The Cosmic Warzone

Detecting Dark Matter with Bulleticity

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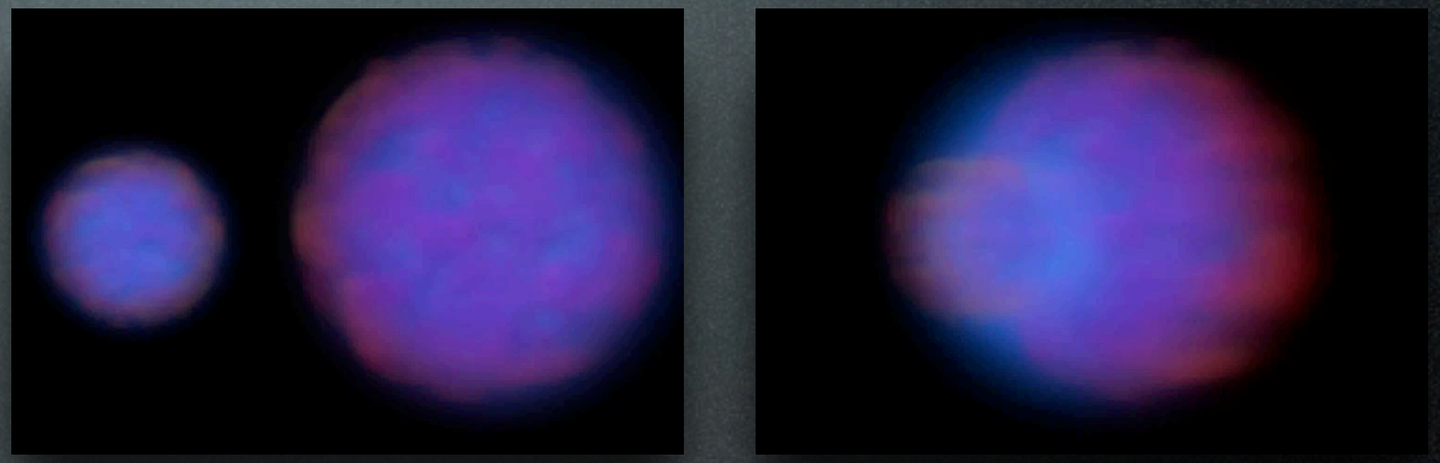
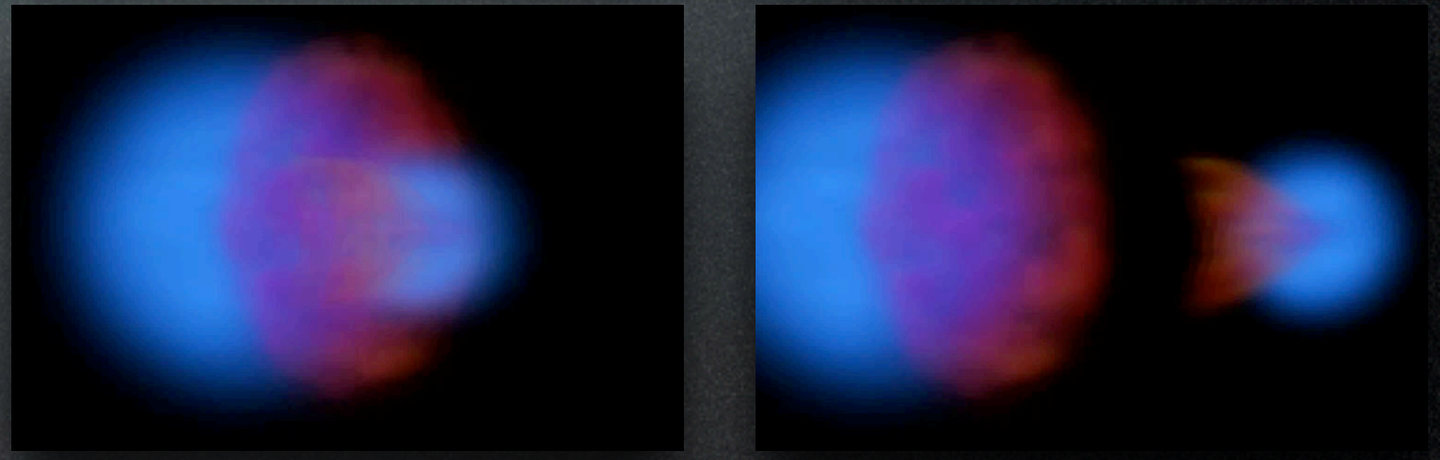
Richard Massey, Tom Kitching, Andy Taylor
University of Edinburgh

Measuring the fundamental properties of Dark Matter

- Current understanding, models & constraints
- Using astronomical events to understand fundamental properties





$$\tau = \Sigma \sigma / m$$

$$\frac{1}{\Sigma} > \sigma / m$$

What are the benchmark estimations?

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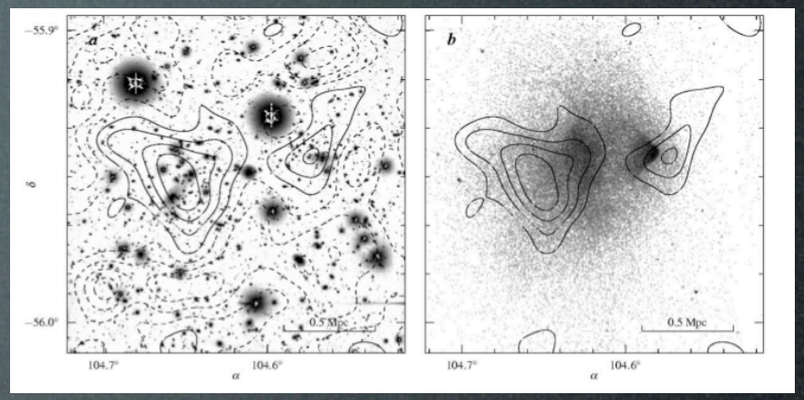
Bullet cluster $\sigma / m < 1 cm^2 g^{-1}$

1E 0657-56, Markevitch et al, 2004



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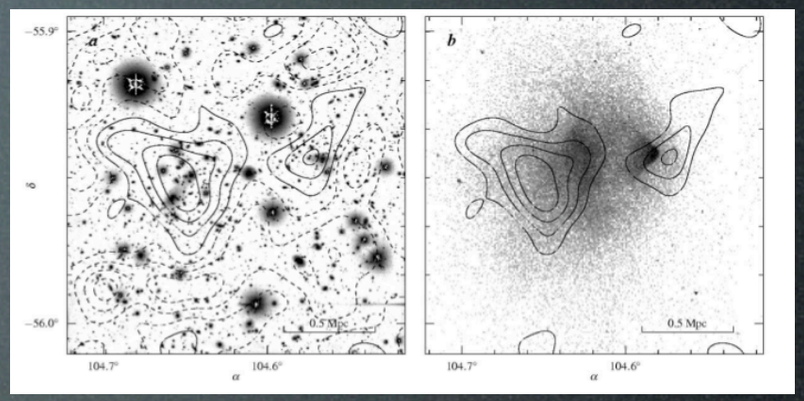
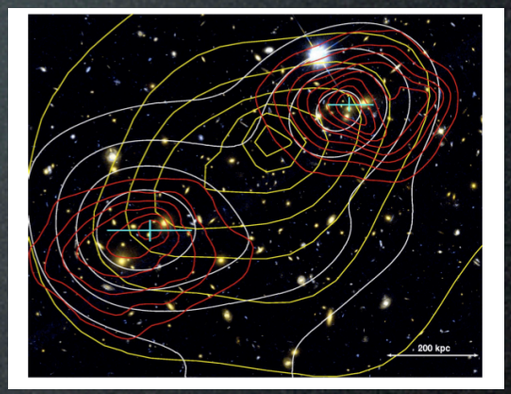


MACSJ0025-1222.4

$$\sigma/m < 4 cm^2 g^{-1}$$

Bradac et al, 2008



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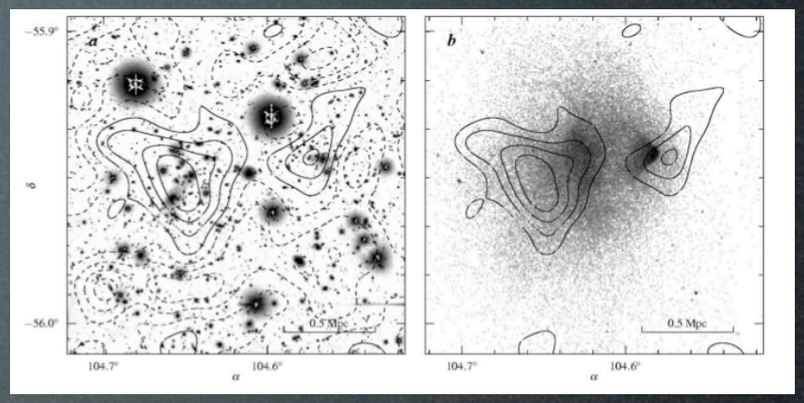

