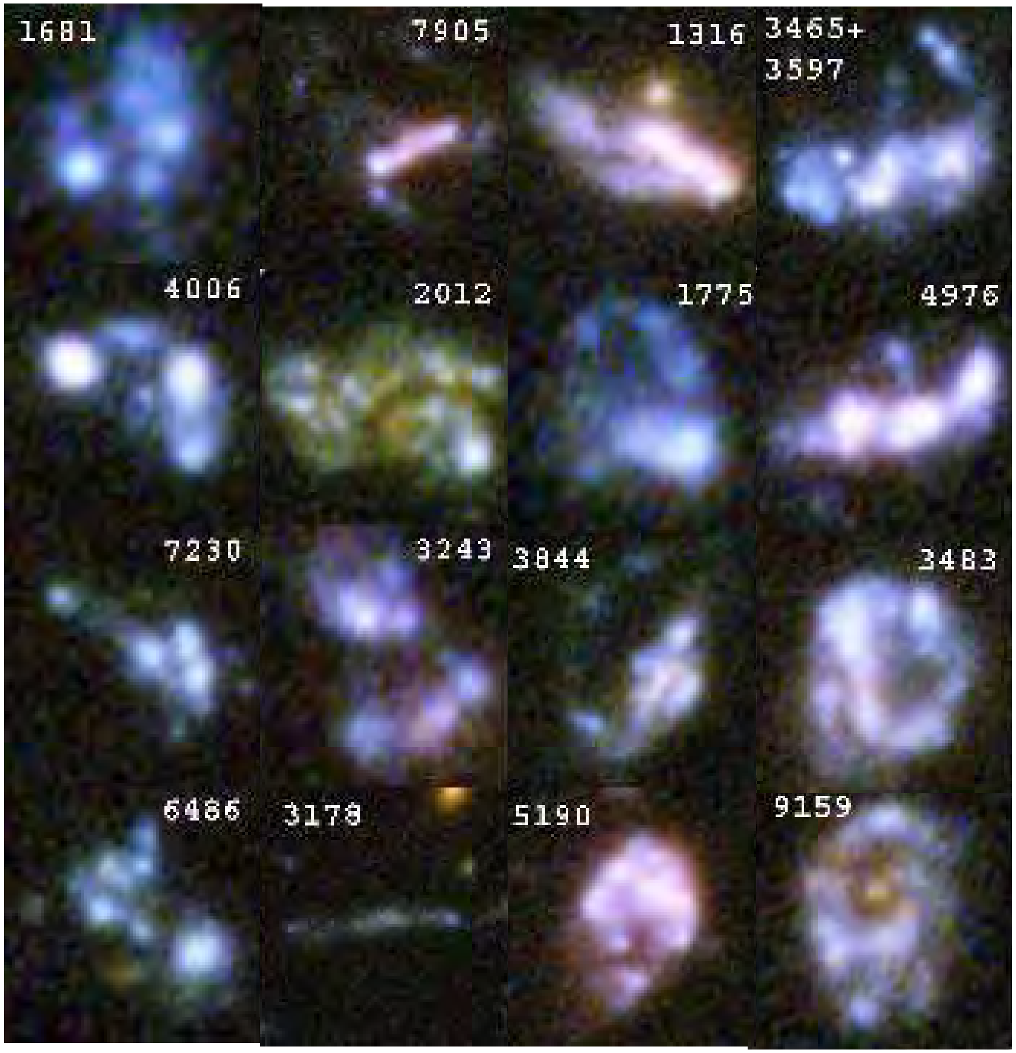
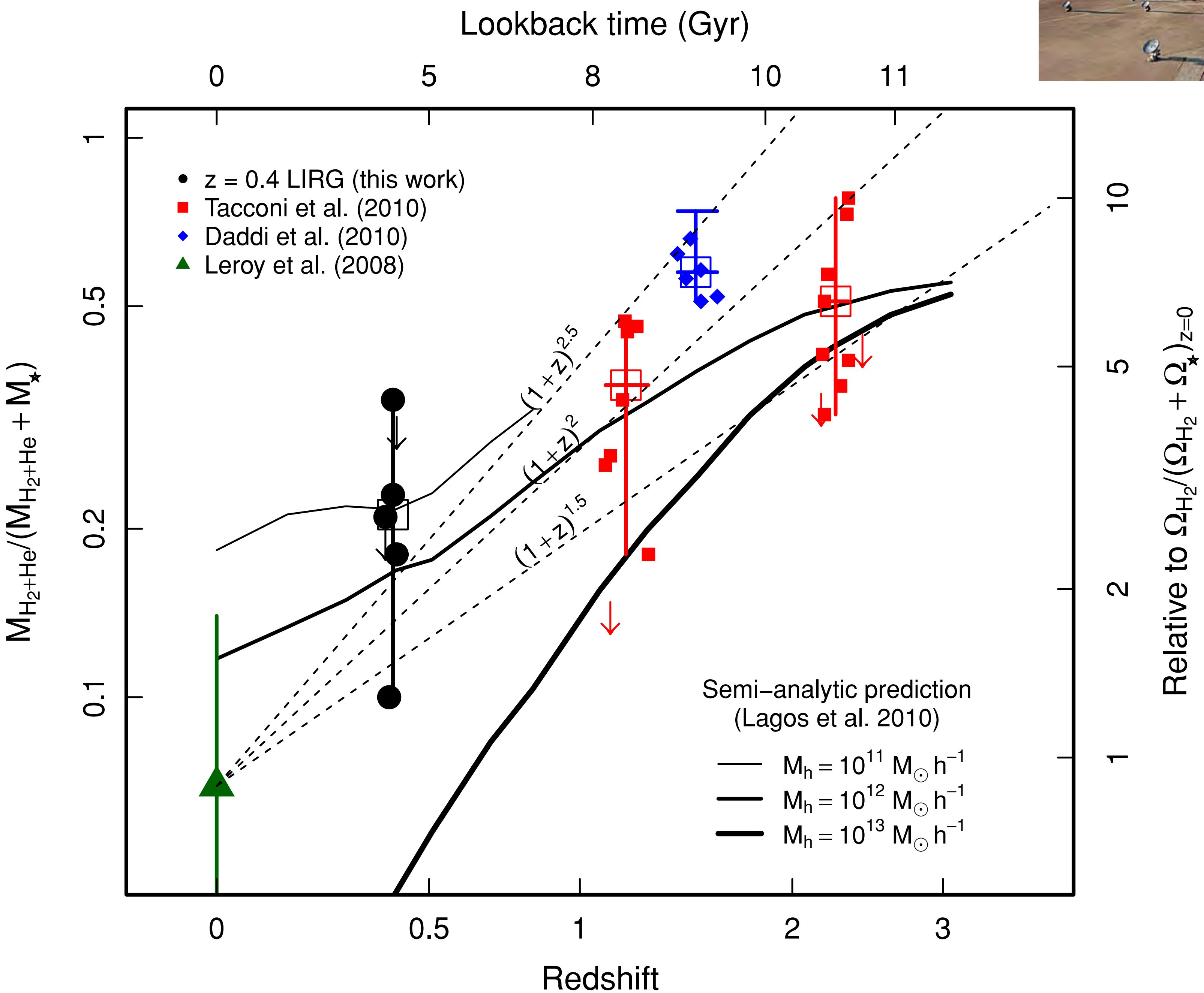
Good things to look forward to and challenges

Dark turbulent galaxies?

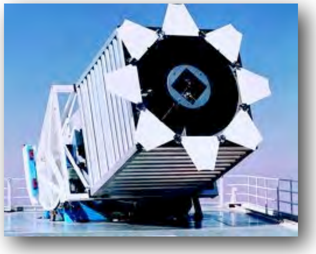


Elmegreen & Burkert 2010 suggest turbulent disks may have a pre-SFR phase for t_{acc}~180 Myr. CO?

f_{gas}

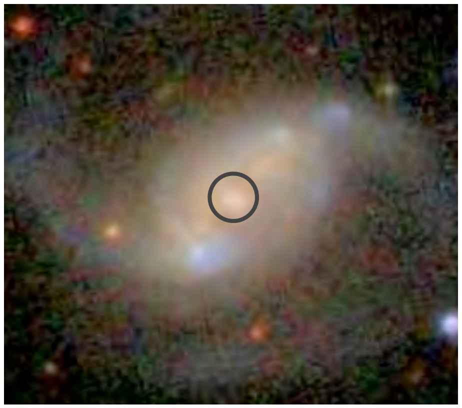


Lookback time (Gyr)
0 5 8 10 11
z = 0.4 LIRG (this work)
Tacconi et al. (2010)
Daddi et al. (2010)
Leroy et al. (2008)
$(1+z)^{2.5}$
$(1+z)^{2}$
$(1+z)^{1.5}$
Semi-analytic prediction
(Lagos et al. 2010)
$M_h = 10^{11}\ M_\odot\ h^{-1}$
$M_h = 10^{12}\ M_\odot\ h^{-1}$
$M_h = 10^{13}\ M_\odot\ h^{-1}$
$M_{H_2+He}/(M_{H_2+He}+M_\star)$
0.1 0.2 0.5 1
Relative to $\Omega_{H_2}/(\Omega_{H_2}+\Omega_\star)_{z=0}$
1 2 5 10
0 0.5 1 2 3
Redshift



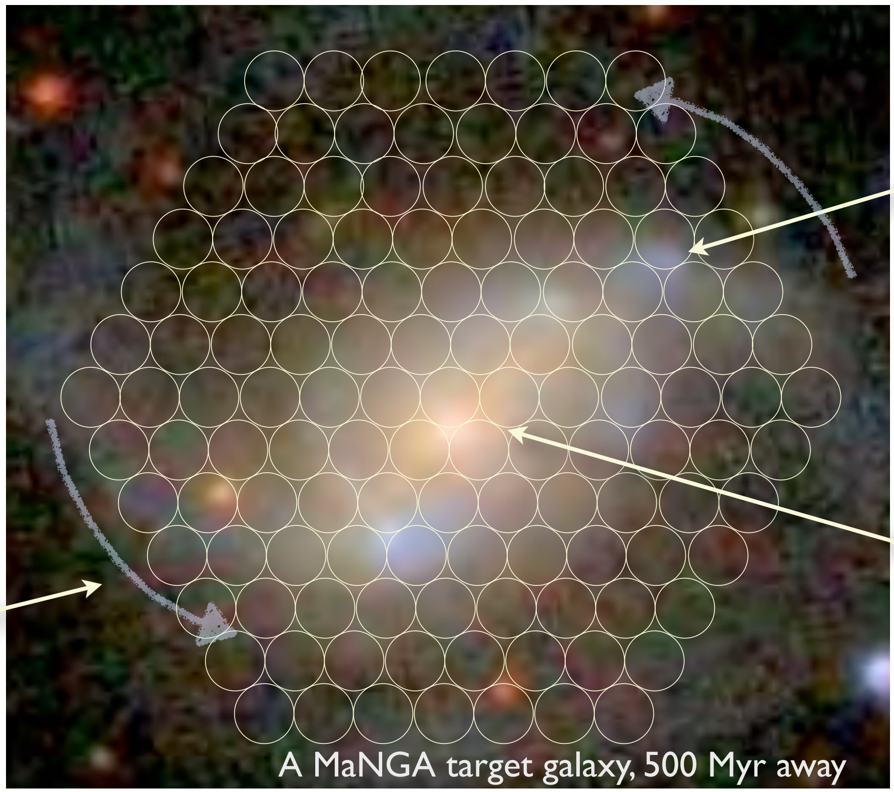
MaNGA: Mapping Nearby Galaxies at APO

Understanding the life-cycle of galaxies



SDSS-I only used a central light-collecting fiber

Birth:
Rotational motion records early formation within a dark matter halo



Life:
New stars forming from fresh gas?

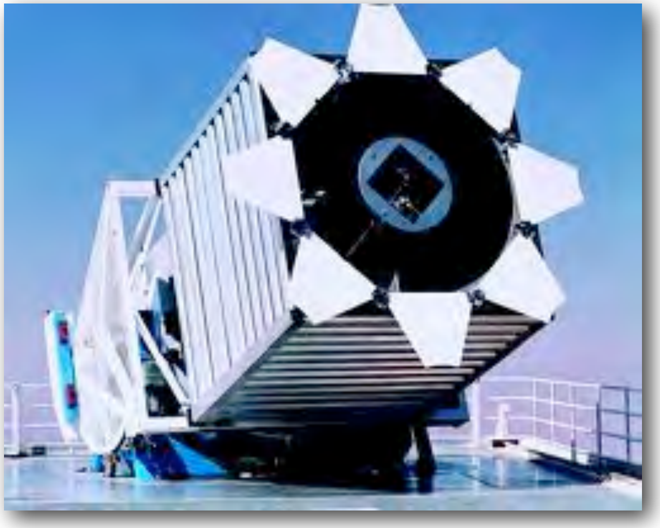
Death:
Is the galaxy "quenching" from central black-hole feedback?

MaNGA's fiber arrays will uncover the internal structure of 10,000 galaxies for the first time

(Slide from Kevin Bundy)

What is MaNGA?

- One of three approved "After-SDSS-III" (AS3) surveys to begin on the Sloan 2.5m in September 2014
- AS3 = MaNGA, eBOSS, APOGEE-2
- MaNGA exploits the existing BOSS instrument (high throughput, pipeline)



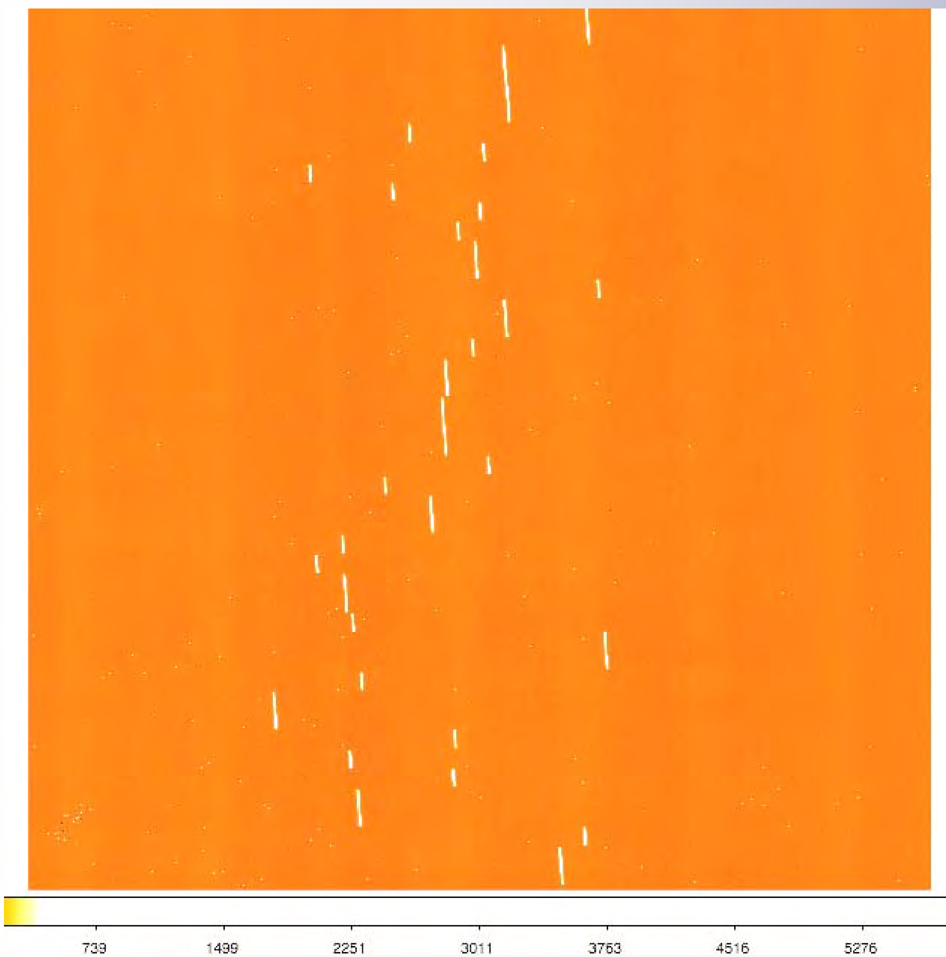
- MaNGA will bundle BOSS fibers to create 15-20 IFUs of various sizes
- IFU survey of ~10k nearby galaxies

(Slide from Kevin Bundy)

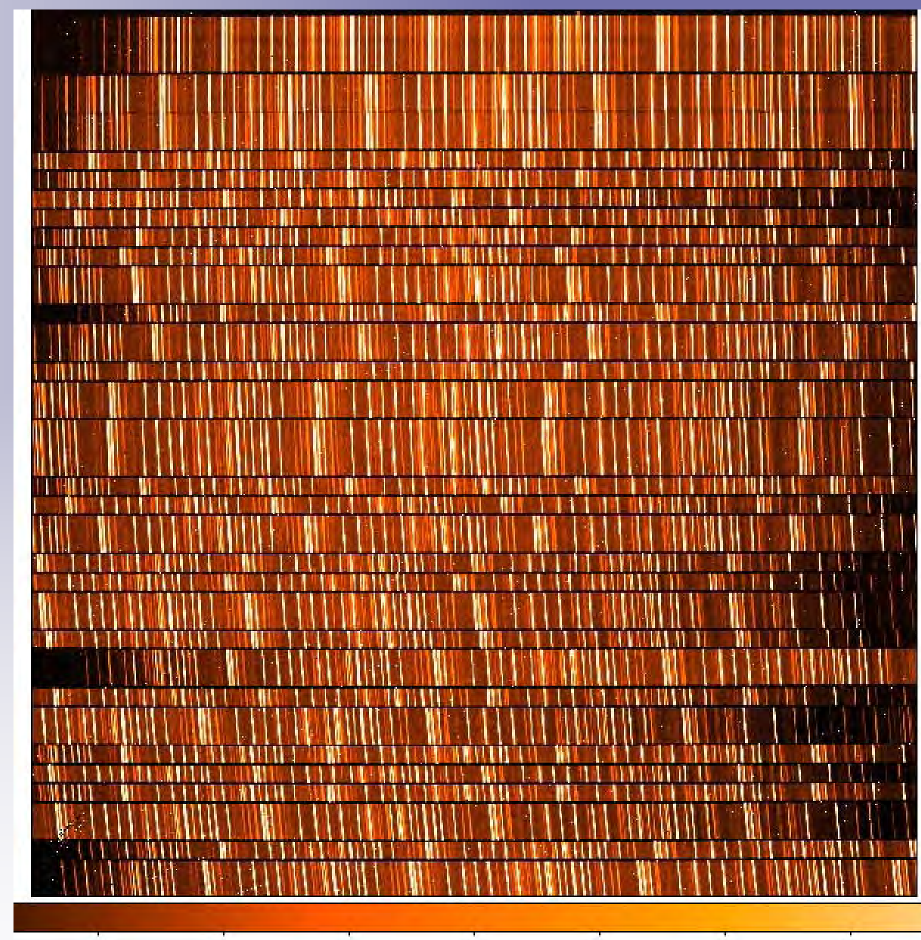
MOSFIRE!

