Free-Form solutions for the Hubble Frontier Fields

J.M. Diego

Daniel Lam, Adi Zitrin, Wei Zheng, Tom Broadhurst, Holland Ford, Jeremy Lim, Sandor Molnar, Txitxo Benitez,

2014 arXiv:1406.1217

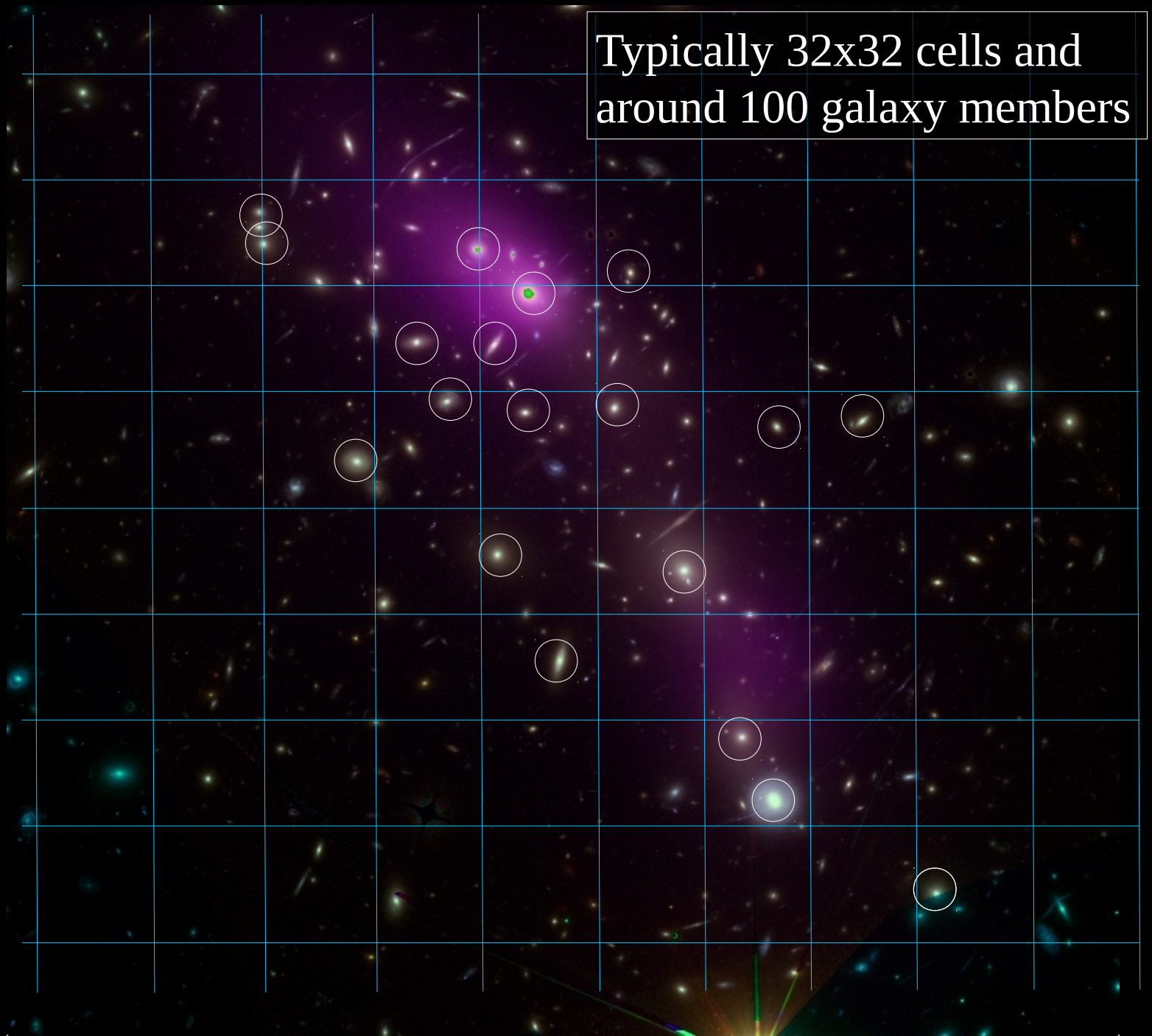
Free-form Lensing Implications for the Collision of Dark Matter and and Gas in the Frontier Fields Cluster MACS J0416.1-2403

2014 arXiv:1410.7019

Hubble Frontier Field Free-Form Mass Mapping of the Massive Multiple-Merging Cluster MACSJ0717.5+3745

2014 arXiv:1409.1578

The Orthogonally Aligned Dark Halo of an Edge-on Lensing Galaxy in the Hubble Frontier Fields: A Challenge for Modified Gravity


