PART III

The Universe in the Cloud

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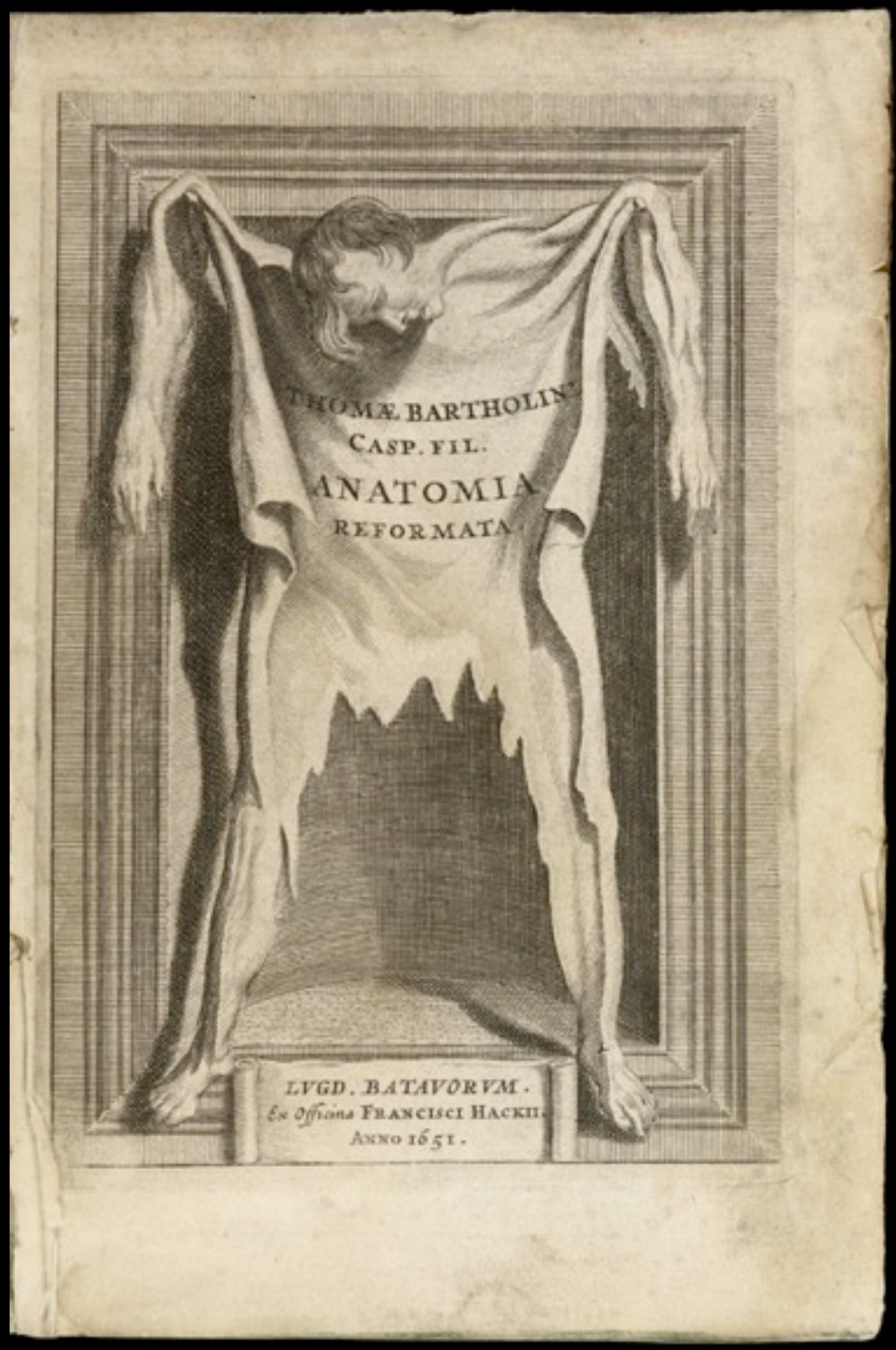
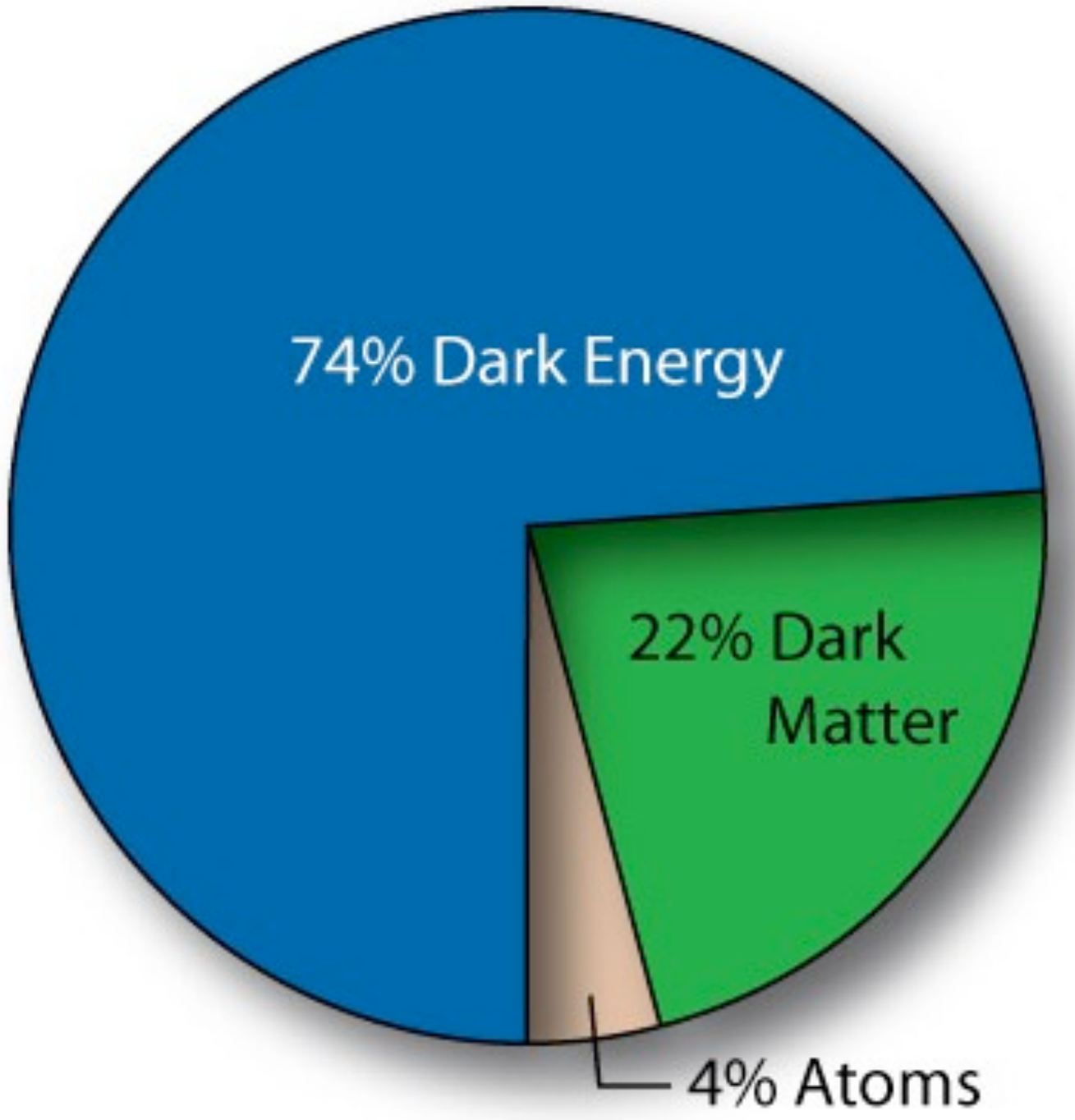
Let's recap...

