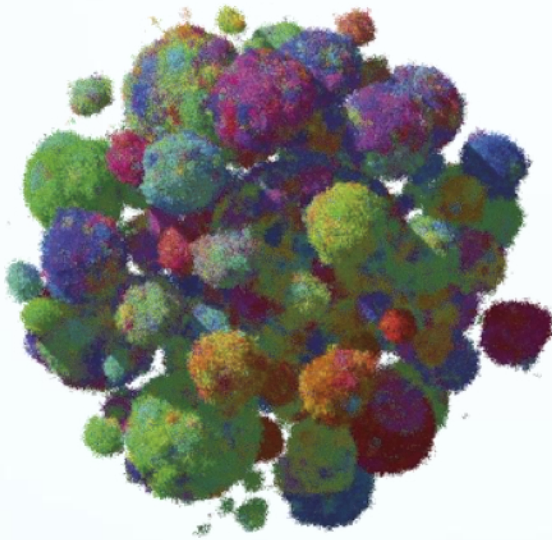


# Predicting tumor growth using a statistical layered population abstraction

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Joint work with Gregory Batt and Blaise Genest

# Tumor Model



## Tumor Simulator

[B. Waclaw, I. Bozic, M. Pittman, R. Hruban, B. Vogelstein & M. Nowak, 2016, A spatial model predicts that dispersal and cell turnover limit intratumour heterogeneity, *Nature*]

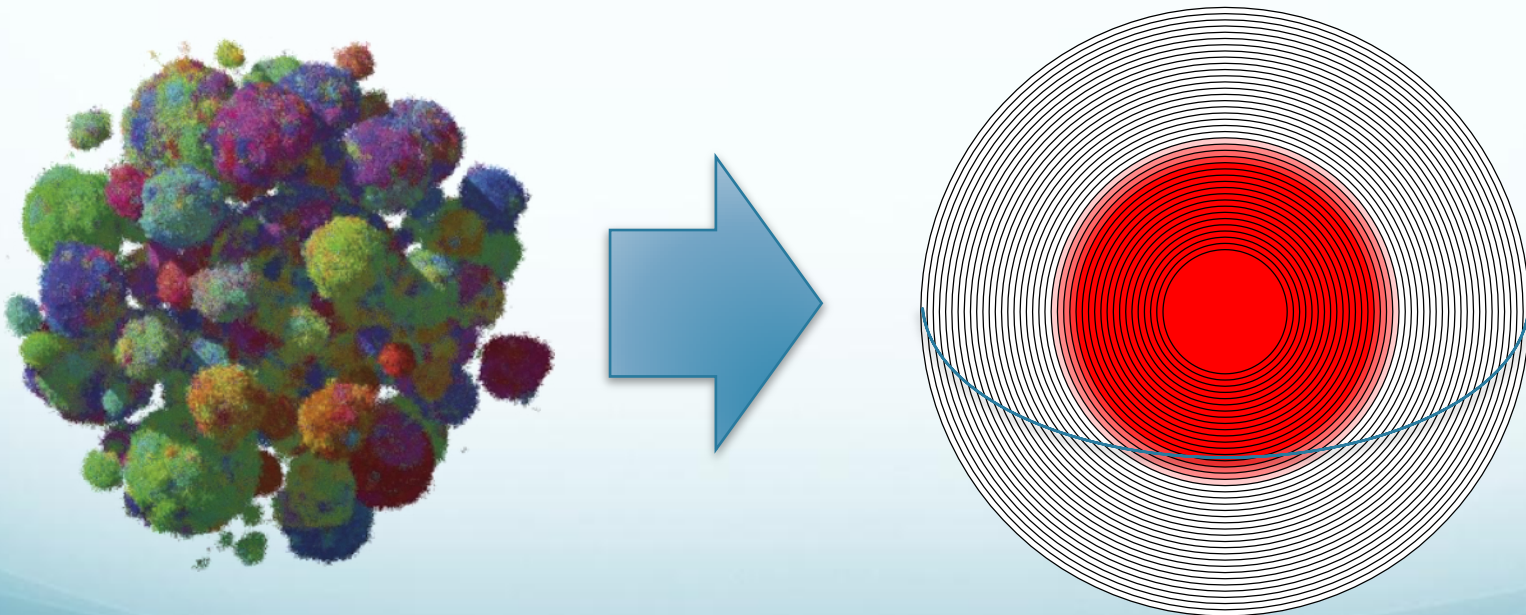
Every Cell represented, grid based.

