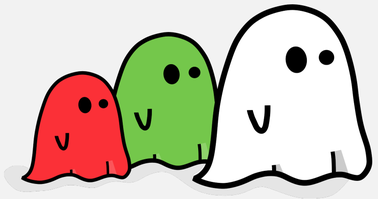
Constraining cosmological parameters using MulGuisin



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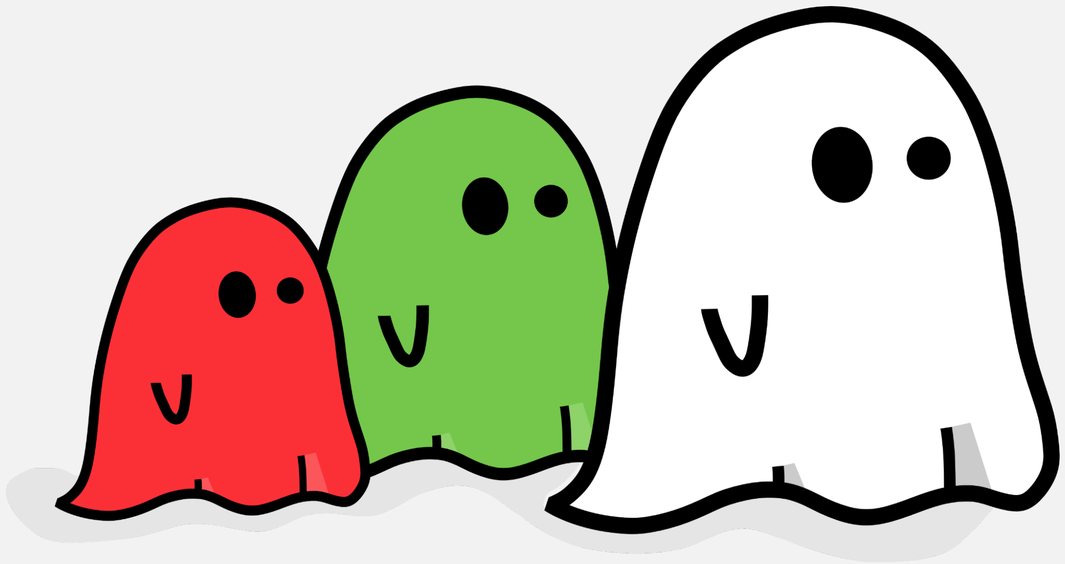
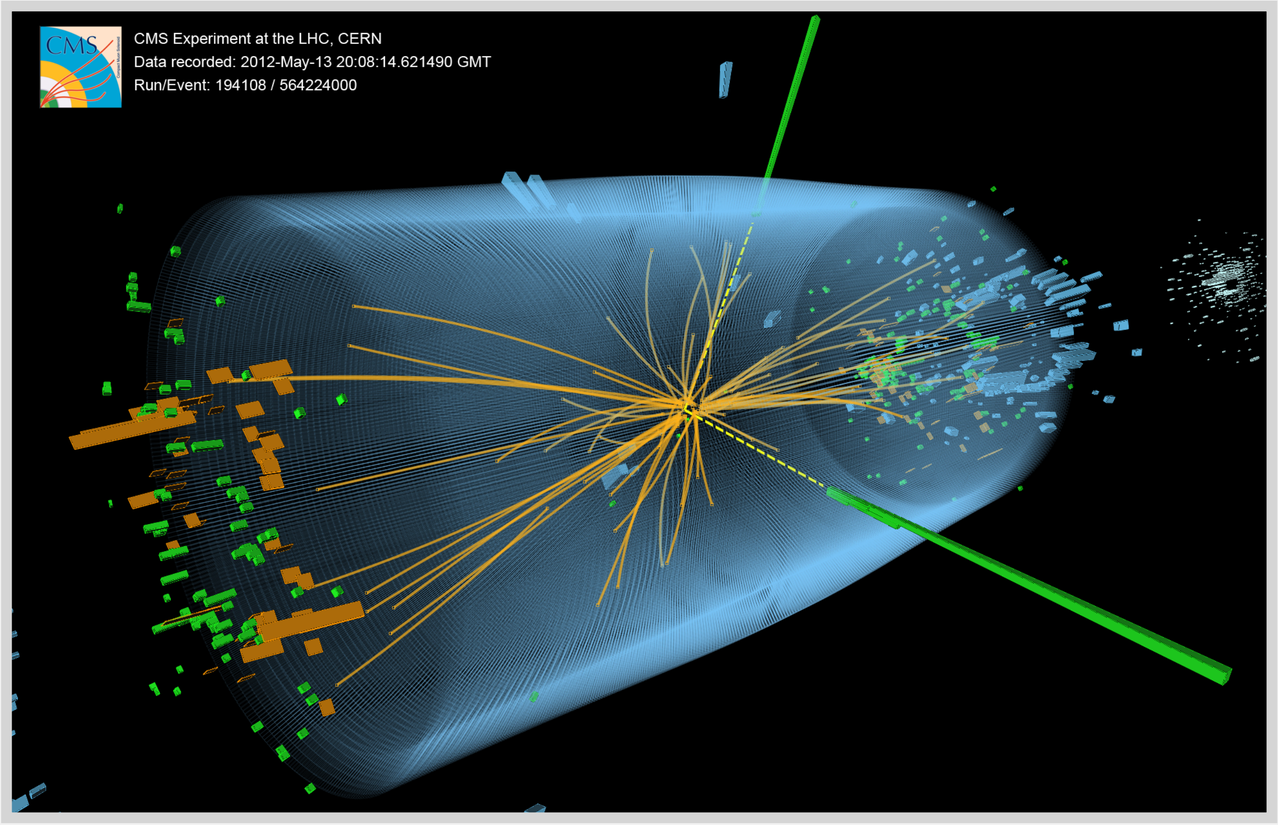
2026 자연과학연구소

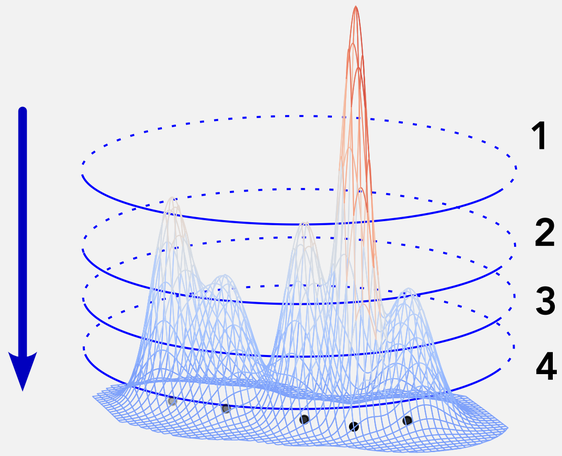
What is MulGuisin algorithm?

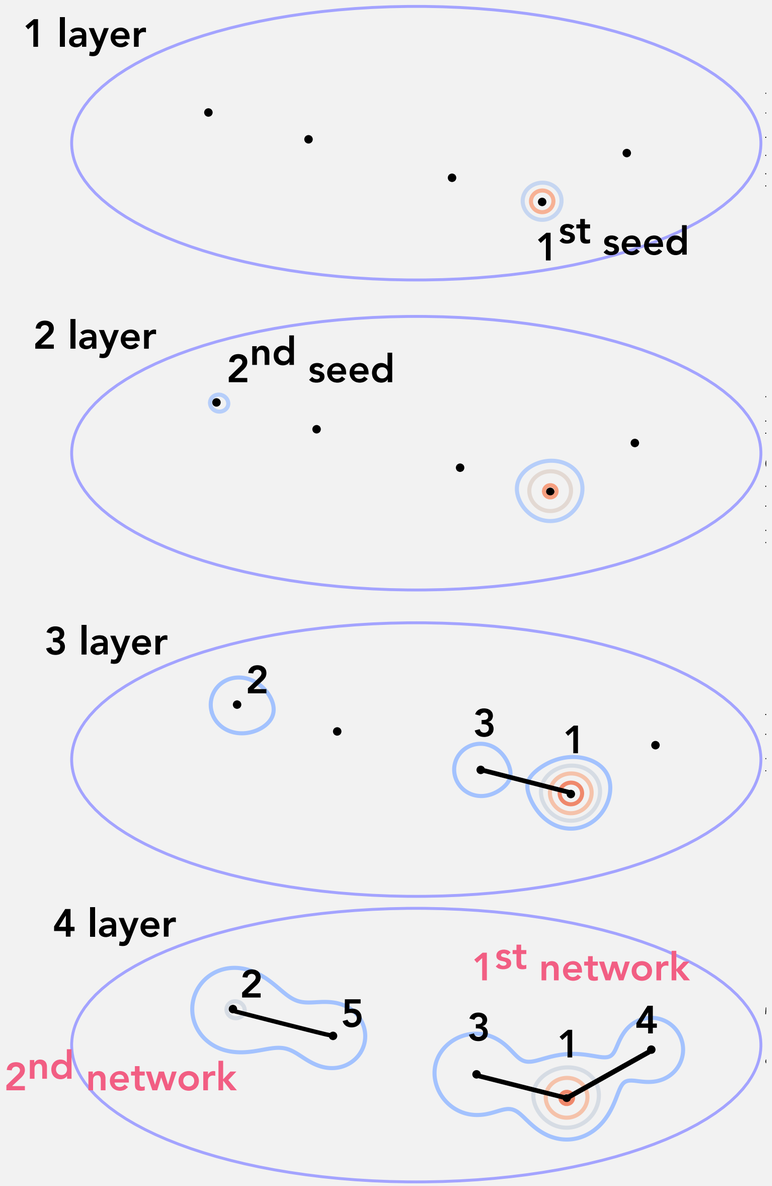
- We propose a new cluster finding algorithm, **Mulguisin(MGS)**



