# Identifying Pseudobulges using the Critical Surface Mass Density

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Collaborators:

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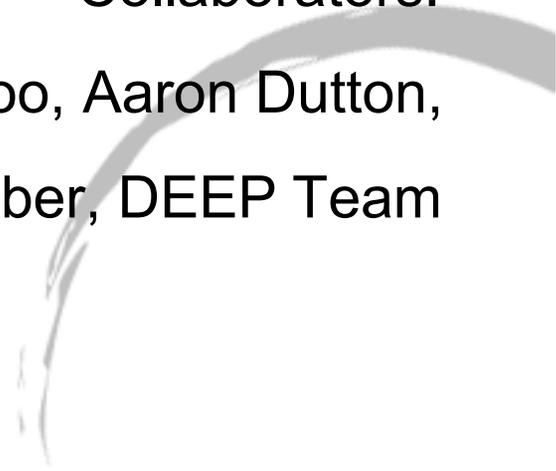
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UCSC Galaxy Workshop

The Different

- Classical Bulge
  - "Merger Hypothesis" (To & Toomre 1972)
  - Clump Instabilities in Dis (Noguchi 1999, Elmegre al. 2009)
- Pseudobulge
  - Secular evolution (Kormendy & Kennicutt 2004)
- Boxy/Peanut Bulges
 - Bar vertical instabilities (Athanassoula 2005)

Why do we care?

- It has been said that…
  - Hierarchical growth is too efficient at forming classical bulges (Combes 2009, Perivolaropoulos 2008, Kormendy & Fisher 2005, Abadi et al. 2003a)
  - Weinzirl et al. (2009) concluded "…contrary to common perception, bulges built via major mergers since $z \leq 4$ seriously fail to account for the [low B/T, ≤ 0.2] bulges present in ~66% of high mass spirals."
- Need to learn more about pseudobulges

Critical Stellar Surface Mass Density

Specific Star Formation Rate

Surface mass density

Maier et al. 2009

(b)

(c) $0.04<z<0.08$ $n<1.5$ $b/a>0.55$ ▲
logM>10.4

(d) $0.04<z<0.08$ $n>2.5$ $b/a>0.55$ ▲
logM>10.4

$\Sigma_{critical}$ is due to transition from disk dominated ($n<1.5$) to bulge dominated ($n>2.5$)
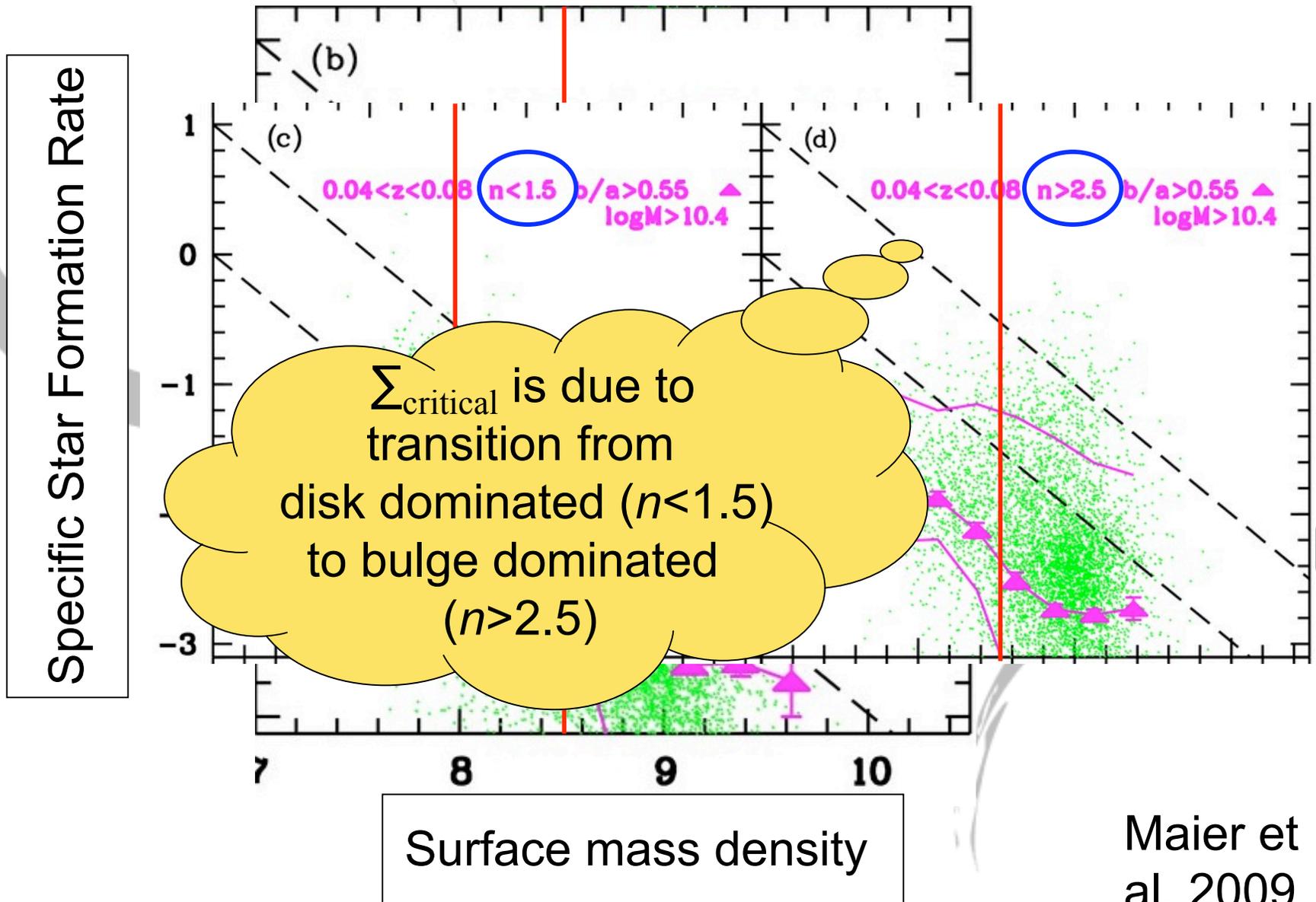
Sérsic vs. Stellar Surface Mass Density Galaxy

