An ODE Model of CLASP Mutants in *A. Thaliana*

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Root Zonation

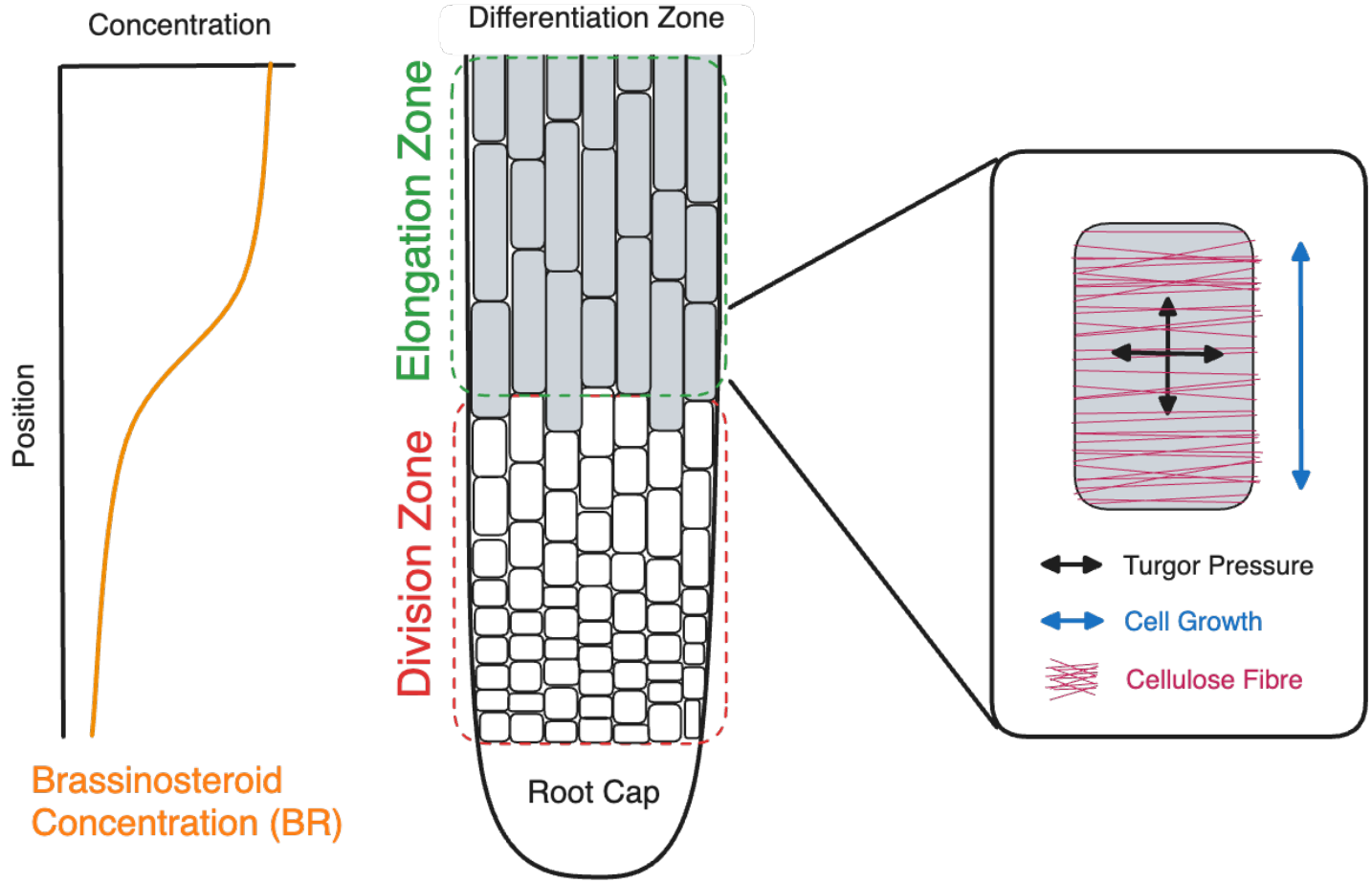

Figure: Zonation in the *A. Thaliana* root. Cells growth is driven by BR. Growth is proportional to length due to the stretching of cellulose fibres.

