CONSTRAINING THE DARK MATTER PROPERTIES IN INTERMEDIATE REDSHIFT CLUSTERS OF GALAXIES

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Université Paul Sabatier

in collaboration with
SOUCAIL G., LIMOUSIN M., RICHARD J. (Lensing team)
POINTECOUTEAU E., ARNAUD M. & PRATT G.W. (Xray team)

SCIENTIFIC GOALS

Clusters of galaxies are usefull for :

+ cosmology tool : number counts, mass function
+ formation/evolution of structures : signature of non grav. process in scaling relations (*e.g.* M-Tx), redshift evolution, self-similarity

⇒ Need reliable mass estimators

difficult @ high z ⟶ combine different data sets : Xrays and lensing

in this work : preliminary results from a lensing analysis of a sample of galaxy clusters

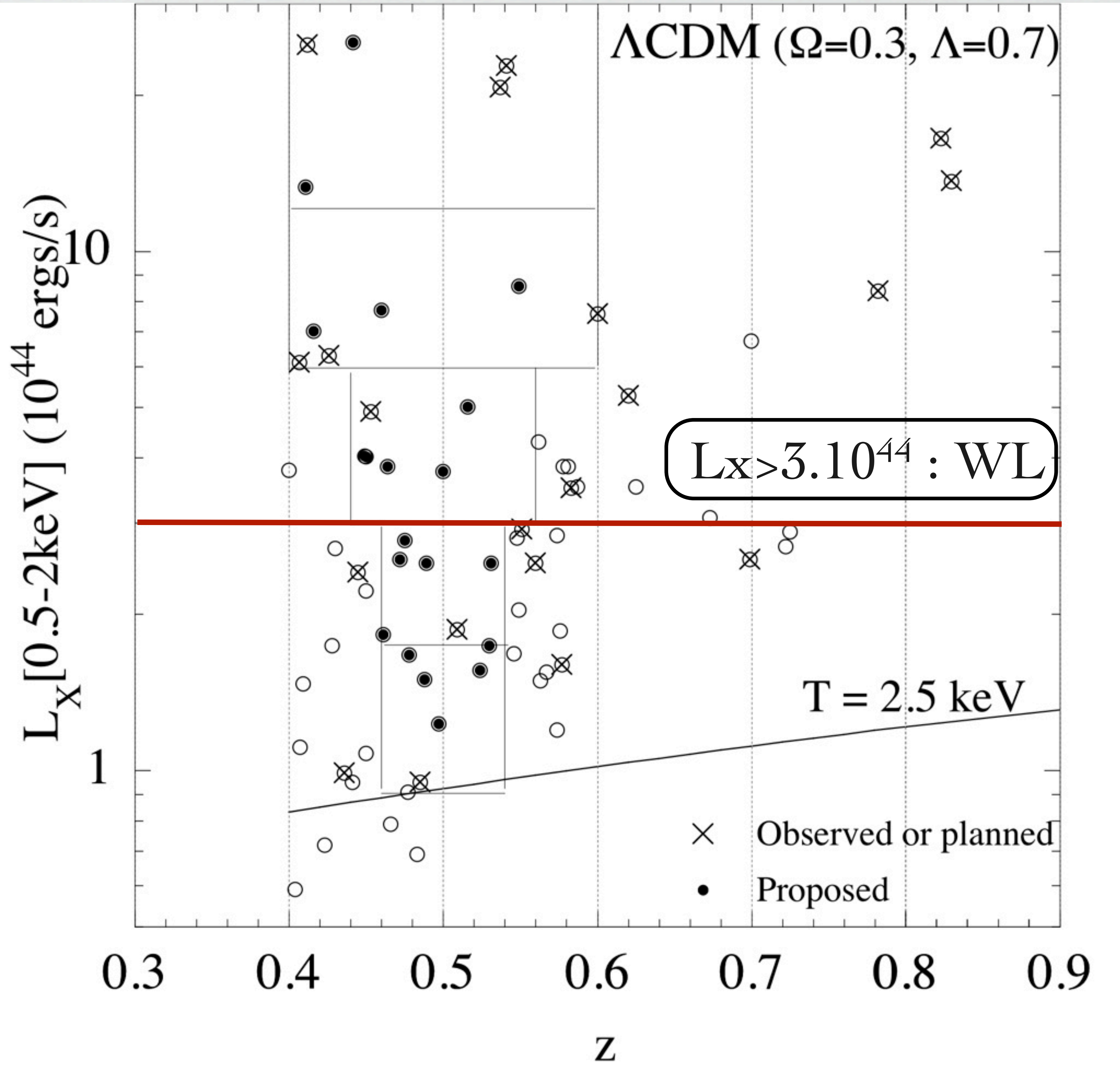
Xrays DATA

XMM-Newton Large Programme
(P.I. M. Arnaud)

unbiased, flux limited sample
20 clusters
2.5 keV < kT < 12 keV
0.4 < z < 0.6
good sampling of Lx

total exposure time ~ 1.1 Msec

defined as the REXCESS sample to compare at low z



LENSING DATA

Megacam @ CFHT
(P.I. G. Soucail)

11 brightest clusters
(Lx>3.10^{44} erg/s)

g' (1.6ksec), **r' (7.2ksec)**
i' (1.2ksec), z' (1.8ksec)

- homogeneous obs.
- good seeing (< 0.8" for r')
- low m_c (~ 26 for r')

weak lensing
+ strong lensing (4 clusters)

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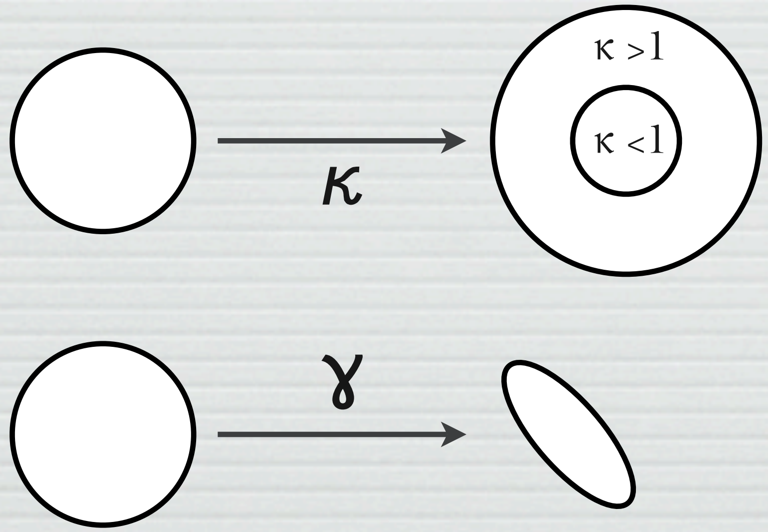
GRAVITATIONAL LENSING BASICS

Deflection of the light by a mass
=f(grav. potential)

2 grav. distorsions :

convergence

shear



high mass density (center) : strong lensing --> arcs, multiple images

low density (outskirt) : weak lensing --> small distorsions, stat. approache

background galaxy ~ ellipse **e**=e_1+ie_2 ⟶ source/image relation : $e = \dfrac{e^{(s)} + g}{1 + g^* e^{(s)}}$

- select galaxies behind a cluster
- mesure <e>, assume <e^s>=0

→ g=f(grav. pot., universe geometry)

⟶ mass

with reduced shear $g = \dfrac{\gamma}{1 - \kappa}$

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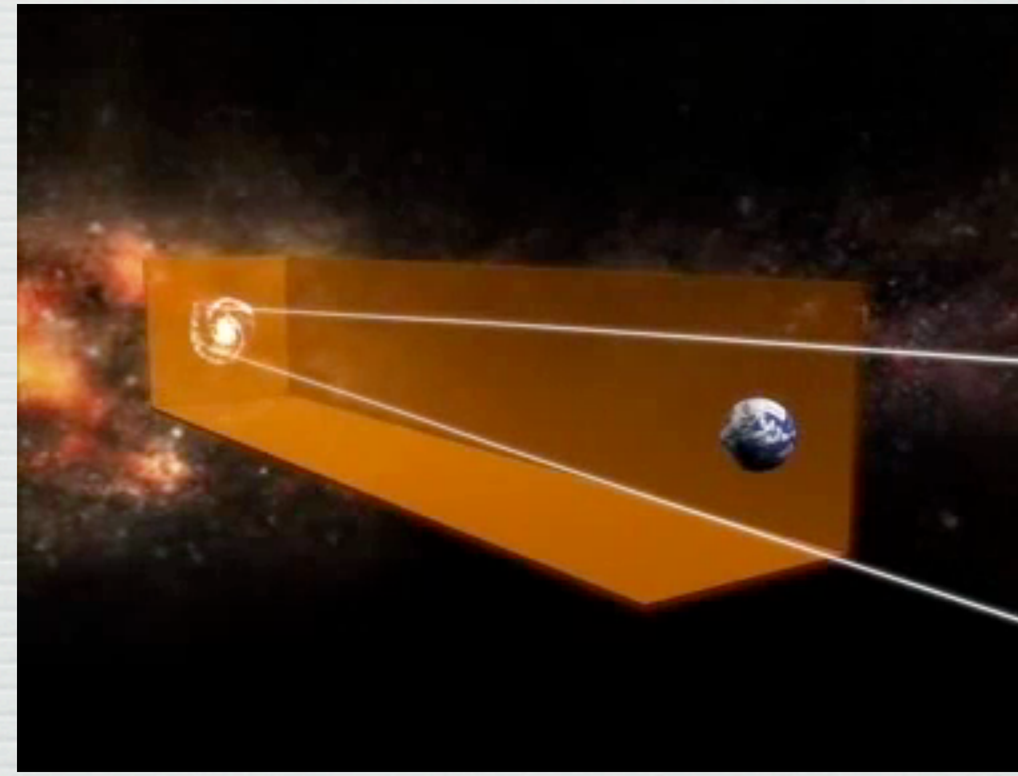

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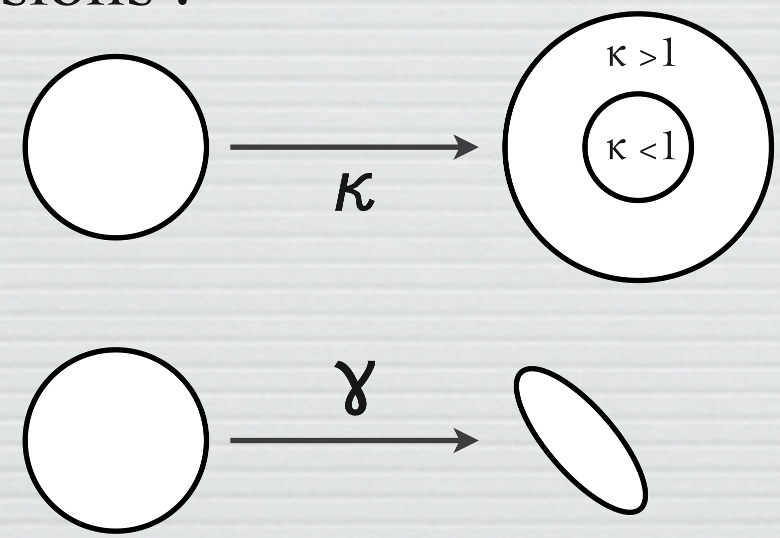

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WEAK LENSING

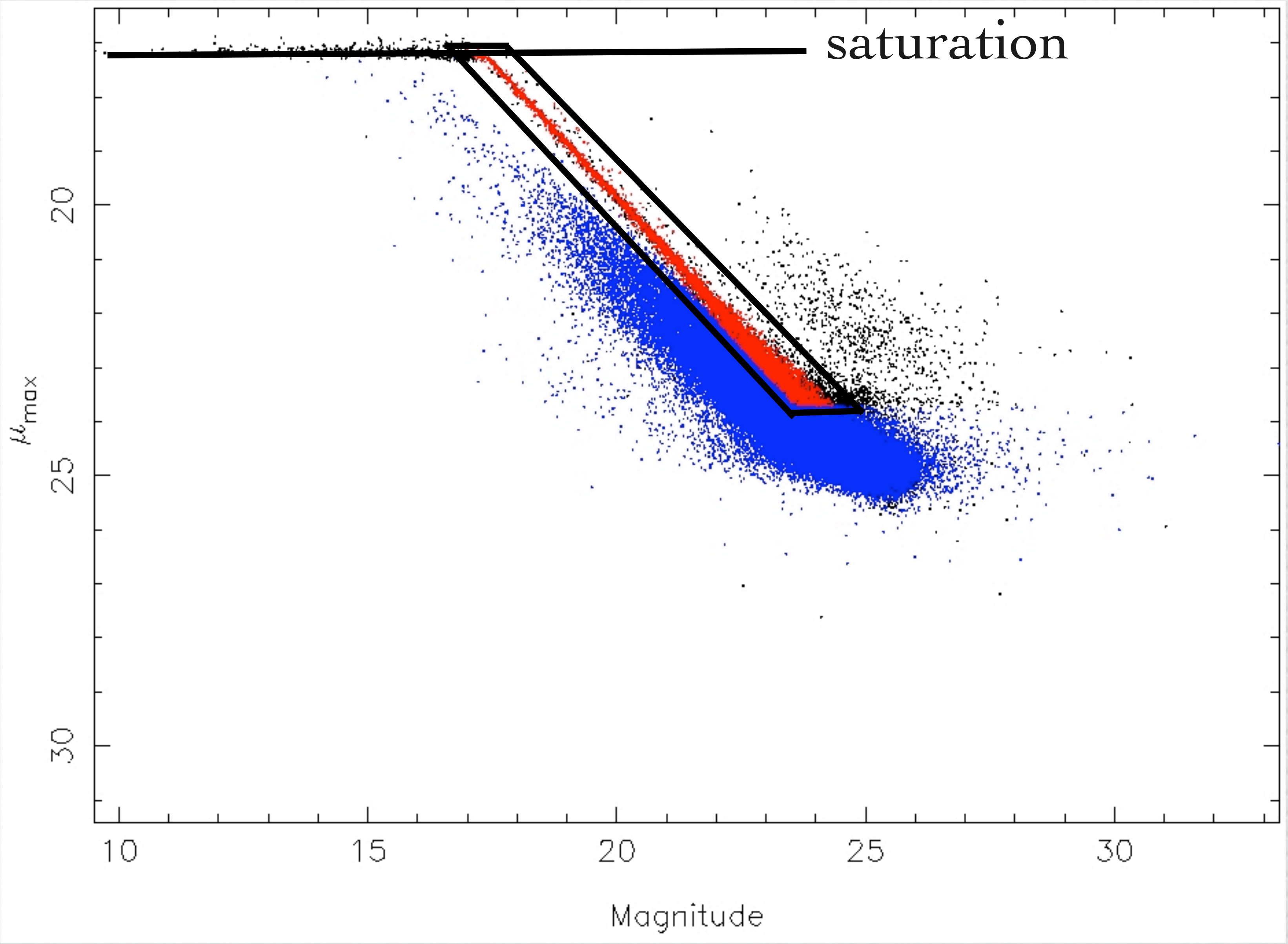
- ☑ star/galaxy separation
- ☐ background members
- ☐ shape parameters
- ☐ geometry of the system

SExtractor
(dual mode on chi2 image)

→ stars (PSF estimation)

