Effects of spindle movement on EB1 comets apparent speed and trajectory straightness

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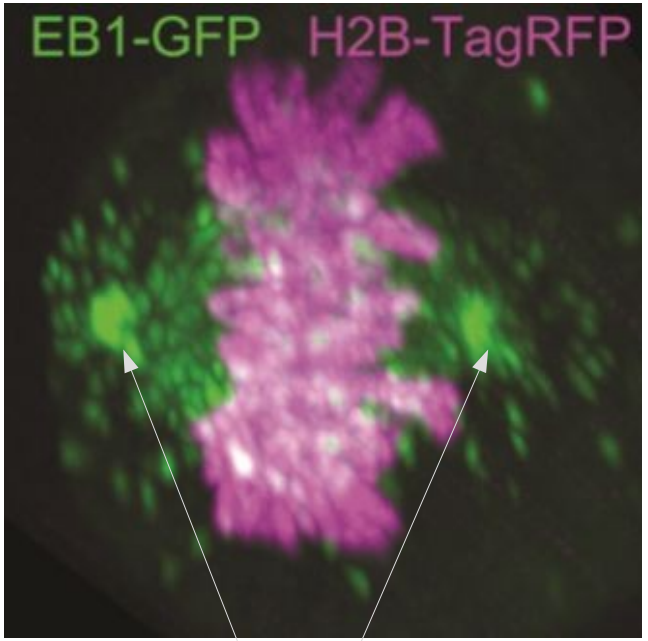
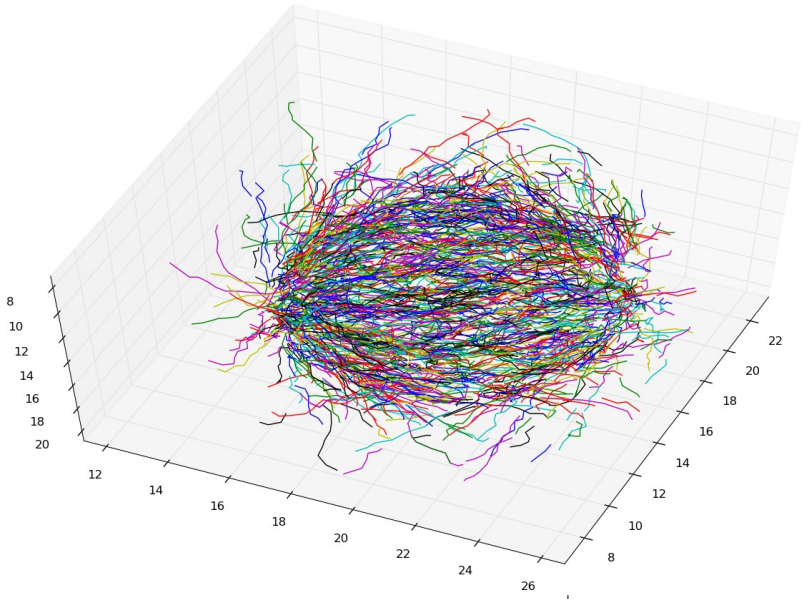
Lbcs,QBiC

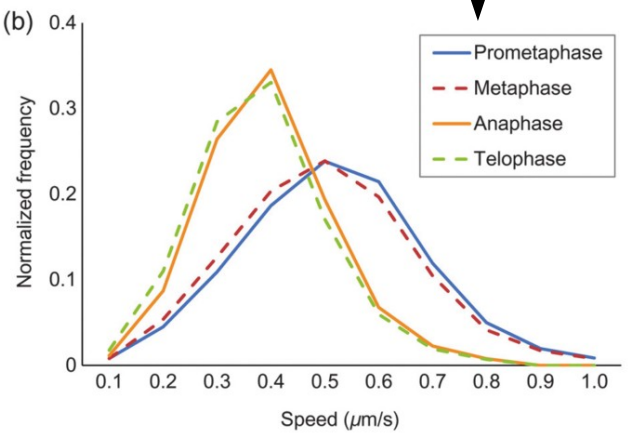
The EB1 comets data and automated tracking

