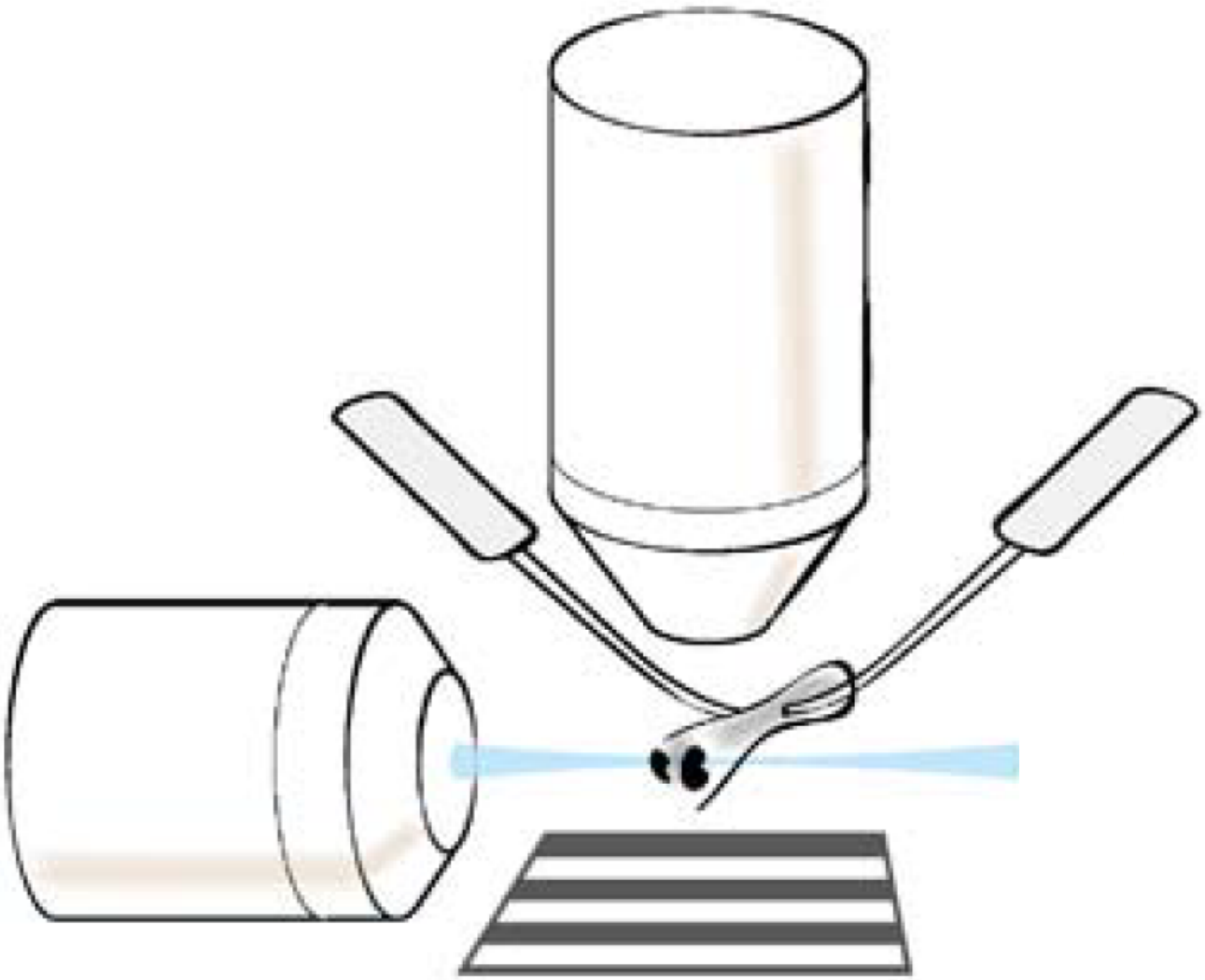
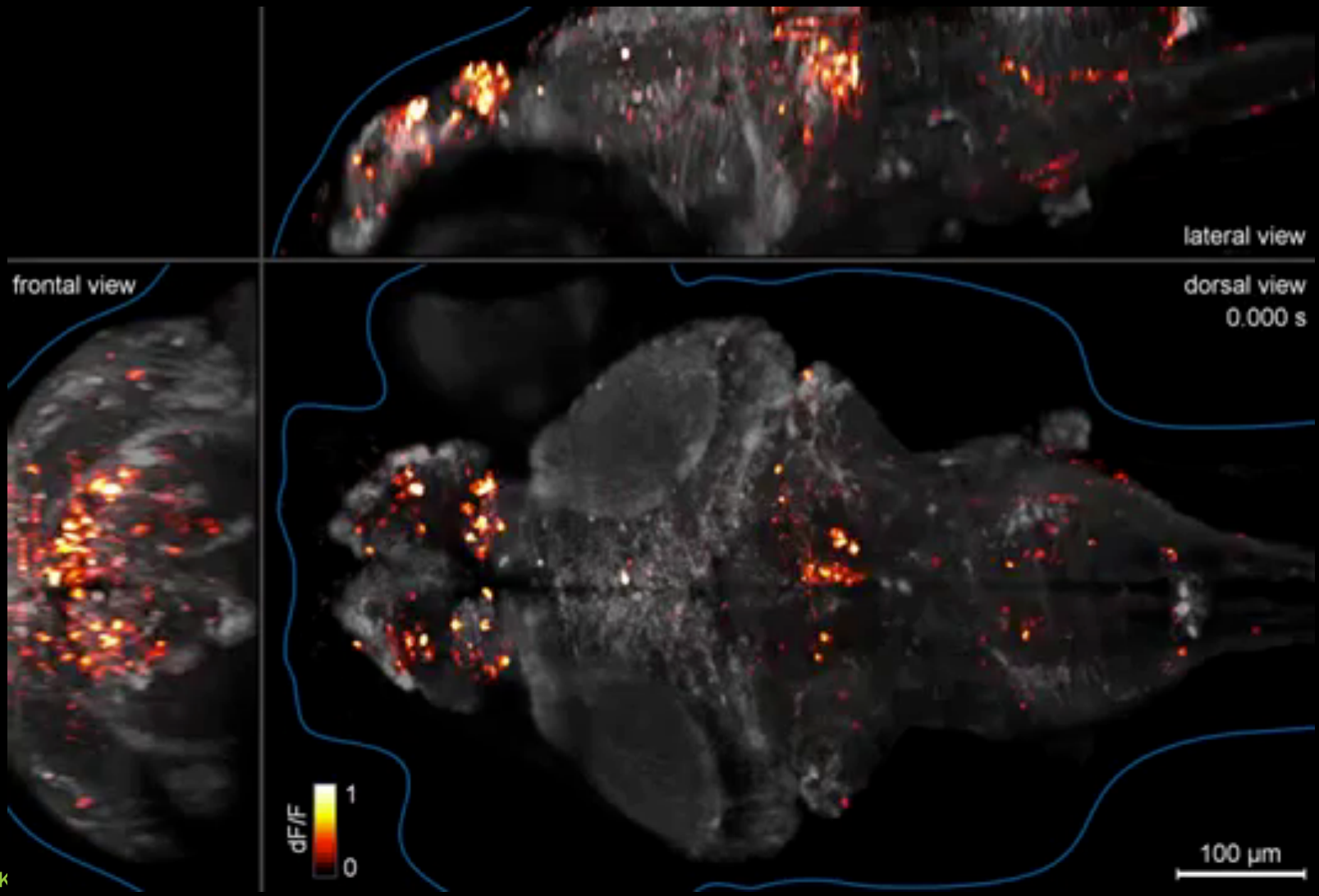
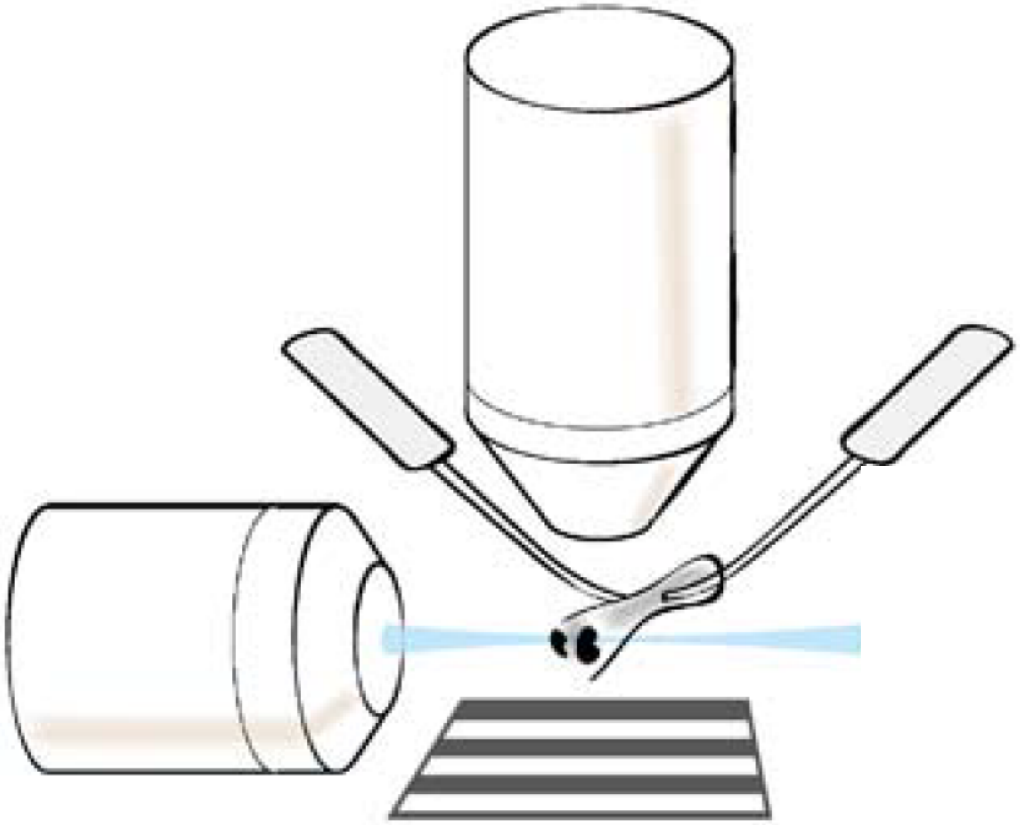
Bolt:
Building a distributed ndarray

