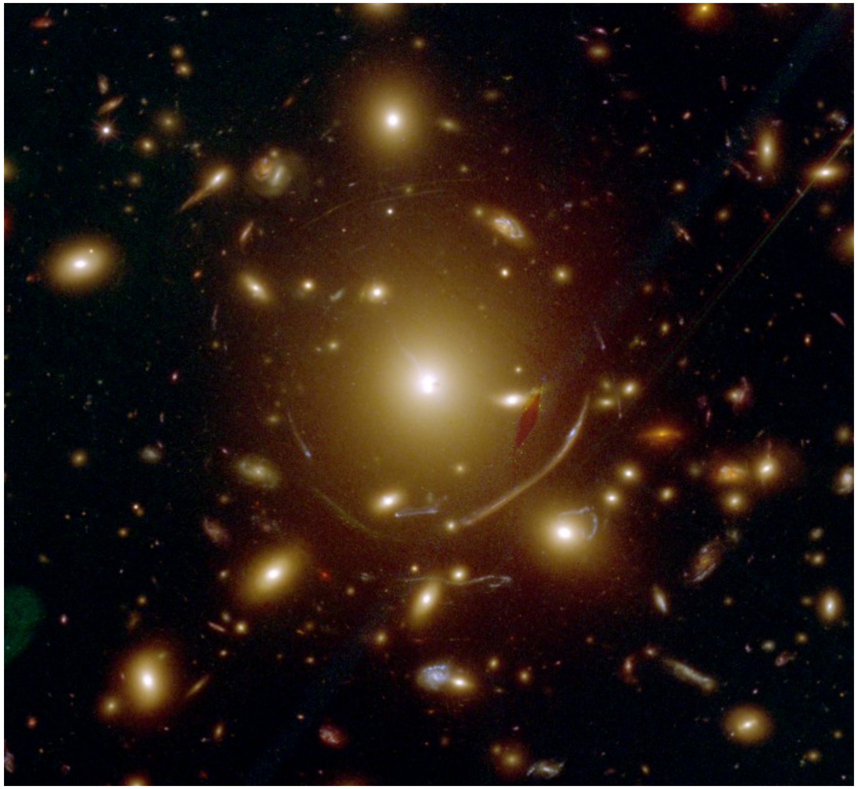
LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Universitäts-Sternwarte München

Constraining the galaxy mass content in the core of clusters like A383: The impact of using velocity dispertion measurements



Monna A, Seitz S., Zitrin A., Geller M.
+CLASH & CLASH-VLT teams

Yale FF Workshop

Anna Monna

Why bothering about galaxies in clusters lensing modelling?

Cluster members have direct impact on the lensing features observeing cluster cores

We cannot neglect them.

(Natarajan & Kneib 1997,2011)

Parametric modelling: too many free parameters when including cluster members

We use Luminosity scaling relations

(e.g. Jullo et al. 2007, Eichner et al. 2013)

Can we improve our knowledge of the scaling relation, i.e. of the galaxies in cluster core?

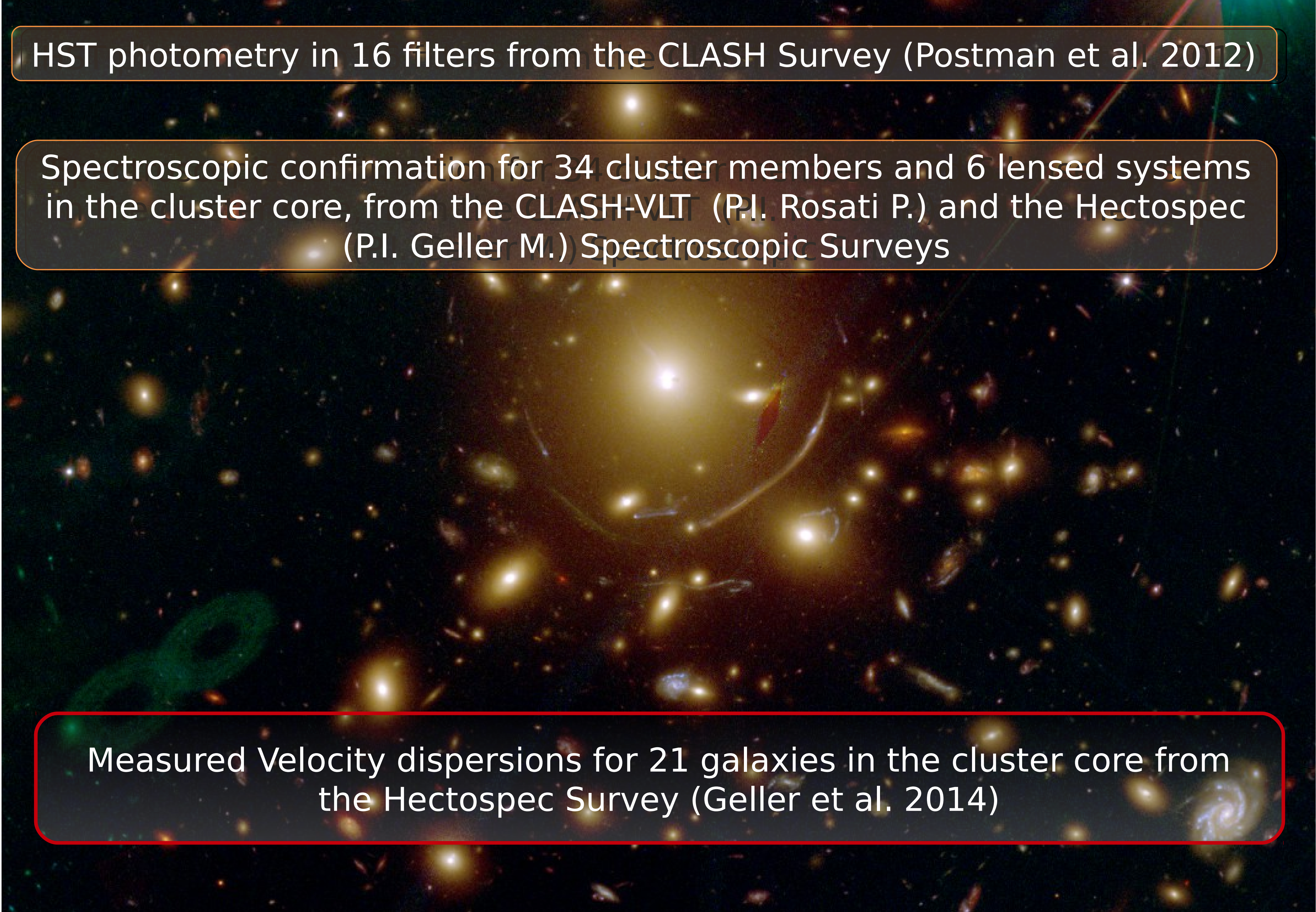
What if we use measurement of cluster members velocity dispersions?

The case of Abell 383 (z~0.189)