- Growth (cellular division if space available around + mobility).  
Natural growth of tumor: nbr cells cubic in time.
- Treatment everywhere (e.g. « ray »)
- Treatment in surface (e.g. « medicine »)

# Goal

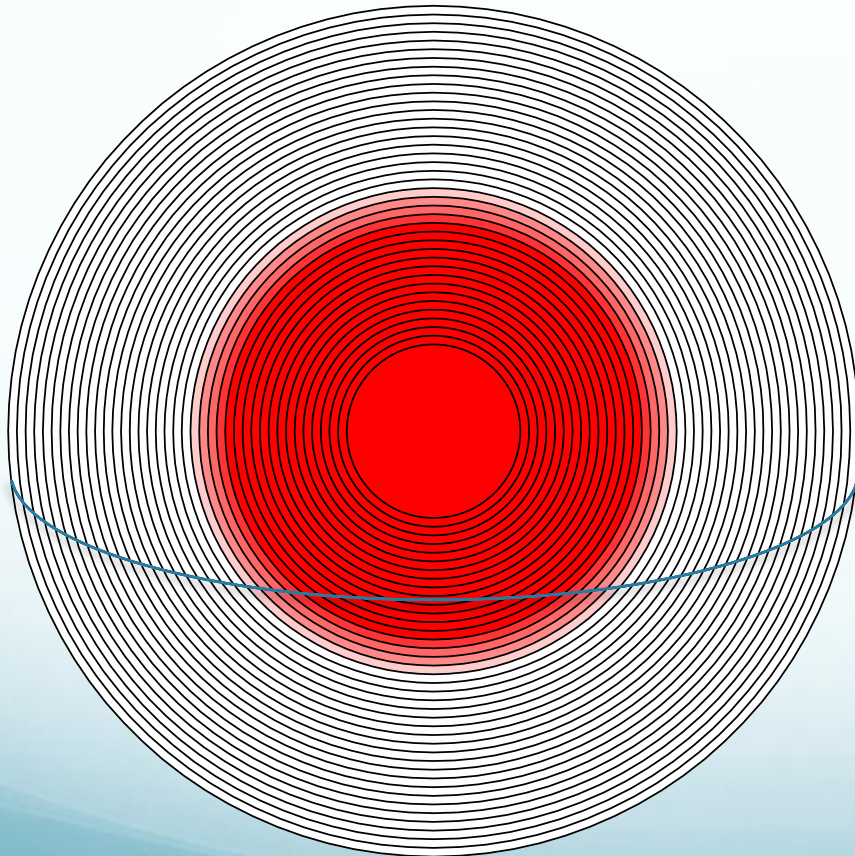
- Obtain a **simpler/faster abstraction** from Tumor Simulator to evaluate speed of growth/death.

If no topological dependencies, easy to obtain equations.  
But growth and surface death depends on positions of cells.



