



# Thematic Interiorization Project

Compact Groups of Galaxies in  
the Multidark Cosmological  
Simulation

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Computational Tools for Astroinformatics

# 01 ★ Previously on... ★

The idea



## Objectives:

- To comprehend basic aspects of working with simulations (hydrodynamics or SAM).
- Deepen and apply knowledge of Python in relation to what is required.
- To relate the analysis to what I do with my thesis.

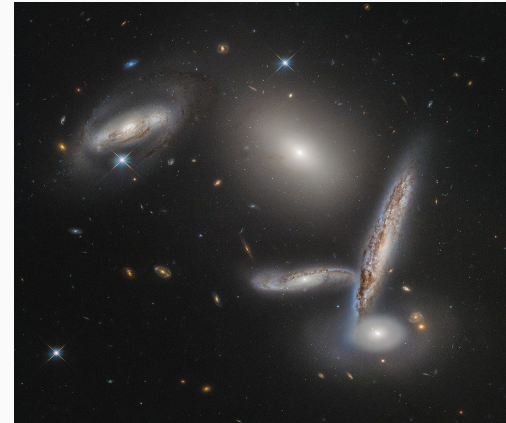
Galaxy-galaxy  
interaction

Physical and  
Morphological  
Changes

What is  
happening to the  
star-formation?

Candidates for  
galaxy  
pre-processing

How do the dark  
matter halos  
behave?



HCG 40, WFC3/HST



### Procedure:

- To determine which simulation would let me explore and accomplish the objectives. ✓
- To analyze the tables and the information available, to establish the feasibility of applying observational criteria to classify compact groups of galaxies as such :

Richness and  
magnitude

$$3 \leq N(14.00 \leq r \leq 17.77) \leq 10$$

Isolation

$$\theta_N \geq 3\theta_G$$

Compactness

$$\mu_r \leq 26.0 \text{ mag arcsec}^{-2}$$



Velocity difference

$$|V - V_i| \leq 1000 \text{ km/s}$$

- Establish/apply a method that allows finding compact groups in these simulations, and visualizing their properties. ✓



02

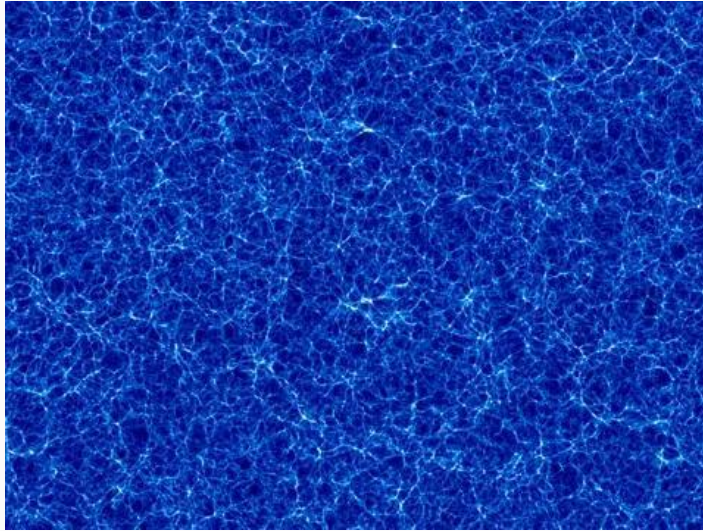


The Data

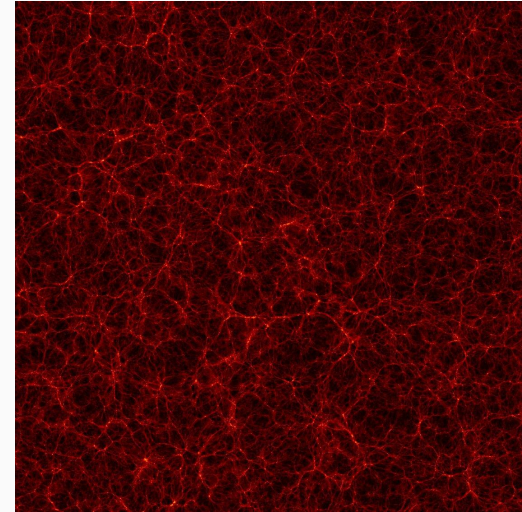


Which simulation?

