Probing Star Formation History at z>1 with Submm Sources

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Outline

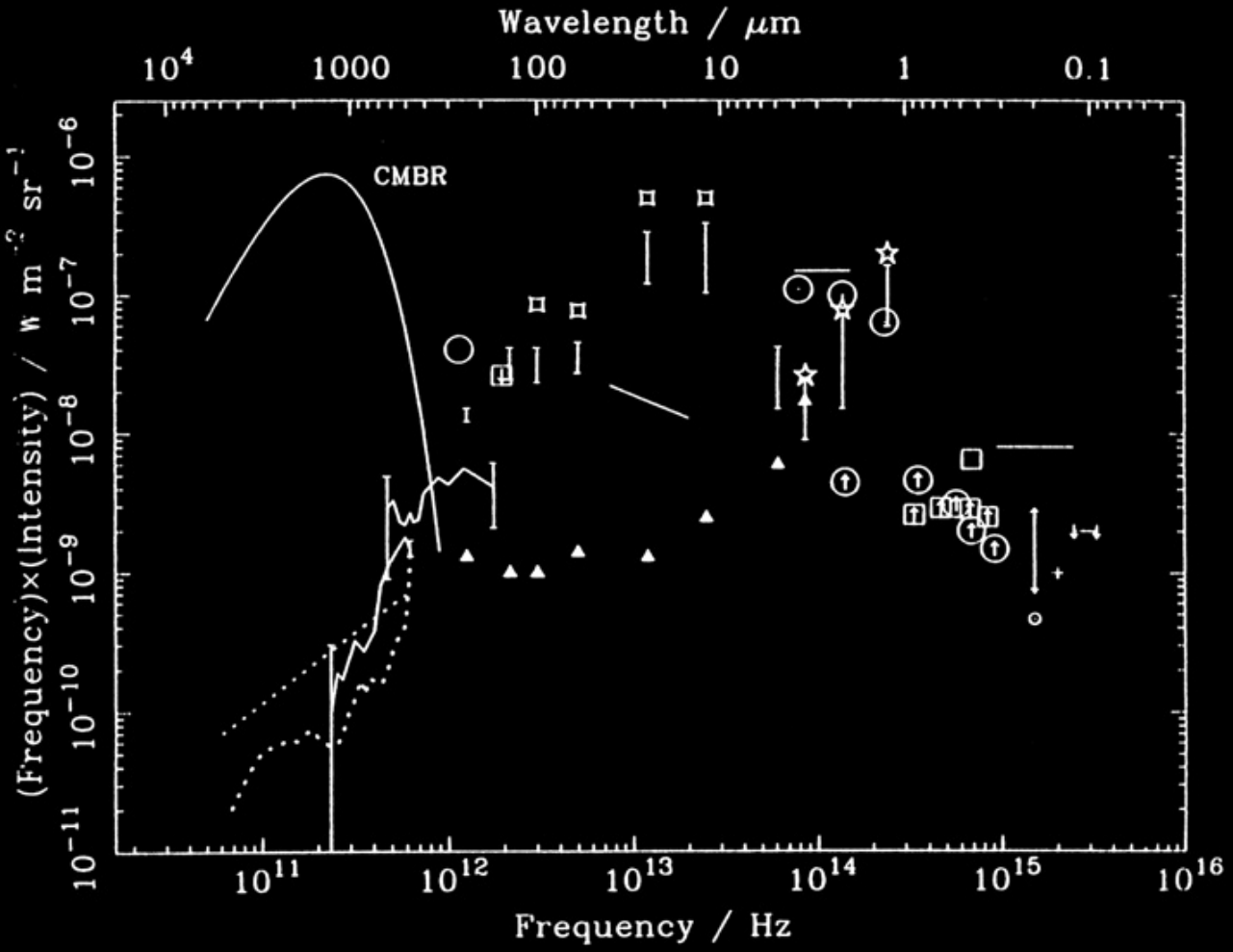
- Overview – History and Open Questions
- Submm Source Number Counts – Our 850 μm Surveys
- Redshift Distribution – Our Optical/Near-IR Surveys

Historical Review

Olber's Paradox:

Why is the sky dark at night?