- $\Sigma_{critical}$ separates red (old) and n >2.5 (bulge - dominated) galaxies from blue (young) and $n < 1.5$ (disk- dominated)

b/a > .55,.8>z>.5

N=441

Sersic Index of Galaxy

Surface Mass Density [Solar Masses/kpc^2]
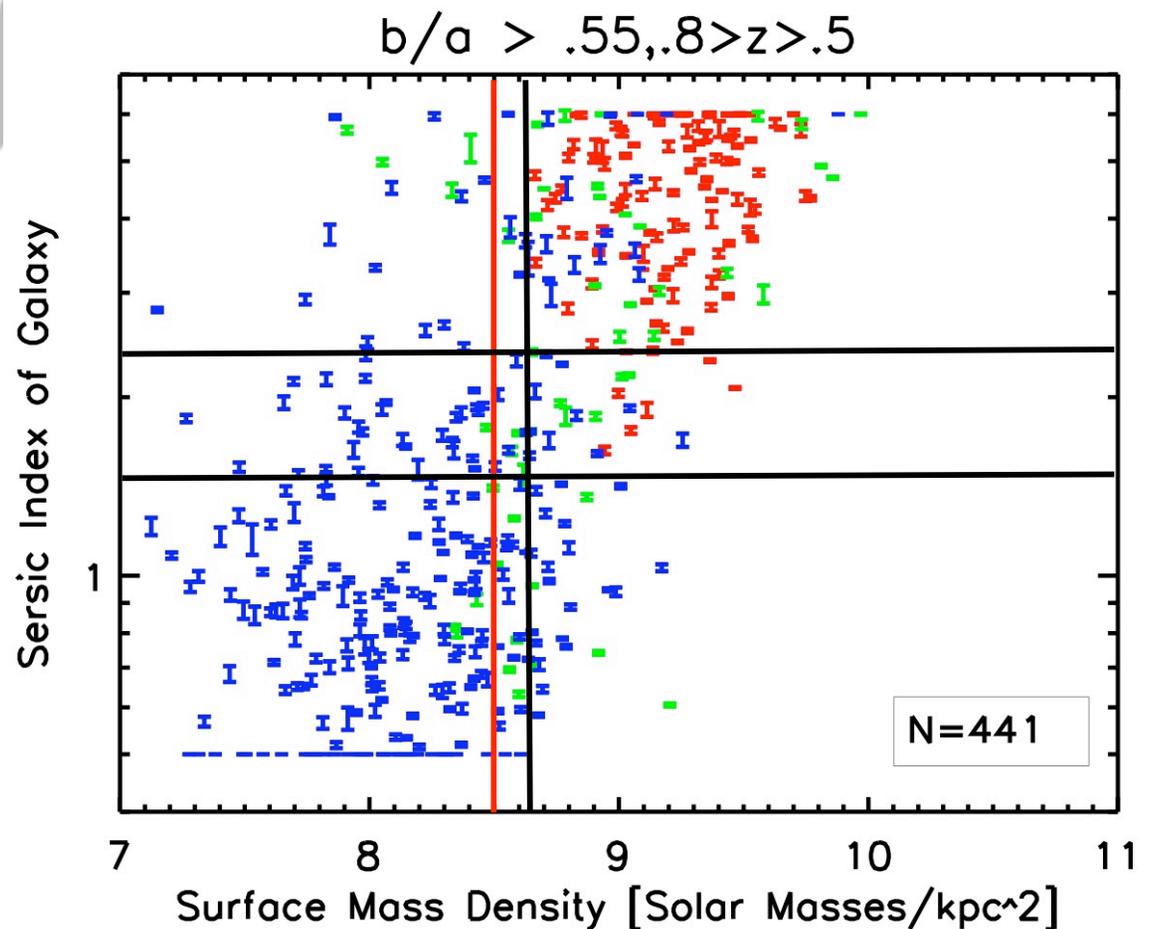
Sérsic vs. Stellar Surface Mass Density Bulge