CLASP and Microtubules

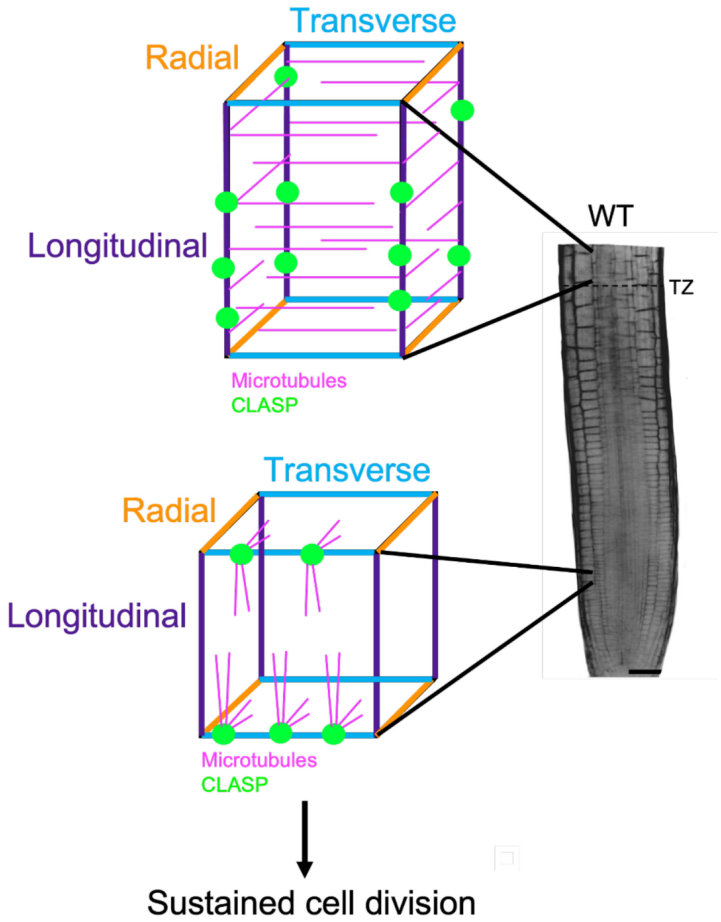

Figure: Halat et al. (2022). The key takeaway from this slide is that *CLASP inhibits growth, especially in shorter cells*.