Typically 32x32 cells and
around 100 galaxy members

MACS J0416


38.2
38.1
19.2
26.3
19.1
1.1
2.1
21.1
2.2
7.1
1.2
21.2
7.2
23.3
19.4
26.2
23.2
8.1
22.2
34.2
8.2
22.3
19.3
26.1
33.2
35.3
22.4
3.1
12.3
32.2
35.2
22.1
36
5.1
2.3
1.3
5.2
5.3
11.2
11.1
3.2
23.1
31.2
32.1
30.2
33.1
29.2
13.1
34.1
12.2
27.2
25.2
12.1
28.2
25.1
14.1
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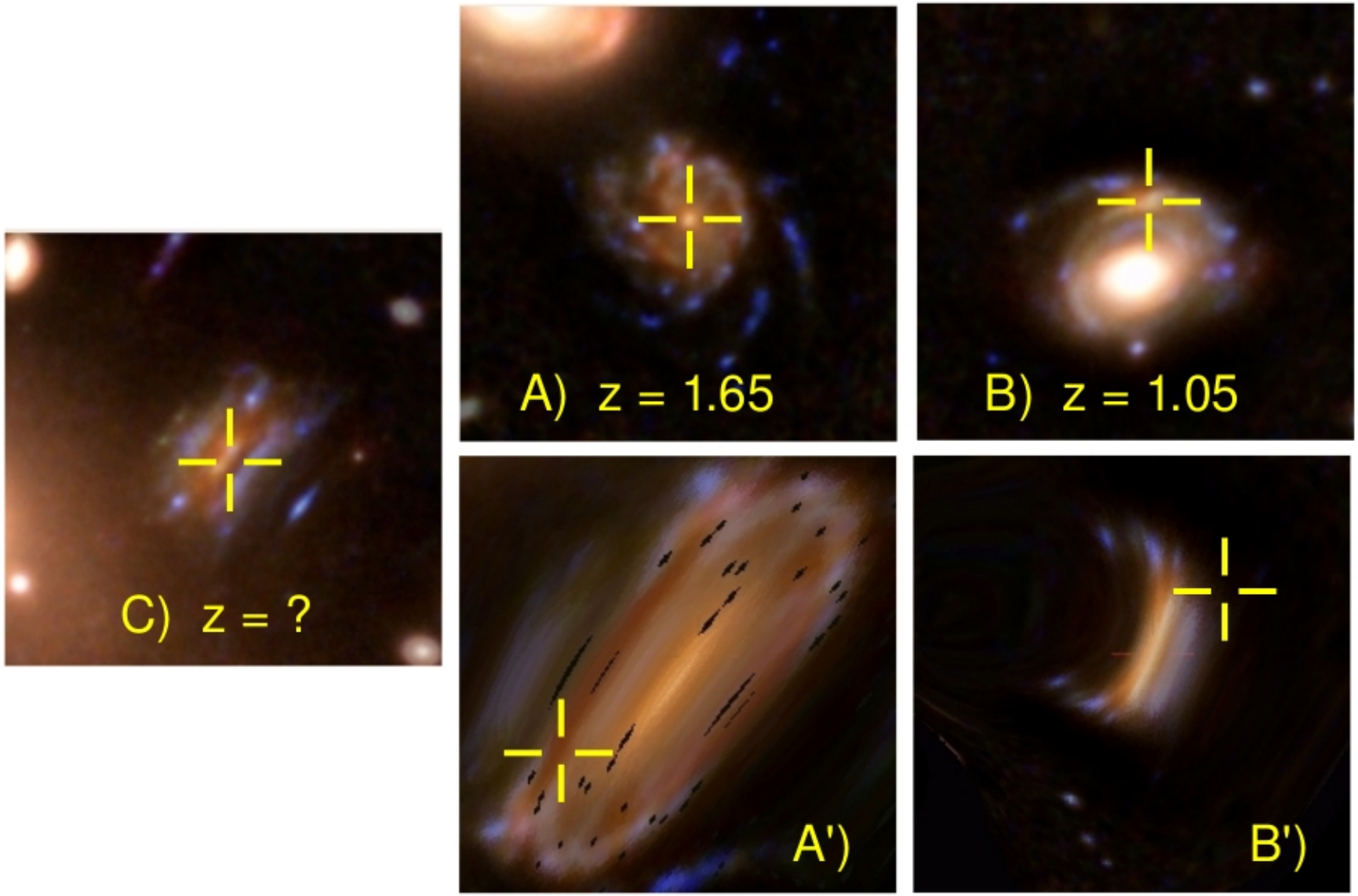
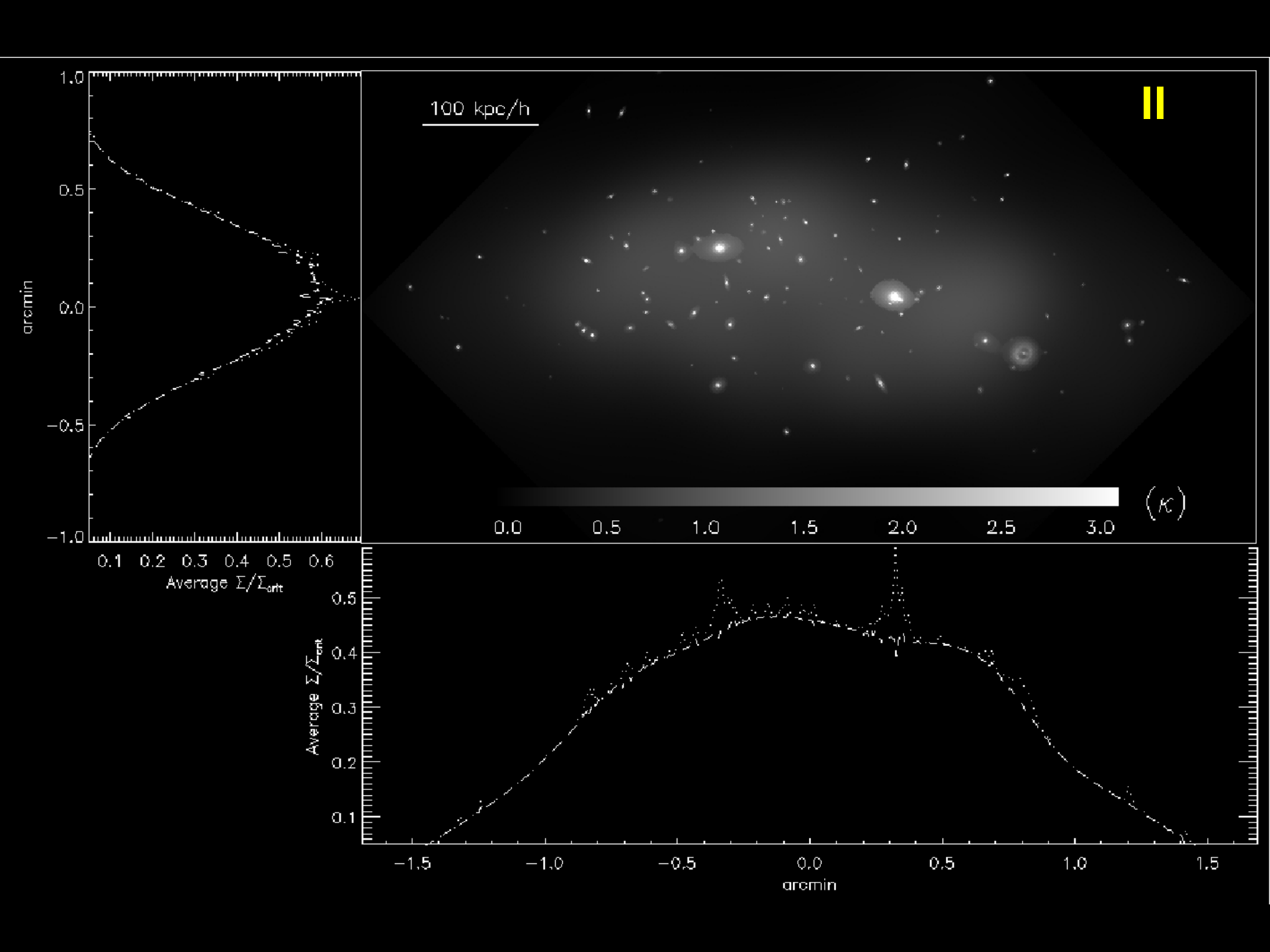
31.1
13.2
3.3
29.1
15.1
30.1
28.1
5.4
10.1
27.1
15.2
9.1
14.2
9.2
10.2
16.1
13.3
14.3
37.2
17.3
37.1
15.3
24.2
18.2
10.3
18.1
16.2
24.1
16.3
17.2
17.1
18.3

The *art* of system identification

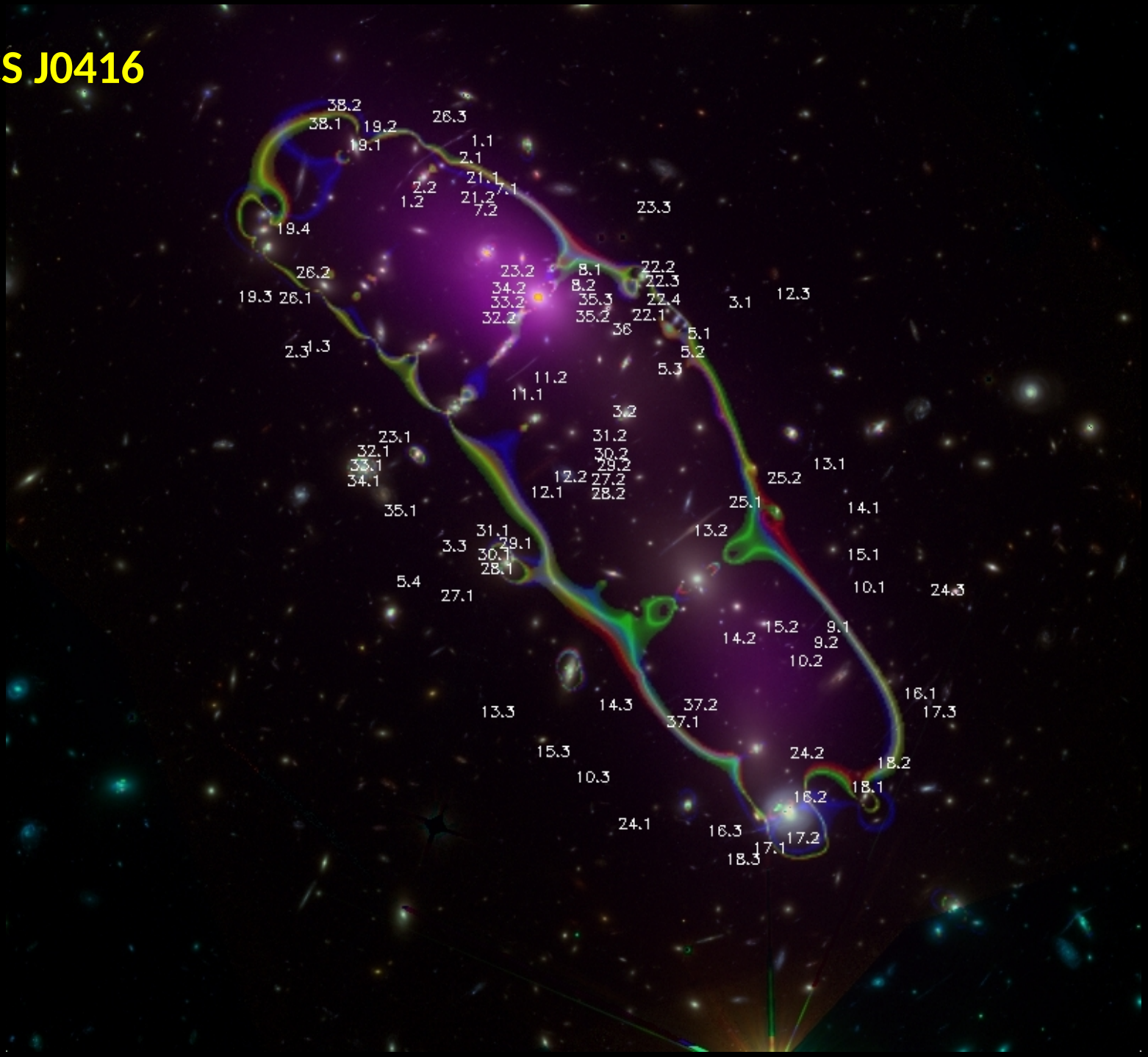
System 35 in Diego 14

System 28 in Jauzac 14




100 kpc/h
II
(κ)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
arcmin
Average Σ/Σcrit
Average Σ/Σcrit
arcmin

