The Merging Systems Identification (MeSsI) Algorithm.

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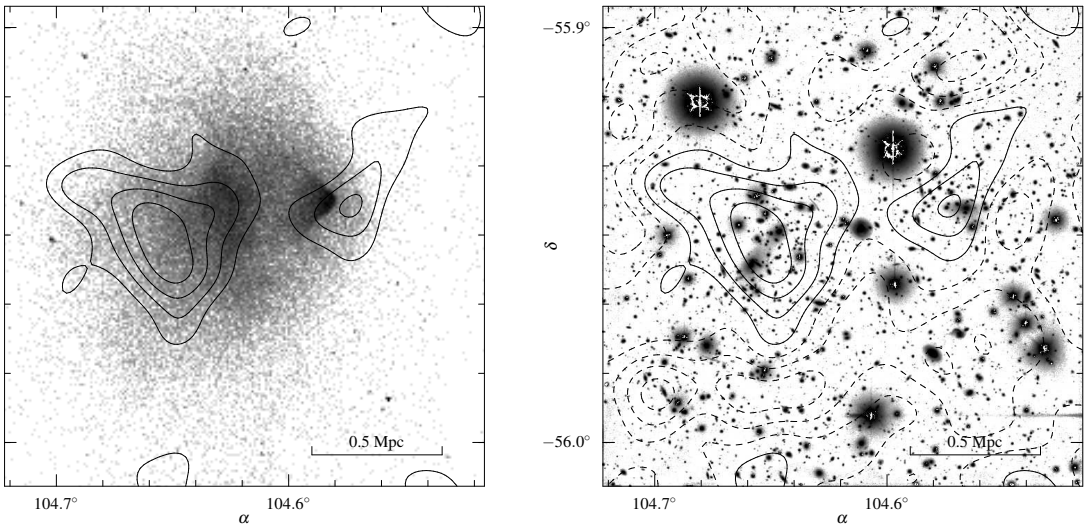
You can study dark matter particle properties



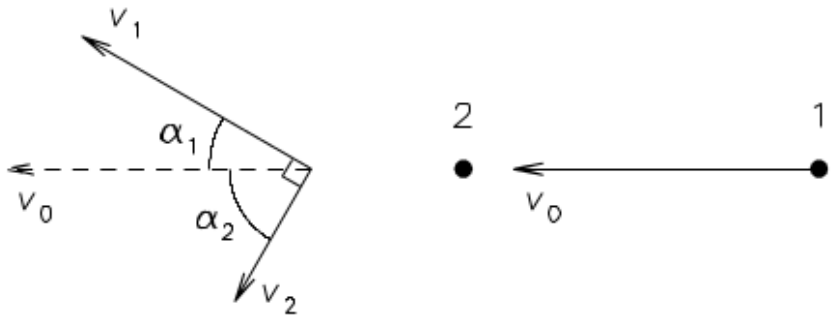
Markevitch et al. 2004

- Offset between Dark-Matter and gas.:

$\tau_s = \frac{\sigma}{m}\Sigma_s$ where σ is the cross-section, m is the particle mass and Σ_s is the superficial density of DM. The mean superficial density in $r = r_{tr}$ is $\Sigma \approx 0.2 g cm^{-2}$, therefore, assuming spherical simetry and $\tau_s < 1$: $\frac{\sigma}{m} < 5 cm^2 g^{-1}$.

Cúmulo	$\frac{\sigma}{m}$
Bullet Cluster	$< 5 cm^2/g$
Musket Ball	$< 7 cm^2/g$
Baby Bullet	$< 4 cm^2/g$

- The grat velocity of the secondary cluster:



$$\bar{p} = mv_s \left[1 - 4 \int_{sen\alpha_c}^{1} x^2 \left(x^2 - \frac{V^2}{v^2}(1 - x^2) \right)^{1/2} dx \right] \approx 0.1 mv_s \quad (1)$$

$$\frac{d(v - v_{ff})}{dt} = \frac{\bar{p}n}{M_s} = \frac{\bar{p}}{m}\frac{\sigma}{m}\rho_m v \quad (2)$$

$$v - v_{ff} = \frac{\bar{p}}{m}\frac{\sigma}{m}\Sigma_m \quad (3)$$

$$v - v_{ff} < 1000 km/s \quad (4)$$

$$\frac{\sigma}{m} < 7 cm^2/g \quad (5)$$

- The survivor of the secondary cluster.

