

# Comparing L-GALAXIES, GALFORM and EAGLE

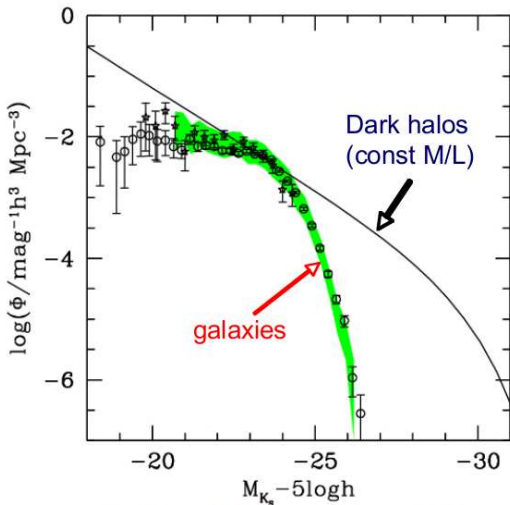
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@violegp

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**Michelle Furlong** (Durham), **Richard Bower** (Durham), **Shaun Cole** (Durham),  
**Rob Crain** (Liverpool), **Carlos Frenk** (Durham), **John Helly** (Durham),  
**Cedric Lacey** (Durham), **Claudia Lagos** (ICRAR), **Peter Mitchell** (Durham),  
**Joop Schaye** (Leiden), **Tom Theuns** (Durham),  
**Carlton Baugh** (Durham) and **Peder Norberg** (Durham)



# The processes that need modelling: gravity alone is not enough



Tom Theuns, <http://www.icc.dur.ac.uk/~tt/>

- If we assume a simple approach: There are more DM halos than galaxies at the faint and bright ends.
- Galaxy formation is an inefficient process!

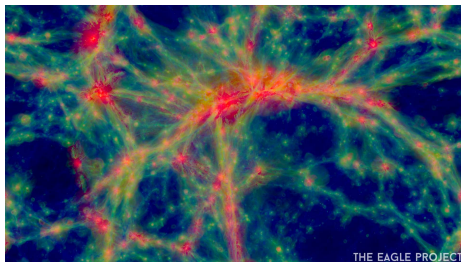
# The processes that need modelling: gravity alone is not enough



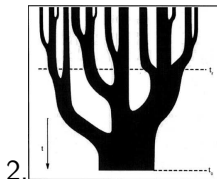
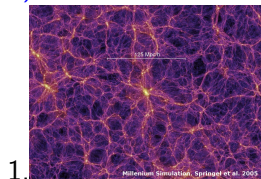
- If we assume a simple approach: There are more DM halos than galaxies at the faint and bright ends.
- Galaxy formation is an inefficient process!
- Galaxies are NOT shaped only by gravity. Gas physics, stellar formation and feedback, mergers, etc., also shape galaxies.

# How to proceed?

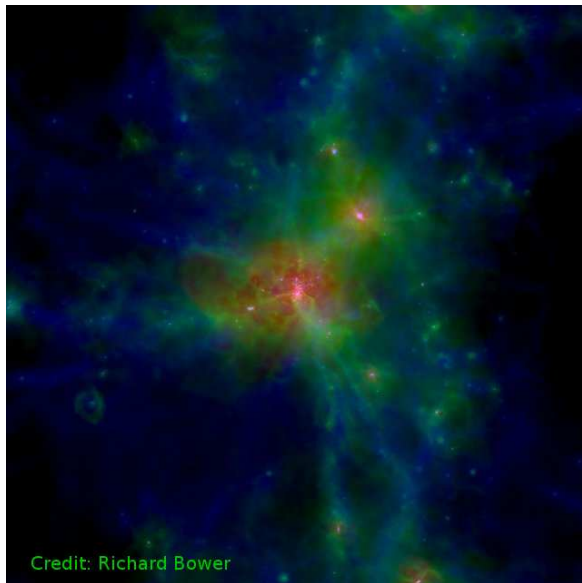
a) **In parallel:** hydrodynamical simulations