MACS J0416


38.2
38.1
19.2
26.3
19.1
1.1
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21.1
2.2
7.1
1.2
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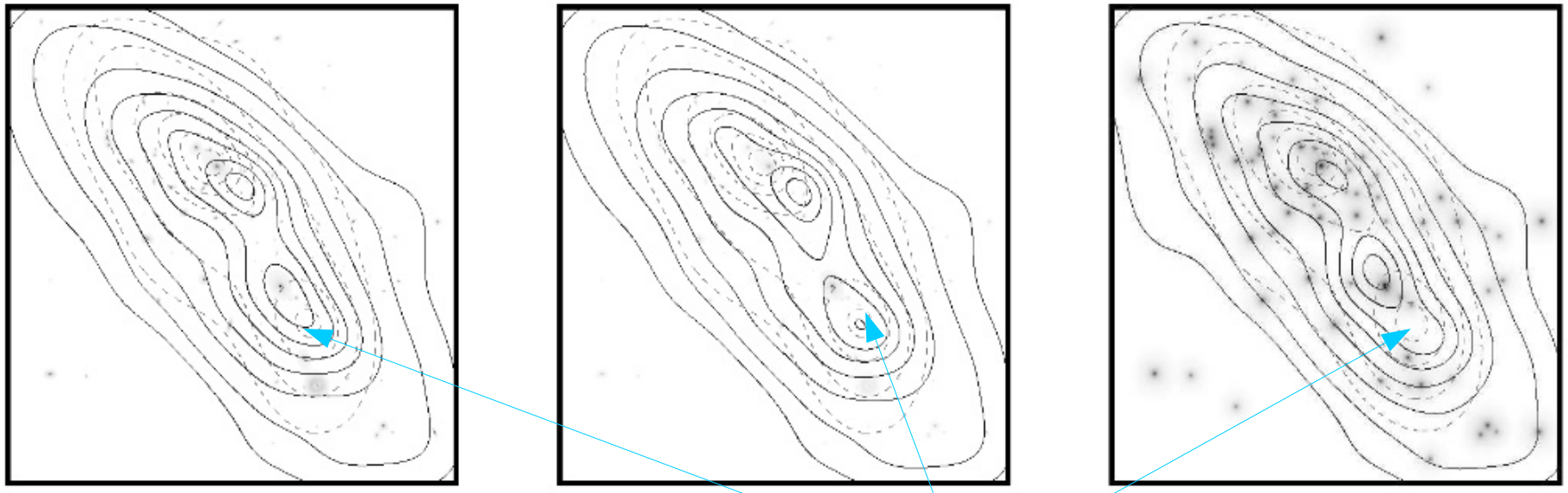
7.2
23.3
19.4
26.2
23.2
8.1
22.2
22.3
34.2
8.2
19.3
26.1
33.2
35.3
22.4
3.1
12.3
32.2
35.2
22.1
36
5.1
2.3
1.3
5.2
5.3
11.2
11.1
3.2
23.1
31.2
32.1
30.2
33.1
29.2
13.1
34.1
12.2
27.2
25.2
12.1
28.2
25.1
14.1
35.1
31.1
13.2
3.3
29.1
15.1
30.1
28.1
5.4
10.1
24.3
27.1
15.2
9.1
14.2
9.2
10.2
16.1
13.3
14.3
37.2
17.3
37.1
15.3
24.2
18.2
10.3
18.1
16.2
24.1
16.3
17.2
17.1
18.3

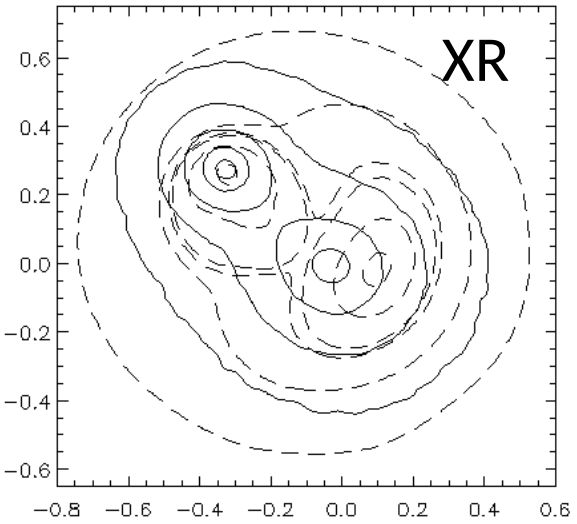
Case I

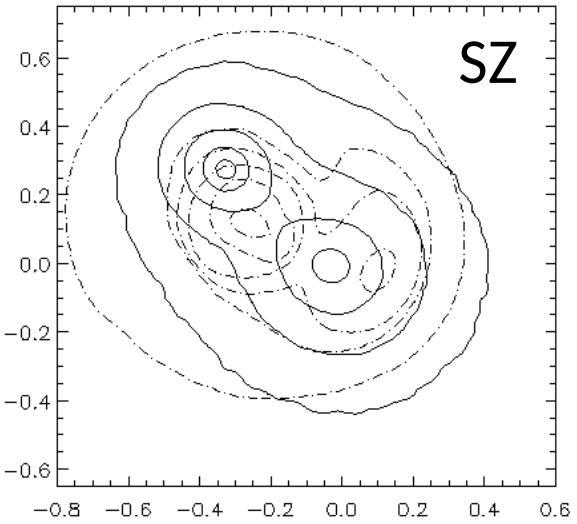
Case II

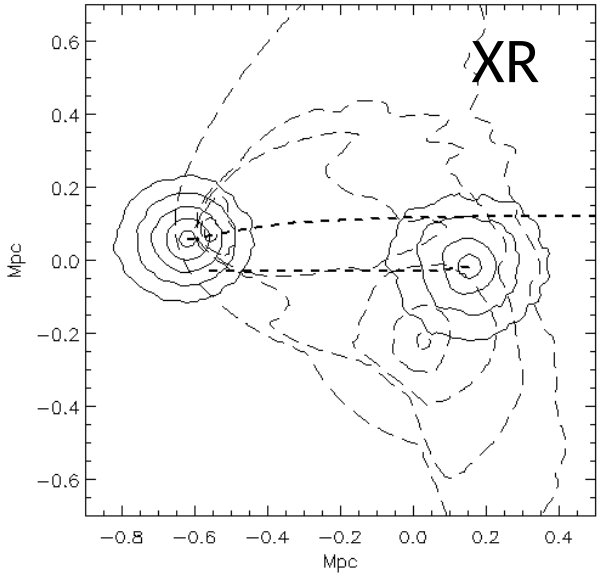
Case III

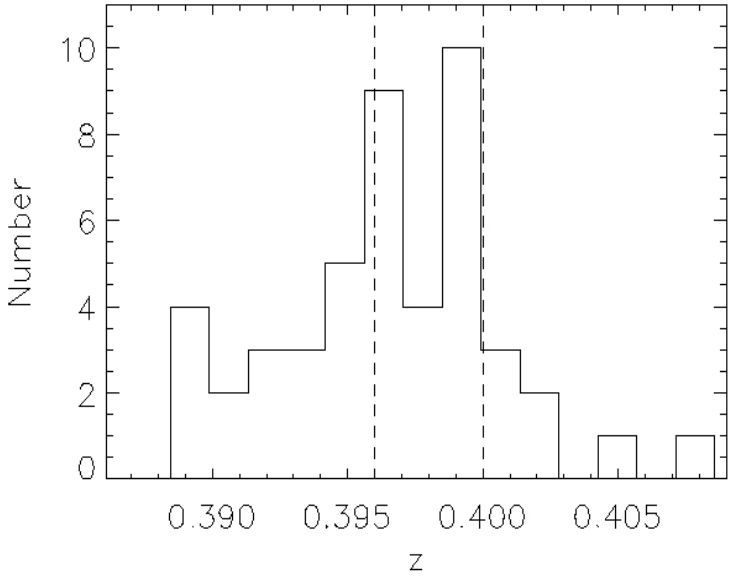


Distribution of DM seems to trace the gas, suggesting that the SL data may be sensitive to the plasma mass.