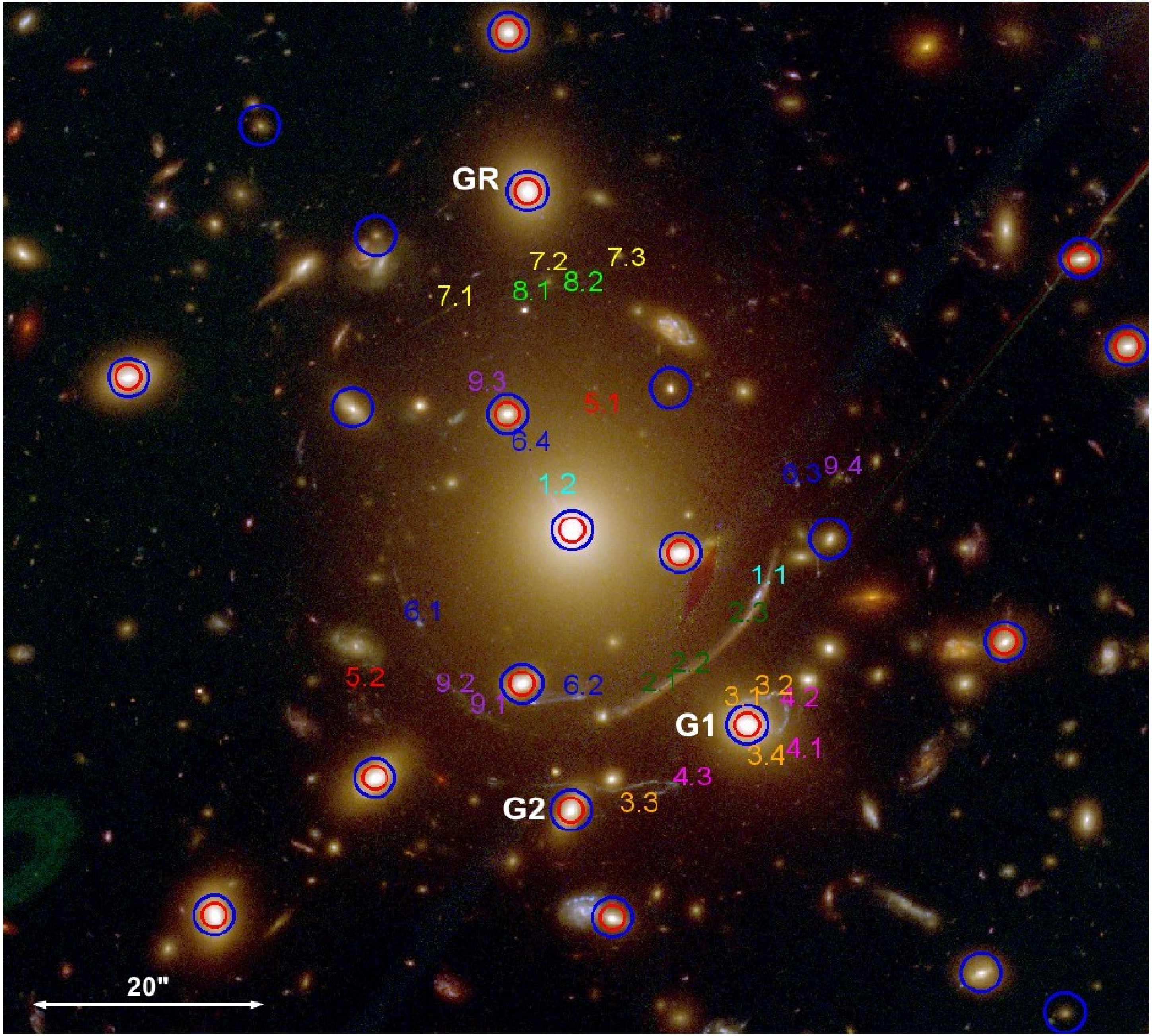
HST photometry in 16 filters from the CLASH Survey (Postman et al. 2012)

Spectroscopic confirmation for 34 cluster members and 6 lensed systems in the cluster core, from the CLASH-VLT (P.I. Rosati P.) and the Hectospec (P.I. Geller M.) Spectroscopic Surveys

Measured Velocity dispersions for 21 galaxies in the cluster core from the Hectospec Survey (Geller et al. 2014)



A383 SL model: Pointlike model+ velocity dispersions



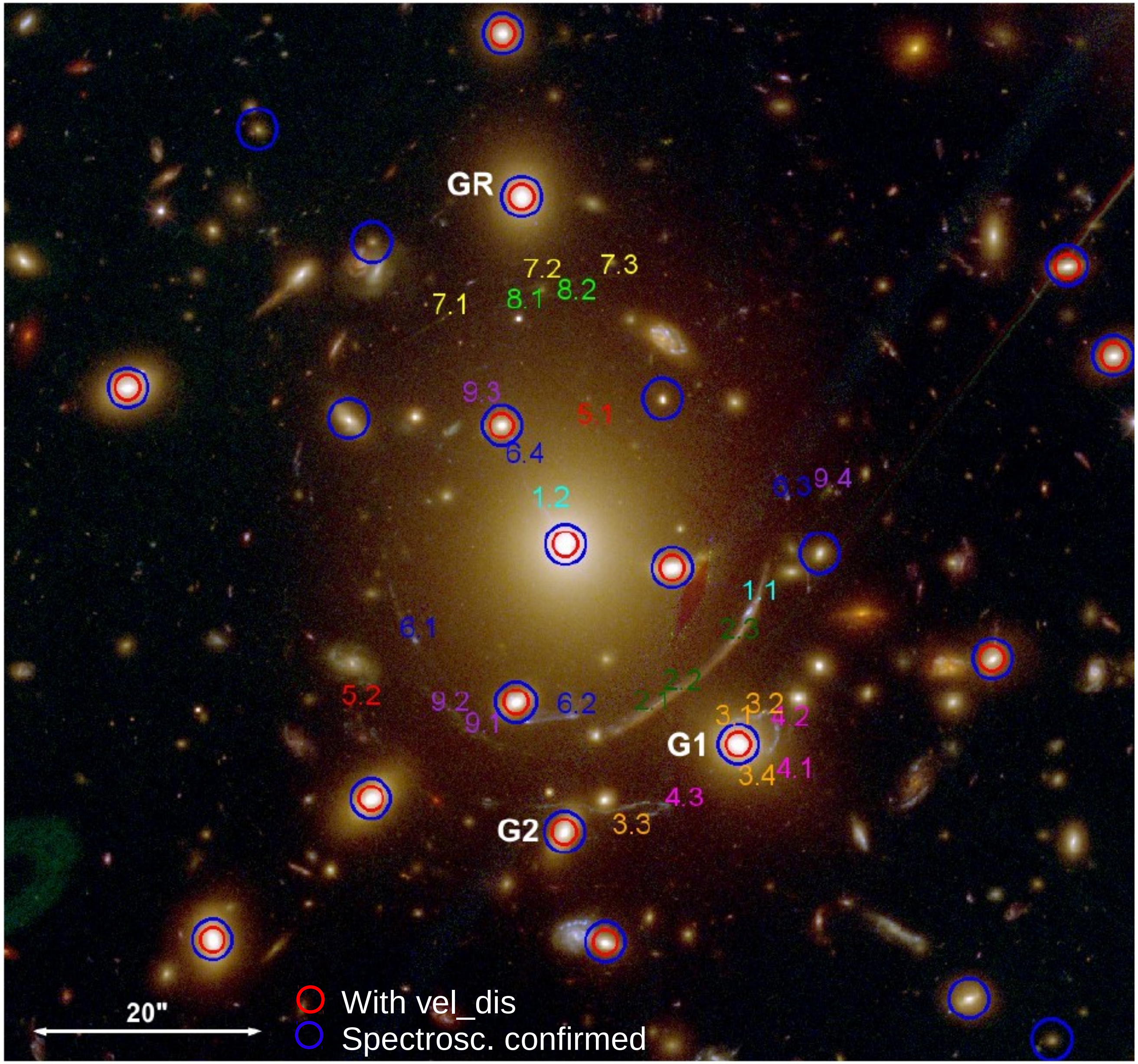
Parallel SL models:

without σ

with σ

What's the impact of measured velocity dispersion in SL models?