Jason Wittenbach
Janelia Research Campus (HHMI)
Freeman Lab

SPARK SUMMIT 2016
DATA SCIENCE AND ENGINEERING AT SCALE
JUNE 6-8, 2016 SAN FRANCISCO




lateral view
frontal view
dorsal view
0.000 s
dF/F
1
0
100 µm



t, (x, y, z)

time ~ 10^4

space ~ 10^7

~ 10^{11} elements

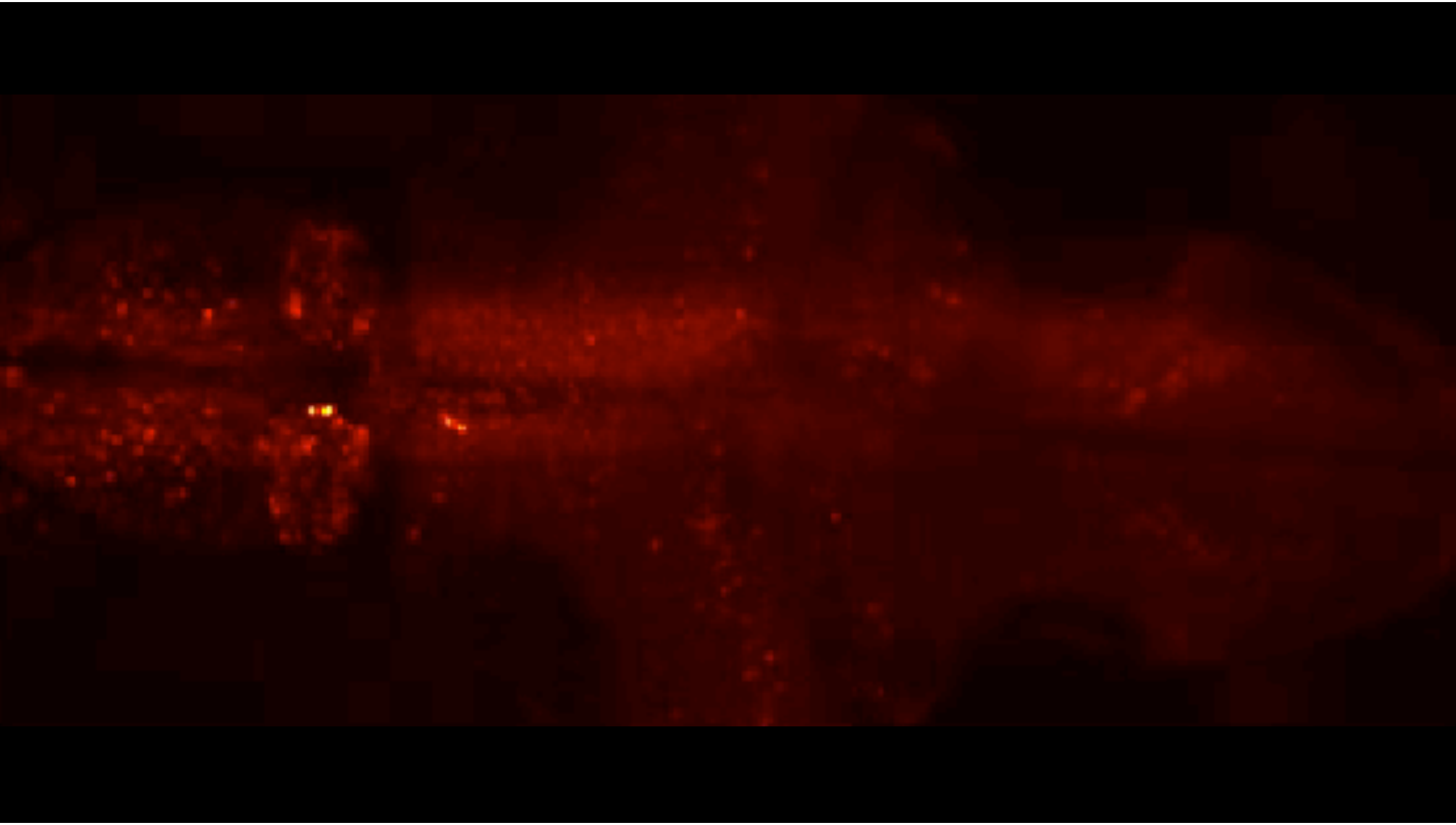
~ 1 TB

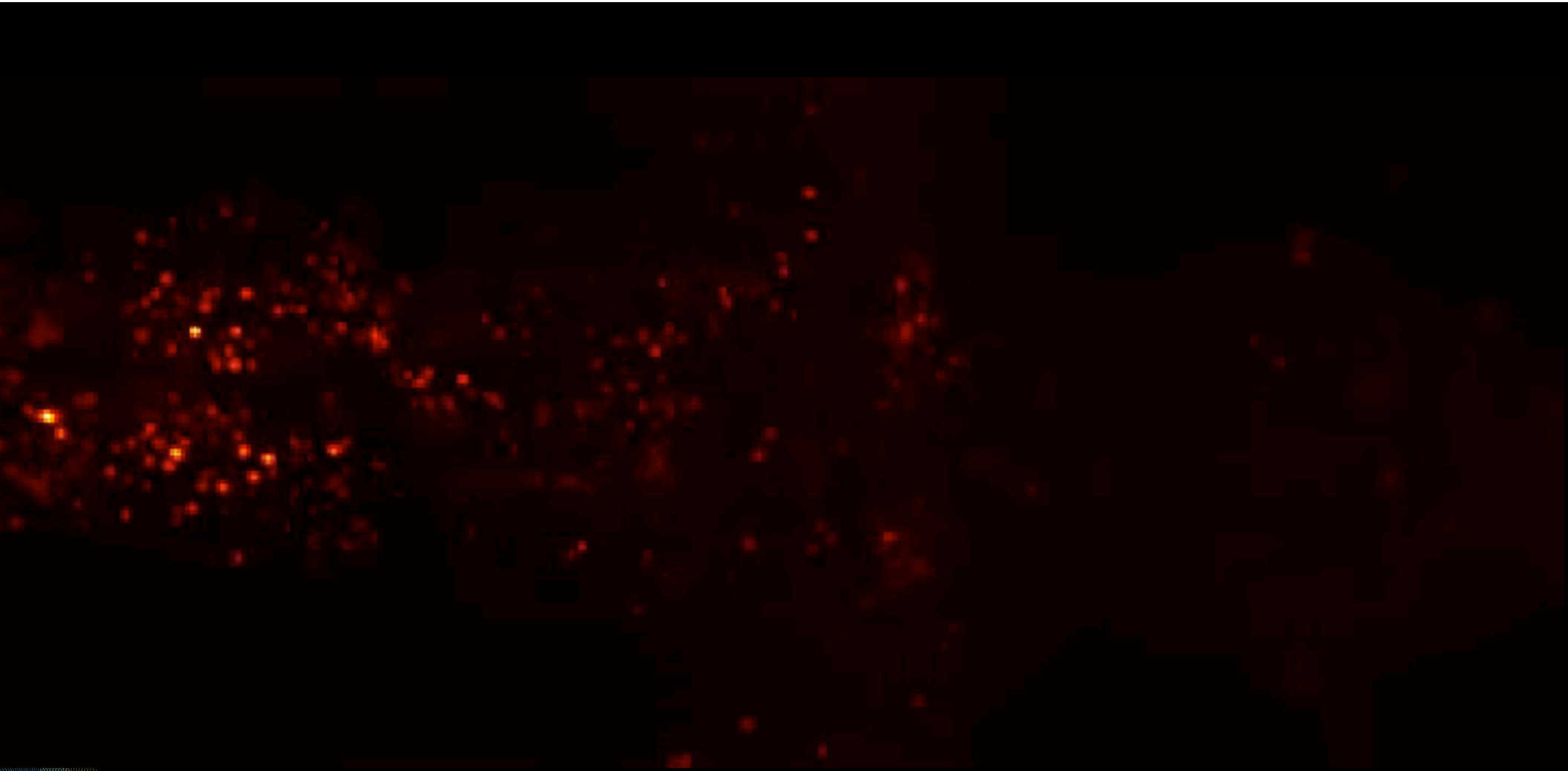
(n, k)