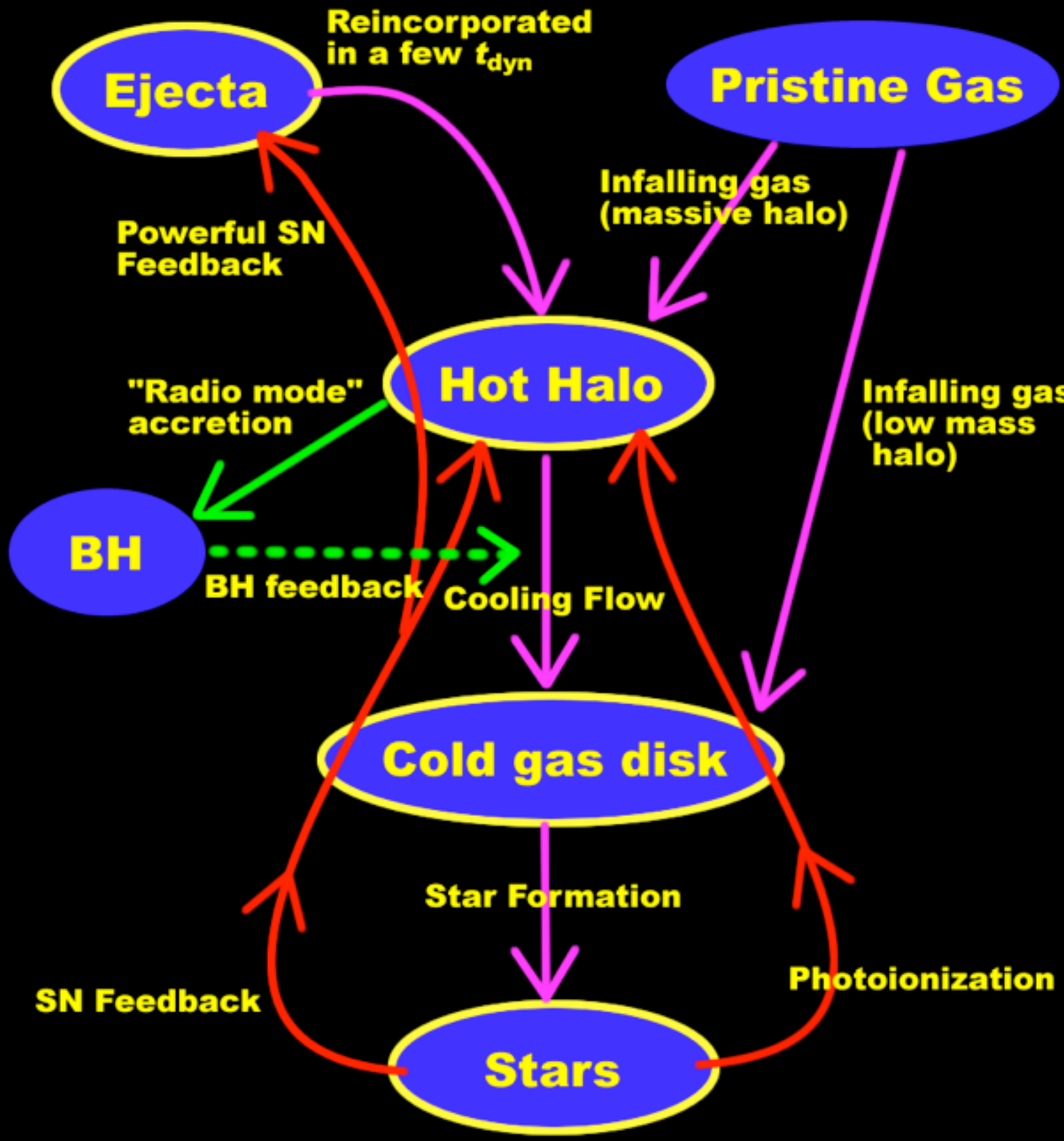
The skeleton



The flesh


74% Dark Energy
22% Dark Matter
4% Atoms


Gordon



- Schmidt law star formation
- SFR dependent SN winds
- satellite gas stripping
- morphological transformation
- assembly through mergers
- starbursts through mergers
- Magorrian relation BH growth
- jet & bubble AGN feedback