→ galaxies (lensing sources)

mag/flux + size/stellarity criteria



RXJ1120.0+3254

WEAK LENSING

- [x] star/galaxy separation
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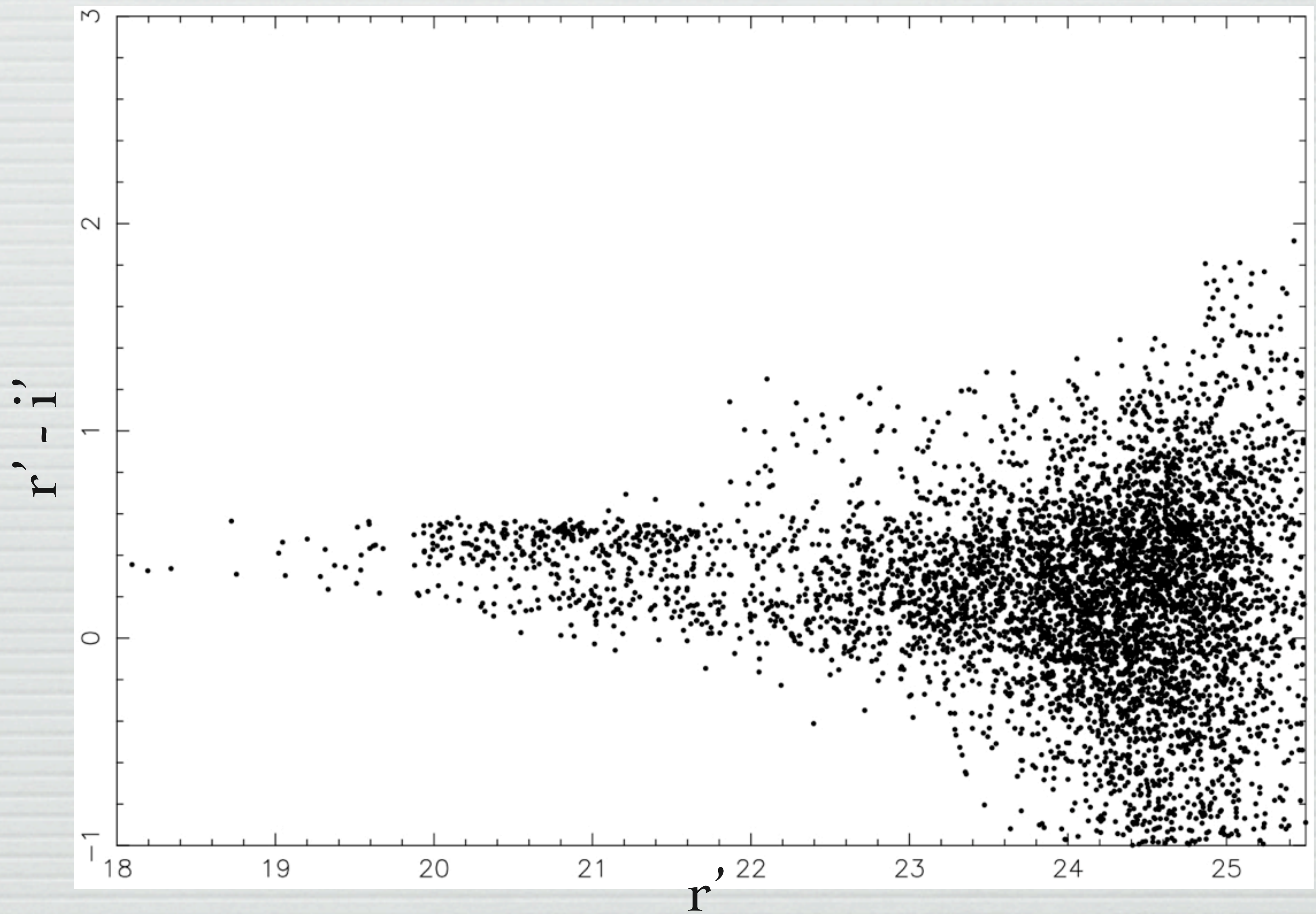
- [ ] geometry of the system



RXJ2228.5+2036

WEAK LENSING

- [x] star/galaxy separation
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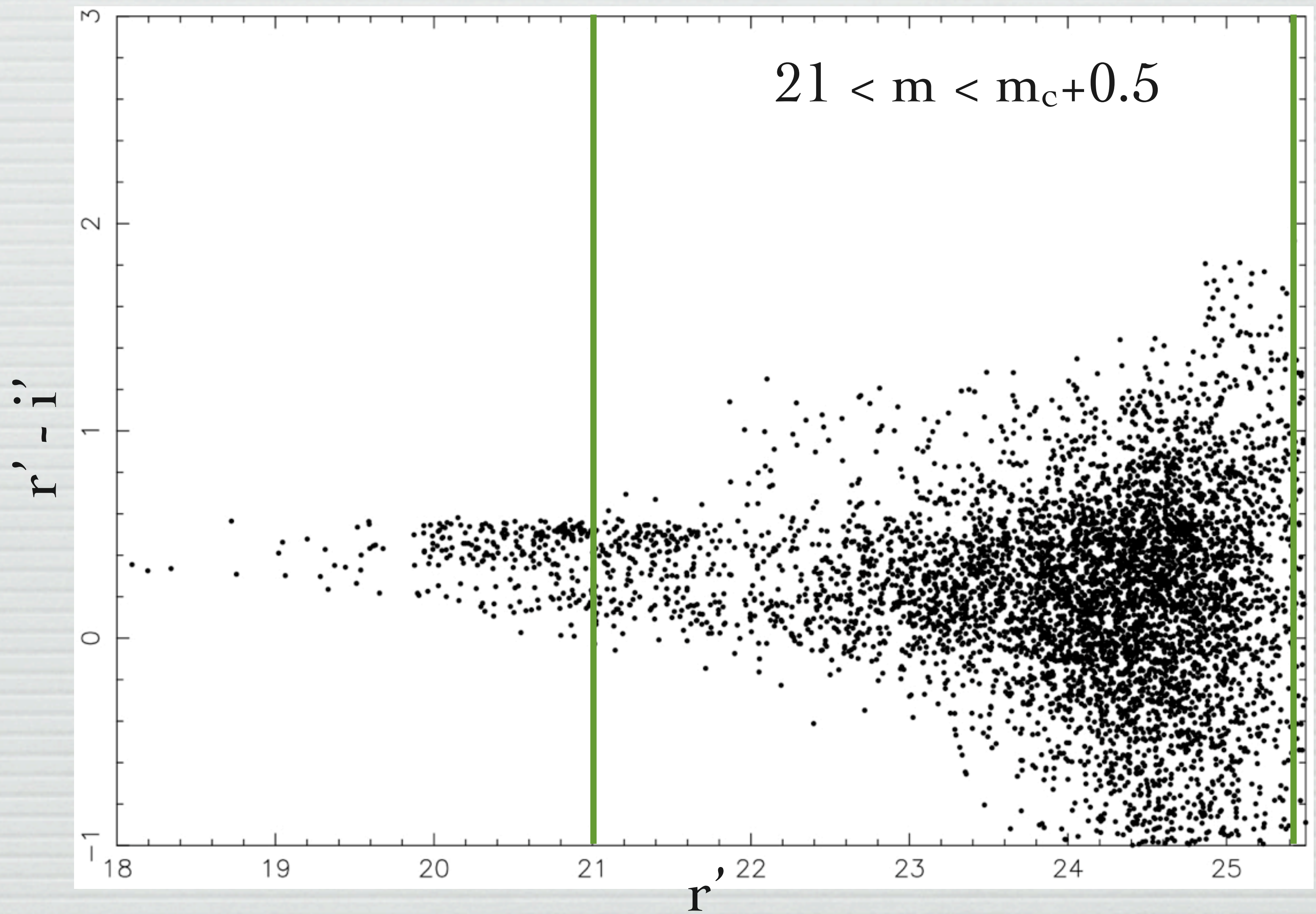
➡ magnitude cuts



RXJ2228.5+2036

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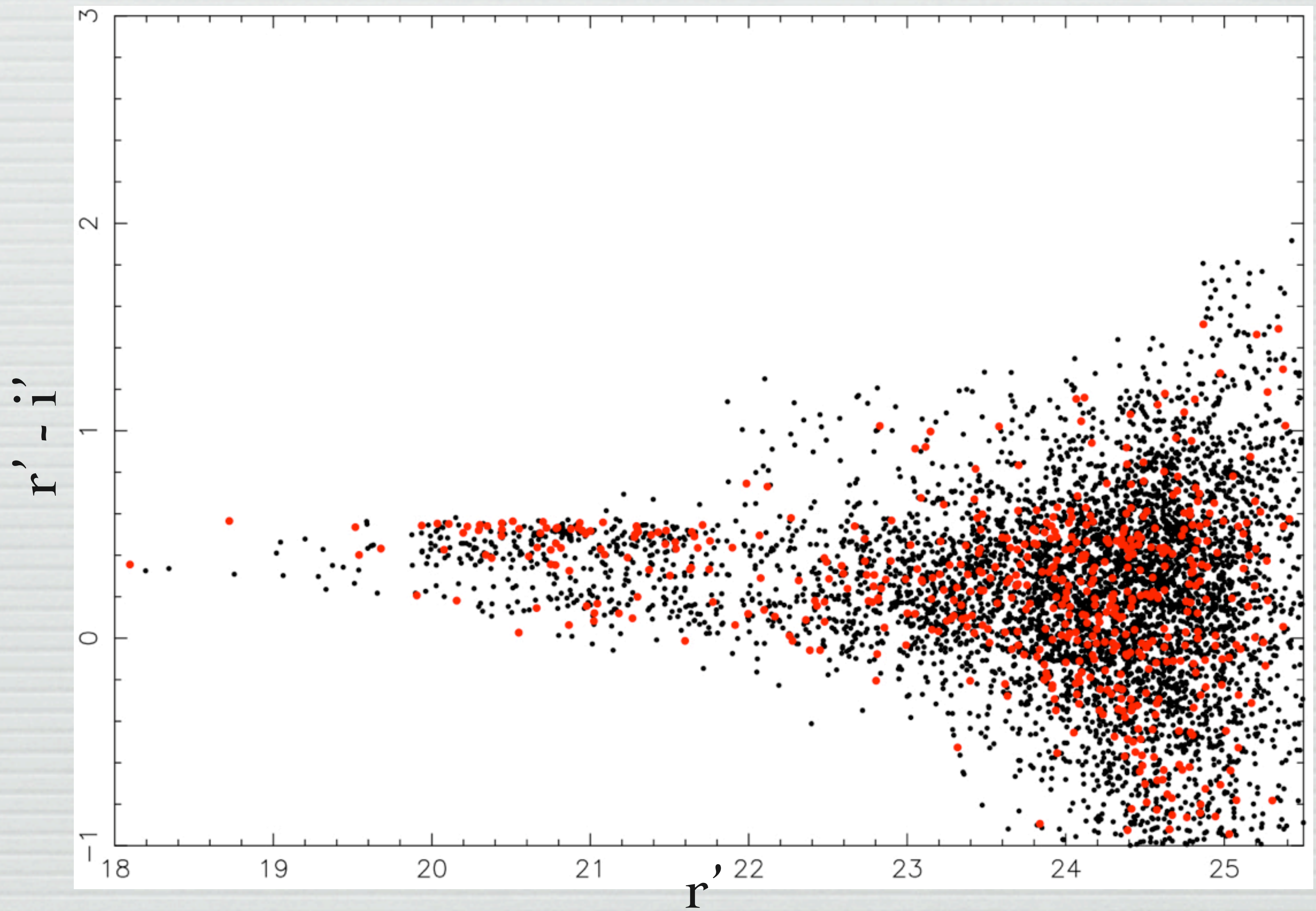

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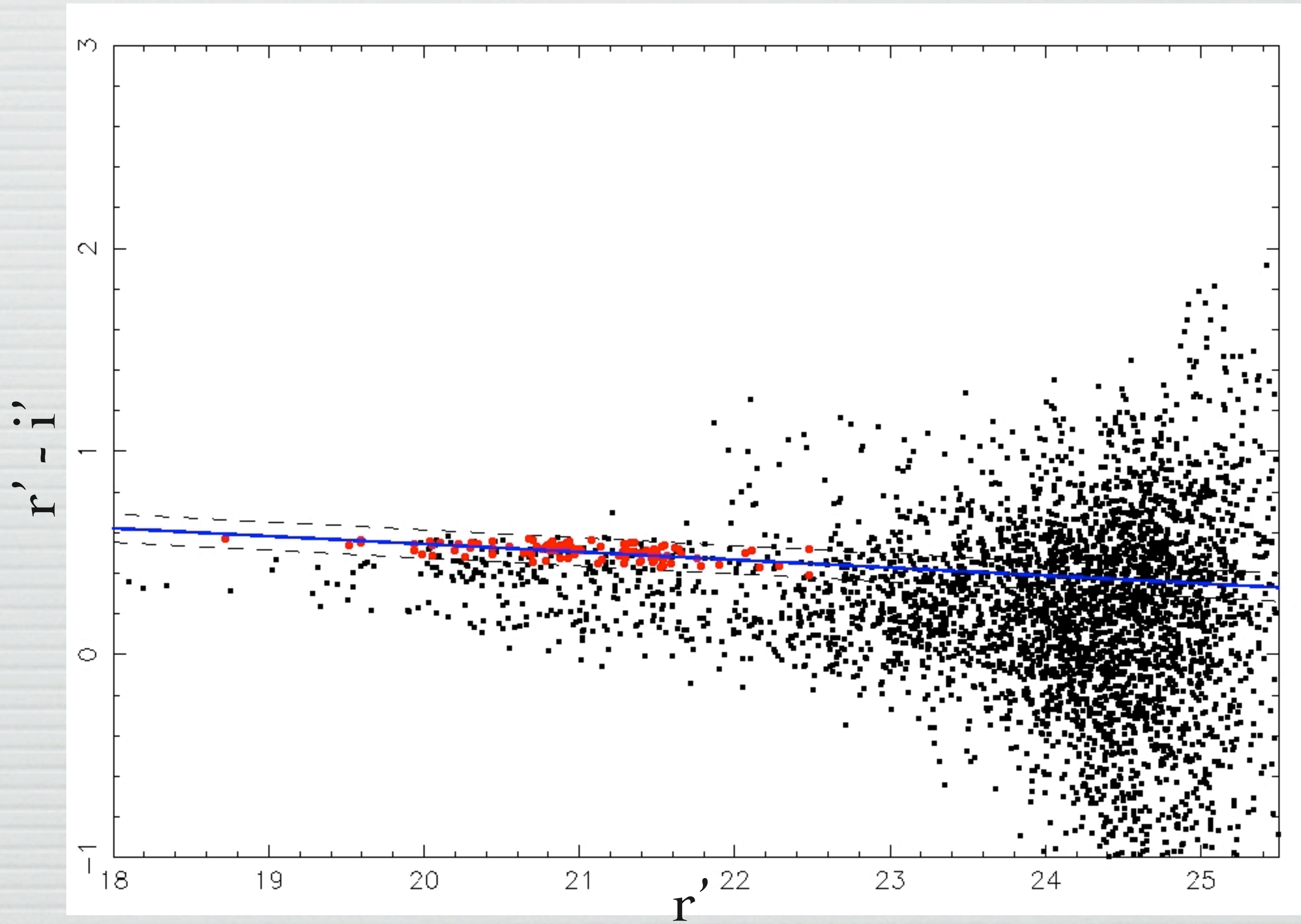

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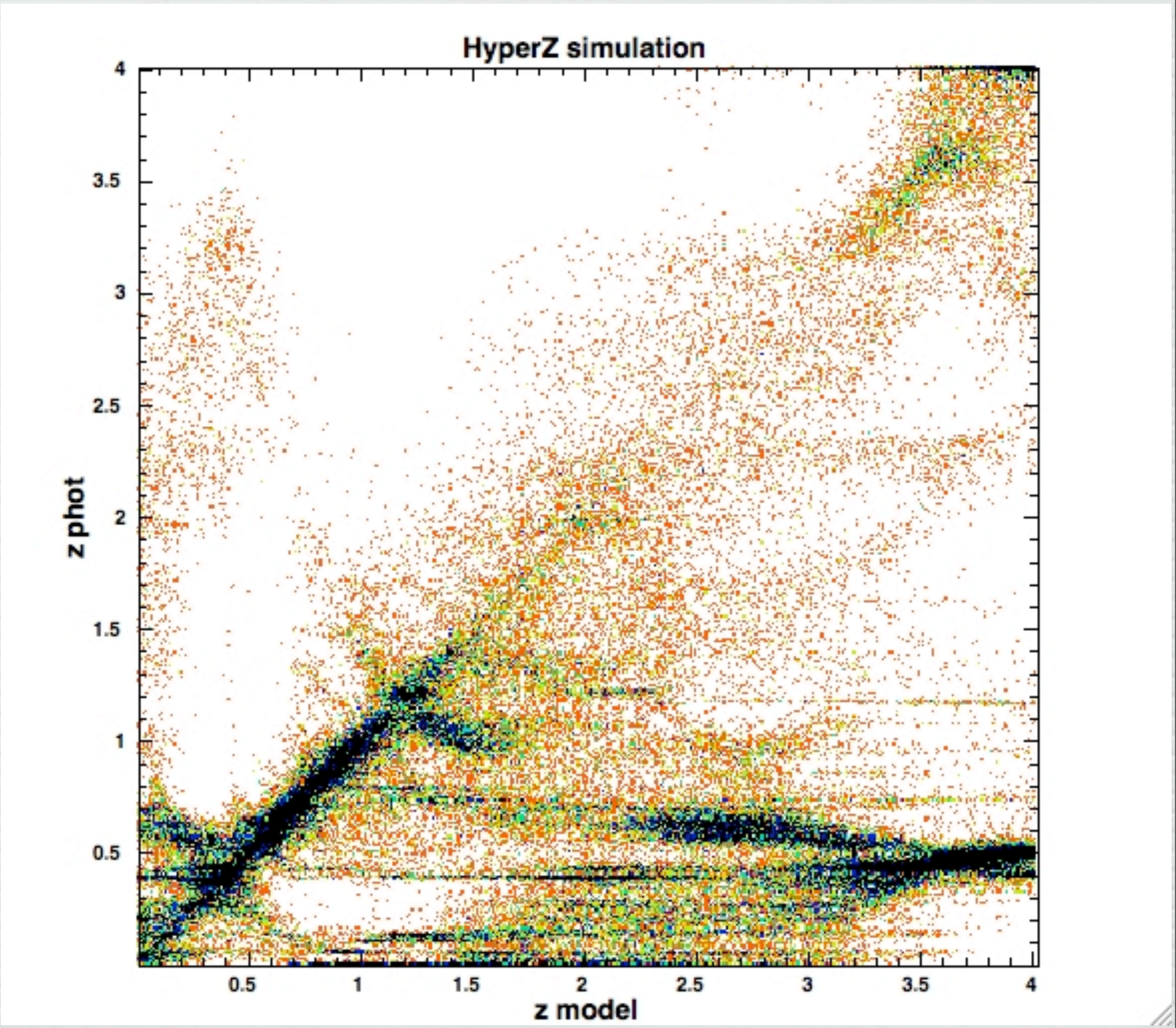

