lower=-290.8, upper=437.2)
```

Distribution of Peak Prominences by Group



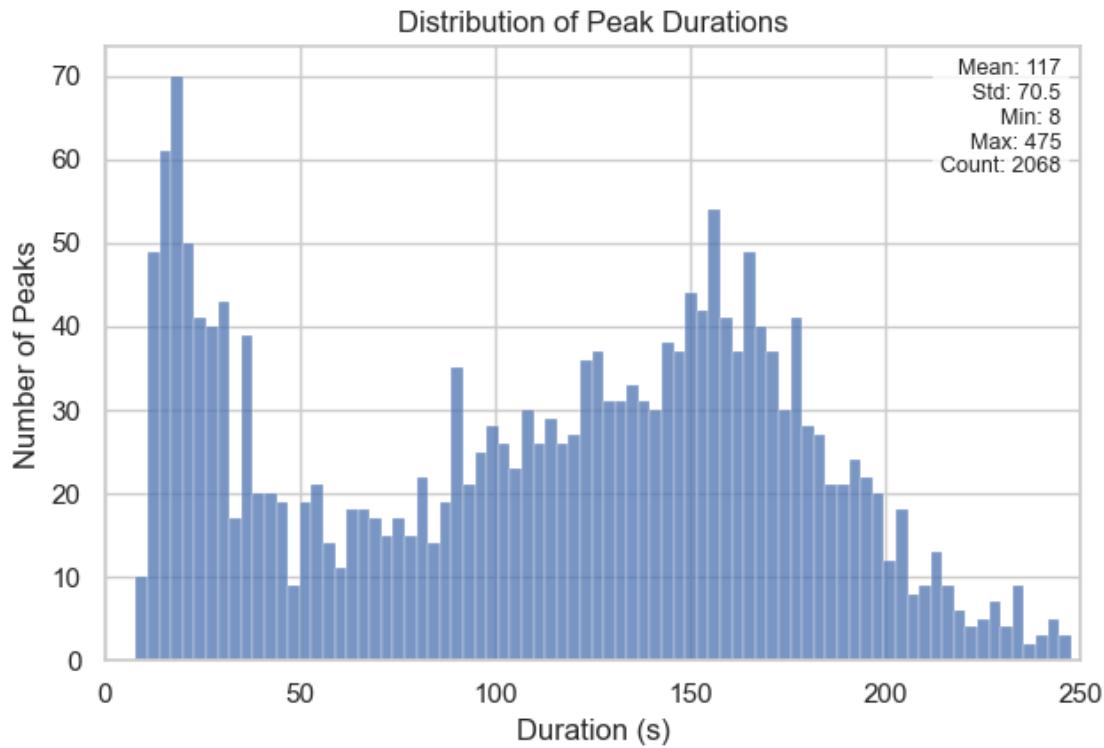
Distribution of Peak Symmetry Scores by Group



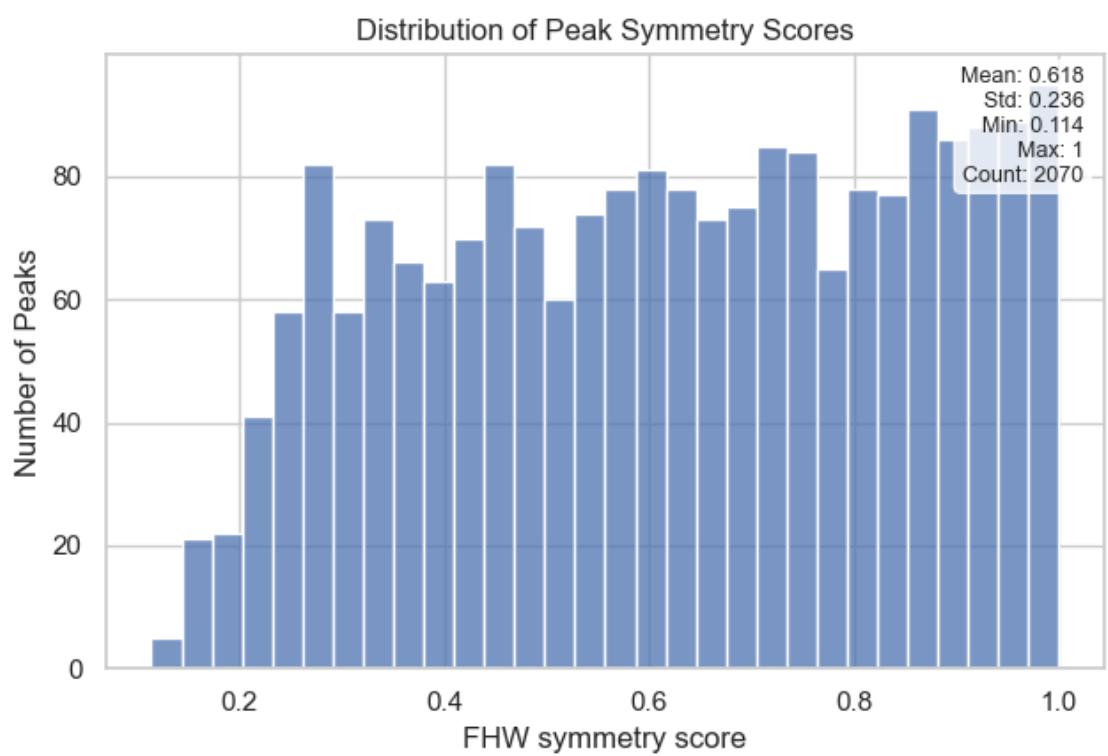
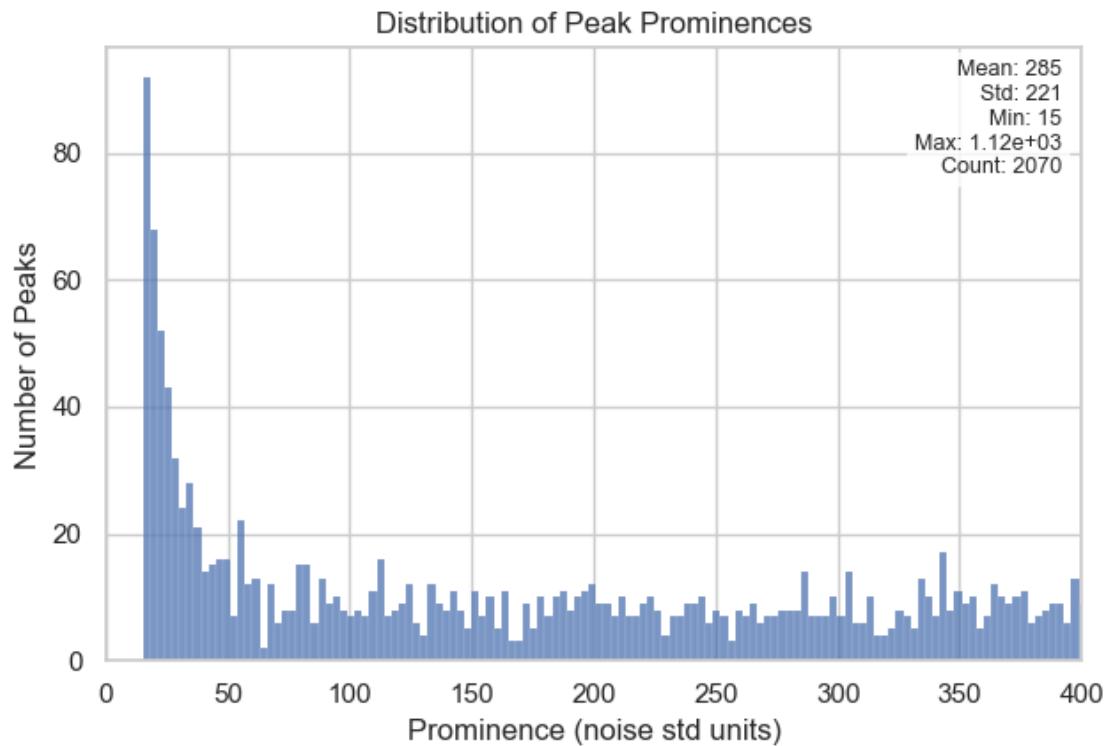
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

[2025-08-13 11:29:13] [INFO] calcium: plot_histogram: removed 2 outliers out of 2070 on 'Duration (s)' (lower=-279, upper=498)

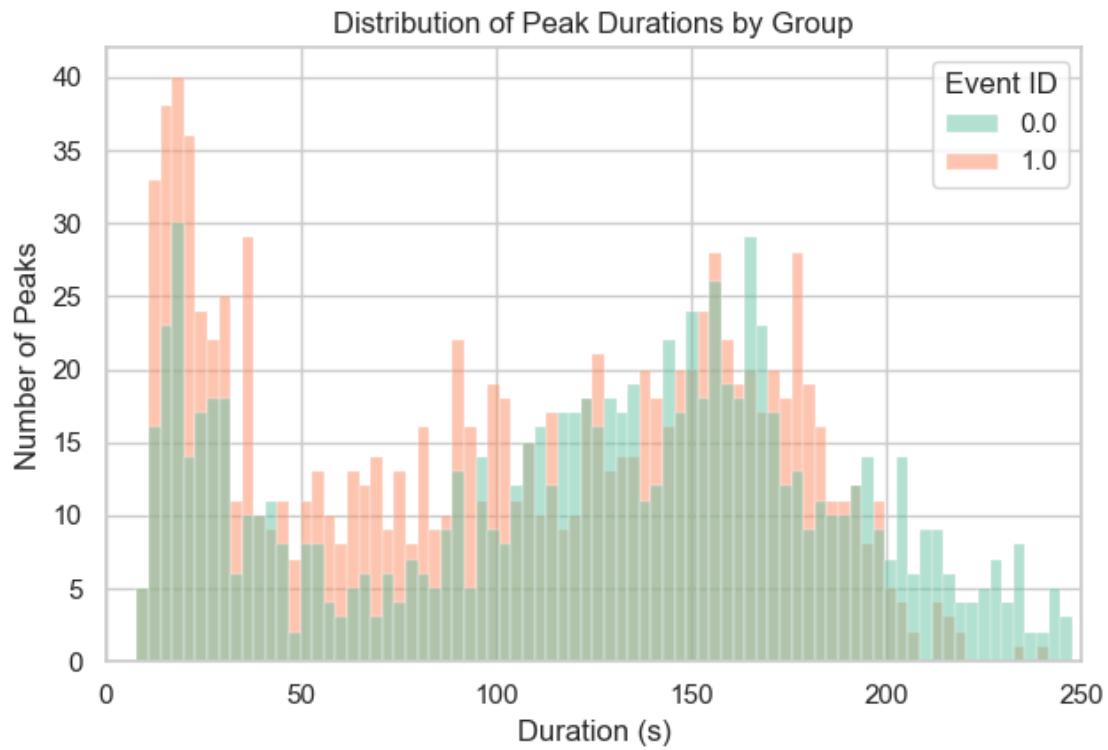


[2025-08-13 11:29:13] [INFO] calcium: plot_histogram: removed 0 outliers out of 2070 on 'Prominence (noise std units)' (lower=-1015.8, upper=1540.6)



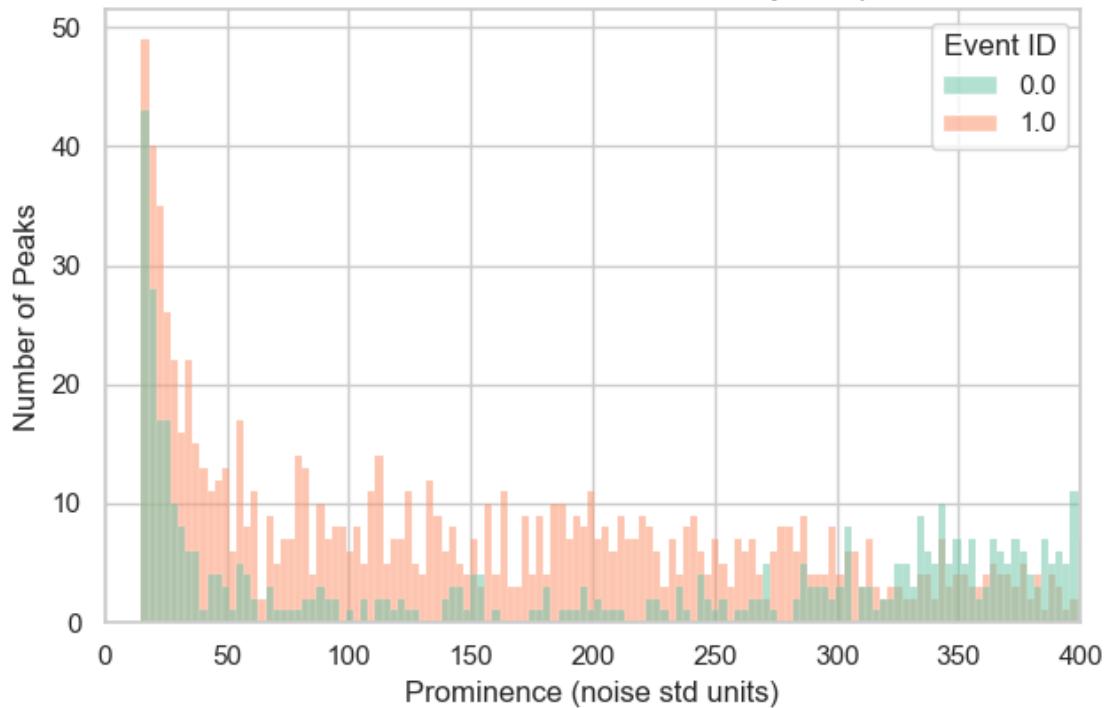
1.2.2 Peak statistics in global event per event ID

[2025-08-13 11:29:14] [INFO] calcium: plot_histogram_by_group: removed 2 outliers out of 2070 on 'Duration (s)' (lower=-279, upper=498)

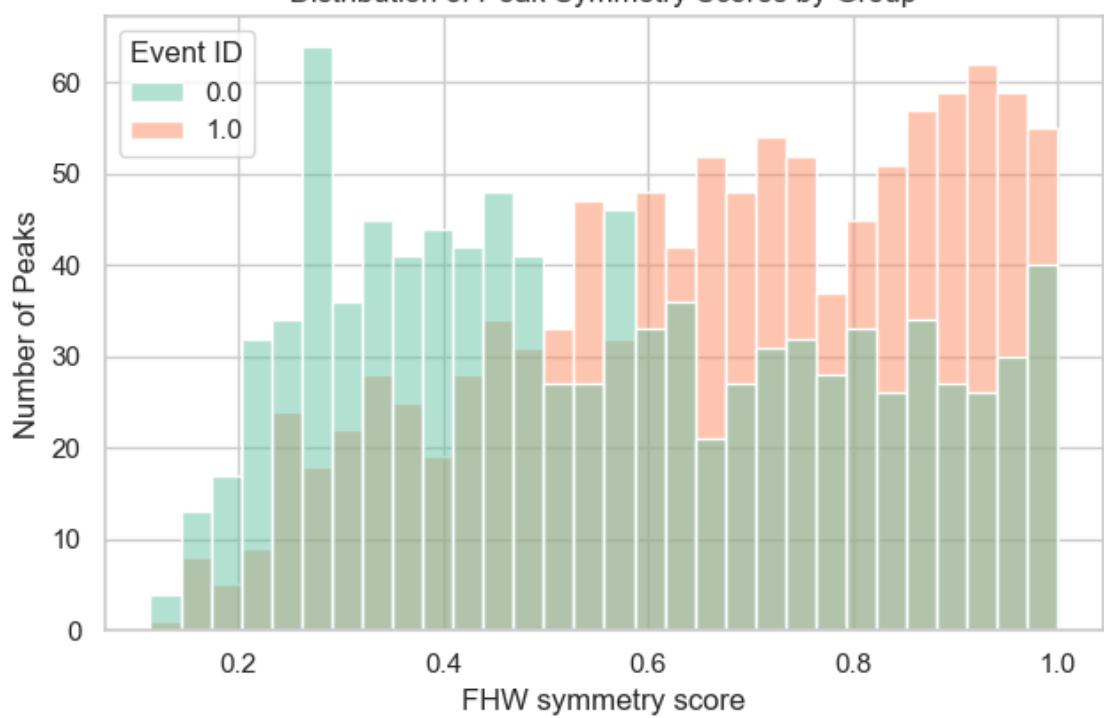


[2025-08-13 11:29:14] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 2070 on 'Prominence (noise std units)' (lower=-1015.8, upper=1540.6)

Distribution of Peak Prominences by Group

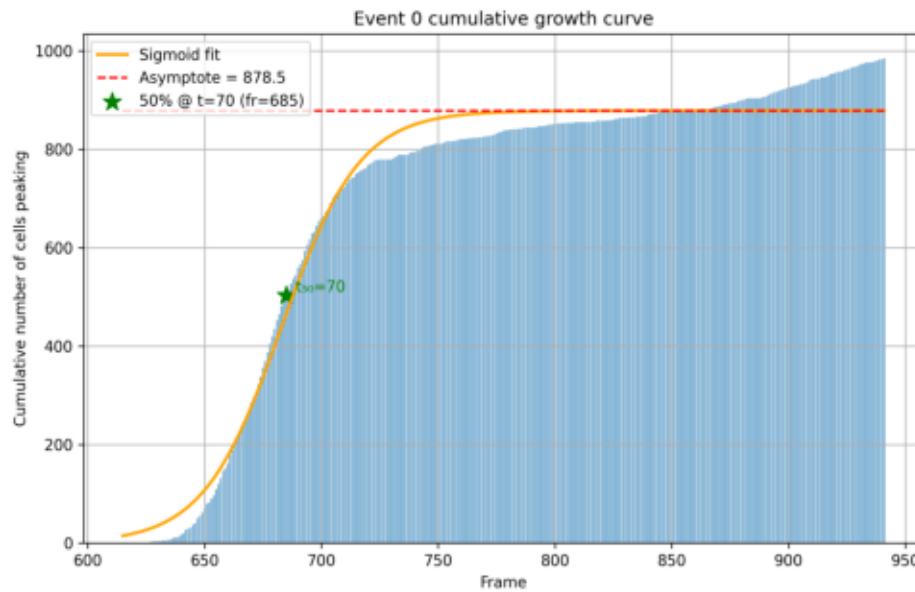


Distribution of Peak Symmetry Scores by Group

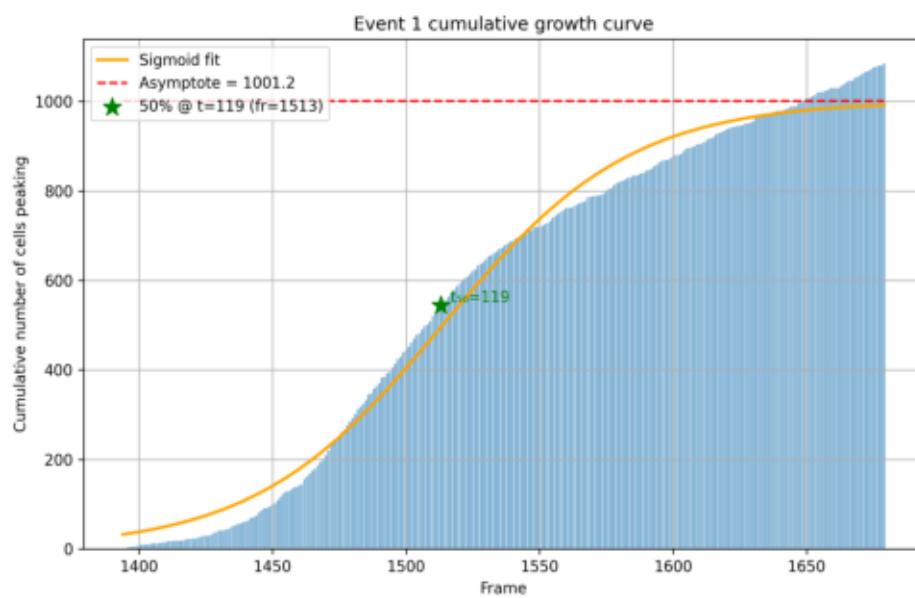


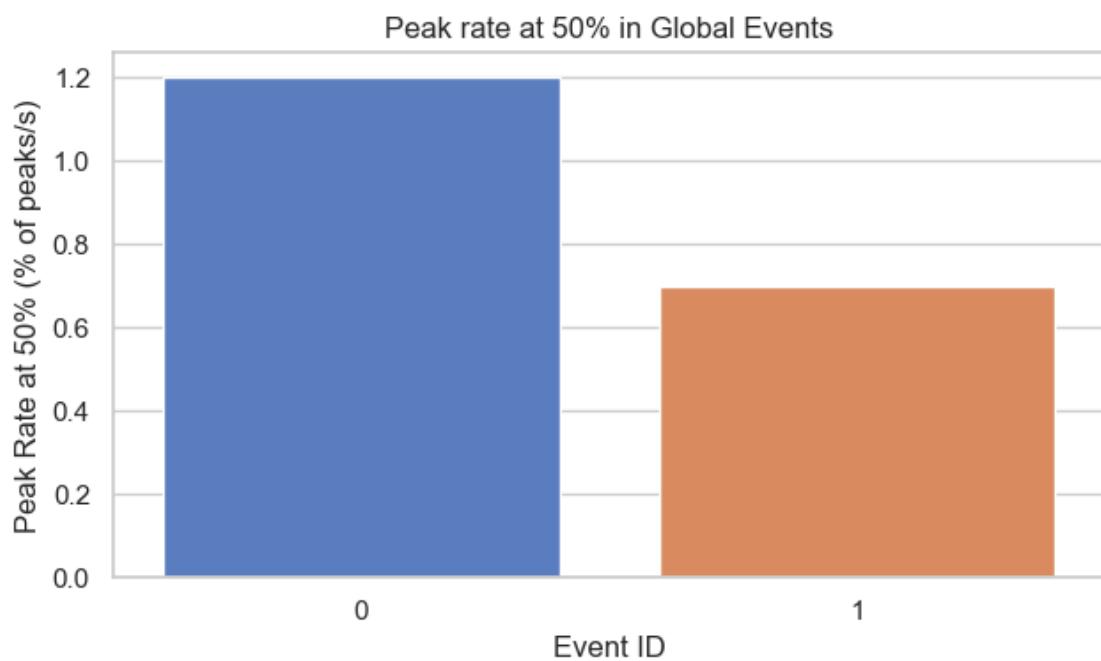
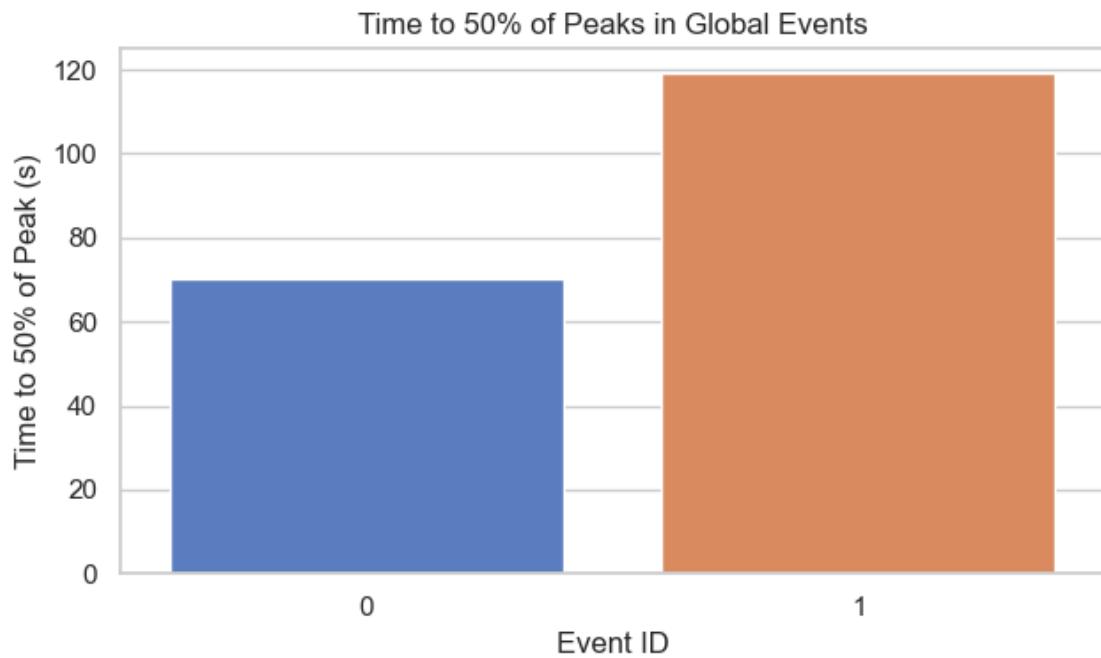
1.2.3 Kinetics of global events

Event Activity Overlay (Event ID: 0) - 20250404_IS3

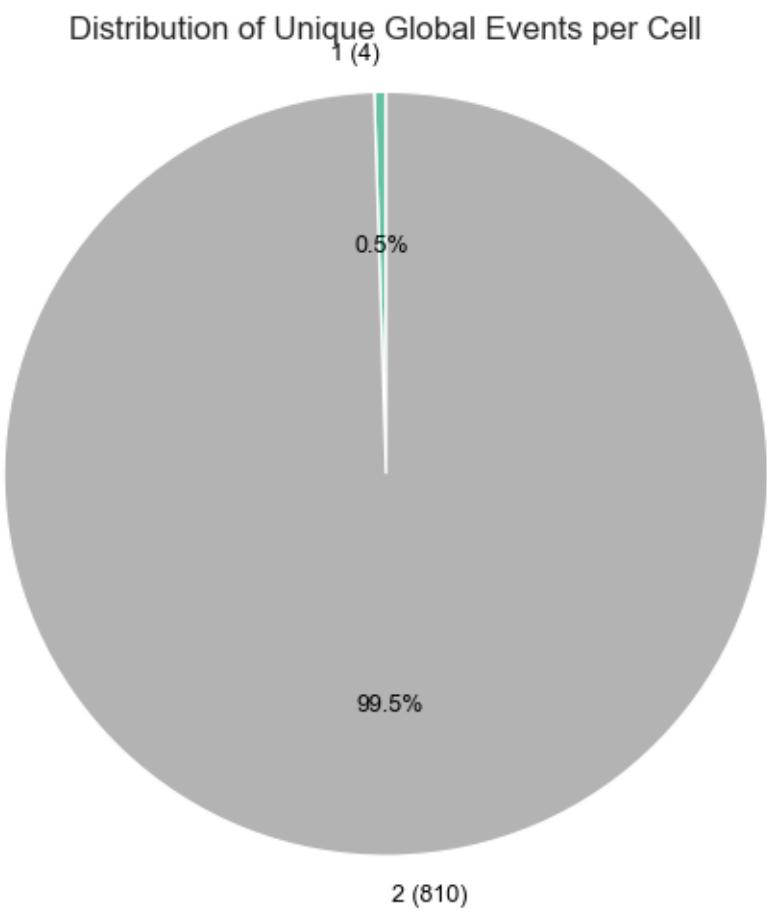


Event Activity Overlay (Event ID: 1) - 20250404_IS3

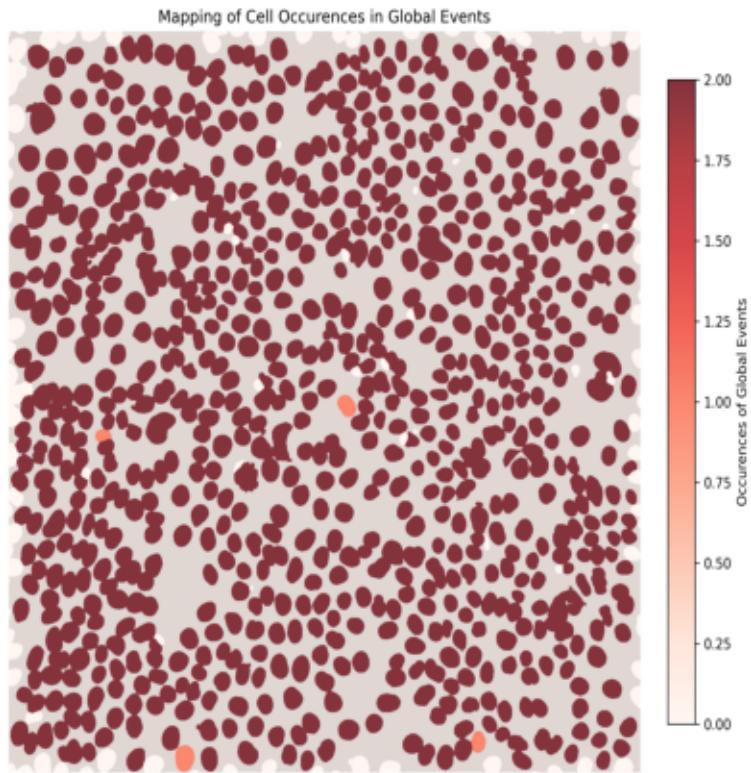


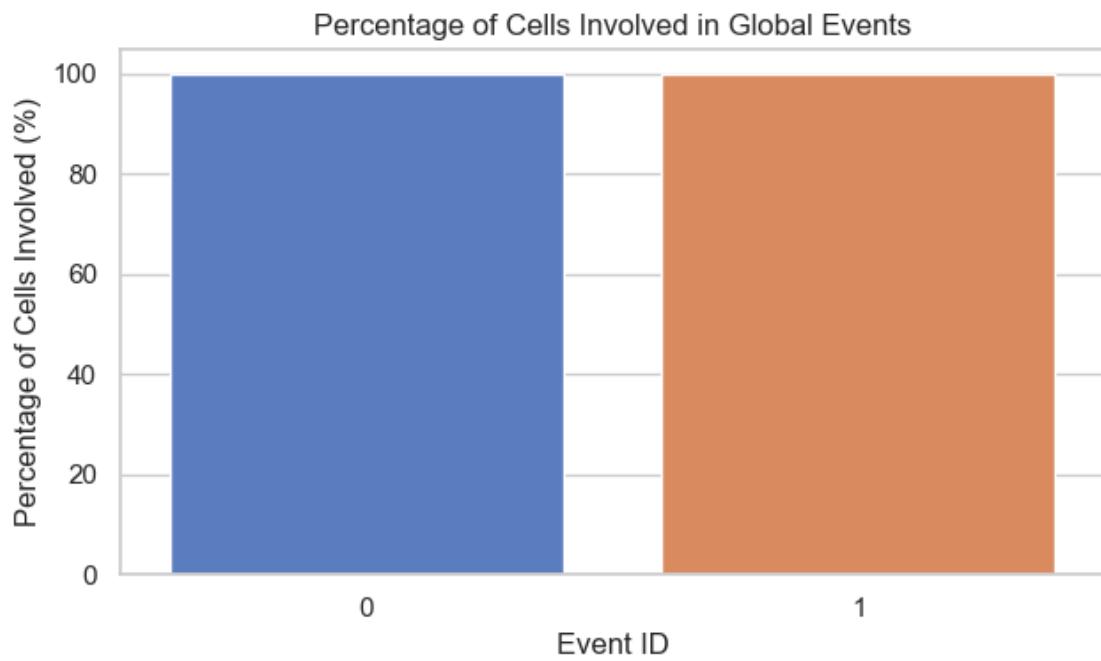


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250404_IS3



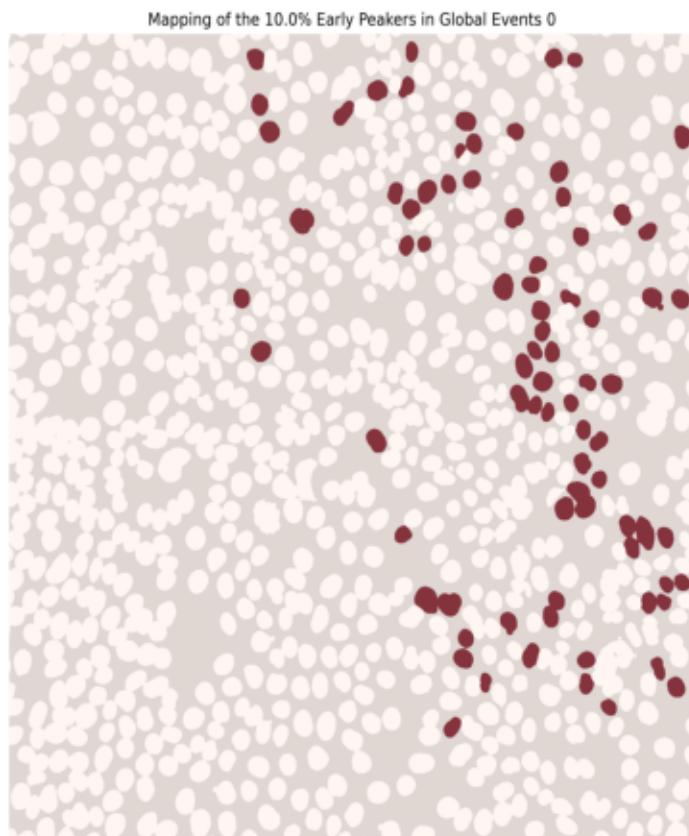


1.2.5 Inter-event interval analysis

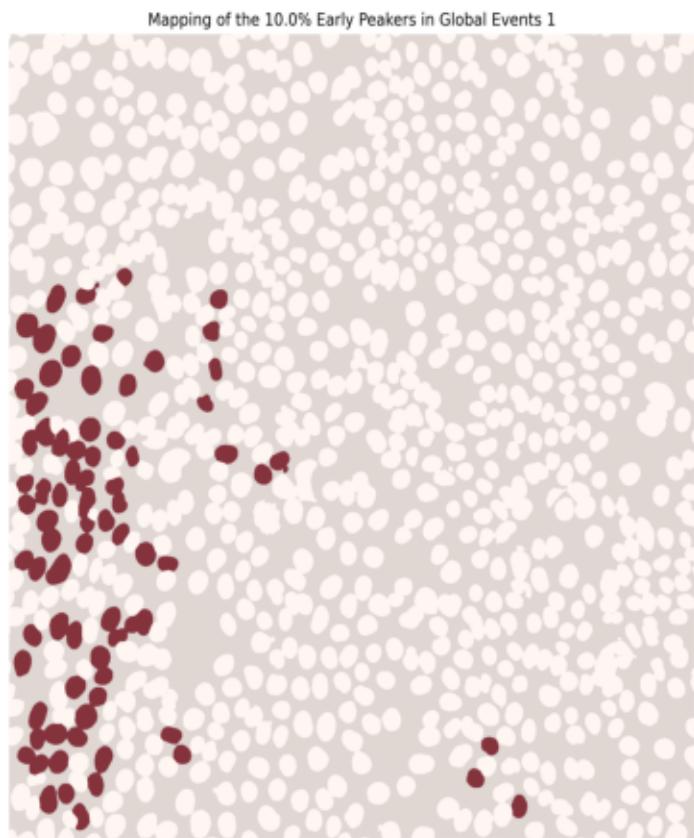
Intervals between global event peaks: [831.0]

1.2.6 Early peakers in the events

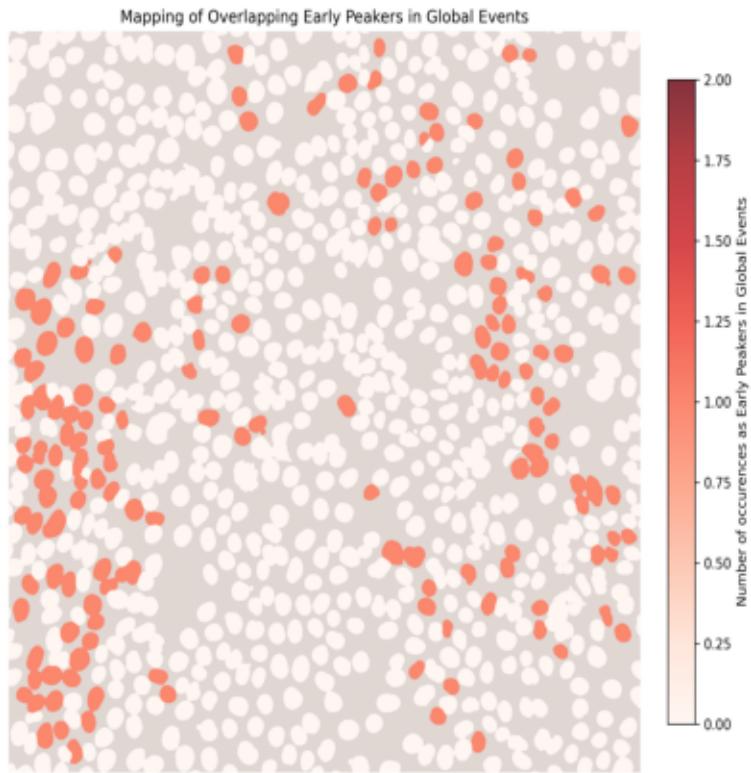
Cell Mapping with Early Peakers Overlay for event 0 - 20250404_IS3

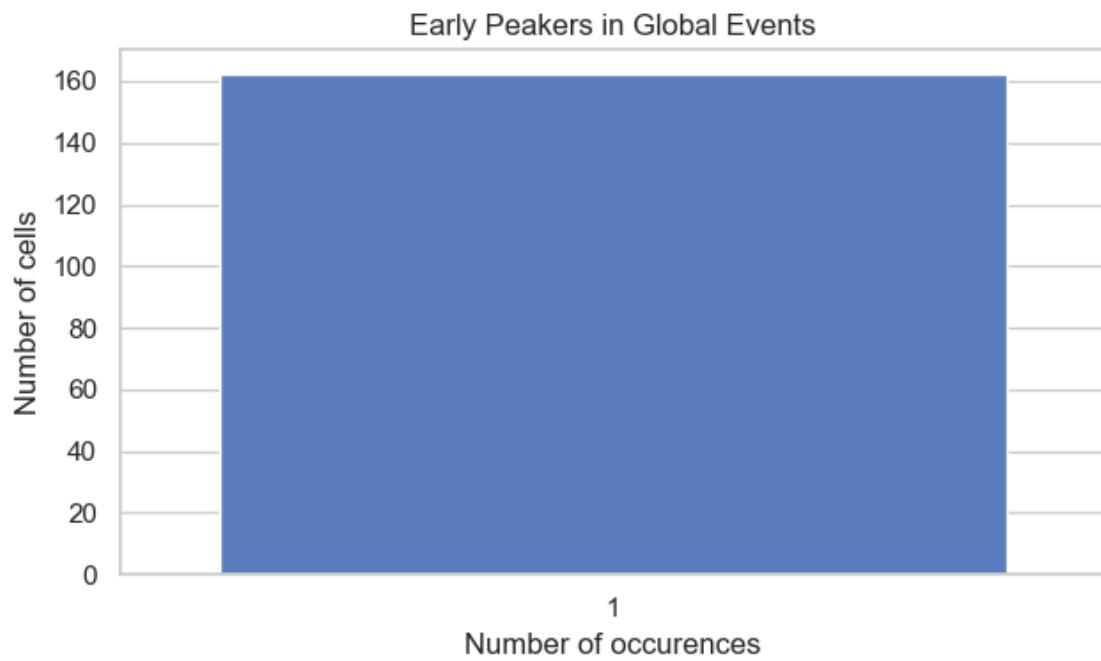


Cell Mapping with Early Peakers Overlay for event 1 - 20250404_IS3

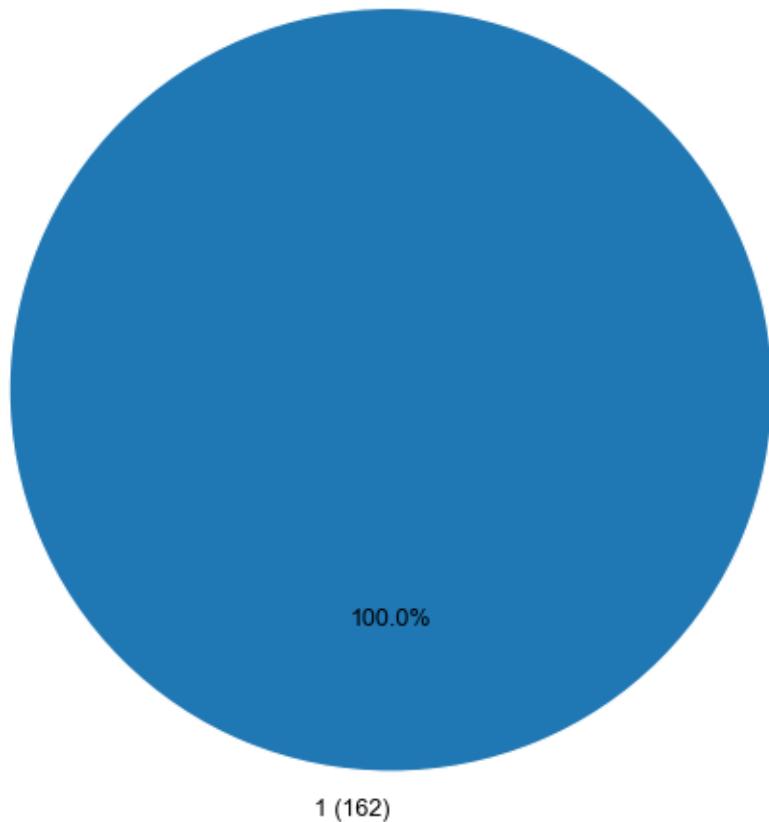


Cell Mapping with Occurrences in Global Events Overlay - 20250404_IS3



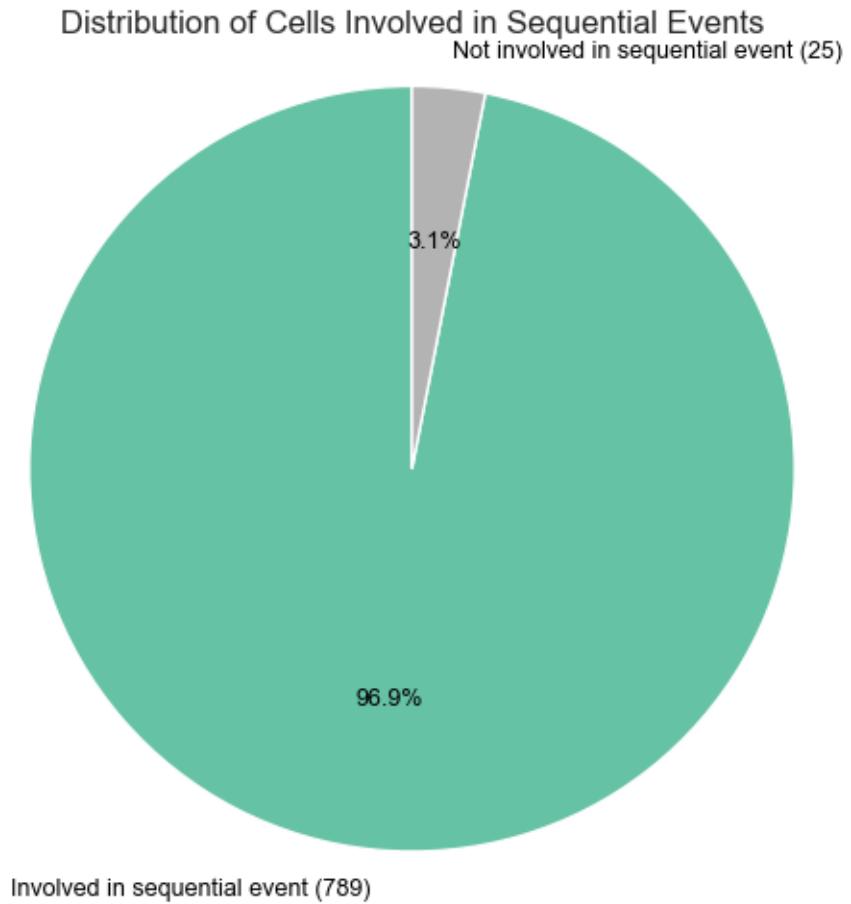


Distribution of Early Peakers in Global Events

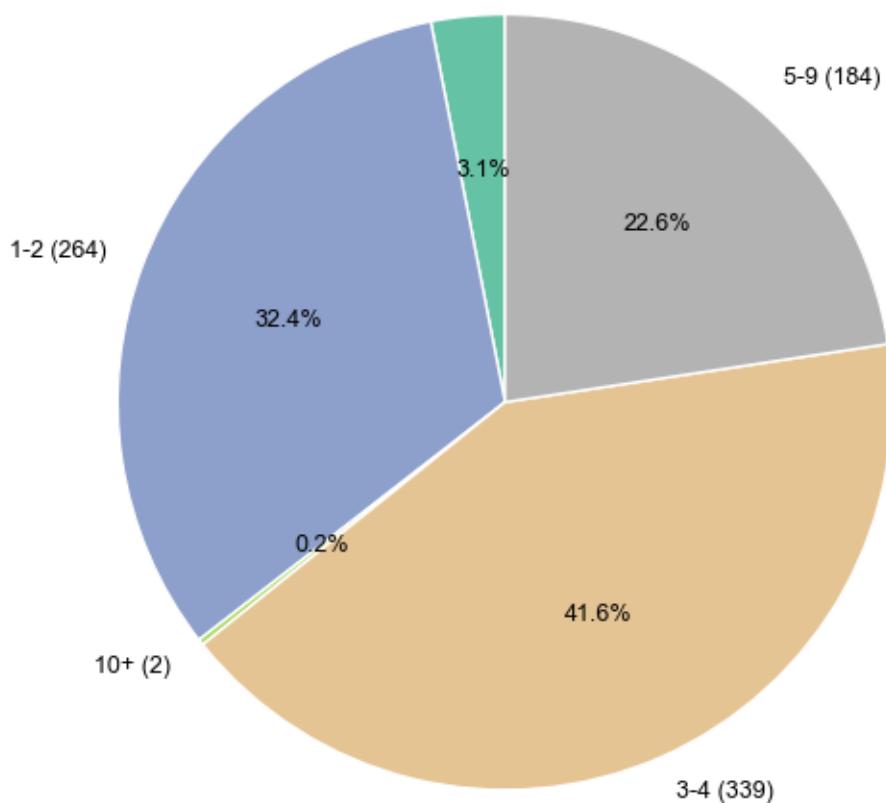


1.3 SEQUENTIAL EVENTS

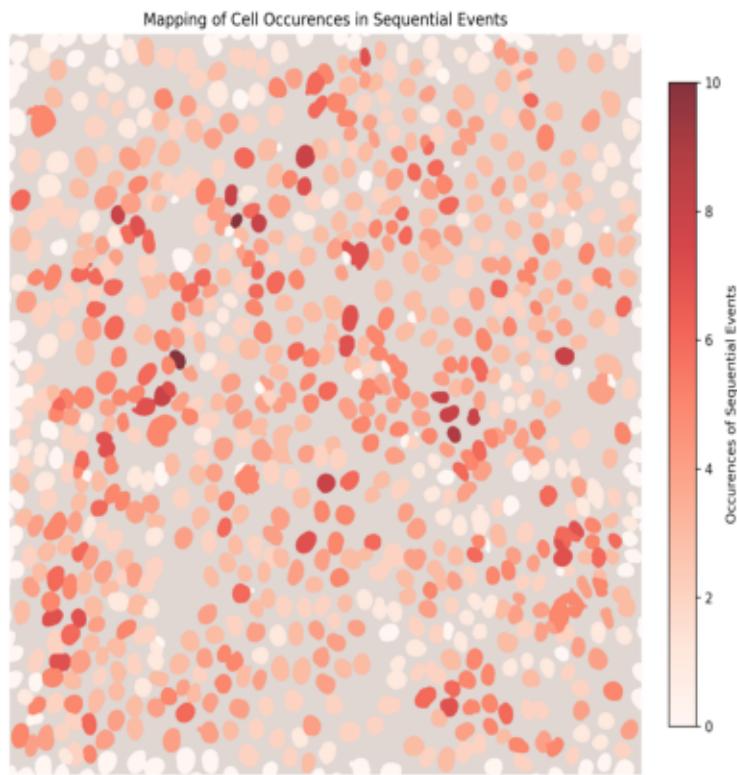
1.3.1 Cells occurrences in sequential events



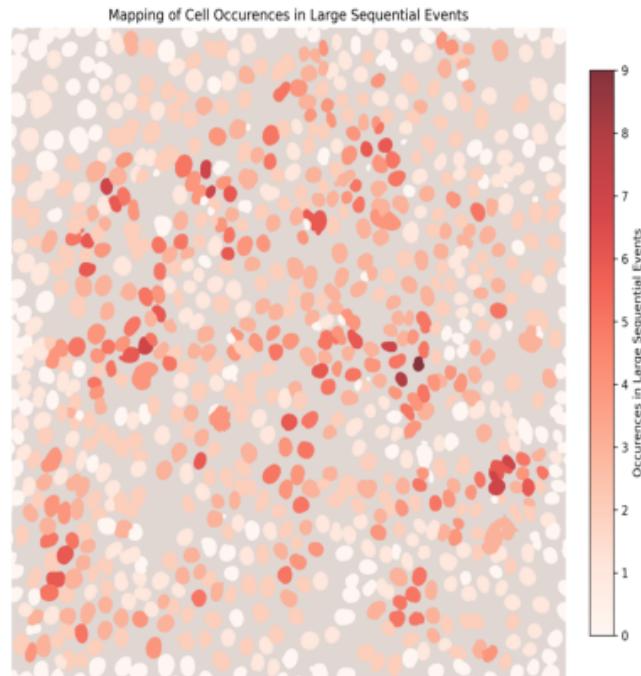
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250404_IS3

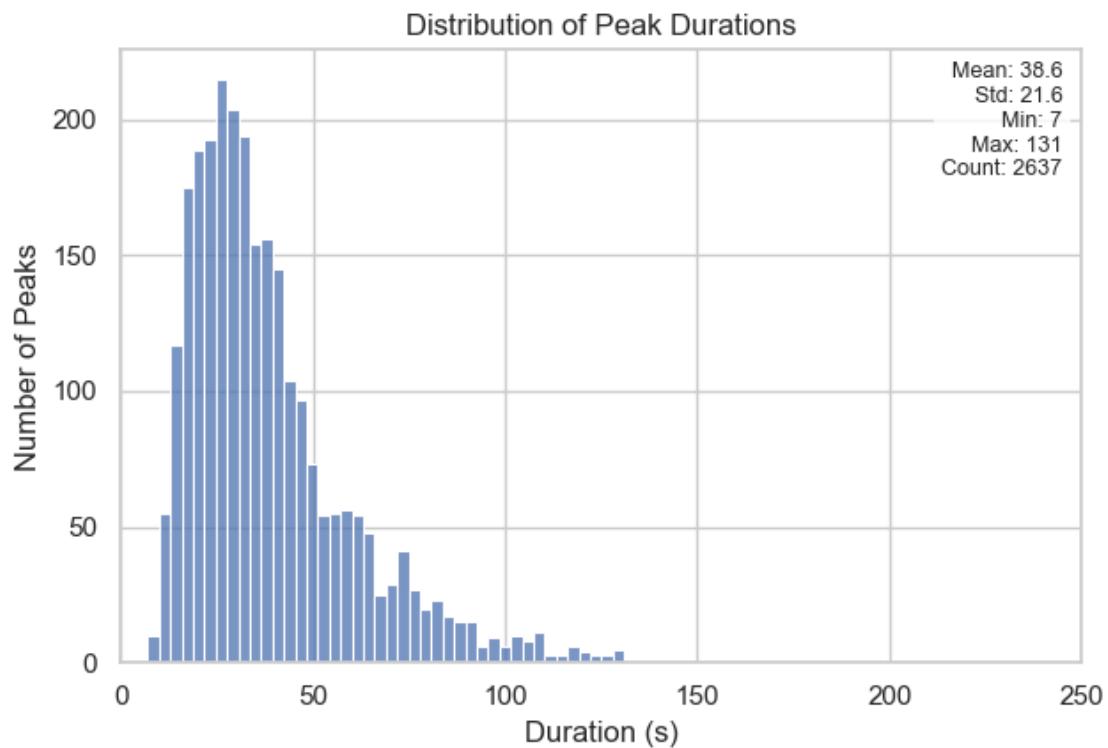


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250404_ISS

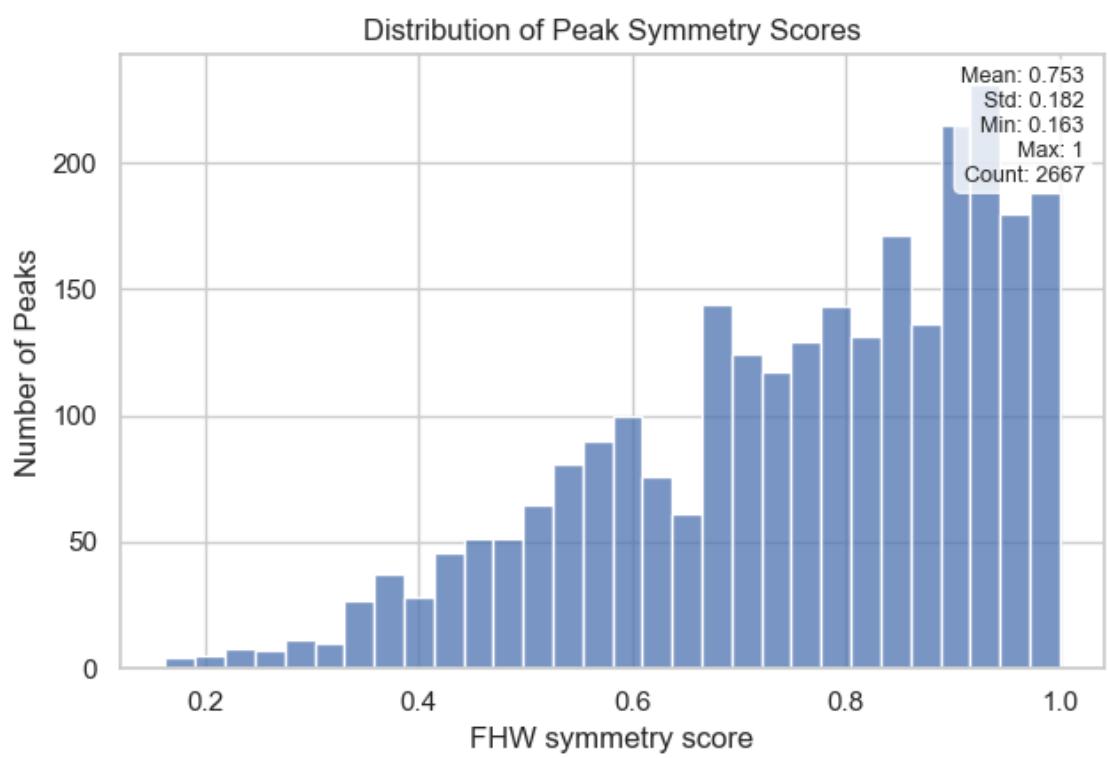
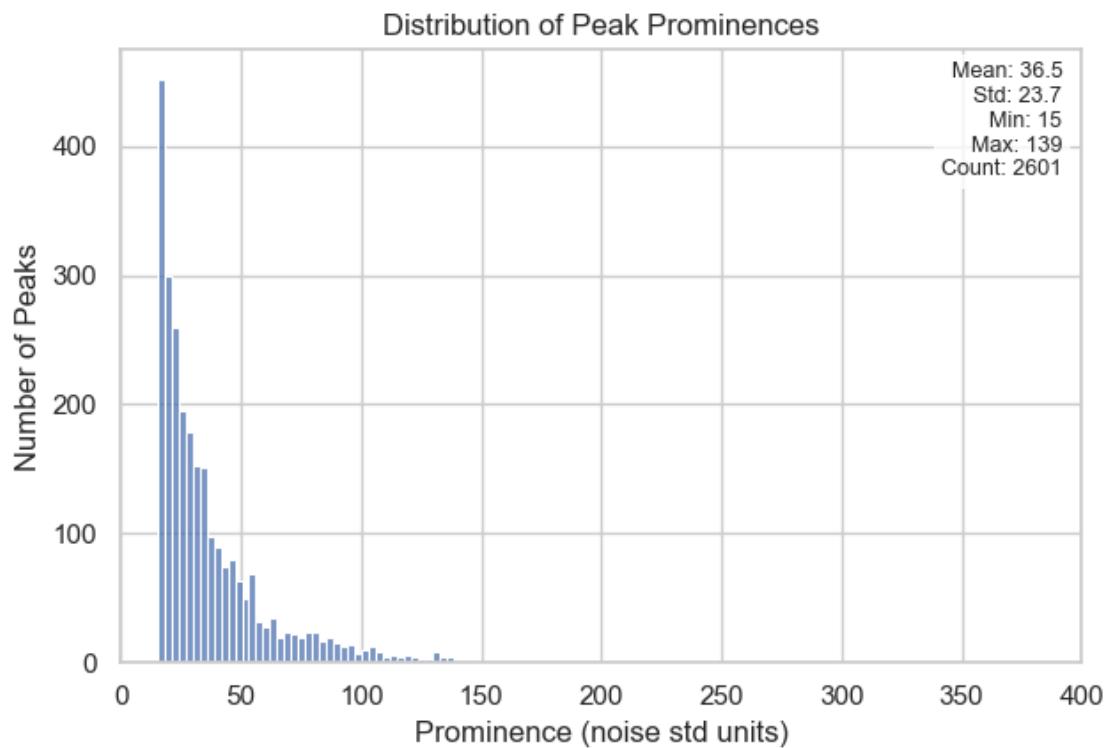


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 11:29:24] [INFO] calcium: plot_histogram: removed 30 outliers out of 2667 on 'Duration (s)' (lower=-13.25, upper=133.75)
```

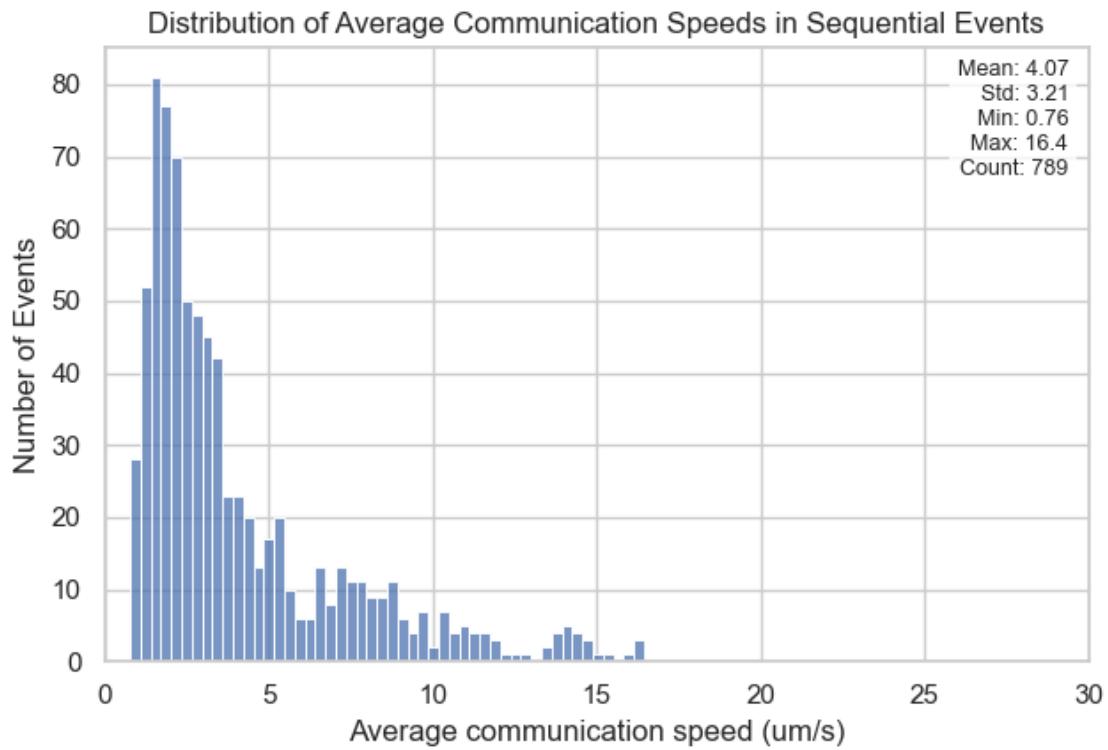


```
[2025-08-13 11:29:25] [INFO] calcium: plot_histogram: removed 66 outliers out of  
2667 on 'Prominence (noise std units)' (lower=-19.9, upper=139.7)
```

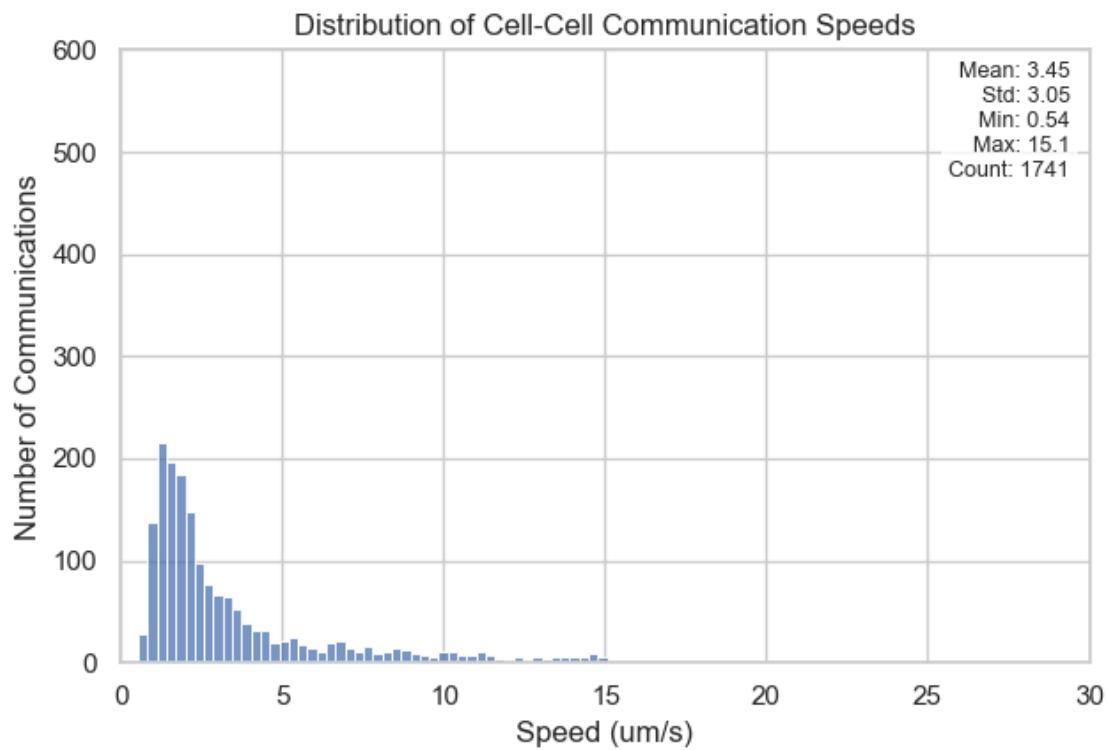


1.3.3 Cell-cell communication speed

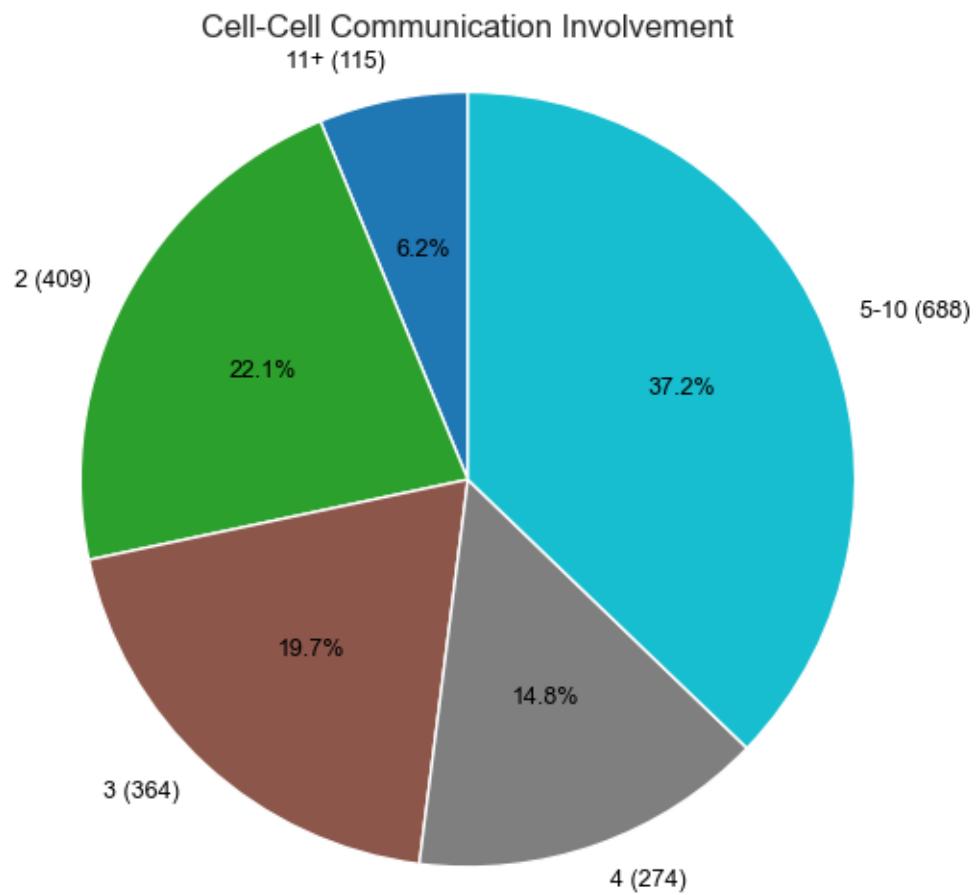
[2025-08-13 11:29:25] [INFO] calcium: plot_histogram: removed 28 outliers out of 817 on 'Average communication speed (um/s)' (lower=-9.3, upper=16.74)



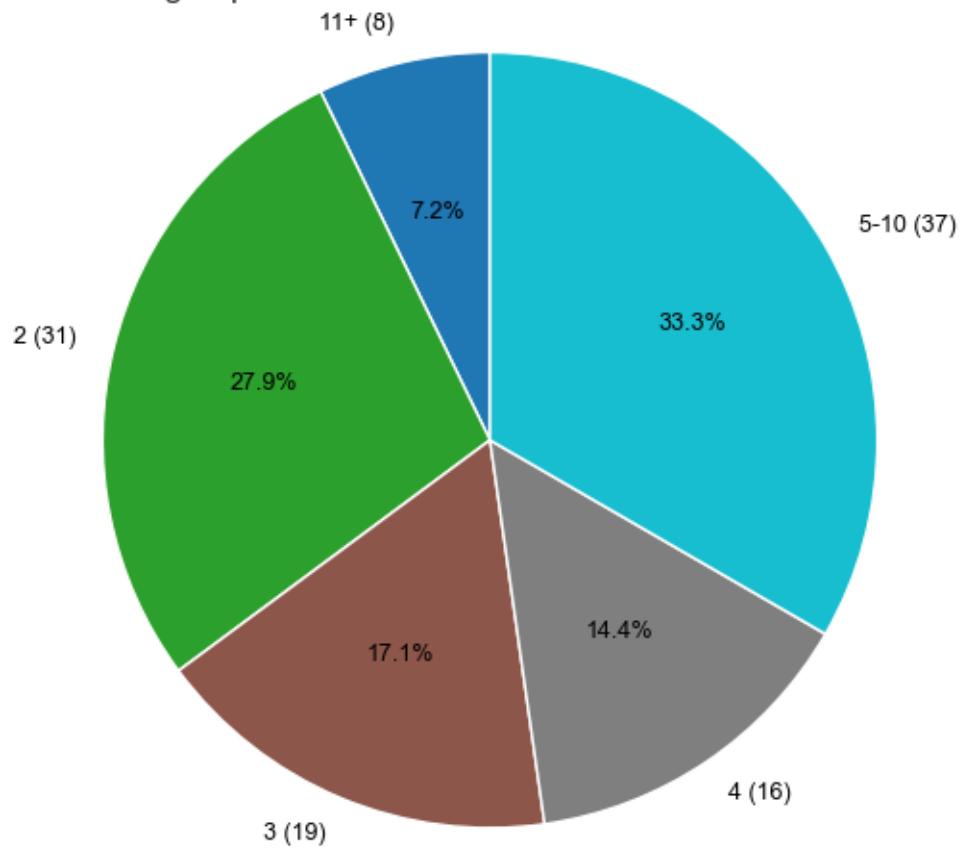
[2025-08-13 11:29:25] [INFO] calcium: plot_histogram: removed 109 outliers out of 1850 on 'Speed (um/s)' (lower=-8.6575, upper=15.09)



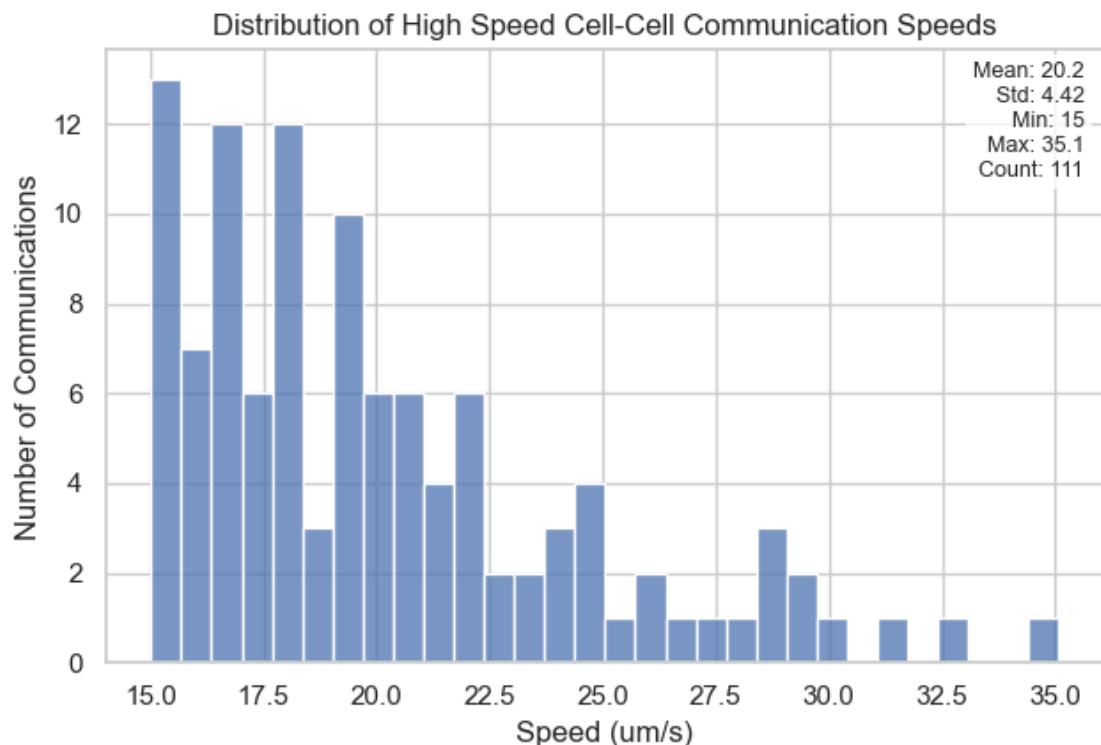
1.3.4 Double distribution in cell-cell communication speeds



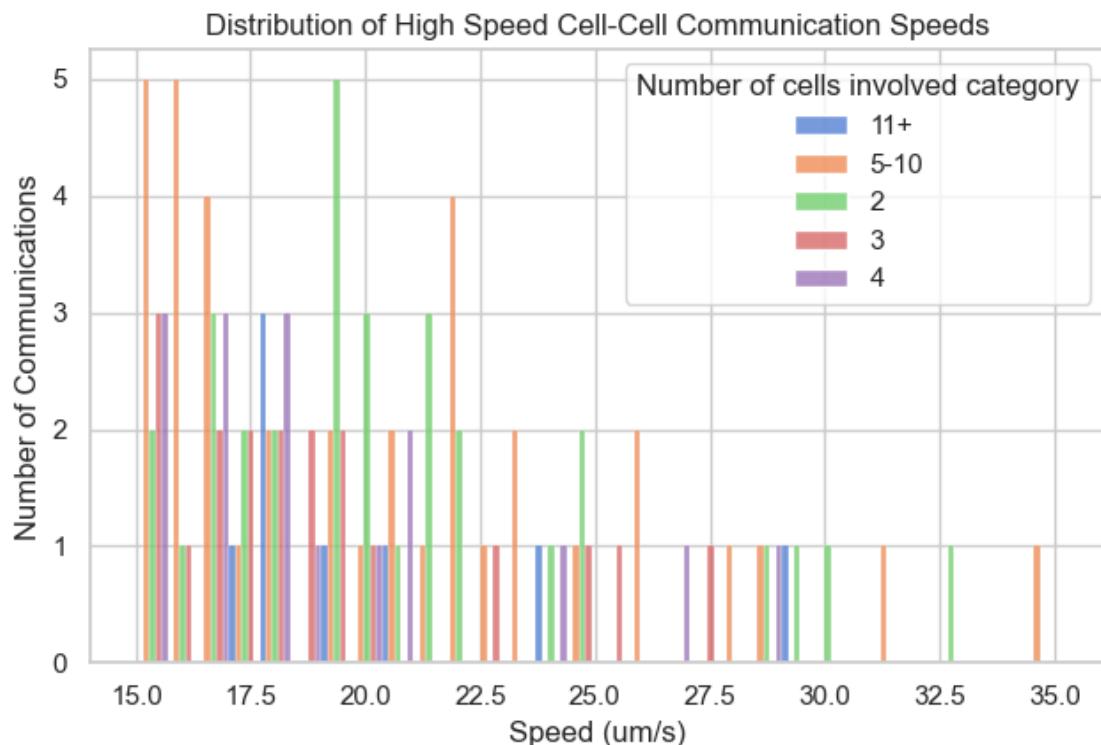
High Speed Cell-Cell Communication Involvement



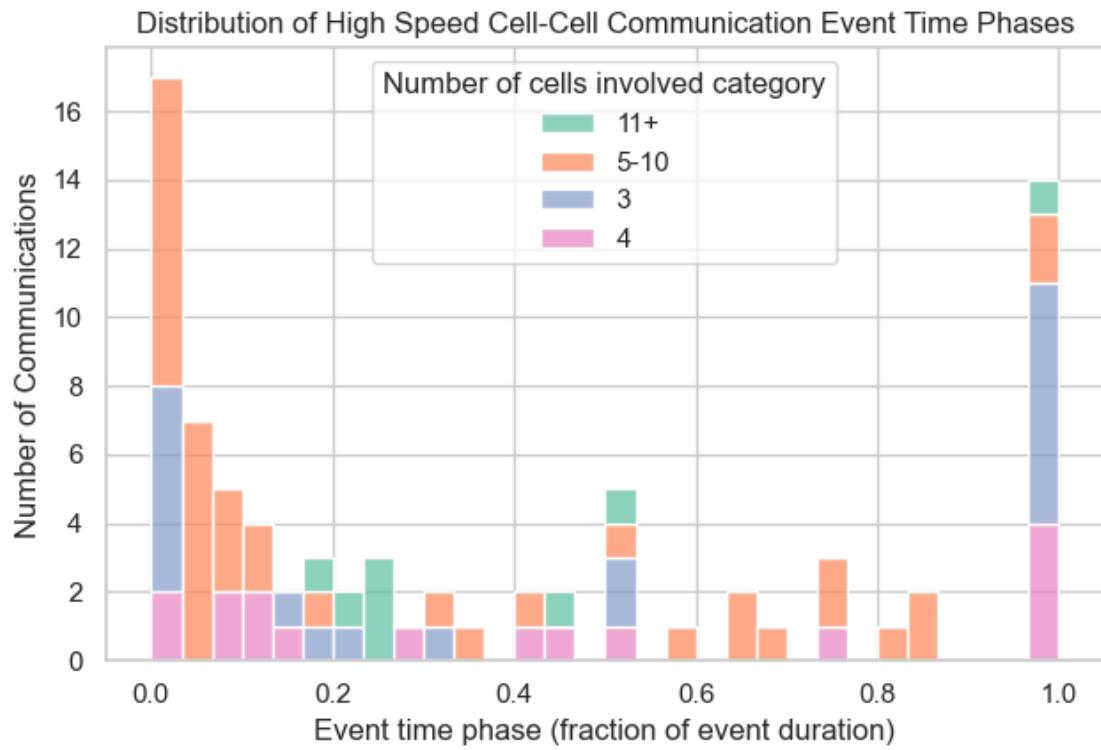
```
[2025-08-13 11:29:26] [INFO] calcium: plot_histogram: removed 0 outliers out of  
111 on 'Speed (um/s)' (lower=0.98, upper=38.08)
```



```
[2025-08-13 11:29:26] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 111 on 'Speed (um/s)' (lower=0.98, upper=38.08)
```

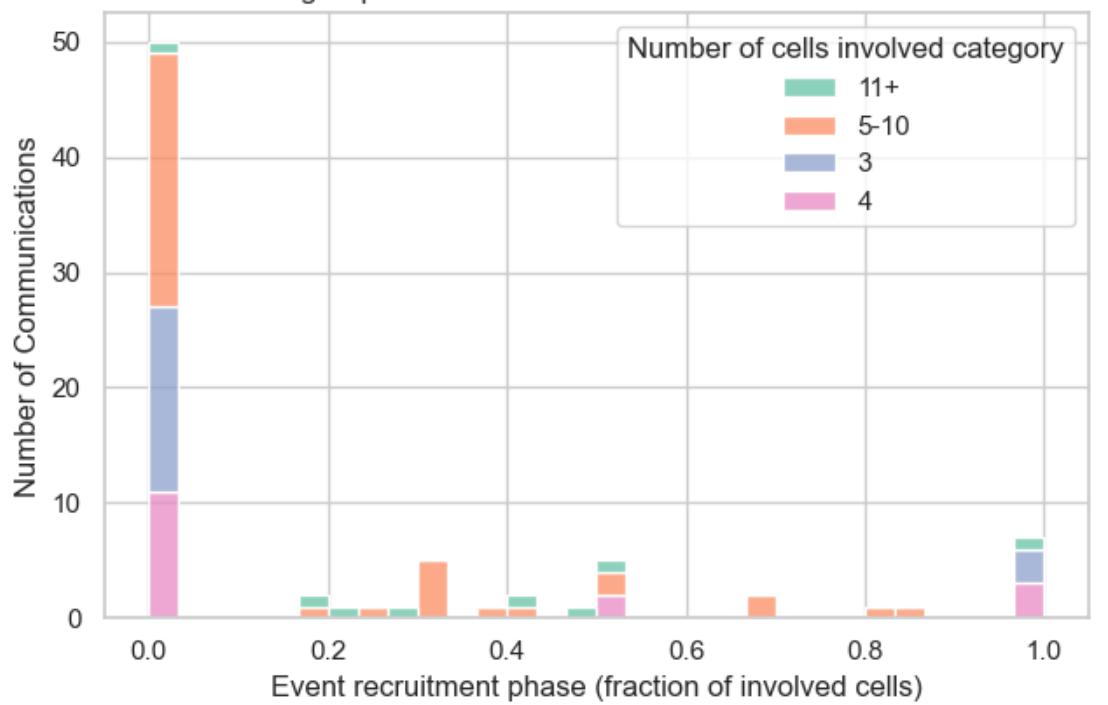


```
[2025-08-13 11:29:26] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 80 on 'Event time phase (fraction of event duration)' (lower=-1.845, upper=2.6)
```

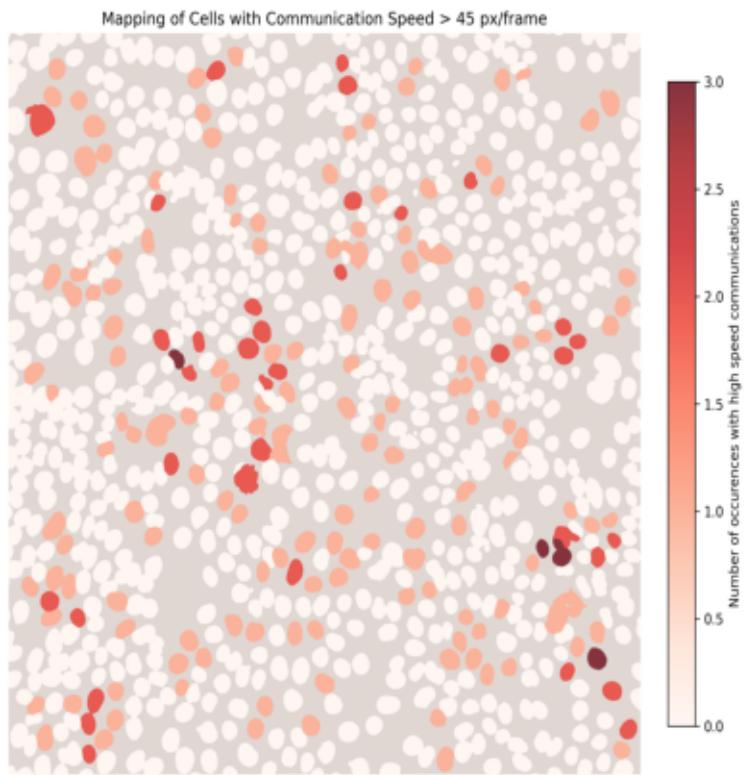


```
[2025-08-13 11:29:27] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 80 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.0275, upper=1.37)
```

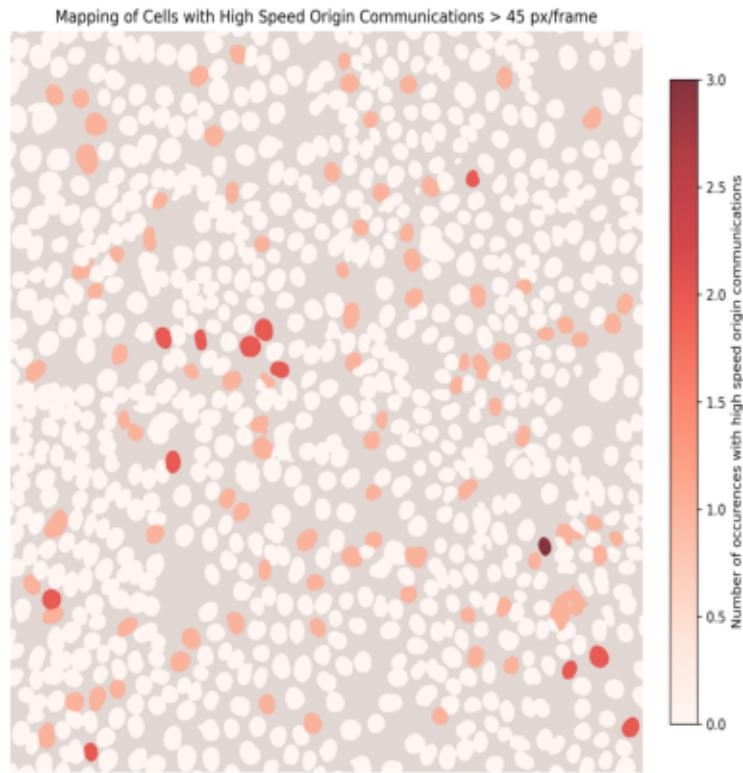
Distribution of High Speed Cell-Cell Communication Event Recruitment Phases



Cell Mapping with High Speed Cells Overlay - 20250404_IS3



Cell Mapping with High Speed Origin Cells Overlay - 20250404_IS3



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
8	1759531955824	5	602		1
16	1759422969792	5	661		0
22	1759531949392	6	520		0
29	1759531950688	7	492		2
36	1759531950736	8	220		0
...
1765	1759488006304	760	1158		5
1766	1759488001600	761	1271		6
1808	1759488004336	786	1303		2
1818	1759488012112	793	1237		0
1834	1759488003376	806	1303		8

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
8	634	1	100.0	100.0	
16	713	0	102.0	103.0	
22	553	1	222.0	222.0	
29	455	1	222.0	222.0	
36	188	1	117.0	117.0	
...	
1765	1215	4	966.0	967.0	
1766	1215	5	1136.0	1137.0	
1808	1264	2	308.0	309.0	
1818	1270	1	241.0	242.0	
1834	1286	7	1114.0	1115.0	
	Duration (s)	Distance (um)	Speed (um/s)	\	
8	0.0	17.70	17.70		
16	1.0	29.26	29.26		
22	0.0	16.45	16.45		
29	0.0	16.86	16.86		
36	0.0	19.13	19.13		
...	
1765	1.0	25.03	25.03		
1766	1.0	28.93	28.93		
1808	1.0	20.15	20.15		
1818	1.0	17.15	17.15		
1834	1.0	15.02	15.02		
	Event time phase (fraction of event duration)	\			
8		0.45			
16		0.51			
22		0.35			
29		0.00			
36		NaN			
...		...			
1765		NaN			
1766		NaN			
1808		NaN			
1818		NaN			
1834		NaN			
	Event recruitment phase (fraction of involved cells)	dataset	\		
8		0.17	20250404_IS3		
16		0.42	20250404_IS3		
22		0.38	20250404_IS3		
29		0.00	20250404_IS3		
36		NaN	20250404_IS3		
...			
1765		NaN	20250404_IS3		
1766		NaN	20250404_IS3		

1808		NaN	20250404_IS3
1818		NaN	20250404_IS3
1834		NaN	20250404_IS3

	Number of cells involved	category	Speed category
8		11+	High speed
16		11+	High speed
22		5-10	High speed
29		5-10	High speed
36		2	High speed
...	
1765		2	High speed
1766		2	High speed
1808		2	High speed
1818		2	High speed
1834		2	High speed

[111 rows x 16 columns]

Origin cell ID	Speed category	High speed	Low speed
153		0	1
154		0	4
155		0	2
156		0	2
161		0	1
...
1303		2	1
1304		0	2
1311		0	2
1319		0	1
1321		0	1

[679 rows x 2 columns]

	Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
1	153	332.48	9.10	
2	154	387.07	9.10	
3	155	292.50	10.72	
4	156	94.58	11.38	
6	161	309.73	13.00	
..	
801	1303	63.05	484.90	
802	1304	188.50	485.88	
807	1311	344.82	488.80	
811	1319	404.95	490.75	
813	1321	235.62	490.75	

Number of peaks Is active Occurences in global events \

1	8	True	2
2	7	True	2
3	8	True	2
4	11	True	2
6	6	True	2
..
801	11	True	2
802	5	True	2
807	9	True	2
811	7	True	2
813	5	True	2

Occurrences in global events as early peaker \

1	0
2	0
3	1
4	0
6	0
..	..
801	0
802	0
807	0
811	0
813	0

Occurrences in sequential events \

1	1
2	4
3	3
4	1
6	1
..	..
801	5
802	2
807	3
811	2
813	3

Occurrences in sequential events as origin \

1	1
2	2
3	1
4	1
6	1
..	..
801	3
802	1
807	1

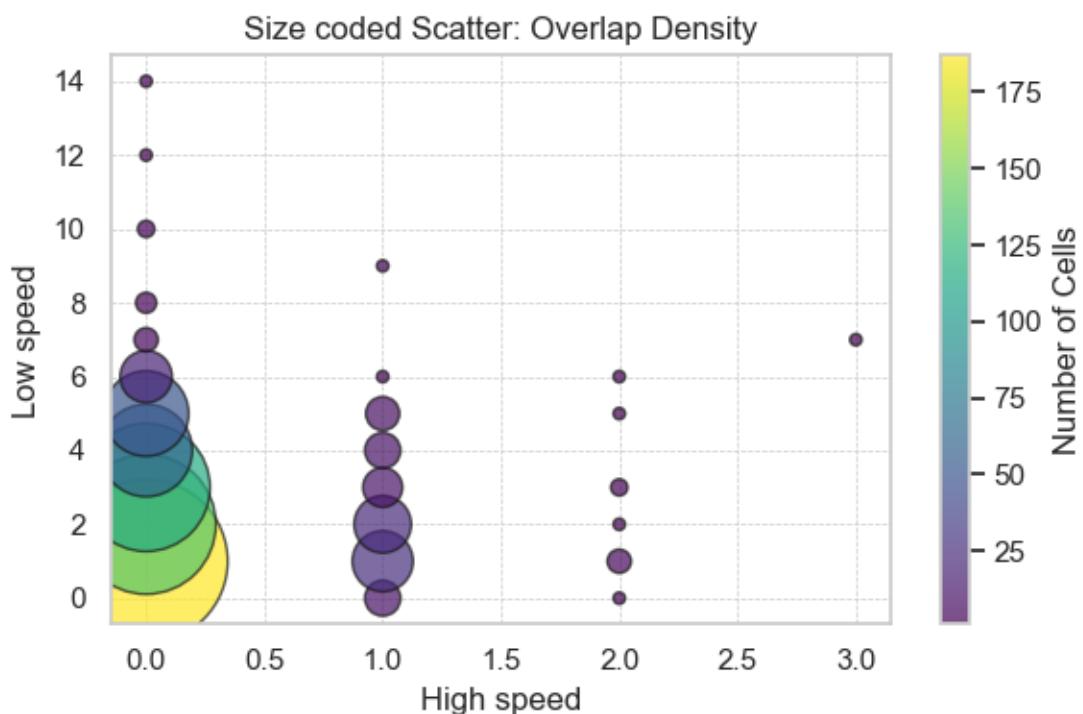
811		1	
813		1	
Occurrences in individual events Peak frequency (Hz) Periodicity score \			
1	4	0.0047	0.69
2	1	0.0041	0.46
3	2	0.0047	0.70
4	8	0.0065	0.55
6	3	0.0035	0.49
..
801	4	0.0065	0.58
802	1	0.0029	0.55
807	4	0.0053	0.60
811	3	0.0041	0.63
813	0	0.0029	0.55
Neighbor count Neighbors (labels) dataset \			
1	3	[162,185,187]	20250404_IS3
2	3	[163,178,201]	20250404_IS3
3	3	[161,167,190]	20250404_IS3
4	4	[152,172,173,203]	20250404_IS3
6	3	[155,185,190]	20250404_IS3
..
801	3	[1264,1286,1302]	20250404_IS3
802	3	[1270,1272,1285]	20250404_IS3
807	4	[1251,1273,1300,1310]	20250404_IS3
811	2	[1292,1294]	20250404_IS3
813	3	[1283,1301,1308]	20250404_IS3
Involved in sequential event Occurrences in sequential events category \			
1	Involved in sequential event		1-2
2	Involved in sequential event		3-4
3	Involved in sequential event		3-4
4	Involved in sequential event		1-2
6	Involved in sequential event		1-2
..
801	Involved in sequential event		5-9
802	Involved in sequential event		1-2
807	Involved in sequential event		3-4
811	Involved in sequential event		1-2
813	Involved in sequential event		3-4
High speed Low speed			
1	0.0	1.0	
2	0.0	4.0	
3	0.0	2.0	
4	0.0	2.0	
6	0.0	1.0	

```

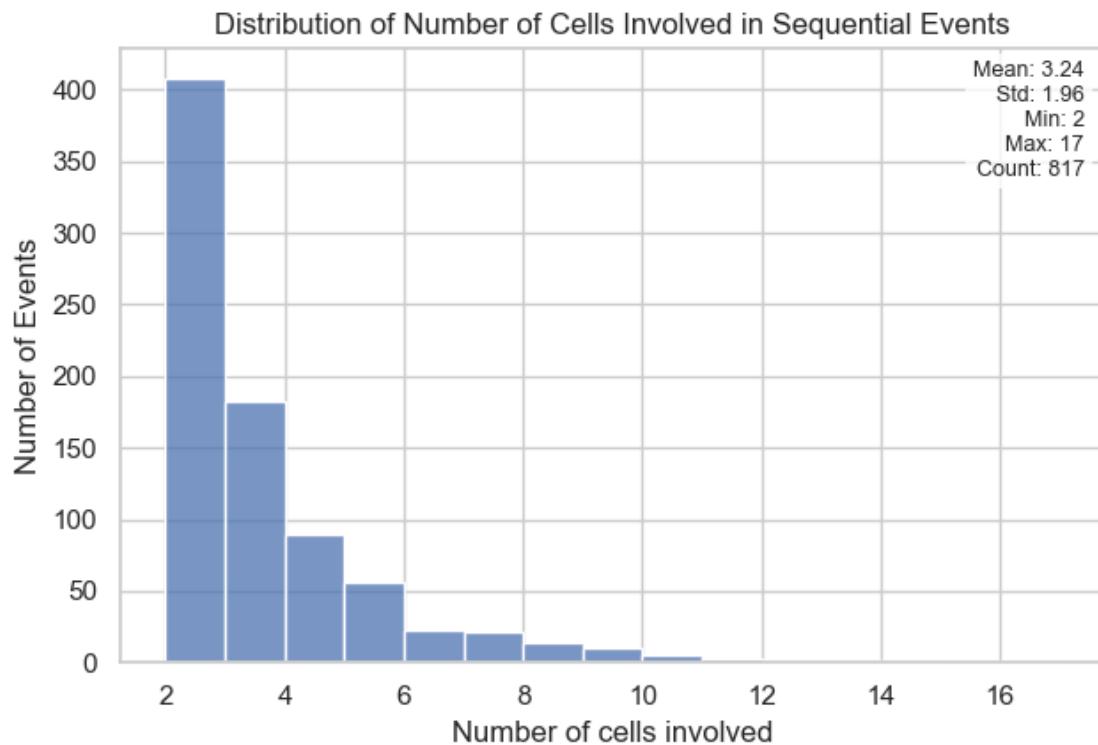
...
801      2.0      1.0
802      0.0      2.0
807      0.0      2.0
811      0.0      1.0
813      0.0      1.0

```

[679 rows x 19 columns]



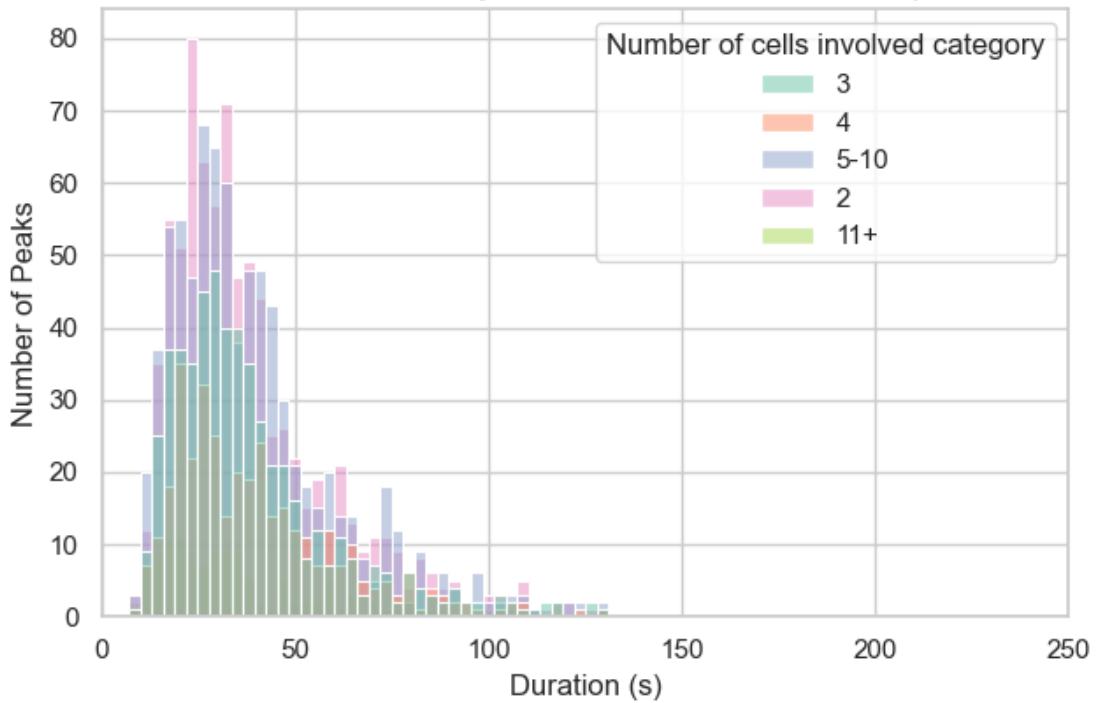
1.3.5 Number of cells involved per sequential events



1.3.6 Influence of cell count per event on statistics

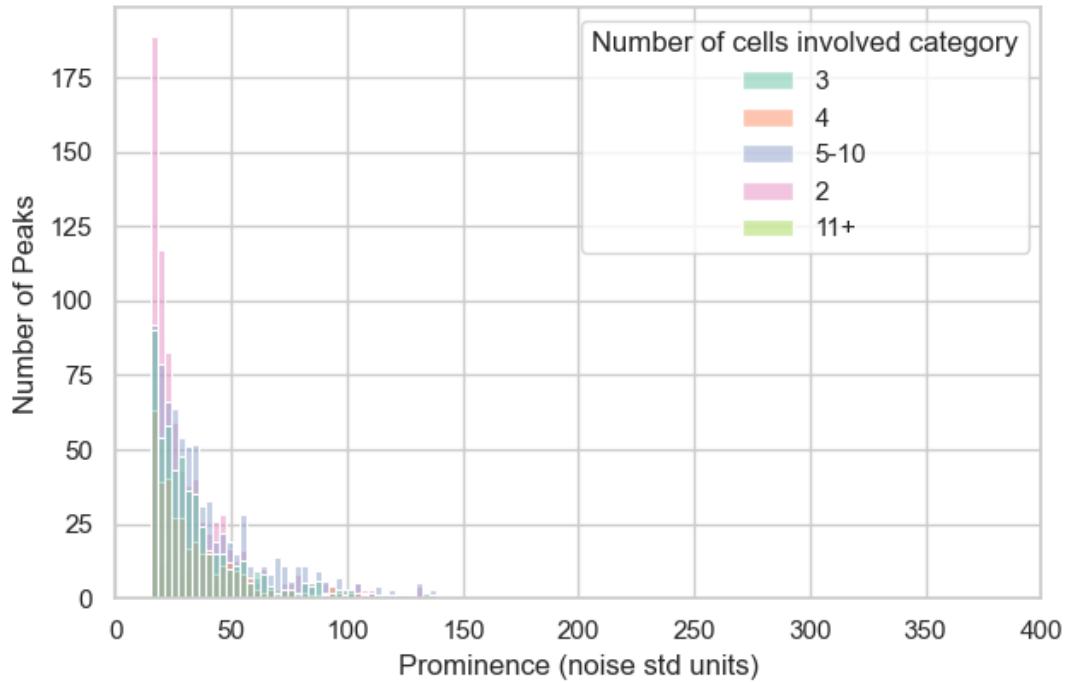
```
[2025-08-13 11:29:30] [INFO] calcium: plot_histogram_by_group: removed 30 outliers out of 2667 on 'Duration (s)' (lower=-13.25, upper=133.75)
```

Distribution of Peak Durations by Number of Cells Involved in Sequential Events

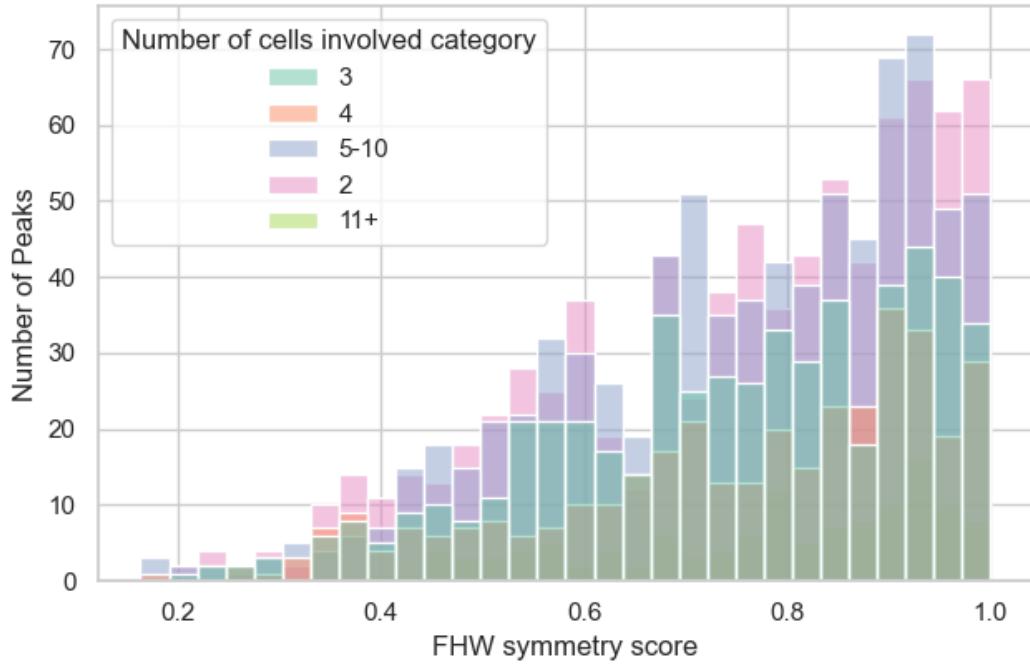


```
[2025-08-13 11:29:30] [INFO] calcium: plot_histogram_by_group: removed 66 outliers out of 2667 on 'Prominence (noise std units)' (lower=-19.9, upper=139.7)
```

Distribution of Peak Prominences by Number of Cells Involved in Sequential Events

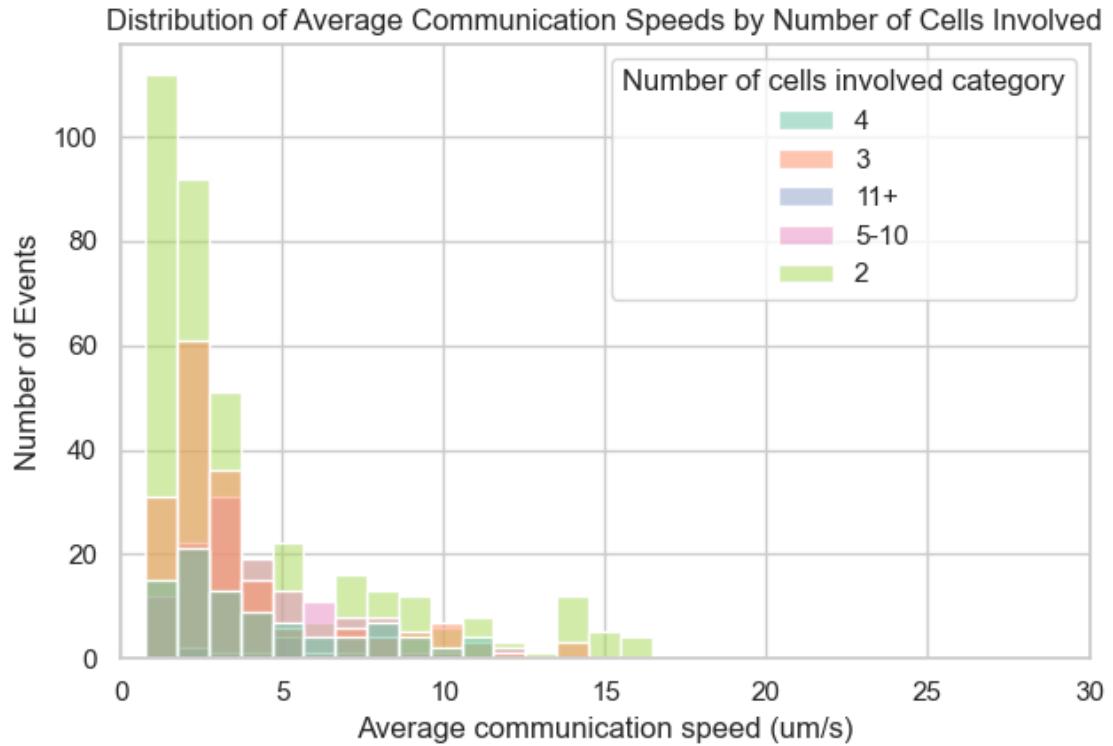


Distribution of Peak Symmetry Scores by Number of Cells Involved in Sequential Events



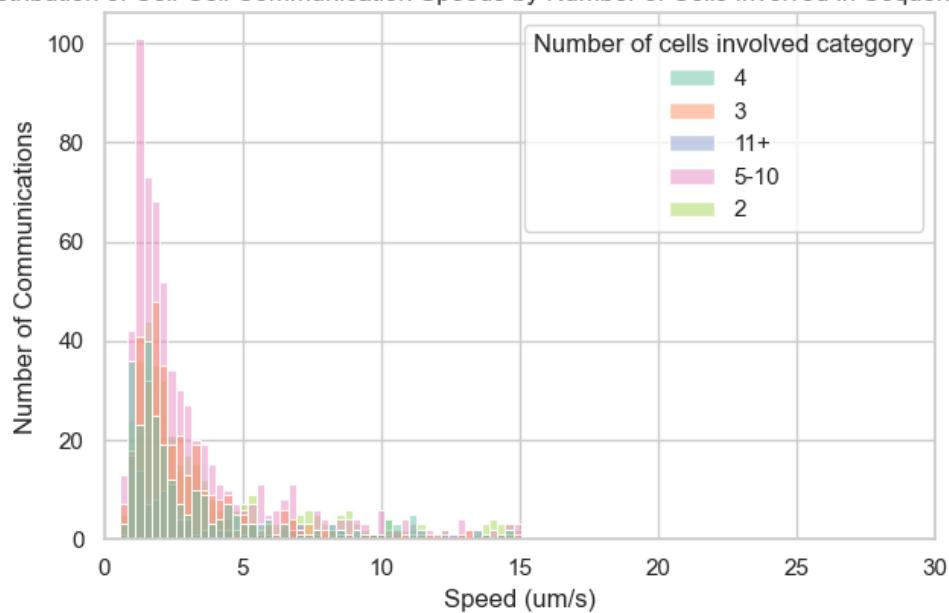
[2025-08-13 11:29:31] [INFO] calcium: plot_histogram_by_group: removed 28

outliers out of 817 on 'Average communication speed (um/s)' (lower=-9.3, upper=16.74)



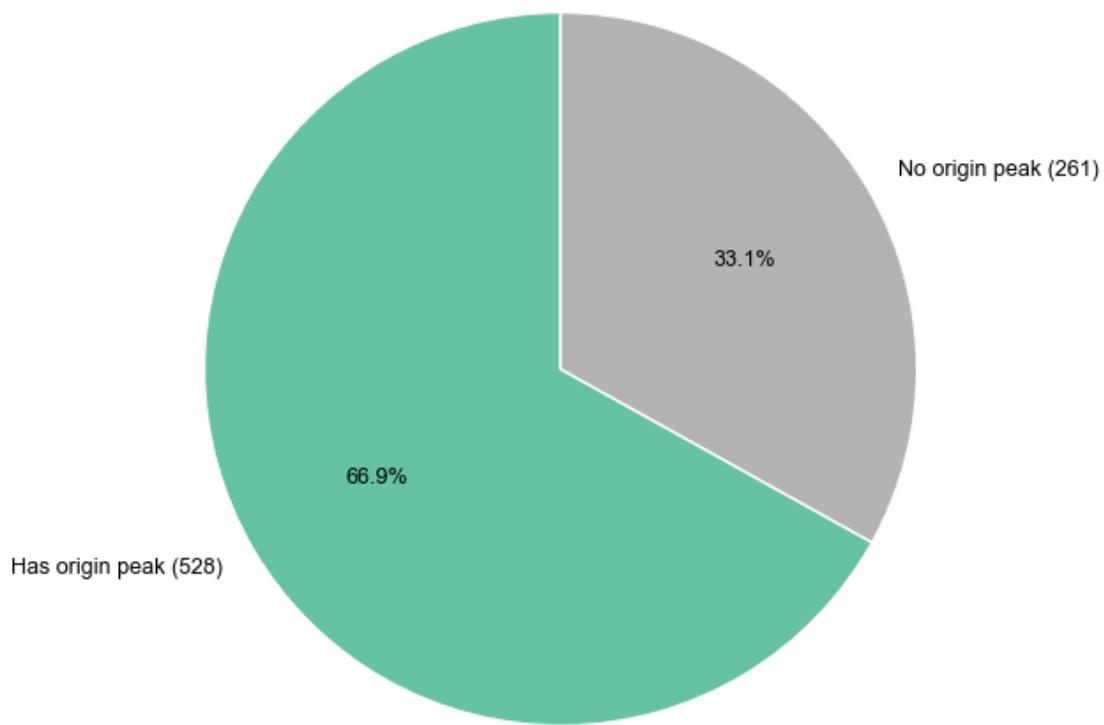
[2025-08-13 11:29:31] [INFO] calcium: plot_histogram_by_group: removed 109 outliers out of 1850 on 'Speed (um/s)' (lower=-8.6575, upper=15.09)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events



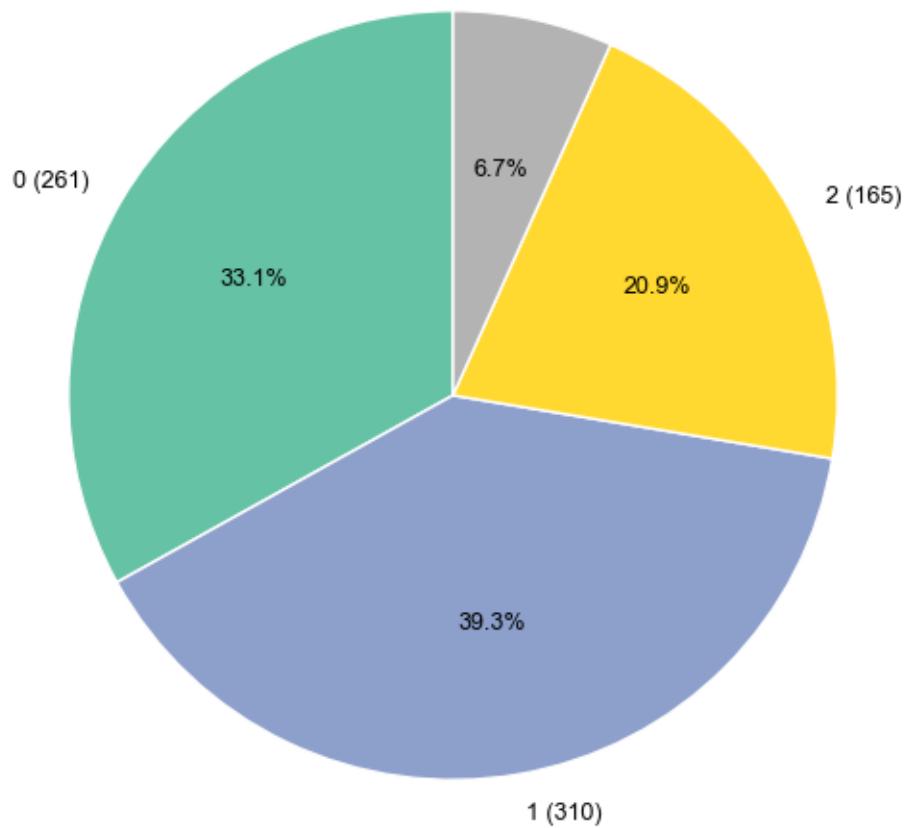
1.3.7 Cells occurrences as origin in sequential events

Distribution of Number of Sequential Event Origin Peaks per Cell

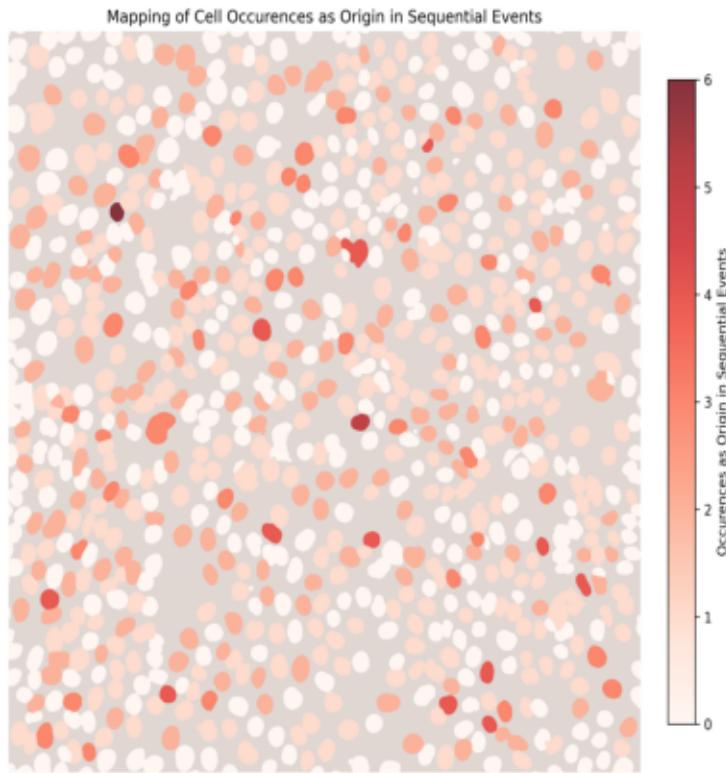


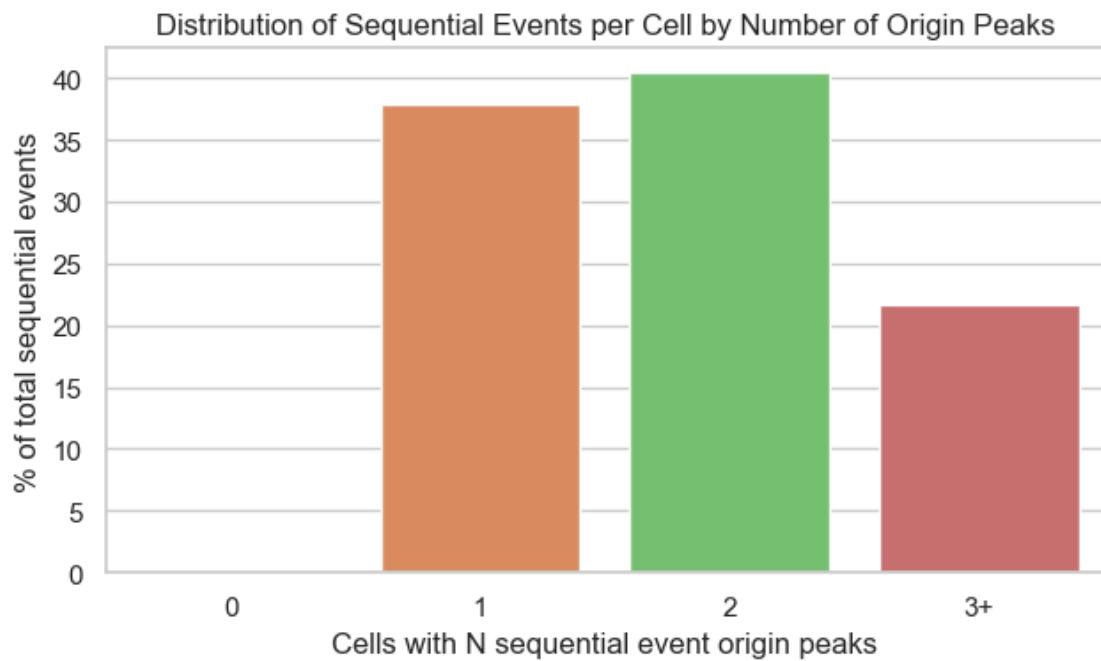
Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)

3+ (53)



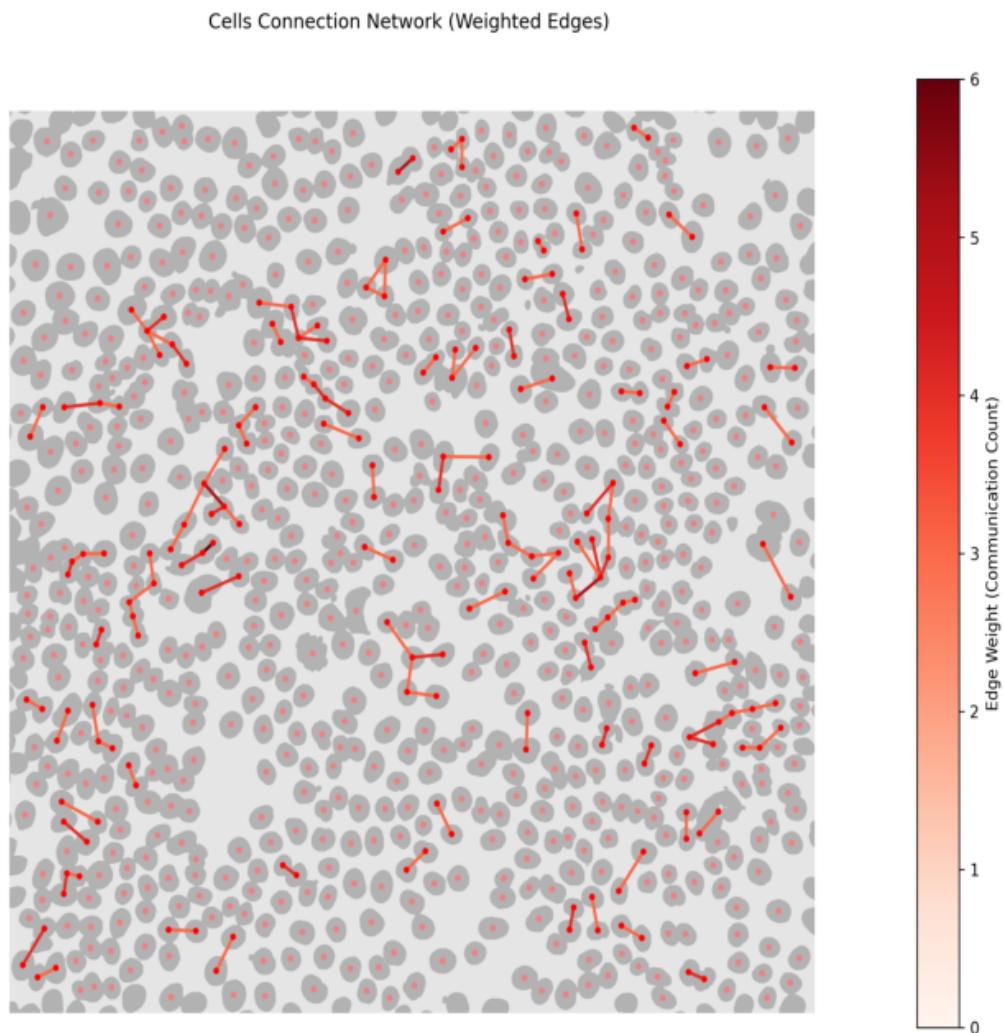
Cell Mapping with Origin Peaks Overlay - 20250404_IS3

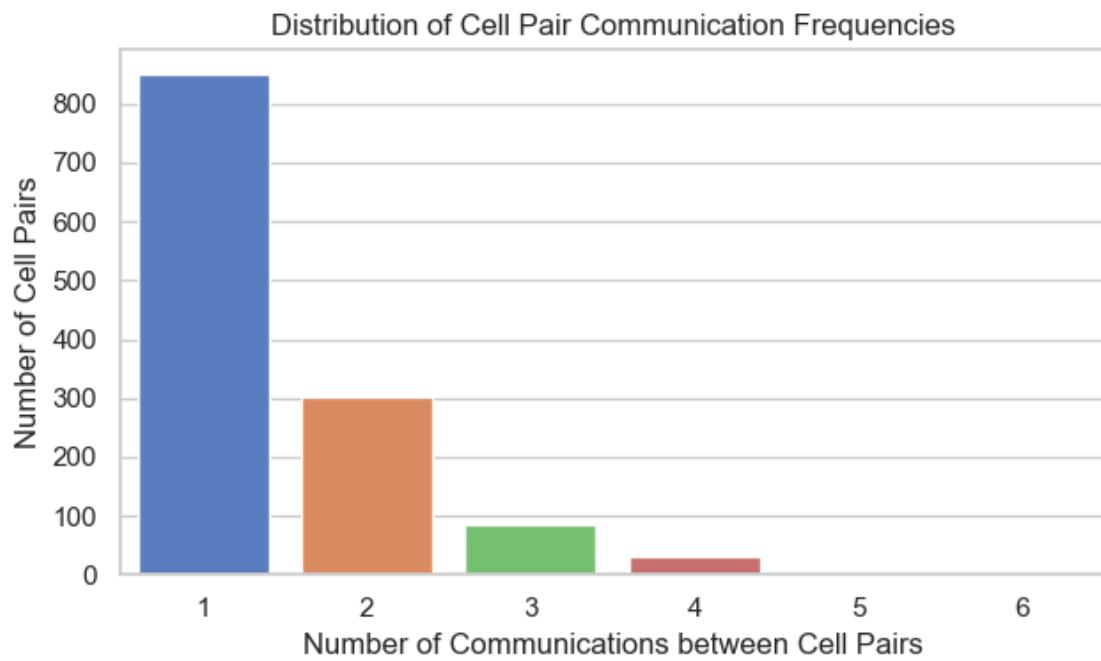




1.3.8 Connection network between cells

Cell Connection Network Graph - 20250404_IS3

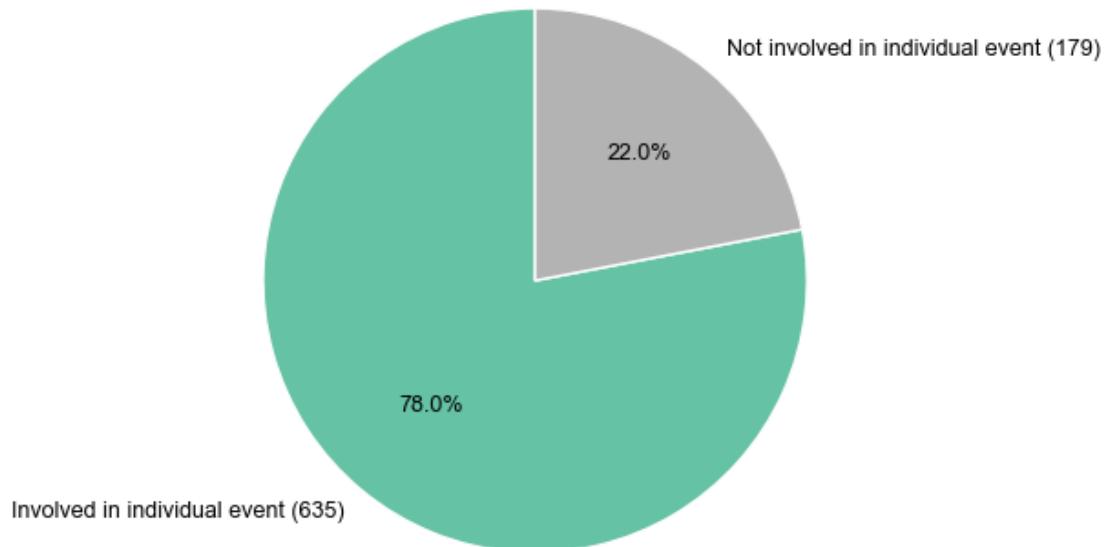




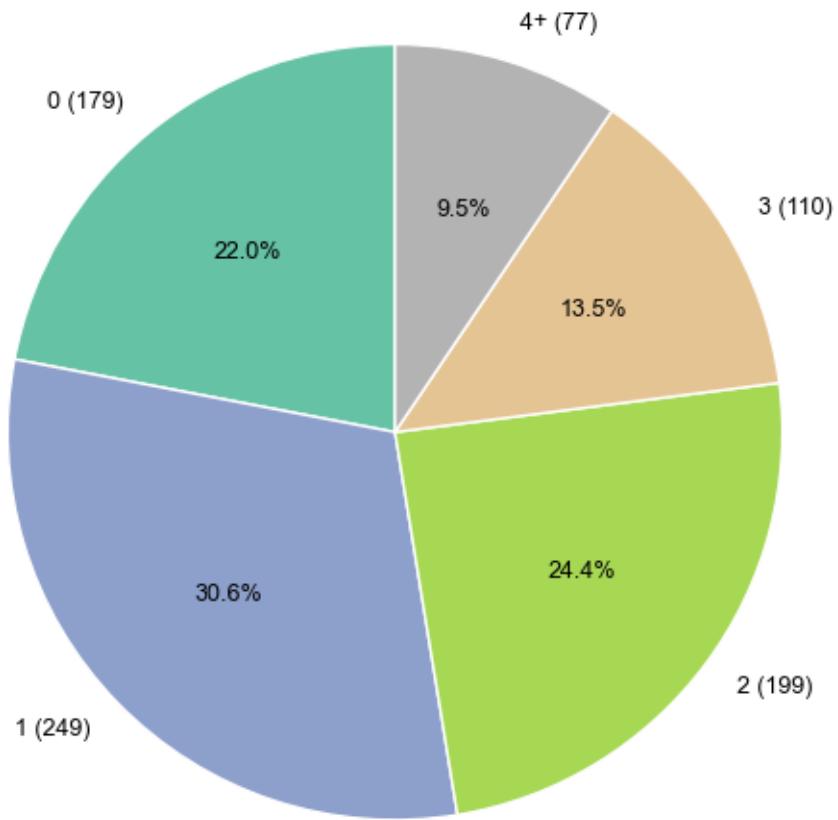
1.4 INDIVIDUAL EVENTS

1.4.1 Cells occurrences in individual events

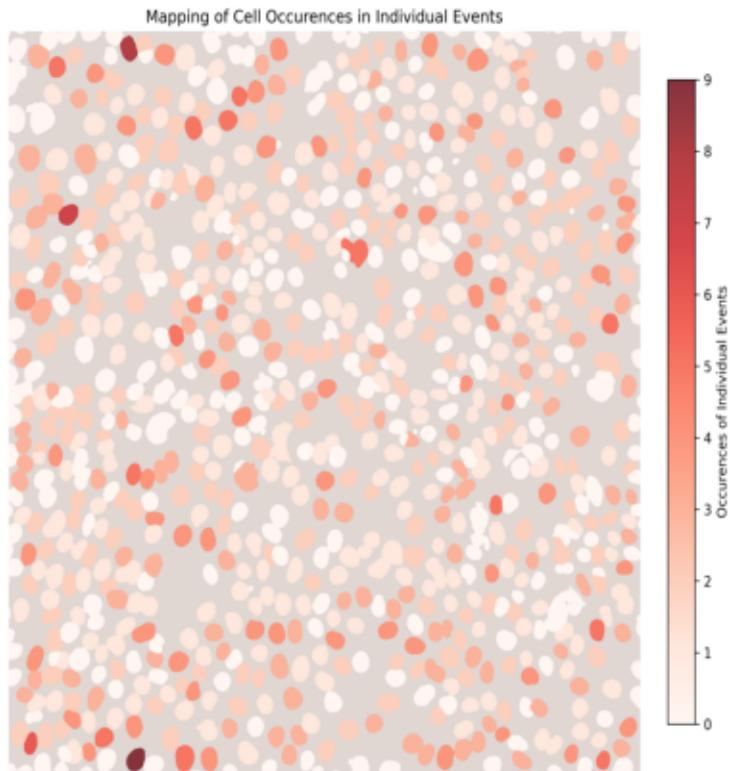
Distribution of Cells Involved in Individual Events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

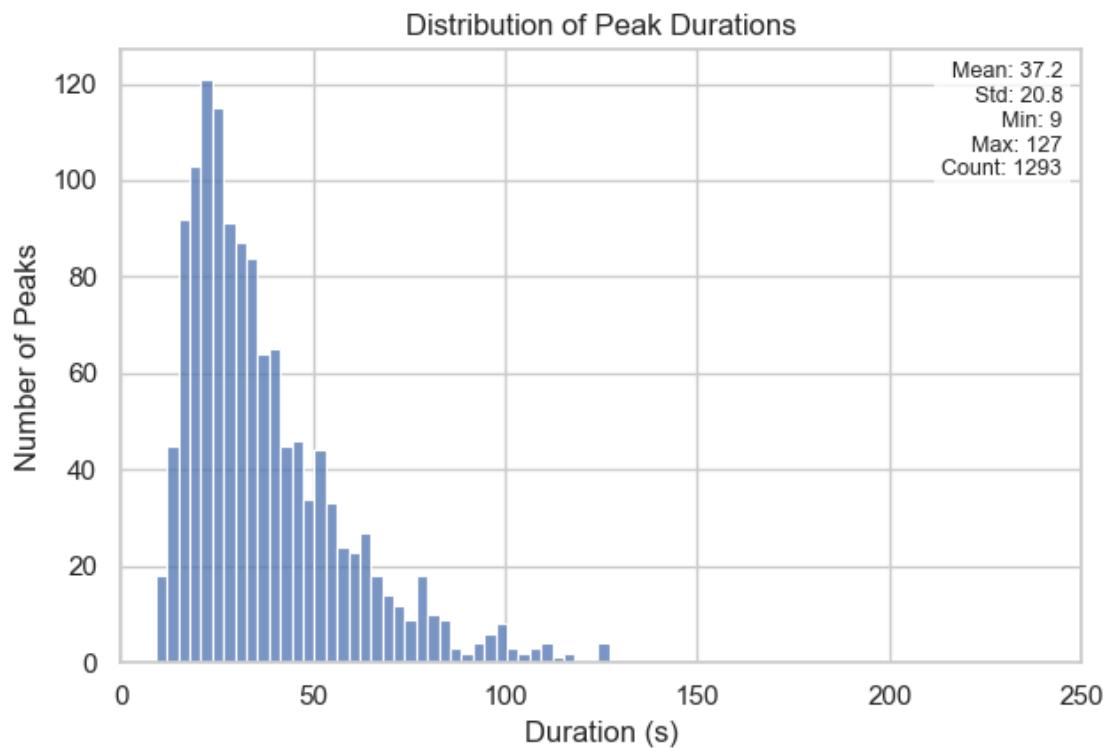


Cell Mapping with Occurrences in Individual Events Overlay - 20250404_IS3

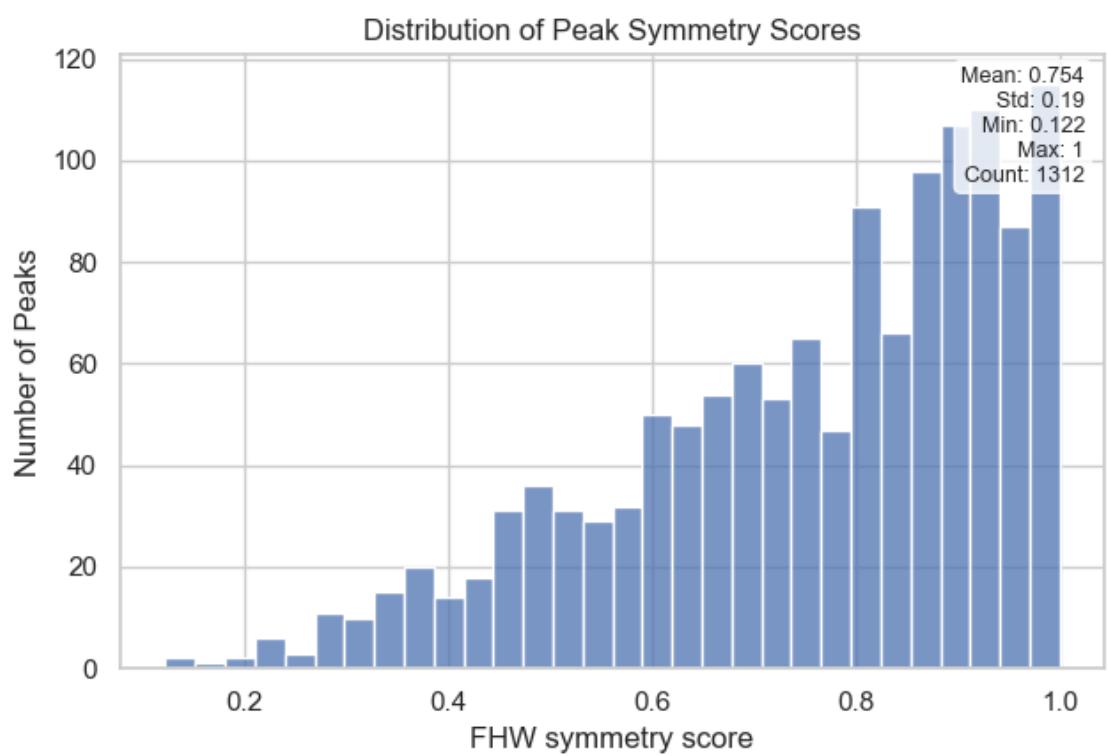
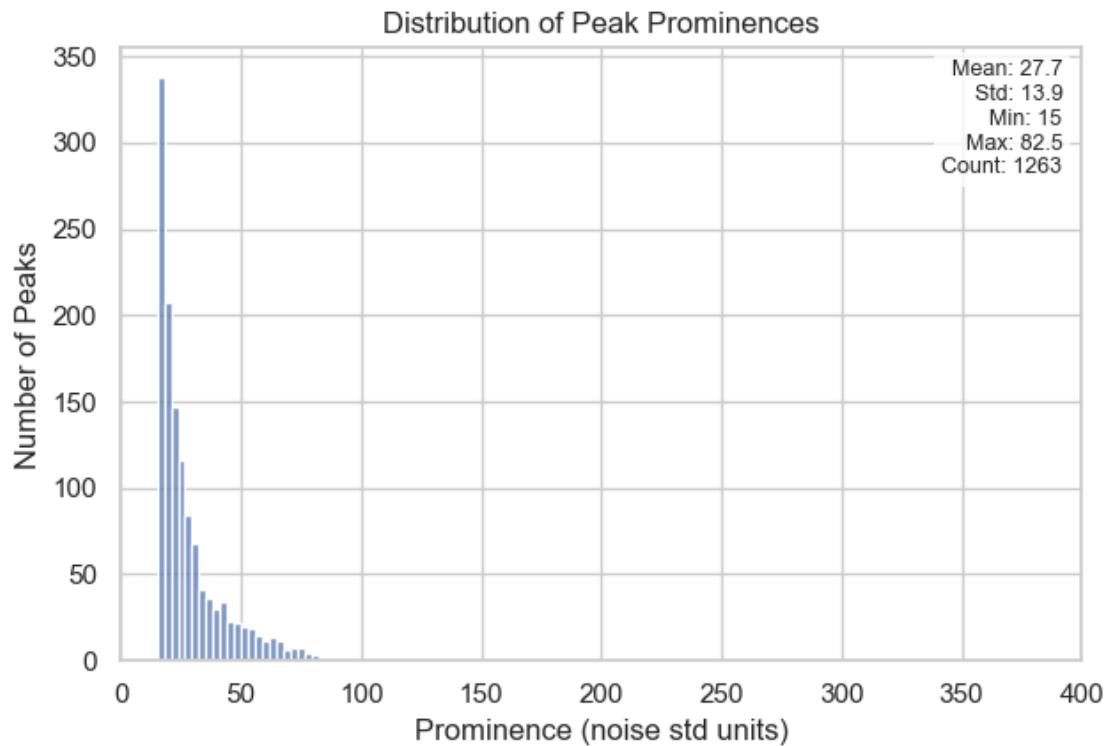


1.4.2 Peaks statistics in individual events

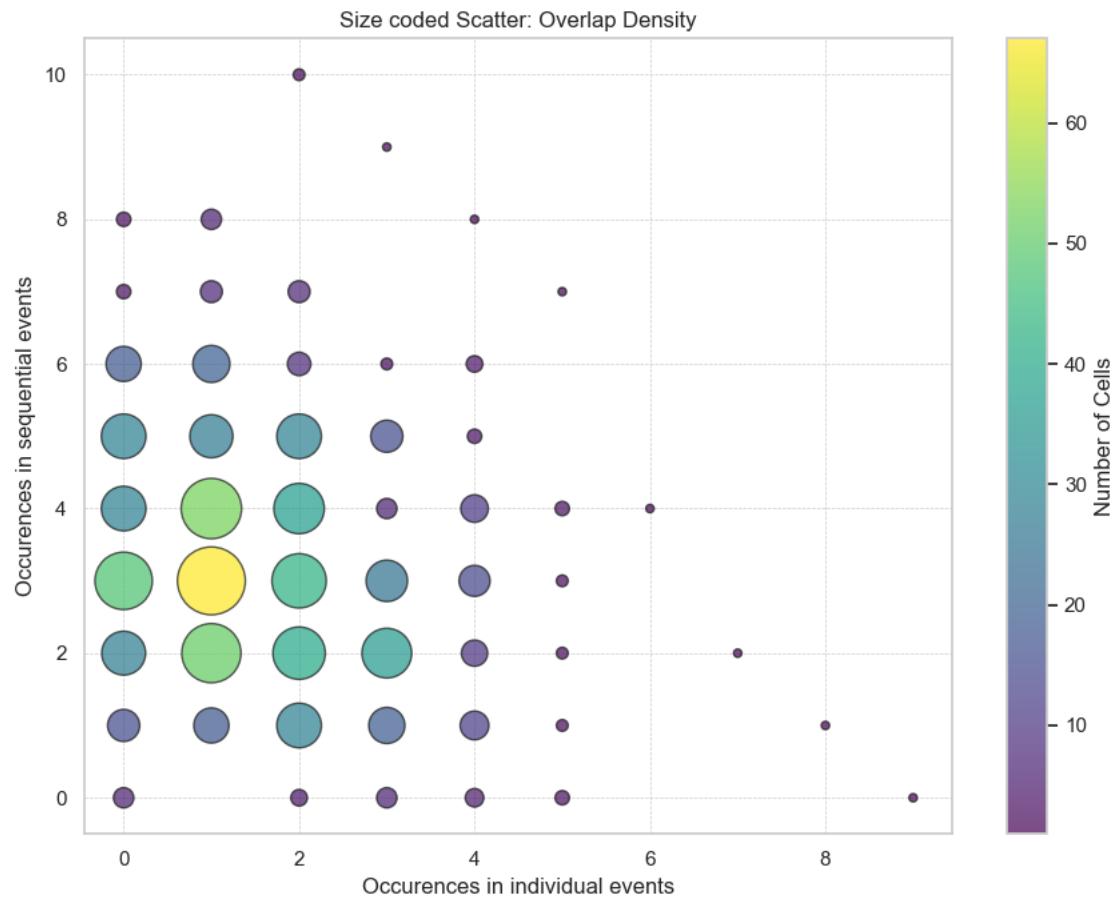
```
[2025-08-13 11:29:37] [INFO] calcium: plot_histogram: removed 19 outliers out of  
1312 on 'Duration (s)' (lower=-56.75, upper=127)
```



```
[2025-08-13 11:29:37] [INFO] calcium: plot_histogram: removed 49 outliers out of 1312 on 'Prominence (noise std units)' (lower=-31.1, upper=83.175)
```

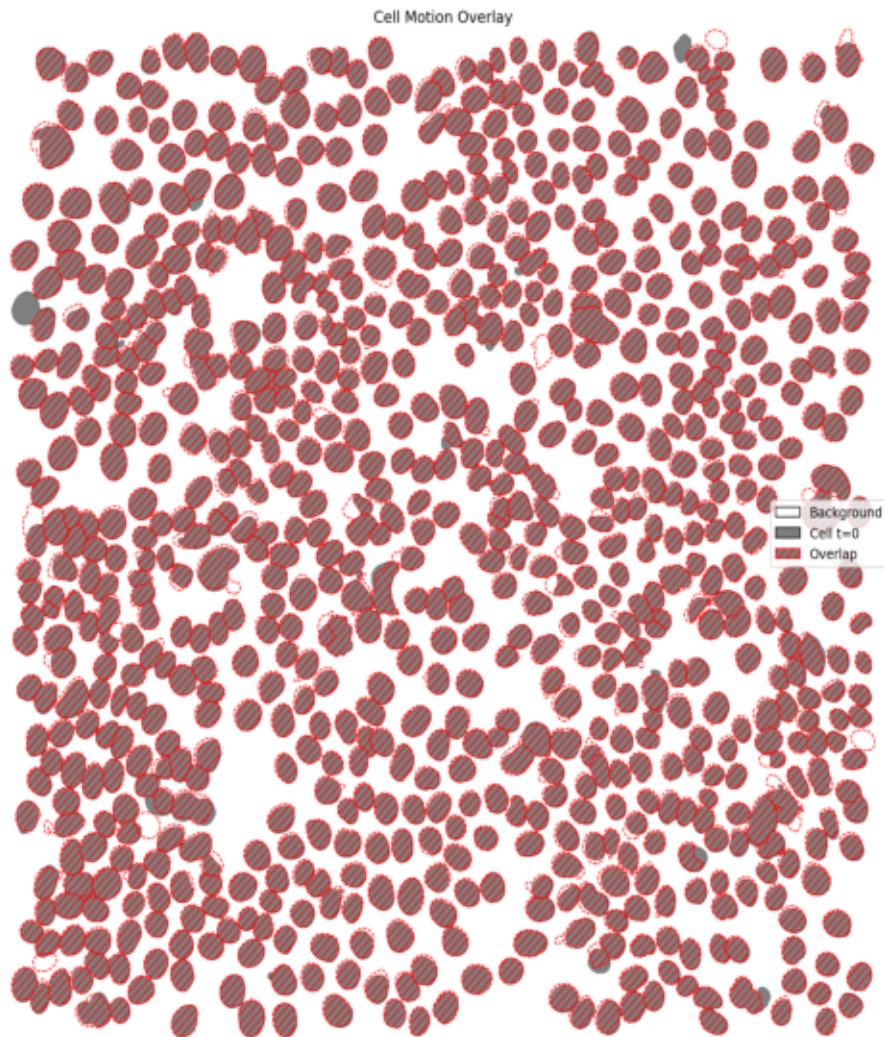


1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250404_IS3



Number of cells:

- Hoechst image taken at t=0: 814
- Hoechst image taken at t=1801: 812
- Number of cells difference: absolute 2, relative 0.25%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 1056876
- Pixels segmented as cell at t=1801: 1081782
- Overlapping pixels between t=0 and t=1801: 988607 (92.45% of total)
- Pixels exclusive to t=0: 68269 (6.46% of total)
- Pixels exclusive to t=1801: 93175 (8.61% of total)

executed

August 13, 2025

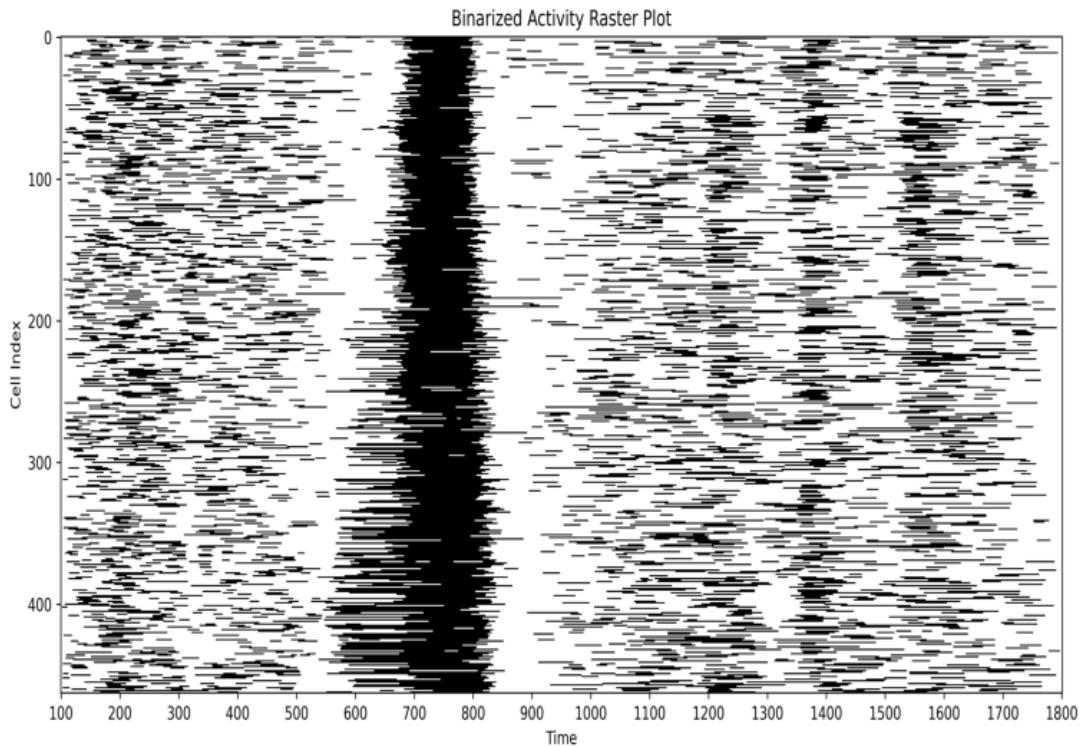
1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

1.0.1 Initialization

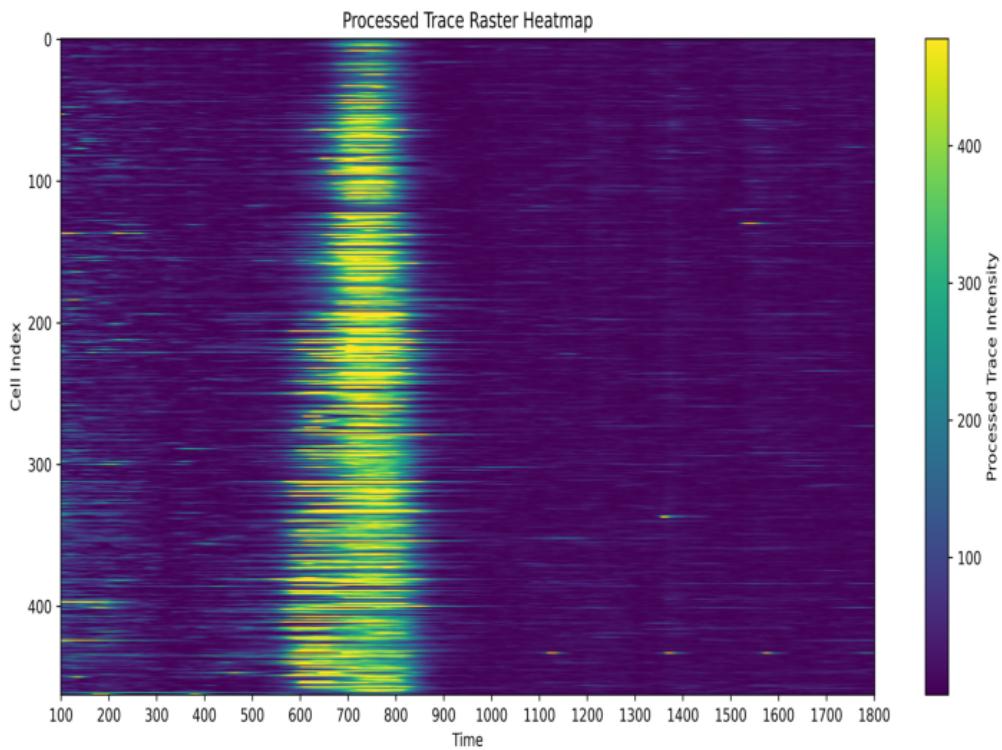
1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot

Binary Activity Raster Plot - 20250409_IS01



Heatmap Activity Raster Plot - 20250409_IS01



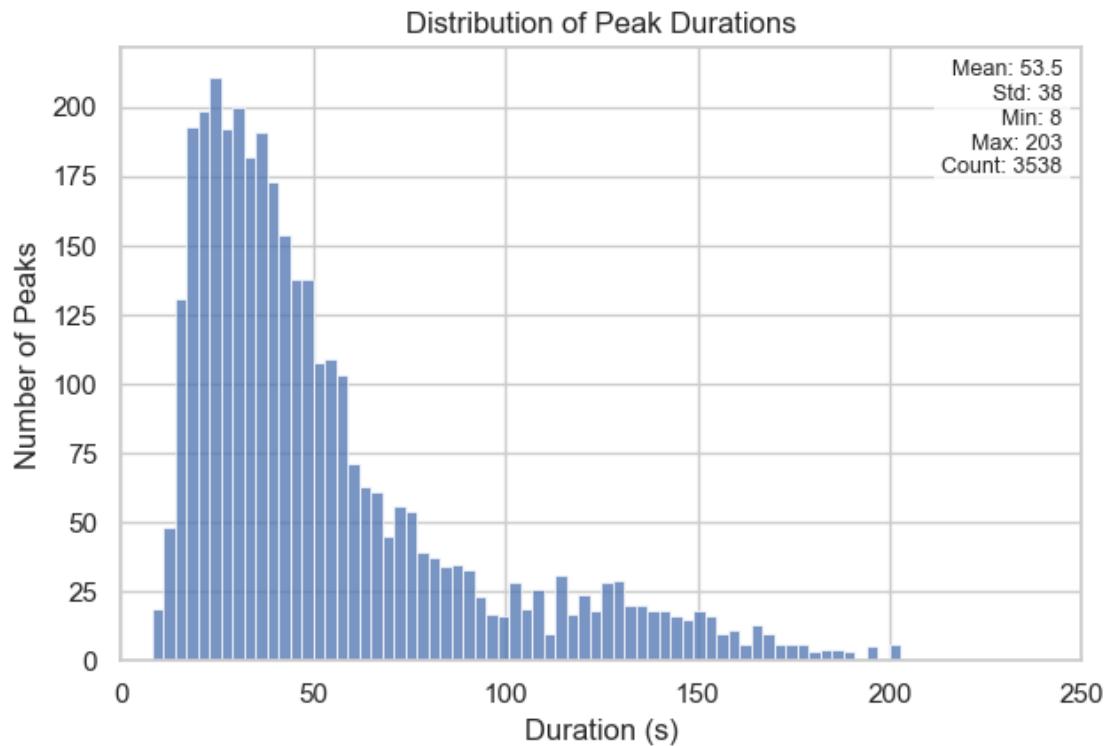
1.1.2 Peaks population

Total number of peaks: 3649

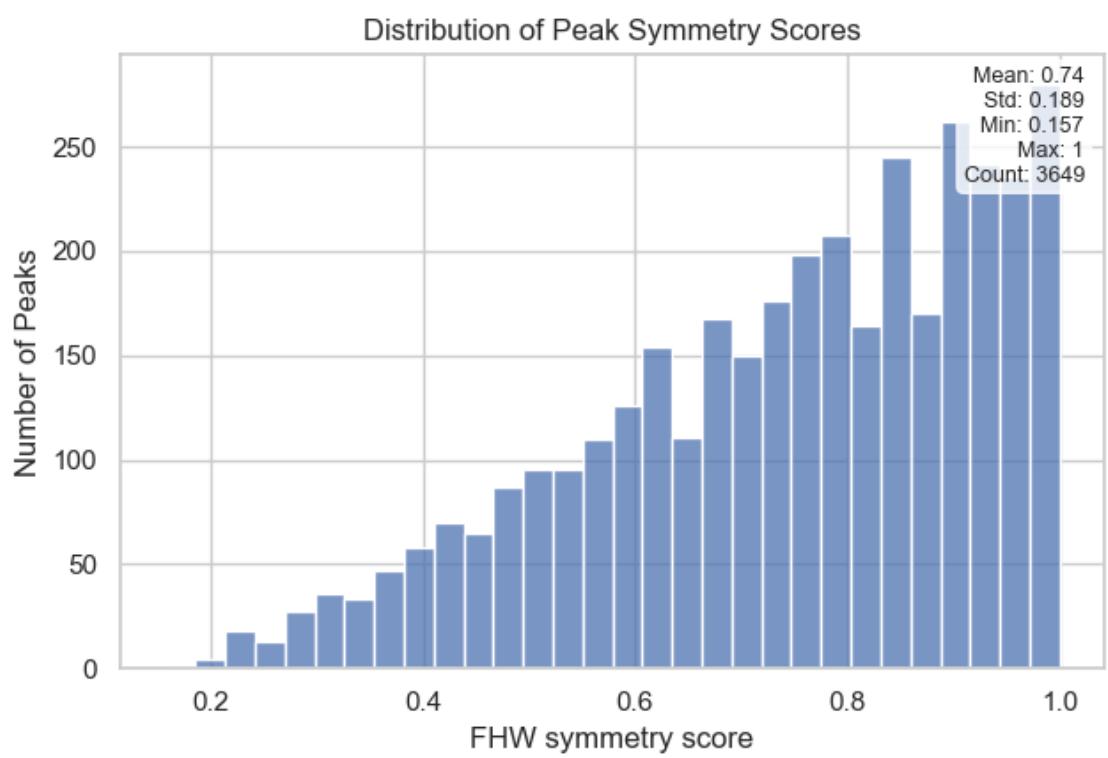
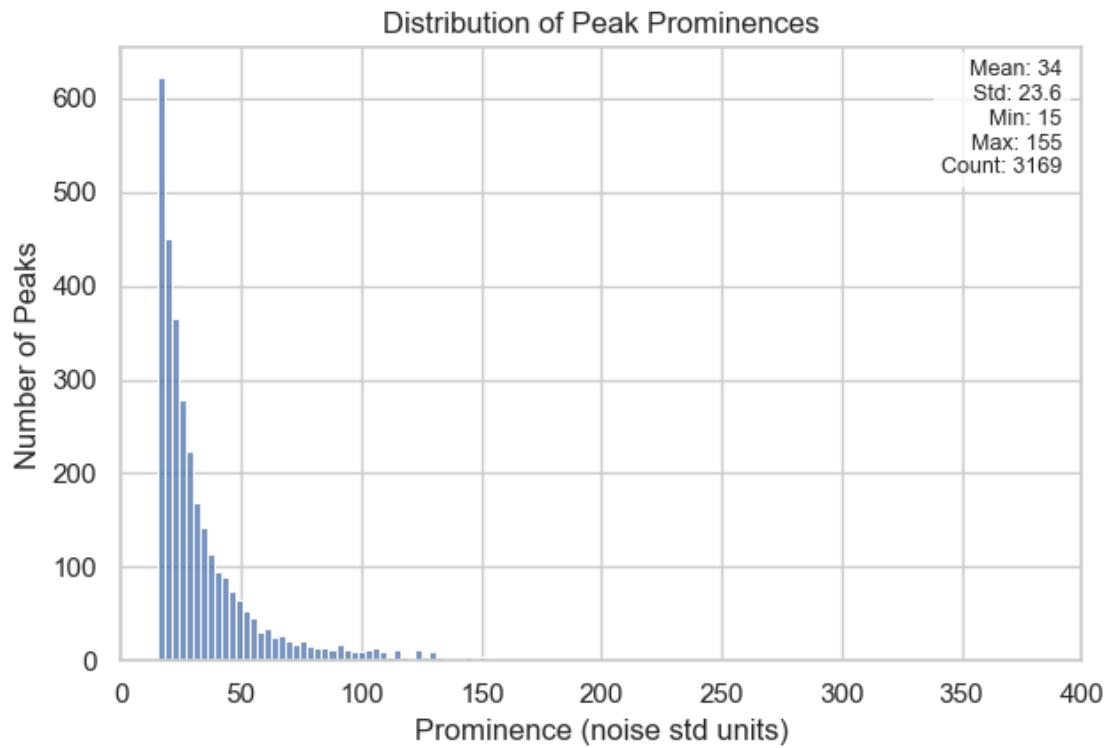
Total number of cells: 463

1.1.3 Peaks statistics

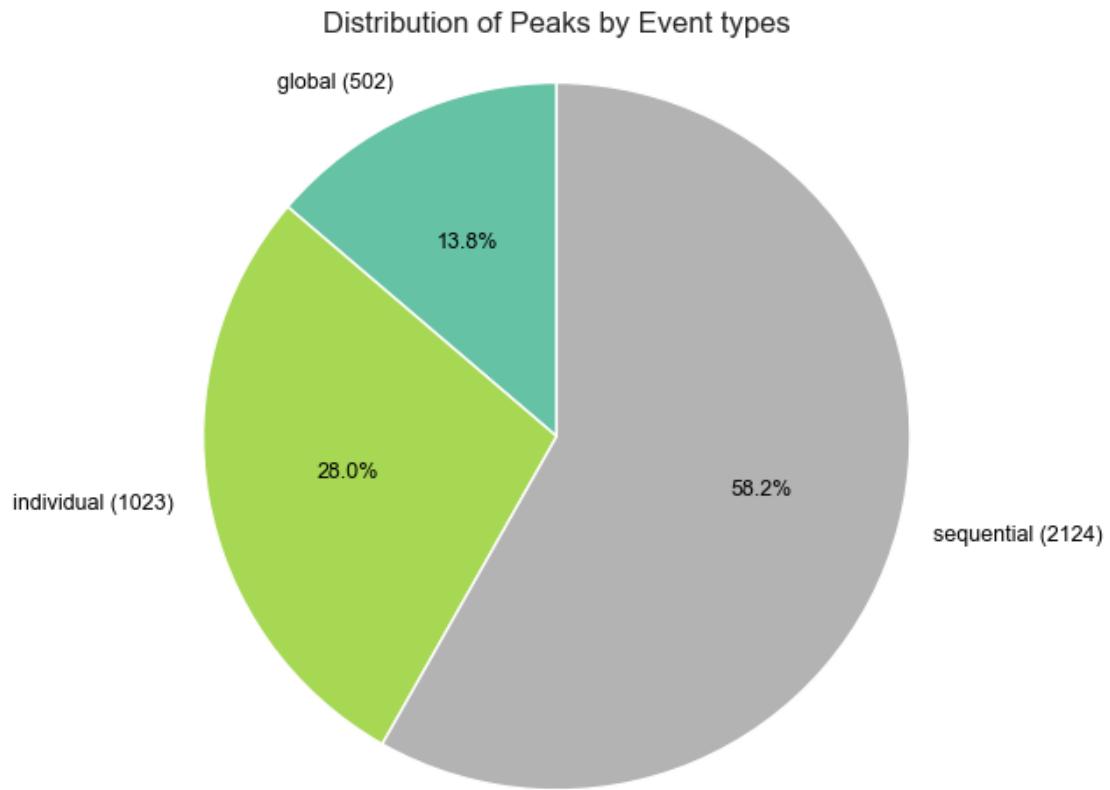
```
[2025-08-13 11:31:58] [INFO] calcium: plot_histogram: removed 111 outliers out  
of 3649 on 'Duration (s)' (lower=-105, upper=203)
```



```
[2025-08-13 11:31:58] [INFO] calcium: plot_histogram: removed 480 outliers out  
of 3649 on 'Prominence (noise std units)' (lower=-81.6, upper=155)
```

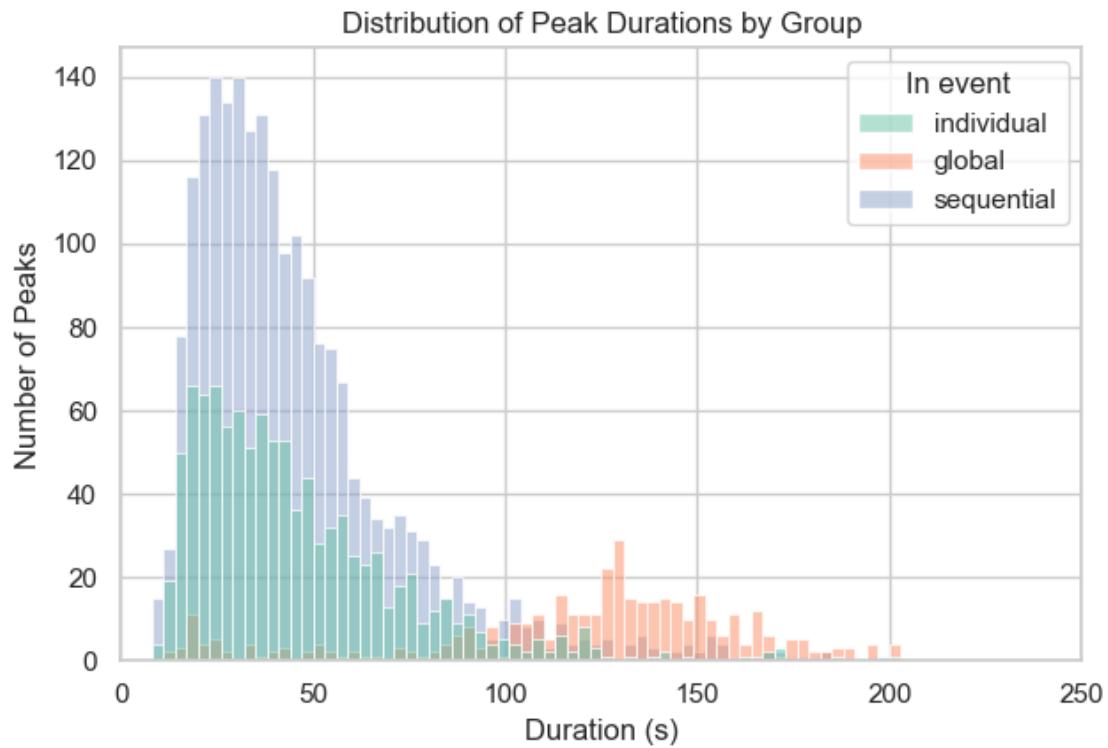


1.1.4 Distribution of peaks per event types

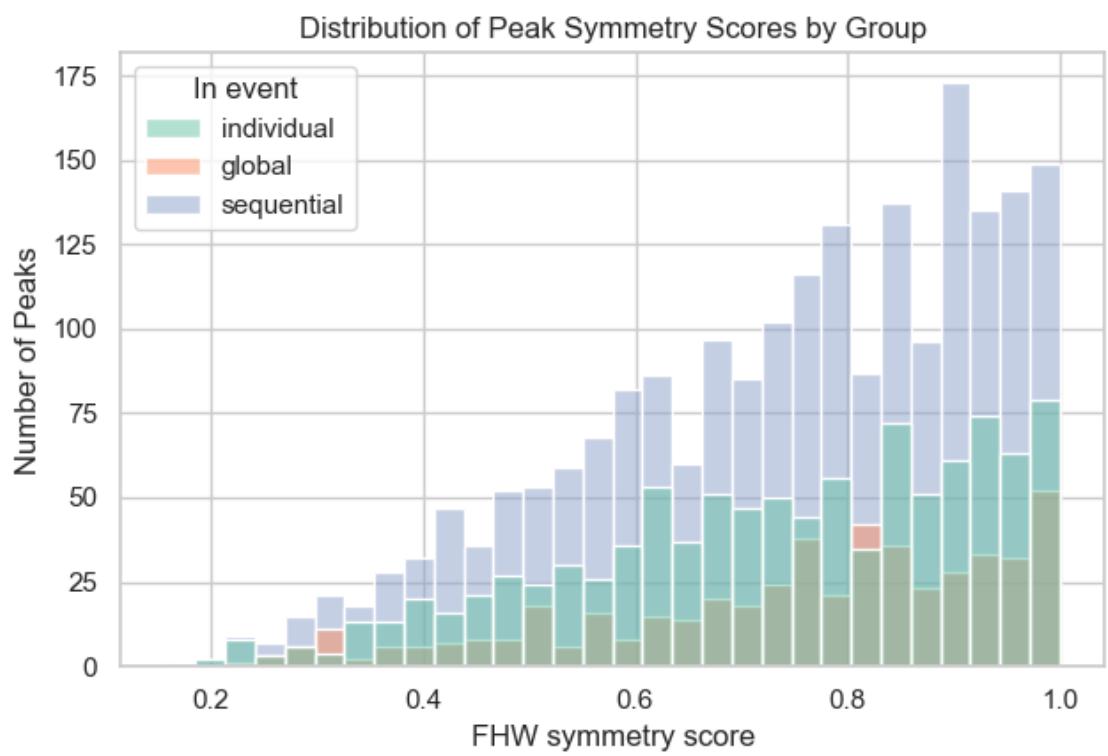
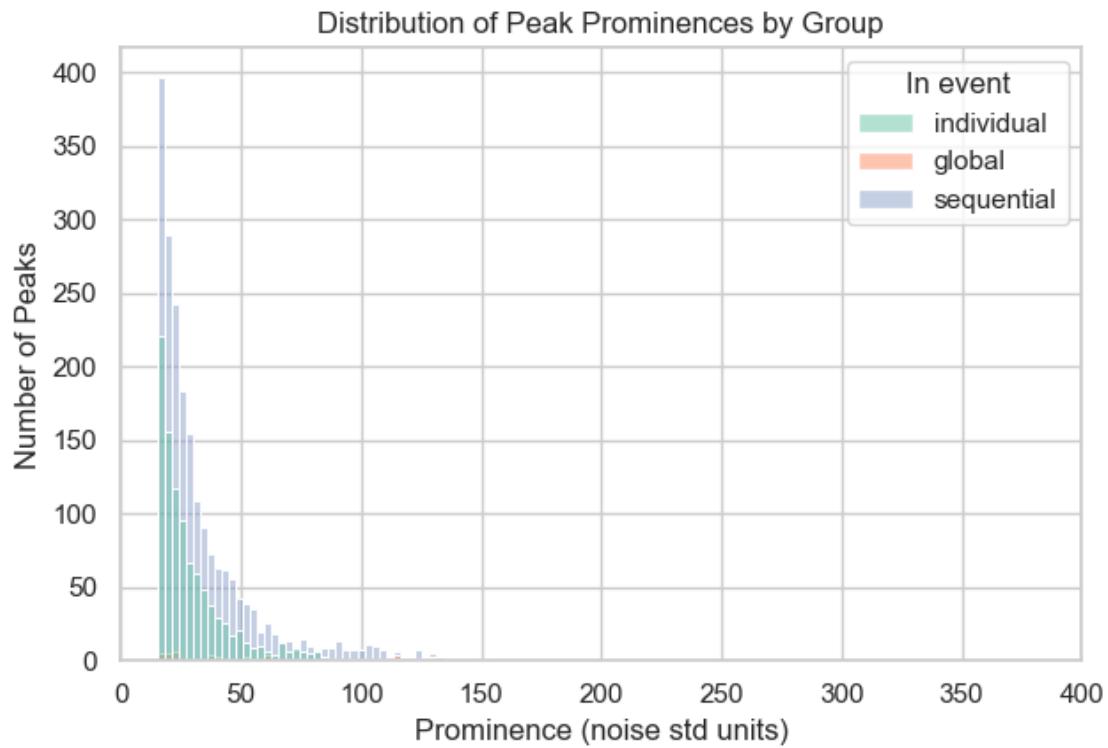


1.1.5 Peaks statistics per event types

```
[2025-08-13 11:31:58] [INFO] calcium: plot_histogram_by_group: removed 111 outliers out of 3649 on 'Duration (s)' (lower=-105, upper=203)
```



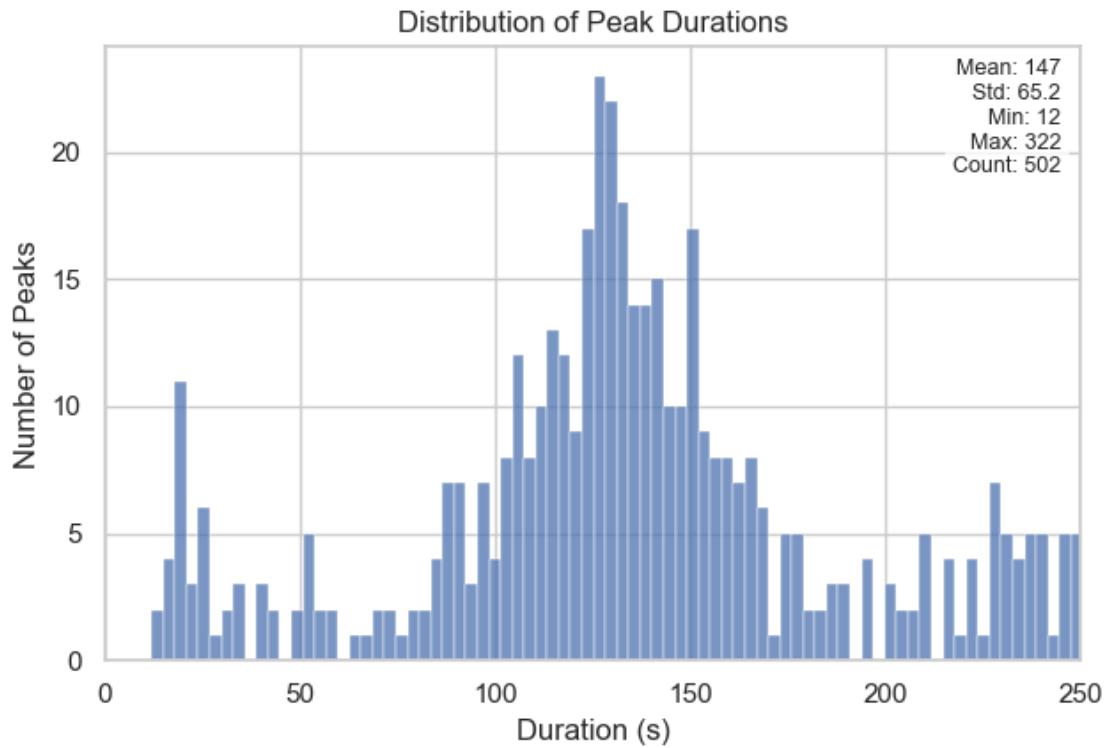
```
[2025-08-13 11:31:59] [INFO] calcium: plot_histogram_by_group: removed 480 outliers out of 3649 on 'Prominence (noise std units)' (lower=-81.6, upper=155)
```



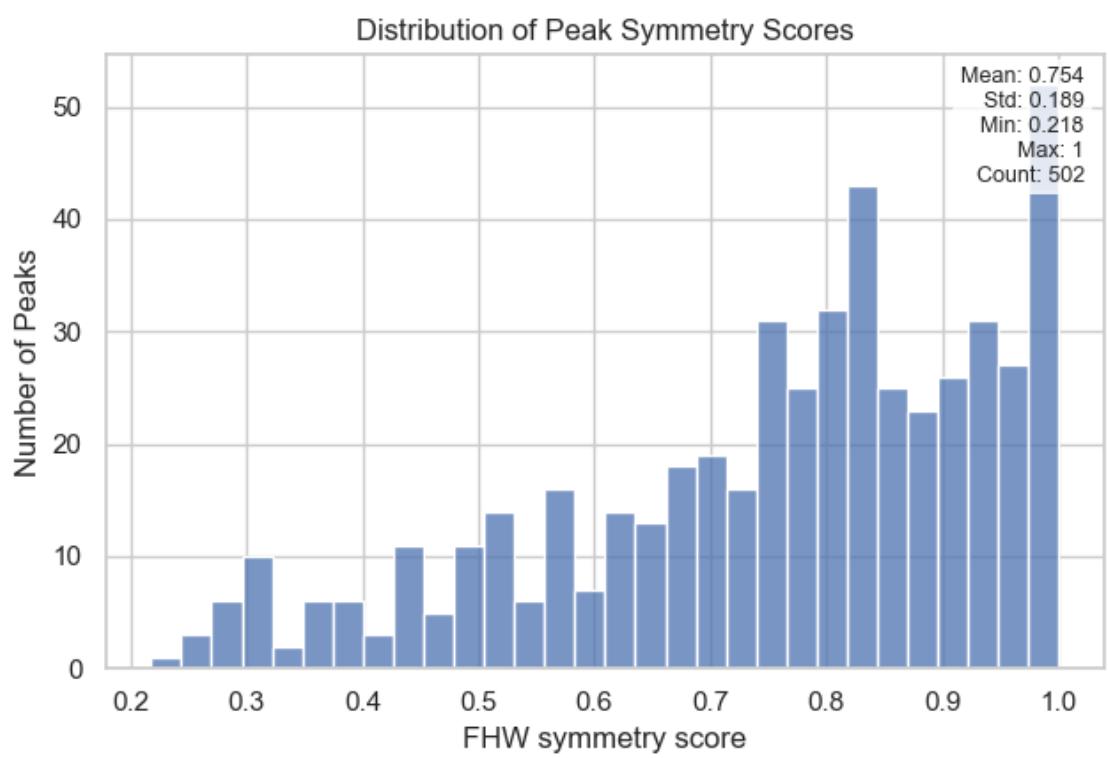
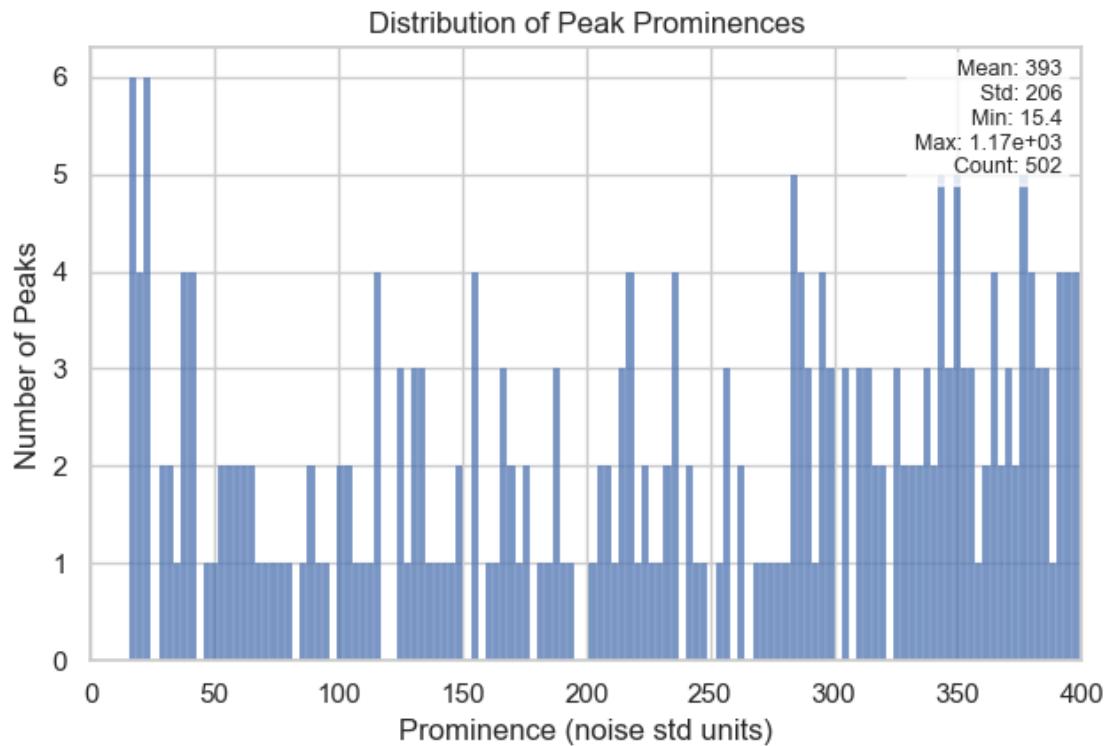
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

[2025-08-13 11:31:59] [INFO] calcium: plot_histogram: removed 0 outliers out of 502 on 'Duration (s)' (lower=-79, upper=369)

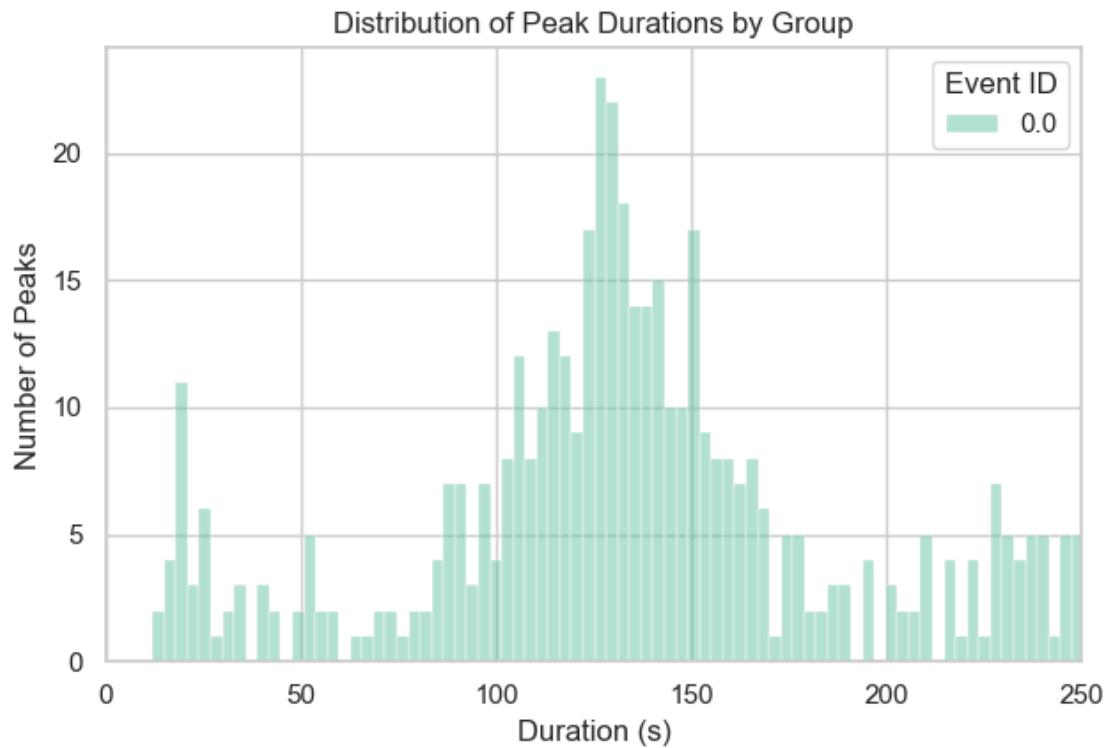


[2025-08-13 11:31:59] [INFO] calcium: plot_histogram: removed 0 outliers out of 502 on 'Prominence (noise std units)' (lower=-583.13, upper=1351)



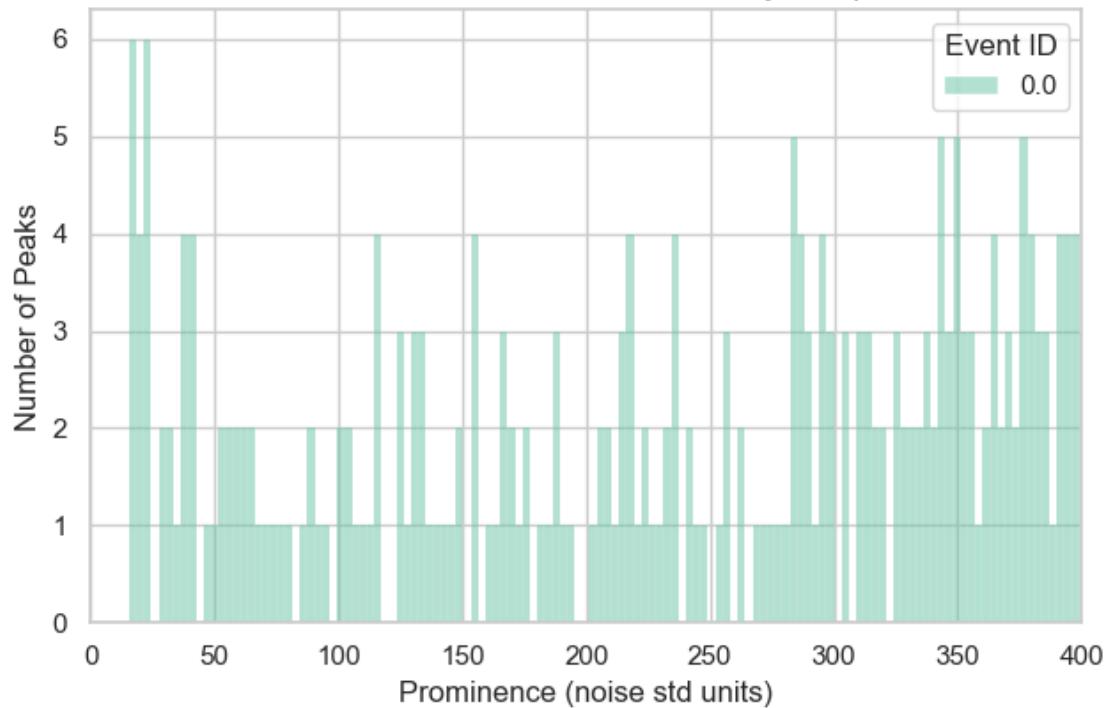
1.2.2 Peak statistics in global event per event ID

```
[2025-08-13 11:32:00] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 502 on 'Duration (s)' (lower=-79, upper=369)
```

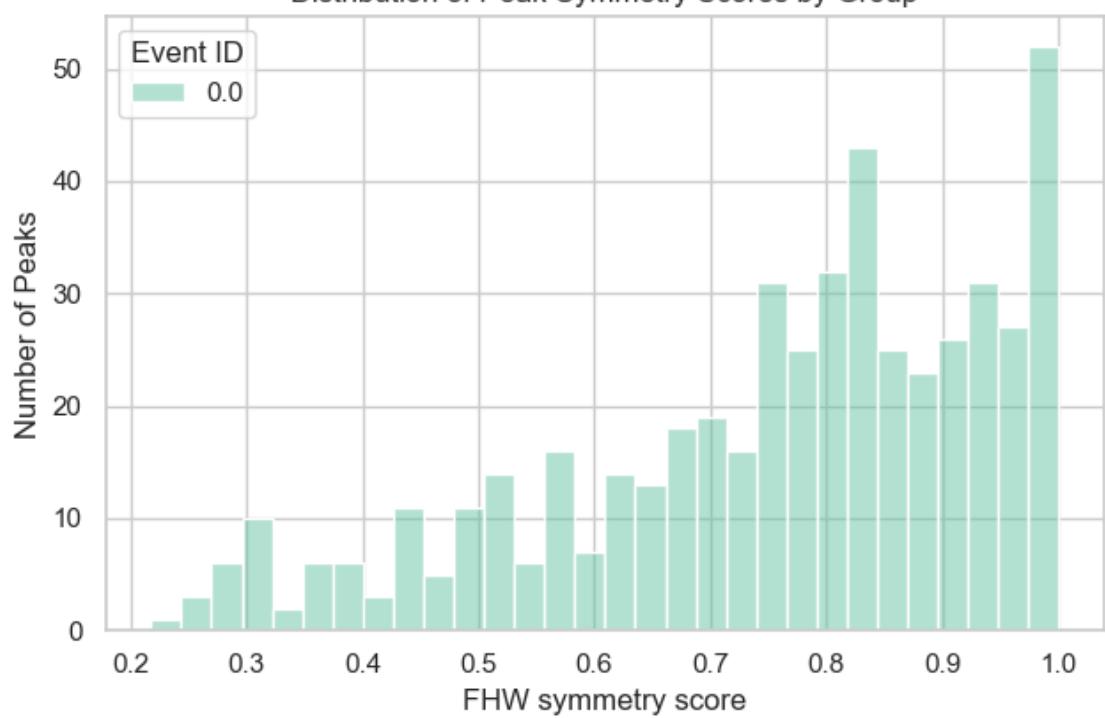


```
[2025-08-13 11:32:00] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 502 on 'Prominence (noise std units)' (lower=-583.13, upper=1351)
```

Distribution of Peak Prominences by Group

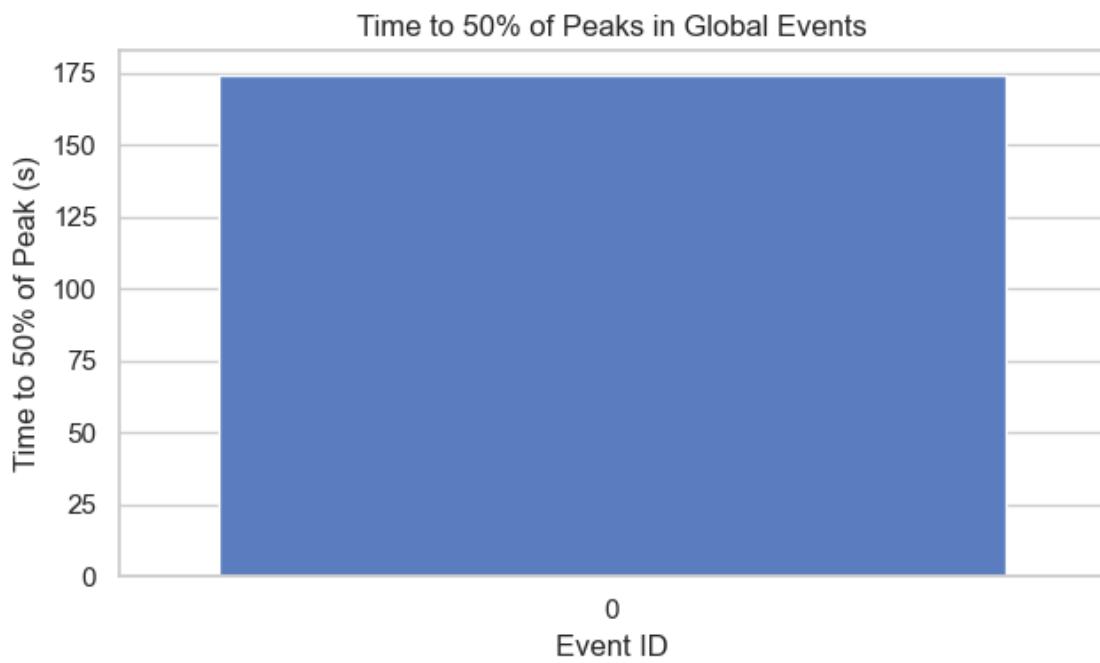
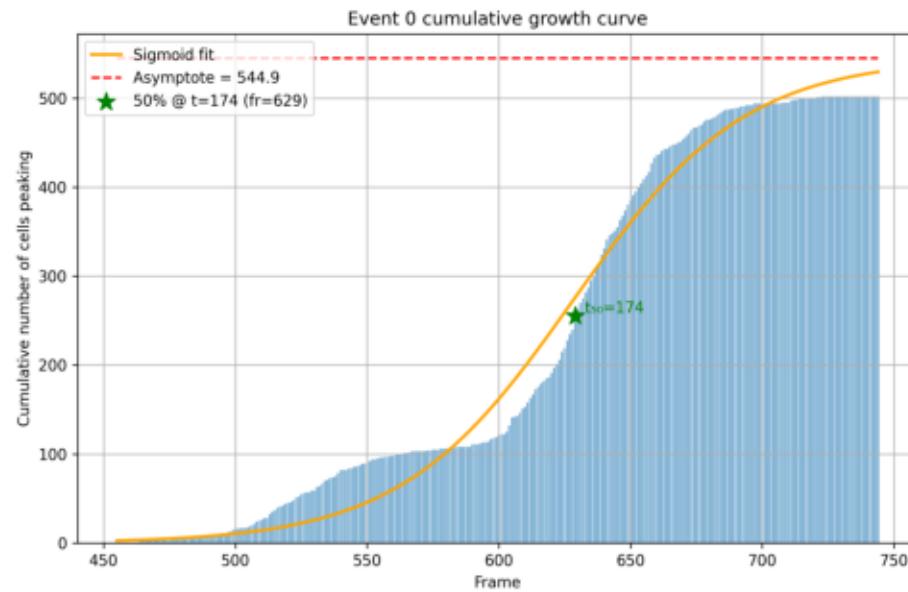


Distribution of Peak Symmetry Scores by Group

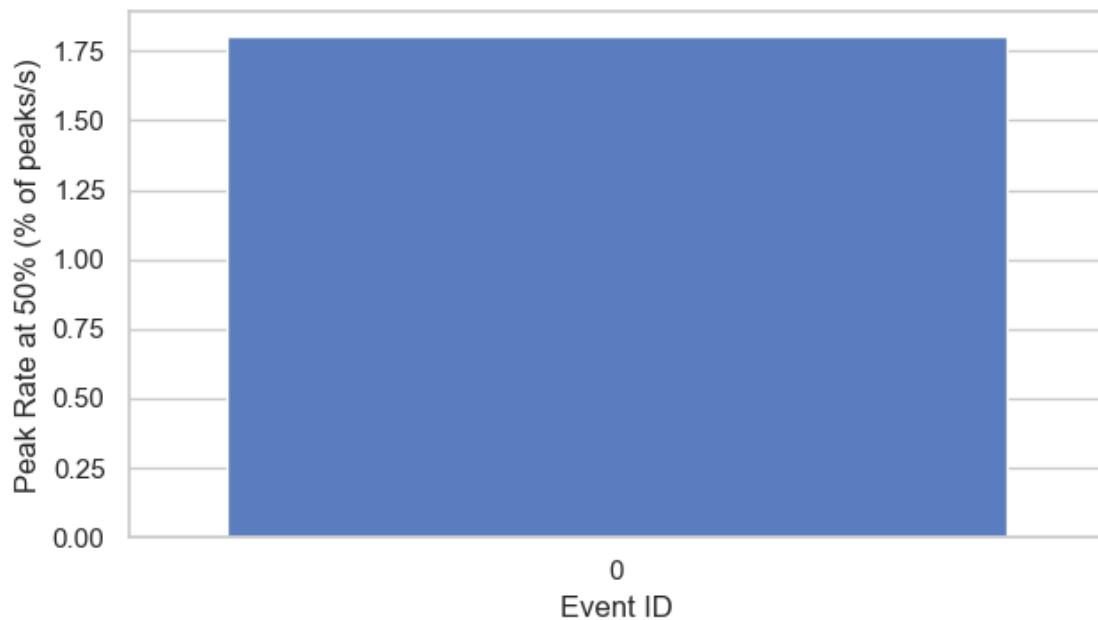


1.2.3 Kinetics of global events

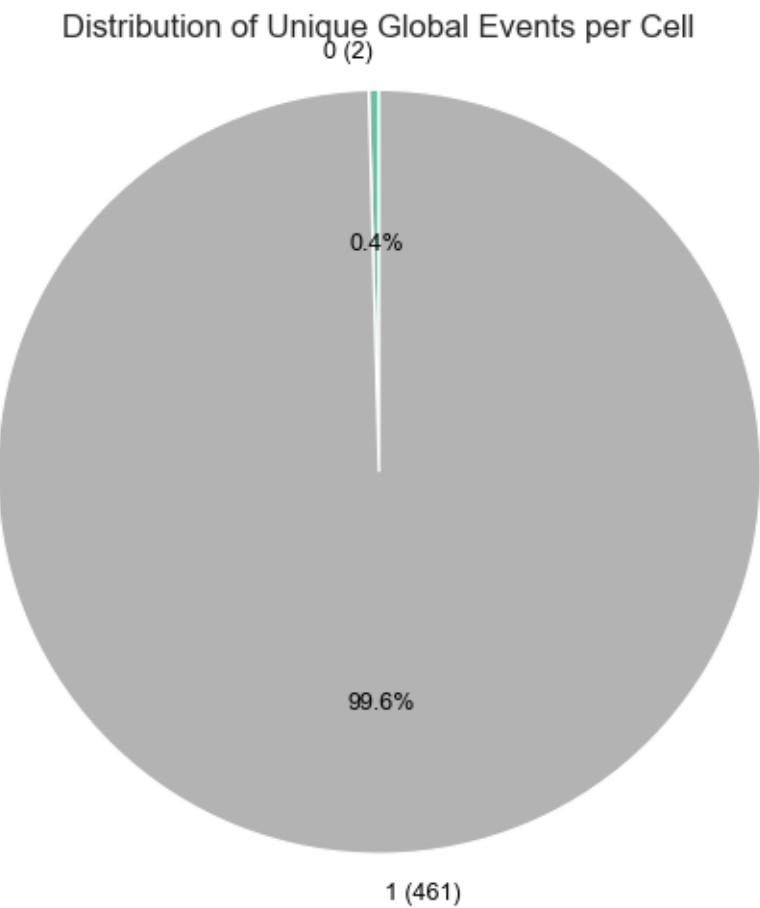
Event Activity Overlay (Event ID: 0) - 20250409_IS01



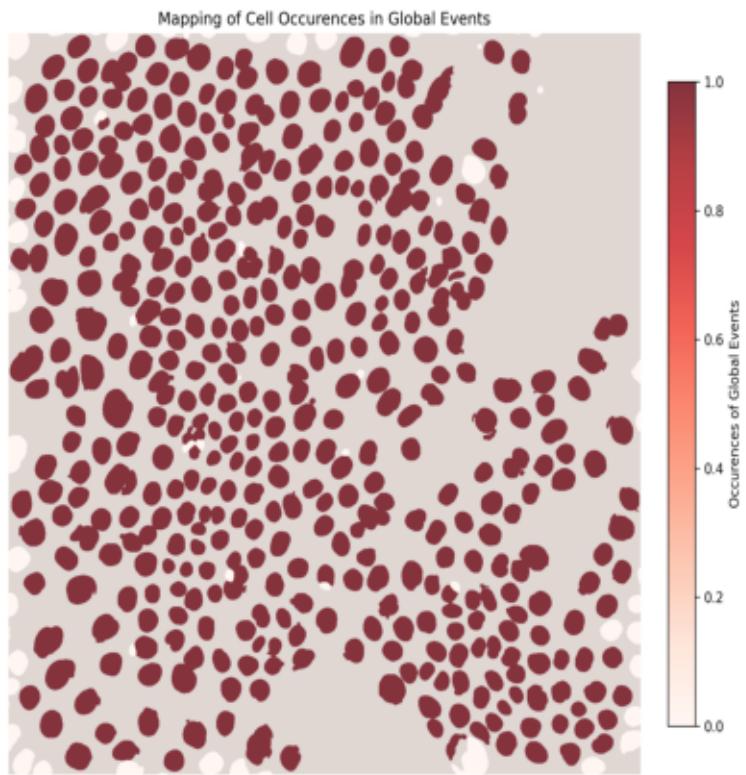
Peak rate at 50% in Global Events

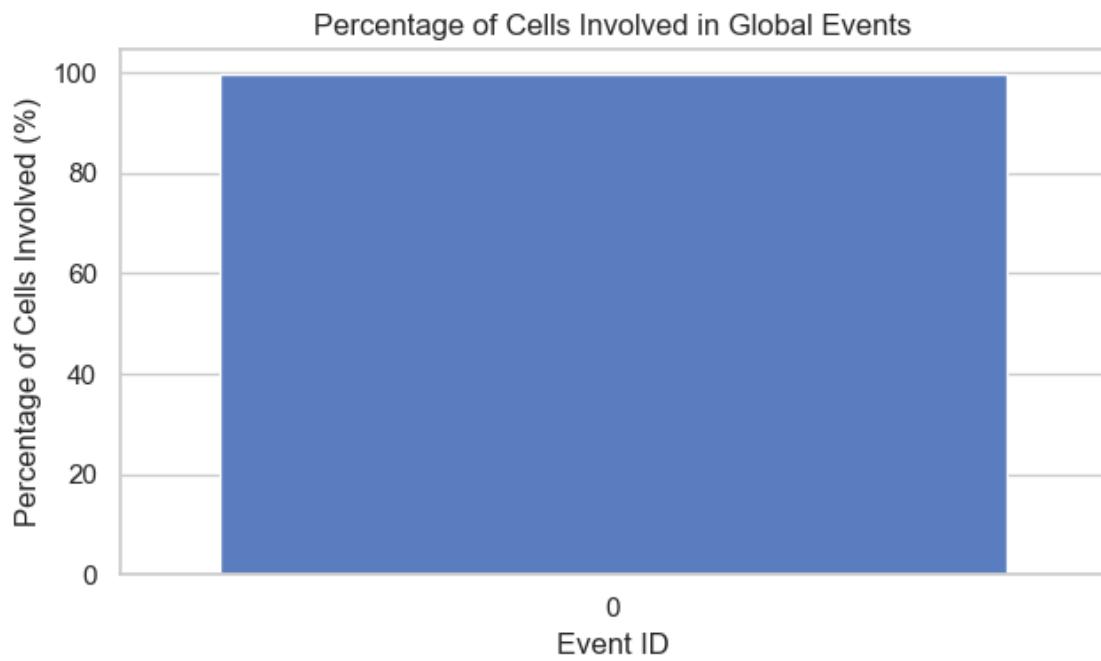


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250409_IS01



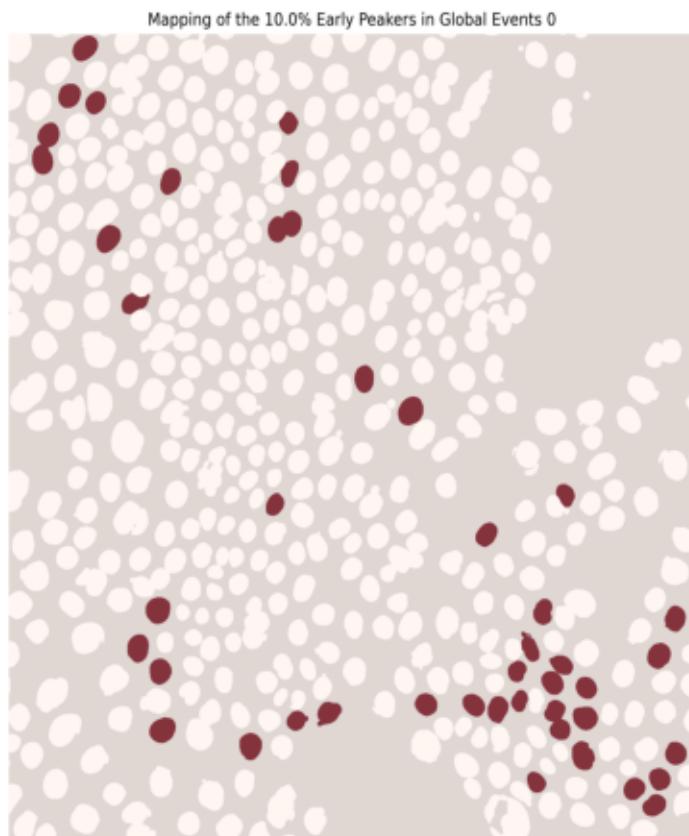


1.2.5 Inter-event interval analysis

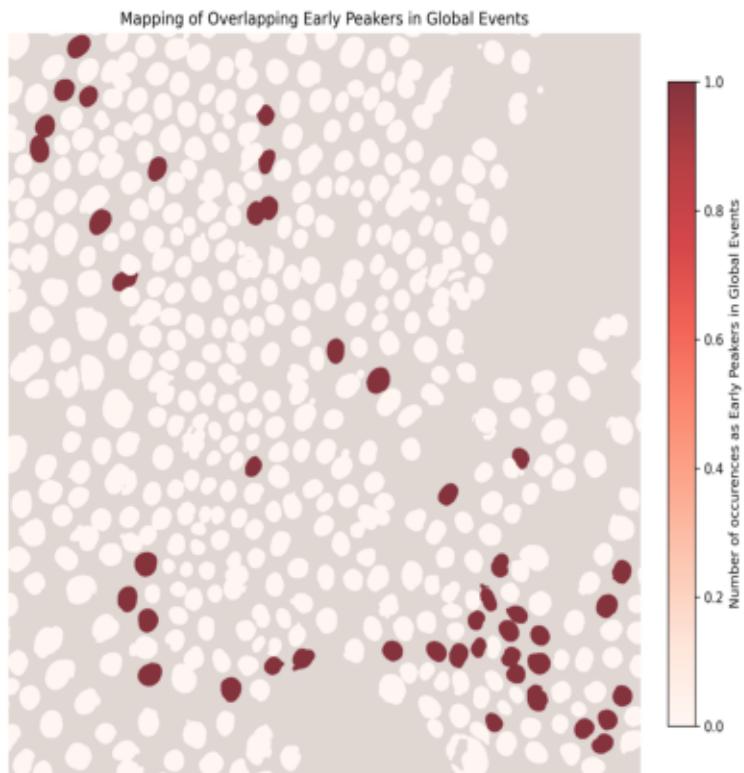
Intervals between global event peaks: []

1.2.6 Early peakers in the events

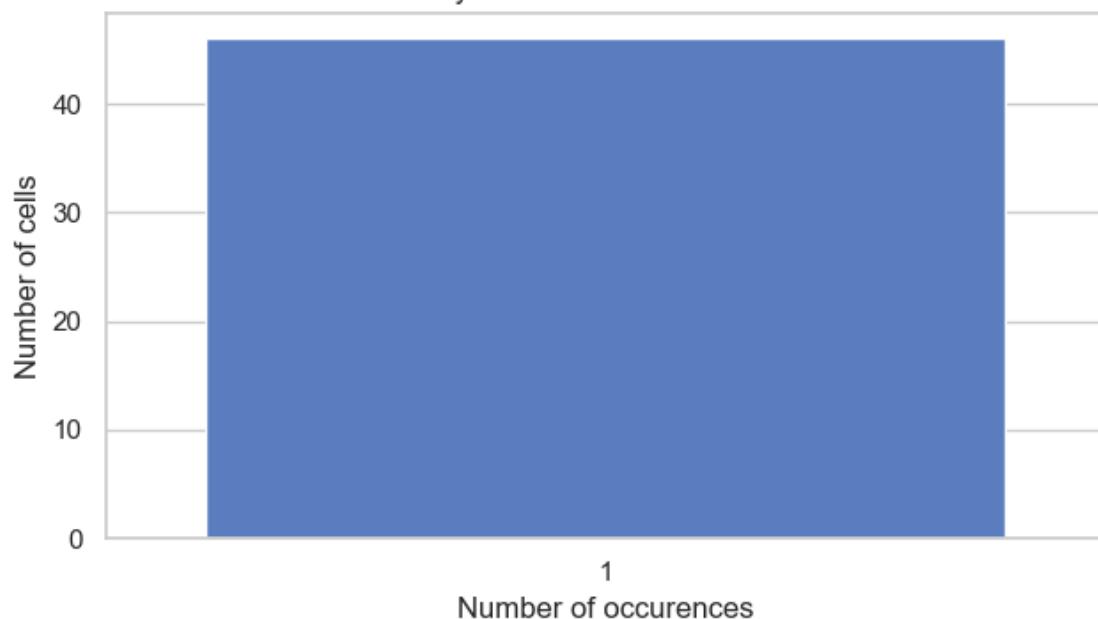
Cell Mapping with Early Peakers Overlay for event 0 - 20250409_IS01



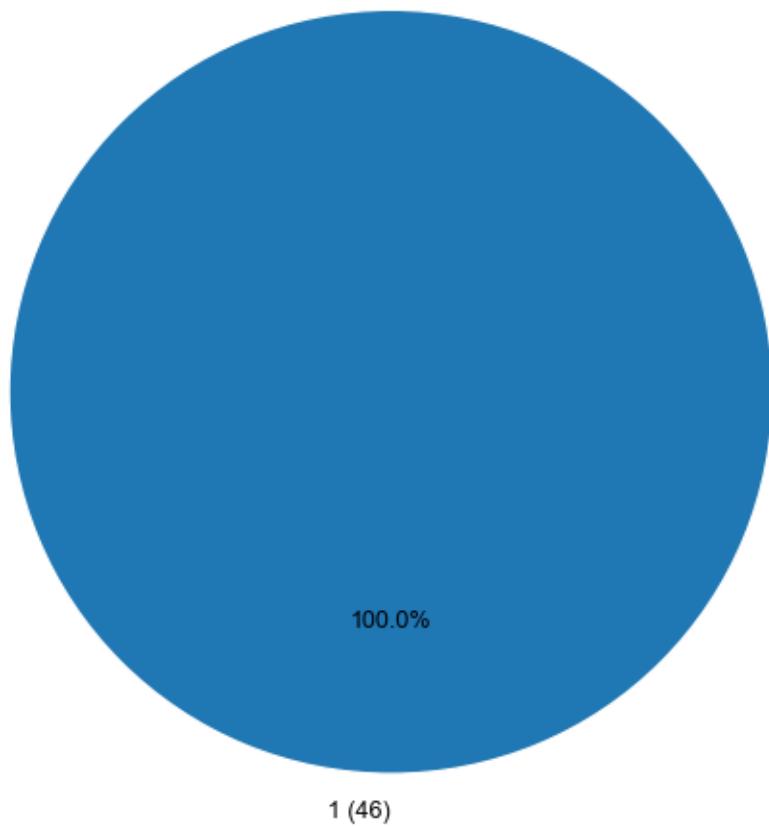
Cell Mapping with Occurrences in Global Events Overlay - 20250409_IS01



Early Peakers in Global Events

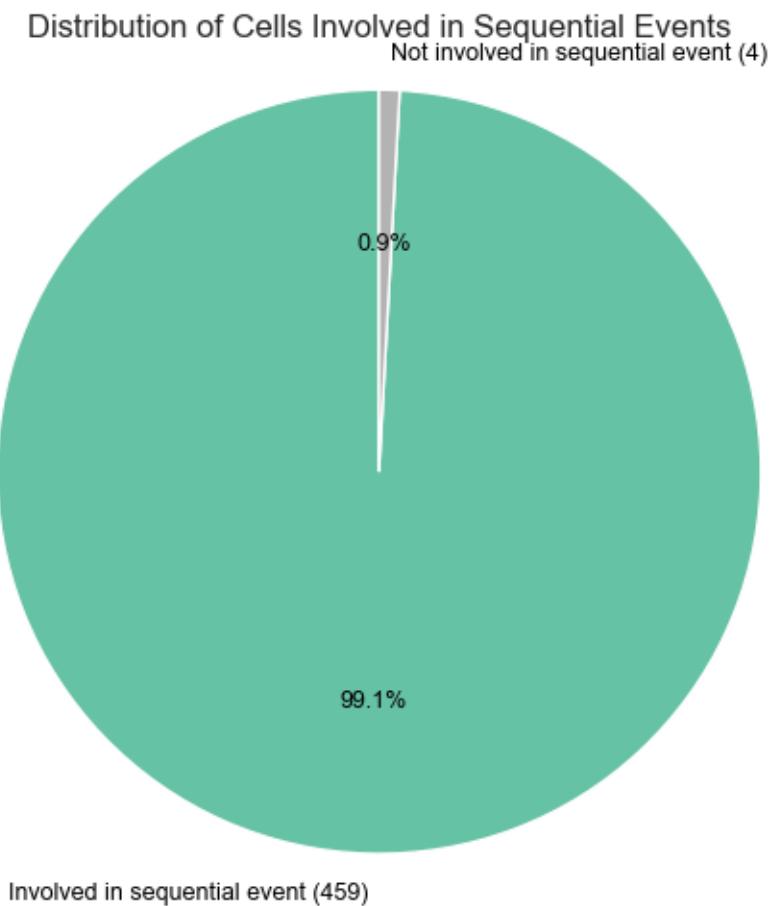


Distribution of Early Peakers in Global Events

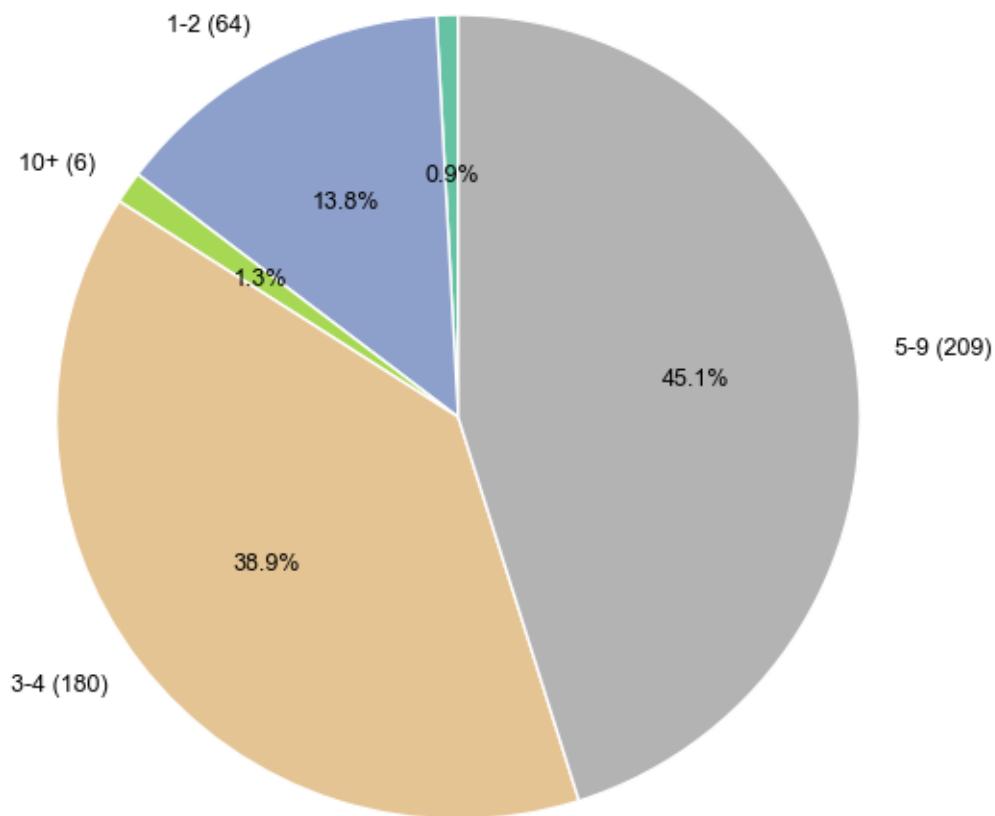


1.3 SEQUENTIAL EVENTS

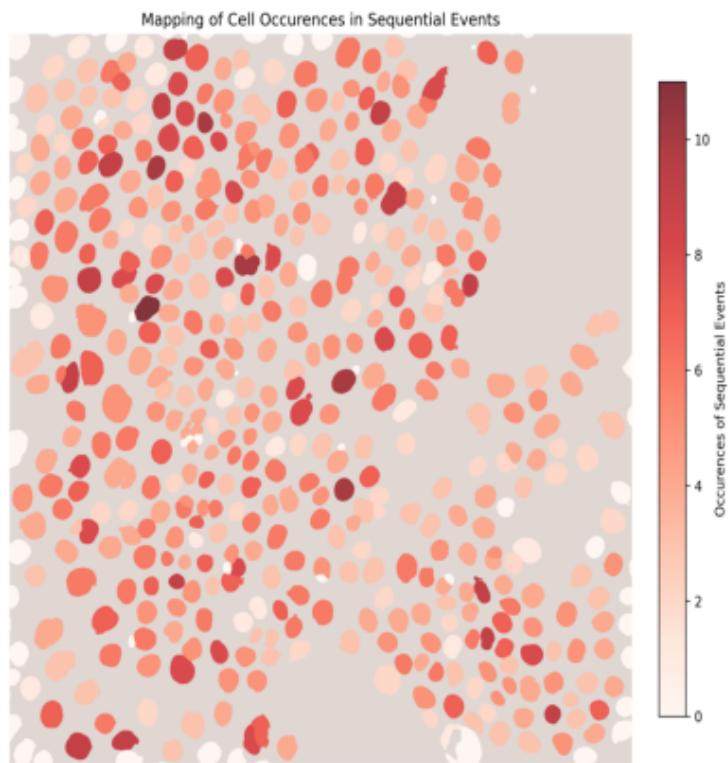
1.3.1 Cells occurrences in sequential events



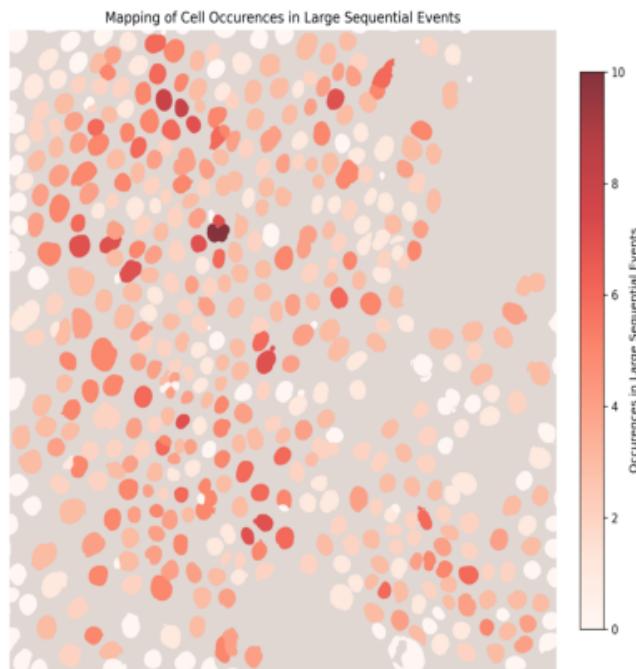
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250409_IS01

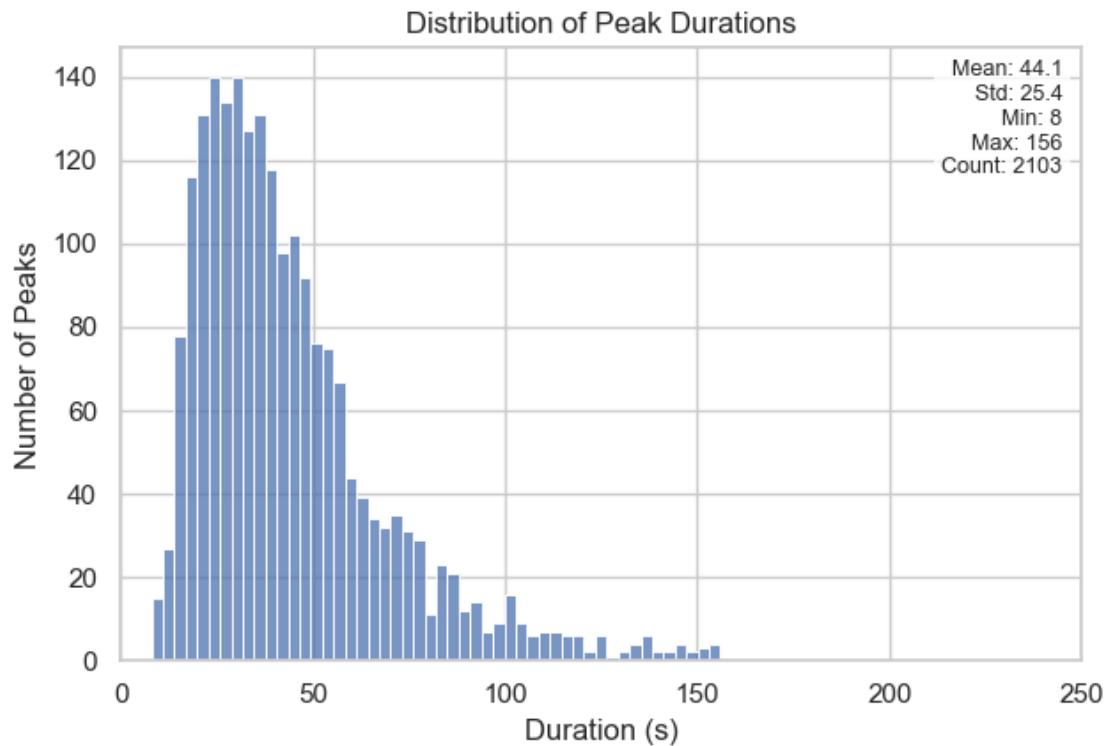


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250409_IS01

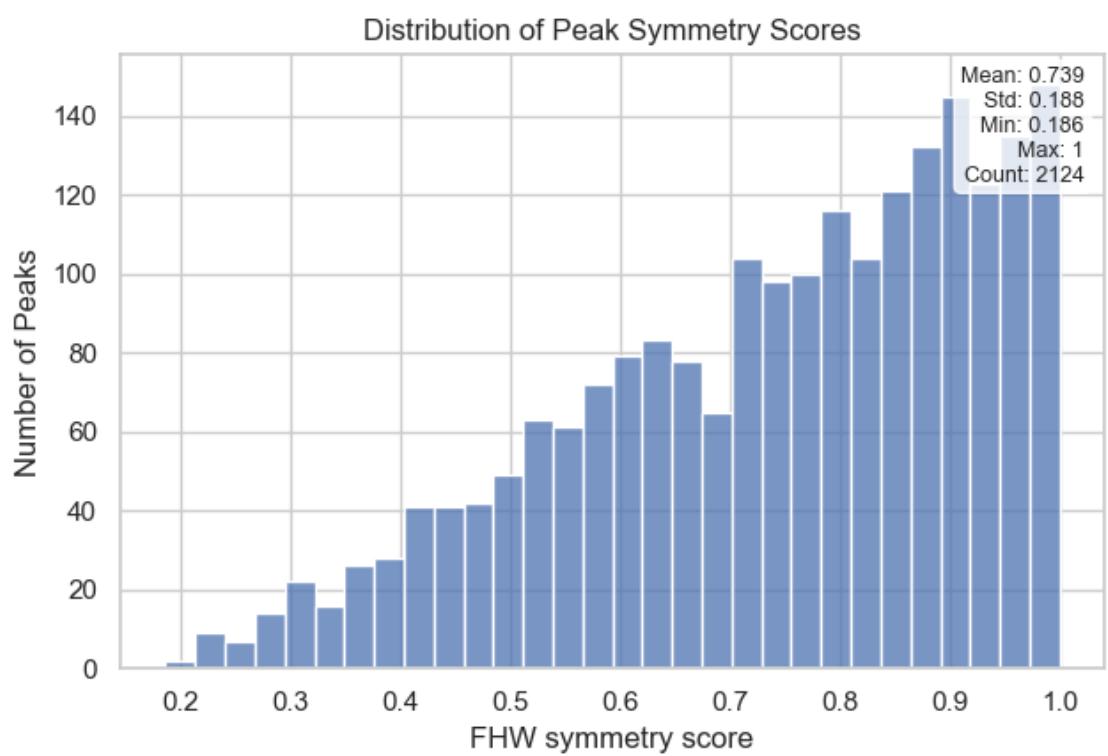
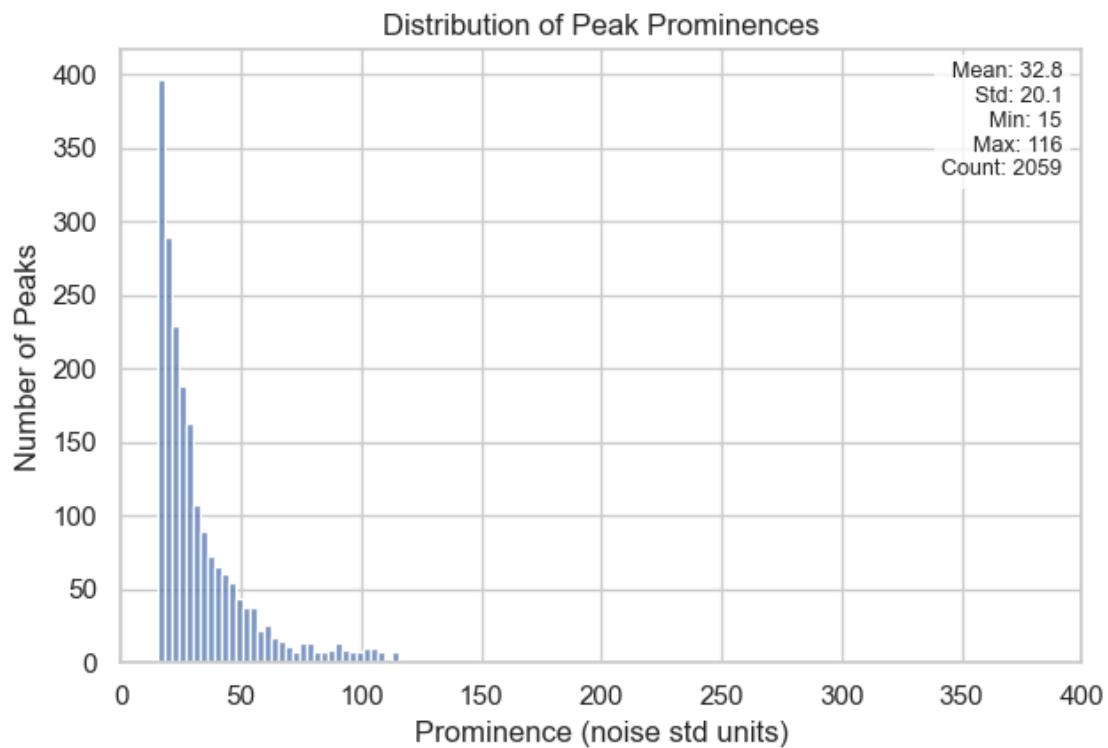


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 11:32:09] [INFO] calcium: plot_histogram: removed 21 outliers out of 2124 on 'Duration (s)' (lower=-17.5, upper=156.5)
```

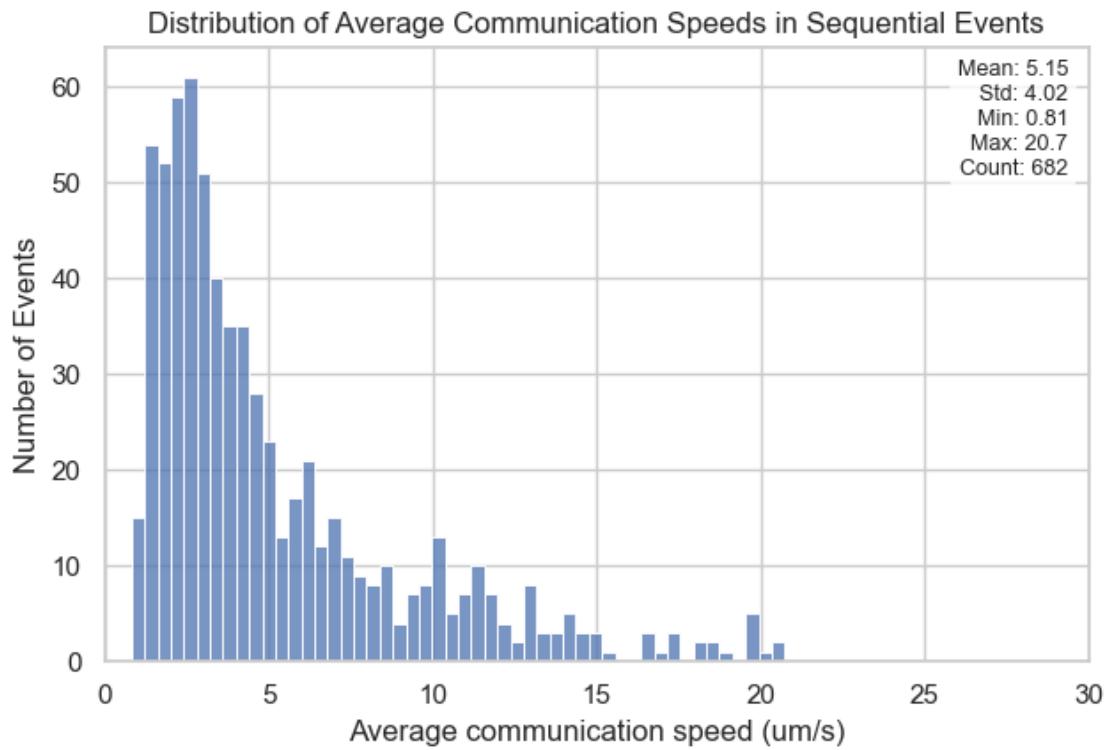


```
[2025-08-13 11:32:09] [INFO] calcium: plot_histogram: removed 65 outliers out of 2124 on 'Prominence (noise std units)' (lower=-13.95, upper=118.65)
```

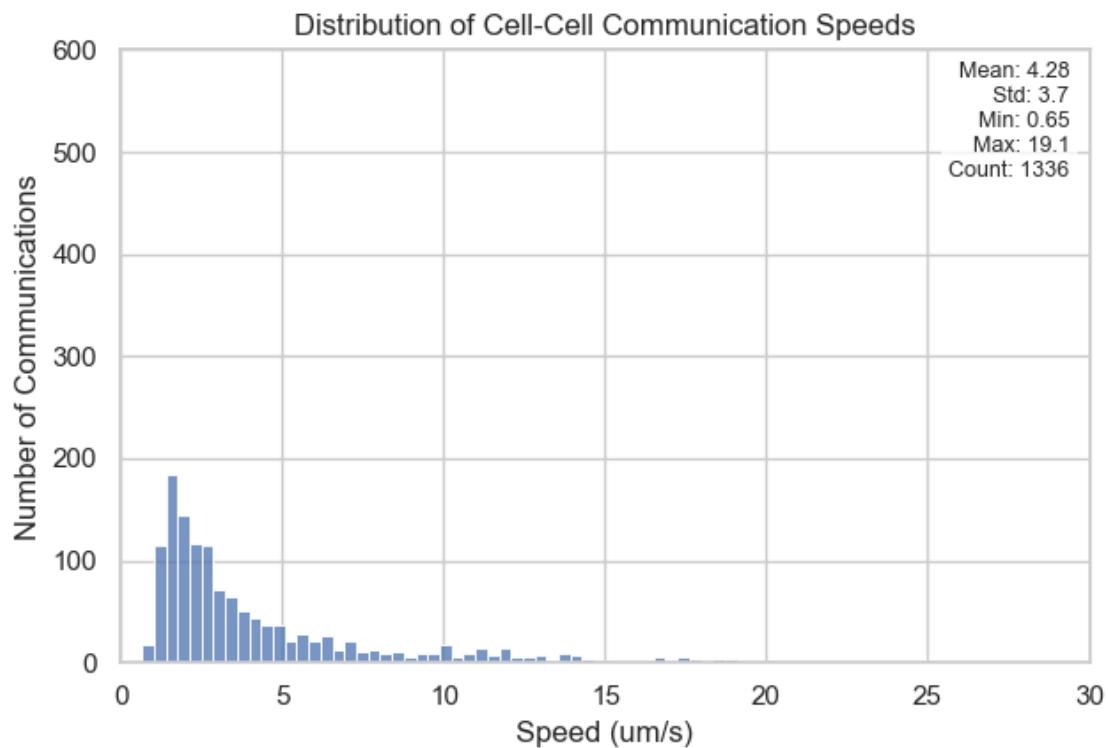


1.3.3 Cell-cell communication speed

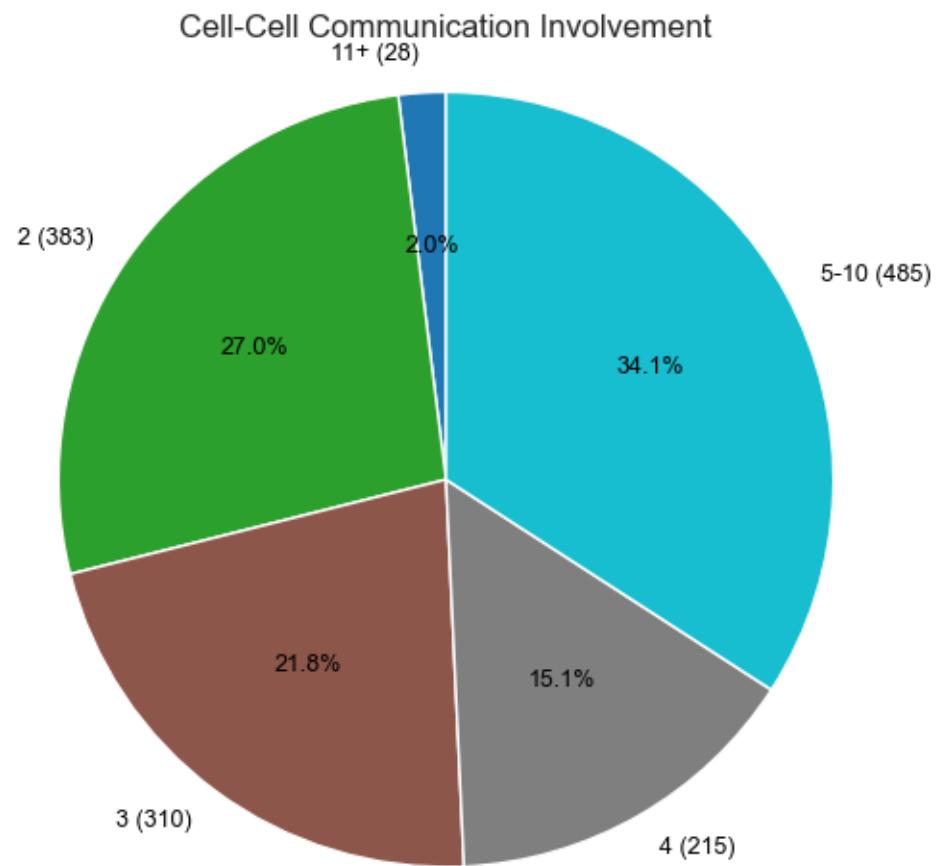
[2025-08-13 11:32:09] [INFO] calcium: plot_histogram: removed 21 outliers out of 703 on 'Average communication speed (um/s)' (lower=-11.8, upper=21.24)



[2025-08-13 11:32:09] [INFO] calcium: plot_histogram: removed 85 outliers out of 1421 on 'Speed (um/s)' (lower=-11.18, upper=19.2)

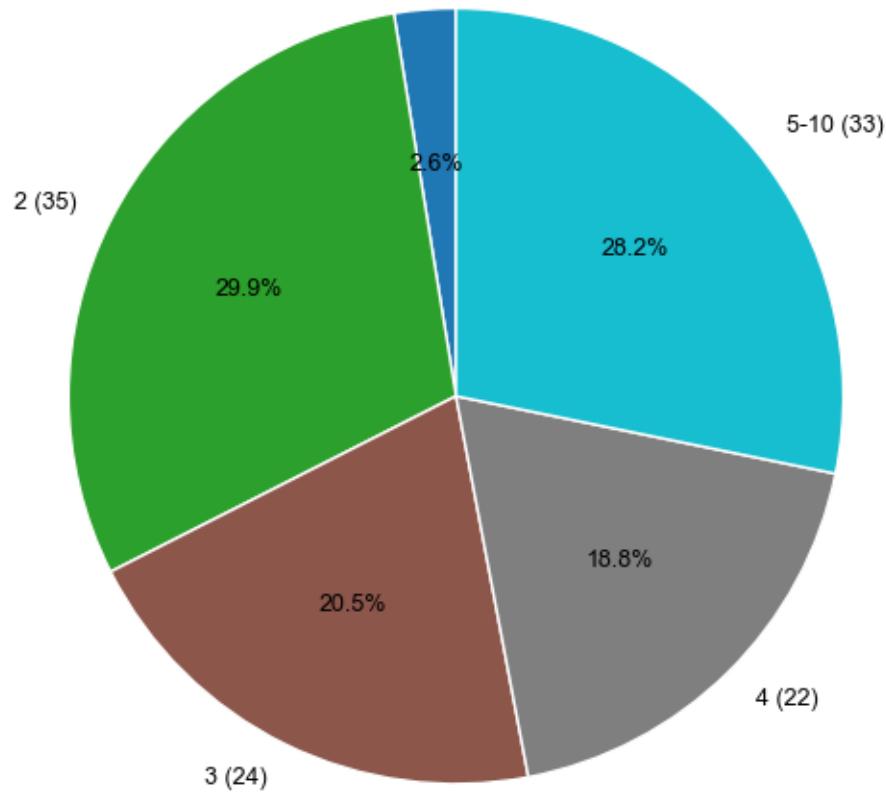


1.3.4 Double distribution in cell-cell communication speeds

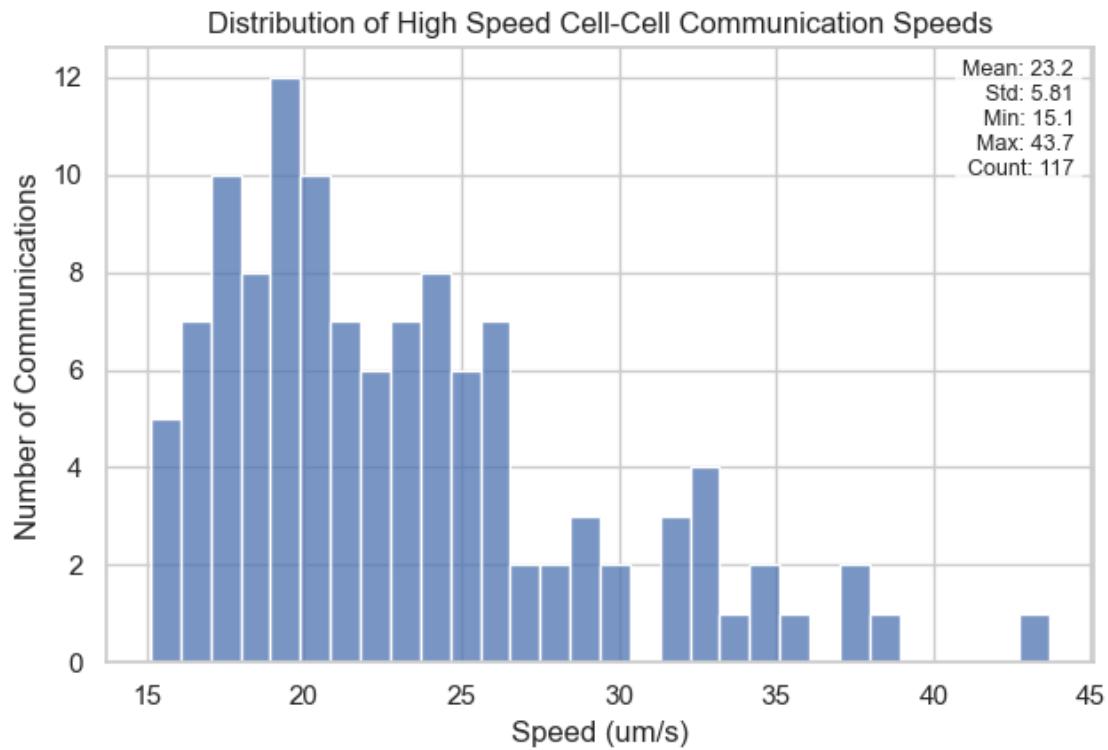


High Speed Cell-Cell Communication Involvement

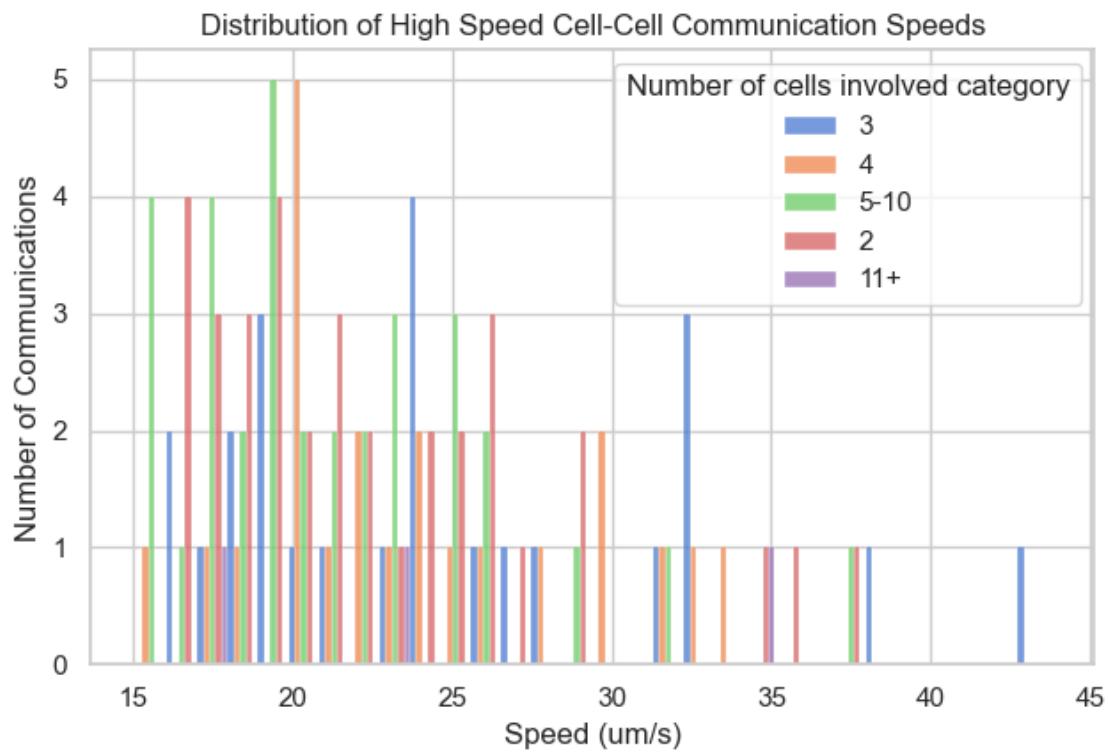
11+ (3)



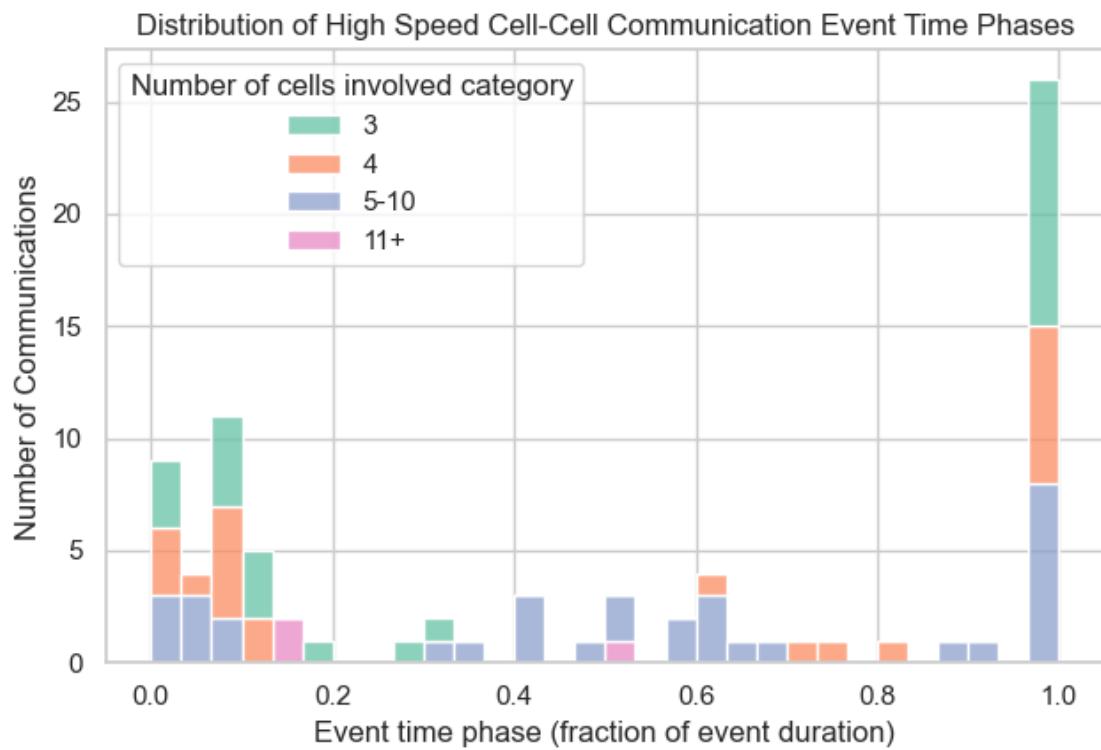
[2025-08-13 11:32:10] [INFO] calcium: plot_histogram: removed 0 outliers out of 117 on 'Speed (um/s)' (lower=-1.87, upper=46.57)



```
[2025-08-13 11:32:10] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 117 on 'Speed (um/s)' (lower=-1.87, upper=46.57)
```

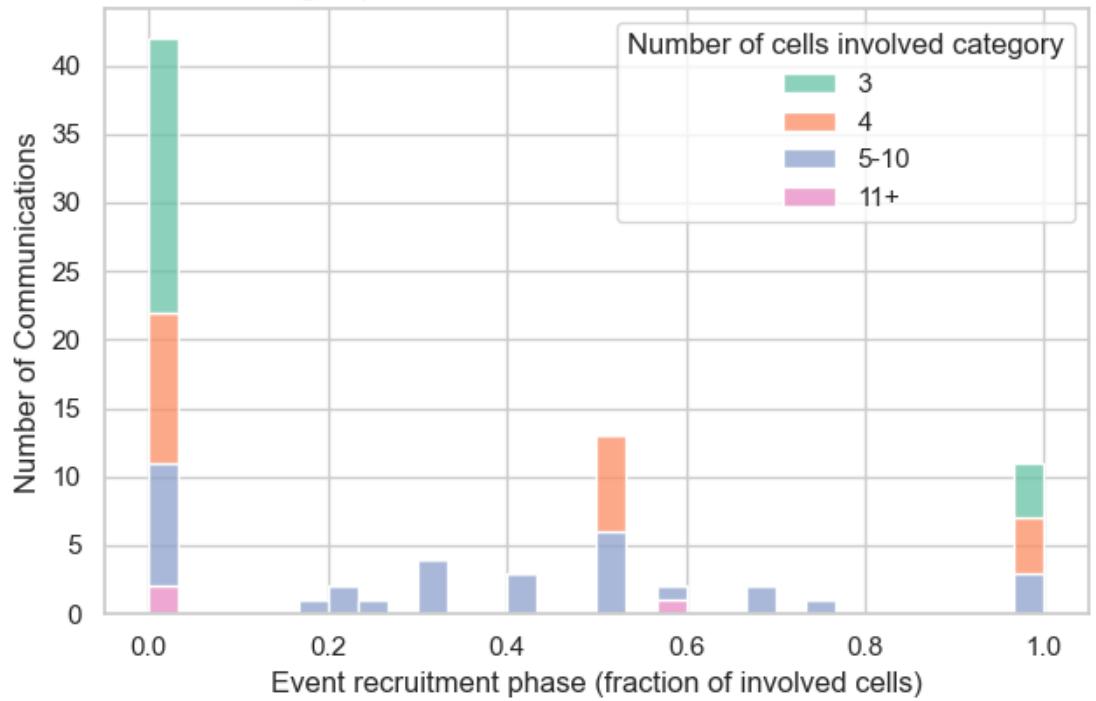


```
[2025-08-13 11:32:11] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 82 on 'Event time phase (fraction of event duration)' (lower=-2.67, upper=3.7525)
```

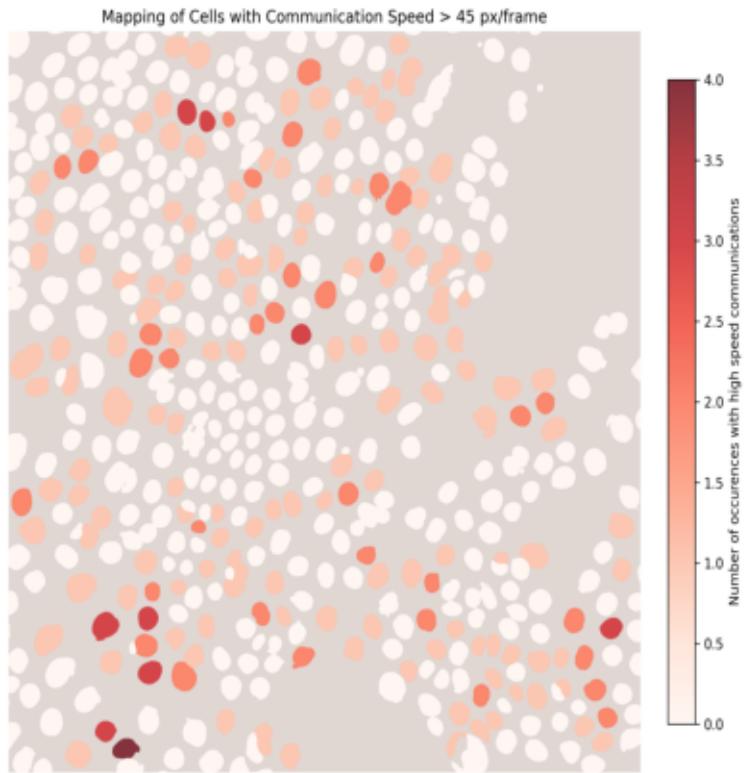


```
[2025-08-13 11:32:11] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 82 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.5, upper=2)
```

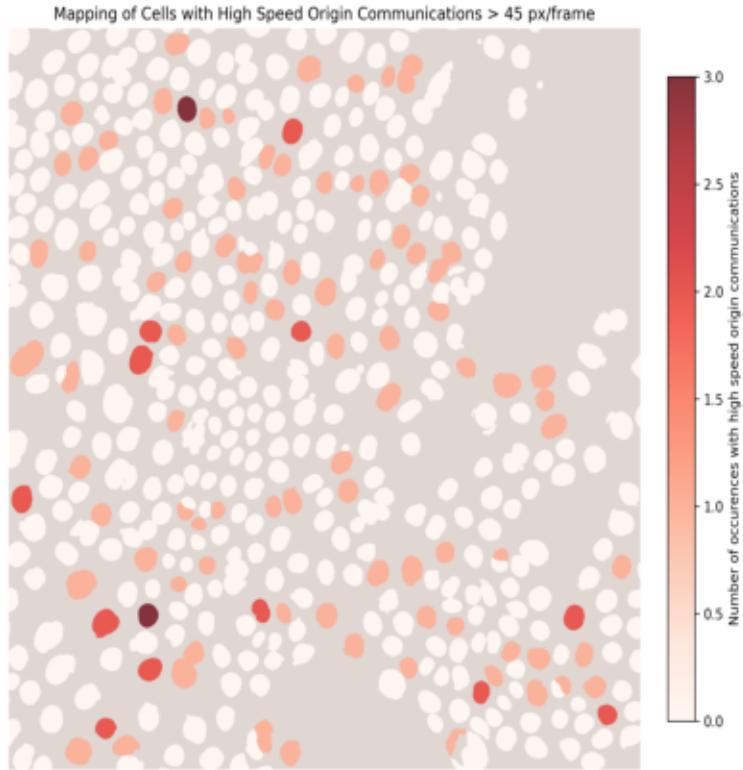
Distribution of High Speed Cell-Cell Communication Event Recruitment Phases



Cell Mapping with High Speed Cells Overlay - 20250409_IS01



Cell Mapping with High Speed Origin Cells Overlay - 20250409_IS01



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
3	1759309285888	2	132	5	
4	1759309294048	3	168	3	
9	1759309284400	4	561	3	
23	1759309286224	8	532	1	
25	1759309298704	9	656	7	
...	
1373	1759498344608	668	703	0	
1378	1759498349744	672	690	2	
1386	1759498338656	677	703	5	
1400	1759498353296	687	725	1	
1402	1759498350464	688	715	2	

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
3	114	5	1514.0	1514.0	
4	193	4	414.0	414.0	
9	556	1	960.0	960.0	
23	544	1	133.0	133.0	
25	624	8	1643.0	1643.0	
...	\
1373	722	1	167.0	168.0	
1378	704	6	1181.0	1182.0	
1386	713	5	1296.0	1297.0	
1400	715	1	163.0	164.0	
1402	725	3	310.0	311.0	
	Duration (s)	Distance (um)	Speed (um/s)		\
3	0.0	18.93	18.93		
4	0.0	21.32	21.32		
9	0.0	26.40	26.40		
23	0.0	18.48	18.48		
25	0.0	22.25	22.25		
...		\
1373	1.0	16.71	16.71		
1378	1.0	19.68	19.68		
1386	1.0	19.53	19.53		
1400	1.0	19.70	19.70		
1402	1.0	19.70	19.70		
	Event time phase (fraction of event duration)				\
3			1.00		
4			0.00		
9			0.41		
23			1.00		
25			1.00		
...			...		\
1373			1.00		
1378			NaN		
1386			0.04		
1400			NaN		
1402			1.00		
	Event recruitment phase (fraction of involved cells)			dataset	\
3			0.0	20250409_IS01	
4			0.0	20250409_IS01	
9			0.0	20250409_IS01	
23			0.0	20250409_IS01	
25			0.0	20250409_IS01	
...			\
1373			1.0	20250409_IS01	
1378			NaN	20250409_IS01	

1386		0.0	20250409_IS01
1400		NaN	20250409_IS01
1402		1.0	20250409_IS01

	Number of cells involved	category	Speed category
3		3	High speed
4		4	High speed
9		5-10	High speed
23		3	High speed
25		4	High speed
...
1373		3	High speed
1378		2	High speed
1386		5-10	High speed
1400		2	High speed
1402		3	High speed

[117 rows x 16 columns]

Speed category	High speed	Low speed
Origin cell ID		
114	0	1
116	1	7
117	0	1
118	0	5
119	0	1
...
727	0	4
729	0	3
731	1	6
732	1	2
733	0	1

[427 rows x 2 columns]

Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
2	114	308.10	8.45
3	116	132.60	10.08
4	117	271.05	12.35
5	118	383.18	12.35
6	119	149.83	15.60
..
458	727	443.62	484.57
459	729	193.05	483.28
460	731	54.93	486.85
461	732	222.30	487.50
462	733	130.65	489.45

Number of peaks Is active Occurences in global events \

2	6	True	1
3	18	True	1
4	9	True	1
5	11	True	1
6	10	True	1
..
458	7	True	1
459	10	True	1
460	13	True	1
461	8	True	1
462	6	True	1

Occurrences in global events as early peaker \

2	0
3	0
4	0
5	0
6	0
..	...
458	0
459	0
460	0
461	0
462	0

Occurrences in sequential events \

2	3
3	9
4	6
5	7
6	7
..	...
458	5
459	8
460	9
461	4
462	3

Occurrences in sequential events as origin \

2	0
3	5
4	1
5	4
6	1
..	...
458	2
459	2
460	5

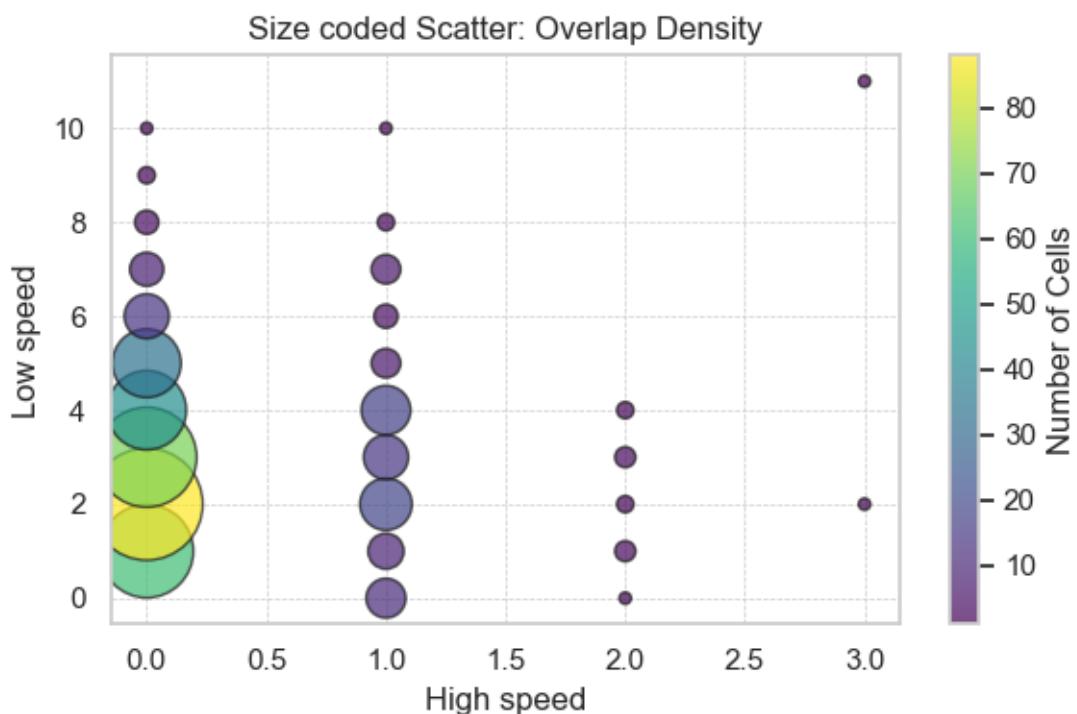
461		2	
462		1	
	Occurrences in individual events	Peak frequency (Hz)	Periodicity score \
2	2	0.0035	0.61
3	7	0.0110	0.55
4	2	0.0053	0.63
5	3	0.0065	0.73
6	1	0.0059	0.58
..
458	1	0.0041	0.60
459	1	0.0059	0.62
460	3	0.0076	0.65
461	3	0.0047	0.62
462	2	0.0035	0.66
	Neighbor count	Neighbors (labels)	dataset \
2	3	[123,132,138]	20250409_IS01
3	4	[113,119,135,140]	20250409_IS01
4	3	[123,136,143]	20250409_IS01
5	3	[125,142,159]	20250409_IS01
6	4	[116,130,140,150]	20250409_IS01
..
458	4	[706,713,722,726]	20250409_IS01
459	3	[705,719,732]	20250409_IS01
460	4	[694,709,715,725]	20250409_IS01
461	7	[647,654,681,684,712,719,729]	20250409_IS01
462	3	[708,716,725]	20250409_IS01
	Involved in sequential event	Occurrences in sequential events category \	
2	Involved in sequential event	3-4	
3	Involved in sequential event	5-9	
4	Involved in sequential event	5-9	
5	Involved in sequential event	5-9	
6	Involved in sequential event	5-9	
..	
458	Involved in sequential event	5-9	
459	Involved in sequential event	5-9	
460	Involved in sequential event	5-9	
461	Involved in sequential event	3-4	
462	Involved in sequential event	3-4	
	High speed	Low speed	
2	0.0	1.0	
3	1.0	7.0	
4	0.0	1.0	
5	0.0	5.0	
6	0.0	1.0	

```

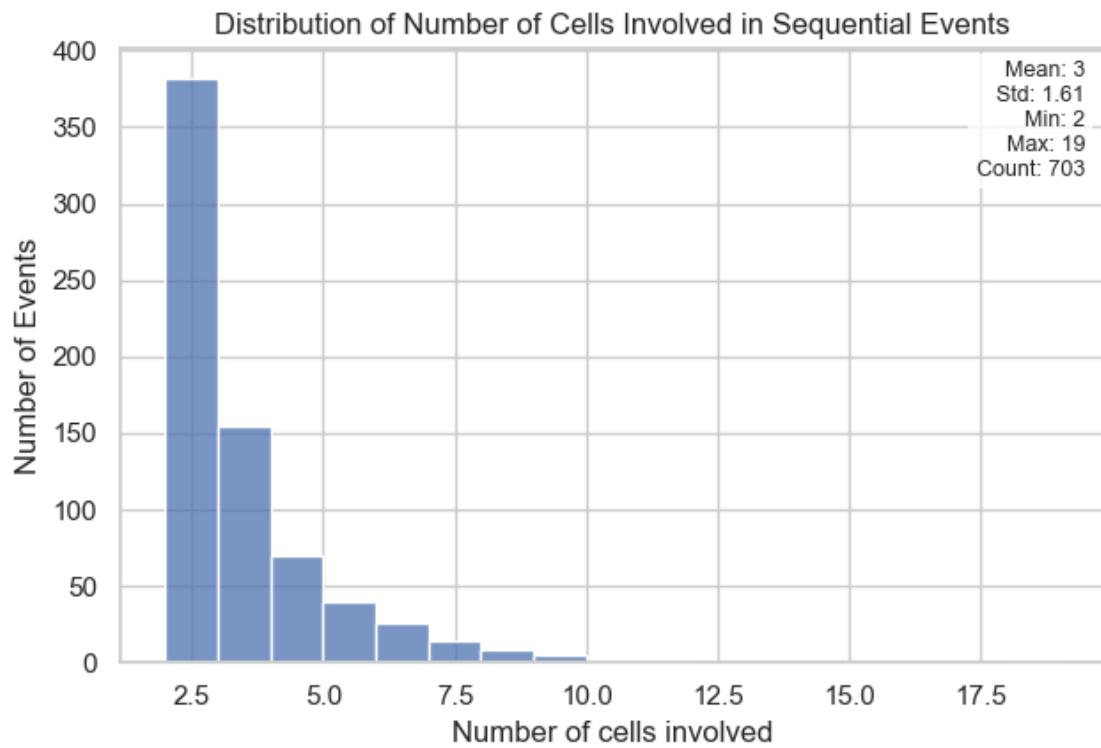
...     ...     ...
458     0.0     4.0
459     0.0     3.0
460     1.0     6.0
461     1.0     2.0
462     0.0     1.0

```

[427 rows x 19 columns]



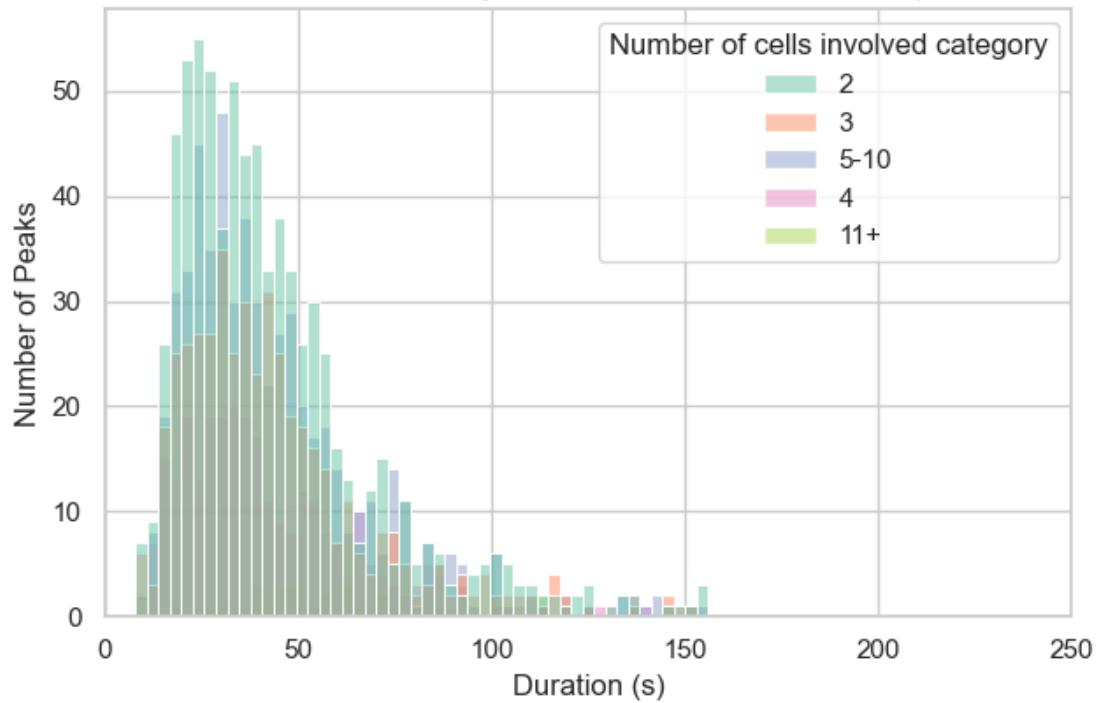
1.3.5 Number of cells involved per sequential events



1.3.6 Influence of cell count per event on statistics

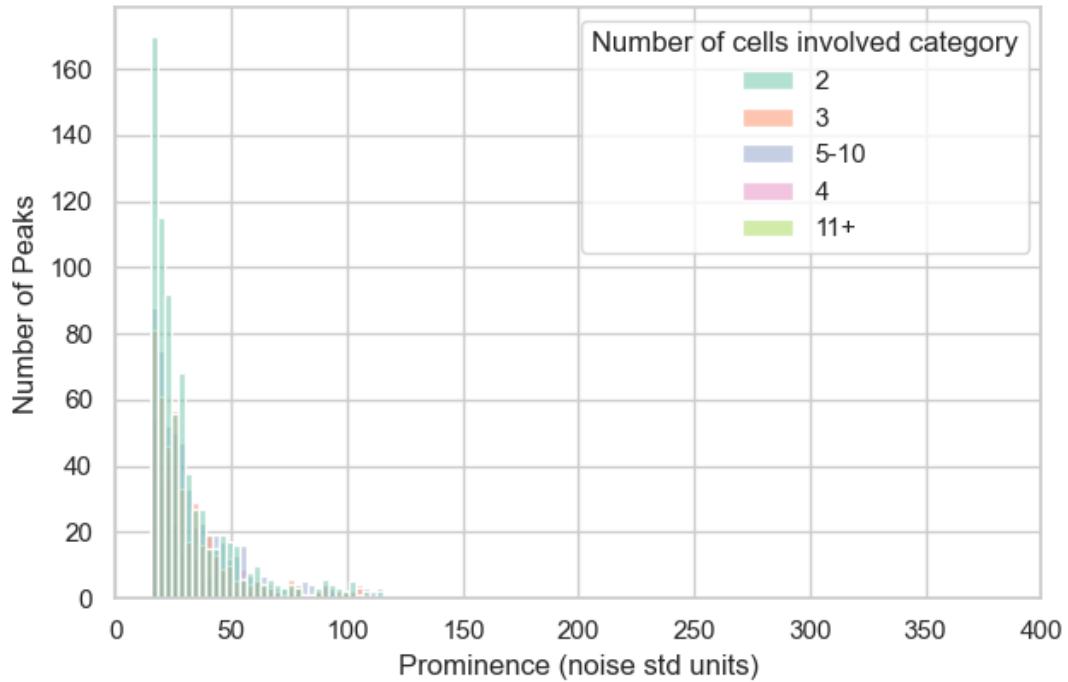
```
[2025-08-13 11:32:14] [INFO] calcium: plot_histogram_by_group: removed 21 outliers out of 2124 on 'Duration (s)' (lower=-17.5, upper=156.5)
```

Distribution of Peak Durations by Number of Cells Involved in Sequential Events

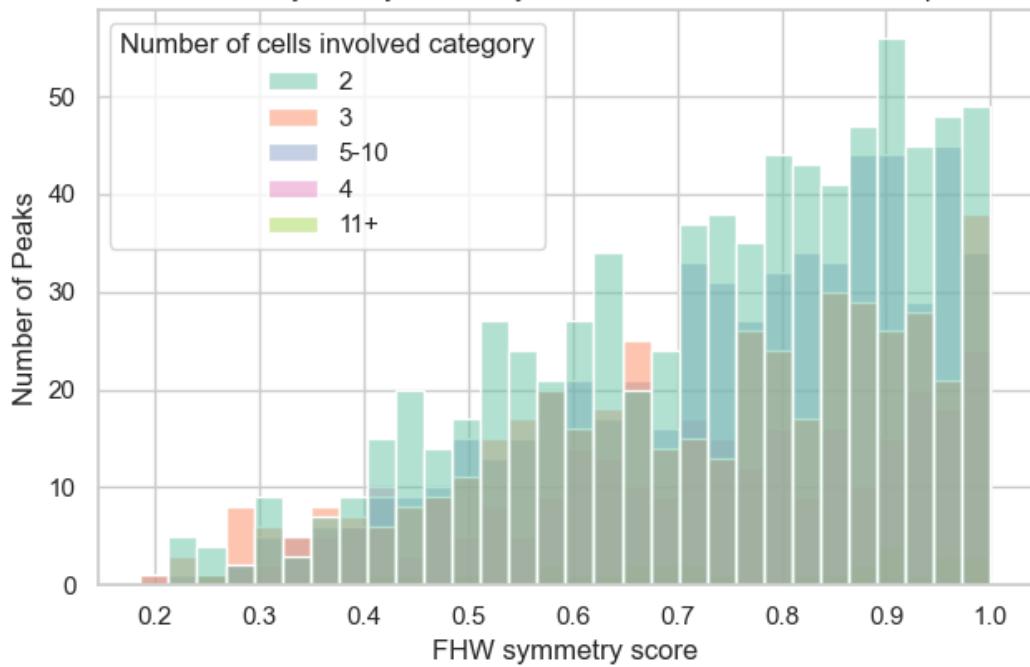


