

Galaxy formation without cosmic variance: exploring the universe through the Sibelius-Dark simulation

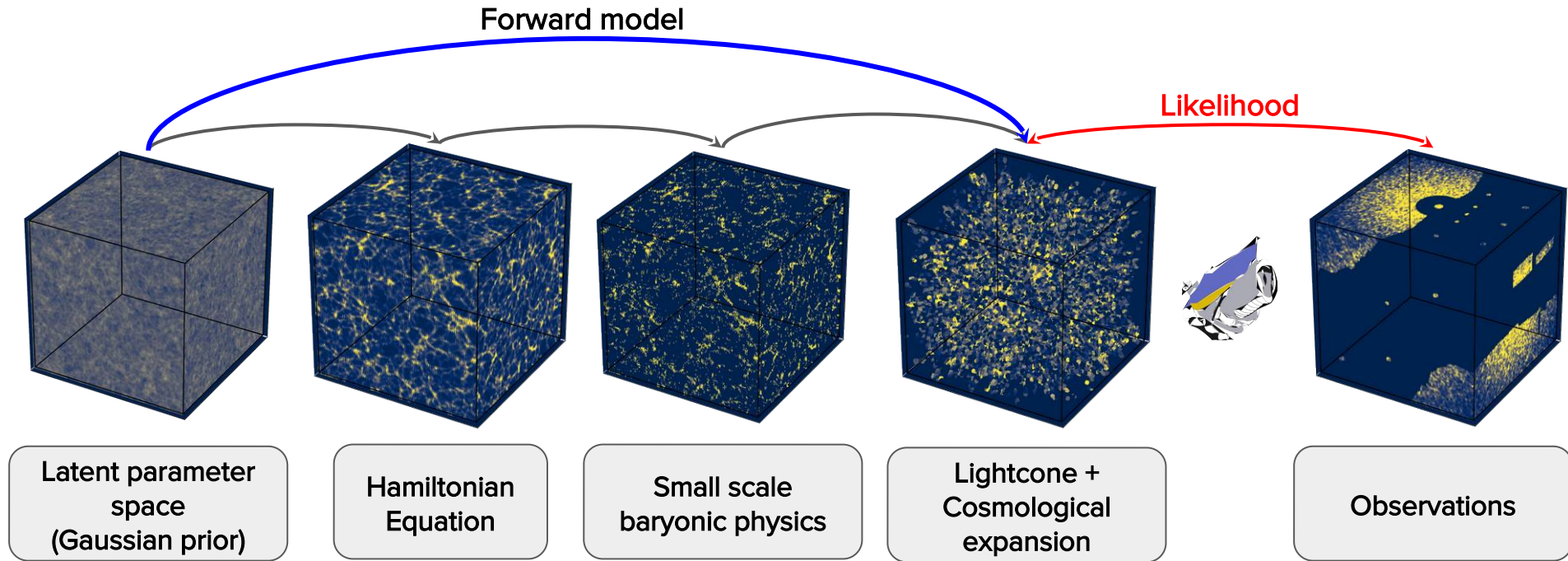
Guilhem Lavaux
(Aquila Consortium+Sibelius collaboration)





Initial condition derivation

The BORG model



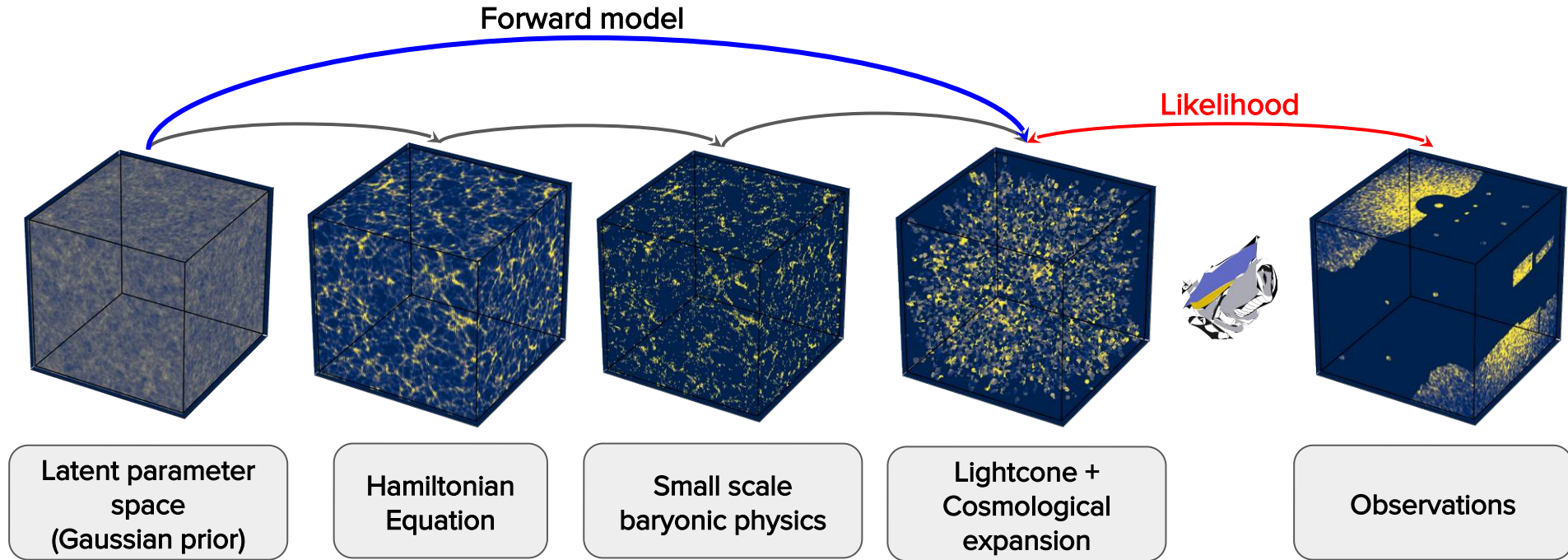
256^3 parameters / 512^3 tracing particles

(so ~low res for current cosmological simulation standards)