$$\chi = 1 - 2\frac{v_{esc}^2}{v_0^2} \quad (6)$$

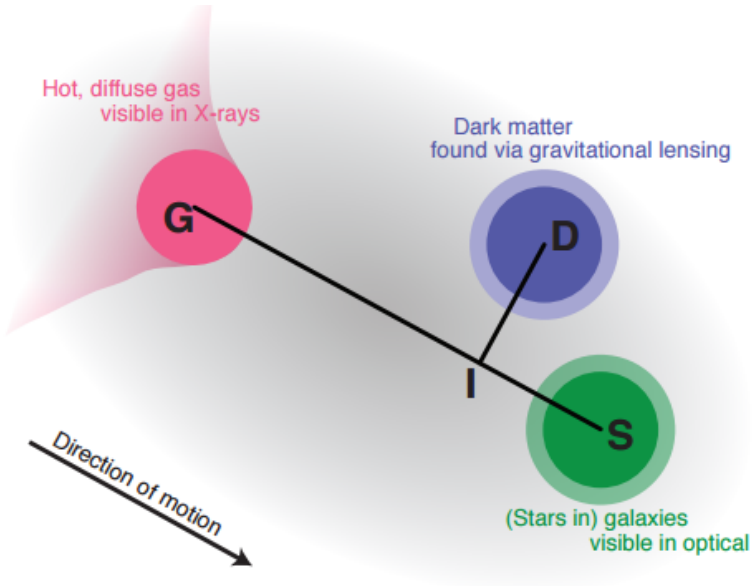
$$\tau_m = \frac{\sigma}{m}\Sigma_m \quad (7)$$

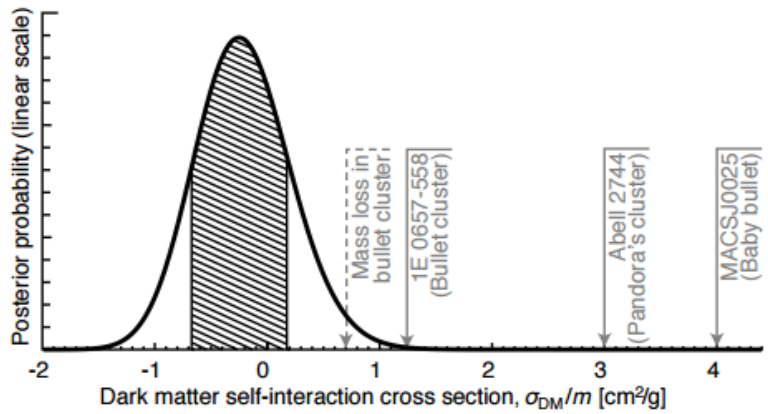
$$\chi\tau_m = \frac{\sigma}{m}\Sigma_m\left[1 - 2\frac{v_{esc}^2}{v_0^2}\right] \quad (8)$$

$$\chi\tau_m < 0.3 \quad (9)$$

$$\frac{\sigma}{m} < 1 cm^2/g \quad (10)$$

Harvey et al. 2015





$$\frac{\sigma}{m} \leq 0.47 cm^2/g$$

You can test your favourite cosmological model.

- Studying the probability of finding a Bullet-like cluster.
  - Hayashi et al. 2006
  - Farrar y Rosen 2007
  - Lee y Komatsu 2010
  - Forero-Romero et al. 2010
  - Thompson y Nagamine 2011
  - Watson et al. 2013
- Hidrodynamical simulation studies.
  - Springel & Farrar. 2005
  - Milosavljevic et al. 2007
  - Mastropietro & Burket. 2008
  - Lage & Farrar 2014

The Rise and Fall of a challenger by Thompson (2014).

- They investigate the probability of finding such a high-velocity pair in large-volume N-body simulations, particularly focusing on differences between halo finding algorithms.
- When employing the Rockstart (Behroozi et al 1013) halo finder that considers particle velocities, they find numerous Bullet-like pair candidates that closely match not only the high pairwise velocity, but also the mass, mass ratio, separation distance, and collision angle that have been shown to produce the Bullet Cluster.
- The probability of finding a massive, high pairwise velocity pair among halos with $M_{\rm halo} \geq 10^{14} M_{\odot}$ is 4.6×10^{-4} using RS, while it is $\approx 45\times$ lower using a friends-of-friends (FOF) based approach as in previous studies.

High velocity tail of Bullet like pairs.

