# Galaxy Evolution in the Mock Galaxy Factory

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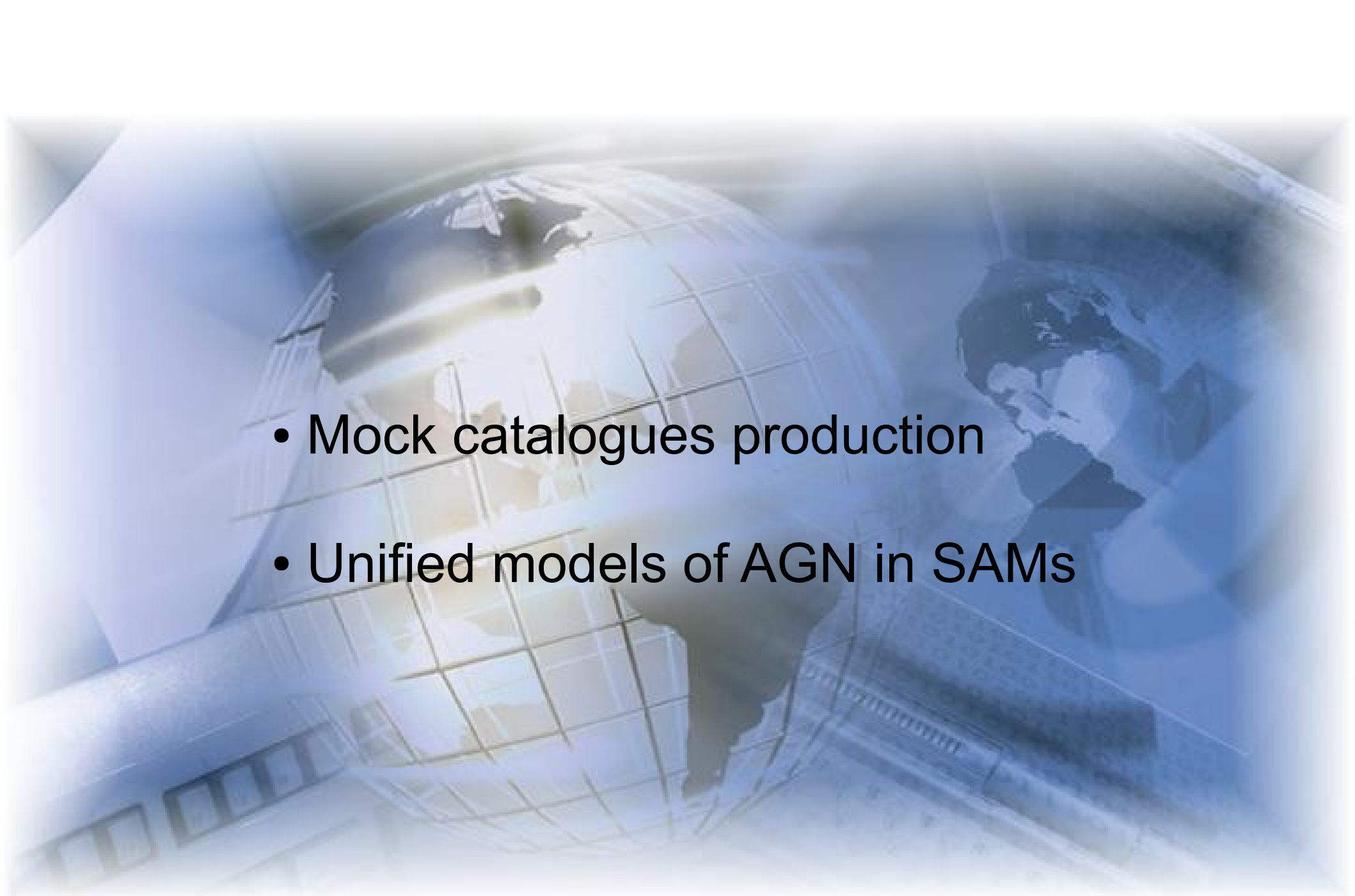
Greg Poole, Simon Mutch

WALLABY Simulations Fest – 20-23 Nov, 2011

CSIRO

SWINBURNE UNIVERSITY OF TECHNOLOGY

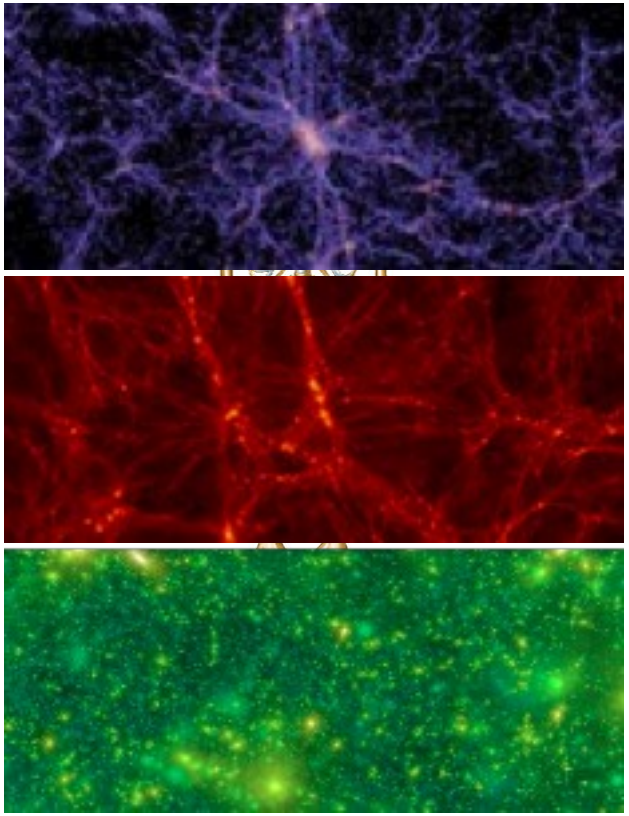

• Mock catalogues production
• Unified models of AGN in SAMs

# Four Steps to Produce a Mock Catalogue

1. Run a Dark Matter simulation
2. Apply a Galaxy Model
3. Apply Stellar Population Synthesis model
4. Remap and/or randomise simulation volume