20 timesteps of Particle-Mesh

RSD at particle level

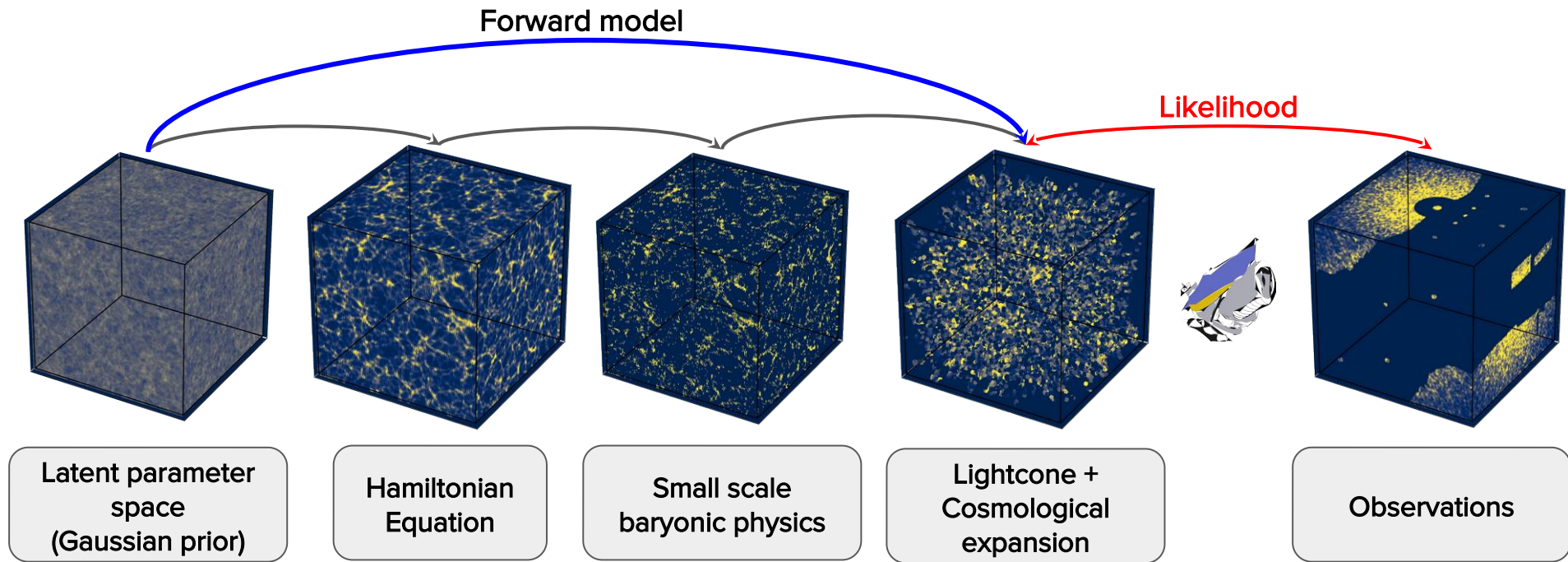
The BORG model



Empirical bias model :
Dark matter \leftrightarrow galaxy abundance



The BORG model



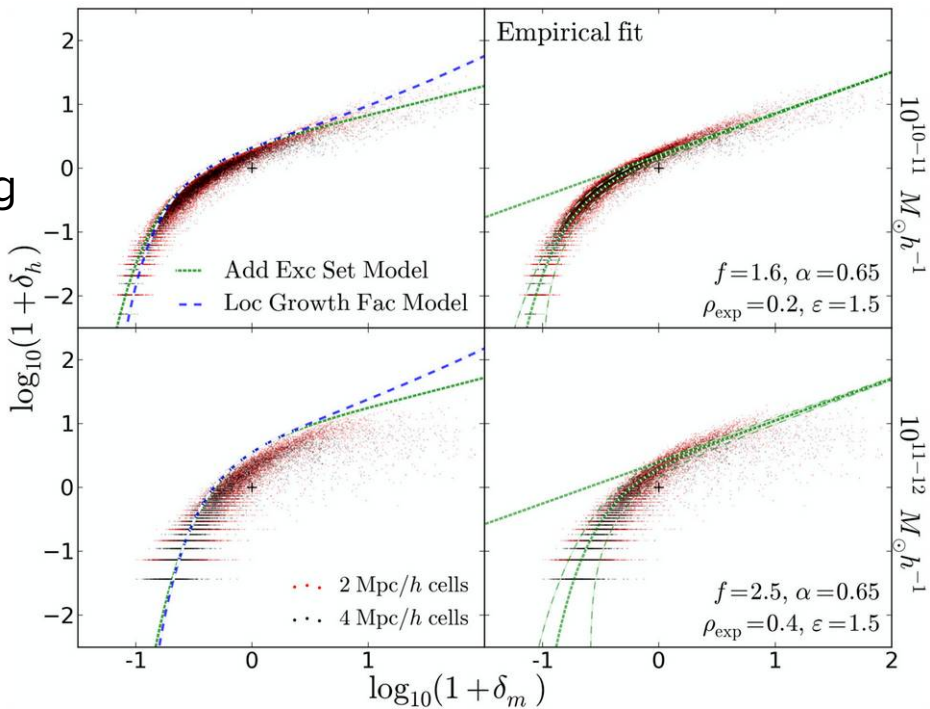
2M++ compilation



Halo bias model in BORG

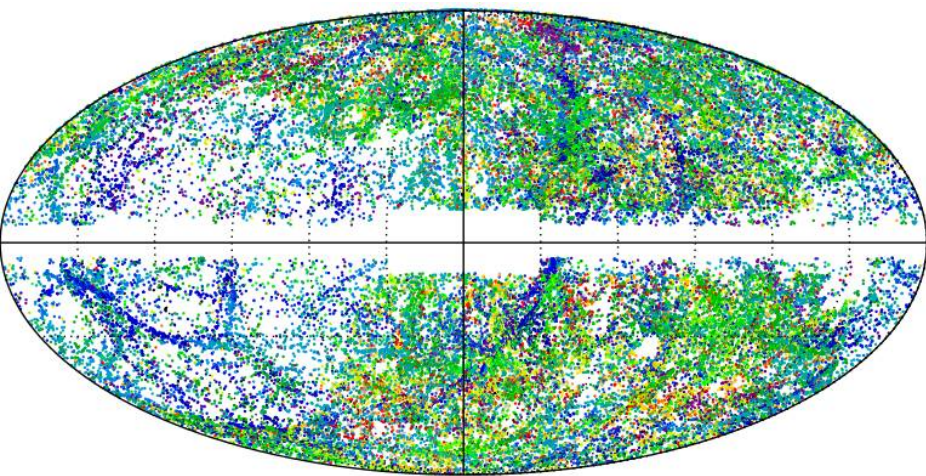
- Based on fit in halo mock catalog
- Similar phenomenology to HOD modeling
 - Power-law at low masses
 - Sharp truncation in cosmic voids
- Mathematical model with 4 parameters

$$\rho_h = f \rho_m^\alpha \exp \left[\left(\rho_m / \rho_{\text{exp}} \right)^{-\varepsilon} \right]$$