- Shows a similar $\Sigma_{critical}$ as well
- Drory & Fisher (2007) shows that blue, low Sérsic (n<2.5) galaxies host pseudobulges

b/a>.55,.5<z<.8,.1<B/T<.9

Sersic Index of Galaxy

Surface Mass Density of Bulge [Solar Masses/kpc^2]

N=185

Classical Bulges
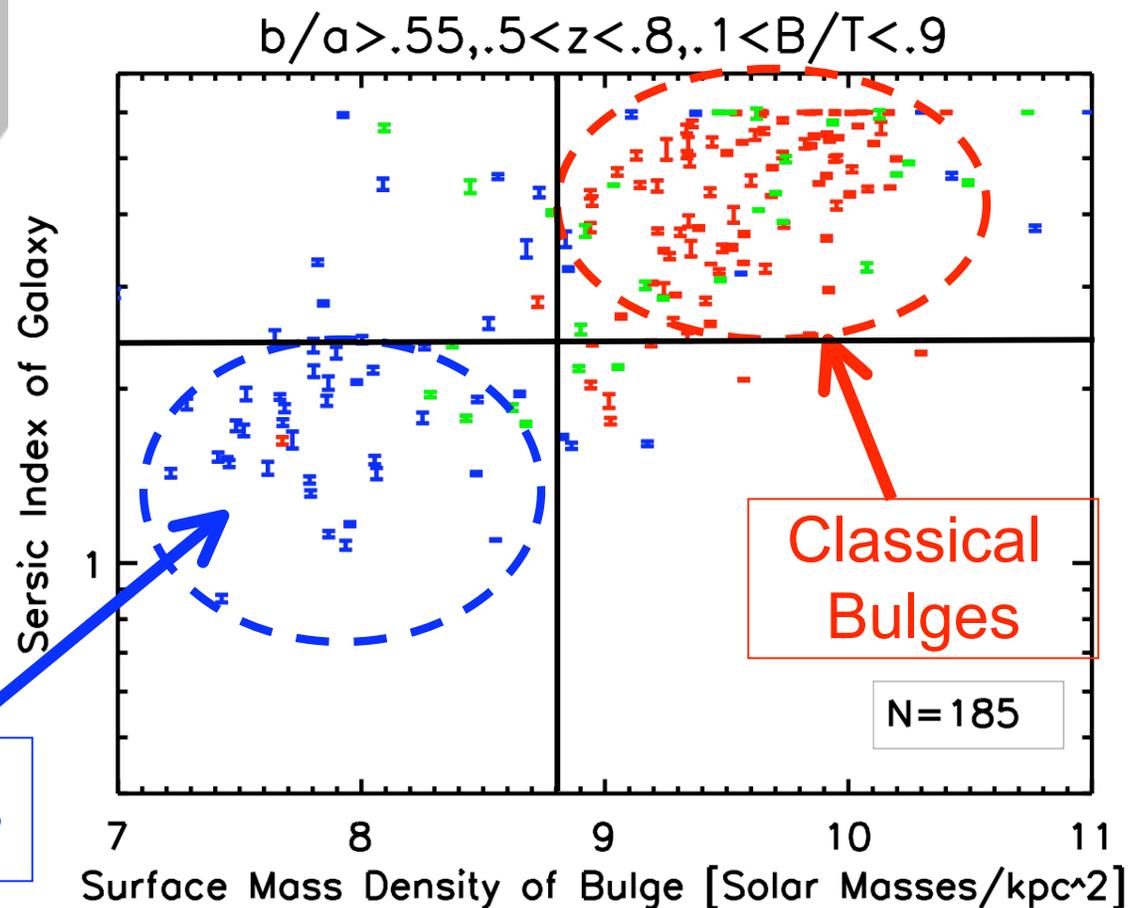
Pseudobulges

Candidate Pseudobulges
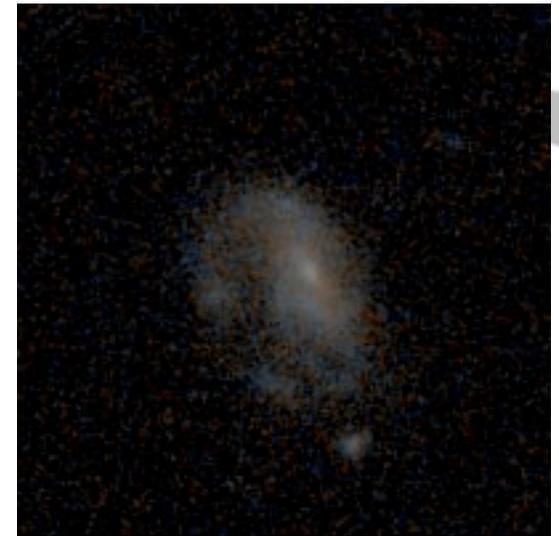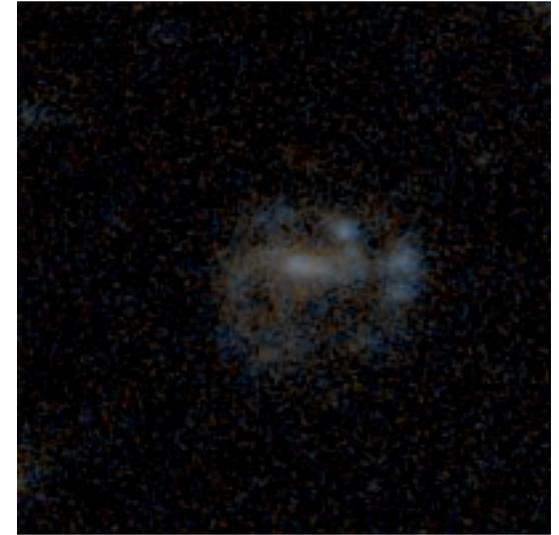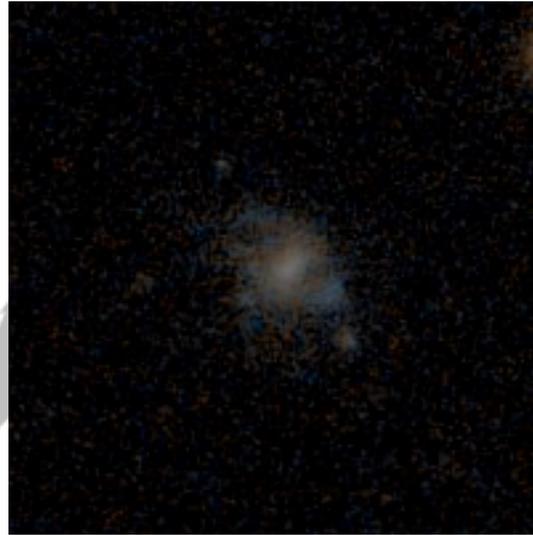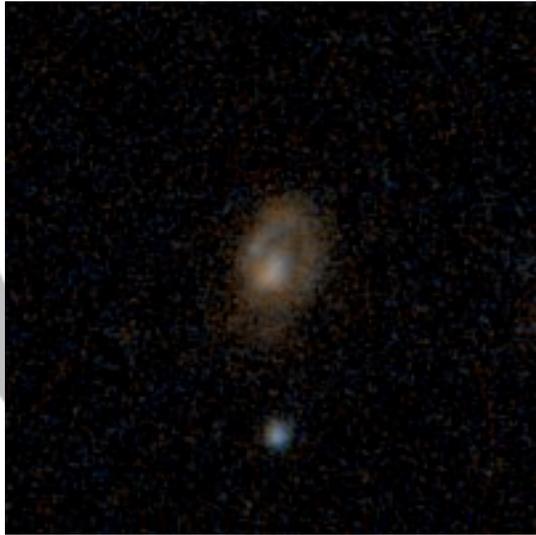
Why is there a critical density?

- Secular evolution tends to destroy the bar that drives it
  - A central mass concentration of 2-10% destroys the bar (Berentzen et al. 1998, Shen & Sellwood 2004)
  - Self-regulating process that might explain the dearth of dense pseudobulges
- However, Kormendy and Kennicutt do not believe there is a limit to the growth of pseudobulges
  - There are examples of barred galaxies with B/D ratio ~1
  - Simulations that predict this destruction doesn't take into account enough physics

Conclusion

- Taking Drory & Fisher's (2007) low redshift classification of pseudobulges, we find that classical bulges and pseudobulges can be distinguished using the critical surface mass density

- The existence of a bulge critical density in my data is consistent with the theoretical prediction that secular evolution is a self-regulating process that limits how dense pseudobulges can grow

- Need to look at the local universe to confirm

Previous Work

- Kormendy & Kennicutt has a list of pseudobulge properties
- Fisher uses sersic index (insert histogram)
- Gadotti uses Kormendy relation (insert plot)