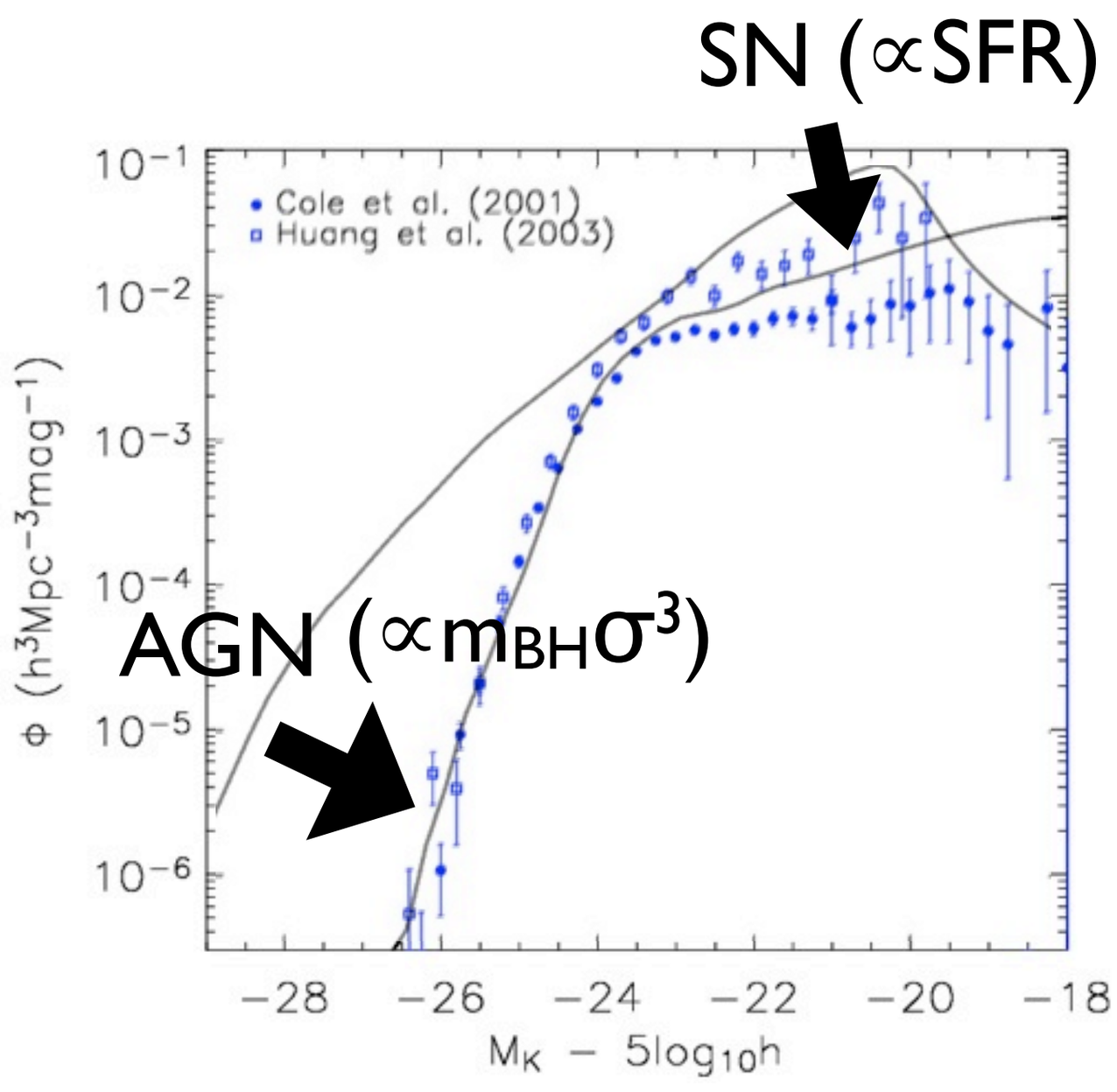
Croton et al. 2006

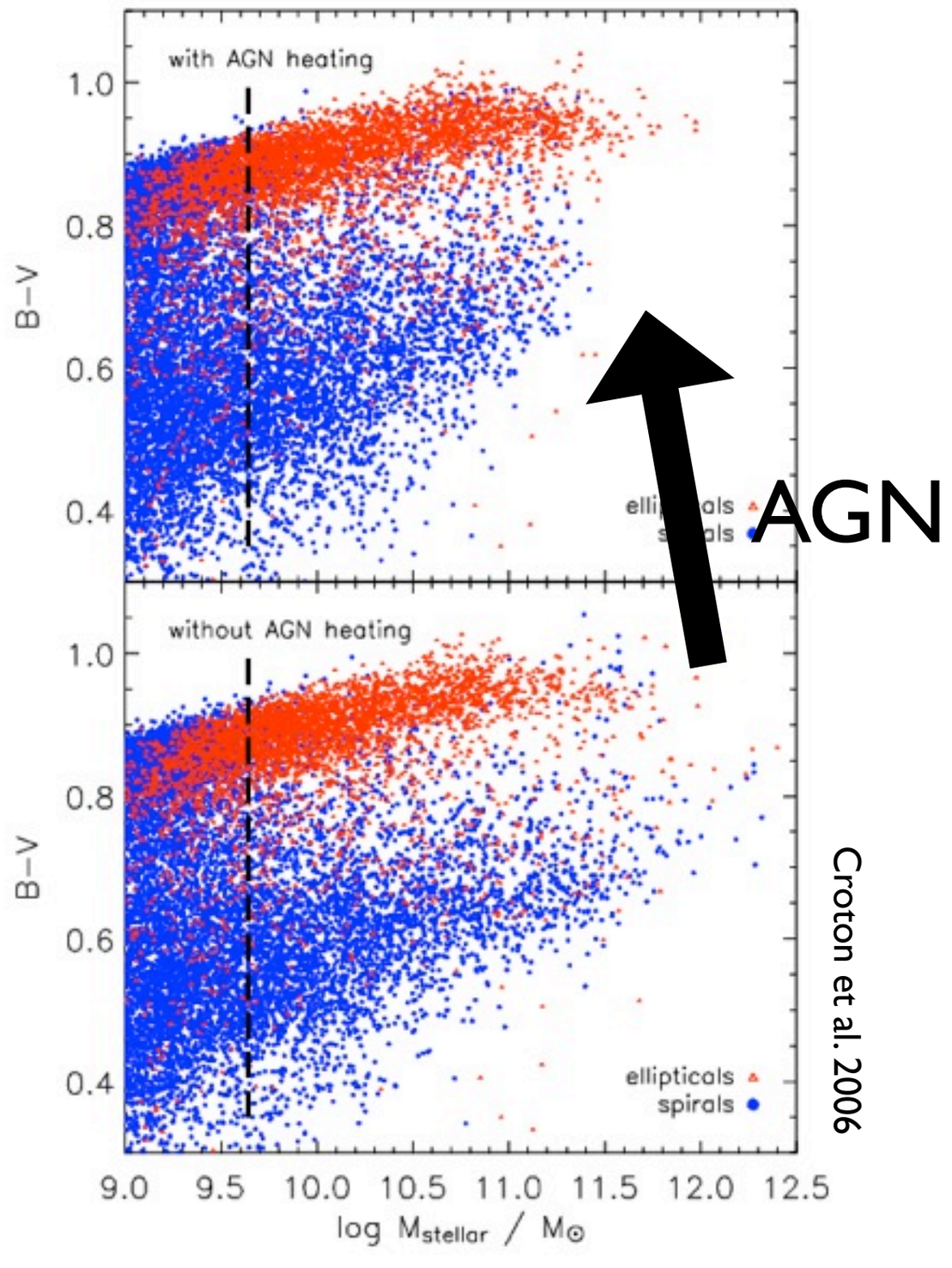
z=0 dark matter

125 Mpc/h

z=0 galaxy light

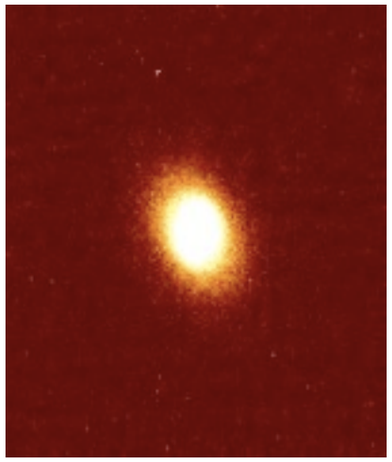
Physical consequences

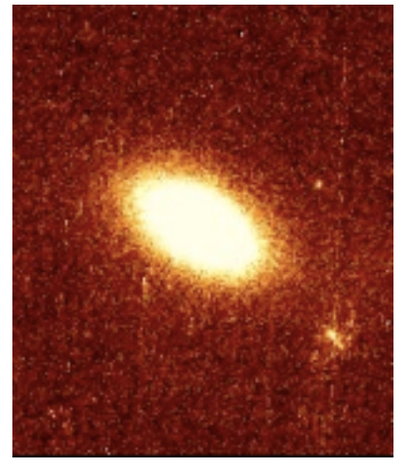




Our model is only as good as the questions we ask

For systems with infinite levels of complexity, our model can never be “correct”





Croton et al. 2005

2dFGRS

late types
early types

cluster (δ_8>6.0)

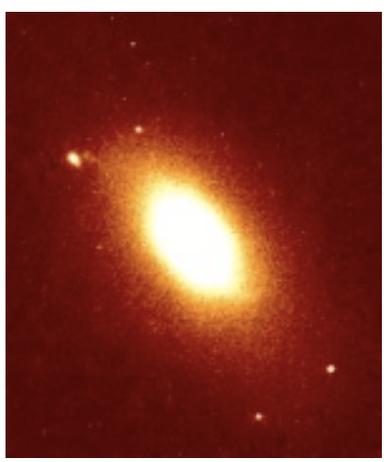
void (δ_8<−0.75)

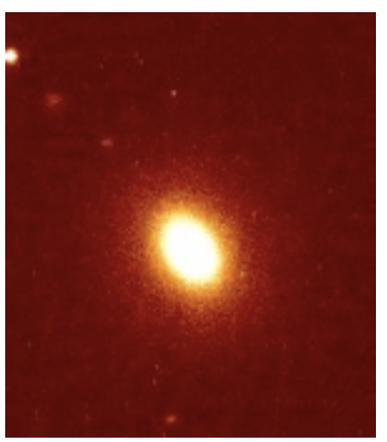
Φ (h^3Mpc^{-3} mag^{-1})

