

Cluster-level Dynamics in a Neutral Phenotype Evolution Model

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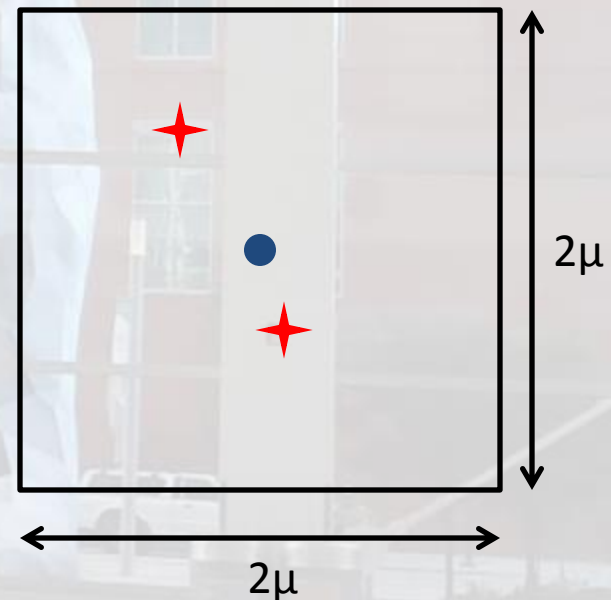
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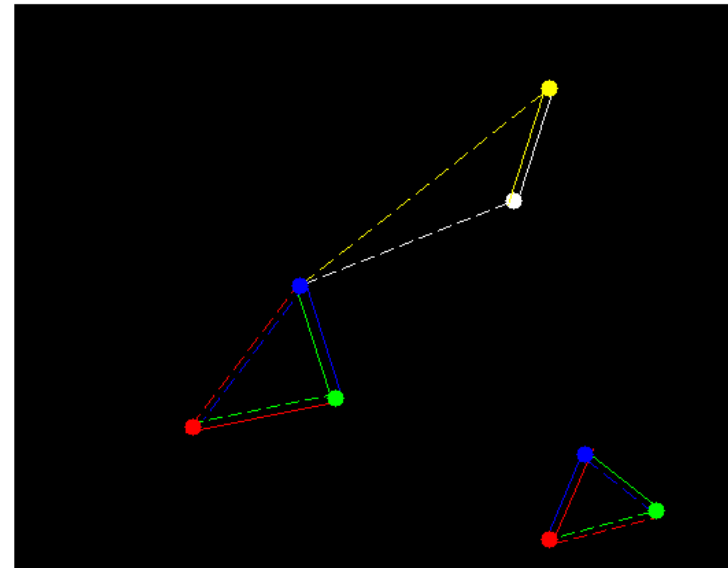
Model

- Spatial branching-coalescing process
 - Asexual reproduction ($A \rightarrow 2A$)
 - Mutability (μ) – control parameter
 - 45x45 phenotype landscape with fitness = 2
 - Competition ($2A \rightarrow A$)
 - Proximity limit = 0.25
 - Random death ($A \rightarrow 0$)
 - Up to 70% population



Clusters

- Nearest-neighbors & second-nearest-neighbors (minimum size is 3)
 - Closed set of seeds