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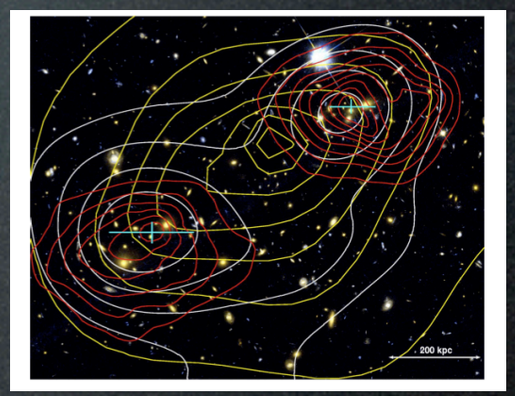
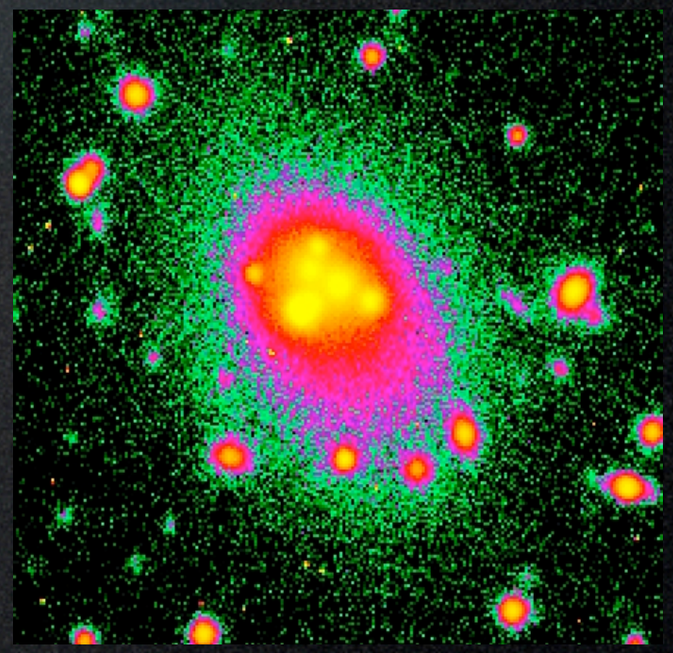


Abell 3827

$$\sigma/m > 4.5 \times 10^{-7} (t/10^{10}\, yr)^{-2} cm^2 g^{-1}$$

Williams & Saha, 2011

$$d \sim (a_{st} - a_{dm}) t^2$$



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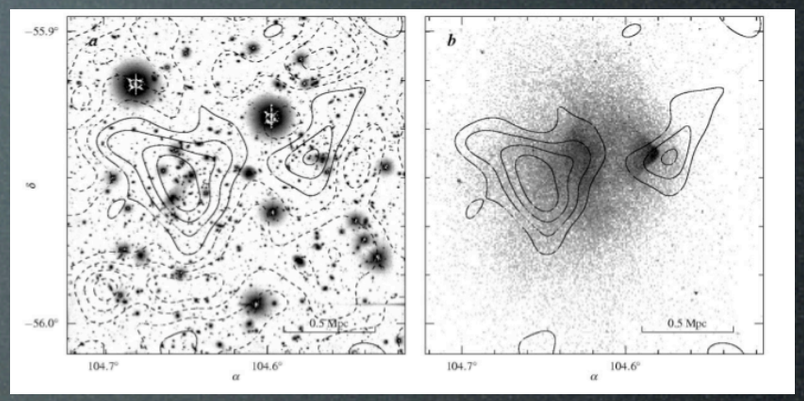

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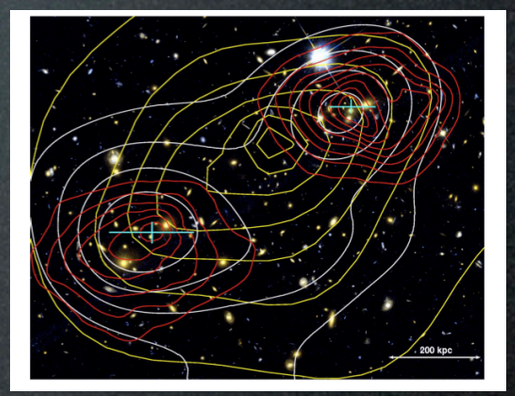

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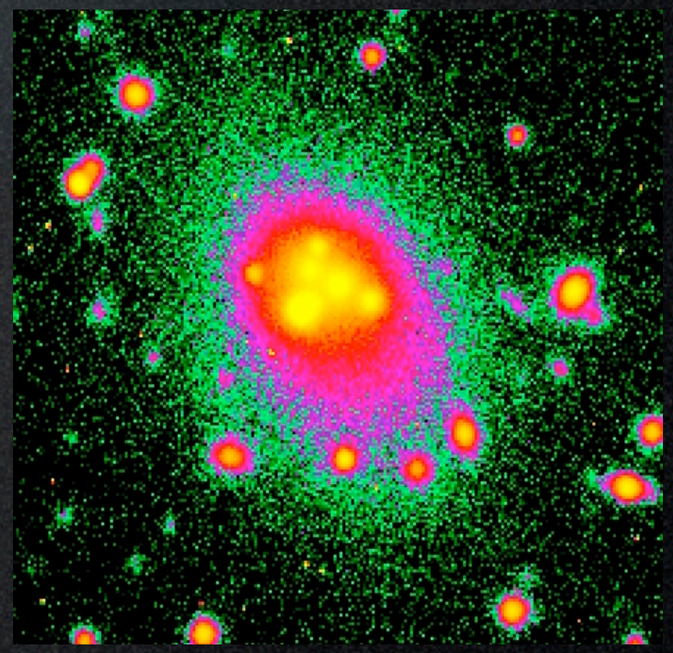

Irregular and rare clusters!!!!

Increasing our sample: Using Bulleticity as a measure for the cross section

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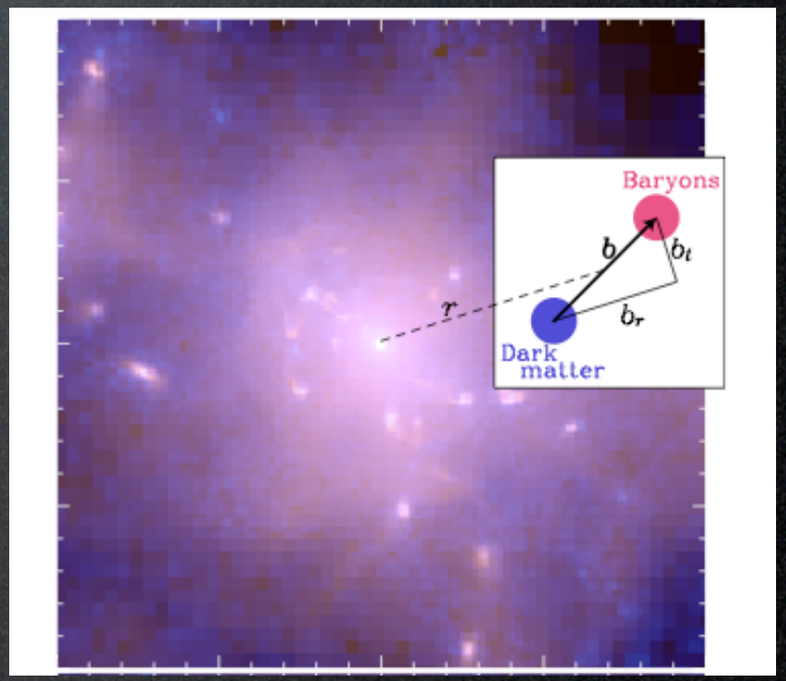

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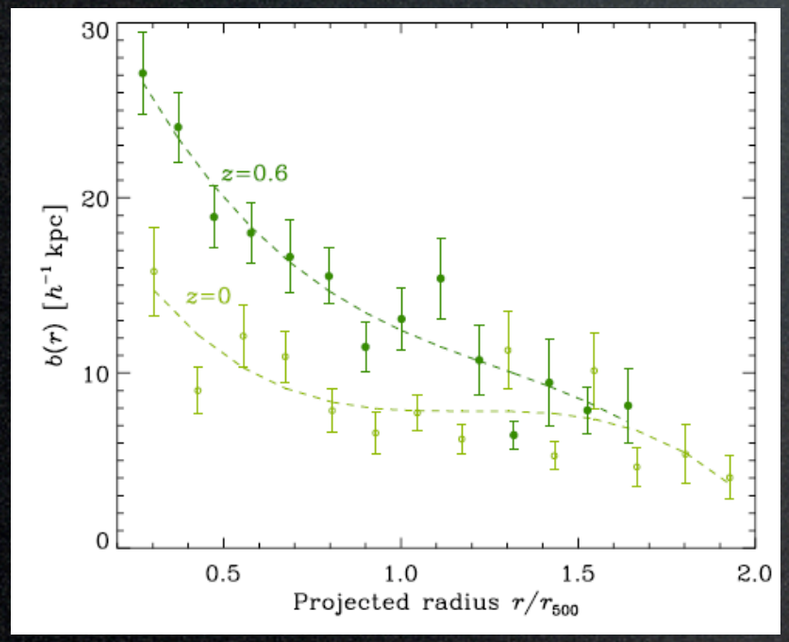