10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}

−17 −18 −19 −20 −21 −22

$M_{bJ} - 5\log_{10}h$



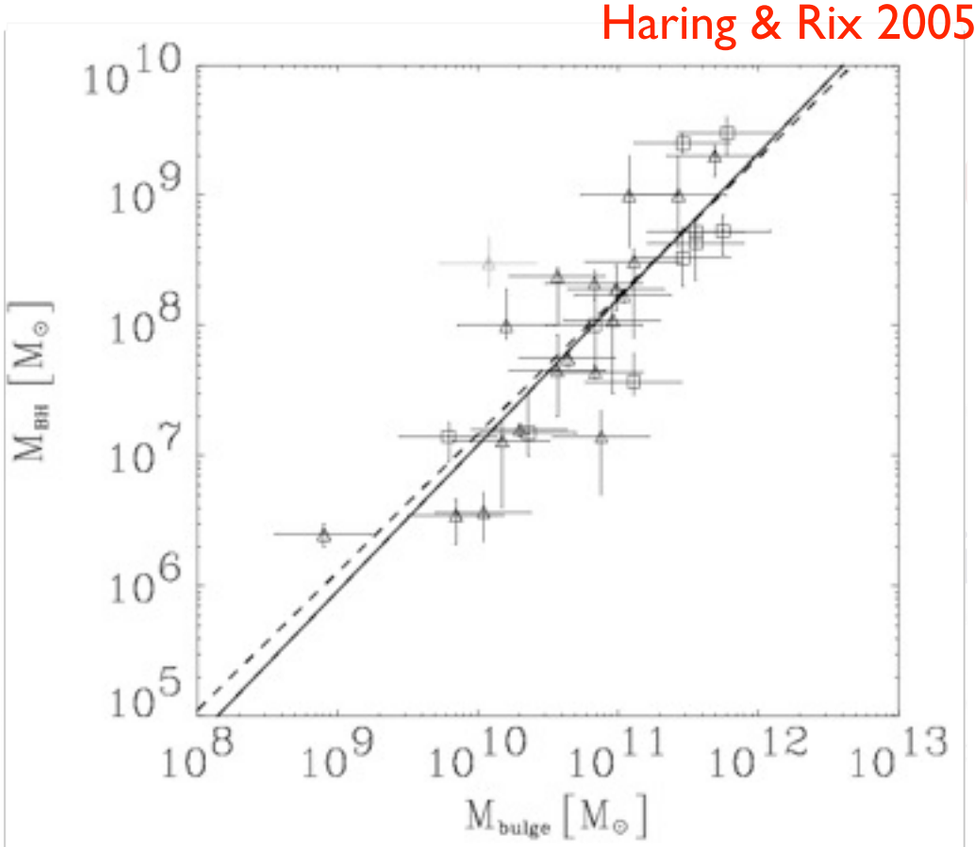


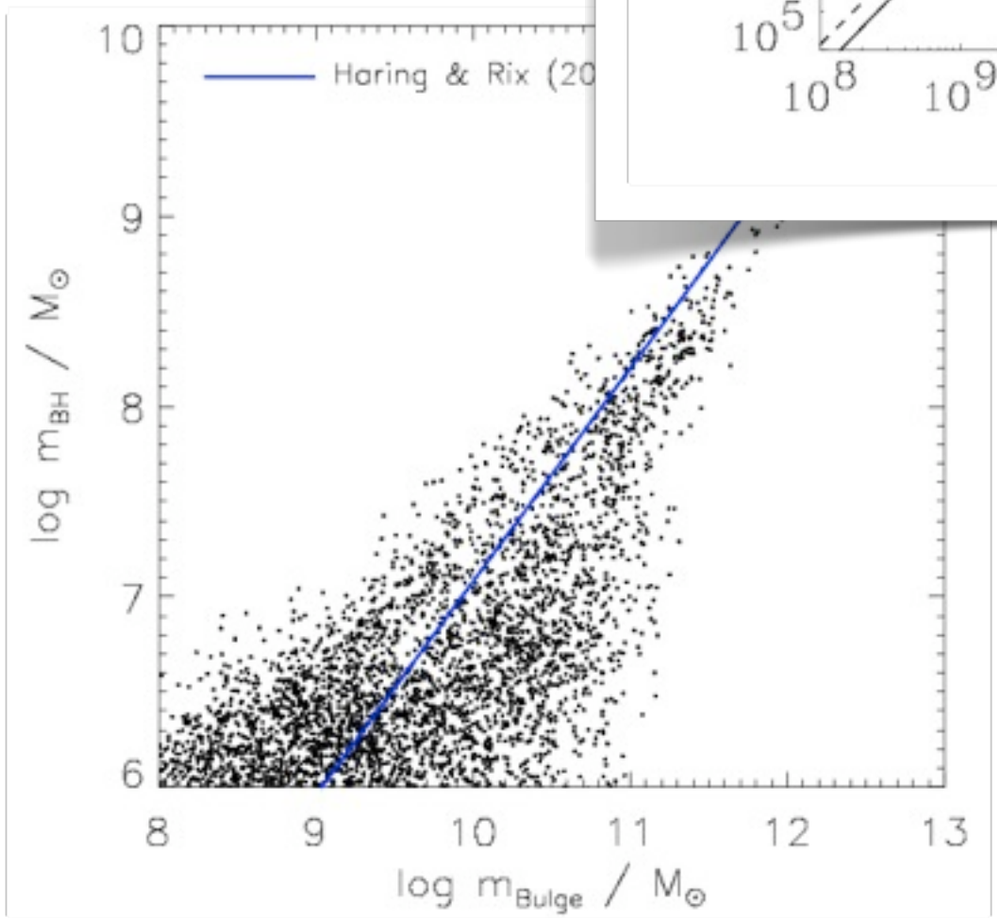
bl ge

merger driven

t instability
ven growth

Haring & Rix 2005





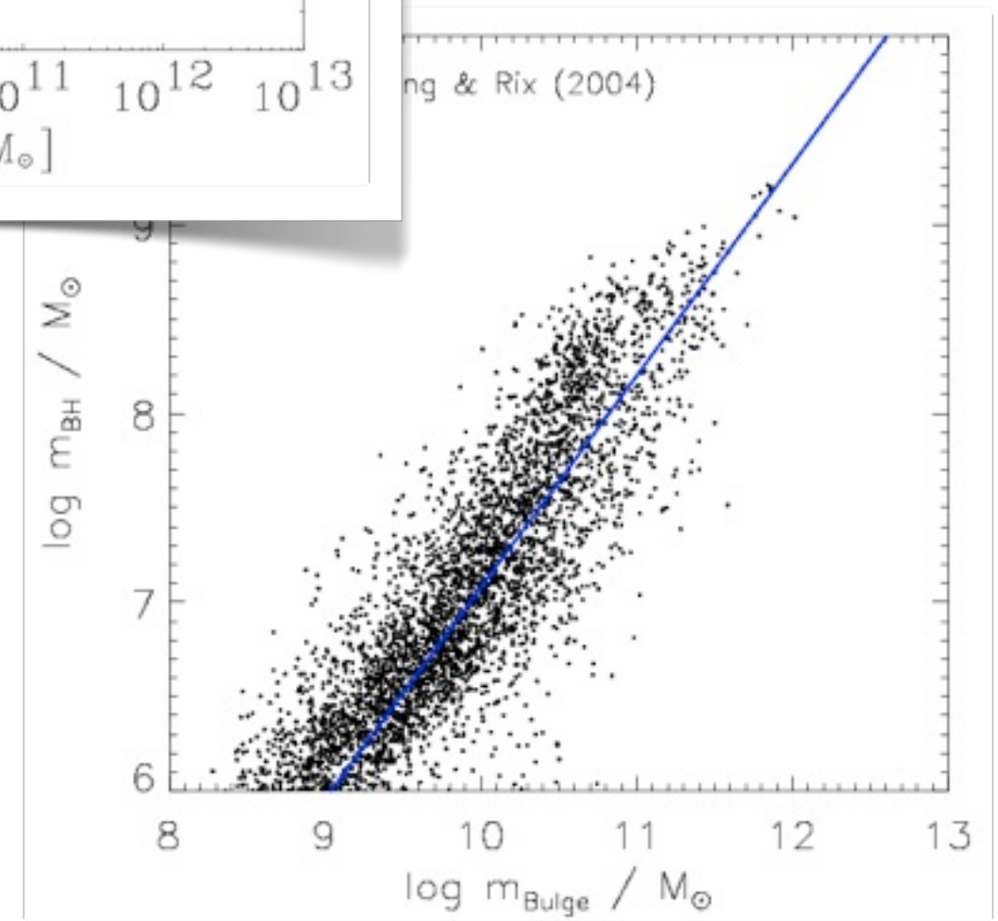


Table 1. A summary of our main model parameters and their best values and plausible ranges, as described in the text. Once set, these values are kept fixed for all results presented in this paper, in particular for models in which AGN feedback is switched off.

Parameter	Description	Best value	Plausible range
$f_{\rm b}$	Cosmic baryon fraction (Section 3.3)	0.17	fixed
z_0, $z_{\rm r}$	Redshift of reionization (Section 3.3)	8, 7	fixed
$f_{\rm BH}$	Merger cold gas BH accretion fraction (Section 3.4.1)	0.03	002–004
$\kappa_{\rm AGN}$	Quiescent hot gas BH accretion rate ($M_\odot\ yr^{-1}$) (Section 3.4.2)	6×10^{-6}	$(4–8) \times 10^{-6}$
$\alpha_{\rm SF}$	Star formation efficiency (Section 3.5)	0.07	005–015
$\epsilon_{\rm disc}$	SN feedback disc reheating efficiency (Section 3.6)	3.5	1–5
$\epsilon_{\rm halo}$	SN feedback halo ejection efficiency (Section 3.6)	0.35	01–05
$\gamma_{\rm ej}$	Ejected gas reincorporation efficiency (Section 3.6)	0.5	01–10
$T_{\rm merger}$	Major merger mass ratio threshold (Section 3.7)	0.3	02–04
R	Instantaneous recycled fraction of SF to the cold disc (Section 3.9)	0.3	02–04
Y	Yield of metals produced per unit SF (Section 3.9)	0.03	002–004

Croton et al. 2006, 2012 (in prep.)

The *exact* values of the parameter choices are (mostly) meaningless

WHAT’S IMPORTANT?

THE QUESTIONS WE ASK!

Questions ...

- What do most astronomers want from mock galaxy catalogues?
- How do they want to access this data?

Questions ...

- Most astronomers I work with don't want to have to learn a new language to download simulated data
- Most are only interested in data access, they want to process it themselves

Stepping stone ...

Put the code behind a curtain and allow people to access and use it remotely via the “cloud”