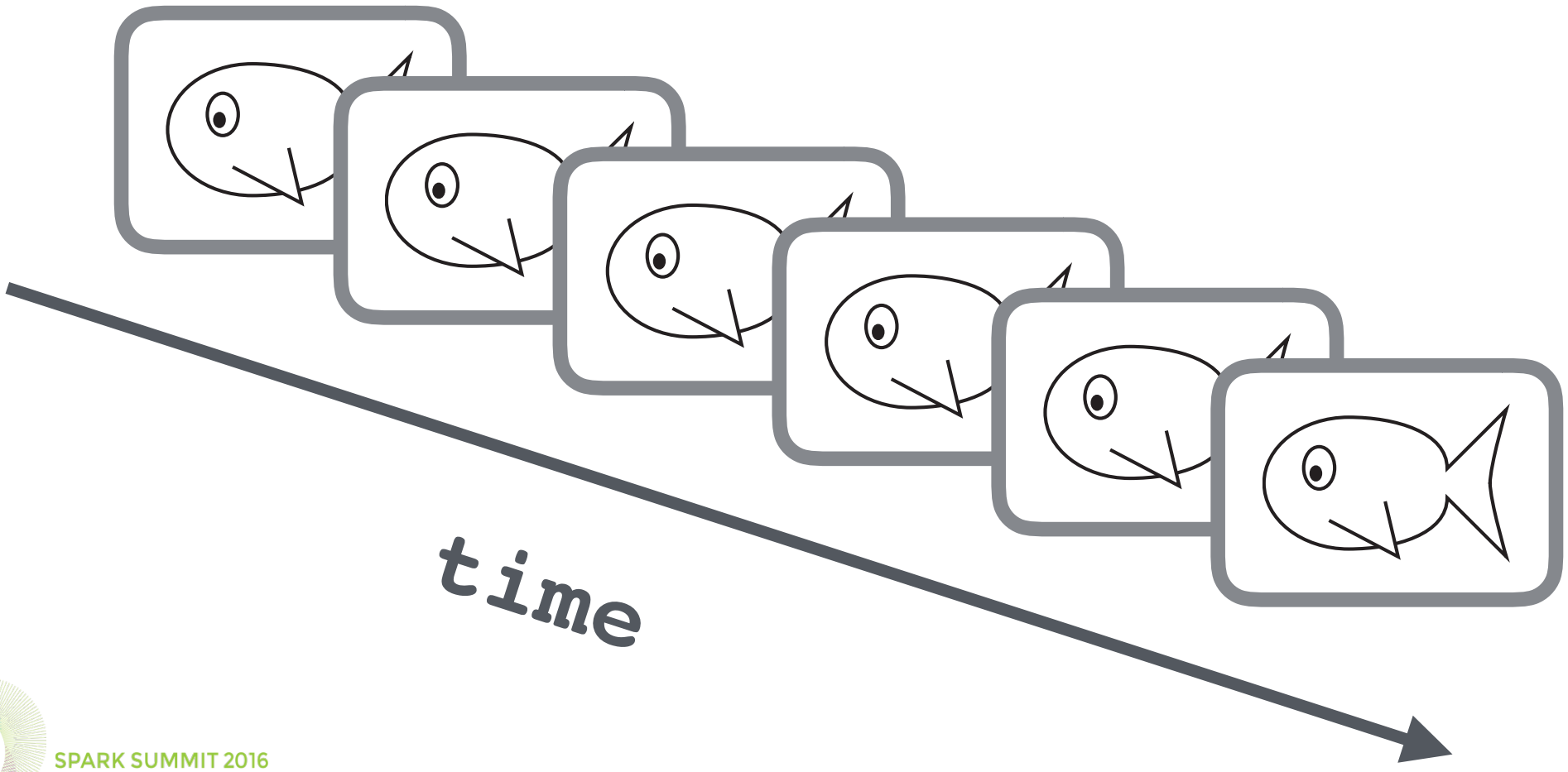
(x, y, t)

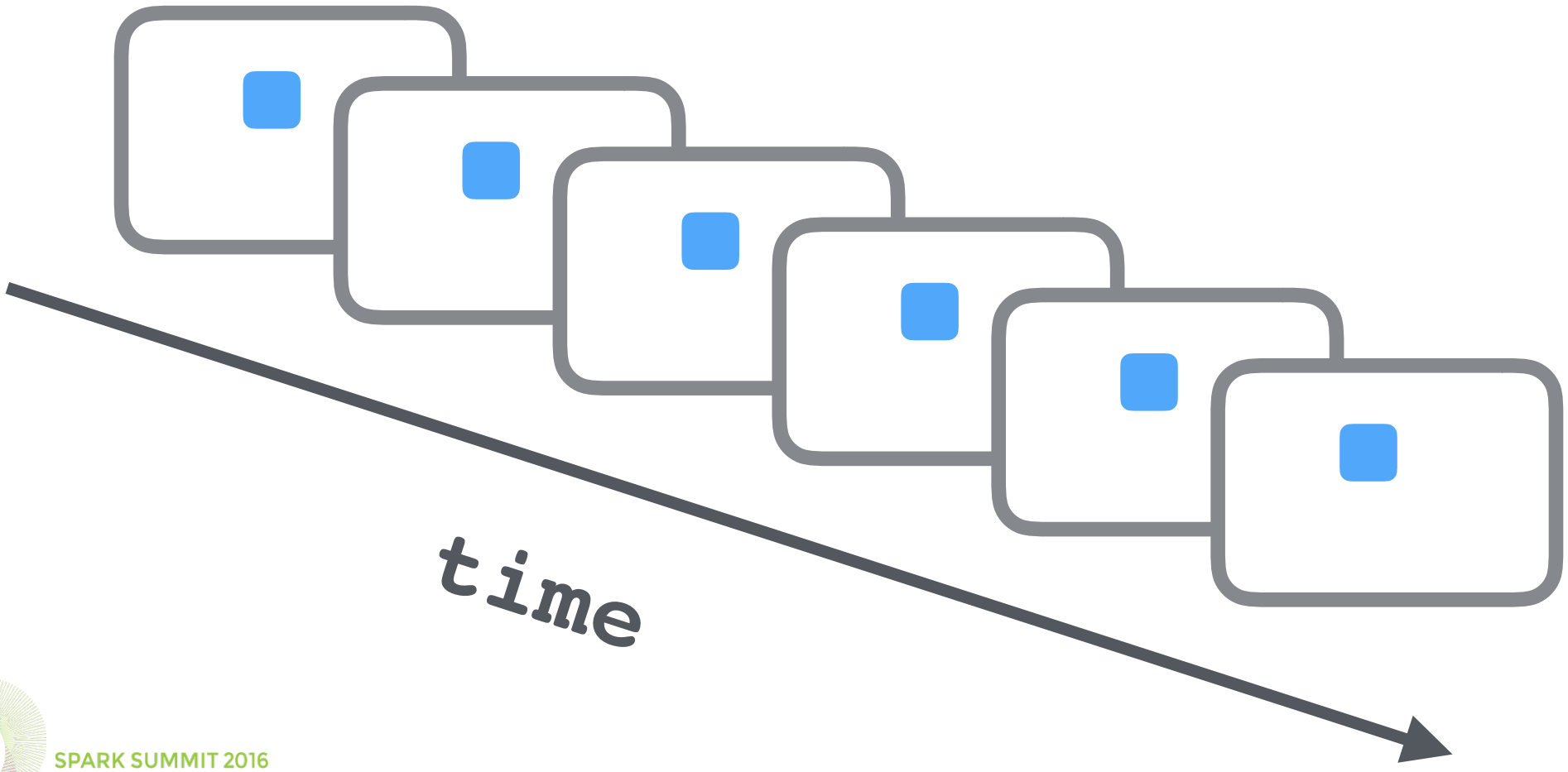
(x, y, z, t)

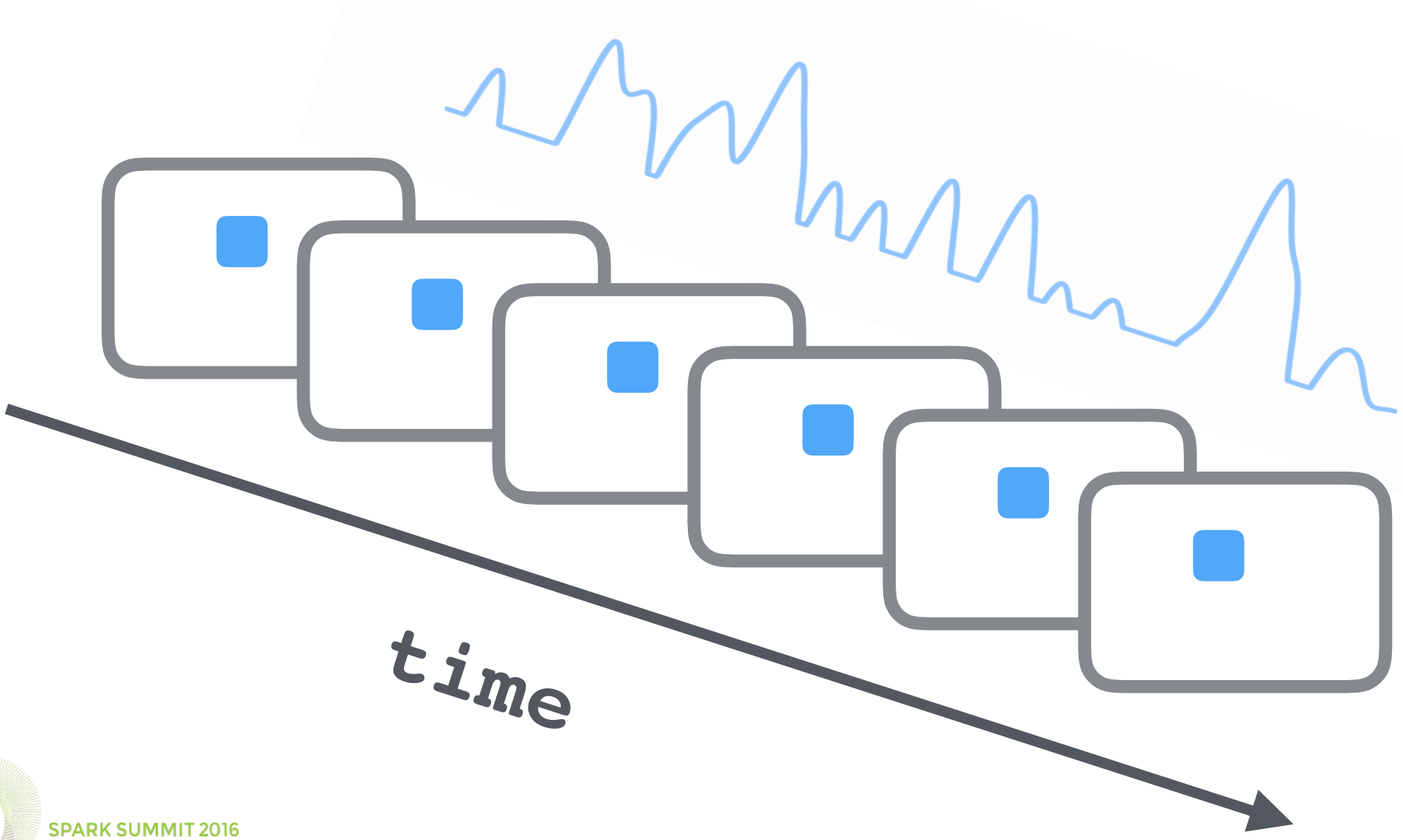
(x, y, z, c, t)

