

Galaxy morphology in rich clusters: Implications for the formation and evolution of galaxies

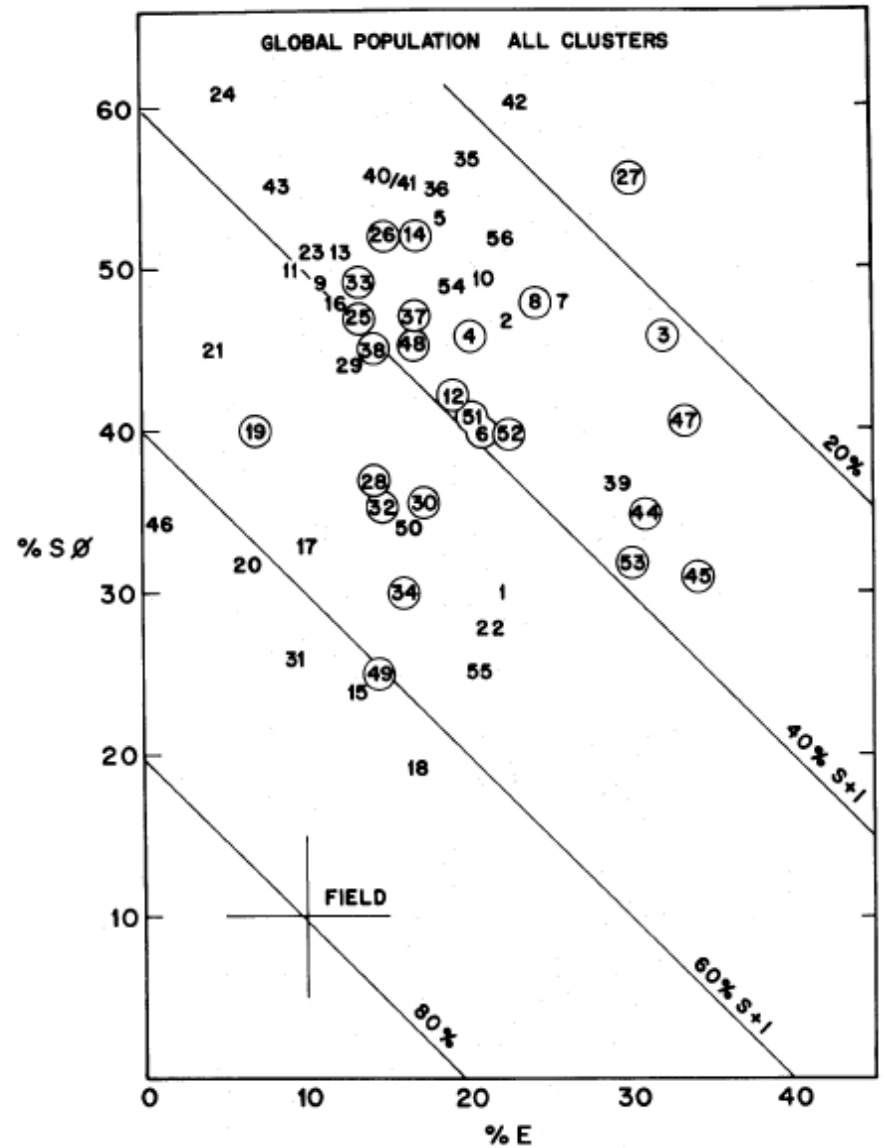
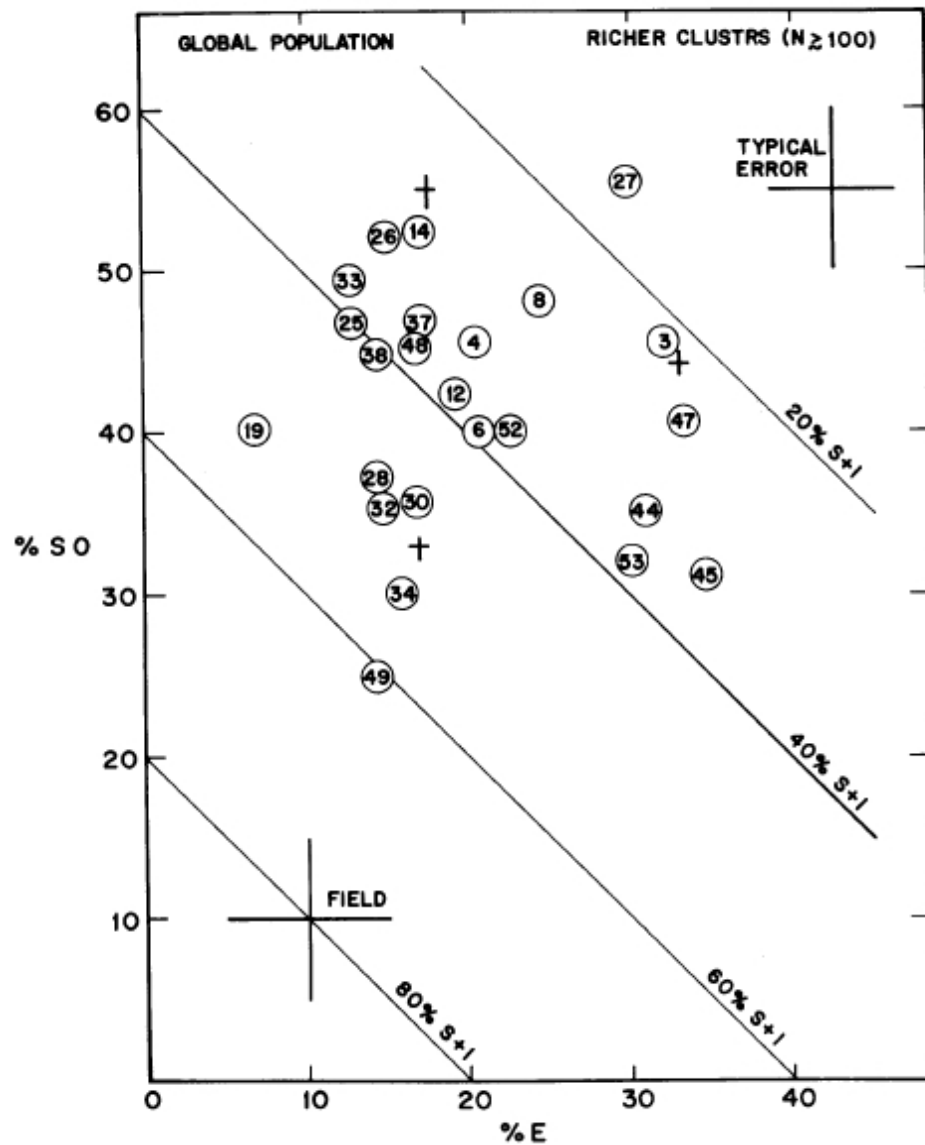
A. Dressler (1980)