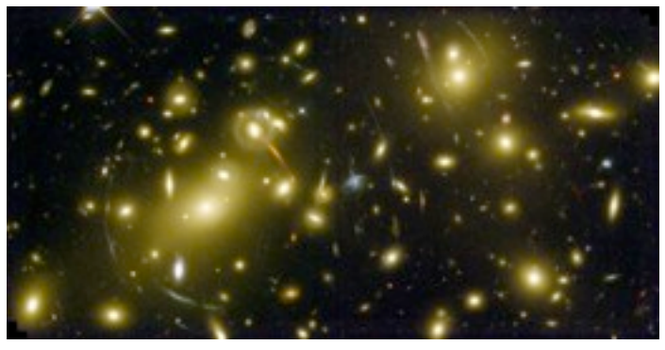
Max
Bernyk

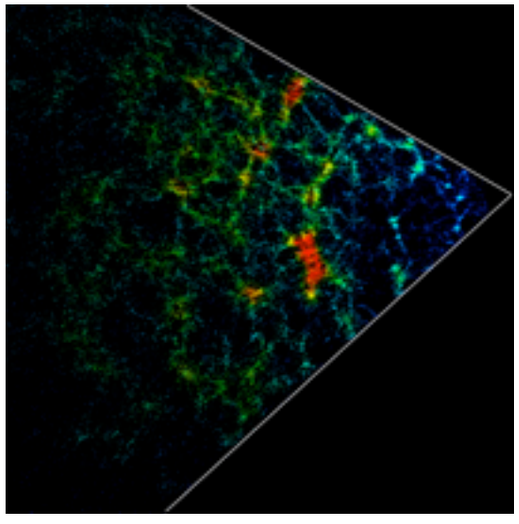
Simon
Mutch

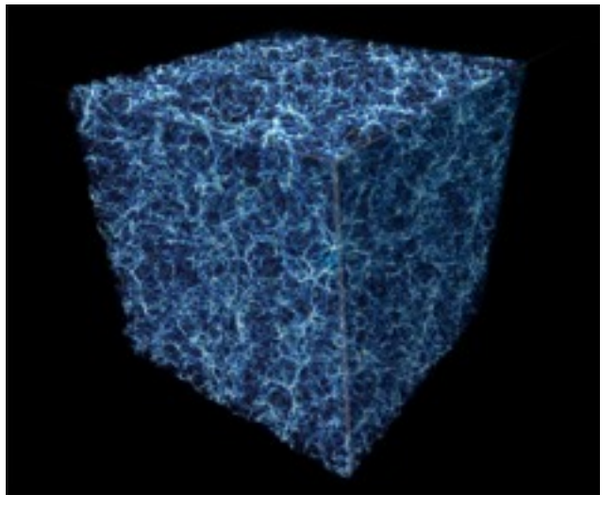
Theoretical Astrophysical Observatory

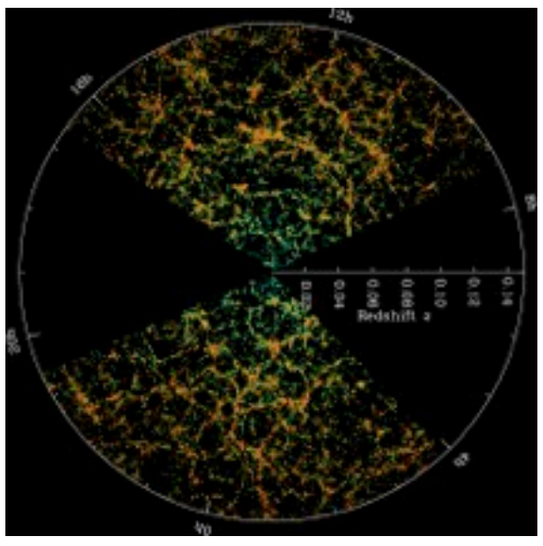
Centre for Astrophysics and Supercomputing - Swinburne University of Technology

Bernyk, Croton et al. 2012 (in prep.)








Redshift z

Astronomy Australia Limited

HPC Working Group Report: Priority 1...

Australia needs to build an astronomical data fabric that links ... data flowing from telescopes like SkyMapper, ASKAP and MWA.

Astronomy Decadal Plan

Mid-Term Review: Priority 5...

Investment at a national level in eResearch-related hardware and software systems ... is needed if we are to fully exploit the coming data tsunami from the current and upcoming telescopes and instruments.


There is a data
tsunami coming

ASKAP
+Pawsey

SkyMapper
+NCI

https://www.nectar.org.au/all-sky-virtual-observatory

nectar

connecting • sharing • collaborating

The All Sky Virtual Observatory

What is the All-Sky Virtual Observatory

New telescopes and facilities coming online in the next three to five years will produce data in volumes never previously experienced in Australian astronomy. To gain maximum scientific benefit from this data flood, the federation of datasets from all types of astronomical facilities in Australia will be needed. This will involve creating the hardware, tools and services to bring together data from radio telescopes, optical telescopes and supercomputers, covering all parts of the southern sky, under a Virtual Observatory.

After extensive consultation with the entire astronomy community, two Australian astronomical facilities were chosen to form the first pillar of the All-Sky Virtual Observatory:

The primary observational dataset will come from the SkyMapper facility, an optical telescope located at Siding Spring Observatory, NSW, built by the Australian National University. SkyMapper is producing the most detailed and sensitive digitized map of the southern sky at optical wavelengths. This nationally significant dataset will be a fundamental reference for astronomers in Australia, and internationally, for many decades.

The Theoretical Astrophysical Observatory (TAO), being developed at Swinburne University of Technology, will house the growing ensemble of Australian theory data sets and galaxy formation models, with value-add tools that will allow astronomers to observe each virtual universe as if it was real. This will be achieved by mapping the simulated data onto an observer's viewpoint and the application of custom telescope simulators, beginning with SkyMapper. TAO provides a direct and vital link between the theoretical and observational aspects of data collection and analysis.

Who is Astronomy Australia?

Astronomy Australia Ltd (AAL) is a not-for-profit company whose members are all the Australian universities and research organisations with a significant astronomical research capability.

Our vision is that astronomers in Australia will have access to the best astronomical research infrastructure. AAL will achieve its

VLs in project negotiation

The All Sky Virtual Observatory

Climate and Weather Science Laboratory

Humanities Networked Infrastructure (HuNI) unlocking and uniting Australia's cultural data

The Genomics Virtual Laboratory

The Characterisation Virtual Laboratory: research environments for exploring inner space

Early Activities

CSIRO - Virtual Geophysics Laboratory

University of Queensland - Virtual Genomics Laboratory

University of Tasmania - Marine Virtual Laboratory

Latest News ...

NeCTAR
ASVO-TAO
“virtual laboratory”

Telescope simulator

Image generation

Light cone generation

Real time,
arbitrary parameters

Almost complete
(Maraston’05, others soon)

SEDs + Filters

Web form data query

Simple (no SQL!)

Millennium, Bolshoi, GiggleZ
plus models: SAGE, others

Simulation database

http://tao.it.swin.edu.au/mock-galaxy-factory/ — Mock Galaxy Factory

Theoretical Astrophysical Observatory

Centre for Astrophysics and Supercomputing - Swinburne University of Technology

About | Group | Surveys and Simulations | Mock Galaxy Factory | TAO Labs

Mock Galaxy Factory

▼ General

Catalogue Type: Simulation Box

Simulation: Millennium Mini

Galaxy Model: Croton et al 2006

▼ Parameters

Filter:

min:

max:

Z (snapshot): 0

Box size (Mpc): 30

▼ Output properties

▼ Core properties

▼ Halo properties

- Central halo Mvir
- Halo Mvir
- Halo Vvir
- Halo Rvir
- Halo velocity dispersion

▶ Intrinsic galaxy properties

▶ Absolute luminosities

select all / deselect all

▼ Miscellaneous

Output format: HDF5

Email results to:

Submit

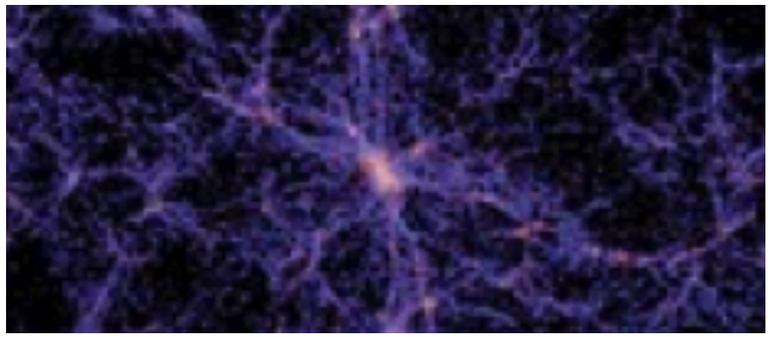
▼ Selected simulation details

- **Mini Millennium**
Paper: Springel et al. 2005
External link: http://www.mpa-garching.mpg.de/galform/millennium/
Cosmology: WMAP-1
Cosmological parameters: Ωm = 0.25, Ωb = 0.045, h = 0.73, ΩΛ = 0.75, n = 1, σ8 = 0.9
Box size: 62.5Mpc

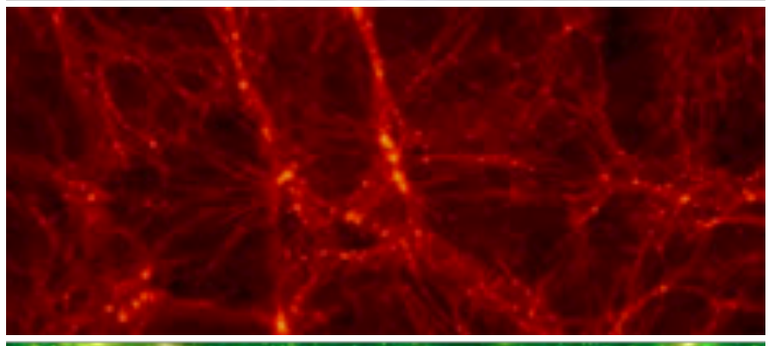
▼ Selected galaxy model details

- **Croton et al. 2006**
Kind: semi-analytic model
Paper: Croton et al. 2006

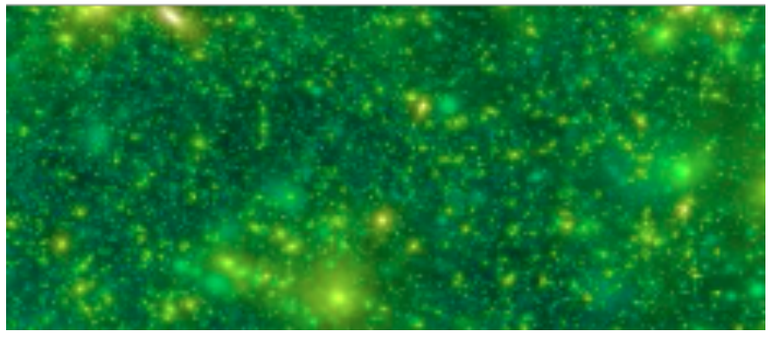
Millennium (Springel et al. 2005)