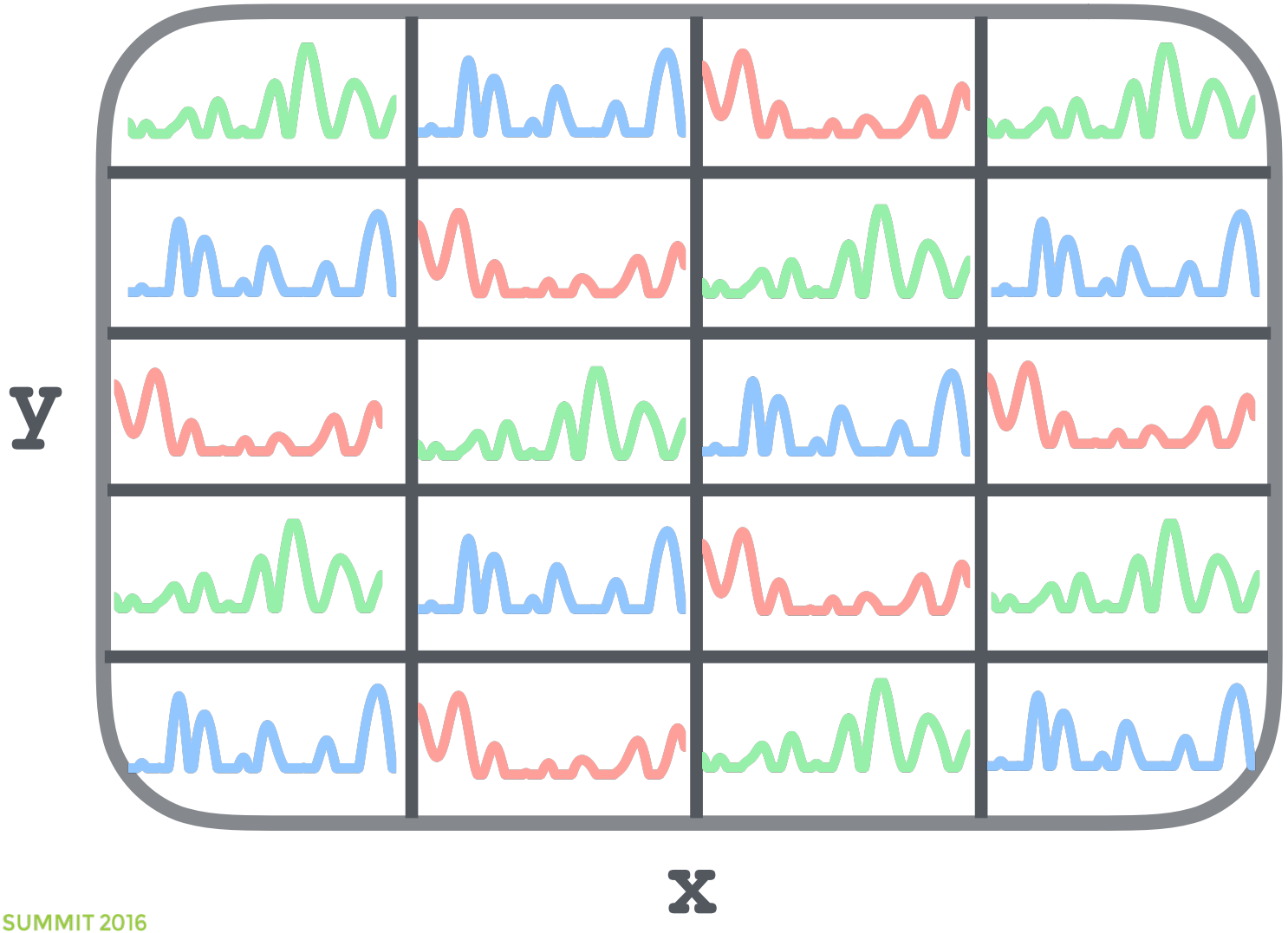





time


time


time


y
x

neuroscience

astronomy

geospatial

climate science

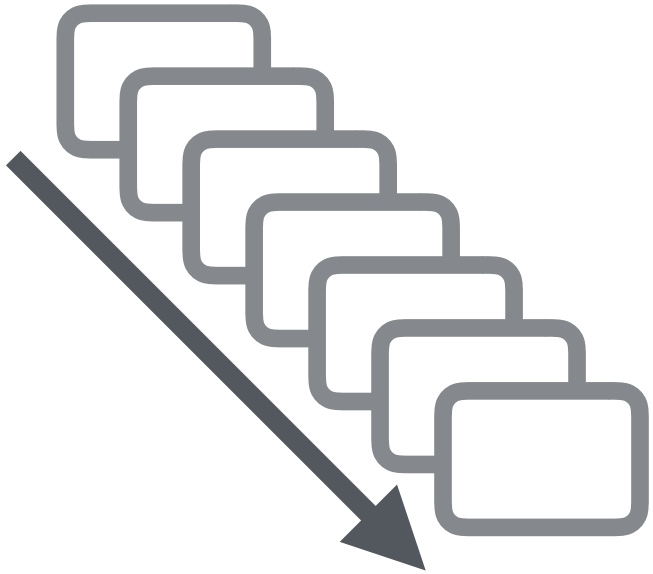
bolt

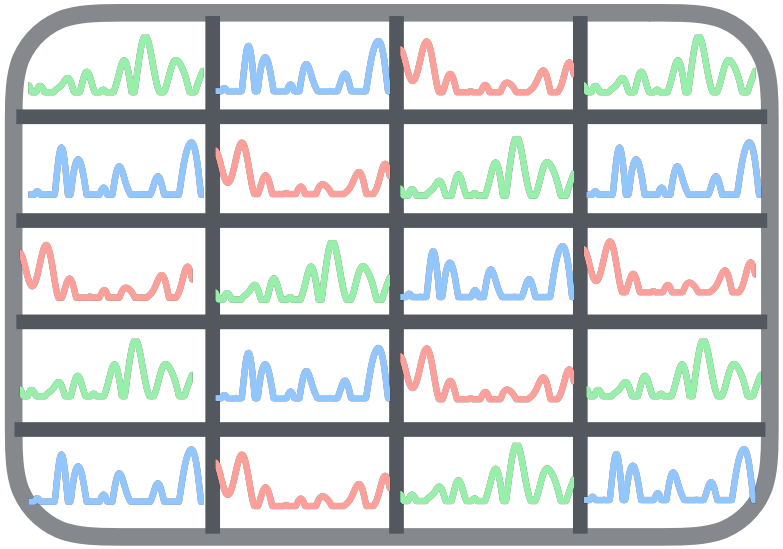
- a distributed ndarray
- built on PySpark
- conforms to NumPy API

```
data.mean(axis=0)

data.T

data[2, 4:10]
```



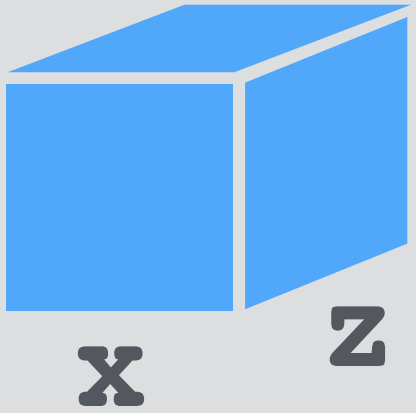


(t,| x, y, z)

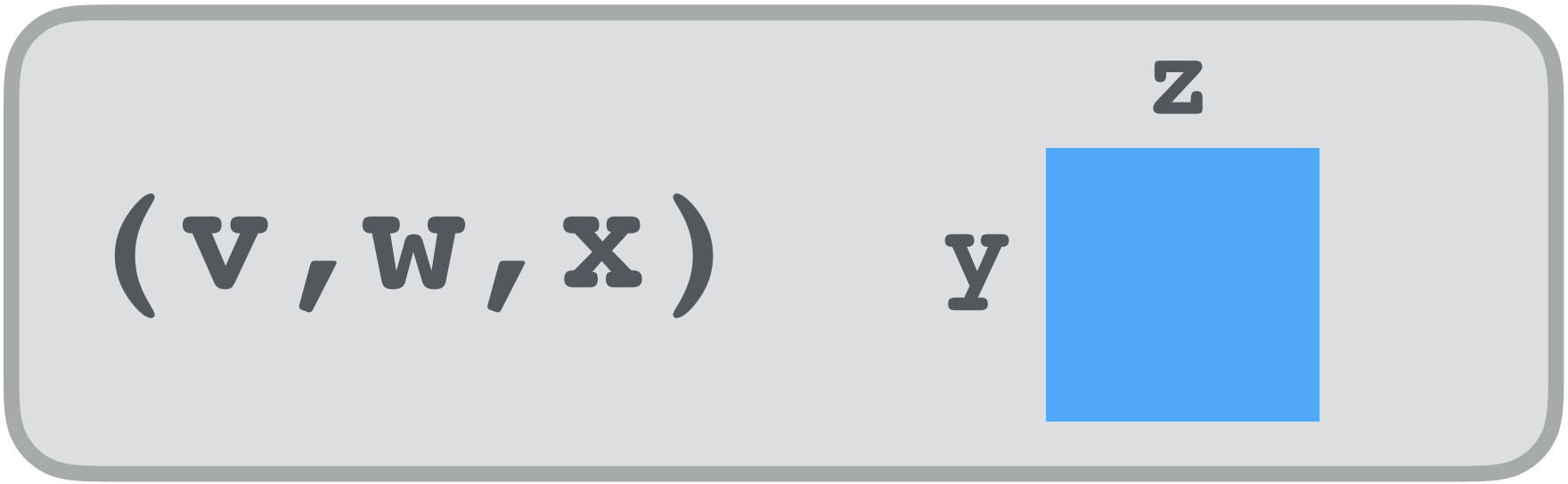
(x, y, z,| t)

