New IR Telescopes: Windows into the Emergence of Structure

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Standard Cosmological Model

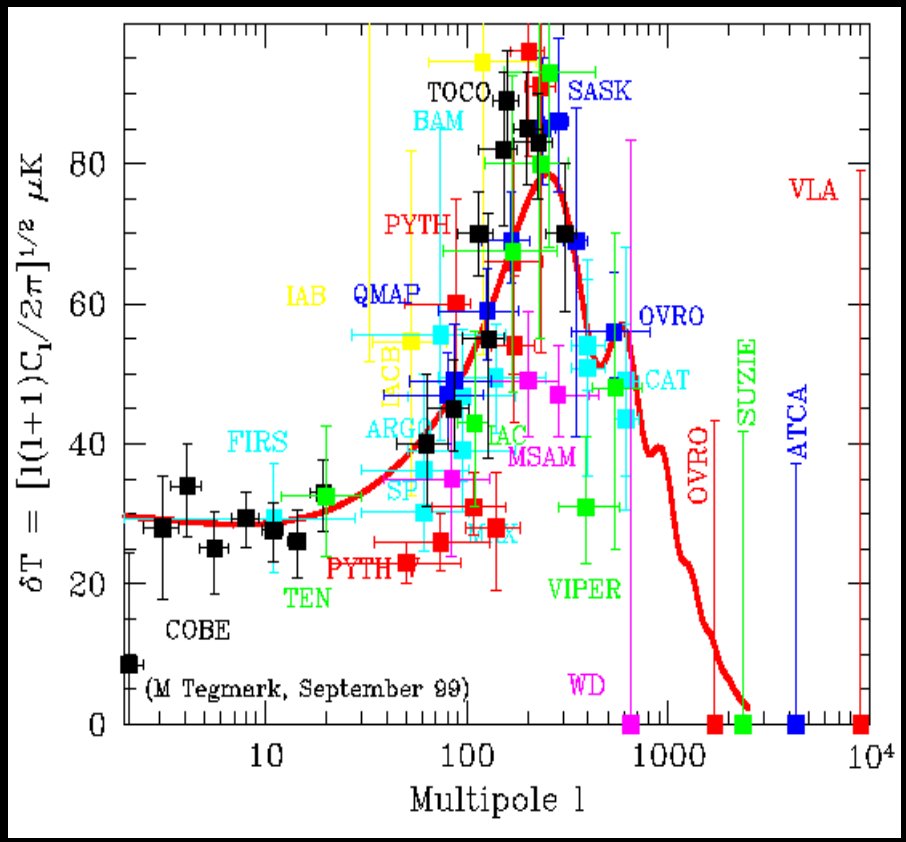
- Inflation produced a flat universe with weak scale-invariant gaussian fluctuations
- Cosmological Constant
- Cold dark Matter

Fits:

•Large scale structure observations

•CMB

•Supernova



CMB data improving rapidly

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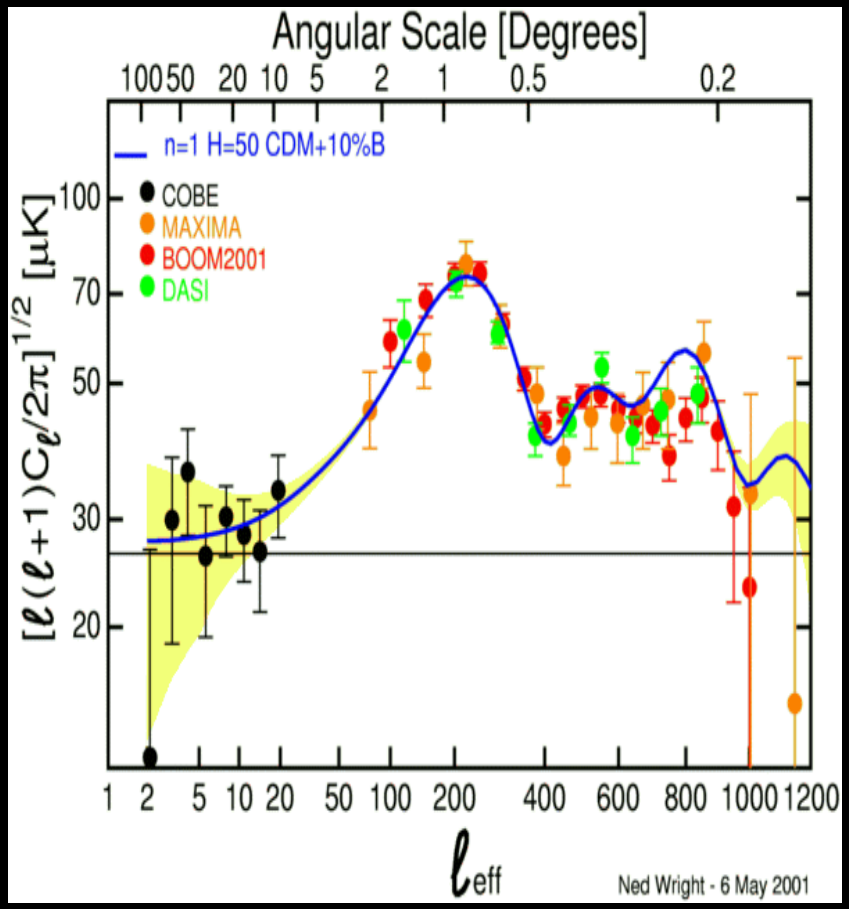

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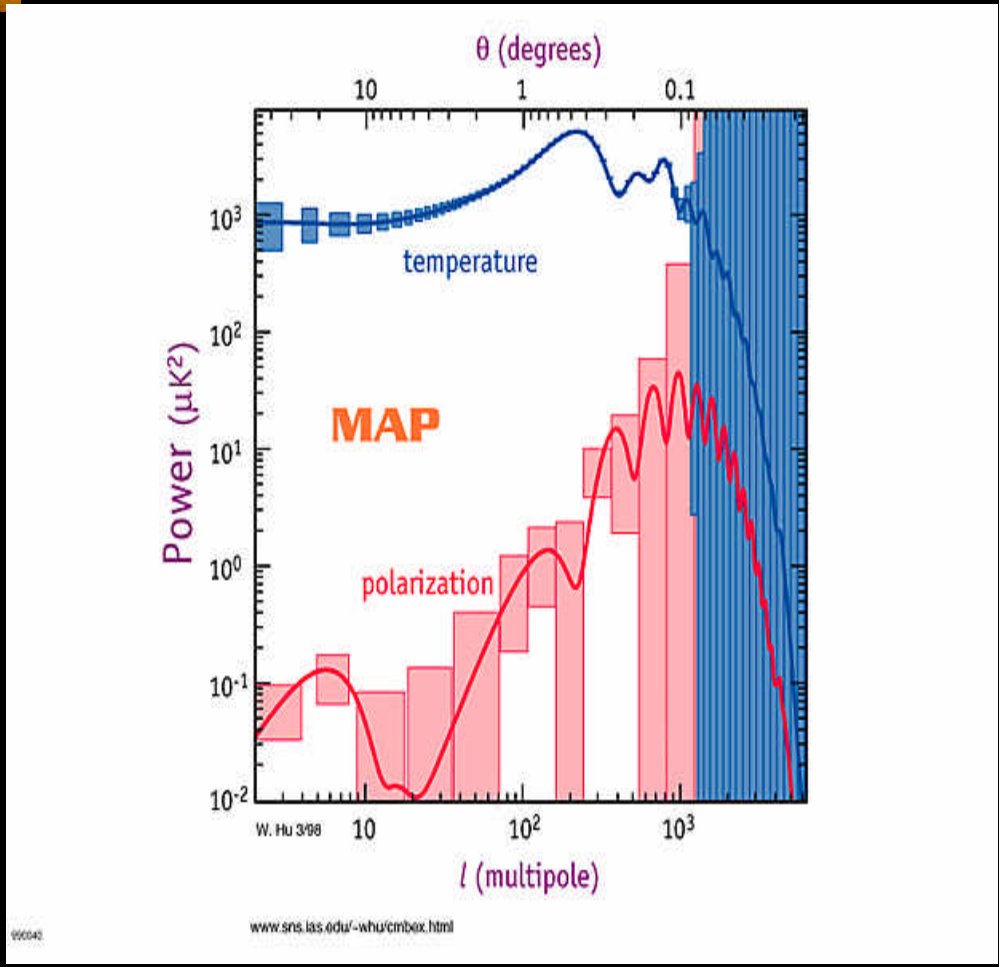

