AMALGAM : the mass distribution of >100 galaxy clusters from CFHT and Subaru archival wide field images

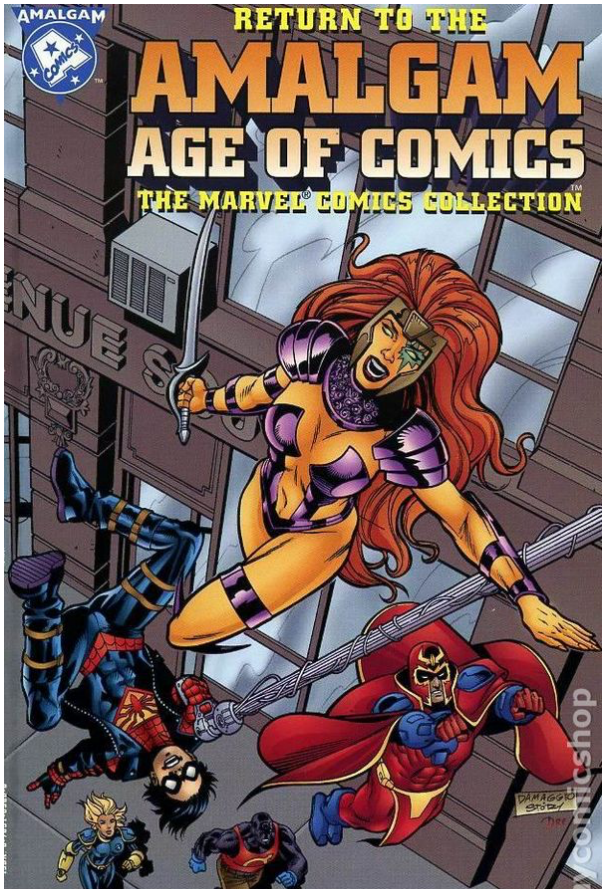
In progress

Stands for “Ajustement de Modèles Appliqué aux Lentilles gravitationnelles dans les AMas de galaxies”,

Raphaël Gavazzi

Ongoing work with A. Donnarumma & E. Bertin

http://amalgam.iap.fr/



PROJET FINANCÉ PAR L'ANR
ANR
PROJECT FUNDED BY THE ANR

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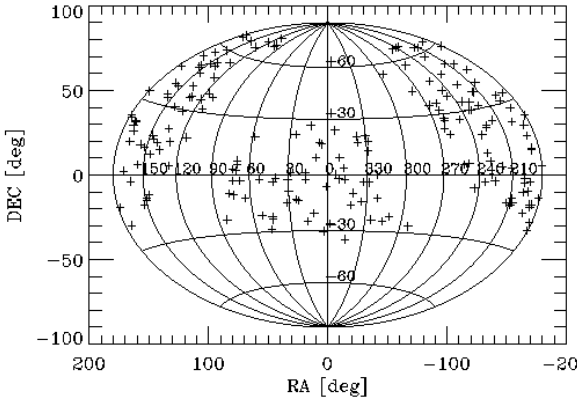
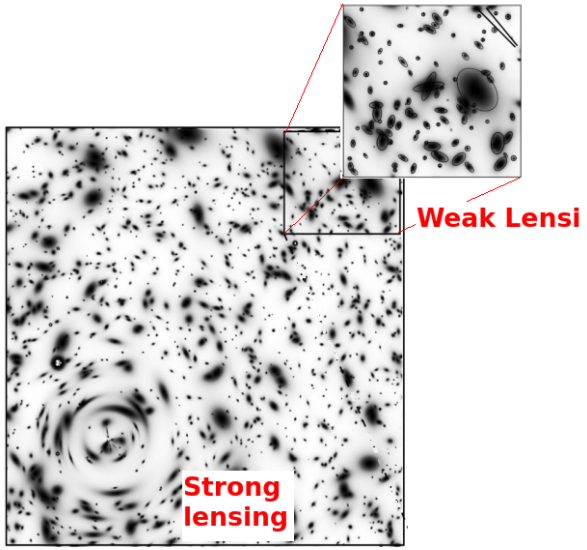
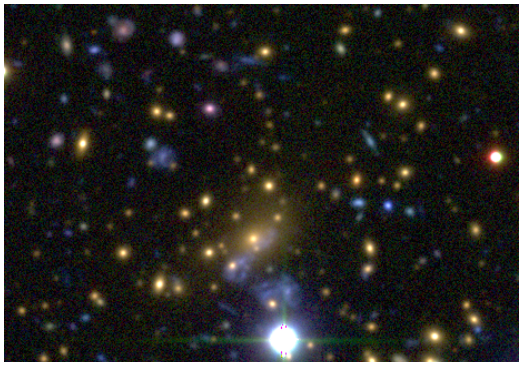
Science goals

- 120 clusters with more than 2 optical wide fov bands with Subaru/ Suprimecam or CFHT/Megacam. We require seeing<0.9'' lensing, <1'' photom to a depth i_{AB}~24.5.
- ~30 with many bands uBgVrRiIz. + sometimes JHKs WIRCAM coverage + ~60 with HST imaging in the core (processing ongoing)
- Full sample should outperform statistical power of CCCP and Weighing the Giants (~30). Large overlap with existing samples.
- Weak lensing -> mass content (overall cluster + substructures)
- Strong lensing Xsection for cluster members and comparison with the field (extend CFHTLS results)
- Multiscale, consistent study of shear, flexion and strong lensing







Data processing

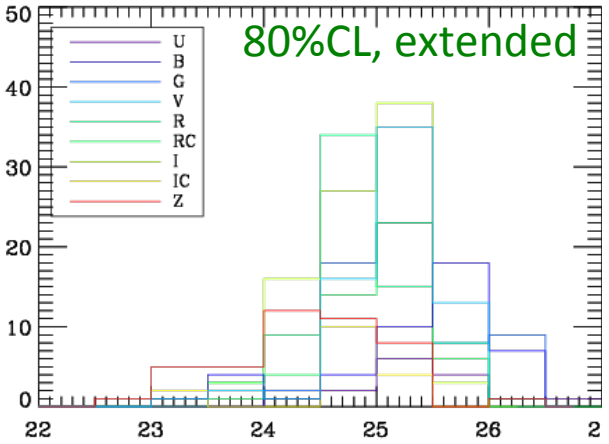
- 140 clusters. 510 optical stacks (2.6 bands on average), ~10000 exposures (including astrometric/photometric calibration frames)

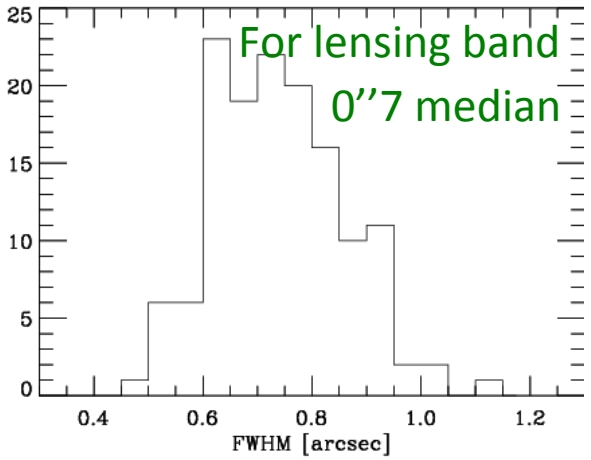
- Subaru archives: metadata are messy and detrending tricky (overscan,gain,cross-talk…).
- Thanks CFHT for smooth preprocessing (ELIXIR)… and clear/reliable data structure (room for improvement in the z-band)

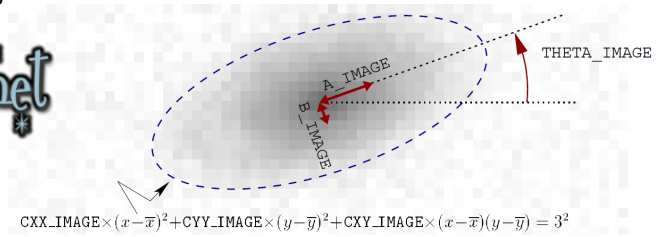
- Data reduction complete (excellent astrometry 10-20 mas rms with LARGE scamp runs).
- We derived starflats for Suprimecam (but current results don't correct for it yet).
- Photometric calibration based on SDSS (when available) or CFHT. More difficult with generally too-long Subaru exposures. Use of BIGMACS (Kelly et al) to perform photometric calibration.

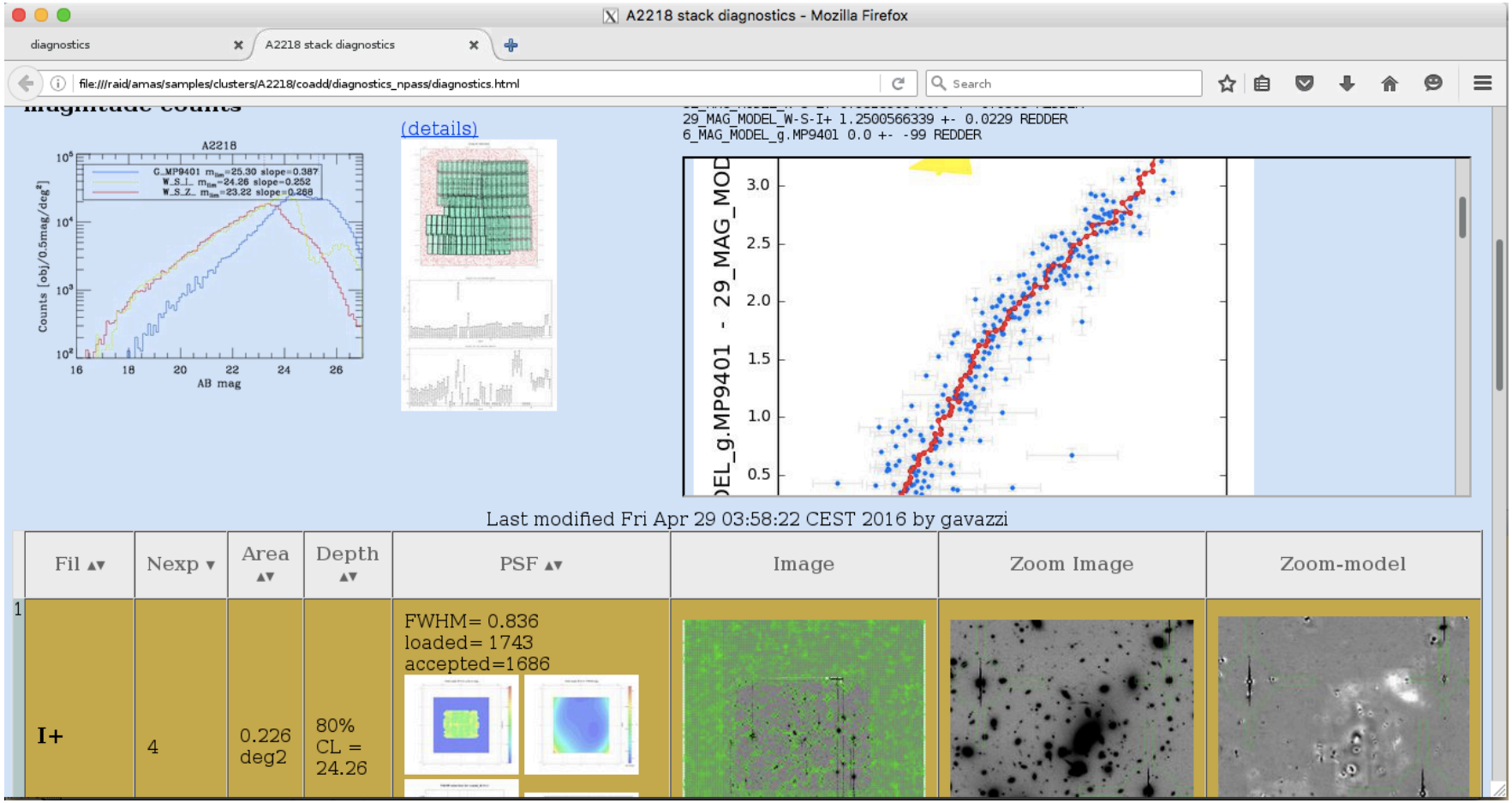
- Archives mined to get large numbers of redshifts to help photo-zs techniques (Le Phare & poorman-z)