```
[2025-08-13 11:32:15] [INFO] calcium: plot_histogram_by_group: removed 65 outliers out of 2124 on 'Prominence (noise std units)' (lower=-13.95, upper=118.65)
```

Distribution of Peak Prominences by Number of Cells Involved in Sequential Events

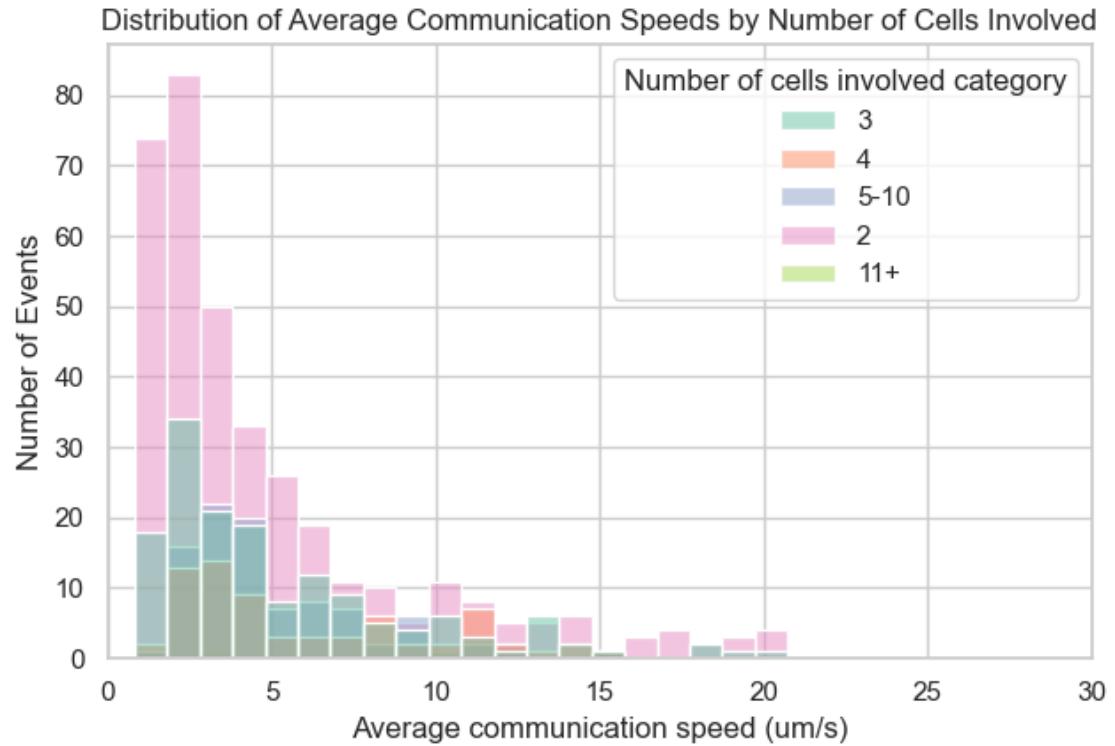


Distribution of Peak Symmetry Scores by Number of Cells Involved in Sequential Events



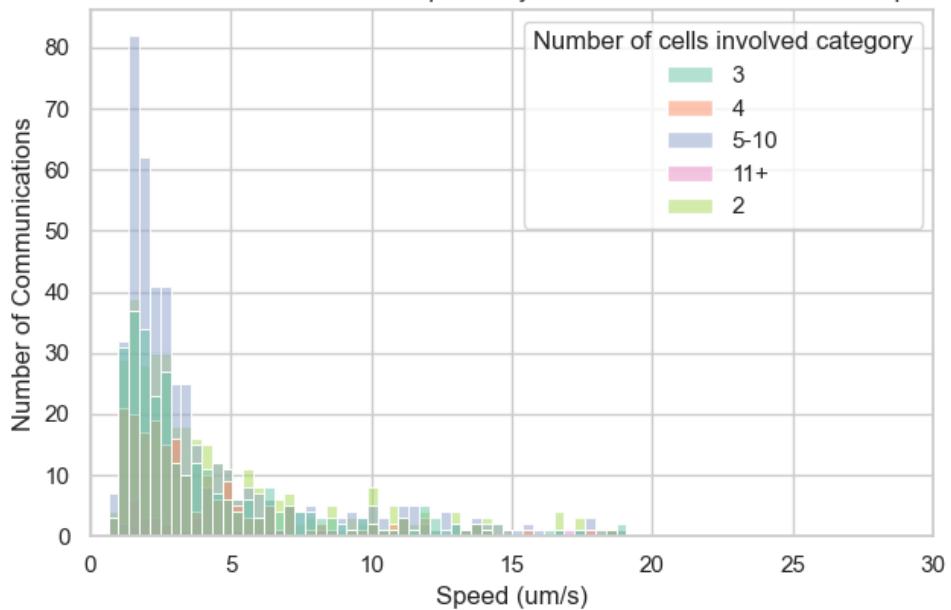
[2025-08-13 11:32:16] [INFO] calcium: plot_histogram_by_group: removed 21

outliers out of 703 on 'Average communication speed (um/s)' (lower=-11.8, upper=21.24)



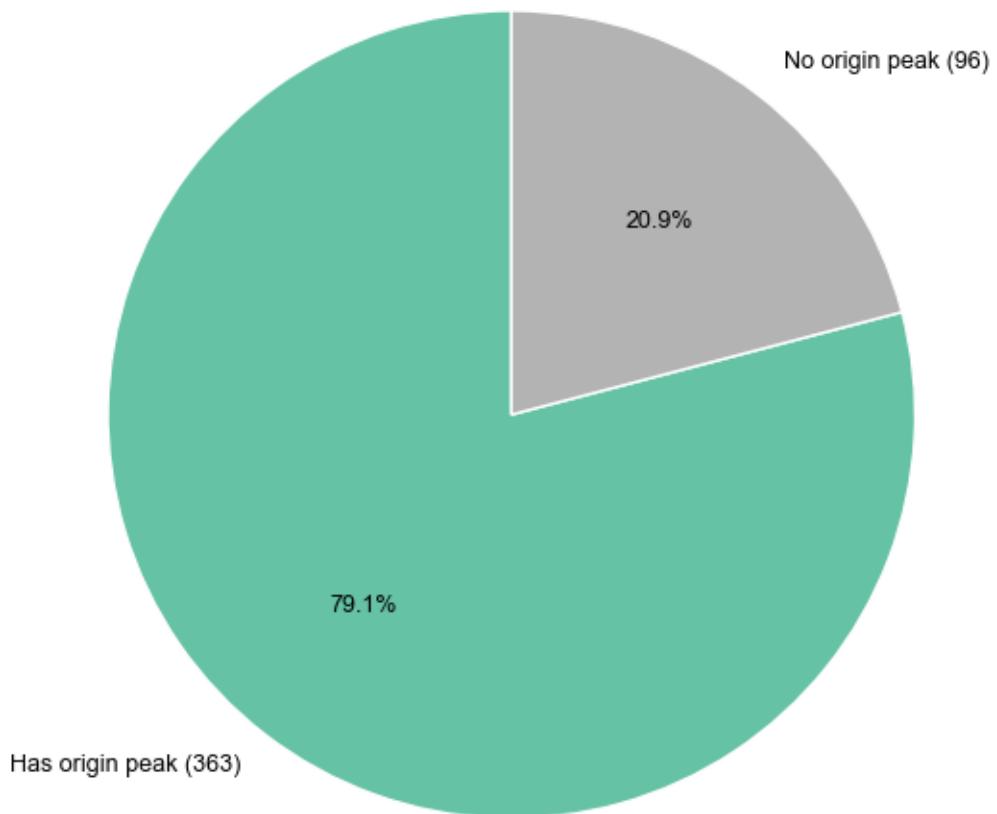
[2025-08-13 11:32:16] [INFO] calcium: plot_histogram_by_group: removed 85 outliers out of 1421 on 'Speed (um/s)' (lower=-11.18, upper=19.2)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events

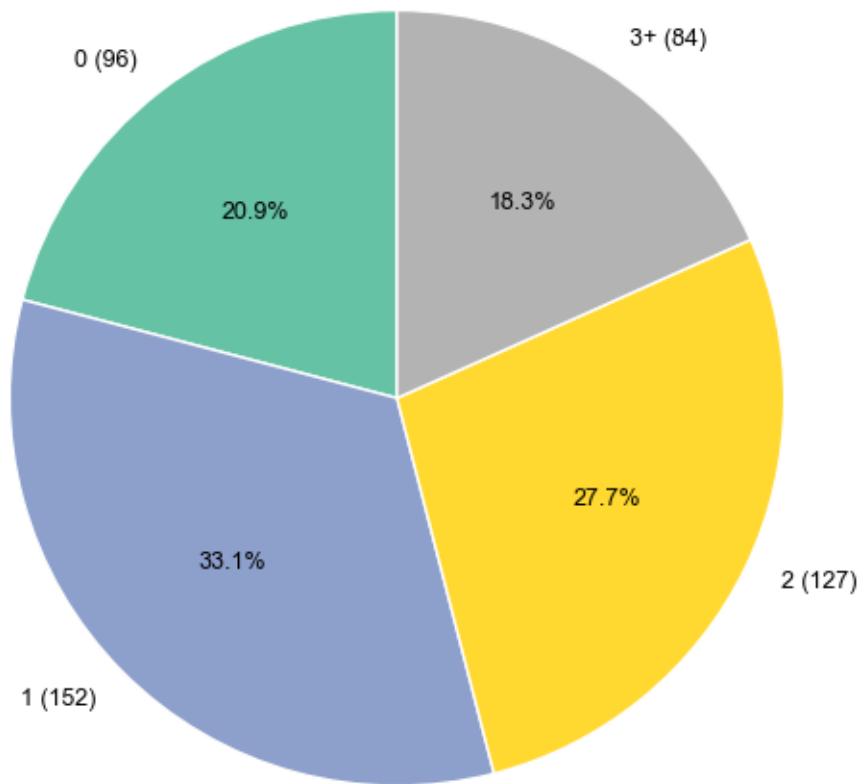


1.3.7 Cells occurrences as origin in sequential events

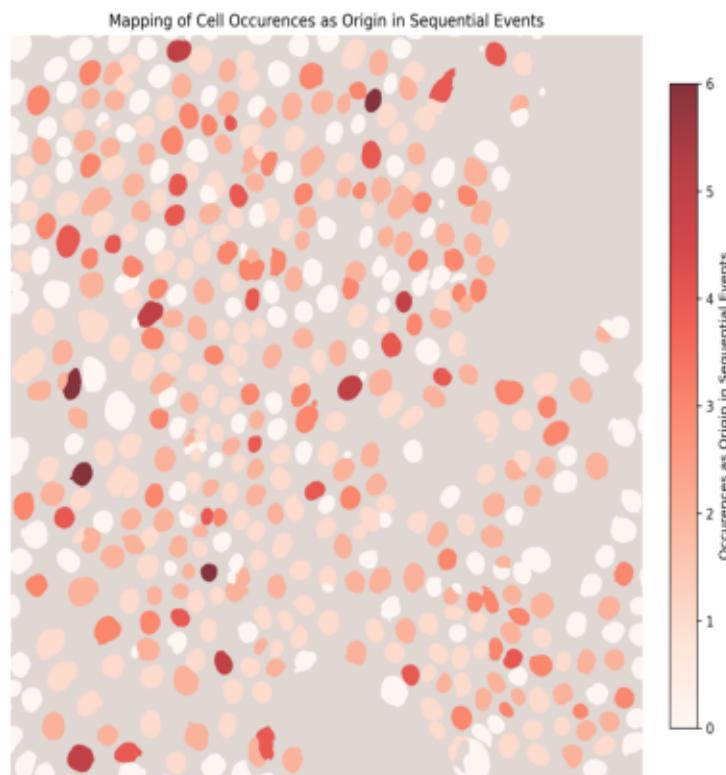
Distribution of Number of Sequential Event Origin Peaks per Cell



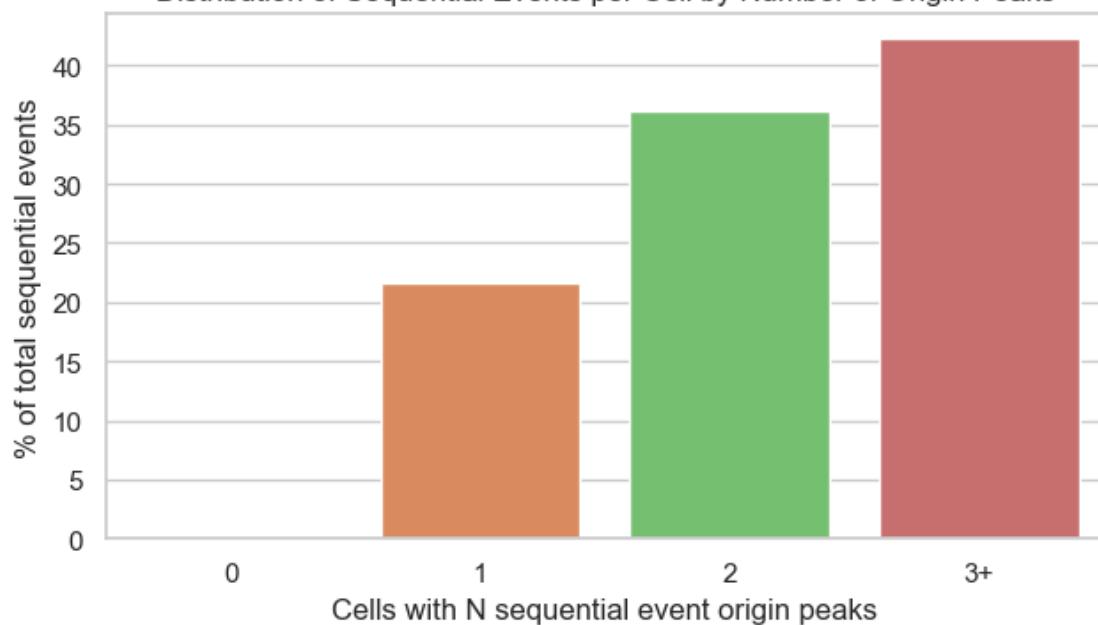
Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)



Cell Mapping with Origin Peaks Overlay - 20250409_IS01

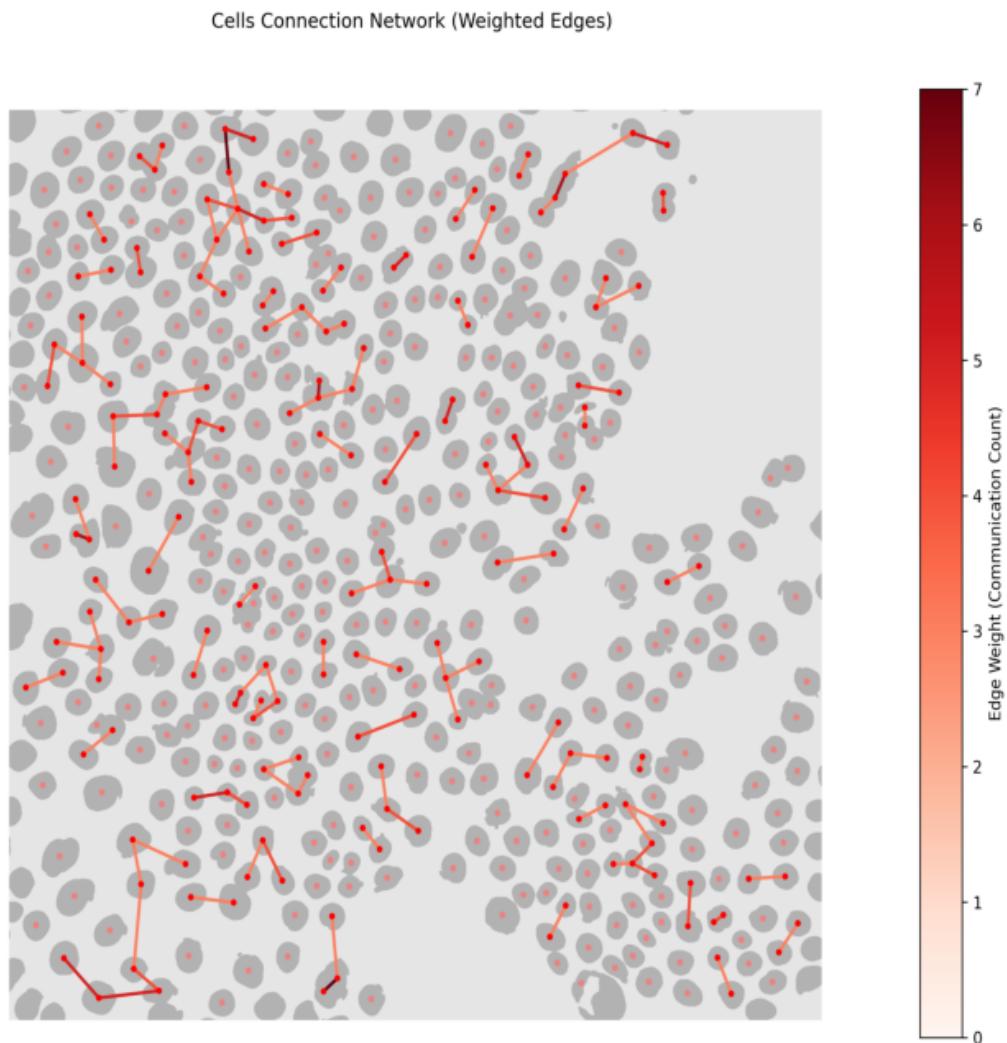


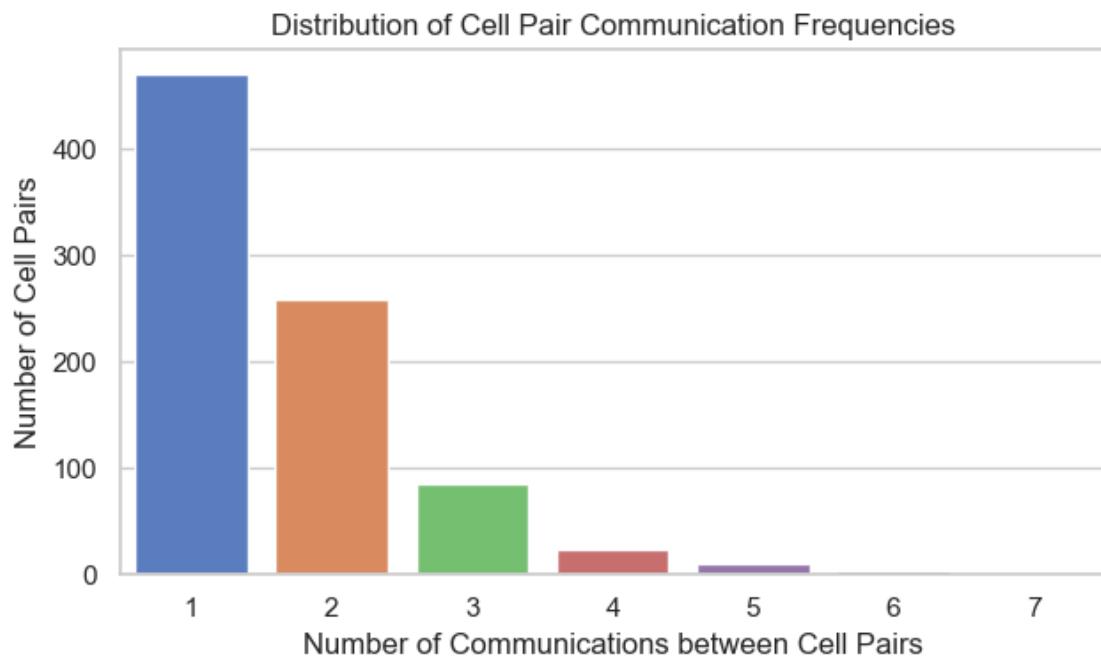
Distribution of Sequential Events per Cell by Number of Origin Peaks



1.3.8 Connection network between cells

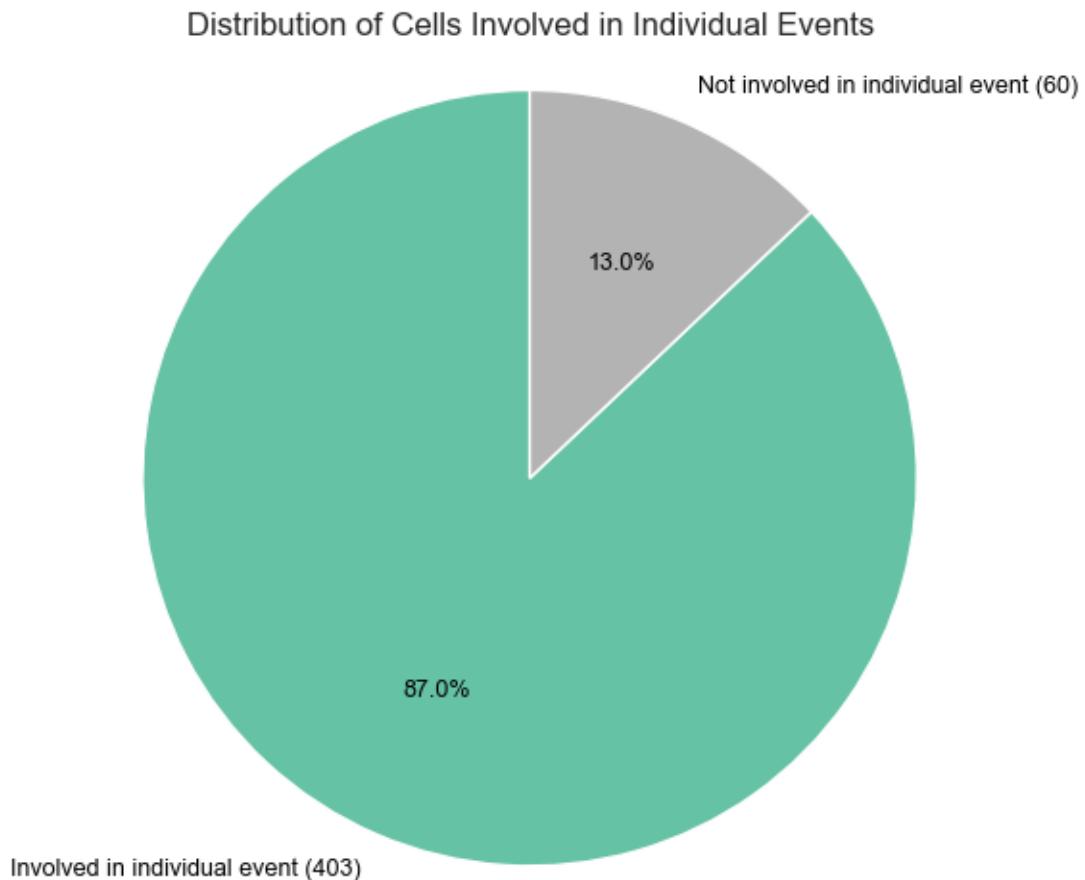
Cell Connection Network Graph - 20250409_IS01



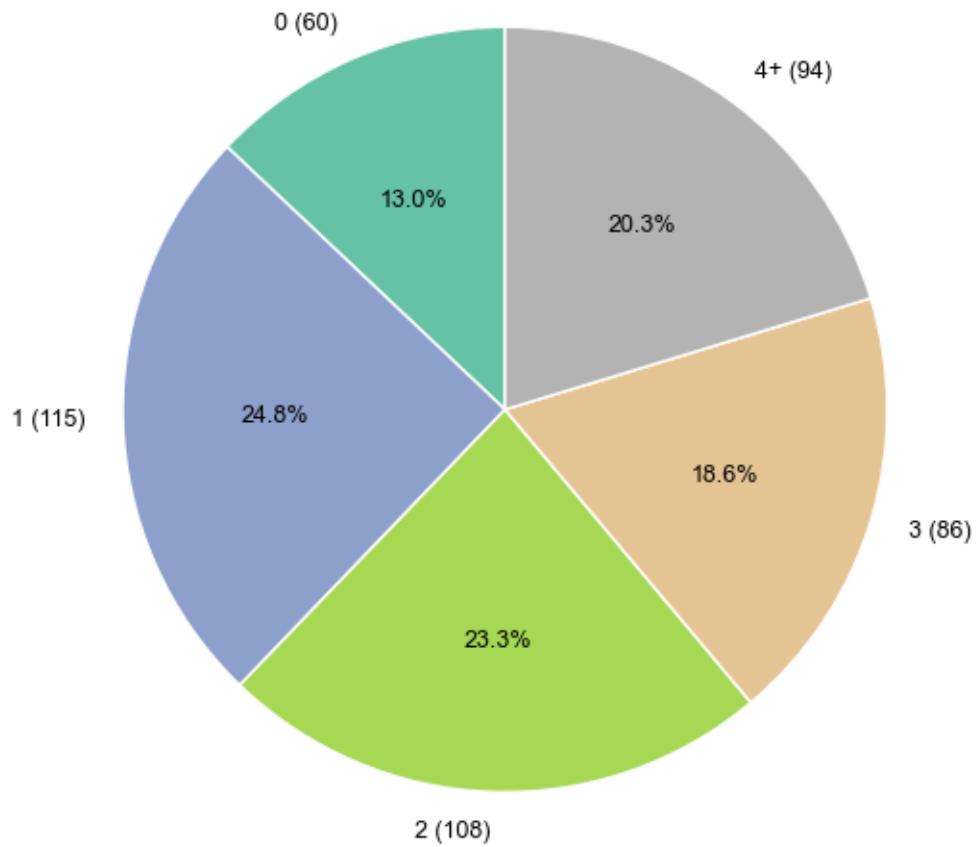


1.4 INDIVIDUAL EVENTS

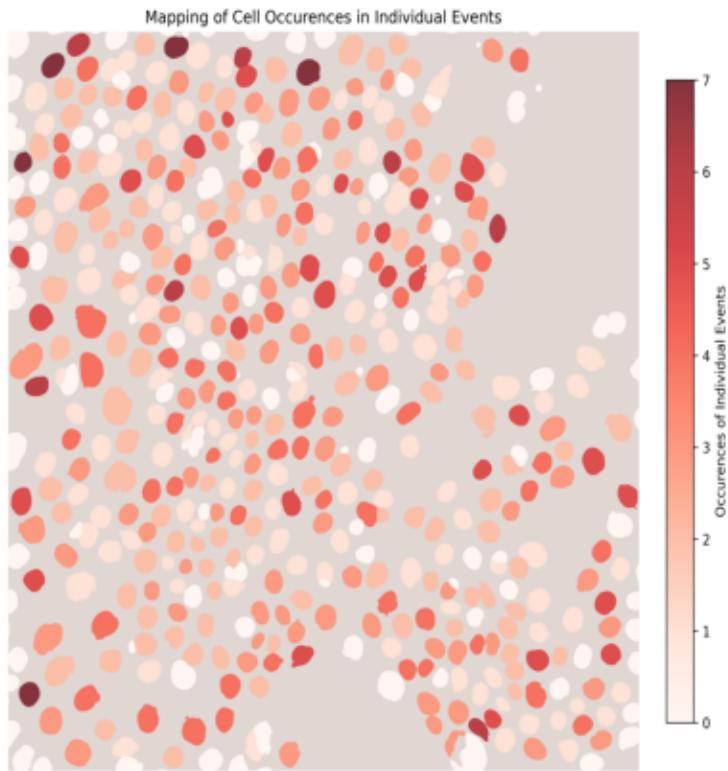
1.4.1 Cells occurrences in individual events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

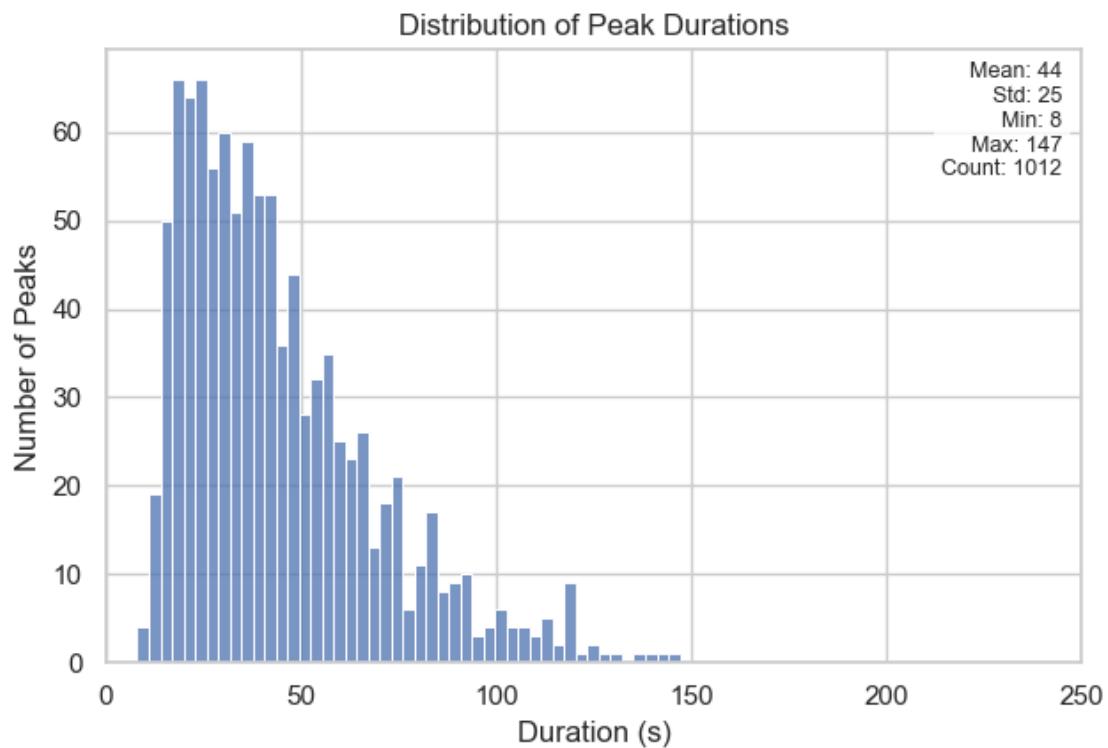


Cell Mapping with Occurrences in Individual Events Overlay - 20250409_IS01

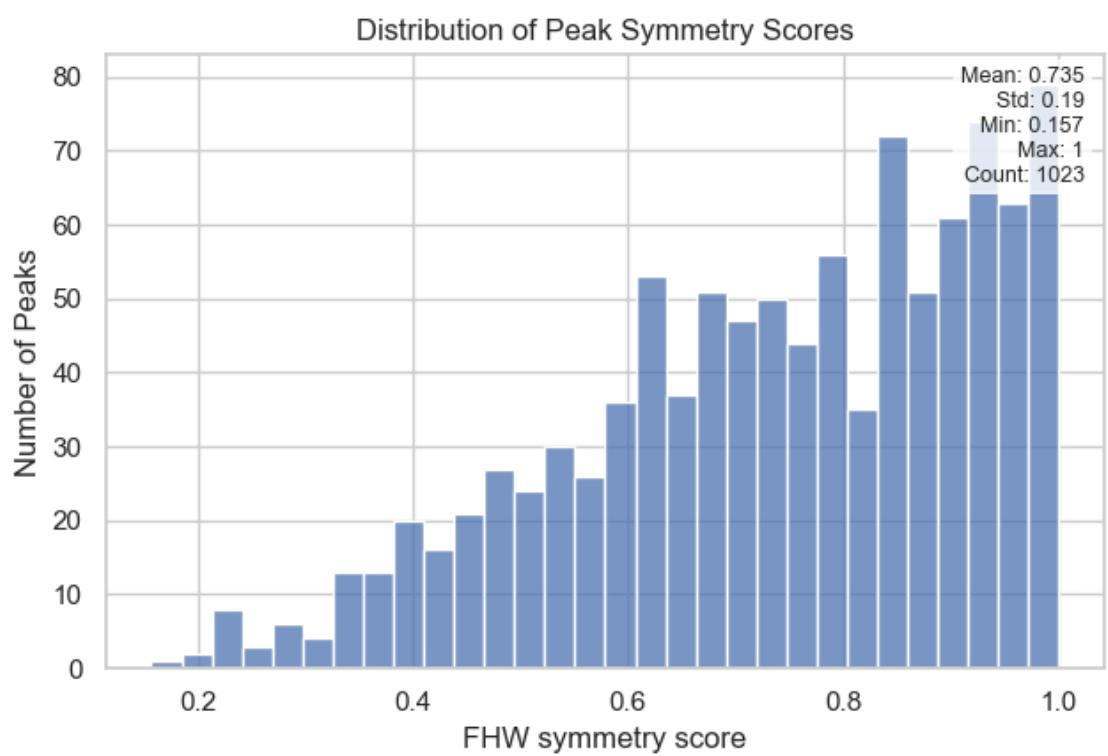
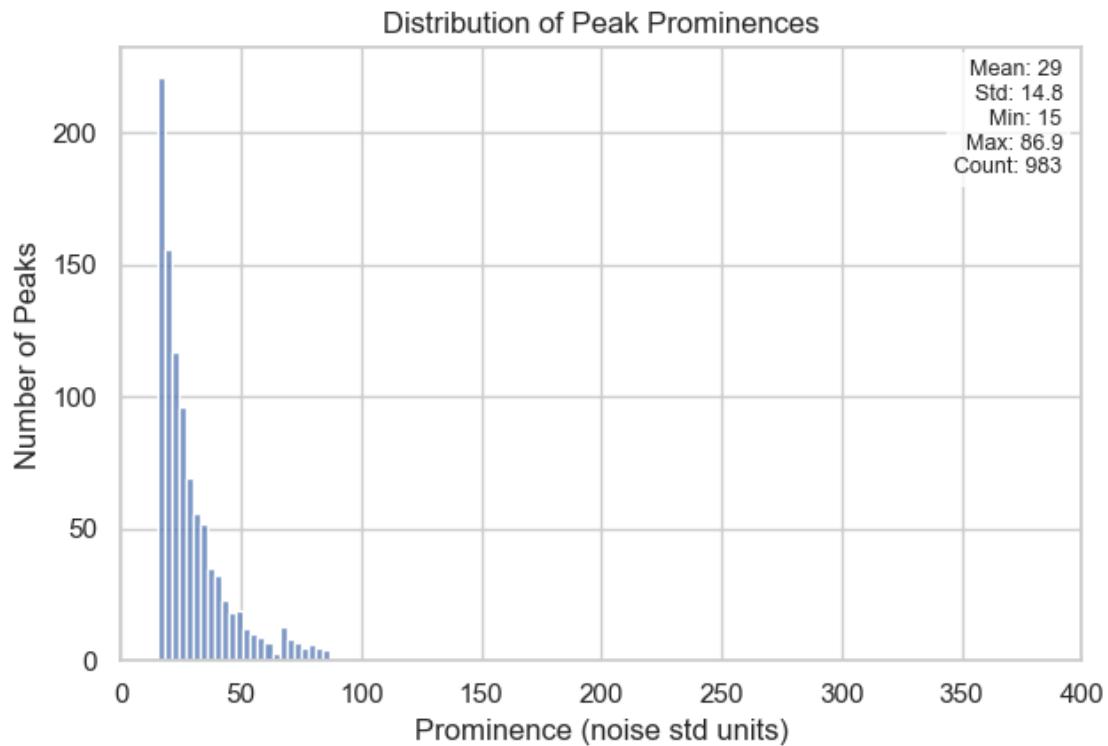


1.4.2 Peaks statistics in individual events

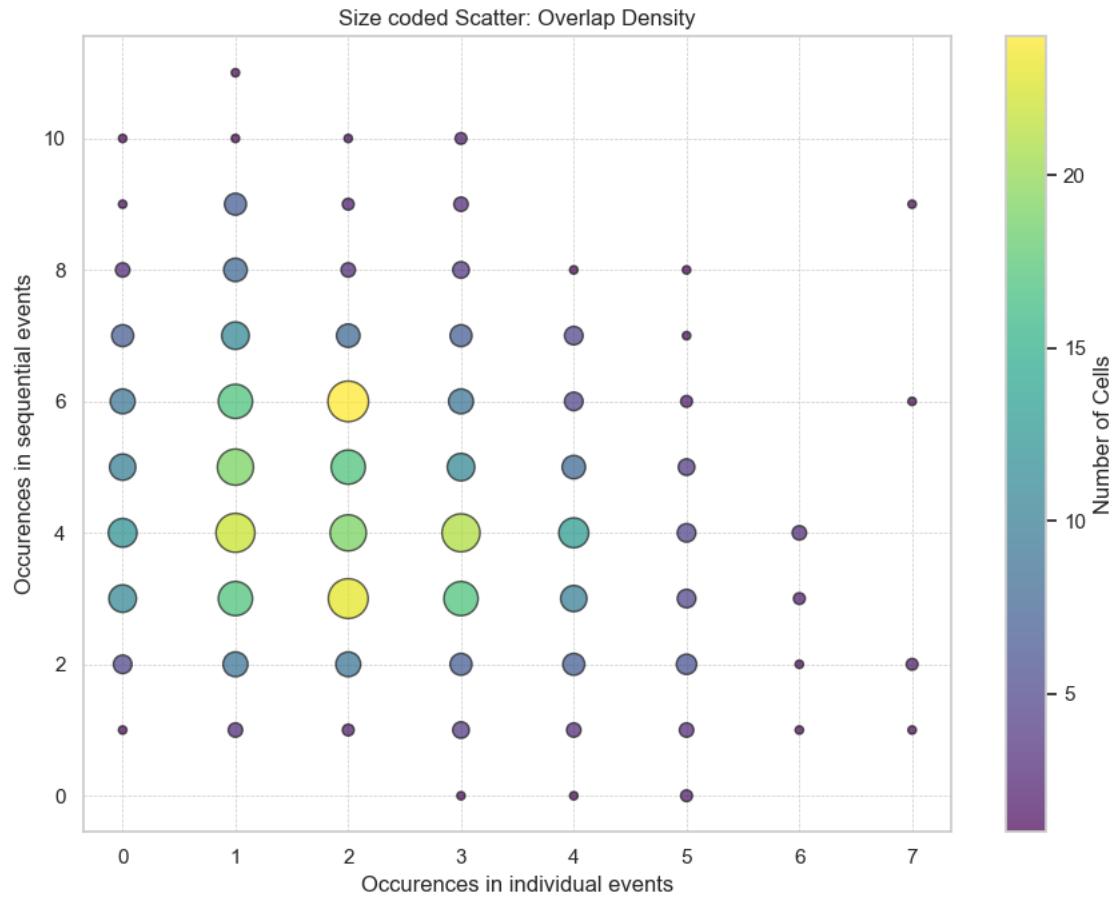
```
[2025-08-13 11:32:22] [INFO] calcium: plot_histogram: removed 11 outliers out of 1023 on 'Duration (s)' (lower=-74, upper=157)
```



```
[2025-08-13 11:32:22] [INFO] calcium: plot_histogram: removed 40 outliers out of 1023 on 'Prominence (noise std units)' (lower=-34.25, upper=88.6)
```



1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250409_IS01



Number of cells:

- Hoechst image taken at t=0: 463
- Hoechst image taken at t=1801: 454
- Number of cells difference: absolute 9, relative 1.96%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 799186
- Pixels segmented as cell at t=1801: 781380
- Overlapping pixels between t=0 and t=1801: 723667 (91.57% of total)
- Pixels exclusive to t=0: 75519 (9.45% of total)
- Pixels exclusive to t=1801: 57713 (7.39% of total)

executed

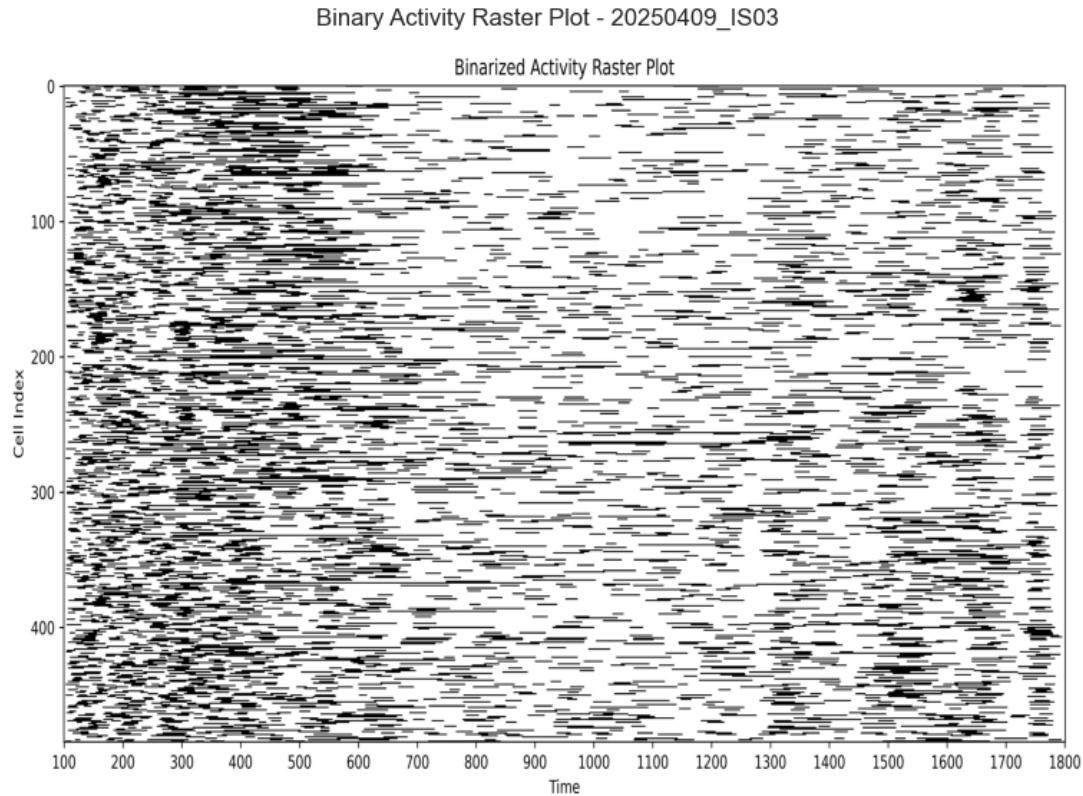
August 13, 2025

1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

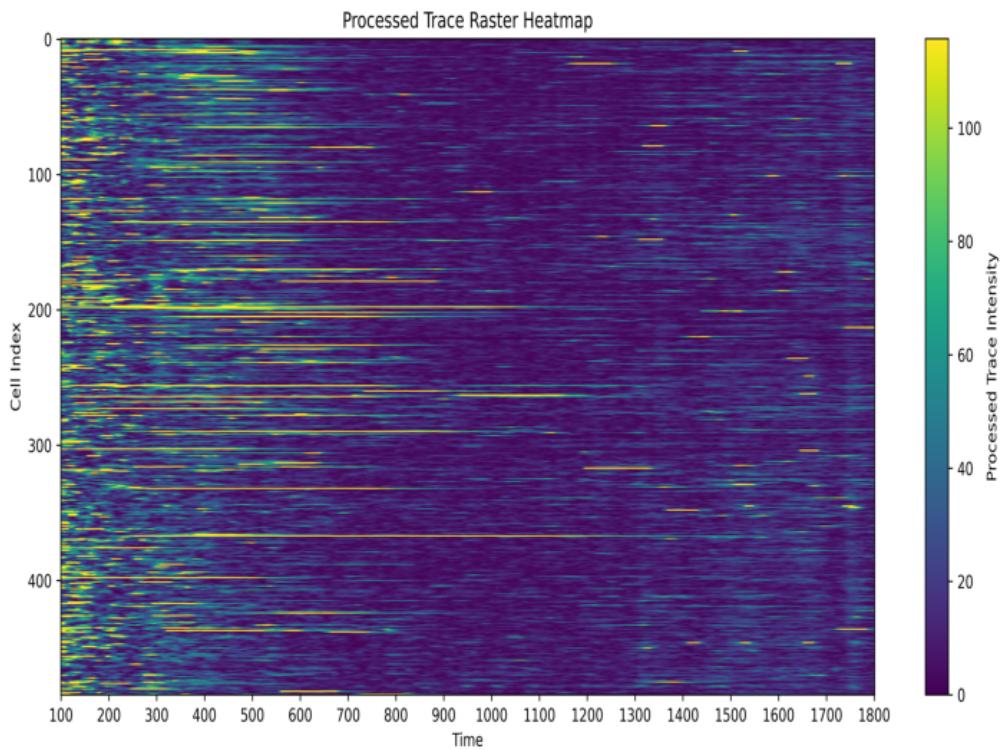
1.0.1 Initialization

1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot



Heatmap Activity Raster Plot - 20250409_IS03



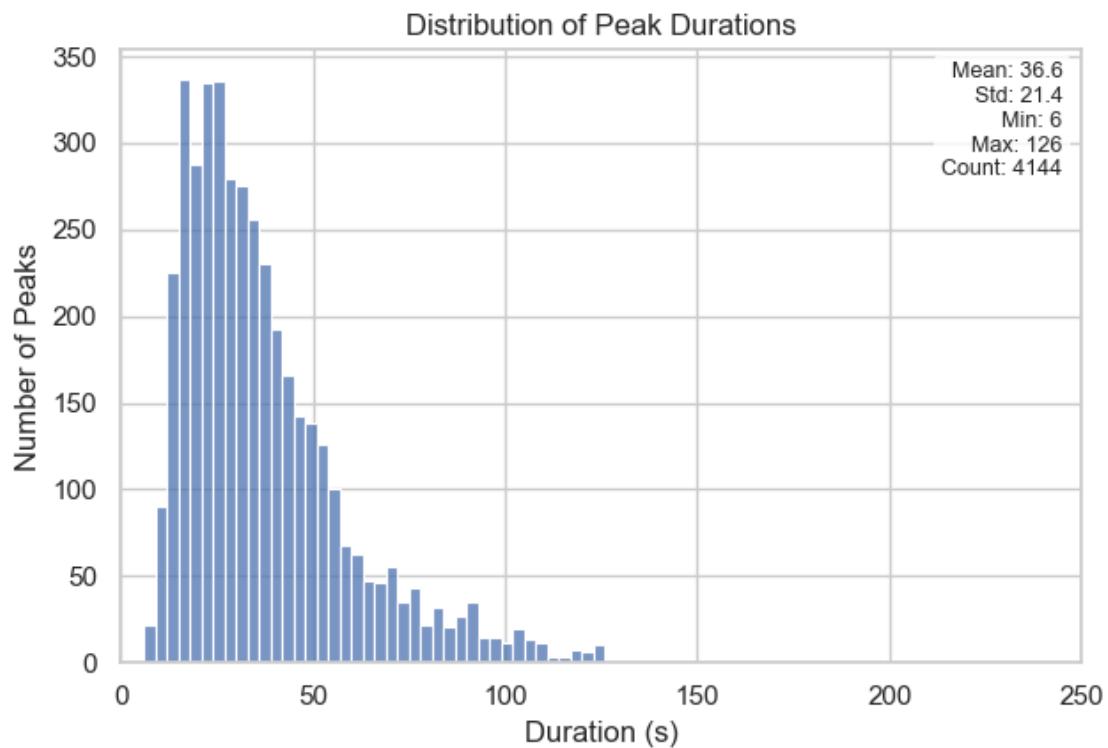
1.1.2 Peaks population

Total number of peaks: 4264

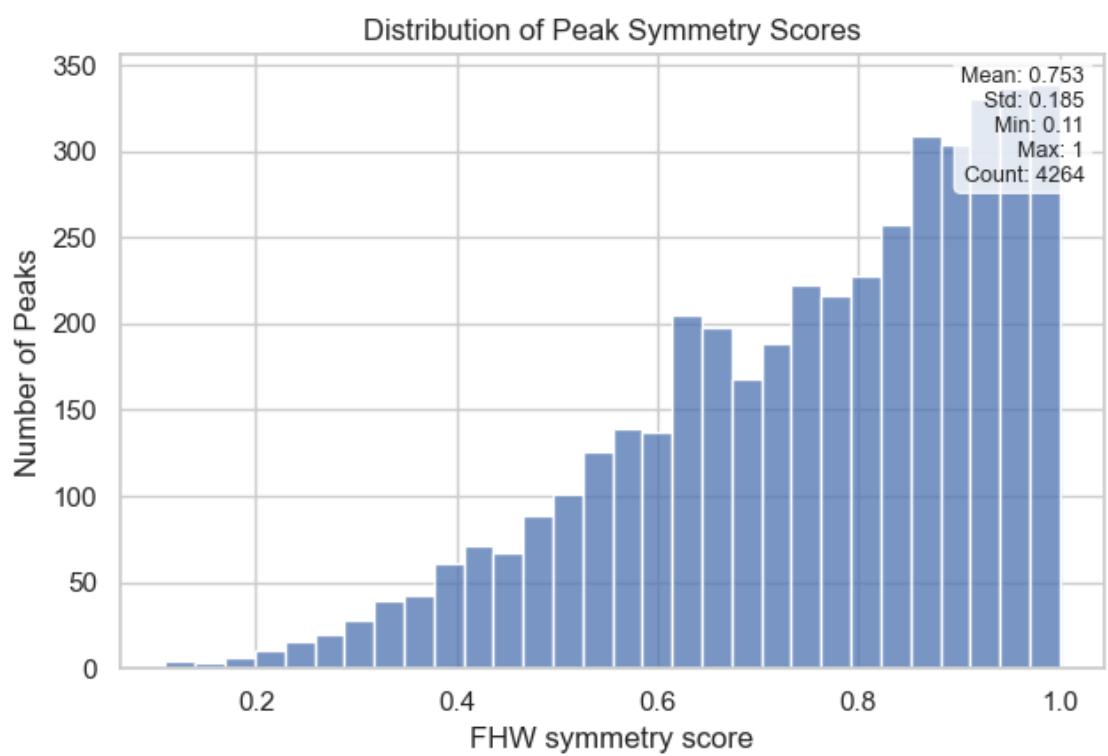
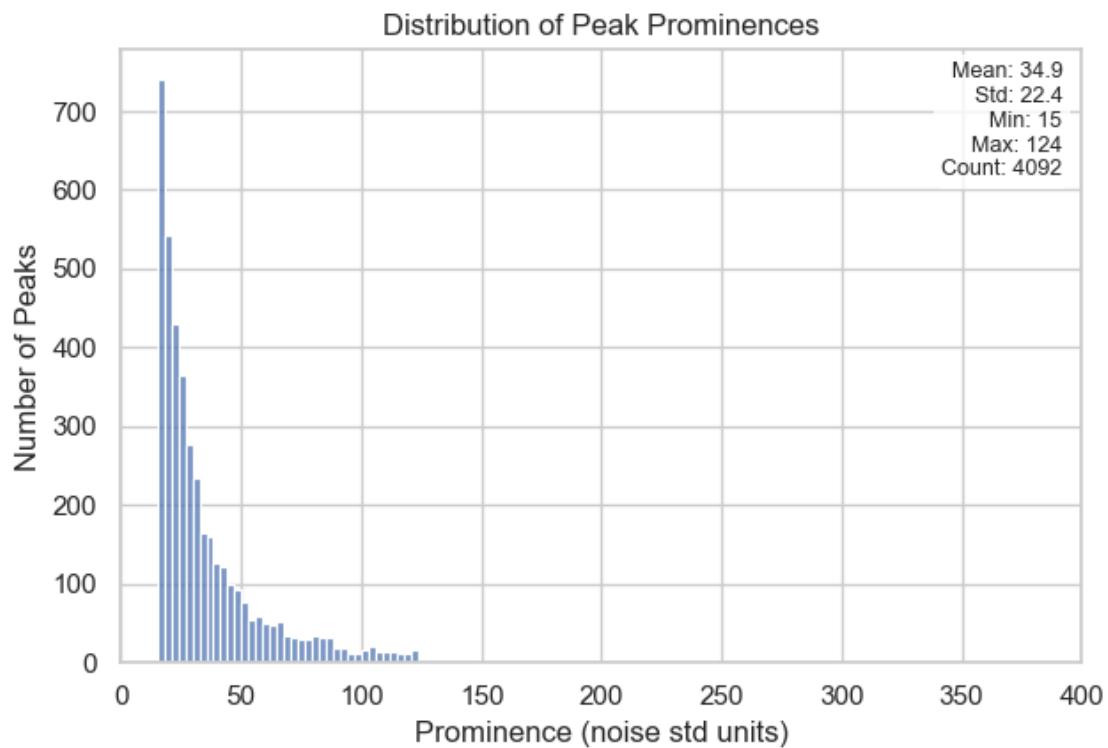
Total number of cells: 485

1.1.3 Peaks statistics

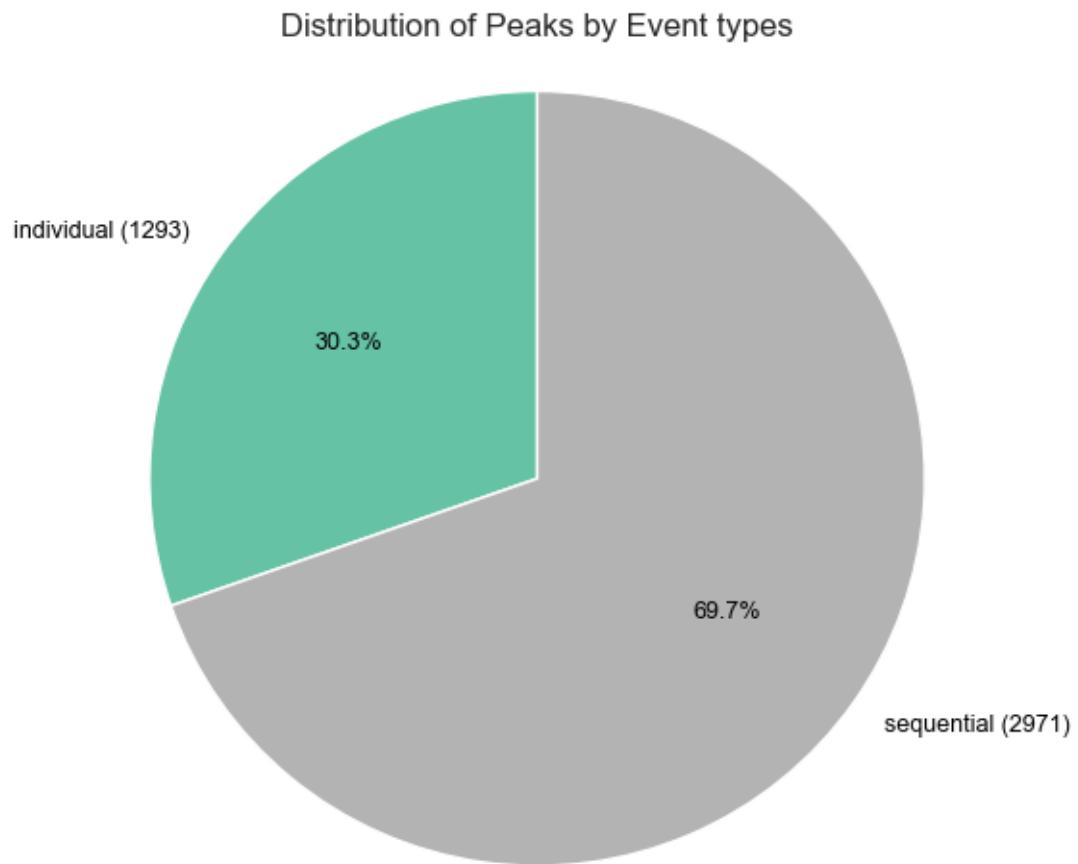
```
[2025-08-13 11:33:55] [INFO] calcium: plot_histogram: removed 120 outliers out  
of 4264 on 'Duration (s)' (lower=-56, upper=126)
```



```
[2025-08-13 11:33:55] [INFO] calcium: plot_histogram: removed 172 outliers out  
of 4264 on 'Prominence (noise std units)' (lower=-58.475, upper=123.7)
```

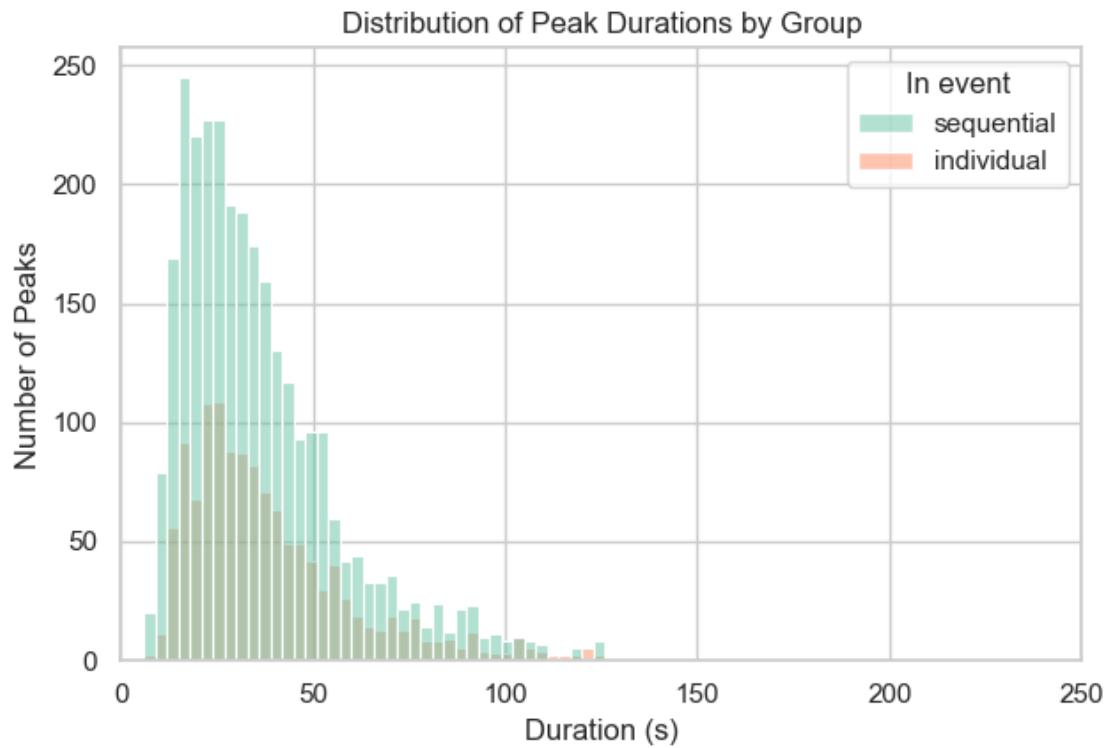


1.1.4 Distribution of peaks per event types



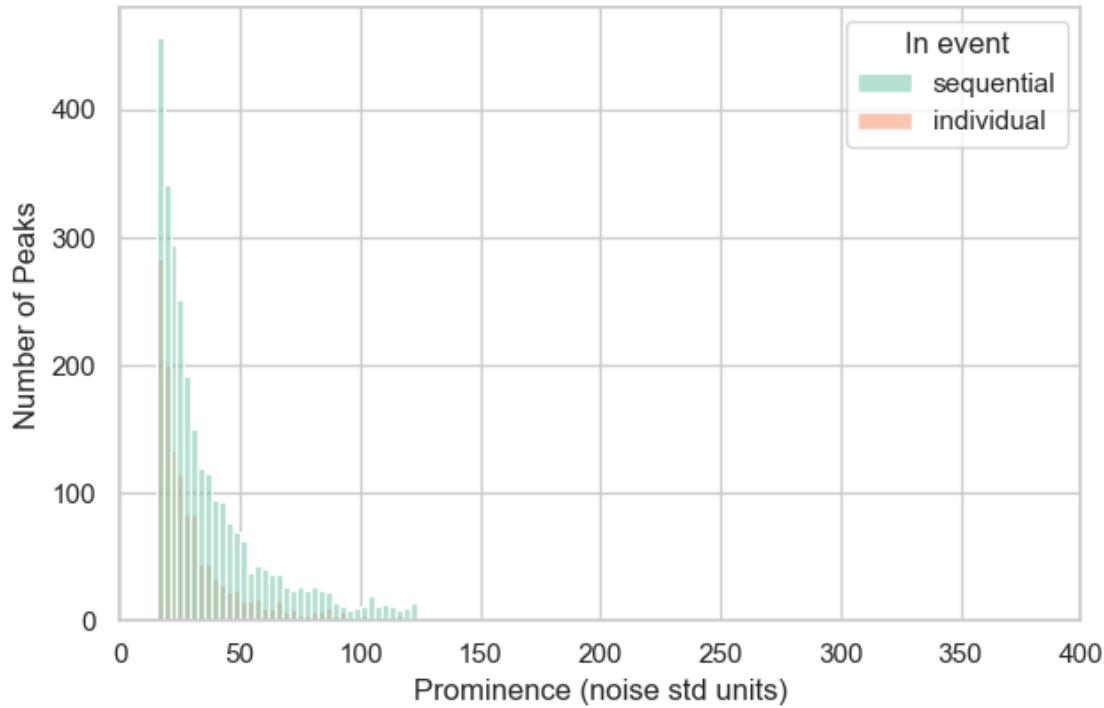
1.1.5 Peaks statistics per event types

```
[2025-08-13 11:33:55] [INFO] calcium: plot_histogram_by_group: removed 120 outliers out of 4264 on 'Duration (s)' (lower=-56, upper=126)
```

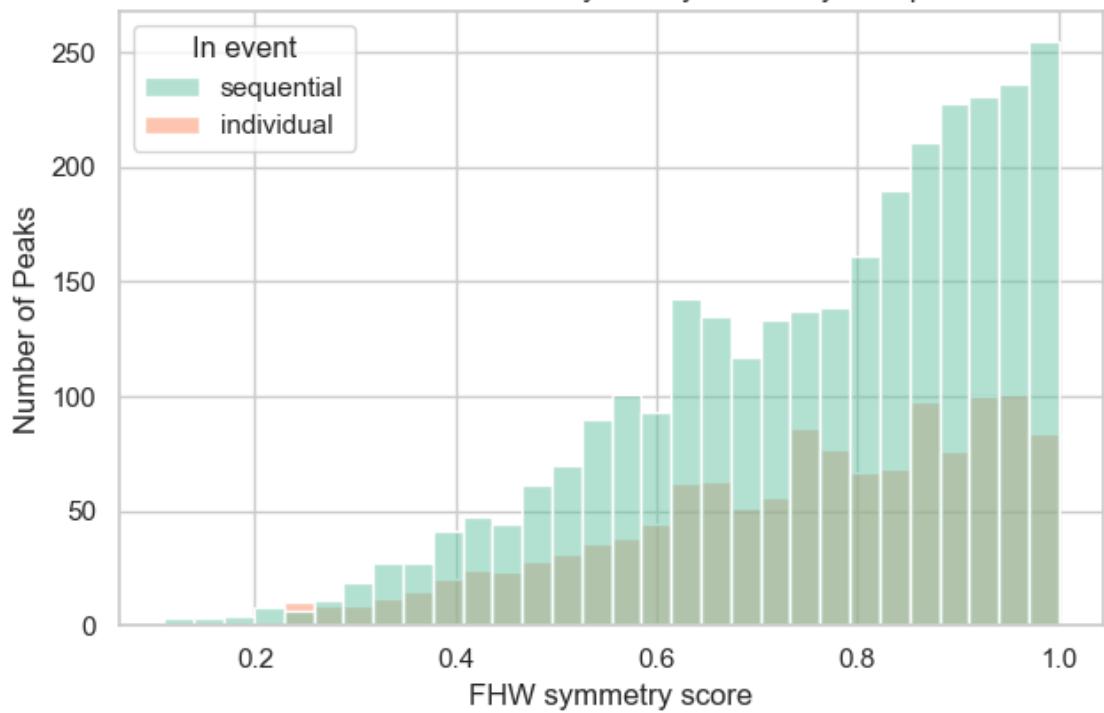


```
[2025-08-13 11:33:56] [INFO] calcium: plot_histogram_by_group: removed 172 outliers out of 4264 on 'Prominence (noise std units)' (lower=-58.475, upper=123.7)
```

Distribution of Peak Prominences by Group



Distribution of Peak Symmetry Scores by Group



1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

```
[2025-08-13 11:33:56] [WARNING] calcium: No data to plot for column 'Duration (s)' - DataFrame is empty.
```

```
[2025-08-13 11:33:56] [WARNING] calcium: No data to plot for column 'Prominence (noise std units)' - DataFrame is empty.
```

```
[2025-08-13 11:33:56] [WARNING] calcium: No data to plot for column 'FWH symmetry score' - DataFrame is empty.
```

1.2.2 Peak statistics in global event per event ID

```
[2025-08-13 11:33:56] [WARNING] calcium: plot_histogram_by_group: empty DataFrame
```

```
[2025-08-13 11:33:56] [WARNING] calcium: plot_histogram_by_group: empty DataFrame
```

```
[2025-08-13 11:33:56] [WARNING] calcium: plot_histogram_by_group: empty DataFrame
```

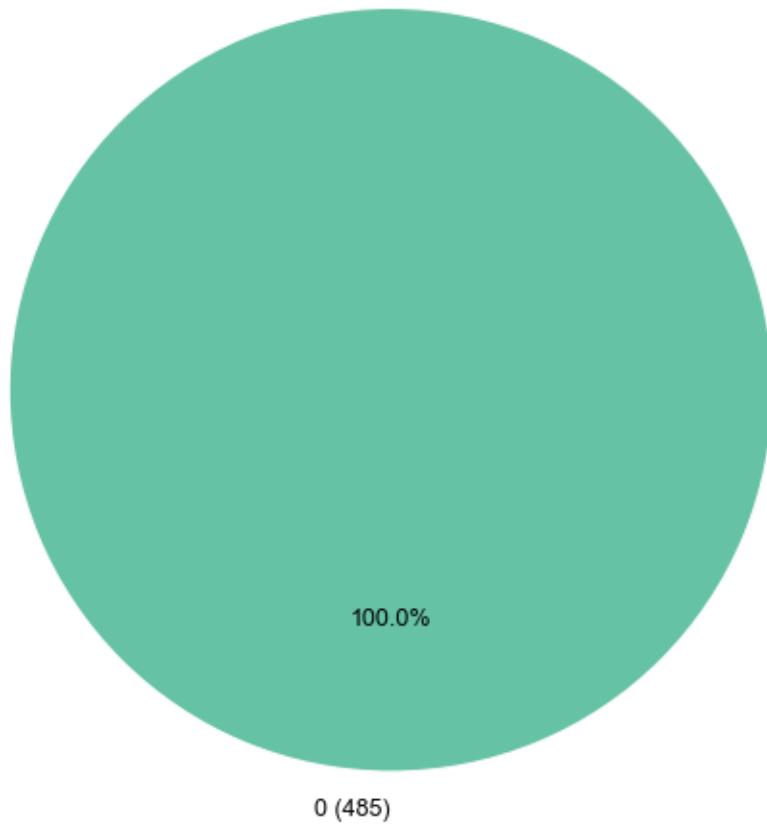
1.2.3 Kinetics of global events

```
[2025-08-13 11:33:56] [WARNING] calcium: plot_bar: received empty DataFrame
```

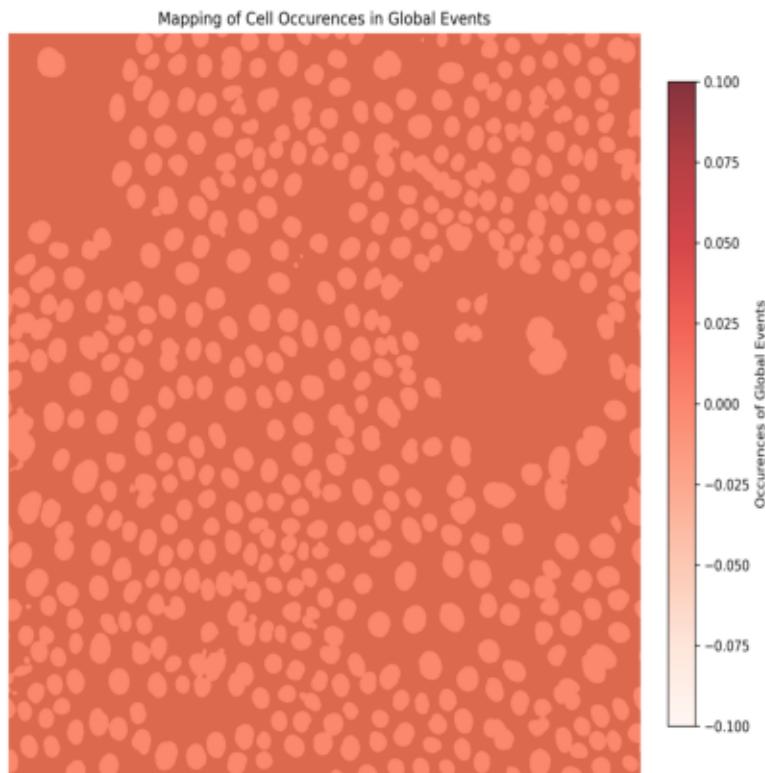
```
[2025-08-13 11:33:56] [WARNING] calcium: plot_bar: received empty DataFrame
```

1.2.4 Cells occurrences in global events

Distribution of Unique Global Events per Cell



Cell Mapping with Occurrences in Global Events Overlay - 20250409_IS03



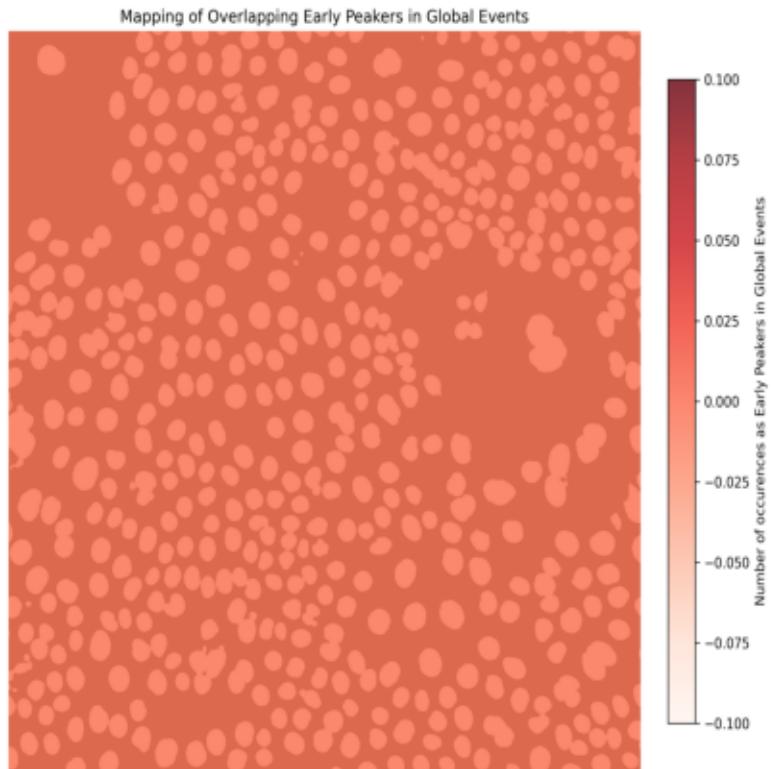
[2025-08-13 11:33:58] [WARNING] calcium: plot_bar: received empty DataFrame

1.2.5 Inter-event interval analysis

Intervals between global event peaks: []

1.2.6 Early peakers in the events

Cell Mapping with Occurrences in Global Events Overlay - 20250409_IS03

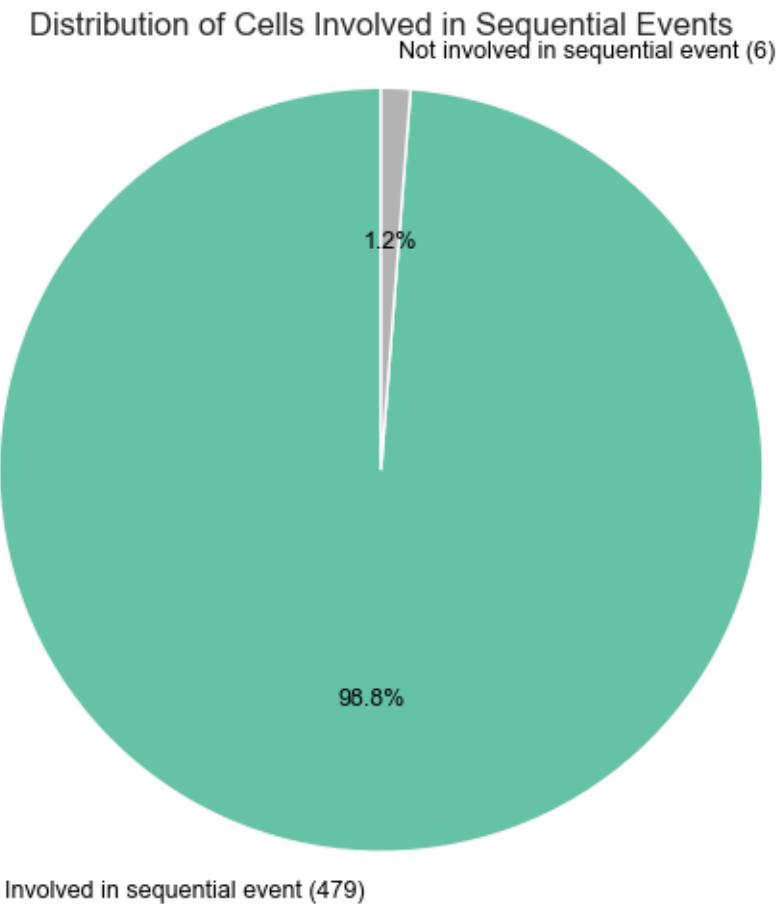


[2025-08-13 11:33:59] [WARNING] calcium: plot_bar: received empty DataFrame

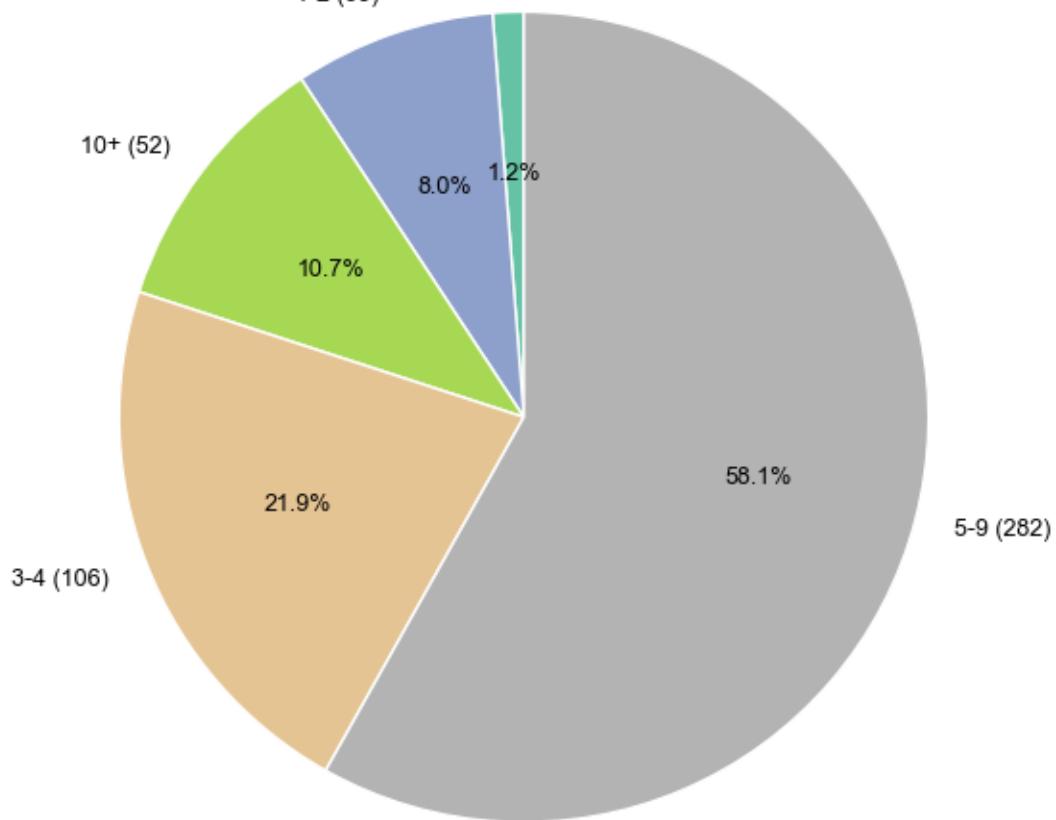
[2025-08-13 11:33:59] [WARNING] calcium: plot_pie_chart: empty DataFrame

1.3 SEQUENTIAL EVENTS

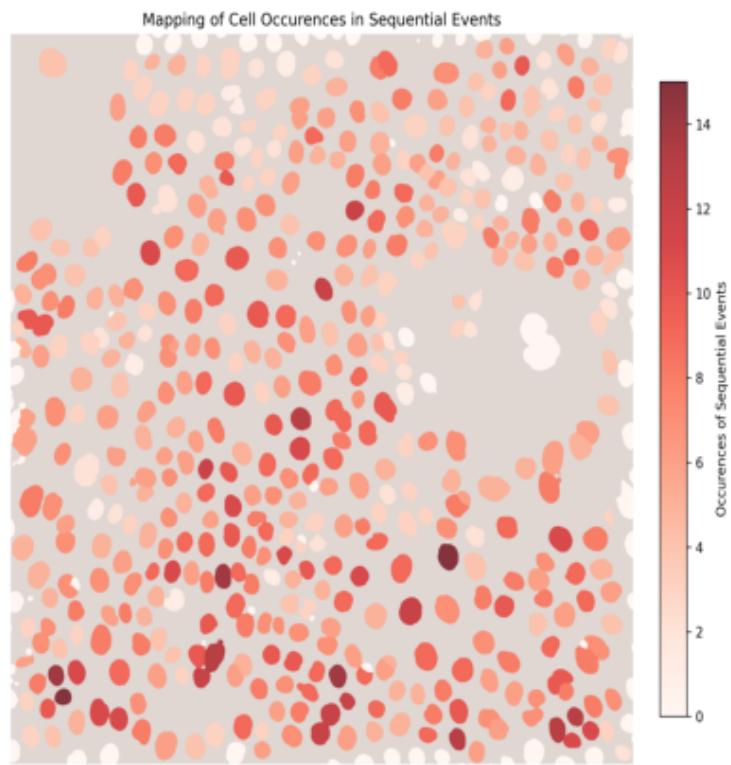
1.3.1 Cells occurrences in sequential events



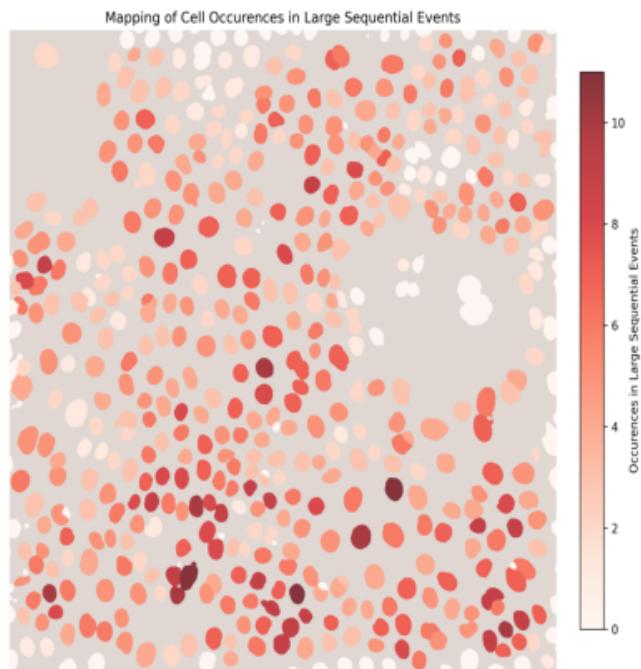
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250409_IS03

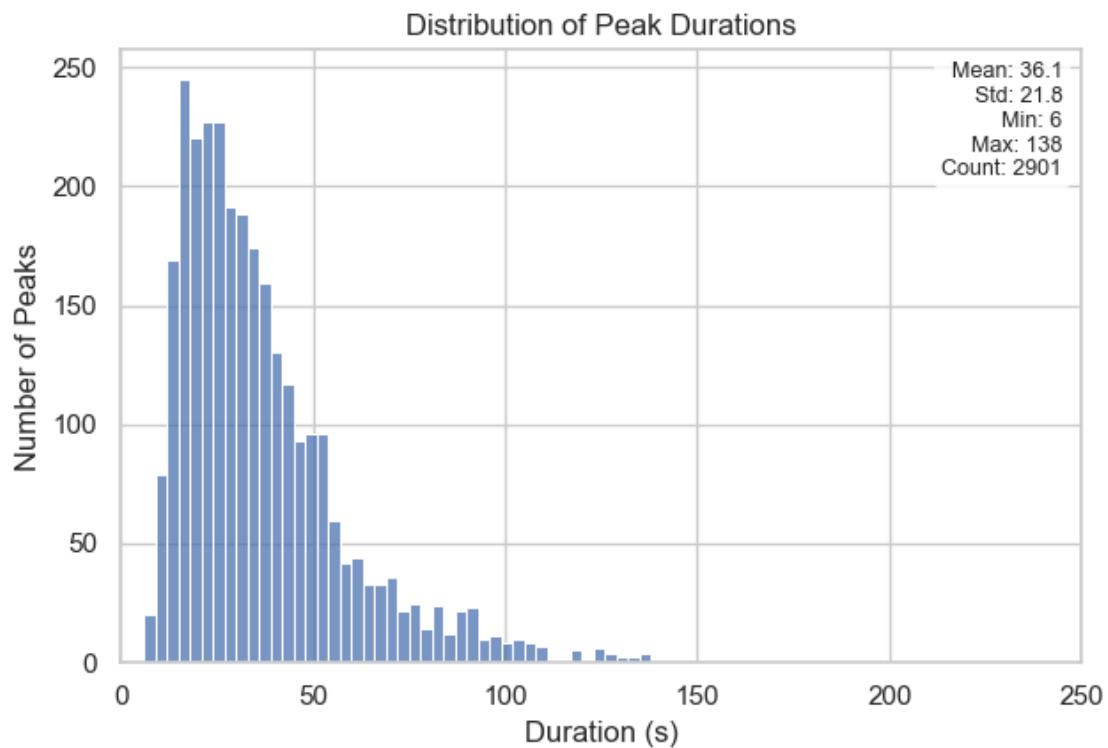


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250409_IS03

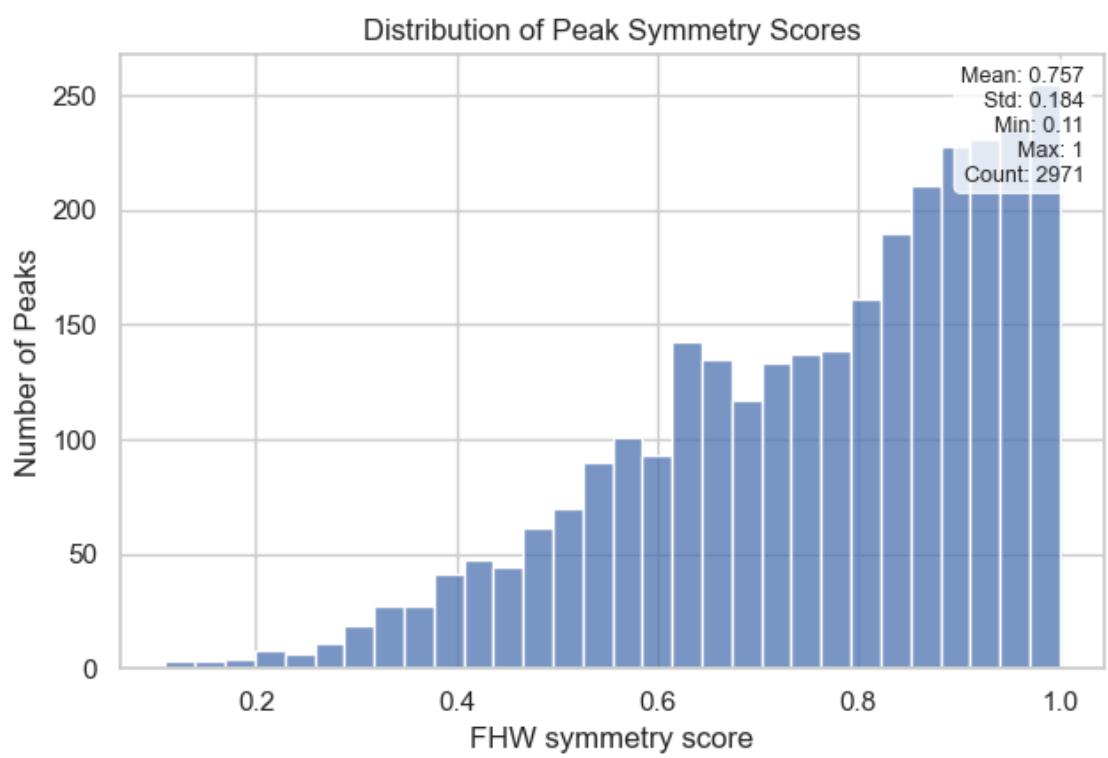
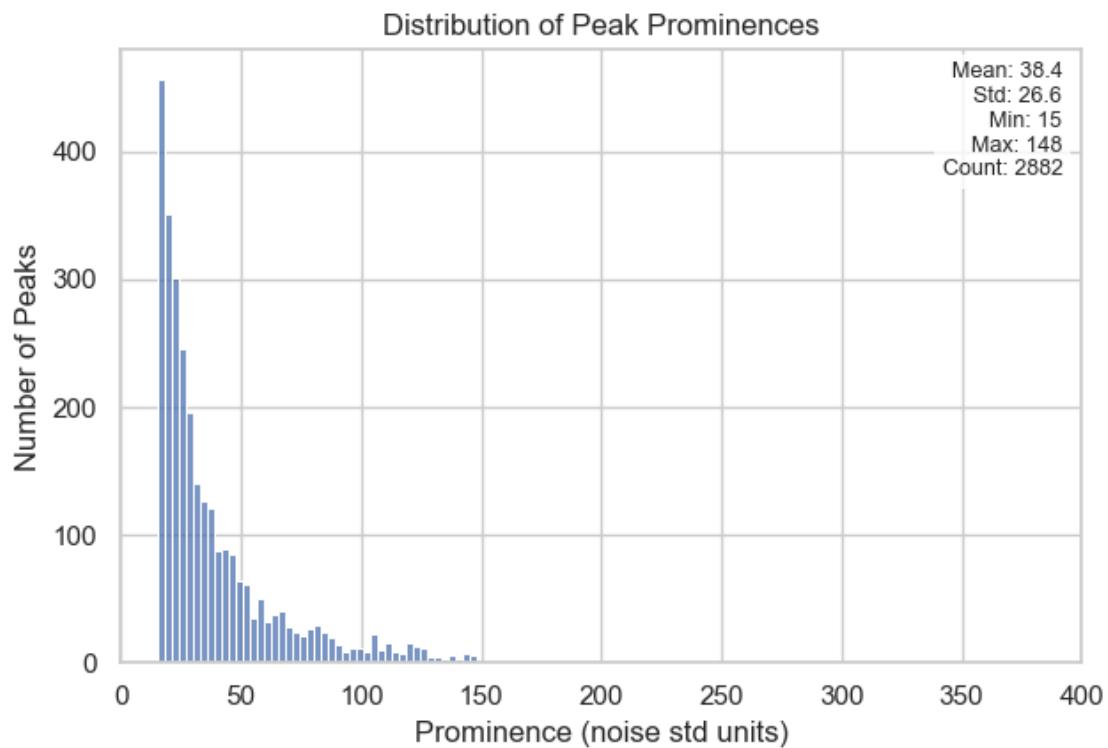


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 11:34:02] [INFO] calcium: plot_histogram: removed 70 outliers out of 2971 on 'Duration (s)' (lower=-18, upper=138)
```

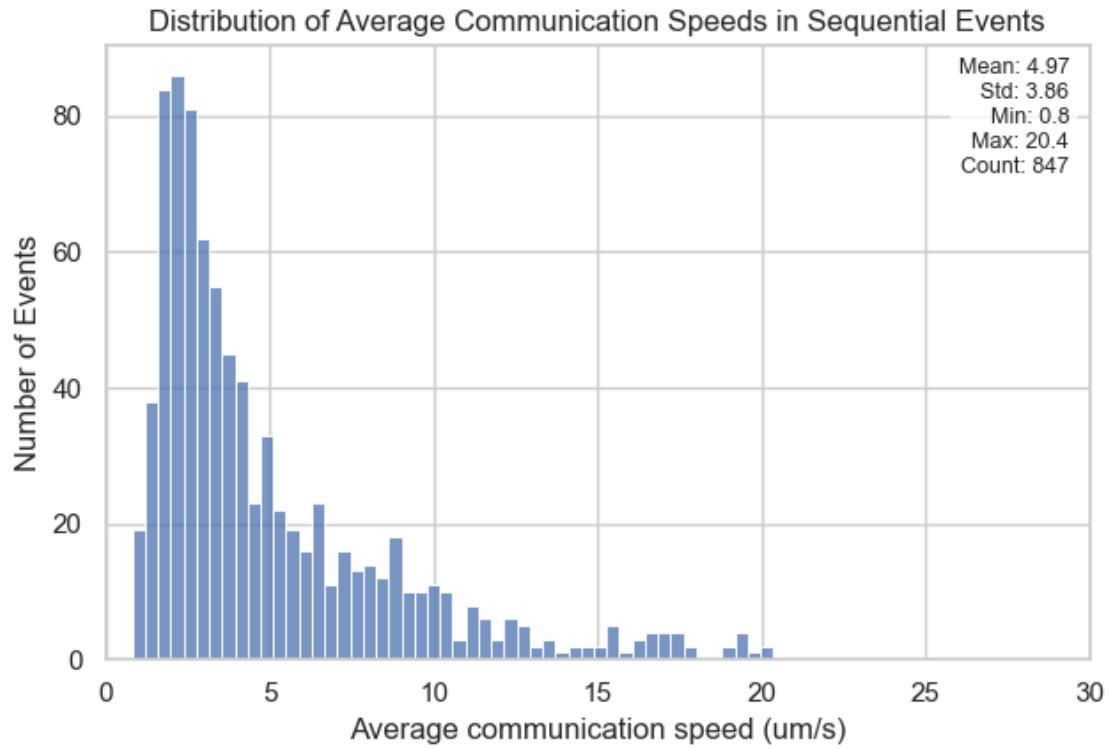


```
[2025-08-13 11:34:02] [INFO] calcium: plot_histogram: removed 89 outliers out of 2971 on 'Prominence (noise std units)' (lower=-22.35, upper=148.65)
```

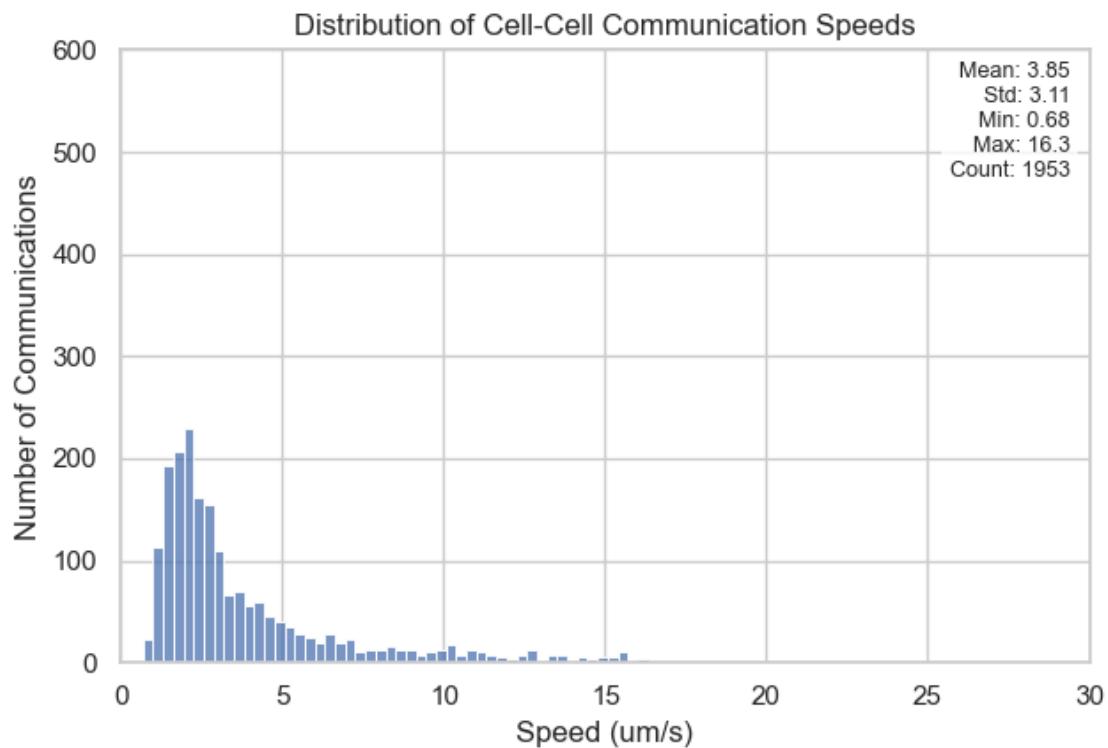


1.3.3 Cell-cell communication speed

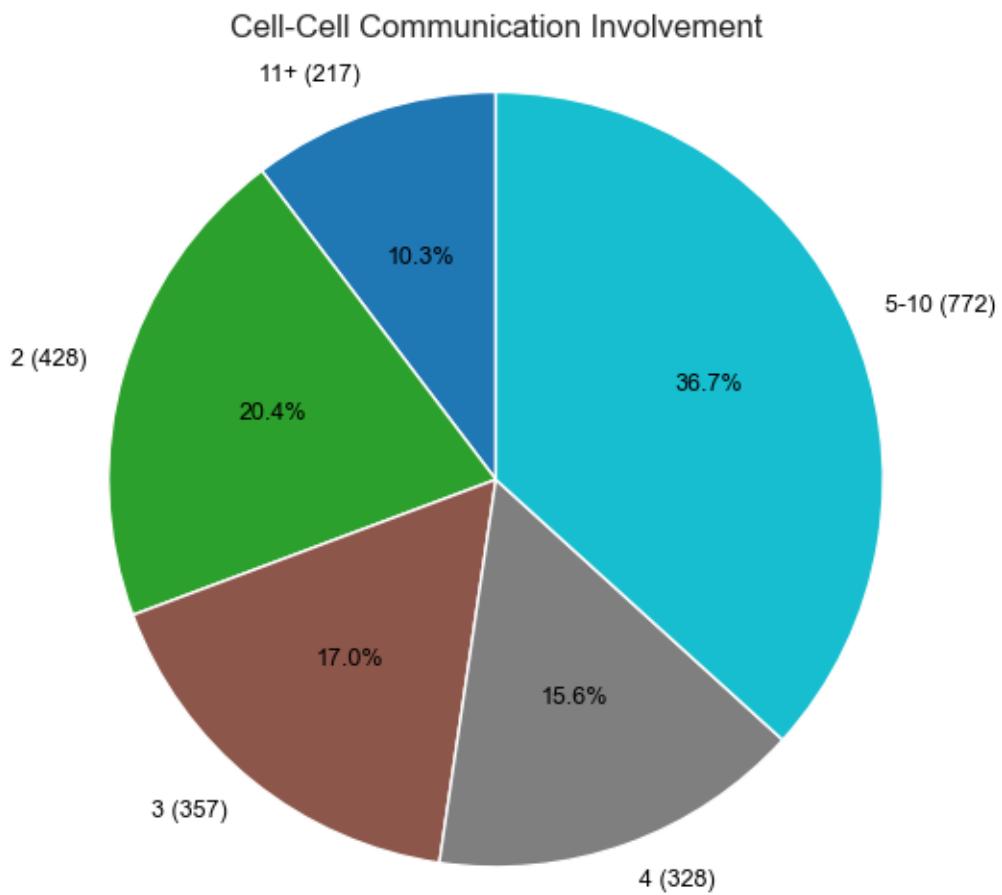
[2025-08-13 11:34:02] [INFO] calcium: plot_histogram: removed 22 outliers out of 869 on 'Average communication speed (um/s)' (lower=-11.27, upper=20.44)



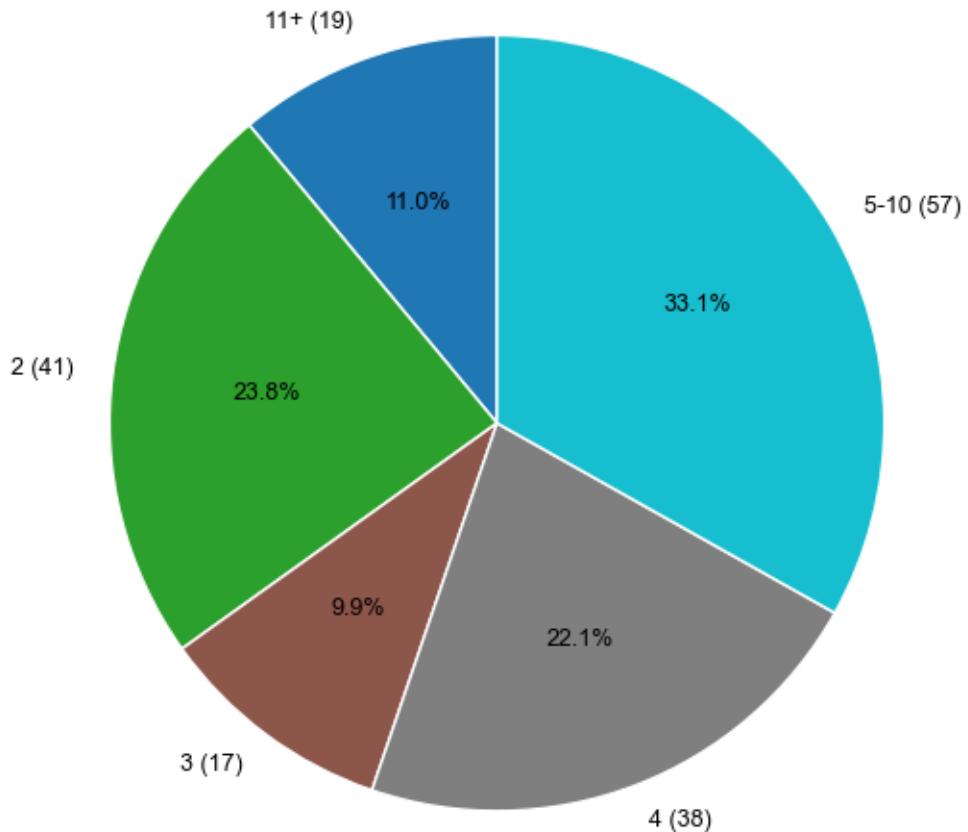
[2025-08-13 11:34:02] [INFO] calcium: plot_histogram: removed 149 outliers out of 2102 on 'Speed (um/s)' (lower=-8.9325, upper=16.373)



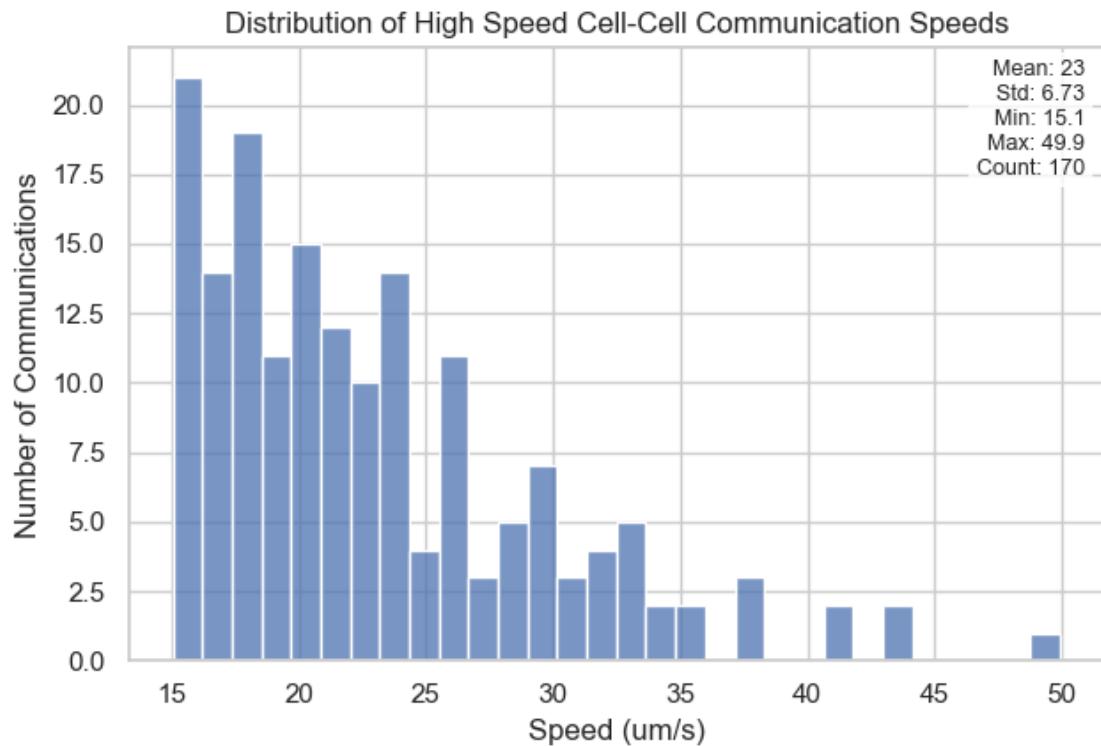
1.3.4 Double distribution in cell-cell communication speeds



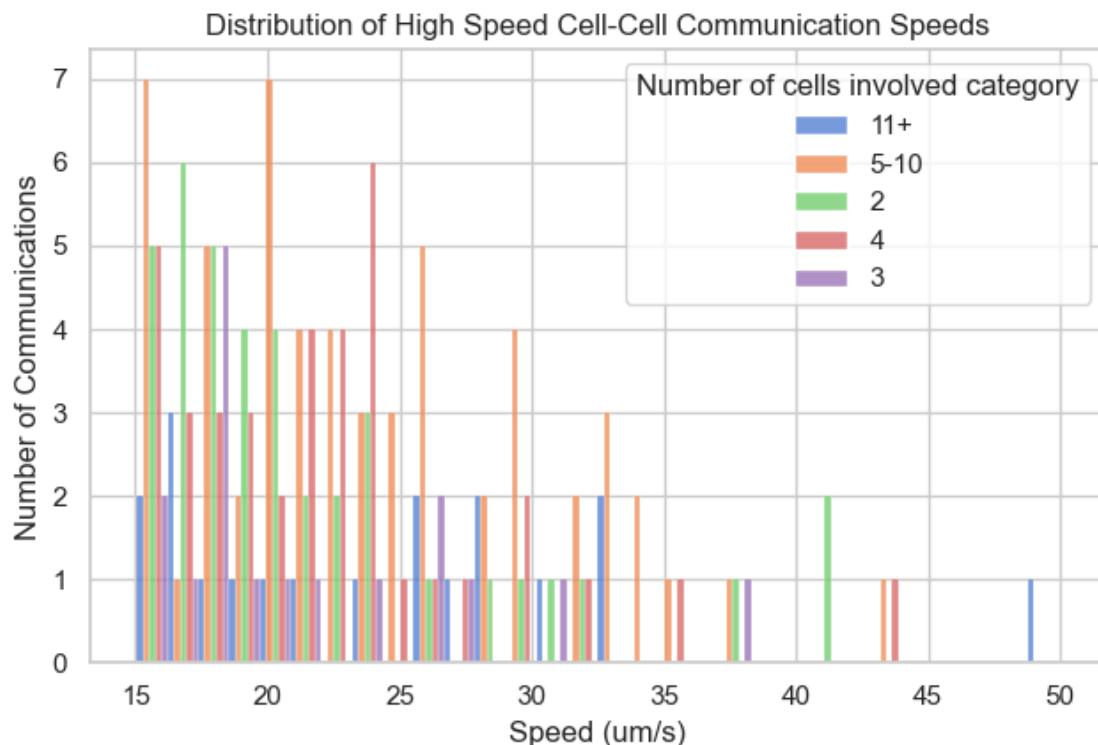
High Speed Cell-Cell Communication Involvement



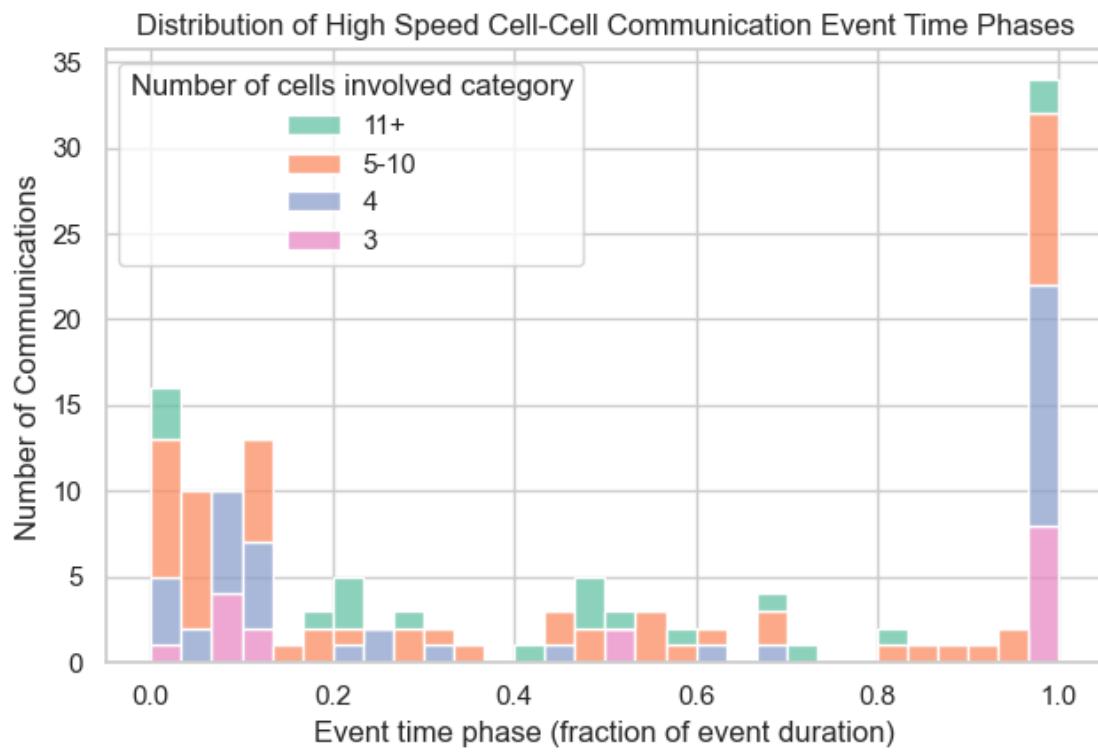
[2025-08-13 11:34:03] [INFO] calcium: plot_histogram: removed 2 outliers out of 172 on 'Speed (um/s)' (lower=-8.9225, upper=53.01)



```
[2025-08-13 11:34:03] [INFO] calcium: plot_histogram_by_group: removed 2 outliers out of 172 on 'Speed (um/s)' (lower=-8.9225, upper=53.01)
```

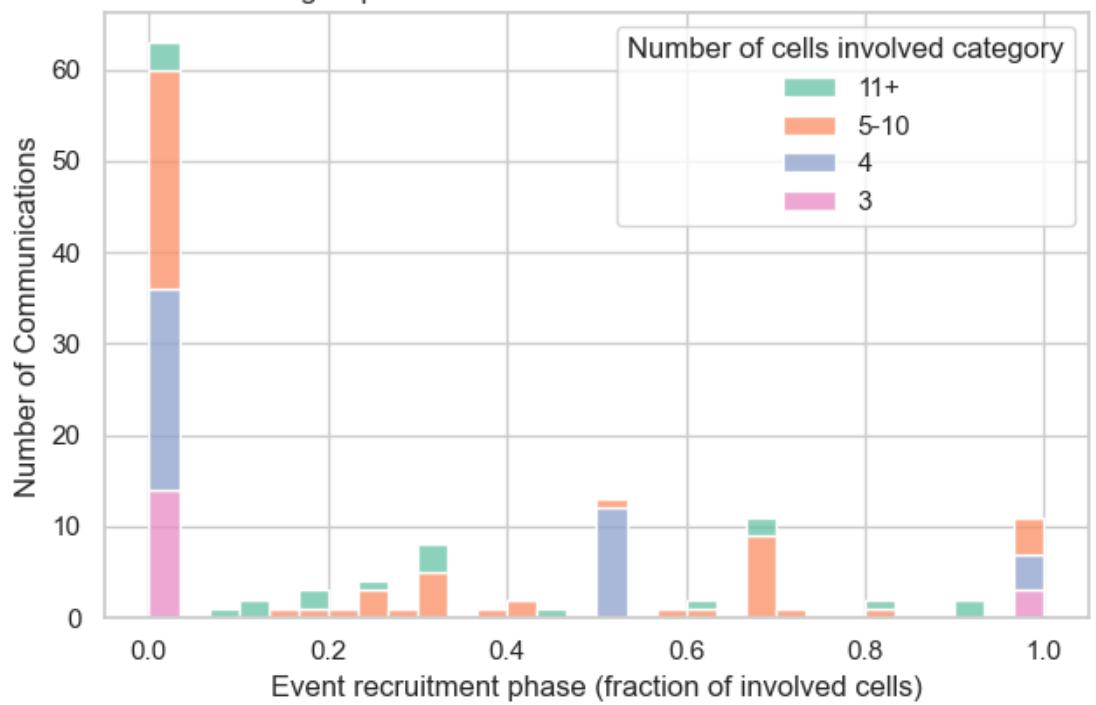


```
[2025-08-13 11:34:04] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 131 on 'Event time phase (fraction of event duration)' (lower=-2.7, upper=3.775)
```

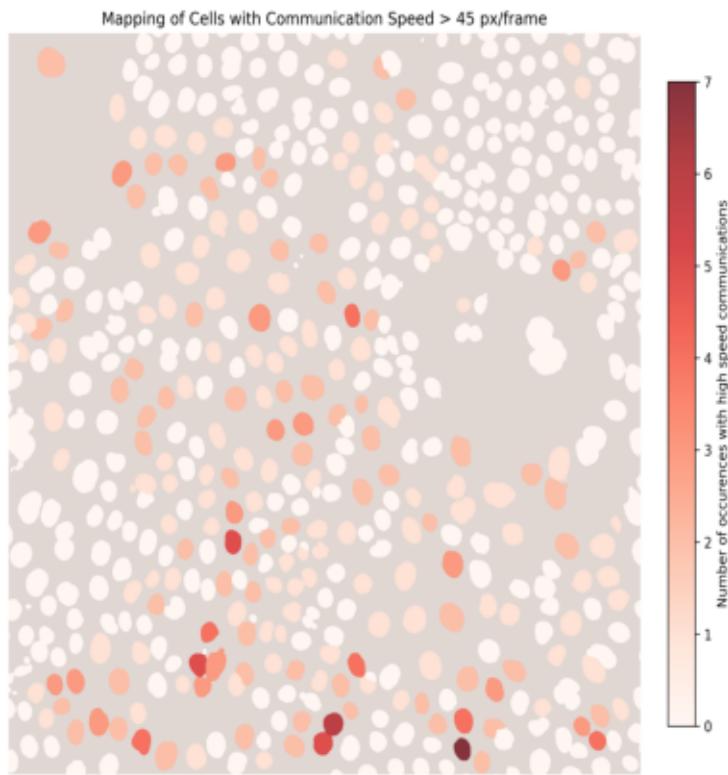


```
[2025-08-13 11:34:04] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 131 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.5, upper=2)
```

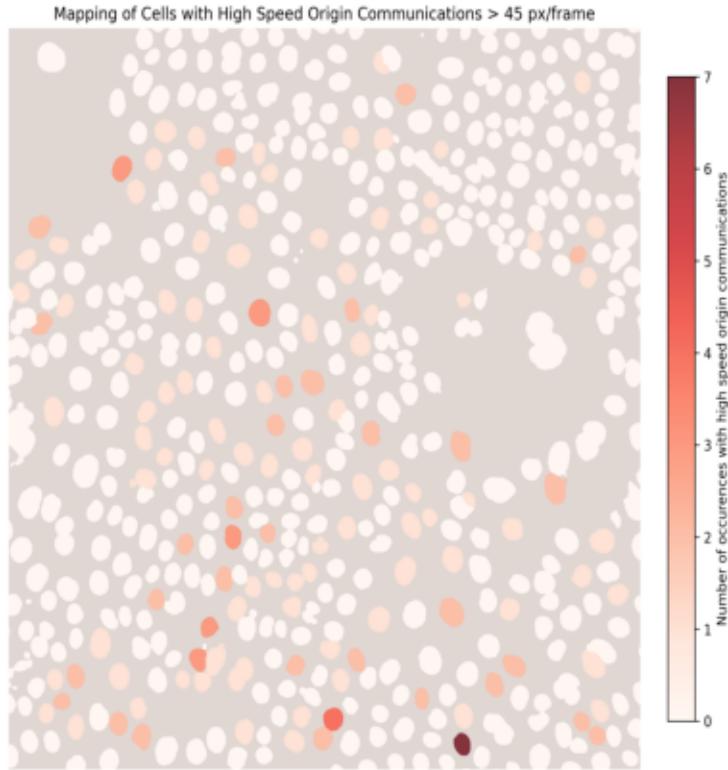
Distribution of High Speed Cell-Cell Communication Event Recruitment Phases



Cell Mapping with High Speed Cells Overlay - 20250409_IS03



Cell Mapping with High Speed Origin Cells Overlay - 20250409_IS03



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
1	1759520410352	0	590	0	
18	1759520422208	1	436	1	
20	1759520421824	1	360	1	
22	1759520413808	1	360	0	
39	1759520422016	3	628	1	
...	
2046	1759486211888	825	756	12	
2048	1759486205936	826	756	15	
2057	1759486202960	831	746	7	
2080	1759486204928	848	731	2	
2082	1759486202384	850	733	4	

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
1	597	1	76.0	76.0	
18	454	2	118.0	118.0	
20	399	1	94.0	94.0	
22	332	0	52.0	52.0	
39	669	1	156.0	156.0	
...	
2046	729	6	1217.0	1218.0	
2048	725	12	1448.0	1449.0	
2057	728	5	494.0	495.0	
2080	744	3	172.0	173.0	
2082	745	3	313.0	314.0	
	Duration (s)	Distance (um)	Speed (um/s)	\	
1	0.0	17.28	17.28		
18	0.0	23.90	23.90		
20	0.0	25.76	25.76		
22	0.0	28.04	28.04		
39	0.0	32.63	32.63		
...	
2046	1.0	25.80	25.80		
2048	1.0	19.20	19.20		
2057	1.0	15.61	15.61		
2080	1.0	15.54	15.54		
2082	1.0	20.36	20.36		
	Event time phase (fraction of event duration)	\			
1		0.29			
18		1.00			
20		0.70			
22		0.17			
39		0.48			
...		...			
2046		0.12			
2048		NaN			
2057		NaN			
2080		NaN			
2082		NaN			
	Event recruitment phase (fraction of involved cells)		dataset	\	
1		0.33	20250409_IS03		
18		0.93	20250409_IS03		
20		0.60	20250409_IS03		
22		0.07	20250409_IS03		
39		0.18	20250409_IS03		
...			
2046		0.00	20250409_IS03		
2048		NaN	20250409_IS03		

2057		NaN	20250409_IS03
2080		NaN	20250409_IS03
2082		NaN	20250409_IS03

	Number of cells involved	category	Speed category
1		11+	High speed
18		11+	High speed
20		11+	High speed
22		11+	High speed
39		11+	High speed
...
2046		4	High speed
2048		2	High speed
2057		2	High speed
2080		2	High speed
2082		2	High speed

[172 rows x 16 columns]

Origin cell ID	Speed category	High speed	Low speed
115		0	2
117		0	2
118		0	2
119		0	2
120		0	3
...
759		0	2
760		0	1
763		0	1
765		0	6
767		0	1

[453 rows x 2 columns]

Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
0	115	397.80	7.80
1	117	479.38	9.43
2	118	379.93	10.40
3	119	489.12	12.68
4	120	444.93	13.65
..
480	759	124.15	486.20
481	760	147.88	486.85
482	763	201.50	489.45
483	765	373.43	490.75
484	767	490.75	491.40

Number of peaks Is active Occurences in global events \

0	7	True	0
1	7	True	0
2	9	True	0
3	6	True	0
4	9	True	0
..
480	8	True	0
481	6	True	0
482	11	True	0
483	13	True	0
484	8	True	0

Occurrences in global events as early peaker \

0	0
1	0
2	0
3	0
4	0
..	..
480	0
481	0
482	0
483	0
484	0

Occurrences in sequential events \

0	6
1	3
2	5
3	2
4	6
..	..
480	6
481	4
482	6
483	6
484	2

Occurrences in sequential events as origin \

0	0
1	1
2	2
3	2
4	3
..	..
480	1
481	1
482	1

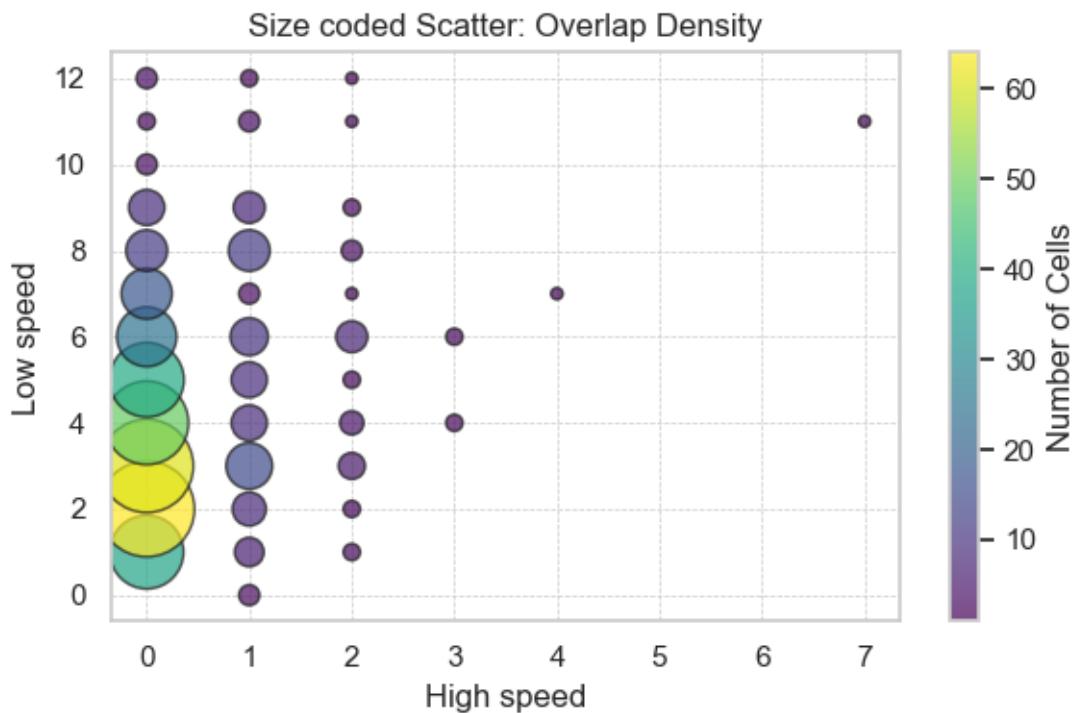
483		3	
484		1	
Occurrences in individual events Peak frequency (Hz) Periodicity score \			
0	1	0.0041	0.62
1	2	0.0041	0.75
2	4	0.0053	0.64
3	4	0.0035	0.60
4	3	0.0053	0.54
..
480	2	0.0047	0.49
481	2	0.0035	0.75
482	5	0.0065	0.59
483	7	0.0076	0.60
484	6	0.0047	0.45
Neighbor count Neighbors (labels) dataset \			
0	3	[118,132,138]	20250409_IS03
1	3	[119,134,147]	20250409_IS03
2	3	[115,138,145]	20250409_IS03
3	2	[117,147]	20250409_IS03
4	4	[125,134,150,152]	20250409_IS03
..
480	5	[686,687,717,745,760]	20250409_IS03
481	4	[687,694,749,759]	20250409_IS03
482	3	[739,743,751]	20250409_IS03
483	3	[734,748,756]	20250409_IS03
484	1	[742]	20250409_IS03
Involved in sequential event Occurrences in sequential events category \			
0	Involved in sequential event		5-9
1	Involved in sequential event		3-4
2	Involved in sequential event		5-9
3	Involved in sequential event		1-2
4	Involved in sequential event		5-9
..
480	Involved in sequential event		5-9
481	Involved in sequential event		3-4
482	Involved in sequential event		5-9
483	Involved in sequential event		5-9
484	Involved in sequential event		1-2
High speed Low speed			
0	0.0	2.0	
1	0.0	2.0	
2	0.0	2.0	
3	0.0	2.0	
4	0.0	3.0	

```

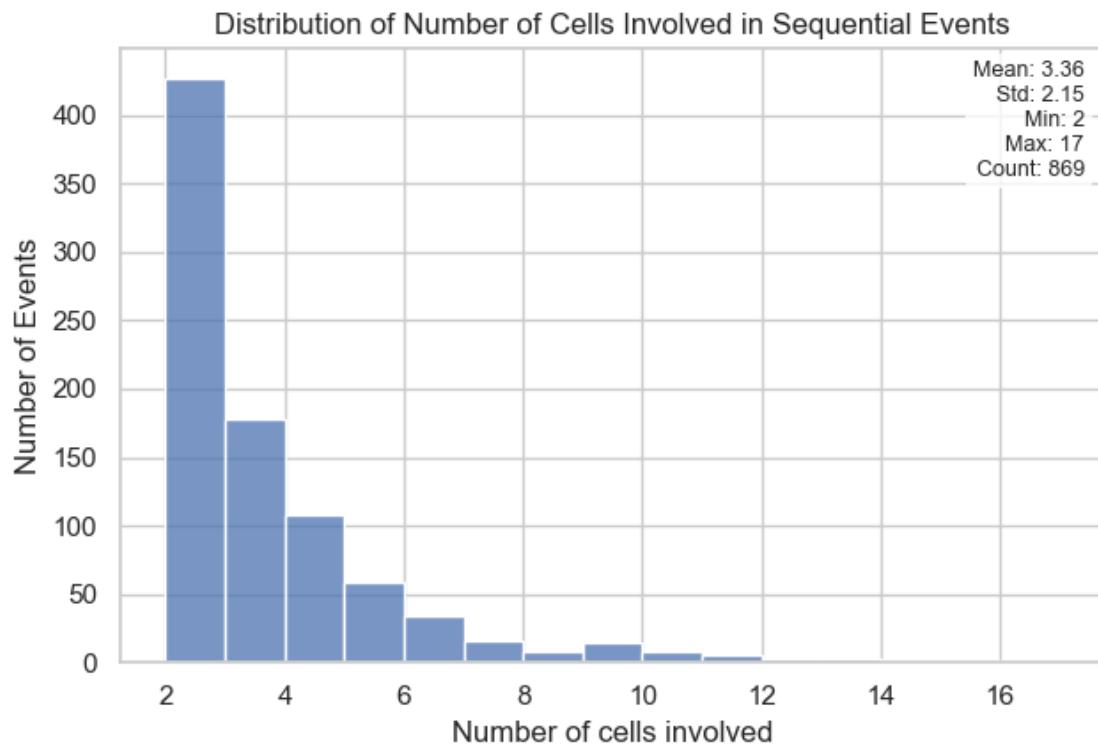
...
480      0.0      2.0
481      0.0      1.0
482      0.0      1.0
483      0.0      6.0
484      0.0      1.0

```

[446 rows x 19 columns]



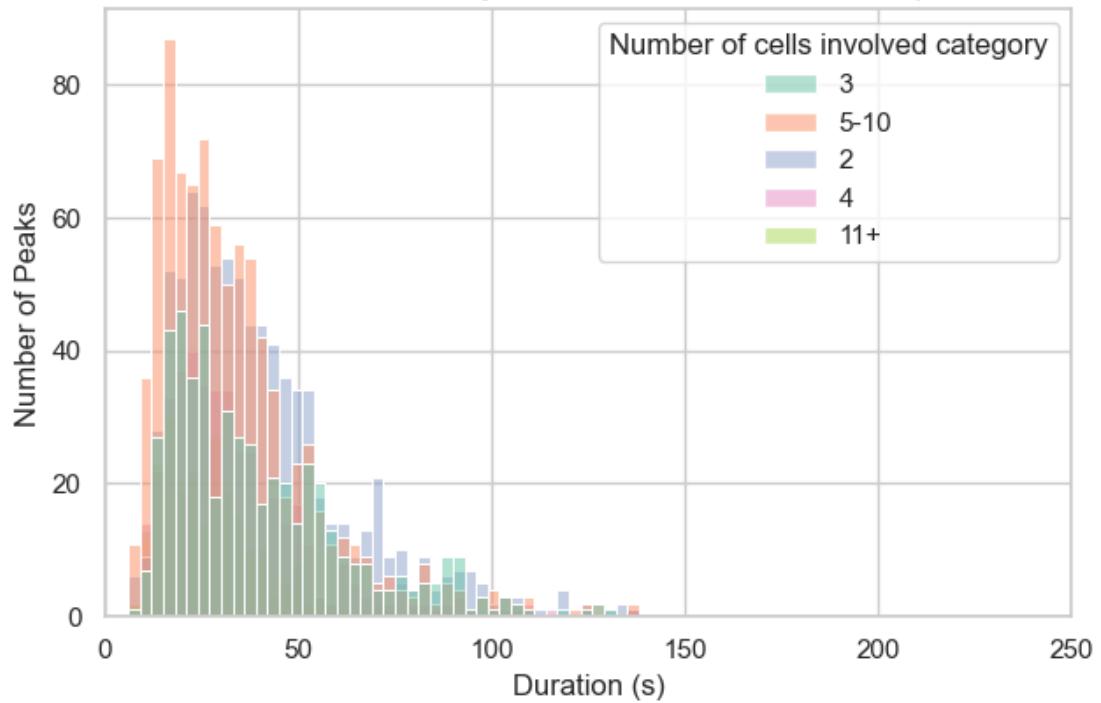
1.3.5 Number of cells involved per sequential events



1.3.6 Influence of cell count per event on statistics

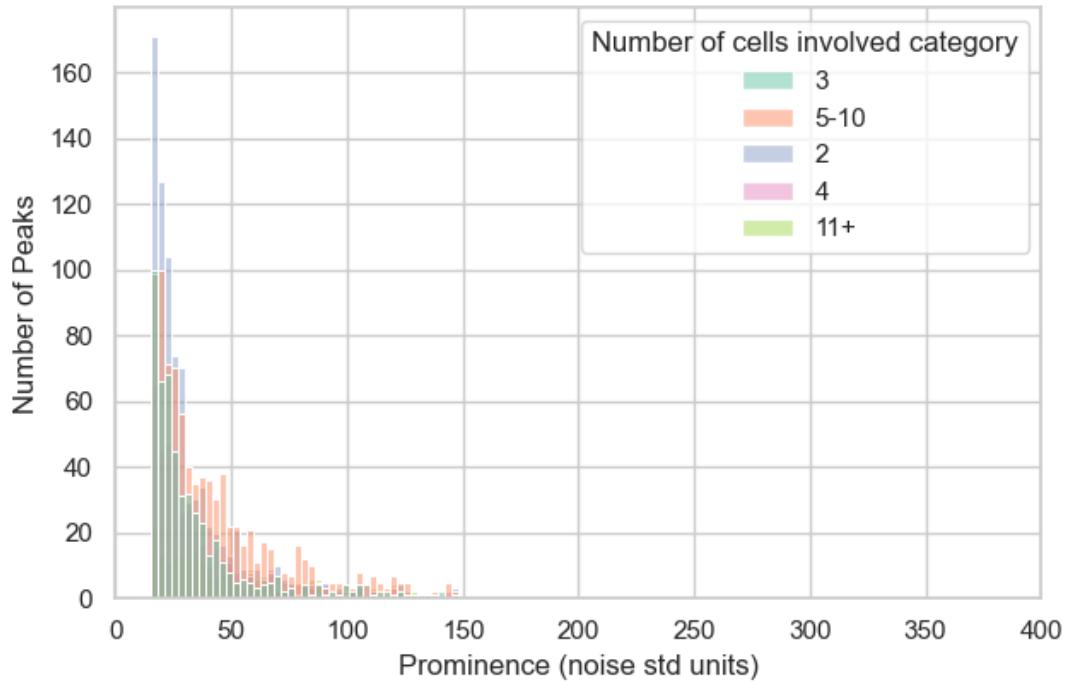
```
[2025-08-13 11:34:07] [INFO] calcium: plot_histogram_by_group: removed 70 outliers out of 2971 on 'Duration (s)' (lower=-18, upper=138)
```

Distribution of Peak Durations by Number of Cells Involved in Sequential Events

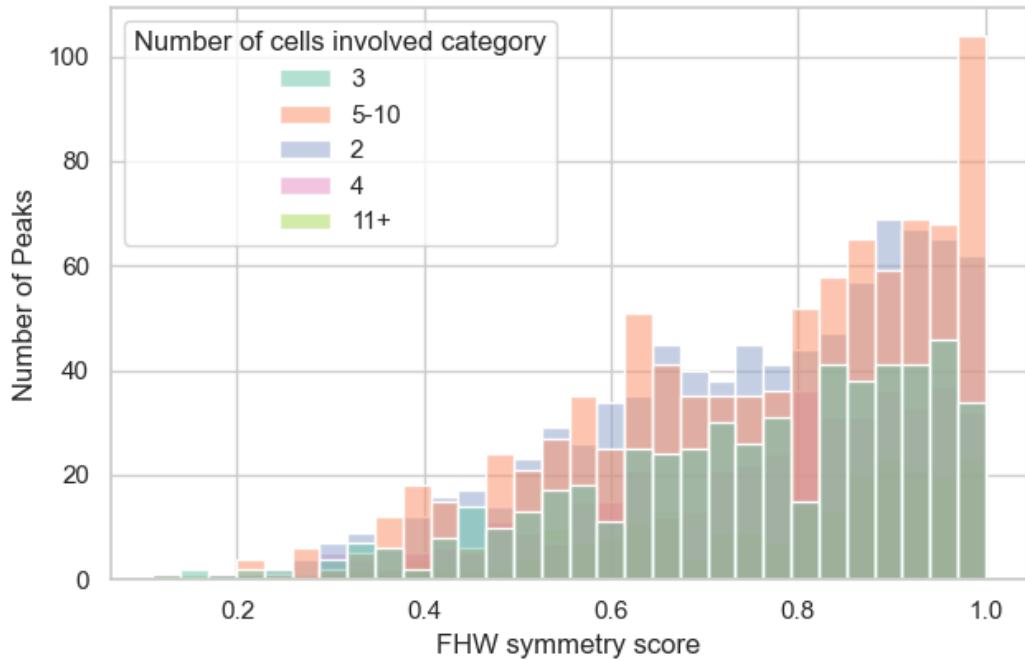


```
[2025-08-13 11:34:08] [INFO] calcium: plot_histogram_by_group: removed 89 outliers out of 2971 on 'Prominence (noise std units)' (lower=-22.35, upper=148.65)
```

Distribution of Peak Prominences by Number of Cells Involved in Sequential Events

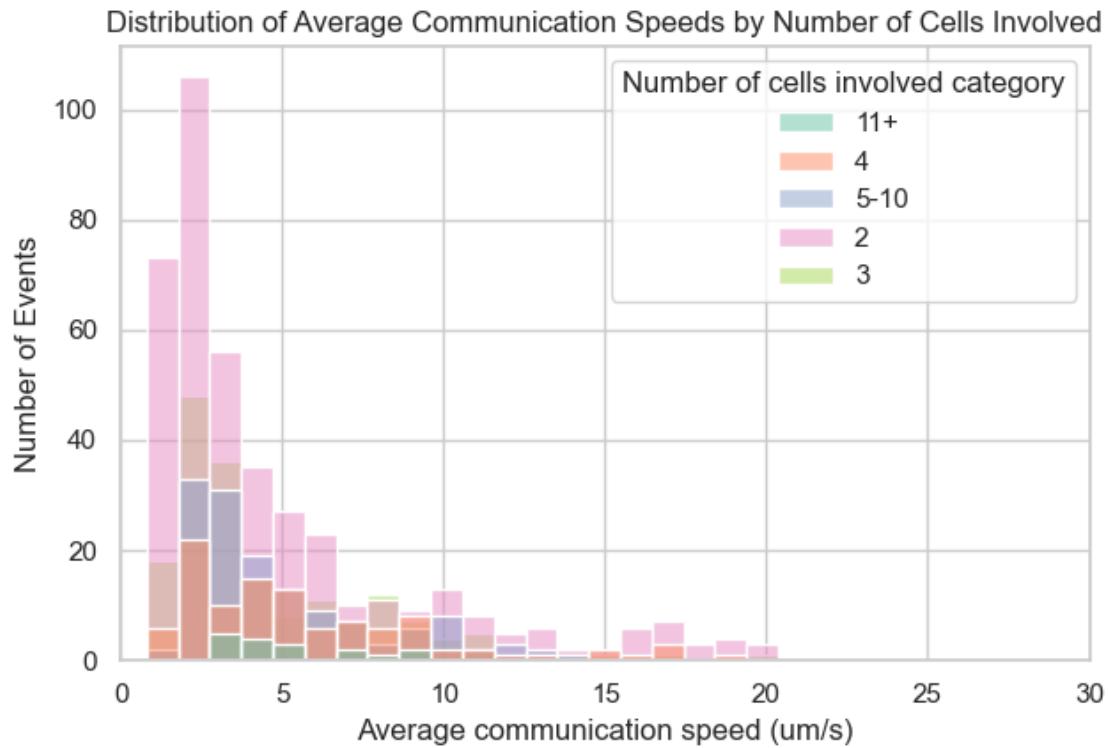


Distribution of Peak Symmetry Scores by Number of Cells Involved in Sequential Events



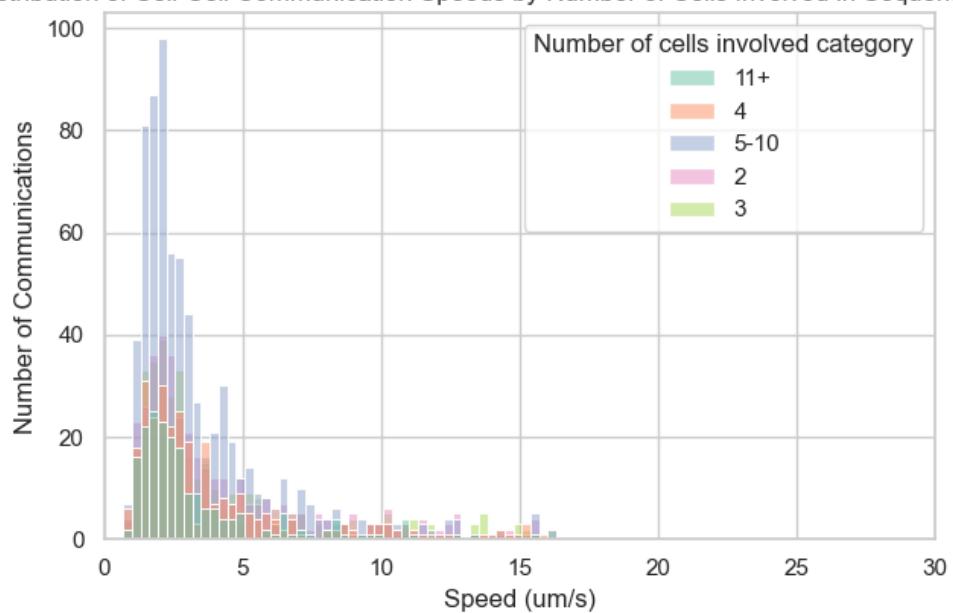
[2025-08-13 11:34:09] [INFO] calcium: plot_histogram_by_group: removed 22

outliers out of 869 on 'Average communication speed (um/s)' (lower=-11.27, upper=20.44)



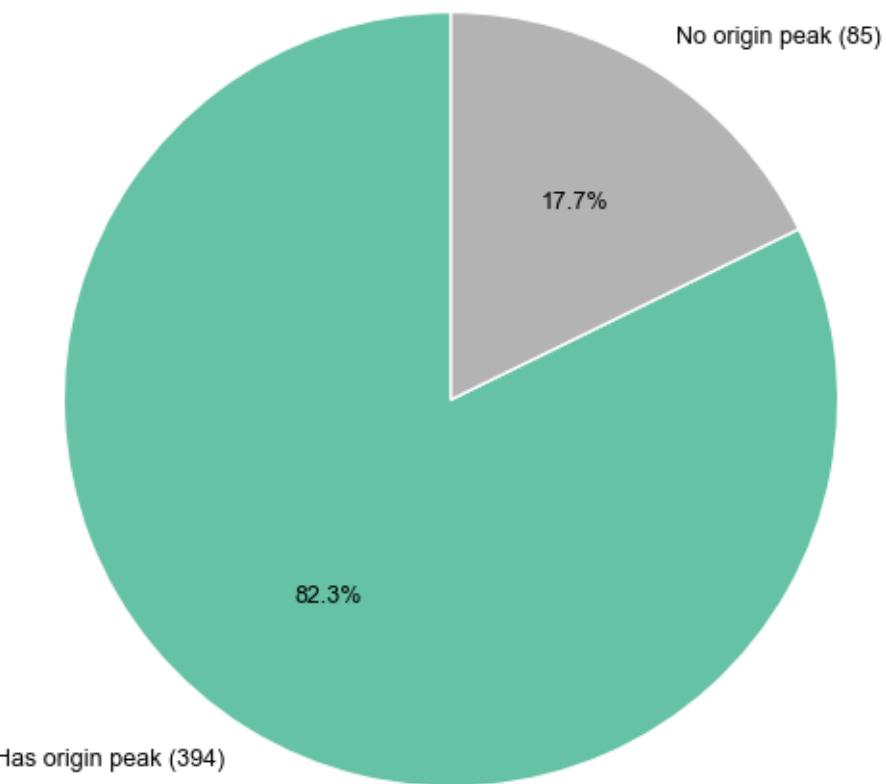
[2025-08-13 11:34:09] [INFO] calcium: plot_histogram_by_group: removed 149 outliers out of 2102 on 'Speed (um/s)' (lower=-8.9325, upper=16.373)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events

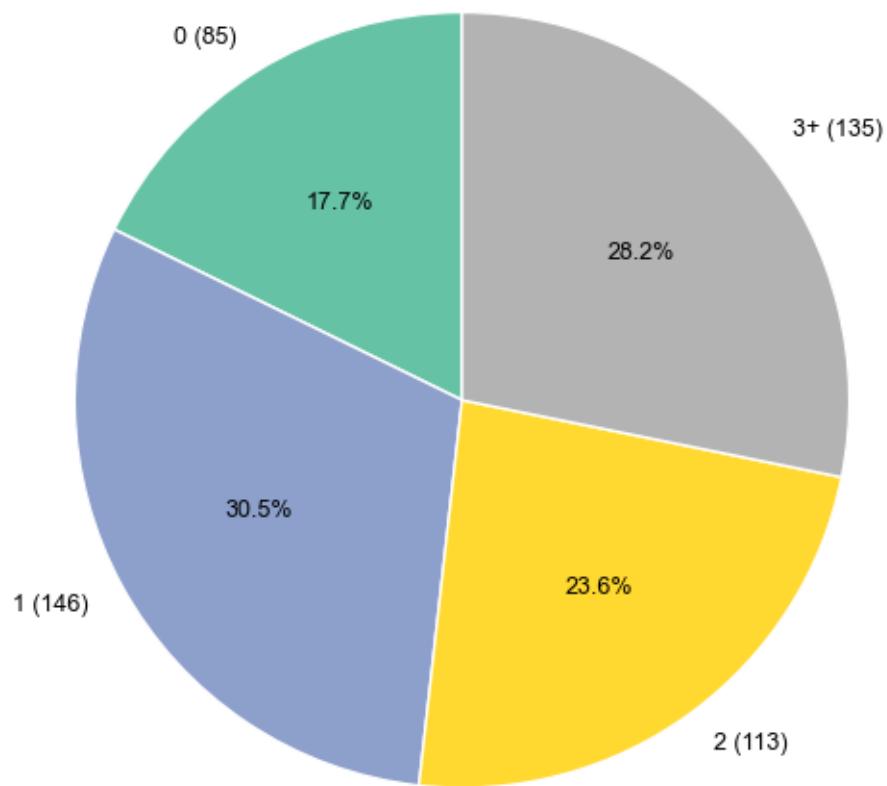


1.3.7 Cells occurrences as origin in sequential events

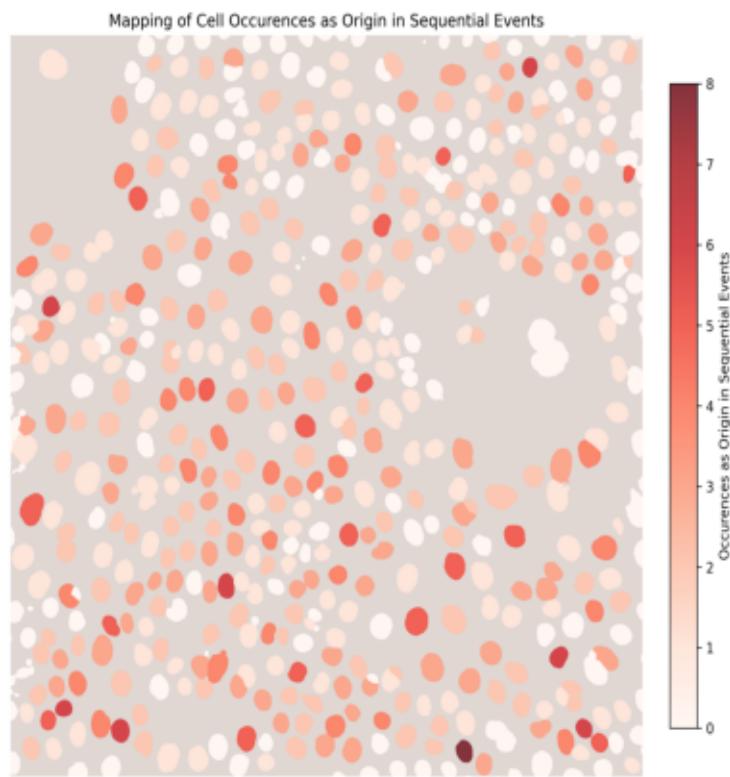
Distribution of Number of Sequential Event Origin Peaks per Cell

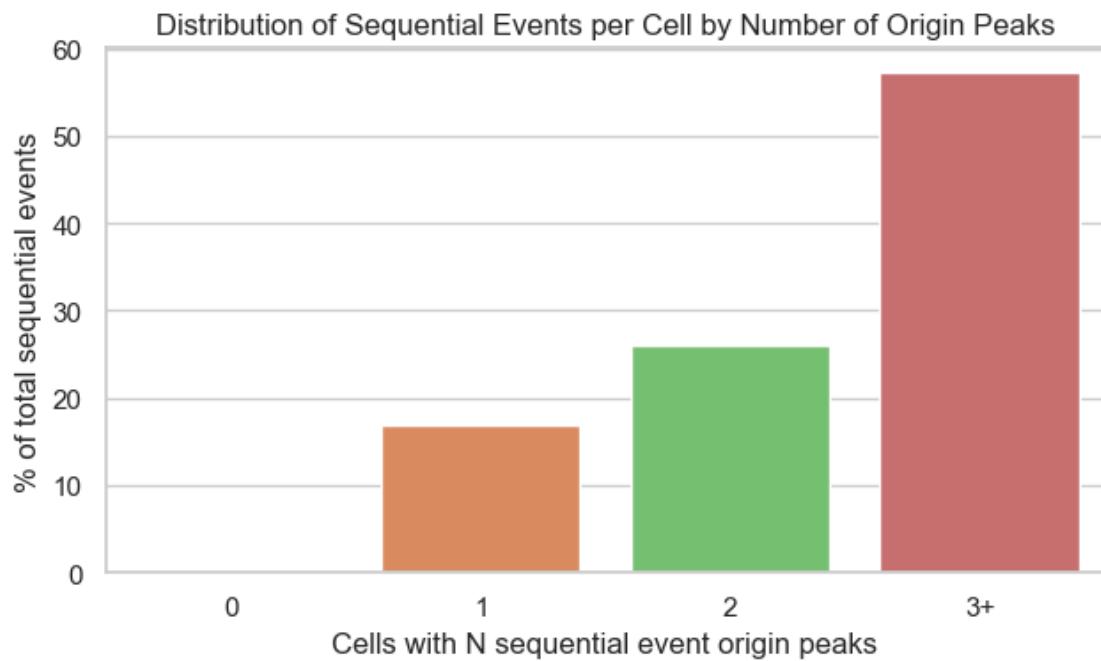


Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)



Cell Mapping with Origin Peaks Overlay - 20250409_IS03

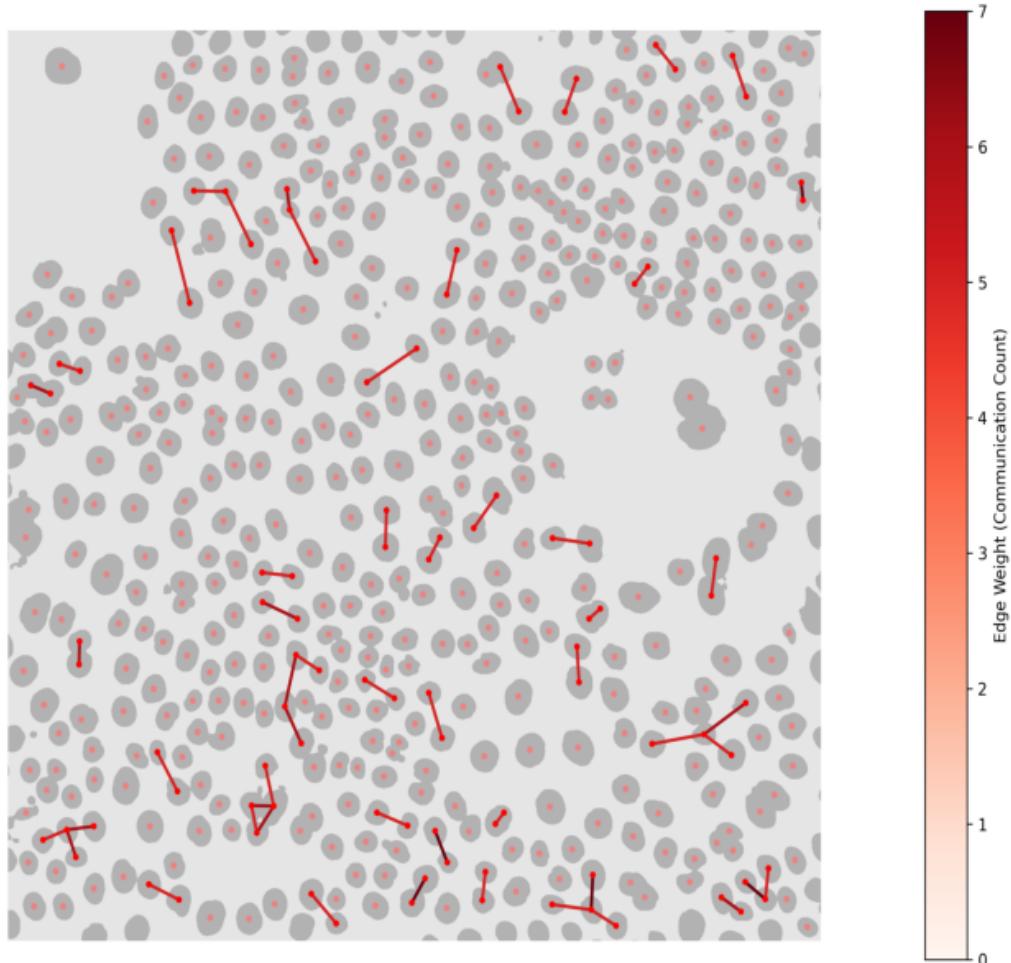


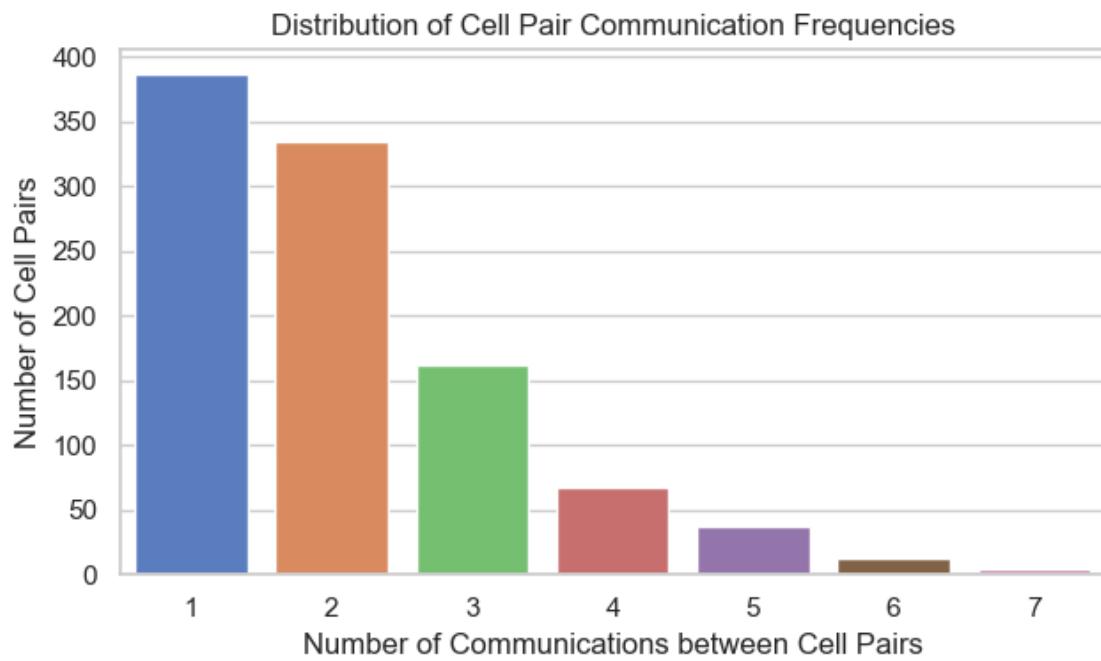


1.3.8 Connection network between cells

Cell Connection Network Graph - 20250409_IS03

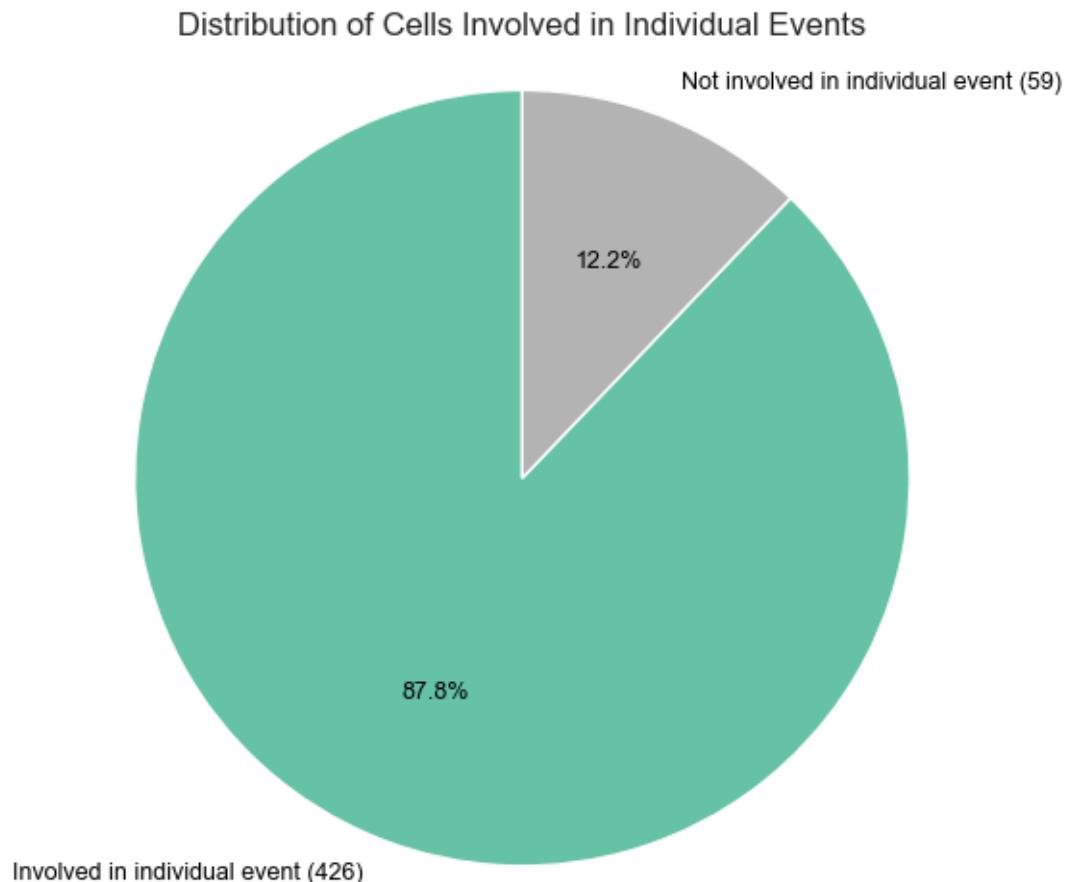
Cells Connection Network (Weighted Edges)



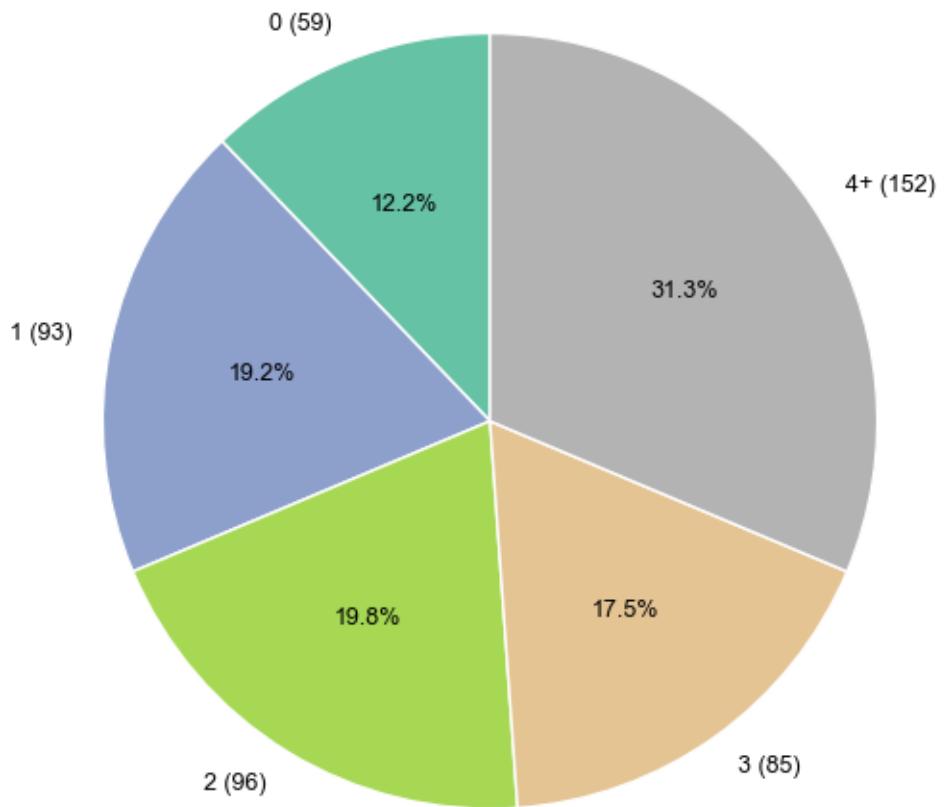


1.4 INDIVIDUAL EVENTS

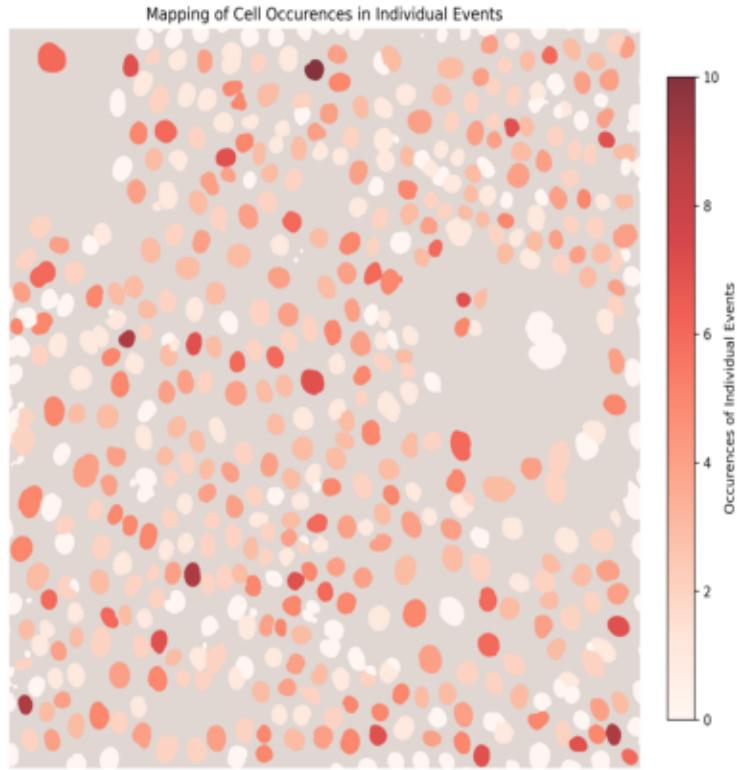
1.4.1 Cells occurrences in individual events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

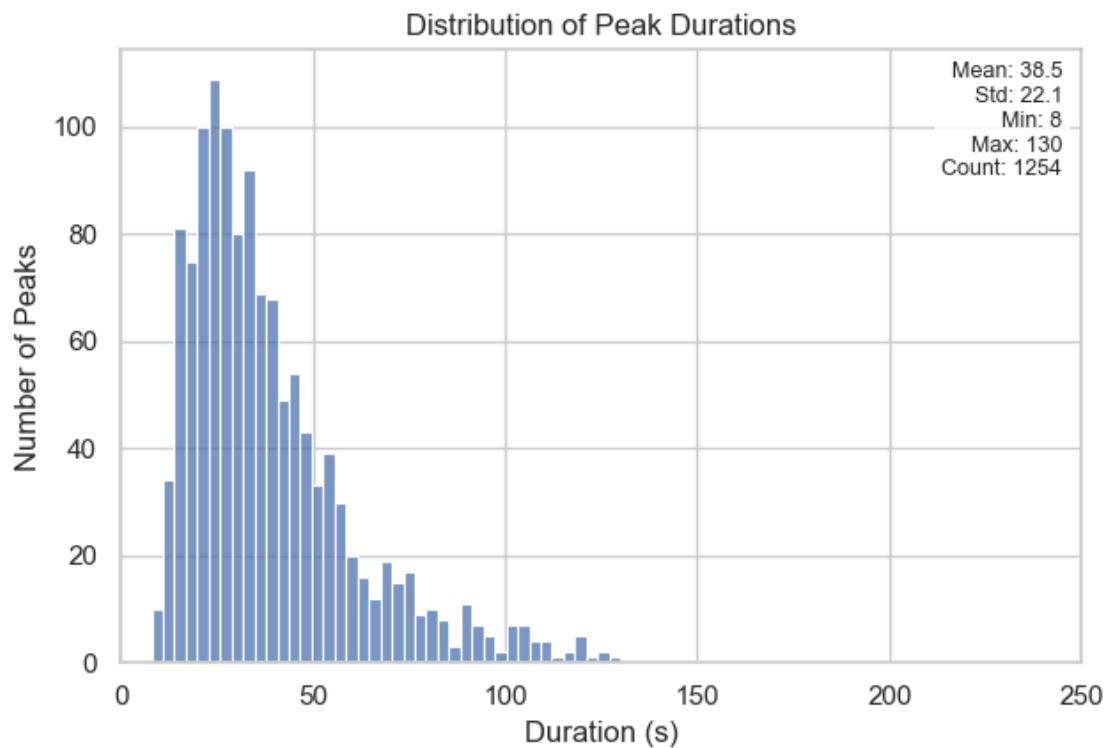


Cell Mapping with Occurrences in Individual Events Overlay - 20250409_IS03

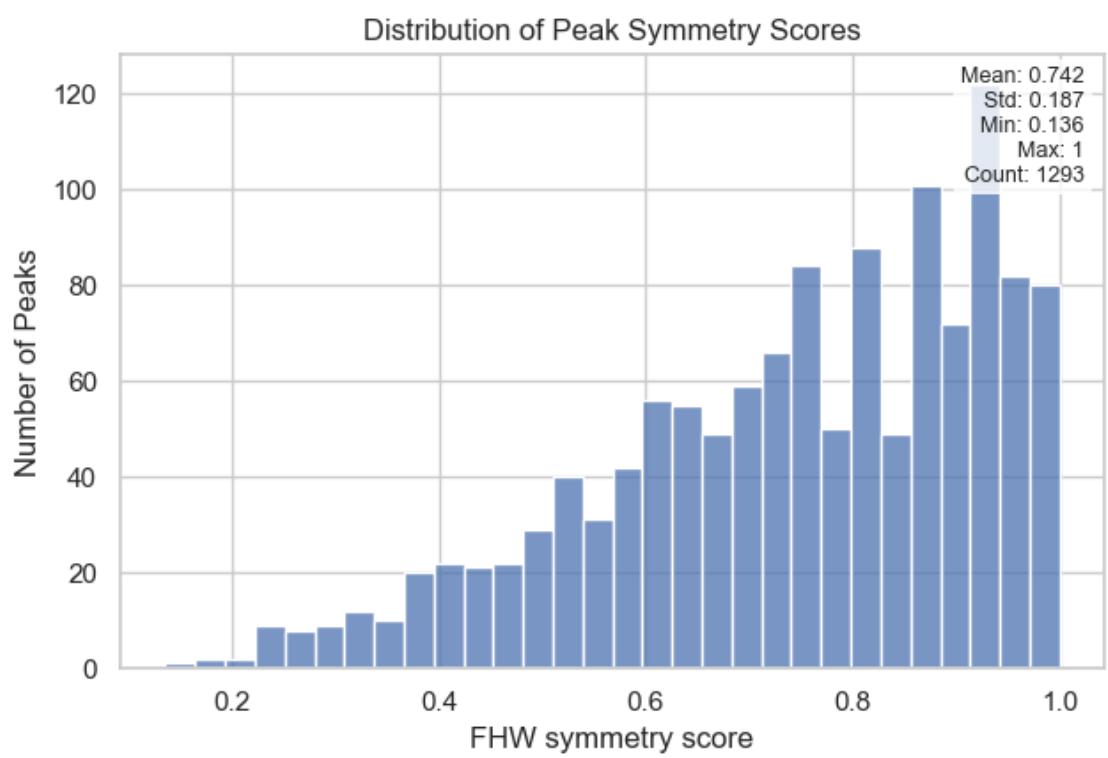
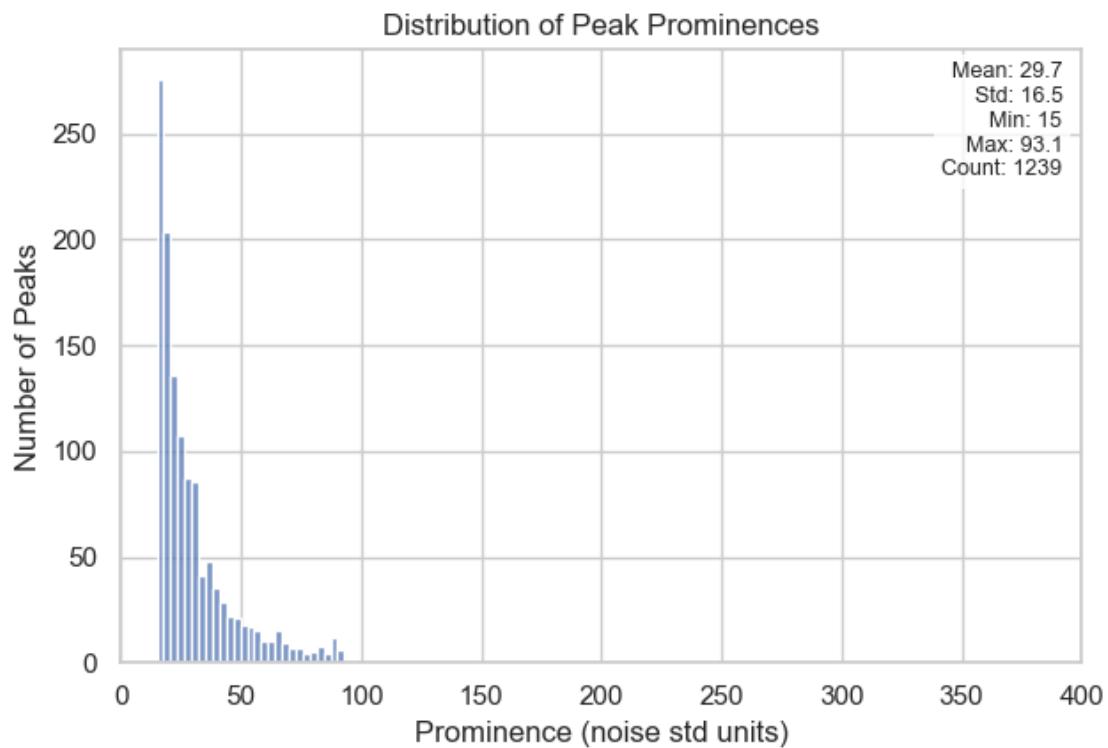


1.4.2 Peaks statistics in individual events

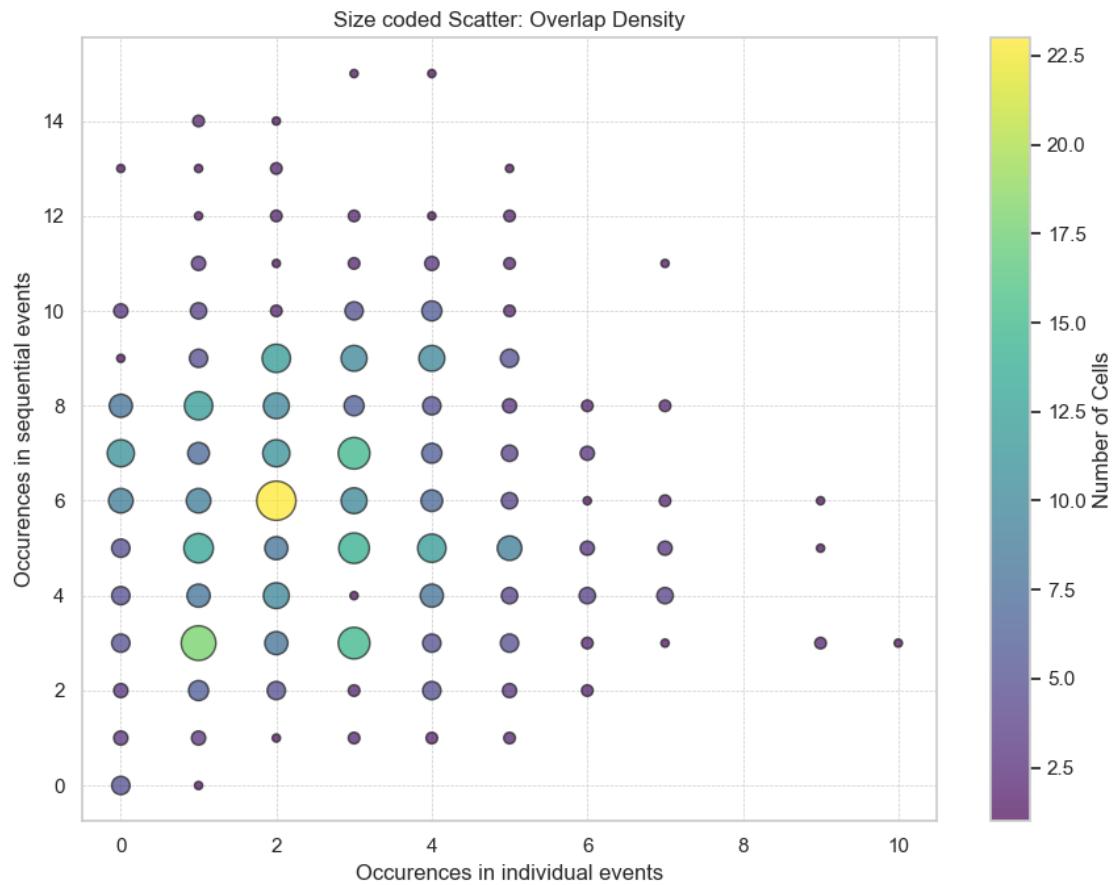
```
[2025-08-13 11:34:15] [INFO] calcium: plot_histogram: removed 39 outliers out of 1293 on 'Duration (s)' (lower=-58, upper=131)
```



```
[2025-08-13 11:34:15] [INFO] calcium: plot_histogram: removed 54 outliers out of 1293 on 'Prominence (noise std units)' (lower=-37.6, upper=93.3)
```

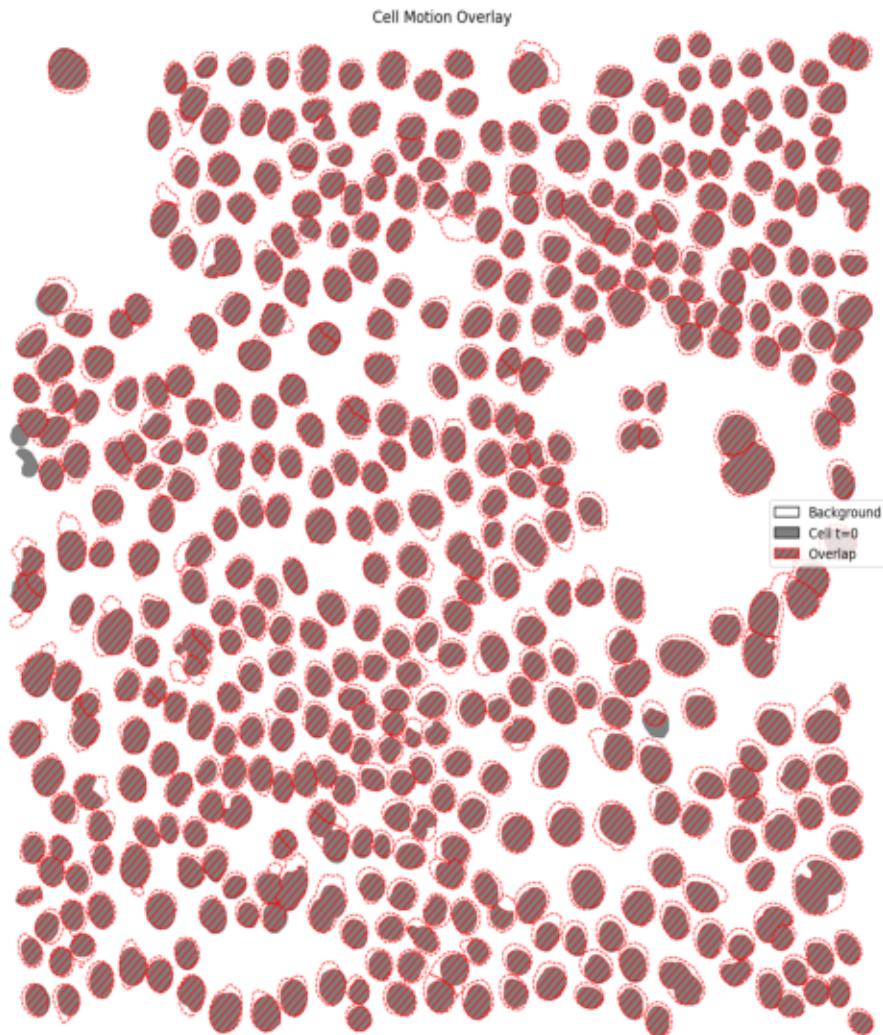


1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250409_IS03



Number of cells:

- Hoechst image taken at t=0: 485
- Hoechst image taken at t=1801: 479
- Number of cells difference: absolute 6, relative 1.24%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 753273
- Pixels segmented as cell at t=1801: 957052
- Overlapping pixels between t=0 and t=1801: 734853 (85.93% of total)
- Pixels exclusive to t=0: 18420 (2.44% of total)
- Pixels exclusive to t=1801: 222199 (23.22% of total)

executed

August 13, 2025

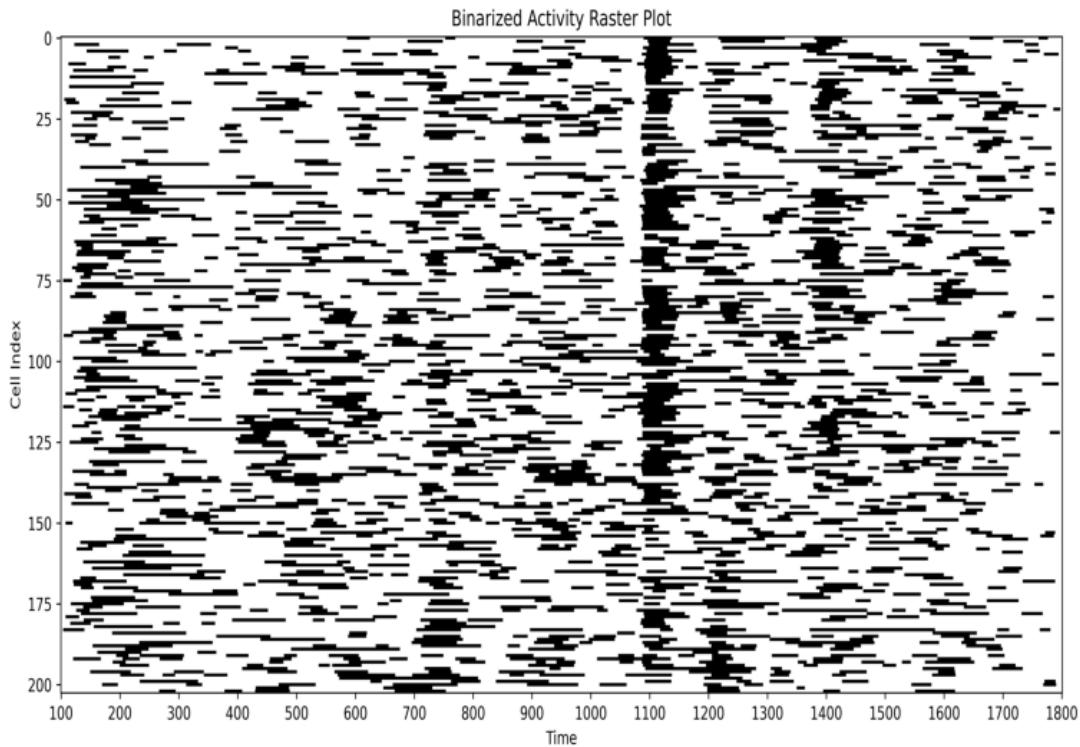
1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

1.0.1 Initialization

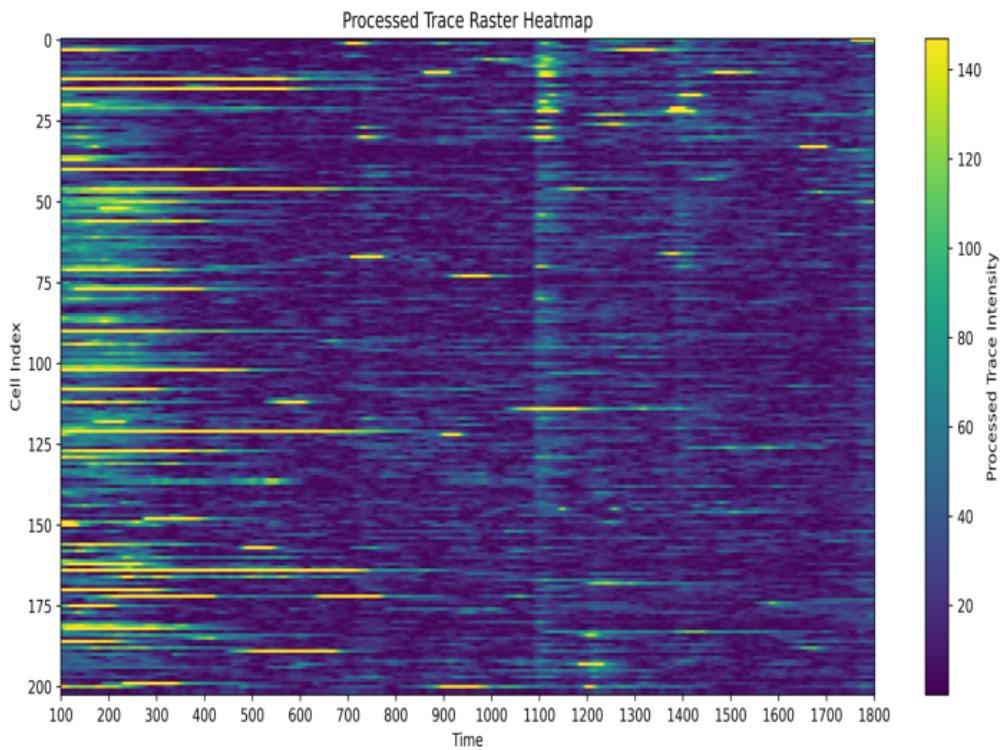
1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot

Binary Activity Raster Plot - 20250409_IS05



Heatmap Activity Raster Plot - 20250409_IS05



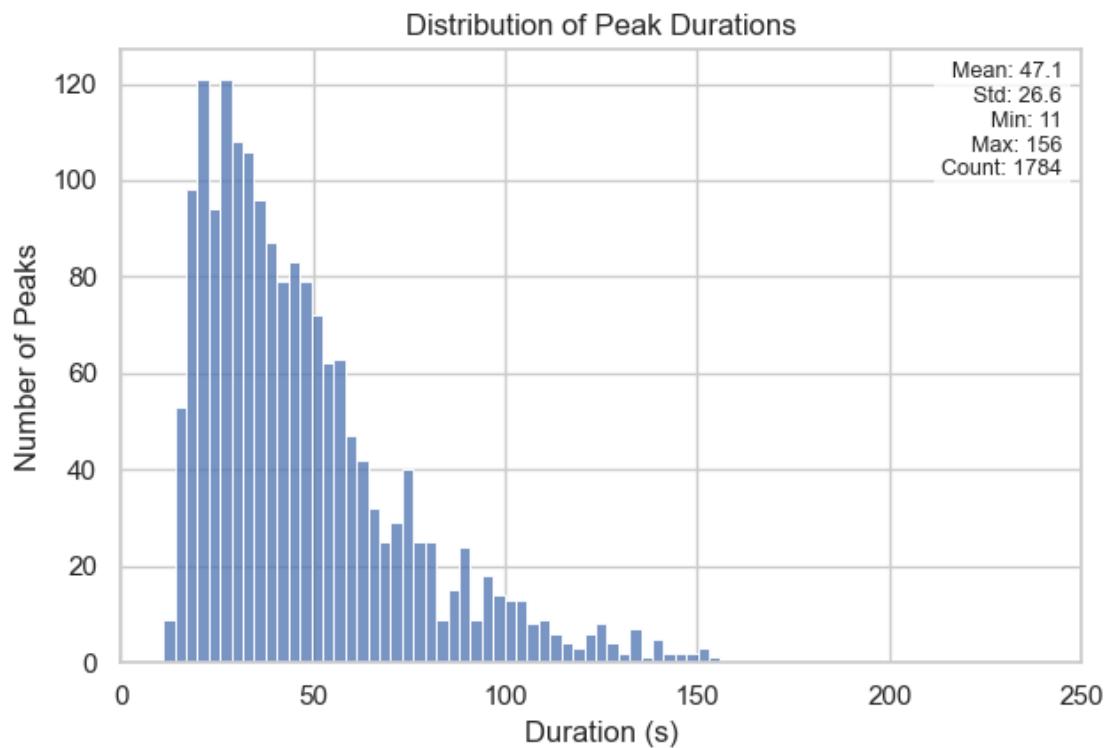
1.1.2 Peaks population

Total number of peaks: 1806

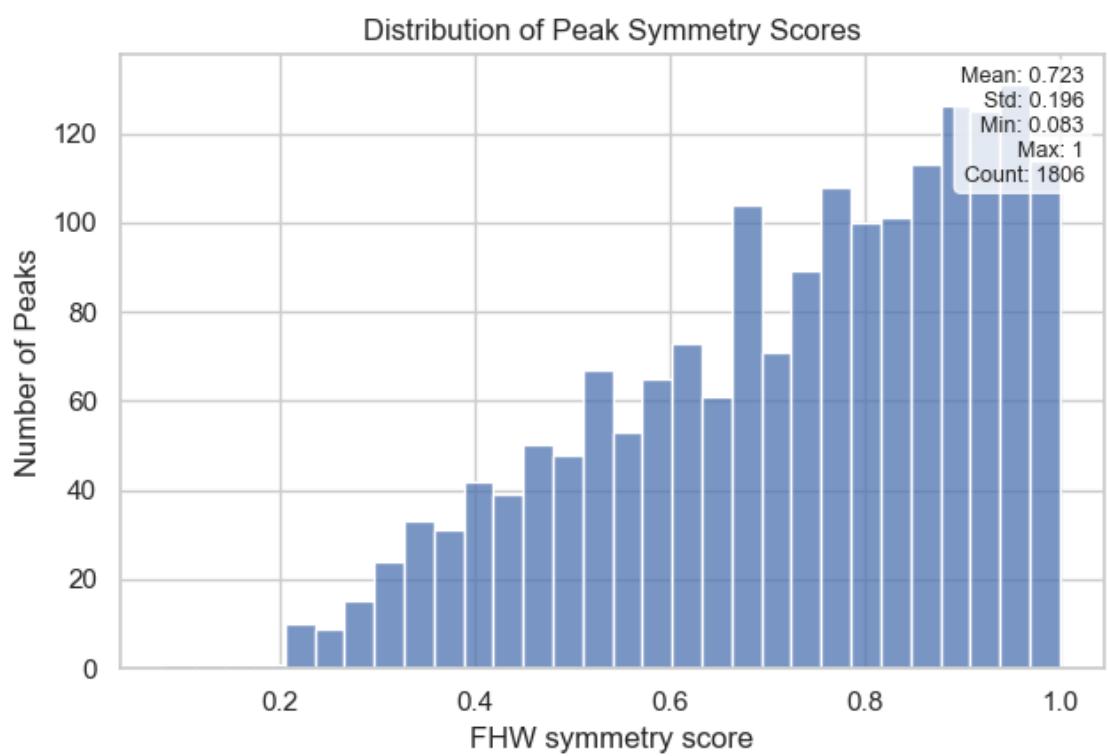
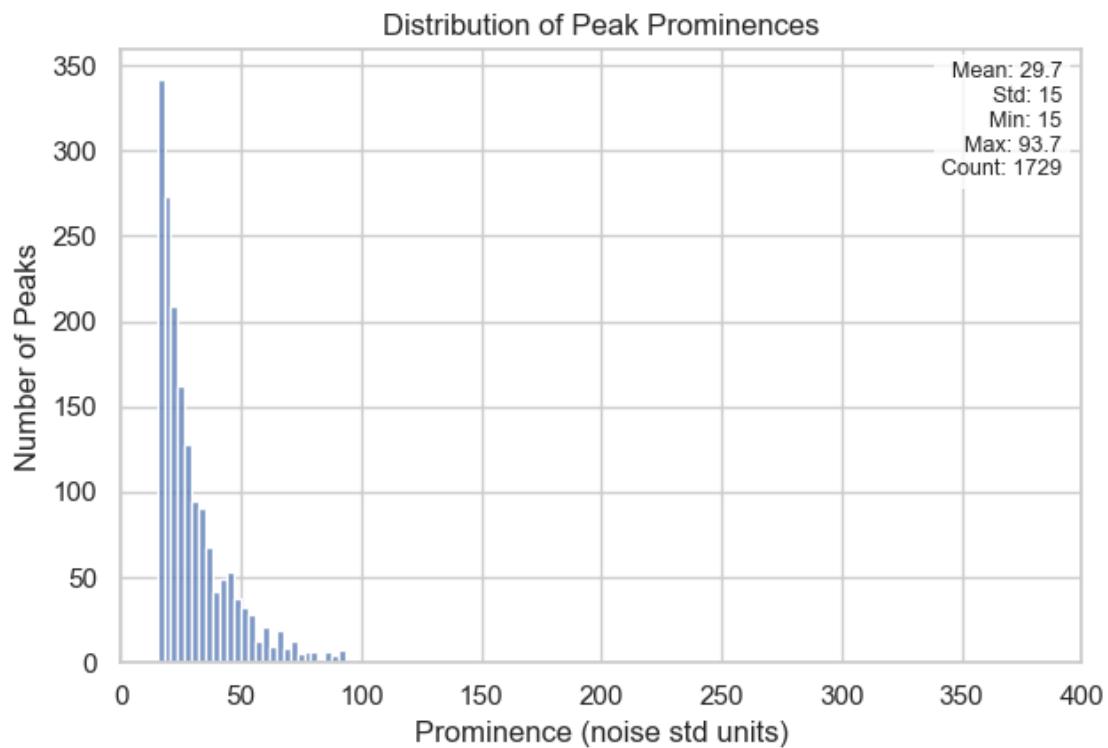
Total number of cells: 203

1.1.3 Peaks statistics

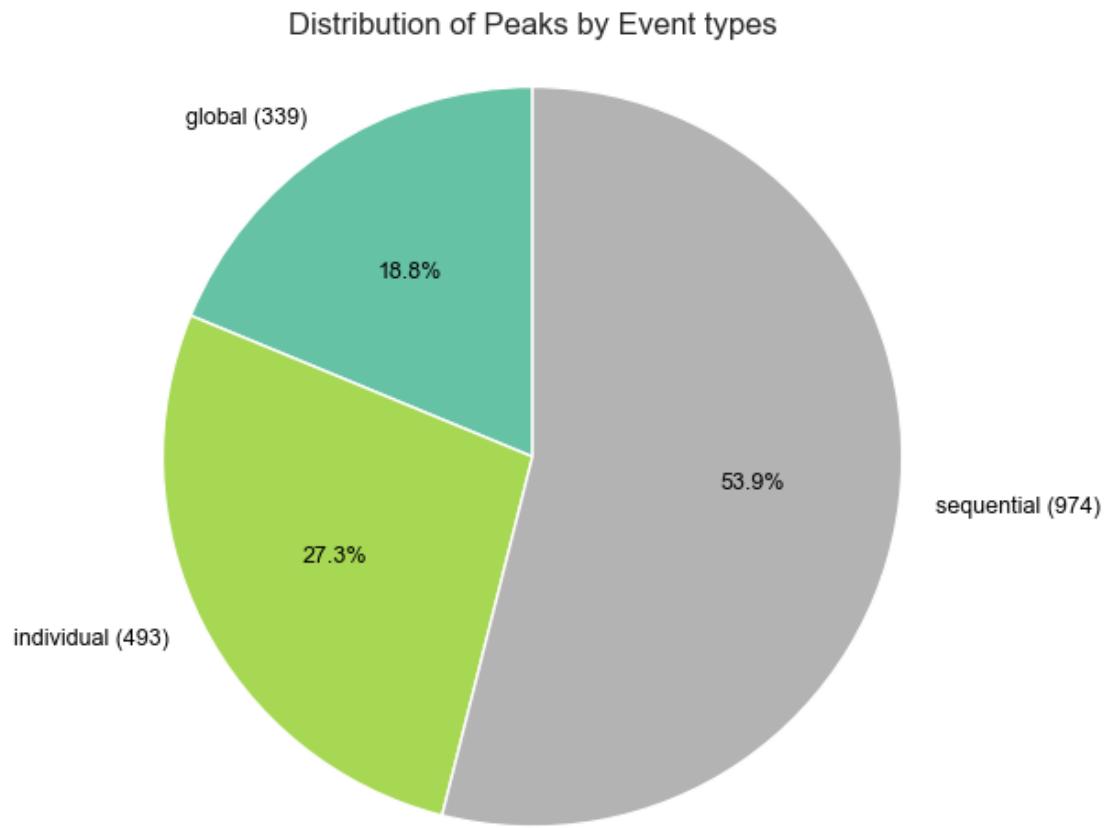
```
[2025-08-13 11:35:42] [INFO] calcium: plot_histogram: removed 22 outliers out of  
1806 on 'Duration (s)' (lower=-68, upper=156)
```



```
[2025-08-13 11:35:42] [INFO] calcium: plot_histogram: removed 77 outliers out of 1806 on 'Prominence (noise std units)' (lower=-37.4, upper=94.2)
```

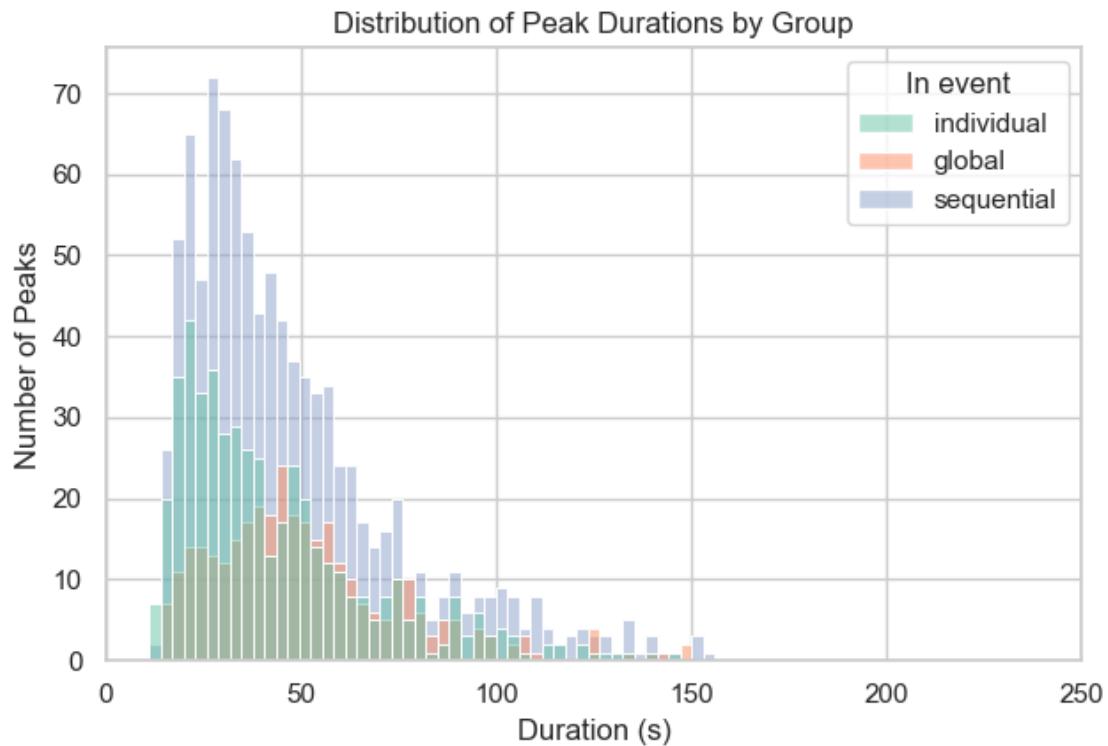


1.1.4 Distribution of peaks per event types



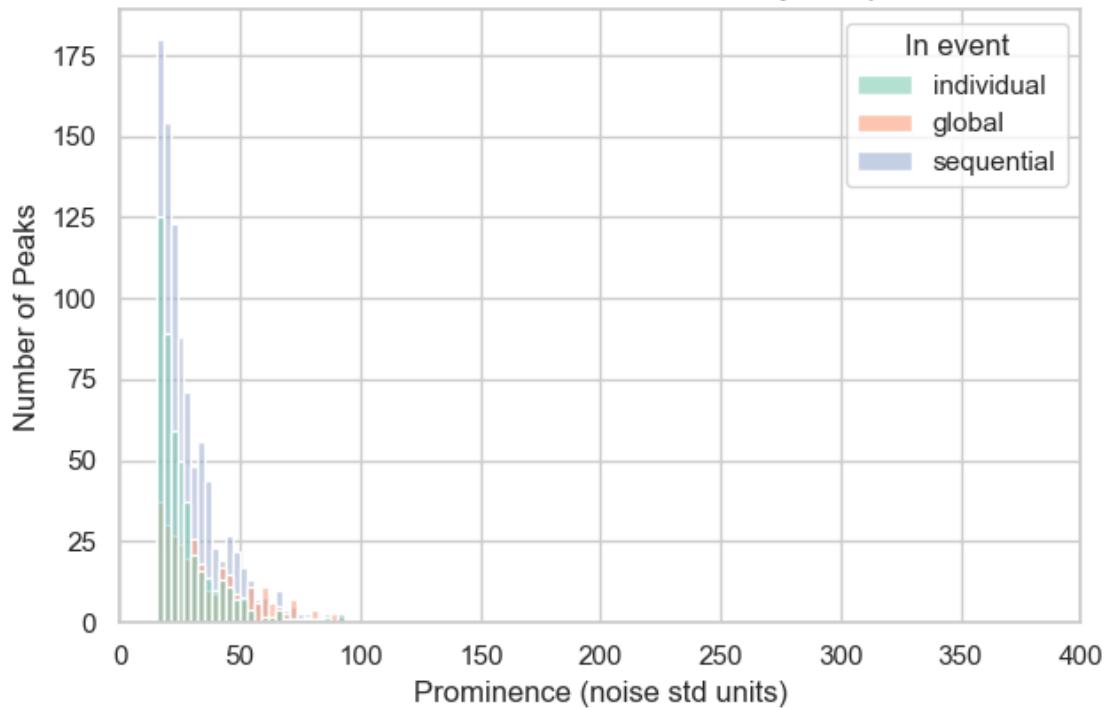
1.1.5 Peaks statistics per event types

```
[2025-08-13 11:35:43] [INFO] calcium: plot_histogram_by_group: removed 22 outliers out of 1806 on 'Duration (s)' (lower=-68, upper=156)
```

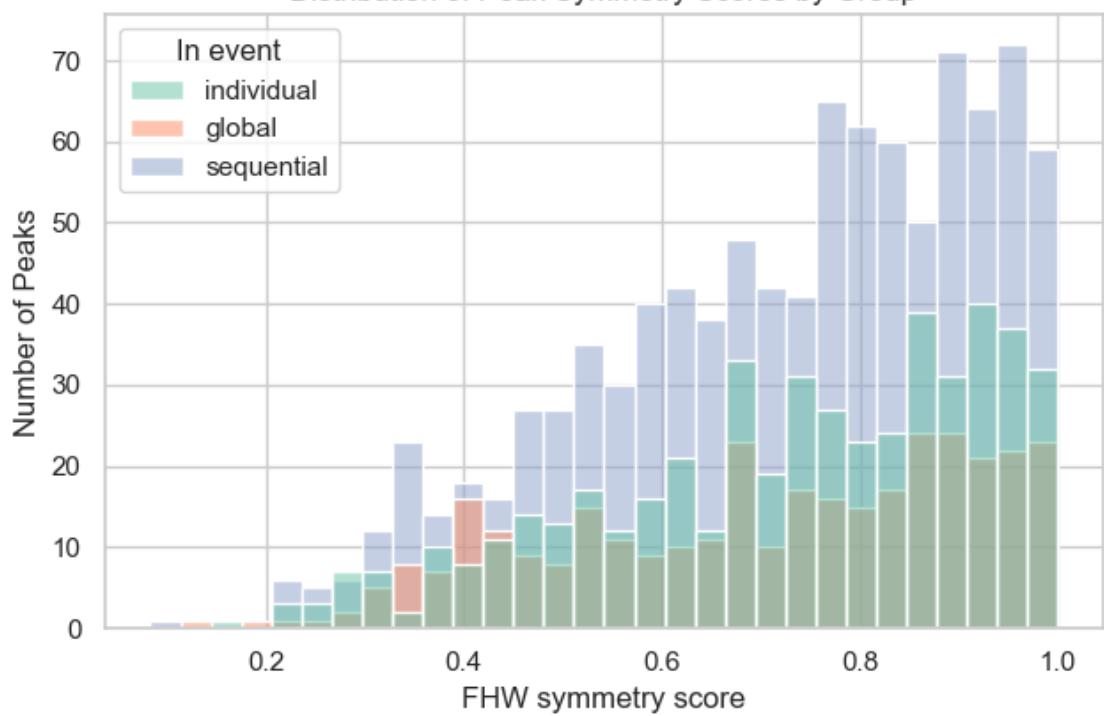


```
[2025-08-13 11:35:43] [INFO] calcium: plot_histogram_by_group: removed 77
outliers out of 1806 on 'Prominence (noise std units)' (lower=-37.4, upper=94.2)
```

Distribution of Peak Prominences by Group



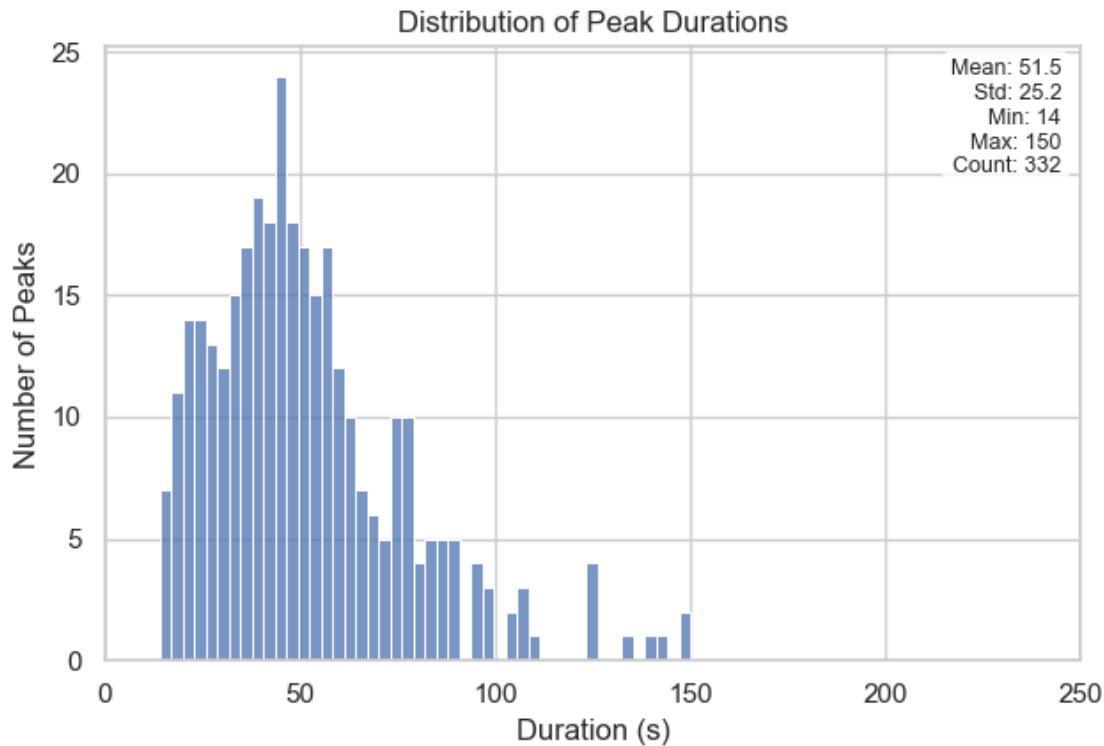
Distribution of Peak Symmetry Scores by Group



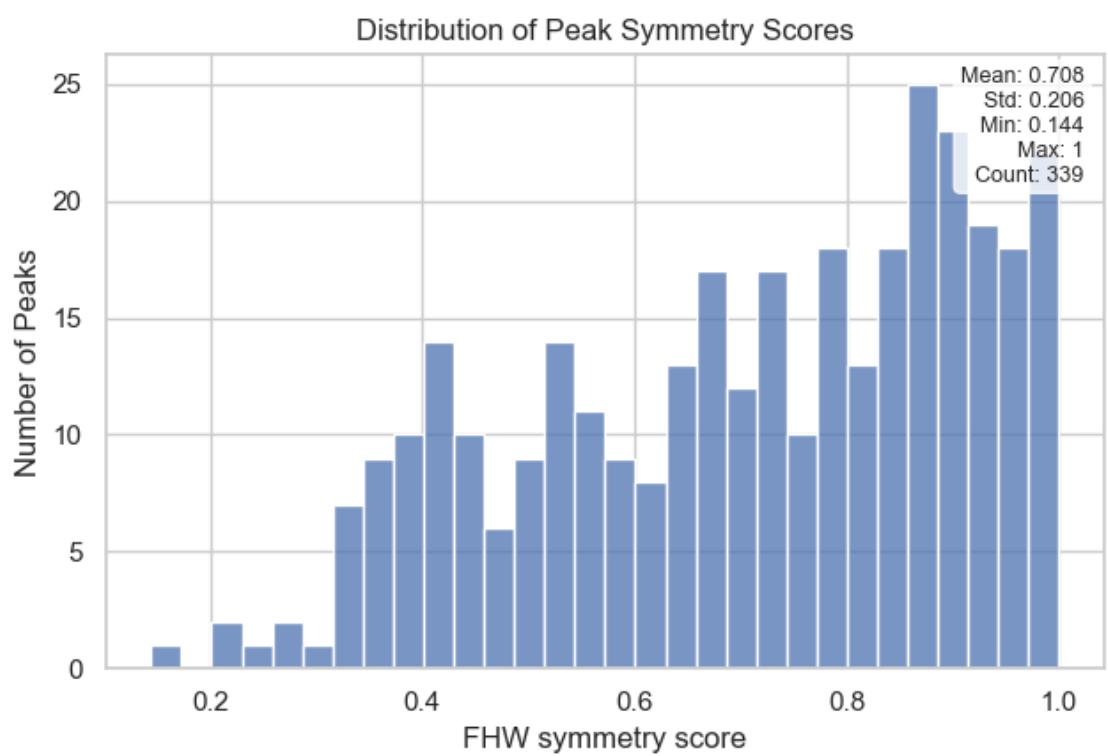
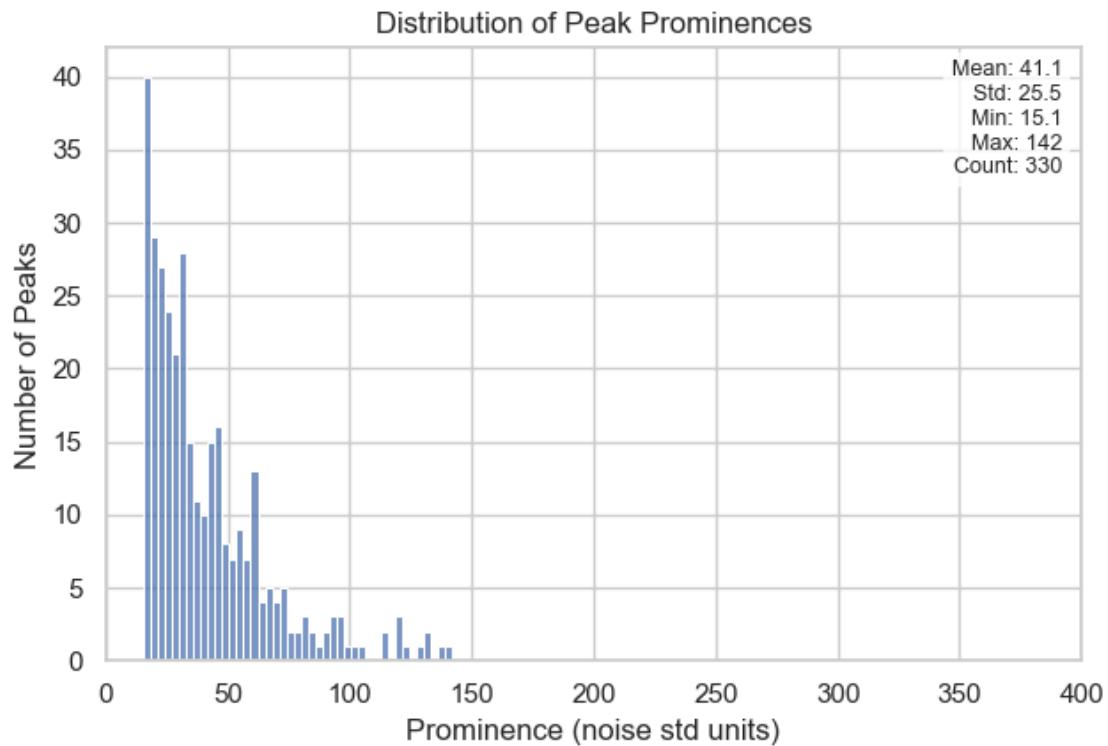
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

[2025-08-13 11:35:44] [INFO] calcium: plot_histogram: removed 7 outliers out of 339 on 'Duration (s)' (lower=-59, upper=158)

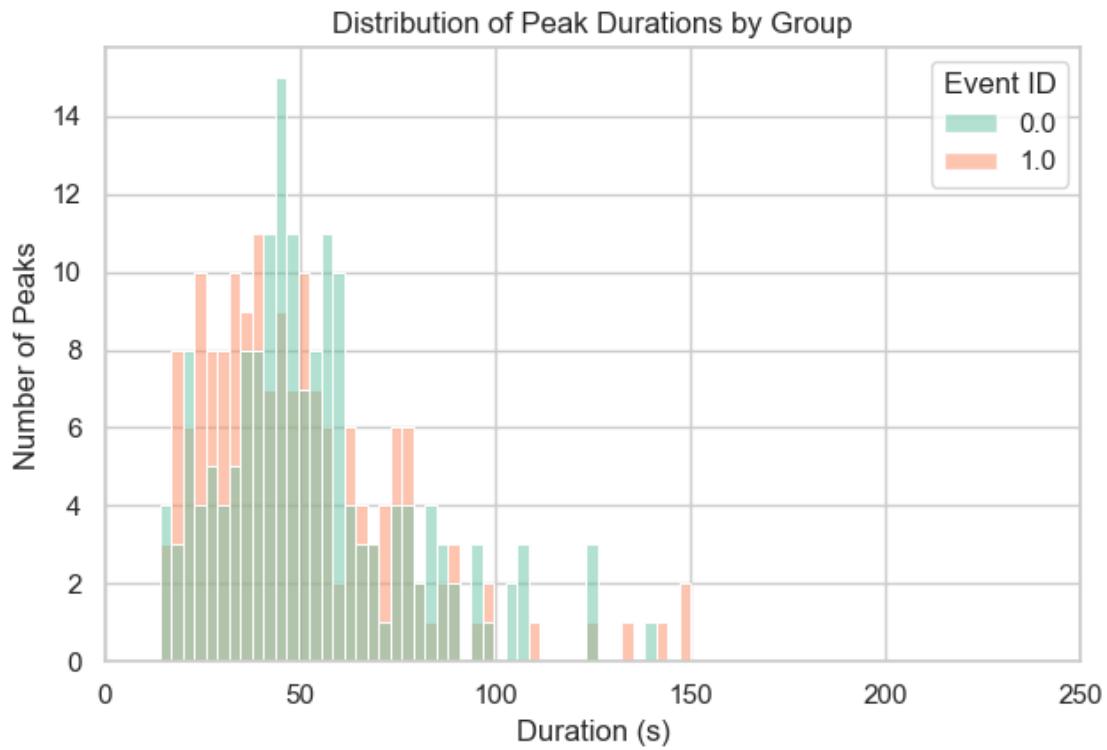


[2025-08-13 11:35:44] [INFO] calcium: plot_histogram: removed 9 outliers out of 339 on 'Prominence (noise std units)' (lower=-73.4, upper=150.25)



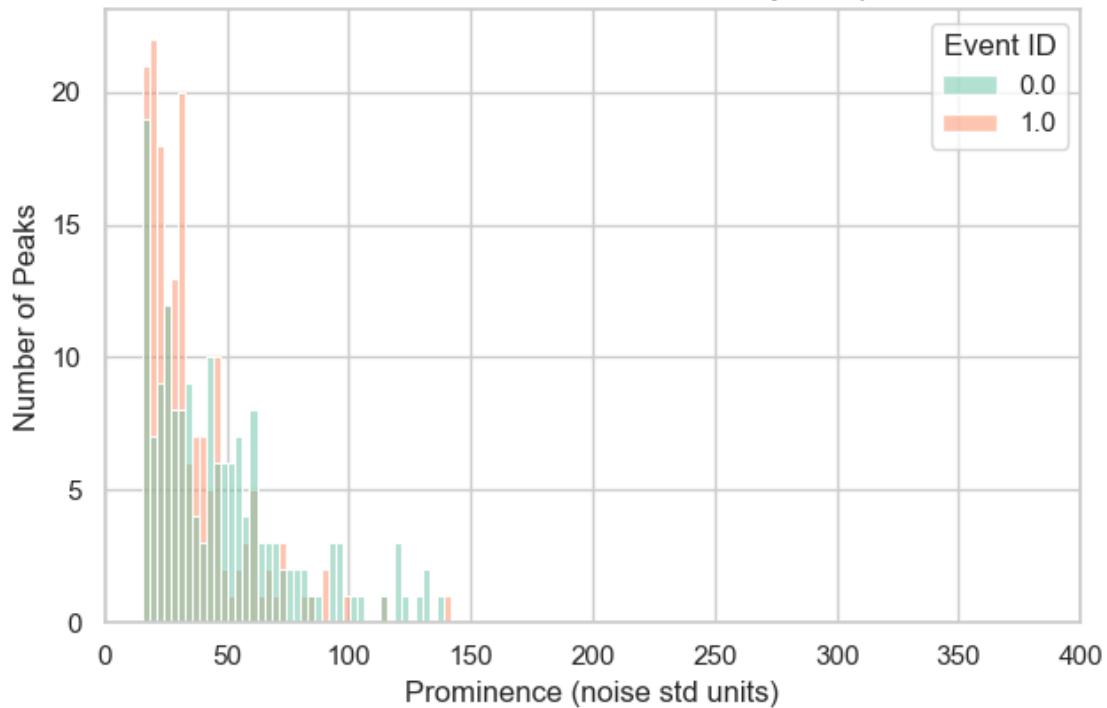
1.2.2 Peak statistics in global event per event ID

[2025-08-13 11:35:45] [INFO] calcium: plot_histogram_by_group: removed 7 outliers out of 339 on 'Duration (s)' (lower=-59, upper=158)

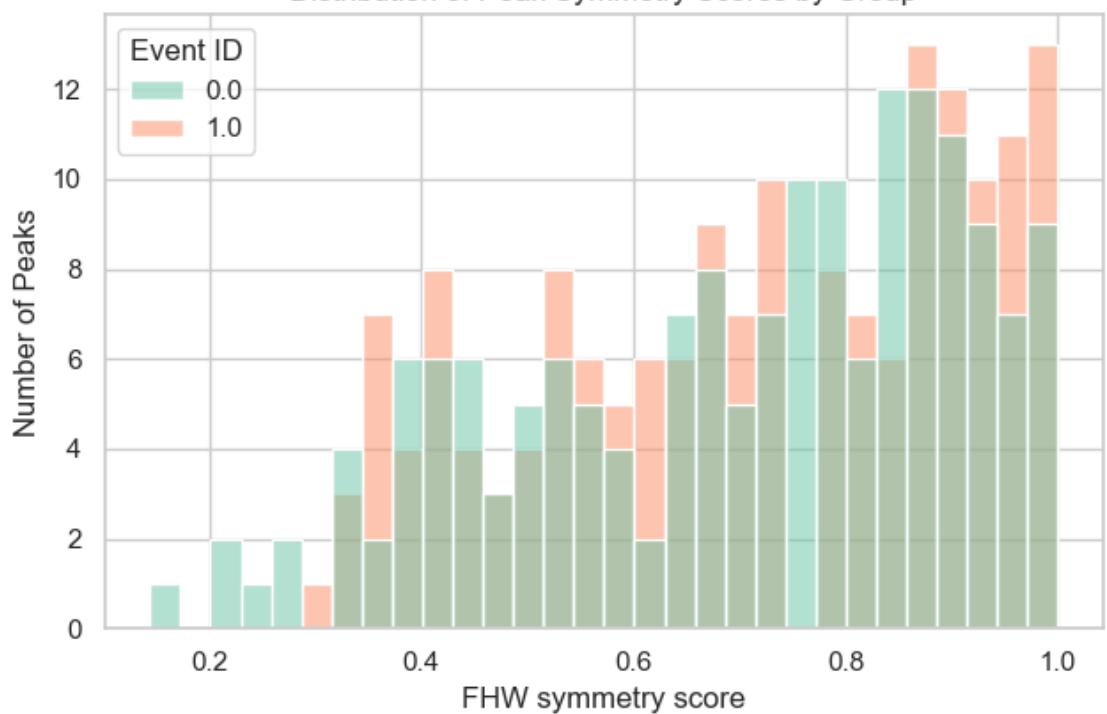


[2025-08-13 11:35:45] [INFO] calcium: plot_histogram_by_group: removed 9 outliers out of 339 on 'Prominence (noise std units)' (lower=-73.4, upper=150.25)

Distribution of Peak Prominences by Group

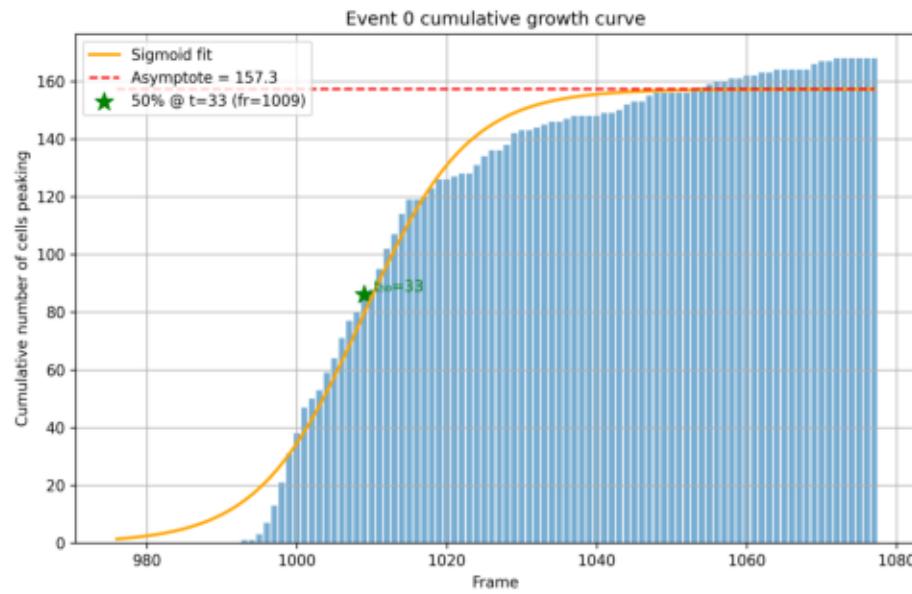


Distribution of Peak Symmetry Scores by Group

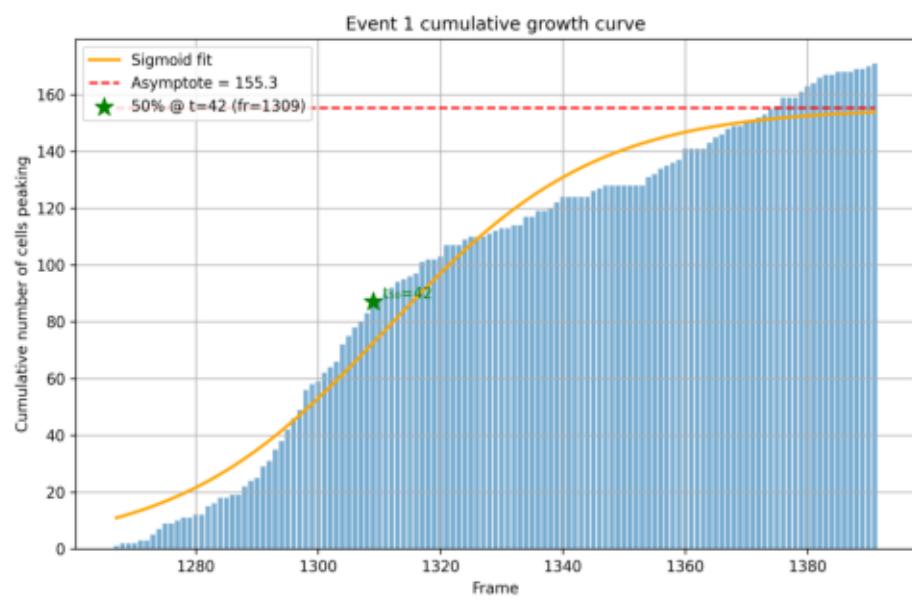


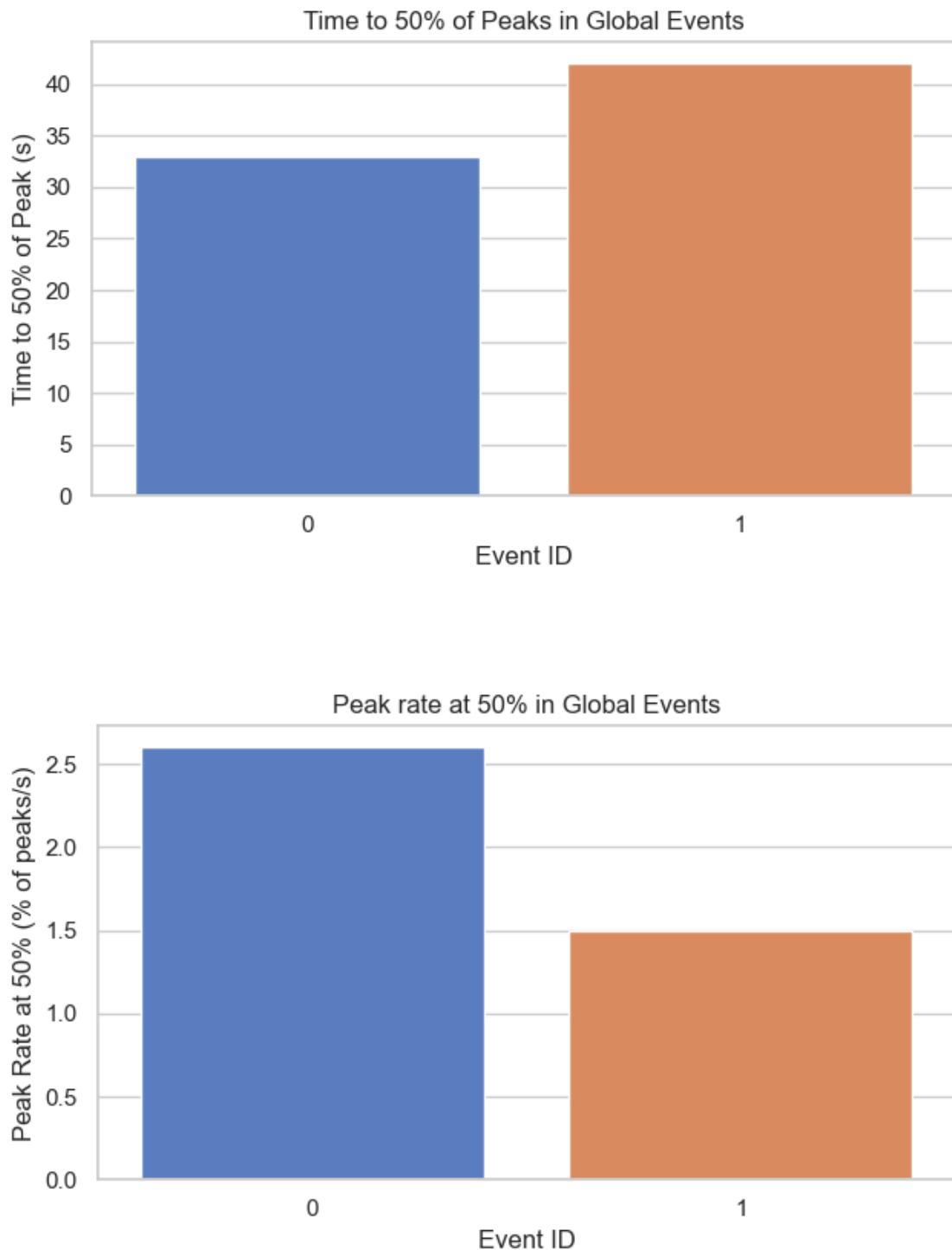
1.2.3 Kinetics of global events

Event Activity Overlay (Event ID: 0) - 20250409_IS05

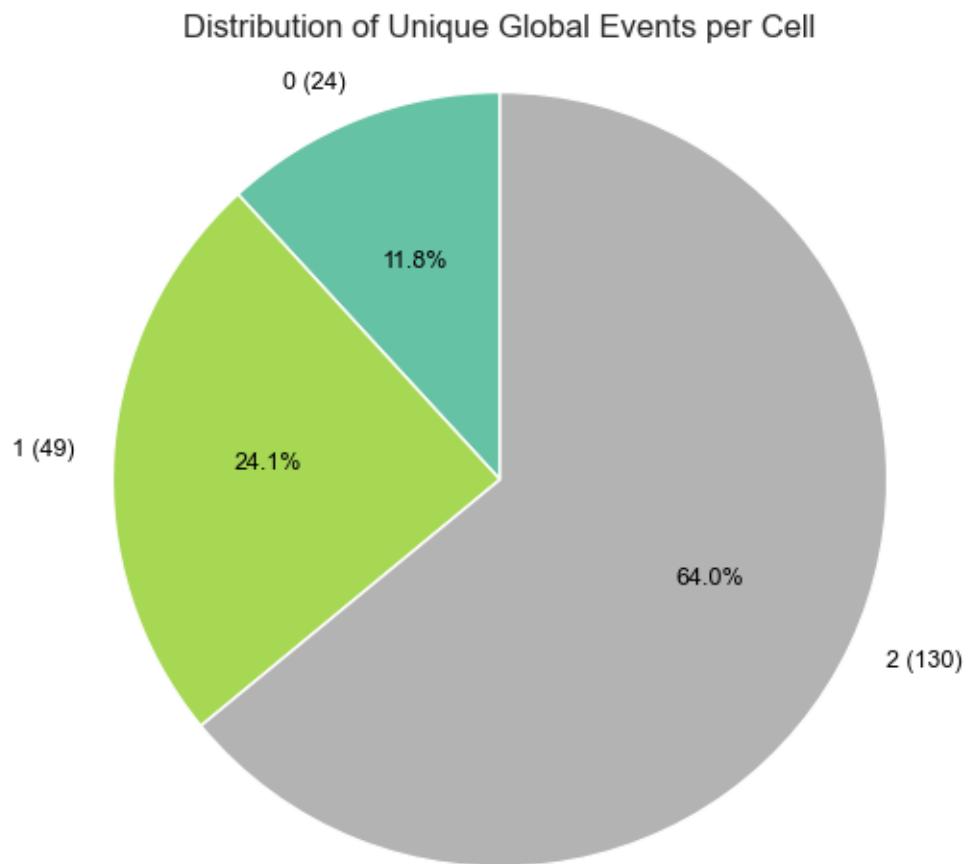


Event Activity Overlay (Event ID: 1) - 20250409_IS05

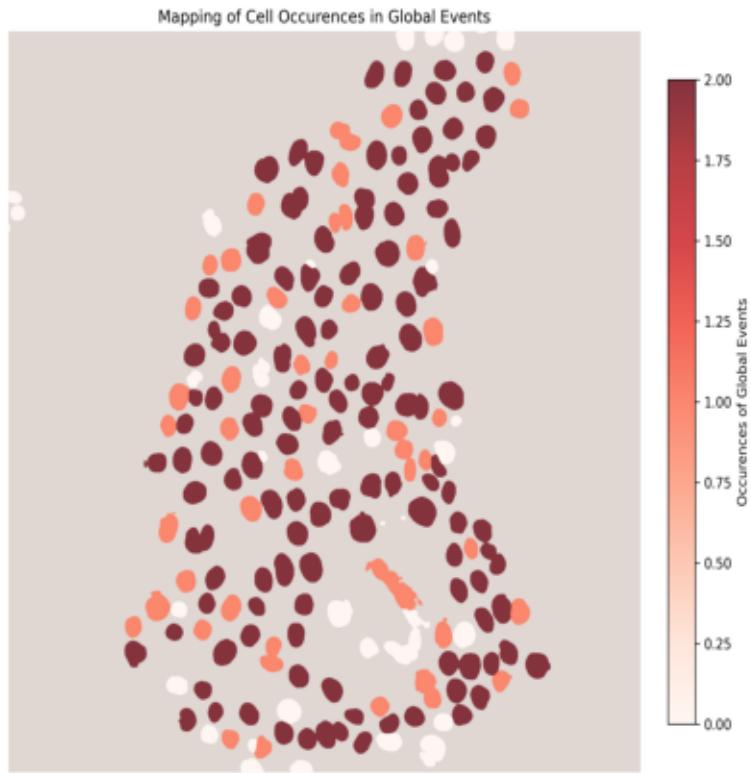


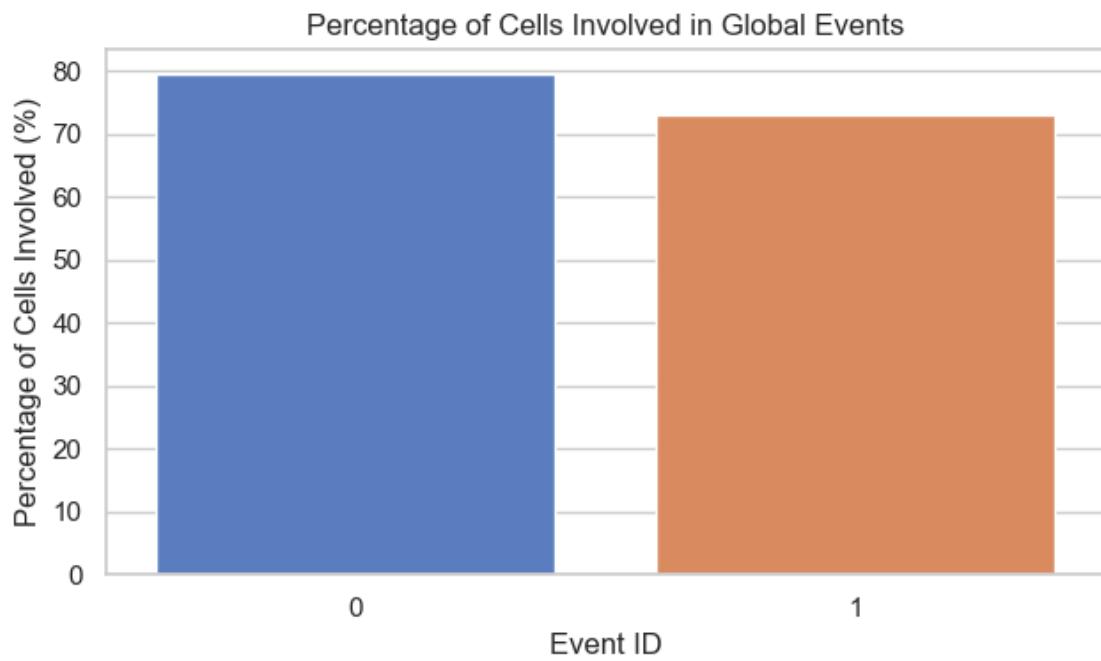


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250409_IS05





1.2.5 Inter-event interval analysis

Intervals between global event peaks: [292.0]

1.2.6 Early peakers in the events

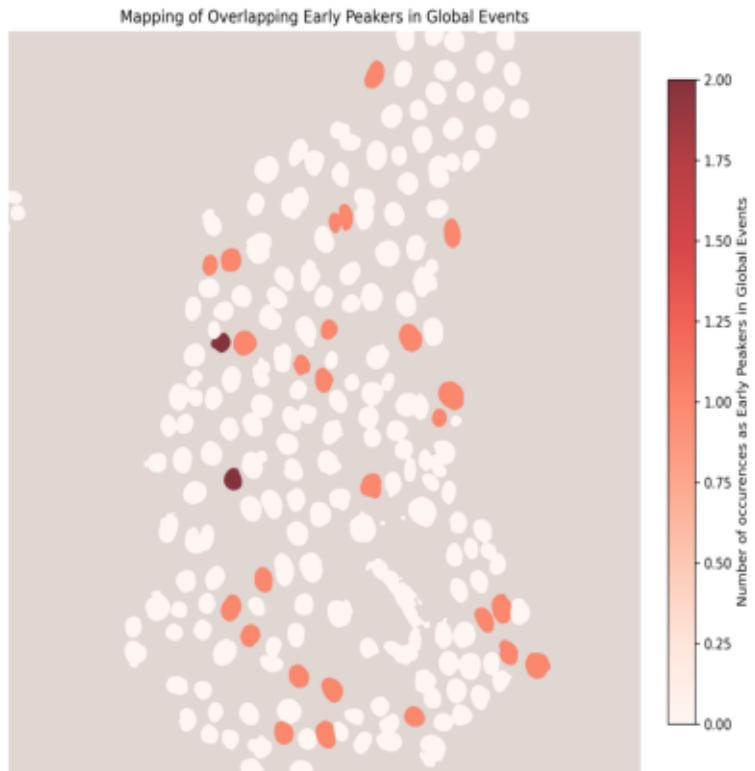
Cell Mapping with Early Peakers Overlay for event 0 - 20250409_IS05



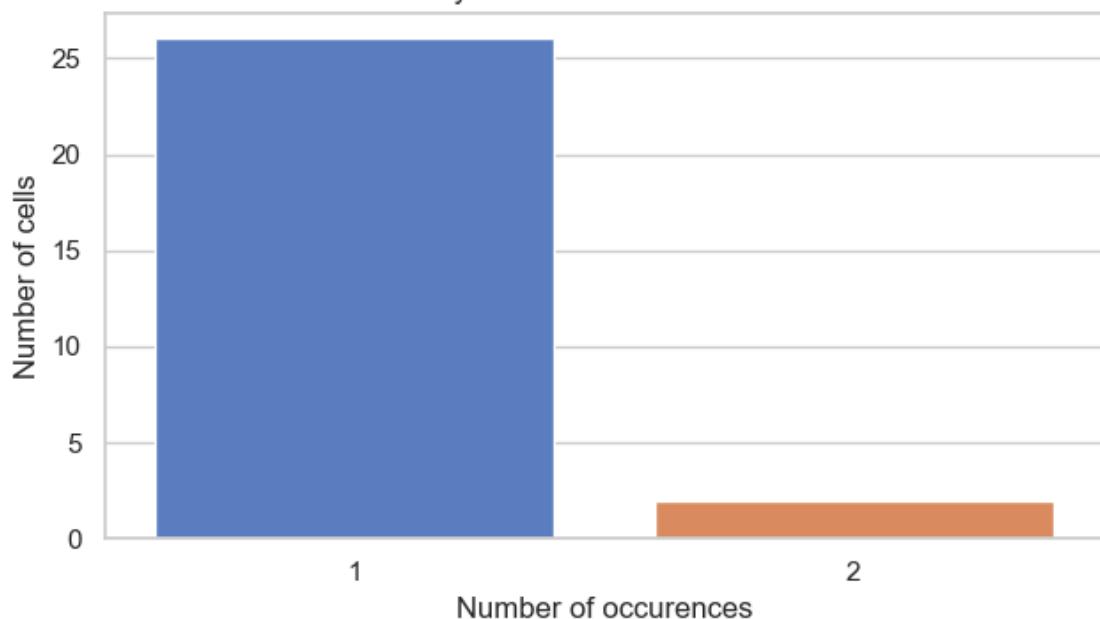
Cell Mapping with Early Peakers Overlay for event 1 - 20250409_IS05



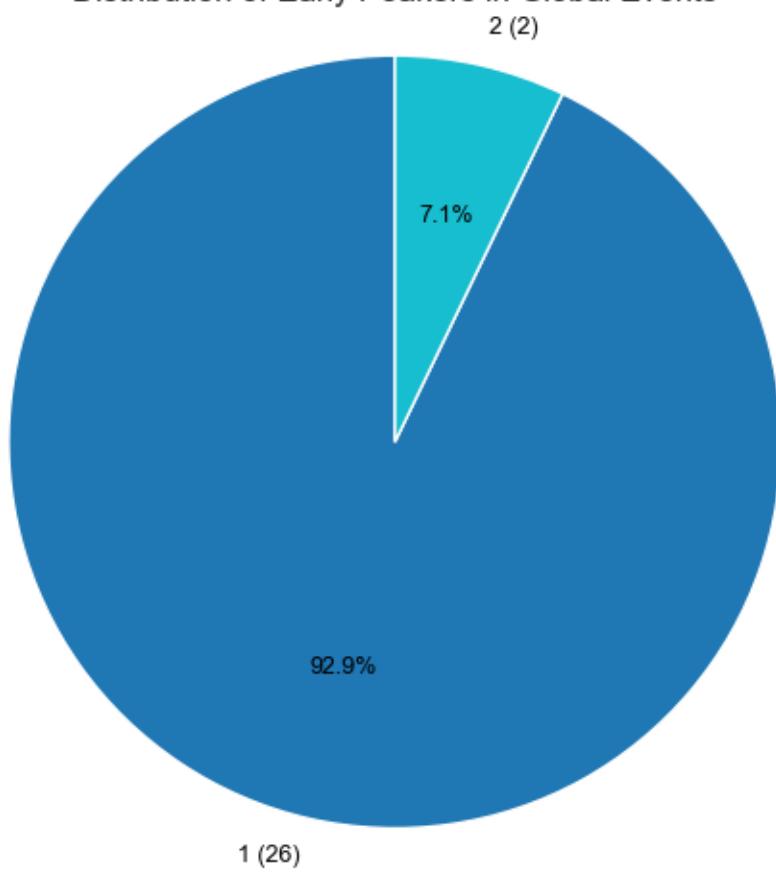
Cell Mapping with Occurrences in Global Events Overlay - 20250409_IS05



Early Peakers in Global Events

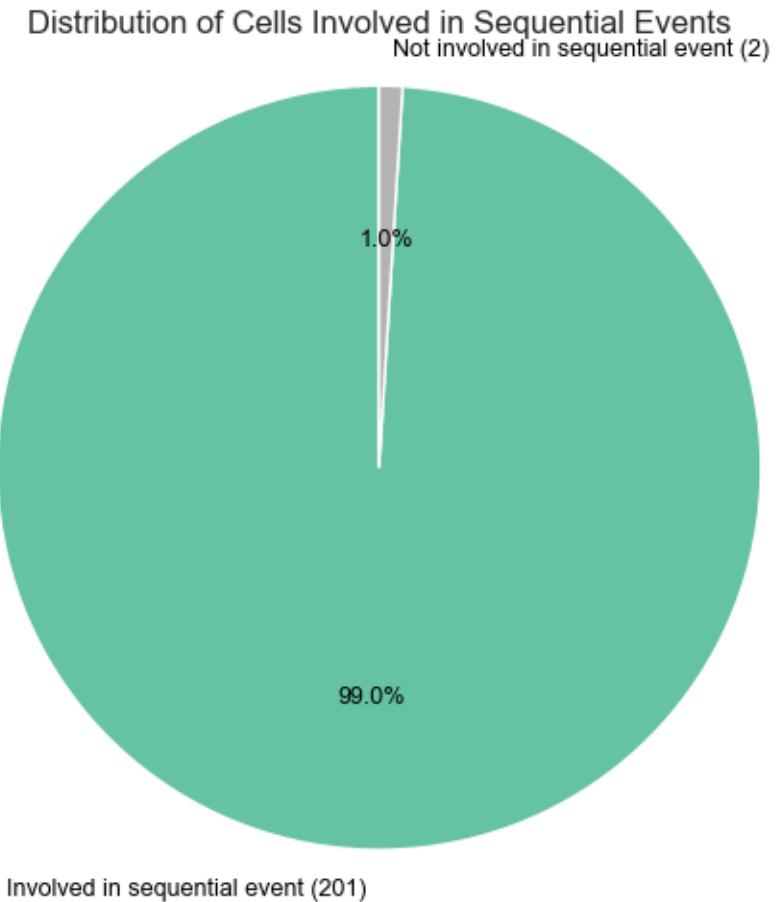


Distribution of Early Peakers in Global Events

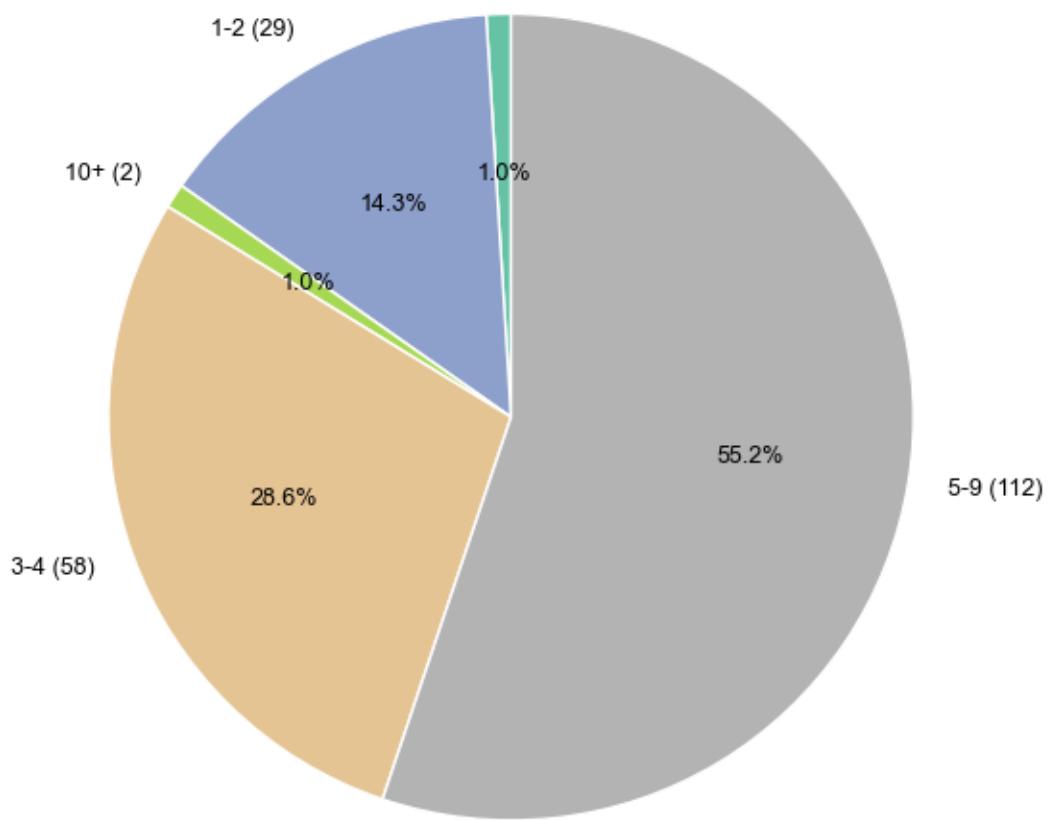


1.3 SEQUENTIAL EVENTS

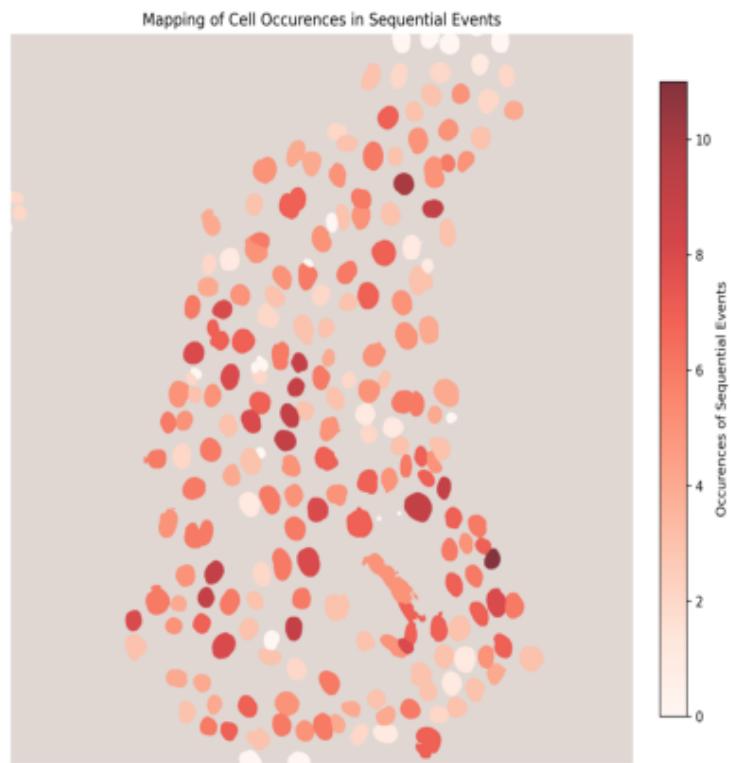
1.3.1 Cells occurrences in sequential events



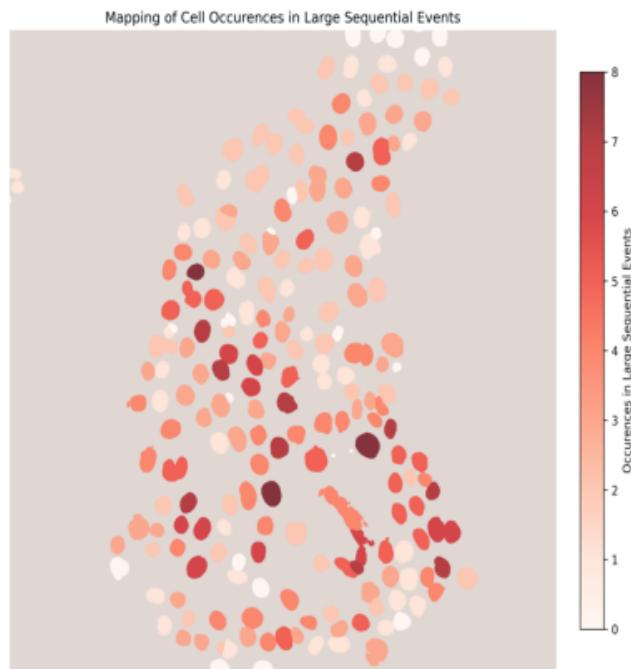
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250409_IS05

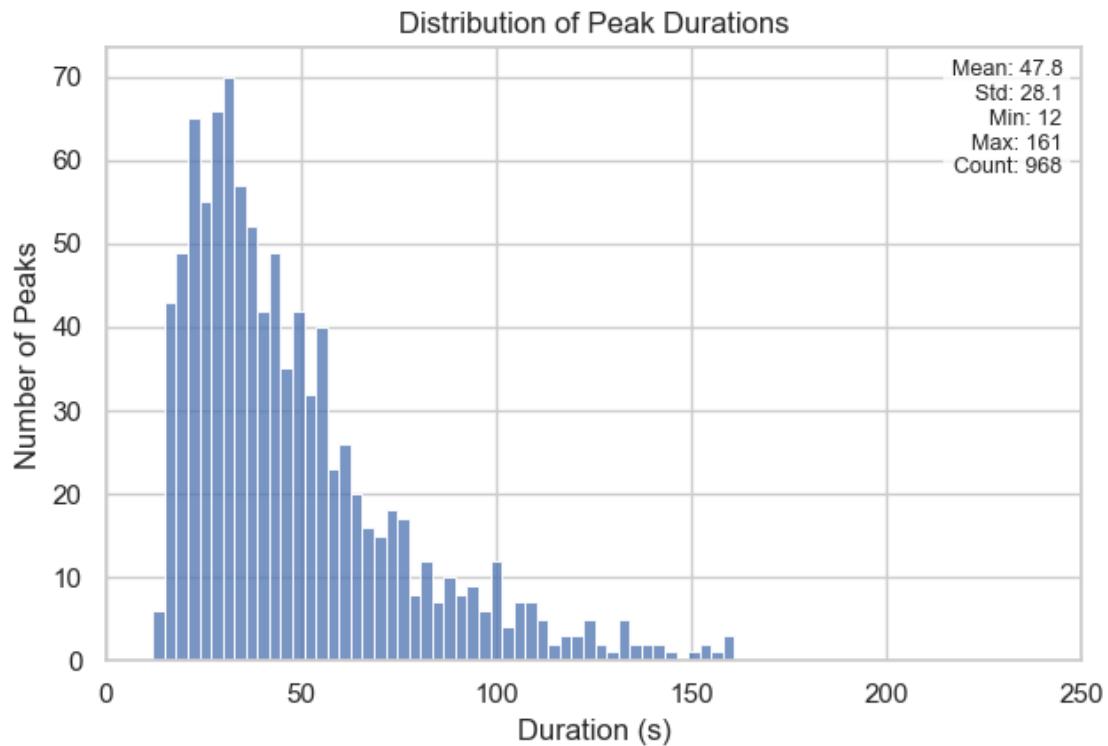


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250409_IS05

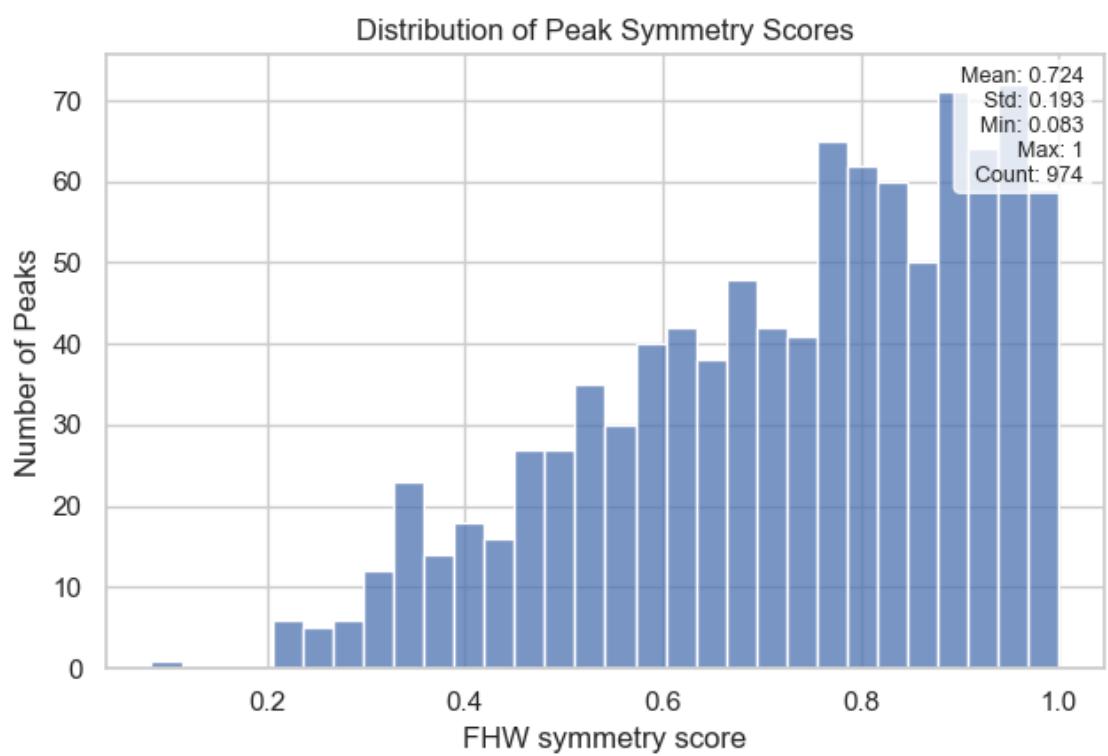
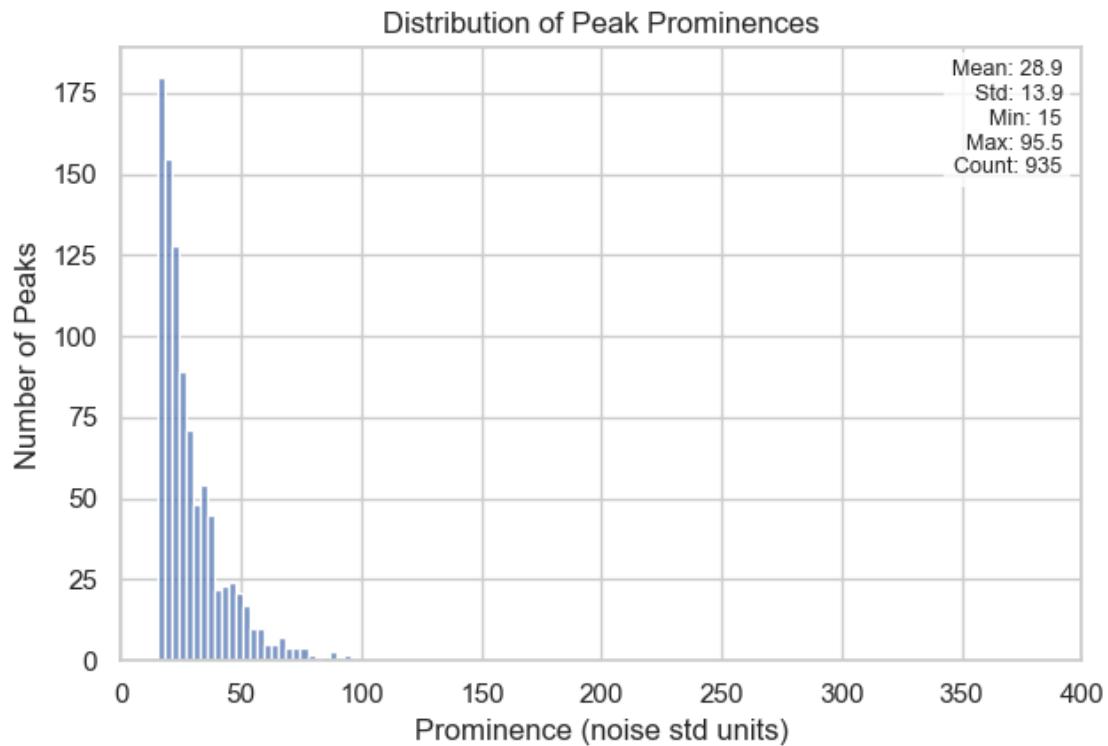


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 11:35:55] [INFO] calcium: plot_histogram: removed 6 outliers out of  
974 on 'Duration (s)' (lower=-20, upper=172)
```

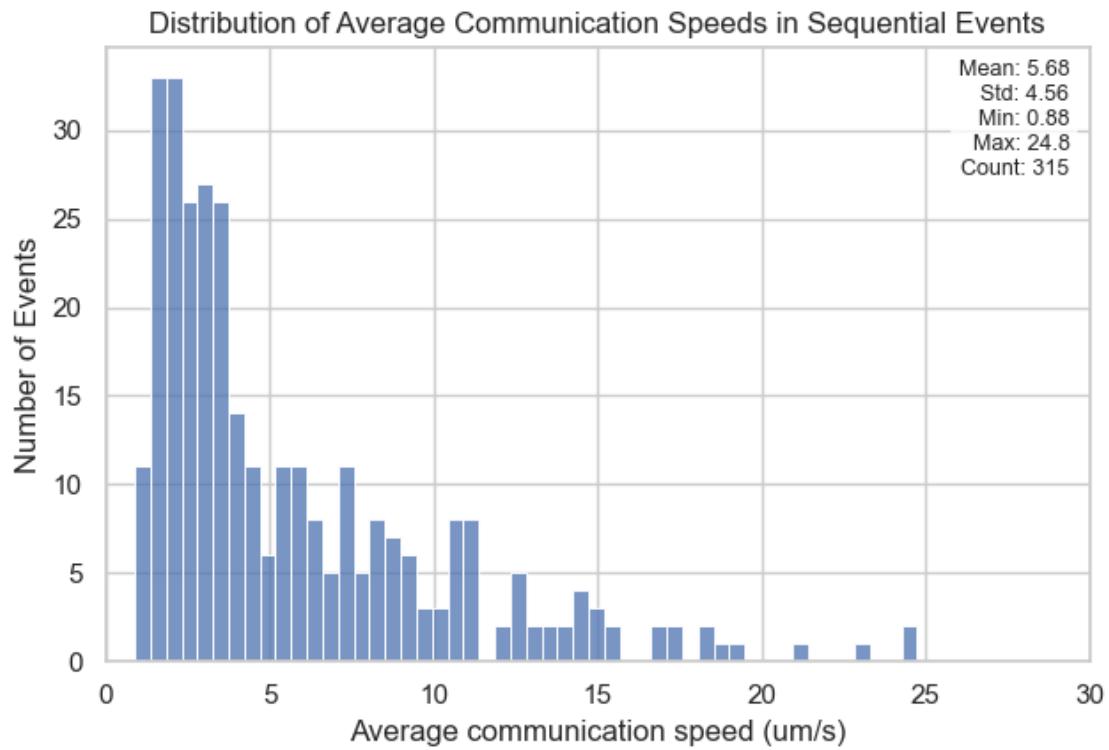


```
[2025-08-13 11:35:55] [INFO] calcium: plot_histogram: removed 39 outliers out of 974 on 'Prominence (noise std units)' (lower=-6.6625, upper=96.387)
```

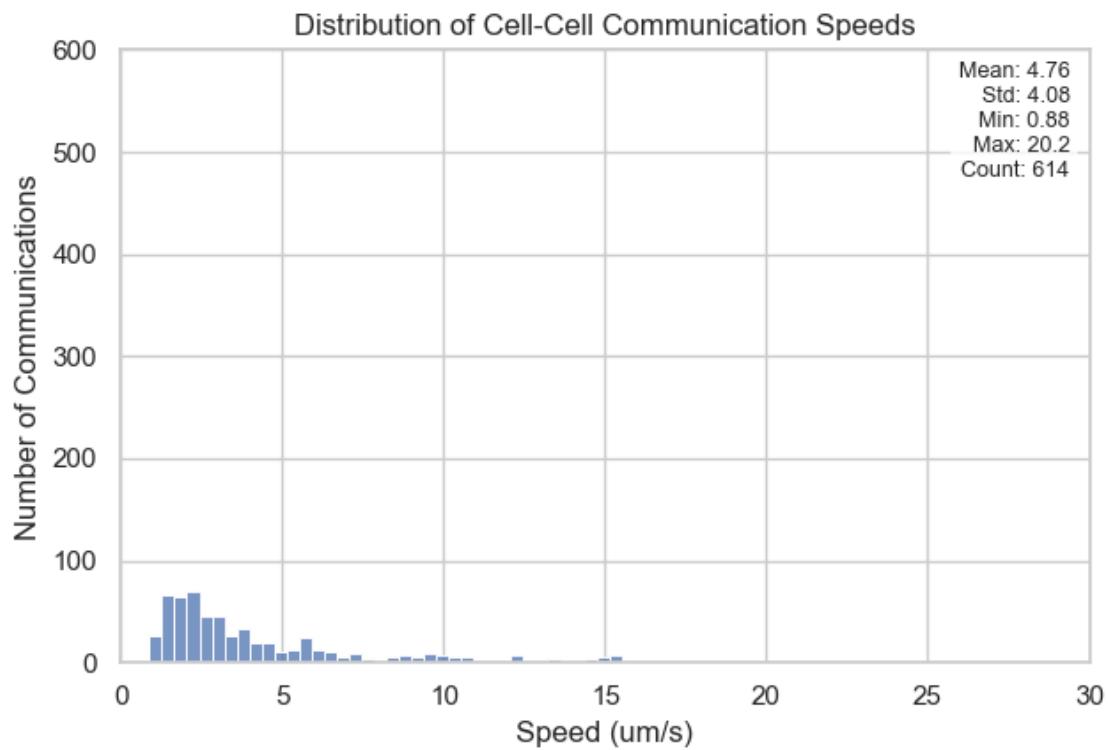


1.3.3 Cell-cell communication speed

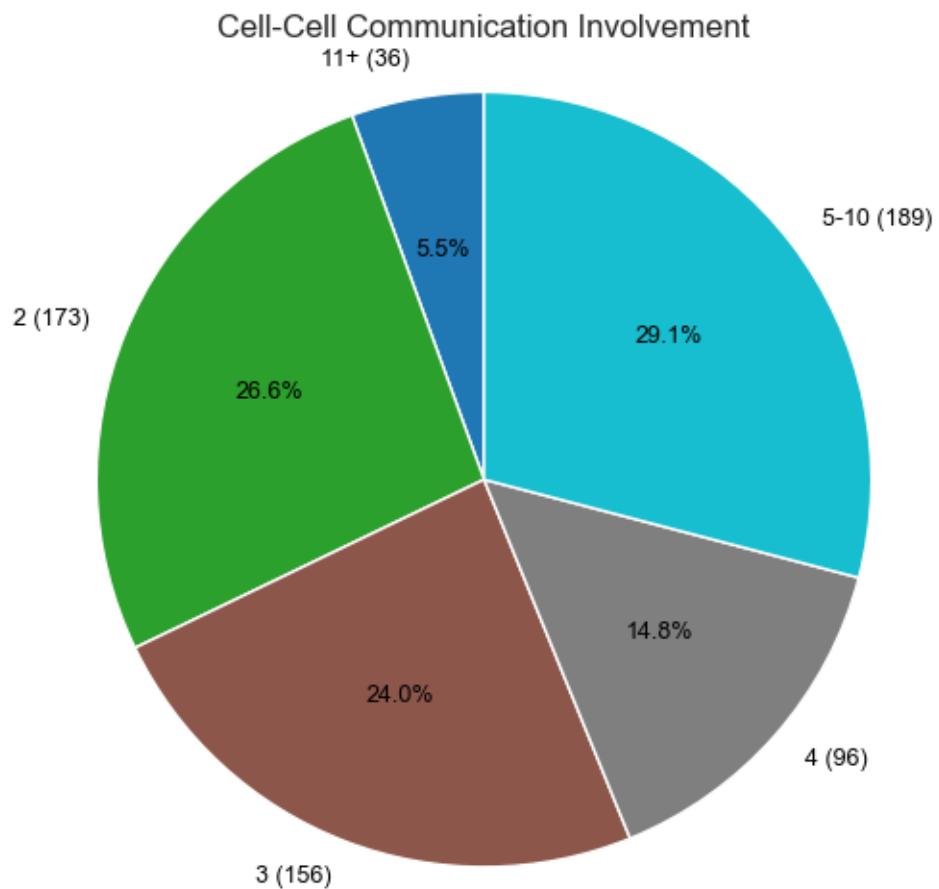
[2025-08-13 11:35:56] [INFO] calcium: plot_histogram: removed 9 outliers out of 324 on 'Average communication speed (um/s)' (lower=-15.145, upper=25.77)



[2025-08-13 11:35:56] [INFO] calcium: plot_histogram: removed 36 outliers out of 650 on 'Speed (um/s)' (lower=-11.897, upper=20.67)

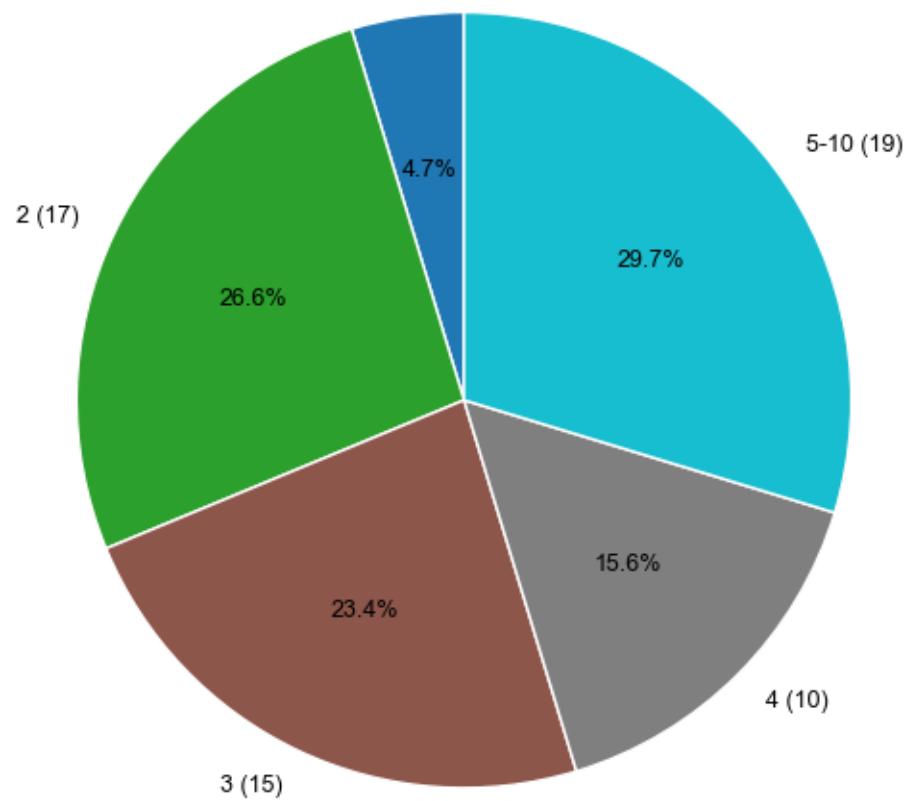


1.3.4 Double distribution in cell-cell communication speeds

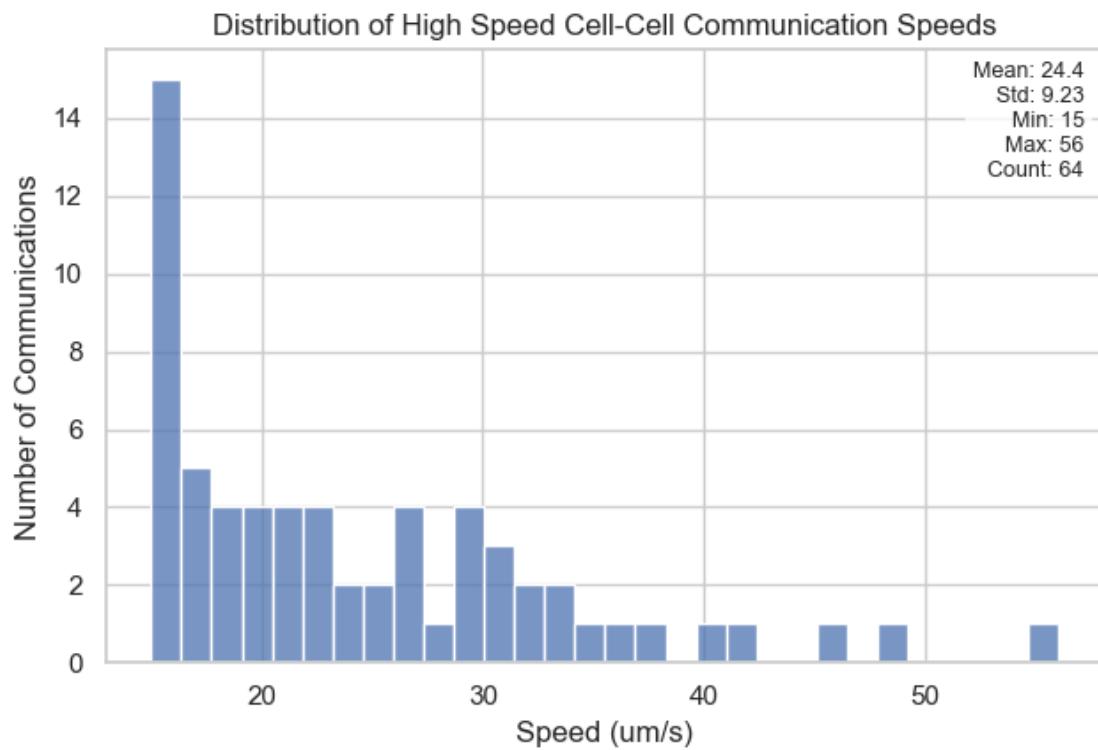


High Speed Cell-Cell Communication Involvement

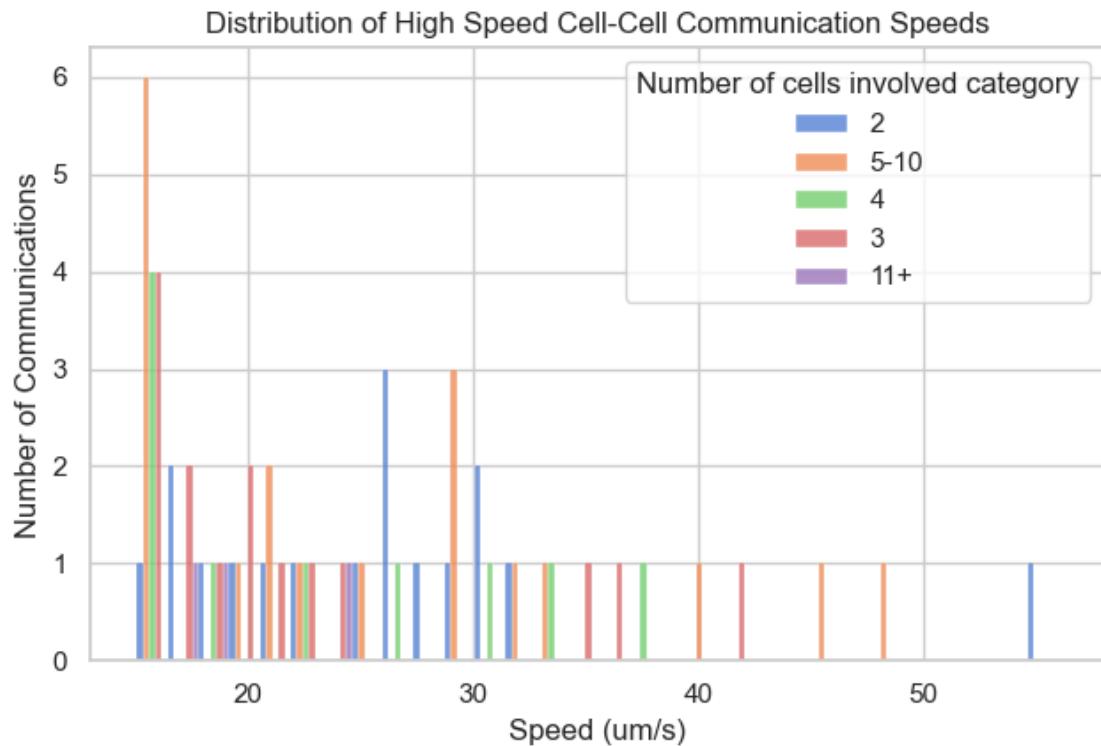
11+ (3)



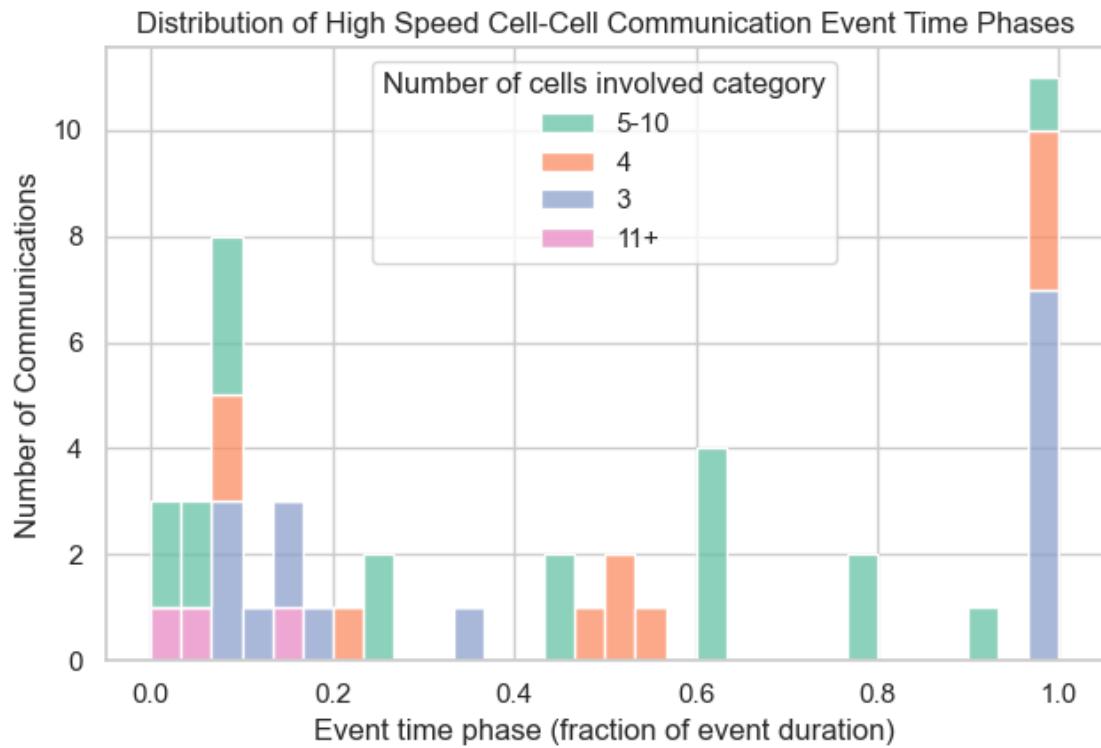
```
[2025-08-13 11:35:57] [INFO] calcium: plot_histogram: removed 0 outliers out of  
64 on 'Speed (um/s)' (lower=-21.6, upper=68.07)
```



```
[2025-08-13 11:35:57] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 64 on 'Speed (um/s)' (lower=-21.6, upper=68.07)
```

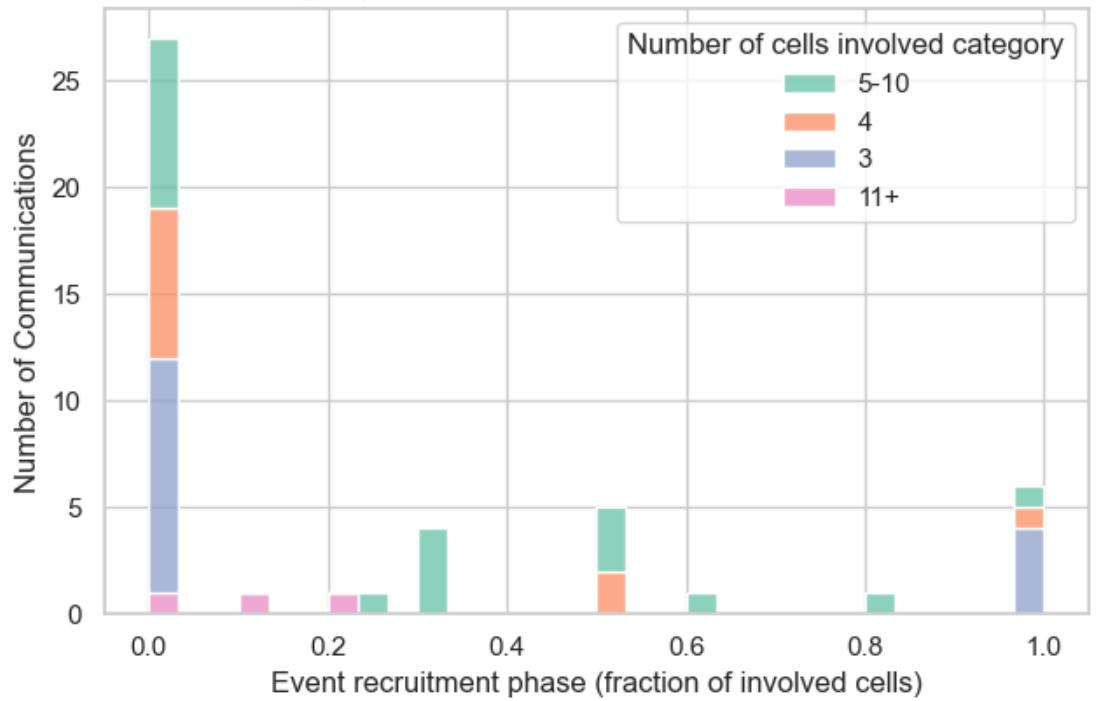