Extragalactic Background Light (EBL) at All Wavelengths



EBL Resolved into Point Sources

- Optical/Near-IR EBL resolved by the HST and large ground-base telescopes.
- X-ray EBL resolved by Chandra.
- Submm/Far-IR EBL resolved by the JCMT. (Smail, Ivison, & Blain 1997)

Submm Sources as a Probe to the High-z Universe

- Limited number of identifications indicate that most submm sources are starbursting protogalaxies at $z>1$.

- Submm radiation dominates the EBL.

$\Rightarrow$ Star formation at $z>1$ hidden by dust is as important as that observed by HST.

- Submm flux of a fixed luminosity is not function of redshift.

$\Rightarrow$ Submm sources are a powerful probe to the high-redshift universe.

Questions

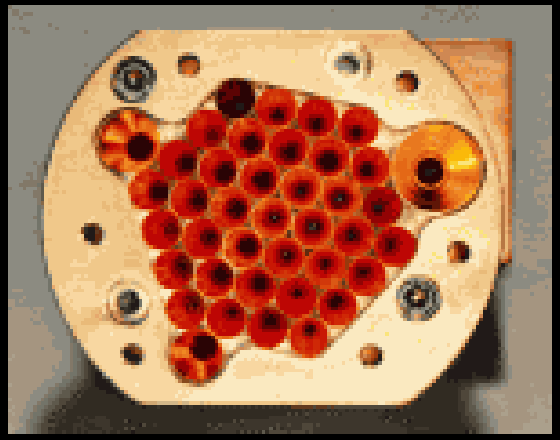
- Energy sources? Morphology at submm and optical. Correlation between submm and other populations.
- How many submm sources are there?
- What's the redshift distribution of the submm sources?

Submm Source Number Counts

- Instrument: Submillimetre Common-User Bolometer Array (SCUBA) on the James Clerk Maxwell Telescop (JCMT).
- Wide-field (~120 arcmin^2) intermediate depth (rms~2mJy) surveys over the Hubble Deep Field North.
- Ultra-deep (rms=0.3-0.6 mJy) surveys over 7 strong lensing clusters.

JCMT and SCUBA

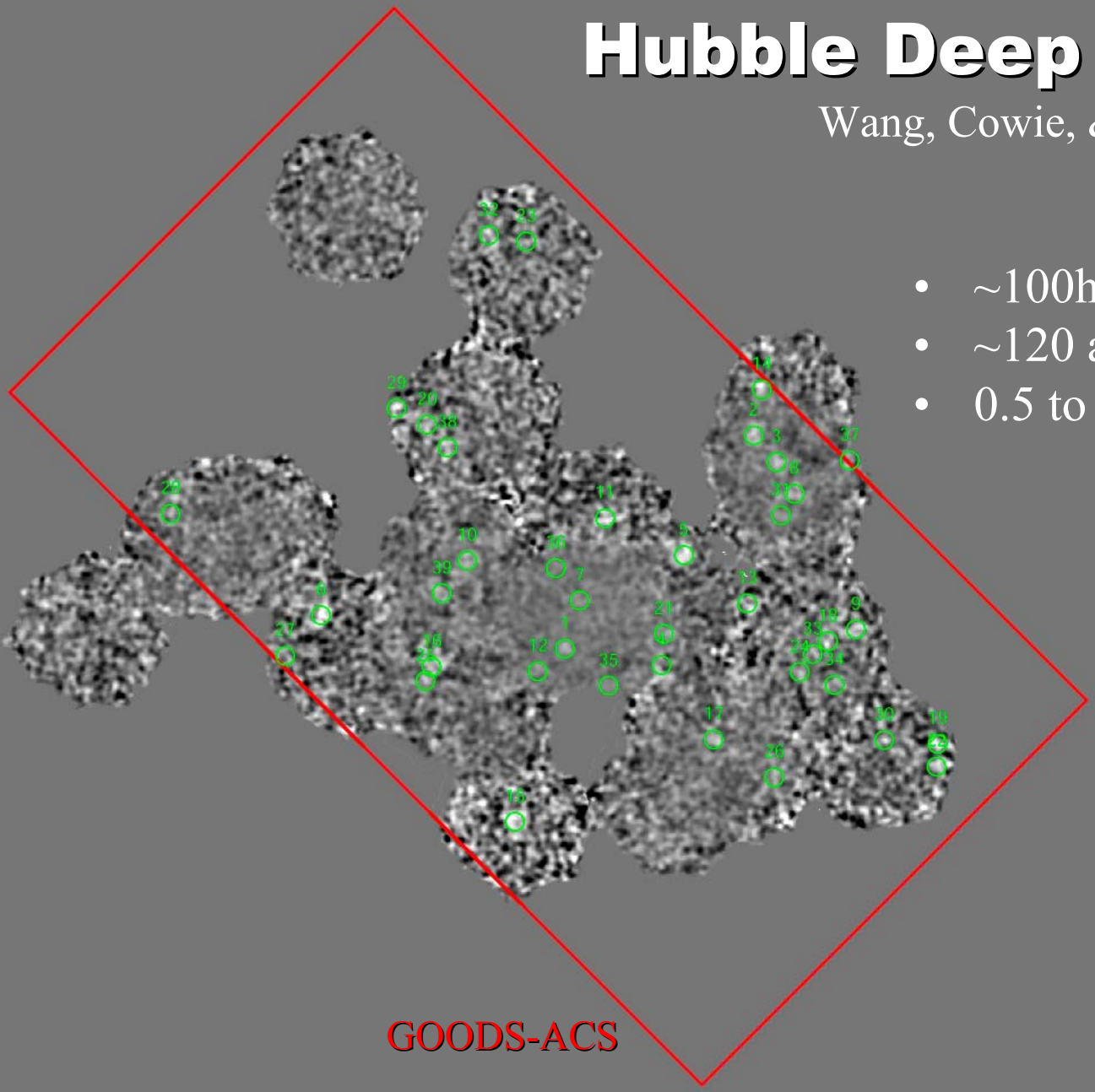
JCMT: 15m single-dish submm telescpe on Mauna Kea.