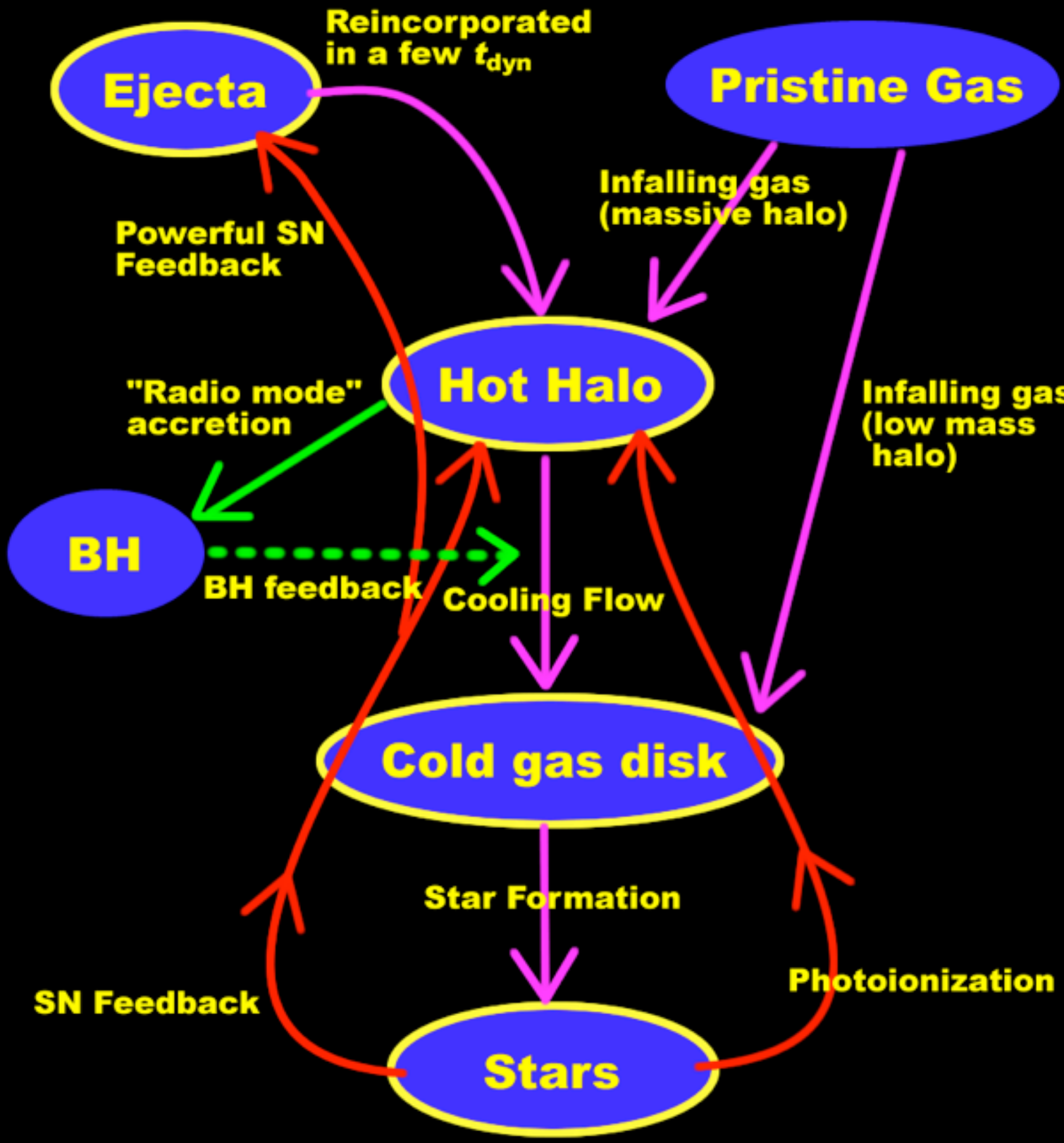


Bolshoi (Klypin et al. 2010)



GiggleZ (Poole et al. in prep.)





- Schmidt law star formation
- SFR dependent SN winds
- satellite gas stripping
- morphological transformation
- assembly through mergers
- starbursts through mergers
- Magorrian relation BH growth
- jet & bubble AGN feedback

From: **tao.it.swin.edu.au** tao_support@astro.swin.edu.au
Subject: Job submitted
Date: 3 February 2011 1:45 PM
To: Darren Croton dcroton@astro.swin.edu.au

Dear dcroton@astro.swin.edu.au,

Your job was successfully submitted. The details are below. Expect another email from us when the job completes with a link to the data.

All the best,
tao.it.swin.edu.au

Job details:
Simulation: Full Millennium
Galaxy model: Croton 2006
Catalogue type: simulation box
Redshift of the snapshot = 0.12
Box size = 100 Mpc
Filter = Black Hole Mass
Filter max = 1.0
Filter min = 0.0001
Include properties: X, Y, Z, Halo Mvir, Halo Velocity Dispersion, B Mag, Stellar Mass, Bulge Mass, Black Hole Mass.

From: **tao.it.swin.edu.au** tao_support@astro.swin.edu.au
Subject: Job finished
Date: 3 February 2011 1:46 PM
To: Darren Croton dcroton@astro.swin.edu.au

Dear dcroton@astro.swin.edu.au,

Your job has successfully completed. You can download the data anytime in the next 48 hours at the following link:
http://tao.it.swin.edu.au/site/lightcone/files/2011-02-03_16-45-42.tar.gz

All the best,
http://tao.it.swin.edu.au

Catalogue details:

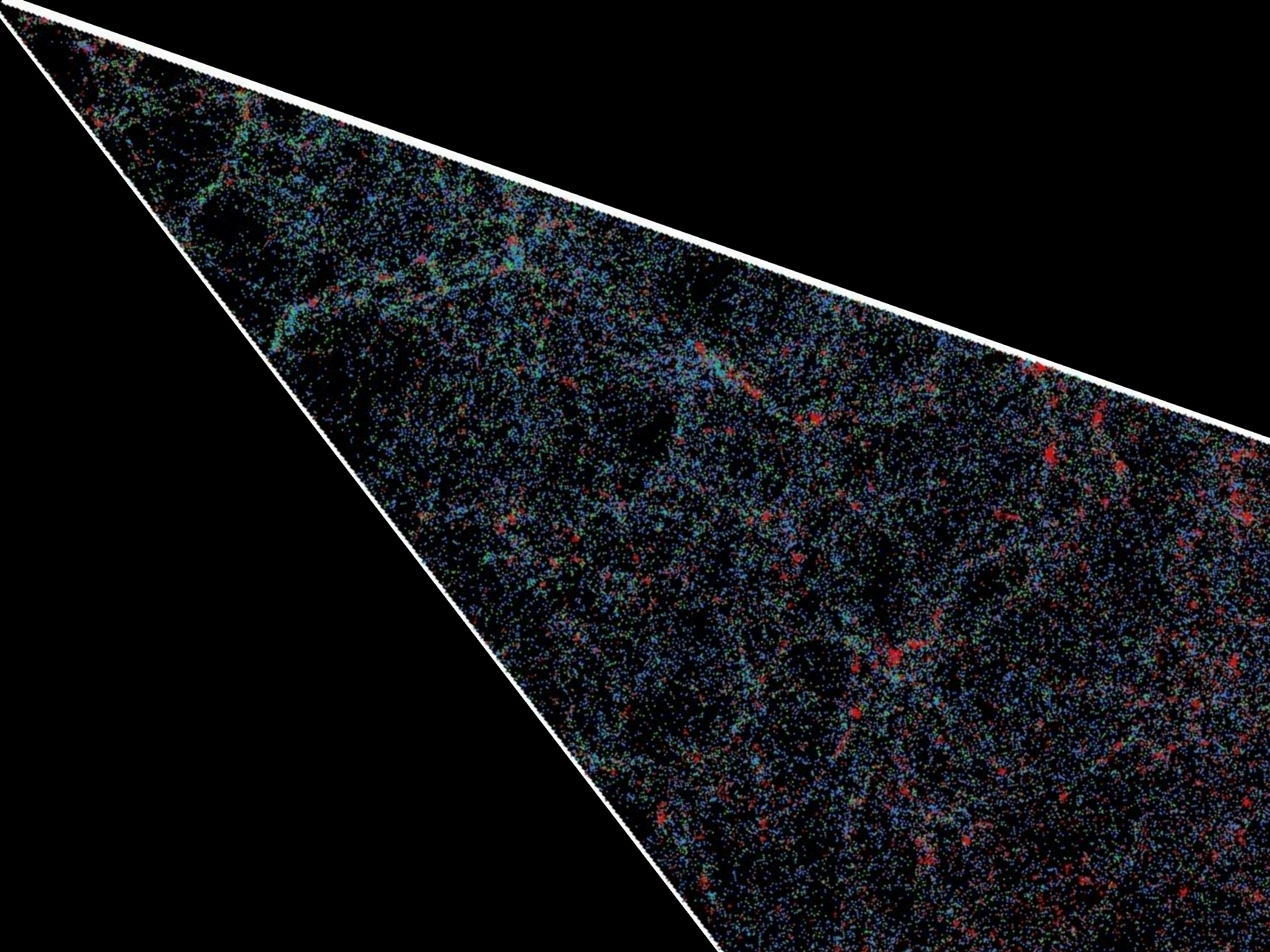
Simulation: Full Millennium
Galaxy model: Croton 2006
Catalogue type: simulation box
Redshift of the snapshot = 0.12
Box size = 100 Mpc
Filter = Black Hole Mass
Filter max = 1.0
Filter min = 0.0001