Brassinosteroid

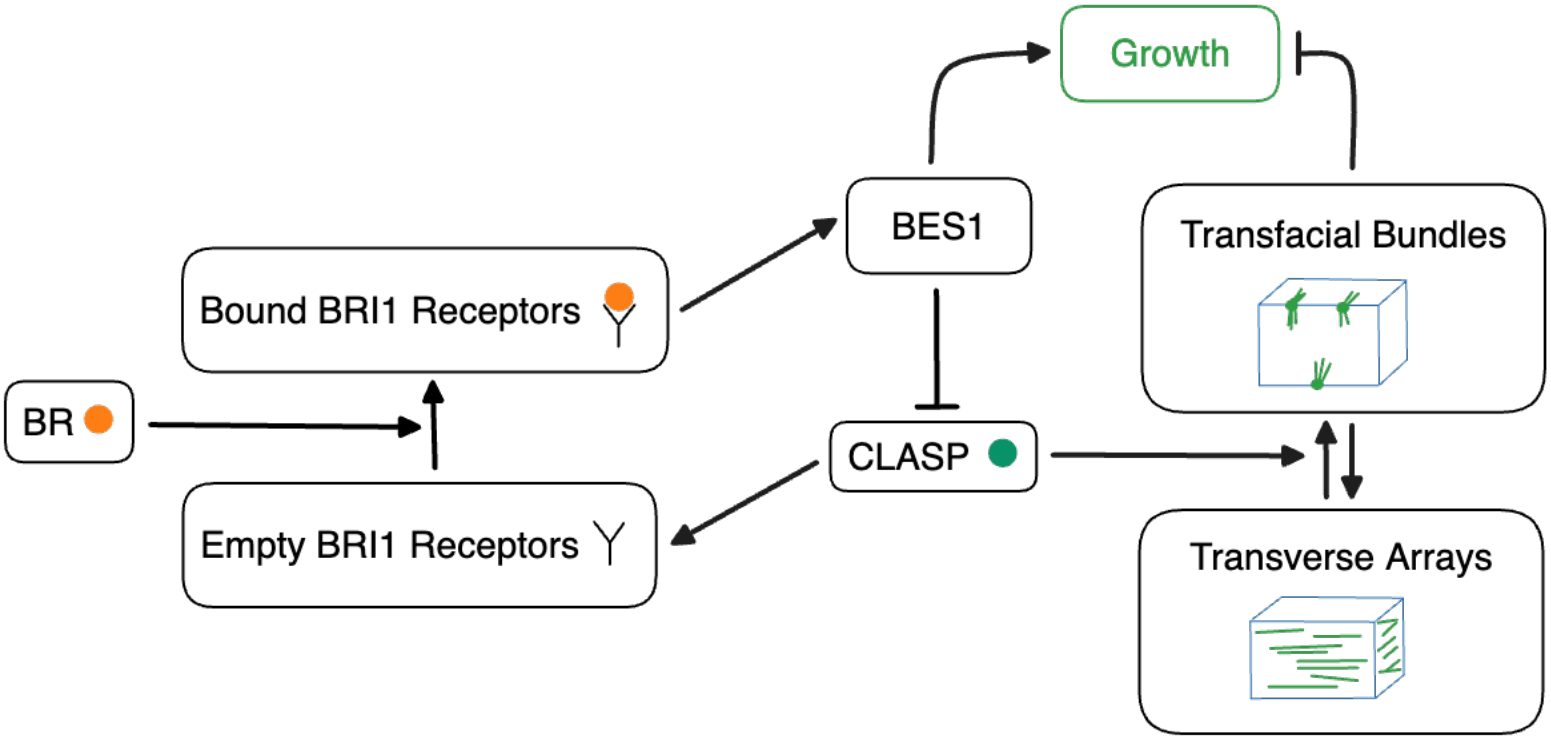

Figure: A simplified sketch of the brassinosteroid signalling network.

Mutant Roots

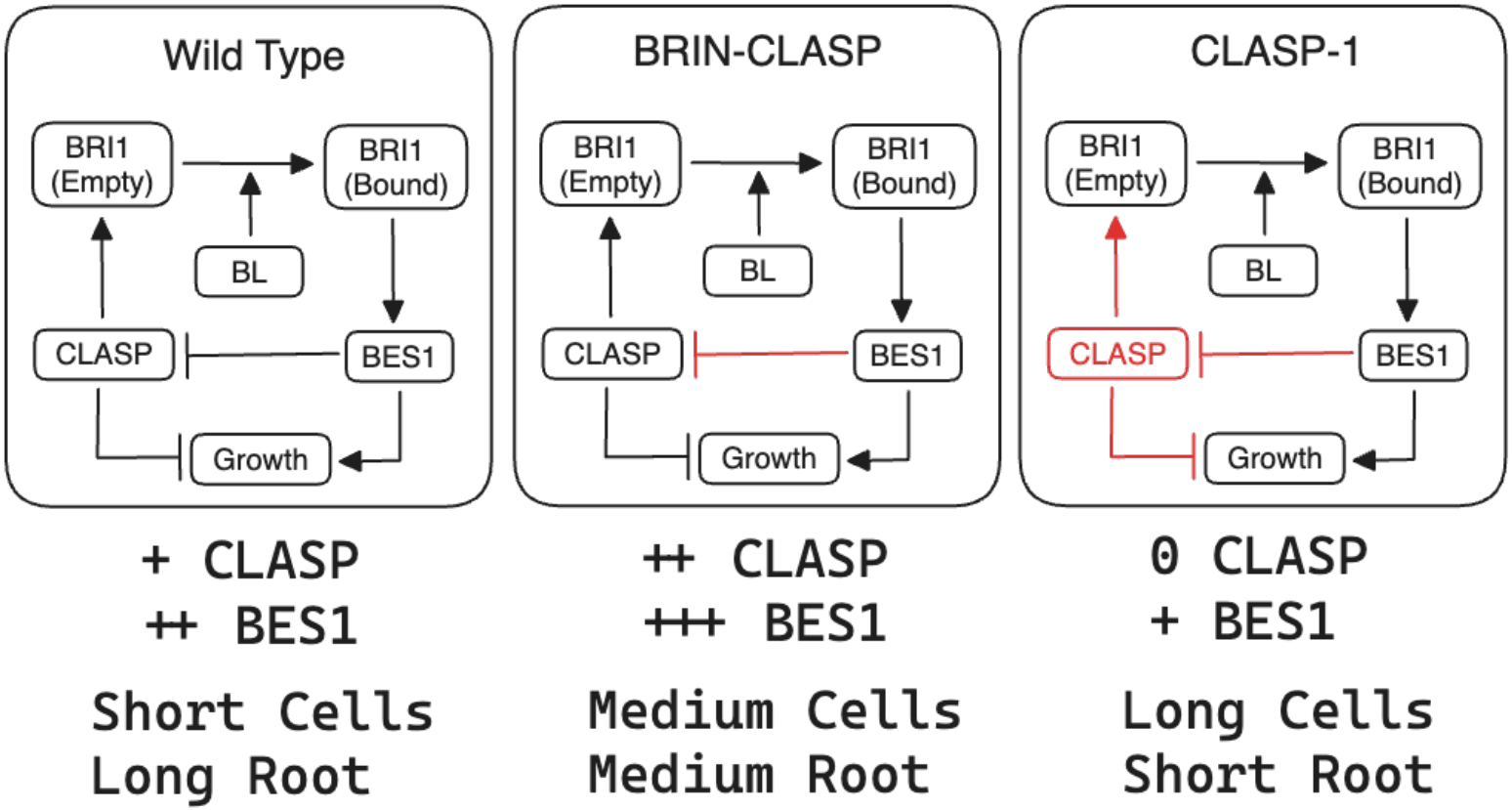

Figure: Signalling networks in the wild type and mutants.