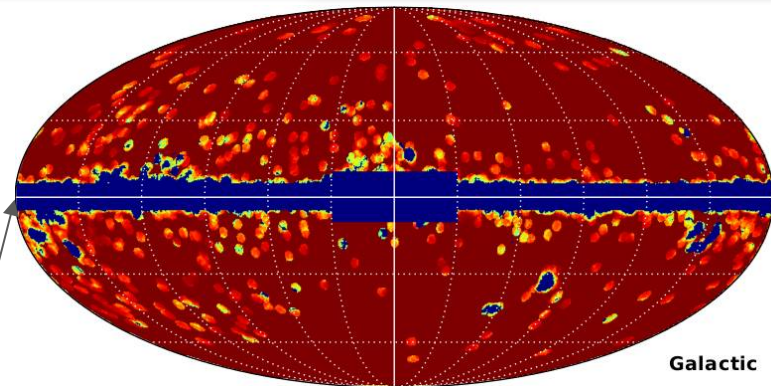
Neyrinck et al (2014, MNRAS)

The 2M++ compilation

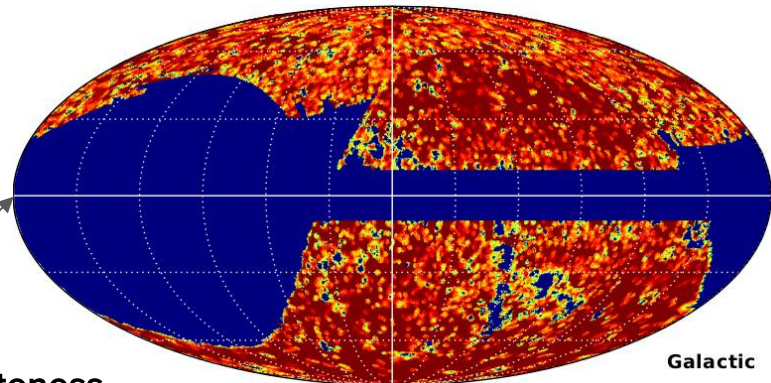


0 Mpc/h

250 Mpc/h



Galactic



Galactic

Sky completeness
at two brightness



The SIBELIUS-Dark simulation

Sibelius-Dark run

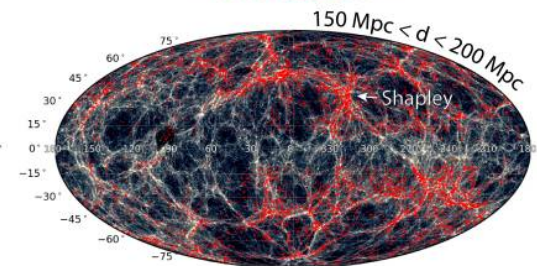
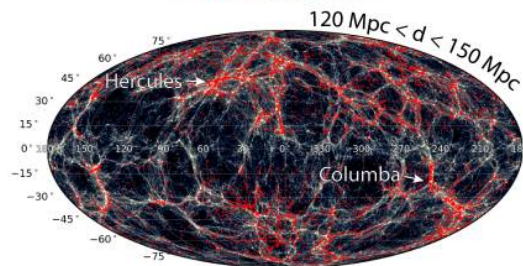
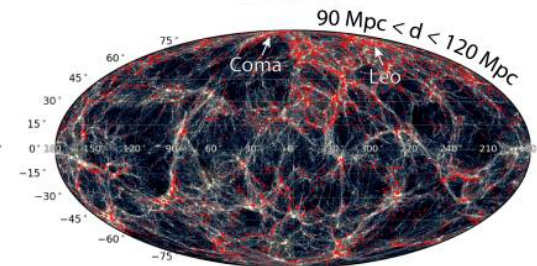
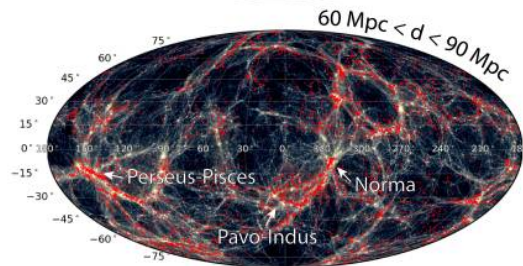
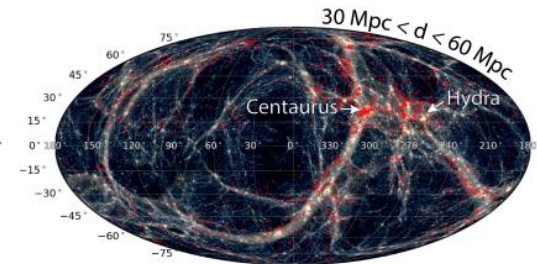
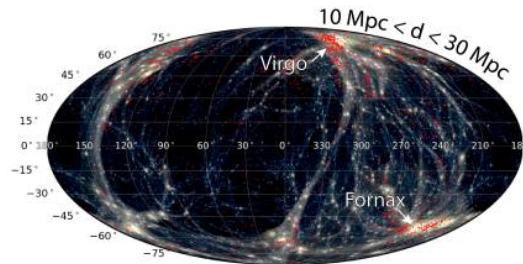


SIBELIUS-Dark :

A resimulation of the nearby Universe (<200 Mpc)