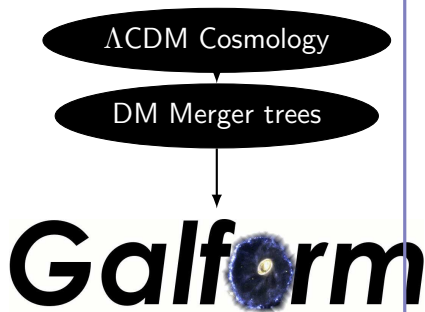
b) **In series:** SAMs, SHAMs, HOD modelling



# The EAGLE simulation



- Hydro simulation using GADGET-3 (SPH) + ANARCHY
- 100 Mpc box with a  $10^6 M_{\odot}$  gas mass resolution
- Planck cosmology



Using analytical equations, containing free parameters, GALFORM calculates the physical processes affecting the evolution of galaxies:

- Gas cooling  $\Rightarrow$  Disk formation
- Galaxy mergers  $\Rightarrow$  Spheroids
- SF\* & Feedback  
from both SNe & AGN
- Chemical Evolution
- Stellar population & Extinction

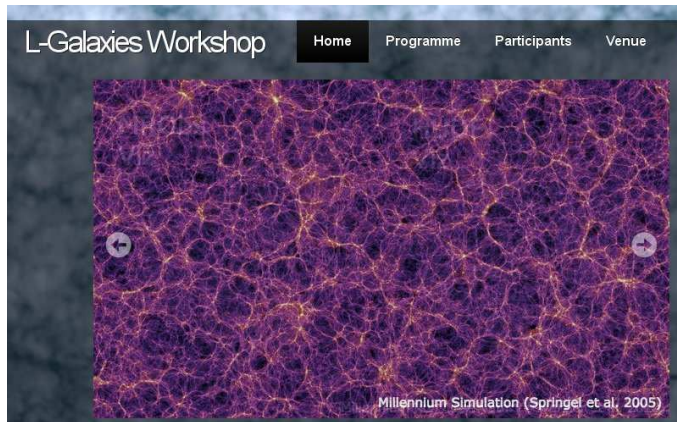
\* New improved treatment of SF in disks (Lagos et al. 2011) based on the empirical law from Blitz & Rosolowsky (2006), following explicitly the He, HI & H<sub>2</sub>:

$$\Sigma_{SFR} = \frac{1}{\tau_{mol. gas}} \times \frac{\Sigma_{mol. gas}}{\Sigma_{total gas}} (P_{hydrostatic} \text{ of the disk}) \times \Sigma_{cold gas}$$

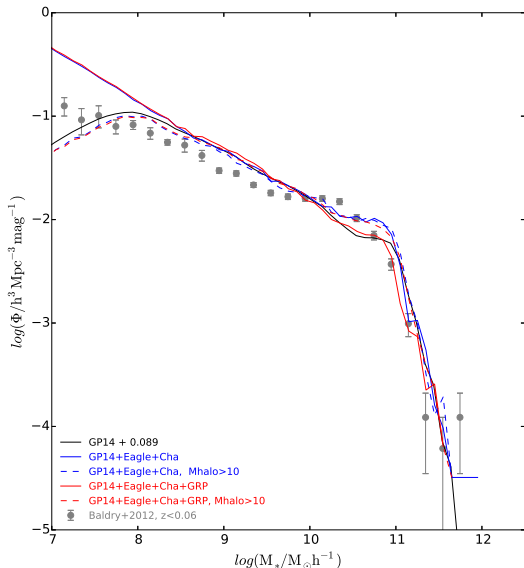
# The L-GALAXIES semi-analytical model

$\Lambda$ CDM Cosmology

DM Merger trees



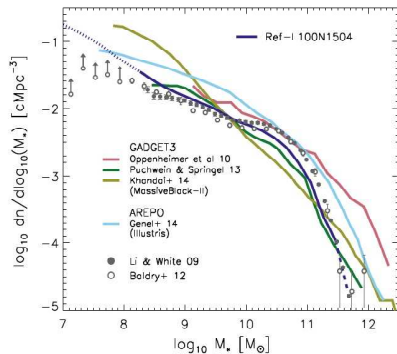
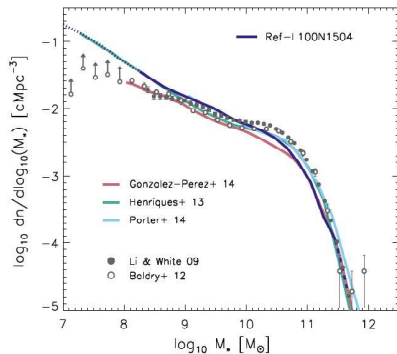
# The effect of changing the mass resolution