→ magnitude cuts

→ red sequence

high z = high foreground contamination = need more than mag cuts

→ photo_z HyperZ (R. Pello)

WEAK LENSING

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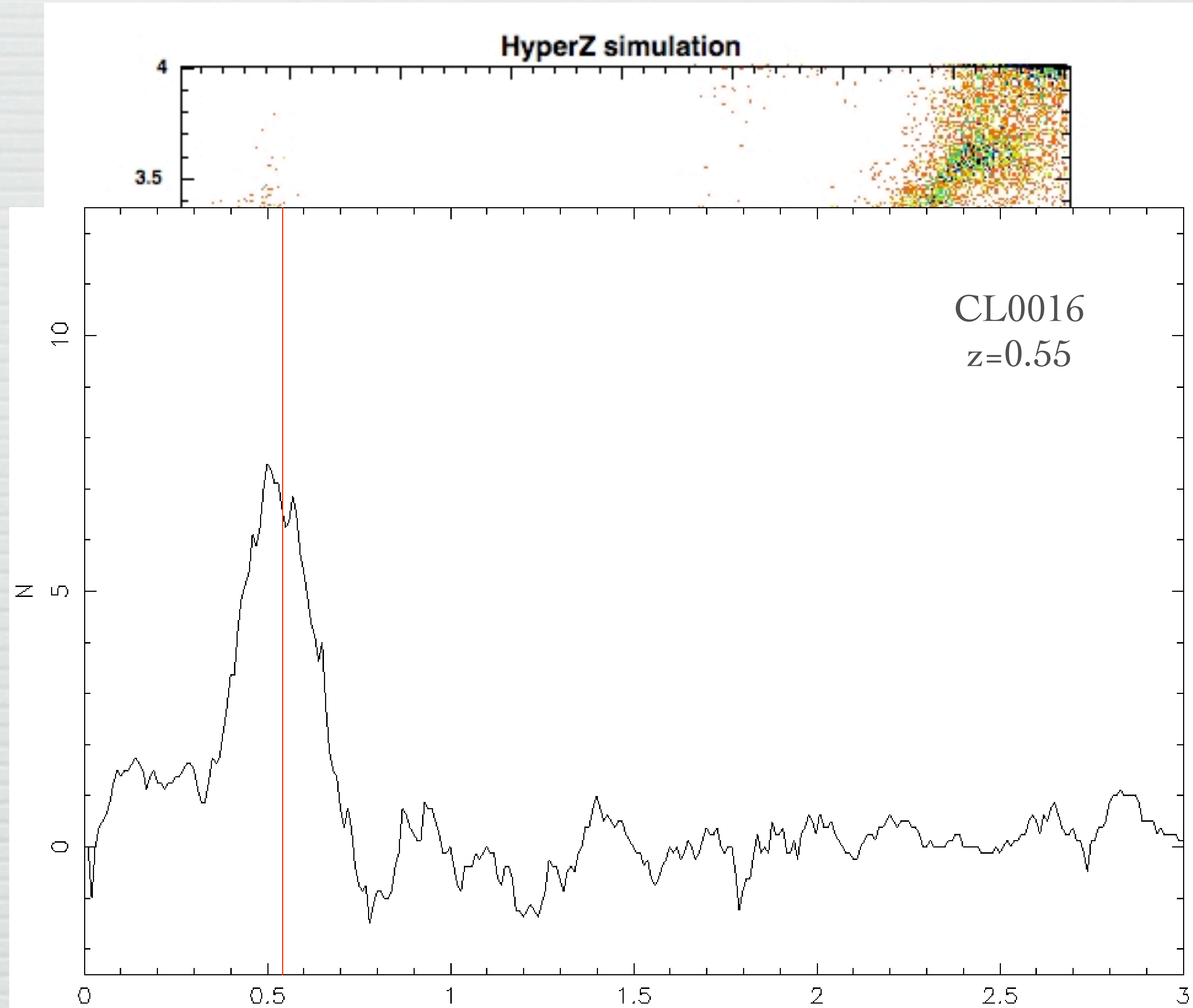

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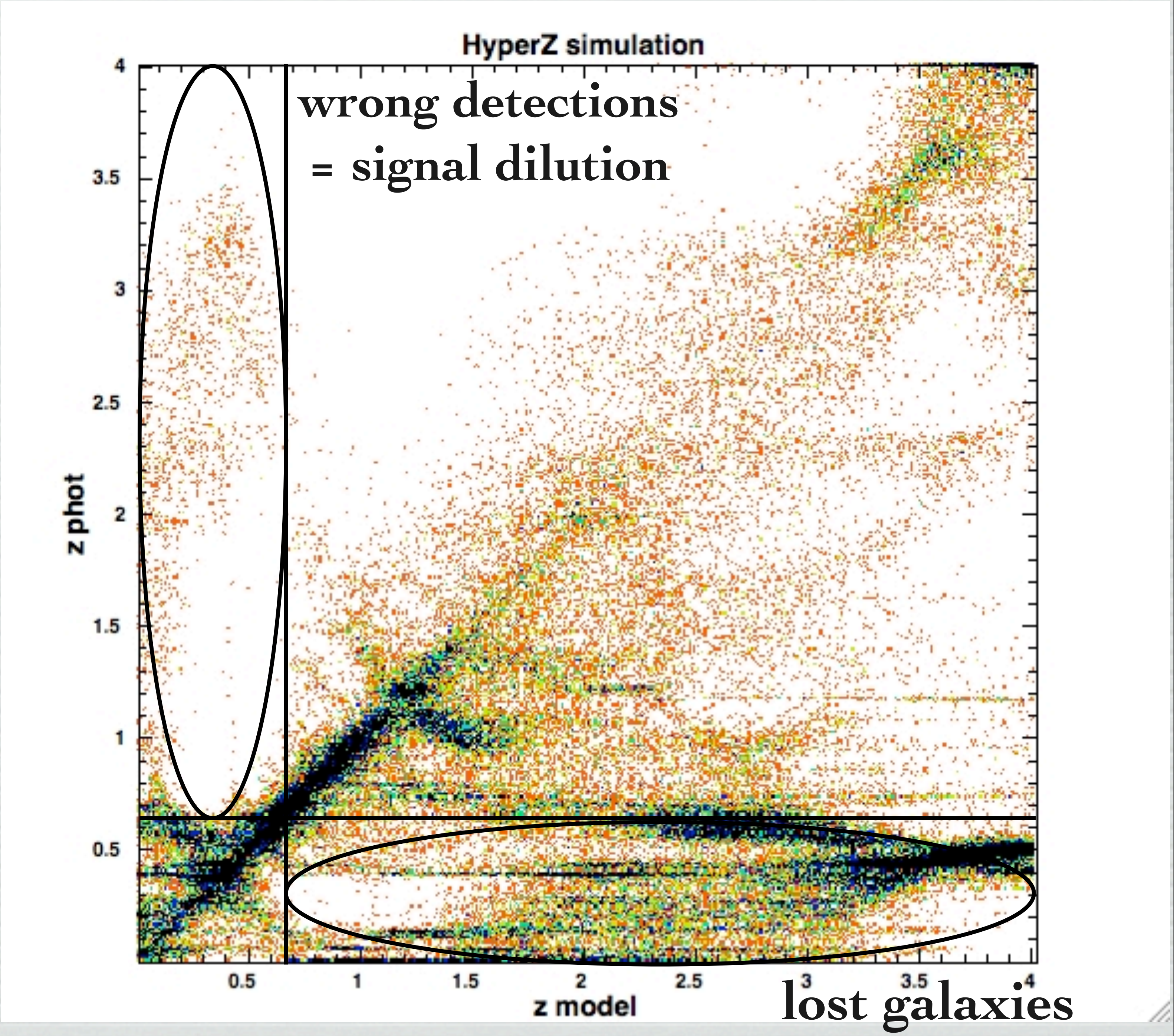

lost galaxies
= decrease in SNR

zphot challenging with 4 bands --> PDZ only as a proba. criterion for $z<z_c$ or $z>z_c$

WEAK LENSING

- [x] star/galaxy separation
- [x] background members
- [ ] shape parameters (r' image)
- [ ] geometry of the system

Im2shape (S. Briddle)

WEAK LENSING

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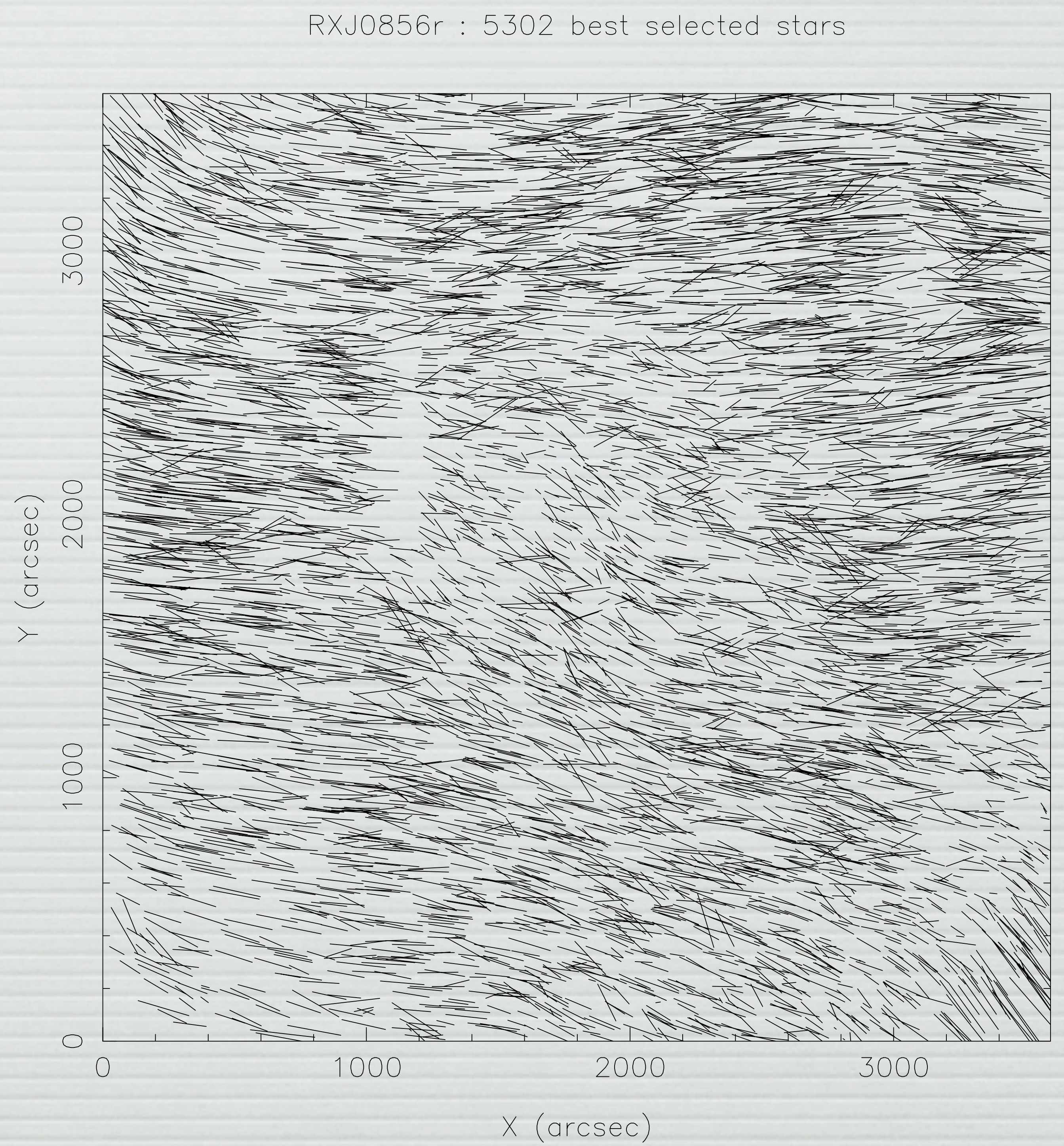
Im2shape (S. Briddle)

→ 1st run on stars = PSF



RXJ0856.1+3756

WEAK LENSING

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- ☑ background members
- ☑ shape parameters (r' image)
- ☐ geometry of the system

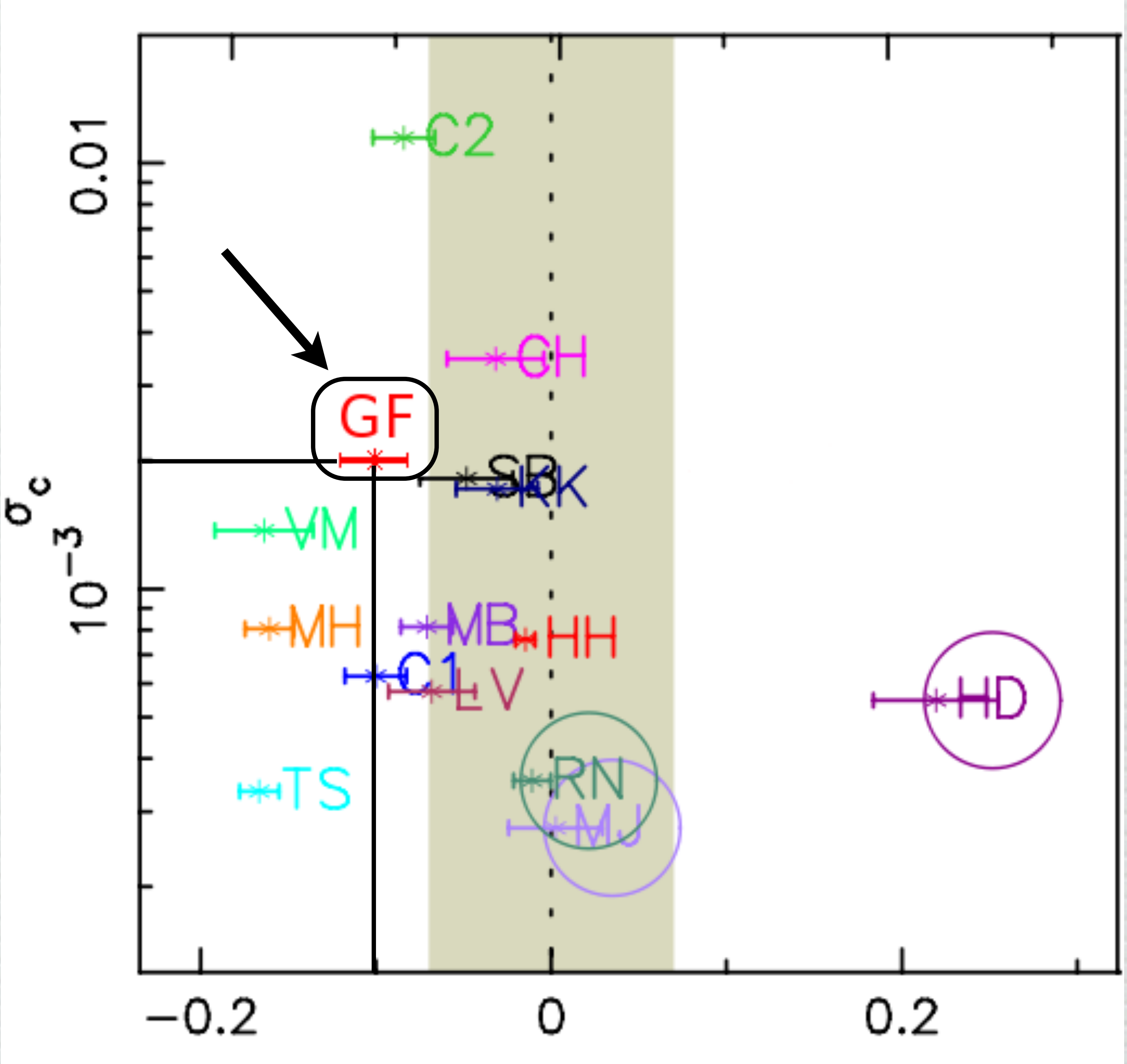
Im2shape (S. Briddle)