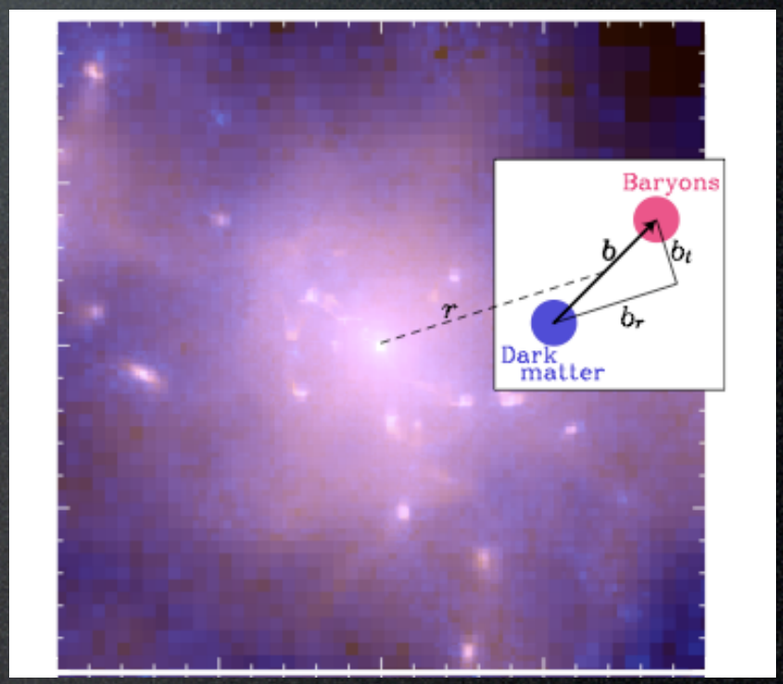

Massey et al,2010

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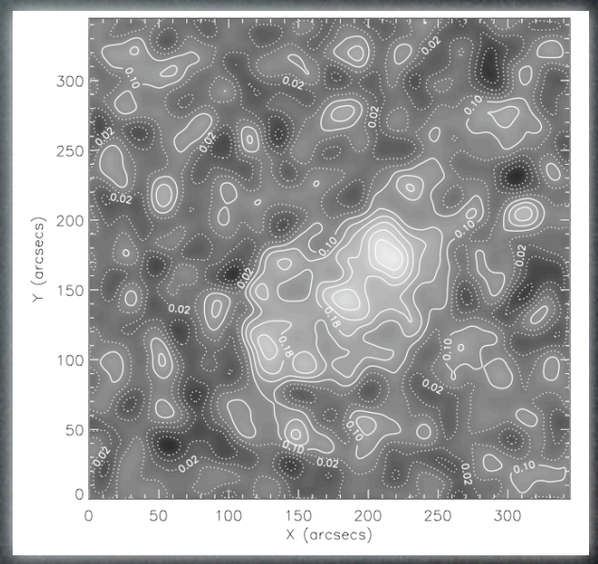

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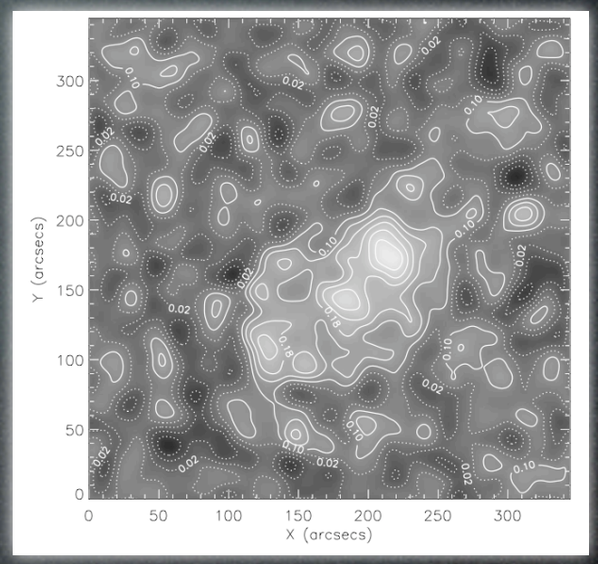
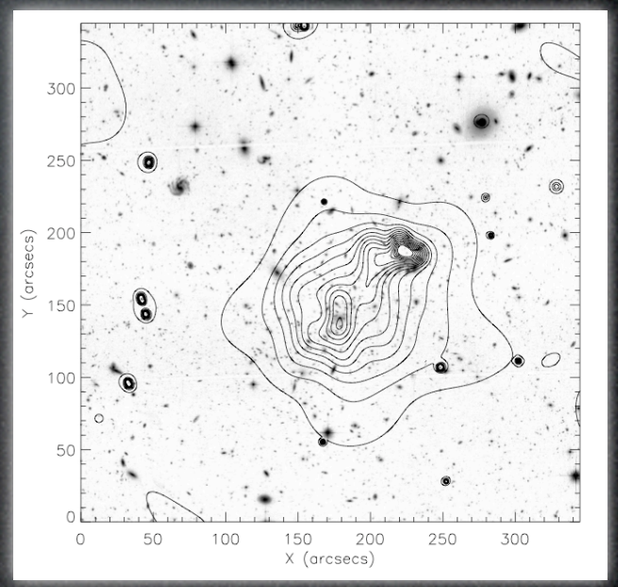
$$S_x(r) \propto \int n_e n_p dl$$





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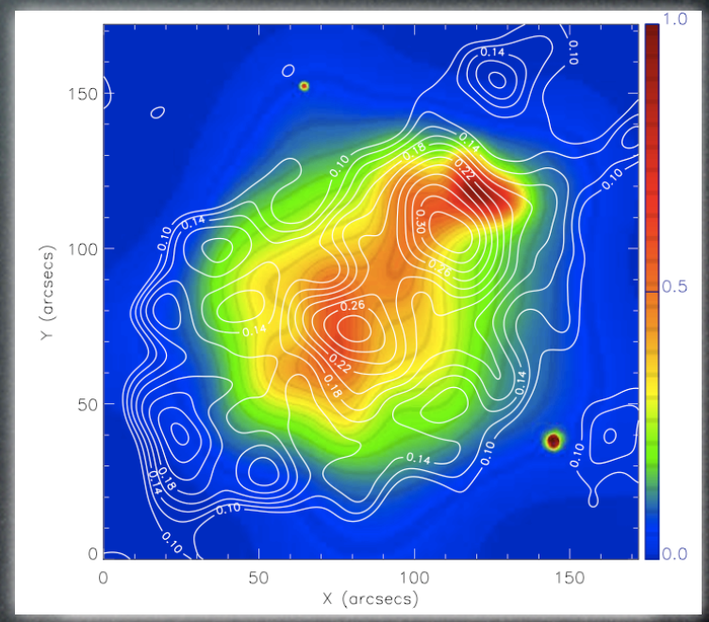