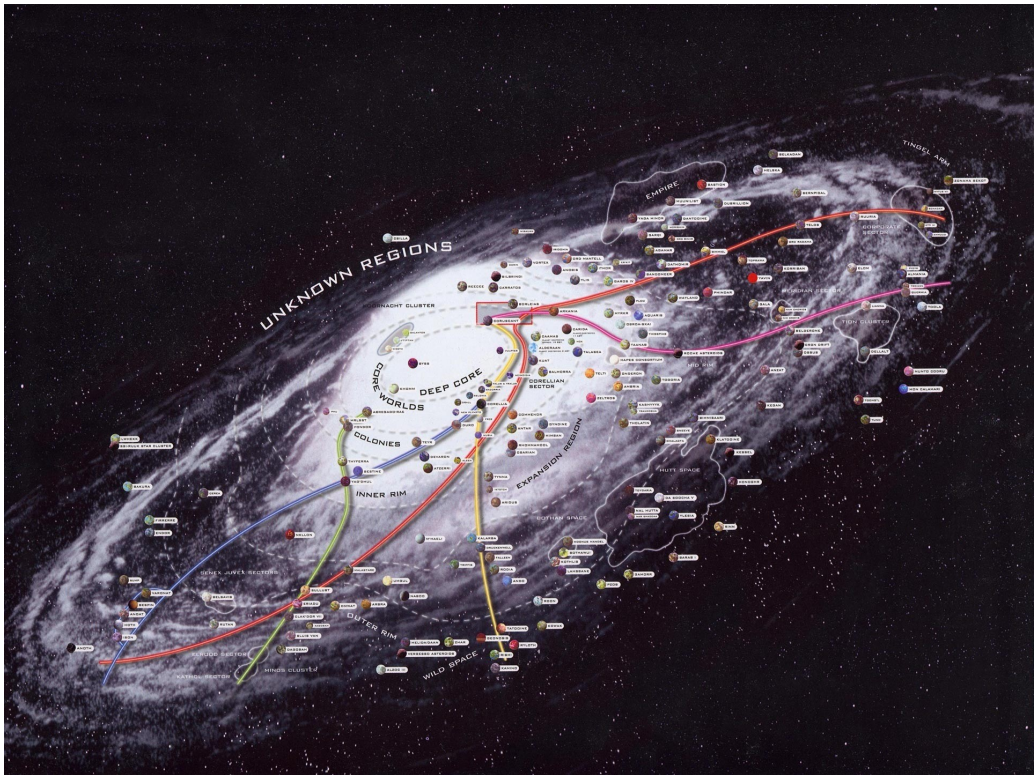
# 1. Dark Matter Simulations

- Millennium (Springel et al. 2005)
- Bolshoi (Klypin et al. 2010)
- GiggleZ (Poole et al. in prep.)