SCUBA: the primary instrument on the JCMT for continuum observations. 37 bolometers at 850 μm and 91 bolometers at 350 μm.

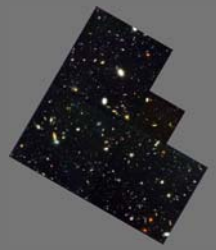
Hubble Deep Field North

Wang, Cowie, & Barger, in prepartation



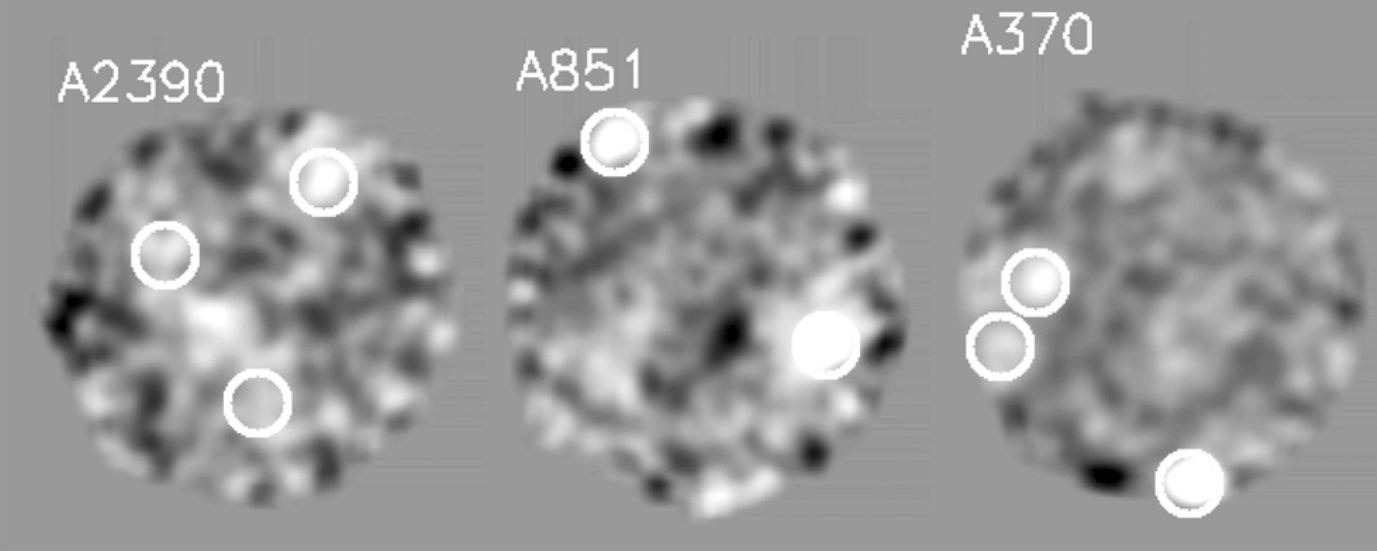
- ~100h integration at 850 μm.
- ~120 arcmin^2 area coverage.
- 0.5 to 2 mJy rms sensitivity.