Gergö Popping

Outline

- Introduction
- Population Gradients
- Are S0 swept spirals?
 - Population density gradient
 - Disk/Bulge ratio
 - How did S0's form?
- Massive bulges in high density regions
- Conclusion

Introduction



Introduction

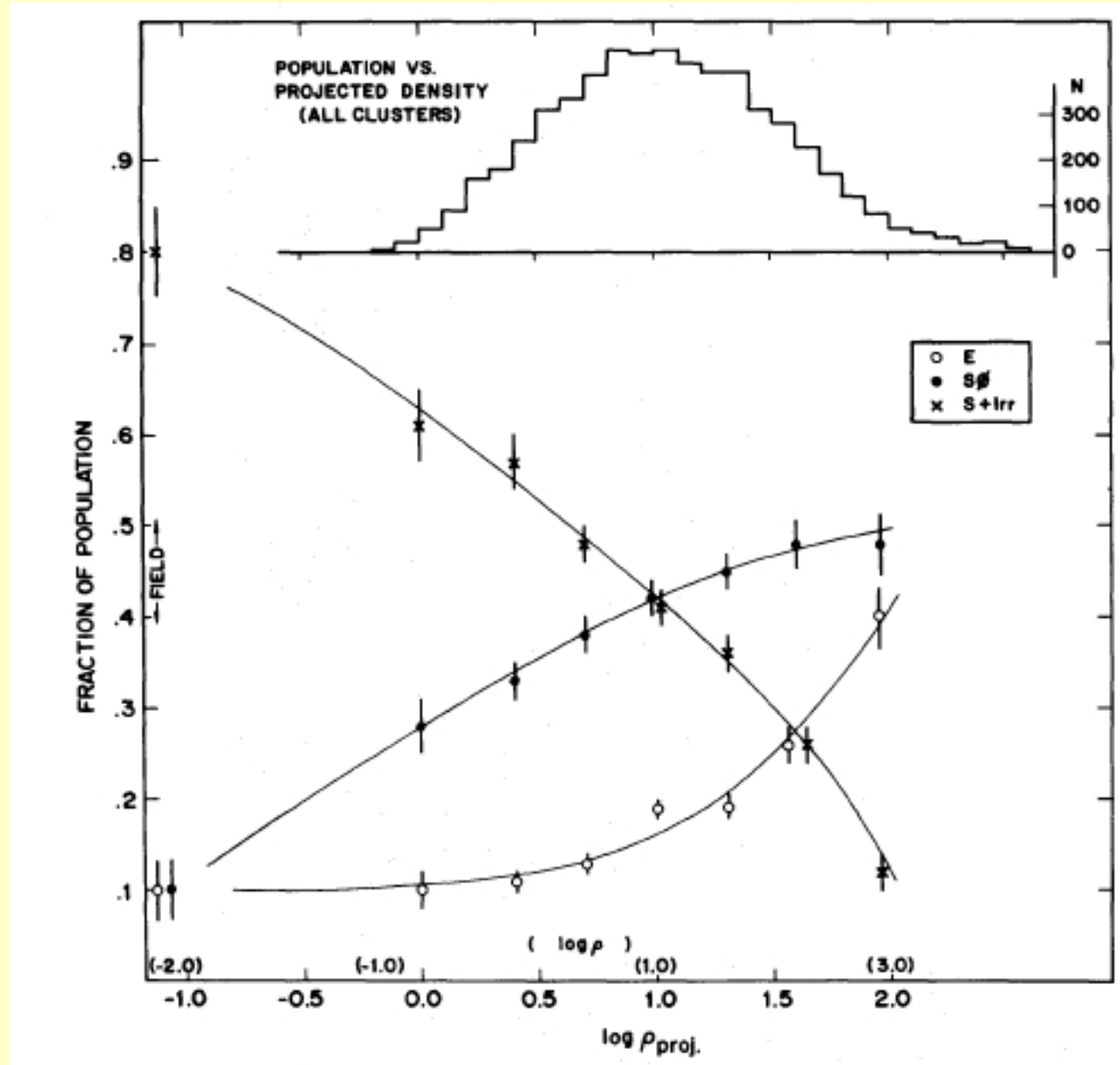
- Cluster of galaxies show a radial gradient in population (Melnick and Sargent (1977))
 - At low radii S0 and elliptical galaxies
 - At high radii spiral and irregular galaxies
- Explanations:
 - Common origin and subsequent evolution of one type to the other at some locations?
 - Differences are native in the formation
 - Differences reflect evolution at an early epoch