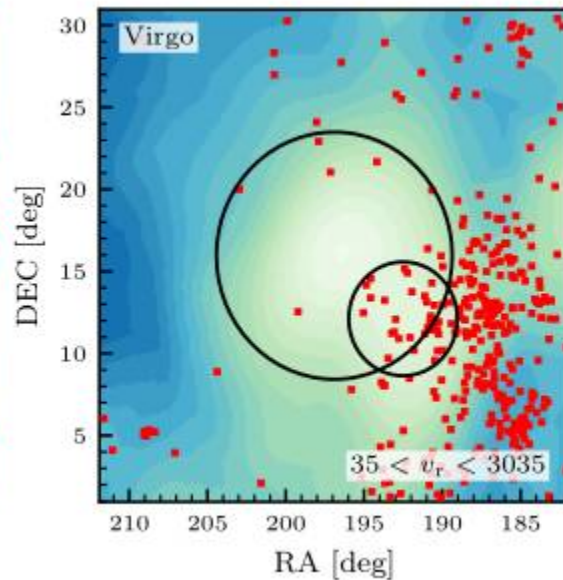
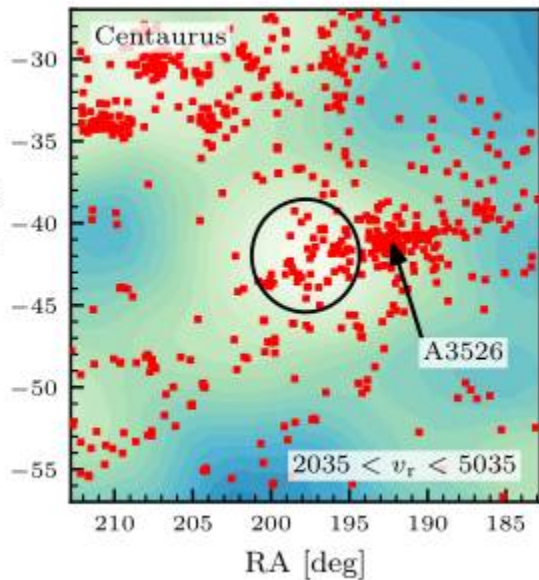
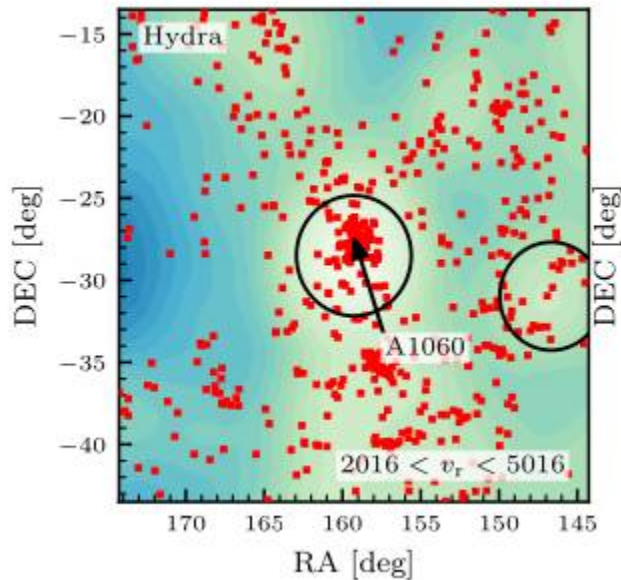
Simulation configuration

- Code simulation SWIFT (Schaller et al 2018)
- Planck like cosmology
- Dark matter only
- $L = 1 \text{ Gpc}$
- Simulation “Zoom” pour <200 Mpc
- $N = 5078^3$
- 4489 cores
- 3.5M CPU-h





Some famous galaxy clusters

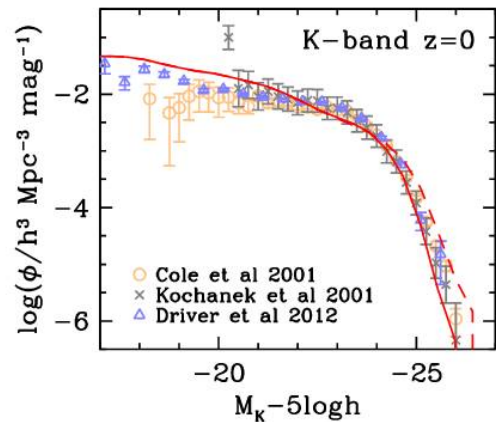
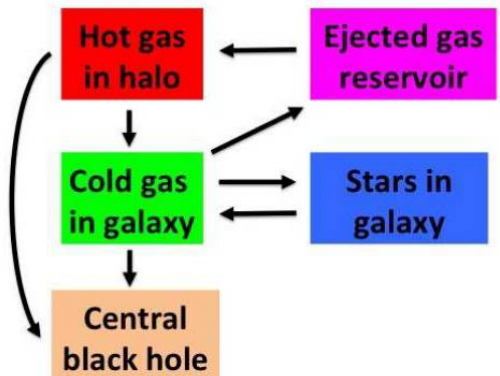


2M++ galaxies

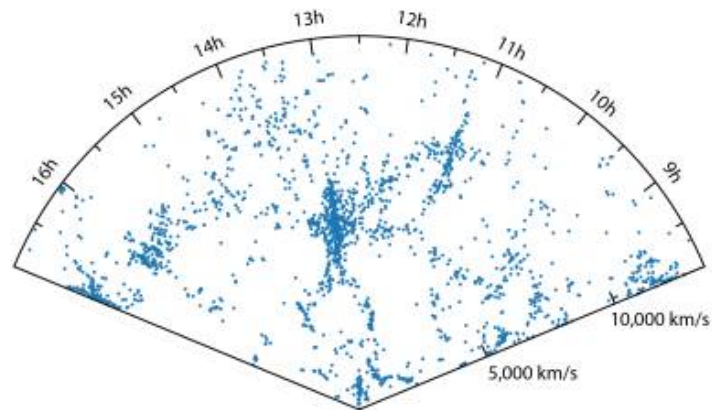
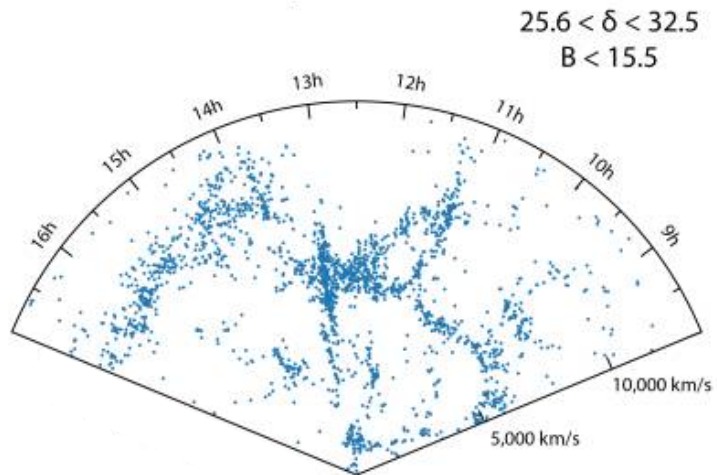


Semi-analytic galaxy formation model: *Galform*

- Initial mass func. for stars: quiescent \neq starbursts
- Number counts of sub-mm selected galaxies
- Tested with observational data
 - $z=0$ to $z=6$
 - Wavelengths from far-UV to sub-mm
- K-band luminosity function and stellar mass function



