High Redshift Galaxy Clusters Prospects for SASIR

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Outline of Talk

- Motivation
- Future Science
- Summarize with “Answers”

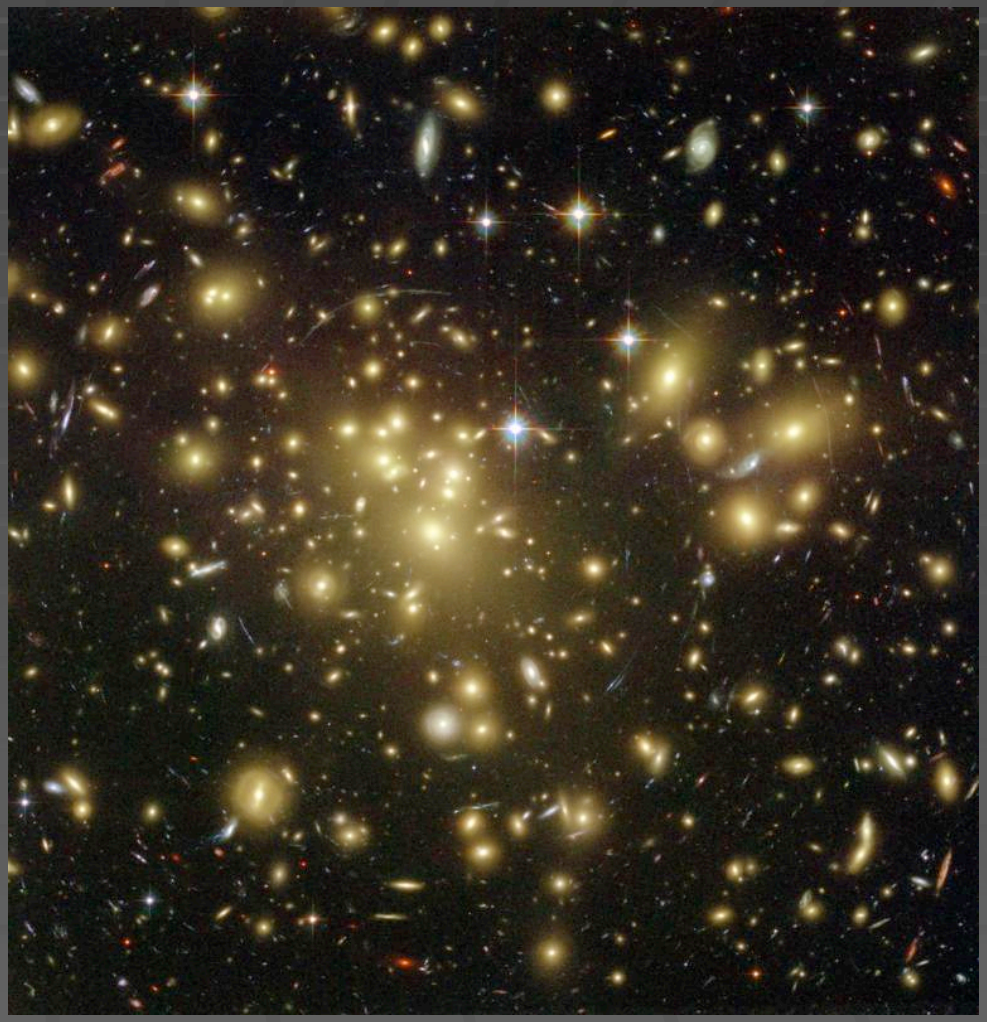
Motivation: Galaxy Evolution

- How old are galaxies?
  - Stellar population age vs galaxy age
- Where did they form?
  - role of environment
- How, when, and where did the galaxy types arise?
  - spirals and ellipticals

- Basic, difficult problems which are likely to be relevant when SASIR begins operation