HDFN-WFPC2



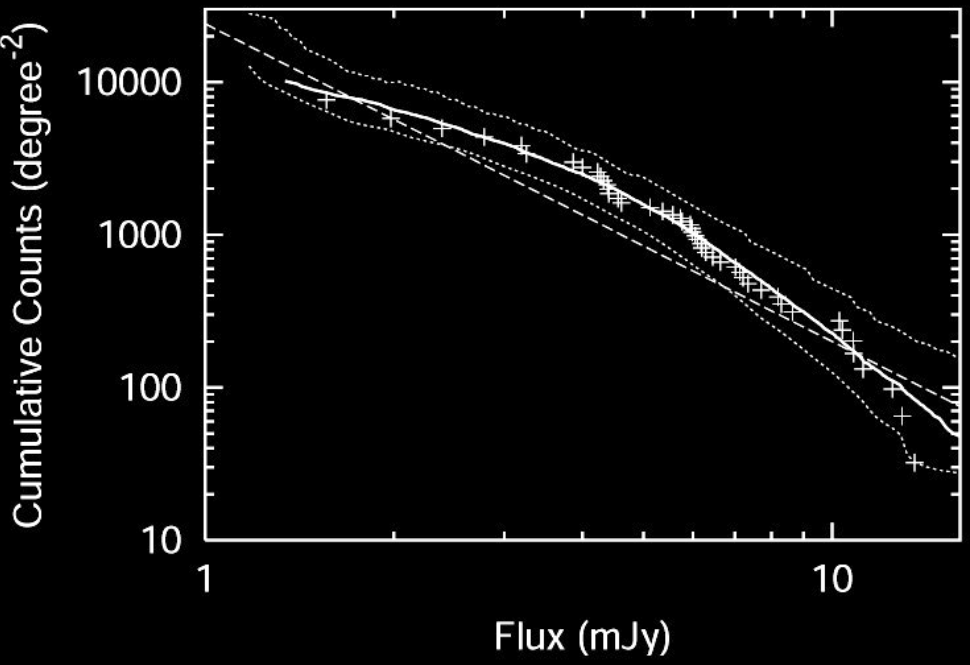
Strong Lensing Clusters

- 20-30h of integration on each cluster.
- Sources as faint as 0.1 mJy are detected.
- Totally 5 clusters were observed. Two more will be observed in 2003 and 2004.

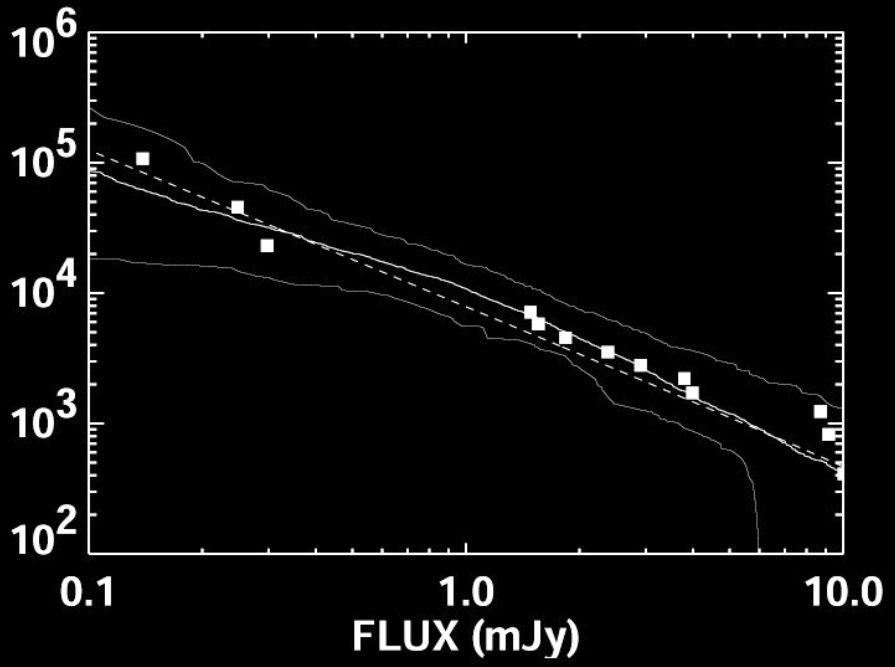


Cowie, Barger, & Kneib 2002

850 μm Number Counts



HDF-N
Wang, Cowie, & Barger, in preparation



Lensing Clusters
Cowie, Barger, & Kneib, 2002

850 μm Number Counts

- **Bright-end counts from the 120 arcmin^2 HDF:**
  N(>8mJy) = 236 (+81/-75)
  cf. N(>8mJy) = 320 (+80/-100) from Scott et al. 2002 (260 arcmin^2)