```
[2025-08-13 11:35:57] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 47 on 'Event time phase (fraction of event duration)' (lower=-2.205, upper=3.15)
```

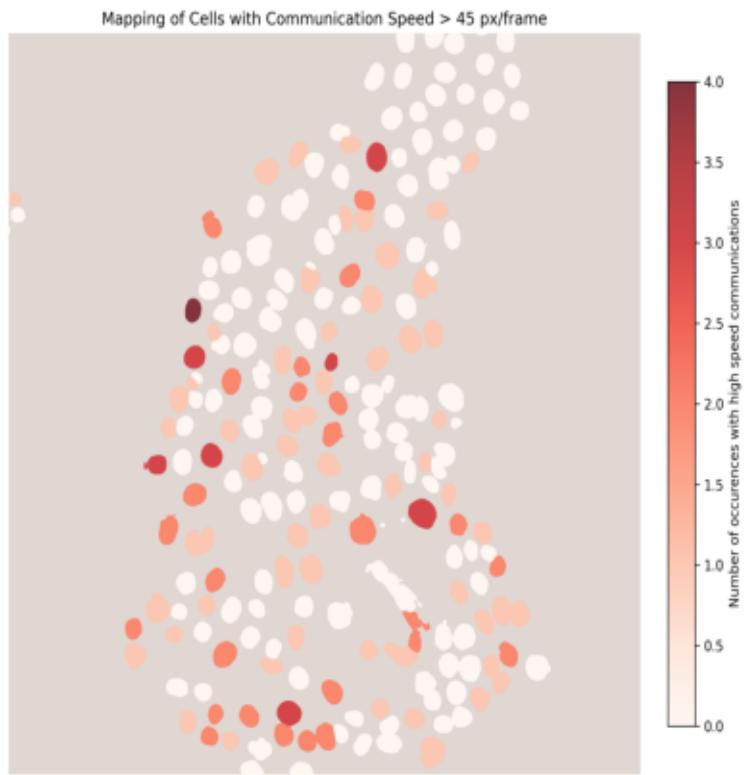


```
[2025-08-13 11:35:57] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 47 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.5, upper=2)
```

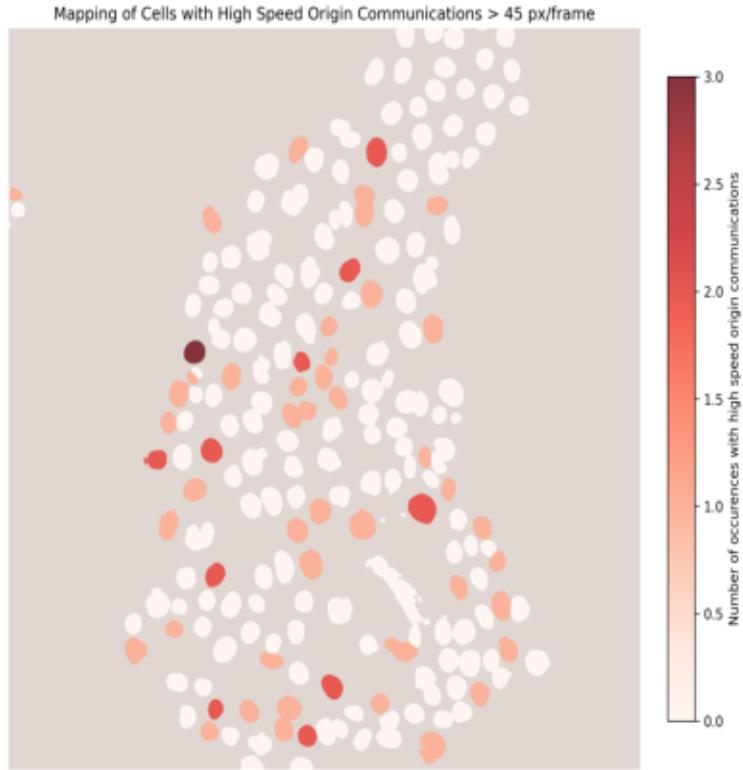
Distribution of High Speed Cell-Cell Communication Event Recruitment Phases



Cell Mapping with High Speed Cells Overlay - 20250409_IS05



Cell Mapping with High Speed Origin Cells Overlay - 20250409_IS05



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
0	1759432782800	2	33	5	
9	1759432773152	4	184	5	
10	1759432773392	4	202	3	
19	1759537996096	5	198	6	
22	1759512477024	6	230	1	
..	
617	1759537995376	302	228	8	
620	1759537987792	303	203	2	
636	1759537993696	313	236	7	
637	1759538003632	314	199	0	
640	1759537995424	317	219	2	

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
0	31	2	890.0	890.0	
9	202	3	639.0	639.0	
10	204	3	639.0	639.0	
19	195	6	1121.0	1122.0	
22	232	4	646.0	646.0	
..	
617	219	3	1104.0	1105.0	
620	220	2	625.0	627.0	
636	223	8	1173.0	1174.0	
637	224	0	127.0	129.0	
640	228	6	960.0	961.0	
	Duration (s)	Distance (um)	Speed (um/s)	\	
0	0.0	22.88	22.88		
9	0.0	30.03	30.03		
10	0.0	15.12	15.12		
19	1.0	22.08	22.08		
22	0.0	16.83	16.83		
..		
617	1.0	15.22	15.22		
620	2.0	38.37	19.19		
636	1.0	26.60	26.60		
637	2.0	60.95	30.48		
640	1.0	15.22	15.22		
	Event time phase (fraction of event duration)	\			
0			NaN		
9			0.79		
10			0.79		
19			0.45		
22			NaN		
..			...		
617			0.07		
620			NaN		
636			NaN		
637			NaN		
640			NaN		
	Event recruitment phase (fraction of involved cells)	dataset	\		
0		NaN	20250409_IS05		
9		0.0	20250409_IS05		
10		0.0	20250409_IS05		
19		0.5	20250409_IS05		
22		NaN	20250409_IS05		
..			
617		0.0	20250409_IS05		
620		NaN	20250409_IS05		

636		NaN	20250409_IS05
637		NaN	20250409_IS05
640		NaN	20250409_IS05

	Number of cells involved	category	Speed category
0		2	High speed
9		5-10	High speed
10		5-10	High speed
19		5-10	High speed
22		2	High speed
..	
617		4	High speed
620		2	High speed
636		2	High speed
637		2	High speed
640		2	High speed

[64 rows x 16 columns]

Origin cell ID	Speed category	High speed	Low speed
16		0	1
17		0	2
18		0	2
19		0	2
21		0	1
..	
230		1	3
232		0	4
233		1	4
236		1	4
237		0	2

[180 rows x 2 columns]

Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
0	16	376.03	20.48
1	17	344.50	26.00
2	18	311.03	28.28
3	19	397.48	28.28
5	21	360.75	40.62
..
195	230	158.28	473.20
196	232	174.85	476.12
197	233	235.62	476.45
200	236	334.43	483.60
201	237	192.40	480.35

Number of peaks Is active Occurences in global events \

0	7	True	2
1	7	True	2
2	6	True	2
3	4	True	1
5	7	True	2
..
195	7	True	0
196	10	True	1
197	12	True	2
200	10	True	0
201	4	True	0

Occurrences in global events as early peaker \

0	0
1	0
2	0
3	0
5	0
..	...
195	0
196	0
197	0
200	0
201	0

Occurrences in sequential events \

0	1
1	2
2	2
3	2
5	5
..	...
195	6
196	7
197	5
200	7
201	3

Occurrences in sequential events as origin \

0	1
1	1
2	2
3	2
5	1
..	...
195	4
196	2
197	2

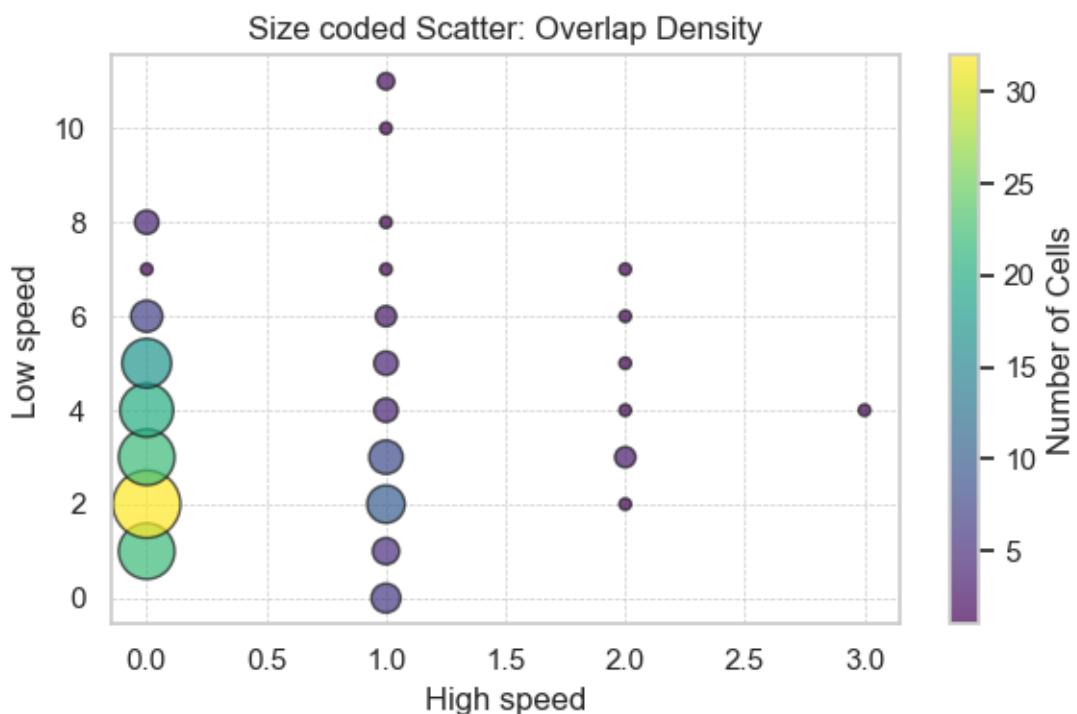
200		3	
201		2	
Occurrences in individual events Peak frequency (Hz) Periodicity score \			
0	4	0.0041	0.71
1	3	0.0041	0.70
2	2	0.0035	0.57
3	1	0.0024	0.61
5	0	0.0041	0.70
..
195	1	0.0041	0.77
196	2	0.0059	0.72
197	5	0.0071	0.72
200	3	0.0059	0.75
201	1	0.0024	0.64
Neighbor count Neighbors (labels) dataset \			
0	4	[17,19,21,23]	20250409_IS05
1	4	[16,18,21,22]	20250409_IS05
2	5	[17,20,22,25,26]	20250409_IS05
3	3	[16,23,24]	20250409_IS05
5	6	[16,17,22,23,27,29]	20250409_IS05
..
195	3	[218,224,232]	20250409_IS05
196	4	[218,220,230,237]	20250409_IS05
197	3	[219,228,229]	20250409_IS05
200	4	[221,223,225,234]	20250409_IS05
201	3	[220,232,238]	20250409_IS05
Involved in sequential event Occurrences in sequential events category \			
0	Involved in sequential event		1-2
1	Involved in sequential event		1-2
2	Involved in sequential event		1-2
3	Involved in sequential event		1-2
5	Involved in sequential event		5-9
..
195	Involved in sequential event		5-9
196	Involved in sequential event		5-9
197	Involved in sequential event		5-9
200	Involved in sequential event		5-9
201	Involved in sequential event		3-4
High speed Low speed			
0	0.0	1.0	
1	0.0	2.0	
2	0.0	2.0	
3	0.0	2.0	
5	0.0	1.0	

```

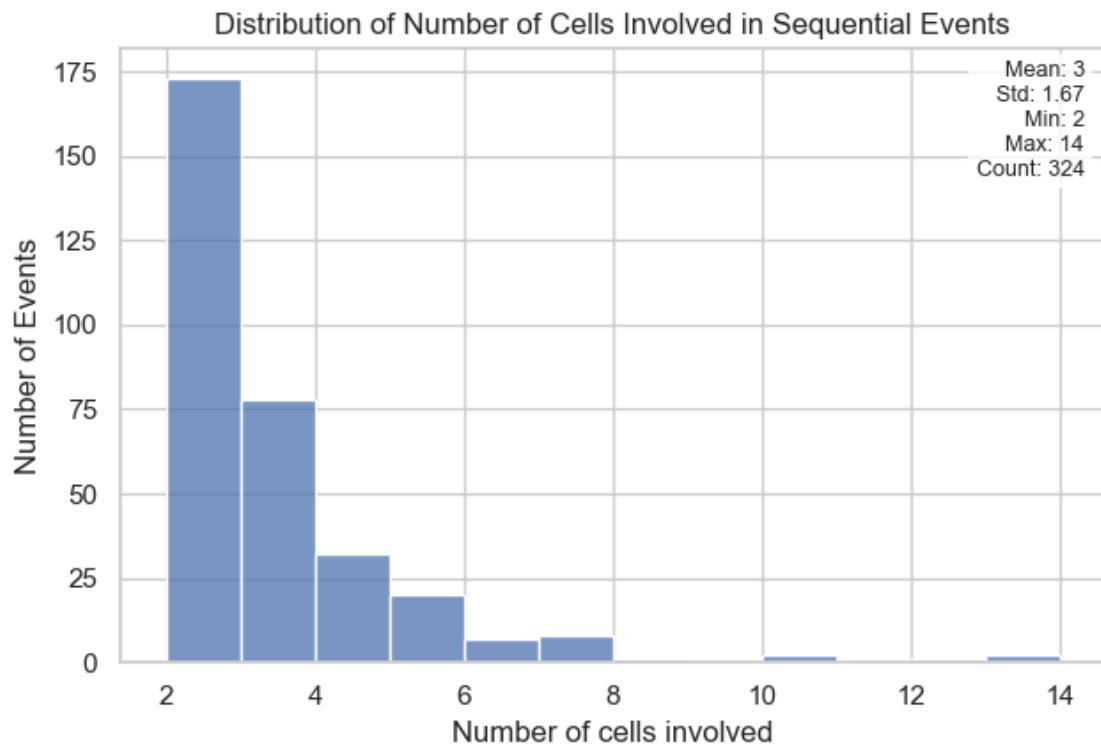
...
195      1.0      3.0
196      0.0      4.0
197      1.0      4.0
200      1.0      4.0
201      0.0      2.0

```

[179 rows x 19 columns]



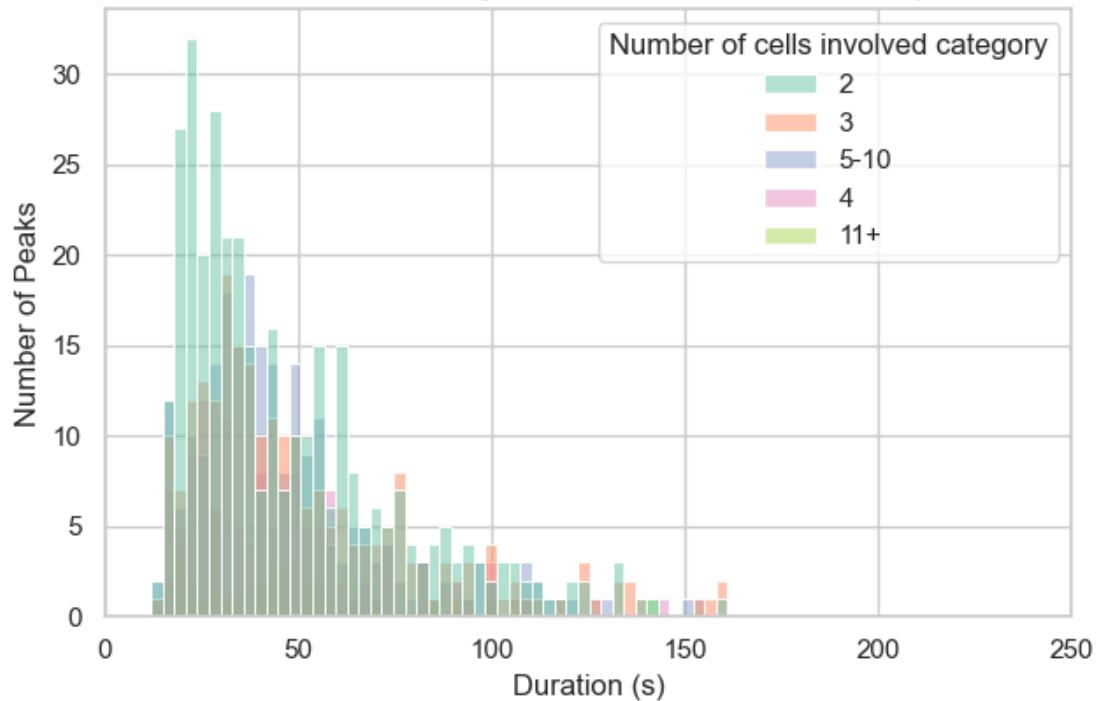
1.3.5 Number of cells involved per sequential events



1.3.6 Influence of cell count per event on statistics

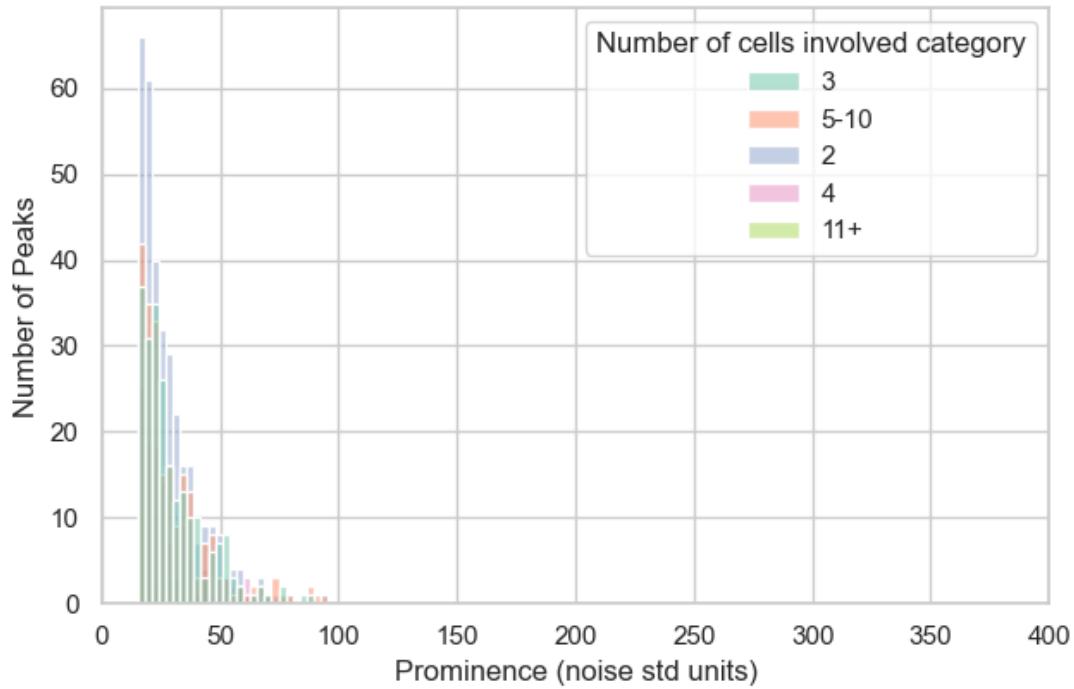
```
[2025-08-13 11:36:01] [INFO] calcium: plot_histogram_by_group: removed 6 outliers out of 974 on 'Duration (s)' (lower=-20, upper=172)
```

Distribution of Peak Durations by Number of Cells Involved in Sequential Events

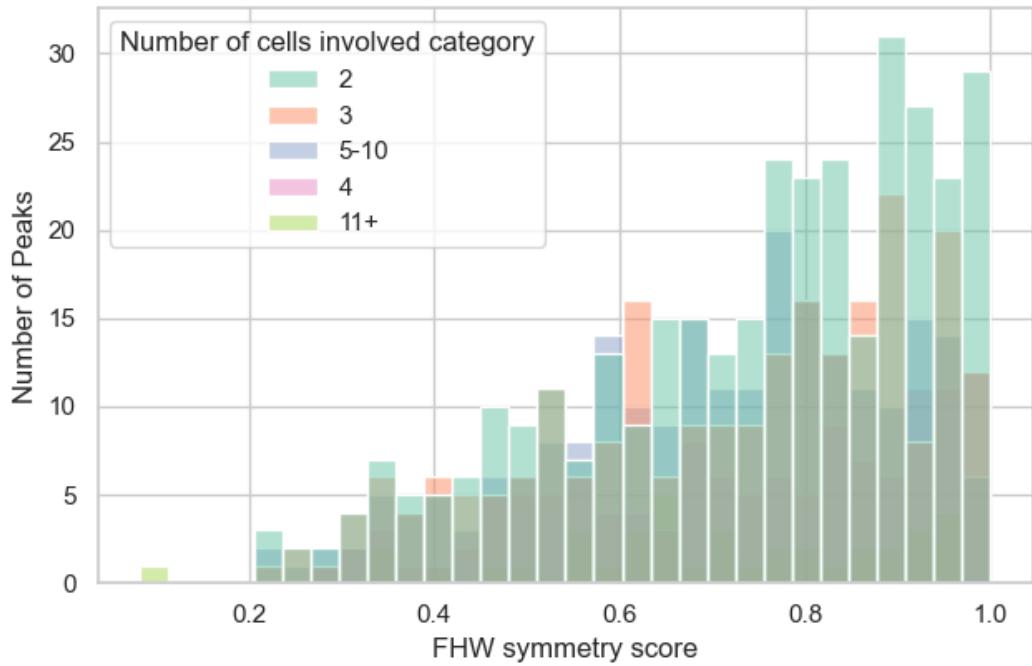


```
[2025-08-13 11:36:01] [INFO] calcium: plot_histogram_by_group: removed 39 outliers out of 974 on 'Prominence (noise std units)' (lower=-6.6625, upper=96.387)
```

Distribution of Peak Prominences by Number of Cells Involved in Sequential Events

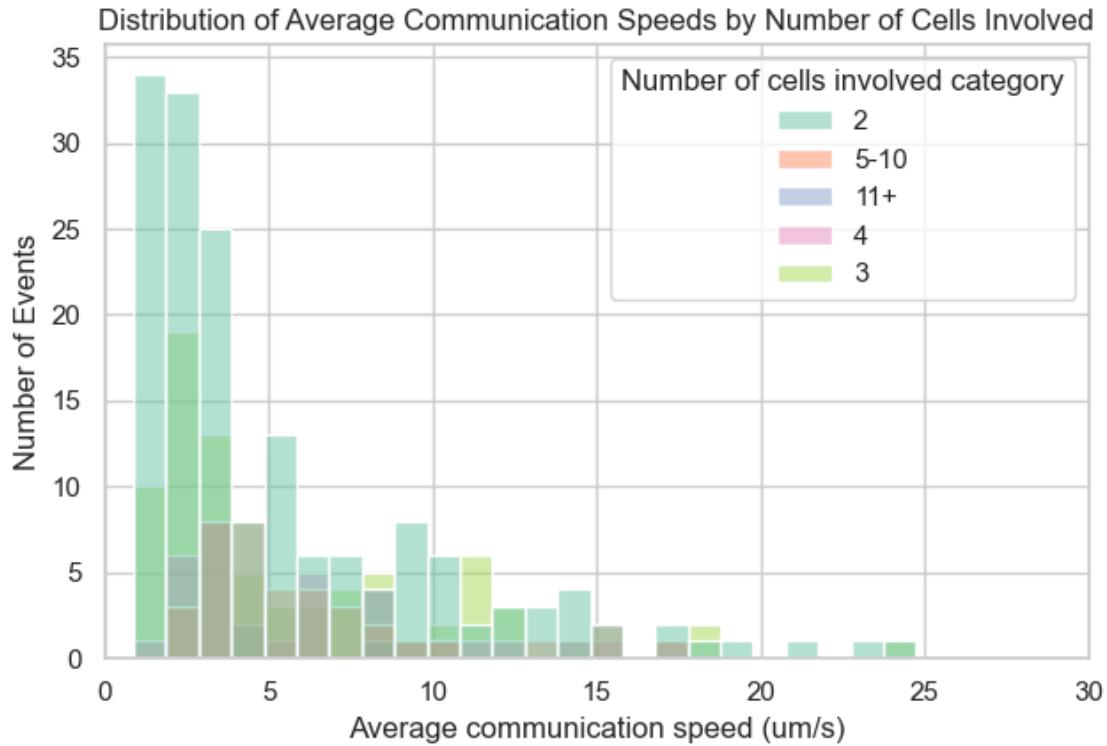


Distribution of Peak Symmetry Scores by Number of Cells Involved in Sequential Events



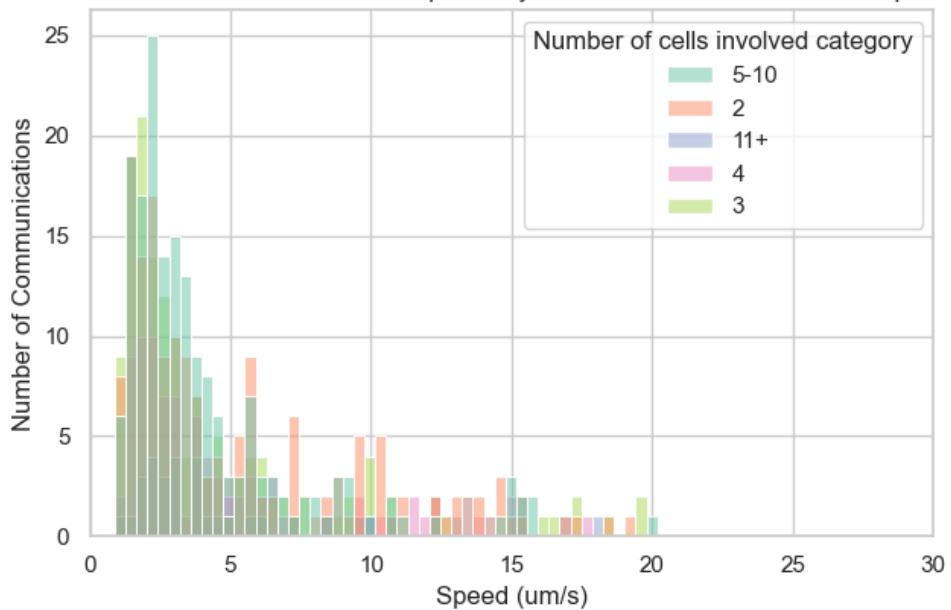
[2025-08-13 11:36:02] [INFO] calcium: plot_histogram_by_group: removed 9

outliers out of 324 on 'Average communication speed (um/s)' (lower=-15.145, upper=25.77)



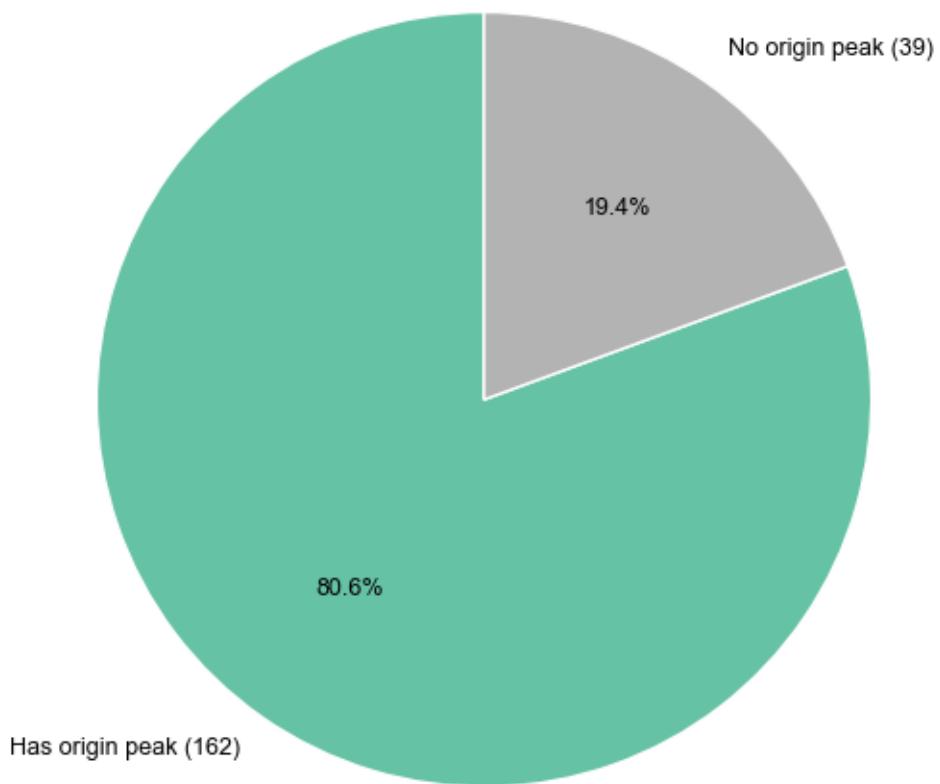
[2025-08-13 11:36:02] [INFO] calcium: plot_histogram_by_group: removed 36 outliers out of 650 on 'Speed (um/s)' (lower=-11.897, upper=20.67)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events

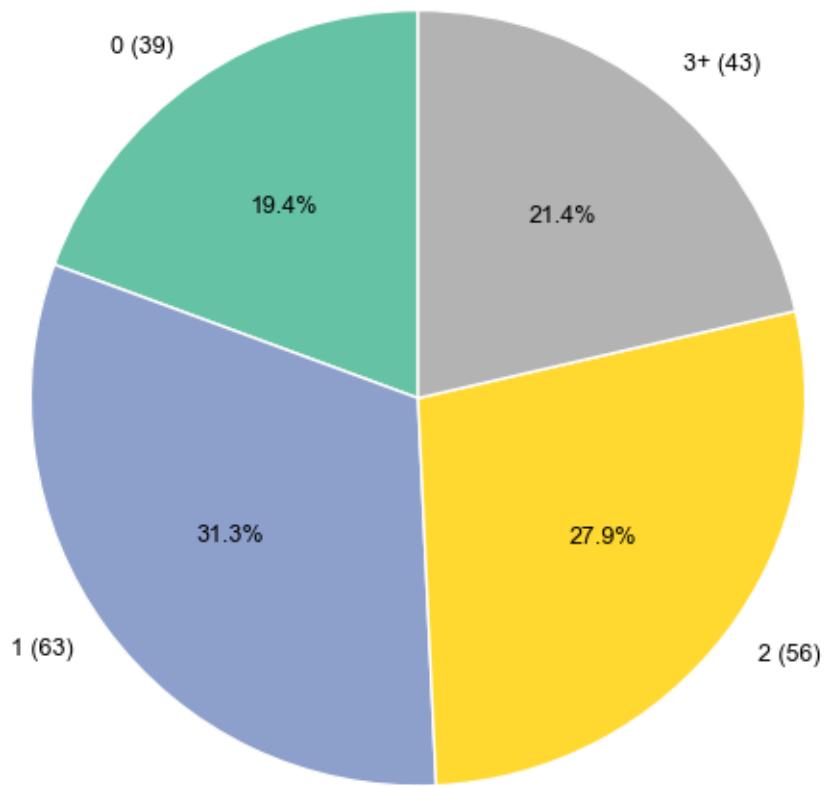


1.3.7 Cells occurrences as origin in sequential events

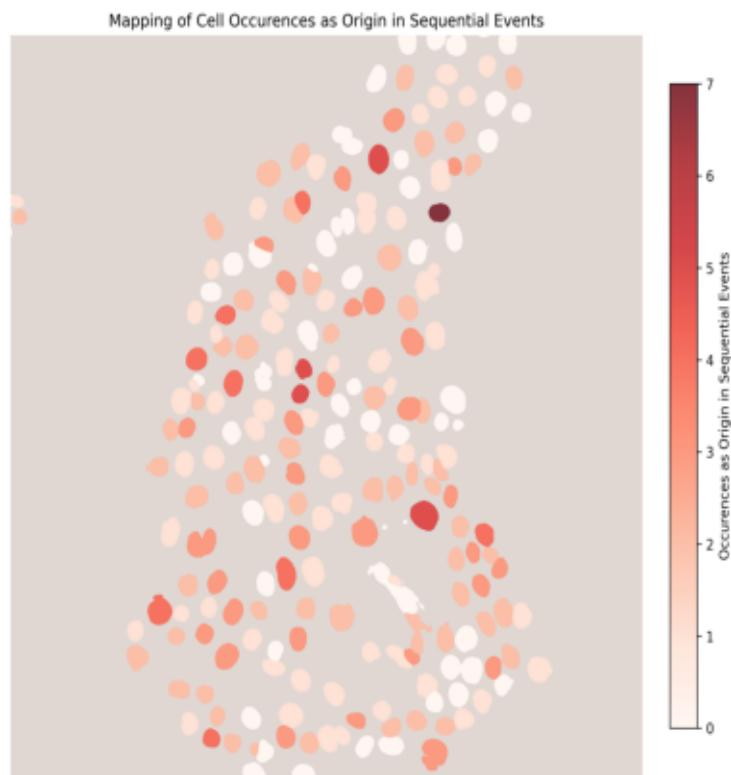
Distribution of Number of Sequential Event Origin Peaks per Cell



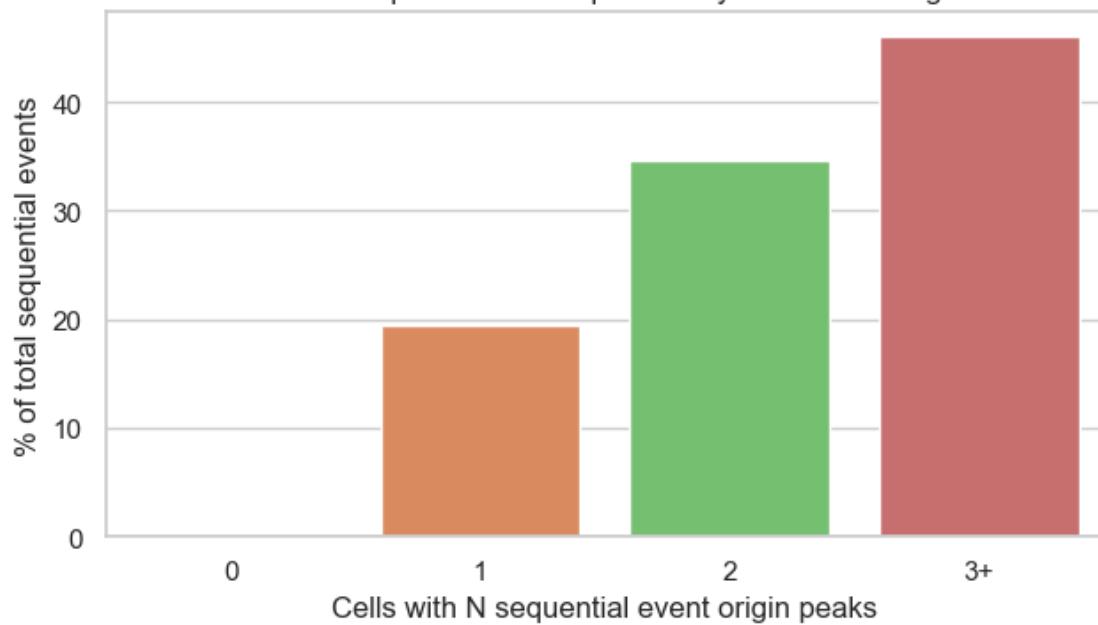
Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)



Cell Mapping with Origin Peaks Overlay - 20250409_IS05

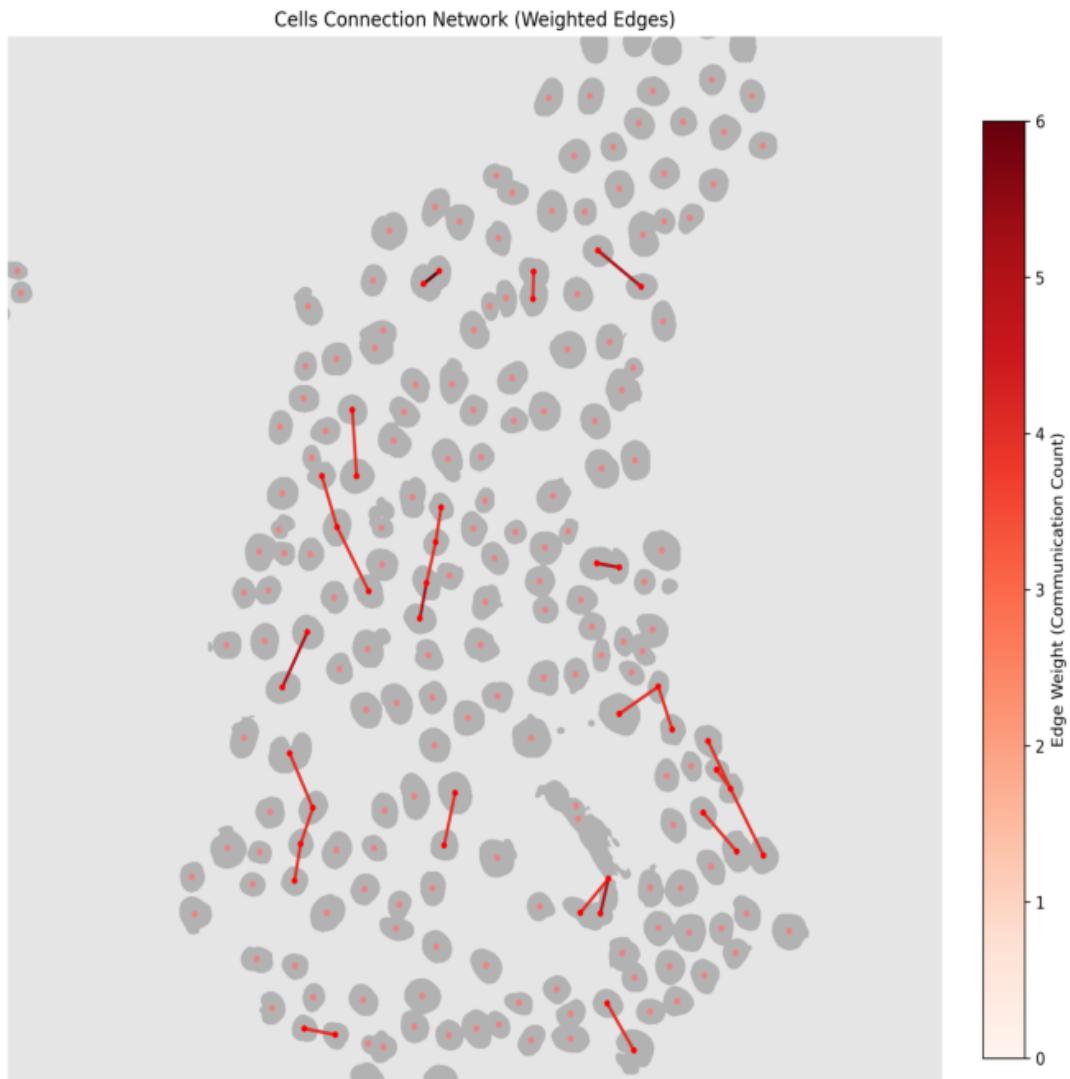


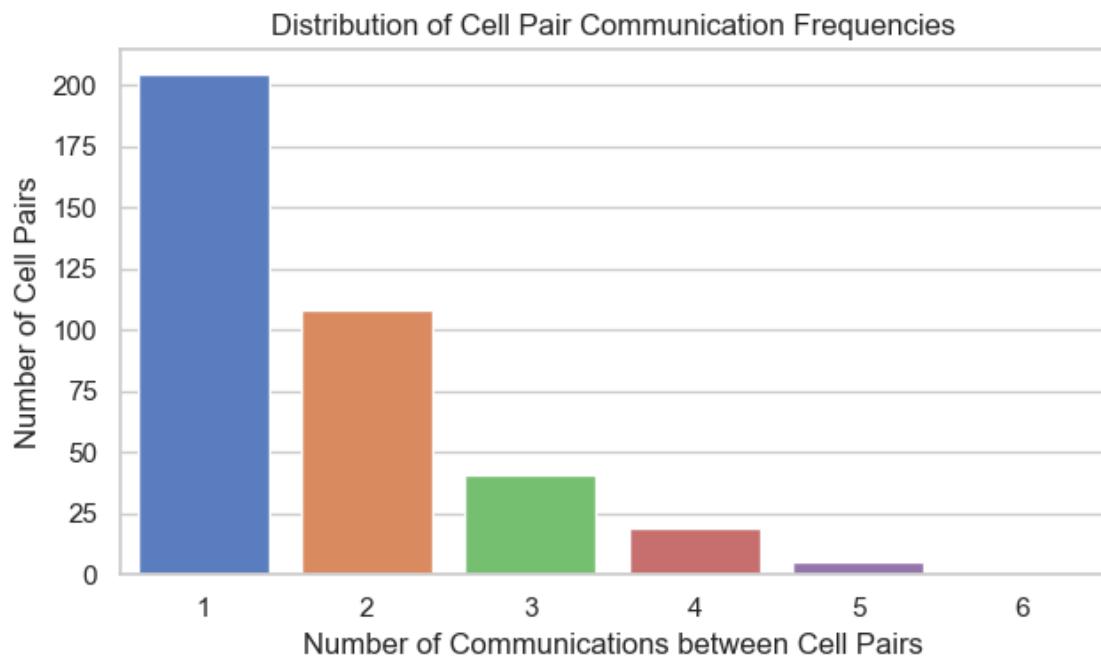
Distribution of Sequential Events per Cell by Number of Origin Peaks



1.3.8 Connection network between cells

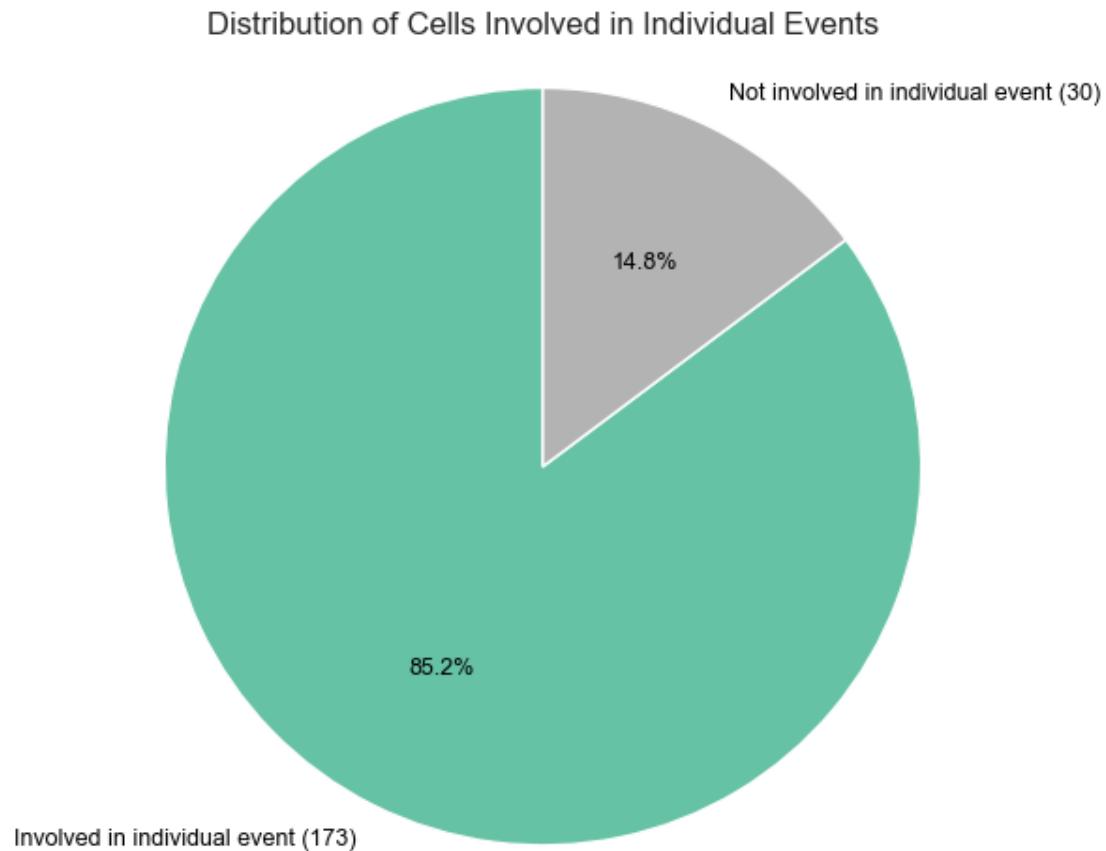
Cell Connection Network Graph - 20250409_IS05



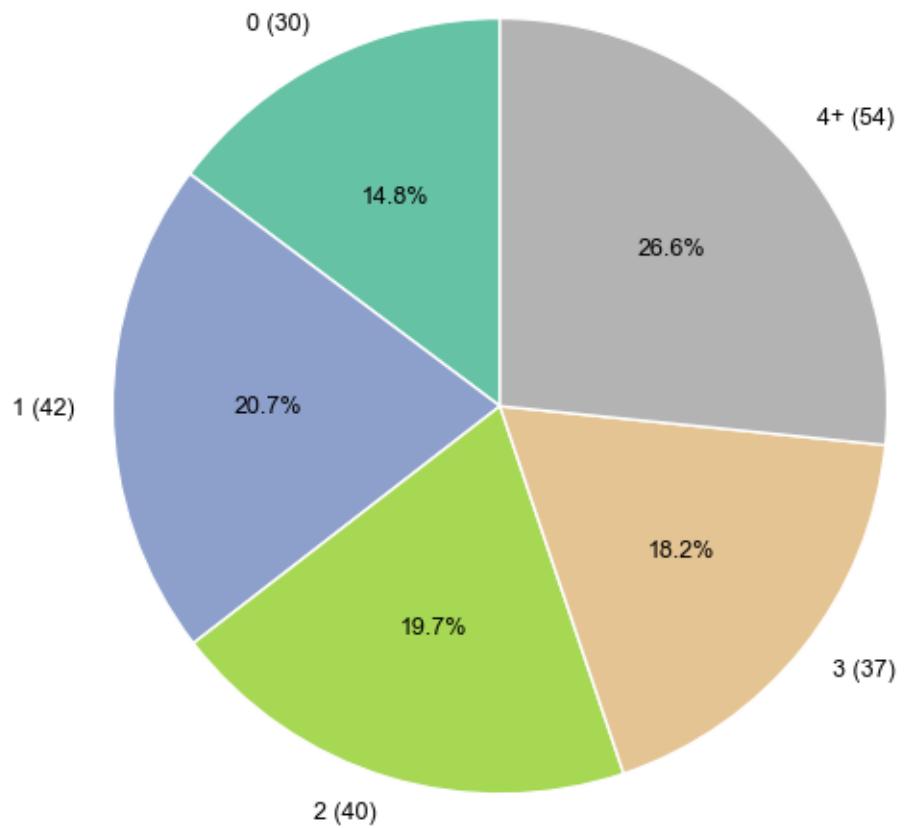


1.4 INDIVIDUAL EVENTS

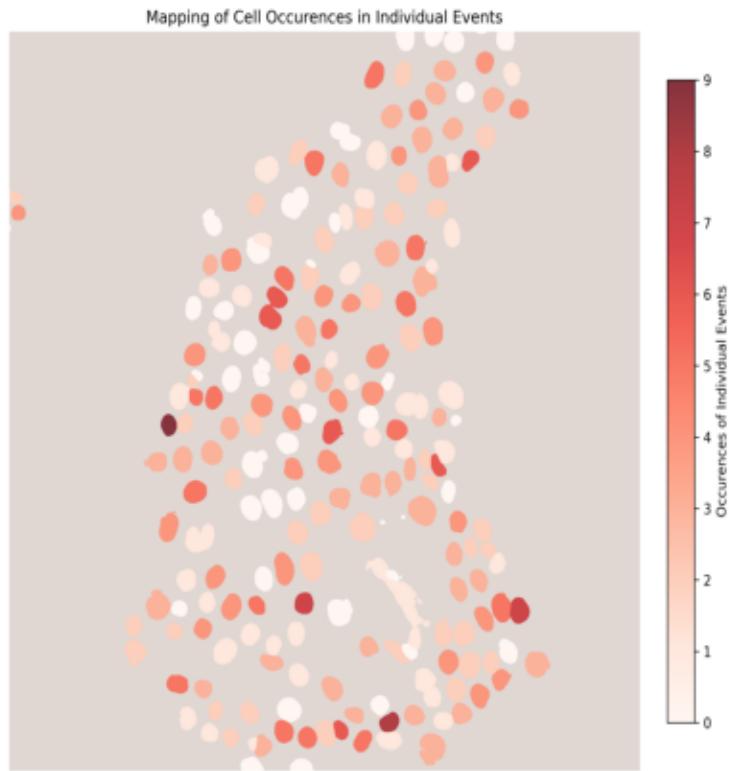
1.4.1 Cells occurrences in individual events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

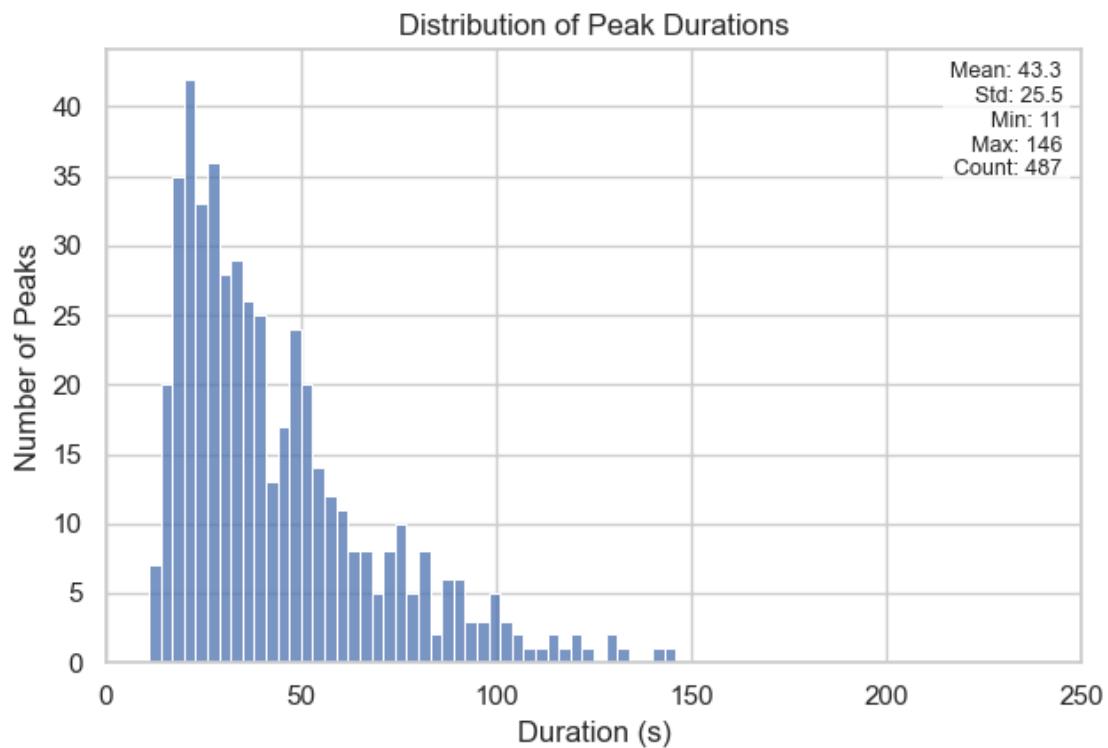


Cell Mapping with Occurrences in Individual Events Overlay - 20250409_IS05

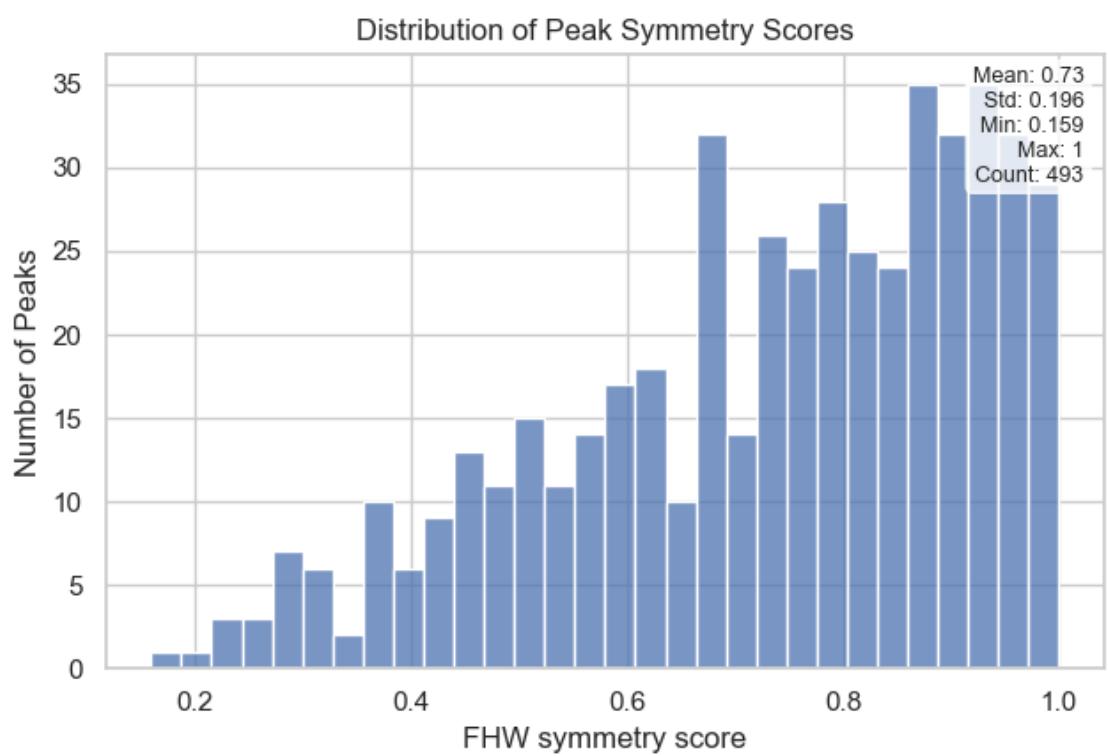
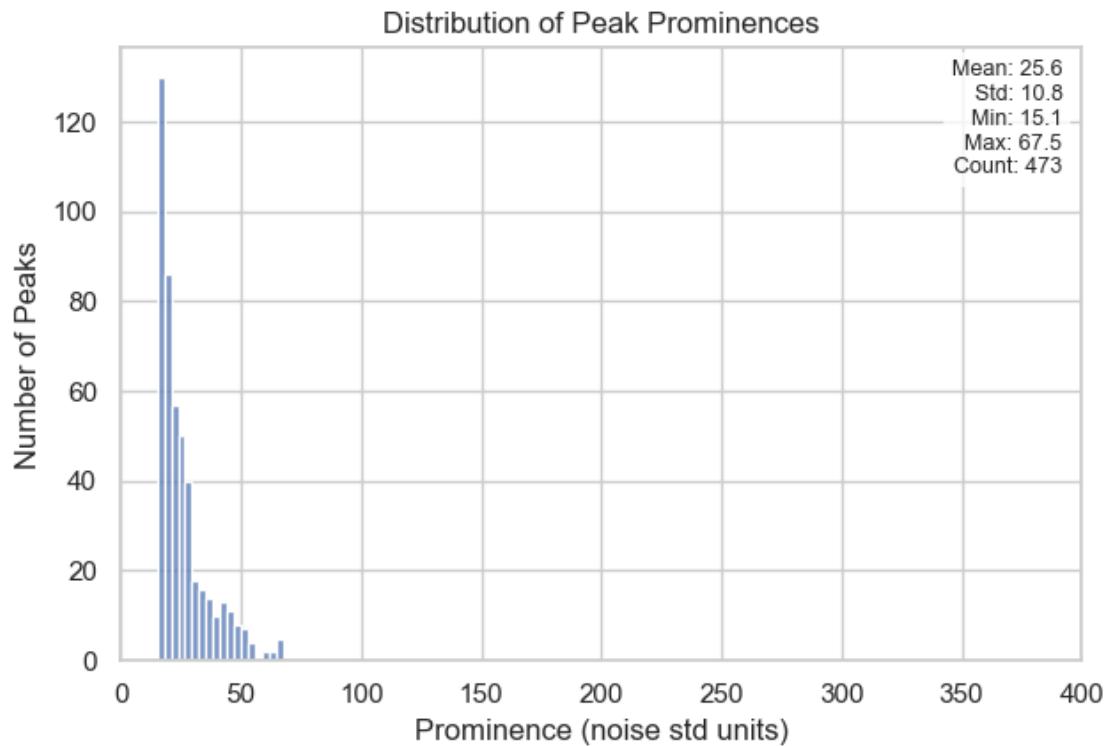


1.4.2 Peaks statistics in individual events

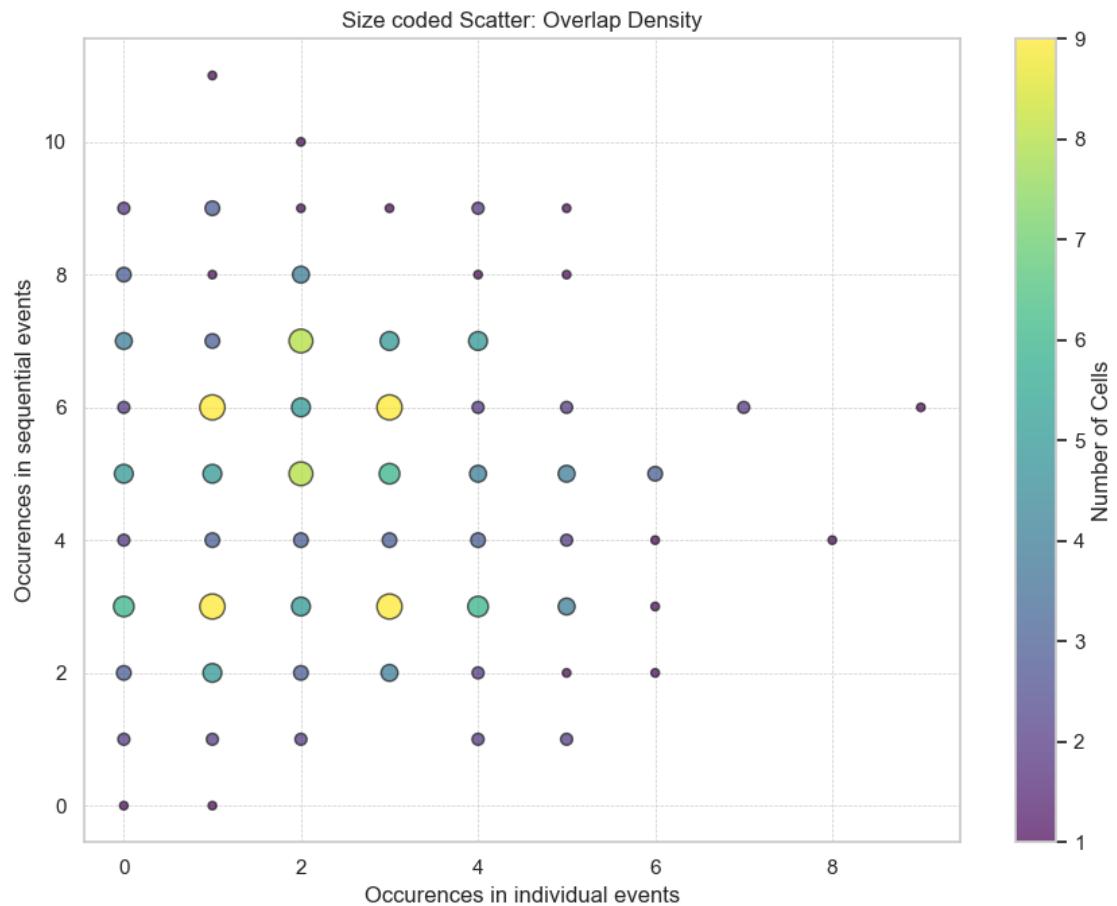
```
[2025-08-13 11:36:08] [INFO] calcium: plot_histogram: removed 6 outliers out of  
493 on 'Duration (s)' (lower=-72, upper=152)
```



```
[2025-08-13 11:36:08] [INFO] calcium: plot_histogram: removed 20 outliers out of 493 on 'Prominence (noise std units)' (lower=-20.8, upper=69.5)
```



1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250409_IS05

Cell Motion Overlay



Number of cells:

- Hoechst image taken at t=0: 203
- Hoechst image taken at t=1801: 204
- Number of cells difference: absolute 1, relative 0.49%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 359358
- Pixels segmented as cell at t=1801: 377004
- Overlapping pixels between t=0 and t=1801: 345439 (93.82% of total)
- Pixels exclusive to t=0: 13919 (3.87% of total)
- Pixels exclusive to t=1801: 31565 (8.37% of total)

executed

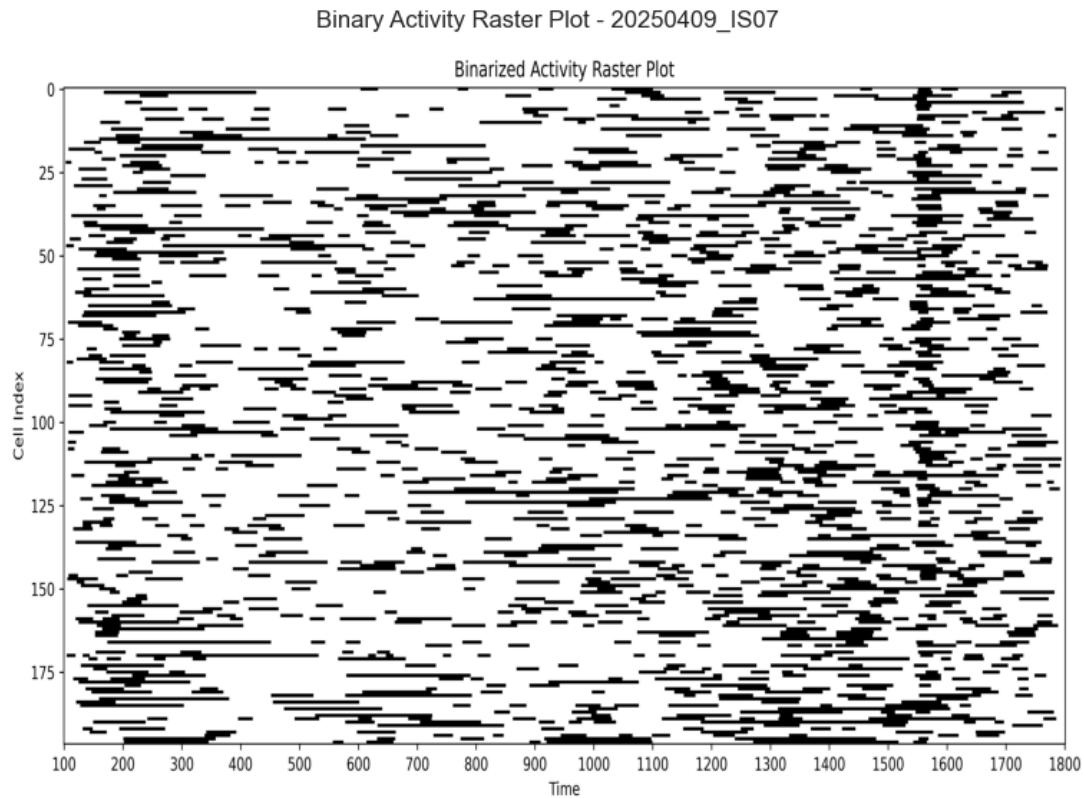
August 13, 2025

1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

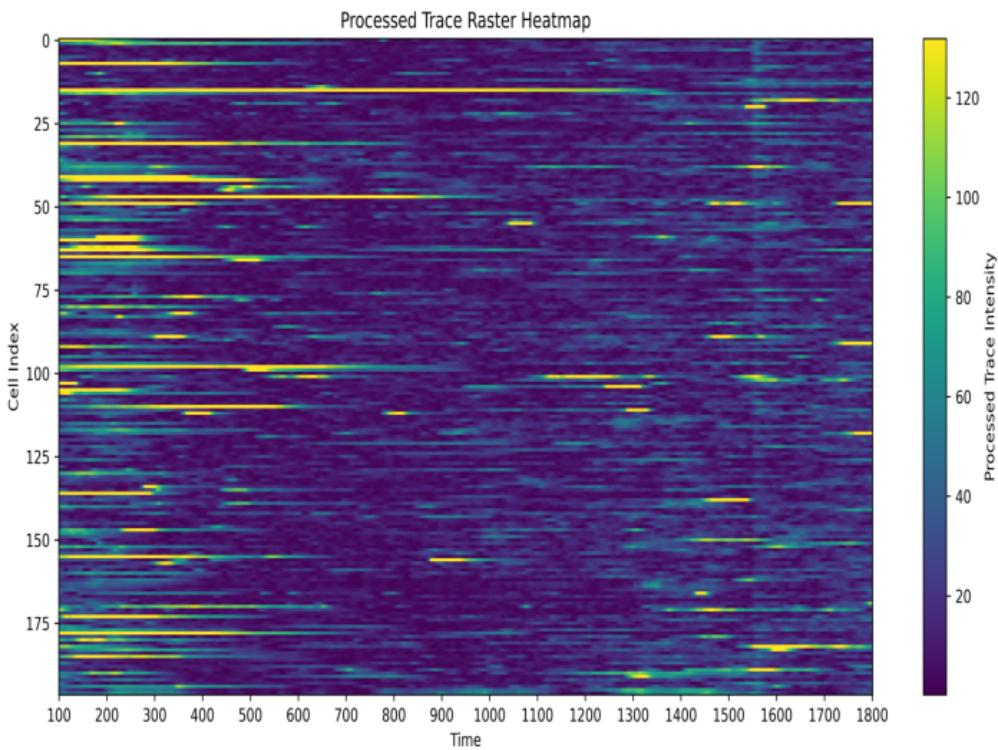
1.0.1 Initialization

1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot



Heatmap Activity Raster Plot - 20250409_IS07



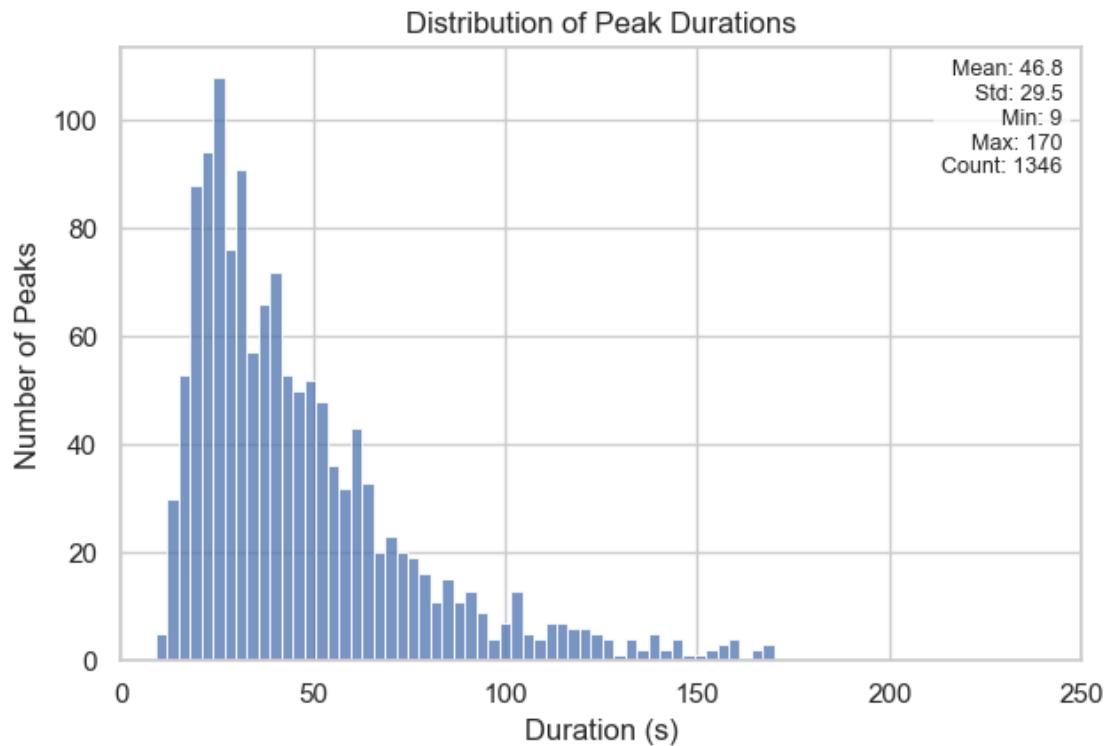
1.1.2 Peaks population

Total number of peaks: 1391

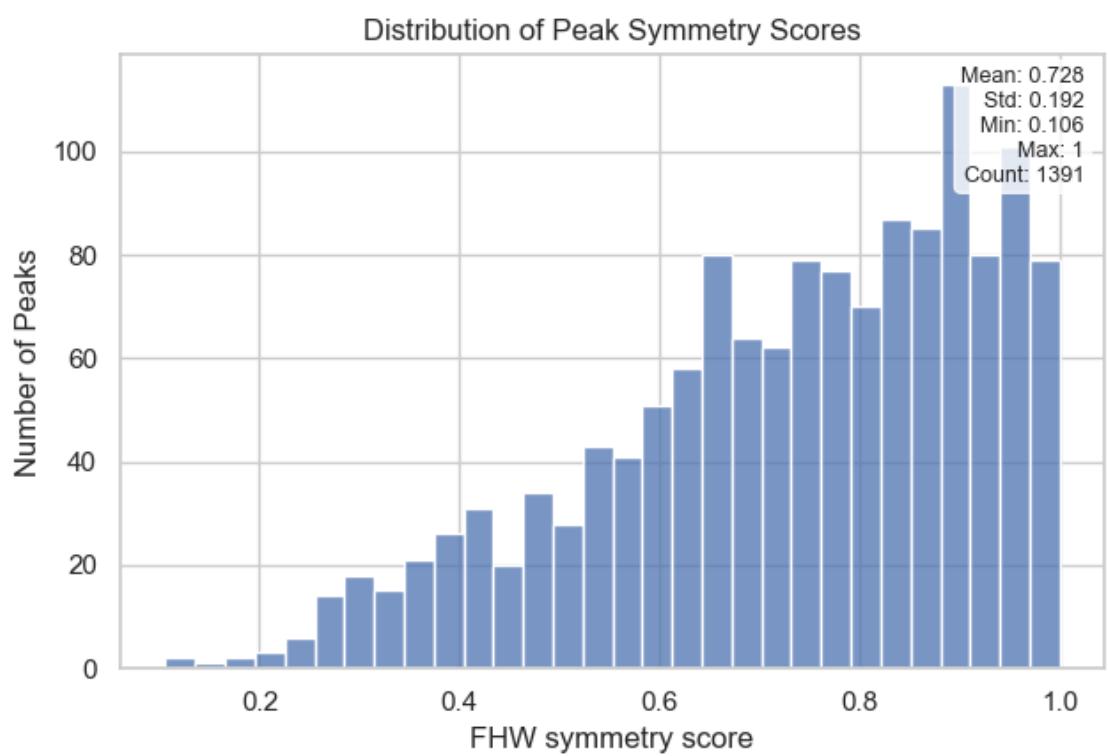
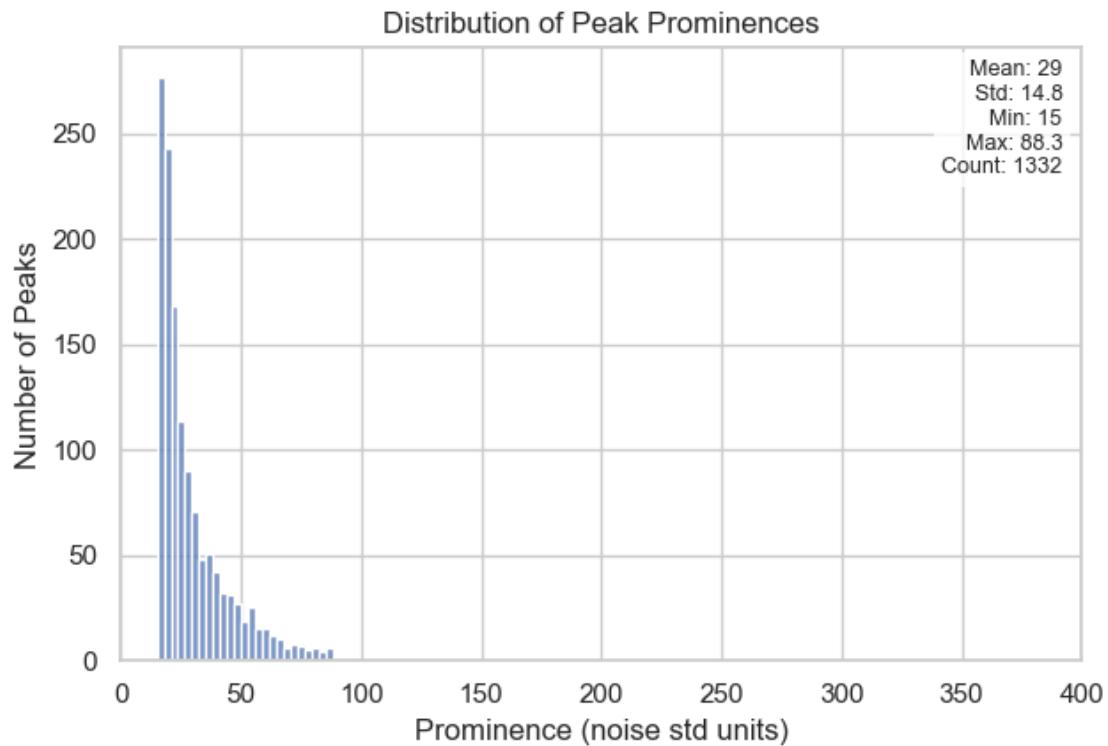
Total number of cells: 197

1.1.3 Peaks statistics

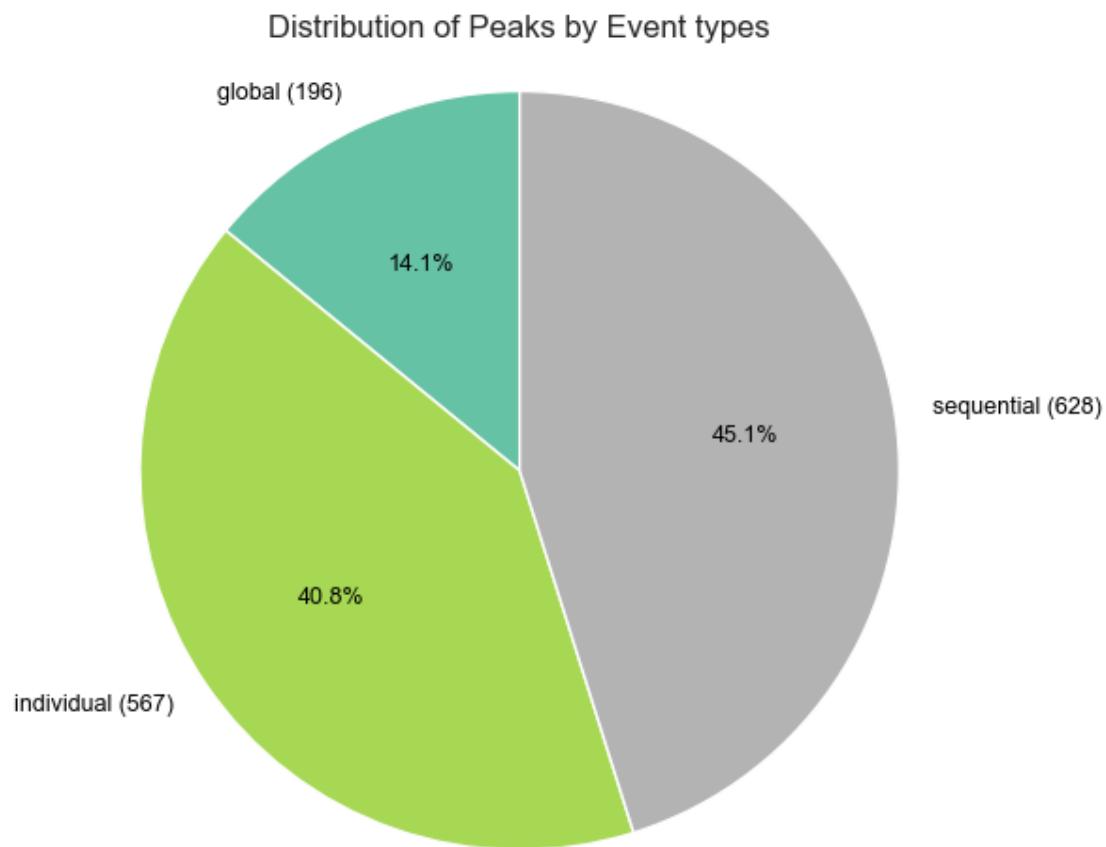
```
[2025-08-13 11:37:33] [INFO] calcium: plot_histogram: removed 45 outliers out of  
1391 on 'Duration (s)' (lower=-82, upper=170)
```



```
[2025-08-13 11:37:33] [INFO] calcium: plot_histogram: removed 59 outliers out of  
1391 on 'Prominence (noise std units)' (lower=-36.05, upper=91.7)
```



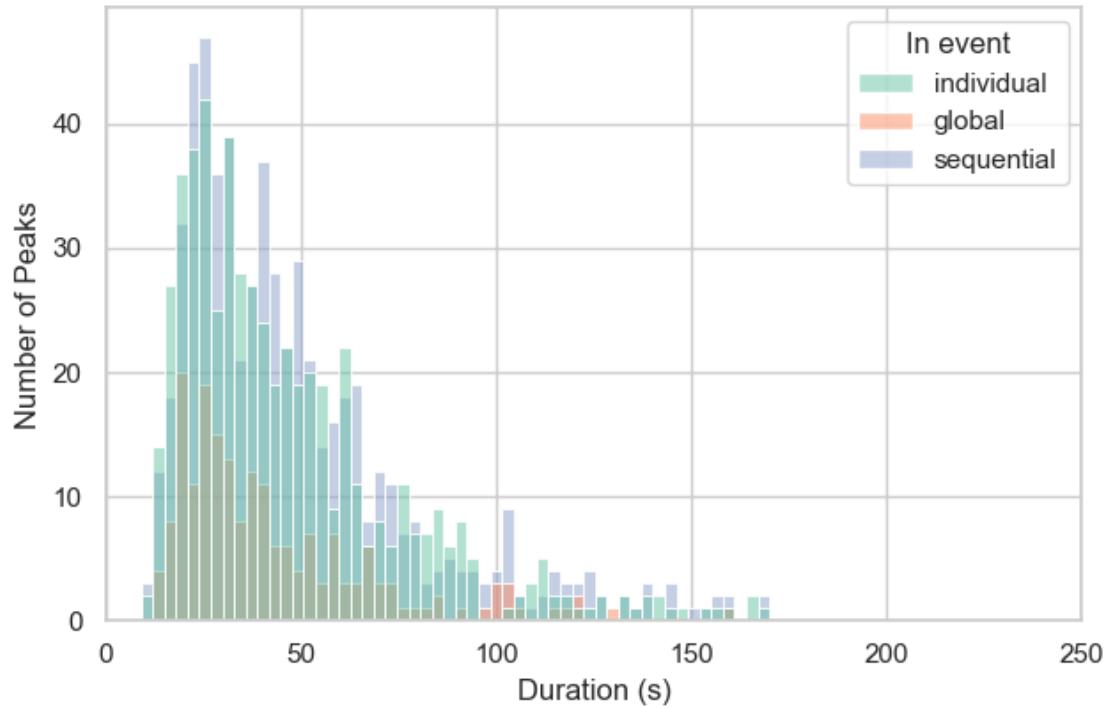
1.1.4 Distribution of peaks per event types



1.1.5 Peaks statistics per event types

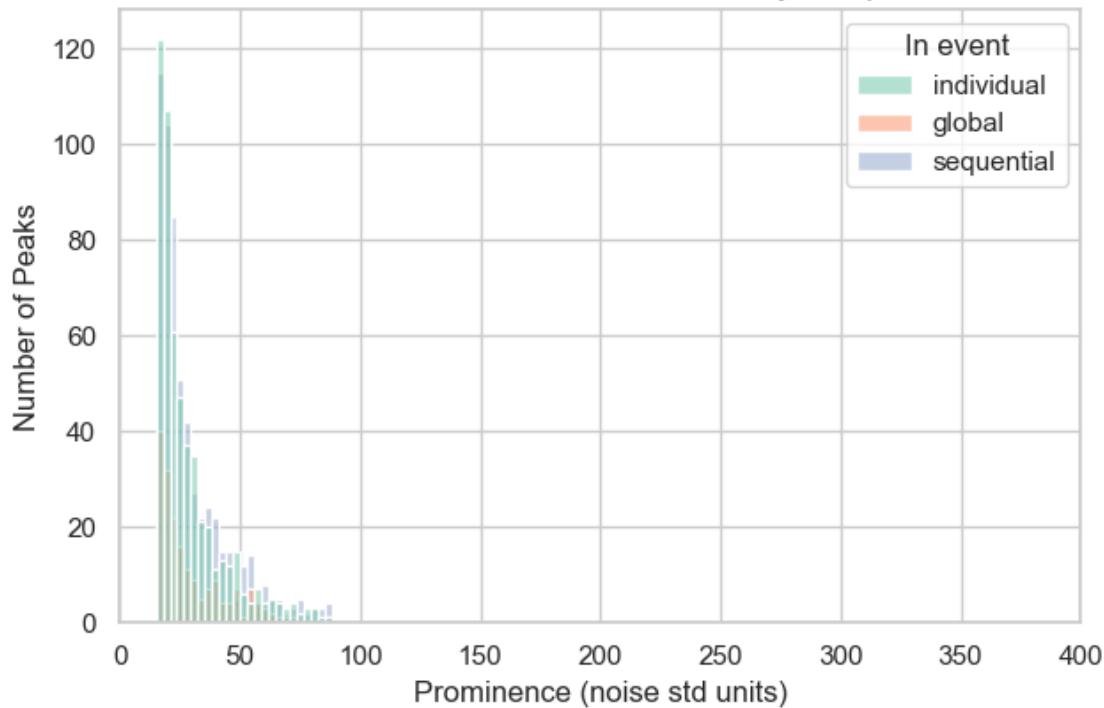
```
[2025-08-13 11:37:34] [INFO] calcium: plot_histogram_by_group: removed 45 outliers out of 1391 on 'Duration (s)' (lower=-82, upper=170)
```

Distribution of Peak Durations by Group

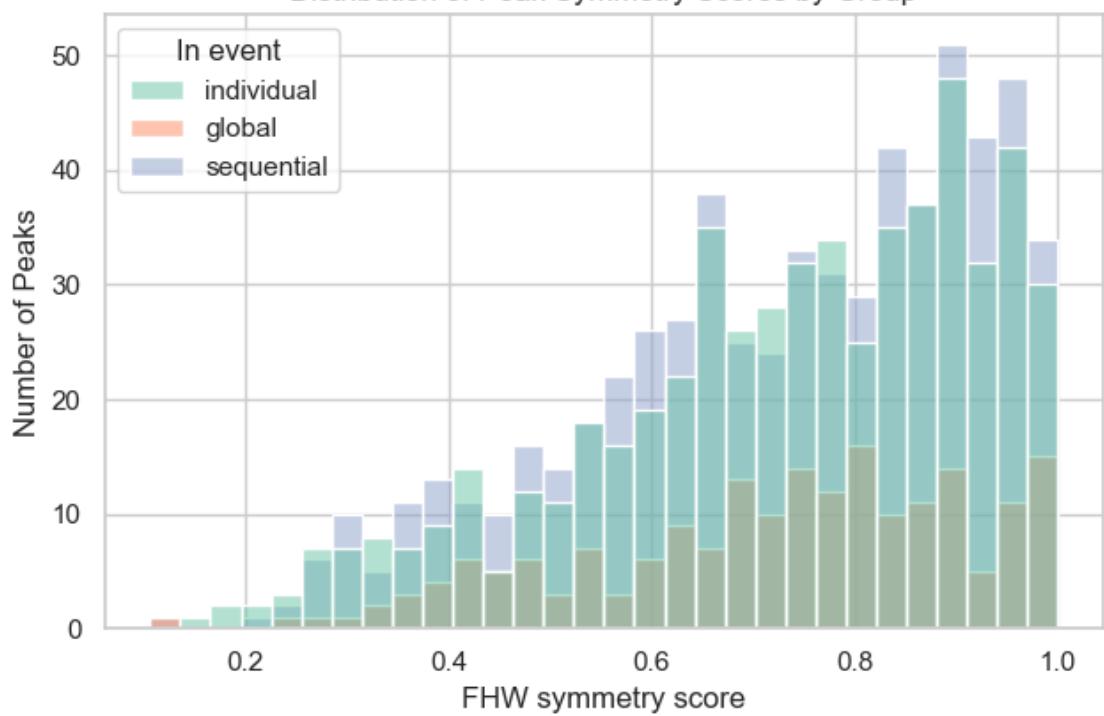


```
[2025-08-13 11:37:34] [INFO] calcium: plot_histogram_by_group: removed 59
outliers out of 1391 on 'Prominence (noise std units)' (lower=-36.05,
upper=91.7)
```

Distribution of Peak Prominences by Group



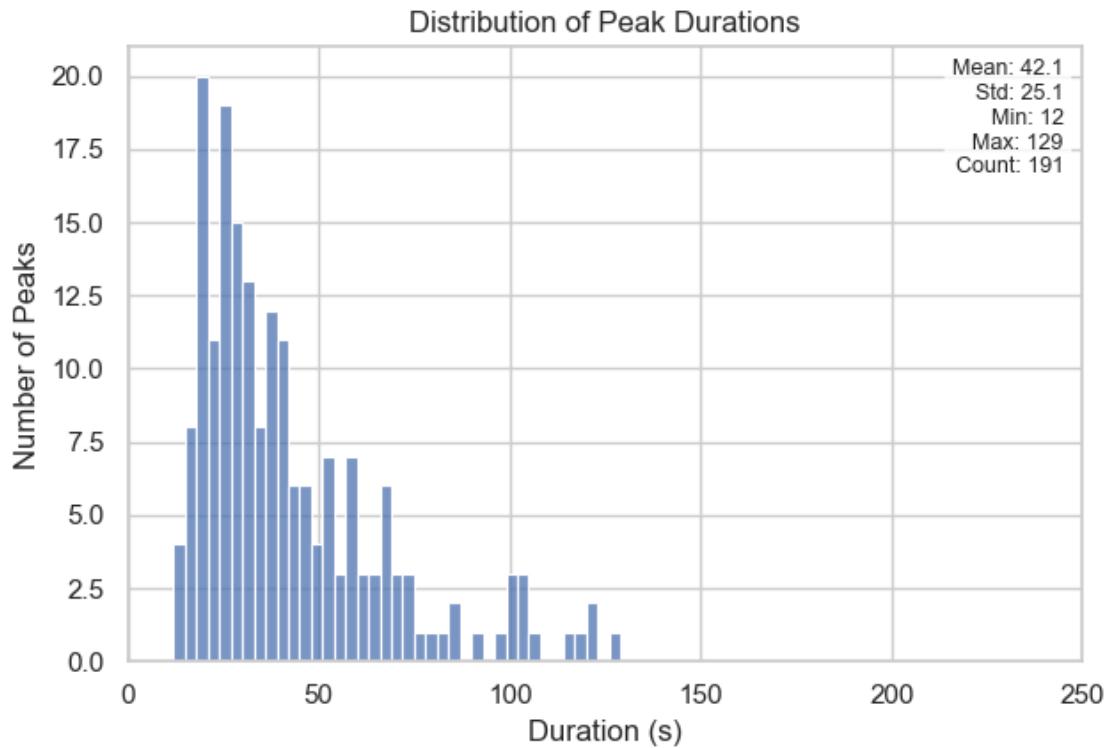
Distribution of Peak Symmetry Scores by Group



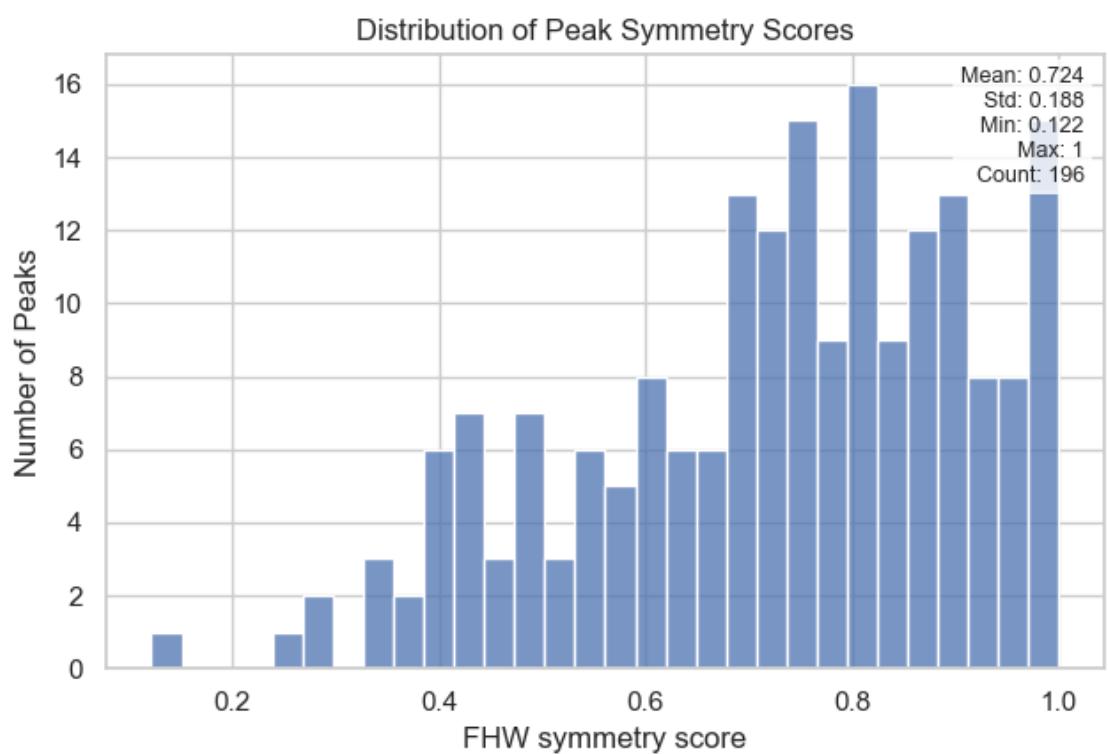
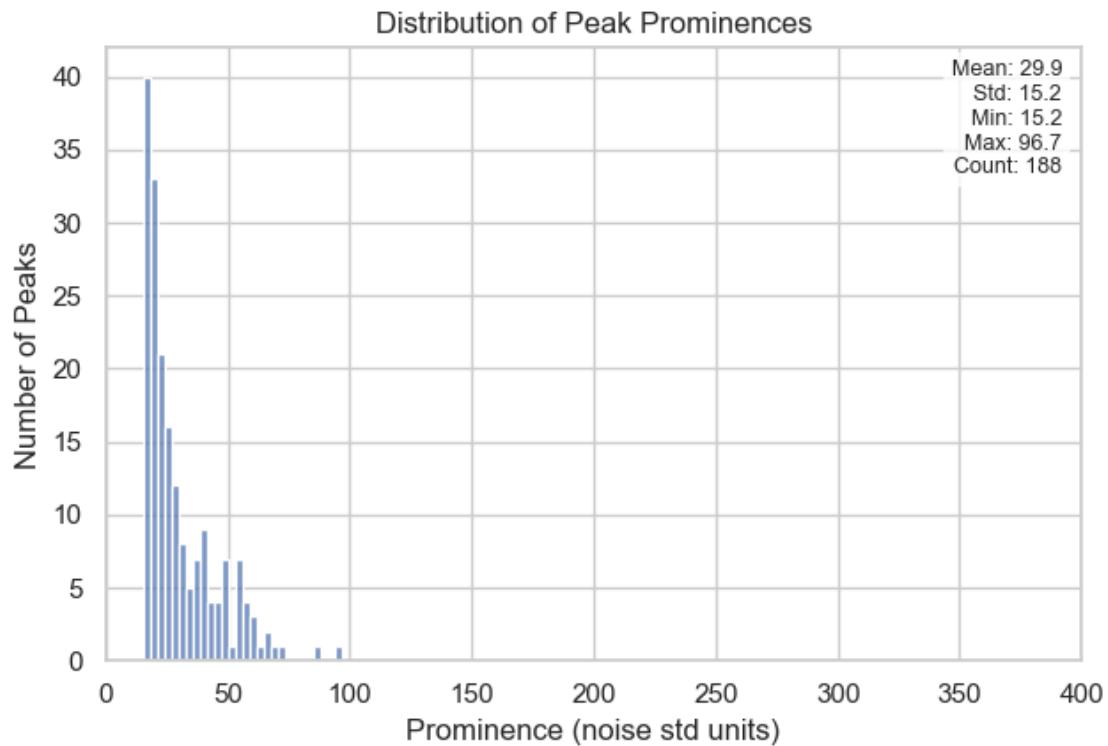
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

[2025-08-13 11:37:35] [INFO] calcium: plot_histogram: removed 5 outliers out of 196 on 'Duration (s)' (lower=-72.75, upper=153)

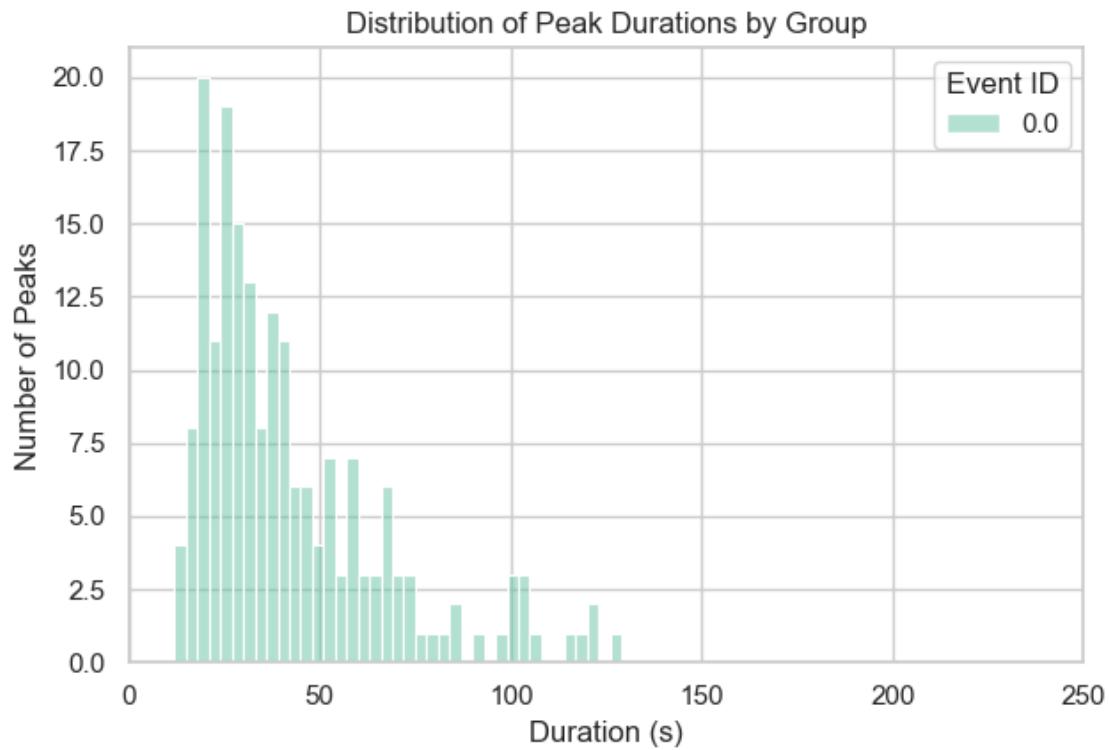


[2025-08-13 11:37:35] [INFO] calcium: plot_histogram: removed 8 outliers out of 196 on 'Prominence (noise std units)' (lower=-44.275, upper=102.9)



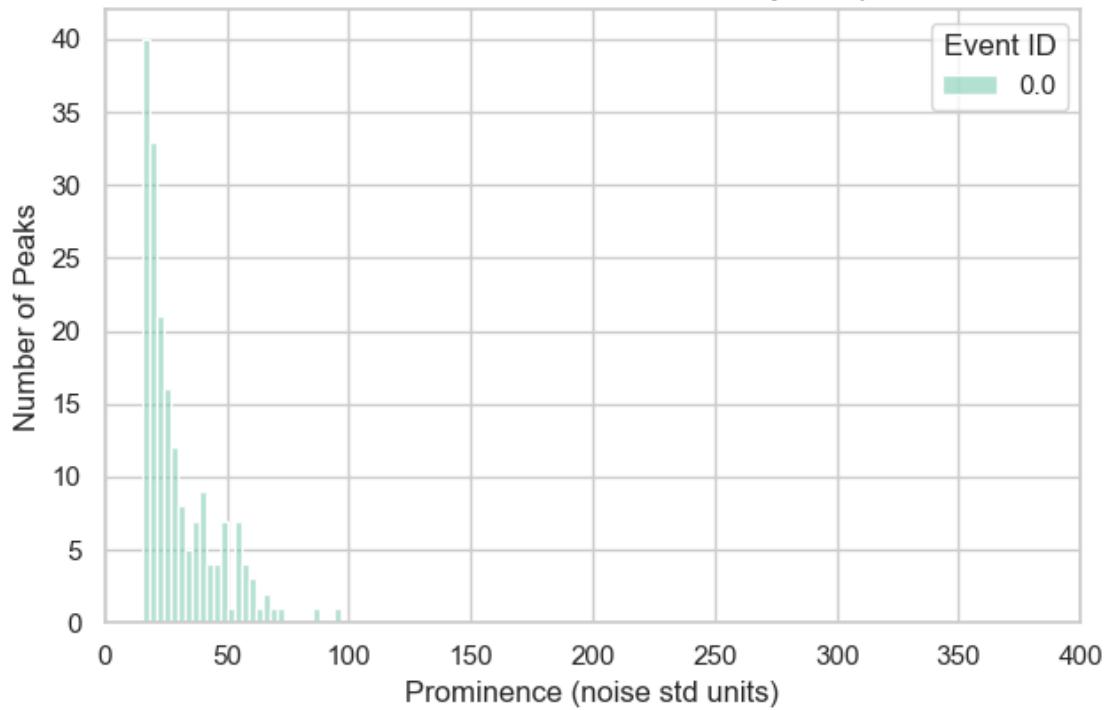
1.2.2 Peak statistics in global event per event ID

[2025-08-13 11:37:35] [INFO] calcium: plot_histogram_by_group: removed 5 outliers out of 196 on 'Duration (s)' (lower=-72.75, upper=153)

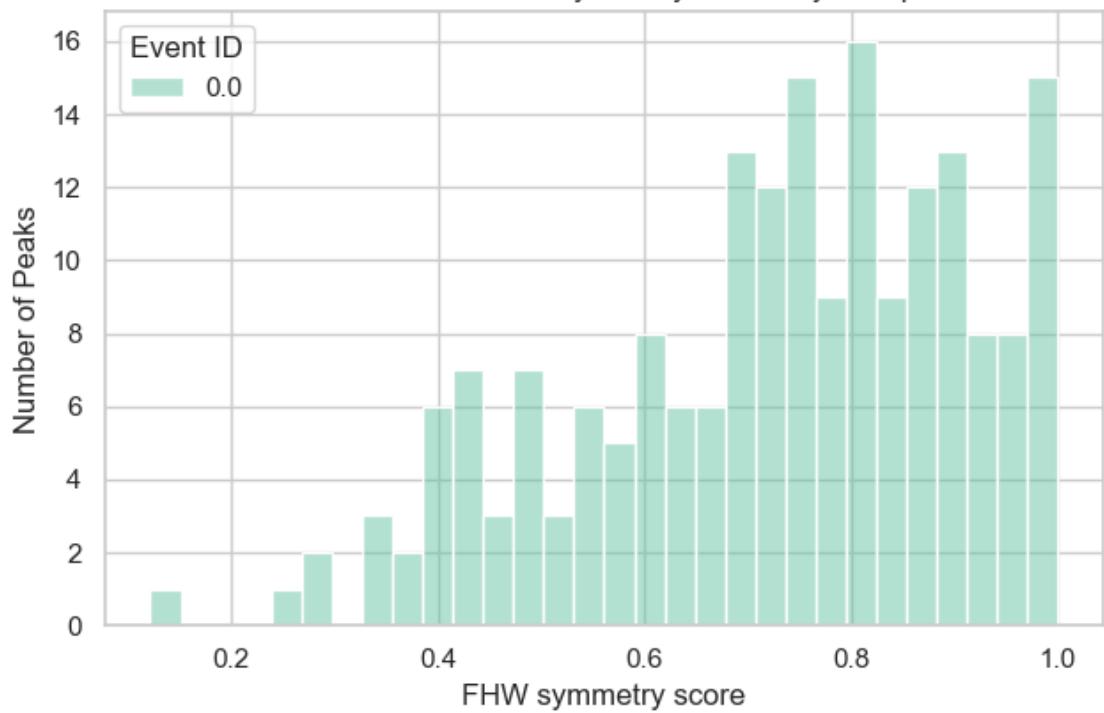


[2025-08-13 11:37:36] [INFO] calcium: plot_histogram_by_group: removed 8 outliers out of 196 on 'Prominence (noise std units)' (lower=-44.275, upper=102.9)

Distribution of Peak Prominences by Group

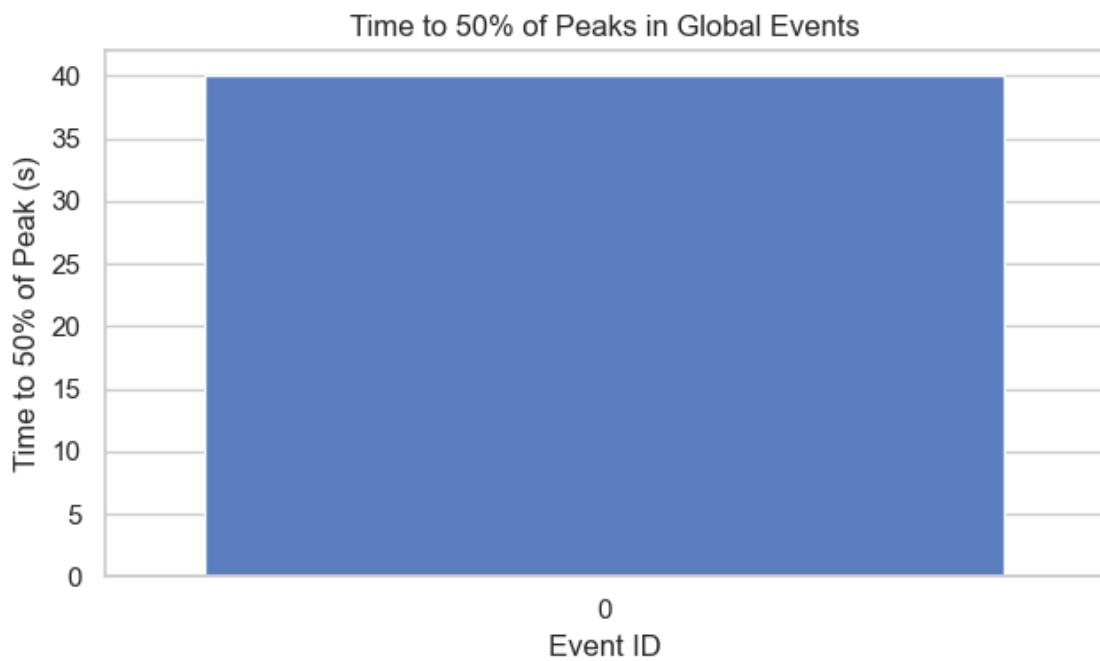
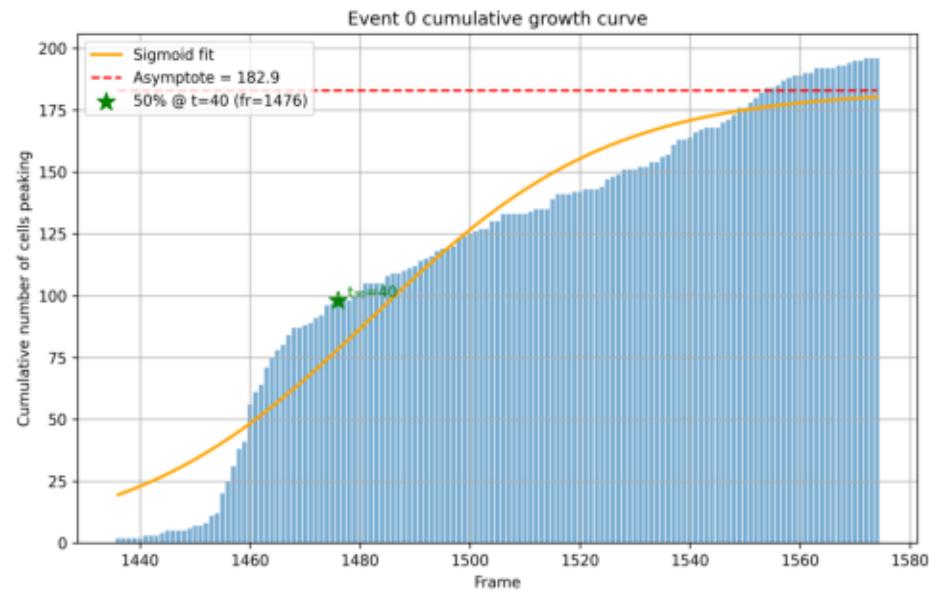


Distribution of Peak Symmetry Scores by Group

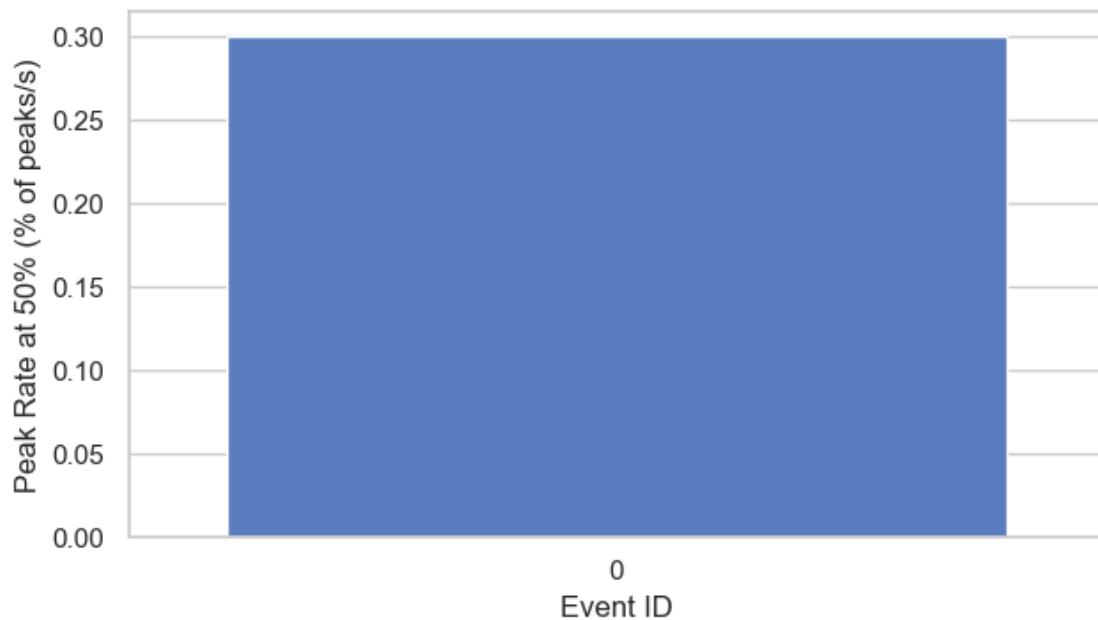


1.2.3 Kinetics of global events

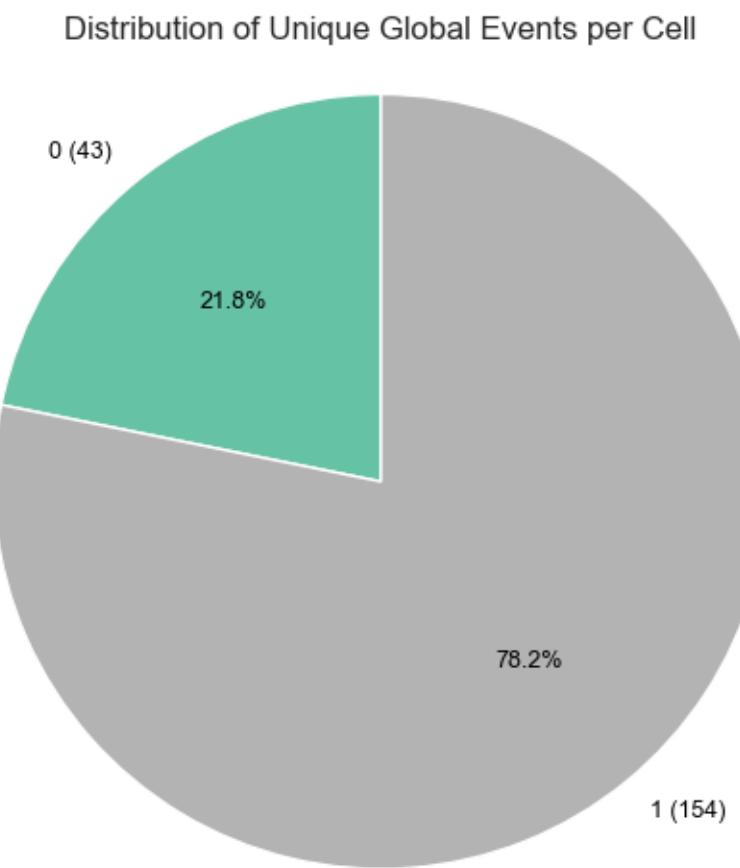
Event Activity Overlay (Event ID: 0) - 20250409_IS07



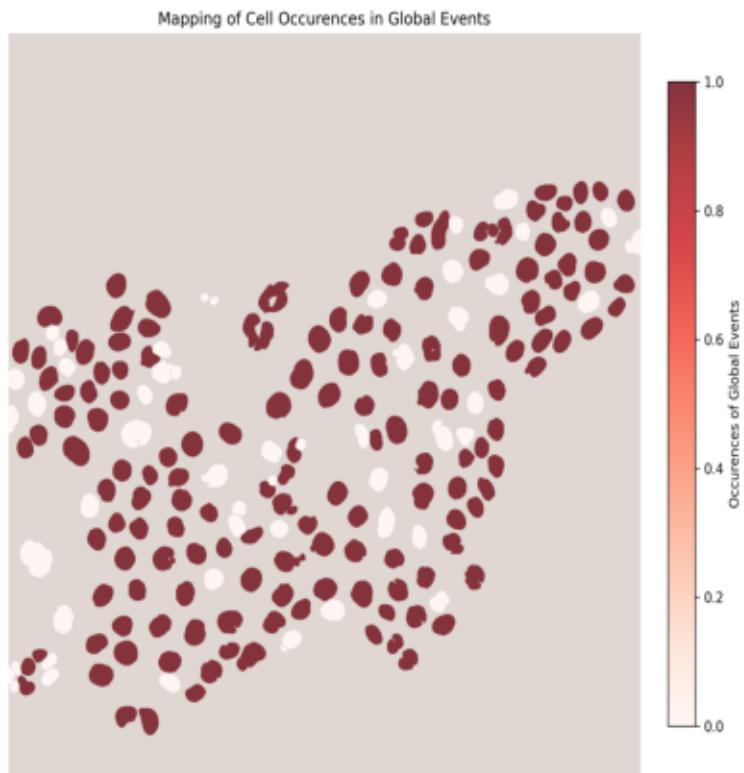
Peak rate at 50% in Global Events

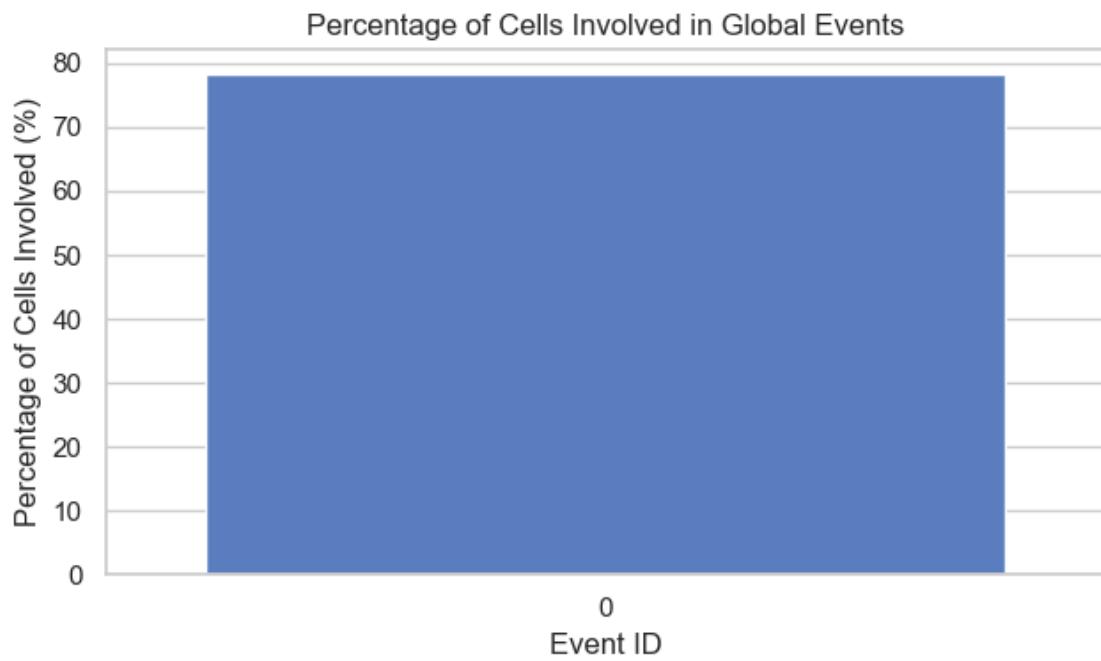


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250409_IS07



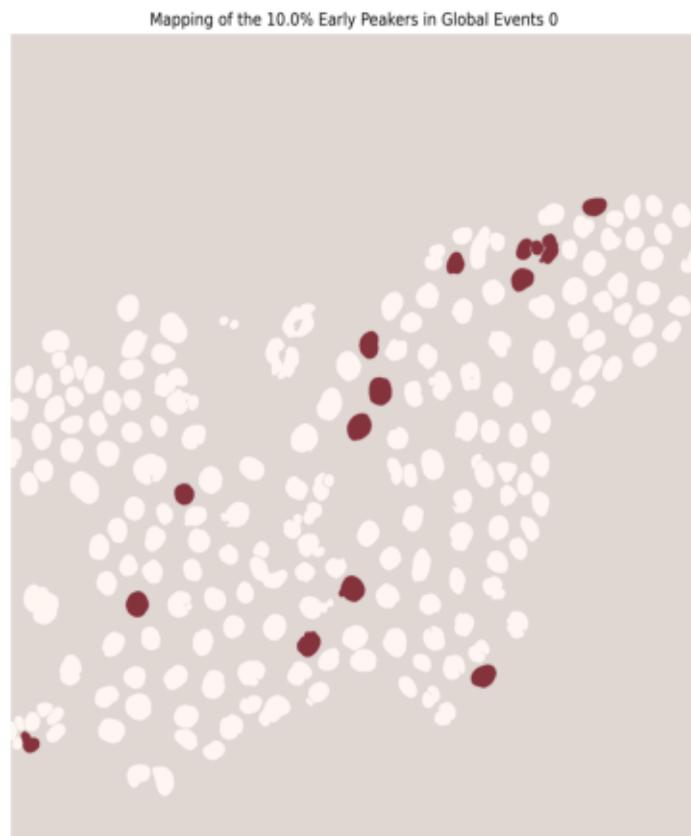


1.2.5 Inter-event interval analysis

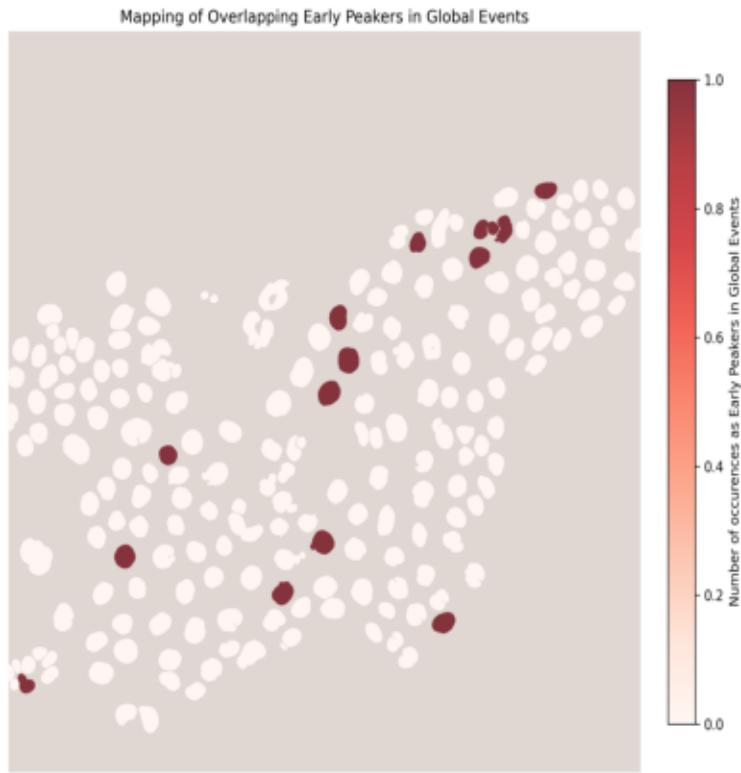
Intervals between global event peaks: []

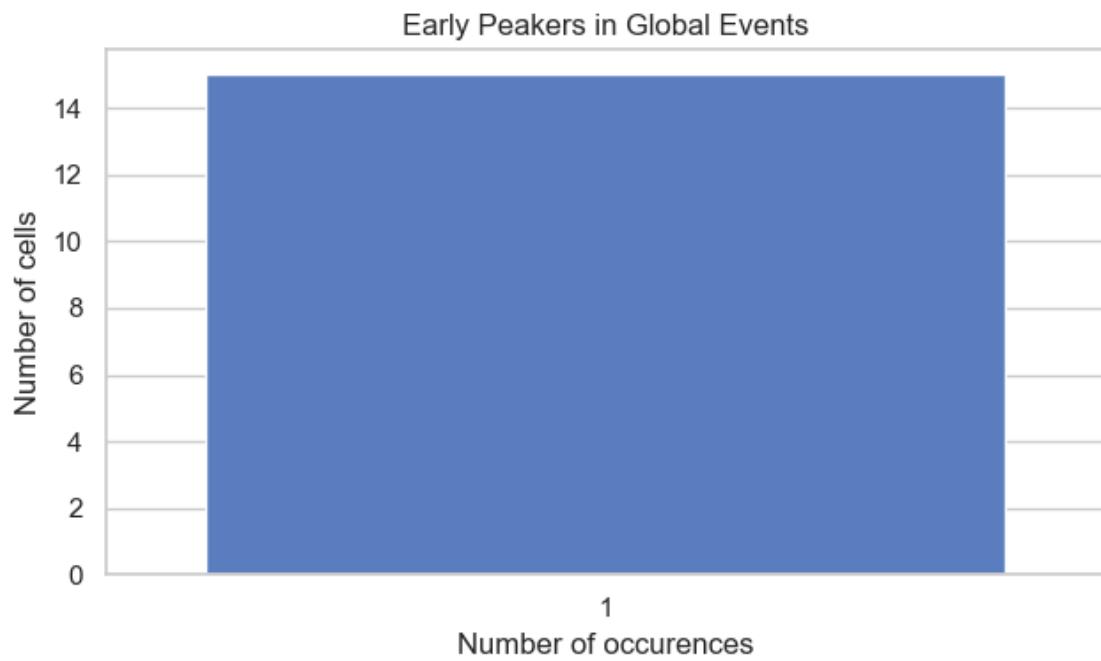
1.2.6 Early peakers in the events

Cell Mapping with Early Peakers Overlay for event 0 - 20250409_IS07

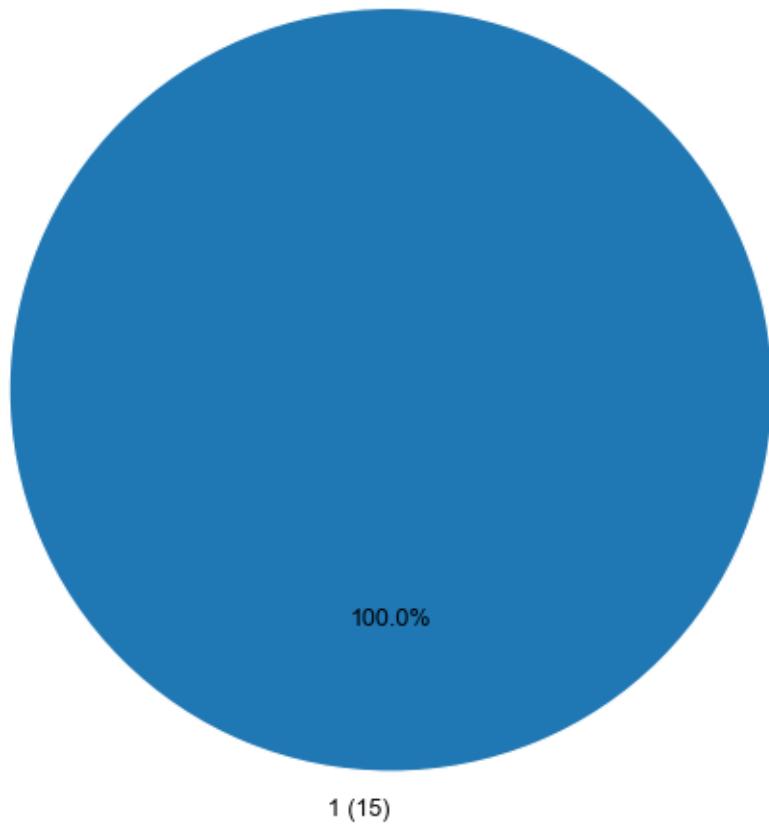


Cell Mapping with Occurrences in Global Events Overlay - 20250409_IS07



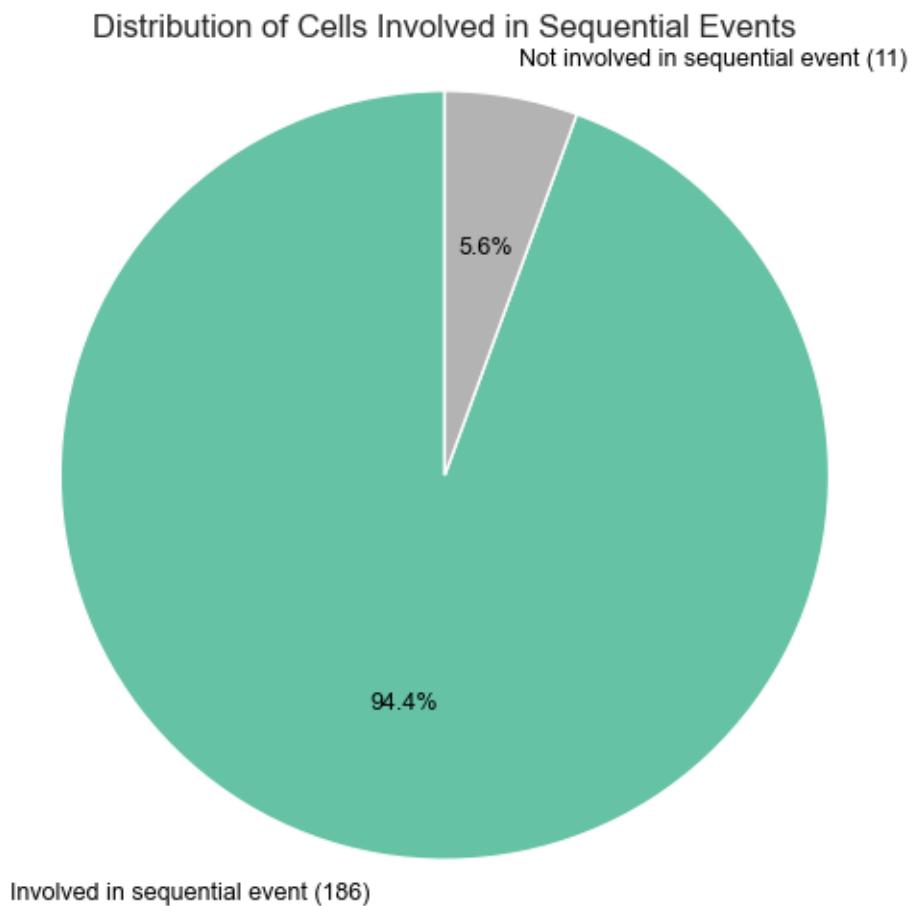


Distribution of Early Peakers in Global Events

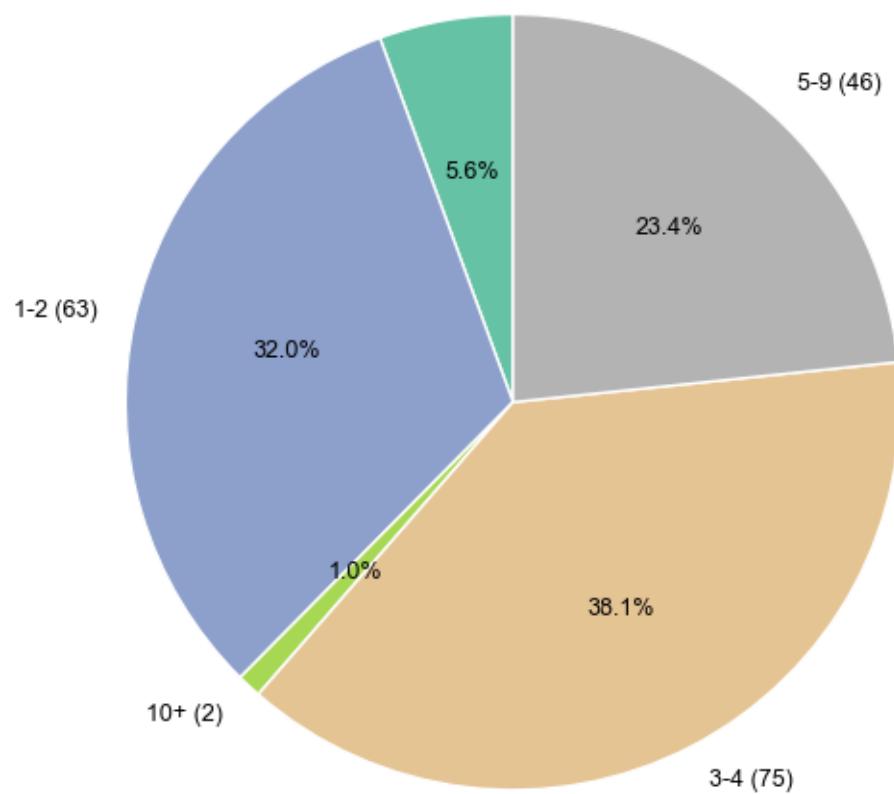


1.3 SEQUENTIAL EVENTS

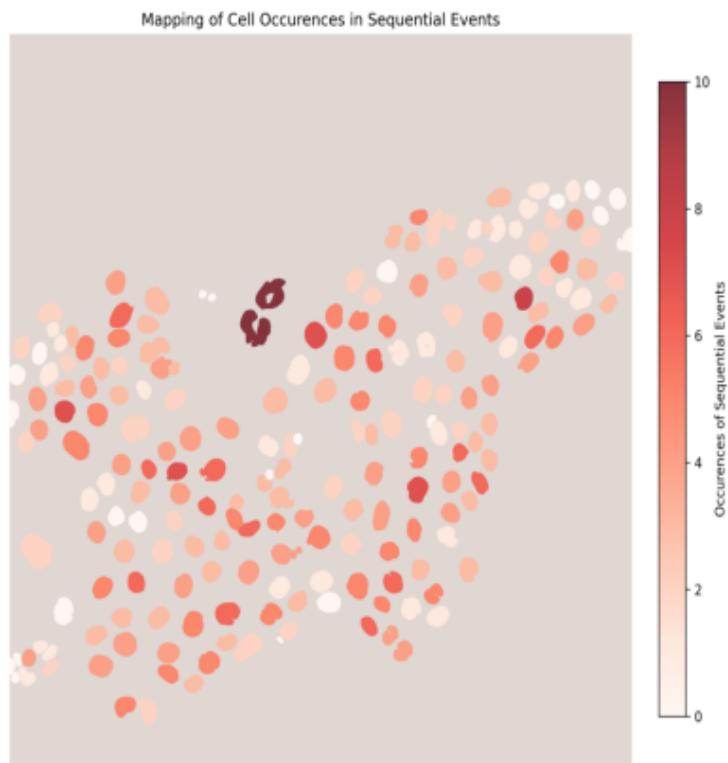
1.3.1 Cells occurrences in sequential events



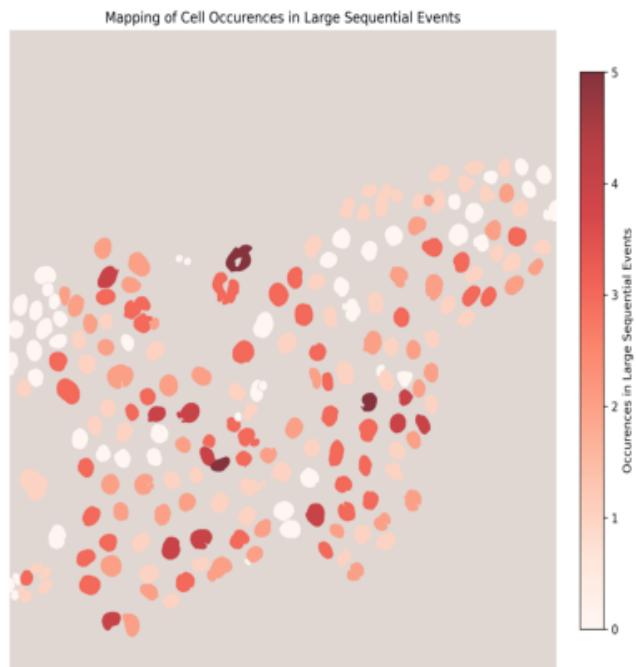
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)
0 (11)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250409_IS07

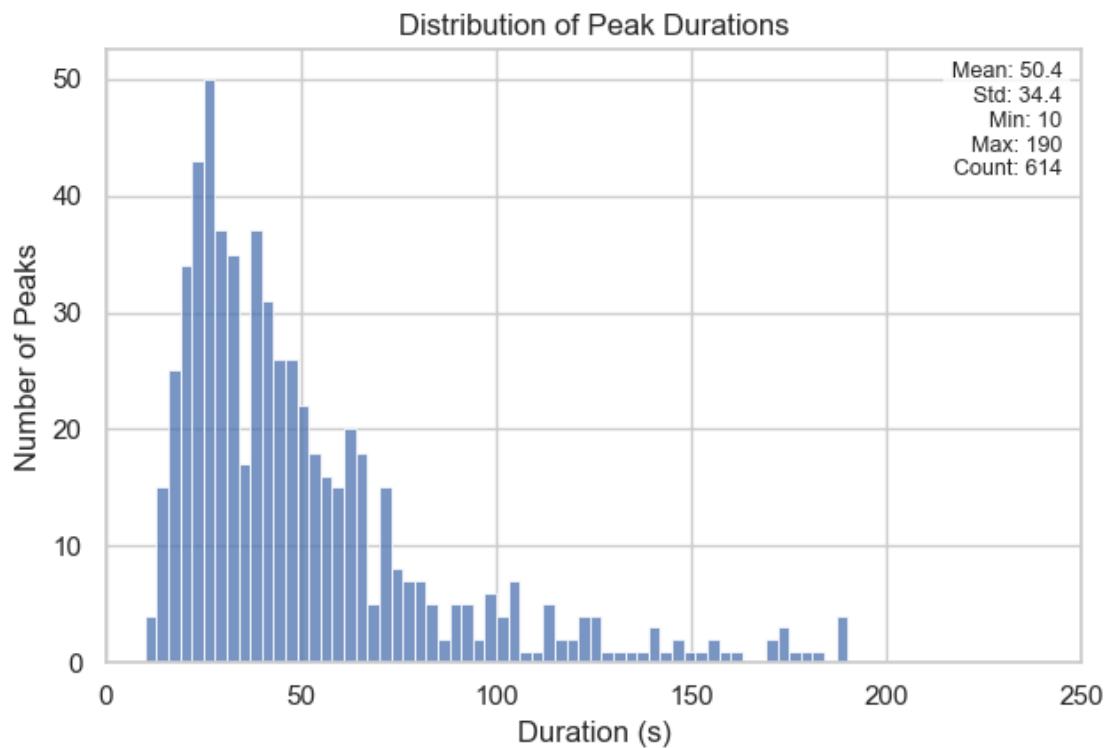


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250409_IS07

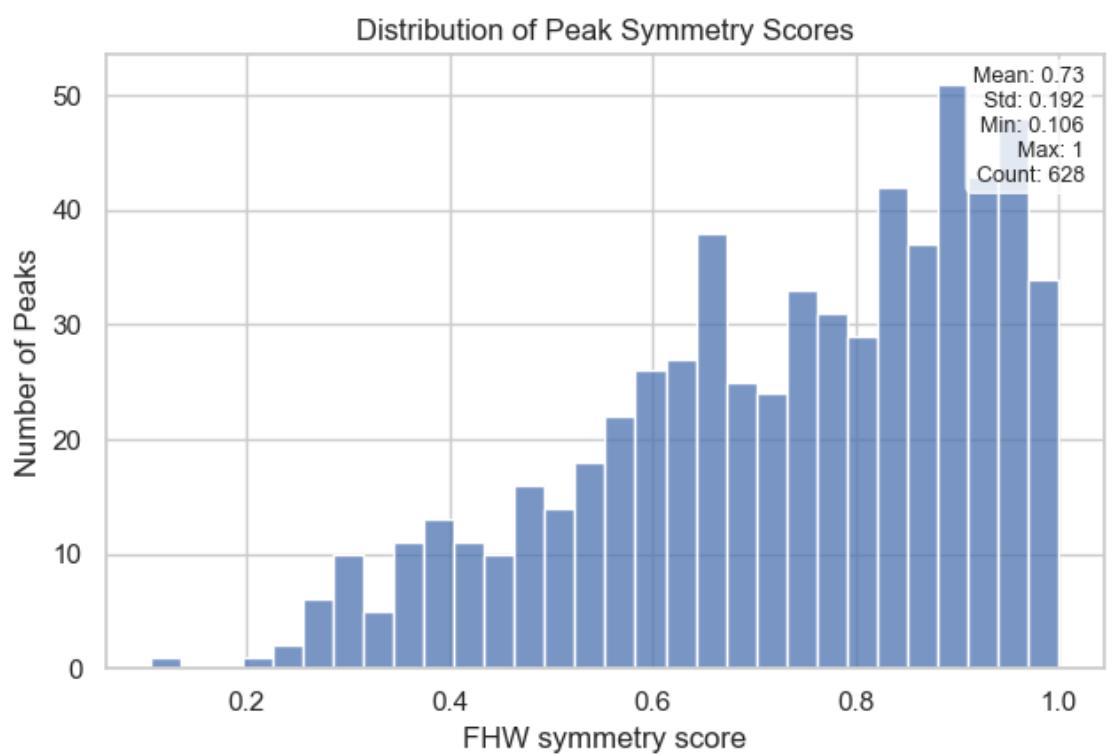
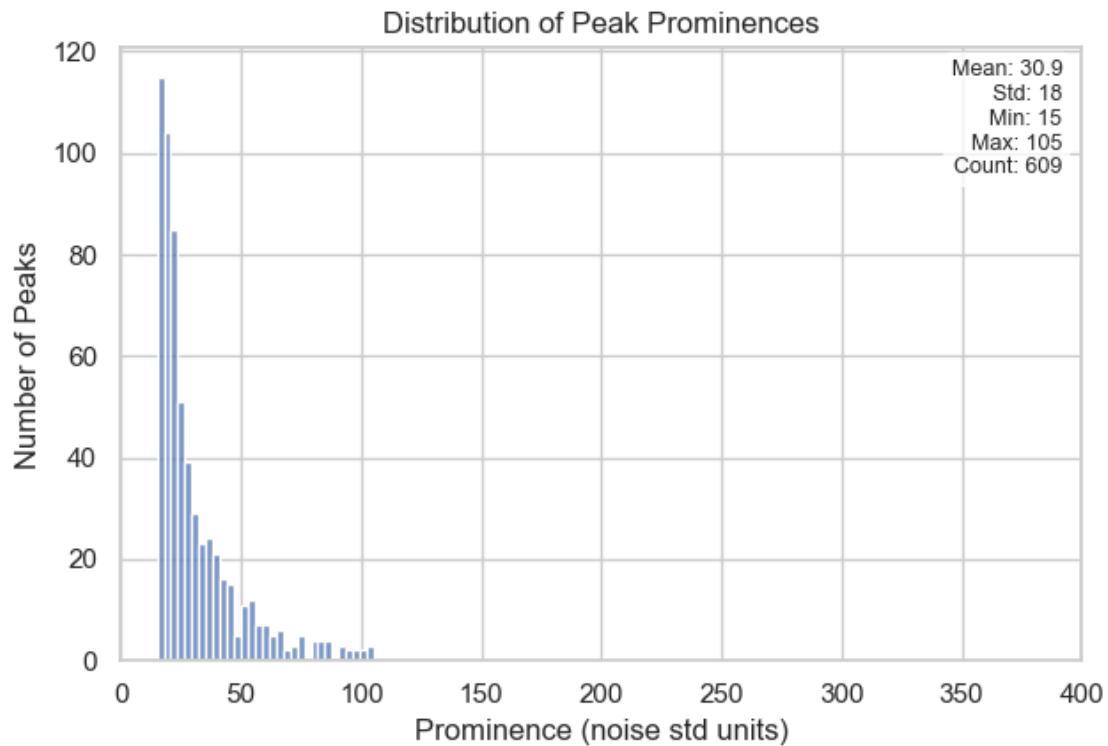


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 11:37:44] [INFO] calcium: plot_histogram: removed 14 outliers out of 628 on 'Duration (s)' (lower=-28, upper=191)
```

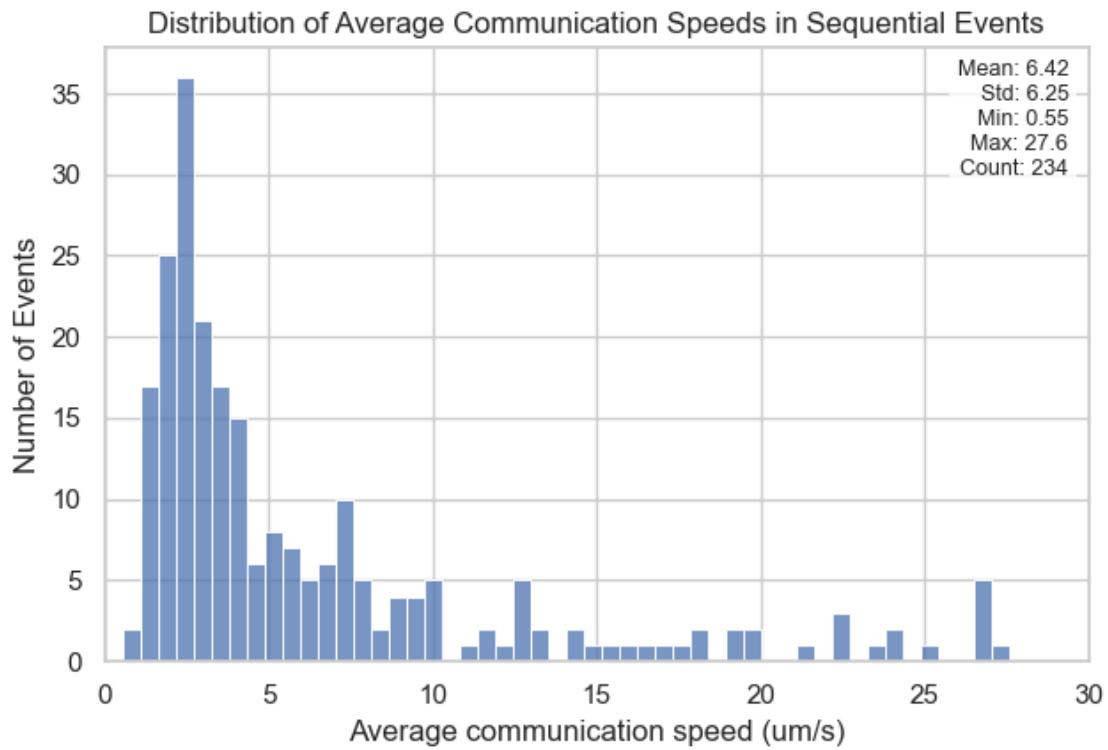


```
[2025-08-13 11:37:44] [INFO] calcium: plot_histogram: removed 19 outliers out of 628 on 'Prominence (noise std units)' (lower=-10.4, upper=107.2)
```

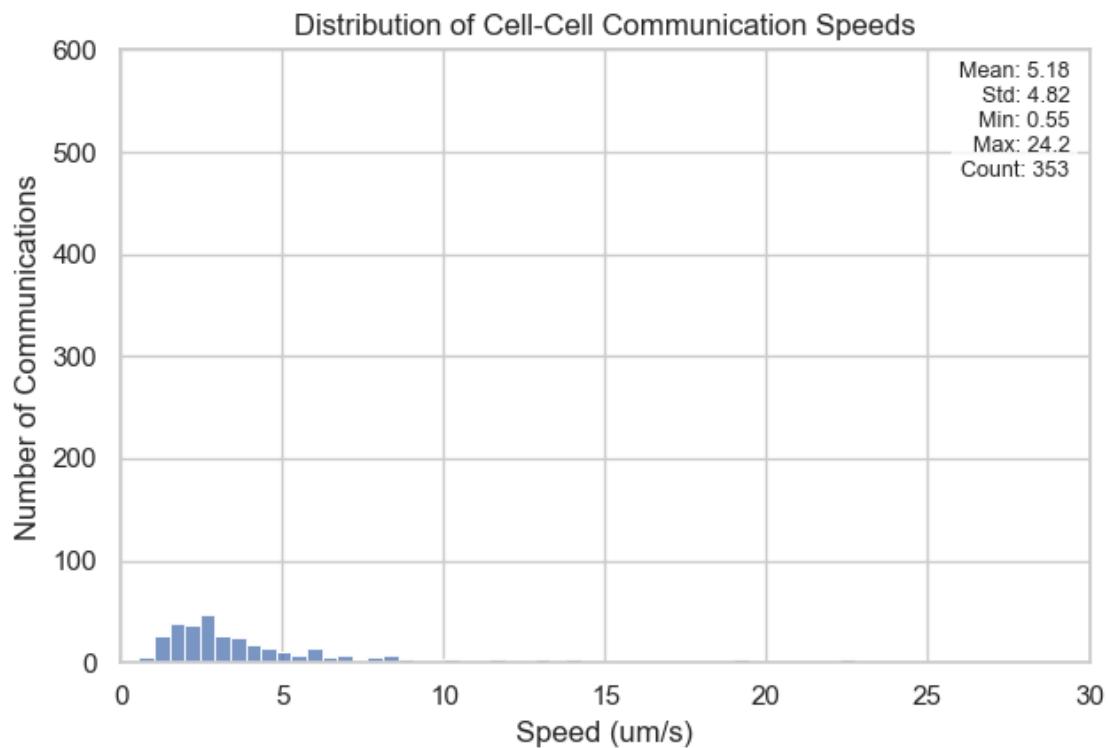


1.3.3 Cell-cell communication speed

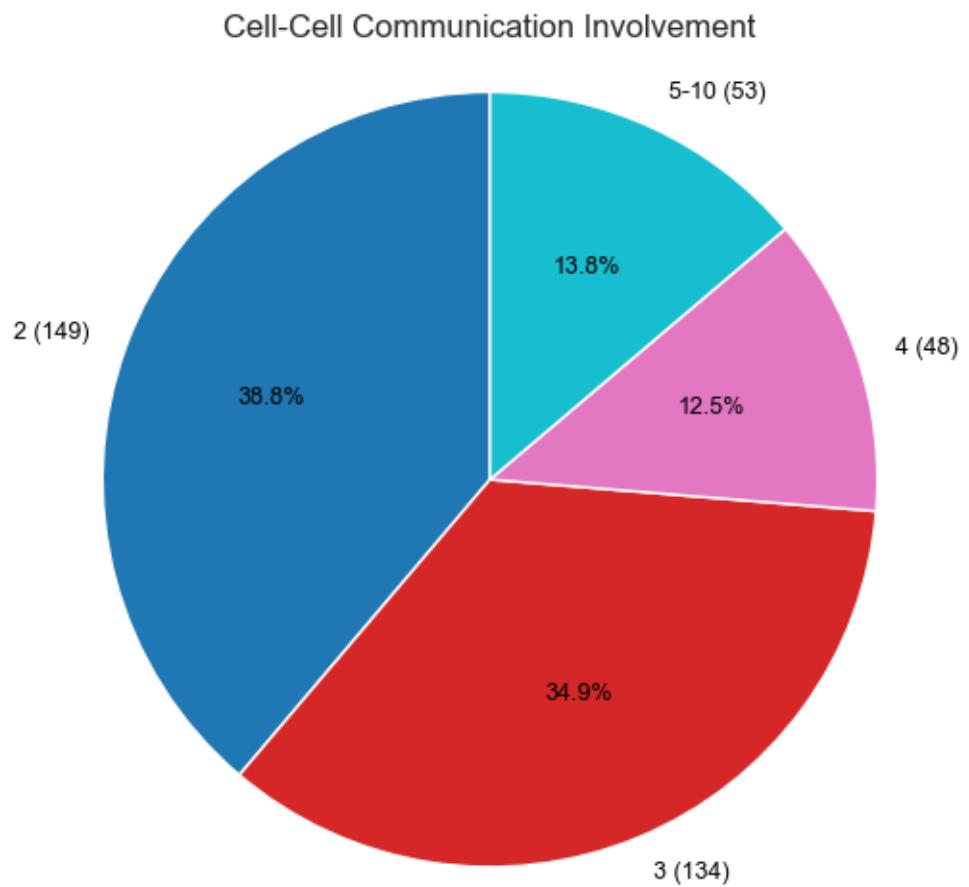
[2025-08-13 11:37:45] [INFO] calcium: plot_histogram: removed 10 outliers out of 244 on 'Average communication speed (um/s)' (lower=-16.5, upper=27.828)



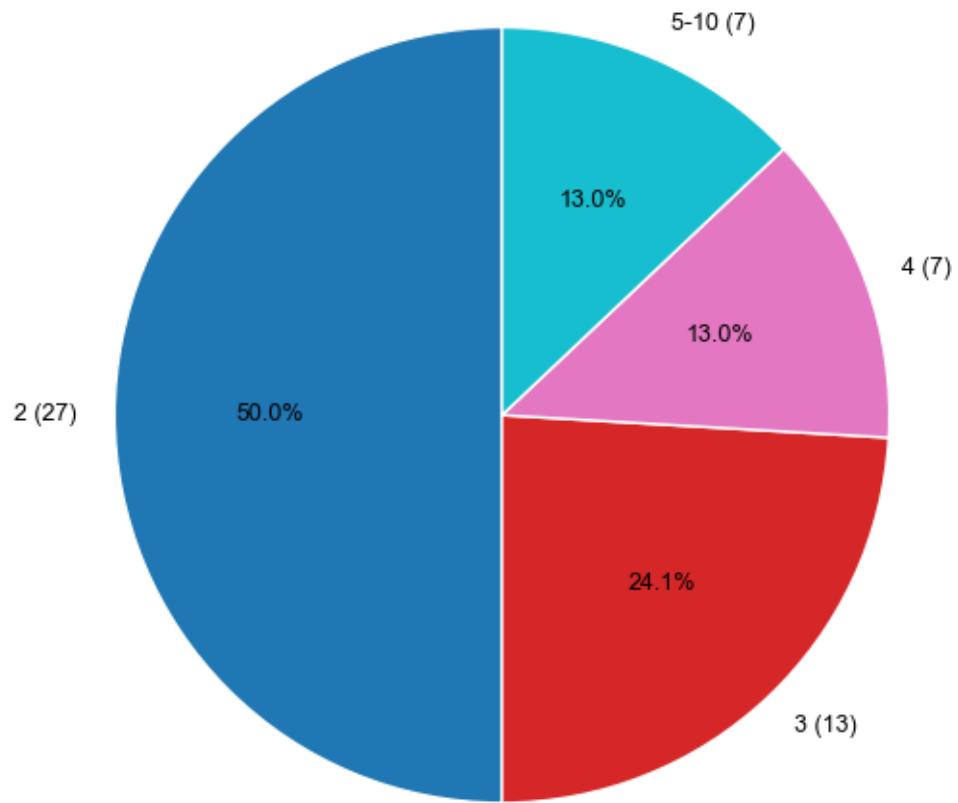
[2025-08-13 11:37:45] [INFO] calcium: plot_histogram: removed 31 outliers out of 384 on 'Speed (um/s)' (lower=-14.235, upper=24.265)



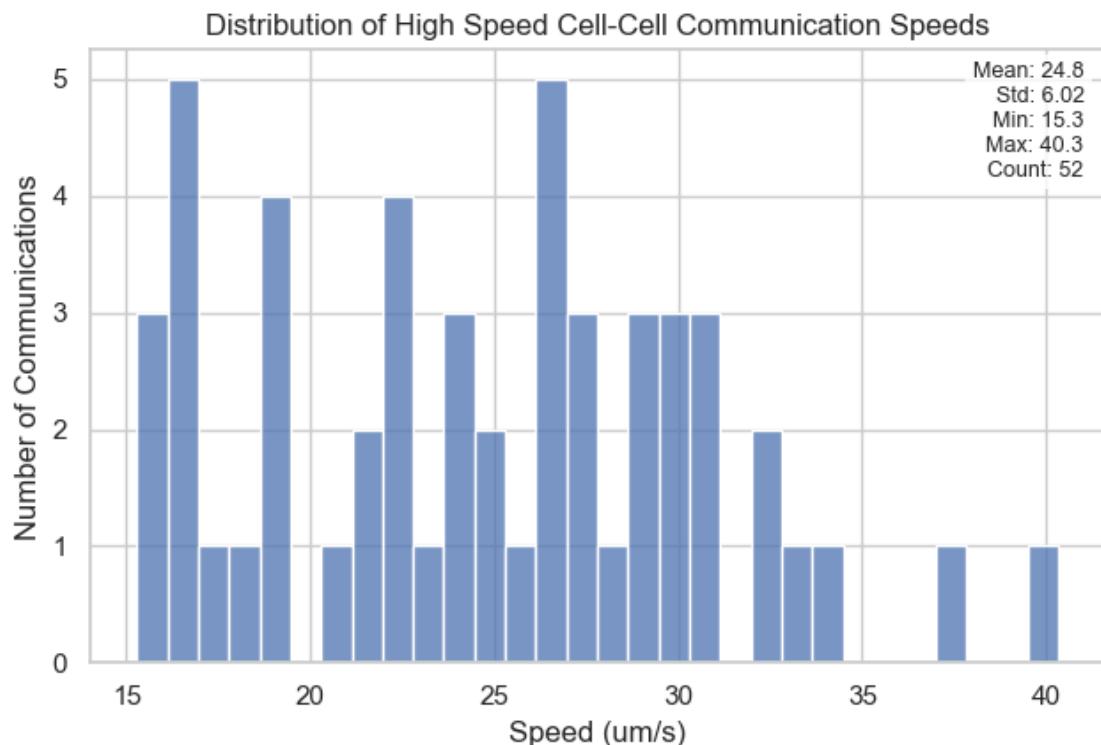
1.3.4 Double distribution in cell-cell communication speeds



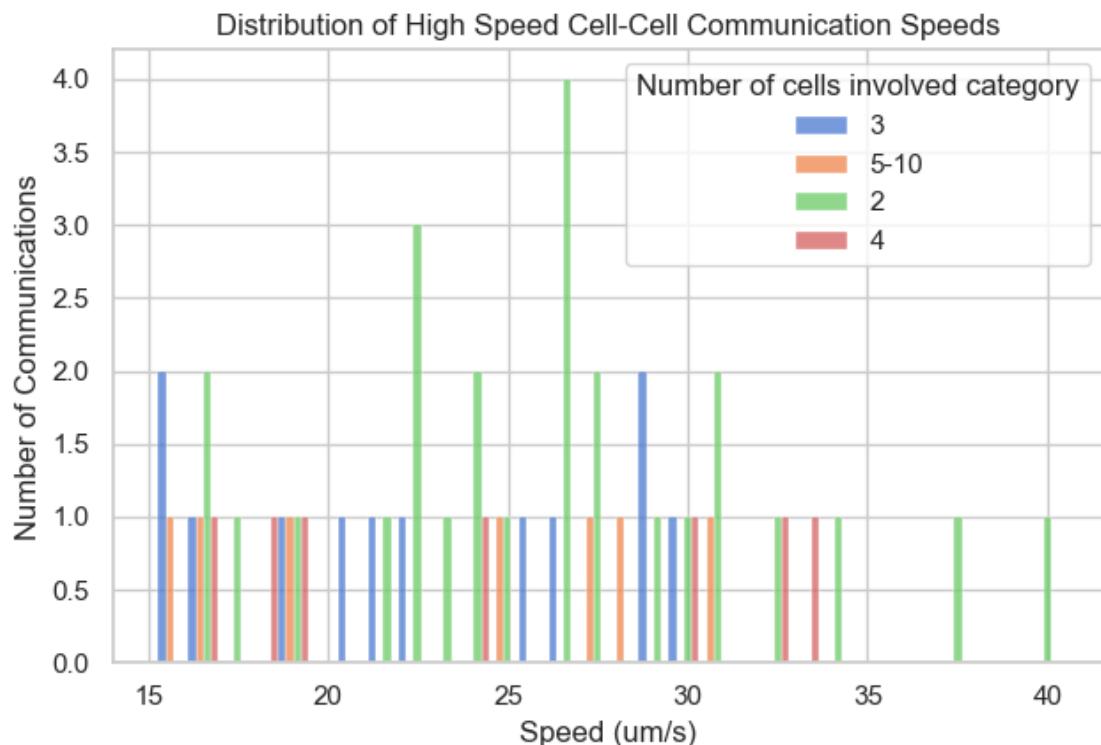
High Speed Cell-Cell Communication Involvement



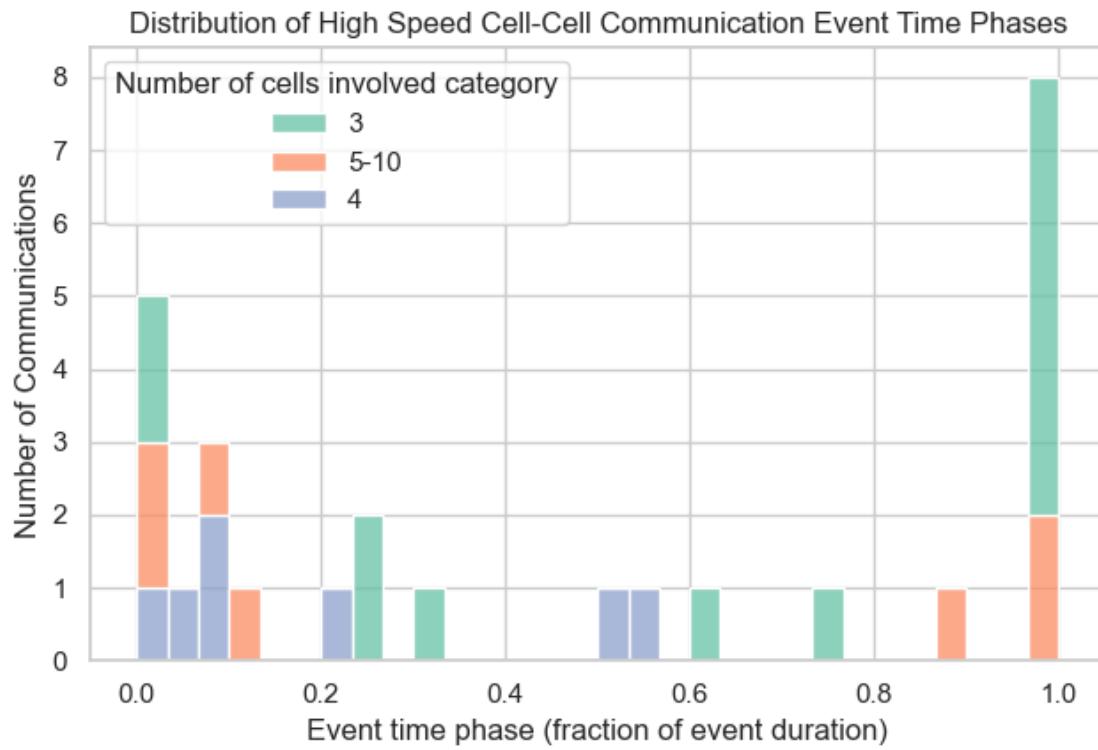
[2025-08-13 11:37:45] [INFO] calcium: plot_histogram: removed 2 outliers out of 54 on 'Speed (um/s)' (lower=-10.912, upper=60.522)



```
[2025-08-13 11:37:46] [INFO] calcium: plot_histogram_by_group: removed 2 outliers out of 54 on 'Speed (um/s)' (lower=-10.912, upper=60.522)
```

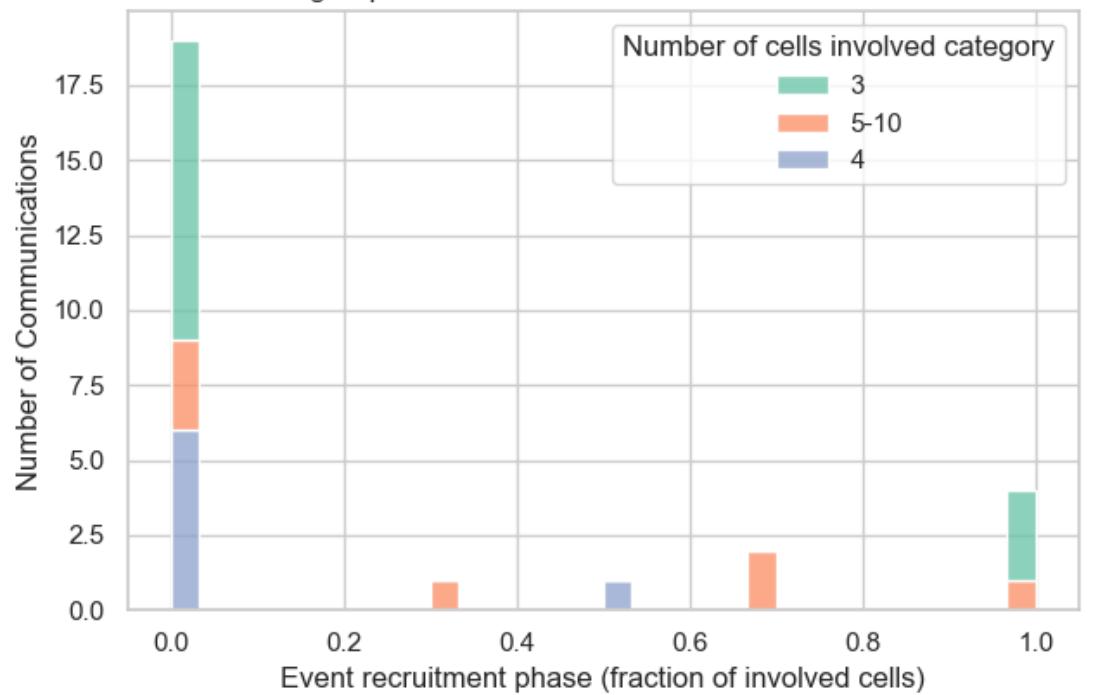


```
[2025-08-13 11:37:46] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 27 on 'Event time phase (fraction of event duration)' (lower=-2.615, upper=3.685)
```

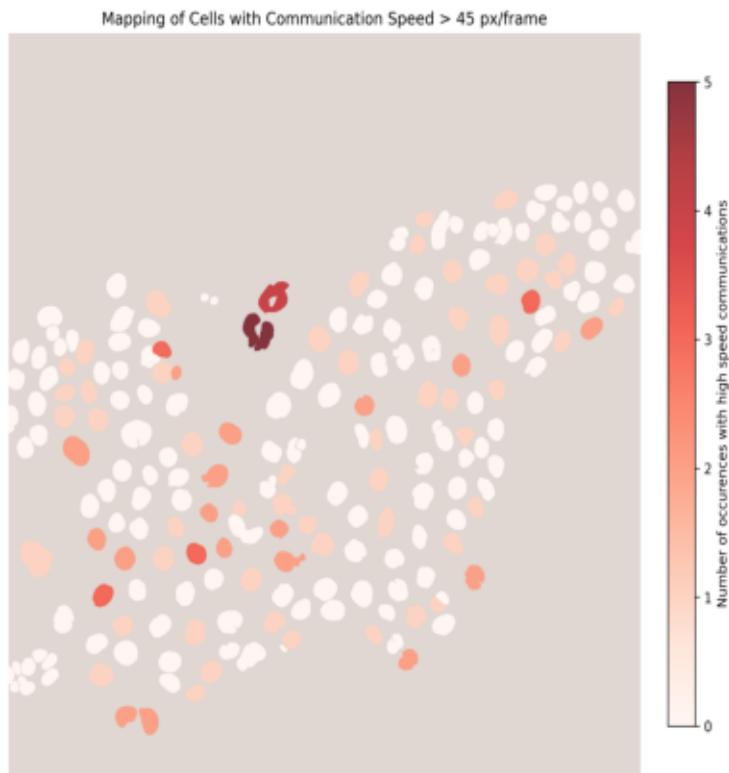


```
[2025-08-13 11:37:46] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 27 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.245, upper=1.66)
```

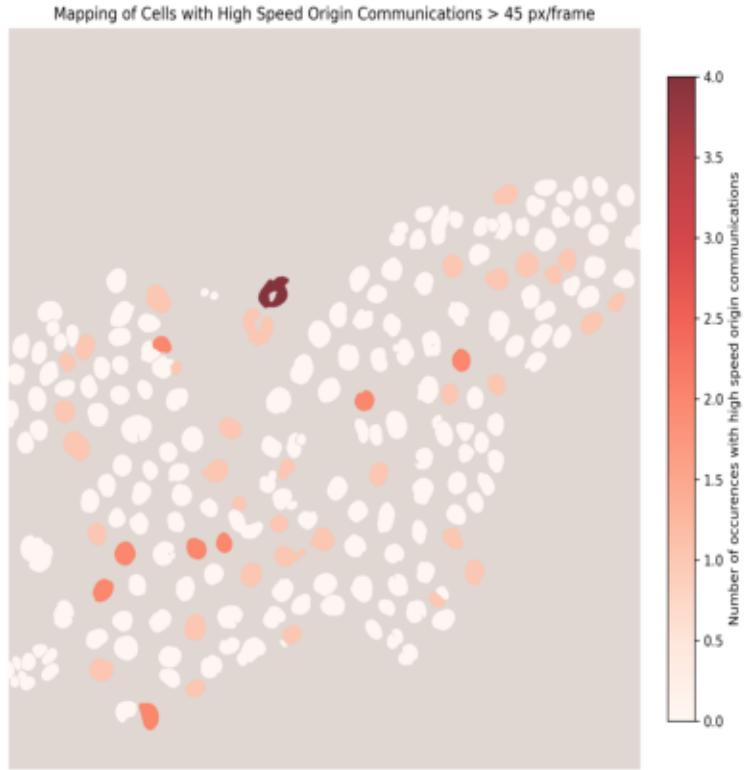
Distribution of High Speed Cell-Cell Communication Event Recruitment Phases



Cell Mapping with High Speed Cells Overlay - 20250409_IS07



Cell Mapping with High Speed Origin Cells Overlay - 20250409_IS07



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
0	1759504248848	1	172		0
3	1759504245392	2	140		0
19	1759504241504	6	85		3
20	1759504251008	7	99		3
21	1759504239776	8	80		2
26	1759470281744	9	68		1
28	1759470277088	10	65		0
30	1759470278192	11	74		1
32	1759470283328	12	97		6
34	1759470277568	12	97		6
35	1759470286208	13	123		5
37	1759470280016	14	150		1

39	1759470275120	15	154	5
40	1759470283184	16	160	2
44	1759470287360	17	188	1
48	1759470284000	20	212	4
49	1759389728096	20	212	4
55	1759470278864	23	7	0
76	1759470274592	37	27	3
77	1759470273056	38	29	4
84	1759389724208	43	46	3
85	1759470288128	44	42	7
102	1759470288656	53	34	0
105	1759470288272	55	32	1
108	1759470273008	58	28	5
114	1759470278672	63	74	0
128	1759470283568	73	167	5
129	1759470283952	73	54	6
135	1759470272576	77	42	0
136	1759470282512	78	45	1
137	1759470275696	79	42	3
138	1759470285824	80	42	4
142	1759470282944	84	57	8
158	1759470283904	94	65	1
176	1759470286112	107	75	1
195	1759470279296	122	115	4
206	1759470282896	129	125	3
217	1759470285920	135	91	5
218	1759470284768	136	105	6
270	1759394599680	172	158	2
273	1759389717968	174	156	5
277	1759389717104	177	127	0
286	1759389713552	181	158	1
288	1759389722000	183	163	0
291	1759389717440	186	172	9
295	1759389728288	190	156	3
300	1759389713792	193	160	3
302	1759389723152	195	153	3
305	1759389719792	196	155	0
333	1759389727040	213	176	0
338	1759389714416	216	190	1
345	1759389713168	220	166	1
370	1759389722096	234	205	6
371	1759389723968	235	210	4

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
0	186	0	62.0	62.0	
3	125	0	209.0	209.0	
19	55	5	1077.0	1077.0	
20	115	1	351.0	351.0	

21	65	2	1024.0	1024.0
26	86	3	454.0	454.0
28	81	1	157.0	158.0
30	88	2	408.0	408.0
32	110	3	1121.0	1121.0
34	73	3	1121.0	1122.0
35	146	4	1291.0	1291.0
37	137	3	598.0	598.0
39	139	3	1000.0	1000.0
40	172	2	785.0	785.0
44	203	4	607.0	607.0
48	211	3	889.0	889.0
49	198	3	889.0	899.0
55	12	2	918.0	922.0
76	24	2	376.0	377.0
77	25	1	1084.0	1085.0
84	167	4	1312.0	1315.0
85	33	2	948.0	951.0
102	43	0	61.0	62.0
105	43	3	631.0	632.0
108	43	8	1300.0	1301.0
114	49	0	147.0	149.0
128	54	6	1380.0	1387.0
129	62	8	1387.0	1388.0
135	57	0	74.0	75.0
136	57	1	209.0	214.0
137	57	2	444.0	445.0
138	57	3	556.0	557.0
142	59	9	1256.0	1258.0
158	80	1	485.0	486.0
176	87	1	872.0	873.0
195	100	4	907.0	908.0
206	105	2	585.0	586.0
217	108	4	1329.0	1330.0
218	111	7	1234.0	1235.0
270	141	2	332.0	333.0
273	141	7	1289.0	1290.0
277	144	0	24.0	25.0
286	148	0	99.0	100.0
288	150	0	84.0	85.0
291	153	5	1668.0	1670.0
295	158	3	1023.0	1024.0
300	161	1	910.0	912.0
302	162	5	1356.0	1359.0
305	163	1	534.0	535.0
333	181	0	73.0	74.0
338	189	4	930.0	933.0
345	182	2	282.0	283.0

370	211	4	1214.0	1216.0
371	198	4	956.0	958.0

	Duration (s)	Distance (um)	Speed (um/s)	\
0	0.0	25.74	25.74	
3	0.0	28.38	28.38	
19	0.0	40.33	40.33	
20	0.0	24.93	24.93	
21	0.0	19.31	19.31	
26	0.0	26.81	26.81	
28	1.0	15.28	15.28	
30	0.0	32.96	32.96	
32	0.0	24.38	24.38	
34	1.0	32.01	32.01	
35	0.0	37.79	37.79	
37	0.0	16.64	16.64	
39	0.0	30.23	30.23	
40	0.0	30.57	30.57	
44	0.0	29.36	29.36	
48	0.0	19.13	19.13	
49	10.0	208.80	20.88	
55	4.0	65.97	16.49	
76	1.0	22.49	22.49	
77	1.0	32.63	32.63	
84	3.0	213.66	71.22	
85	3.0	67.98	22.66	
102	1.0	28.68	28.68	
105	1.0	23.30	23.30	
108	1.0	21.65	21.65	
114	2.0	31.93	15.97	
128	7.0	191.42	27.35	
129	1.0	25.11	25.11	
135	1.0	26.61	26.61	
136	5.0	81.19	16.24	
137	1.0	26.61	26.61	
138	1.0	26.61	26.61	
142	2.0	48.64	24.32	
158	1.0	19.31	19.31	
176	1.0	17.63	17.63	
195	1.0	27.05	27.05	
206	1.0	30.96	30.96	
217	1.0	27.62	27.62	
218	1.0	30.74	30.74	
270	1.0	29.10	29.10	
273	1.0	26.60	26.60	
277	1.0	30.09	30.09	
286	1.0	24.16	24.16	
288	1.0	22.72	22.72	

291	2.0	38.34	19.17
295	1.0	22.39	22.39
300	2.0	30.55	15.28
302	3.0	49.20	16.40
305	1.0	30.18	30.18
333	1.0	18.18	18.18
338	3.0	64.76	21.59
345	1.0	33.73	33.73
370	2.0	33.36	16.68
371	2.0	169.88	84.94

	Event time phase (fraction of event duration)	\
0		0.00
3		0.12
19		NaN
20		NaN
21		0.00
26		NaN
28		1.00
30		0.56
32		0.00
34		0.08
35		NaN
37		1.00
39		1.00
40		0.00
44		NaN
48		0.00
49		1.00
55		NaN
76		NaN
77		NaN
84		0.60
85		0.75
102		0.25
105		NaN
108		NaN
114		0.88
128		0.97
129		1.00
135		NaN
136		NaN
137		NaN
138		NaN
142		NaN
158		0.50
176		NaN
195		NaN

206	NaN
217	NaN
218	NaN
270	0.33
273	1.00
277	0.06
286	NaN
288	NaN
291	NaN
295	NaN
300	1.00
302	0.21
305	NaN
333	0.09
338	0.25
345	NaN
370	0.09
371	NaN

	Event recruitment phase (fraction of involved cells)	dataset \
0	0.00	20250409_IS07
3	0.33	20250409_IS07
19	NaN	20250409_IS07
20	NaN	20250409_IS07
21	0.00	20250409_IS07
26	NaN	20250409_IS07
28	0.00	20250409_IS07
30	0.00	20250409_IS07
32	0.00	20250409_IS07
34	0.50	20250409_IS07
35	NaN	20250409_IS07
37	0.00	20250409_IS07
39	0.00	20250409_IS07
40	0.00	20250409_IS07
44	NaN	20250409_IS07
48	0.00	20250409_IS07
49	1.00	20250409_IS07
55	NaN	20250409_IS07
76	NaN	20250409_IS07
77	NaN	20250409_IS07
84	0.00	20250409_IS07
85	0.00	20250409_IS07
102	0.00	20250409_IS07
105	NaN	20250409_IS07
108	NaN	20250409_IS07
114	0.67	20250409_IS07
128	0.67	20250409_IS07
129	1.00	20250409_IS07

135	NaN	20250409_IS07
136	NaN	20250409_IS07
137	NaN	20250409_IS07
138	NaN	20250409_IS07
142	NaN	20250409_IS07
158	0.00	20250409_IS07
176	NaN	20250409_IS07
195	NaN	20250409_IS07
206	NaN	20250409_IS07
217	NaN	20250409_IS07
218	NaN	20250409_IS07
270	0.00	20250409_IS07
273	1.00	20250409_IS07
277	0.00	20250409_IS07
286	NaN	20250409_IS07
288	NaN	20250409_IS07
291	NaN	20250409_IS07
295	NaN	20250409_IS07
300	1.00	20250409_IS07
302	0.00	20250409_IS07
305	NaN	20250409_IS07
333	0.00	20250409_IS07
338	0.00	20250409_IS07
345	NaN	20250409_IS07
370	0.00	20250409_IS07
371	NaN	20250409_IS07

Number of cells involved	category	Speed category
0	3	High speed
3	5-10	High speed
19	2	High speed
20	2	High speed
21	5-10	High speed
26	2	High speed
28	3	High speed
30	4	High speed
32	4	High speed
34	4	High speed
35	2	High speed
37	3	High speed
39	3	High speed
40	5-10	High speed
44	2	High speed
48	3	High speed
49	3	High speed
55	2	High speed
76	2	High speed
77	2	High speed

84	3	High speed
85	3	High speed
102	3	High speed
105	2	High speed
108	2	High speed
114	5-10	High speed
128	5-10	High speed
129	5-10	High speed
135	2	High speed
136	2	High speed
137	2	High speed
138	2	High speed
142	2	High speed
158	4	High speed
176	2	High speed
195	2	High speed
206	2	High speed
217	2	High speed
218	2	High speed
270	3	High speed
273	3	High speed
277	4	High speed
286	2	High speed
288	2	High speed
291	2	High speed
295	2	High speed
300	3	High speed
302	4	High speed
305	2	High speed
333	4	High speed
338	3	High speed
345	2	High speed
370	5-10	High speed
371	2	High speed

Speed category	High speed	Low speed
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Origin cell ID

5	0	1
7	1	3
12	0	1
13	0	2
14	0	1
...
207	0	1
209	0	1
210	1	1
211	0	3
212	2	0

[151 rows x 2 columns]

	Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um) \
1	5	451.75	106.92
3	7	392.60	111.80
8	12	327.93	124.80
9	13	453.38	126.75
10	14	435.18	127.40
..

192	207	127.40	437.12
193	209	13.33	439.40
194	210	147.22	444.28
195	211	91.98	459.23
196	212	110.83	462.48

	Number of peaks	Is active	Occurrences in global events \
1	5	True	1
3	5	True	0
8	8	True	1
9	8	True	1
10	5	True	1
..
192	7	True	0
193	6	True	1
194	10	True	1
195	6	True	1
196	7	True	1

	Occurrences in global events as early peaker \
1	0
3	0
8	0
9	0
10	0
..	..
192	0
193	1
194	0
195	0
196	0

	Occurrences in sequential events \
1	1
3	3
8	5
9	4
10	2

```

...
192          ...
193          5
194          1
195          3
196          5
197          2

    Occurrences in sequential events as origin \
1           0
3           2
8           1
9           2
10          0
...
192          ...
193          1
194          0
195          2
196          1

    Occurrences in individual events  Peak frequency (Hz) Periodicity score \
1           3           0.0029          0.56
3           2           0.0029          0.77
8           2           0.0047          0.69
9           3           0.0047          0.58
10          2           0.0029          0.65
...
192          ...
193          ...
194          ...
195          ...
196          ...

    Neighbor count      Neighbors (labels)      dataset \
1           4           [4,6,9,13]      20250409_IS07
3           8           [6,10,12,15,16,18,19,20] 20250409_IS07
8           5           [7,15,17,23,25] 20250409_IS07
9           7           [4,5,9,11,14,21,27] 20250409_IS07
10          6           [6,9,10,13,24,27] 20250409_IS07
...
192          ...
193          ...
194          ...
195          ...
196          ...

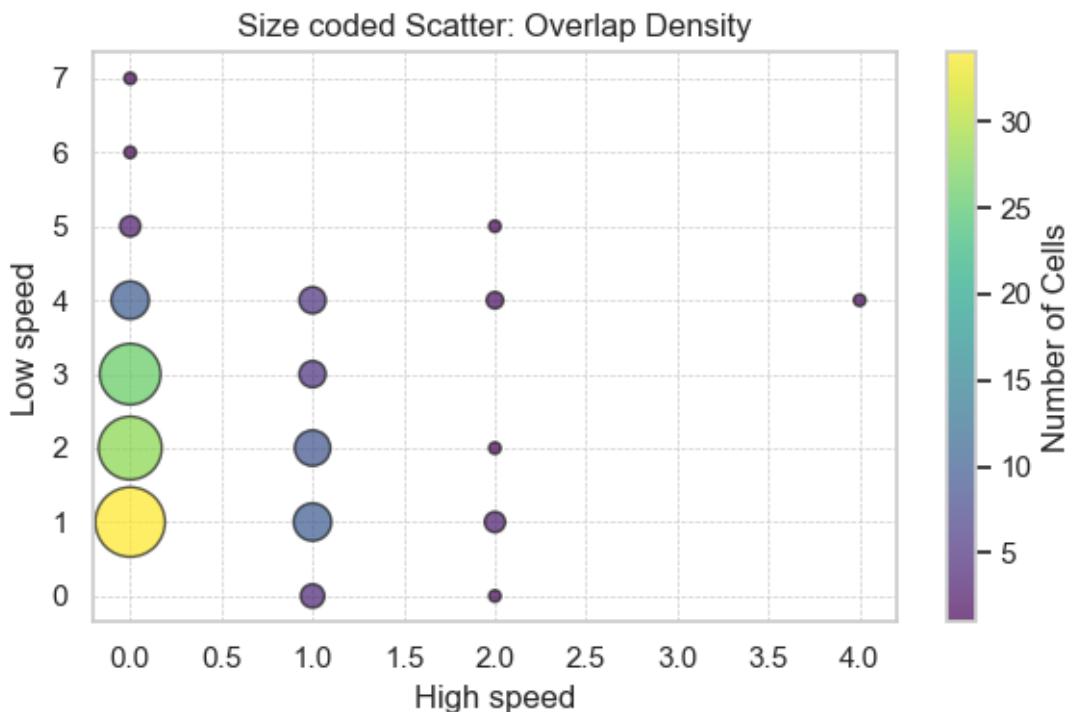
    Involved in sequential event Occurrences in sequential events category \
1     Involved in sequential event                                1-2

```

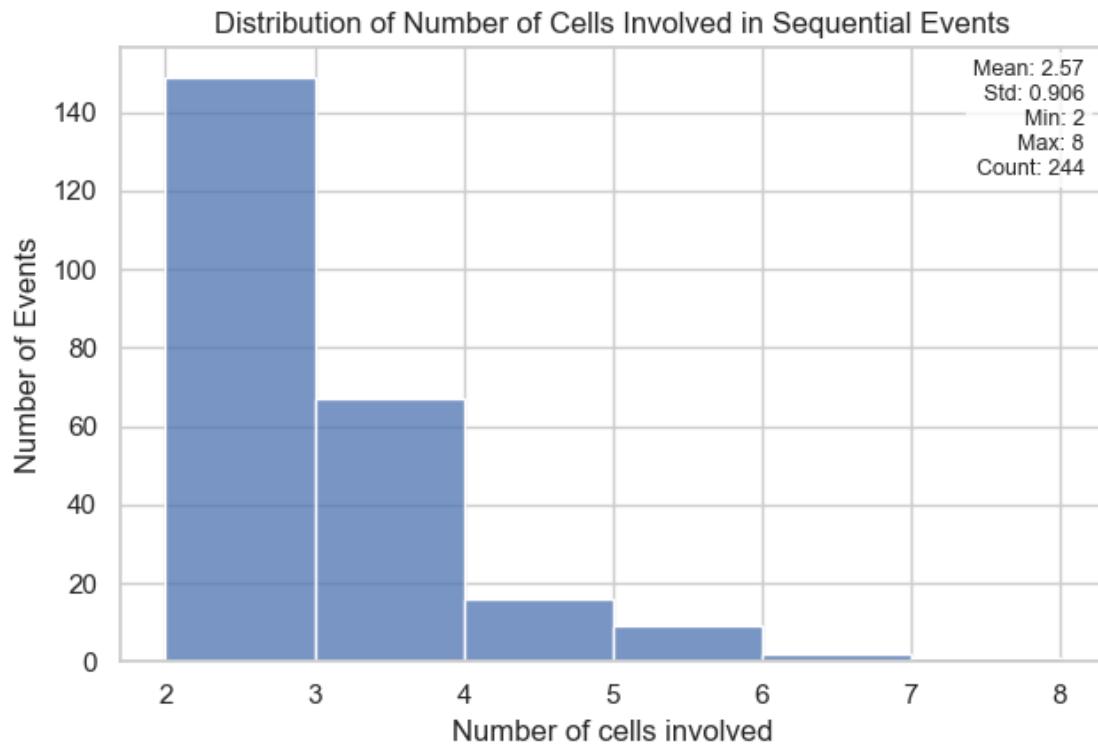
3	Involved in sequential event	3-4
8	Involved in sequential event	5-9
9	Involved in sequential event	3-4
10	Involved in sequential event	1-2
..
192	Involved in sequential event	5-9
193	Involved in sequential event	1-2
194	Involved in sequential event	3-4
195	Involved in sequential event	5-9
196	Involved in sequential event	1-2

	High speed	Low speed
1	0.0	1.0
3	1.0	3.0
8	0.0	1.0
9	0.0	2.0
10	0.0	1.0
..
192	0.0	1.0
193	0.0	1.0
194	1.0	1.0
195	0.0	3.0
196	2.0	0.0

[145 rows x 19 columns]



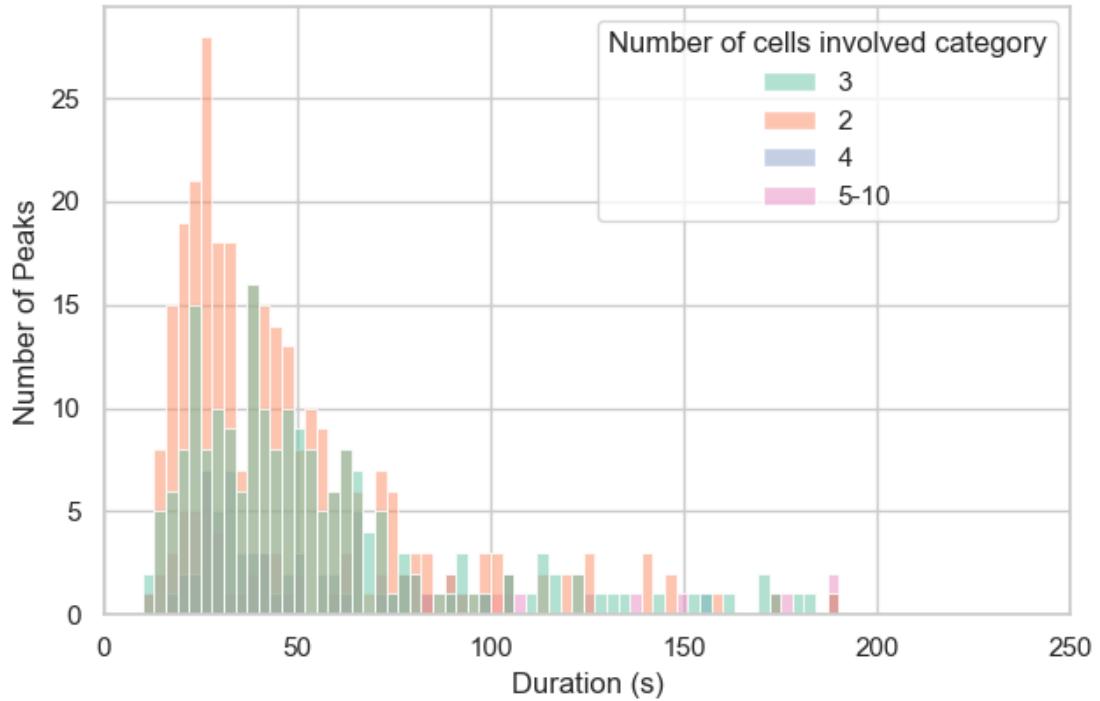
1.3.5 Number of cells involved per sequential events



1.3.6 Influence of cell count per event on statistics

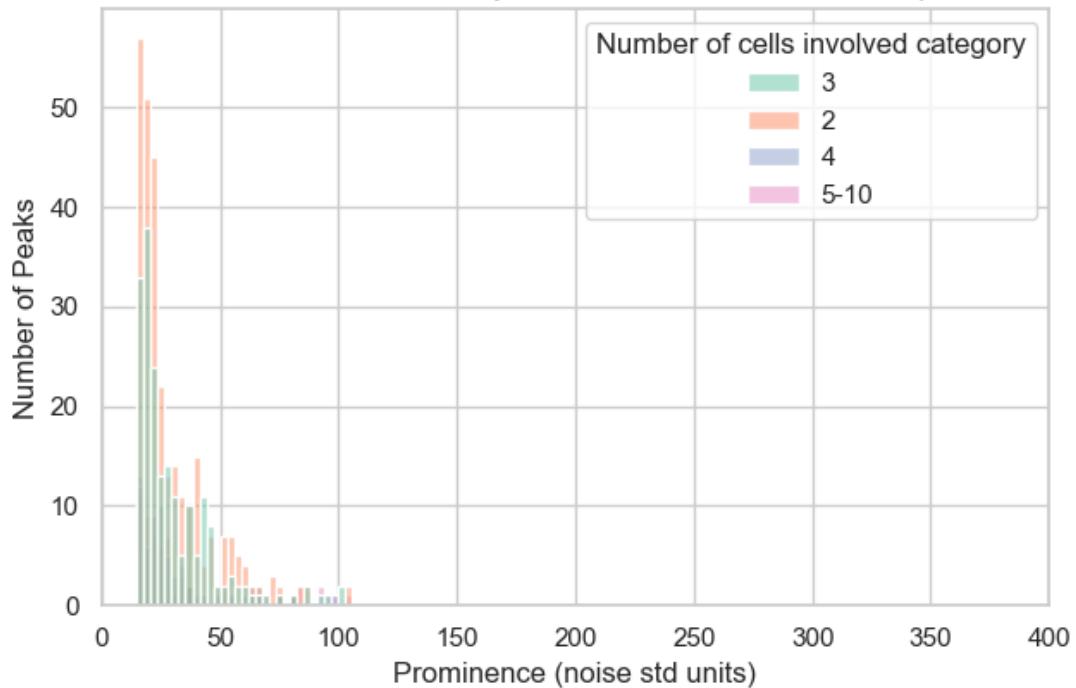
```
[2025-08-13 11:37:50] [INFO] calcium: plot_histogram_by_group: removed 14 outliers out of 628 on 'Duration (s)' (lower=-28, upper=191)
```

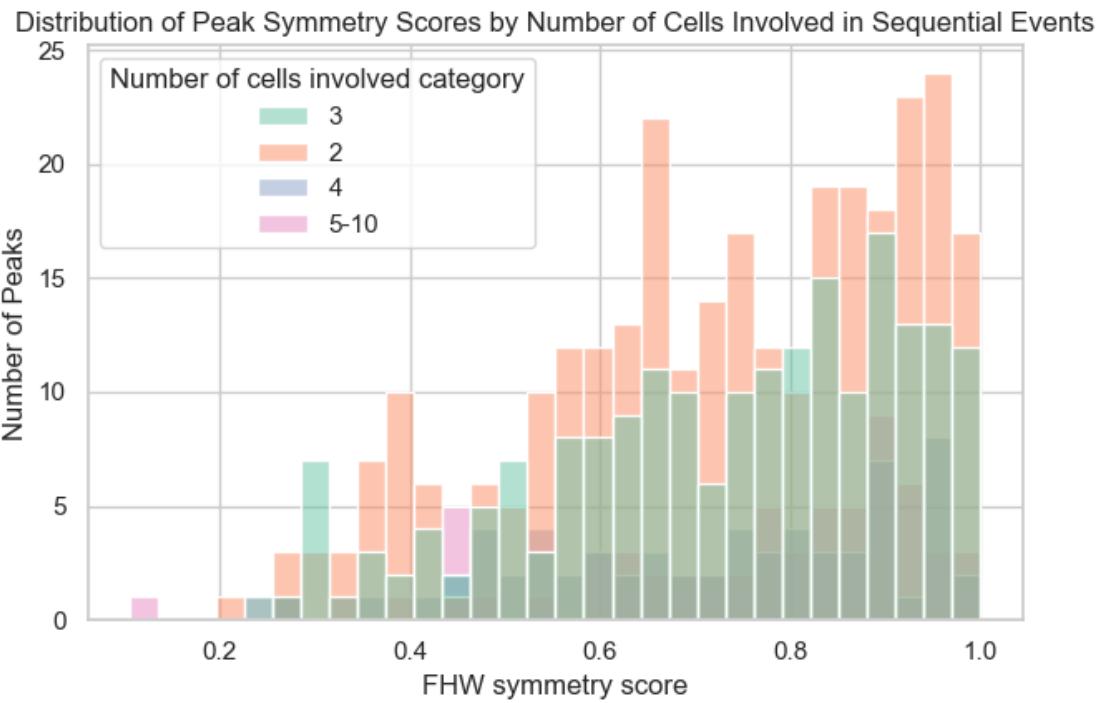
Distribution of Peak Durations by Number of Cells Involved in Sequential Events



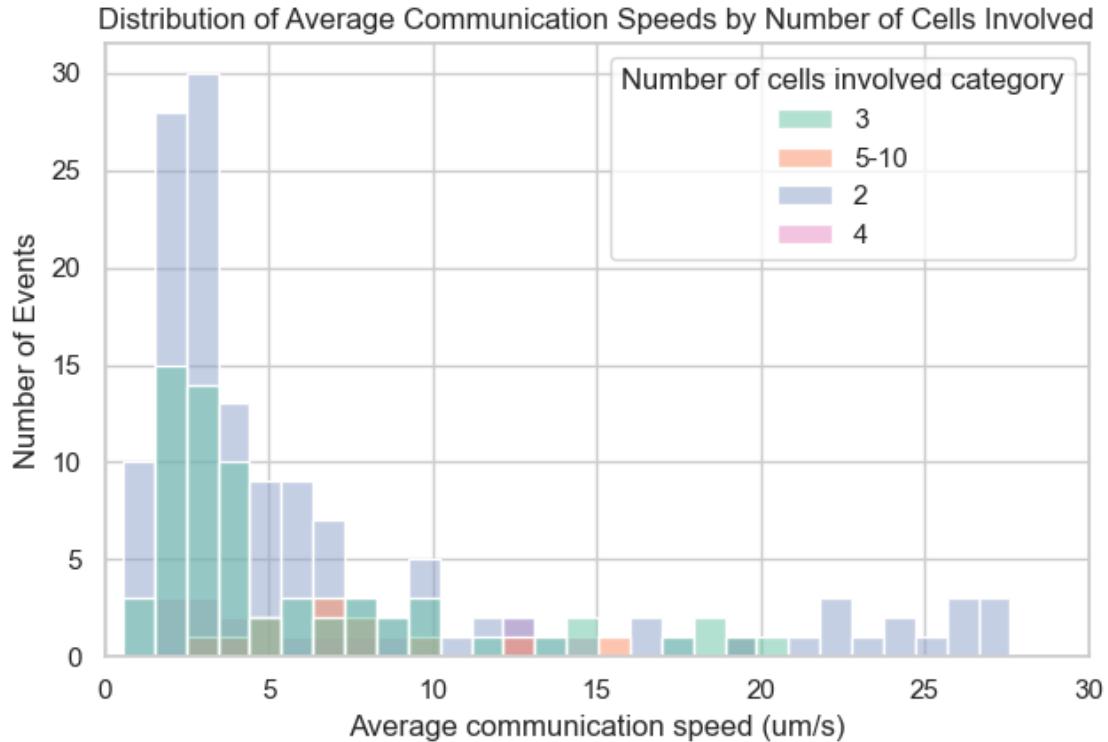
```
[2025-08-13 11:37:50] [INFO] calcium: plot_histogram_by_group: removed 19 outliers out of 628 on 'Prominence (noise std units)' (lower=-10.4, upper=107.2)
```

Distribution of Peak Prominences by Number of Cells Involved in Sequential Events

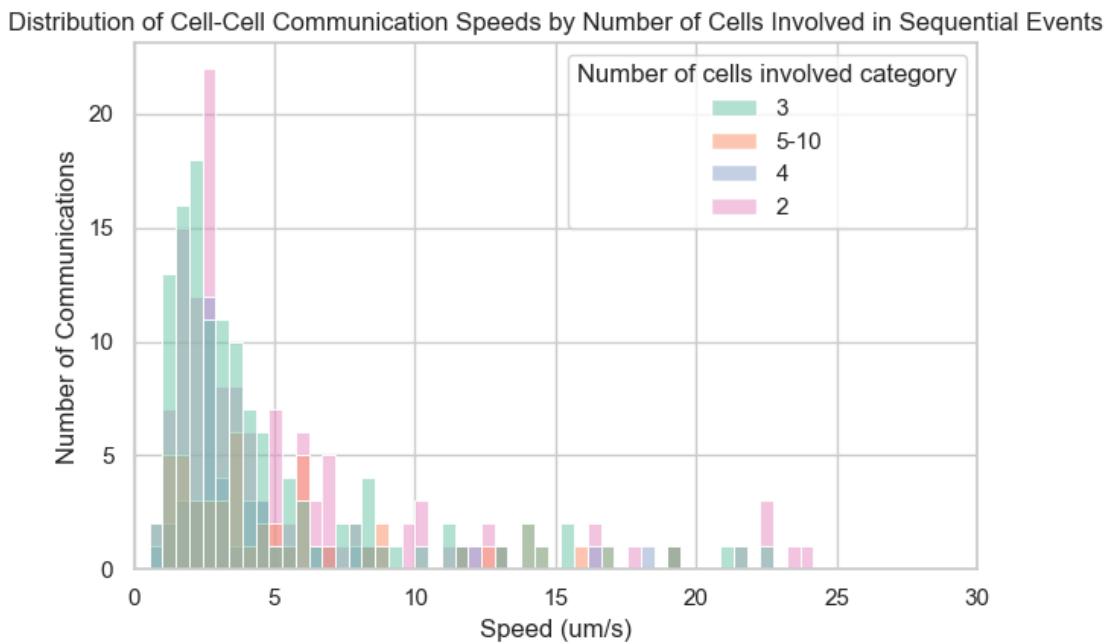




```
[2025-08-13 11:37:51] [INFO] calcium: plot_histogram_by_group: removed 10 outliers out of 244 on 'Average communication speed (um/s)' (lower=-16.5, upper=27.828)
```

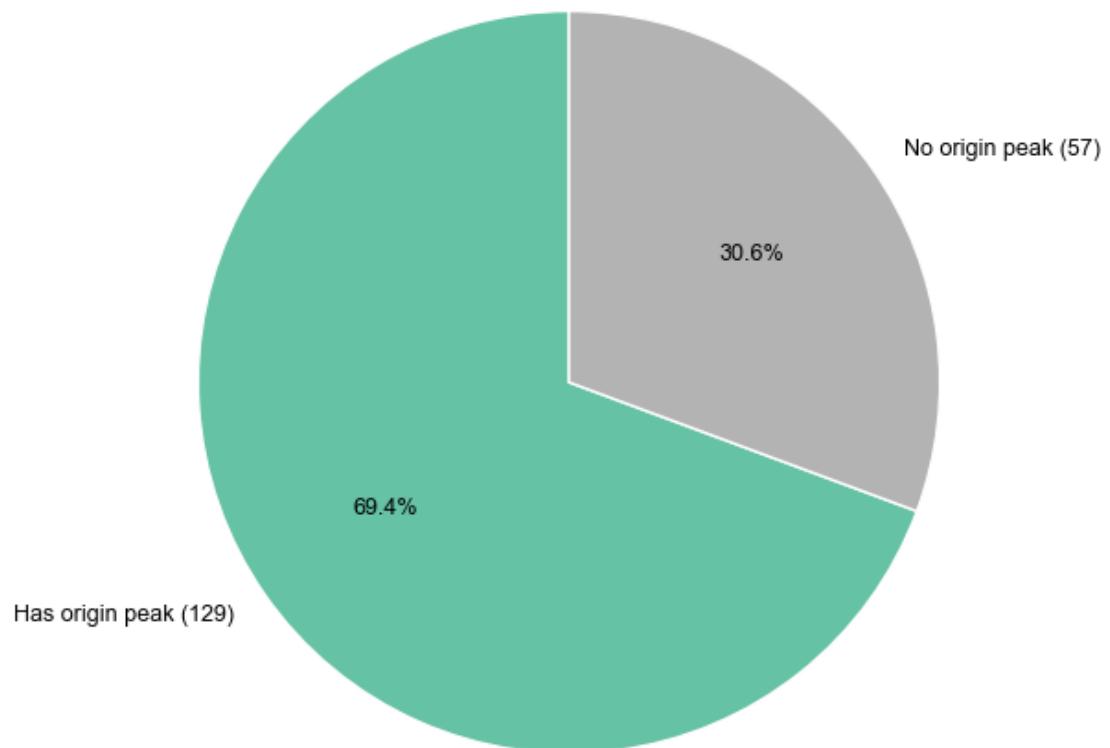


```
[2025-08-13 11:37:51] [INFO] calcium: plot_histogram_by_group: removed 31 outliers out of 384 on 'Speed (um/s)' (lower=-14.235, upper=24.265)
```

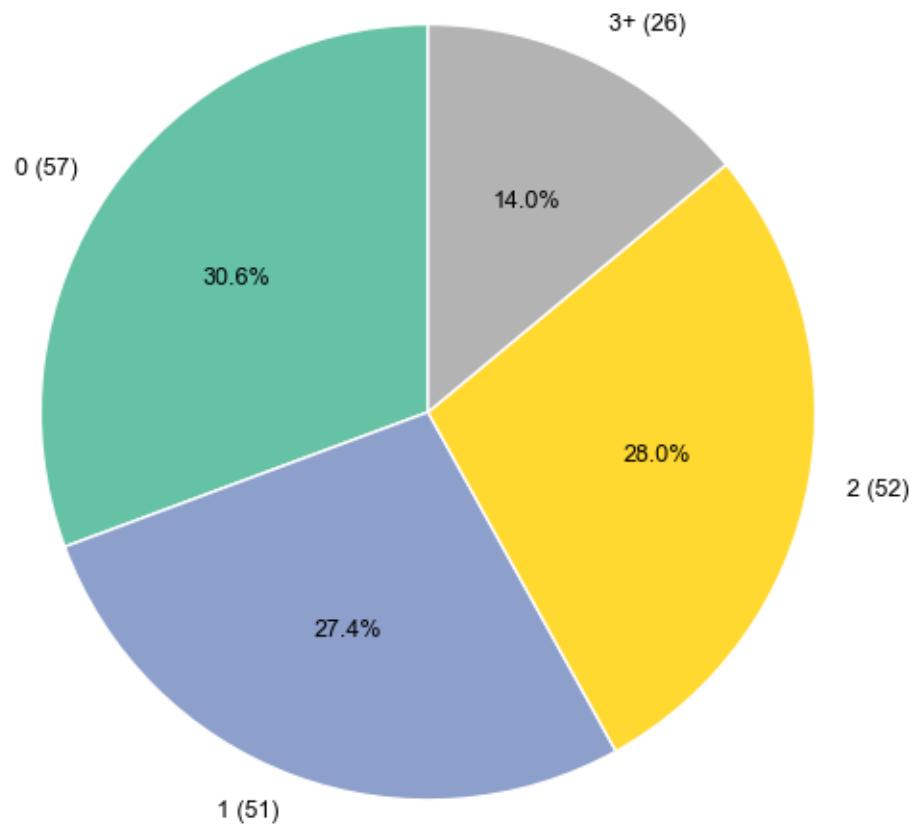


1.3.7 Cells occurrences as origin in sequential events

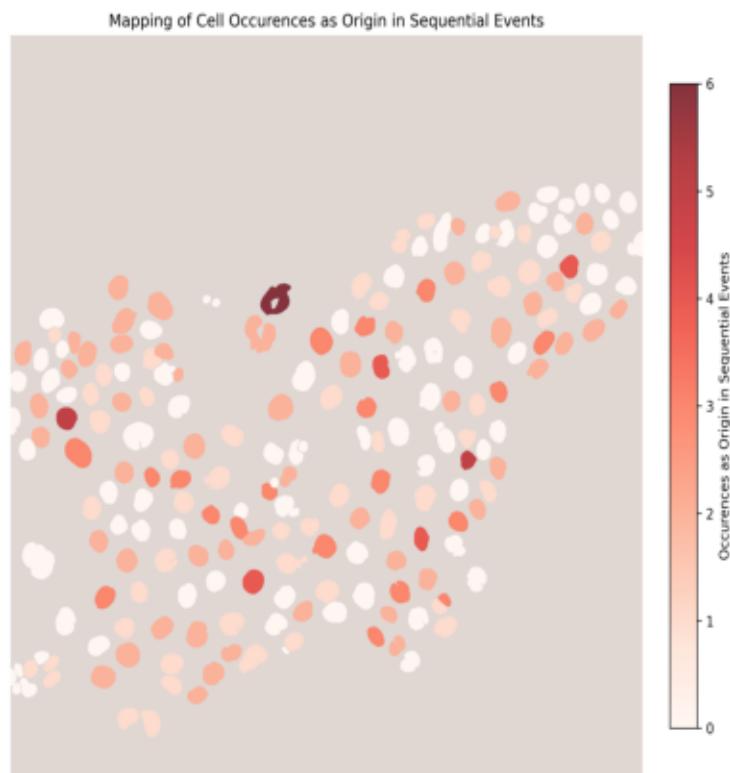
Distribution of Number of Sequential Event Origin Peaks per Cell



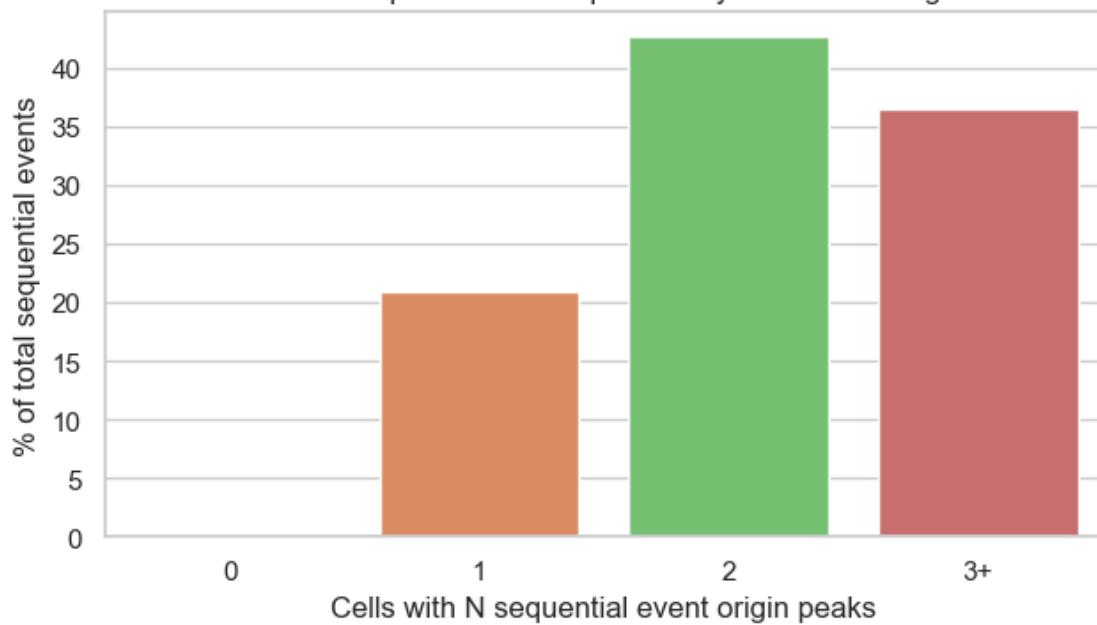
Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)



Cell Mapping with Origin Peaks Overlay - 20250409_IS07

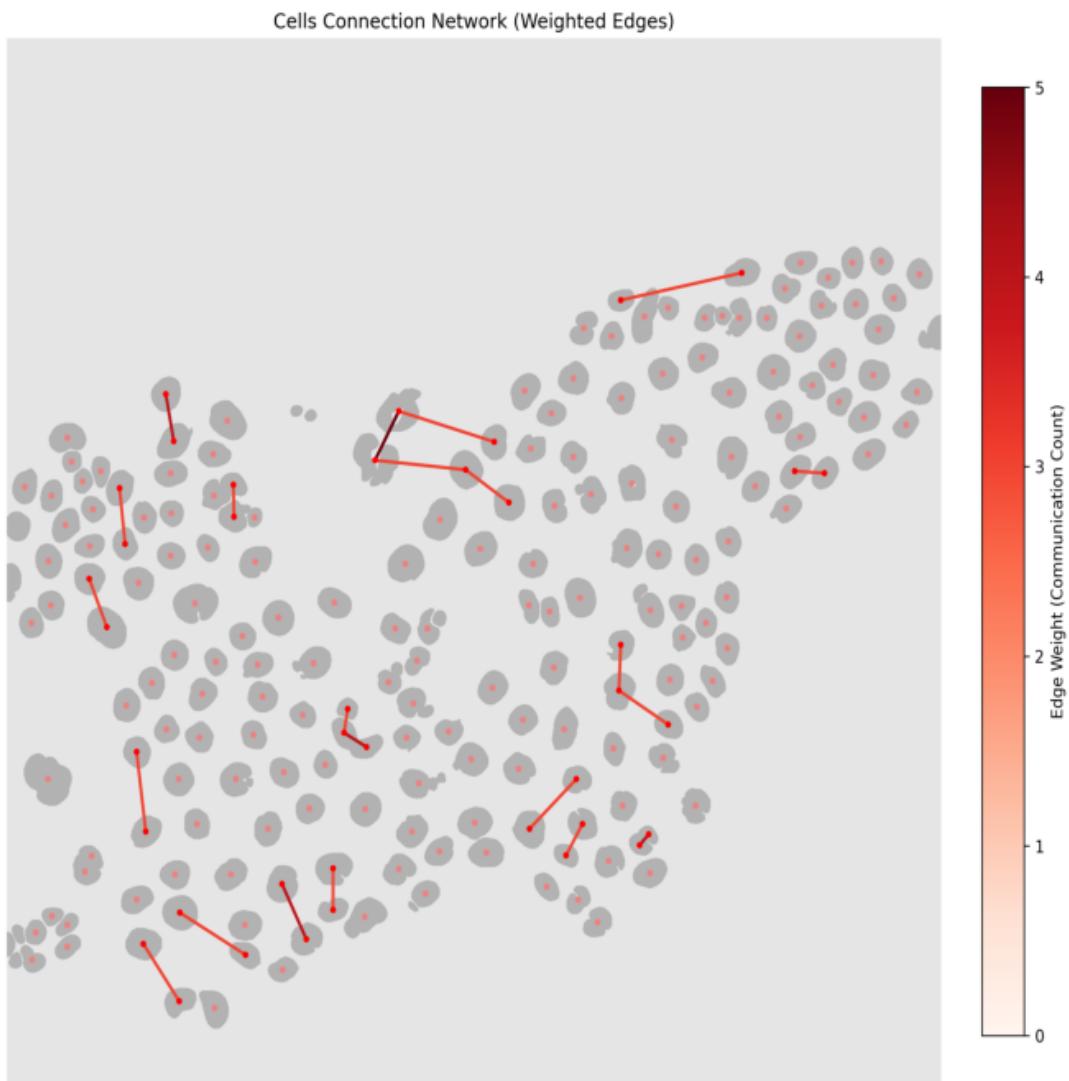


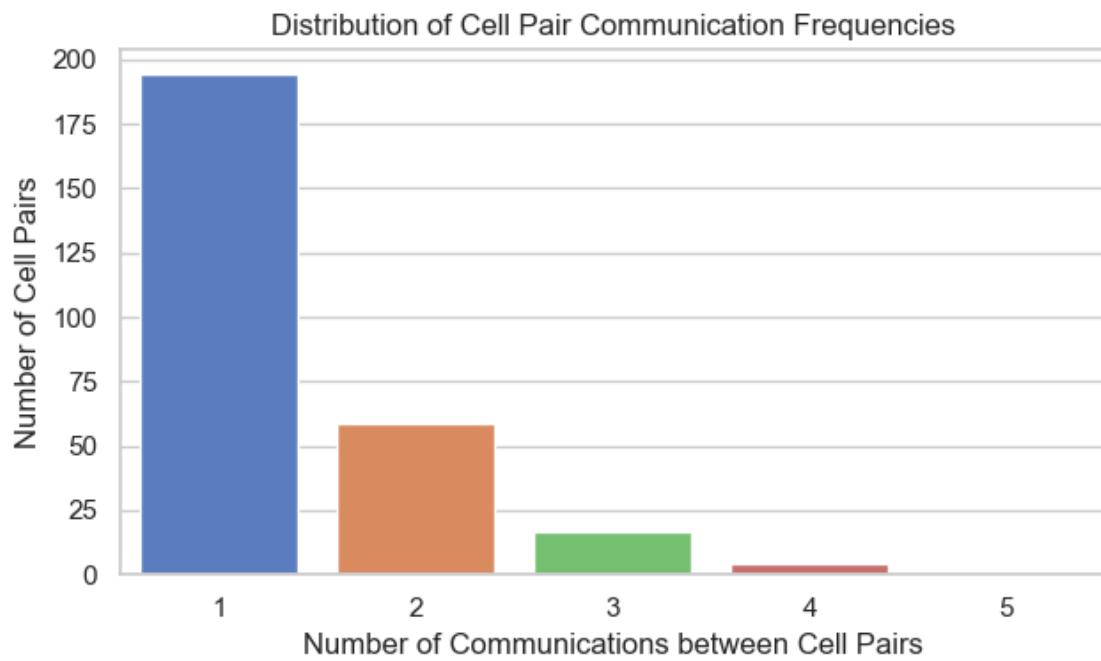
Distribution of Sequential Events per Cell by Number of Origin Peaks



1.3.8 Connection network between cells

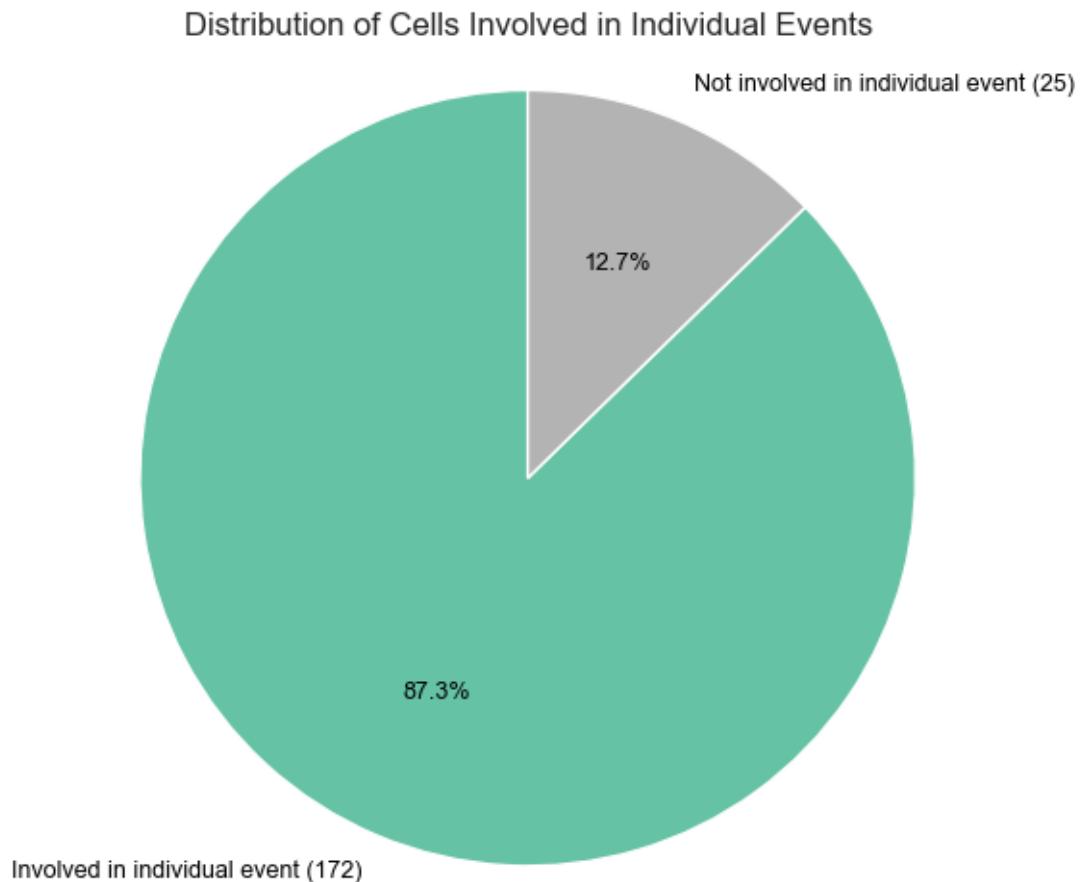
Cell Connection Network Graph - 20250409_IS07



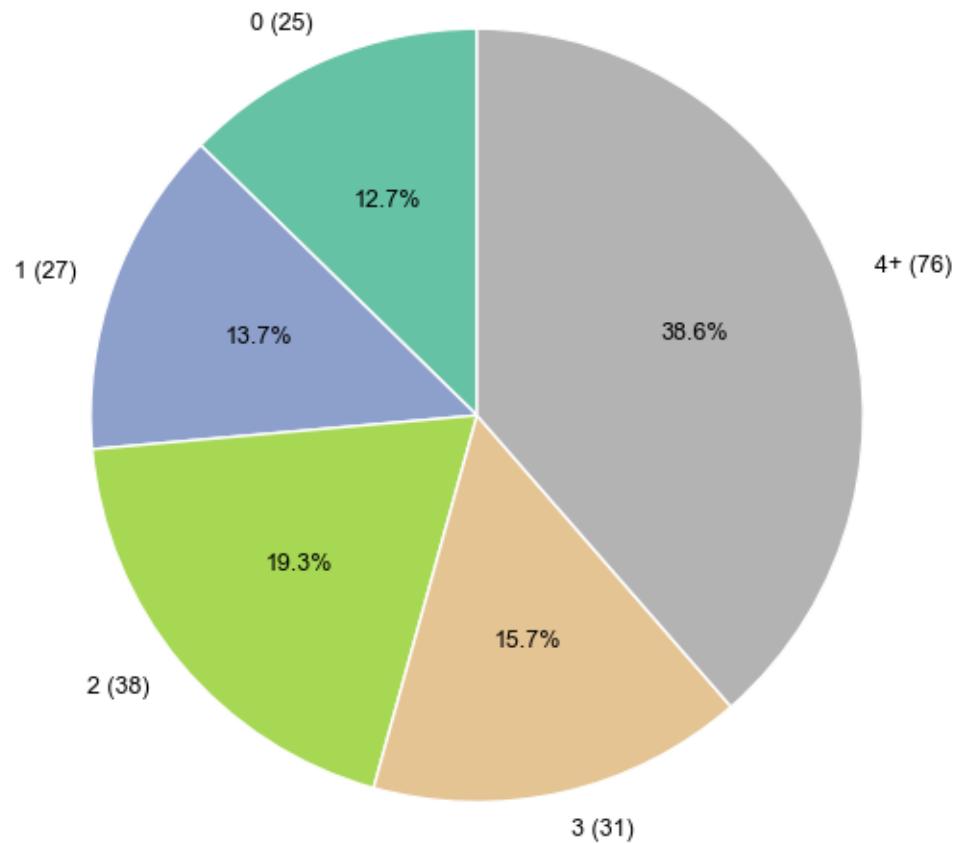


1.4 INDIVIDUAL EVENTS

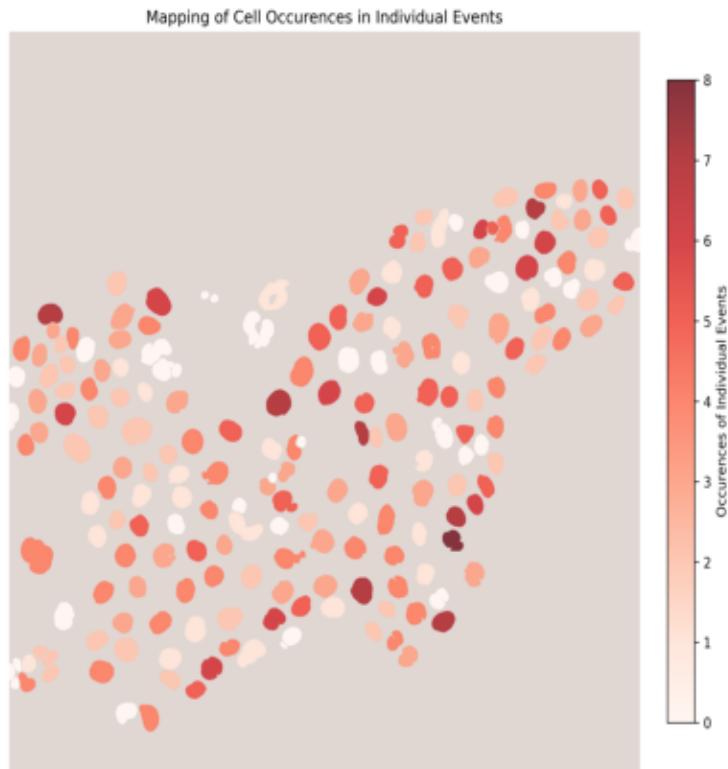
1.4.1 Cells occurrences in individual events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

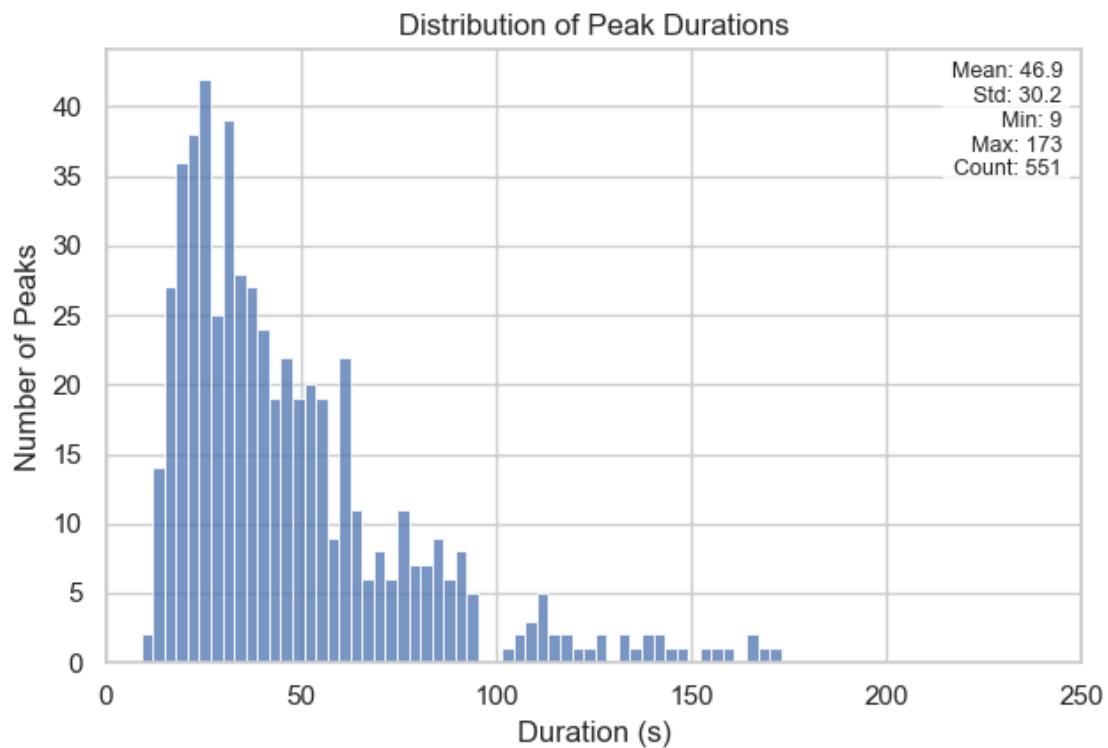


Cell Mapping with Occurrences in Individual Events Overlay - 20250409_IS07

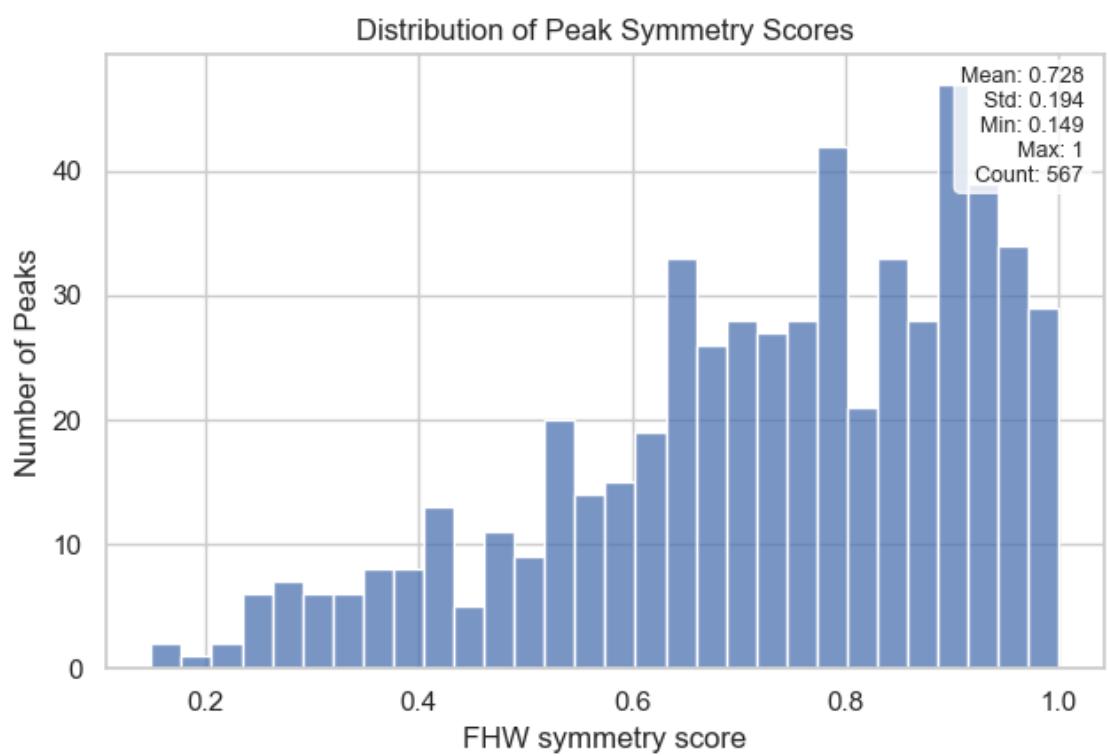
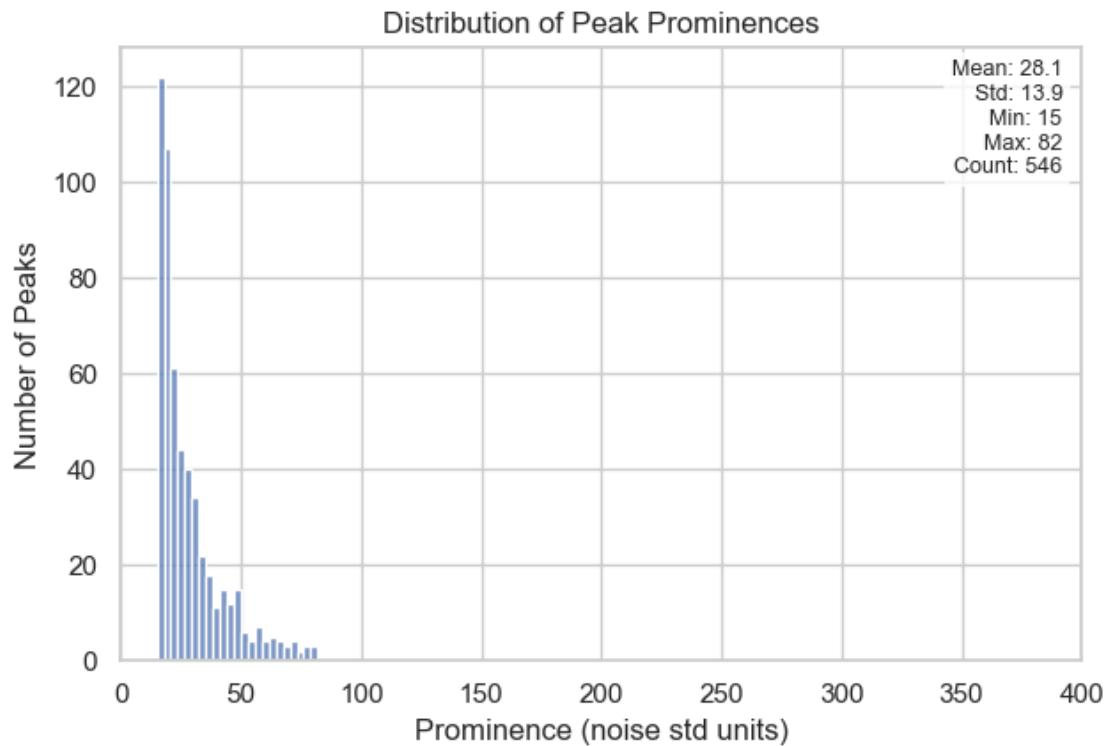


1.4.2 Peaks statistics in individual events

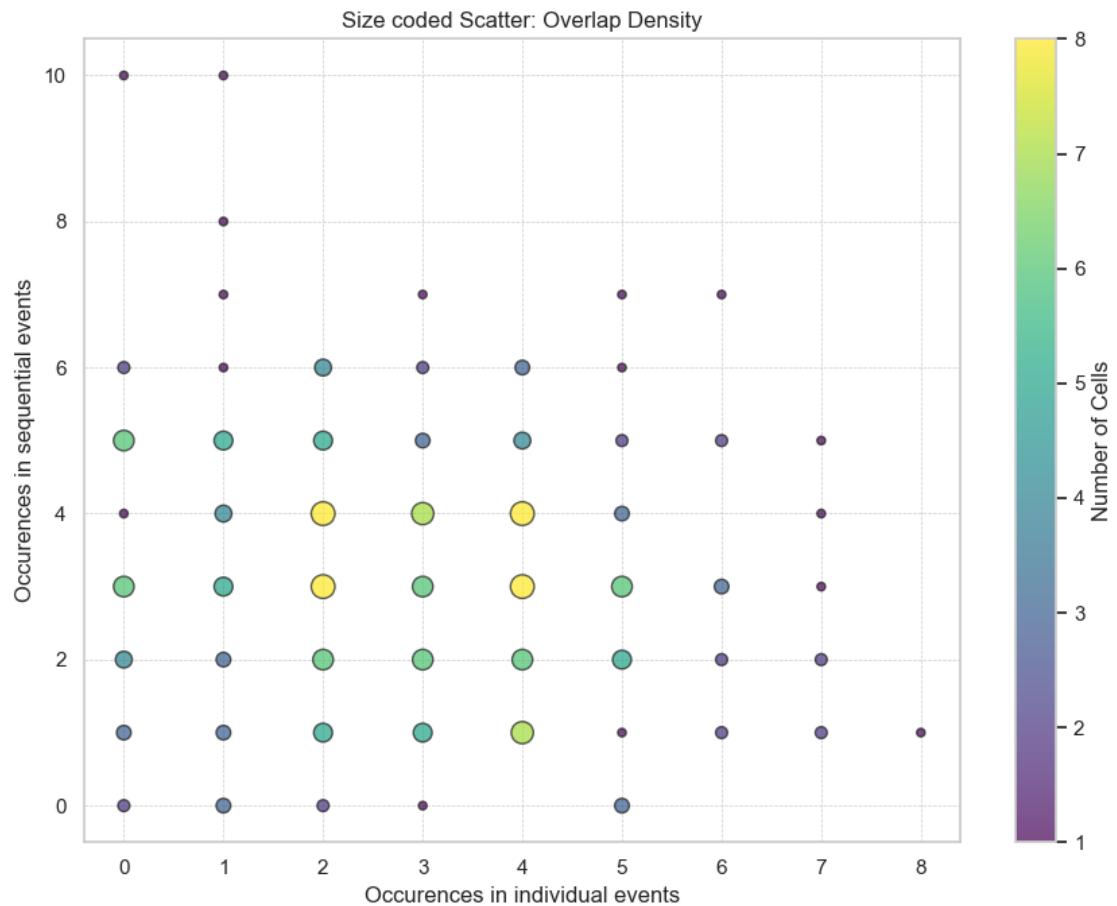
```
[2025-08-13 11:37:56] [INFO] calcium: plot_histogram: removed 16 outliers out of 567 on 'Duration (s)' (lower=-86, upper=173)
```



```
[2025-08-13 11:37:57] [INFO] calcium: plot_histogram: removed 21 outliers out of 567 on 'Prominence (noise std units)' (lower=-29.6, upper=82.4)
```



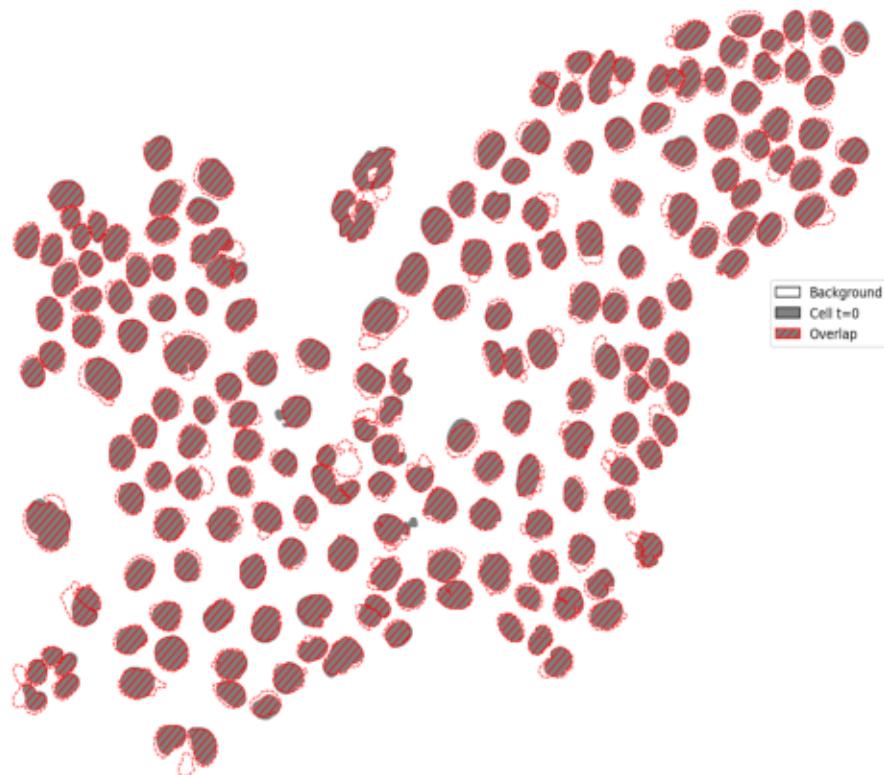
1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250409_IS07

Cell Motion Overlay



Number of cells:

- Hoechst image taken at t=0: 197
- Hoechst image taken at t=1801: 200
- Number of cells difference: absolute 3, relative 1.51%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 333101
- Pixels segmented as cell at t=1801: 378795
- Overlapping pixels between t=0 and t=1801: 317727 (89.26% of total)
- Pixels exclusive to t=0: 15374 (4.61% of total)
- Pixels exclusive to t=1801: 61068 (16.12% of total)

executed

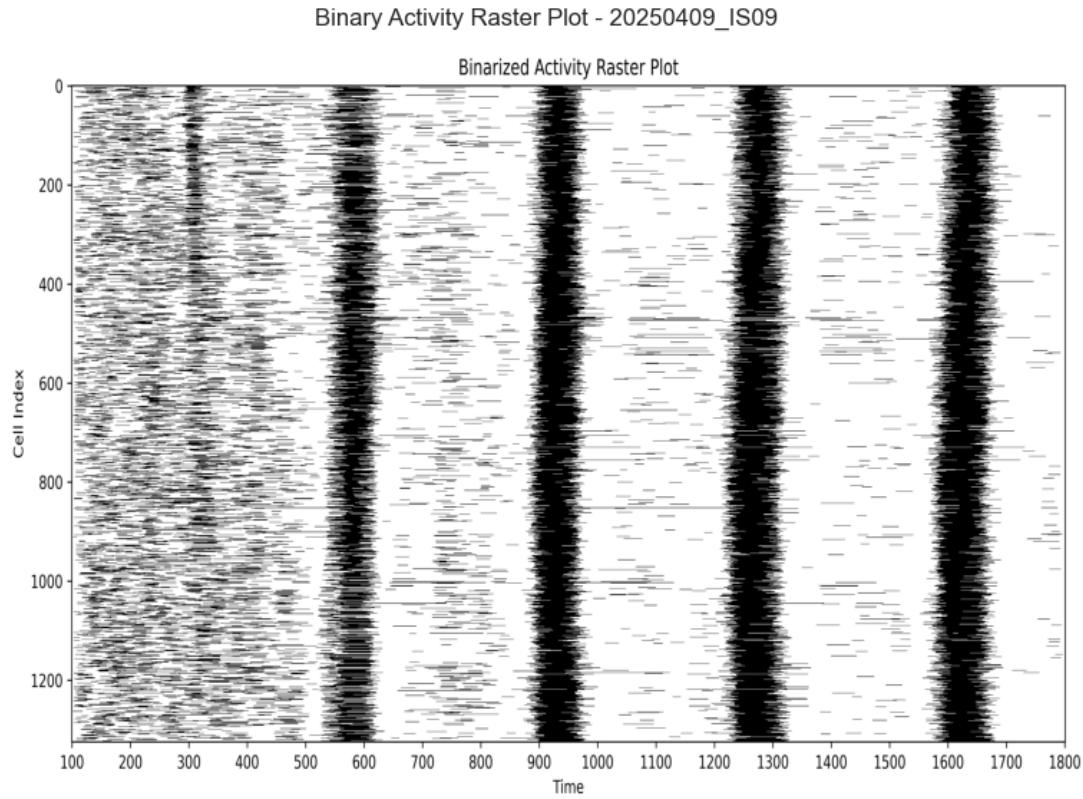
August 13, 2025

1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

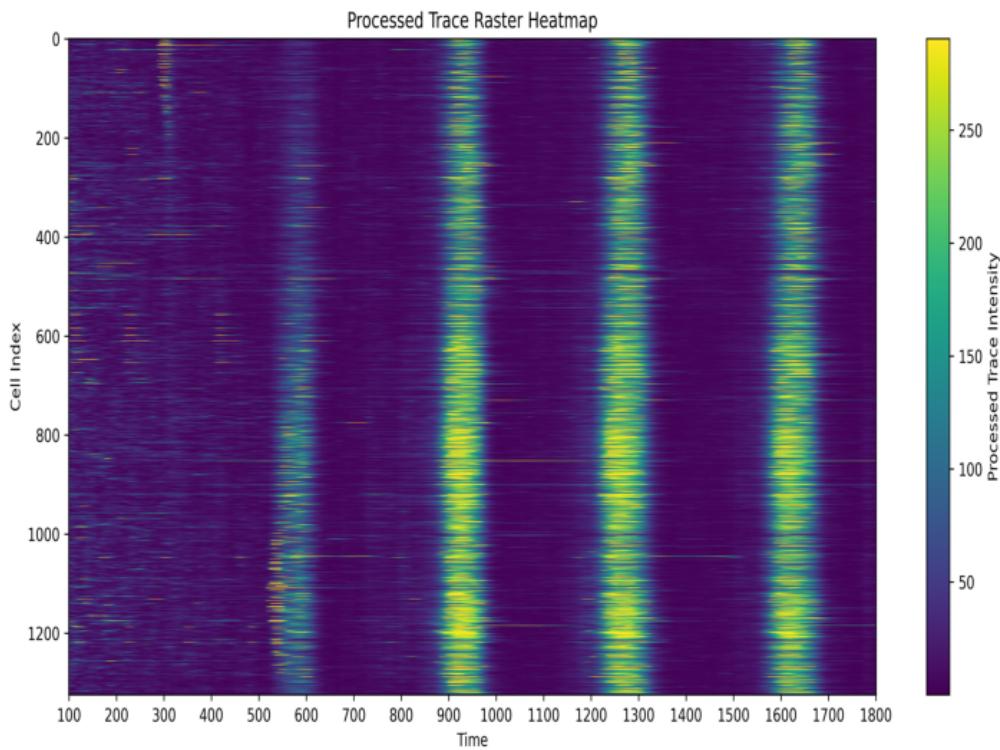
1.0.1 Initialization

1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot



Heatmap Activity Raster Plot - 20250409_IS09



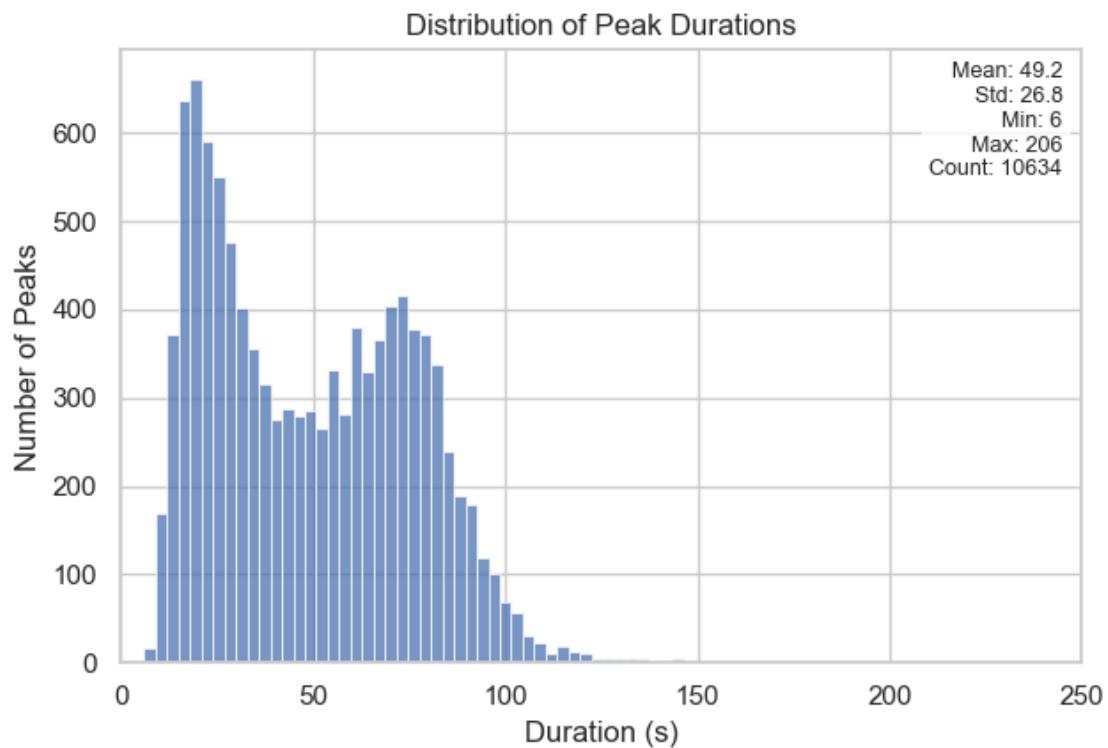
1.1.2 Peaks population

Total number of peaks: 10638

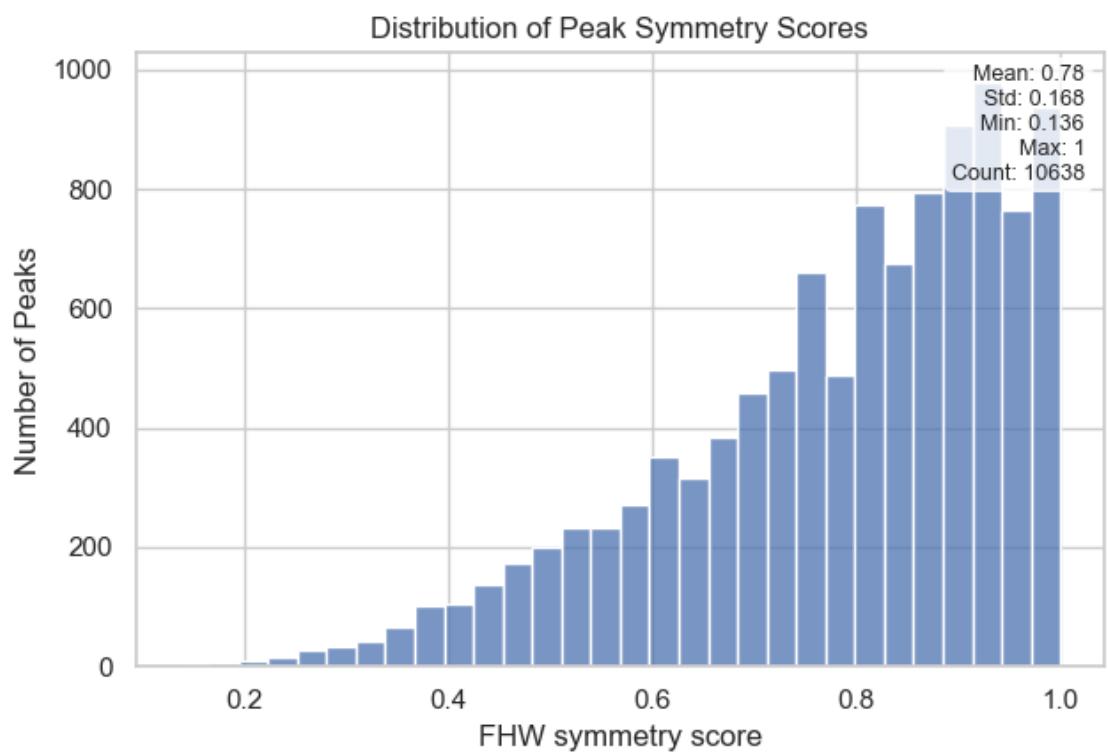
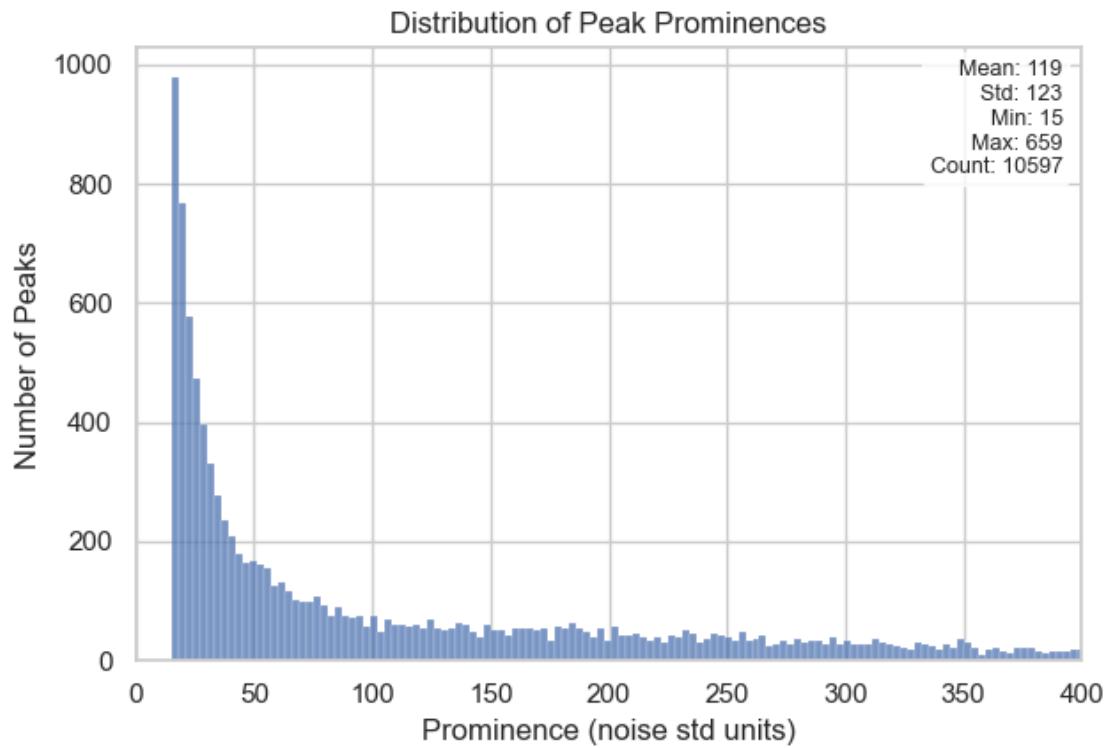
Total number of cells: 1325

1.1.3 Peaks statistics

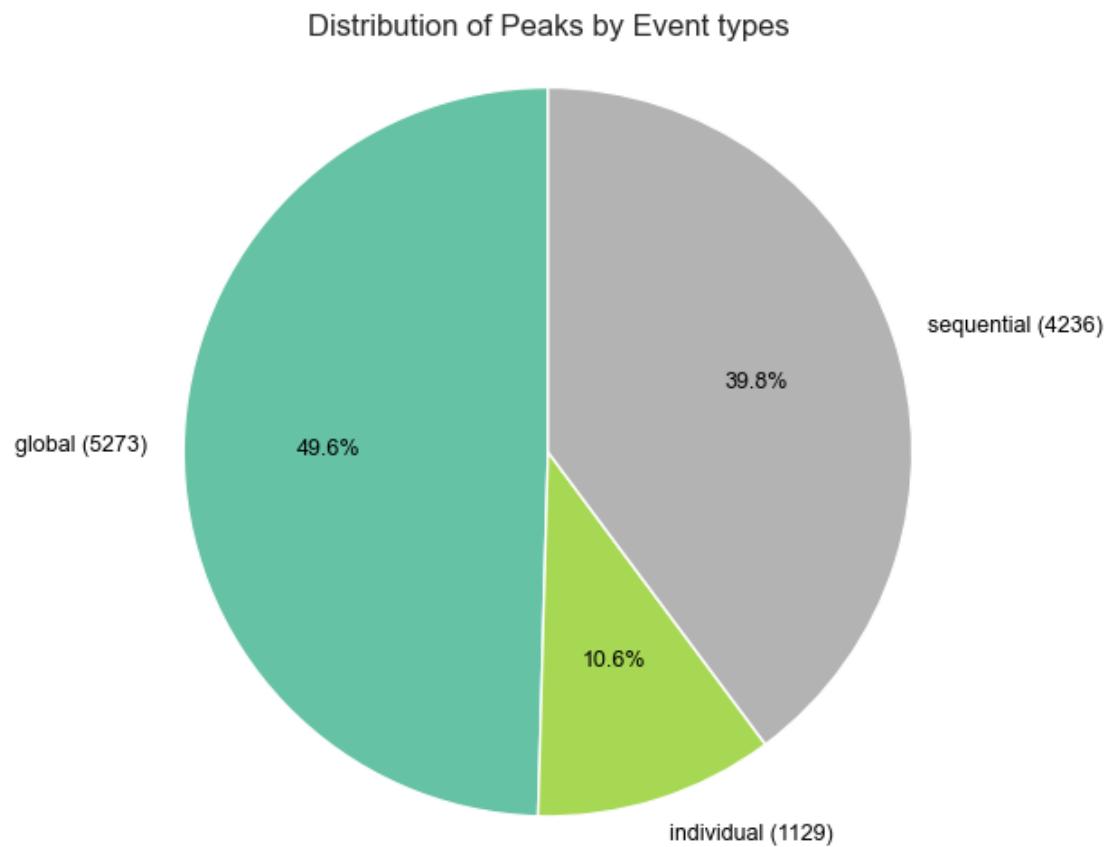
```
[2025-08-13 11:39:23] [INFO] calcium: plot_histogram: removed 4 outliers out of  
10638 on 'Duration (s)' (lower=-113, upper=209)
```



```
[2025-08-13 11:39:23] [INFO] calcium: plot_histogram: removed 41 outliers out of 10638 on 'Prominence (noise std units)' (lower=-449.93, upper=660.8)
```

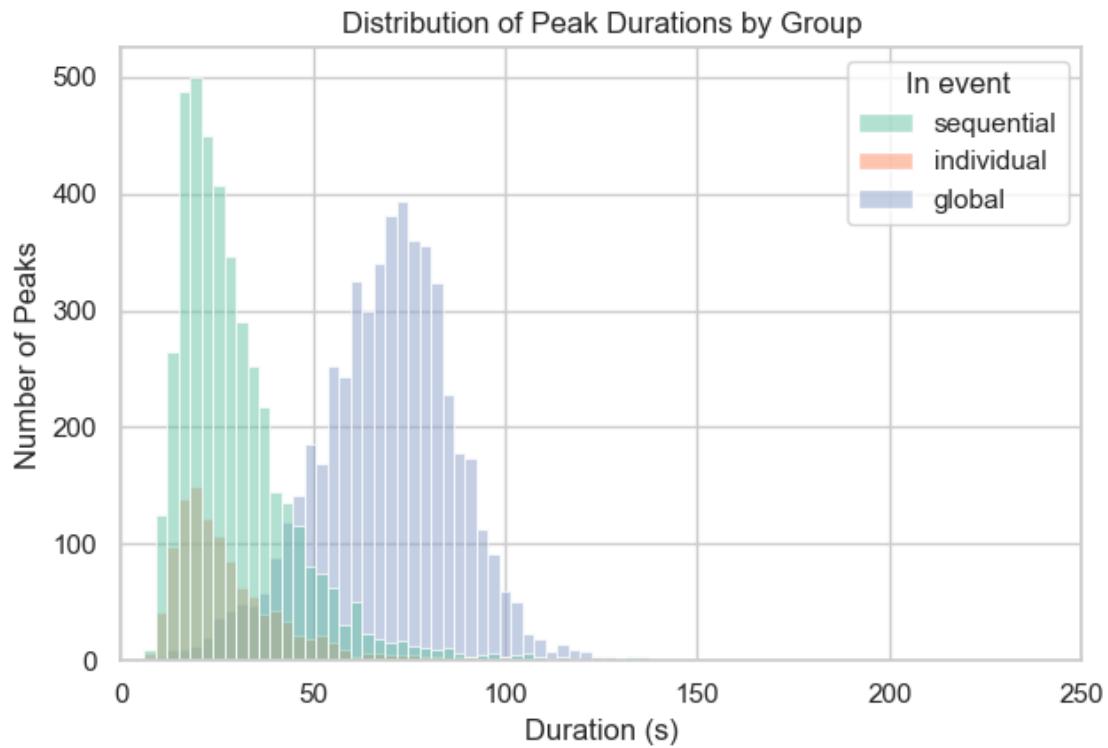


1.1.4 Distribution of peaks per event types



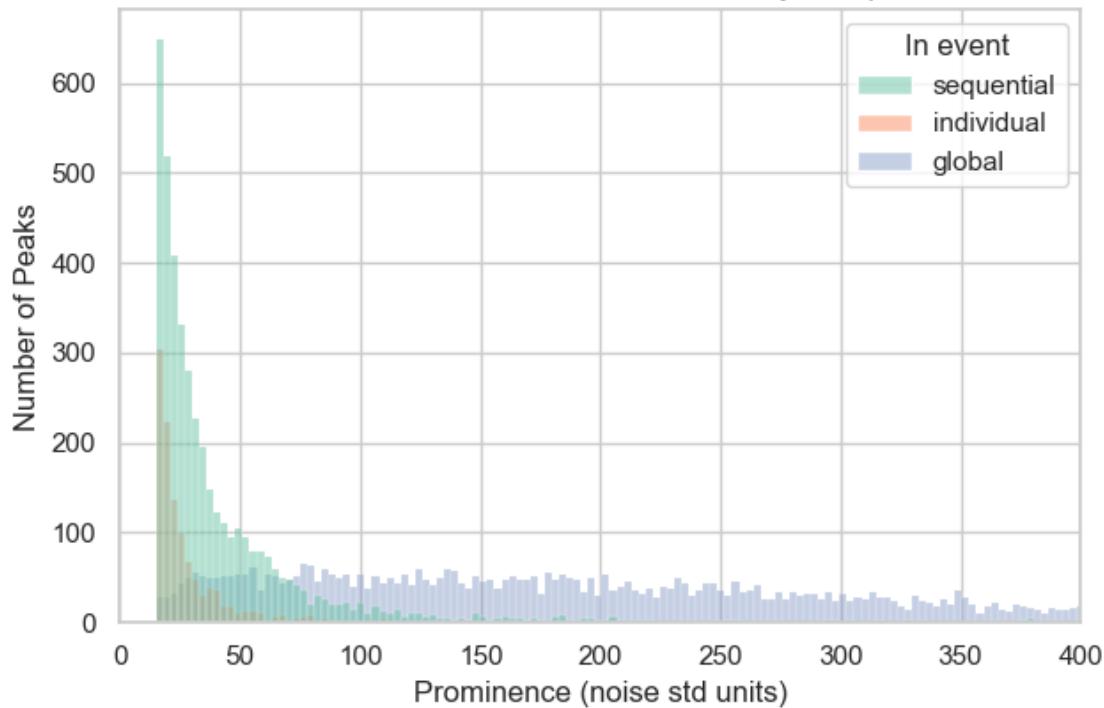
1.1.5 Peaks statistics per event types

```
[2025-08-13 11:39:24] [INFO] calcium: plot_histogram_by_group: removed 4 outliers out of 10638 on 'Duration (s)' (lower=-113, upper=209)
```

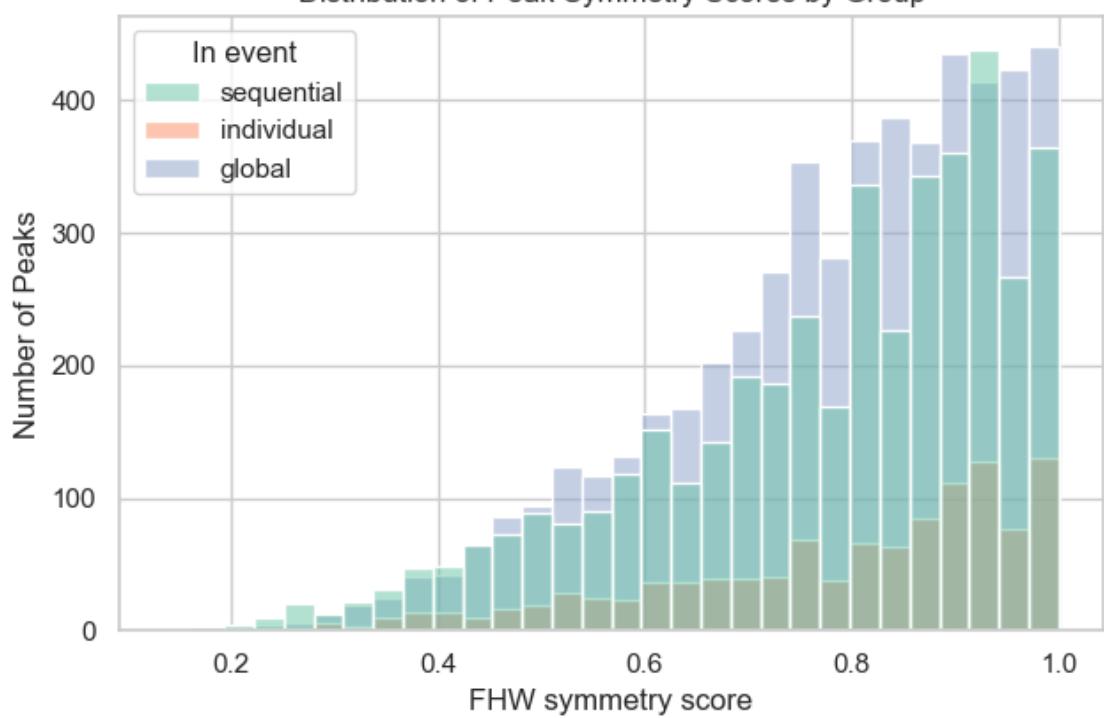


```
[2025-08-13 11:39:24] [INFO] calcium: plot_histogram_by_group: removed 41
outliers out of 10638 on 'Prominence (noise std units)' (lower=-449.93,
upper=660.8)
```

Distribution of Peak Prominences by Group



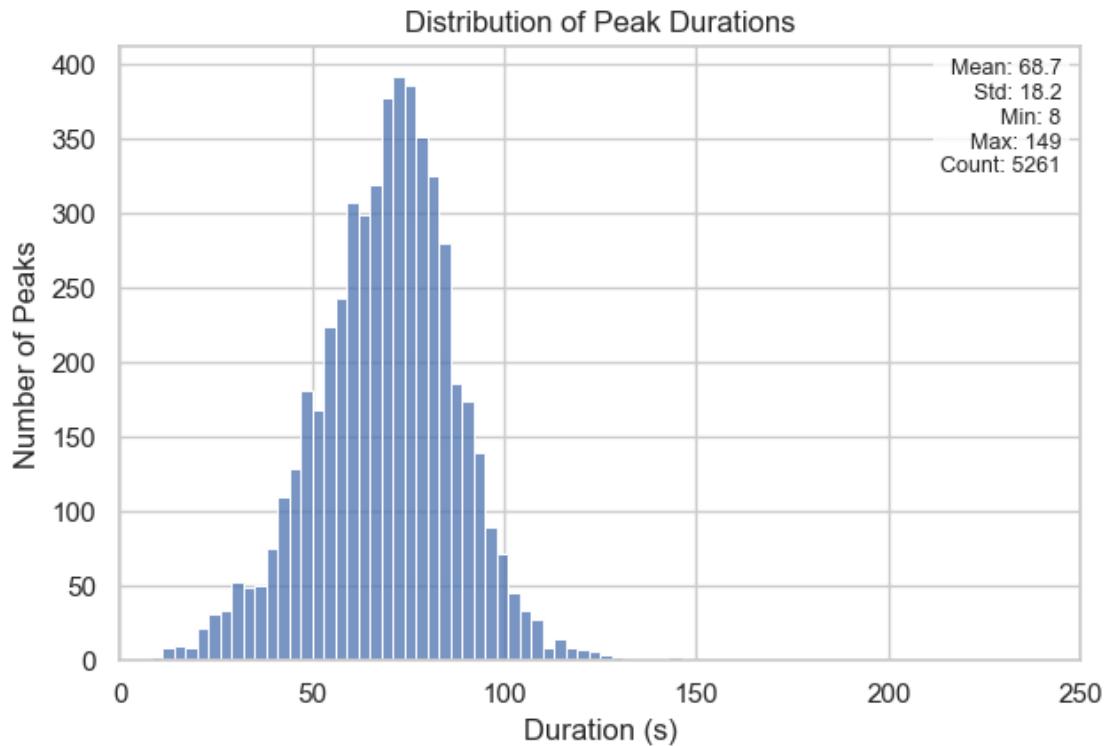
Distribution of Peak Symmetry Scores by Group



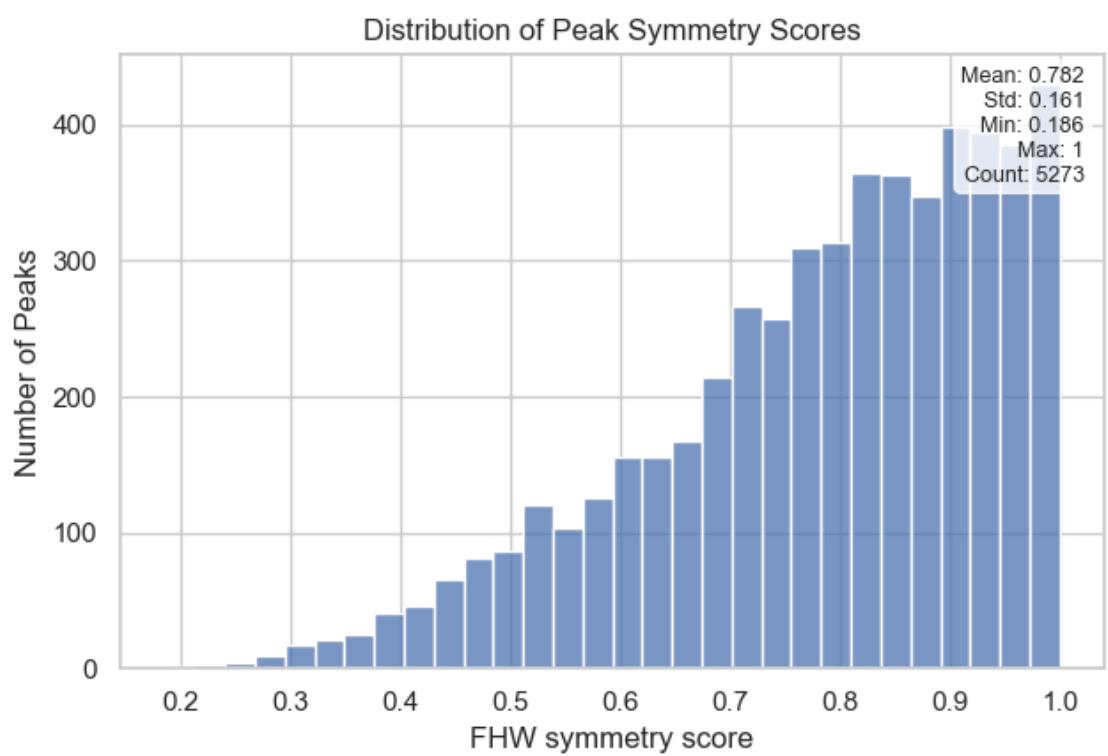
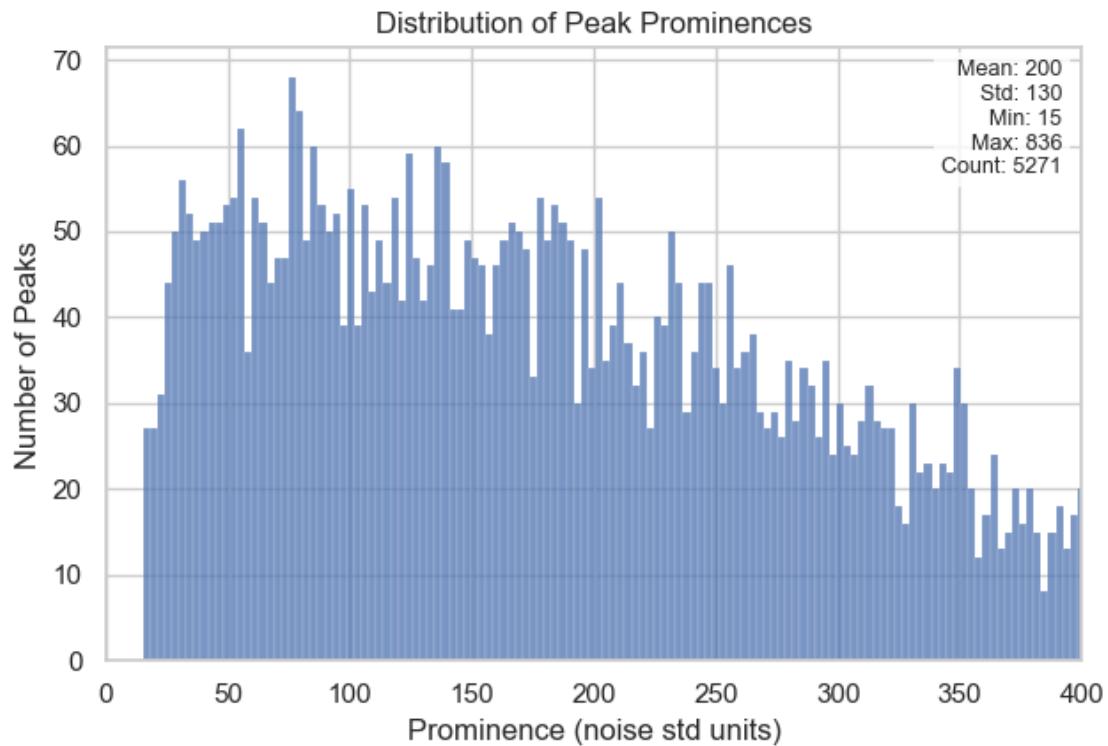
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

[2025-08-13 11:39:25] [INFO] calcium: plot_histogram: removed 12 outliers out of 5273 on 'Duration (s)' (lower=-11, upper=150)

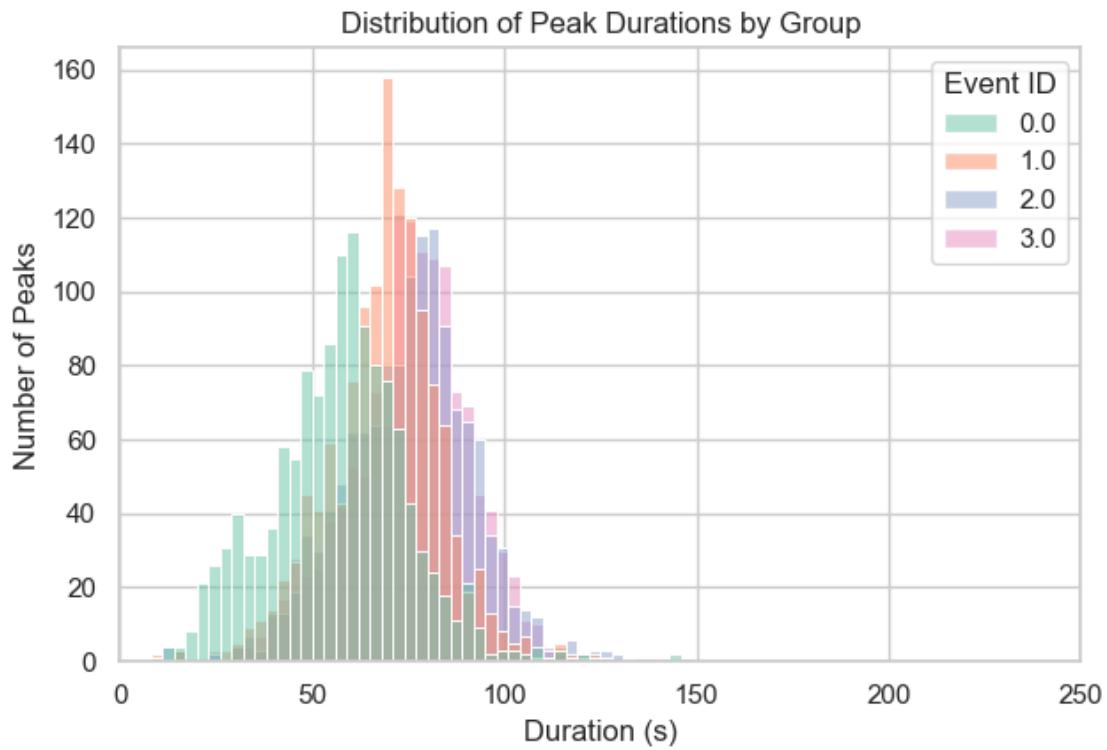


[2025-08-13 11:39:25] [INFO] calcium: plot_histogram: removed 2 outliers out of 5273 on 'Prominence (noise std units)' (lower=-461.2, upper=837.3)



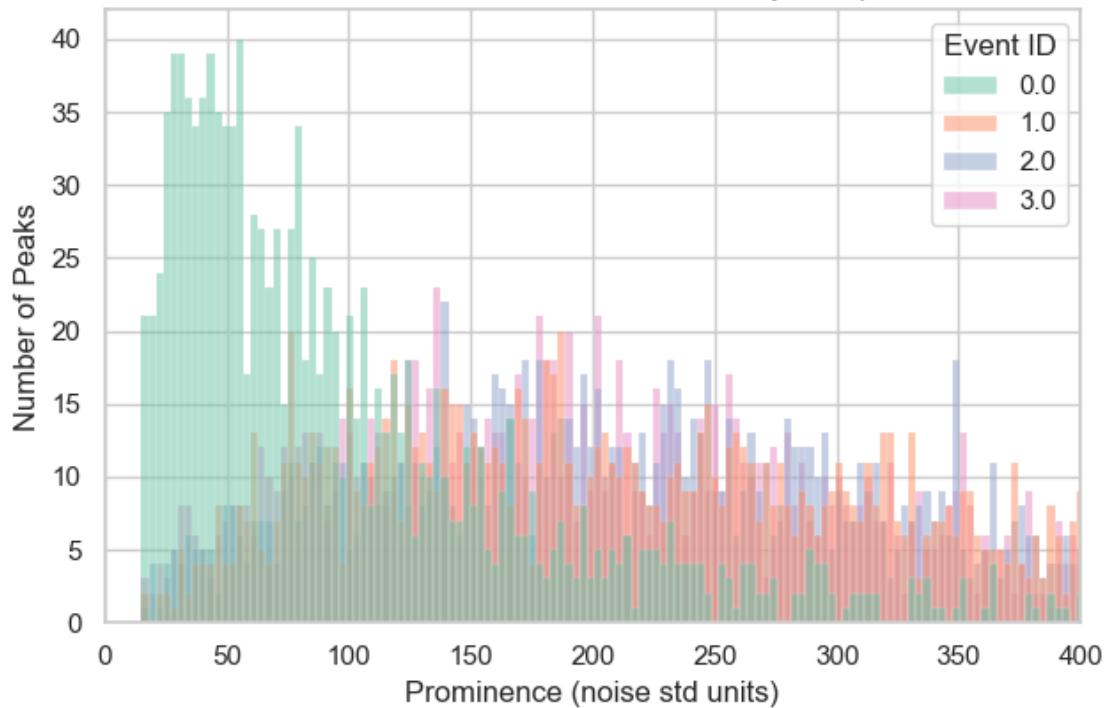
1.2.2 Peak statistics in global event per event ID

[2025-08-13 11:39:26] [INFO] calcium: plot_histogram_by_group: removed 12 outliers out of 5273 on 'Duration (s)' (lower=-11, upper=150)

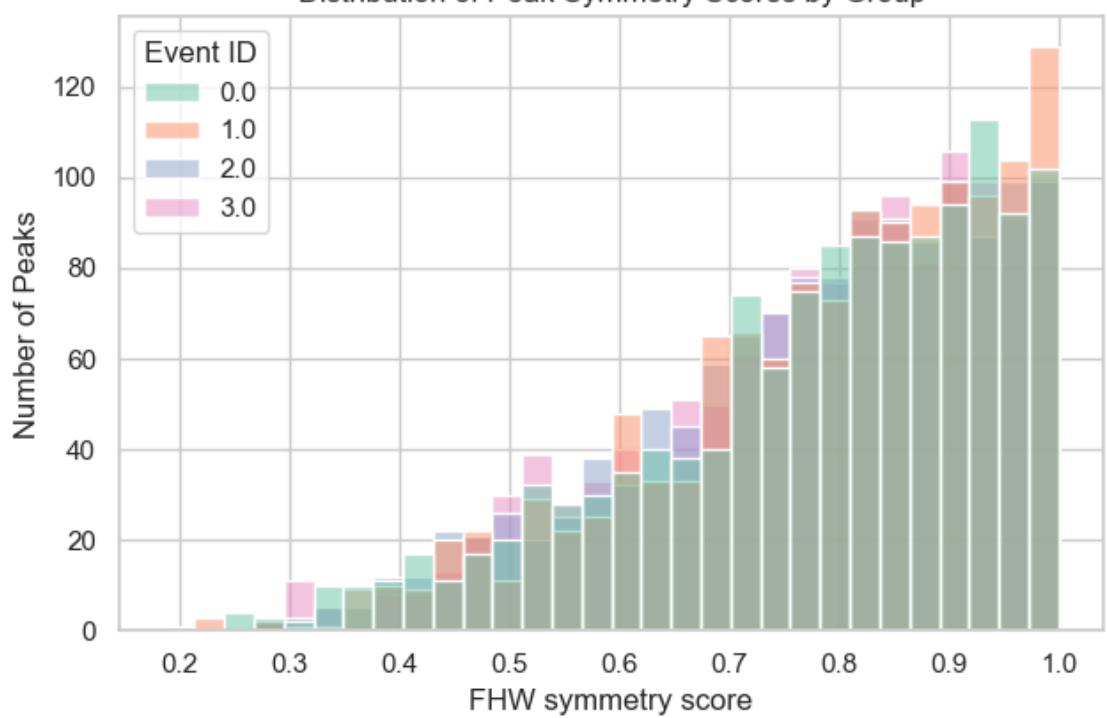


[2025-08-13 11:39:26] [INFO] calcium: plot_histogram_by_group: removed 2 outliers out of 5273 on 'Prominence (noise std units)' (lower=-461.2, upper=837.3)

Distribution of Peak Prominences by Group

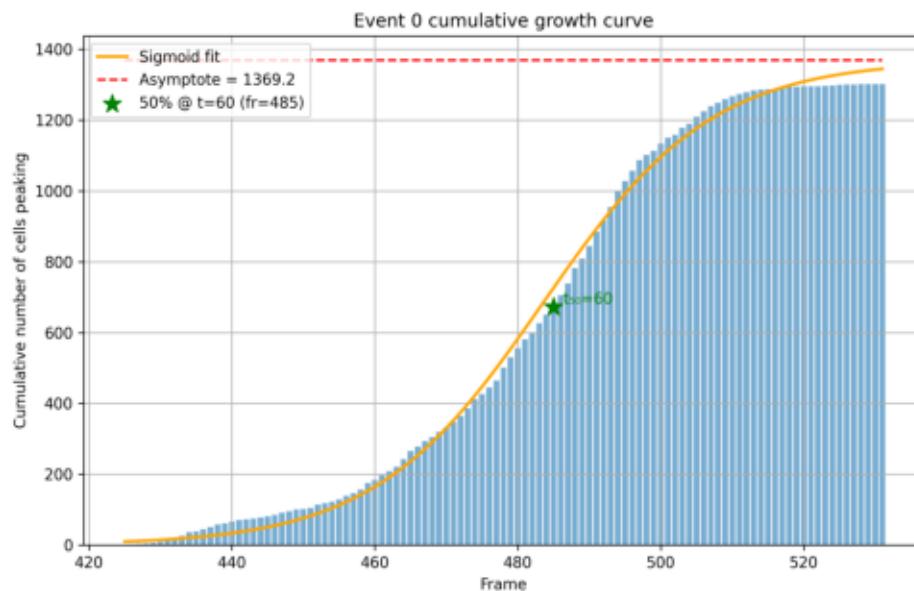


Distribution of Peak Symmetry Scores by Group

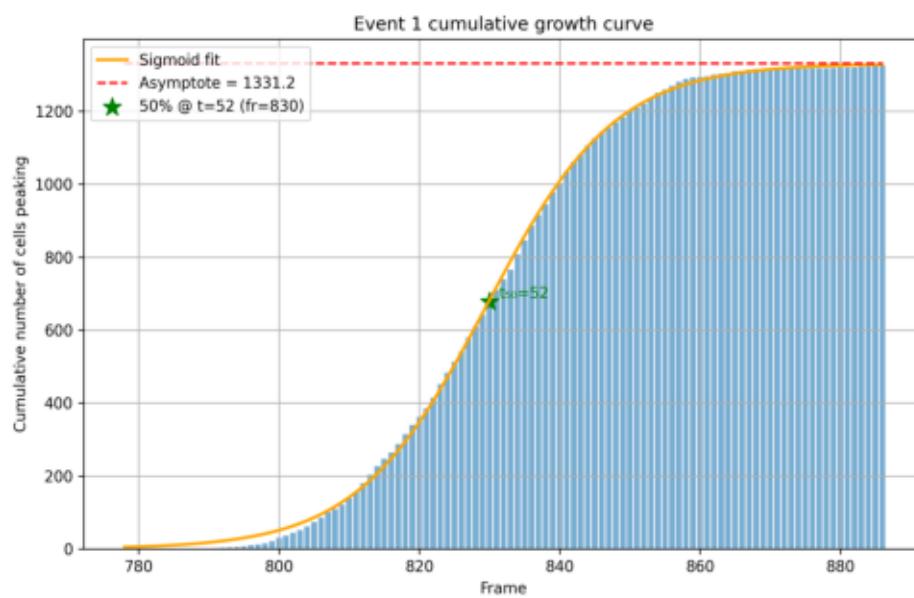


1.2.3 Kinetics of global events

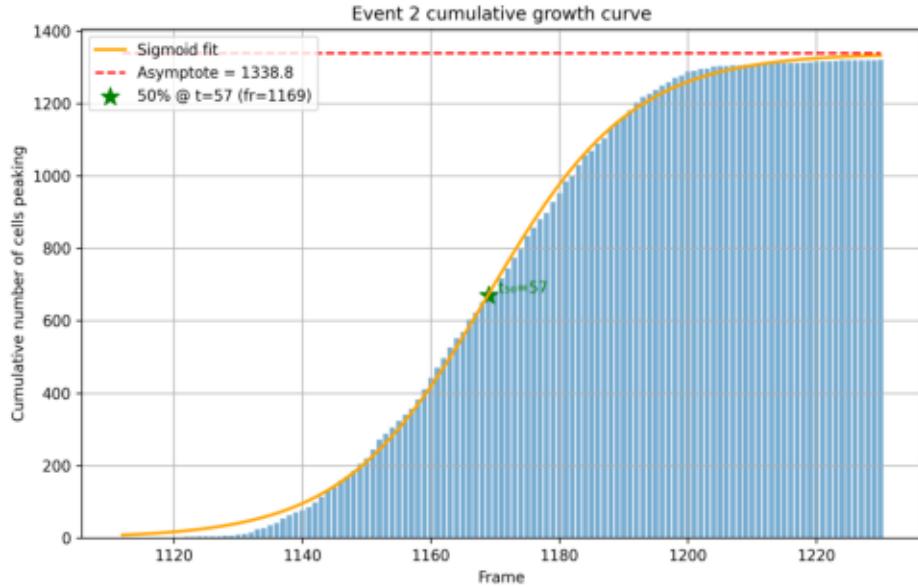
Event Activity Overlay (Event ID: 0) - 20250409_IS09



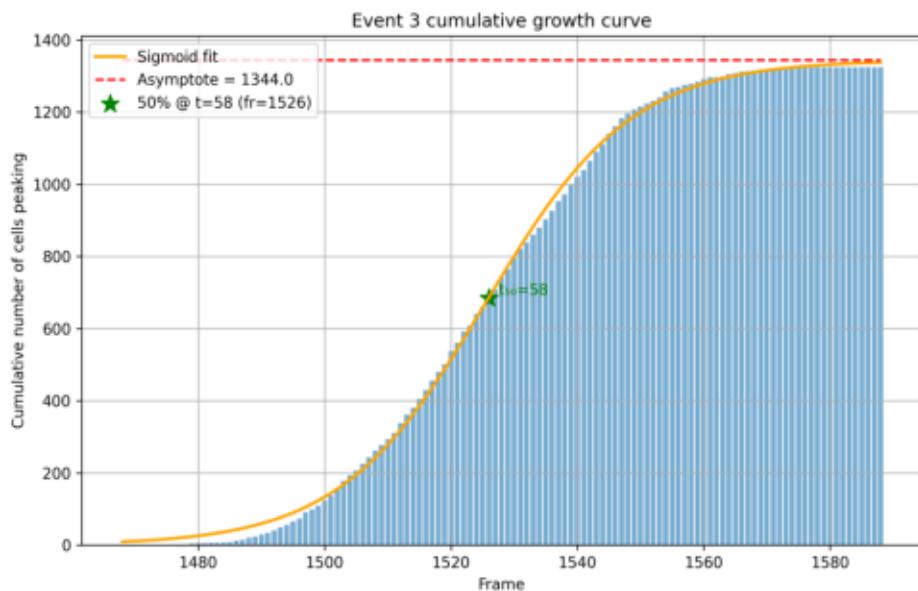
Event Activity Overlay (Event ID: 1) - 20250409_IS09

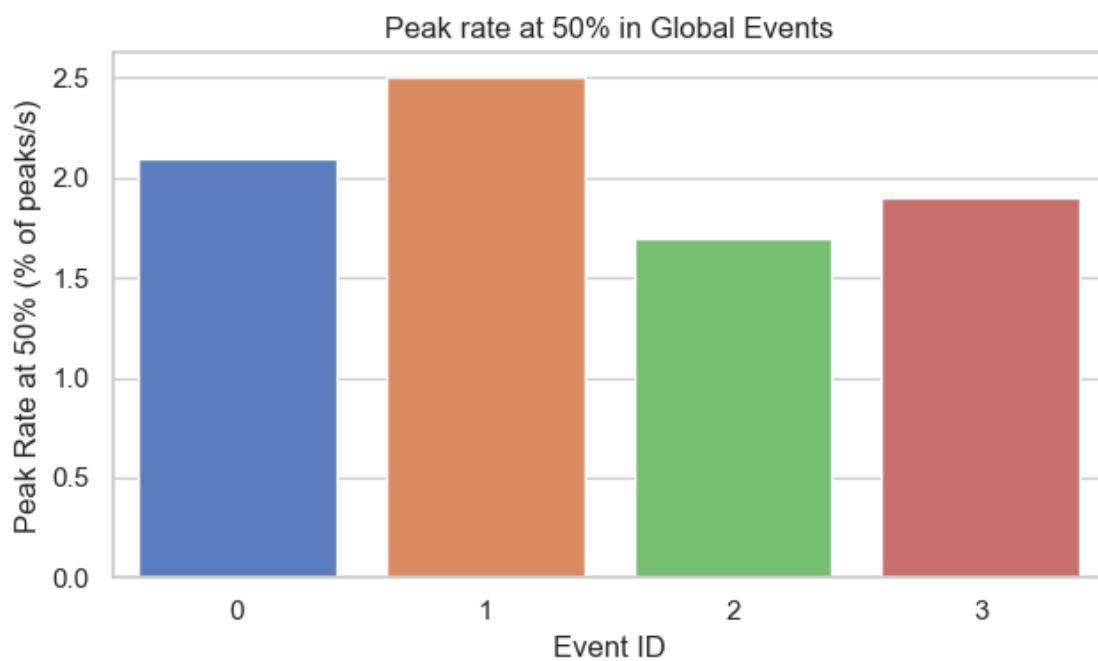
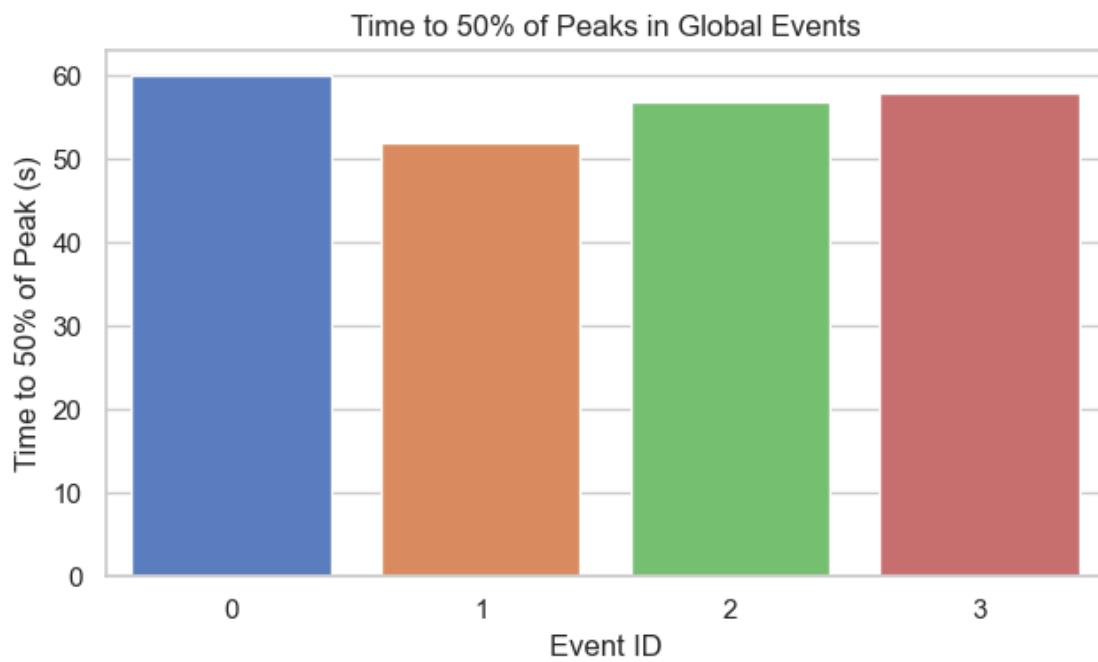


Event Activity Overlay (Event ID: 2) - 20250409_IS09

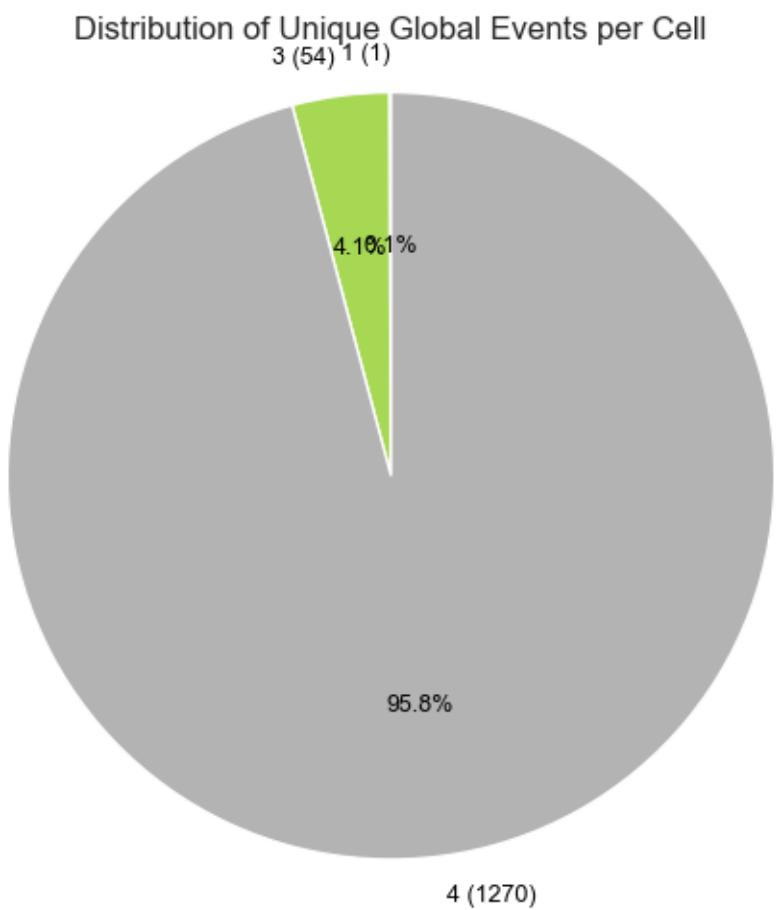


Event Activity Overlay (Event ID: 3) - 20250409_IS09

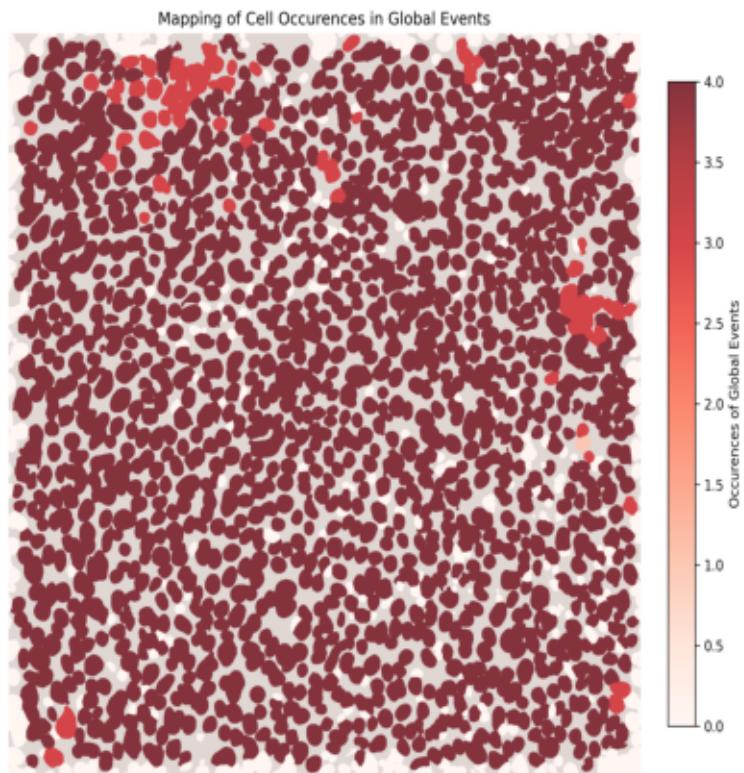


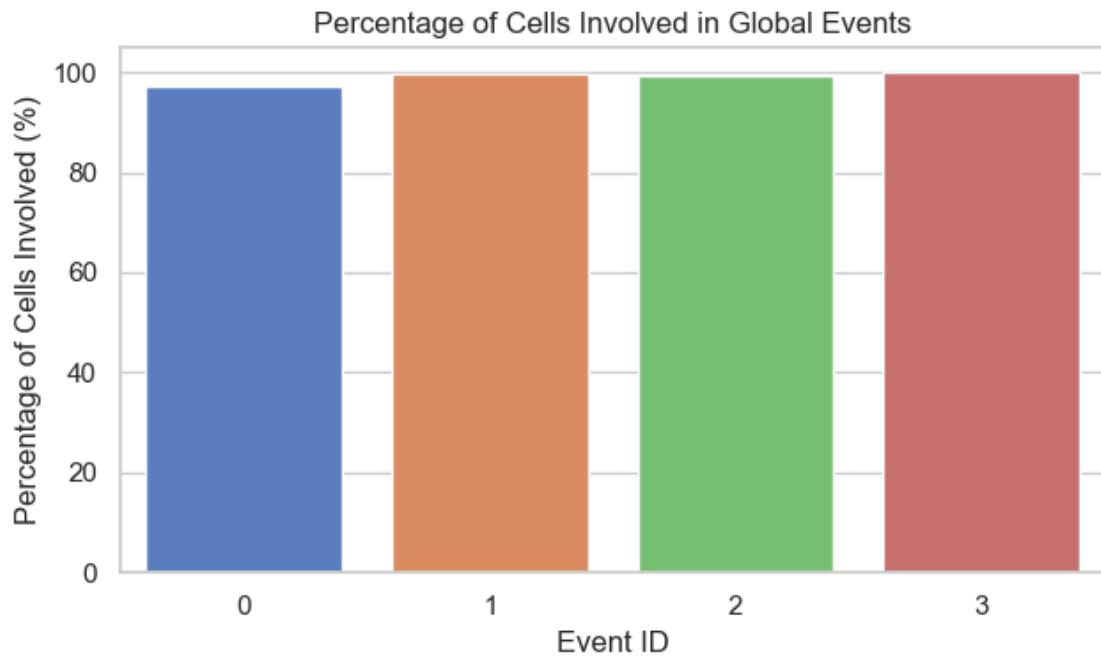


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250409_IS09





1.2.5 Inter-event interval analysis

Intervals between global event peaks: [348.0, 342.0, 357.0]

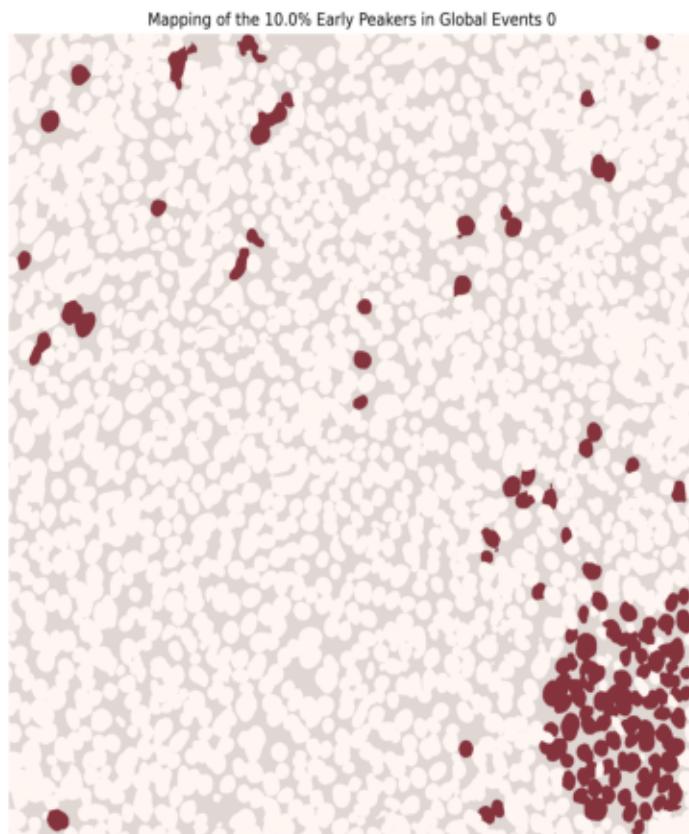
Estimated periodicity: 0.983

The global events exhibit a regular periodic pattern.