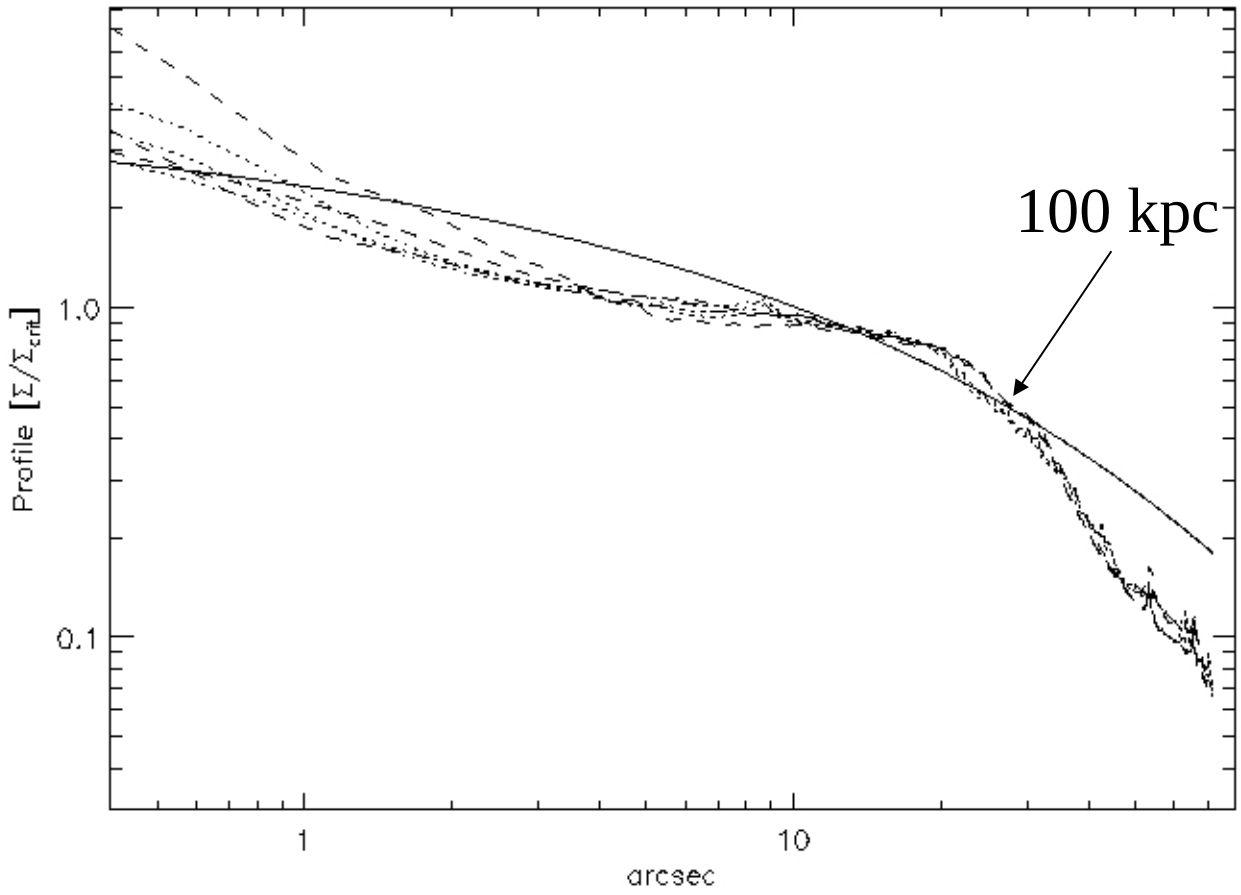






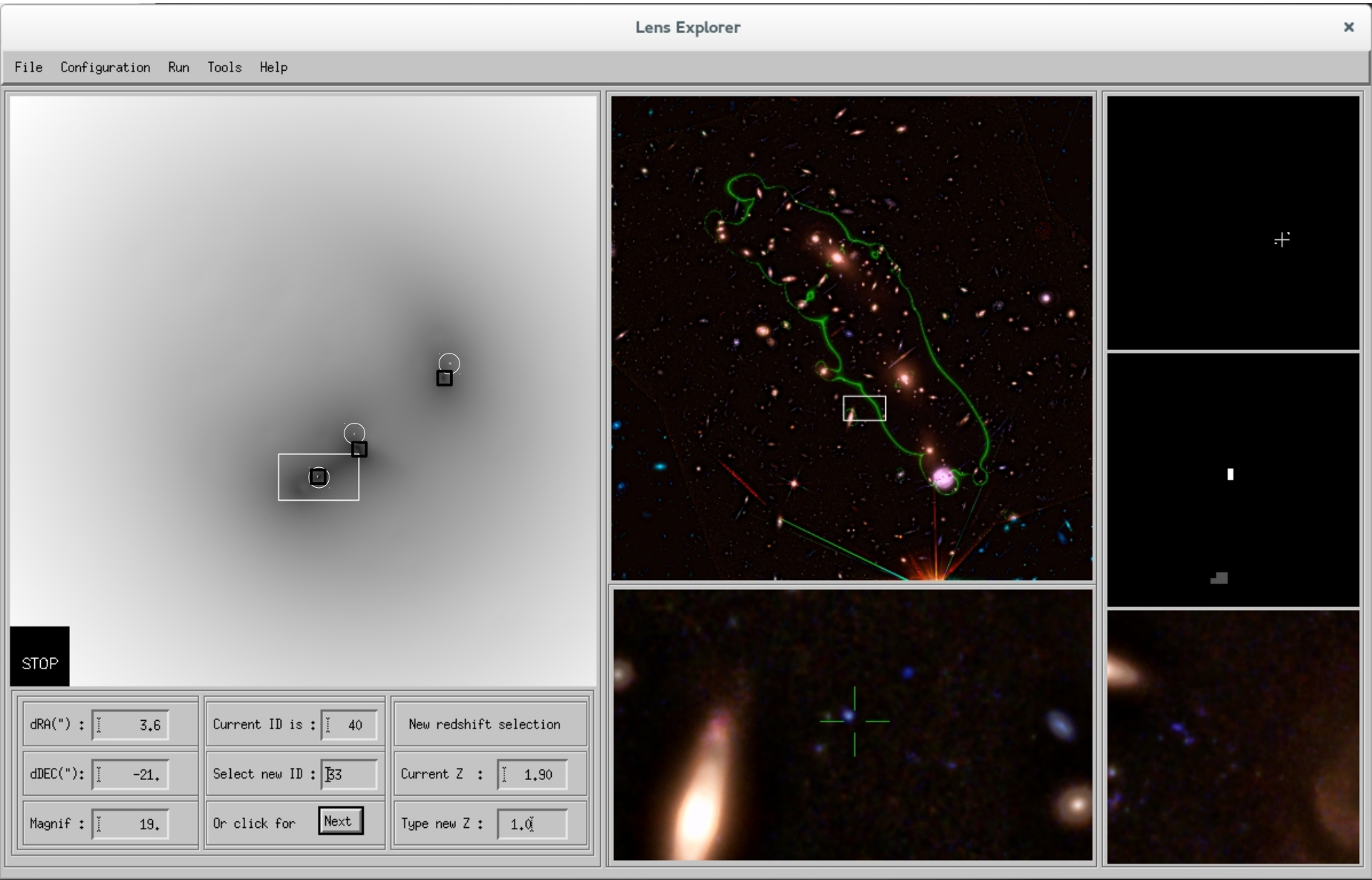
The dynamical state seems to be consistent with a pre-merger collision along the line of sight. SZ should have a displaced peak.

A Very Shallow Profile?

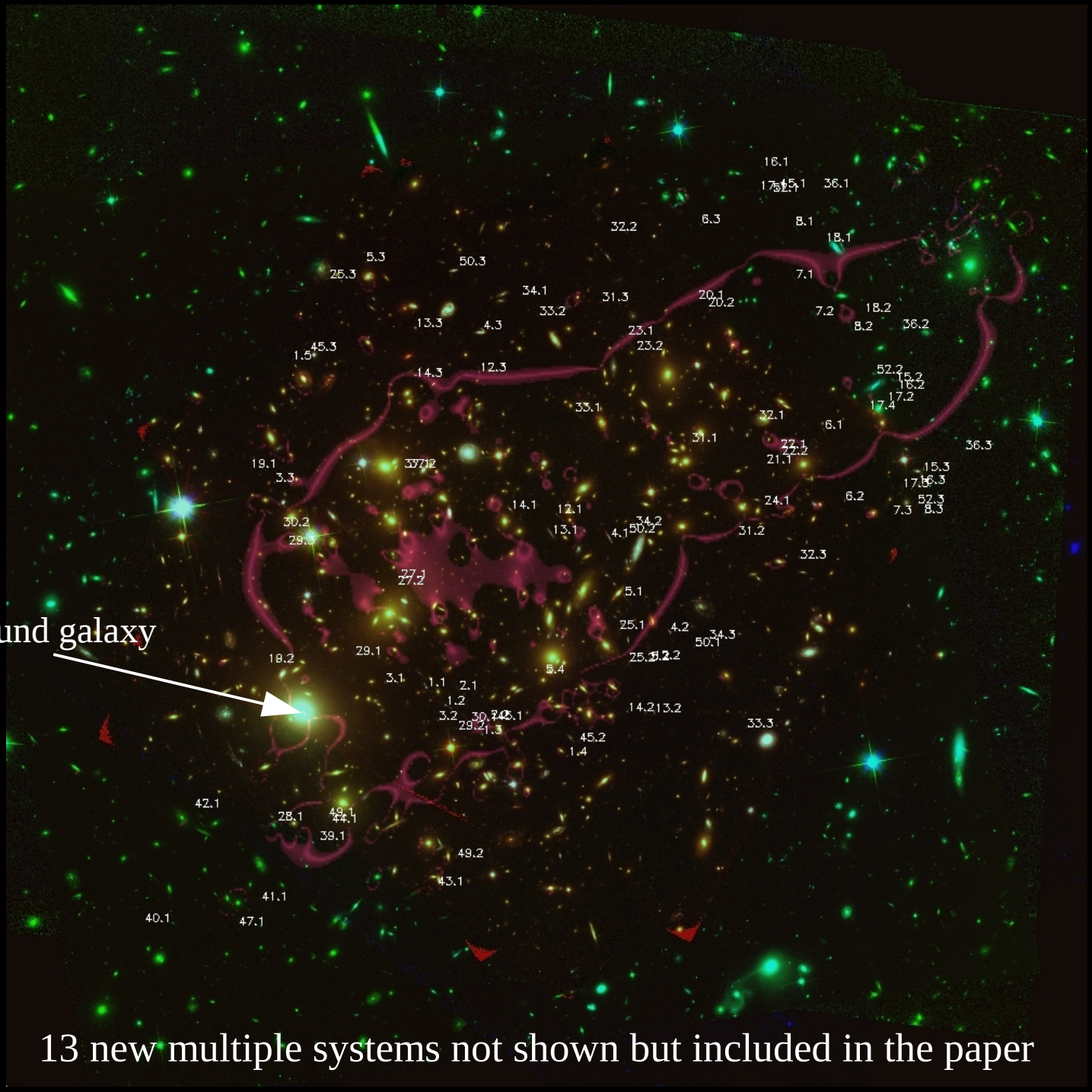


Possible explanations include tidal forces (no cusp?), SMBH (small scales only?), self-interaction DM (no head on collision?), DM+gas combined profile?