A383 Strong Lensing pointlike models (Glee, See Suyu & Halkola 2010)



Constraints

9 systems of multiple images From Zitrin et al. 2011

Mass Components

Smooth Dark Halo (DH) modeled with PIEMD profile

$$\Sigma(R)_{\text{PIEMD}} = \frac{\sigma^2}{2G}\left(\frac{1}{\sqrt{r_c^2 + R^2}}\right)$$

92 Galaxies

(34 from spectroscopy 58 from photometry) modeled with dPIE profiles

- 4 galaxies are individually optimised
- The others are rescaled using the luminosity relations

$$\Sigma(R)_{\text{dPIE}} = \frac{\sigma^2}{2GR}\frac{r_{tr}^2}{r_{tr}^2 - r_c^2}\left(\frac{1}{\sqrt{1 + r_c^2/R^2}} - \frac{1}{\sqrt{1 + r_{tr}^2/R^2}}\right) \qquad M_{\text{tot}} = \frac{\pi\sigma^2 r_{\text{t}}}{G}$$

Galaxies' Luminosity Scaling Relations

(see e.g. Jullo et al. 2007, Halkola et al. 2007, Eichner et al. 2013)

Faber-Jackson Relation

$$\sigma = \sigma^* \left(\frac{L}{L^*}\right)^{\delta}$$

Fundamental Plane

$$r_{\rm t} = r_{\rm t}^* \left(\frac{L}{L^*}\right)^{\alpha} = r_{\rm t}^* \left(\frac{\sigma}{\sigma^*}\right)^{\frac{\alpha}{\delta}}$$

Mass to Light Ratio

$$\frac{M_{\rm tot}}{L} \propto L^{\epsilon}$$

$$\boxed{\alpha = \epsilon - 2\delta + 1}$$

ε=0 → compromise between field (ε=0.2) and stripped (ε=-0.3) galaxies

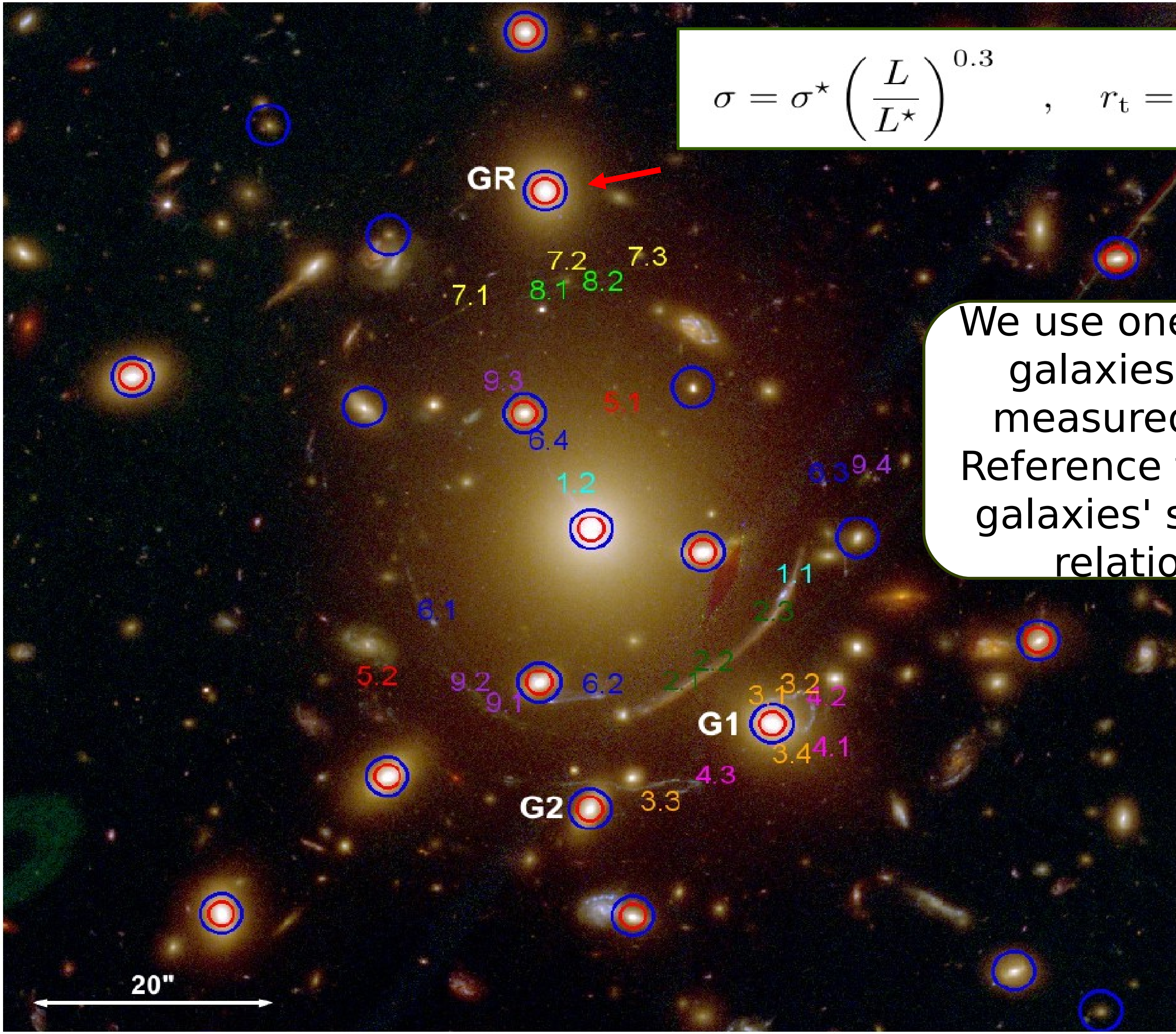
δ=0.3 → Measured from the Hectospec sample

α=0.4

$$M_{\rm tot} = \frac{\pi \sigma^2 r_{\rm t}}{\rm G}$$

$$\boxed{\sigma = \sigma^{\star} \left(\frac{L}{L^{\star}}\right)^{0.3} \quad , \quad r_{\rm t} = r_{\rm t}^{\star} \left(\frac{\sigma}{\sigma^{\star}}\right)^{\frac{4}{3}}}$$

A383 SL model: Pointlike model+ velocity dispersions

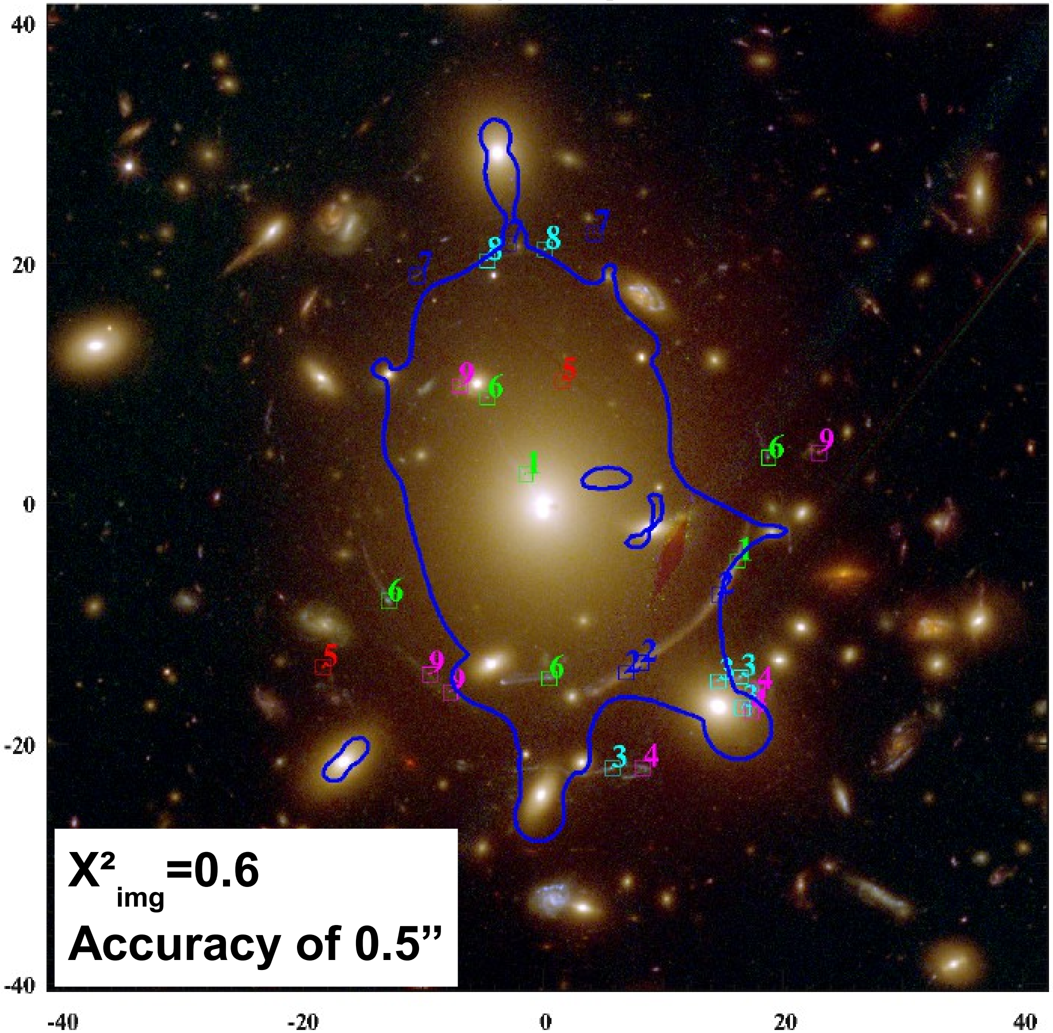


$$\sigma = \sigma^\star \left(\frac{L}{L^\star} \right)^{0.3} \quad , \quad r_t = r_t^\star \left(\frac{\sigma}{\sigma^\star} \right)^{\frac{4}{3}}$$

