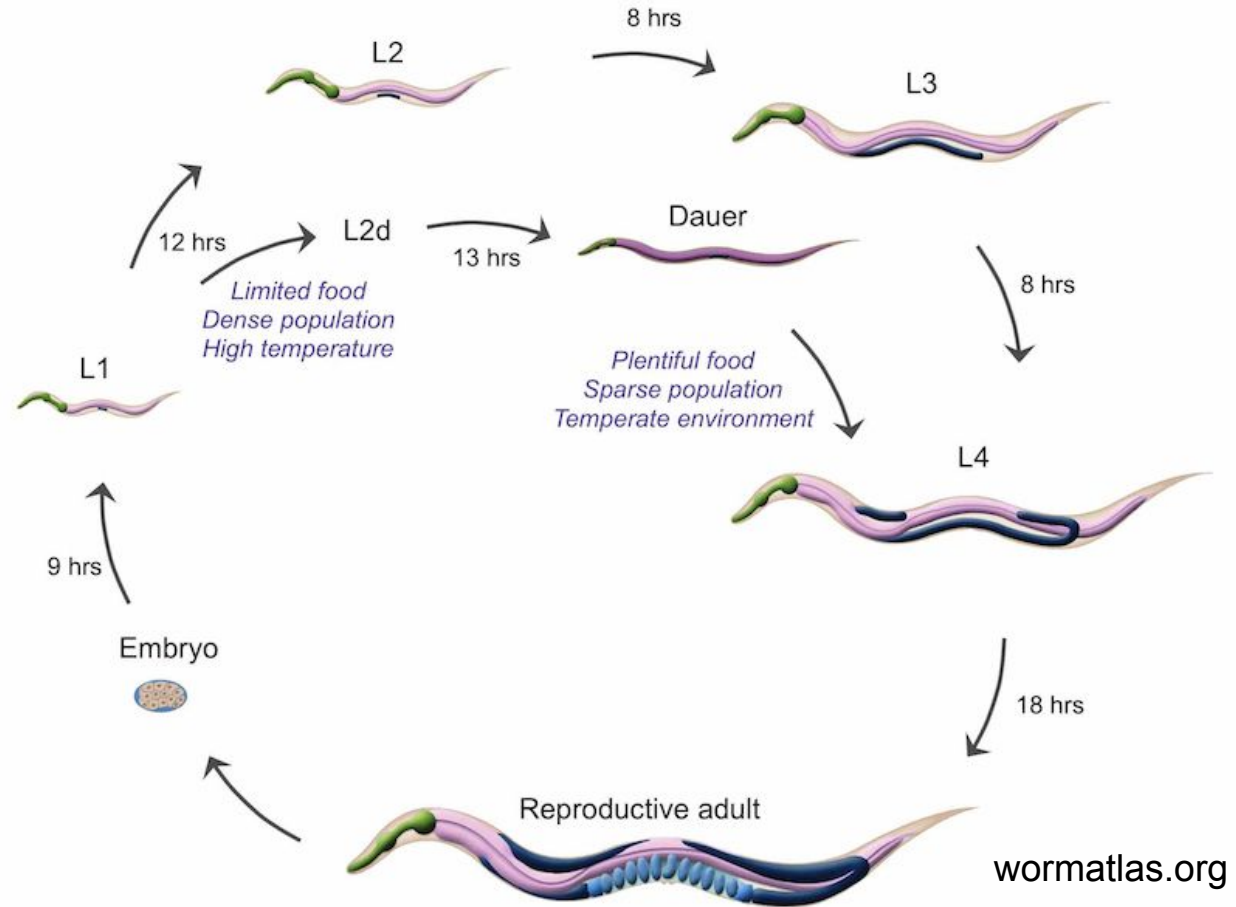# Dauer vs Non-dauer

Ali Fathi
Zhen Lab, Sep 2022
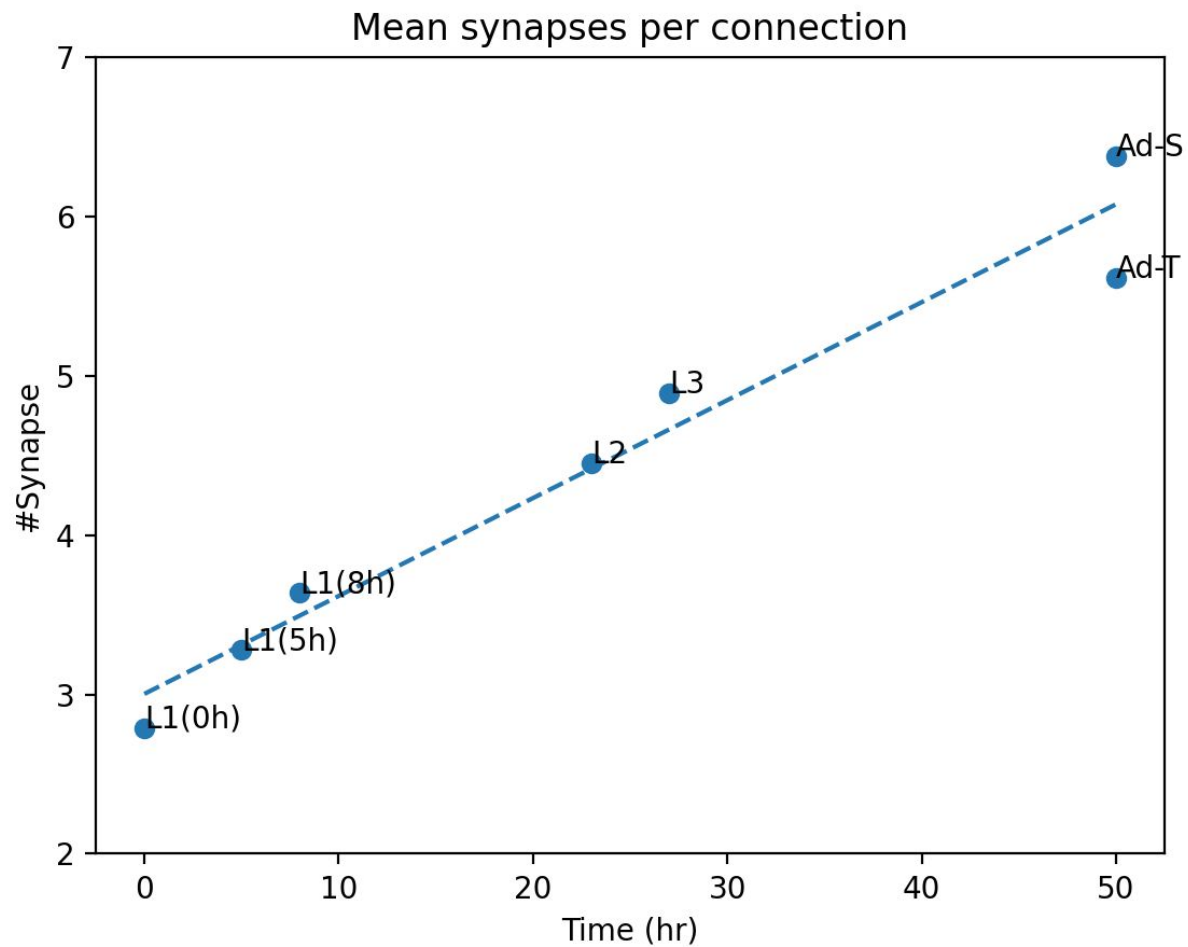
Deficiencies (mostly lack of time)

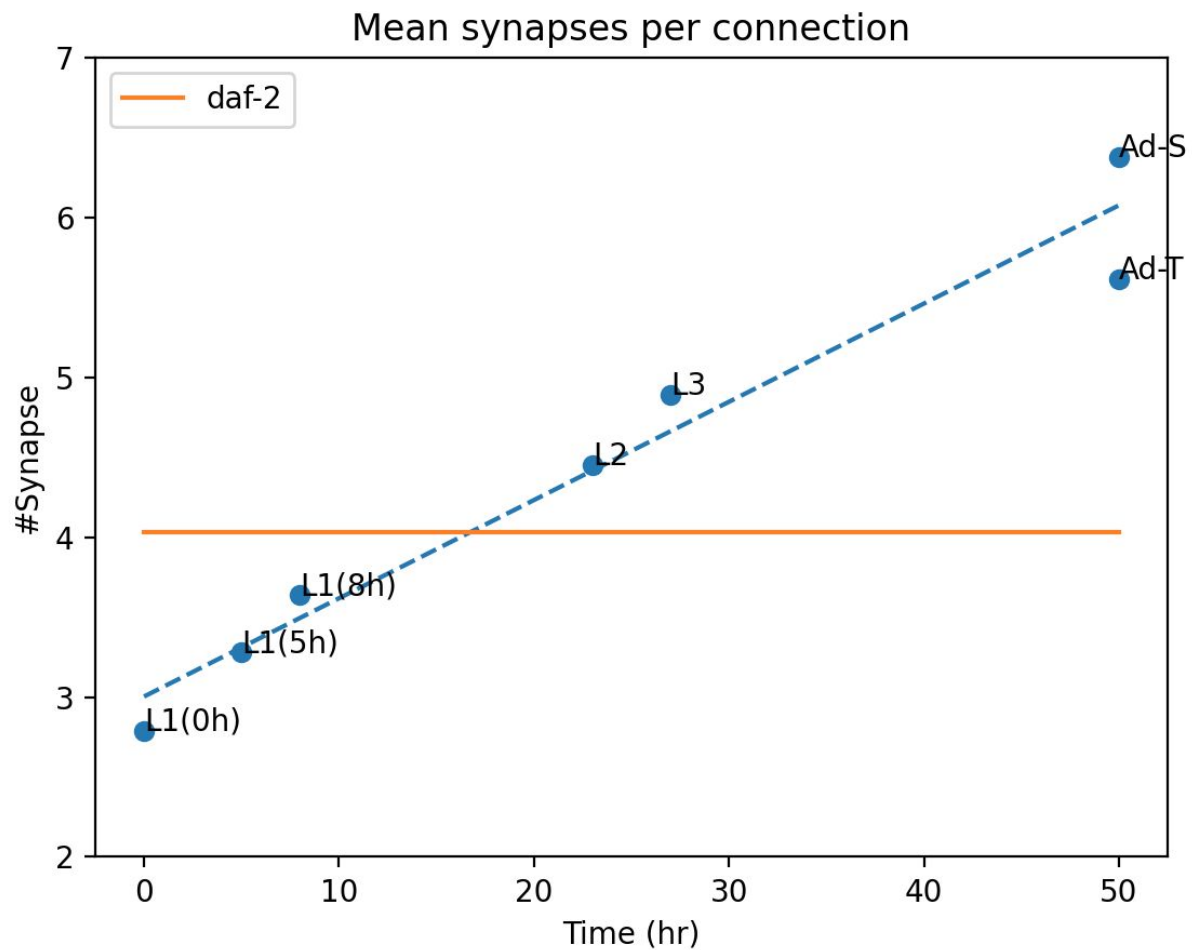- Some results may not be correct
  (problems in codes, reading data, methods, …)