EB1 spots > spots detection > spots tracking



centrosomes

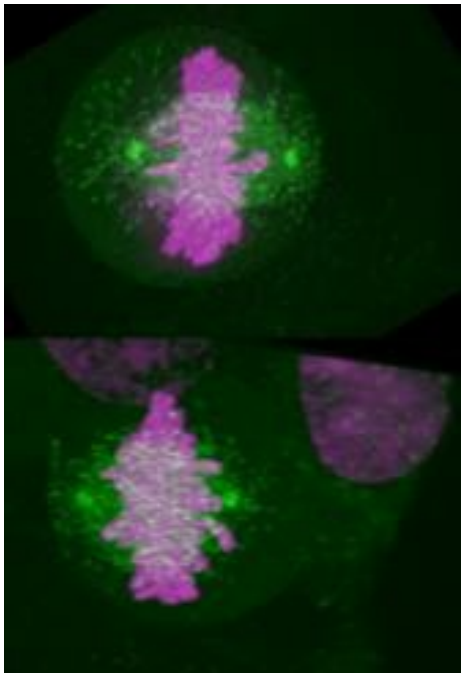




Yamashita et al. JBO 2015

Existing problem

- Limitation and error in automated tracking due to motion of spindle.

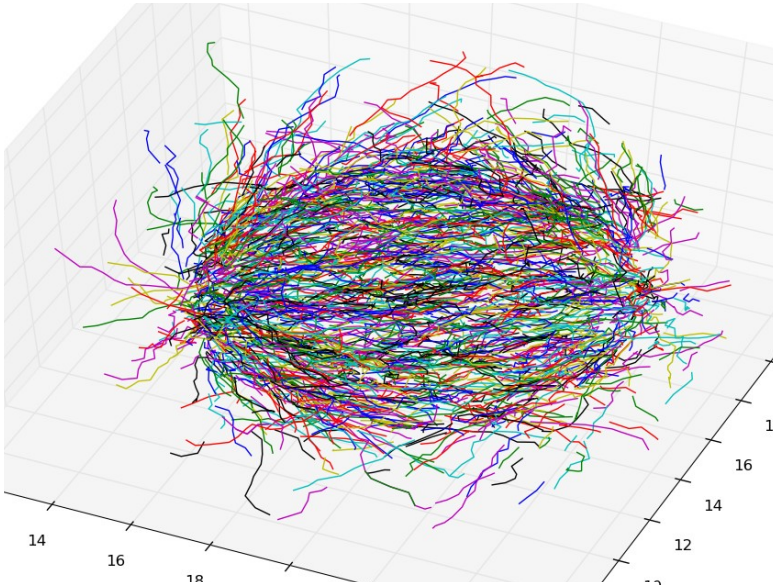


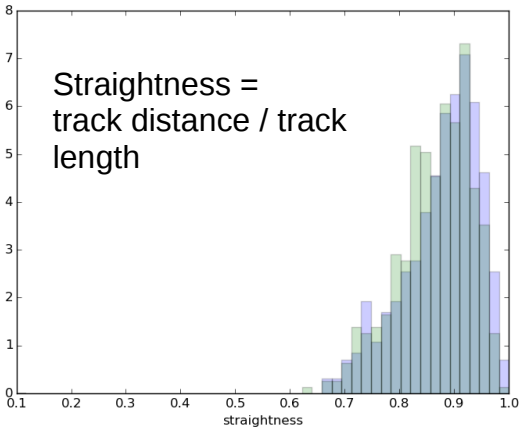
Solution: drift correction (to remove translational and rotational motion wrt cell)

After 'drift-correction'