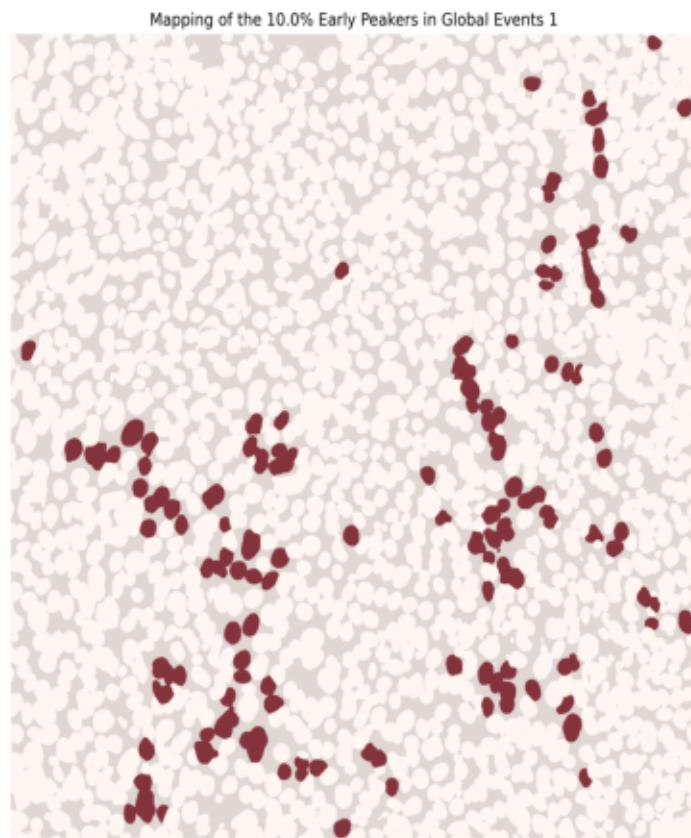
Estimated frequency (1/mean interval): 0.003 Hz

1.2.6 Early peakers in the events

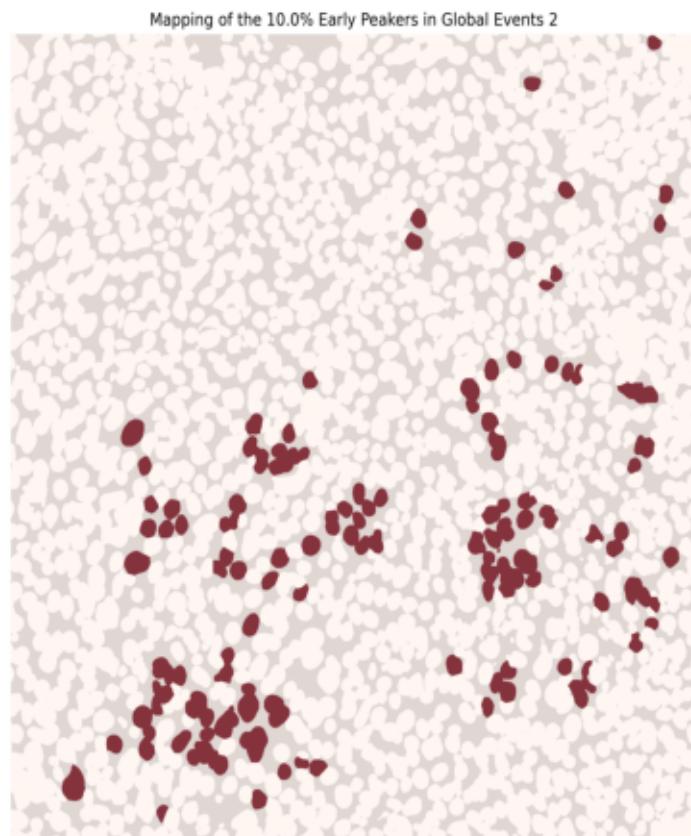
Cell Mapping with Early Peakers Overlay for event 0 - 20250409_IS09



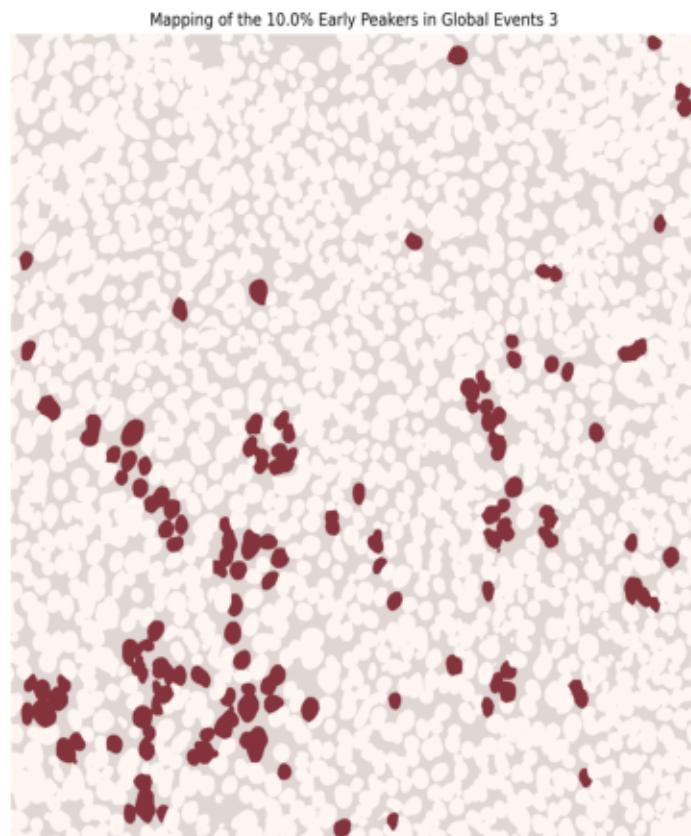
Cell Mapping with Early Peakers Overlay for event 1 - 20250409_IS09



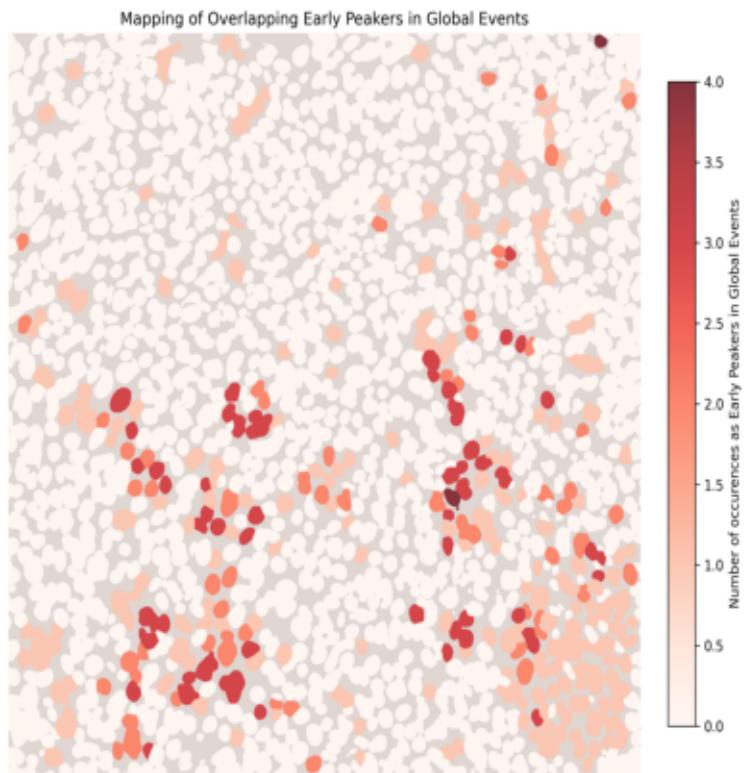
Cell Mapping with Early Peakers Overlay for event 2 - 20250409_IS09

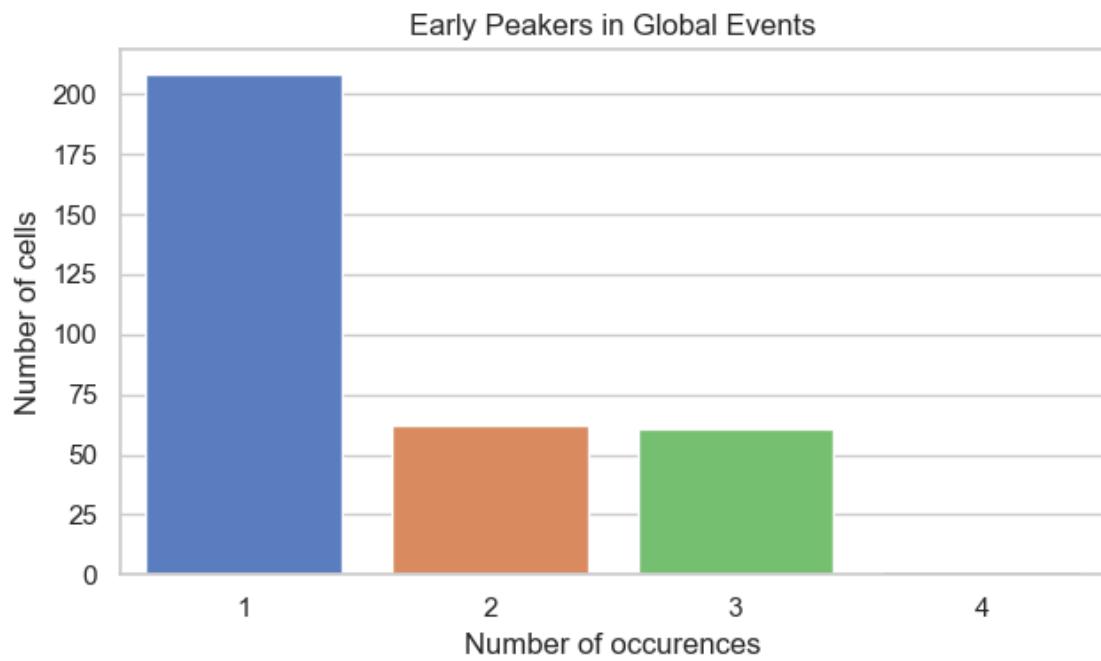


Cell Mapping with Early Peakers Overlay for event 3 - 20250409_IS09

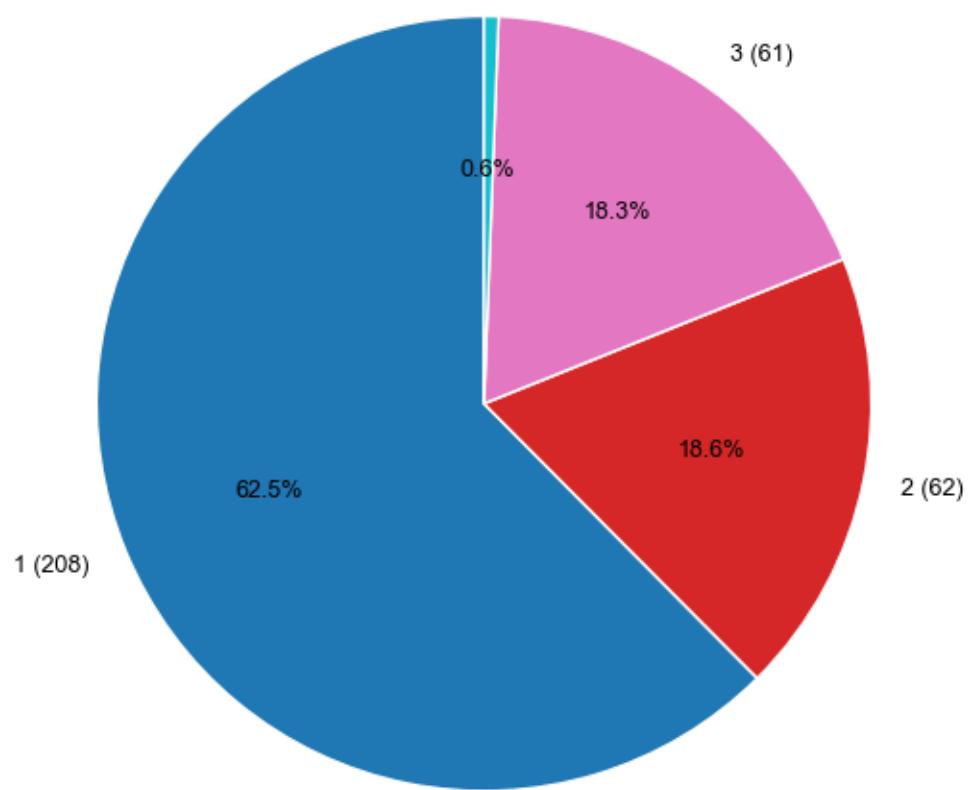


Cell Mapping with Occurrences in Global Events Overlay - 20250409_IS09



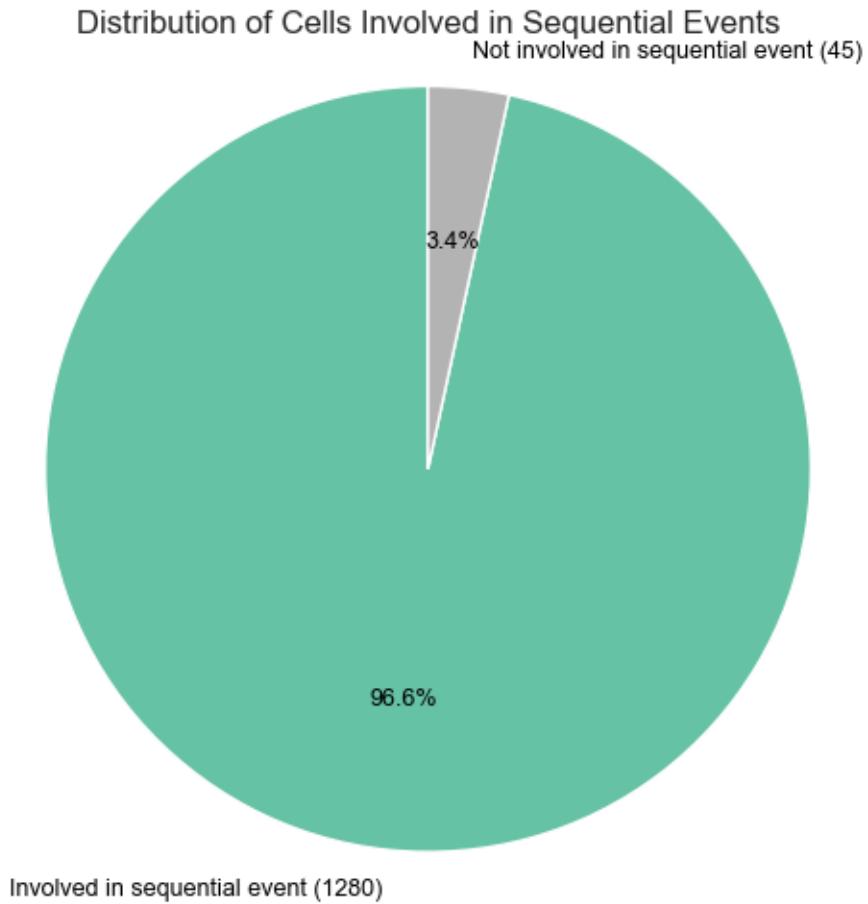


Distribution of Early Peakers in Global Events

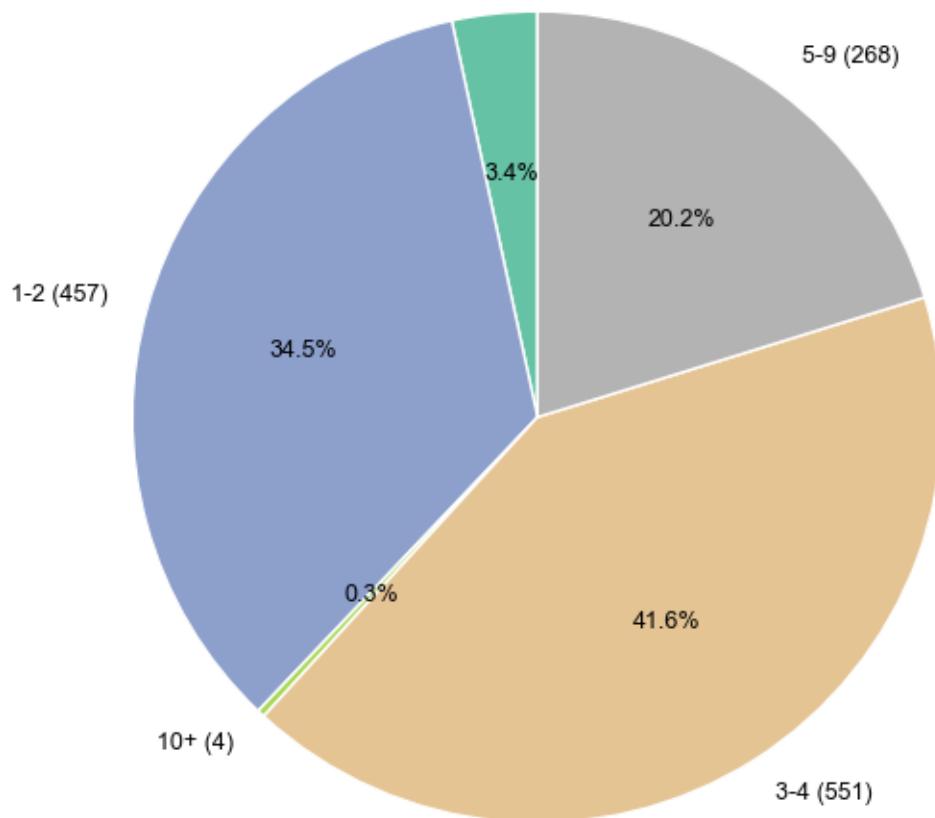


1.3 SEQUENTIAL EVENTS

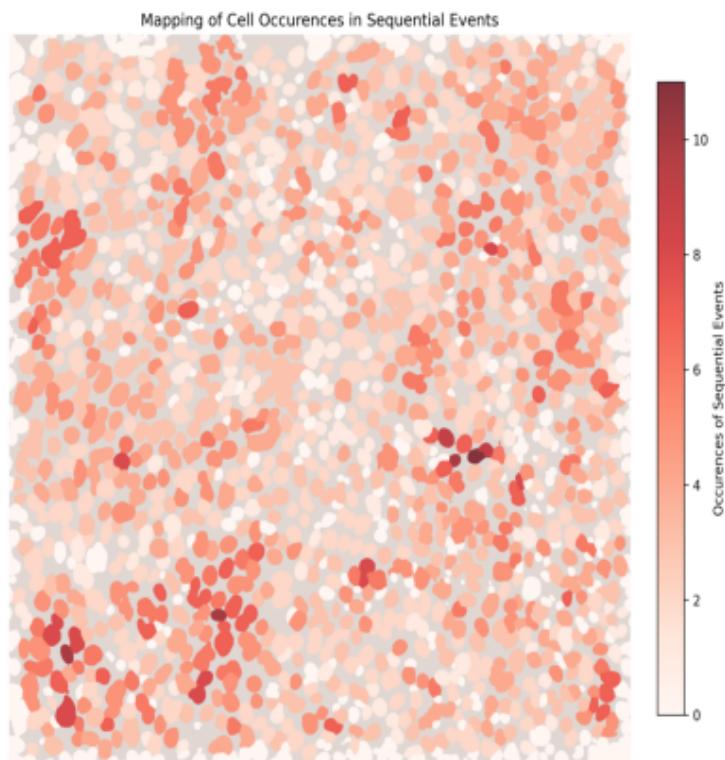
1.3.1 Cells occurrences in sequential events



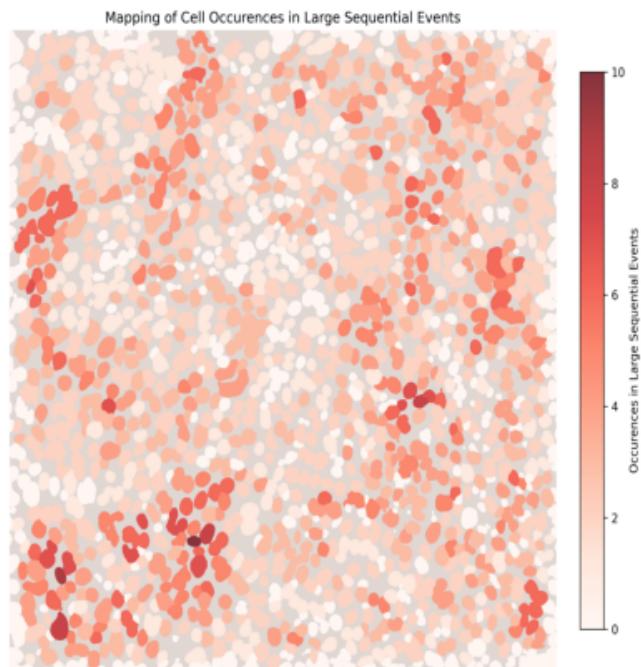
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250409_IS09

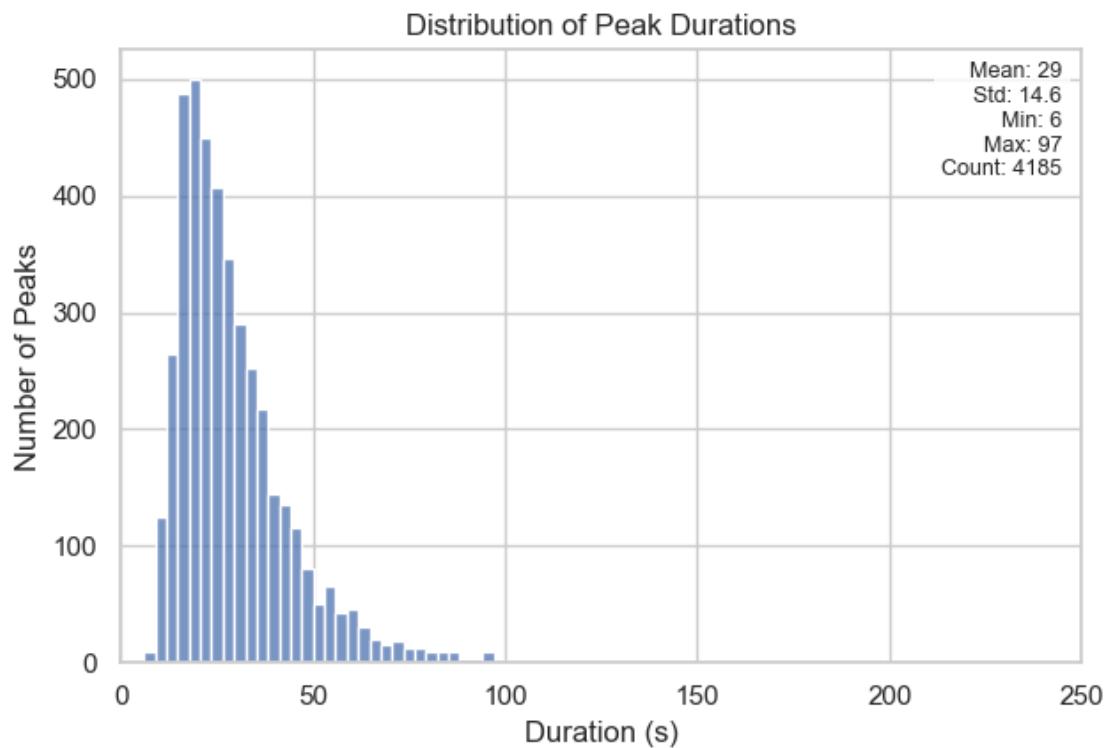


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250409_IS09

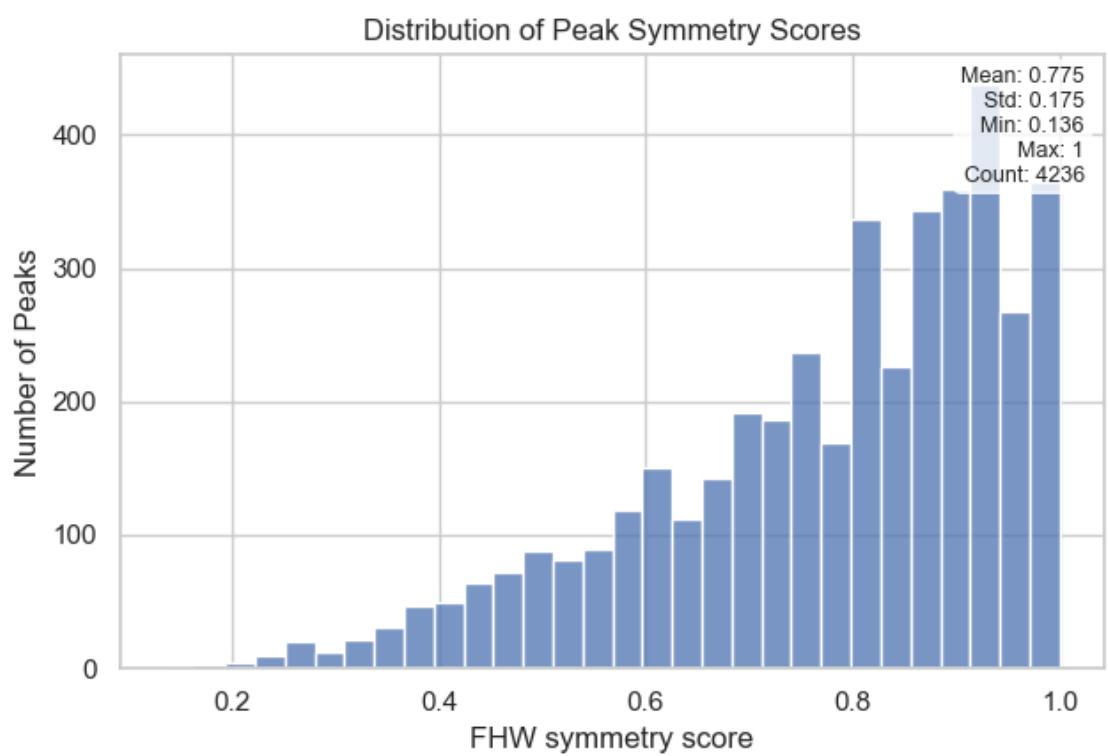
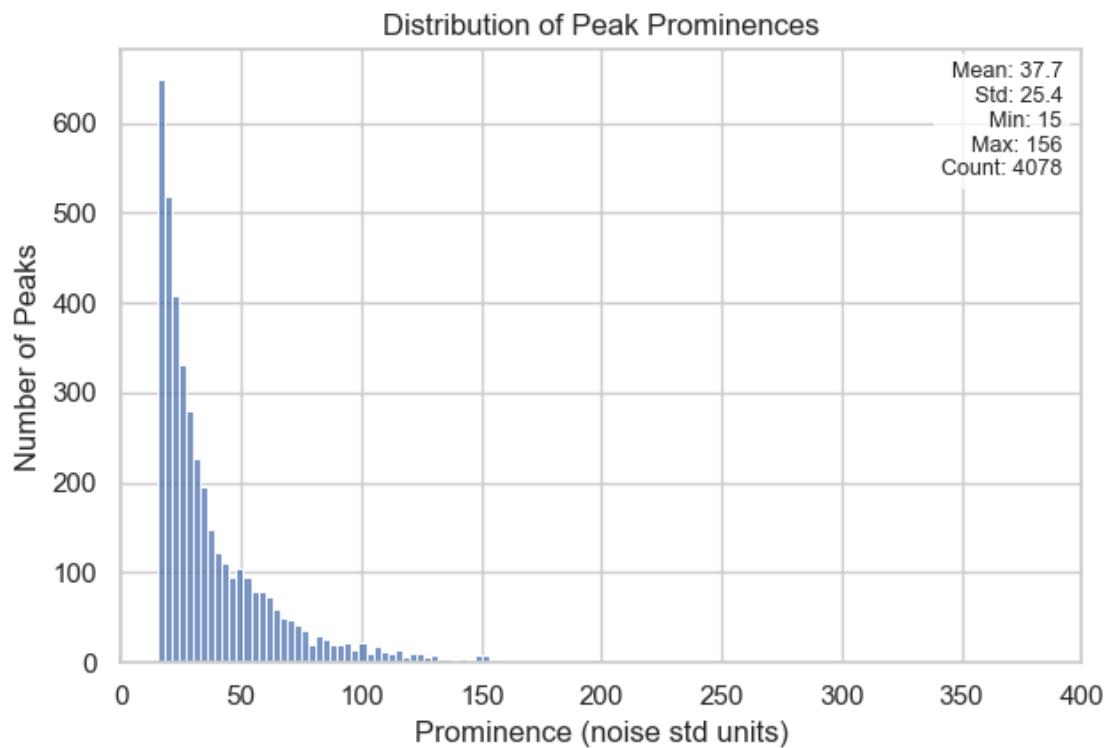


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 11:39:42] [INFO] calcium: plot_histogram: removed 51 outliers out of 4236 on 'Duration (s)' (lower=-9, upper=99)
```

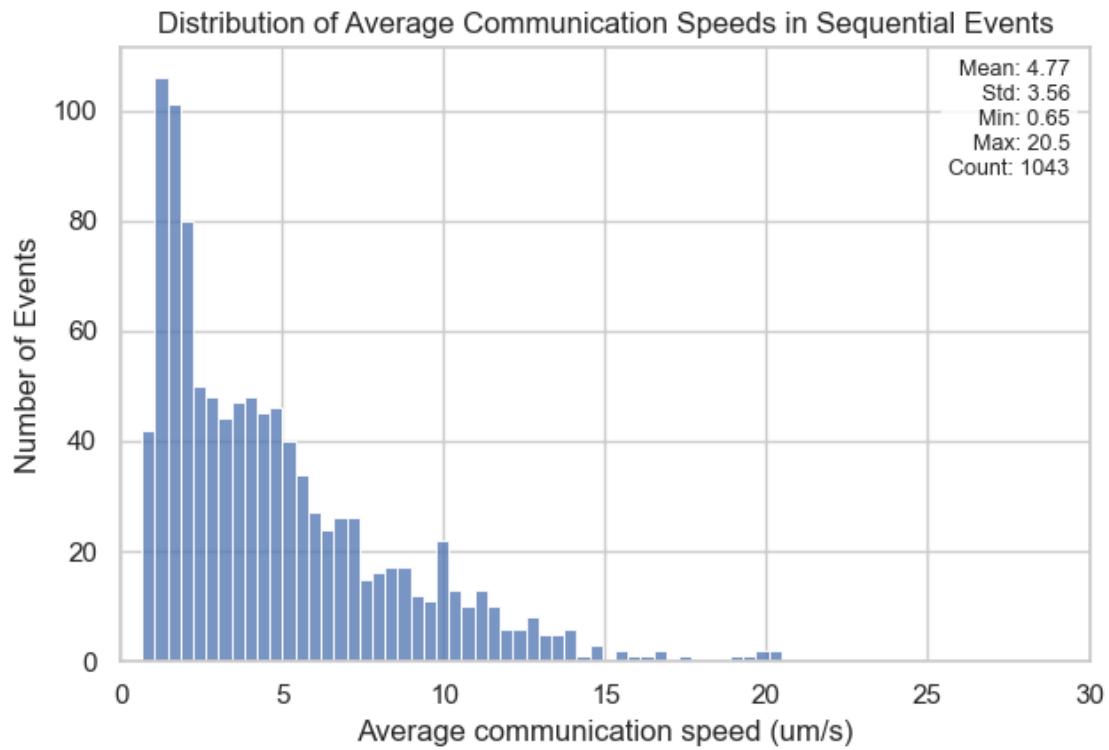


```
[2025-08-13 11:39:42] [INFO] calcium: plot_histogram: removed 158 outliers out of 4236 on 'Prominence (noise std units)' (lower=-25.287, upper=156.66)
```

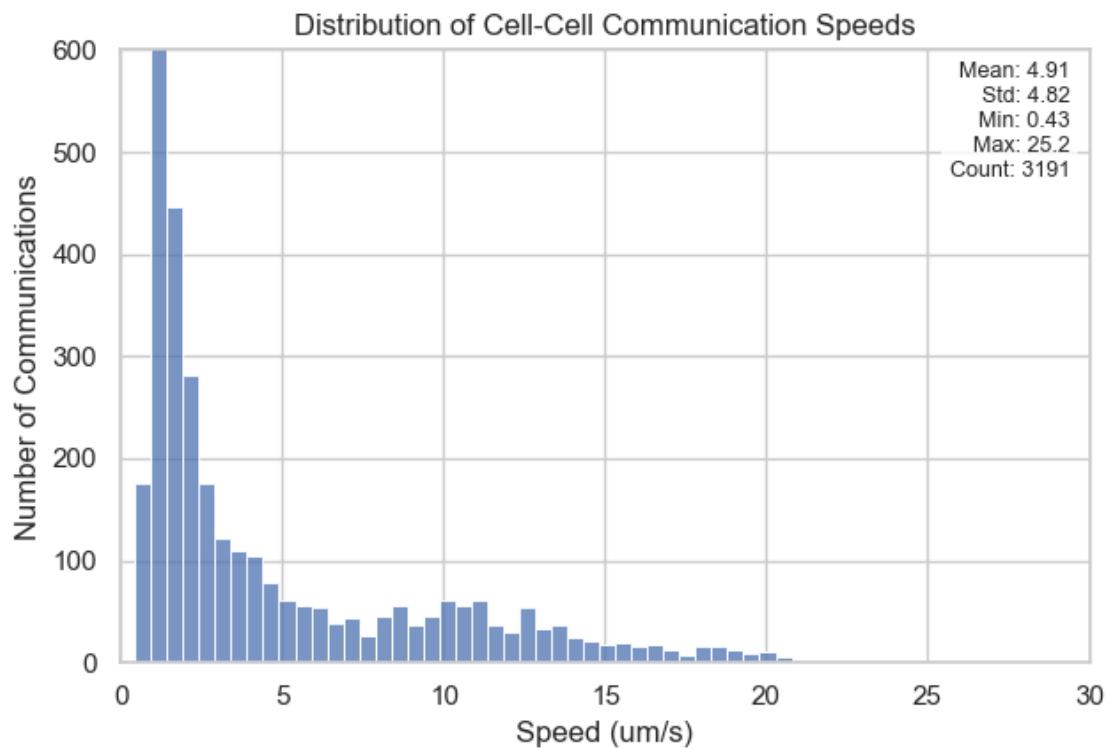


1.3.3 Cell-cell communication speed

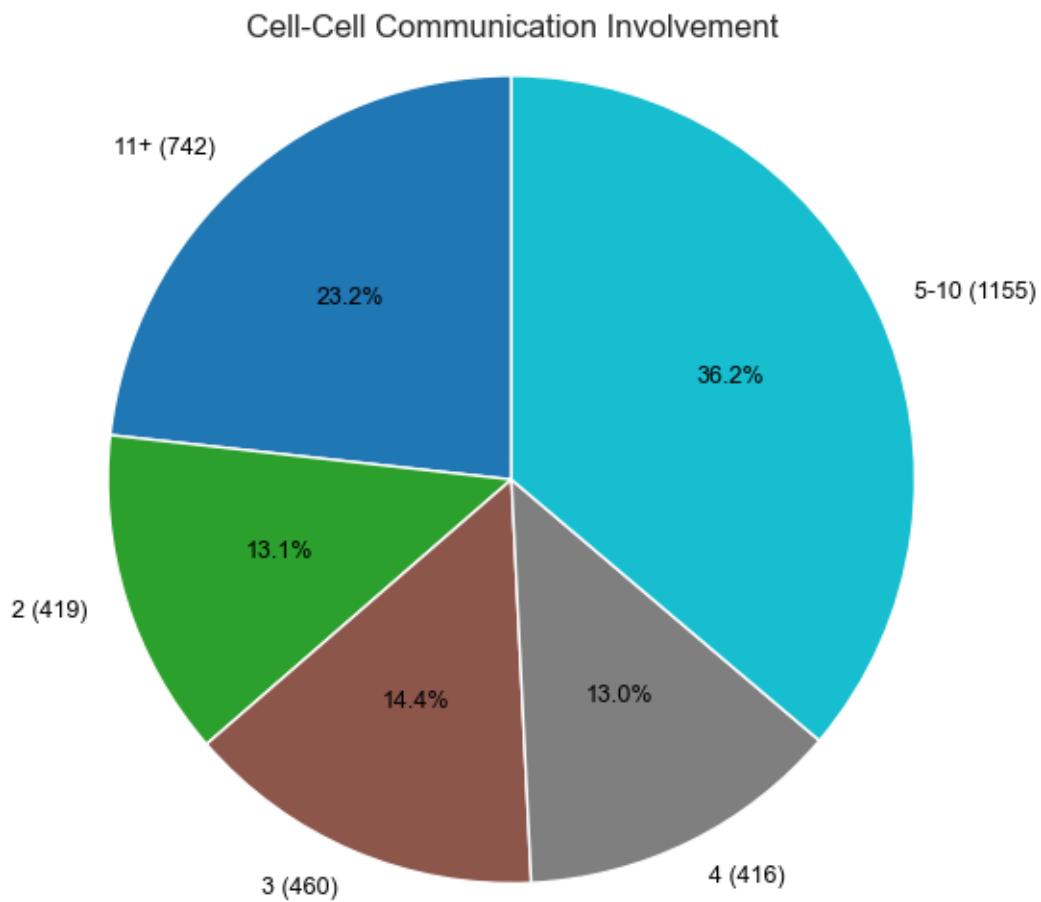
[2025-08-13 11:39:43] [INFO] calcium: plot_histogram: removed 1 outliers out of 1044 on 'Average communication speed (um/s)' (lower=-12.305, upper=20.787)



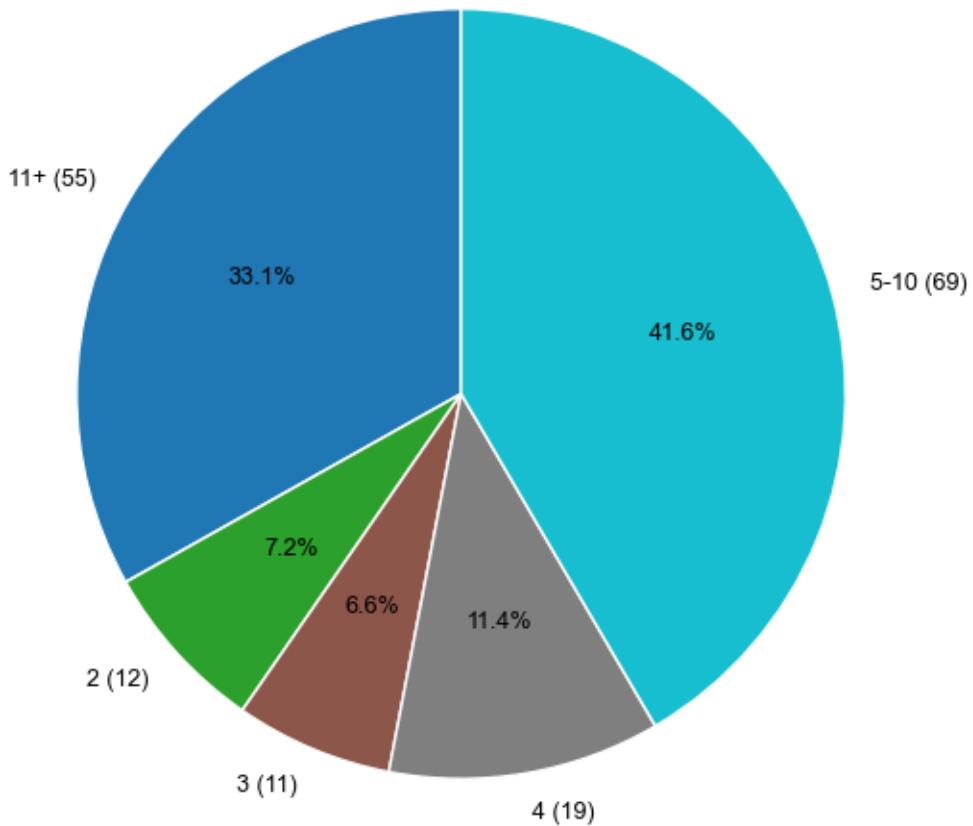
[2025-08-13 11:39:43] [INFO] calcium: plot_histogram: removed 1 outliers out of 3192 on 'Speed (um/s)' (lower=-16.555, upper=25.34)



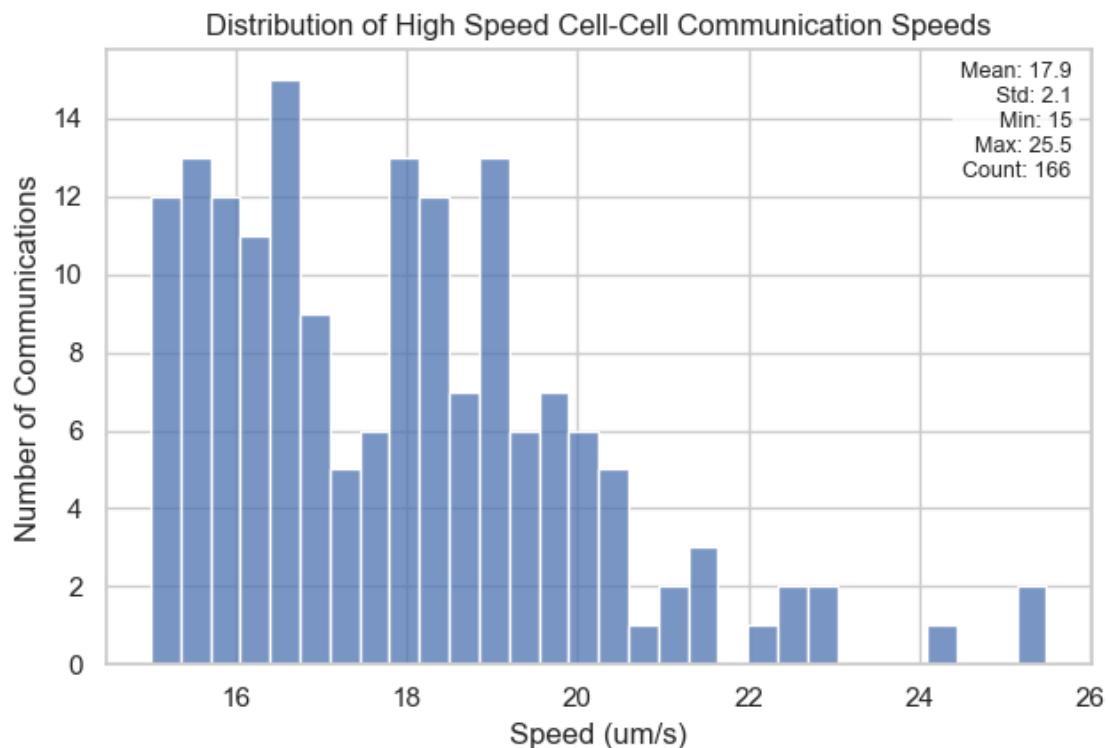
1.3.4 Double distribution in cell-cell communication speeds



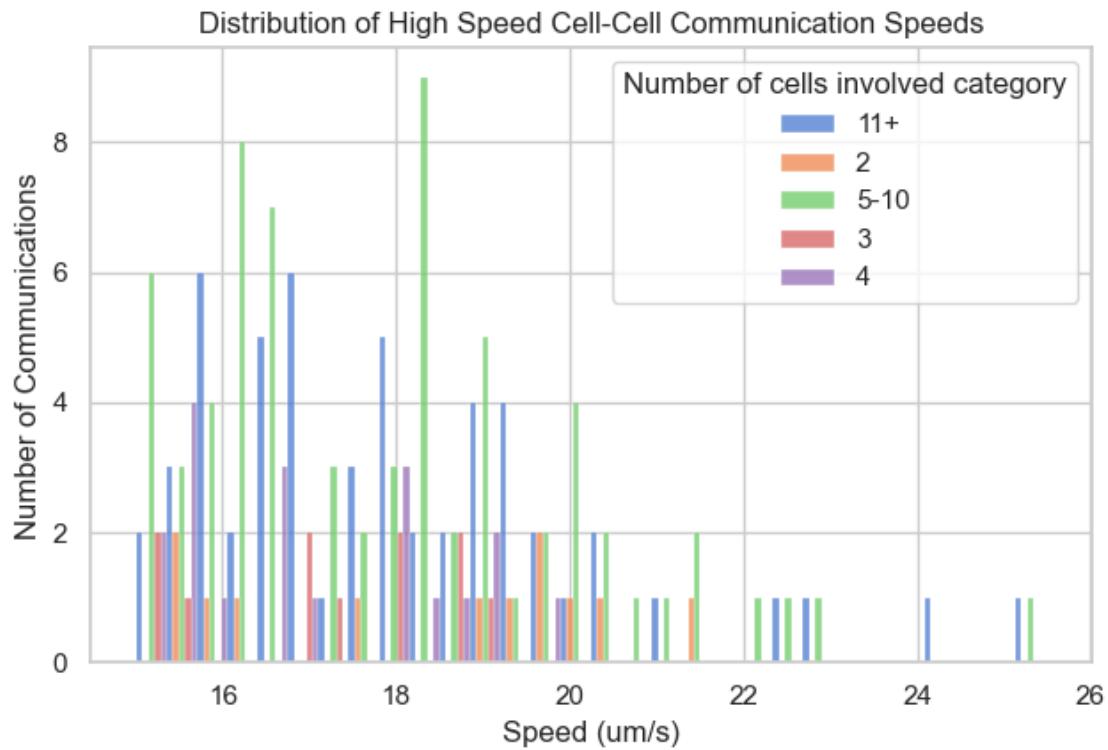
High Speed Cell-Cell Communication Involvement



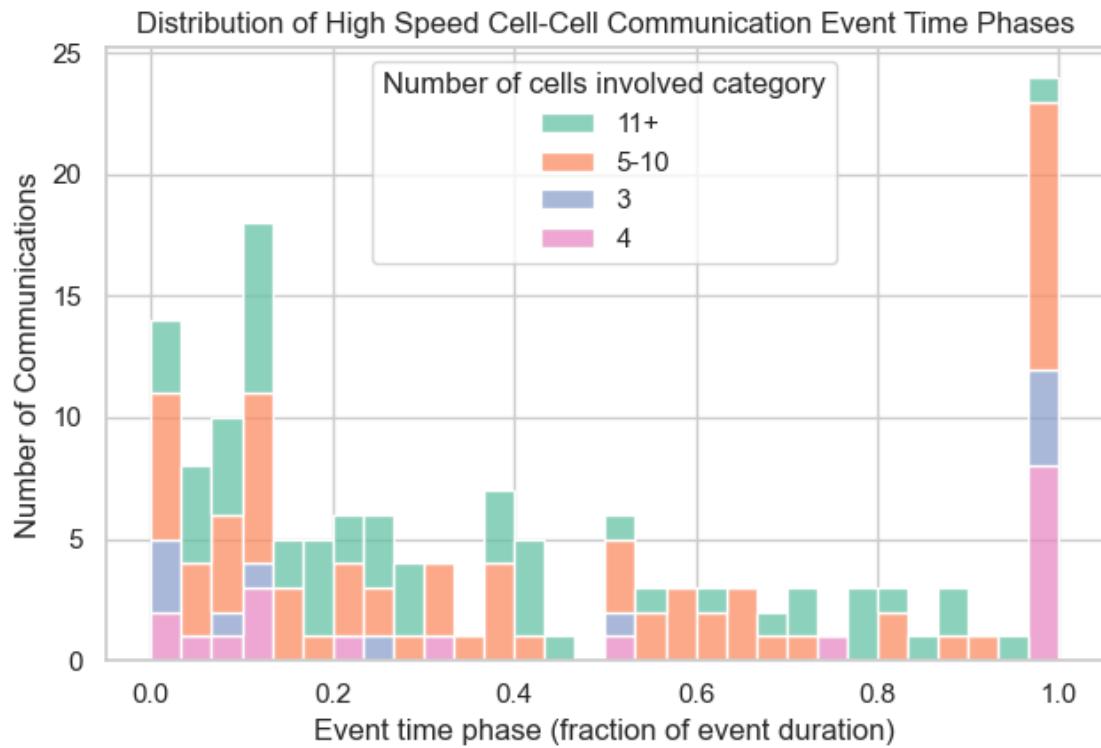
[2025-08-13 11:39:44] [INFO] calcium: plot_histogram: removed 0 outliers out of 166 on 'Speed (um/s)' (lower=7.845, upper=27.48)



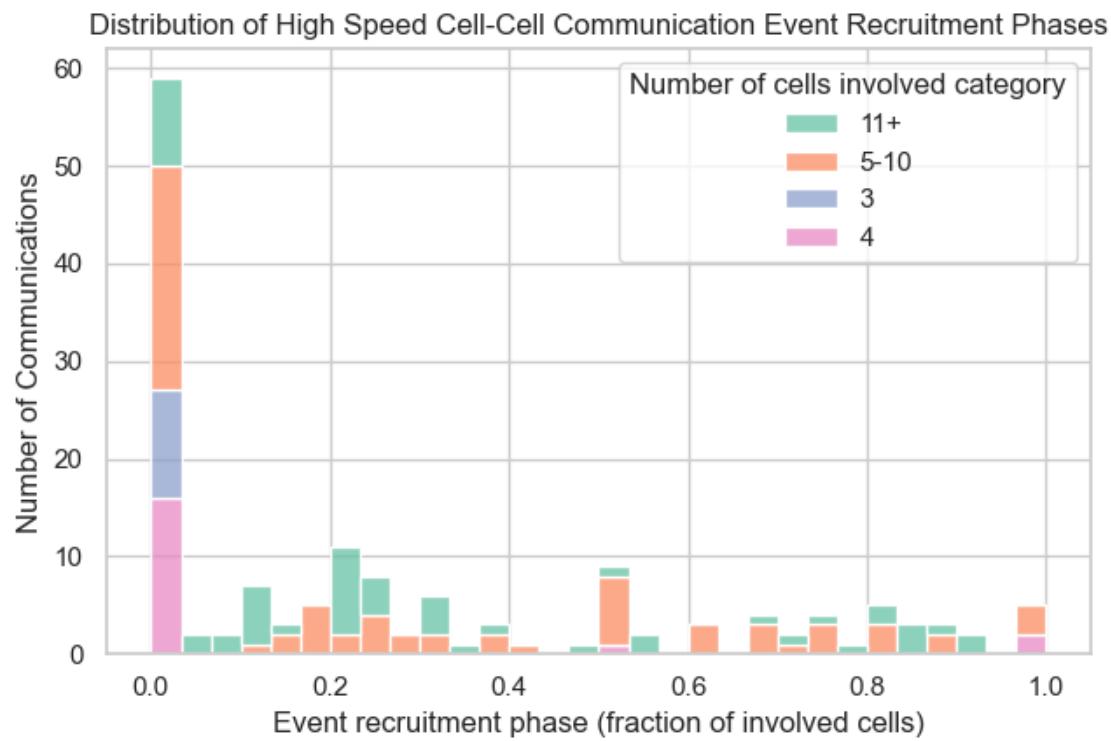
```
[2025-08-13 11:39:44] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 166 on 'Speed (um/s)' (lower=7.845, upper=27.48)
```



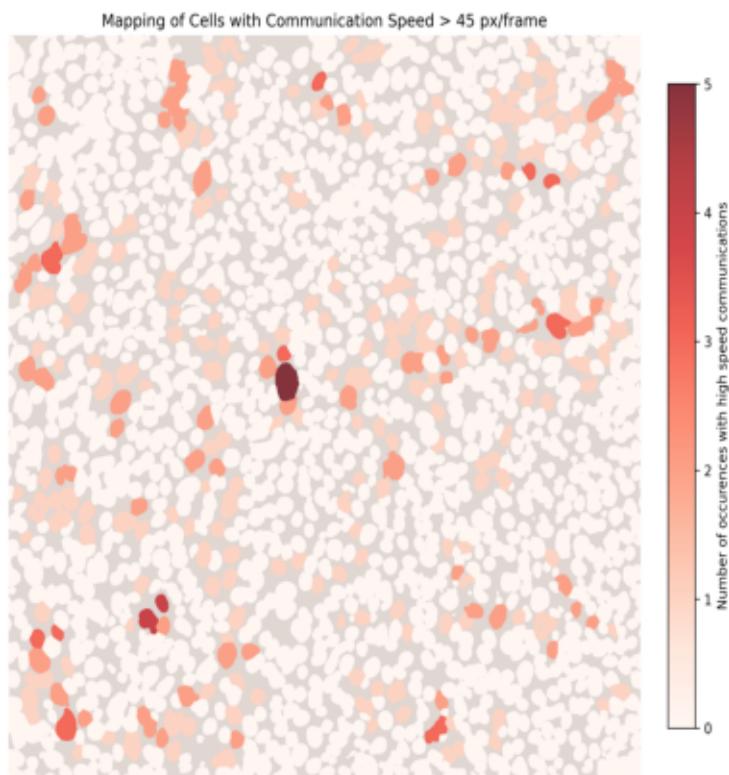
```
[2025-08-13 11:39:44] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 154 on 'Event time phase (fraction of event duration)' (lower=-1.7125, upper=2.54)
```



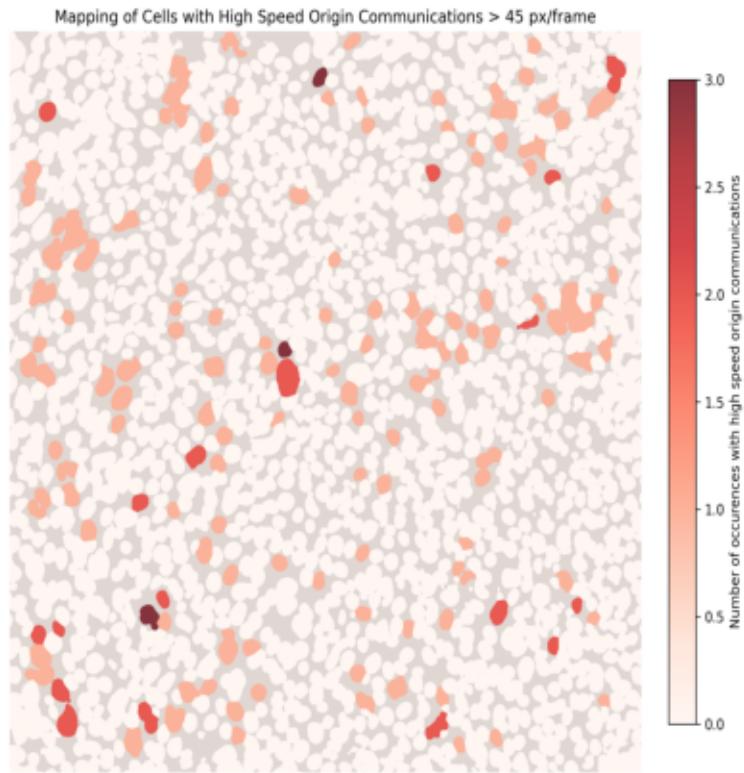
```
[2025-08-13 11:39:44] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 154 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.5, upper=2)
```



Cell Mapping with High Speed Cells Overlay - 20250409_IS09



Cell Mapping with High Speed Origin Cells Overlay - 20250409_IS09



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
1	1759523372672	4	1044		1
22	1759523358416	6	961		0
41	1759452875312	8	1136		0
56	1759523368160	9	343		2
61	1759523365664	9	385		0
...
3084	1759500651008	986	1942		6
3085	1759500663536	986	1984		6
3092	1759500651920	990	2106		4
3099	1759500660704	994	2148		1
3184	1759376864352	1040	2078		0

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
1	1008	0	48.0	48.0	
22	964	0	48.0	48.0	
41	1227	1	111.0	112.0	
56	289	1	211.0	211.0	
61	384	0	203.0	203.0	
...	
3084	1995	5	648.0	649.0	
3085	2090	7	657.0	658.0	
3092	2005	5	611.0	612.0	
3099	2076	1	174.0	175.0	
3184	2160	0	48.0	49.0	
	Duration (s)	Distance (um)	Speed (um/s)	\	
1	0.0	15.02	15.02		
22	0.0	21.46	21.46		
41	1.0	22.45	22.45		
56	0.0	18.43	18.43		
61	0.0	18.86	18.86		
...	
3084	1.0	18.18	18.18		
3085	1.0	21.61	21.61		
3092	1.0	20.46	20.46		
3099	1.0	18.11	18.11		
3184	1.0	19.50	19.50		
	Event time phase (fraction of event duration)	\			
1		0.02			
22		NaN			
41		0.39			
56		0.38			
61		0.19			
...		...			
3084		0.10			
3085		1.00			
3092		NaN			
3099		0.10			
3184		NaN			
	Event recruitment phase (fraction of involved cells)	dataset	\		
1		0.00	20250409_IS09		
22		NaN	20250409_IS09		
41		0.30	20250409_IS09		
56		0.82	20250409_IS09		
61		0.35	20250409_IS09		
...			
3084		0.00	20250409_IS09		
3085		1.00	20250409_IS09		

3092		NaN	20250409_IS09
3099		0.00	20250409_IS09
3184		NaN	20250409_IS09

	Number of cells involved	category	Speed category
1		11+	High speed
22		2	High speed
41		11+	High speed
56		11+	High speed
61		11+	High speed
...	
3084		5-10	High speed
3085		5-10	High speed
3092		2	High speed
3099		4	High speed
3184		2	High speed

[166 rows x 16 columns]

Origin cell ID	Speed category	High speed	Low speed
189		1	4
195		1	2
200		0	1
202		0	2
204		0	3
...
2181		0	2
2182		0	2
2188		0	1
2189		0	1
2200		0	2

[1082 rows x 2 columns]

	Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
0	189	175.50		8.45
2	195	270.40		6.50
3	200	402.03		8.12
4	202	414.05		9.43
5	204	427.38		9.75
...
1316	2181	277.23		487.18
1317	2182	35.10		487.50
1318	2188	416.32		488.80
1319	2189	385.12		489.12
1324	2200	240.50		491.73

Number of peaks	Is active	Occurrences in global events	\
-----------------	-----------	------------------------------	---

0	13	True	4
2	5	True	3
3	7	True	4
4	9	True	4
5	8	True	4
...
1316	7	True	4
1317	12	True	3
1318	9	True	4
1319	6	True	4
1324	11	True	4

Occurences in global events as early peaker \

0	1
2	0
3	0
4	0
5	0
...	...
1316	1
1317	1
1318	0
1319	0
1324	2

Occurences in sequential events \

0	5
2	1
3	2
4	3
5	4
...	...
1316	2
1317	3
1318	1
1319	2
1324	2

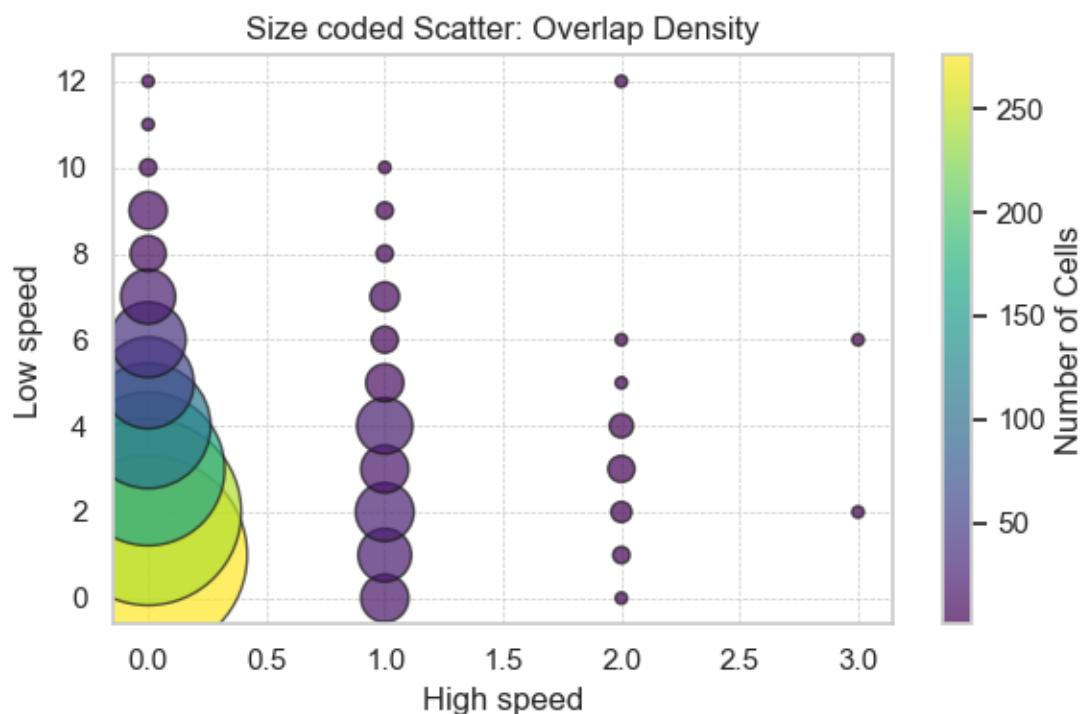
Occurences in sequential events as origin \

0	3
2	1
3	0
4	0
5	1
...	...
1316	1
1317	1
1318	1

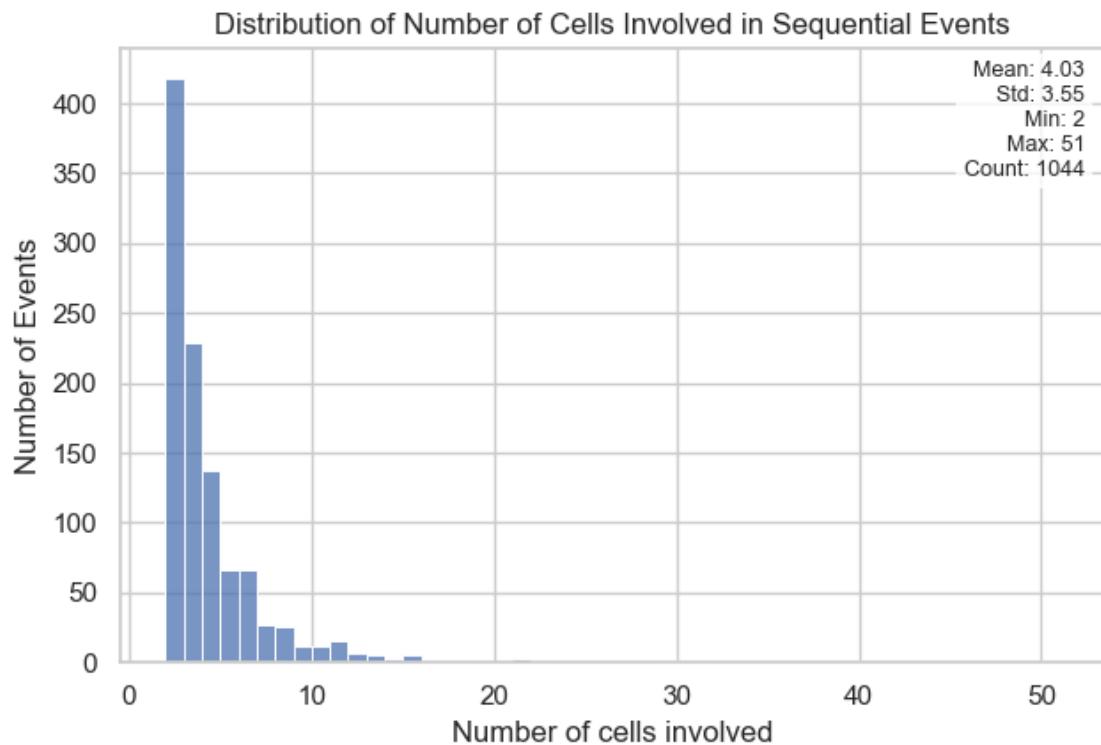
1319		1		
1324		1		
	Occurrences in individual events	Peak frequency (Hz)	Periodicity score	\
0	3	0.0076	0.53	
2	1	0.0029	0.90	
3	1	0.0041	0.67	
4	2	0.0053	0.64	
5	0	0.0047	0.64	
...
1316	1	0.0041	0.71	
1317	5	0.0071	0.54	
1318	4	0.0053	0.63	
1319	0	0.0035	0.72	
1324	5	0.0065	0.58	
	Neighbor count	Neighbors (labels)	dataset	\
0	5	[219, 227, 238, 242, 248]	20250409_IS09	
2	3	[210, 228, 241]	20250409_IS09	
3	4	[202, 206, 229, 236]	20250409_IS09	
4	4	[200, 204, 229, 239]	20250409_IS09	
5	3	[202, 221, 239]	20250409_IS09	
...
1316	4	[2125, 2141, 2144, 2153]	20250409_IS09	
1317	3	[2136, 2163, 2193]	20250409_IS09	
1318	3	[2115, 2146, 2151]	20250409_IS09	
1319	3	[2132, 2156, 2175]	20250409_IS09	
1324	3	[2113, 2153, 2166]	20250409_IS09	
	Involved in sequential event	Occurrences in sequential events	category	\
0	Involved in sequential event		5-9	
2	Involved in sequential event		1-2	
3	Involved in sequential event		1-2	
4	Involved in sequential event		3-4	
5	Involved in sequential event		3-4	
...
1316	Involved in sequential event		1-2	
1317	Involved in sequential event		3-4	
1318	Involved in sequential event		1-2	
1319	Involved in sequential event		1-2	
1324	Involved in sequential event		1-2	
	High speed	Low speed		
0	1.0	4.0		
2	1.0	2.0		
3	0.0	1.0		
4	0.0	2.0		
5	0.0	3.0		

...	0.0	2.0
1316	0.0	2.0
1317	0.0	2.0
1318	0.0	1.0
1319	0.0	1.0
1324	0.0	2.0

[1082 rows x 19 columns]

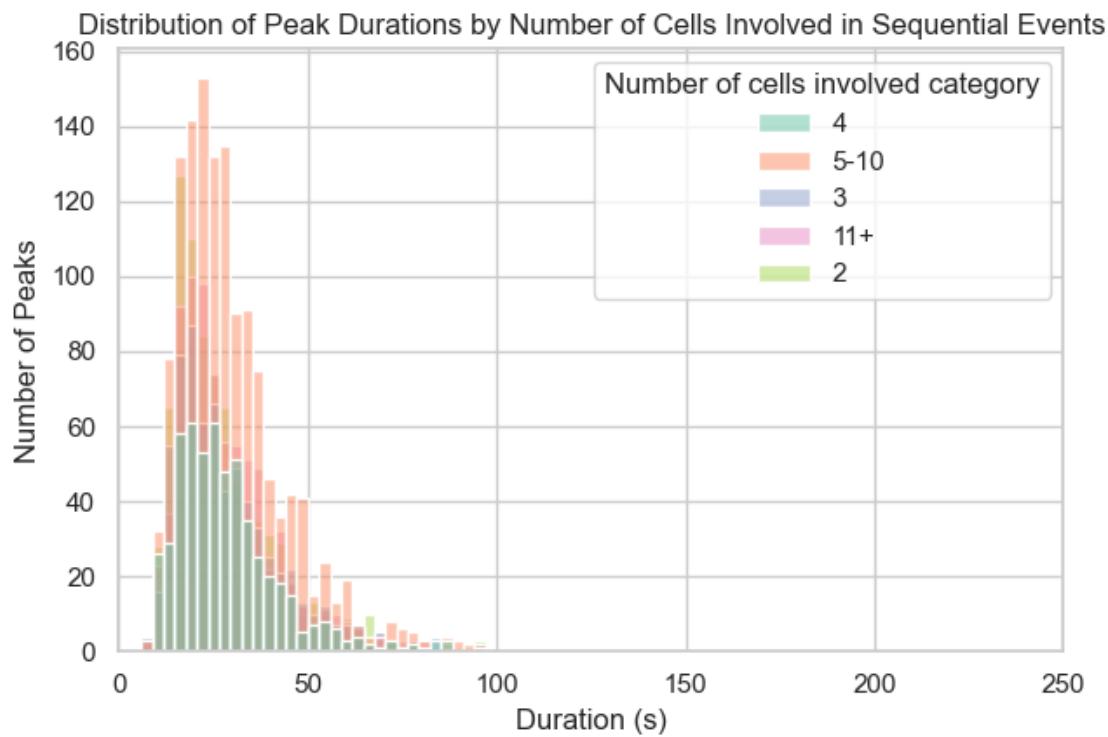


1.3.5 Number of cells involved per sequential events



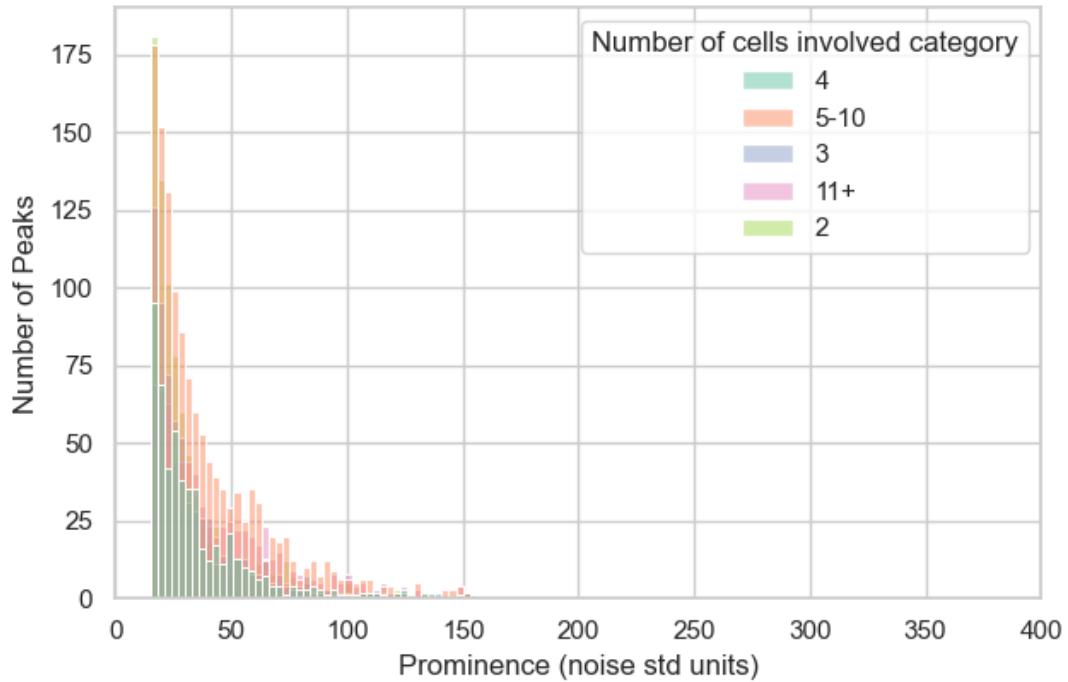
1.3.6 Influence of cell count per event on statistics

```
[2025-08-13 11:39:48] [INFO] calcium: plot_histogram_by_group: removed 51 outliers out of 4236 on 'Duration (s)' (lower=-9, upper=99)
```

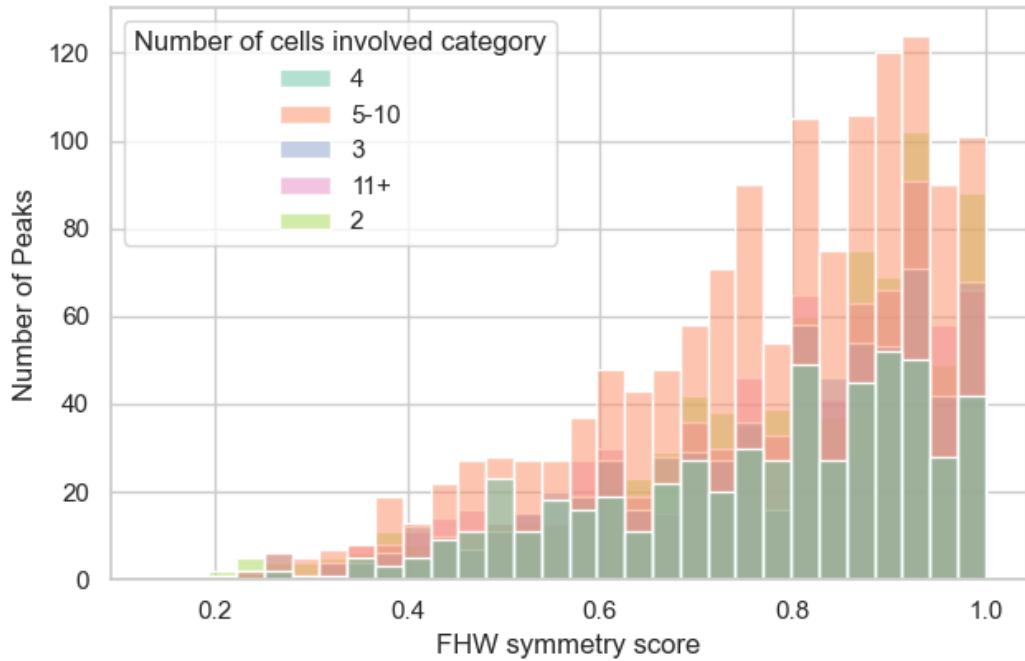


```
[2025-08-13 11:39:48] [INFO] calcium: plot_histogram_by_group: removed 158 outliers out of 4236 on 'Prominence (noise std units)' (lower=-25.287, upper=156.66)
```

Distribution of Peak Prominences by Number of Cells Involved in Sequential Events

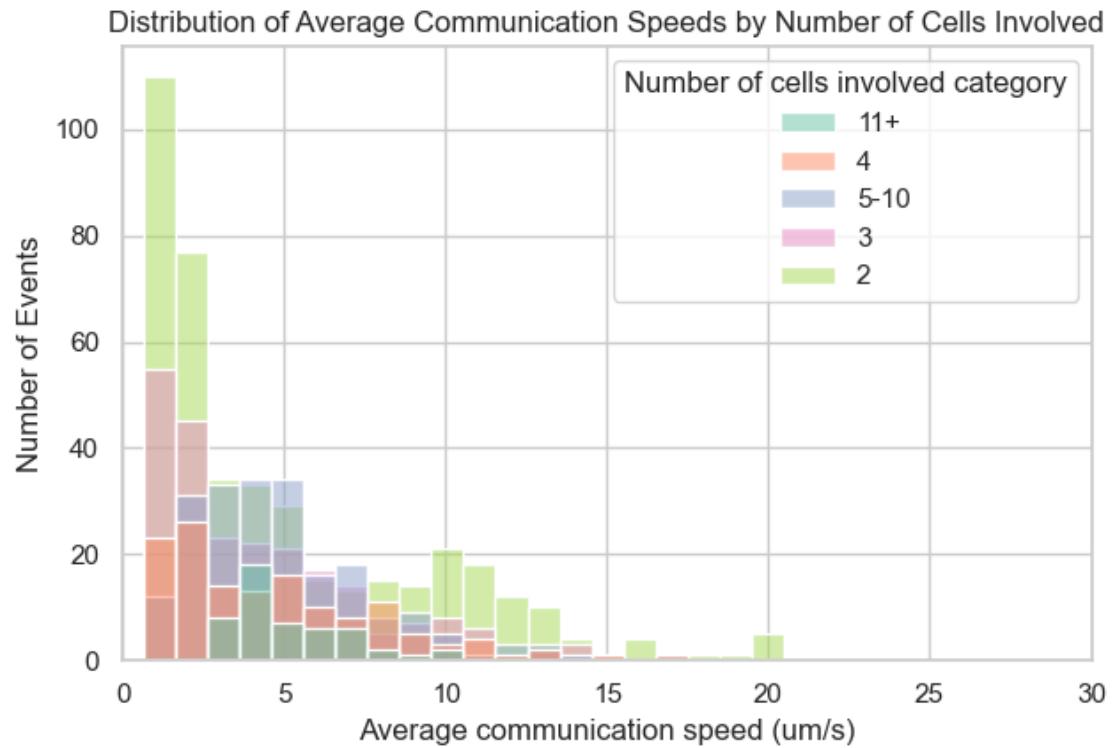


Distribution of Peak Symmetry Scores by Number of Cells Involved in Sequential Events



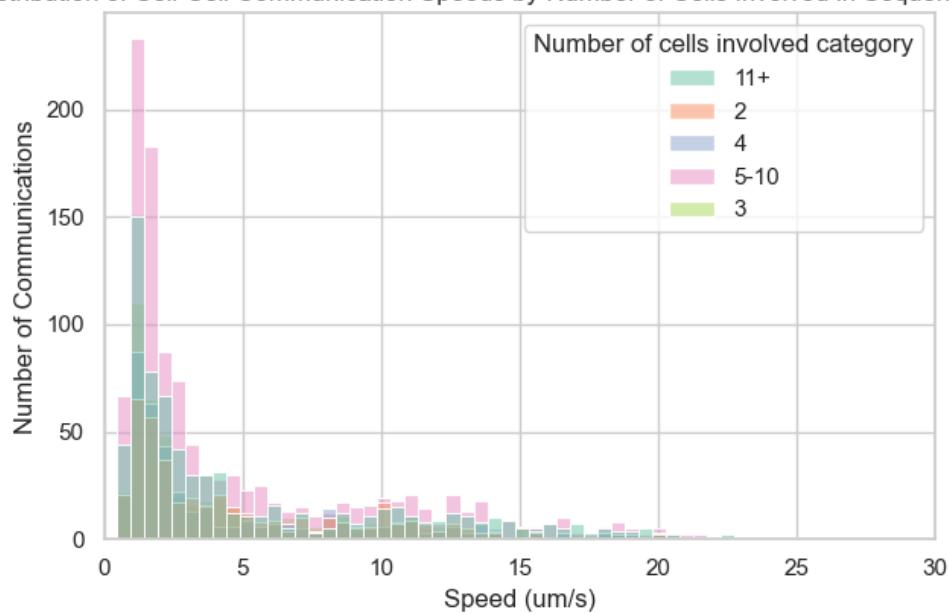
[2025-08-13 11:39:49] [INFO] calcium: plot_histogram_by_group: removed 1

outliers out of 1044 on 'Average communication speed (um/s)' (lower=-12.305, upper=20.787)



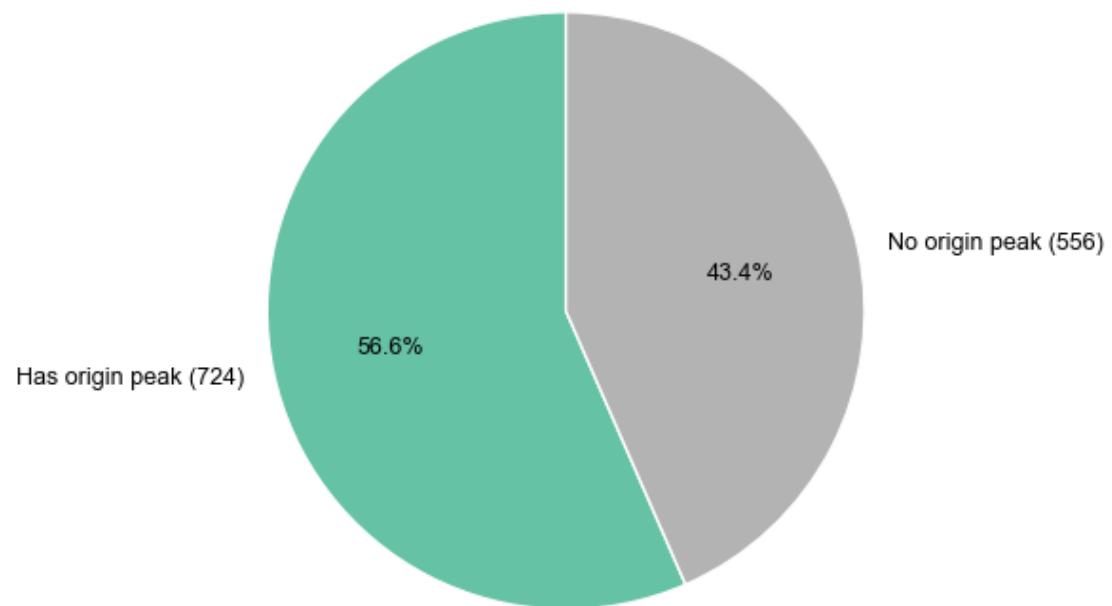
[2025-08-13 11:39:50] [INFO] calcium: plot_histogram_by_group: removed 1 outliers out of 3192 on 'Speed (um/s)' (lower=-16.555, upper=25.34)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events

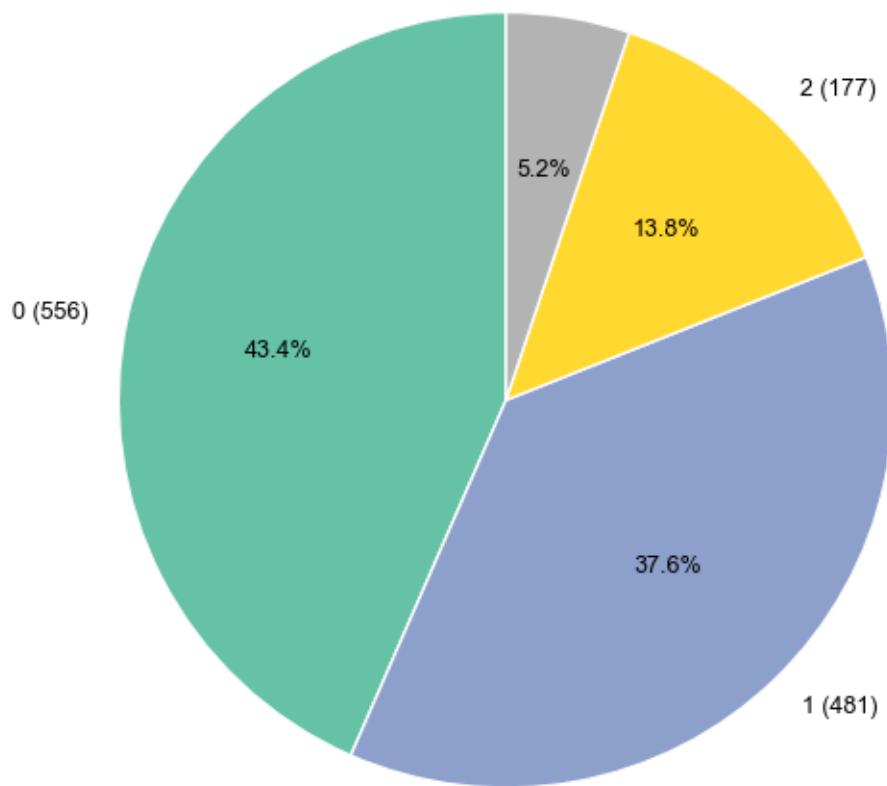


1.3.7 Cells occurrences as origin in sequential events

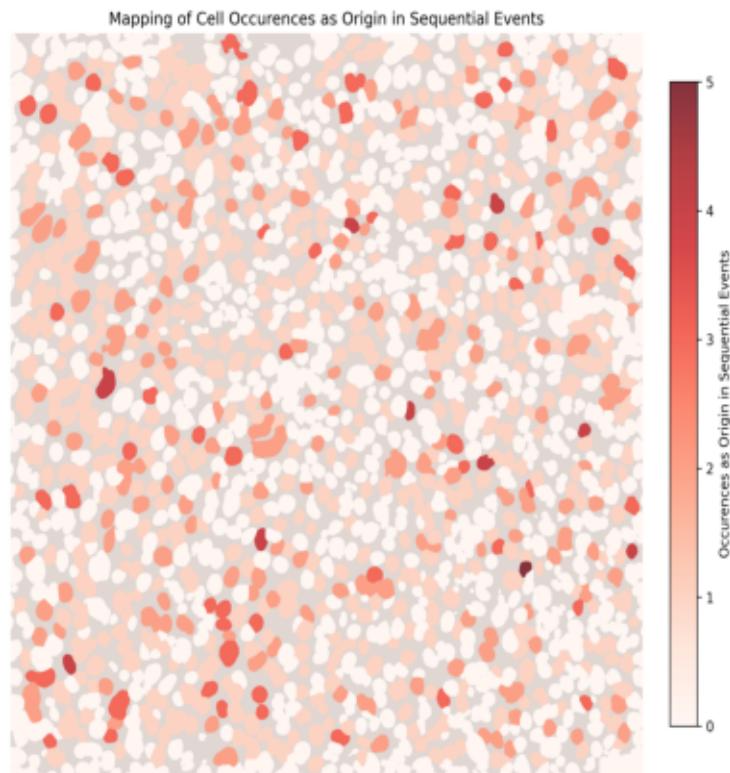
Distribution of Number of Sequential Event Origin Peaks per Cell



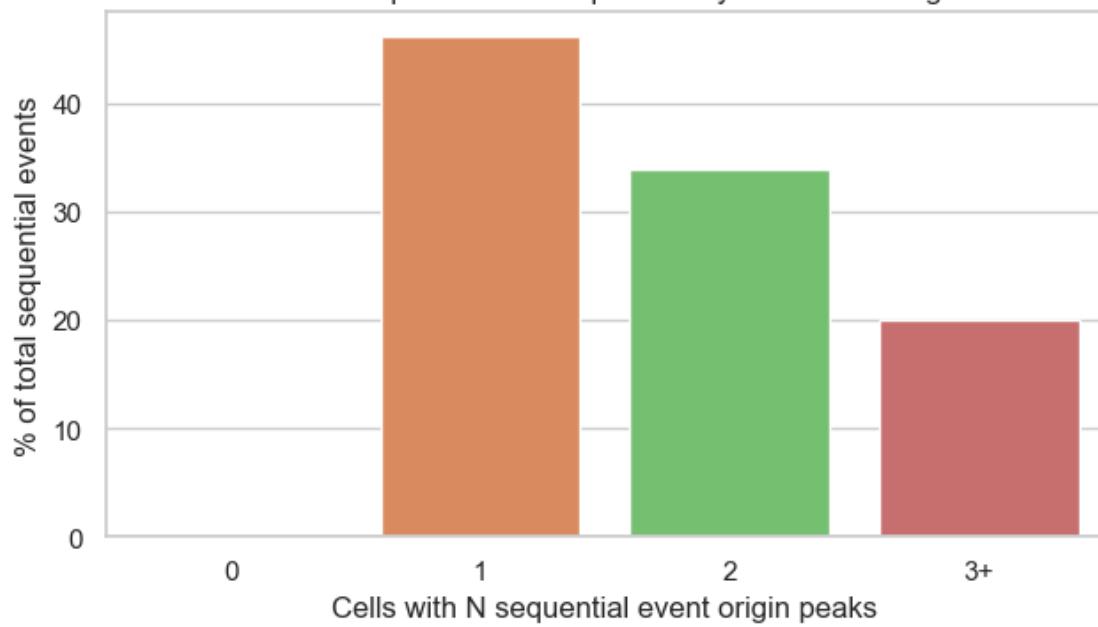
Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)
3+ (66)



Cell Mapping with Origin Peaks Overlay - 20250409_IS09

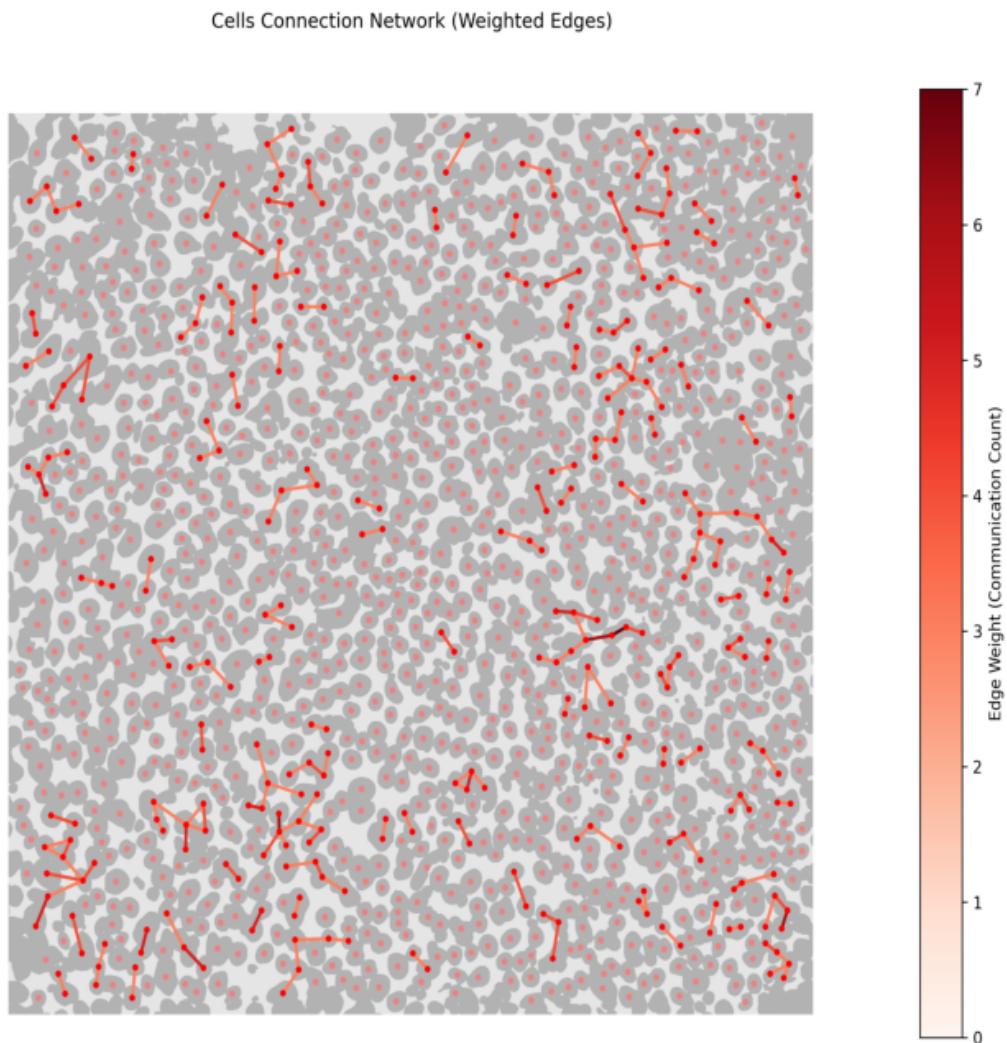


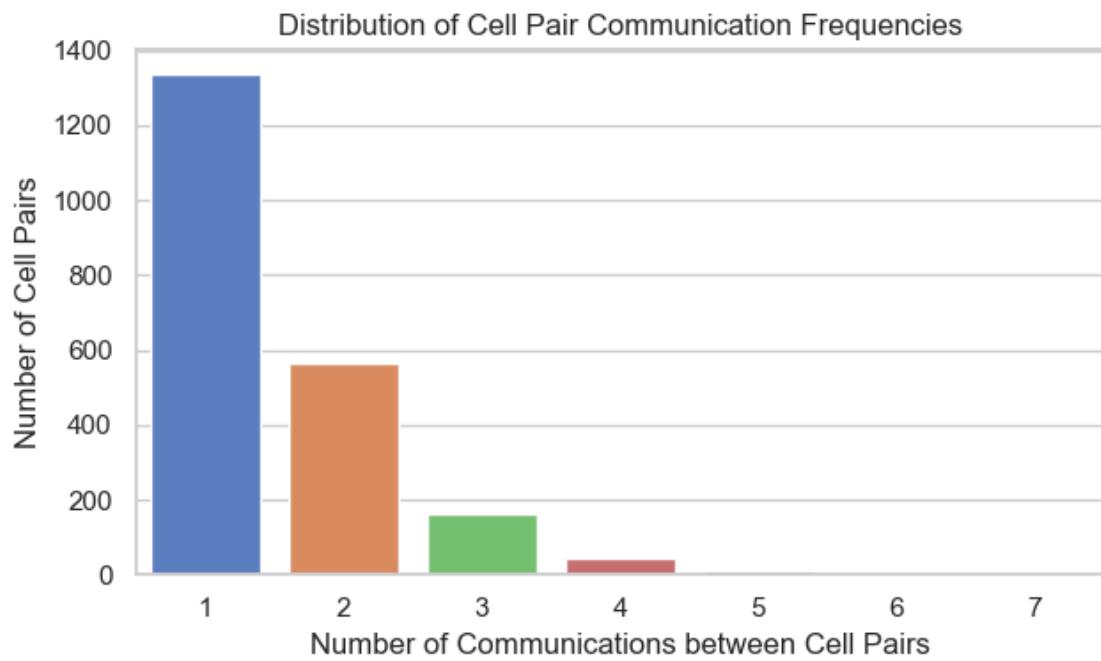
Distribution of Sequential Events per Cell by Number of Origin Peaks



1.3.8 Connection network between cells

Cell Connection Network Graph - 20250409_IS09

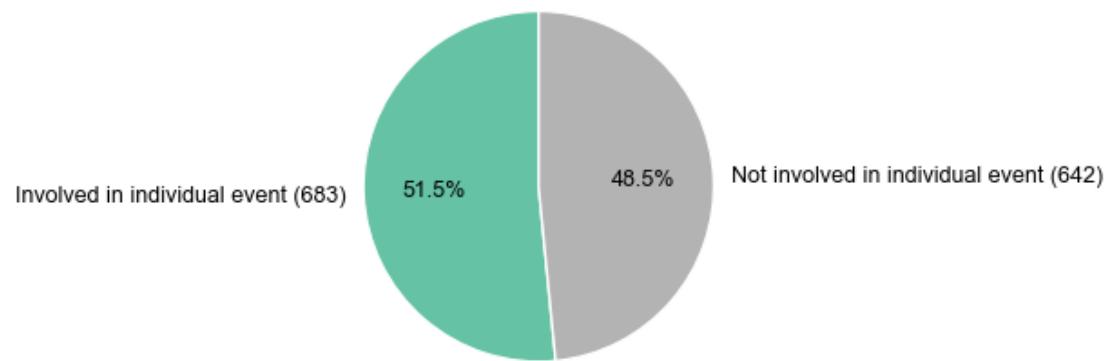




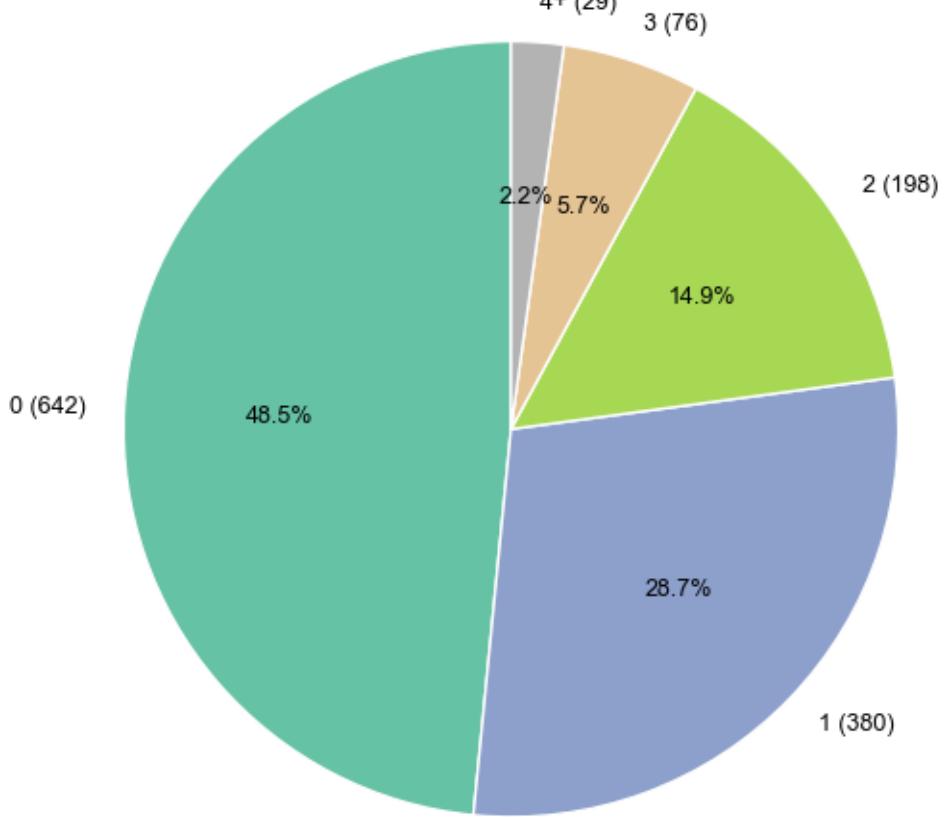
1.4 INDIVIDUAL EVENTS

1.4.1 Cells occurrences in individual events

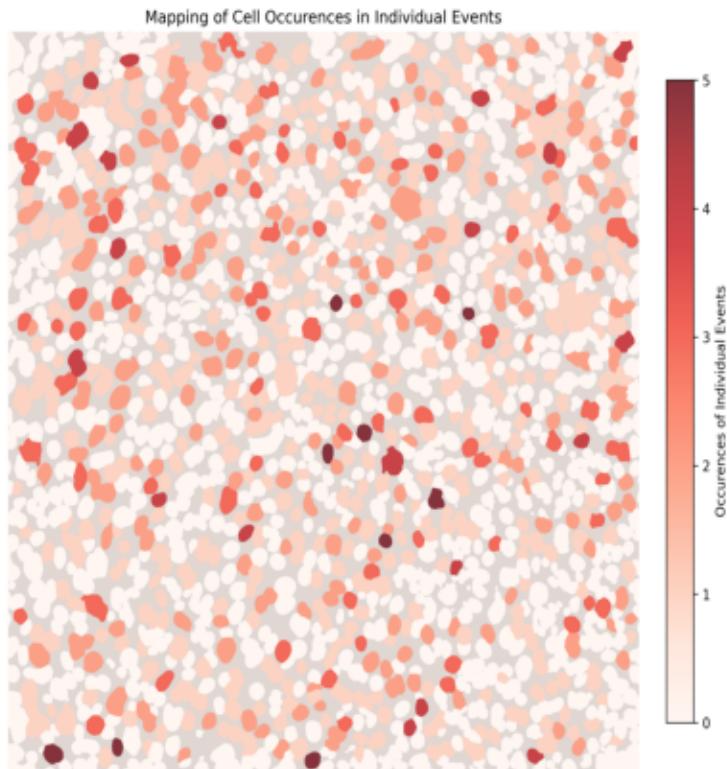
Distribution of Cells Involved in Individual Events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

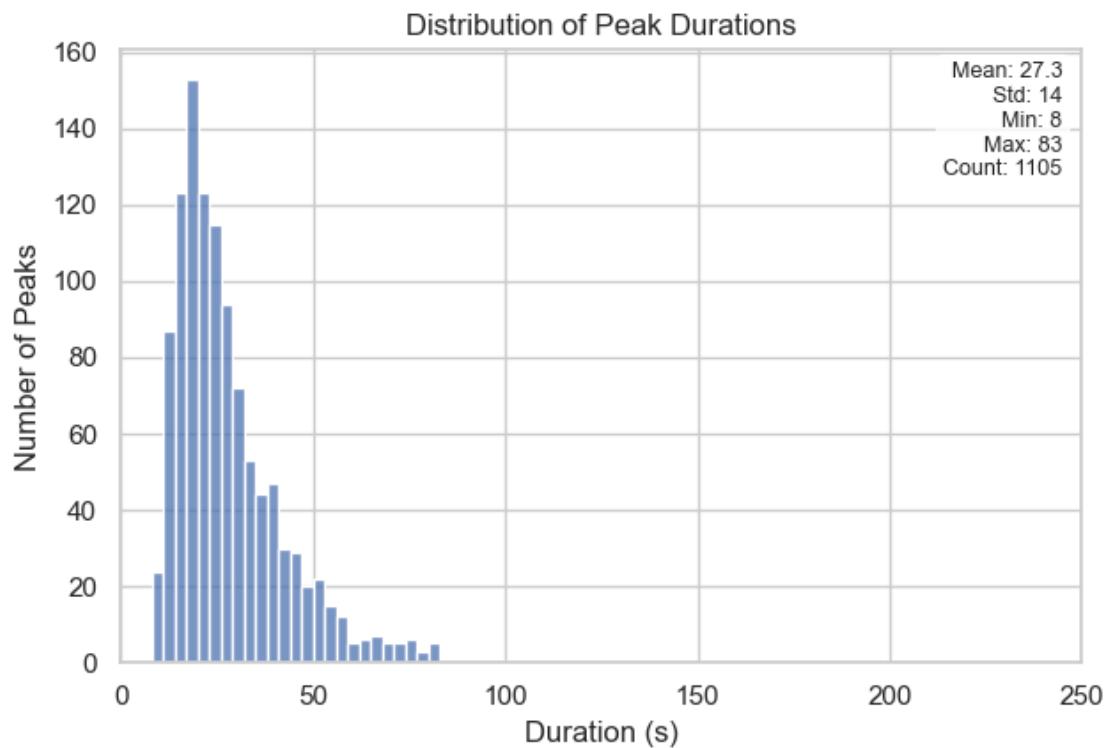


Cell Mapping with Occurrences in Individual Events Overlay - 20250409_IS09

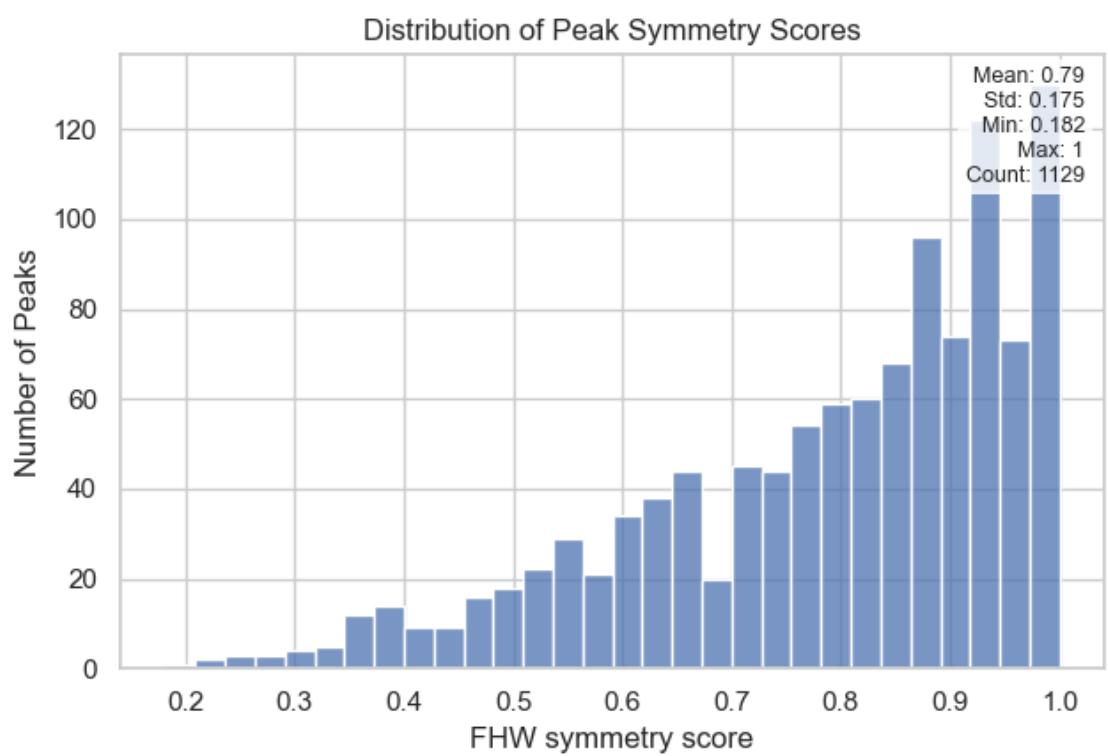
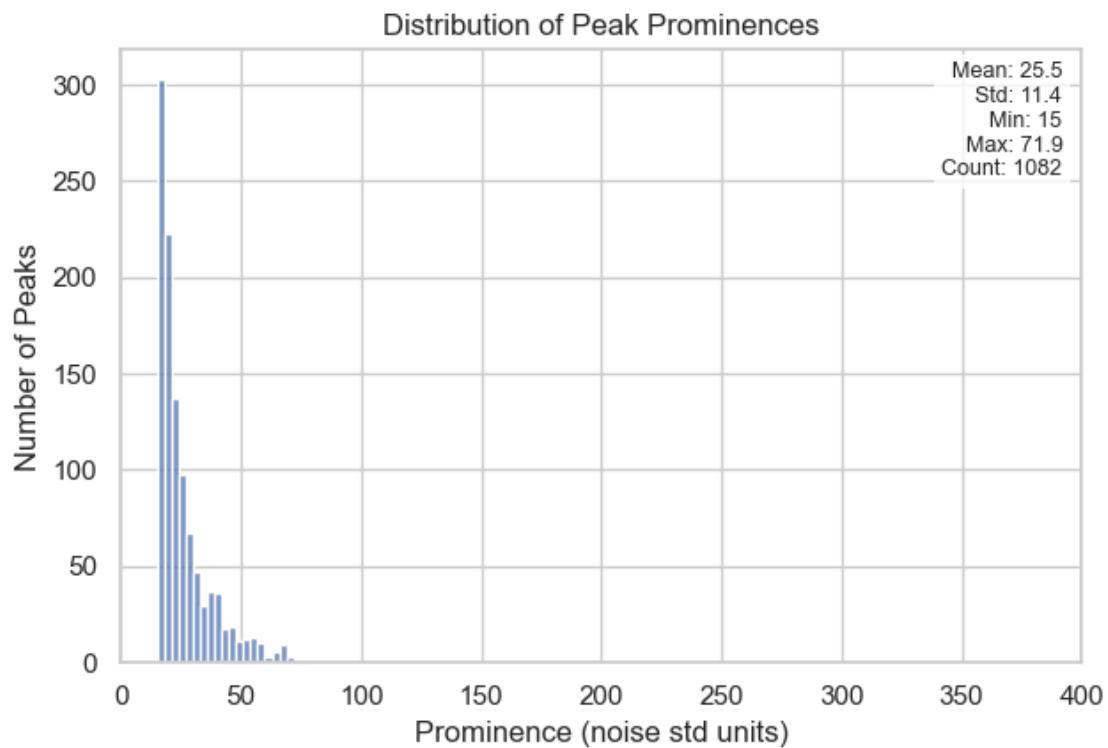


1.4.2 Peaks statistics in individual events

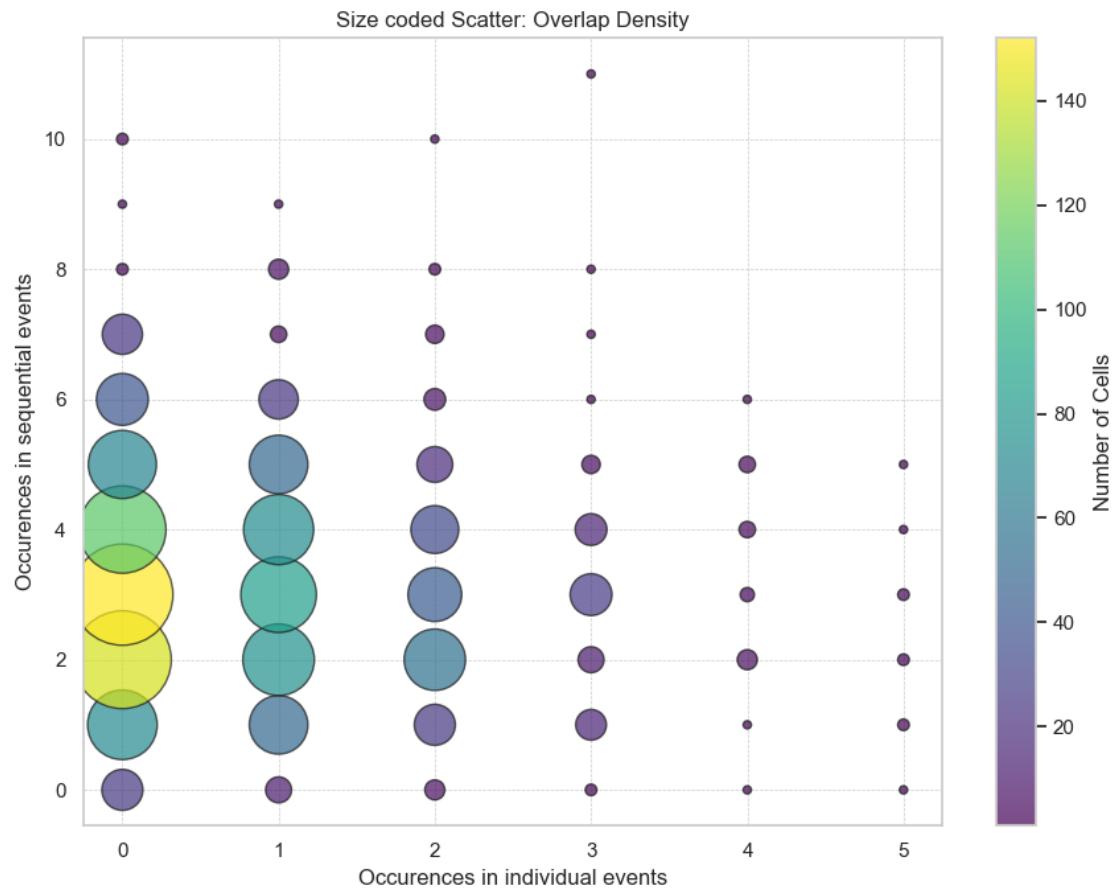
```
[2025-08-13 11:39:55] [INFO] calcium: plot_histogram: removed 24 outliers out of 1129 on 'Duration (s)' (lower=-33, upper=86)
```



```
[2025-08-13 11:39:56] [INFO] calcium: plot_histogram: removed 47 outliers out of 1129 on 'Prominence (noise std units)' (lower=-23.4, upper=72.5)
```

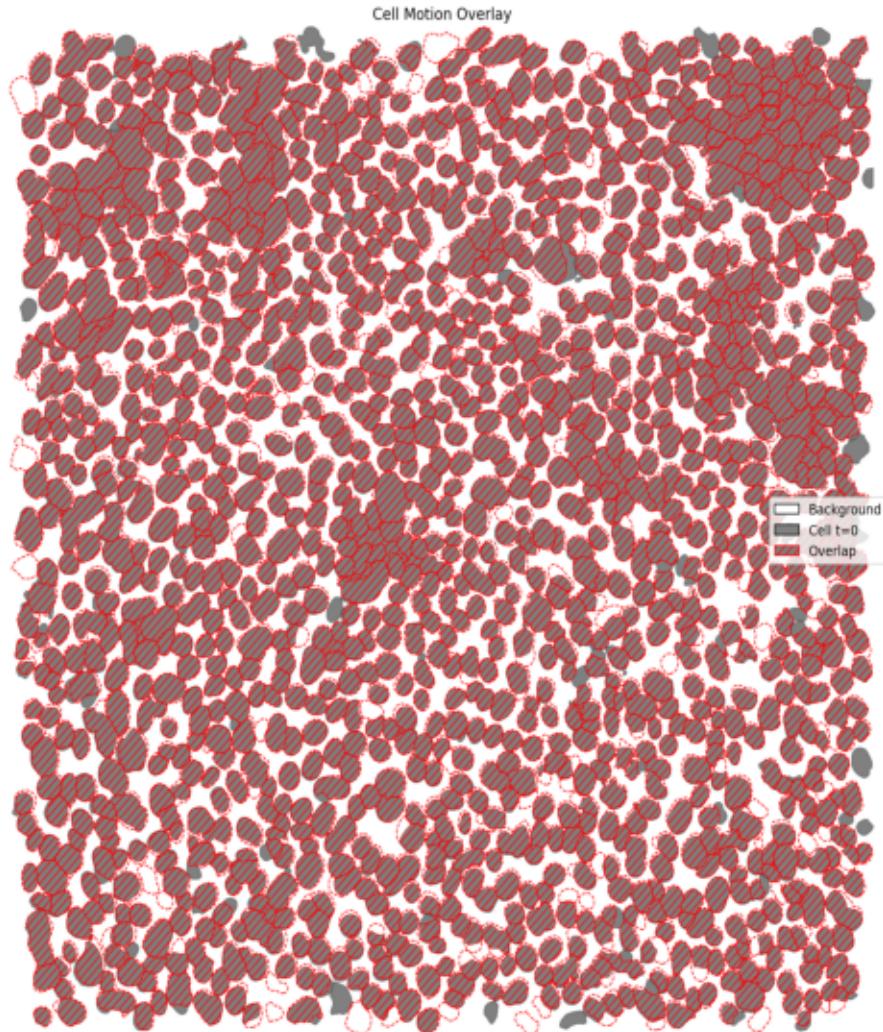


1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250409_IS09



Number of cells:

- Hoechst image taken at t=0: 1325
- Hoechst image taken at t=1801: 1321
- Number of cells difference: absolute 4, relative 0.30%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 1444822
- Pixels segmented as cell at t=1801: 1510000
- Overlapping pixels between t=0 and t=1801: 1328466 (89.92% of total)
- Pixels exclusive to t=0: 116356 (8.05% of total)
- Pixels exclusive to t=1801: 181534 (12.02% of total)

executed

August 13, 2025

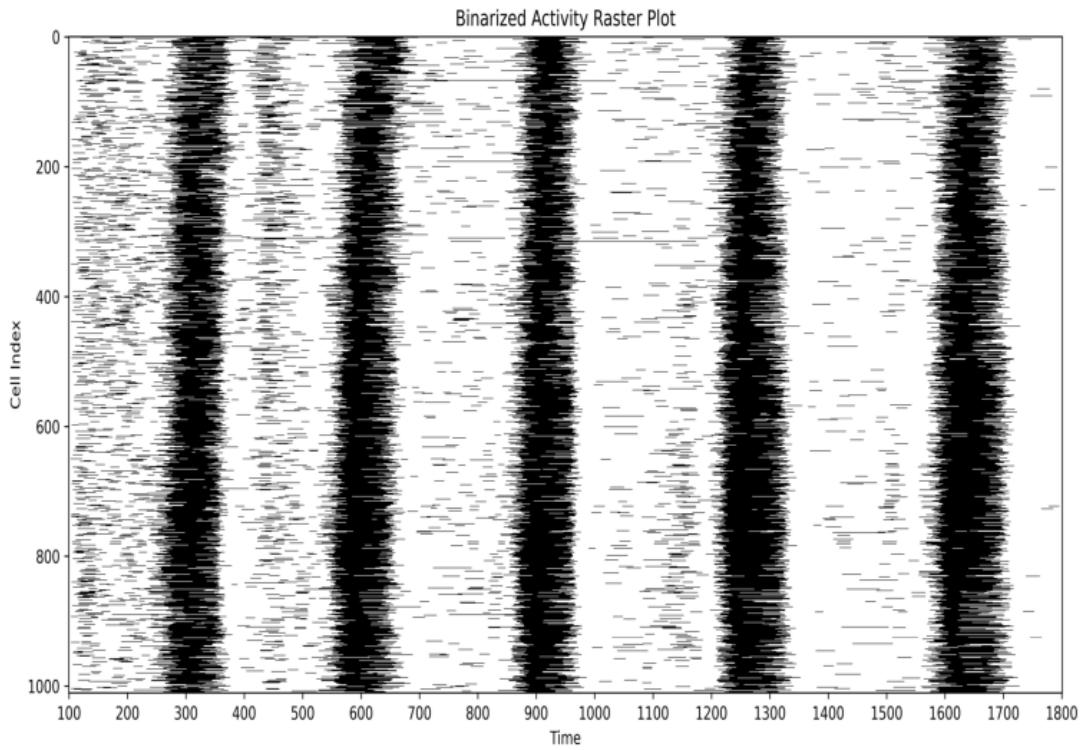
1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

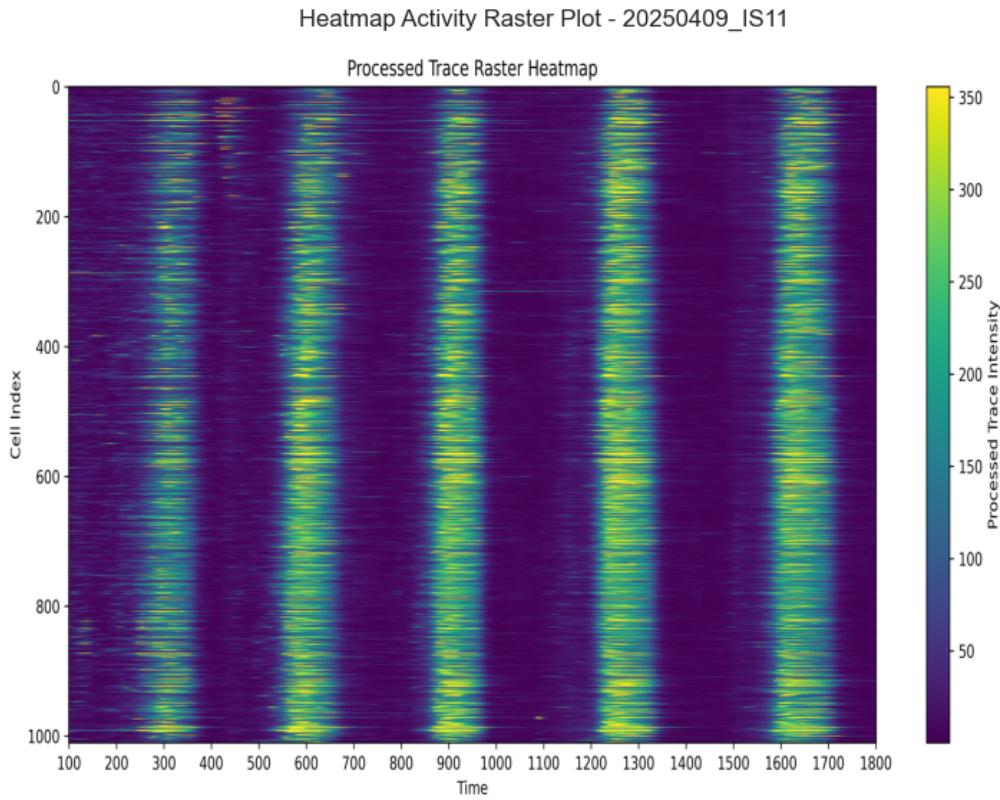
1.0.1 Initialization

1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot

Binary Activity Raster Plot - 20250409_IS11





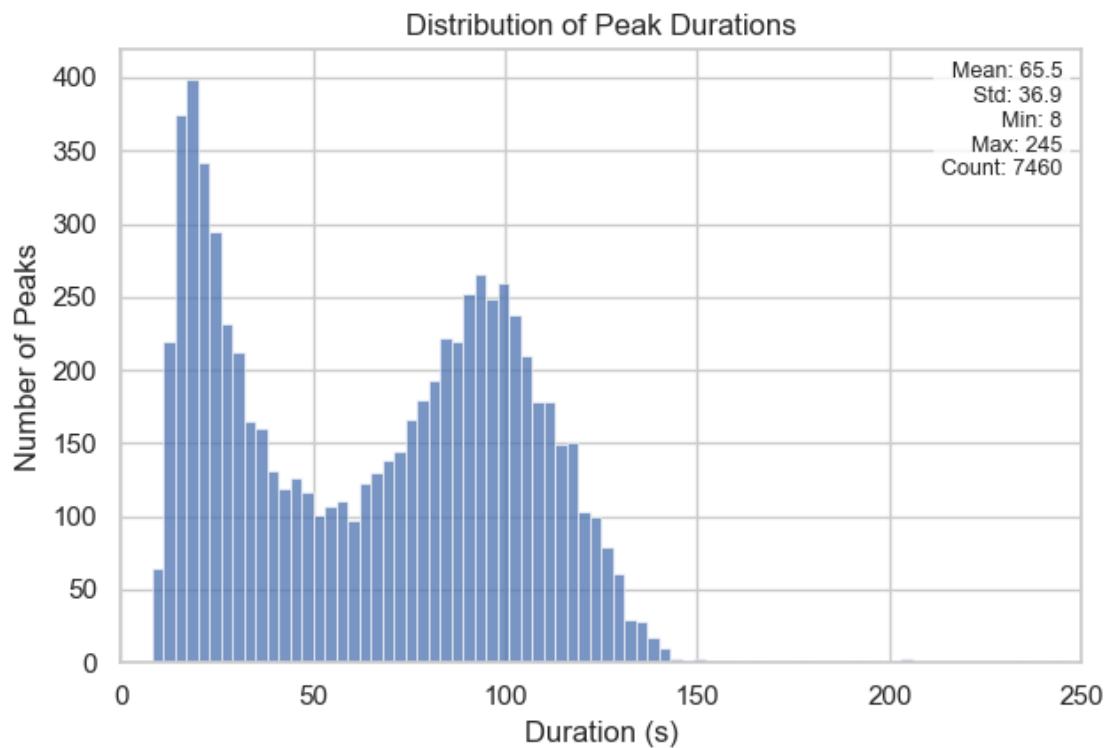
1.1.2 Peaks population

Total number of peaks: 7461

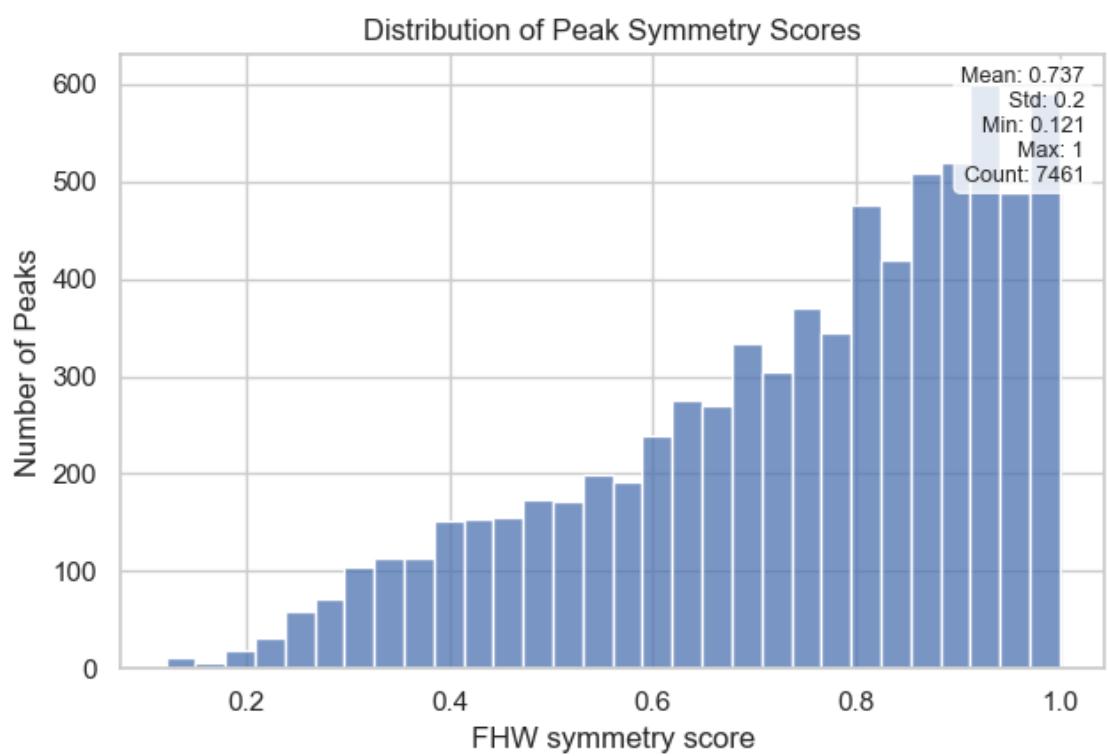
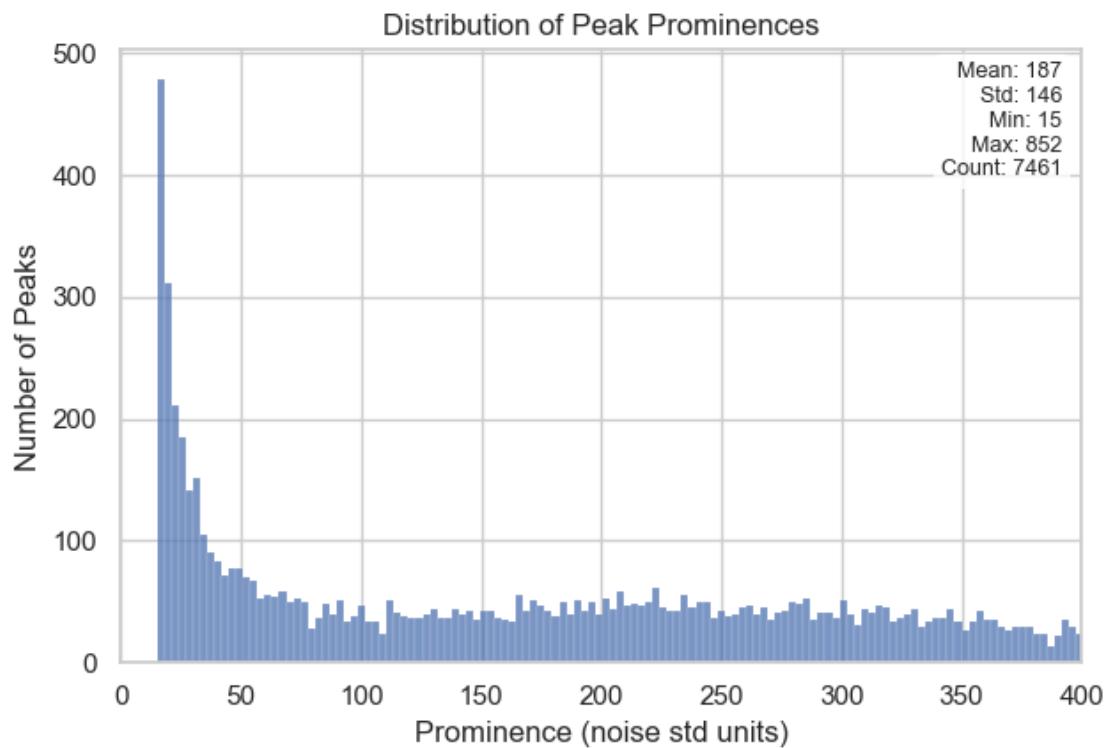
Total number of cells: 1011

1.1.3 Peaks statistics

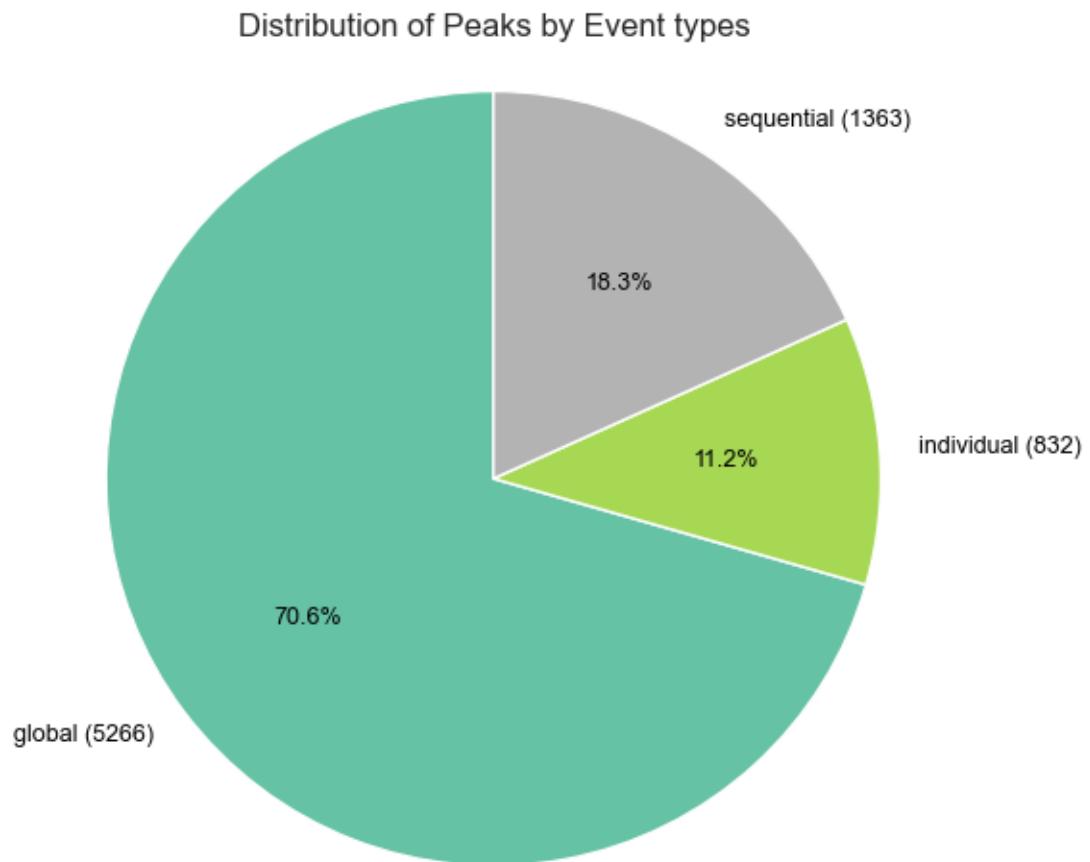
```
[2025-08-13 11:41:31] [INFO] calcium: plot_histogram: removed 1 outliers out of  
7461 on 'Duration (s)' (lower=-179, upper=304)
```



```
[2025-08-13 11:41:31] [INFO] calcium: plot_histogram: removed 0 outliers out of  
7461 on 'Prominence (noise std units)' (lower=-698, upper=1038.7)
```

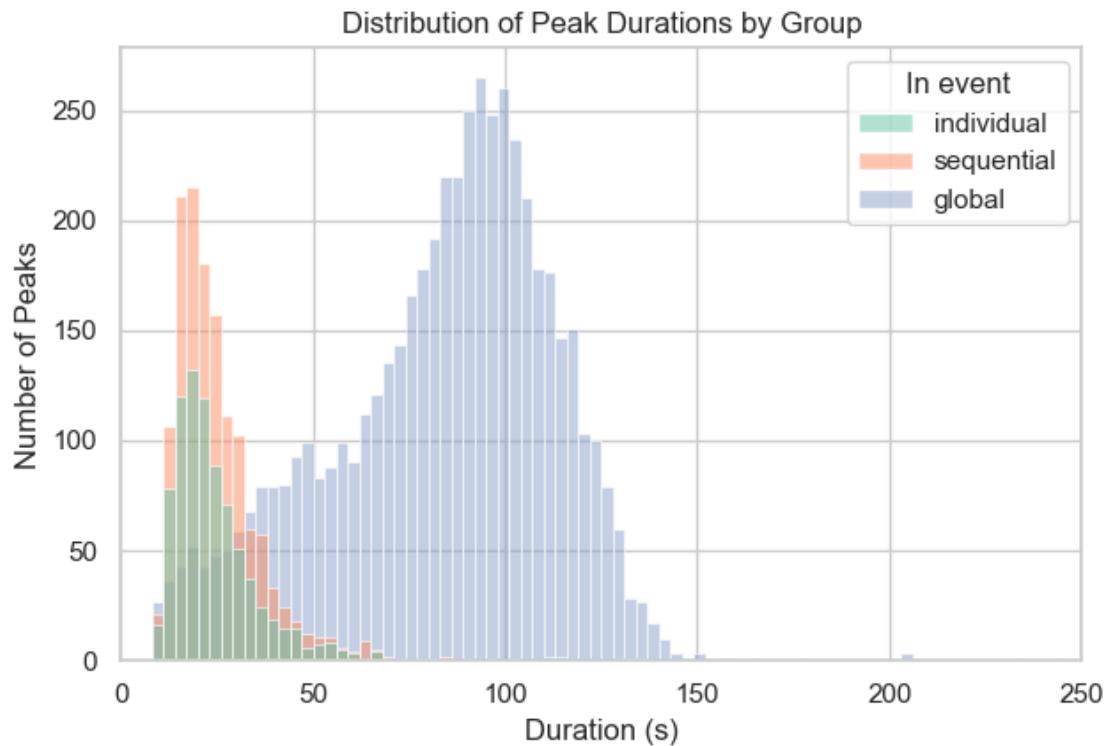


1.1.4 Distribution of peaks per event types



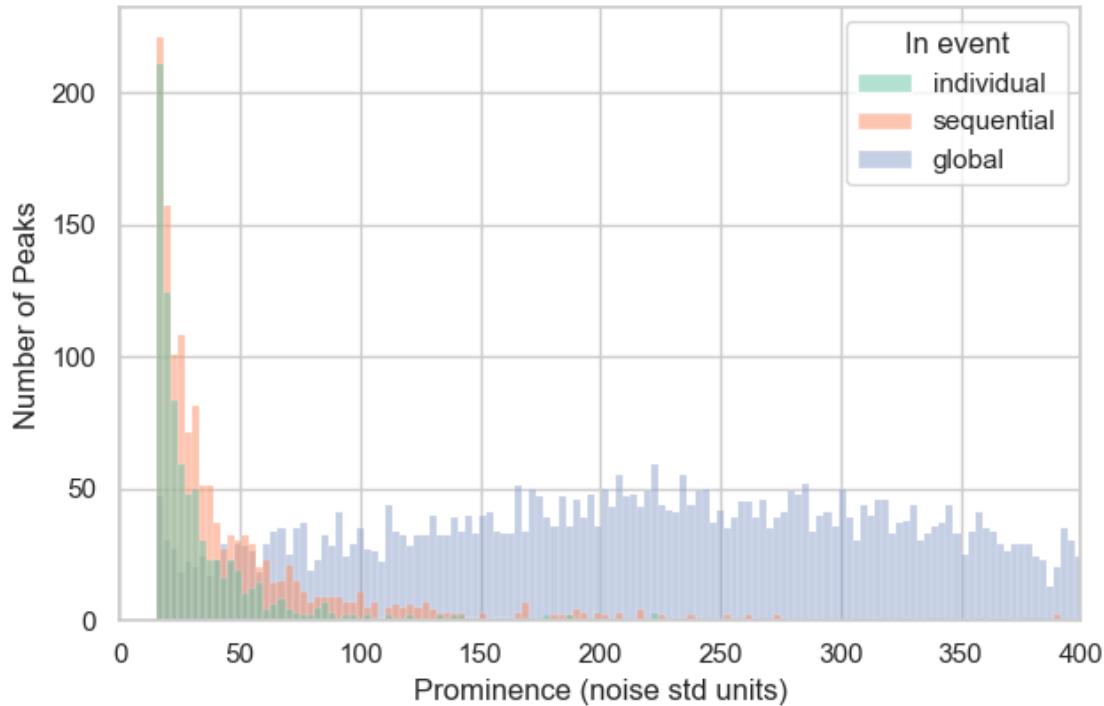
1.1.5 Peaks statistics per event types

```
[2025-08-13 11:41:32] [INFO] calcium: plot_histogram_by_group: removed 1 outliers out of 7461 on 'Duration (s)' (lower=-179, upper=304)
```

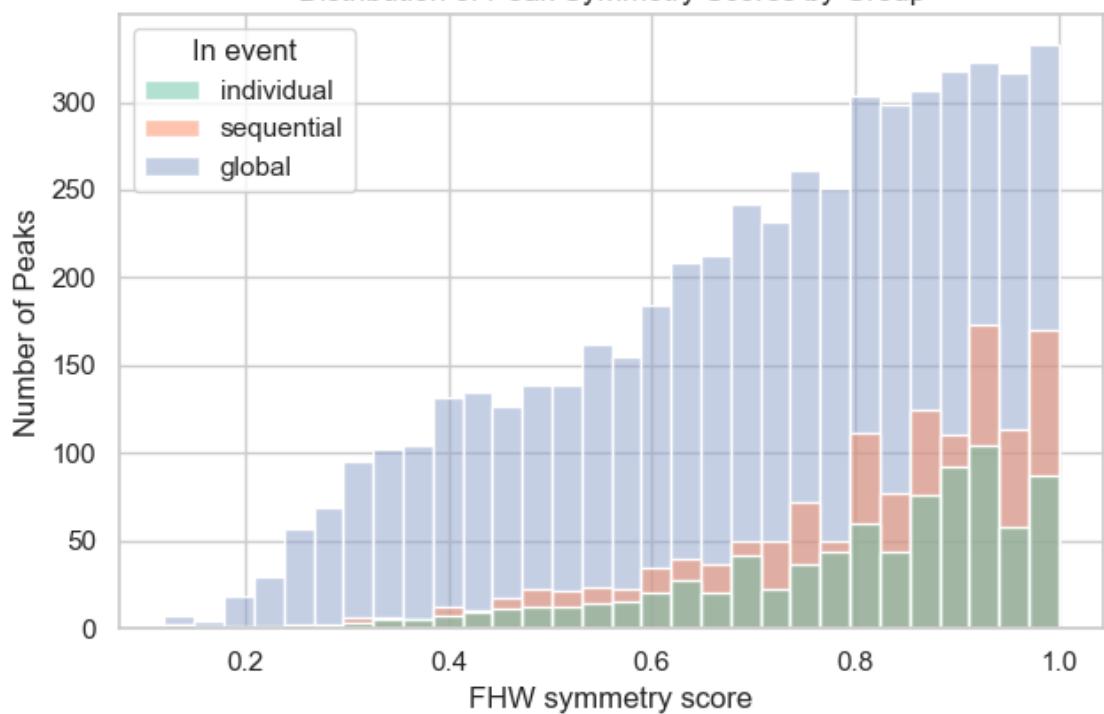


```
[2025-08-13 11:41:32] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 7461 on 'Prominence (noise std units)' (lower=-698, upper=1038.7)
```

Distribution of Peak Prominences by Group



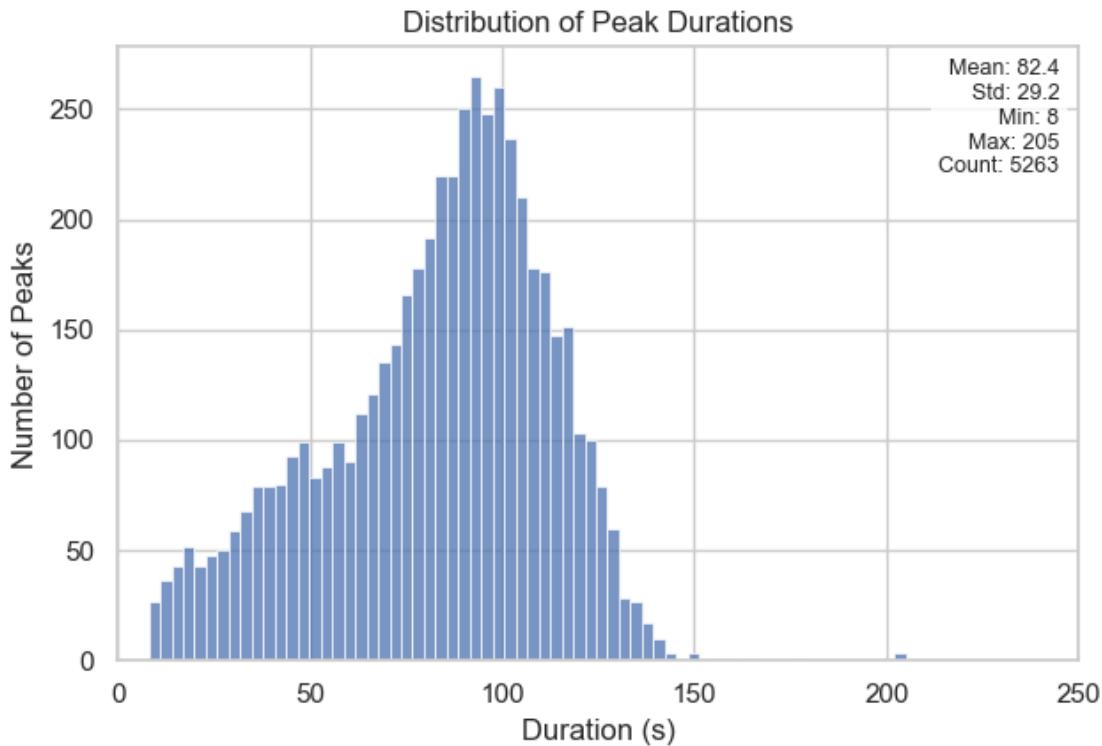
Distribution of Peak Symmetry Scores by Group



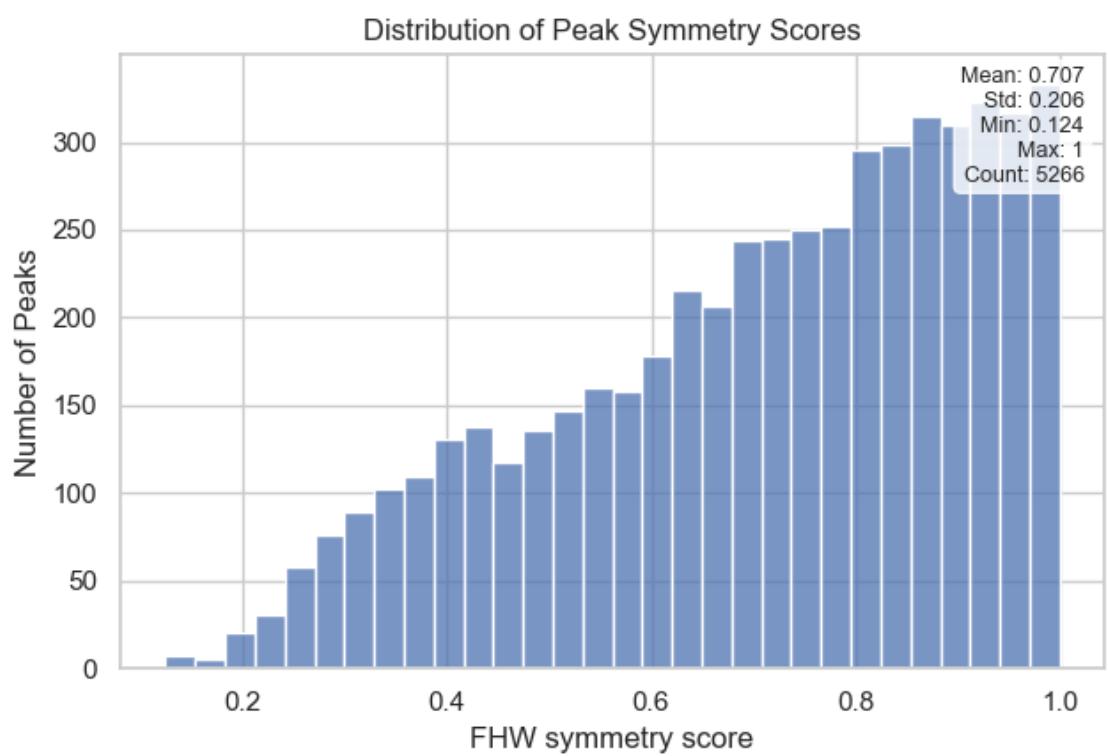
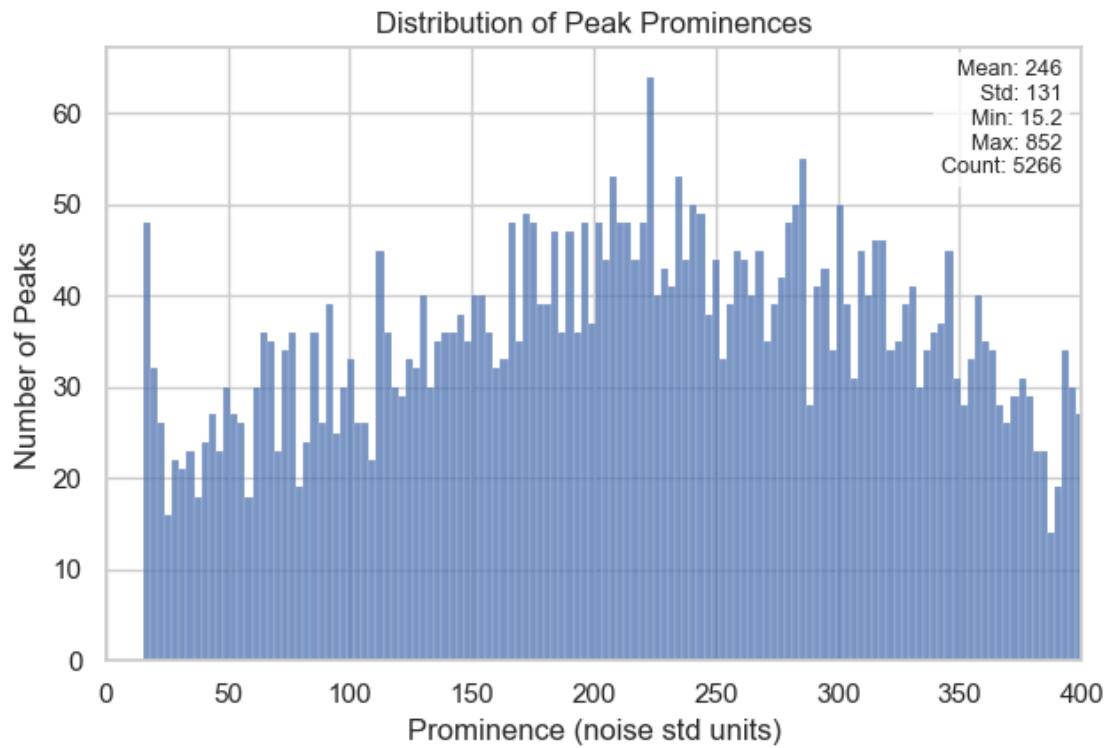
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

[2025-08-13 11:41:34] [INFO] calcium: plot_histogram: removed 3 outliers out of 5266 on 'Duration (s)' (lower=-53, upper=220)

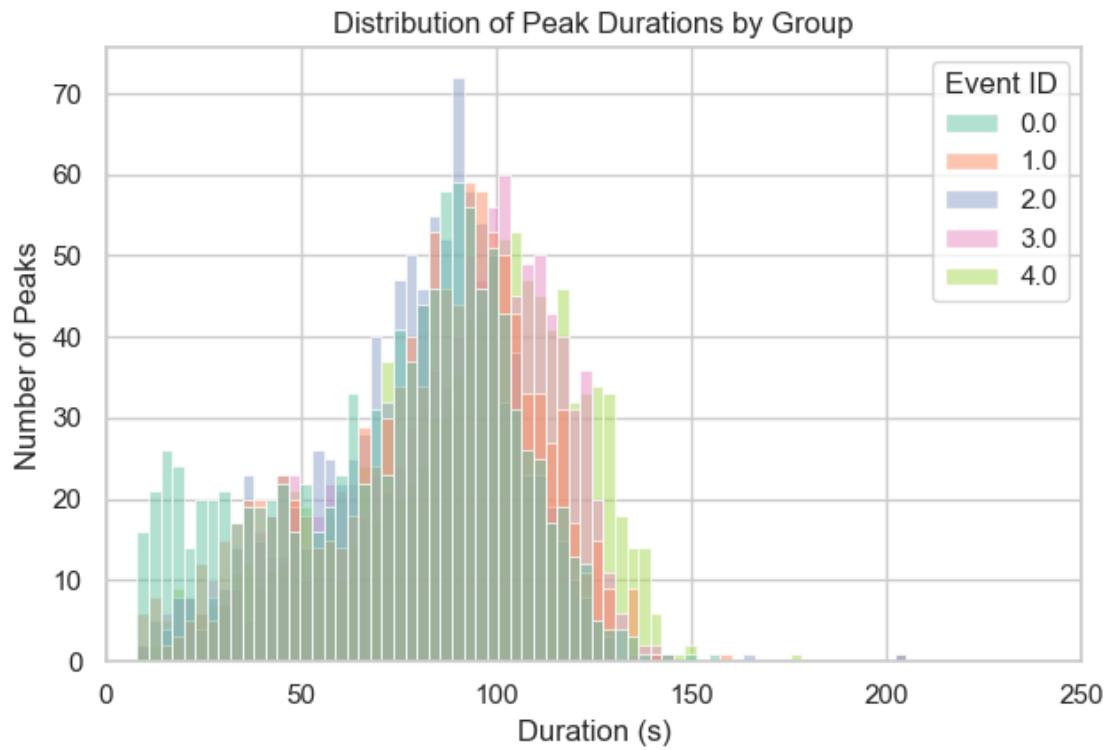


[2025-08-13 11:41:34] [INFO] calcium: plot_histogram: removed 0 outliers out of 5266 on 'Prominence (noise std units)' (lower=-410, upper=891.82)

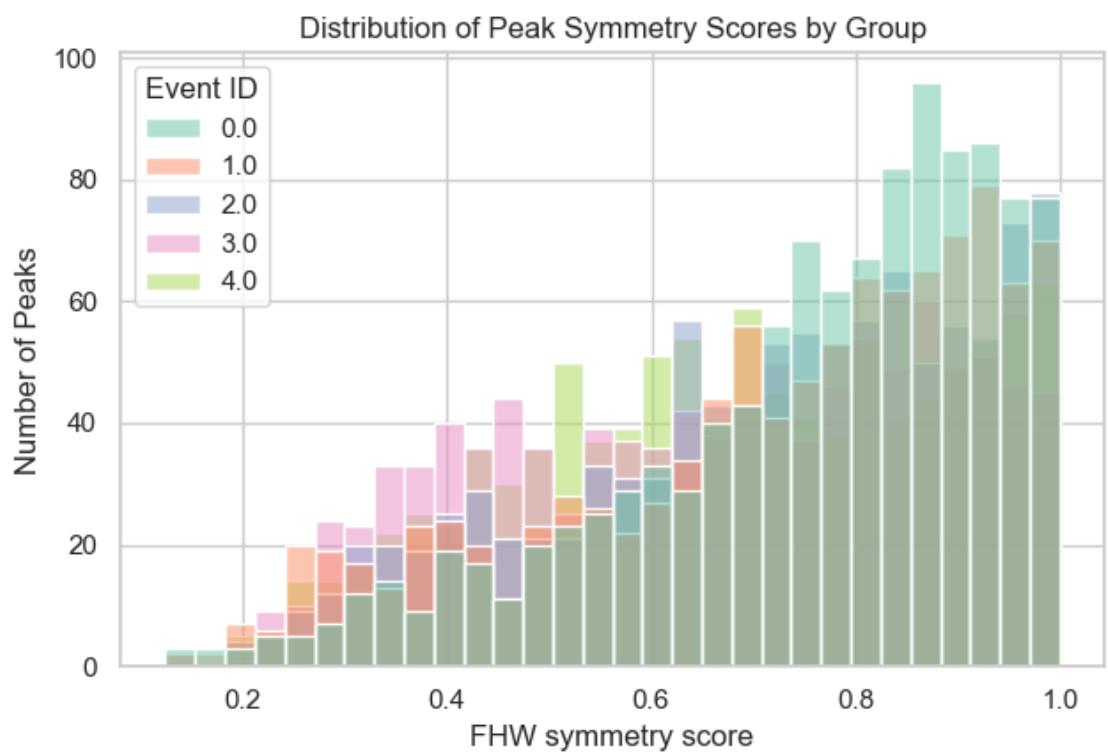
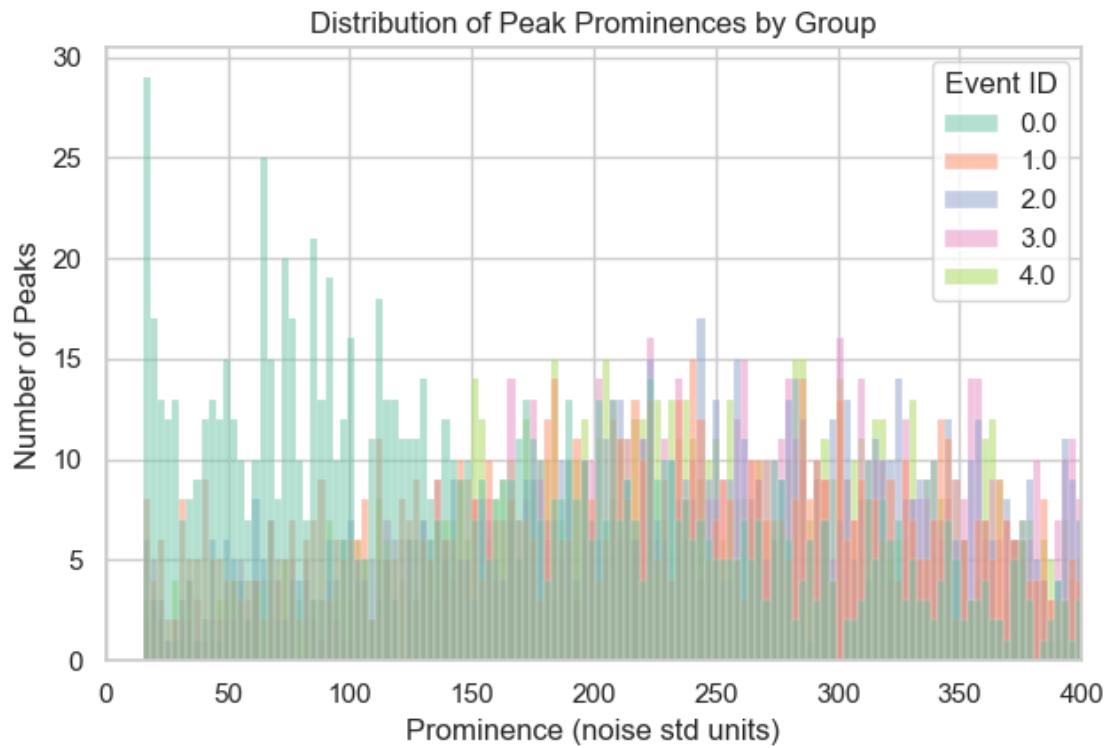


1.2.2 Peak statistics in global event per event ID

[2025-08-13 11:41:35] [INFO] calcium: plot_histogram_by_group: removed 3 outliers out of 5266 on 'Duration (s)' (lower=-53, upper=220)

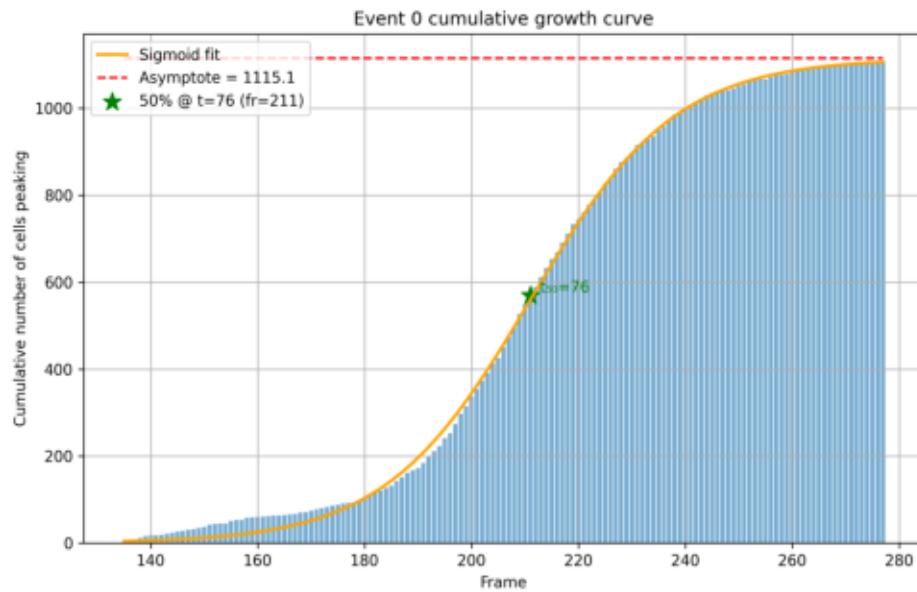


[2025-08-13 11:41:35] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 5266 on 'Prominence (noise std units)' (lower=-410, upper=891.82)

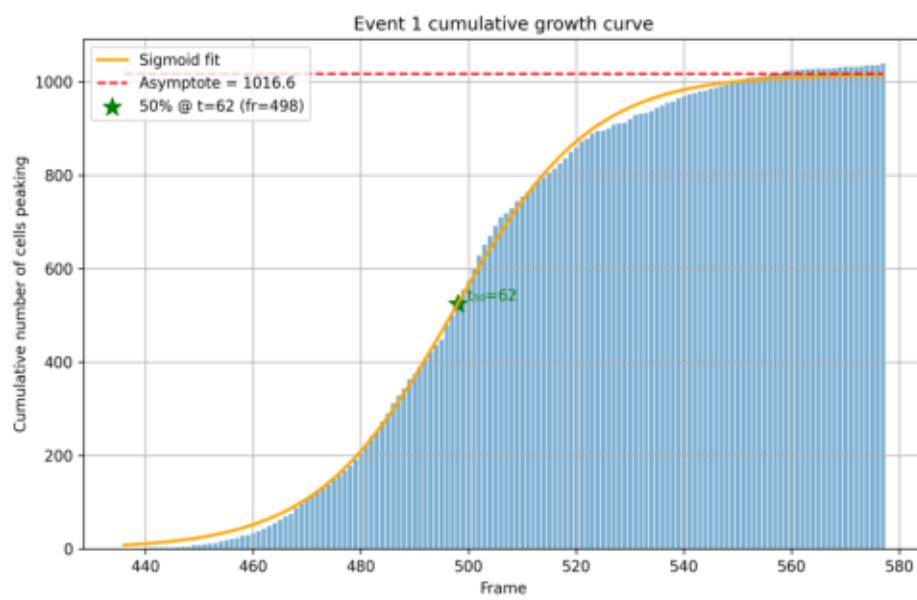


1.2.3 Kinetics of global events

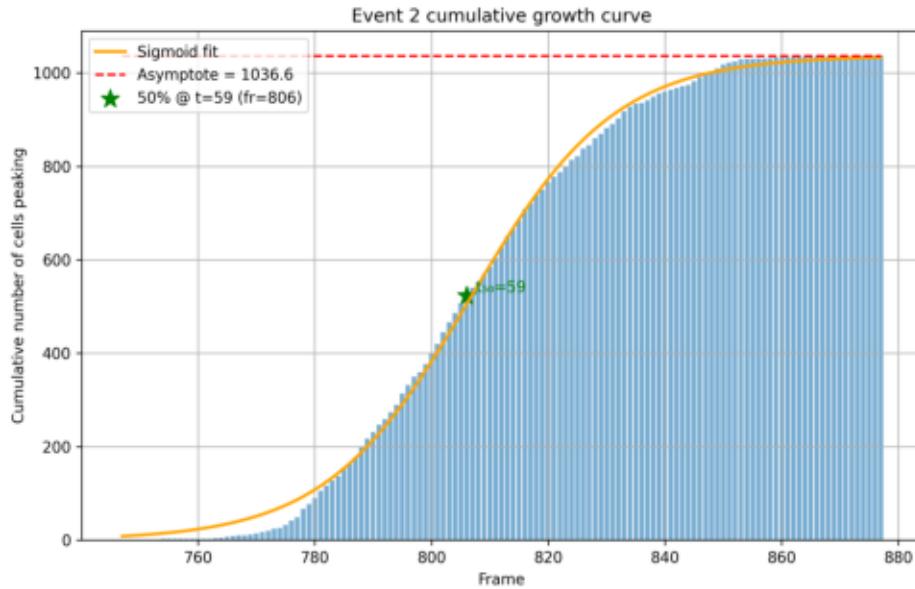
Event Activity Overlay (Event ID: 0) - 20250409_IS11



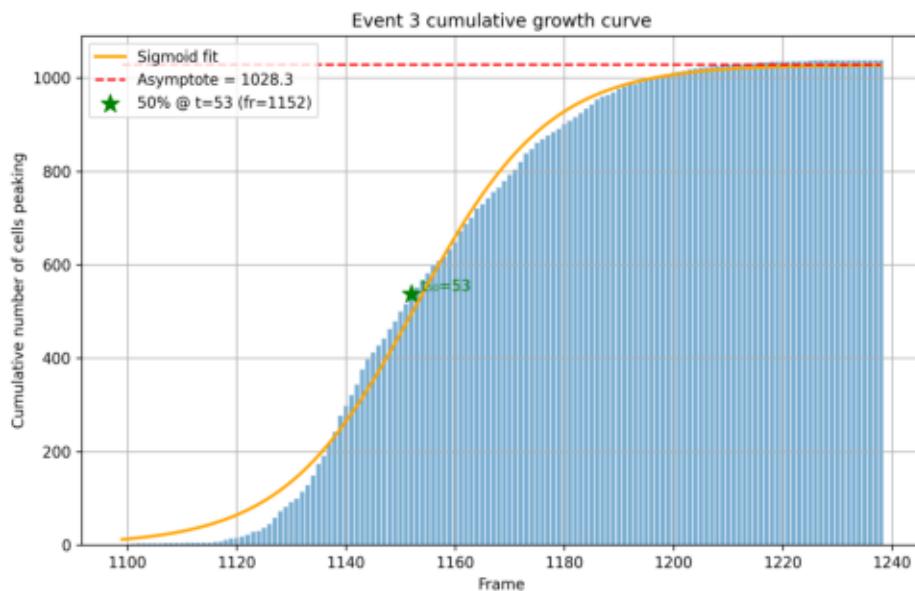
Event Activity Overlay (Event ID: 1) - 20250409_IS11



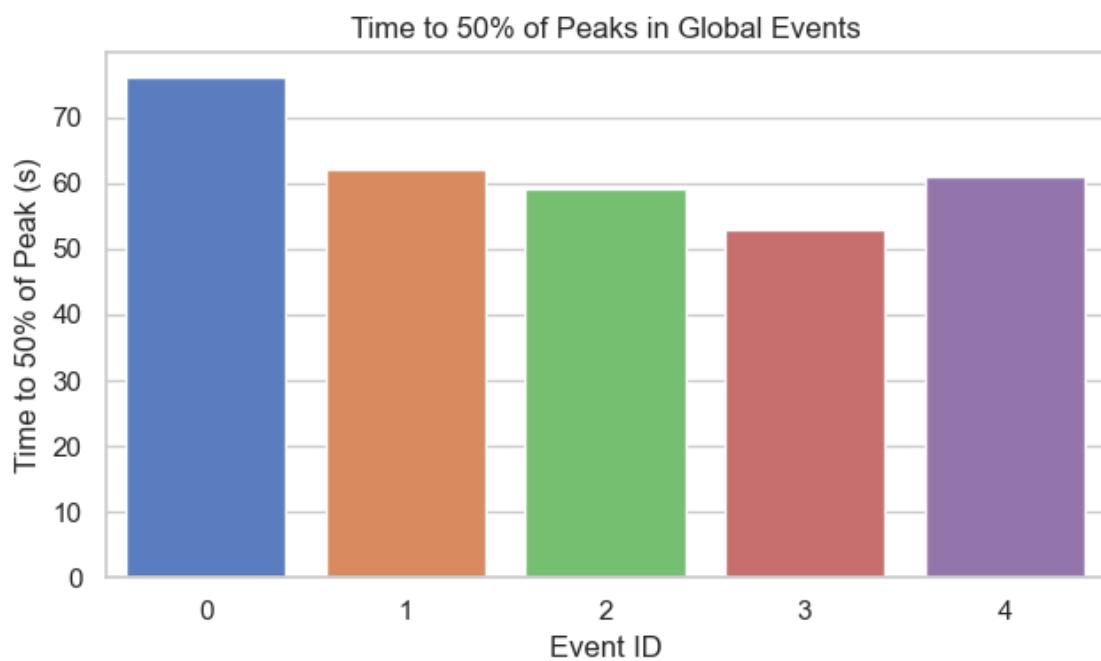
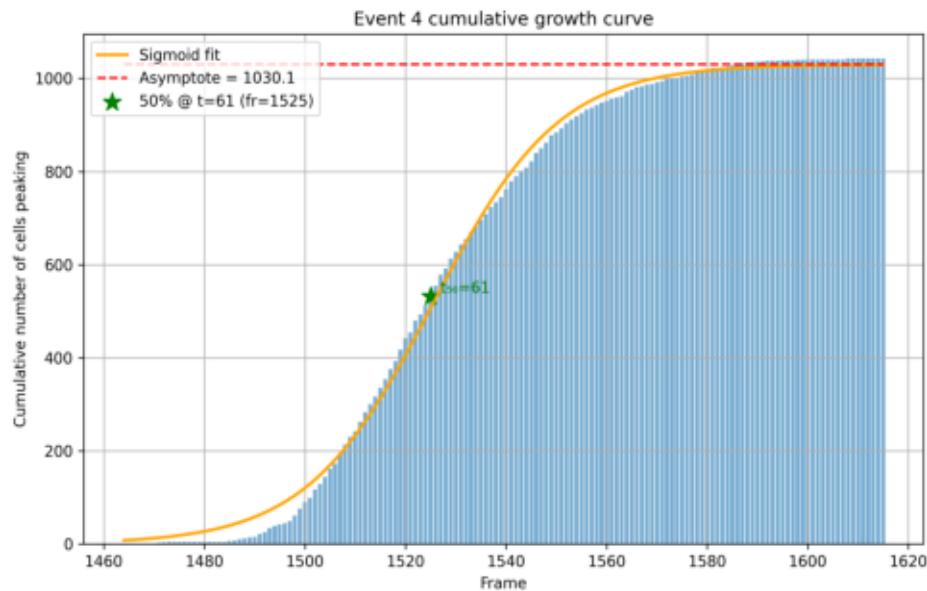
Event Activity Overlay (Event ID: 2) - 20250409_IS11

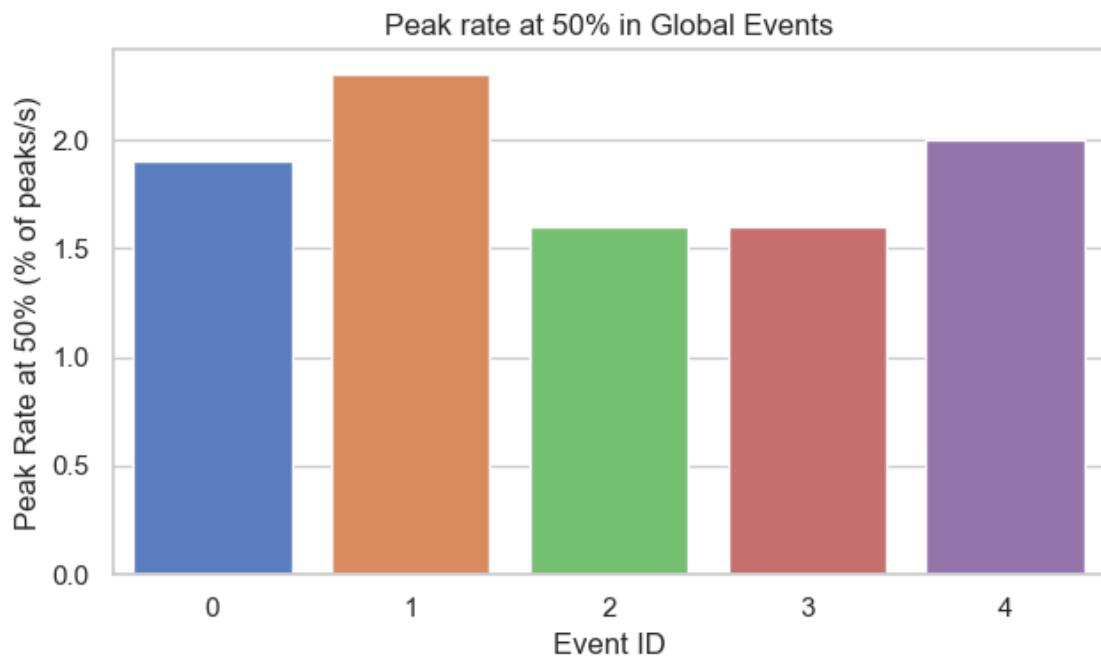


Event Activity Overlay (Event ID: 3) - 20250409_IS11

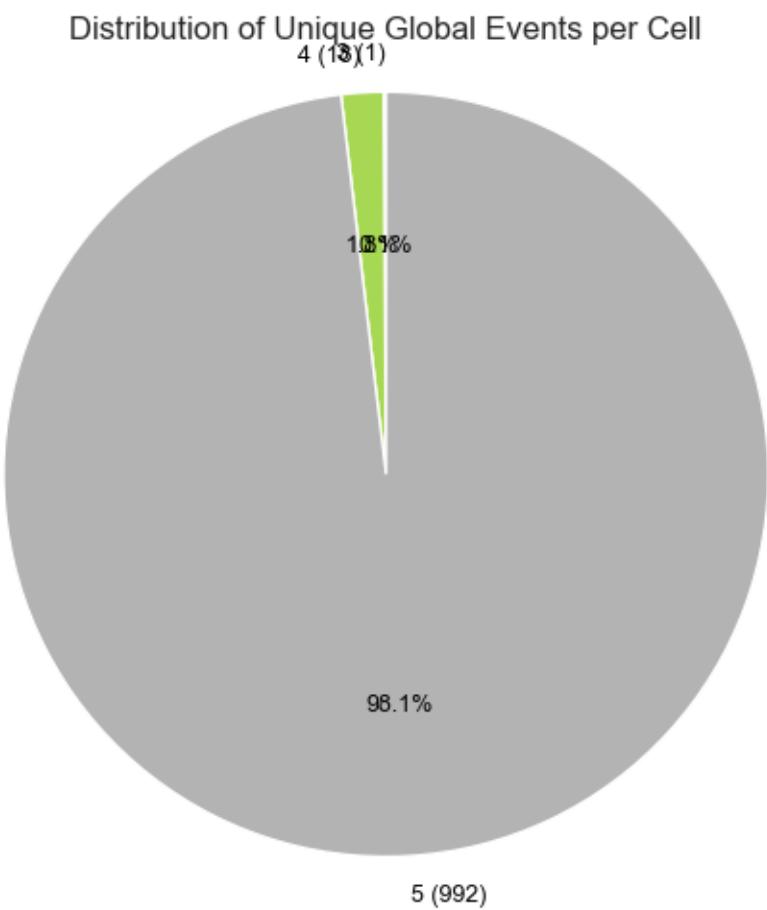


Event Activity Overlay (Event ID: 4) - 20250409_IS11

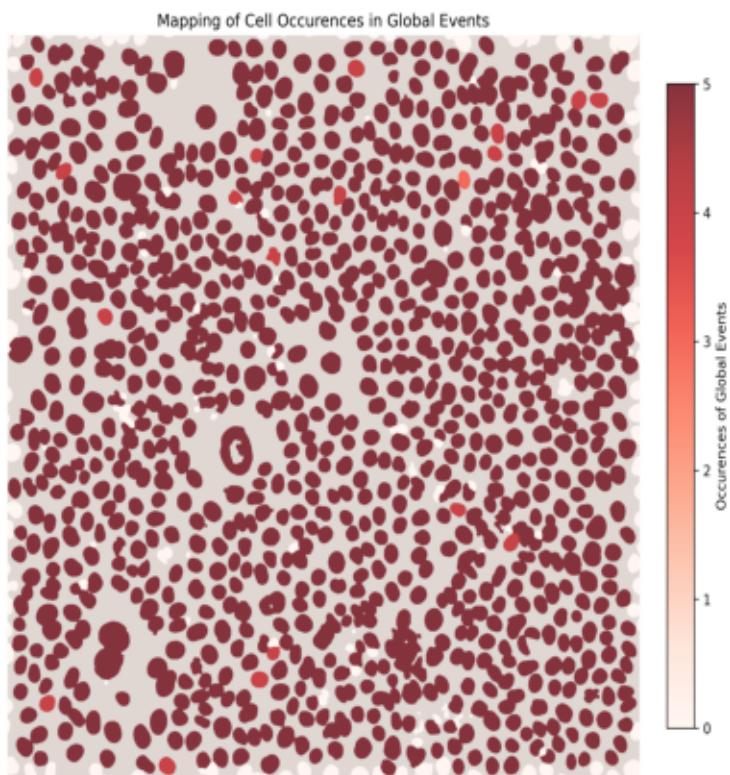


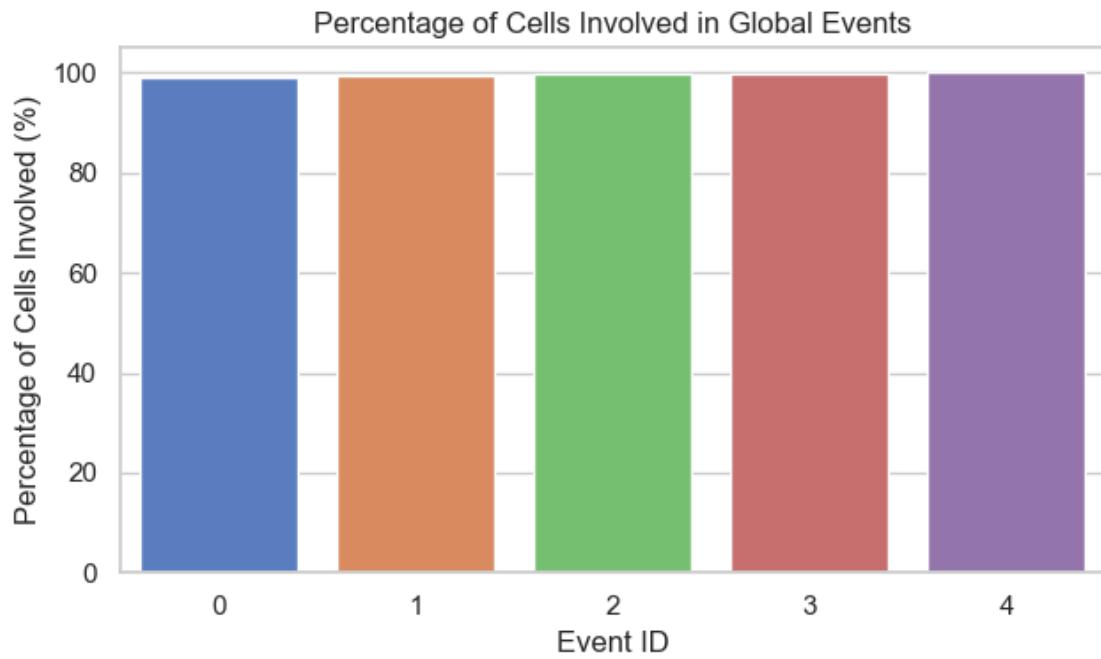


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250409_IS11





1.2.5 Inter-event interval analysis

Intervals between global event peaks: [288.0, 309.0, 350.0, 377.0]

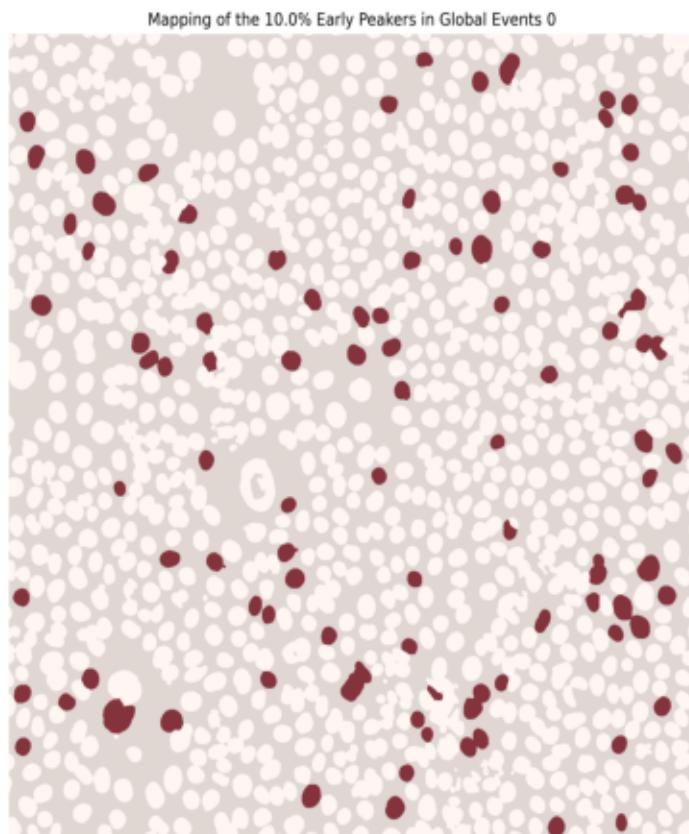
Estimated periodicity: 0.905

The global events exhibit a regular periodic pattern.

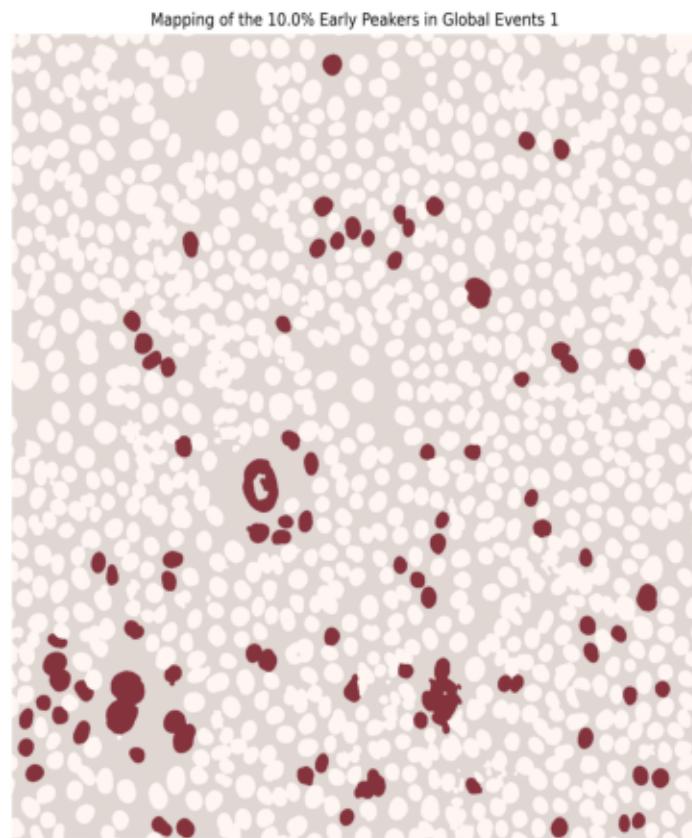
Estimated frequency (1/mean interval): 0.003 Hz

1.2.6 Early peakers in the events

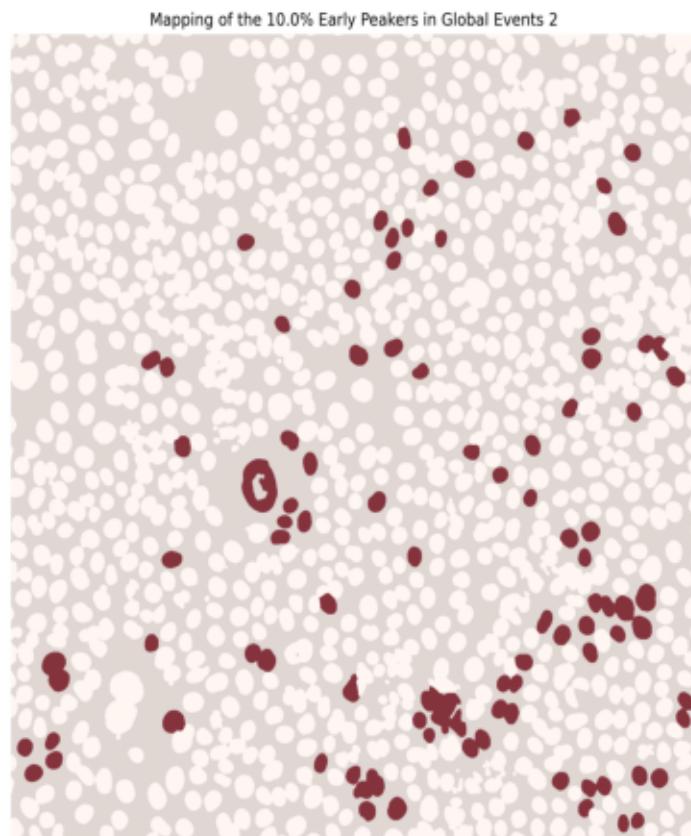
Cell Mapping with Early Peakers Overlay for event 0 - 20250409_IS11



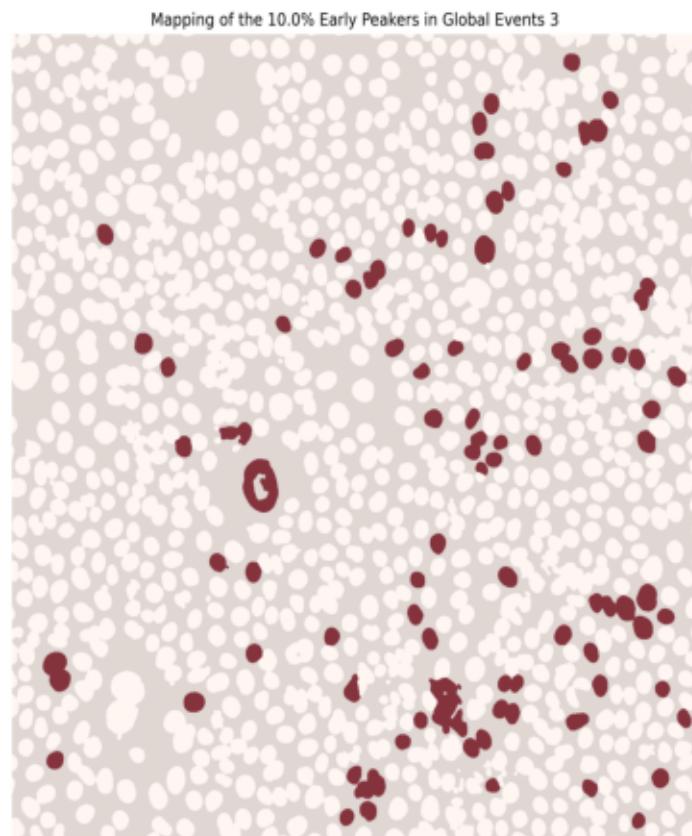
Cell Mapping with Early Peakers Overlay for event 1 - 20250409_IS11



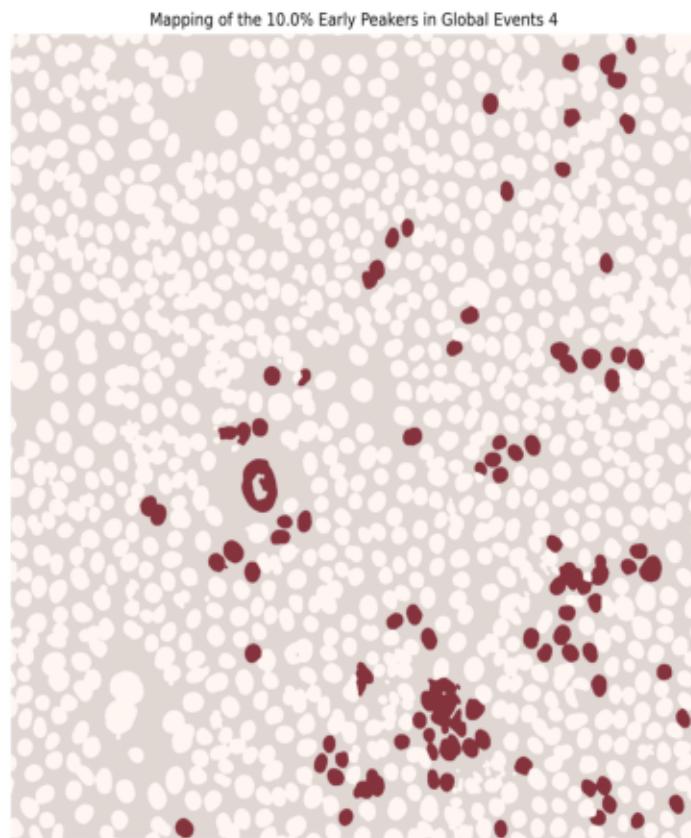
Cell Mapping with Early Peakers Overlay for event 2 - 20250409_IS11



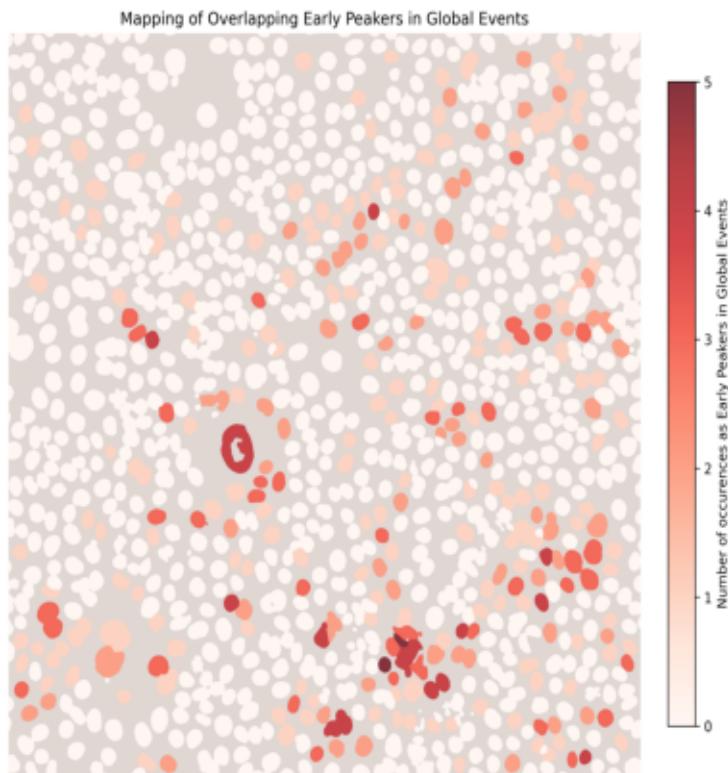
Cell Mapping with Early Peakers Overlay for event 3 - 20250409_IS11

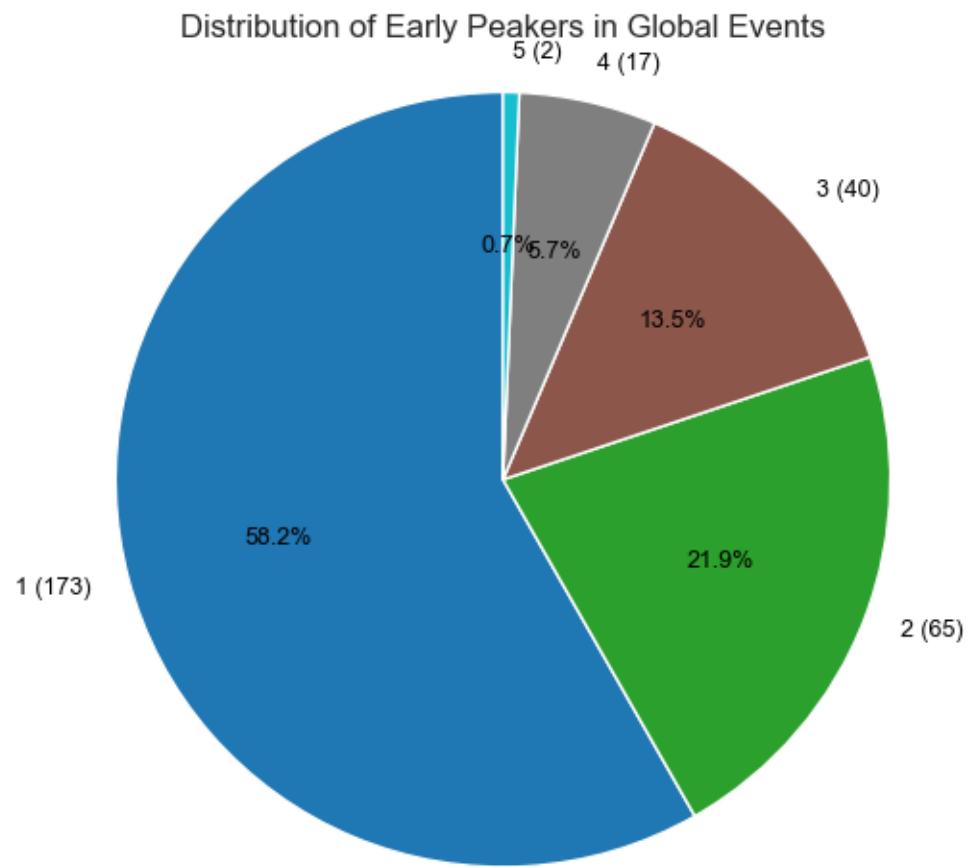
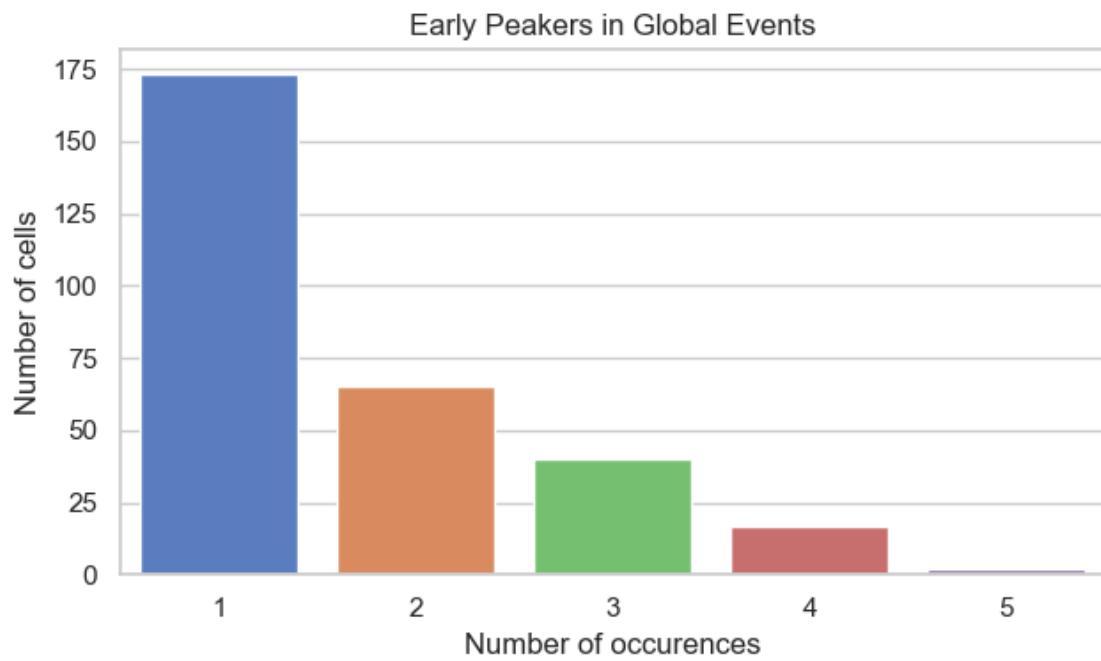


Cell Mapping with Early Peakers Overlay for event 4 - 20250409_IS11



Cell Mapping with Occurrences in Global Events Overlay - 20250409_IS11

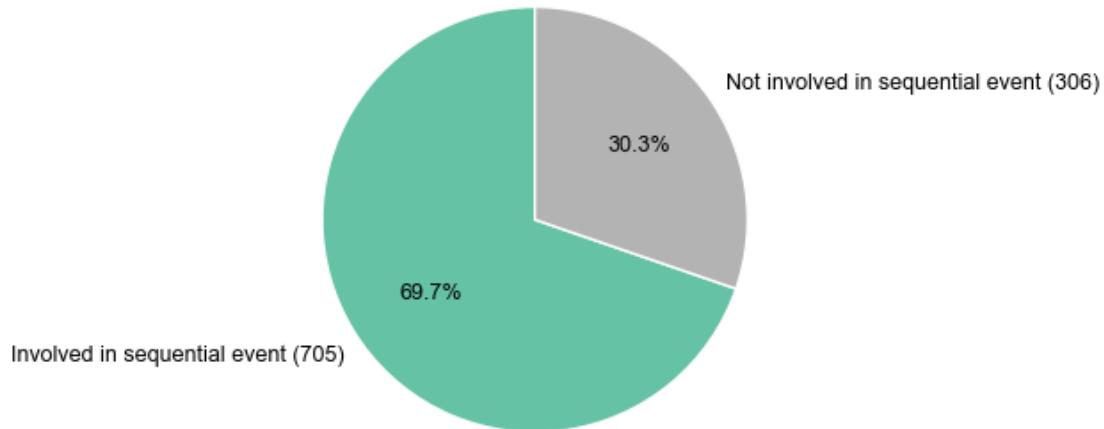




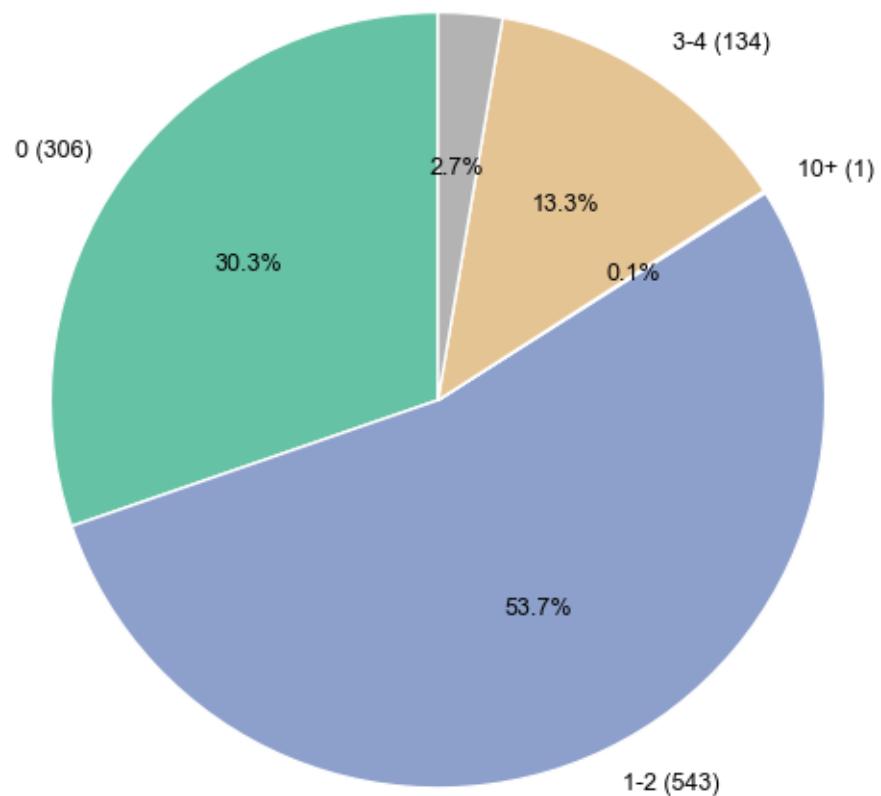
1.3 SEQUENTIAL EVENTS

1.3.1 Cells occurrences in sequencial events

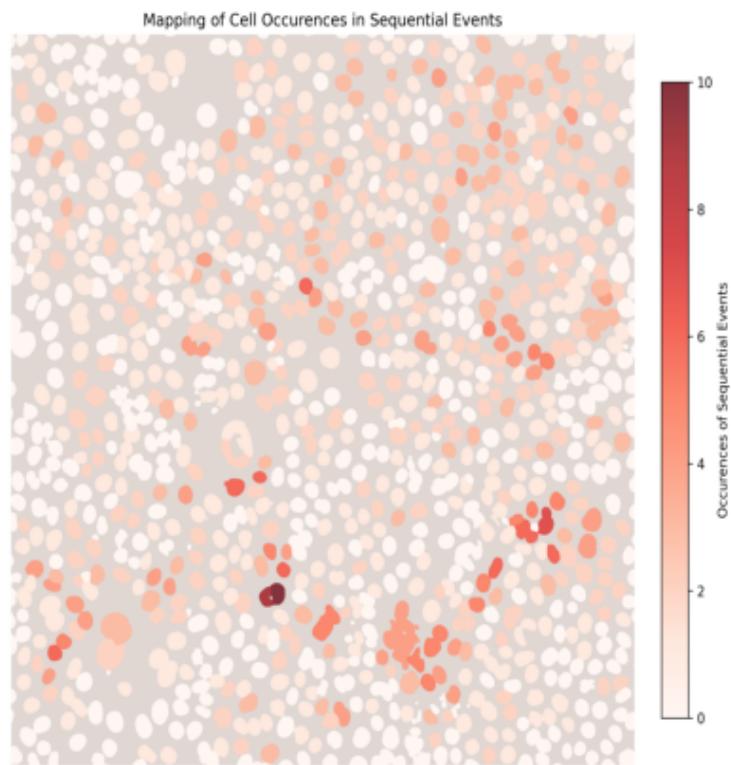
Distribution of Cells Involved in Sequential Events



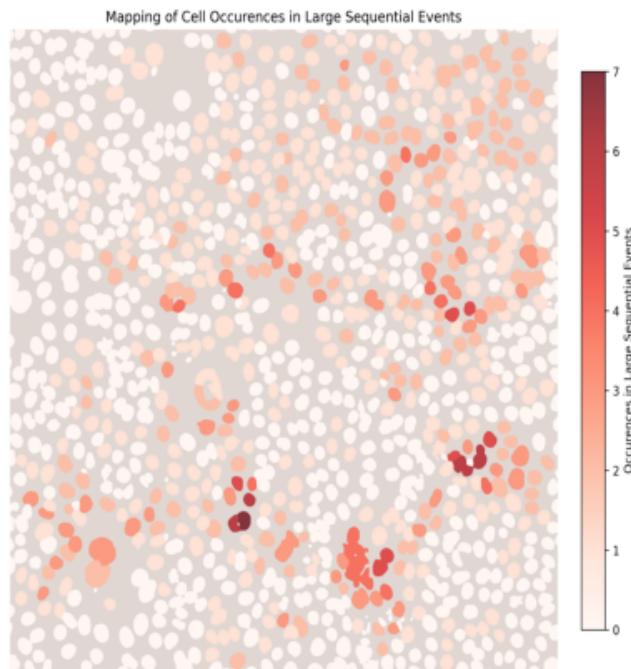
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)
5-9 (27)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250409_IS11

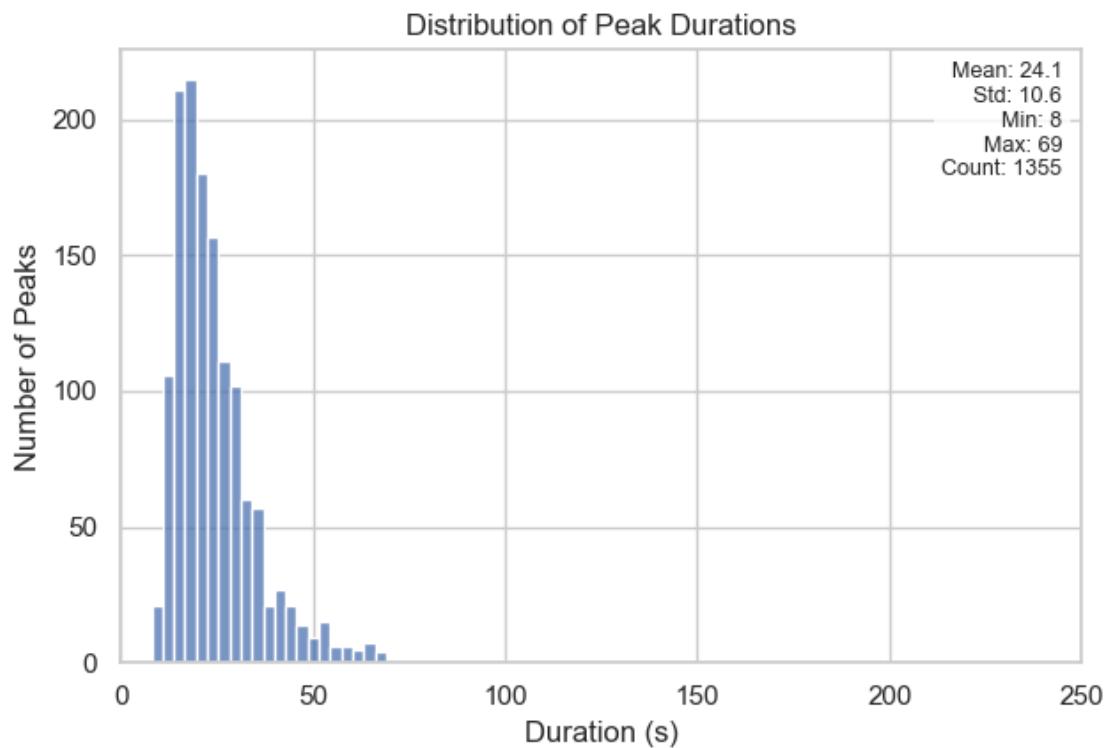


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250409_IS11

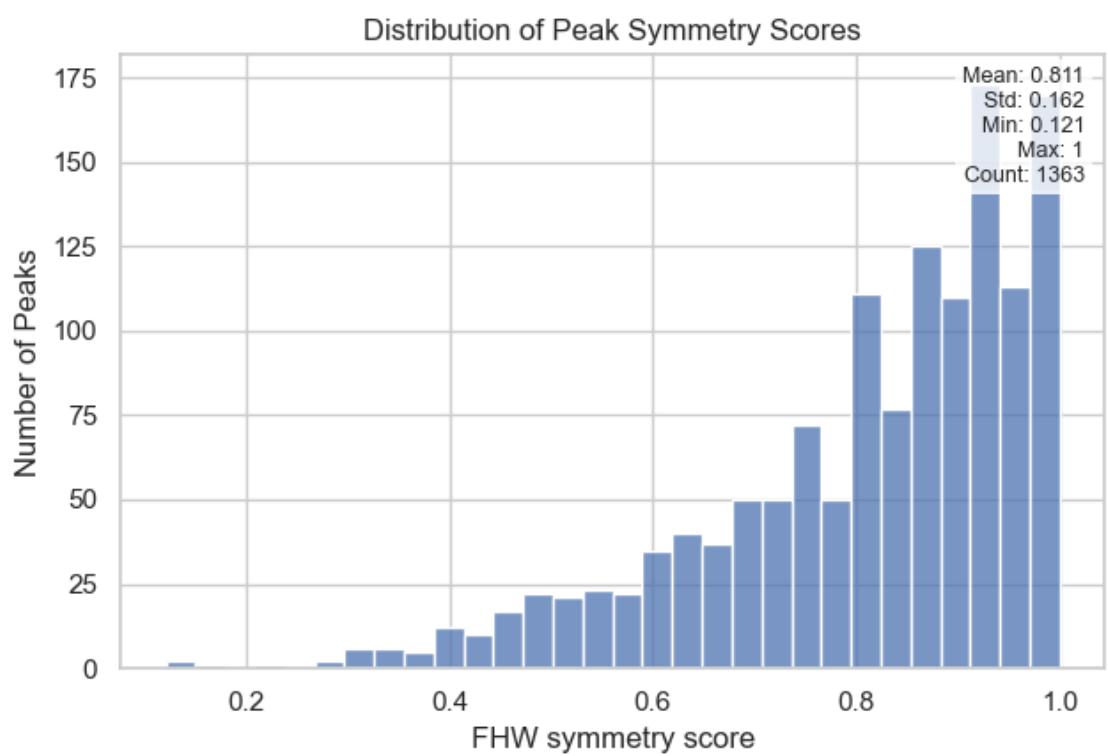
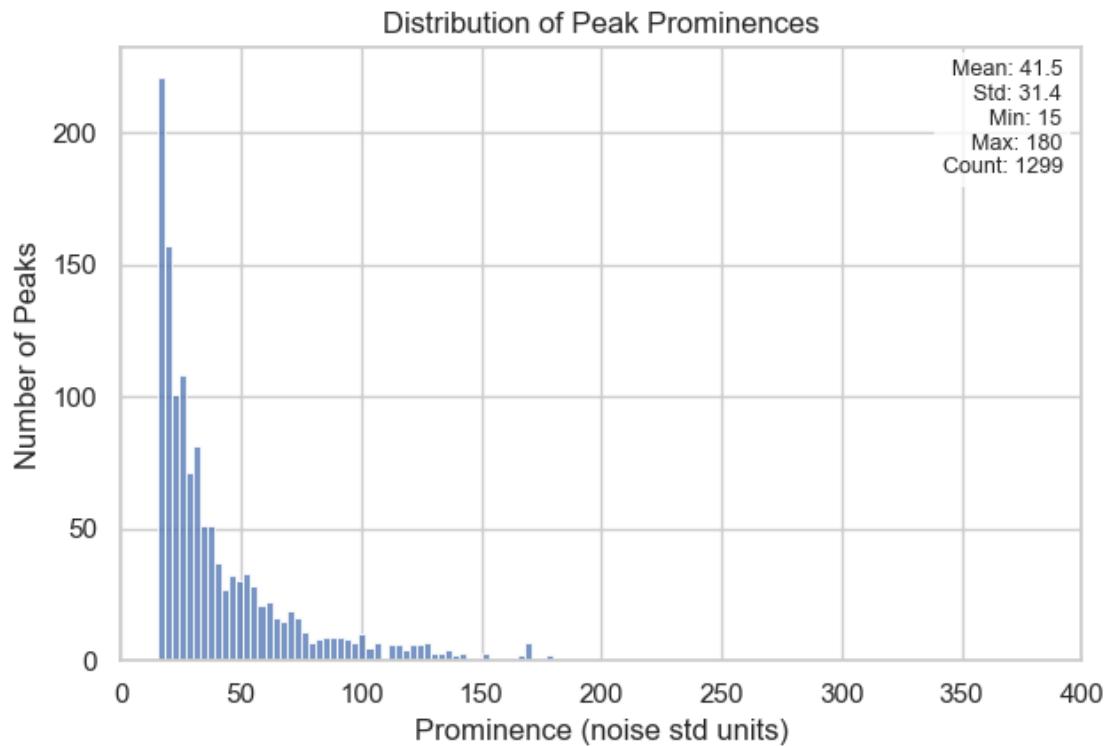


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 11:41:53] [INFO] calcium: plot_histogram: removed 8 outliers out of  
1363 on 'Duration (s)' (lower=-1, upper=71)
```

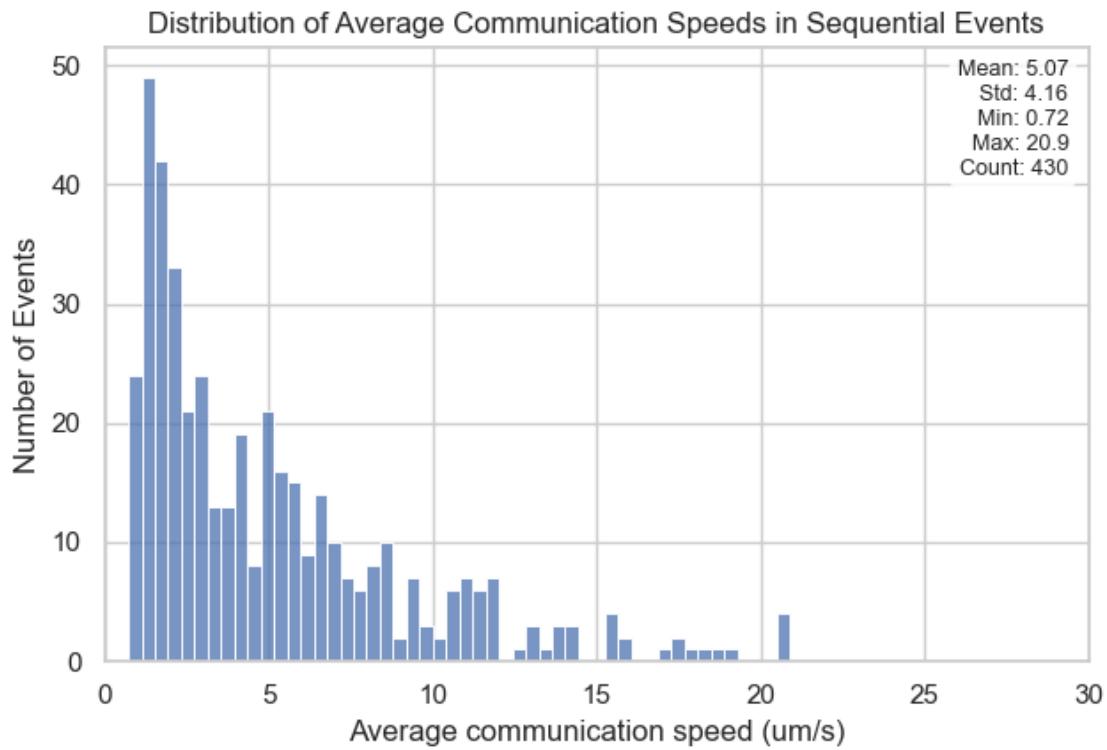


```
[2025-08-13 11:41:53] [INFO] calcium: plot_histogram: removed 64 outliers out of  
1363 on 'Prominence (noise std units)' (lower=-33.725, upper=181.98)
```

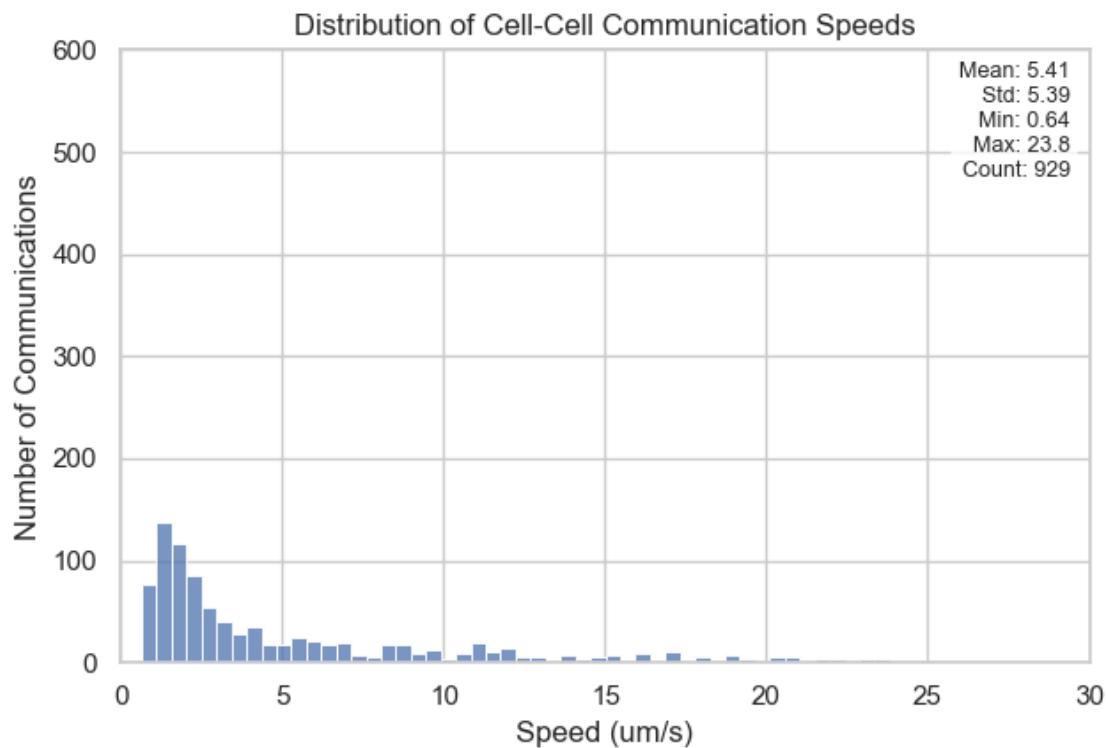


1.3.3 Cell-cell communication speed

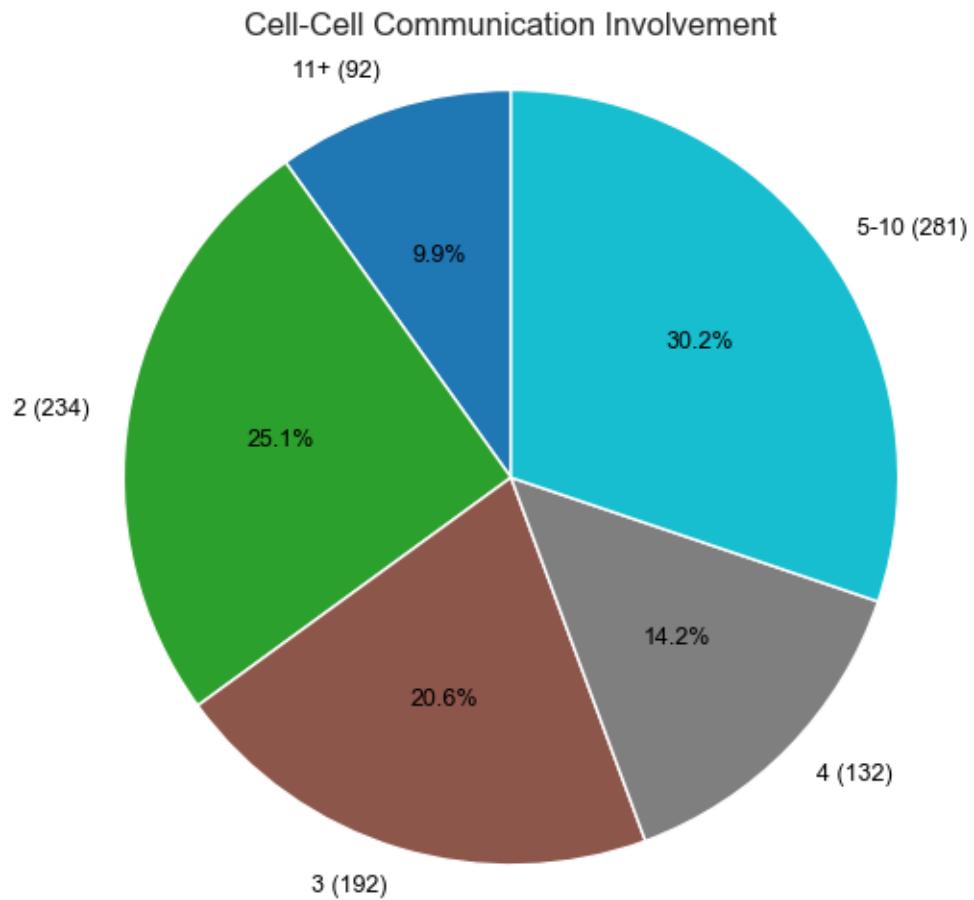
[2025-08-13 11:41:53] [INFO] calcium: plot_histogram: removed 2 outliers out of 432 on 'Average communication speed (um/s)' (lower=-13.078, upper=21.8)



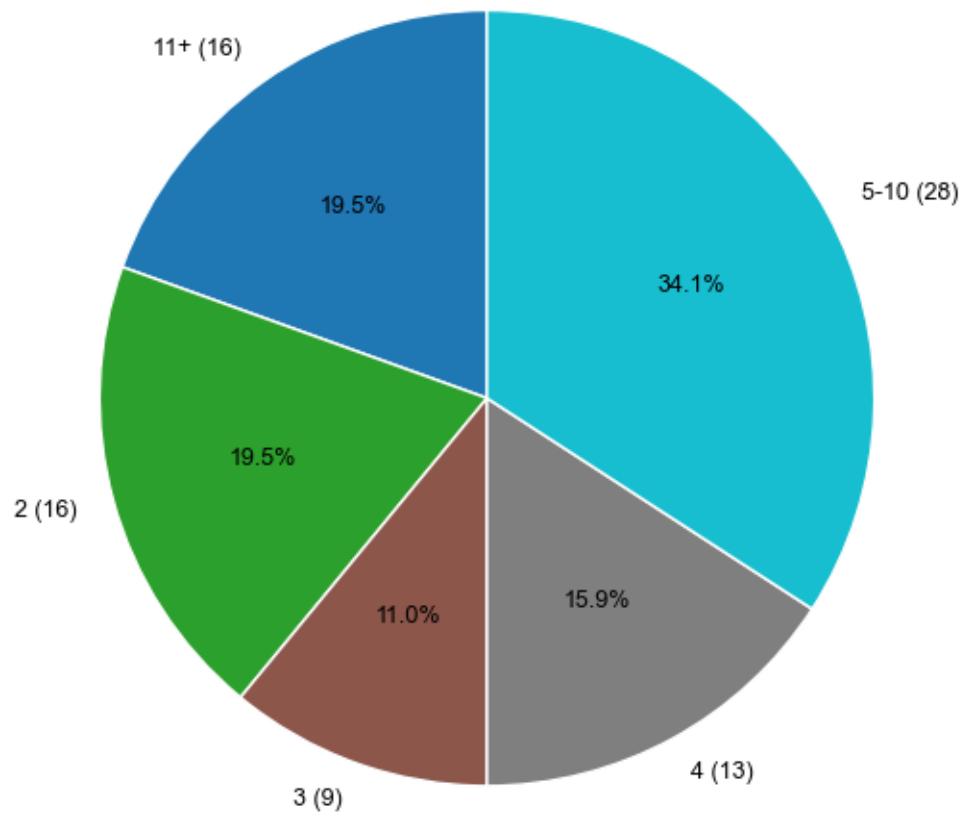
[2025-08-13 11:41:54] [INFO] calcium: plot_histogram: removed 2 outliers out of 931 on 'Speed (um/s)' (lower=-16.195, upper=25.385)



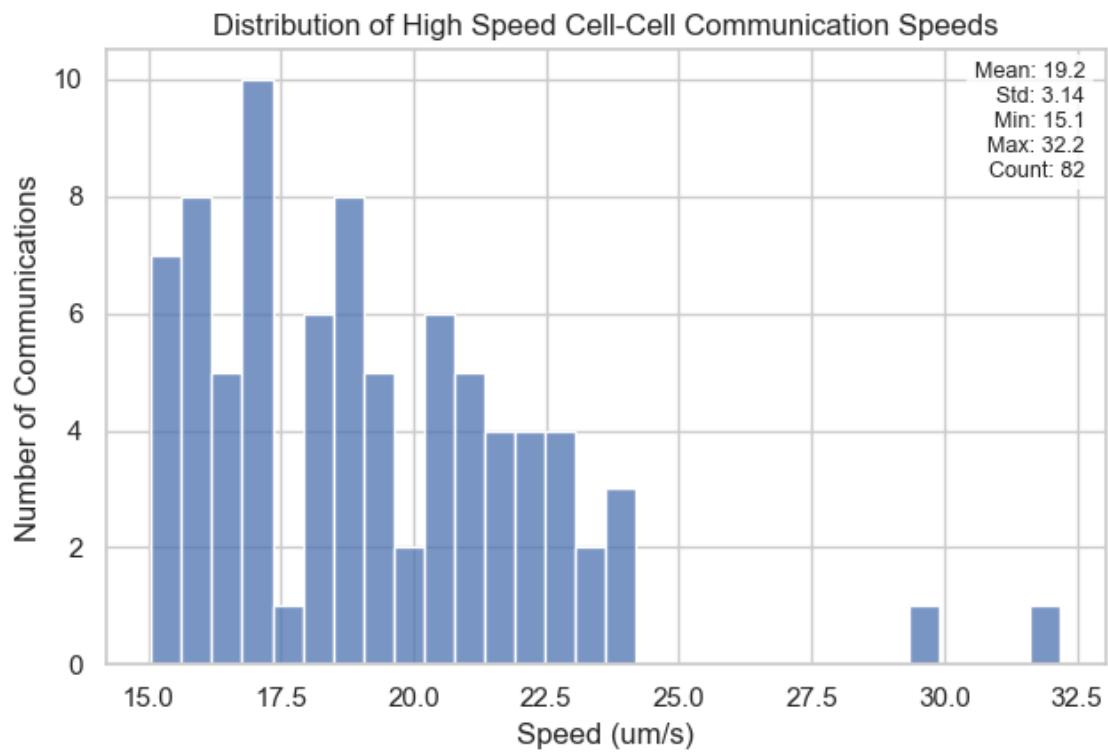
1.3.4 Double distribution in cell-cell communication speeds



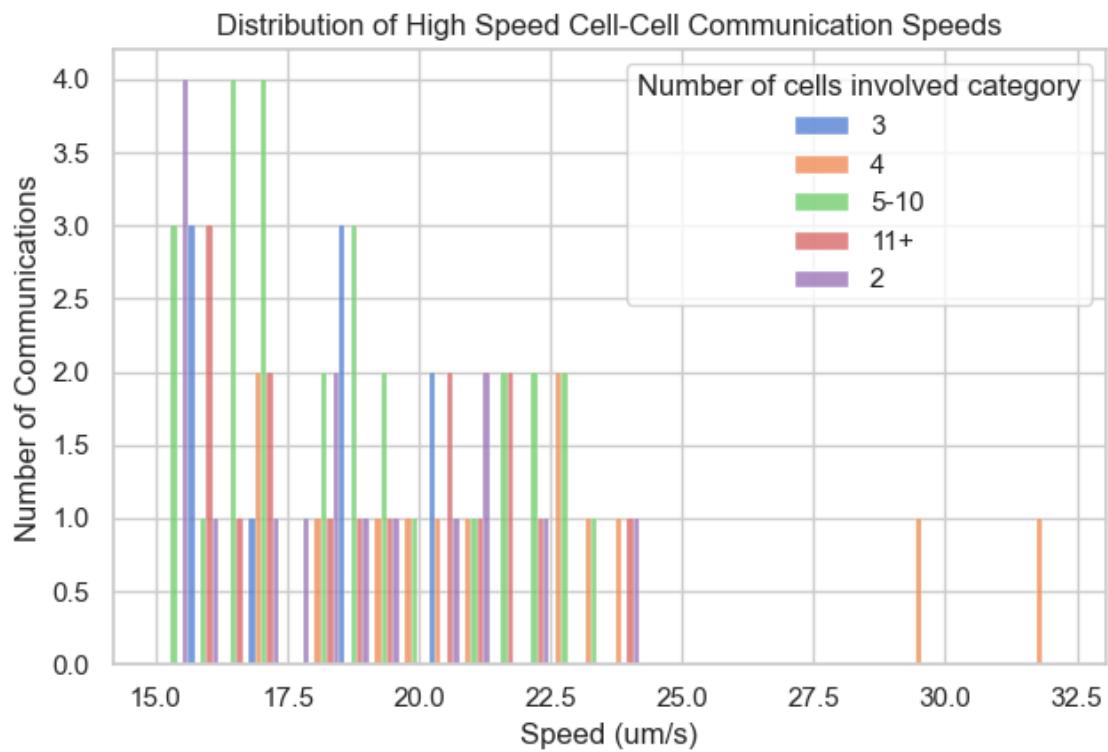
High Speed Cell-Cell Communication Involvement



[2025-08-13 11:41:54] [INFO] calcium: plot_histogram: removed 0 outliers out of 82 on 'Speed (um/s)' (lower=5.2, upper=32.833)

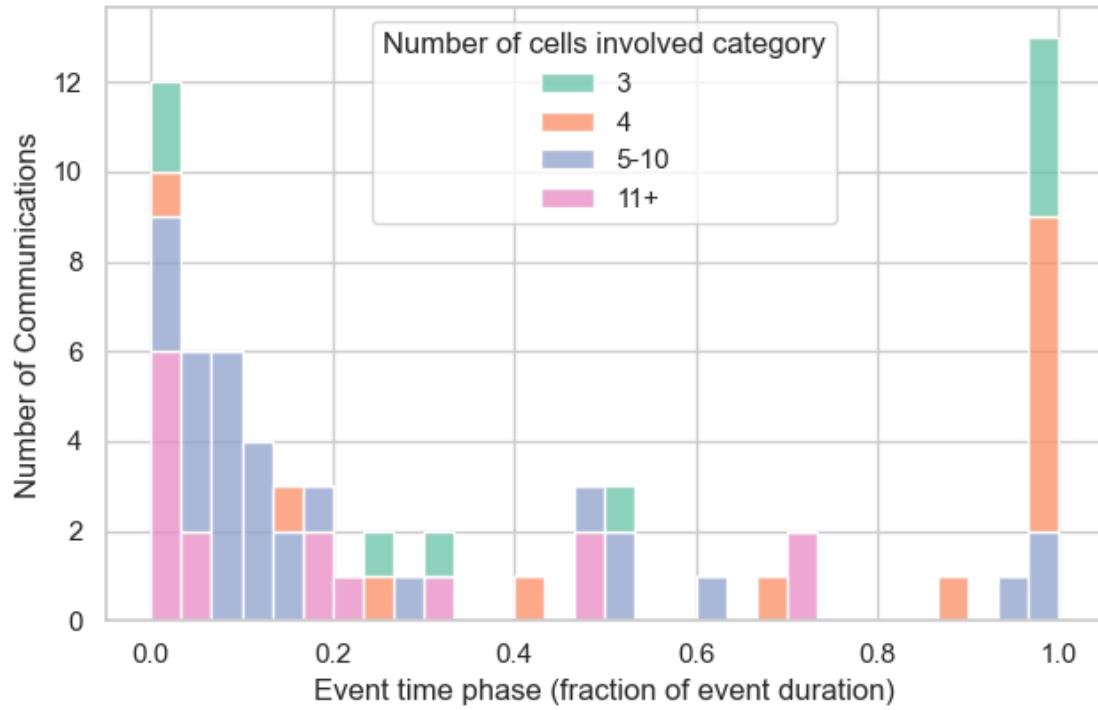


```
[2025-08-13 11:41:54] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 82 on 'Speed (um/s)' (lower=5.2, upper=32.833)
```

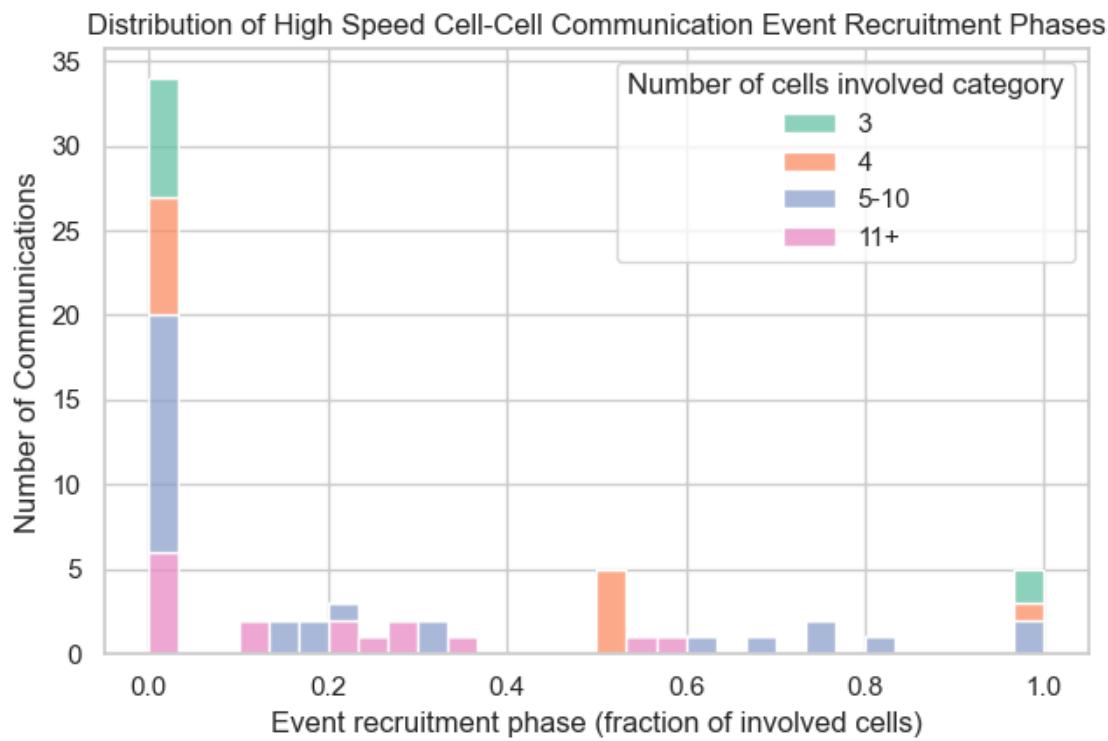


```
[2025-08-13 11:41:55] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 66 on 'Event time phase (fraction of event duration)' (lower=-1.92, upper=2.665)
```

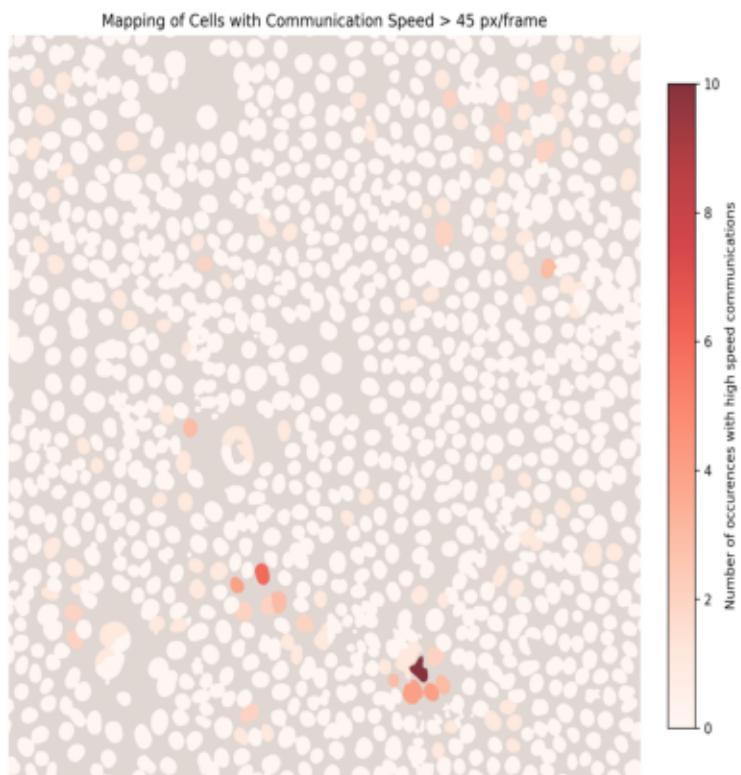
Distribution of High Speed Cell-Cell Communication Event Time Phases



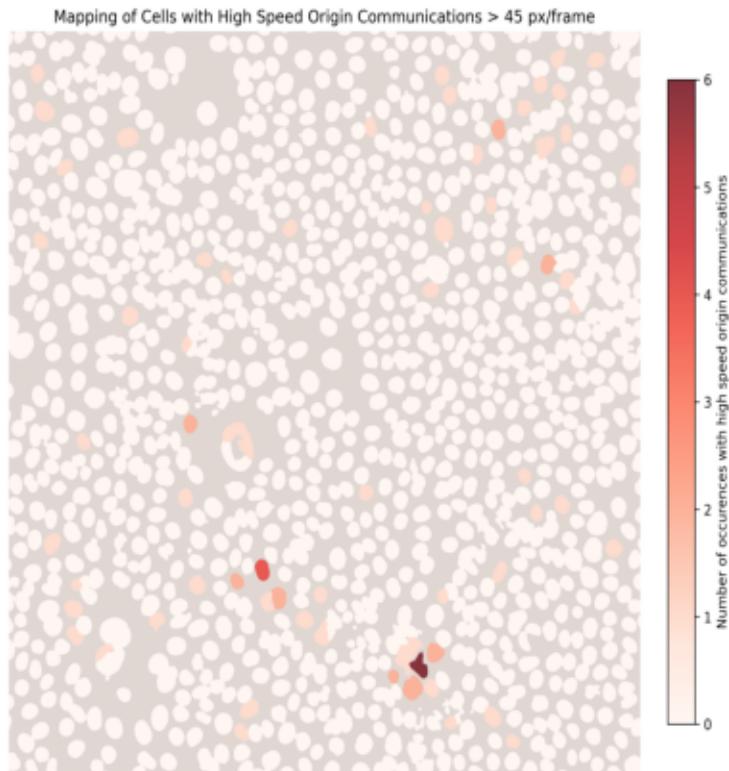
```
[2025-08-13 11:41:55] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 66 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.395, upper=1.86)
```



Cell Mapping with High Speed Cells Overlay - 20250409_IS11



Cell Mapping with High Speed Origin Cells Overlay - 20250409_IS11



Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
4	1759474603472	6	1364	2
7	1759474602512	7	1360	4
11	1759511354080	9	830	5
13	1759438314064	10	641	1
17	1759438313920	11	1042	0
..
827	1759474598240	360	1335	0
860	1759474608944	383	1473	3
869	1759474605536	389	1405	2
897	1759474606880	410	1540	9
921	1759474606352	429	1648	0

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
4	1382	1	124.0	125.0	
7	1304	4	359.0	360.0	
11	790	3	669.0	670.0	
13	594	0	53.0	53.0	
17	999	0	109.0	109.0	
..	
827	1347	0	37.0	38.0	
860	1424	4	687.0	688.0	
869	1412	1	339.0	340.0	
897	1504	8	1418.0	1419.0	
921	1606	0	25.0	26.0	
	Duration (s)	Distance (um)	Speed (um/s)	\	
4	1.0	18.61	18.61		
7	1.0	22.90	22.90		
11	1.0	23.48	23.48		
13	0.0	17.30	17.30		
17	0.0	32.18	32.18		
..		
827	1.0	21.10	21.10		
860	1.0	16.30	16.30		
869	1.0	17.56	17.56		
897	1.0	17.23	17.23		
921	1.0	15.65	15.65		
	Event time phase (fraction of event duration)	\			
4		1.00			
7		1.00			
11		1.00			
13		0.00			
17		1.00			
..		...			
827		0.63			
860		0.08			
869		NaN			
897		NaN			
921		0.50			
	Event recruitment phase (fraction of involved cells)	dataset	\		
4		1.00	20250409_IS11		
7		1.00	20250409_IS11		
11		0.50	20250409_IS11		
13		0.00	20250409_IS11		
17		0.00	20250409_IS11		
..			
827		0.67	20250409_IS11		
860		0.00	20250409_IS11		

869		NaN	20250409_IS11
897		NaN	20250409_IS11
921		0.00	20250409_IS11

	Number of cells involved	category	Speed category
4		3	High speed
7		4	High speed
11		4	High speed
13		3	High speed
17		4	High speed
..	
827		5-10	High speed
860		5-10	High speed
869		2	High speed
897		2	High speed
921		3	High speed

[82 rows x 16 columns]

Origin cell ID	Speed category	High speed	Low speed
252		0	2
256		0	1
258		0	1
260		0	1
262		0	1
..	
1667		0	1
1669		0	2
1680		0	1
1683		0	1
1684		0	2

[472 rows x 2 columns]

	Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
1	252	378.30		6.50
5	256	292.18		8.45
7	258	194.35		8.45
9	260	214.50		9.10
11	262	338.32		9.43
..
993	1667	243.10		484.90
995	1669	183.95		485.55
1005	1680	207.03		490.43
1007	1683	125.78		491.73
1008	1684	382.53		491.73

Number of peaks Is active Occurences in global events \

1	9	True	5
5	9	True	5
7	7	True	5
9	8	True	5
11	7	True	5
...
993	9	True	5
995	7	True	5
1005	9	True	5
1007	7	True	4
1008	7	True	5

Occurences in global events as early peaker \

1	0
5	0
7	0
9	0
11	0
...	...
993	3
995	0
1005	0
1007	2
1008	0

Occurences in sequential events \

1	3
5	1
7	2
9	1
11	2
...	...
993	1
995	2
1005	3
1007	1
1008	2

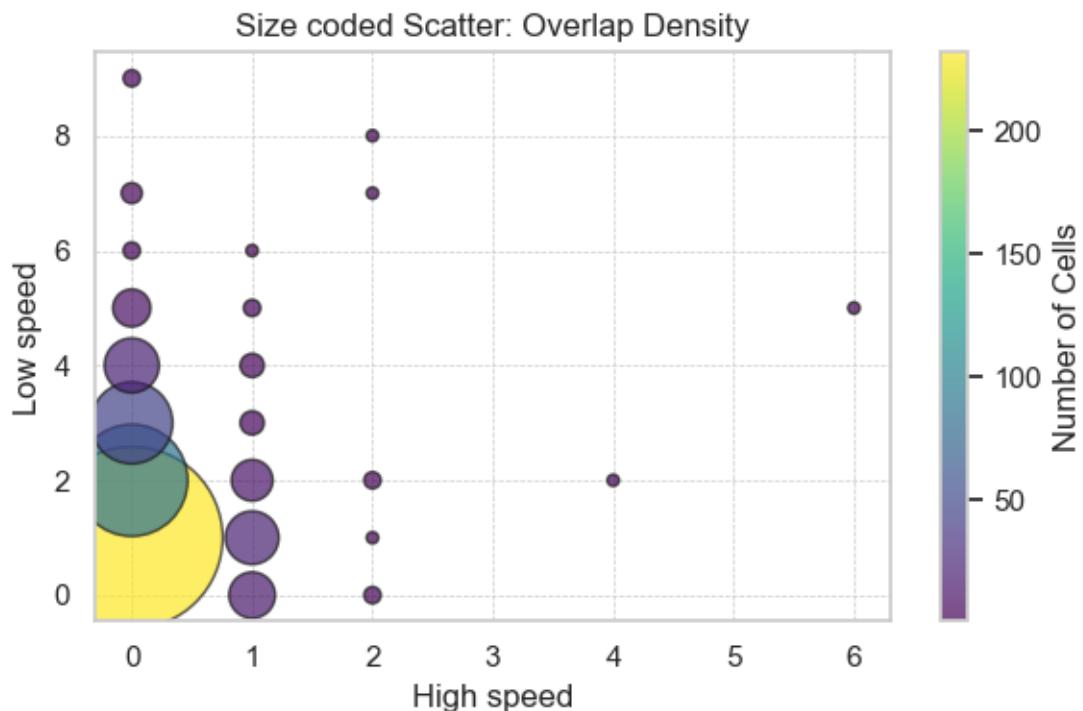
Occurences in sequential events as origin \

1	2
5	0
7	0
9	0
11	1
...	...
993	1
995	1
1005	1

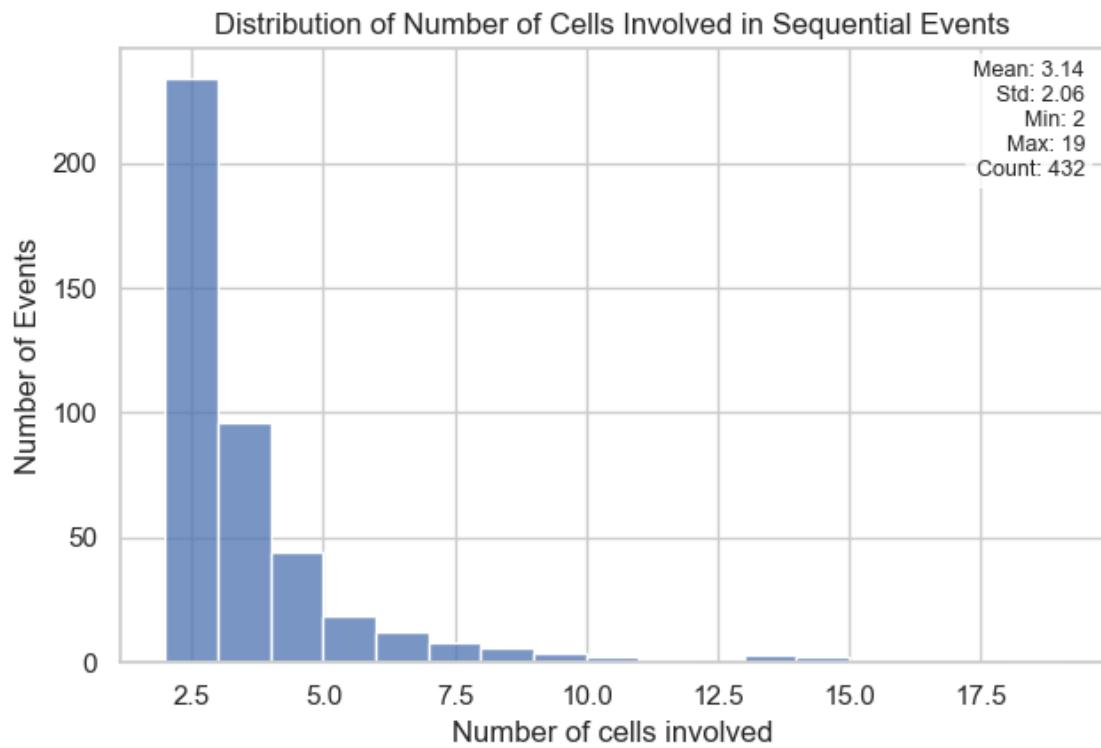
1007		1		
1008		2		
	Occurrences in individual events	Peak frequency (Hz)	Periodicity score	\
1	1	0.0053	0.65	
5	2	0.0053	0.63	
7	0	0.0041	0.64	
9	2	0.0047	0.70	
11	0	0.0041	0.71	
...
993	3	0.0053	0.70	
995	0	0.0041	0.71	
1005	1	0.0053	0.73	
1007	1	0.0041	0.68	
1008	0	0.0041	0.67	
	Neighbor count	Neighbors (labels)	dataset	\
1	3	[273, 289, 298]	20250409_IS11	
5	3	[261, 271, 290]	20250409_IS11	
7	5	[259, 260, 291, 294, 296]	20250409_IS11	
9	3	[258, 281, 291]	20250409_IS11	
11	4	[257, 268, 288, 305]	20250409_IS11	
...
993	3	[1623, 1647, 1659]	20250409_IS11	
995	4	[1633, 1635, 1670, 1680]	20250409_IS11	
1005	5	[1626, 1635, 1636, 1647, 1669]	20250409_IS11	
1007	5	[1634, 1638, 1639, 1677, 1679]	20250409_IS11	
1008	3	[1646, 1671, 1681]	20250409_IS11	
	Involved in sequential event	Occurrences in sequential events	category	\
1	Involved in sequential event		3-4	
5	Involved in sequential event		1-2	
7	Involved in sequential event		1-2	
9	Involved in sequential event		1-2	
11	Involved in sequential event		1-2	
...
993	Involved in sequential event		1-2	
995	Involved in sequential event		1-2	
1005	Involved in sequential event		3-4	
1007	Involved in sequential event		1-2	
1008	Involved in sequential event		1-2	
	High speed	Low speed		
1	0.0	2.0		
5	0.0	1.0		
7	0.0	1.0		
9	0.0	1.0		
11	0.0	1.0		

```
...      ...      ...
993      0.0      1.0
995      0.0      2.0
1005     0.0      1.0
1007     0.0      1.0
1008     0.0      2.0
```

