High Redshift Galaxies

A Systems Perspective

P. J. McCarthy

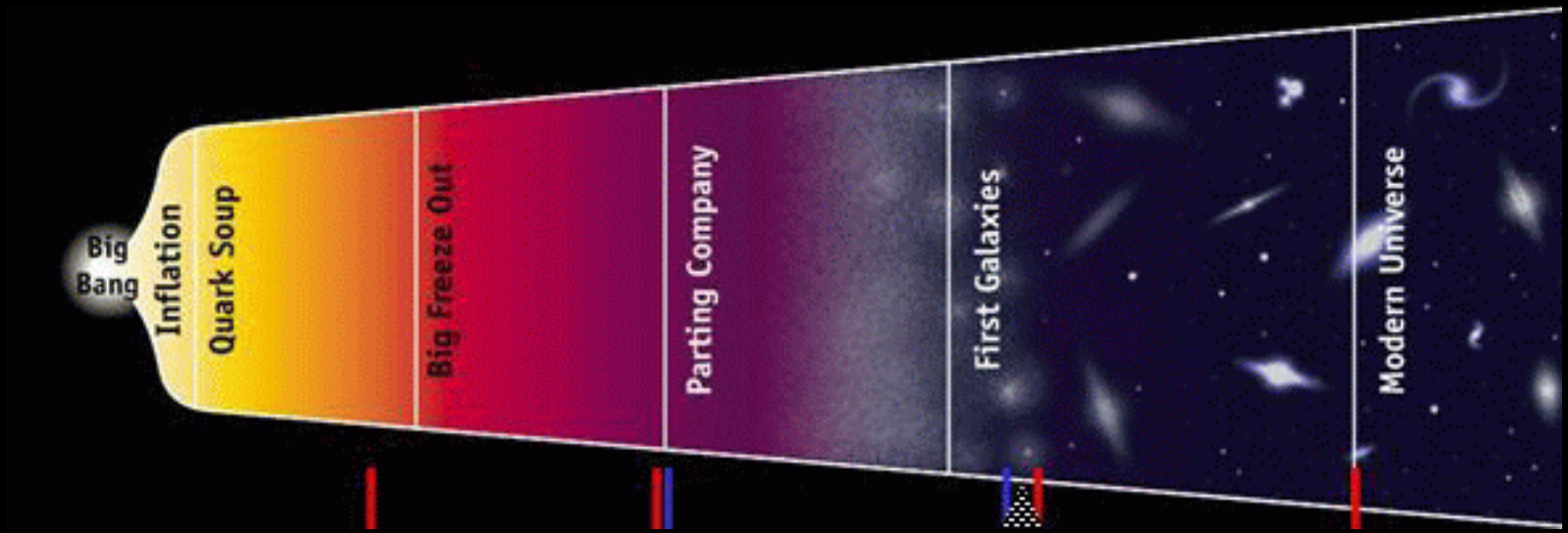
Carnegie Observatories

NOAO System II

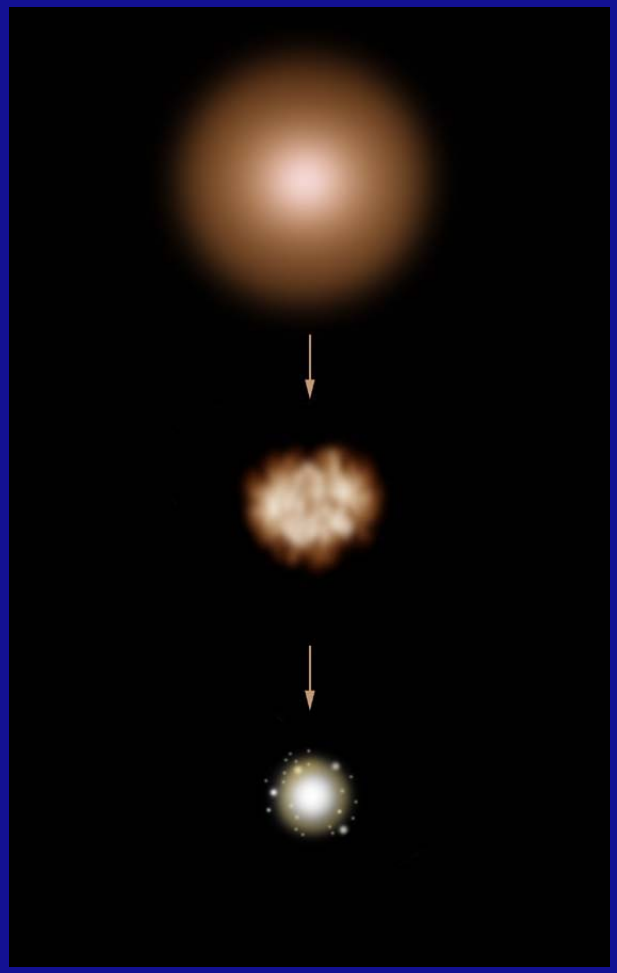
May 13, 2004

Mission Statement:

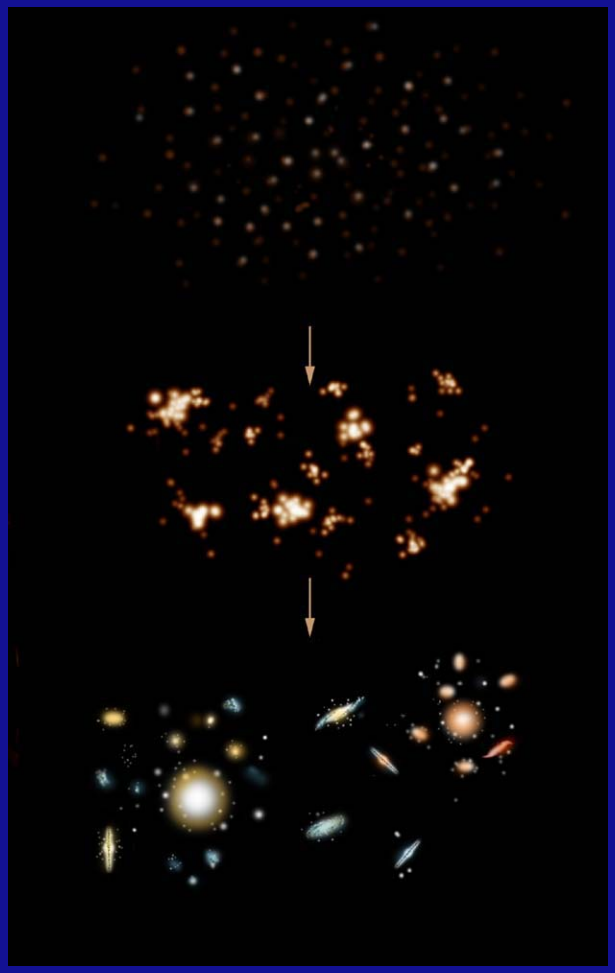
How did the present chaos arise from near perfect order in the early Universe?



How are Galaxies Formed?