# Multidark-Galaxy Simulation



Box size	1 Gpc/h	side length of the cosmological cube
Number of particles	$3840^3$	total number of dark matter particles
Mass resolution	$1.51 \cdot 10^9 M_{\text{sun}}/h$	mass of one dark matter particle



1 Gpc

<https://www.cosmosim.org/cms/images-and-movies/>

## Datalinks for MDPL2\_sag\_snapdir

### Data Links

access_url	description	content_length
<a href="https://www.cosmosim.org/data/catalogs/NewMD_3840_Planck1/SAG/snapshot_125/gal_125_SAG-7.128_BOX_001.hdf5">https://www.cosmosim.org/data/catalogs/NewMD_3840_Planck1/SAG/snapshot_125/gal_125_SAG-7.128_BOX_001.hdf5</a>	MDPL2: SAG - Snapshots	437 MB
<a href="https://www.cosmosim.org/data/catalogs/NewMD_3840_Planck1/SAG/snapshot_125/gal_125_SAG-7.128_BOX_002.hdf5">https://www.cosmosim.org/data/catalogs/NewMD_3840_Planck1/SAG/snapshot_125/gal_125_SAG-7.128_BOX_002.hdf5</a>	MDPL2: SAG - Snapshots	437 MB
<a href="https://www.cosmosim.org/data/catalogs/NewMD_3840_Planck1/SAG/snapshot_125/gal_125_SAG-7.128_BOX_003.hdf5">https://www.cosmosim.org/data/catalogs/NewMD_3840_Planck1/SAG/snapshot_125/gal_125_SAG-7.128_BOX_003.hdf5</a>	MDPL2: SAG - Snapshots	437 MB
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<a href="https://www.cosmosim.org/data/catalogs/NewMD_3840_Planck1/SAG/snapshot_125/gal_125_SAG-7.128_BOX_005.hdf5">https://www.cosmosim.org/data/catalogs/NewMD_3840_Planck1/SAG/snapshot_125/gal_125_SAG-7.128_BOX_005.hdf5</a>	MDPL2: SAG - Snapshots	437 MB
<a href="https://www.cosmosim.org/data/catalogs/NewMD_3840_Planck1/SAG/snapshot_125/gal_125_SAG-7.128_BOX_006.hdf5">https://www.cosmosim.org/data/catalogs/NewMD_3840_Planck1/SAG/snapshot_125/gal_125_SAG-7.128_BOX_006.hdf5</a>	MDPL2: SAG - Snapshots	437 MB
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<a href="https://www.cosmosim.org/data/catalogs/NewMD_3840_Planck1/SAG/snapshot_125/gal_125_SAG-7.128_BOX_008.hdf5">https://www.cosmosim.org/data/catalogs/NewMD_3840_Planck1/SAG/snapshot_125/gal_125_SAG-7.128_BOX_008.hdf5</a>	MDPL2: SAG - Snapshots	437 MB
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HDF5 files!

- gal\_125\_SAG-7.128\_BOX\_001.1
  - FeH\_hot\_halo
  - FeH\_stars
  - ForestID
  - GalaxyHostID
  - GalaxyStaticID
  - Galaxy\_Type
  - Halo
    - HaloID
    - InstantSfrBulge
    - InstantSfrQuies
    - MZ\_ICstars
    - MZ\_gas\_bulge
    - MZ\_gas\_disk
    - MZ\_hot\_halo
    - MZ\_stars\_bulge
    - MZ\_stars\_disk
    - M\_ICstars
    - M\_gas\_bulge
    - M\_gas\_disk
    - M\_hot
    - M\_star\_bulge
    - M\_star\_disk
  - Magnitudes
    - MainHaloID
    - Mbh
    - OH\_gas\_disk\_bulge
    - Rhalf\_bulge
    - Rhalf\_disk
    - SFR
    - SFR\_bulge
    - SFR\_bulge\_DI
    - T\_stars
    - Vx
    - Vy
    - Vz
    - X
    - Y
    - Z



# Multidark-Galaxy Simulation

Identifiers

Main Halo ID, Galaxy Type

Galaxy properties

X, Y, Z position;  $V_x$ ,  $V_y$ ,  $V_z$  velocities

Absolute magnitudes

SDSS r filter

Halo properties

R200 Main Halo





03



Pipeline



How was it done?