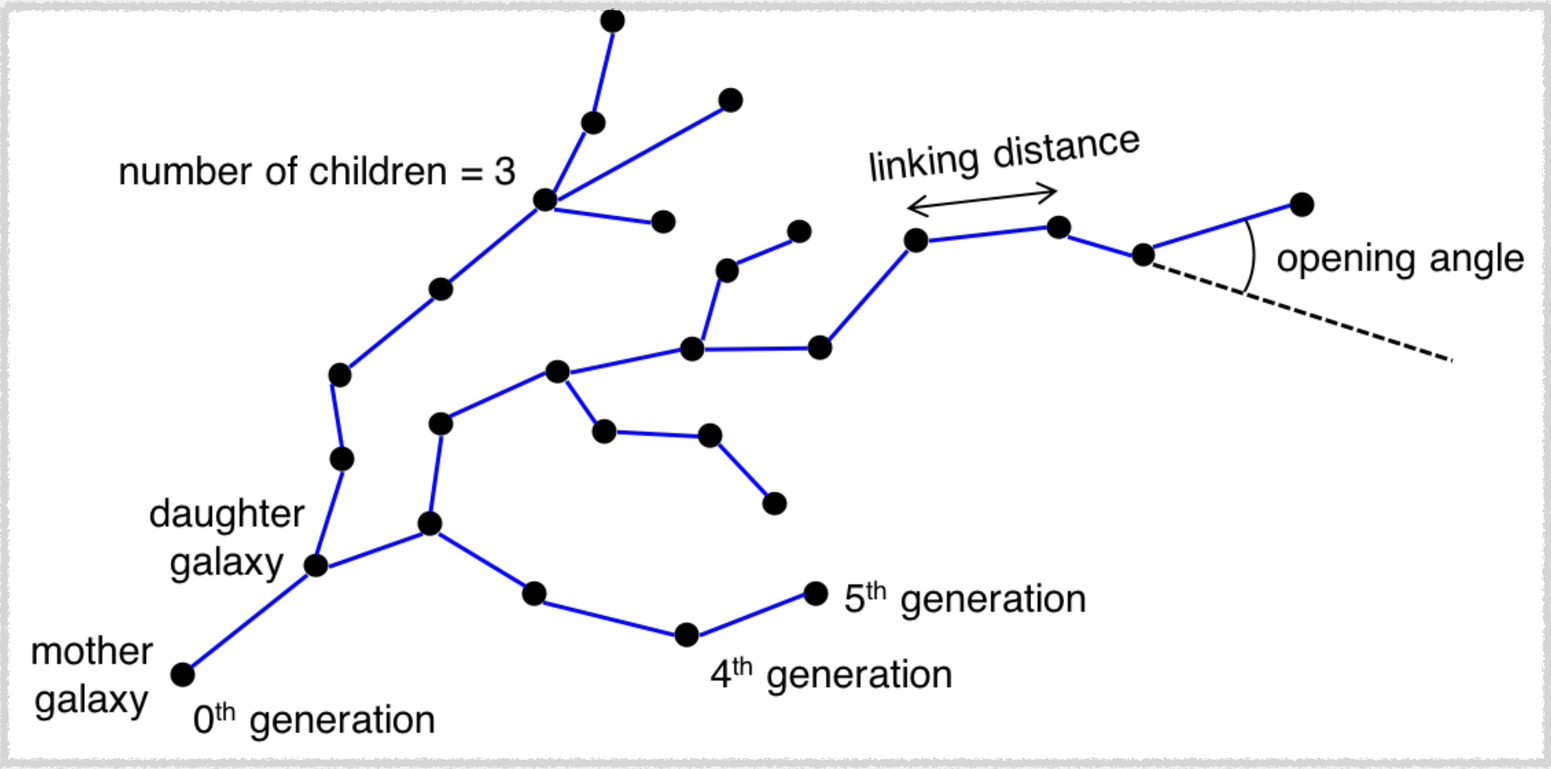


MGS mechanism





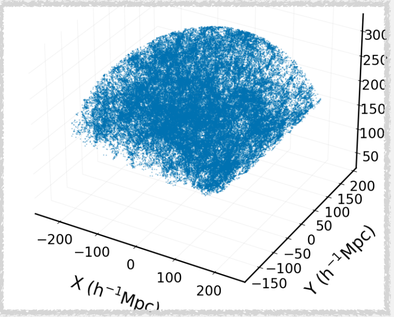
Feature of MGS

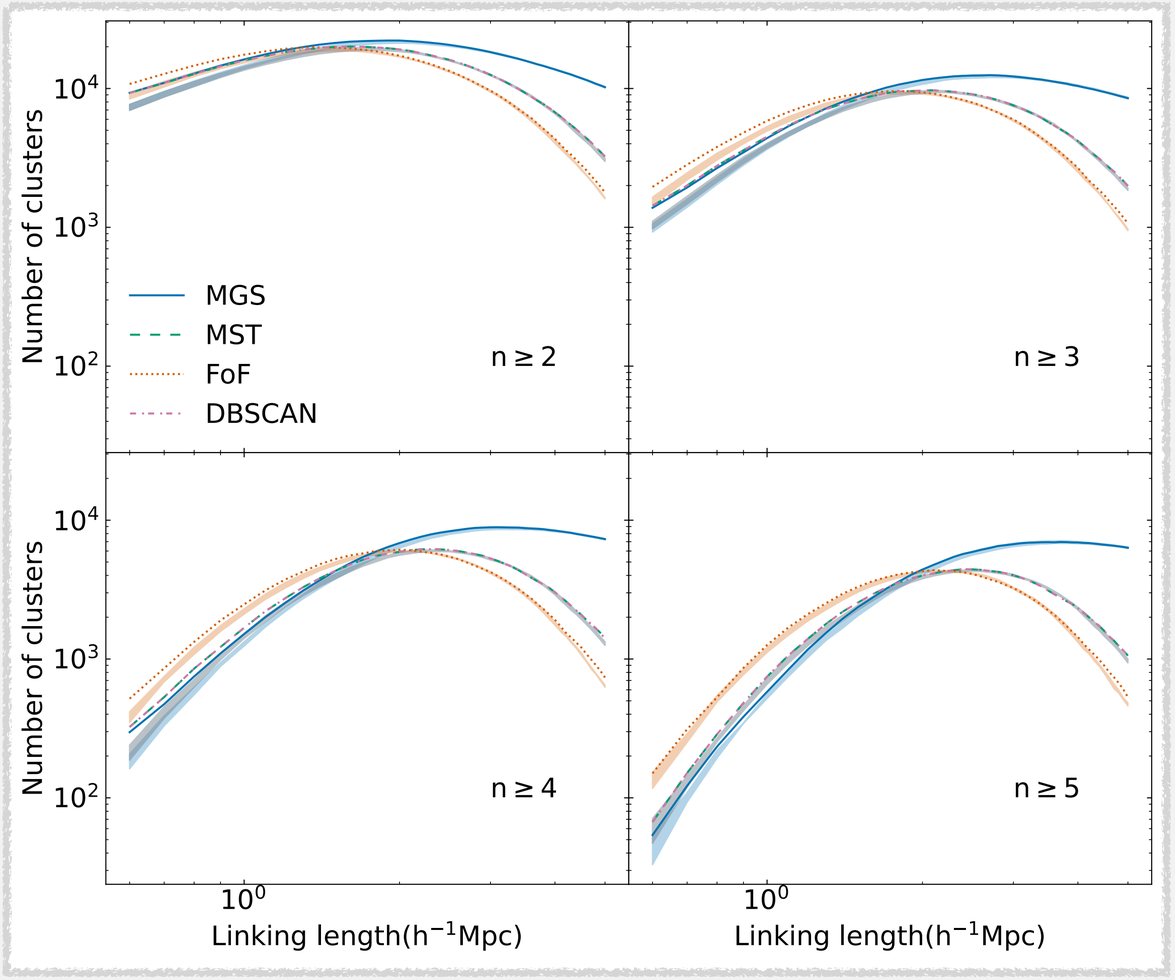


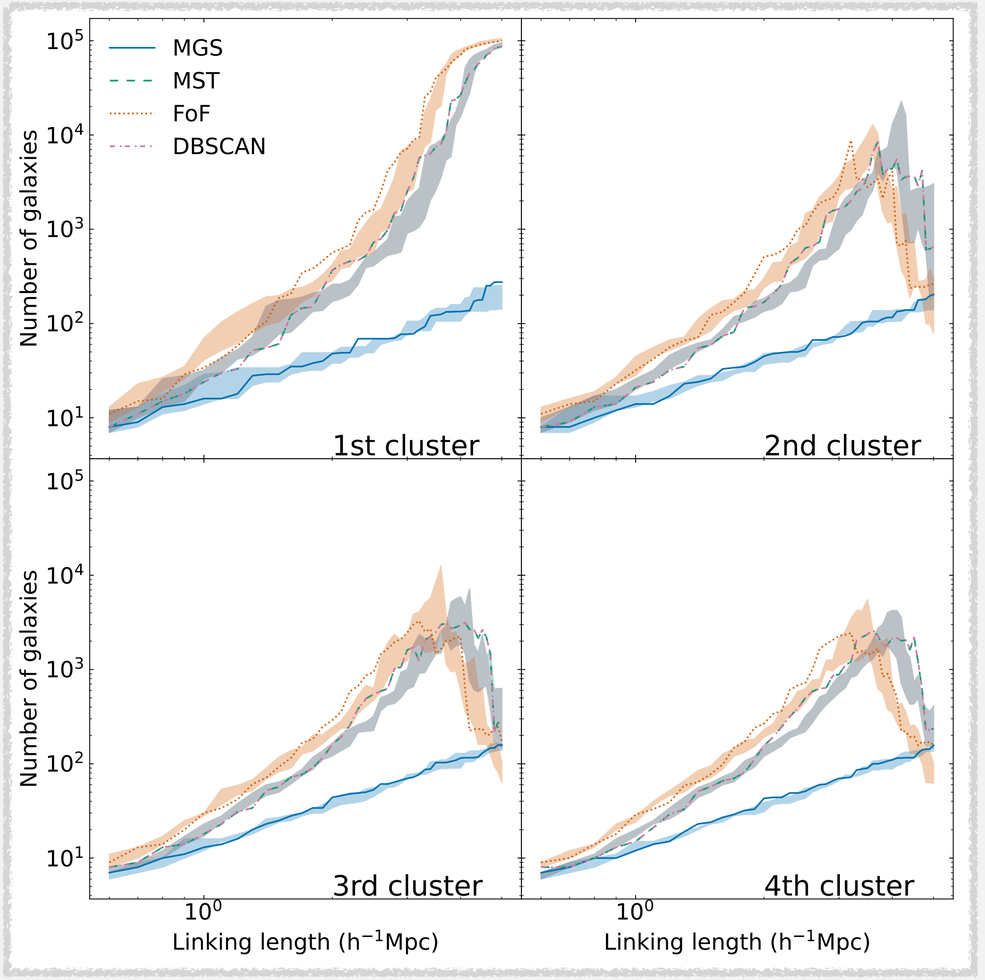
- MGS can find structure of group/cluster from galaxy data in detail
- Provide topological informations