- MS-W7 haloes  $> 10^{10} M_\odot/h$
- EagleDM haloes  $> 10^8 M_\odot/h$

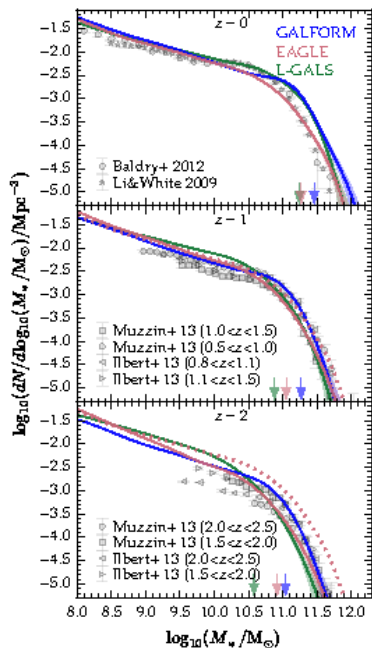
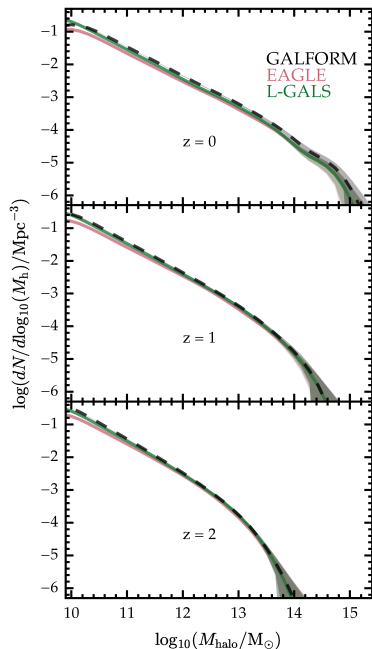


# Starting point: the stellar mass function

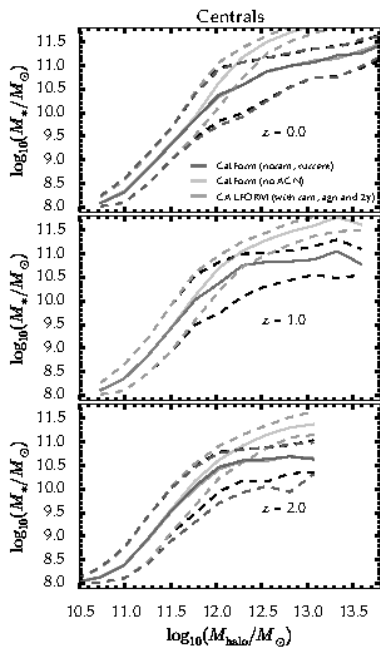
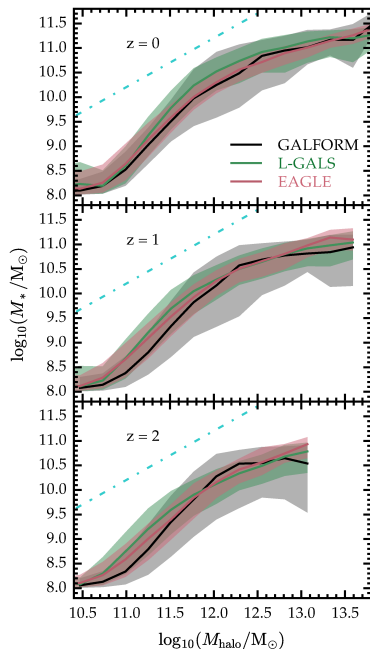