[472 rows x 19 columns]



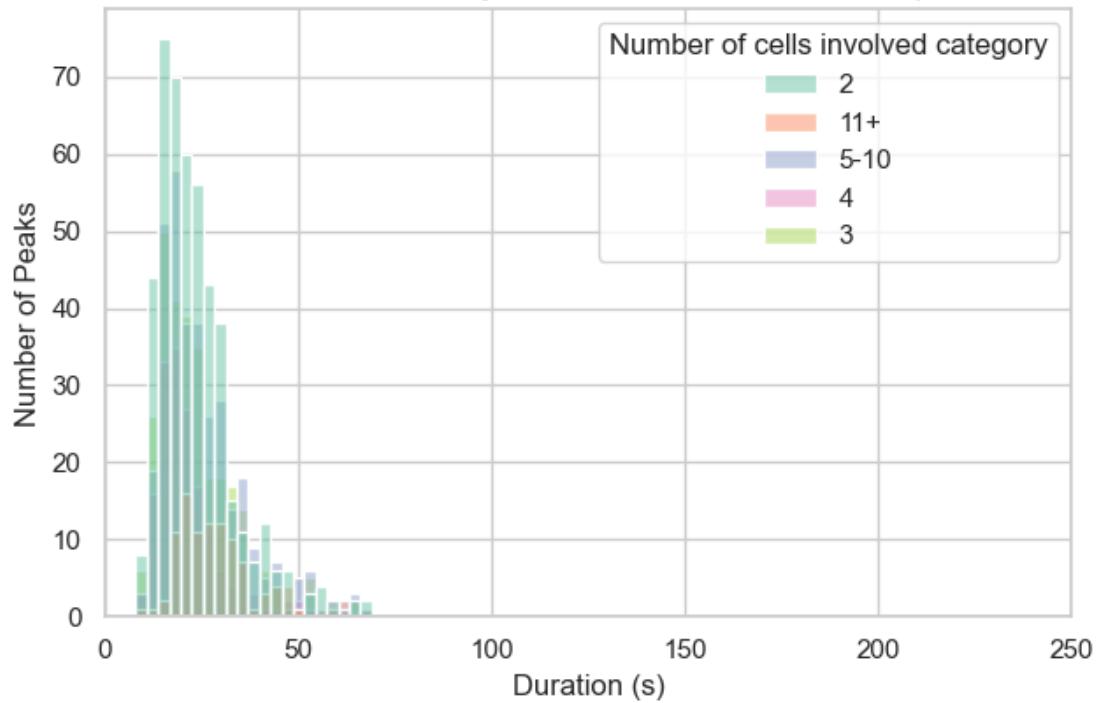
1.3.5 Number of cells involved per sequential events



1.3.6 Influence of cell count per event on statistics

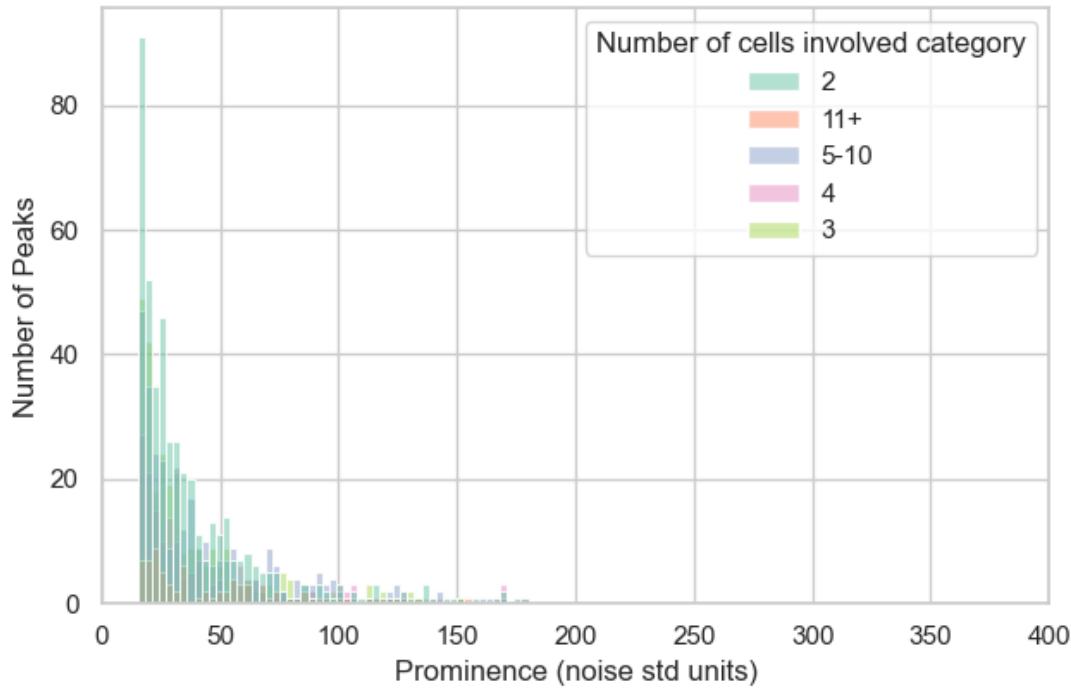
```
[2025-08-13 11:41:59] [INFO] calcium: plot_histogram_by_group: removed 8 outliers out of 1363 on 'Duration (s)' (lower=-1, upper=71)
```

Distribution of Peak Durations by Number of Cells Involved in Sequential Events

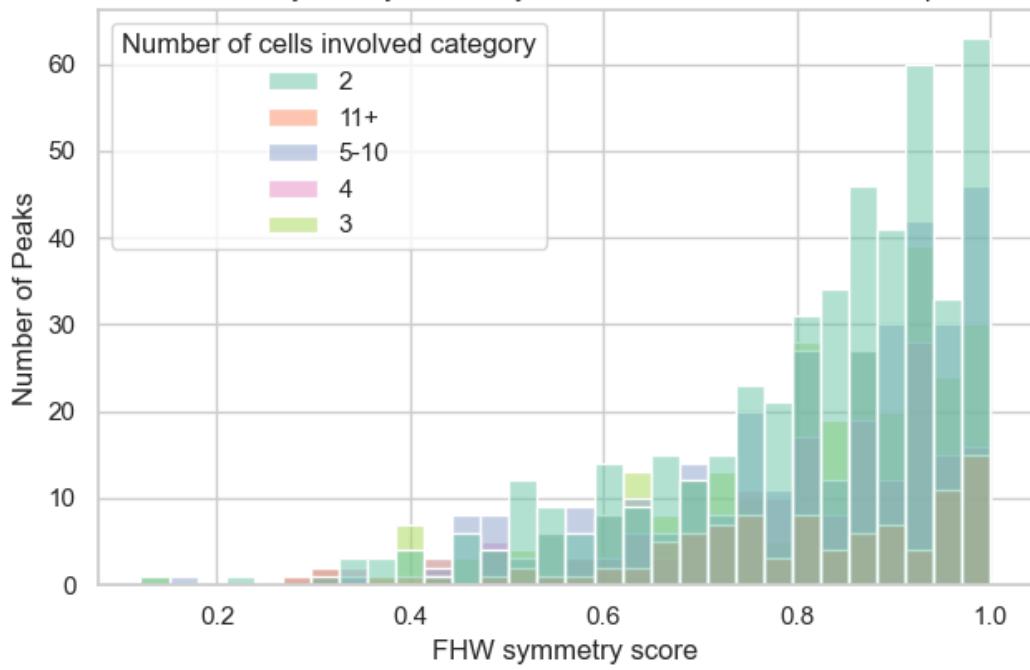


```
[2025-08-13 11:41:59] [INFO] calcium: plot_histogram_by_group: removed 64 outliers out of 1363 on 'Prominence (noise std units)' (lower=-33.725, upper=181.98)
```

Distribution of Peak Prominences by Number of Cells Involved in Sequential Events

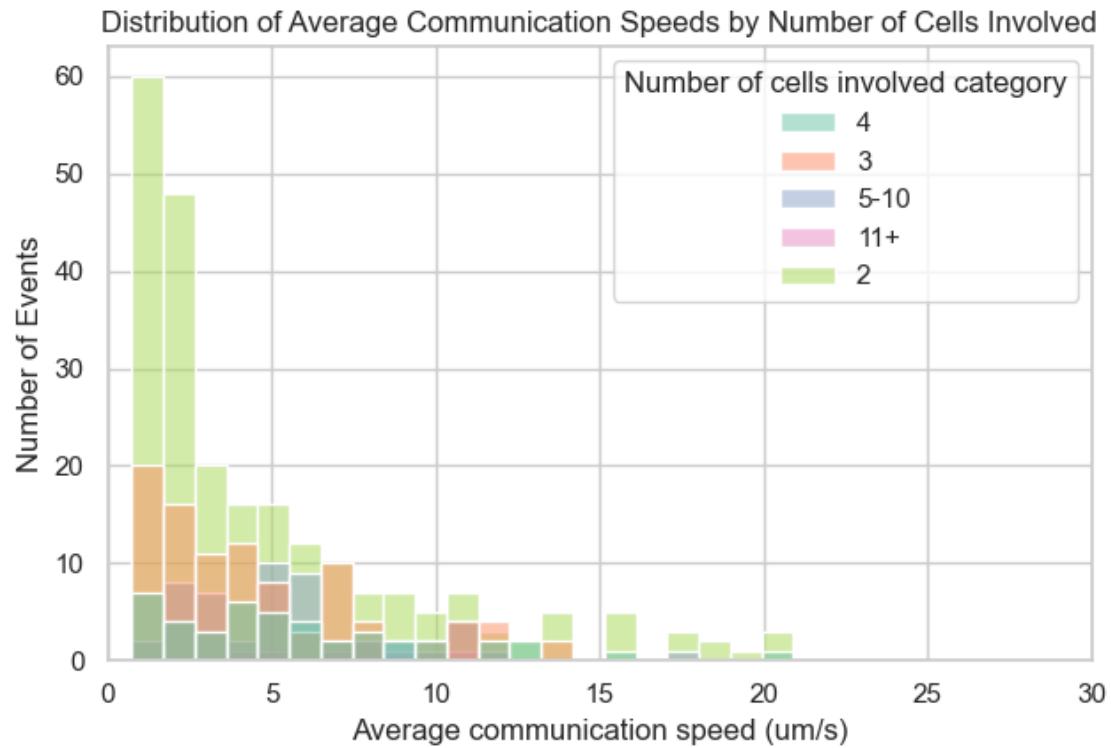


Distribution of Peak Symmetry Scores by Number of Cells Involved in Sequential Events



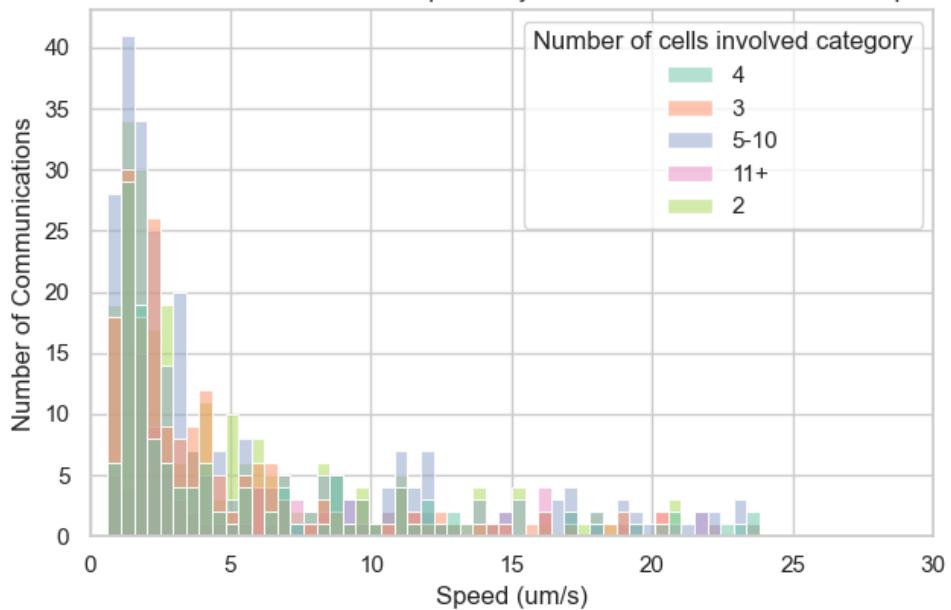
[2025-08-13 11:42:00] [INFO] calcium: plot_histogram_by_group: removed 2

outliers out of 432 on 'Average communication speed (um/s)' (lower=-13.078, upper=21.8)



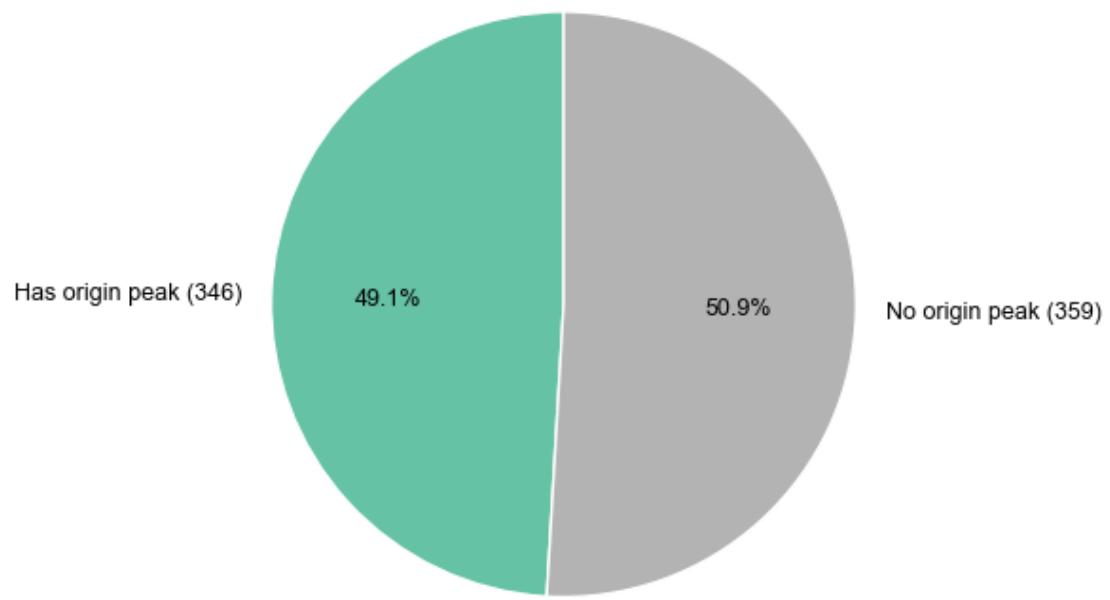
[2025-08-13 11:42:00] [INFO] calcium: plot_histogram_by_group: removed 2 outliers out of 931 on 'Speed (um/s)' (lower=-16.195, upper=25.385)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events

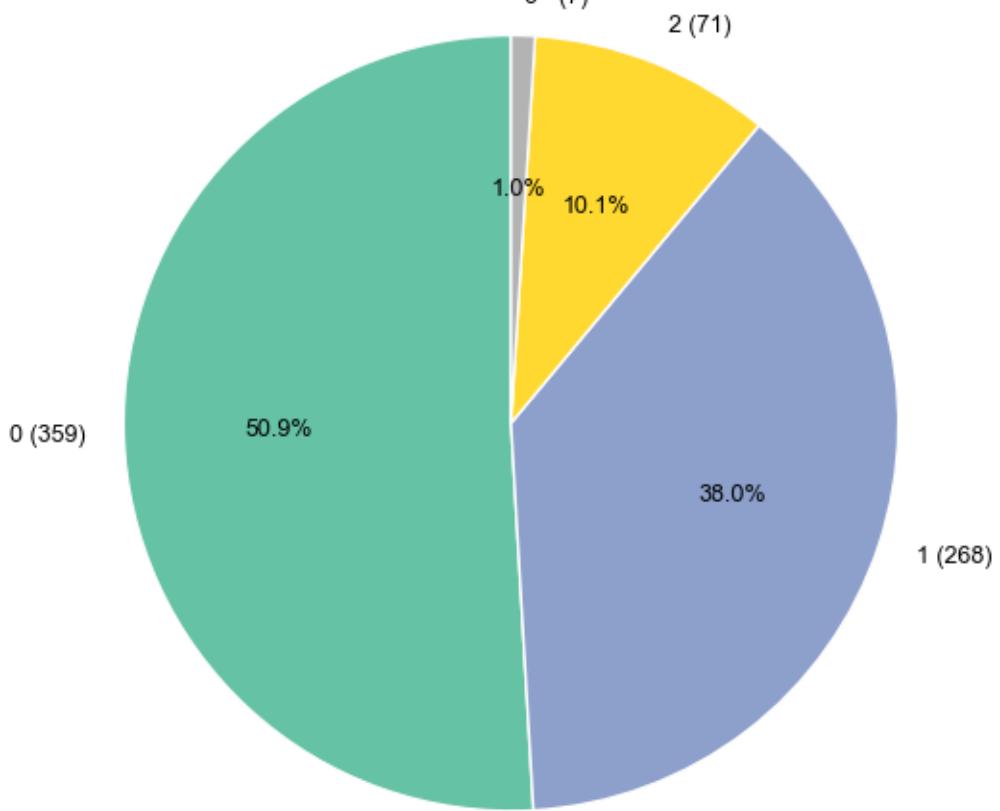


1.3.7 Cells occurrences as origin in sequential events

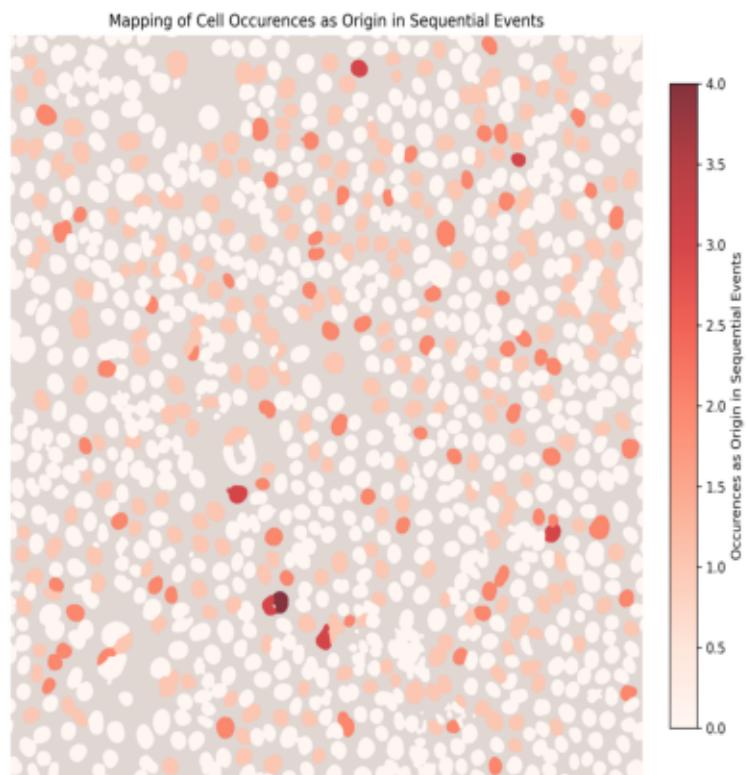
Distribution of Number of Sequential Event Origin Peaks per Cell



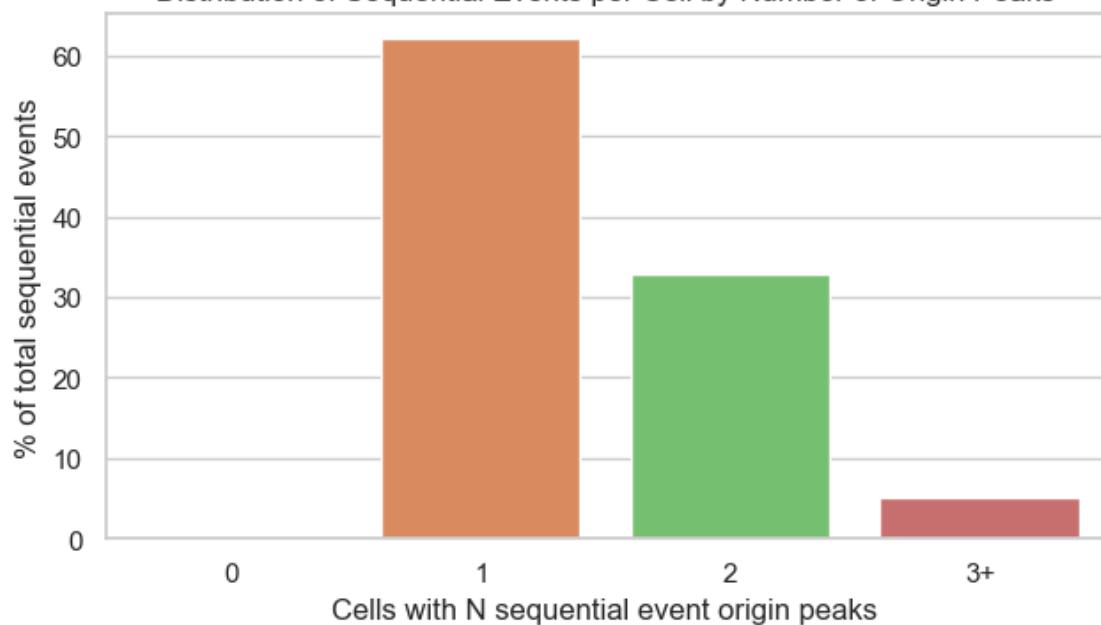
Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)



Cell Mapping with Origin Peaks Overlay - 20250409_IS11



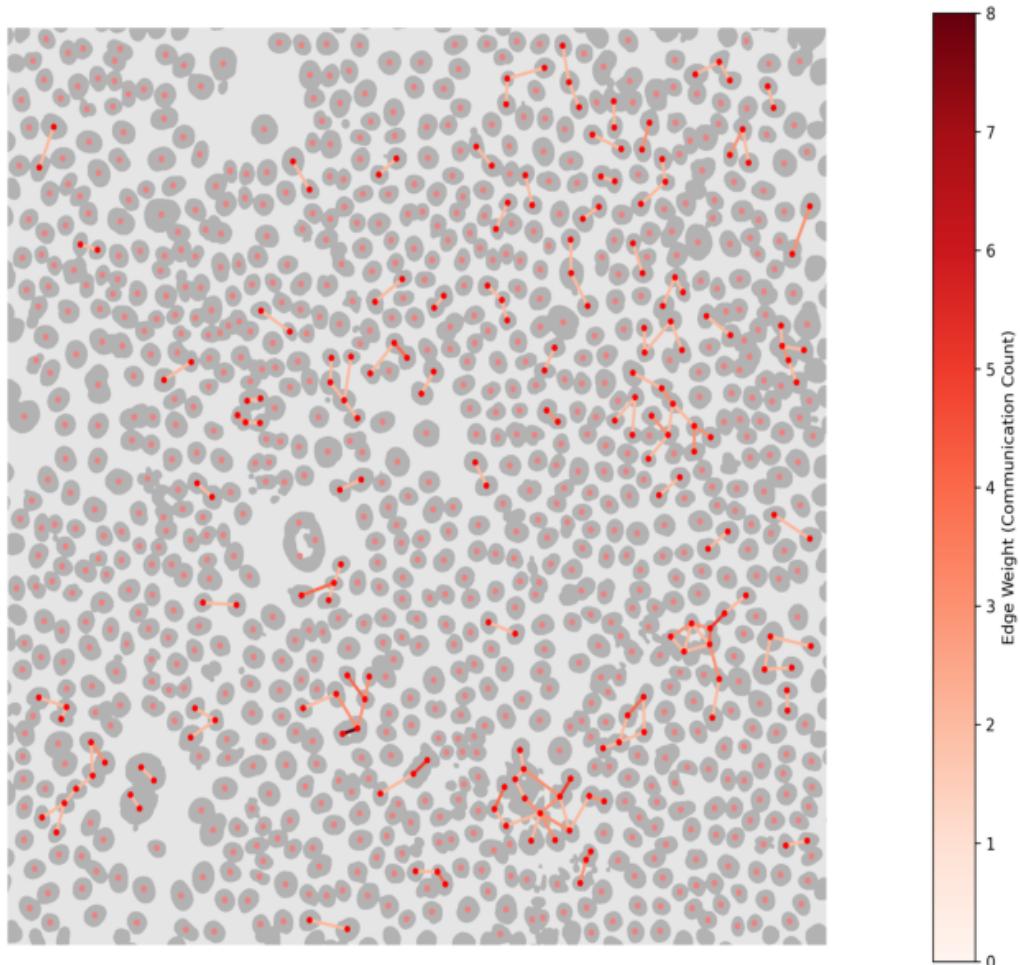
Distribution of Sequential Events per Cell by Number of Origin Peaks

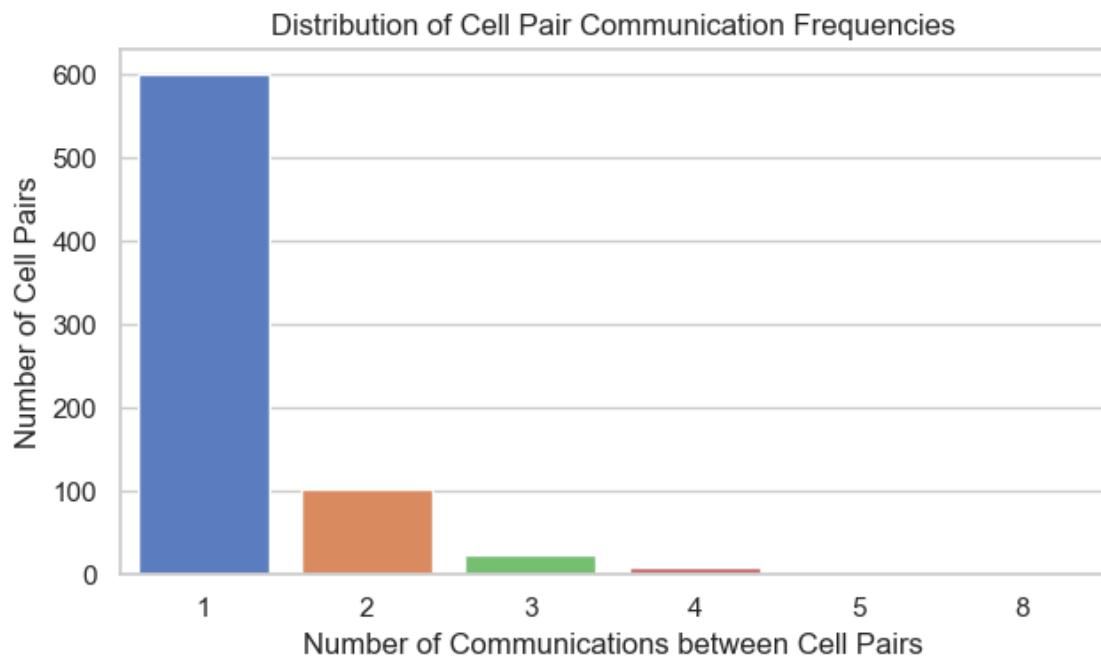


1.3.8 Connection network between cells

Cell Connection Network Graph - 20250409_IS11

Cells Connection Network (Weighted Edges)

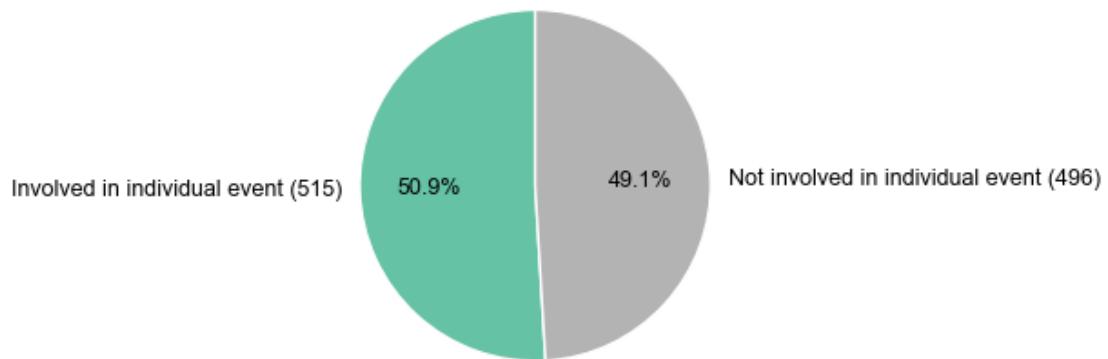




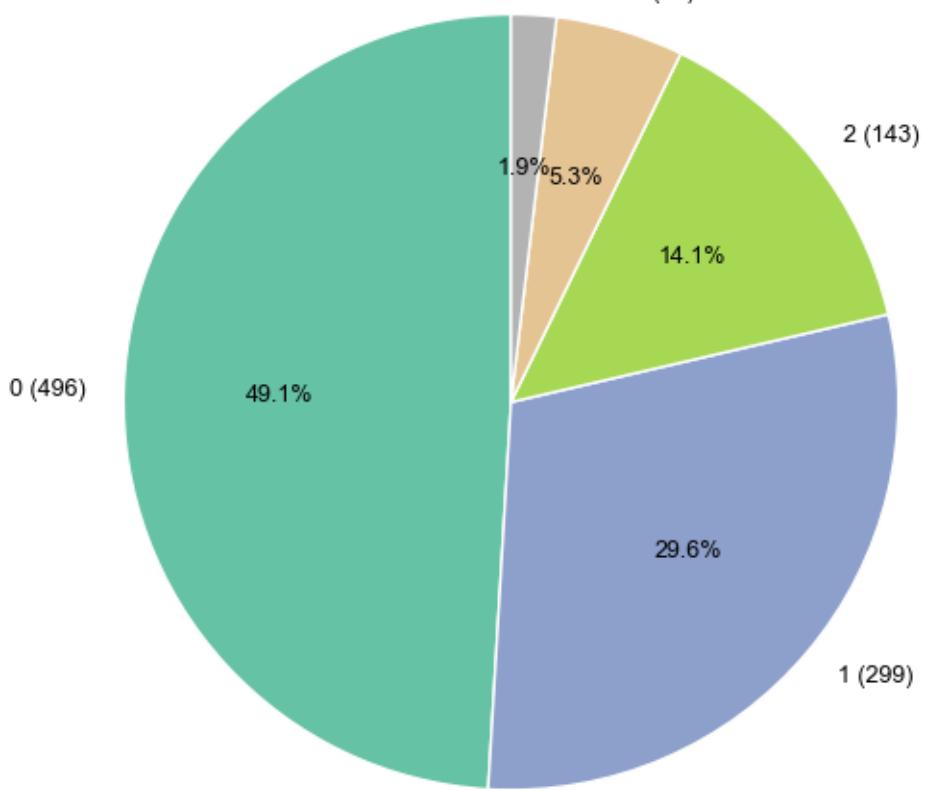
1.4 INDIVIDUAL EVENTS

1.4.1 Cells occurrences in individual events

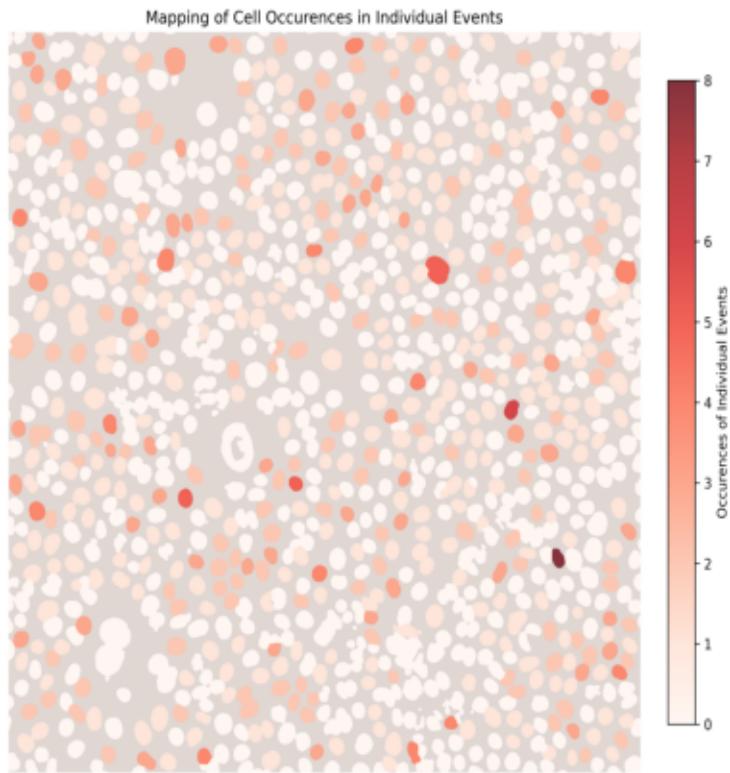
Distribution of Cells Involved in Individual Events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

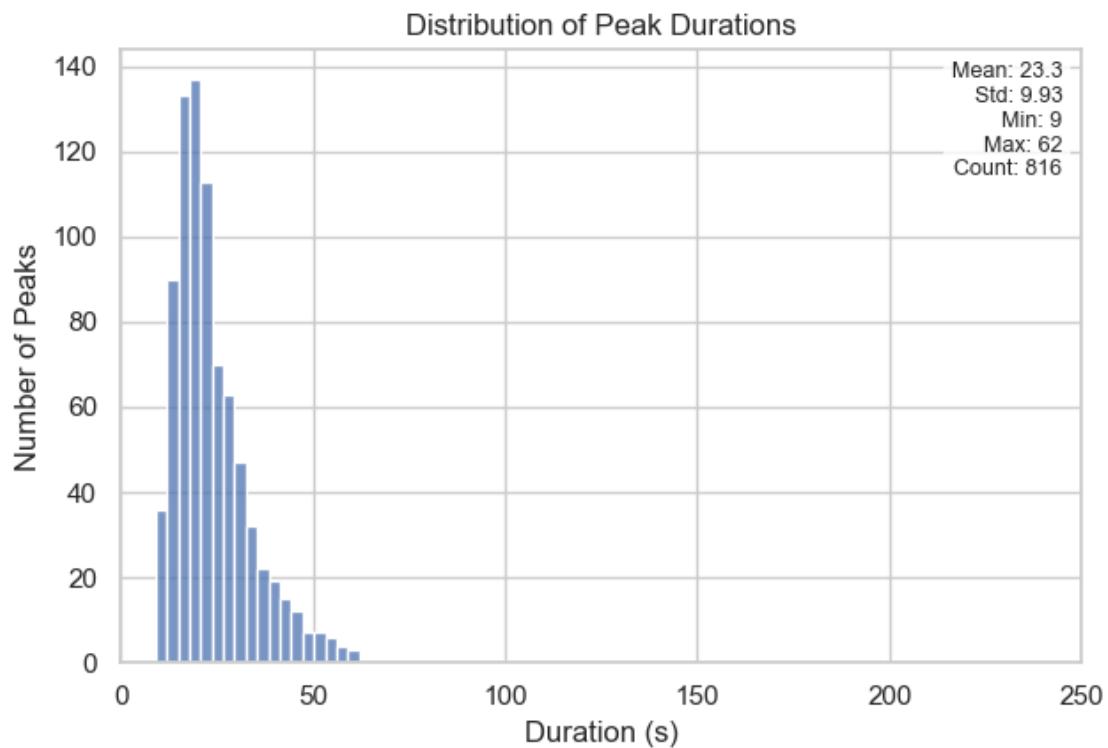


Cell Mapping with Occurrences in Individual Events Overlay - 20250409_IS11

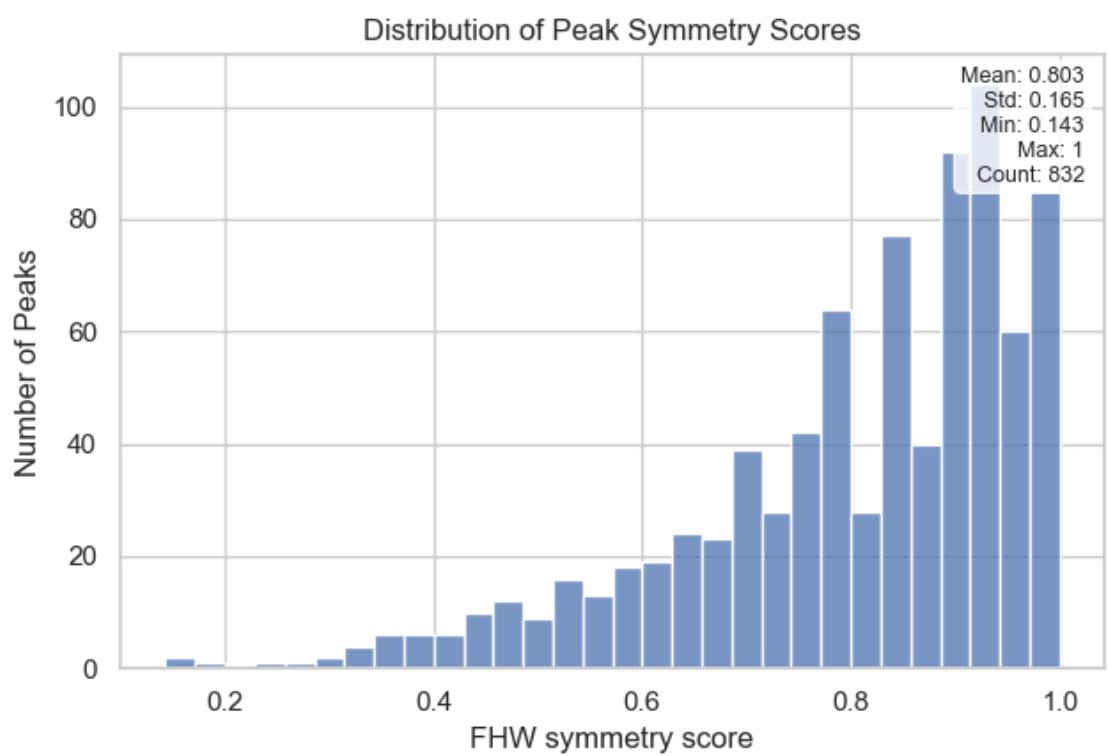
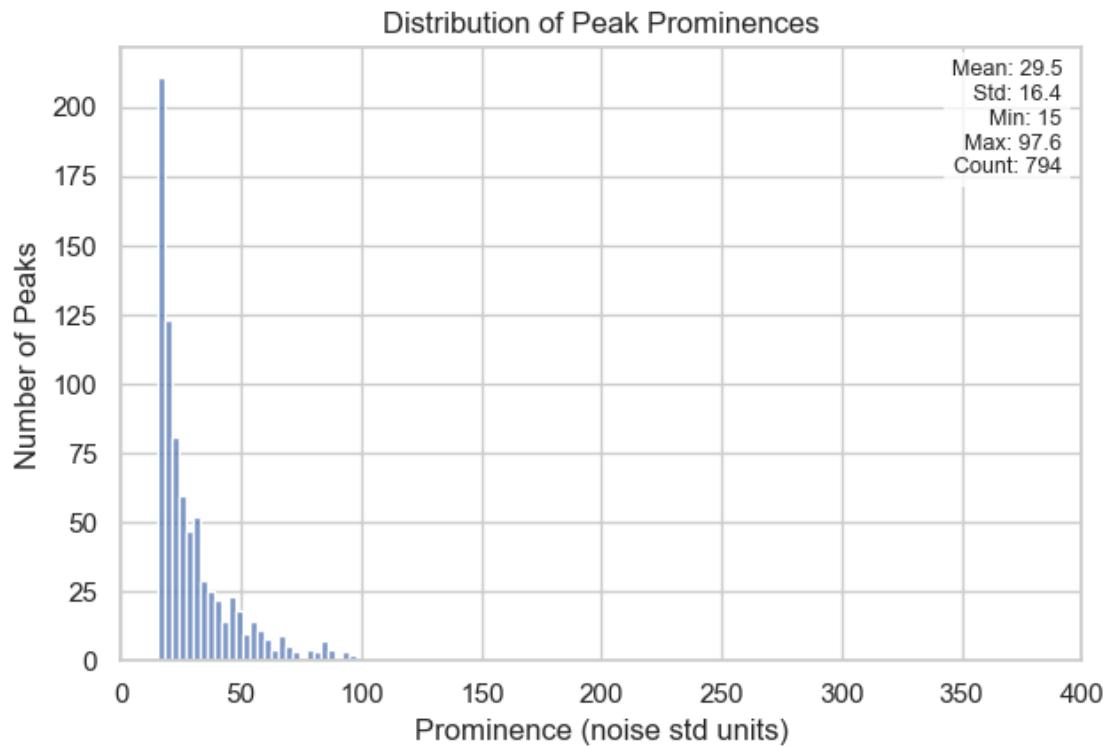


1.4.2 Peaks statistics in individual events

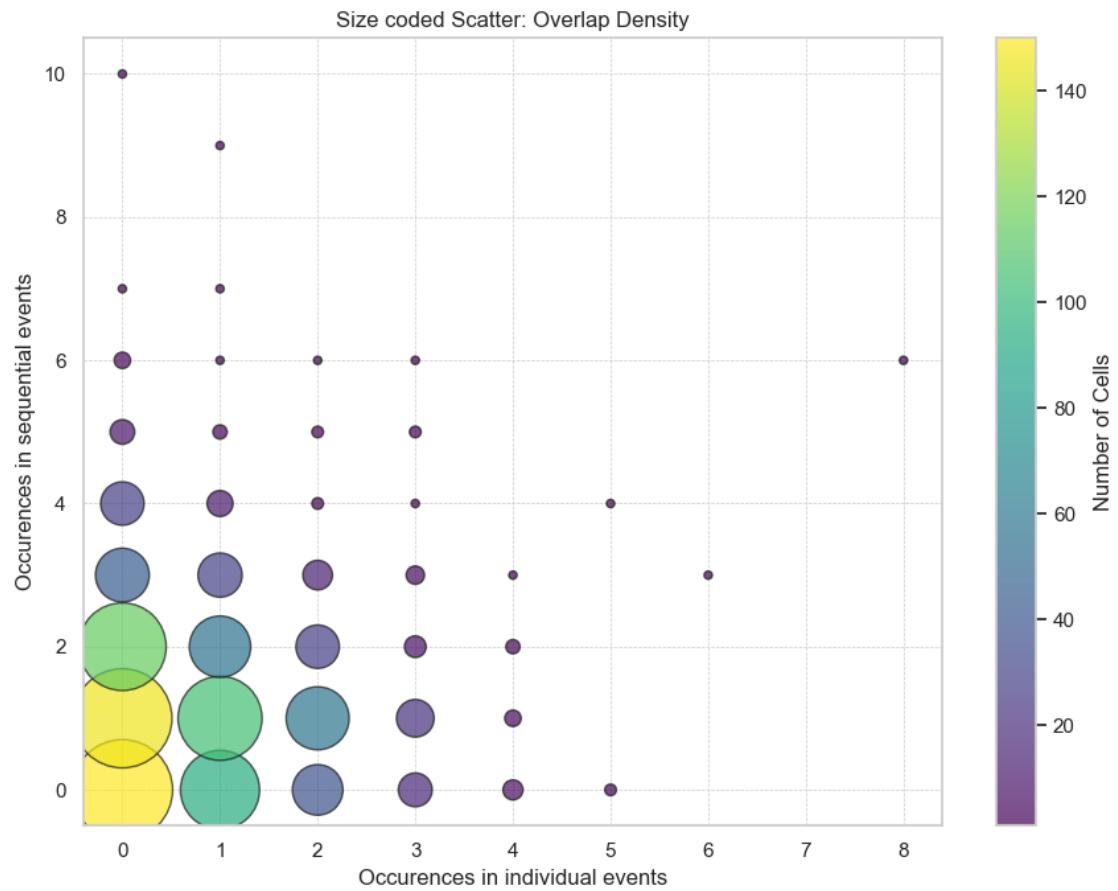
```
[2025-08-13 11:42:06] [INFO] calcium: plot_histogram: removed 16 outliers out of  
832 on 'Duration (s)' (lower=-20, upper=64)
```



```
[2025-08-13 11:42:06] [INFO] calcium: plot_histogram: removed 38 outliers out of 832 on 'Prominence (noise std units)' (lower=-43.075, upper=99.2)
```

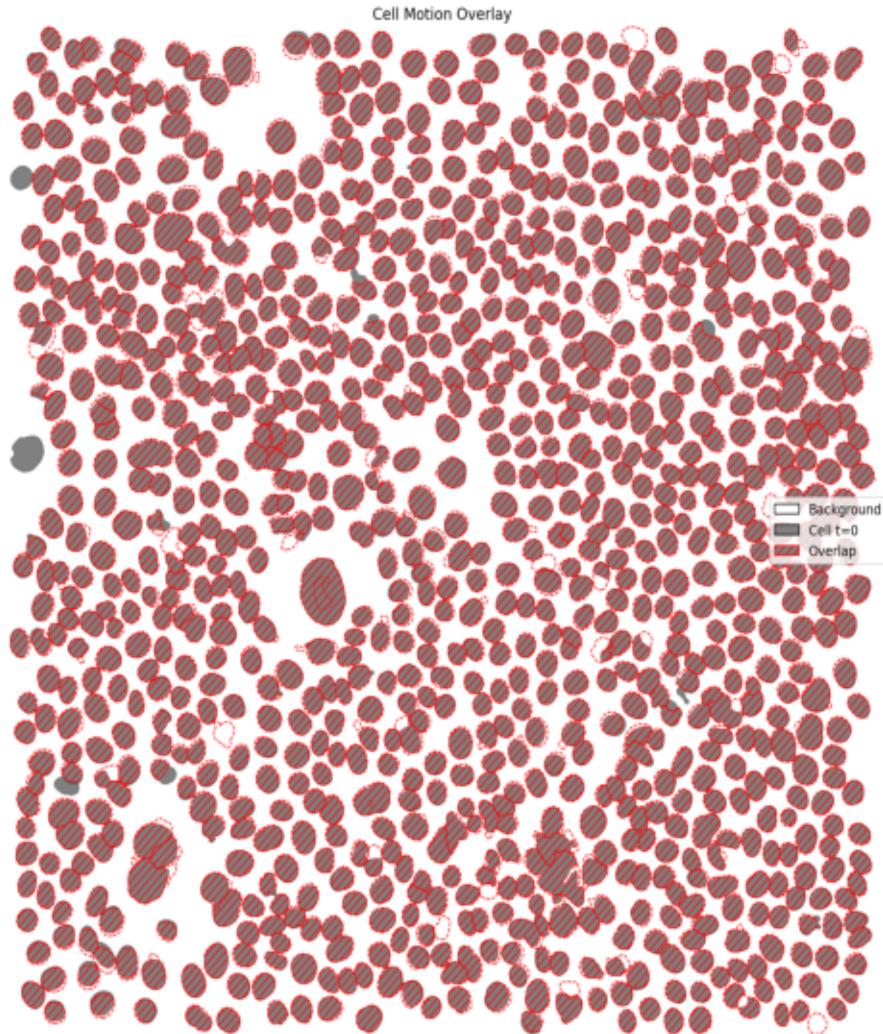


1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250409_IS11



Number of cells:

- Hoechst image taken at t=0: 1011
- Hoechst image taken at t=1801: 1007
- Number of cells difference: absolute 4, relative 0.40%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 1078456
- Pixels segmented as cell at t=1801: 1126020
- Overlapping pixels between t=0 and t=1801: 1020007 (92.54% of total)
- Pixels exclusive to t=0: 58449 (5.42% of total)
- Pixels exclusive to t=1801: 106013 (9.41% of total)

executed

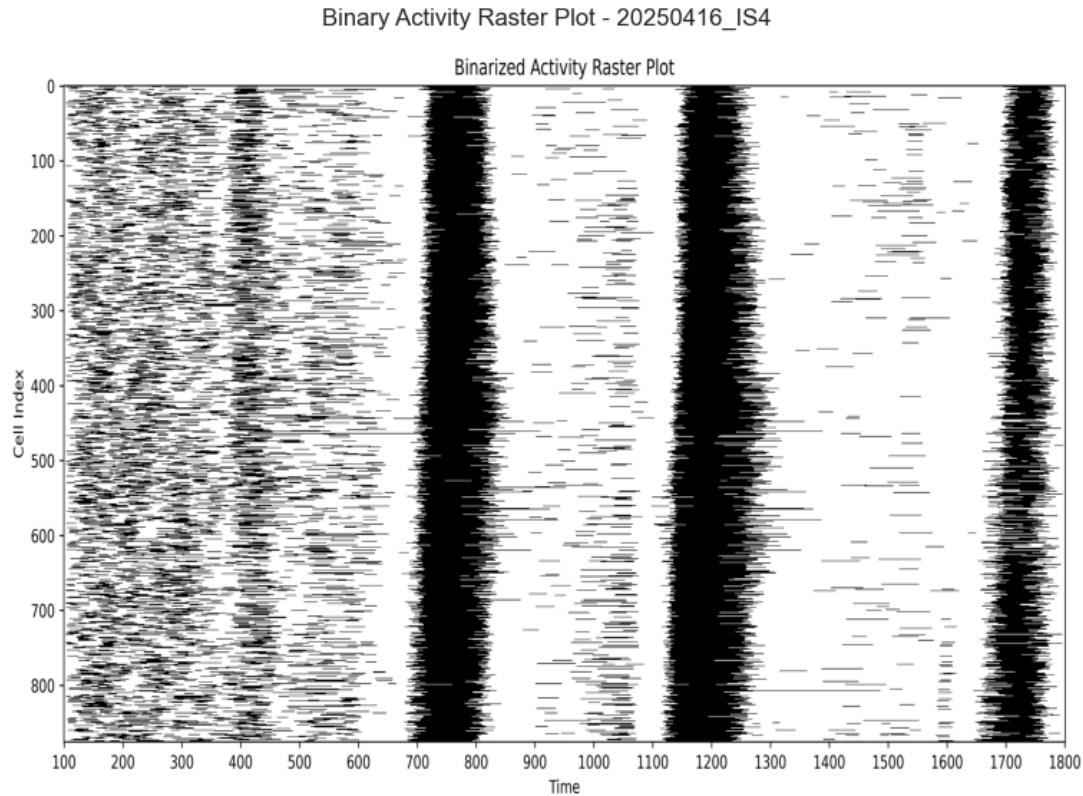
August 13, 2025

1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

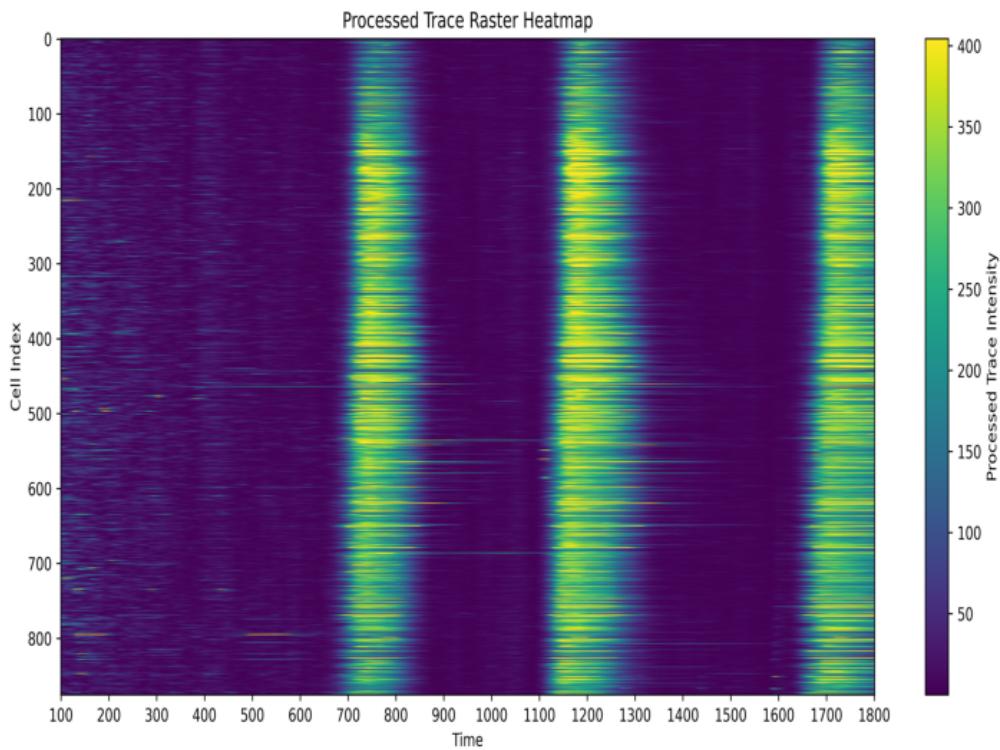
1.0.1 Initialization

1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot



Heatmap Activity Raster Plot - 20250416_IS4



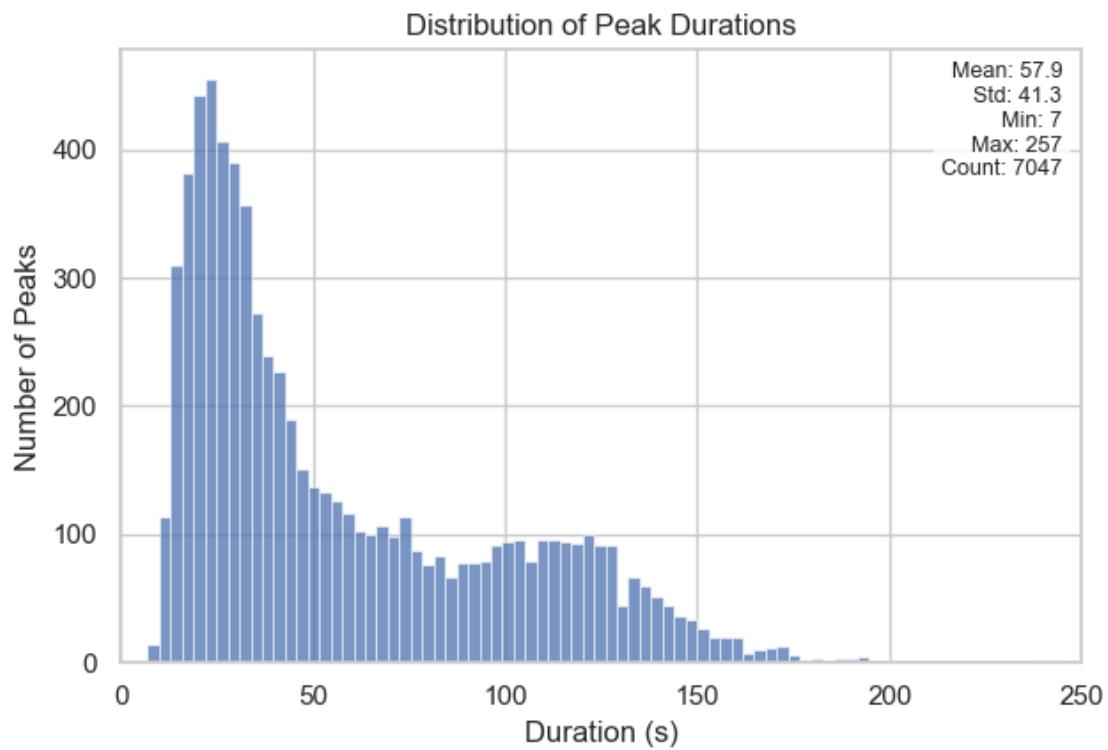
1.1.2 Peaks population

Total number of peaks: 7049

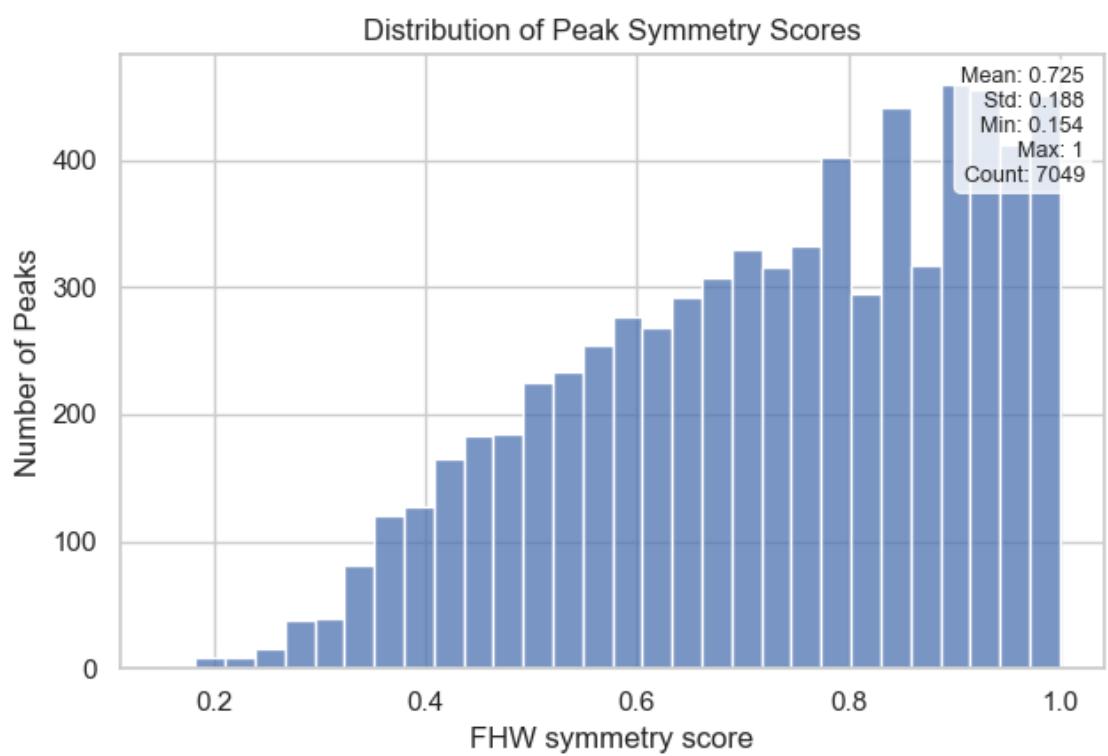
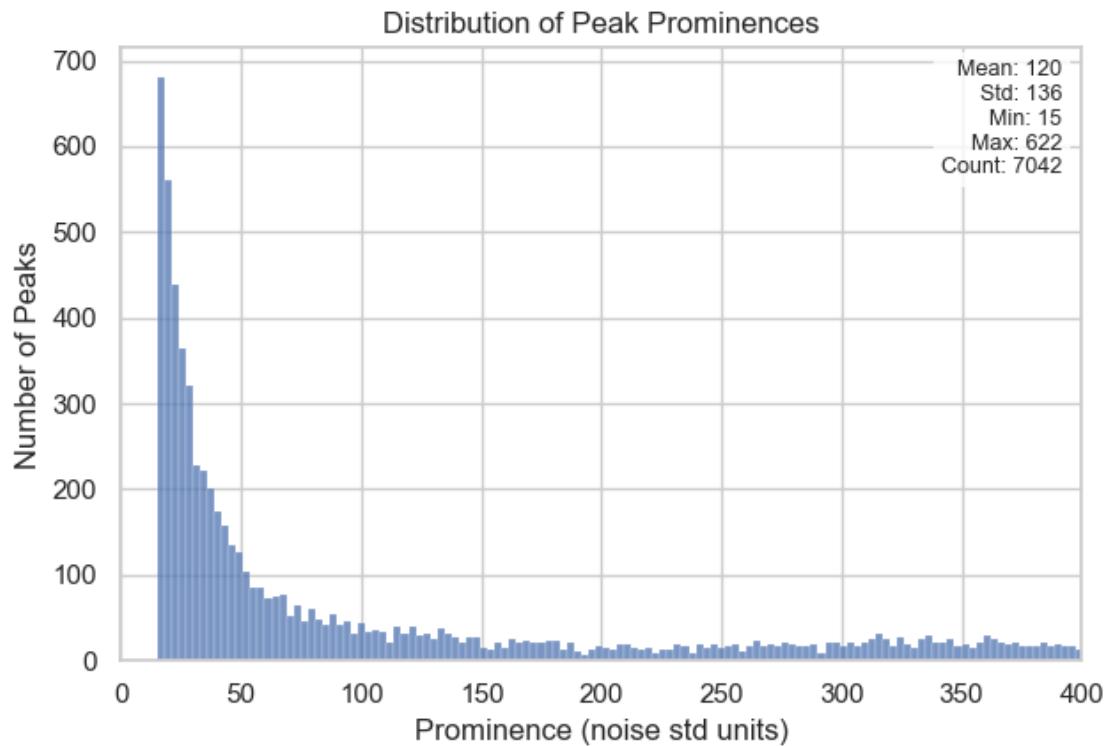
Total number of cells: 876

1.1.3 Peaks statistics

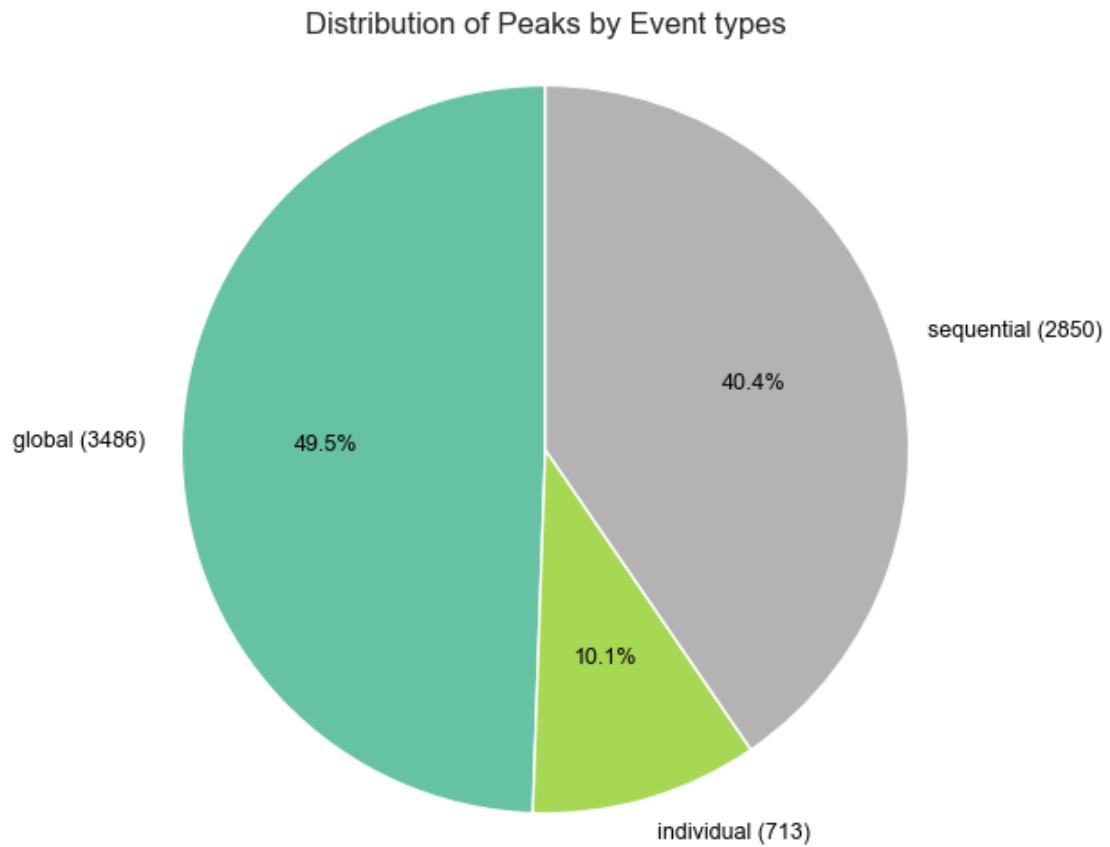
```
[2025-08-13 11:47:27] [INFO] calcium: plot_histogram: removed 2 outliers out of  
7049 on 'Duration (s)' (lower=-161, upper=273)
```



```
[2025-08-13 11:47:27] [INFO] calcium: plot_histogram: removed 7 outliers out of 7049 on 'Prominence (noise std units)' (lower=-427.2, upper=627)
```

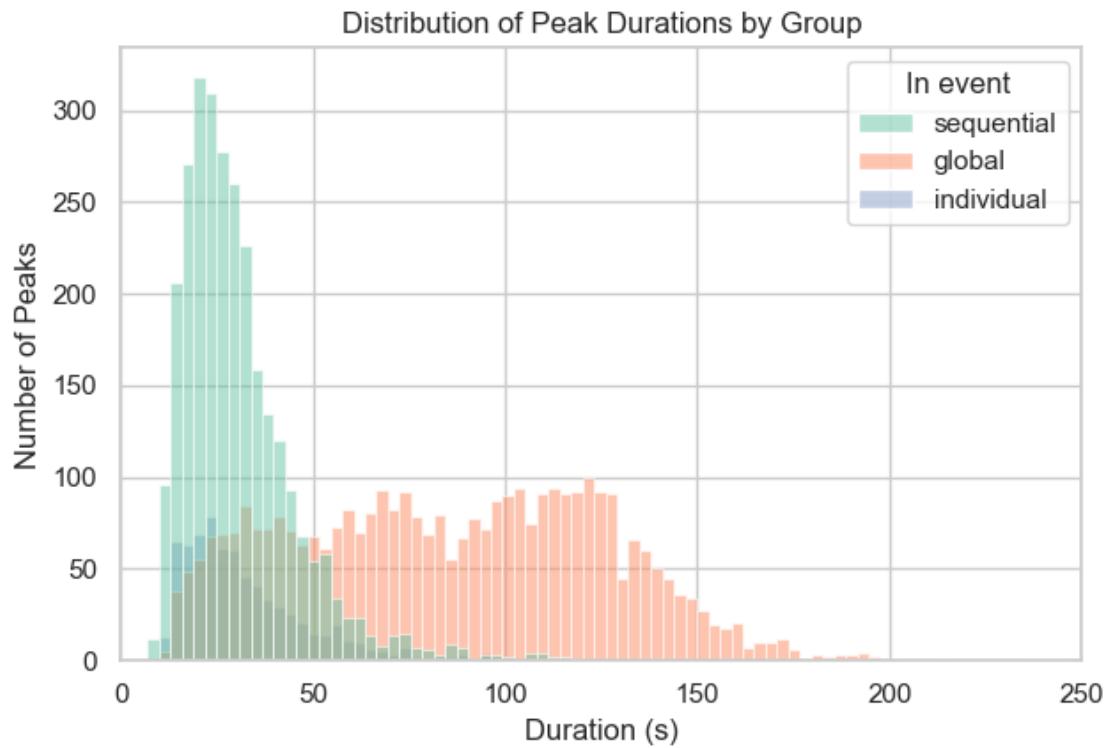


1.1.4 Distribution of peaks per event types



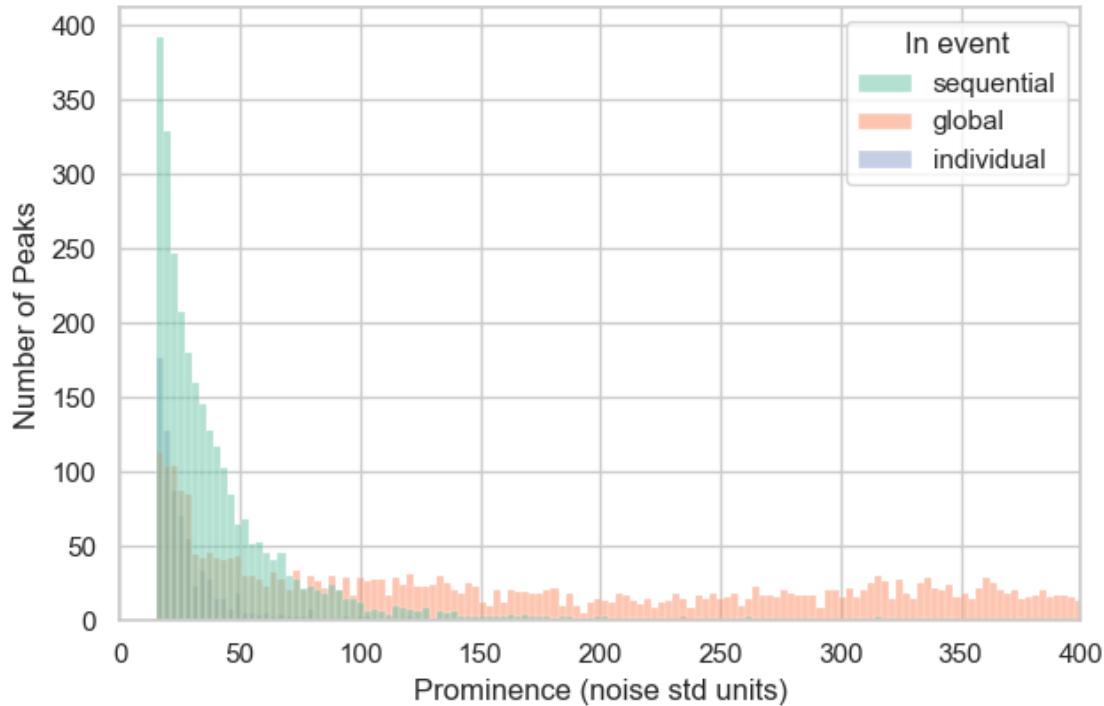
1.1.5 Peaks statistics per event types

```
[2025-08-13 11:47:28] [INFO] calcium: plot_histogram_by_group: removed 2 outliers out of 7049 on 'Duration (s)' (lower=-161, upper=273)
```

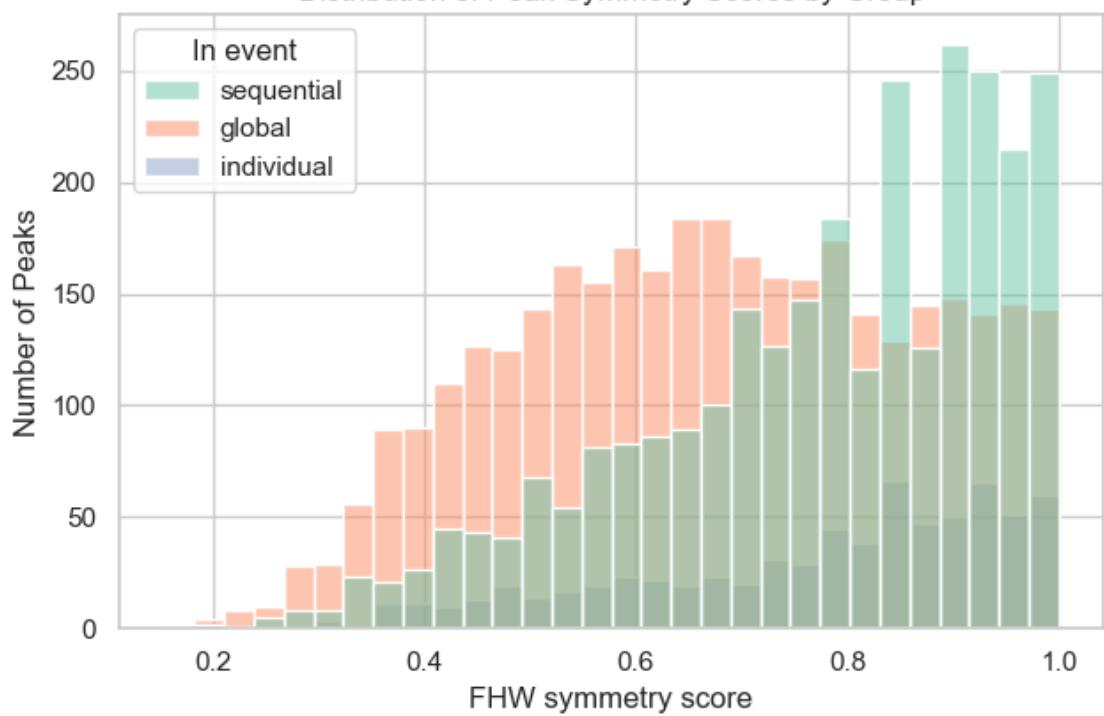


```
[2025-08-13 11:47:28] [INFO] calcium: plot_histogram_by_group: removed 7 outliers out of 7049 on 'Prominence (noise std units)' (lower=-427.2, upper=627)
```

Distribution of Peak Prominences by Group



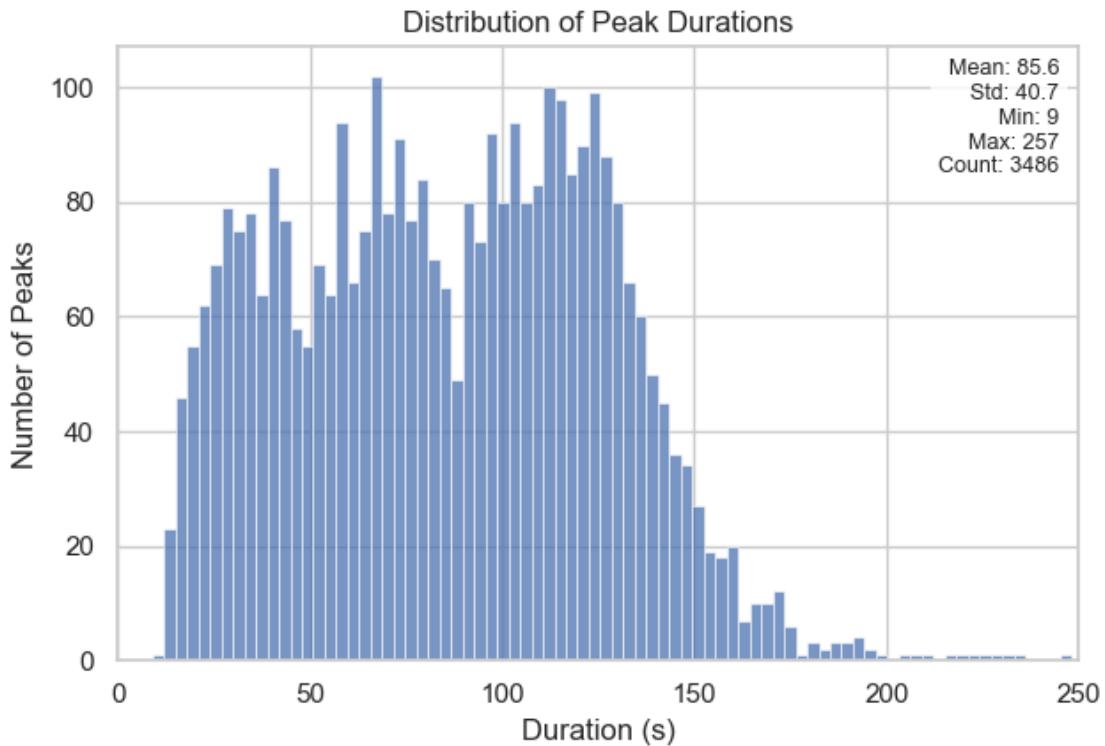
Distribution of Peak Symmetry Scores by Group



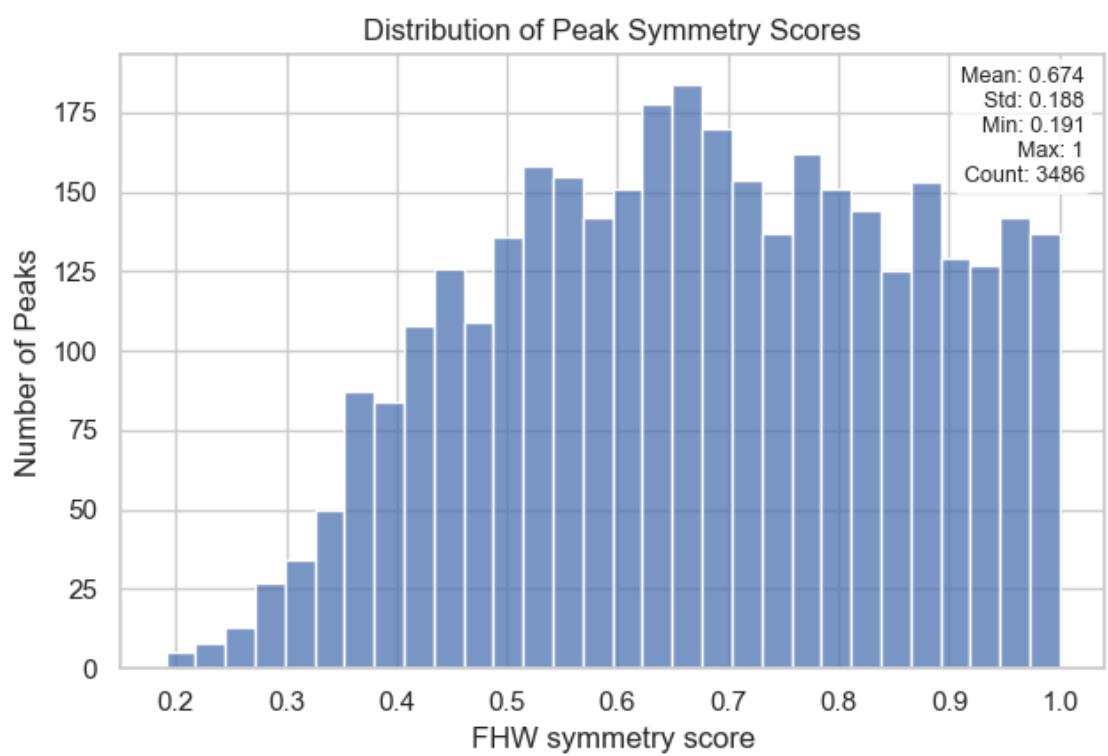
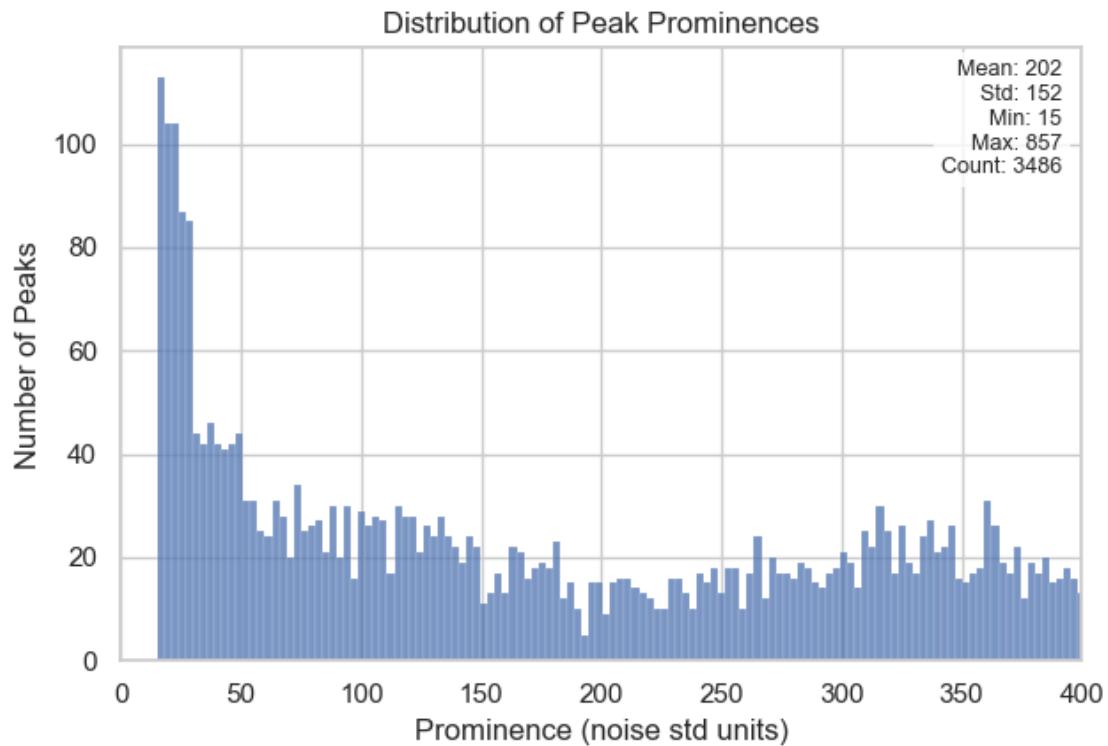
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

[2025-08-13 11:47:30] [INFO] calcium: plot_histogram: removed 0 outliers out of 3486 on 'Duration (s)' (lower=-145.25, upper=315)

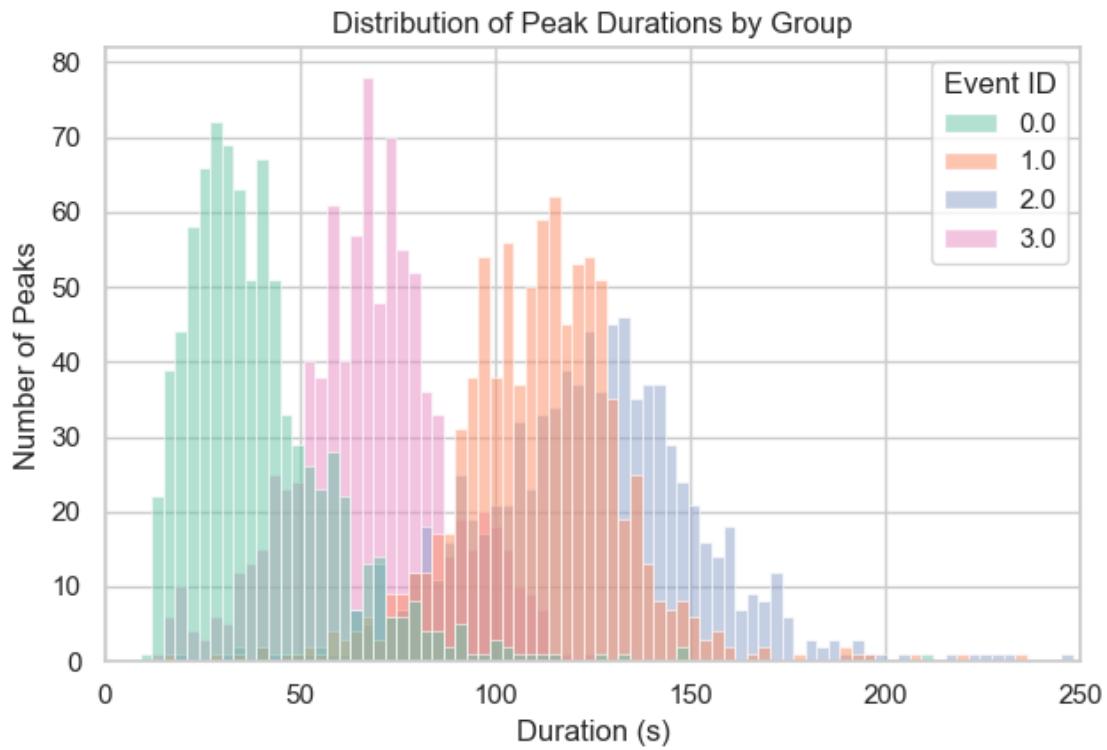


[2025-08-13 11:47:30] [INFO] calcium: plot_histogram: removed 0 outliers out of 3486 on 'Prominence (noise std units)' (lower=-751.12, upper=1138)



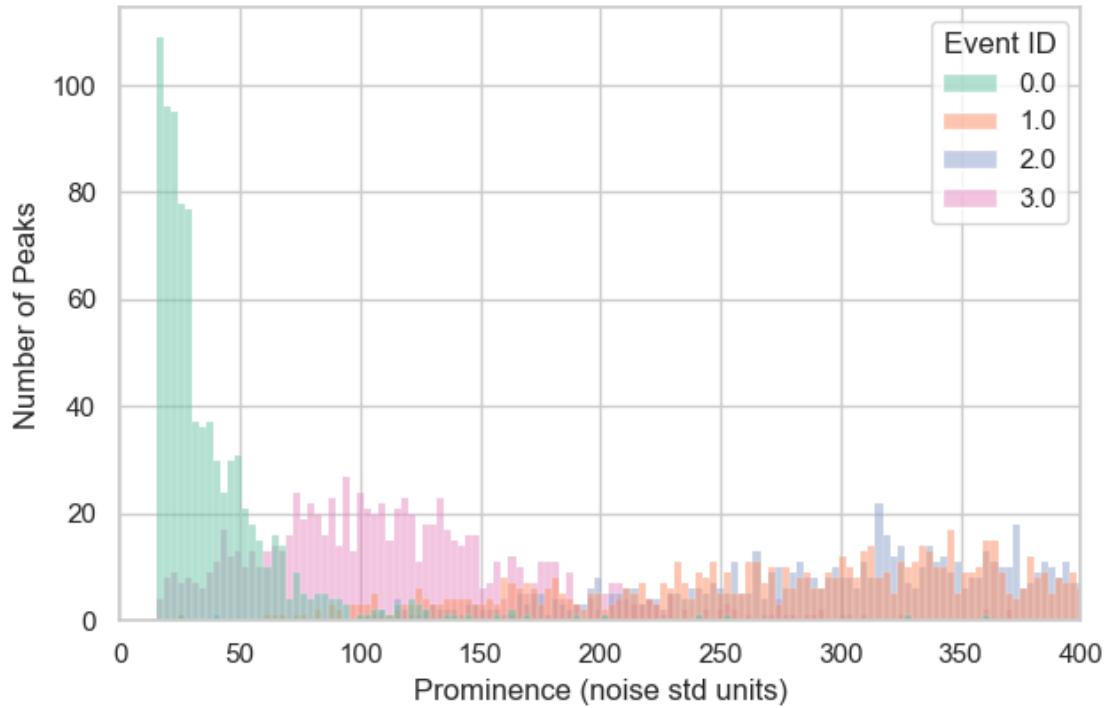
1.2.2 Peak statistics in global event per event ID

[2025-08-13 11:47:30] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 3486 on 'Duration (s)' (lower=-145.25, upper=315)

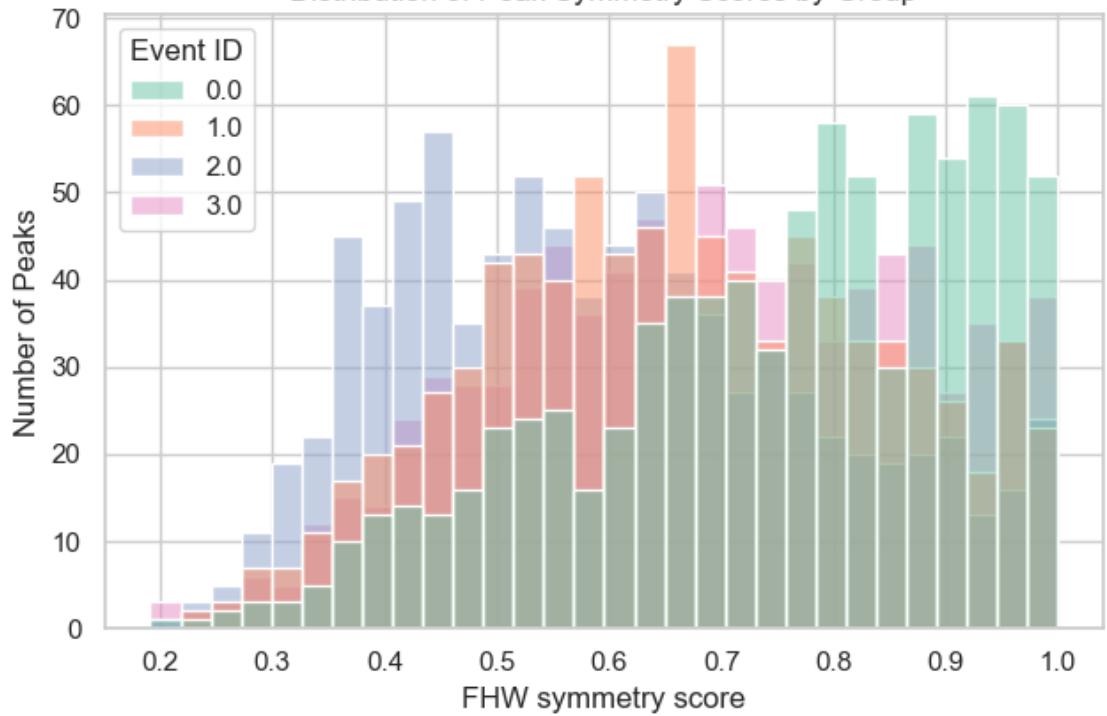


[2025-08-13 11:47:31] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 3486 on 'Prominence (noise std units)' (lower=-751.12, upper=1138)

Distribution of Peak Prominences by Group

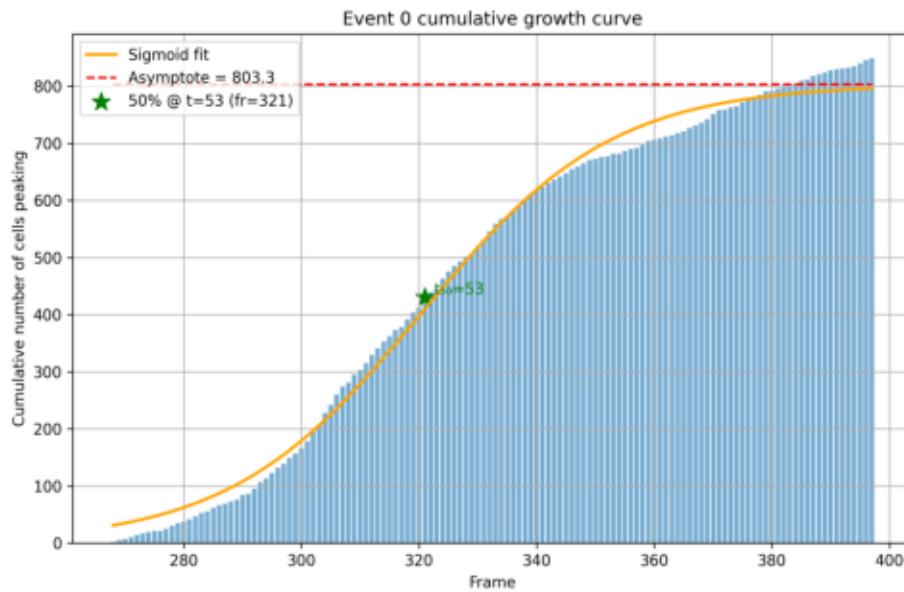


Distribution of Peak Symmetry Scores by Group

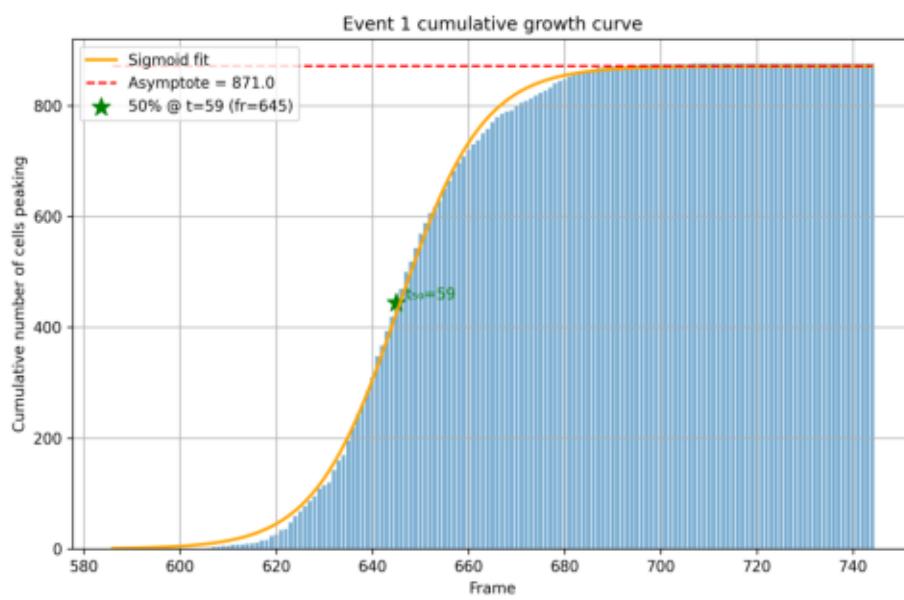


1.2.3 Kinetics of global events

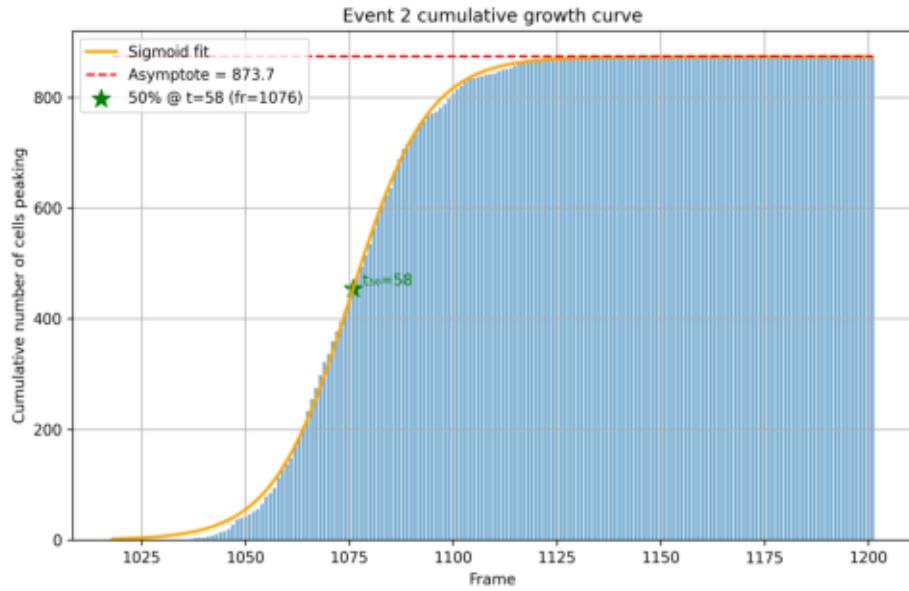
Event Activity Overlay (Event ID: 0) - 20250416_IS4



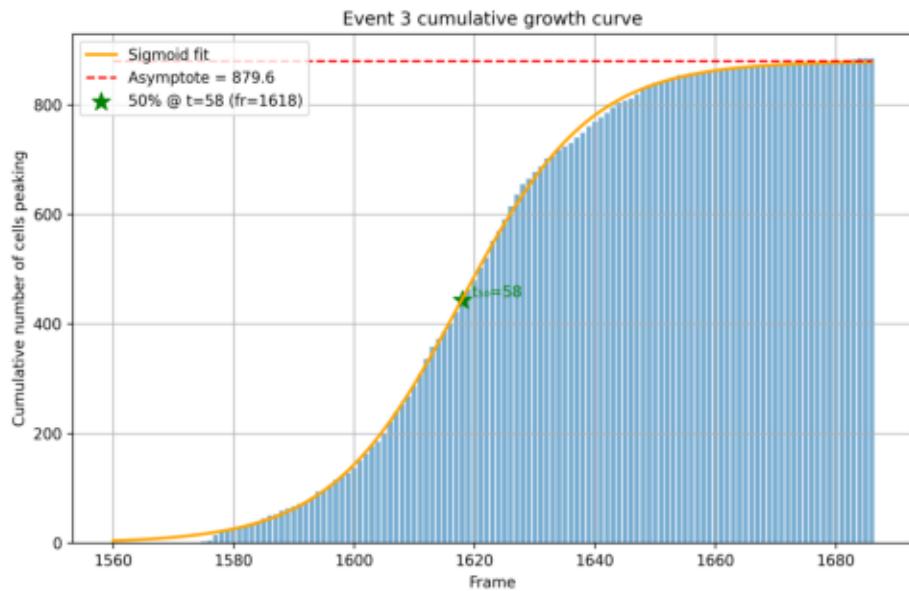
Event Activity Overlay (Event ID: 1) - 20250416_IS4

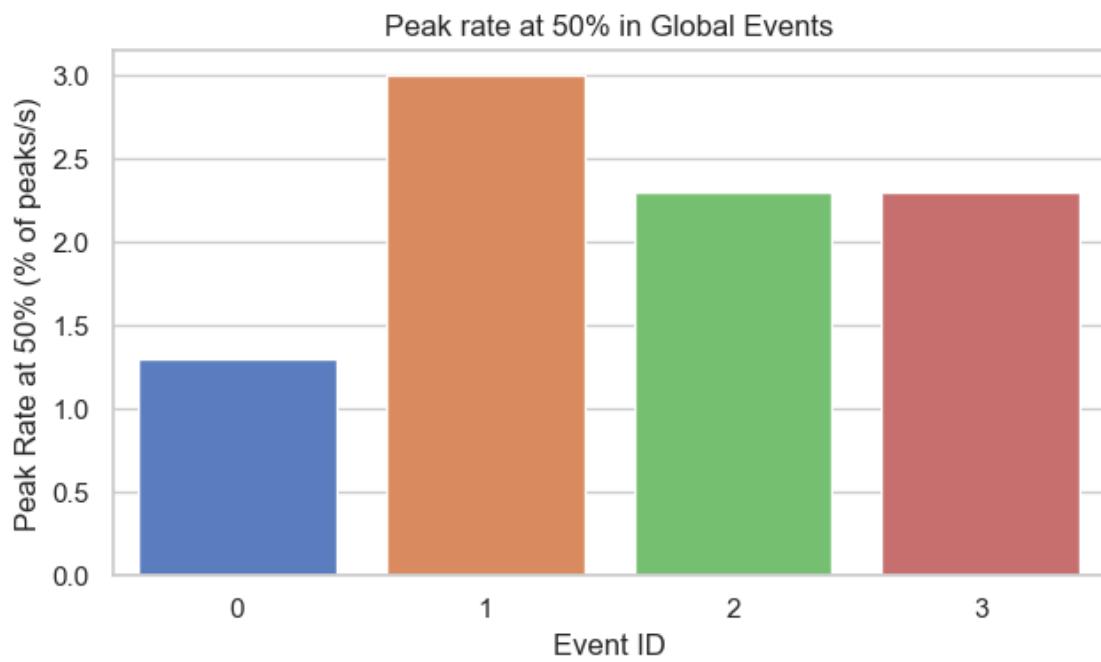
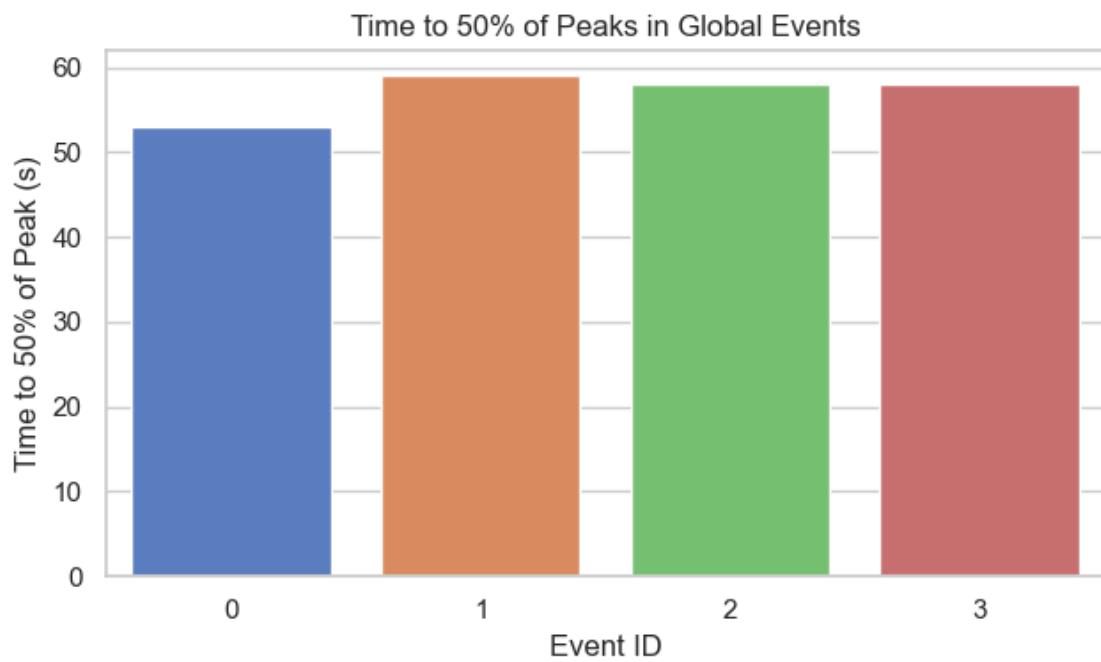


Event Activity Overlay (Event ID: 2) - 20250416_IS4

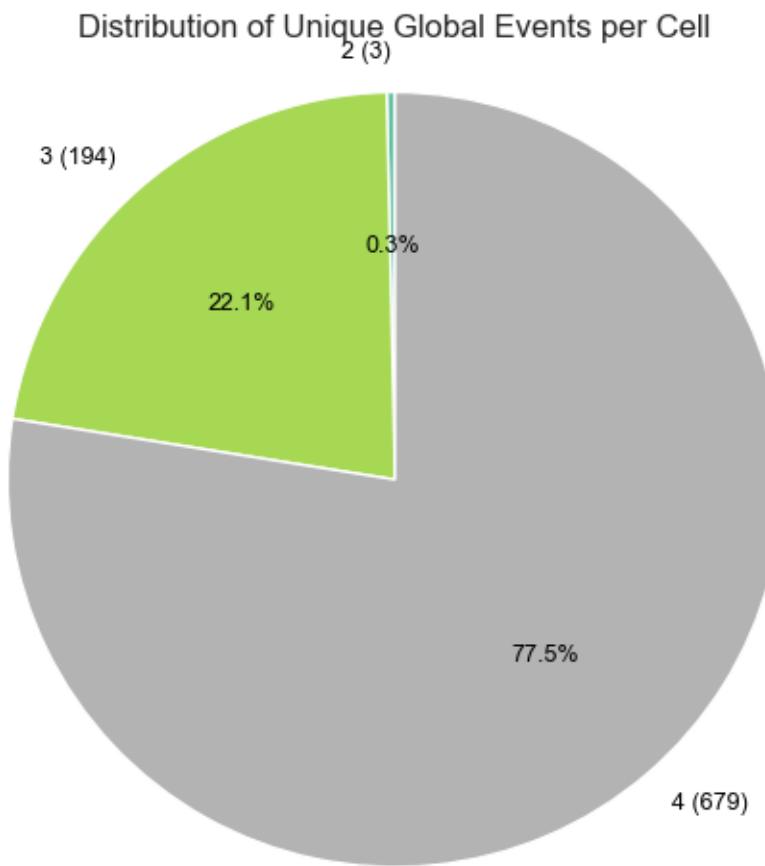


Event Activity Overlay (Event ID: 3) - 20250416_IS4

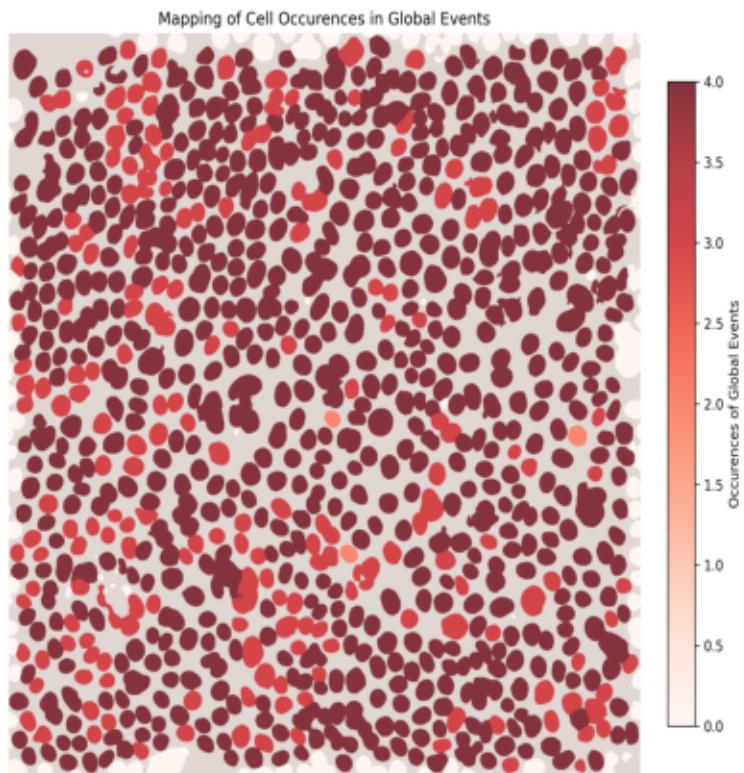


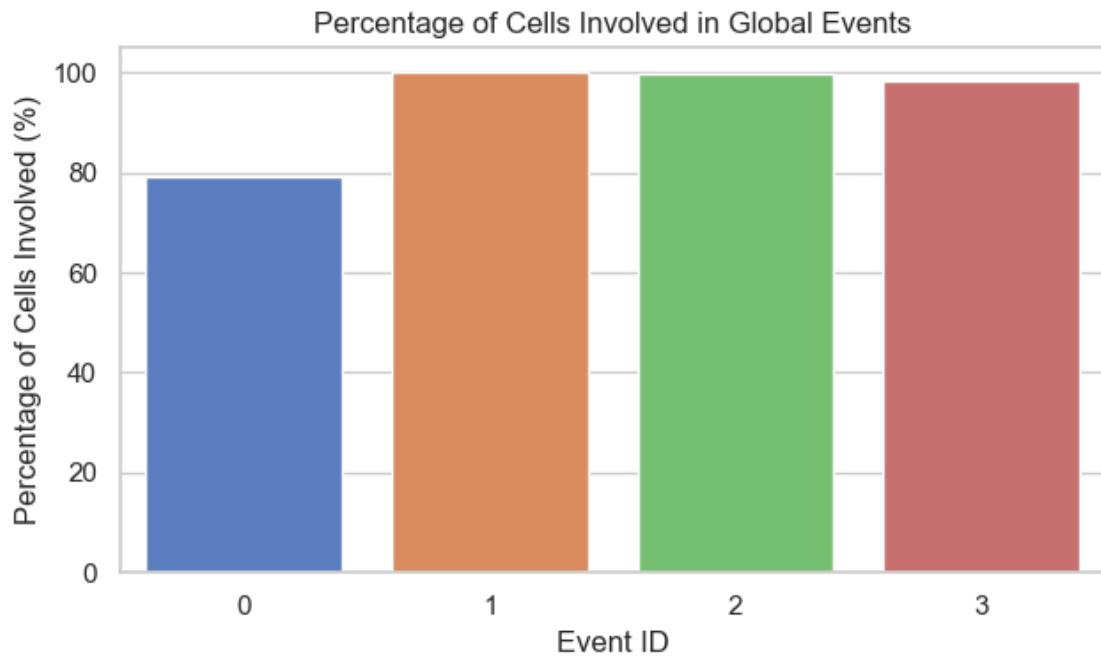


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250416_IS4





1.2.5 Inter-event interval analysis

Intervals between global event peaks: [343.0, 428.0, 540.0]

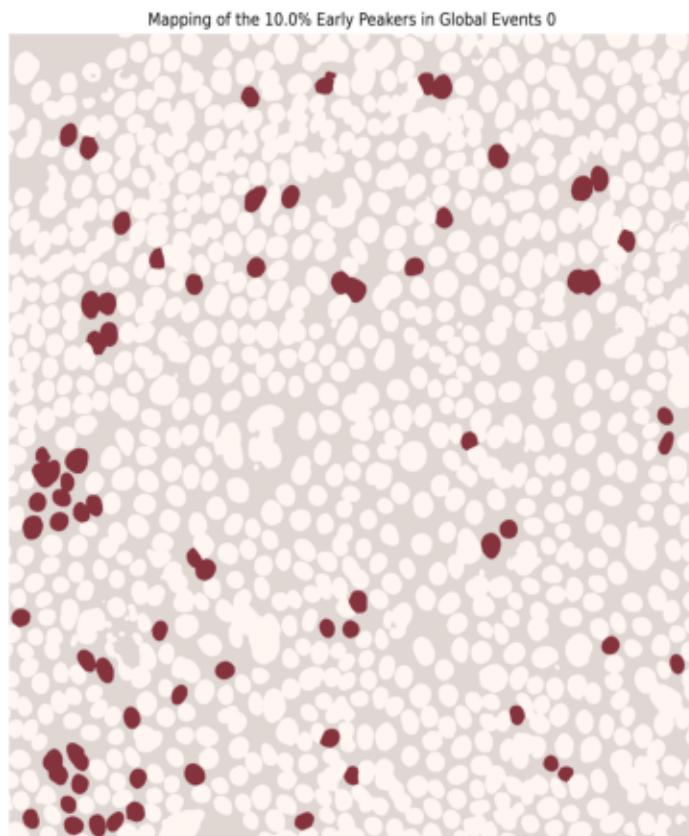
Estimated periodicity: 0.844

The global events exhibit a regular periodic pattern.

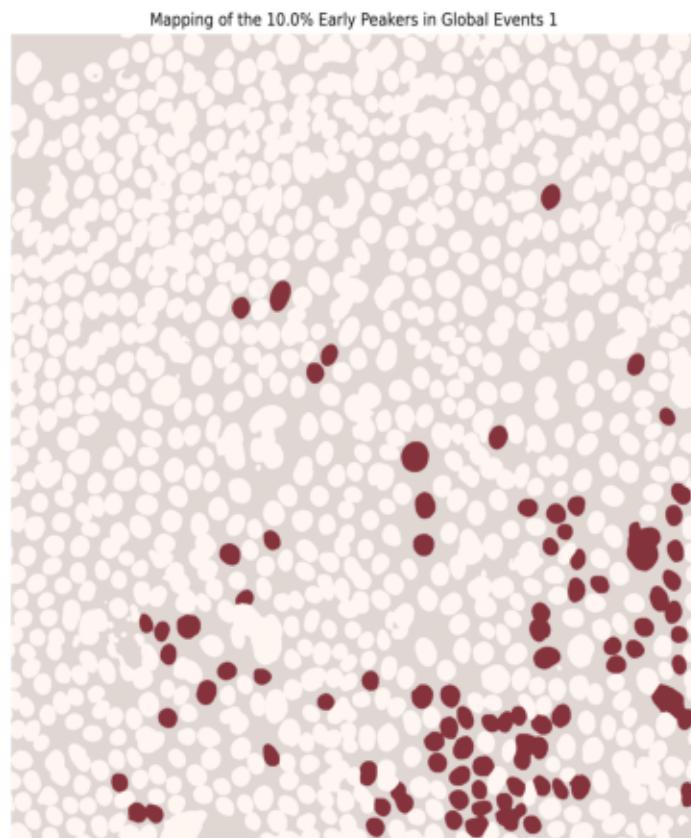
Estimated frequency (1/mean interval): 0.002 Hz

1.2.6 Early peakers in the events

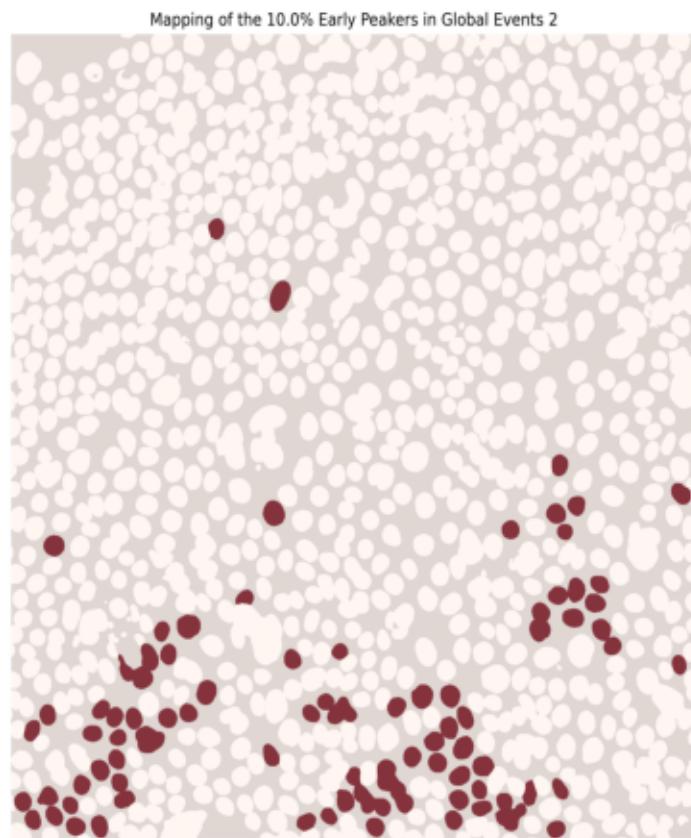
Cell Mapping with Early Peakers Overlay for event 0 - 20250416_IS4



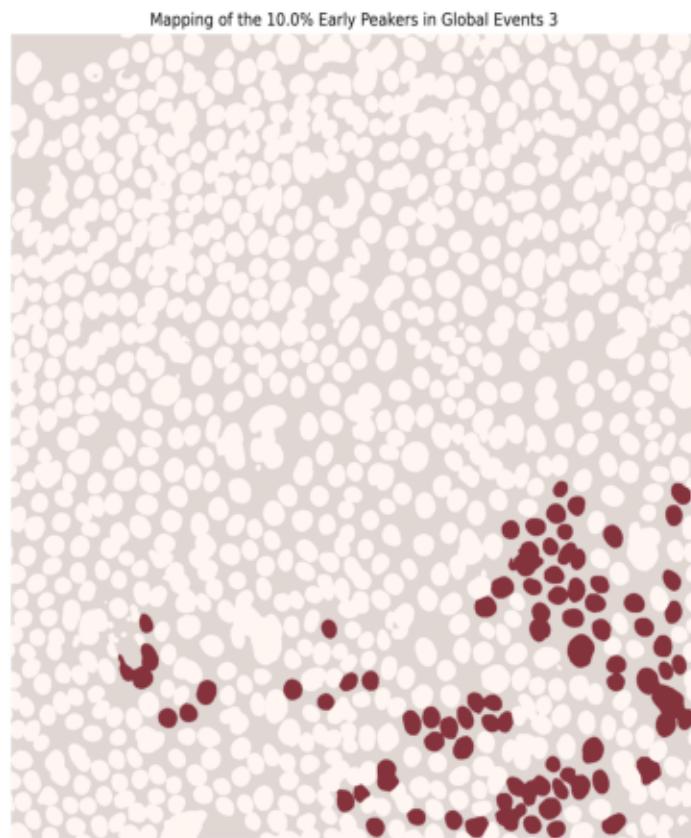
Cell Mapping with Early Peakers Overlay for event 1 - 20250416_IS4



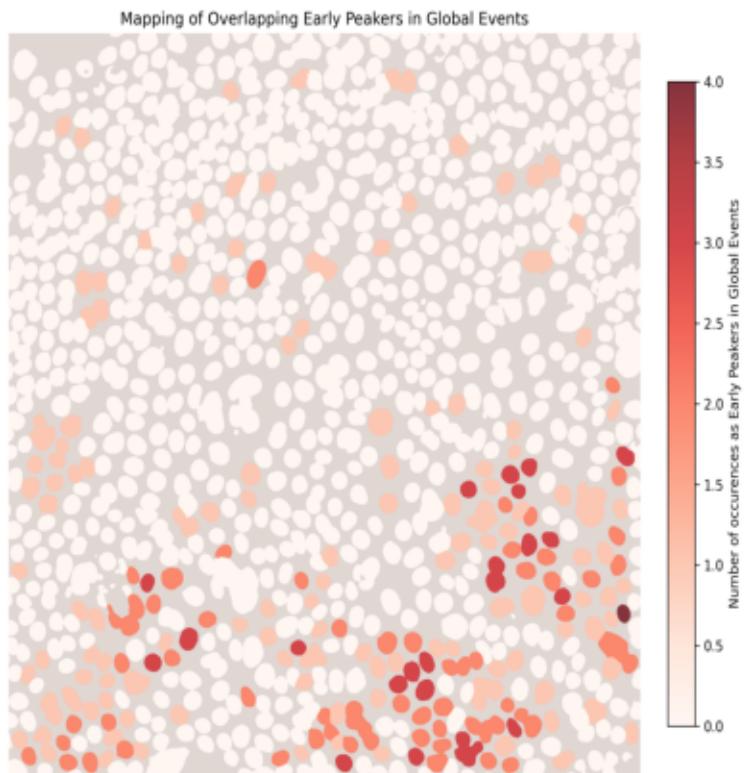
Cell Mapping with Early Peakers Overlay for event 2 - 20250416_IS4

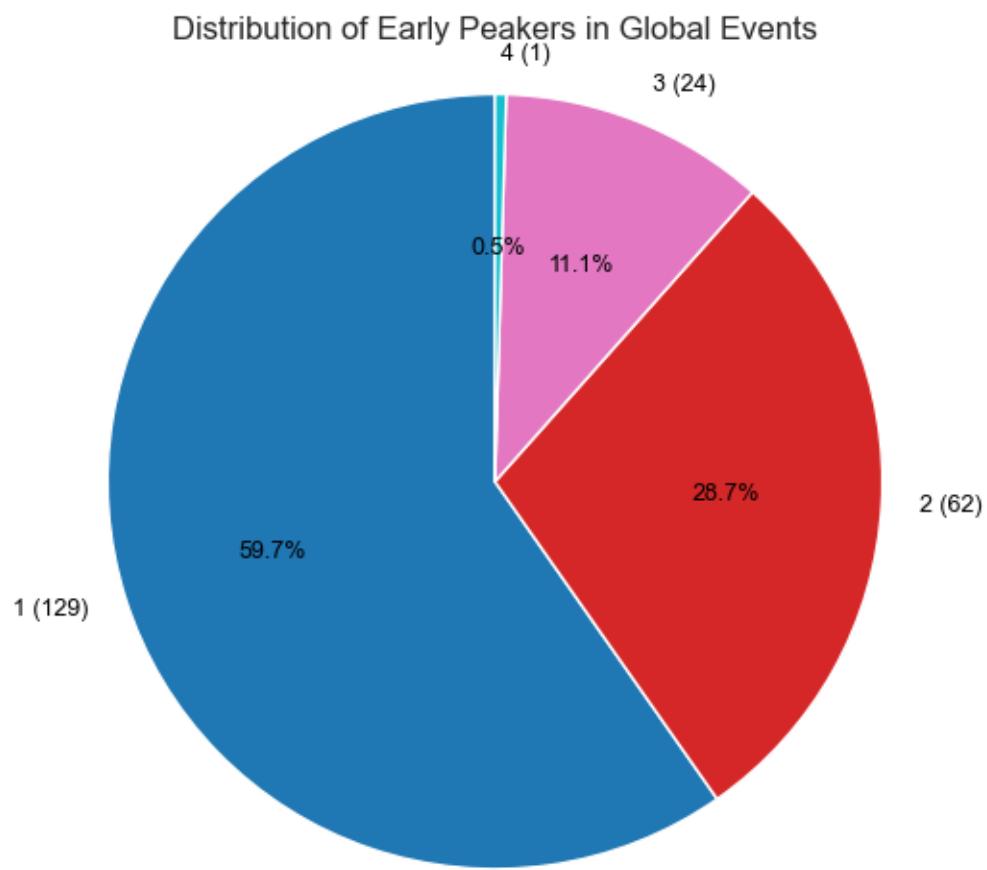
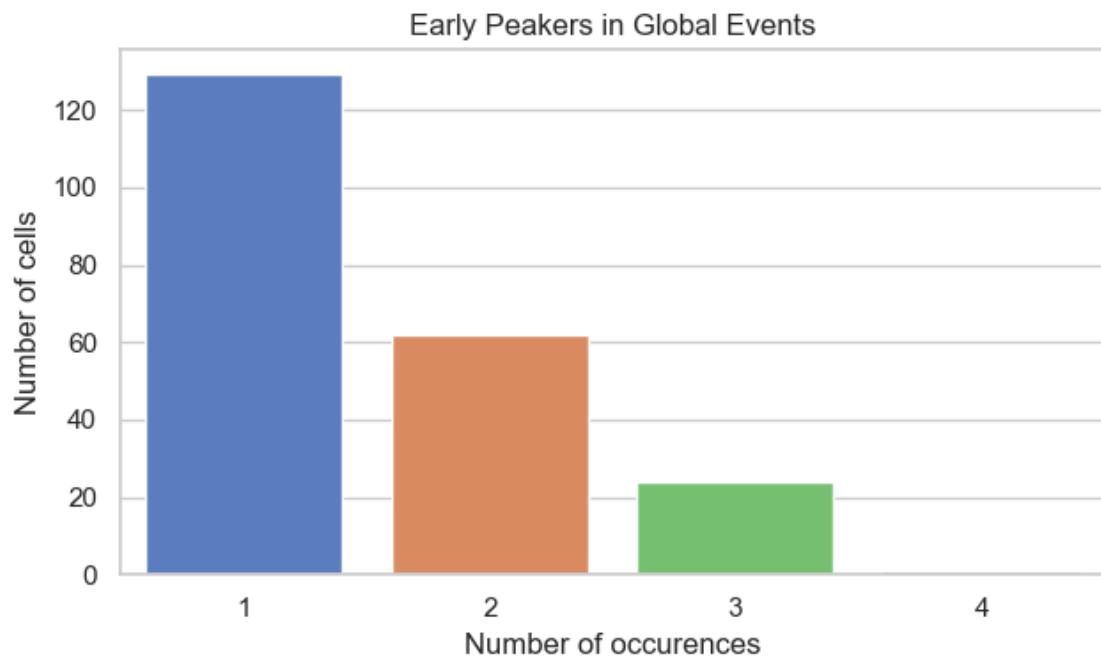


Cell Mapping with Early Peakers Overlay for event 3 - 20250416_IS4



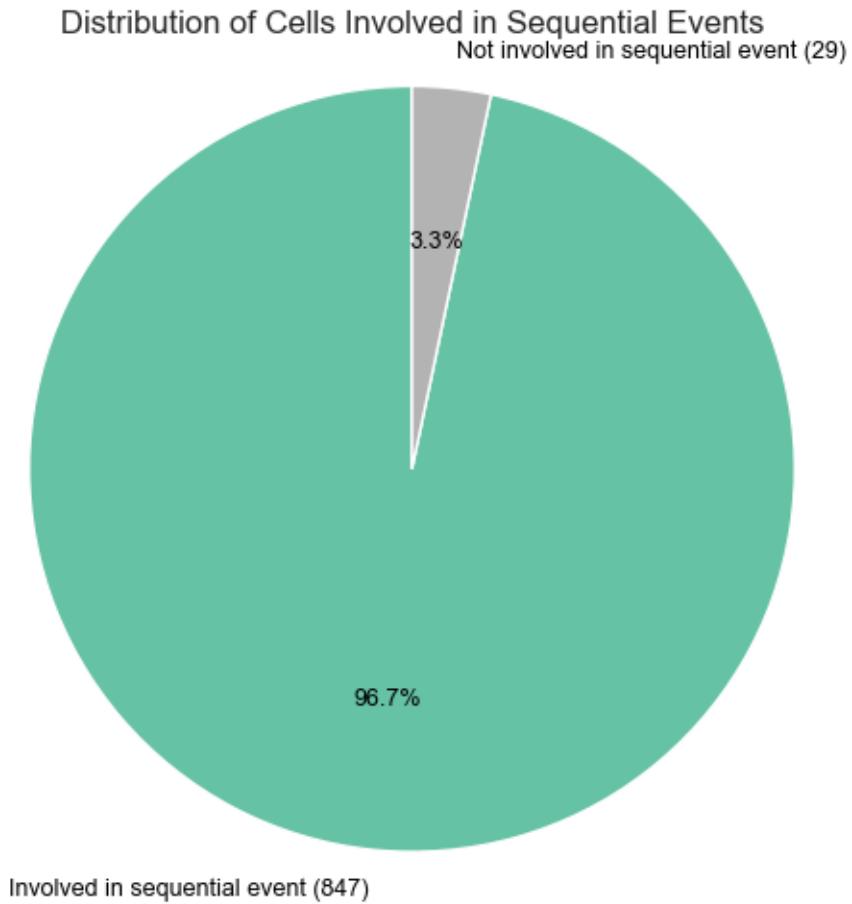
Cell Mapping with Occurrences in Global Events Overlay - 20250416_IS4



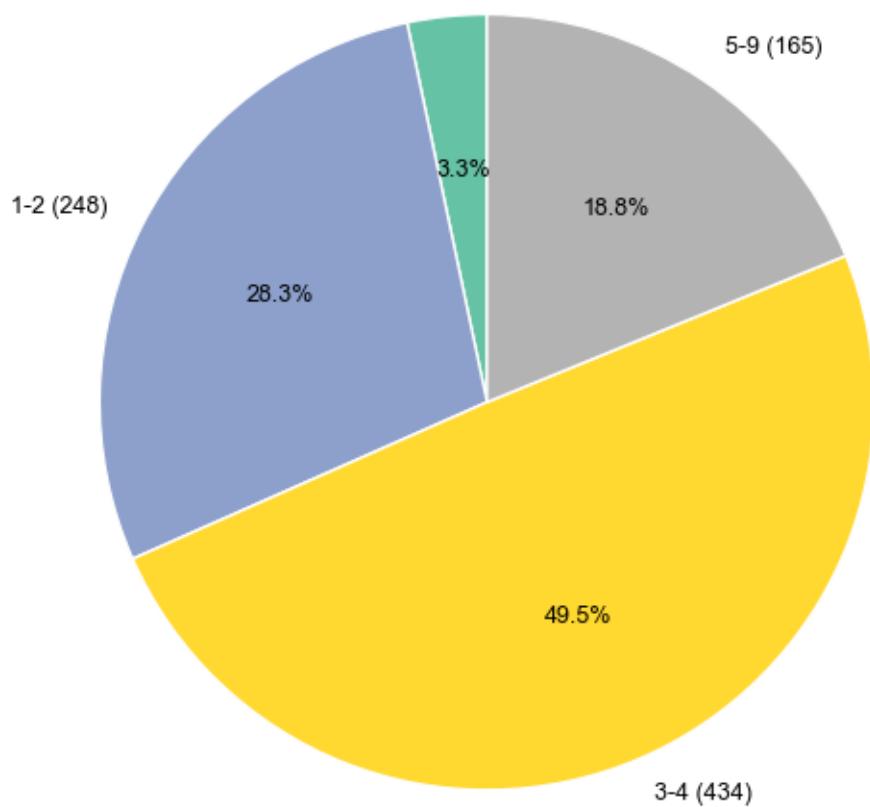


1.3 SEQUENTIAL EVENTS

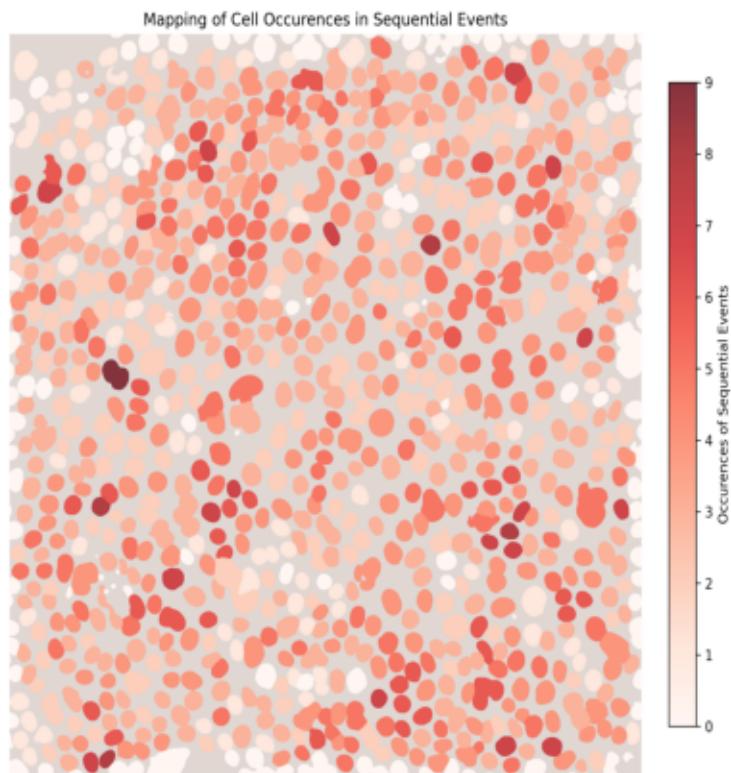
1.3.1 Cells occurrences in sequential events



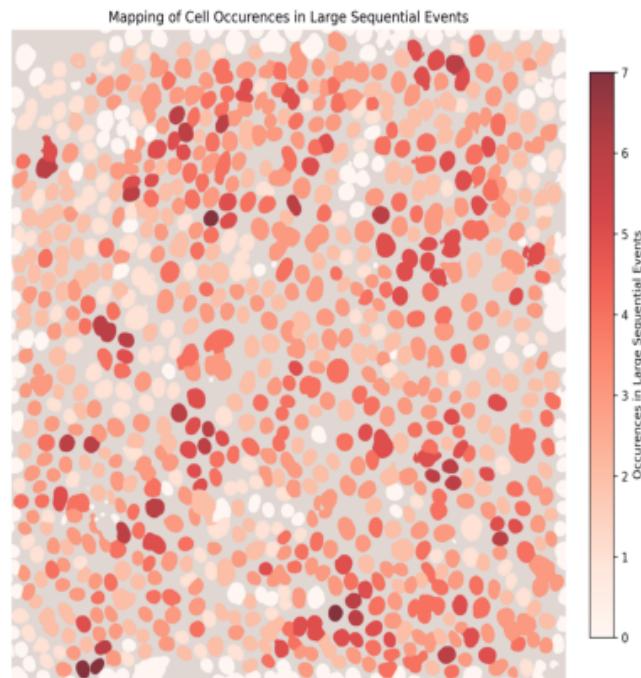
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)
0 (29)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250416_IS4

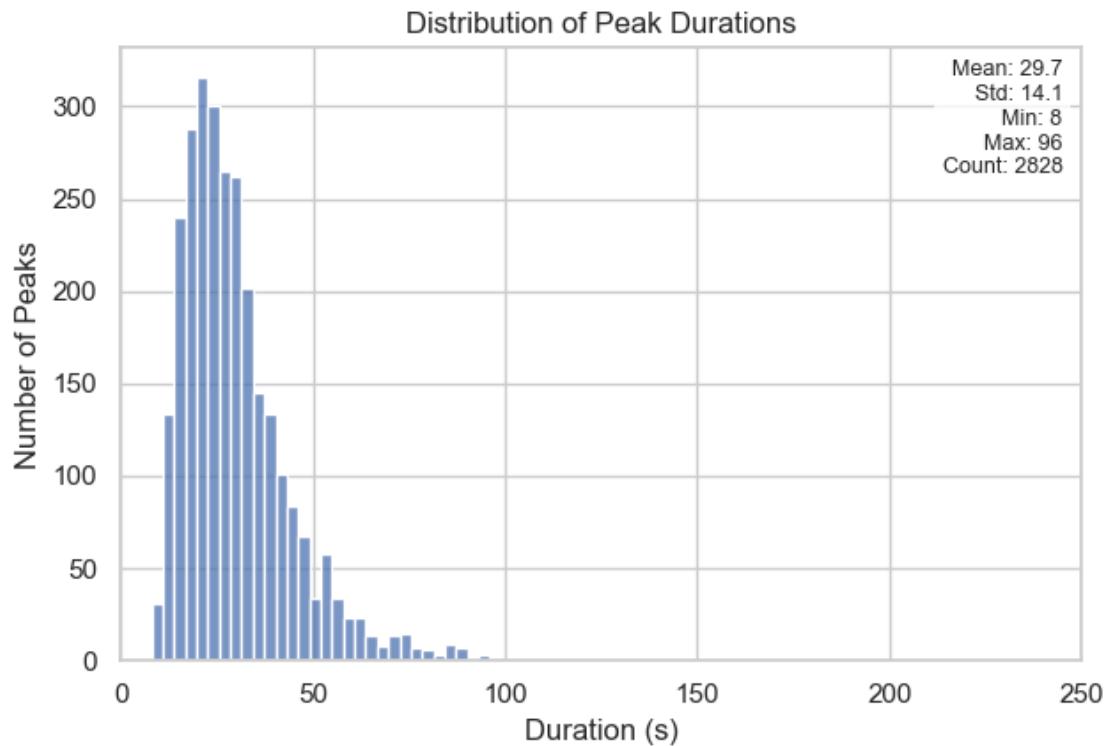


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250416_IS4

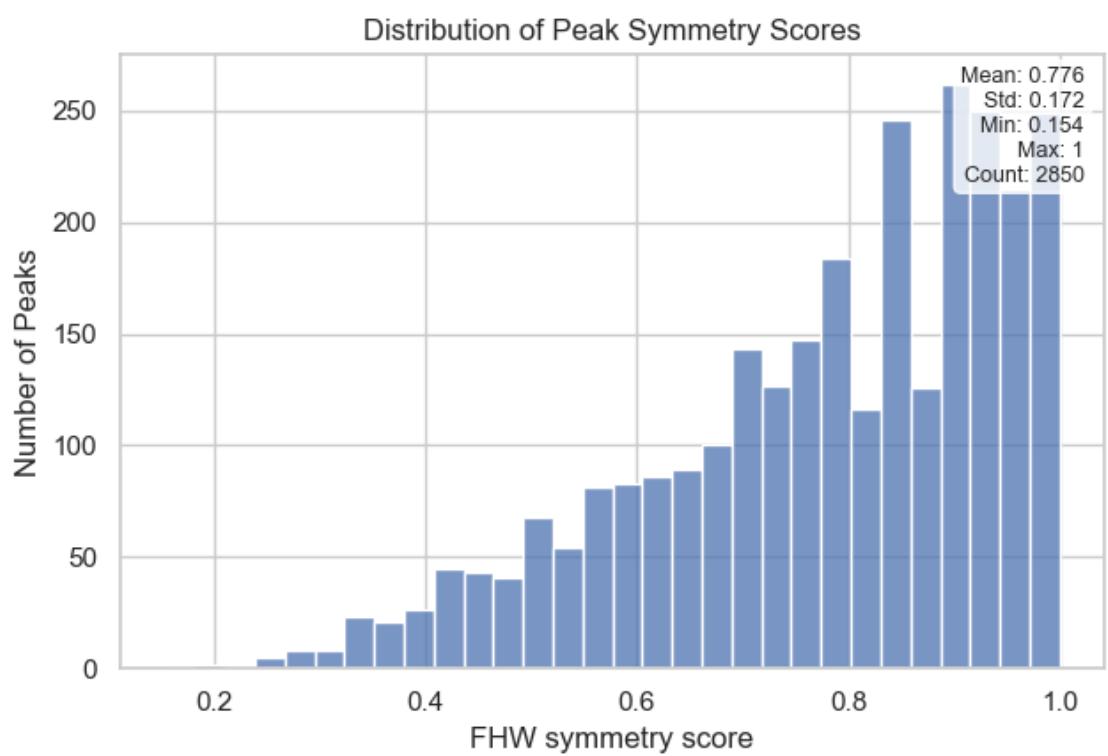
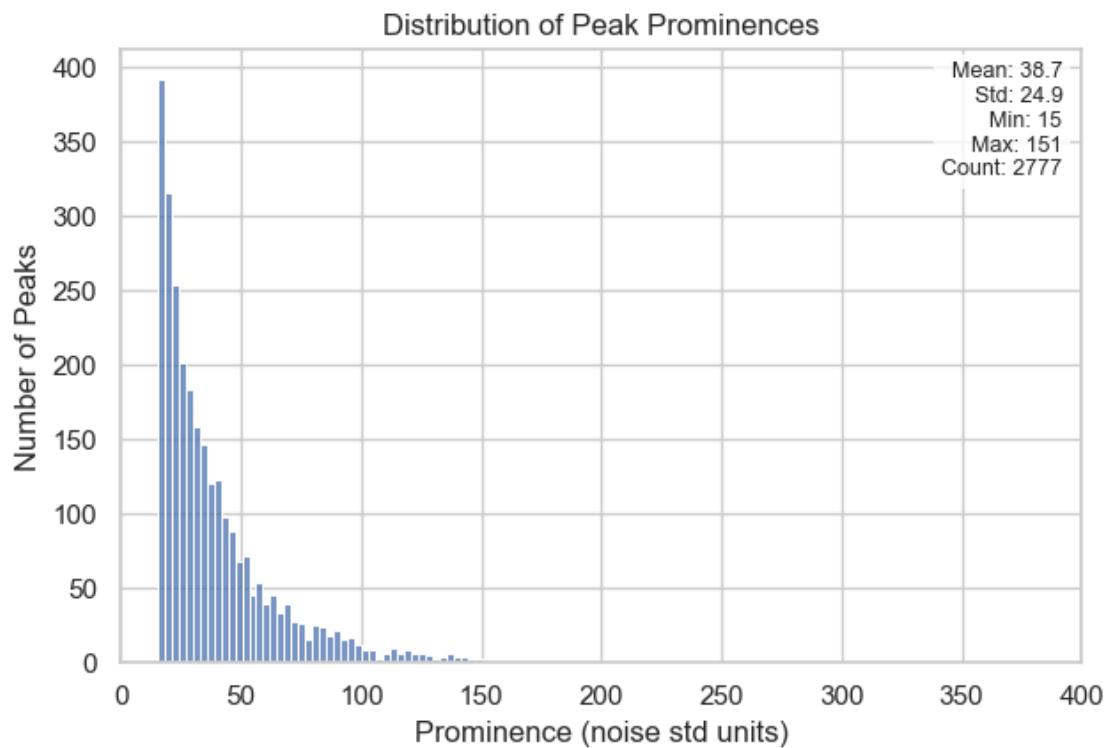


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 11:47:46] [INFO] calcium: plot_histogram: removed 22 outliers out of 2850 on 'Duration (s)' (lower=-5.5, upper=96.5)
```

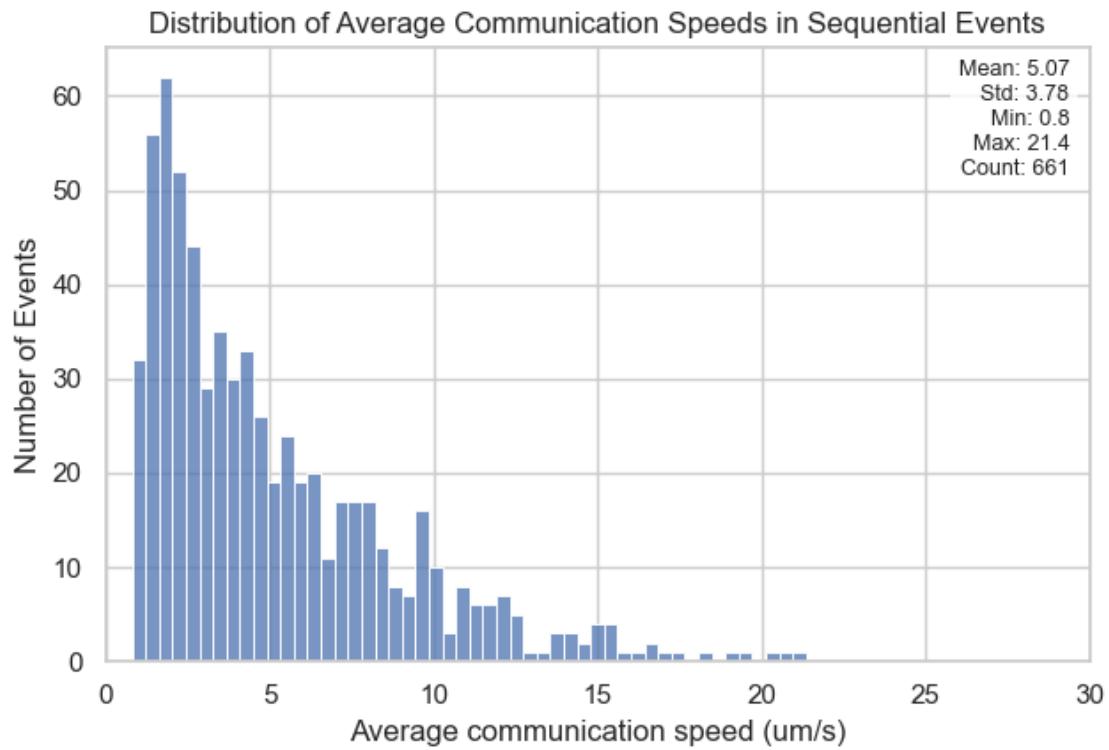


```
[2025-08-13 11:47:46] [INFO] calcium: plot_histogram: removed 73 outliers out of 2850 on 'Prominence (noise std units)' (lower=-22.563, upper=151.29)
```

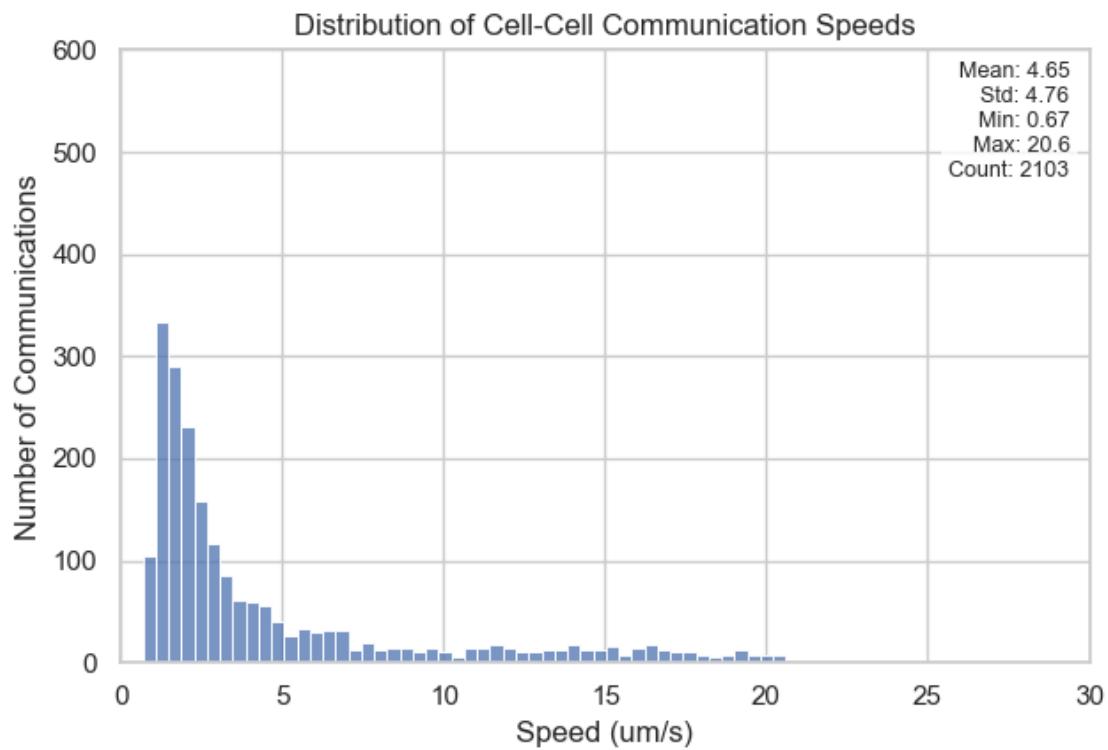


1.3.3 Cell-cell communication speed

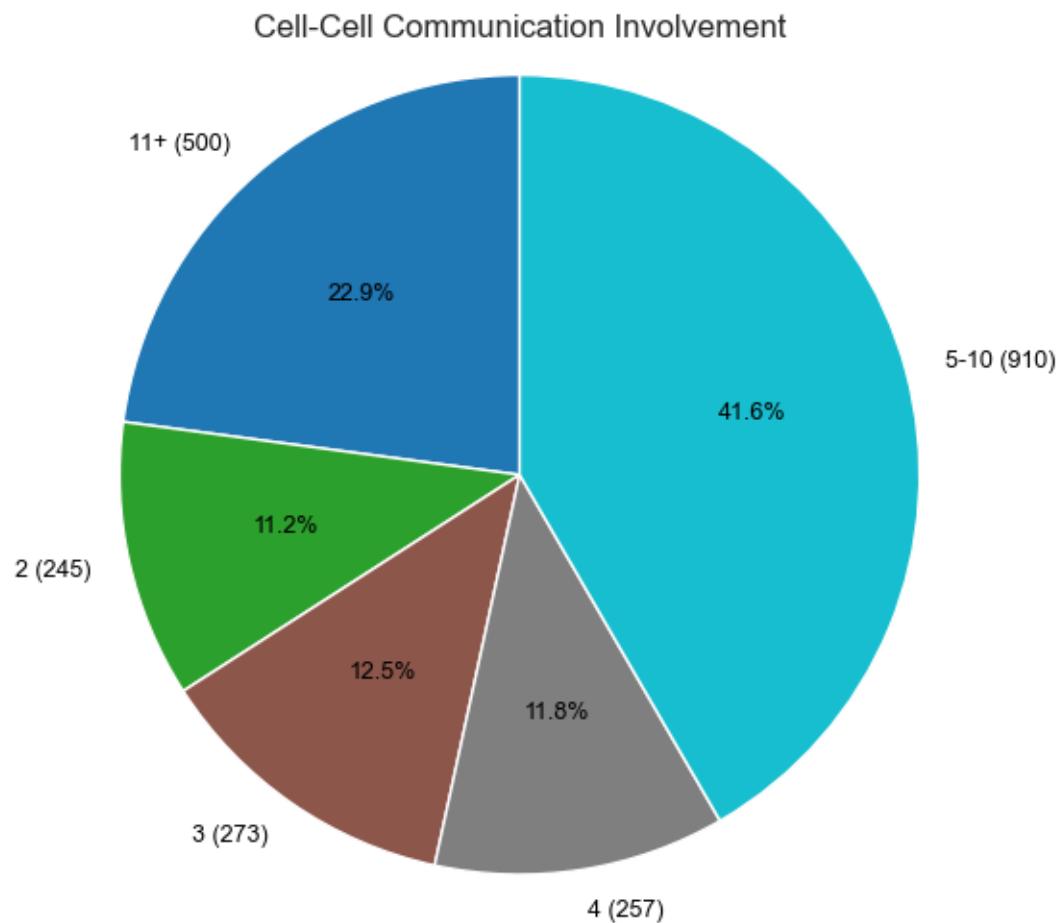
[2025-08-13 11:47:47] [INFO] calcium: plot_histogram: removed 4 outliers out of 665 on 'Average communication speed (um/s)' (lower=-12.83, upper=22.03)



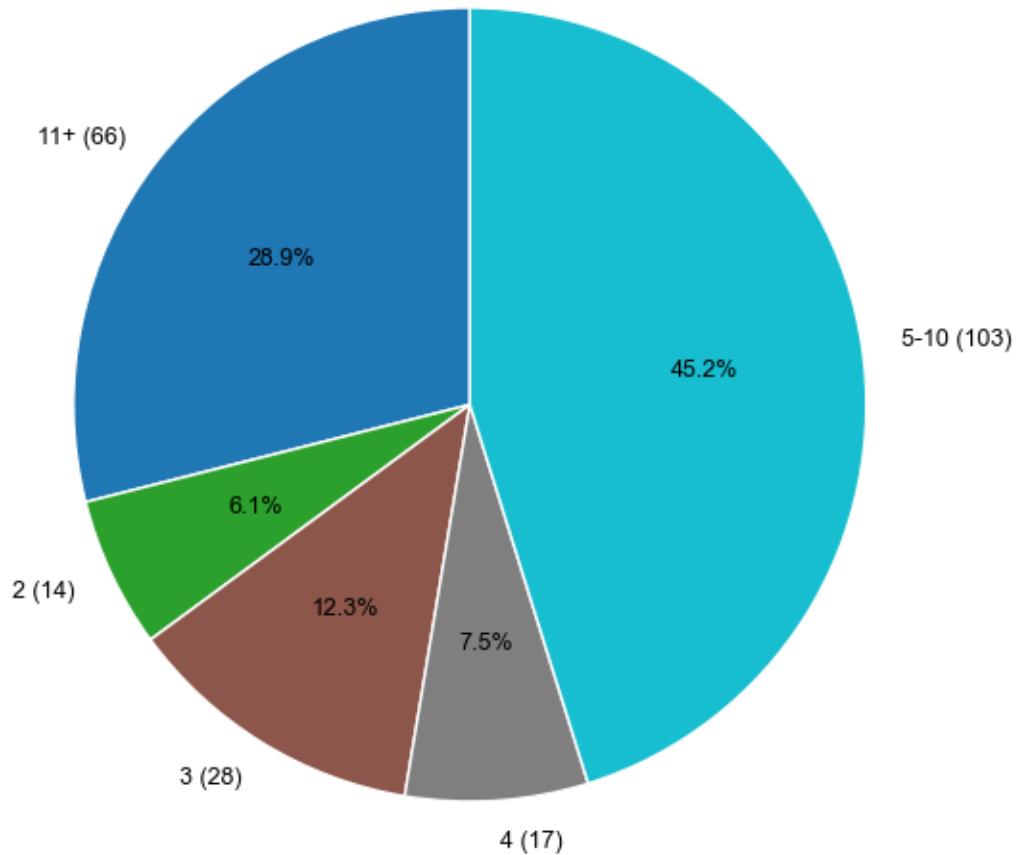
[2025-08-13 11:47:47] [INFO] calcium: plot_histogram: removed 82 outliers out of 2185 on 'Speed (um/s)' (lower=-12.69, upper=20.63)



1.3.4 Double distribution in cell-cell communication speeds

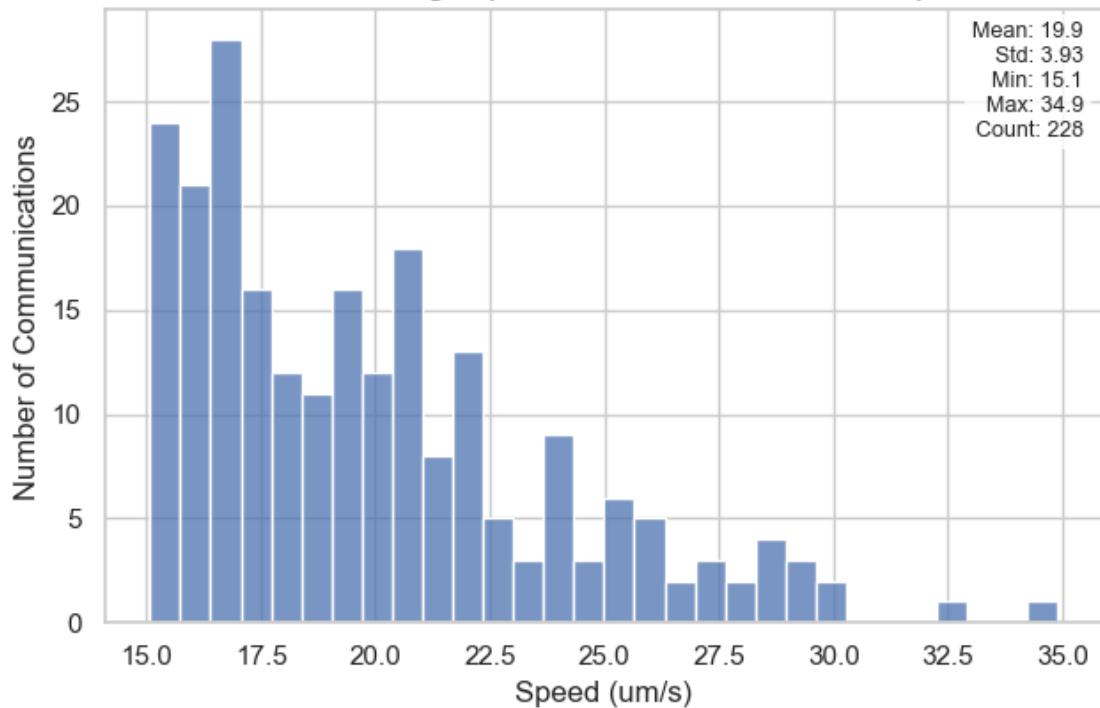


High Speed Cell-Cell Communication Involvement

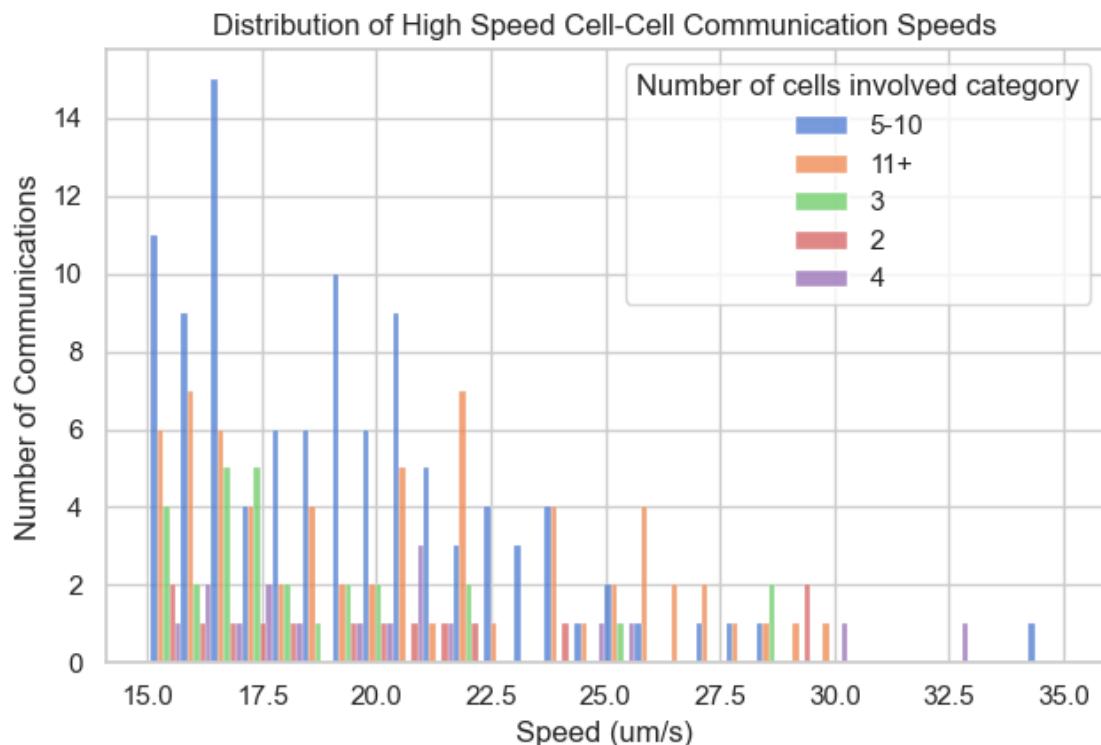


```
[2025-08-13 11:47:48] [INFO] calcium: plot_histogram: removed 0 outliers out of  
228 on 'Speed (um/s)' (lower=0.715, upper=37.85)
```

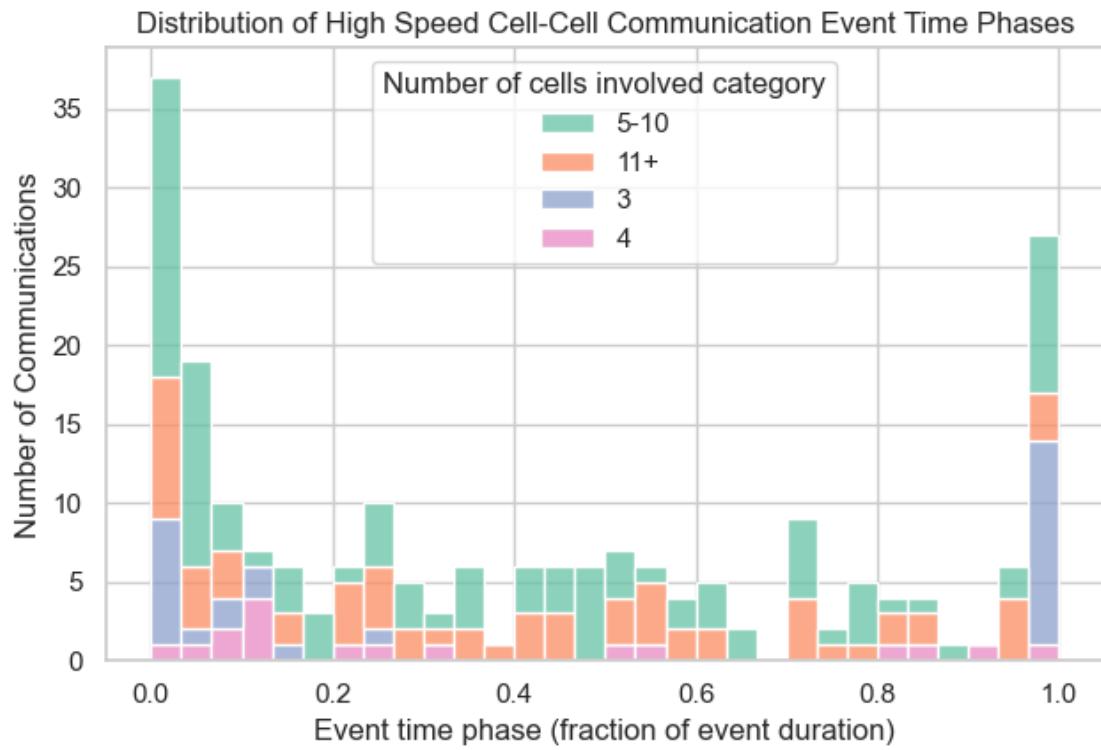
Distribution of High Speed Cell-Cell Communication Speeds



```
[2025-08-13 11:47:48] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 228 on 'Speed (um/s)' (lower=0.715, upper=37.85)
```

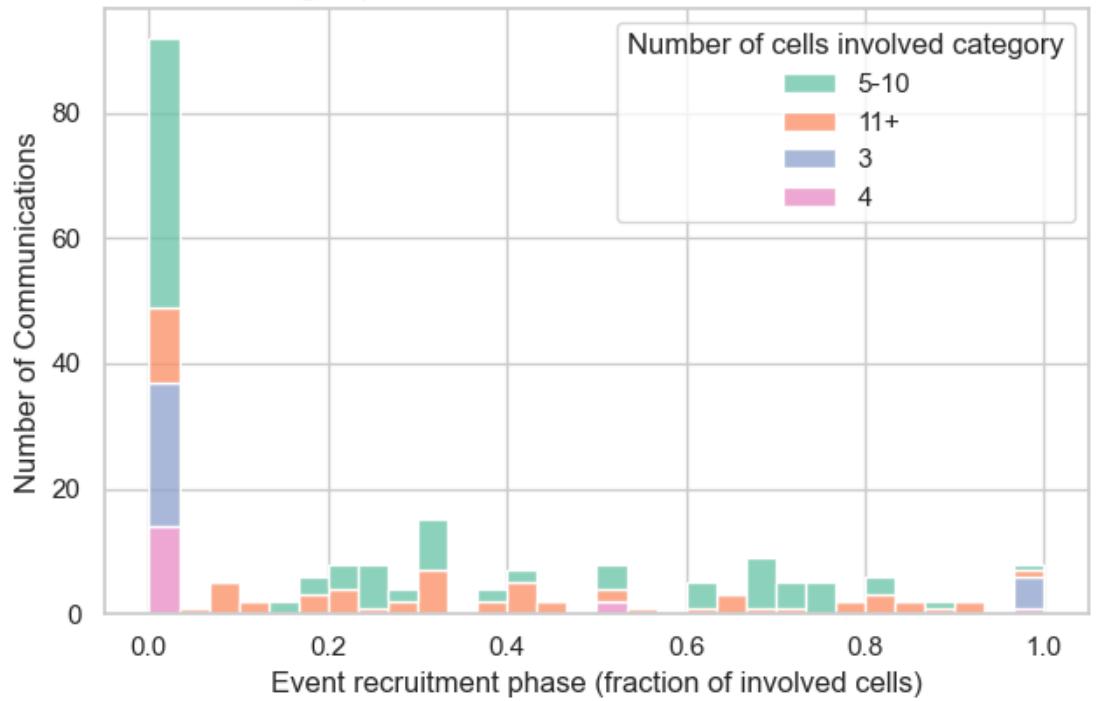


```
[2025-08-13 11:47:48] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 214 on 'Event time phase (fraction of event duration)' (lower=-1.92, upper=2.7)
```

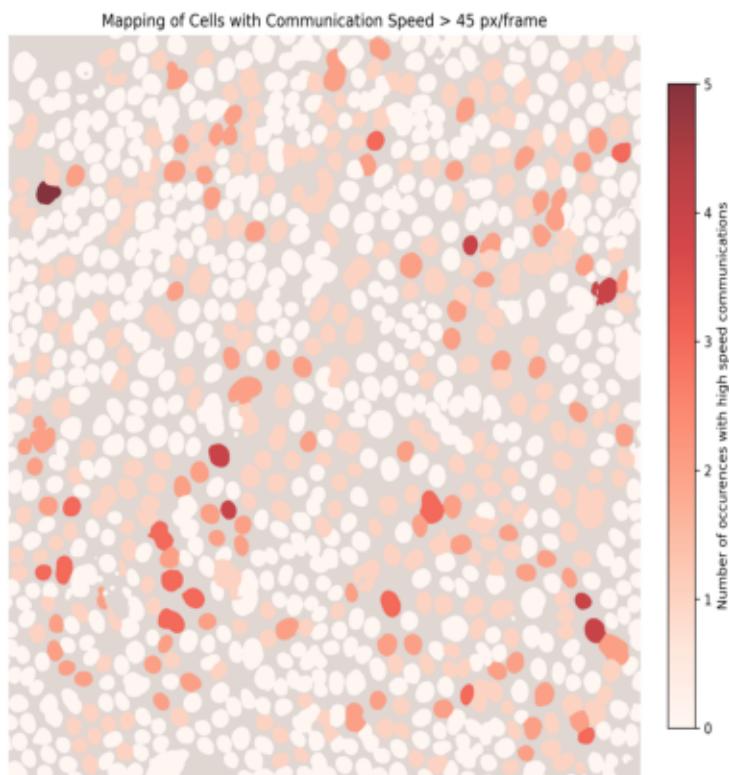


```
[2025-08-13 11:47:49] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 214 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.5, upper=2)
```

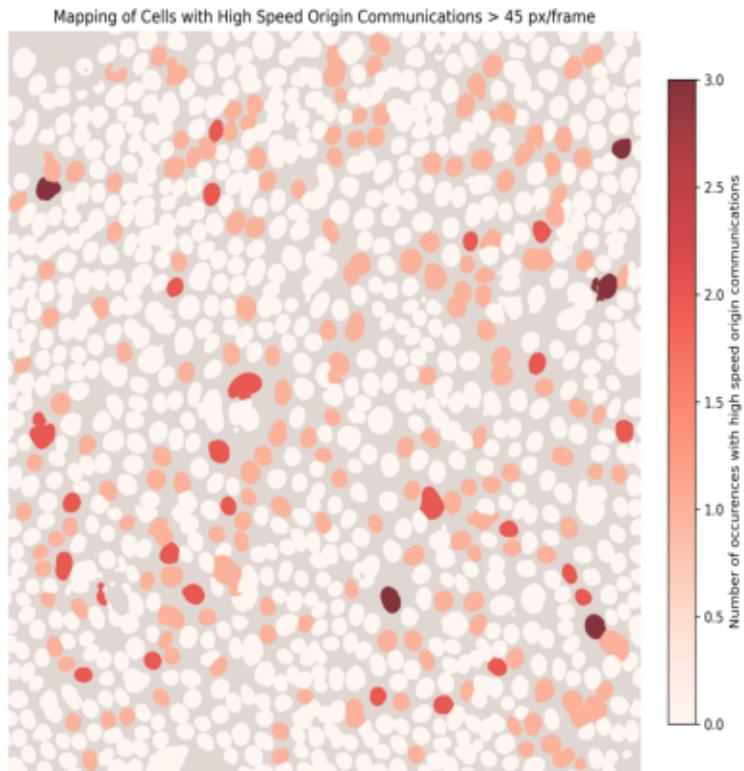
Distribution of High Speed Cell-Cell Communication Event Recruitment Phases



Cell Mapping with High Speed Cells Overlay - 20250416_IS4



Cell Mapping with High Speed Origin Cells Overlay - 20250416_IS4



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
1	1759499102016	4	1099	1	
3	1759499093904	4	1059	0	
11	1759499101008	6	282	1	
15	1759499105520	7	958	0	
39	1759499095296	9	985	1	
...	
2062	1759578508256	614	1159	0	
2091	1759309292944	621	1277	7	
2126	1759578509360	635	1222	0	
2150	1759309298224	643	1272	6	
2179	1759309285360	663	1269	3	

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
1	1108	1	78.0	78.0	
3	1057	0	64.0	64.0	
11	322	1	157.0	157.0	
15	918	1	75.0	75.0	
39	1059	1	109.0	109.0	
...	
2062	1187	0	26.0	27.0	
2091	1244	4	436.0	437.0	
2126	1199	0	69.0	70.0	
2150	1224	4	1336.0	1337.0	
2179	1261	6	474.0	475.0	
	Duration (s)	Distance (um)	Speed (um/s)	\	
1	0.0	18.23	18.23		
3	0.0	20.15	20.15		
11	0.0	22.76	22.76		
15	0.0	26.14	26.14		
39	0.0	27.75	27.75		
...	
2062	1.0	19.19	19.19		
2091	1.0	15.23	15.23		
2126	1.0	15.23	15.23		
2150	1.0	25.28	25.28		
2179	1.0	16.64	16.64		
	Event time phase (fraction of event duration)	\			
1		0.85			
3		0.49			
11		0.82			
15		0.72			
39		0.96			
...		...			
2062		1.00			
2091		0.05			
2126		0.03			
2150		0.25			
2179		NaN			
	Event recruitment phase (fraction of involved cells)	dataset	\		
1		0.67	20250416_IS4		
3		0.17	20250416_IS4		
11		0.33	20250416_IS4		
15		0.50	20250416_IS4		
39		0.82	20250416_IS4		
...			
2062		1.00	20250416_IS4		
2091		0.00	20250416_IS4		

2126		0.00	20250416_IS4
2150		0.00	20250416_IS4
2179		NaN	20250416_IS4

	Number of cells involved	category	Speed category
1		5-10	High speed
3		5-10	High speed
11		5-10	High speed
15		11+	High speed
39		11+	High speed
...	
2062		3	High speed
2091		5-10	High speed
2126		5-10	High speed
2150		4	High speed
2179		2	High speed

[228 rows x 16 columns]

Origin cell ID	Speed category	High speed	Low speed
66		1	2
71		0	3
74		0	4
75		0	1
77		1	3
...
1276		0	4
1277		1	6
1278		0	3
1283		0	1
1285		1	1

[730 rows x 2 columns]

Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
0	66	292.82	8.78
2	71	418.60	11.70
5	74	363.35	15.28
6	75	155.35	15.28
8	77	460.85	16.25
..
870	1276	46.48	490.75
871	1277	64.03	490.75
872	1278	338.32	490.75
874	1283	396.18	492.38
875	1285	451.43	493.03

Number of peaks	Is active	Occurrences in global events	\
-----------------	-----------	------------------------------	---

0	10	True	4
2	8	True	4
5	11	True	4
6	9	True	4
8	9	True	4
..
870	7	True	4
871	13	True	4
872	11	True	4
874	9	True	3
875	6	True	3

Occurrences in global events as early peaker \

0	0
2	0
5	0
6	0
8	0
..	..
870	2
871	2
872	2
874	2
875	0

Occurrences in sequential events \

0	5
2	4
5	5
6	2
8	3
..	..
870	3
871	7
872	4
874	5
875	3

Occurrences in sequential events as origin \

0	2
2	1
5	2
6	0
8	3
..	..
870	2
871	4
872	1

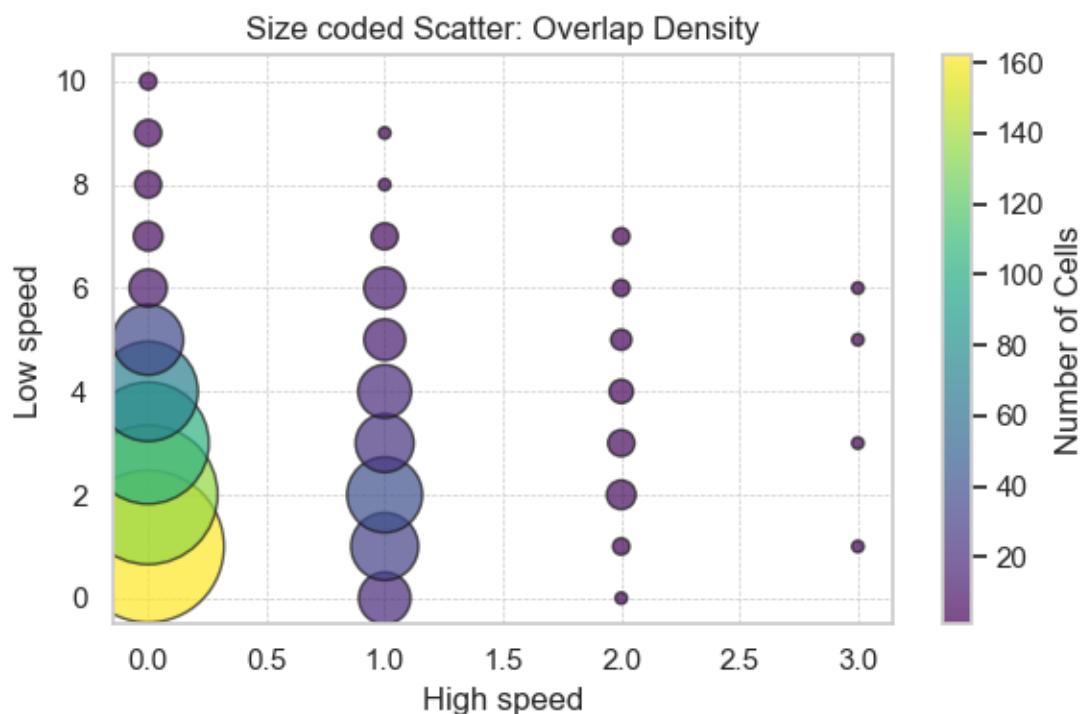
874		0		
875		0		
Occurrences in individual events Peak frequency (Hz) Periodicity score \				
0	1	0.0059	0.52	
2	0	0.0047	0.54	
5	1	0.0065	0.47	
6	3	0.0053	0.53	
8	2	0.0053	0.58	
..
870	0	0.0041	0.57	
871	0	0.0076	0.46	
872	2	0.0065	0.61	
874	1	0.0053	0.54	
875	0	0.0035	0.61	
Neighbor count Neighbors (labels) dataset \				
0	4	[70,81,89,113]	20250416_IS4	
2	4	[73,79,95,109]	20250416_IS4	
5	3	[87,90,116]	20250416_IS4	
6	3	[88,100,104]	20250416_IS4	
8	3	[83,91,97]	20250416_IS4	
..
870	4	[1241,1244,1259,1277]	20250416_IS4	
871	4	[1225,1244,1270,1276]	20250416_IS4	
872	3	[1232,1247,1265]	20250416_IS4	
874	3	[1248,1258,1273]	20250416_IS4	
875	3	[1224,1272,1274]	20250416_IS4	
Involved in sequential event Occurrences in sequential events category \				
0	Involved in sequential event		5-9	
2	Involved in sequential event		3-4	
5	Involved in sequential event		5-9	
6	Involved in sequential event		1-2	
8	Involved in sequential event		3-4	
..
870	Involved in sequential event		3-4	
871	Involved in sequential event		5-9	
872	Involved in sequential event		3-4	
874	Involved in sequential event		5-9	
875	Involved in sequential event		3-4	
High speed Low speed				
0	1.0	2.0		
2	0.0	3.0		
5	0.0	4.0		
6	0.0	1.0		
8	1.0	3.0		

```

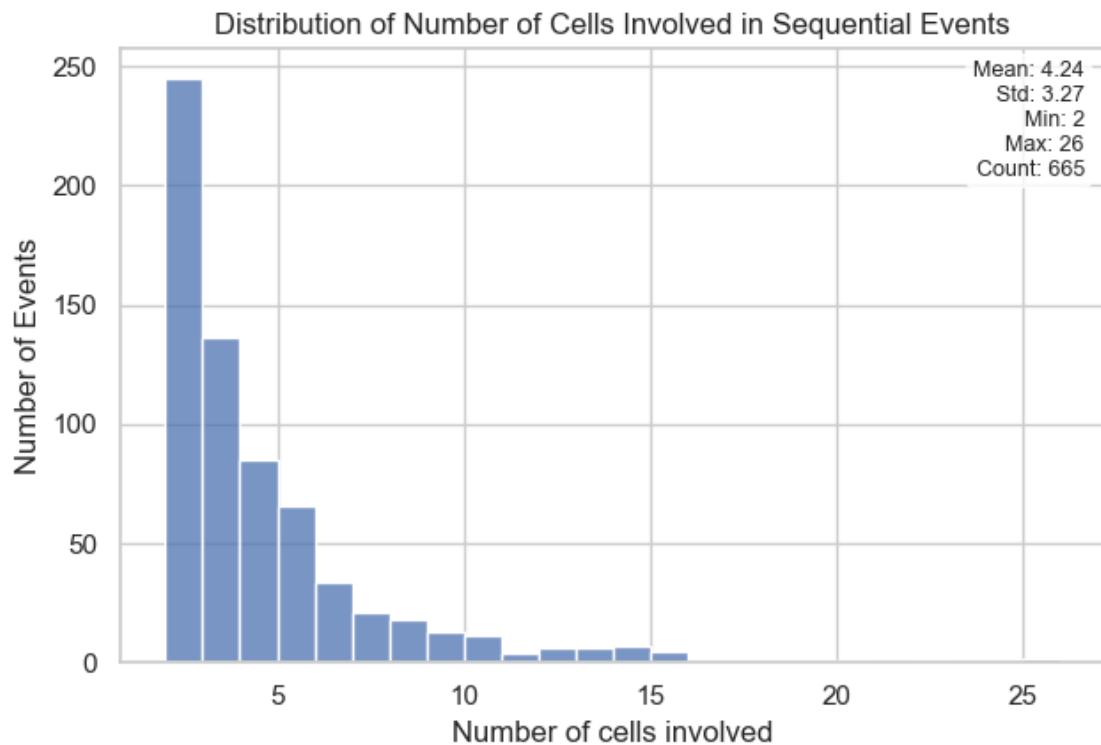
...     ...     ...
870    0.0     4.0
871    1.0     6.0
872    0.0     3.0
874    0.0     1.0
875    1.0     1.0

```

[730 rows x 19 columns]

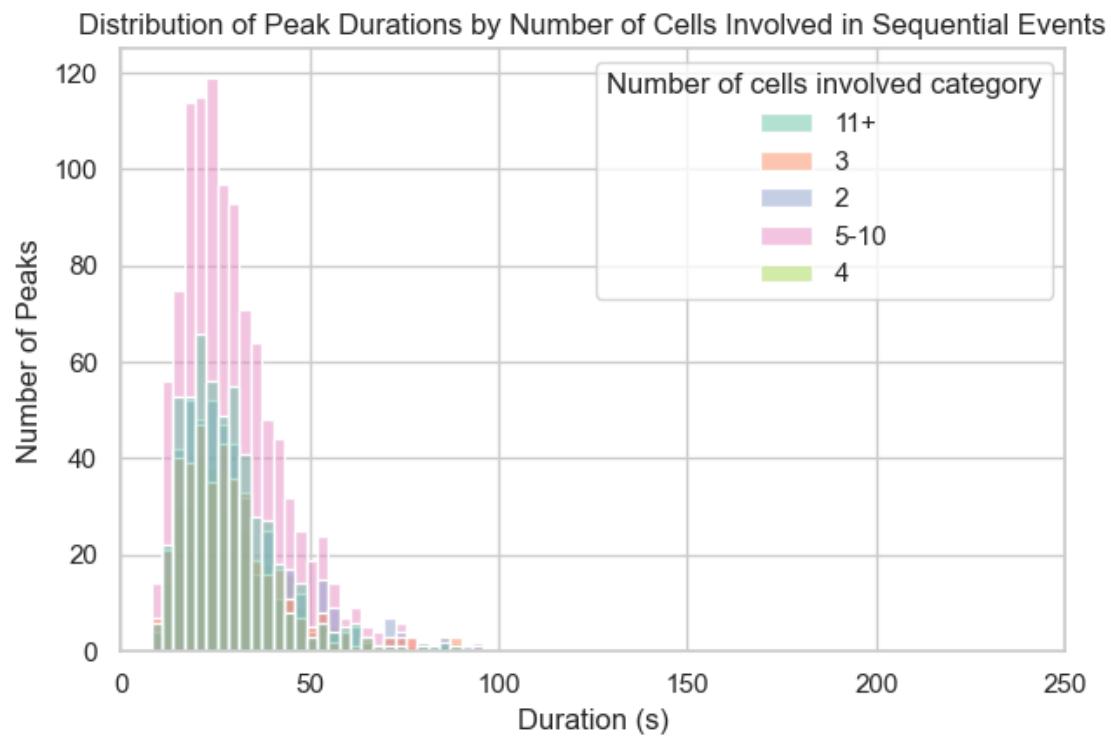


1.3.5 Number of cells involved per sequential events



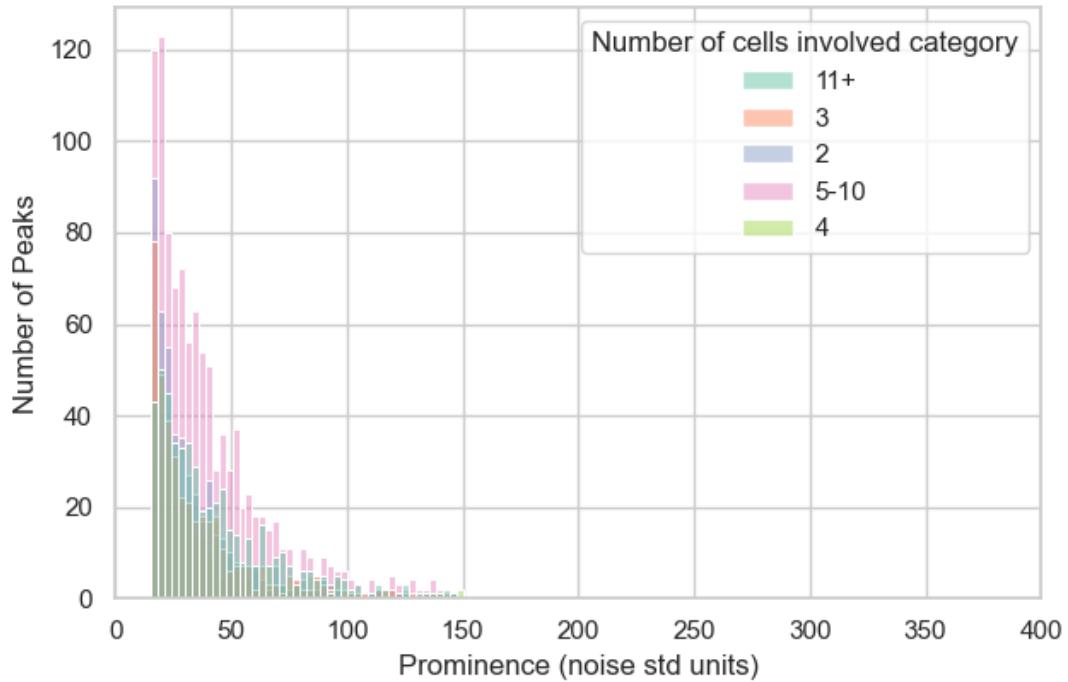
1.3.6 Influence of cell count per event on statistics

```
[2025-08-13 11:47:52] [INFO] calcium: plot_histogram_by_group: removed 22 outliers out of 2850 on 'Duration (s)' (lower=-5.5, upper=96.5)
```

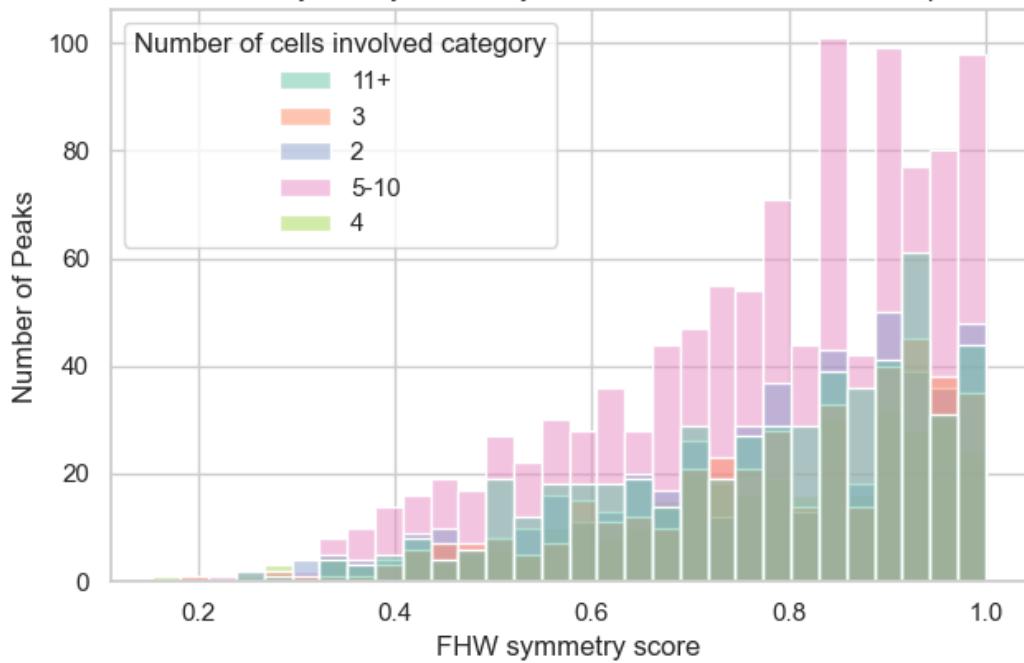


```
[2025-08-13 11:47:53] [INFO] calcium: plot_histogram_by_group: removed 73 outliers out of 2850 on 'Prominence (noise std units)' (lower=-22.563, upper=151.29)
```

Distribution of Peak Prominences by Number of Cells Involved in Sequential Events

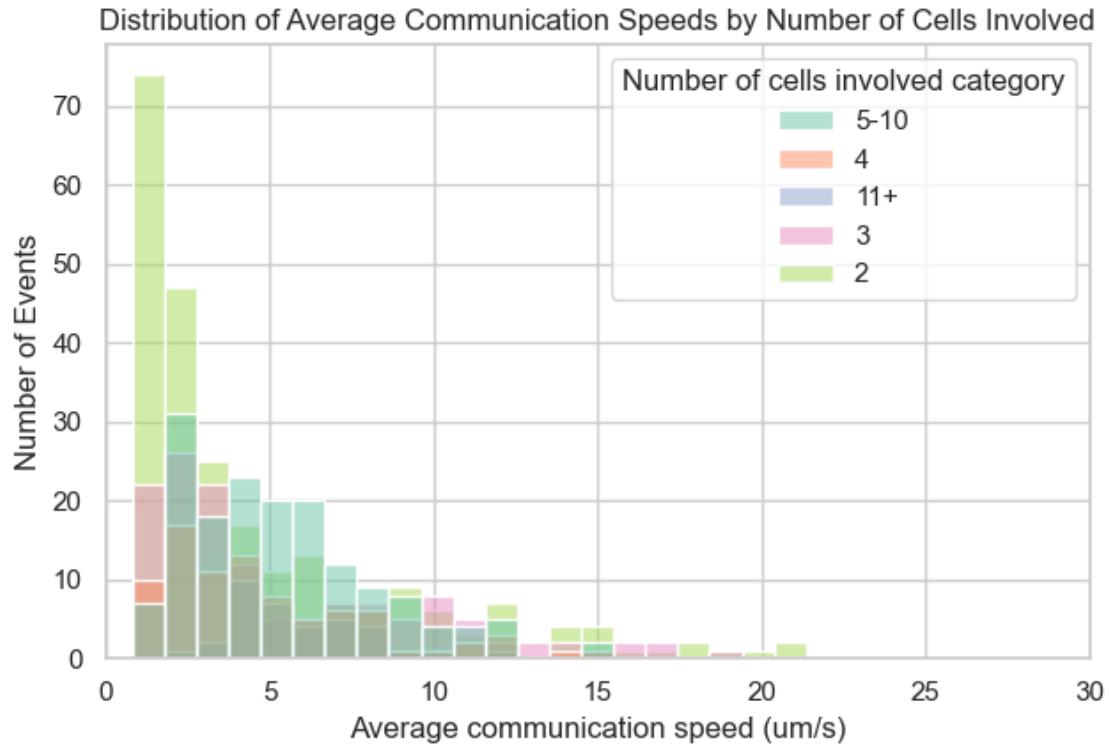


Distribution of Peak Symmetry Scores by Number of Cells Involved in Sequential Events



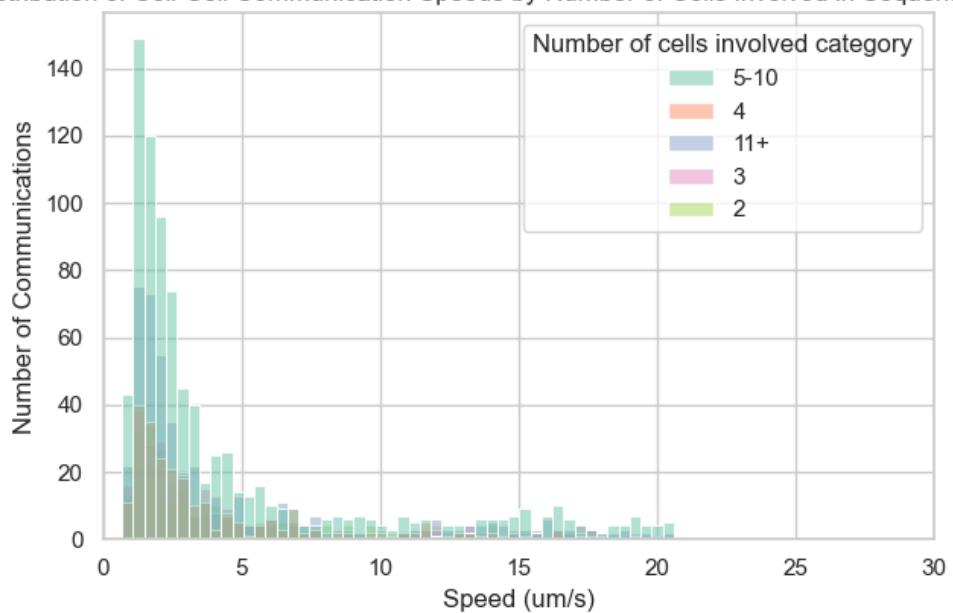
[2025-08-13 11:47:53] [INFO] calcium: plot_histogram_by_group: removed 4

outliers out of 665 on 'Average communication speed (um/s)' (lower=-12.83, upper=22.03)



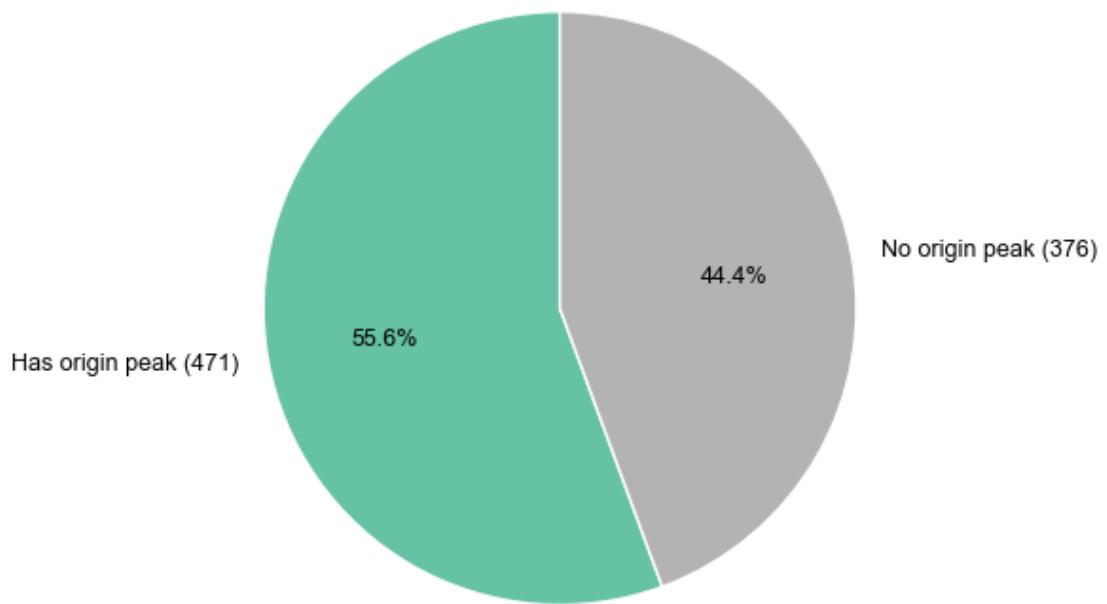
[2025-08-13 11:47:54] [INFO] calcium: plot_histogram_by_group: removed 82 outliers out of 2185 on 'Speed (um/s)' (lower=-12.69, upper=20.63)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events

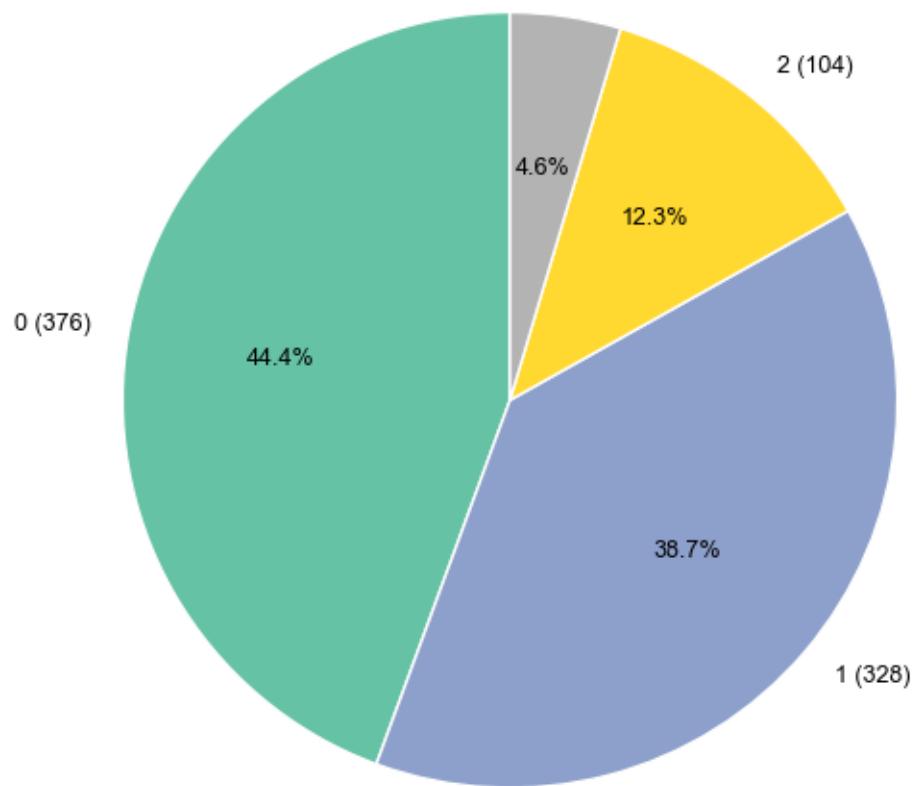


1.3.7 Cells occurrences as origin in sequential events

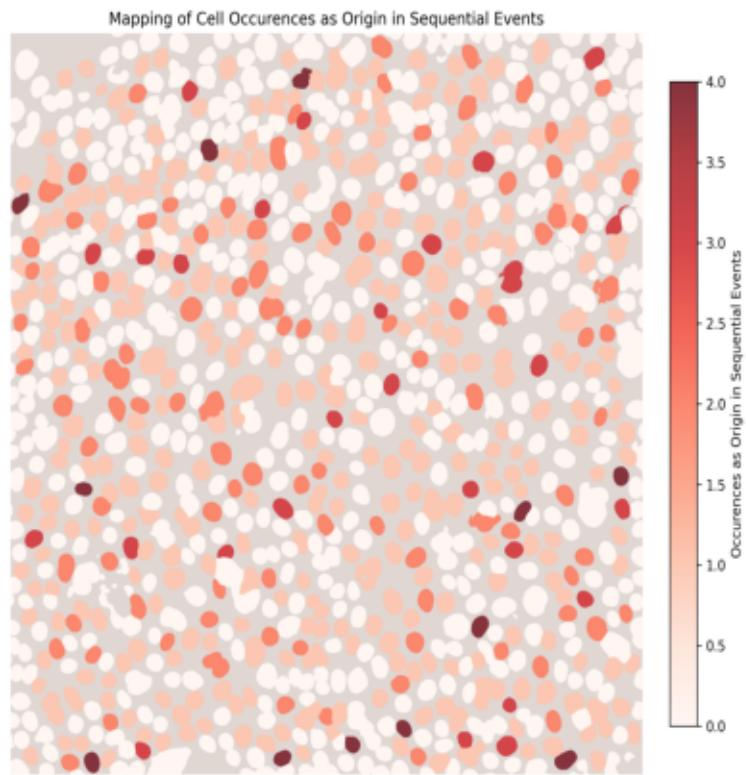
Distribution of Number of Sequential Event Origin Peaks per Cell

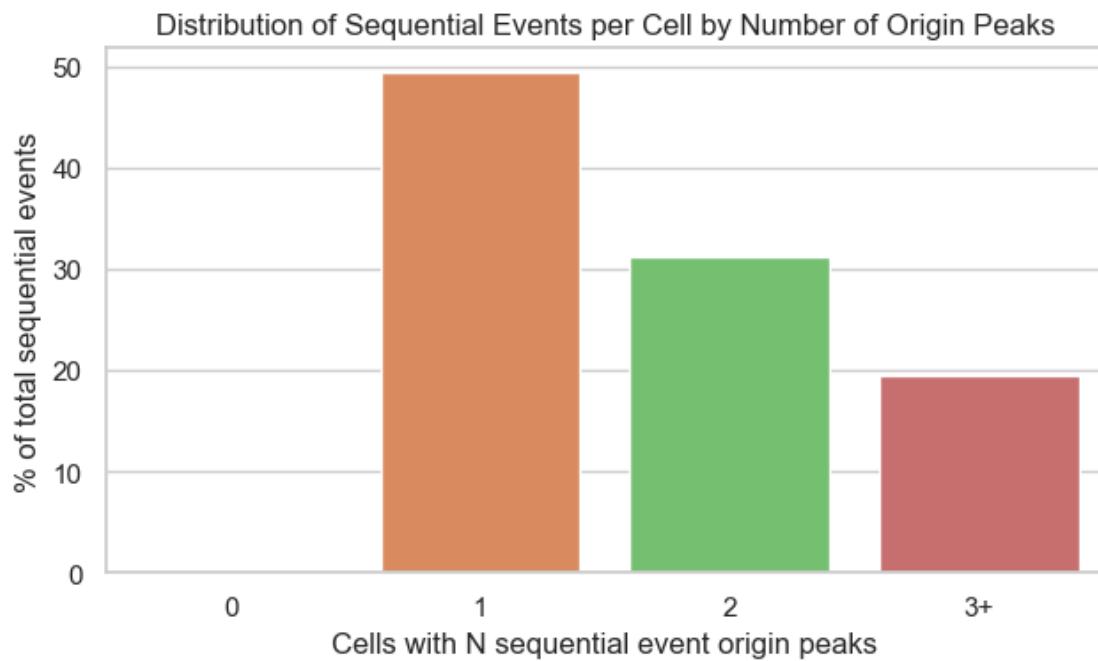


Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)
3+ (39)



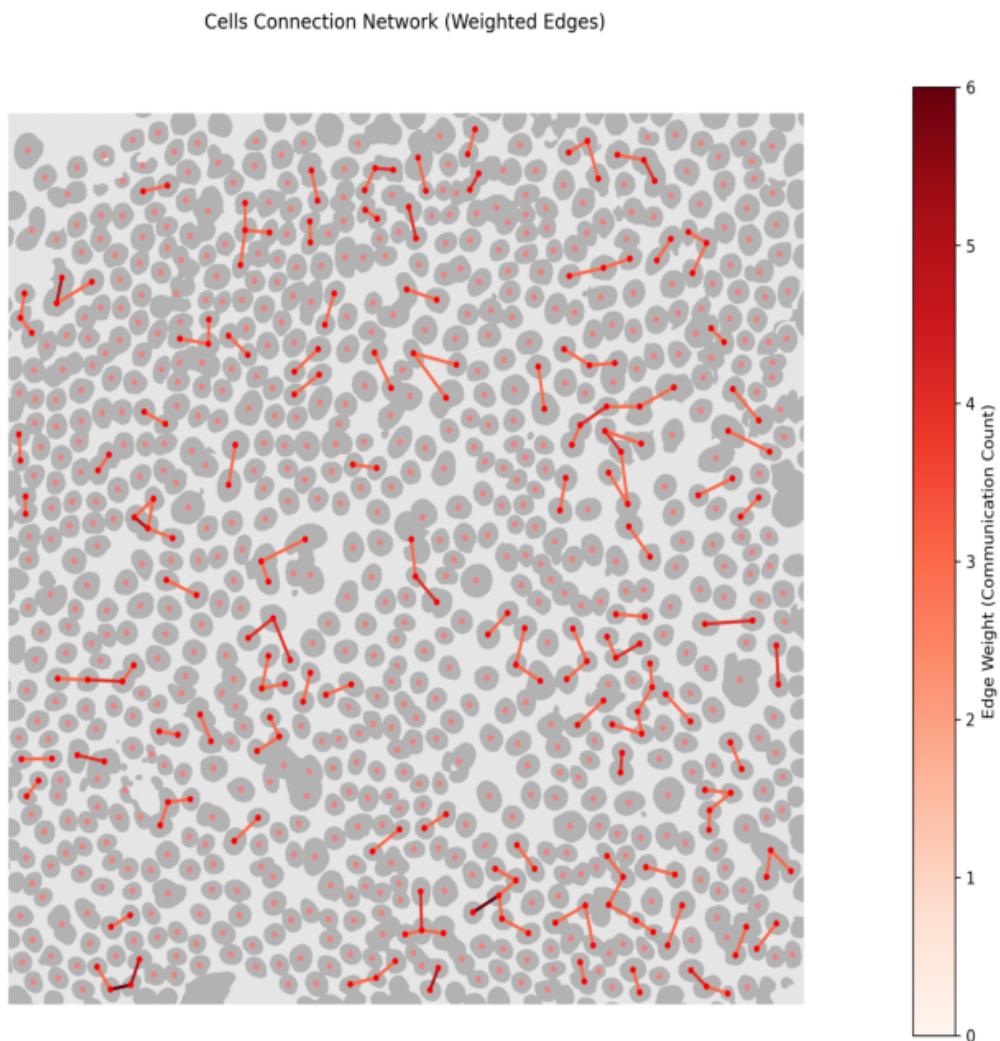
Cell Mapping with Origin Peaks Overlay - 20250416_IS4

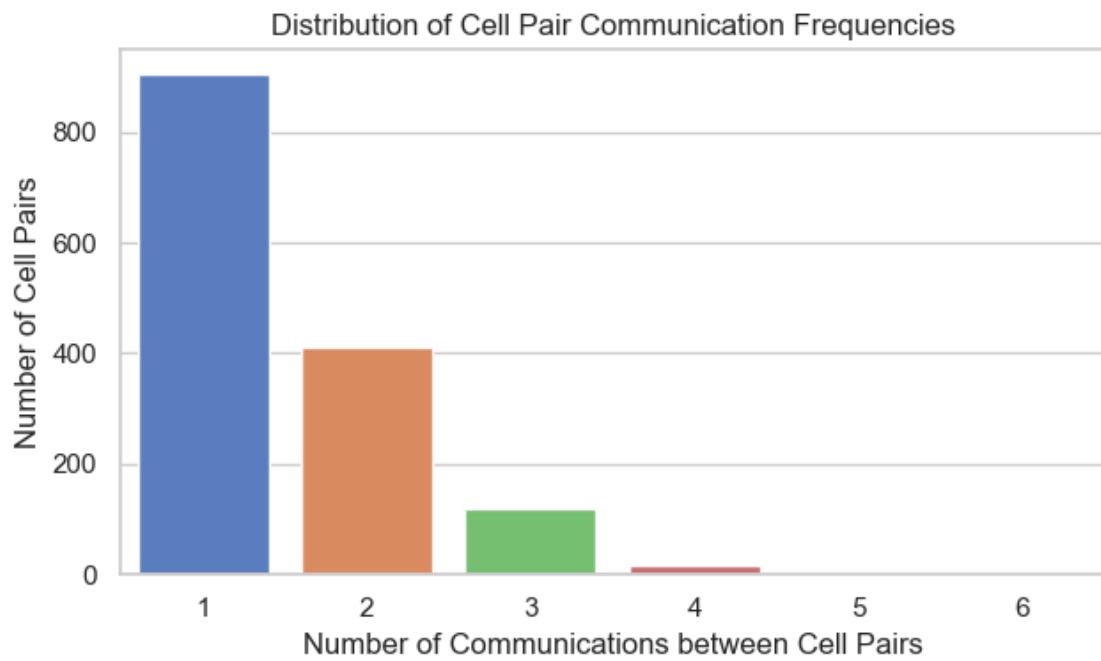




1.3.8 Connection network between cells

Cell Connection Network Graph - 20250416_IS4

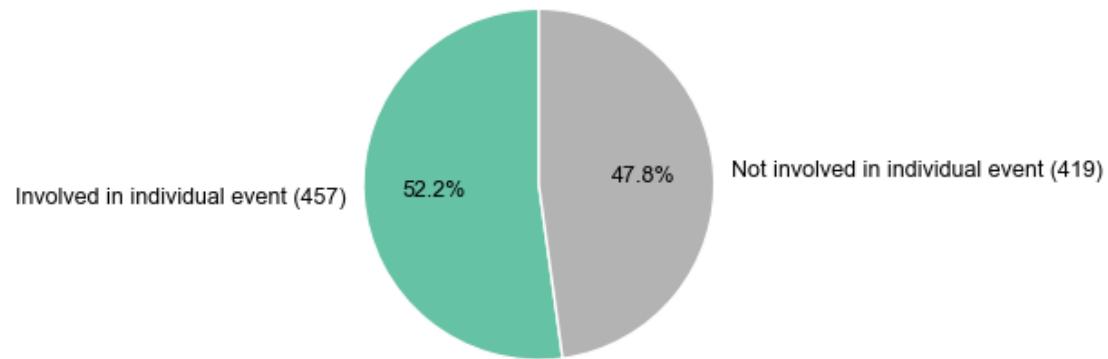




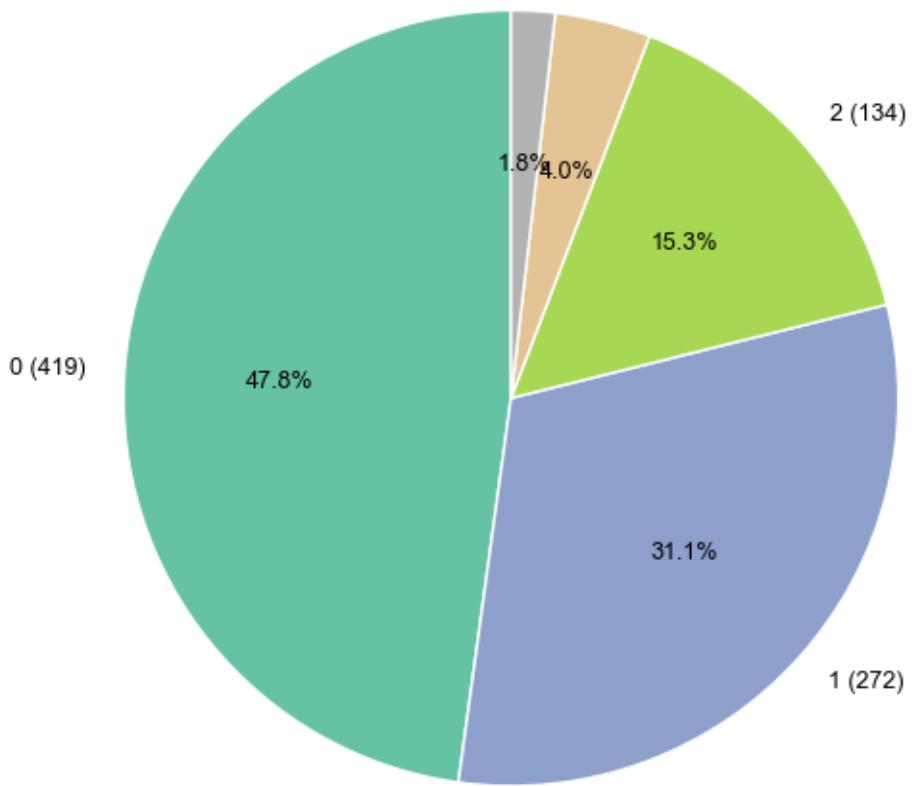
1.4 INDIVIDUAL EVENTS

1.4.1 Cells occurrences in individual events

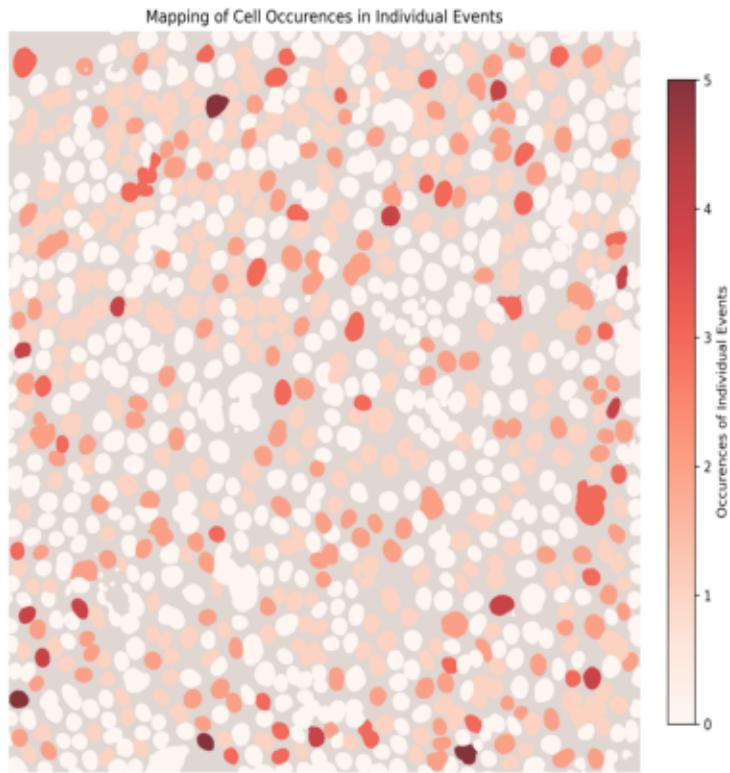
Distribution of Cells Involved in Individual Events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

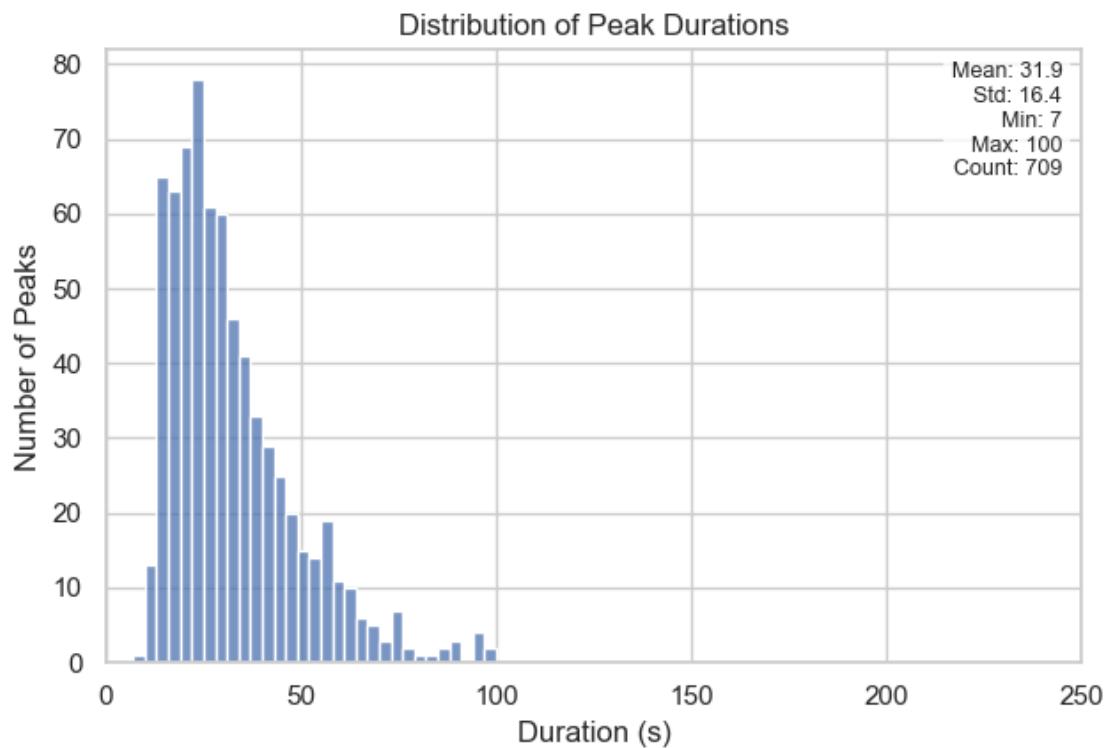


Cell Mapping with Occurrences in Individual Events Overlay - 20250416_IS4

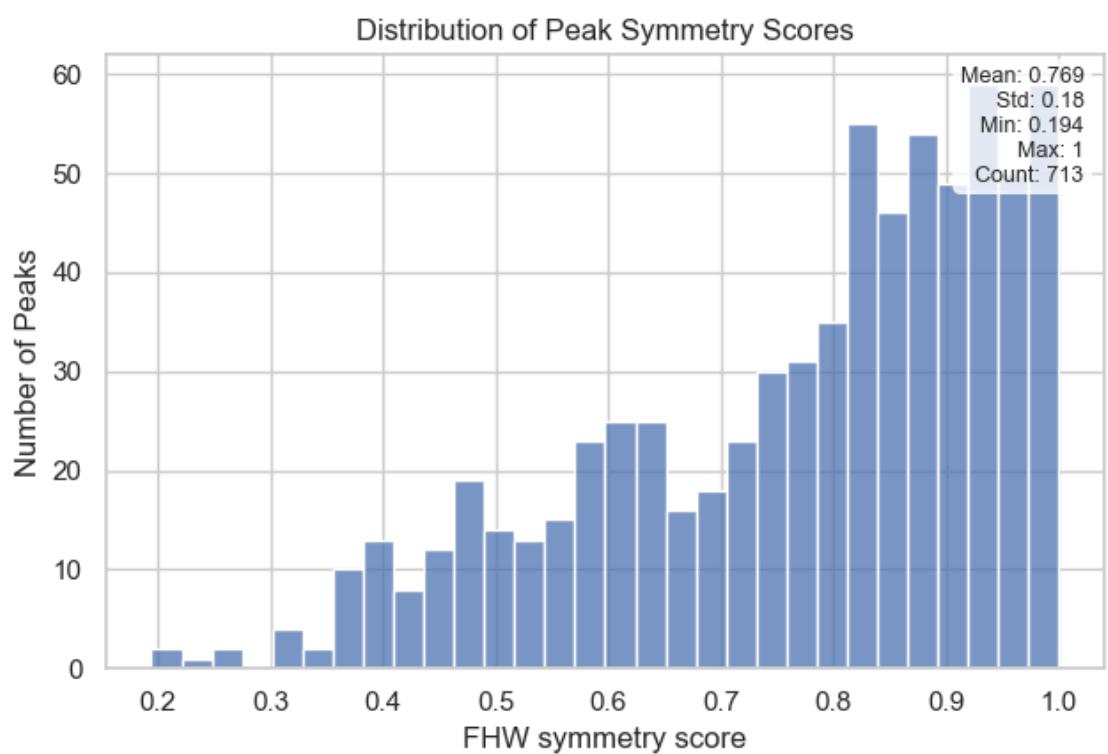
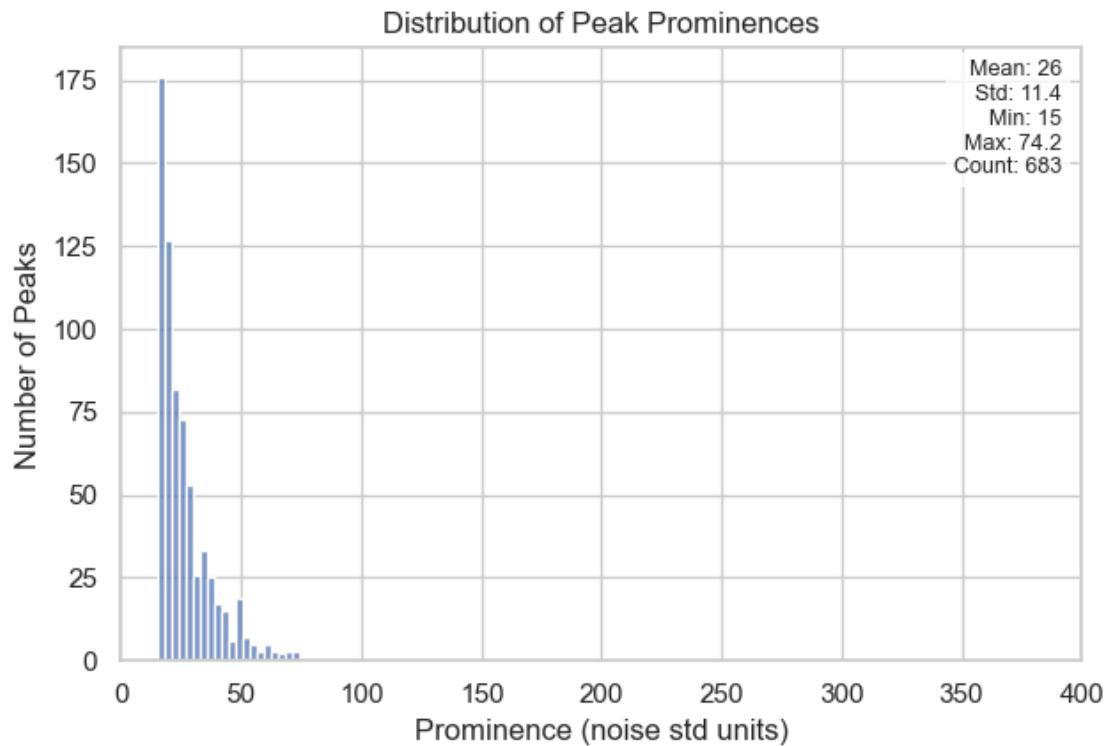


1.4.2 Peaks statistics in individual events

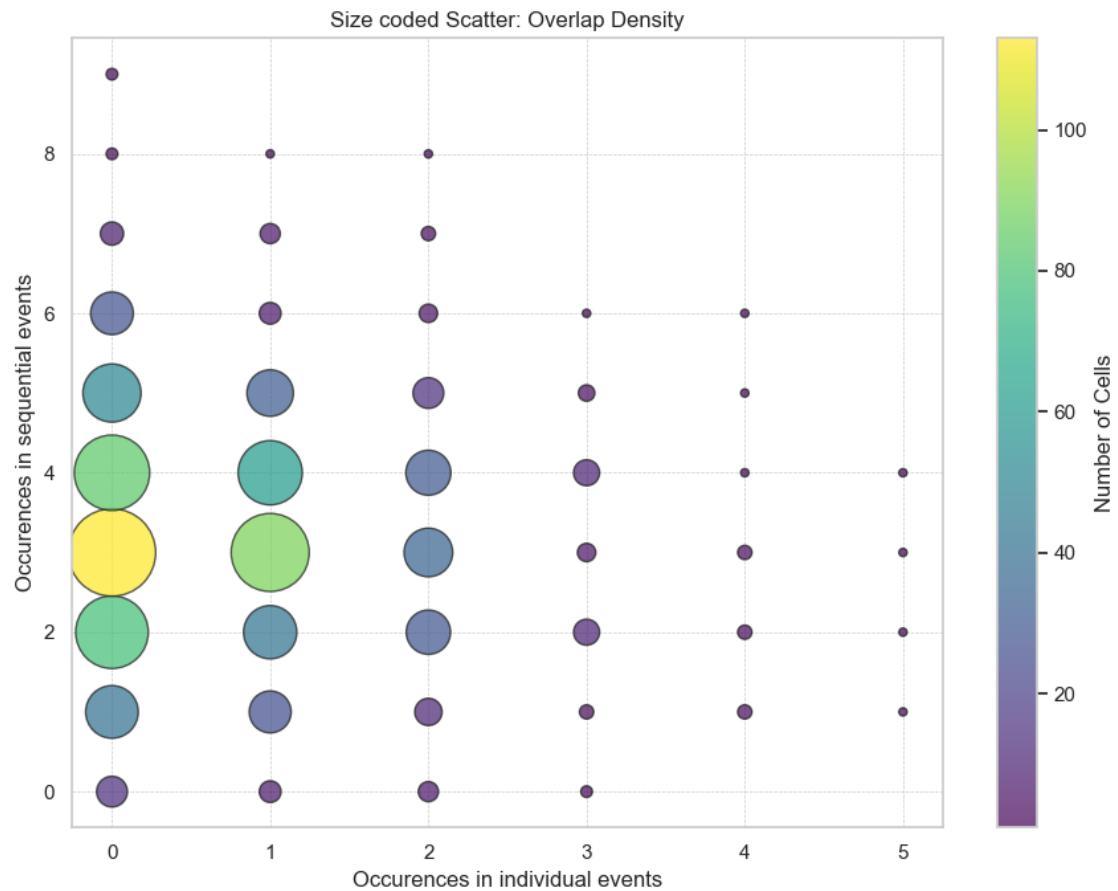
```
[2025-08-13 11:47:59] [INFO] calcium: plot_histogram: removed 4 outliers out of  
713 on 'Duration (s)' (lower=-40, upper=100)
```



```
[2025-08-13 11:48:00] [INFO] calcium: plot_histogram: removed 30 outliers out of  
713 on 'Prominence (noise std units)' (lower=-24.5, upper=74.9)
```

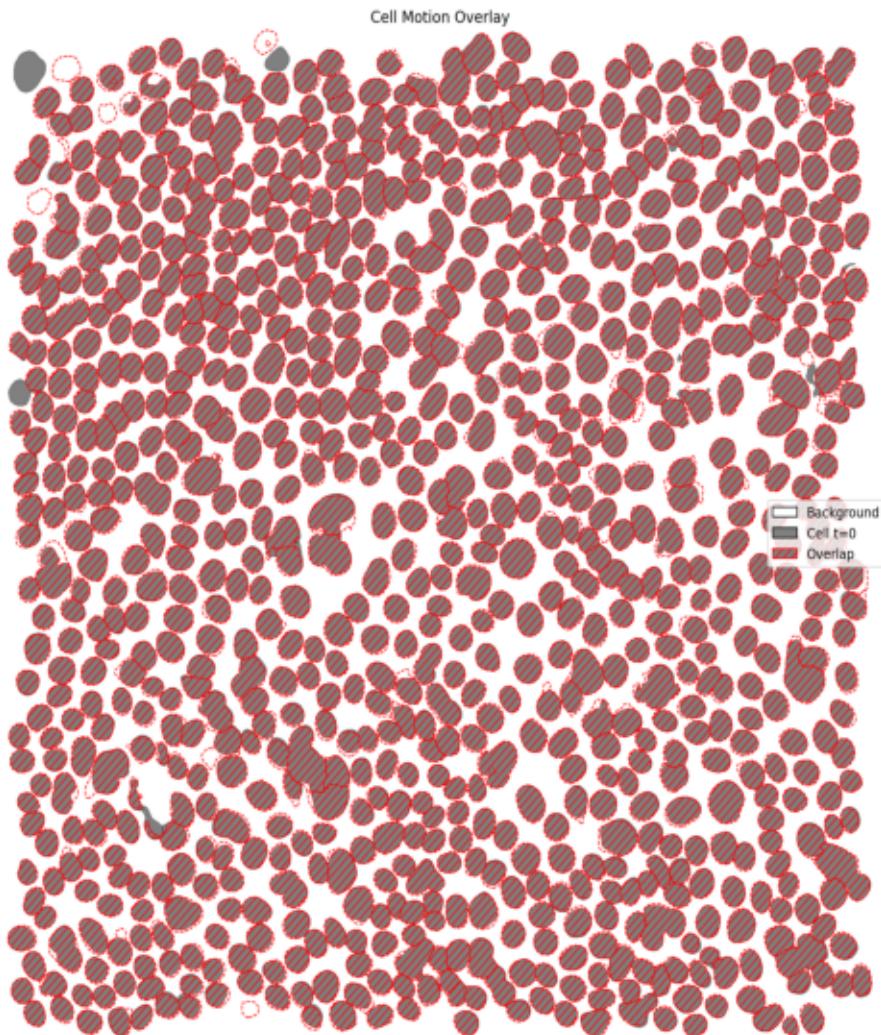


1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250416_IS4



Number of cells:

- Hoechst image taken at t=0: 876
- Hoechst image taken at t=1801: 868
- Number of cells difference: absolute 8, relative 0.92%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 1254566
- Pixels segmented as cell at t=1801: 1290238
- Overlapping pixels between t=0 and t=1801: 1201518 (94.43% of total)
- Pixels exclusive to t=0: 53048 (4.23% of total)
- Pixels exclusive to t=1801: 88720 (6.88% of total)

executed

August 13, 2025

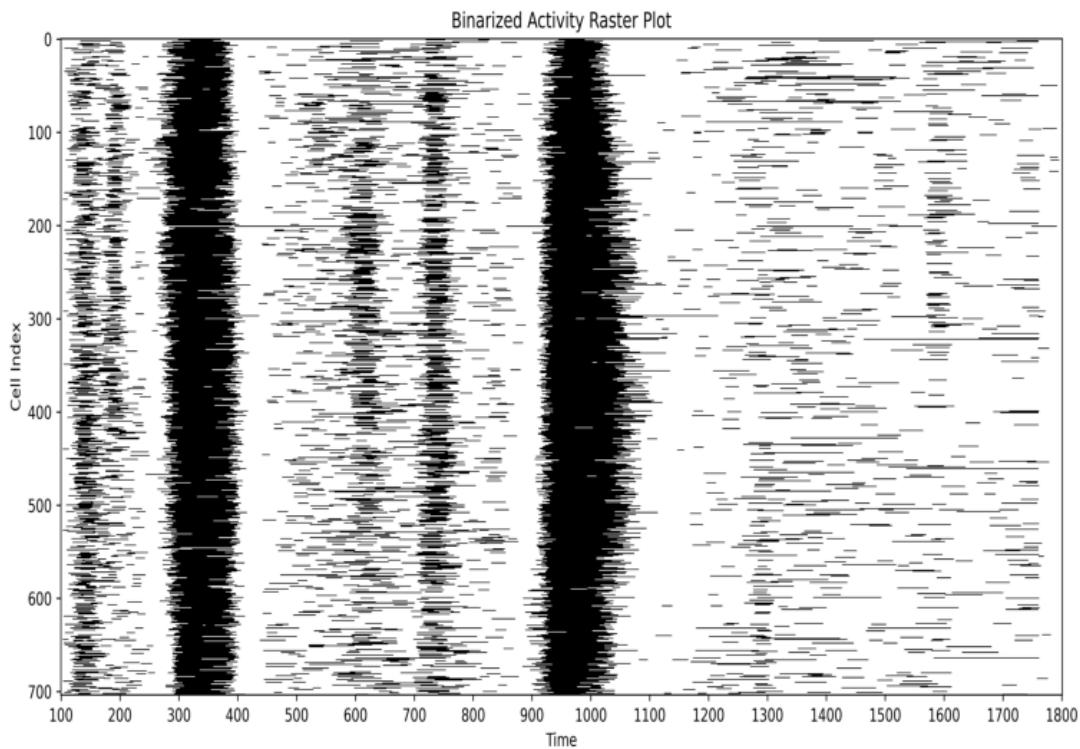
1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

1.0.1 Initialization

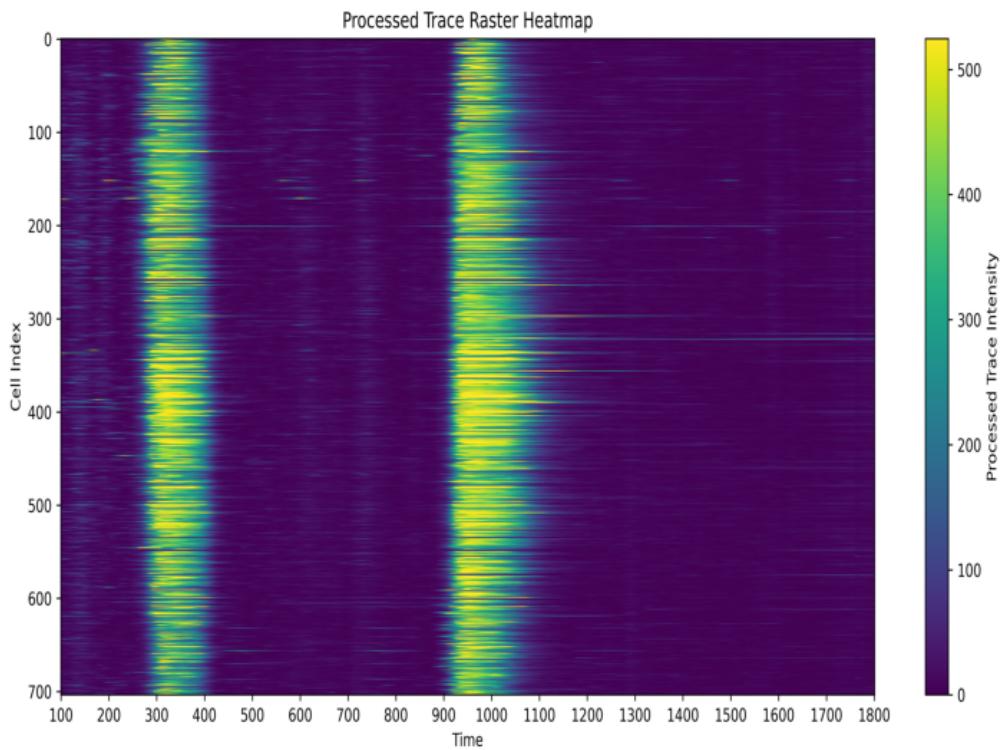
1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot

Binary Activity Raster Plot - 20250624_IS01



Heatmap Activity Raster Plot - 20250624_IS01



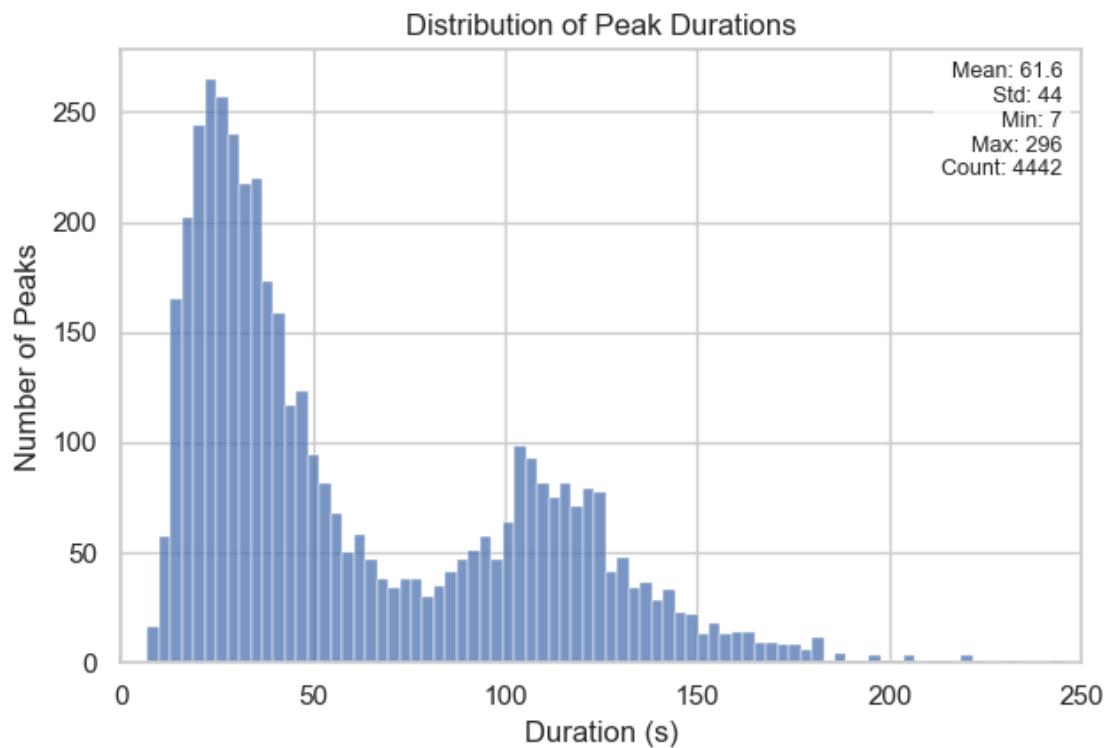
1.1.2 Peaks population

Total number of peaks: 4443

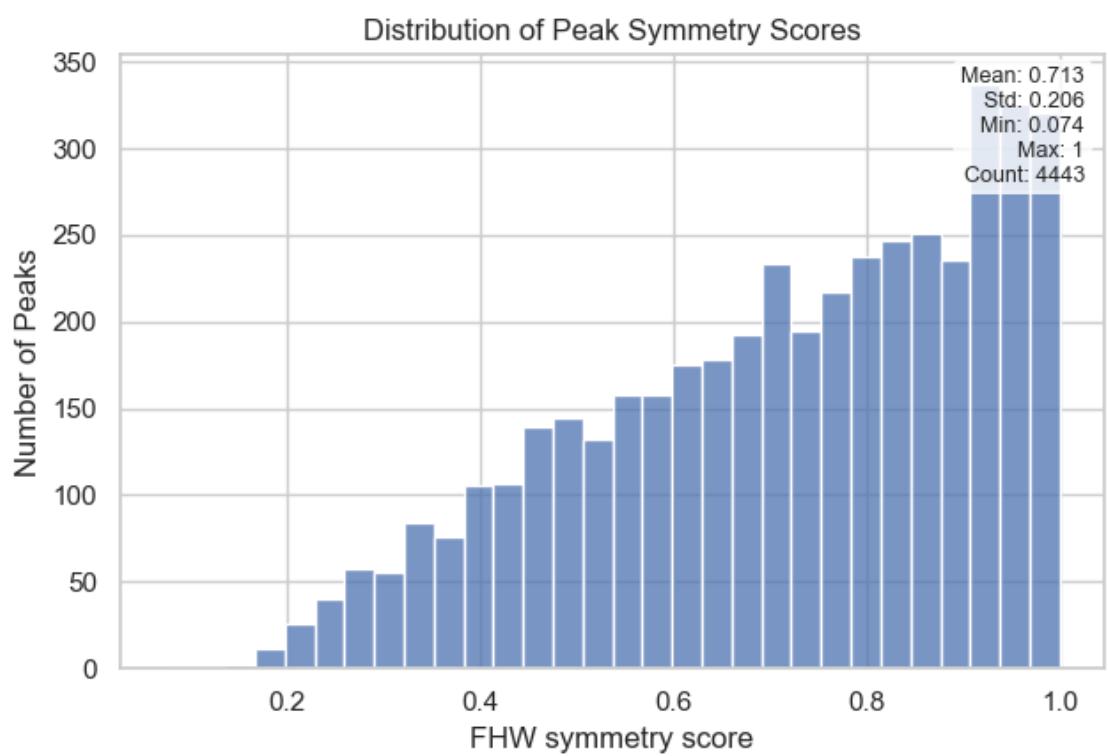
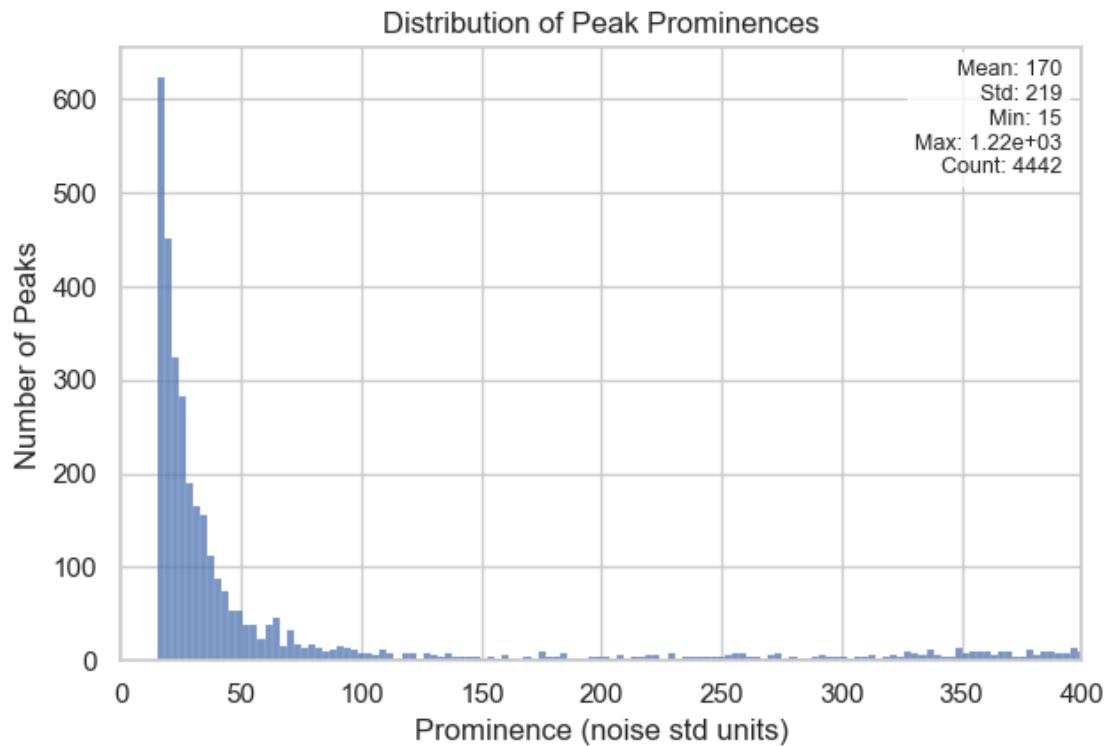
Total number of cells: 704

1.1.3 Peaks statistics

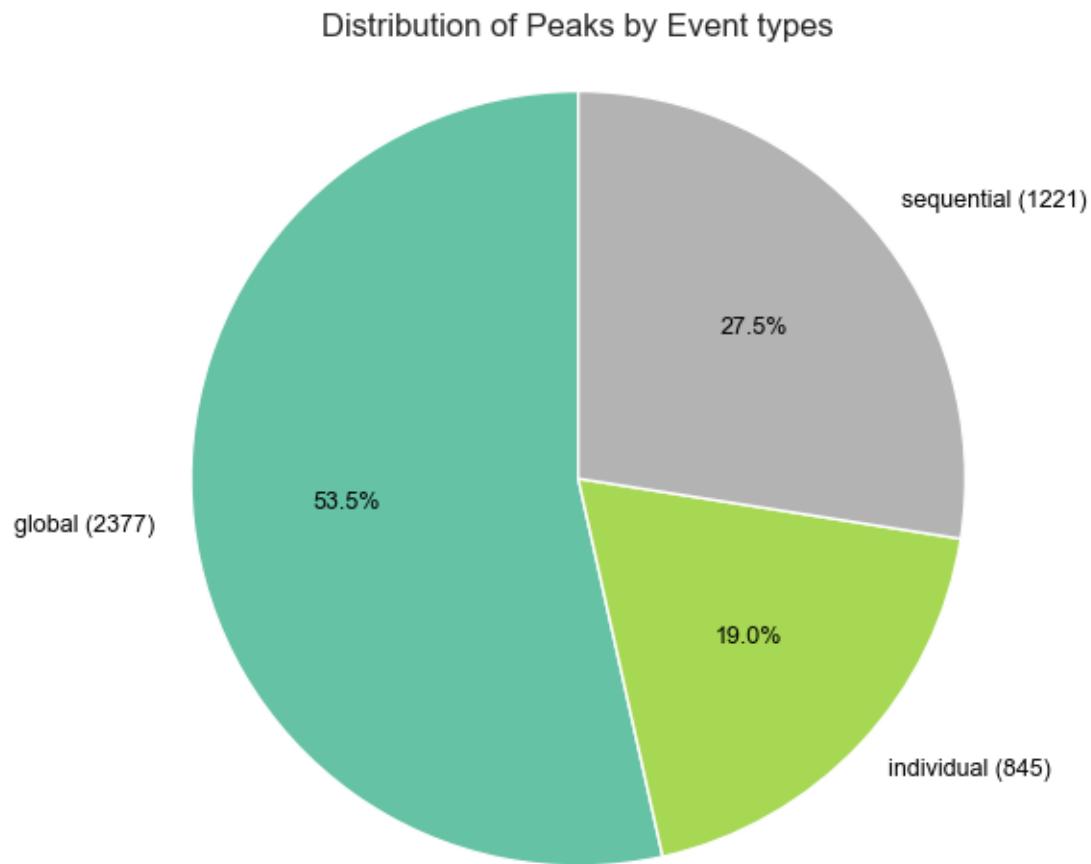
```
[2025-08-13 12:19:51] [INFO] calcium: plot_histogram: removed 1 outliers out of  
4443 on 'Duration (s)' (lower=-199, upper=326)
```



```
[2025-08-13 12:19:51] [INFO] calcium: plot_histogram: removed 1 outliers out of 4443 on 'Prominence (noise std units)' (lower=-929.05, upper=1288.2)
```

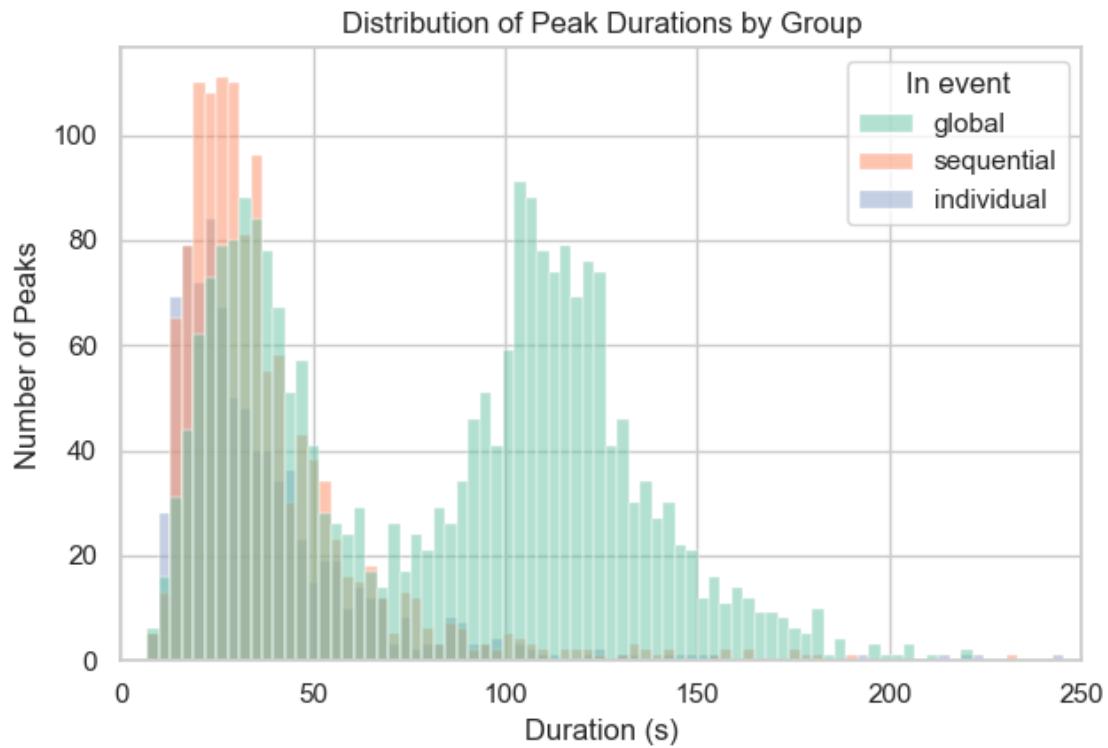


1.1.4 Distribution of peaks per event types



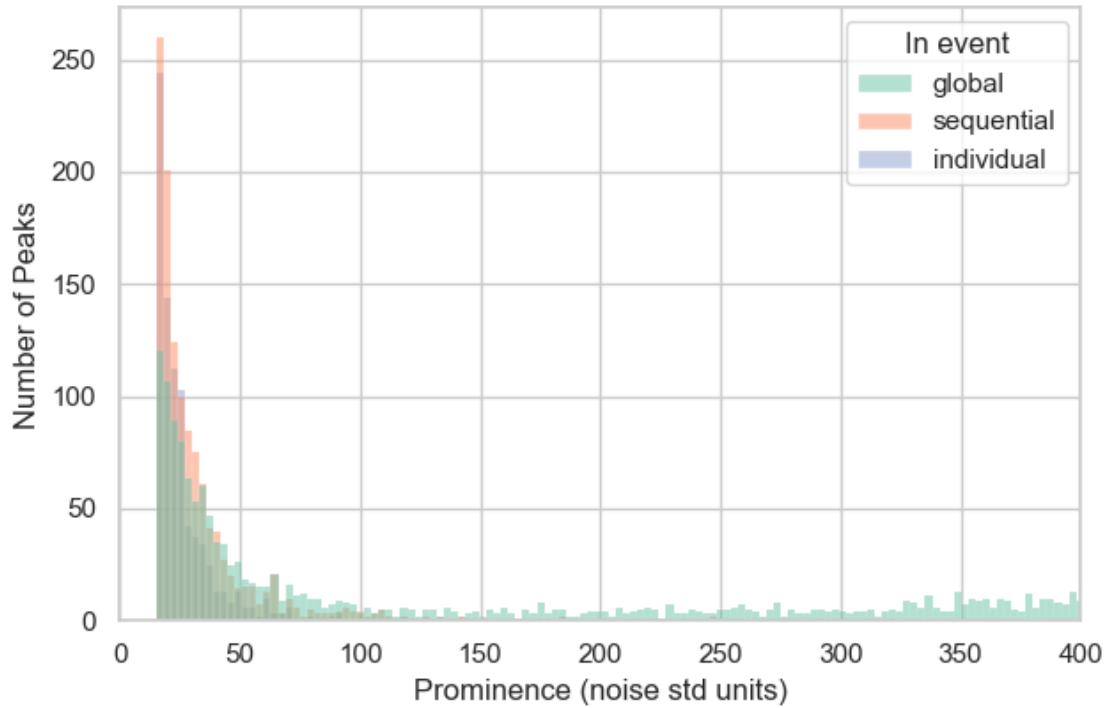
1.1.5 Peaks statistics per event types

```
[2025-08-13 12:19:52] [INFO] calcium: plot_histogram_by_group: removed 1 outliers out of 4443 on 'Duration (s)' (lower=-199, upper=326)
```

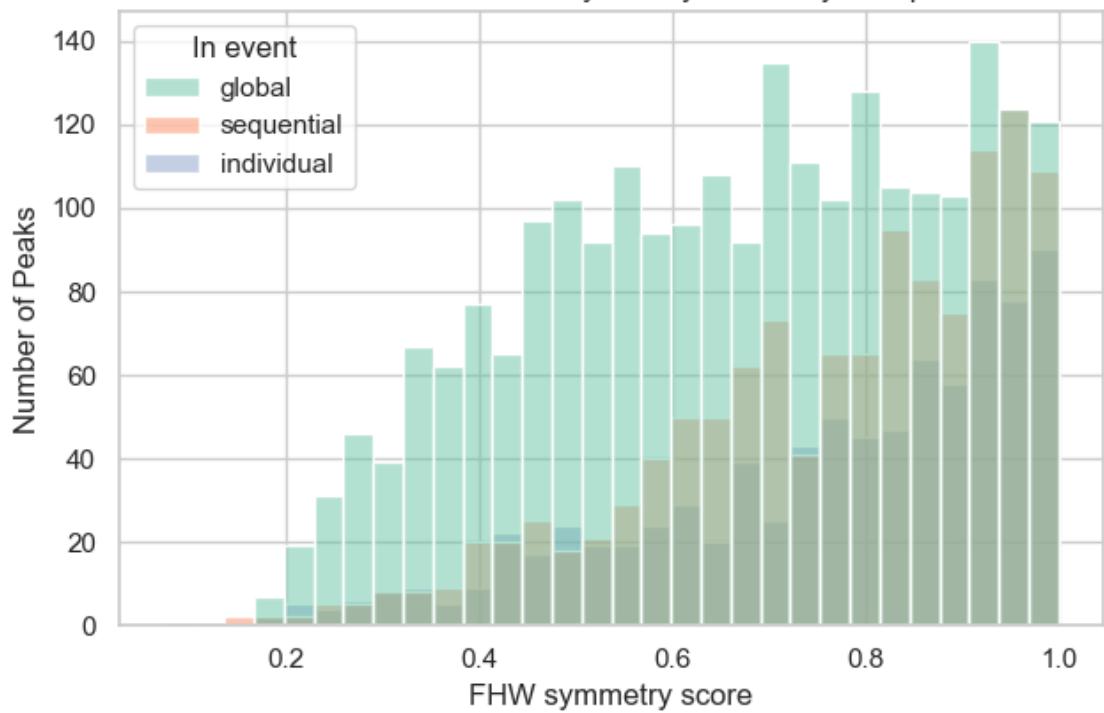


```
[2025-08-13 12:19:52] [INFO] calcium: plot_histogram_by_group: removed 1 outliers out of 4443 on 'Prominence (noise std units)' (lower=-929.05, upper=1288.2)
```

Distribution of Peak Prominences by Group



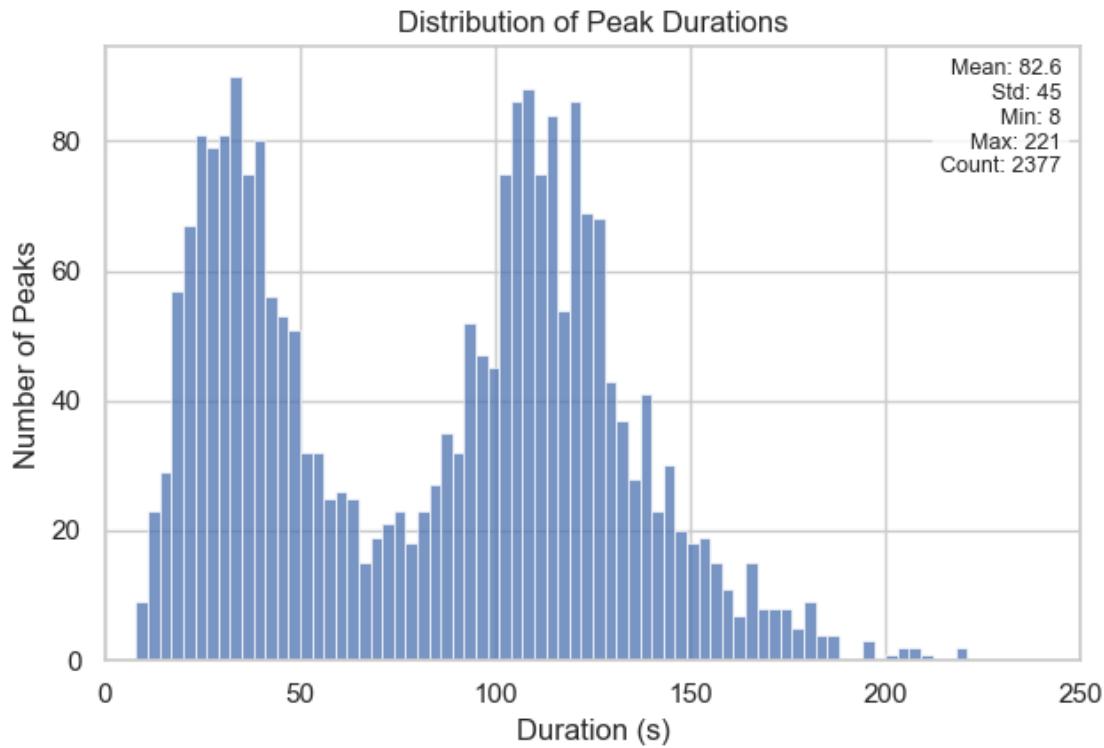
Distribution of Peak Symmetry Scores by Group



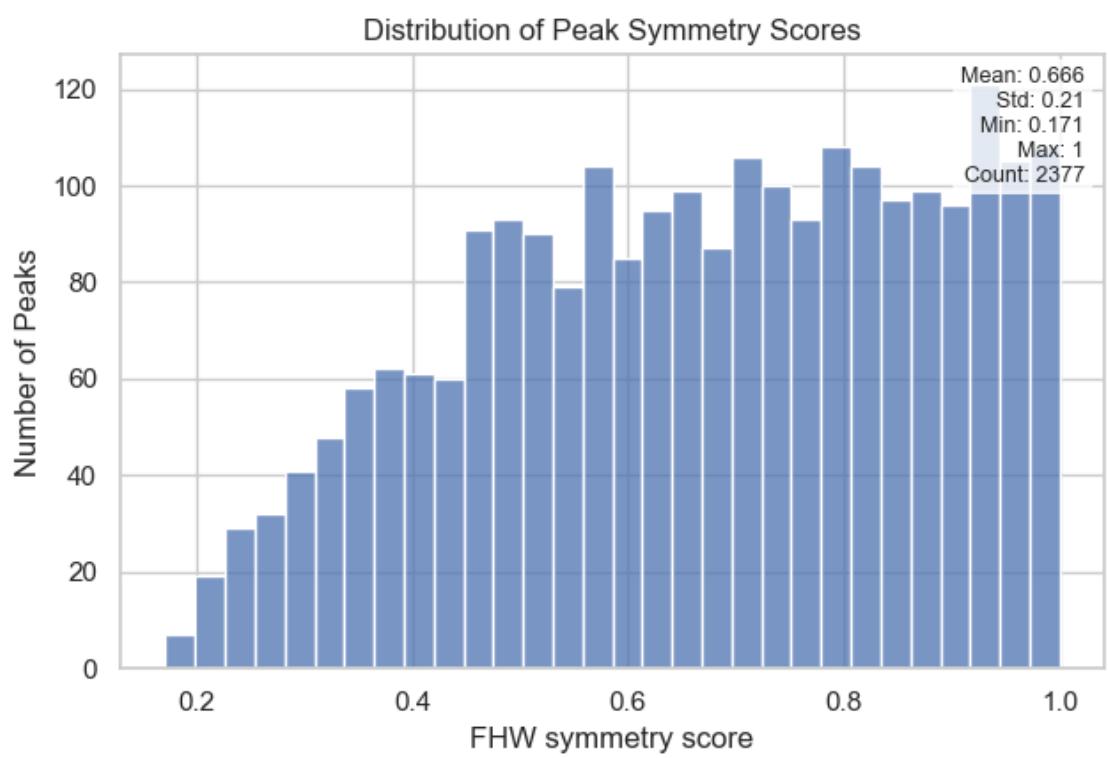
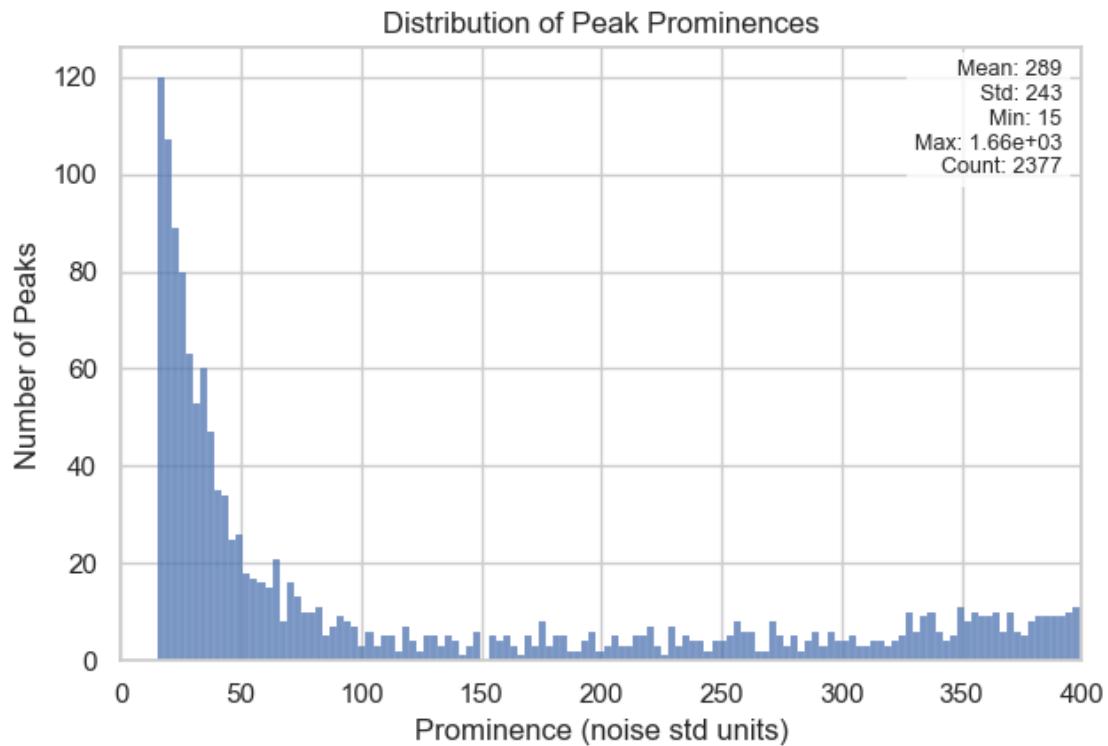
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

[2025-08-13 12:19:54] [INFO] calcium: plot_histogram: removed 0 outliers out of 2377 on 'Duration (s)' (lower=-202, upper=358)

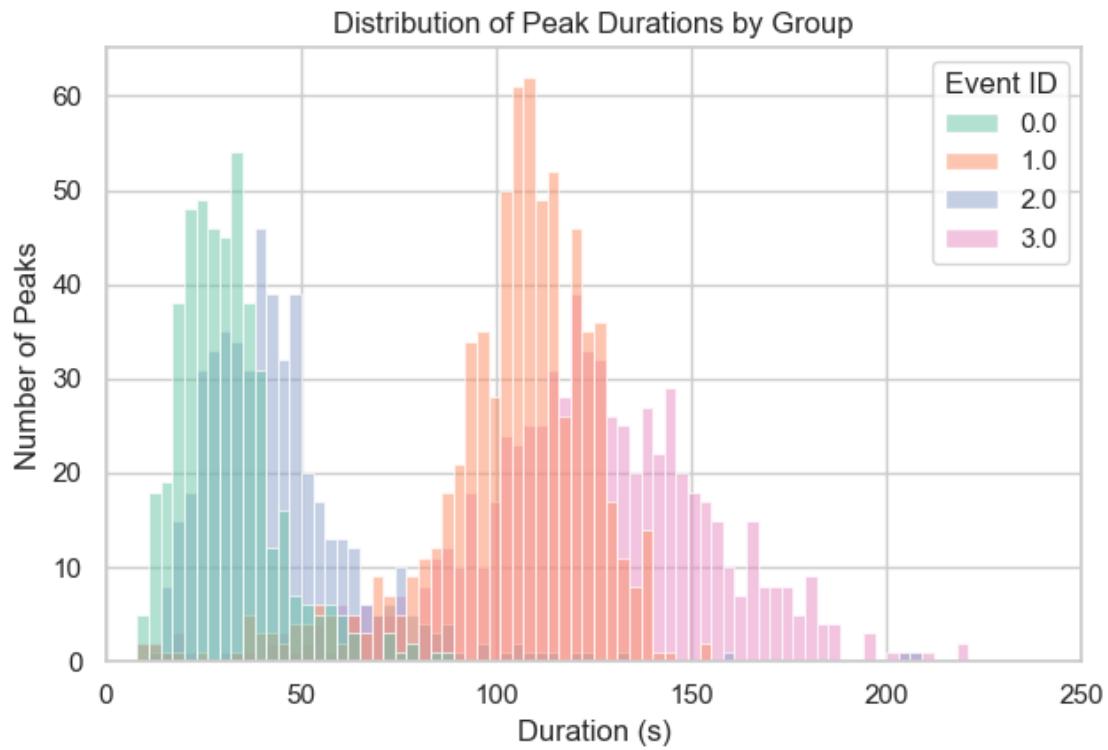


[2025-08-13 12:19:54] [INFO] calcium: plot_histogram: removed 0 outliers out of 2377 on 'Prominence (noise std units)' (lower=-1329.4, upper=1859.8)



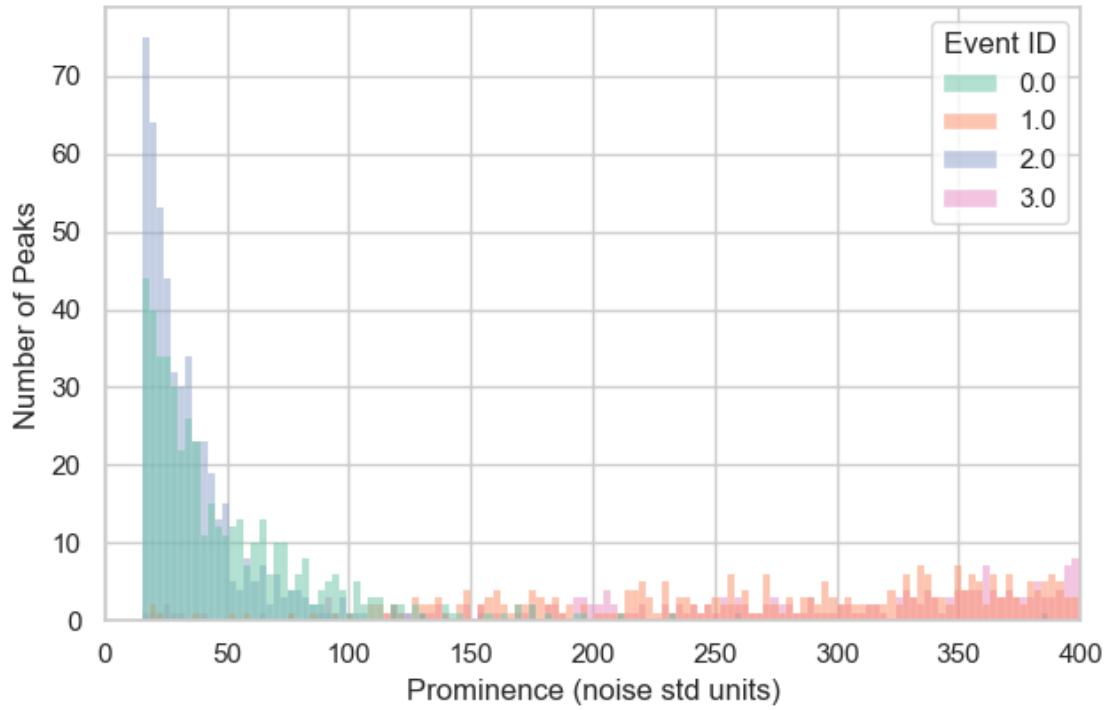
1.2.2 Peak statistics in global event per event ID

```
[2025-08-13 12:19:55] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 2377 on 'Duration (s)' (lower=-202, upper=358)
```

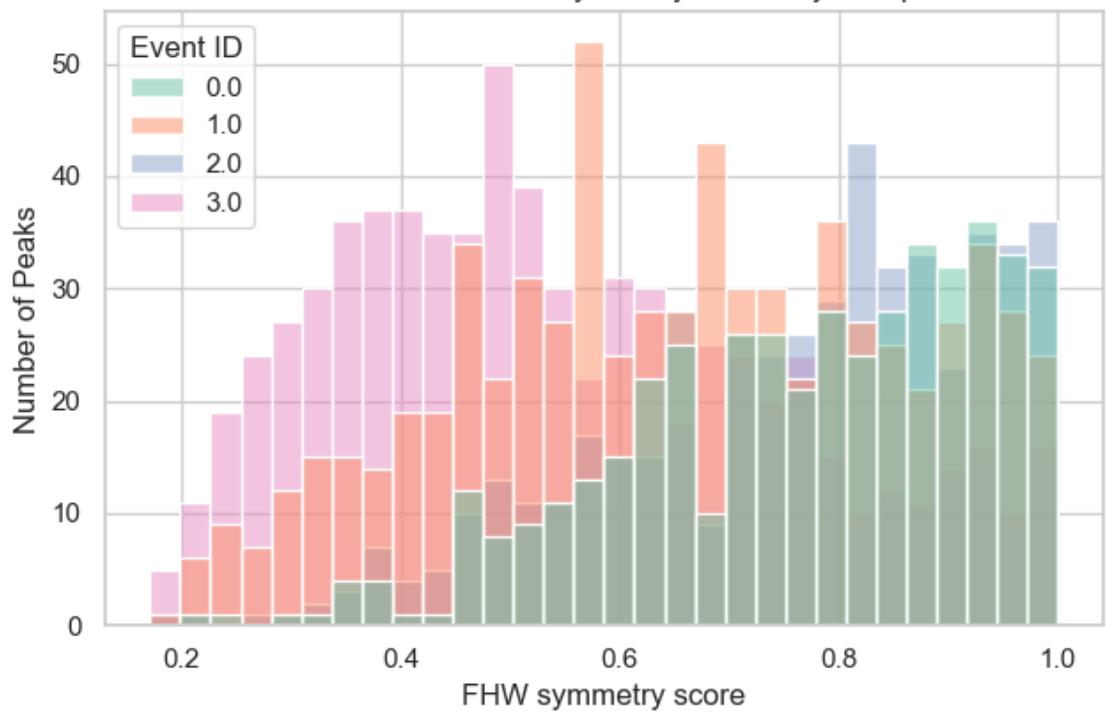