Some oldies: the CfA great wall & Coma cluster

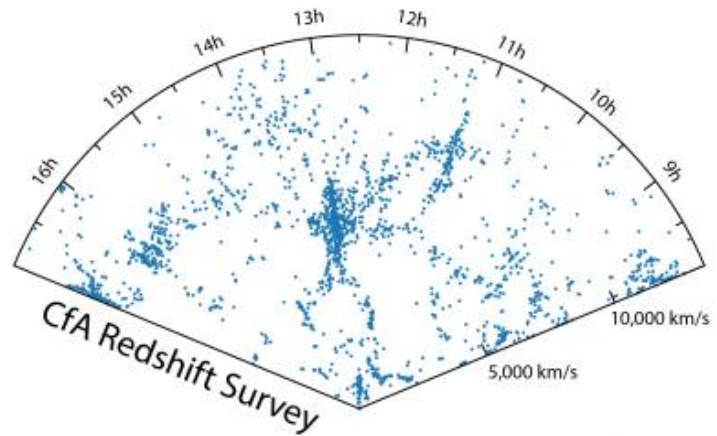
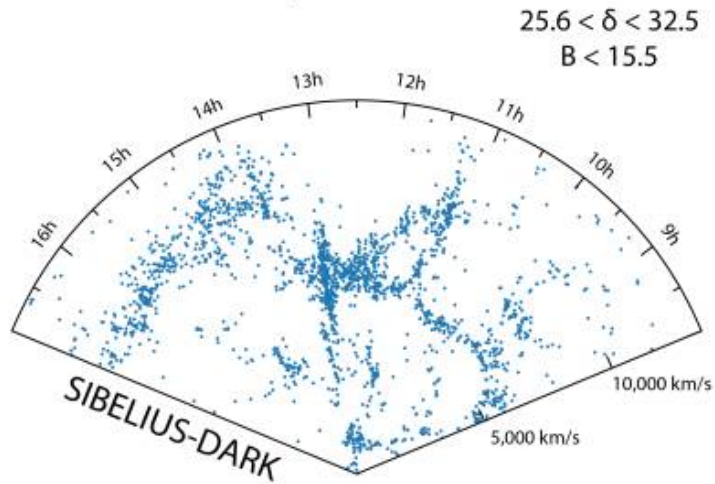


Which one is the real one?

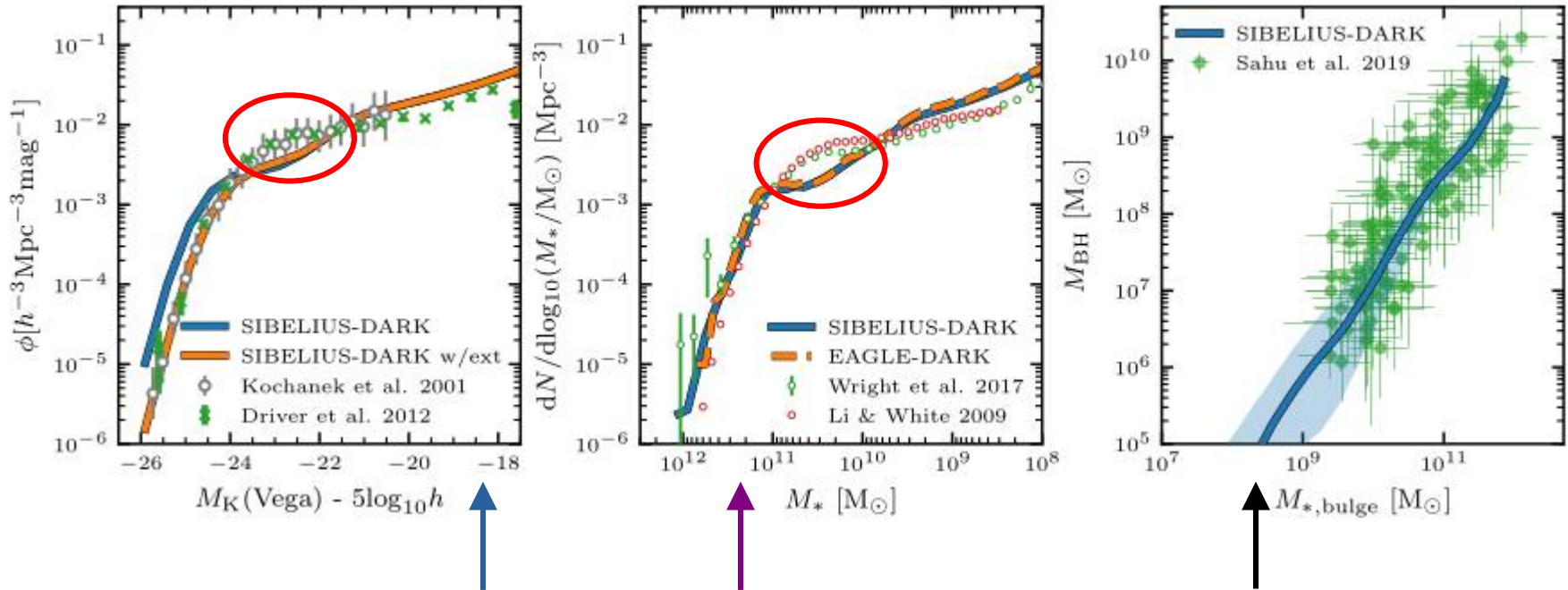




Some oldies: the CfA great wall & Coma cluster



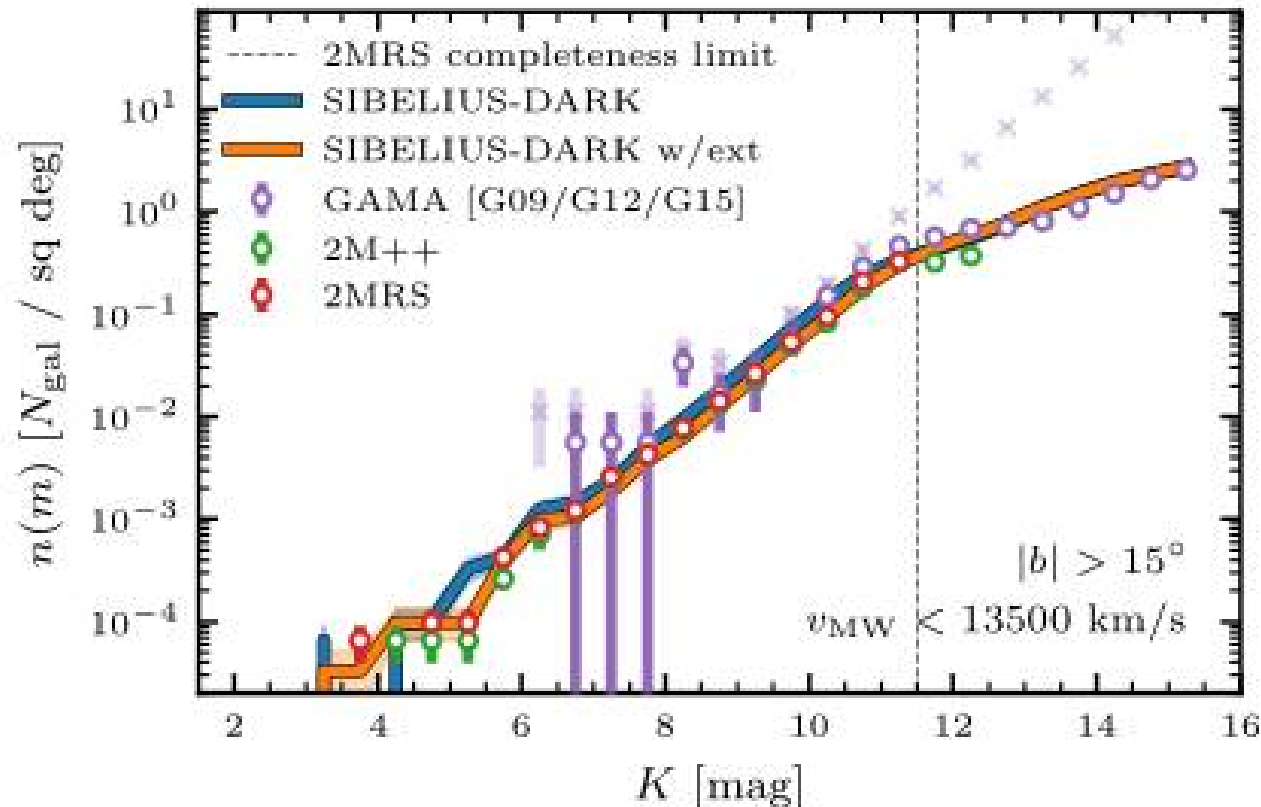
Some diagnostic on local luminosity function / Black Hole