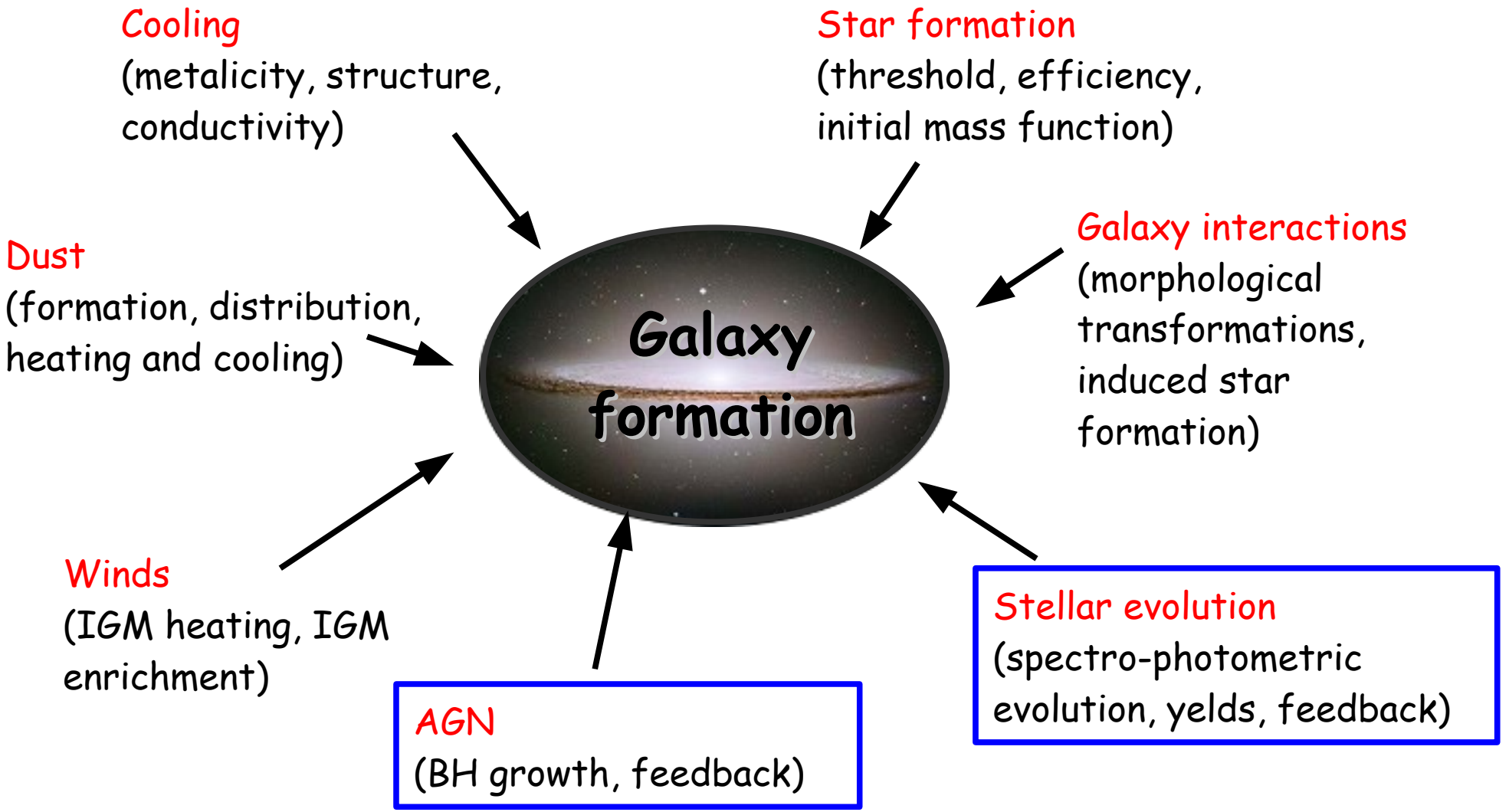


# 2. Galaxy Model

- Croton et al. 2006
- Somerville et al. 2008
- Benson et al. 2011



# Semi Analytical Galaxy Evolution (SAGE)

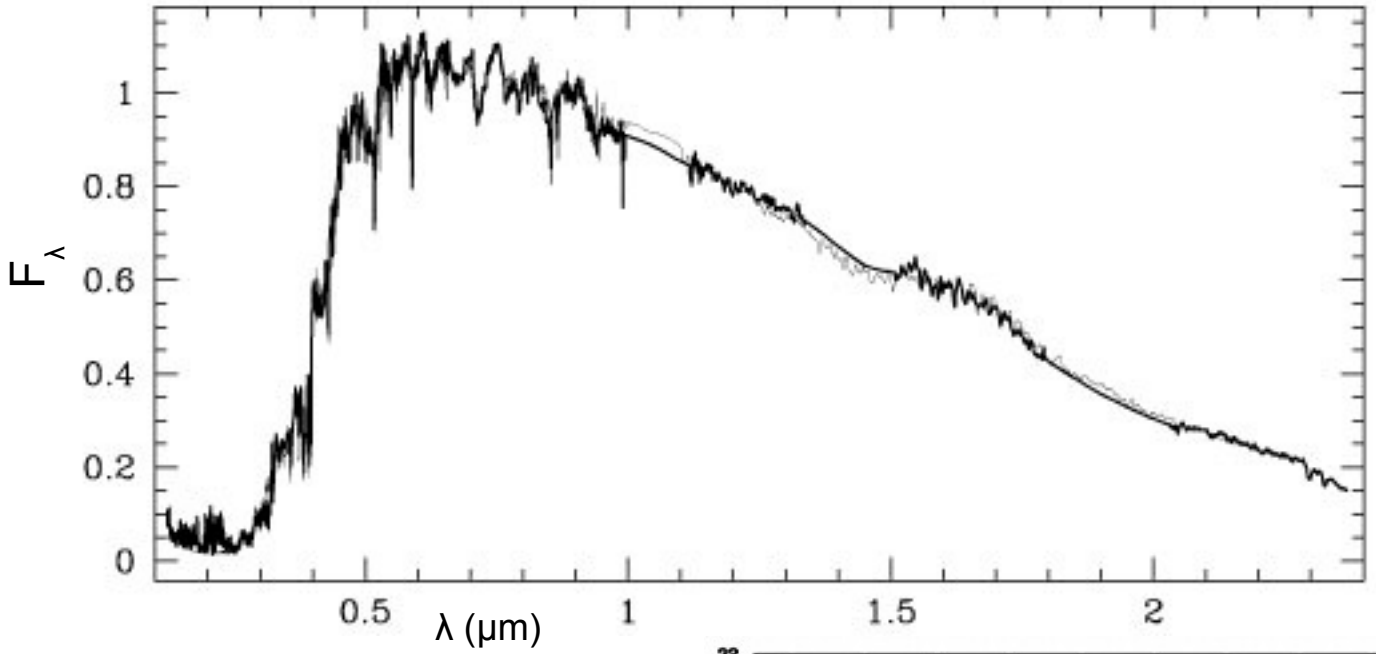



Croton et al. 2006

# 3. Stellar Population Synthesis models

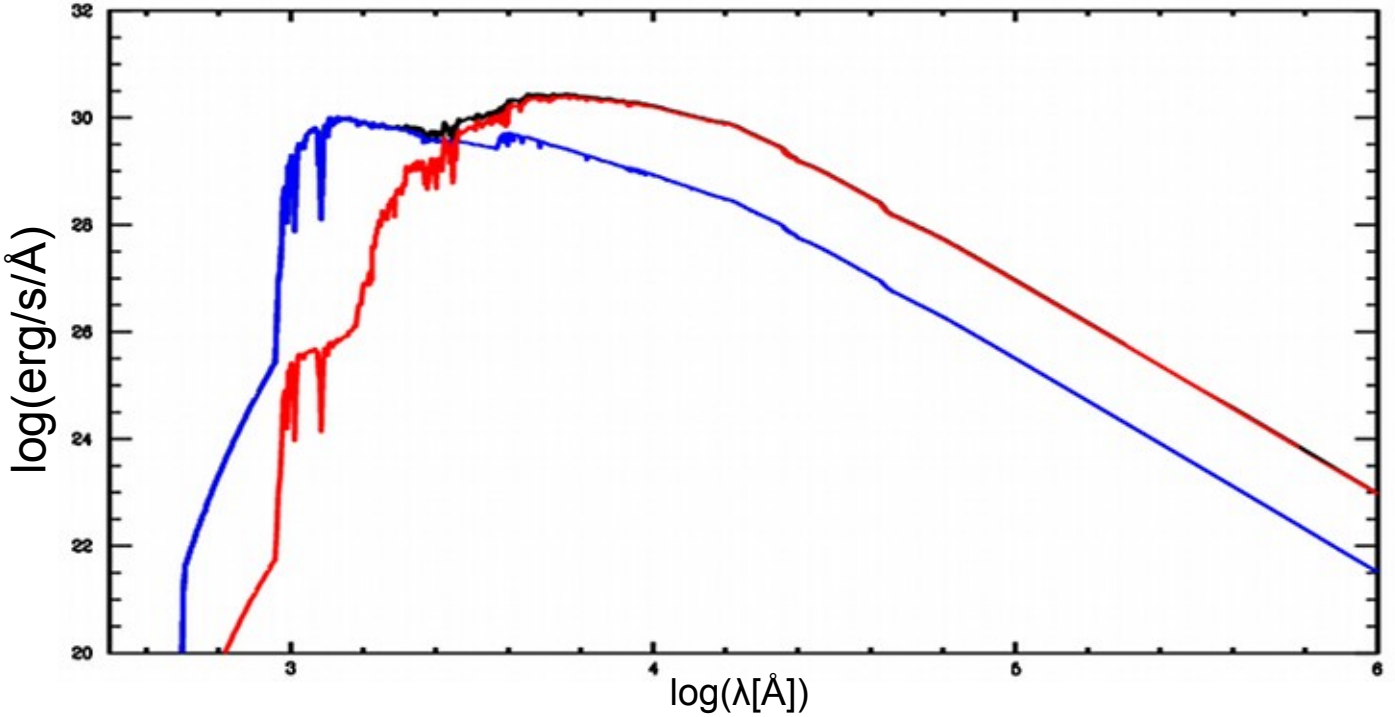
- Bruzual & Charlot 2003
- Maraston 2005
- Conroy et al. 2009