First slit mask – looking at sky

Slit mask image

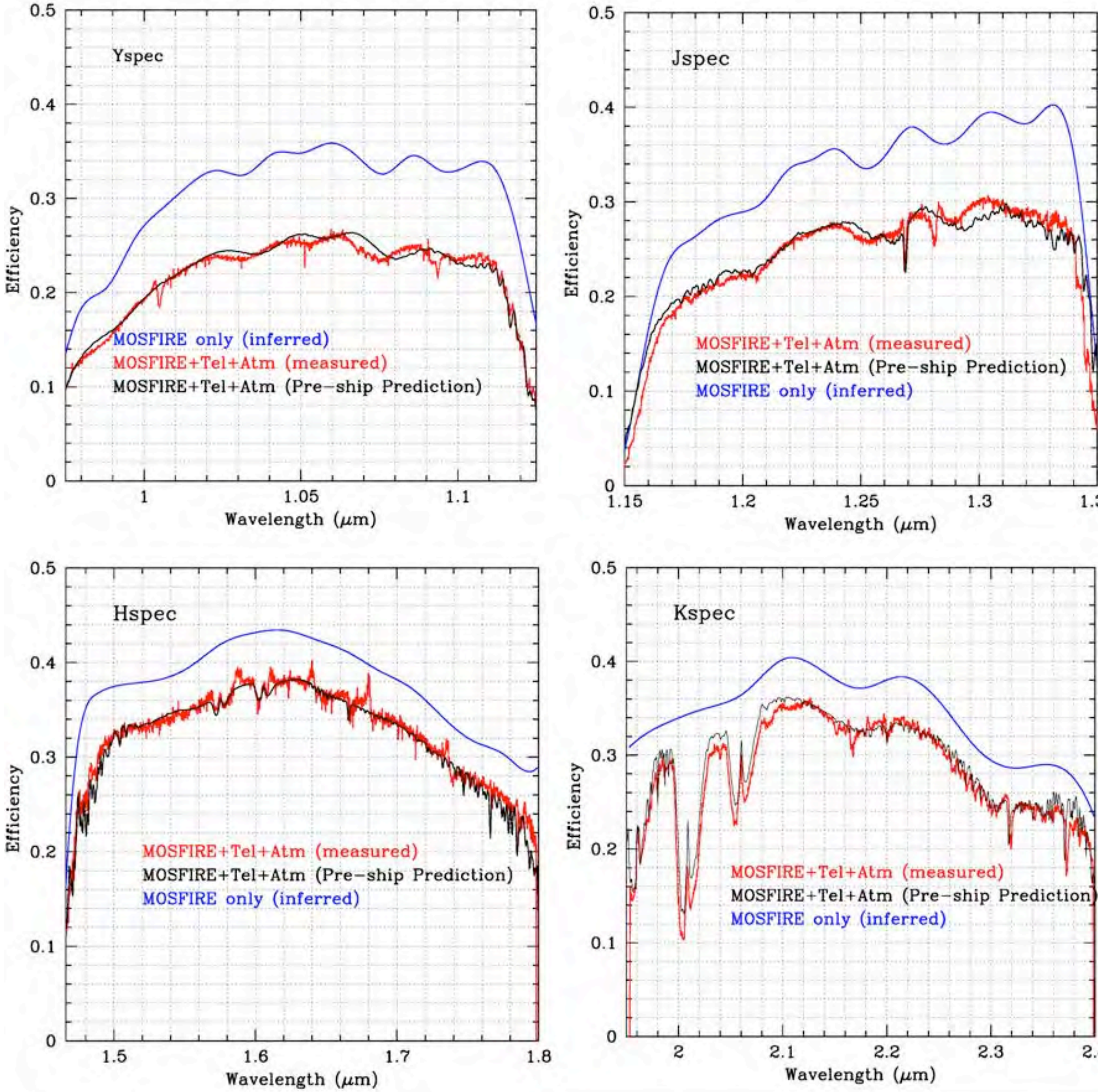


OH Sky Spectra at H-band, 30 s exposure



(slide: McLean, Adkins & Steidel 2012)

W. M. KECK OBSERVATORY



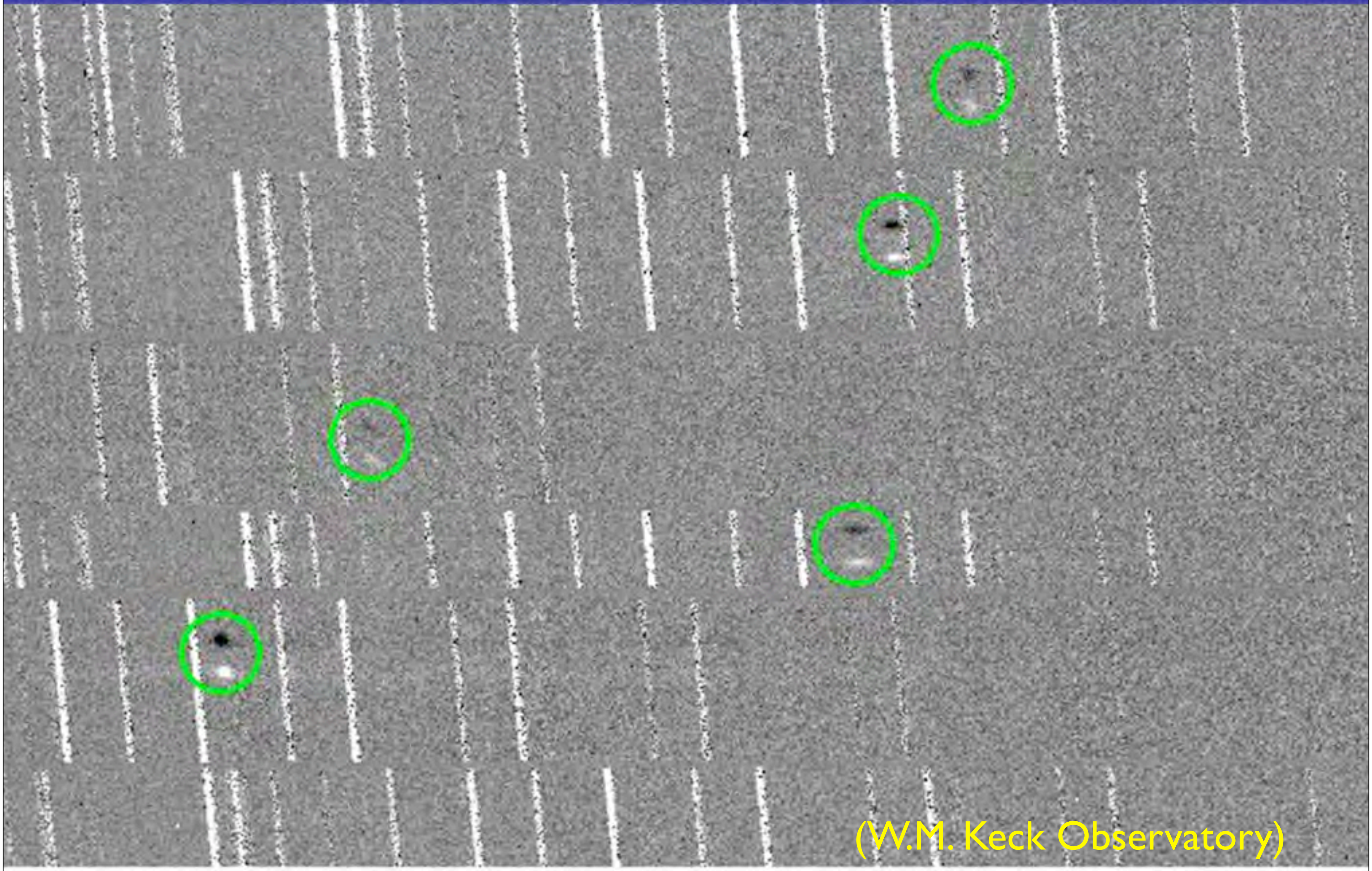
6 arcmin x
3 arcmin FOV

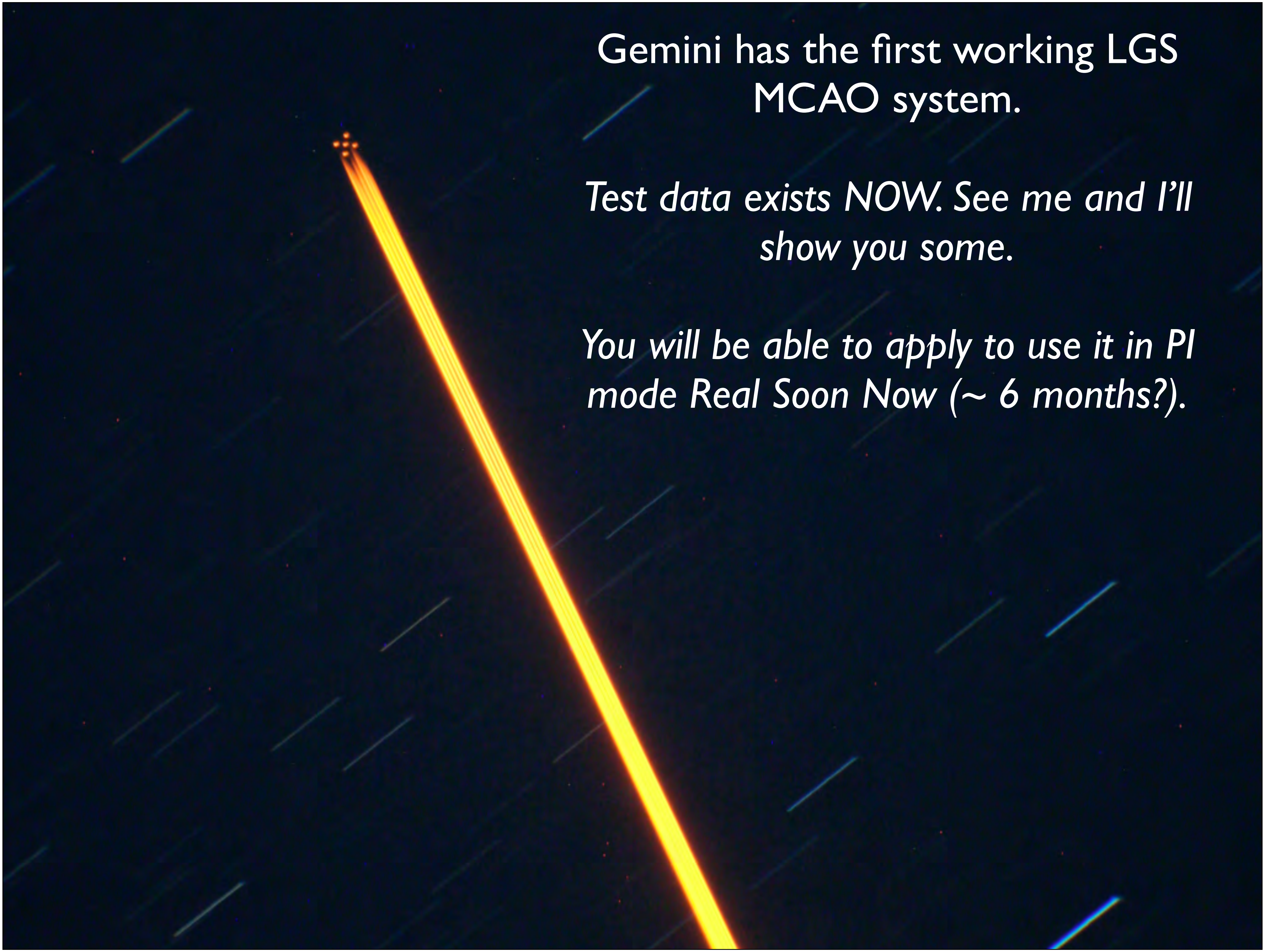
R=3000
0.4μm coverage

45 slits

(W.M. Keck Observatory)

These are all H-alpha lines, z~2.4-2.5, based on nothing more than interleaved difference of ten 3-min exposures in K band.




Gemini has the first working LGS MCAO system.
Test data exists NOW. See me and I'll show you some.
You will be able to apply to use it in PI mode Real Soon Now (~ 6 months?).

Challenges

Why are massive galaxies so small?

Massive high-redshift galaxies are surprisingly small (observation papers)

Daddi et al. 2005
Trujillo et al. 2006
Longhetti et al. 2007
Zirm et a. 2007
Toft et al. 2007
Cimatti et al. 2008
Franx et al. 2008
Buitrago et al. 2008
van Dokkum et al. 2008
Bezanson et al. 2009
Damjanov et al. 2009
van Dokkum et al. 2009
Trujillo et al. 2009
Cassata et al. 2010
Newman et al. 2010
Szomoru et al. 2010
Ryan et al. 2011
Brammer et al. 2011
Saracco et al. 2011
van de Sande et al. 2011
Damjanov et al. 2011
van der Wel et al 2011
Targett et al 2011

Local analogs do exist:

Valentinuzzi et al. 2010a,b

Considerably smaller effect when morphological selection is used:

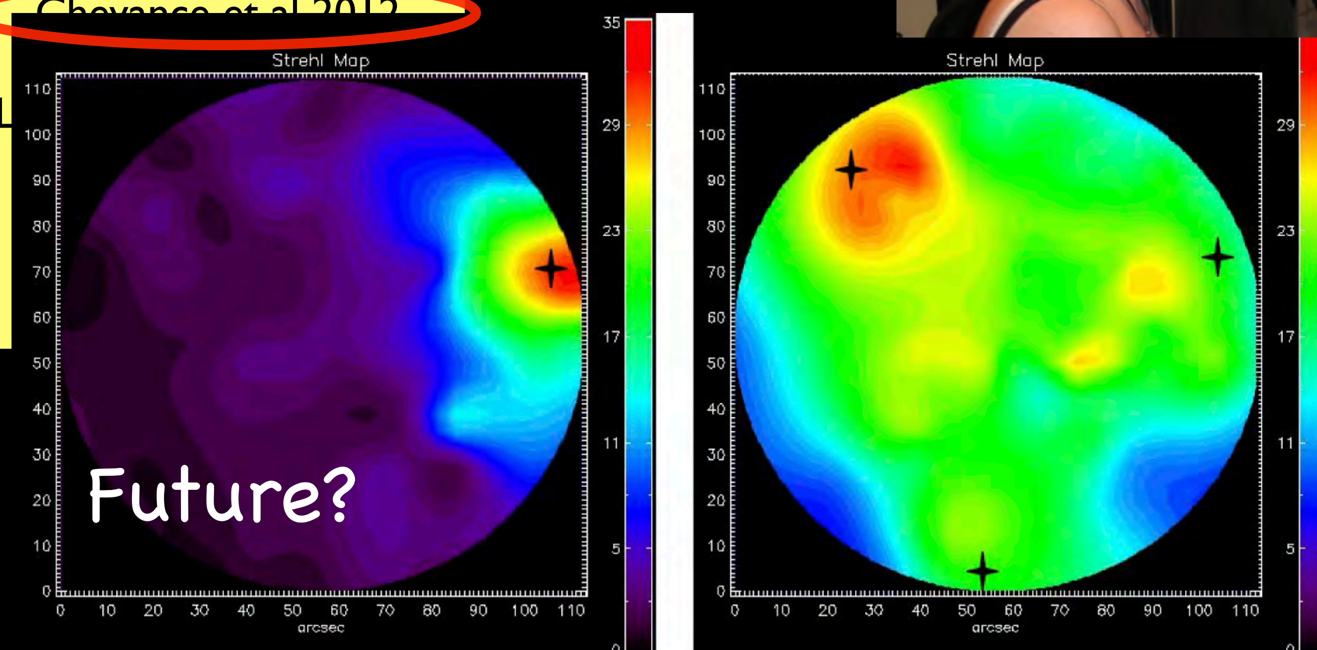
Saracco et al 2012

Size-mass/Size-luminosity relation surprisingly tight:

Nipoti et al. 2009
Nair et al. 2011

Ivana Damjanov
Toronto/Harvard

Anne-Marie Weijmans
Toronto



An attempt at synthesis

Papers which claim that massive high-redshift galaxies are surprisingly small

Daddi et al. 2005
Trujillo et al. 2006
Longhetti et al. 2007
Zirm et a. 2007
Toft et al. 2007
Cimatti et al. 2008
Buitrago et al. 2008
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Damjanov et al. 2009
van Dokkum et al. 2009
Trujillo et al. 2009
Cassata et al. 2010
Newman et al. 2010
Szomoru et al. 2010
Ryan et al. 2011
Saracco et al. 2011
van de Sande et al. 2011
Damjanov et al. 2011
van der Wel et al 2011
Chevance et al. 2012
Bruce et al. 2012
Lopez-Sanjuan et al. 2012
McLure et al. 2012
Ryan et al 2012
Trujillo et al 2012
Szomuru et al 2012

Is galactic size growth a process or an event?