```
[2025-08-13 12:19:55] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 2377 on 'Prominence (noise std units)' (lower=-1329.4, upper=1859.8)
```

Distribution of Peak Prominences by Group

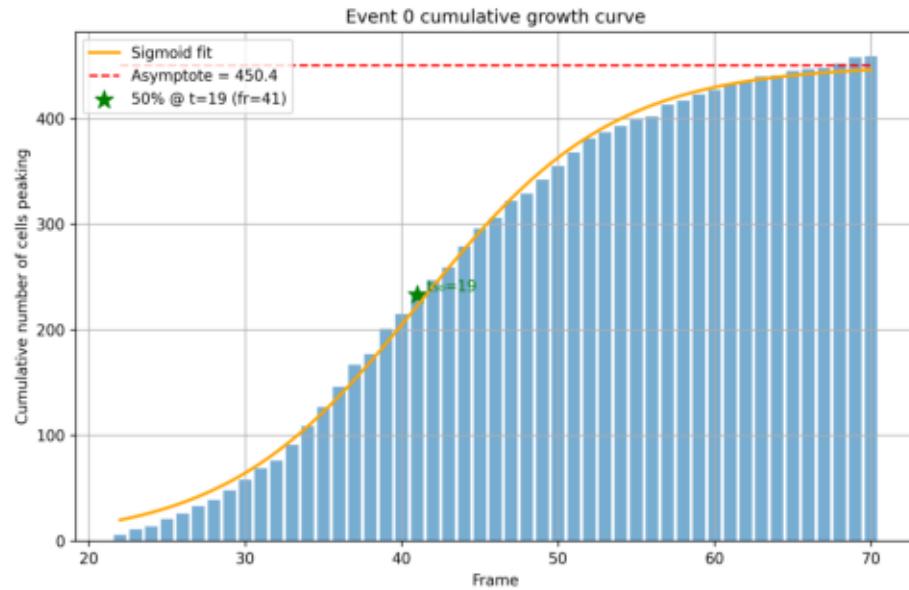


Distribution of Peak Symmetry Scores by Group

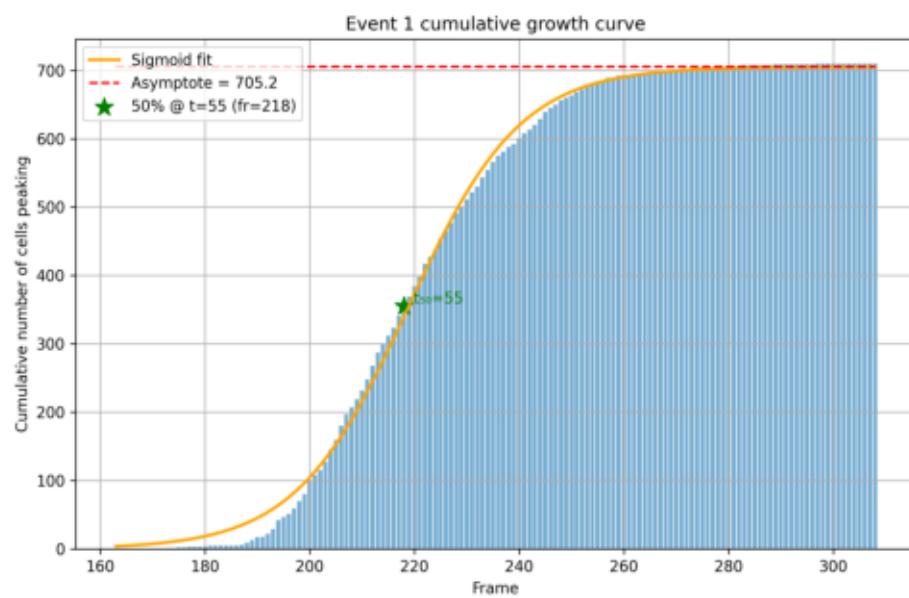


1.2.3 Kinetics of global events

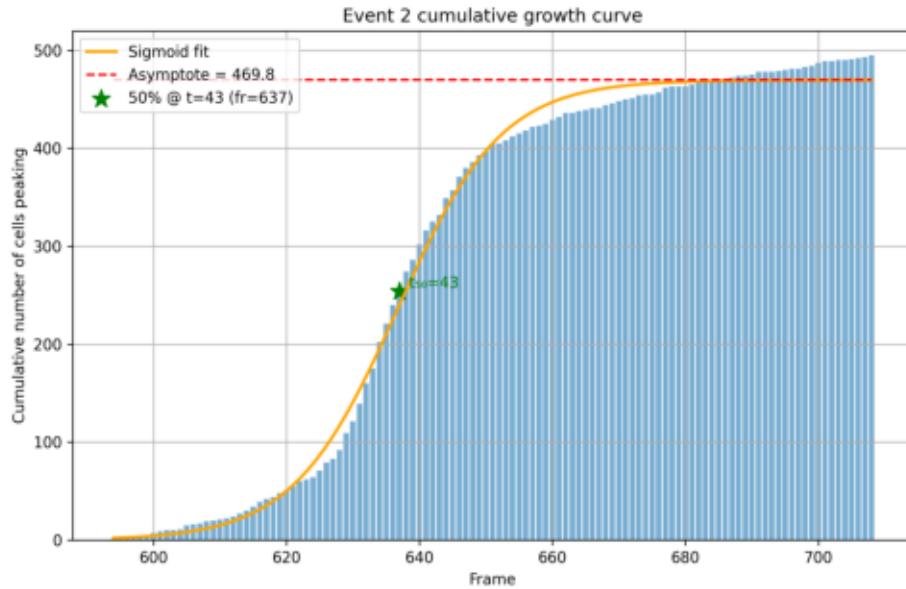
Event Activity Overlay (Event ID: 0) - 20250624_IS01



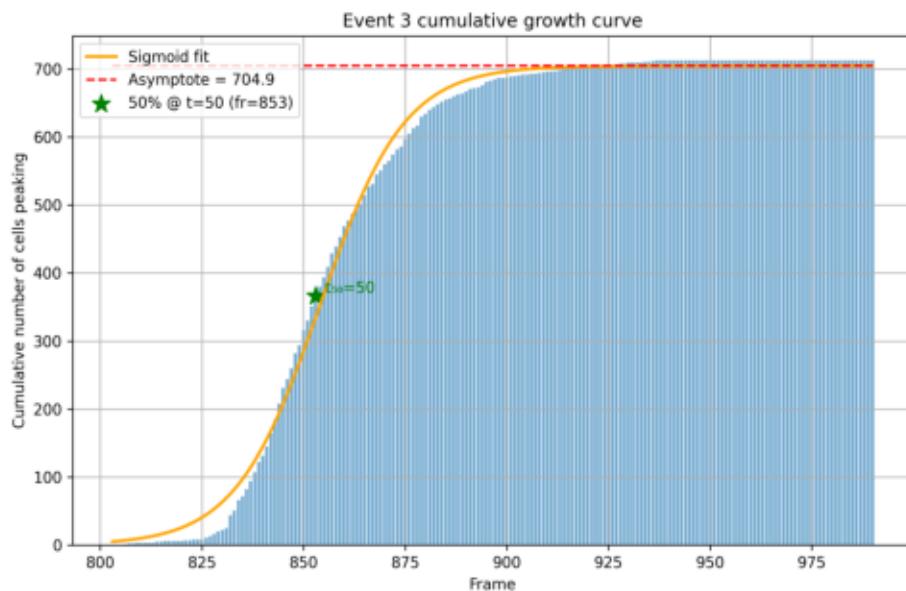
Event Activity Overlay (Event ID: 1) - 20250624_IS01

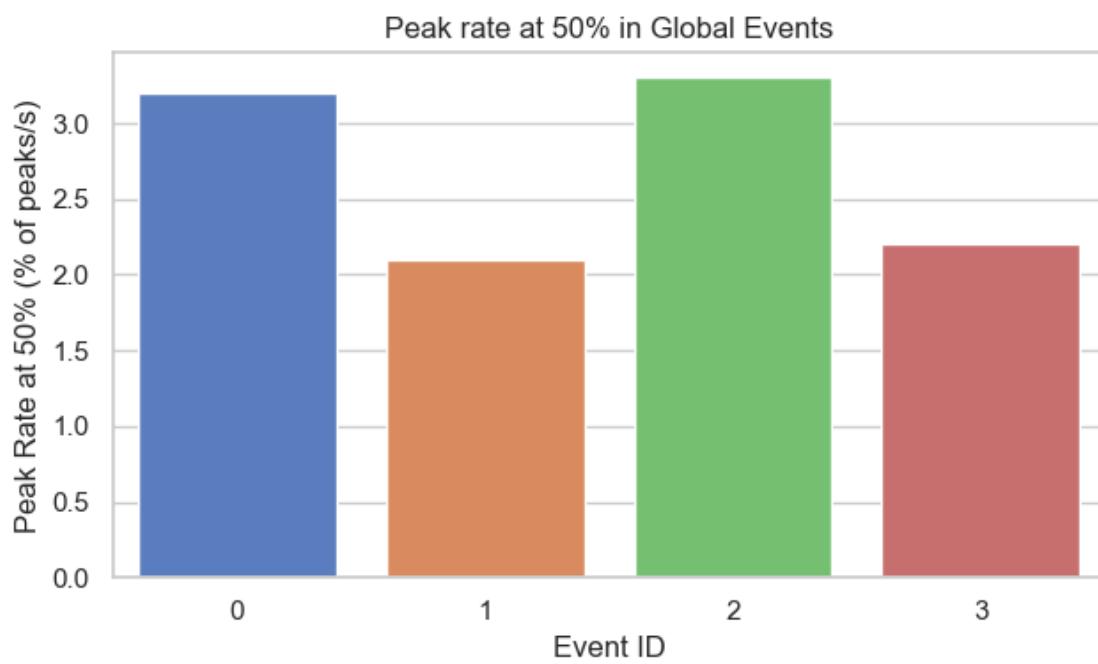
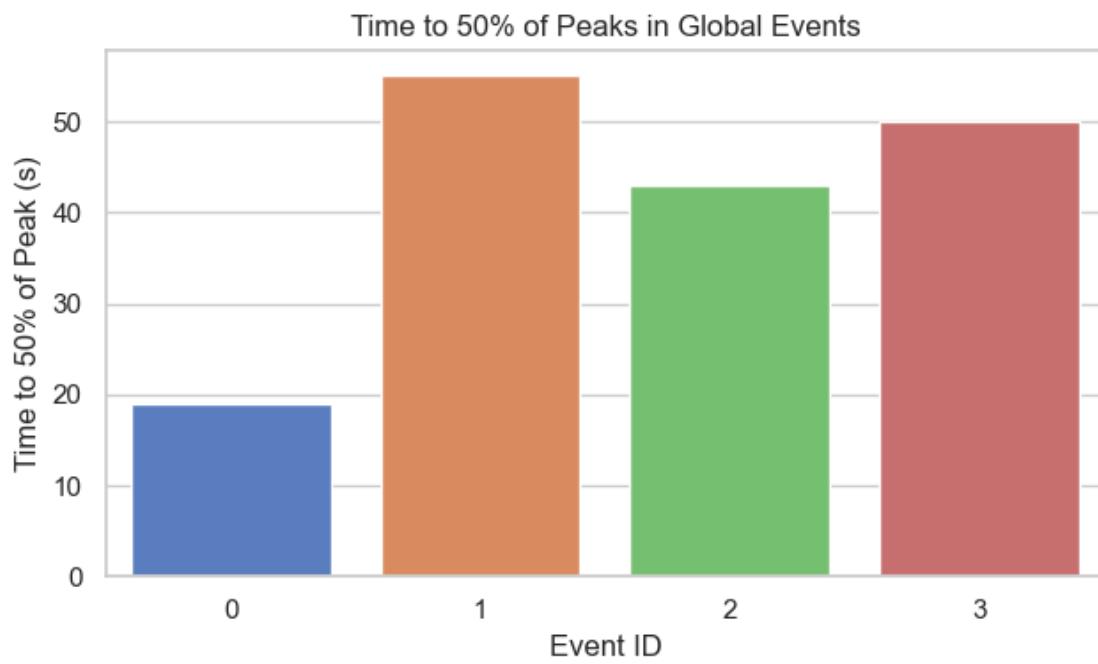


Event Activity Overlay (Event ID: 2) - 20250624_IS01

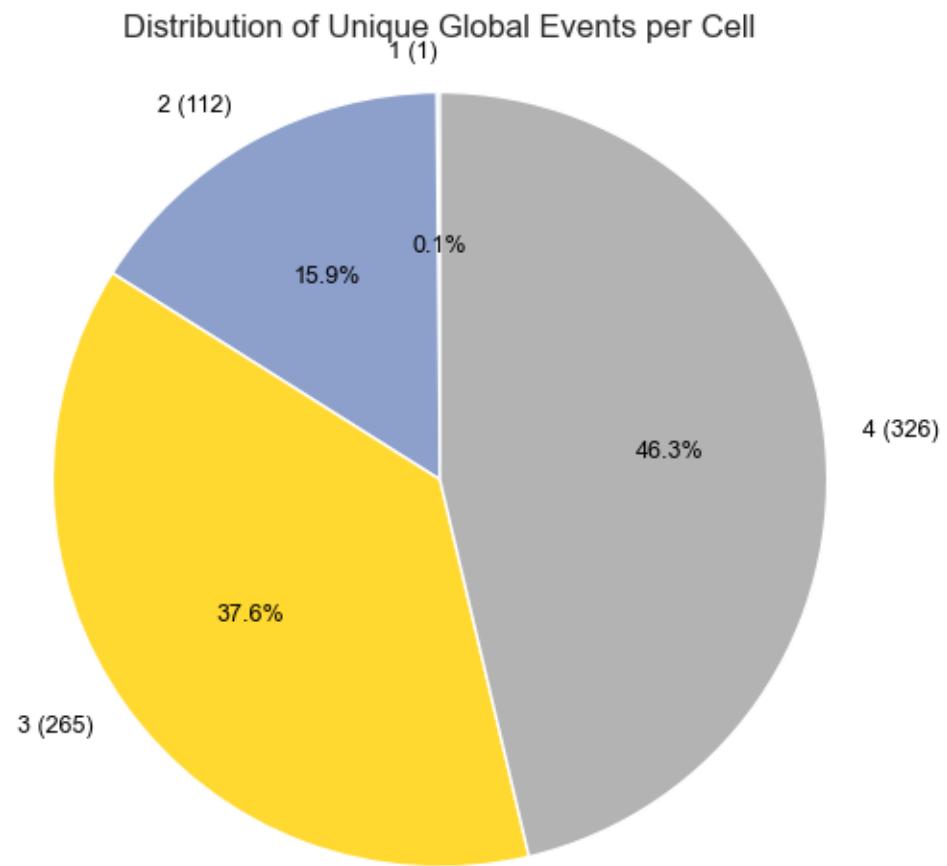


Event Activity Overlay (Event ID: 3) - 20250624_IS01

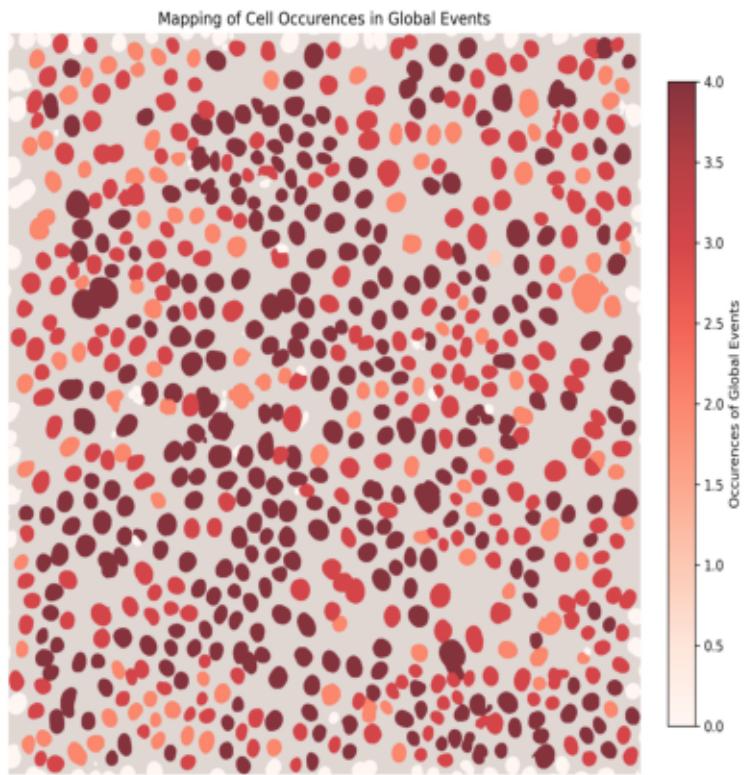


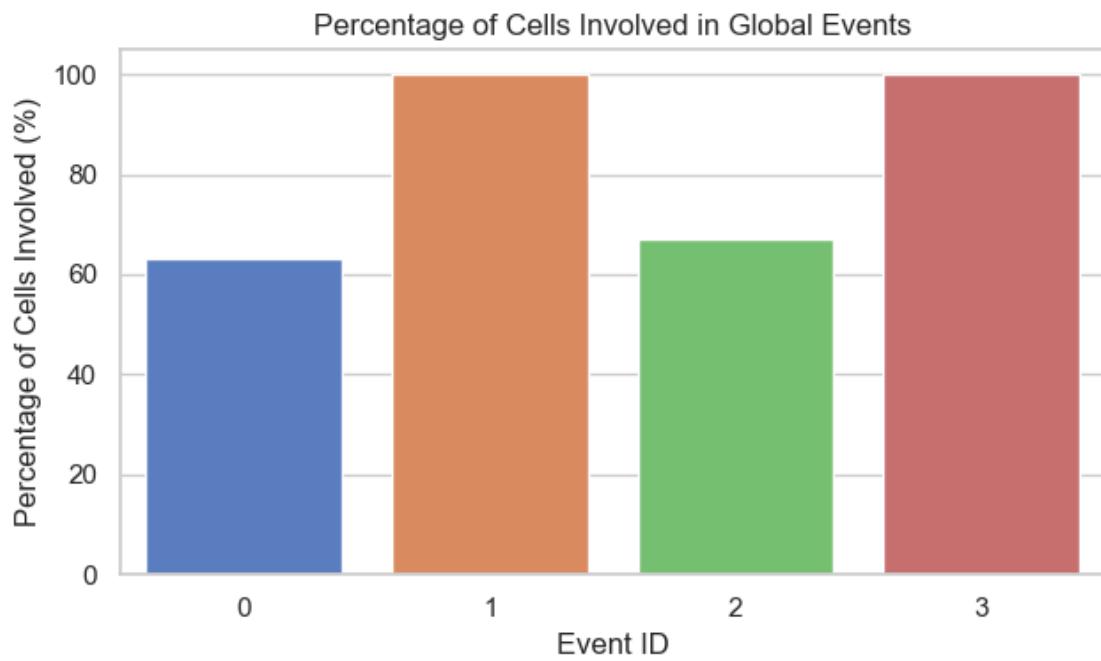


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250624_IS01





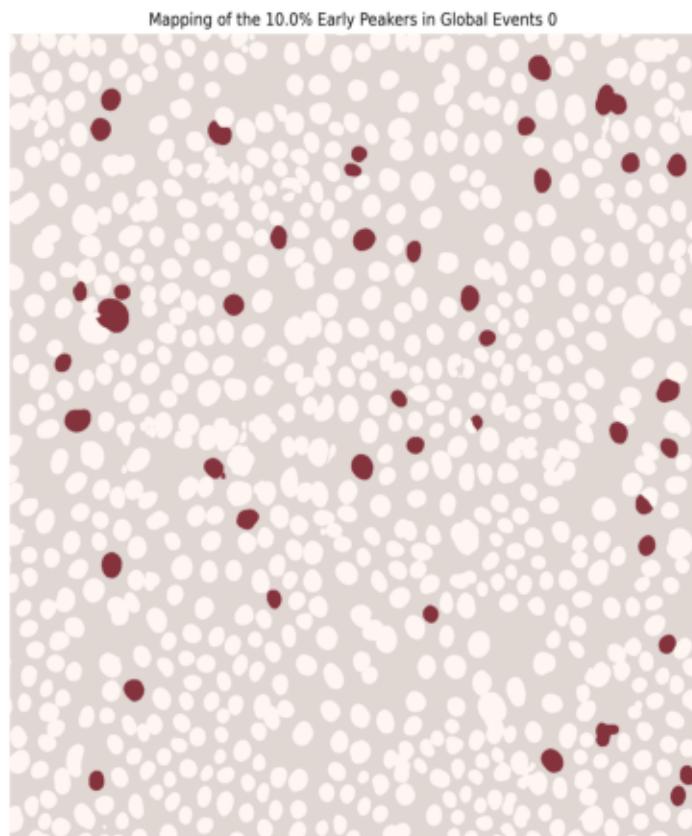
1.2.5 Inter-event interval analysis

Intervals between global event peaks: [188.0, 407.0, 232.0]

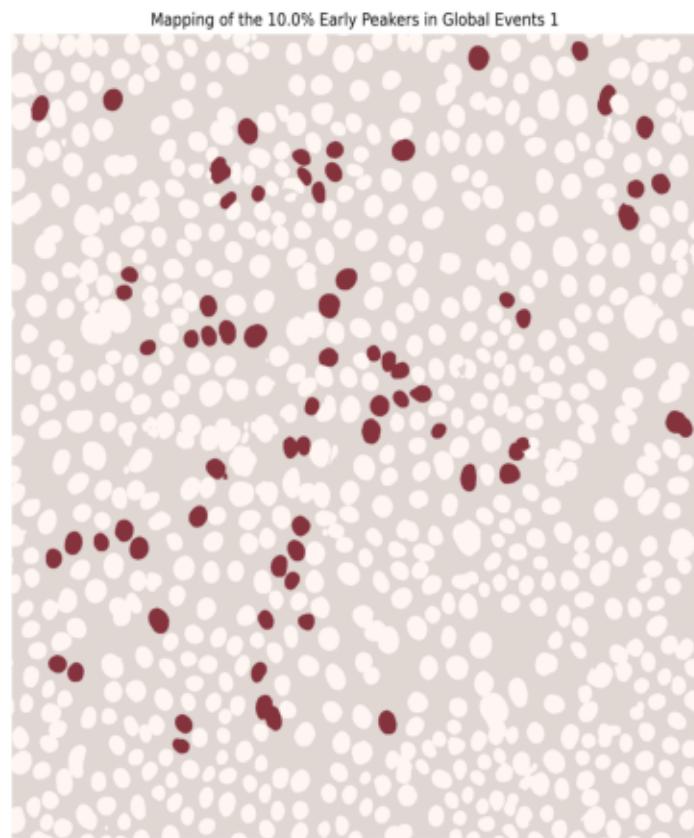
Estimated periodicity: 0.745

1.2.6 Early peakers in the events

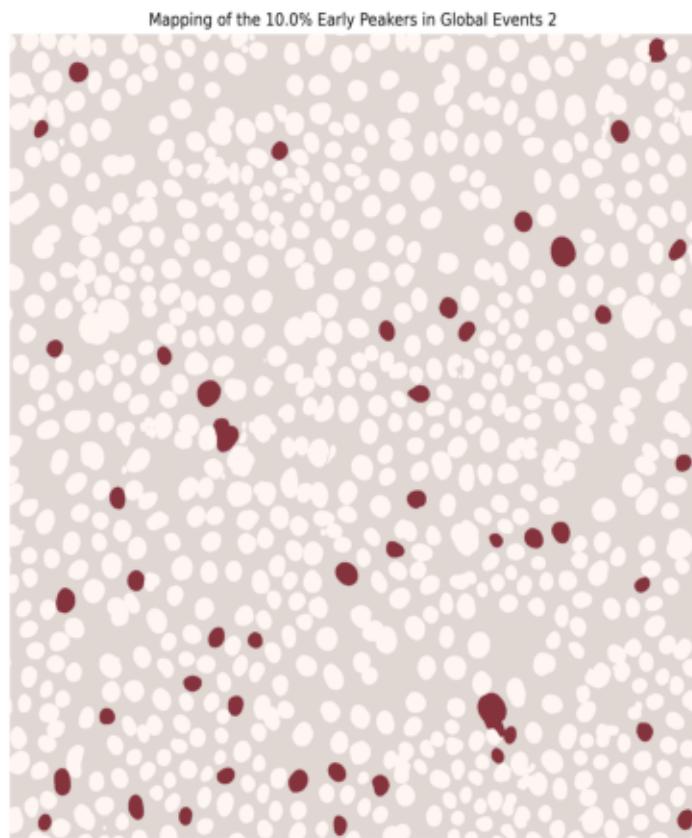
Cell Mapping with Early Peakers Overlay for event 0 - 20250624_IS01



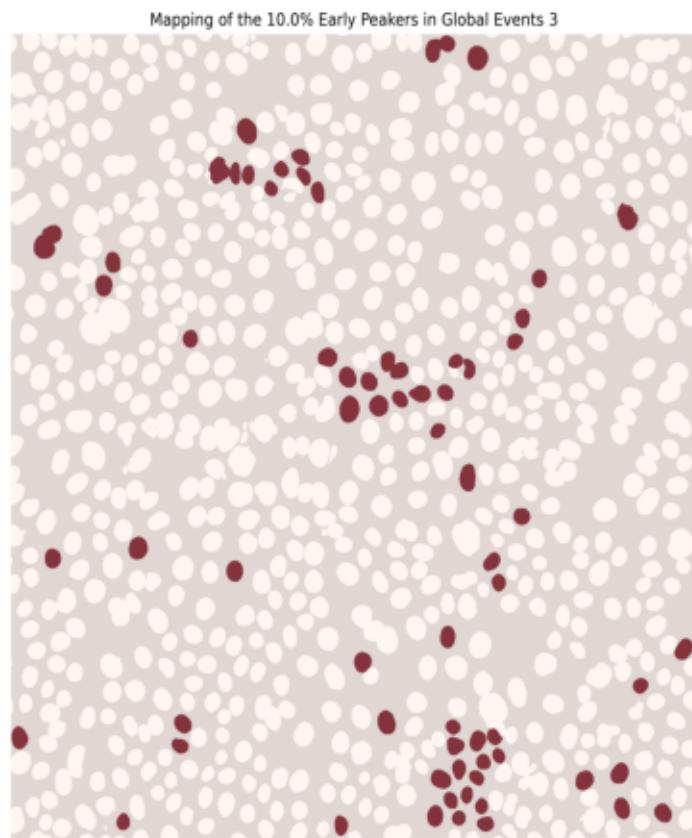
Cell Mapping with Early Peakers Overlay for event 1 - 20250624_IS01



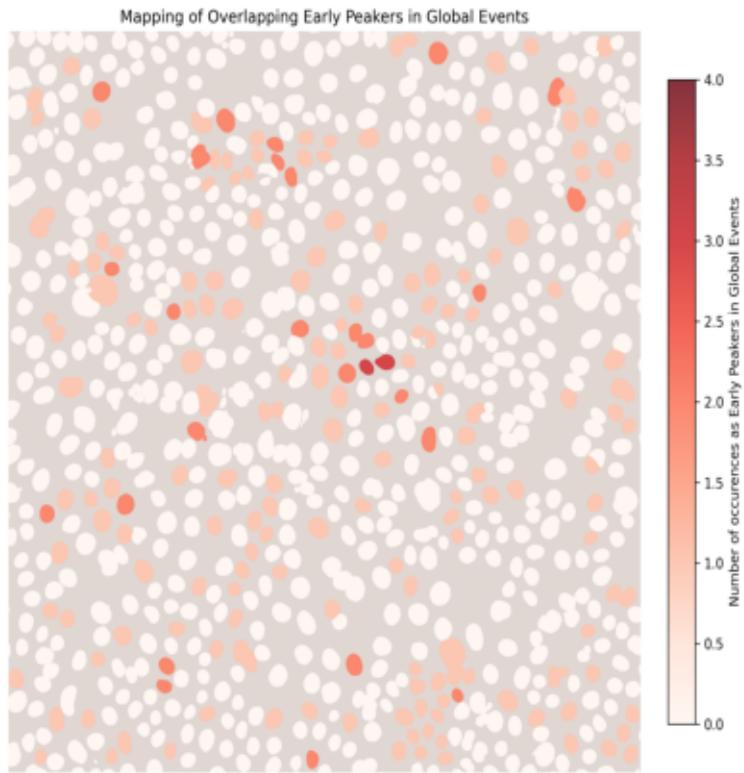
Cell Mapping with Early Peakers Overlay for event 2 - 20250624_IS01

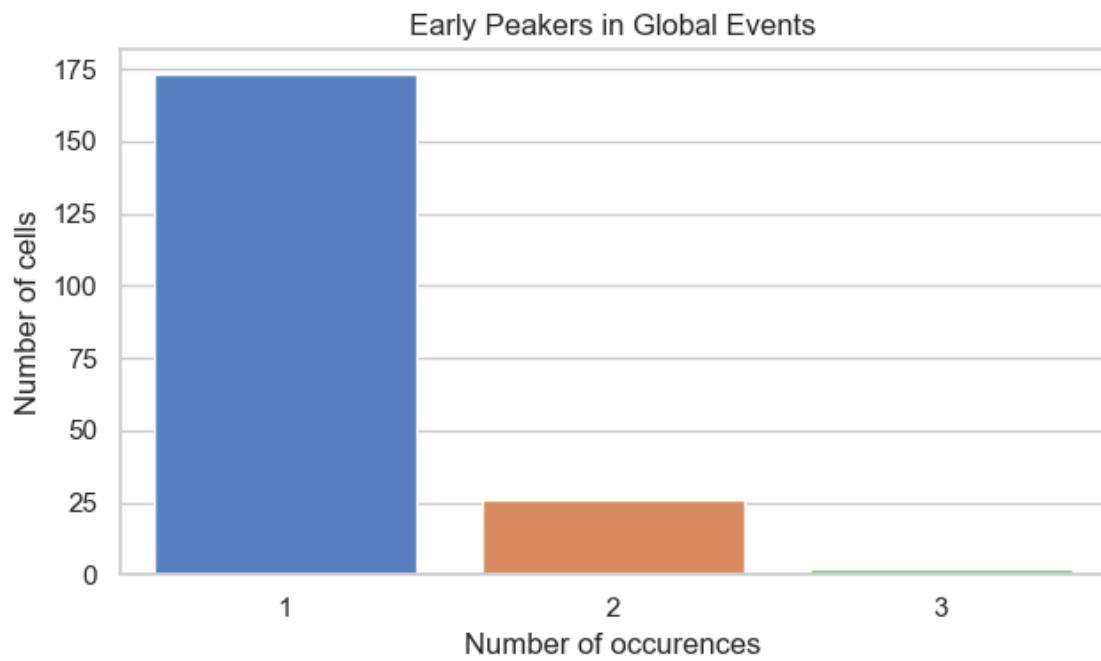


Cell Mapping with Early Peakers Overlay for event 3 - 20250624_IS01

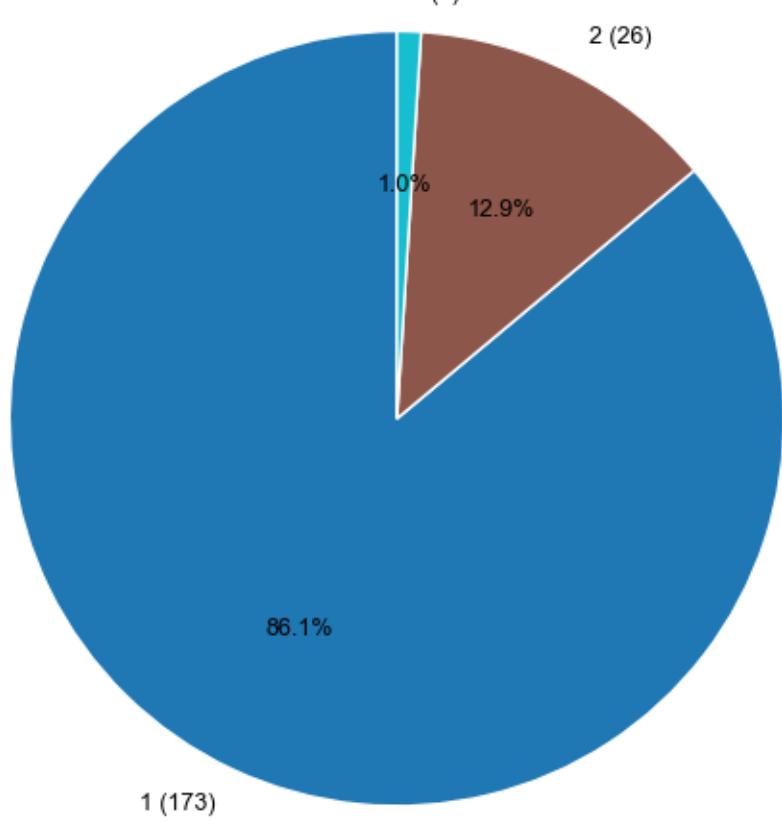


Cell Mapping with Occurrences in Global Events Overlay - 20250624_IS01





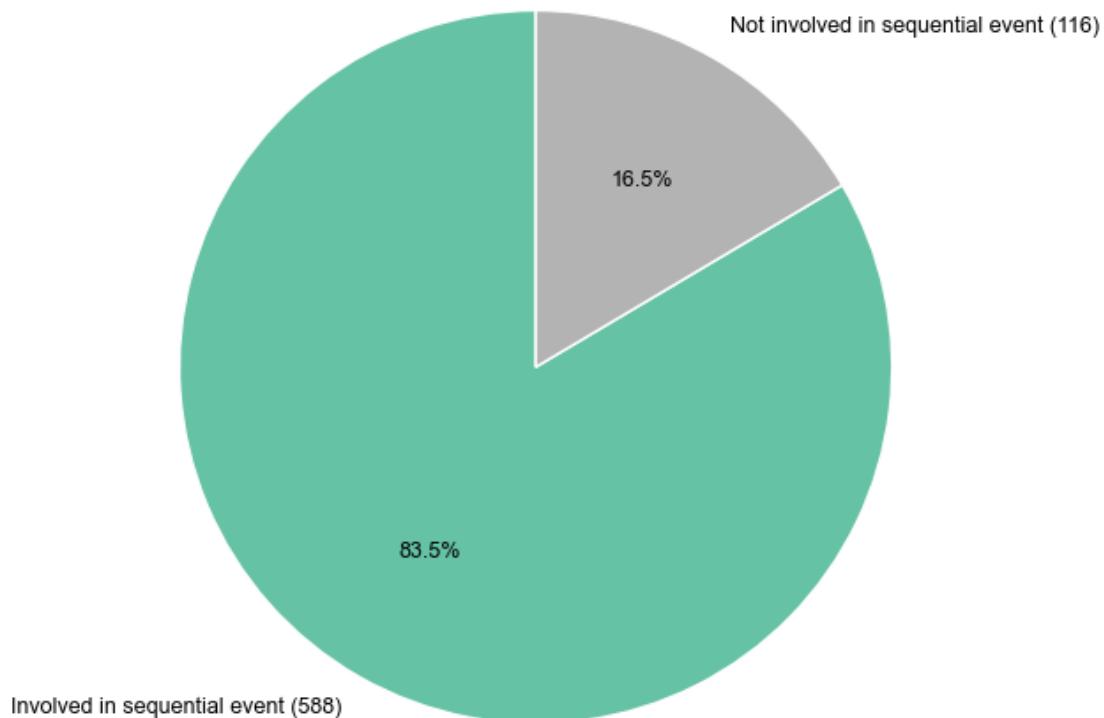
Distribution of Early Peakers in Global Events



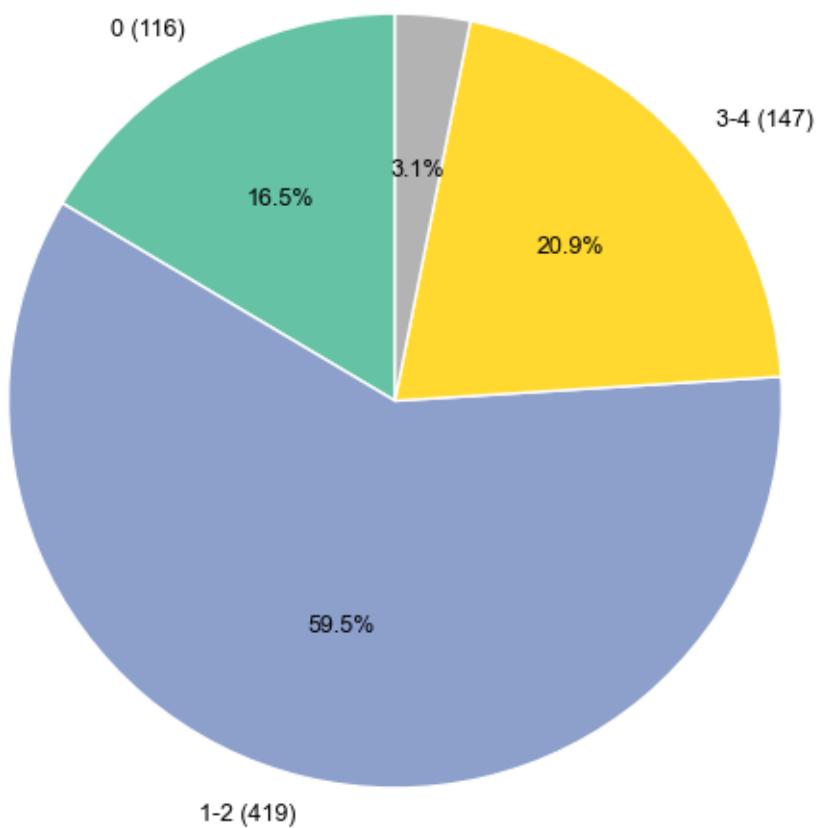
1.3 SEQUENTIAL EVENTS

1.3.1 Cells occurrences in sequential events

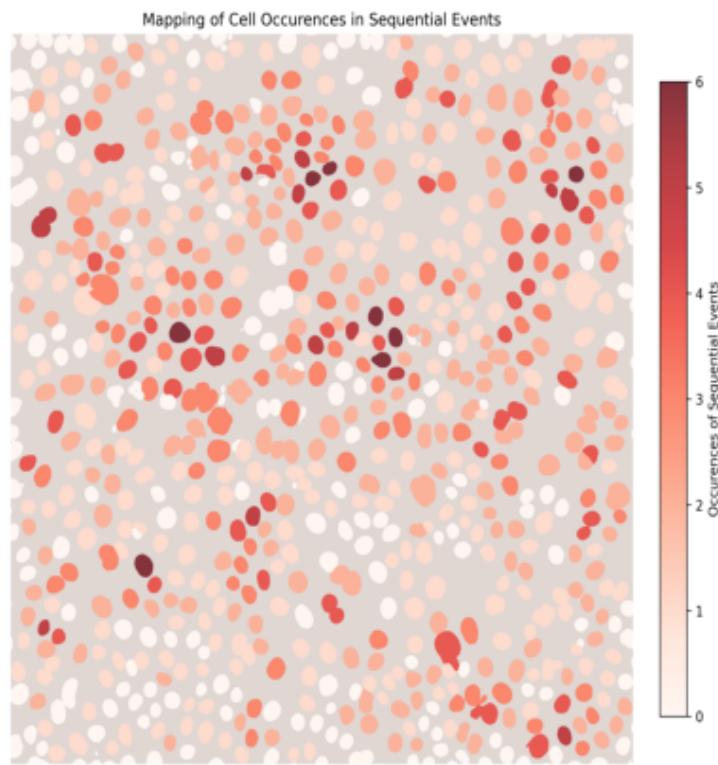
Distribution of Cells Involved in Sequential Events



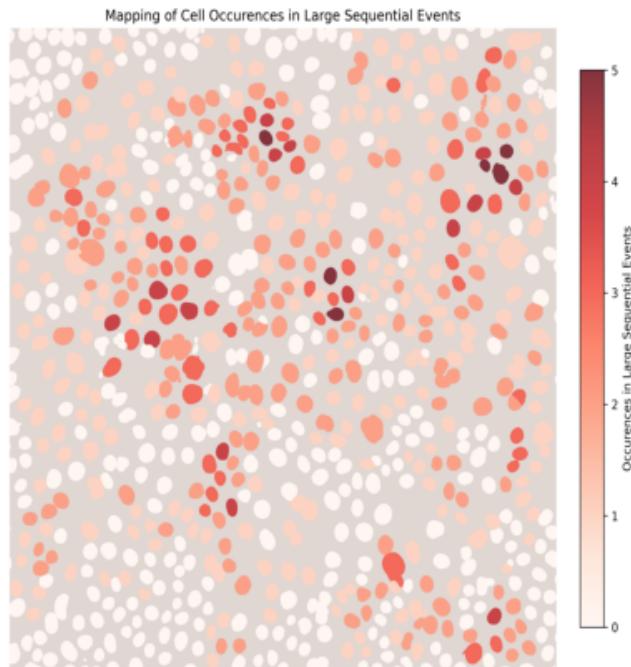
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)
5-9 (22)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250624_IS01

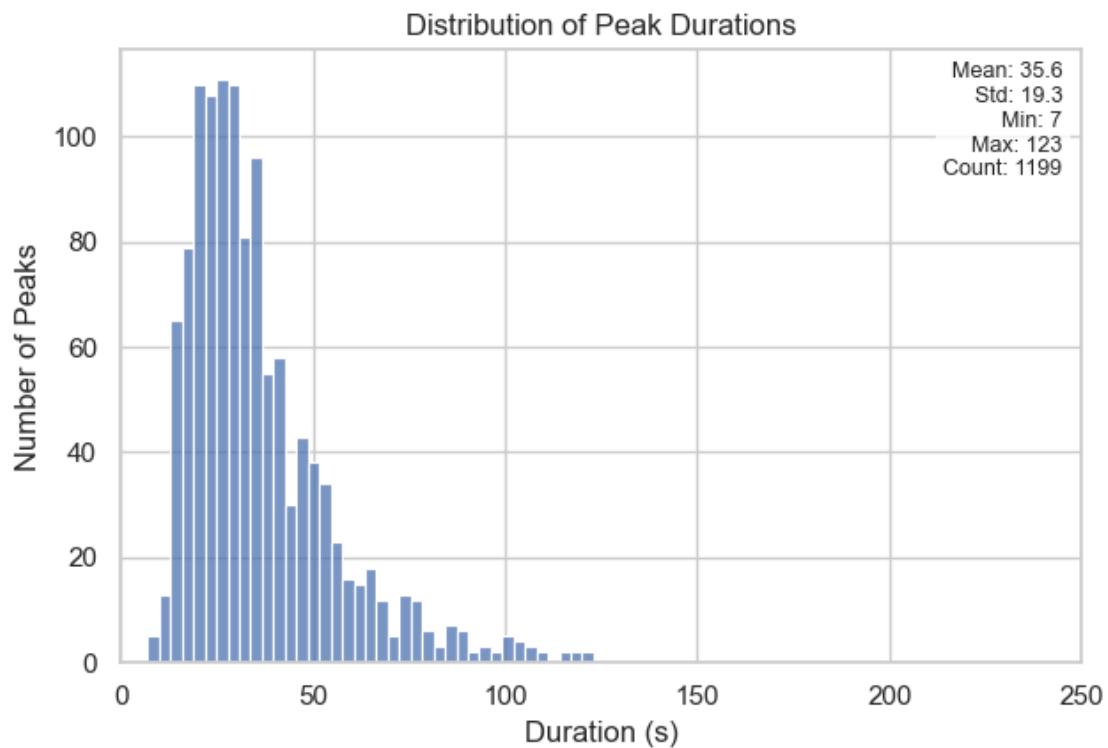


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250624_IS01

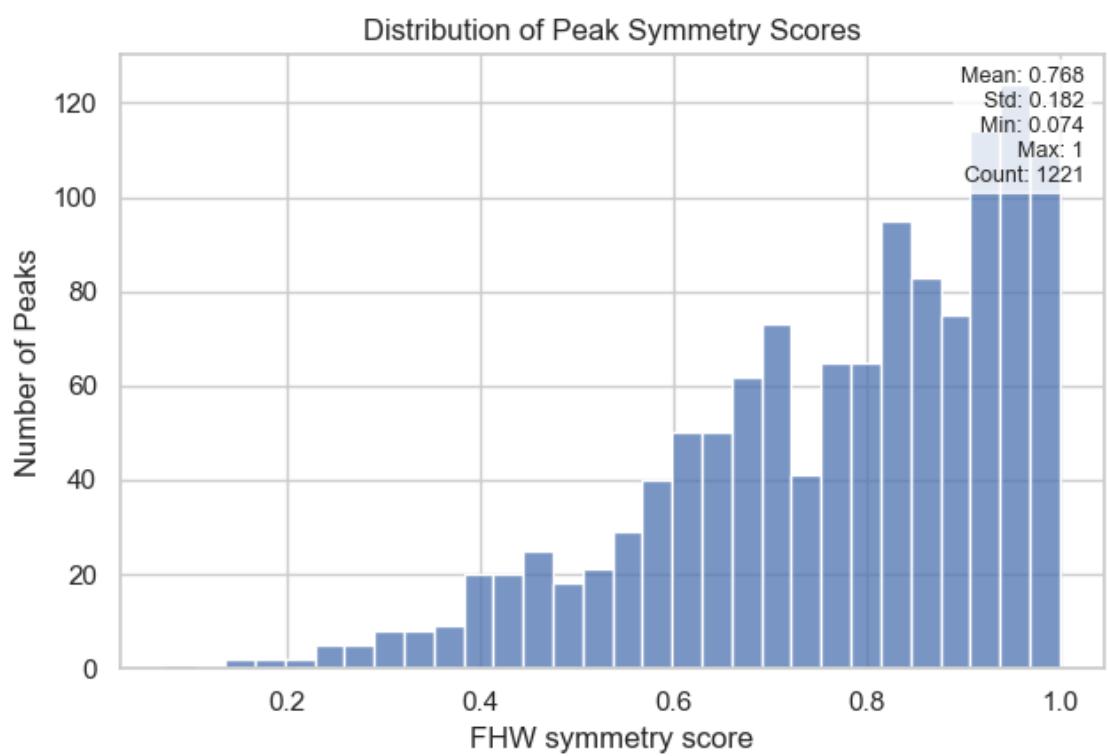
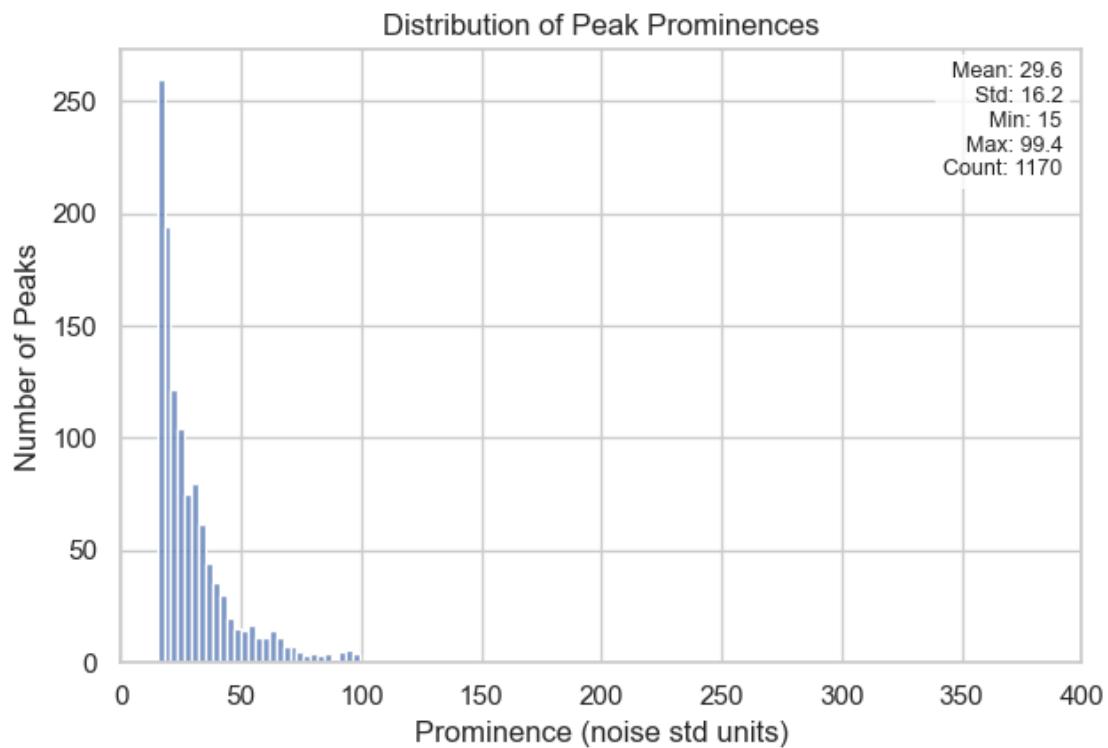


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 12:20:12] [INFO] calcium: plot_histogram: removed 22 outliers out of 1221 on 'Duration (s)' (lower=-12.5, upper=125.5)
```

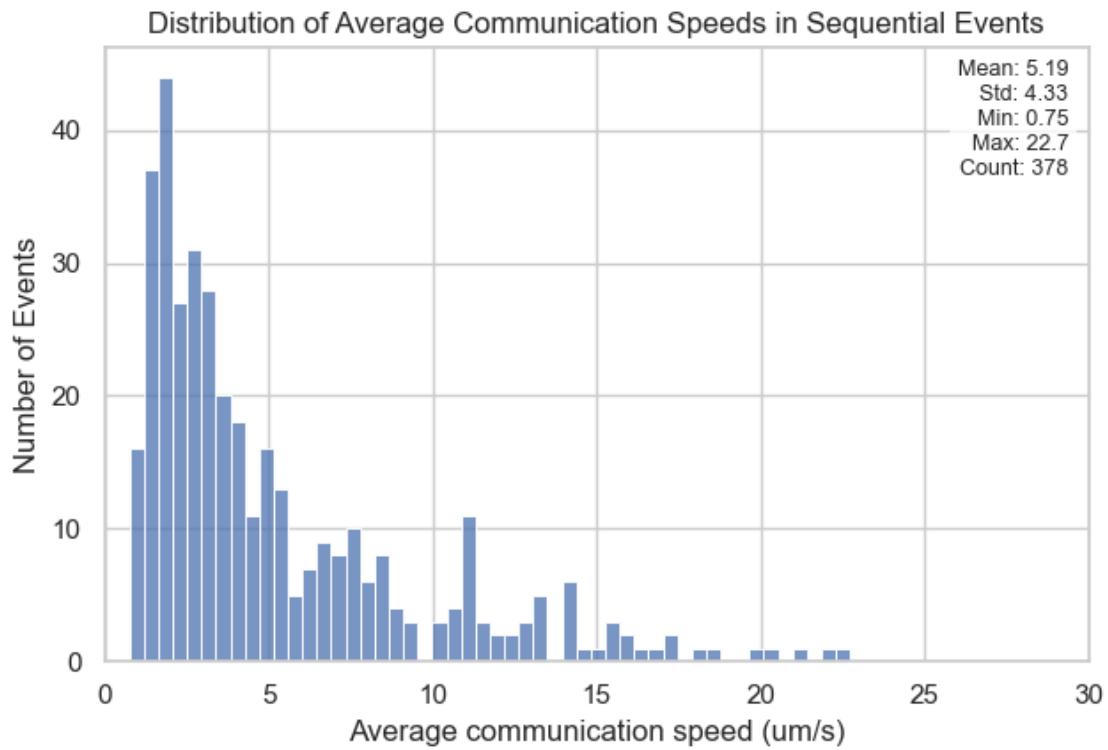


```
[2025-08-13 12:20:12] [INFO] calcium: plot_histogram: removed 51 outliers out of 1221 on 'Prominence (noise std units)' (lower=-8.4, upper=99.6)
```

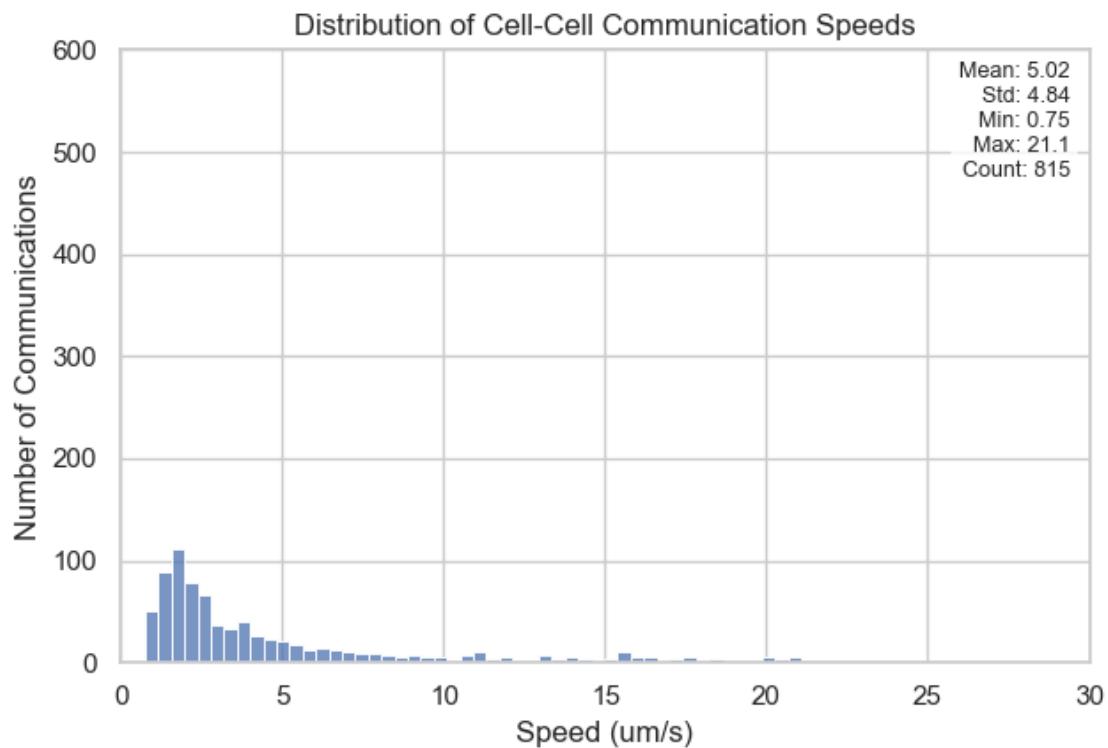


1.3.3 Cell-cell communication speed

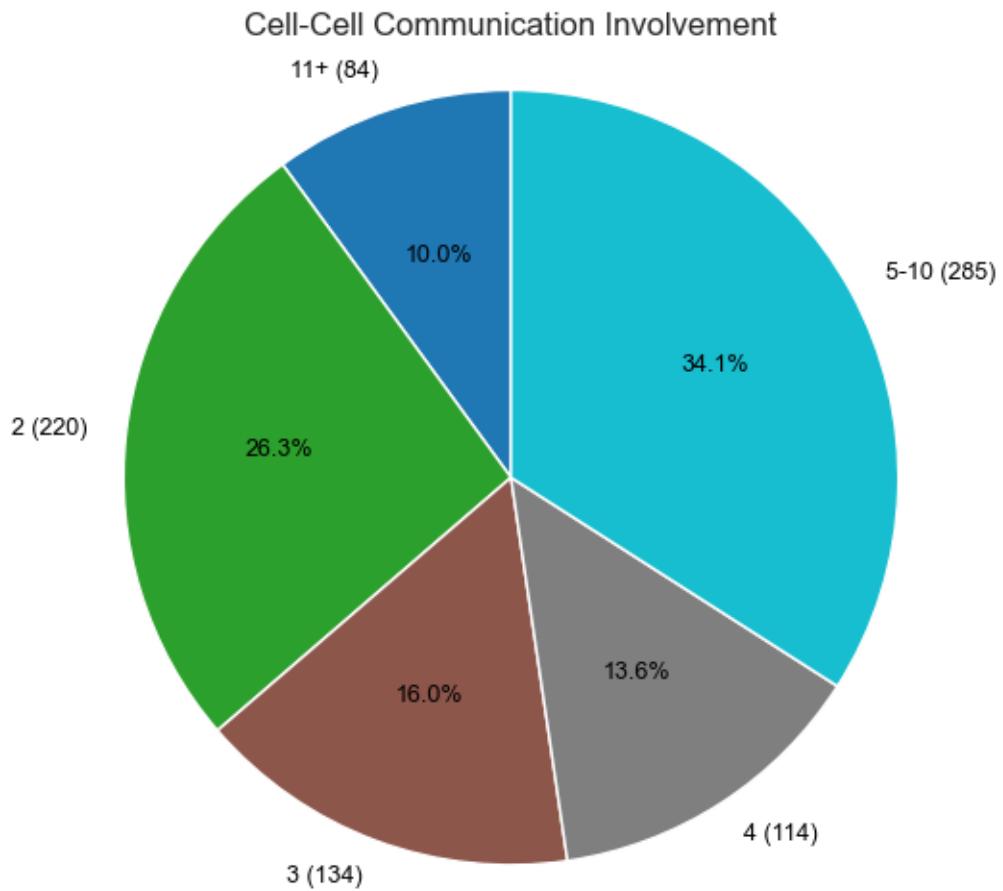
[2025-08-13 12:20:12] [INFO] calcium: plot_histogram: removed 6 outliers out of 384 on 'Average communication speed (um/s)' (lower=-13.56, upper=22.875)



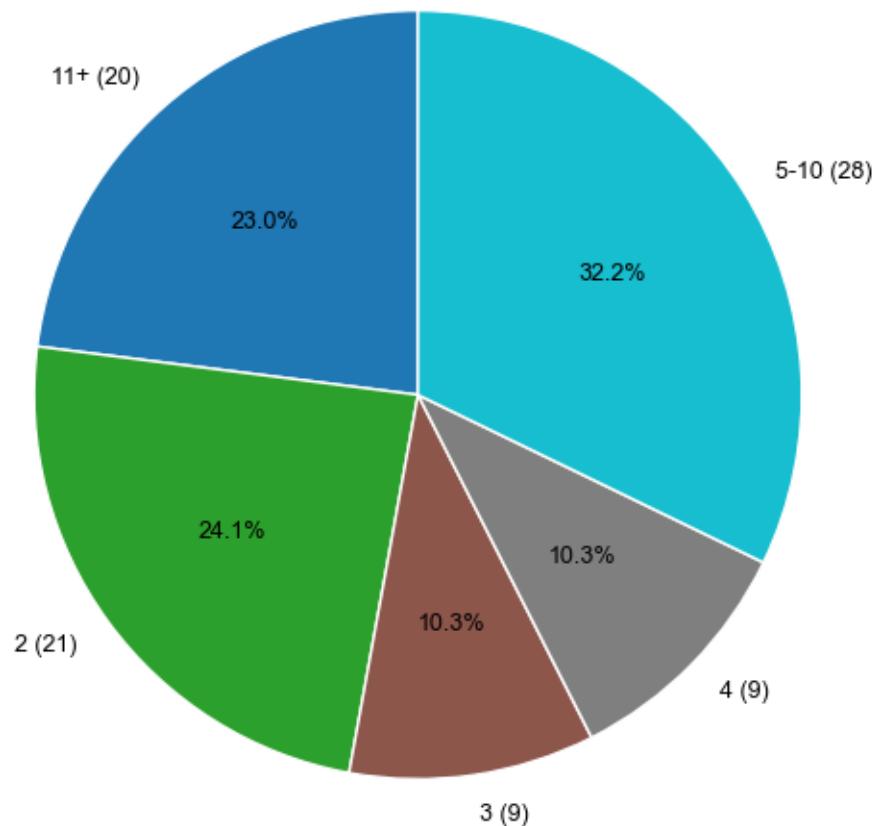
[2025-08-13 12:20:13] [INFO] calcium: plot_histogram: removed 22 outliers out of 837 on 'Speed (um/s)' (lower=-12.7, upper=21.11)



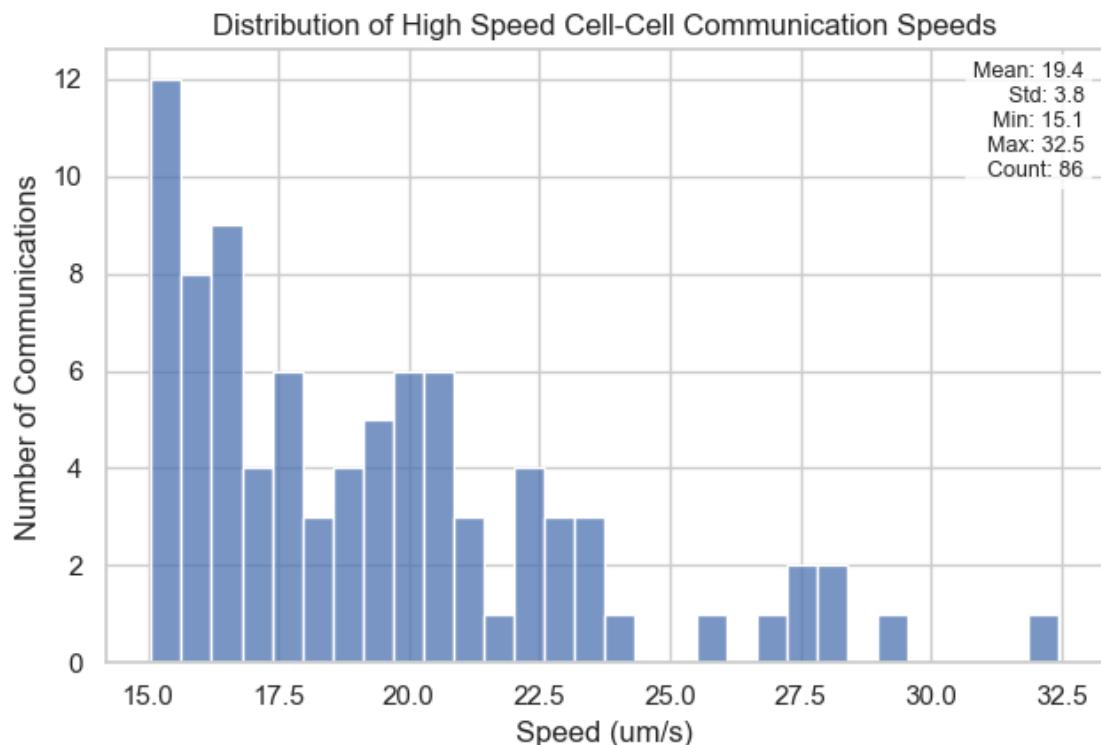
1.3.4 Double distribution in cell-cell communication speeds



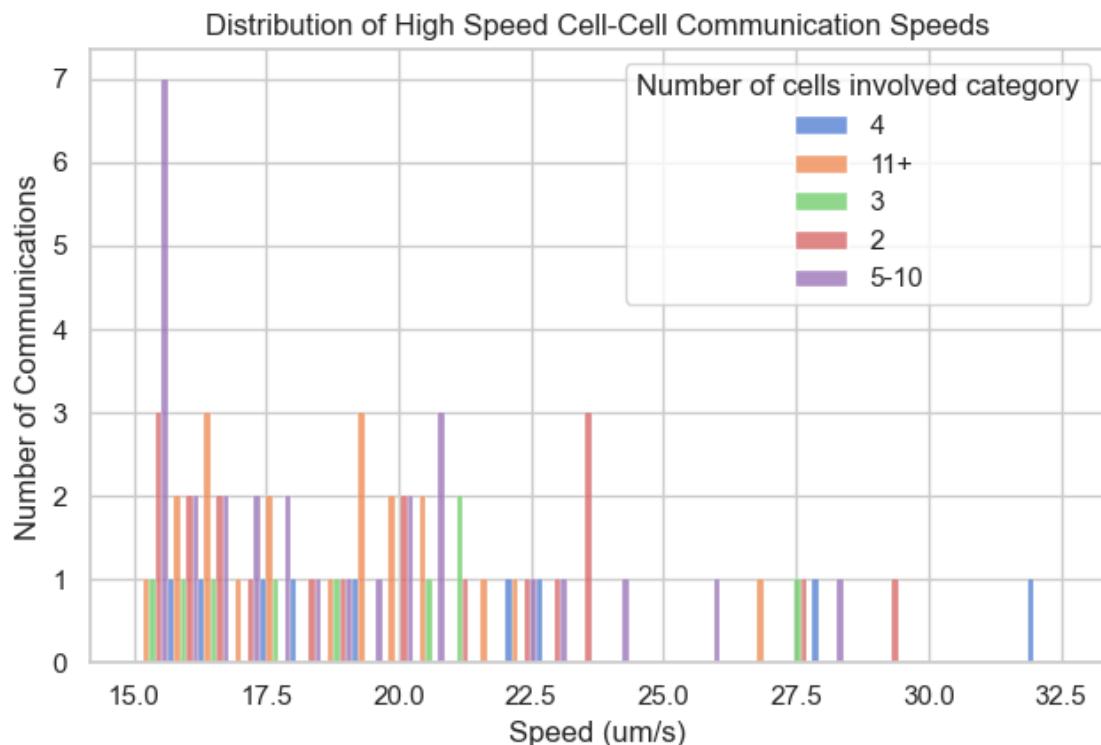
High Speed Cell-Cell Communication Involvement



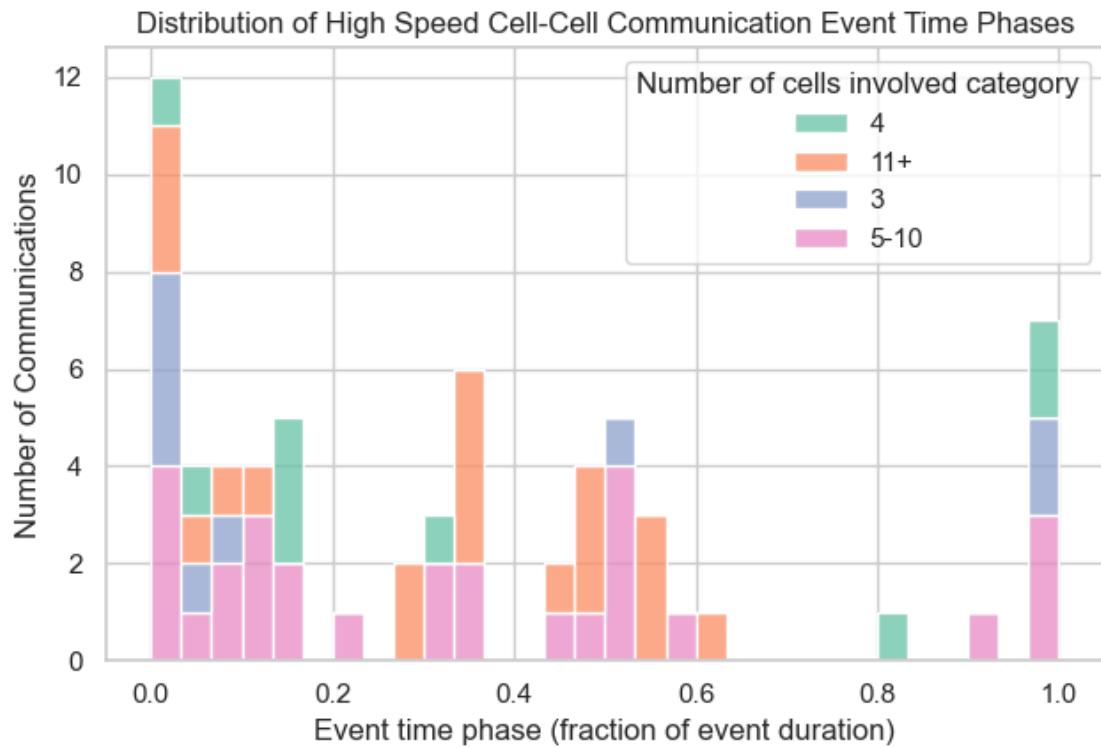
[2025-08-13 12:20:13] [INFO] calcium: plot_histogram: removed 1 outliers out of 87 on 'Speed (um/s)' (lower=1.6, upper=35.865)



```
[2025-08-13 12:20:13] [INFO] calcium: plot_histogram_by_group: removed 1 outliers out of 87 on 'Speed (um/s)' (lower=1.6, upper=35.865)
```

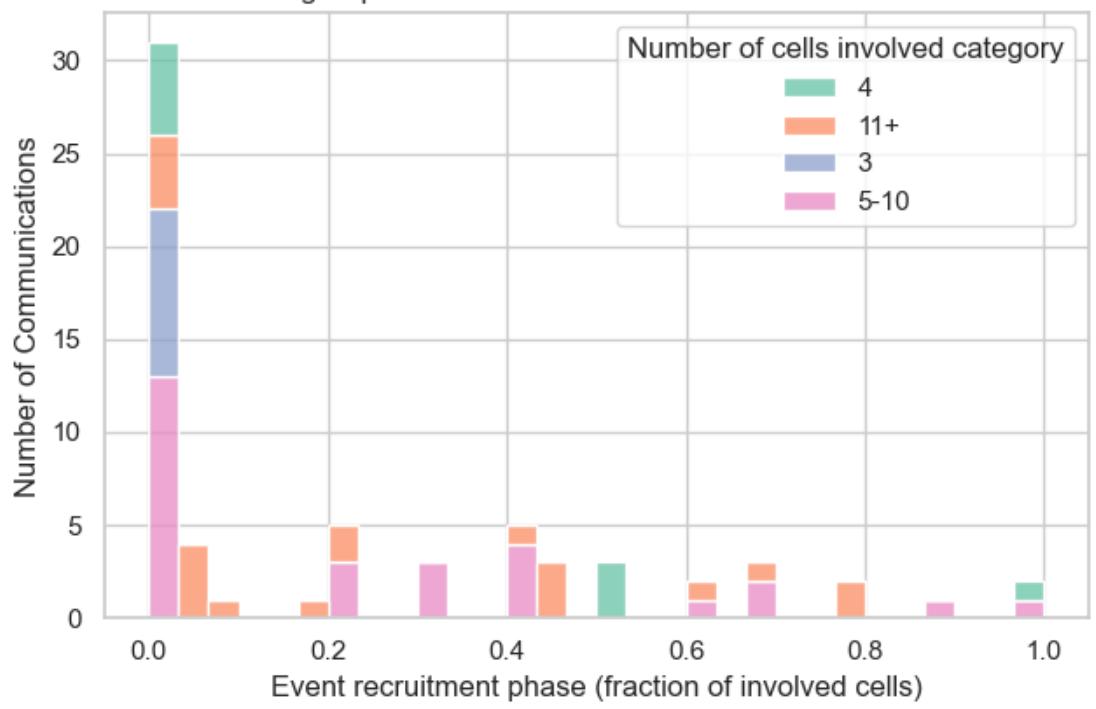


```
[2025-08-13 12:20:14] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 66 on 'Event time phase (fraction of event duration)' (lower=-1.21, upper=1.7825)
```

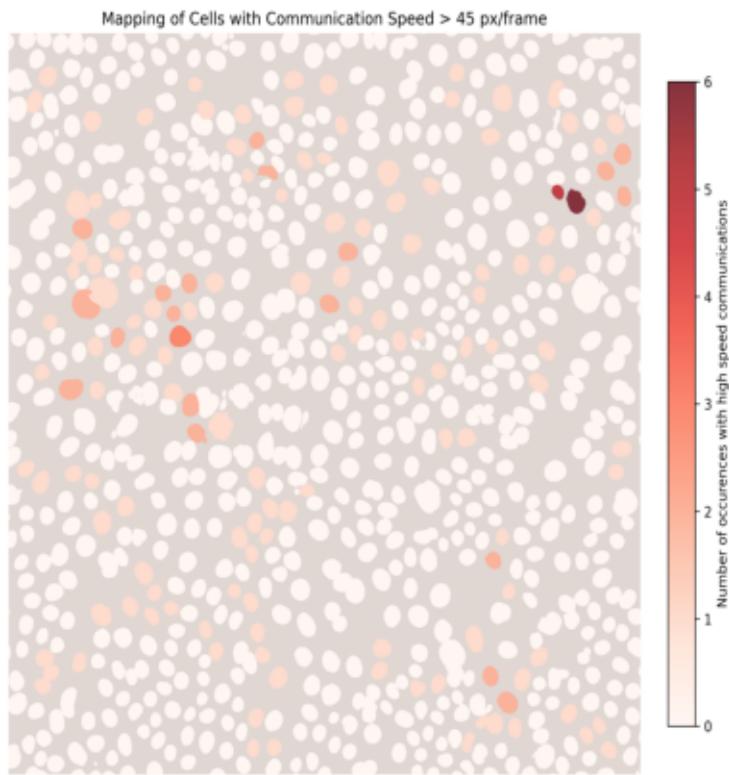


```
[2025-08-13 12:20:14] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 66 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.275, upper=1.7)
```

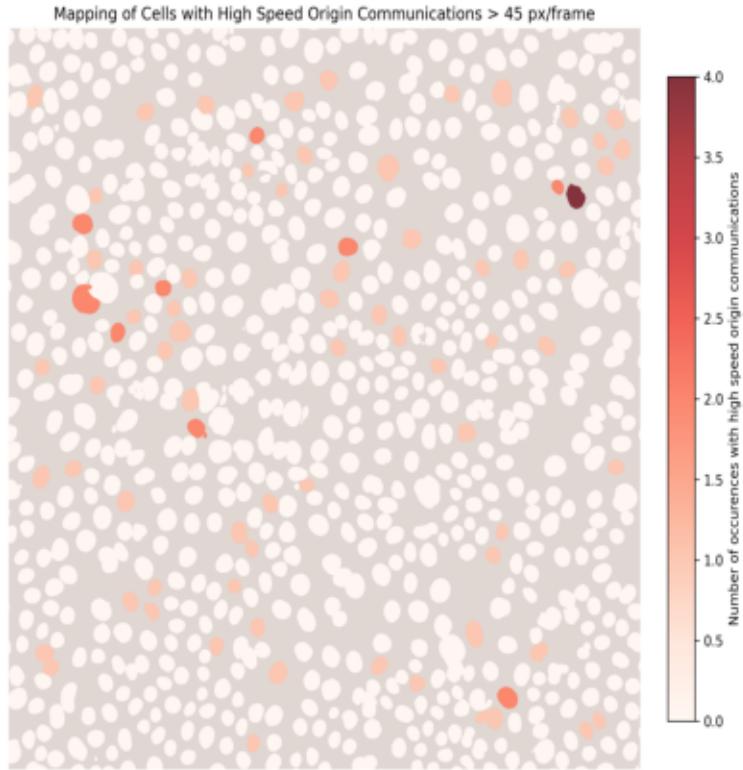
Distribution of High Speed Cell-Cell Communication Event Recruitment Phases



Cell Mapping with High Speed Cells Overlay - 20250624_IS01



Cell Mapping with High Speed Origin Cells Overlay - 20250624_IS01



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
1	1759528804384	4	797	4	
14	1759528798192	8	517	0	
15	1759528805968	8	488	1	
16	1759372527504	8	631	1	
19	1759523820240	8	594	0	
..	
775	1759523543392	344	995	6	
777	1759523551744	346	928	2	
784	1759523547280	350	1033	7	
800	1759523549152	362	1044	7	
821	1759523538976	374	1064	7	

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
1	774	3	529.0	529.0	
14	488	1	92.0	92.0	
15	455	0	92.0	92.0	
16	623	1	85.0	85.0	
19	575	1	86.0	87.0	
..	
775	1034	5	1188.0	1189.0	
777	961	2	468.0	469.0	
784	1065	9	1459.0	1460.0	
800	1014	7	1188.0	1189.0	
821	1063	4	1284.0	1285.0	
	Duration (s)	Distance (um)	Speed (um/s)	\	
1	0.0	16.32	16.32		
14	0.0	17.47	17.47		
15	0.0	19.21	19.21		
16	0.0	19.47	19.47		
19	1.0	15.78	15.78		
..		
775	1.0	17.88	17.88		
777	1.0	20.27	20.27		
784	1.0	18.18	18.18		
800	1.0	20.23	20.23		
821	1.0	16.25	16.25		
	Event time phase (fraction of event duration)	\			
1		1.00			
14		0.47			
15		0.47			
16		0.00			
19		0.13			
..		...			
775		0.14			
777		NaN			
784		0.04			
800		0.20			
821		0.50			
	Event recruitment phase (fraction of involved cells)	dataset	\		
1		0.50	20250624_IS01		
14		0.45	20250624_IS01		
15		0.45	20250624_IS01		
16		0.00	20250624_IS01		
19		0.18	20250624_IS01		
..			
775		0.00	20250624_IS01		
777		NaN	20250624_IS01		

784		0.00	20250624_IS01
800		0.00	20250624_IS01
821		0.00	20250624_IS01

	Number of cells involved	category	Speed category
1		4	High speed
14		11+	High speed
15		11+	High speed
16		11+	High speed
19		11+	High speed
..	
775		4	High speed
777		2	High speed
784		4	High speed
800		5-10	High speed
821		3	High speed

[87 rows x 16 columns]

Origin cell ID	Speed category	High speed	Low speed
129		0	1
133		0	1
135		0	1
136		0	1
138		0	1
..	
1072		0	1
1073		0	1
1075		0	2
1079		0	1
1084		0	1

[414 rows x 2 columns]

Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
4	129	129.35	7.80
7	133	180.05	9.75
9	135	470.28	9.75
10	136	306.80	9.75
12	138	204.75	11.70
..
690	1072	127.40	484.25
691	1073	53.95	484.90
693	1075	423.15	486.53
696	1079	458.25	488.15
700	1084	239.53	490.10

Number of peaks Is active Occurences in global events \

4	8	True	3
7	5	True	3
9	8	True	4
10	7	True	3
12	7	True	3
..
690	9	True	4
691	3	True	2
693	11	True	4
696	9	True	3
700	9	True	4

Occurrences in global events as early peaker \

4	0
7	0
9	1
10	1
12	0
..	..
690	1
691	0
693	0
696	0
700	2

Occurrences in sequential events \

4	1
7	1
9	1
10	1
12	1
..	..
690	2
691	1
693	4
696	3
700	1

Occurrences in sequential events as origin \

4	1
7	1
9	0
10	1
12	0
..	..
690	1
691	1
693	1

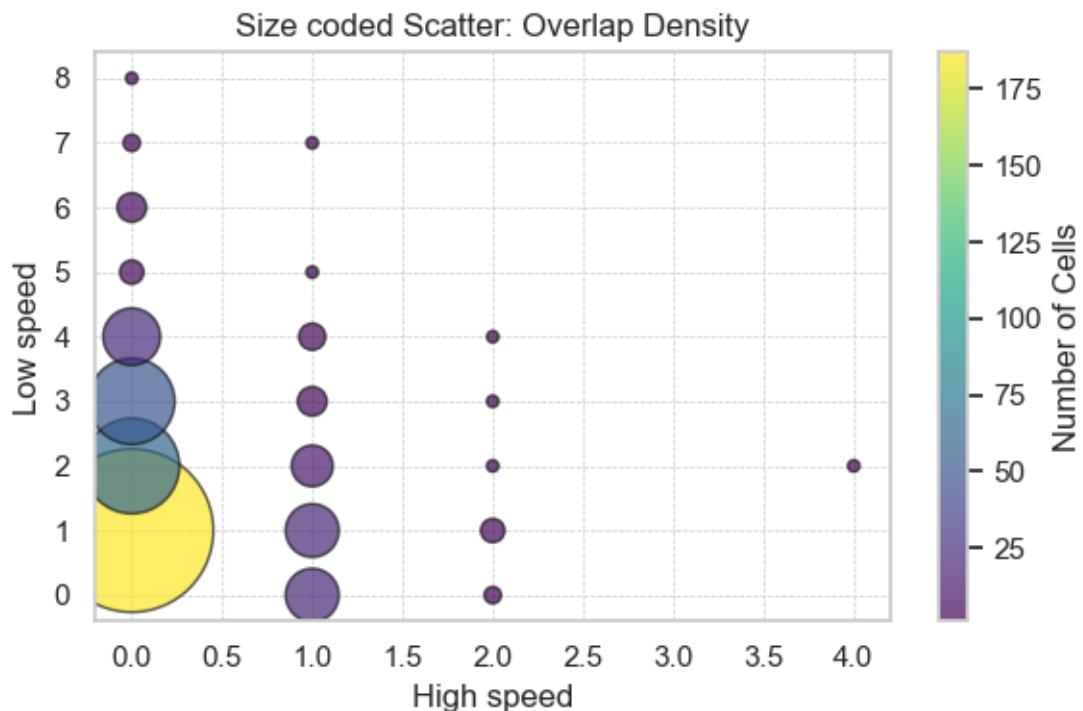
696		1		
700		1		
	Occurrences in individual events	Peak frequency (Hz)	Periodicity score	\
4	4	0.0047	0.61	
7	1	0.0029	0.73	
9	3	0.0047	0.68	
10	3	0.0041	0.73	
12	3	0.0041	0.64	
..
690	3	0.0053	0.69	
691	0	0.0018	0.92	
693	2	0.0065	0.56	
696	3	0.0053	0.58	
700	4	0.0053	0.59	
	Neighbor count	Neighbors (labels)	dataset	\
4	3	[143,145,164]	20250624_IS01	
7	4	[138,147,169,193]	20250624_IS01	
9	4	[127,131,156,160]	20250624_IS01	
10	5	[122,158,162,176,182]	20250624_IS01	
12	3	[133,169,170]	20250624_IS01	
..
690	3	[1045,1054,1083]	20250624_IS01	
691	5	[1028,1029,1051,1057,1086]	20250624_IS01	
693	2	[1046,1062]	20250624_IS01	
696	3	[1044,1062,1065]	20250624_IS01	
700	4	[1037,1039,1060,1089]	20250624_IS01	
	Involved in sequential event	Occurrences in sequential events category		\
4	Involved in sequential event			1-2
7	Involved in sequential event			1-2
9	Involved in sequential event			1-2
10	Involved in sequential event			1-2
12	Involved in sequential event			1-2
..
690	Involved in sequential event			1-2
691	Involved in sequential event			1-2
693	Involved in sequential event			3-4
696	Involved in sequential event			3-4
700	Involved in sequential event			1-2
	High speed	Low speed		
4	0.0	1.0		
7	0.0	1.0		
9	0.0	1.0		
10	0.0	1.0		
12	0.0	1.0		

```

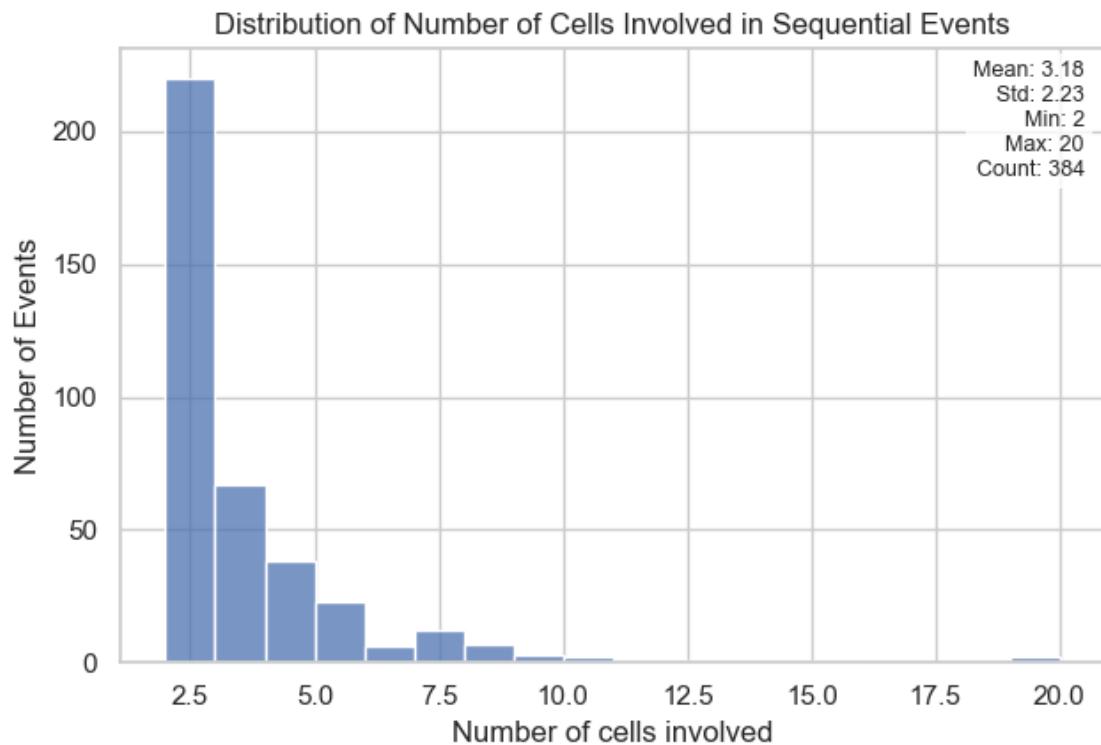
...
690      0.0      1.0
691      0.0      1.0
693      0.0      2.0
696      0.0      1.0
700      0.0      1.0

```

[414 rows x 19 columns]



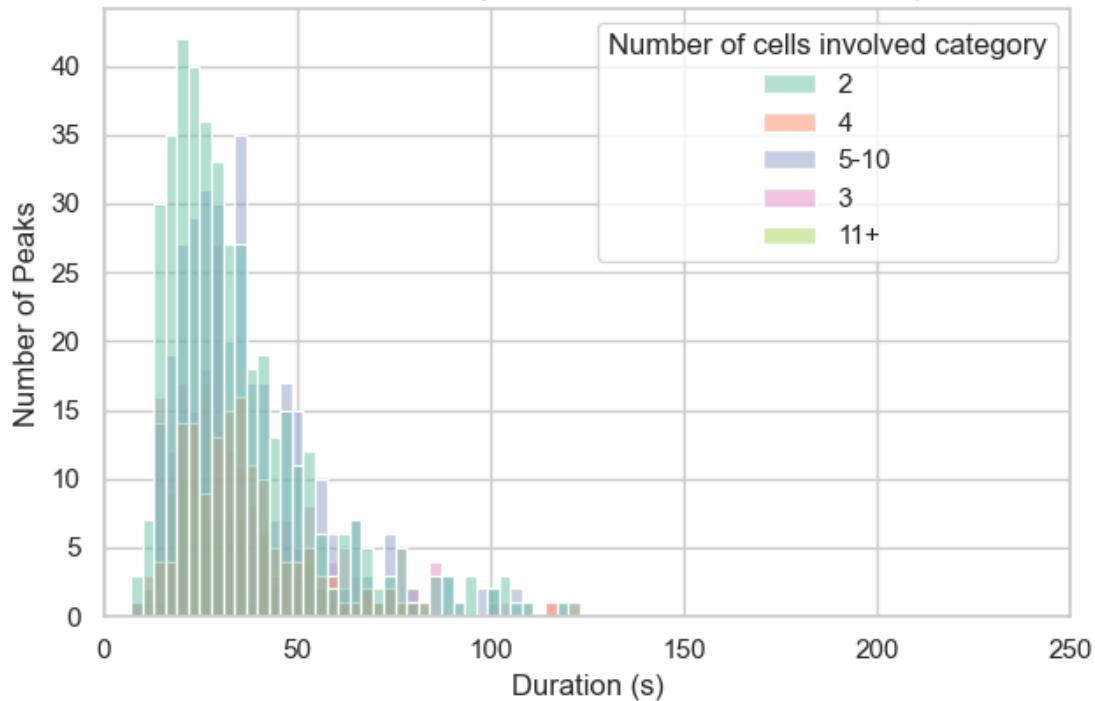
1.3.5 Number of cells involved per sequential events



1.3.6 Influence of cell count per event on statistics

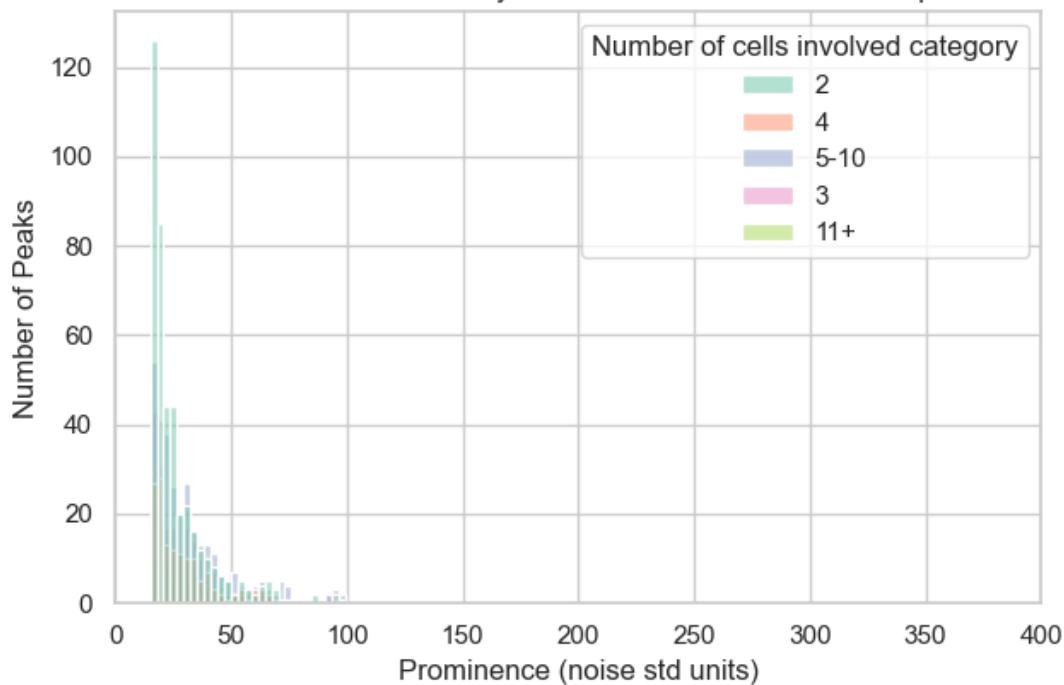
```
[2025-08-13 12:20:18] [INFO] calcium: plot_histogram_by_group: removed 22 outliers out of 1221 on 'Duration (s)' (lower=-12.5, upper=125.5)
```

Distribution of Peak Durations by Number of Cells Involved in Sequential Events

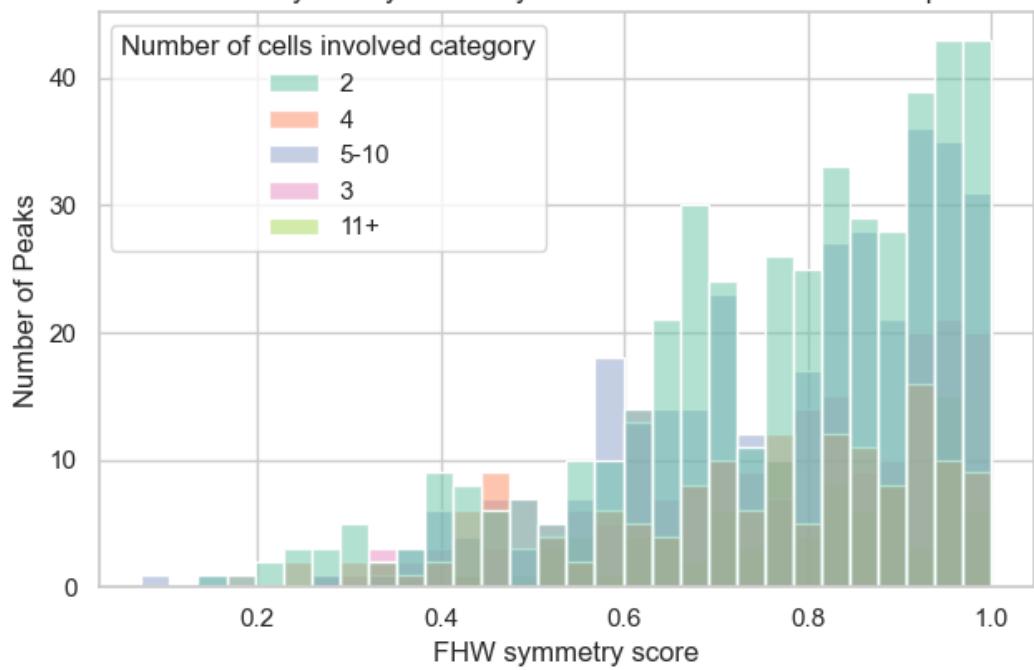


[2025-08-13 12:20:18] [INFO] calcium: plot_histogram_by_group: removed 51 outliers out of 1221 on 'Prominence (noise std units)' (lower=-8.4, upper=99.6)

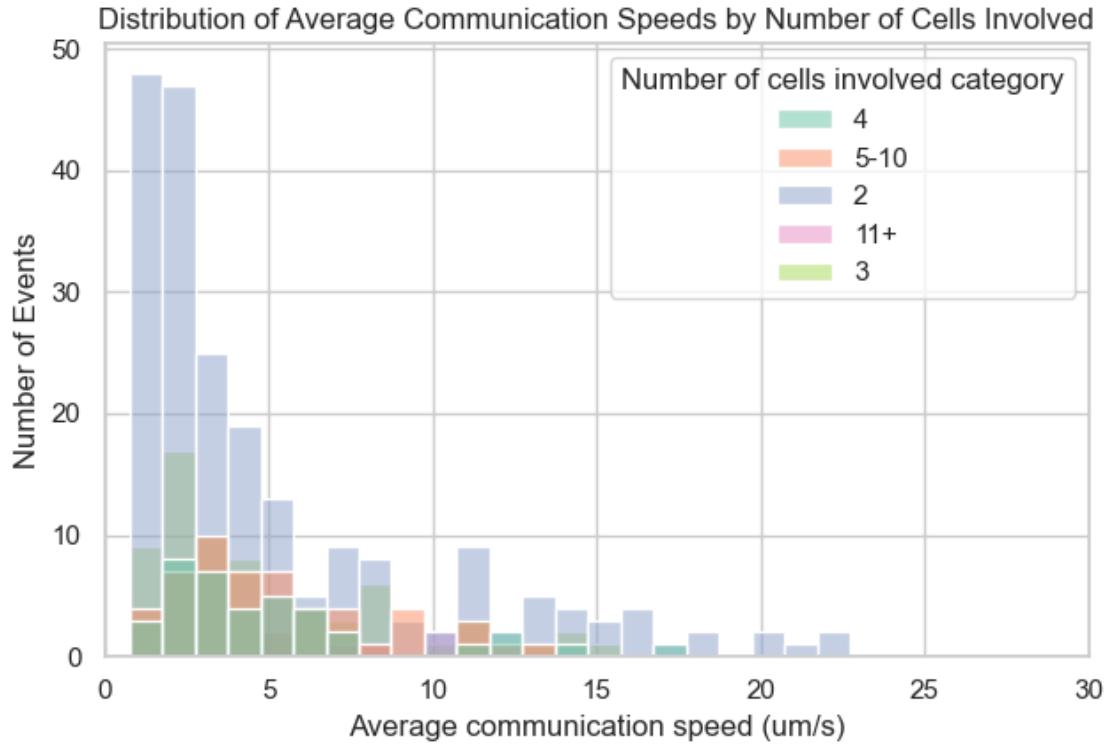
Distribution of Peak Prominences by Number of Cells Involved in Sequential Events



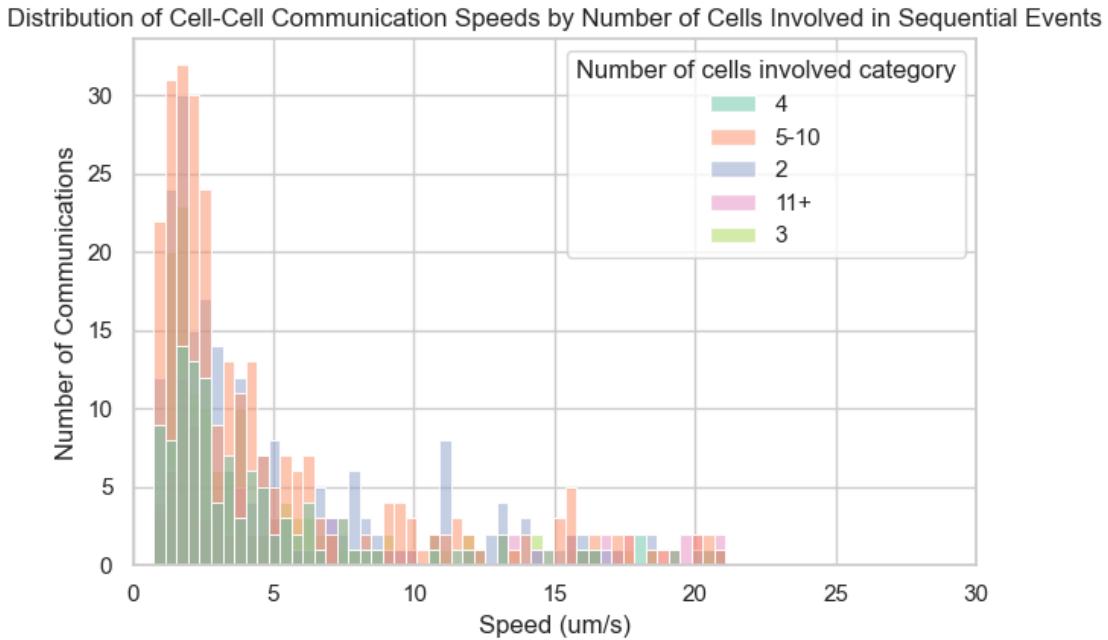
Distribution of Peak Symmetry Scores by Number of Cells Involved in Sequential Events



```
[2025-08-13 12:20:19] [INFO] calcium: plot_histogram_by_group: removed 6 outliers out of 384 on 'Average communication speed (um/s)' (lower=-13.56, upper=22.875)
```

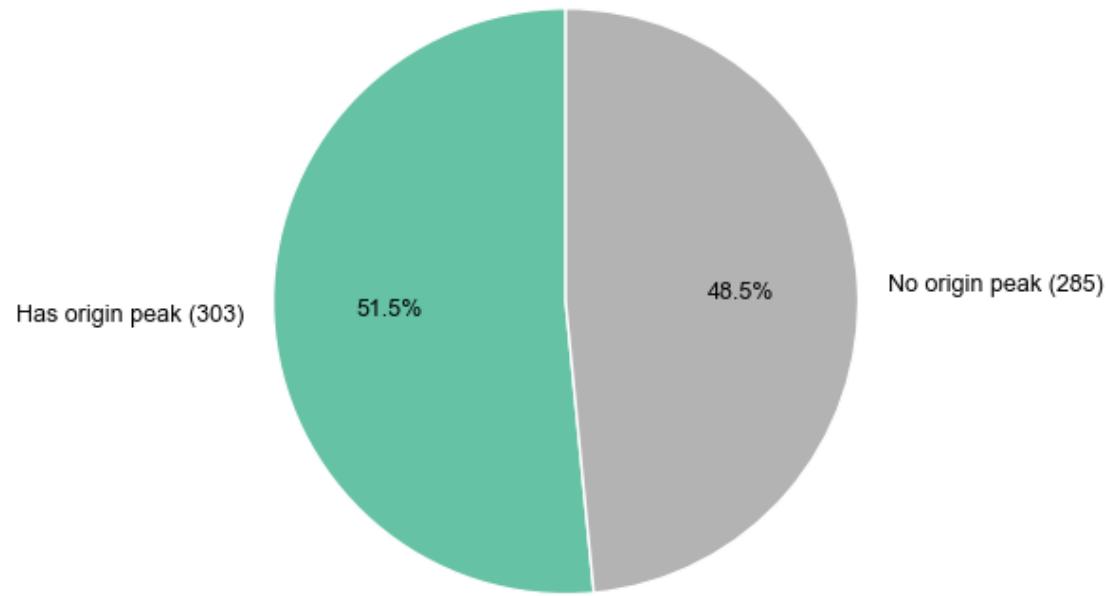


```
[2025-08-13 12:20:19] [INFO] calcium: plot_histogram_by_group: removed 22 outliers out of 837 on 'Speed (um/s)' (lower=-12.7, upper=21.11)
```

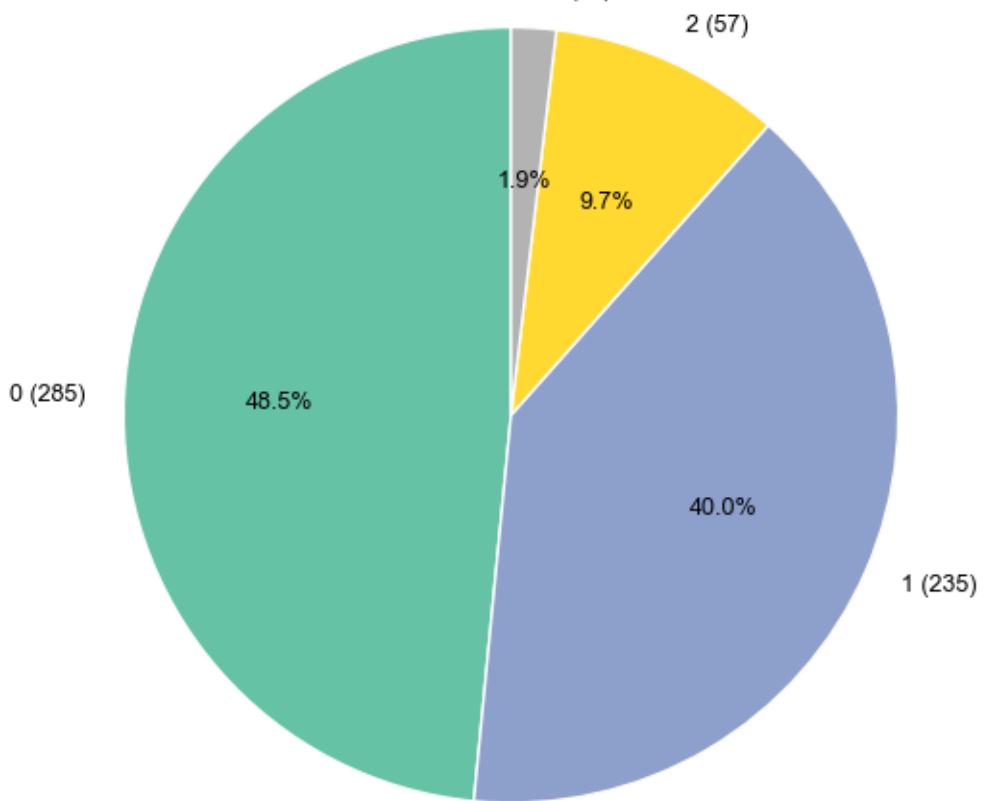


1.3.7 Cells occurrences as origin in sequential events

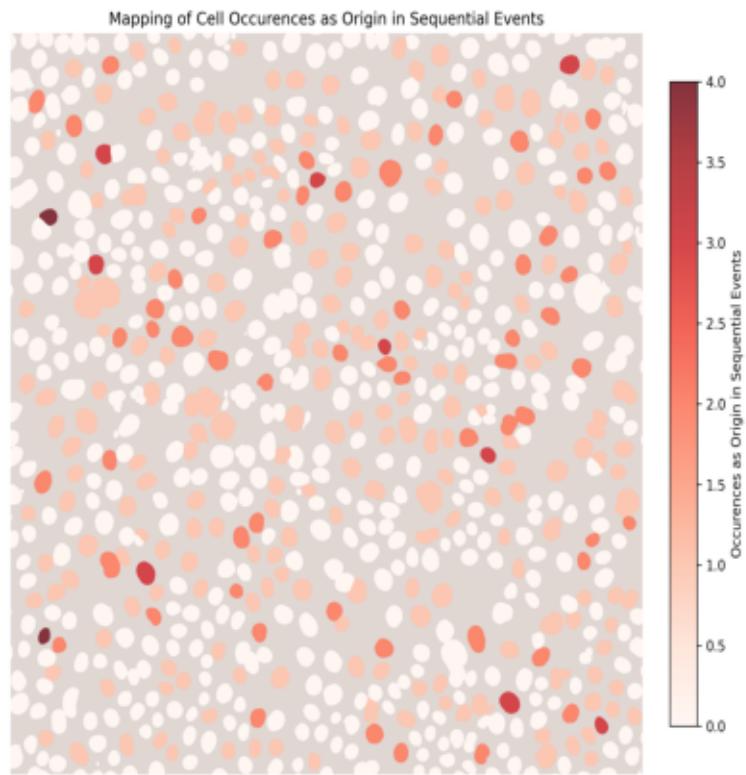
Distribution of Number of Sequential Event Origin Peaks per Cell



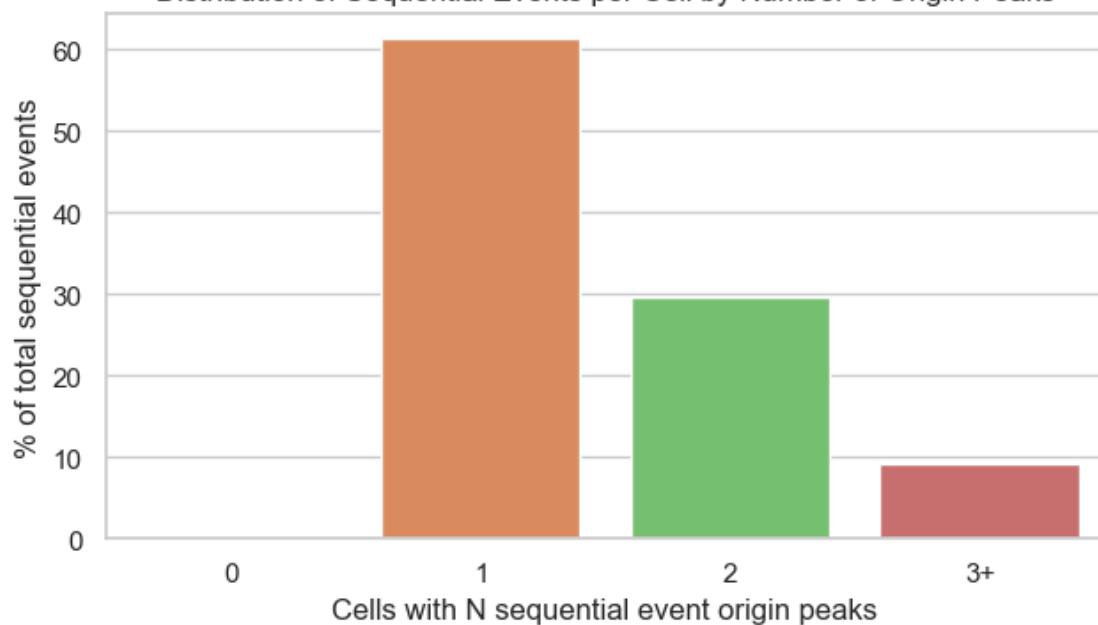
Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)



Cell Mapping with Origin Peaks Overlay - 20250624_IS01

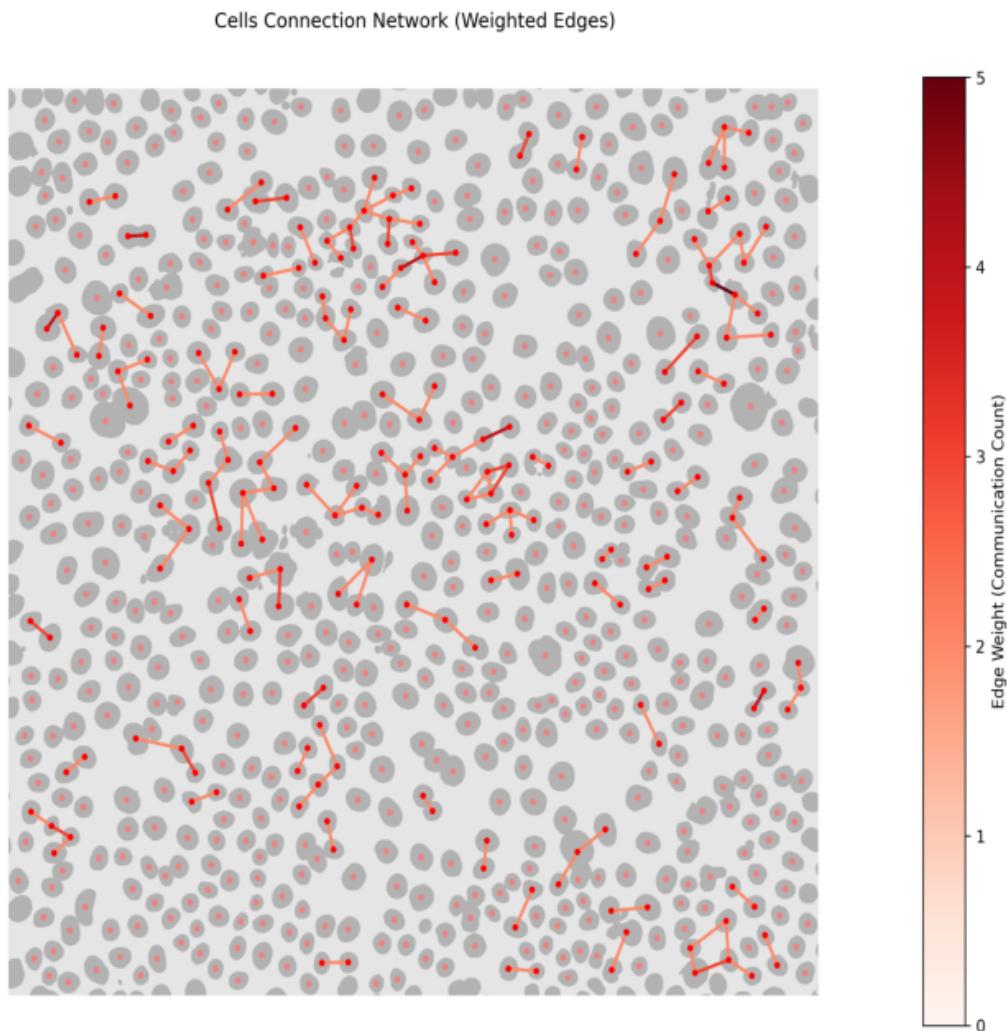


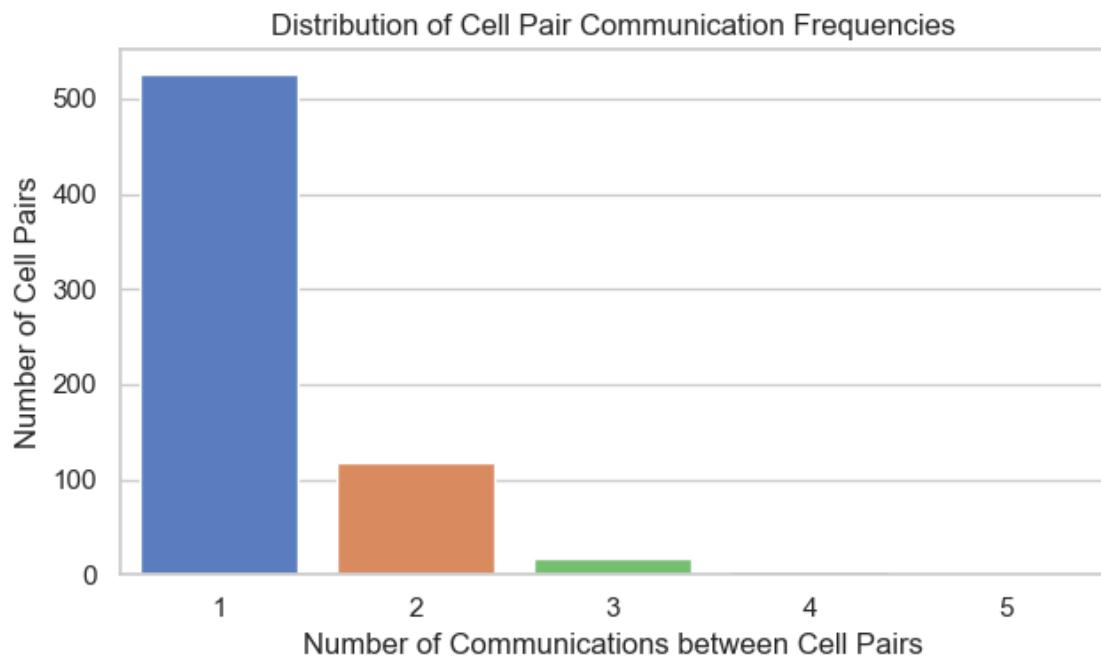
Distribution of Sequential Events per Cell by Number of Origin Peaks



1.3.8 Connection network between cells

Cell Connection Network Graph - 20250624_IS01

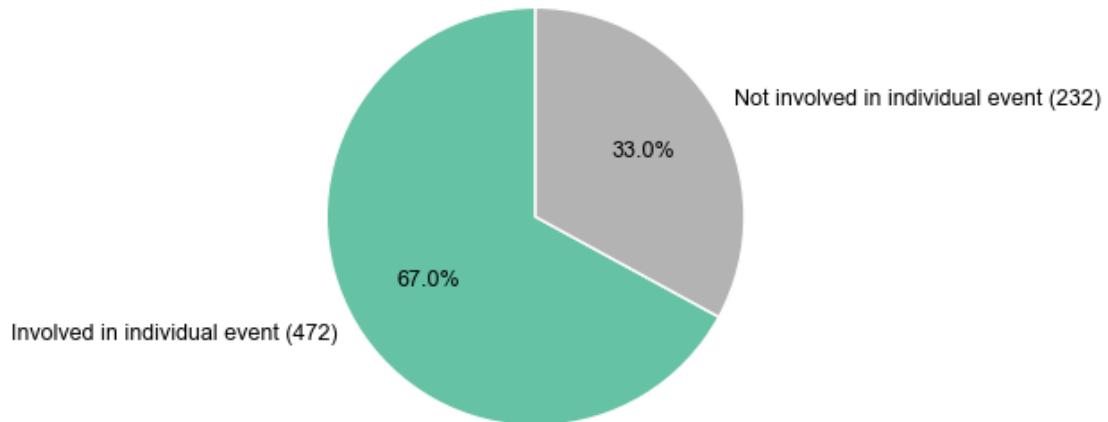




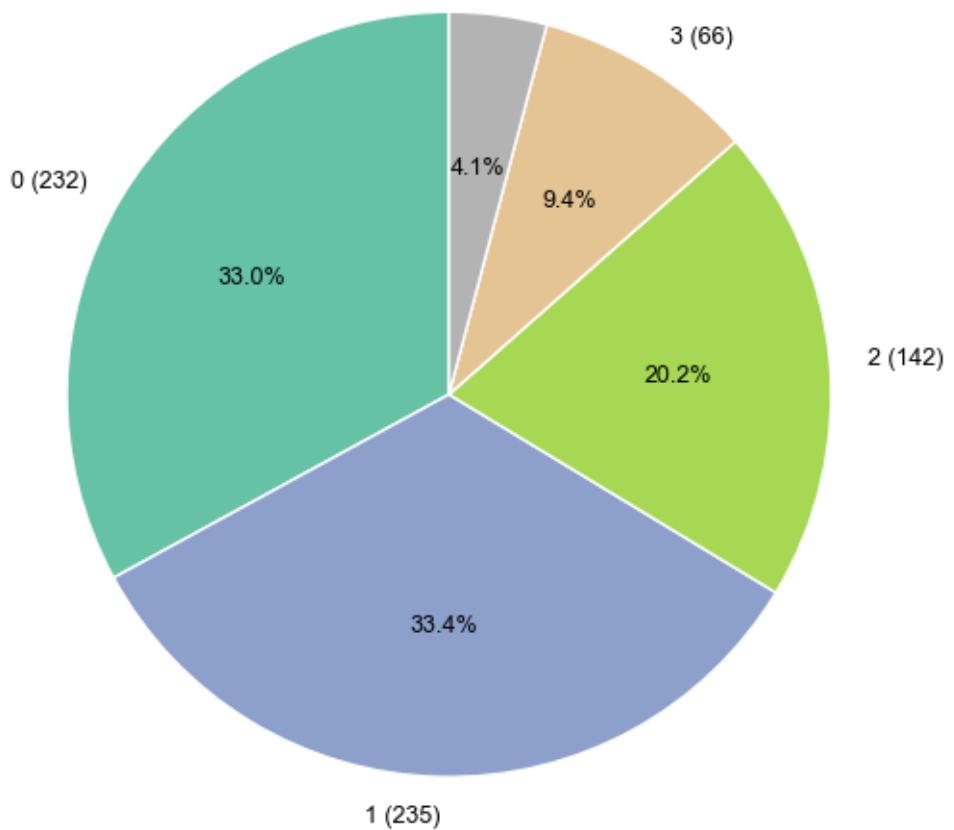
1.4 INDIVIDUAL EVENTS

1.4.1 Cells occurrences in individual events

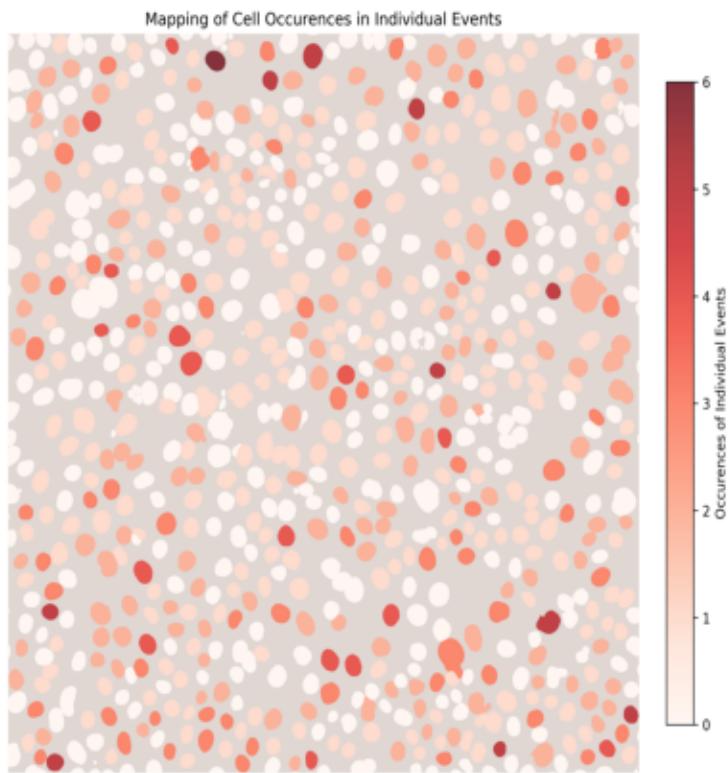
Distribution of Cells Involved in Individual Events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)
4+ (29)

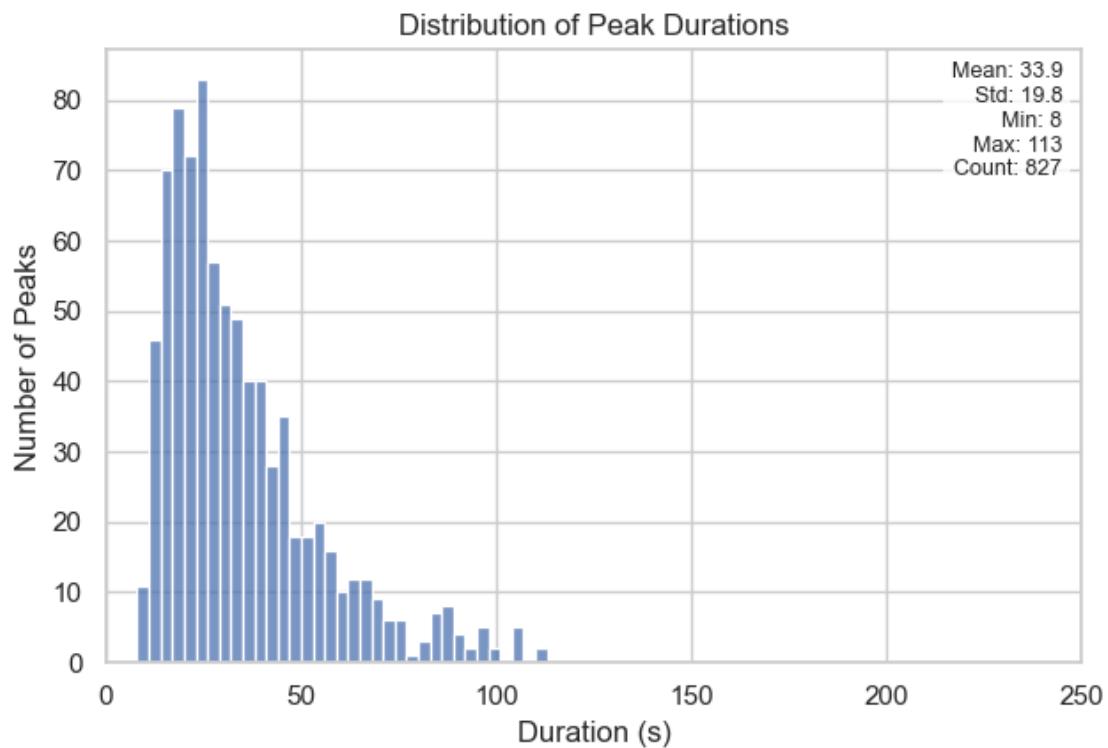


Cell Mapping with Occurrences in Individual Events Overlay - 20250624_IS01

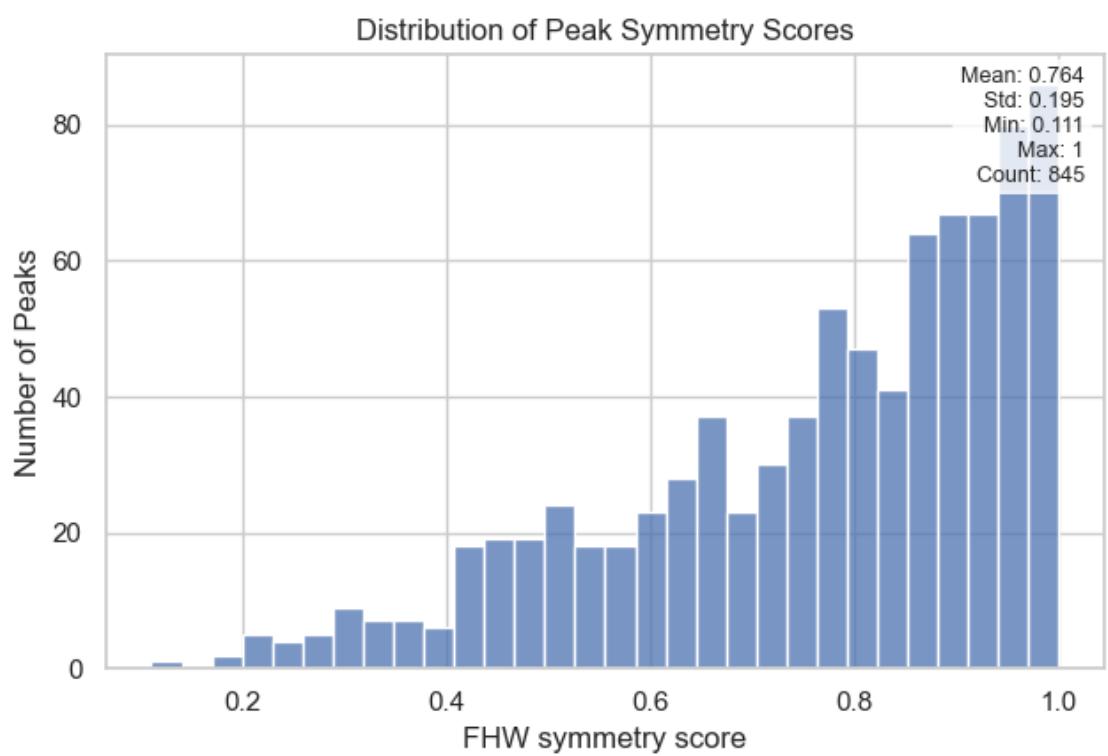
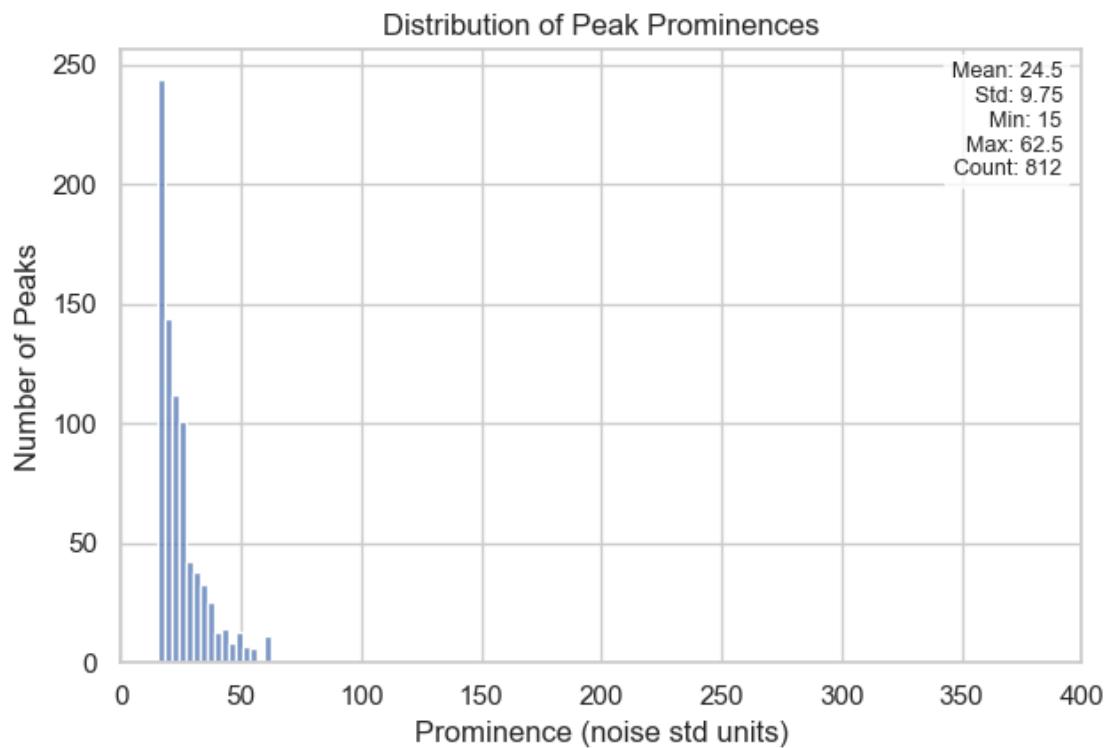


1.4.2 Peaks statistics in individual events

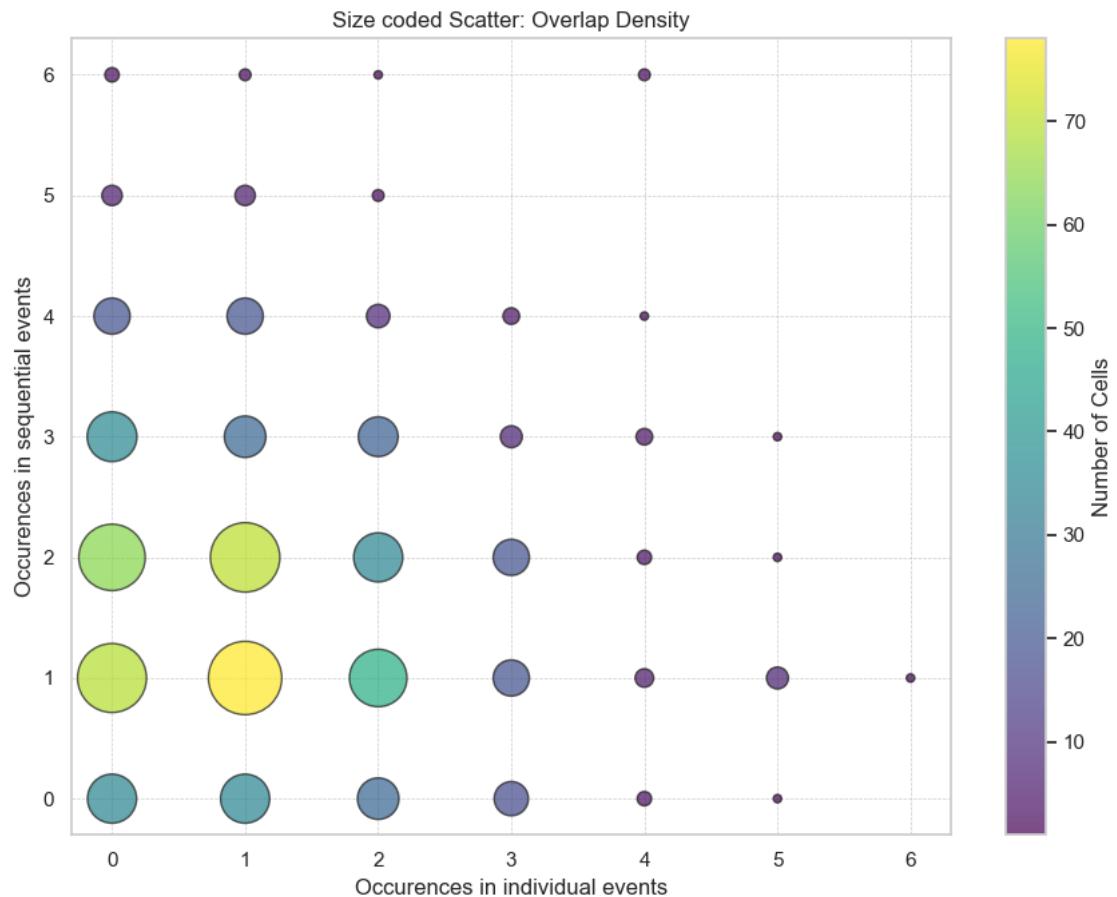
```
[2025-08-13 12:20:25] [INFO] calcium: plot_histogram: removed 18 outliers out of  
845 on 'Duration (s)' (lower=-52, upper=116)
```



```
[2025-08-13 12:20:26] [INFO] calcium: plot_histogram: removed 33 outliers out of 845 on 'Prominence (noise std units)' (lower=-16.3, upper=62.8)
```

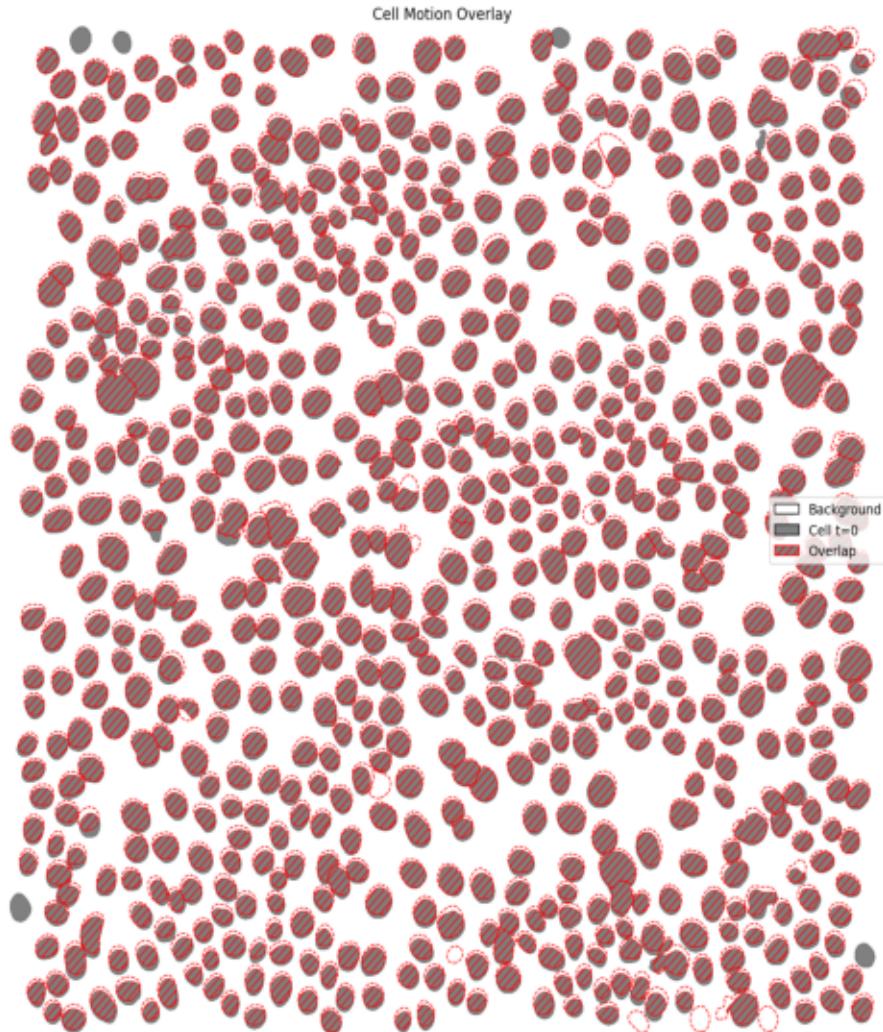


1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250624_IS01



Number of cells:

- Hoechst image taken at t=0: 704
- Hoechst image taken at t=1801: 700
- Number of cells difference: absolute 4, relative 0.57%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 864200
- Pixels segmented as cell at t=1801: 858437
- Overlapping pixels between t=0 and t=1801: 706604 (82.04% of total)
- Pixels exclusive to t=0: 157596 (18.24% of total)
- Pixels exclusive to t=1801: 151833 (17.69% of total)

executed

August 13, 2025

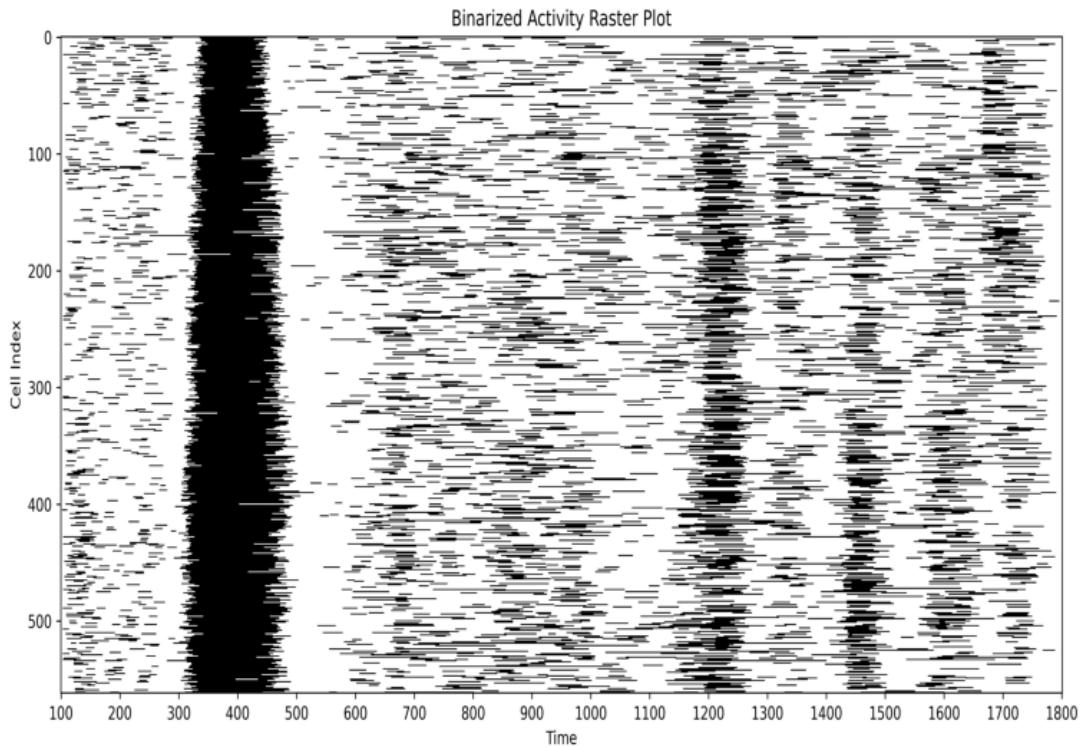
1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

1.0.1 Initialization

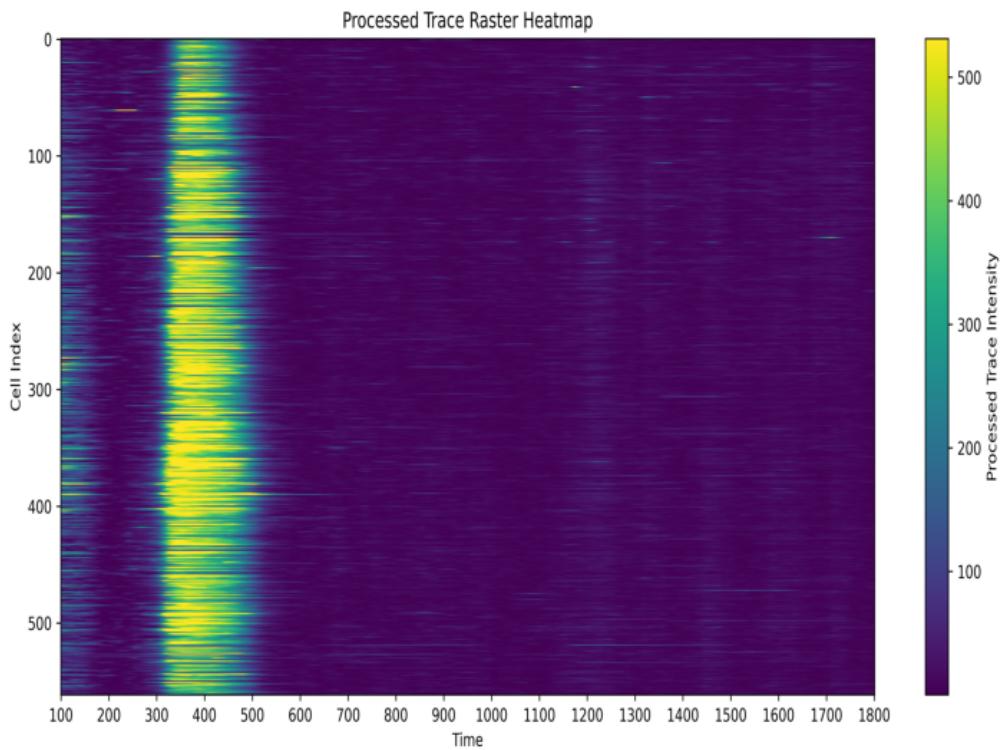
1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot

Binary Activity Raster Plot - 20250624_IS03



Heatmap Activity Raster Plot - 20250624_IS03



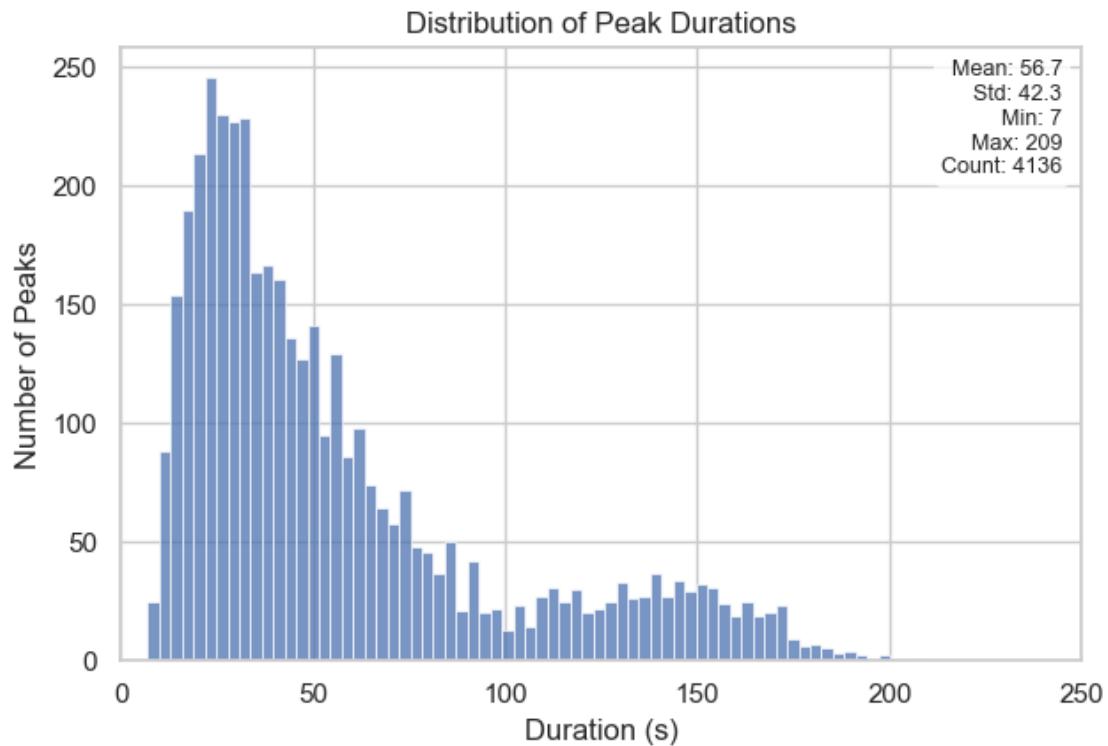
1.1.2 Peaks population

Total number of peaks: 4143

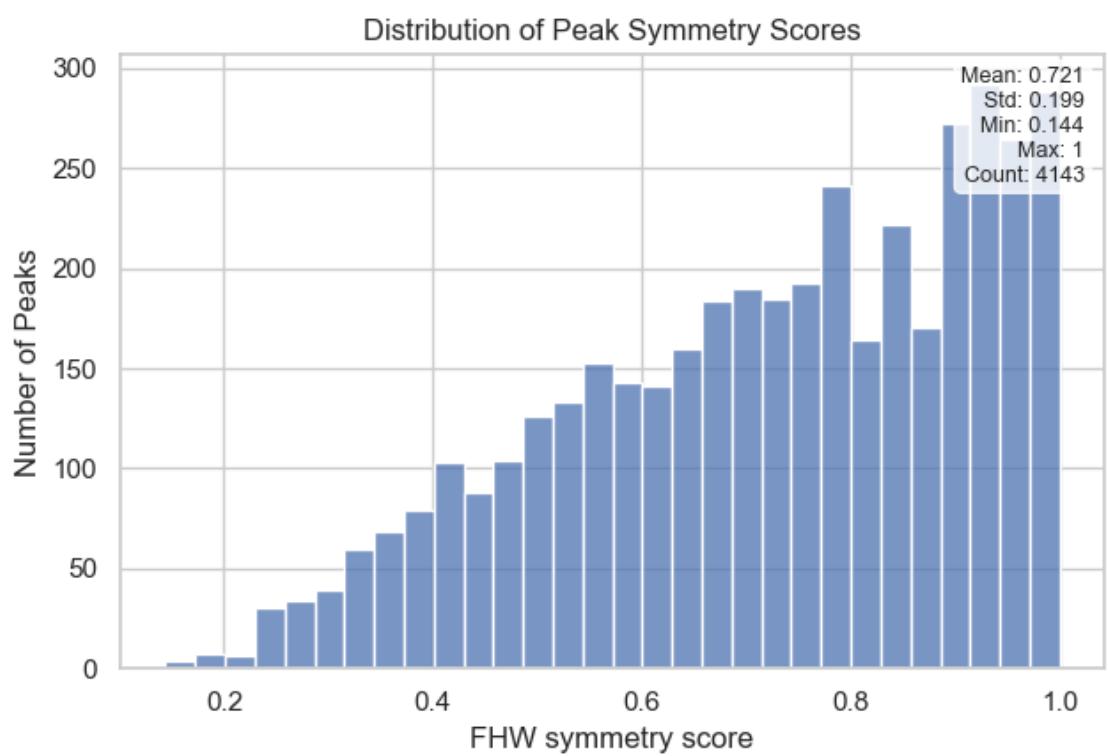
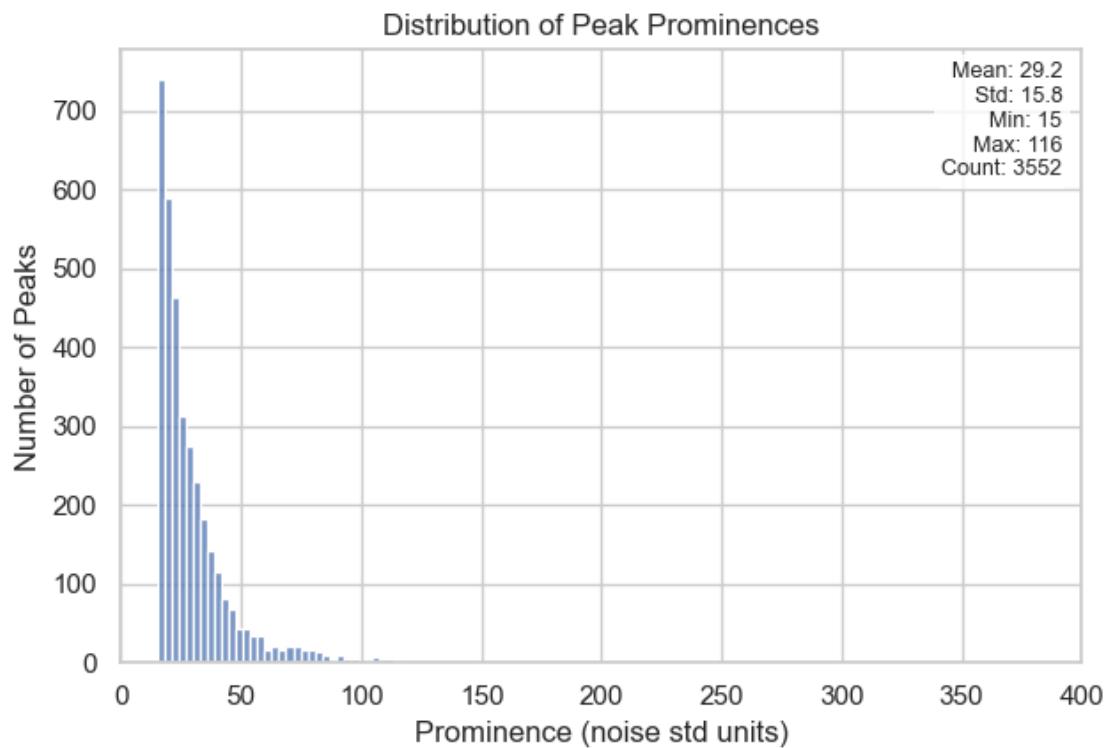
Total number of cells: 562

1.1.3 Peaks statistics

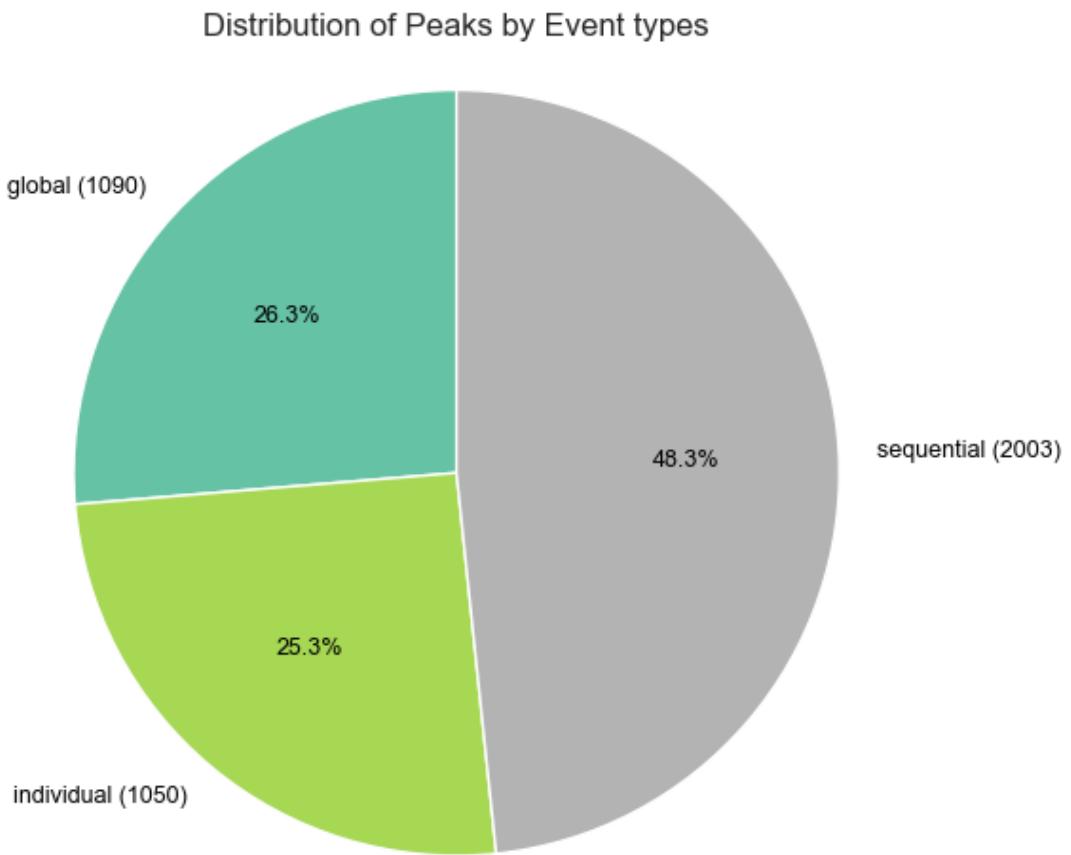
```
[2025-08-13 12:22:01] [INFO] calcium: plot_histogram: removed 7 outliers out of  
4143 on 'Duration (s)' (lower=-115, upper=214)
```



```
[2025-08-13 12:22:02] [INFO] calcium: plot_histogram: removed 591 outliers out  
of 4143 on 'Prominence (noise std units)' (lower=-54.35, upper=117.5)
```

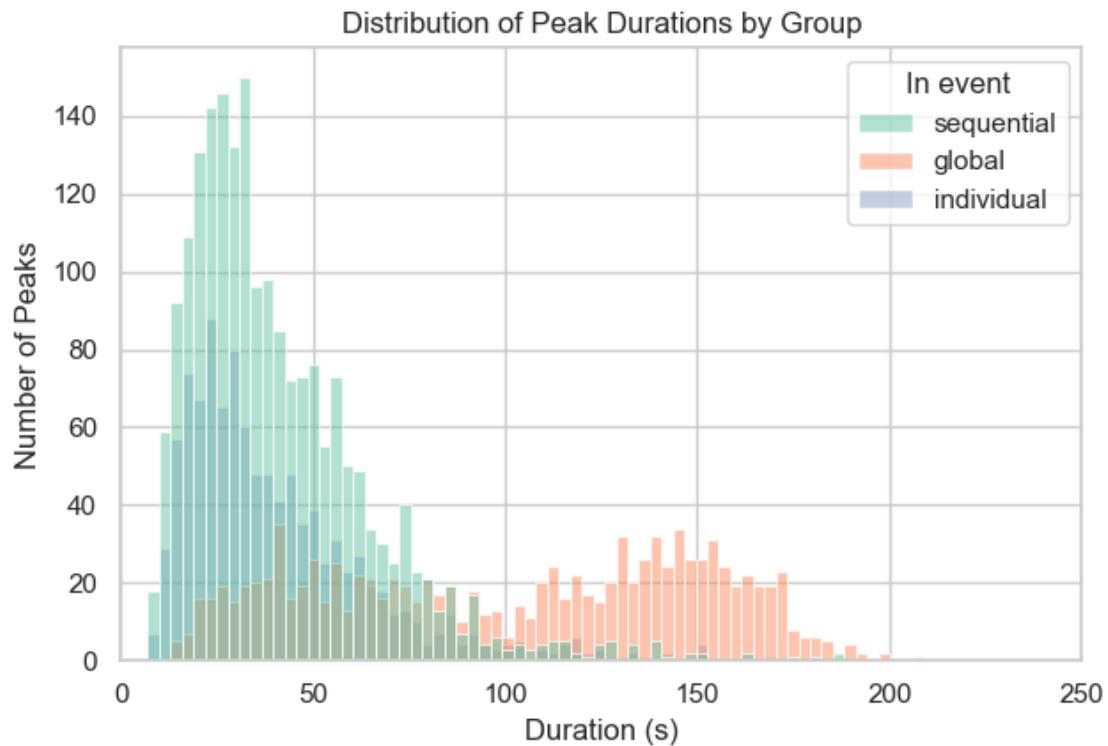


1.1.4 Distribution of peaks per event types

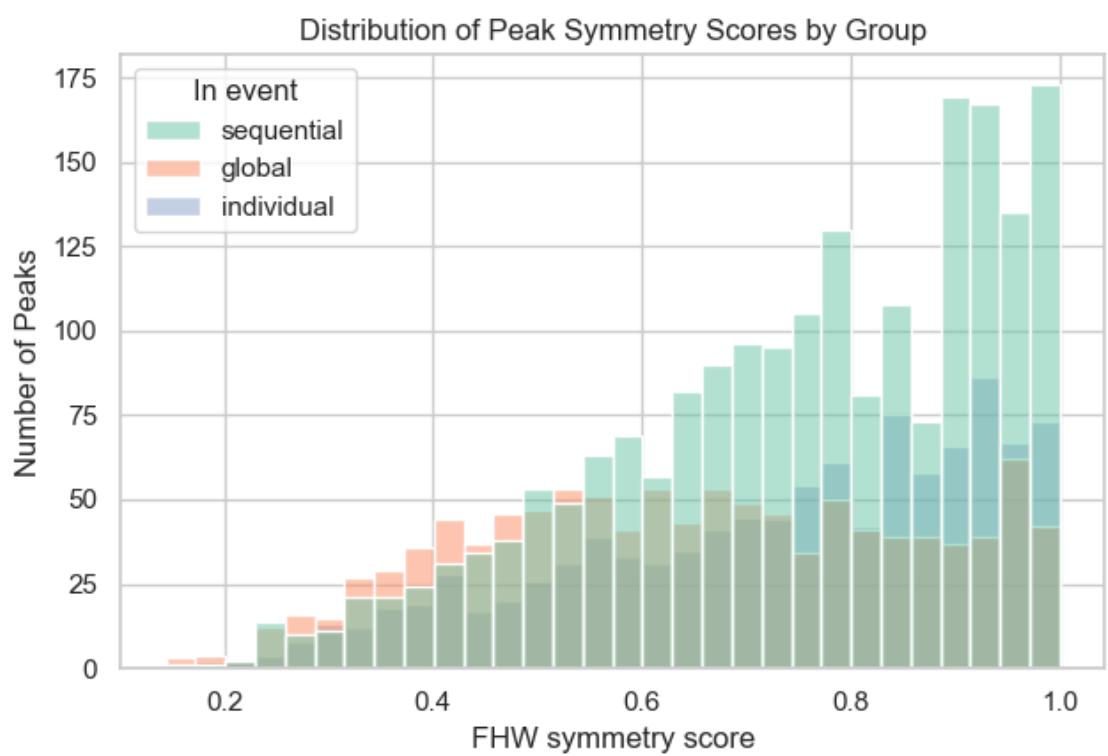
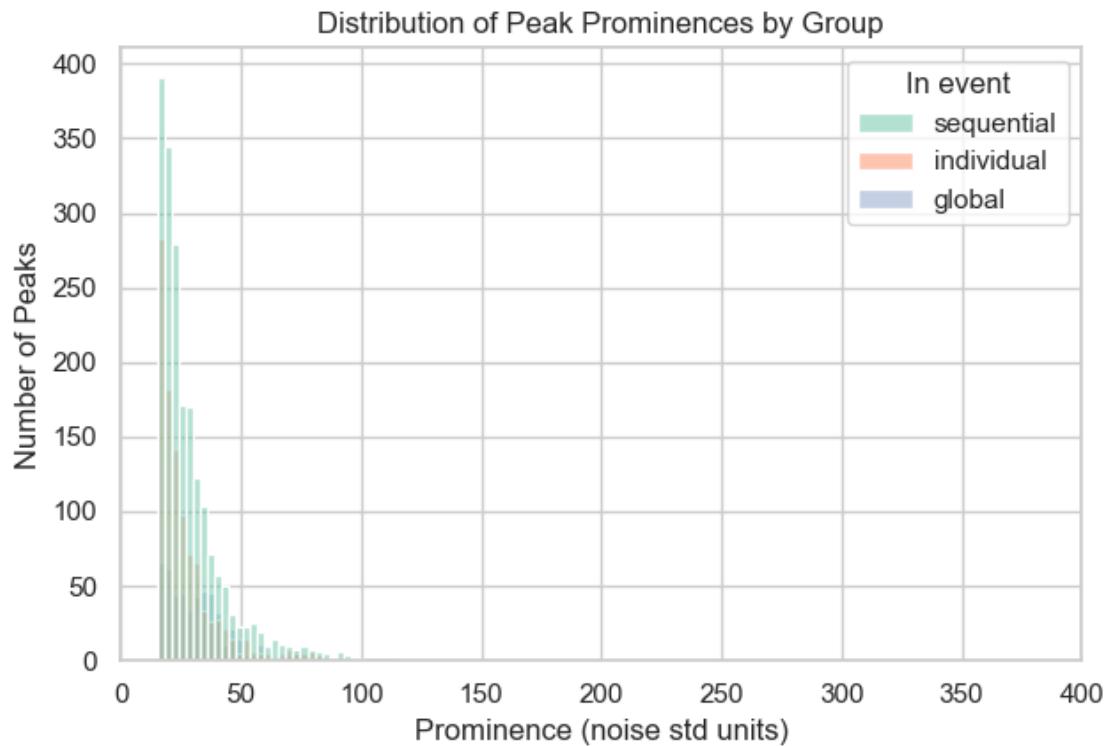


1.1.5 Peaks statistics per event types

```
[2025-08-13 12:22:02] [INFO] calcium: plot_histogram_by_group: removed 7 outliers out of 4143 on 'Duration (s)' (lower=-115, upper=214)
```



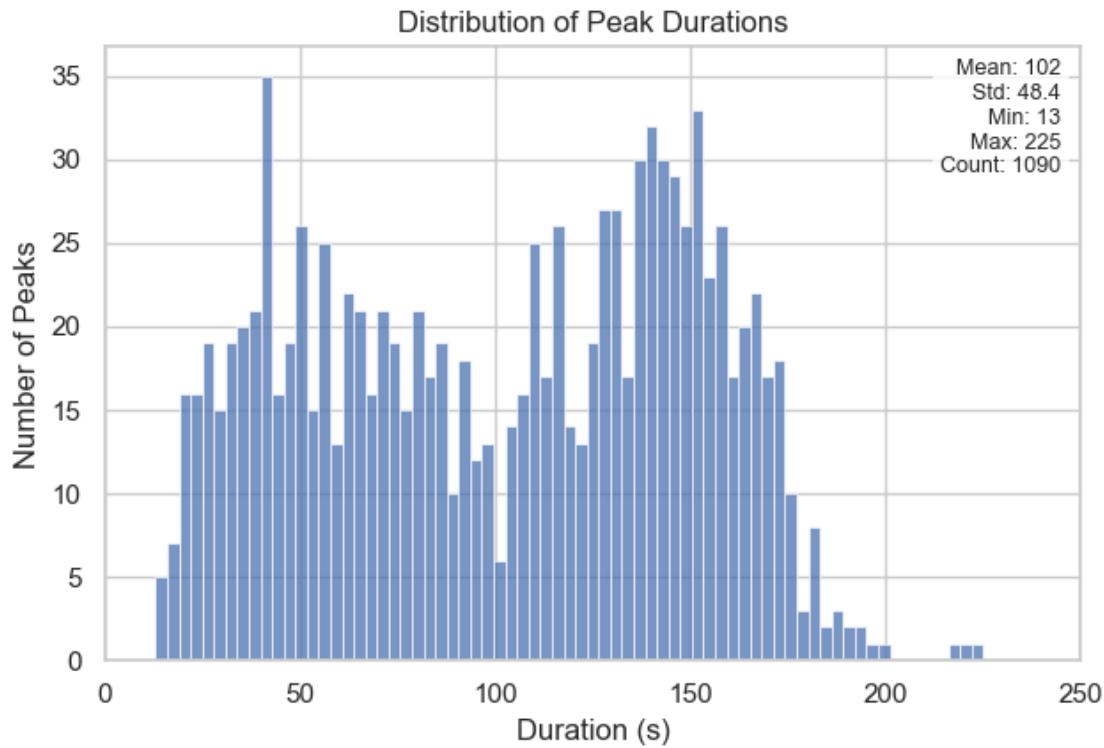
```
[2025-08-13 12:22:03] [INFO] calcium: plot_histogram_by_group: removed 591
outliers out of 4143 on 'Prominence (noise std units)' (lower=-54.35,
upper=117.5)
```



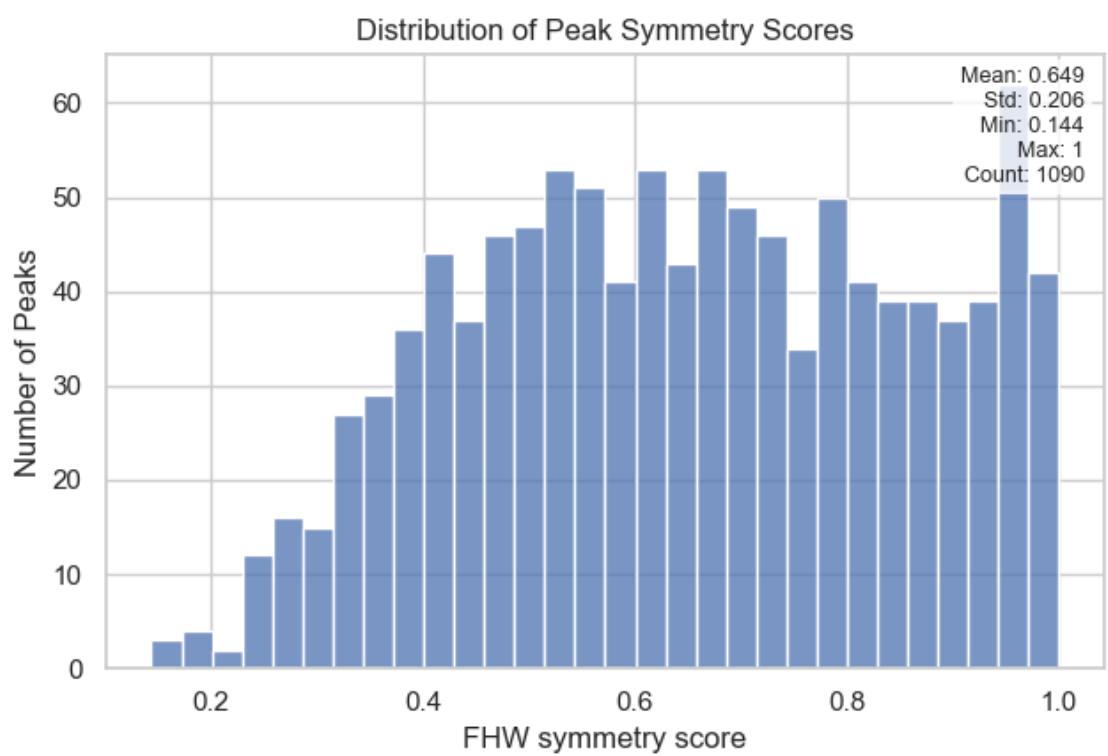
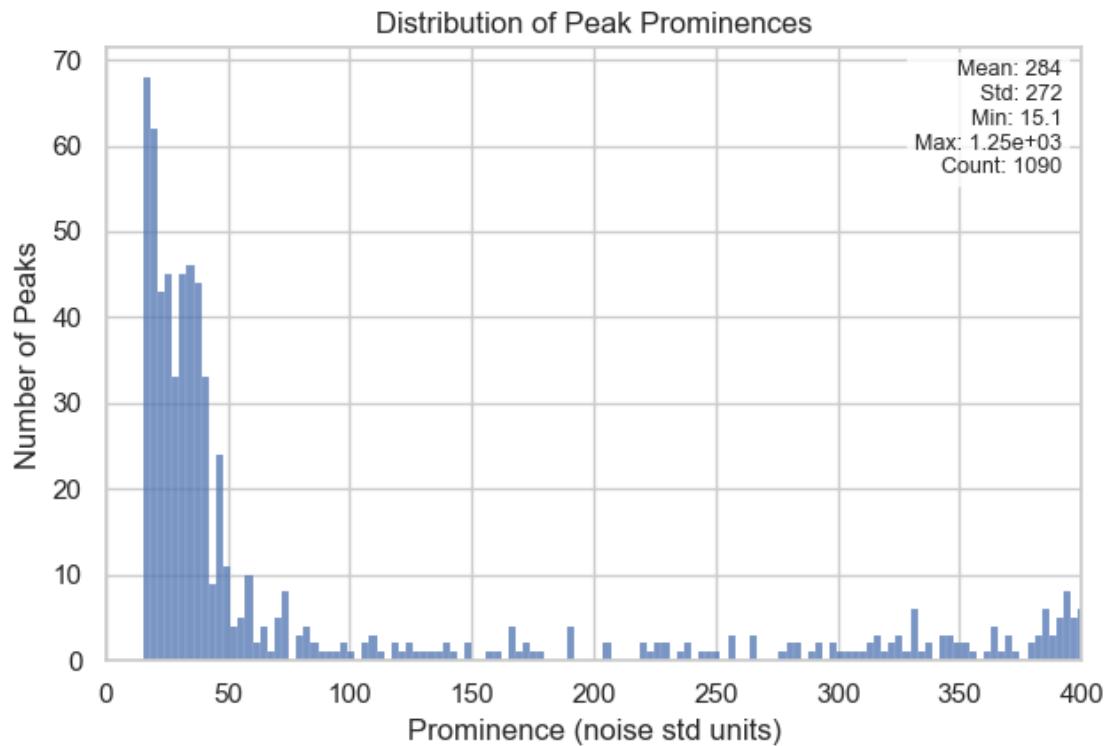
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

[2025-08-13 12:22:03] [INFO] calcium: plot_histogram: removed 0 outliers out of 1090 on 'Duration (s)' (lower=-204, upper=405)

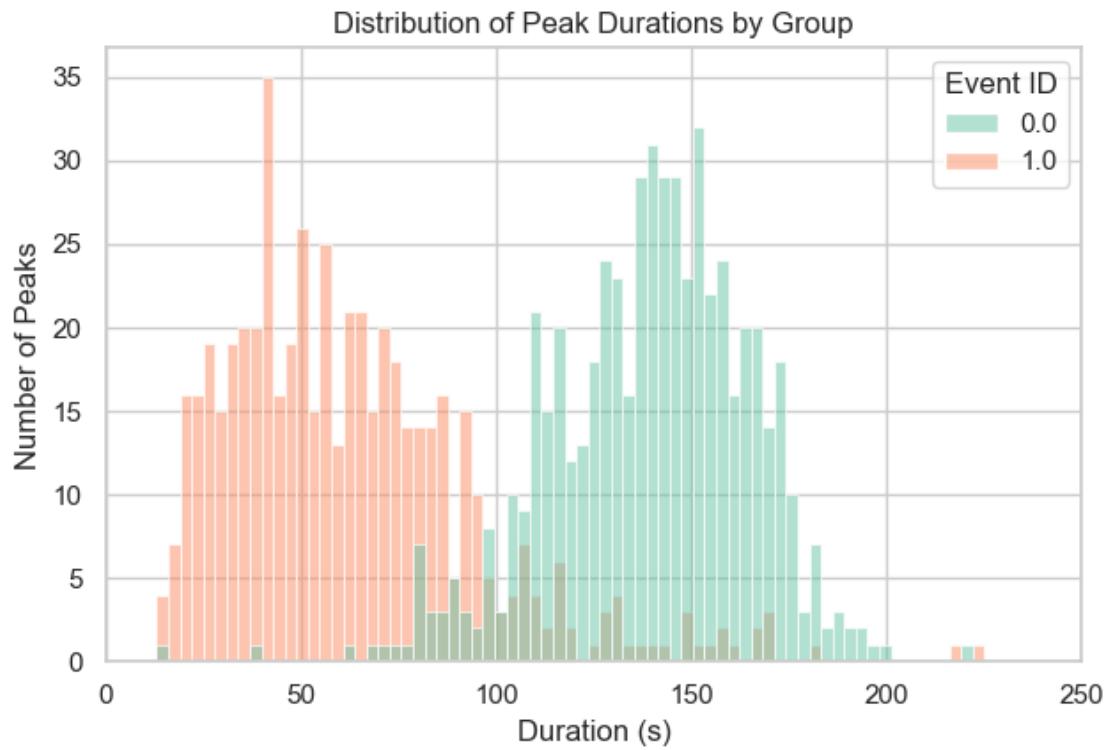


[2025-08-13 12:22:03] [INFO] calcium: plot_histogram: removed 0 outliers out of 1090 on 'Prominence (noise std units)' (lower=-1448.5, upper=2003.7)

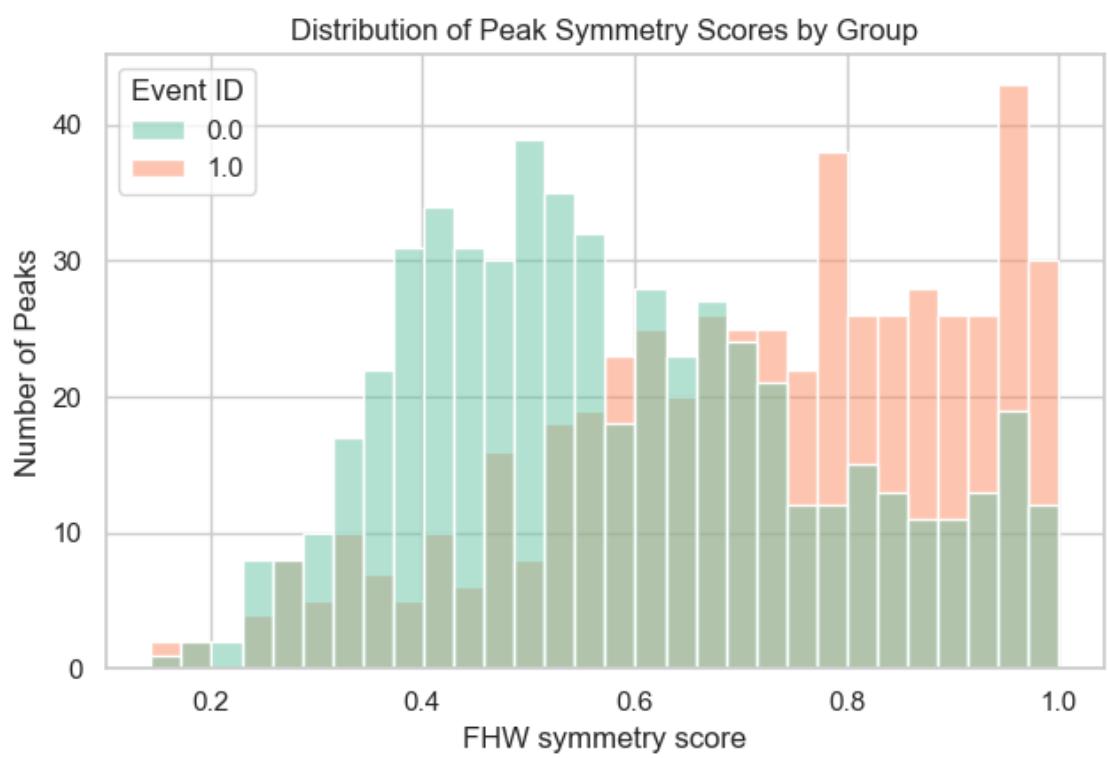
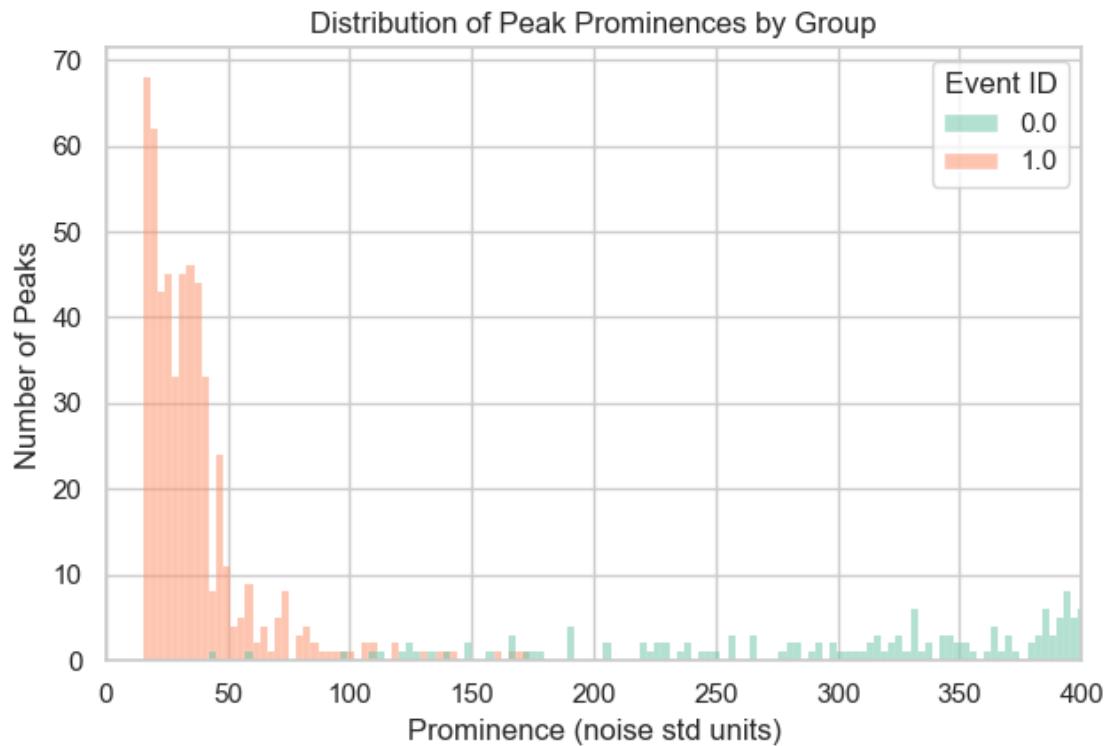


1.2.2 Peak statistics in global event per event ID

[2025-08-13 12:22:04] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 1090 on 'Duration (s)' (lower=-204, upper=405)

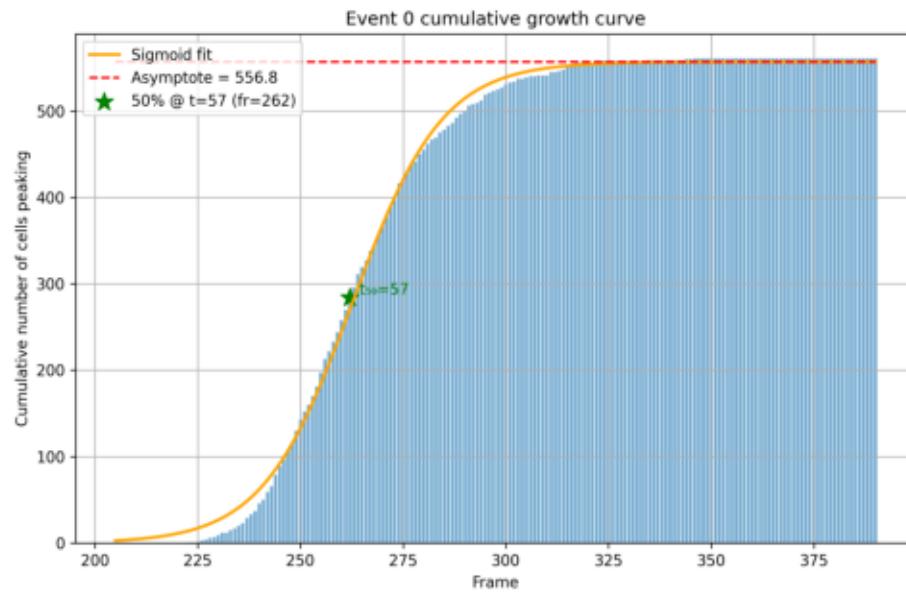


[2025-08-13 12:22:04] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 1090 on 'Prominence (noise std units)' (lower=-1448.5, upper=2003.7)

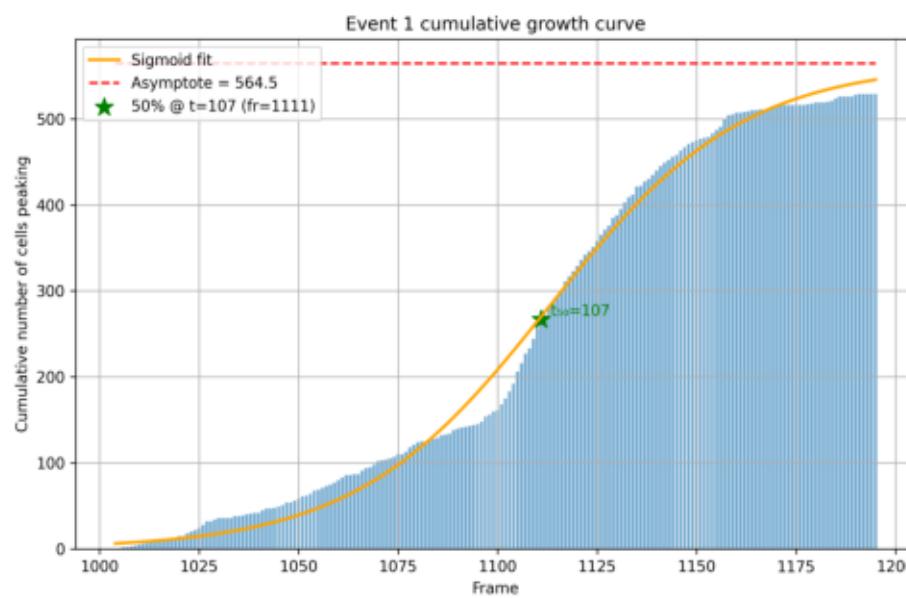


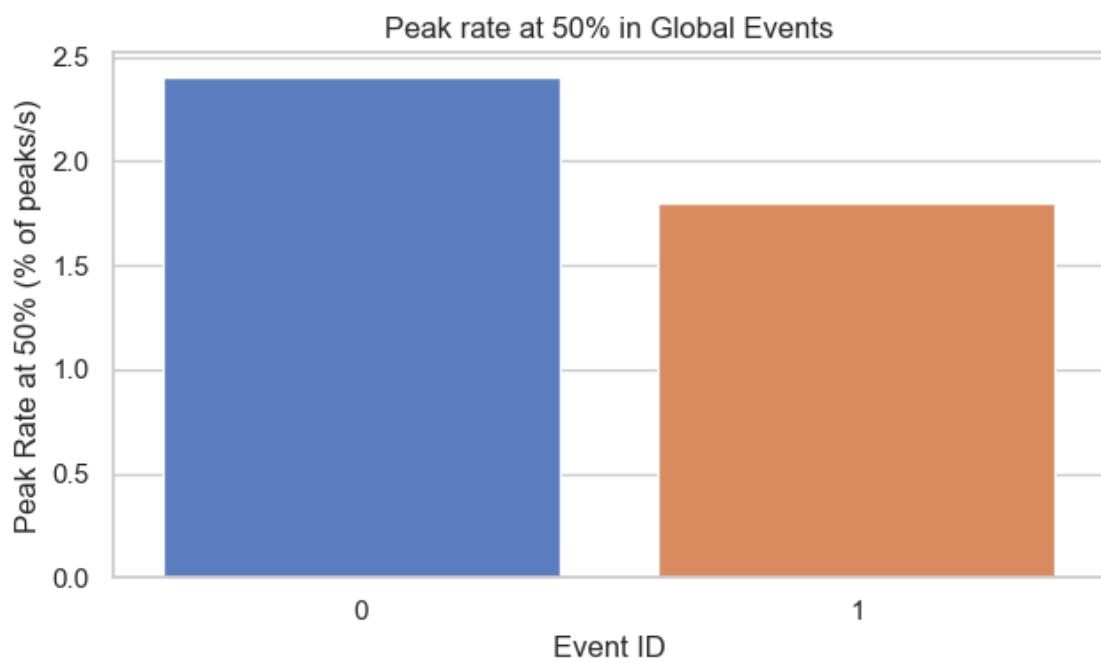
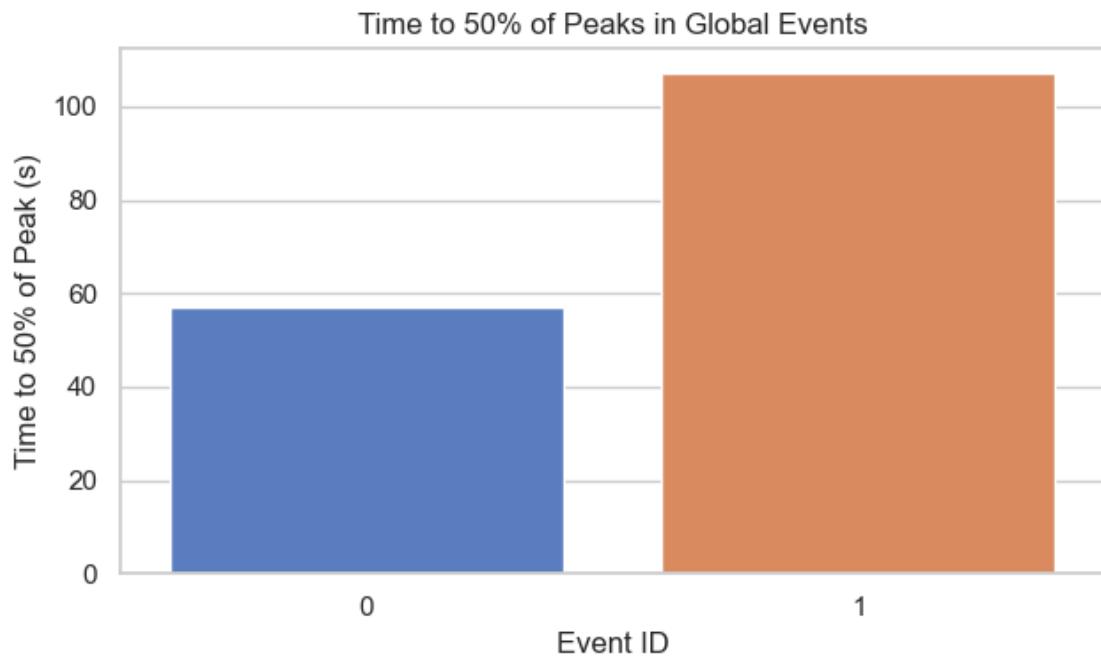
1.2.3 Kinetics of global events

Event Activity Overlay (Event ID: 0) - 20250624_IS03

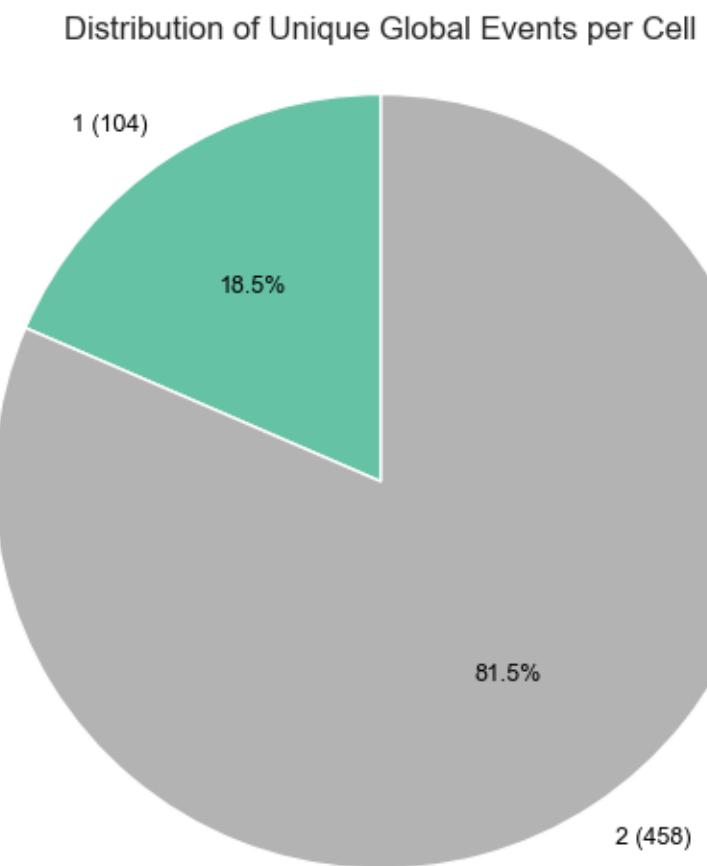


Event Activity Overlay (Event ID: 1) - 20250624_IS03

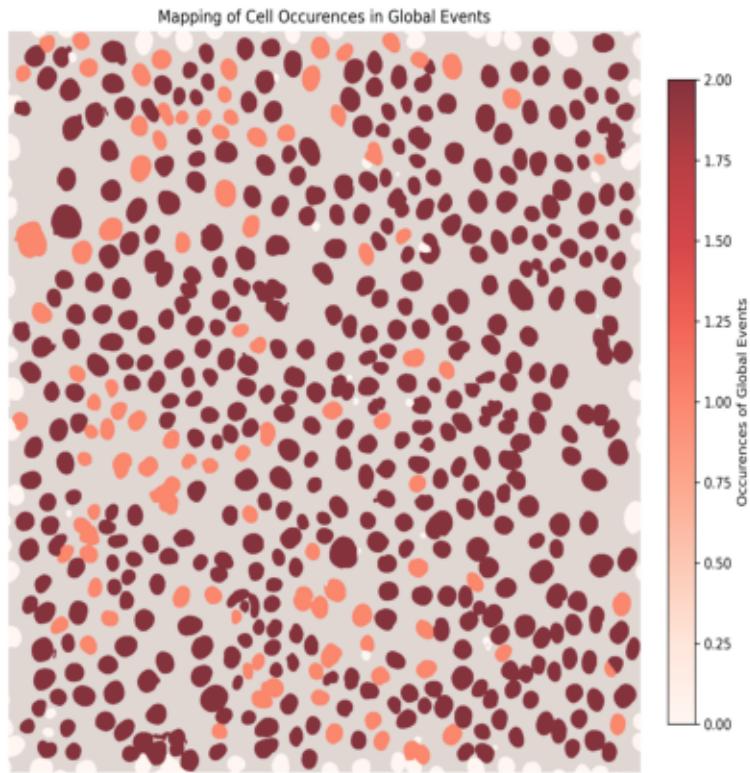


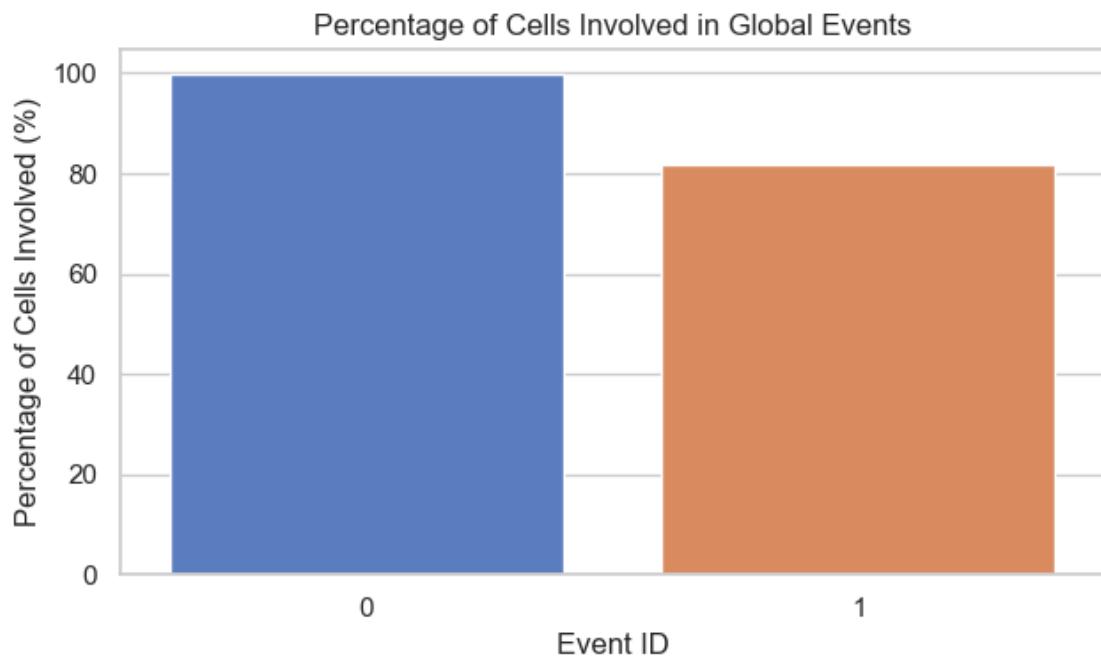


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250624_IS03



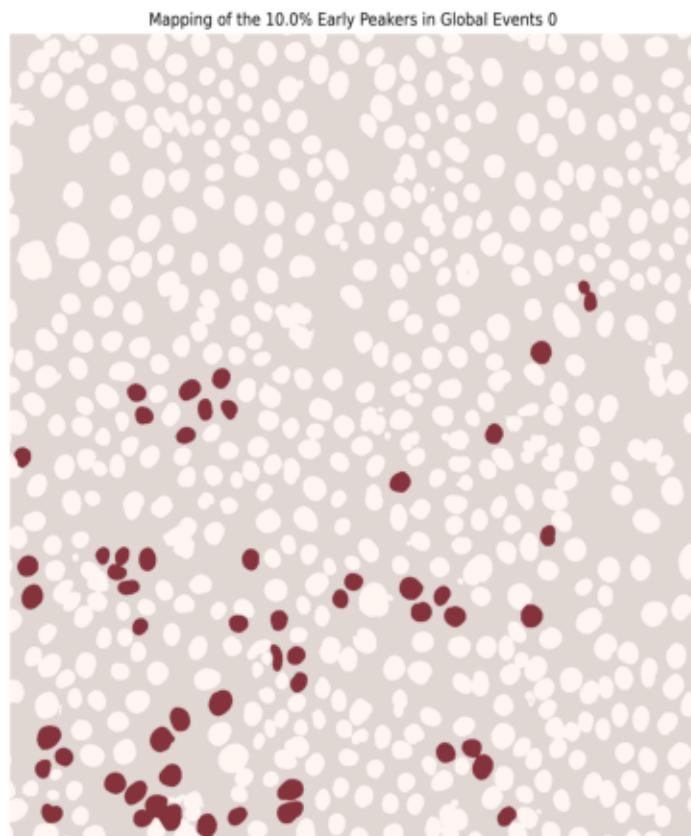


1.2.5 Inter-event interval analysis

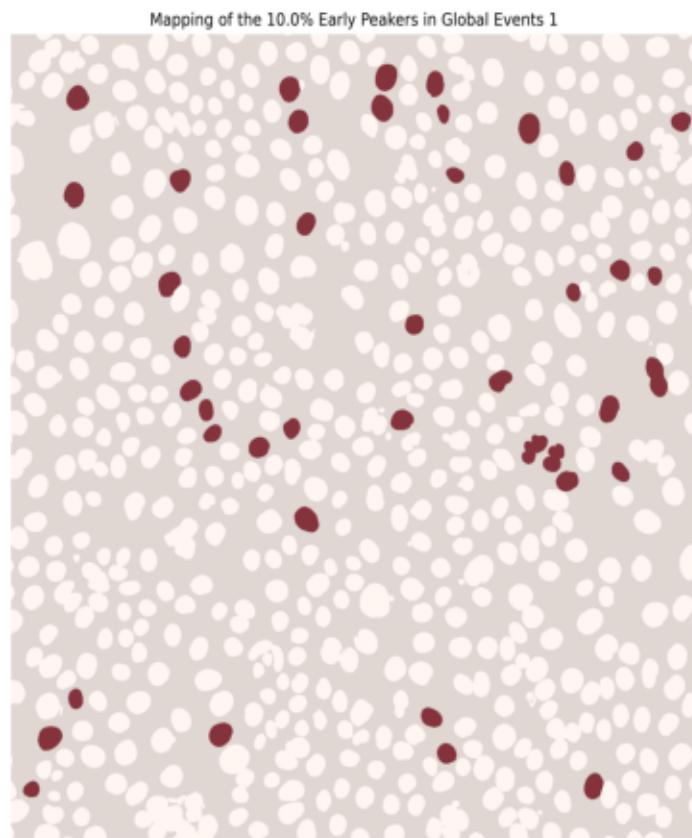
Intervals between global event peaks: [832.0]

1.2.6 Early peakers in the events

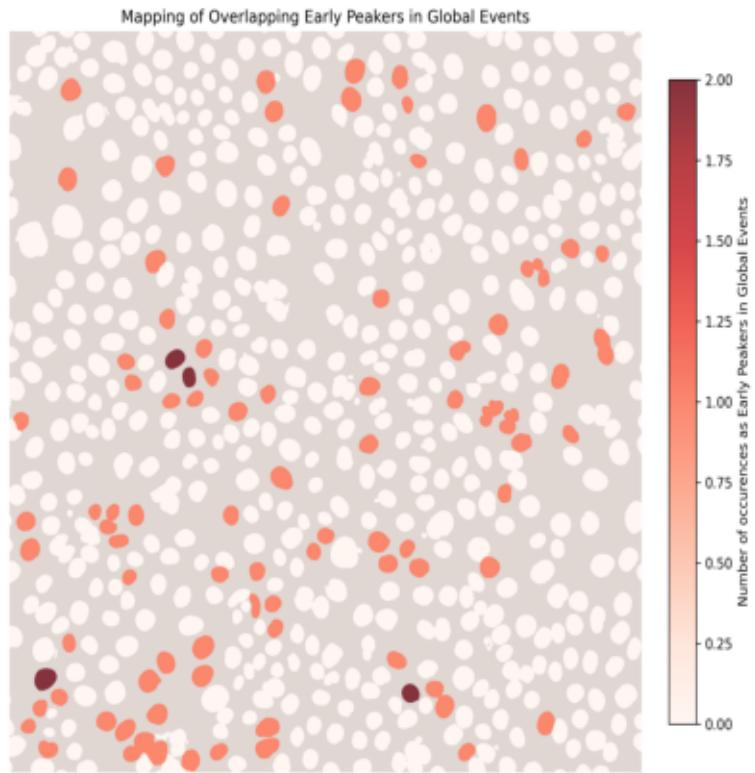
Cell Mapping with Early Peakers Overlay for event 0 - 20250624_IS03



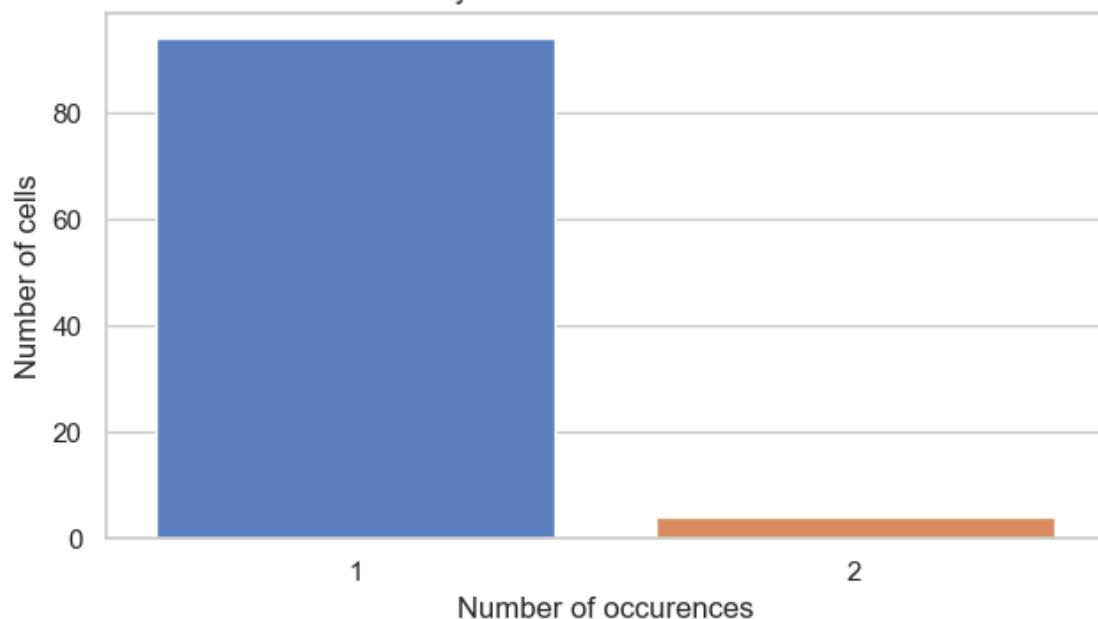
Cell Mapping with Early Peakers Overlay for event 1 - 20250624_IS03



Cell Mapping with Occurrences in Global Events Overlay - 20250624_IS03



Early Peakers in Global Events



Distribution of Early Peakers in Global Events

2 (4)

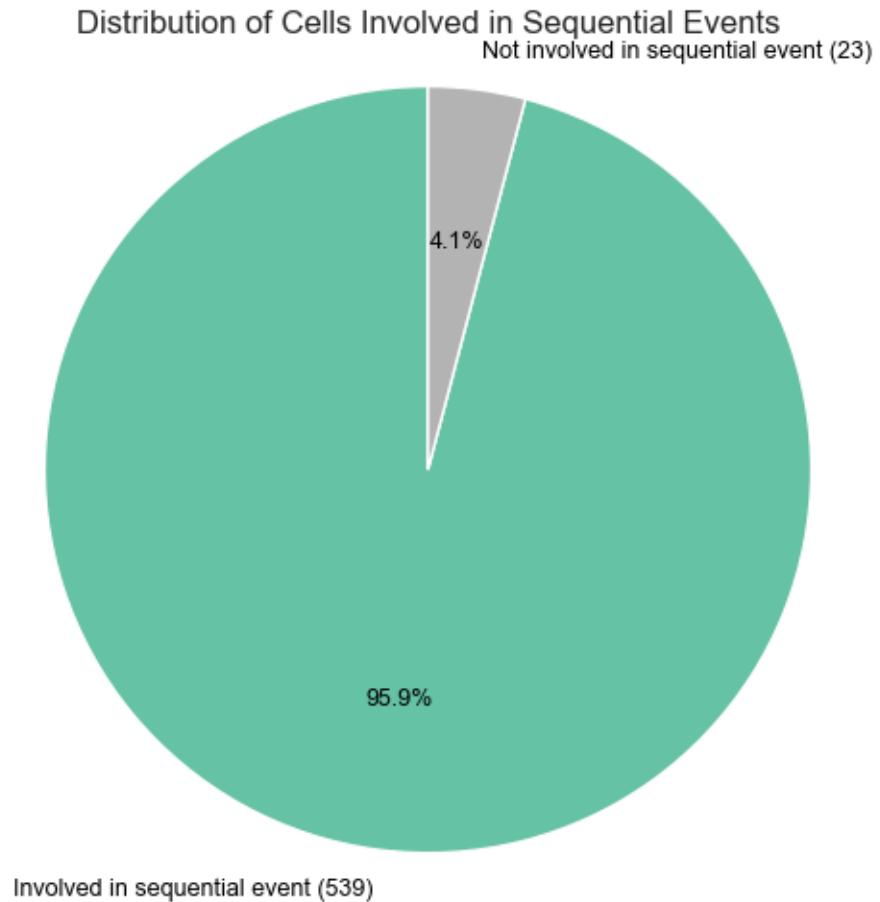
4.1%

95.9%

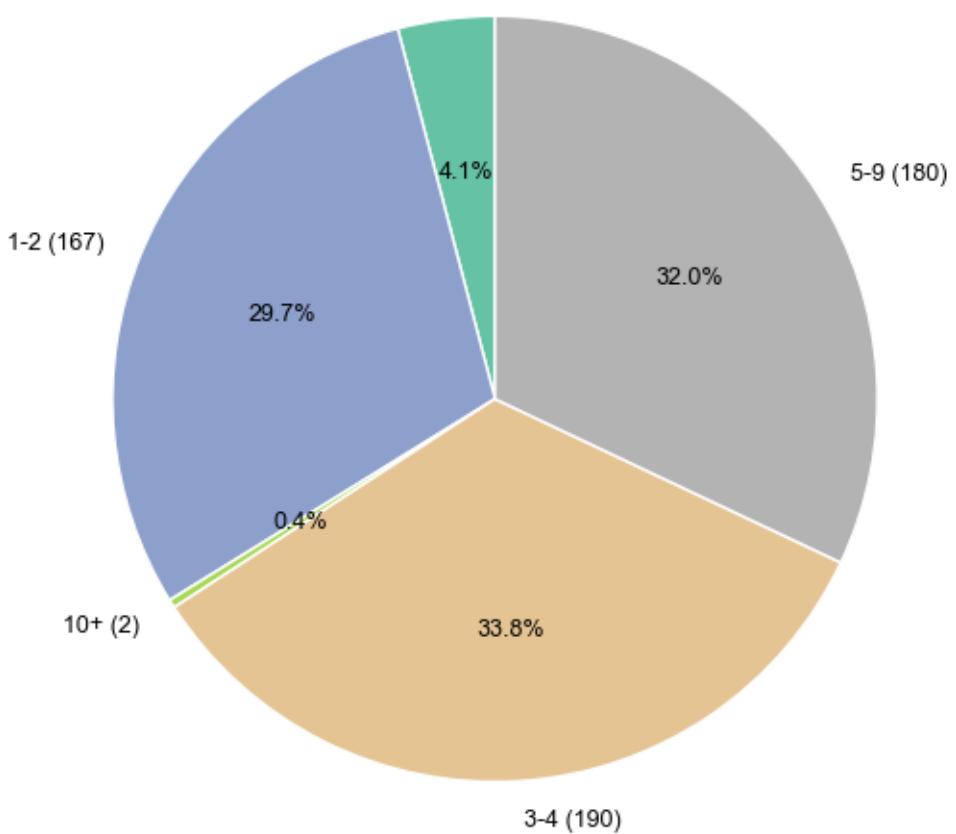
1 (94)

1.3 SEQUENTIAL EVENTS

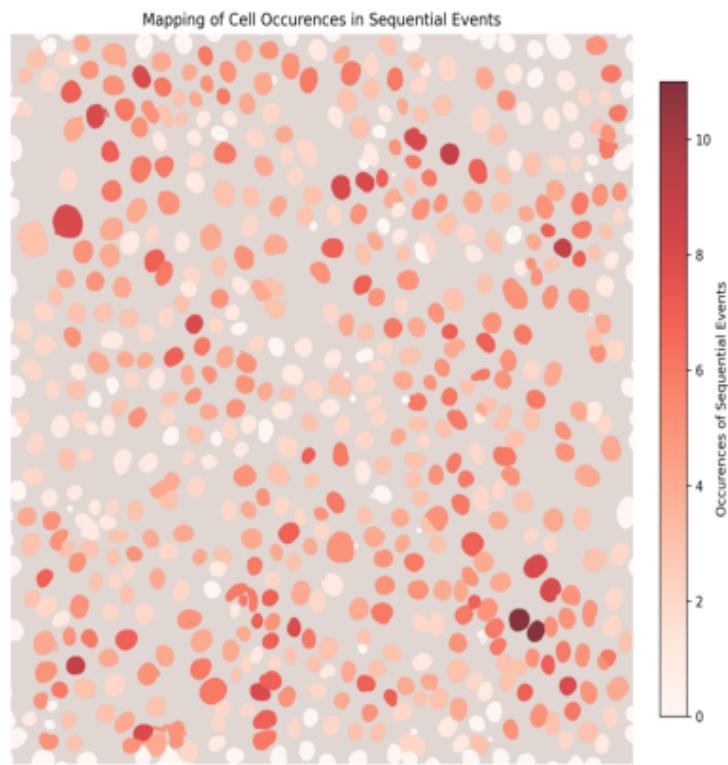
1.3.1 Cells occurrences in sequential events



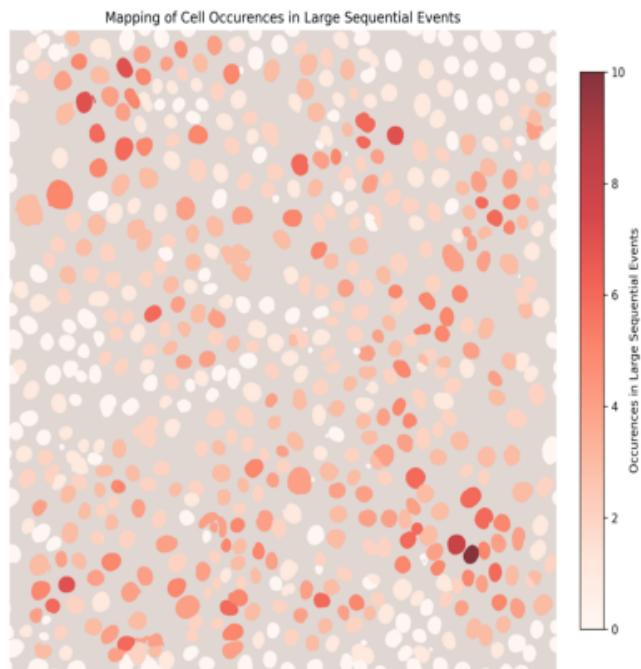
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250624_IS03

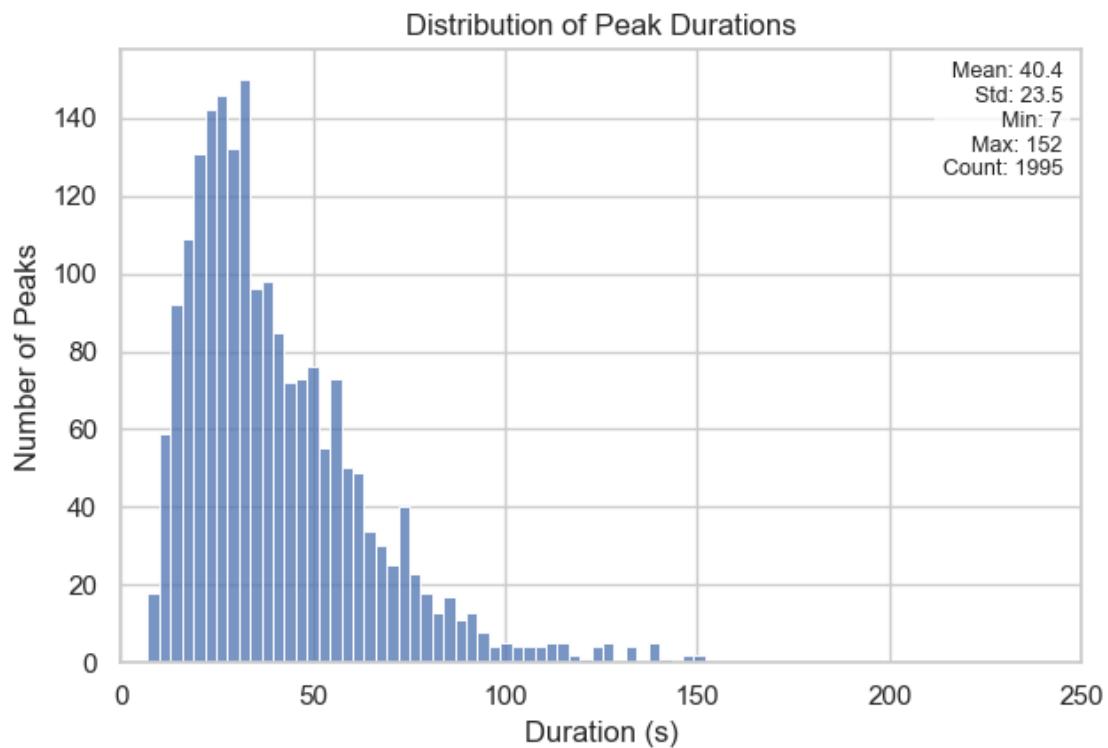


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250624_IS03

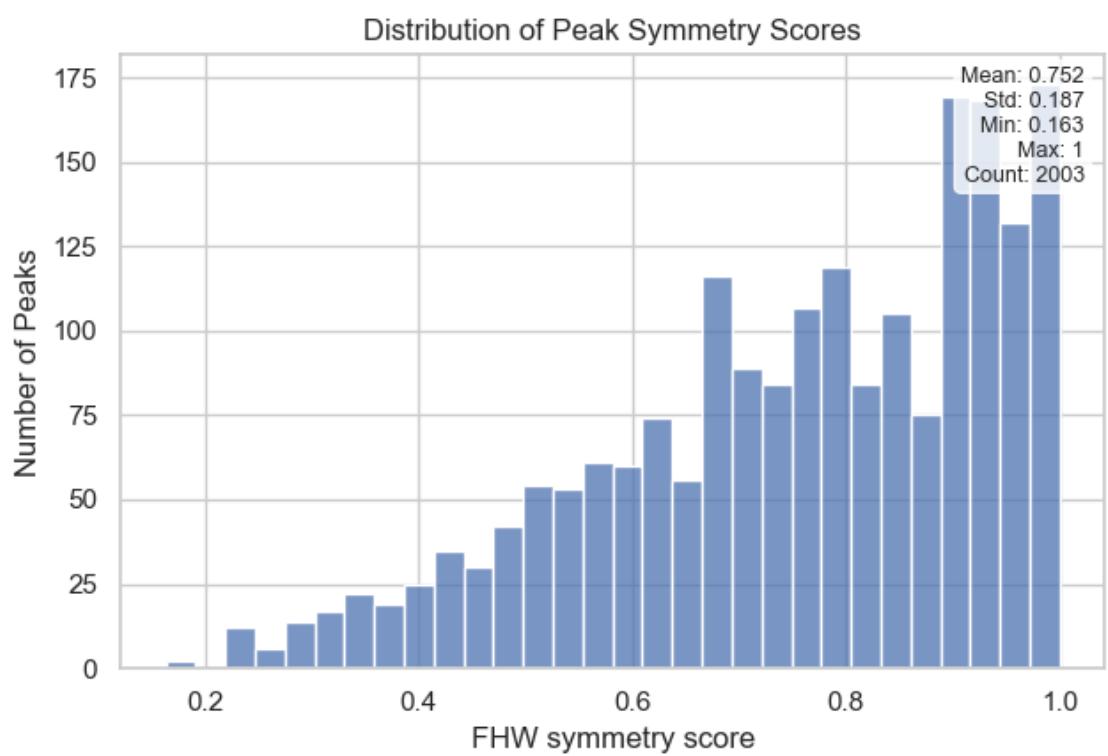
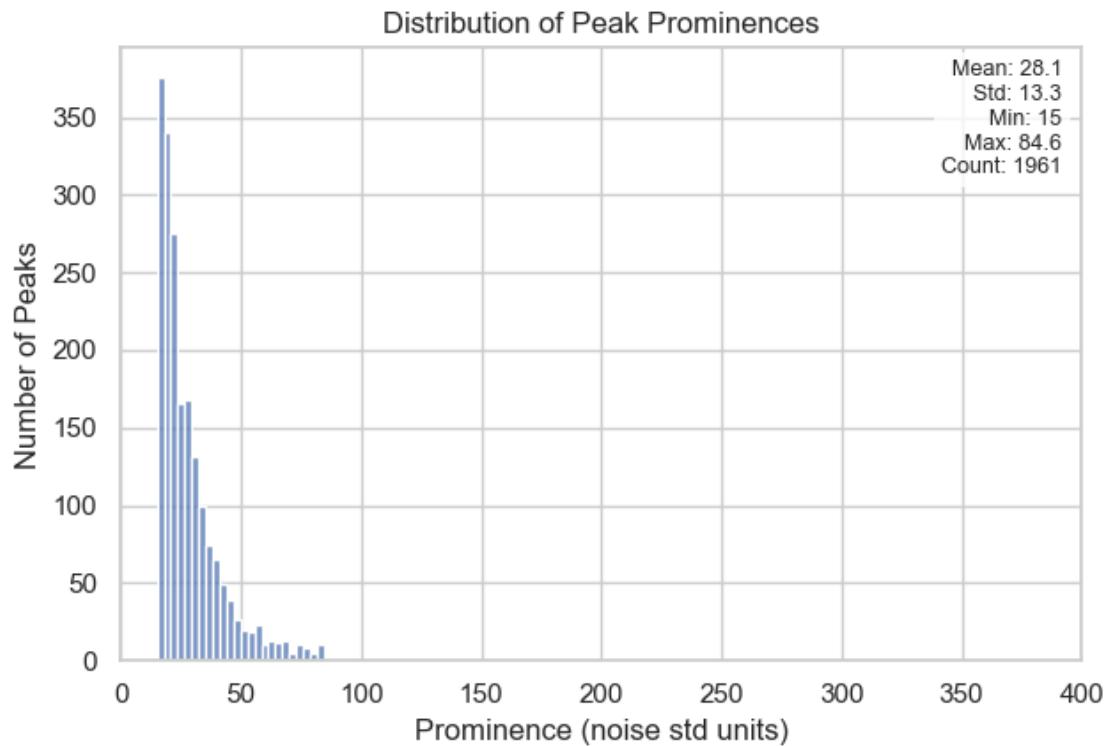


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 12:22:16] [INFO] calcium: plot_histogram: removed 8 outliers out of 2003 on 'Duration (s)' (lower=-22, upper=158)
```

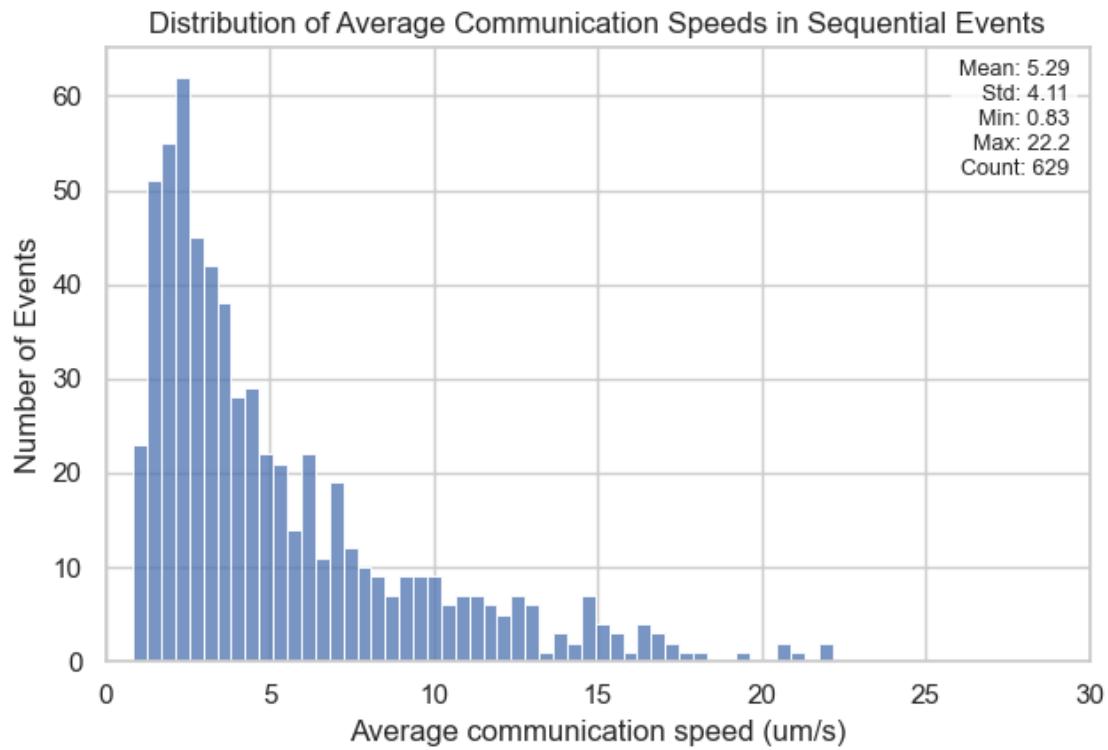


[2025-08-13 12:22:16] [INFO] calcium: plot_histogram: removed 42 outliers out of 2003 on 'Prominence (noise std units)' (lower=-3.45, upper=85.95)

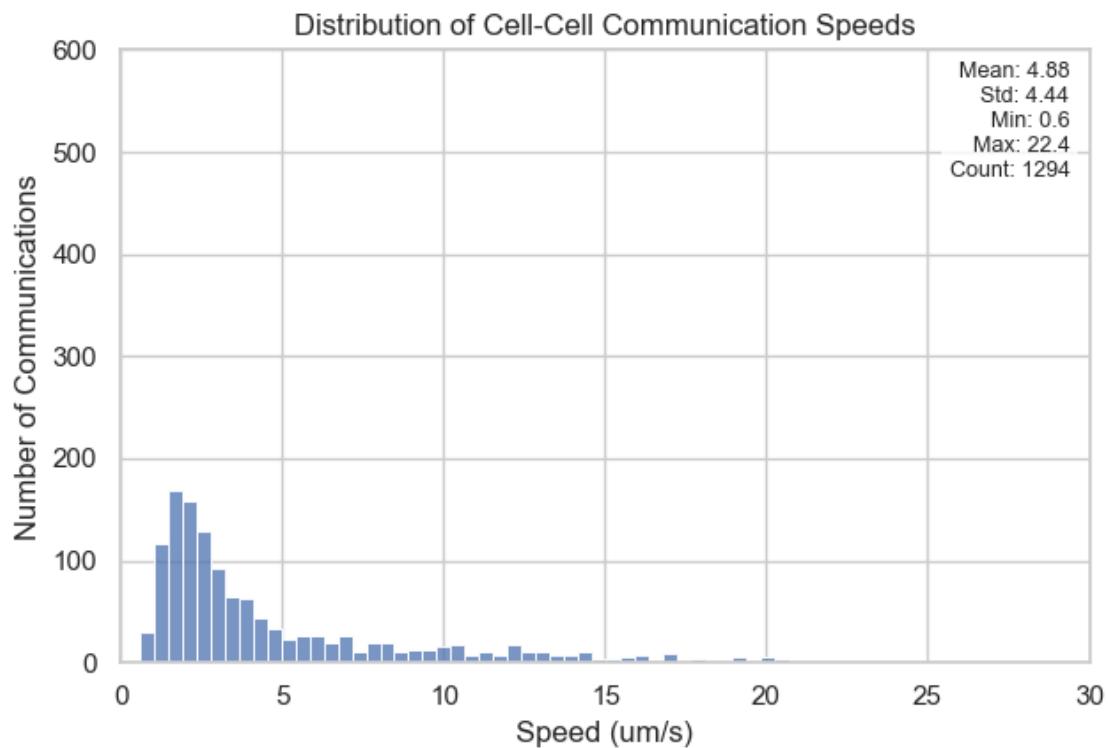


1.3.3 Cell-cell communication speed

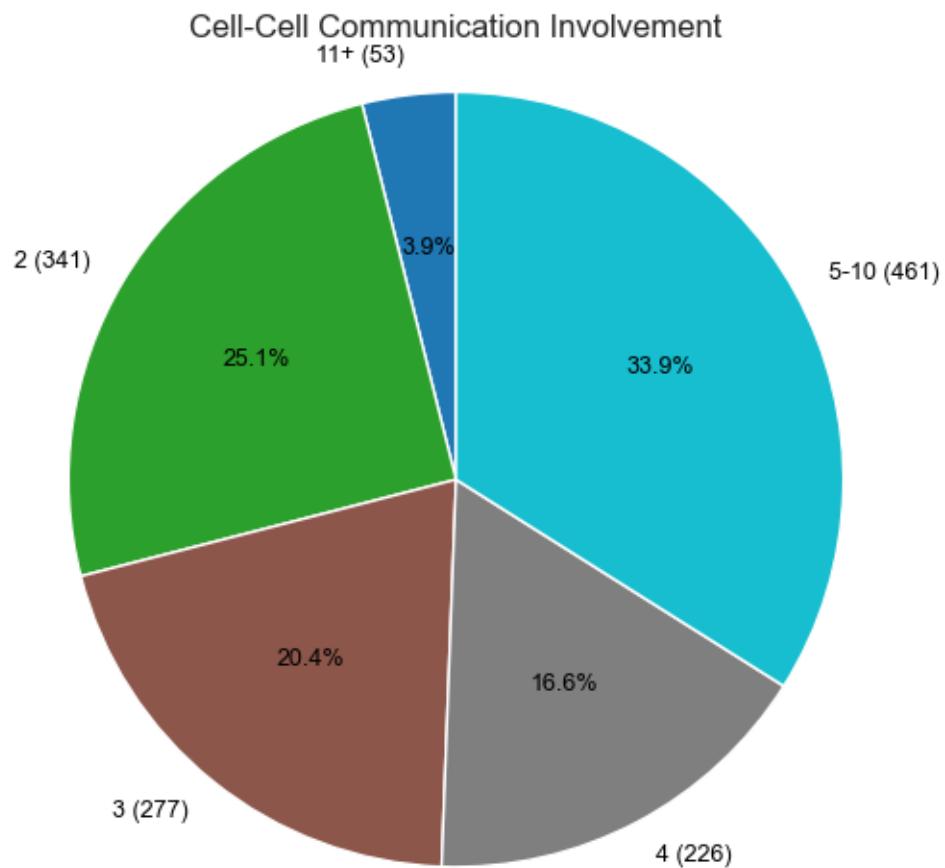
[2025-08-13 12:22:17] [INFO] calcium: plot_histogram: removed 16 outliers out of 645 on 'Average communication speed (um/s)' (lower=-12.71, upper=22.43)



[2025-08-13 12:22:17] [INFO] calcium: plot_histogram: removed 64 outliers out of 1358 on 'Speed (um/s)' (lower=-13.422, upper=22.47)

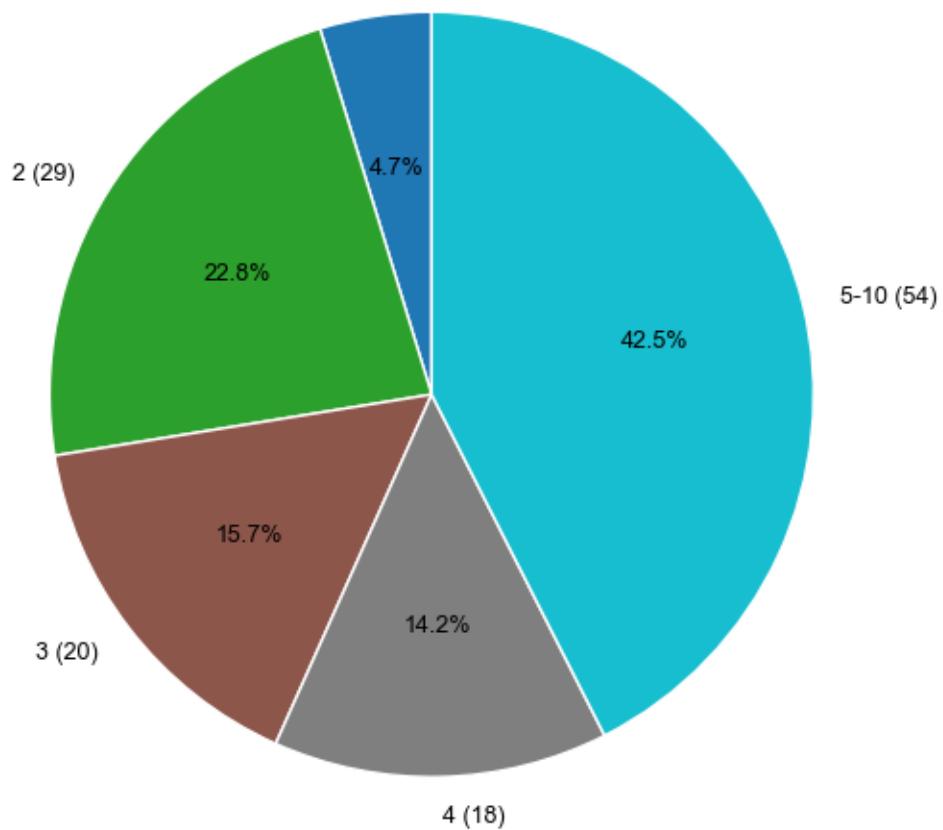


1.3.4 Double distribution in cell-cell communication speeds

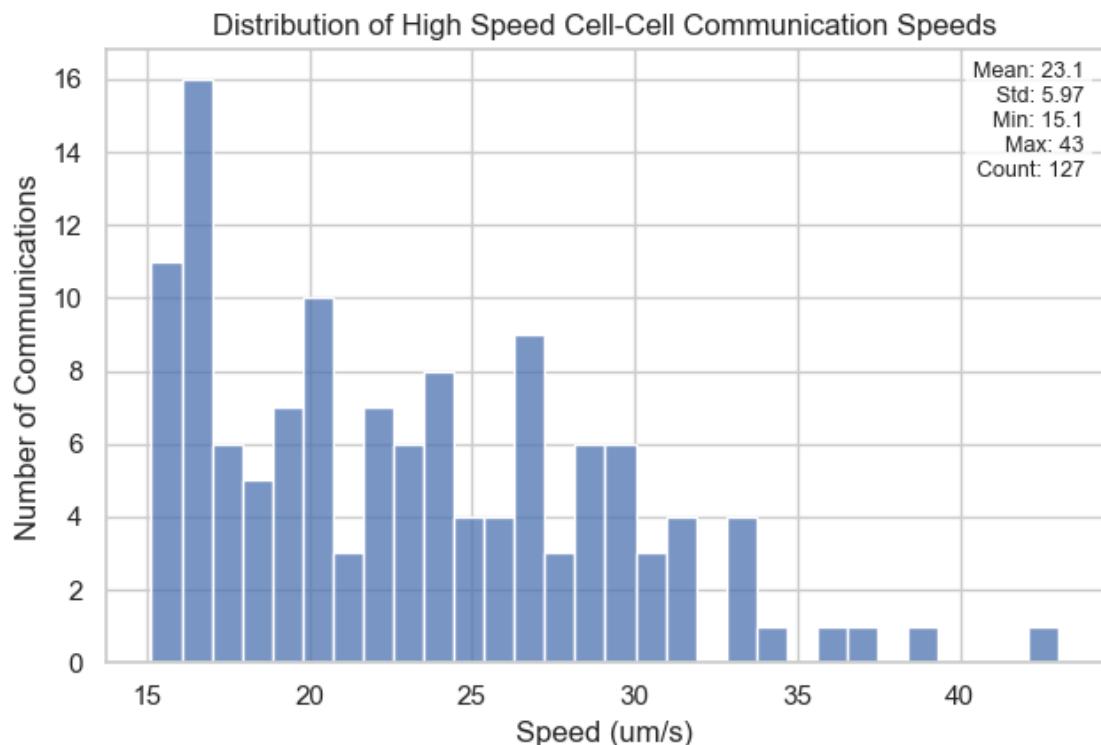


High Speed Cell-Cell Communication Involvement

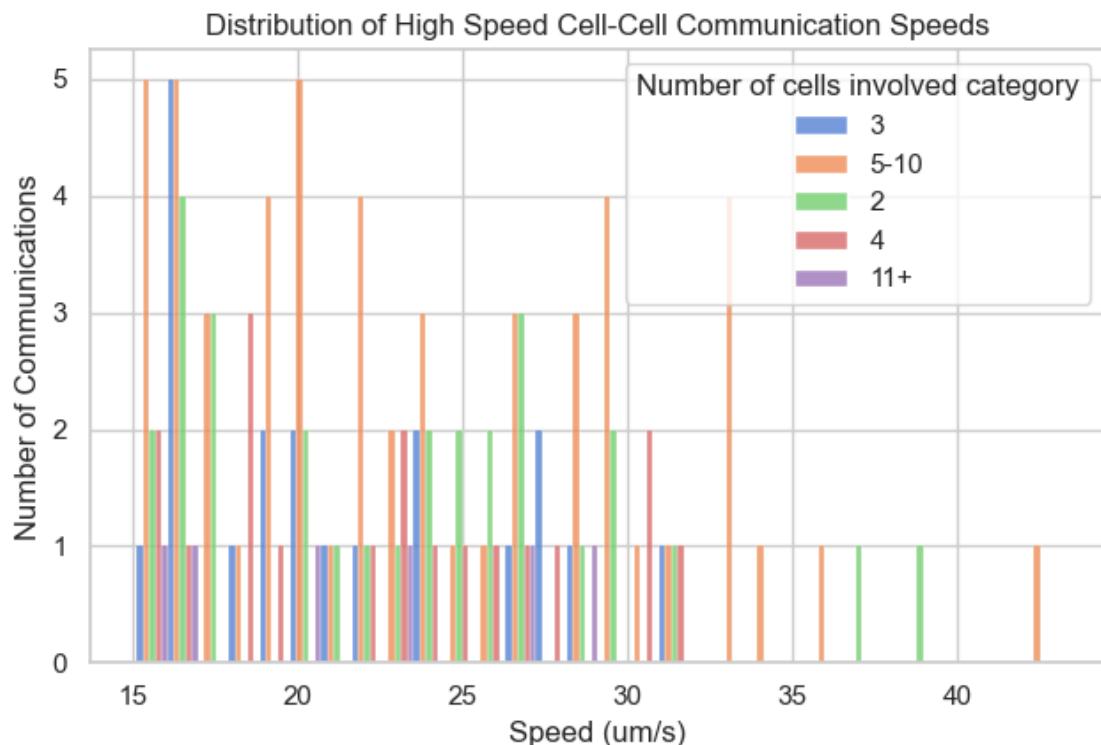
11+ (6)



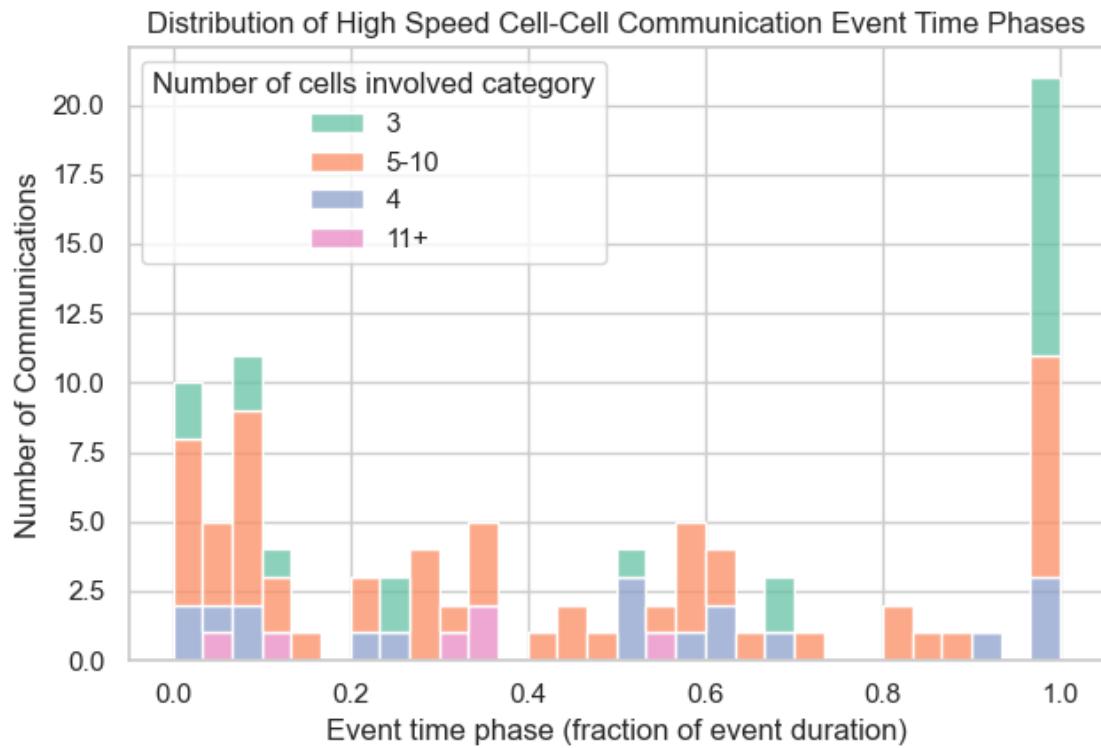
[2025-08-13 12:22:18] [INFO] calcium: plot_histogram: removed 0 outliers out of 127 on 'Speed (um/s)' (lower=-9.97, upper=54.99)



```
[2025-08-13 12:22:18] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 127 on 'Speed (um/s)' (lower=-9.97, upper=54.99)
```

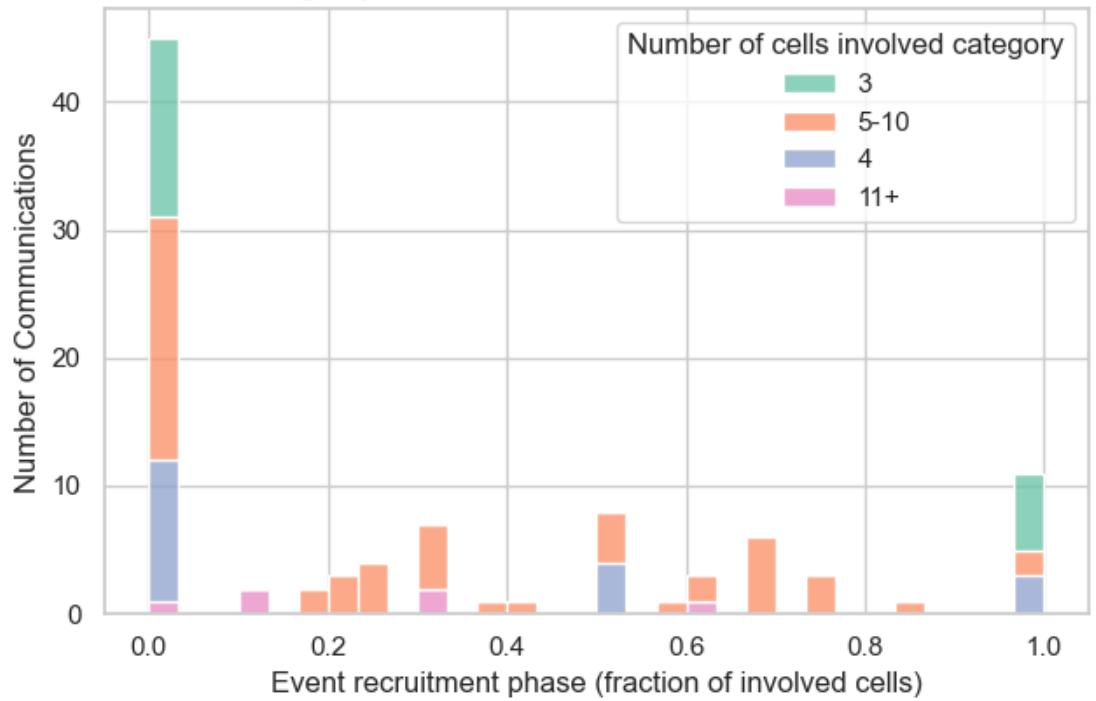


```
[2025-08-13 12:22:18] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 98 on 'Event time phase (fraction of event duration)' (lower=-2.04, upper=2.93)
```

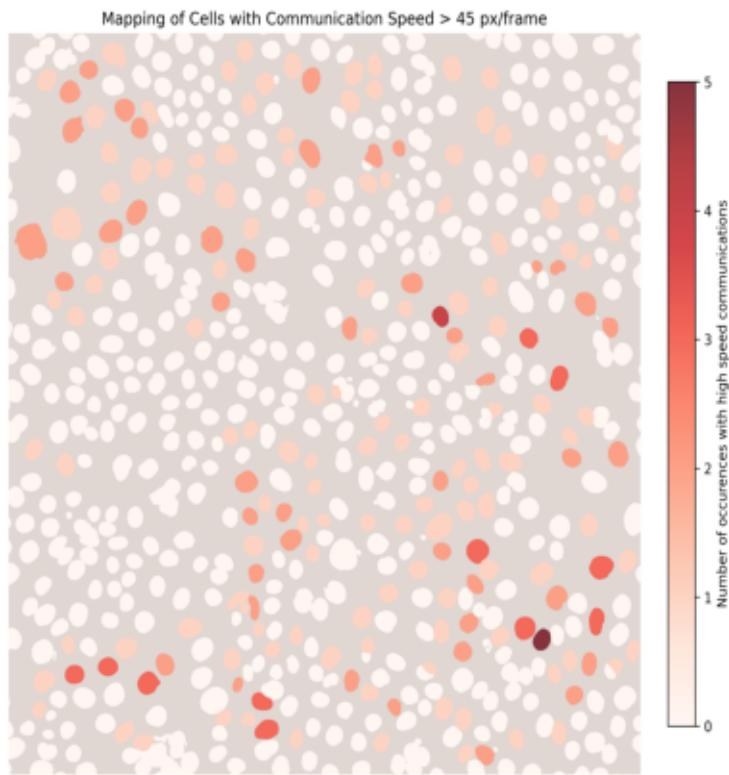


```
[2025-08-13 12:22:19] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 98 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.6575, upper=2.21)
```

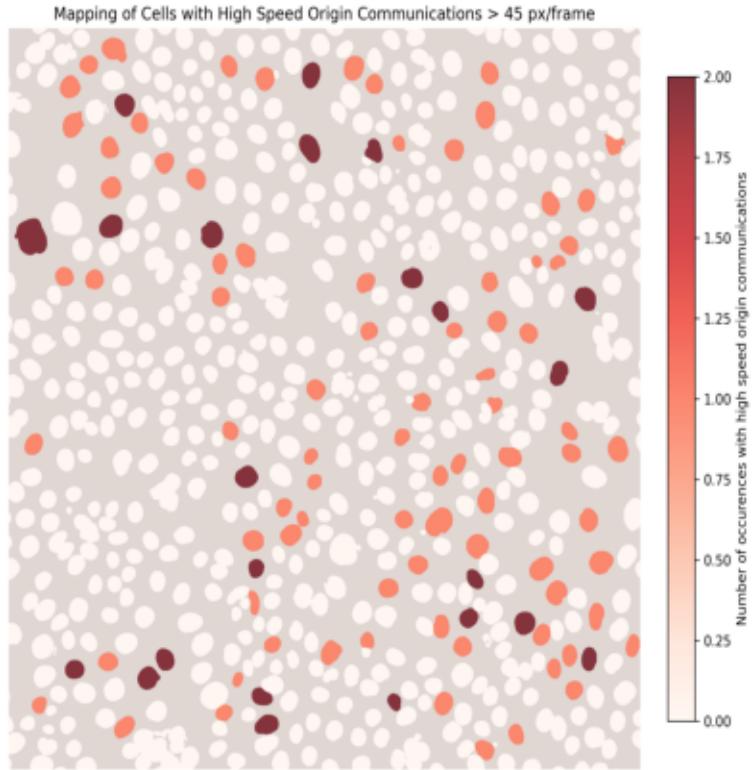
Distribution of High Speed Cell-Cell Communication Event Recruitment Phases



Cell Mapping with High Speed Cells Overlay - 20250624_IS03



Cell Mapping with High Speed Origin Cells Overlay - 20250624_IS03



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
5	1759519297056	3	138	2	
24	1760041143792	5	533	4	
28	1759519308720	6	358	6	
35	1759519299984	8	146	0	
41	1759519306224	10	136	5	
...	
1255	1759462652992	578	733	0	
1328	1759510979456	622	811	4	
1344	1759510984976	633	809	3	
1356	1759510985312	645	872	5	
1357	1759510986128	646	848	6	

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
5	104	1	144.0	144.0	
24	528	1	599.0	600.0	
28	379	8	1226.0	1226.0	
35	118	1	139.0	139.0	
41	119	8	1430.0	1430.0	
...	\
1255	753	1	64.0	65.0	
1328	820	3	858.0	859.0	
1344	854	3	724.0	725.0	
1356	870	7	1375.0	1376.0	
1357	872	6	1517.0	1518.0	
	Duration (s)	Distance (um)	Speed (um/s)		\
5	0.0	27.32	27.32		
24	1.0	21.84	21.84		
28	0.0	24.72	24.72		
35	0.0	16.25	16.25		
41	0.0	17.13	17.13		
...	\
1255	1.0	16.51	16.51		
1328	1.0	16.87	16.87		
1344	1.0	26.08	26.08		
1356	1.0	15.29	15.29		
1357	1.0	27.10	27.10		
	Event time phase (fraction of event duration)				\
5			1.00		
24			0.62		
28			1.00		
35			0.43		
41			NaN		
...			...		\
1255			NaN		
1328			NaN		
1344			NaN		
1356			NaN		
1357			NaN		
	Event recruitment phase (fraction of involved cells)		dataset		\
5		0.00	20250624_IS03		
24		0.75	20250624_IS03		
28		0.33	20250624_IS03		
35		0.25	20250624_IS03		
41		NaN	20250624_IS03		
...			\
1255		NaN	20250624_IS03		
1328		NaN	20250624_IS03		

1344		NaN	20250624_IS03
1356		NaN	20250624_IS03
1357		NaN	20250624_IS03

	Number of cells involved	category	Speed category
5		3	High speed
24		5-10	High speed
28		5-10	High speed
35		5-10	High speed
41		2	High speed
...
1255		2	High speed
1328		2	High speed
1344		2	High speed
1356		2	High speed
1357		2	High speed

[127 rows x 16 columns]

Origin cell ID	Speed category	High speed	Low speed
94		0	2
96		0	1
97		0	2
101		0	4
102		0	1
...
871		0	1
872		1	0
873		0	2
875		0	2
878		0	3

[459 rows x 2 columns]

Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
0	94	56.88	6.17
1	96	302.25	7.48
2	97	469.62	7.48
5	101	207.03	10.72
6	102	246.03	11.05
..
556	871	474.18	485.23
557	872	376.03	485.55
558	873	96.85	486.20
559	875	327.28	487.18
561	878	142.68	490.75

Number of peaks Is active Occurences in global events \

0	6	True	1
1	8	True	1
2	10	True	2
5	8	True	2
6	4	True	1
..
556	6	True	2
557	7	True	2
558	9	True	2
559	3	True	1
561	10	True	2

Occurrences in global events as early peaker \

0	0
1	0
2	0
5	0
6	0
..	..
556	0
557	0
558	1
559	0
561	1

Occurrences in sequential events \

0	4
1	3
2	5
5	5
6	1
..	..
556	1
557	3
558	5
559	2
561	2

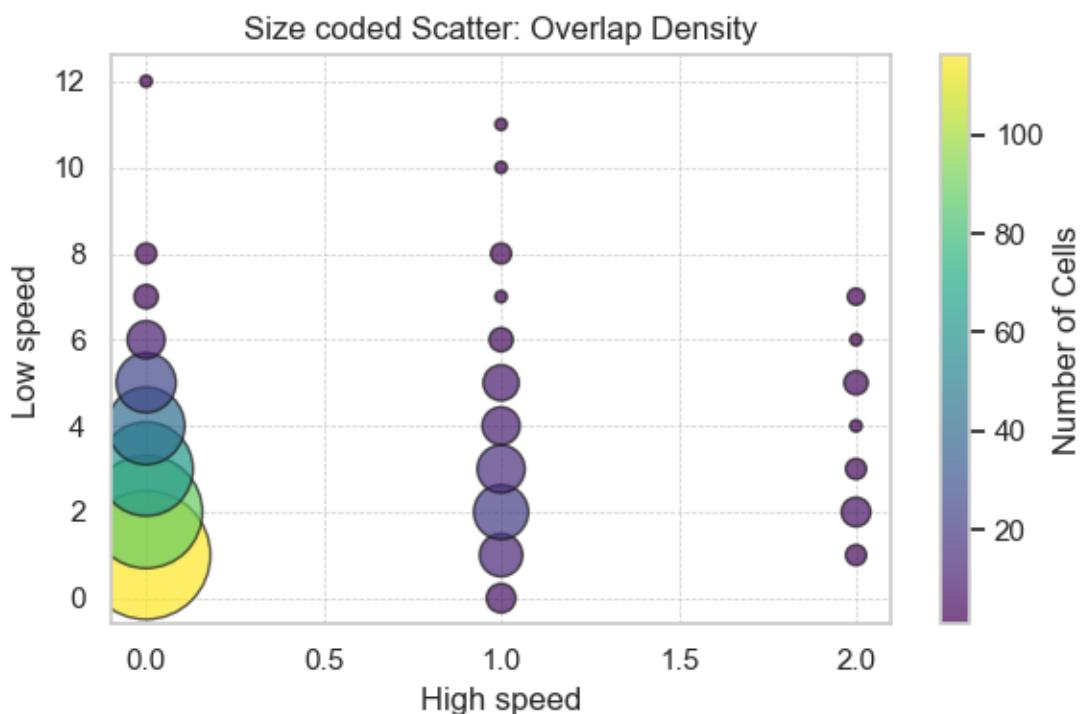
Occurrences in sequential events as origin \

0	2
1	1
2	2
5	3
6	1
..	..
556	1
557	1
558	2

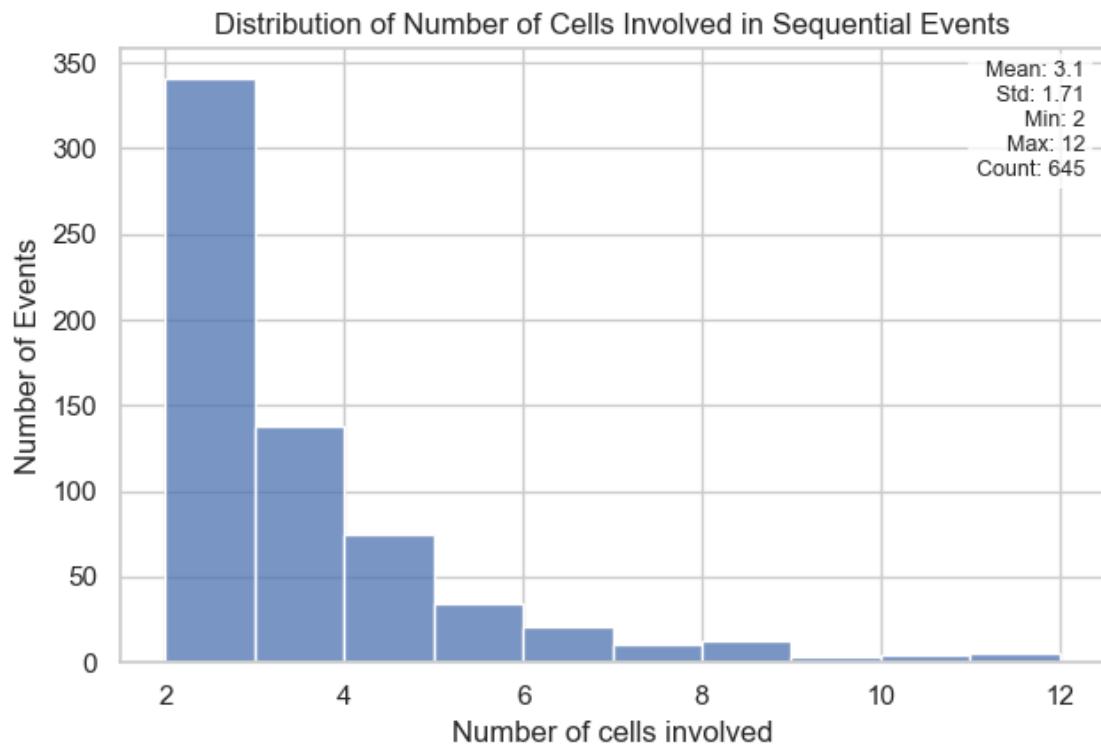
559		1		\
561		2		
	Occurrences in individual events	Peak frequency (Hz)	Periodicity score	\
0	1	0.0035	0.63	
1	4	0.0047	0.58	
2	3	0.0059	0.54	
5	1	0.0047	0.54	
6	2	0.0024	0.73	
..
556	3	0.0035	0.72	
557	2	0.0041	0.75	
558	2	0.0053	0.69	
559	0	0.0018	0.97	
561	5	0.0059	0.62	
	Neighbor count	Neighbors (labels)	dataset	\
0	3	[106,111,121]	20250624_IS03	
1	3	[116,118,133]	20250624_IS03	
2	3	[127,137,151]	20250624_IS03	
5	3	[104,119,138]	20250624_IS03	
6	3	[107,119,136]	20250624_IS03	
..
556	2	[831,855]	20250624_IS03	
557	4	[826,842,848,870]	20250624_IS03	
558	2	[839,851]	20250624_IS03	
559	4	[810,824,845,867]	20250624_IS03	
561	4	[840,850,864,869]	20250624_IS03	
	Involved in sequential event	Occurrences in sequential events category	\	
0	Involved in sequential event			3-4
1	Involved in sequential event			3-4
2	Involved in sequential event			5-9
5	Involved in sequential event			5-9
6	Involved in sequential event			1-2
..
556	Involved in sequential event			1-2
557	Involved in sequential event			3-4
558	Involved in sequential event			5-9
559	Involved in sequential event			1-2
561	Involved in sequential event			1-2
	High speed	Low speed		
0	0.0	2.0		
1	0.0	1.0		
2	0.0	2.0		
5	0.0	4.0		
6	0.0	1.0		

```
..      ...    ...
556      0.0    1.0
557      1.0    0.0
558      0.0    2.0
559      0.0    2.0
561      0.0    3.0
```

[457 rows x 19 columns]

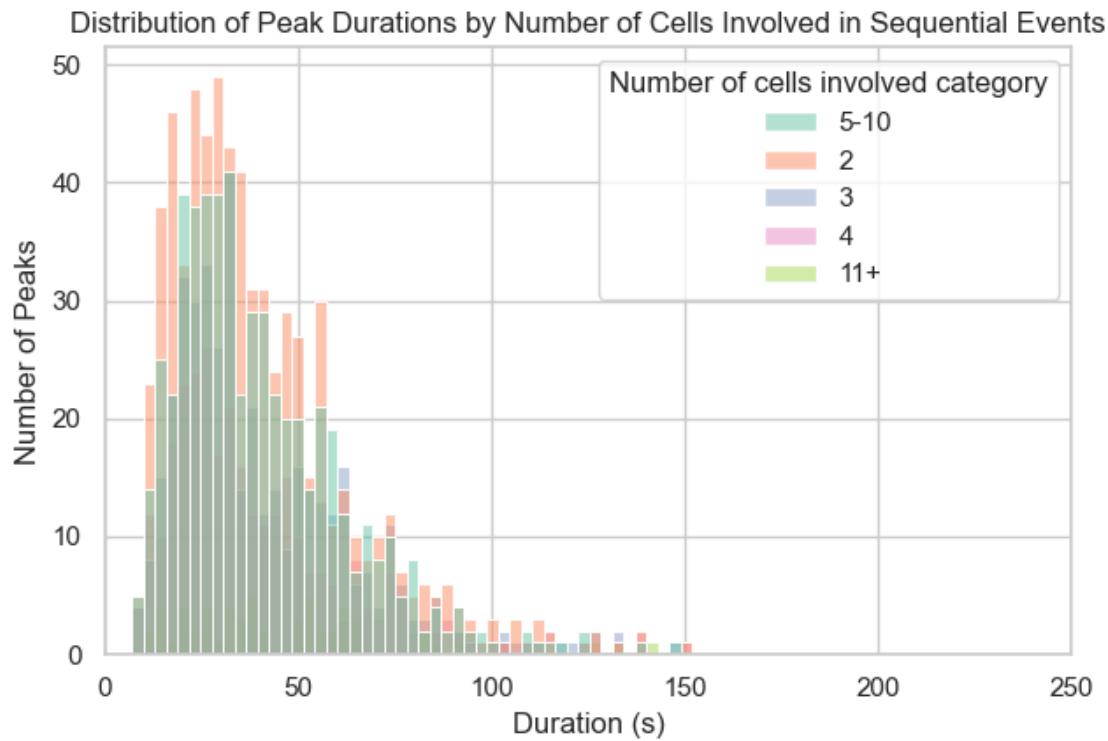


1.3.5 Number of cells involved per sequential events



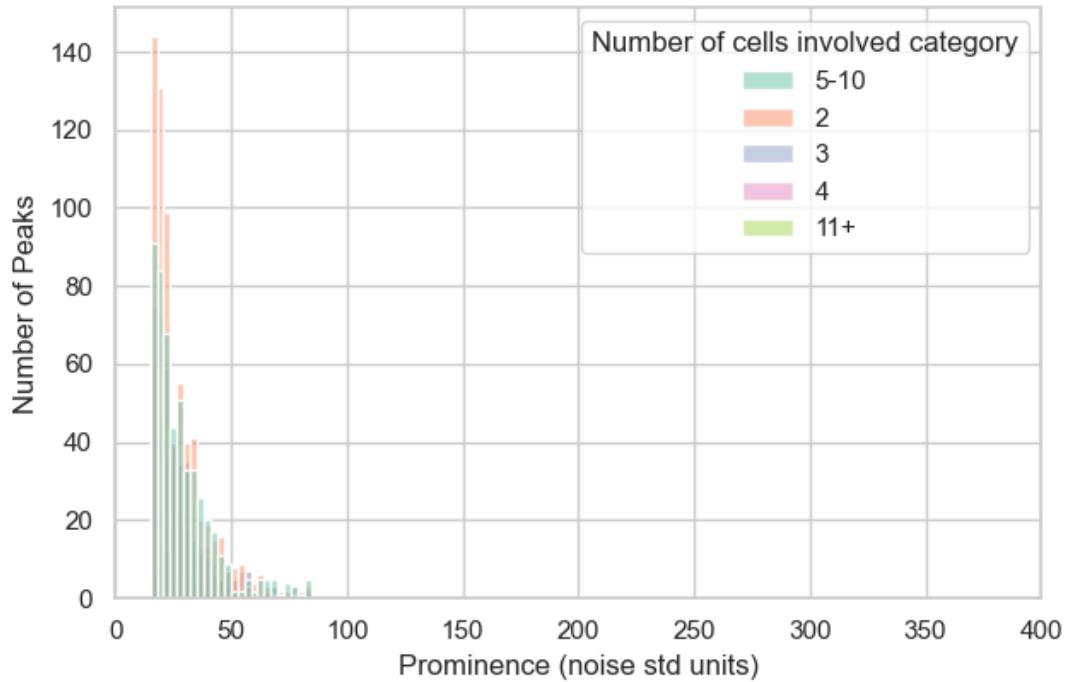
1.3.6 Influence of cell count per event on statistics

```
[2025-08-13 12:22:22] [INFO] calcium: plot_histogram_by_group: removed 8 outliers out of 2003 on 'Duration (s)' (lower=-22, upper=158)
```

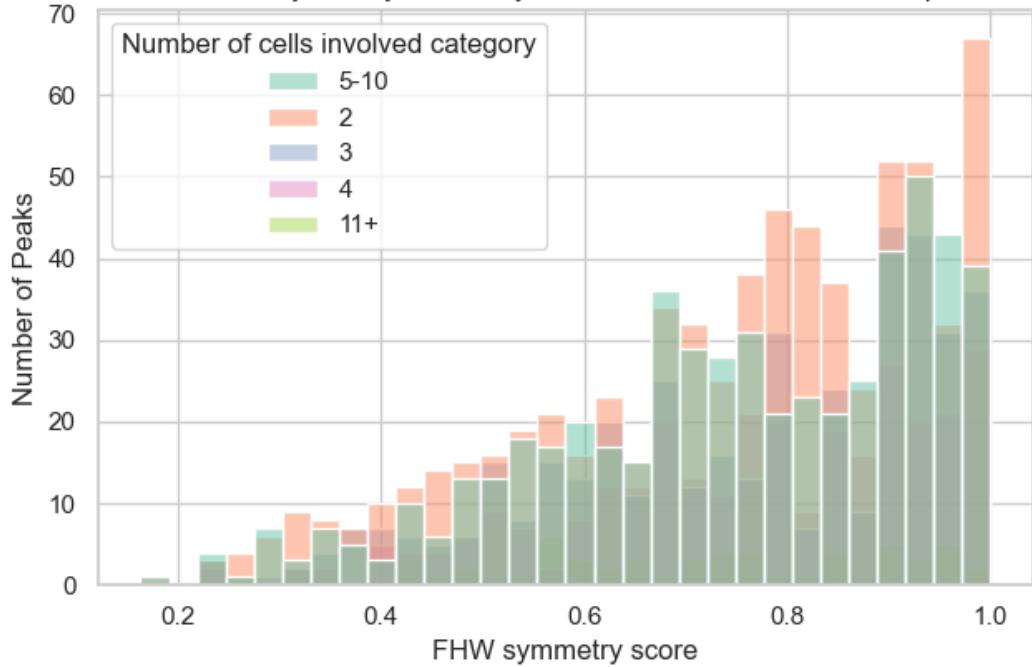