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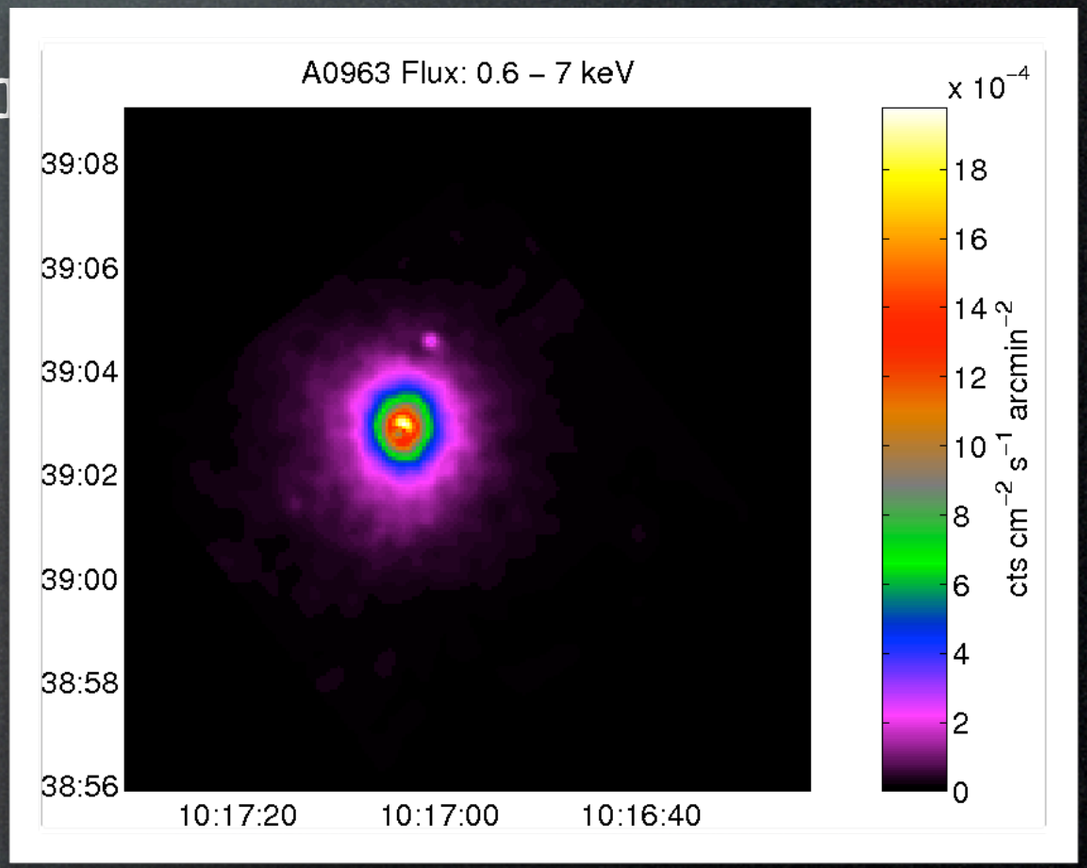

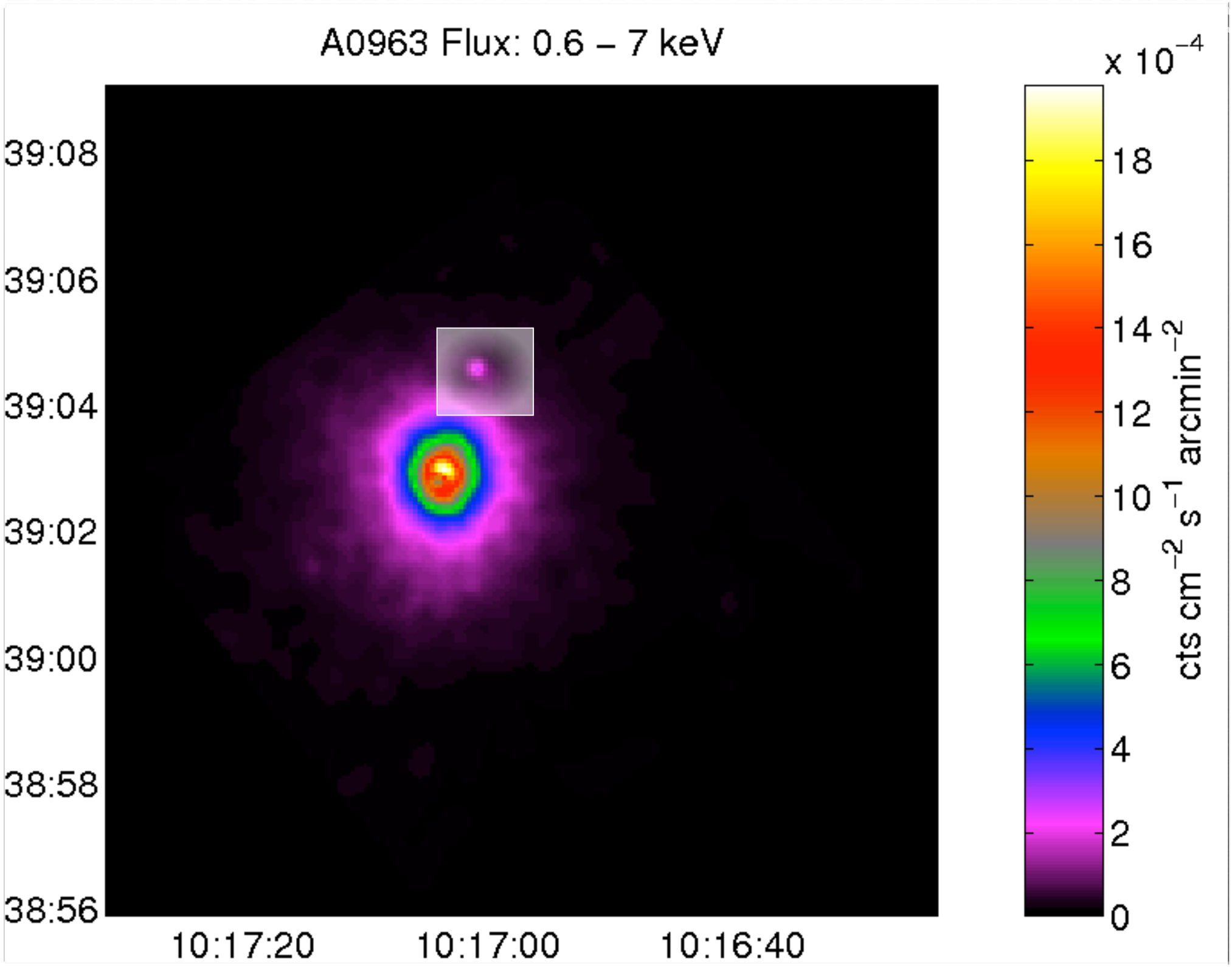
A0963 Flux: 0.6 – 7 keV
39:08
39:06
39:04
39:02
39:00
38:58
38:56
10:17:20
10:17:00
10:16:40
x 10^-4
18
16
14
12
10
8
6
4
2
0
cts cm^-2 s^-1 arcmin^-2

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39:08

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38:58

38:56

10:17:20

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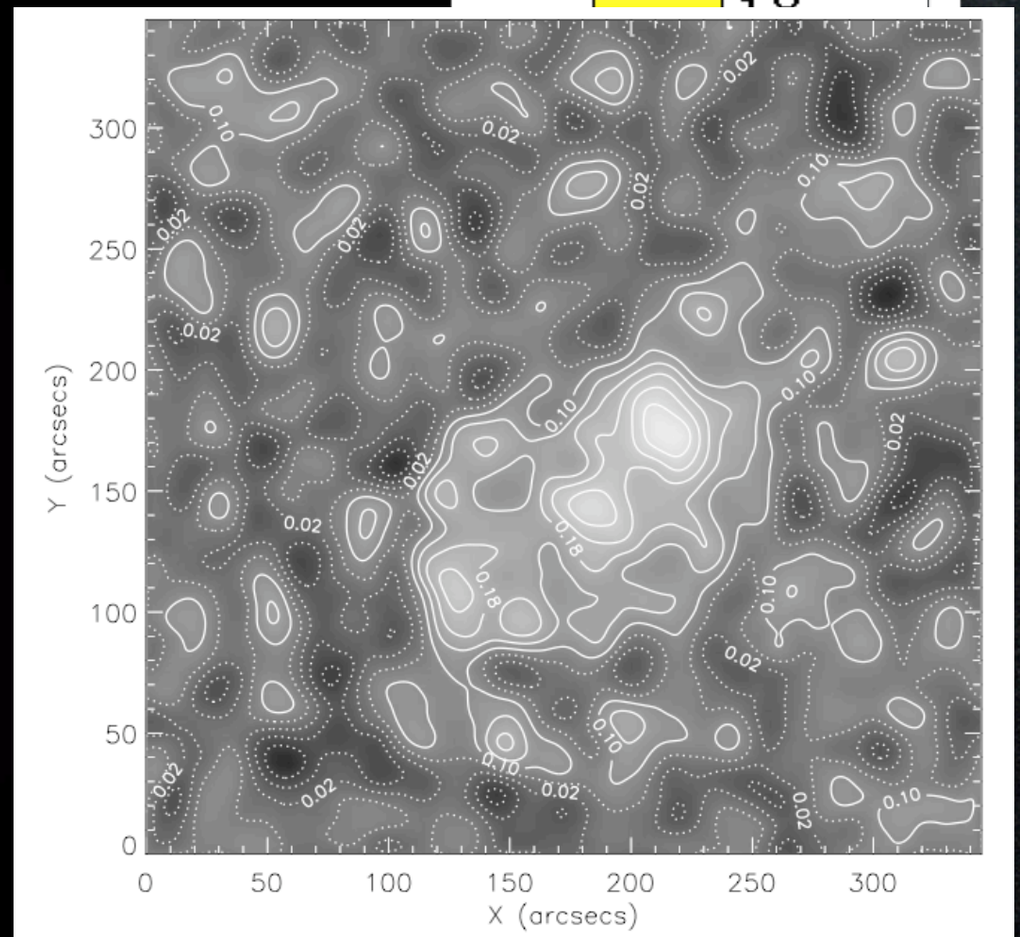