# Spectral Energy Distribution (SED)




observed

simulated



# Stellar Population Synthesis models require Star Formation Histories

Complications:

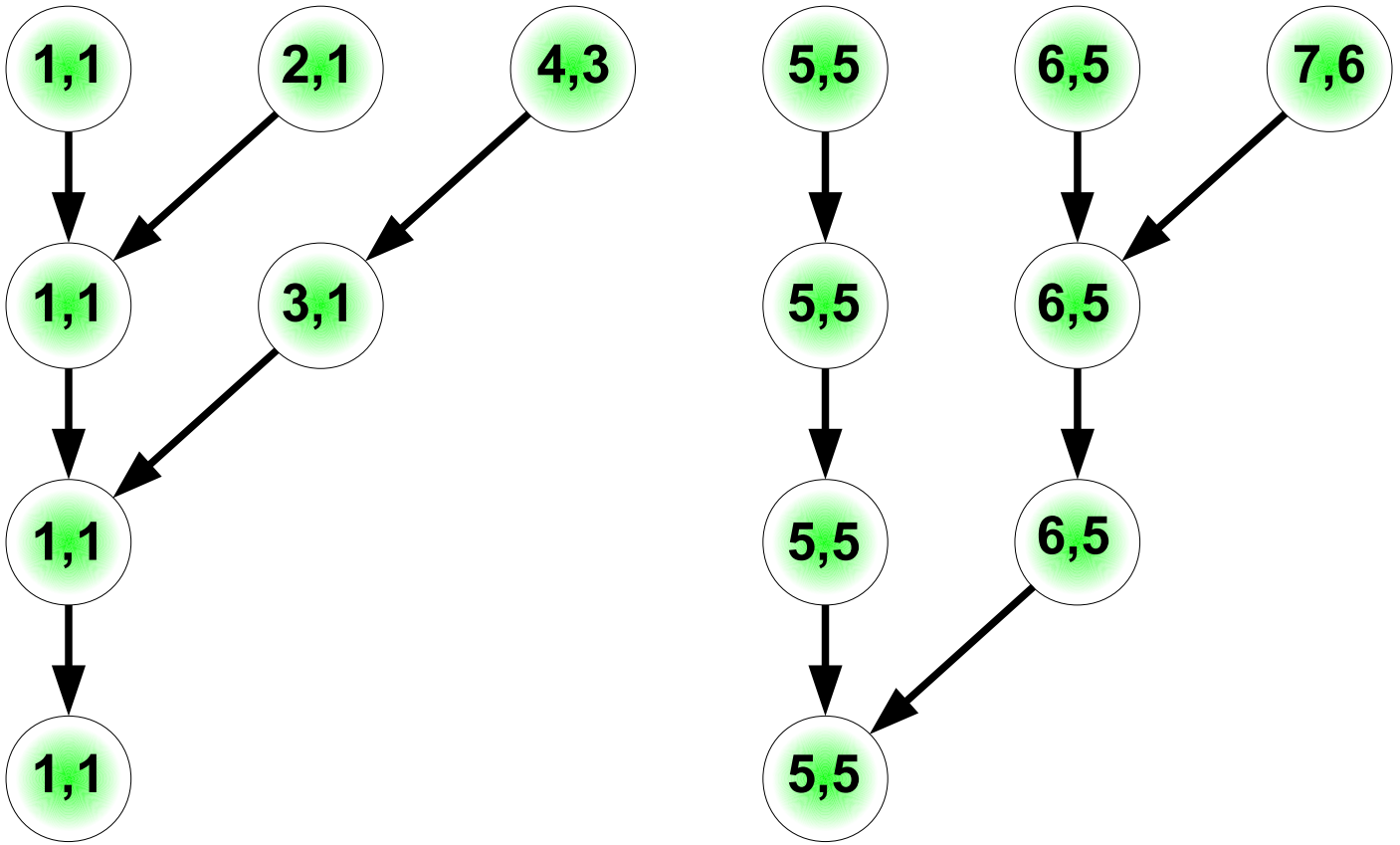
- Occupy large disk space
- Processing is time consuming
- Interpolation and re-binning

One of the solutions:

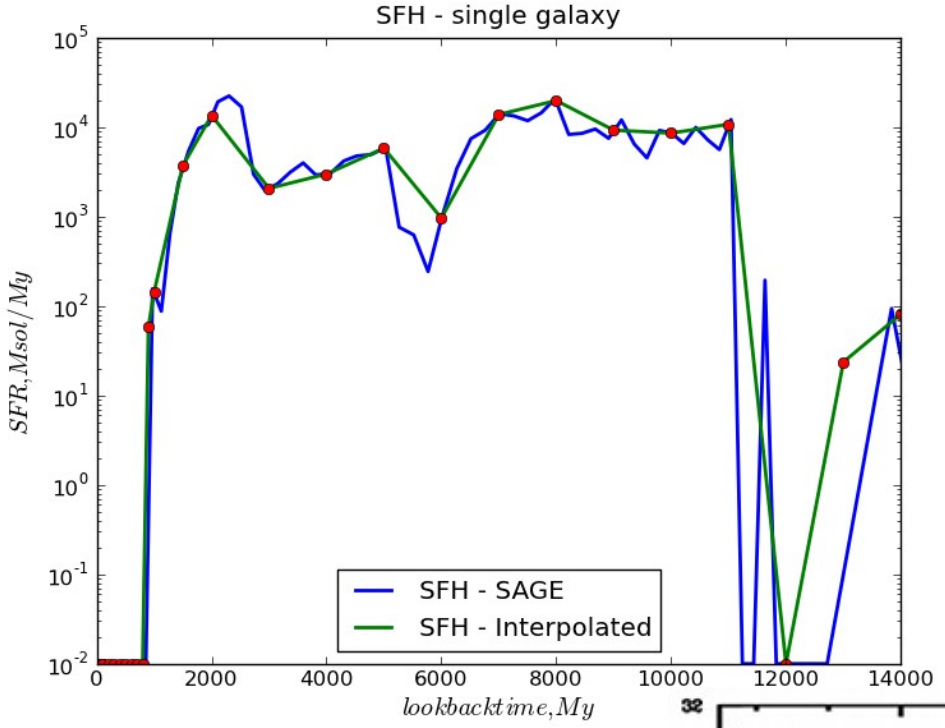
- Walking galaxies merger trees

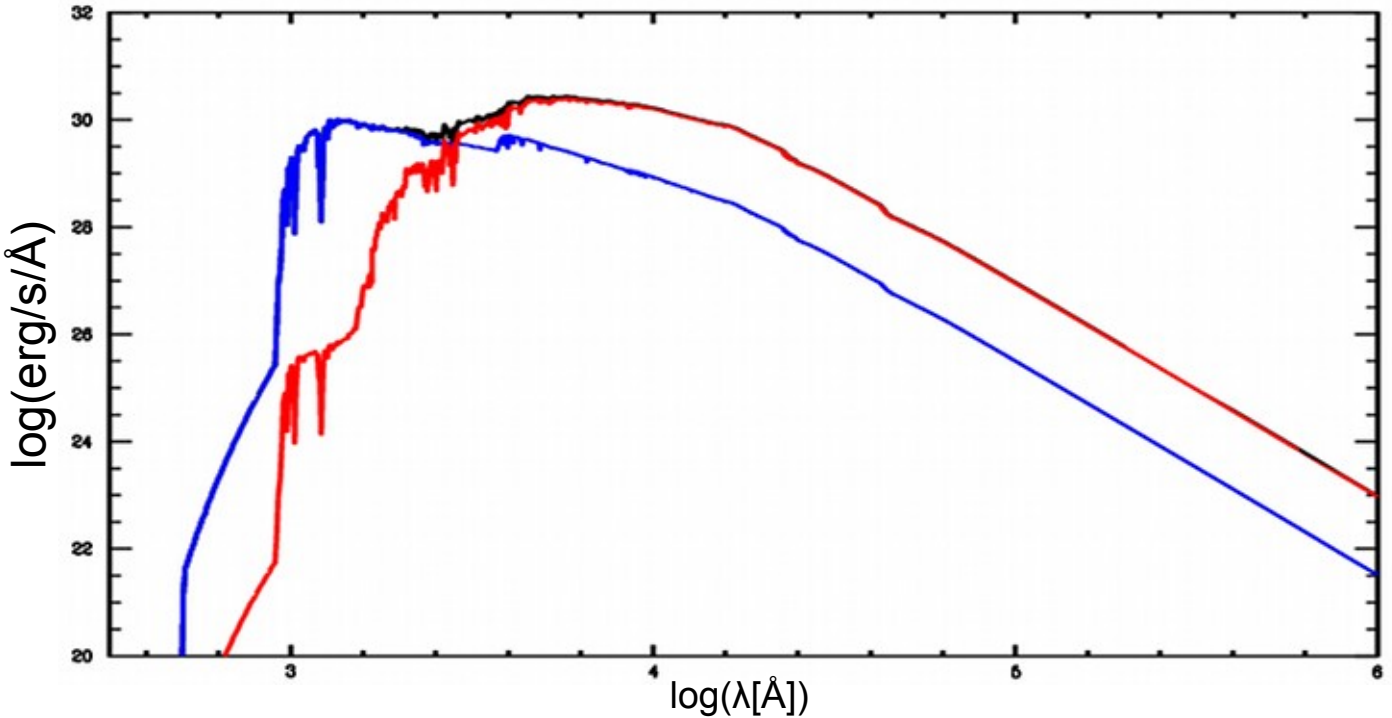
# Galaxy Merger Trees

- Galaxy unique ID
- ID of a galaxy it will merge with