Schaye+15  
See also Somerville and Dave 2015

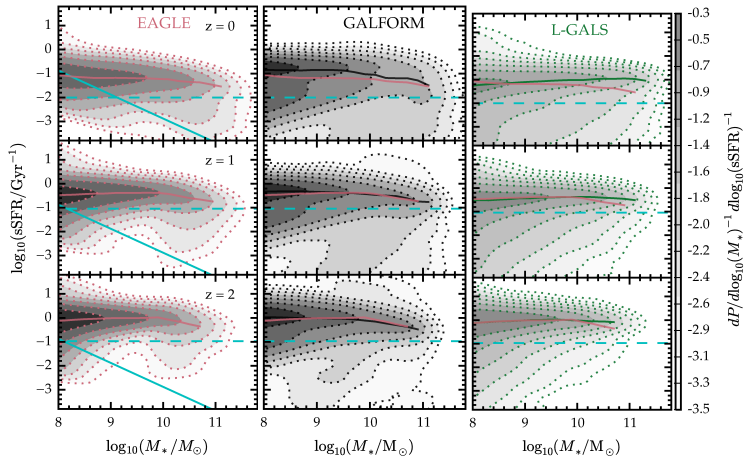
# Compared mass functions



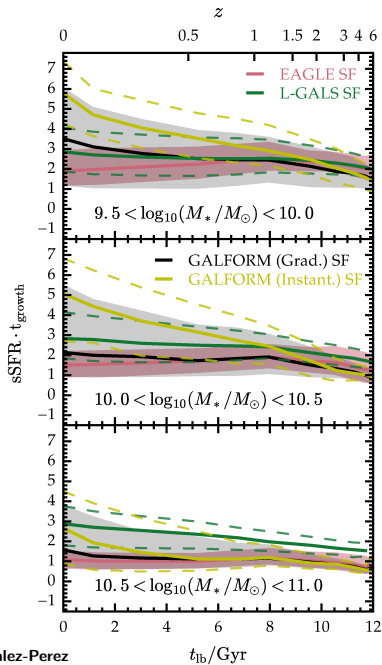
# The $M_* - M_{\text{halo}}$ relation



# The SF sequence from different models

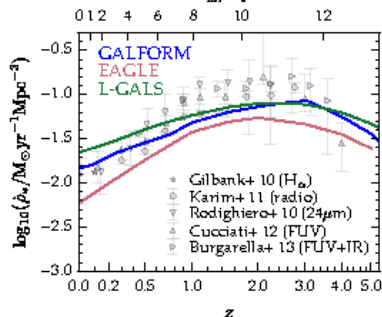


# The SFRD and sSFR evolution

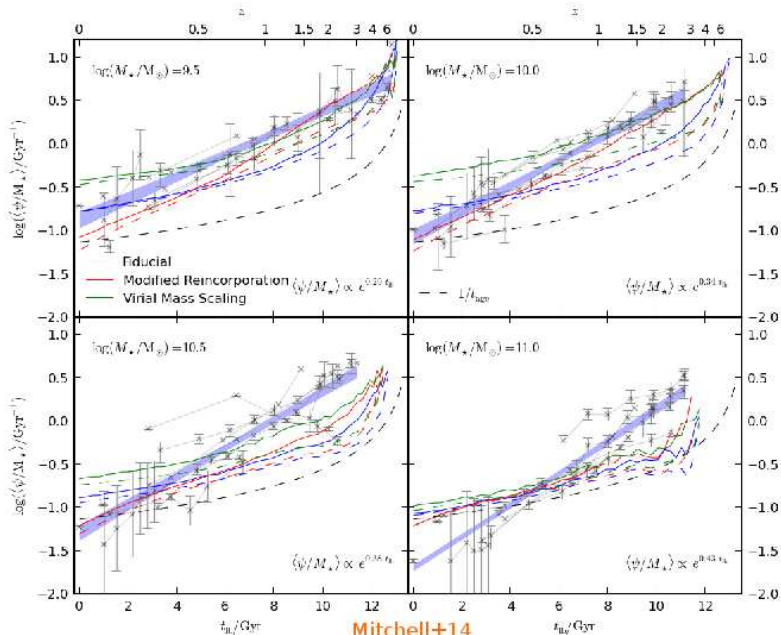


$$t_{\text{growth}}^{-1} (\text{Gyr}^{-1}) = \frac{dM/dt}{M(z)}$$