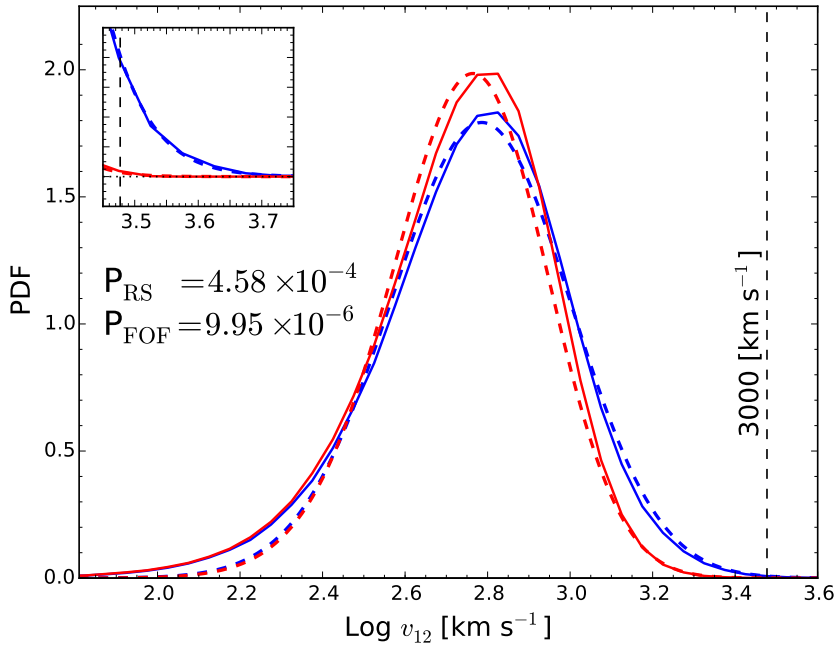
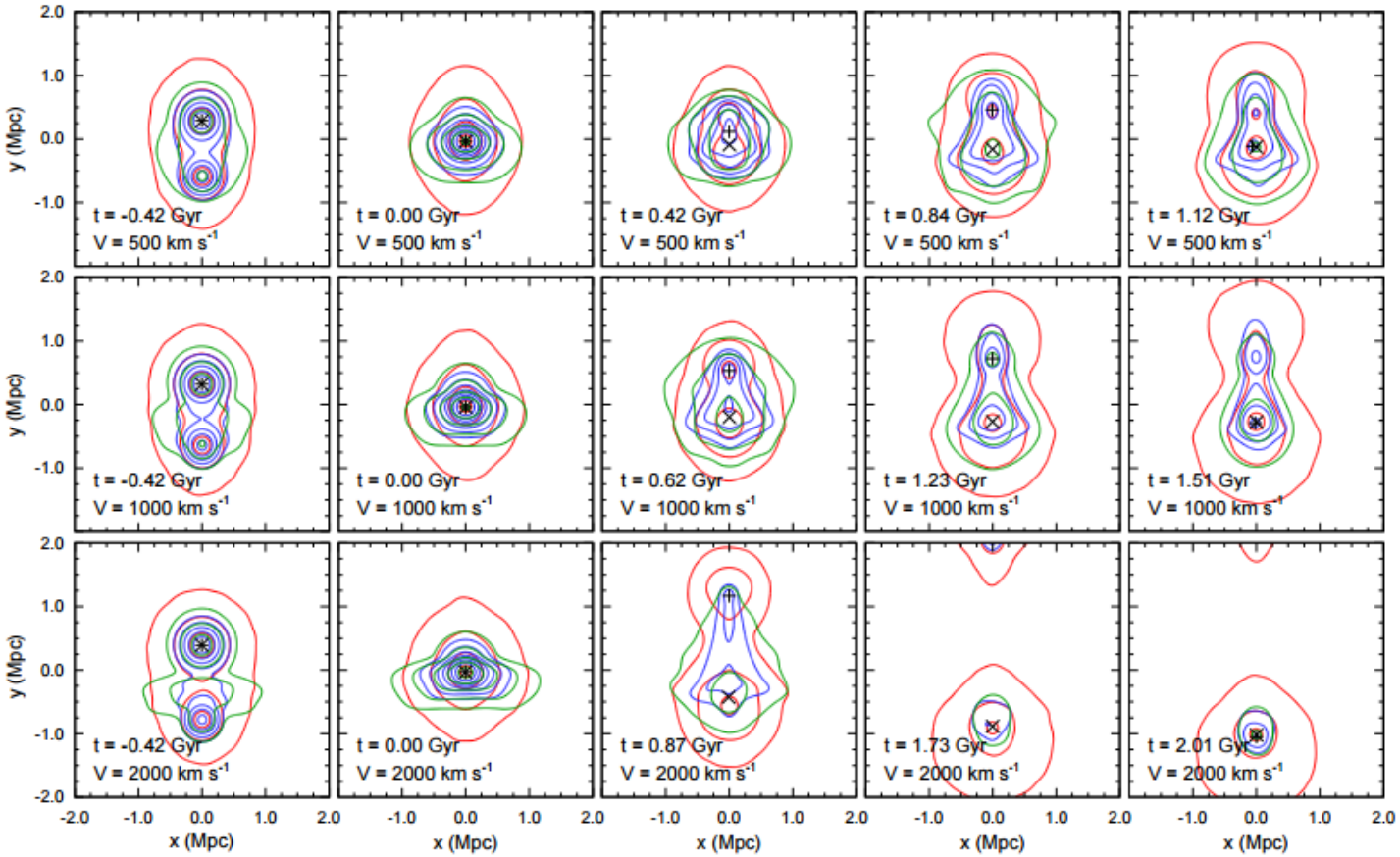