  # of nodes
  # of branches
  # of children
  average node generation
  ...

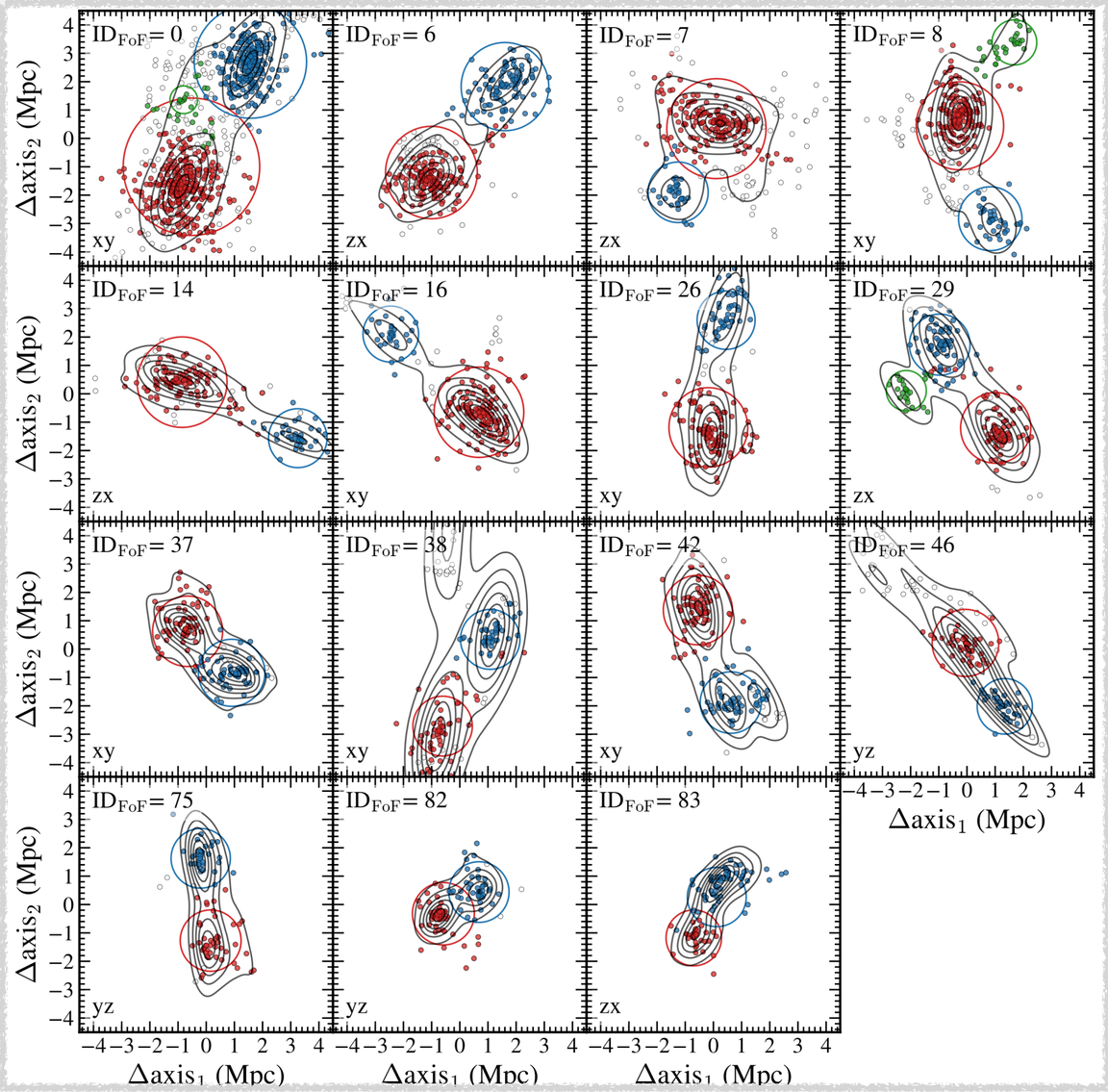
Performance test - SDSS data







Comparison of MGS and FoF

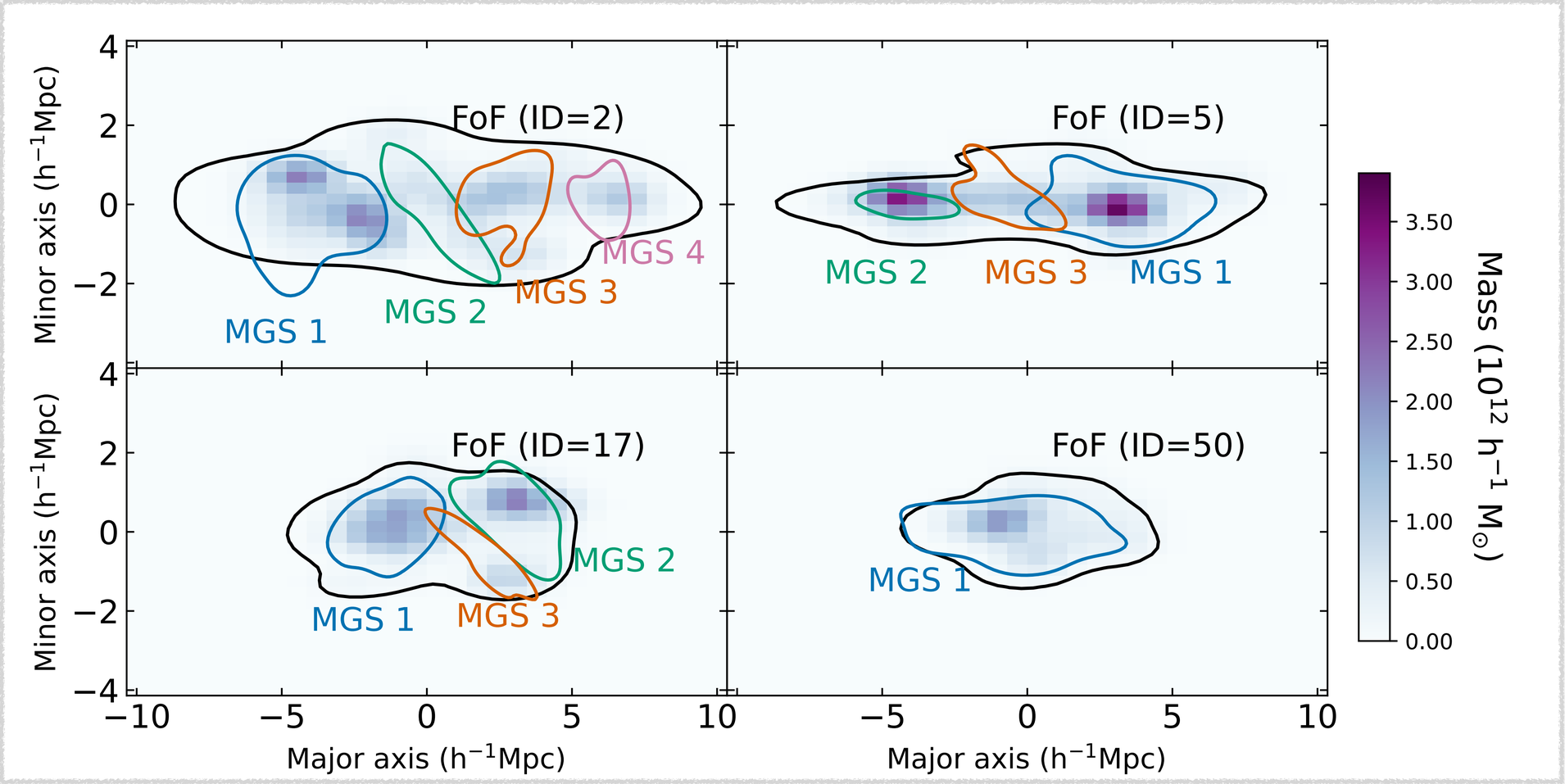


Shin et al. 2024

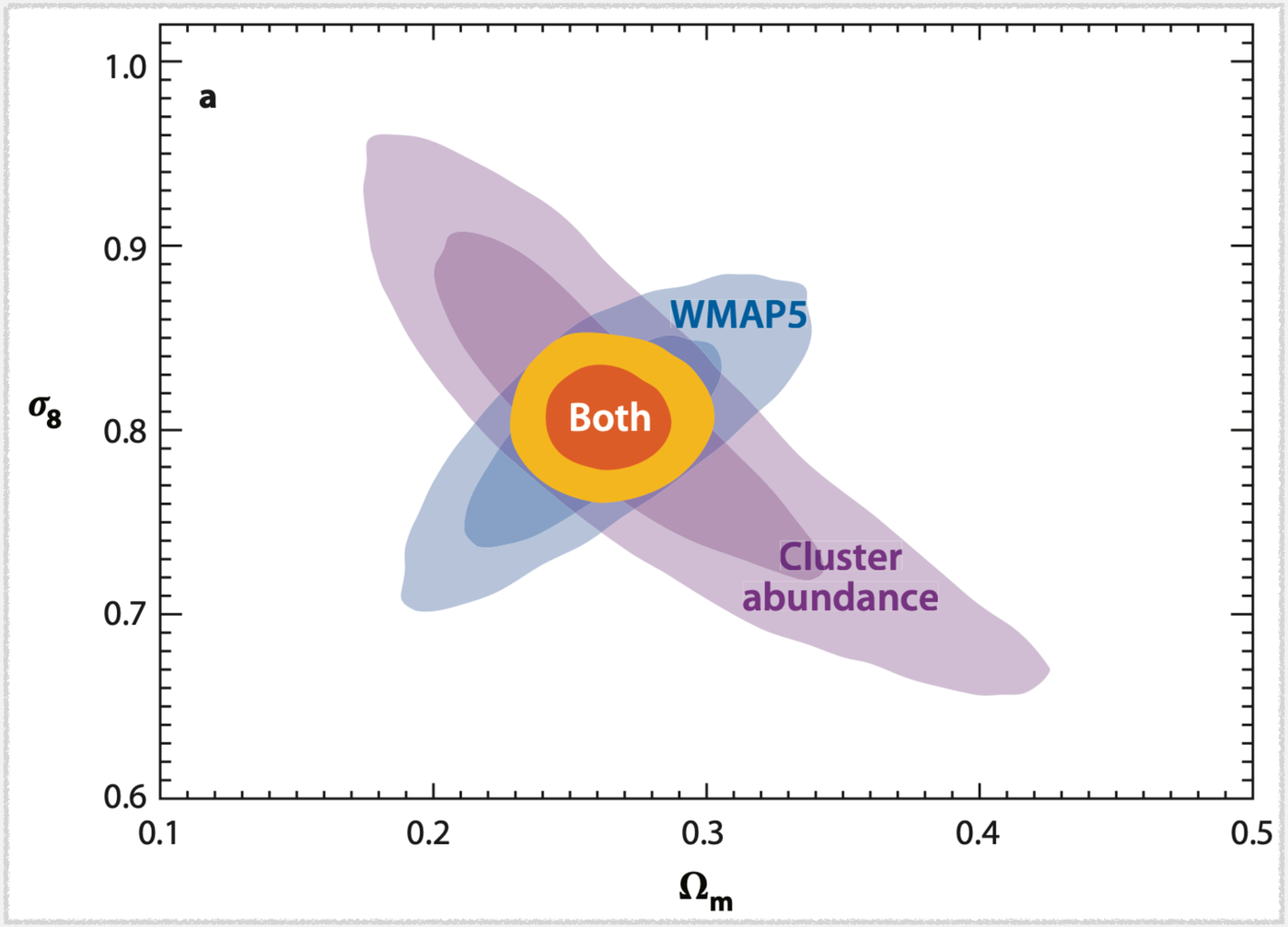
- **Shin et al. 2024** already test MGS algorithm with IllustrisTNG simulation
- MGS identify substructure in a single system

Comparison of MGS and FoF

- 2D projection of FoF and corresponding MGS clusters



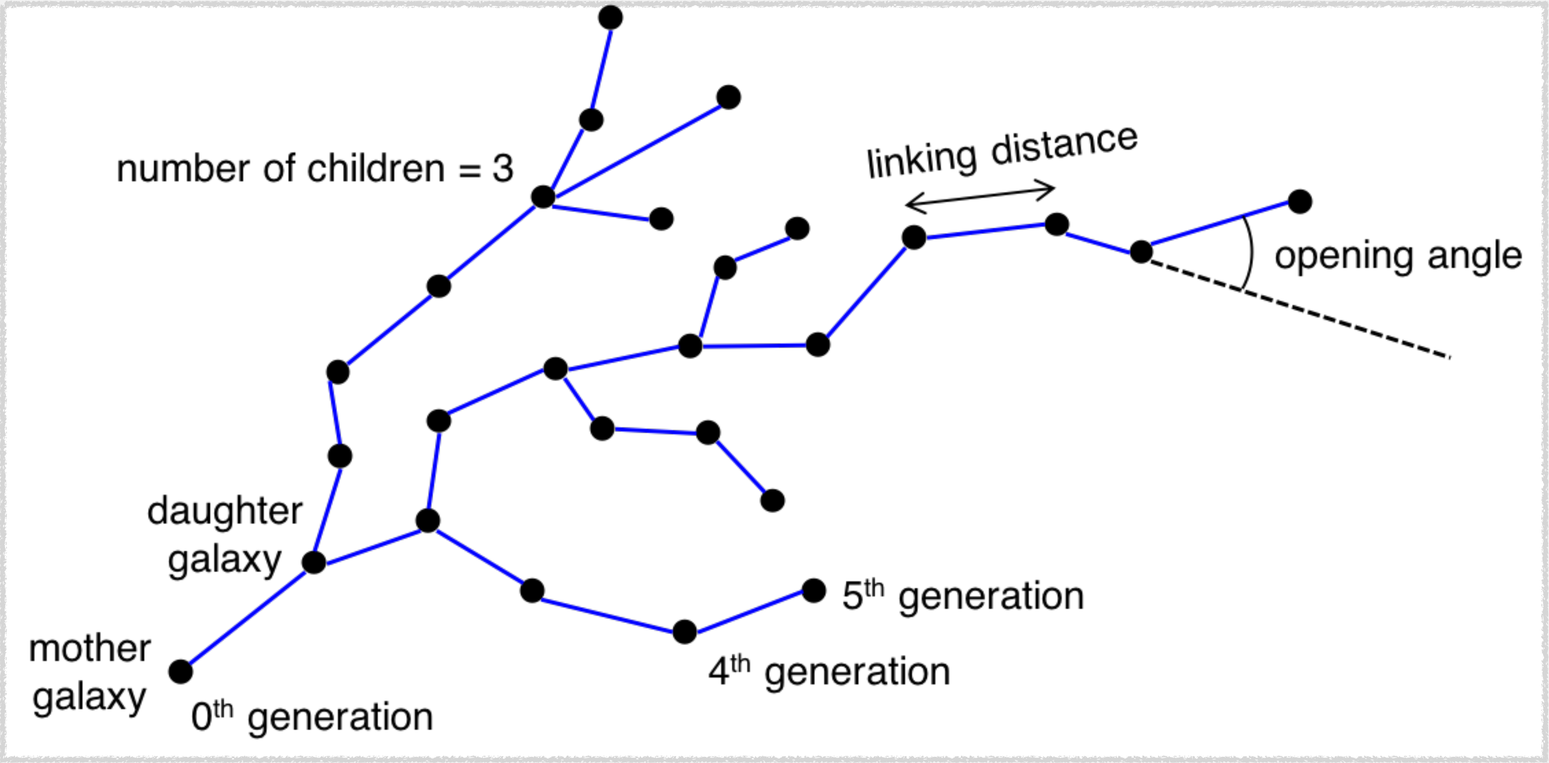
Constrain cosmological parameters



Rozo+2010