Mutant Roots

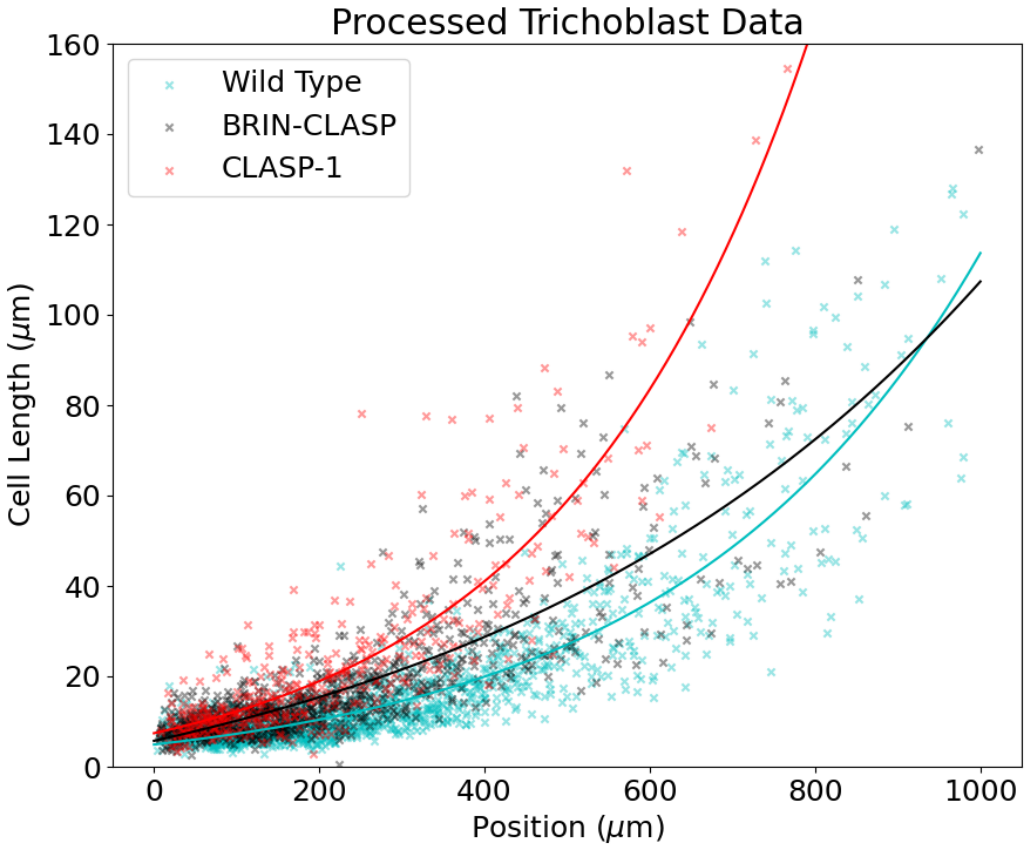

Figure: Experimental data from the wild type and mutants.