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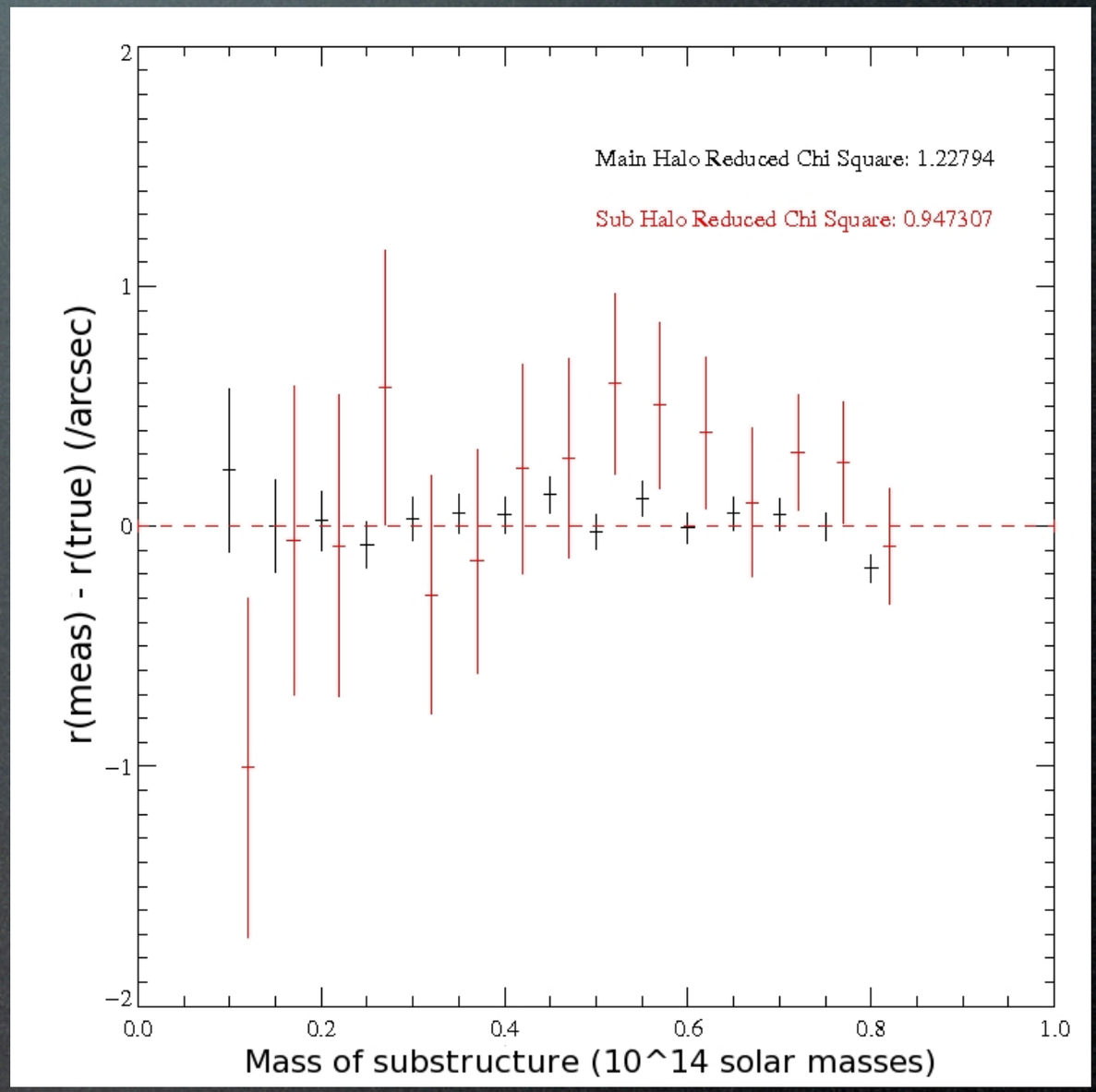
- Analytic simulations:
  - Assumption of sub dominant xray peak error
  - Hubble Advance Camera field of view
  - Galaxy density : 80 galaxies / sq.arc min
  - 2 Body NFW Halo configuration
  - Given Mass:Concentration relation
  - Source galaxies redshift of 1

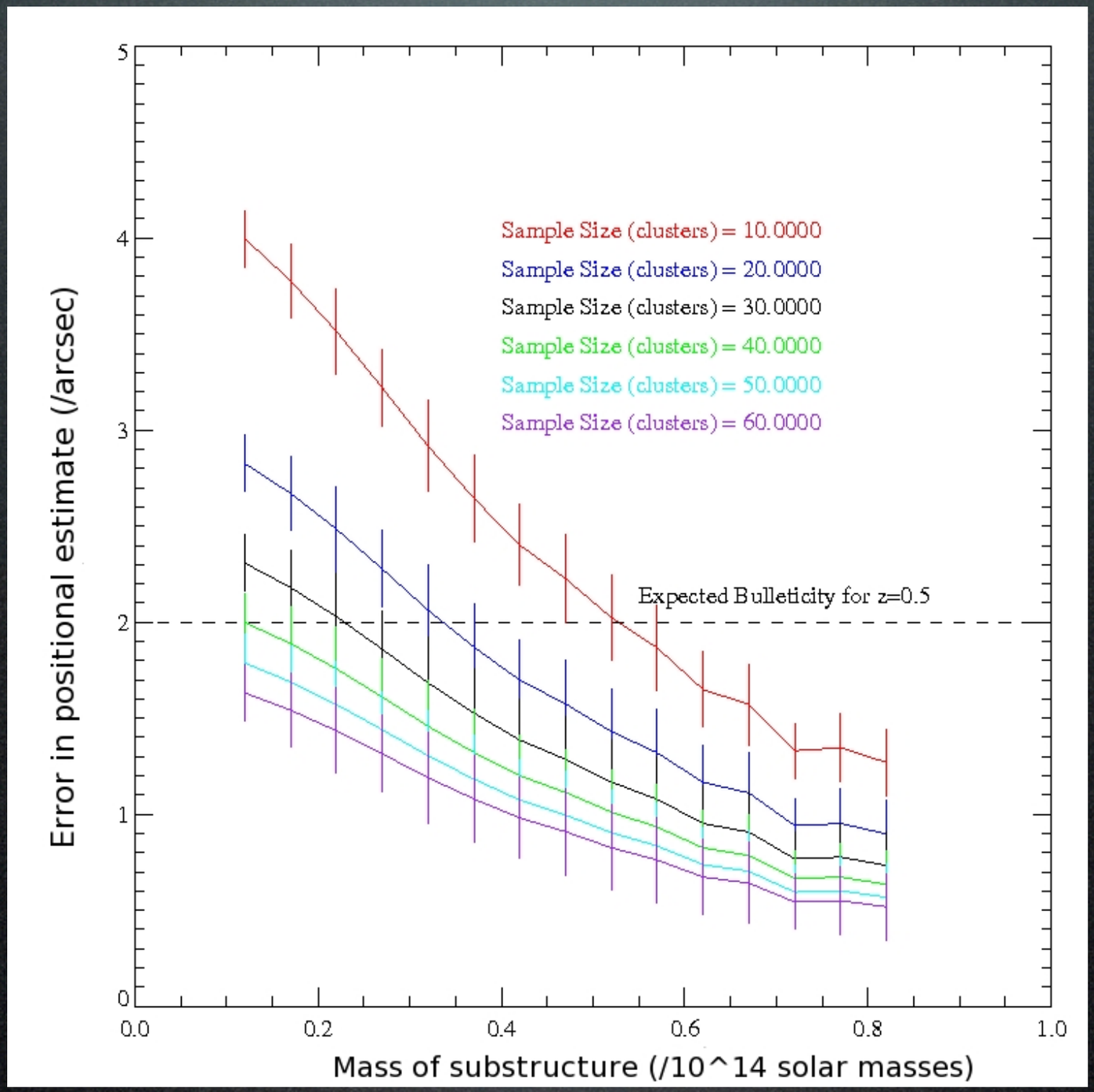
Potential Systematics

Realism:

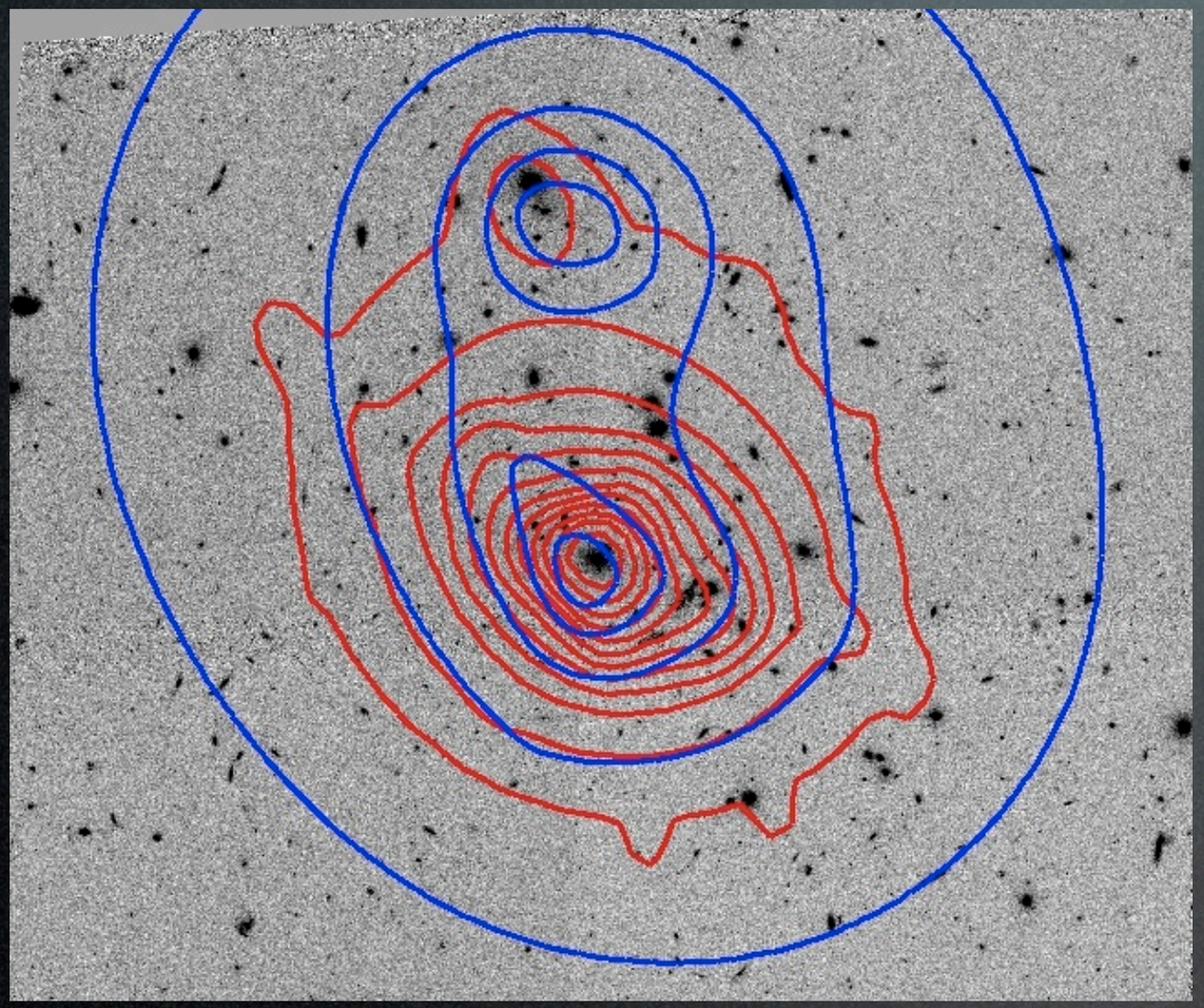
- ✓ Intrisic ellipticities
- ✓ Elliptical haloes
- ✓ Shape measurement bias
- ✓ Source redshift error

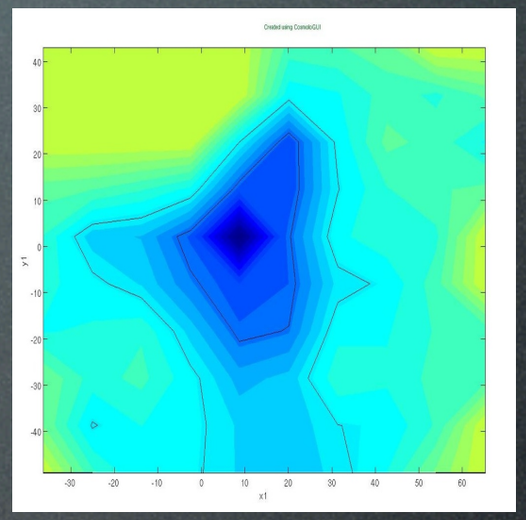


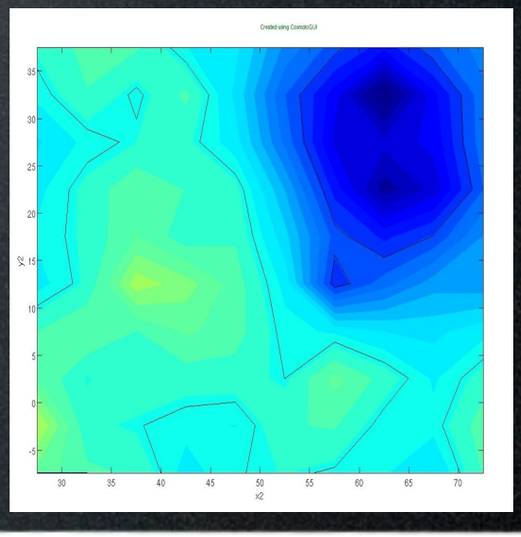
How many clusters do I need to detect a Dark Matter offset?



MACSJ0152







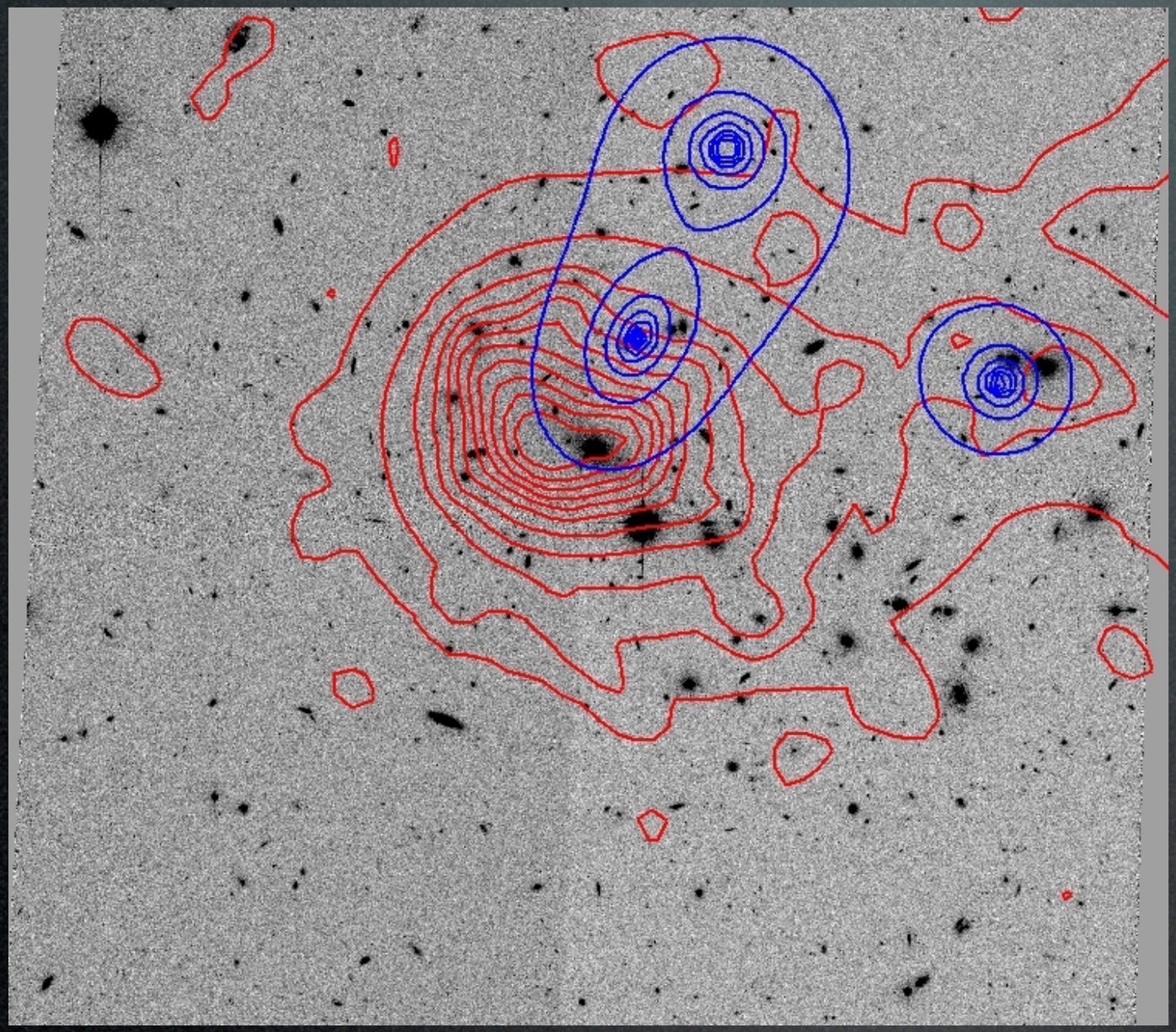
$$M_{main} = 5.2^{7.9}_{-1.1} \times 10^{13} M_{\Theta}$$