- The concordance model is described with six cosmological parameters
- With various surveys, researchers try to constrain cosmological parameters using different methods

Constrain cosmological parameters



- Our aim is to constrain cosmological parameters using topological MGS information

DATA

- **MG-PICOLA simulation**

- COmoving Lagrangian Acceleration (COLA) method calculate **Lagrangian Perturbation Theory (LPT)** and generate large scale structure of the universe

MGS informations

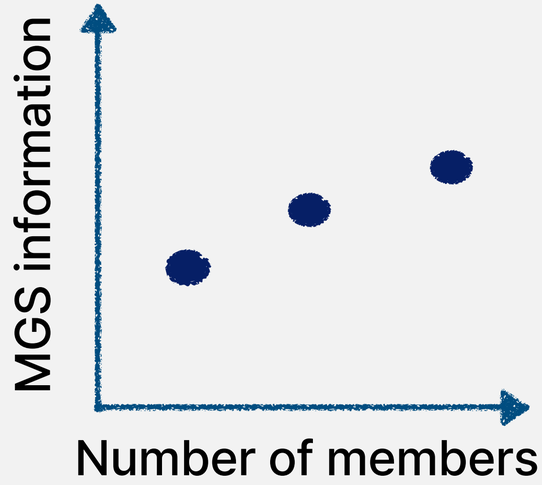
MG-PICOLA simulation (Dark matter)