Hypothesis

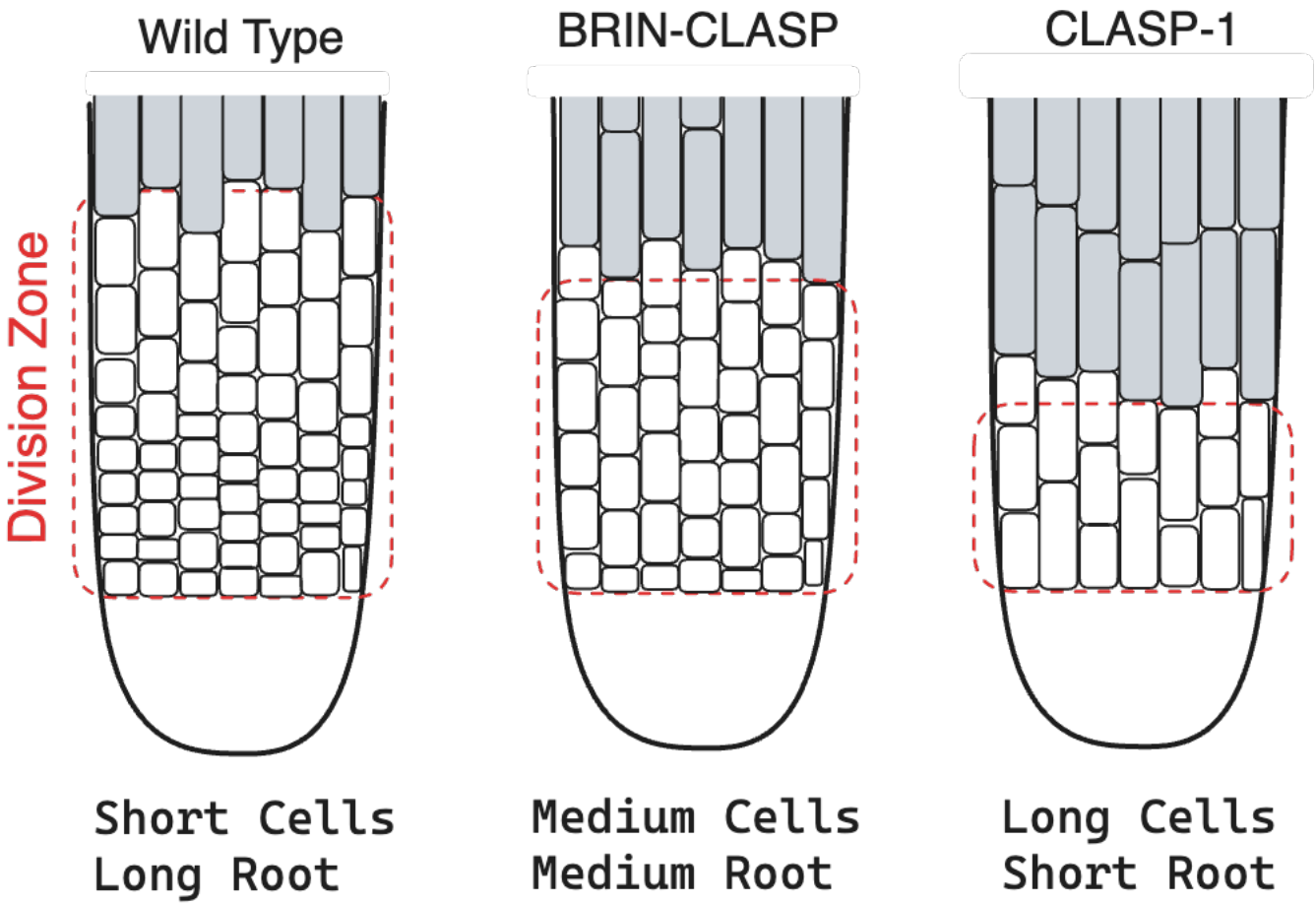

Figure: A length-driven division mechanism (might) produce the different phenotypes in the wild type, BRIN-CLASP, and CLASP-1 roots!

Growth Model

- We model a *single column* of cells over time.
- Our data has no time dependence so Δt is arbitrary.
- Cells grow at a basal rate $g_0 L$.
- This basal rate is inhibited by CLASP due to TFB formation.
- Cell growth is increased by BES1 at a rate $g_1 PL$. We assume that BES1 signalling is linear with cell position (it is, usually).
- The parameter g_1 is proportional the number of receptors R.

Division Model

- Cells complete a cell cycle and divide when $D = 1$.
- Cells also must be at least 9μm long to divide.
- Cell division creates two cells with length $L/2$ and $D = 0$.
- Progress in the cell cyle proceeds at a basal rate d_0.
- Progress in the cell cyle is inhibited by *length*.

Model Equations

In the equations below, C1, BC, and WT stand in for the CLASP-1, BRIN-CLASP, and wild type roots respectively.

$$\text{C1: } \frac{dL}{dt} = ((g_0 - 0) + R_{C1}P)\,L, \qquad \frac{dD}{dt} = d_0\left(1 - \frac{L^n}{d_L^n + L^n}\right)$$

$$\text{BC: } \frac{dL}{dt} = ((g_0 - C_{BC}) + R_{BC}P)\,L, \qquad \frac{dD}{dt} = d_0\left(1 - \frac{L^n}{d_L^n + L^n}\right)$$

$$\text{WT: } \frac{dL}{dt} = ((g_0 - C_{WT}) + R_{WT}P)\,L, \qquad \frac{dD}{dt} = d_0\left(1 - \frac{L^n}{d_L^n + L^n}\right)$$

Recall that $0 < C_{WT} < C_{BC}$ and $R_{C1} < R_{WT} < R_{BC}$.

Results (1)