→ 1st run on stars = PSF

→ 2nd run on galaxies (fit gauss*PSF)

→ tested on STEP simu. (Shear TEsting Programme)

$$\gamma_1 - \gamma_1^{true} = q(\gamma_1^{true})^2 + m\gamma_1^{true} + c_1$$



(Heymans06)

q = 0 | <m> ~ -0.1 | $\sigma_c \sim 2.10^{-3}$ → underestimation **~10%** of the shear

WEAK LENSING

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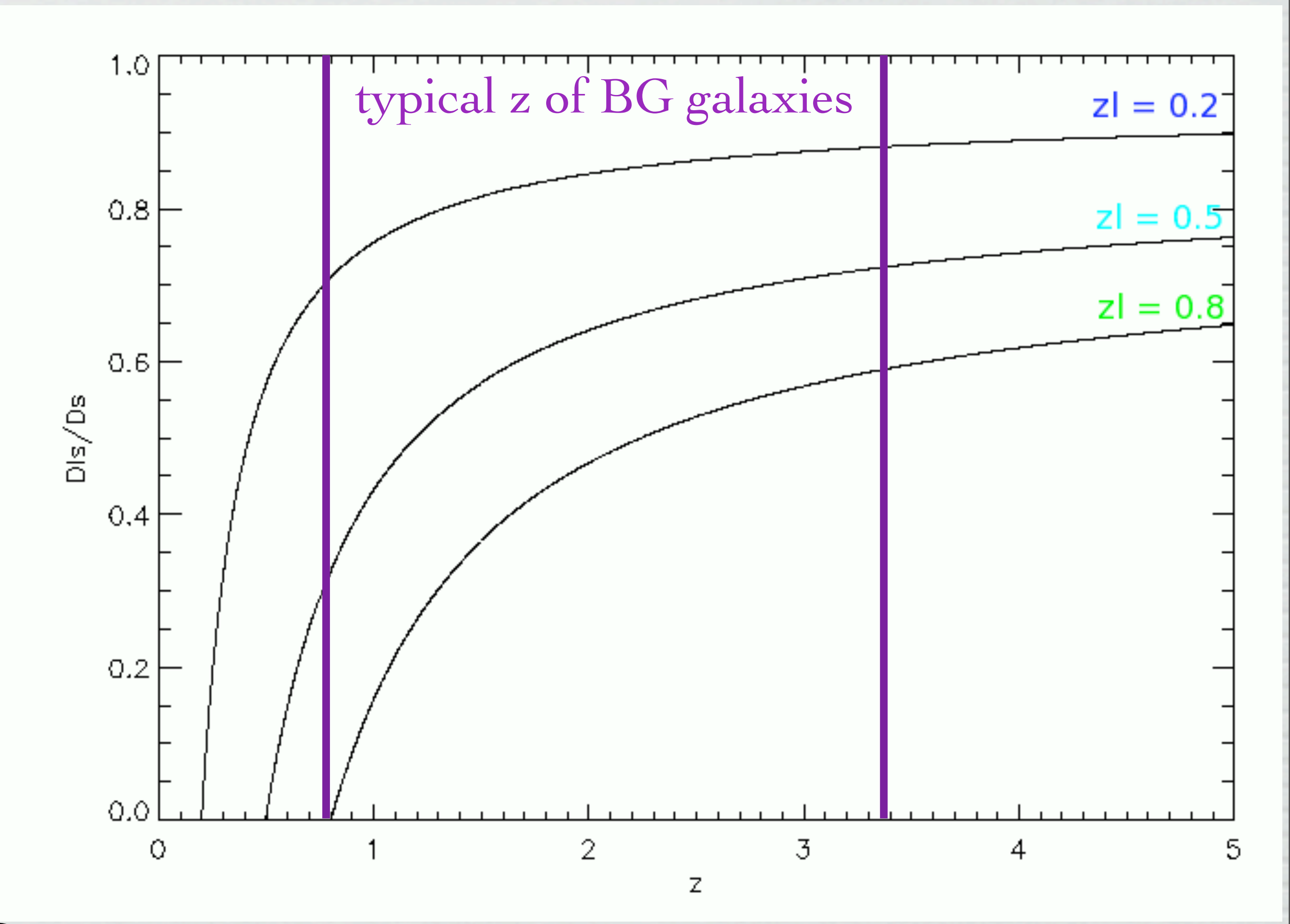

→ geometrical factor $\beta(z_s) = D_{ls}/D_s$

$$g = \frac{\gamma}{1-\kappa} = \frac{\beta_s \gamma^\infty}{1-\beta_s \kappa^\infty}$$

weak lensing

average of BG galaxies : $\langle g(z)\rangle \sim \langle \gamma(z)\rangle = \langle \beta(z)\rangle . \gamma^\infty$

low z_l : $\langle \beta(z)\rangle \sim \beta(\langle z\rangle) \sim \beta(1)$

high z_l : $$\langle \beta(z) \rangle = \frac{\int_{z_l}^{z_{max}} p(z)\beta(z)dz}{\int_{z_l}^{z_{max}} p(z)dz}$$ → p(z) ?

+ deep obs. with same instrument
+ more filters (ugriz)
+ catalogue of calibrated zphot (private comm.)

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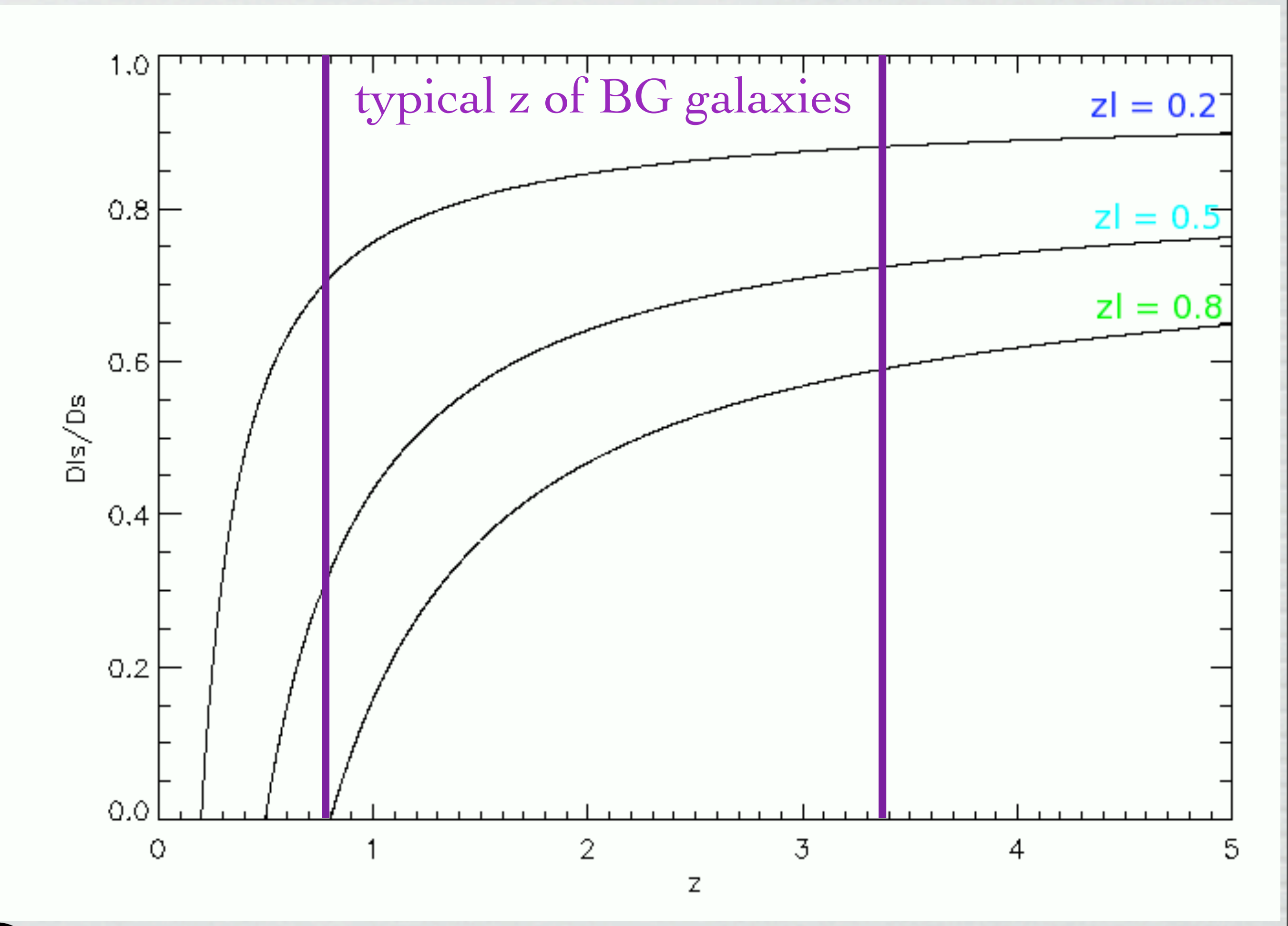

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high z_l : $$< \beta(z) >= \frac{\int_{z_l}^{z_{max}} p(z)\beta(z)dz}{\int_{z_l}^{z_{max}} p(z)dz}$$

p(z) ?

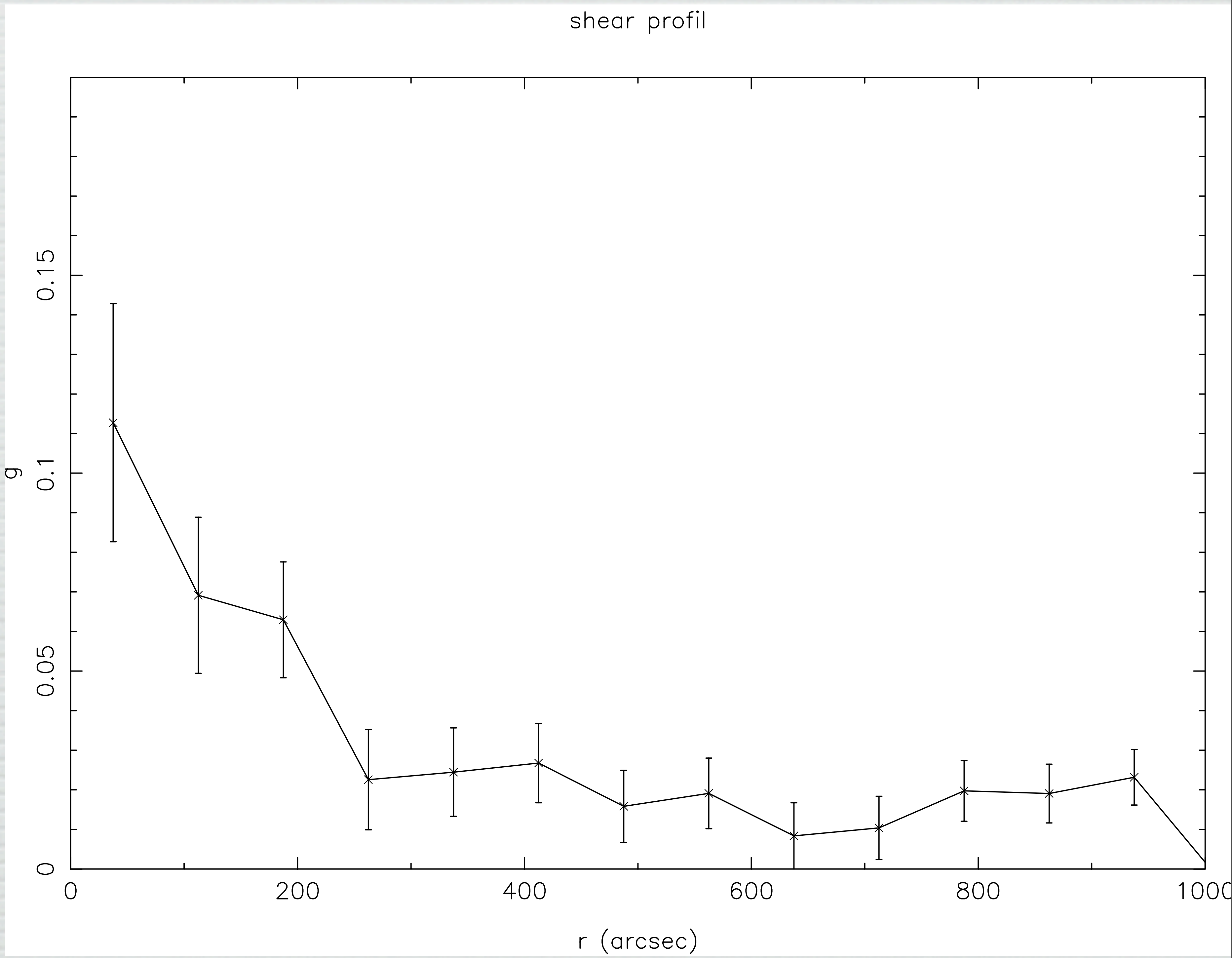
CFHTLS-Deep (T0004 release)

+ deep obs. with same instrument
+ more filters (ugriz)
+ catalogue of calibrated zphot (private comm.)

MASS ESTIMATION

1D analysis : **shear profile**

model fitting



MACSJ1206.2-0848

MASS ESTIMATION

1D analysis : **shear profile**

model fitting

- **SIS** (velocity dispersion)
- **NFW** (c, virial mass)

↓

analytical g

↓

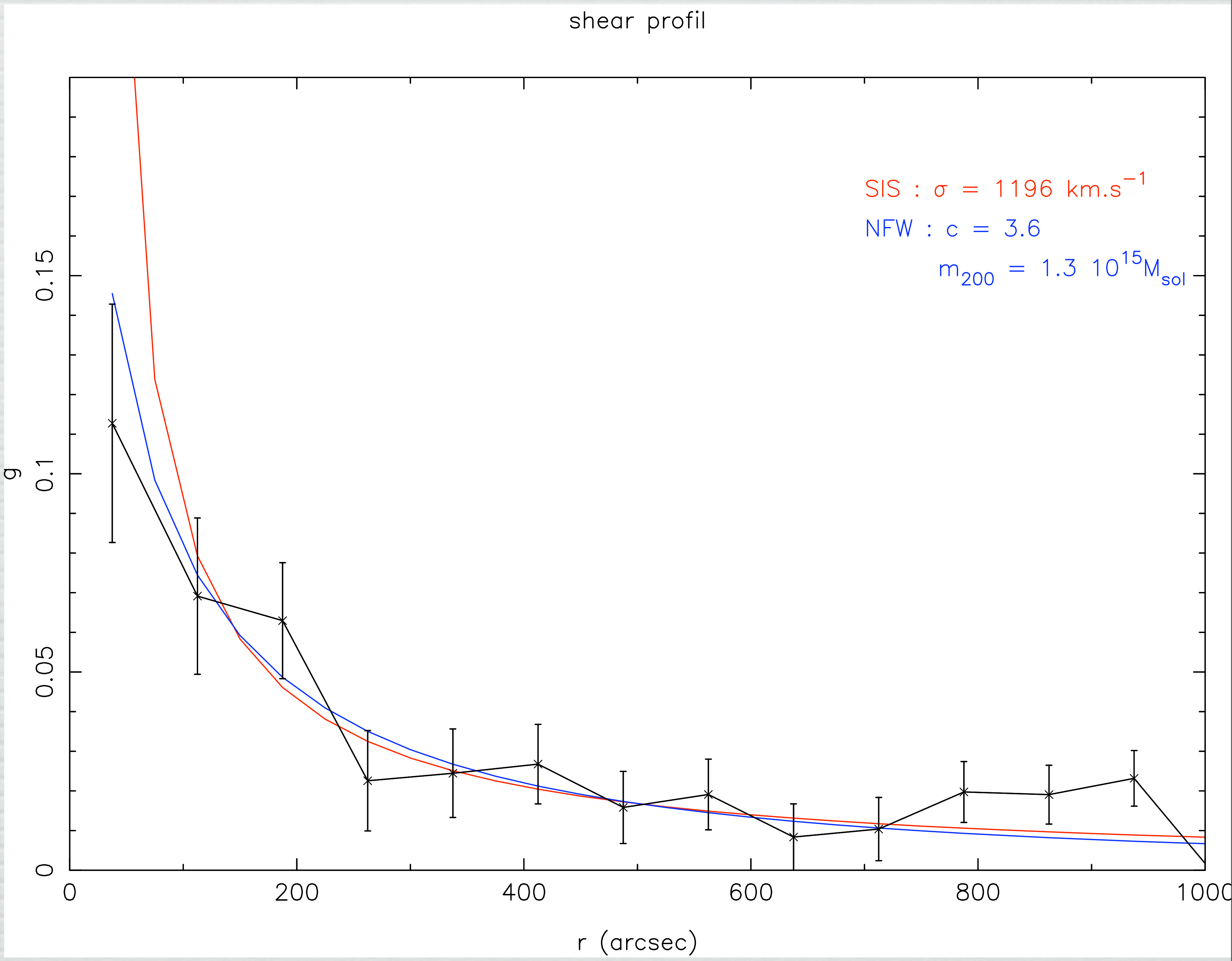
χ^2 with $\mathbf{<e_{tan}>\sim g^{obs}}$