- Not manually curated (including artifacts)

- Incomplete results

- So many overlap with Daniel, William, and Mona's works

Intro: dauer

L2

8 hrs

L3

12 hrs → L2d

Limited food
Dense population
High temperature

13 hrs → Dauer

8 hrs

Plentiful food
Sparse population
Temperate environment

L1

L4

9 hrs

Embryo

18 hrs

Reproductive adult

wormatlas.org

3

Where (When) is dauer?

Mean synapses per connection

Mean synapses per connection

- daf-2
- Ad-S
- Ad-T
- L3
- L2
- L1(8h)
- L1(5h)
- L1(0h)

#Synapse

Time (hr)

Total number of synapses

Total number of synapses
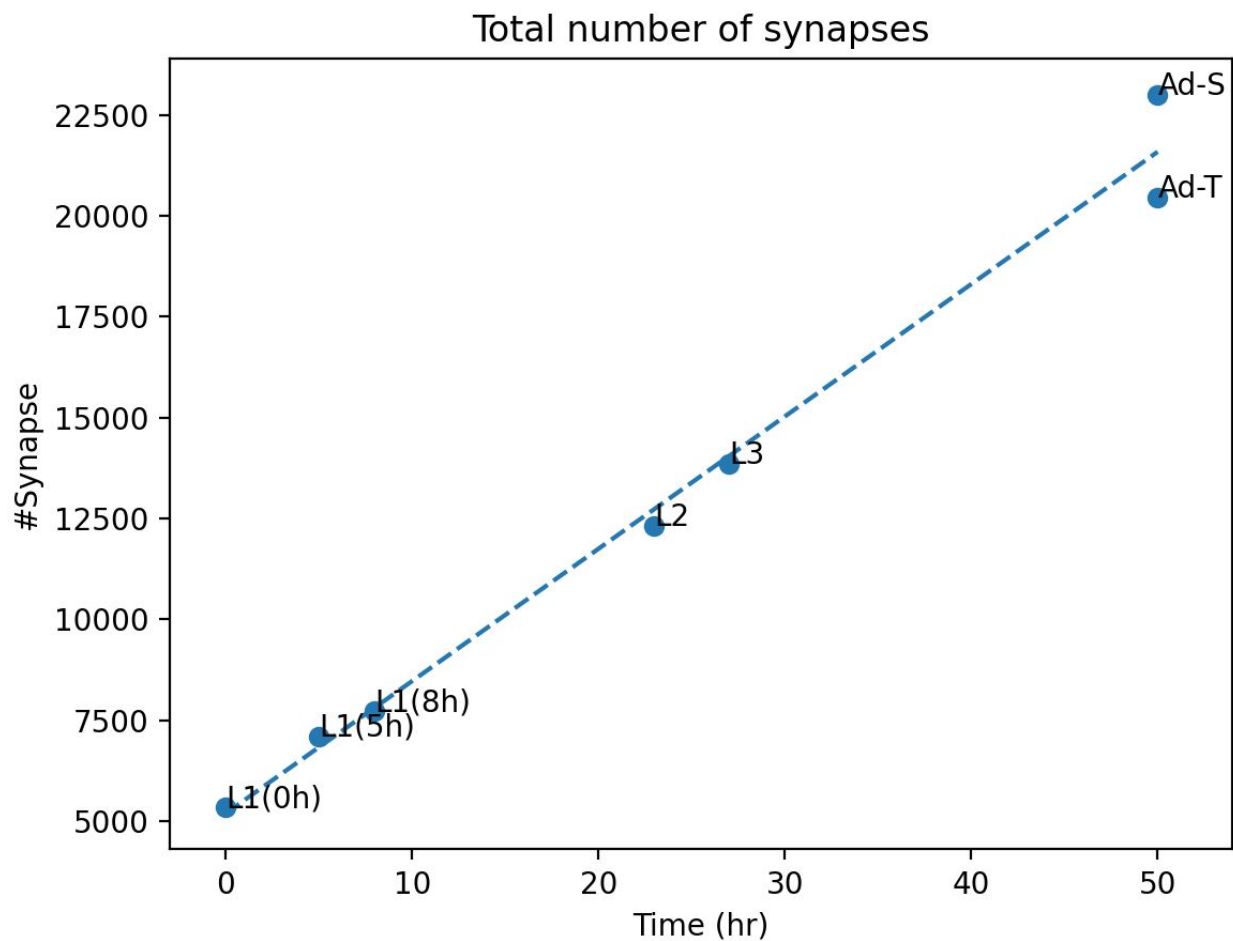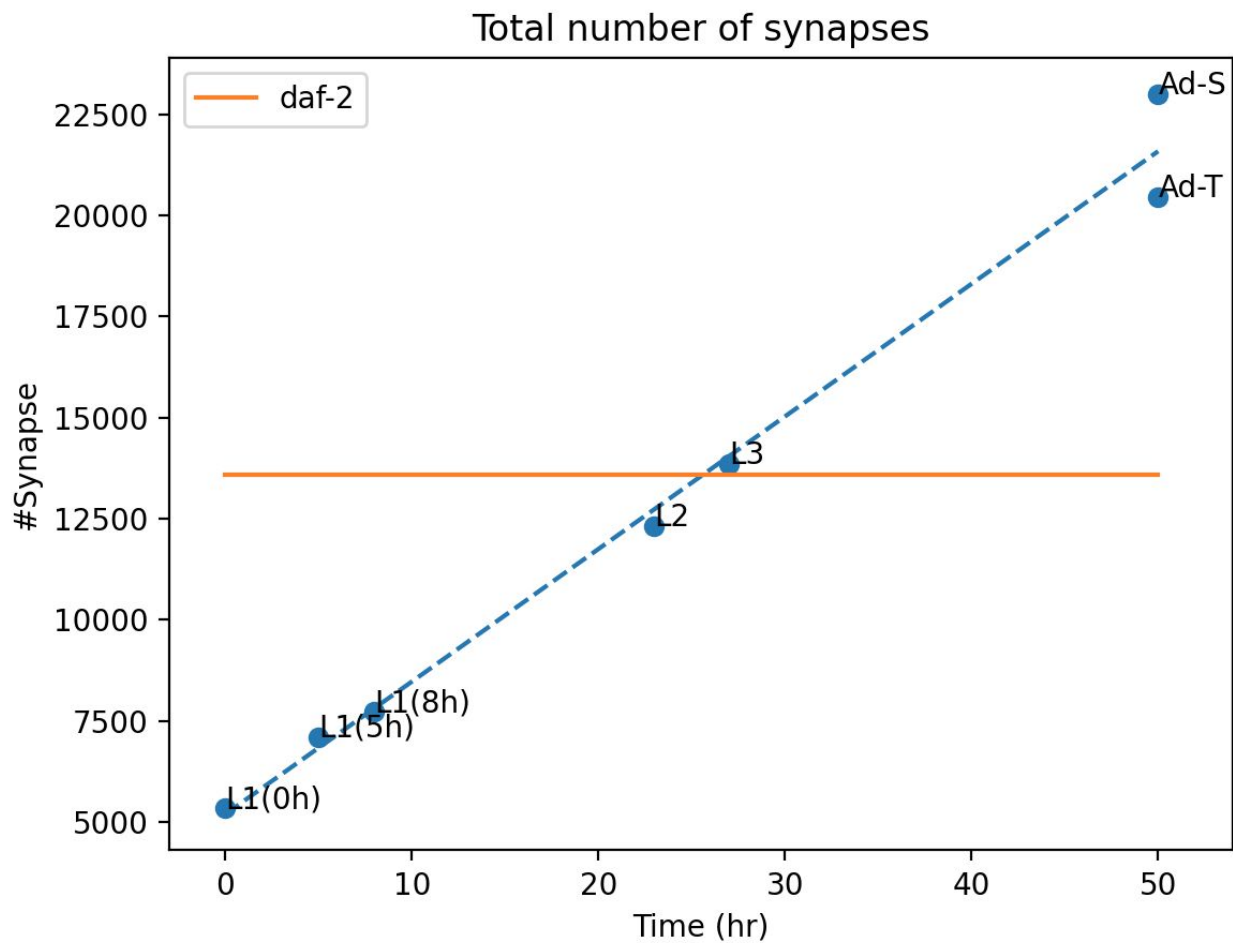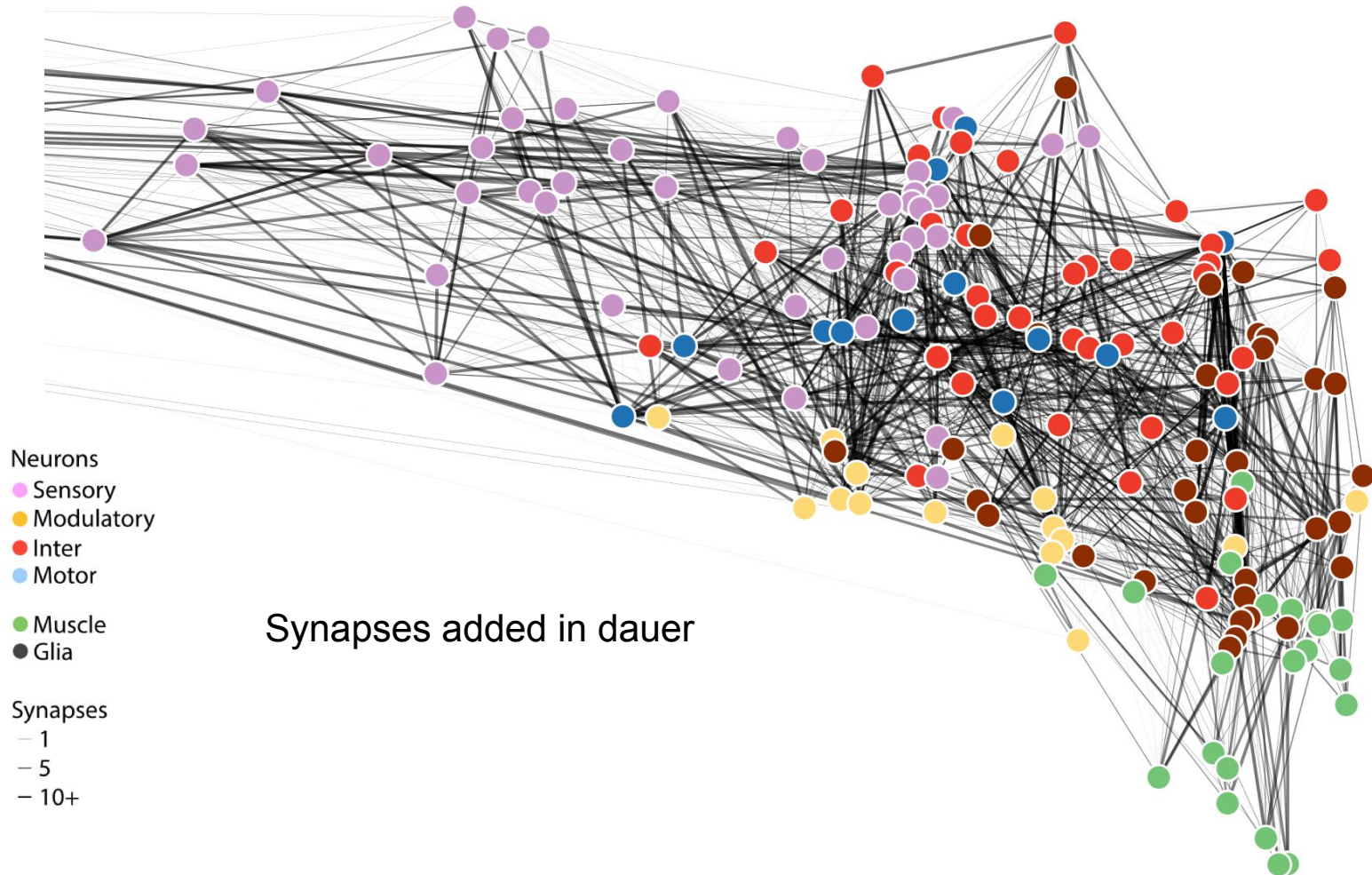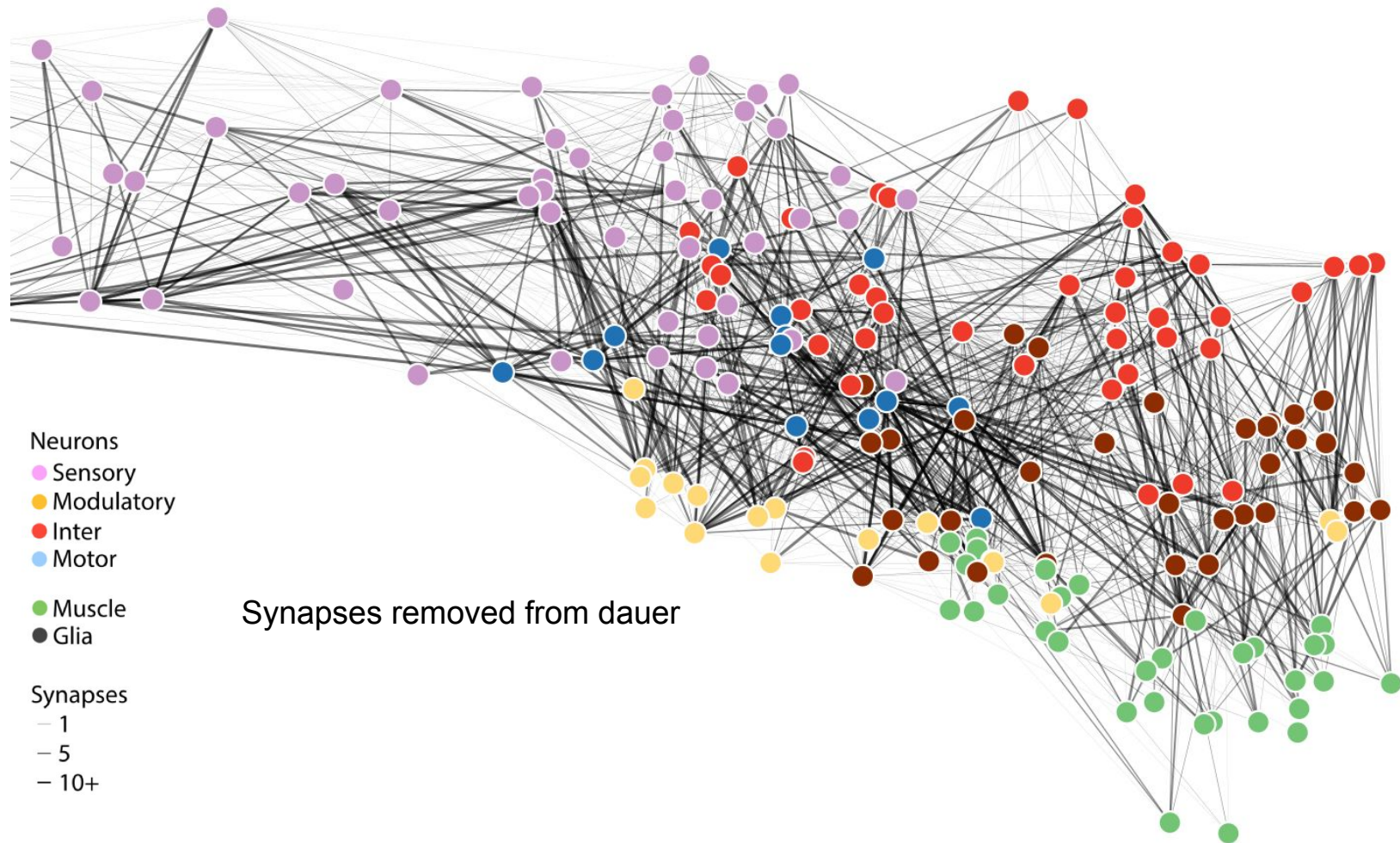
Source of Data

- CATMAID API (Pymaid)

```python
class Skeleton:
    def __init__(self, project_id: int):
        pymaid.CatmaidInstance(
            server='https://zhencatmaid.com/',
            api_token='c48243e19b85edf37345ced8049ce5d6c5802412',
            project_id=project_id
            # http_user='user',  # omit if not required
            # http_password='pw',  # omit if not required
        )
        self.project_id = project_id
        self.num_neurons = None
        self.neurons_index_map = {}
        self.neurons_reverse_index_map = {}
        self.adjacency_matrix = None
        self.make_neurons_index_map()
```

Overall comparison
(Network graph)

Synapses added in dauer

Neurons
- Sensory
- Modulatory
- Inter
- Motor

- Muscle
- Glia

Synapses
— 1
— 5
— 10+

Neurons
- Sensory (magenta)
- Modulatory (orange)
- Inter (red)
- Motor (blue)

- Muscle (green)
- Glia (black)

Synapses
- 1
- 5
- 10+

Synapses removed from dauer

12

Connections morphology

L3 vs daf-2 dauer

- Looking at 20 neurons (with the most dauer-specific changes in connections) (William's thesis)