Population Gradients

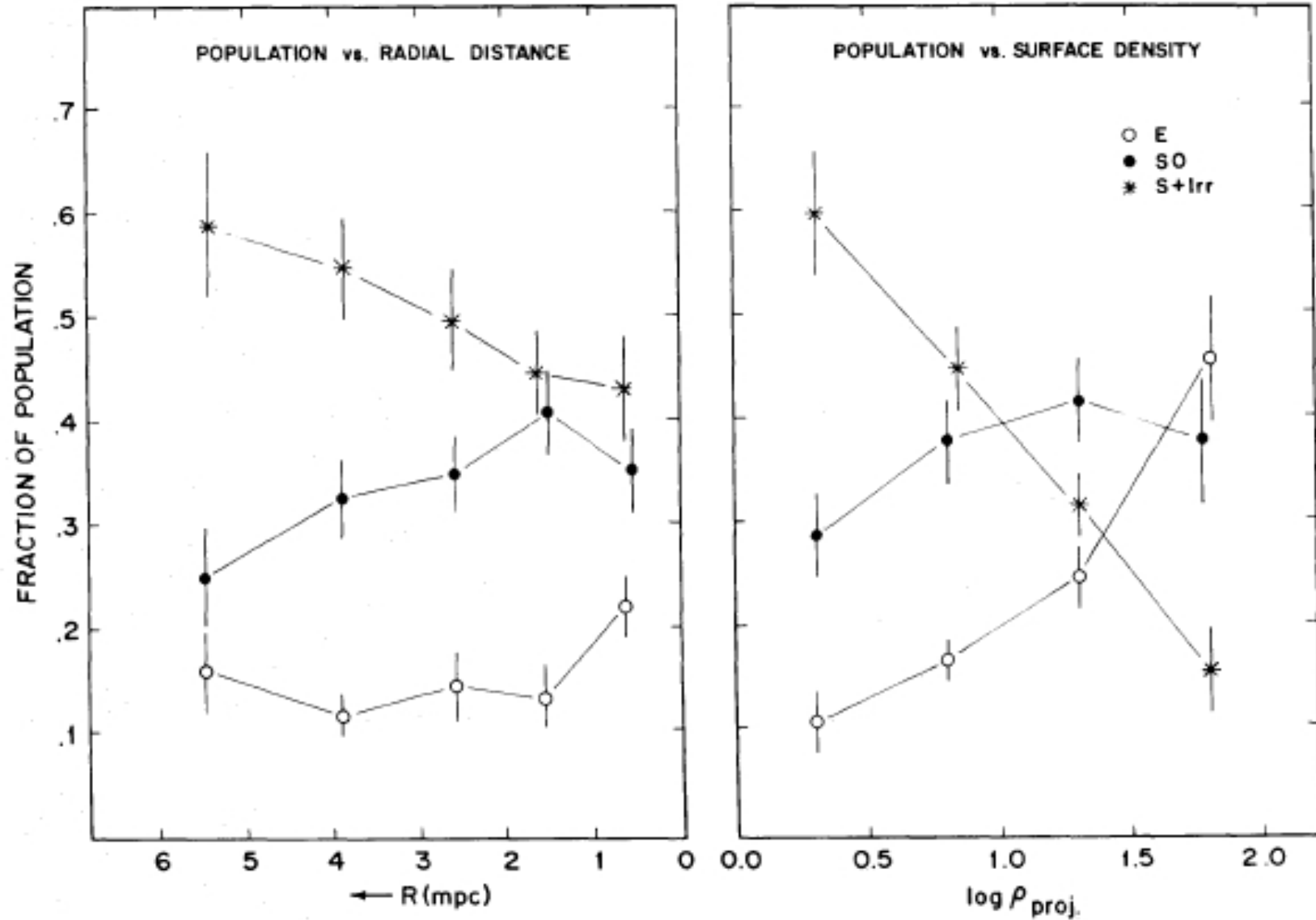
- Population gradient in clusters with radius.
 - Increase of proportion of spirals with radius
 - Decrease of proportion of S0 and ellipticals with radius
- Radius is not a good parameter, since the majority of clusters are irregular and have no well defined center

Population Gradients

- Correlation between local density and population of galaxy types



Population Gradients



Are S0 swept spirals?