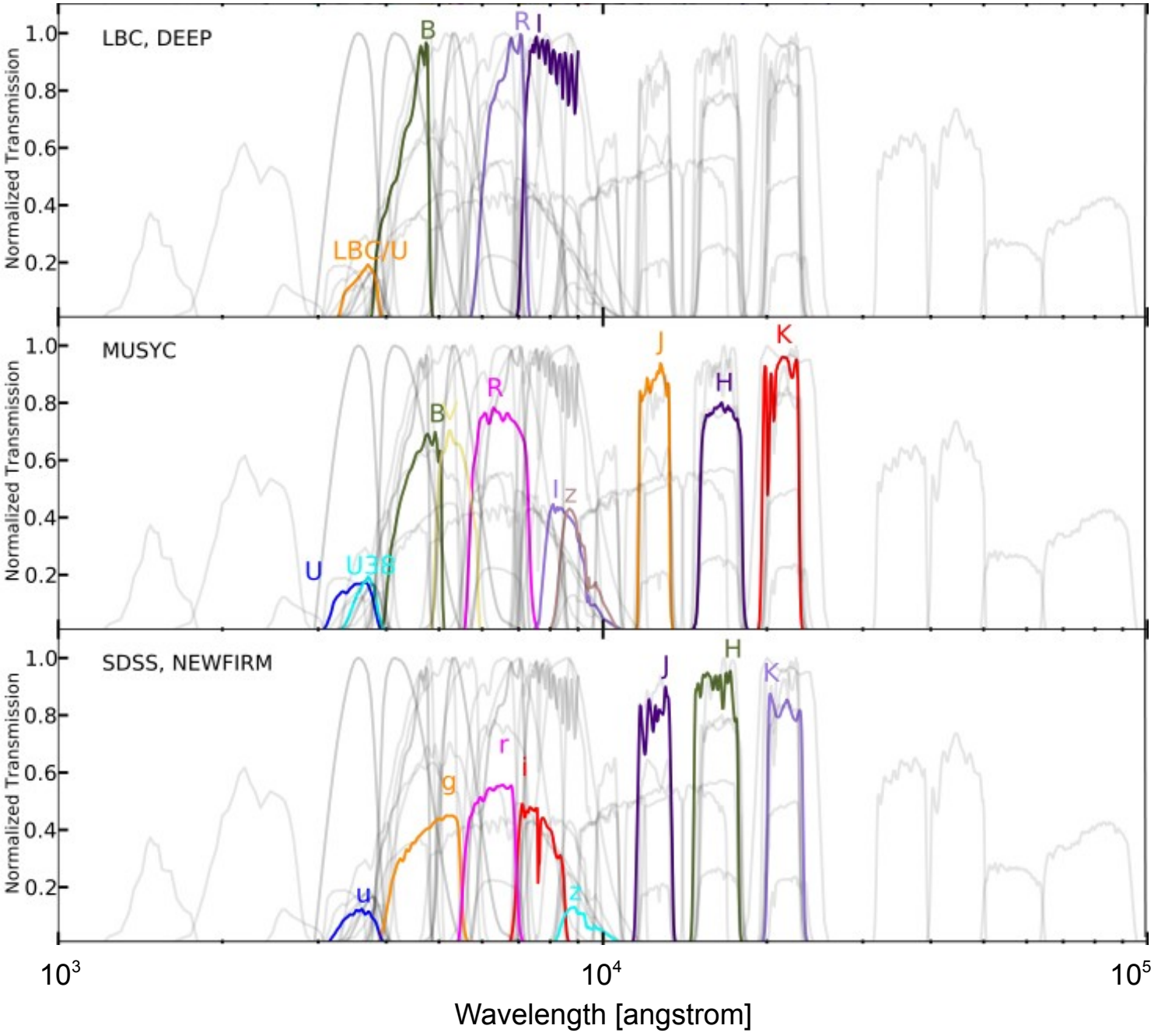


# Spectral Energy Distribution (SED)

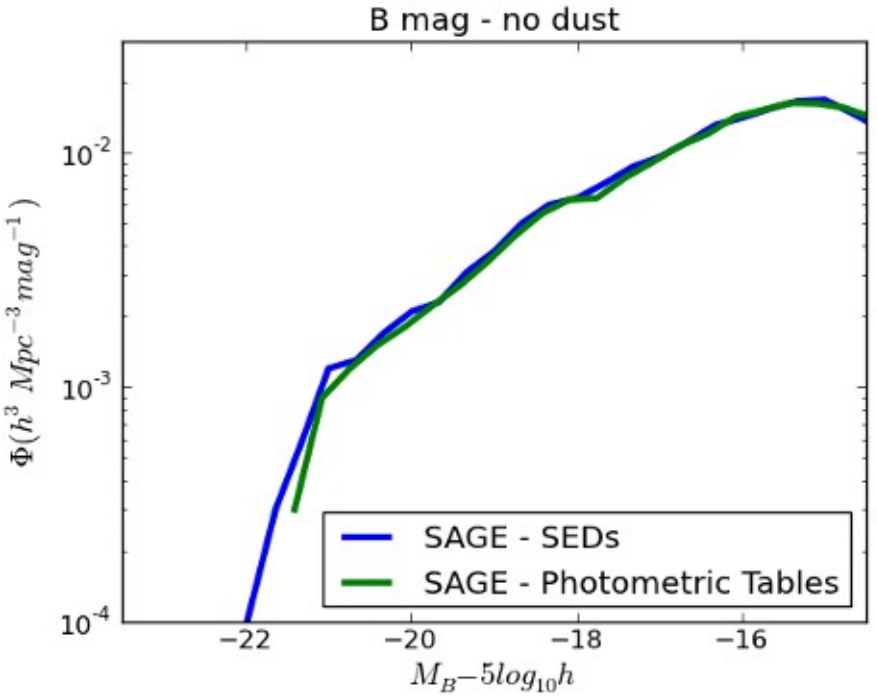


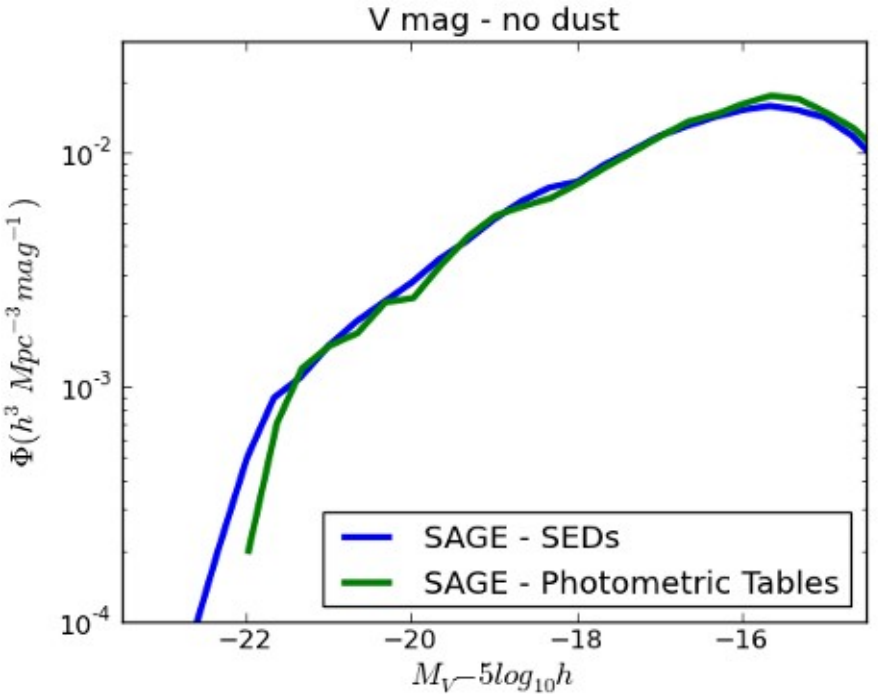



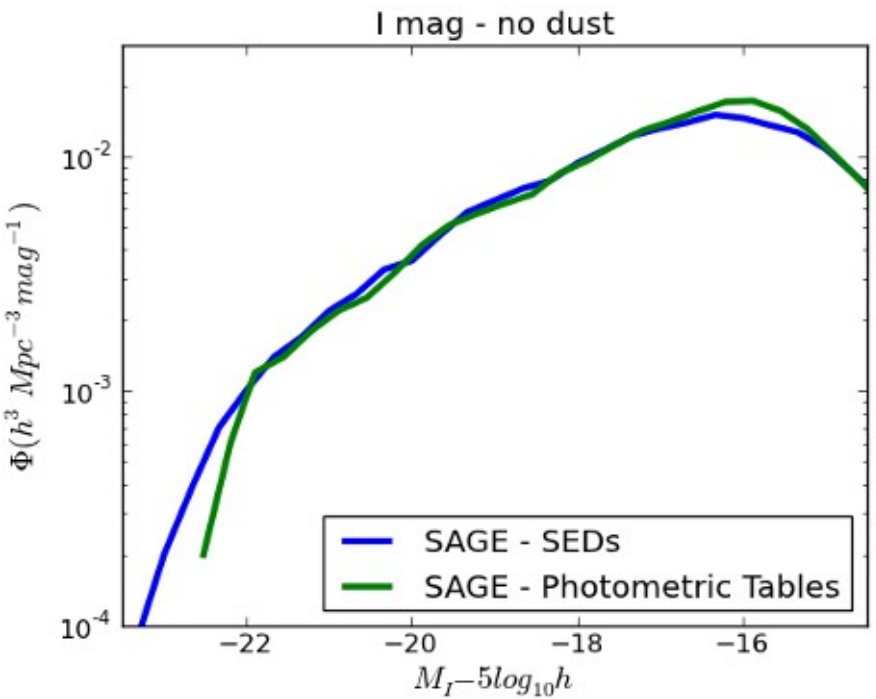