*Try to nail down trends for **quiescent** galaxies in **spectroscopic redshift** surveys.*

Ivana Damjanov
Toronto/Harvard

Table 1. Summary of the compilation of samples used to construct the size evolution diagram

Sample[a]	$z_{\rm spec}$	$\lambda_{\rm rest}(R_e)$ (nm)	M_*[b] (10^{11} M$_\odot$)	N	$n \geqslant 2.5$ (%)	Quiescent (%)	$n \geqslant 2.5$ quiescent (%)	Compact (%)	$n \geqslant 2.5$ compact (%)	Ref
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
EDisCS	0.24-0.96	415- 656	0.12- 6.85	154	87.66	100.00	87.66	23.37	$\geqslant$ 47.22	1
CFRS	0.29-0.99	409- 631	0.04- 3.09	36	100.00	72.50	100.00	5.55	100.00	2
GN/DEIMOS	0.18-1.14	283- 514	0.03- 7.04	76	100.00	75.00	100.00	26.32	100.00	3,4
MS1054/CDFS	0.84-1.14	353- 464	0.42-11.33[c]	32	100.00	100.00	100.00	9.37	100.00	5
CL1252/CDFS	1.09-1.35	362- 407	0.29- 3.64	44	N/A	100.00	N/A	25.00	N/A	6
EGS/SSA22/GN	1.05-1.59	328- 397	0.33- 1.55	17	100.00	100.00	100.00	35.29	100.00	7
Radio-loud QSOs	1.29-1.59	618- 699	1.54- 2.87	5	60.00	100.00	60.00	0.00	0.00	8,9
MUNICS	1.23-1.71	590- 717	2.06- 5.95	9	66.66	100.00	66.66	11.12	100.00	10
GS/WFC3	1.33-1.62	611- 687	0.37- 1.45	6	66.66	100.00	66.66	66.66	75.00	11
GDDS/ACS	0.62-1.74	297- 502	0.04- 2.25	31	54.84	100.00	54.84	41.94	53.85	12
EGS	1.24-1.36	932- 982	3.09- 3.98	3	66.66	N/A	N/A	0.00	0.00	13
GDDS/NICMOS	1.39-1.85	561- 669	0.55- 3.17	10	60.00	90.00	55.55	30.00	66.66	14
GS/ACS	0.95-1.92	291- 436	0.05- 2.08	15	100.00	100.00	100.00	13.34	100.00	15,16
HUDF/WFC3	1.32-1.98	537- 690	0.23- 0.67	4	50.00	100.00	50.00	75.00	33.34	17
GMASS	1.42-1.98	285- 351	0.32- 0.99	8	37.51	100.00	37.51	75.00	33.34	18
HUDF	1.39-2.67	232- 356	0.76- 6.74	6	83.34	100.00	83.34	50.00	66.66	19
MUSYC	2.03-2.55	451- 528	0.52- 2.71	9	44.45	100.00	44.45	77.77	42.85	20
TOTAL	0.2 – 2.67	232 – 982	0.03 – 11.33	465	$\geqslant$ 78.07	$\geqslant$ 92.90	$\geqslant$ 76.09	25.80	$\geqslant$ 59.17	

Note. — Column 1: survey from which the sample is drawn; Column 2: redshift range; Columns 3: the range of rest-frame central wavelengths of the R_e measurements; Column 4: mass range; Column 5: number of objects in the sample; Column 6: fraction of passively evolving objects; Column 7: fraction of spheroids; Column 8: fraction of passively evolving galaxies with spheroid-like profiles; Column 9: fraction of (compact) objects with $R_e \lesssim 1$ kpc; Column 10: fraction of compact objects with spheroid-like profiles ; Column 11: references: 1. Saglia et al. (2010); 2. Schade et al. (1999); 3. Treu et al. (2005); 4. Bundy et al. (2007); 5. van der Wel et al. (2008); 6. Rettura et al. (2010); 7. Newman et al. (2010); 8. McGrath et al. (2007); 9. McGrath et al. (2008); 10. Longhetti et al. (2007); 11. Ryan et al. (2011); 12. data presented here; 13.Carrasco et al. (2010); 14. Damjanov et al. (2009); 15. Gargiulo et al. (2011); 16. Saracco et al. (2011); 17. Cassata et al. (2010); 18. Cimatti et al. (2008); 19. Daddi et al. (2005); 20. van Dokkum et al. (2008)

[a] Selection criteria for each sample are denoted by the font style: roman denotes spectroscopically selected objects with old stellar population, boldface is used for morphologically selected early-type galaxies, and italics font corresponds to the quiescent galaxies selected by colour.

[b] Stellar mass estimates have been converted to the Baldry & Glazebrook (2003) IMF.

[c] Based on dynamical masses $M_{\rm dyn}$ and the $M_{\rm dyn} \sim 1.4 \times M_*$ relation (van der Wel et al. 2008).

Damjanov et al. 2011

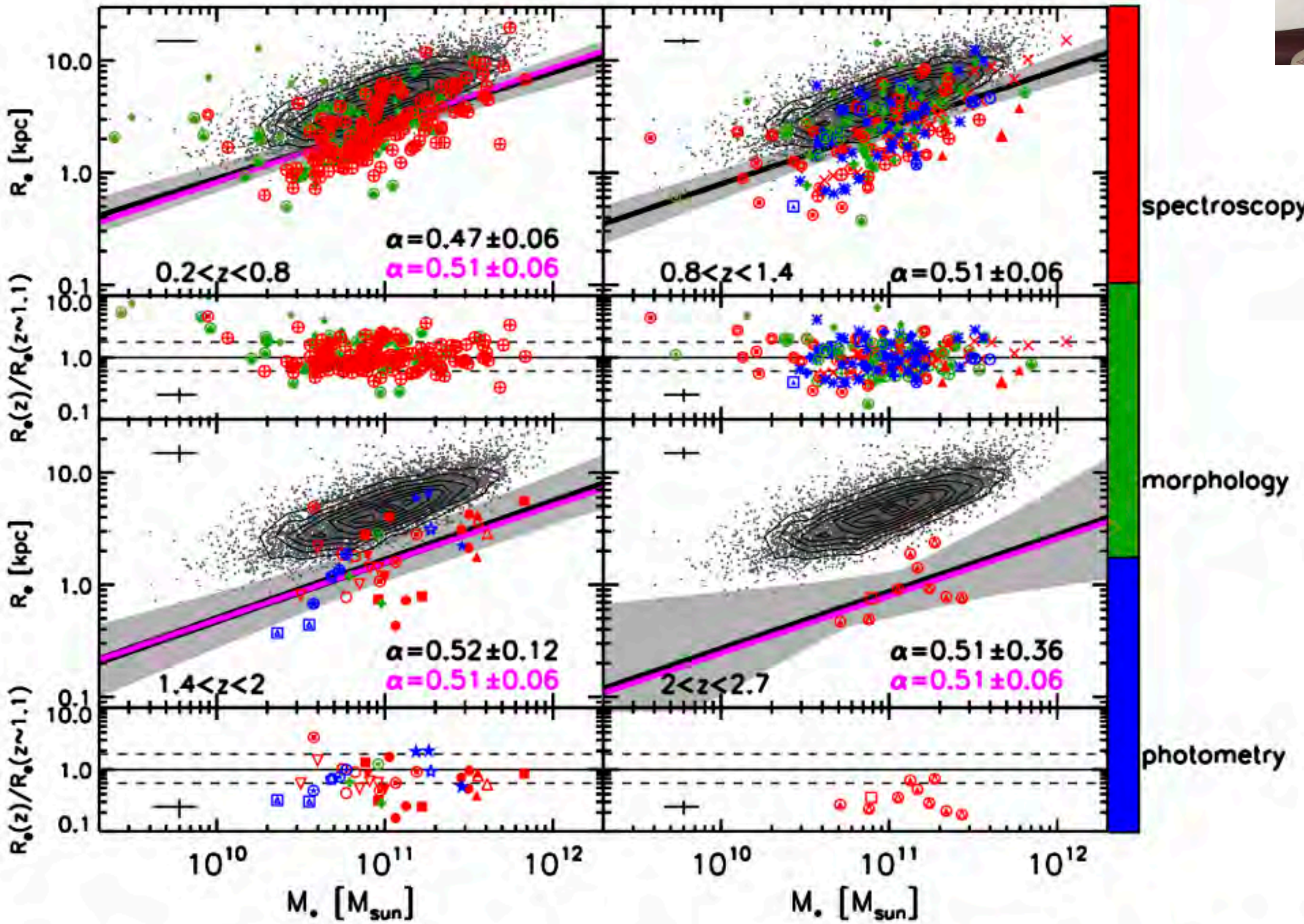
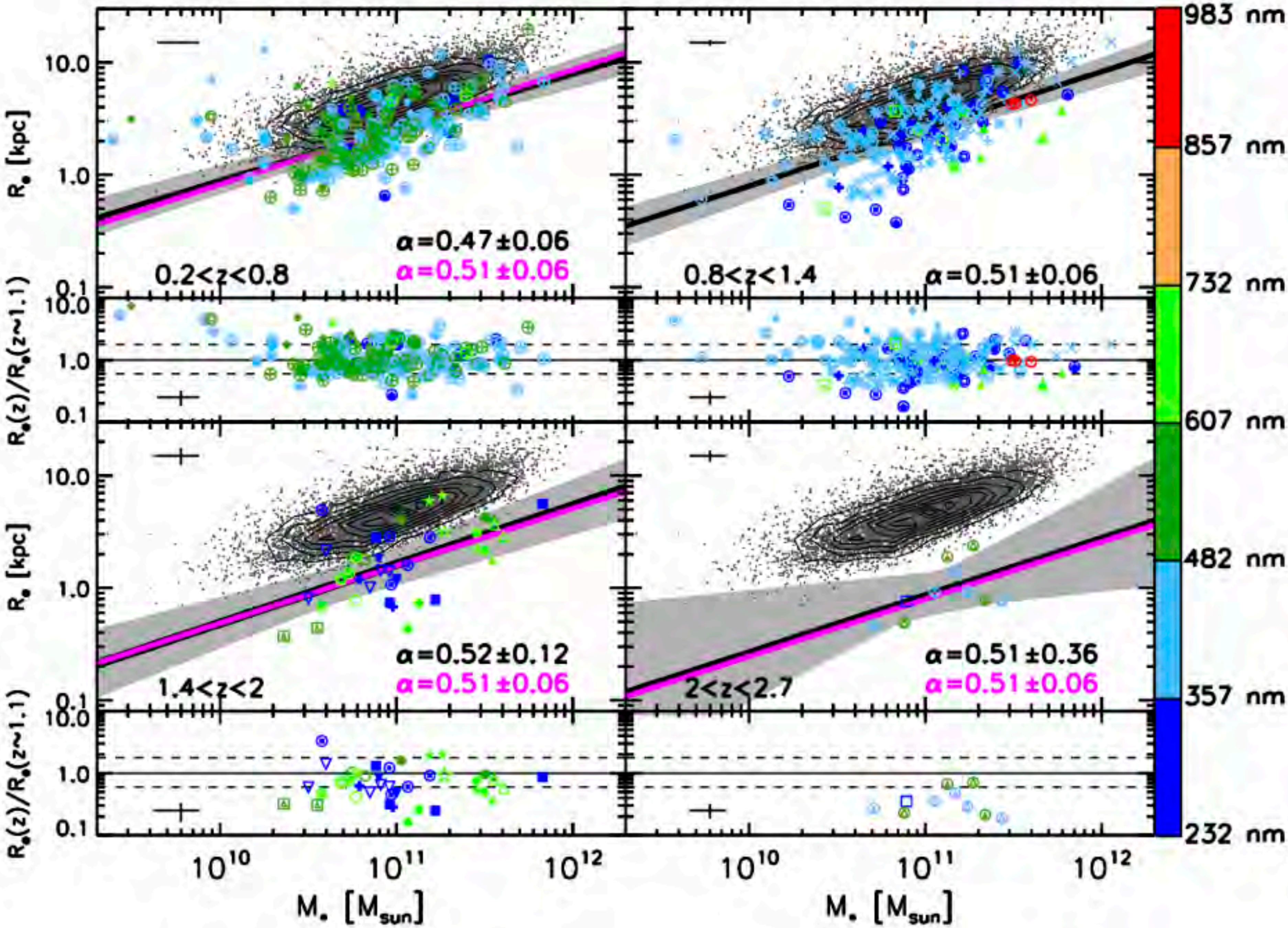


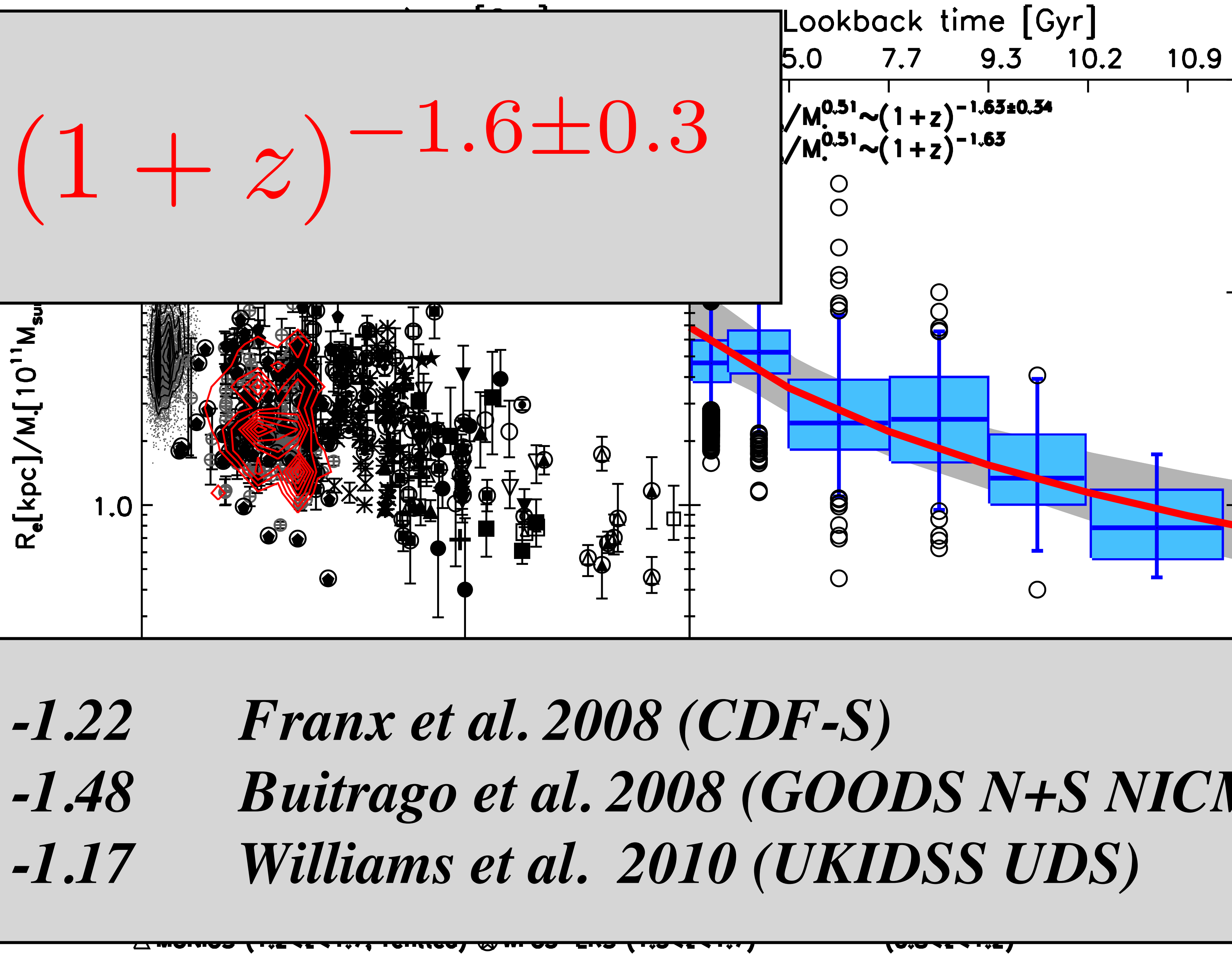
Fig. 2.— Effective radius R_e as a function of stellar mass for a sample of 465 passively evolving galaxies in the redshift range $0.2 < z < 2.7$. The notation is the same as in Figure 1 except that the color coding is now based on the sample selection criteria given in Table 1.