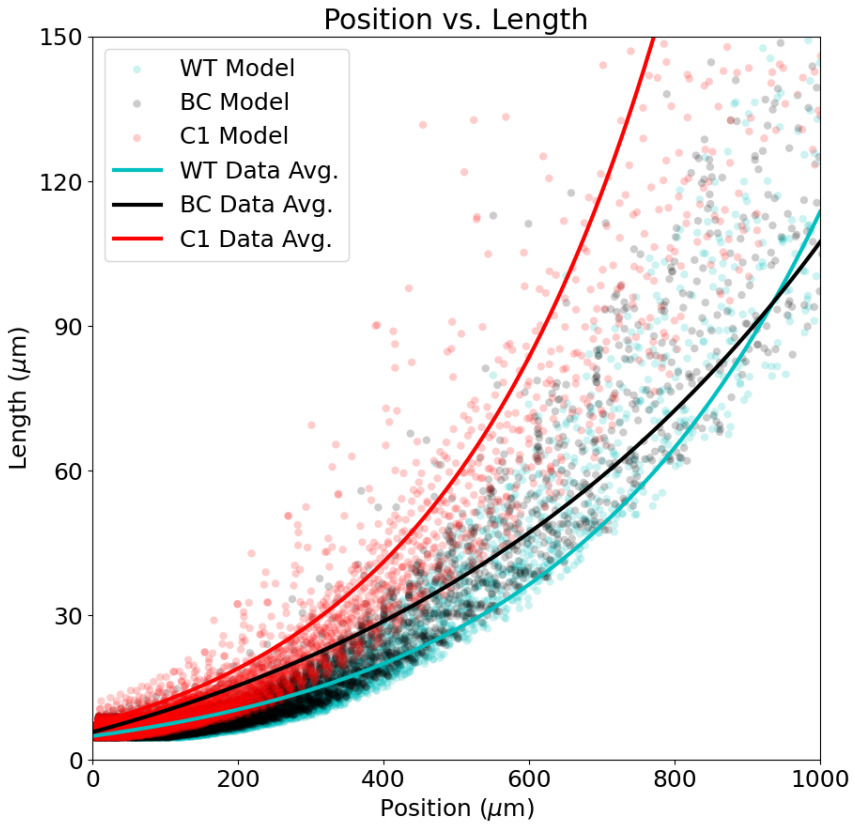

Figure: Fitted cell column model compared to data.

Results (2)

Parameter	Units	Value
g_0	$1/t$	0.02500
c_{WT}	$1/t$	0.01400
c_{BC}	$1/t$	0.02200
R_{C1}	$1/(\mu m \cdot t)$	0.00028
R_{WT}	$1/(\mu m \cdot t)$	0.00029
R_{BC}	$1/(\mu m \cdot t)$	0.00030
d_0	D/t	0.05000
d_L	μm	20.0000
n	1	20.0000

Table: Parameter values for cell column model.

Results (3)

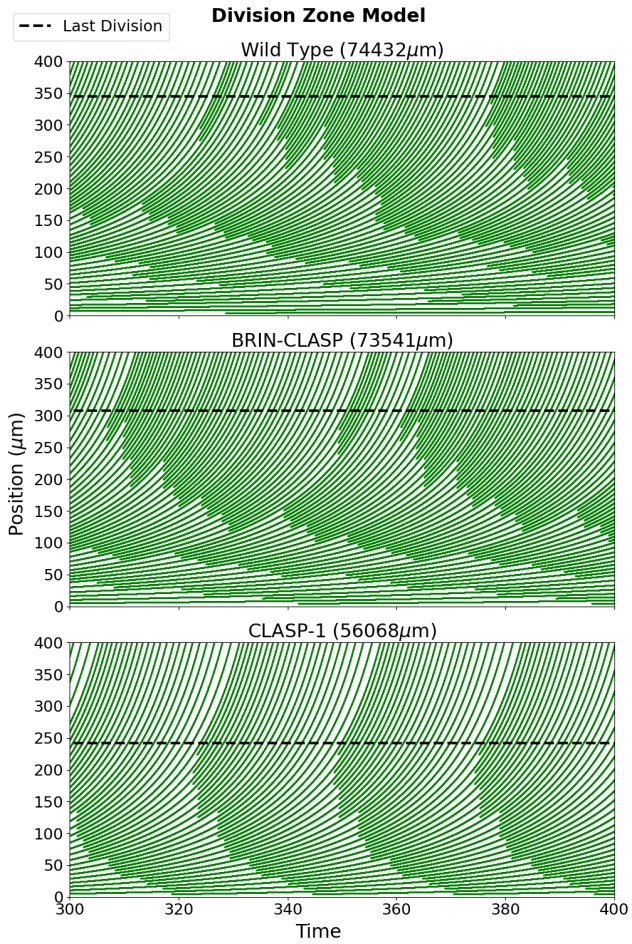

Figure: Division zone behaviour in $t = [300, 400]$.