↓

best fit parameters

↓

analytical mass profil



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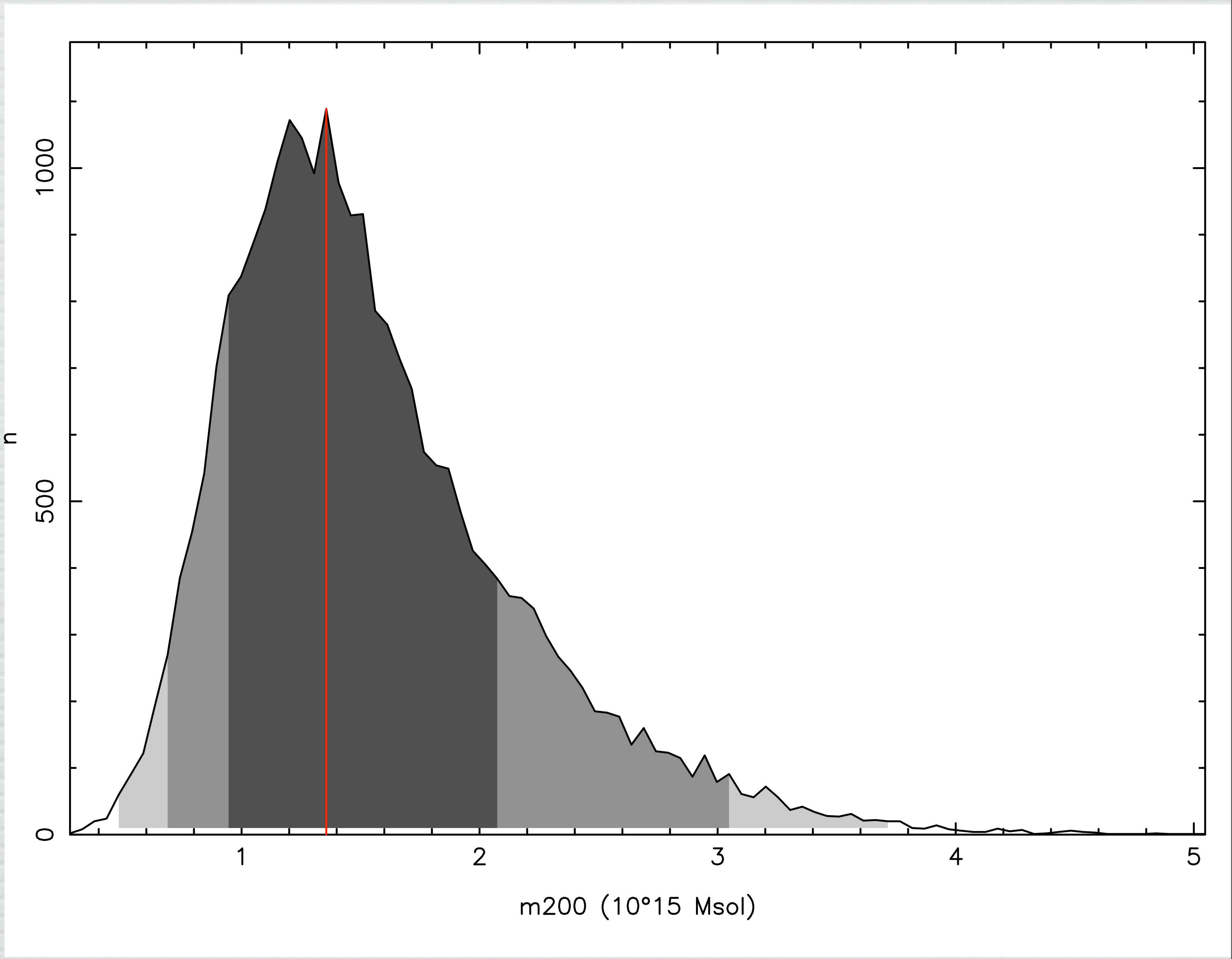


MACSJ1206.2-0848

+ g_{obs} gauss. ⟶ best fit for severals MC g-profiles ⟶ best fit param. distrib.

MASS ESTIMATION

2D analysis

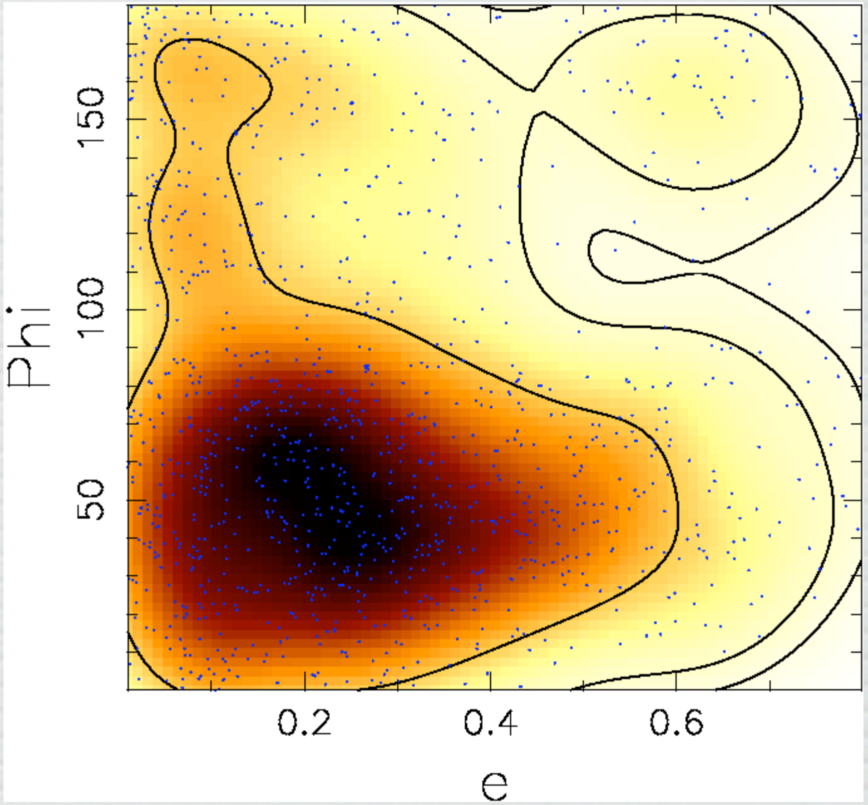
model fitting with Lenstool

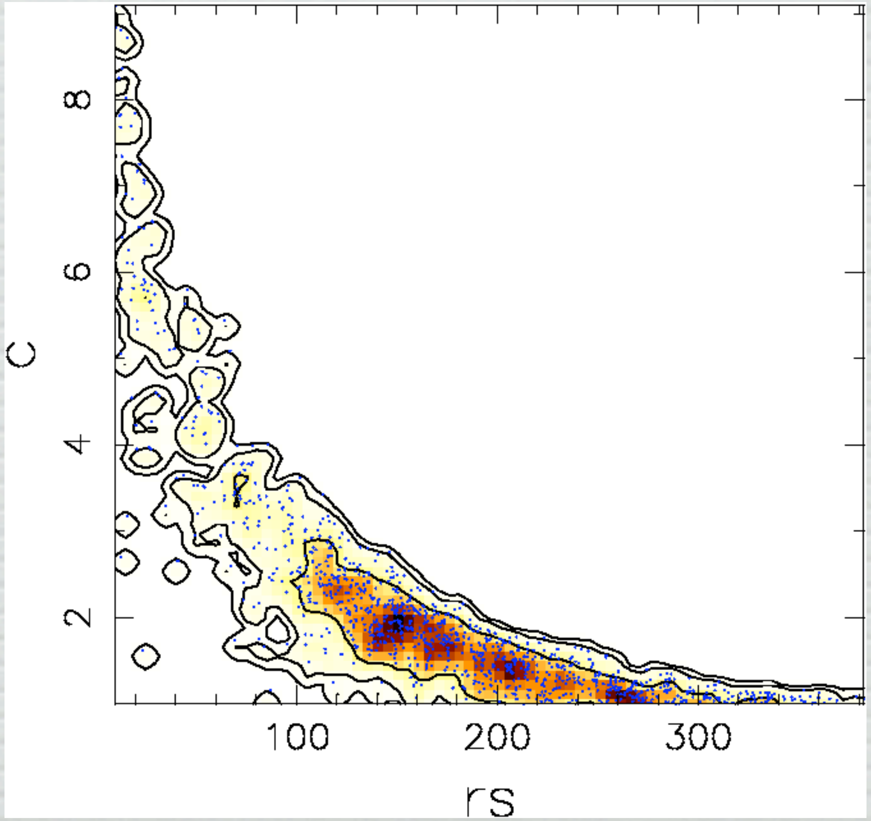
(J.P. Kneib/E. Jullo)

- 'unlens' each galaxy : $e^s = f(e^i, g^{theo})$
- use z_{eff} for each galaxy ($\beta(z_{eff}) = \langle\beta(z)\rangle$)
- fit the likelihood $L = \Pi\,(P_i(e^s))$ to $N(0, \sigma\sim0.3)$
- bayesian MCMC optimization

+ more complex models (x,y,e,φ)

+ WL+SL (work in progress)





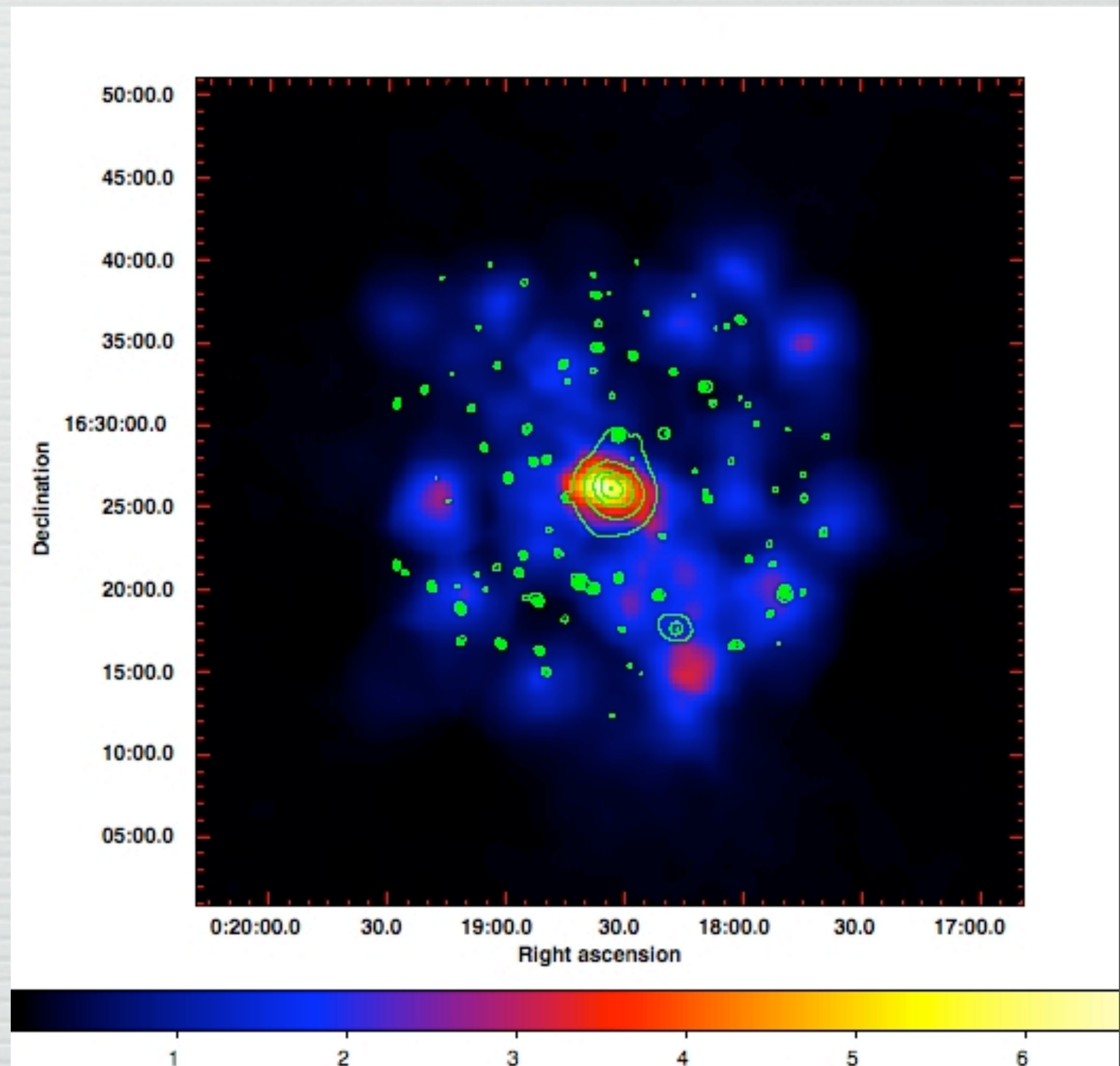
MACSJ1206.2-0848

MASS ESTIMATION

2D analysis

with

(P. Marshall)



CL0016

input model = grid of mass pixels Σ

uses each galaxy shape component e_i as a reduced shear estimator

$$\downarrow$$

Likelihood : $\Pr(\mathrm{Data}|\Sigma) = \frac{1}{Z_L} \exp(-\frac{\chi^2}{2})$

with $\chi^2 = \sum_{i=1}^{N} \sum_{j=1}^{2} \frac{(\epsilon_{j,i} - g_{j,i})^2}{\sigma^2}$

ML with bayesian MCMC optimization $\longrightarrow$ mass & SNR maps

MASS ESTIMATION

2D analysis

non parametric with LensEnt2
(P. Marshall)

input model = grid of mass pixels Σ

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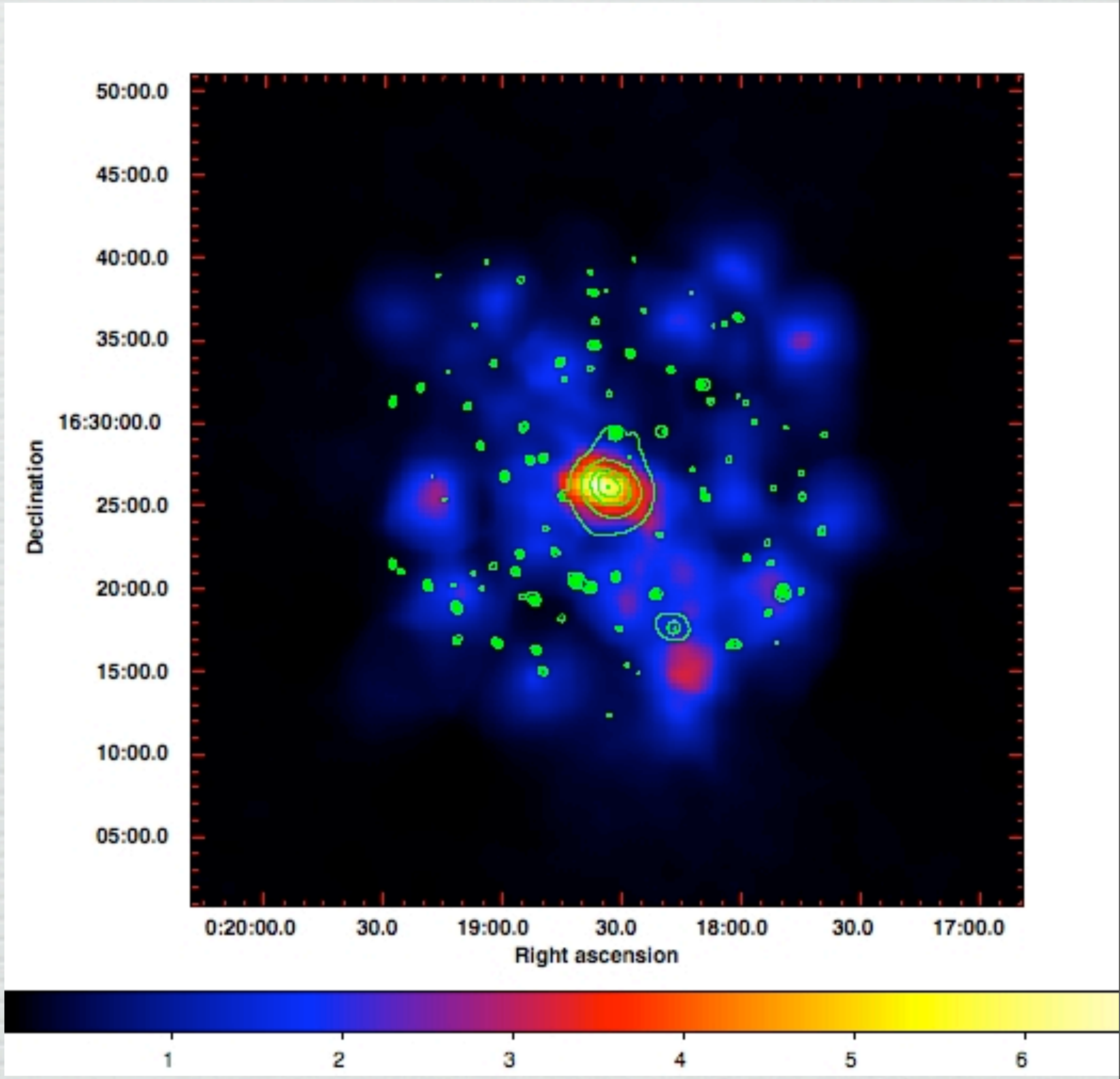


CL0016

ML with bayesian MCMC optimization ⟶ mass & SNR maps

ERROR ESTIMATION

List of uncertainties :

- shape measurements :
- contamination
- geometry

STEP simu : -10% bias

correction of g_{obs}

!! based on simu. !!