$$c_{main} = 3.2^{+4}_{-0.1}$$

$$M_{sub} = 6.8^{+10.}_{-1.3} \times 10^{13} M_{\Theta}$$

$$c_{sub} = 2.8^{+3.2}_{-0.09}$$

MACSJ1006



$$M_{central} = 6.9^{+11.2}_{-1.7} \times 10^{13} M_{\Theta}$$

$$c_{central} = 3.0^{+3.4}_{-0.1}$$

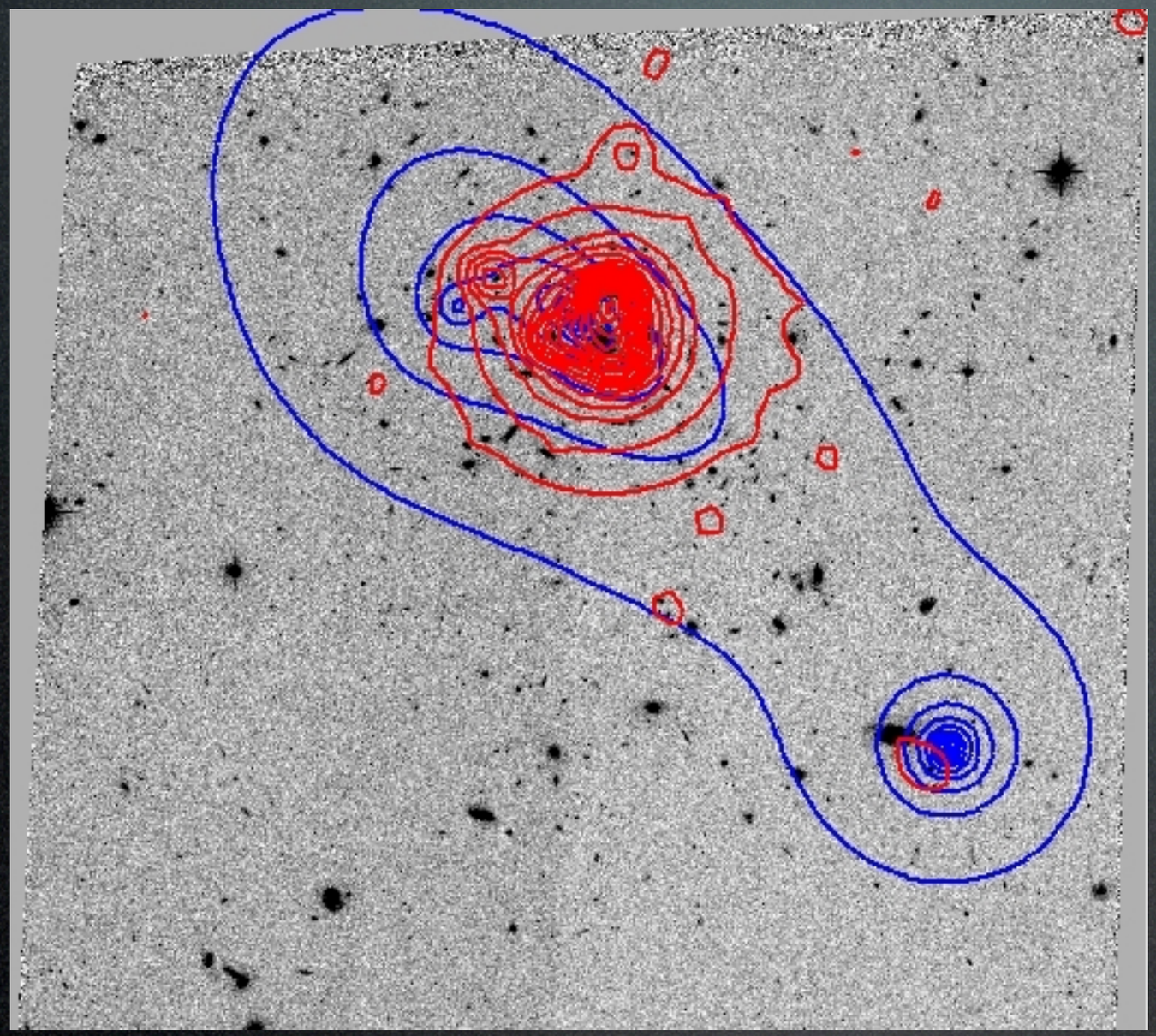
$$M_{north} = 5.6^{+4.5}_{-1.6} \times 10^{13} M_{\Theta}$$