NGEN*1/3

NGEN*2/3

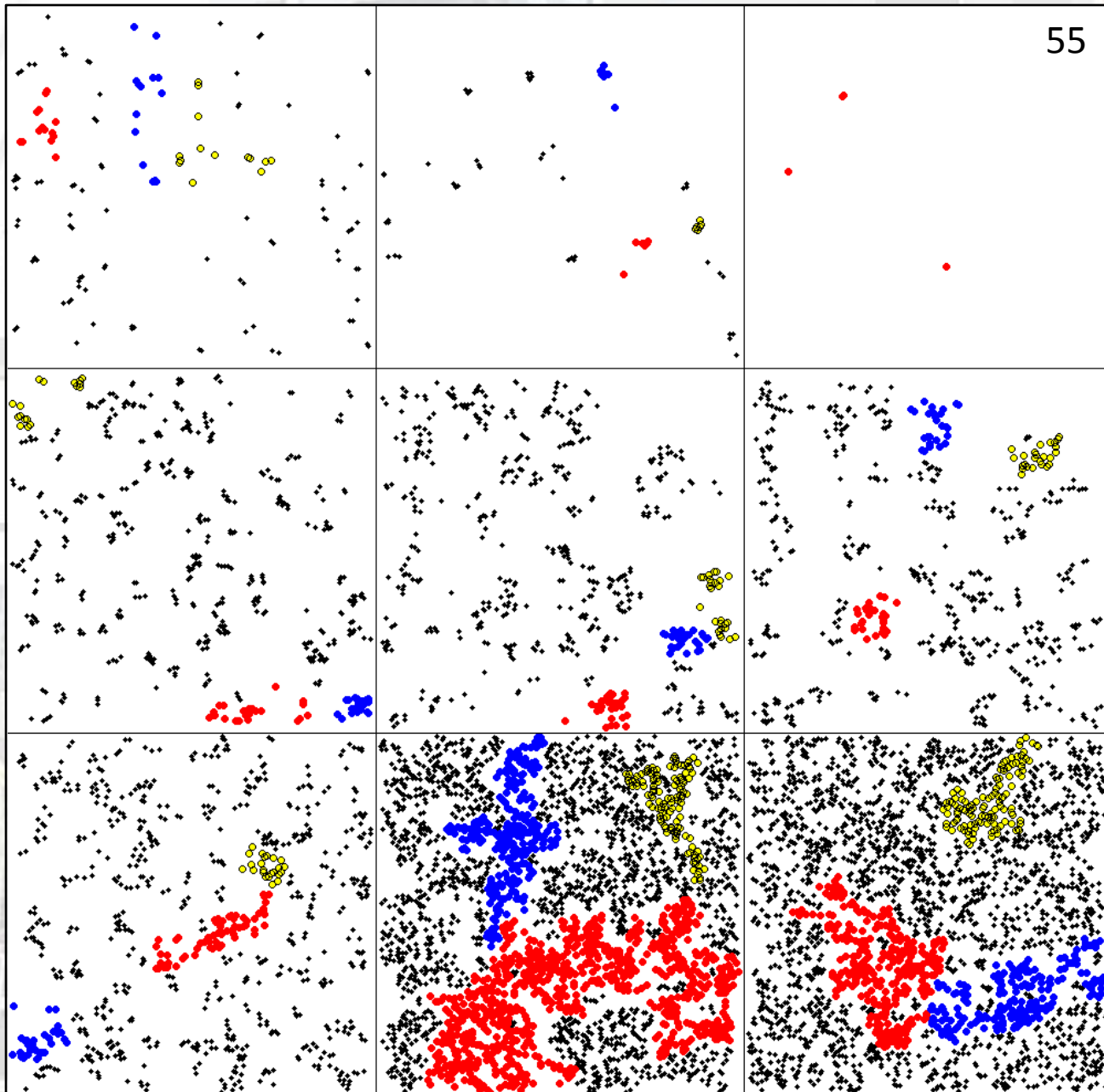
NGEN = 2000

0.25

55

0.35

0.45

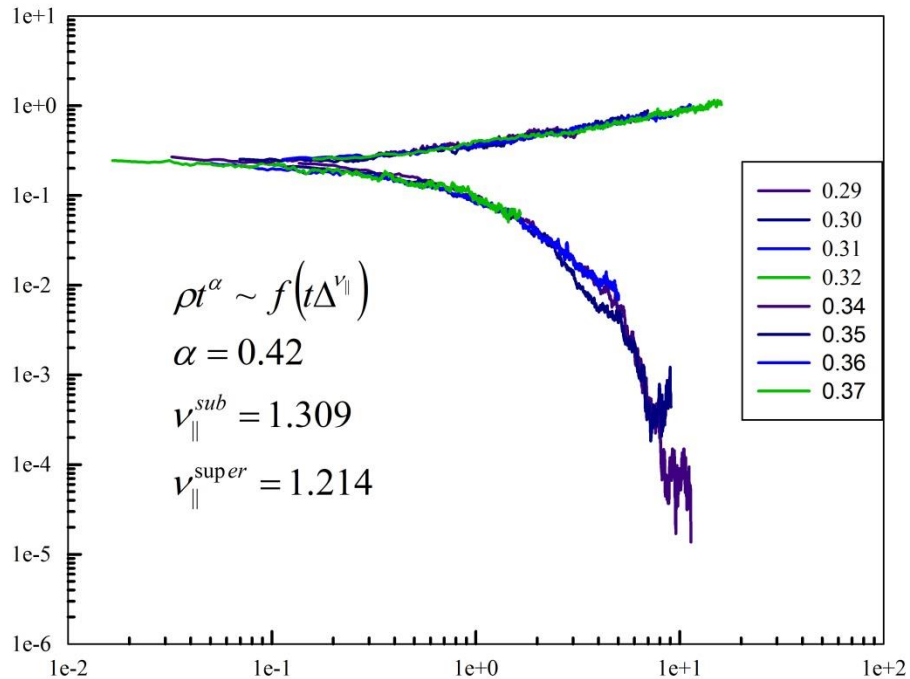


Motivations

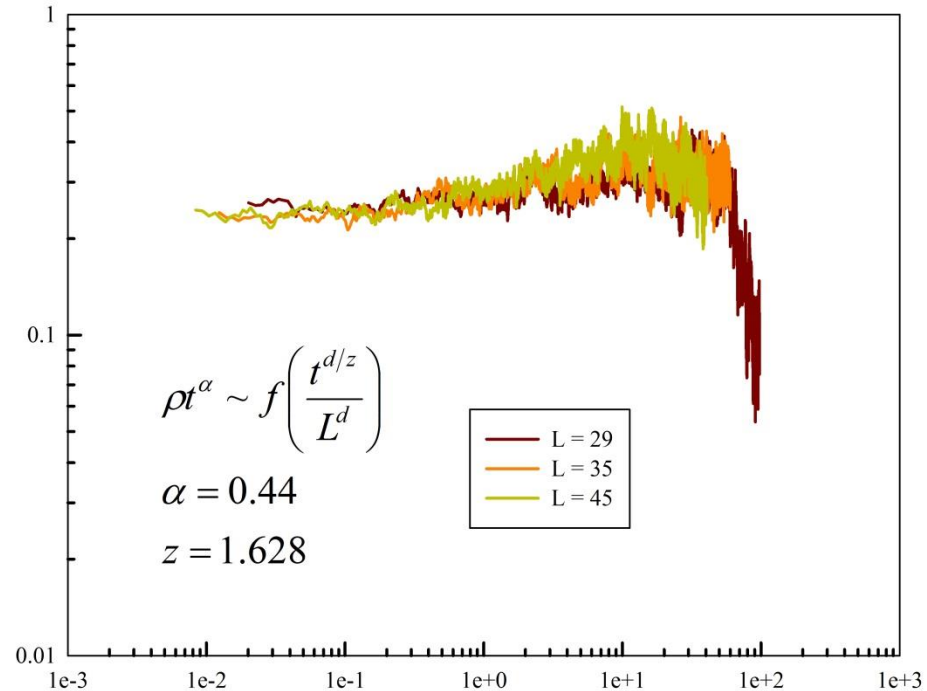
- Scale-free
 - Observed directed percolation (unpublished)
 - Power law cluster-size distribution (Scott et al 2013)
- Multiple levels of selection
 - Group selection arguments (Okasha 2006)
 - MLS1 = cluster fitness related to number of individual offspring (benefit of organisms by being in a cluster)
 - MLS2 = cluster fitness related to number of cluster offspring (benefit of a cluster by producing clusters)