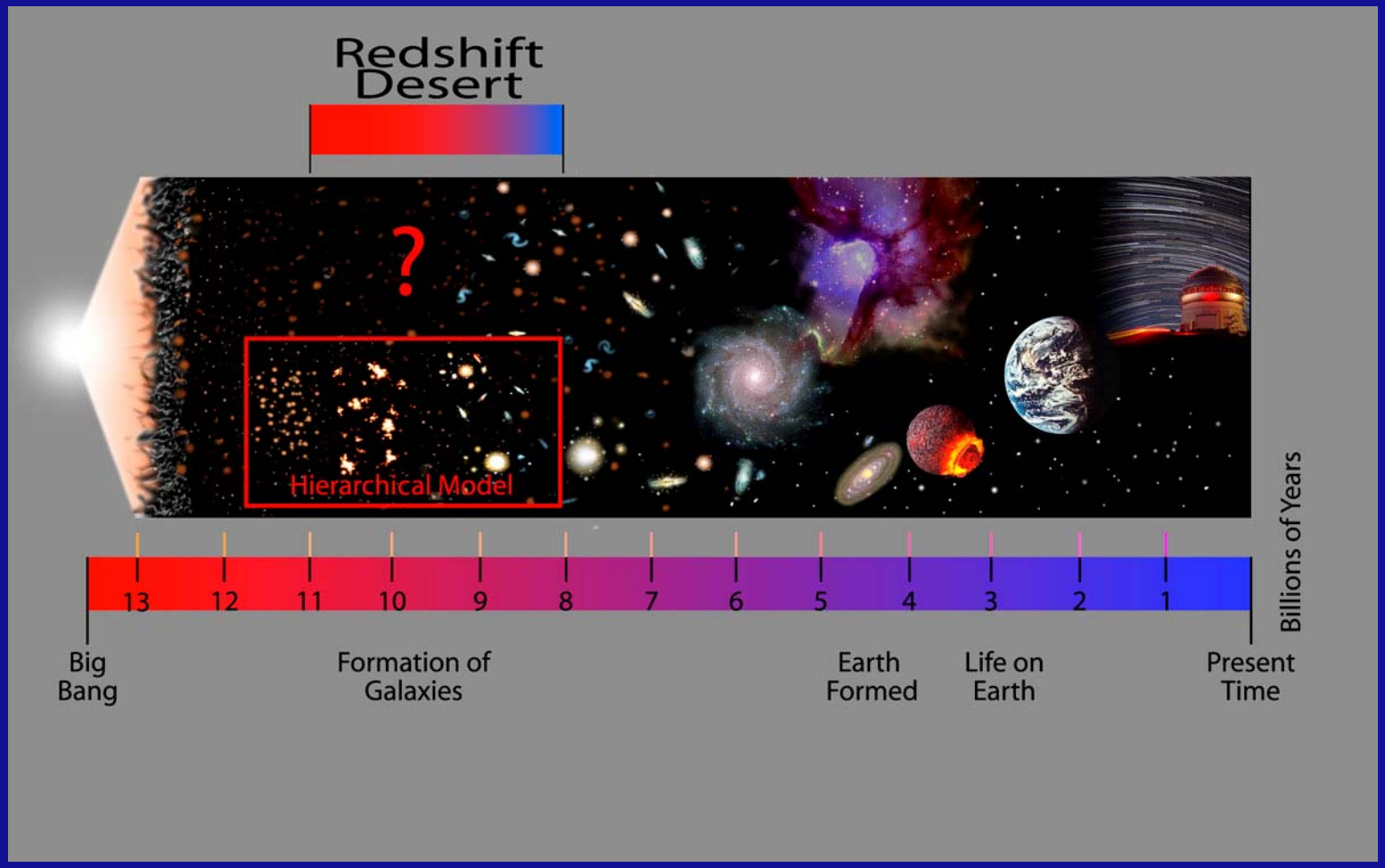


Monolithic Collapse
ala ELS



Hierarchical
Assembly

When did they Form?



Gemini Press Office

TWO APPROACHES:

GLOBAL CENSUS:

Star formation *Metal production*

Galaxy Assembly *Population evolution*

VIVISECTION:

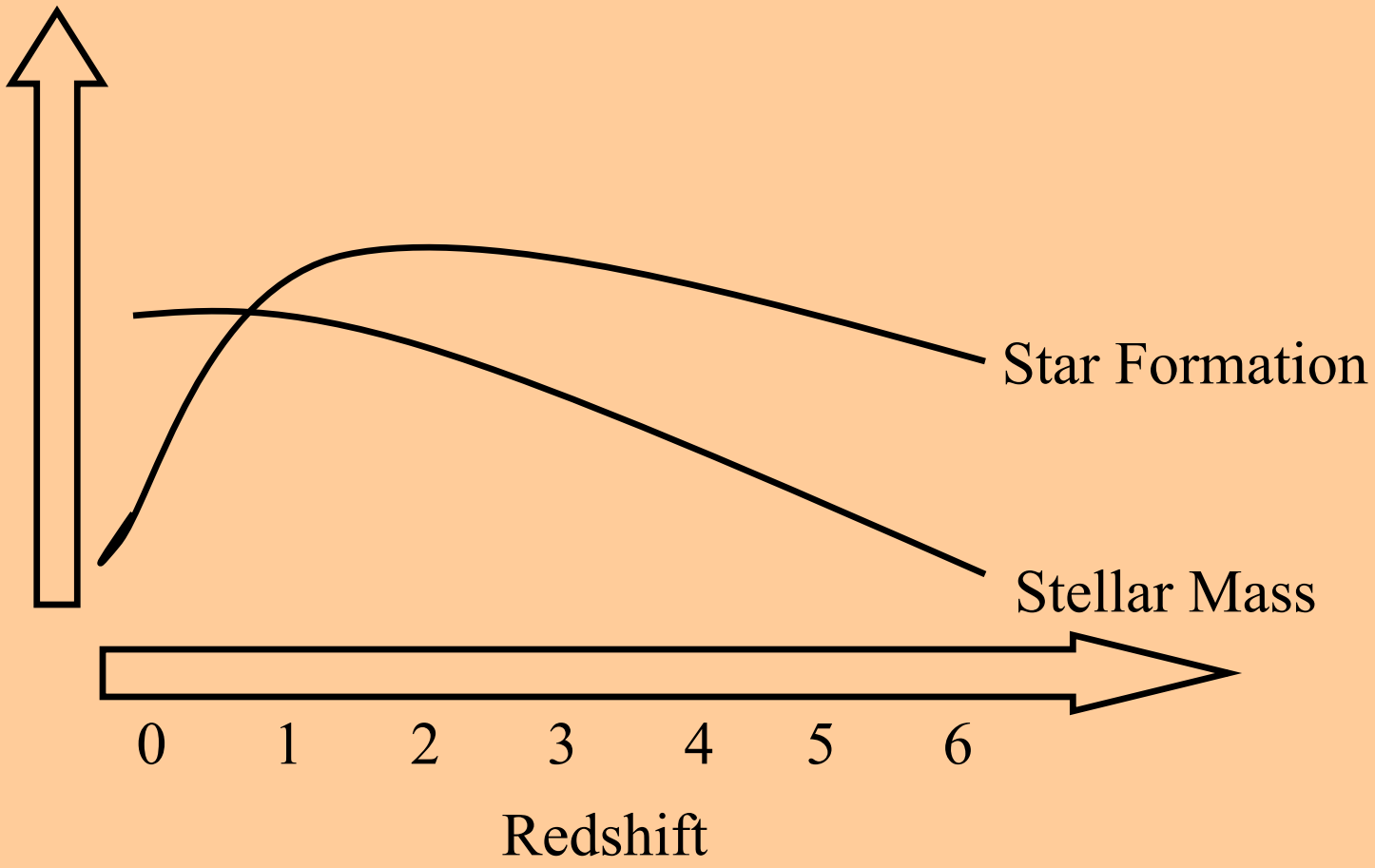
Internal dynamics *Stellar populations*

Abundances and abundance Gradients

Morphologies and internal structure

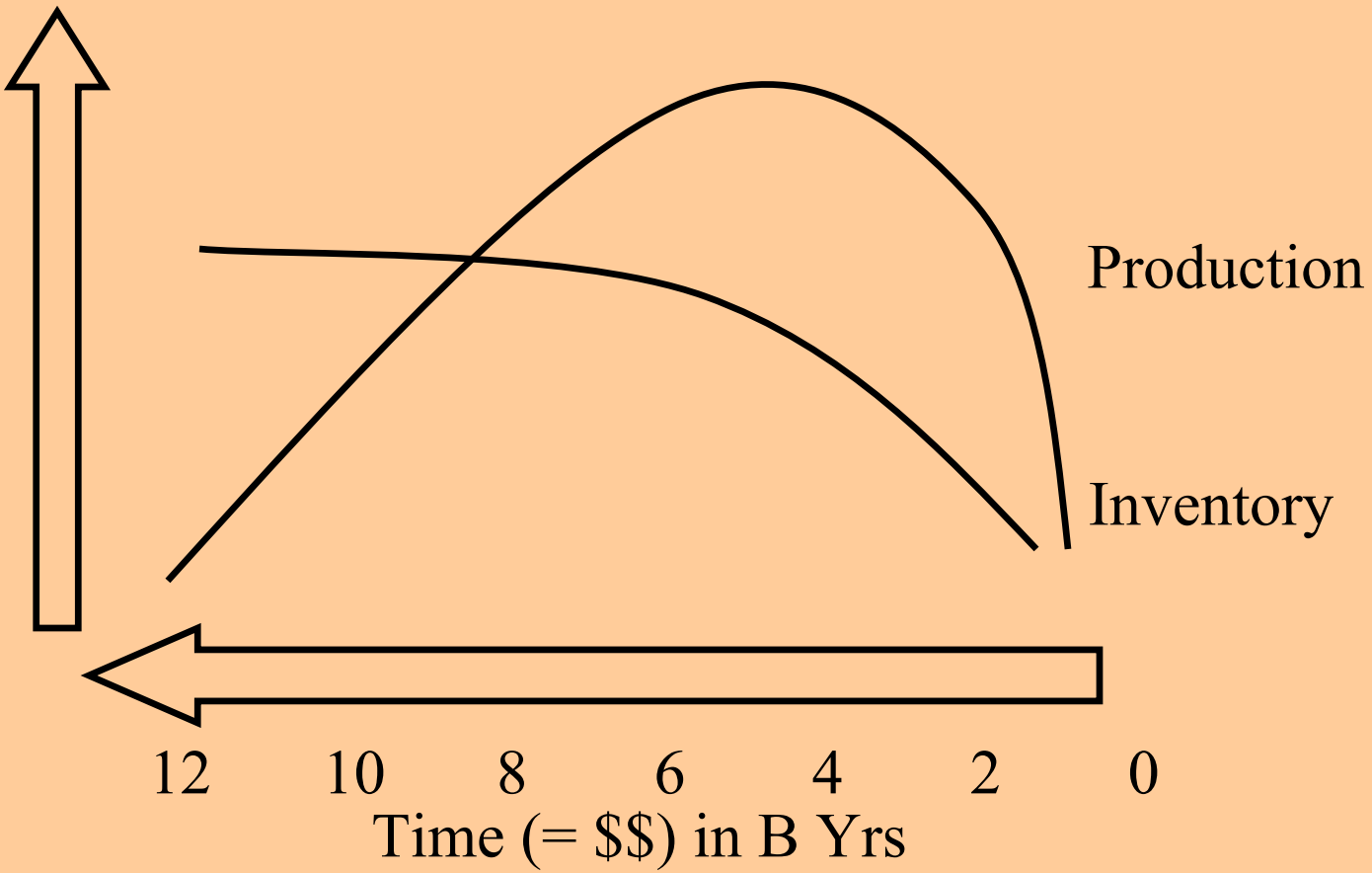
THE GLOBAL PERSPECTIVE

COSMIC History for CEOs



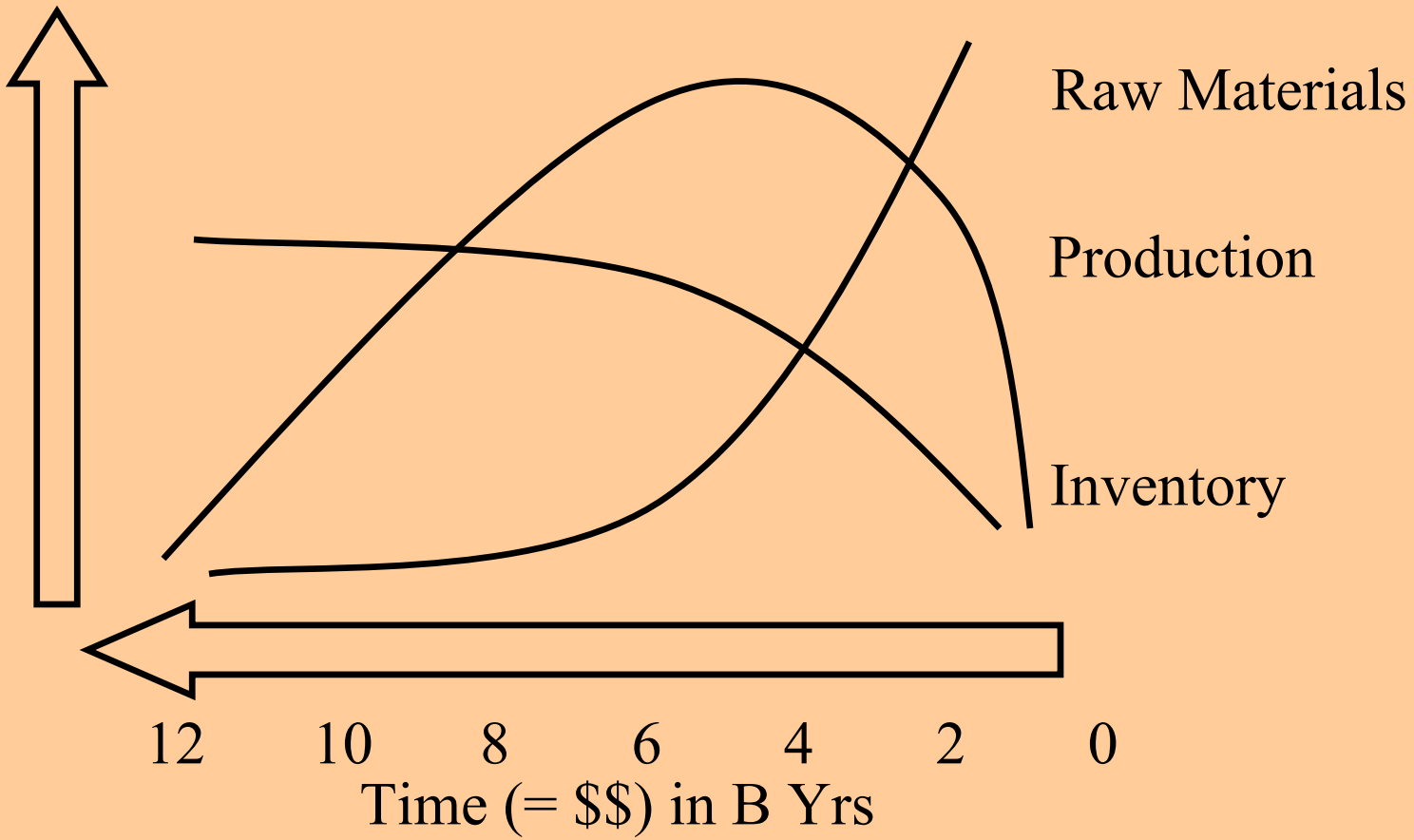
THE GLOBAL PERSPECTIVE

COSMIC History for CFOs



THE GLOBAL PERSPECTIVE

COSMIC History for CFOs



GLOBAL CENSUS:

- Diffuse Backgrounds (Far-IR --> X-ray)

  DIRBE, EGBL, Voyager (UV), XRB

- Luminosity Functions and Integrals - prim. UV

  GALEX, visible-near-IR, SPITZER (IMF?)