Neuron Pair	Output					Input					Sum	
	Dauer New	Dauer increased	Dauer decreased	Dauer pruned	Un-changed	Dauer New	Dauer increased	Dauer decreased	Dauer pruned	Un-changed	New/ Increased	Pruned/ Decreased
RIP	0	0	0	0	0	10(46)	0	0	6 (54)	5	10 (46)	6 (54)
IL2V	1 (5)	0	1 (9)	6 (48)	0	1 (7)	2 (7)	0	0	1	4 (19)	7 (57)
RIC	0	1 (20)	0	3 (31)	4	2 (8)	0	0	2 (8)	5	3 (28)	5 (39)
IL1(L/R)	1 (5)	1 (12)	1 (15)	3 (27)	2	0	0	0	2 (6)	1	2 (17)	6 (48)
URB	4 (20)	1 (10)	1 (10)	3 (7)	4	5 (14)	1 (3)	0	0	2	11 (47)	4 (17)
AVA	0	0	0	0	0	2 (6)	3 (26)	0	3 (32)	16	5 (32)	3 (32)
AVB	0	0	0	0	0	4 (9)	4 (40)	1 (11)	0	15	8 (49)	1 (11)
AIM	0	2 (17)	0	3 (14)	2	3 (19)	2 (8)	0	1 (2)	1	7 (44)	4 (16)
IL2D	2 (5)	0	2 (13)	4 (34)	0	2 (7)	0	0	0	0	4 (12)	6 (47)

Datasets alignment

- Simplest idea: using an "affine" transformation to align two datasets
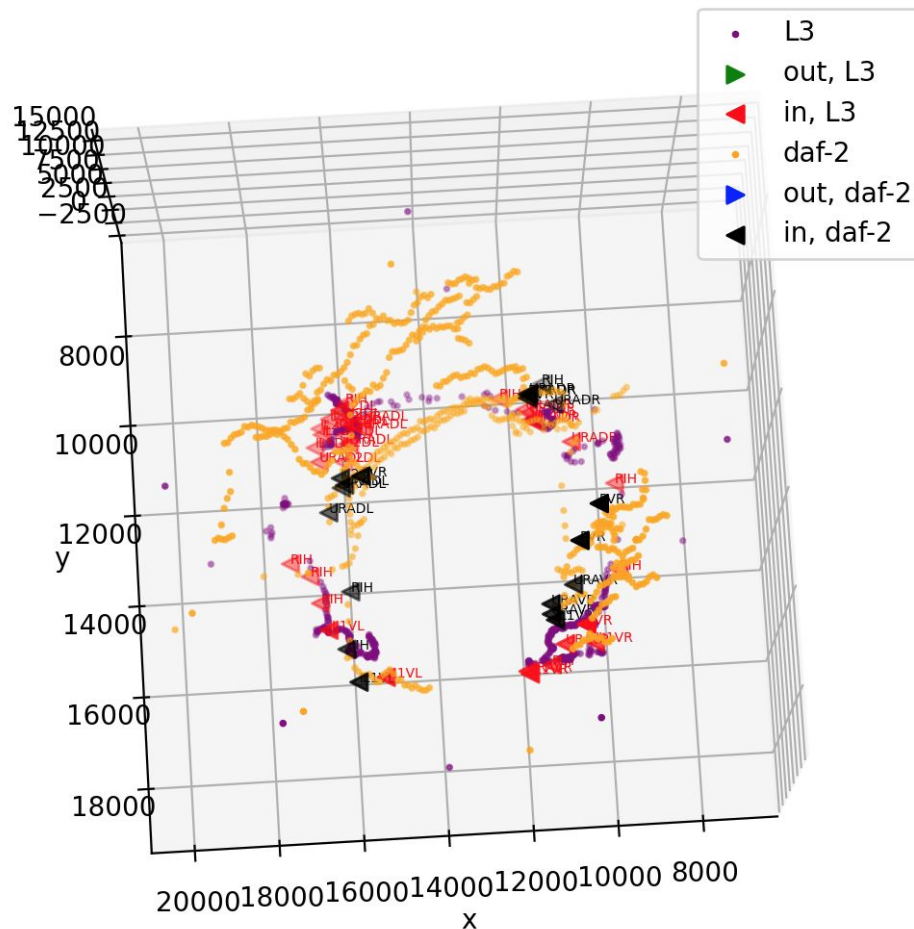
- Objective function: cell bodies of 11 firm neurons:
  ```
  ['RID', 'AVAL', 'AVAR', 'RIPL', 'RIPR', 'RMEV', 'SMDDL', 'SMDDR', 'RMED', 'BAGL', 'BAGR']
  ```

Cell bodies (before alignment)
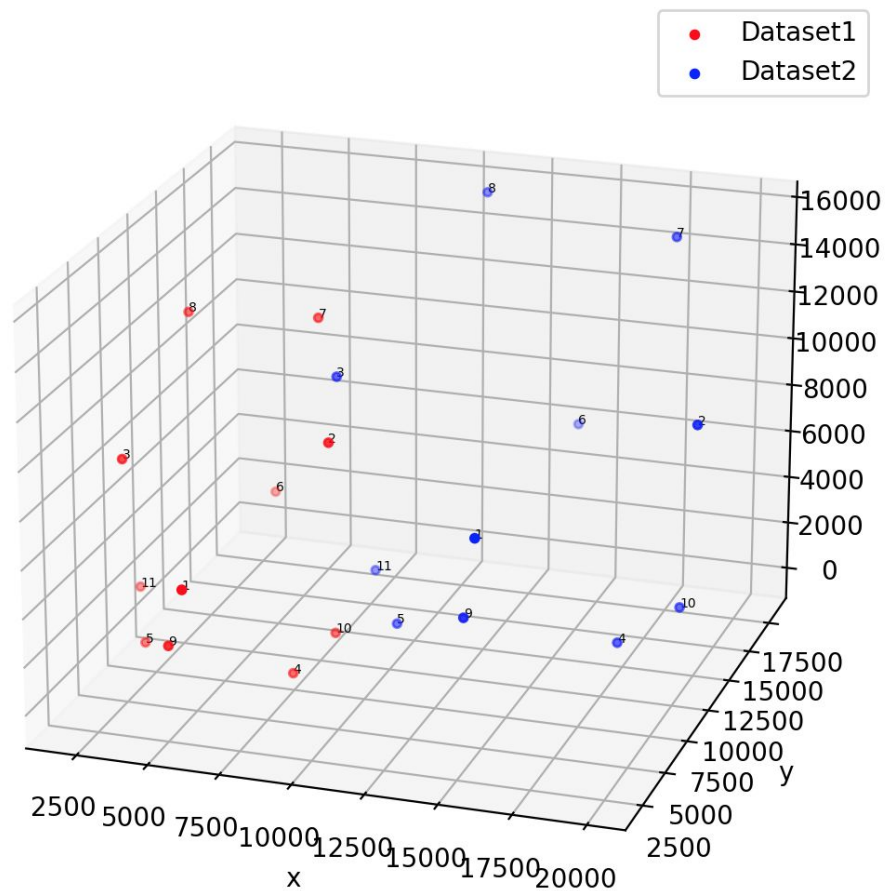
L3 vs daf-2: RIP, sharing synapses

- No output connection
- **Input connections:**
  ['URADL', 'RIH', 'PVR',
 'IL2DL', 'IL1VL', 'RIH',
  'URAVR', 'URADR',
  'IL1VR']

- **Dauer sends to:**
  ['ASHR,PVPR,ASKR,AIBR,AIAR']
  (at one spot)
- **Dauer receives from:**
  {'PVQL' (4), 'ADLR' (2), 'AWBR' (2),
  'AWAR' (12), 'ADFL' (1), 'AWAL' (5),
  'AWBL' (1), 'ASER' (1), 'AVHL' (2), 'ALA'
  (2), 'PVQR' (7), 'RIFL' (1), 'OLLL' (1),
  'BDUL' (3), 'AVJL' (1), 'ASKR' (1), 'ASKL'
  (2), 'ASHL' (1), 'AINR' (2), 'ADFR' (1),
  'BDUR' (2), 'AVHR' (1), 'AIAR' (2),
  'URBR' (1), 'AWCR' (1), 'URYVR' (1)}
- **Dauer doesn't receive from:**
  {'IL1DL' (4), 'IL2VL' (10), 'URYVL' (1),
  'URAVL' (3), 'CEPDL' (2), 'ADAL' (1),
  'IL2DR' (10), 'RMDVL' (1), 'IL2VR' (12),
  'IL1DR' (2), 'CEPVR' (2), 'ADAR' (4)}
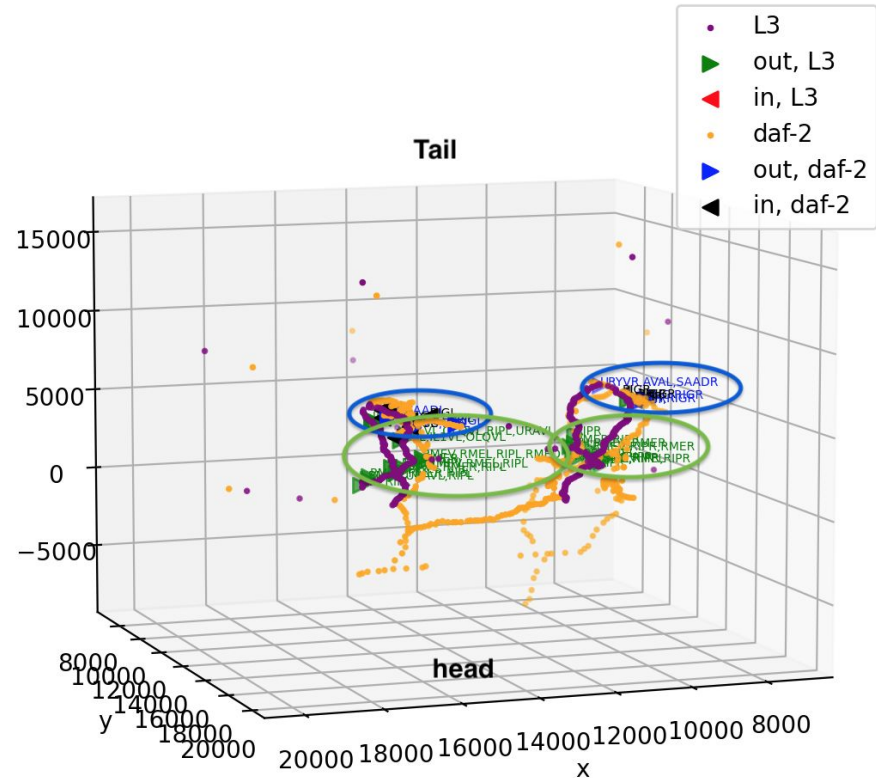