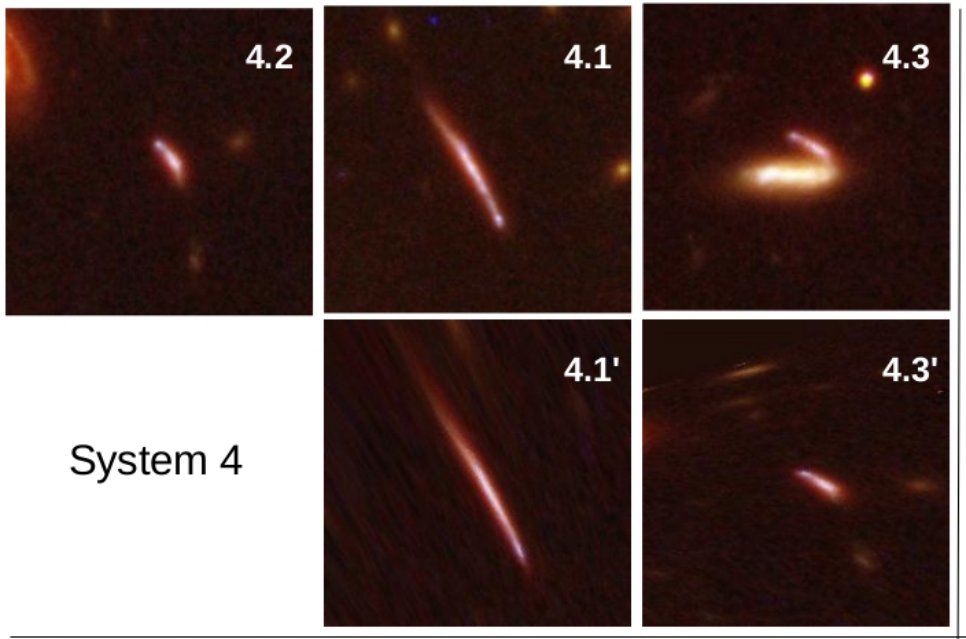
LensExplorer. Model Comparisson

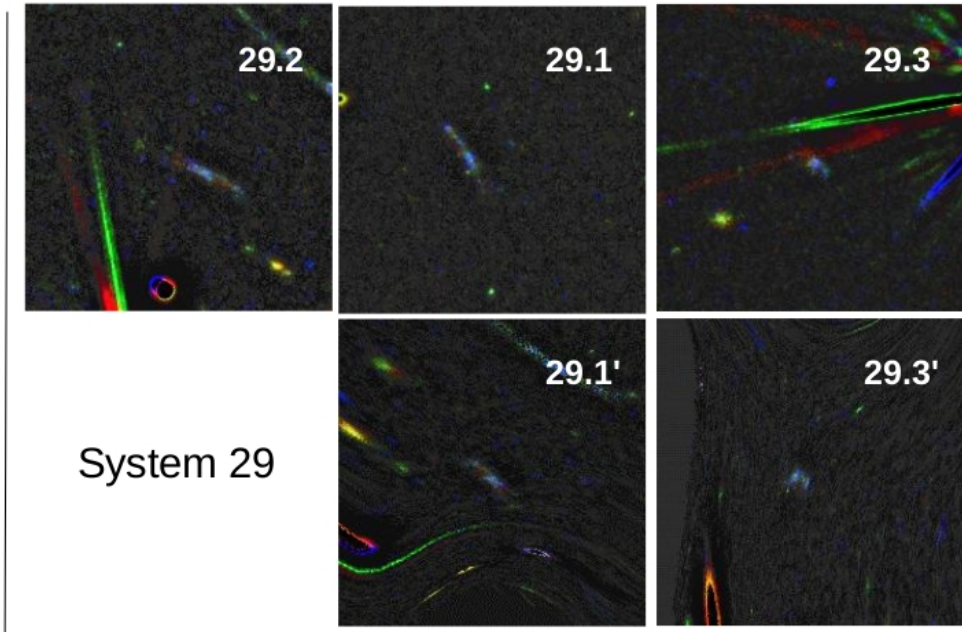


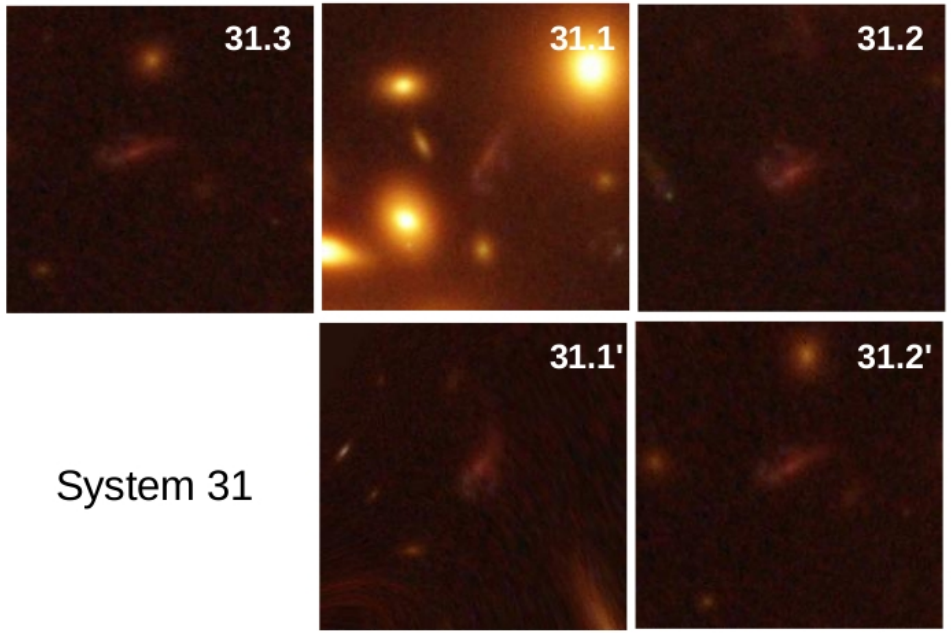
MACS J0717

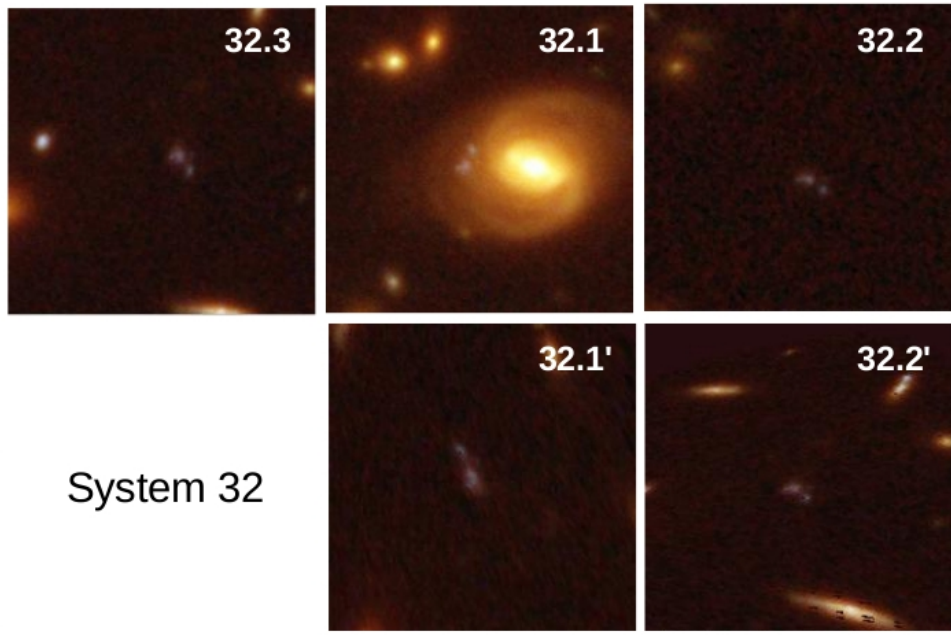


13 new multiple systems not shown but included in the paper

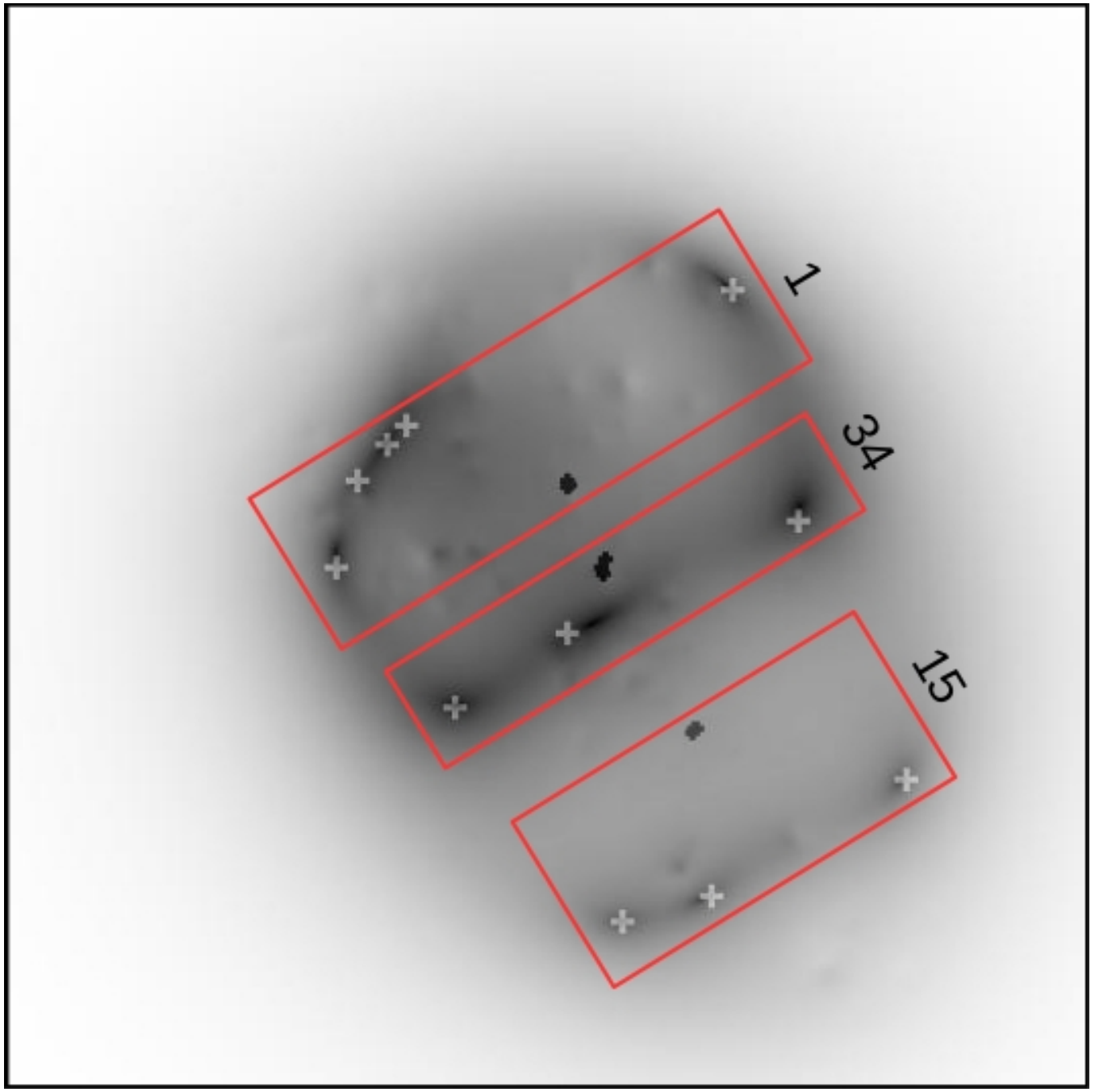

4.2
4.1
4.3
4.1'
4.3'
System 4


29.2
29.1
29.3
29.1'
29.3'
System 29

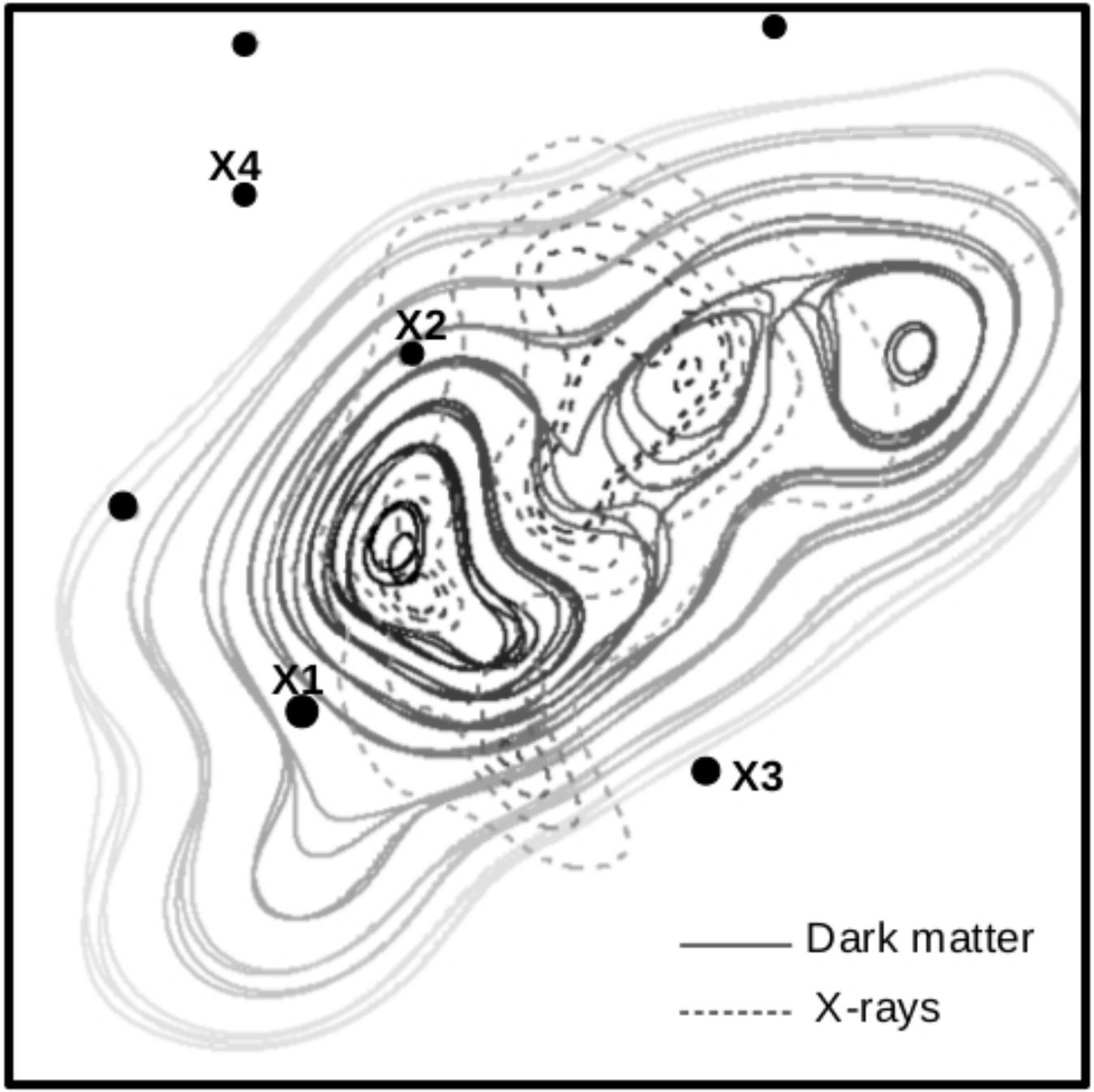

31.3
31.1
31.2
31.1'
31.2'
System 31


32.3
32.1
32.2
32.1'
32.2'
System 32

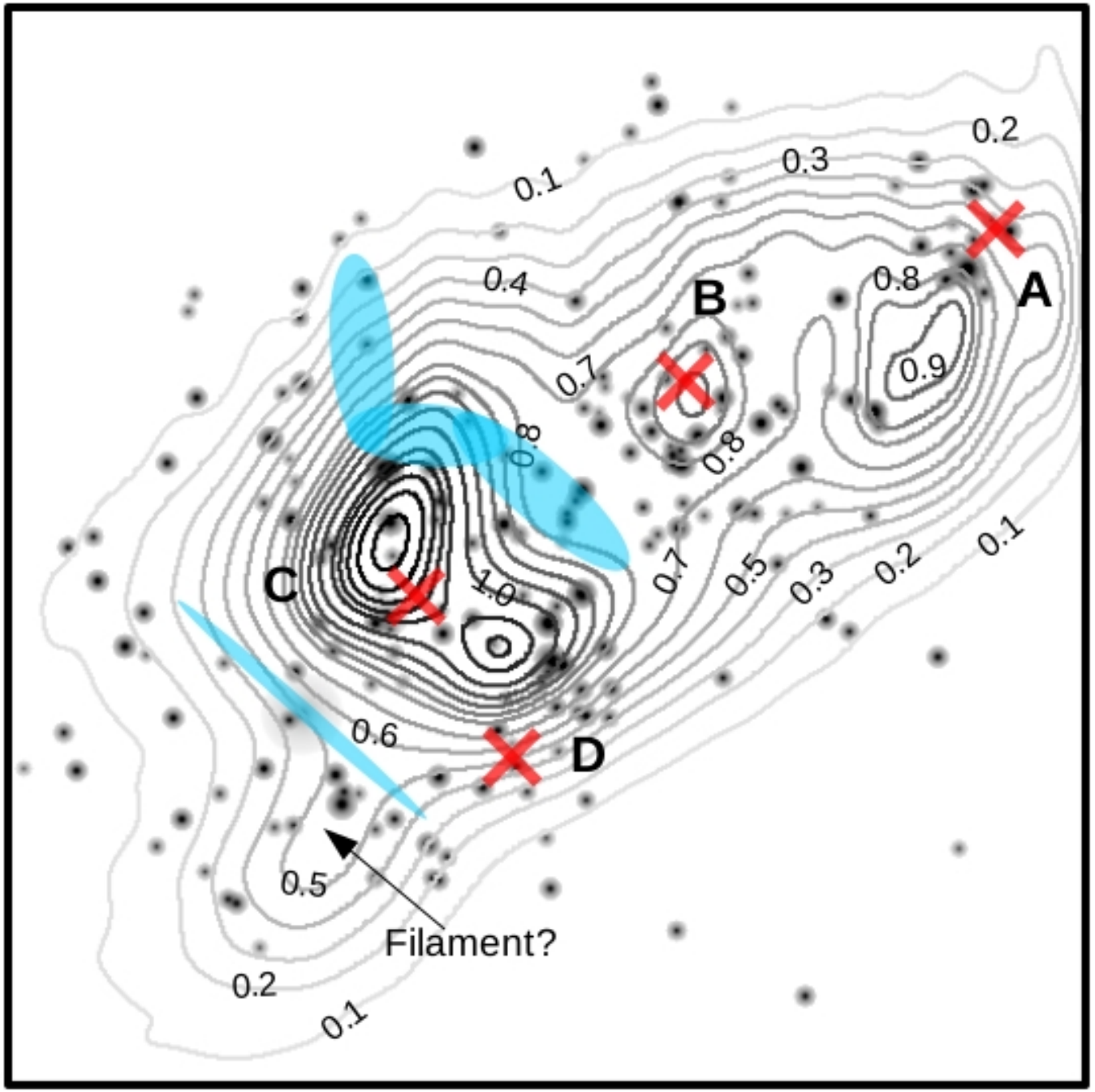
Model prediction vs. data



Mass models vs X-ray

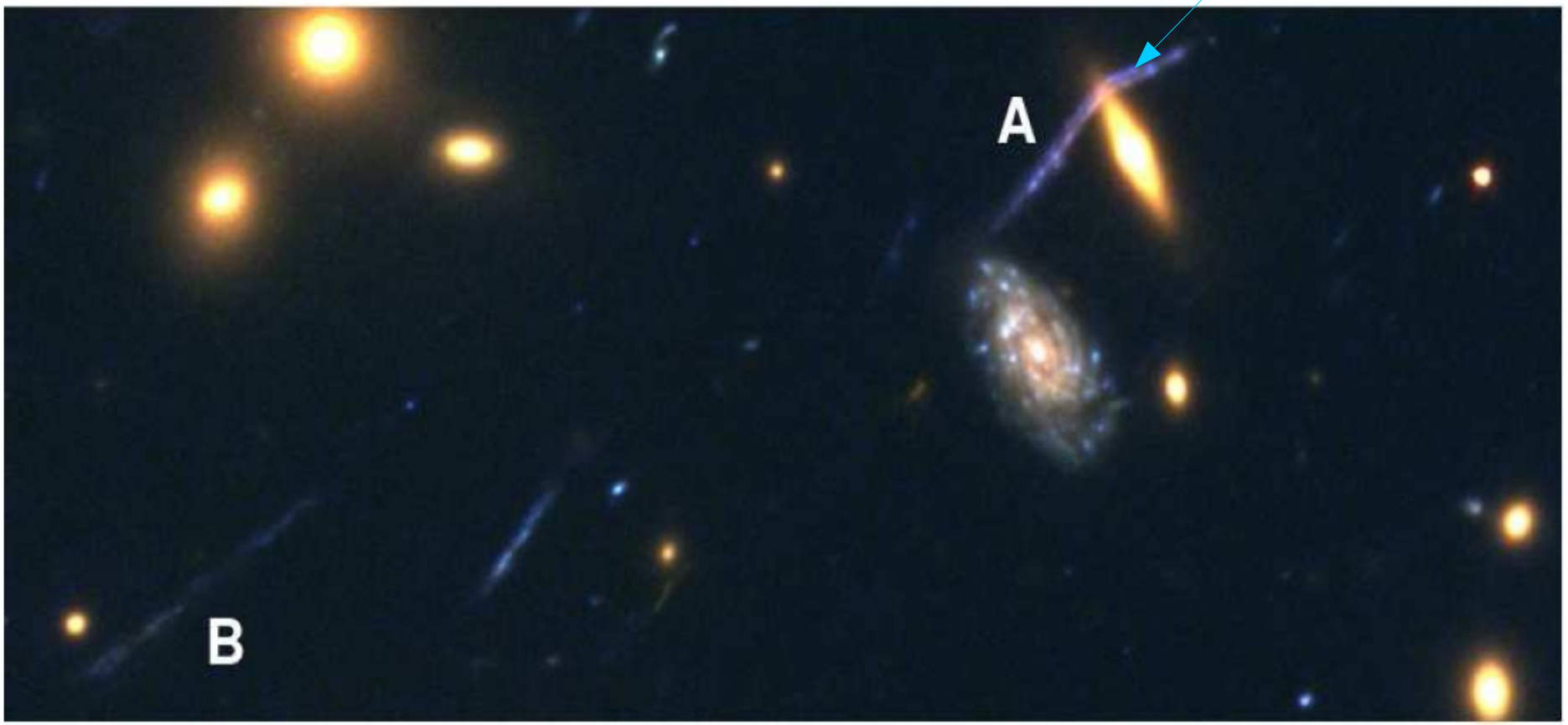


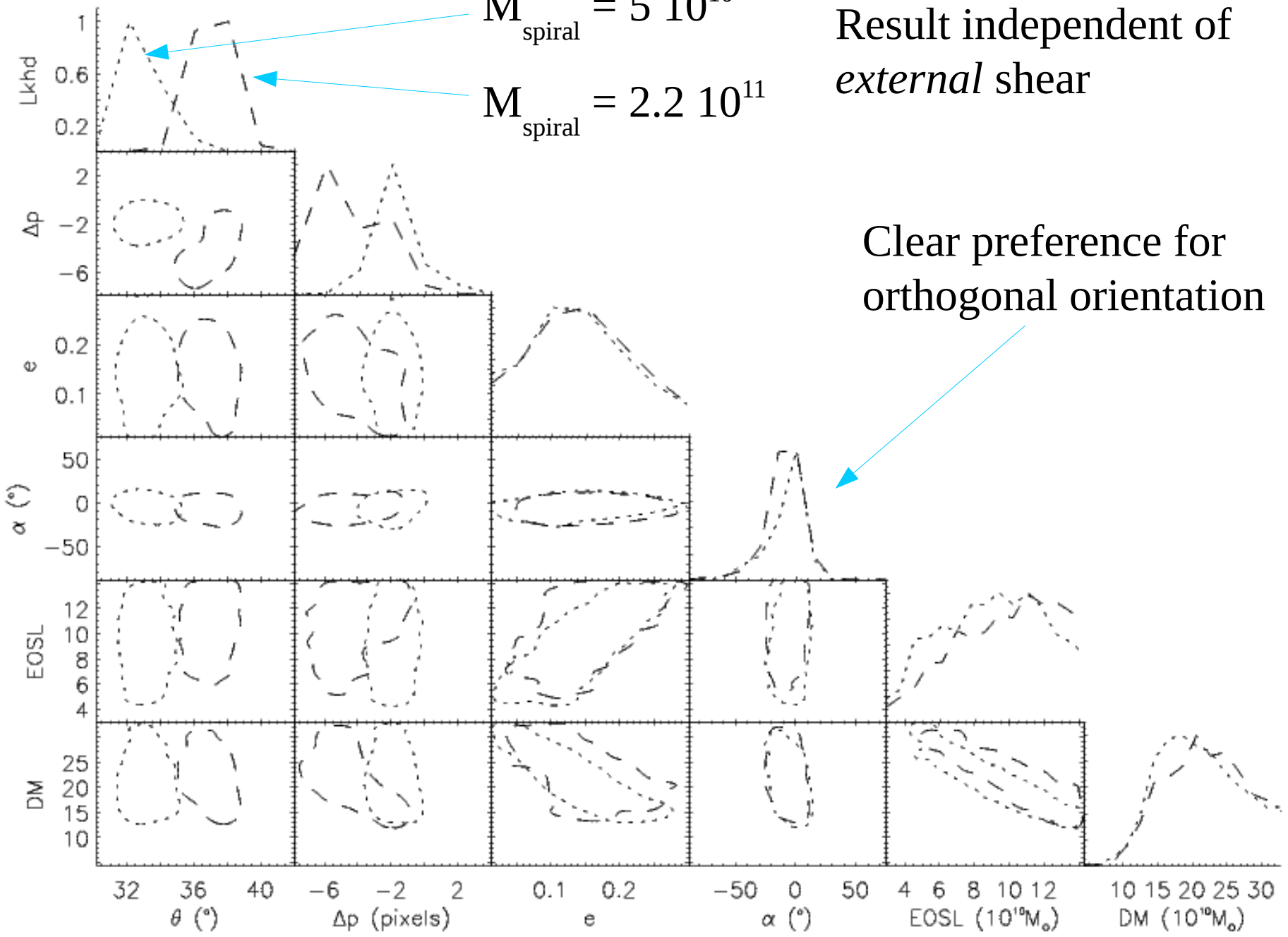
Mass models vs X-ray vs Radio

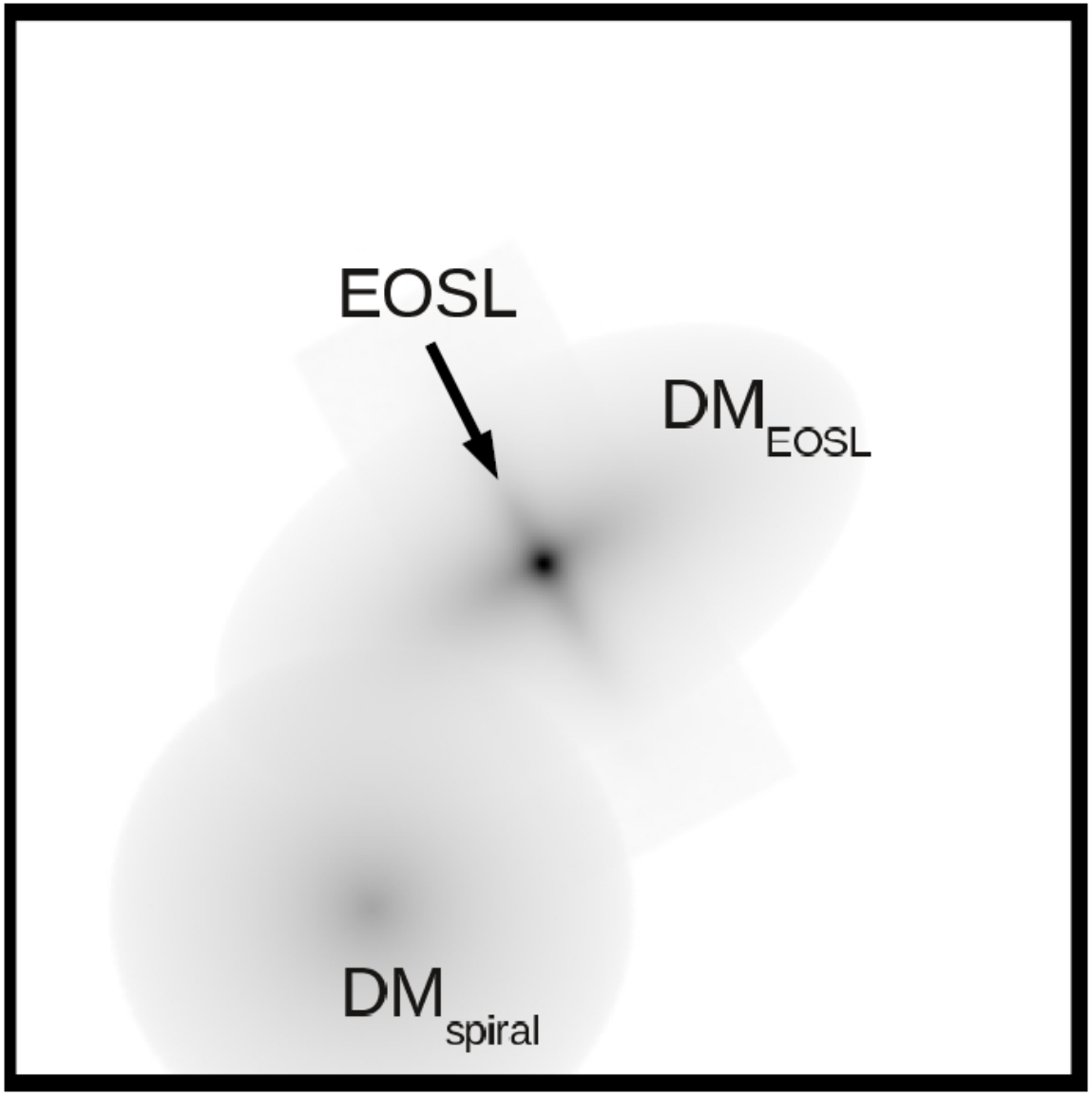


A Secondary Edge-On Galaxy in MACSJ0416

A test case for gravity models




$M_{spiral} = 5\ 10^{10}$
$M_{spiral} = 2.2\ 10^{11}$
Result independent of *external* shear
Clear preference for orthogonal orientation
Lkhd
Δp
e