# Optical Filters

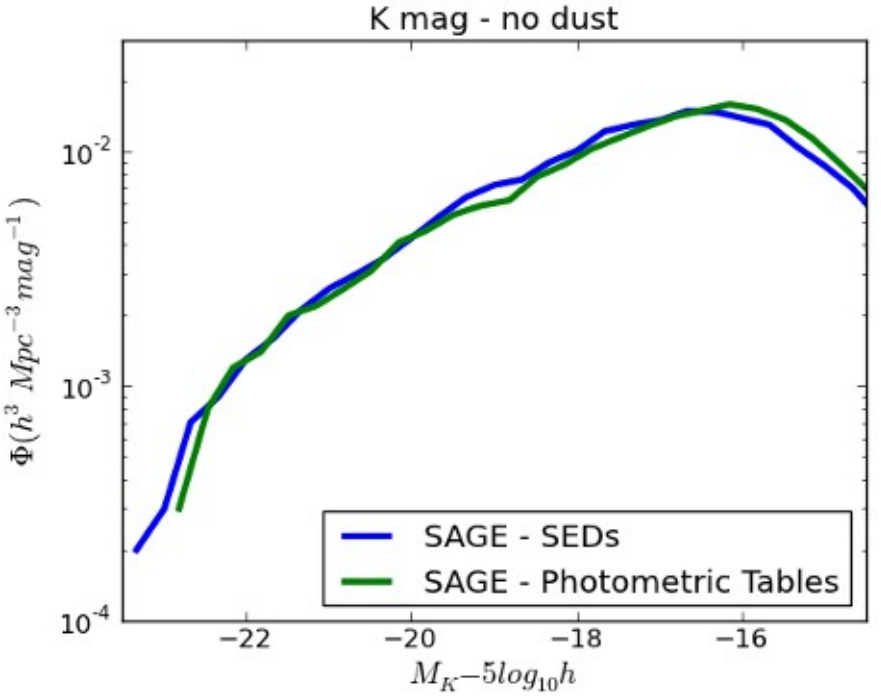


# Luminosity Function

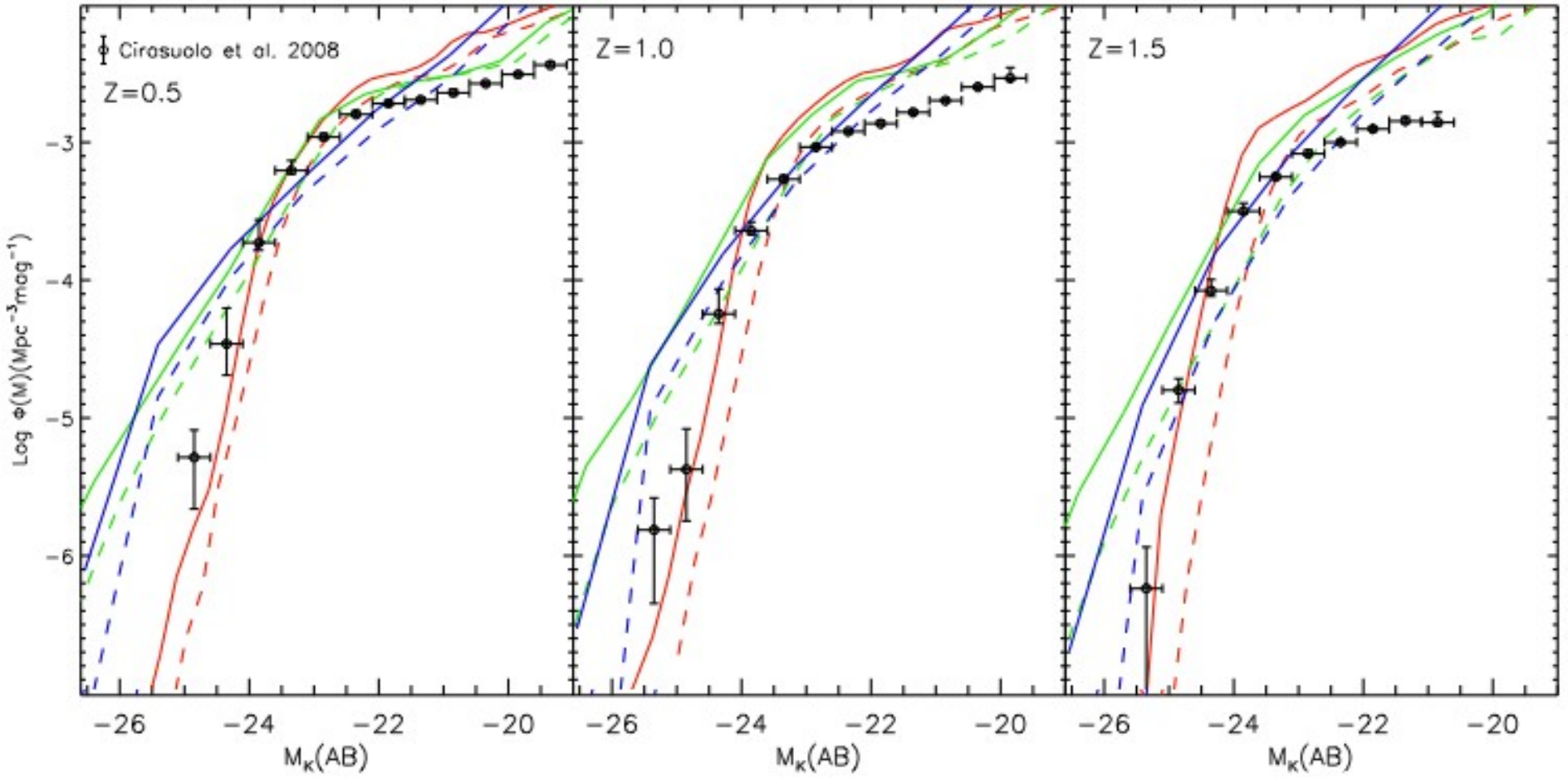


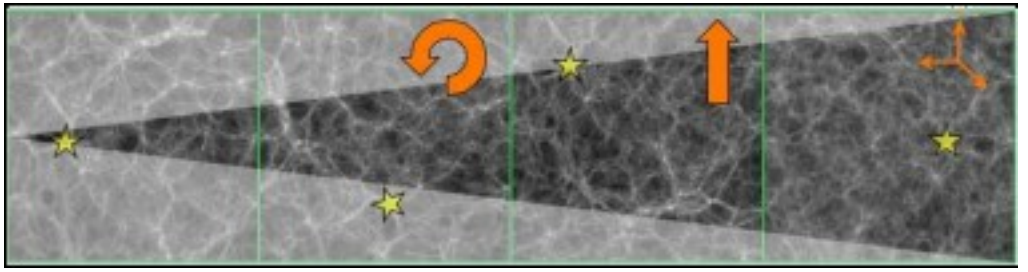
# K-Band Luminosity function with and without TP-AGB evolutionary phase