Results (4)

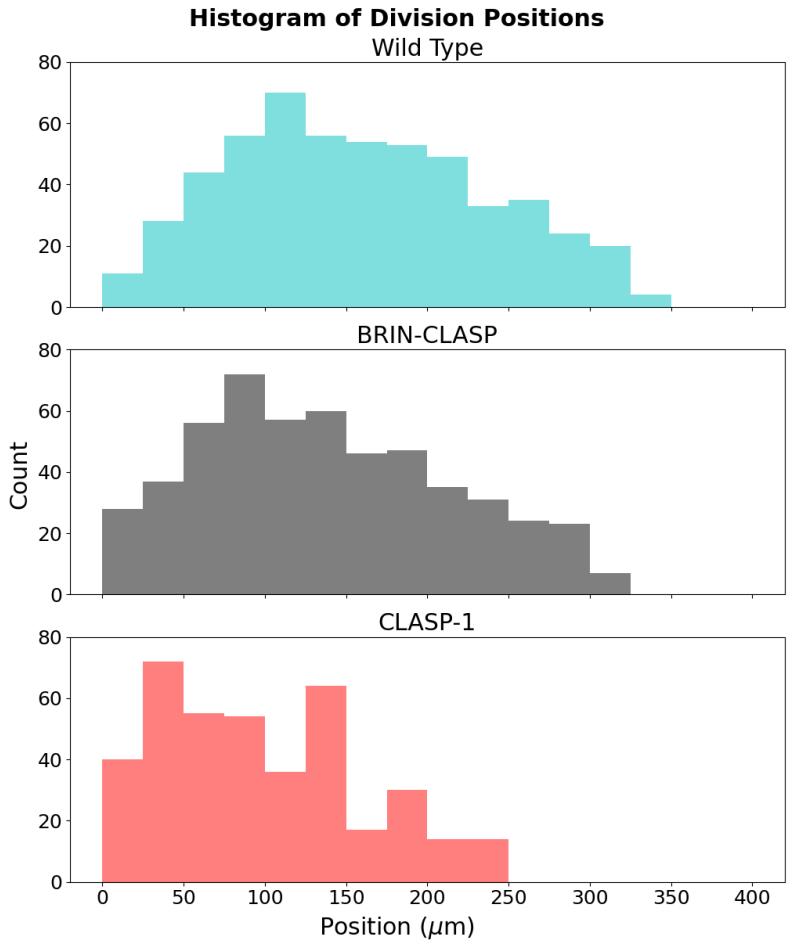

Figure: Division positions by mutant for the entire simulation.

Results (5)

Model	Mean Div.	Median Div.	Max Div.	# Divs.
Wild Type	158.51	151.41	344.34	537
BRIN-CLASP	138.26	131.49	307.45	523
CLASP-1	96.28	83.80	241.98	396

Table: Overview of division behaviour in cell column models.

Results (6)

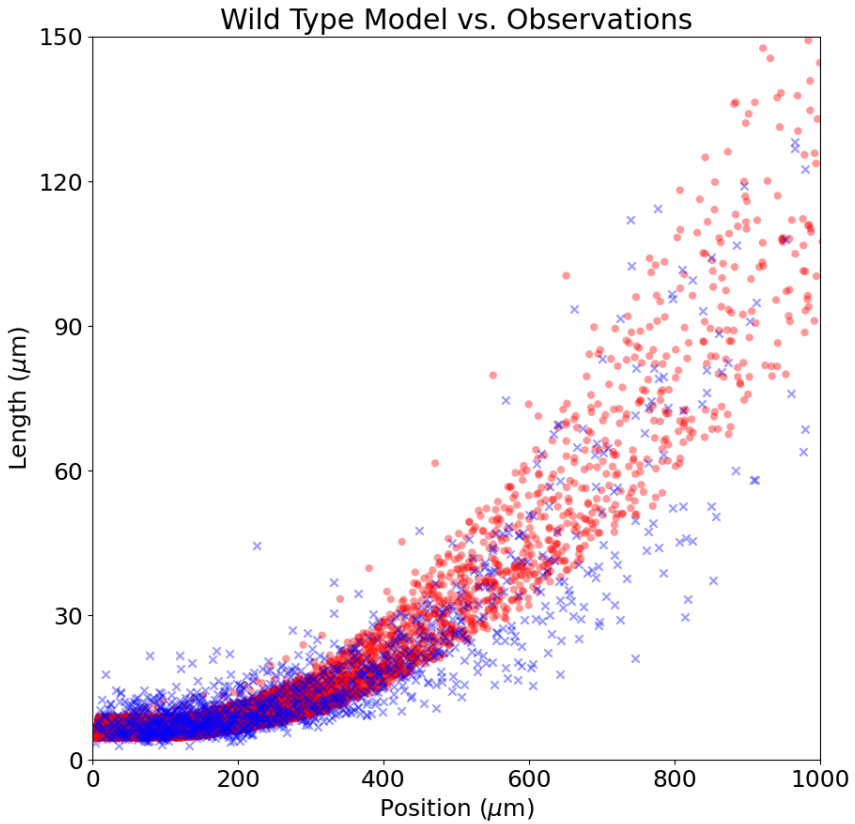

Figure: Comparison of wild type model to observations.