- averaged over several different shear/PSF
- could change over the field/from a cluster to another

ERROR ESTIMATION

List of uncertainties :

shape measurements

contamination

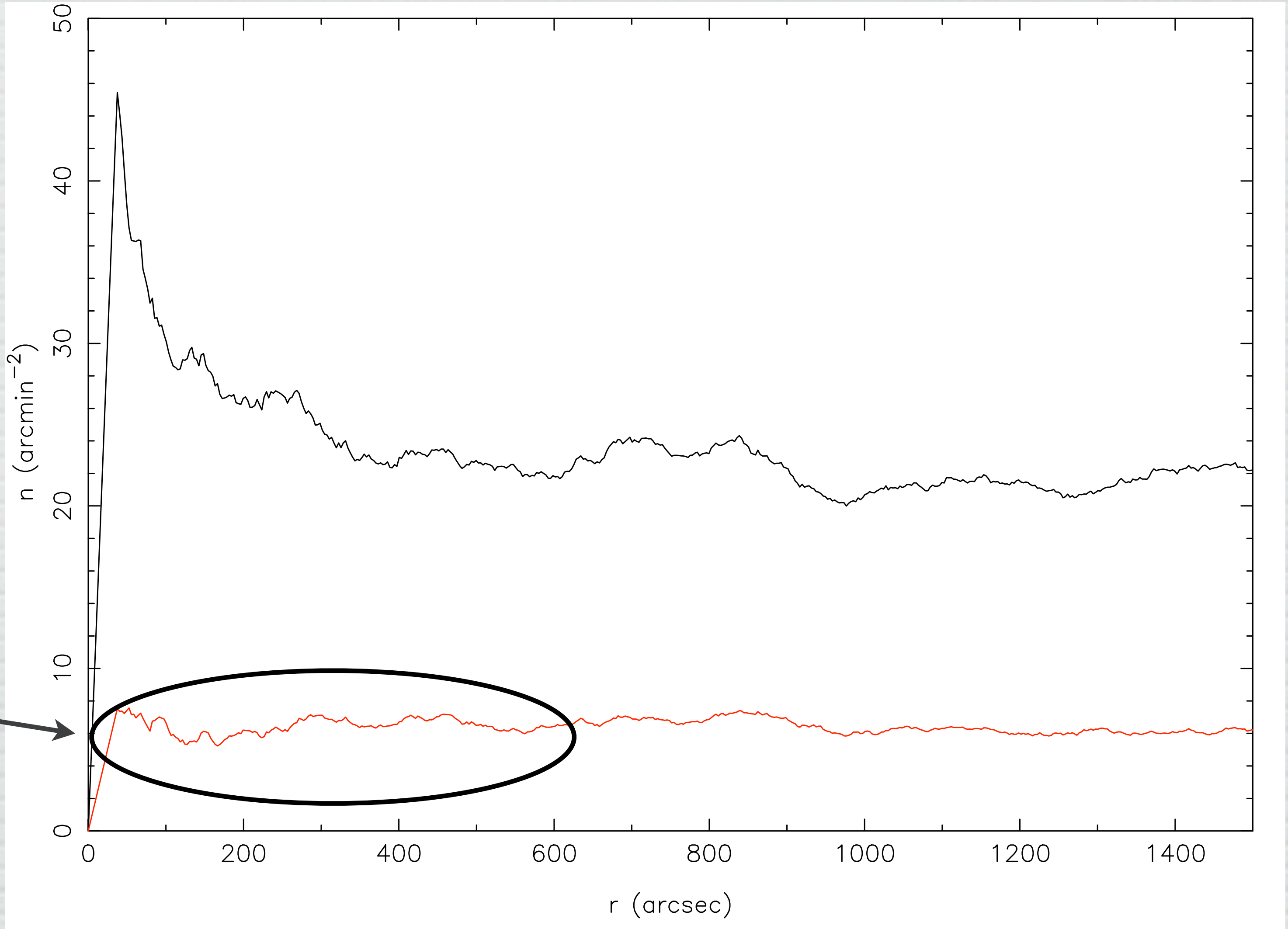
geometry

cluster members removed
(rs+zphot)

strong selection cuts
--> low bg density
% of fg gal. remaining ?

$$g \sim \frac{\sum_{i}^{N_{back}} e_{\parallel}^{i} + \sum_{j}^{N_{fore}} e_{\parallel}^{j}}{N_{back} + N_{fore}} \simeq \frac{N_{back}}{N_{back} + N_{fore}} g^{true}$$

underestimation of the shear
= underestimation of the mass



RXJ2228.5+2036

requires a good sources catalogue !

compromise between contamination and SNR

ERROR ESTIMATION

List of uncertainties :

$\beta(z_s)=D_{ls}/D_s$

- shape measurements
- contamination
- geometry

- $<\beta>$ from CFHTLS good ??
  - errors on z
  - cosmic variance
  - structures (e.g. clusters) in the field

WL : $g \sim \beta.\gamma^{\infty}$

if : $\beta = x.\beta_{true}$

then : $\gamma^{\infty} = \dfrac{\gamma^{\infty}_{true}}{x}$

x % overestimation on β

~ x% underestimation on the mass

- $<g(\beta)> \neq g(<\beta>)$

measure

fit

$$g = \frac{\gamma}{1-\kappa}$$

negligible for r>100" @ z~0.5

don't use the galaxies in the central part

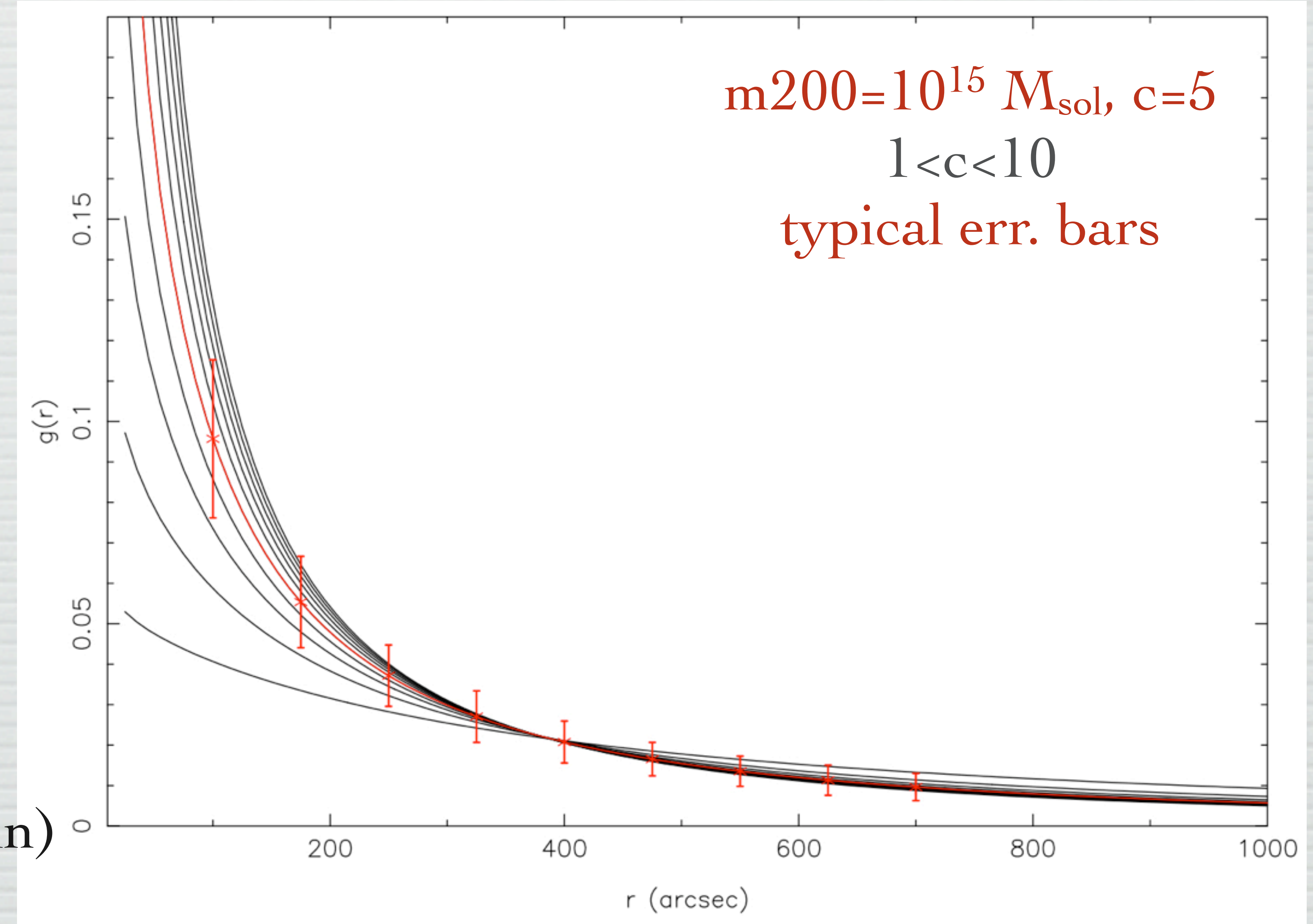
ERROR ESTIMATION

List of uncertainties :

- shape measurements
- contamination
- geometry

hard to derive reliable error bars

increasing err. towards the center
(SL effects, low number of gal./bin)



→ no reliable info. on c

Need other data (SL, X) to constrain the center and decrease error bars

ERROR ESTIMATION

List of uncertainties :

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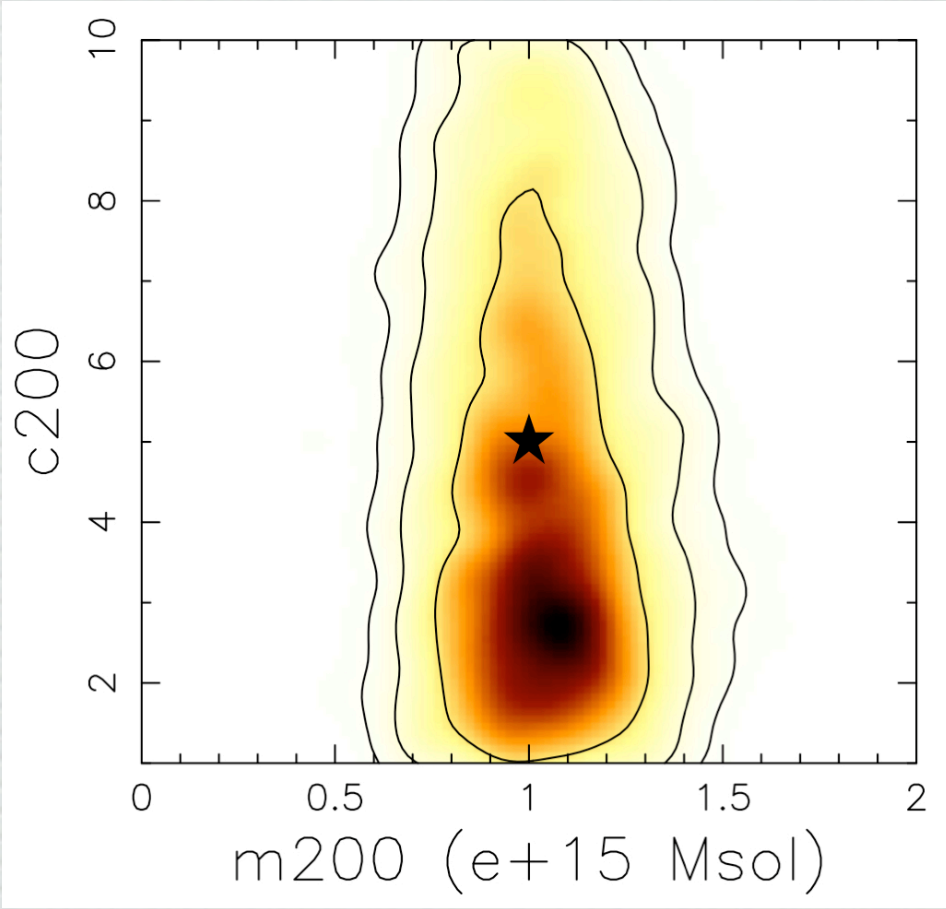
simulation
(z=0.5, ρ_b=10 arcmin^{-2}, ρ_f=0, n_{clust}=0)