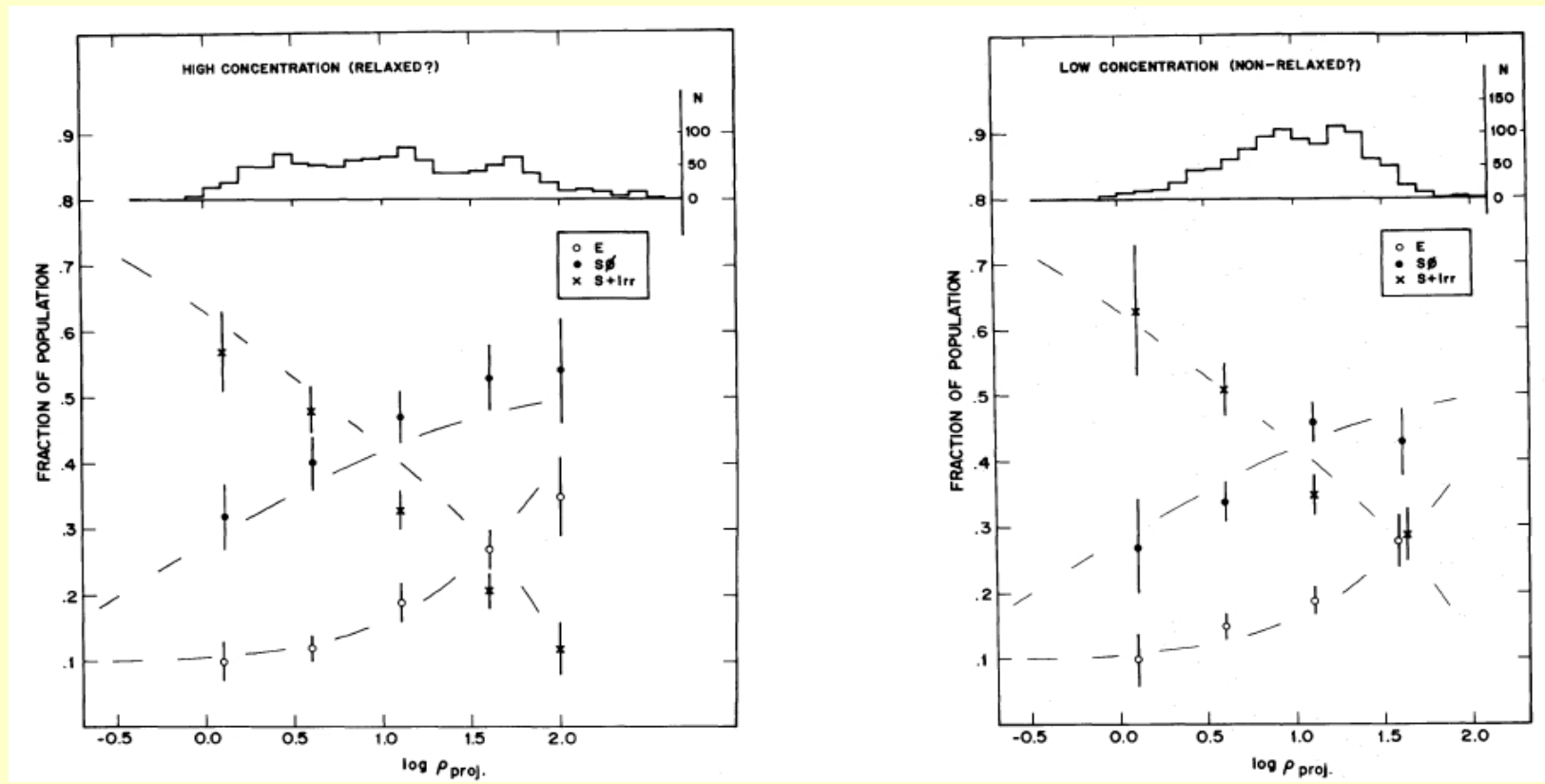
Population density gradient

- Sweeping: gas is removed faster than it is injected in the disk by interaction with IGM
- Butcher and Oemler (1978) argue that spirals are swept of gas during the development of high concentration cores of clusters
- A substantial difference in population gradients in clusters of high and low concentration is expected

Are S0 swept spirals?