(v, w, | x, y, z)

(v,w)

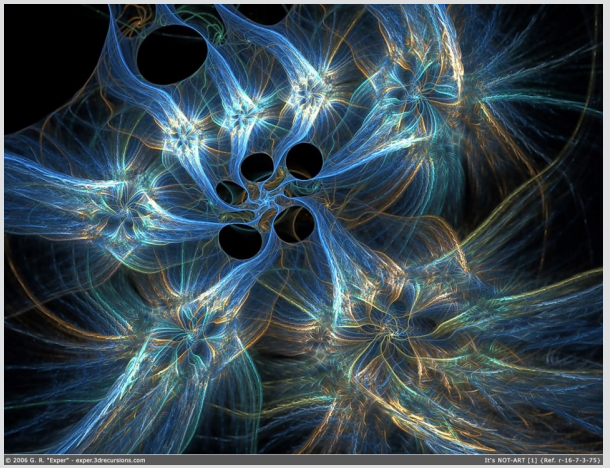


(v, w, x, | y, z)



```
(v, | w, x, y, z)
```

```
(v)
```



```
indexing          slicing
    apply-along-axis
```

indexing slicing

apply-along-axis

transpose reshape

indexing slicing

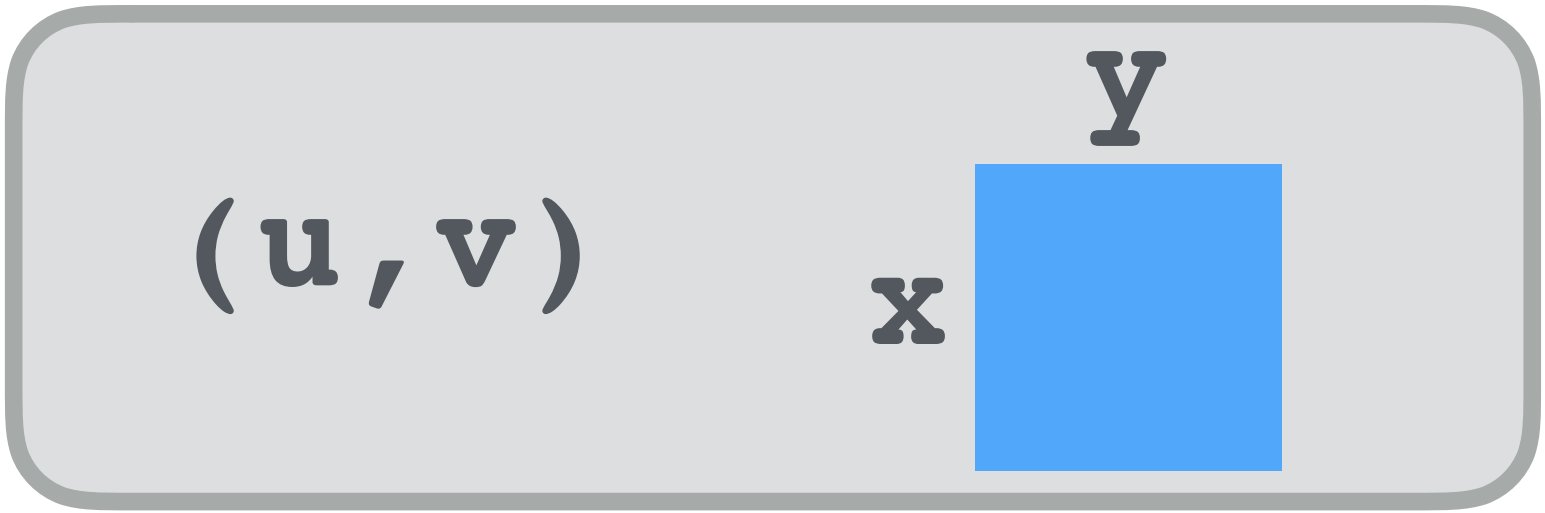
apply-along-axis

transpose reshape

map reduce filter

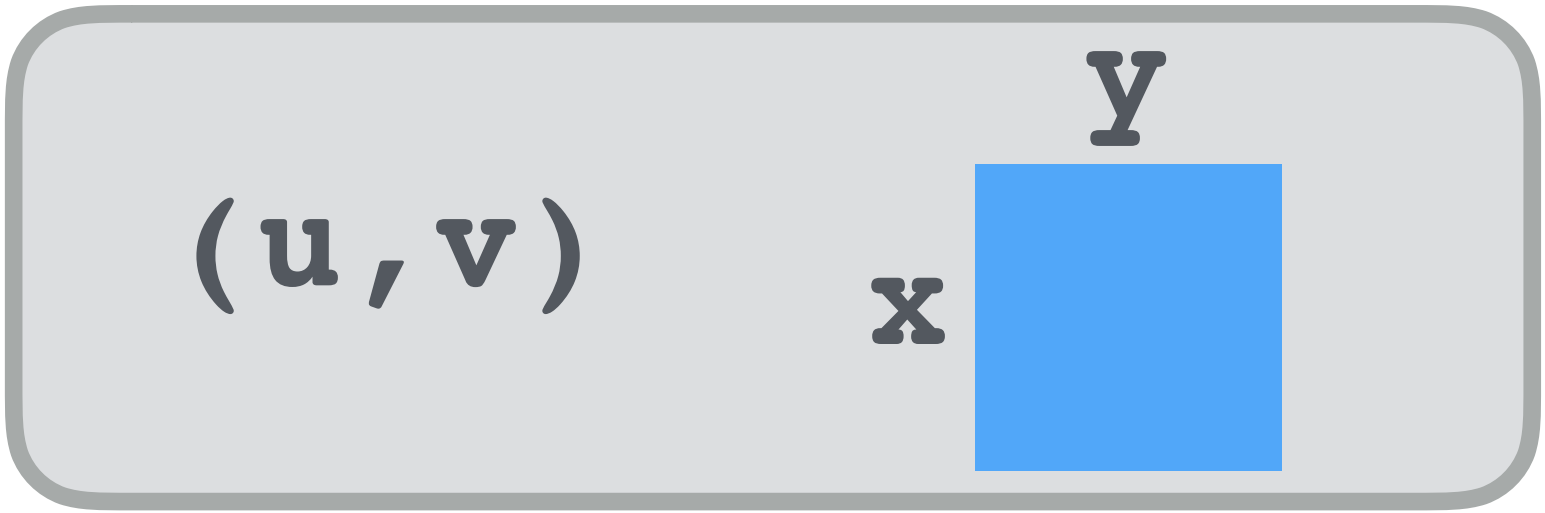
chunking padding

indexing → filter
map

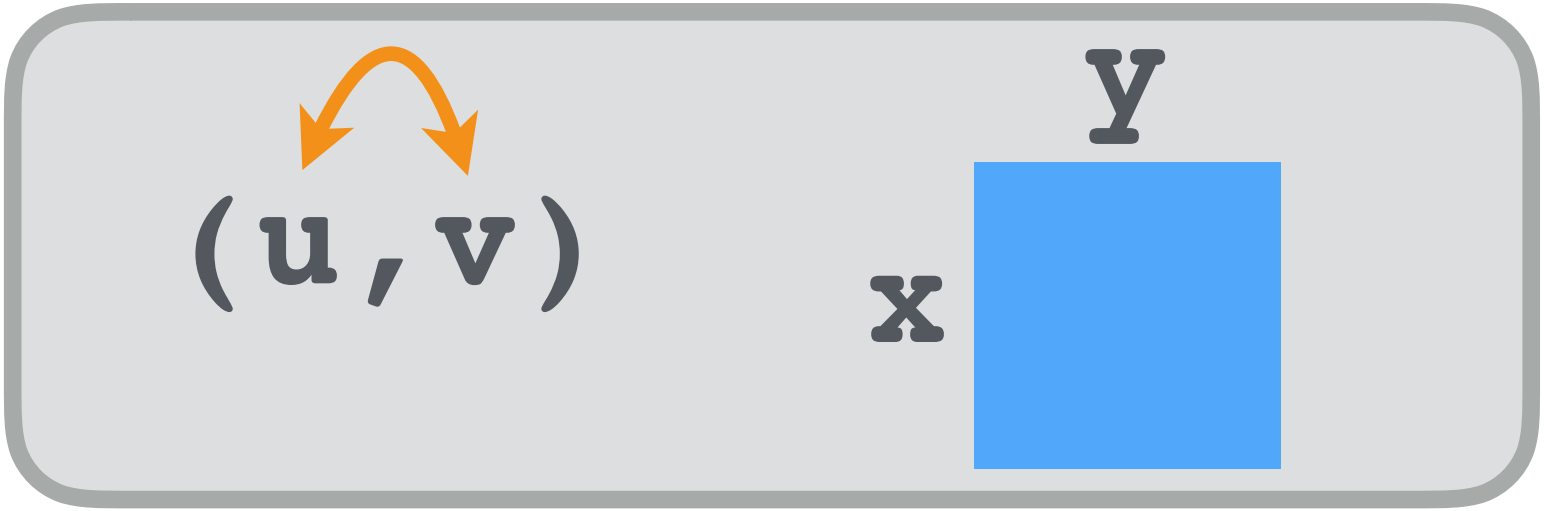


apply-along-axis

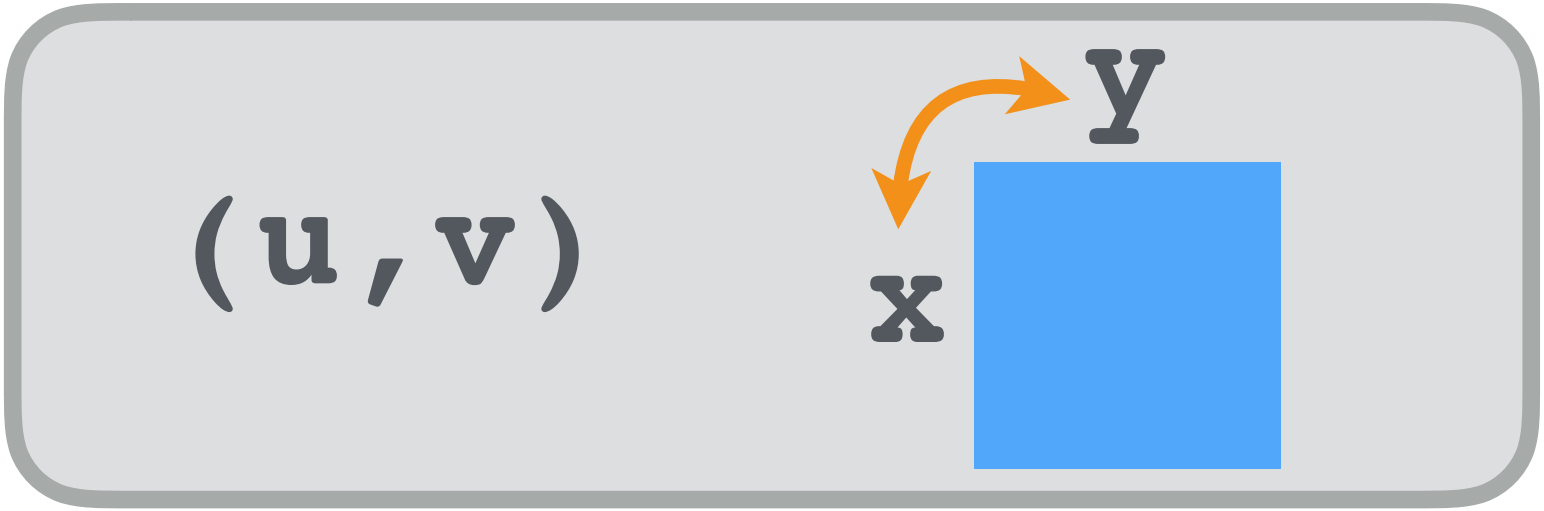
map reduceByKey



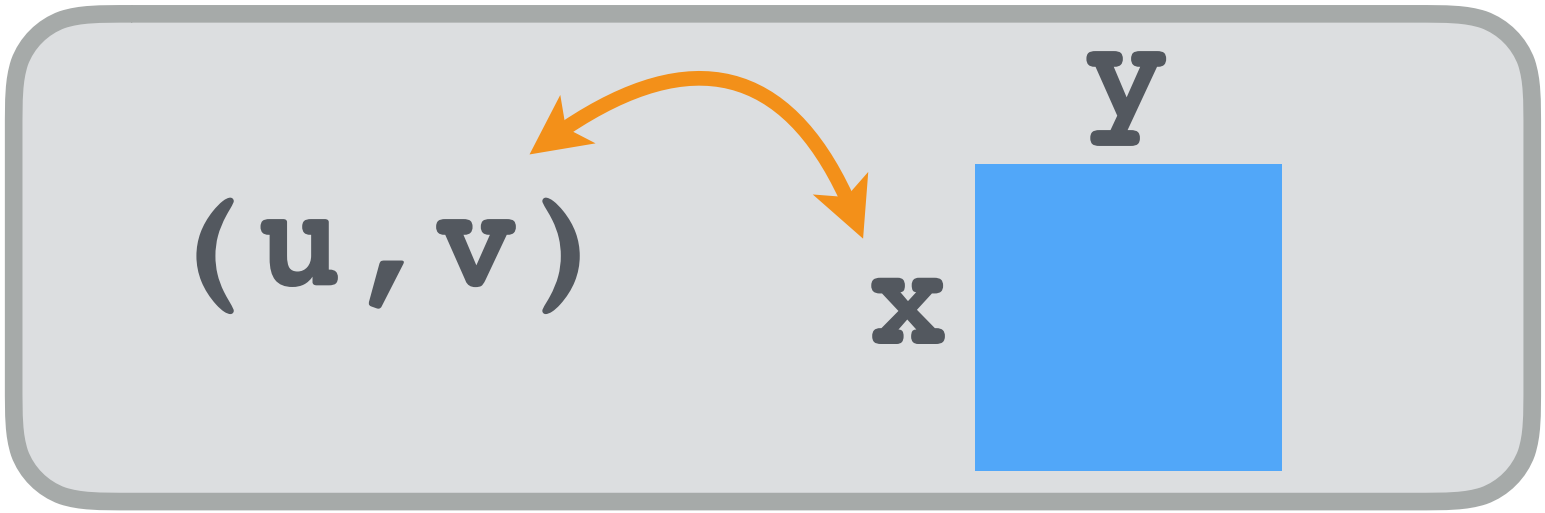
transpose → map

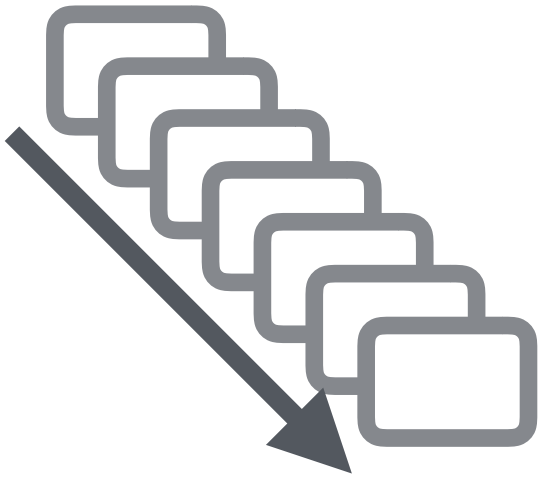


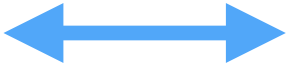
transpose → map

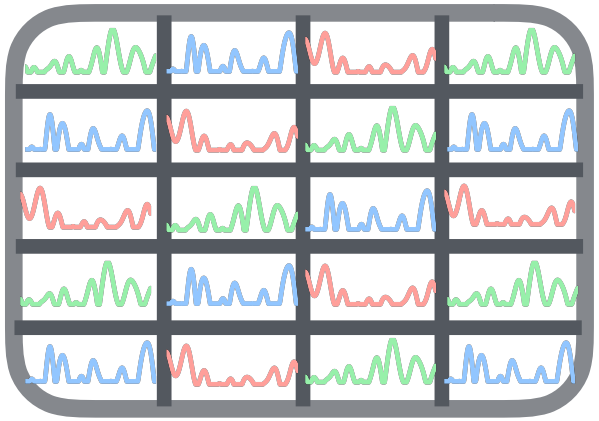


transpose → shuffle







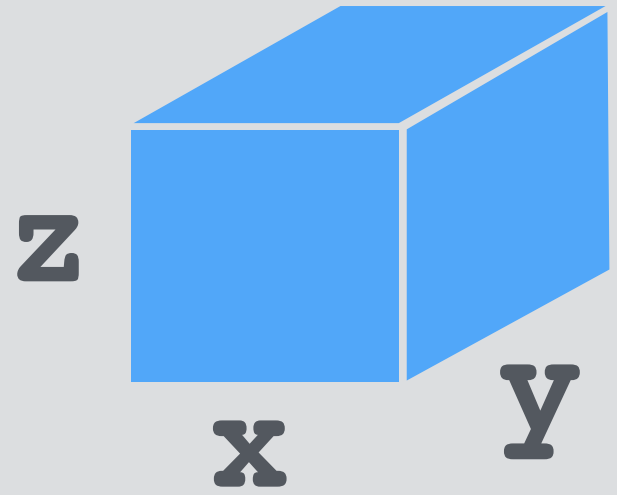


(t | x,y,z)

(x,y,z | t)

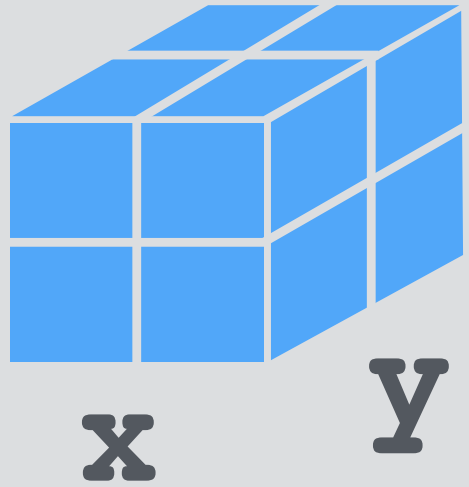
(t | x, y, z)

(t)

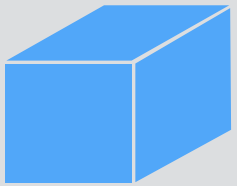


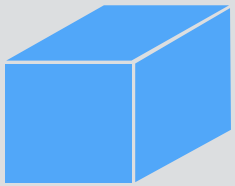
(t | x, y, z)

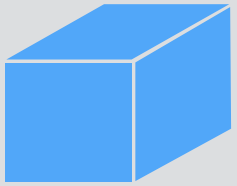
(t)



(t | x, y, z)

(t,chunk) 

(t,chunk) 

(t,chunk) 