$$M(z) = M_0 \left(1 + \frac{z}{t_{lb}/\text{Gyr}}\right)^\alpha e^{\beta z}$$

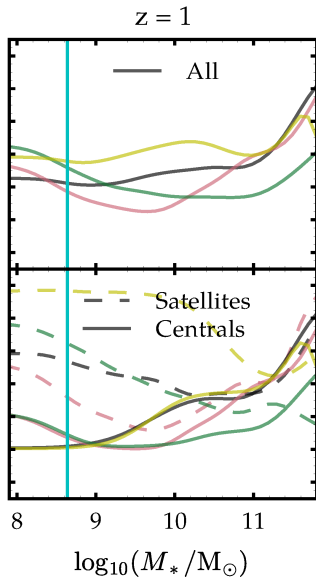
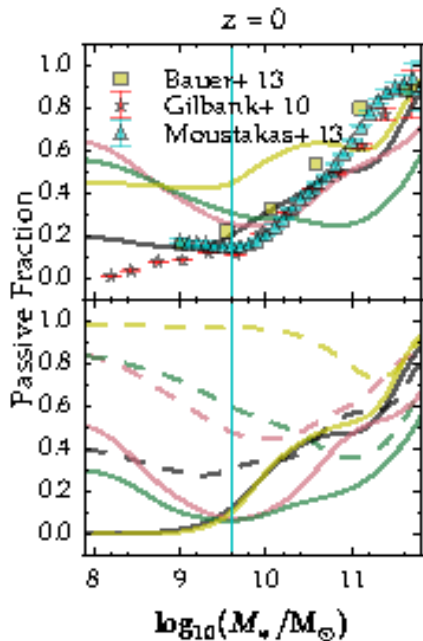


# The evolution of the sSFR compared with observations

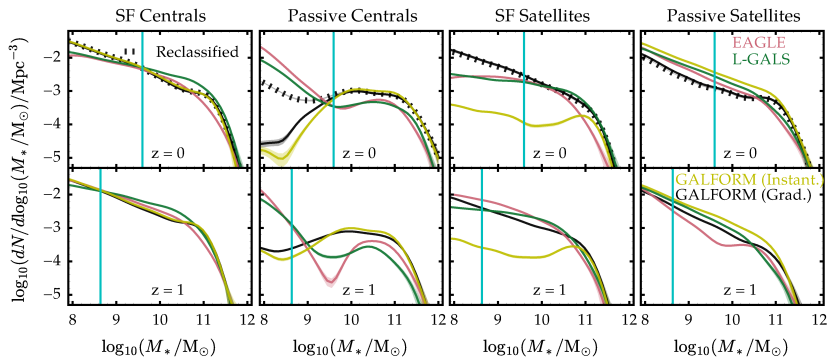


Mitchell+14

# The passive fractions

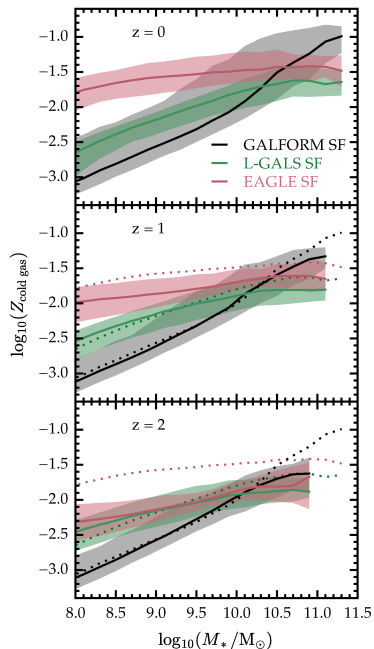
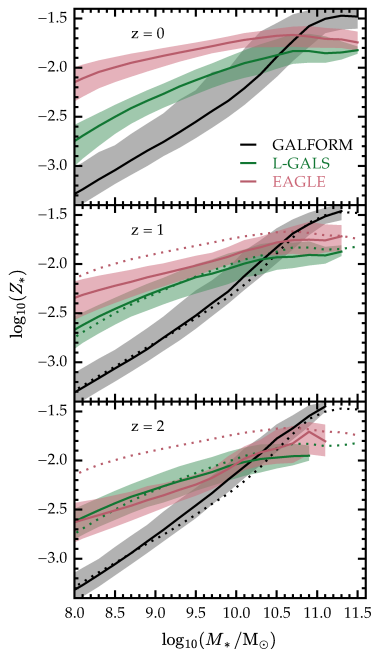