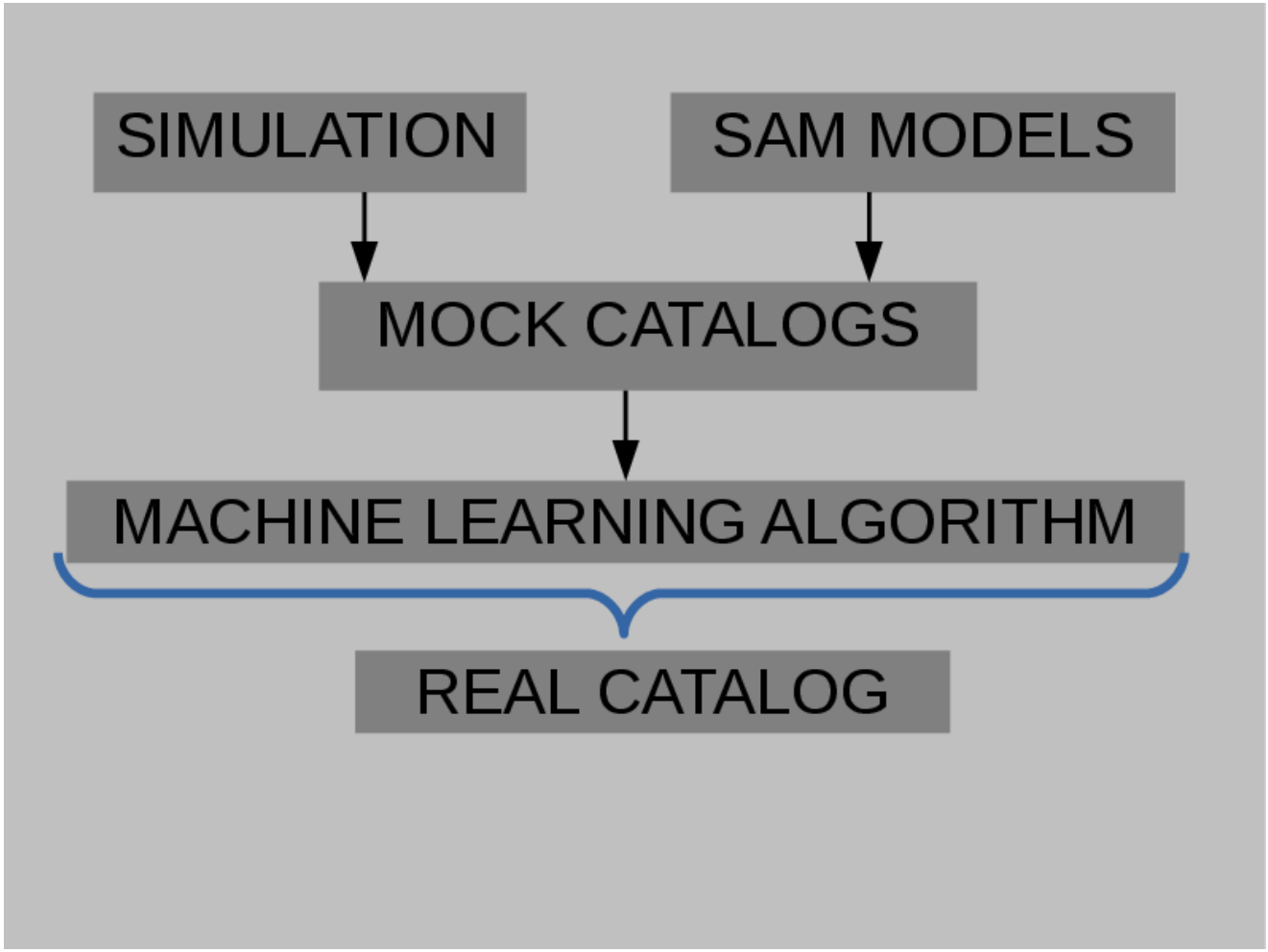