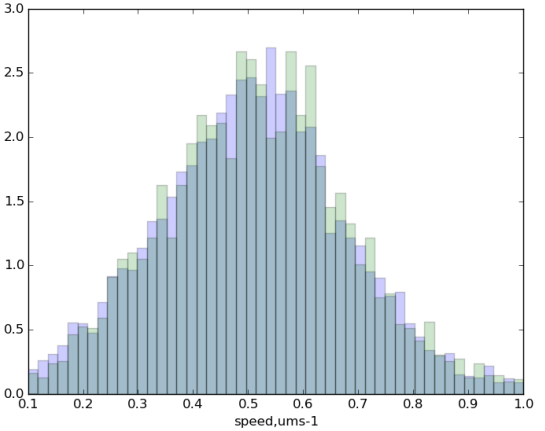
Spindle rotation and translation wrt to cell are removed. However...

- Straightness of trajectory





- Speed distribution

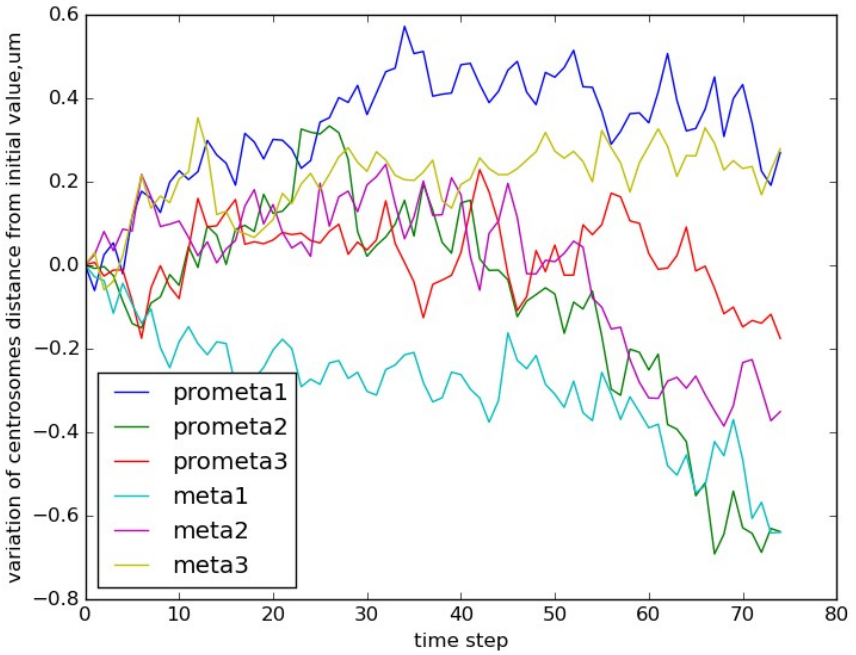


Instantaneous speed of astral MT in prometaphase and metaphase cells

Intrinsic?
neglected spindle motion?
Other systematic effects?