Output properties:

```
-------------------------------------------------------------
                              X   |   (Mpc/h)
                              Y   |   (Mpc/h)
                              Z   |   (Mpc/h)
                       Halo Mvir  |   (10^10 M⊙/h)
      Halo Velocity Dispersion    |   (km/s)
                          B Mag   |   (-5*log_10(h))
                   Stellar Mass   |   (10^10 M⊙/h)
                     Bulge Mass   |   (10^10 M⊙/h)
                Black Hole Mass   |   (10^10 M⊙/h)
-------------------------------------------------------------
```

Total galaxies in the catalogue: 27752

Download file size: 1.3 MB

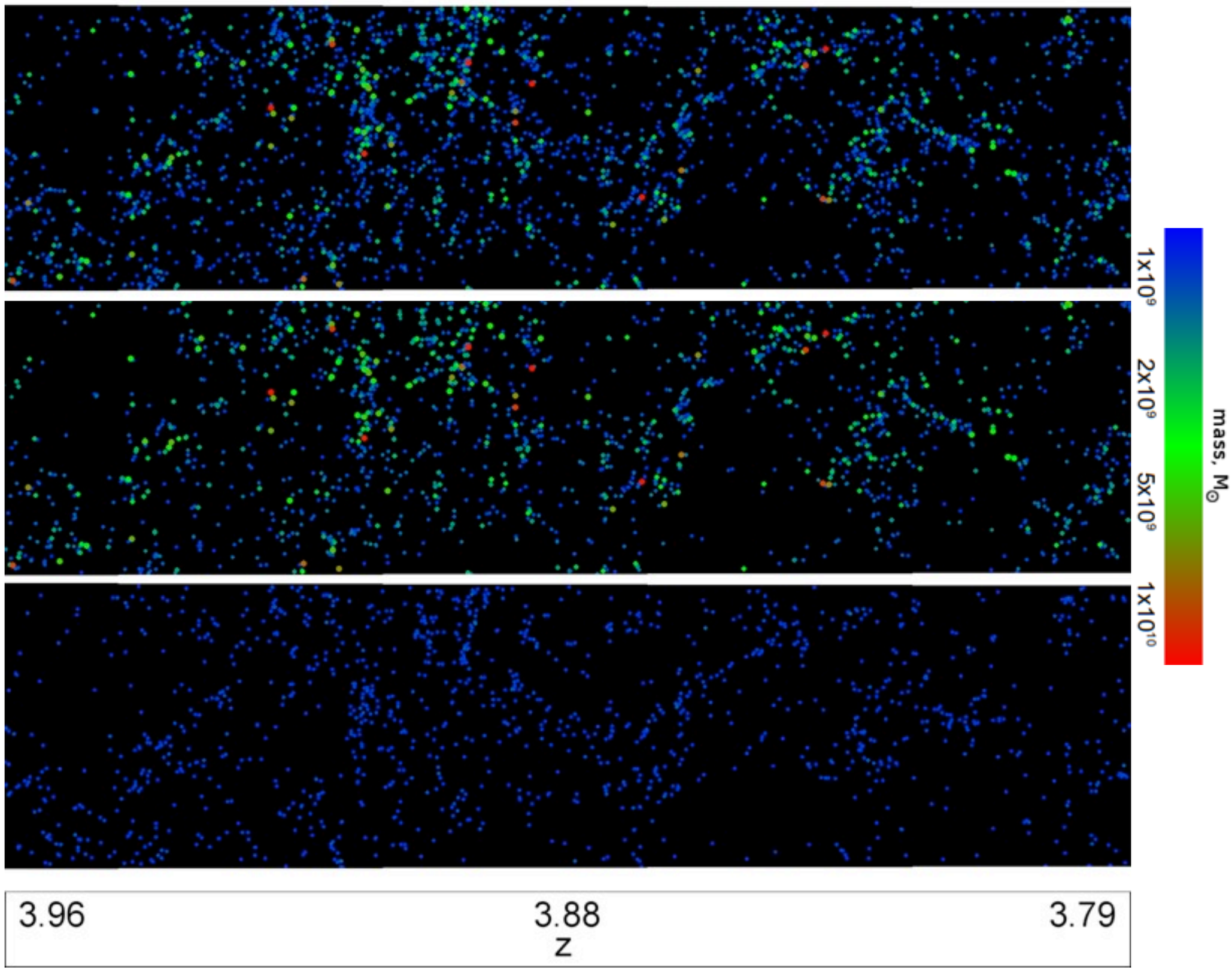


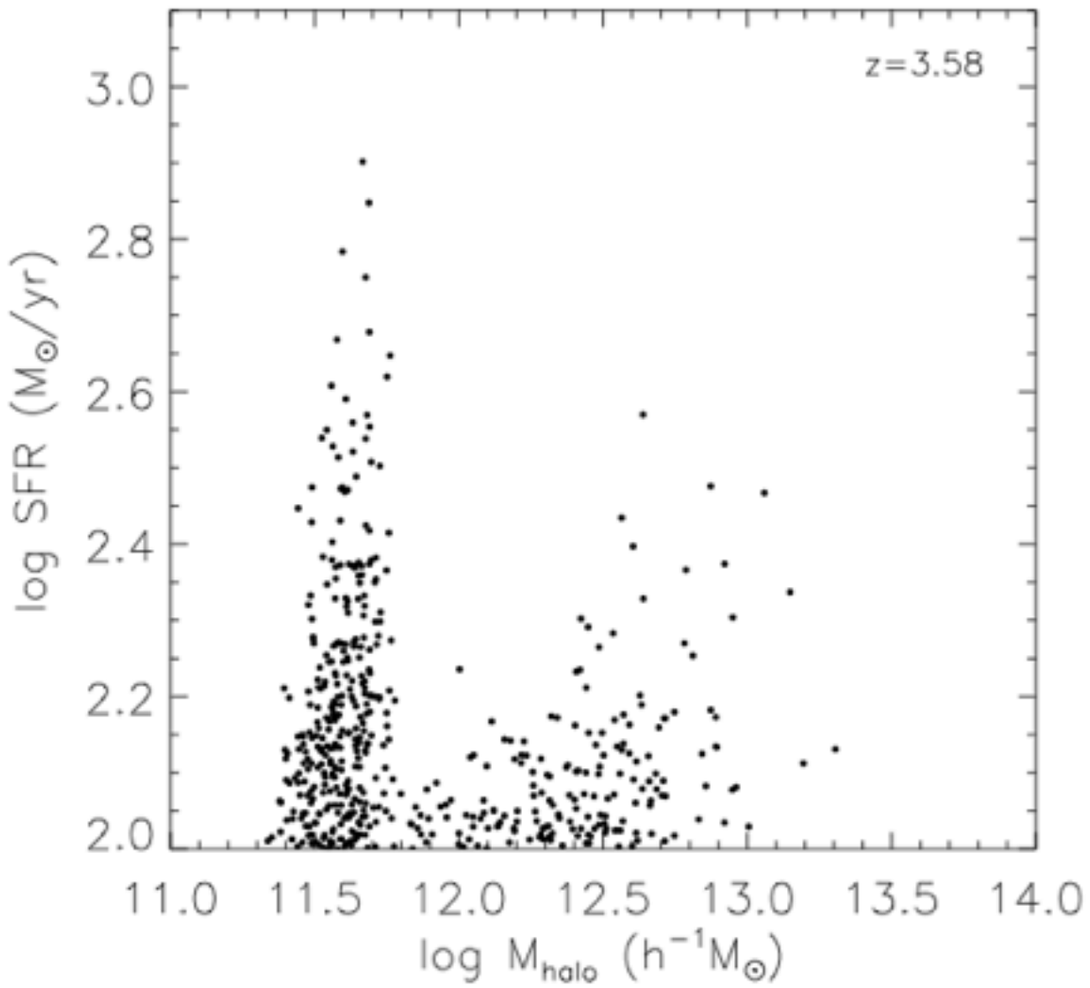
What will CANDELS miss?