Figure: Probability distribution function of massive halo pairs in largest simulation (L4500) identified by FOF (Red solid line) and RS (Blue solid line).

You can study the ICM properties (Zhang et al. 2014).



Mass contours. SZ Emission. X-ray Emission.


SIMULATION
SAM MODELS
MOCK CATALOGS
MACHINE LEARNING ALGORITHM
REAL CATALOG

Clusters identification.

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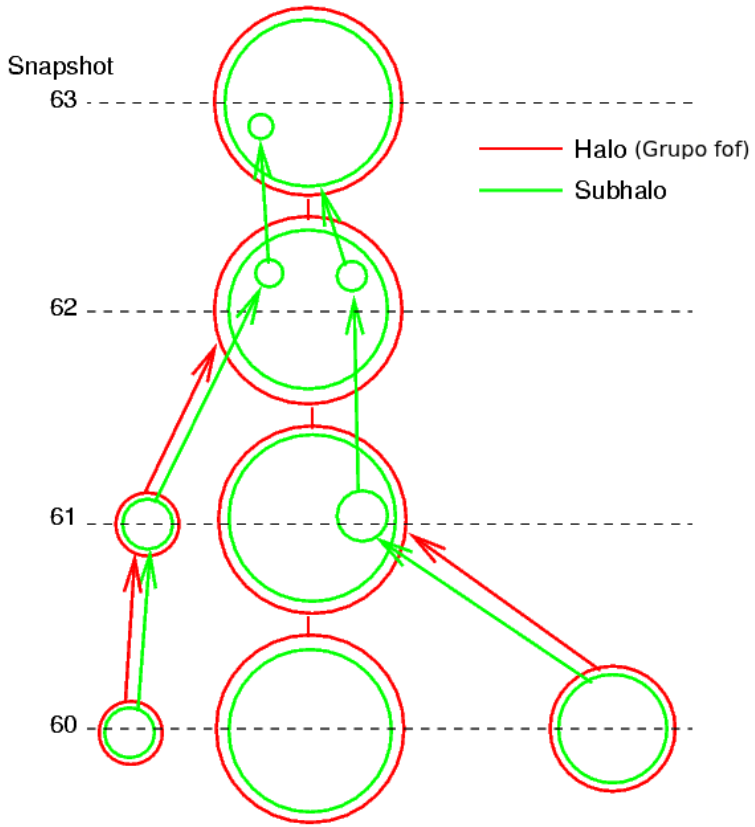
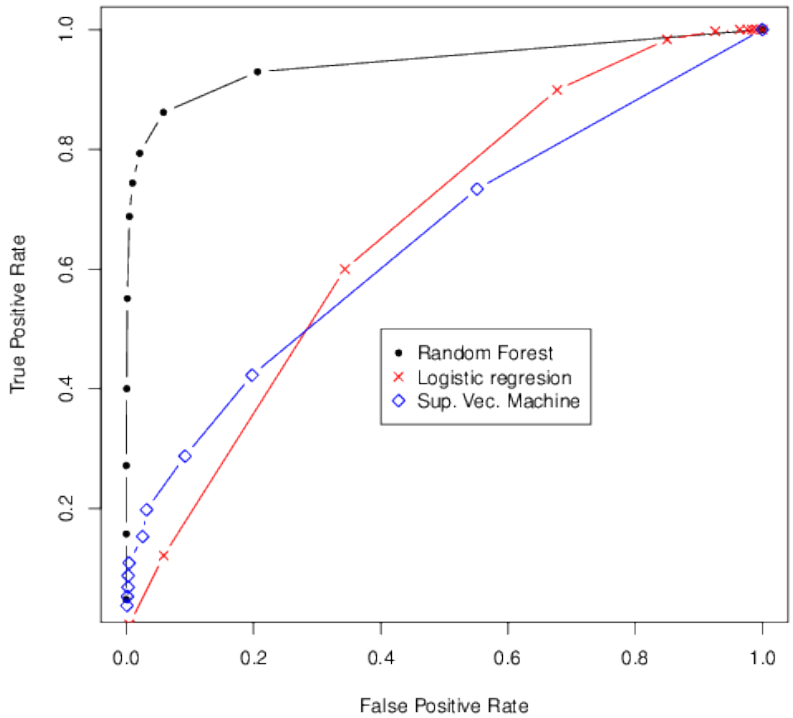
- We Perform a friend-of-friend algorithm (*Merchan & Zandivares 2002*) to the mock catalog in order to identify the clusters.
- We assign each identified cluster with a fof-group in the simulation.

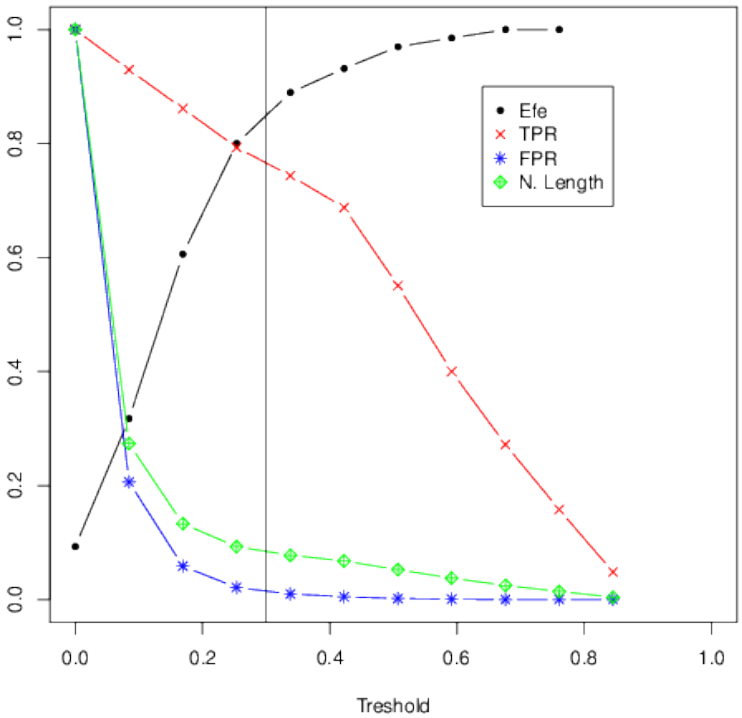
Study of the merger trees.