other spindle motion

Spindle length fluctuation

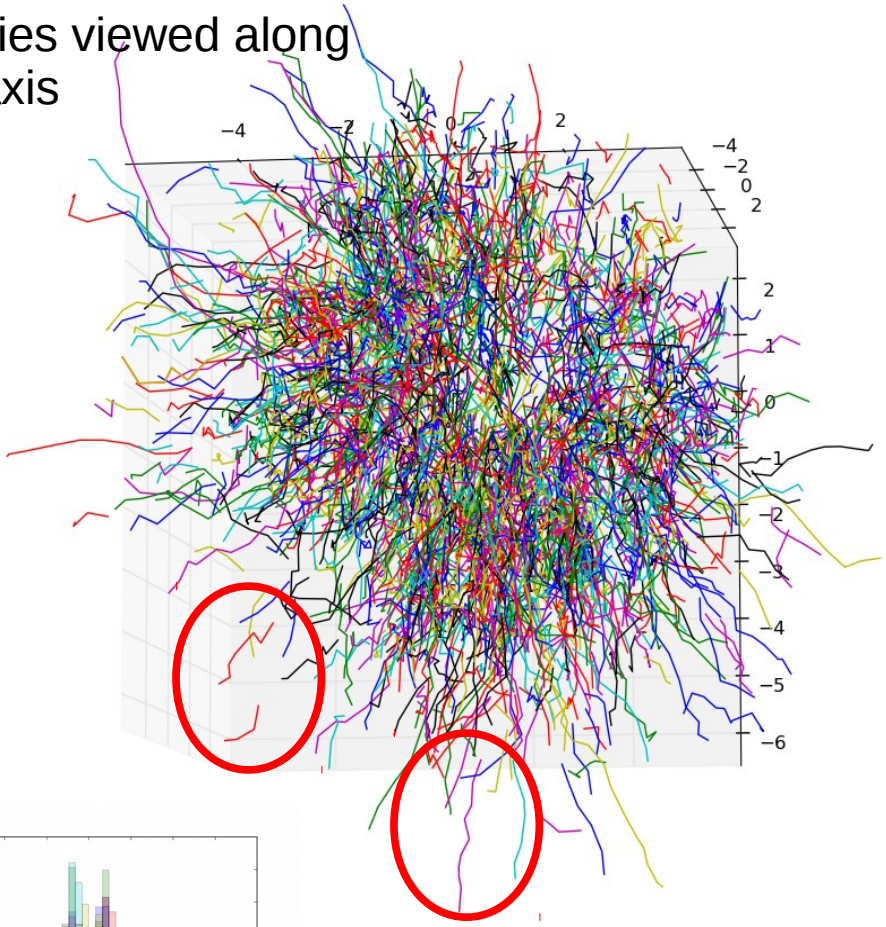


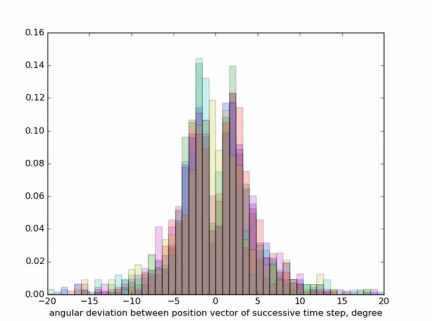
Maximum displacement:
Prometaphase : 0.6 um
Metaphase : 0.38 um
(Comet displacement per time step ~0.4um)