- Shapes measured w/ Sextractor+PSFEx (currently on stacks, eventually on individual exposures)









- Diagnostic tools showing galaxy counts, footprint of exposures, BIGMACS (Kelly et al) stellar loci
- PSF model (PSFEx)
- Masks (Theli automask tool)

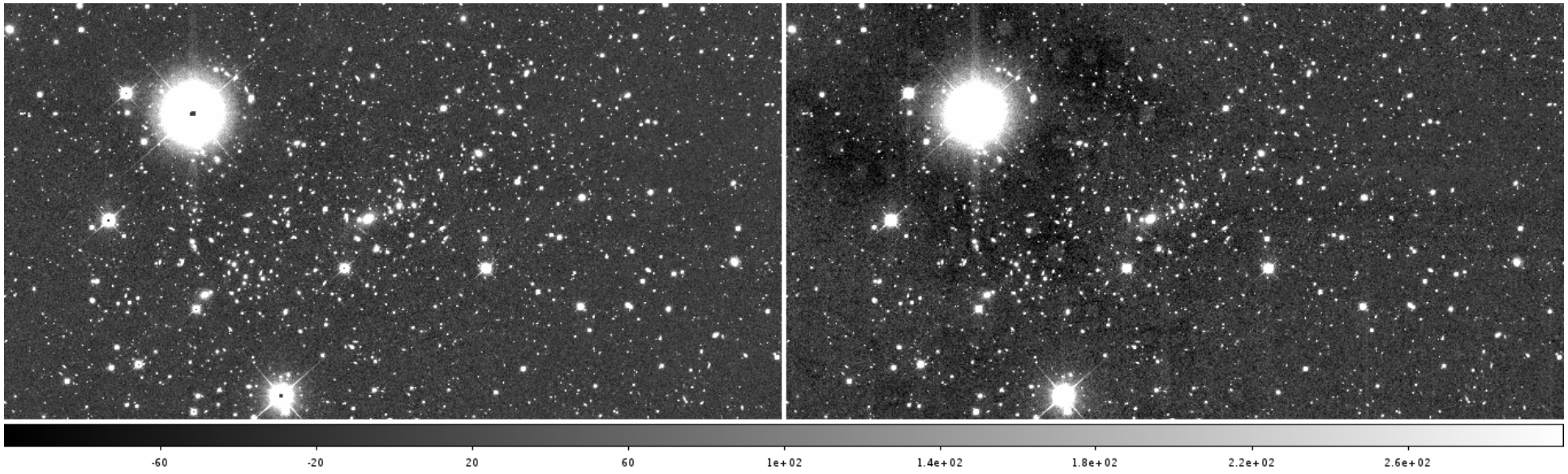
- Galaxies are modeled as Sersic profile. Above, image and image-model. Currently done on stacks… but....

WIRCAM imaging

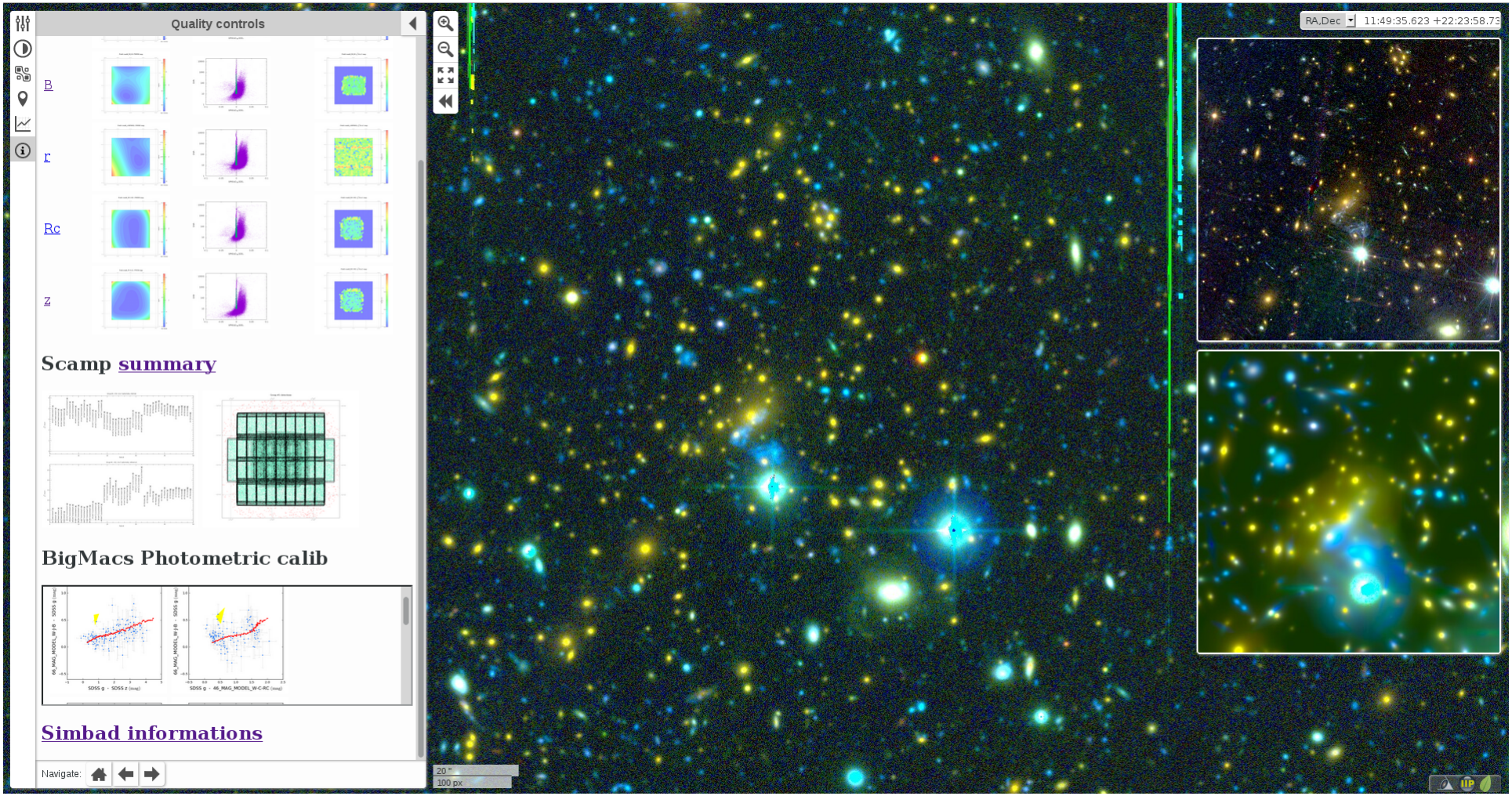
- For 37 clusters out of 141, some partial JHK coverage of the Suprimecam/Megacam footprint but rarely at the desired depth (~24AB).
- It helps disentangling fg/bg galaxies in cluster cores and improves fg stellar mass estimates
- Analysis ongoing… careful stacking and calibration pending.

Terapix processing (Bouflous, Hudelot @ IAP)

Direct stacking



Image/metadata navigation tool based on visiomatic tool (leaflet js)



Protoype browsable http://image.iap.fr/amalgam

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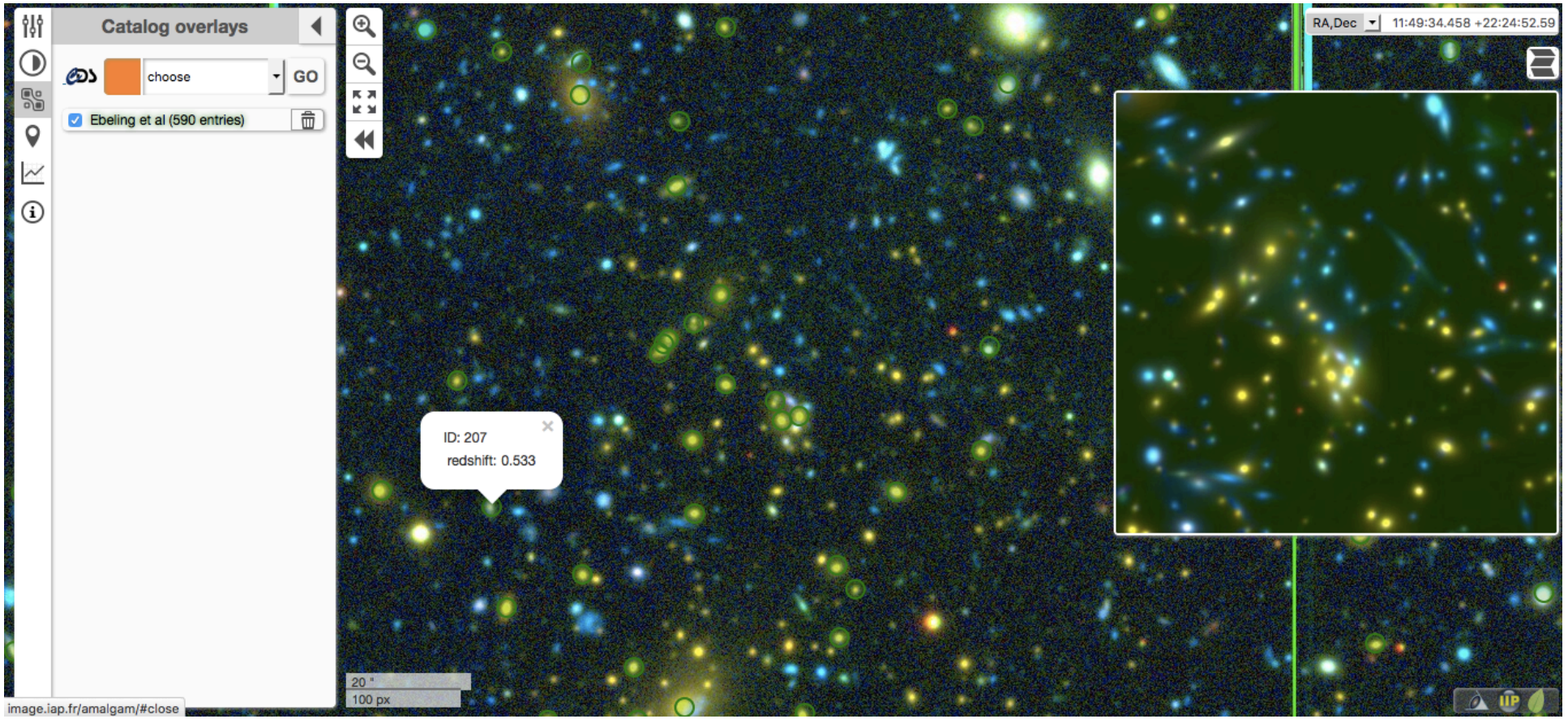