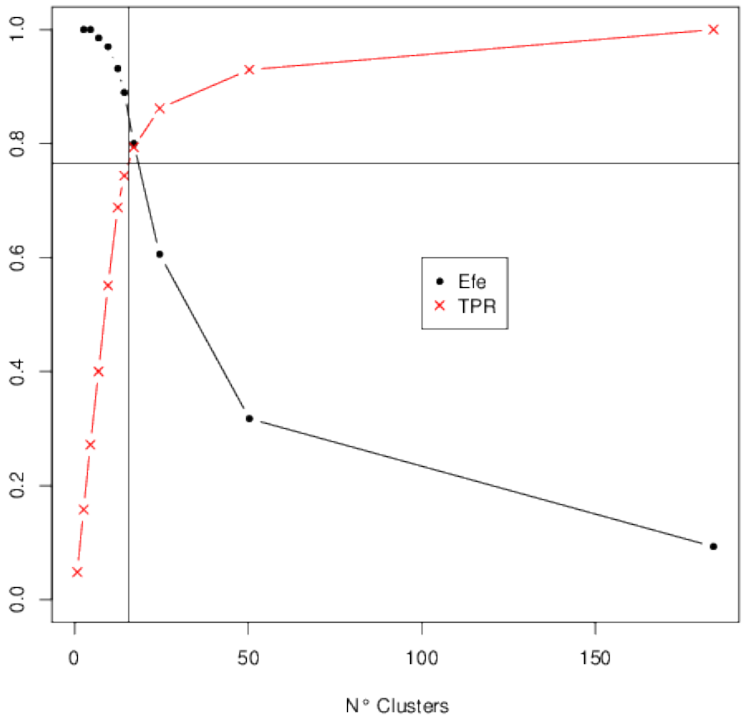
- Based on the subhalos merger trees, we construct the merger tree for every fof group in the simulation.



- Dressler-Shectman test.
- Non gaussianity test.
- Color.
- Number of galaxies.




Efe
TPR
FPR
N. Length
0.0
0.2
0.4
0.6
0.8
1.0
Treshold


Efe
TPR
0.0
0.2
0.4
0.6
0.8
1.0
0
50
100
150
N° Clusters

Study of the identified substructures.

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- After that, we estimate the velocity dispersion and the virial radius.

$$
\begin{aligned}
R_{vir} &= \frac{\pi}{2} \frac{ngal(ngal-1)}{\sum_{i>j}^{ngal} R_{ij}^{-1}} \\
\sigma &= \frac{\sqrt{\pi}}{ngal(ngal-1)} \sum_{i=1}^{ngal-1} \omega_i g_i \\
\omega_i &= i(ngal-i) \\
g_i &= v_{i+1} - v_i
\end{aligned}
\tag{11}
$$

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- We compare the center of the identified substructures with the centers of the associated subhalos, finding a good estimation.
- We compare the virial radius of the identified substructures with the virial radius of the subhalos, finding that we are overestimating the real values.
- We compare the velocity dispersion of the identified substructures with the velocity dispersion of the associated subhalos, finding that our values are in good concordance with the real values.

With this association between substructure and subhalos in the mock, we find 3 cases:

1. Clusters where we identify the type 0 subhalo (the principal subhalo of the fof group) and a type 1 subhalo.

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3. Clusters where Mclust find two substructures that are associated to the same type 0 subhalo.