=> Try with «layer»-based model, learnt from **statistics**

# Our model

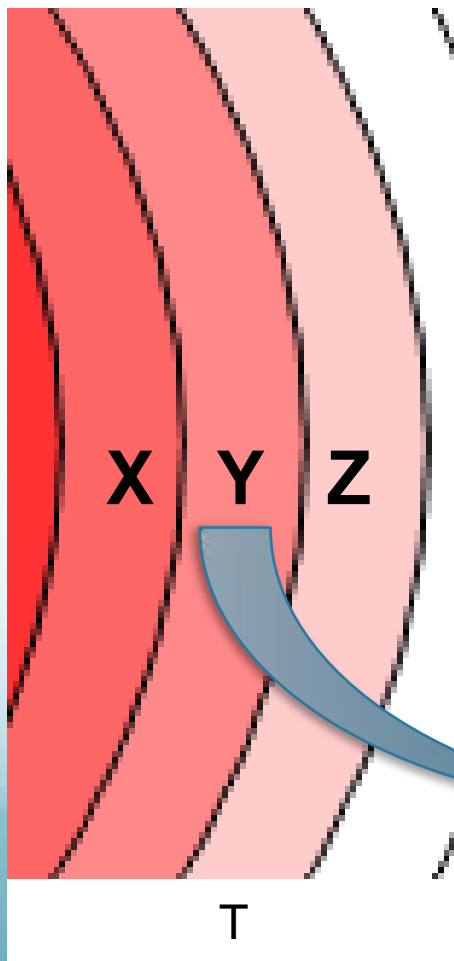


Layers linear with radius  
(follow the  $t^3$  natural growth)

Each layer has a variable for  
cell concentration in that layer  
(100 values)

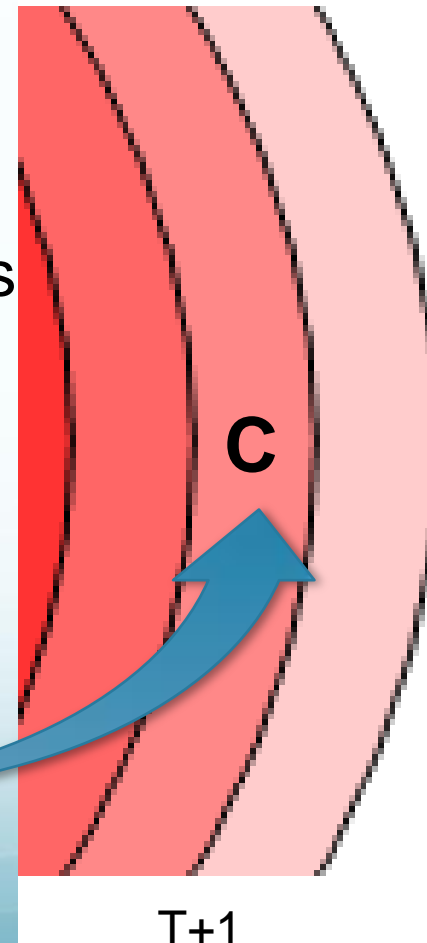
# Probability Tables

Locality : Layer depends on previous, self and next layer



How concentration  $C$  relates to concentrations  $X, Y, Z$  ?

~5.000 simulations to learn the « rules »



Rules of the form:

For  
 $X=64$   
 $Y=41$   
 $Z=18$

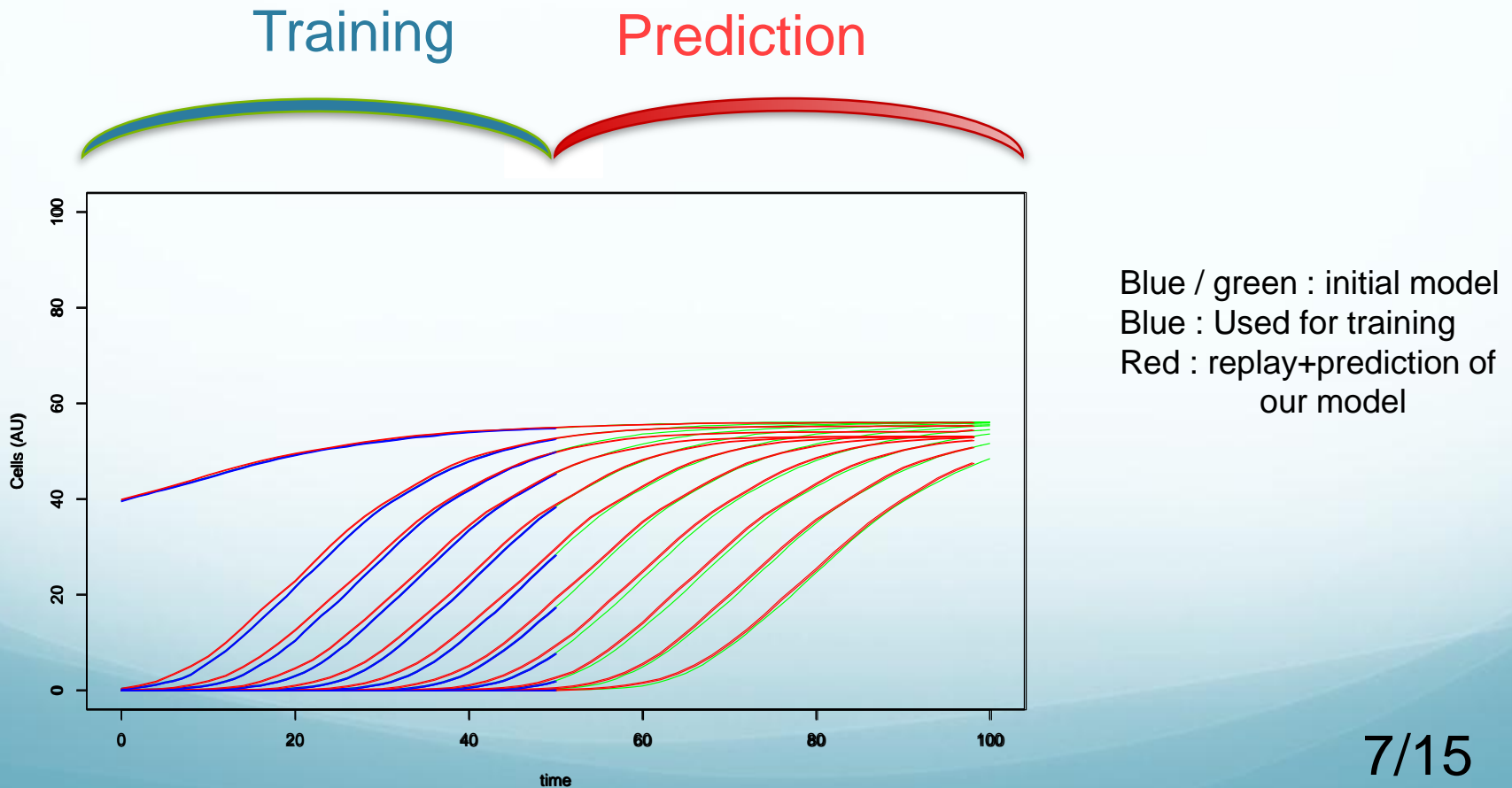
$\text{Prob}(C=52)=0.2$

Time and layer independent

# Results

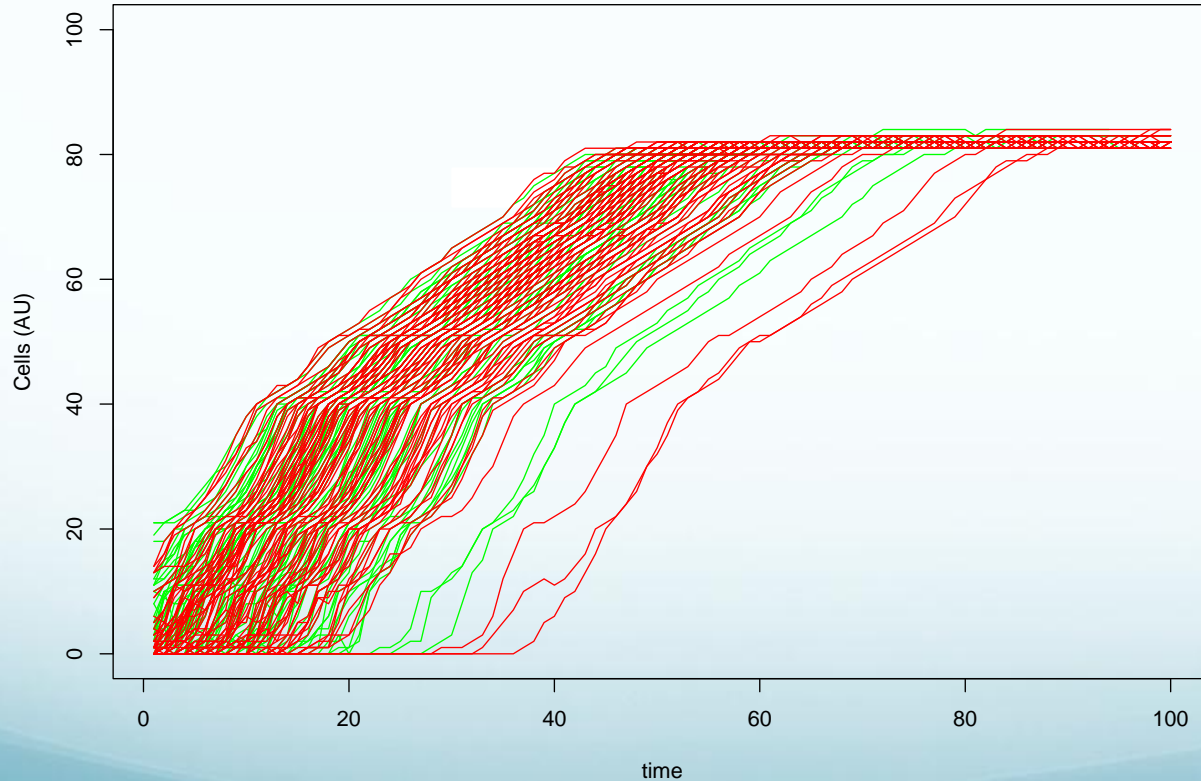
# Results 1: growth (mean)

Growth model (means)