L3 vs daf-2: RIP, varying synapses

18
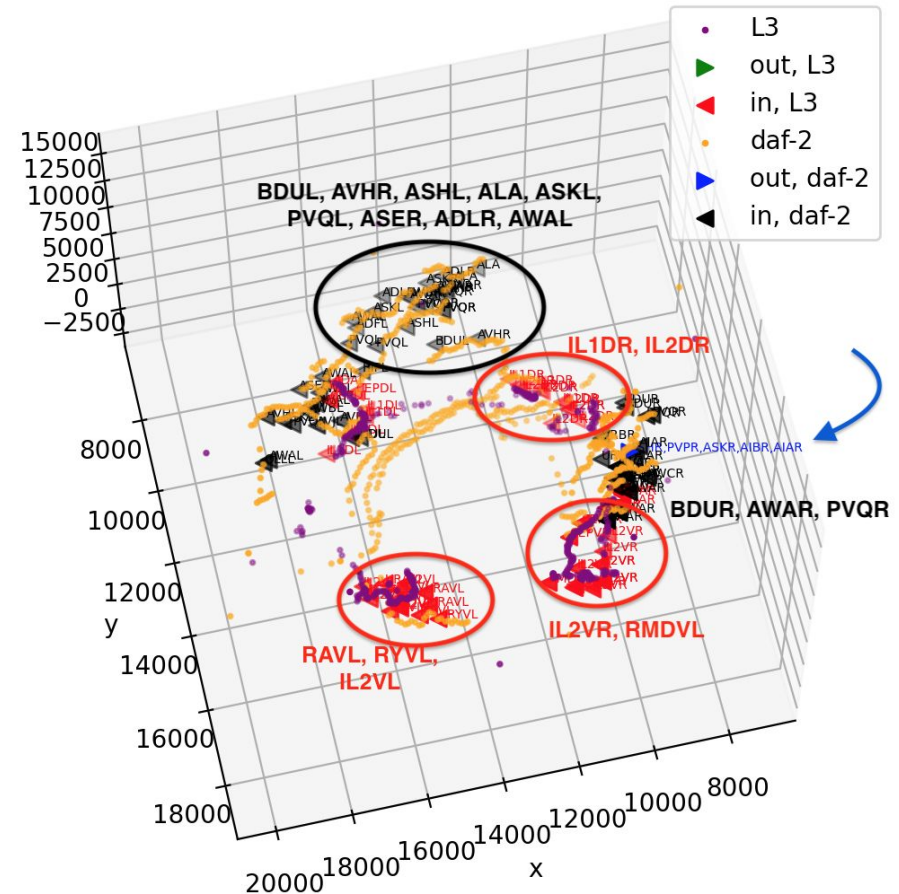
L3 vs daf-2: IL2V, sharing synapses

- **Significant change in the neuron!**

- **Sending:**
  (L3) {'URAVR' (7), 'IL1VR' (2)}
  (dauer) {'IL1VR,' (1), 'URAVR' (1)}

- **Receiving:**
  (L3) {'RIH' (4), 'IL2R' (1), 'DVC' (1)}
 (dauer) {'DVC' (4), 'RIH' (1), 'IL2R' (2)}
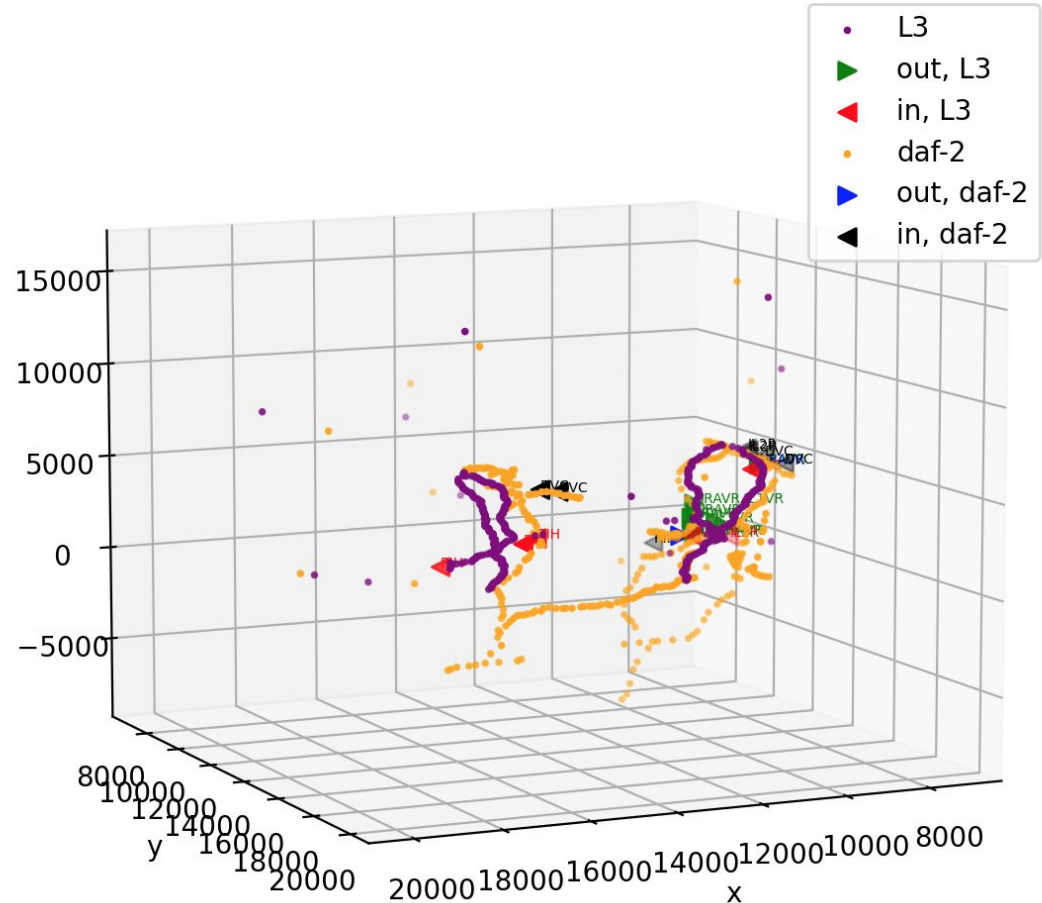
- (Not well-aligned)
- **Dauer does not send to**:
  {'IL1VL,OLQVL,RIPL,URAVL' (1), 'URXL,RIAL' (1),
  'RMER' (1), 'IL1VL,RIAL,URXL' (1),
  'RIPL,IL1VL,OLQVL' (1), 'URAVL,RMER,RIPL' (1),
  'RMER,URAVL,RIPL' (1), 'RIH,RIPL' (1),
  'RMEV,RMEL,RIPL,RMED' (1), 'RMER,RIPL' (1),
  'IL1VL,RMEV,RMEL,RIPL' (1), 'RIPL' (1),
  'RMED,RMER,RIPL' (1), 'RIPR,RIPR' (1),
  'RMEL,RIPR,RIPR' (1), 'RIAR' (1), 'RIPR' (2),
  'RMER,RIPR' (1), 'RIPR,RIH' (1),
  'RIH,RMEV,RMER' (1), 'RMEV,RIPR,RMER' (1),
  'RIPR,RMEL' (2), 'RMEL,RIPR' (1)}
- **Dauer sends:**
  {'RIGL' (2), 'DVC,RIGL' (1), 'SAADL' (1),
  'DVC,RIGR' (1), 'RIGR' (1), 'AQR,RIGR' (1),
  'URYVR,AVAL,SAADR' (1)}
- **Dauer receives from:**
  {'RIGL' (4), 'IL2L' (2), 'PVT' (1), 'RIGR' (4)}
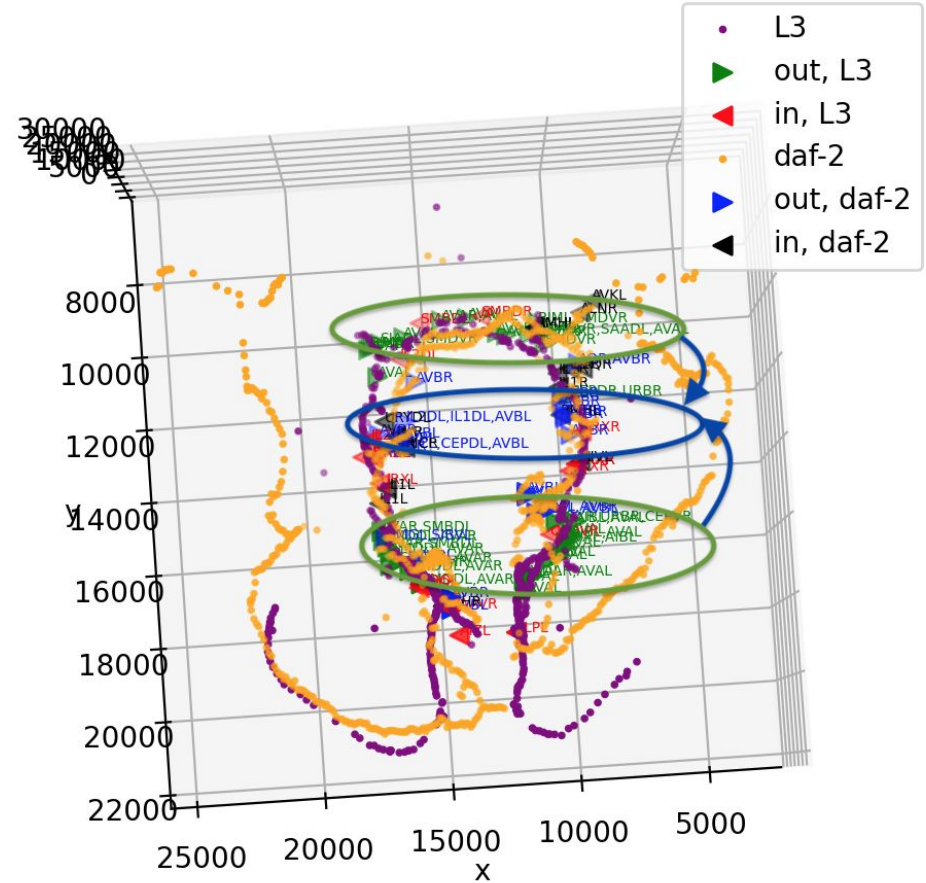- Differences are in different depths