Directed Percolation

Critical-Quench Data-Collapse on 45x45, $t = [1, 1000]$

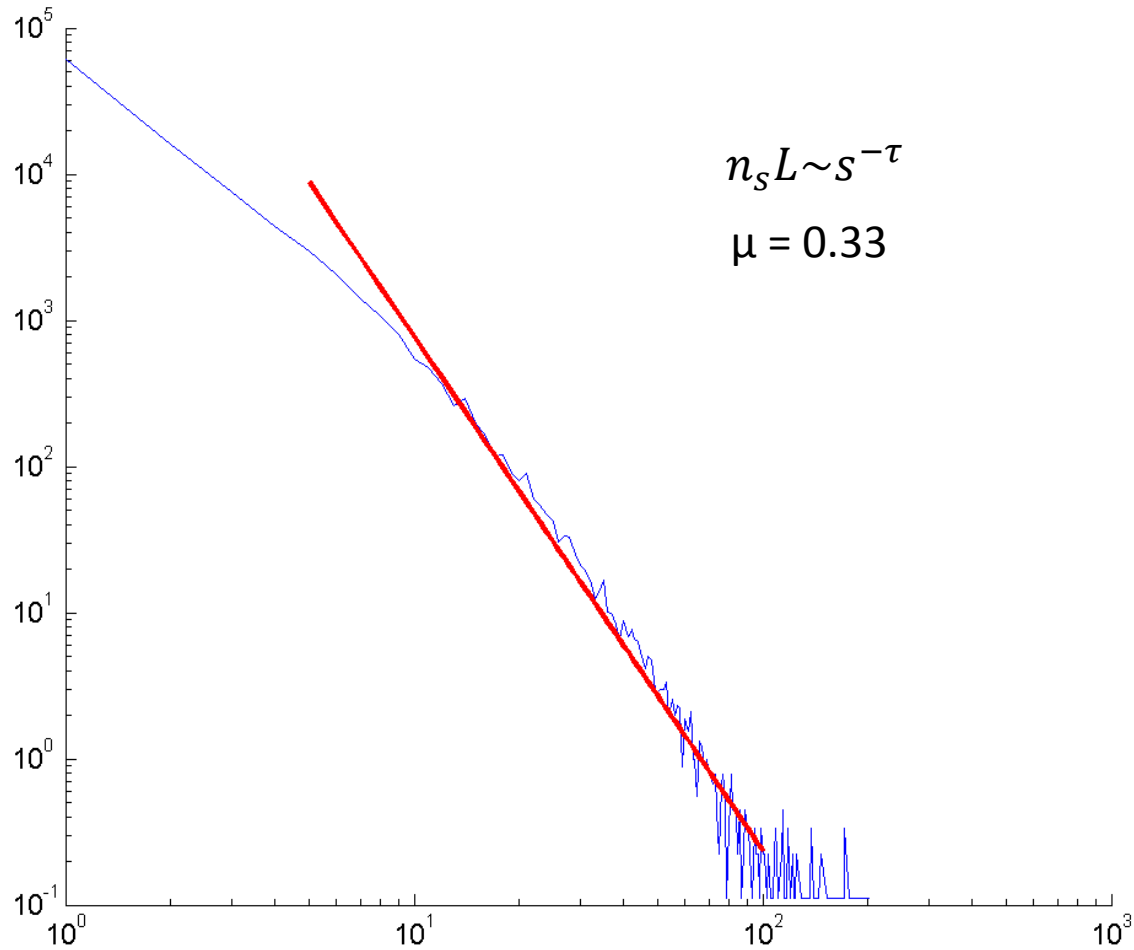


Finite-Size Data-Collapse $t = [1, 10000]$



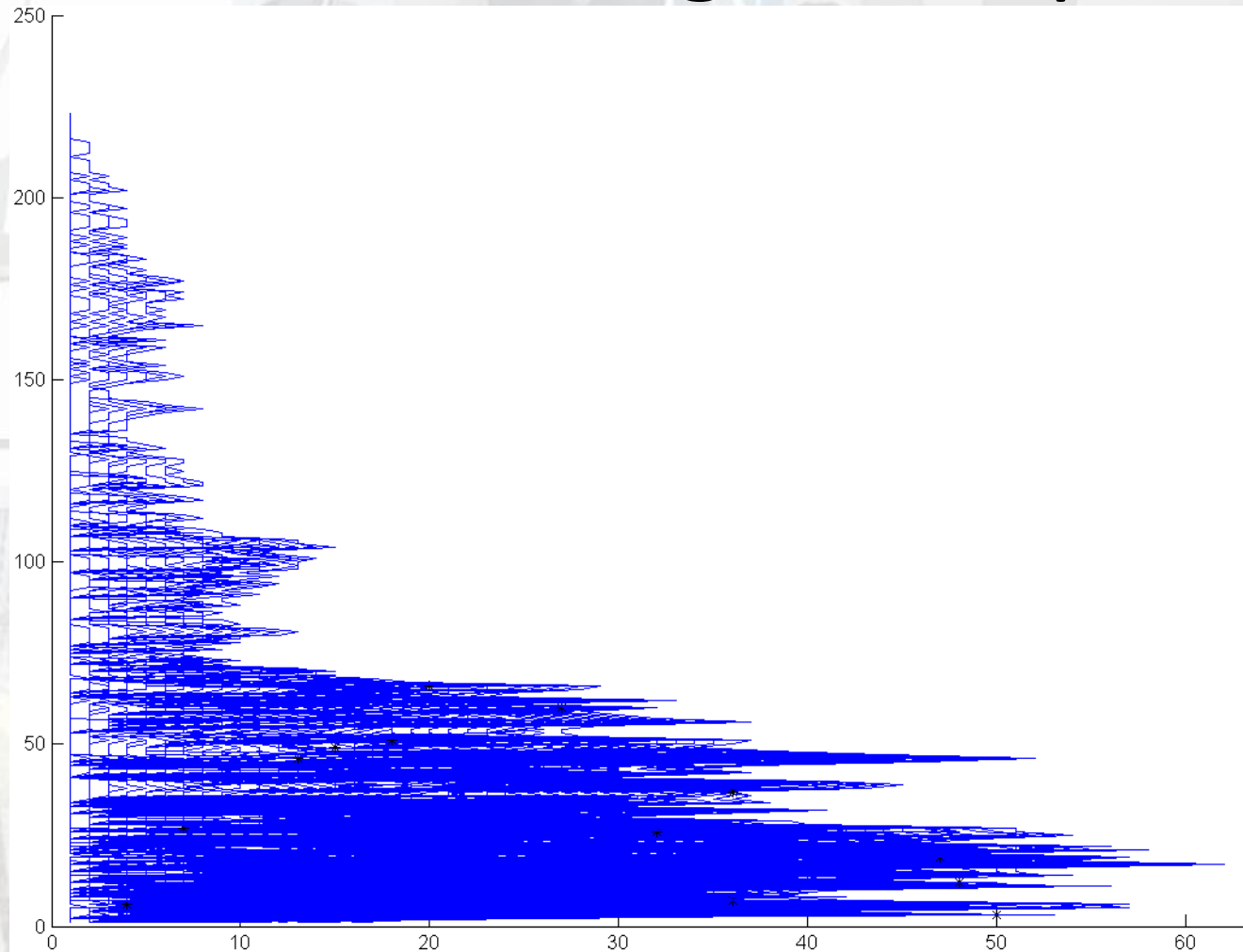