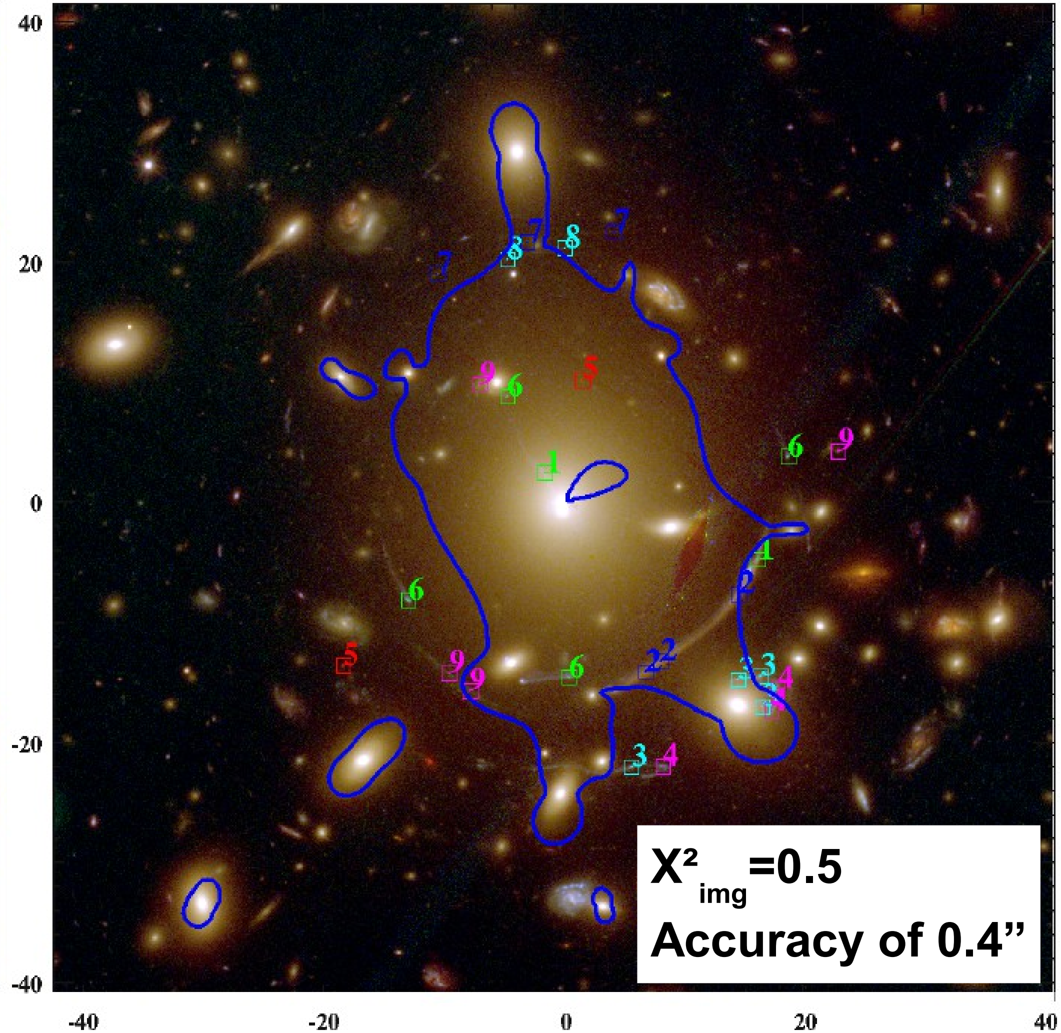
We use one of the galaxies with measured σ as Reference for the galaxies' scaling relations