L3 vs daf-2: IL2V, varying synapses

- Sending:
  'RIVR', 'SMDDR', 'ADAL': 1, 'SMDVL',
  'SIBDL', 'SDQR', 'SMDDR', 'SMDVL',
  'CEPVL', 'SMDVL', 'SMDDR'

- Receiving:
  'URBR', 'URBL', 'SDQR', 'OLQVL',
  'OLQDR', 'CEPVR', 'CEPVL', 'CEPDR',
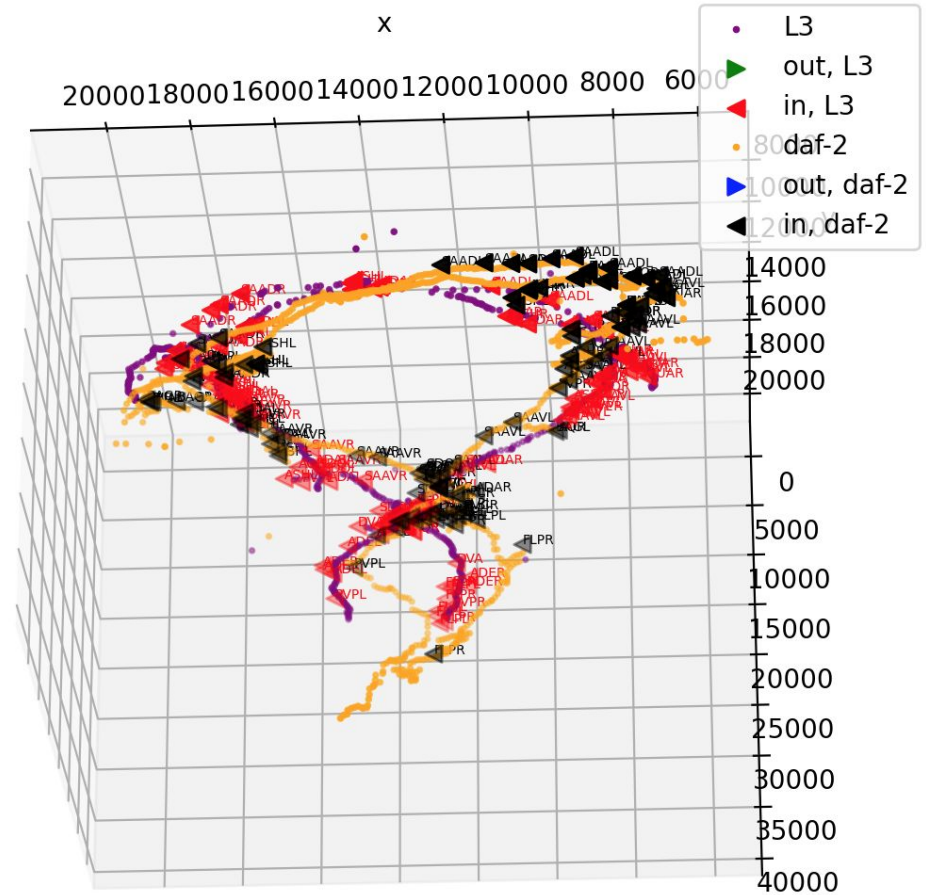 'CEPDL', 'OLQDL', 'AVKR'

L3 vs daf-2: RIC, sharing synapses
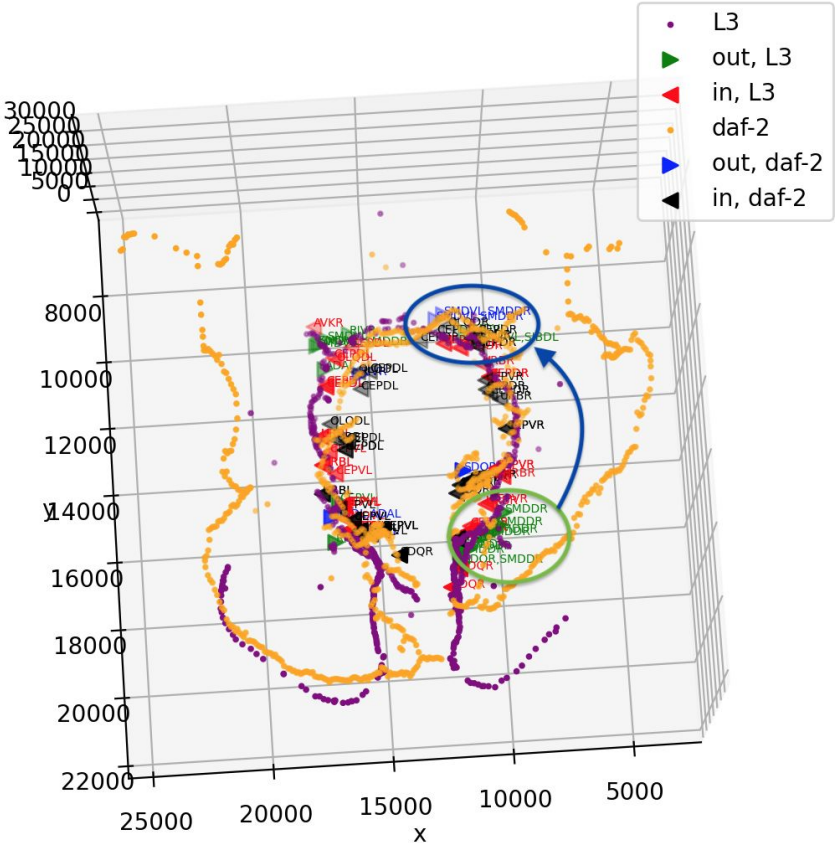
L3 vs daf-2: RIC, varying synapses

- So much AVA to AVB!