# The GSMF split in to passive and star-forming galaxies

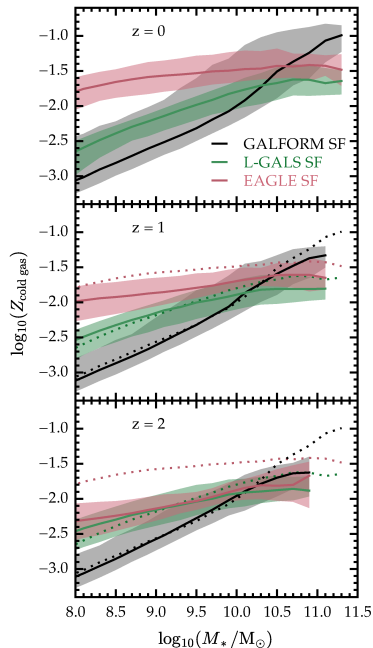
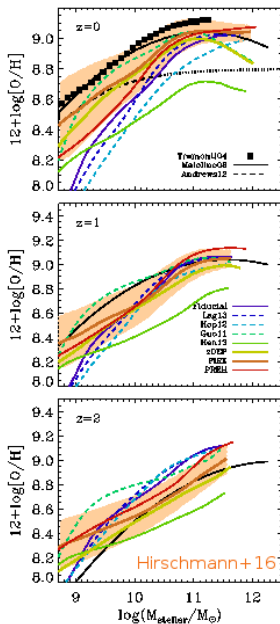


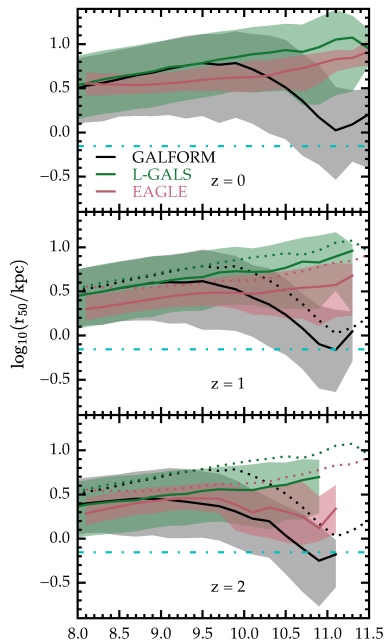
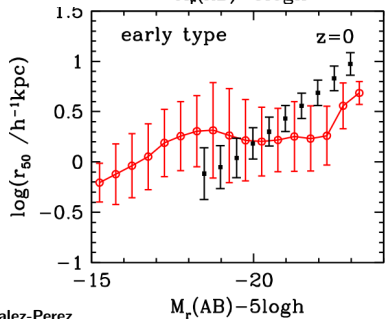
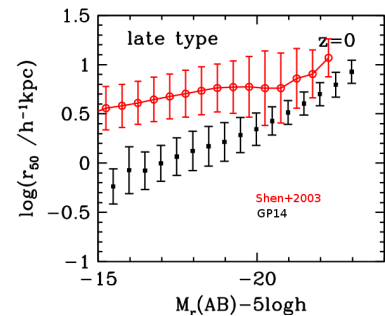


# Metallicity



# Metallicity





- The stellar mass assembly history closely follows that of the dark matter, which is not the case for observations.
- The GSMF and SF sequence in SAMs have very similar evolution to hydrodynamical simulations.
- The **modelling of sizes** needs a major improvement. The problem is: sizes affect everything!
- The observed mass-metallicity relation is not reproduced by models which points to a excessively crude **modelling of flows**.