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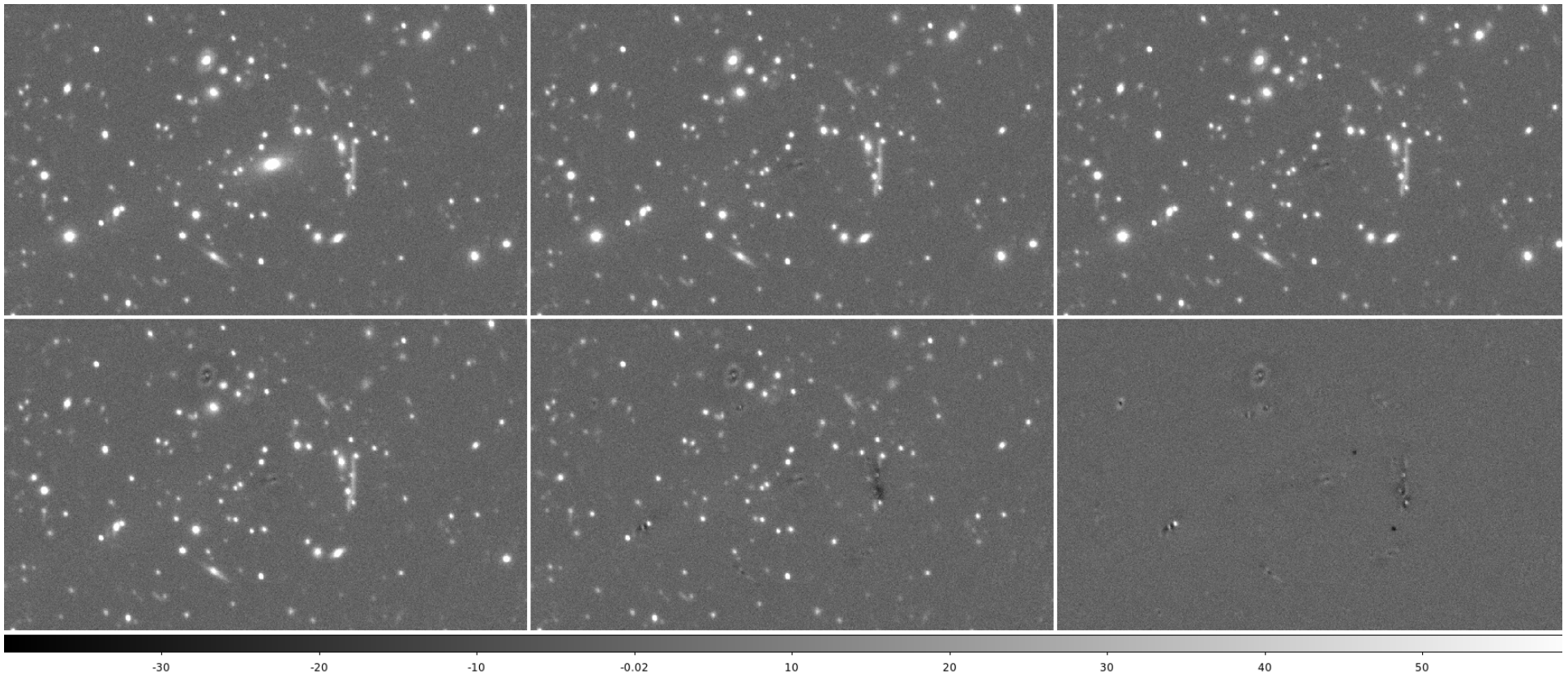
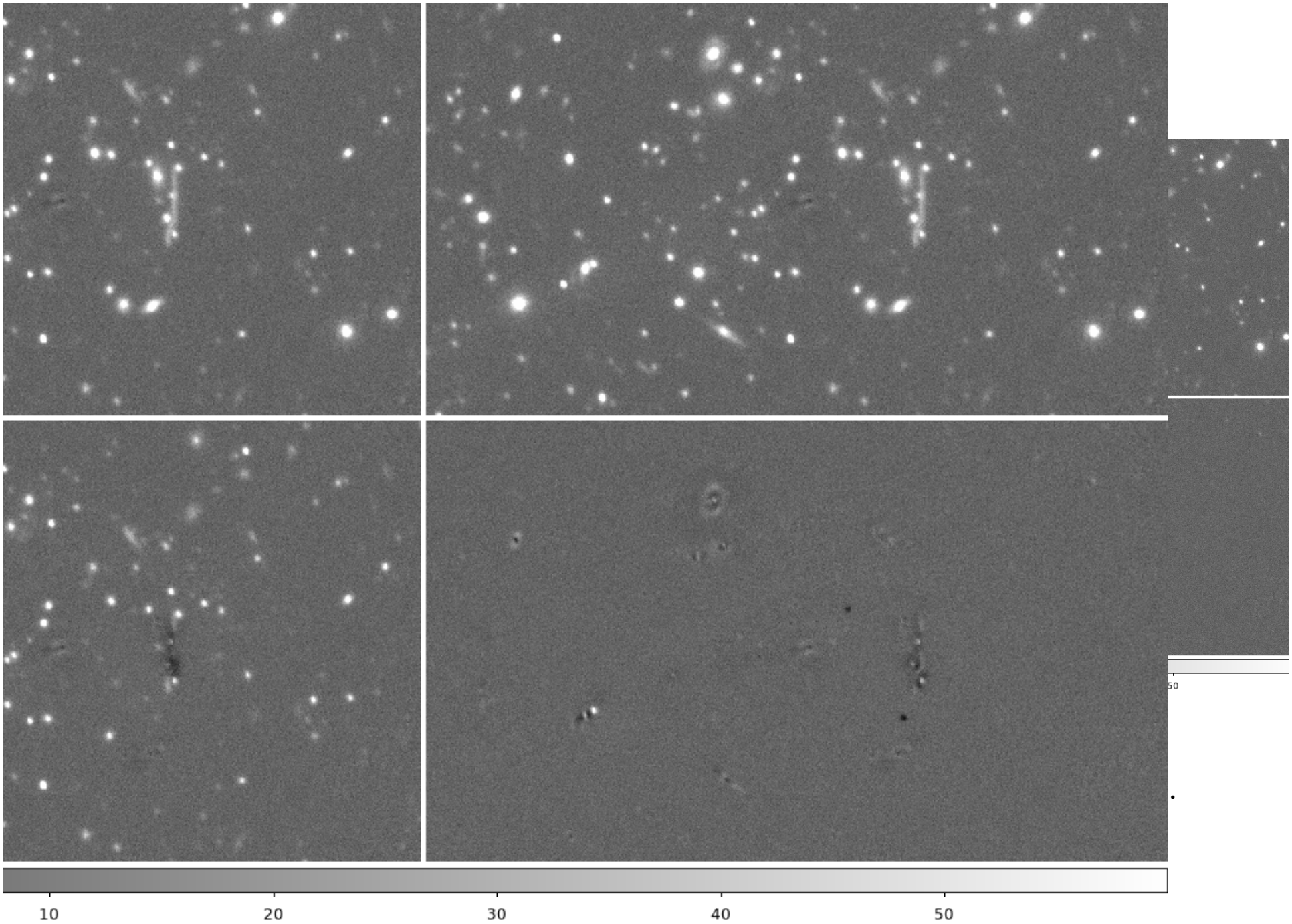
Sersic model fitting capabilities of Sextractor + PSFEx



In crowded areas, fitting brighest objects first reduces crosstalk of blended objects.


10
20
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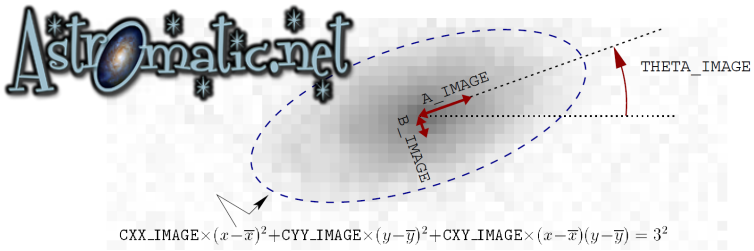
Shape Measurements



- Improved model-fitting capabilities of SExtractor coupled to PSFEx
- Great3 outcome is very encouraging : 2nd team out of several 10th.
- Extremely fast (10-40 gals/sec) with much improved deblending.
- Biases ~< 10^{-3} , very little dependence on SNR once above 10.
- So far, multi-exposure fitting still under development!

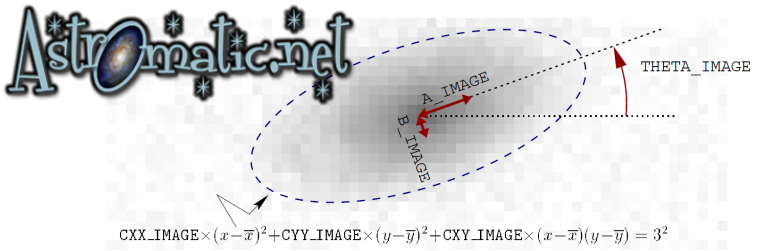
Home | Get Data | Overall Leaderboard | Archived Challenge Leaderboards | Post-challenge Leaderboards | Login

The Great-3 challenge is now complete and the winners decided. We have also now deactivated the post-challenge leaderboards, so no more submissions can be made at all.