Galaxy Evolution and Clusters

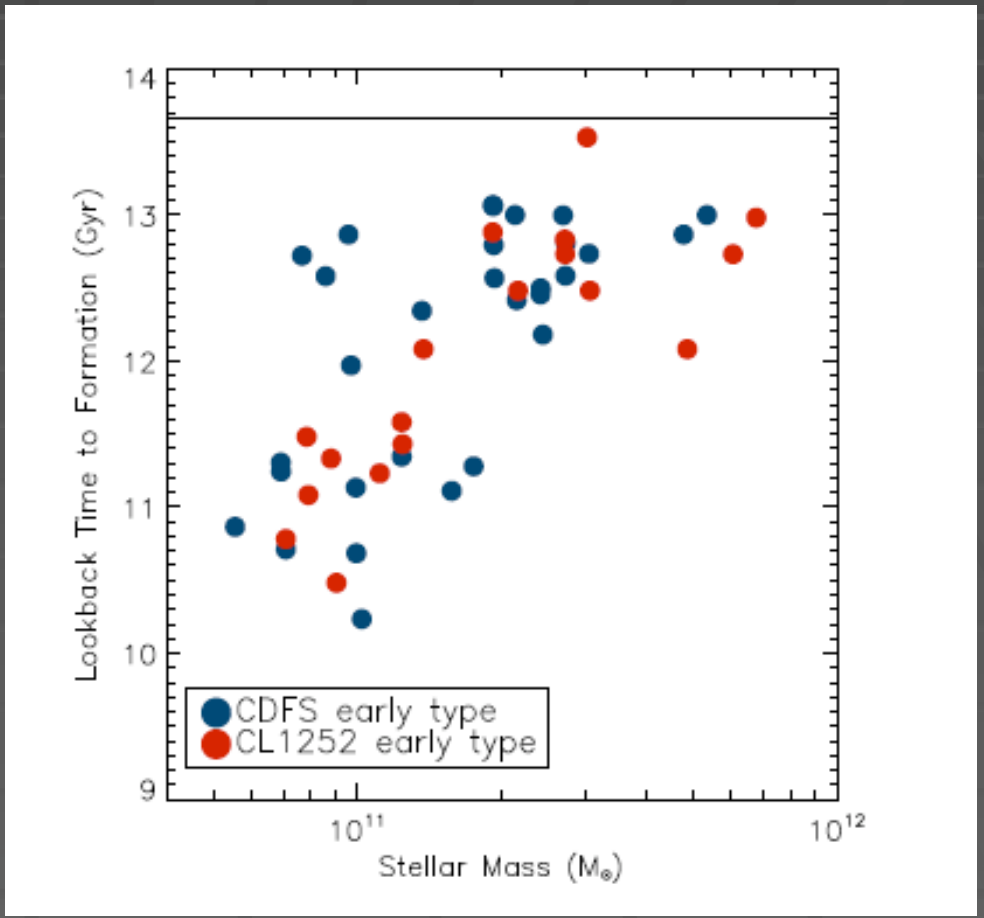
- Efficient way to sample universe at known z
- Wide range of galaxy density enables study of the effects of environment on galaxy evolution (e.g. T-Σ relation; Butcher-Oemler Effect)



Abell 1689 (ACS; Benitez et al.)

Clusters and Massive Galaxies

- Clusters are dominated by massive galaxies, which are also clustered in the field
- Evidence for early formation of massive galaxies, beyond z~1, at least of their stellar populations
- Formation timescale of massive galaxies in the field still much debated



Rettura et al. (2008)

Why 1 < z < 2?

- SFR peaks at 1<z<2
- Most of the stellar mass is created in this redshift regime

Need unbiased census of massive galaxies at 1 < z < 2

Dickinson et al. (2003)