A383 Pointlike models

Without velocity dispersions



With velocity dispersions

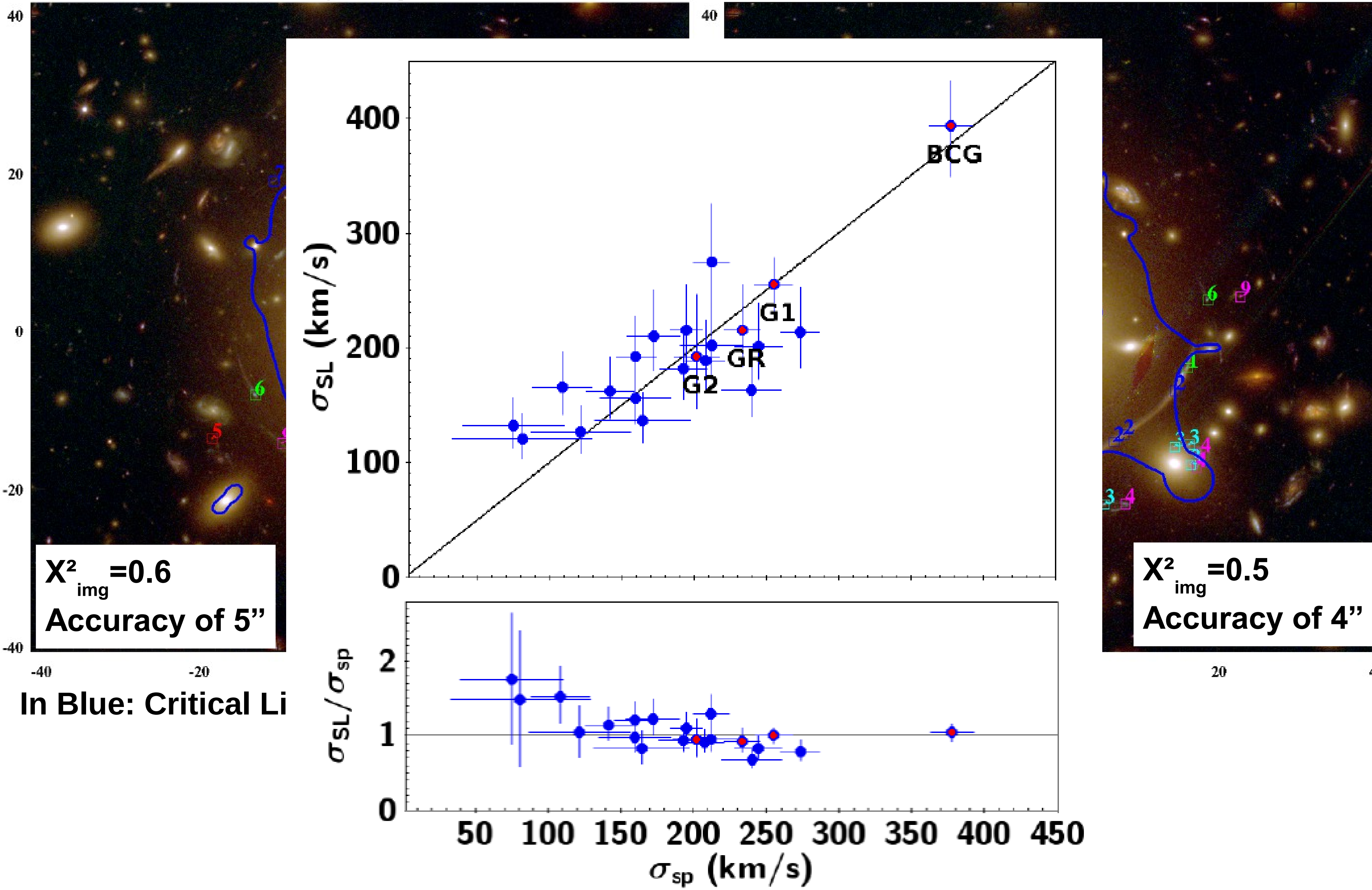


In Blue: Critical Lines for a source at z=2.85

A383 Pointlike models

Without velocity dispersions

With velocity dispersions



In Blue: Critical Li

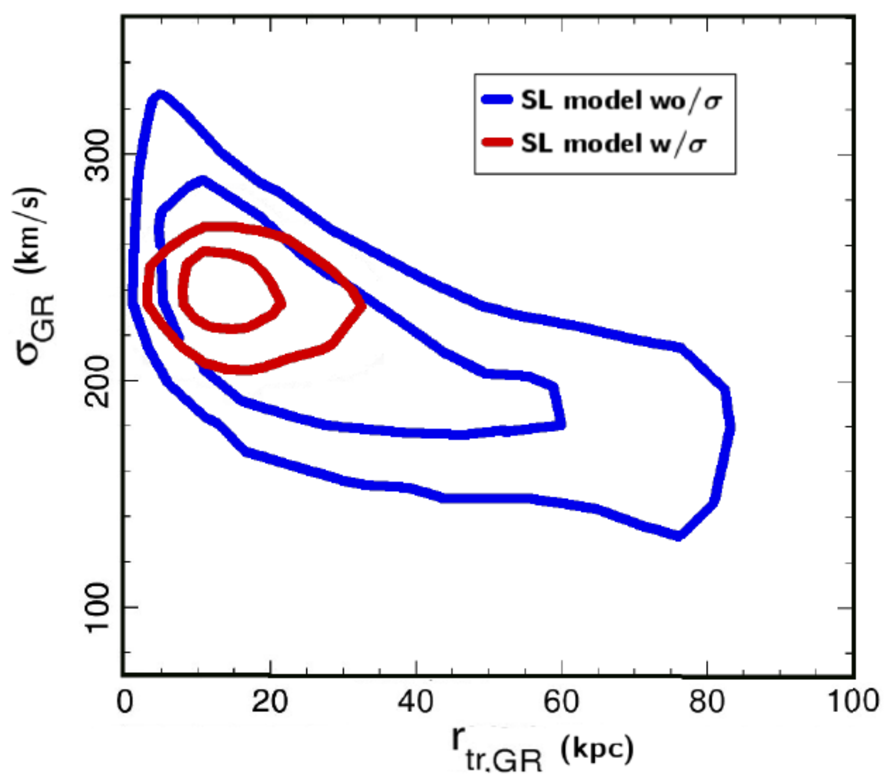
A383 Pointlike models

The constraints on the DH are refined by ~10%

For the reference galaxy, they improve by ~50%

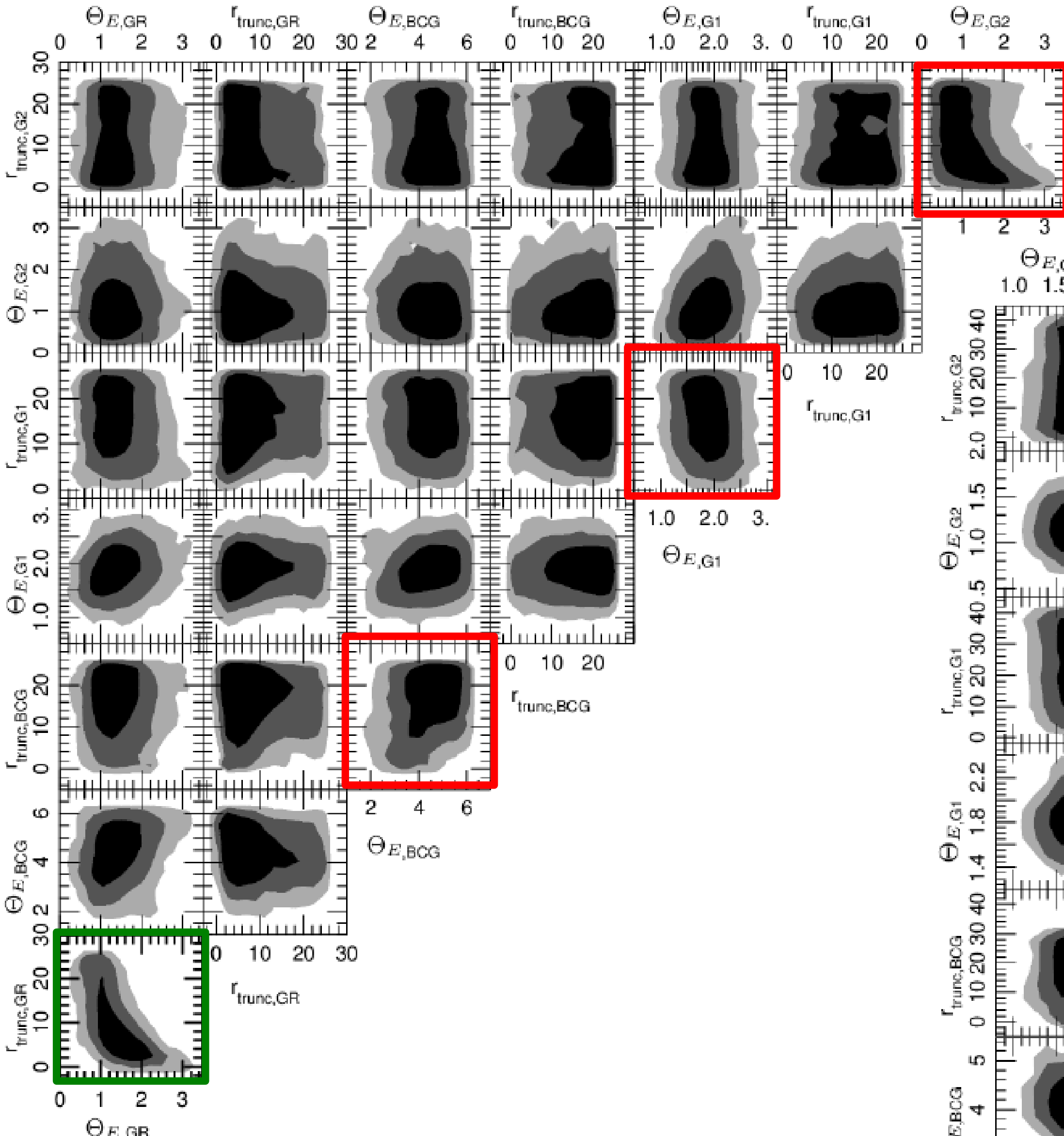
$$r_{tr,wo/\sigma} = 23.1^{+29.4}_{-12.8}\text{kpc}\left(\frac{\sigma}{214^{+40}_{-32}\,\text{km/s}}\right)^{\frac{4}{3}}$$

$$r_{tr,w/\sigma} = 13.2^{+6.2}_{-4.3}\text{kpc}\left(\frac{\sigma}{238 \pm 15\,\text{km/s}}\right)^{\frac{4}{3}}$$