Damjanov et al. 2011



Damjanov et al. 2011

Note: Re(M) corrected sizes used!



$$(1+z)^{-1.6\pm0.3}$$

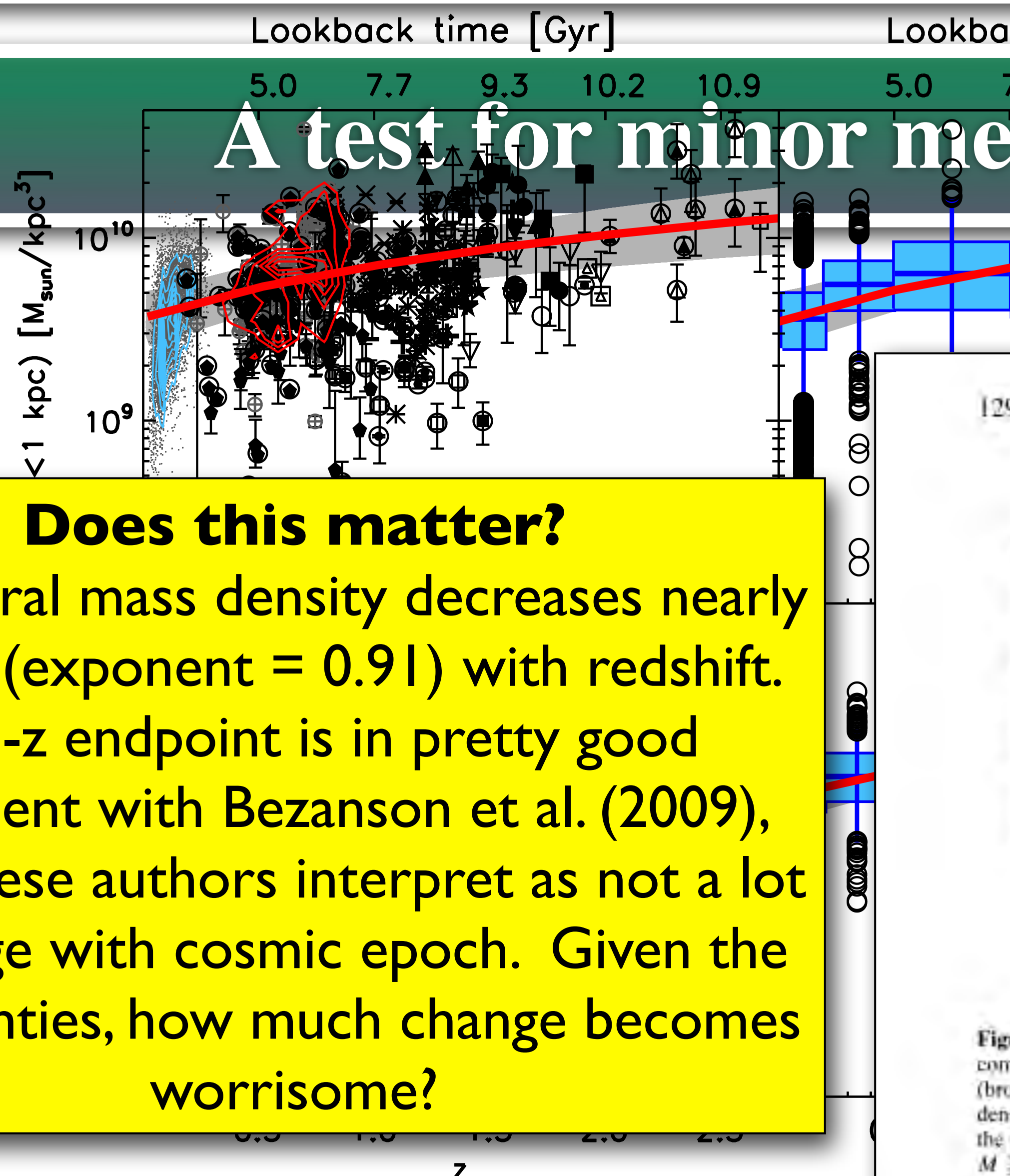
-1.22 Franx et al. 2008 (CDF-S)

-1.48 Buitrago et al. 2008 (GOODS N+S NICMOS)

-1.17 Williams et al. 2010 (UKIDSS UDS)

Use the CENTRAL DENSITY-Z RELATION

A test for minor mergers?



Does this matter?

The central mass density decreases nearly linearly (exponent = 0.91) with redshift. High-z endpoint is in pretty good agreement with Bezanson et al. (2009), which these authors interpret as not a lot of change with cosmic epoch. Given the uncertainties, how much change becomes worrisome?

1292 BEZANSON

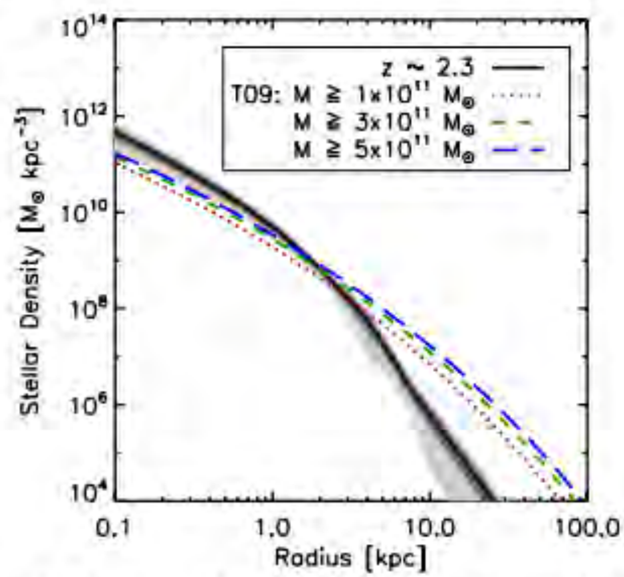
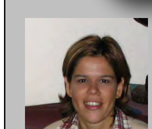


Figure 1. Comparison of the mean stellar density profiles of high-redshift compact galaxies (solid line) with nearby elliptical galaxies from the T09 sample (broken lines). High-redshift 1 and 2σ contours are shown in gray. The average density profile for nearby galaxies with $M \geqslant 10^{11}\ M_\odot$ is represented by the red, dashed line; the green, short dashed line corresponds to galaxies with $M \geqslant 3 \times 10^{11}\ M_\odot$; and the most massive local galaxies with $M \geqslant 5 \times 10^{11}\ M_\odot$ are shown by the blue, long-dashed line. Note that the profiles of the nearby galaxies are fairly similar to those of the compact galaxies at radii $r \lesssim 3$ kpc, qualitatively consistent with expectations for inside-out growth.



Papers which claim that massive high-redshift galaxies are surprisingly small

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van Dokkum et al. 2008
Bezanson et al. 2009
Damjanov et al. 2009
van Dokkum et al. 2009
Trujillo et al. 2009
Cassata et al. 2010
Newman et al. 2010
Szomoru et al. 2010
Ryan et al. 2011
Saracco et al. 2011
van de Sande et al. 2011
Damjanov et al. 2011
van der Wel et al 2011
Chevance et al. 2012
Bruce et al. 2012
Lopez-Sanjuan et al. 2012

What are these things anyway?

Not an attempt at synthesis! An attempt to use GDDS data to see if van der Wel et al. (2011) is right or not.

Anne-Marie Weijmans
Dunlap Institute, UToronto

Lyman-break galaxy morphologies from Law et al. 2010

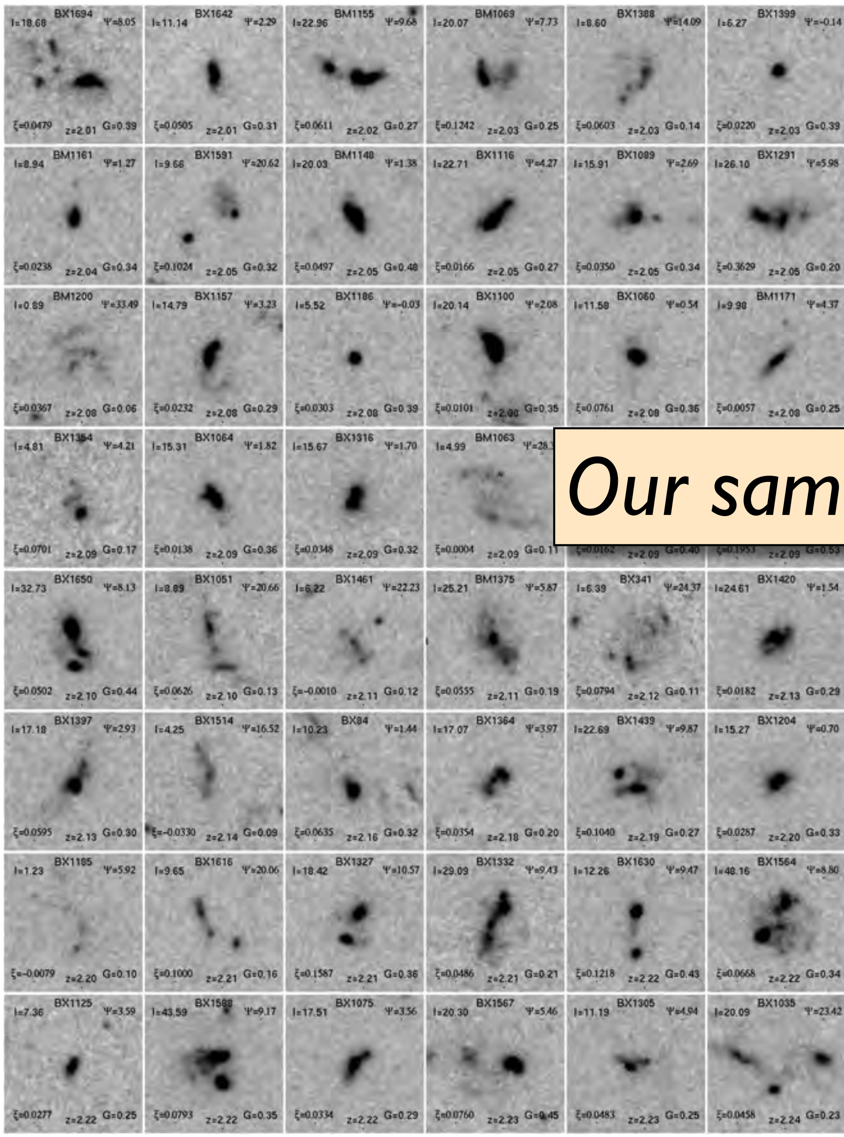


FIG. 2.—*Continued*

Our sample avoids these…

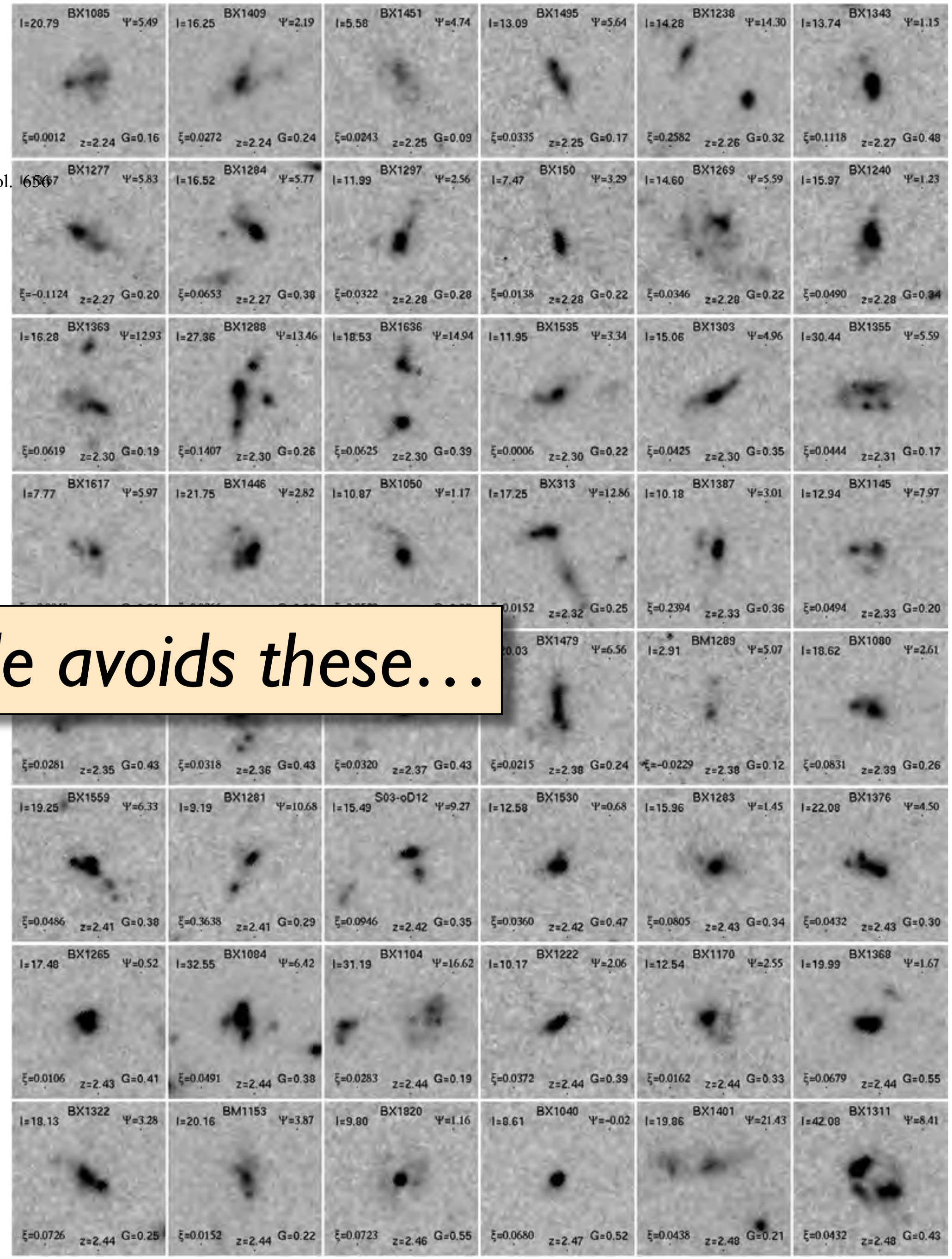
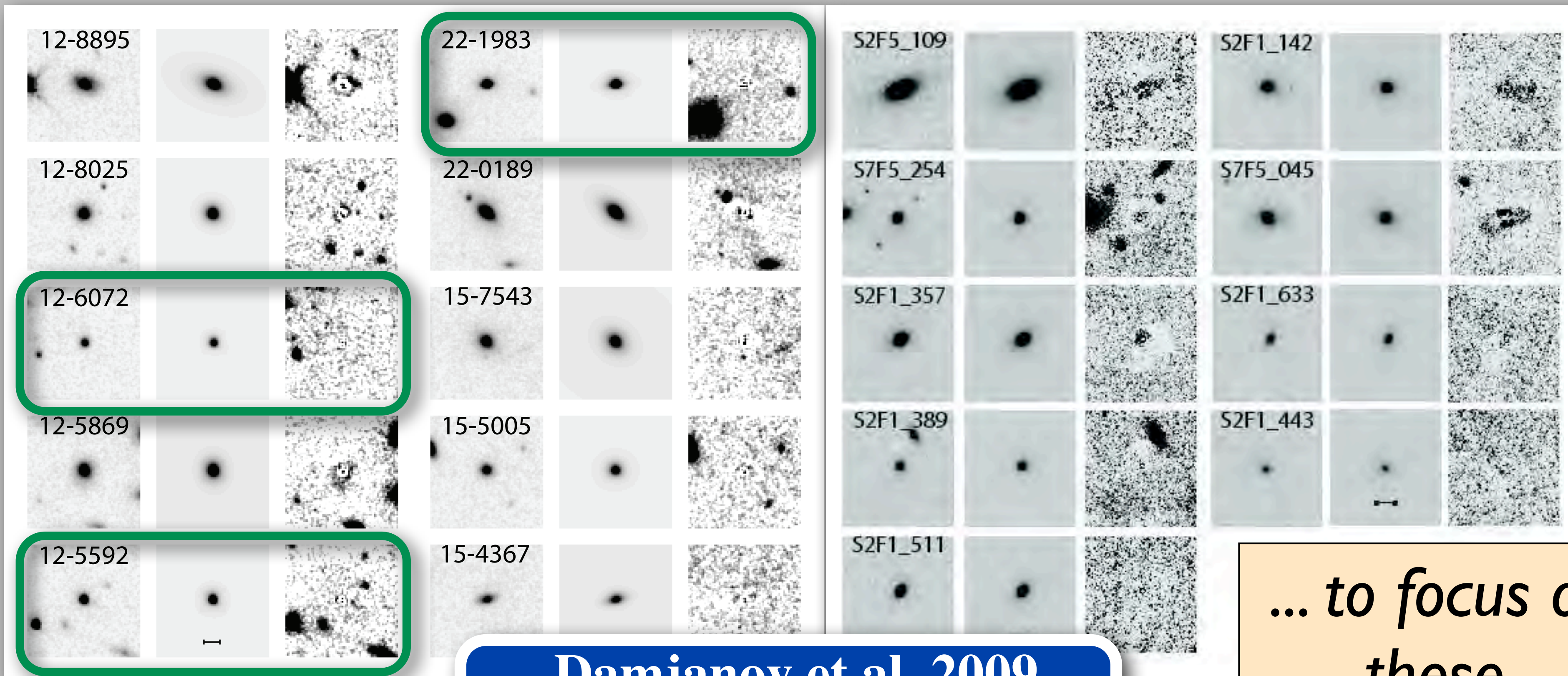


FIG. 2.—*Continued*

NICMOS SAMPLE (1.1 < z < 2)



Damjanov et al. 2009

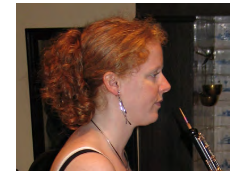
... to focus on these.