Scott et al, manuscript in progress

Cluster-size distribution



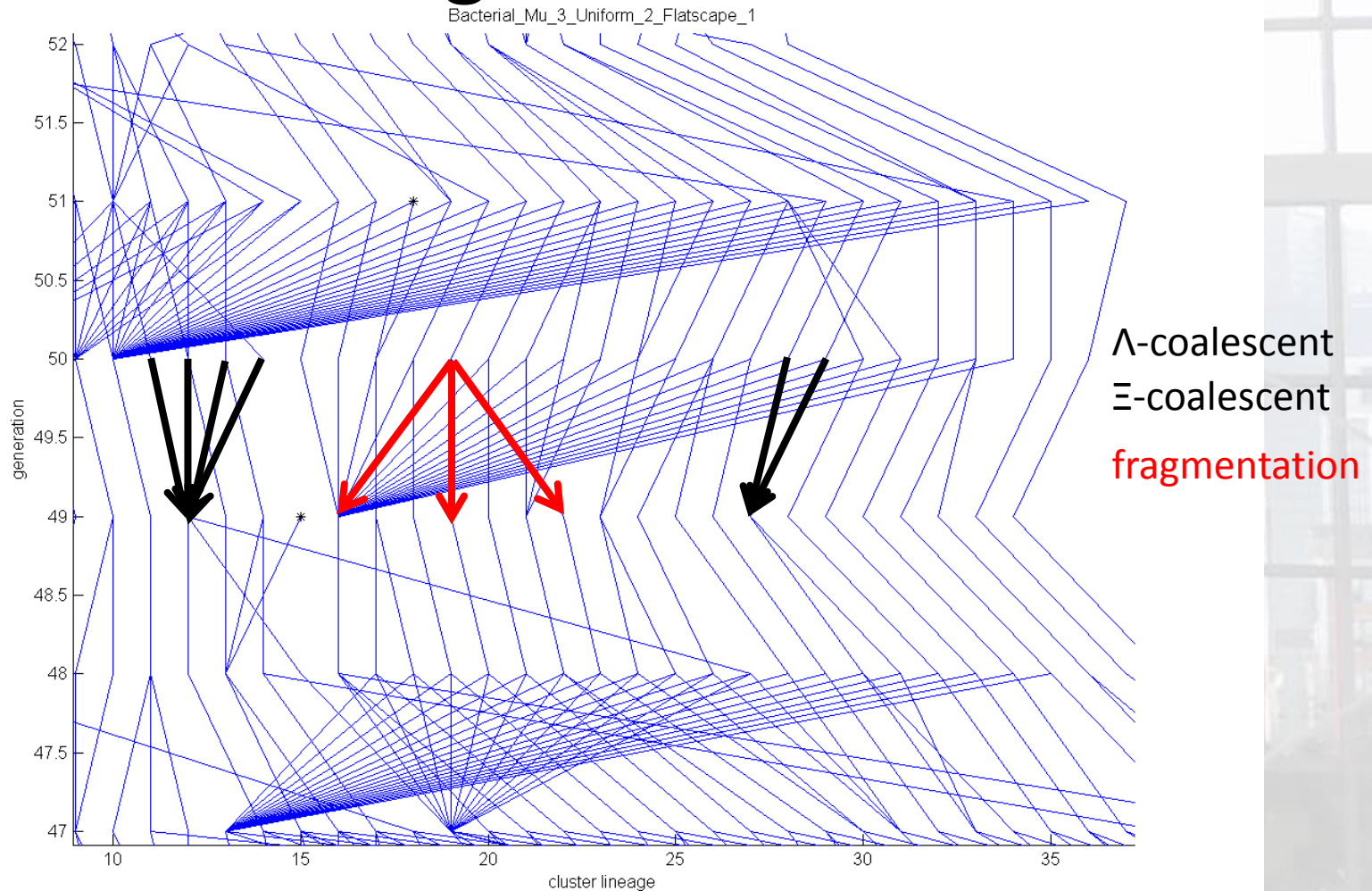
Scott et al, unpublished

Cluster Lineage Example



Example zoom