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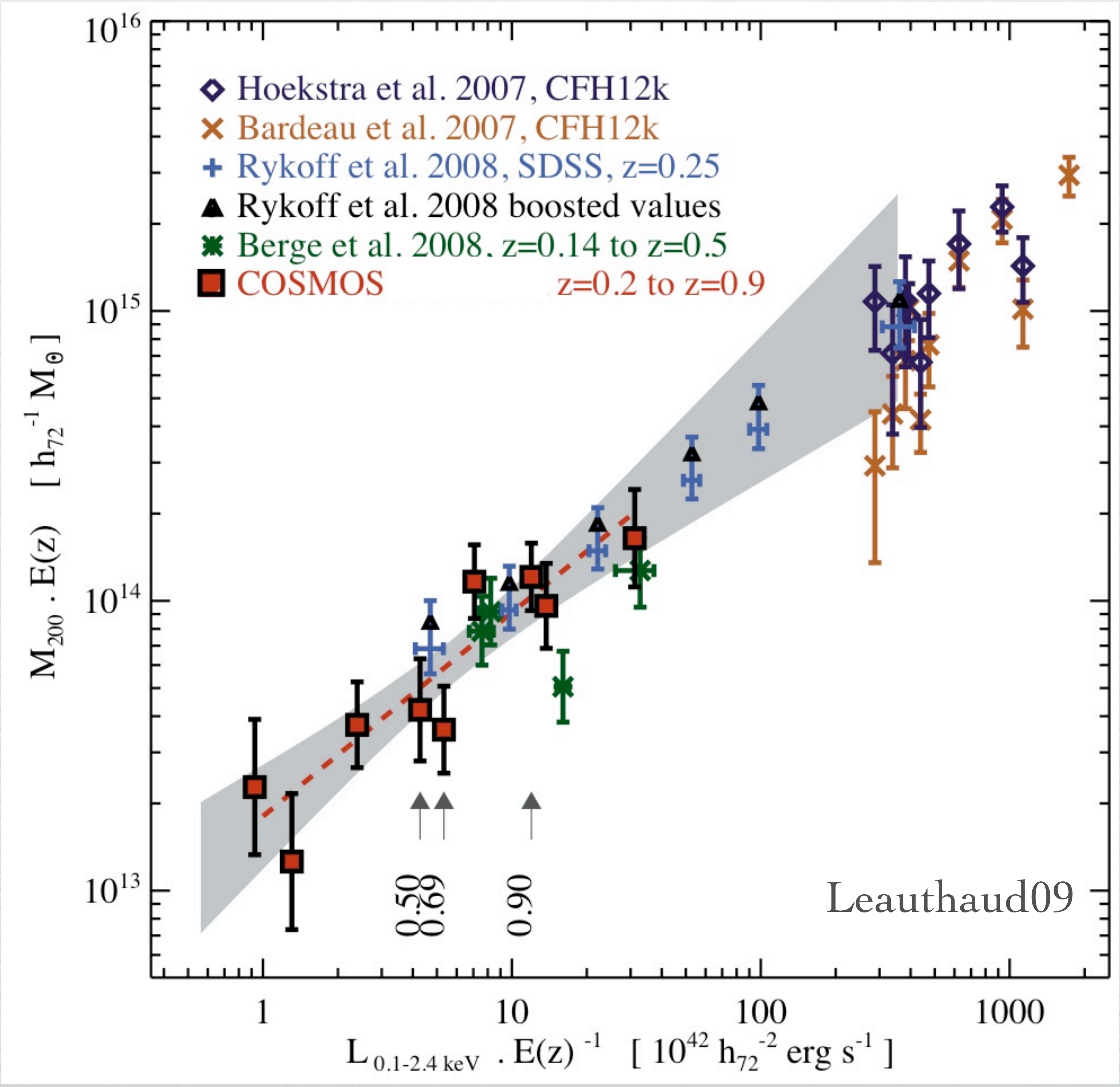
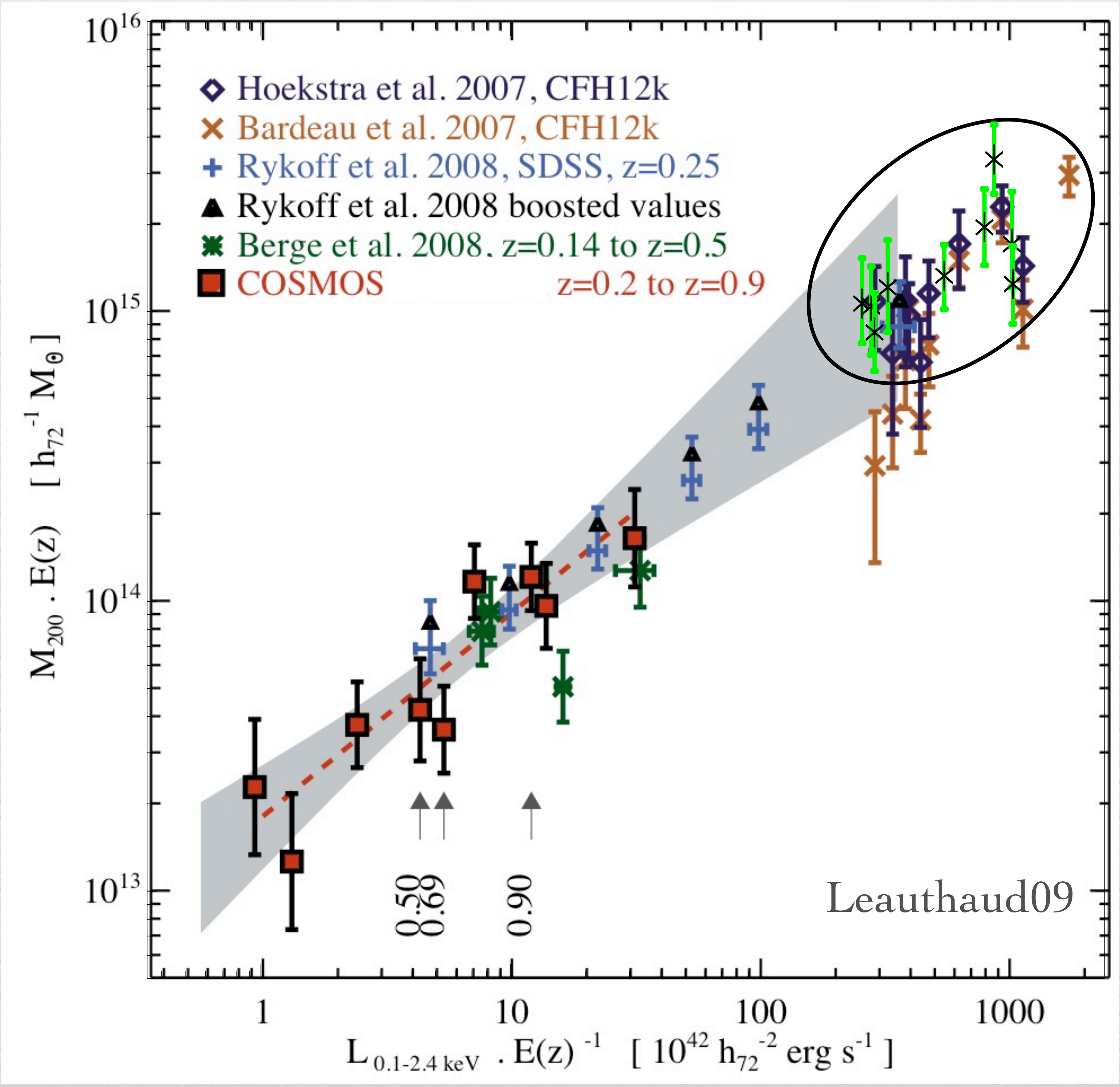
SCALING RELATIONS



- M200 from shear profil
- Lx Rosat

preliminary....

SCALING RELATIONS



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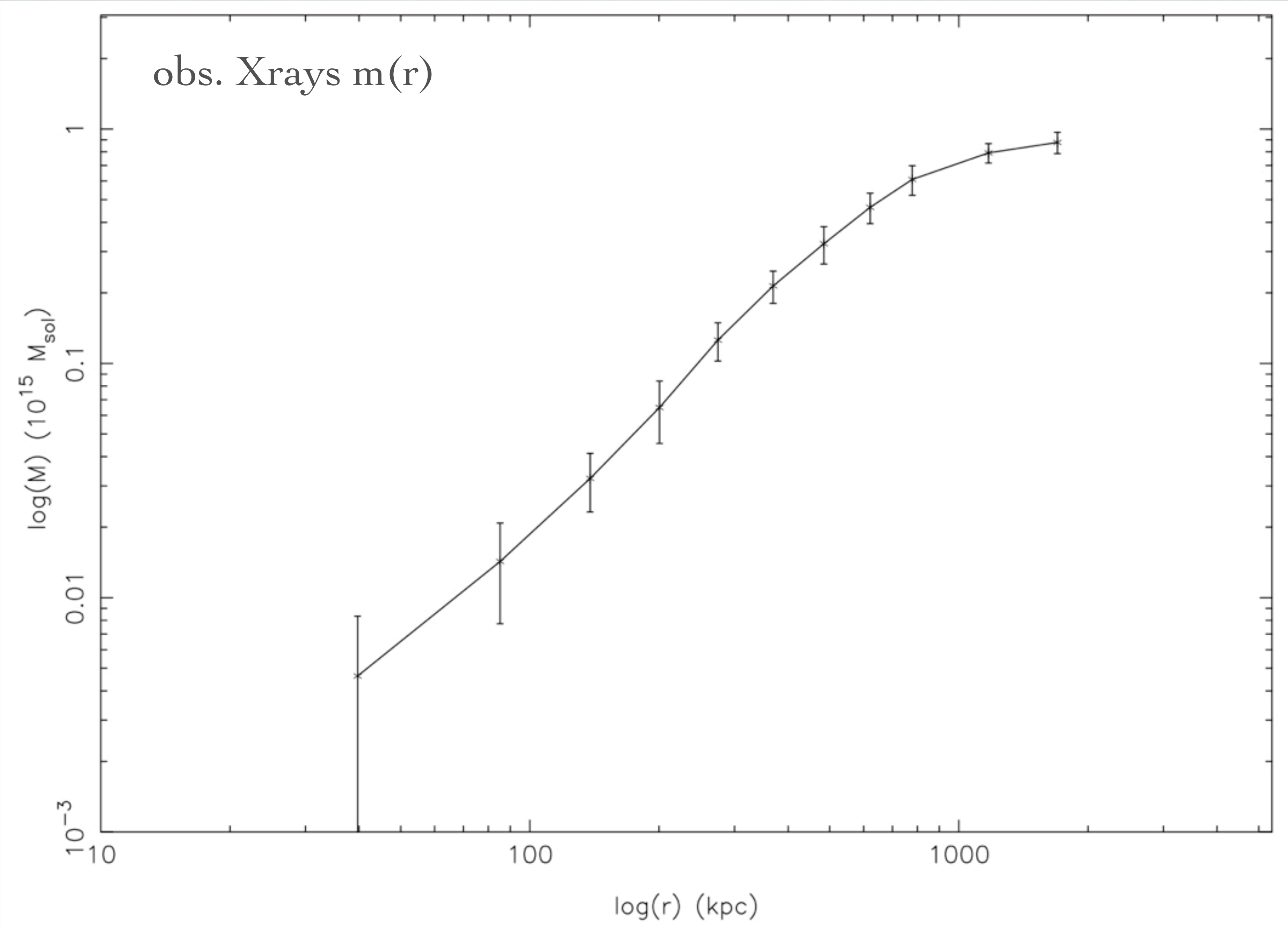
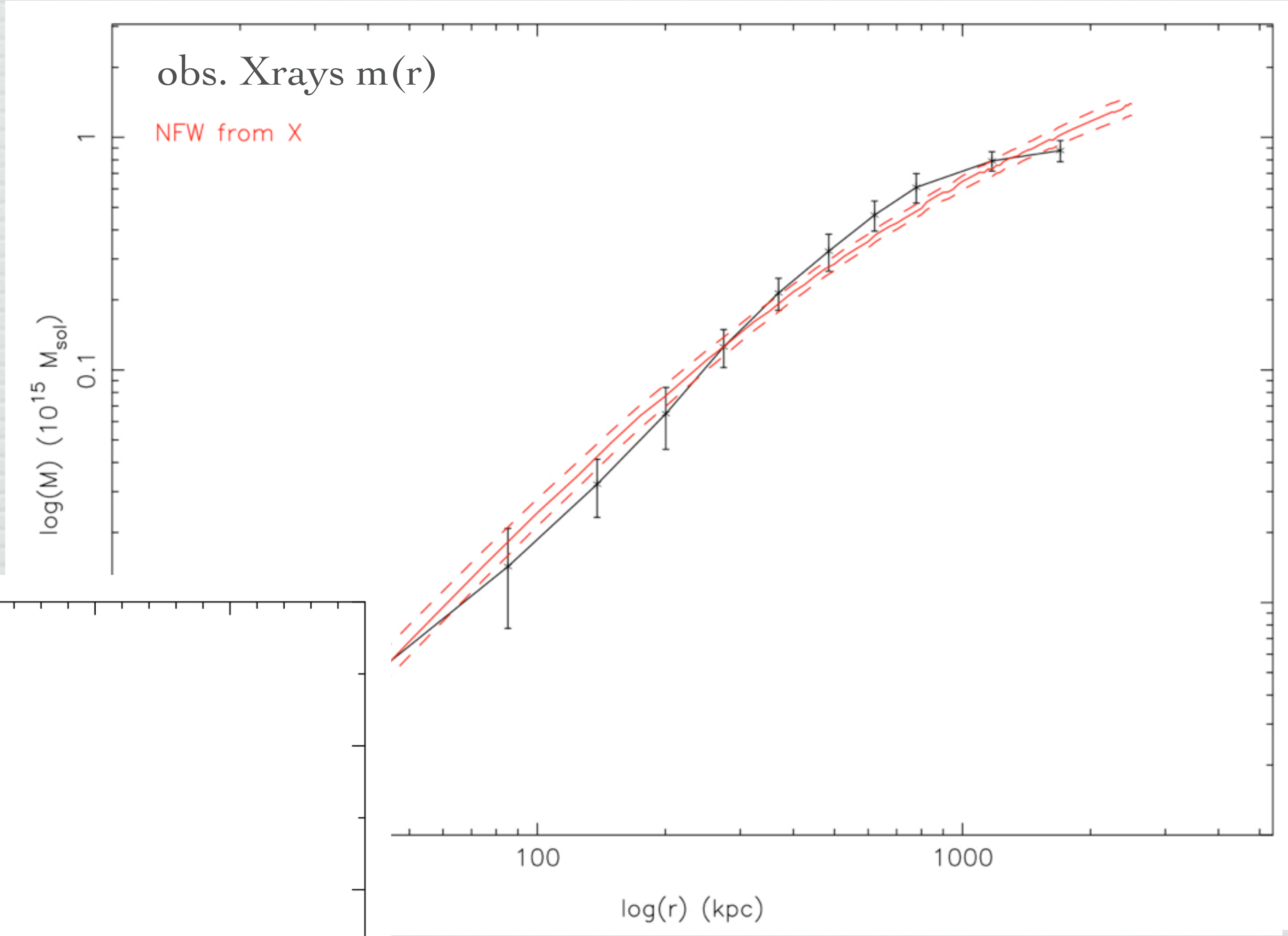
COMPARE/COMBINE

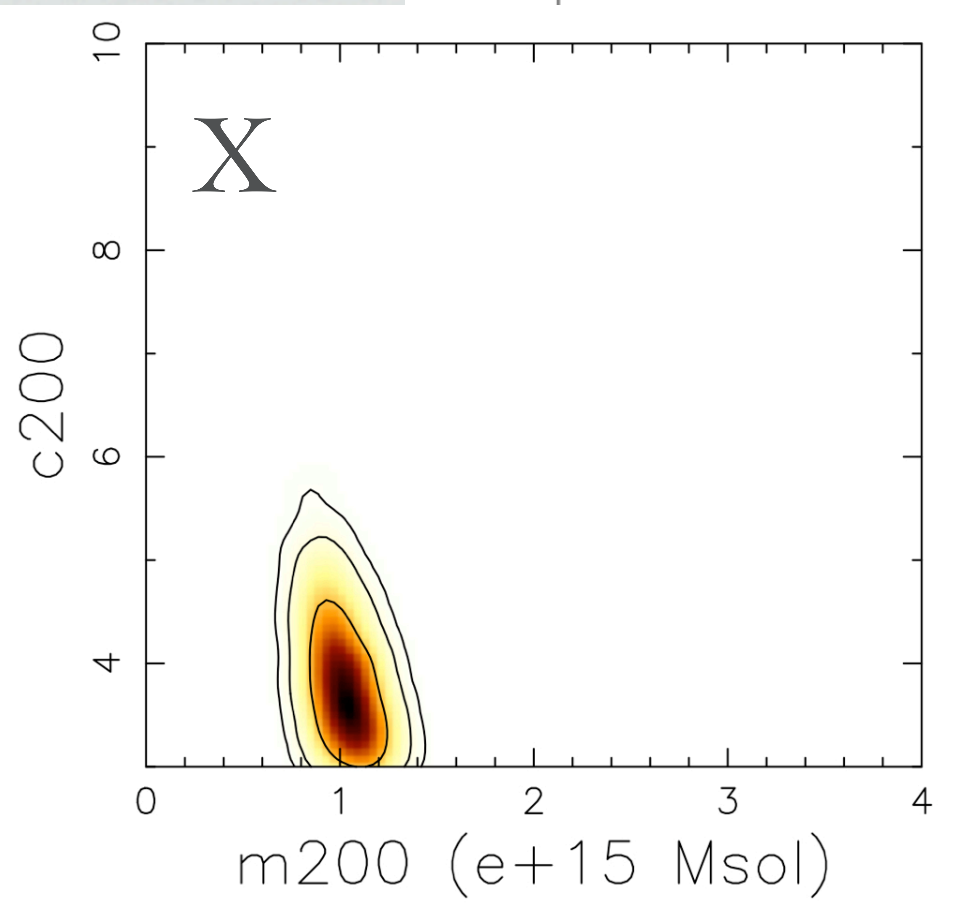


CL0016

preliminary....