Sersic profile

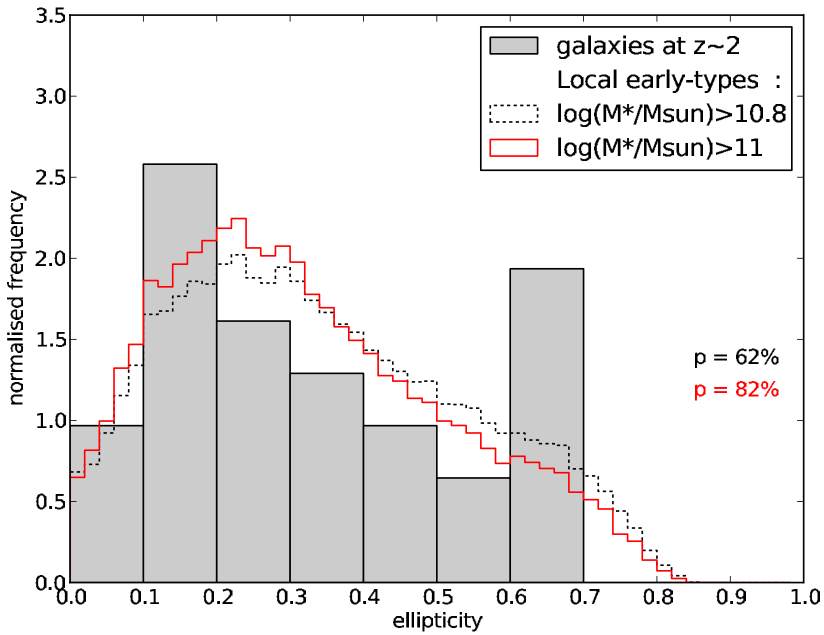
$$\mu\left(R\right) = \mu_e exp\left\{-b_n\left[\left(\frac{R}{R_e}\right)^{\frac{1}{n}} - 1\right]\right\}$$

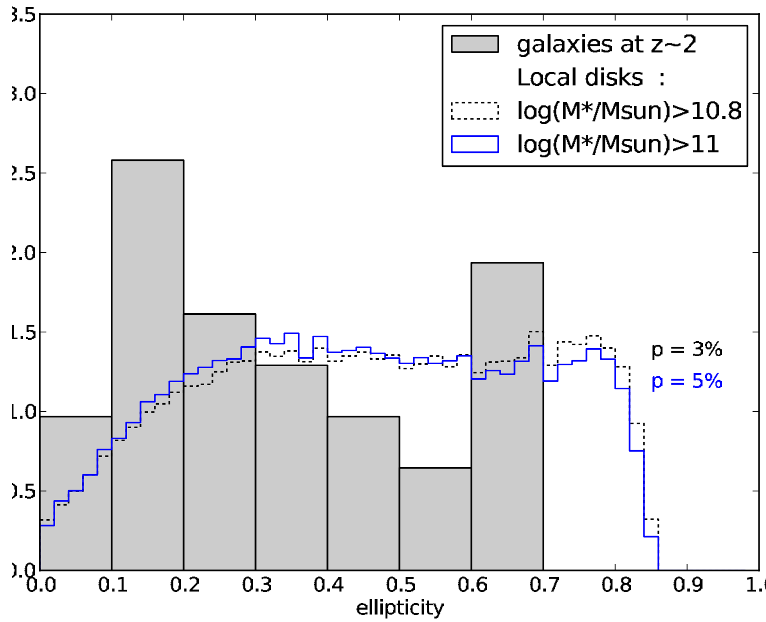
Early types?

Disks?

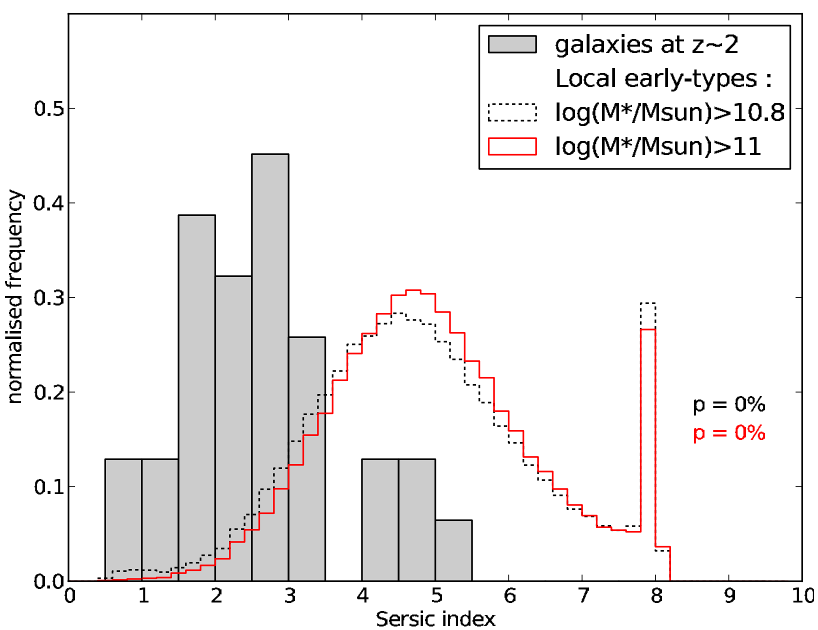


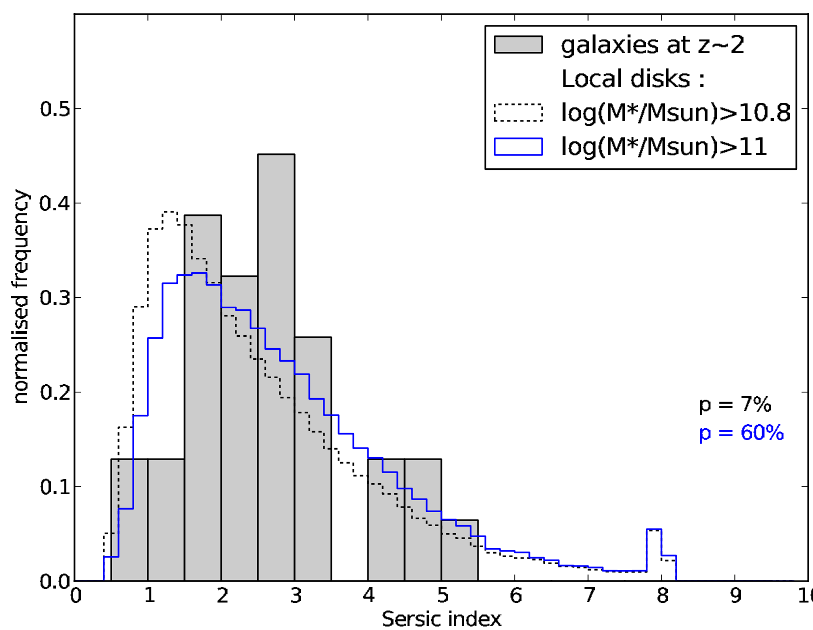
Flattening



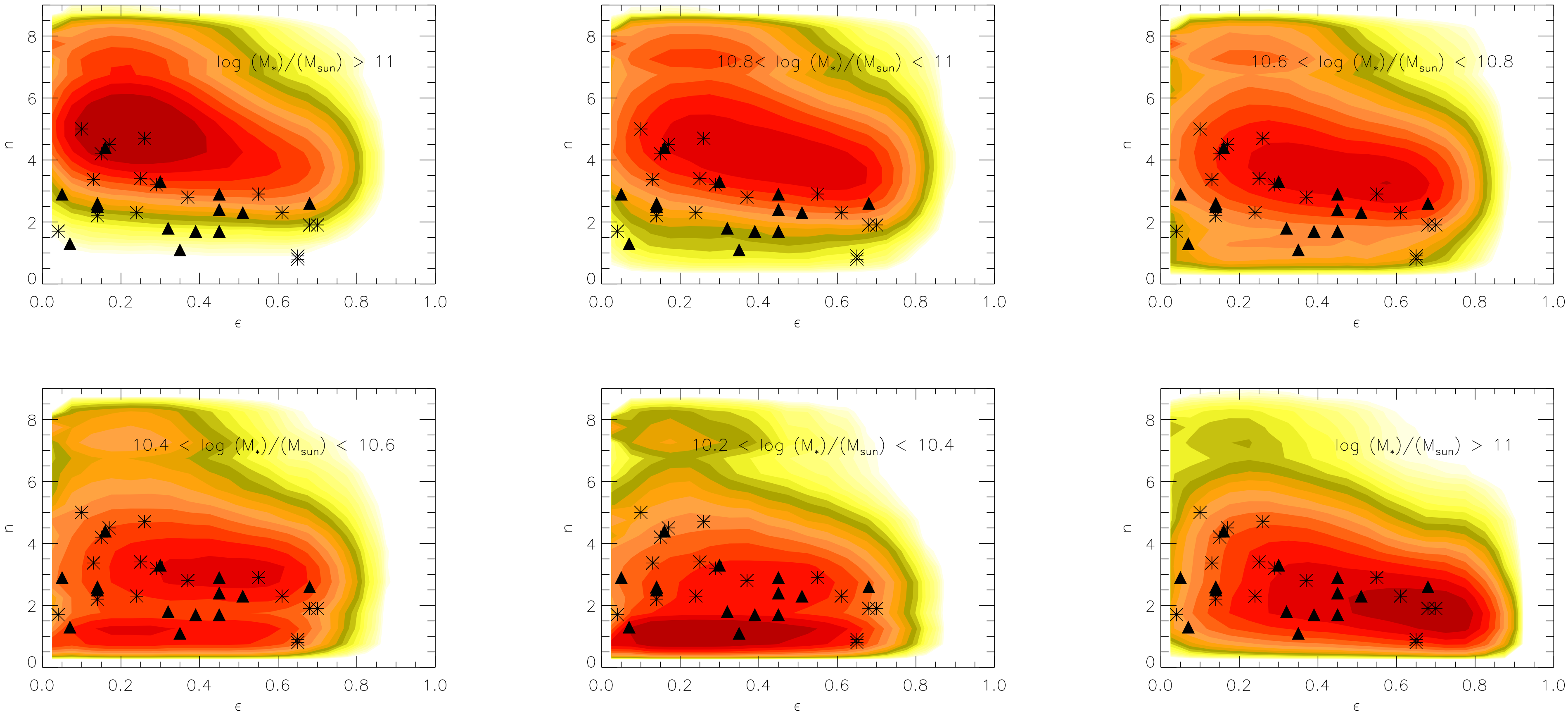


Sersic index





Bivariate sersic index vs flattening in mass bins, compared to local samples



Nothing seems to work!

1. *Compact quiescents are a mixed bag. Or…*
2. *Compact quiescents are something new that don't correspond to any local archetype.*

What keeps me up at night about the whole minor merger thing

- ***Not this:*** Central density seems to be (mildy) evolving. Given the many uncertainties, which we've compounded by piling together so many surveys, I'm not sure if this is yet at the stage where it is worth worrying about.
- ***Not this (very much):*** Compact quiescent galaxies are a mixture of early-types and disks (or something new). It's interesting in that case that whatever is growing the galaxies is independent of morphology. Or maybe they're like nothing nearby and progenitor bias is going to be extreme.
- ***This:*** Many (most?) of us think the destiny of these things is to wind up as local early-type galaxies (van Dokkum papers, Bezanson, etc). But the *local* size-mass (size-L) relation is insanely tight, and getting tighter.

A Fundamental Line for Elliptical Galaxies

Preethi Nair
Toronto/STScI

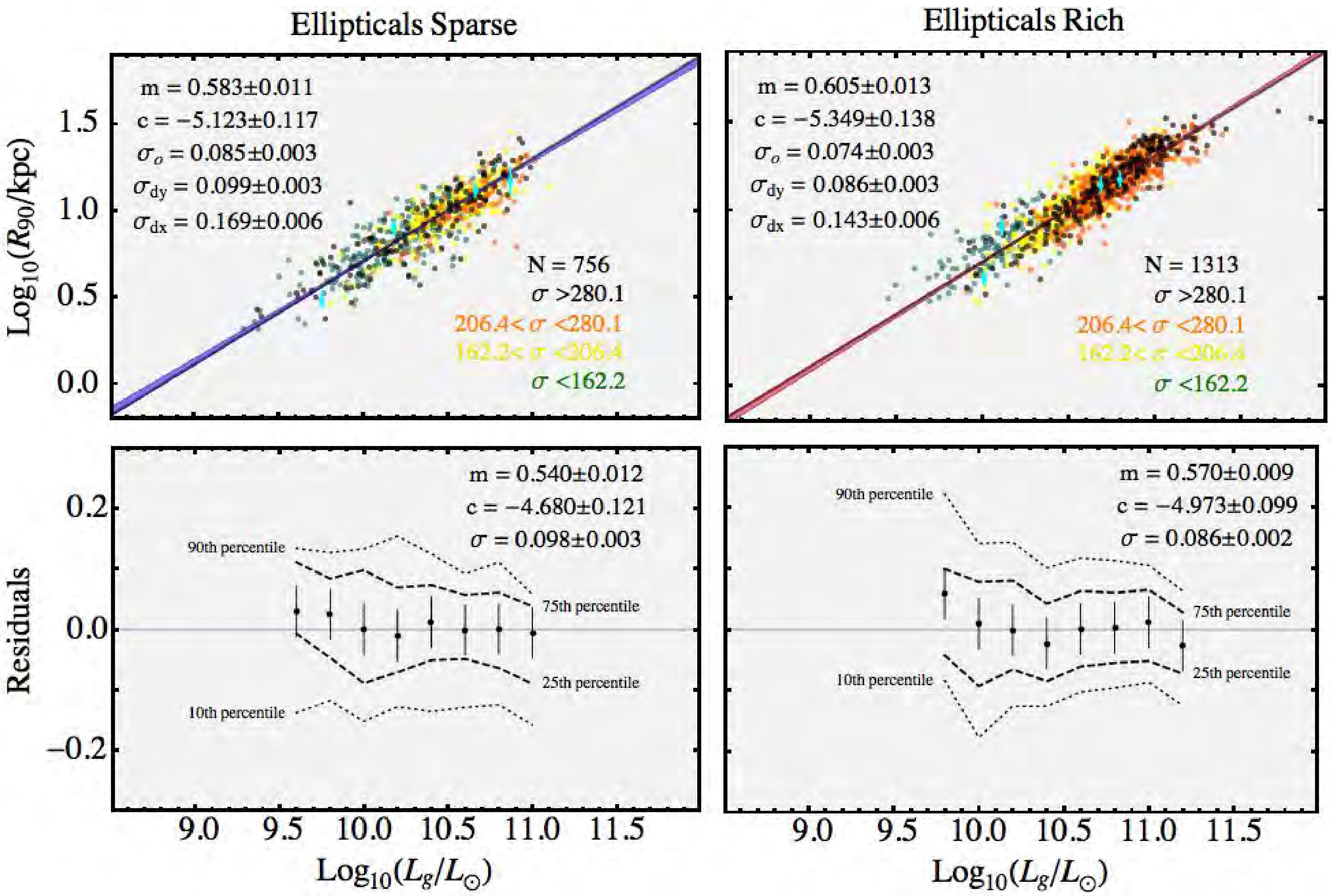


FIG. 1.— **Petrosian size–luminosity relationships for nearby elliptical galaxies.** The top row shows the relationships obtained from the Nair & Abraham (2010) elliptical galaxy sample where the size of each galaxy is parameterized by the radius enclosing 90% of the galaxy's light contained within twice the Petrosian radius, R_{90} (see the text for details). The left-hand panel corresponds to galaxies in the field, while the right hand panels correspond to galaxies in dense environments. Symbol colors are keyed to corrected central velocity dispersion of the galaxies, in four broad bins. In cyan are error bars for four random points. In each panel the best-fit orthogonal linear model (blue/red lines) is superposed on the data, with the parameters for the model inset. σ_{dx} and σ_{dy} are the scatter in the x and y parameters. The black line shows the best-fit relation for all elliptical galaxies. The bottom row shows the residuals in size from the direct best fit analysis, with the parameters for the model inset. The dashed lines show the 25th–75th percentile range, while the dotted lines show the 10th–90th percentile range. The error bars show the median error in size, including 1% error in sky, in small bins of luminosity.

What keeps me up at night about the whole minor merger thing

- ***Not this:*** Central density seems to be (mildy) evolving. Given the many uncertainties, which we've compounded by piling together so many surveys, I'm not sure if this is yet at the stage where it is worth worrying about.
- ***Not this (very much):*** Some of the compact quiescent galaxies are a mixture of early-types and disks (or something new). Presumably whatever is growing the galaxies is independent of morphology.
- ***This:*** Many (most?) of us think the destiny of these things is to wind up as local early-type galaxies (van Dokkum papers, Bezanson, etc). But the *local* size-mass (size-L) relation is insanely tight, and getting tighter.