Results (7)

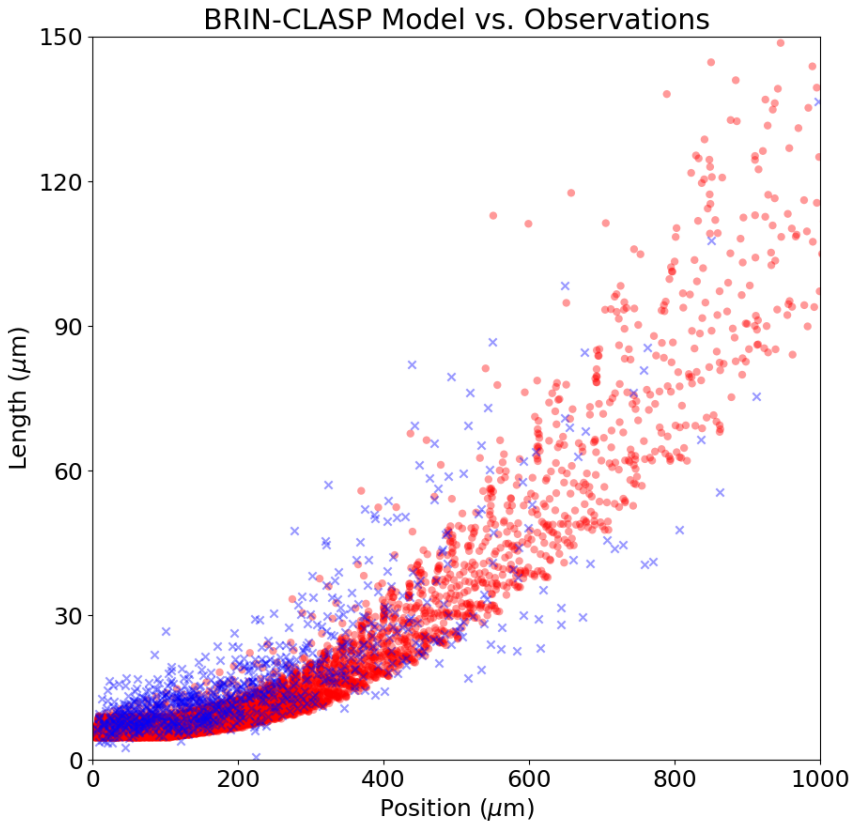

Figure: Comparison of BRIN-CLASP model to observations.

Results (8)

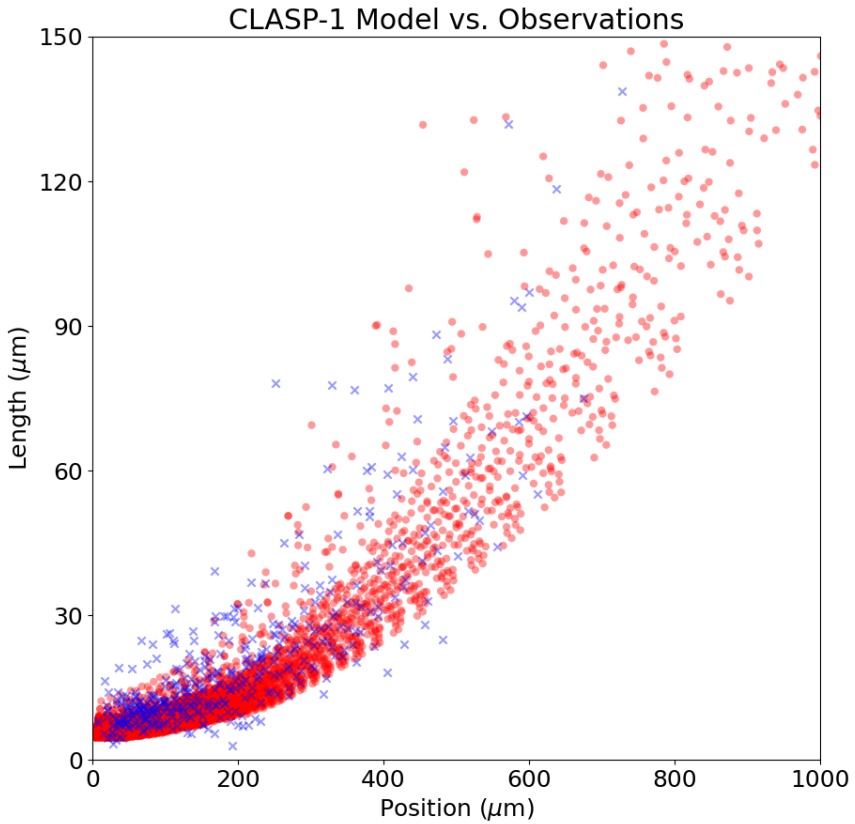

Figure: Comparison of CLASP-1 model to observations.