Increment of fluctuation:
Maximum: 0.15 um
Mean: 0
std : 0.05um

Axial rotation along spindle axis

Trajectories viewed along spindle axis





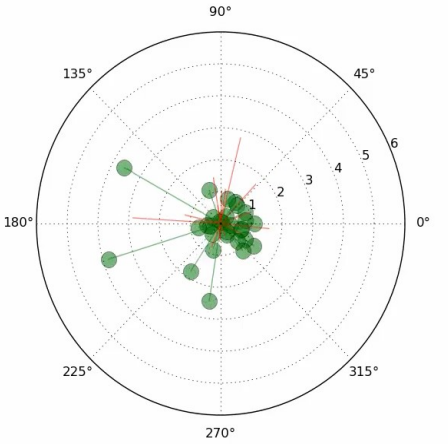
Rotation angle
Std : 7 degree

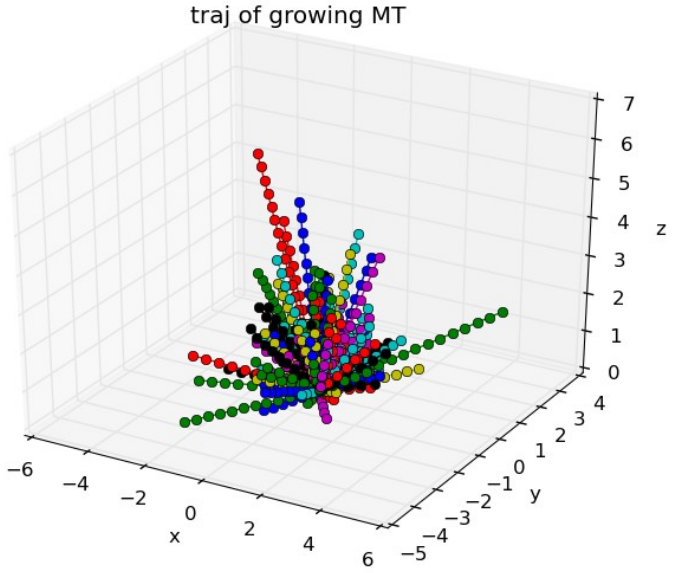
Task

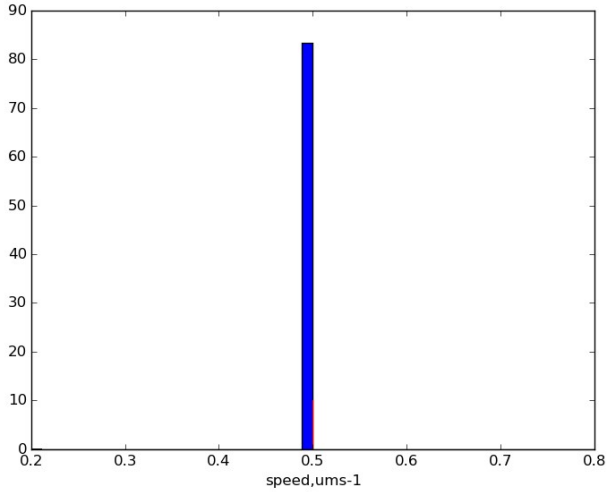
- Simulate comet spots (plus-end of microtubule) growing from centrosome which undergoes vertical fluctuation and axial rotation.
- Inspect the effects of spindle motion on apparent comet speed and trajectory straightness.

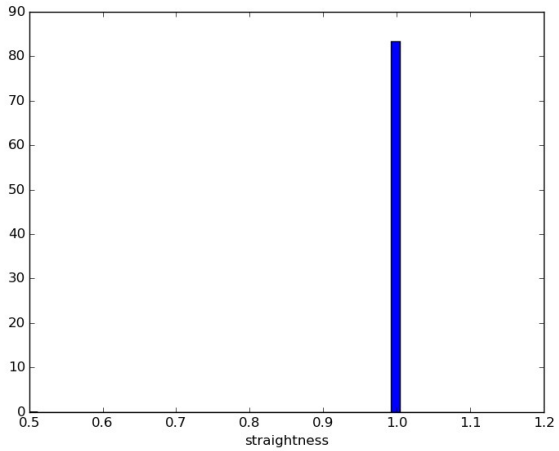
Simulation settings

- Single centrosome with astral microtubules
- Microtubule undergoes dynamics instability (parameterized by growth and shrink rate, catastrophe and rescue frequency)
- Only consider a hemisphere.