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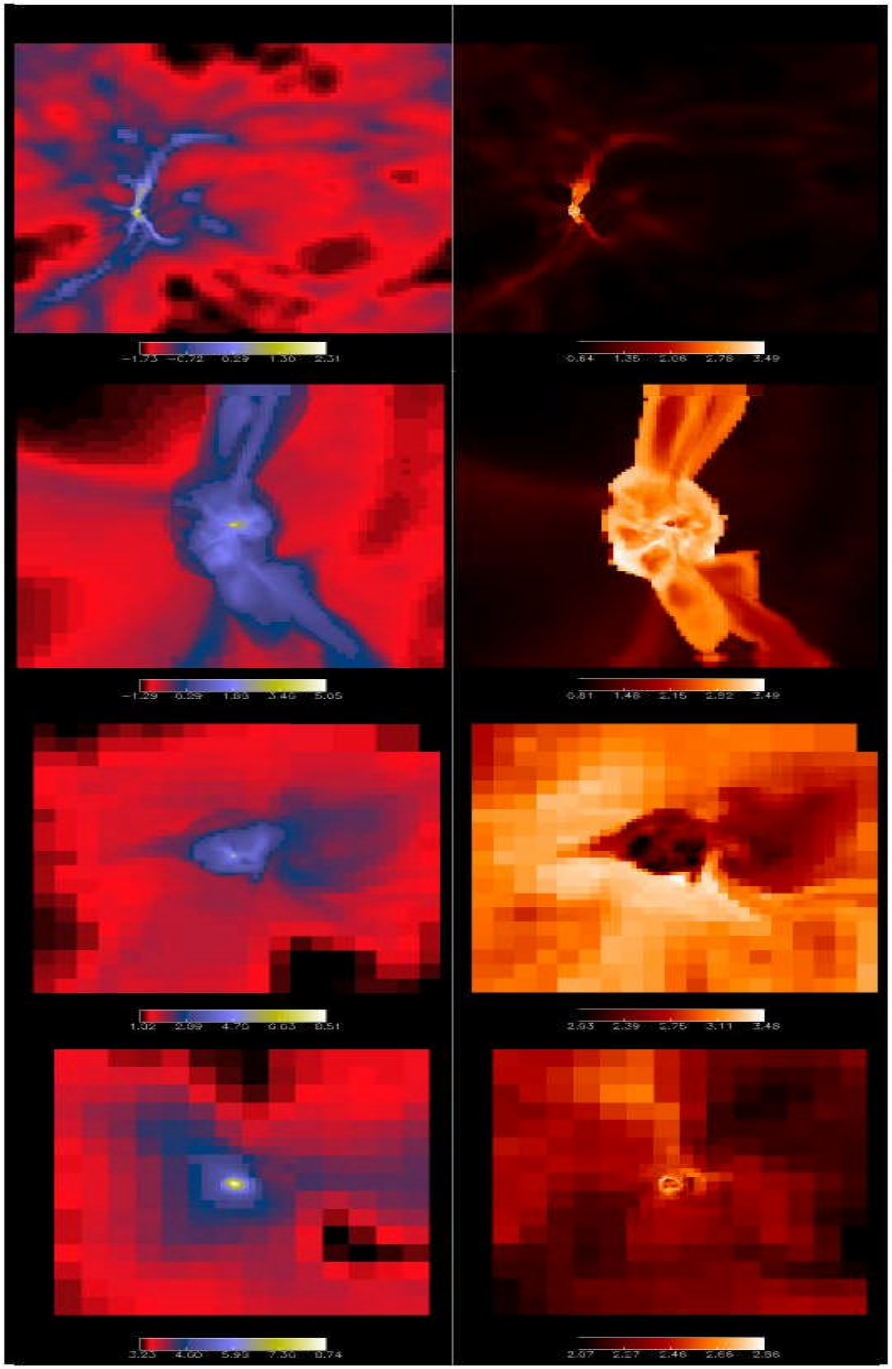
How did these fluctuations grow into galaxies?