Overall Leaderboard

Name	Notes	Score	Number of entries
sFIT	Modified DLS stackfit algorithm	80001	162
Amalgam@IAP	Some fellows developing software based around SExtractor and PSFex for real-life shape measurements.	80000	215
CEA-EPFL	The team wants to investigate if we could improve shear estimation by combining gfit with sparse representation methods.	72000	340
MegaLUT	Evolutions of the MegaLUT technique : how far can we go with SExtractor + Machine Learning ?	52000	234
Fourier_Quad	Our team uses the quadrupole moments of the spectral density of galaxy images in Fourier space to measure shear.	32000	36
EPFL_gfit	Using the gfit shear measurement method, testing how far one can go by using forward model fitting + new approaches for bias calibration	24000	124

Shape Measurements



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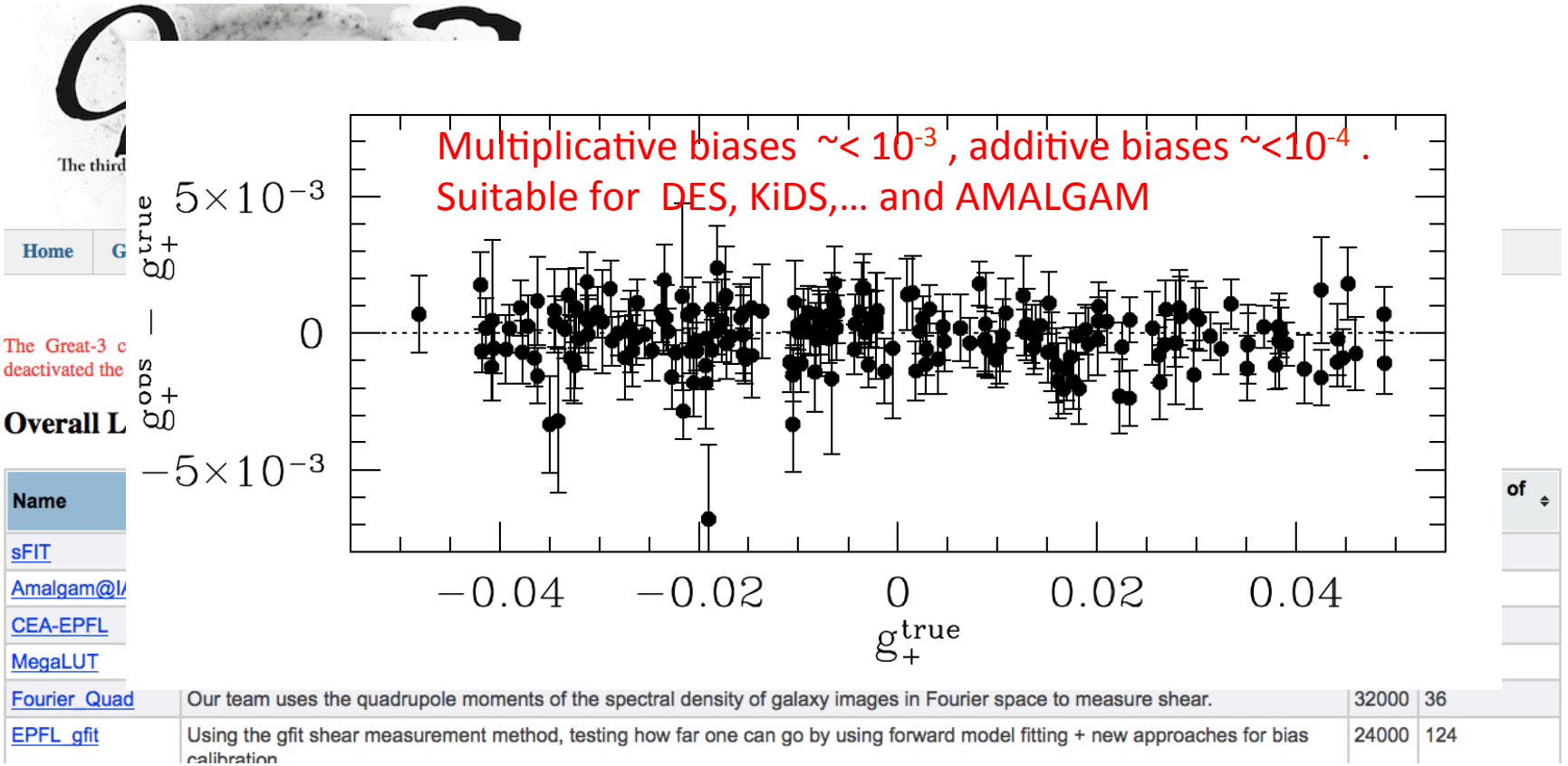


Redshift of sources

- Required to calibrate lensing , ie to convert induced ellipticity into mass.

- Required to get rid of cluster members.

$$\varepsilon = \varepsilon_s + w\gamma\,,$$

with $w = D_{\rm ls}/D_{\rm s}$

Crude approach

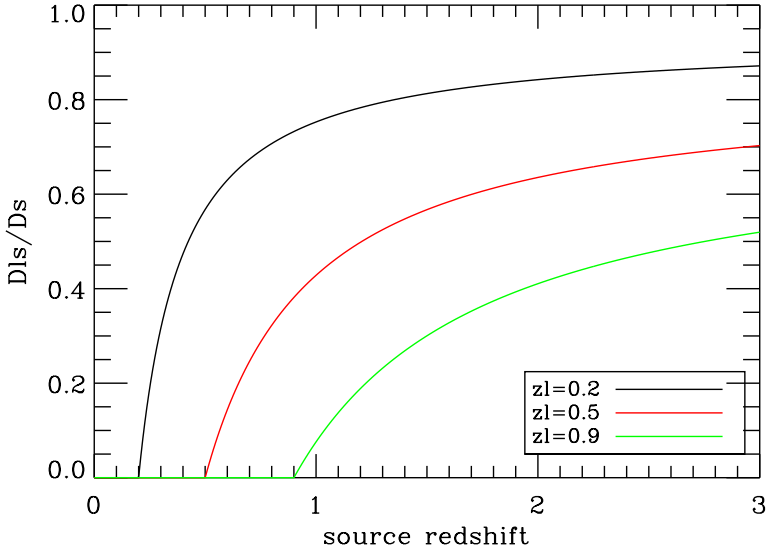
$$\gamma = \frac{\sum_i \varepsilon_i}{\overline{w}N}$$

$$\sigma_\gamma = \frac{\sigma_s}{\overline{w}\sqrt{N}}$$

Ideal approach

$$\gamma = \frac{\sum_i w_i\varepsilon_i}{\sum_i w_i^2}$$

$$\sigma_\gamma = \frac{\sigma_s}{\sqrt{N\overline{w^2}}}$$



Bayesian approach by carrying redshift PDF (whatever its width…)

$$p(\gamma|\varepsilon) \propto p(\gamma) \prod_i \int_0^1 {\rm d}w_i\, p(w_i)\, p_s\left(\varepsilon_i - w_i\gamma\right)$$

Can also efficiently sample posterior p(γ,**w**| ε), with Gibbs algorithms

Redshift of sources

Nearly optimal:

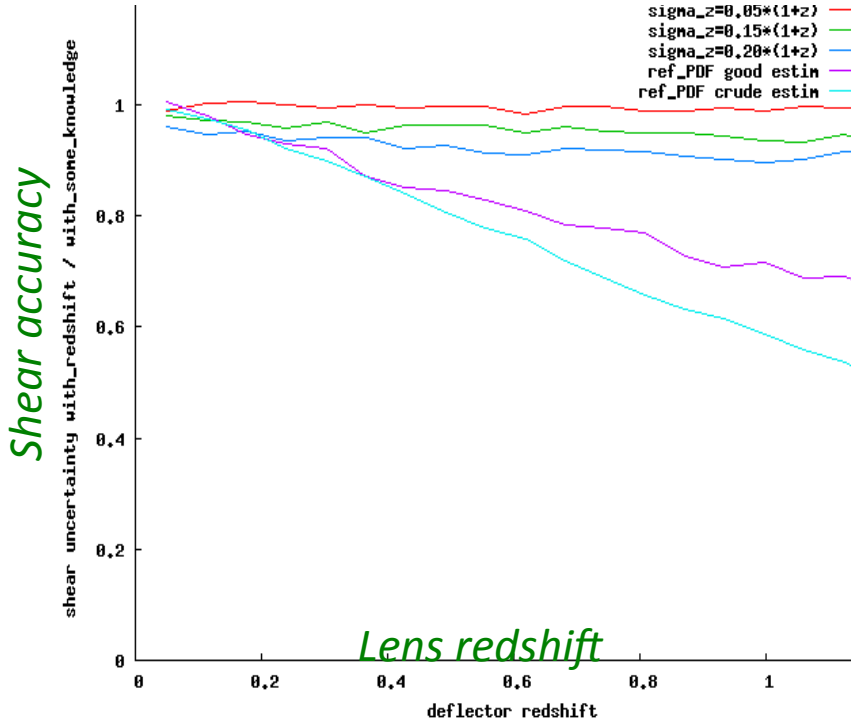
$$\sigma_\gamma = \int d\gamma \int \cdots \int d^N z\ (\gamma - \hat{\gamma})^2\ p(\gamma, \mathbf{z}|\varepsilon)$$
$$\simeq \frac{\sigma_s}{\sqrt{\sum_i \overline{w_i^2}}}.$$

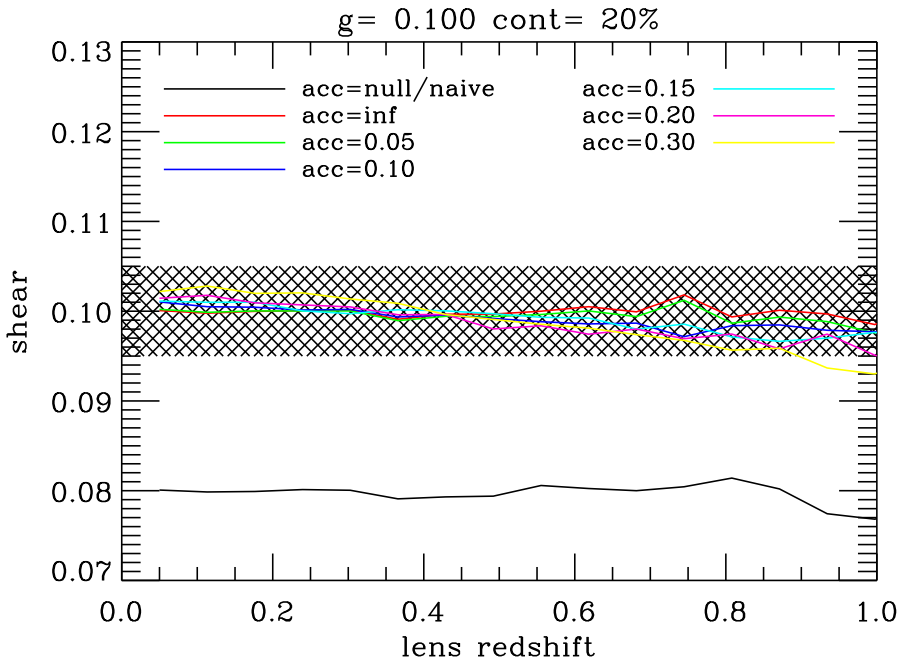
Most of the signal is recovered for σ_z~0.3 (1+z)

Badly biased:

$$\hat{\gamma} = \int d\gamma \int \cdots \int d^N z\, \gamma p(\gamma, \mathbf{z}|\varepsilon)$$
$$= \gamma \frac{\sum_i \overline{w_i} w_i}{\sum_i \overline{w_i^2}}.$$