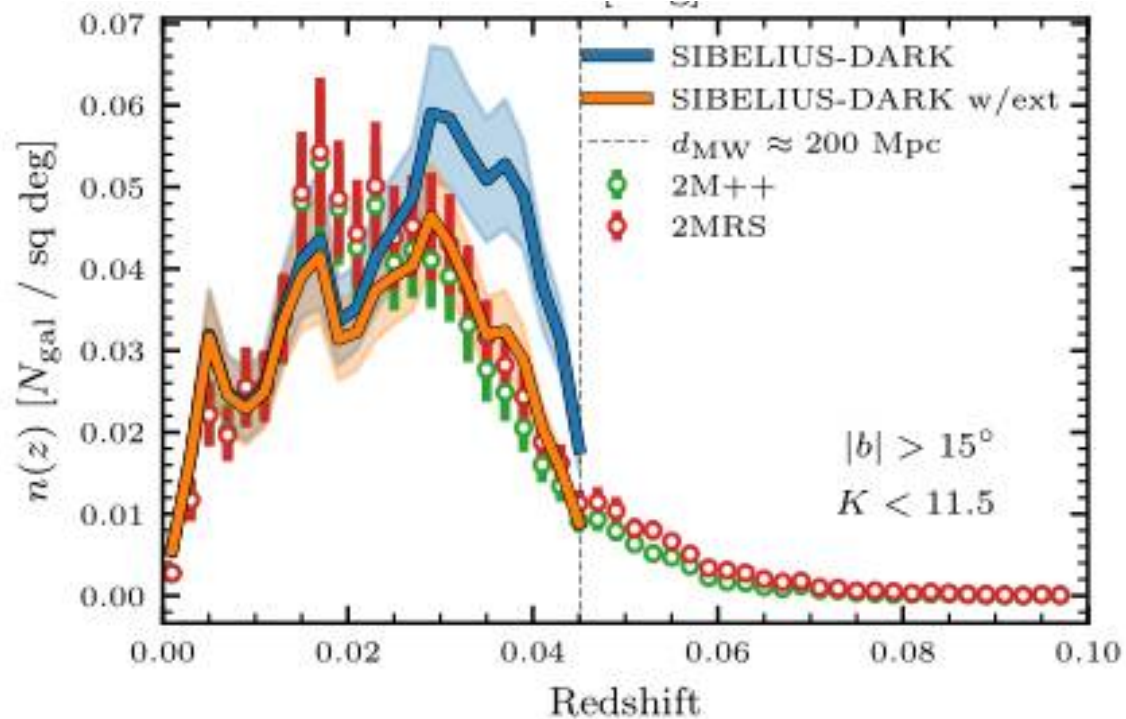
K-band luminosity function and stellar mass function

Black hole / Bulge mass

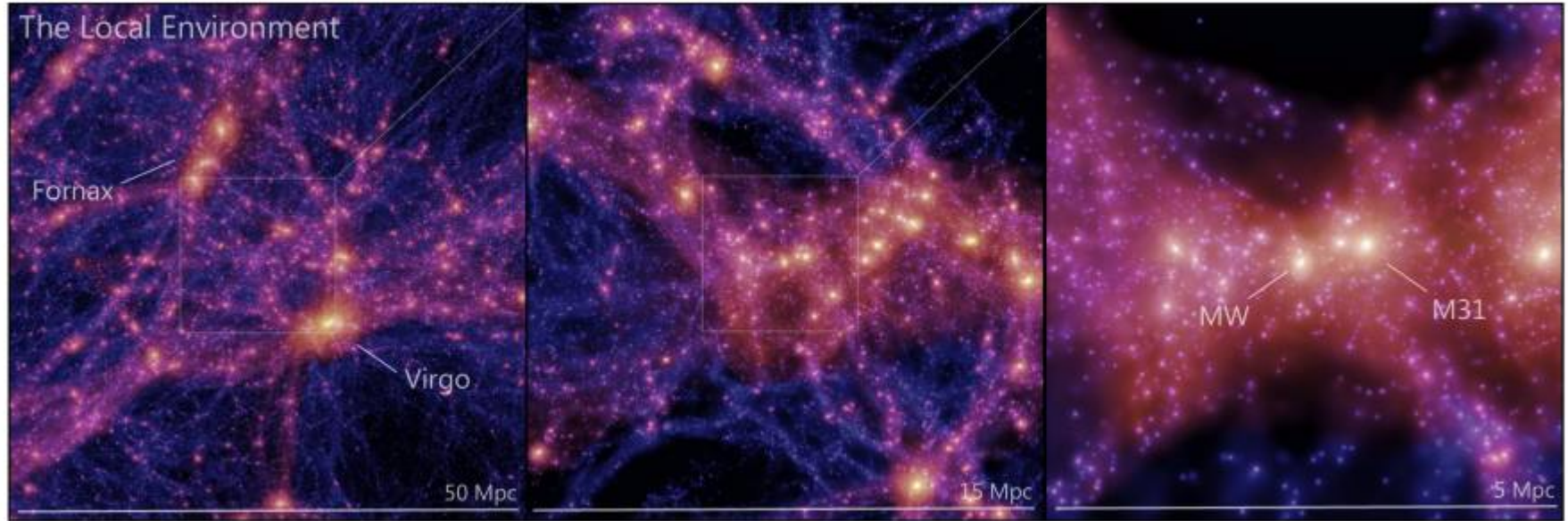
Apparent magnitude luminosity function is alright