- IGM Abundances

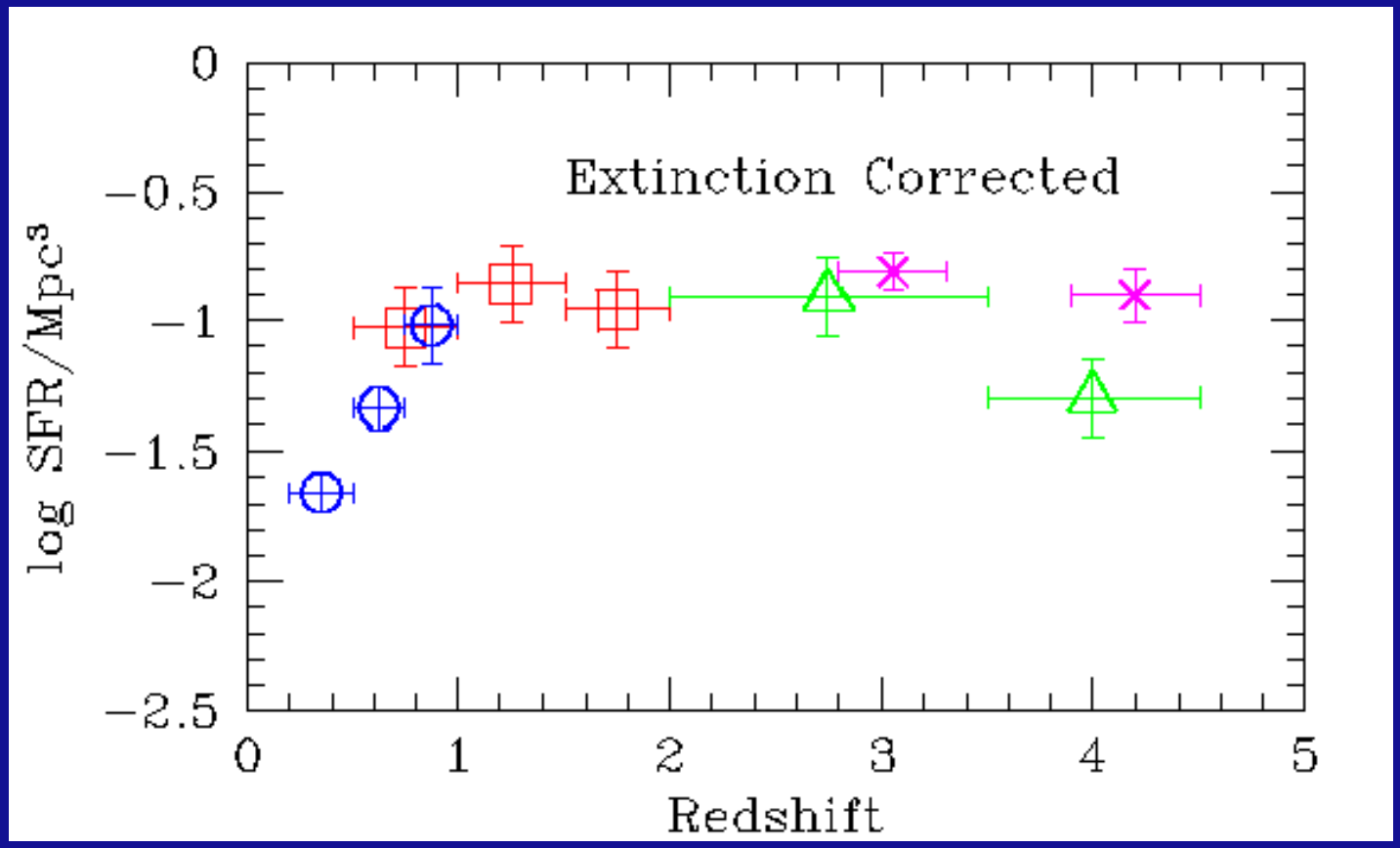
  QALs

- Stellar Mass Functions and Integrals

  Gemini, VLT, HST, SPITZER

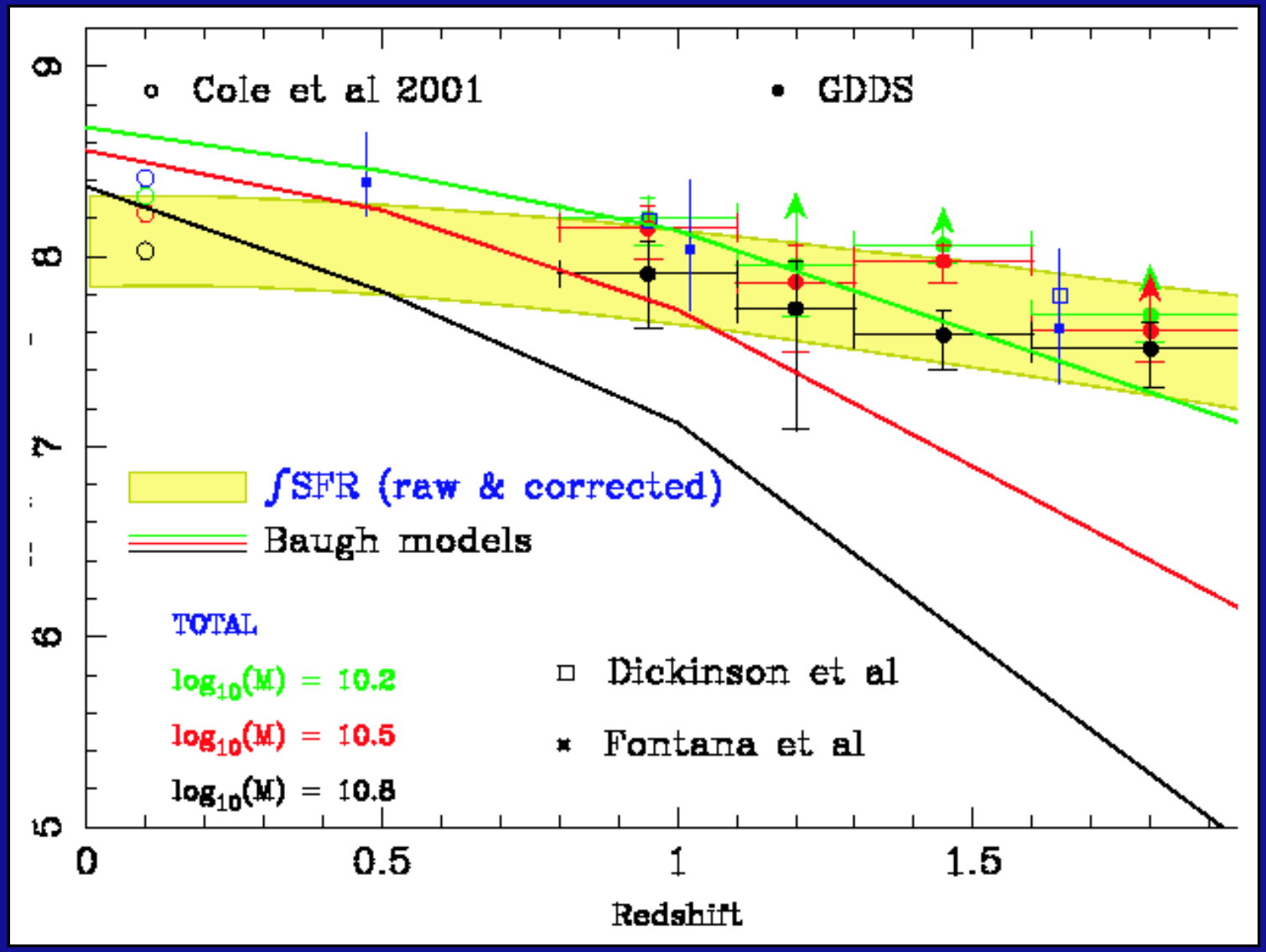
Optical Redshifts and near-IR photometry crucial

GLOBAL EVOLUTION OF STAR FORMATION



Steidel et al. 1999

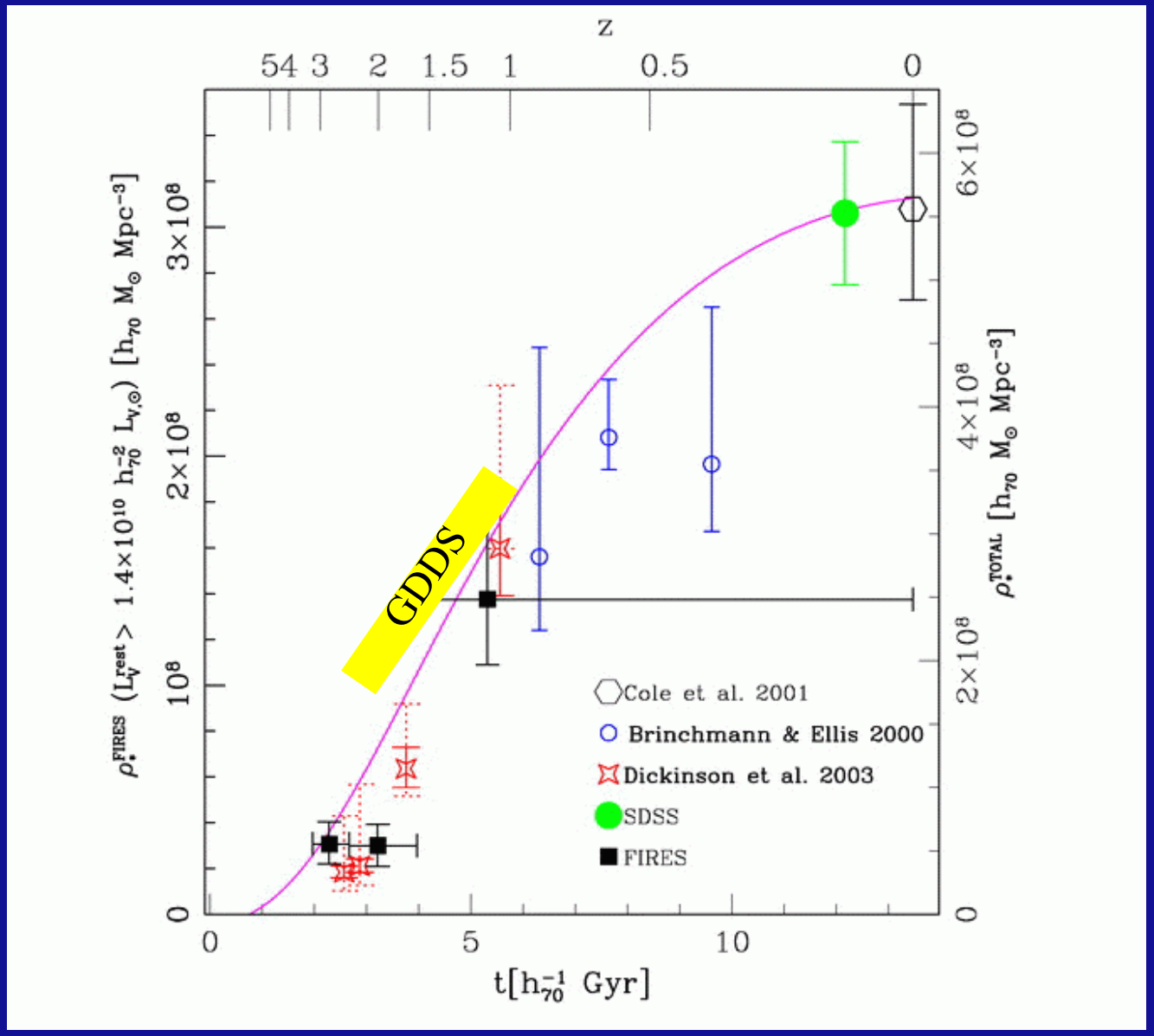
GLOBAL EVOLUTION OF STELLAR MASS DENSITY