Guo, Gonzalez-Perez et al., 2016.

# Use the Virgo-Millennium and EAGLE Data Bases:

## Virgo - Millennium Database

Documentation

CREDITS/Acknowledgments

Registration

News

Public Databases

- ⊞ Bower2006a
- ⊞ DESI\_v1
- ⊞ DGalaxies
- ⊞ EUCLID\_v1
- ⊞ FoF
- ⊞ FoFTrees
- ⊞ GAMA\_v1
- ⊞ Gonzalez2014a
- ⊞ Lagos2012a
- ⊞ MField
- ⊞ millimil
- ⊞ MMSnapshots
- ⊞ MPAGalaxies
- ⊞ MPAHaloTrees
- ⊞ MPAMocks
- ⊞ Snapshots

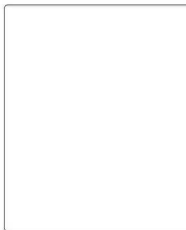
Private (MyDB) Databases

- ⊞ Eagle (r)
- ⊞ violeta\_db (rw) (context)



<http://virgo.dur.ac.uk>

Welcome Violeta Gonzales.  
Streaming queries return uncancelled after 1800 seconds.  
Browser queries return maxii after 90 seconds.



Maximum number of rows to

**Demo queries:** click a button  
Holding the mouse over the I  
query. These queries are als

### EAGLE Database

Documentation 9) | CREDITS/Acknowledgments 10)

Public Databases

- ⊞ Eagle
  - ⊞ Tables
    - AGN079L005N0752\_Aperture
    - AGN079L005N0752\_FOF
    - AGN079L005N0752\_Magnitudes
    - AGN079L005N0752\_Sizes
    - AGN079L005N0752\_Subhalo
    - Rec0L0025N0752\_Aperture
    - Rec0L0025N0752\_FOF
    - Rec0L0025N0752\_Magnitudes
    - Rec0L0025N0752\_Sizes
    - Rec0L0025N0752\_Subhalo
    - RefL0025N0752\_Aperture
    - RefL0025N0752\_FOF
    - RefL0025N0752\_Magnitudes
    - RefL0025N0752\_Sizes
    - RefL0025N0752\_Subhalo
    - RefL005N0752\_Aperture
    - RefL005N0752\_FOF
    - RefL005N0752\_Magnitudes
    - RefL005N0752\_Sizes
    - RefL005N0752\_Subhalo
    - RefL005N0752\_Aperture
    - RefL005N0752\_FOF
    - RefL005N0752\_Magnitudes
    - RefL005N0752\_Sizes
    - RefL005N0752\_Subhalo
    - RefL100N1504\_Aperture
    - RefL100N1504\_FOF
    - RefL100N1504\_Magnitudes
    - RefL100N1504\_Sizes
    - RefL100N1504\_Subhalo
    - Snapshots

6) Available Simulations

1) Query area

```

SELECT
  VmAbsZ as r_max, -- The two variables we
  W as v_max      -- want to extract
FROM
  RefL100N1504_Subhalo -- The simulation
WHERE
  Snapshot = 28        -- The snapshot
  
```

2) Execute query

Query (present)

Query (previous)

Help

Maximum number of rows to return to the query form:

Previous queries

List of all queries executed earlier 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 this window will load the latest queries again.

SELECT VmAbsZ as r\_max, -- The two variables we VmAbsZ as v\_max

3) Show All

4)

Demo queries: click a button and the query will show in the query window. Holding the mouse over the buttons will give a short explanation of the goal of the query. These queries are also available on this page.

5) Demo queries

Subhalo:

Sizes:

Magnitudes:

McAlpine+2015

Metadata queries: The SQL statements under these buttons provide examples for querying and managing the state of a private database. Holding the mouse over the button will give a short explanation of the goal of the statement.

<http://www.eaglesim.org/database.html>