- The First Stars: when and what?
- How and When did Galaxies Form?
  - Is galaxy formation a hierarchical process?
  - How important is feedback?
- How did supermassive black holes form?
  - What is the relationship between AGNs and their hosts?

Population III

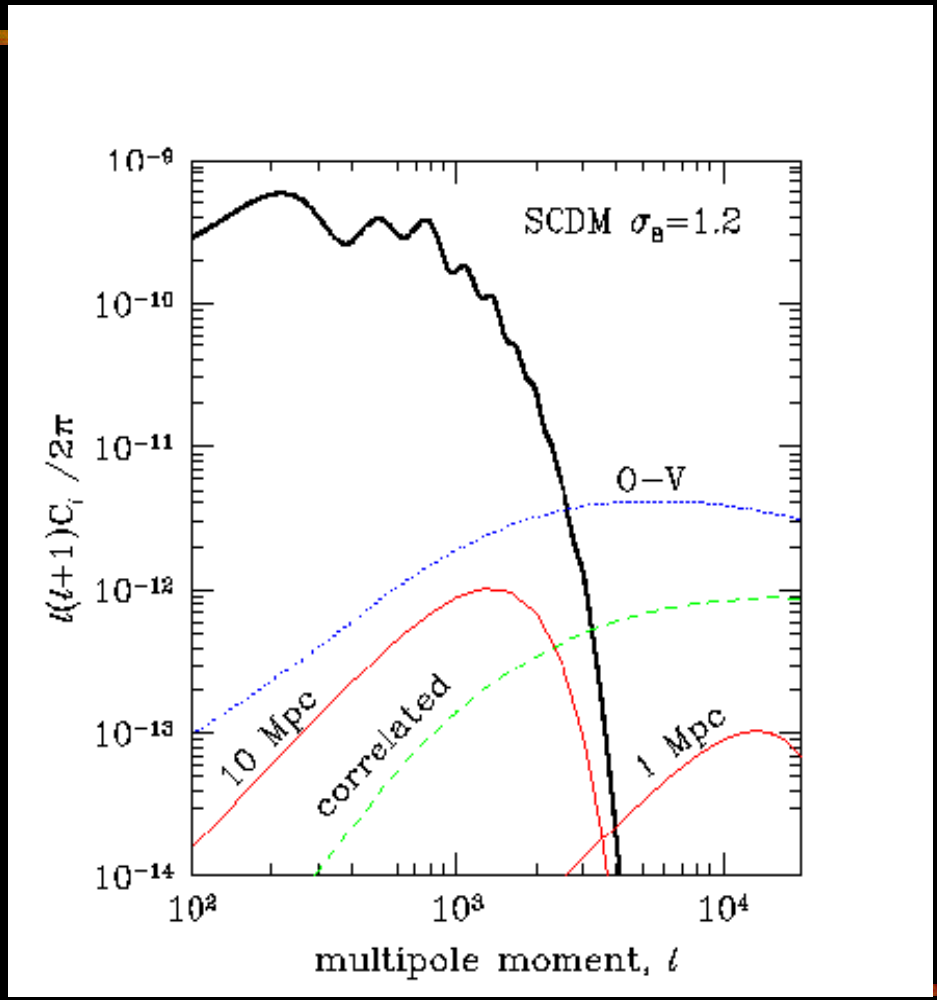
- No heavy elements available for cooling
- Likely occurred in Dense Regions
- Reionized the universe (z ~10)
  - Low density regions first (see Oh 1999; Haiman & Knox 1999)



Bryan and Norman 1999

Detecting Population III stars

- OV ->**mm telescopes**
- Lyman α–> **NGST**
- CII -> ALMA, SPECS
- Br lines -> SPECS
- H2 cooling lines -> SPECS



Haiman & Knox 1999

How Did Galaxies Form?