Glazebrook et al. 2004

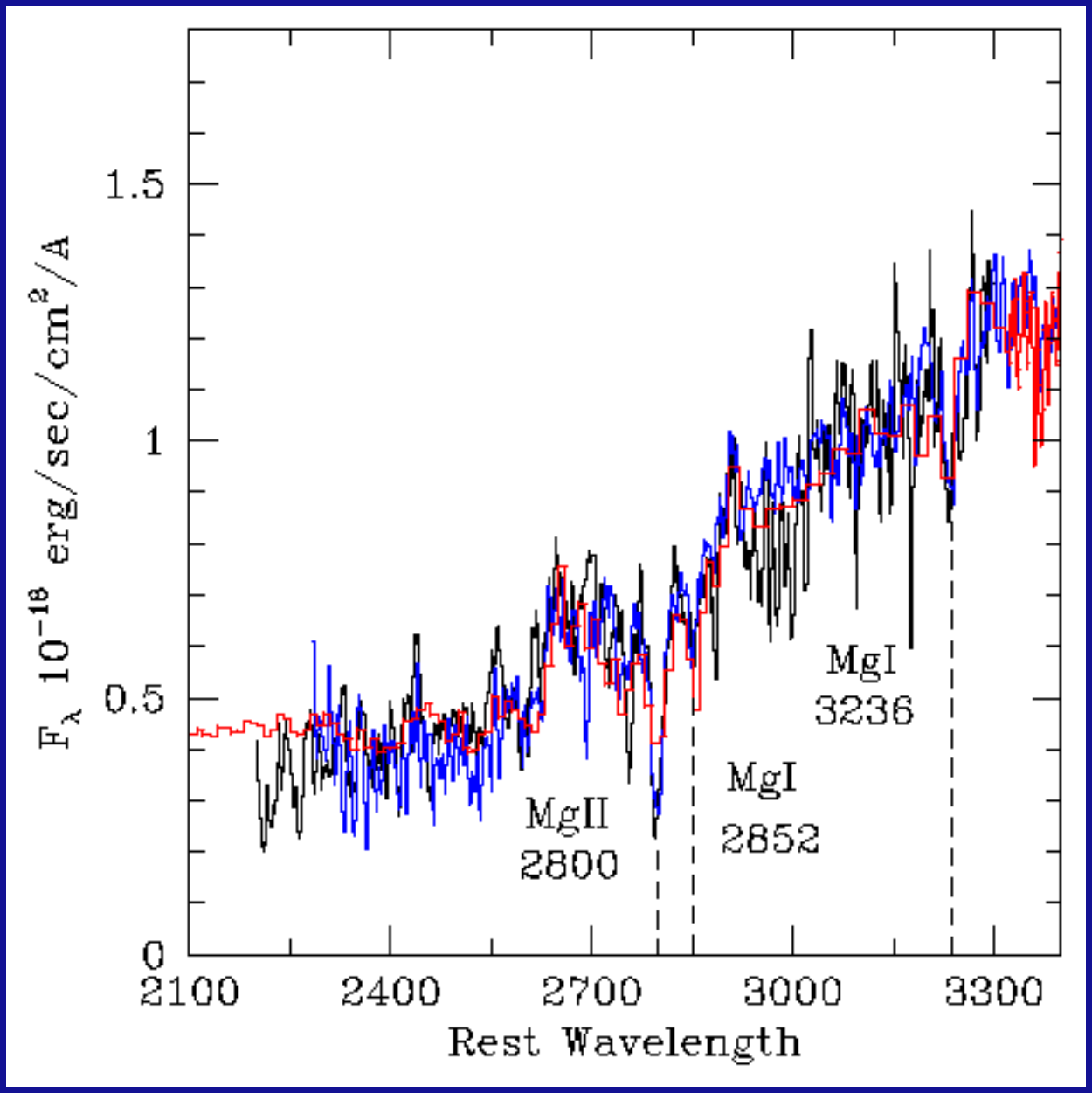
Gemini Deep Deep Survey

GLOBAL EVOLUTION OF STELLAR MASS DENSITY



Rudnick et al. 2004

Abundances and Ages



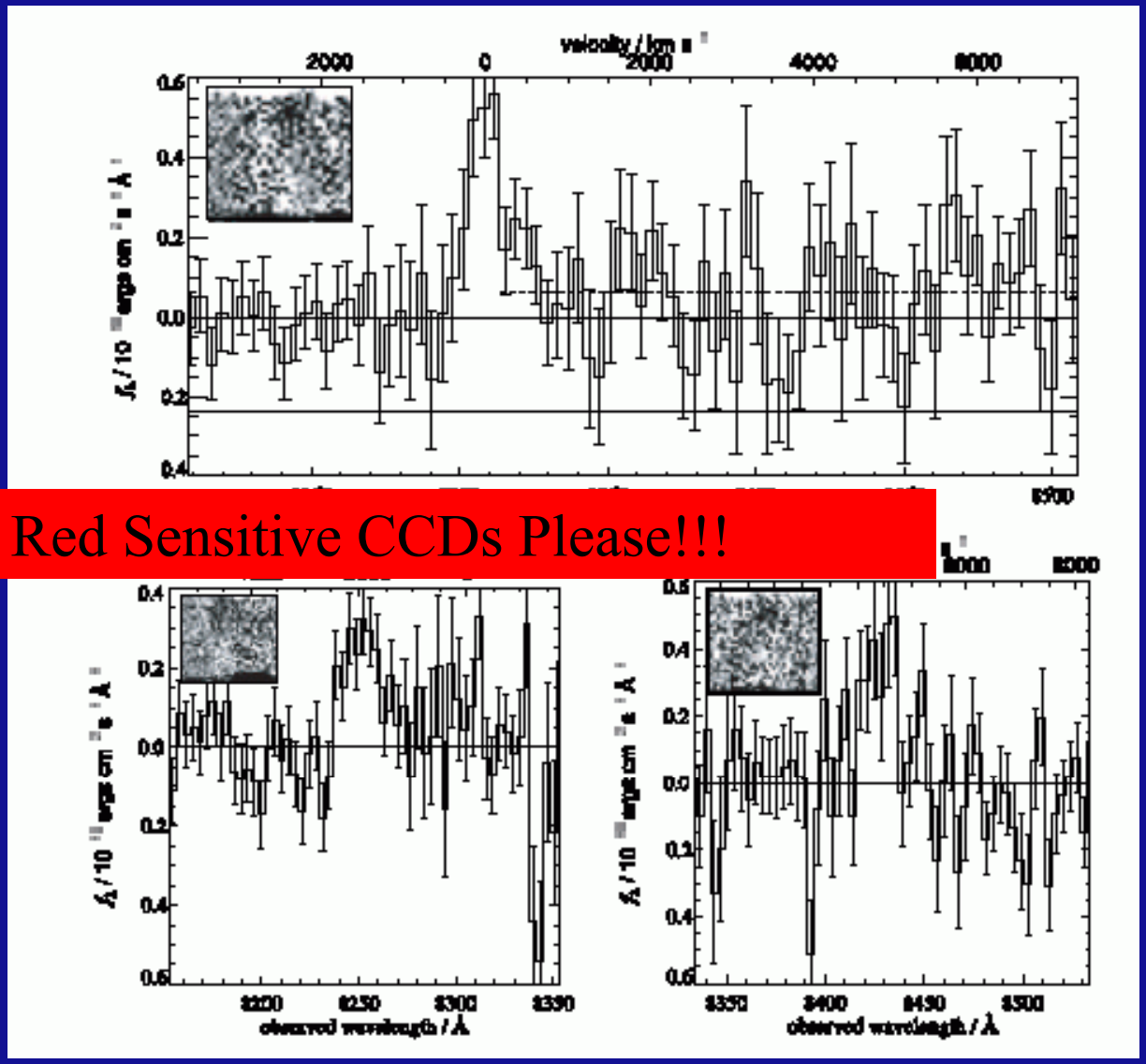
<z>=1.3

<z>=1.8

2Gyr

Solar

The Earliest Galaxies

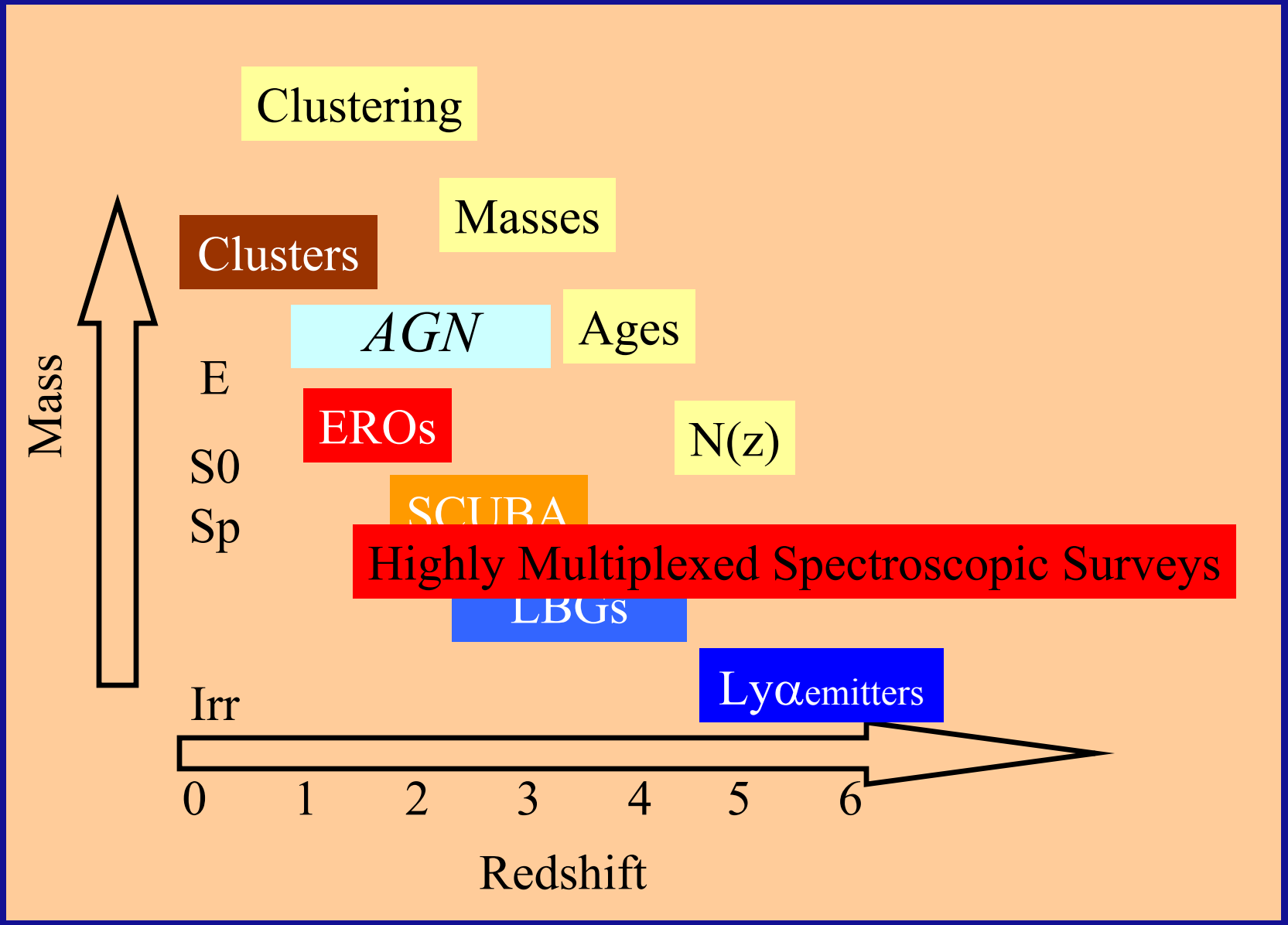


Red Sensitive CCDs Please!!!

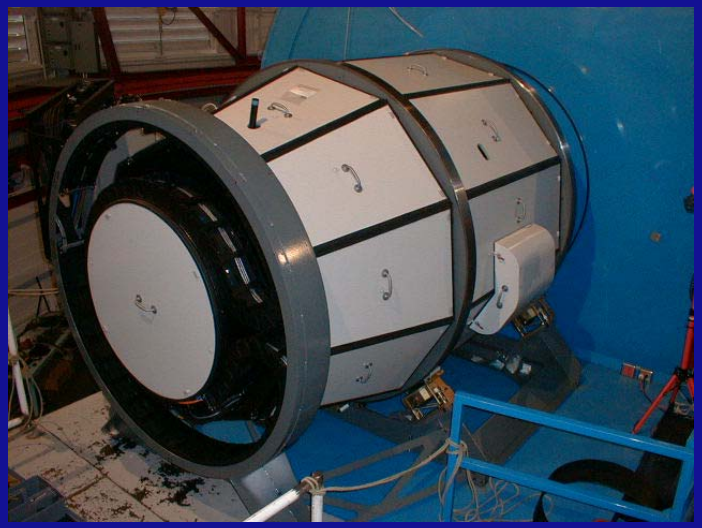
Stanway et al. 2004