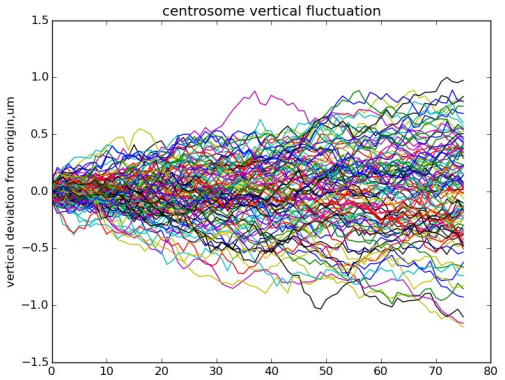


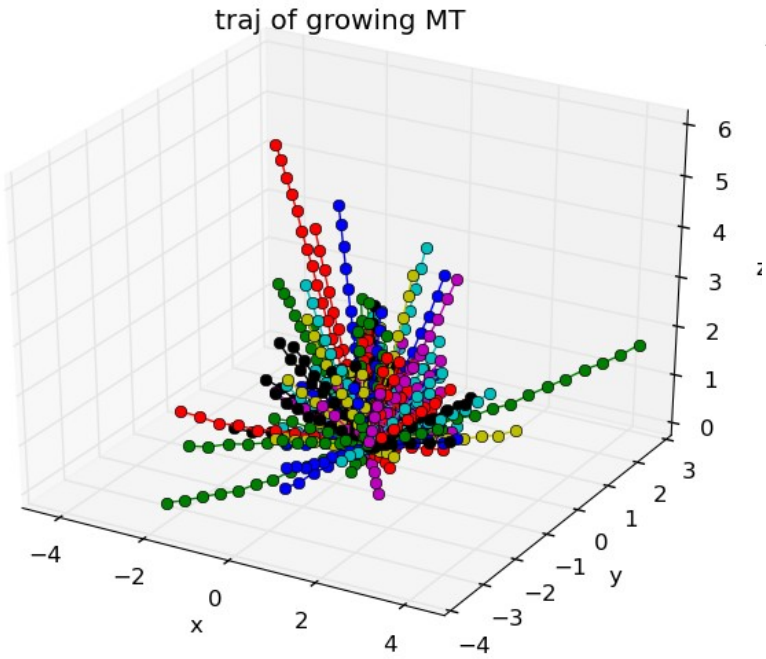


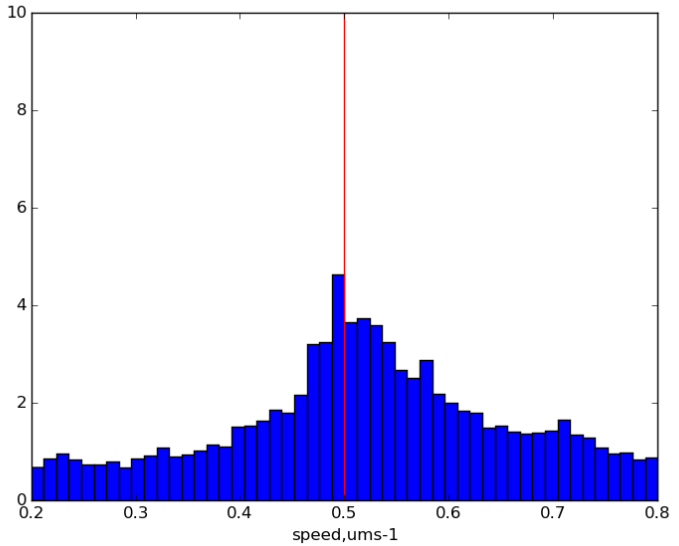


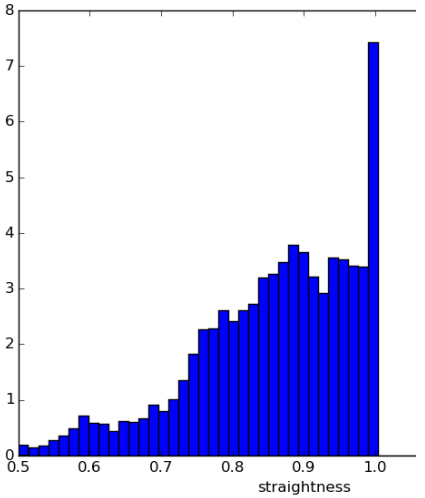
Vertical oscillation

- Centrosome fluctuate along z-axis with normal distributed displacement.