Change Ω_m σ_8

Cluster finding & MGS informations

# of generations
# of branches
# of children
...

Generate MGS profile



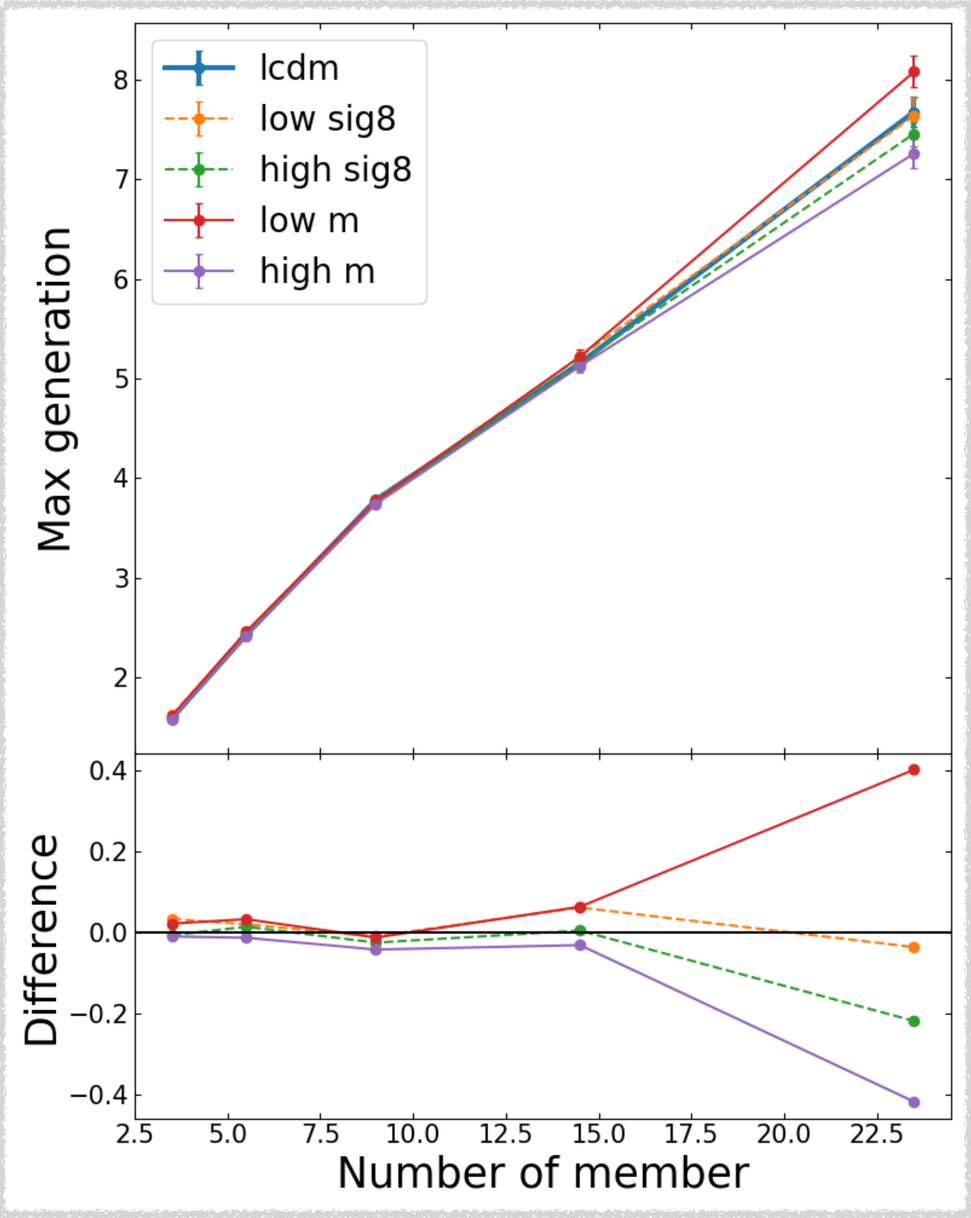
Fisher information matrix

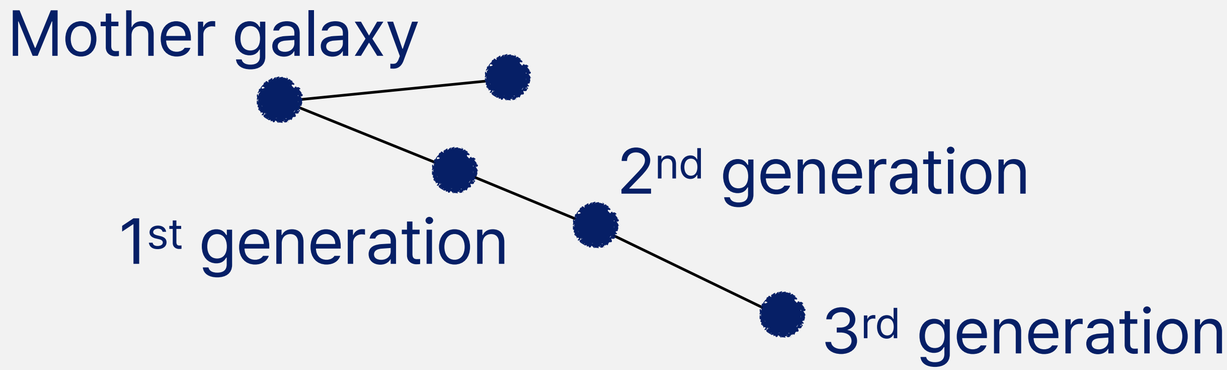
- One way to estimate uncertainty of parameters is Fisher information matrix

$$F_{ij} \equiv \left\langle \frac{\partial^2 \mathscr{L}}{\partial\theta_i \partial\theta_j} \right\rangle \qquad \mathscr{L} = \log p(\theta \,|\, \mathrm{data}, \mathrm{I}) : \text{Log likelihood}$$

- Inverse of Fisher matrix is covariance matrix.
- We check covariance matrix and how MGS information constrains cosmological parameters

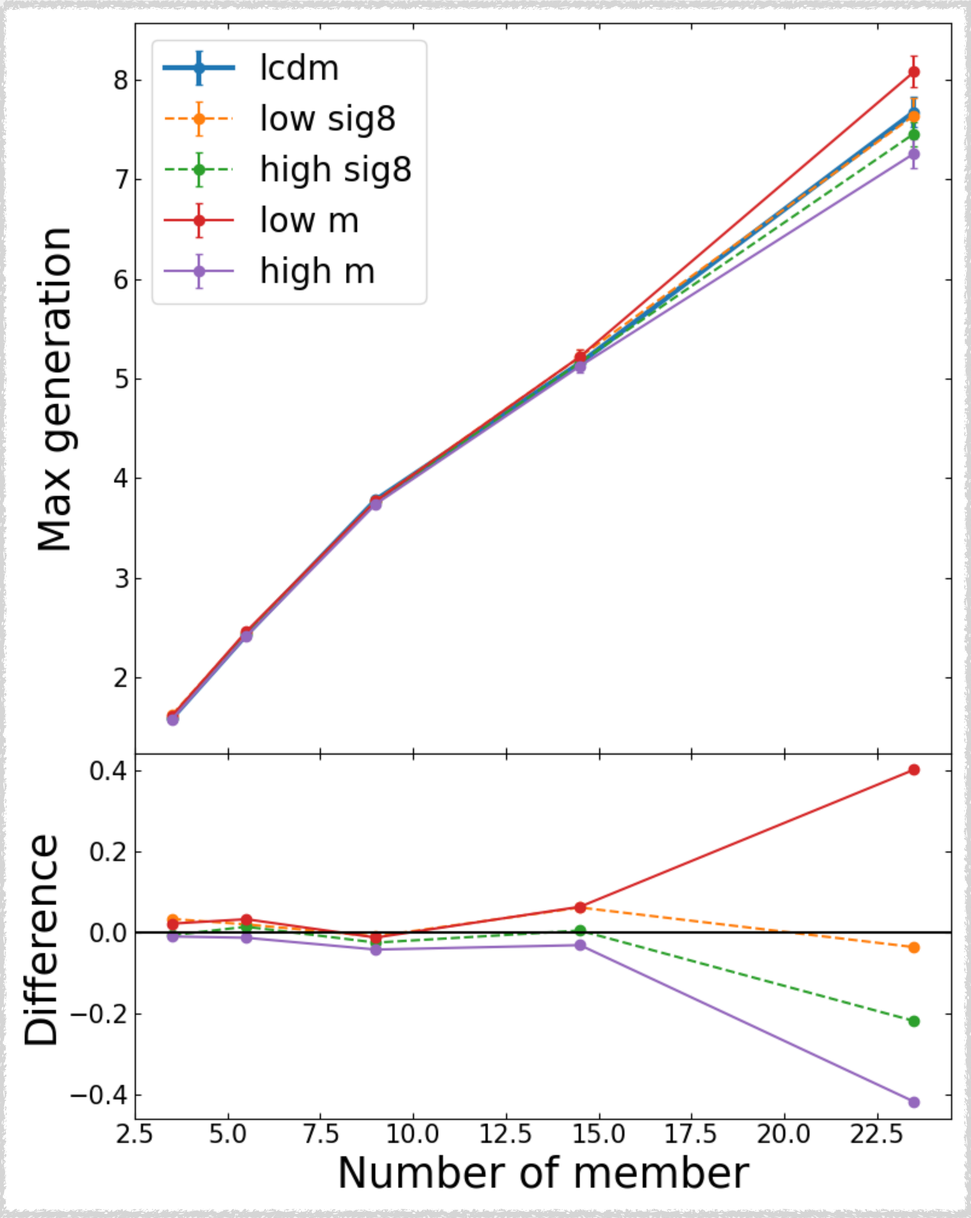
MGS information : **Generation**





- Four different simulation changing cosmological parameters
- Low matter case has higher generation than LCDM