## 1) Hickson criteria to select Compact Groups

Richness and magnitude

$$3 \leq N(14.00 \leq r \leq 17.77) \leq 10$$

Compactness

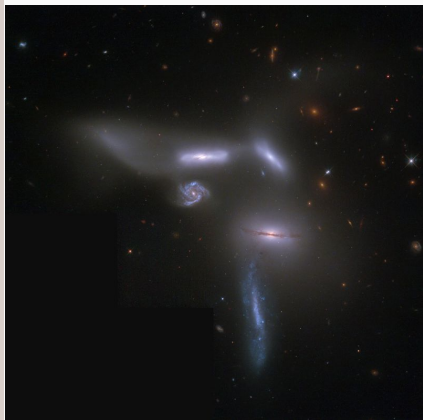
$$\mu_r \leq 26.0 \text{ mag arcsec}^{-2}$$

Isolation

$$\theta_N \geq 3\theta_G$$

Velocity difference

$$|V - V_i| \leq 1000 \text{ km/s}$$

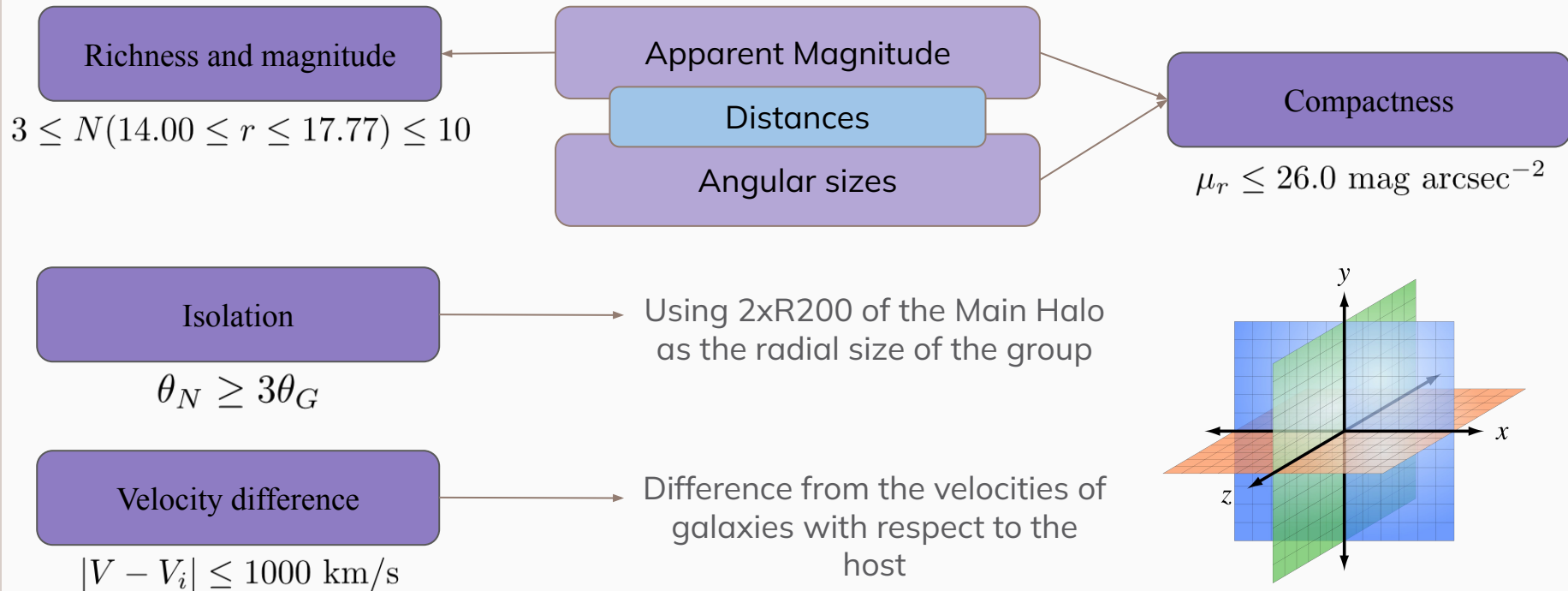


HCG 79  
Legacy Survey DR10



HCG 92,  
WFC3/HST

## 2) Adaptability to data from simulation



### 3) Application of the criteria to the sample

Trying to do it efficiently...