Population density gradient

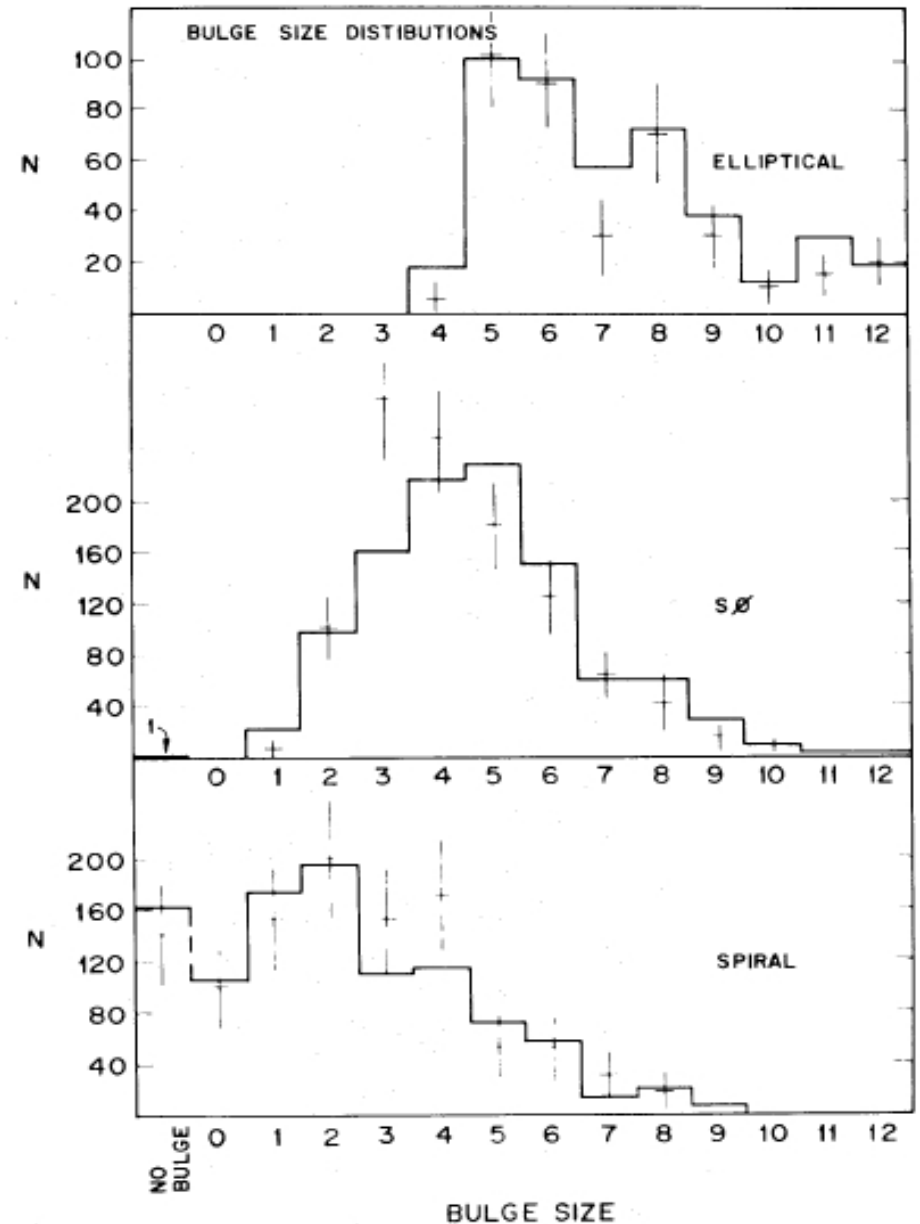
- Relationship between population and local density holds regardless of type of cluster
- Cluster populations are independent of dynamical global history of cluster



Are S0 swept spirals?

Disk/Bulge ratio

- Bulges are tightly bound and will not be disturbed when gas is removed from the disk of a spiral
- If S0 galaxies descend from spirals there disk/bulge ratio (D/B) should be similar