MGS information : **Generation**



Mother galaxy

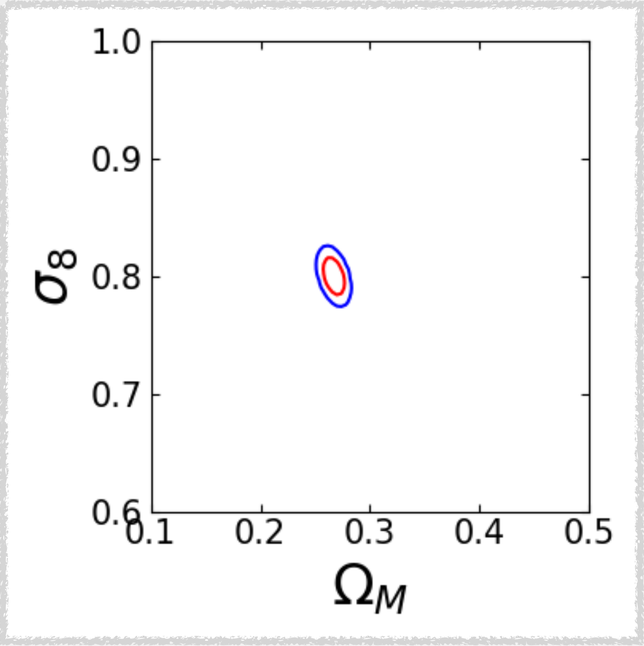
1st generation

2nd generation

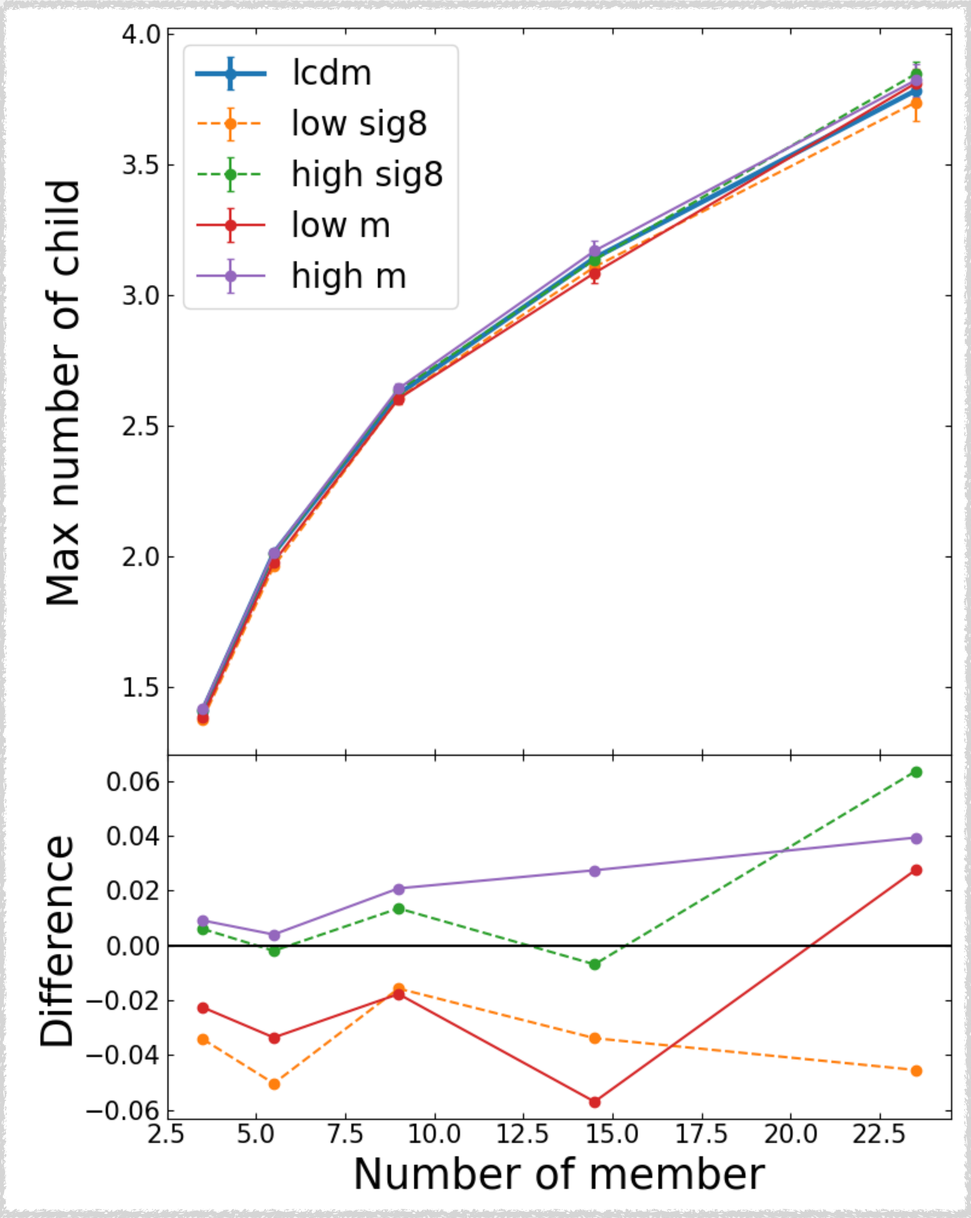
3rd generation

Fisher matrix &

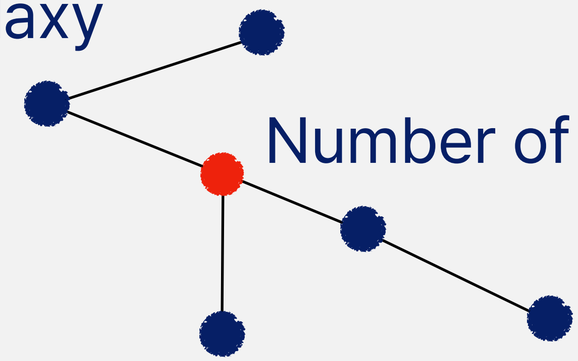
Covariance contour



MGS information : **Number of child**



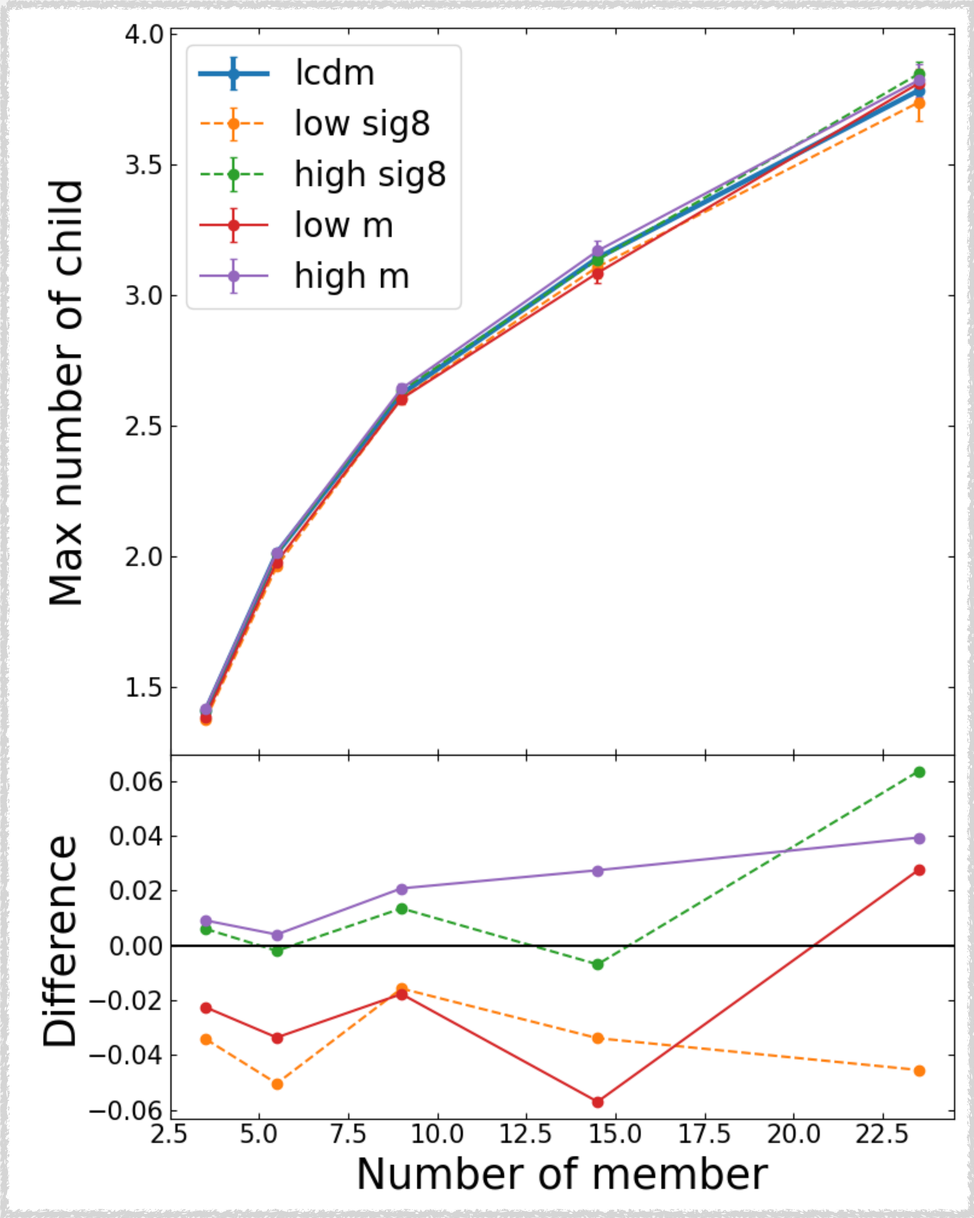
Mother galaxy



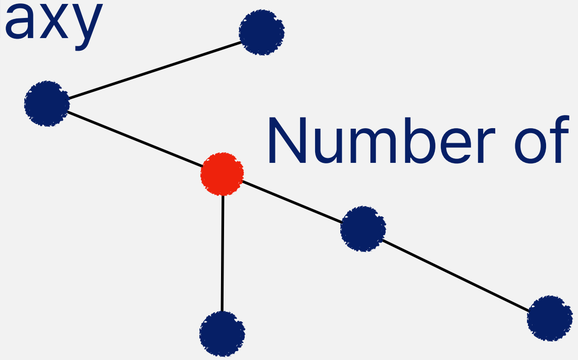
Number of child = 2

- Higher matter case has larger number of child than LCDM

MGS information : **Number of child**



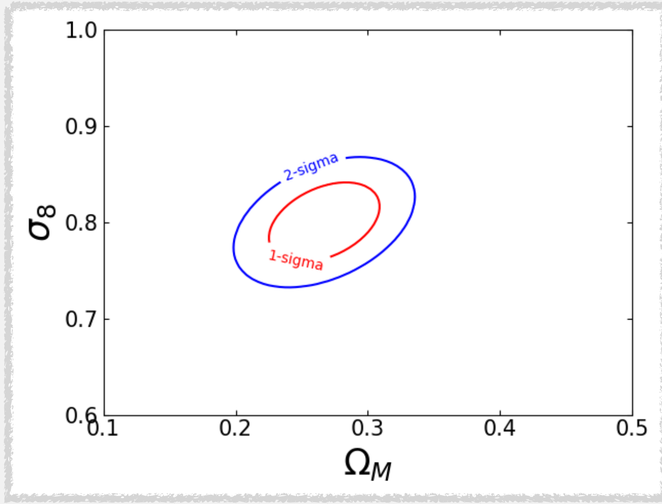
Mother galaxy



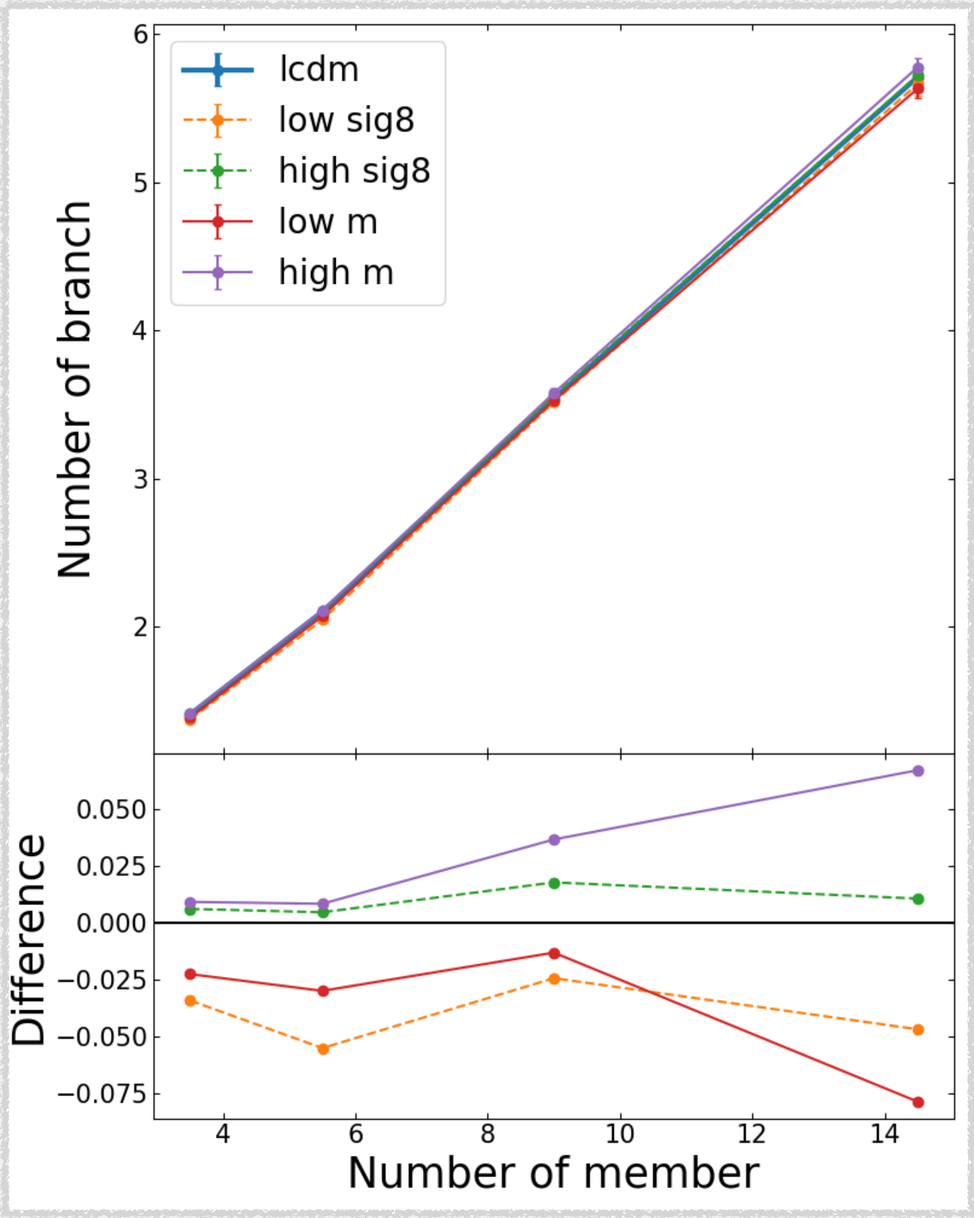