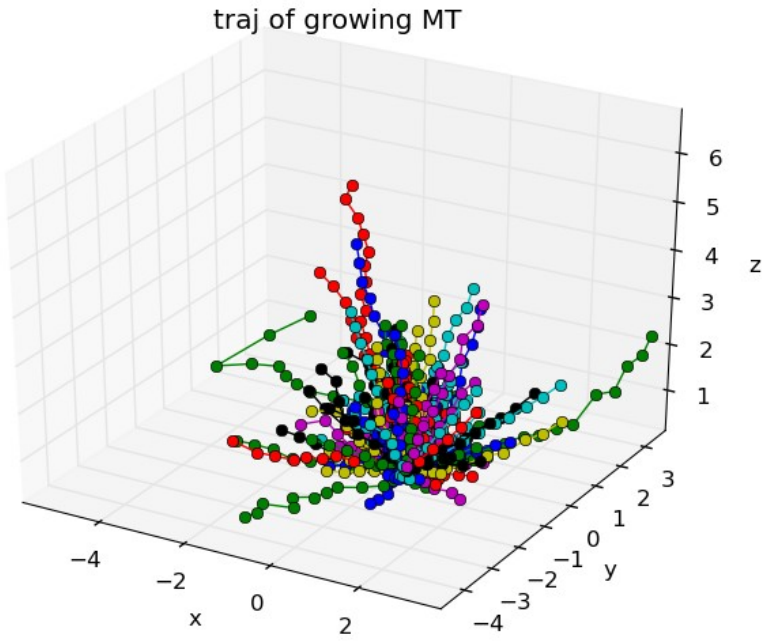


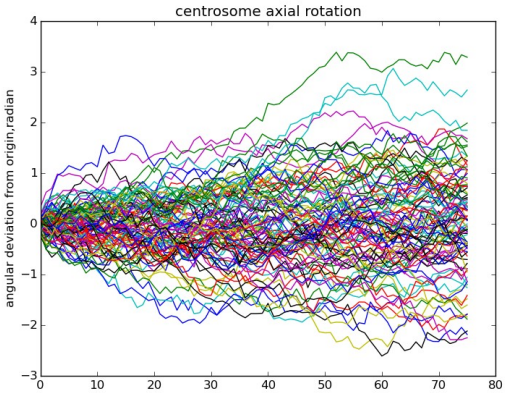


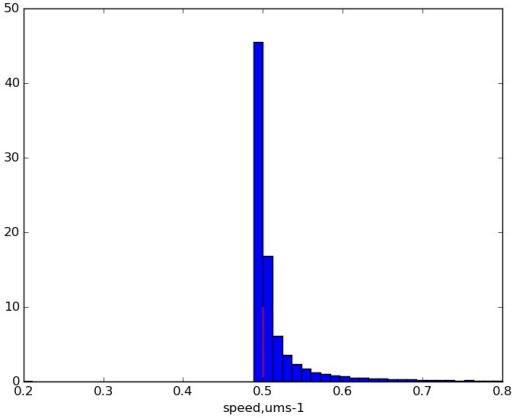


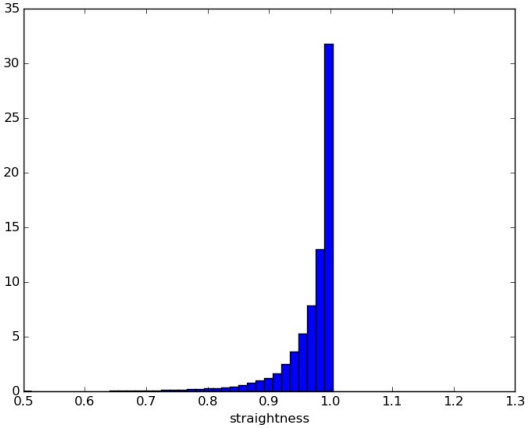
Axial rotation

- Centrosome rotate axially with normal distributed angular fluctuation.