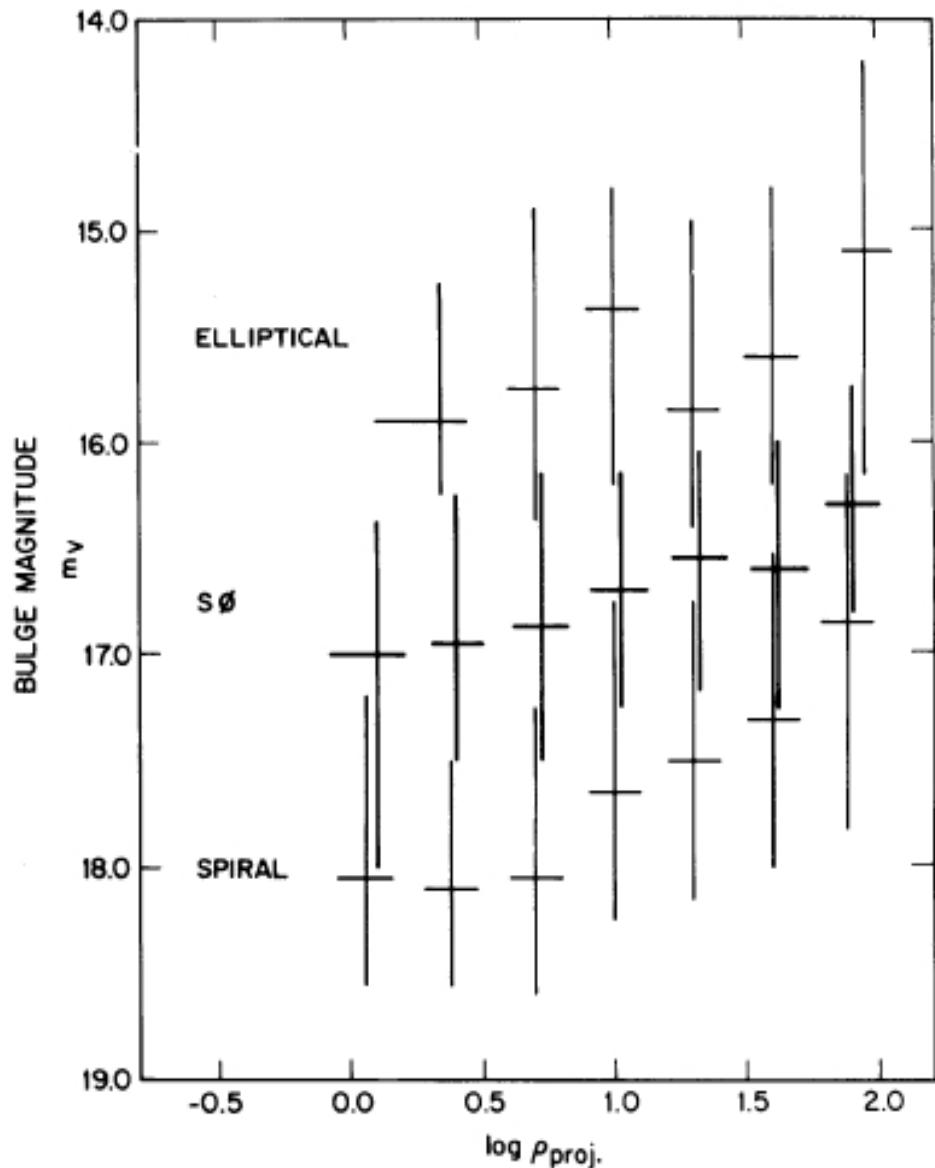


Are S0 swept spirals?

How did S0's form?

- The formation of a disk is a slow process taking several billion years. This process can be interrupted by interactions among galaxies.
- Tidal encounters and collisions unbind the gas reservoirs of S0's, the remaining gas is exhausted by star formation. (Larson et al. 1979)

Massive bulges in high density regions



- This does not explain the larger bulge sizes of S0's and the larger bulge systems in denser regions

Massive bulges in high density regions

- Galaxies form later ($z < 10$) with more evolved enhancements to become clusters
- Basic cluster structures form early and mergers are important for several billion years
- Early epoch differences in densities are small, but eventually translate in large differences in amount of material bound to galaxy
- Correlation between low- (cluster) and high-frequency (galaxy) fluctuations in initial perturbation spectrum

Conclusion

- There is a relation between density and population type within clusters
 - Fraction of spirals and irregulars decreases with density
 - Fraction of ellipticals and S0's increases with density
- S0's are not swept spirals
 - population/density relation is same in all types of clusters
 - Bulges of S0's are larger than of spirals

Conclusion

- Longer disk formation time can describe S0 creation in denser fields
- Spheroidal components are more massive in high density regions
 - Late galaxy formation
 - Mergers
 - Density sensitive formation mechanism
 - Low- and high frequency perturbations in early universe