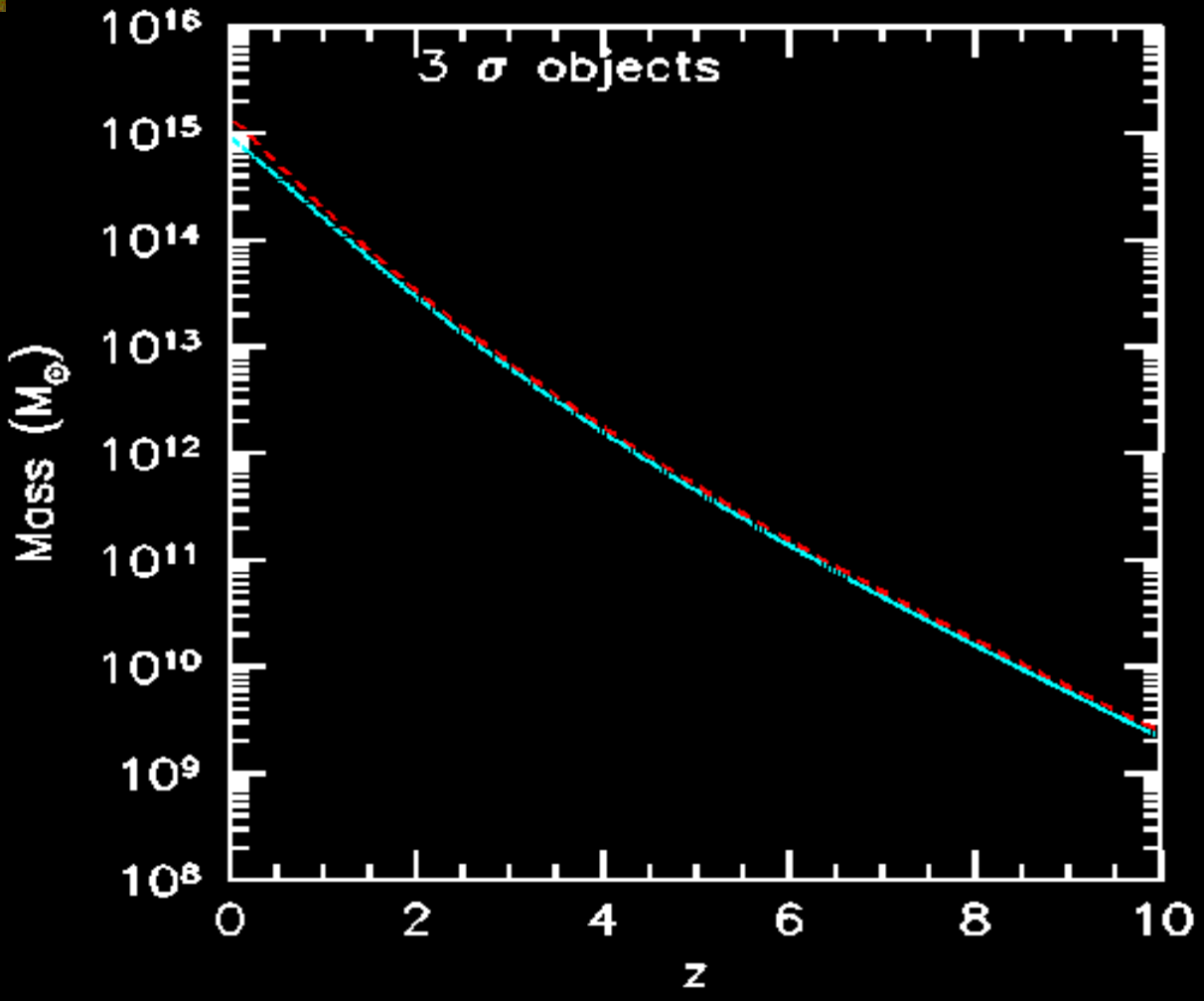
- Bulges form first, disks form later? Or disks merge to form bulges?
  - Need to observe dusty regions
  - Galactic bulge GMC 1 kpc across?
- Is galaxy formation hierarchical?
  - Disk angular momentum problem
  - Core problem?