- **Faint-end counts from 3 lensing clusters:**
  N(>0.5mJy) = 18000 (+12000/-9000)
  cf. N(>0.5mJy) = 27000 (+/-10000) from Smail et al. 2002 (7 clusters)

- **850 μm EBL:**
  3.1 to 4.4 mJy/degree2 (COBE, Puget et al. 1996; Fixen et al. 1998)
  3.2 mJy/degree^2 (our SCUBA sources between 0.3 and 12 mJy)

Redshifts of Submm Sources

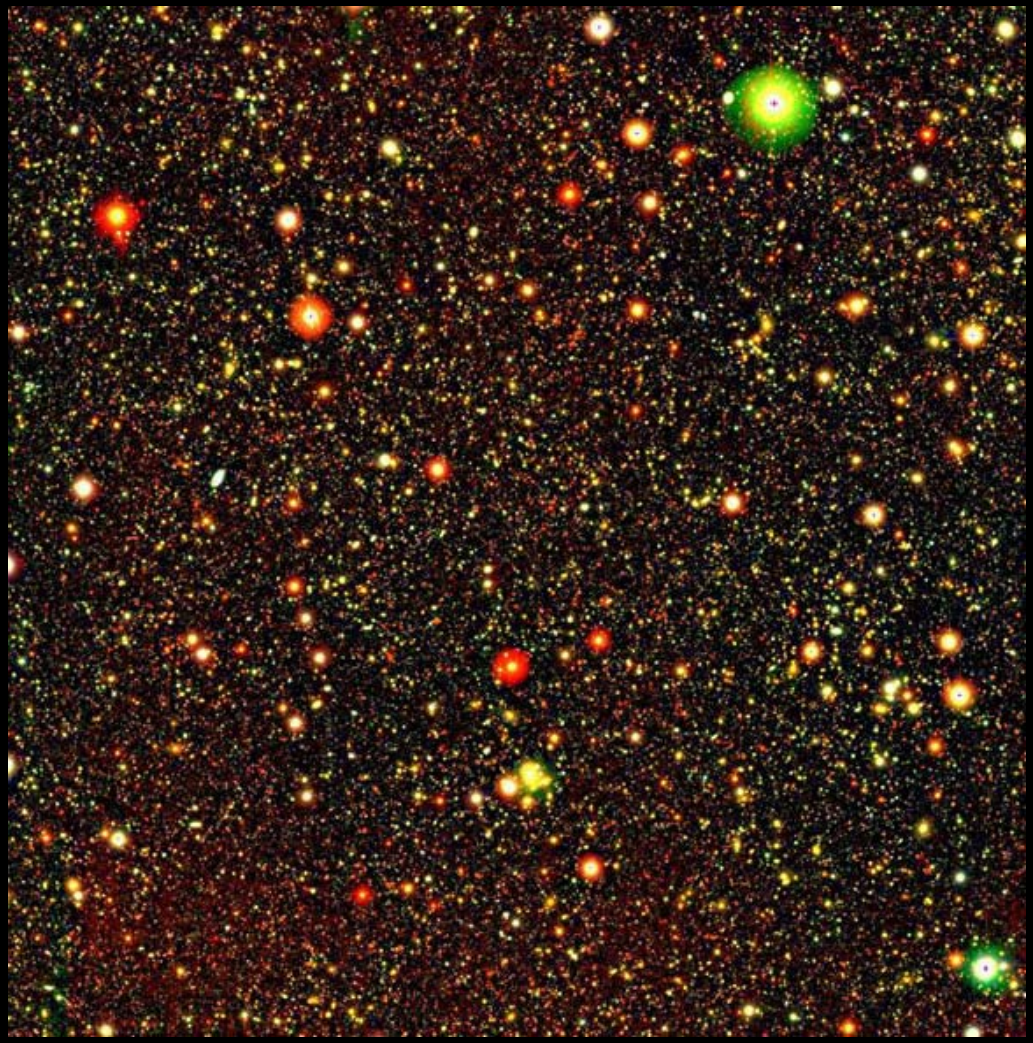
Difficulties:

- Astrometry at submm is poor (FWHM=15” for JCMT) to pinpoint the location of the submm emission.
- Submm sources are optically faint due to dust extinction and K-correction. Optical spectrometry is time consuming even with Keck.