$$c_{north} = 6.8^{+1.3}_{-3.2}$$

$$M_{east} = 6.9^{+12.2}_{-0.4} \times 10^{13} M_{\Theta}$$

$$c_{east} = 2.3^{+2.8}_{-0.1}$$

SDSS1004



$$M_{central} = 9.1^{+34}_{-3.9} \times 10^{13}\, M_{\Theta}$$

$$c_{central} = 2.6^{+2.5}_{-0.1}$$

$$M_{west} = 4.0^{+9.9}_{-3.3} \times 10^{13}\, M_{\Theta}$$

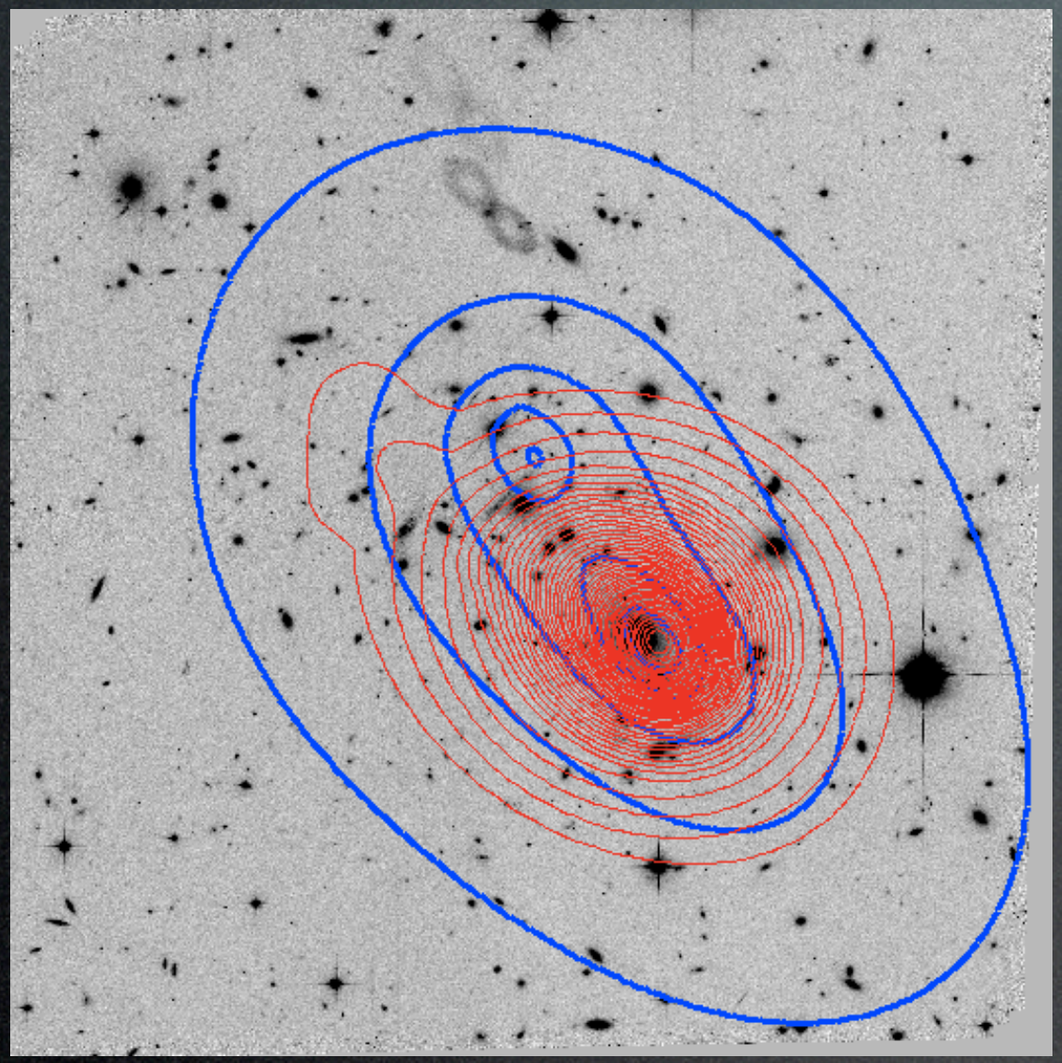
$$c_{central} = 2.4^{+2.4}_{-0.1}$$

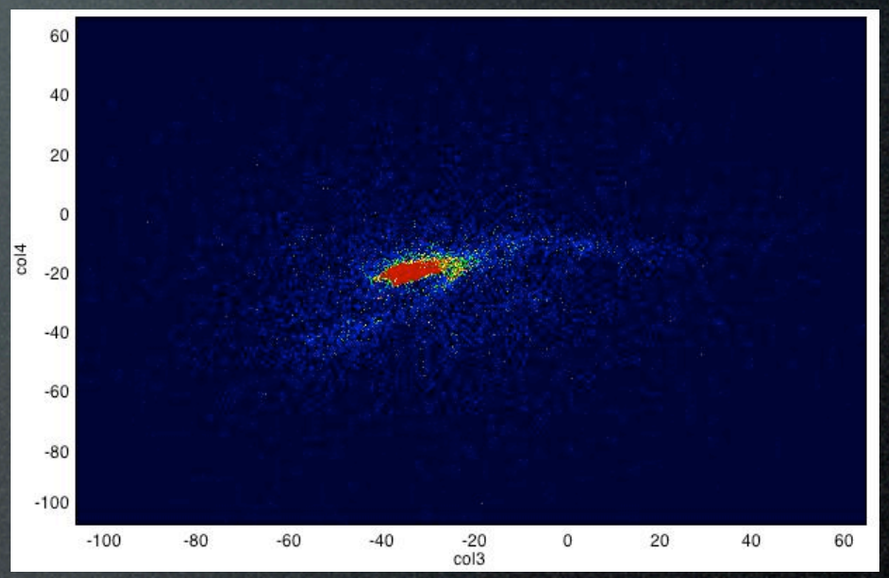
$$M_{south} = 6.6^{+11}_{-1.7} \times 10^{13}\, M_{\Theta}$$

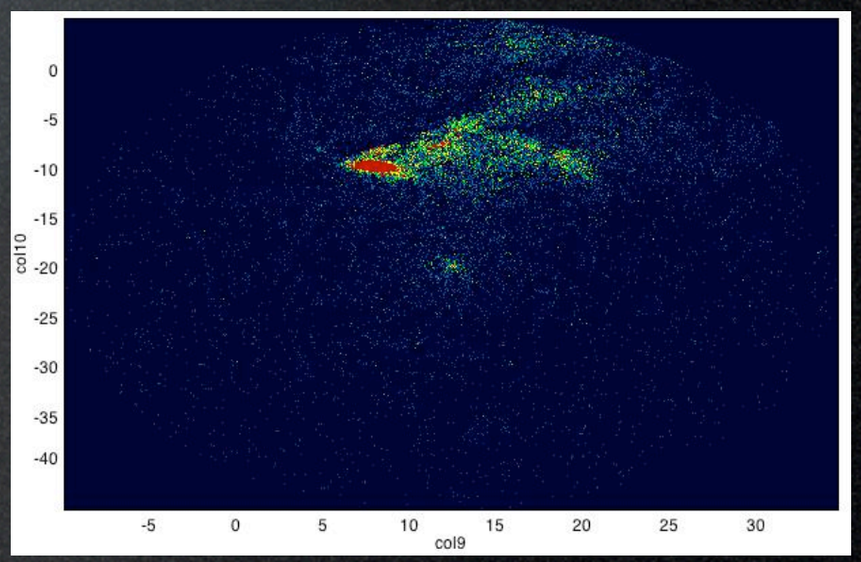
$$c_{south} = 3.9^{+5.4}_{-0.2}$$

A2390: Strong + Weak Lensing

Preliminary







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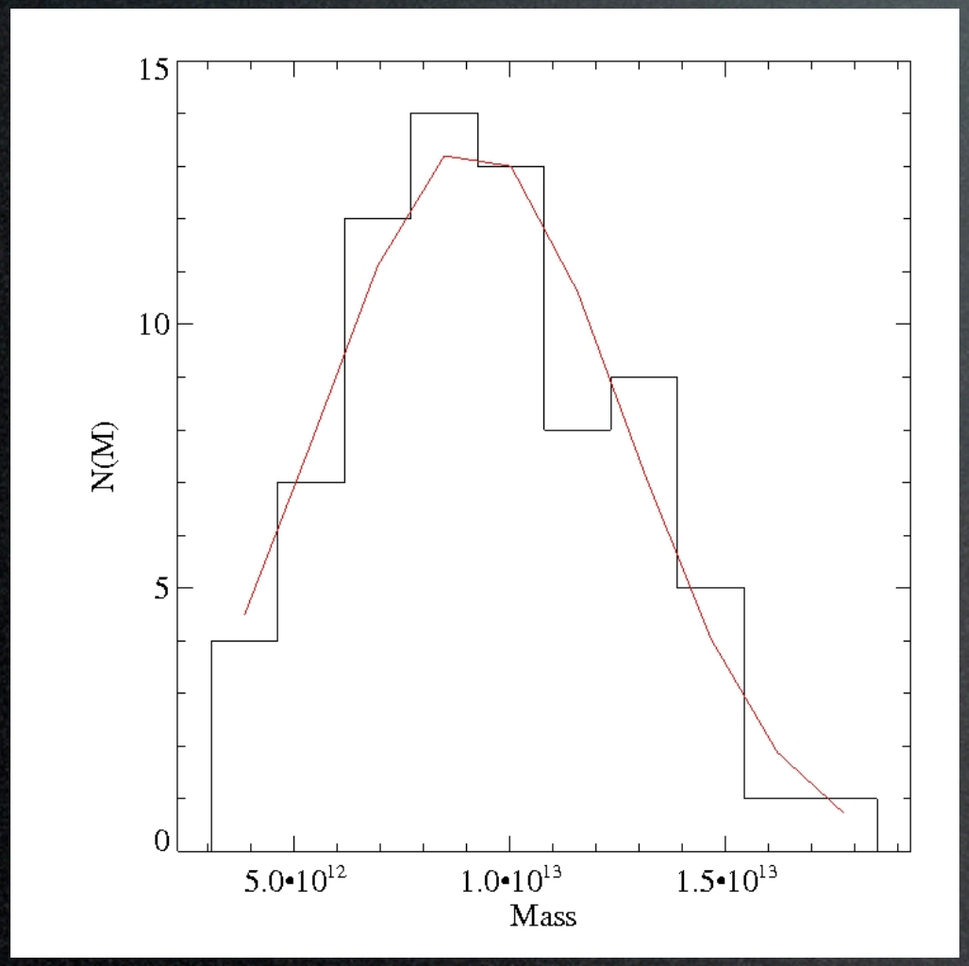
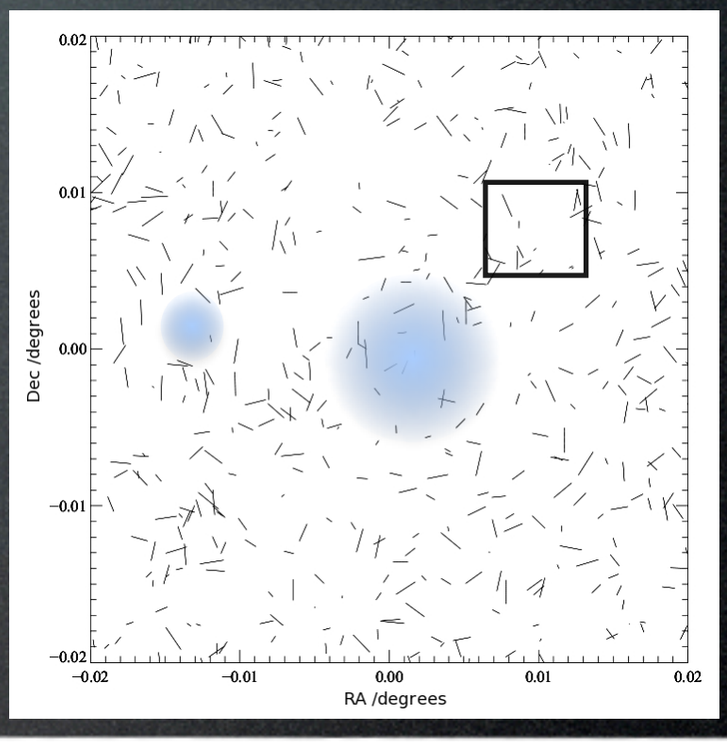
- Sims : Add cosmic shear, multiple clumps, different profiles.
- Study more clusters!

Problem with prior: Fake xray detection

- Assumption that all xray peaks have associated dark matter: what if it is just xray noise?
- Characteristic reconstructed mass





$$95\% = 2 \times 10^{13} M_{\Theta}$$