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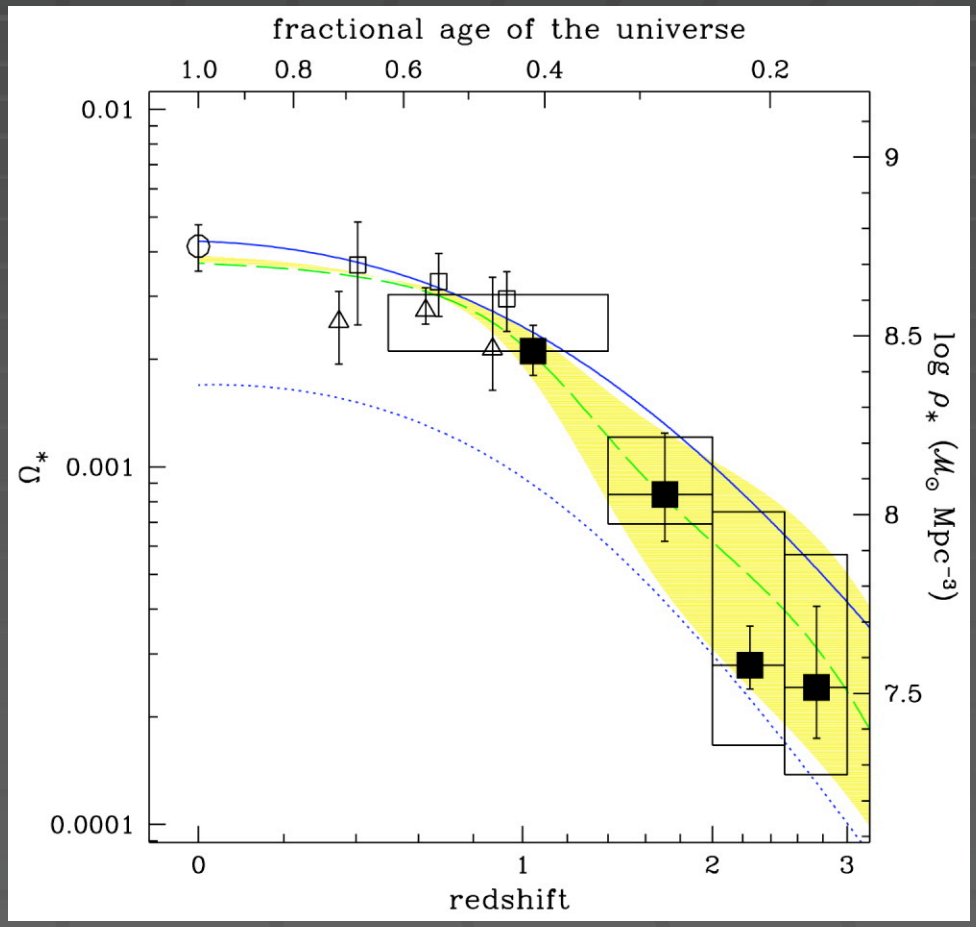