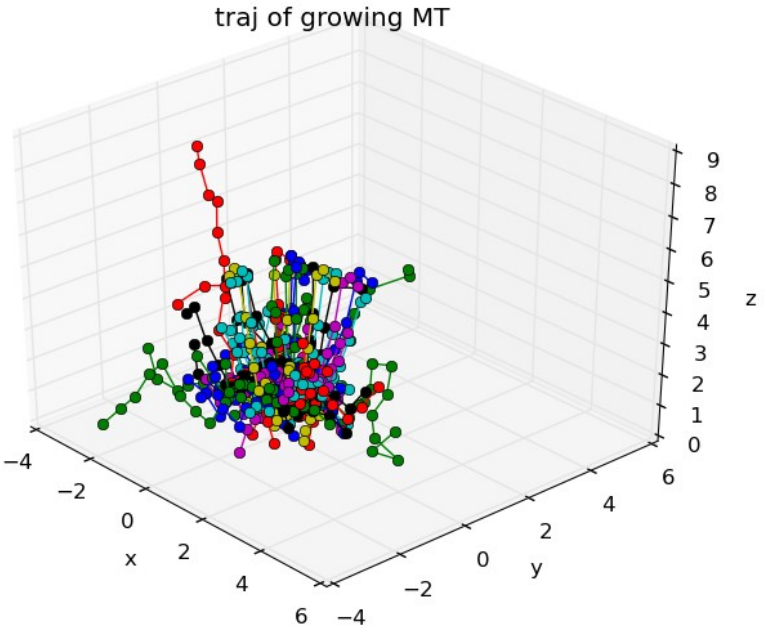


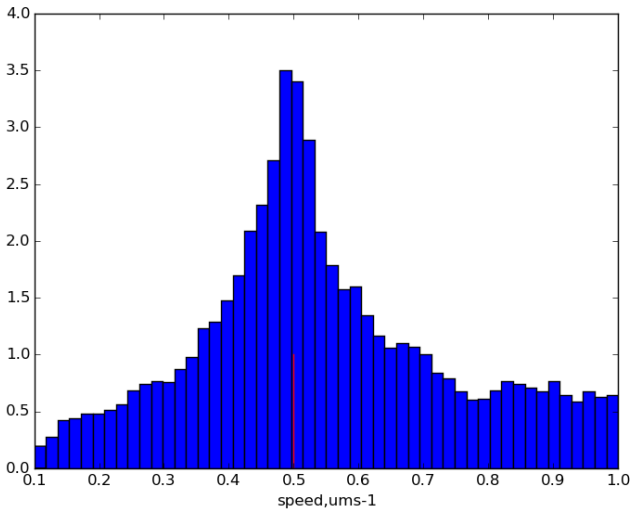


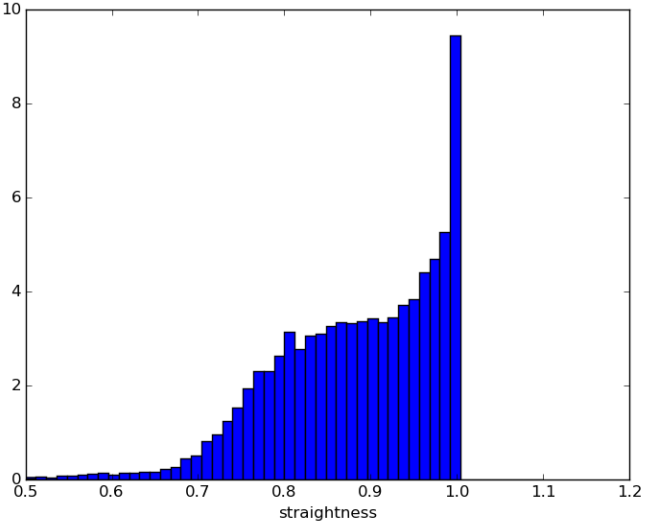




Vertical oscillation and axial rotation







summary

- Spindle motions previously neglected (spindle length fluctuation and axial rotation) do widen the speed distribution and distort the comet trajectories.

  Future work:

- Motion correction before subjected to automated tracking.
- Other factor to consider: error from centrosome coordinate estimation