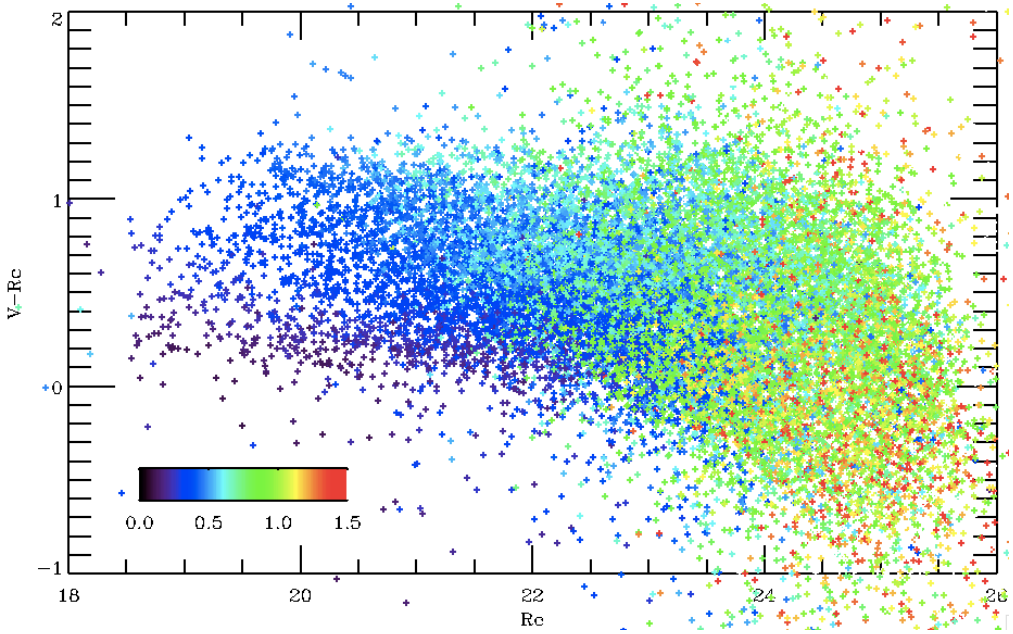
To mitigate the bias (within 5%), one can pick those sources with the lowest w uncertainty so that $\sigma_w/w < 0.8$. Quite easily achieved as long as $z_s >> z_l$, even with severe contamination by cluster members.

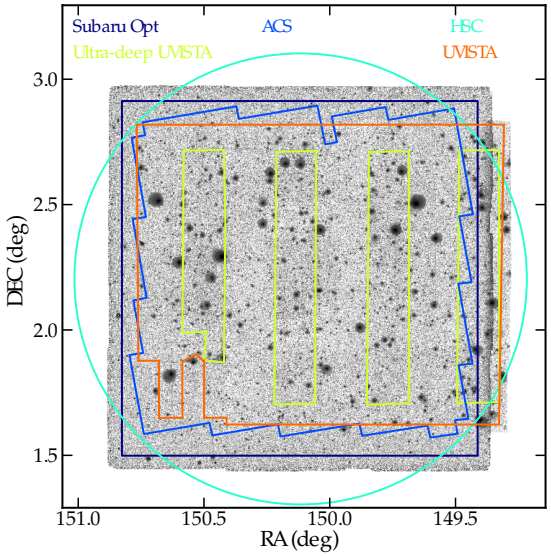


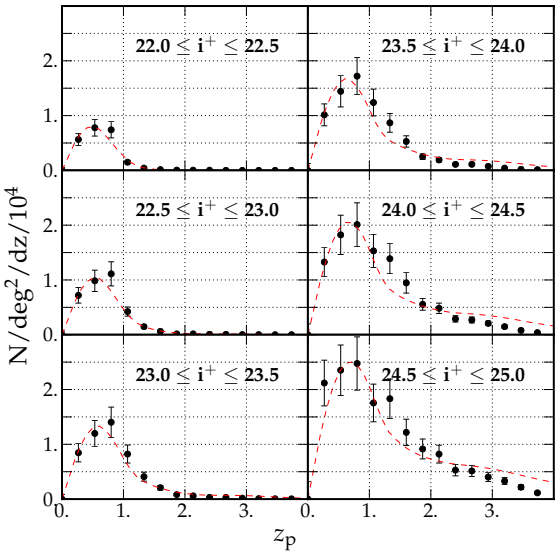


Redshift of sources

- Photometric redshift (LePhare)
- color cuts…
- poorman-z : k-NN redshift picker from latest COSMOS photo-z (photometry degraded to our depth in each band)







COSMOS 2015 (Laigle et al 2016)
2 deg^2

$$p_{\rm ref}(z) = \frac{{\rm e}^{-z/z_0}}{z_0\Gamma(a)}\left(\frac{z}{z_0}\right)^{a-1}$$

i band limiting mag	≤ 23	≤ 24	≤ 25
z_0	0.214	0.344	0.513
a	2.83	2.38	2.09

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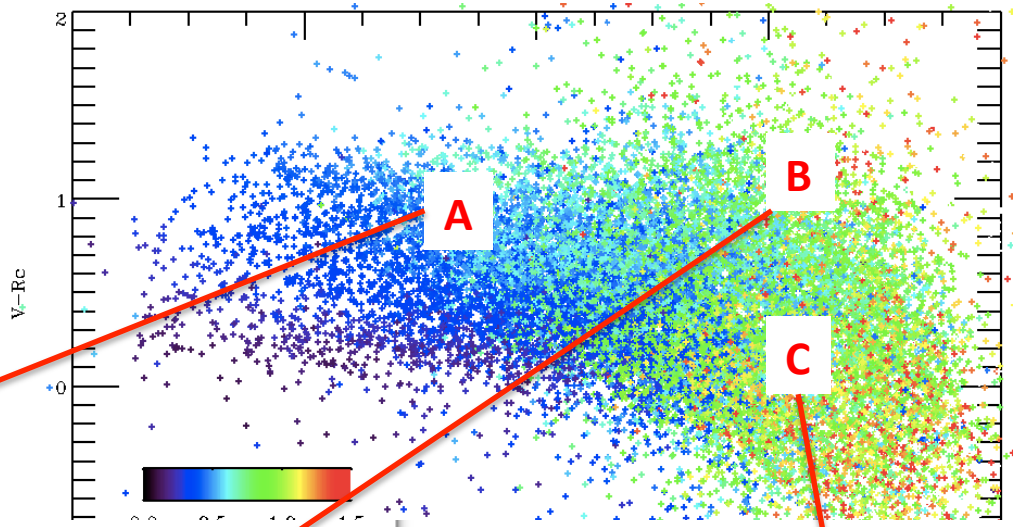
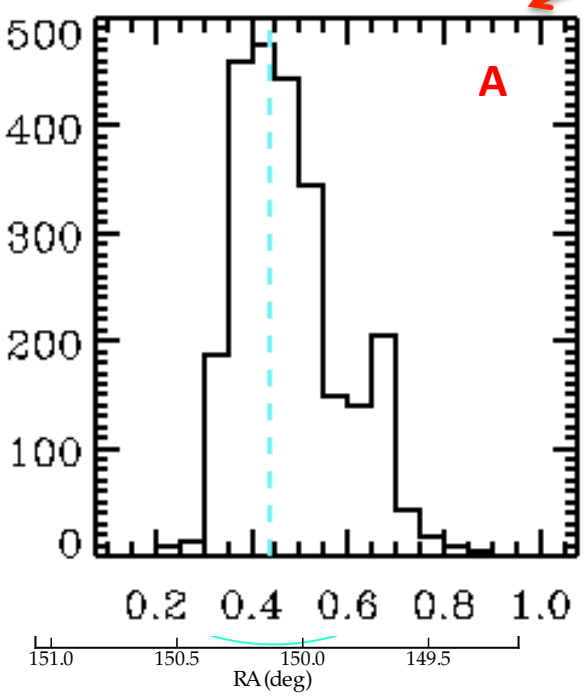
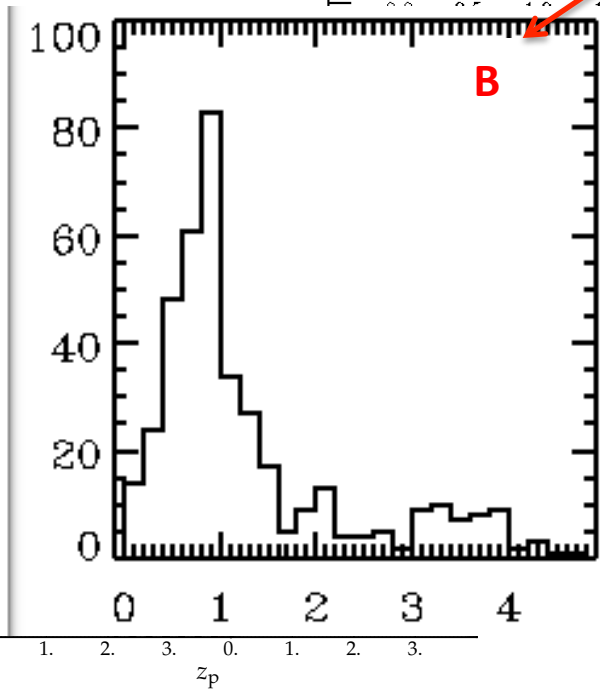
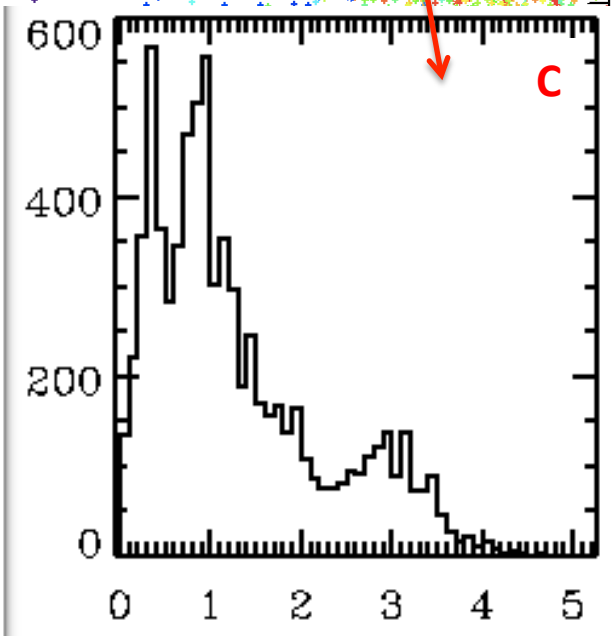