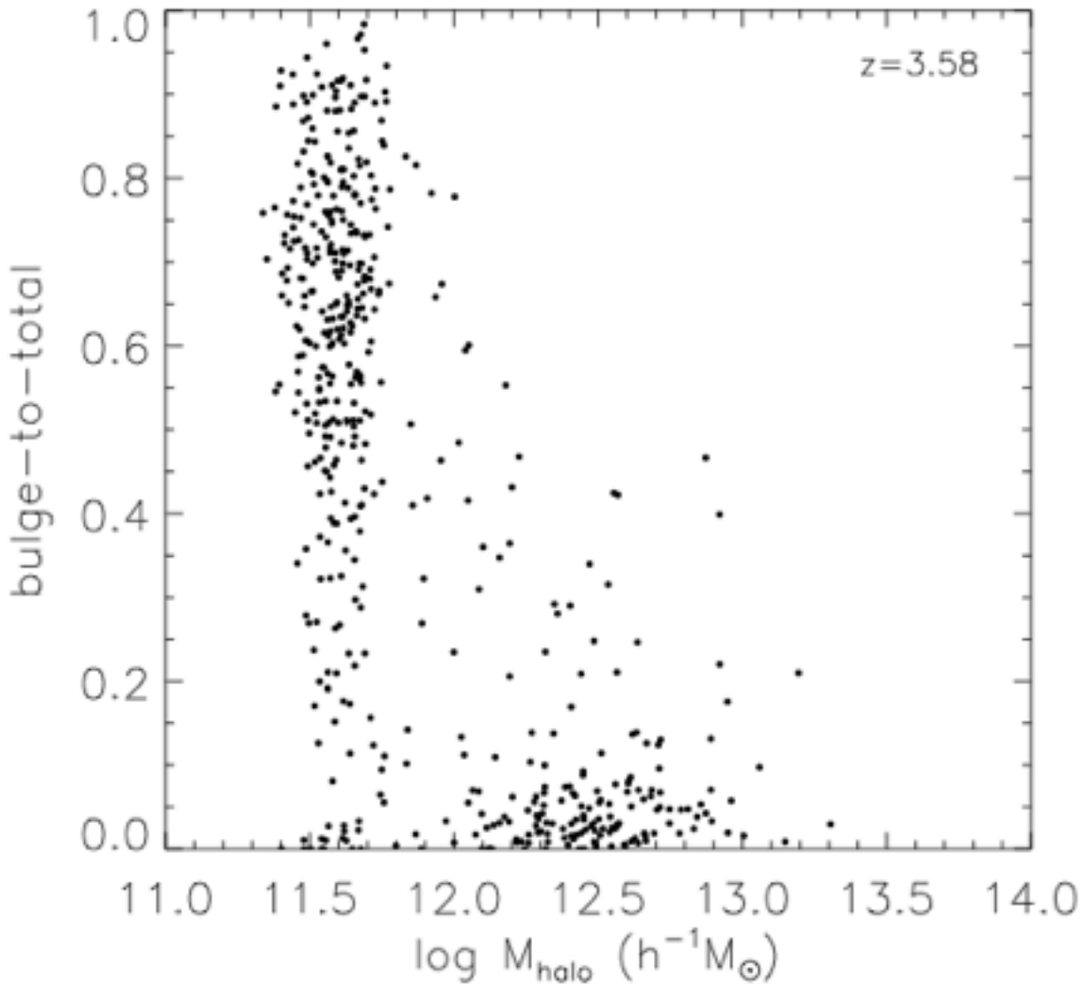
ALL
stars>10^9

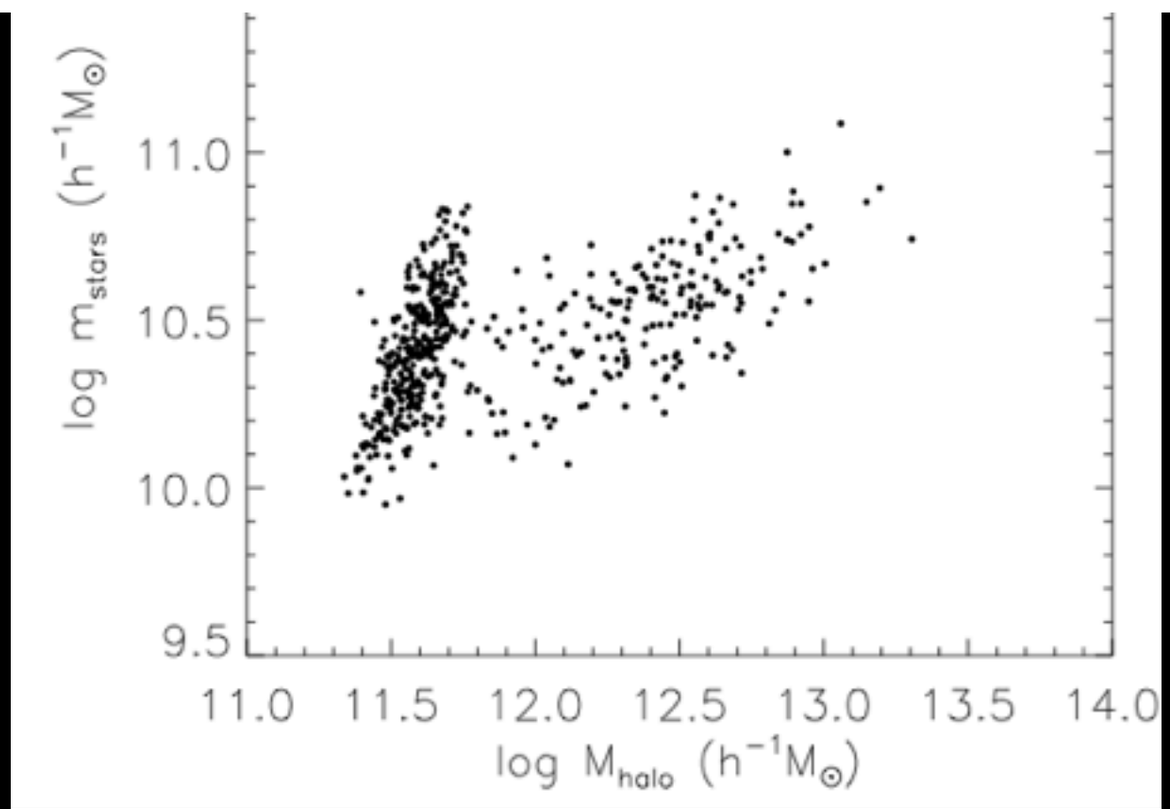
I<28.6
stars>10^9

I>28.6
stars>10^9




z=3.58
log SFR (M⊙/yr)
3.0
2.8
2.6
2.4
2.2
2.0
11.0 11.5 12.0 12.5 13.0 13.5 14.0
log M_halo (h^-1 M⊙)


z=3.58
bulge−to−total
1.0
0.8
0.6
0.4
0.2
0.0
11.0 11.5 12.0 12.5 13.0 13.5 14.0
log M_halo (h^-1 M⊙)


log m_stars (h^-1 M⊙)
11.0
10.5
10.0
9.5
11.0 11.5 12.0 12.5 13.0 13.5 14.0
log M_halo (h^-1 M⊙)

What you get ...

Multiple simulations (Millennium, Bolshoi, GiggleZ Suite, ...)

Multiple galaxy formation models (Croton, Somerville, ...)

Preset survey parameters

What we're working on ...

Light cones and telescope simulators

Full SED modelling of mock galaxies

Realtime mock image generation

Spatially resolved disks, bulges and halo gas

MCMC tools to easily build models using any simulation

What we're working on ....

Models in the cloud - Galacticus, PySAGE, others (tough to do!)

Progress as a community ....

- Common data format
- Sharing of codes, simulations and models

The Future

- Simple access to theory data resources (visual, no coding)
- Common data format and interchangeable tools
- Same model on different simulations, different models on the same simulations (plug in and play)
- Online “natural language” analytic and semi-analytic galaxy modelling
- Transparency is key

Bryan Gaensler (@SciBry)
4/06/12 9:44 AM
.@MatthewColless: Prediction for astronomy in the year 2022 - 'data scientists' will outnumber 'observers' by 2:1 #SCCSV

Bryan Gaensler (@SciBry)
4/06/12 9:39 AM
.@MatthewColless: The best surveys make data public as quickly as possible. Guarantees maximum uptake (and citations) #SCCSV

Back to the beginning...

PART I: Building synthetic universes

PART II: The parameters of galaxy formation

PART III: The universe in the cloud

The basics of how galaxies are built and evolve

The uses and limitations of semi-analytic galaxy models

The challenge of data access and delivery

http://tao.it.swin.edu.au/mock-galaxy-factory/

https://www.nectar.org.au/all-sky-virtual-observatory