Z = 6 Ly alpha - 12 hours on Gemini

Matching Galaxy Samples



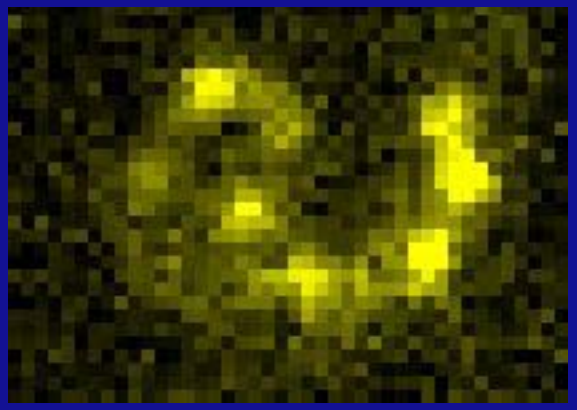
GMOS/Gemini North



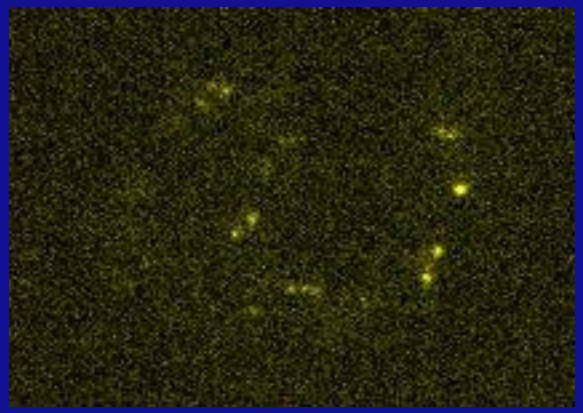
IMACS/Baade 6.5m

DEIMOS/KECK

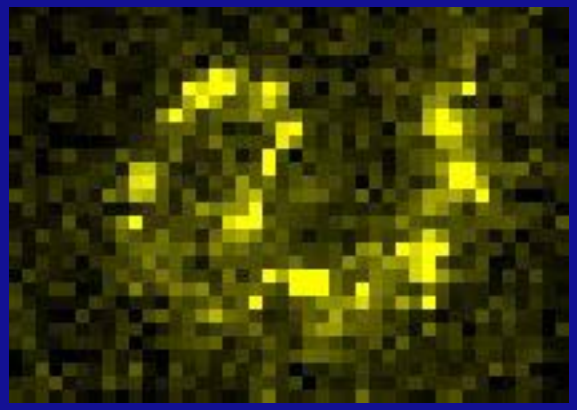
Ground-Layer Adaptive Optics



GMT GLAO



MCAO small pixels



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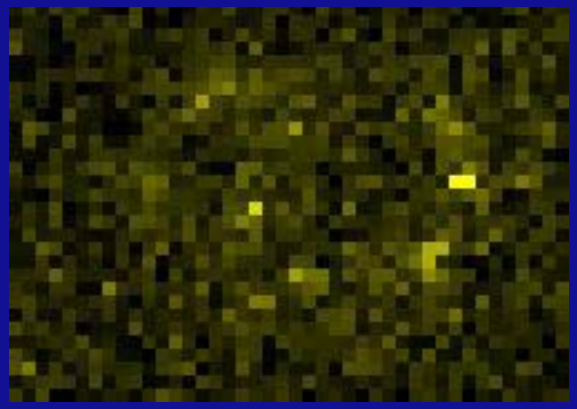