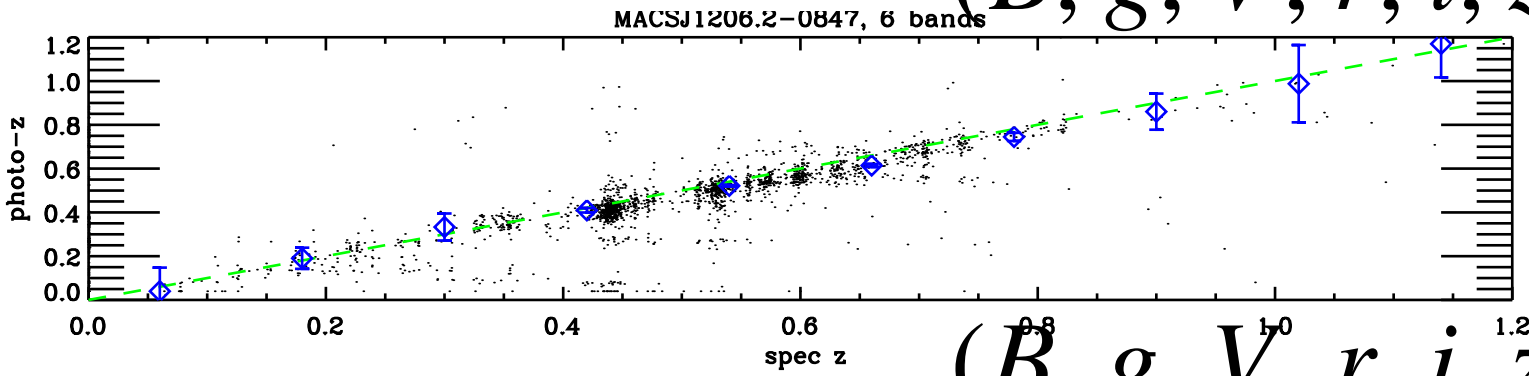




Redshift of sources

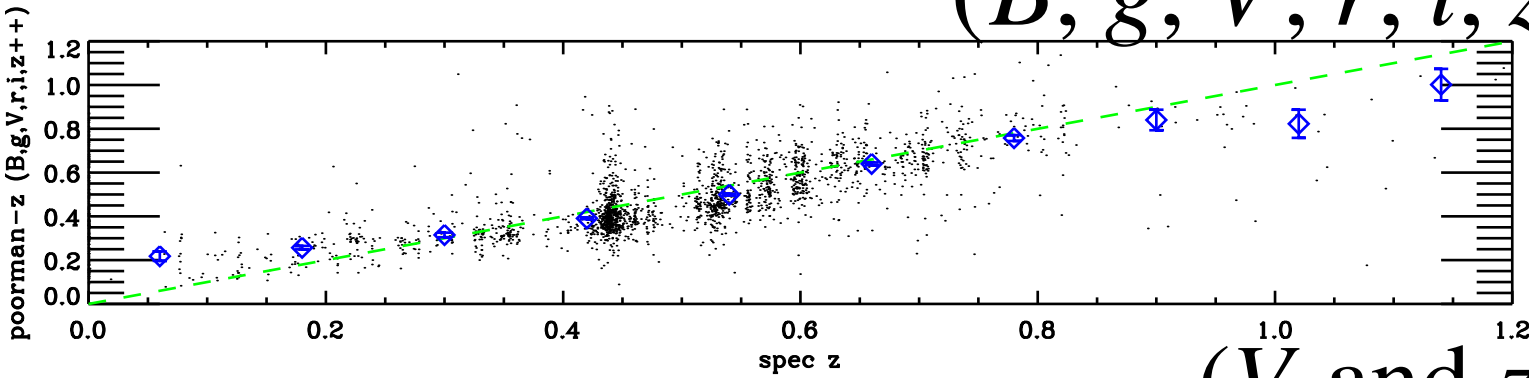
(B, g, V, r, i, z^{++}).

LePhare



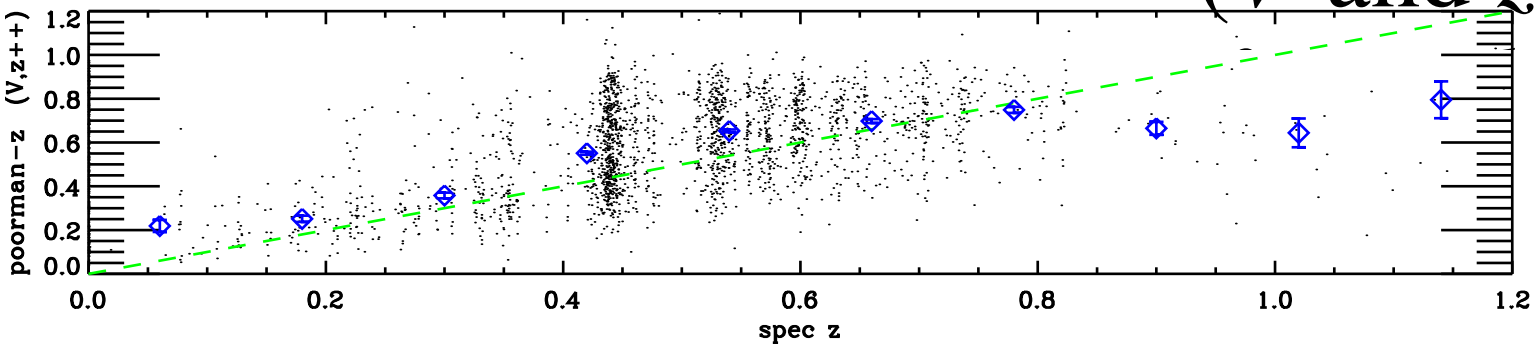
(B, g, V, r, i, z^{++}).

k-NN 6d



$(V$ and $z^{++})$.

k-NN 2d

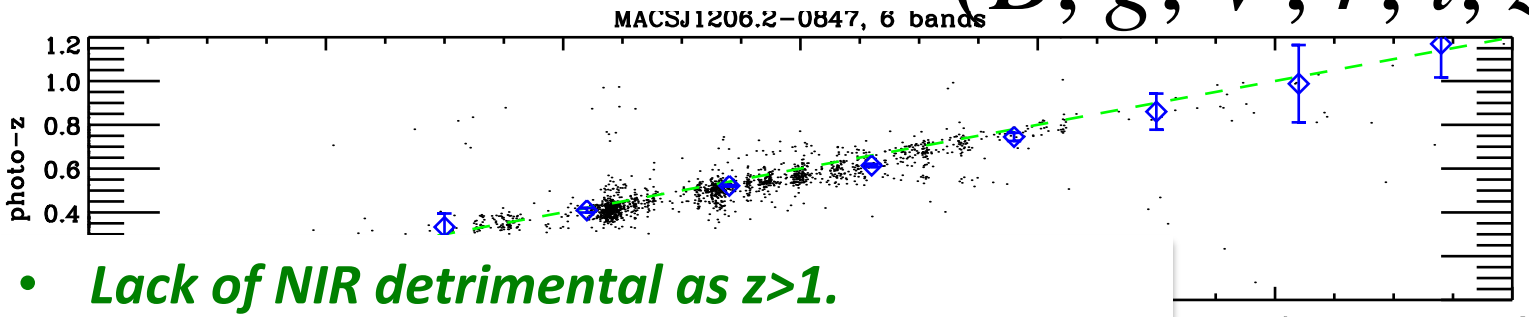


poorman-z vs CLASH-VLT spec-z (Girardi et al).

Redshift of sources

(B, g, V, r, i, z^{++}).

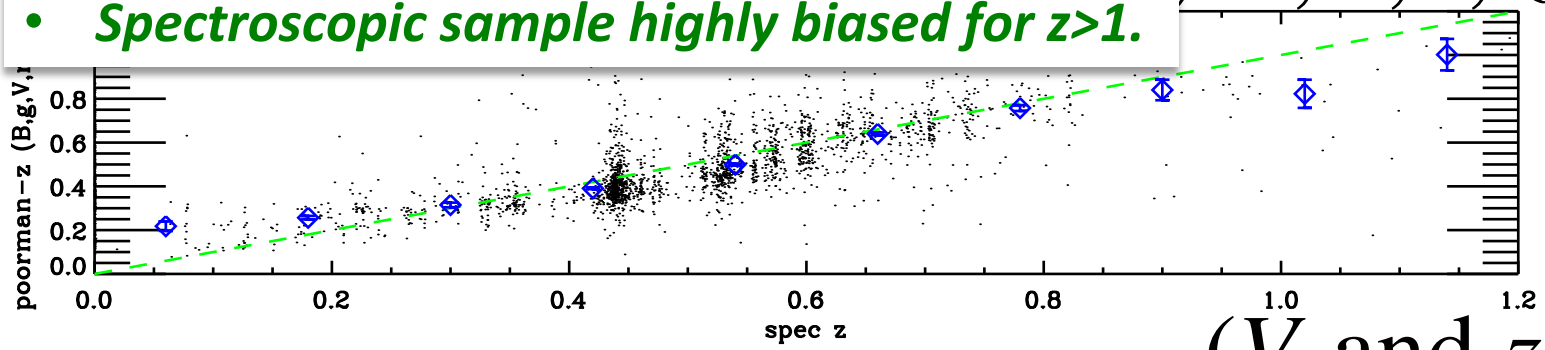
LePhare



- *Lack of NIR detrimental as z>1.*
- *Spectroscopic sample highly biased for z>1.*

$V, r, i, z^{++})$.

k-NN 6d



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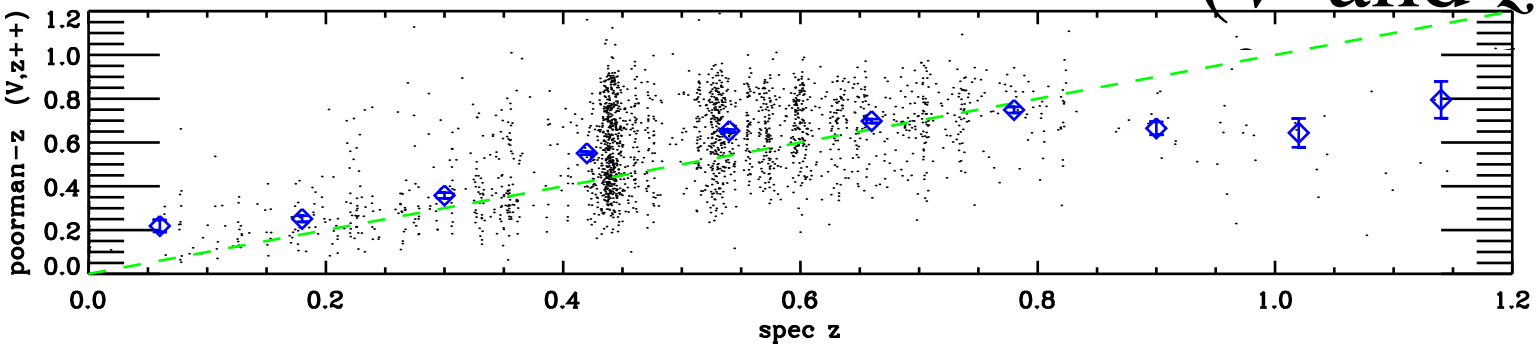


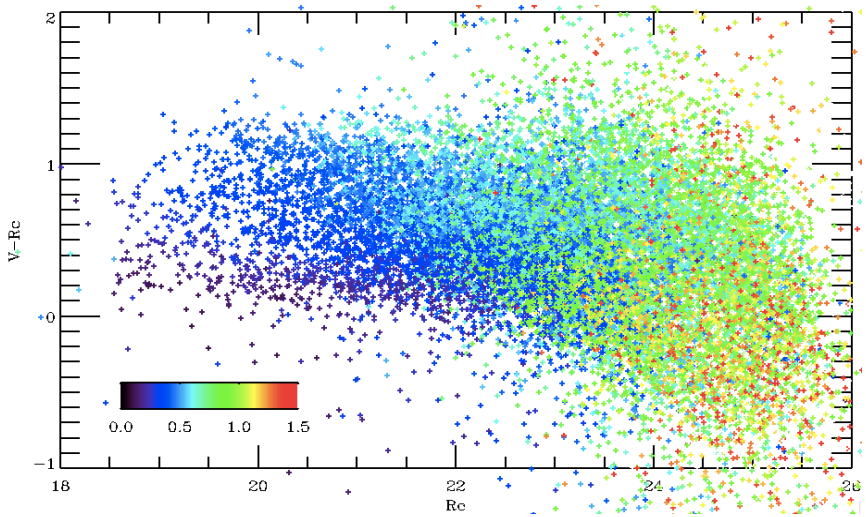
poorman-z vs CLASH-VLT spec-z (Girardi et al).