Richness and magnitude

$$3 \leq N(14.00 \leq r \leq 17.77) \leq 10$$

Velocity difference

$$|V - V_i| \leq 1000 \text{ km/s}$$

Compactness

$$\mu_r \leq 26.0 \text{ mag arcsec}^{-2}$$

Isolation

$$\theta_N \geq 3\theta_G$$

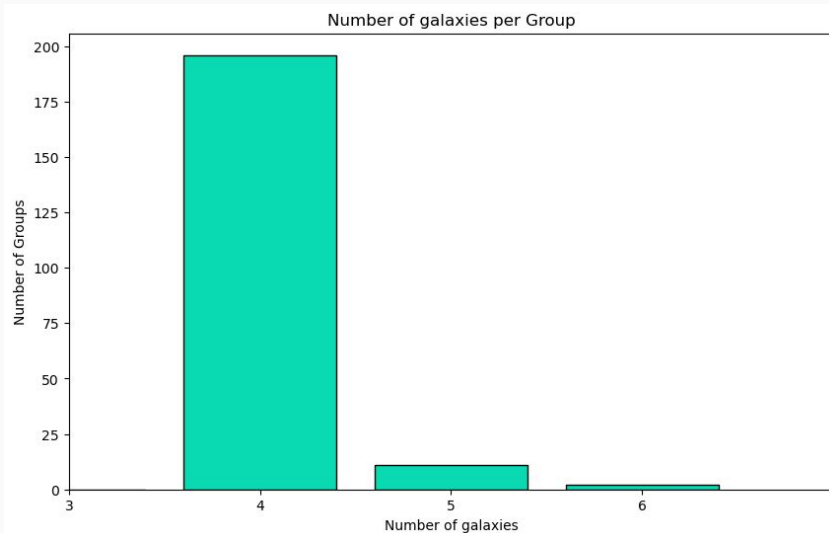

# 04

# Results



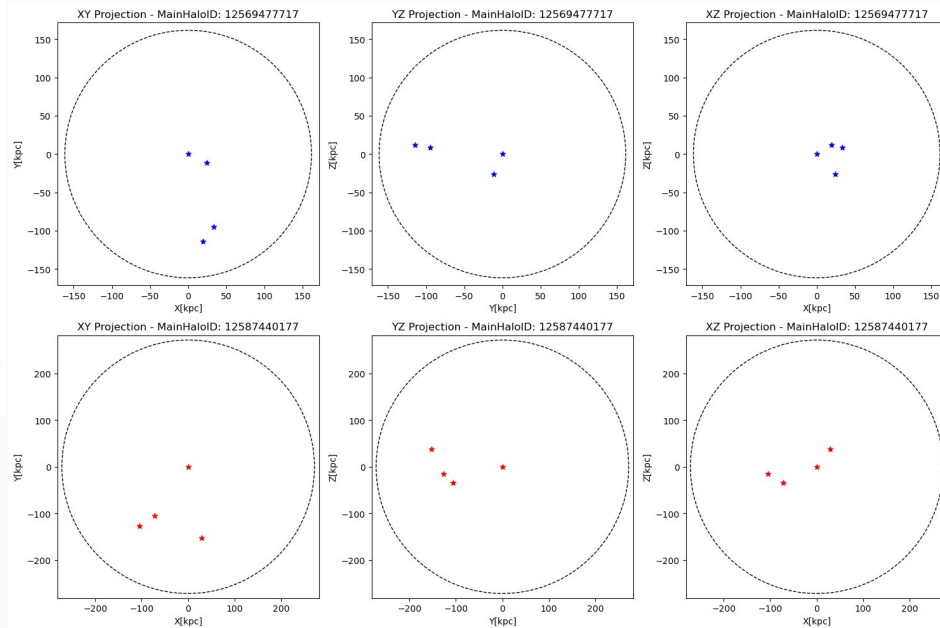
What was it found? (or at least I think it was)