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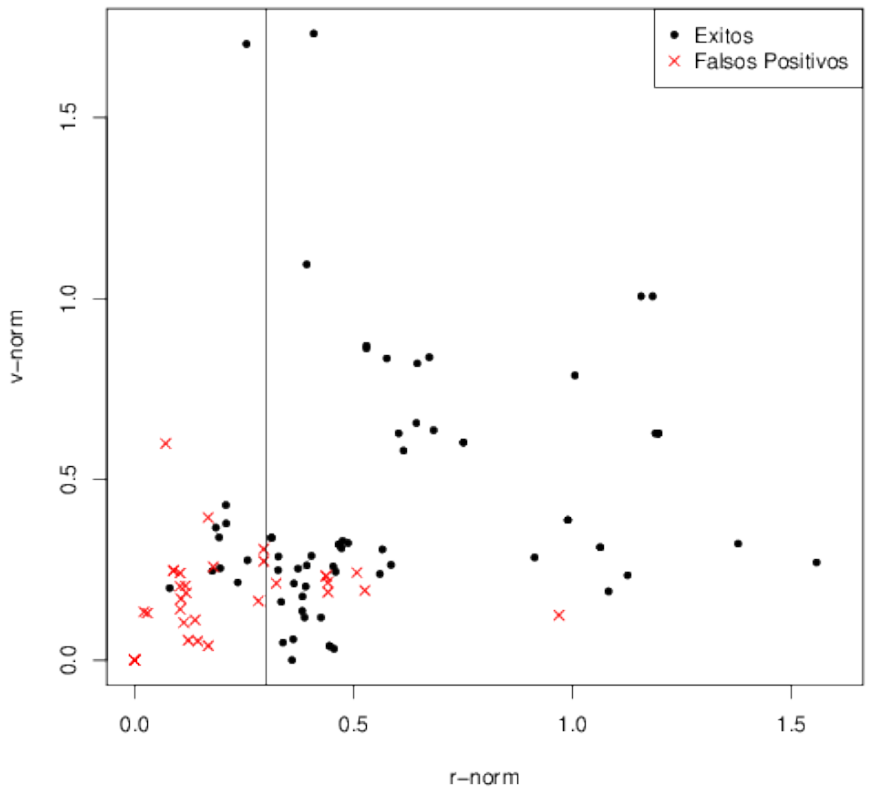
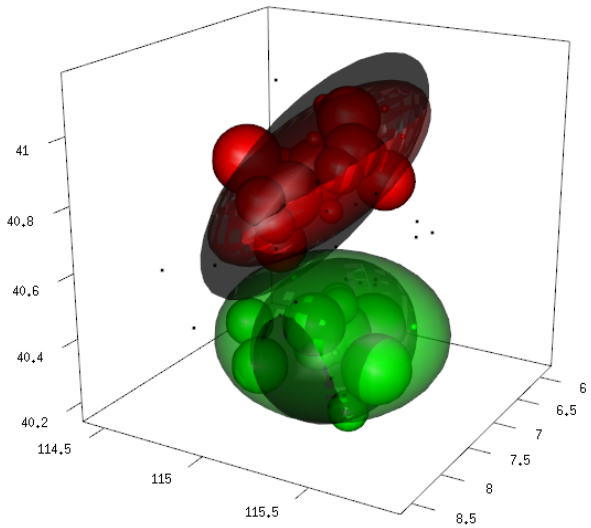
2. Clusters where we identify two type 1 subhalos.
3. Clusters where Mclust find two substructures that are associated to the same type 0 subhalo.



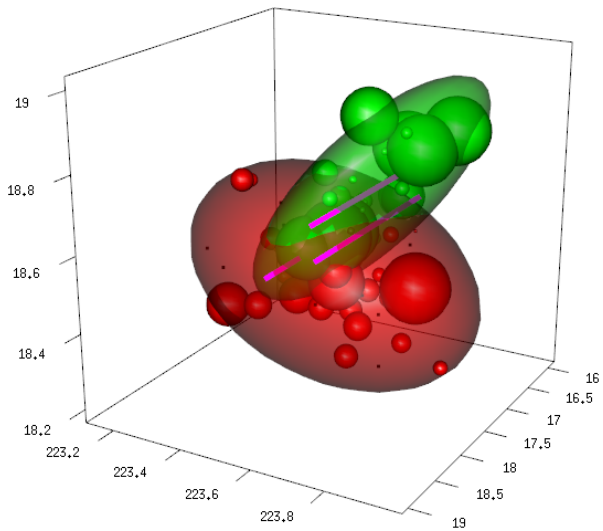
Mock Clusters



Application of the MeSsI Algorithm to spectroscopy catalogues

- We find 12 (5) Clusters with high probability of been in a merger in the SDSS DR7.

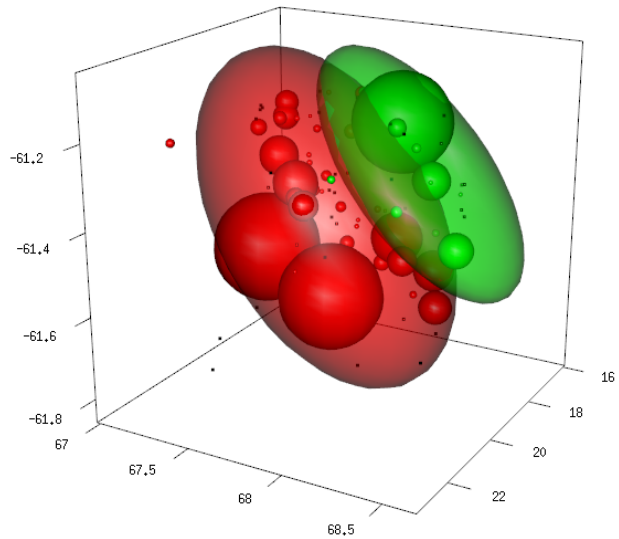
Abell 1991



Application of the MeSsI Algorithm to spectroscopy catalogues

- We find 7(3) Clusters with high probability of been in a merger in the WINGS Clusters.