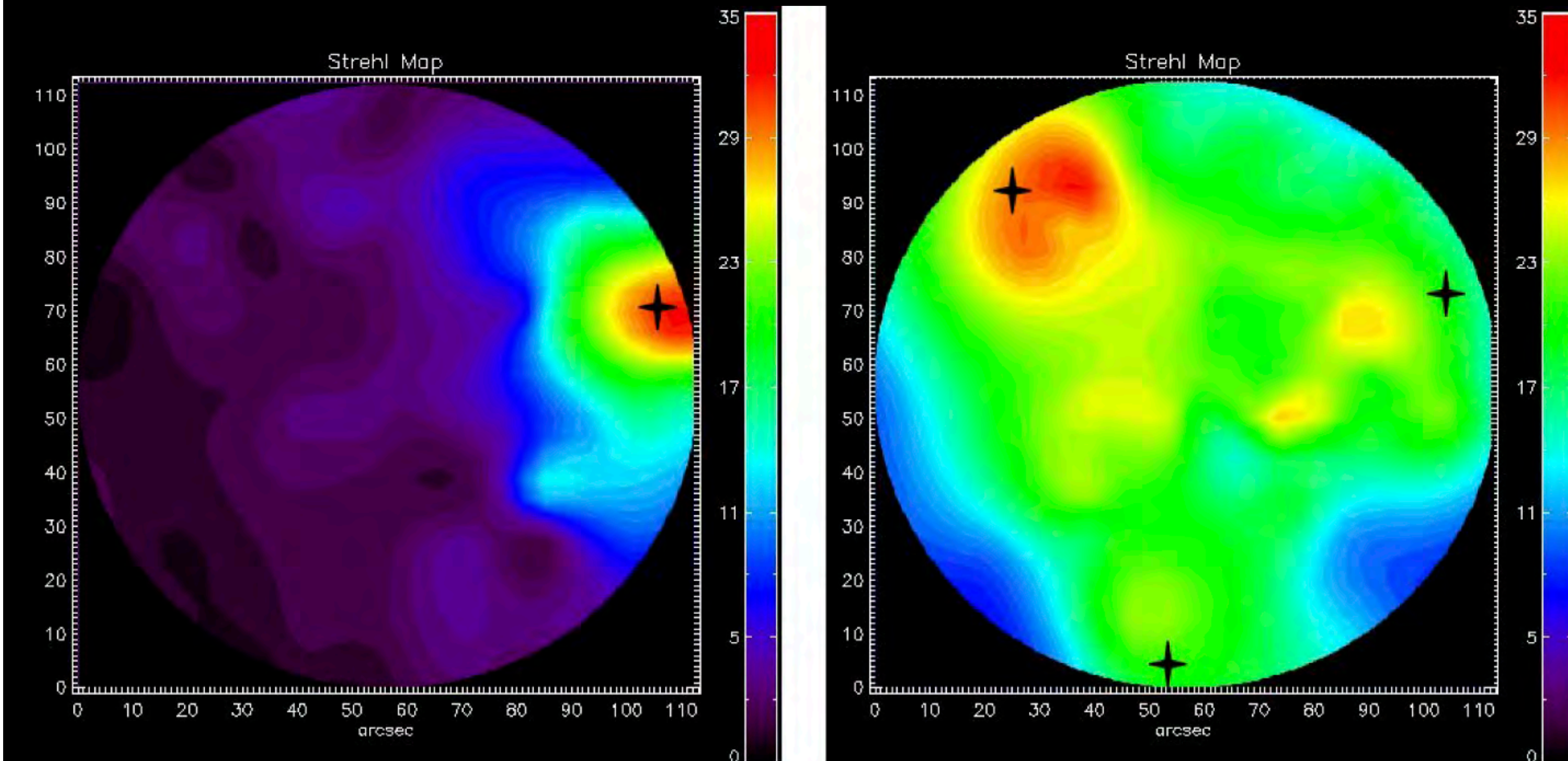
We need more resolution

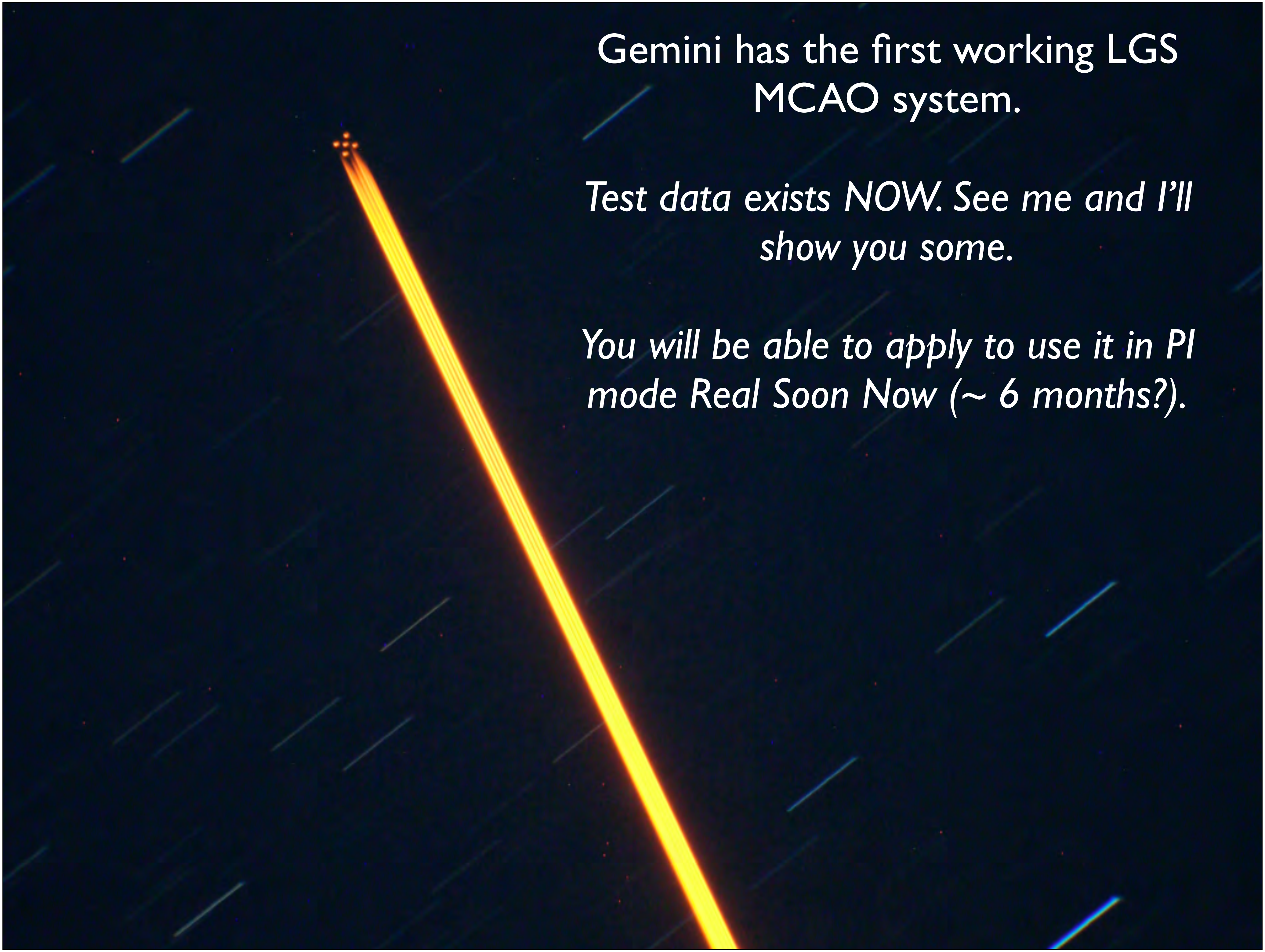


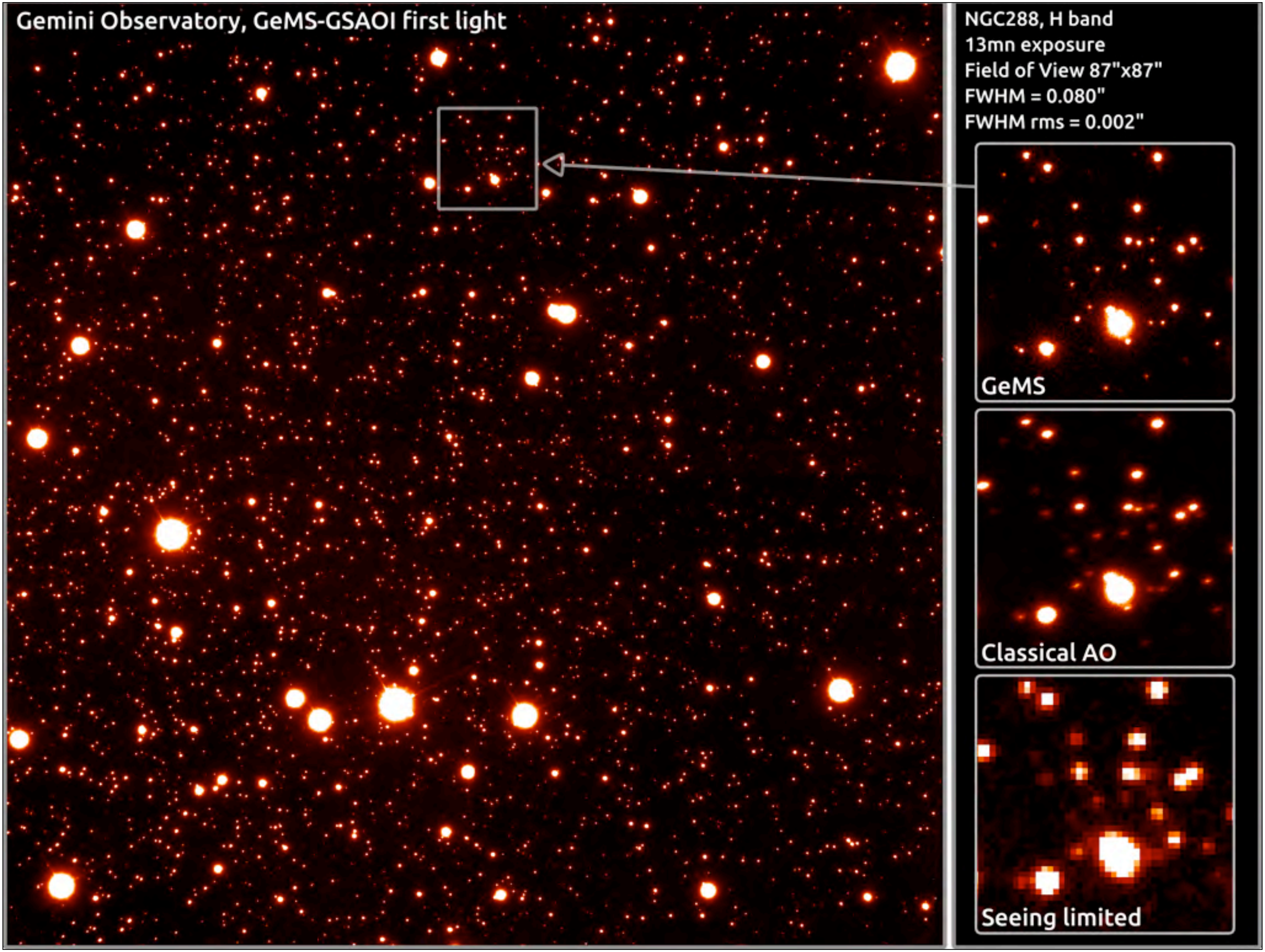

ESO MAD results

Conventional

MCAO




Gemini has the first working LGS MCAO system.
Test data exists NOW. See me and I'll show you some.
You will be able to apply to use it in PI mode Real Soon Now (~ 6 months?).


Gemini Observatory, GeMS-GSAOI first light
NGC288, H band
13mn exposure
Field of View 87"x87"
FWHM = 0.080"
FWHM rms = 0.002"
GeMS
Classical AO
Seeing limited

Gemini/GSAOI Simulations courtesy of Peter McGregor (ANU)

GSAOI PI

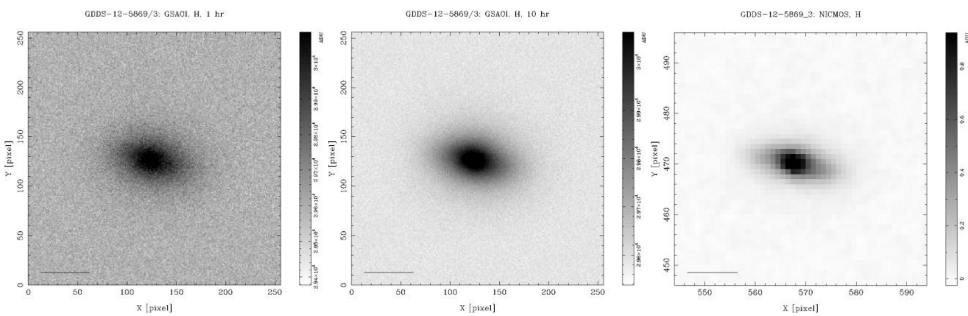


Figure 23: Simulated GSAOI *H*-band images of the GDDS-12-5869/3 in 1 hr (*left*) and 10 hr (*middle*), and the NICMOS *H*-band image on which the simulation is based (*right*). The images are presented as in Figure 2.

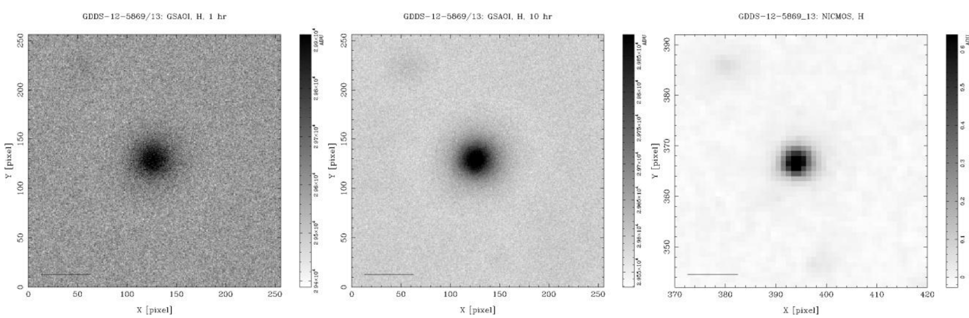


Figure 24: Simulated GSAOI *H*-band images of the GDDS-12-5869/13 in 1 hr (*left*) and 10 hr (*middle*), and the NICMOS *H*-band image on which the simulation is based (*right*). The images are presented as in Figure 2.

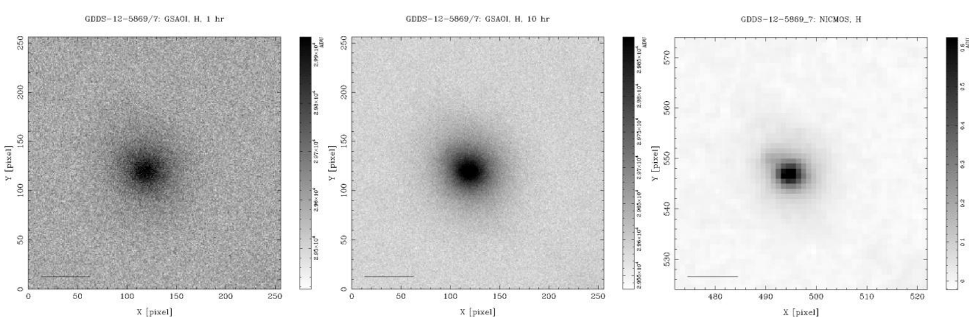


Figure 25: Simulated GSAOI *H*-band images of the GDDS-12-5869/7 in 1 hr (*left*) and 10 hr (*middle*), and the NICMOS *H*-band image on which the simulation is based (*right*). The images are presented as in Figure 2.

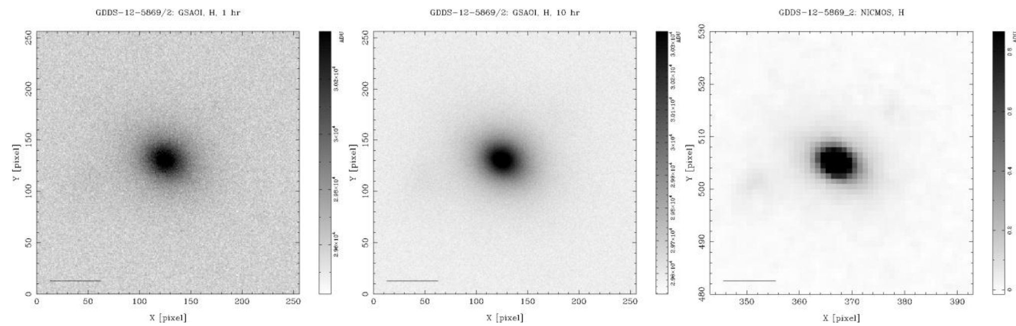


Figure 20: Simulated GSAOI *H*-band images of the GDDS-12-5869/2 in 1 hr (*left*) and 10 hr (*middle*), and the NICMOS *H*-band image on which the simulation is based (*right*). The images are presented as in Figure 2.