α (°)
EOSL
DM
θ (°)
Δp (pixels)
e
α (°)
EOSL ($10^{10}M_\odot$)
DM ($10^{10}M_\odot$)



The geometry is inconsistent with MOND models

A ***Dragon Kick*** galaxy in action !

SUMMARY

- **Free-form reconstruction** gives competitive and comparable results to parametric methods.
- **MACSJ0416** seems to be colliding in the line of sight.
- **Strong lensing data** seems to suggest sensitivity to the gas mass seen in XR.
- **Profiles** seem to be very shallow pointing towards interesting physics.
- **MACSJ0717** multiple merger of at least 4 massive halos. Evidence for the filament?
- **Offset between DM and baryons** a systematic effect?
- **Dragon Kick galaxies** are useful (and powerful) proves of gravity.
- **Future HFF** will reveal very interesting results but more work is needed to understand the degeneracies in the lensing models.

COSMOCRUISE 2015: At the Edge of Discovery

September 2-9 2015

Barcelona, Naples(*Pompeii*), Civitavechia(*Rome*), La Spezia(*Cinque Terre*),Canes, Mallorca, Barcelona

http://max.ifca.unican.es/CosmoCruise2015/

Join us in the first Cosmology meeting at the sea on the spectacular ship MSC Divina. A meeting dedicated to cover the latest results in Cosmology ranging from the early Universe to on-going dark matter experiments on planet earth. 20015 will be an important year for Cosmology with key experiments expected to deliver relevant results based on observations of the CMB polarization, LSS studies based on large surveys, and tight constraints on DM properties based on direct and indirect searches. The meeting will start and end in the beautiful city of Barcelona, Spain, but will visit also other countries in the Mediterranean (France and Italy). The meeting is family friendly with children under 17 yr old paying only taxes and port fees so bring them on!

The meeting includes the following topics:

- Inlation
- Theory
- CMB (T and P)
- Reionization
- Large Scale Structure
- Lensing
- Galaxy Clusters