Galaxy redshift selection



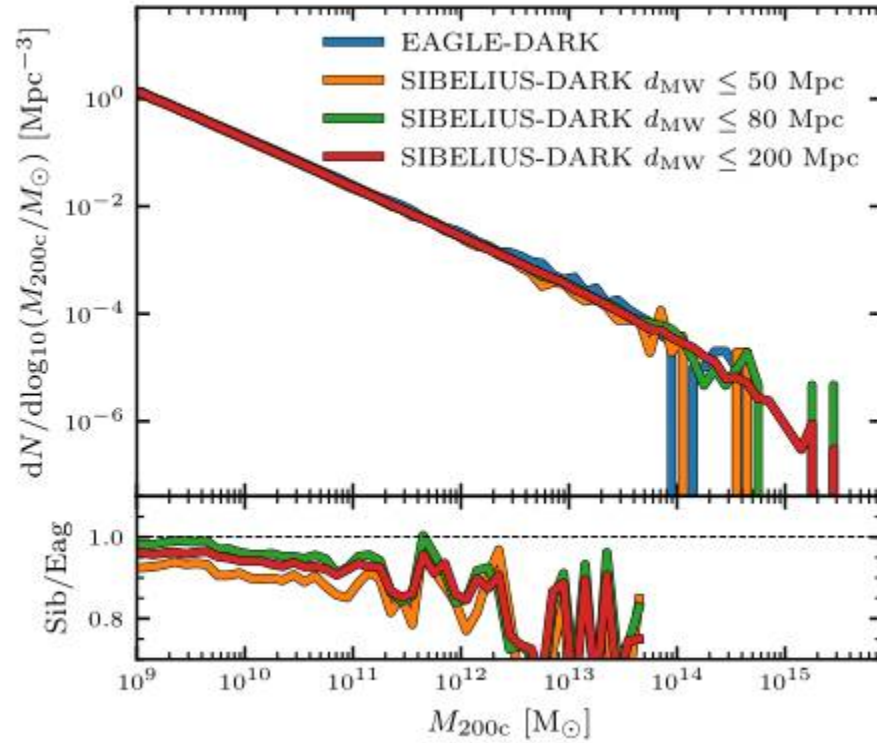
Milky way and M31





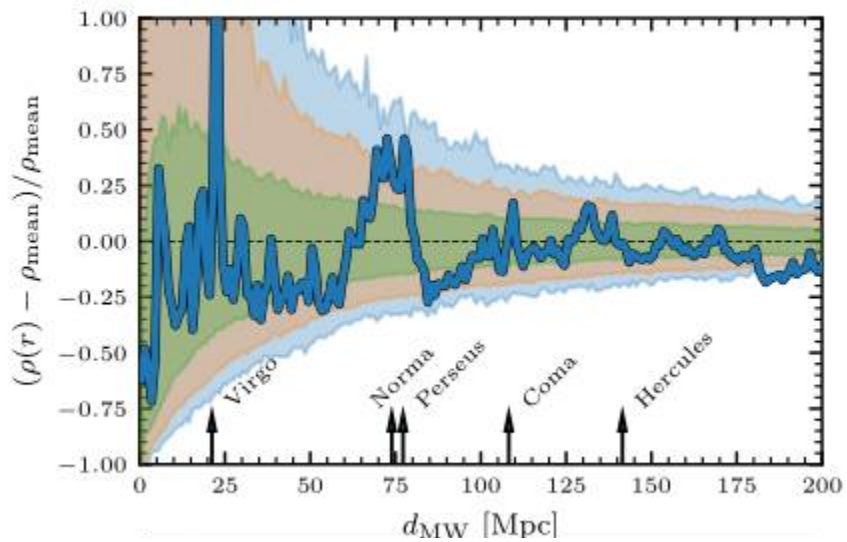
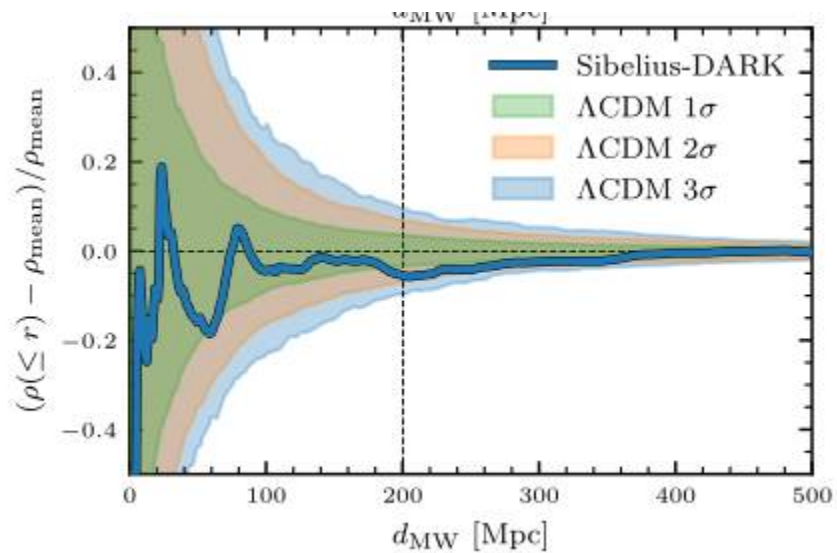
What about problems?