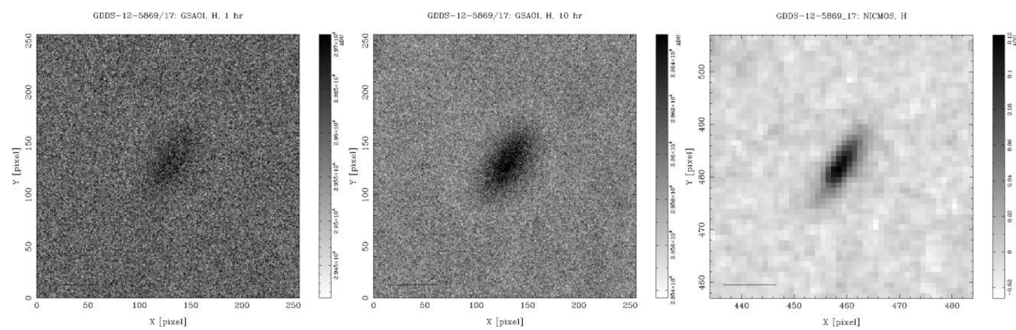
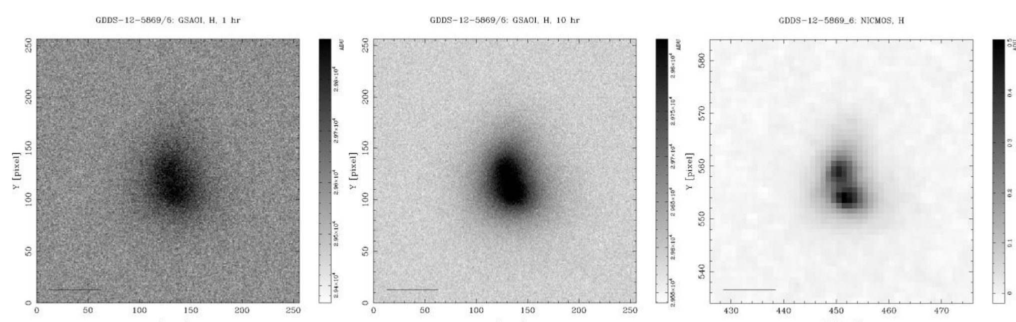
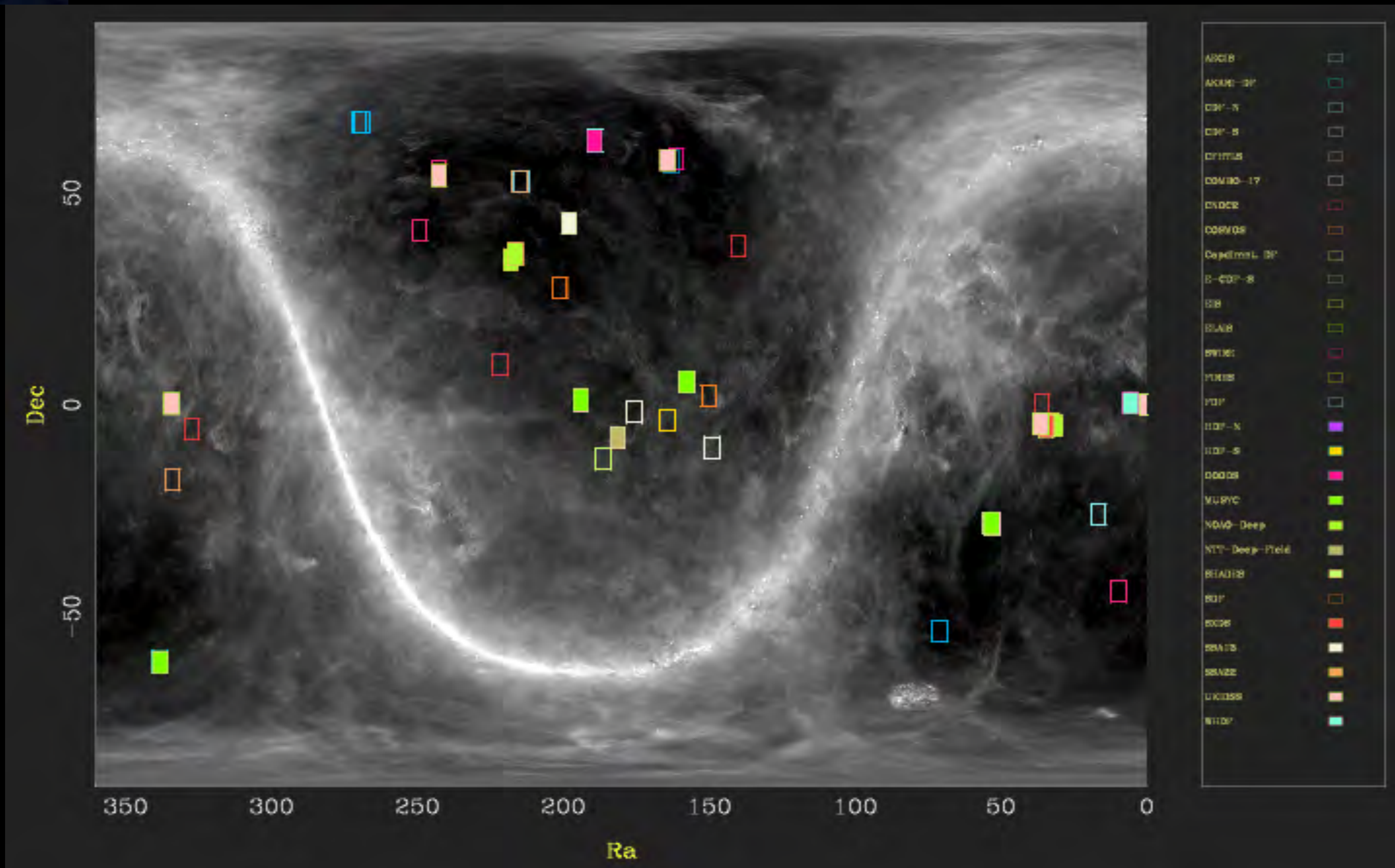


Figure 21: Simulated GSAOI *H*-band images of the GDDS-12-5869/17 in 1 hr (*left*) and 10 hr (*middle*), and the NICMOS *H*-band image on which the simulation is based (*right*). The images are presented as in Figure 2.



The real killer is the limited sky coverage...

Brinchmann's summary of existing deep fields



High-performance laser-guide star AO is possible in NONE of these fields.

If you want uniform Strehl, position of the NATURAL guide stars matters (Flicker and Rigaut analysis for Gemini MCAO system).

You want your natural guide stars to be arranged as equilateral triangles with the right side length.

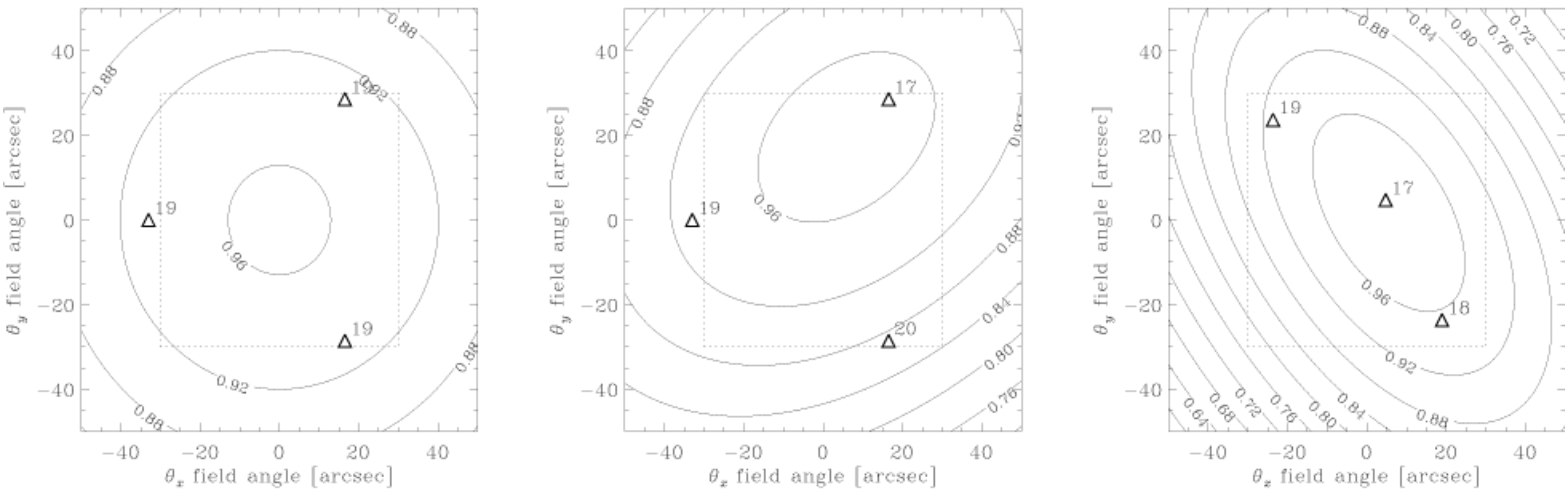
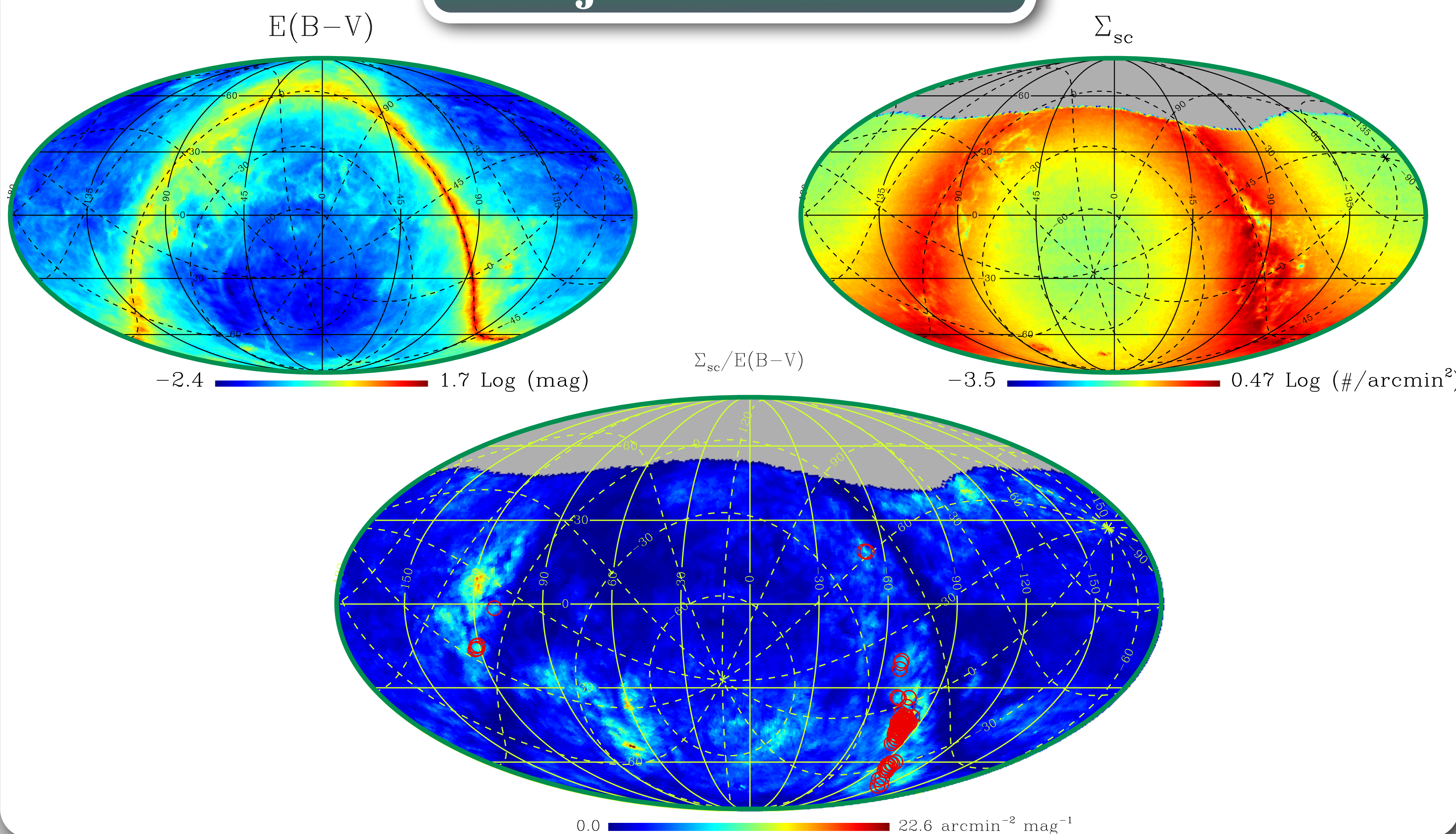


Figure 3. Strehl contour plots versus field angle for three sample NGS configurations with a first order integrator (top row) and the ideal predictor (top row). NGS locations are marked by triangles and their R band magnitudes, and the dotted lines define the square spanned by the LGS.

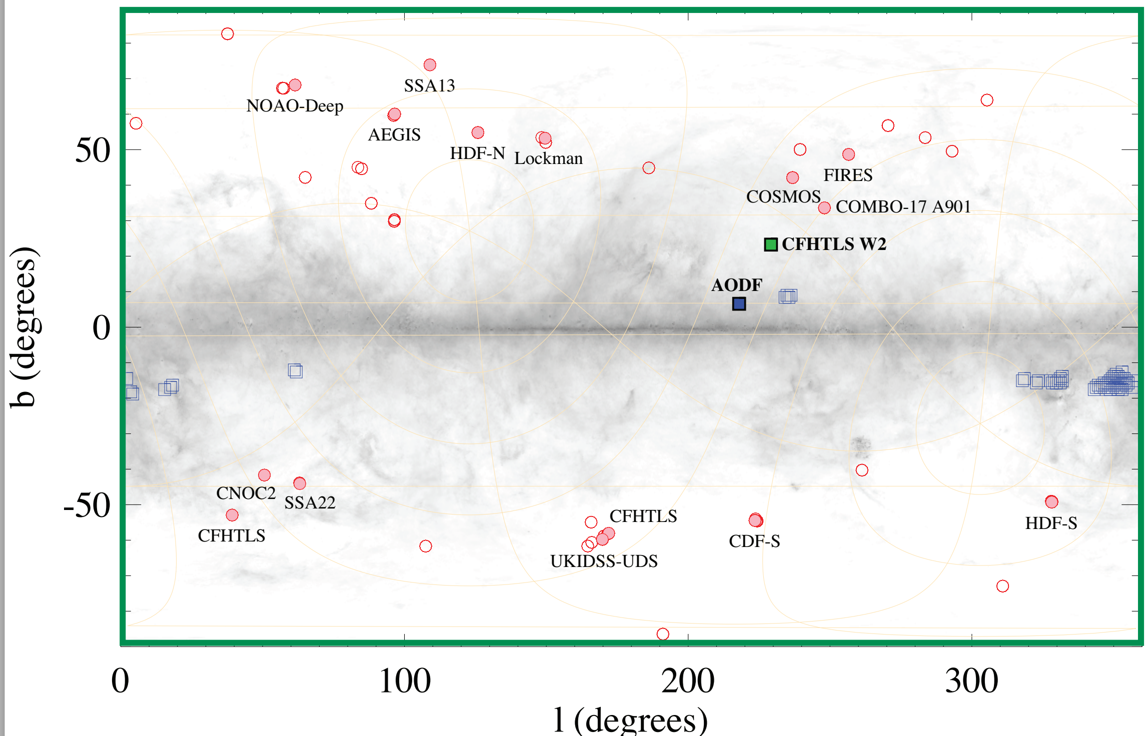
Deep Fields Optimized for Adaptive Optics

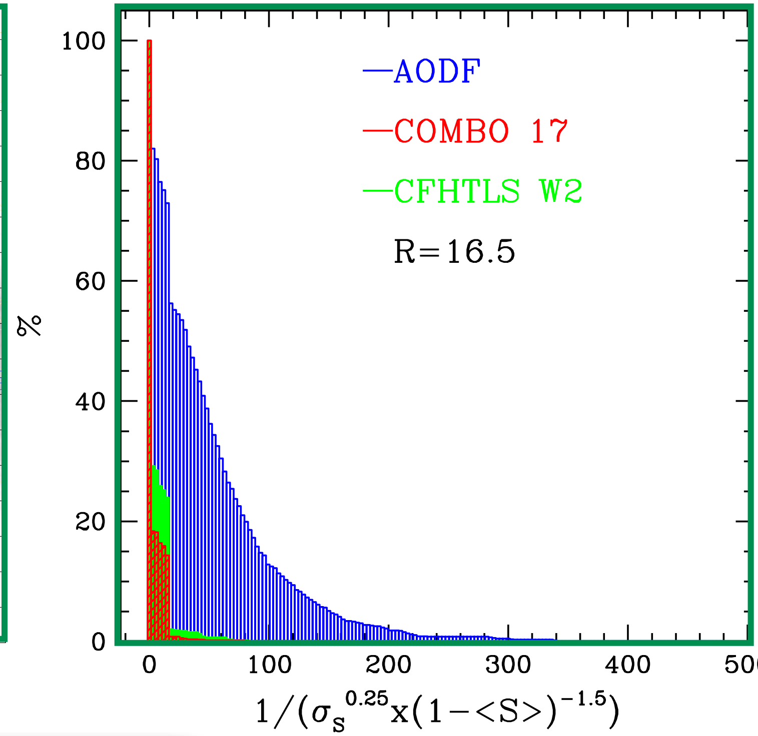
Damjanov et al. 2011a



Adaptive Optics Deep Field

RA: 7h24m3s, Dec: −1deg27′15″





Damjanov et al. 2011a

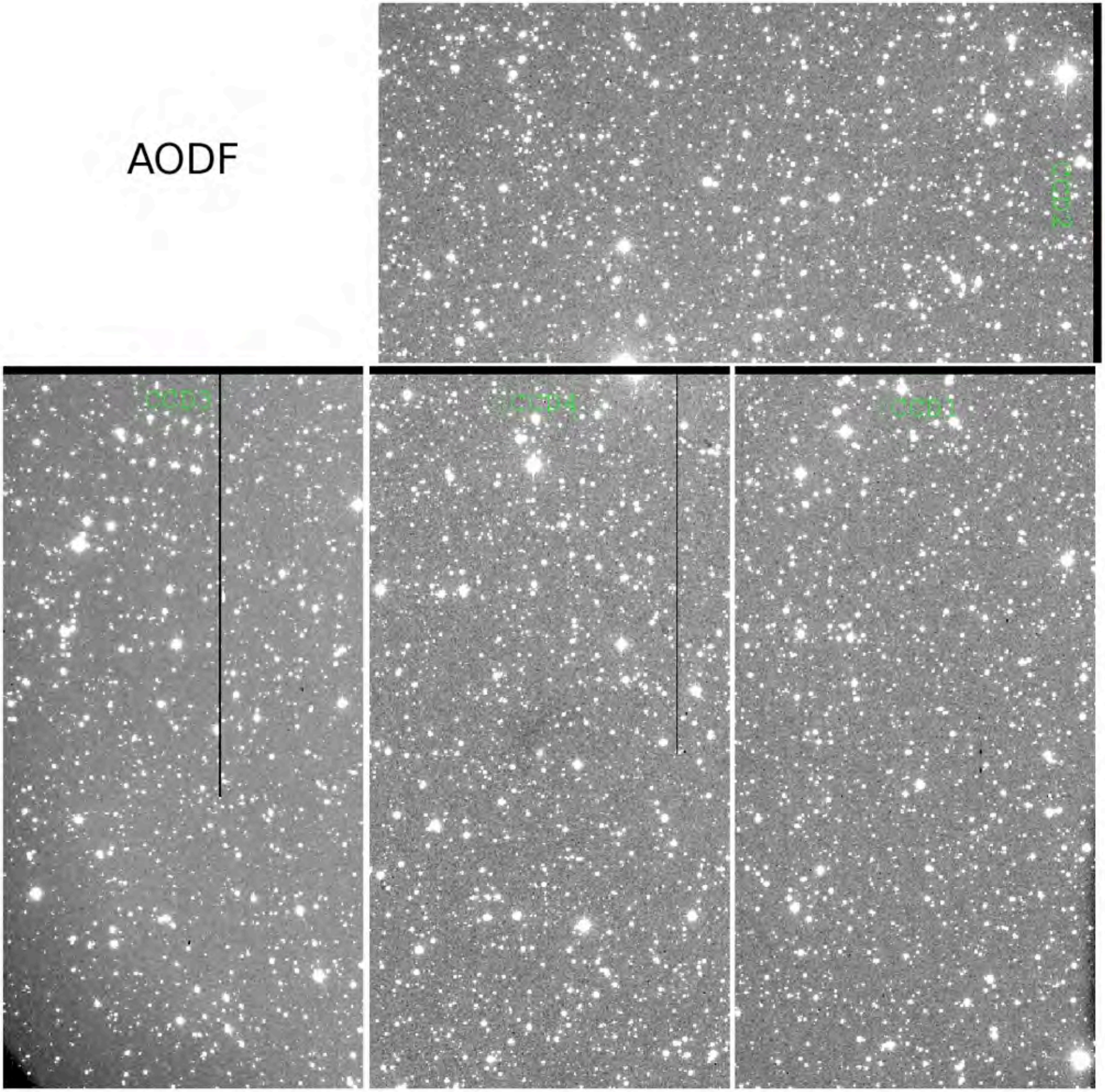
Do your extragalactic AO in the AODF field and be 20x - 100x more efficient.