# Growth (distribution)

Growth (100 runs of **original** and **abstraction**, Layer 6 )

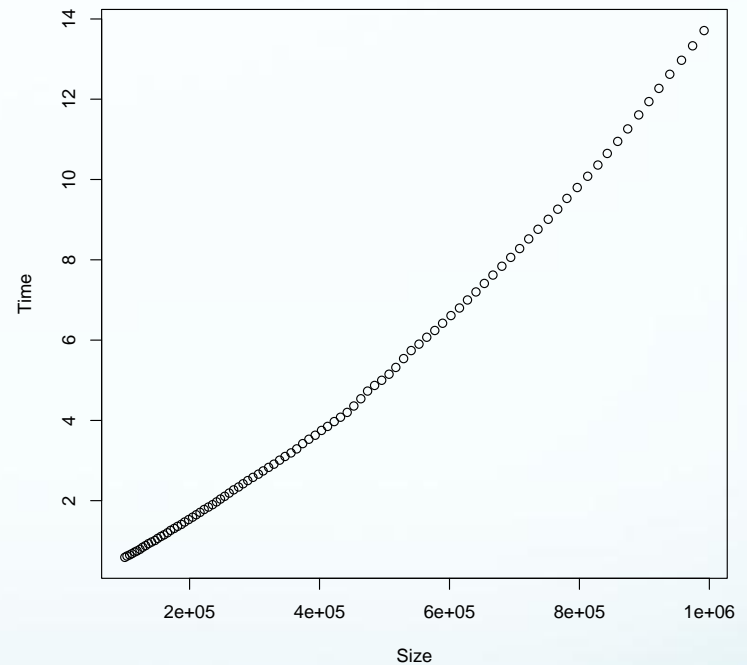




# Running Time

growth till one million cells

- Original : 14.3 seconds
- **Our program** : 1.15 seconds  
(12X faster)