- Galaxy Formation
- Dark Matter
- Dark Energy
- Particle Astrophysics

Preliminary list of invited Speakers(*):

Laura Baudis	Hiranya Peiris
Gianfranco Bertone	Lisa Randall
Martin Bucher	Alexandre Refregier
Claudia de Rham	Douglas Scott
Tom Broadhurst	Paul Shapiro
Josh Frieman	Jennifer Siegal-Gaskins
Justin Khoury	Joseph Silk
John Kovac	Alexei Starobinski
Ghung-Pei Ma	Rashid Sunyaev
Reno Mandolesi	Masahiro Takada

(*)The final list of invited speakers will be announced together with the final program.

SOC members: G. Barenboim, S. Bridle, M. Bucher, J. Carlstrom, A. Cooray, J.M. Diego, K. Freese, B. Jain, W. Kinney, J. Khoury, E. Komatsu, A. Liddle, C.-P. Ma, R. Mandolesi, H. Peiris, L. Randall, A. Refregier, S. Sarkar, D. Scott, J. Silk, A. Starobinski, R. Sunyaev, M. Zaldarriaga

LOC: Laura Bonavera, Elizabeth Brait, José M. Diego, Joaquín González-Nuevo, Diego Molinari (IFCA), Diego Pavón (Univ. Autonoma Barcelona), Marcos Pereda (Viajes el Corte Ingles)