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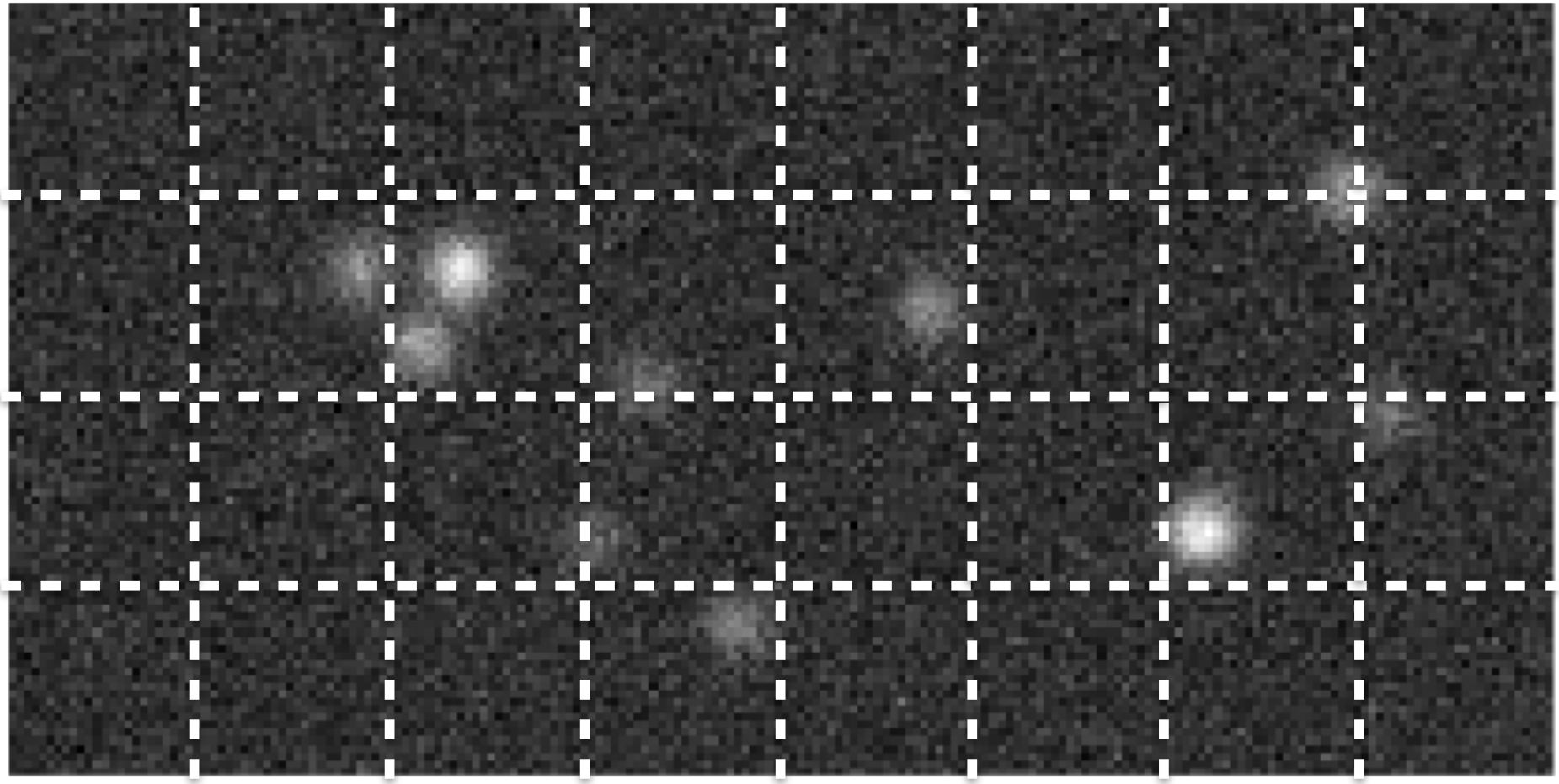
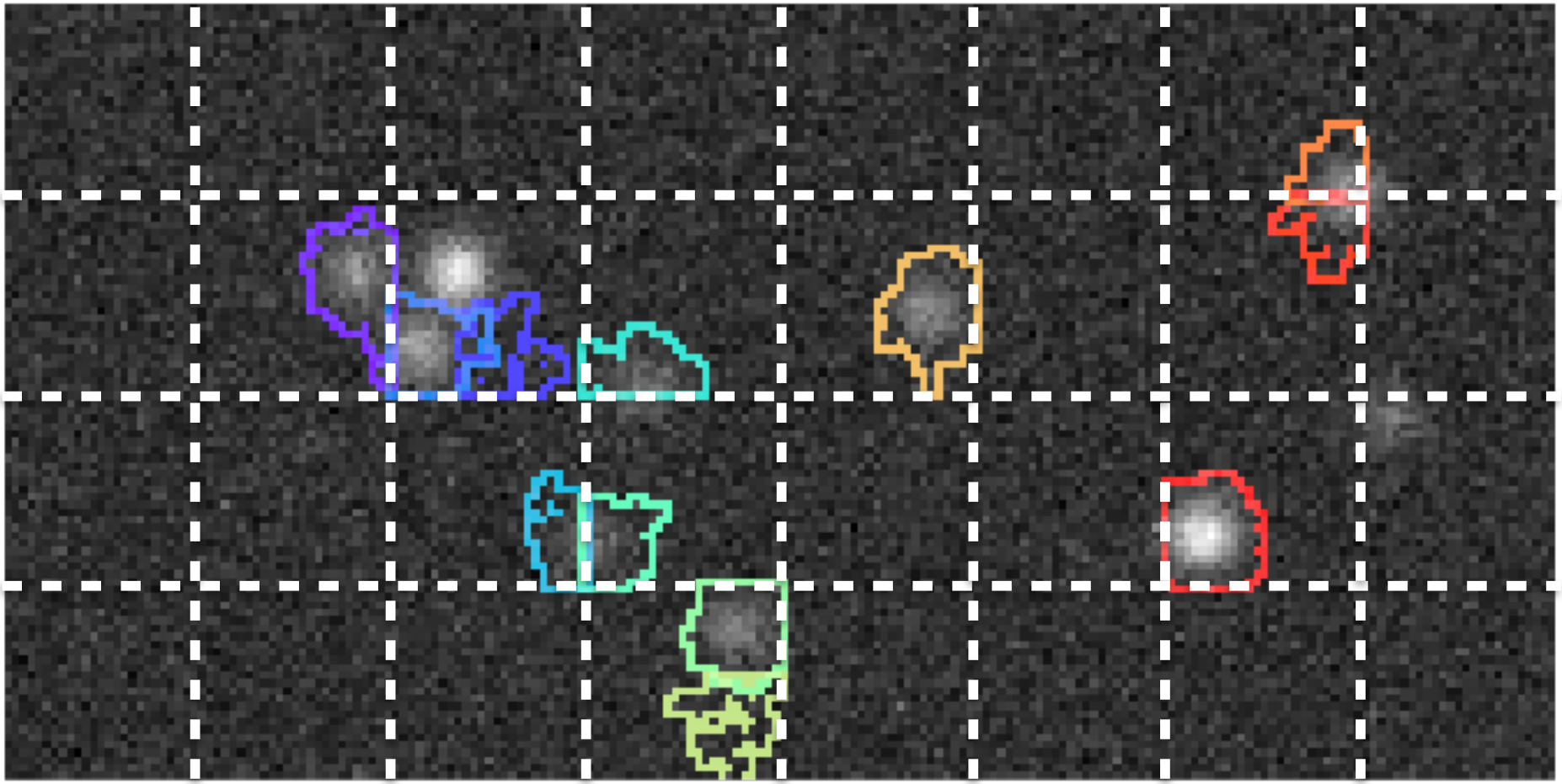