- More in the middle

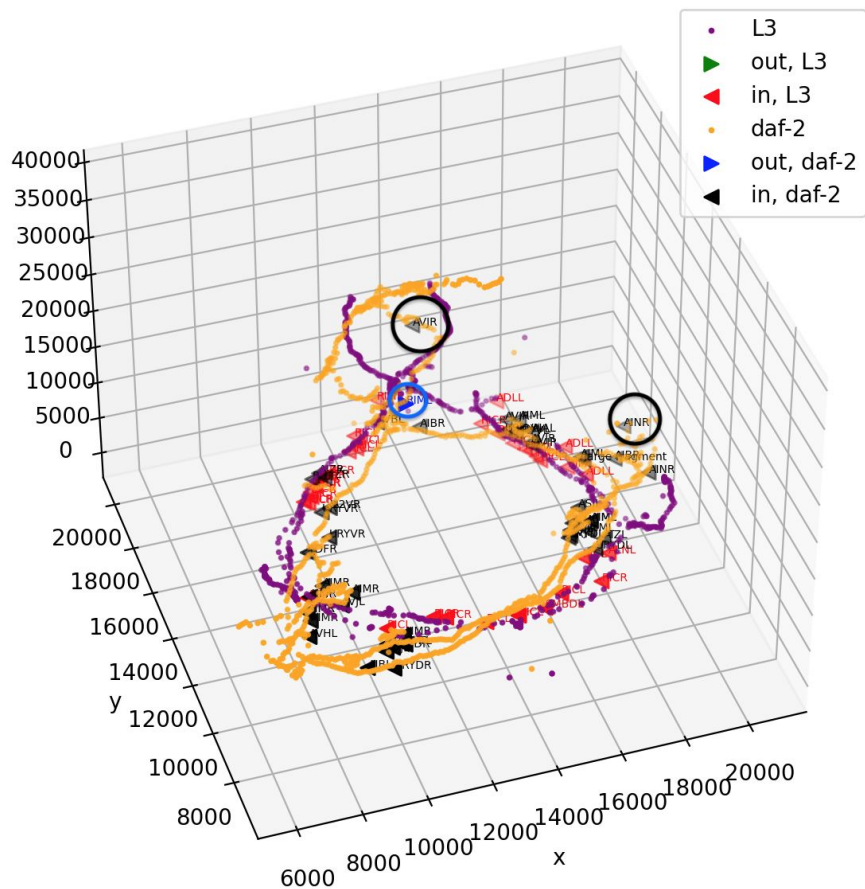# L3 vs daf-2: AVA, sharing synapses

- Dauer sends: 'RIML' (1)
- Dauer receives:
  {'AIBR' (2), 'AIML' (7), 'URYVL' (3), 'URYDR' (2), 'AINR' (2), 'RIGR' (1), 'AVJR' (5), 'URYDL' (2), 'AVBL' (1), 'AIZR' (2), 'AIAL' (1), 'URYVR' (2), 'IL2VR' (1), 'ASJL' (1), 'AIBL' (1), 'AIMR' (8), 'AVJL' (2), 'AVFL' (1), 'AIZL' (1), 'AIAR' (1), 'ADFR' (1), 'AVHL' (1)}
- Dauer does not receive:
  {'SMBDL' (1), 'RIMR' (1), 'RICR' (12), 'RICL' (15), 'ADLL' (3), 'RIML' (1), 'ASIR' (1), 'ALNL' (1), 'ADLR' (1)}
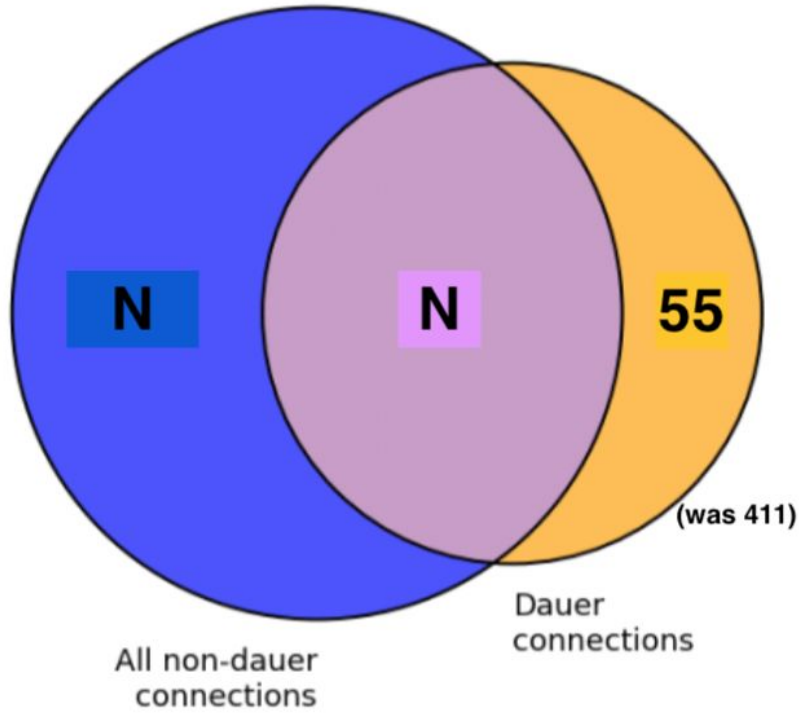

L3 vs daf-2: AVA, varying synapses

For future

- Add volumetric data (3D shape of neurons)

- Enhance transformation (a simple step: orthogonal transform)
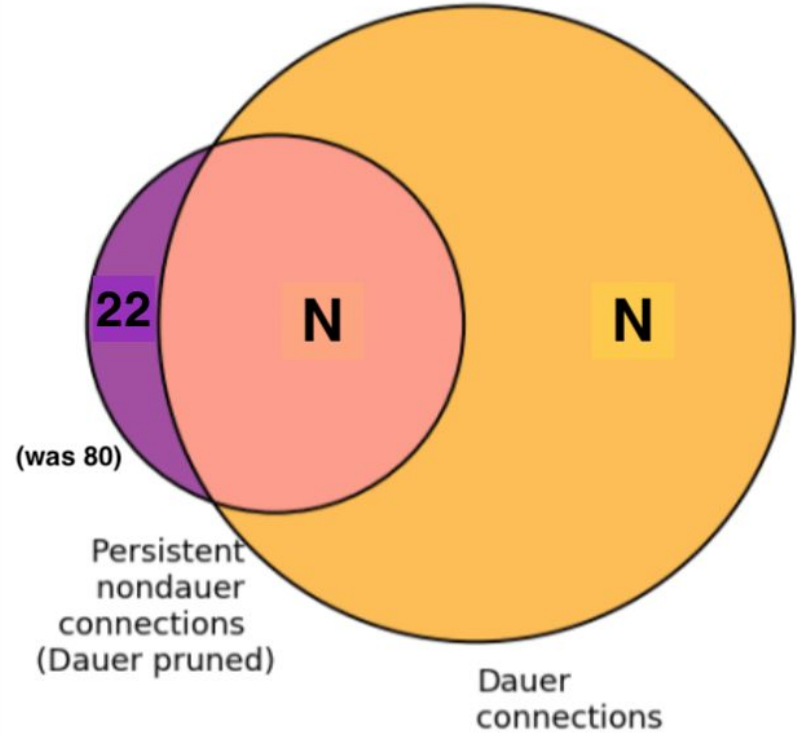
Set theoretical comparison
For the new WT dauer

A (Threshold: 2 synapses)

N   N   55 (was 411)

All non-dauer connections

Dauer connections

B Bad: bias of post-embryonic

22 (was 80)   N   N

Persistent nondauer connections (Dauer pruned)

Dauer connections

Dauer-specific connections:

('AWC', 'ADA'), ('URAV', 'RMDD'), ('AWB', 'AIB'), ('AWB', 'ADA'), ('ALA', 'ASK'), ('ALA', 'ADL'), ('OLL', 'URB'), ('ASH', 'BDU'), ('IL1V', 'URB'), ('IL1V', 'SMDV'), ('URYV', 'AVA'), ('ADF', 'AVJ'), ('ADF', 'RIF'), ('ADF', 'AIM'), ('ADF', 'RIP'), ('ASE', 'RIR'), ('ASE', 'ADA'), ('BDU', 'RIM'), ('BDU', 'RIP'), ('RIH', 'URX'), ('AVH', 'RIP'), ('IL2V', 'RIG'), ('IL2V', 'SAAD'), ('ASG', 'ASI'), ('IL1L/R', 'RIC'), ('URB', 'URAV'), ('URB', 'RMEL/R'), ('URB', 'AIM'), ('IL2L/R', 'AIY'), ('IL2L/R', 'IL2V'), ('IL1D', 'URB'), ('IL1D', 'RMH'), ('ASK', 'ALA'), ('ASK', 'AVJ'), ('ASK', 'ASJ'), ('AIM', 'AVA'), ('DVC', 'RIH'), ('DVC', 'IL2V'), ('DVC', 'IL2D'), ('DVC', 'IL2L/R'), ('DVC', 'RIA'), ('OLQD', 'OLL'), ('OLQD', 'RMDV'), ('RMH', 'RMEL/R'), ('AFD', 'AIA'), ('ALN', 'SAAD'), ('ASJ', 'AIM'), ('BAG', 'AQR'), ('RMDV', 'URAV'), ('PVQ', 'BDU'), ('PVQ', 'RIP'), ('AWA', 'RIP'), ('OLQV', 'OLL'), ('OLQV', 'AVE'), ('OLQV', 'RIB')
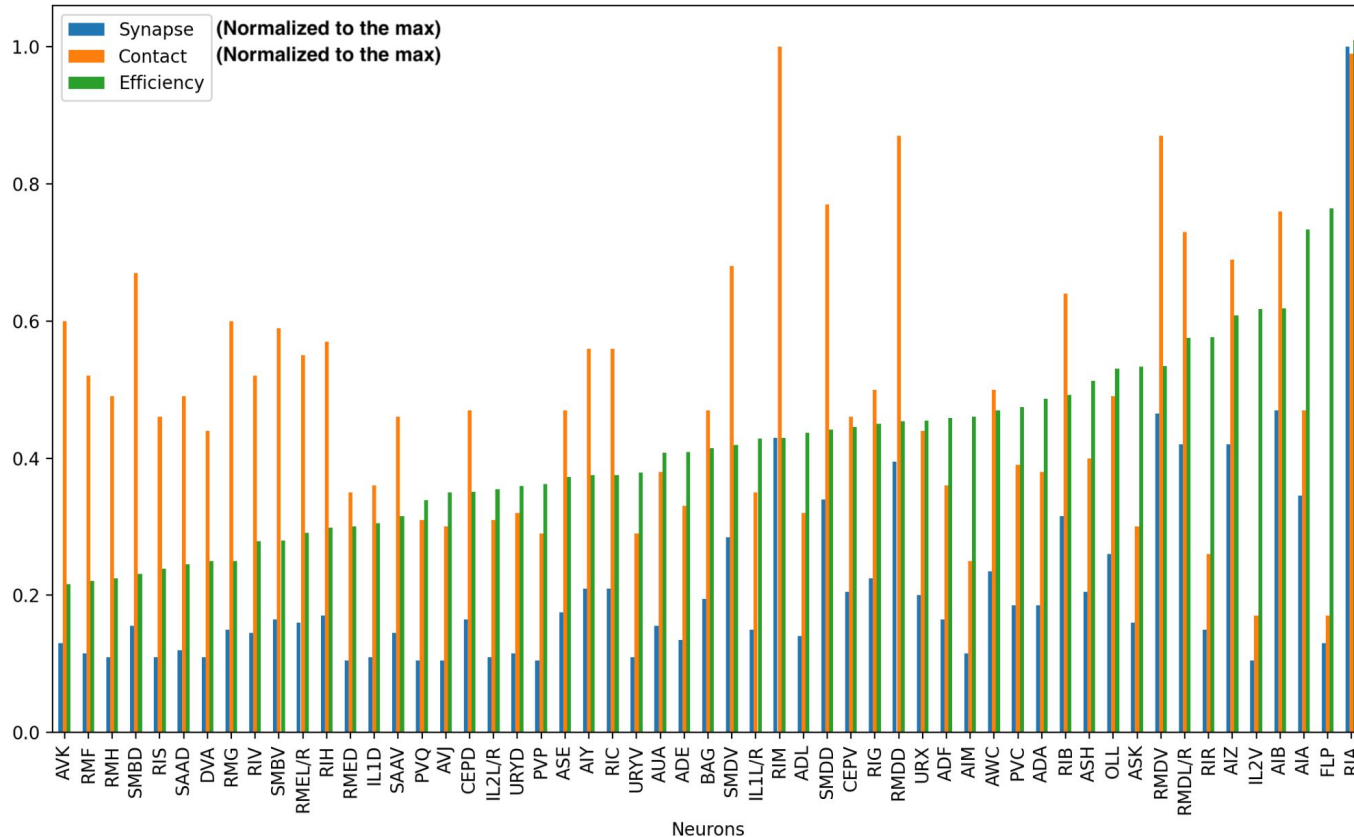
In 7 connected components
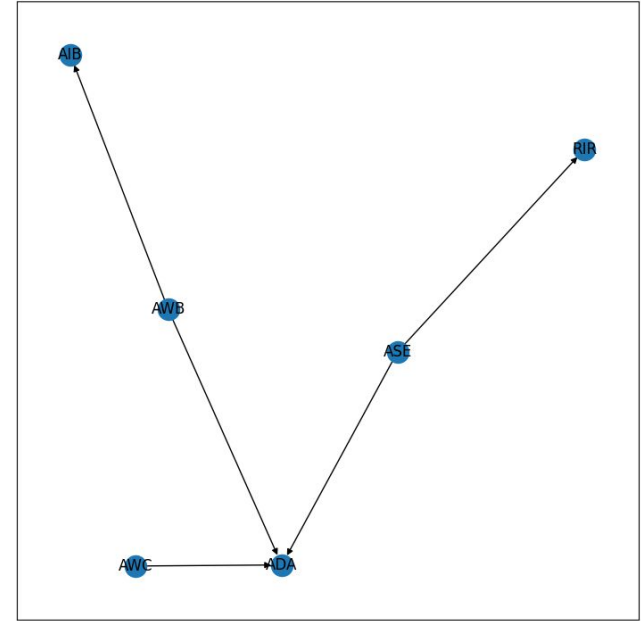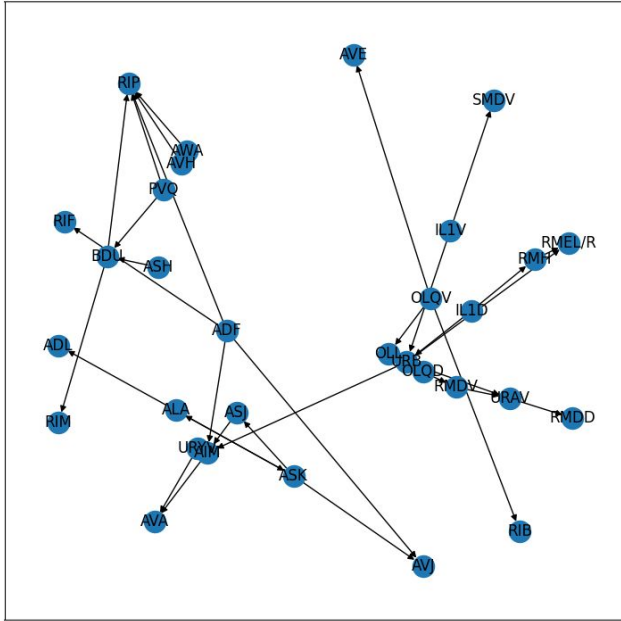
Non-dauer specific connections
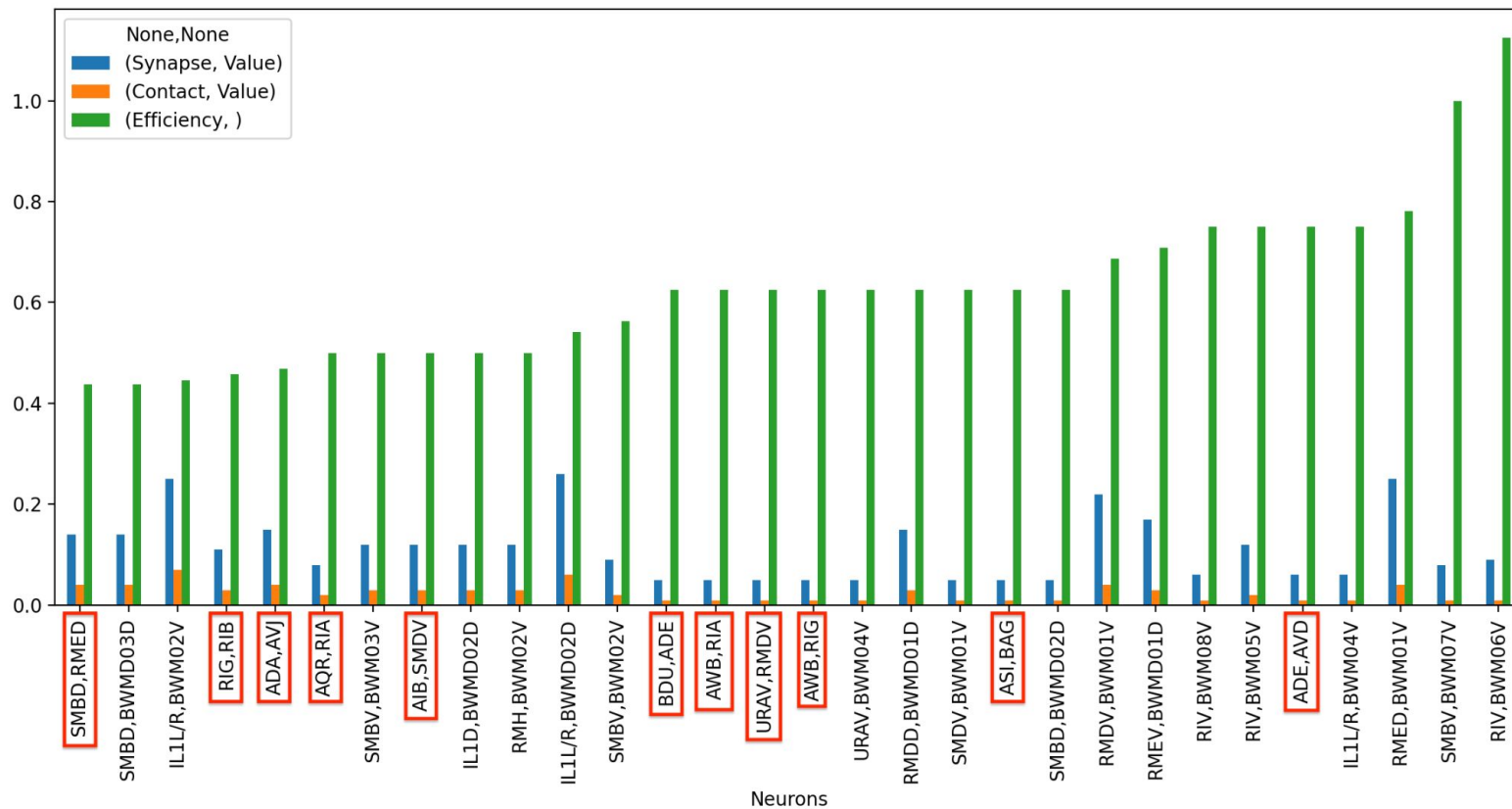
–> Problematic: post-embryonic artifact

('ALA', 'AVE'), ('SMBV', 'BWM02V'), ('RIG', 'RMG'), ('RIG', 'OLQV'), ('PVP', 'AQR'), ('ALM', 'PVN'), ('BDU', 'PVN'), ('URX', 'RIC'), ('ASG', 'AIM'), ('IL1L/R', 'BWMD02D'), ('IL2D', 'RMEL/R'), ('HSN', 'PVN'), ('URB', 'CEPD'), ('URB', 'IL1L/R'), ('RIC', 'ADA'), ('AIM', 'ASG'), ('AVF', 'PVN'), ('PVN', 'BDU'), ('PVN', 'RIF'), ('PVN', 'PVN'), ('PVQ', 'ASJ'), ('OLQV', 'IL2L/R')

Contactome

How much does a neuron utilize a contact to make synapse?

Pairs

What about dauers?

- Good question :))
  Data is not ready yet (dilation code)

Acknowledgements

Dr. Mei Zhen

William

Mona

All Zhen Lab members :))

Thanks :))