## Applying the code to the simulation...

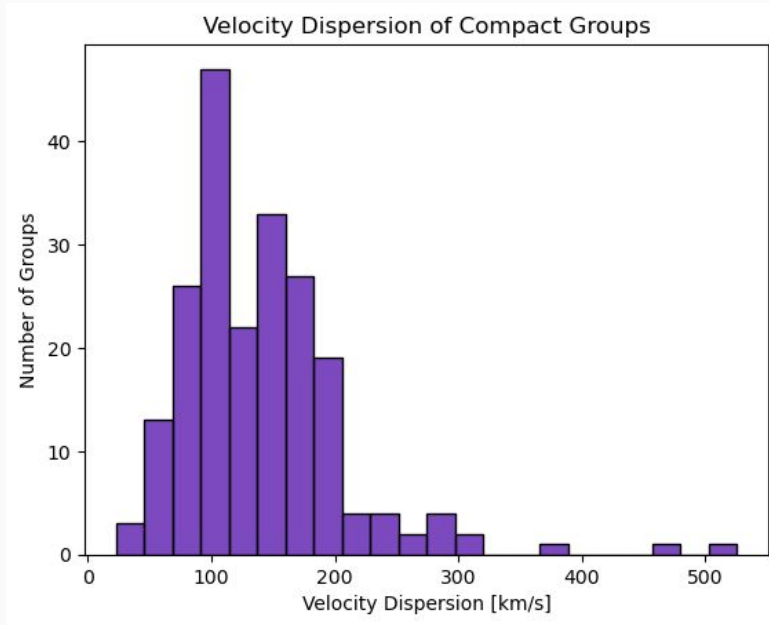


196 groups → 4 members  
11 groups → 5 members  
2 group → 6 members

Group sizes from 72 to 682 [kpc]  
 $20.14 \leq \mu_r \leq 23.46$  [mag/arcsec<sup>2</sup>]