Number of child = 2

Fisher matrix &

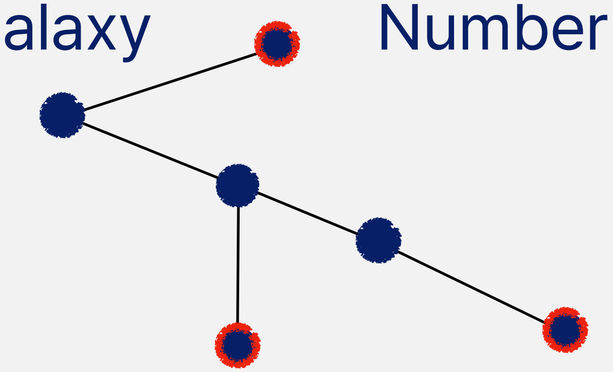
Covariance contour



MGS information : **Number of branch**



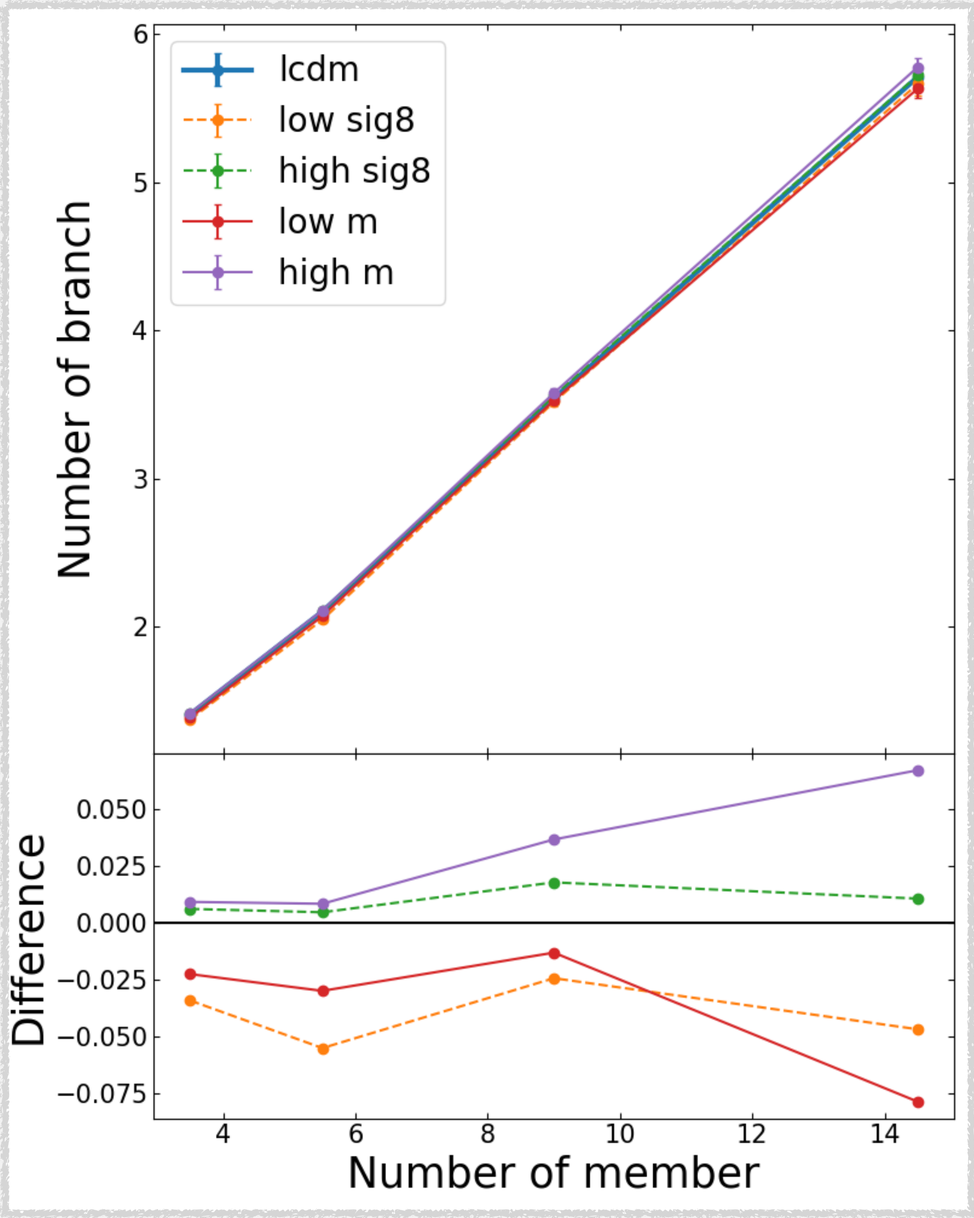
Mother galaxy



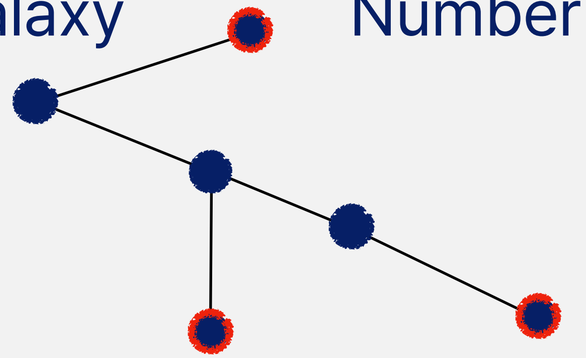
Number of branch = 3

- High matter and sigma 8 case have more number of branches than LCDM case

MGS information : **Number of branch**



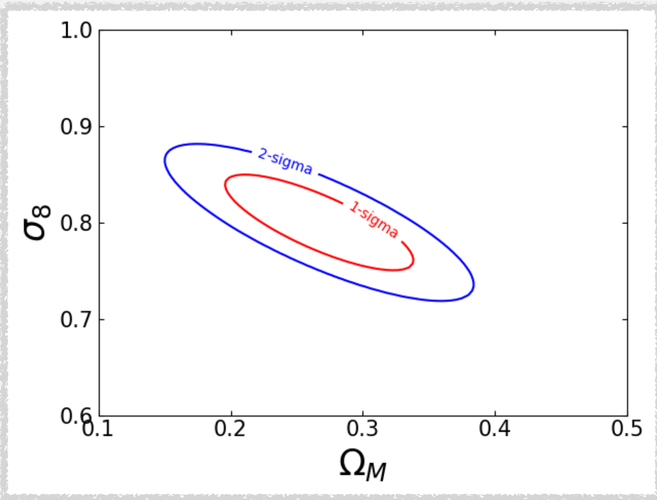
Mother galaxy



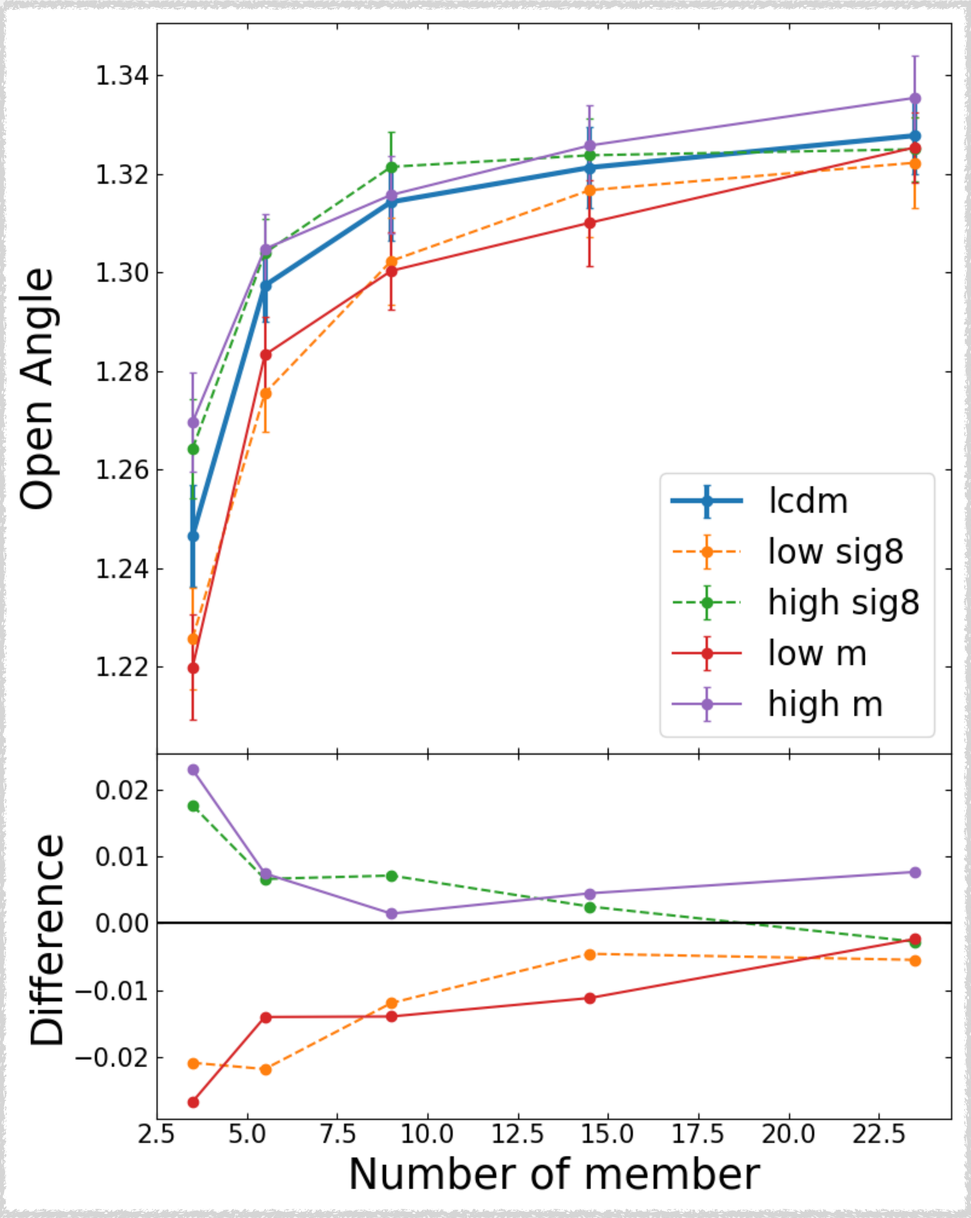
Number of branch = 3

Fisher matrix &

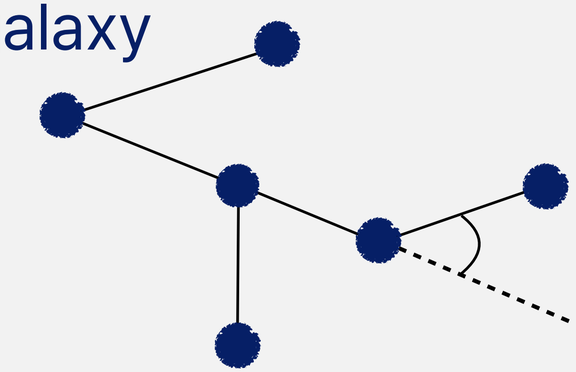
Covariance contour



MGS information : **Opening Angle**