Photometric Redshifts for Submm Sources

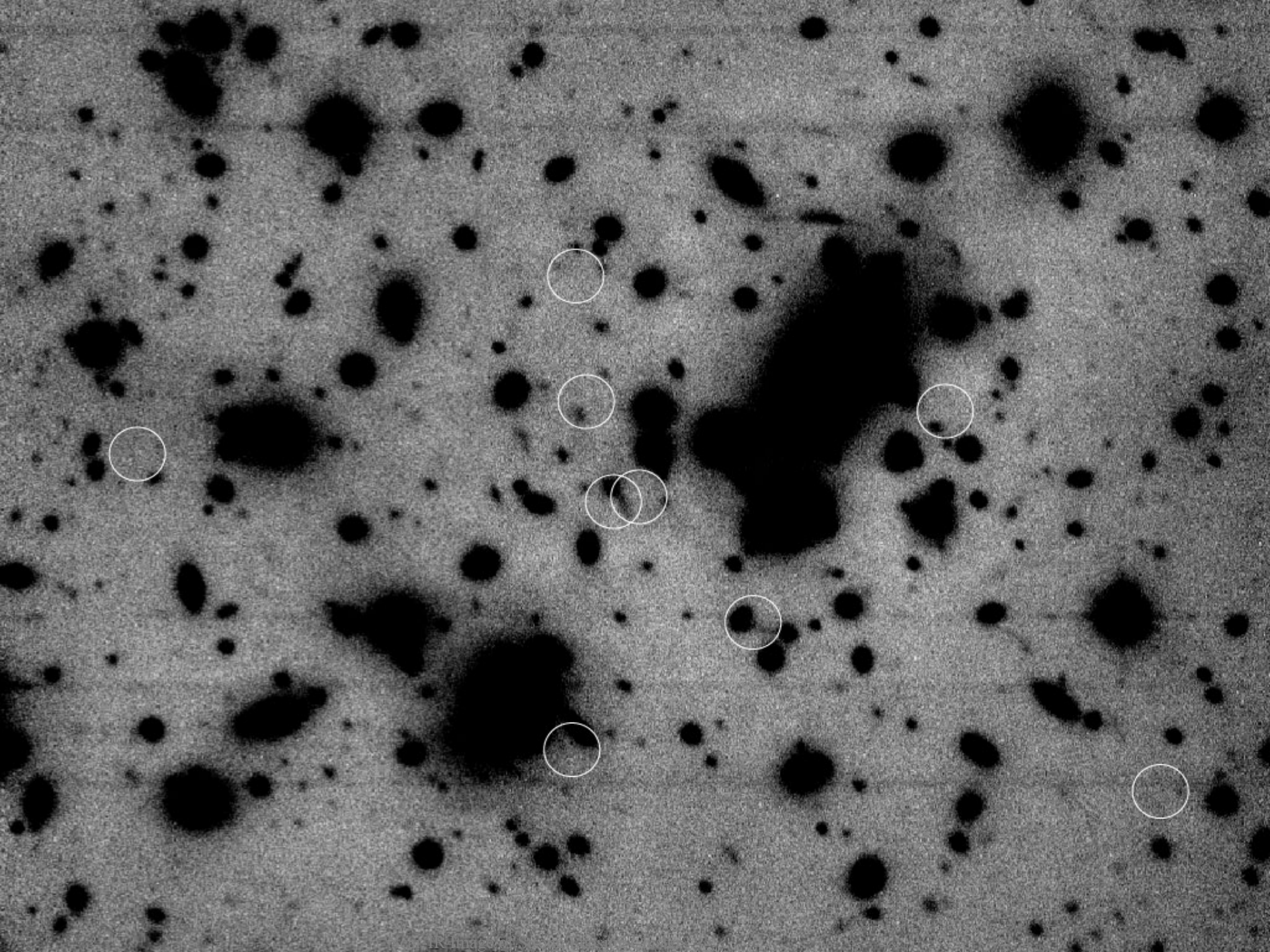
- Deep Optical/NIR broadband imaging covering the HDF-N and at least 5 clusters.
- B, V, R, I, z' bands using Suprime-Cam on Subaru and LRIS on Keck.
- U band using Mega-Prime on CFHT and KPNO 4m.
- J, H, K' bands using CISCO on Subaru and UH 2.2m.