## Applying the code to the simulation...

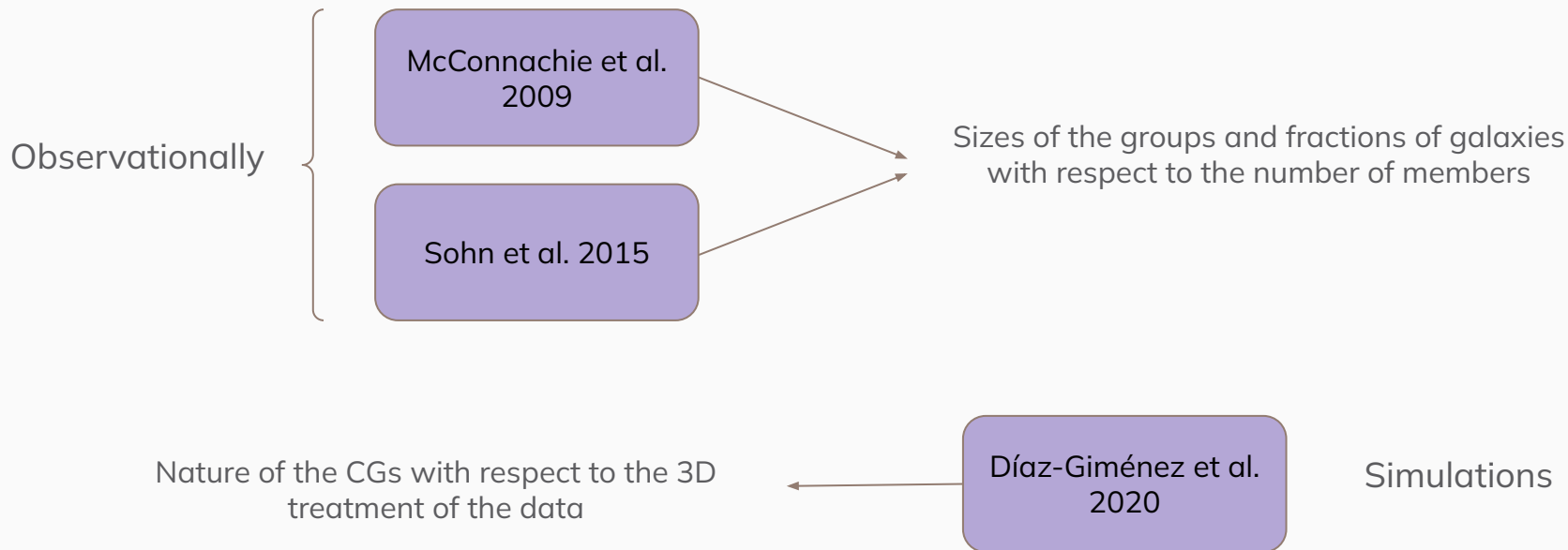


Velocity dispersion ranging between 22.57 to 525.70 km/s

Mean velocity dispersion ~ 139.92 km/s



## Results in general agree with literature...







**05**

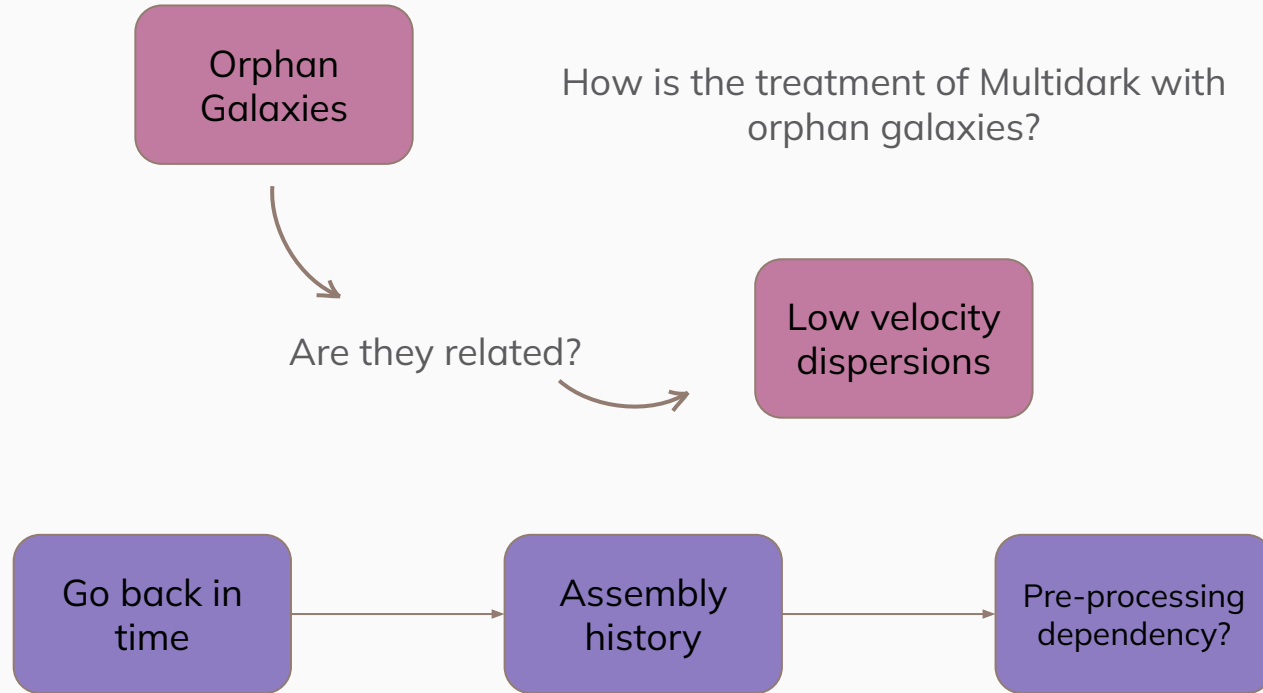


**Conclusions**



What can be done?

## Things to keep in mind...





# Thanks!



Do you have any questions?

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## References

- [1] McConnachie, A. W., Patton, D. R., Ellison, S. L., and Simard, L., “Compact groups in theory and practice - III. Compact groups of galaxies in the Sixth Data Release of the Sloan Digital Sky Survey”, *Monthly Notices of the Royal Astronomical Society*, vol. 395, no. 1, pp. 255–268, 2009. doi:10.1111/j.1365-2966.2008.14340.x.
- [2] Sohn, J., “Compact Groups of Galaxies with Complete Spectroscopic Redshifts in the Local Universe”, *Journal of Korean Astronomical Society*, vol. 48, no. 6, pp. 381–398, 2015. doi:10.5303/JKAS.2015.48.6.381.
- [3] Díaz-Giménez, E., Taverna, A., Zandivarez, A., and Mamon, G. A., “Compact groups from semi-analytical models of galaxy formation - I. A comparative study of frequency and nature”, *Monthly Notices of the Royal Astronomical Society*, vol. 492, no. 2, pp. 2588–2605, 2020. doi:10.1093/mnras/stz3356.
- [4] Celiz, B. M., Benavides, J. A., and Abadi, M. G., “Formación de grupos compactos de galaxias en simulaciones cosmológicas hidrodinámicas”, *Boletín de la Asociación Argentina de Astronomía La Plata Argentina*, vol. 64, pp. 229–231, 2023.
- [5] Knebe, A., “MULTIDARK-GALAXIES: data release and first results”, *Monthly Notices of the Royal Astronomical Society*, vol. 474, no. 4, pp. 5206–5231, 2018. doi:10.1093/mnras/stx2662.