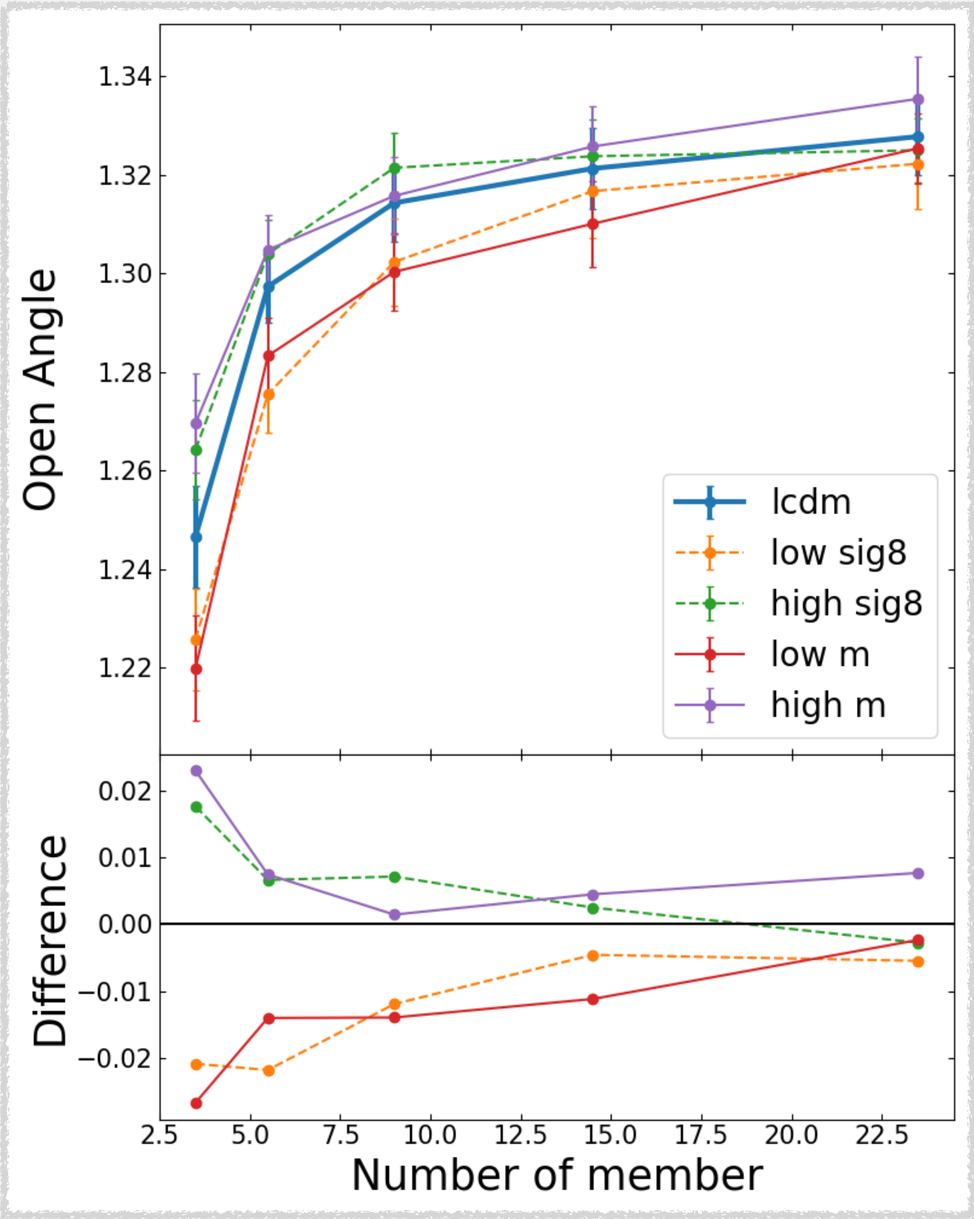
Mother galaxy



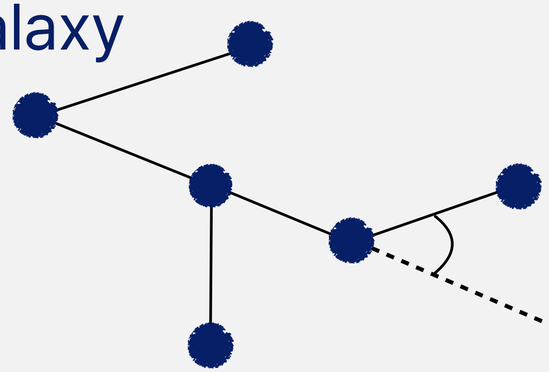
Opening Angle

- It seems to be saturated at larger cluster

MGS information : **Opening Angle**



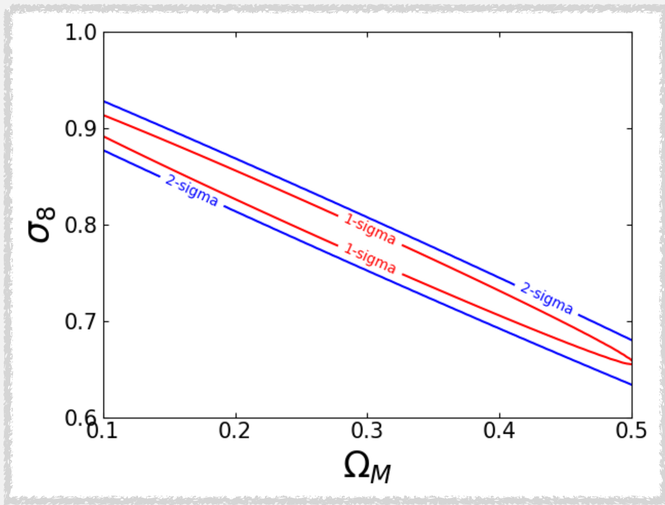
Mother galaxy



Opening Angle

Fisher matrix &

Covariance contour



Conclusion

- We propose a new cluster finding algorithm, MGS
- MGS shows good performance when we test with SDSS data
- MGS can find distinct structures with complex systems
- It can give us novel perspective with regard to cosmological studies, specifically constraining cosmological parameters