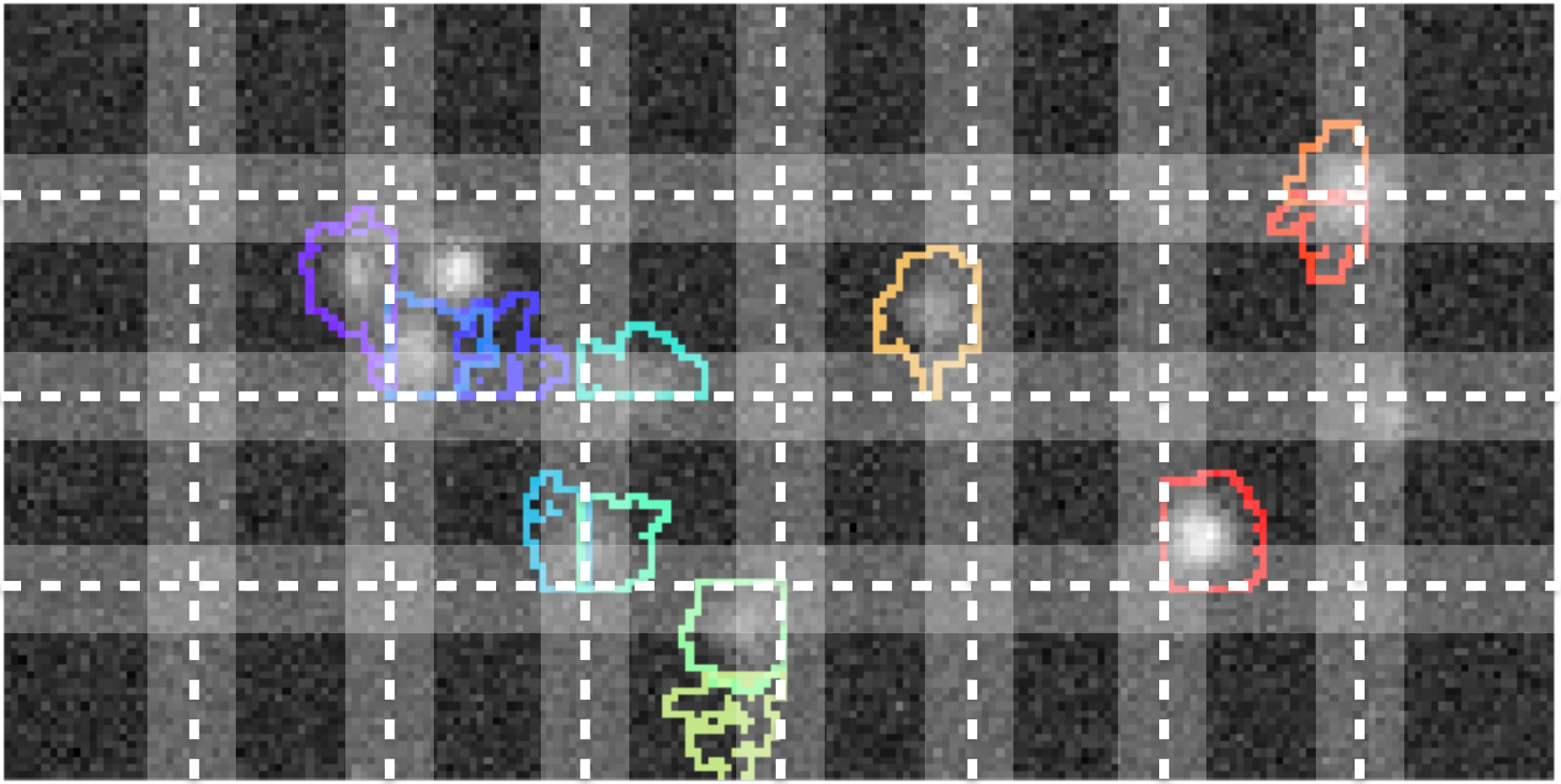
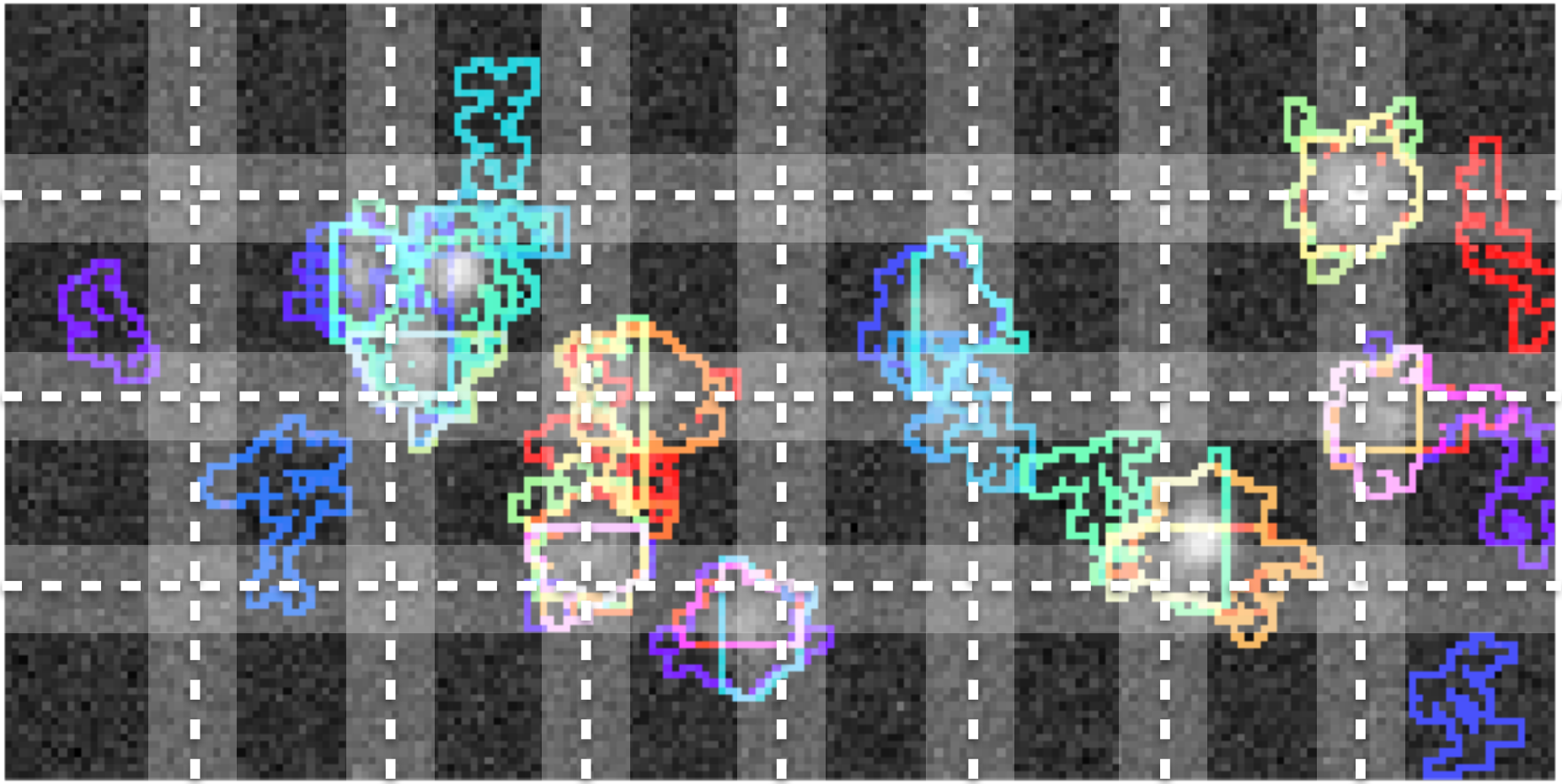
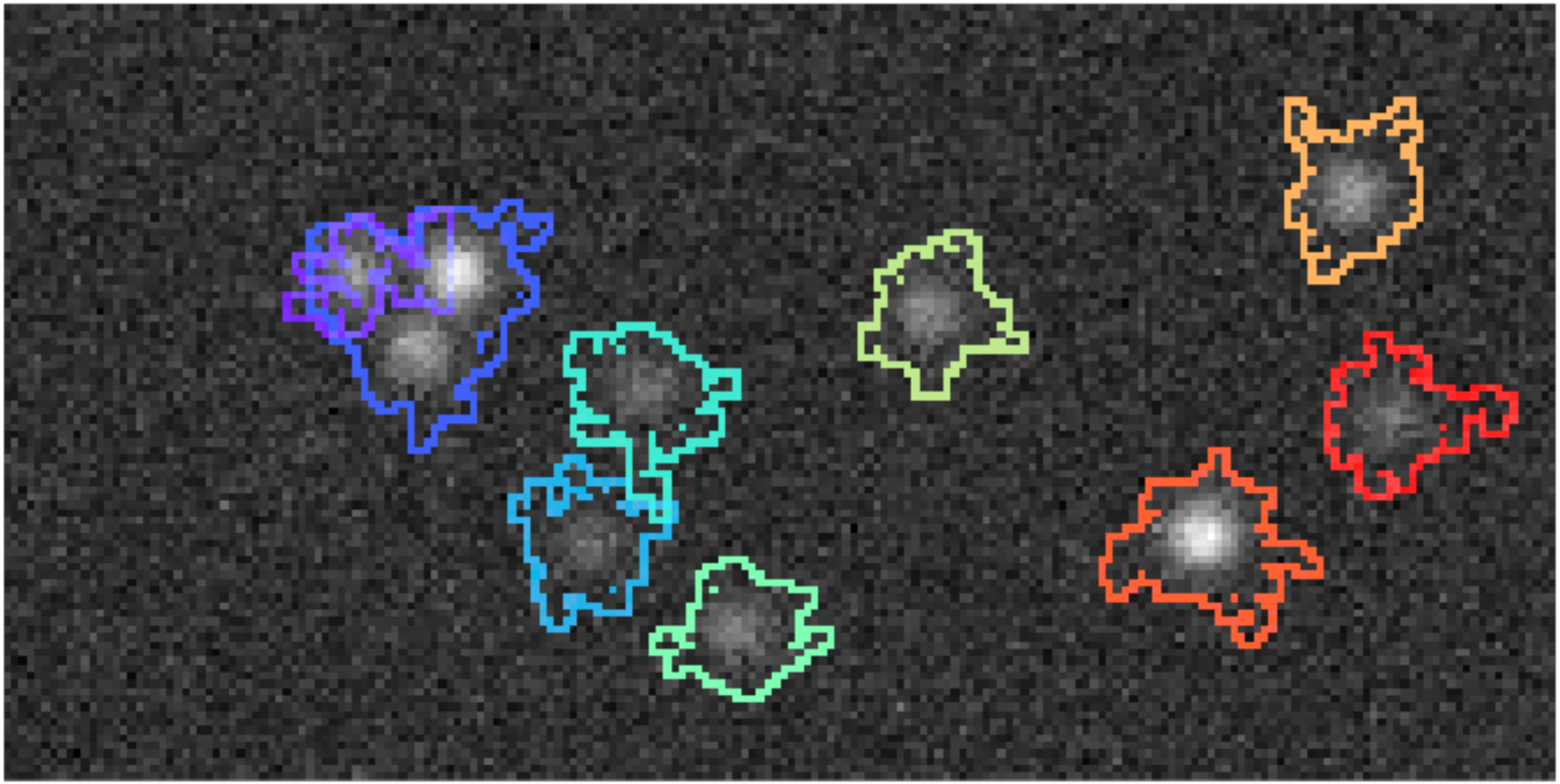