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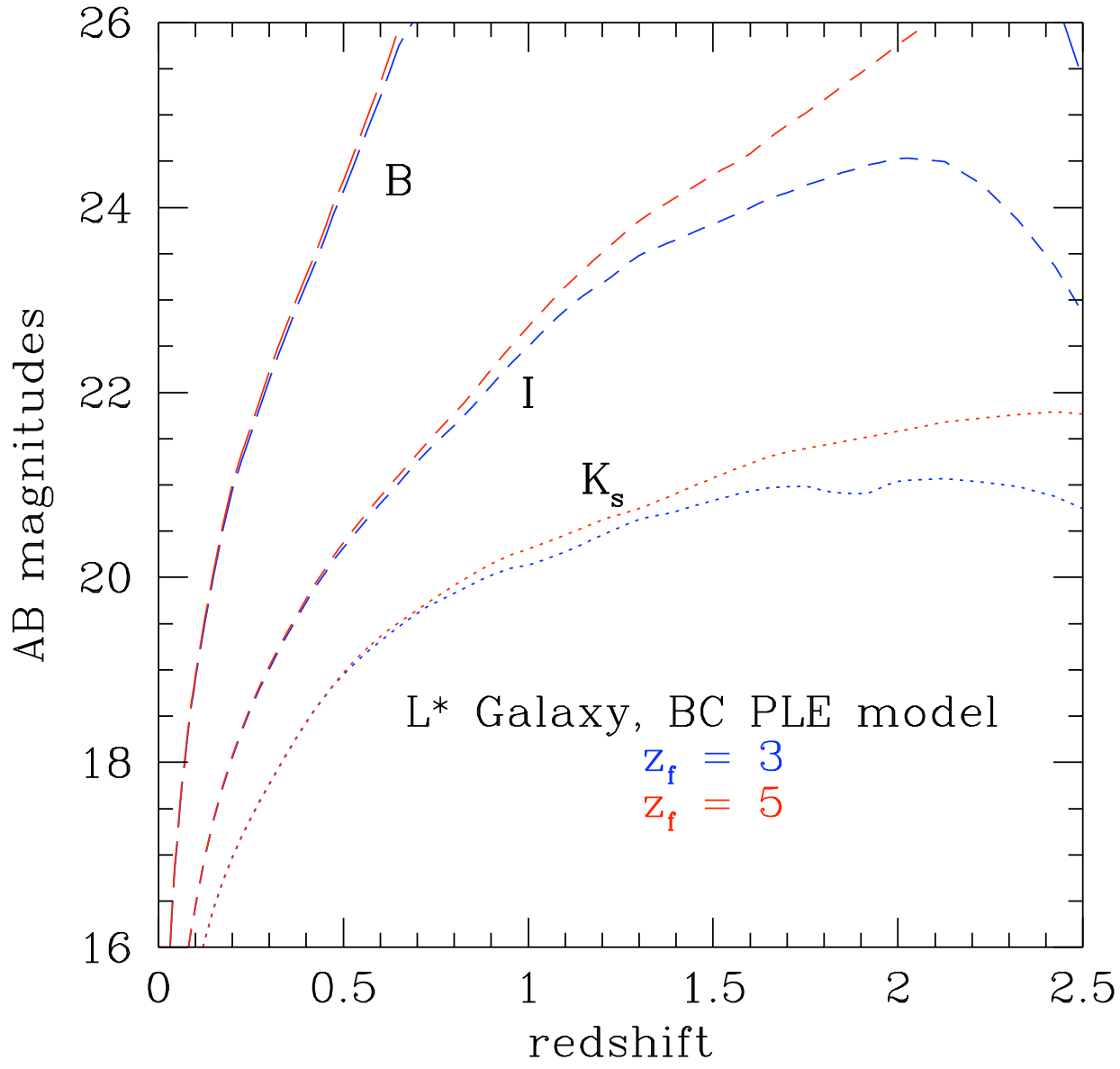
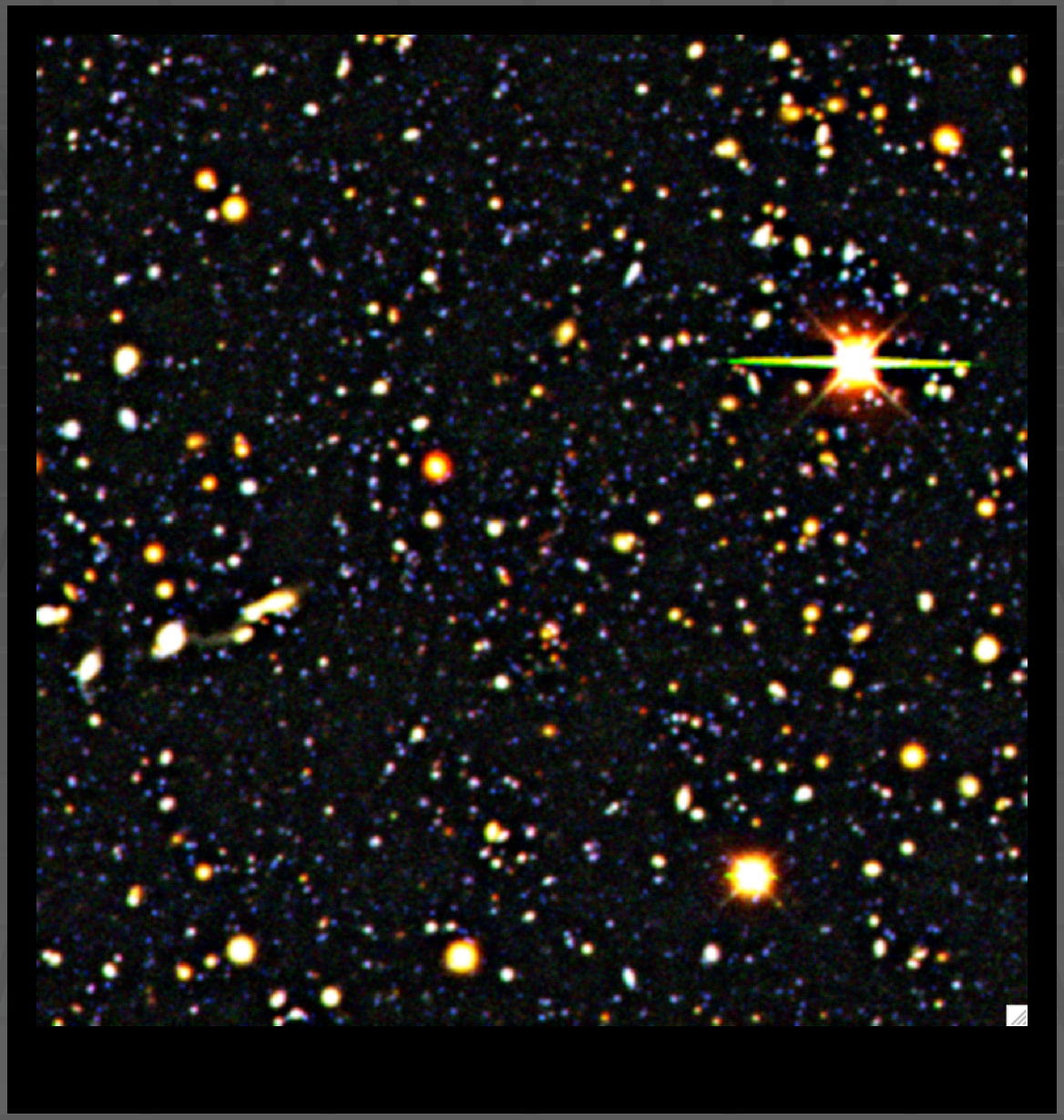