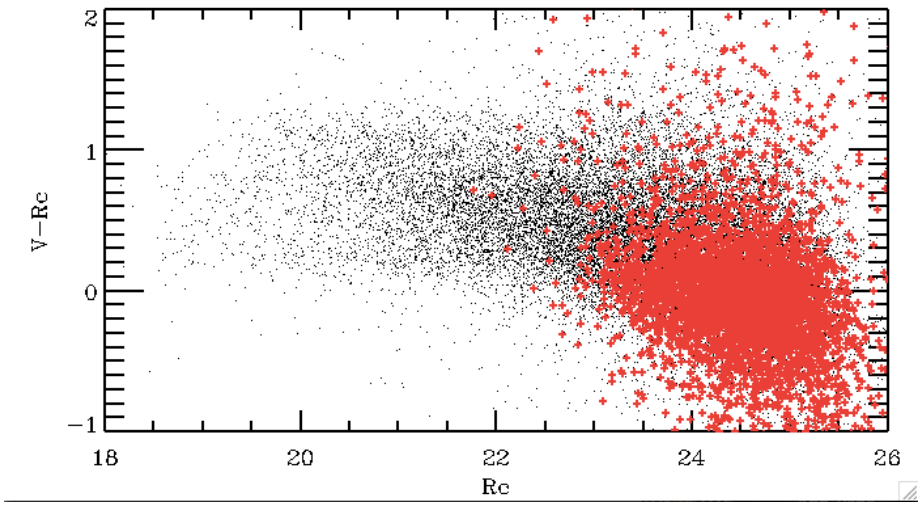
Redshift of sources

$$w = \bar{D}_{\rm ls}/D_{\rm s}$$

Unbiased shear requirement $\sigma_w/w < 0.8$ translates into a natural downweight of Red Sequence. More straightforward than cuts!

8-band case, BgVrRiIz





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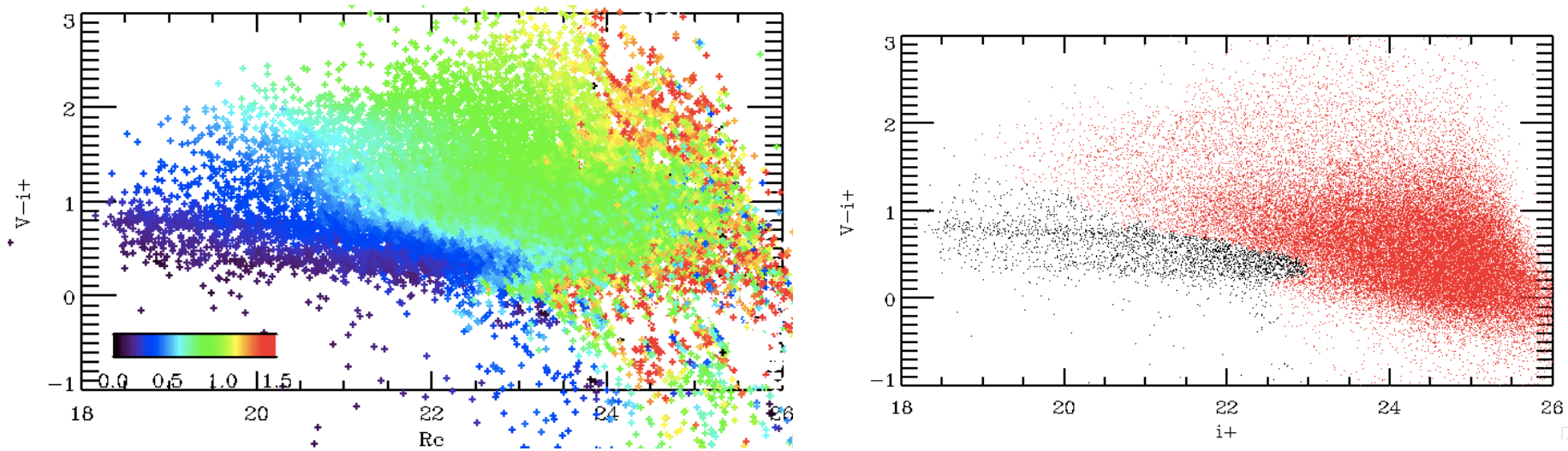
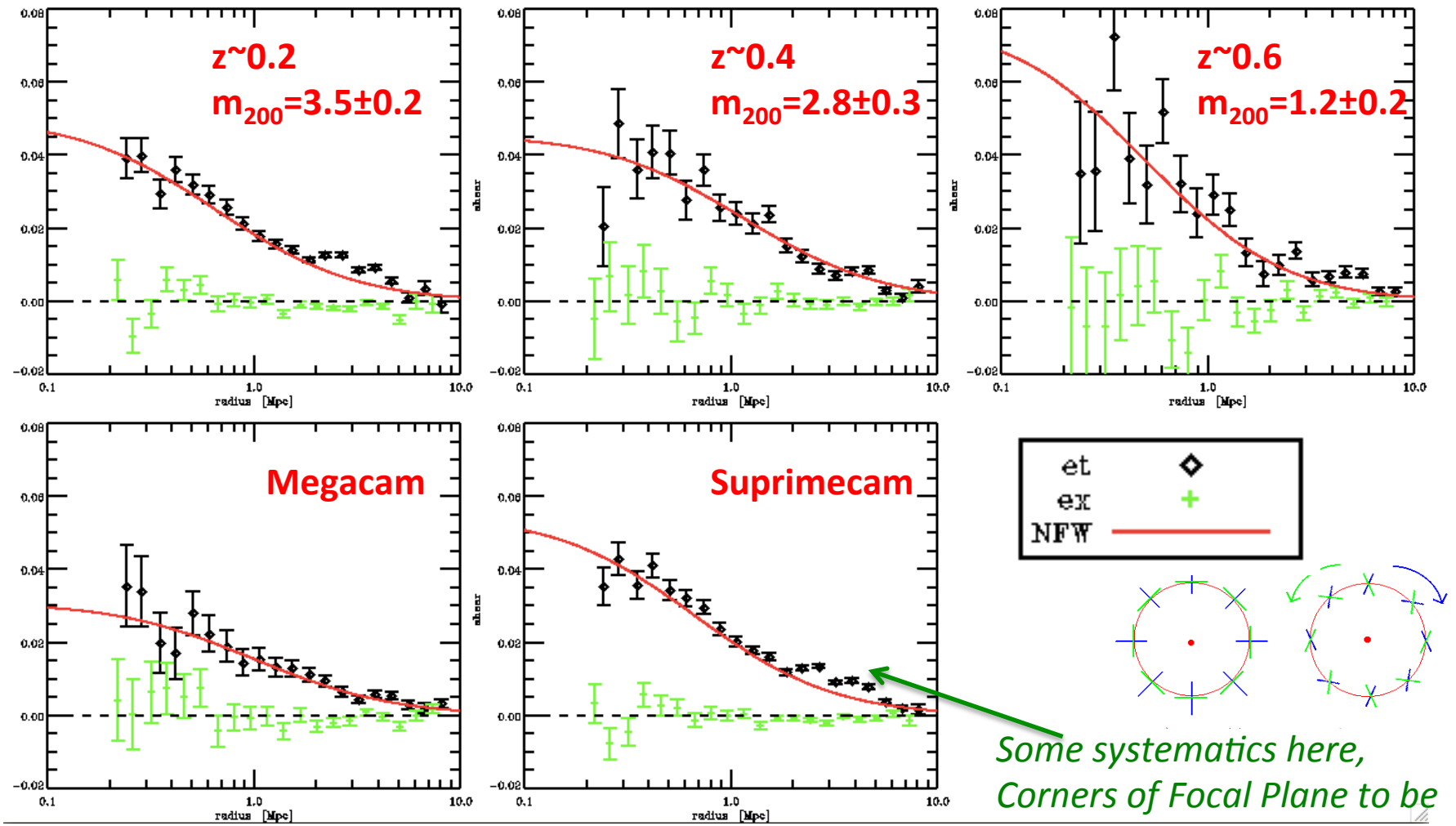
2-band case Vi