Coalescent-Fragmentation Processes



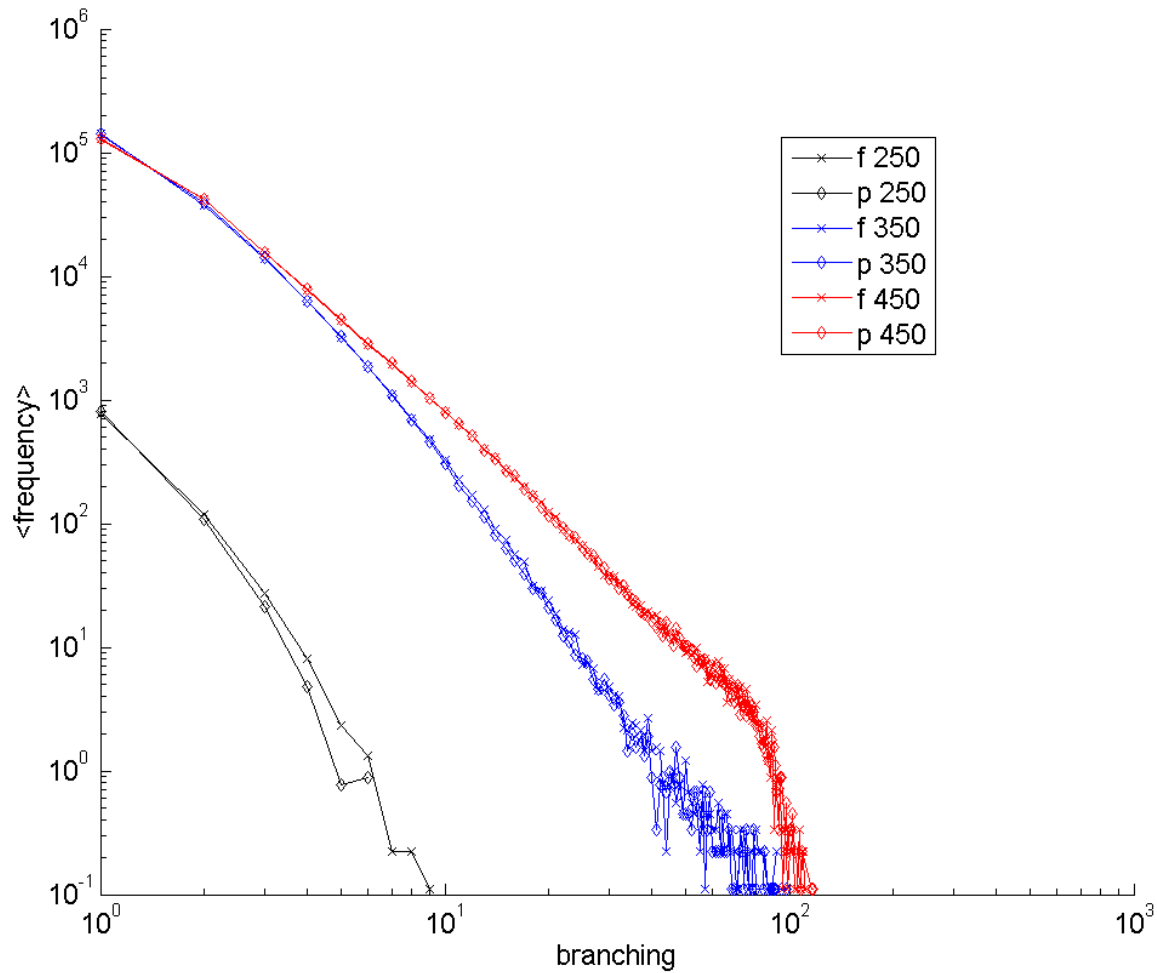
(Pitman 1999; Sagitov 1999)
(Berestycki 2004)

(Schweinsberg 2000; Sagitov & Möhle 2001)
(Limic & Sturm 2006)