```
[2025-08-13 12:22:22] [INFO] calcium: plot_histogram_by_group: removed 42 outliers out of 2003 on 'Prominence (noise std units)' (lower=-3.45, upper=85.95)
```

Distribution of Peak Prominences by Number of Cells Involved in Sequential Events

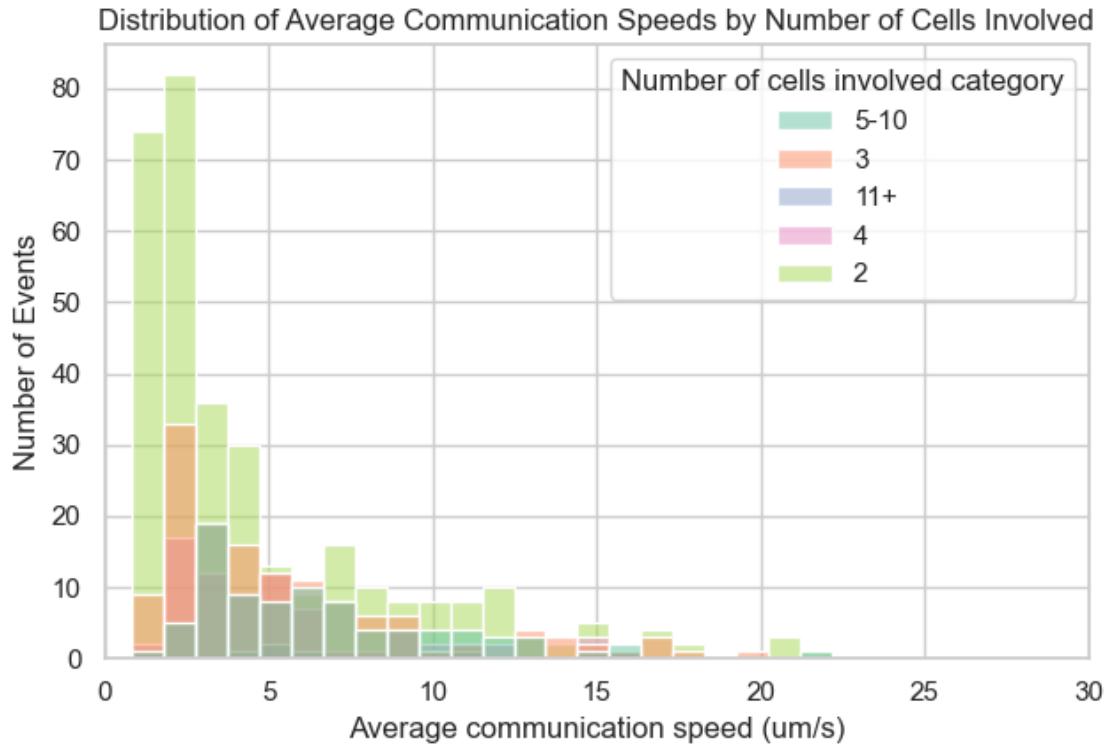


Distribution of Peak Symmetry Scores by Number of Cells Involved in Sequential Events



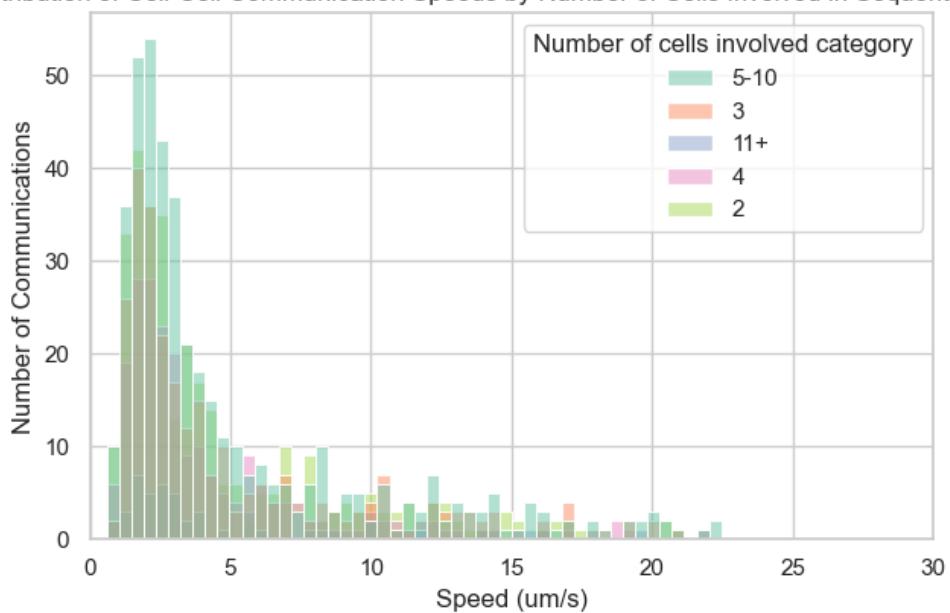
[2025-08-13 12:22:23] [INFO] calcium: plot_histogram_by_group: removed 16

outliers out of 645 on 'Average communication speed (um/s)' (lower=-12.71, upper=22.43)



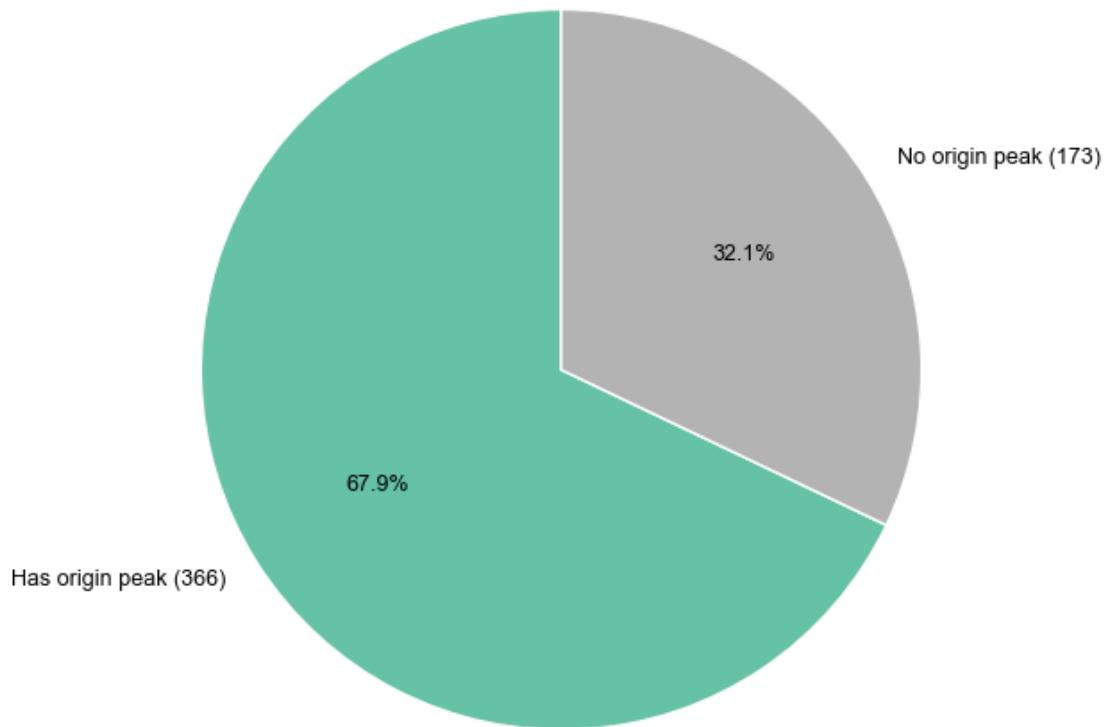
[2025-08-13 12:22:23] [INFO] calcium: plot_histogram_by_group: removed 64 outliers out of 1358 on 'Speed (um/s)' (lower=-13.422, upper=22.47)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events

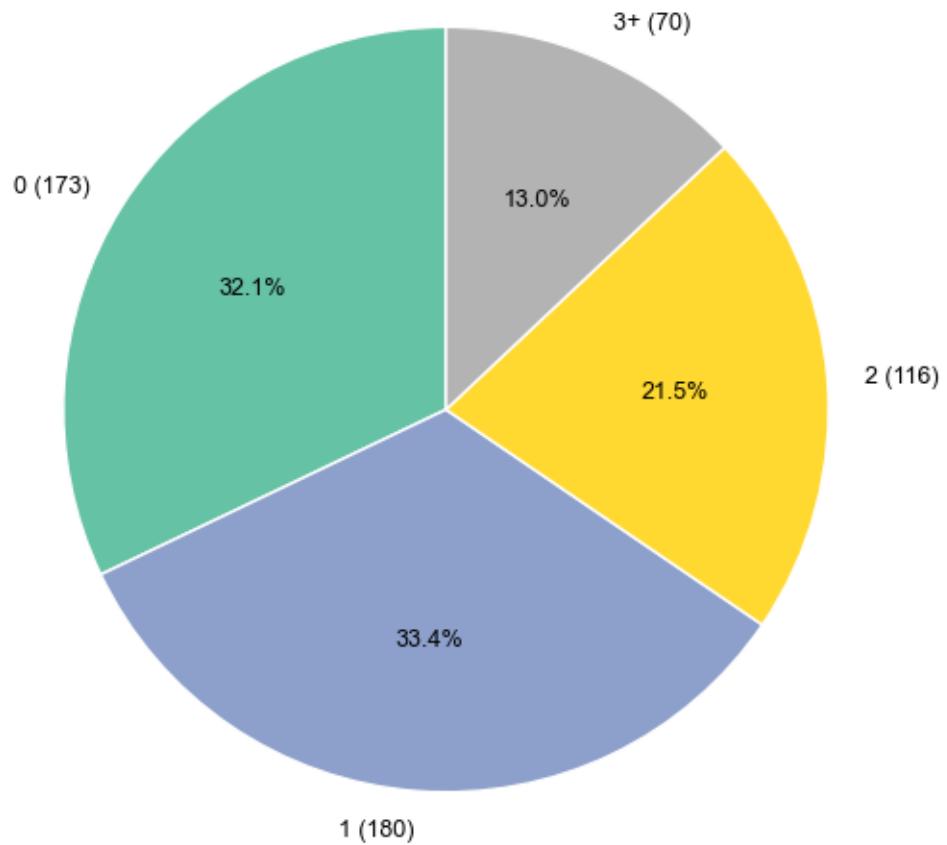


1.3.7 Cells occurrences as origin in sequential events

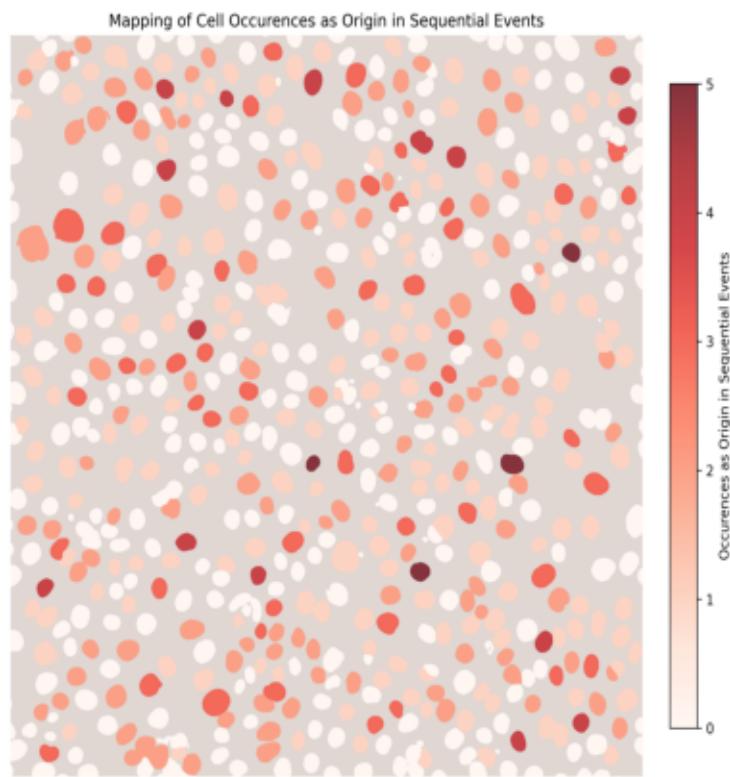
Distribution of Number of Sequential Event Origin Peaks per Cell



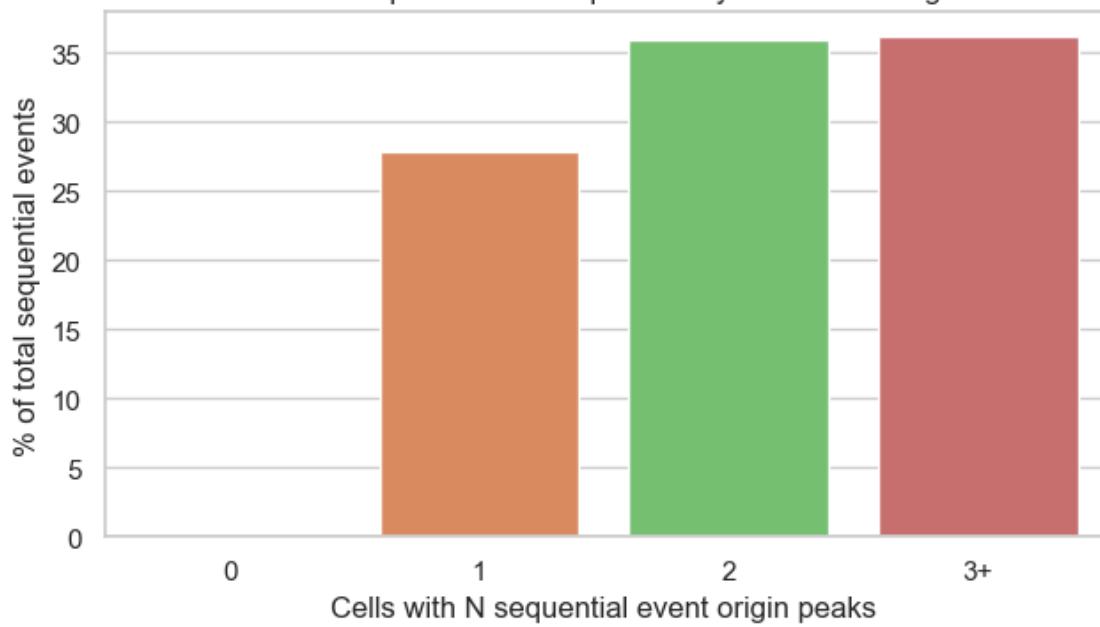
Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)



Cell Mapping with Origin Peaks Overlay - 20250624_IS03

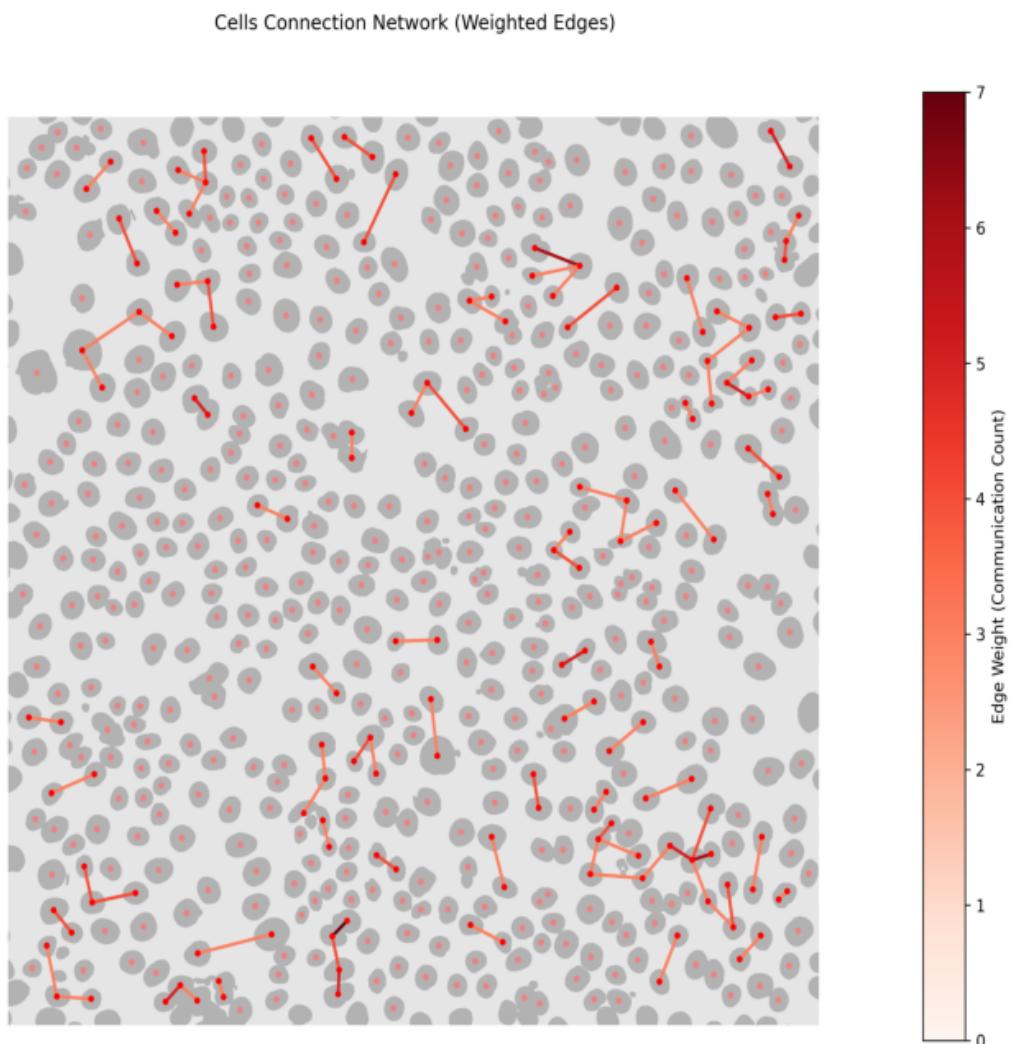


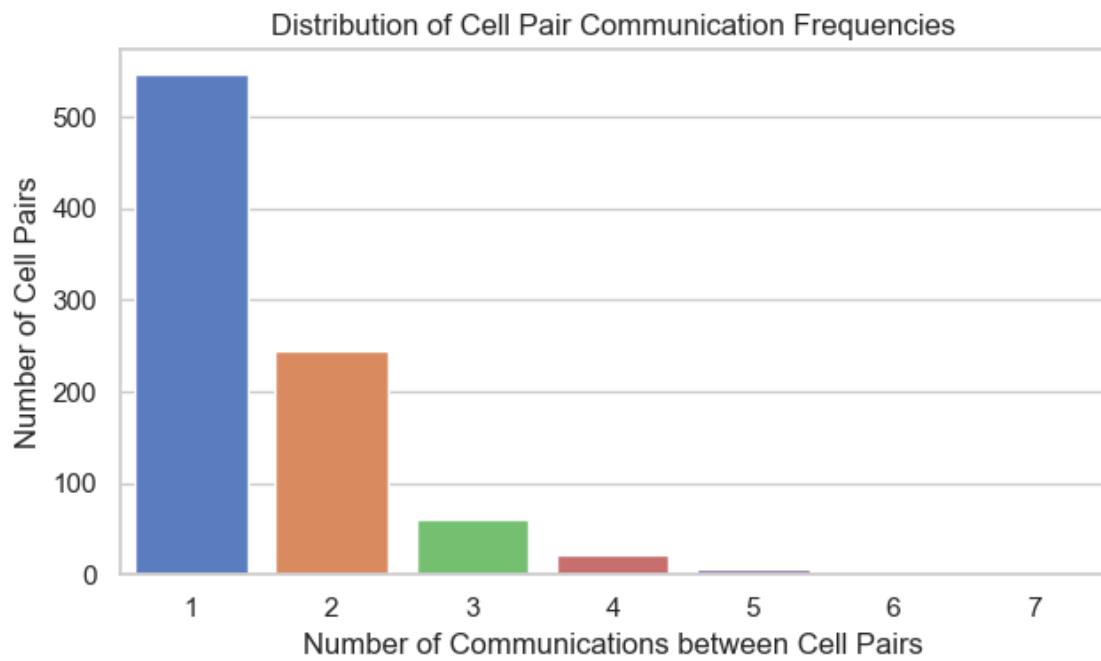
Distribution of Sequential Events per Cell by Number of Origin Peaks



1.3.8 Connection network between cells

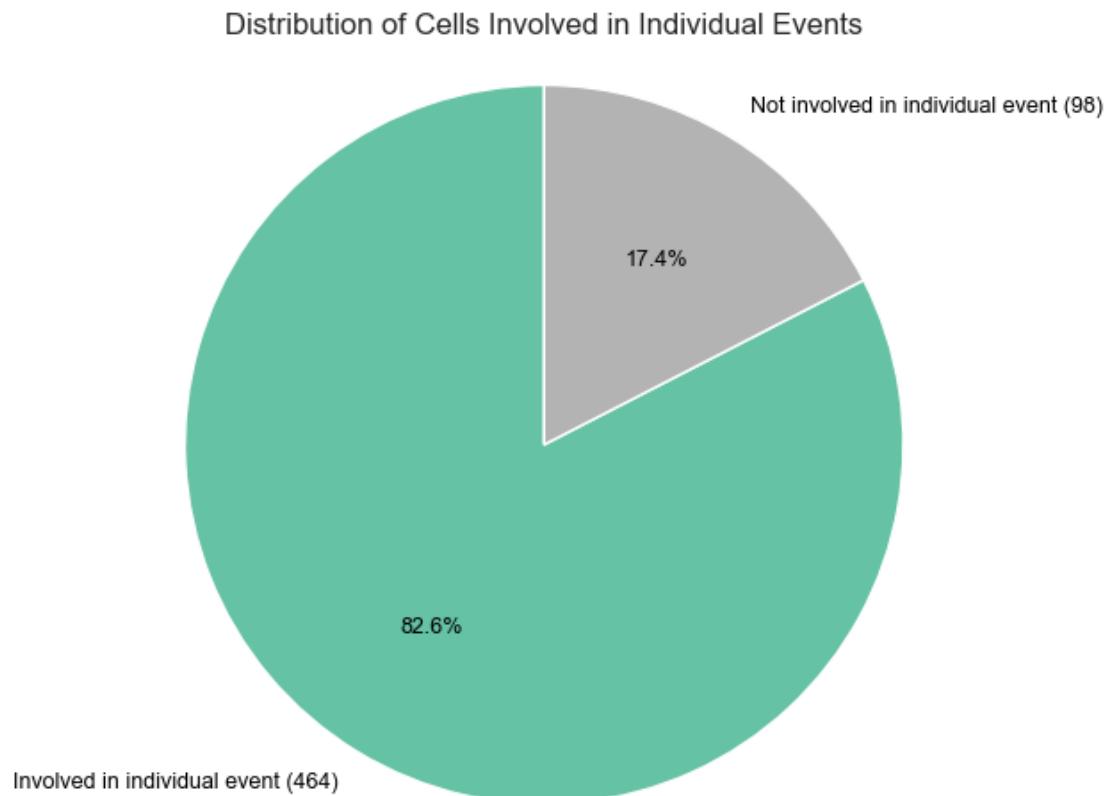
Cell Connection Network Graph - 20250624_IS03



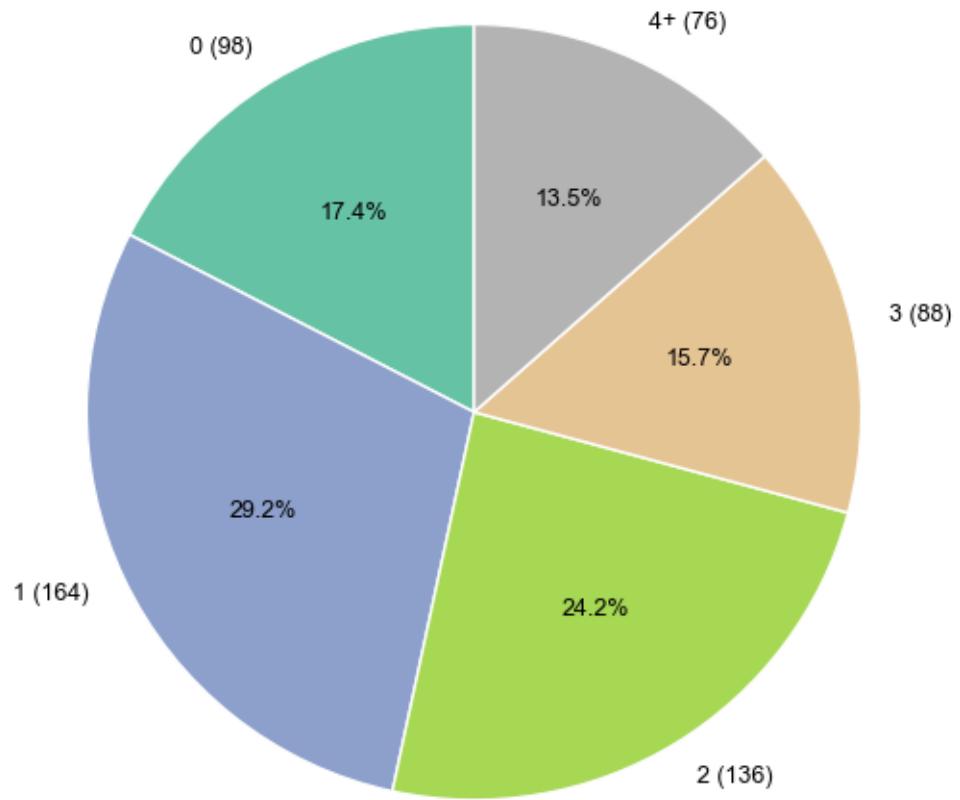


1.4 INDIVIDUAL EVENTS

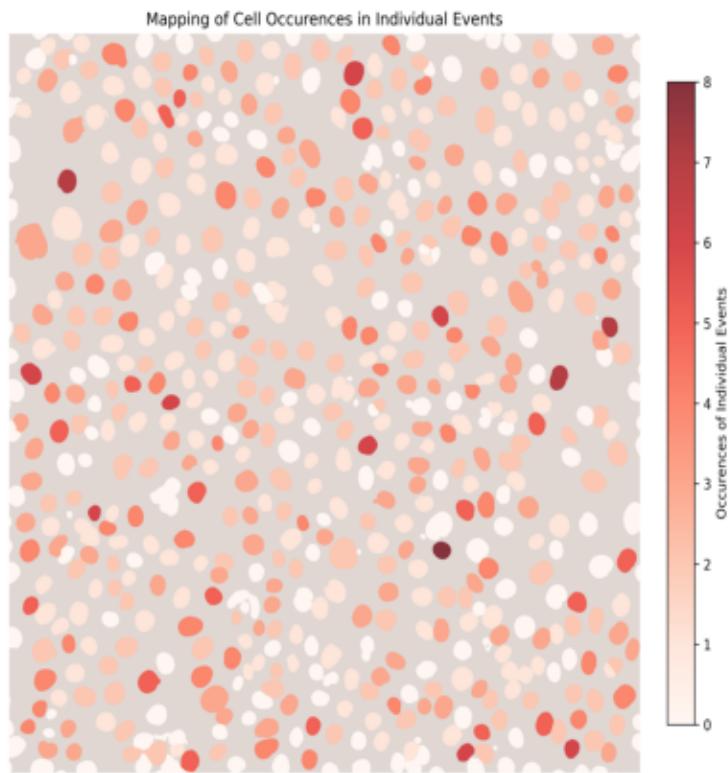
1.4.1 Cells occurrences in individual events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

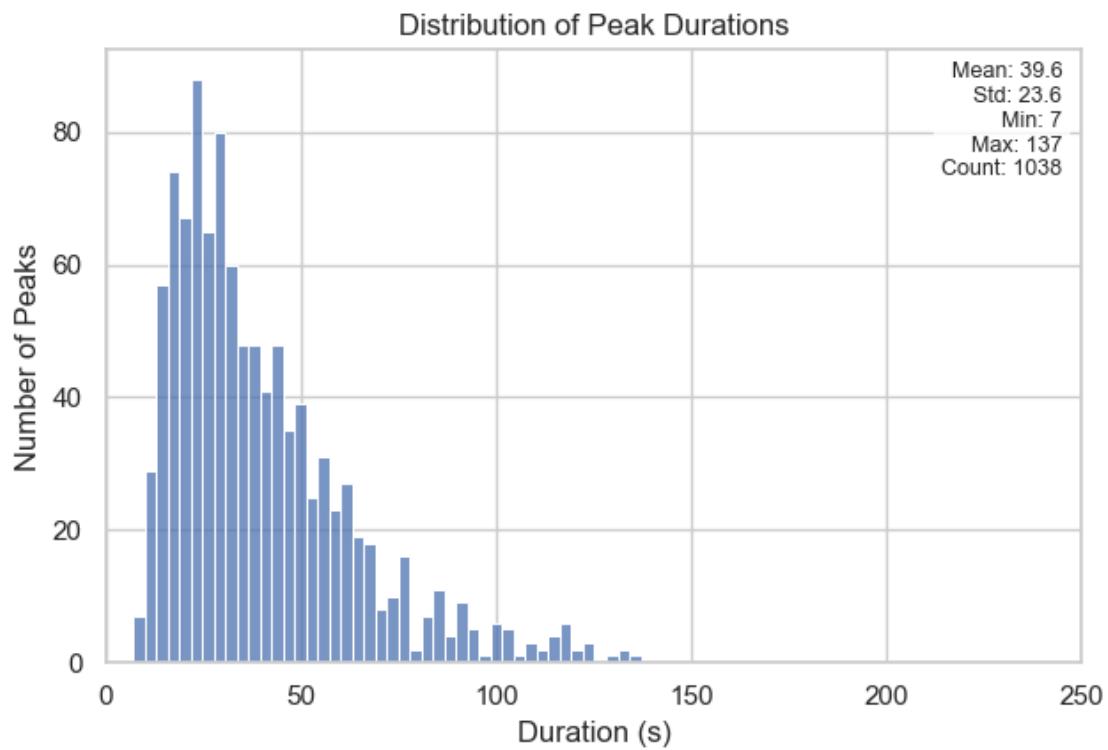


Cell Mapping with Occurrences in Individual Events Overlay - 20250624_IS03

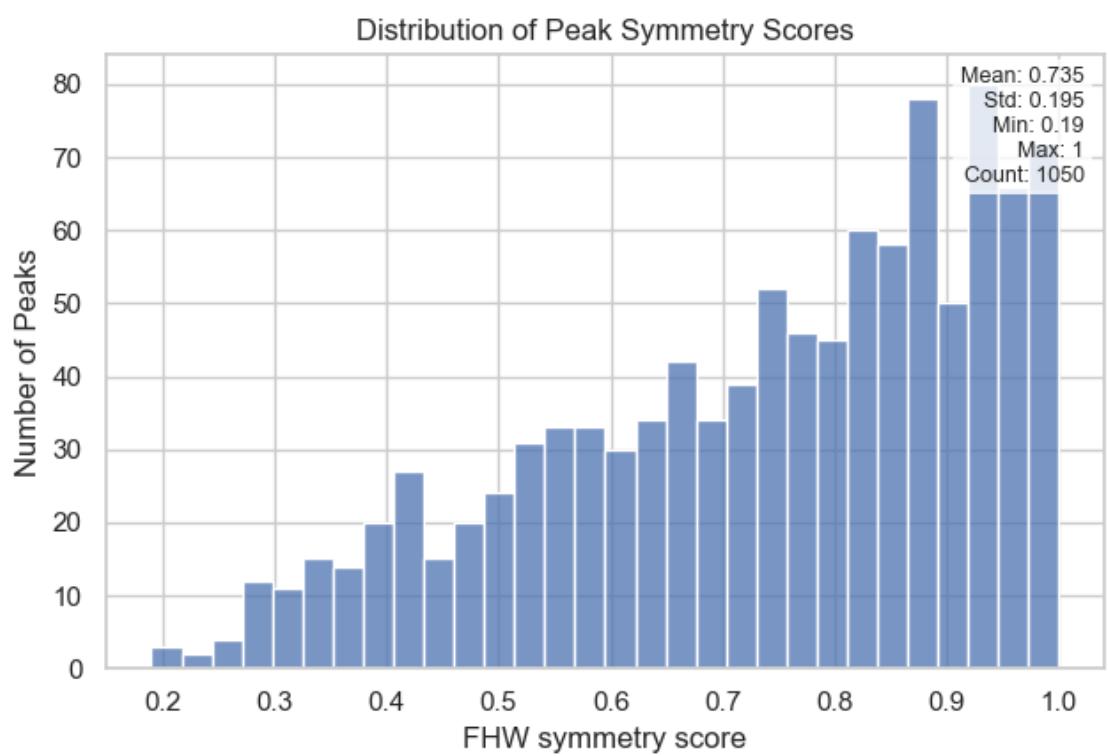
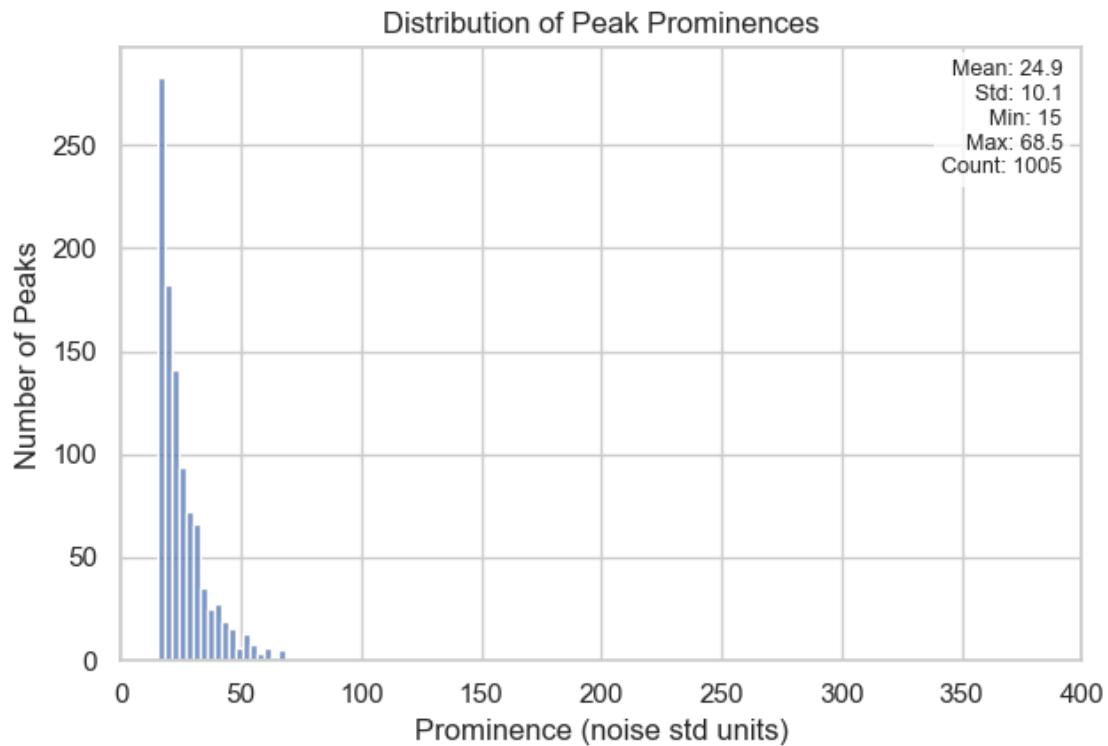


1.4.2 Peaks statistics in individual events

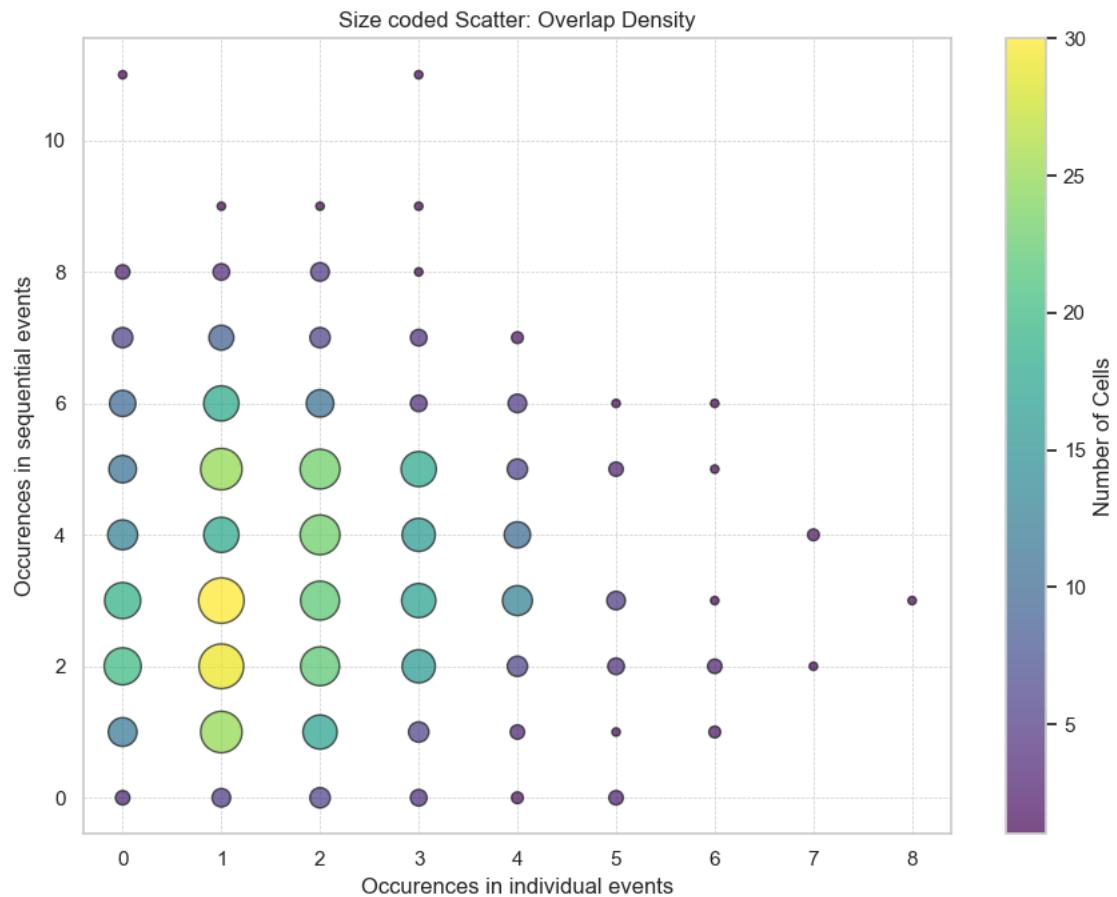
```
[2025-08-13 12:22:29] [INFO] calcium: plot_histogram: removed 12 outliers out of  
1050 on 'Duration (s)' (lower=-64, upper=139)
```



```
[2025-08-13 12:22:29] [INFO] calcium: plot_histogram: removed 45 outliers out of 1050 on 'Prominence (noise std units)' (lower=-21.3, upper=69.7)
```

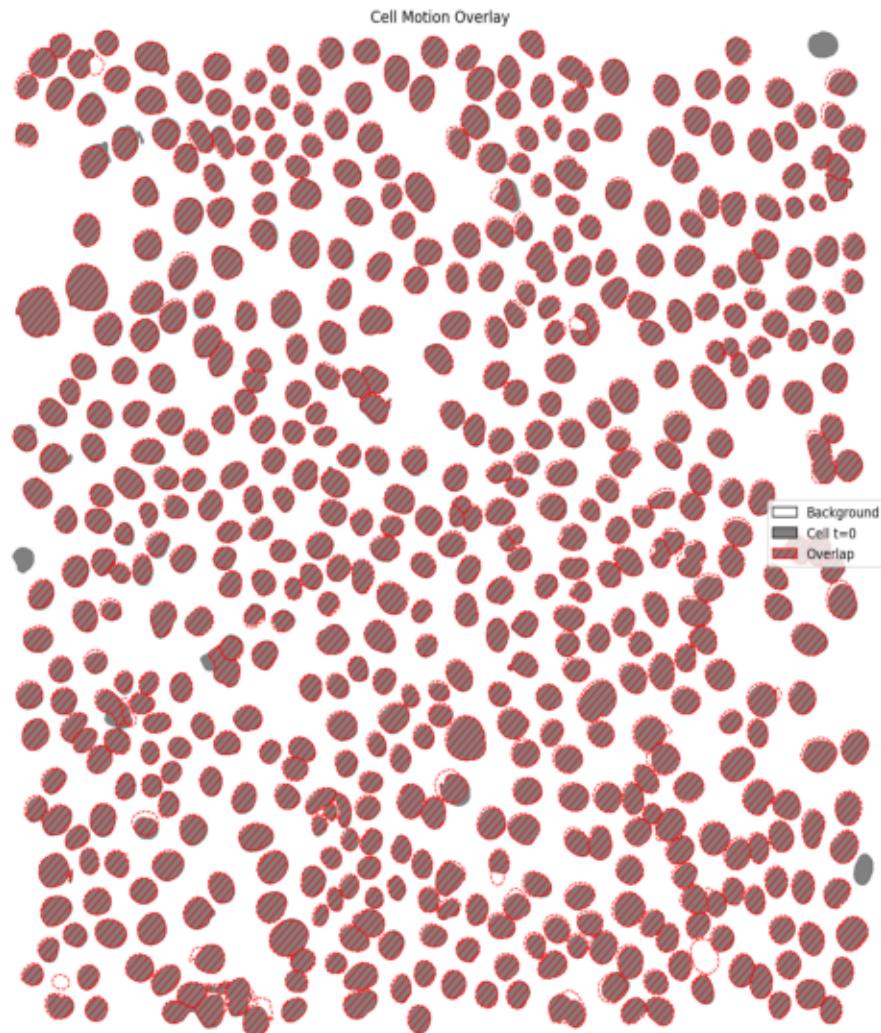


1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250624_IS03



Number of cells:

- Hoechst image taken at t=0: 562
- Hoechst image taken at t=1801: 552
- Number of cells difference: absolute 10, relative 1.80%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 780011
- Pixels segmented as cell at t=1801: 787021
- Overlapping pixels between t=0 and t=1801: 725792 (92.63% of total)
- Pixels exclusive to t=0: 54219 (6.95% of total)
- Pixels exclusive to t=1801: 61229 (7.78% of total)

executed

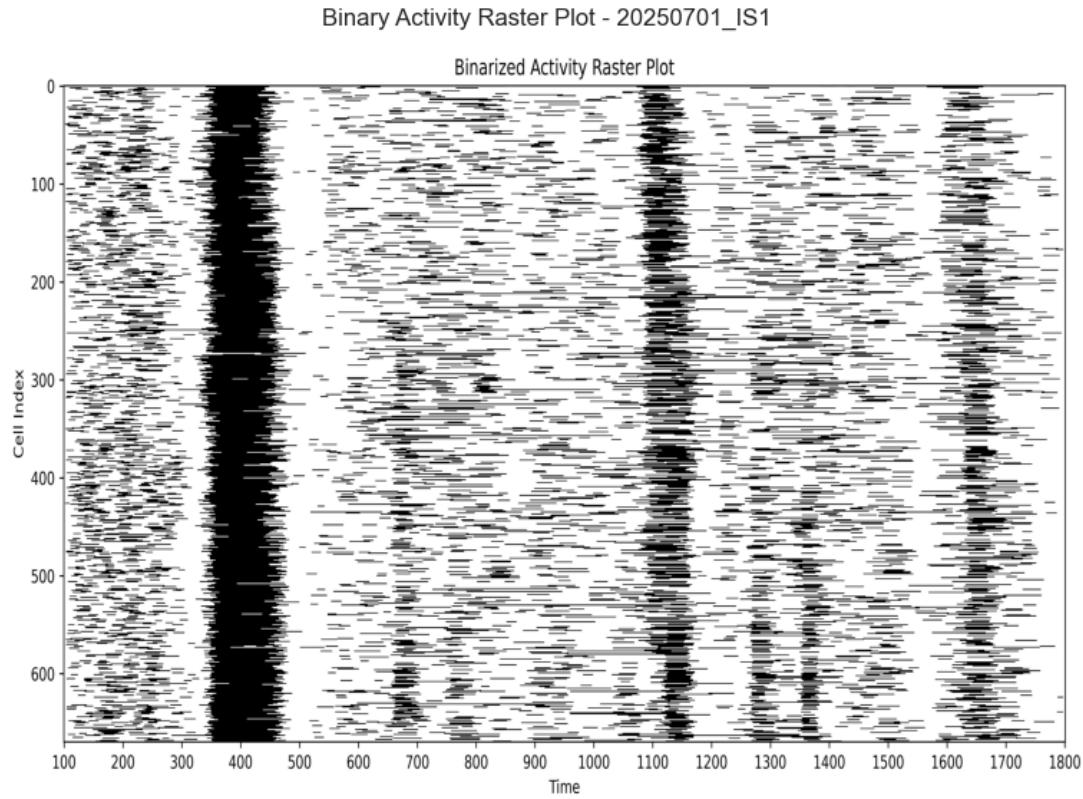
August 13, 2025

1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

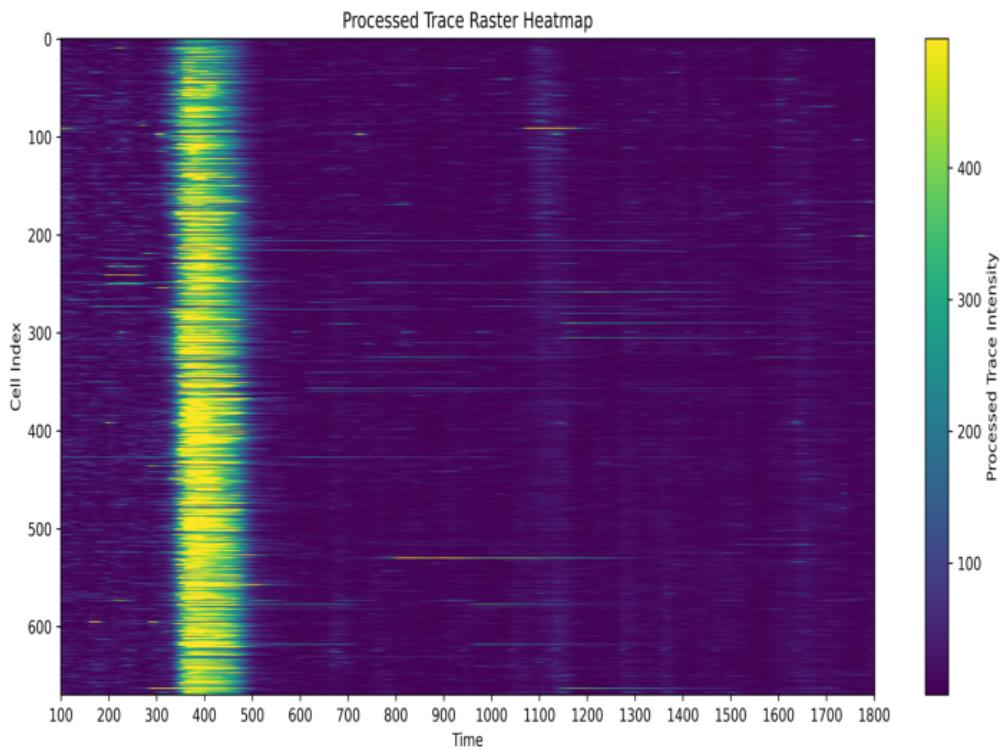
1.0.1 Initialization

1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot



Heatmap Activity Raster Plot - 20250701_IS1



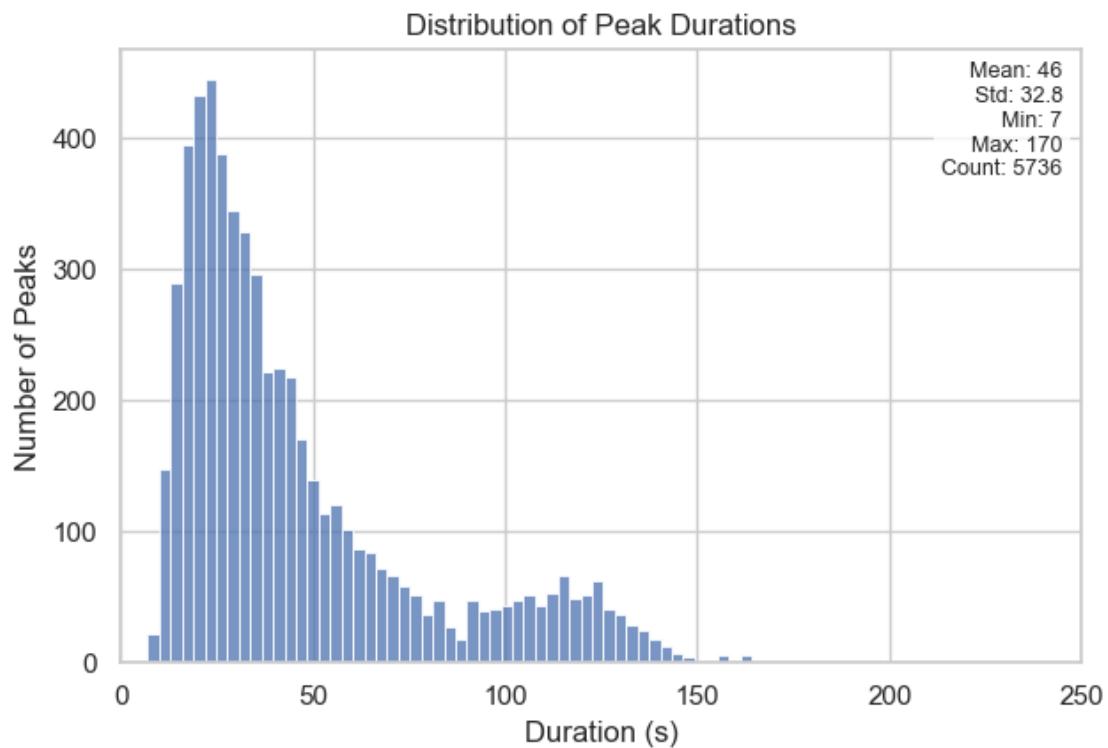
1.1.2 Peaks population

Total number of peaks: 5765

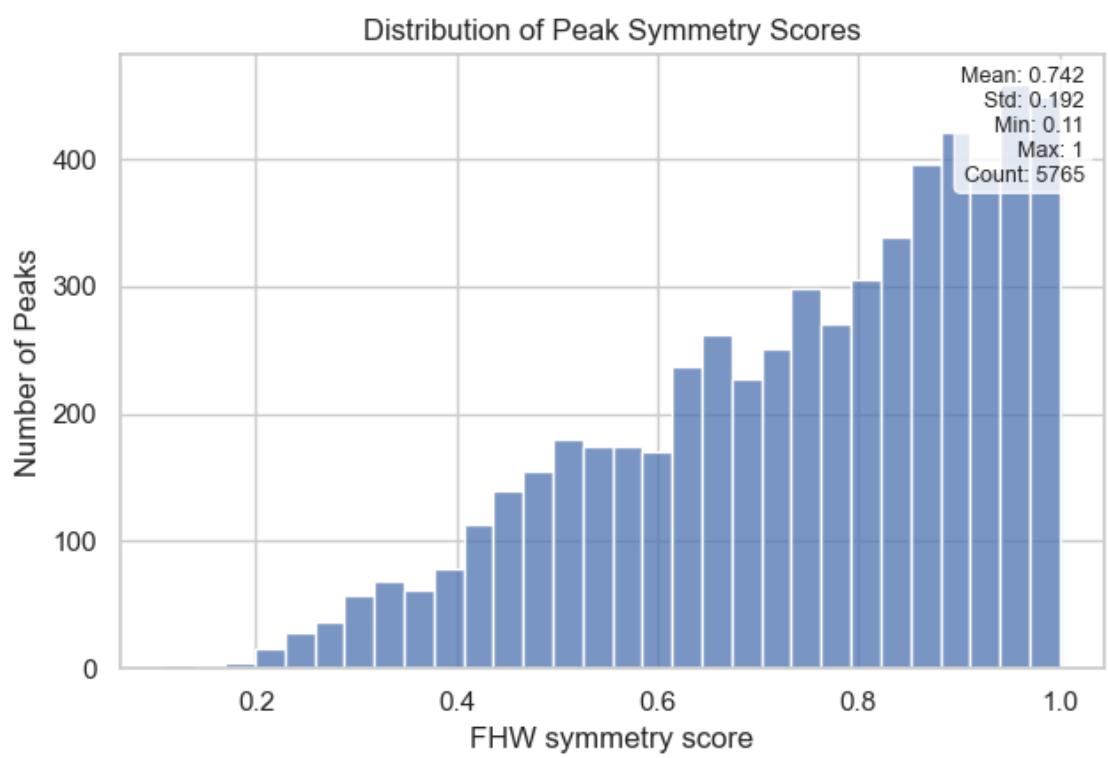
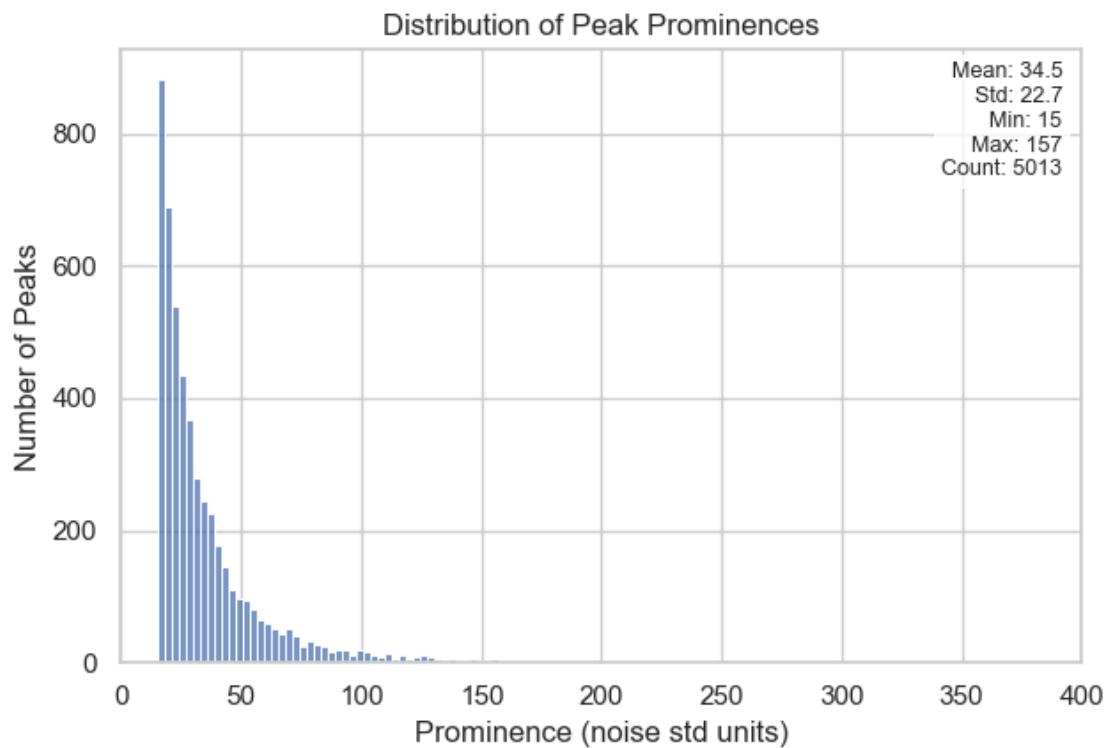
Total number of cells: 670

1.1.3 Peaks statistics

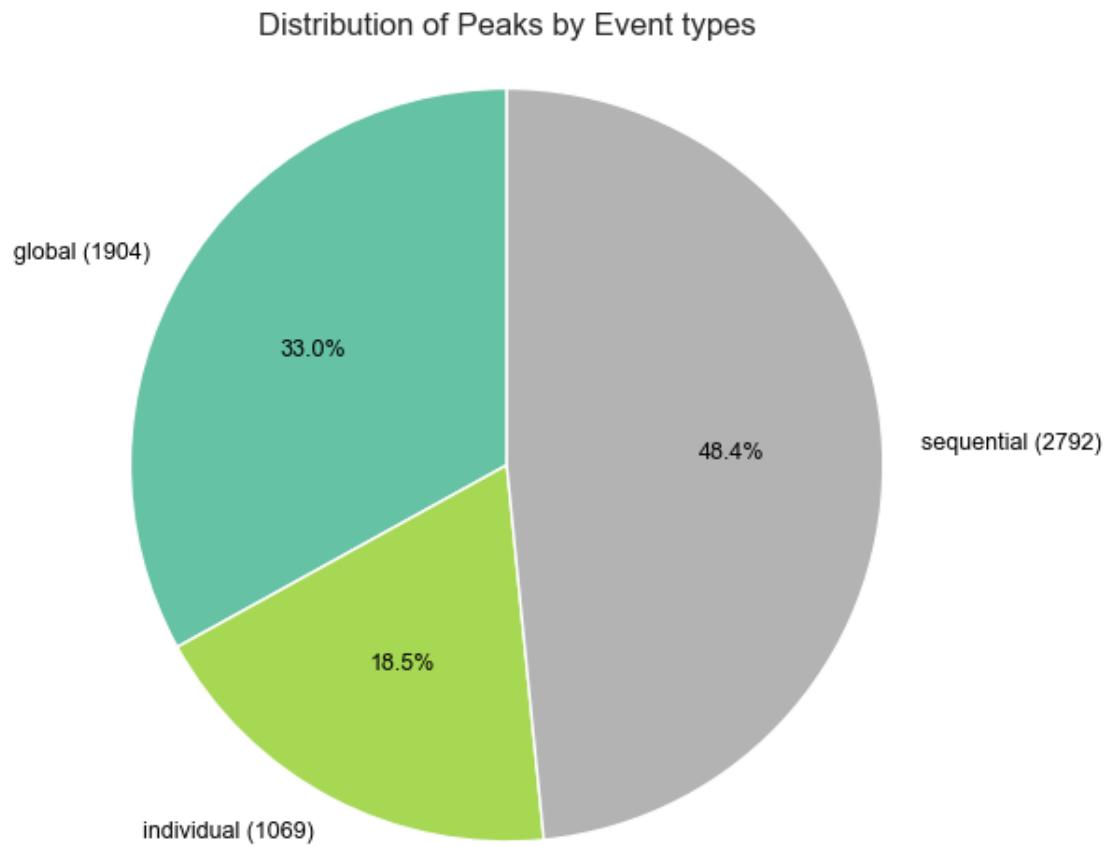
```
[2025-08-13 12:32:02] [INFO] calcium: plot_histogram: removed 29 outliers out of  
5765 on 'Duration (s)' (lower=-89, upper=170)
```



```
[2025-08-13 12:32:02] [INFO] calcium: plot_histogram: removed 752 outliers out  
of 5765 on 'Prominence (noise std units)' (lower=-83.2, upper=158.3)
```

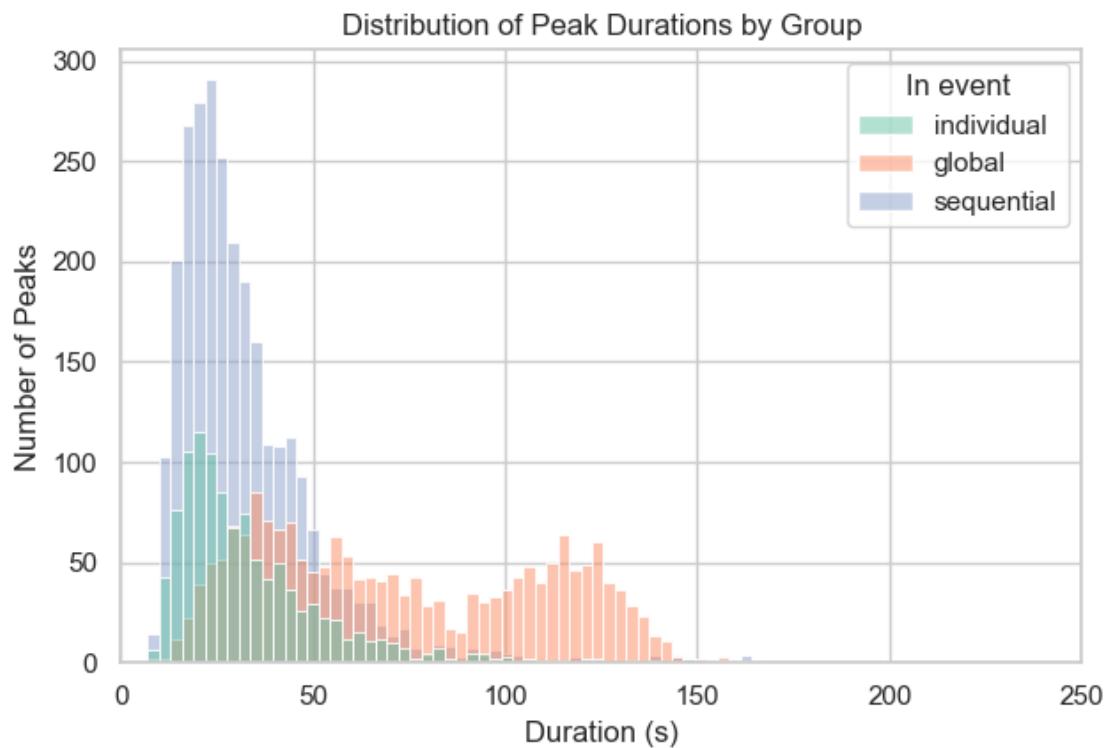


1.1.4 Distribution of peaks per event types



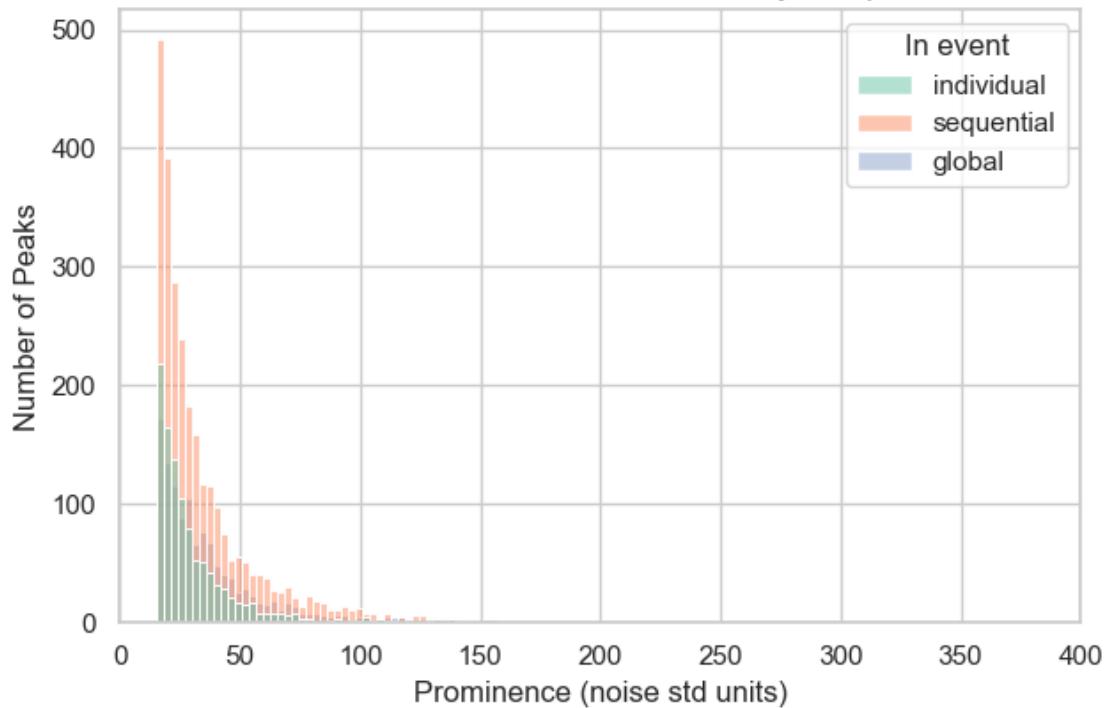
1.1.5 Peaks statistics per event types

```
[2025-08-13 12:32:03] [INFO] calcium: plot_histogram_by_group: removed 29 outliers out of 5765 on 'Duration (s)' (lower=-89, upper=170)
```

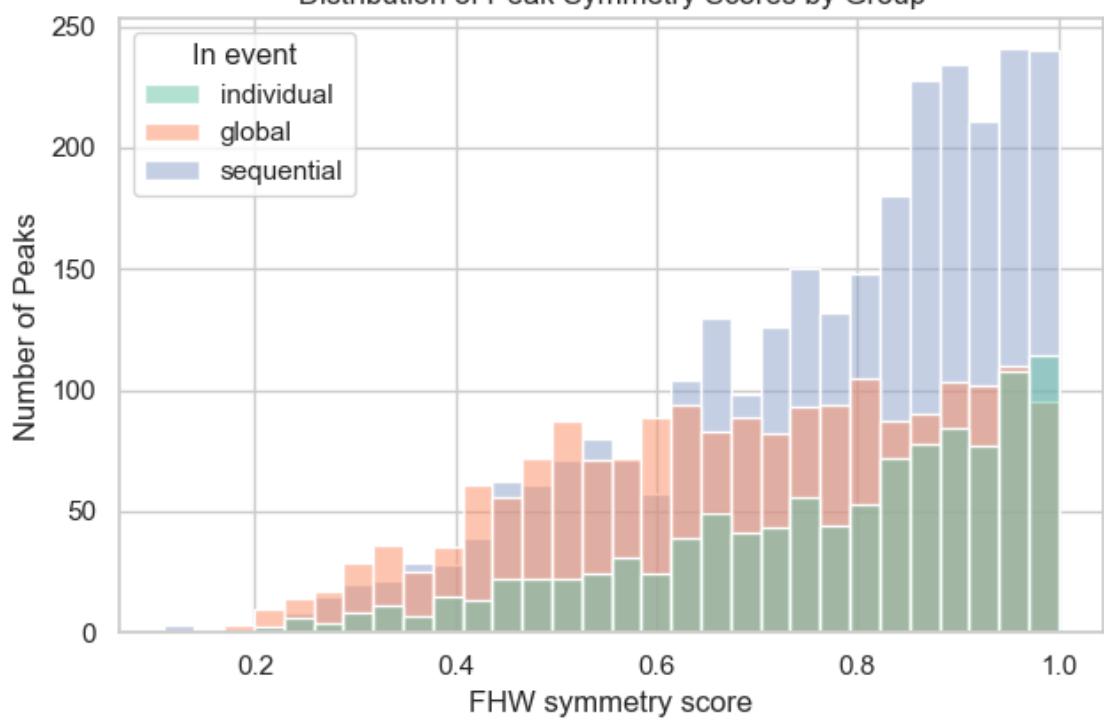


```
[2025-08-13 12:32:03] [INFO] calcium: plot_histogram_by_group: removed 752 outliers out of 5765 on 'Prominence (noise std units)' (lower=-83.2, upper=158.3)
```

Distribution of Peak Prominences by Group



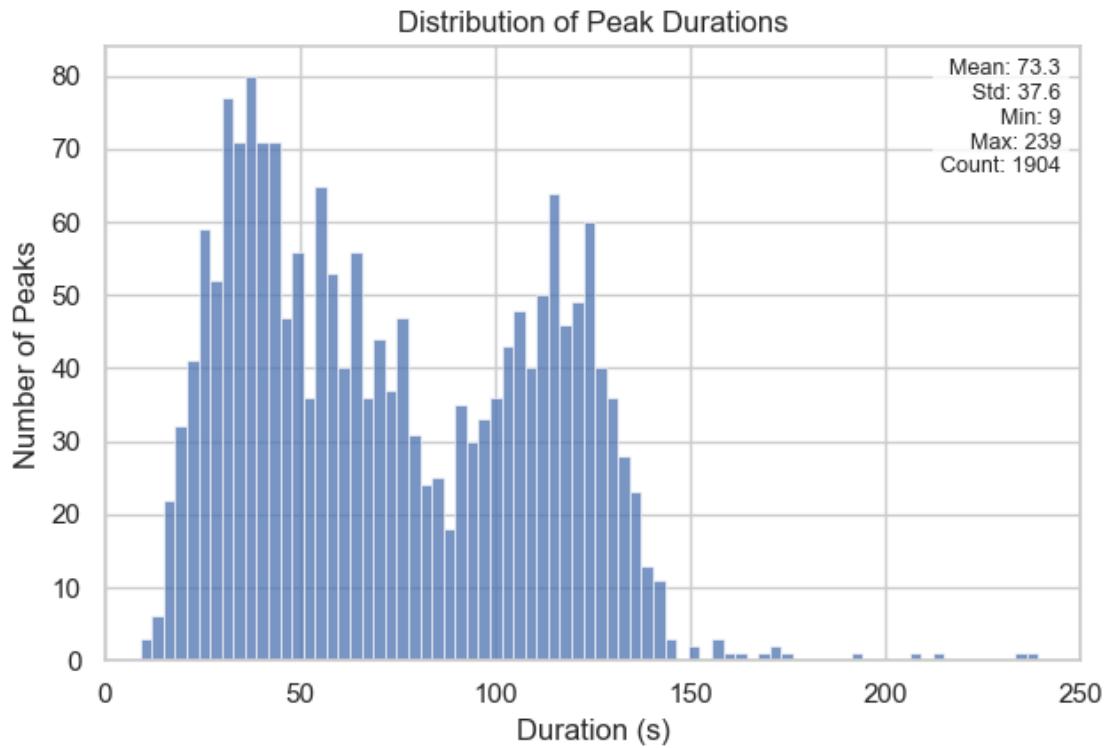
Distribution of Peak Symmetry Scores by Group



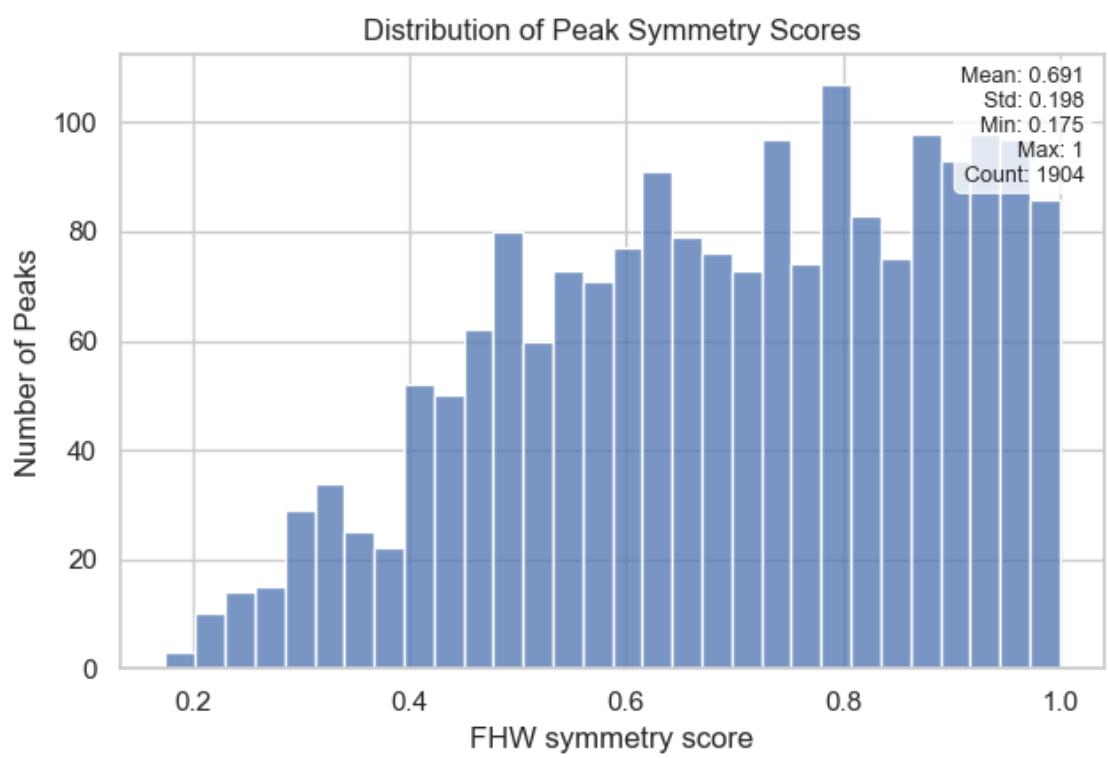
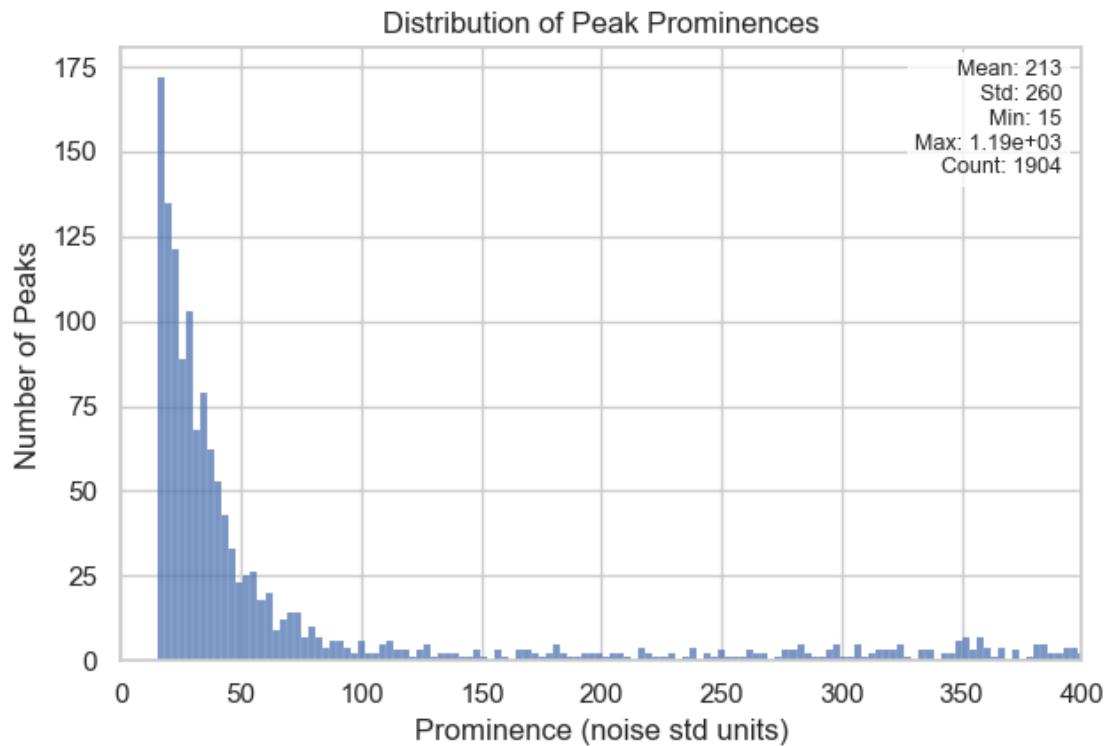
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

```
[2025-08-13 12:32:04] [INFO] calcium: plot_histogram: removed 0 outliers out of  
1904 on 'Duration (s)' (lower=-164, upper=312)
```

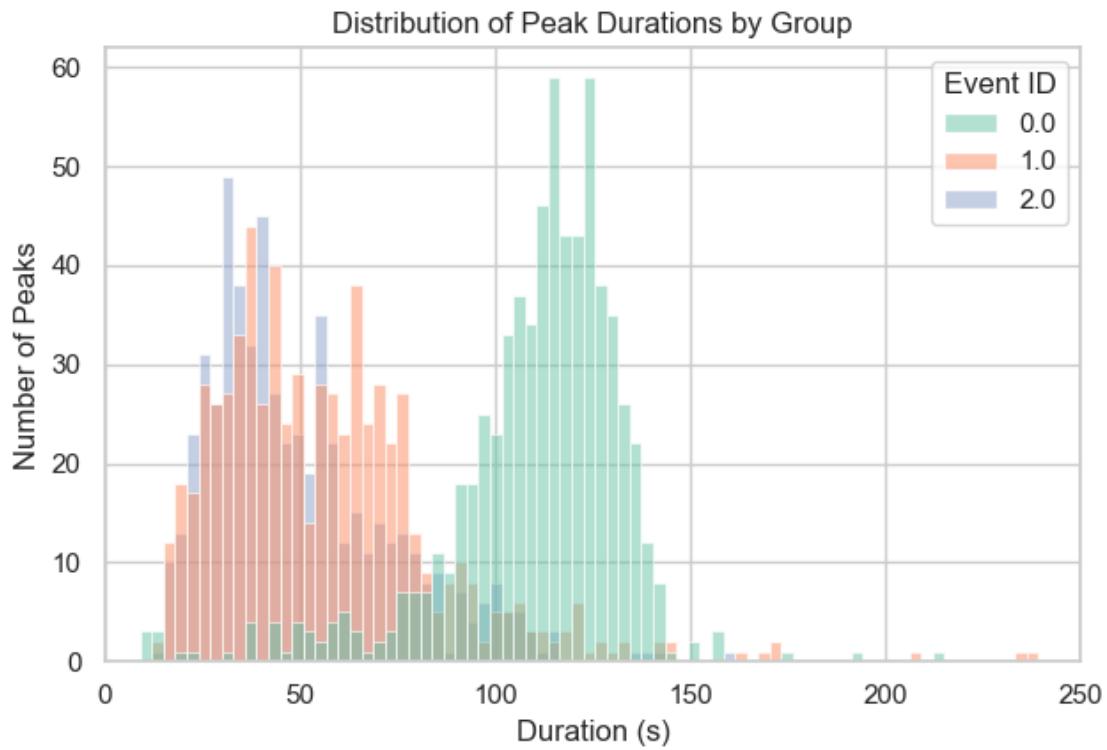


```
[2025-08-13 12:32:04] [INFO] calcium: plot_histogram: removed 0 outliers out of  
1904 on 'Prominence (noise std units)' (lower=-1164.4, upper=1611.3)
```



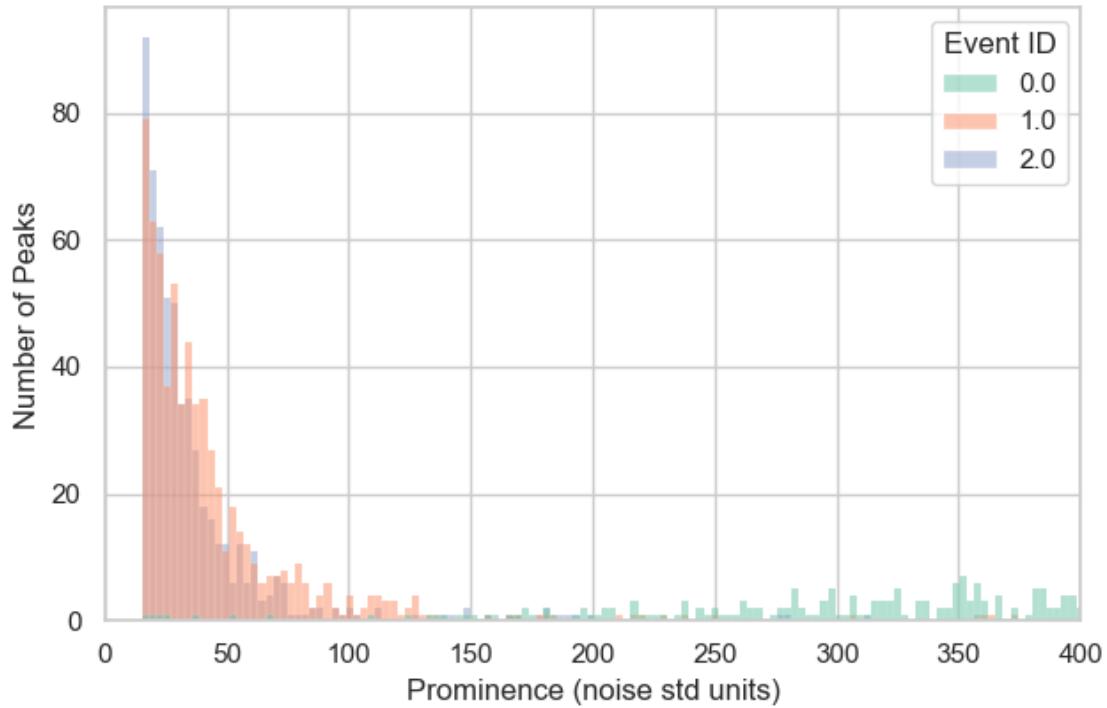
1.2.2 Peak statistics in global event per event ID

[2025-08-13 12:32:05] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 1904 on 'Duration (s)' (lower=-164, upper=312)

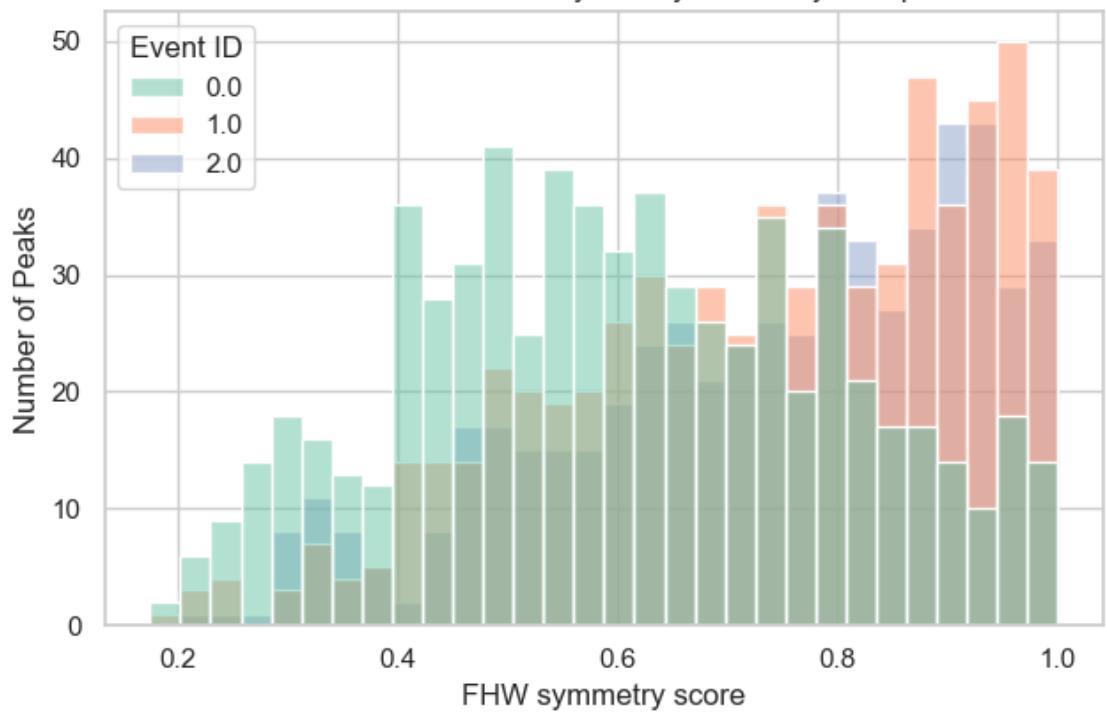


[2025-08-13 12:32:06] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 1904 on 'Prominence (noise std units)' (lower=-1164.4, upper=1611.3)

Distribution of Peak Prominences by Group

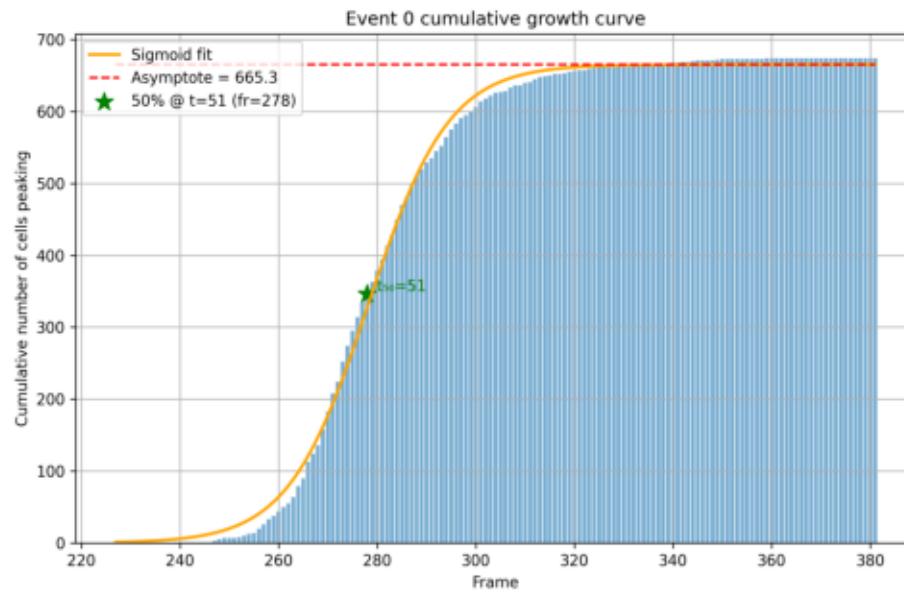


Distribution of Peak Symmetry Scores by Group

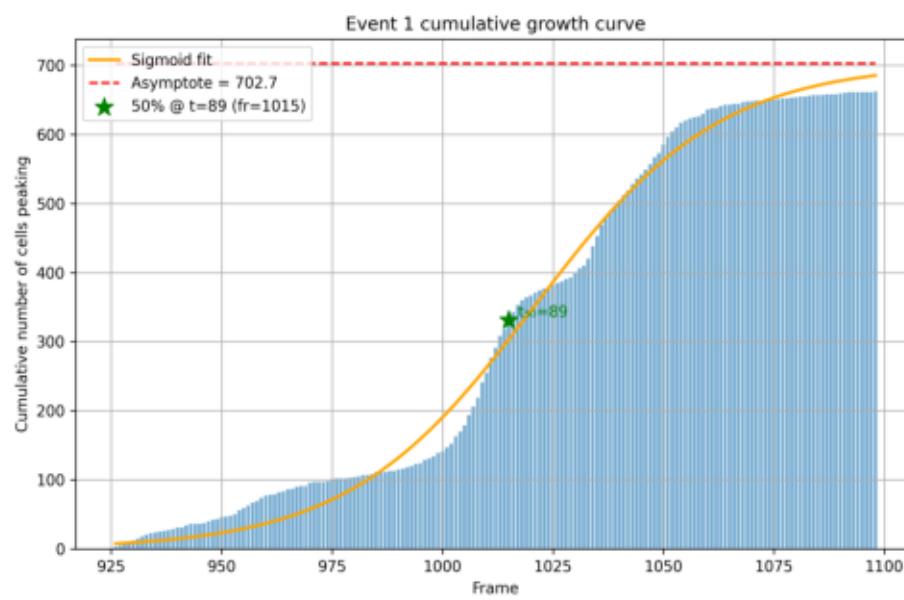


1.2.3 Kinetics of global events

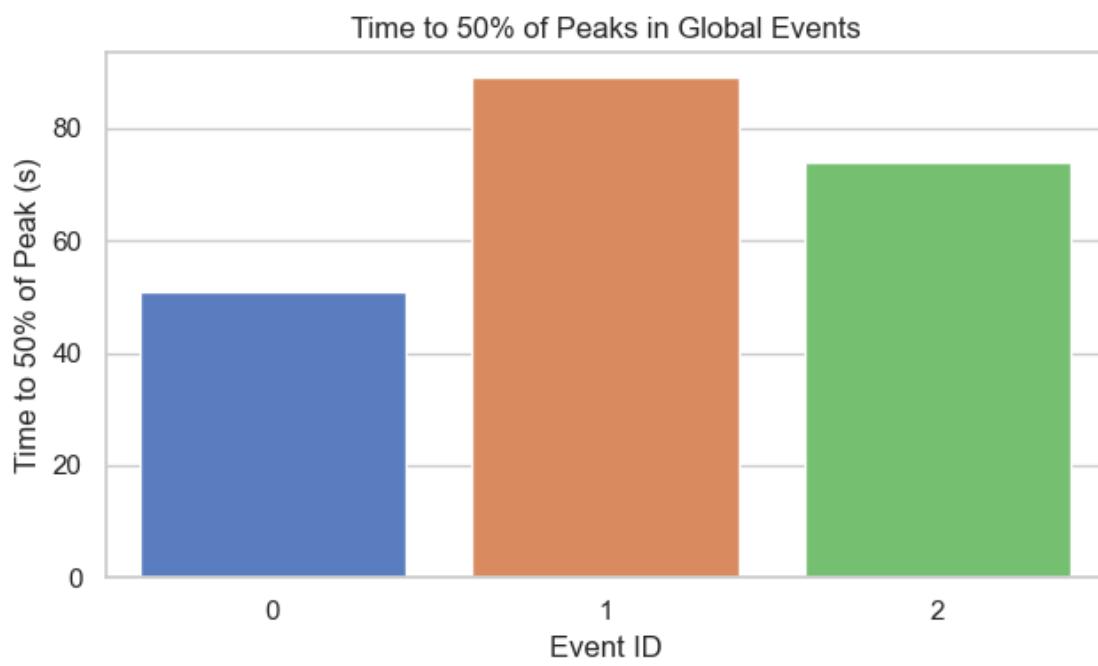
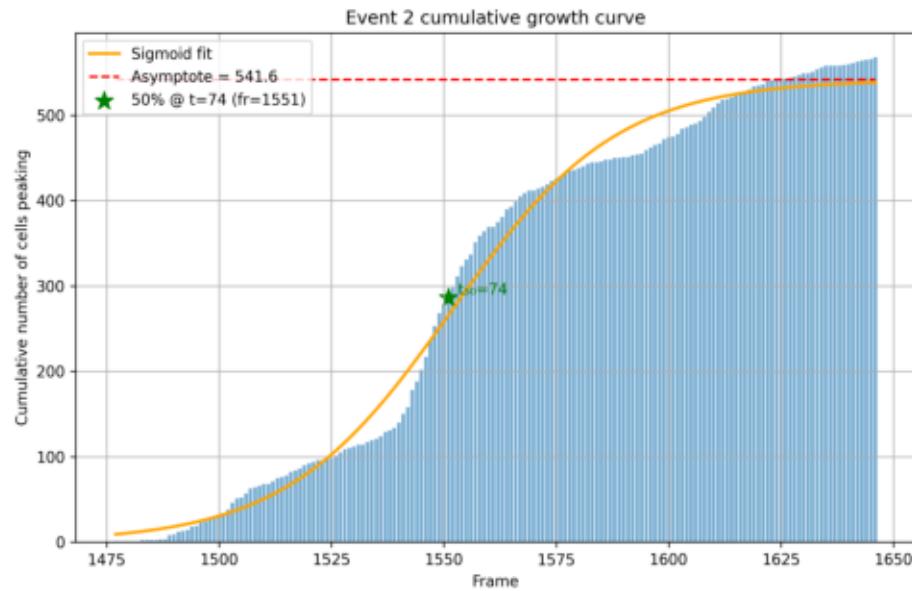
Event Activity Overlay (Event ID: 0) - 20250701_IS1



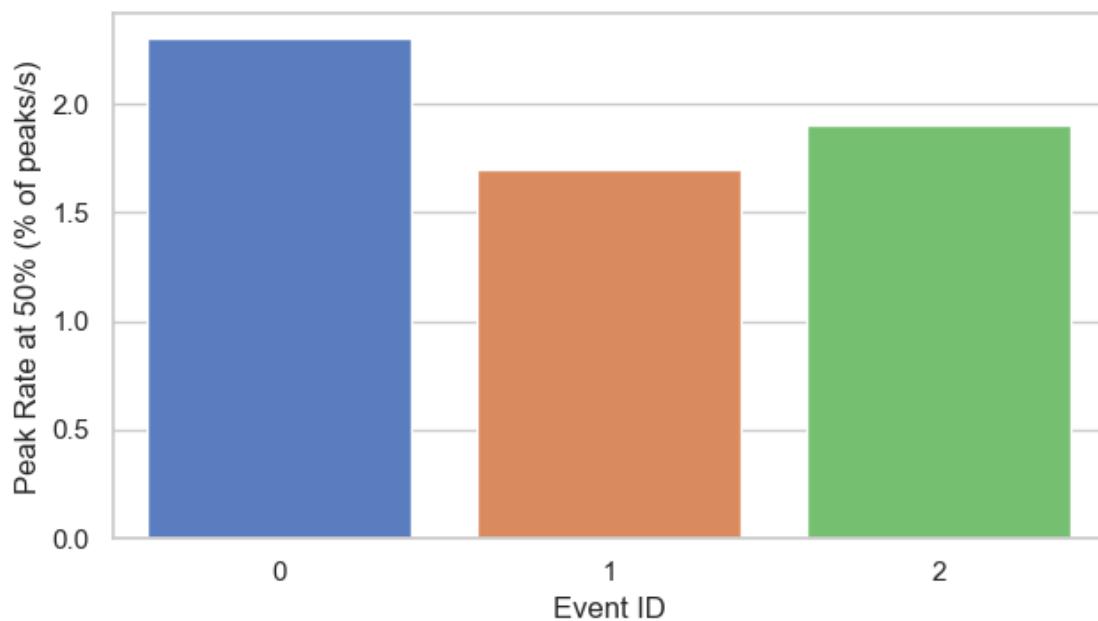
Event Activity Overlay (Event ID: 1) - 20250701_IS1



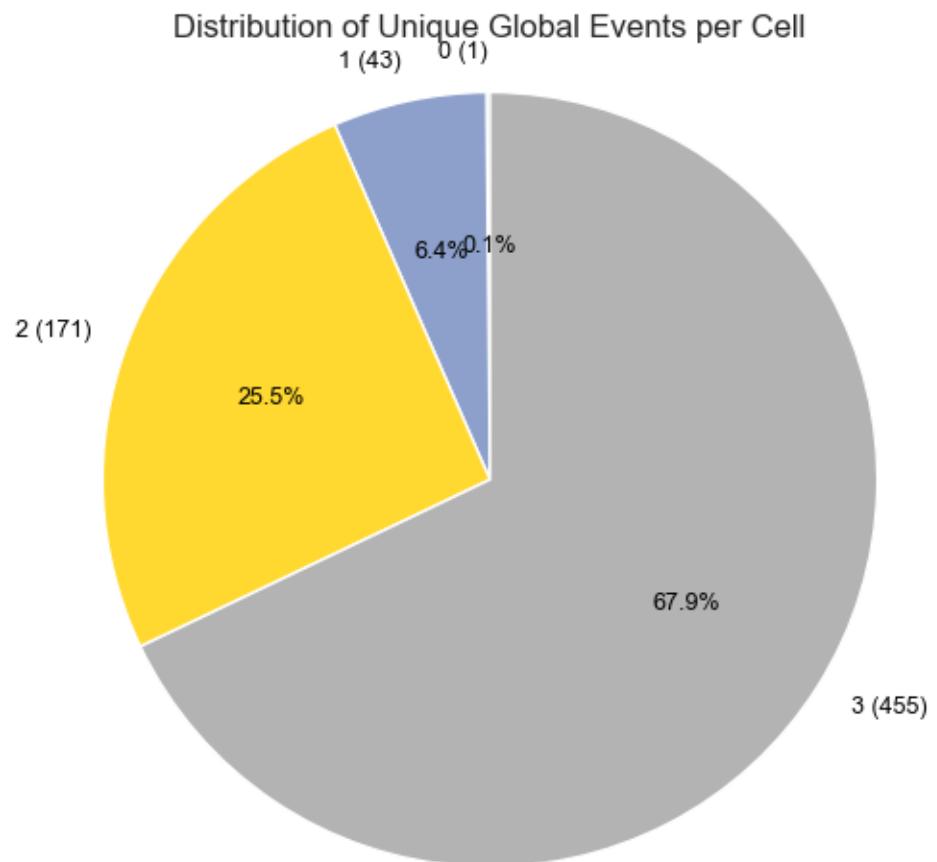
Event Activity Overlay (Event ID: 2) - 20250701_IS1



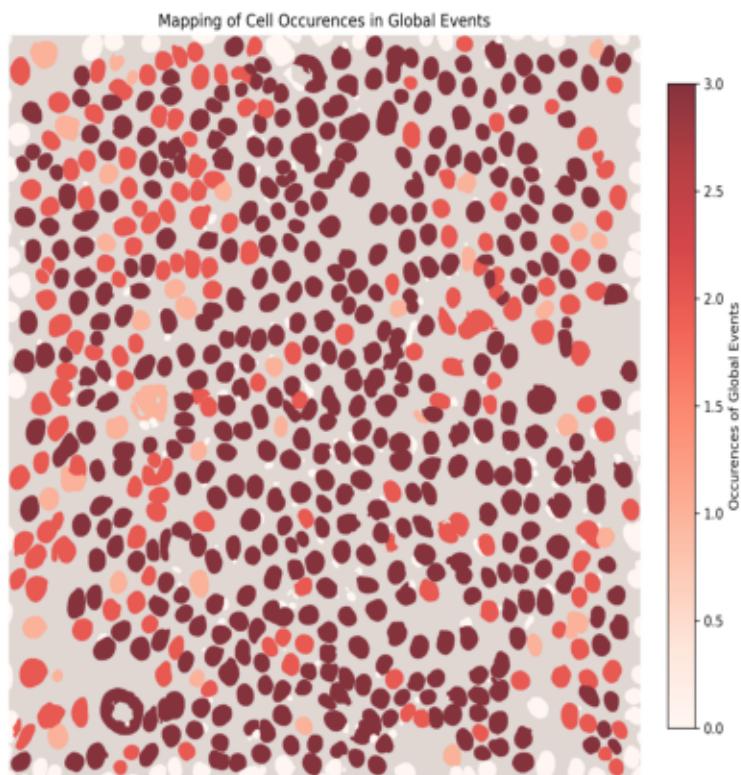
Peak rate at 50% in Global Events

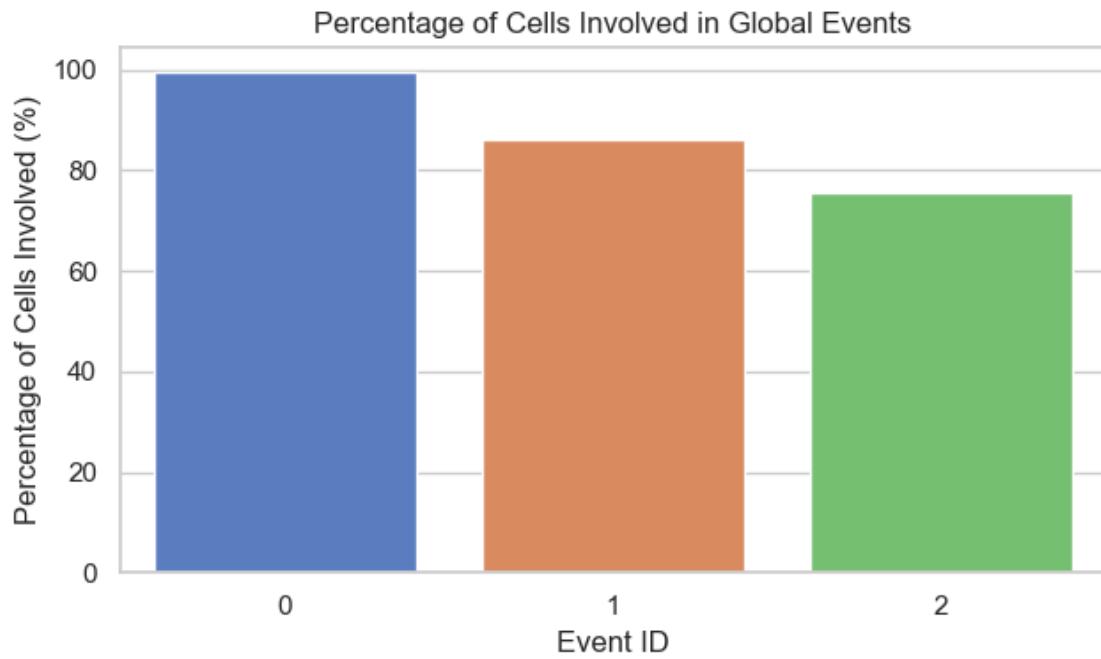


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250701_IS1





1.2.5 Inter-event interval analysis

Intervals between global event peaks: [744.0, 523.0]

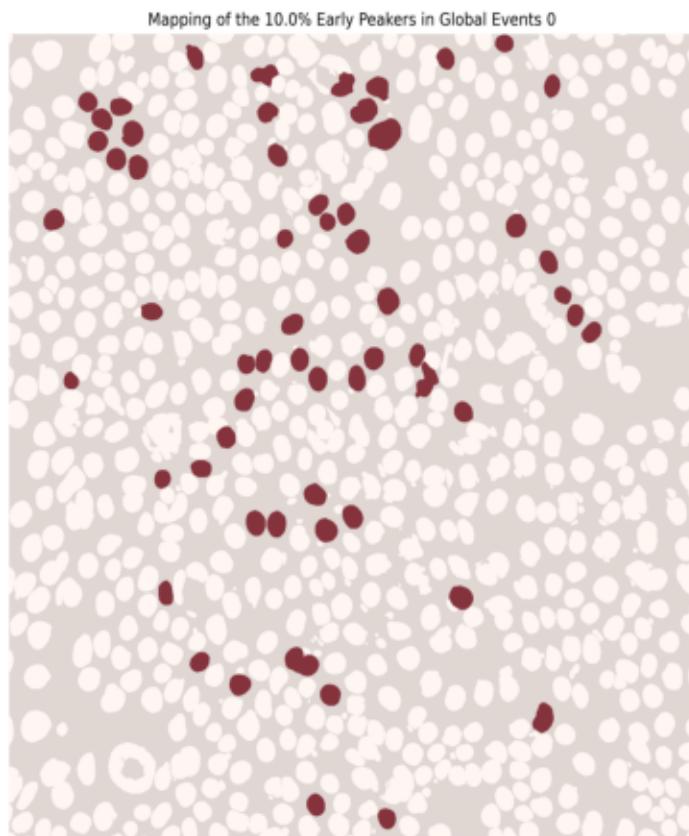
Estimated periodicity: 0.851

The global events exhibit a regular periodic pattern.

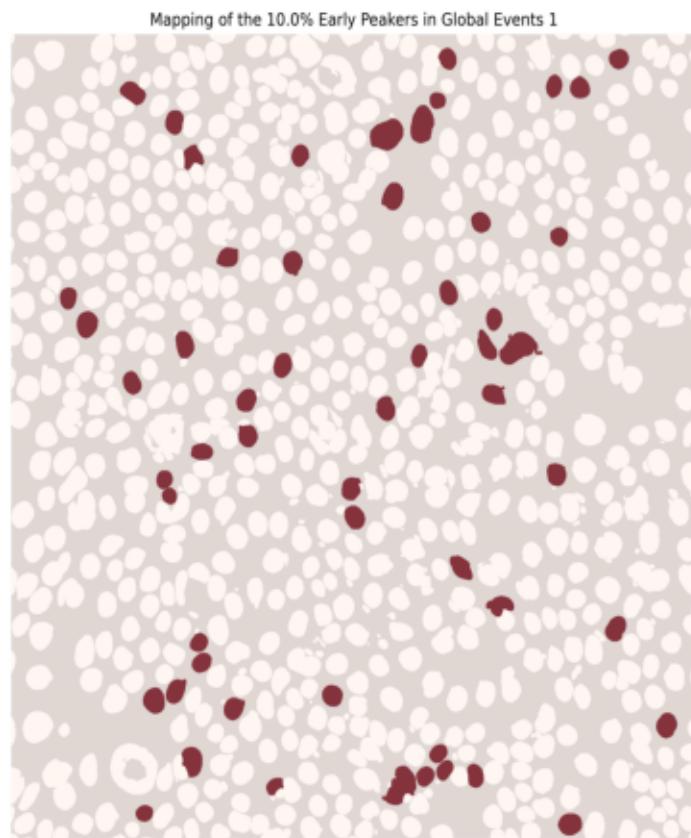
Estimated frequency (1/mean interval): 0.002 Hz

1.2.6 Early peakers in the events

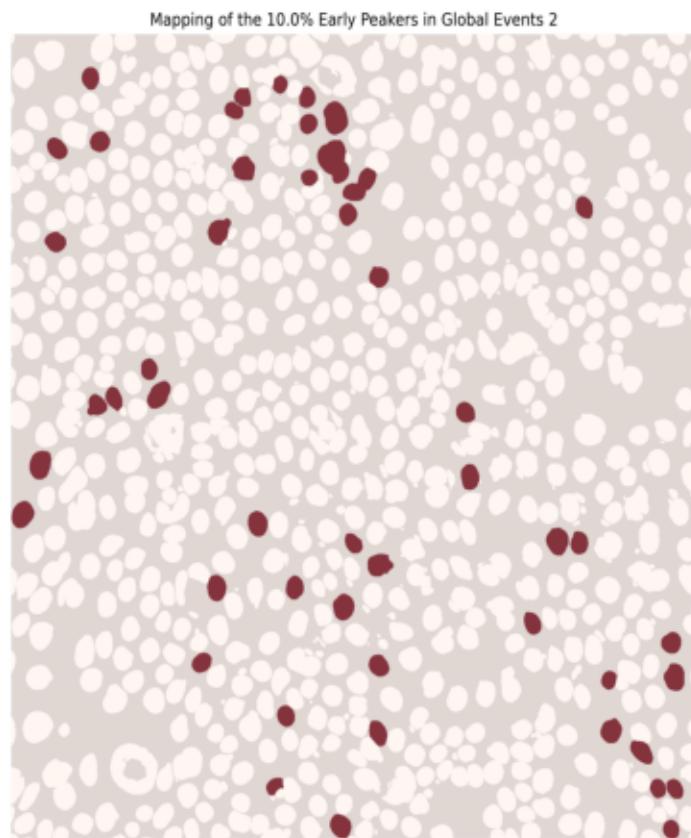
Cell Mapping with Early Peakers Overlay for event 0 - 20250701_IS1



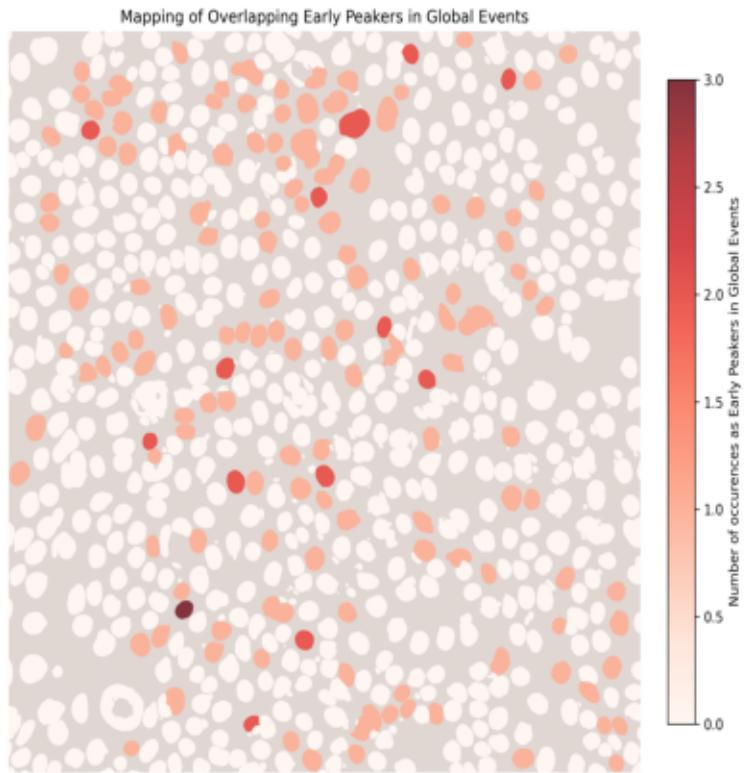
Cell Mapping with Early Peakers Overlay for event 1 - 20250701_IS1

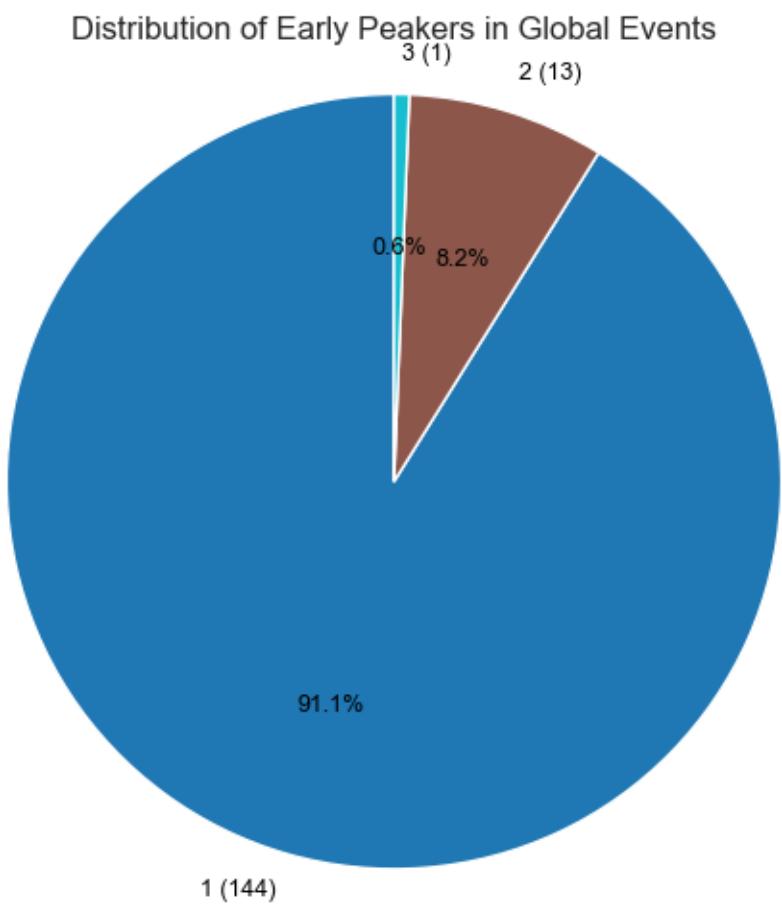
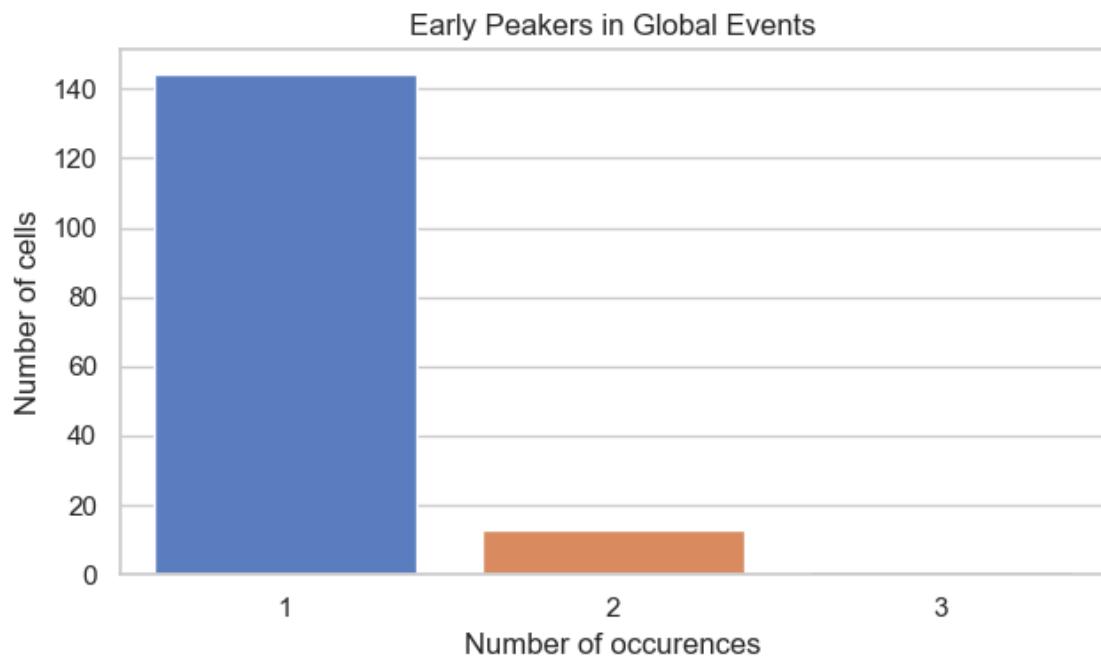


Cell Mapping with Early Peakers Overlay for event 2 - 20250701_IS1



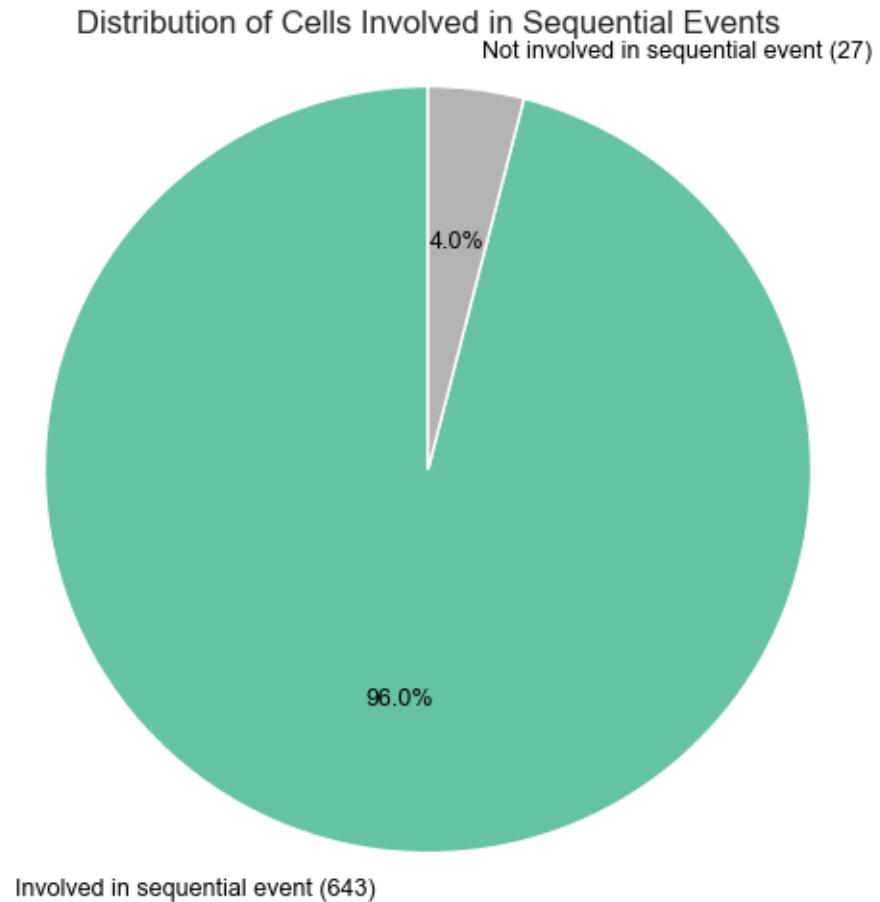
Cell Mapping with Occurrences in Global Events Overlay - 20250701_IS1



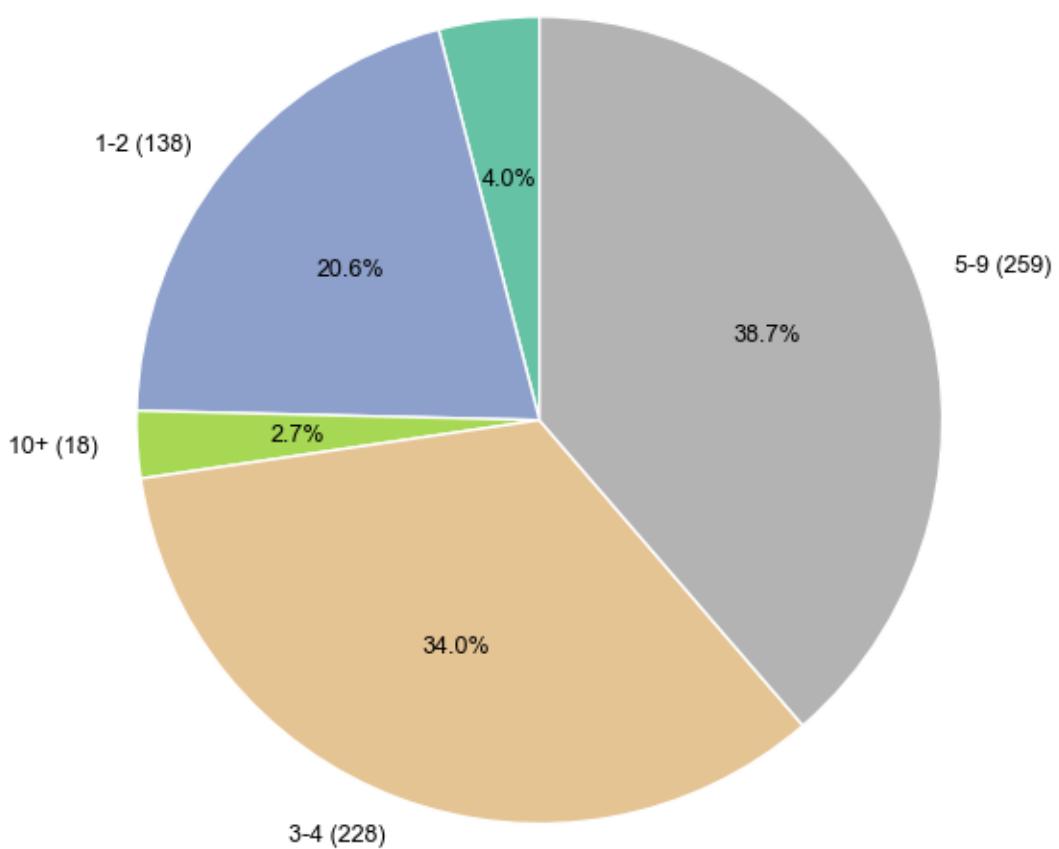


1.3 SEQUENTIAL EVENTS

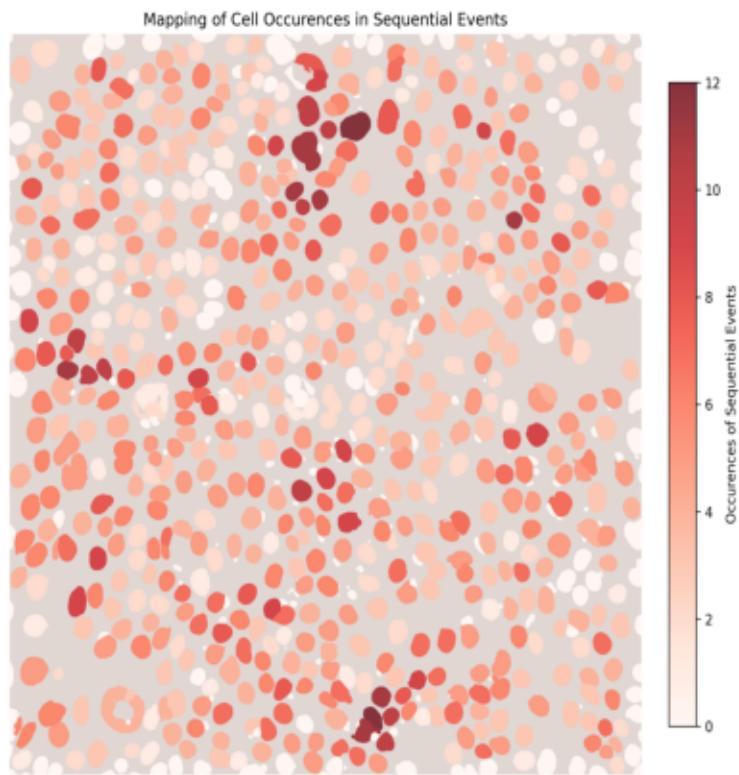
1.3.1 Cells occurrences in sequential events



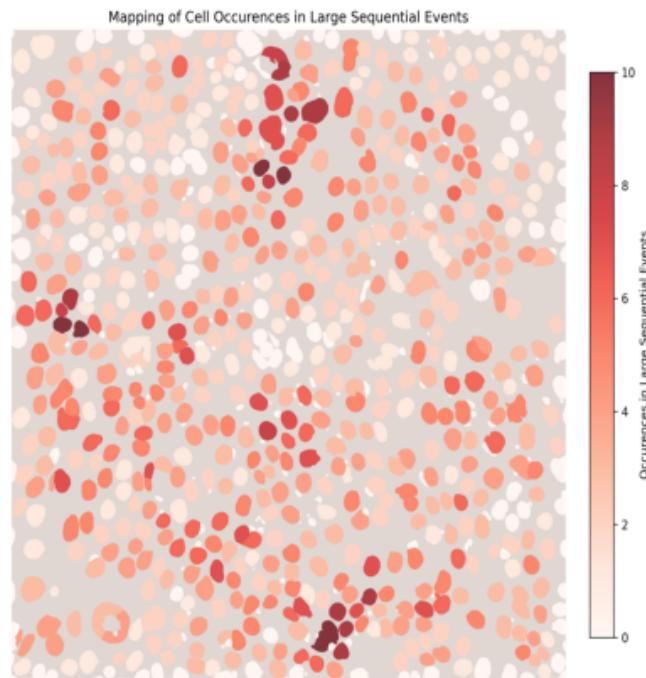
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250701_IS1

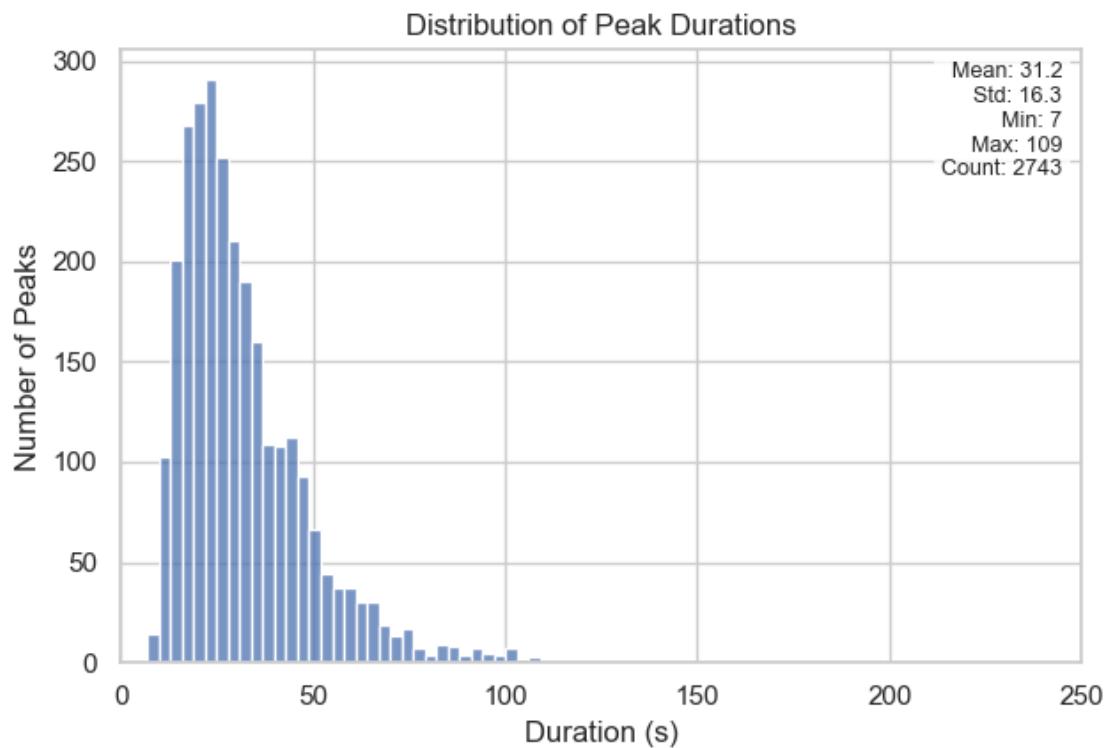


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250701_IS1

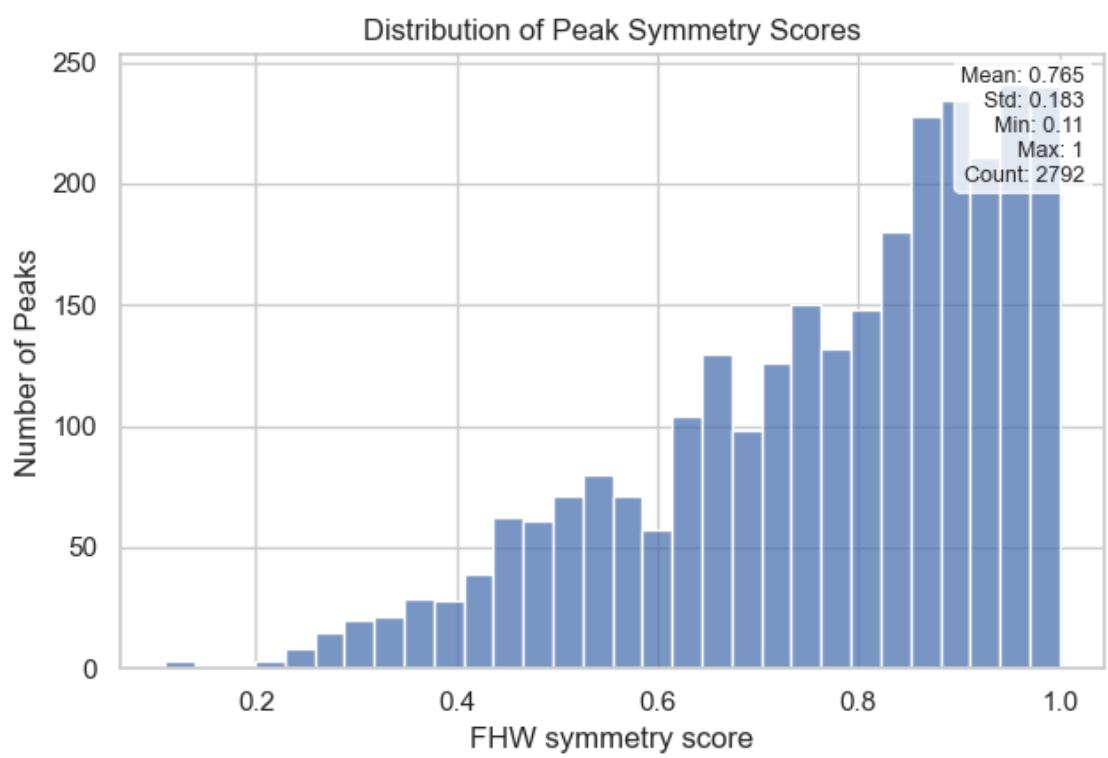
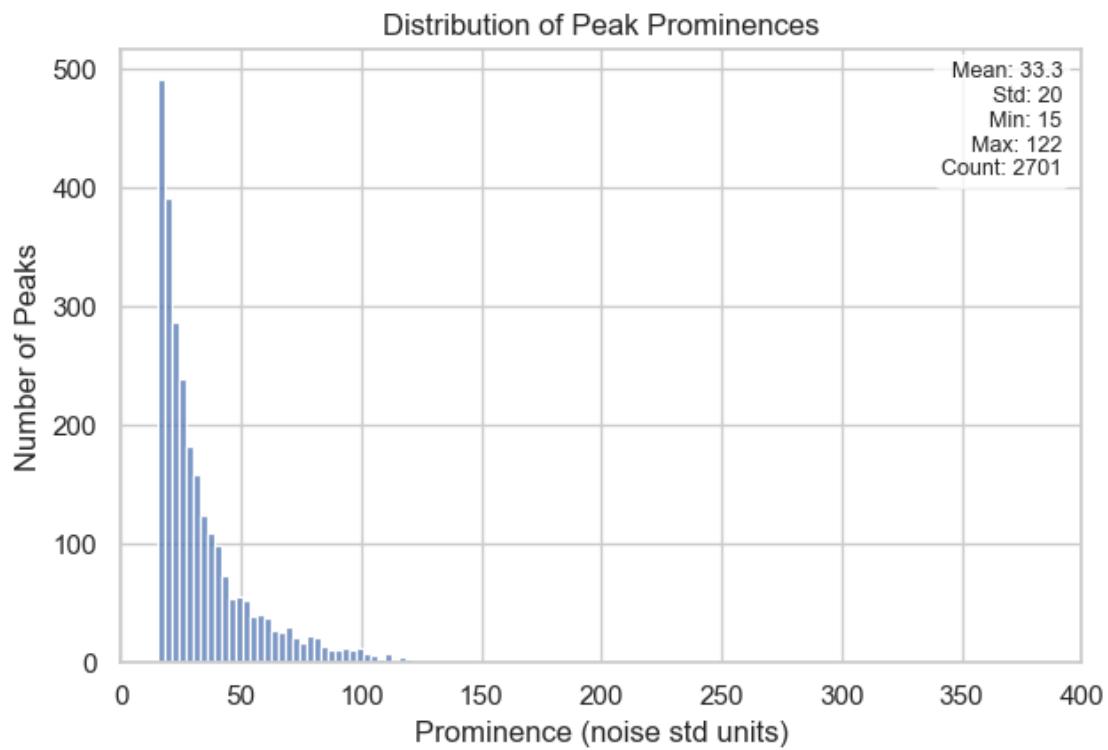


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 12:32:19] [INFO] calcium: plot_histogram: removed 49 outliers out of 2792 on 'Duration (s)' (lower=-10, upper=110)
```

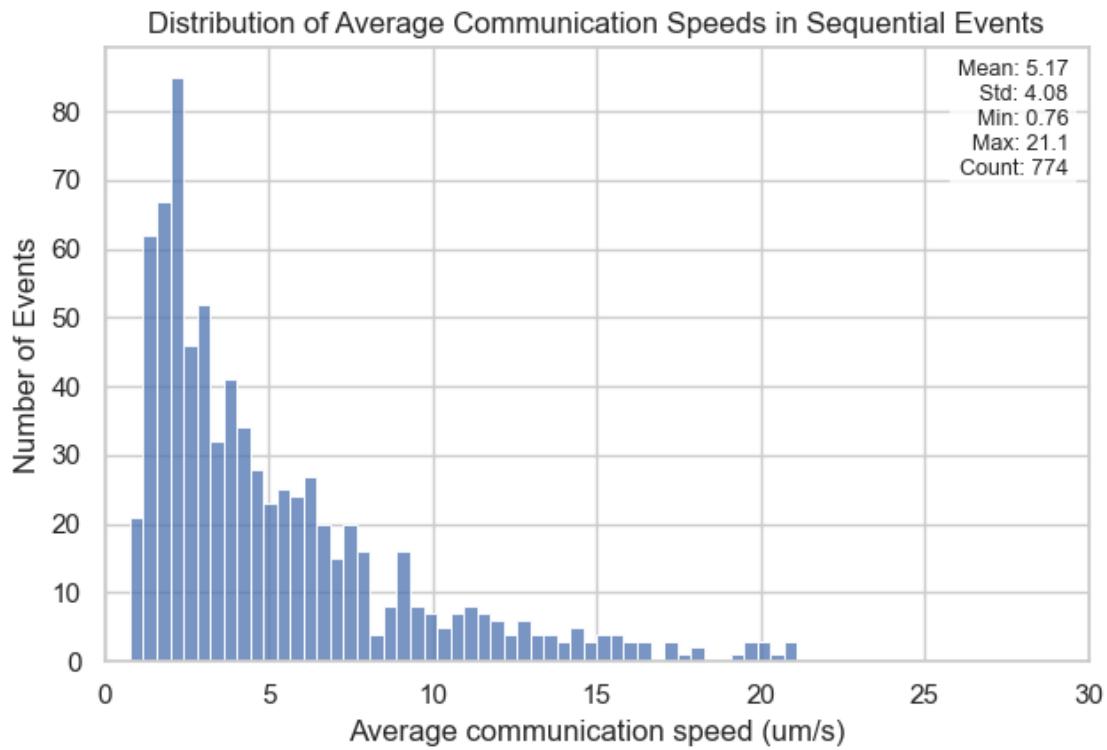


```
[2025-08-13 12:32:19] [INFO] calcium: plot_histogram: removed 91 outliers out of 2792 on 'Prominence (noise std units)' (lower=-14.787, upper=121.56)
```

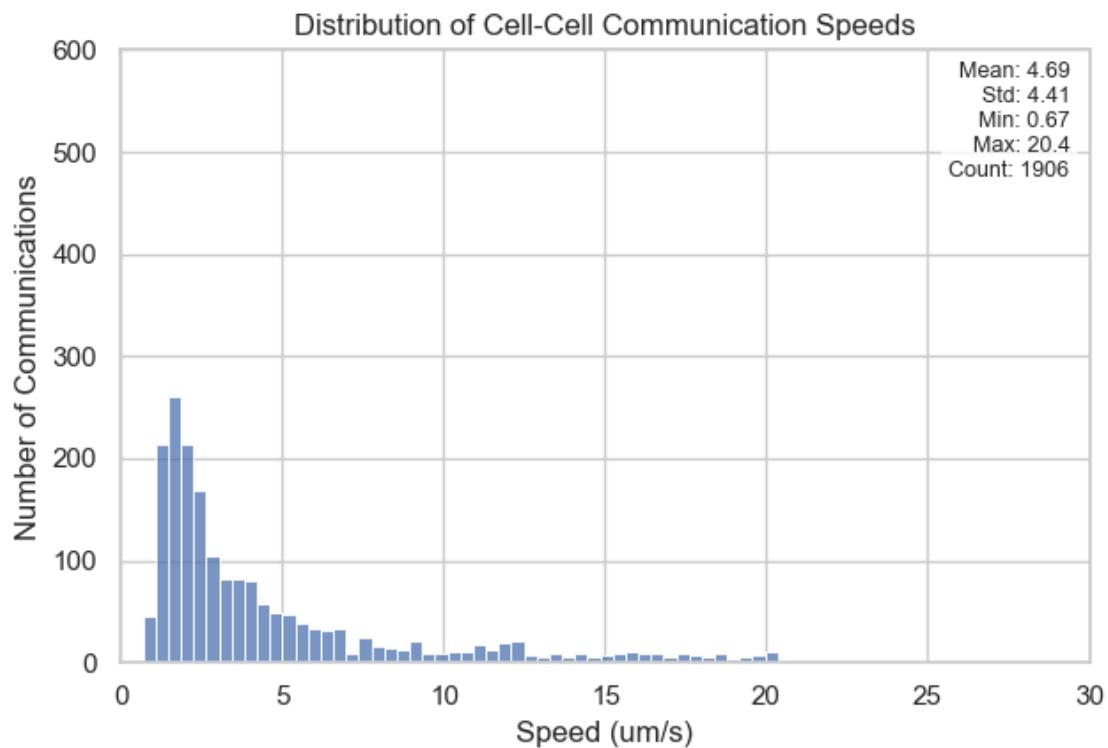


1.3.3 Cell-cell communication speed

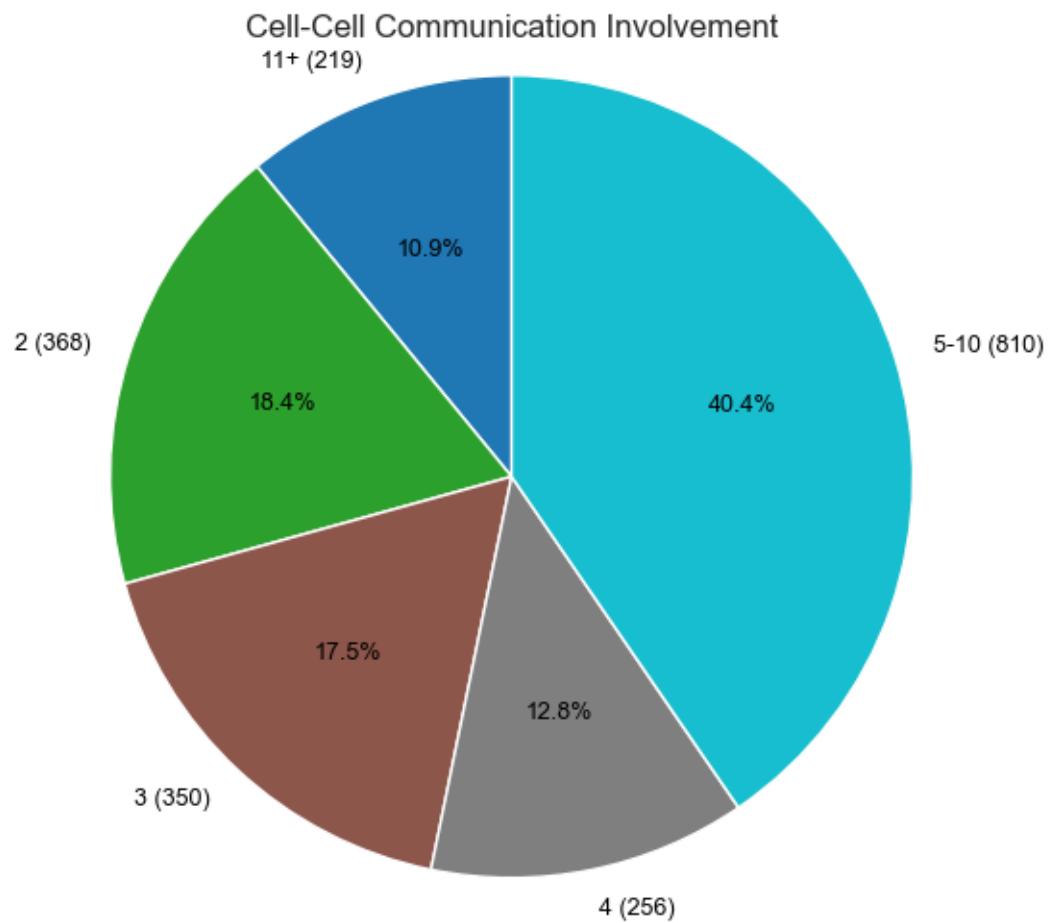
[2025-08-13 12:32:20] [INFO] calcium: plot_histogram: removed 15 outliers out of 789 on 'Average communication speed (um/s)' (lower=-12.04, upper=21.21)



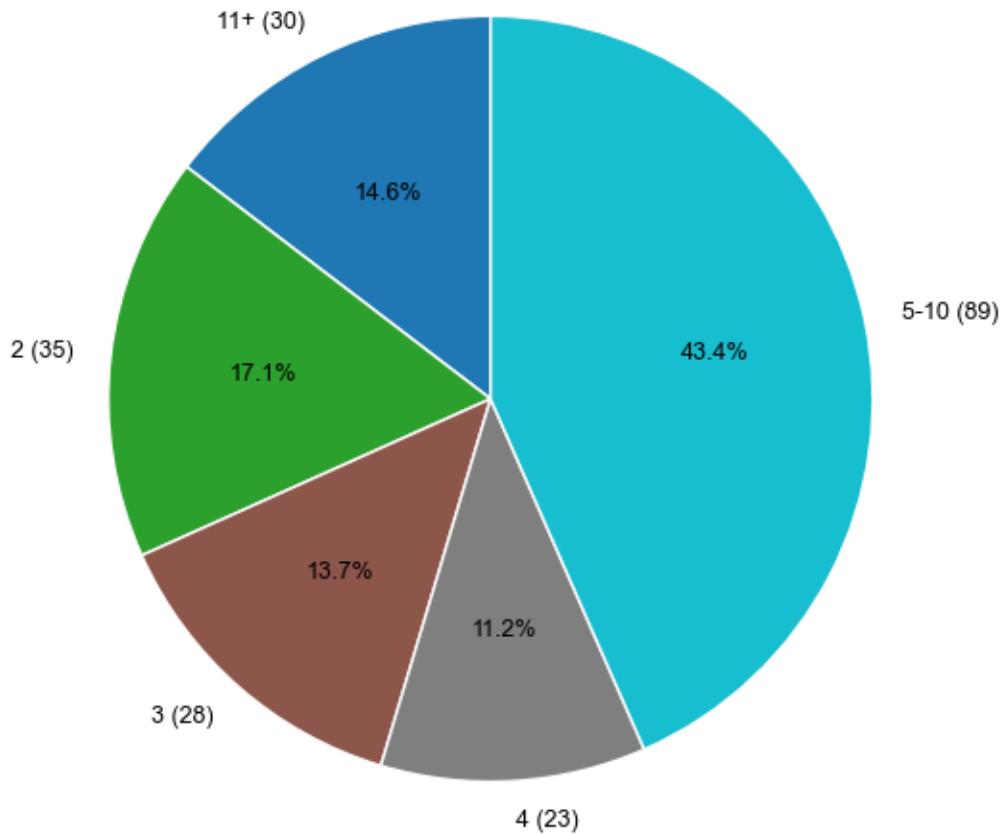
[2025-08-13 12:32:20] [INFO] calcium: plot_histogram: removed 97 outliers out of 2003 on 'Speed (um/s)' (lower=-12.09, upper=20.39)



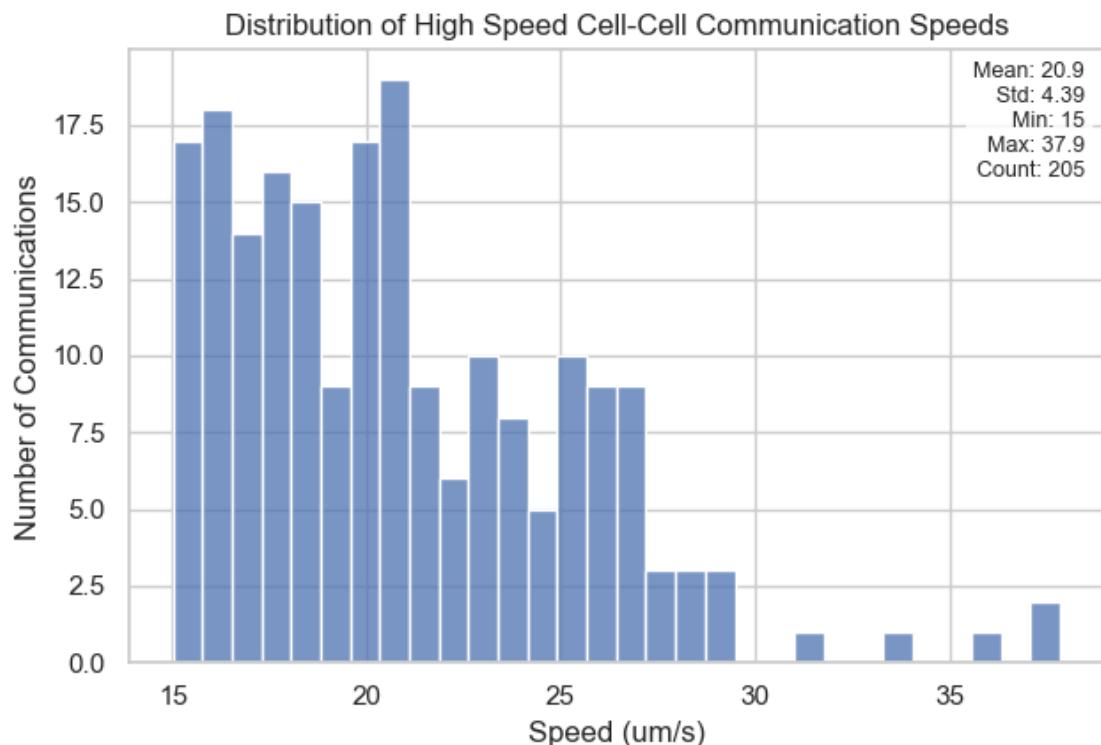
1.3.4 Double distribution in cell-cell communication speeds



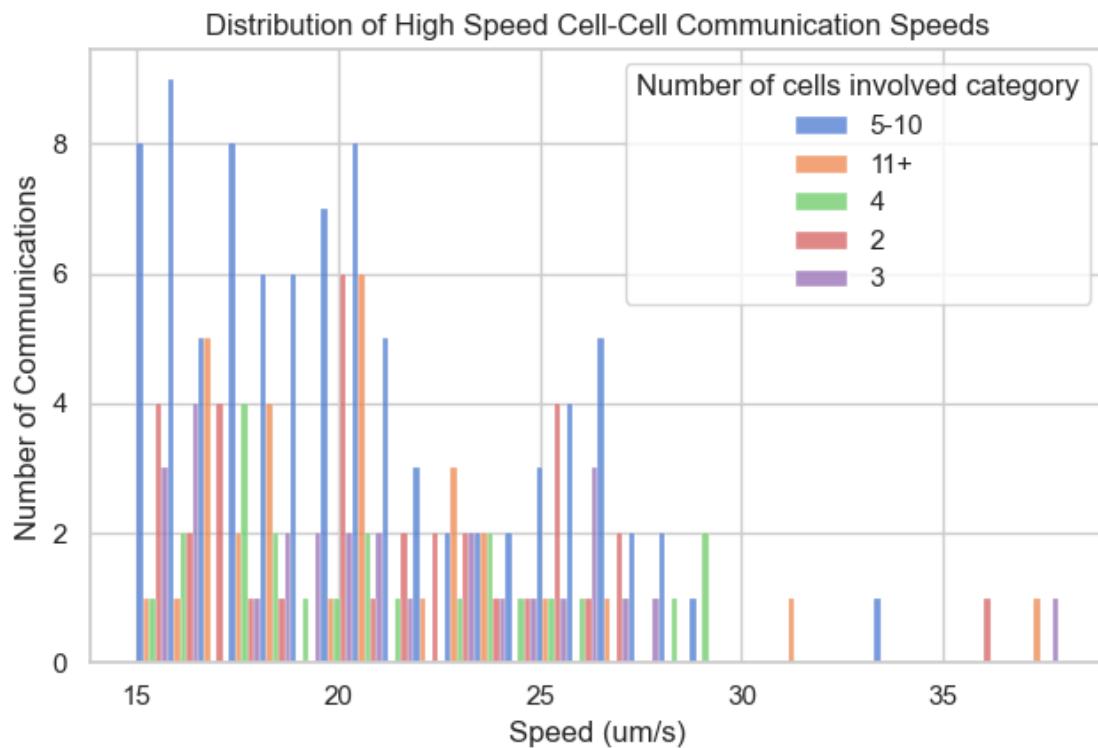
High Speed Cell-Cell Communication Involvement



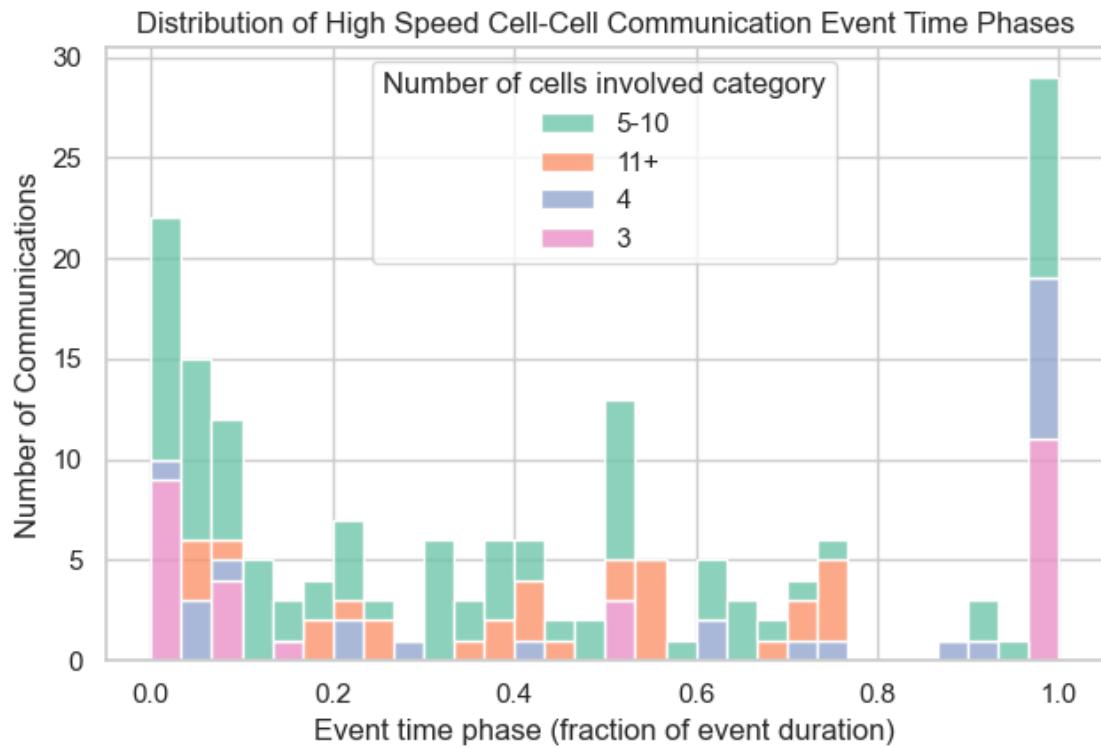
```
[2025-08-13 12:32:21] [INFO] calcium: plot_histogram: removed 0 outliers out of  
205 on 'Speed (um/s)' (lower=-1.06, upper=42.06)
```



```
[2025-08-13 12:32:21] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 205 on 'Speed (um/s)' (lower=-1.06, upper=42.06)
```

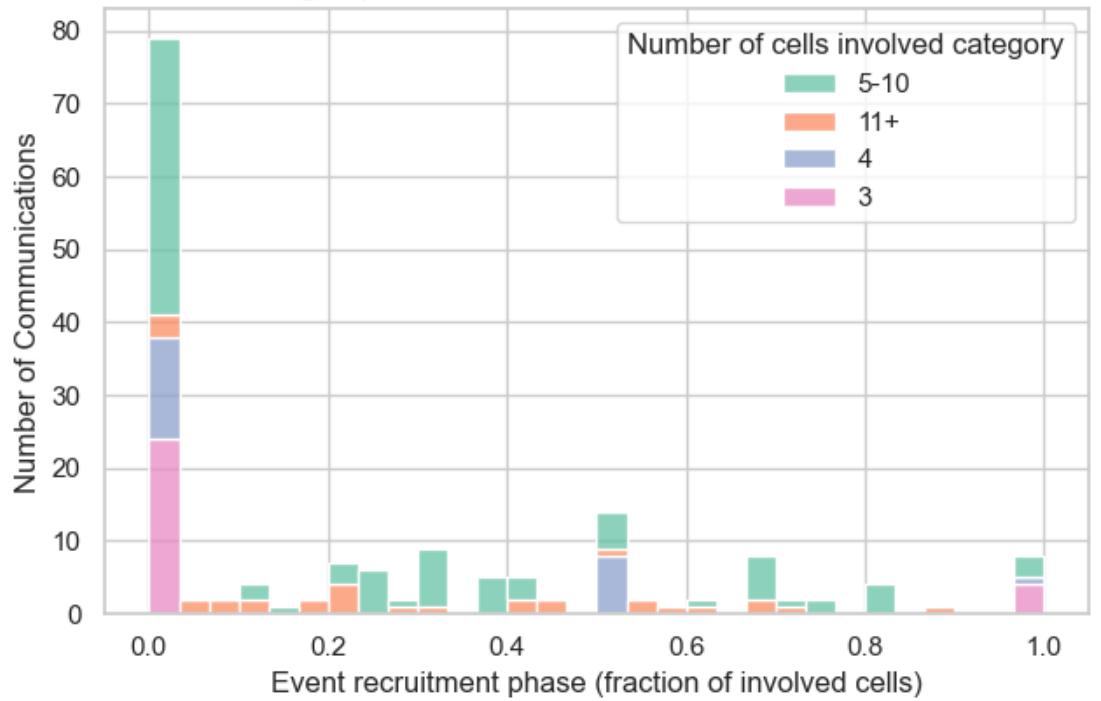


```
[2025-08-13 12:32:21] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 170 on 'Event time phase (fraction of event duration)' (lower=-1.81, upper=2.6)
```

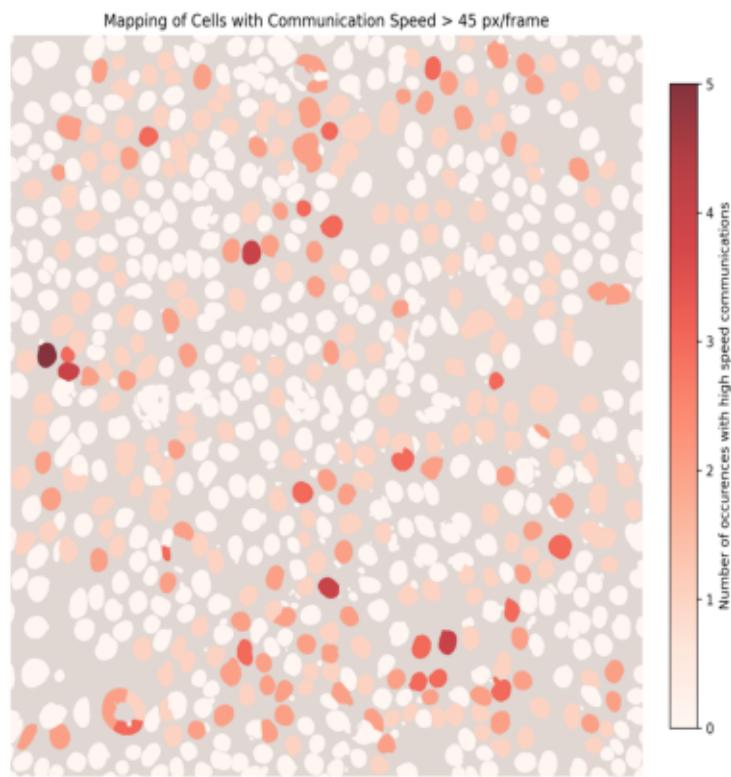


```
[2025-08-13 12:32:21] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 170 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.5, upper=2)
```

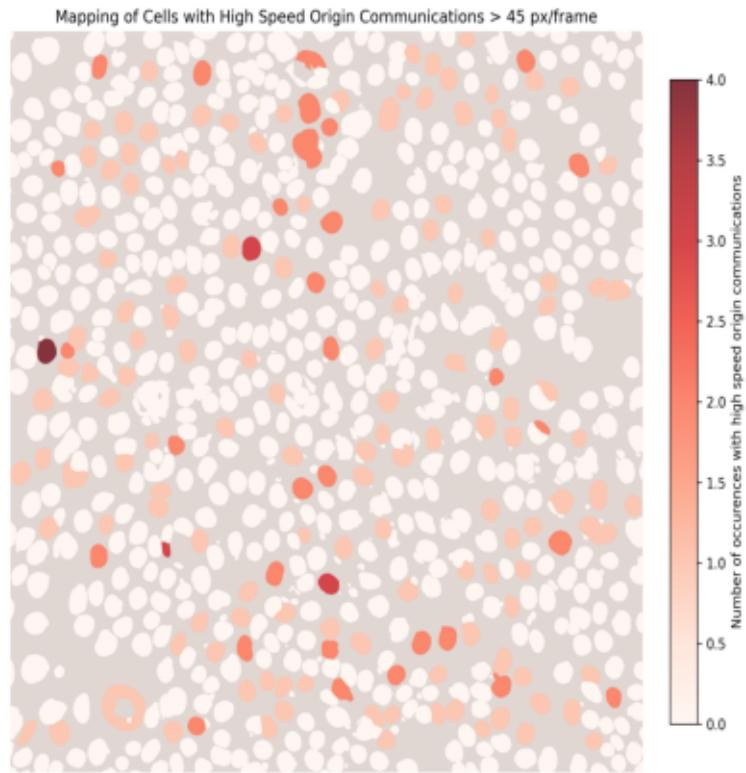
Distribution of High Speed Cell-Cell Communication Event Recruitment Phases



Cell Mapping with High Speed Cells Overlay - 20250701_IS1



Cell Mapping with High Speed Origin Cells Overlay - 20250701_IS1



Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
20	1759516418848	7	311	1
26	1759516422688	8	1082	1
27	1759463553296	8	1082	0
35	1759516412848	9	1042	0
47	1759516421344	10	836	1
...
1928	1759463548880	742	1161	9
1931	1759463548256	745	1169	4
1953	1759463545568	757	1114	0
1963	1759464612064	762	1184	2
1965	1759463551760	763	1172	7

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
20	271	3	137.0	137.0	
26	1085	2	65.0	65.0	
27	1085	1	38.0	39.0	
35	1071	0	83.0	83.0	
47	787	2	126.0	126.0	
...	
1928	1131	11	1266.0	1267.0	
1931	1125	4	783.0	784.0	
1953	1160	0	40.0	41.0	
1963	1216	1	213.0	214.0	
1965	1173	6	886.0	887.0	
	Duration (s)	Distance (um)	Speed (um/s)	\	
20	0.0	27.32	27.32		
26	0.0	17.98	17.98		
27	1.0	17.98	17.98		
35	0.0	20.52	20.52		
47	0.0	28.35	28.35		
...	
1928	1.0	23.70	23.70		
1931	1.0	17.27	17.27		
1953	1.0	19.74	19.74		
1963	1.0	15.15	15.15		
1965	1.0	25.68	25.68		
	Event time phase (fraction of event duration)	\			
20		0.35			
26		0.63			
27		0.02			
35		0.06			
47		0.23			
...	
1928		0.50			
1931		NaN			
1953		NaN			
1963		0.91			
1965		1.00			
	Event recruitment phase (fraction of involved cells)	dataset	\		
20		0.20	20250701_IS1		
26		0.71	20250701_IS1		
27		0.00	20250701_IS1		
35		0.00	20250701_IS1		
47		0.00	20250701_IS1		
...	
1928		0.00	20250701_IS1		
1931		NaN	20250701_IS1		

1953		NaN	20250701_IS1
1963		0.67	20250701_IS1
1965		1.00	20250701_IS1

	Number of cells involved	category	Speed category
20		5-10	High speed
26		5-10	High speed
27		5-10	High speed
35		11+	High speed
47		5-10	High speed
...
1928		3	High speed
1931		2	High speed
1953		2	High speed
1963		5-10	High speed
1965		3	High speed

[205 rows x 16 columns]

Speed category	High speed	Low speed
Origin cell ID		
159	1	1
164	0	1
168	0	1
171	0	3
173	0	1
...
1211	0	1
1212	0	1
1213	0	2
1214	0	2
1220	0	1

[570 rows x 2 columns]

Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
0	159	360.10	5.53
2	164	177.78	7.48
4	168	464.43	8.78
5	171	146.90	11.05
6	173	27.62	12.35
..
662	1211	9.43	488.80
663	1212	406.25	489.45
664	1213	51.68	489.12
665	1214	180.38	489.45
668	1220	480.03	492.70

Number of peaks Is active Occurences in global events \

0	8	True	2
2	11	True	3
4	3	True	1
5	6	True	2
6	5	True	1
..
662	14	True	3
663	6	True	3
664	6	True	3
665	7	True	3
668	8	True	2

Occurrences in global events as early peaker \

0	1
2	0
4	0
5	0
6	0
..	...
662	0
663	1
664	0
665	0
668	1

Occurrences in sequential events \

0	3
2	2
4	1
5	2
6	2
..	...
662	1
663	1
664	2
665	1
668	2

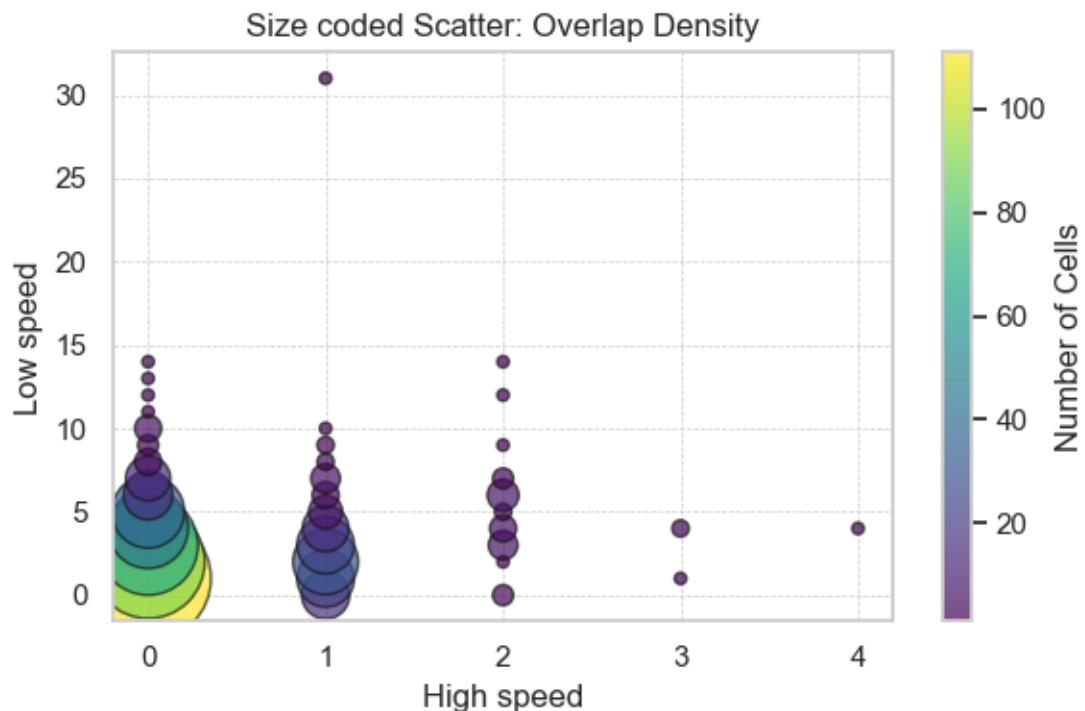
Occurrences in sequential events as origin \

0	2
2	0
4	0
5	2
6	1
..	...
662	1
663	1
664	2

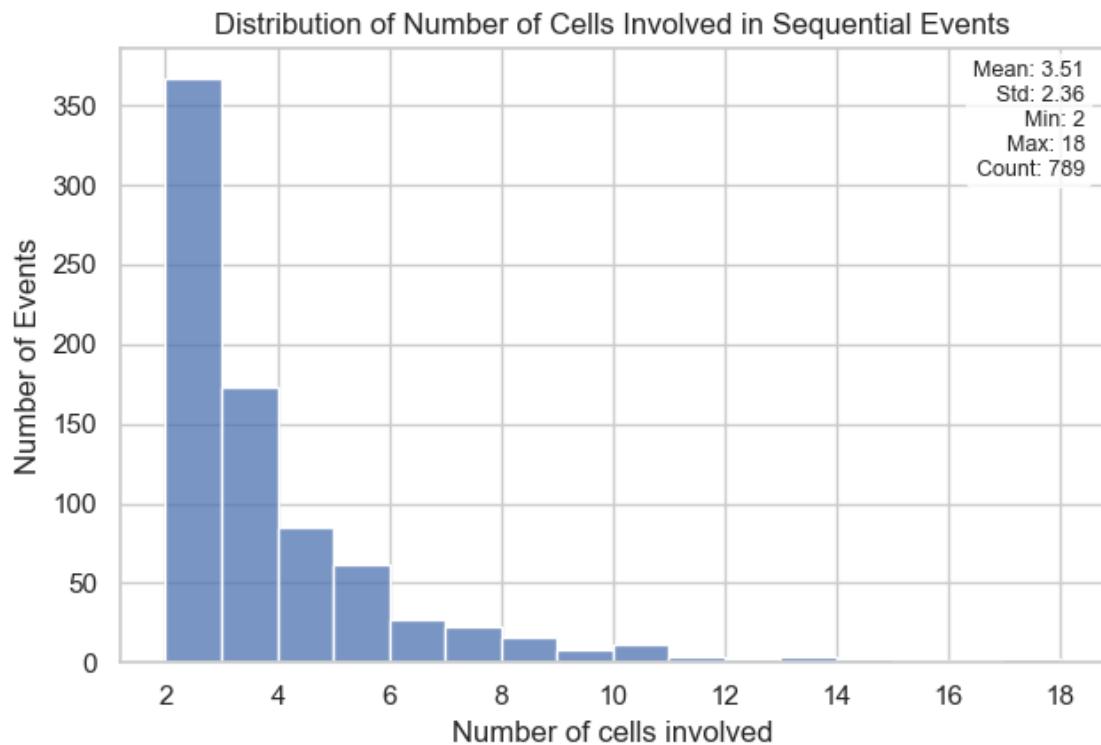
665		1	
668		1	
Occurrences in individual events Peak frequency (Hz) Periodicity score \			
0	3	0.0047	0.64
2	6	0.0065	0.66
4	1	0.0018	0.71
5	2	0.0035	0.66
6	2	0.0029	0.81
..
662	9	0.0082	0.65
663	1	0.0035	0.65
664	1	0.0035	0.77
665	3	0.0041	0.77
668	4	0.0047	0.58
Neighbor count Neighbors (labels) dataset \			
0	2	[174,190]	20250701_IS1
2	4	[165,198,201,203]	20250701_IS1
4	3	[178,181,212]	20250701_IS1
5	3	[179,203,208]	20250701_IS1
6	3	[200,205,243]	20250701_IS1
..
662	1	[1173]	20250701_IS1
663	2	[1175,1190]	20250701_IS1
664	3	[1129,1172,1203]	20250701_IS1
665	4	[1158,1180,1197,1209]	20250701_IS1
668	2	[1188,1200]	20250701_IS1
Involved in sequential event Occurrences in sequential events category \			
0	Involved in sequential event		3-4
2	Involved in sequential event		1-2
4	Involved in sequential event		1-2
5	Involved in sequential event		1-2
6	Involved in sequential event		1-2
..
662	Involved in sequential event		1-2
663	Involved in sequential event		1-2
664	Involved in sequential event		1-2
665	Involved in sequential event		1-2
668	Involved in sequential event		1-2
High speed Low speed			
0	1.0	1.0	
2	0.0	1.0	
4	0.0	1.0	
5	0.0	3.0	
6	0.0	1.0	

```
...      ...      ...
662      0.0      1.0
663      0.0      1.0
664      0.0      2.0
665      0.0      2.0
668      0.0      1.0
```

[567 rows x 19 columns]

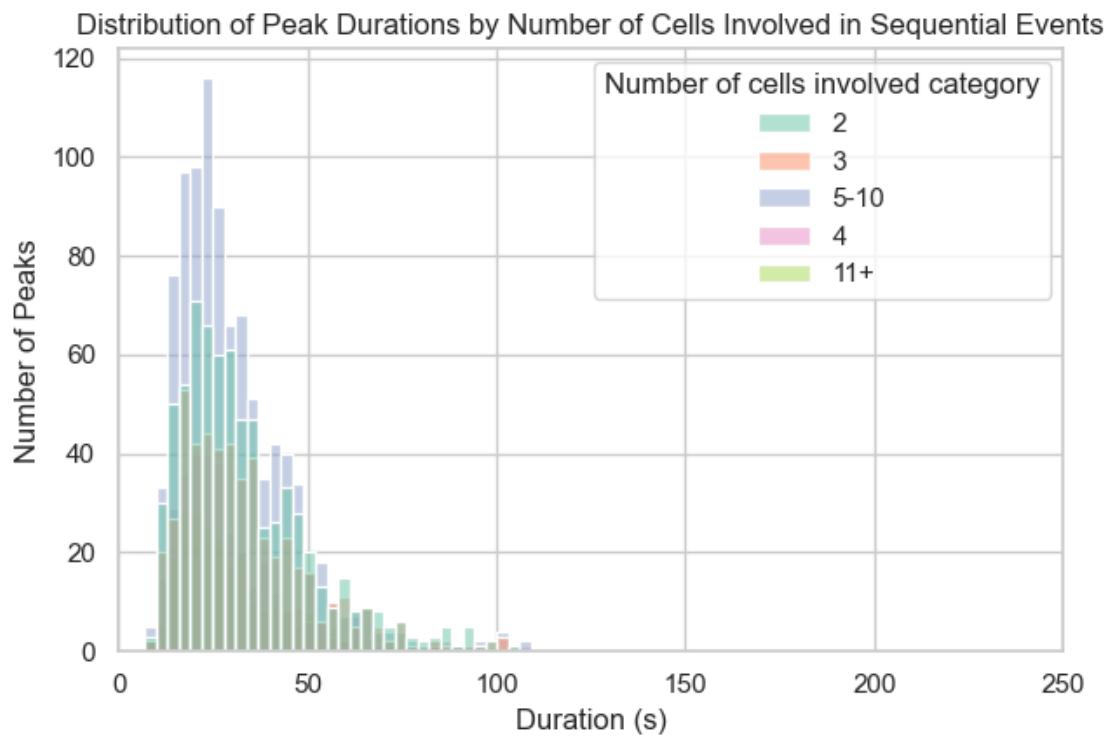


1.3.5 Number of cells involved per sequential events

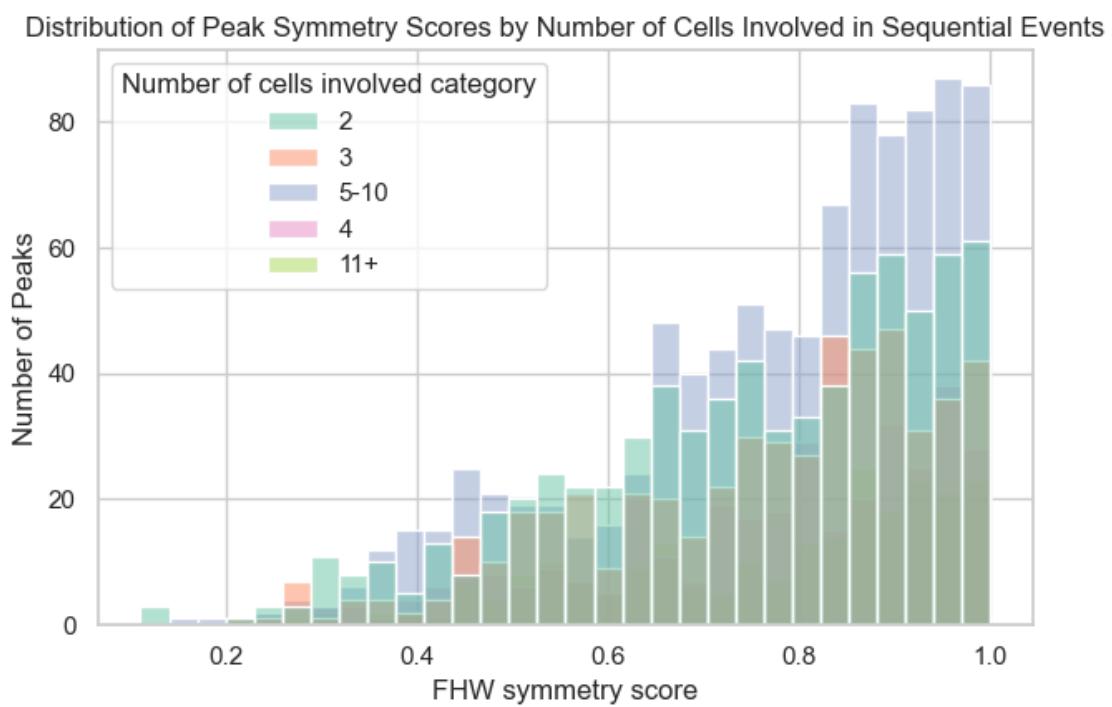
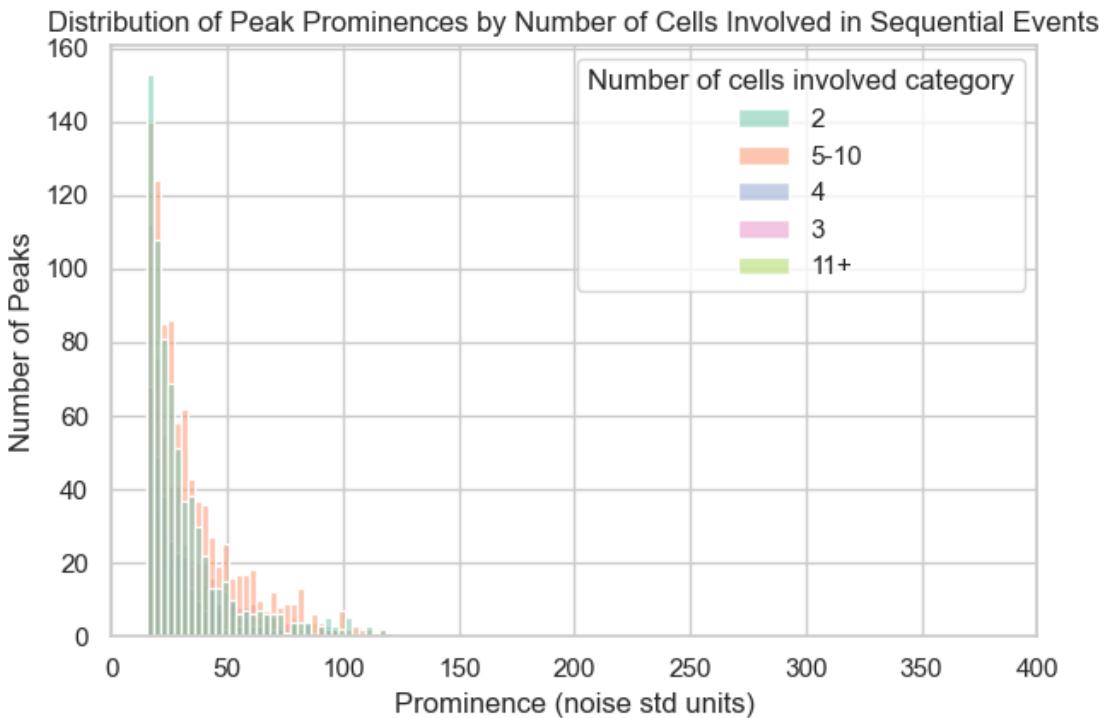


1.3.6 Influence of cell count per event on statistics

```
[2025-08-13 12:32:25] [INFO] calcium: plot_histogram_by_group: removed 49 outliers out of 2792 on 'Duration (s)' (lower=-10, upper=110)
```

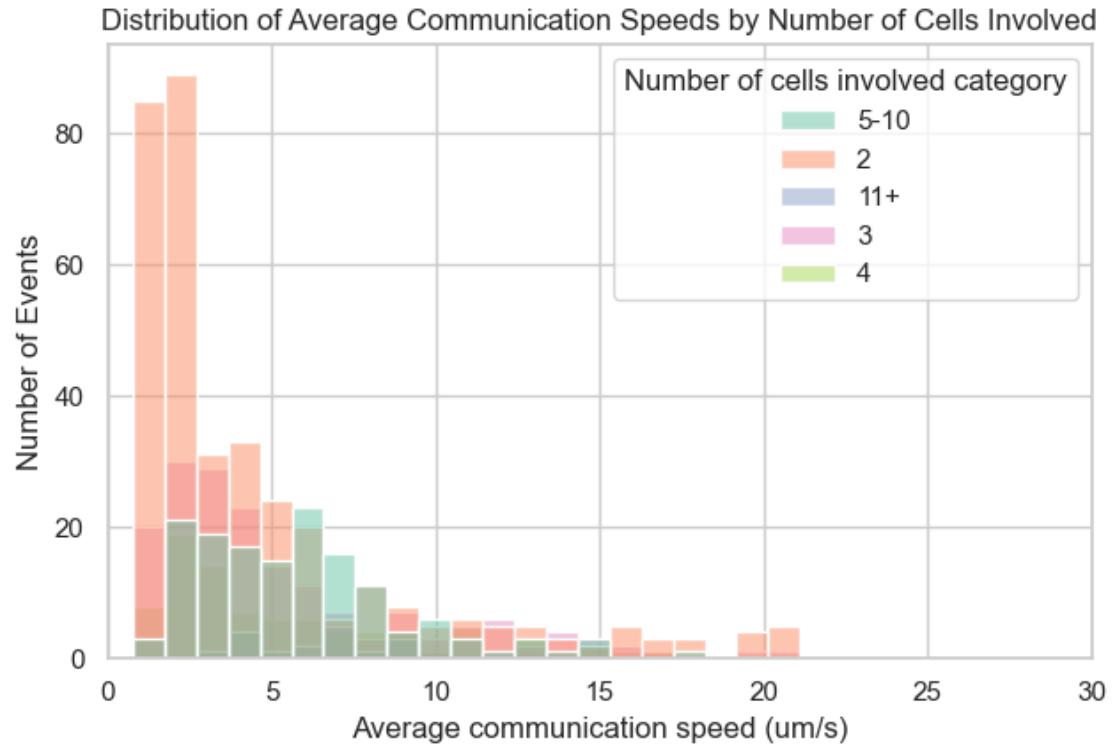


```
[2025-08-13 12:32:25] [INFO] calcium: plot_histogram_by_group: removed 91 outliers out of 2792 on 'Prominence (noise std units)' (lower=-14.787, upper=121.56)
```



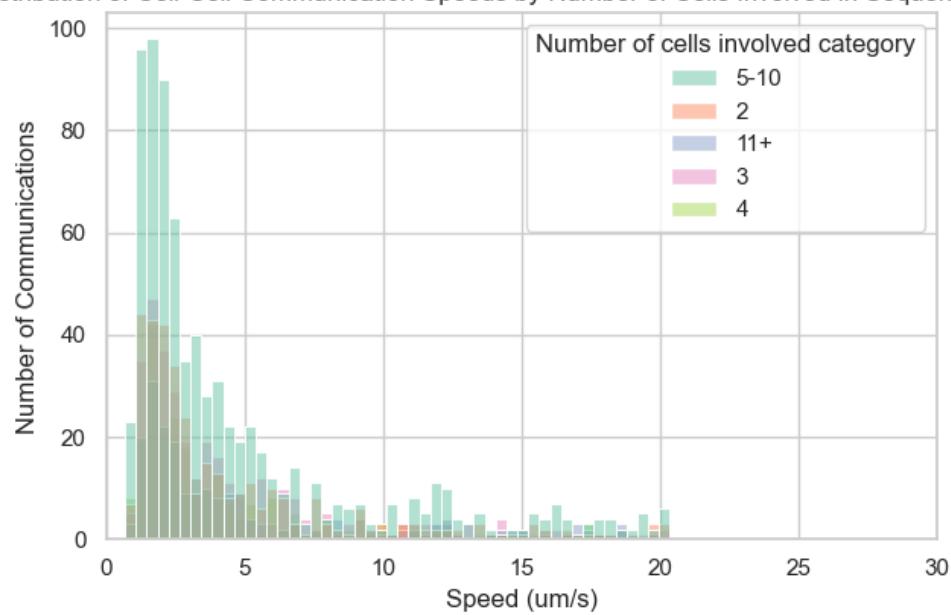
[2025-08-13 12:32:26] [INFO] calcium: plot_histogram_by_group: removed 15

outliers out of 789 on 'Average communication speed (um/s)' (lower=-12.04, upper=21.21)



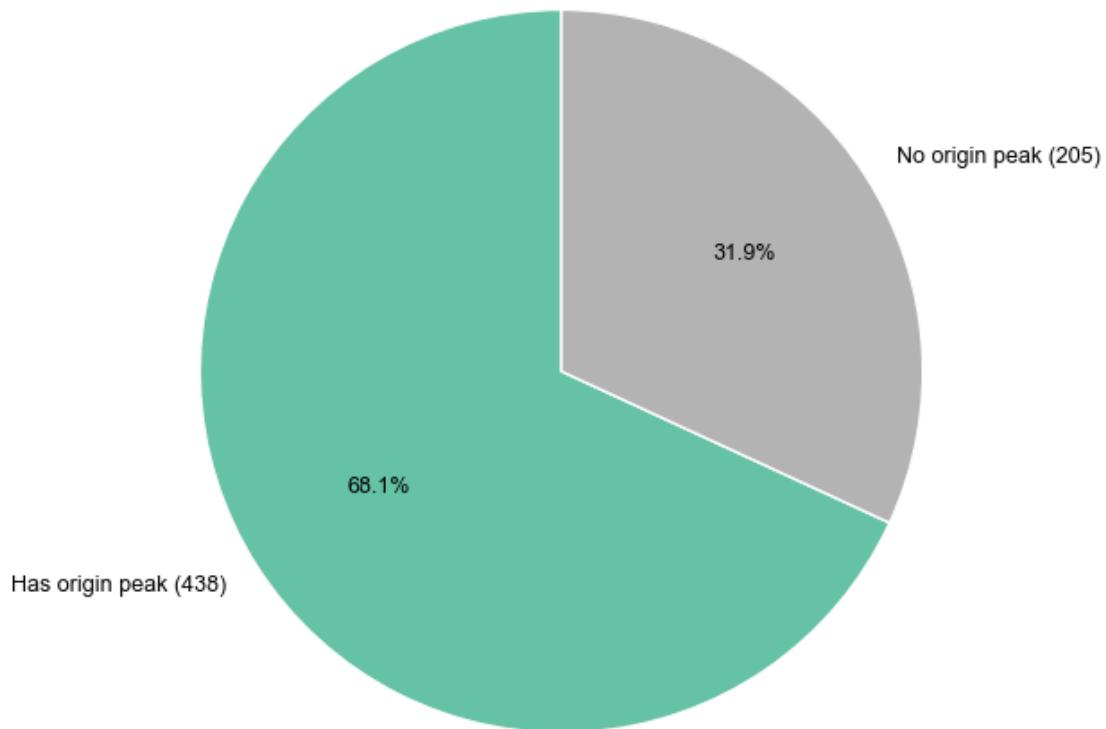
[2025-08-13 12:32:26] [INFO] calcium: plot_histogram_by_group: removed 97 outliers out of 2003 on 'Speed (um/s)' (lower=-12.09, upper=20.39)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events

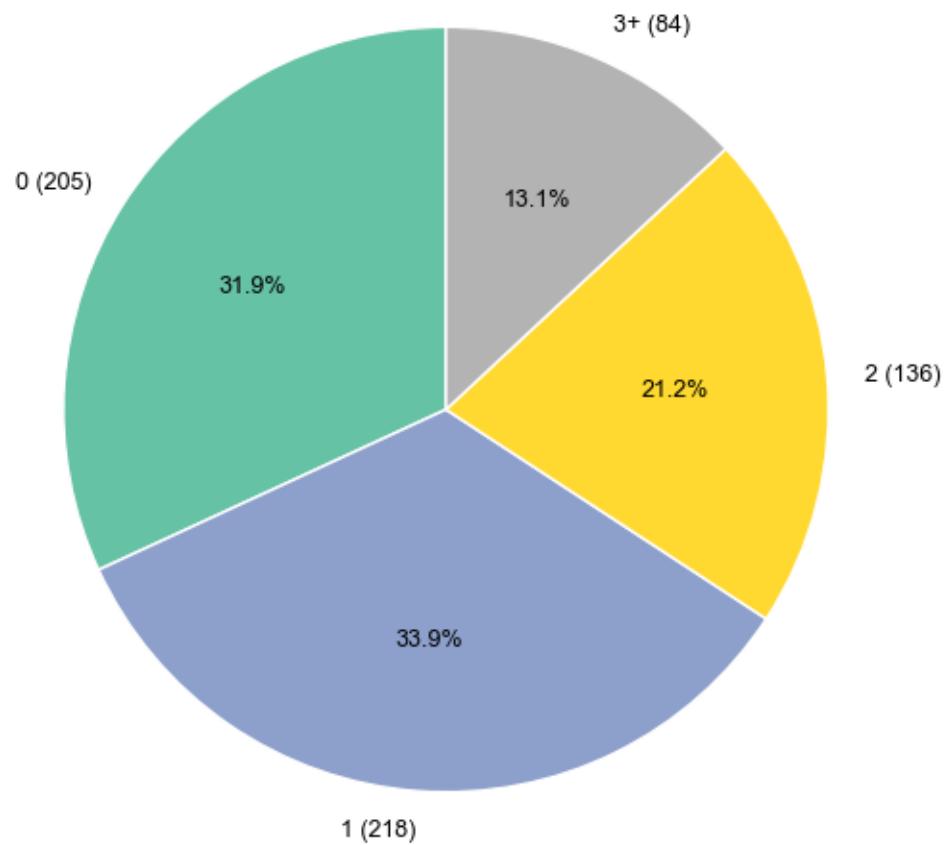


1.3.7 Cells occurrences as origin in sequential events

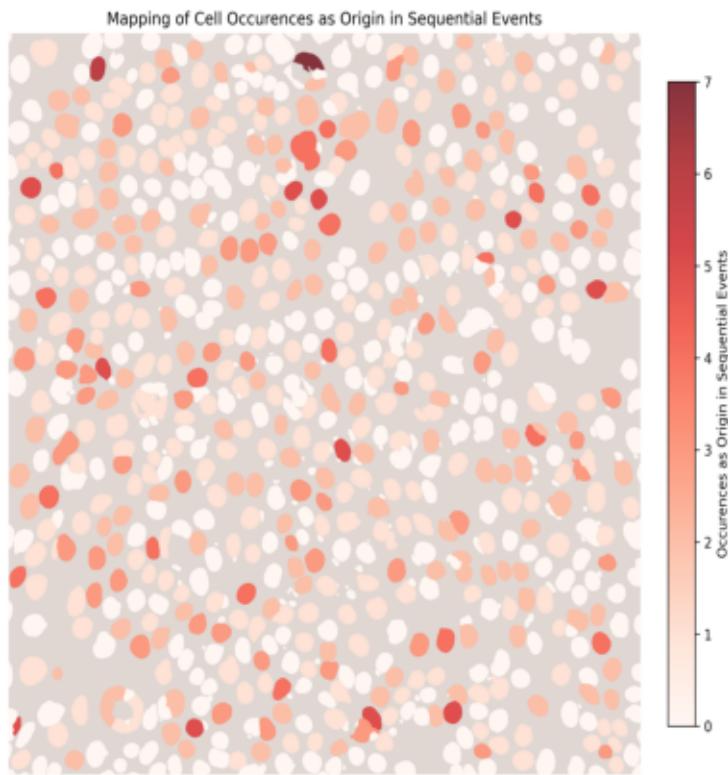
Distribution of Number of Sequential Event Origin Peaks per Cell



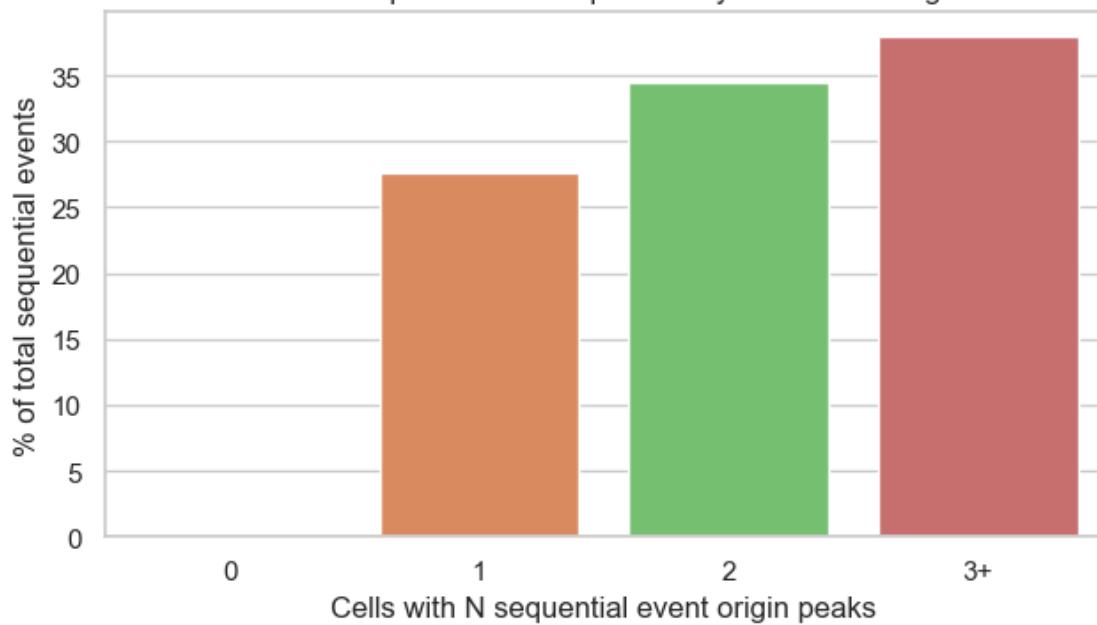
Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)



Cell Mapping with Origin Peaks Overlay - 20250701_IS1



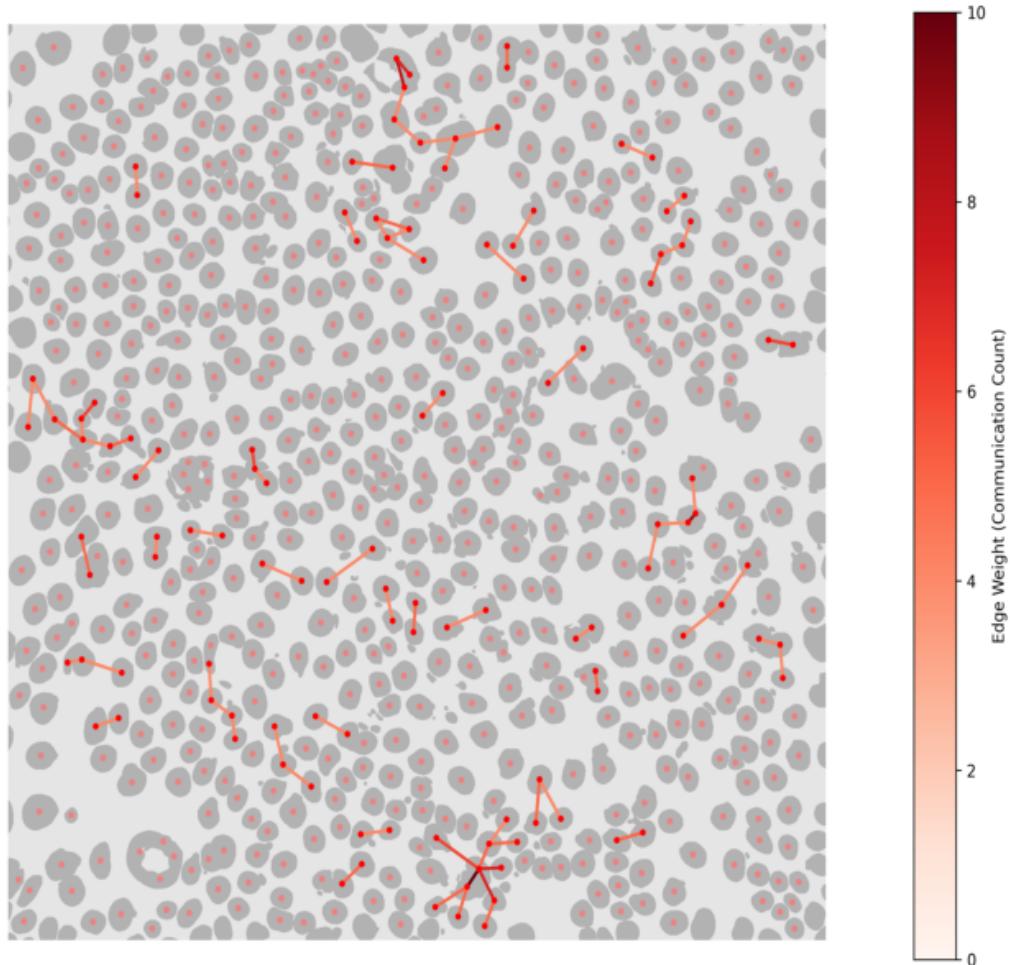
Distribution of Sequential Events per Cell by Number of Origin Peaks

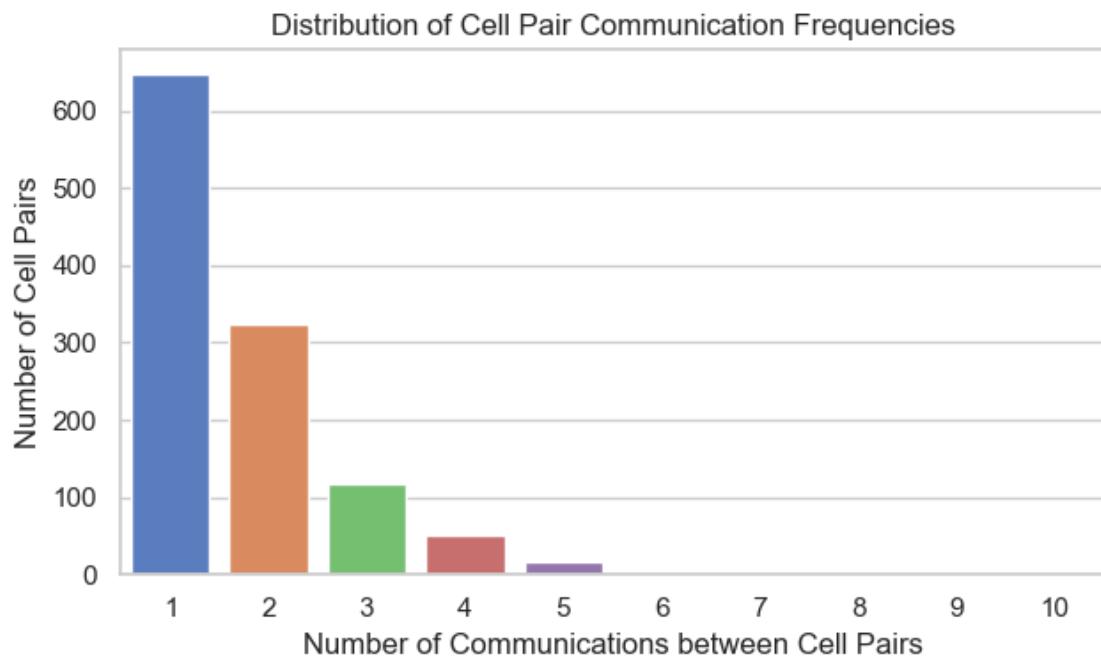


1.3.8 Connection network between cells

Cell Connection Network Graph - 20250701_IS1

Cells Connection Network (Weighted Edges)

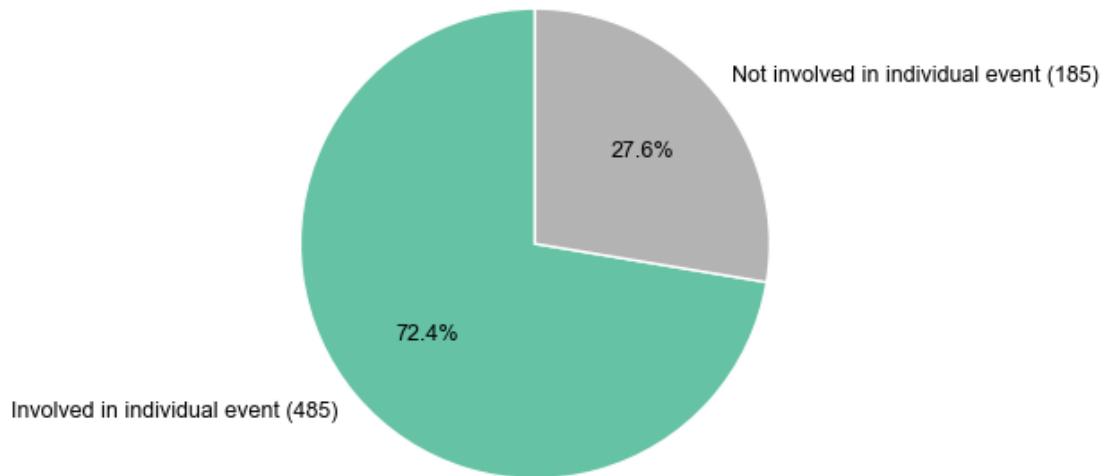




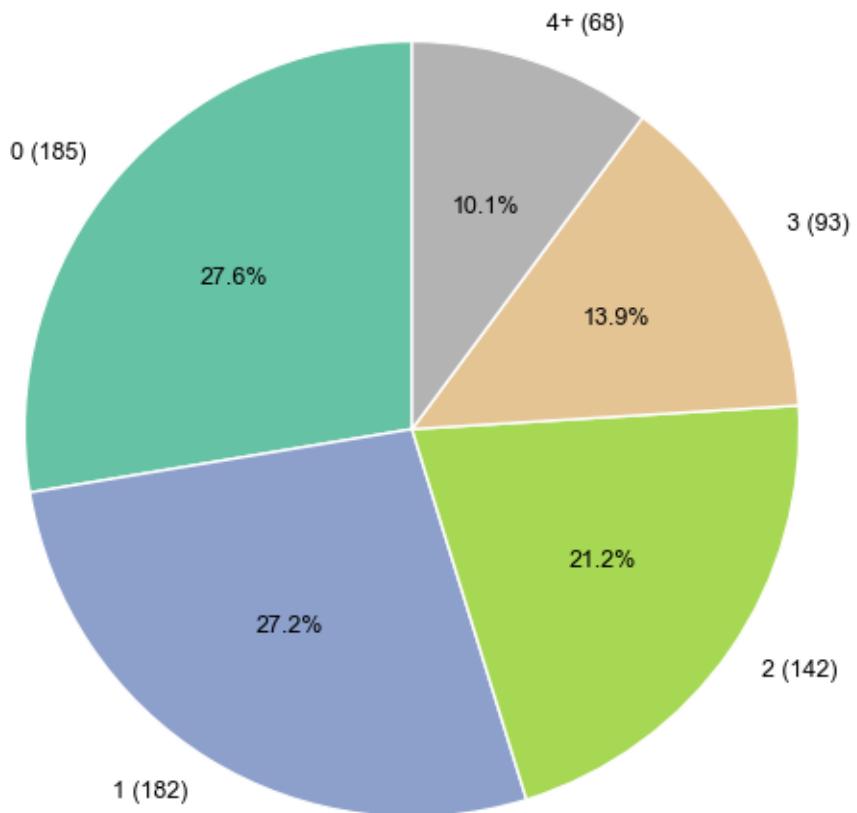
1.4 INDIVIDUAL EVENTS

1.4.1 Cells occurrences in individual events

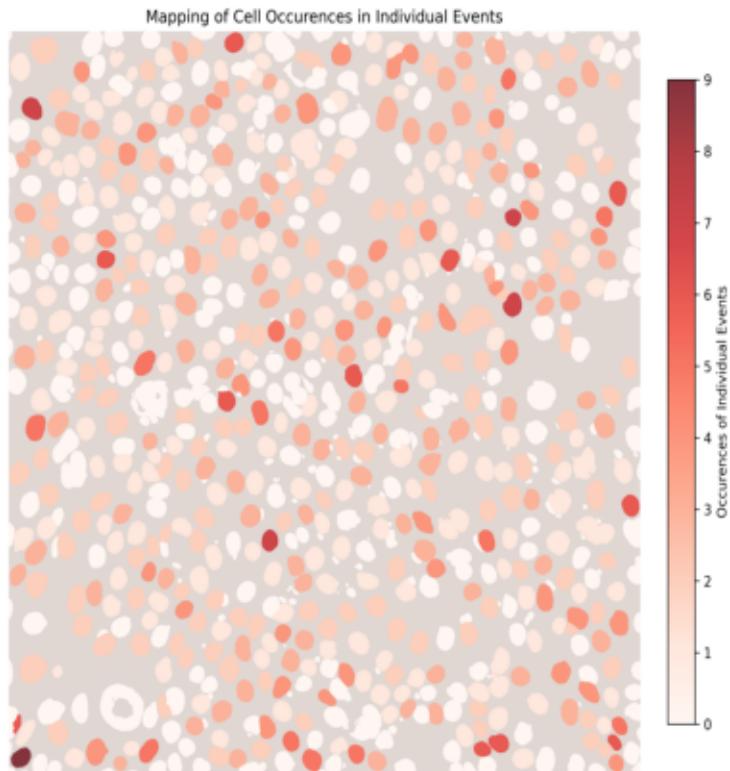
Distribution of Cells Involved in Individual Events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

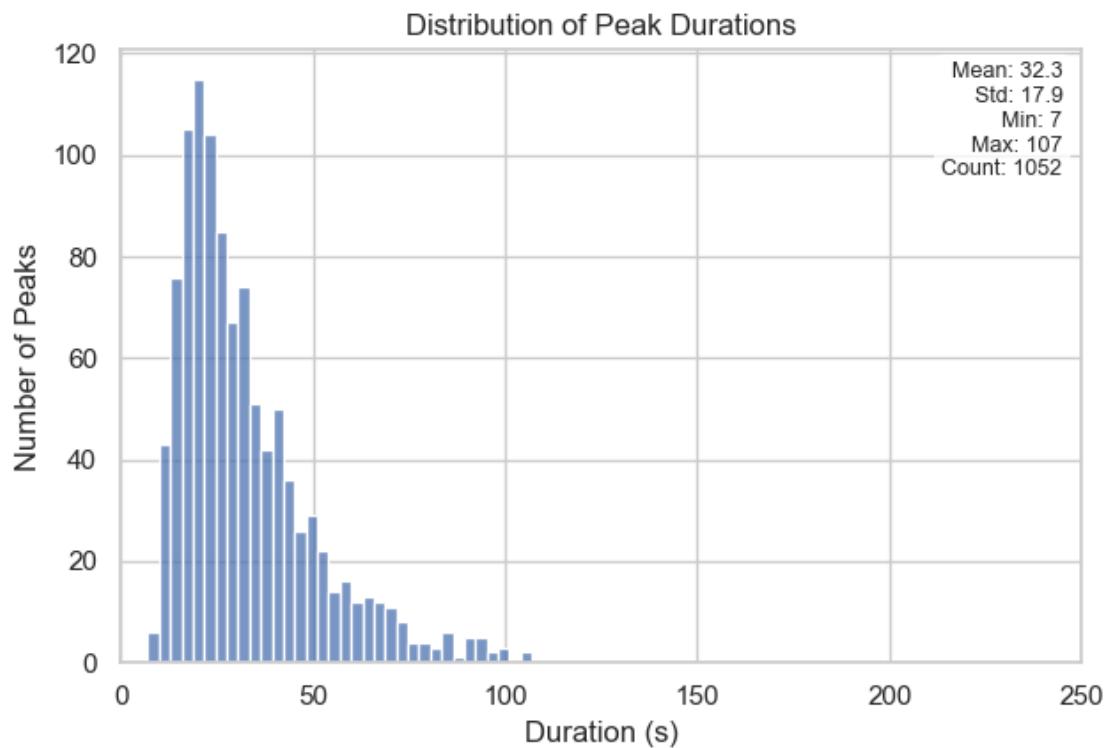


Cell Mapping with Occurrences in Individual Events Overlay - 20250701_IS1

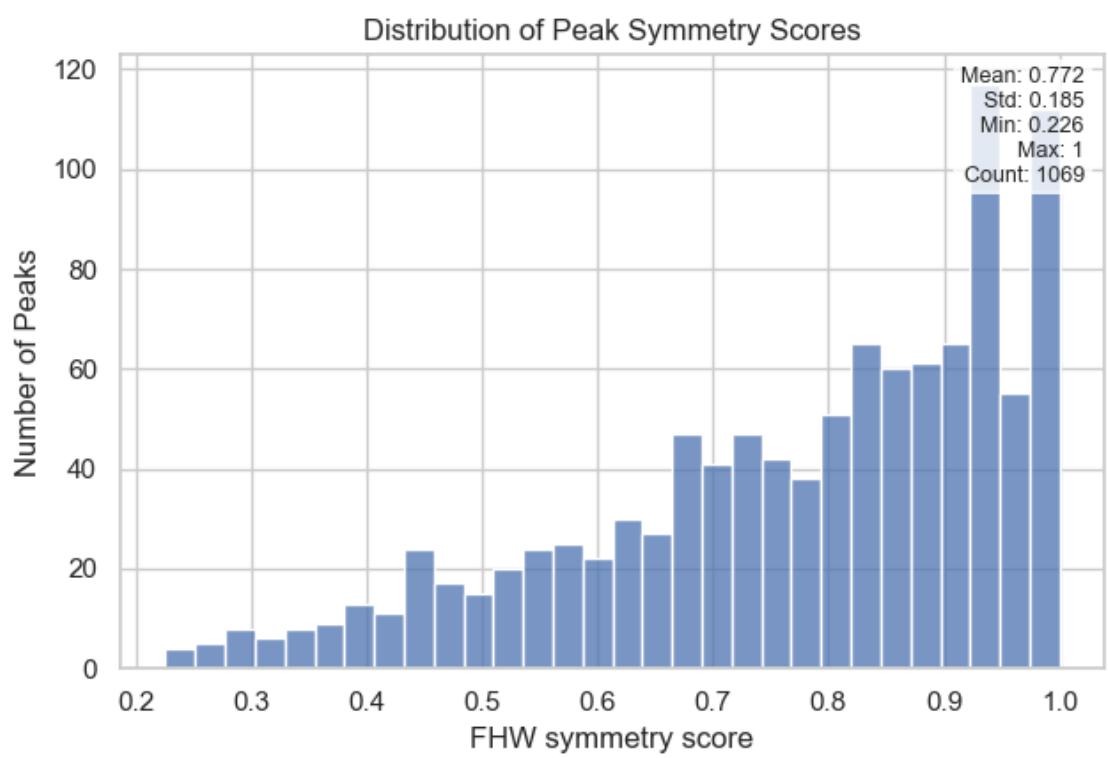
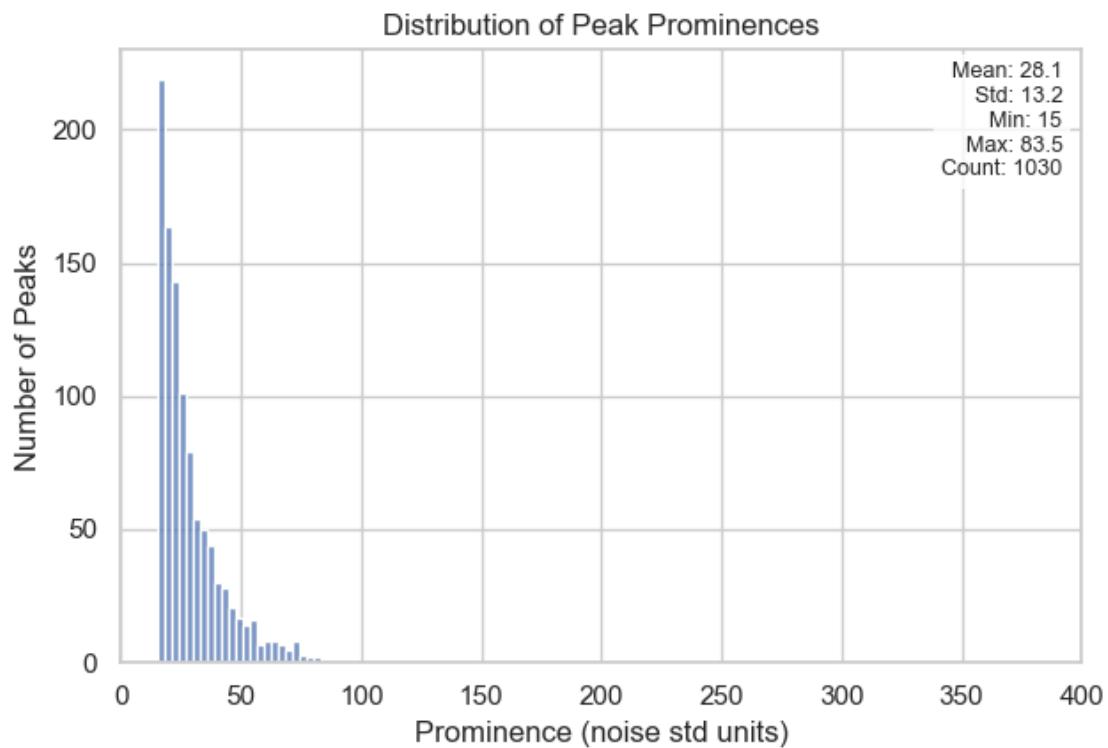


1.4.2 Peaks statistics in individual events

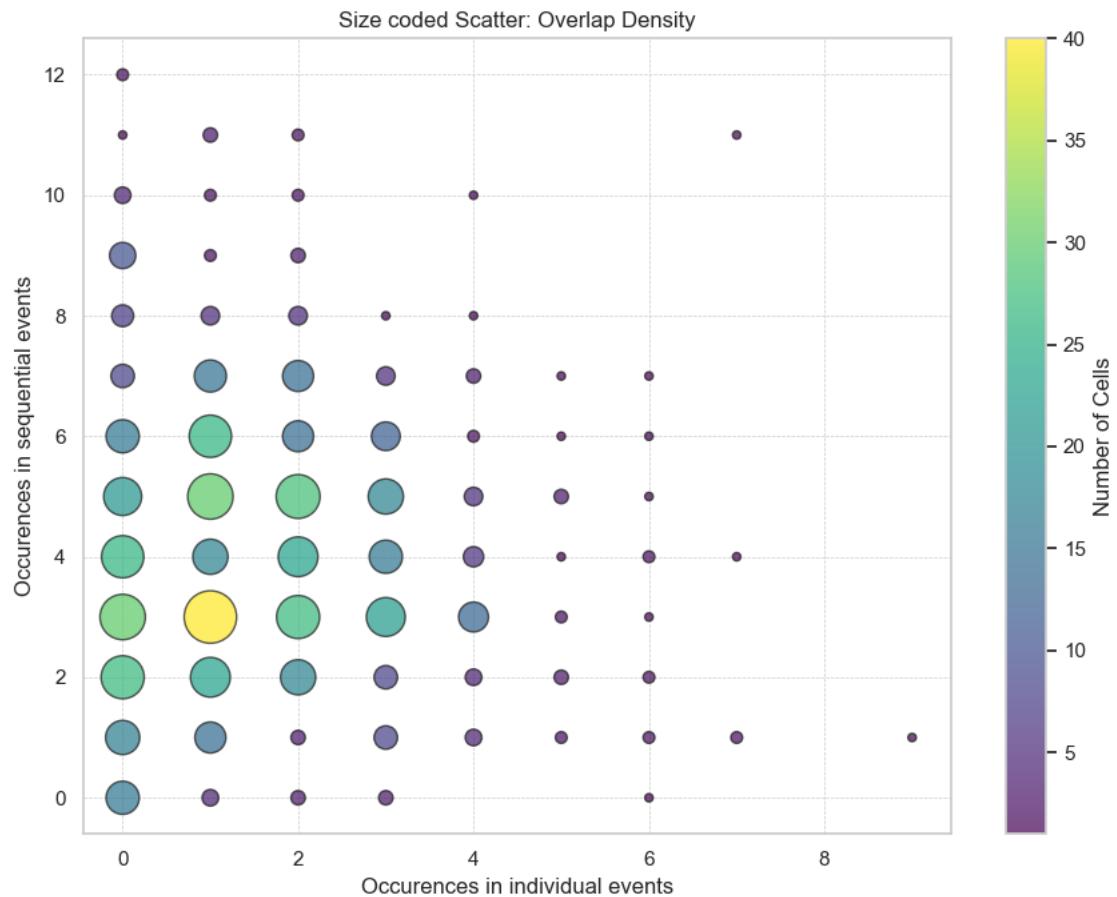
```
[2025-08-13 12:32:32] [INFO] calcium: plot_histogram: removed 17 outliers out of  
1069 on 'Duration (s)' (lower=-47, upper=107)
```



```
[2025-08-13 12:32:32] [INFO] calcium: plot_histogram: removed 39 outliers out of 1069 on 'Prominence (noise std units)' (lower=-31.8, upper=85.8)
```

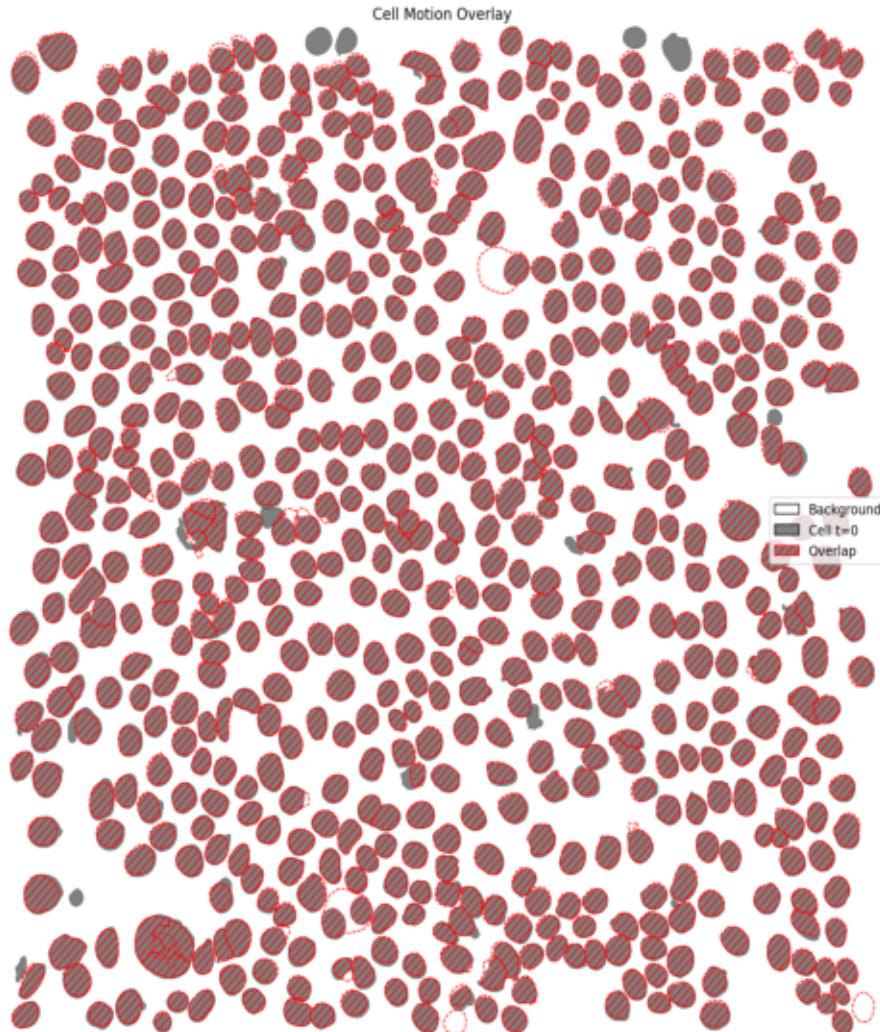


1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250701_IS1



Number of cells:

- Hoechst image taken at t=0: 670
- Hoechst image taken at t=1801: 649
- Number of cells difference: absolute 21, relative 3.18%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 989219
- Pixels segmented as cell at t=1801: 878100
- Overlapping pixels between t=0 and t=1801: 841293 (90.11% of total)
- Pixels exclusive to t=0: 147926 (14.95% of total)
- Pixels exclusive to t=1801: 36807 (4.19% of total)

executed

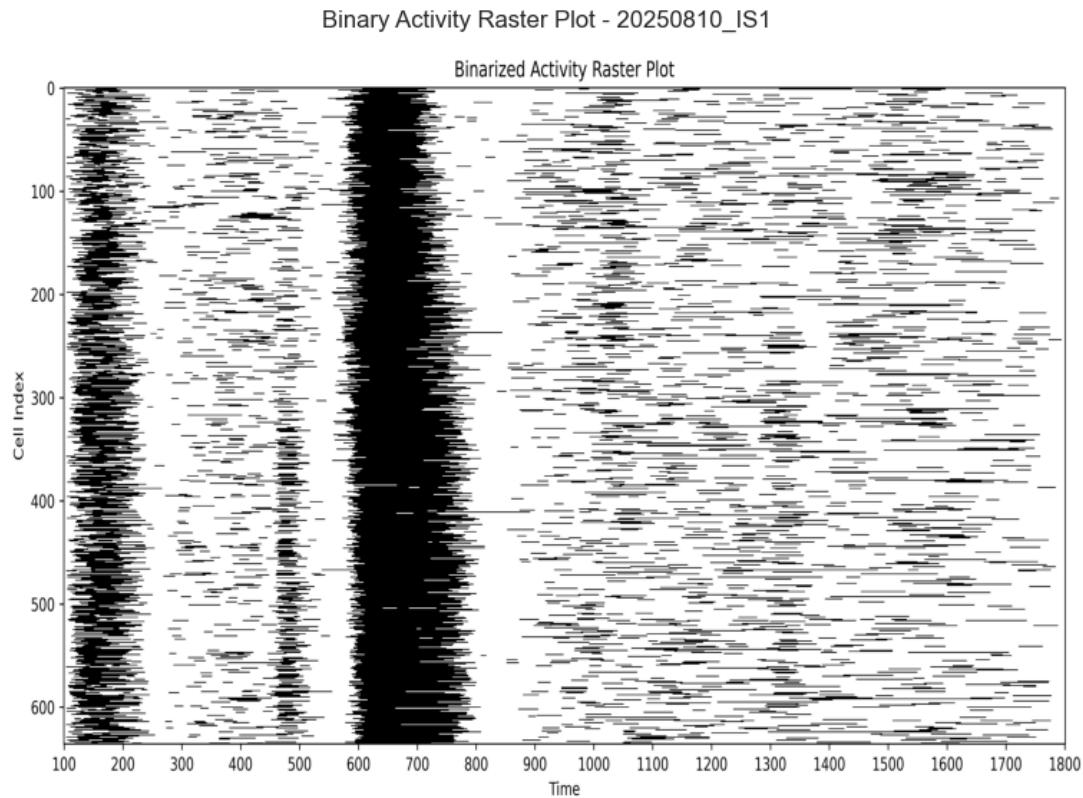
August 13, 2025

1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

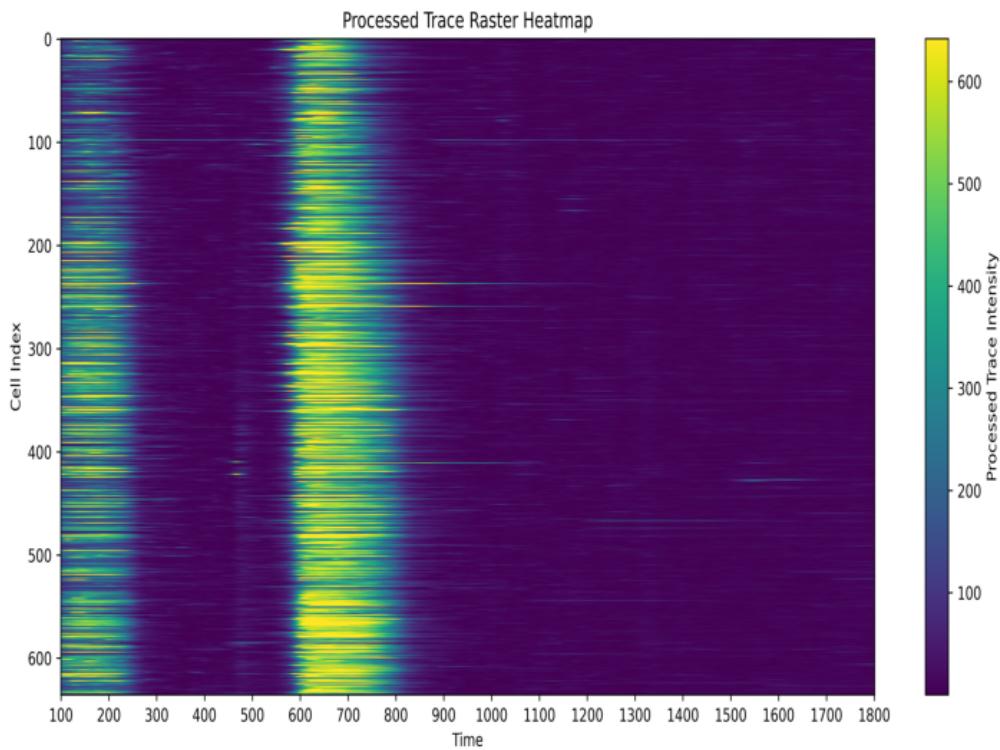
1.0.1 Initialization

1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot



Heatmap Activity Raster Plot - 20250810_IS1



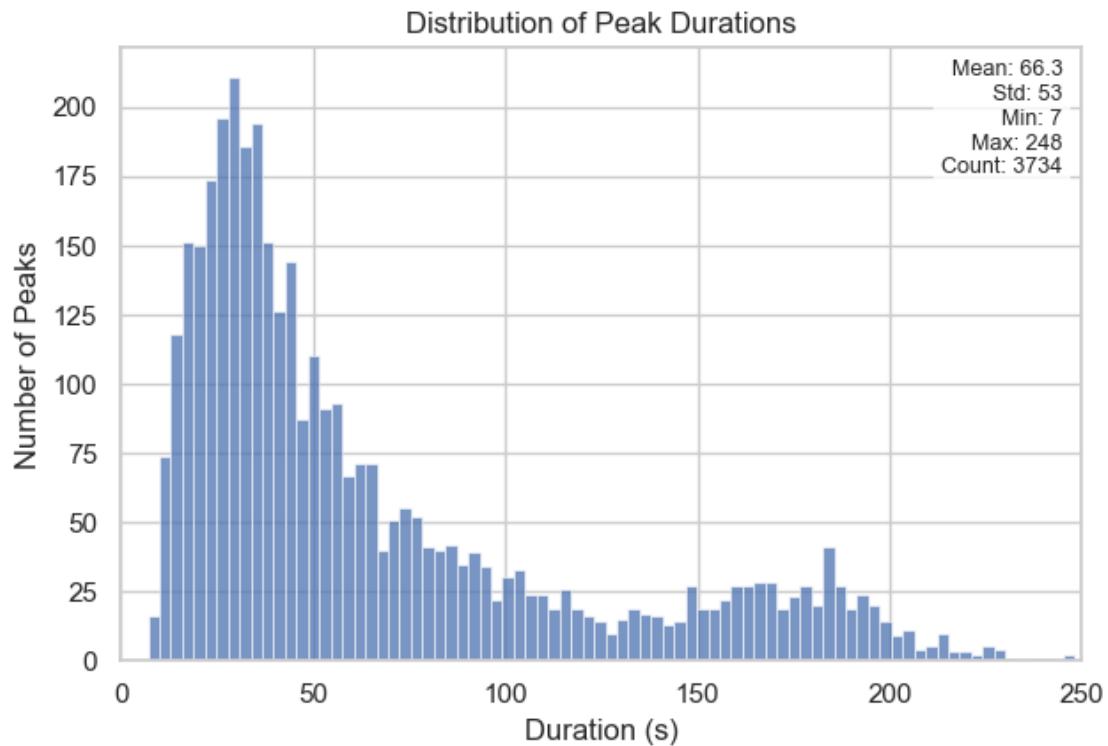
1.1.2 Peaks population

Total number of peaks: 3740

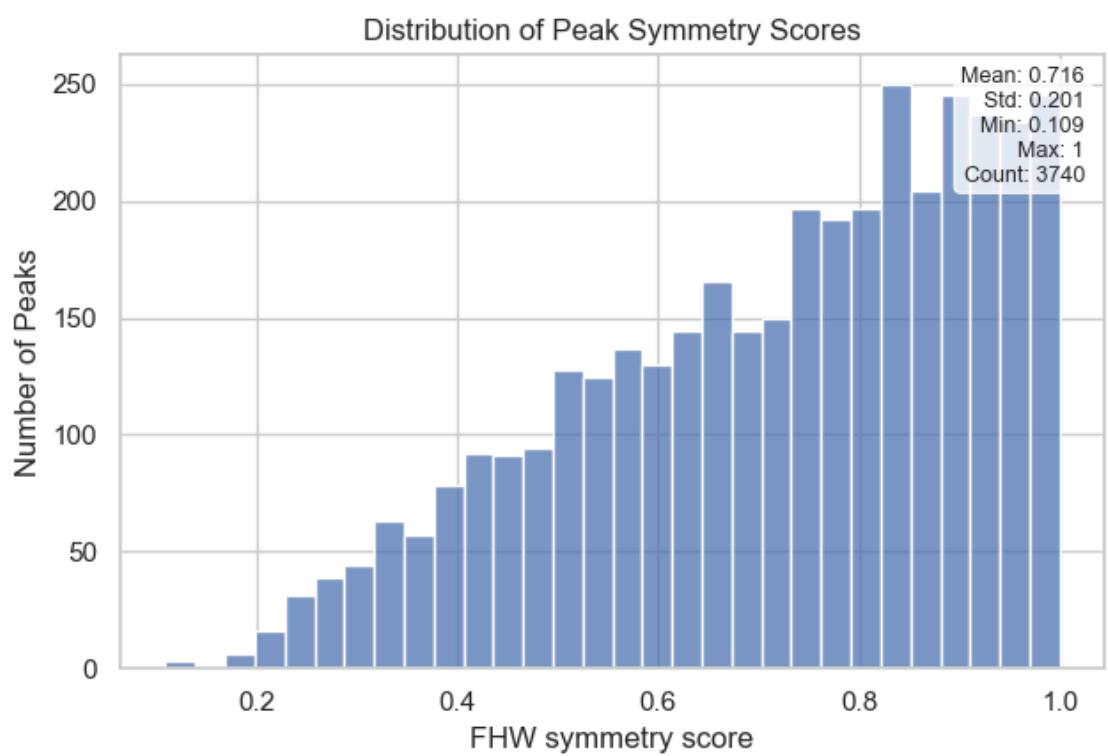
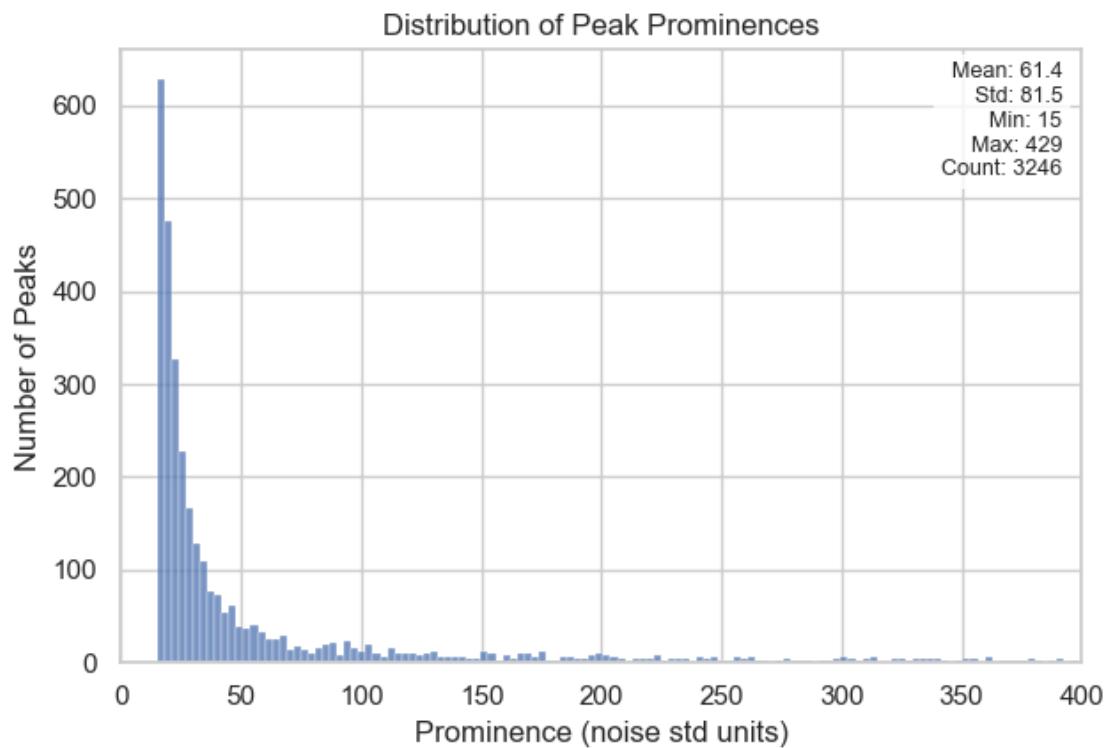
Total number of cells: 636

1.1.3 Peaks statistics

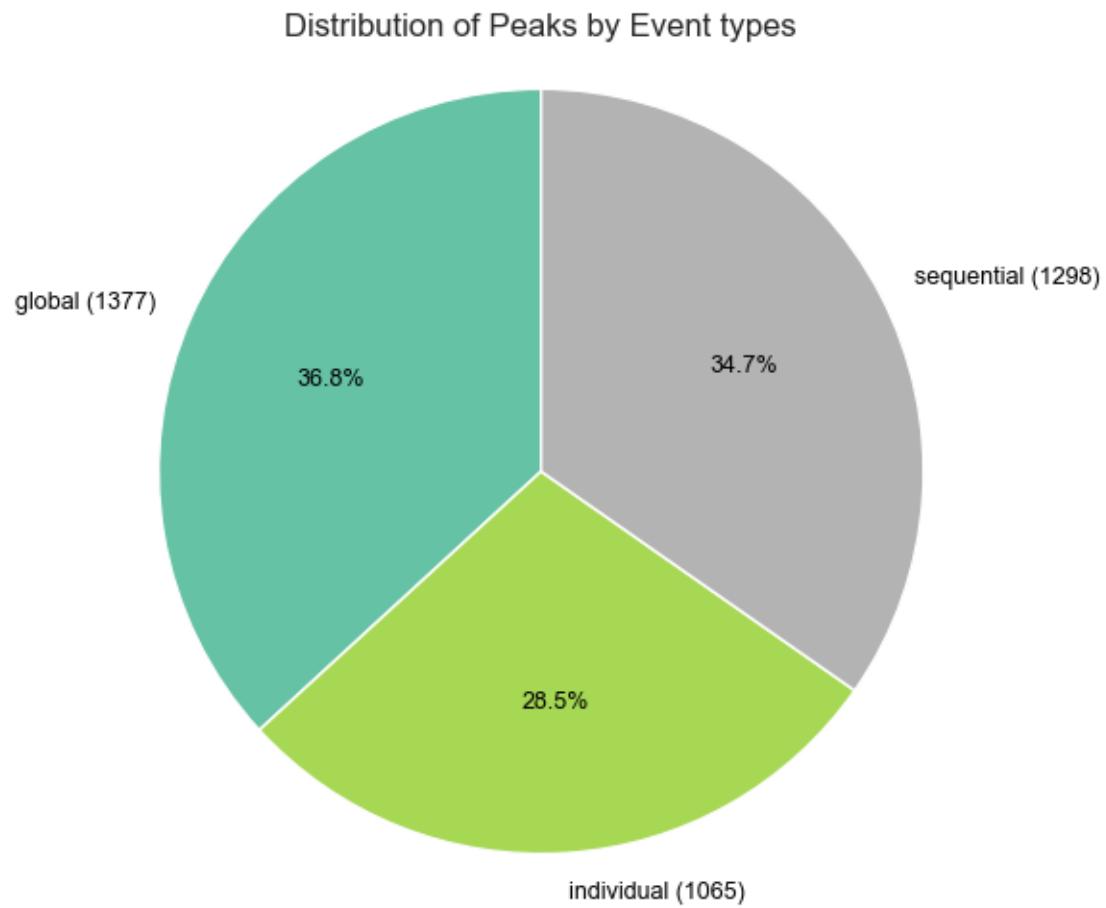
```
[2025-08-13 12:39:21] [INFO] calcium: plot_histogram: removed 6 outliers out of  
3740 on 'Duration (s)' (lower=-152, upper=268)
```



```
[2025-08-13 12:39:21] [INFO] calcium: plot_histogram: removed 494 outliers out  
of 3740 on 'Prominence (noise std units)' (lower=-287.32, upper=429.3)
```

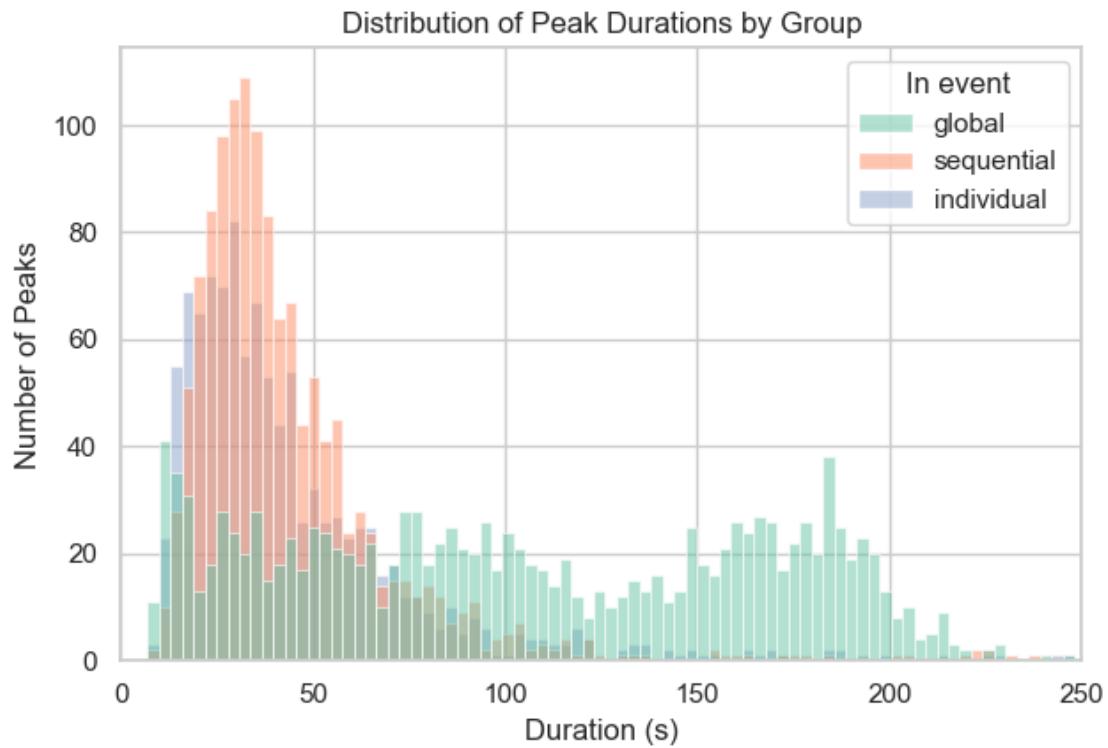


1.1.4 Distribution of peaks per event types



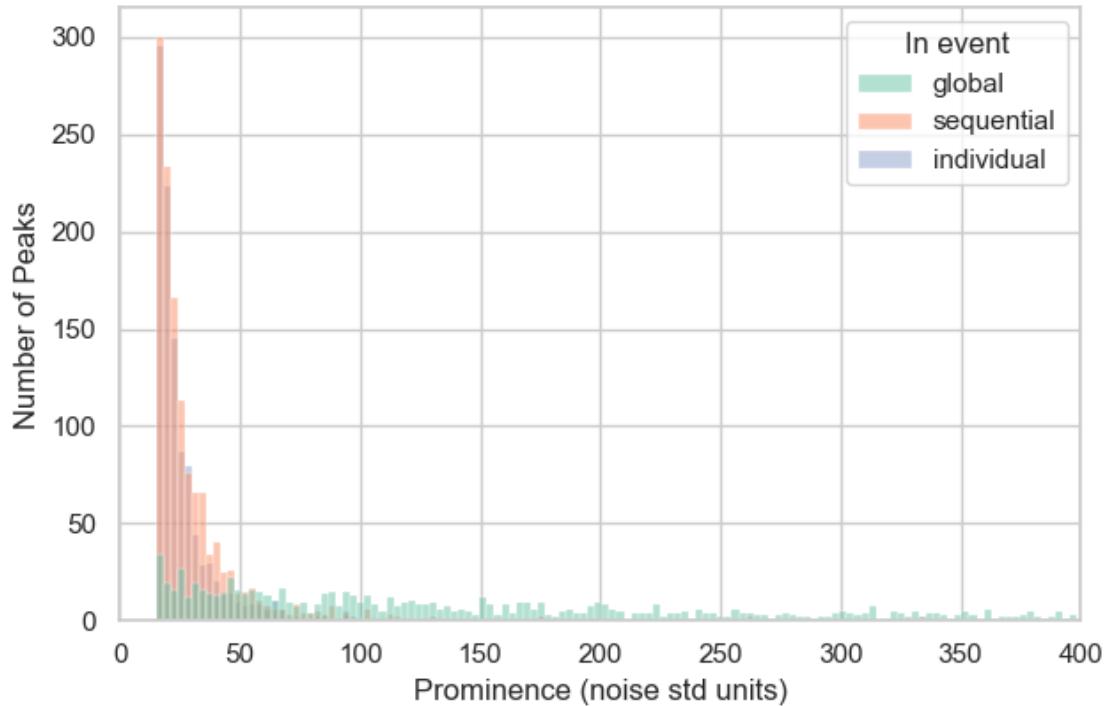
1.1.5 Peaks statistics per event types

```
[2025-08-13 12:39:21] [INFO] calcium: plot_histogram_by_group: removed 6 outliers out of 3740 on 'Duration (s)' (lower=-152, upper=268)
```

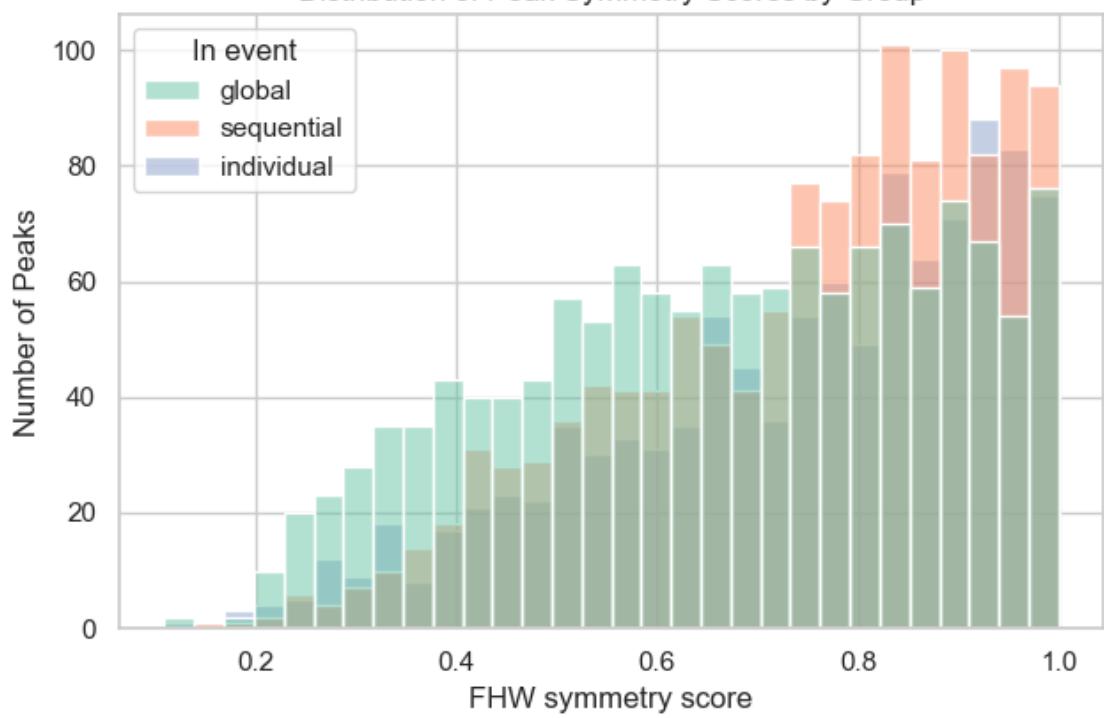


```
[2025-08-13 12:39:22] [INFO] calcium: plot_histogram_by_group: removed 494 outliers out of 3740 on 'Prominence (noise std units)' (lower=-287.32, upper=429.3)
```

Distribution of Peak Prominences by Group



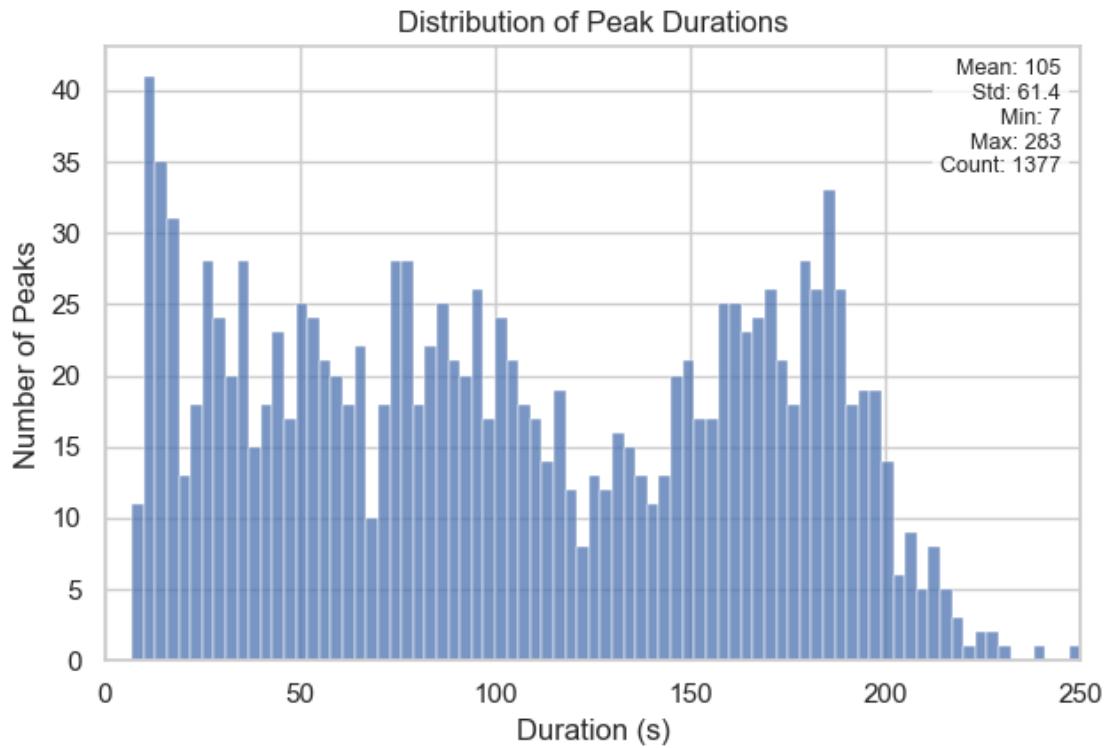
Distribution of Peak Symmetry Scores by Group



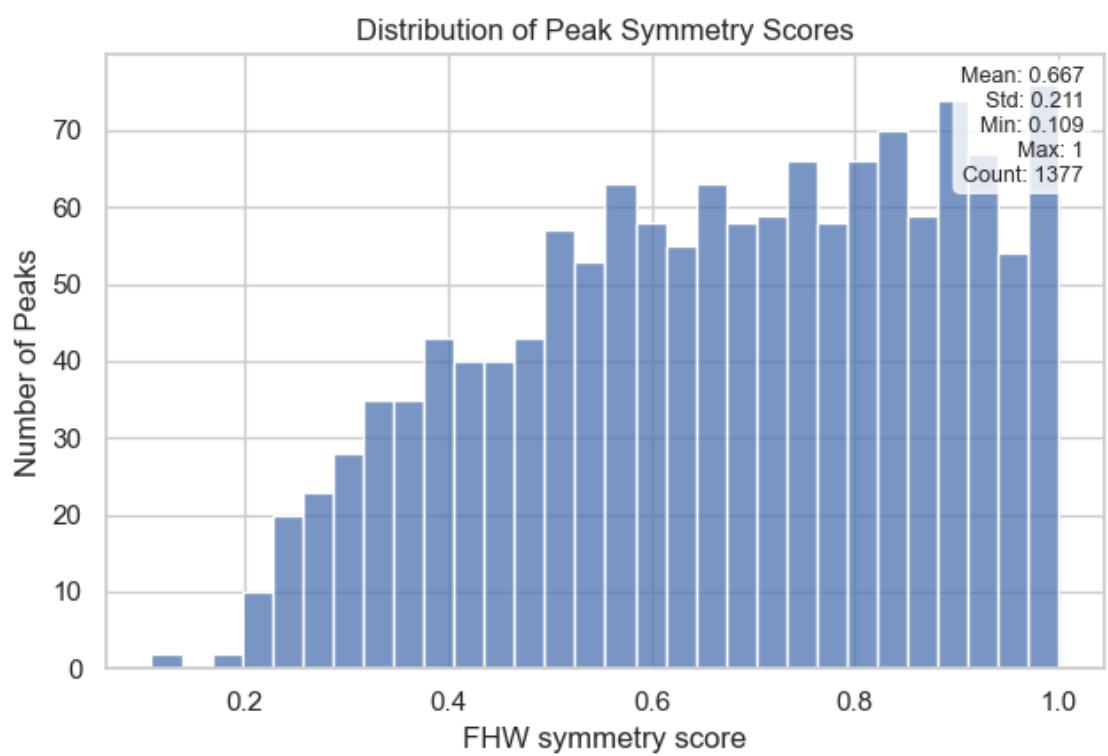
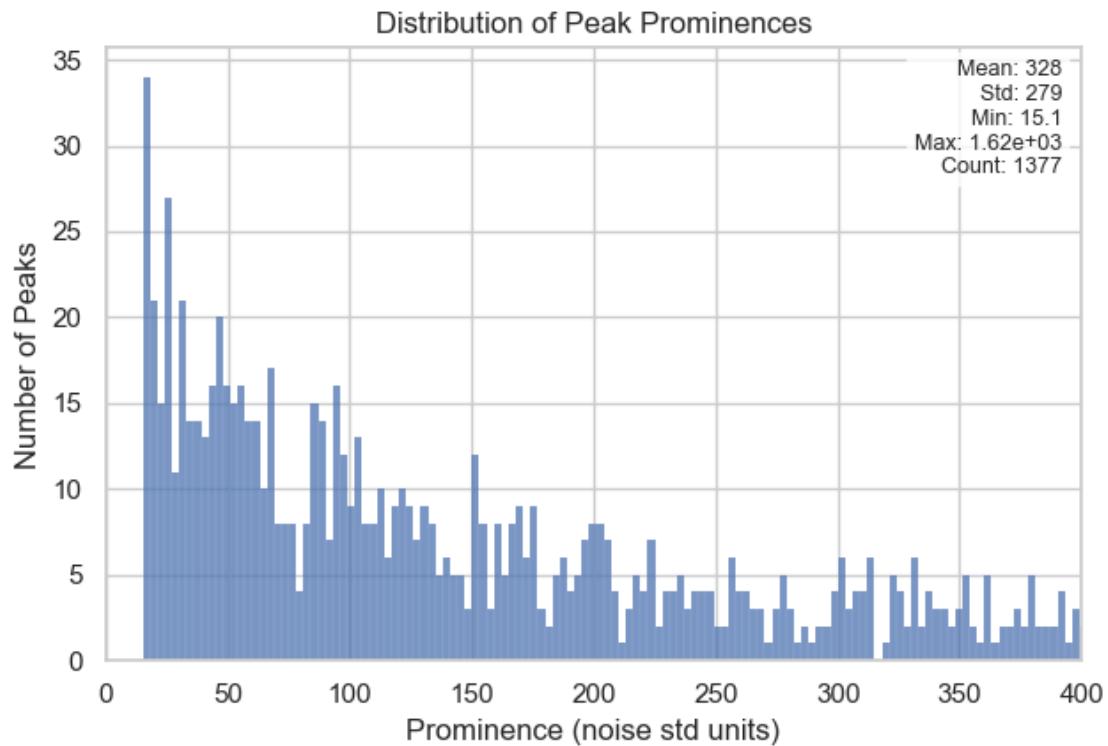
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

[2025-08-13 12:39:23] [INFO] calcium: plot_histogram: removed 0 outliers out of 1377 on 'Duration (s)' (lower=-282, upper=495)

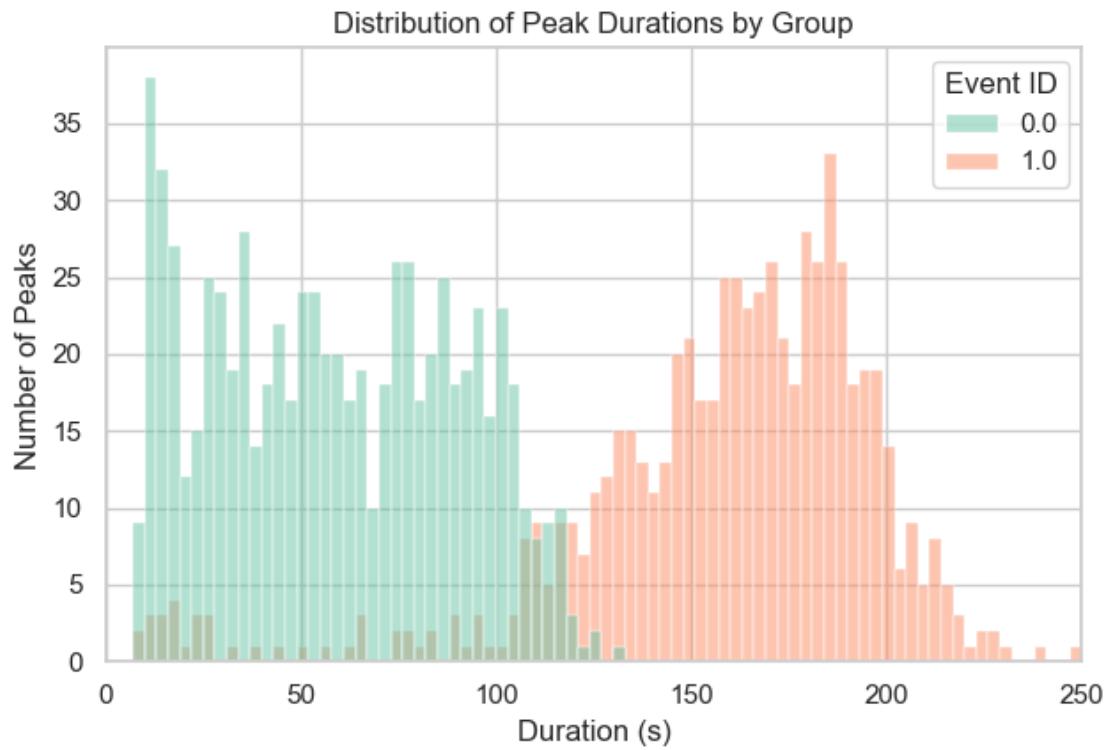


[2025-08-13 12:39:23] [INFO] calcium: plot_histogram: removed 0 outliers out of 1377 on 'Prominence (noise std units)' (lower=-1338.2, upper=1981.2)

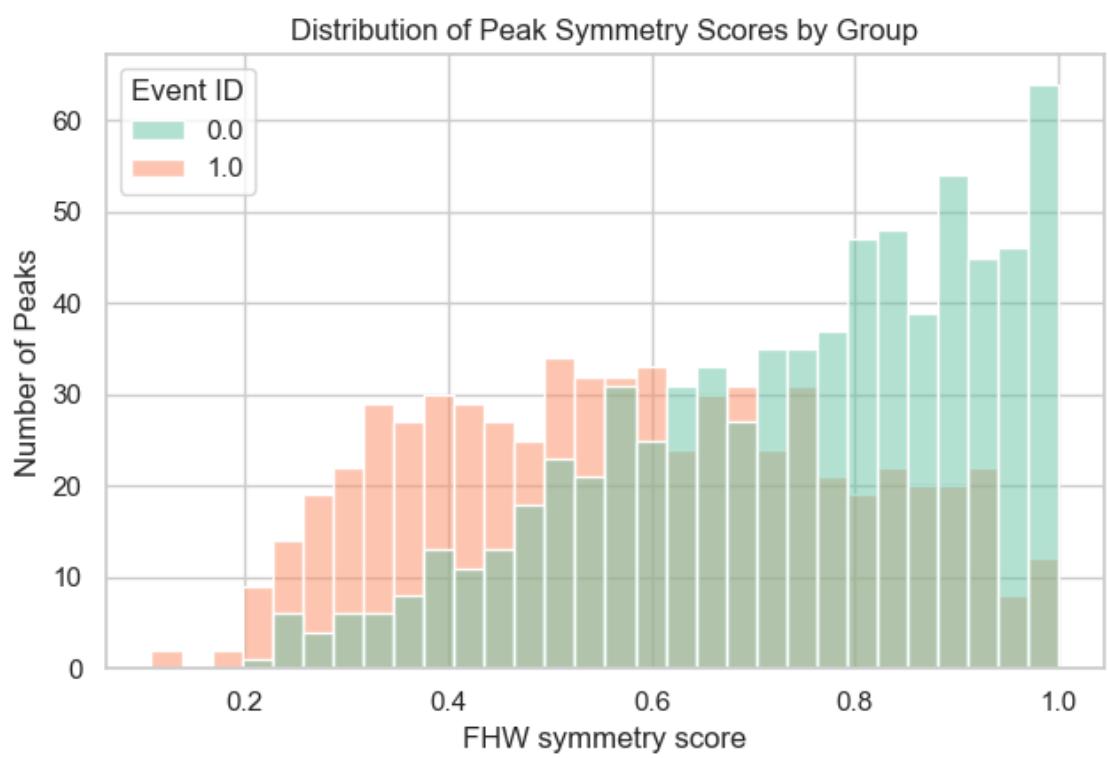
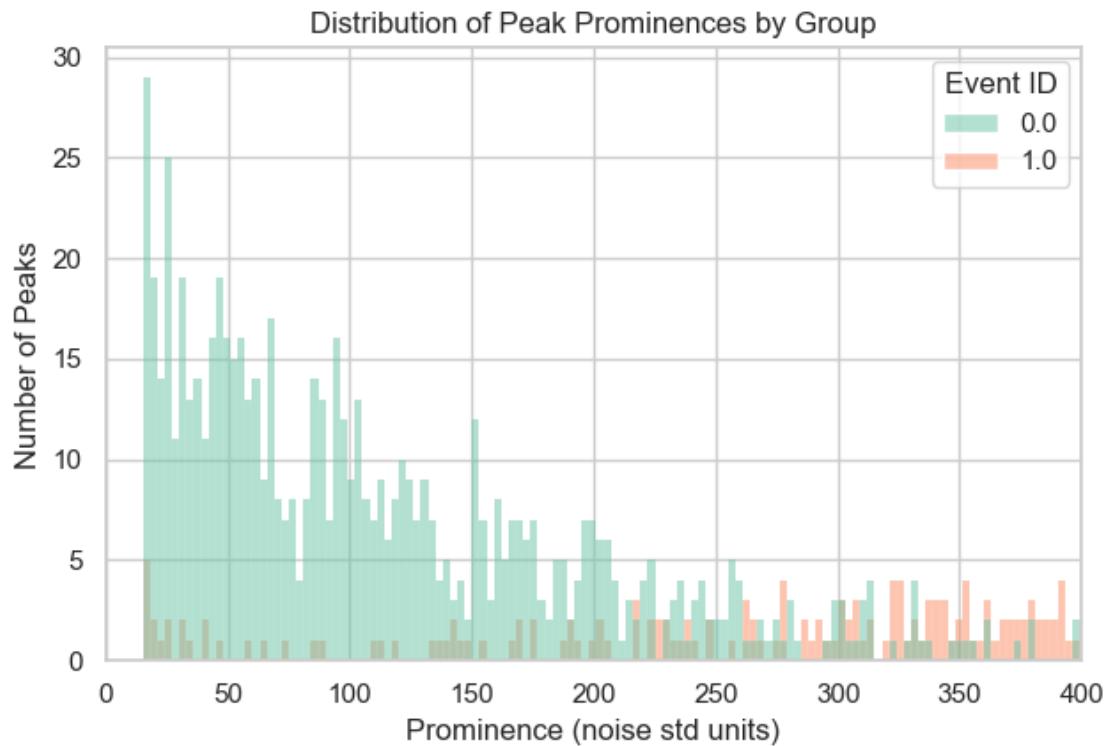


1.2.2 Peak statistics in global event per event ID

```
[2025-08-13 12:39:24] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 1377 on 'Duration (s)' (lower=-282, upper=495)
```

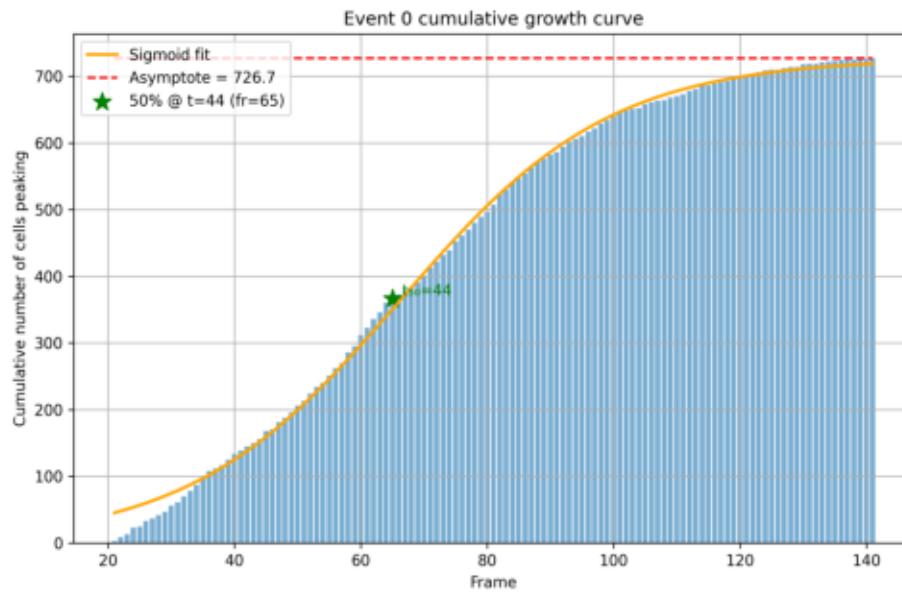


```
[2025-08-13 12:39:24] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 1377 on 'Prominence (noise std units)' (lower=-1338.2, upper=1981.2)
```

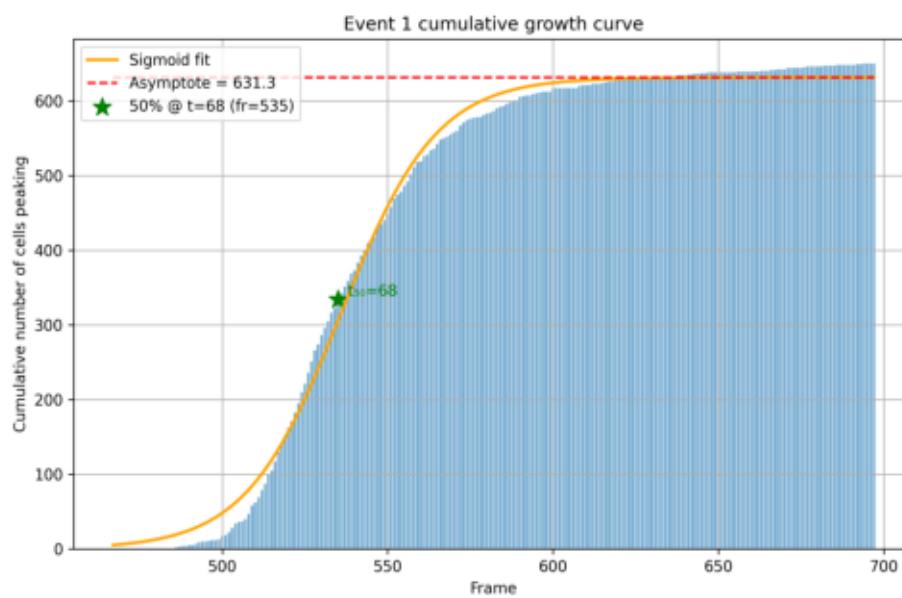


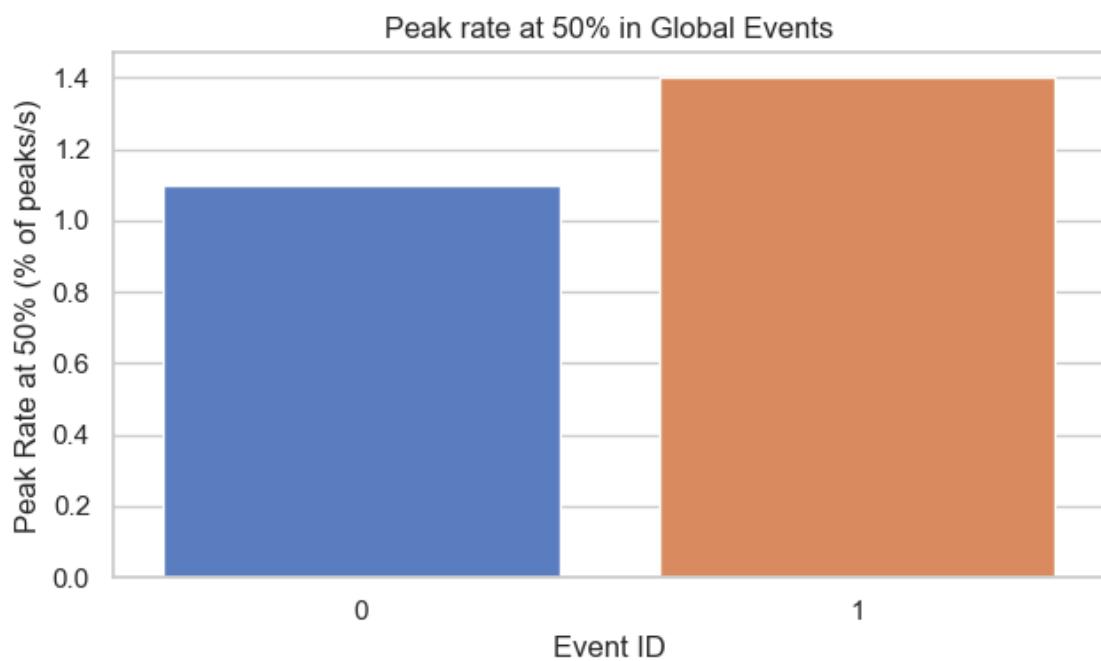
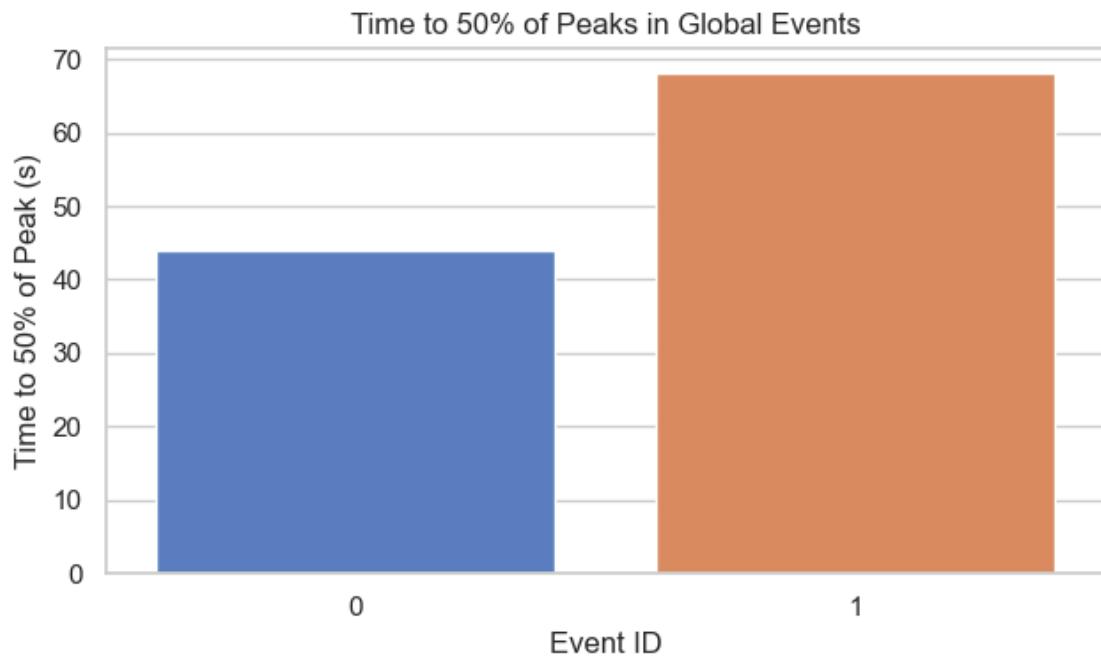
1.2.3 Kinetics of global events

Event Activity Overlay (Event ID: 0) - 20250810_IS1

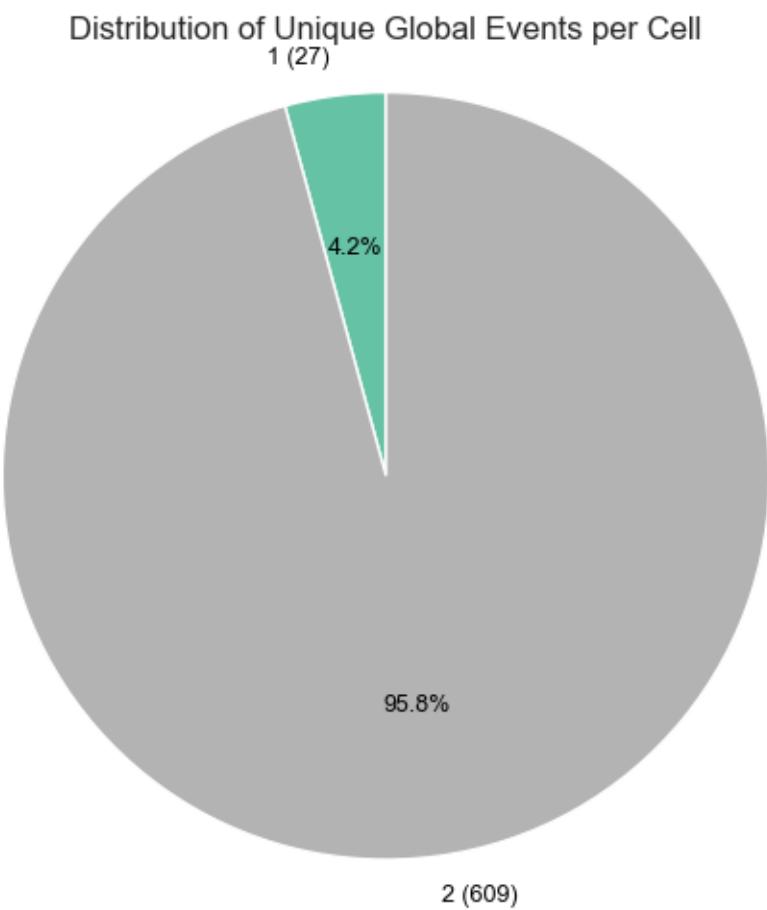


Event Activity Overlay (Event ID: 1) - 20250810_IS1

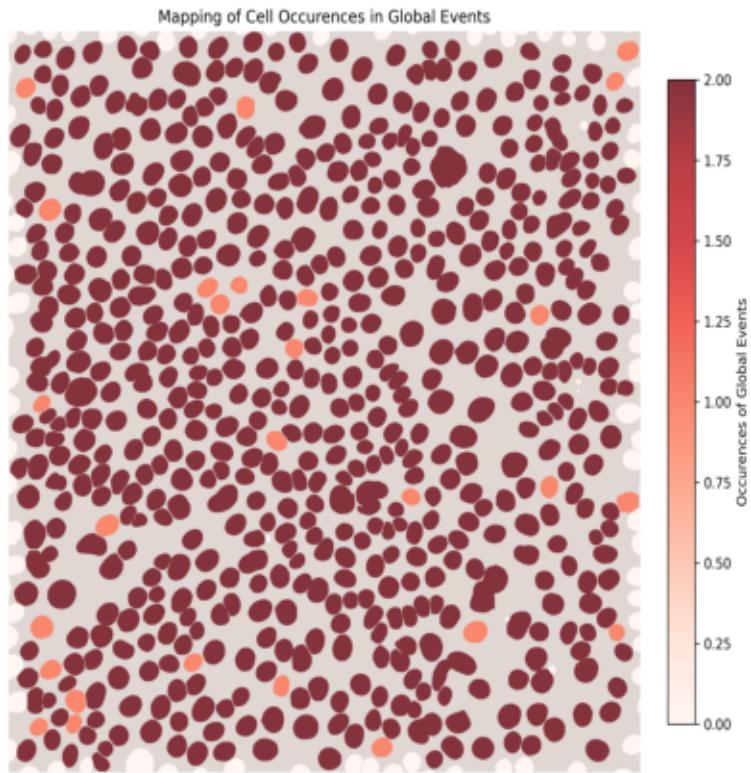


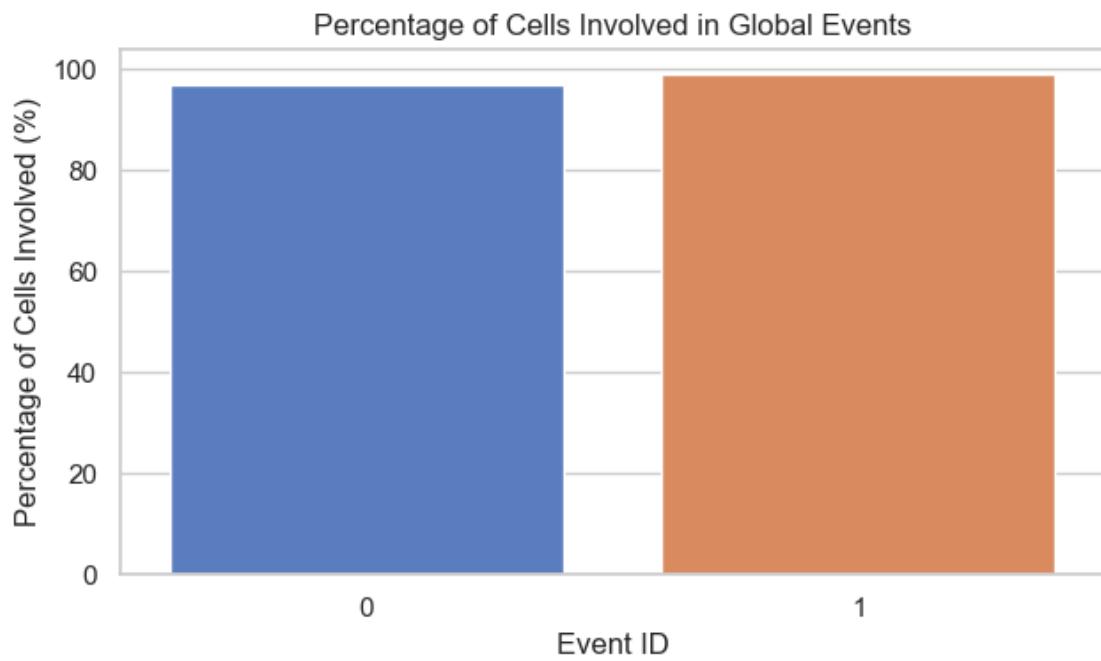


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250810_IS1



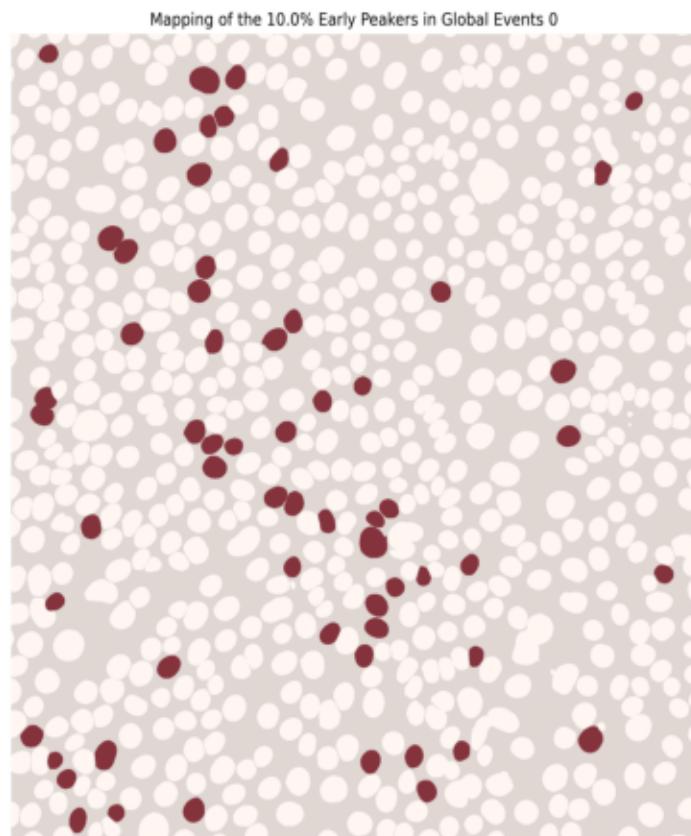


1.2.5 Inter-event interval analysis

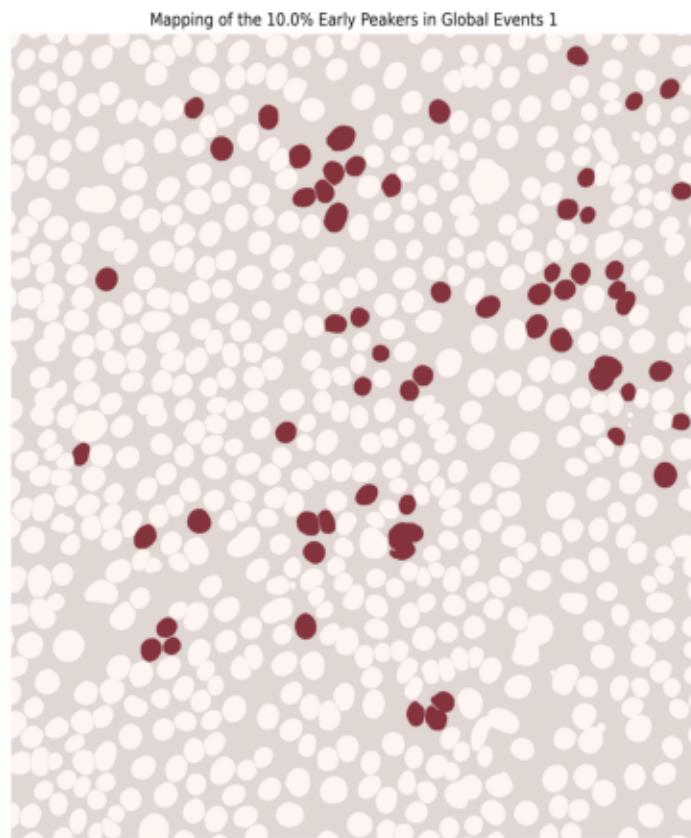
Intervals between global event peaks: [476.0]

1.2.6 Early peakers in the events

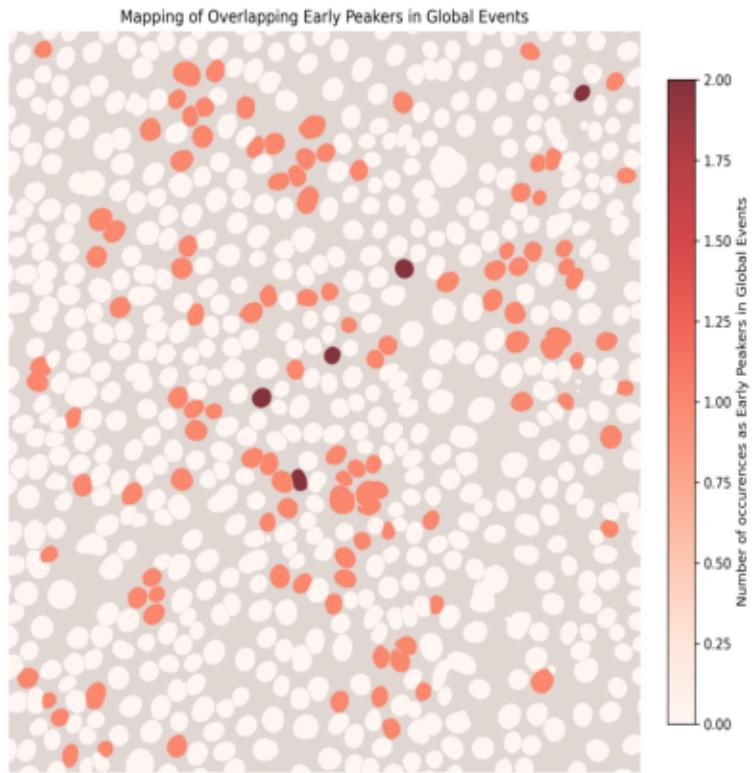
Cell Mapping with Early Peakers Overlay for event 0 - 20250810_IS1



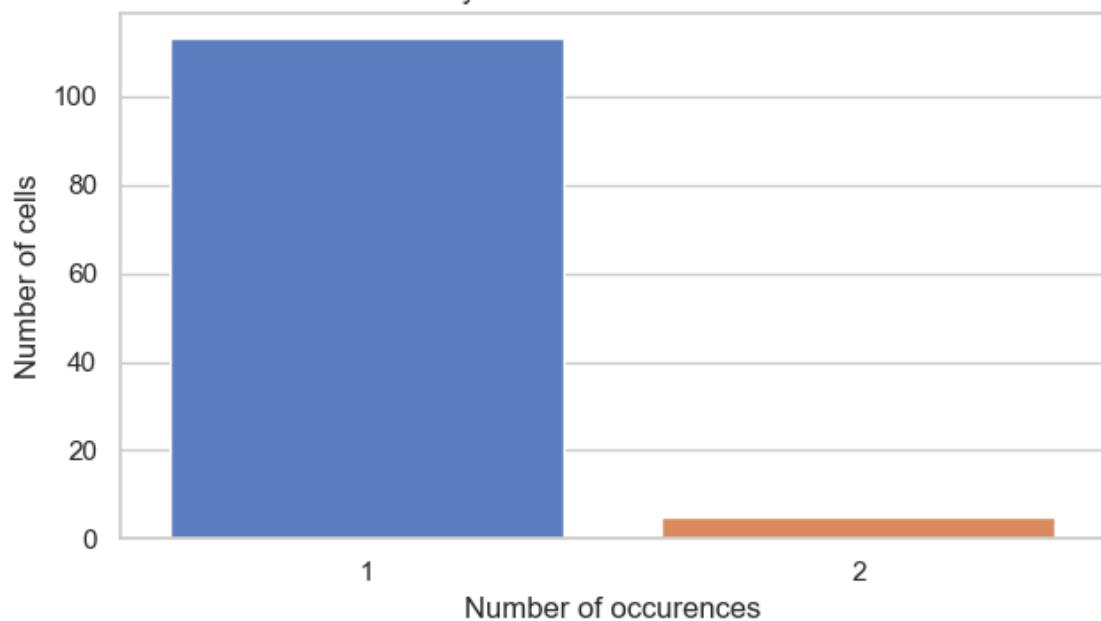
Cell Mapping with Early Peakers Overlay for event 1 - 20250810_IS1



Cell Mapping with Occurrences in Global Events Overlay - 20250810_IS1



Early Peakers in Global Events



Distribution of Early Peakers in Global Events

2 (5)

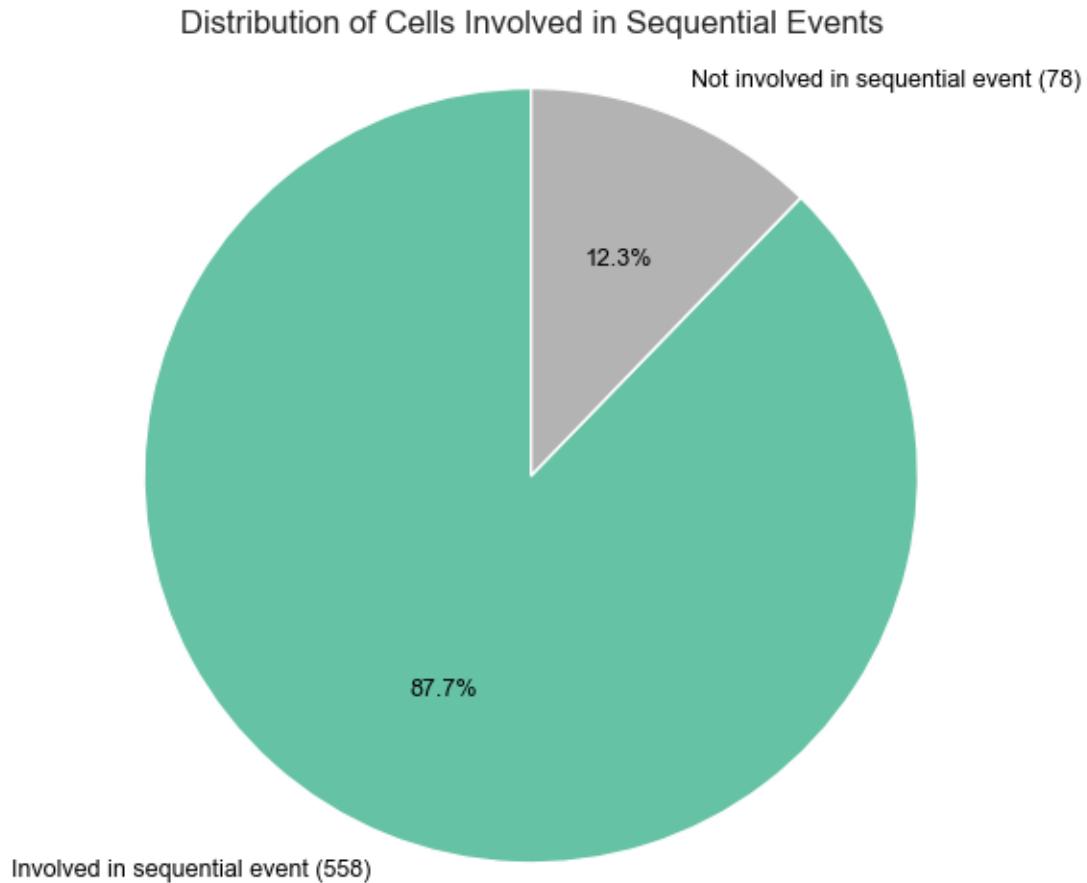
4.2%

95.8%

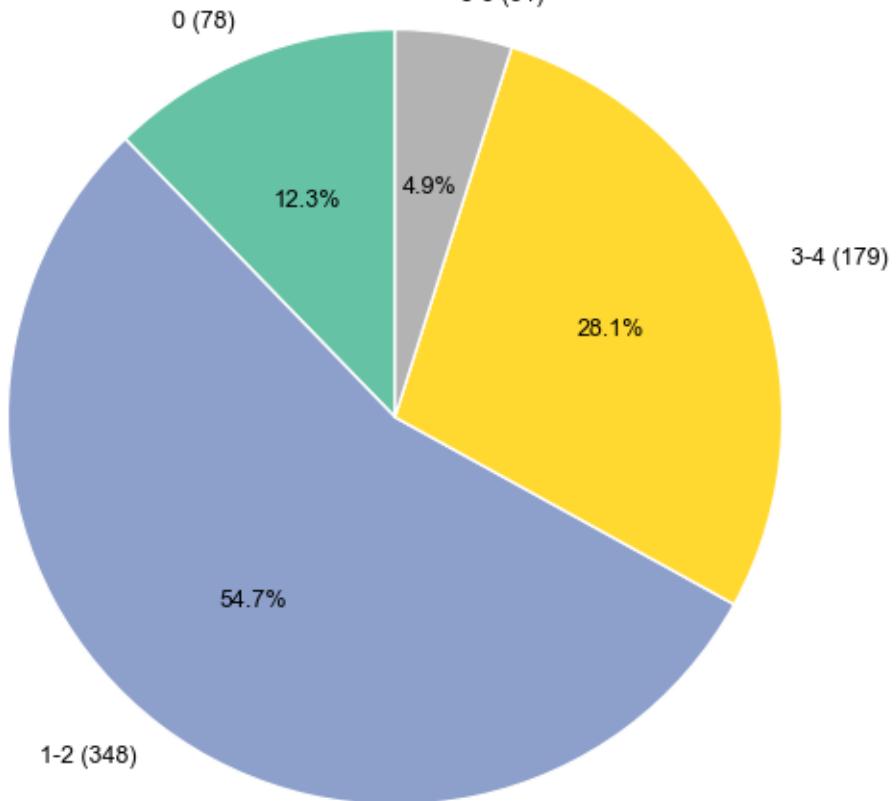
1 (113)