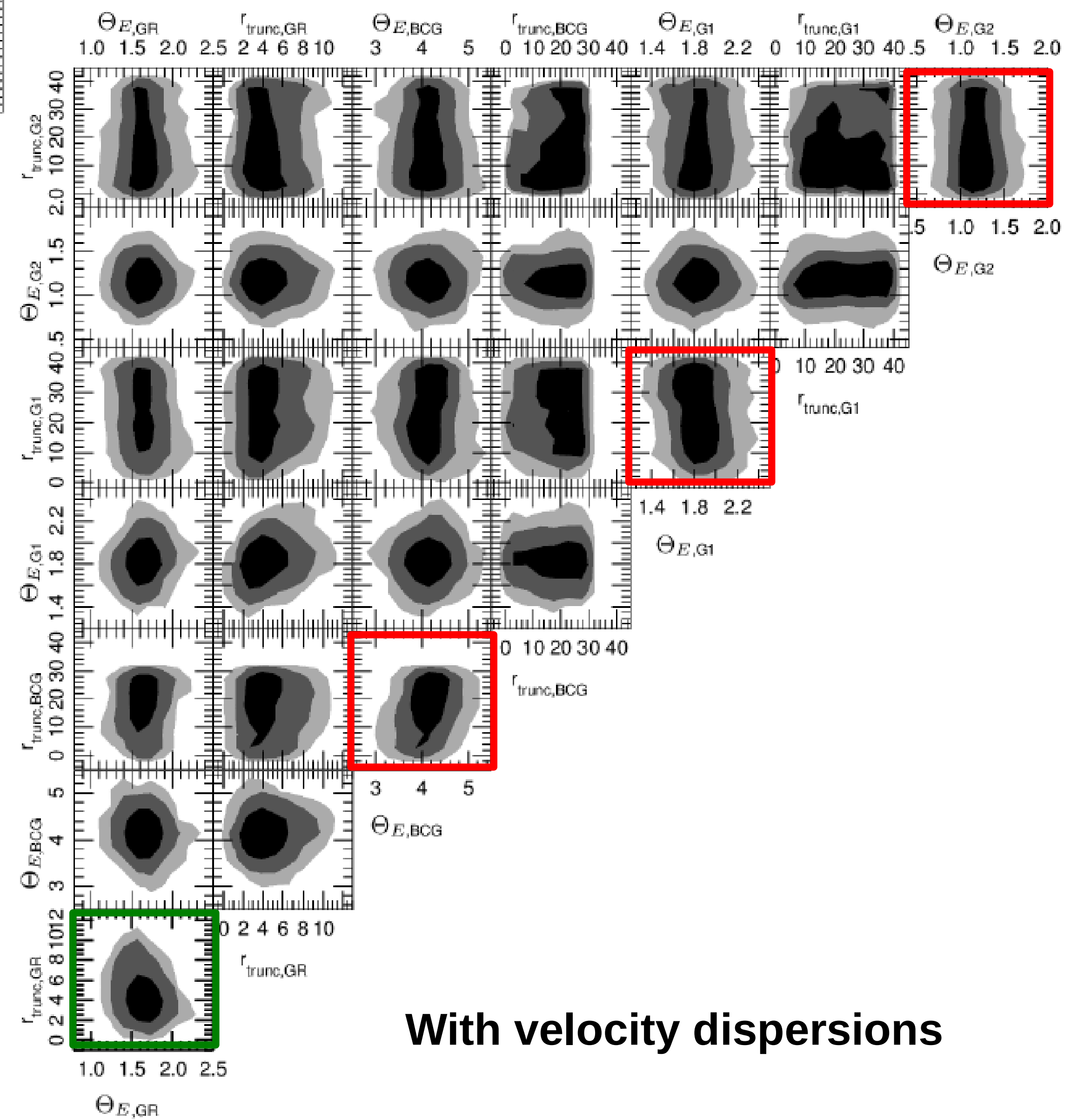


Param	wo/σ	w/σ
External shear		
γ	0.07 ± 0.03	0.04 ± 0.02
$\theta[°]$	51^{+17}_{-11}	37^{+17}_{-26}
Dark Halo		
δx [$''$]	0.7 ± 0.5	1.0 ± 0.4
δy [$''$]	1.0 ± 0.8	$2.4^{+0.4}_{-0.6}$
PA [°]	88^{+10}_{-14}	111 ± 20
b/a	0.8 ± 0.1	0.90 ± 0.06
θ_E [$''$]	$11.6^{+2.3}_{-1.9}$	$11.1^{+2.1}_{-1.6}$
r_{core} [kpc]	$37.5^{+5.6}_{-7.7}$	$39.5^{+5.3}_{-5.7}$
BCG		
PA [°]	$94° \pm 23°$	$98° \pm 9°$
b/a	$0.61^{+0.18}_{-0.15}$	$0.60^{+0.17}_{-0.13}$
σ [km/s]	395^{+39}_{-44}	379 ± 21
r_{tr} [kpc]	$53.1^{+15.6}_{-25.0}$	$58.4^{+24.9}_{-33.2}$
GR		
σ [km/s]	214^{+40}_{-32}	238 ± 15
r_{tr} [kpc]	$23.1^{+29.4}_{-12.8}$	$13.2^{+6.2}_{-4.3}$
G1		
σ [km/s]	253 ± 23	252 ± 14
r_{tr} [kpc]	47.8 ± 20.9	$73.1^{+38.7}_{-35.5}$
G2		
σ [km/s]	194^{+54}_{-45}	201 ± 20
r_{tr} [kpc]	$32.2^{+31.5}_{-23.4}$	$53.2^{+49.2}_{-36.3}$

A383 Pointlike models



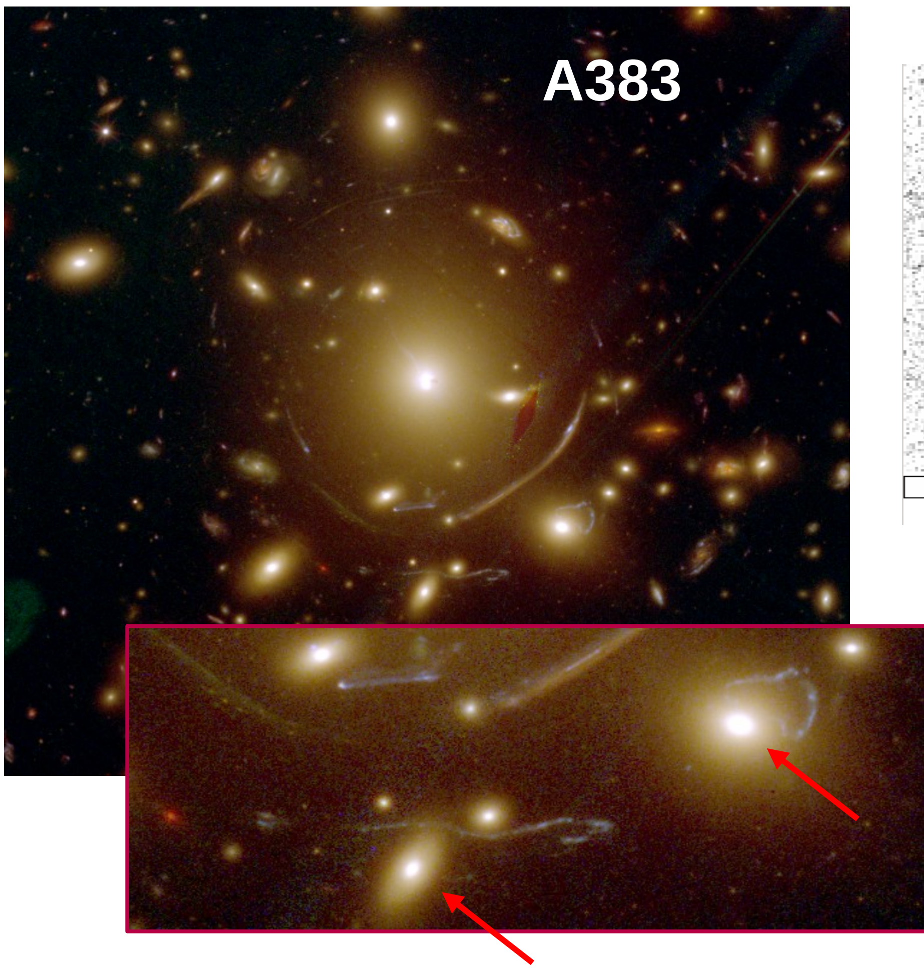
Without velocity dispersions



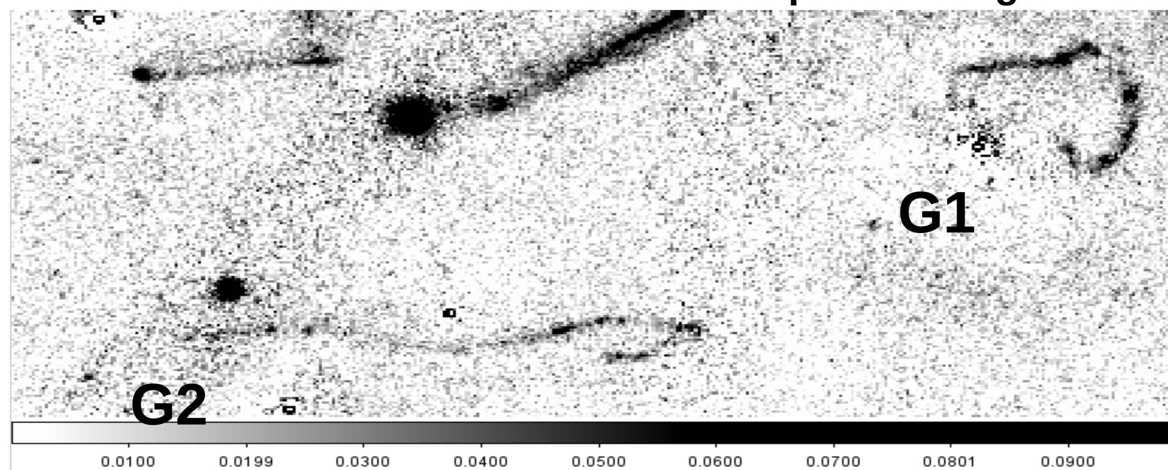
With velocity dispersions

A383: Surface Brightness reconstruction

Surface Brightness reconstruction of the blue arcs at z_s=2.58 in HST/F775 image



Galaxies subtracted with the SNUC[1] isophote fitting routine



GLEE:
Linear inversion method to reconstruct the pixellated source brightness + regularization of the source