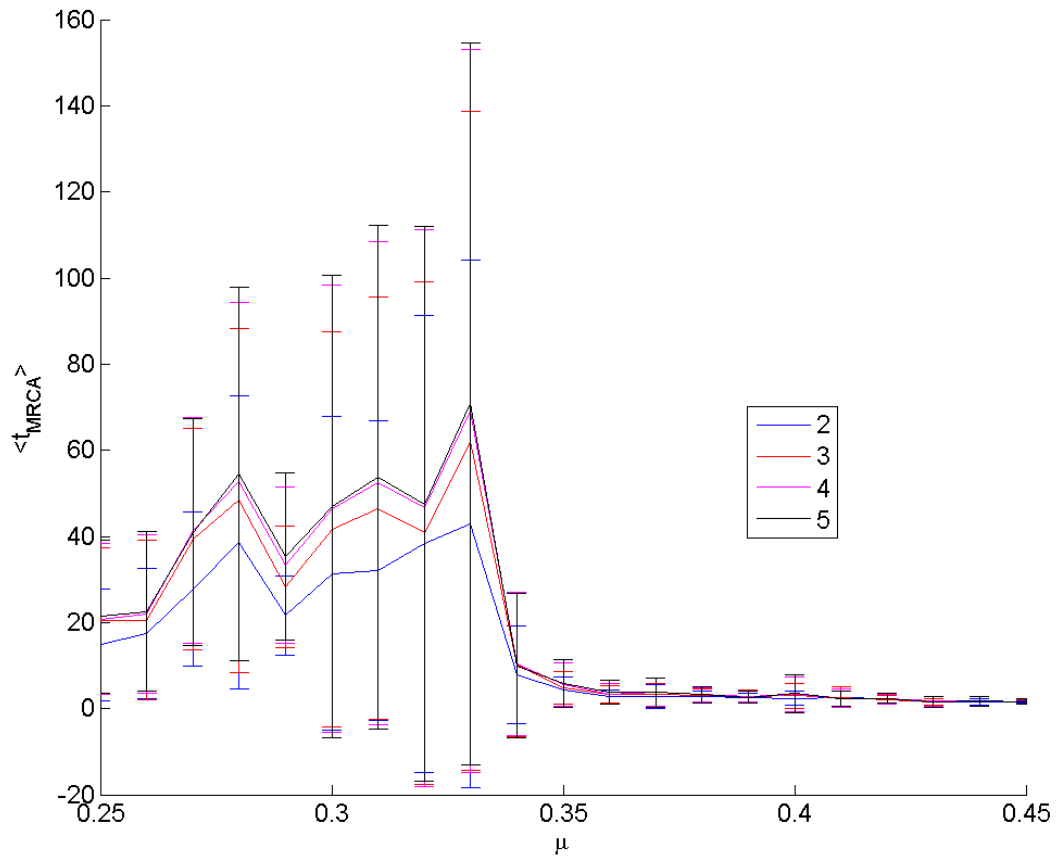
Cluster dynamics

- Cluster lineage
 - Coalescence – fragmentation processes (CFP)
 - Ξ -coalescent & fragmentations
 - Most recent common ancestor (MRCA)
 - Diverging correlation time and lengths with DP