chunking

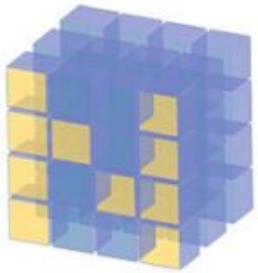
+

transpose

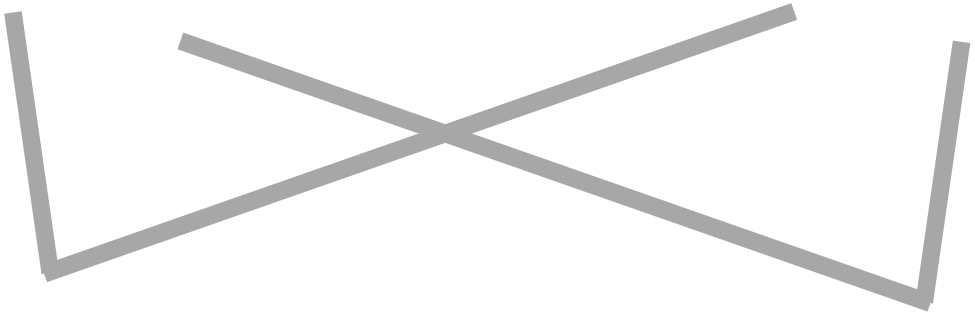
=

shuffle optimization

bolt



NumPy



thunder

???

thanks

Freeman Lab

Jeremy Freeman
Nicholas Sofroniew
Andrew Osheroff

Janelia Scientific Computing

Ken Carlile
Robert Lines

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