COMPARE/COMBINE

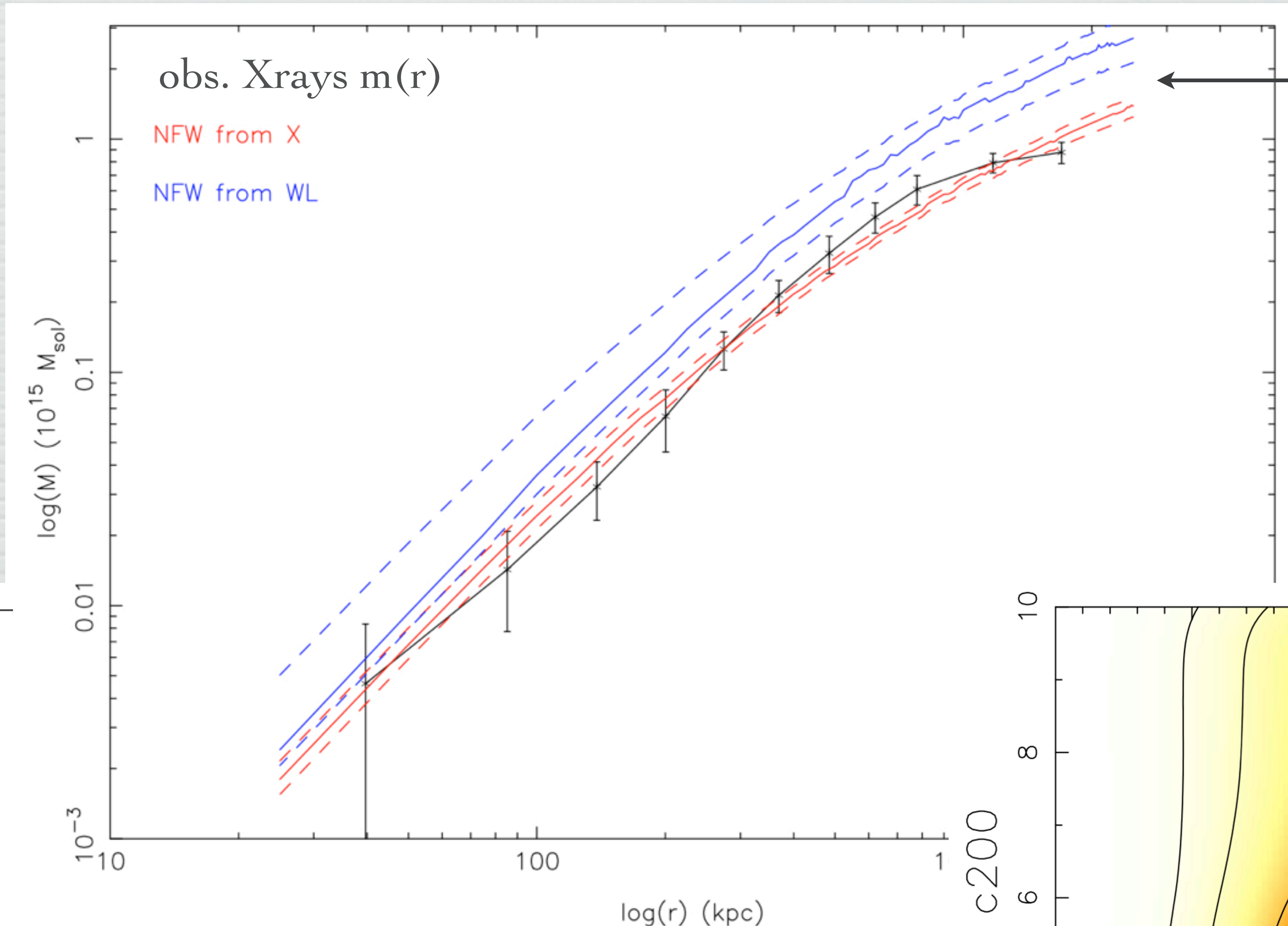




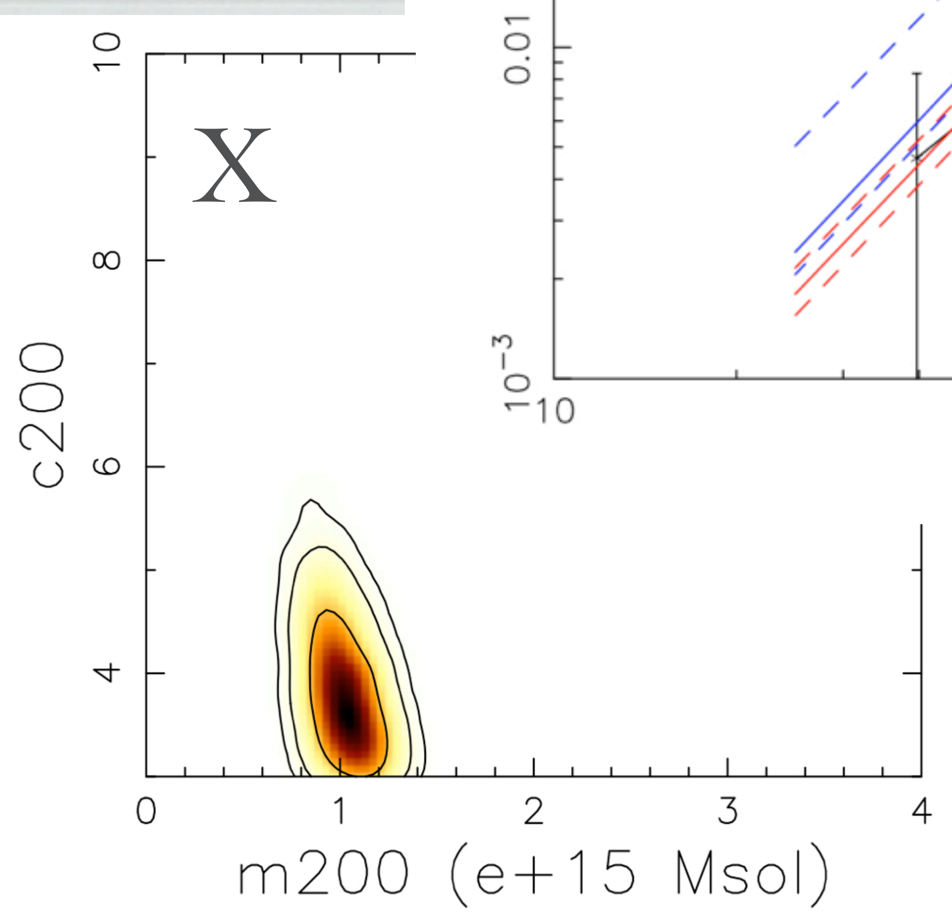
CL0016

preliminary....

COMPARE/COMBINE

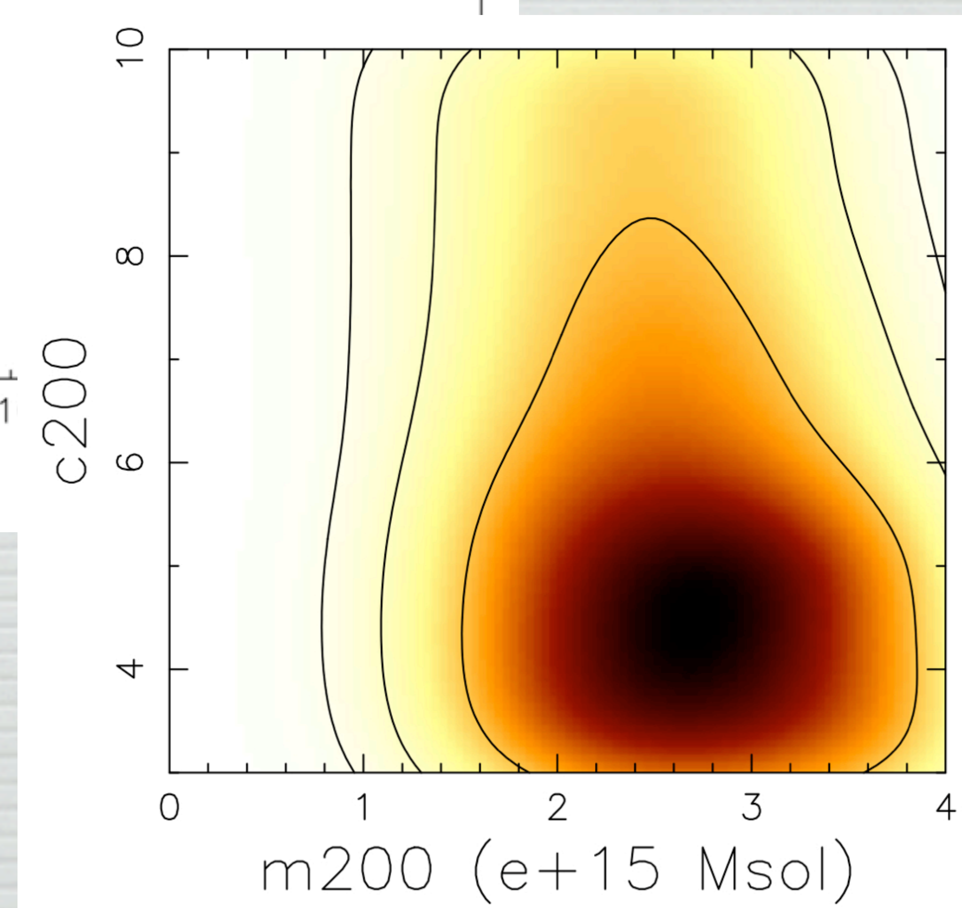


HE wrong ?
large
structure ?

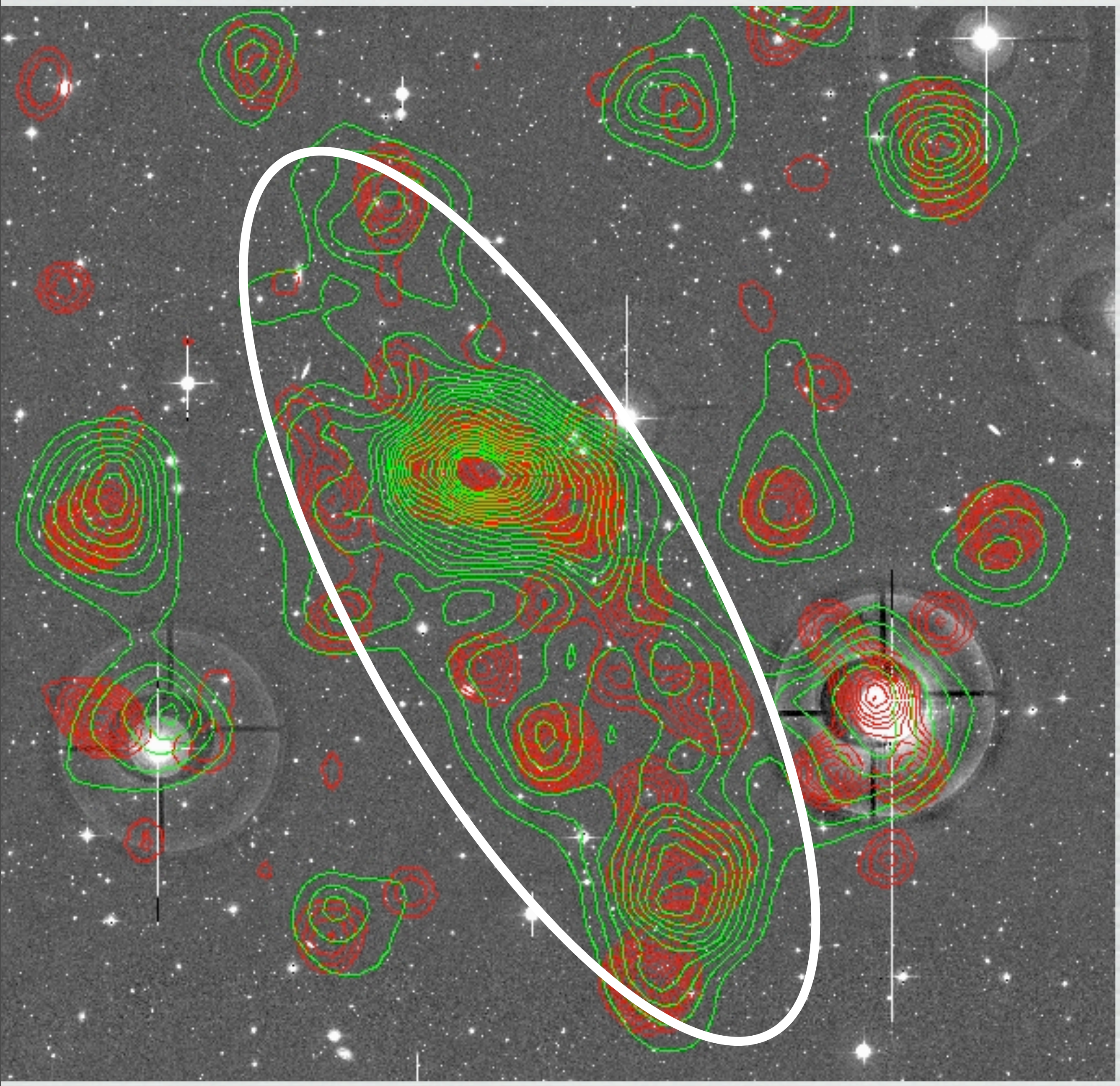


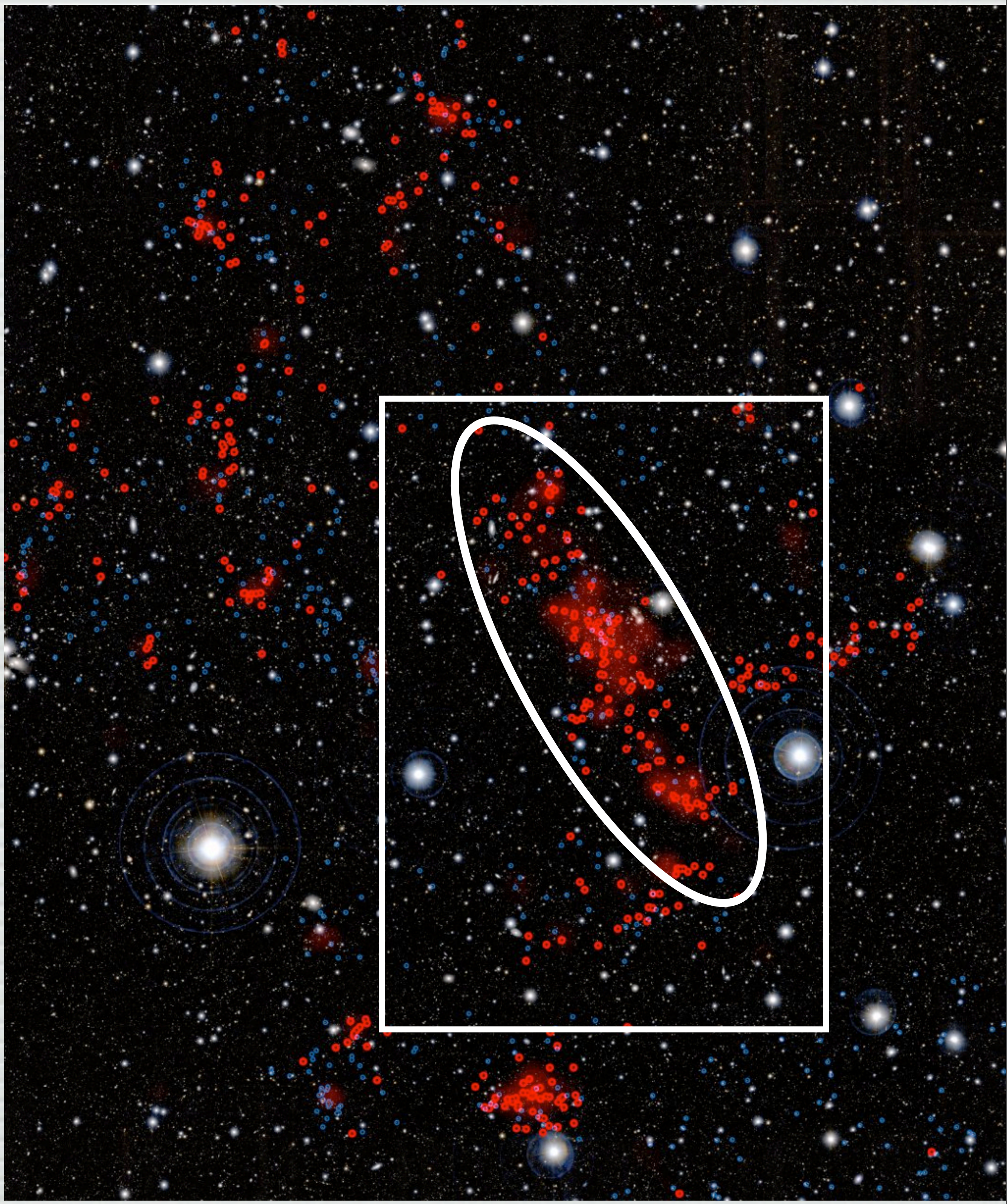
CL0016

preliminary....



CL0016 (z=0.54)





Tanaka09

preliminary....

CONCLUSION/PERSPECTIVES

+ weak lensing analysis of 11 clusters

+ efficient to constrain the mass at large scales

high z :

- contamination by foreground galaxies (= large fraction at these z)
- low density of background galaxies
- need other data (X, SL) to explore the clusters center
- hard to estimate truthfull error bars

→ weak lensing @ high z is challenging and requires very good data (space based)

<u>Next steps</u> :

combine the data sets and optimize the mass/concentration estimation

explore mass properties, scaling laws

put constraints on evolution (comparison with REXCESS sample)