Halo mass function... not 100% there

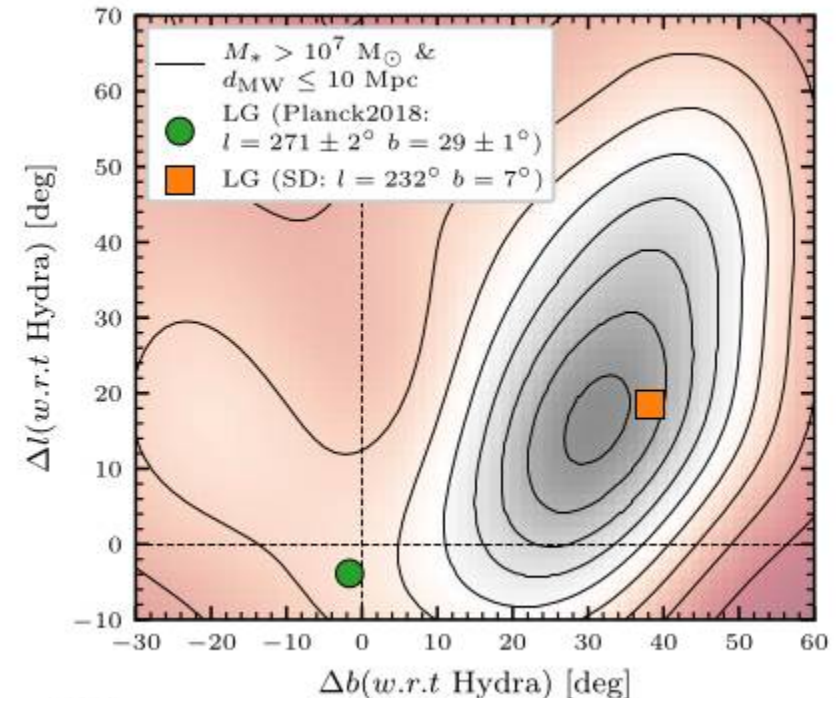
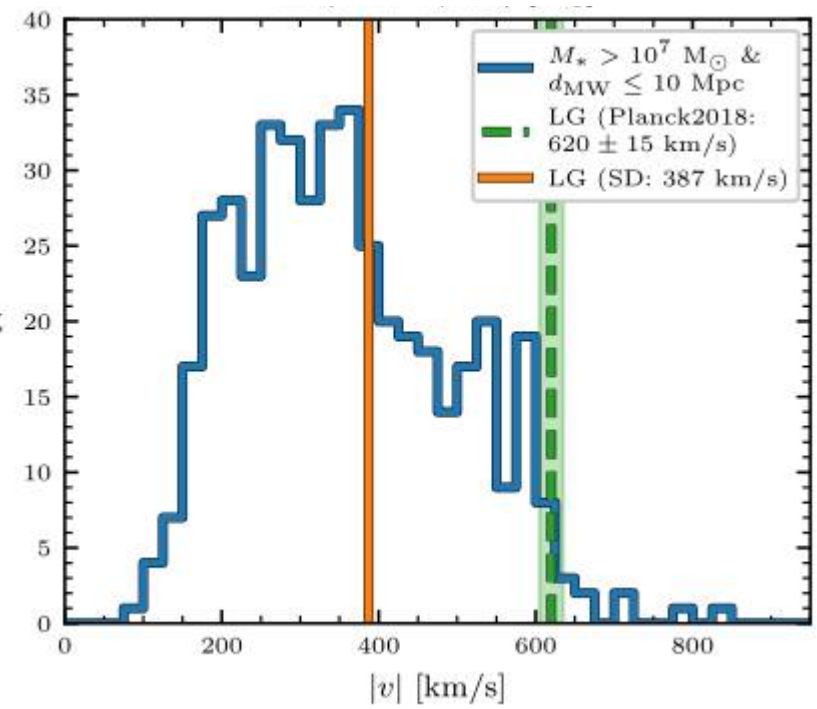




Local void ? Or not ?



Local group motion: something hidden in the IC





How to get the data



Login:

[Millennium](#)[EAGLE](#)[Request a new account](#)

Links

[COSMA](#)[COSMA usage](#)[ICC](#)

Welcome to VirgoDB

VirgoDB is a portal to all Virgo related data stored at the ICC, within Durham University. The access and usage comes with certain conditions, including the relevant acknowledgements. See specific databases for those conditions (usually given within a credits/acknowledgments section).

Millennium DB:

The Millennium public database contains dark matter halo properties and galaxy properties of a number of N-body simulations part of the Millennium suite of simulations performed by the Virgo Consortium and populated with galaxies properties using different methods (primarily semi-analytic galaxy formation models, but also statistical methods). It contains also a series of lightcones, constructed for specific surveys.

The Millennium DB, accessed via the VirgoDB, is only a partial mirror of a similar database, hosted by the Munich Virgo group: <http://gavo.mpa-garching.mpg.de/Millennium/>. The Munich Millennium DB does not contain all the latest GALFORM models or survey lightcones constructed by the Durham Virgo group, but contains more recent L-Galaxies models. The accounts between the two Millennium DB are not linked.

For more information: [Millennium DB](#)

EAGLE DB:

EAGLE (Evolution and Assembly of GaLaxies and their Environments) is a simulation aimed at understanding how galaxies form and evolve. The EAGLE public database contains galaxy properties (such as masses, star formation rates, luminosities and metallicities), merger histories and images for more than one million simulated galaxies spanning the whole observable redshift range in the EAGLE Universe!

For more information: [EAGLE project homepage](#)



Virgo - Millennium Database

Documentation

CREDITS/Acknowledgments

Registration

News

Public Databases

- ⊞ Alam2020a
- ⊞ Bower2006a
- ⊞ DGalaxies
- ⊞ DHaloTrees
- ⊞ FoF
- ⊞ FoFTrees
- ⊞ Gonzalez2014a
- ⊞ Grand2018a
- ⊞ Guo2013a
- ⊞ Henriques2012a
- ⊞ Henriques2015a
- ⊞ Lacey2016a
- ⊞ Lagos2012a
- ⊞ McAlpine2022a
 - Tables
 - Galaxy
 - Halo
- ⊞ MField
- ⊞ MillenniumII
- ⊞ millimil
- ⊞ mInIMIII
- ⊞ MMSnapshots
- ⊞ MPAGalaxies
- ⊞ MPAHaloTrees
- ⊞ MPAMocks
- ⊞ Smith2017a
- ⊞ Snapshots

Private (MvDB) Databases

Welcome Database User.

Streaming queries return unlimited number of rows in CSV format and are cancelled after 1800 seconds.

Browser queries return maximum of 1000 rows in HTML format and are cancelled after 90 seconds.

There is a partial mirror of this database in Munich at <http://gavo.mpa-garching.mpg.de/Millennium/>.

The Munich database does not contain all the latest GALFORM models but does contain more recent L-Galaxies models.

```
-- Select the quantities we want
SELECT halo.m200_crit ,
       gal.dist
FROM mcalpine2022a..halo as halo,
     mcalpine2022a..galaxy as gal
WHERE gal.hosthaloid = halo.hosthaloid
      AND gal.rank = 0 AND halo.m200_crit >= 1e9;
```

Query (stream)

Query (browser)

Help

Maximum number of rows to return to the query form:

Previous queries:

List of all queries executed sofar in this session. Selecting a query will make it appear in the query window.

The button will show all of them in a separate window. Refreshing that window will load the latest queries again.

-- Select the quantities we want SELECT halo.m200_crit , gal.dist FRO

Demo queries: click a button and the query will show in the query window.

Holding the mouse over the button will give a short explanation of the goal of the query. These queries are also available on this page.

Galaxies:

Lightcones:



Conclusion



- Sibelius-Dark recovers the spatial galaxy distribution from nearby Universe
- Optical properties are fairly simulated with Galform
- Reproduce a Gaia-compatible M31/MW pair at right place

- Cluster masses in general good agreement with other observables
- K-band/ stellar mass function still problematic

- Halo mass function biased at small masses
- Some defect for the local group velocity