Tools for studying galaxy formation

- Key Windows:
  - Redshifted stellar optical emission
  - Thermal dust emission
  - CO emission
  - CII, OI, CI line

All require mid-IR to far-IR observations

Theoretical Expectation:Small objects form first..

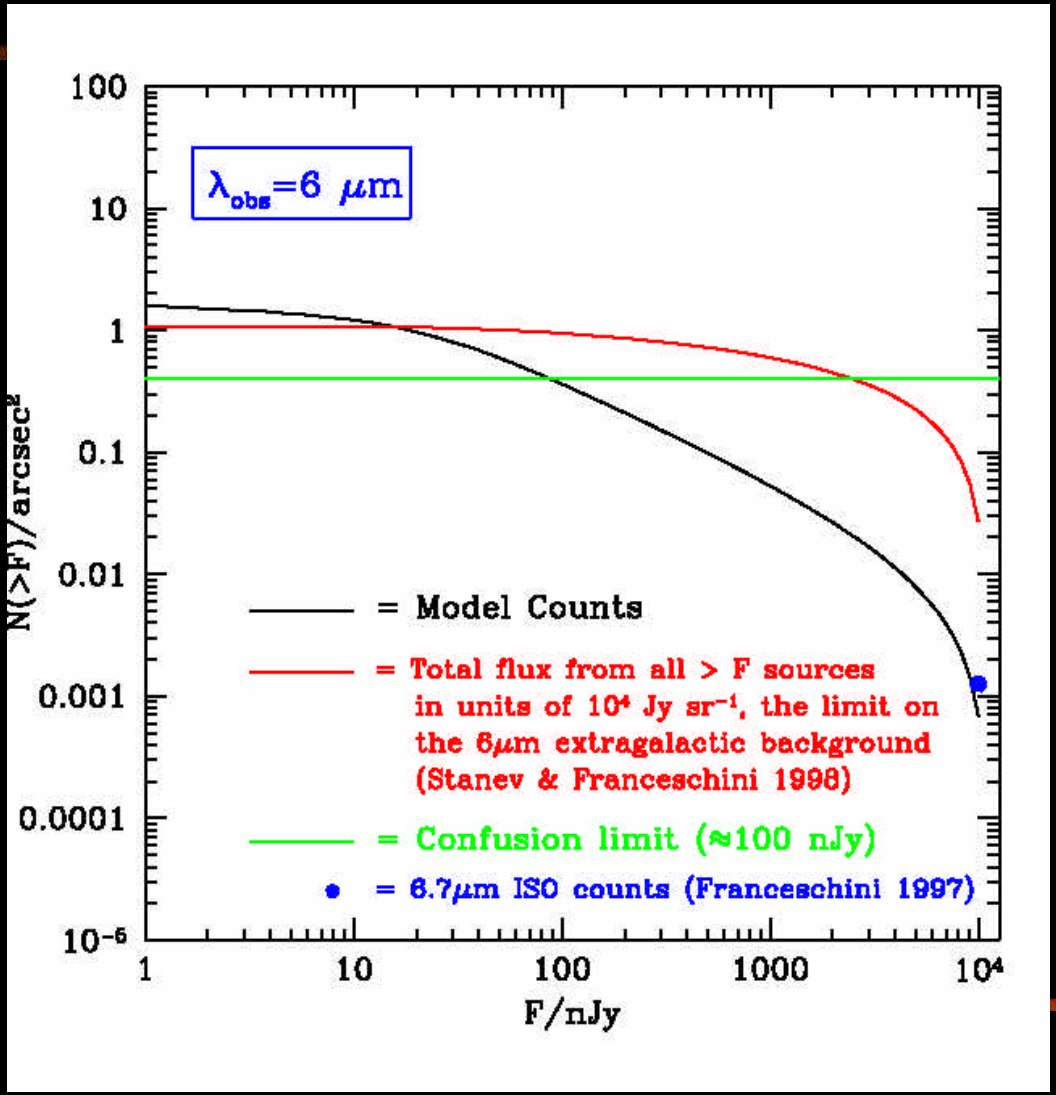


These small objects should be detectable in mid and far-IR

Haiman et al.