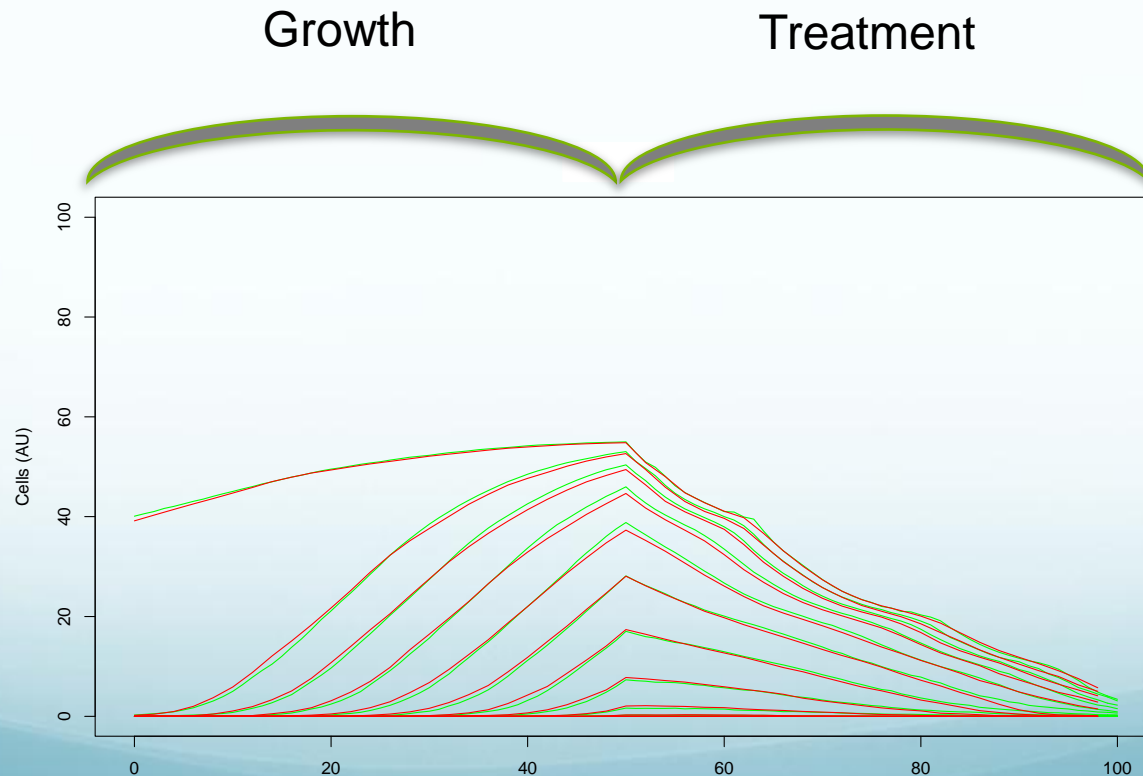


**ADD A CURVE FOR OUR PROGRAM**

# Results 2: treatment (mean)

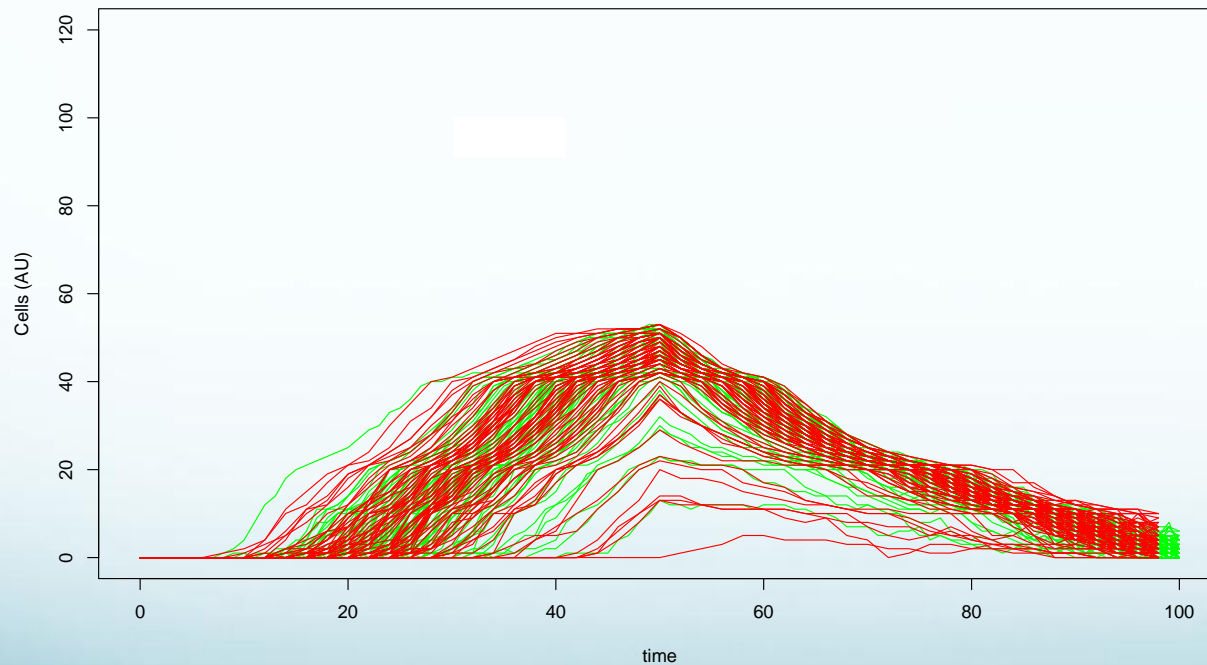
Growth model + treatment model

Treatment considered to reach all cells equally (ray)



# Treatment (distribution)

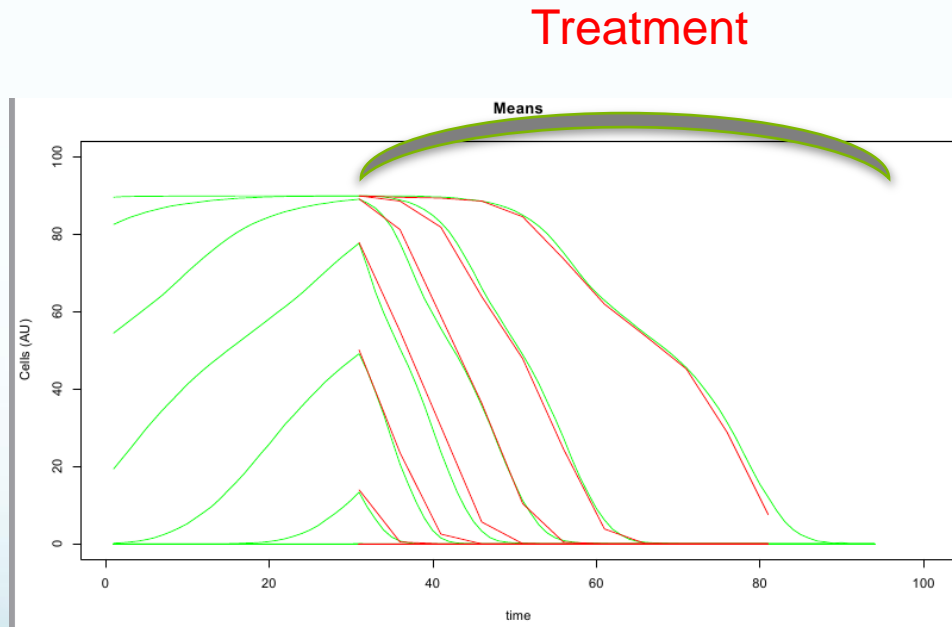
Growth+death ( 100 runs of **original** and **abstraction**, Layer 3 )



# Results 3: surface treatment

treatment (death on surface)

Treatment reaches the surface cells mostly



Can replay from same configurations

Not enough data yet for better abstraction

# Future work

# Future work

- Predict outcome of alternations between treatment and no treatment
  - We need more/better data!
  - produced data actively rather than by observation
- Consider more realistic Tumor models  
(e.g. Drasdo's models)

# Future work

- Consider multi level models (more accurate for treatment):
  - Lower level: treatment with TRAIL (signaling pathway for each cell) [Palaniappan et al. 2017, Bioinformatics]