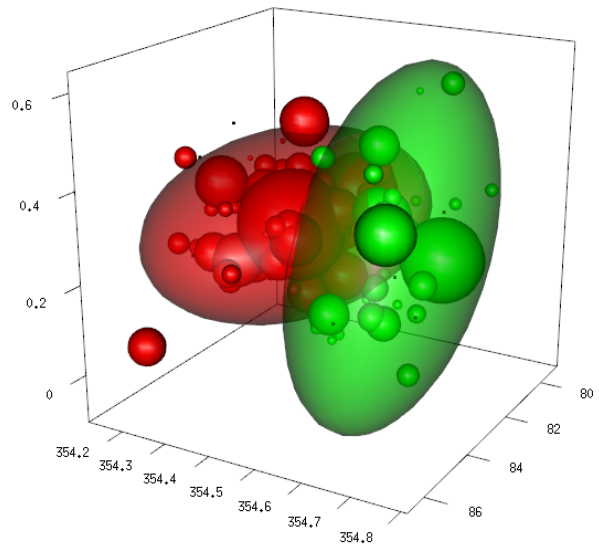
Abell 3266



Application of the MeSsI Algorithm to spectroscopy catalogues

- We find 15(2) Clusters with high probability of been in a merger in the HECs Clusters.

Abell 2631



200.16.29.98/martin/merclust/

Buscar

MeSsI Algorithm (v 0.1)

Load Examples

Choose CSV File

Examinar... No se seleccionó un archivo.

Separator

- Tab
- Semicolon
- Comma

Observatorio Astronómico de Córdoba

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Hits: 25

submit | graphics | Merger identification

MeSsI

Welcome to MeSsI (Merging System Identification) Algorithm

MeSsI algorithm is a machine learning algorithm trained with mock catalogues that allowed you to clas

Data Input

You must upload a table of galaxies in the clusters to be study. Each cluster cannot have more than 10 in size. The table must have the next structure.:

*id: A numeric column with the cluster id of the system that each galaxy belong.

*ra: A numeric column with the galaxy rigth ascension in decimal degrees.

*dec: A numeric column with the galaxy declination in decimal degrees.

*z: A numeric column with the galaxy redshift.

*mag: A numeric column with the galaxy apparent magnitude.

*color: A numeric column with the galaxy color.

We recommend to upload low redshift clusters only ($z < 0.2$).

Example Table

In the example table you can study 6 Abell clusters preloaded:

*id=1: Abell 1991.

Future Work

- Perform astrophysical test over our sample of colliding cluster candidates of the catalog looking for impose some constraints on dark matter particle properties.

Future work.

- Apply the detection method to more deep real catalogs.

We will make a ligth-cone mock (Merson et al. 2012) and re-calibrate our machine learning algorithm for high-redshift clusters in order to study the dynamics status of deep real catalogs like the EDISc and the Morphs Clusters.

Future Work

- Reconstruct the 3d merger with the Bayesian techniques presented by *Dawson et al. 2012*.

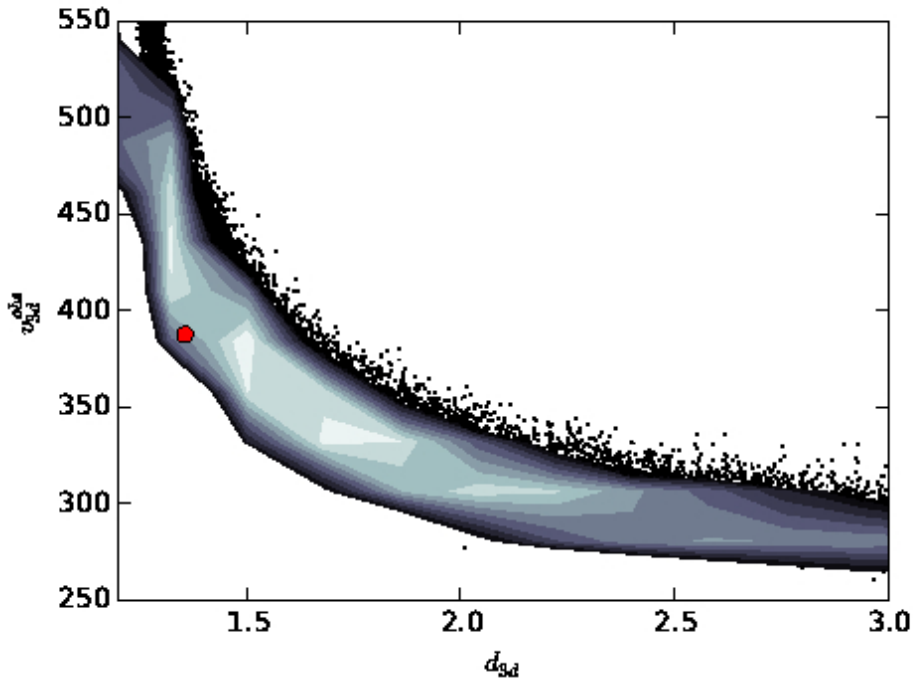

Figure: Distribution of posterior probability in the 3D distance (Mpc) and 3D velocity (Km/s) space for a simulated merging cluster, red dot indicates the real current values.

Future Work

- Study the physics properties of the galaxies that belong to the identified substructures, ordering them in a temporal line by the merger state.

Future Work

- Construct a catalog of relaxed clusters in order to study the dark matter equation of state (Serra & Dominguez 2011).

THANK YOU