Poster #77.13

0.4 29 mag source
per square arc second



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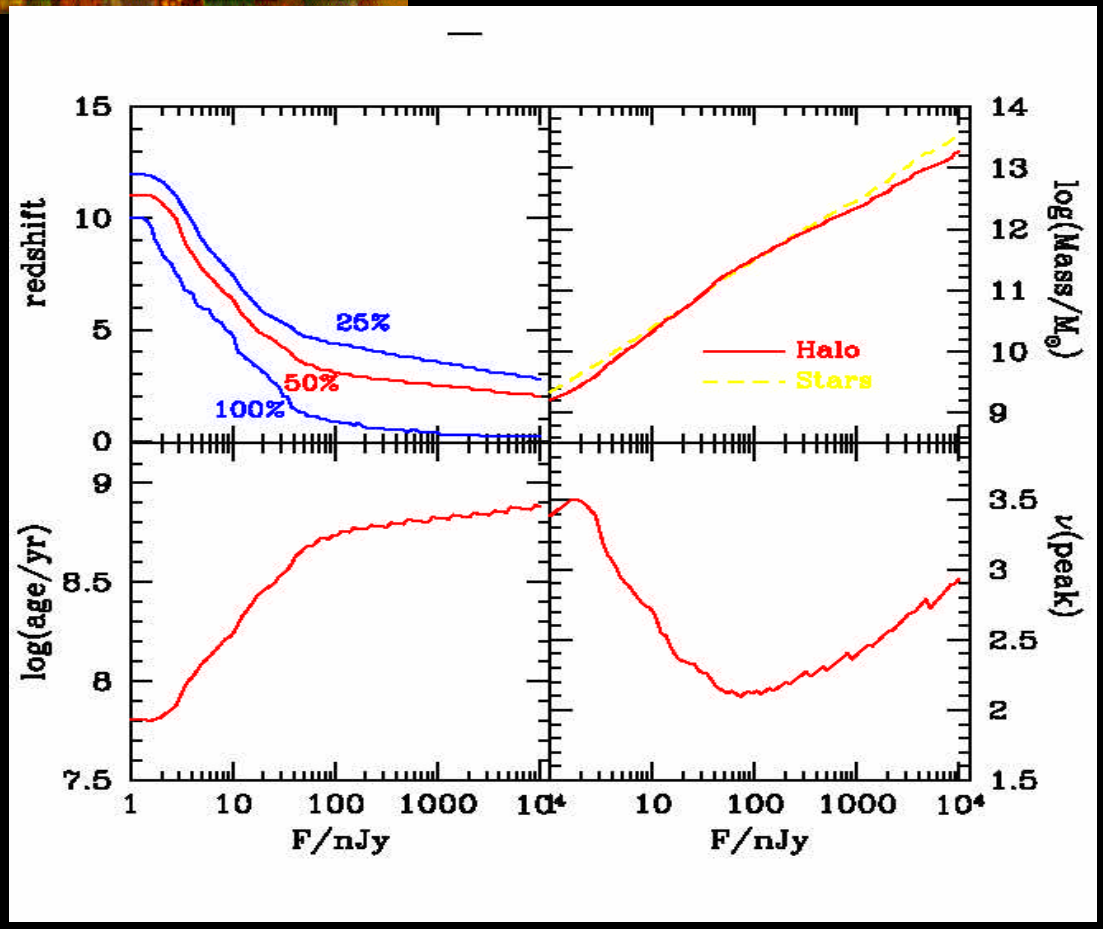

Bulges & AGNs: What is the connection?