1.3 SEQUENTIAL EVENTS

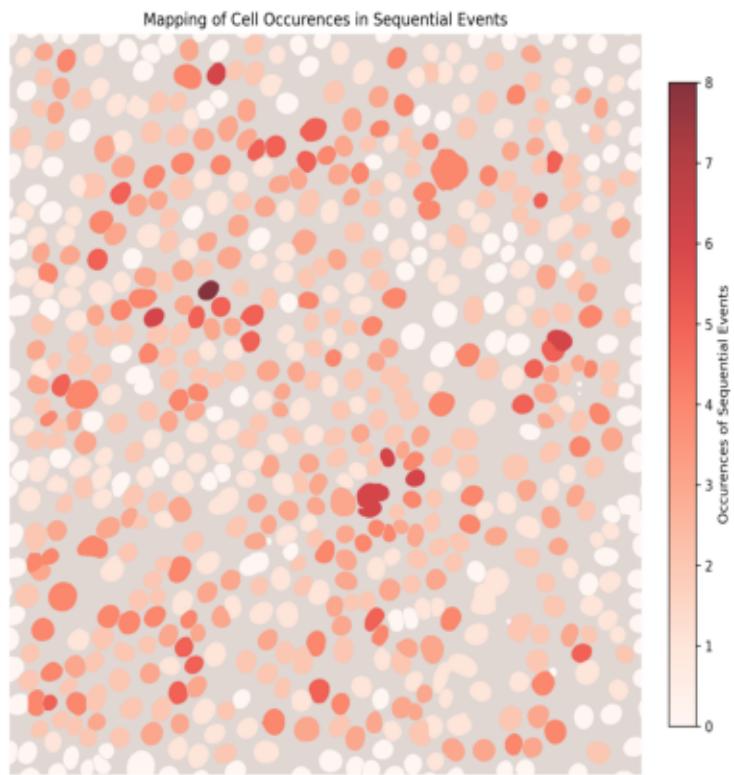
1.3.1 Cells occurrences in sequential events



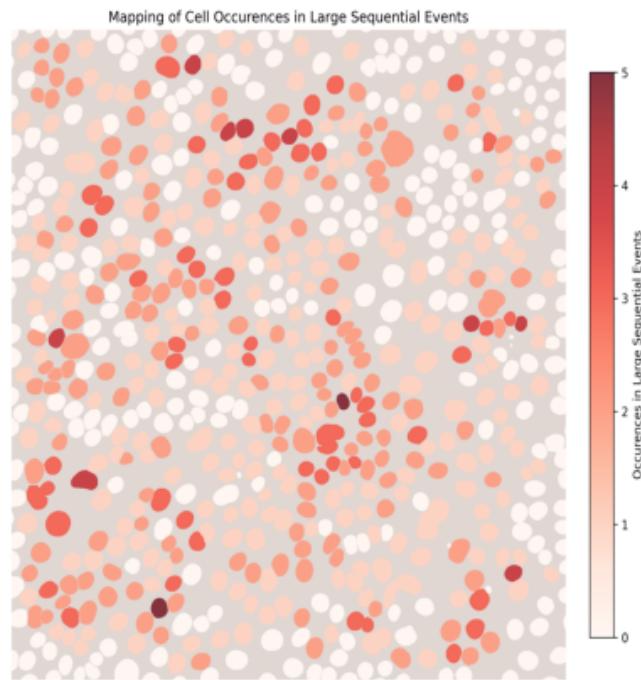
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250810_IS1

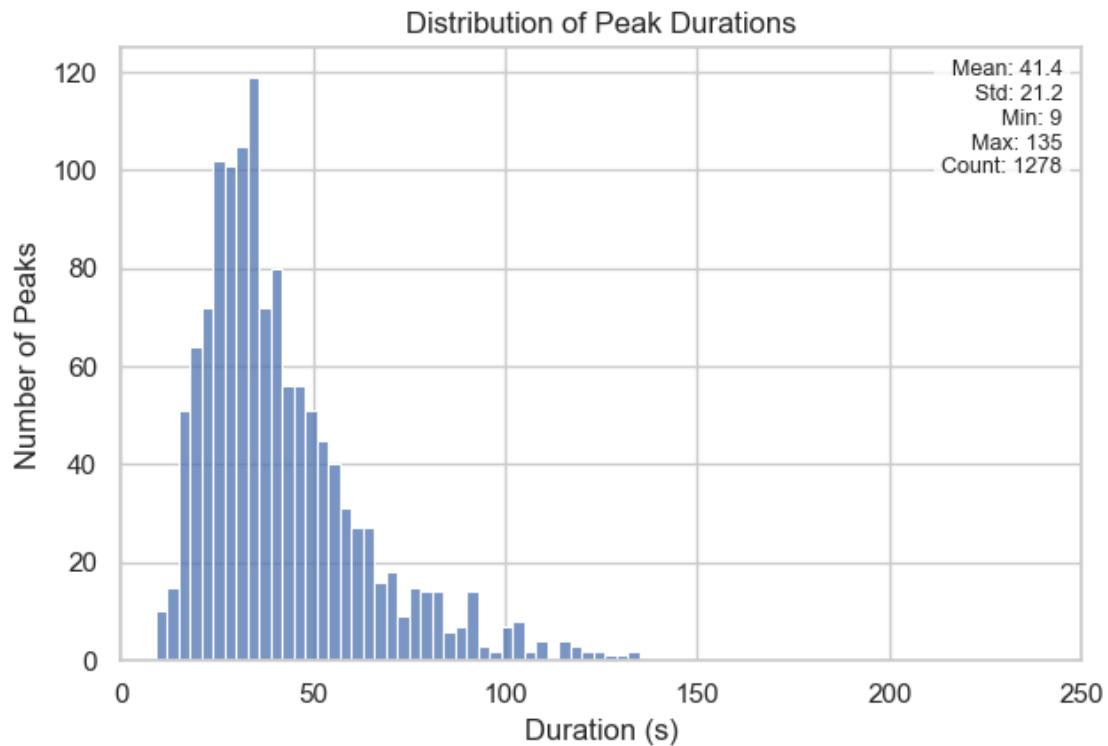


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250810_IS1

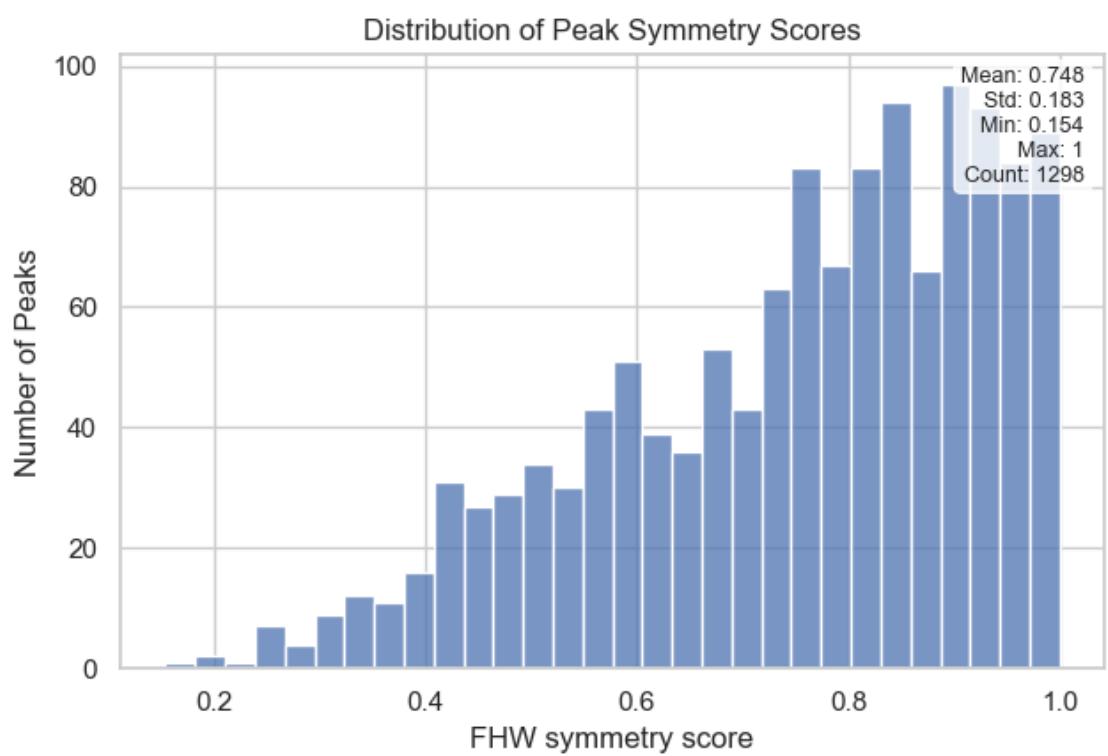
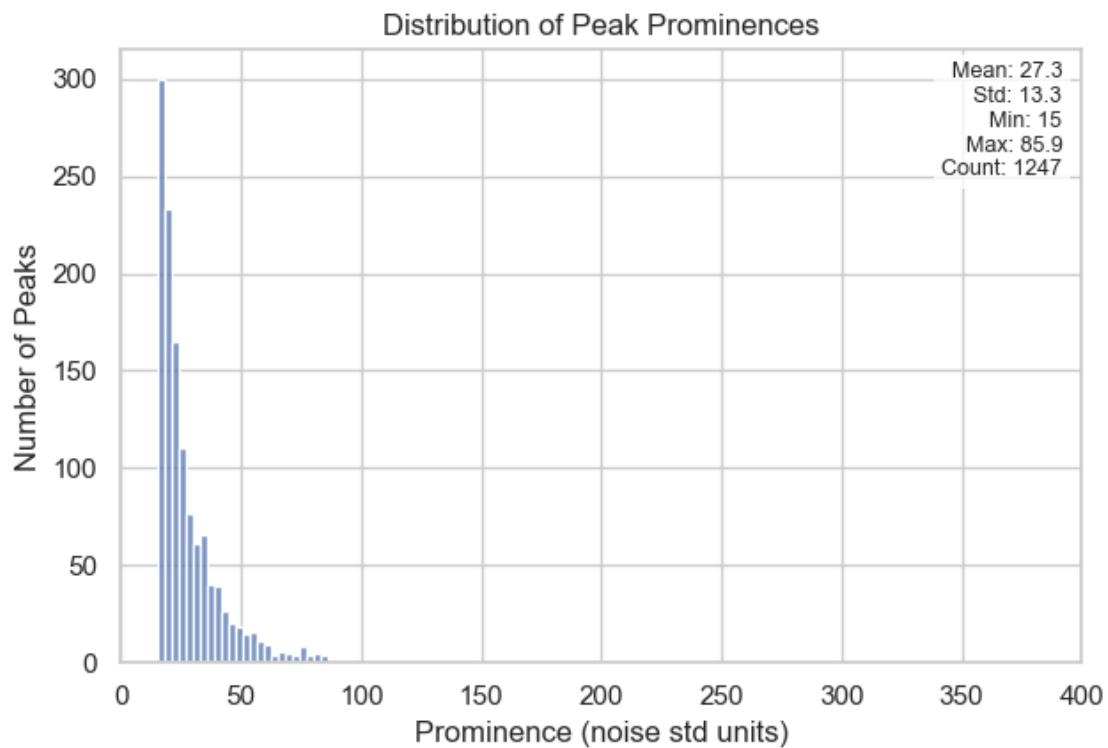


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 12:39:36] [INFO] calcium: plot_histogram: removed 20 outliers out of 1298 on 'Duration (s)' (lower=-10.5, upper=139.5)
```

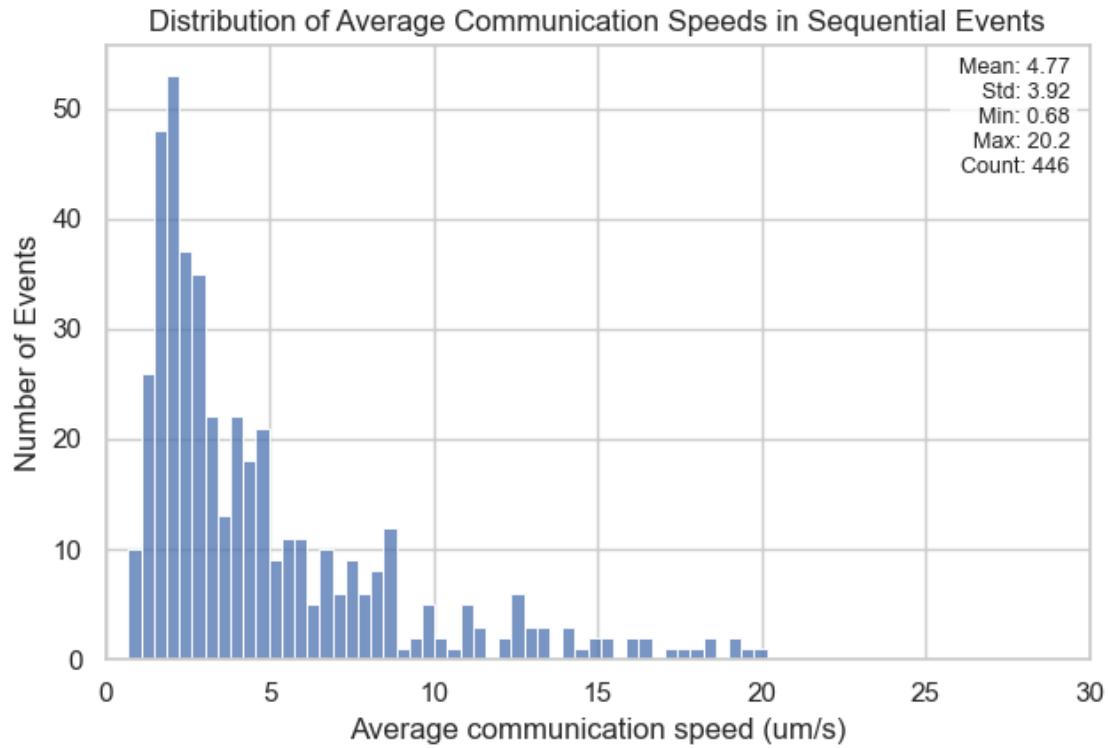


```
[2025-08-13 12:39:36] [INFO] calcium: plot_histogram: removed 51 outliers out of 1298 on 'Prominence (noise std units)' (lower=-4.65, upper=87.15)
```

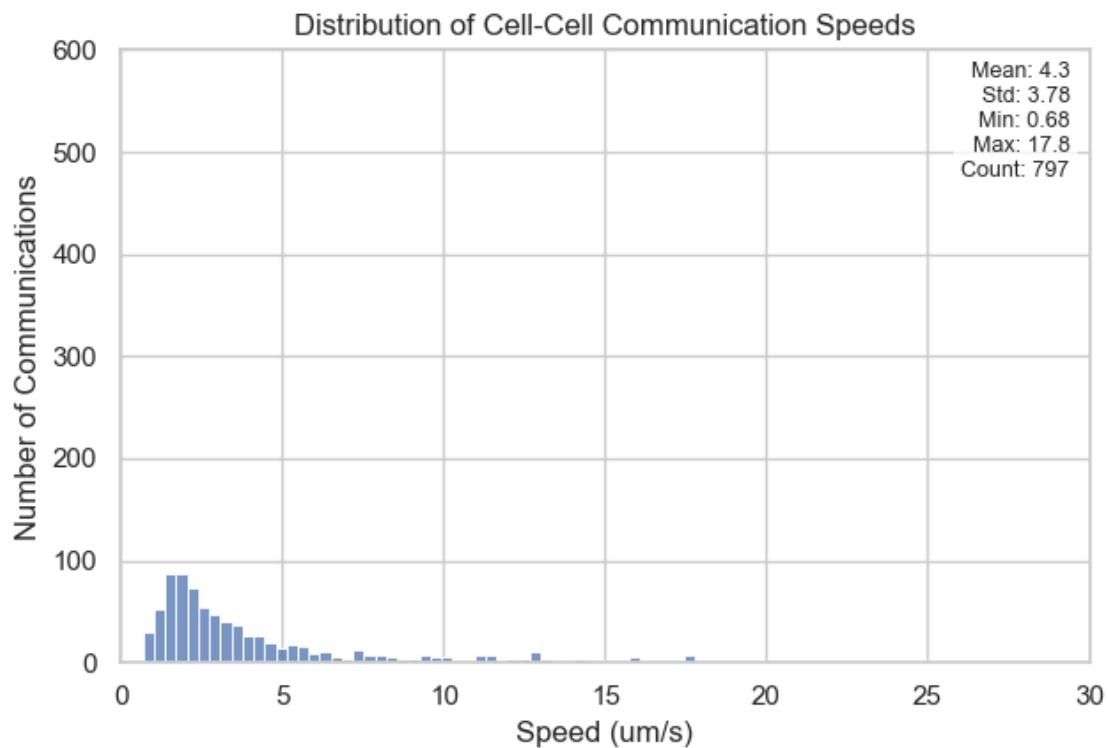


1.3.3 Cell-cell communication speed

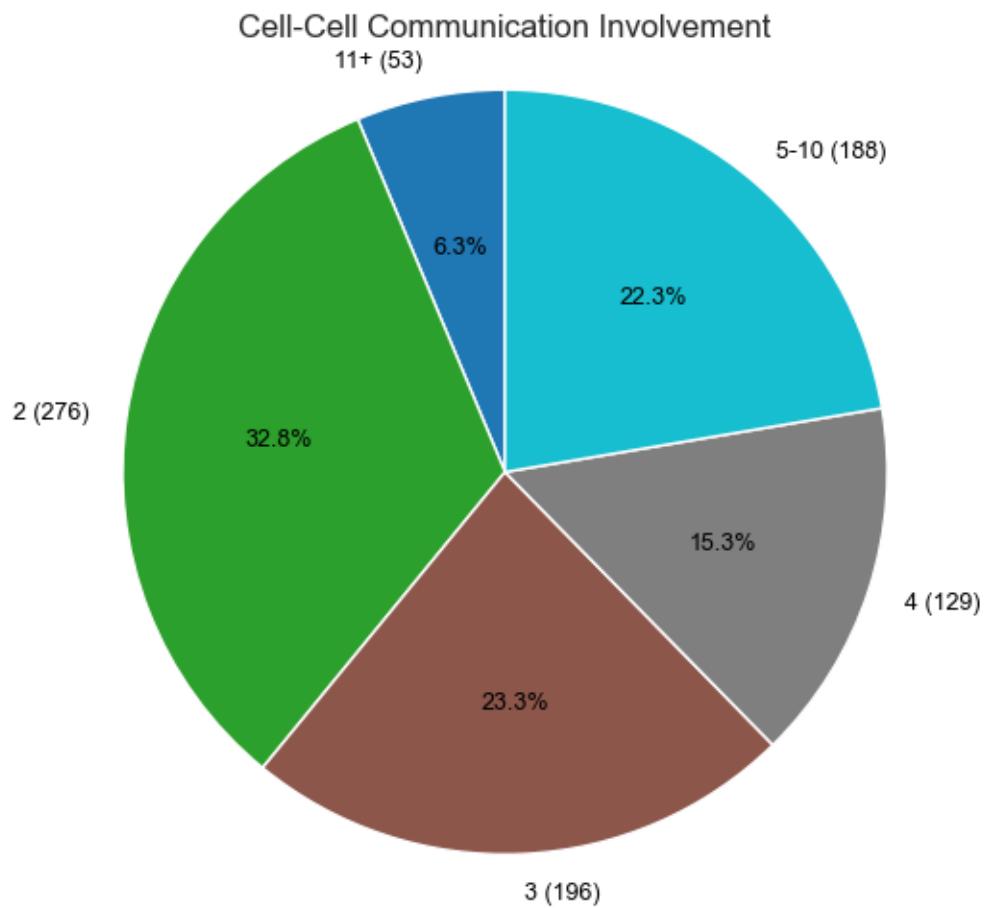
[2025-08-13 12:39:36] [INFO] calcium: plot_histogram: removed 10 outliers out of 456 on 'Average communication speed (um/s)' (lower=-11.542, upper=20.237)



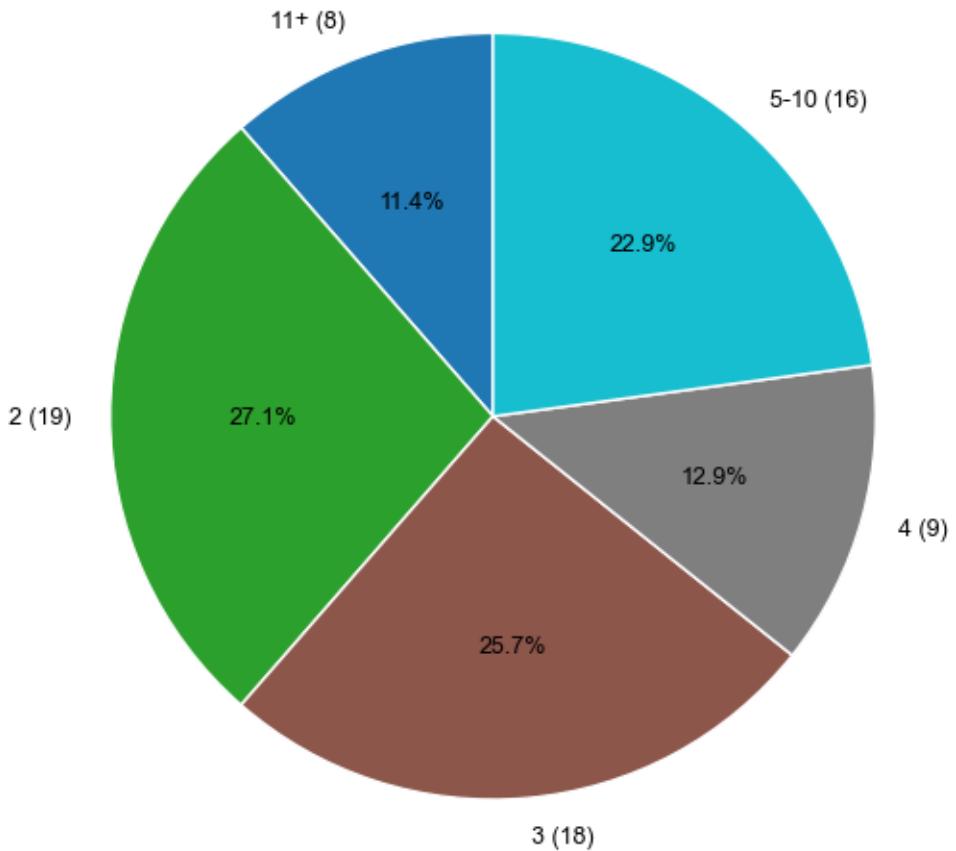
[2025-08-13 12:39:36] [INFO] calcium: plot_histogram: removed 45 outliers out of 842 on 'Speed (um/s)' (lower=-10.193, upper=17.983)



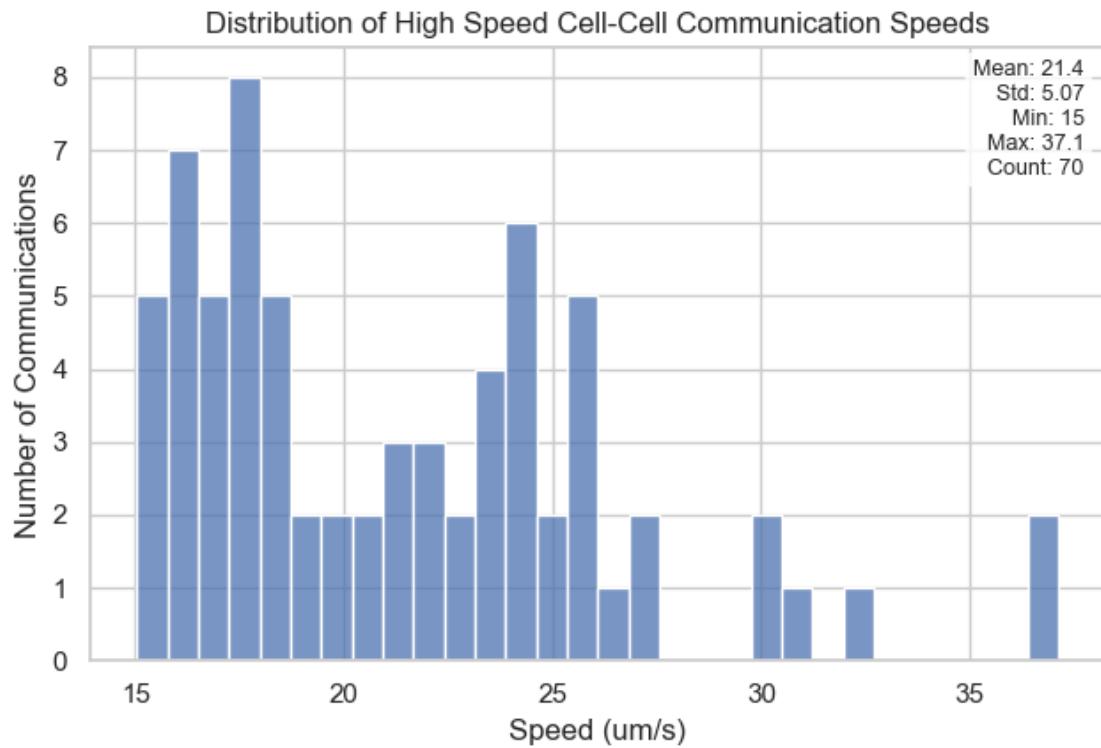
1.3.4 Double distribution in cell-cell communication speeds



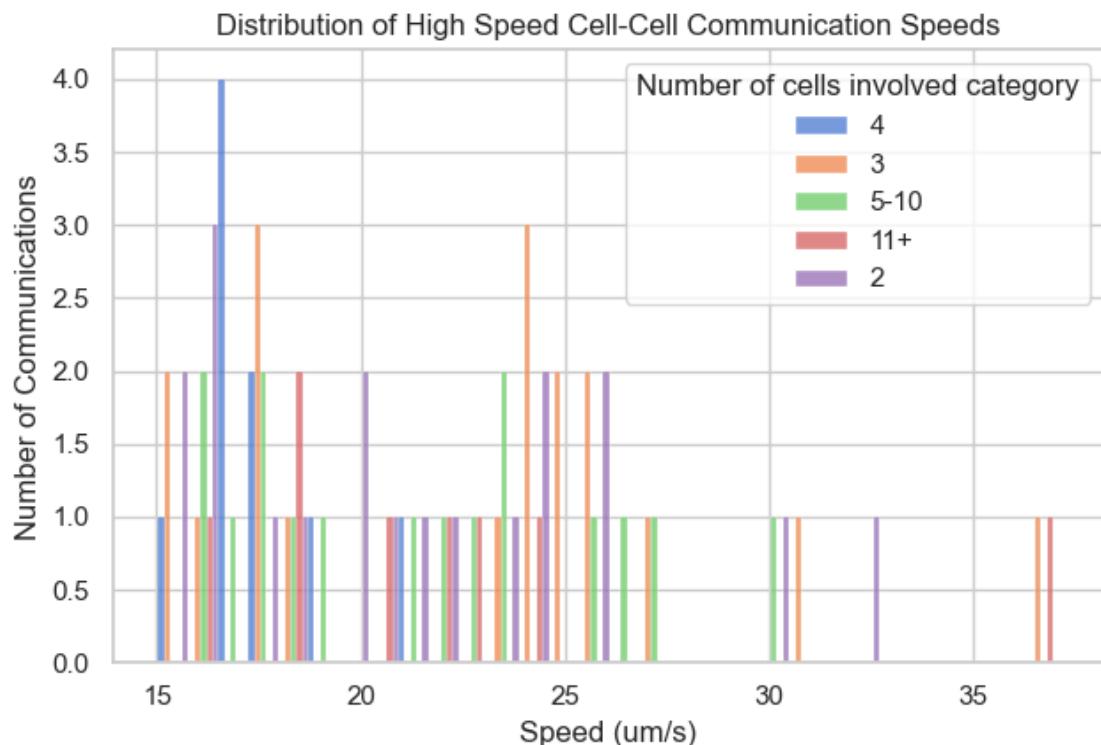
High Speed Cell-Cell Communication Involvement



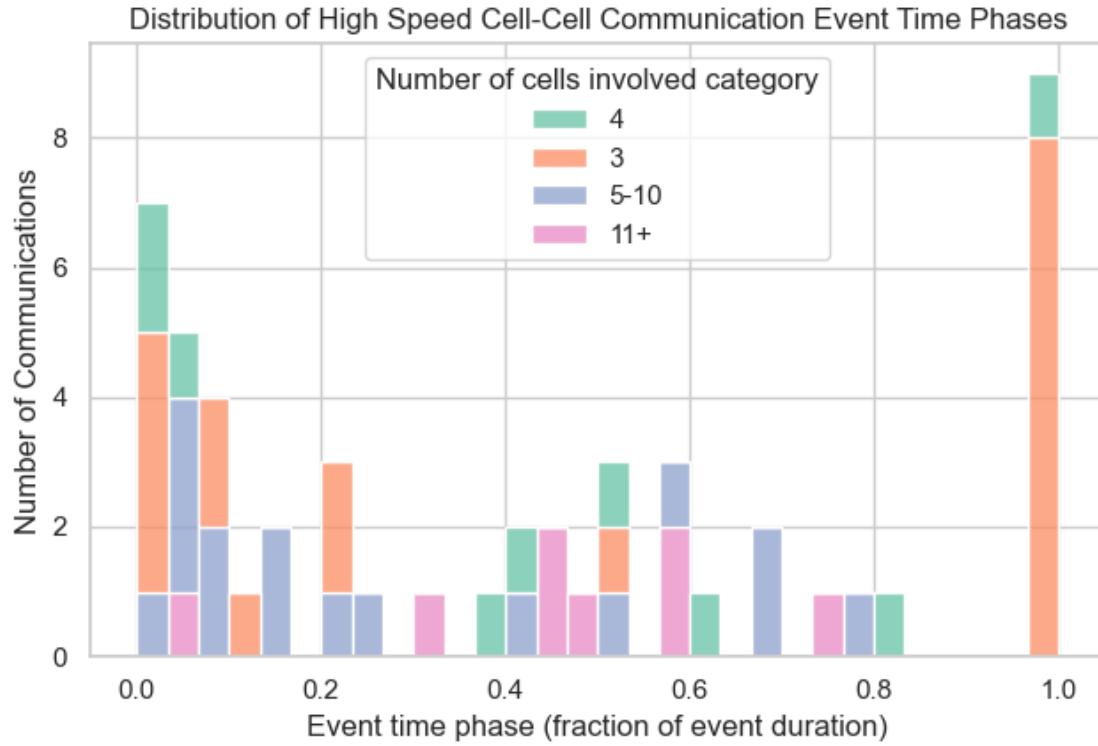
```
[2025-08-13 12:39:37] [INFO] calcium: plot_histogram: removed 0 outliers out of  
70 on 'Speed (um/s)' (lower=-2.5625, upper=44.372)
```



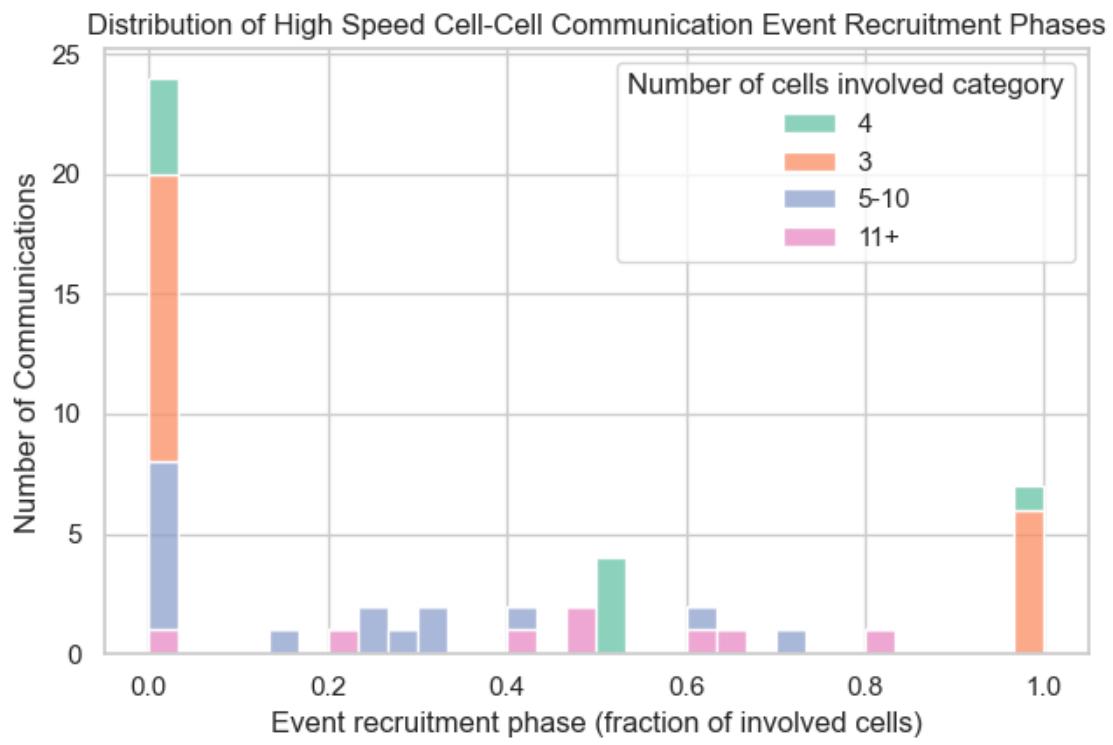
```
[2025-08-13 12:39:37] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 70 on 'Speed (um/s)' (lower=-2.5625, upper=44.372)
```



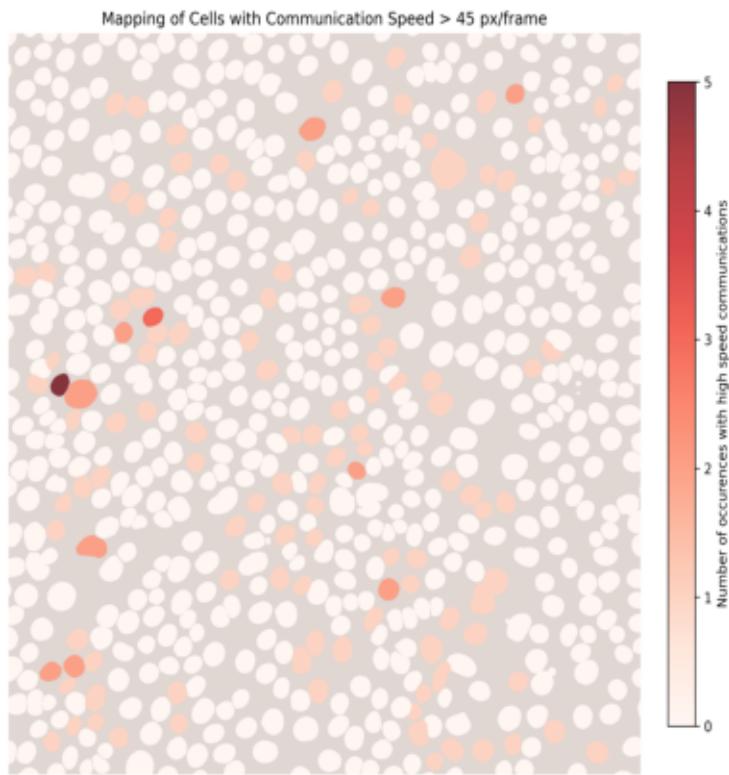
```
[2025-08-13 12:39:38] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 51 on 'Event time phase (fraction of event duration)' (lower=-1.775, upper=2.53)
```



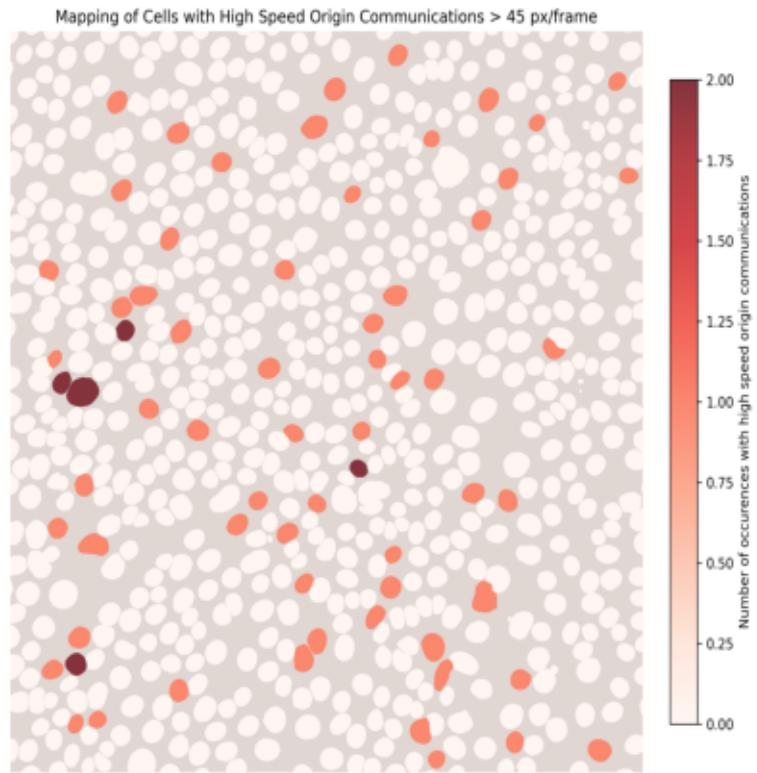
```
[2025-08-13 12:39:38] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 51 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.5, upper=2)
```



Cell Mapping with High Speed Cells Overlay - 20250810_IS1



Cell Mapping with High Speed Origin Cells Overlay - 20250810_IS1



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
2	1759504248320	3	235	2	
4	1759504242944	4	949	5	
7	1759504239824	5	570	3	
10	1759504239344	6	231	5	
13	1759504245728	7	482	2	
..	
827	1759536656592	445	1043	1	
833	1759536656352	450	1005	2	
834	1759536654288	451	1012	1	
837	1759536650304	453	1032	5	
838	1759536647280	454	1052	3	

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
2	238	3	933.0	933.0	
4	943	4	903.0	903.0	
7	606	4	891.0	891.0	
10	220	5	1197.0	1197.0	
13	495	1	370.0	370.0	
..
827	1021	3	413.0	415.0	
833	1026	1	238.0	239.0	
834	1030	1	345.0	346.0	
837	1040	3	827.0	828.0	
838	1038	4	958.0	959.0	
	Duration (s)	Distance (um)	Speed (um/s)		\
2	0.0	16.98	16.98		
4	0.0	15.30	15.30		
7	0.0	16.86	16.86		
10	0.0	23.34	23.34		
13	0.0	27.47	27.47		
..		
827	2.0	36.58	18.29		
833	1.0	20.96	20.96		
834	1.0	20.29	20.29		
837	1.0	24.04	24.04		
838	1.0	16.45	16.45		
	Event time phase (fraction of event duration)				\
2		0.52			
4		0.00			
7		0.00			
10		0.00			
13		0.15			
..		...			
827		NaN			
833		NaN			
834		NaN			
837		0.20			
838		NaN			
	Event recruitment phase (fraction of involved cells)		dataset		\
2		0.0	20250810_IS1		
4		0.0	20250810_IS1		
7		0.0	20250810_IS1		
10		0.0	20250810_IS1		
13		0.0	20250810_IS1		
..			
827		NaN	20250810_IS1		
833		NaN	20250810_IS1		

834		NaN	20250810_IS1
837		0.0	20250810_IS1
838		NaN	20250810_IS1

	Number of cells involved	category	Speed category
2	4	High speed	
4	4	High speed	
7	4	High speed	
10	3	High speed	
13	5-10	High speed	
..
827	2	High speed	
833	2	High speed	
834	2	High speed	
837	3	High speed	
838	2	High speed	

[70 rows x 16 columns]

Origin cell ID	Speed category	High speed	Low speed
160		0	1
164		0	3
169		0	4
175		0	1
176		0	2
..
1037		0	1
1040		0	2
1043		1	0
1047		0	2
1052		1	0

[421 rows x 2 columns]

	Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um) \
0	160	192.72	6.83
3	164	141.70	10.40
5	169	26.98	12.03
11	175	411.78	13.33
12	176	65.98	13.65
..
622	1037	132.60	481.32
625	1040	374.40	482.30
628	1043	464.75	483.93
631	1047	148.53	486.20
634	1052	336.05	490.10

Number of peaks Is active Occurences in global events \

0	4	True	2
3	6	True	2
5	6	True	2
11	7	True	2
12	4	True	2
..
622	6	True	2
625	6	True	2
628	4	True	2
631	5	True	2
634	5	True	2

Occurrences in global events as early peaker \

0	0
3	0
5	1
11	1
12	0
..	..
622	1
625	0
628	0
631	0
634	0

Occurrences in sequential events \

0	2
3	3
5	3
11	3
12	1
..	..
622	1
625	3
628	2
631	1
634	1

Occurrences in sequential events as origin \

0	0
3	2
5	2
11	1
12	1
..	..
622	1
625	1
628	1

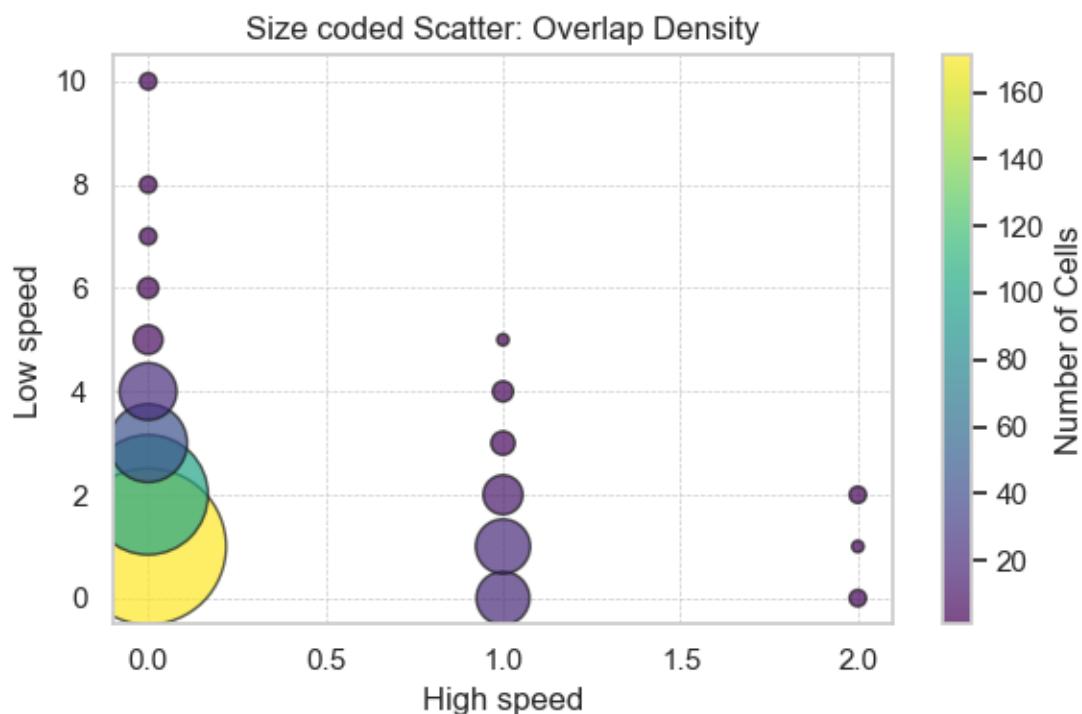
631		1	
634		1	
Occurrences in individual events Peak frequency (Hz) Periodicity score \			
0	0	0.0024	0.59
3	1	0.0035	0.63
5	0	0.0035	0.59
11	2	0.0041	0.59
12	1	0.0024	0.77
..
622	3	0.0035	0.70
625	1	0.0035	0.64
628	0	0.0024	0.67
631	2	0.0029	0.73
634	2	0.0029	0.72
Neighbor count Neighbors (labels) dataset \			
0	4	[165,177,189,194]	20250810_IS1
3	3	[165,196,198]	20250810_IS1
5	3	[178,181,201]	20250810_IS1
11	3	[182,185,205]	20250810_IS1
12	4	[163,181,212,223]	20250810_IS1
..
622	3	[1009,1023,1047]	20250810_IS1
625	5	[974,1002,1014,1032,1038]	20250810_IS1
628	3	[999,1001,1021]	20250810_IS1
631	4	[1009,1024,1037,1046]	20250810_IS1
634	3	[1015,1025,1038]	20250810_IS1
Involved in sequential event Occurrences in sequential events category \			
0	Involved in sequential event		1-2
3	Involved in sequential event		3-4
5	Involved in sequential event		3-4
11	Involved in sequential event		3-4
12	Involved in sequential event		1-2
..
622	Involved in sequential event		1-2
625	Involved in sequential event		3-4
628	Involved in sequential event		1-2
631	Involved in sequential event		1-2
634	Involved in sequential event		1-2
High speed Low speed			
0	0.0	1.0	
3	0.0	3.0	
5	0.0	4.0	
11	0.0	1.0	
12	0.0	2.0	

```

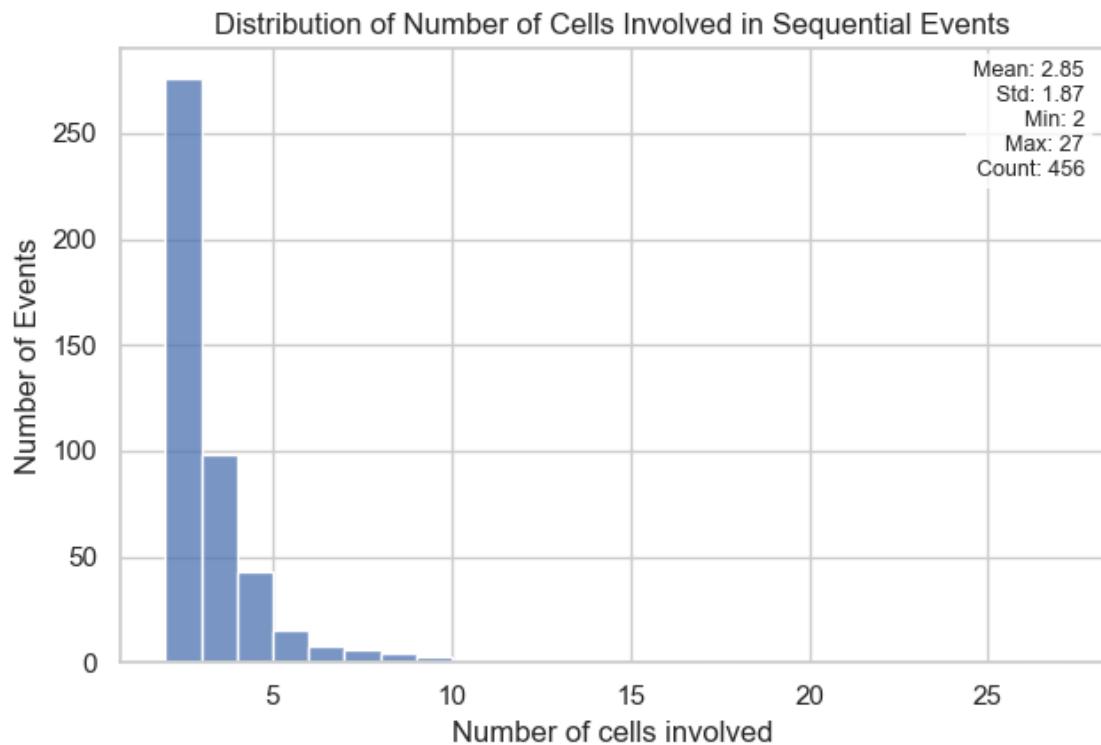
...
622      0.0      1.0
625      0.0      2.0
628      1.0      0.0
631      0.0      2.0
634      1.0      0.0

```

[418 rows x 19 columns]



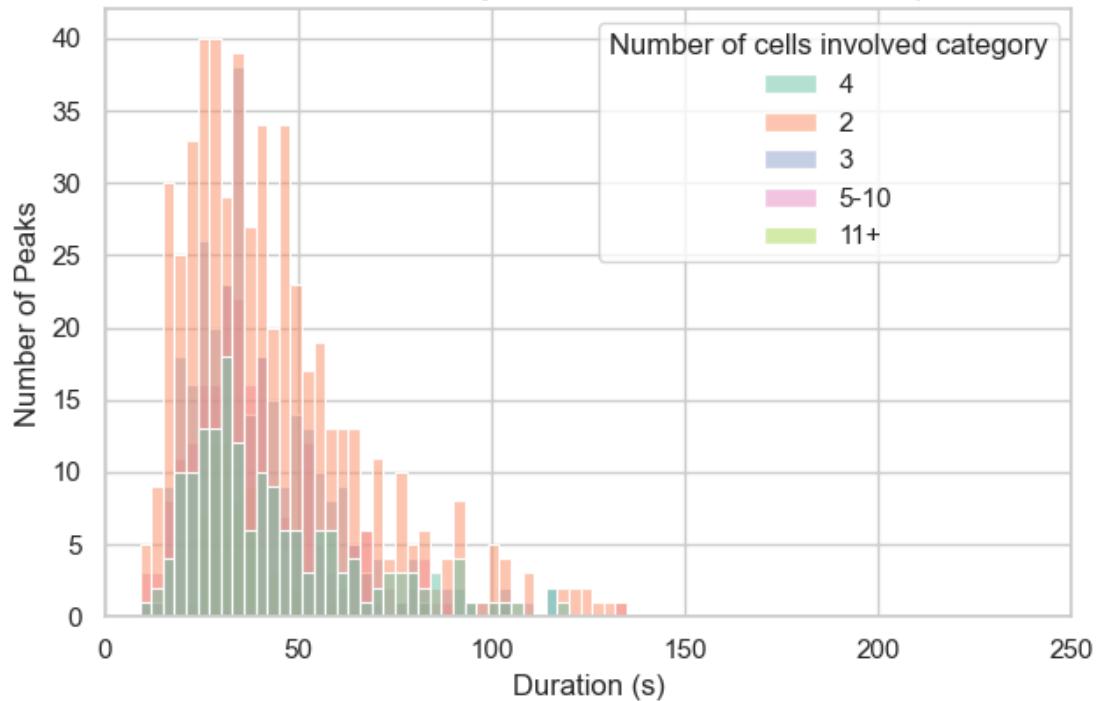
1.3.5 Number of cells involved per sequential events



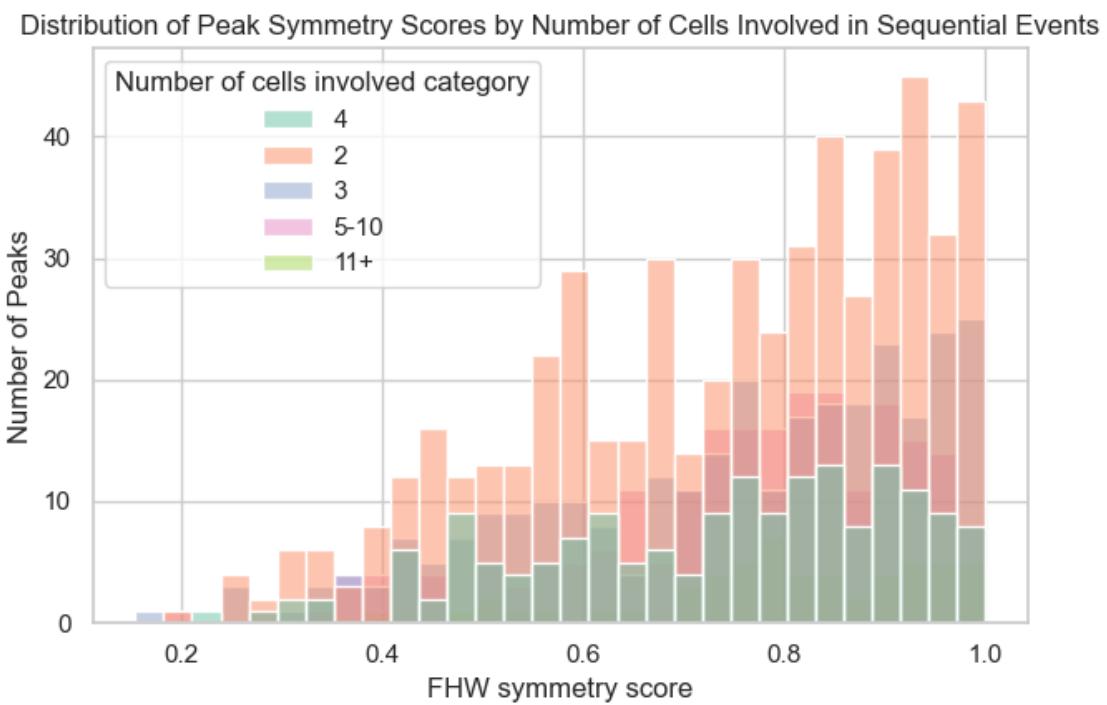
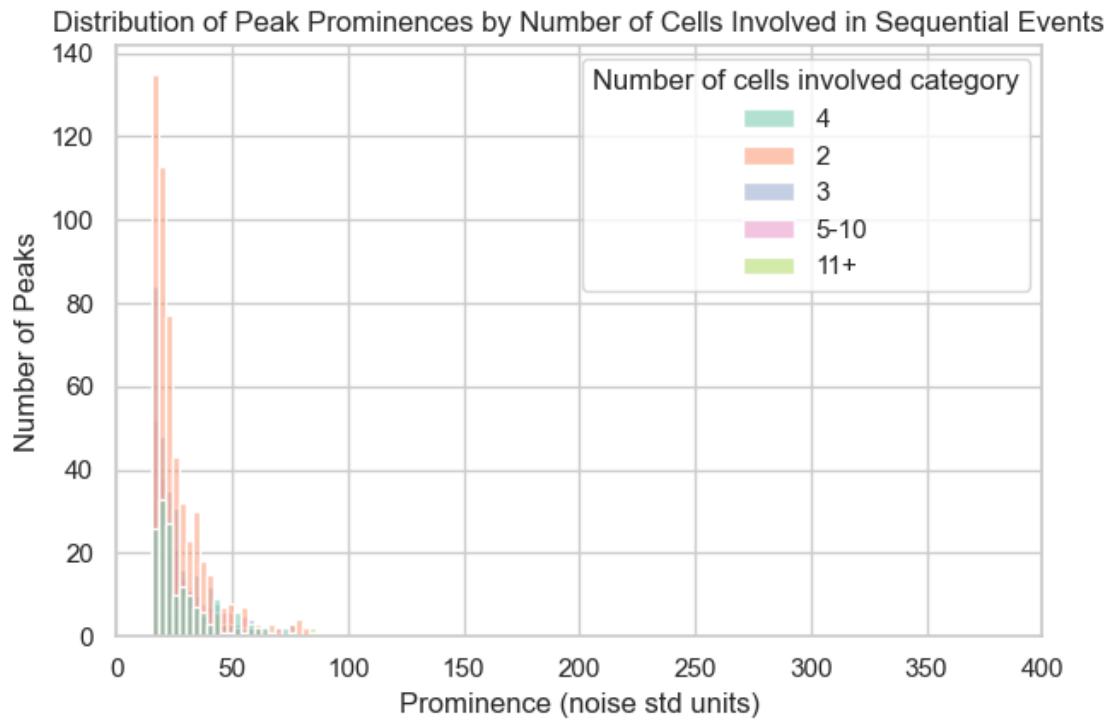
1.3.6 Influence of cell count per event on statistics

```
[2025-08-13 12:39:42] [INFO] calcium: plot_histogram_by_group: removed 20 outliers out of 1298 on 'Duration (s)' (lower=-10.5, upper=139.5)
```

Distribution of Peak Durations by Number of Cells Involved in Sequential Events

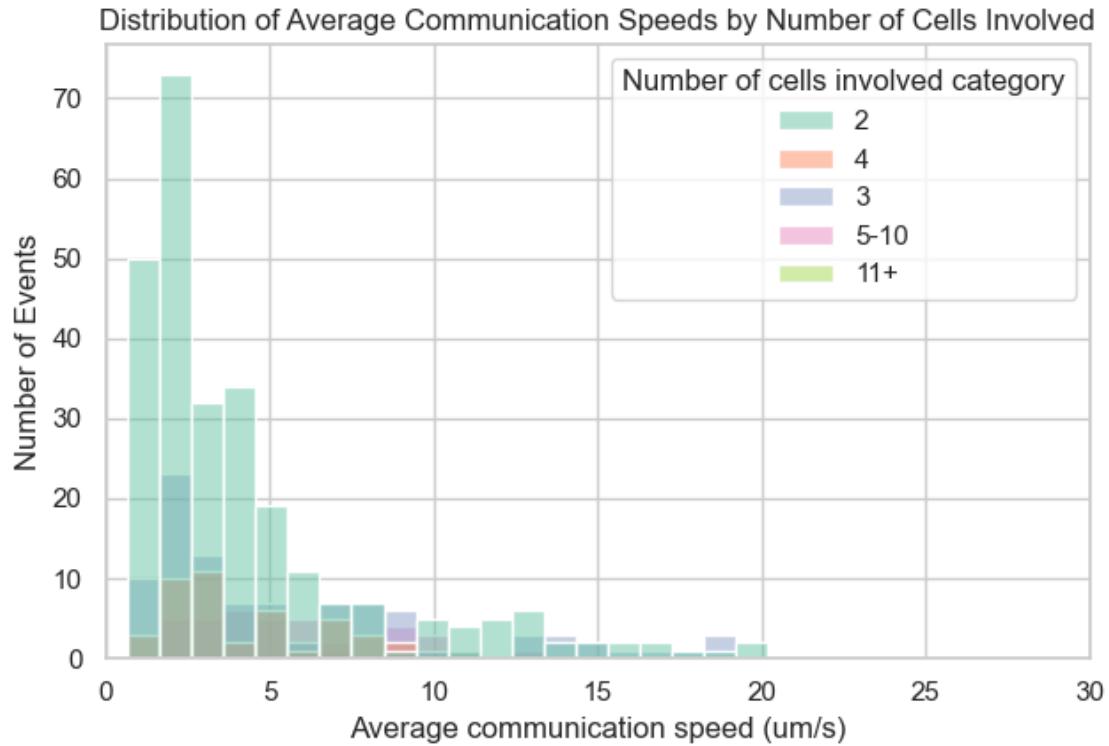


```
[2025-08-13 12:39:42] [INFO] calcium: plot_histogram_by_group: removed 51 outliers out of 1298 on 'Prominence (noise std units)' (lower=-4.65, upper=87.15)
```



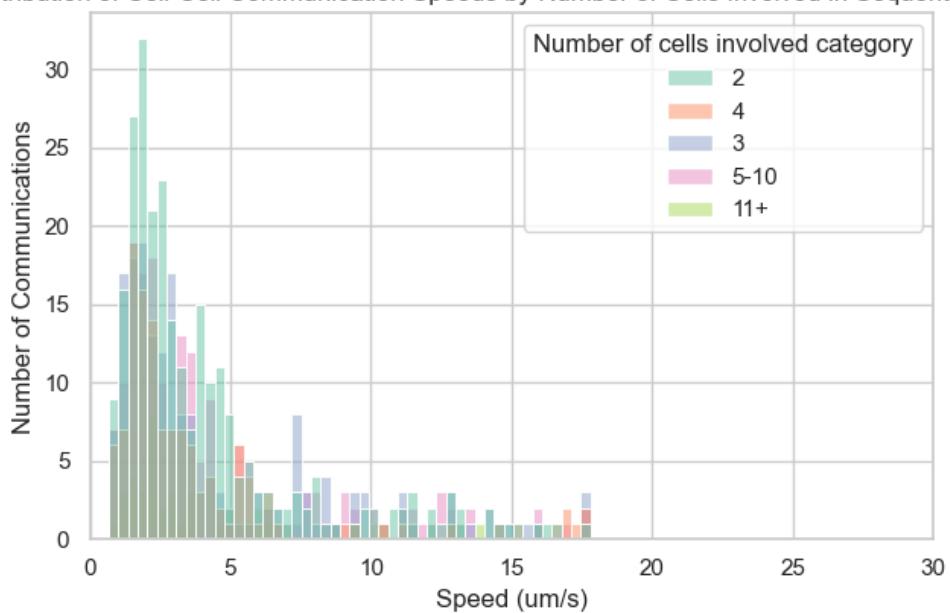
[2025-08-13 12:39:43] [INFO] calcium: plot_histogram_by_group: removed 10

outliers out of 456 on 'Average communication speed (um/s)' (lower=-11.542, upper=20.237)



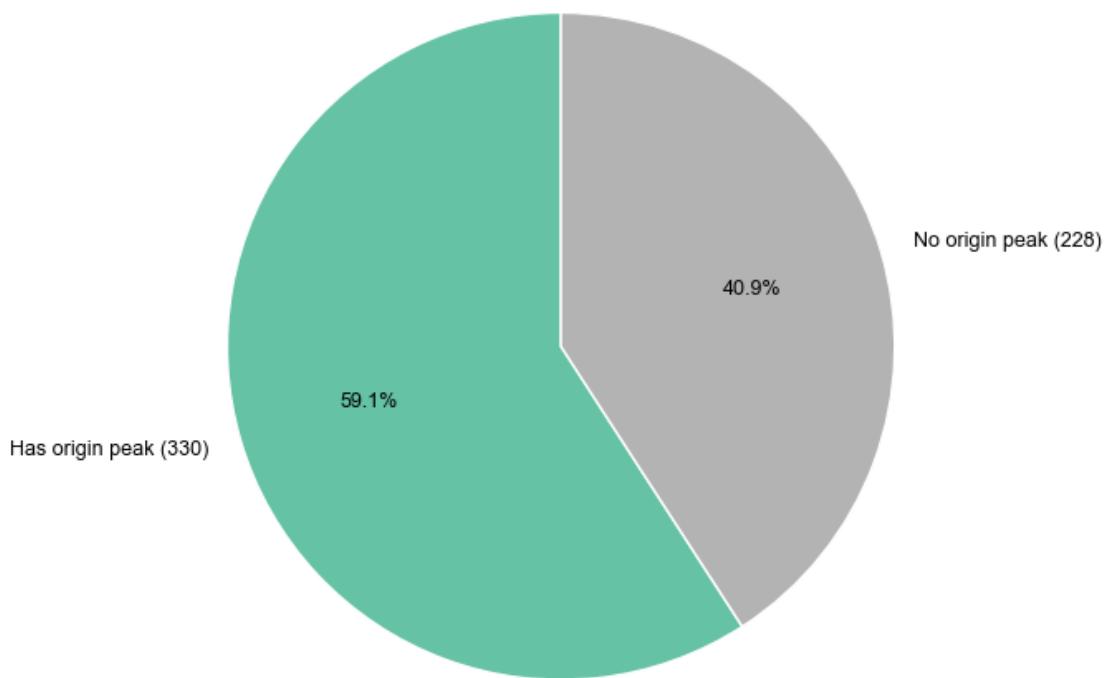
[2025-08-13 12:39:43] [INFO] calcium: plot_histogram_by_group: removed 45 outliers out of 842 on 'Speed (um/s)' (lower=-10.193, upper=17.983)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events

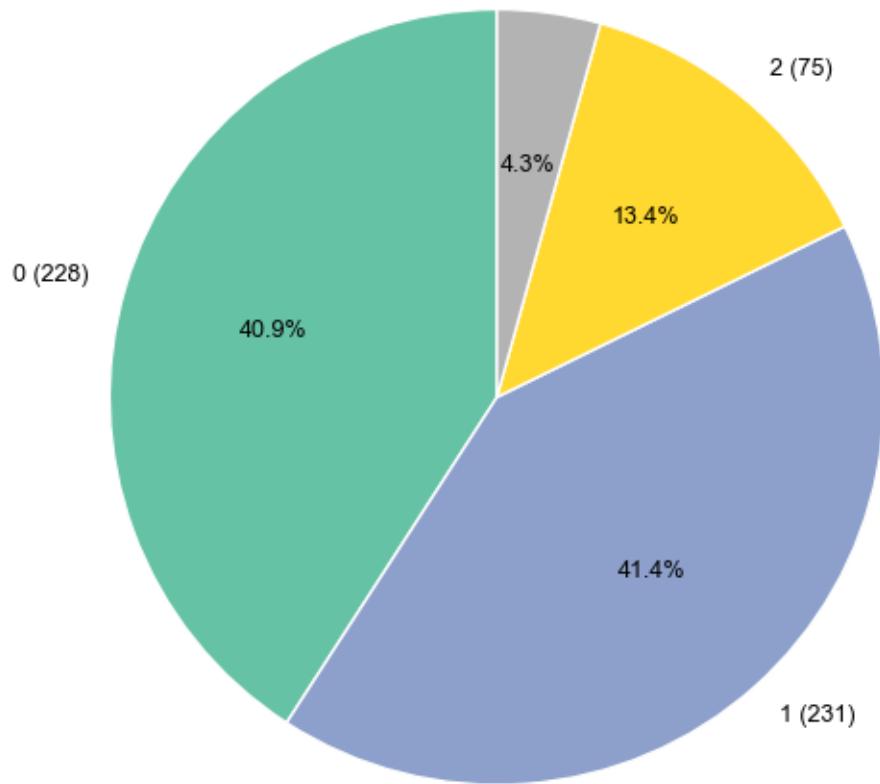


1.3.7 Cells occurrences as origin in sequential events

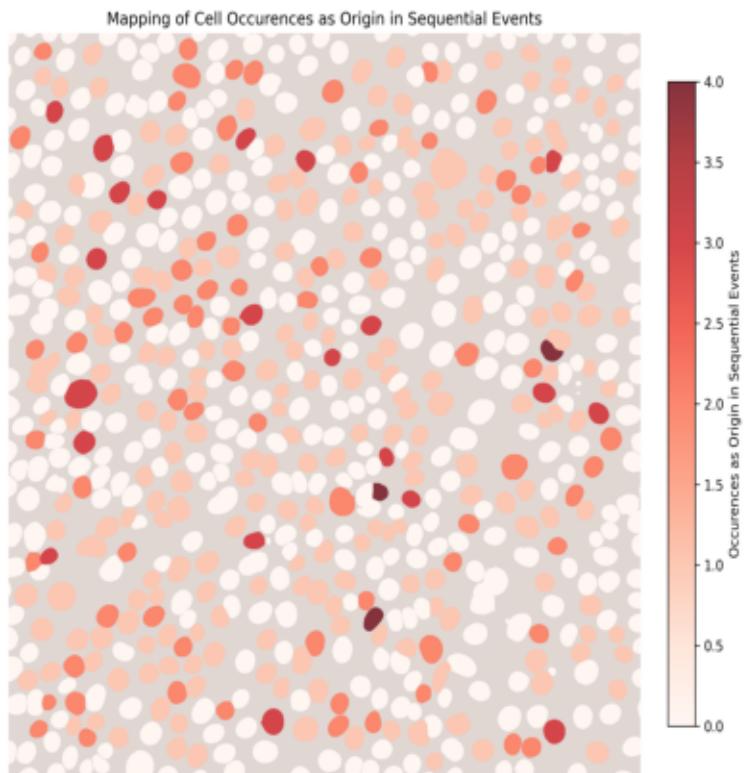
Distribution of Number of Sequential Event Origin Peaks per Cell



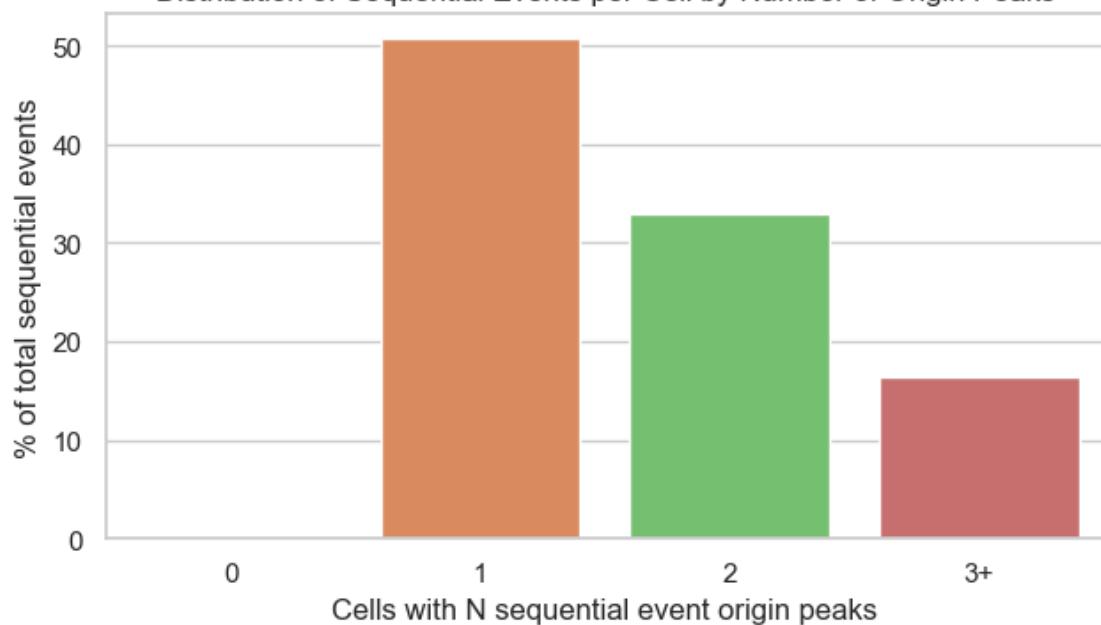
Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)
3+ (24)



Cell Mapping with Origin Peaks Overlay - 20250810_IS1



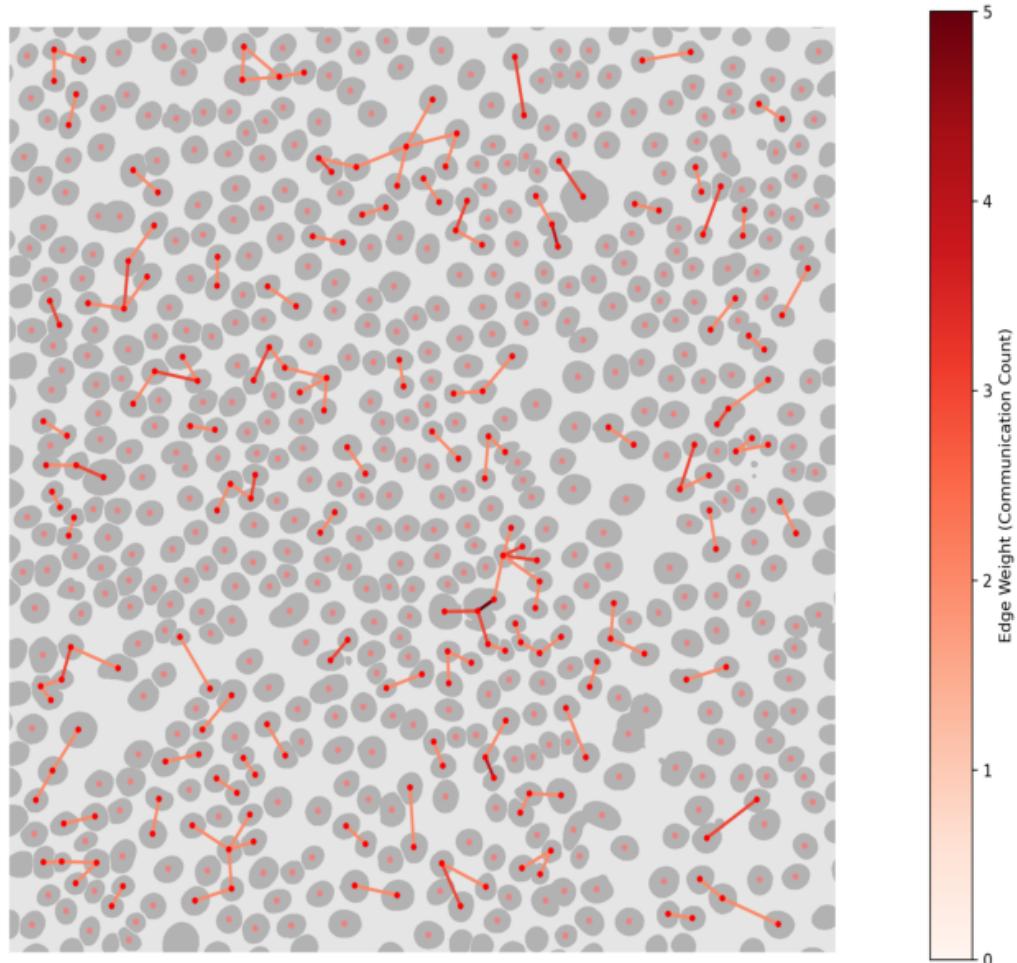
Distribution of Sequential Events per Cell by Number of Origin Peaks

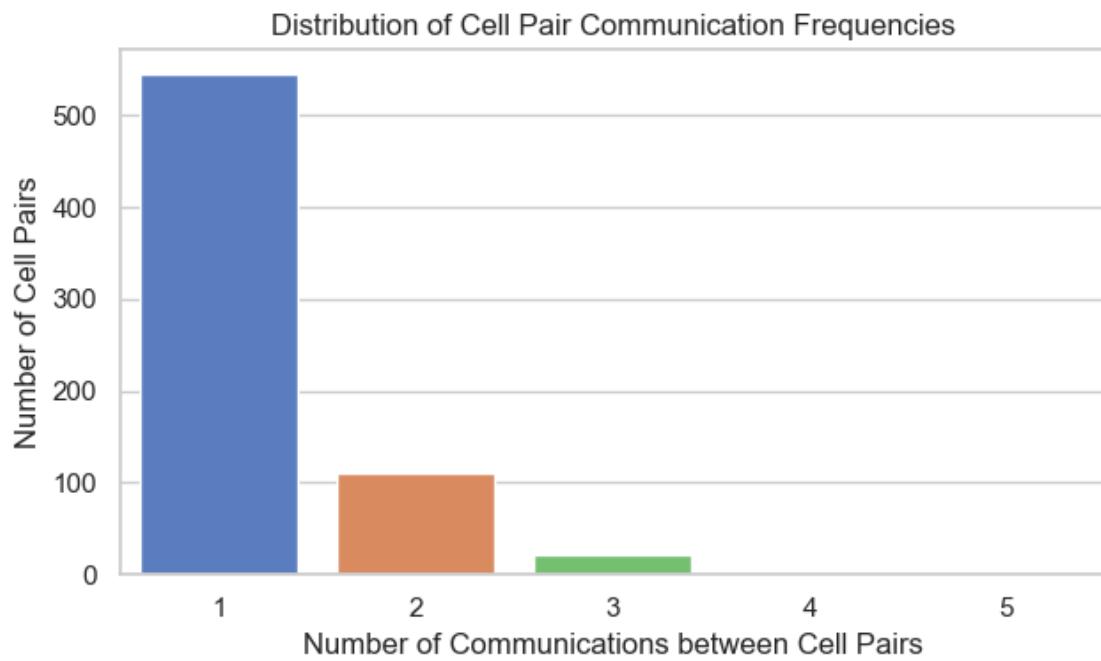


1.3.8 Connection network between cells

Cell Connection Network Graph - 20250810_IS1

Cells Connection Network (Weighted Edges)

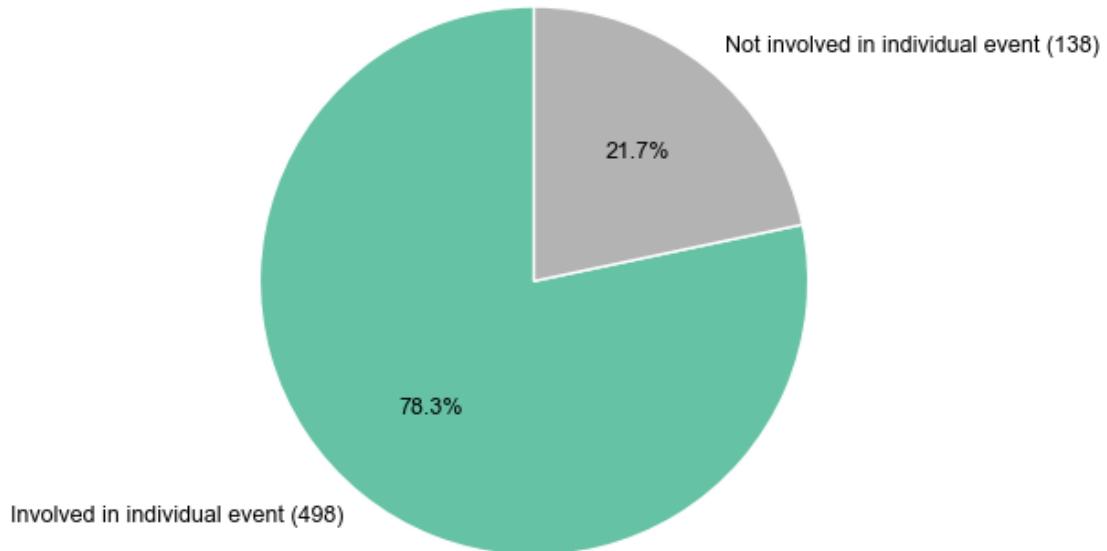




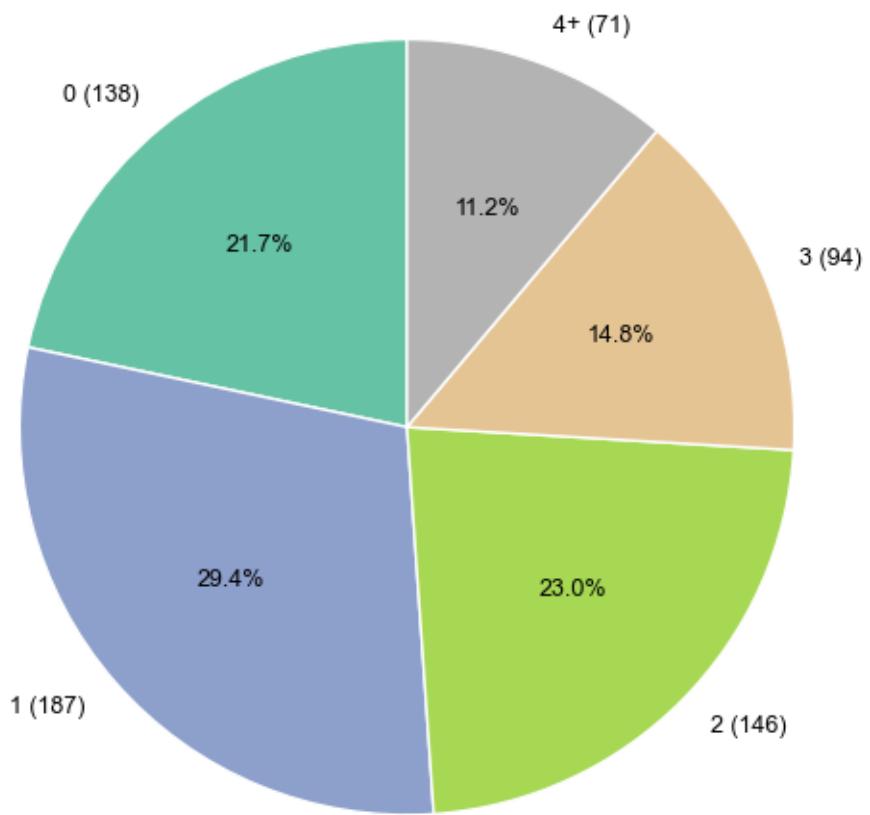
1.4 INDIVIDUAL EVENTS

1.4.1 Cells occurrences in individual events

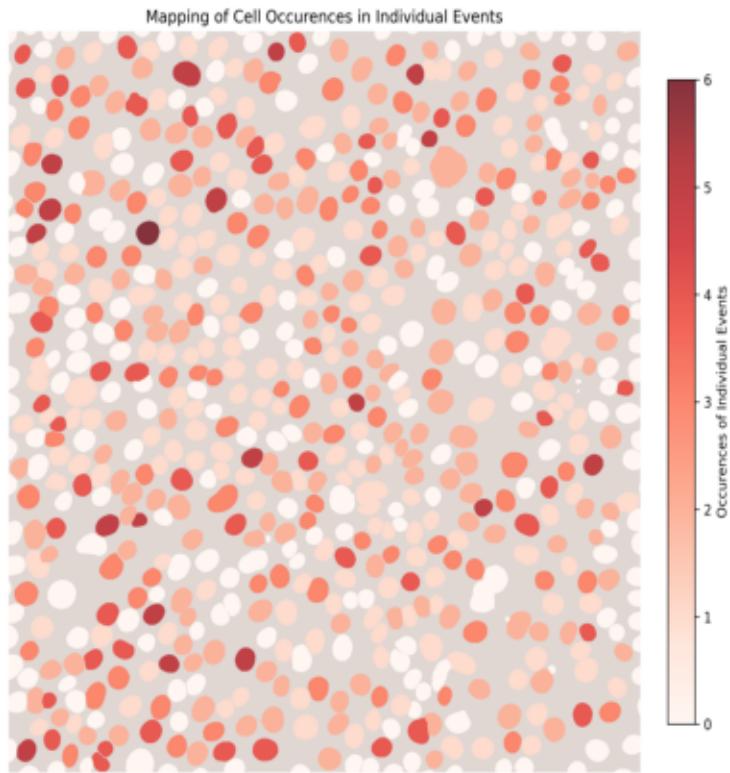
Distribution of Cells Involved in Individual Events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

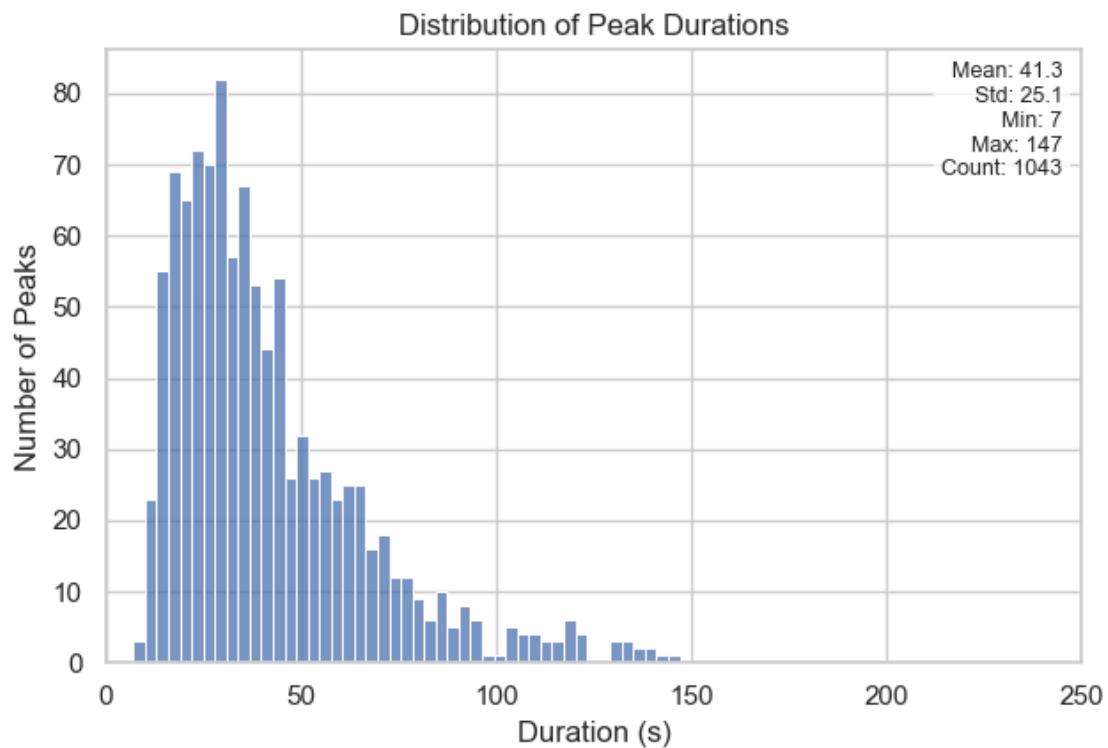


Cell Mapping with Occurrences in Individual Events Overlay - 20250810_IS1

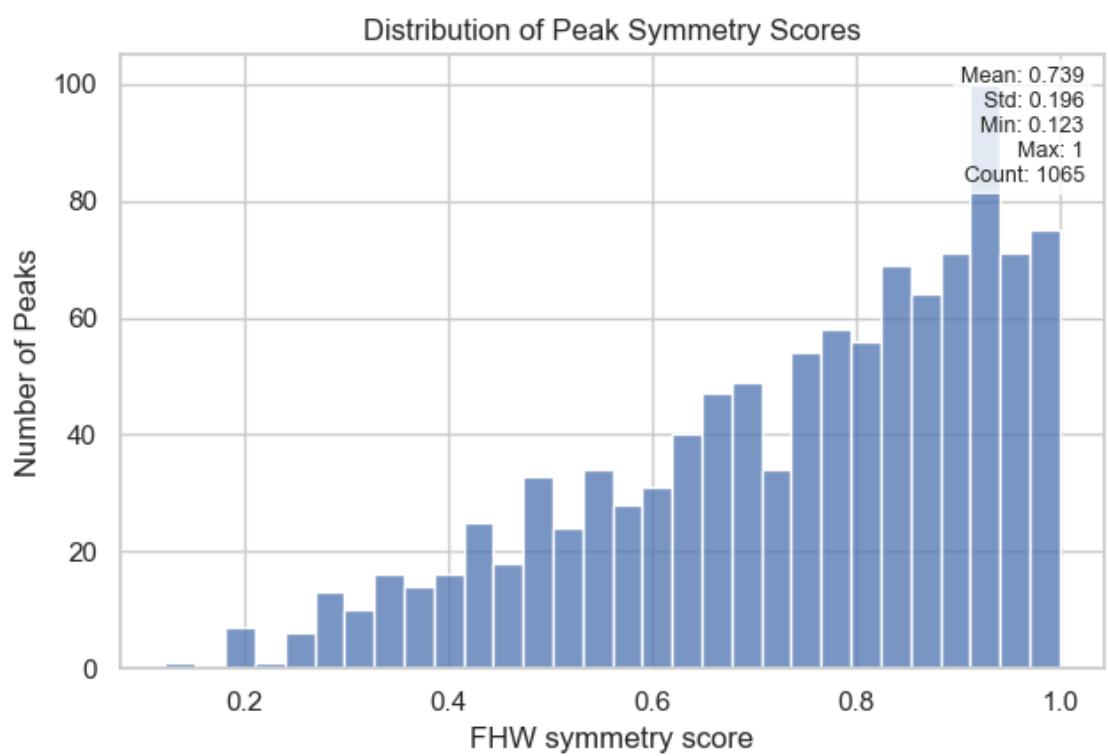
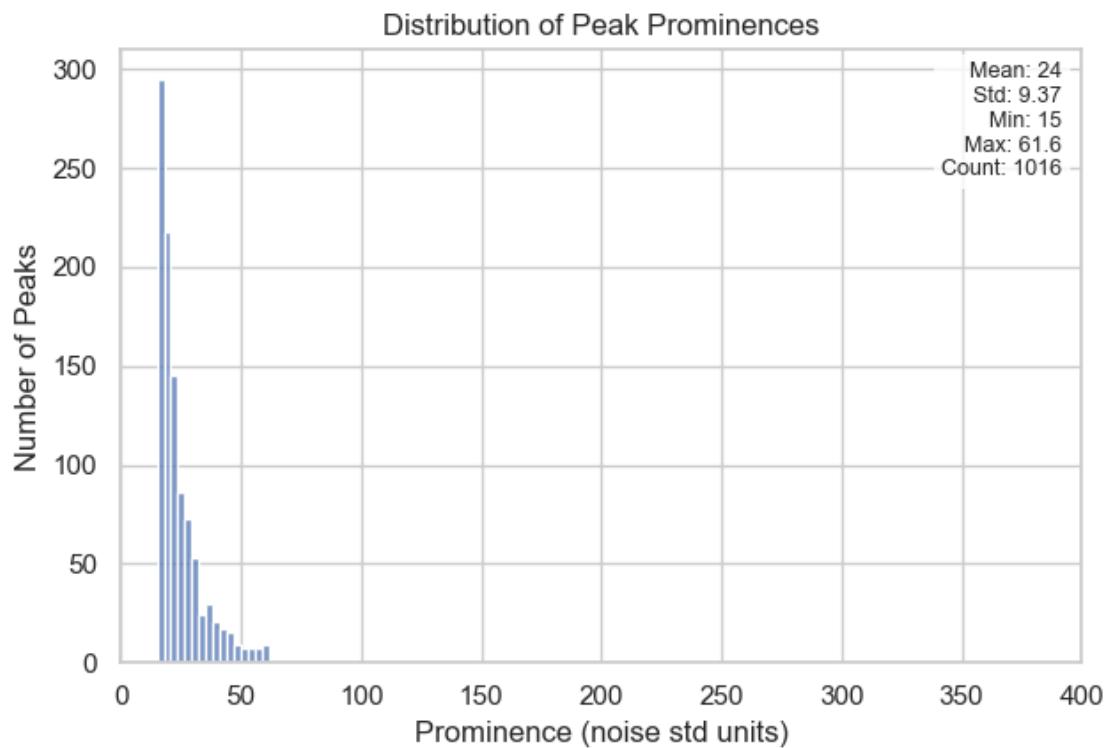


1.4.2 Peaks statistics in individual events

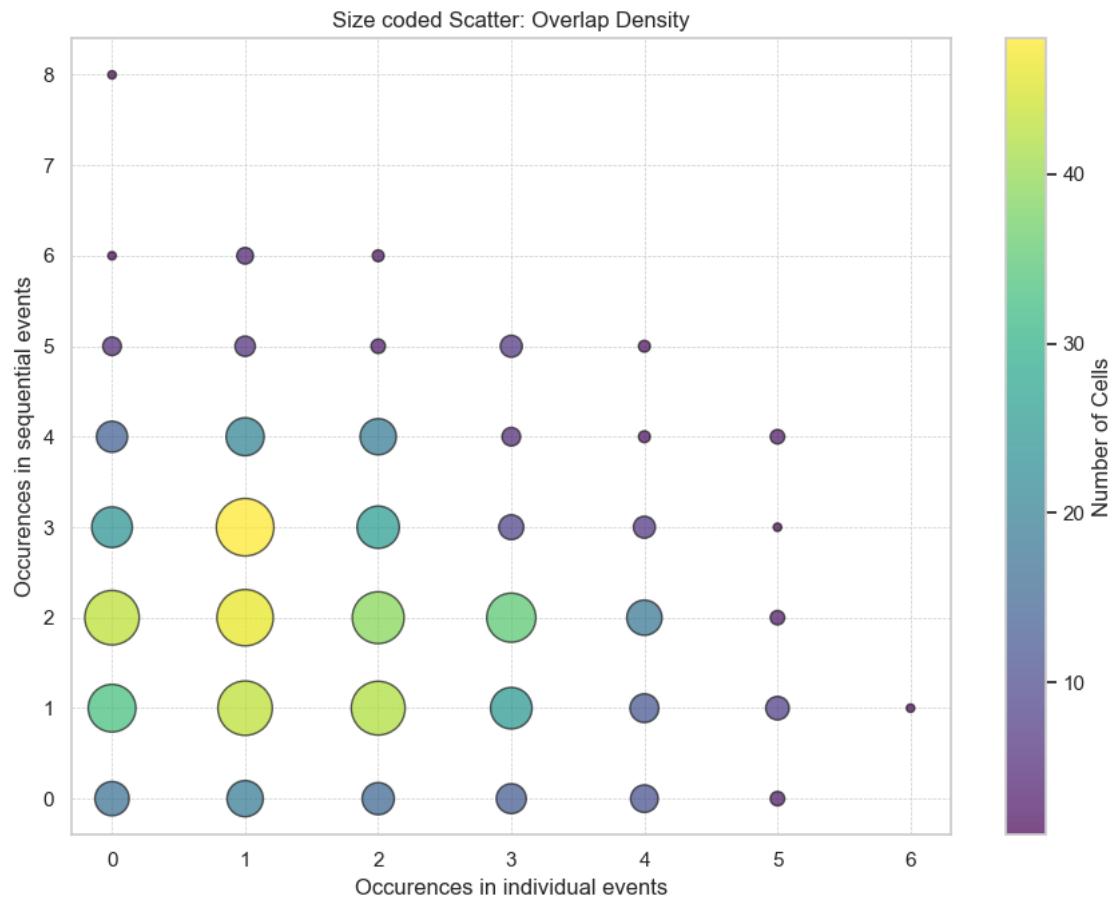
```
[2025-08-13 12:39:49] [INFO] calcium: plot_histogram: removed 22 outliers out of  
1065 on 'Duration (s)' (lower=-69, upper=148)
```



```
[2025-08-13 12:39:49] [INFO] calcium: plot_histogram: removed 49 outliers out of 1065 on 'Prominence (noise std units)' (lower=-16.1, upper=62.3)
```

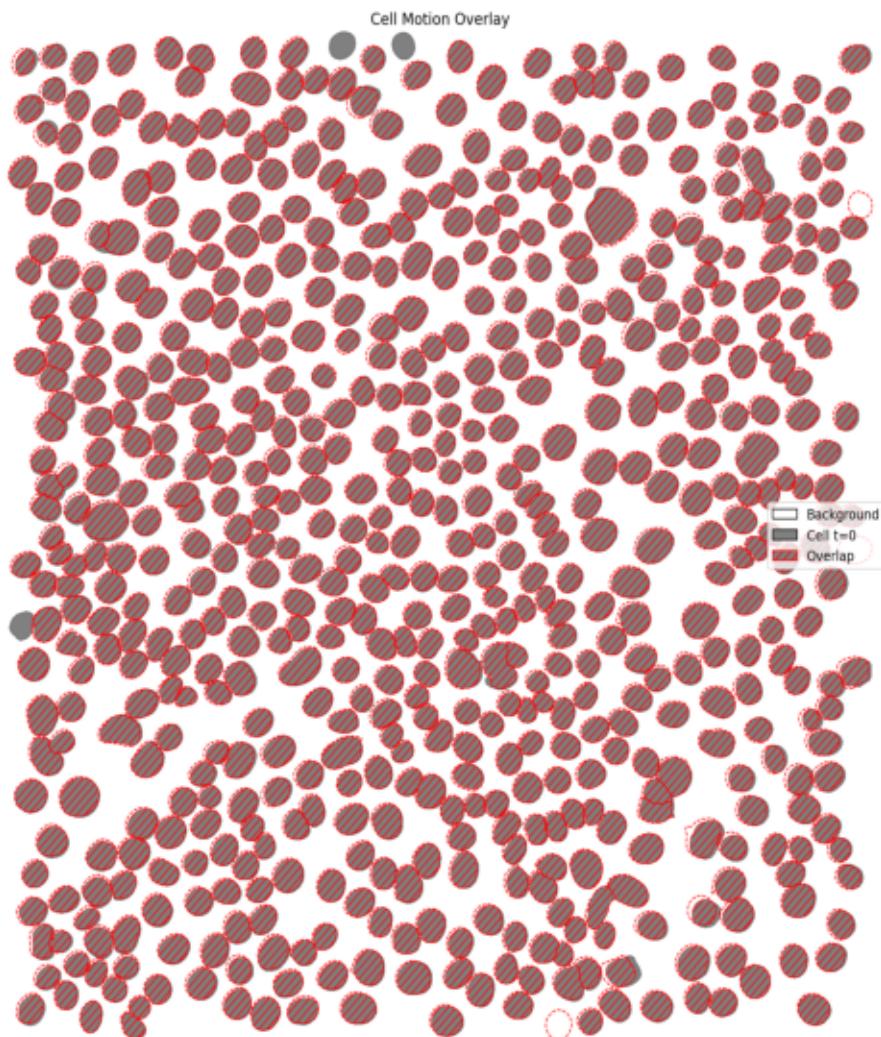


1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250810_IS1



Number of cells:

- Hoechst image taken at t=0: 636
- Hoechst image taken at t=1801: 635
- Number of cells difference: absolute 1, relative 0.16%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 1026939
- Pixels segmented as cell at t=1801: 1030506
- Overlapping pixels between t=0 and t=1801: 934102 (90.80% of total)
- Pixels exclusive to t=0: 92837 (9.04% of total)
- Pixels exclusive to t=1801: 96404 (9.35% of total)

executed

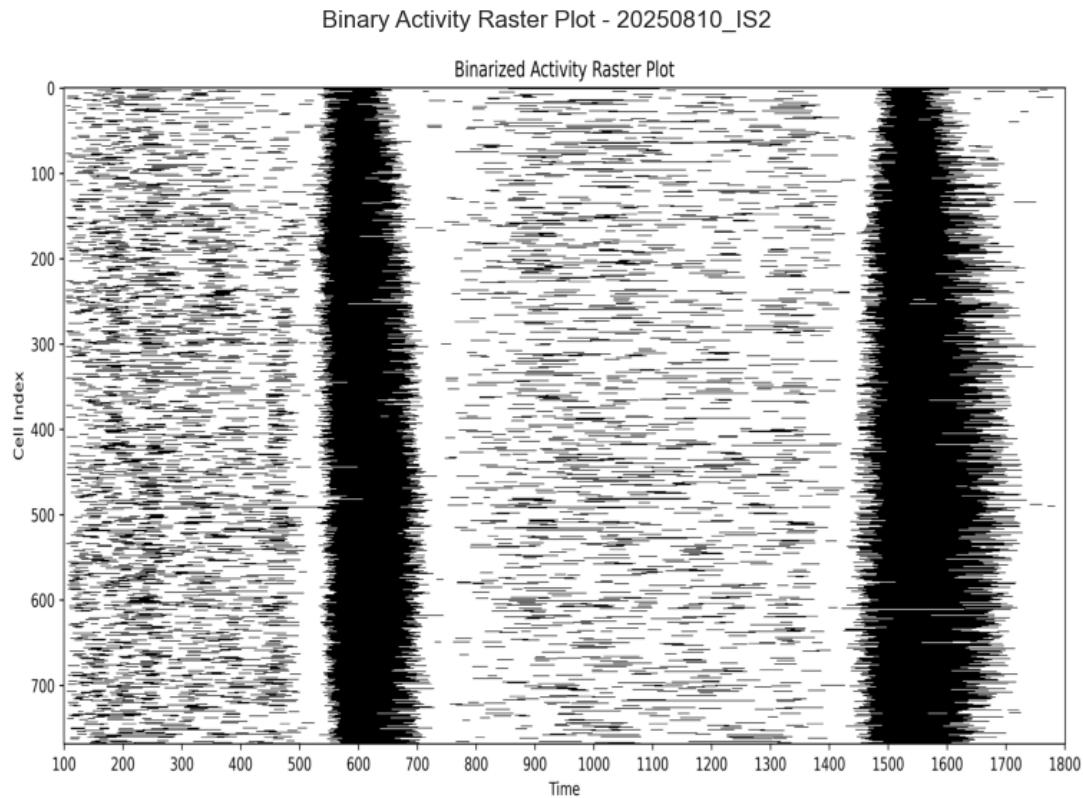
August 13, 2025

1 ANALYSIS OF AN IMAGE SEQUENCE AFTER DATA GENERATION USING THE CALCIUM CHARACTERIZATION PIPELINE

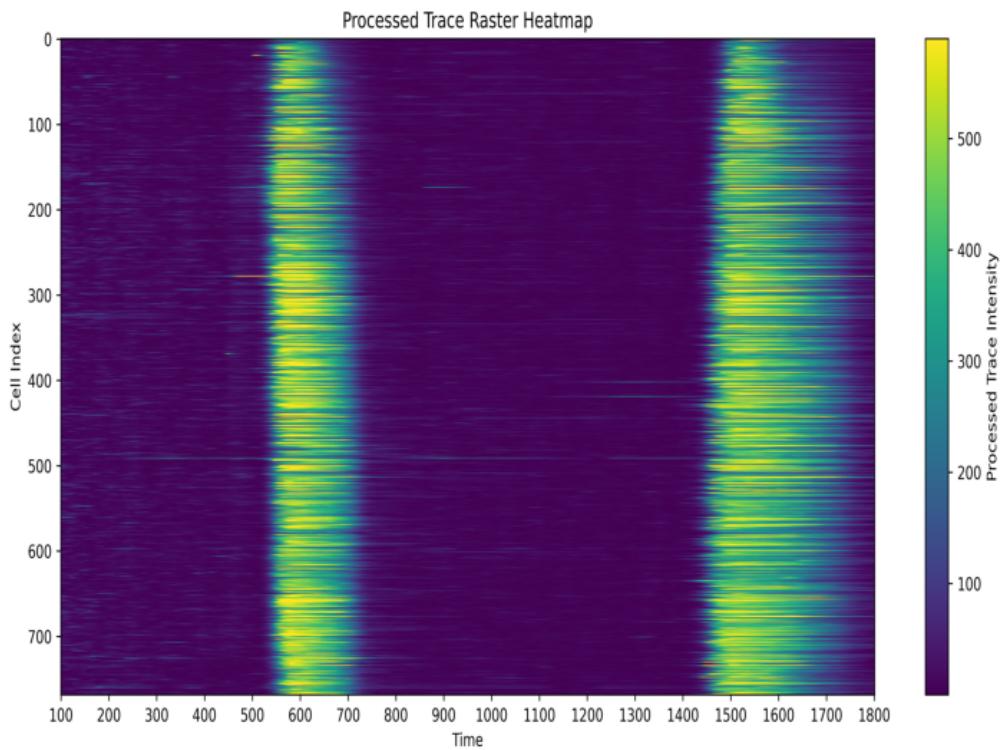
1.0.1 Initialization

1.1 POPULATION

1.1.1 Binary & Heatmap Raster Plot



Heatmap Activity Raster Plot - 20250810_IS2



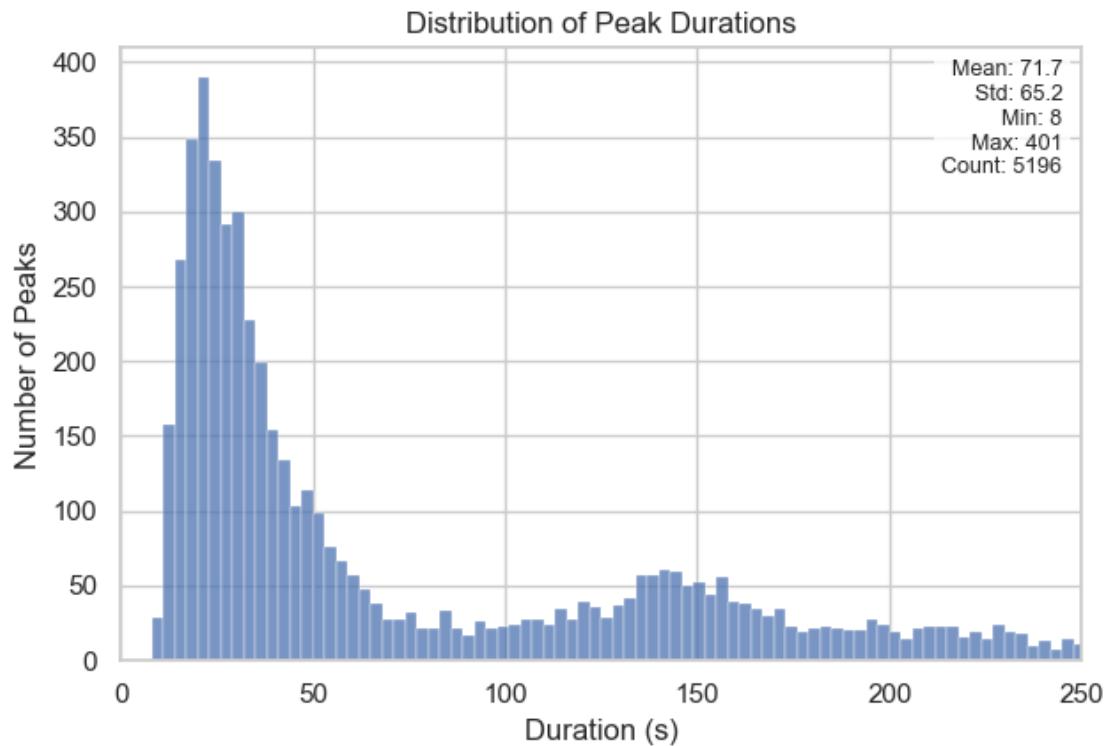
1.1.2 Peaks population

Total number of peaks: 5196

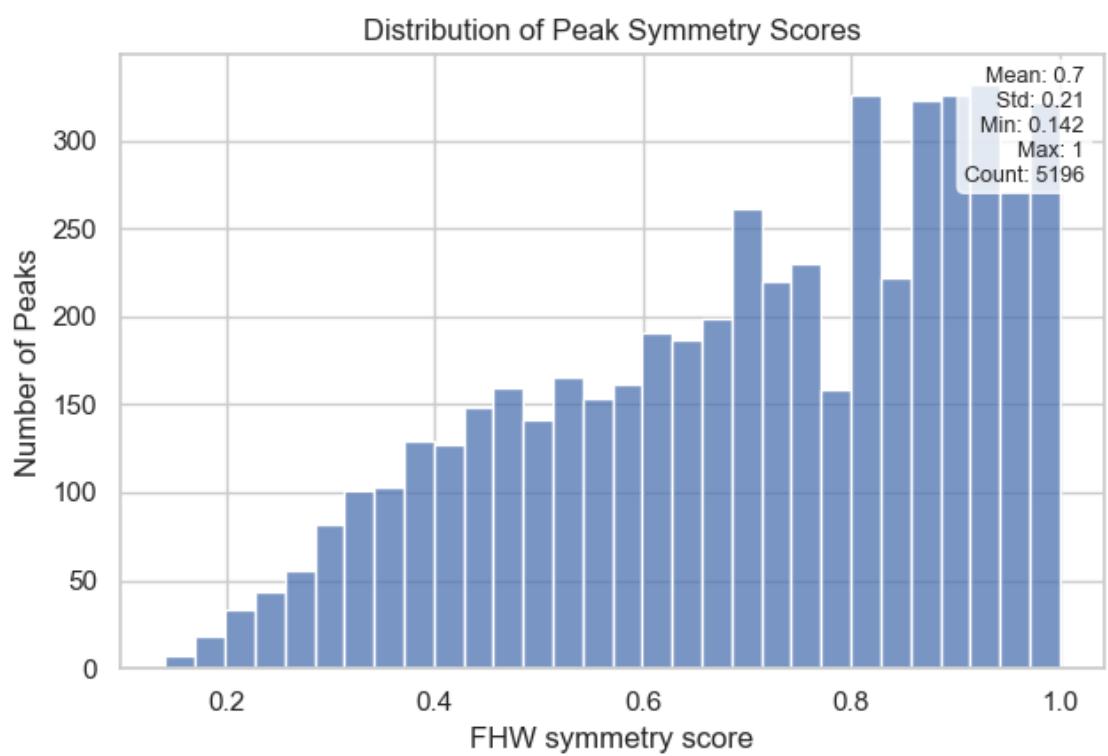
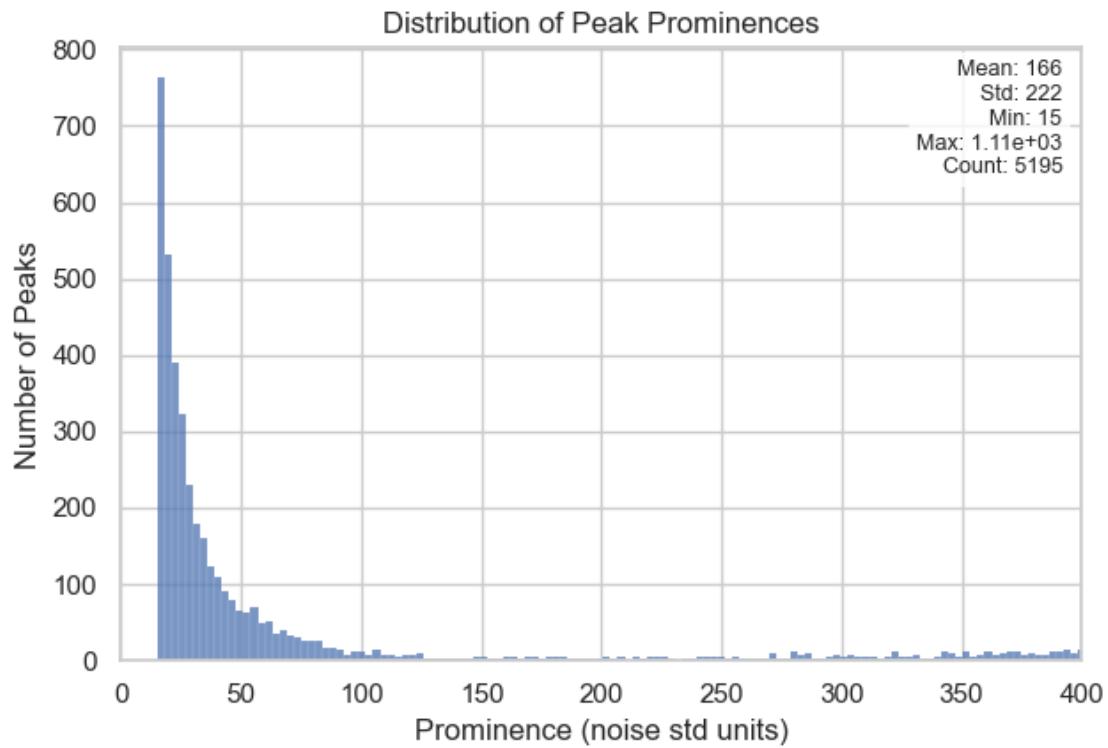
Total number of cells: 769

1.1.3 Peaks statistics

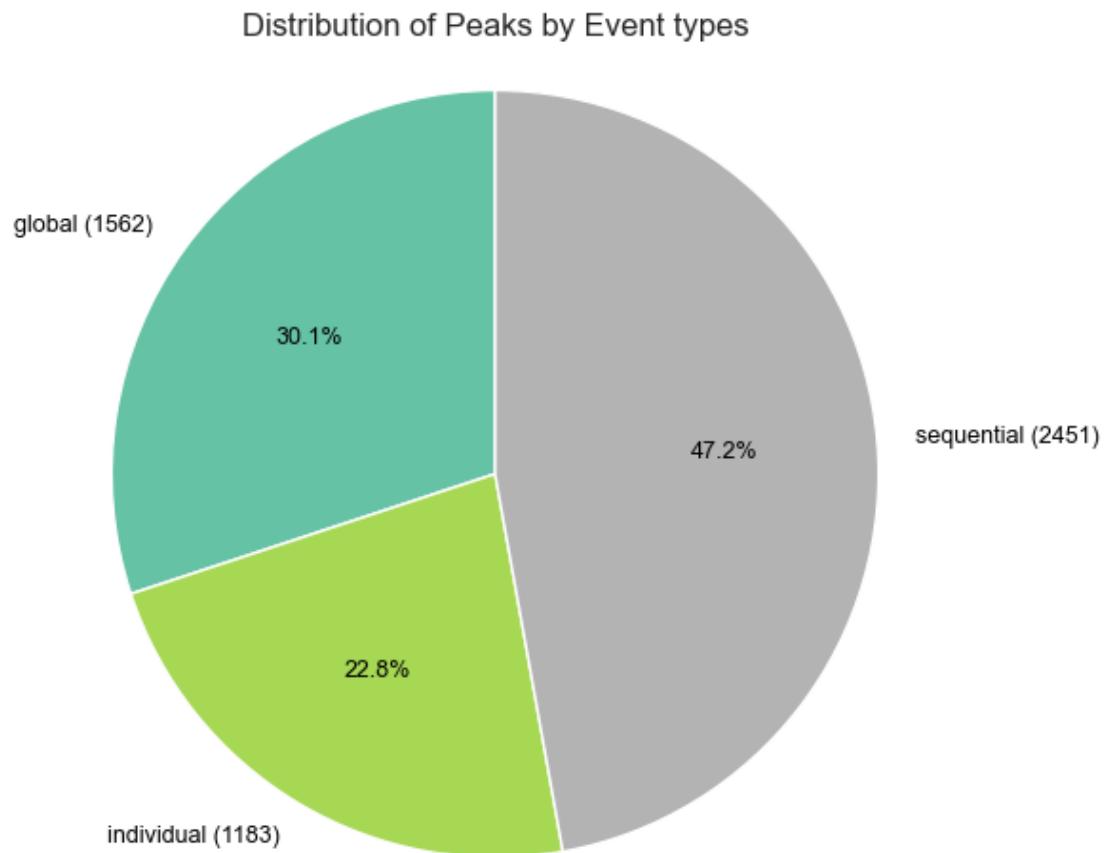
```
[2025-08-13 12:40:27] [INFO] calcium: plot_histogram: removed 0 outliers out of 5196 on 'Duration (s)' (lower=-271, upper=415)
```



```
[2025-08-13 12:40:27] [INFO] calcium: plot_histogram: removed 1 outliers out of 5196 on 'Prominence (noise std units)' (lower=-888.45, upper=1233.6)
```

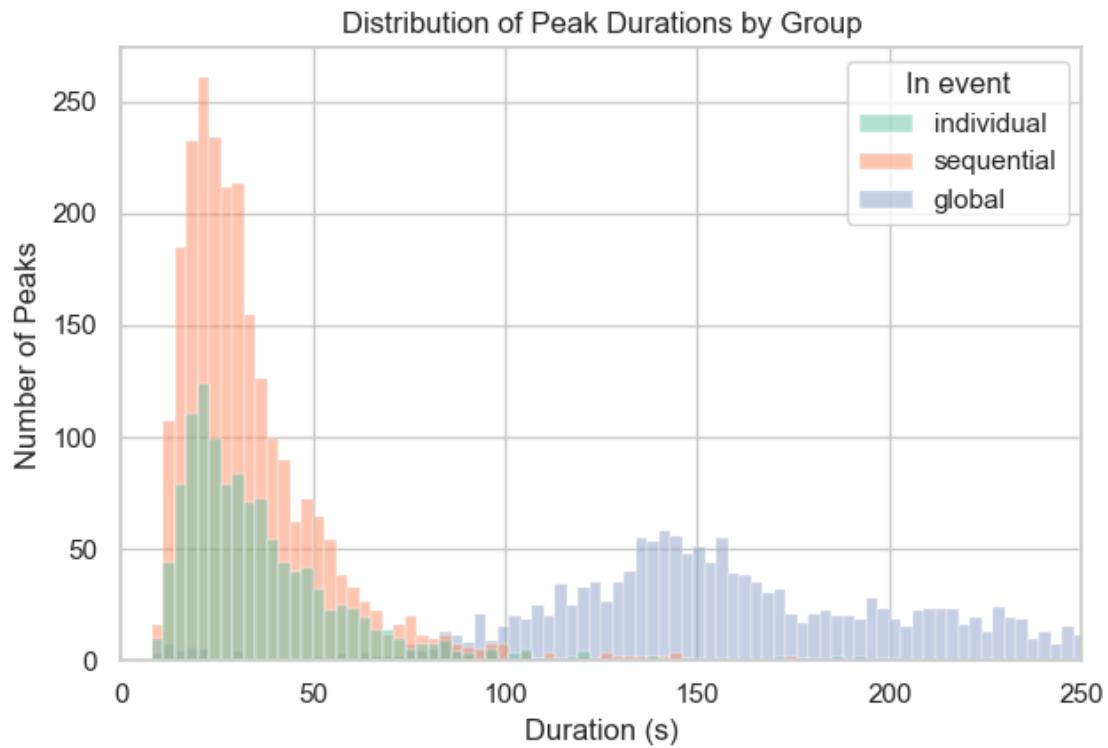


1.1.4 Distribution of peaks per event types



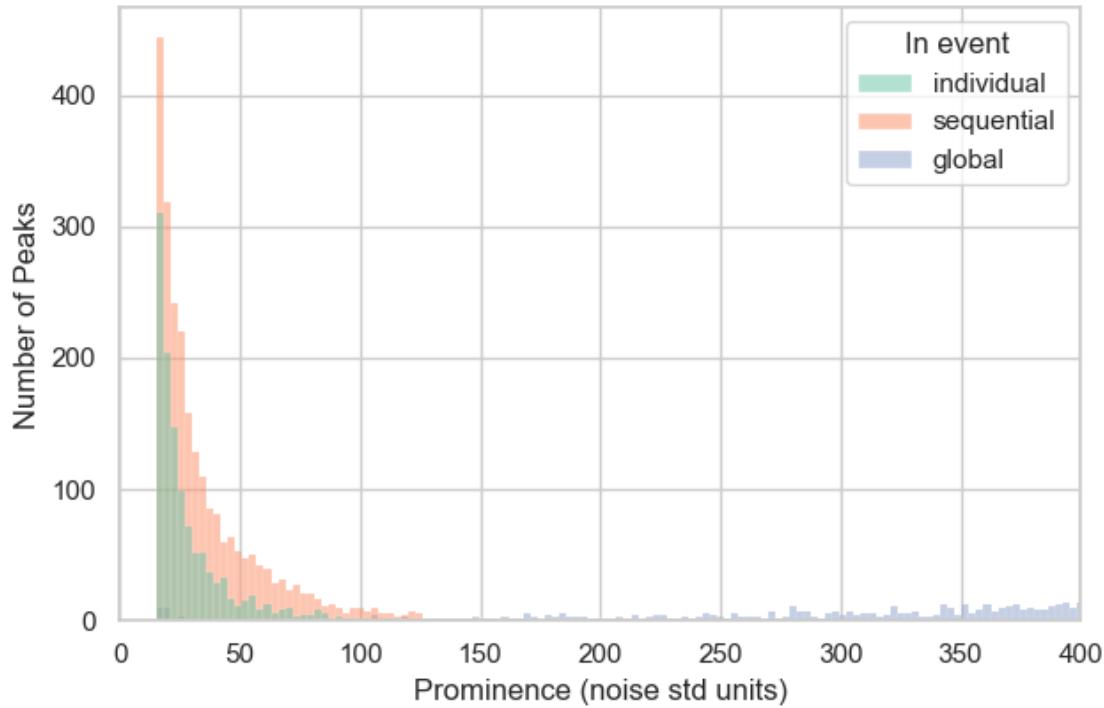
1.1.5 Peaks statistics per event types

```
[2025-08-13 12:40:28] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 5196 on 'Duration (s)' (lower=-271, upper=415)
```

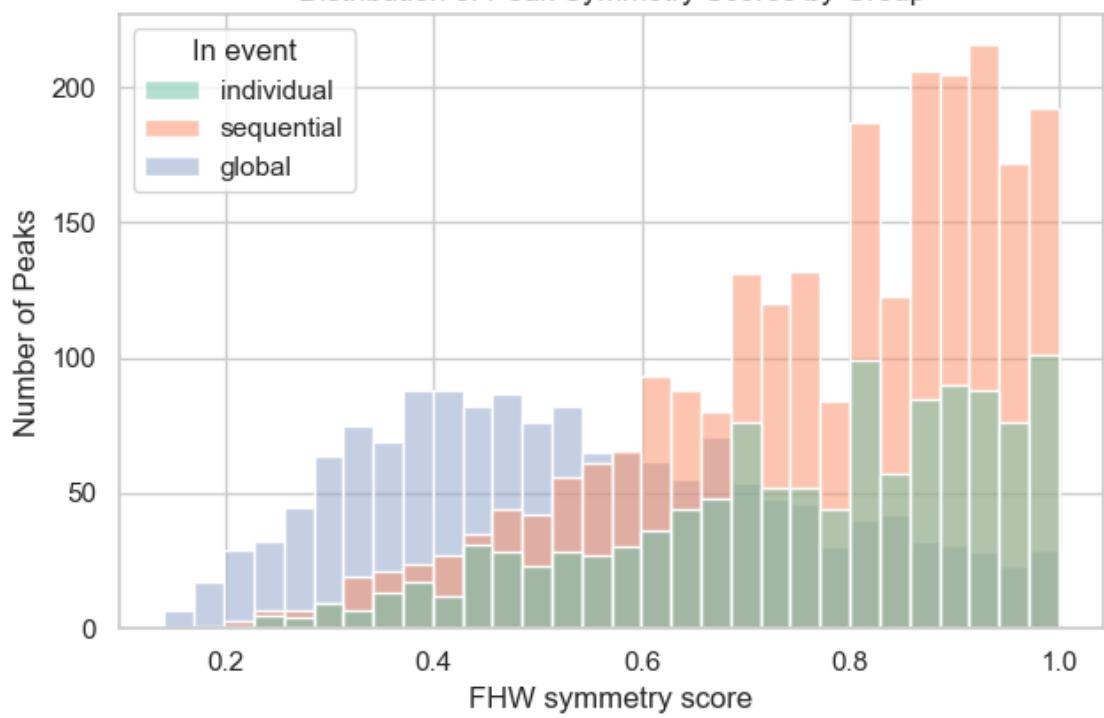


```
[2025-08-13 12:40:29] [INFO] calcium: plot_histogram_by_group: removed 1 outliers out of 5196 on 'Prominence (noise std units)' (lower=-888.45, upper=1233.6)
```

Distribution of Peak Prominences by Group



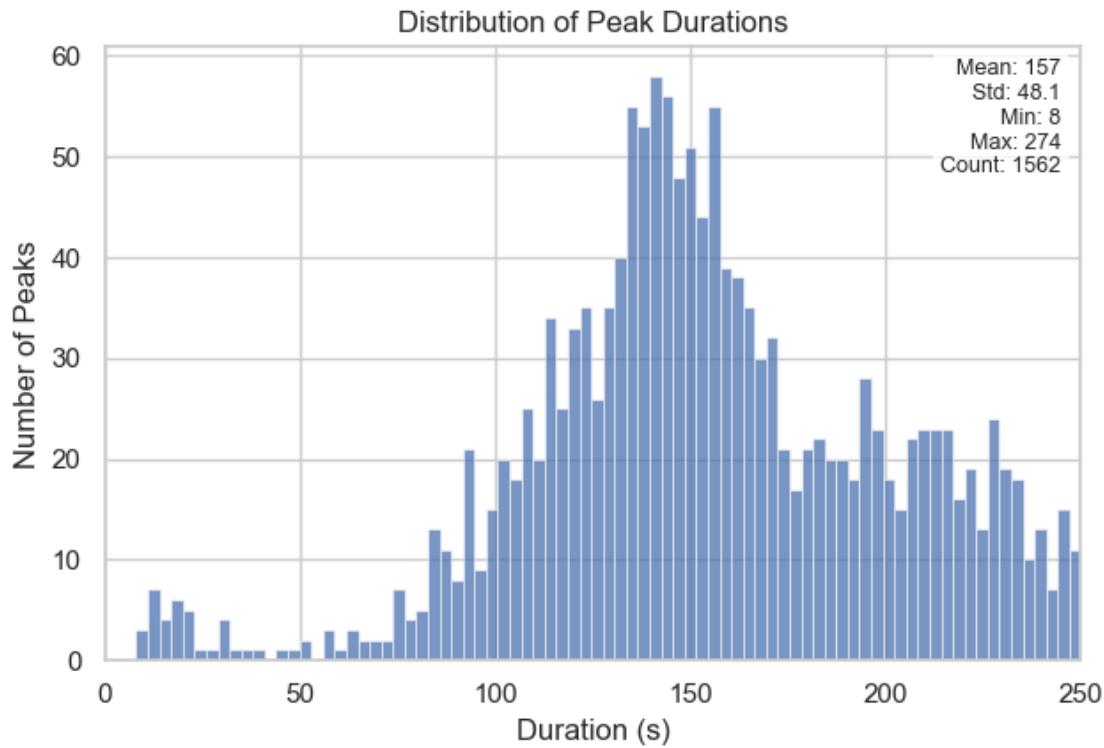
Distribution of Peak Symmetry Scores by Group



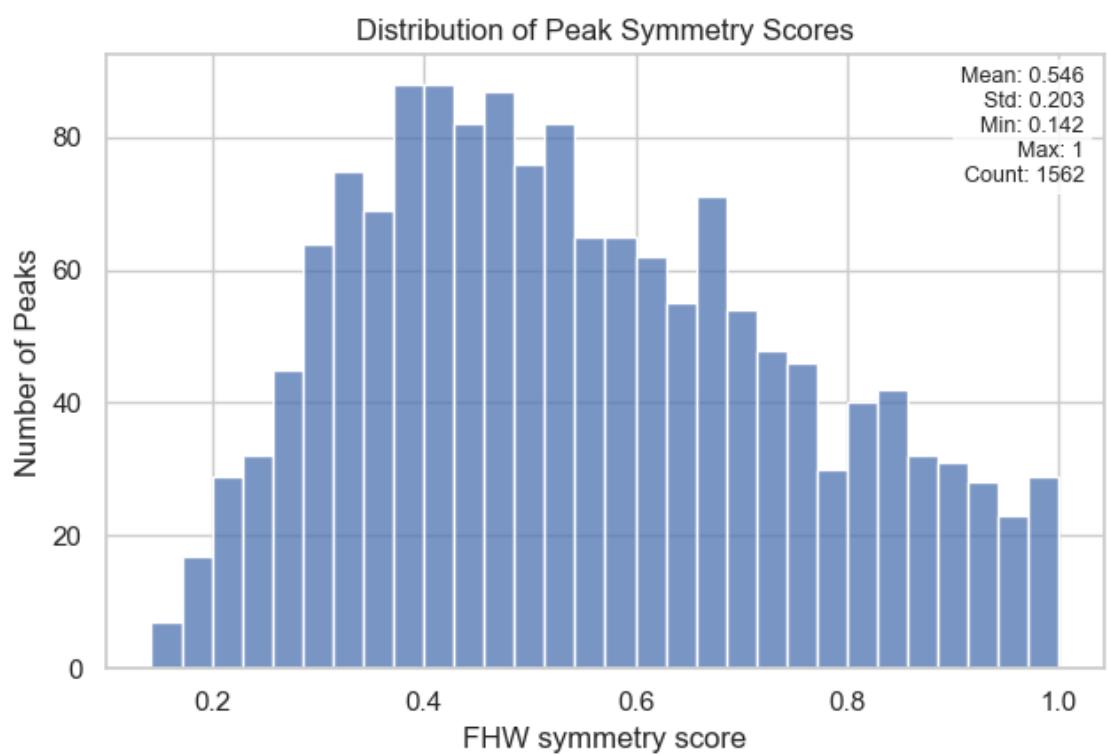
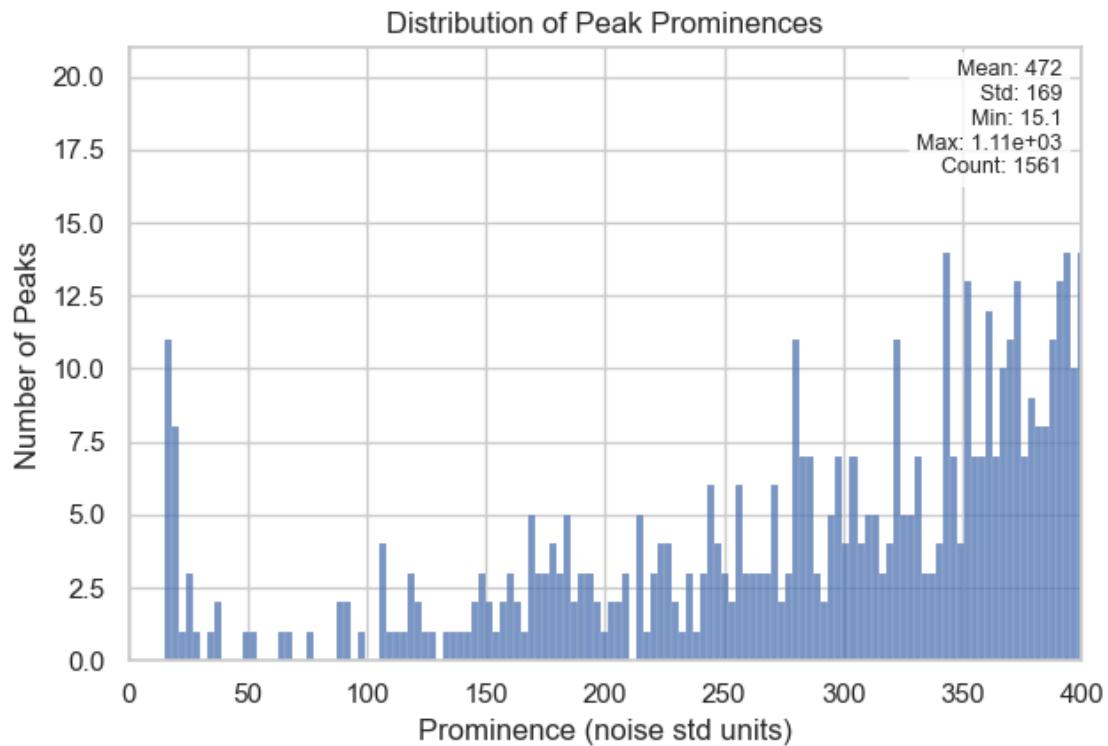
1.2 GLOBAL EVENTS

1.2.1 Peak statistics in global events

```
[2025-08-13 12:40:31] [INFO] calcium: plot_histogram: removed 0 outliers out of  
1562 on 'Duration (s)' (lower=-61, upper=380)
```

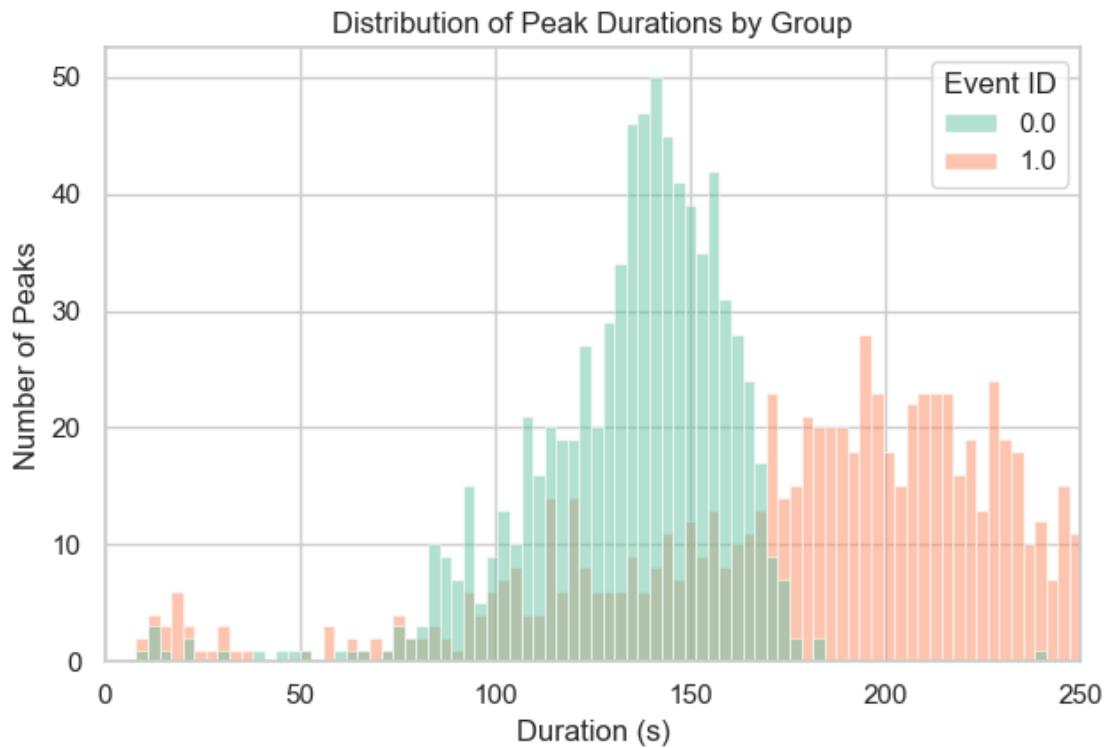


```
[2025-08-13 12:40:31] [INFO] calcium: plot_histogram: removed 1 outliers out of  
1562 on 'Prominence (noise std units)' (lower=-243, upper=1193.8)
```

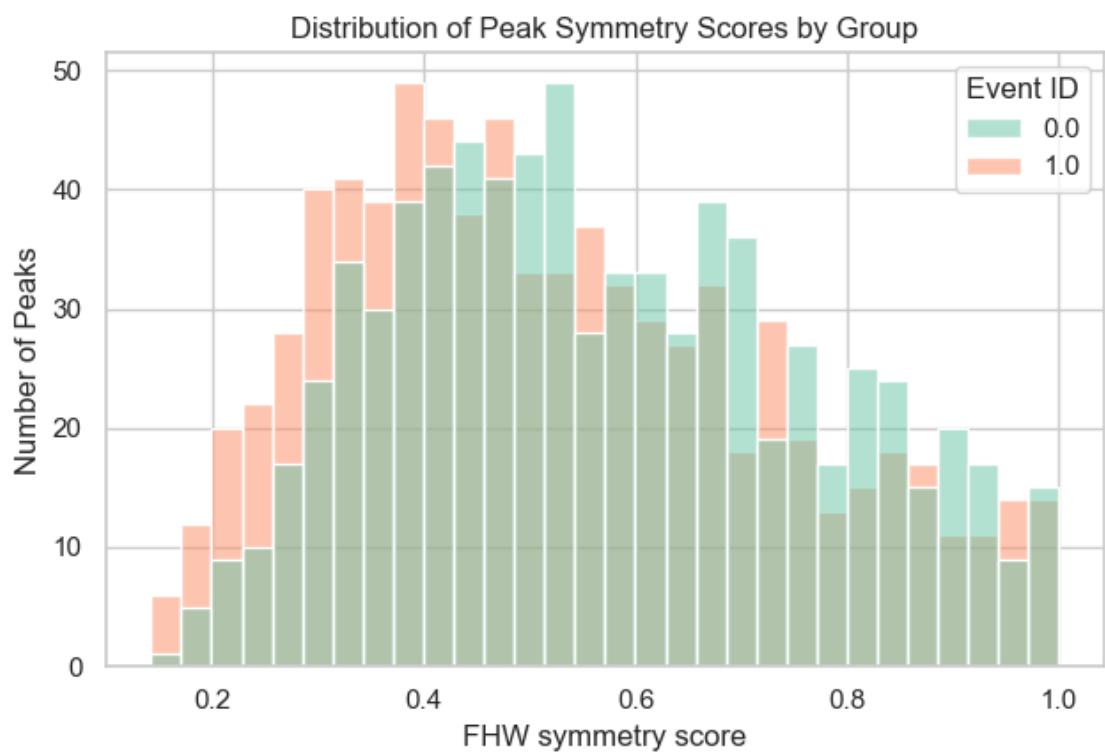
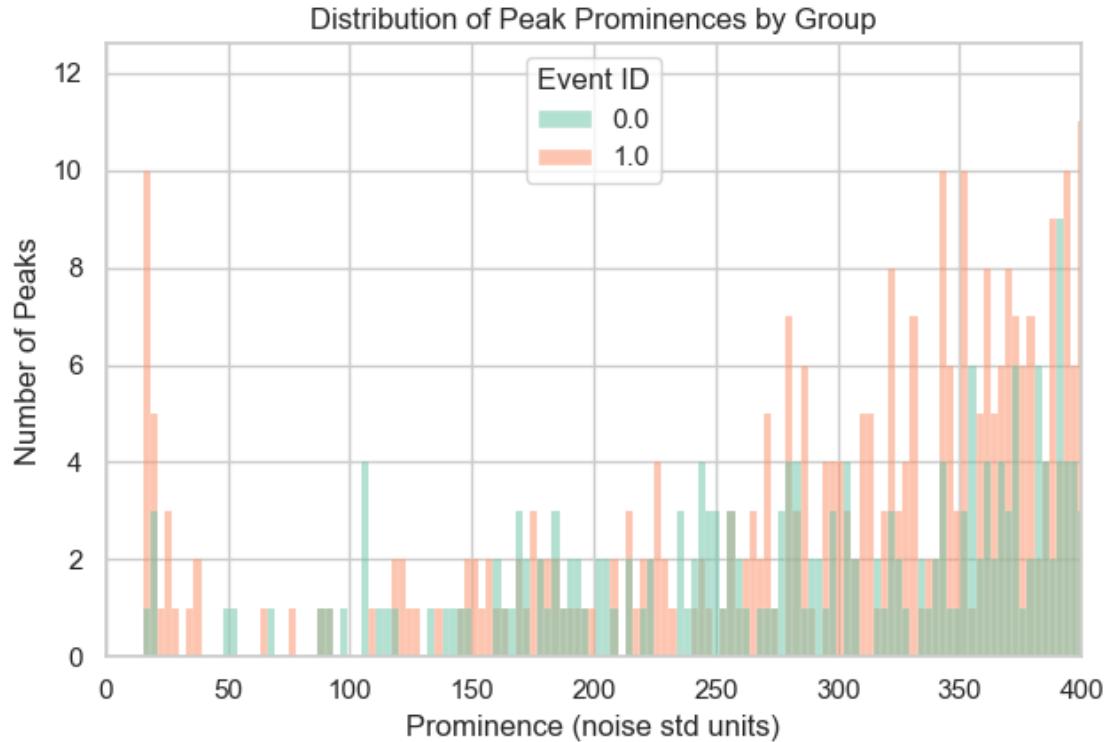


1.2.2 Peak statistics in global event per event ID

```
[2025-08-13 12:40:31] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 1562 on 'Duration (s)' (lower=-61, upper=380)
```

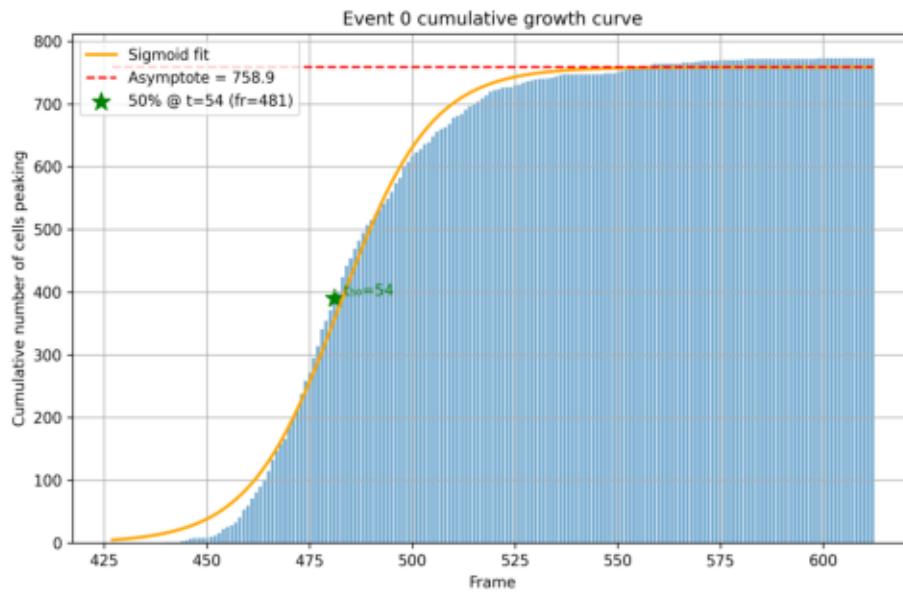


```
[2025-08-13 12:40:32] [INFO] calcium: plot_histogram_by_group: removed 1 outliers out of 1562 on 'Prominence (noise std units)' (lower=-243, upper=1193.8)
```

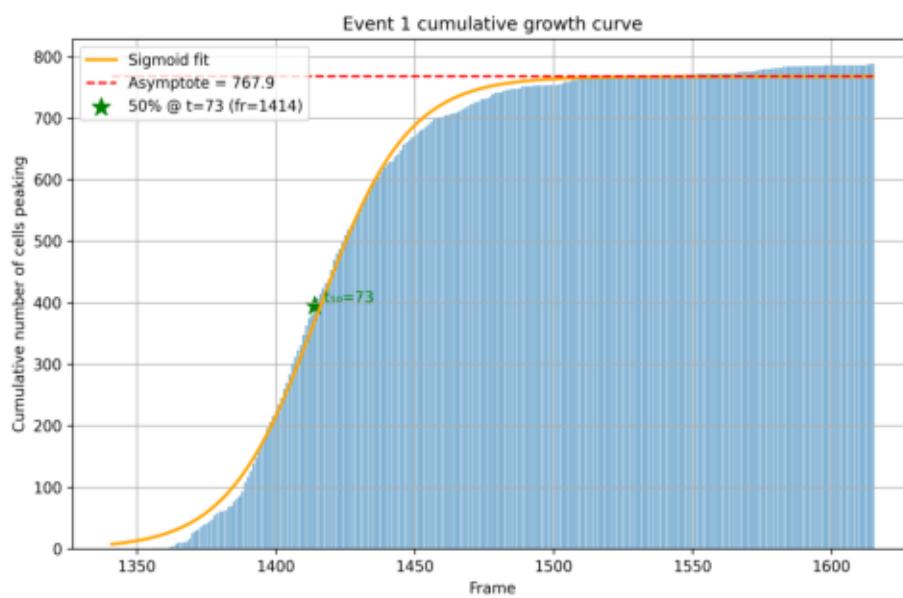


1.2.3 Kinetics of global events

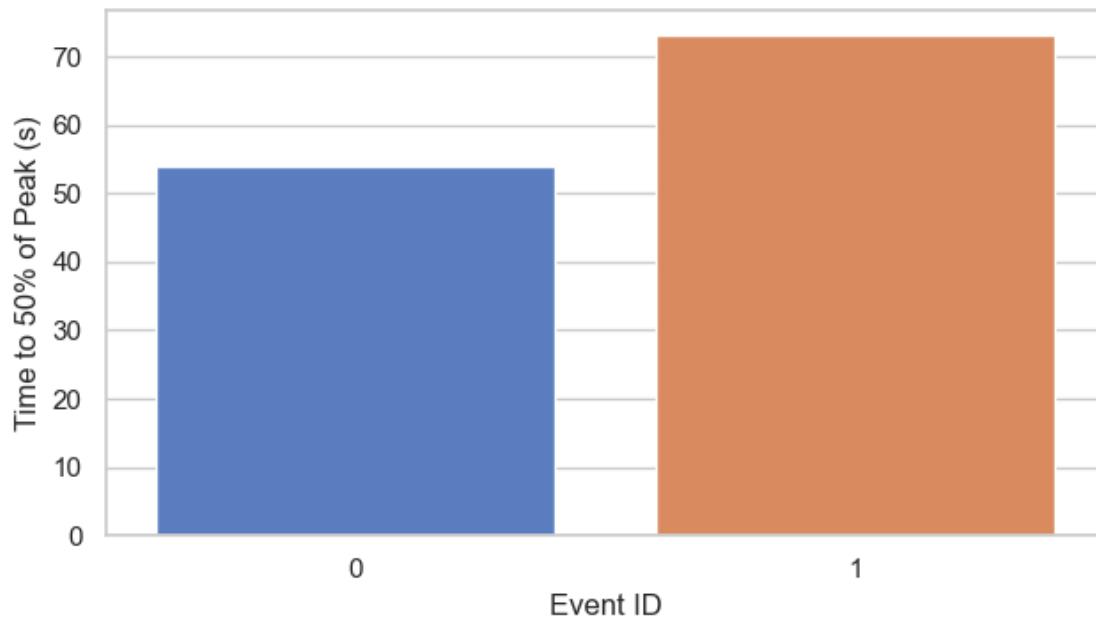
Event Activity Overlay (Event ID: 0) - 20250810_IS2



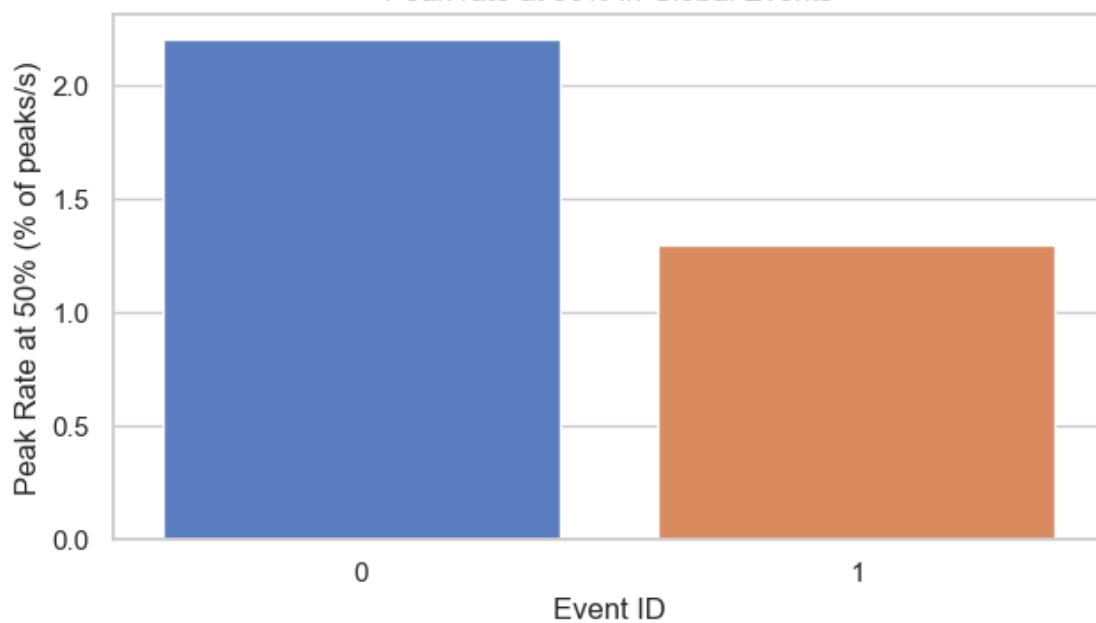
Event Activity Overlay (Event ID: 1) - 20250810_IS2



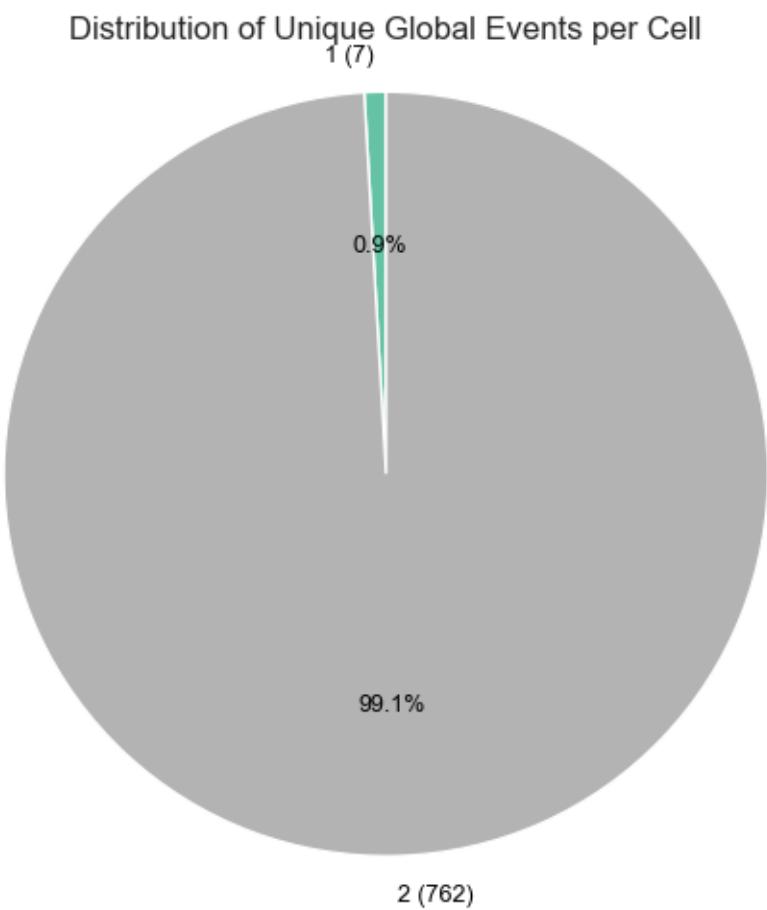
Time to 50% of Peaks in Global Events



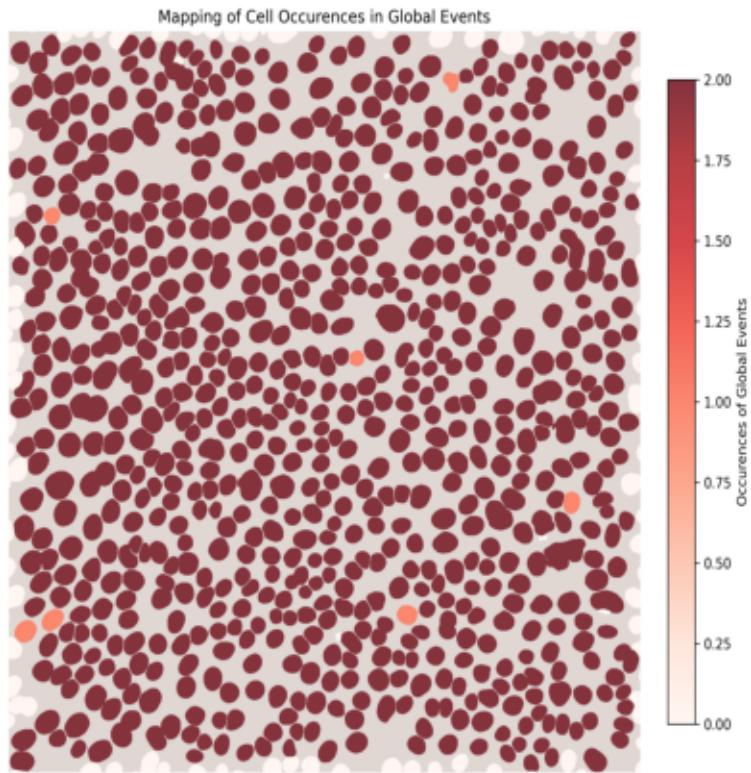
Peak rate at 50% in Global Events

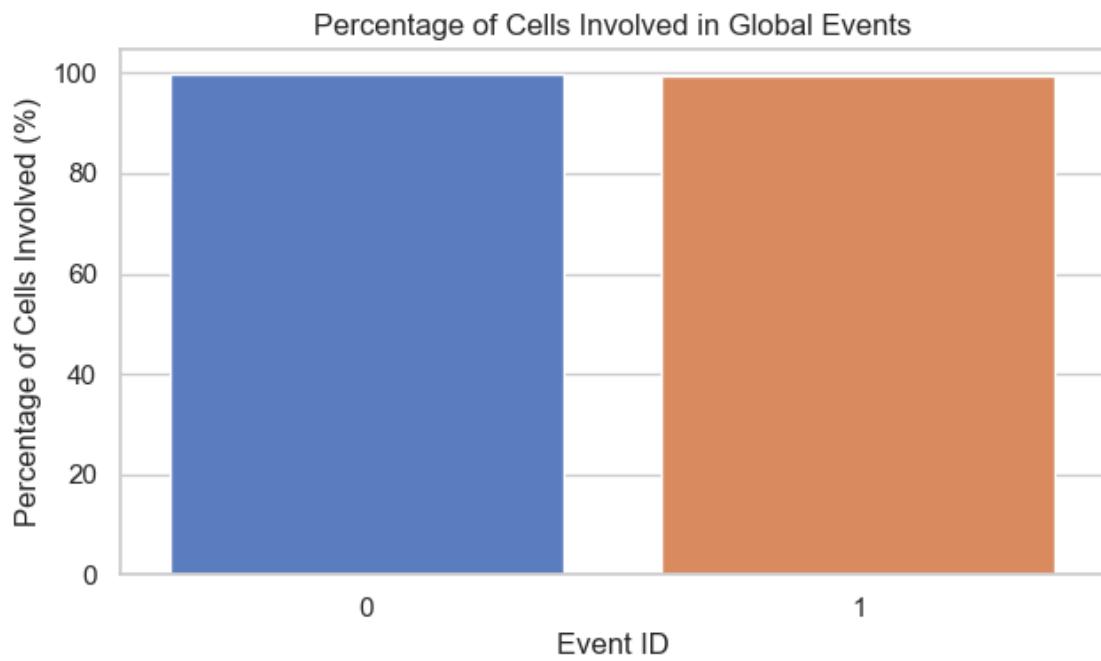


1.2.4 Cells occurrences in global events



Cell Mapping with Occurrences in Global Events Overlay - 20250810_IS2



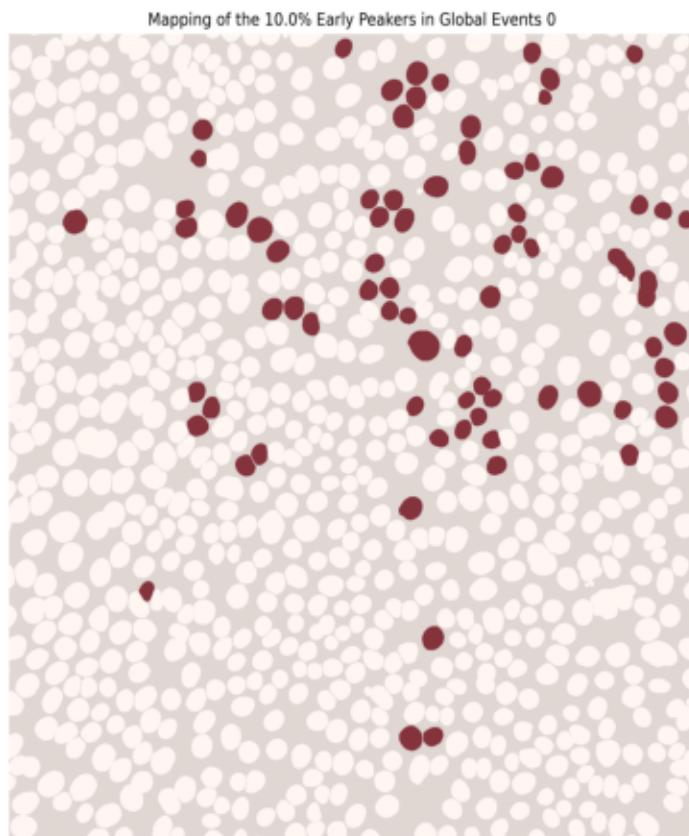


1.2.5 Inter-event interval analysis

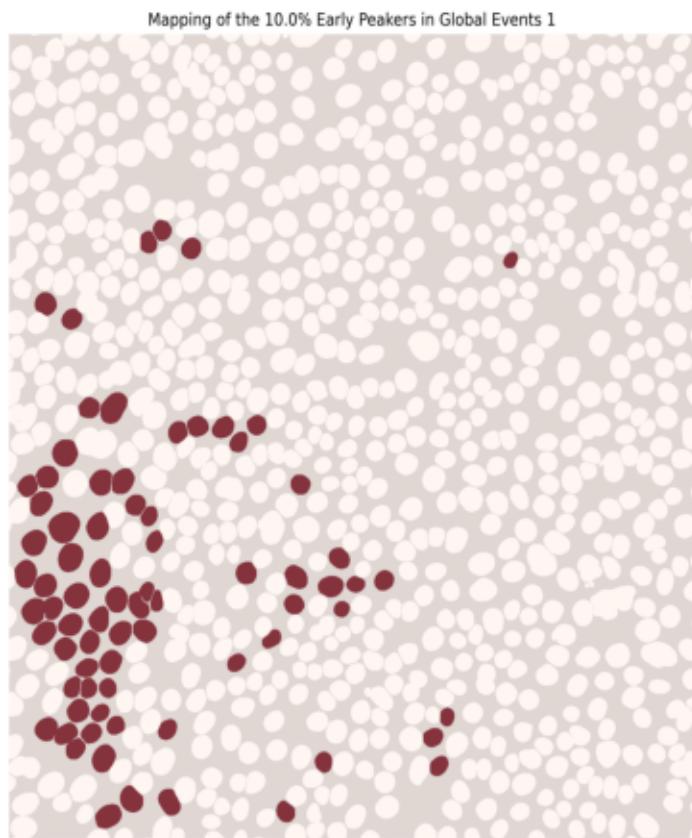
Intervals between global event peaks: [933.0]

1.2.6 Early peakers in the events

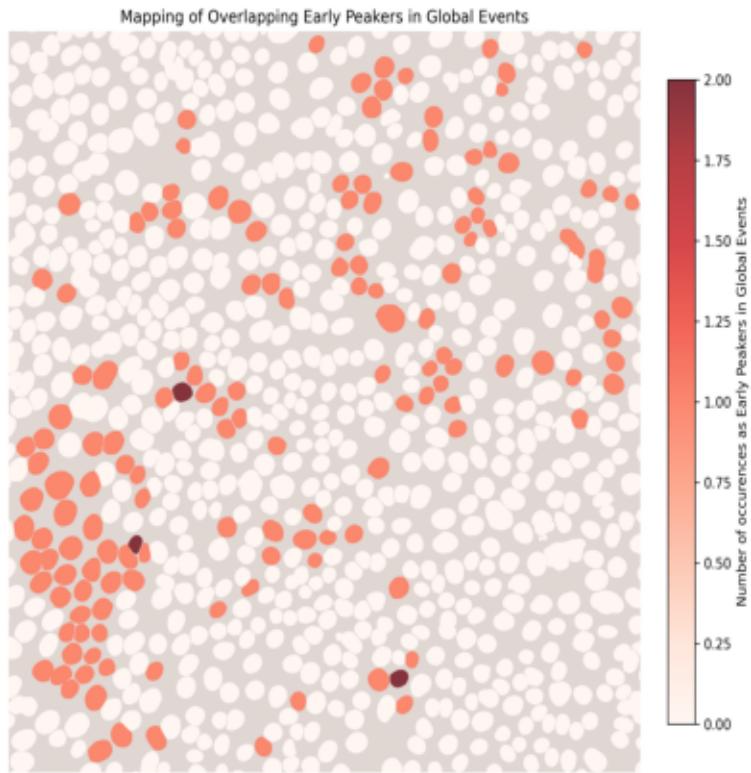
Cell Mapping with Early Peakers Overlay for event 0 - 20250810_IS2



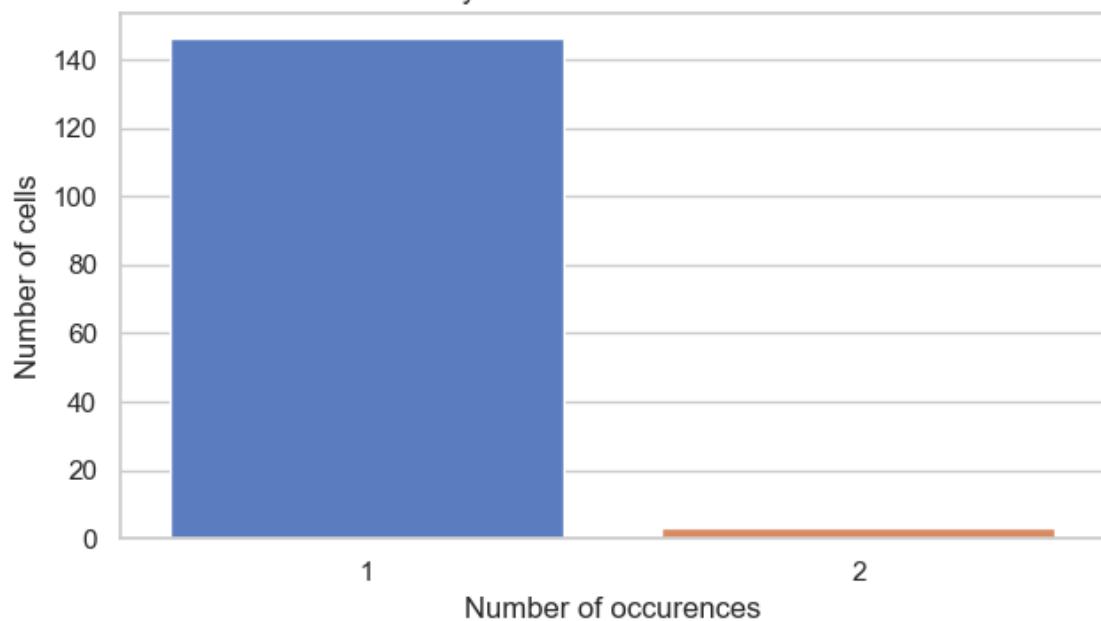
Cell Mapping with Early Peakers Overlay for event 1 - 20250810_IS2



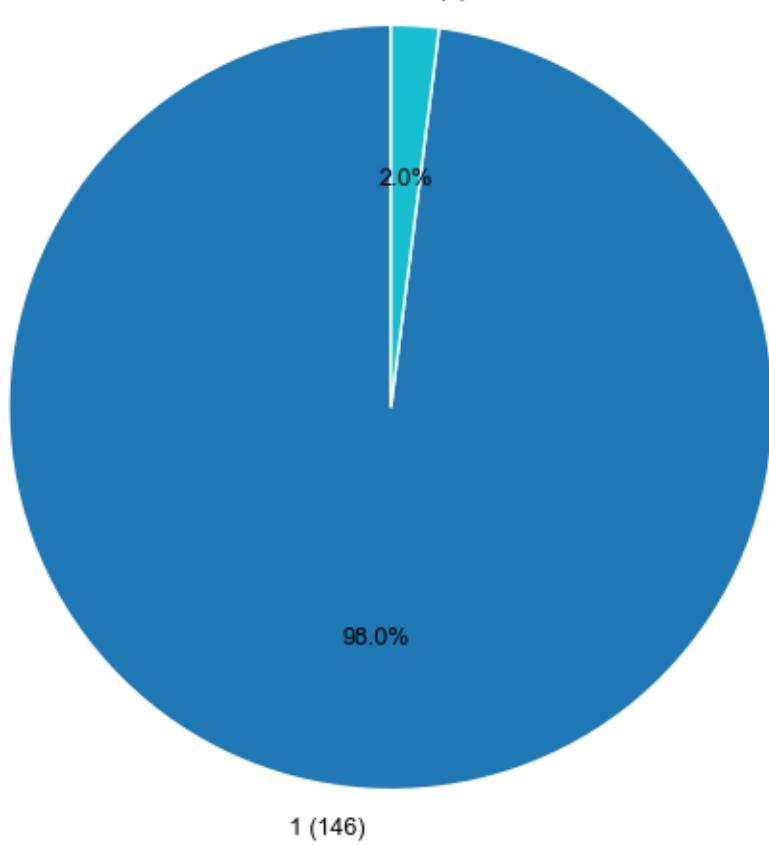
Cell Mapping with Occurrences in Global Events Overlay - 20250810_IS2



Early Peakers in Global Events

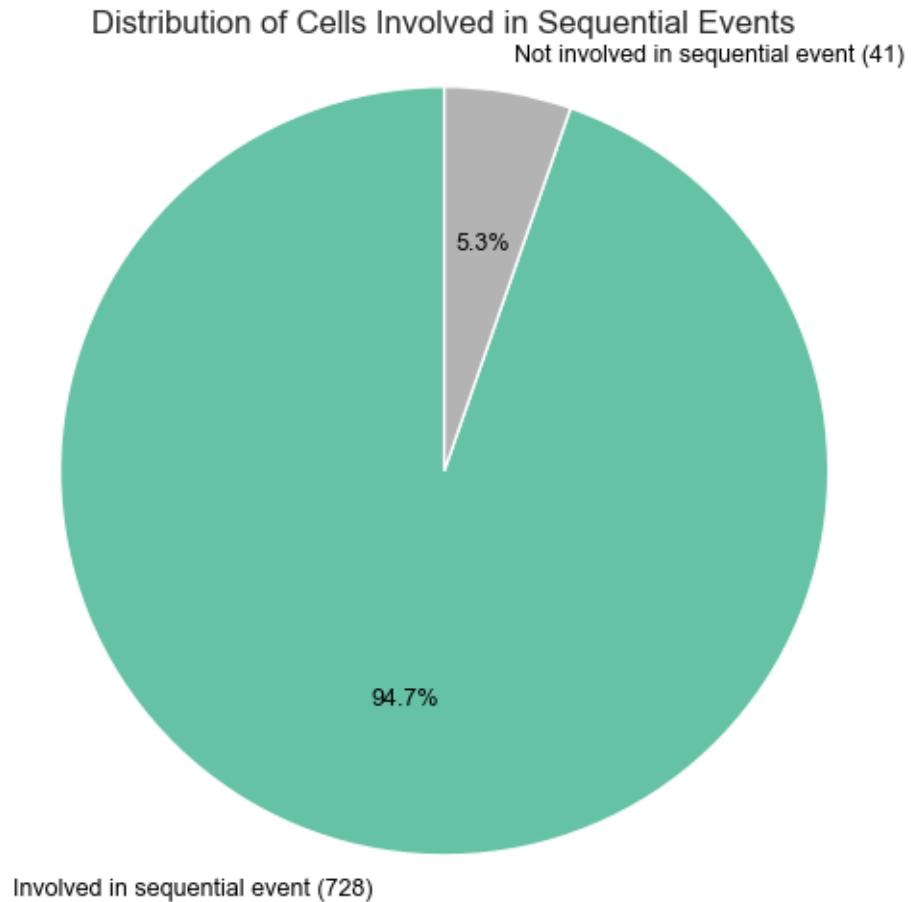


Distribution of Early Peakers in Global Events

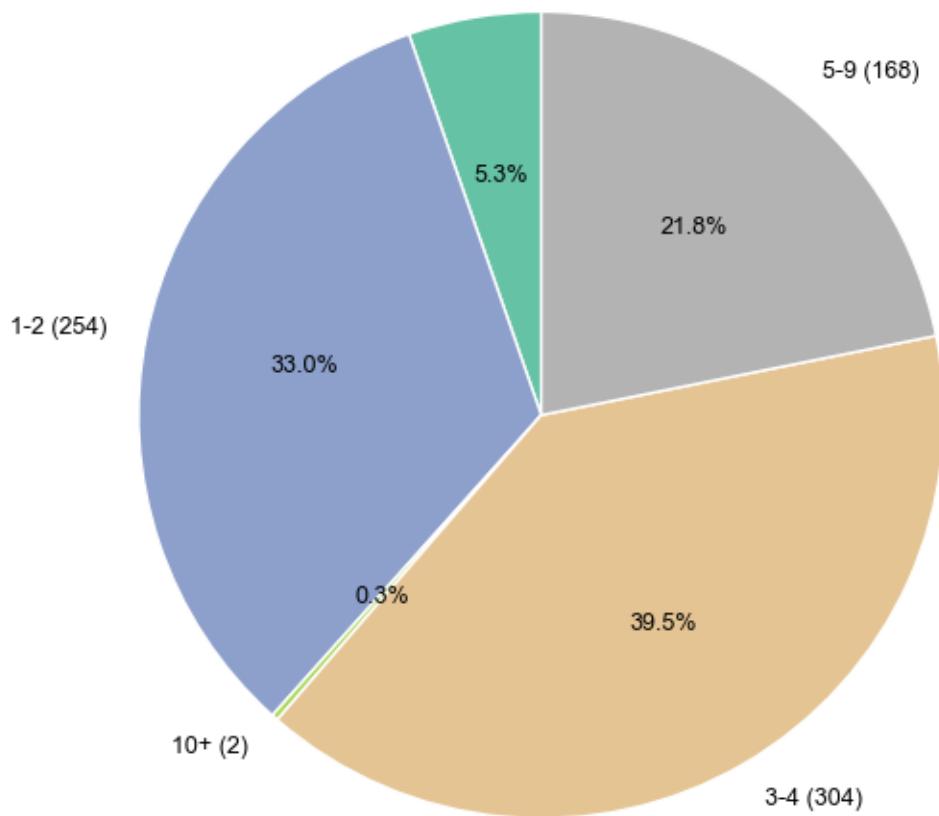


1.3 SEQUENTIAL EVENTS

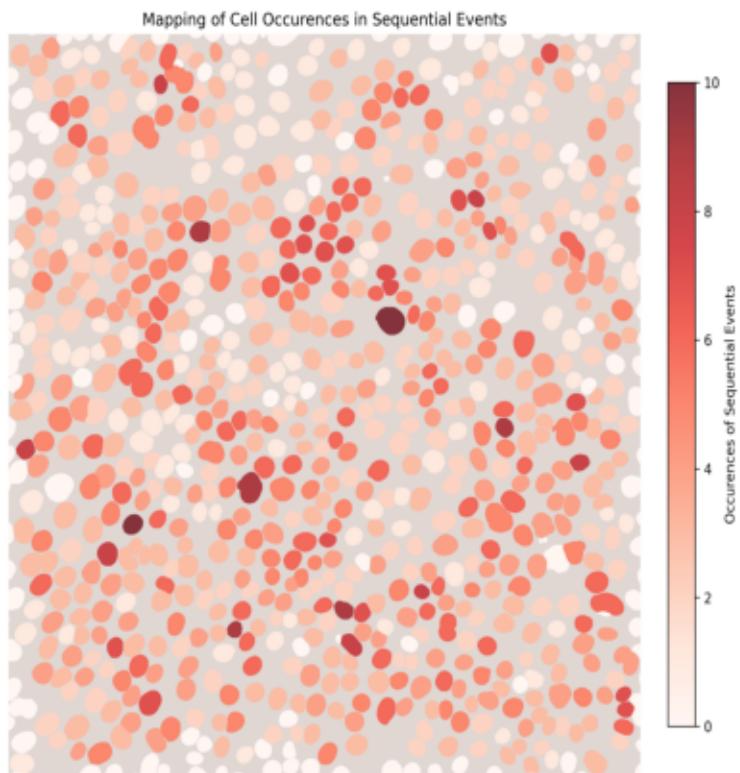
1.3.1 Cells occurrences in sequential events



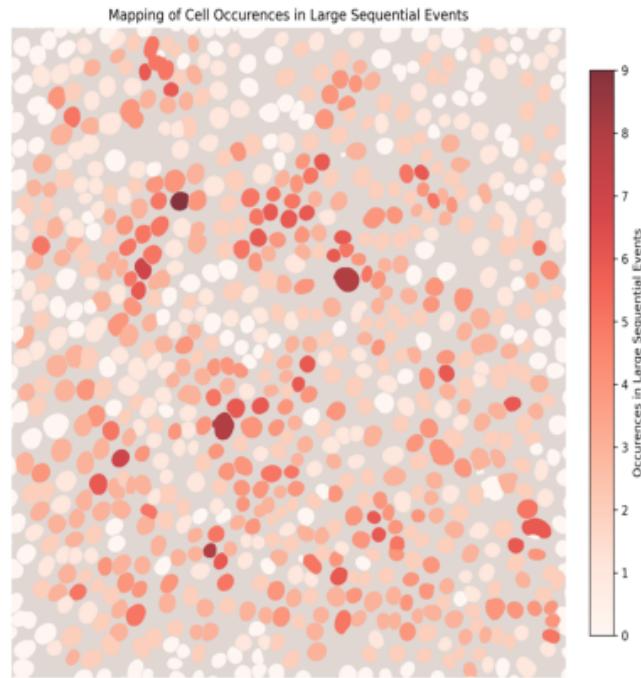
Distribution of Sequential Event Occurrences per Cell (0, 1-2, 3-4, 5-9, 10+)



Cell Mapping with Occurrences in Sequential Events Overlay - 20250810_IS2

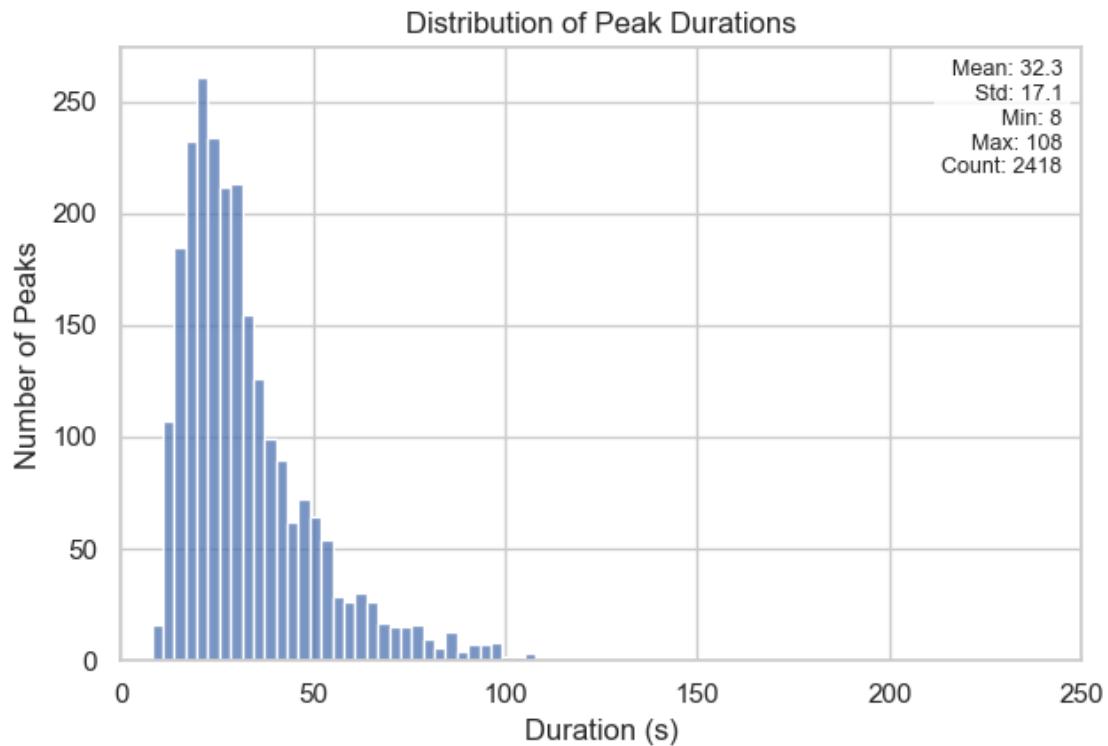


Cell Mapping with Occurrences in Large Sequential Events Overlay (>2) - 20250810_IS2

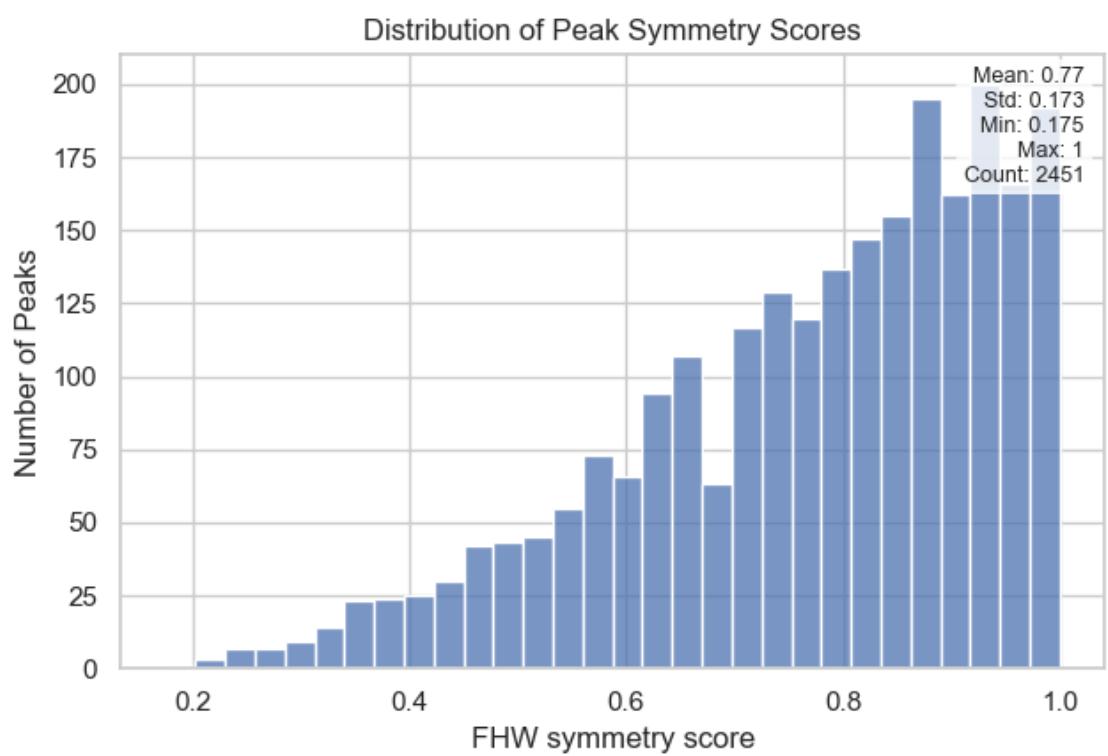
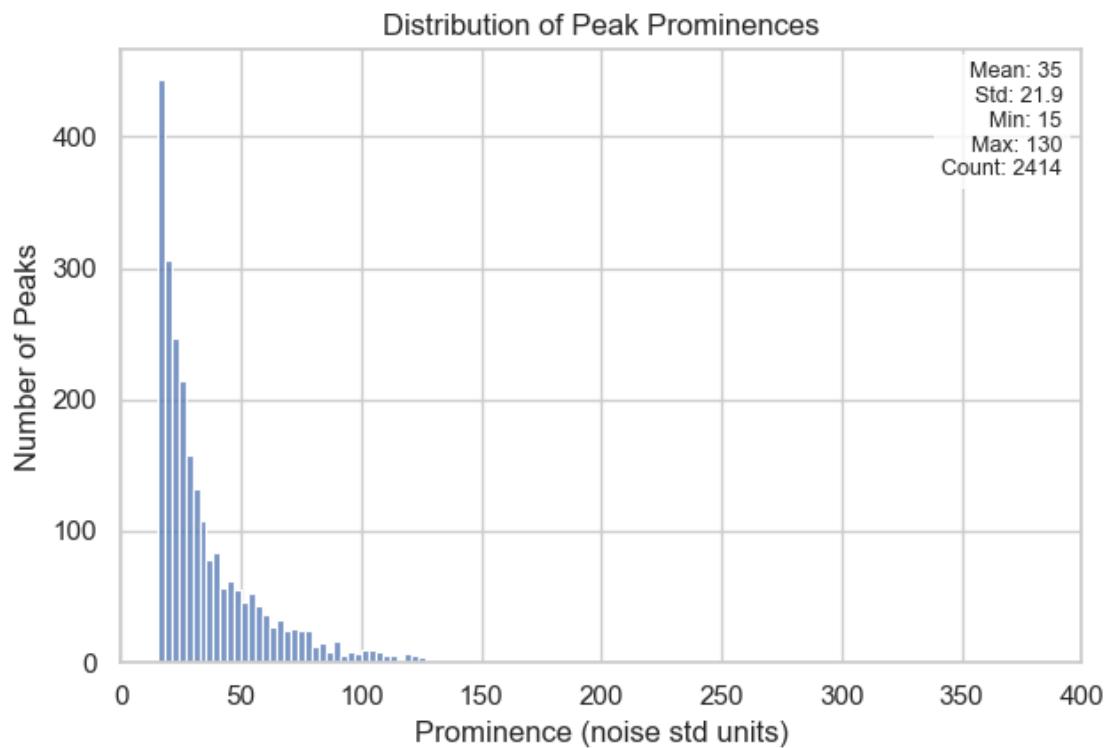


1.3.2 Peaks statistics in sequential events

```
[2025-08-13 12:40:43] [INFO] calcium: plot_histogram: removed 33 outliers out of 2451 on 'Duration (s)' (lower=-10, upper=110)
```

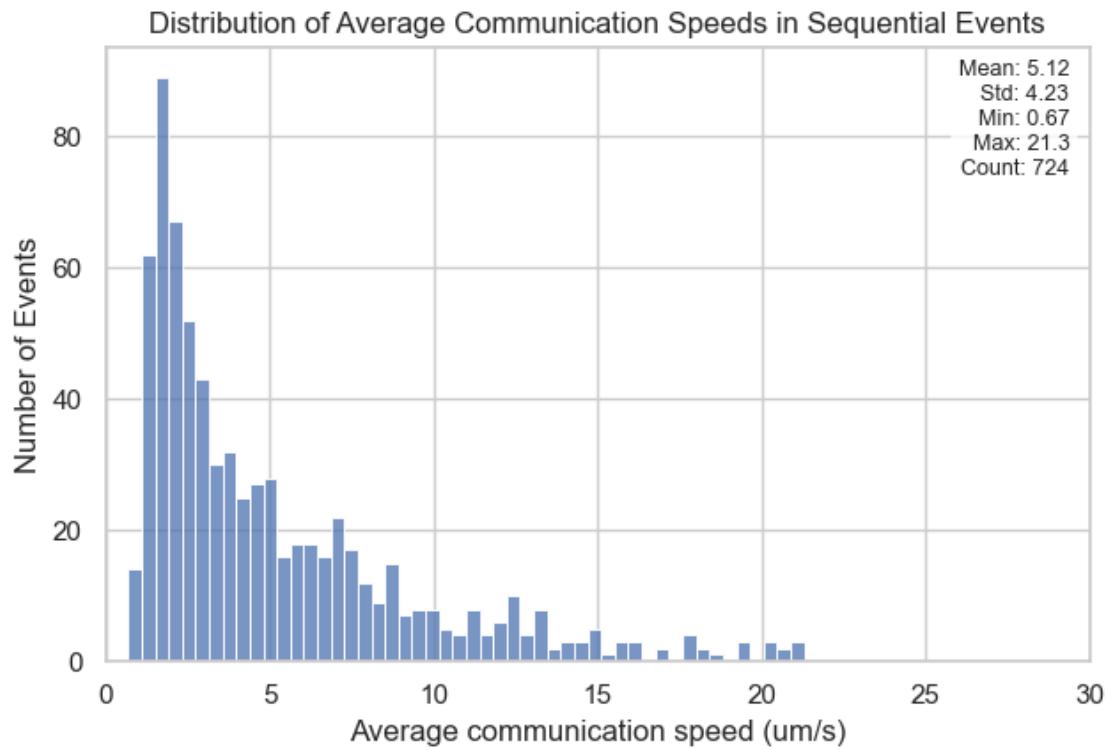


```
[2025-08-13 12:40:43] [INFO] calcium: plot_histogram: removed 37 outliers out of 2451 on 'Prominence (noise std units)' (lower=-18.625, upper=133.48)
```

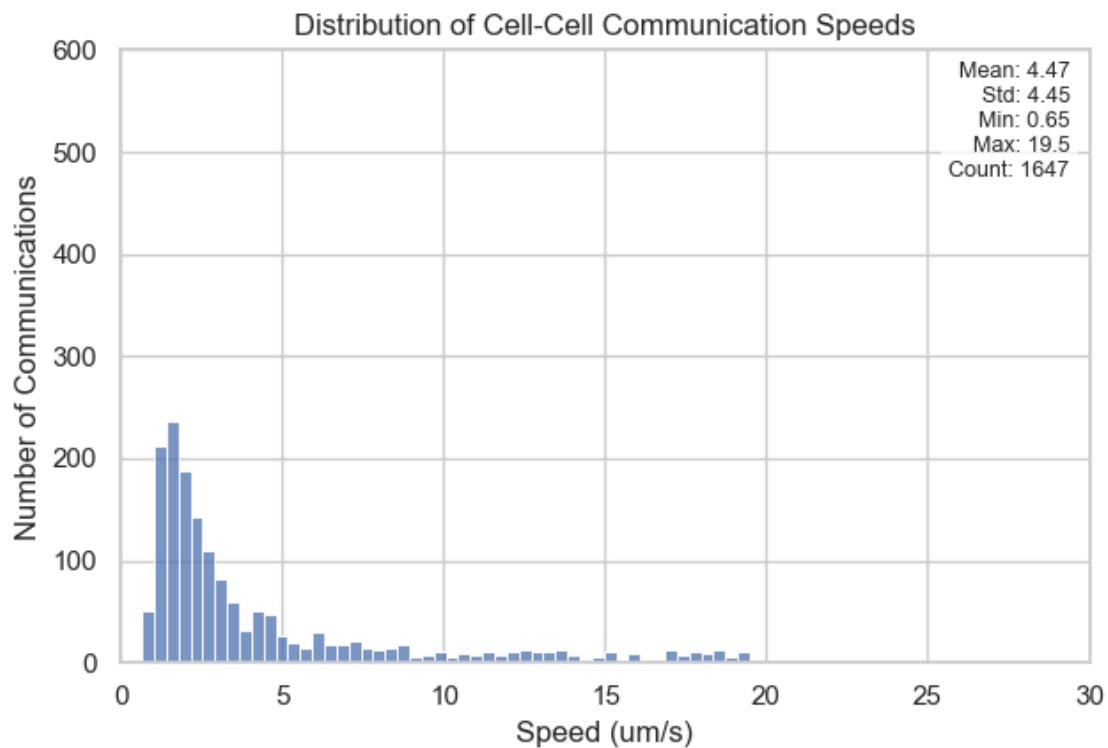


1.3.3 Cell-cell communication speed

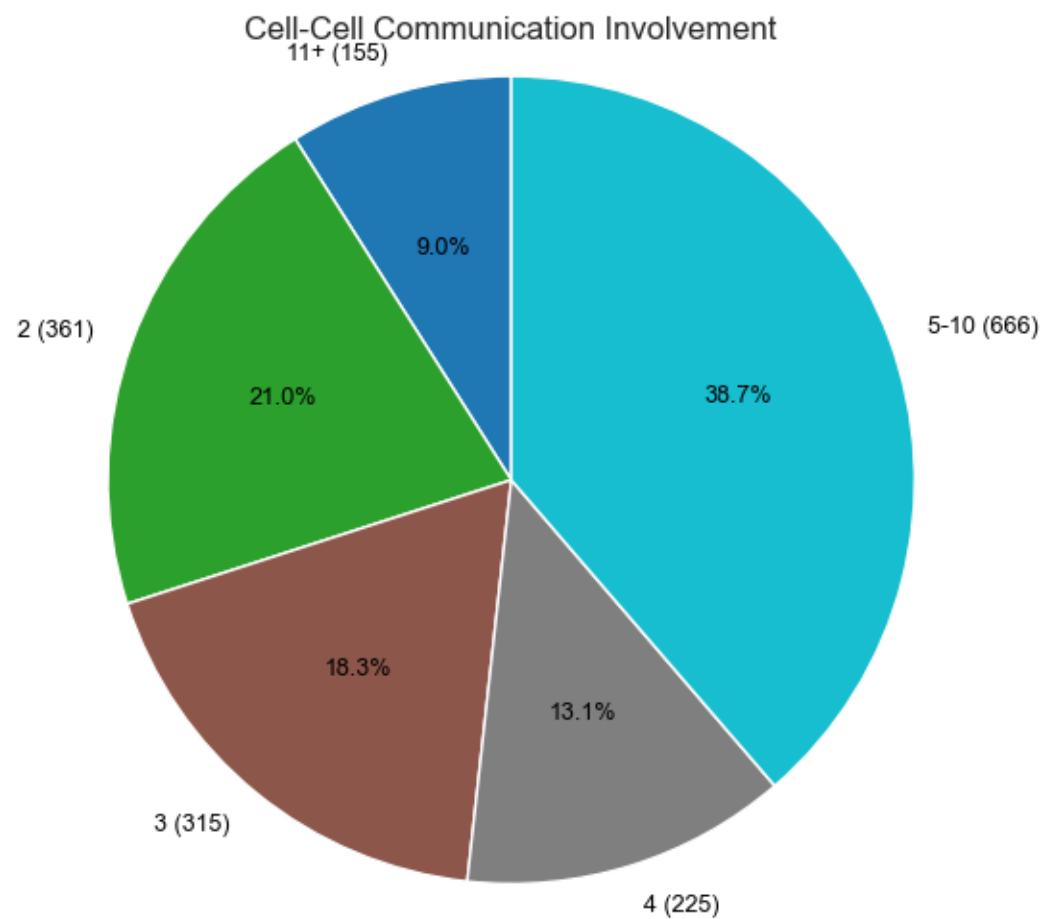
[2025-08-13 12:40:44] [INFO] calcium: plot_histogram: removed 5 outliers out of 729 on 'Average communication speed (um/s)' (lower=-13.33, upper=22.44)



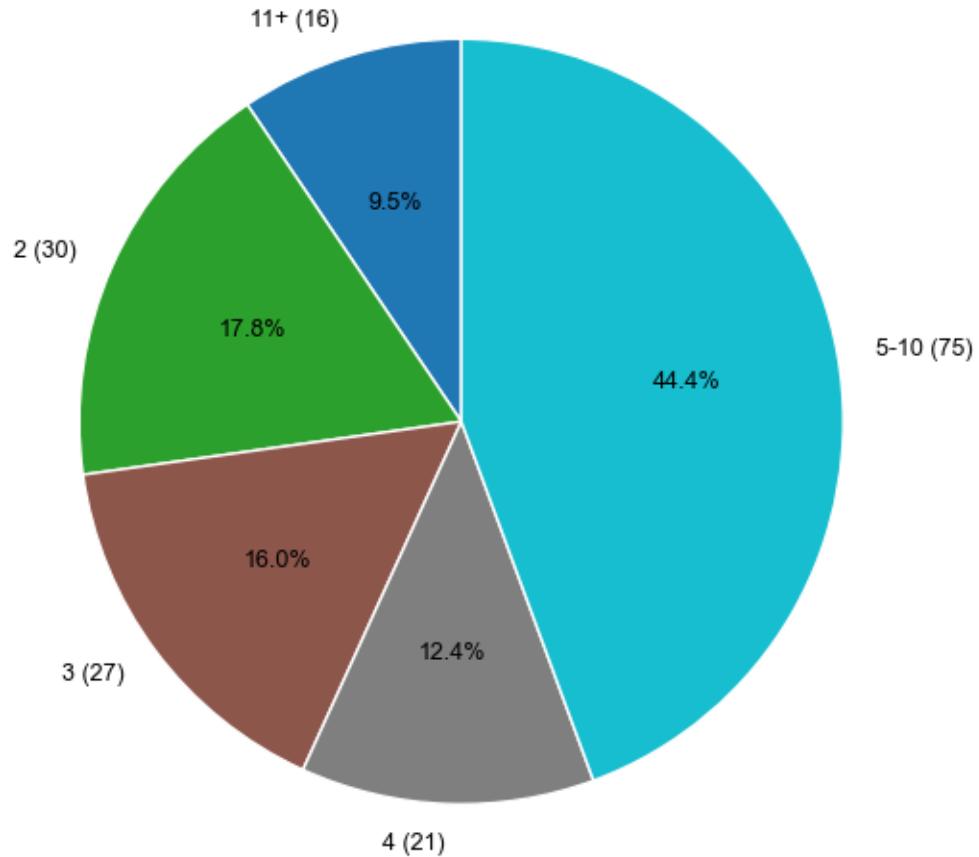
[2025-08-13 12:40:44] [INFO] calcium: plot_histogram: removed 75 outliers out of 1722 on 'Speed (um/s)' (lower=-11.763, upper=19.58)



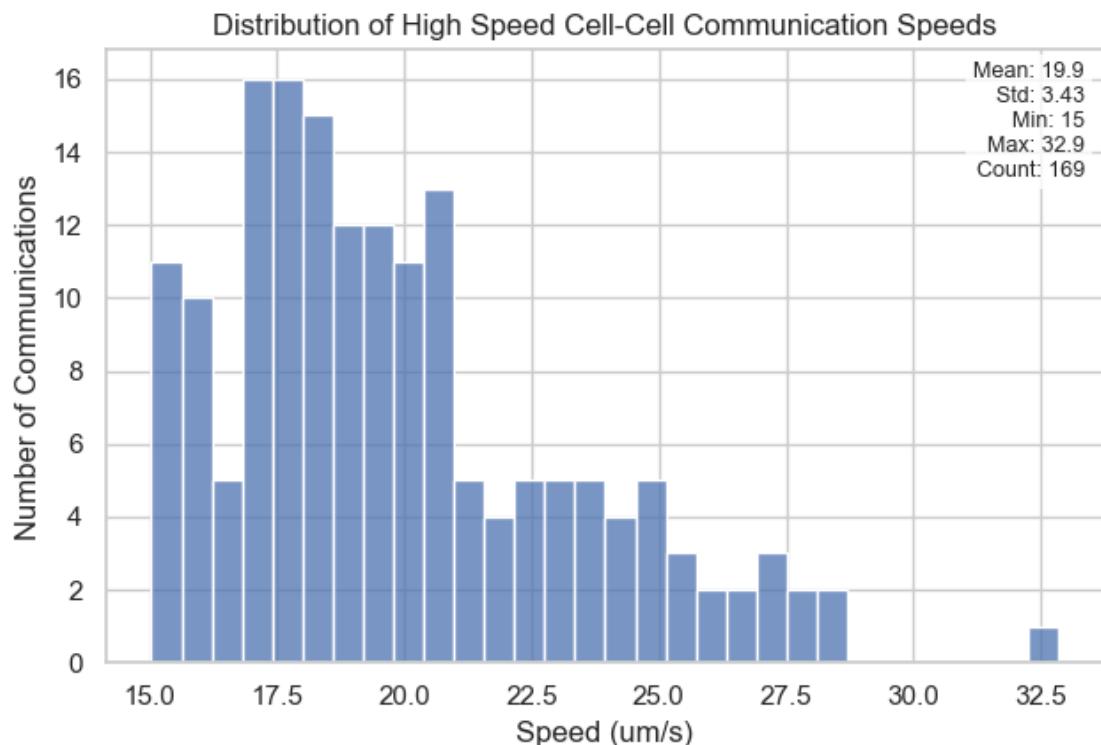
1.3.4 Double distribution in cell-cell communication speeds



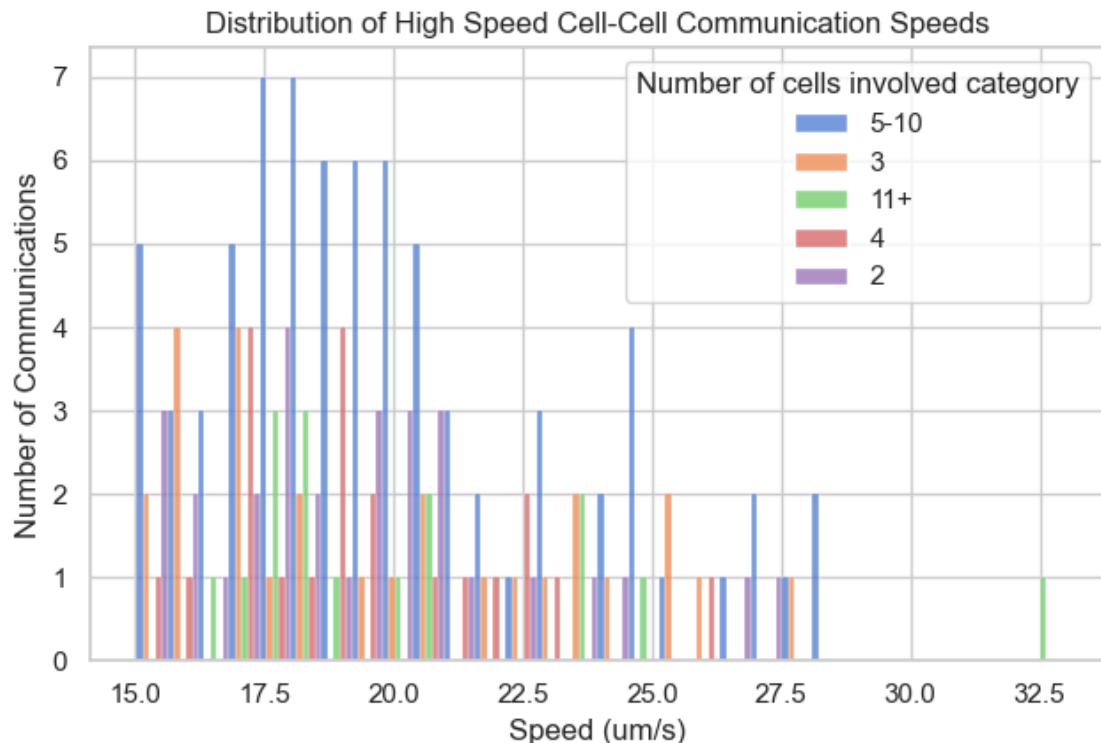
High Speed Cell-Cell Communication Involvement



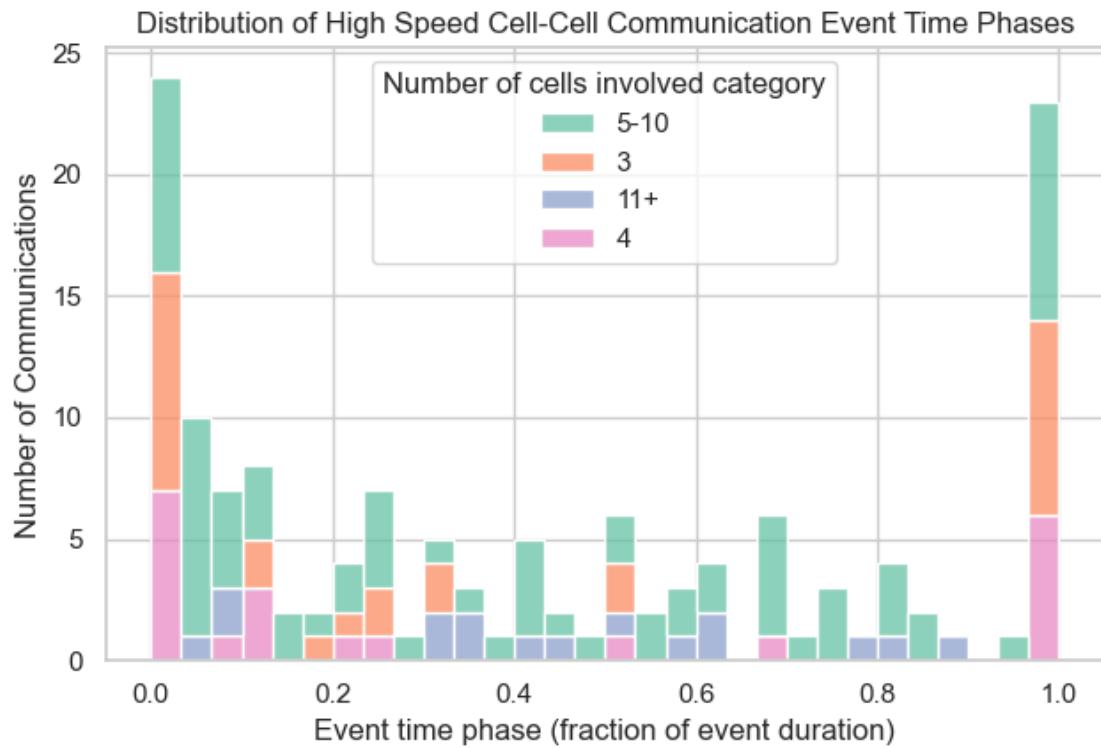
[2025-08-13 12:40:44] [INFO] calcium: plot_histogram: removed 0 outliers out of 169 on 'Speed (um/s)' (lower=4.76, upper=34.3)



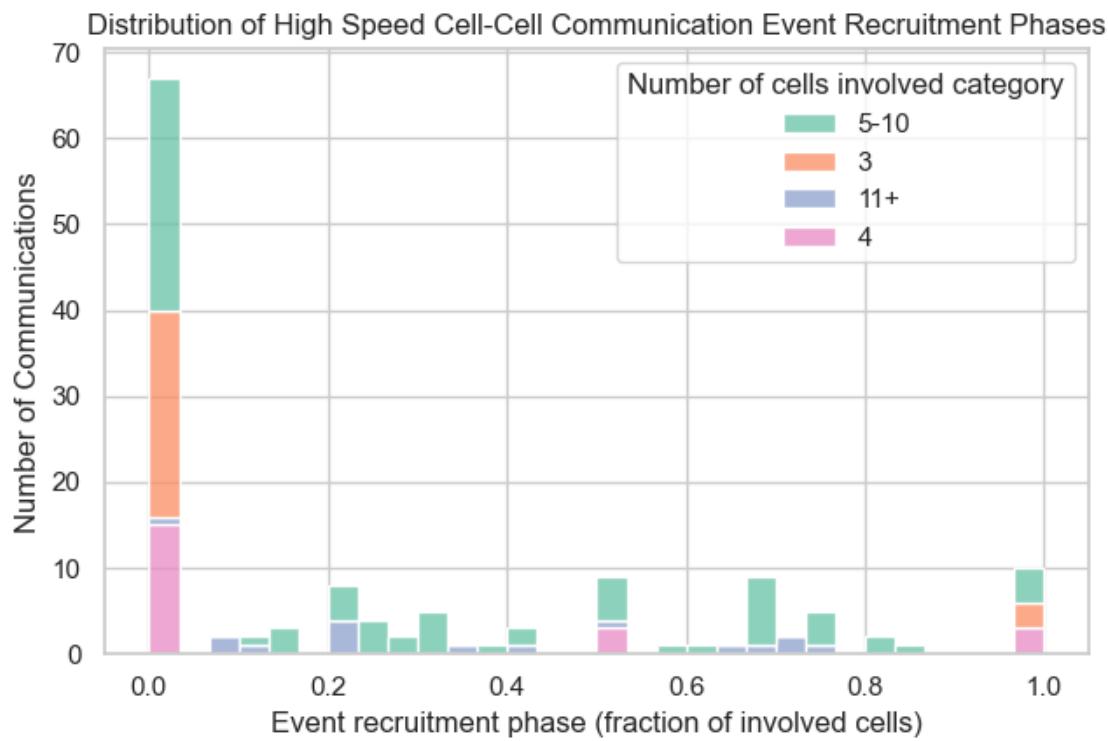
```
[2025-08-13 12:40:44] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 169 on 'Speed (um/s)' (lower=4.76, upper=34.3)
```



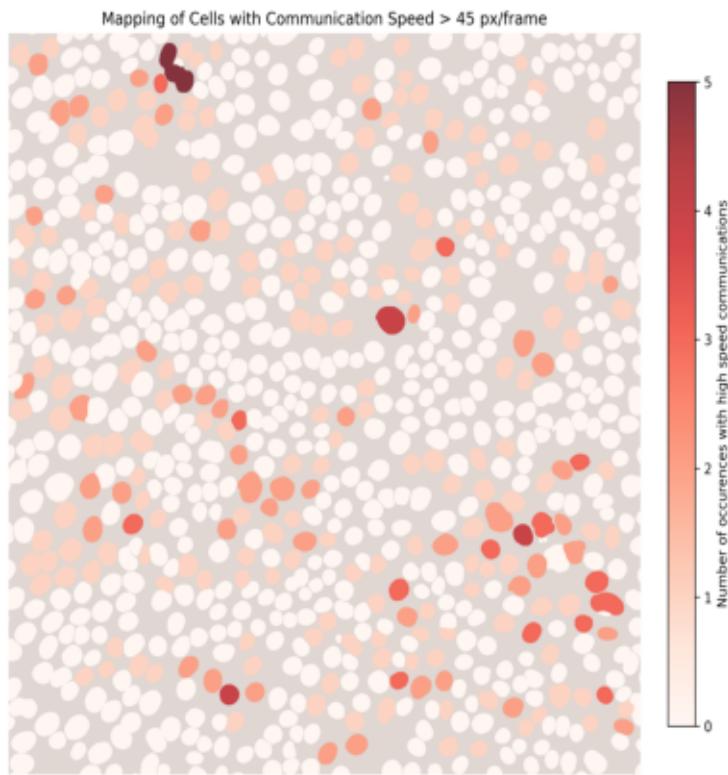
```
[2025-08-13 12:40:45] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 139 on 'Event time phase (fraction of event duration)' (lower=-1.925, upper=2.73)
```



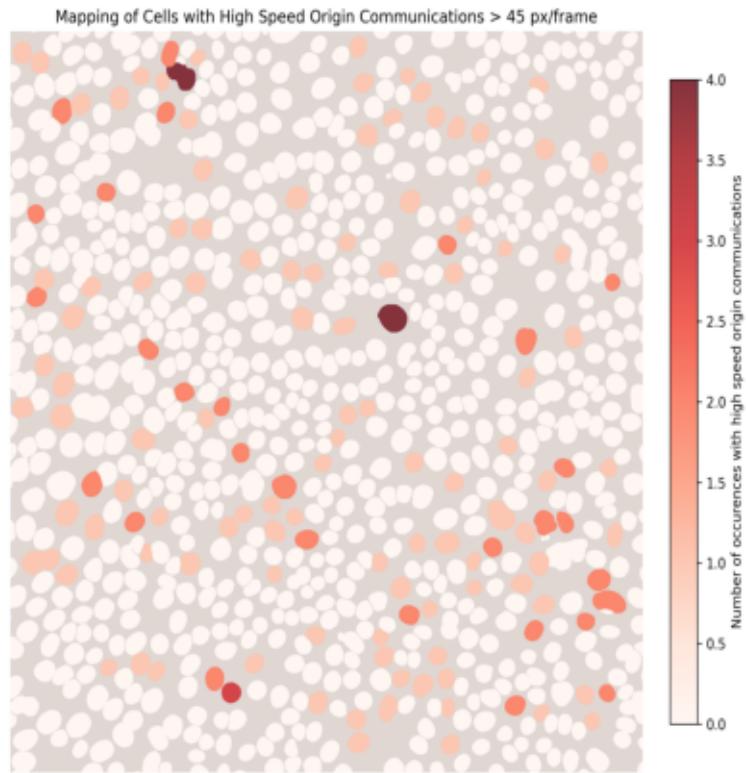
```
[2025-08-13 12:40:45] [INFO] calcium: plot_histogram_by_group: removed 0 outliers out of 139 on 'Event recruitment phase (fraction of involved cells)' (lower=-1.5, upper=2)
```



Cell Mapping with High Speed Cells Overlay - 20250810_IS2



Cell Mapping with High Speed Origin Cells Overlay - 20250810_IS2



	Communication ID	Event ID	Origin cell ID	Origin cell peak ID	\
1	1759469454432	2	533	3	
7	1759394924240	3	545	2	
16	1759496100912	4	1012	3	
20	1759469462112	6	949	4	
22	1759469459376	7	1158	0	
...	
1631	1760039254624	676	1135	1	
1637	1760039248048	676	1234	1	
1671	1760039245456	696	1178	5	
1684	1760039248144	702	1192	0	
1704	1760039250592	715	1198	3	

	Cause cell ID	Cause cell peak ID	Start time (s)	End time (s)	\
1	535	3	267.0	267.0	
7	526	4	249.0	250.0	
16	1059	4	787.0	788.0	
20	966	2	790.0	790.0	
22	1156	1	98.0	98.0	
...	
1631	1143	1	96.0	97.0	
1637	1238	1	108.0	109.0	
1671	1164	5	878.0	879.0	
1684	1244	0	14.0	16.0	
1704	1206	4	740.0	741.0	
	Duration (s)	Distance (um)	Speed (um/s)	\	
1	0.0	20.84	20.84		
7	1.0	16.97	16.97		
16	1.0	20.15	20.15		
20	0.0	20.05	20.05		
22	0.0	17.58	17.58		
...	
1631	1.0	19.00	19.00		
1637	1.0	24.43	24.43		
1671	1.0	20.10	20.10		
1684	2.0	30.33	15.17		
1704	1.0	26.78	26.78		
	Event time phase (fraction of event duration)	\			
1		1.00			
7		0.71			
16		0.21			
20		1.00			
22		0.35			
...		...			
1631		0.26			
1637		0.55			
1671		NaN			
1684		0.06			
1704		NaN			
	Event recruitment phase (fraction of involved cells)	dataset	\		
1		0.67	20250810_IS2		
7		0.75	20250810_IS2		
16		0.67	20250810_IS2		
20		0.00	20250810_IS2		
22		0.11	20250810_IS2		
...			
1631		0.25	20250810_IS2		
1637		0.62	20250810_IS2		

1671		NaN	20250810_IS2
1684		0.00	20250810_IS2
1704		NaN	20250810_IS2

	Number of cells involved	category	Speed category
1		5-10	High speed
7		5-10	High speed
16		5-10	High speed
20		3	High speed
22		11+	High speed
...	
1631		5-10	High speed
1637		5-10	High speed
1671		2	High speed
1684		5-10	High speed
1704		2	High speed

[169 rows x 16 columns]

Origin cell ID	Speed category	High speed	Low speed
195		0	1
200		0	1
201		0	2
202		0	1
203		0	2
...
1244		0	3
1246		0	1
1247		0	3
1252		0	2
1258		0	2

[613 rows x 2 columns]

	Cell ID	Centroid X coordinate (um)	Centroid Y coordinate (um)	\
0	195	489.12		5.20
3	200	94.90		9.43
4	201	33.15		9.43
5	202	274.30		10.08
6	203	109.53		11.05
..
761	1244	251.55		484.57
762	1246	186.55		485.23
763	1247	393.90		486.20
766	1252	463.12		490.43
768	1258	412.75		492.70

Number of peaks Is active Occurences in global events \

0	7	True	2
3	8	True	2
4	9	True	2
5	4	True	2
6	5	True	2
..
761	9	True	2
762	5	True	2
763	6	True	2
766	9	True	2
768	7	True	2

Occurrences in global events as early peaker \

0	0
3	0
4	0
5	0
6	0
..	..
761	0
762	0
763	0
766	0
768	0

Occurrences in sequential events \

0	1
3	2
4	4
5	1
6	3
..	..
761	5
762	1
763	3
766	3
768	3

Occurrences in sequential events as origin \

0	1
3	1
4	2
5	0
6	1
..	..
761	2
762	1
763	2

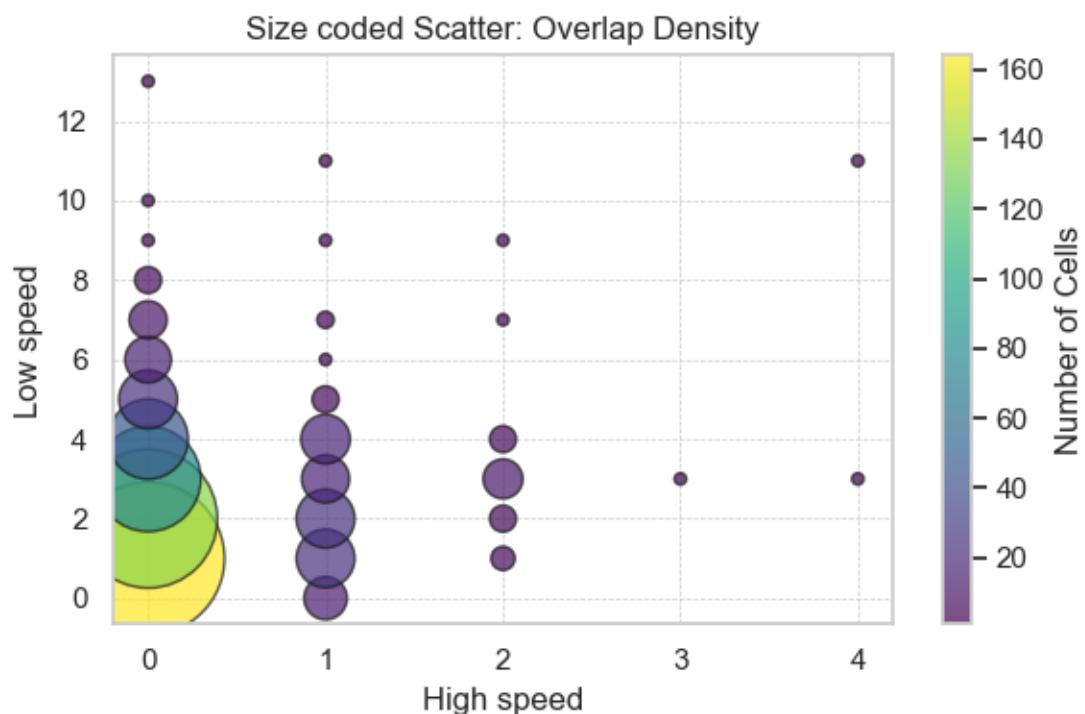
766		2	
768		0	
Occurrences in individual events Peak frequency (Hz) Periodicity score \			
0	4	0.0041	0.68
3	4	0.0047	0.50
4	2	0.0053	0.69
5	1	0.0024	0.74
6	0	0.0029	0.49
..
761	2	0.0053	0.58
762	2	0.0029	0.59
763	1	0.0035	0.54
766	4	0.0053	0.66
768	2	0.0041	0.54
Neighbor count Neighbors (labels) dataset \			
0	1 [224]	20250810_IS2	
3	2 [203, 232]	20250810_IS2	
4	4 [216, 219, 231, 263]	20250810_IS2	
5	3 [220, 238, 262]	20250810_IS2	
6	5 [200, 217, 232, 250, 260]	20250810_IS2	
..
761	4 [1183, 1192, 1214, 1230]	20250810_IS2	
762	3 [1195, 1233, 1239]	20250810_IS2	
763	4 [1216, 1232, 1238, 1258]	20250810_IS2	
766	3 [1198, 1212, 1223]	20250810_IS2	
768	4 [1232, 1237, 1247, 1251]	20250810_IS2	
Involved in sequential event Occurrences in sequential events category \			
0	Involved in sequential event		1-2
3	Involved in sequential event		1-2
4	Involved in sequential event		3-4
5	Involved in sequential event		1-2
6	Involved in sequential event		3-4
..
761	Involved in sequential event		5-9
762	Involved in sequential event		1-2
763	Involved in sequential event		3-4
766	Involved in sequential event		3-4
768	Involved in sequential event		3-4
High speed Low speed			
0	0.0	1.0	
3	0.0	1.0	
4	0.0	2.0	
5	0.0	1.0	
6	0.0	2.0	

```

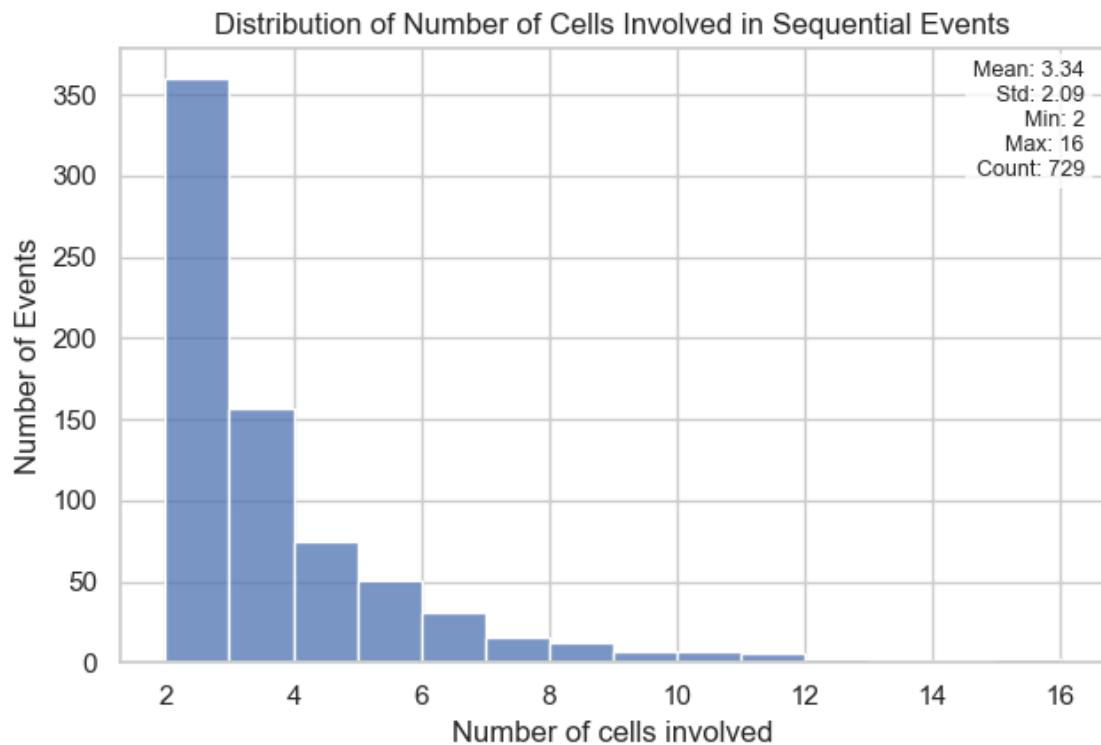
...
761      0.0      3.0
762      0.0      1.0
763      0.0      3.0
766      0.0      2.0
768      0.0      2.0

```

[613 rows x 19 columns]



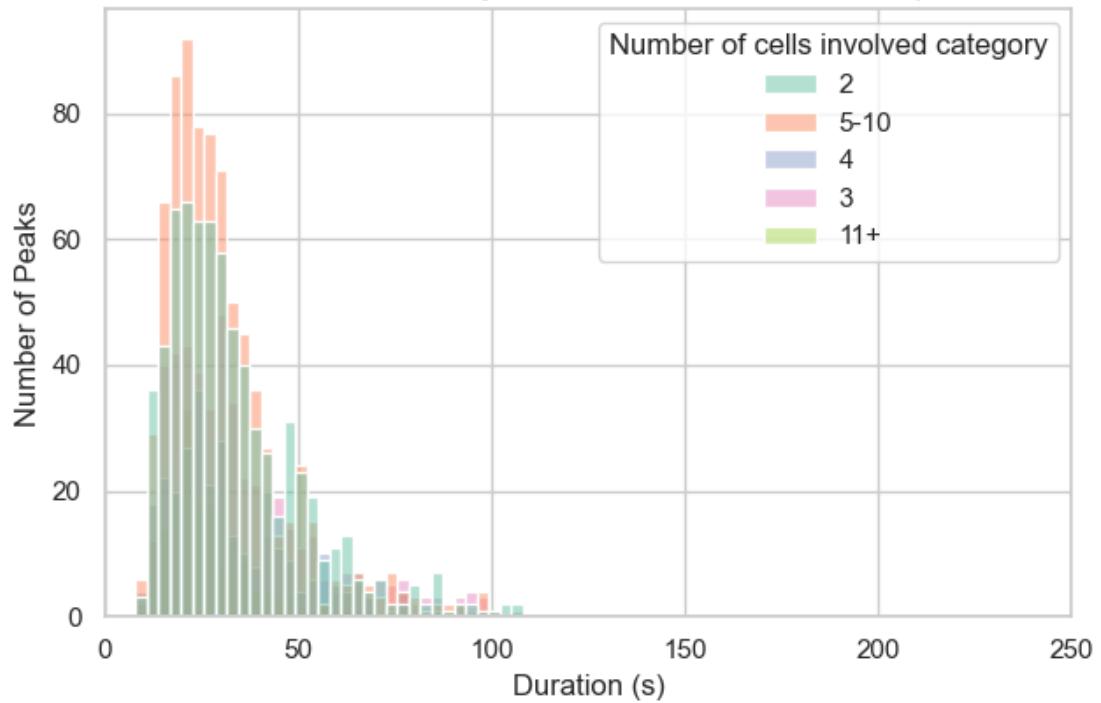
1.3.5 Number of cells involved per sequential events



1.3.6 Influence of cell count per event on statistics

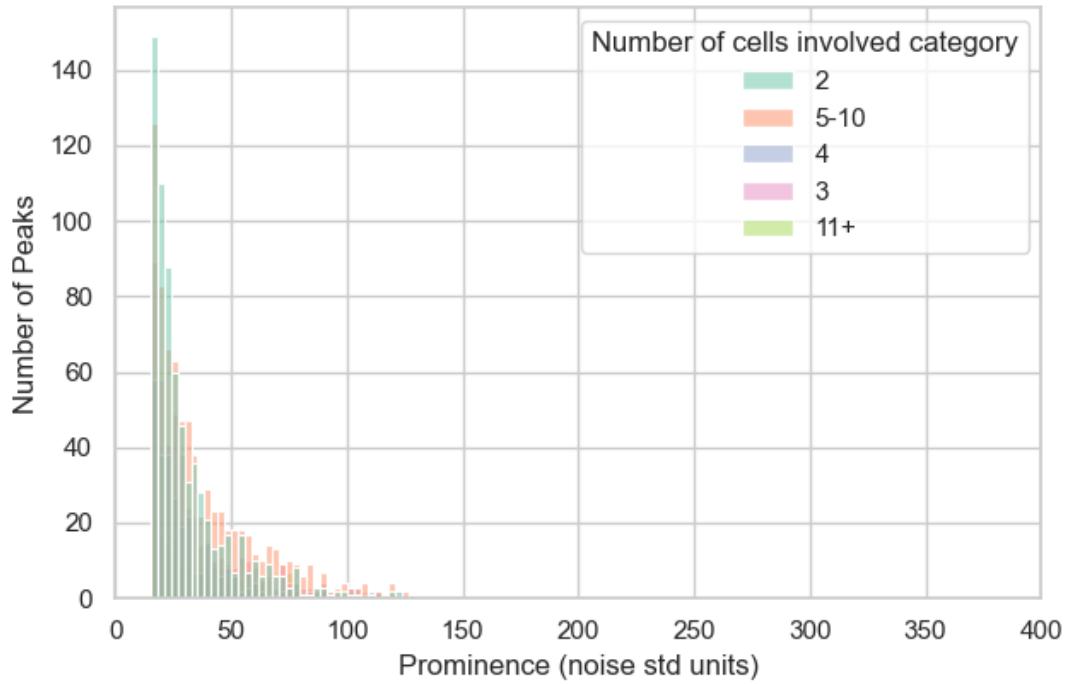
```
[2025-08-13 12:40:49] [INFO] calcium: plot_histogram_by_group: removed 33 outliers out of 2451 on 'Duration (s)' (lower=-10, upper=110)
```

Distribution of Peak Durations by Number of Cells Involved in Sequential Events

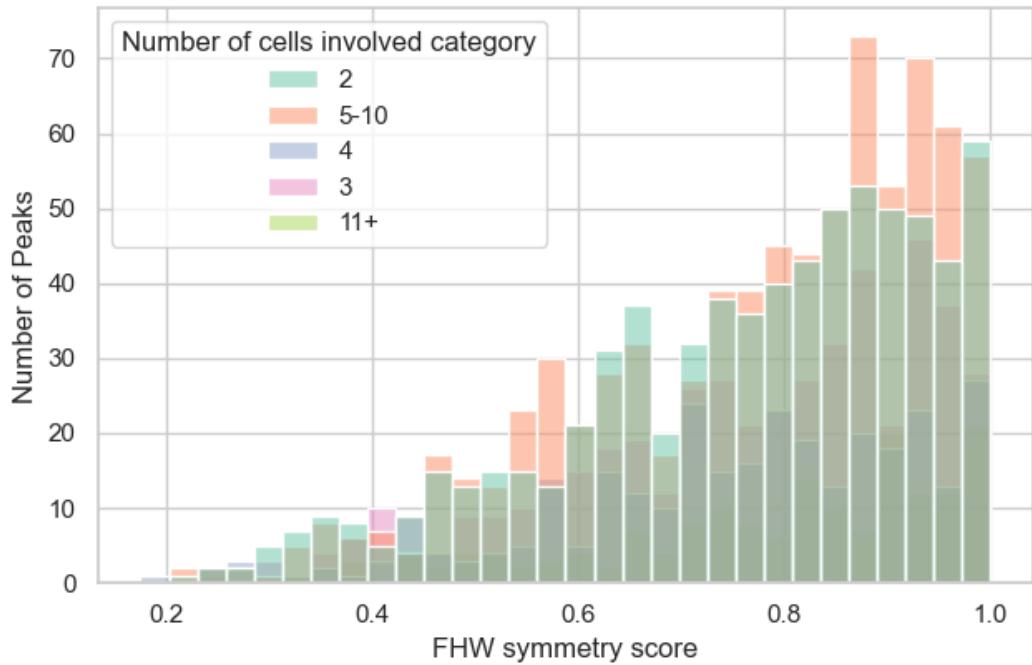


```
[2025-08-13 12:40:49] [INFO] calcium: plot_histogram_by_group: removed 37 outliers out of 2451 on 'Prominence (noise std units)' (lower=-18.625, upper=133.48)
```

Distribution of Peak Prominences by Number of Cells Involved in Sequential Events

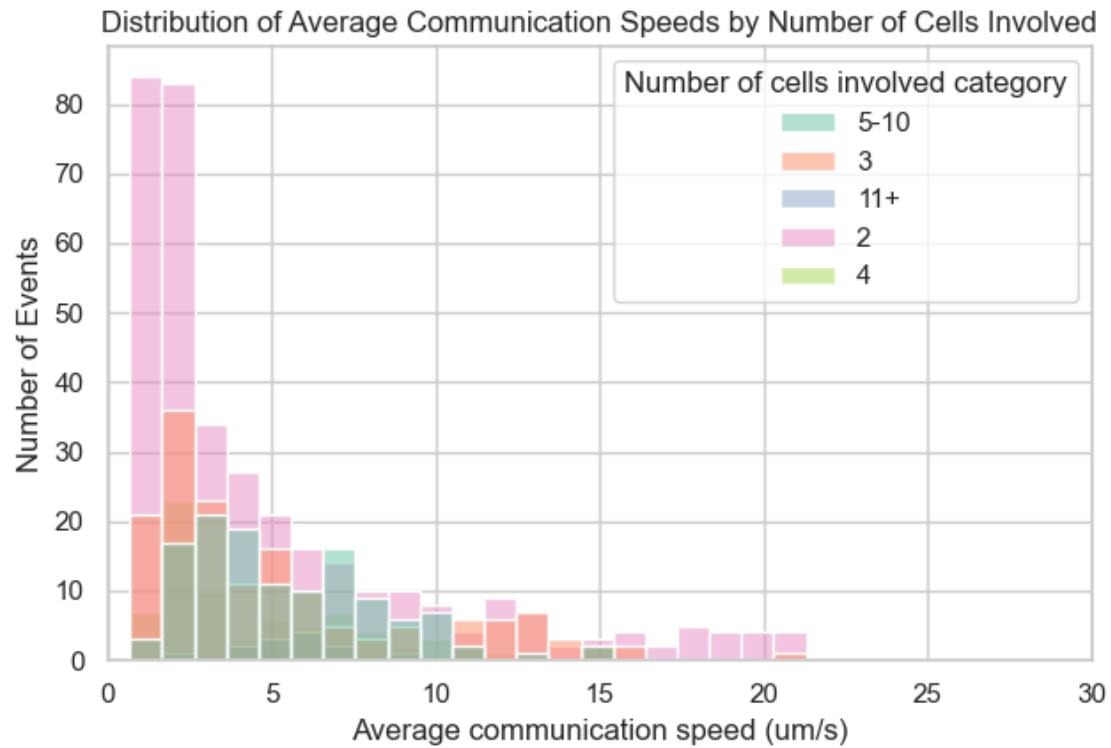


Distribution of Peak Symmetry Scores by Number of Cells Involved in Sequential Events



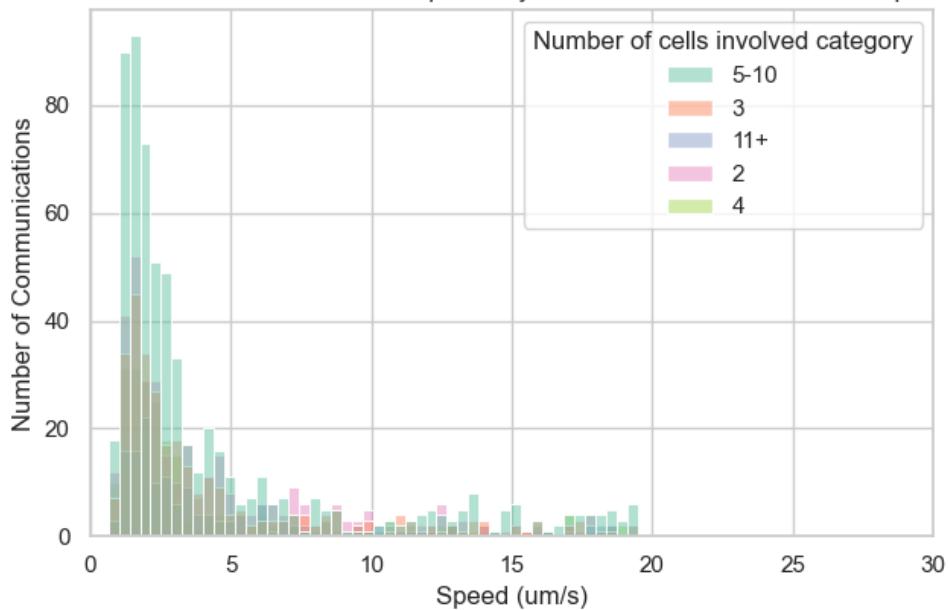
[2025-08-13 12:40:50] [INFO] calcium: plot_histogram_by_group: removed 5

outliers out of 729 on 'Average communication speed (um/s)' (lower=-13.33, upper=22.44)



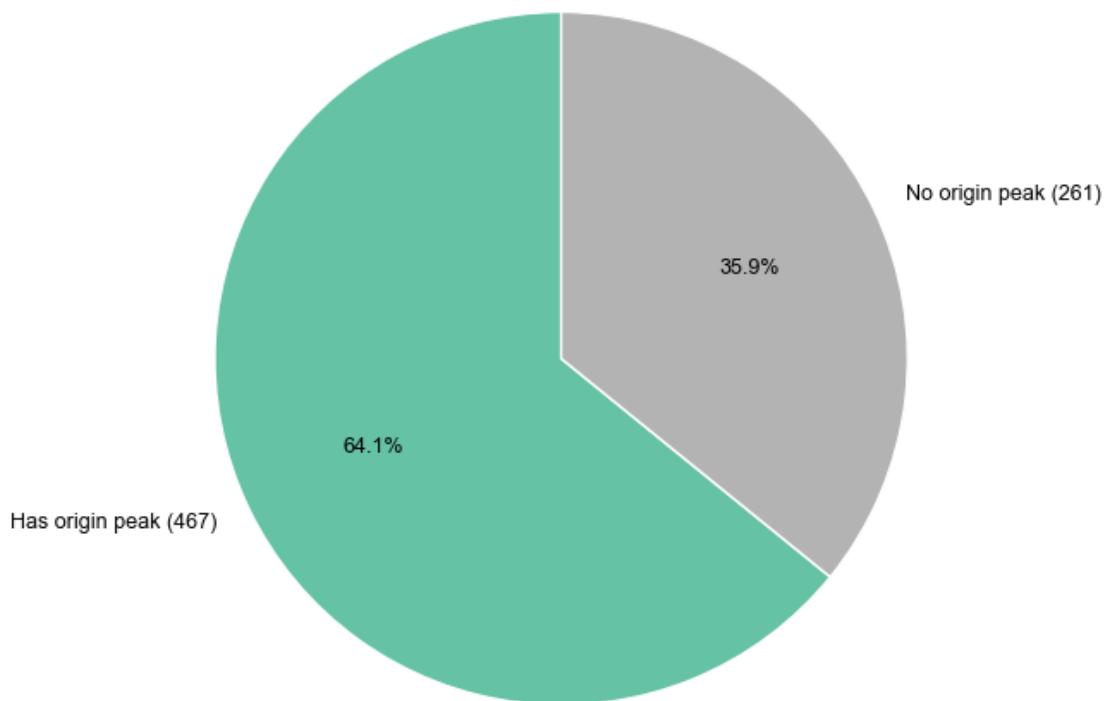
[2025-08-13 12:40:50] [INFO] calcium: plot_histogram_by_group: removed 75 outliers out of 1722 on 'Speed (um/s)' (lower=-11.763, upper=19.58)

Distribution of Cell-Cell Communication Speeds by Number of Cells Involved in Sequential Events

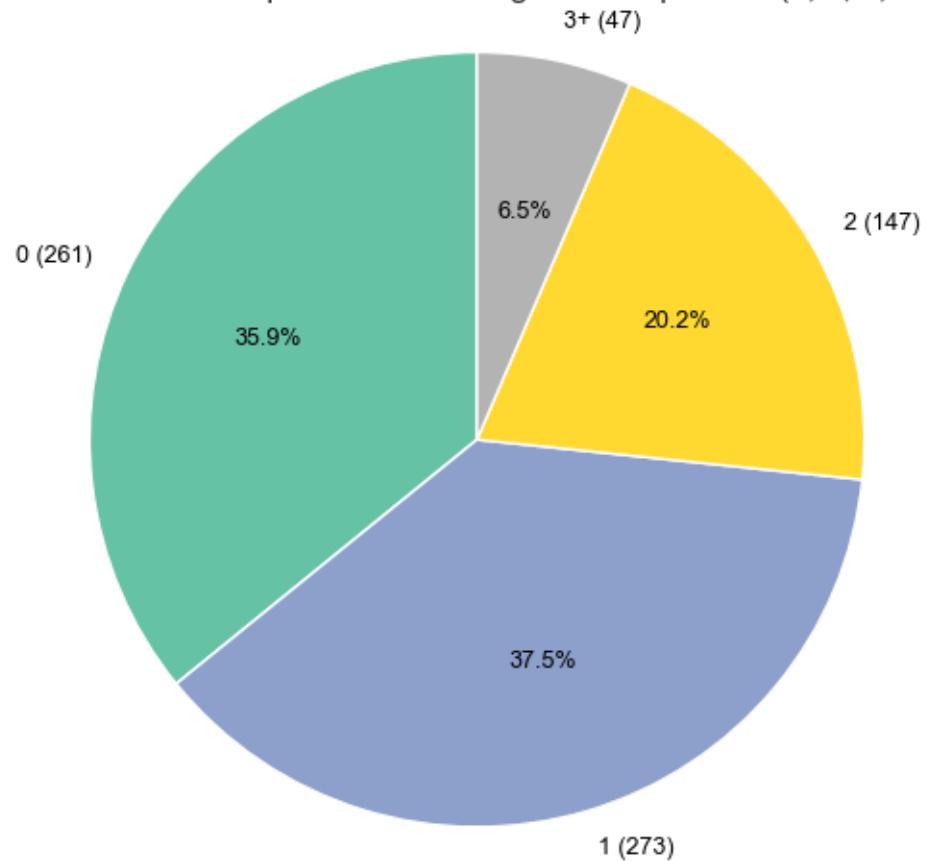


1.3.7 Cells occurrences as origin in sequential events

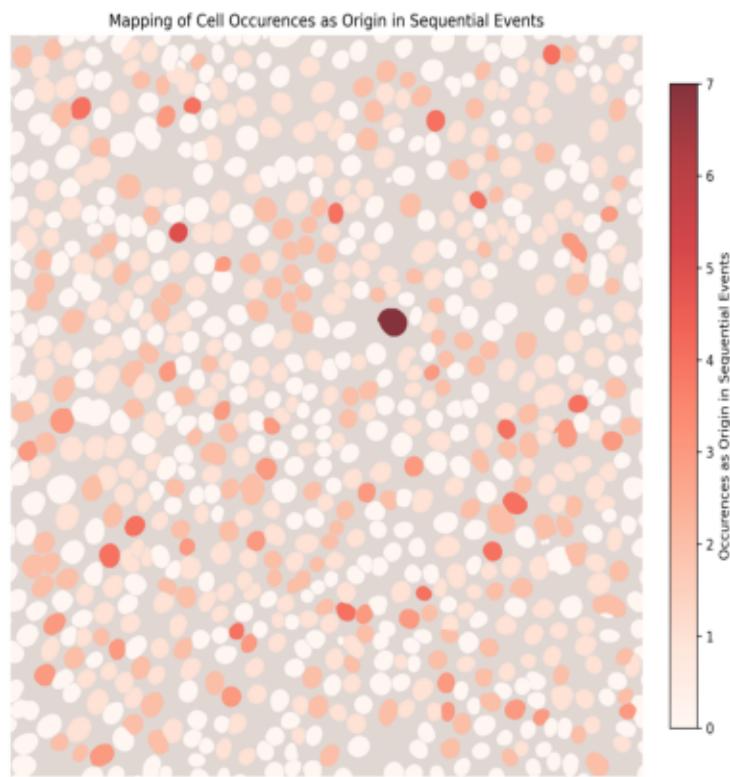
Distribution of Number of Sequential Event Origin Peaks per Cell

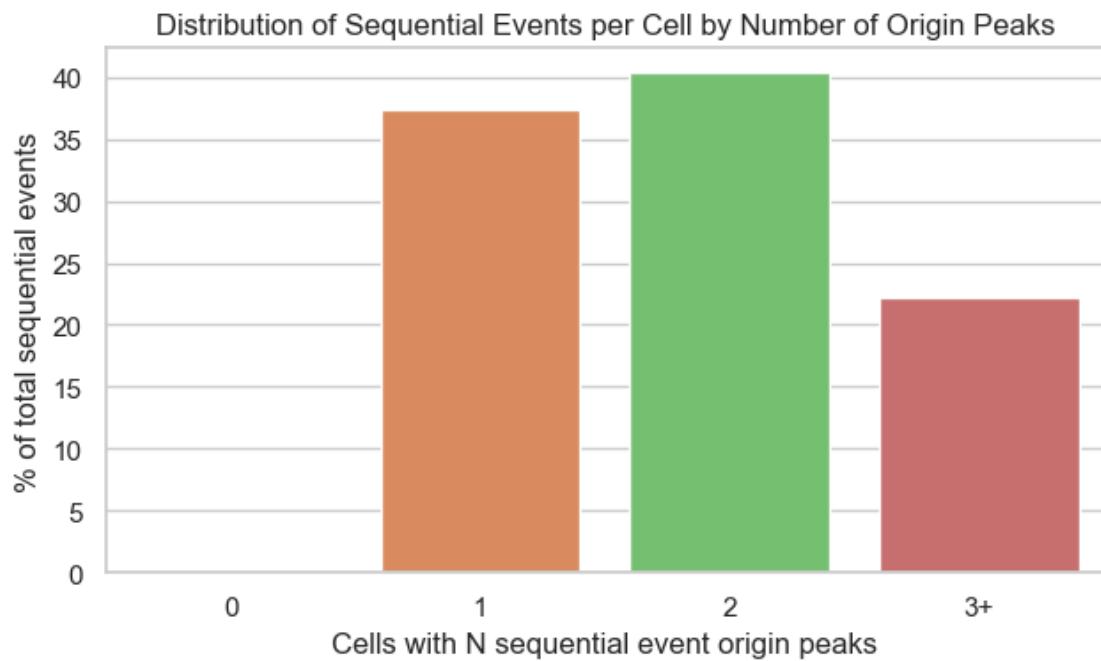


Distribution of Sequential Event Origin Peaks per Cell (0, 1, 2, 3+)



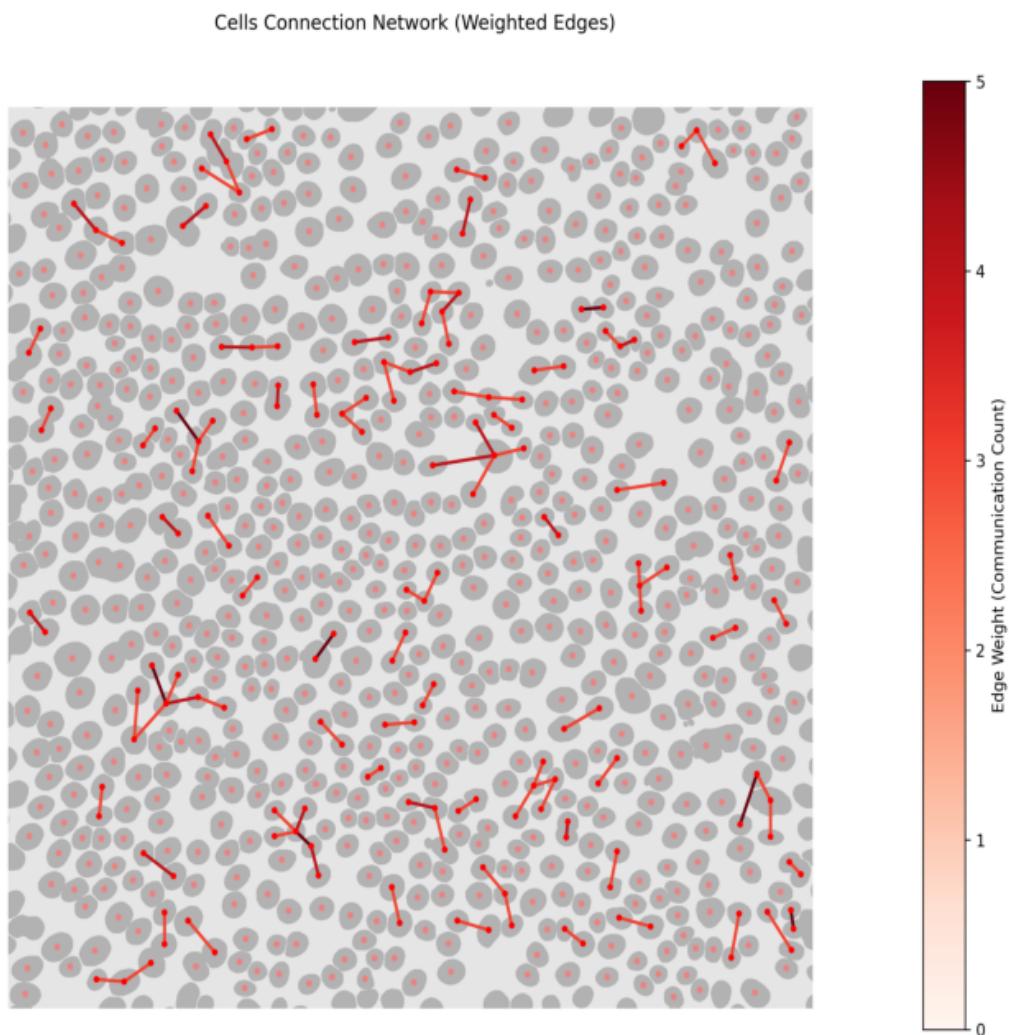
Cell Mapping with Origin Peaks Overlay - 20250810_IS2

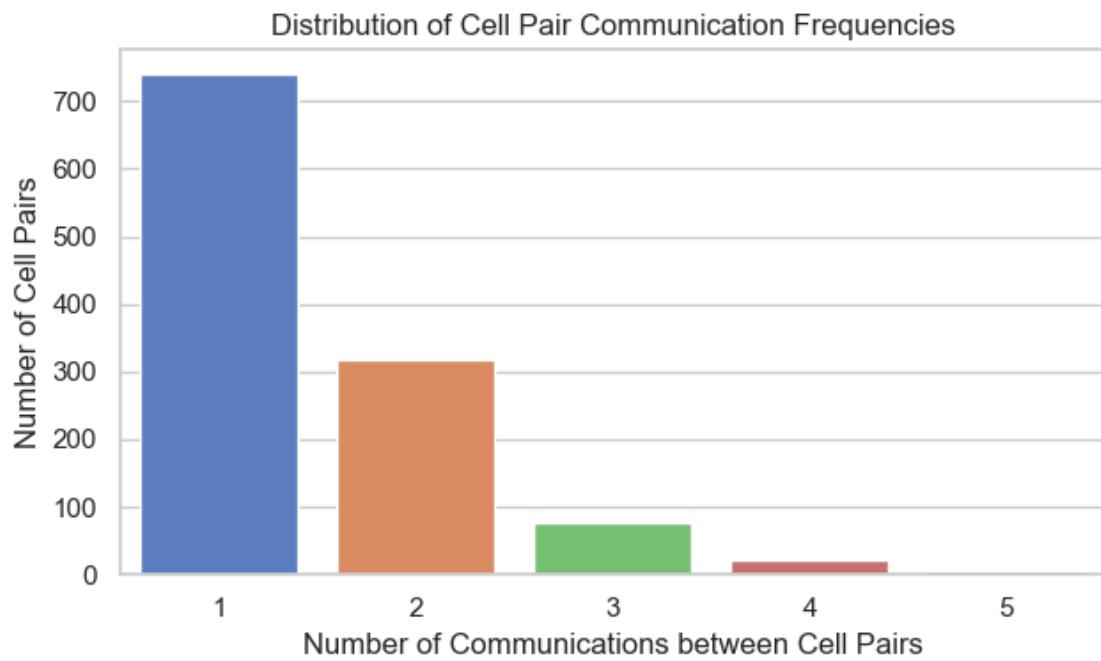




1.3.8 Connection network between cells

Cell Connection Network Graph - 20250810_IS2

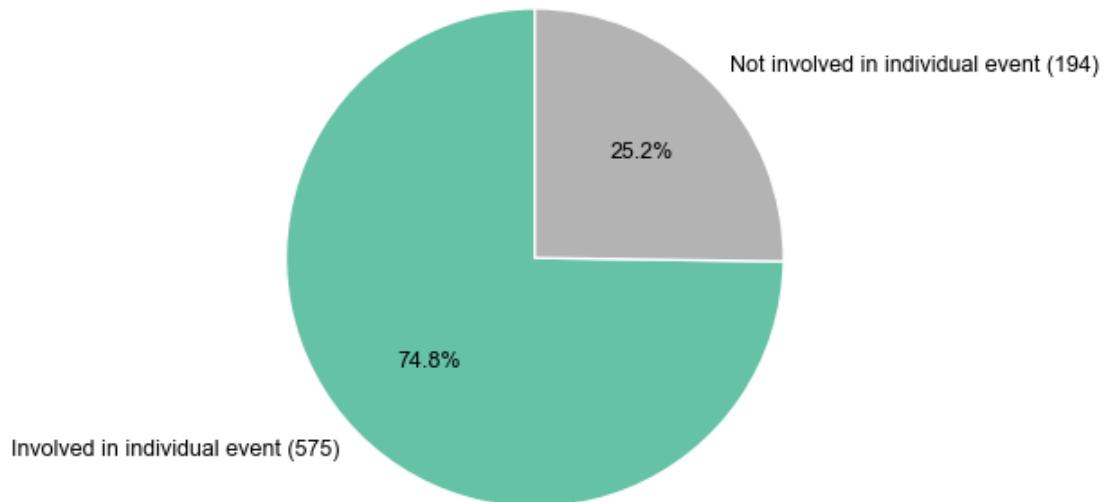




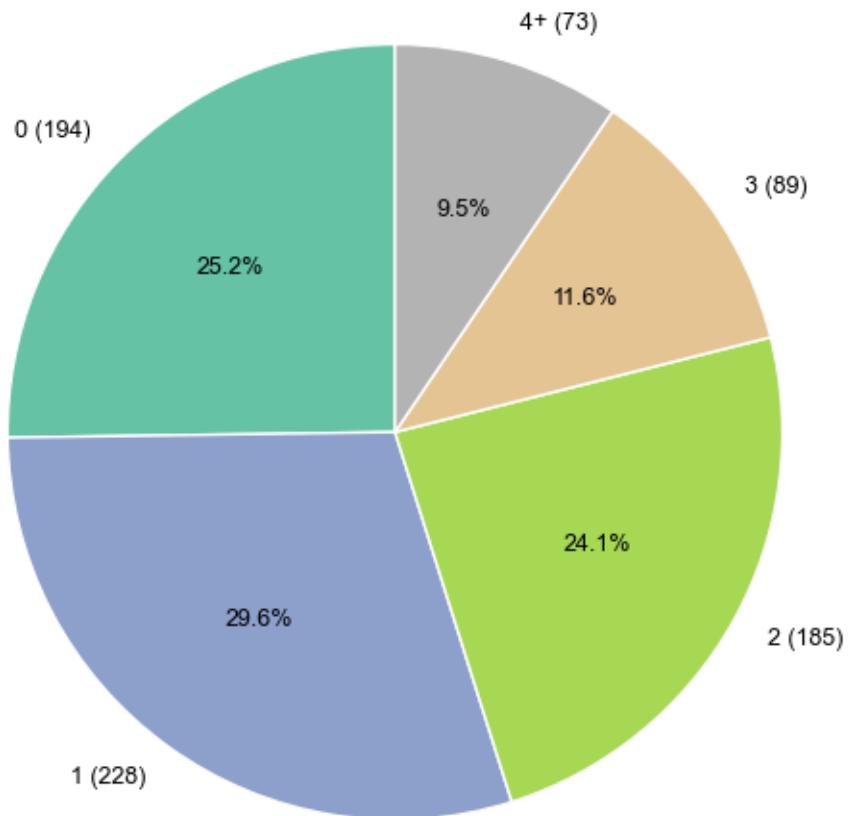
1.4 INDIVIDUAL EVENTS

1.4.1 Cells occurrences in individual events

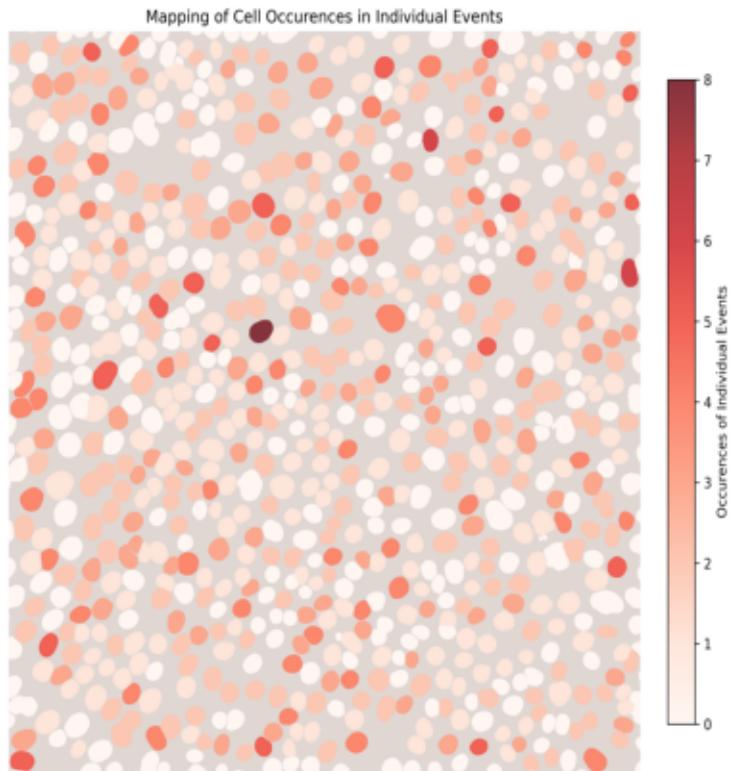
Distribution of Cells Involved in Individual Events



Distribution of Individual Event Occurrences per Cell (0, 1, 2, 3, 4+)

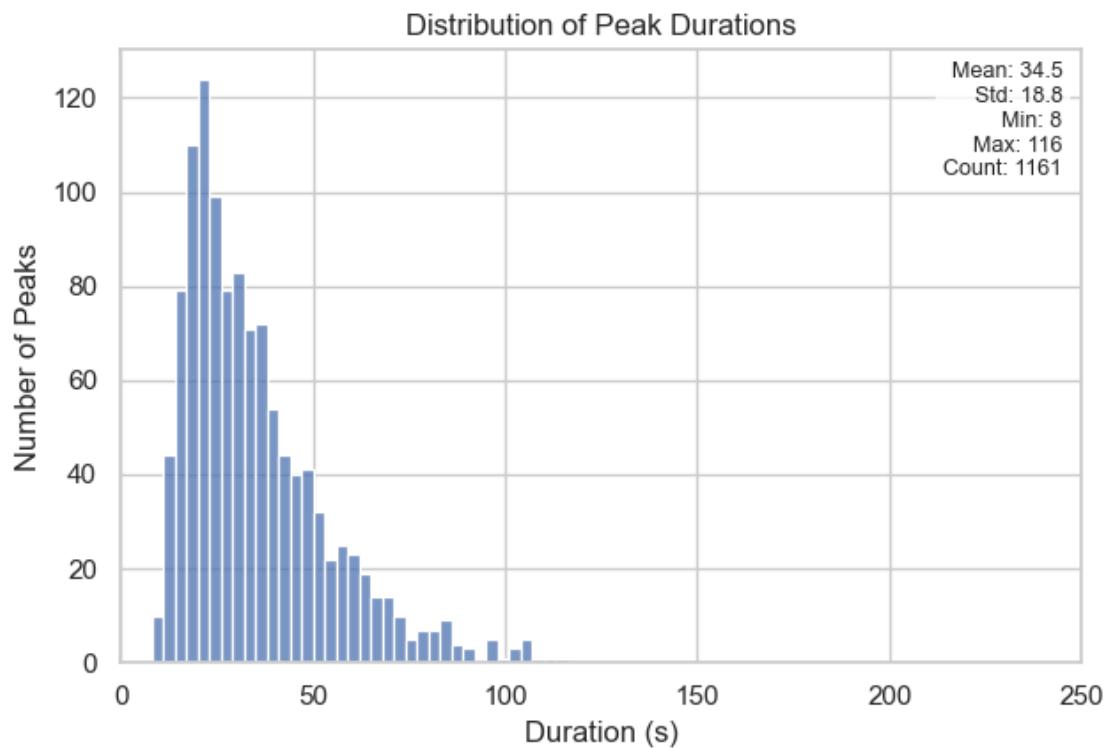


Cell Mapping with Occurrences in Individual Events Overlay - 20250810_IS2

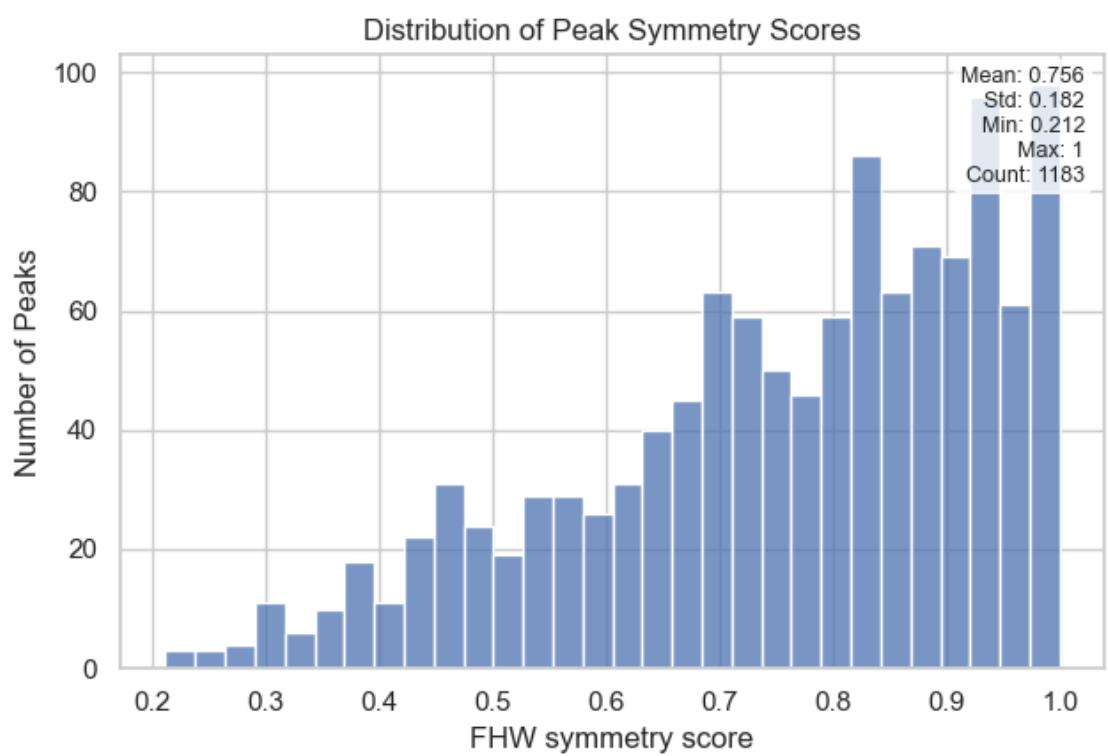
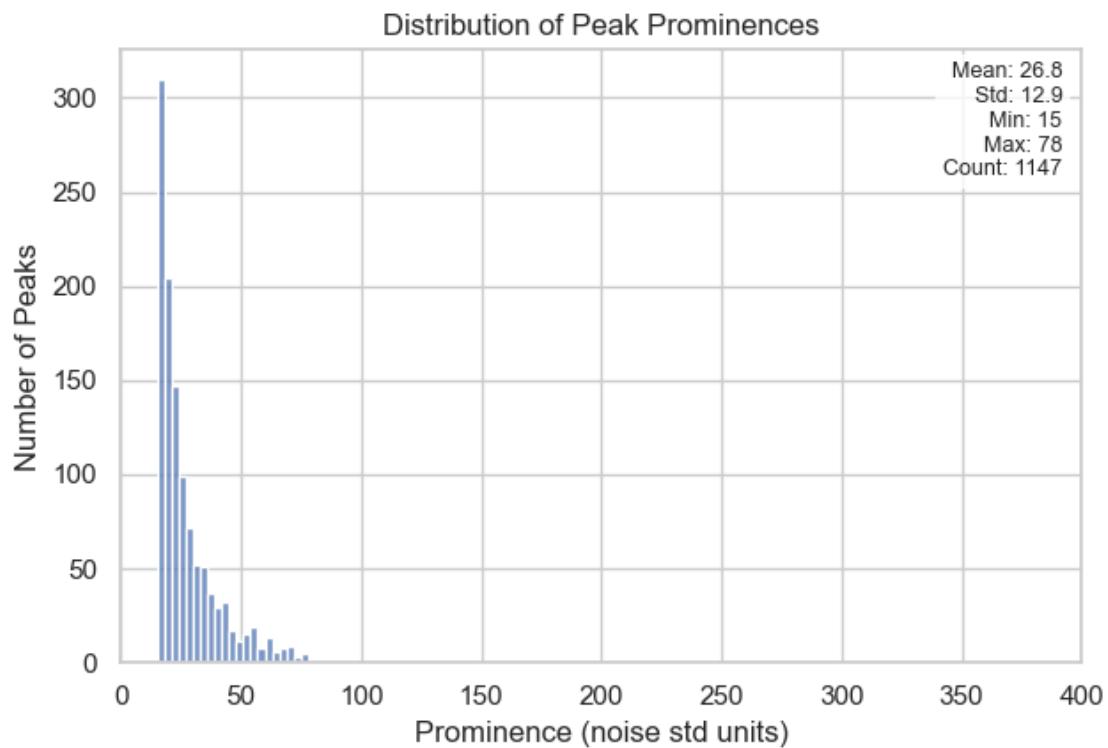


1.4.2 Peaks statistics in individual events

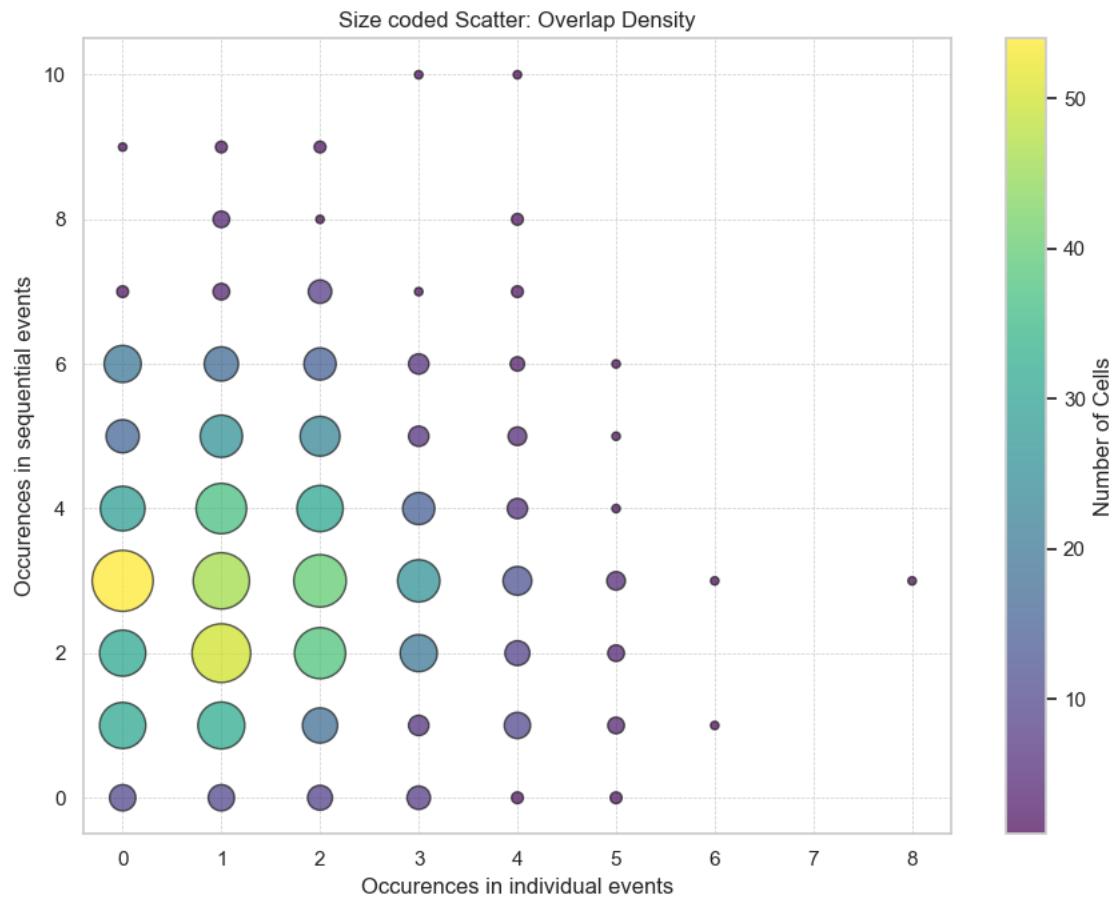
```
[2025-08-13 12:40:56] [INFO] calcium: plot_histogram: removed 22 outliers out of  
1183 on 'Duration (s)' (lower=-51, upper=117)
```



```
[2025-08-13 12:40:56] [INFO] calcium: plot_histogram: removed 36 outliers out of 1183 on 'Prominence (noise std units)' (lower=-28.5, upper=79.3)
```

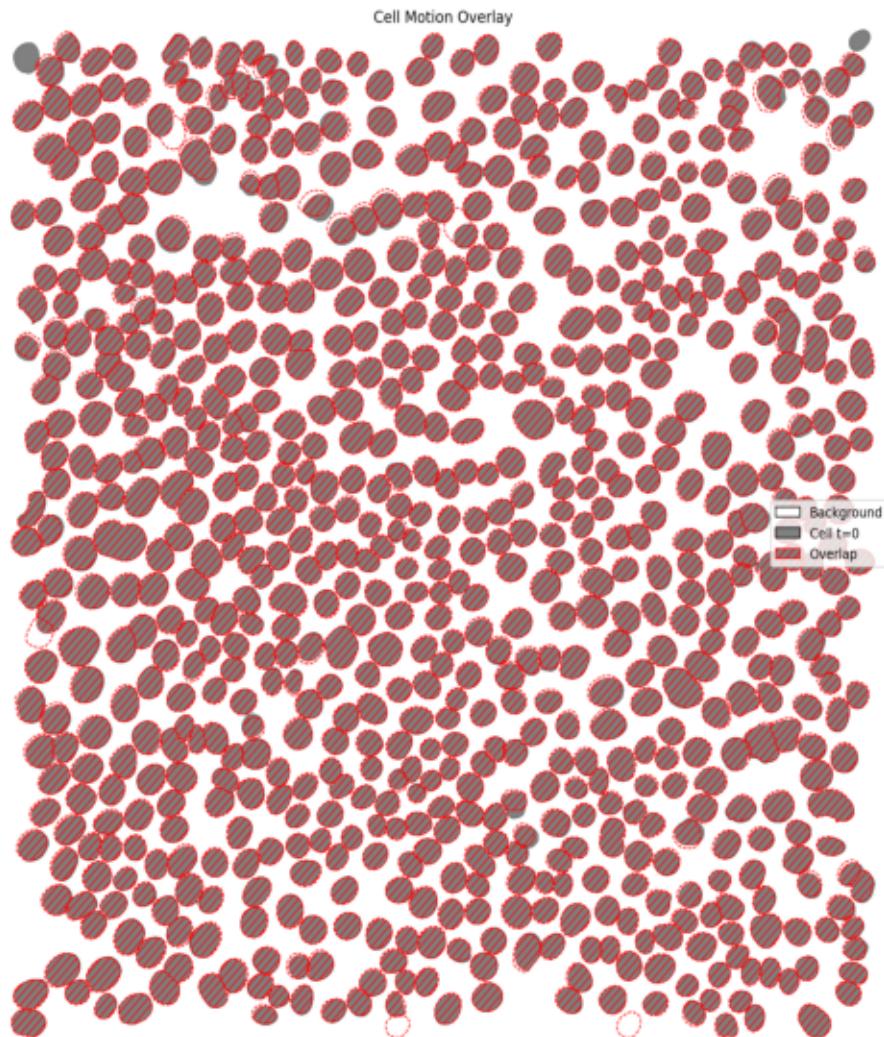


1.4.3 Correlation between event activity level & individual activity level



1.5 CELLS MOTION

Cell Motion Comparison Overlay - 20250810_IS2



Number of cells:

- Hoechst image taken at t=0: 769
- Hoechst image taken at t=1801: 772
- Number of cells difference: absolute 3, relative 0.39%

Pixel-level cell segmentation:

- Total number of pixels in image: 4194304
- Pixels segmented as cell at t=0: 1131703
- Pixels segmented as cell at t=1801: 1147604
- Overlapping pixels between t=0 and t=1801: 1070512 (93.93% of total)
- Pixels exclusive to t=0: 61191 (5.41% of total)
- Pixels exclusive to t=1801: 77092 (6.72% of total)