Branching frequencies



$\langle t_{\text{MRCA}} \rangle$ for 2-5 lineages



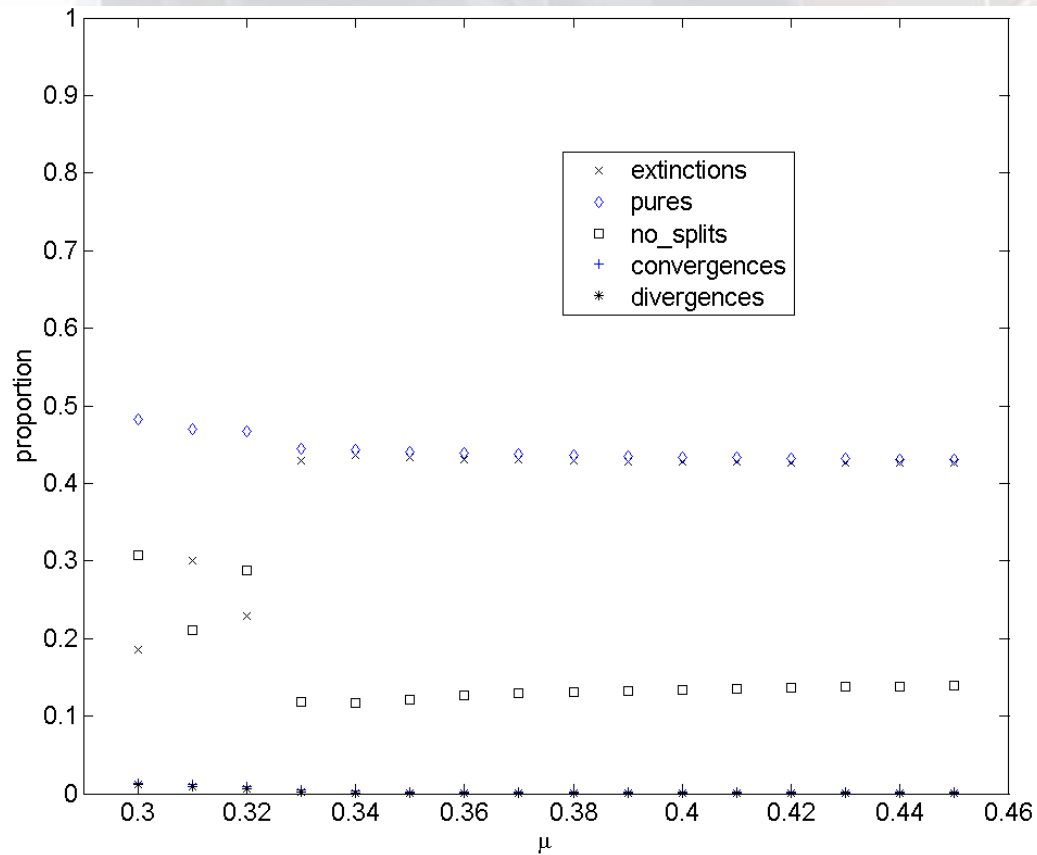
Conclusions

- Diverging $\langle t_{\text{MRCA}} \rangle$ at DP critical point
 - $\sigma(t_{\text{MRCA}})$ at space filling transition
- Power law tail branching frequencies at DP
- Future work:
 - Measure Ξ -coalescents (fragmentation) for clusters
 - Branching number relating to Hausdorff dimension (Lyons 1990)
 - Organism relationship to Kingman's coalescent

References

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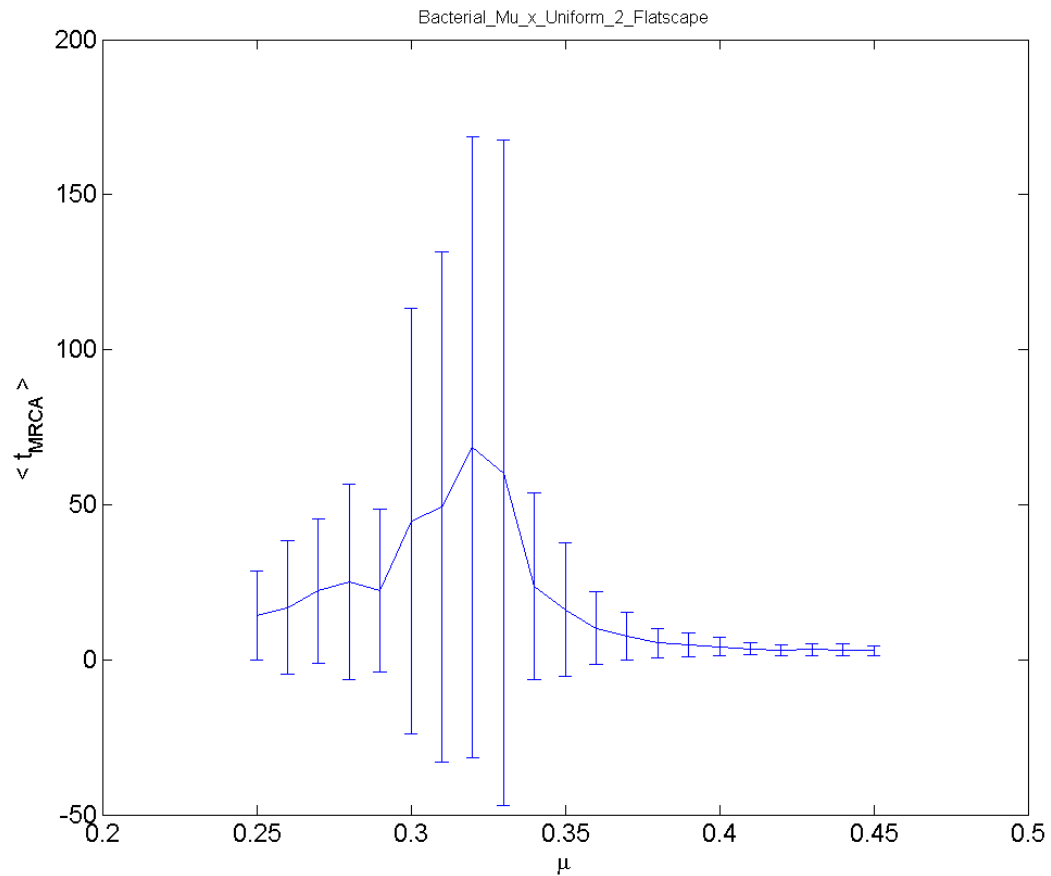
Branching by μ



Cluster dynamics

- Cluster mass
 - Growth and splitting
 - Coagulation – fragmentation processes
 - Smoluchowski coagulation
 - Becker-Döring
 - Marcus-Lishnikov
 - Stochastic-coalescent (Aldous 1999)

Time to MRCA, $k = 2$



$\langle t_{\text{MRCA}} \rangle$ for 2-10 lineages