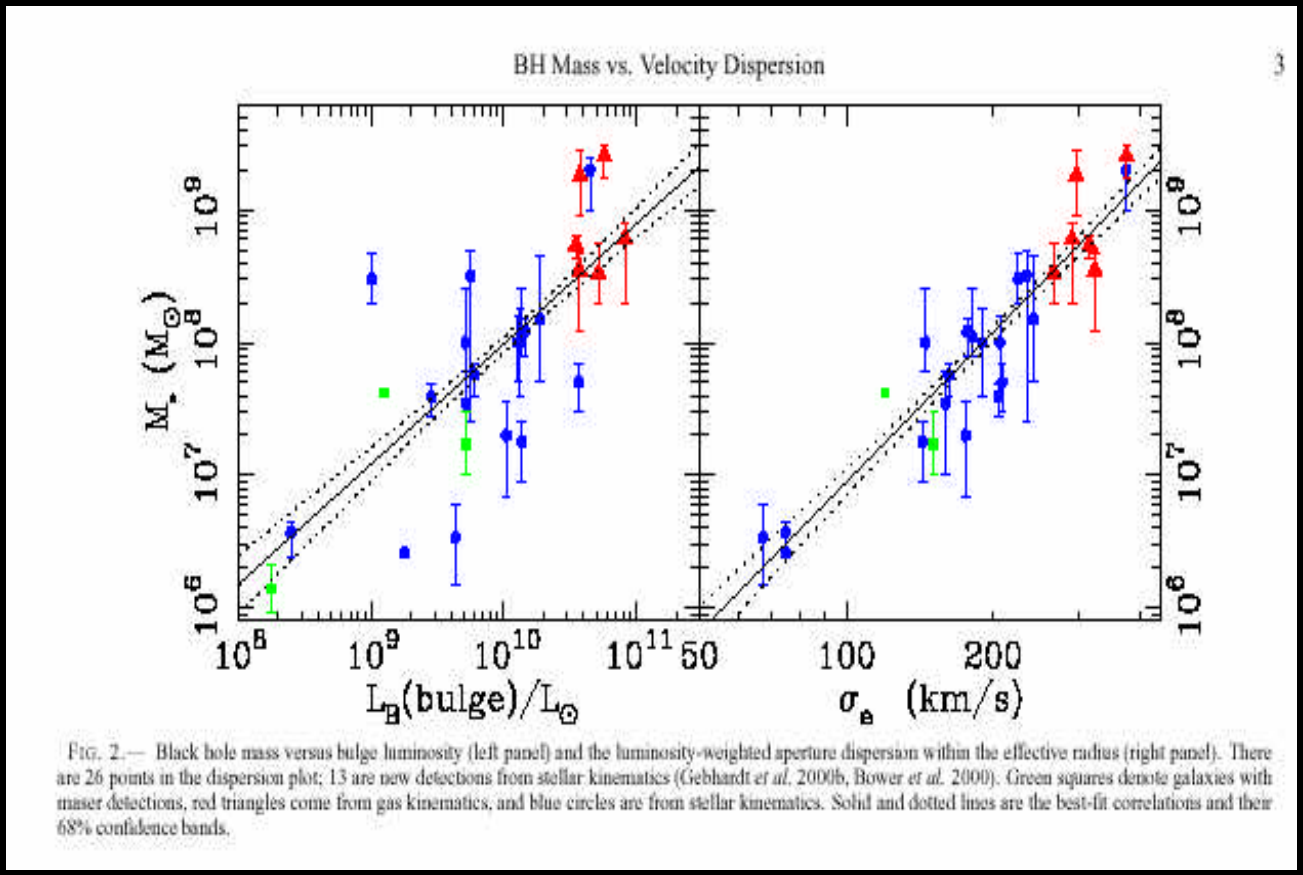

FIG. 2.— Black hole mass versus bulge luminosity (left panel) and the luminosity-weighted aperture dispersion within the effective radius (right panel). There are 26 points in the dispersion plot; 13 are new detections from stellar kinematics (Gebhardt *et al.* 2000b, Bower *et al.* 2000). Green squares denote galaxies with maser detections, red triangles come from gas kinematics, and blue circles are from stellar kinematics. Solid and dotted lines are the best-fit correlations and their 68% confidence bands.

Gebhardt et al.

Conclusions

- Mid and Far- IR telescopes will be important tools that will help us understand how the complex universe that we see today emerges out of the nearly smooth initial conditions seen in the microwave sky.