Data collection is currently progress (CFHT WIRCam, INT WFC, CTIO DECam).

All material obtained is instantly public.

HELP US HELP YOU

AODF



SUMMARY

• Distant early-type galaxies are a factor of 2 – 5 smaller than the analogous nearby galaxies in the same mass range.

• We don't know why. Maybe a combination of many things? Mergers are the most common explanation but there are problems…

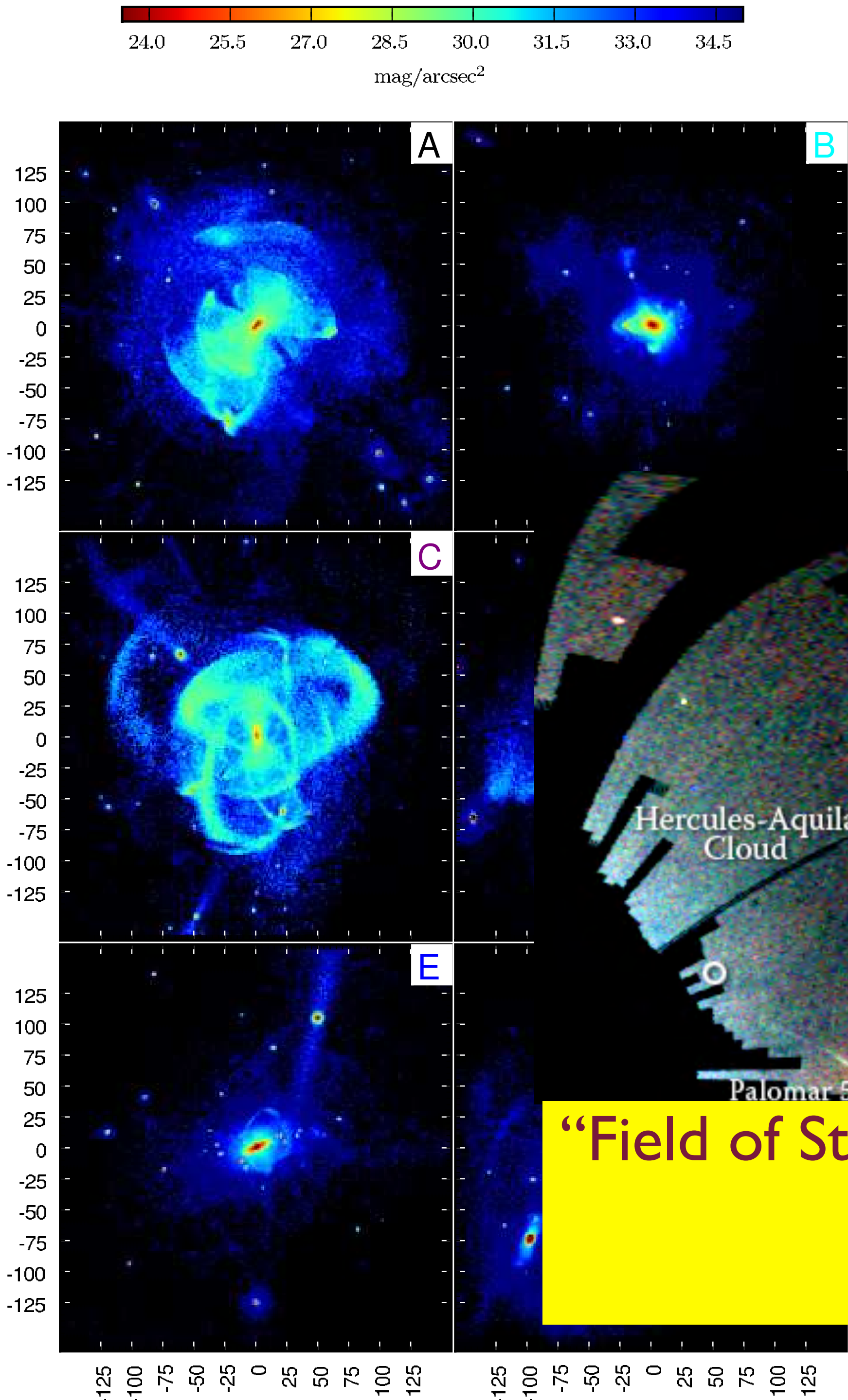
• It's questionable whether 'analogous' galaxies are really analogous. In some ways this appears to be a different population.

• Size growth is a continuous process that has been occuring more-or-less smoothly and gradually from $z = 2.5$ to $z = 0$

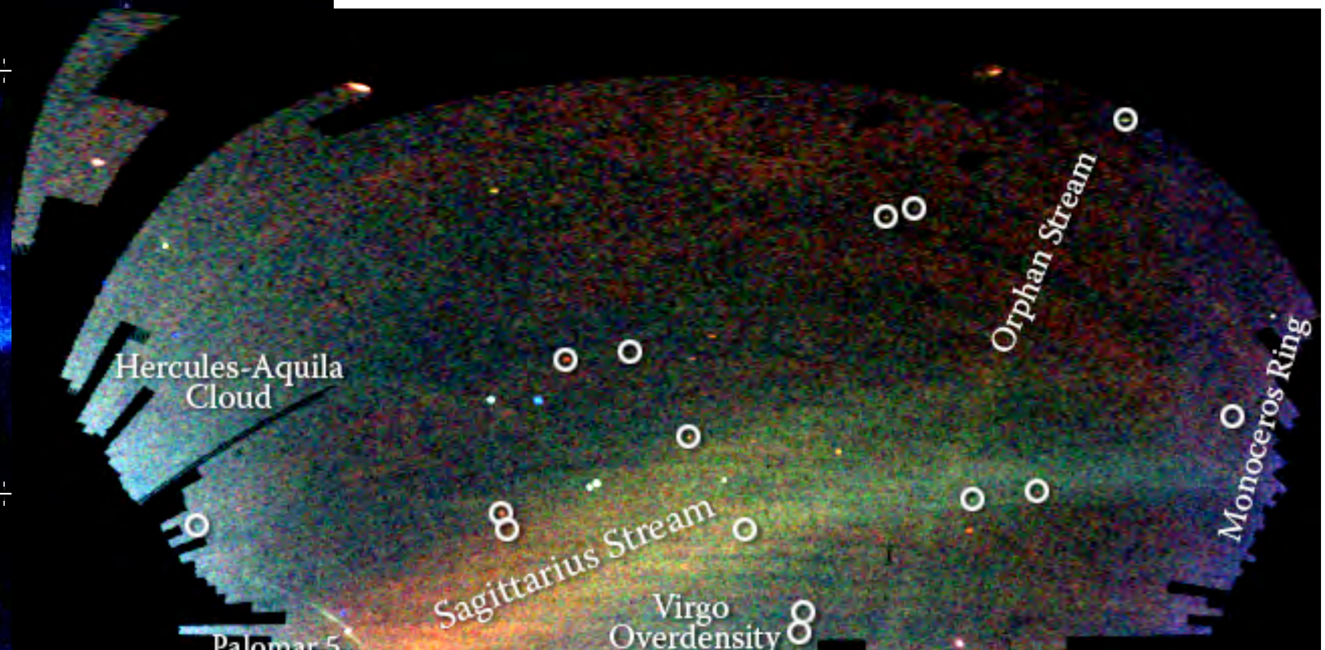
• Learning more requires more resolution and more photons. A new adaptive optics technology to let us do the job is here, but we have to use it in an unusual way to be effective.

Can we directly image the cosmic web?

Cooper et al. 2010

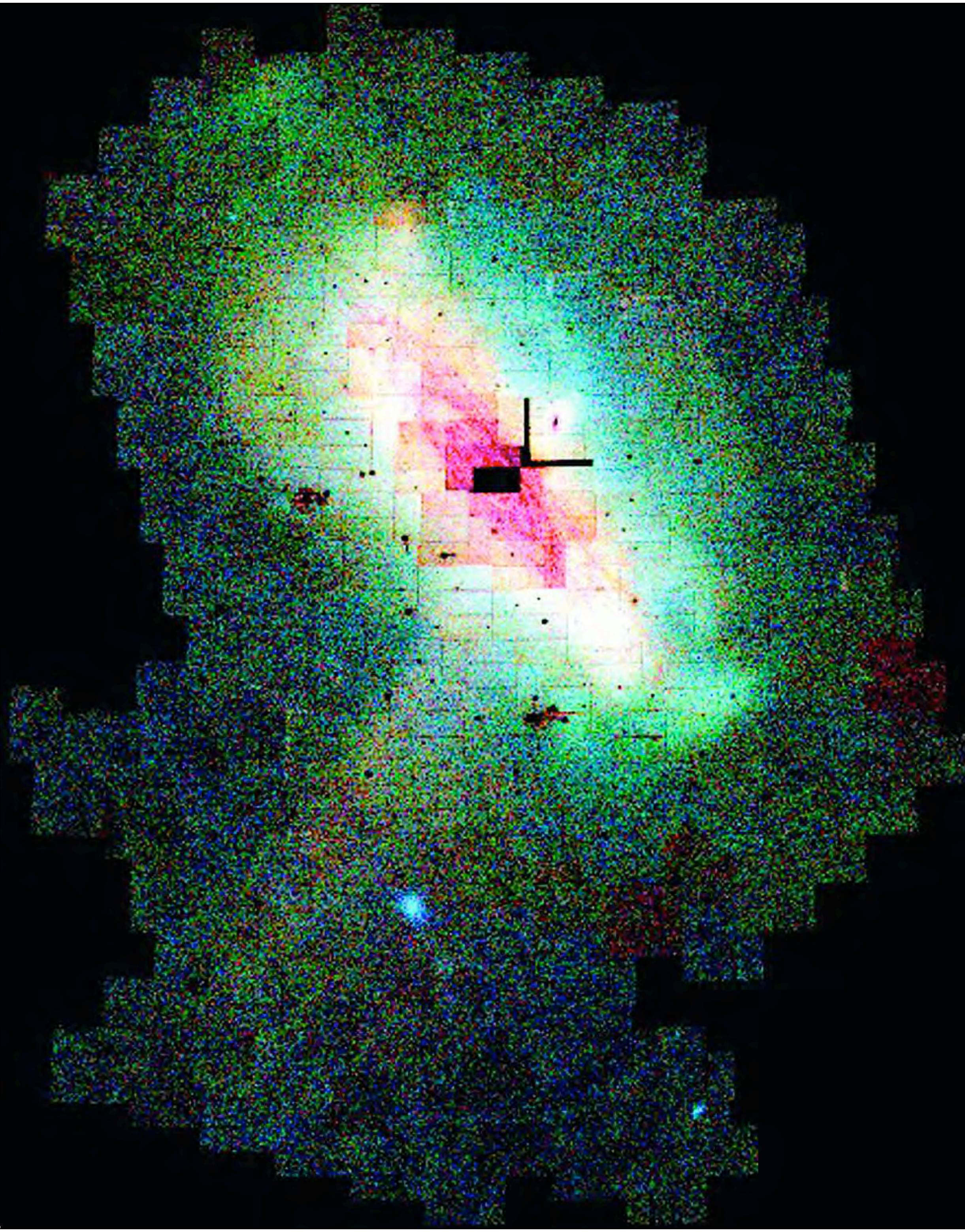


/-band surface brightness of our model haloes (and surviving satellites), to a limiting depth of 35 mag/arcsec^2. The axis scales are in kiloparsecs.
formed in satellites are present in our particle model; there is no contribution to these maps from a central galactic disc or bulge formed in situ (see



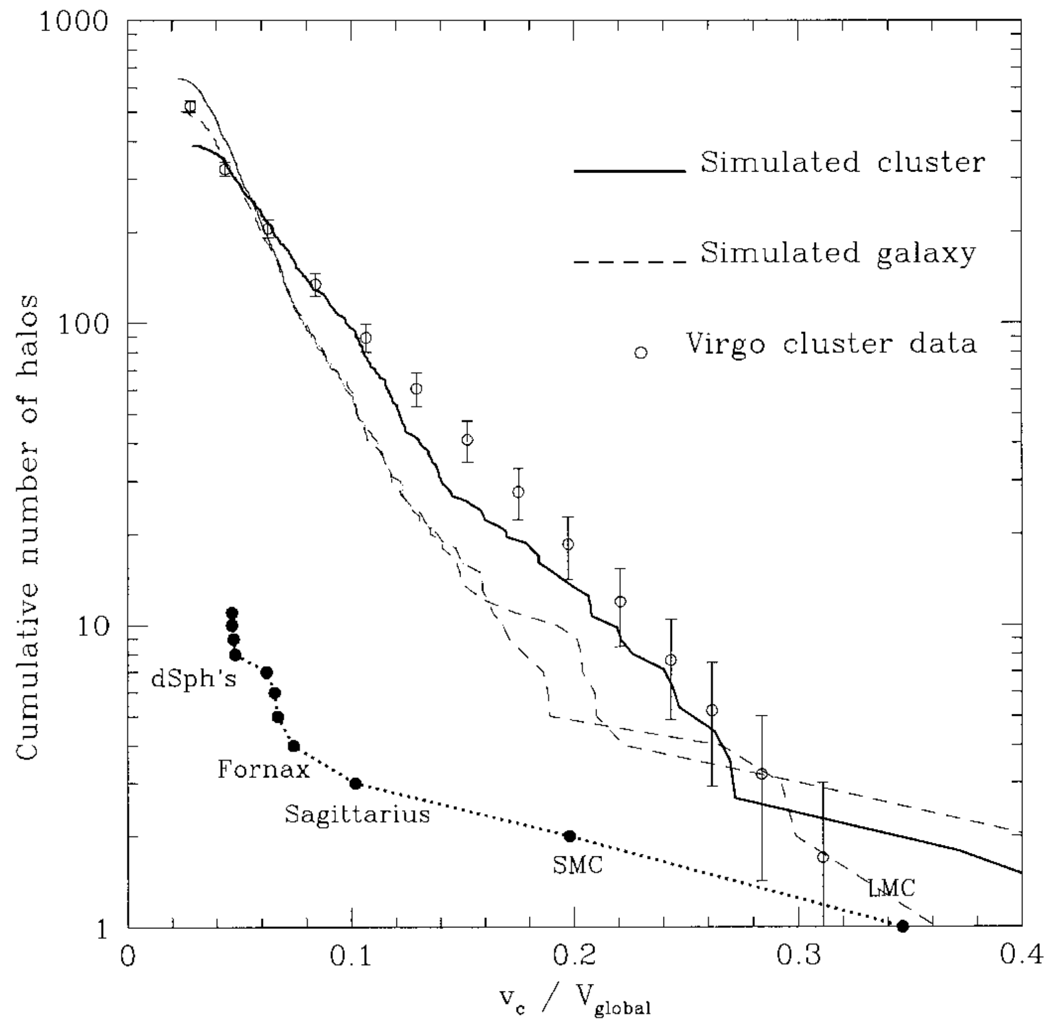
"Field of Streams" structure in the halo around the N. Galactic cap
(Belokurov et al. 2006)

Streams in M31 from the INT WFC Survey (McConnachie et al.)



Moore et al. 1999

FIG. 1.—Density of dark matter within a cluster halo of mass $5 \times 10^{14}\ M_\odot$ (*top*) and a galaxy halo of mass $2 \times 10^{12}\ M_\odot$ (*bottom*). The edge of the box is the virial radius, 300 kpc for the galaxy and 2000 kpc for the cluster (with peak circular velocities of 200 and 1100 km s^{-1}, respectively).



What's the problem?

- Low-SB limited by systematics. You cannot solve this with a bigger telescope or by integrating longer.
- What you really want:
  - No reflective surfaces (no micro-roughness, no pinholes)
  - Unobstructed pupil (minimize energy in PSF wings, minimize "aureole".
  - Quasi-perfect optical coatings (no ghosts)
  - Be extremely optically fast. (When resolution is unimportant, time to get to a given SB depends only on f-ratio not aperture).
  - Redundant optical paths imaging the sky at the same time (to average over systematics).
  - Wide field of view (Virgo elliptical >1 deg in size at 30 mag/arcsec^2)

Disruptive technology


Last month

Last month

Next month