8m MCAO

E. Barton

The Antennae at z = 3.3 in [OII]3727

Galaxy Dissection:

- Internal kinematics & rotation curves

  DEIMOS, IMACS, NIRSPEC, MMIRS

  AO-fed - OSIRIS, NIFS…

- Abundances and gradients

  NIRSPEC, MMIRS

- Morphologies

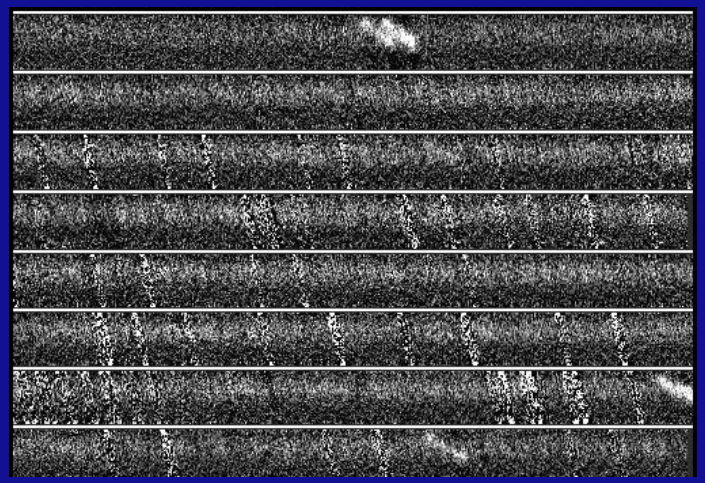
  HST/ACS AO? GLAO?

- Stellar Populations

  GMOS, DEIMOS, IMACS etc

UV to near-IR spectroscopy crucial

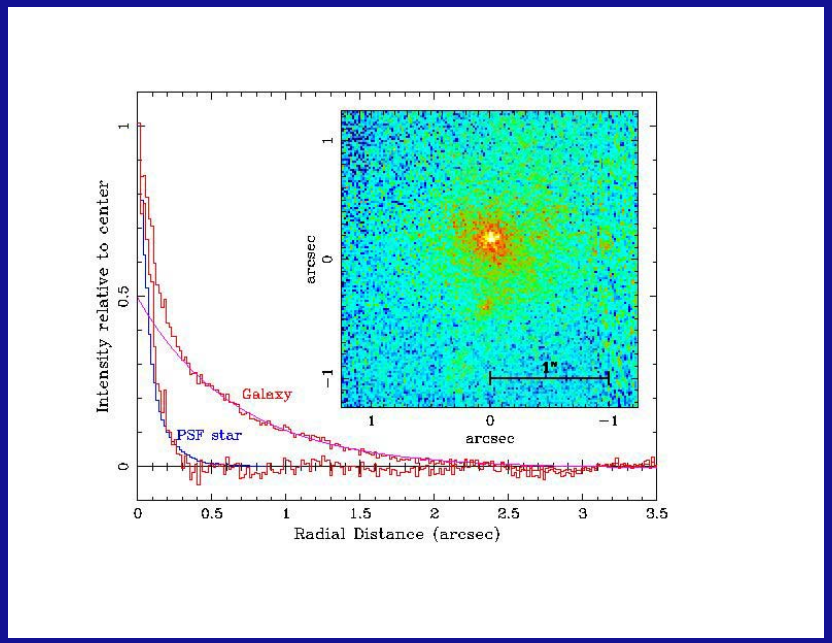
Galaxy Dissection:



Near-IR allows one to push

to z ~ 3 for small samples

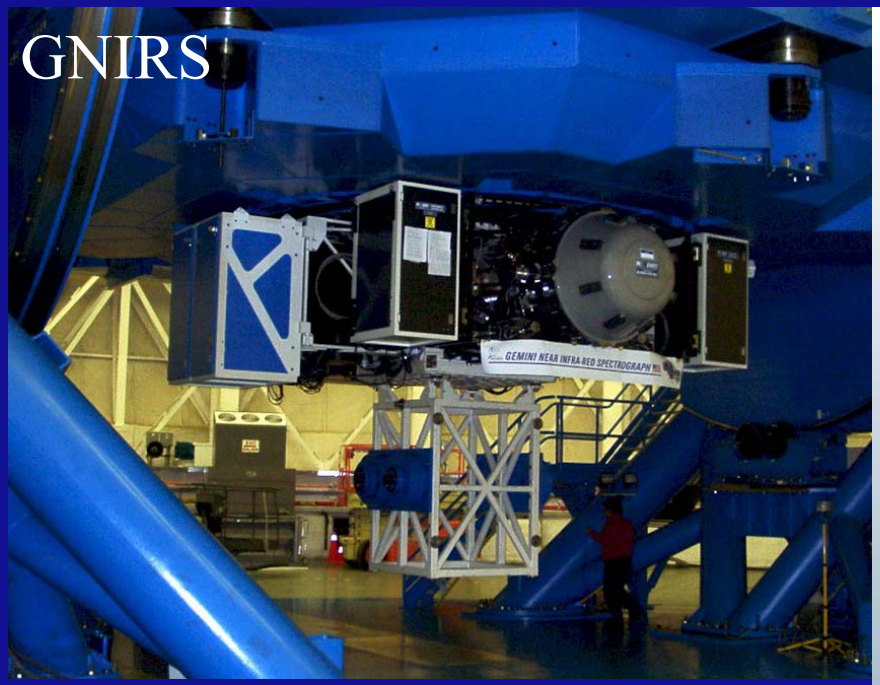
DEEPII - Dynamical masses to z = 1.3

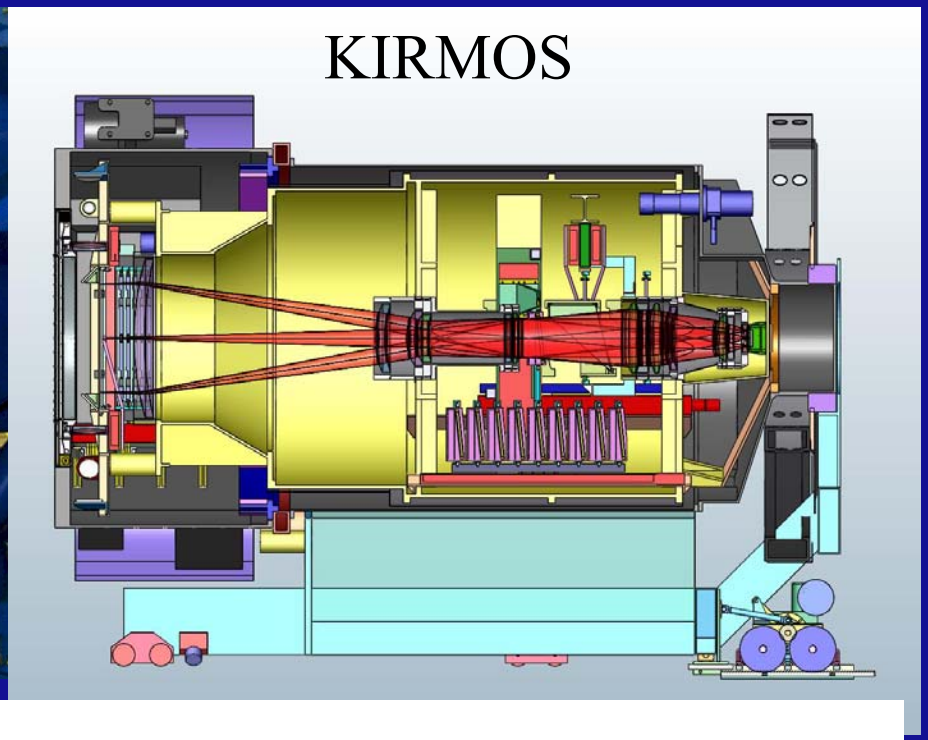


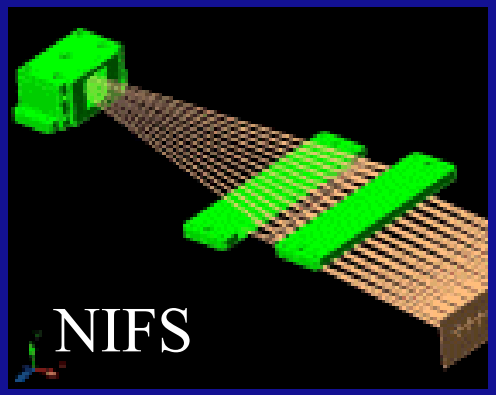
Larkin et al.