26
24
22
20
18
16
AB magnitudes
0
0.5
1
1.5
2
2.5
redshift
B
I
K_s
L* Galaxy, BC PLE model
z_f = 3
z_f = 5

Infrared Advantage

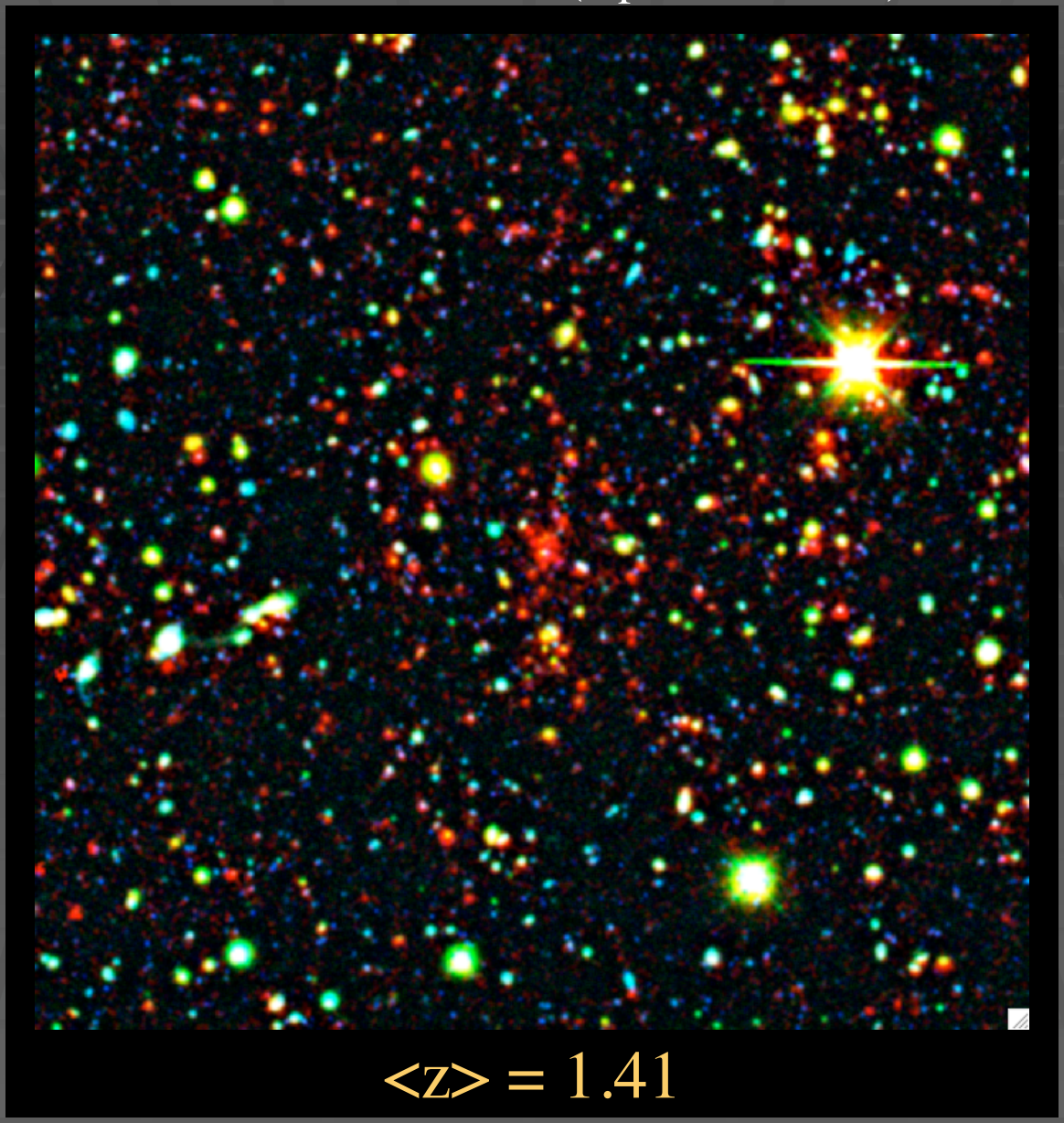
- Bruzual & Charlot model
  - 0.1 Gyr Burst, $z_f = 3, 5$
  - $H_0=70$; $\Omega_M = 0.3$; $\Omega_\Lambda = 0.7$
- Red galaxies quickly fade with redshift in optical due to strong k-correction
- Near-IR better but hard to go deep over large areas