Multi-Color Optical Image of the HDF

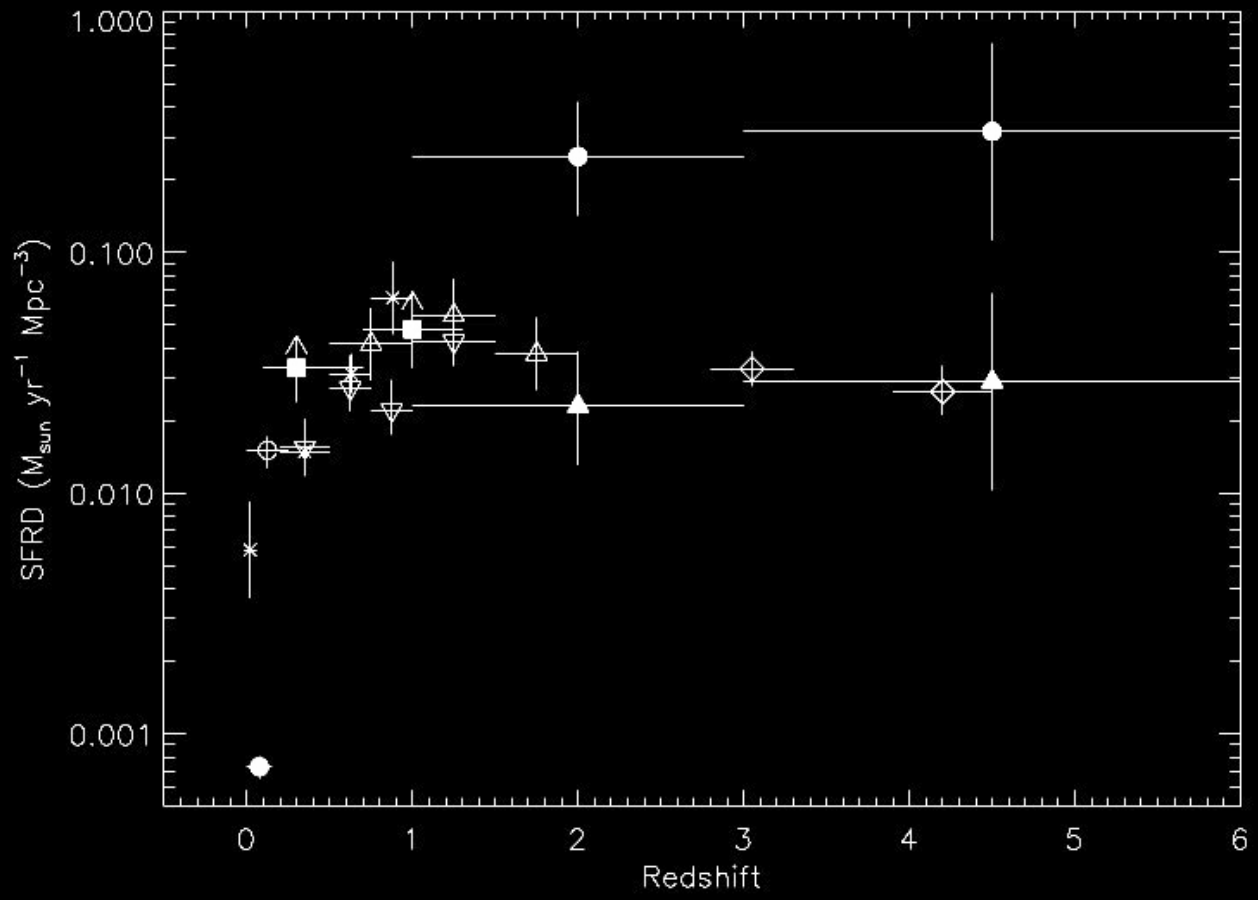


Capak, Cowie, & Hu, 2003

Capak & Cowie, 2003



The Goal:
Star Formation History at z>1



Barger, Cowie, & Richard 2000