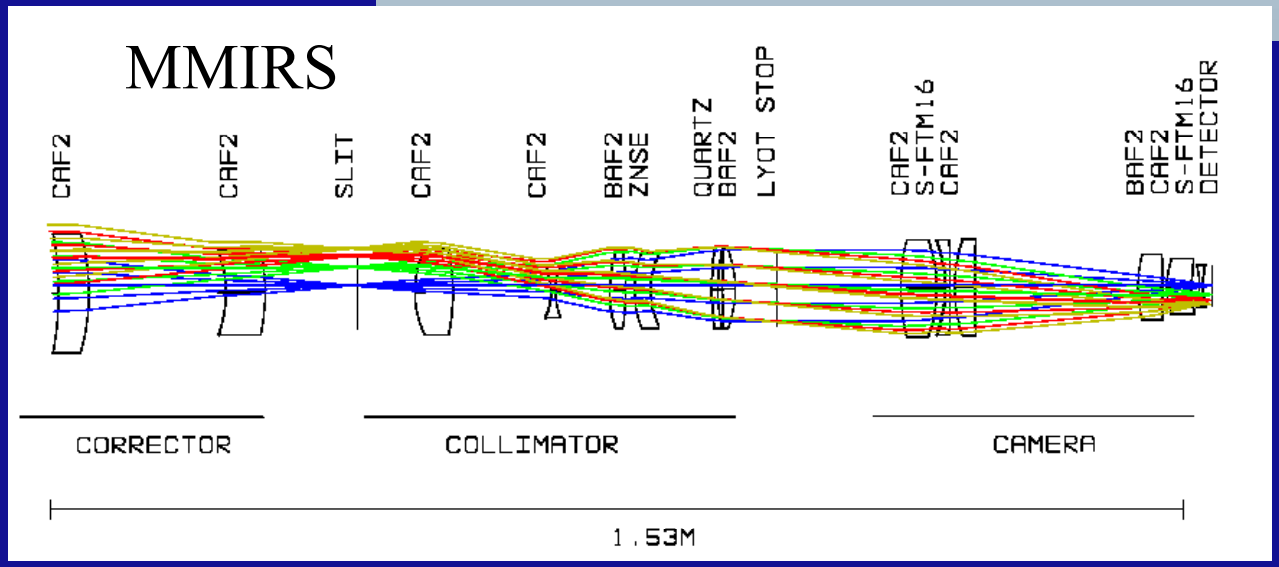
OSIRIS AO-fed IFU

Galaxy Dissection: Near-IR Spectrometers

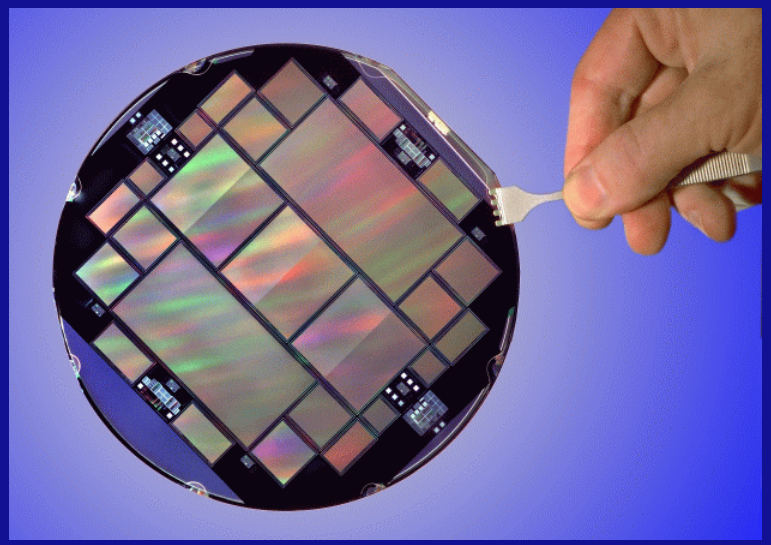








Optical and near-IR Detectors

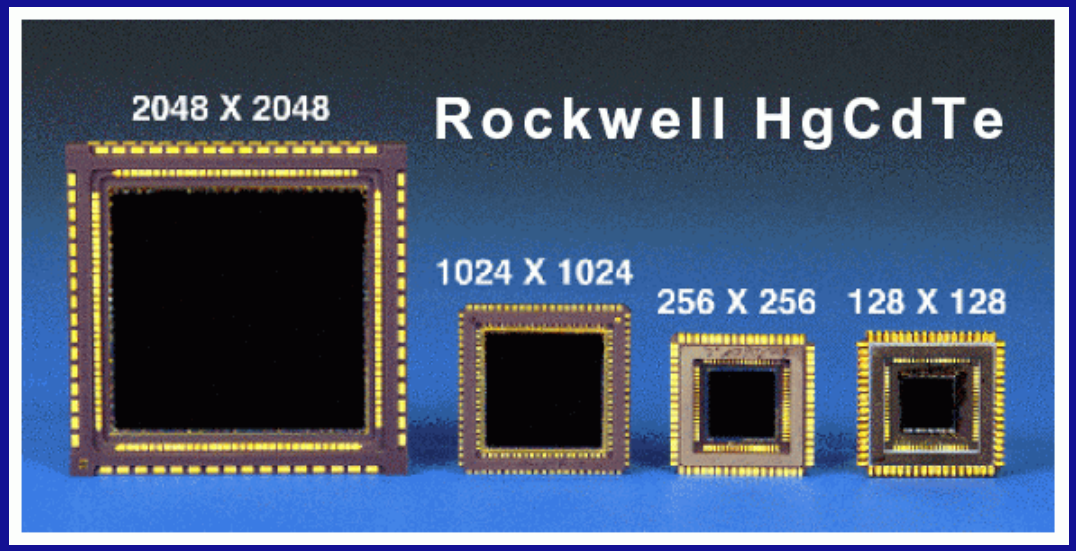


Large formats: 2k x 4k

3 edge buttable

100 Mpixel FPAs common

Cheap - $ 0.01 per pixel



2k x 2k maximum
Non-buttable
Expensive

$ 0.13 per pixel !

4-STAR

Needed Technology Investments

Detectors:

Plentiful Red Sensitive CCDs

Affordable near-IR Mosaics

Low-noise IR arrays for spectroscopy

Spectrographs:

Maximize multiplexing

Good blue/UV sensitivity

Needed Technology Investments

Adaptive Optics:

Ground-truth about GLAO

Low-noise fast-readout WFS

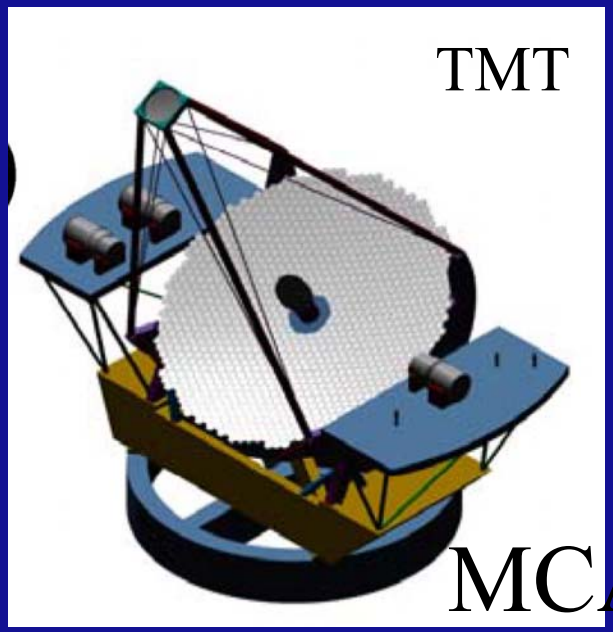
Adaptive secondaries

Needed for 8-10m as well as ELTs!

The Future of the System

Public

Access



MCAO

Wide-Field …. The system of the future

What do we need now?

More effective use of the "system"

What do we need now?

Detectors!

- Red CCDs in large format
- Affordable large IR arrays

Ground-Layer AO Development

- Ground layer characterization
- Fast detectors

Innovation!