+

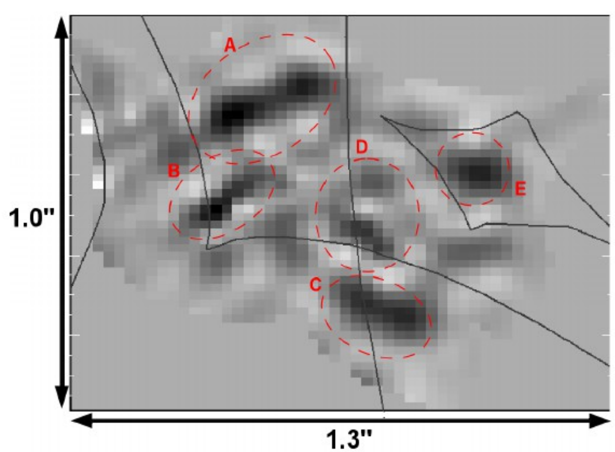
Measured σ^{sp} for G1&G2

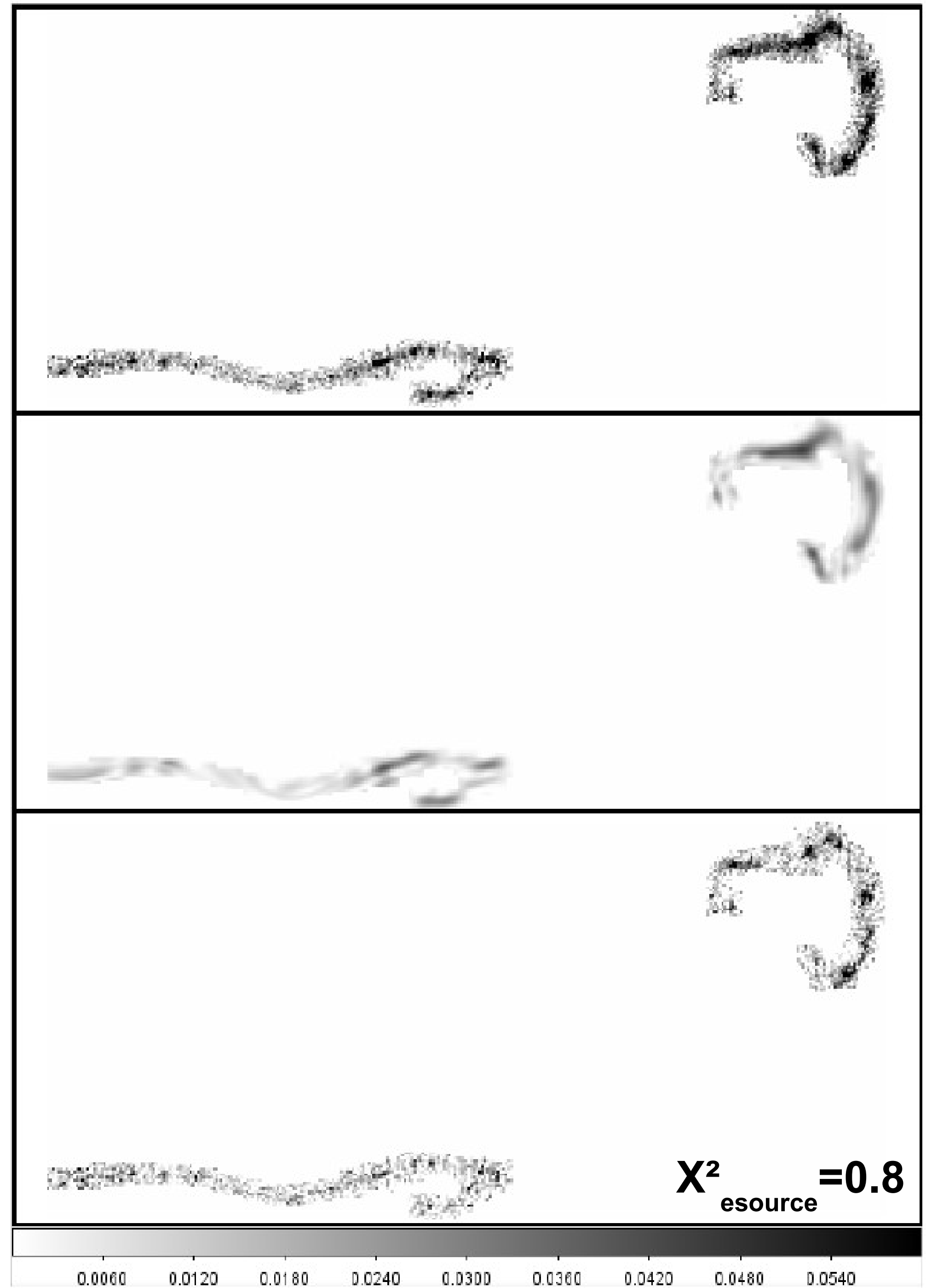
Modeled with dPIE profiles

[1] http://astronomy.nmsu.edu/holtz/xvista/index.html

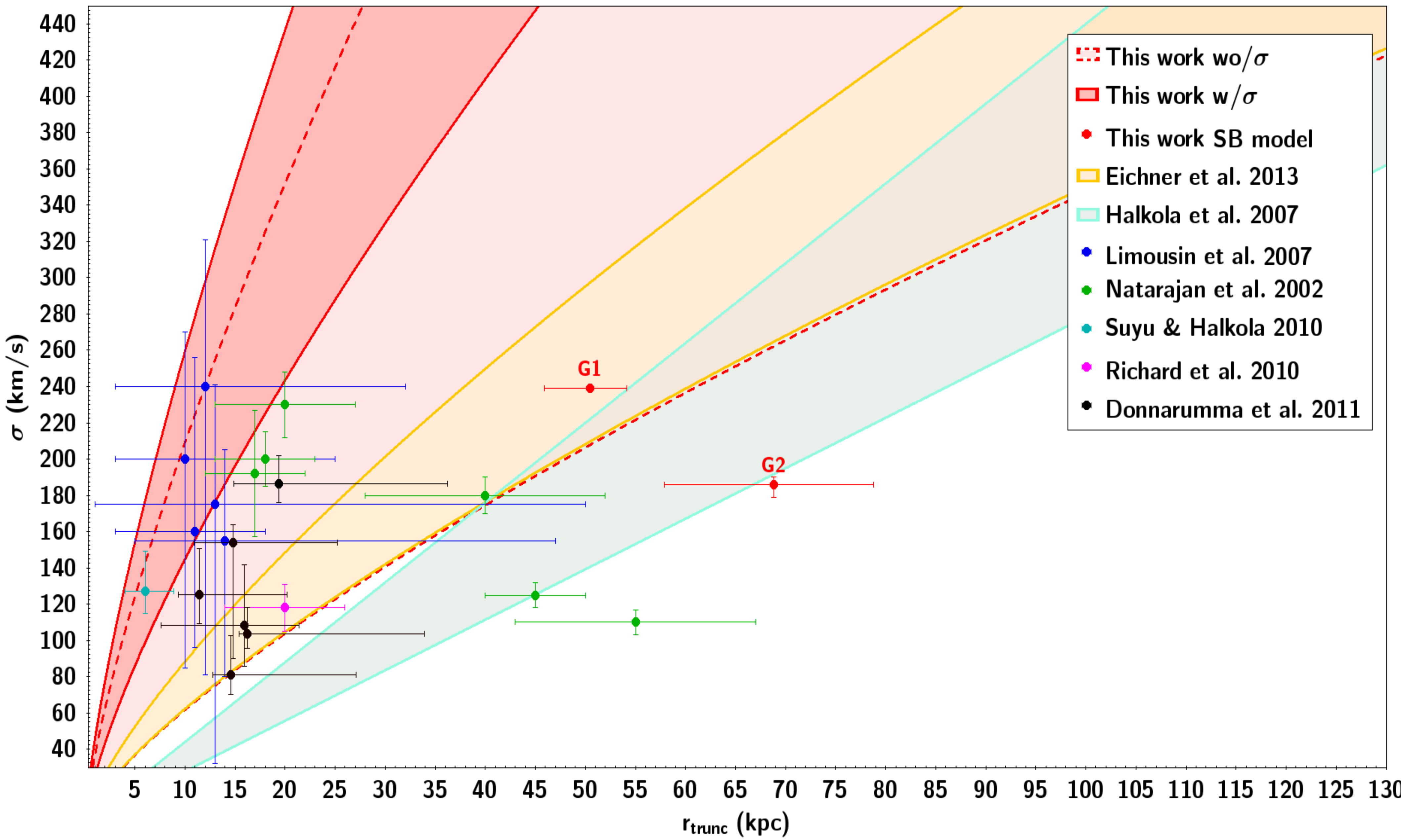
A383 Surface Brightness reconstruction

Galaxy	wo/σ	w/σ	Ext_model
G1			
b/a	0.8	0.8	0.82 ± 0.01
PA	151	151	150.7 ± 0.6
σ [km/s]	253 ± 23	252 ± 14	239 ± 2
r_{core} [kpc]	0.	0.	1.3 ± 0.1
r_{tr} [kpc]	47.8 ± 20.9	$56.8^{+24.8}_{-25.6}$	$50.5^{+3.6}_{-4.6}$
$M\,[10^{12} M_\odot]$	2.2 ± 1.4	$2.6^{+1.4}_{-1.5}$	2.1 ± 0.2
G2			
b/a	0.58	0.58	0.57 ± 0.01
PA	63	63	63 ± 1
σ [km/s]	194^{+54}_{-45}	201 ± 20	186^{+4}_{-7}
r_{core} [kpc]	0.	0.	$0.3^{+0.3}_{-0.2}$
r_{tr} [kpc]	$32.2^{+31.5}_{-23.4}$	$53.2^{+49.2}_{-36.3}$	$68.8^{+10.0}_{-10.9}$
$M_{tot}\,[10^{12} M_\odot]$	$0.9^{+1.3}_{-1.1}$	$1.6^{+1.8}_{-1.4}$	1.7 ± 1.3





A383 Scaling Relations:



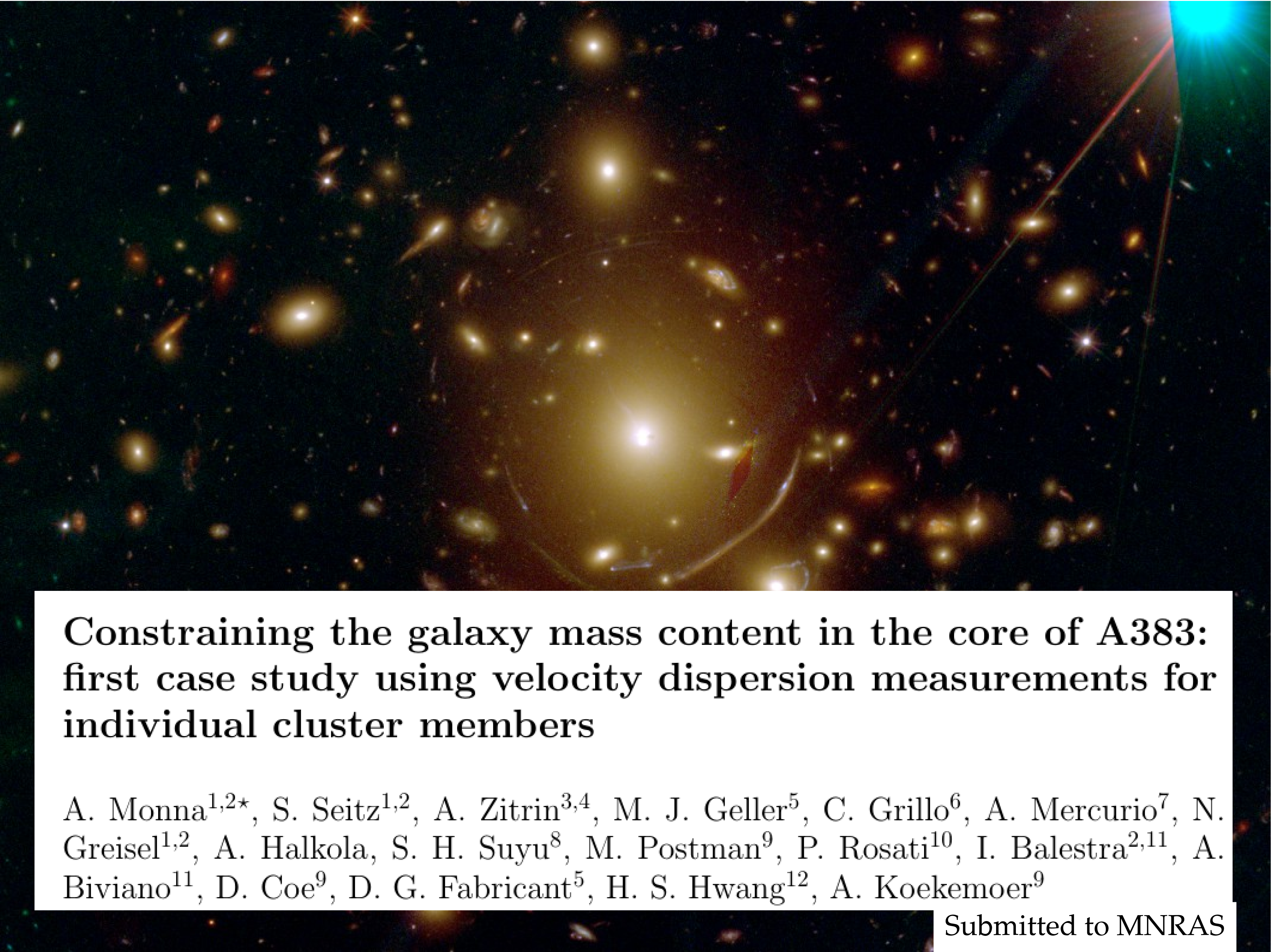
Conclusions

- **Strong lensing prediction of cluster members' σ are in good agreements with measured σ_{sp}**

- **Including measurements of velocity dispersions of the cluster members in SL analysis**
  - **- improves the accuracy of the models**
  - **- improves the constraints on the DH (by ~10%)**
  - **- allows to break the degeneracy between r_t and σ of GR**

- **Surface brightness reconstruction of giant arcs**
  - **- breaks the degeneracy between r_t and σ of galaxies close to the giant arcs, which have measured σ**

- **Future Work: we plan to apply this analysis to other galaxy clusters which have measurements of cluster members σ**



Constraining the galaxy mass content in the core of A383: first case study using velocity dispersion measurements for individual cluster members

A. Monna[1,2⋆], S. Seitz[1,2], A. Zitrin[3,4], M. J. Geller[5], C. Grillo[6], A. Mercurio[7], N. Greisel[1,2], A. Halkola, S. H. Suyu[8], M. Postman[9], P. Rosati[10], I. Balestra[2,11], A. Biviano[11], D. Coe[9], D. G. Fabricant[5], H. S. Hwang[12], A. Koekemoer[9]

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