Optical Alone



Stanford et al. 2005 (ApJ, 634, 129L)

Optical
+
IR



<z> = 1.41

Cluster Search Methods

Method	Z<1	Z>1
X-ray	Efficient	Poor (sensitivity); Biased (shocks, concentration)
Optical (e.g. Red-Sequence)	Efficient	Poor (4000Å break leaves optical window); Biased (against clusters with star formation)
Multi-λ Photo-z	**Efficient**	**Efficient; Unbiased**
Future		
Sunyaev-Zeldovich	Great Potential; Will *Still* Require Multi-λ follow-up to calibrate	Great Potential; Will *Still* Require Multi-λ follow-up to calibrate

Preliminary Answers

- What are the main science results? and where would we excel relative to other surveys?
  - Probe galaxy evolution in full range of environment using samples of ~10,000 clusters at $1 < z < 2$ and ~500 at $2 < z < 3$ with $M > 10^{14}$ M(sun). VIKING +KIDS will be limited to $z < 1.5$.
  - Unbiased census of stellar mass at $1 < z < 2$ down to 4-5 magnitudes below L*, in the field as well. VIKING +KIDS will be limited to ~1 mag below L* at z~1.5.
  - Statistical methods necessary to exploit the full value of the large survey area/volume, e.g. use the halo occupation distribution methodology

Preliminary Answers

- What are the requirements on the design and operation of SASIR?
  - Bands: all four YJHK; K important to fill the gap between the NIR and MIR
  - Depth more important than area, so more new science likely to result from medium and deep modes
  - Calibration very important to be able to determine accurate phot-z in combination with optical surveys
  - Collaboration with optical surveys is CRUCIAL

Preliminary Answers

- What are the synergies with other large projects?
  - Collaboration with optical surveys is CRUCIAL
  - Large optical surveys (e.g. PanStarrs) are limited in their reach at $1 < z < 3$ but provide the necessary optical photometry for determining photometric redshifts which are most important for any galaxy evolution science
  - Cross comparison of clusters selected by SASIR with those selected by eRosita will improve our understanding of cluster formation
  - WISE will provide an all-sky mid-IR complement for studies at $z < 1$