Results on clusters masses

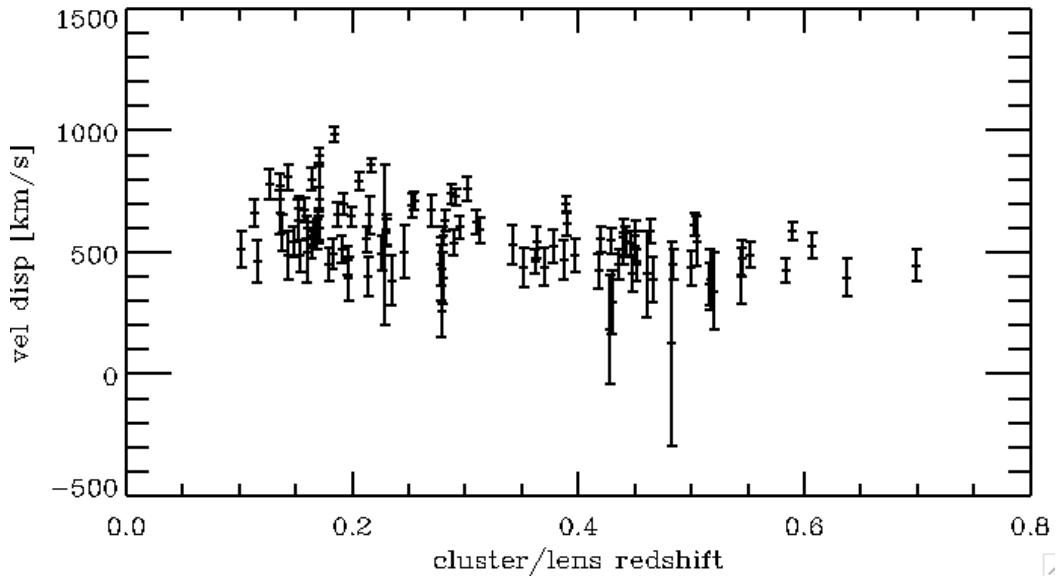
Stacked radial shear profile

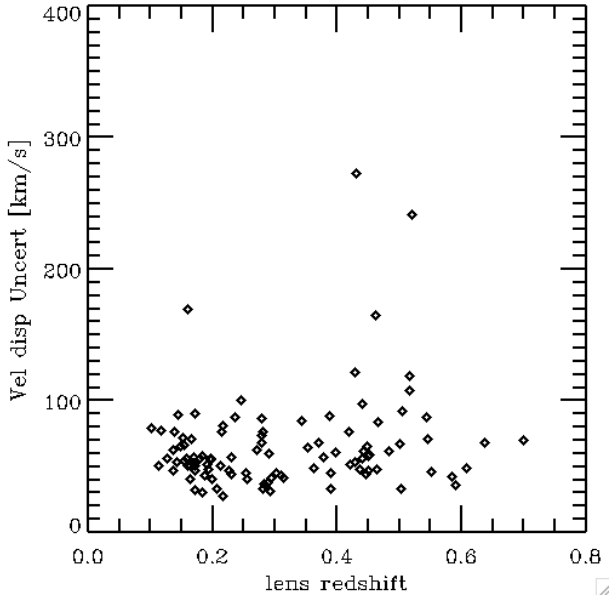
$m_{200}=M_{200}/1e14$

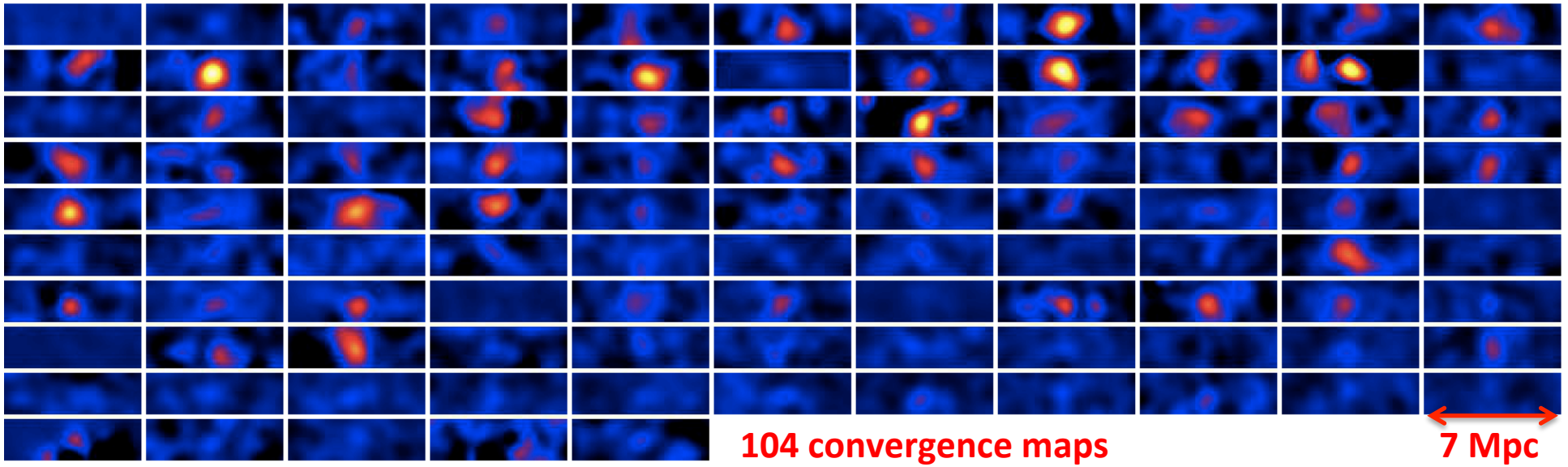


Some systematics here, Corners of Focal Plane to be chopped off…

Results on clusters masses







Results on clusters masses

TBD:

Exhaustive z-spec -- poorman-z & z-spec -- zphot _LePhare comparisons.

compare masses with LOCUSS, Weighing the Giants, CCCP,…

Derive scaling relations with optical richness / X-ray mass proxies

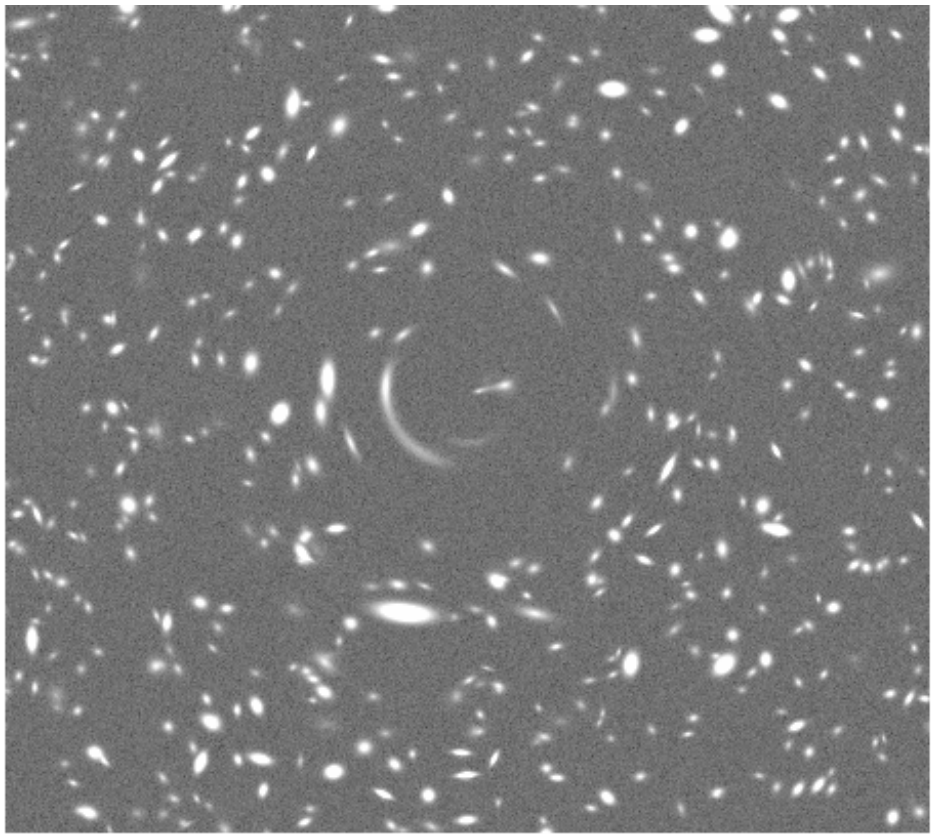
Conclusions

- Largest sample of +/- homogeneous galaxy clusters $0.1 < z < 0.7$
- Mass profiles for 100+ clusters being determined by weak lensing:
- Shapes measured with Sextractor+PSFEx software. Validated with Great3 challenge. Should soon work in individual images.
- Check outermost parts of Suprime FOV. Revisit subtraction of stellar halos (reflexions) especially on Suprime, starflats on Suprime.
- Handling of the redshift distribution of bg sources: flexible enough to cope with small/ variable number of filters, within 3-5% systematics. Should benefit from a more extensive use of WIRCAM (and VISTA) NIR photometry.
- Soon: Weak lensing detailed analysis of cluster members and comparison to field galaxies (CFHTLS). Should yield interesting constraints on the tidal stripping of cluster members!
- Soon: HST ACS/WFC3 archives also mined for detailed strong lensing and flexion studies of cluster cores.

Flexion?

Unlike for shear no public effort/challenge existing so far. Very difficult measurement involving higher order moments of the surface brightness profile. Our own mock images will be used to measure flexion!

So far, tests suggest the so-called noise bias affecting Max-Likelihood (or MAP) estimators is even stronger with flexion than shear!!! Still being tested.



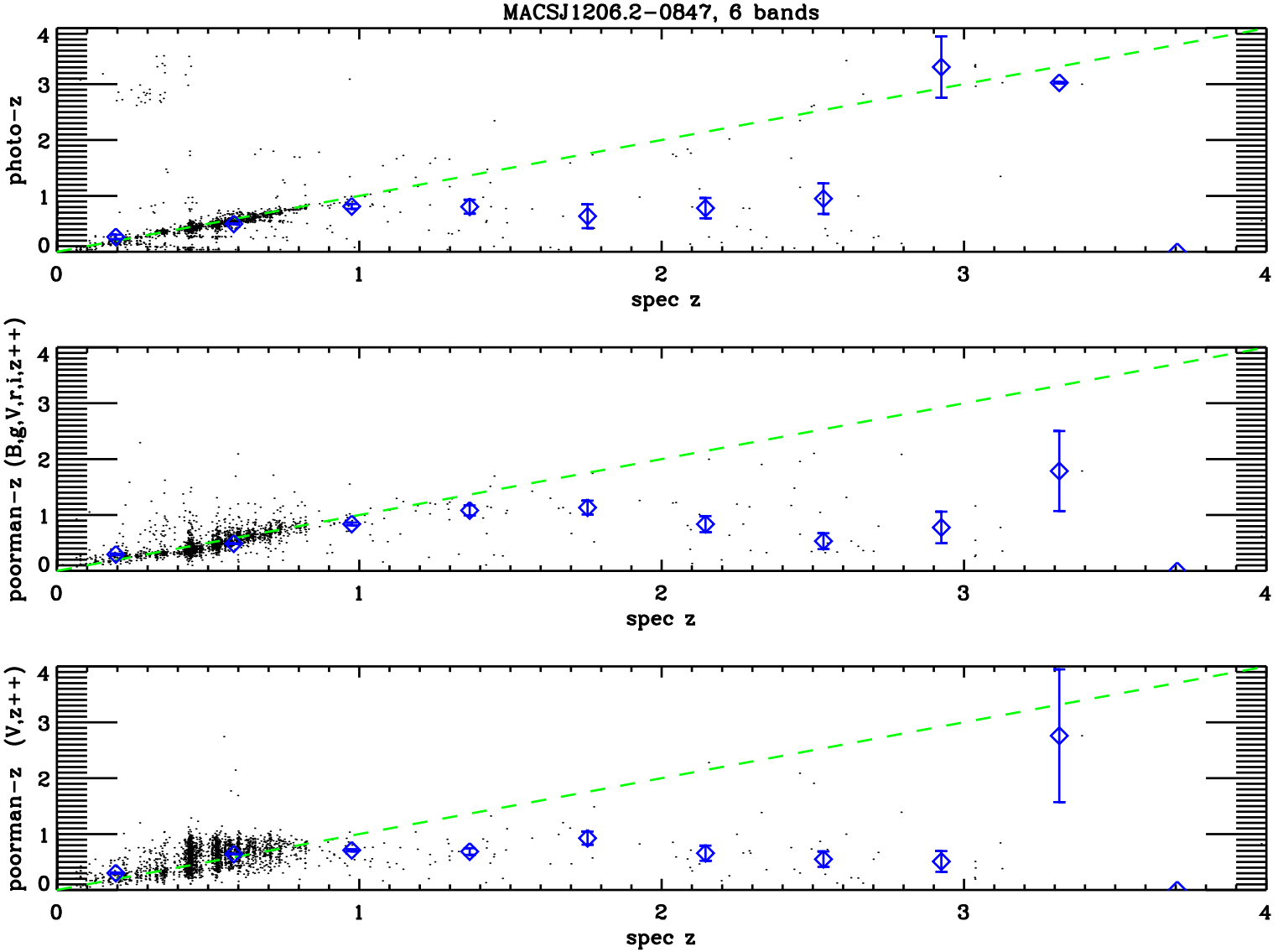
Correction of reflexion halos

BLABLABLA

Illumination correction/starflats

BLABLABLA

Redshift of sources



poorman-z vs CLASH-VLT spec-z.

Redshift of sources