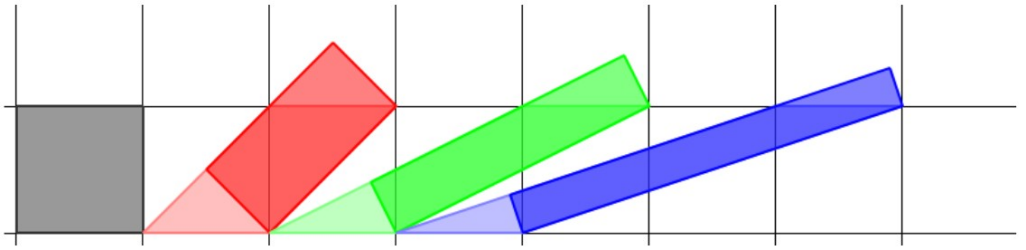



In red – semi-analytic model from De Lucia & Blaizot 2007, green – Monaco et al. 2007, and blue – Menci et al. 2006. Solid lines corespond to Maraston 2005 stellar population synthesis model, dashed – Bruzual & Charlot 2003. Data points from Cirasuolo et al. 2010 shown as black circles present data obtained from UKIDSS survey using UK Infrared Telescope in Hawaii.

# 4. Build a Lightcone

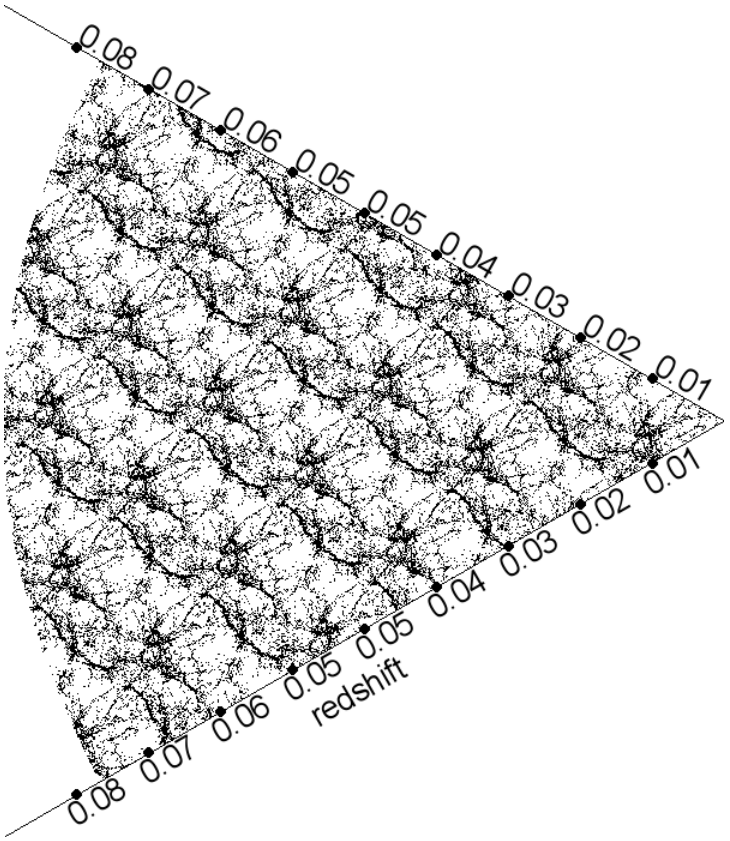
- Blaizot et al. 2004
- Carlson & White 2010
- Bernyk et al. in prep.

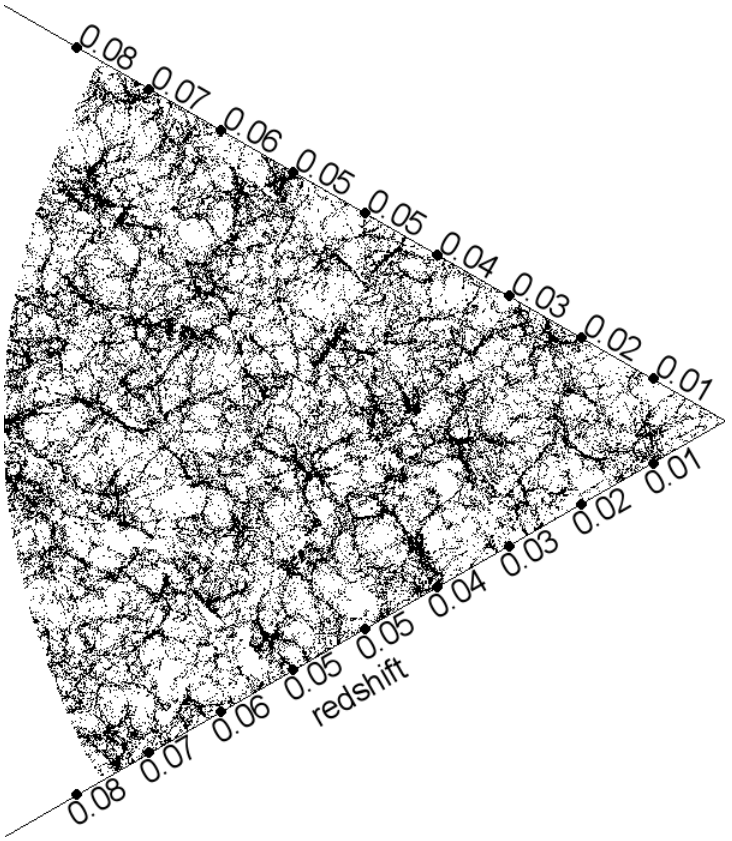




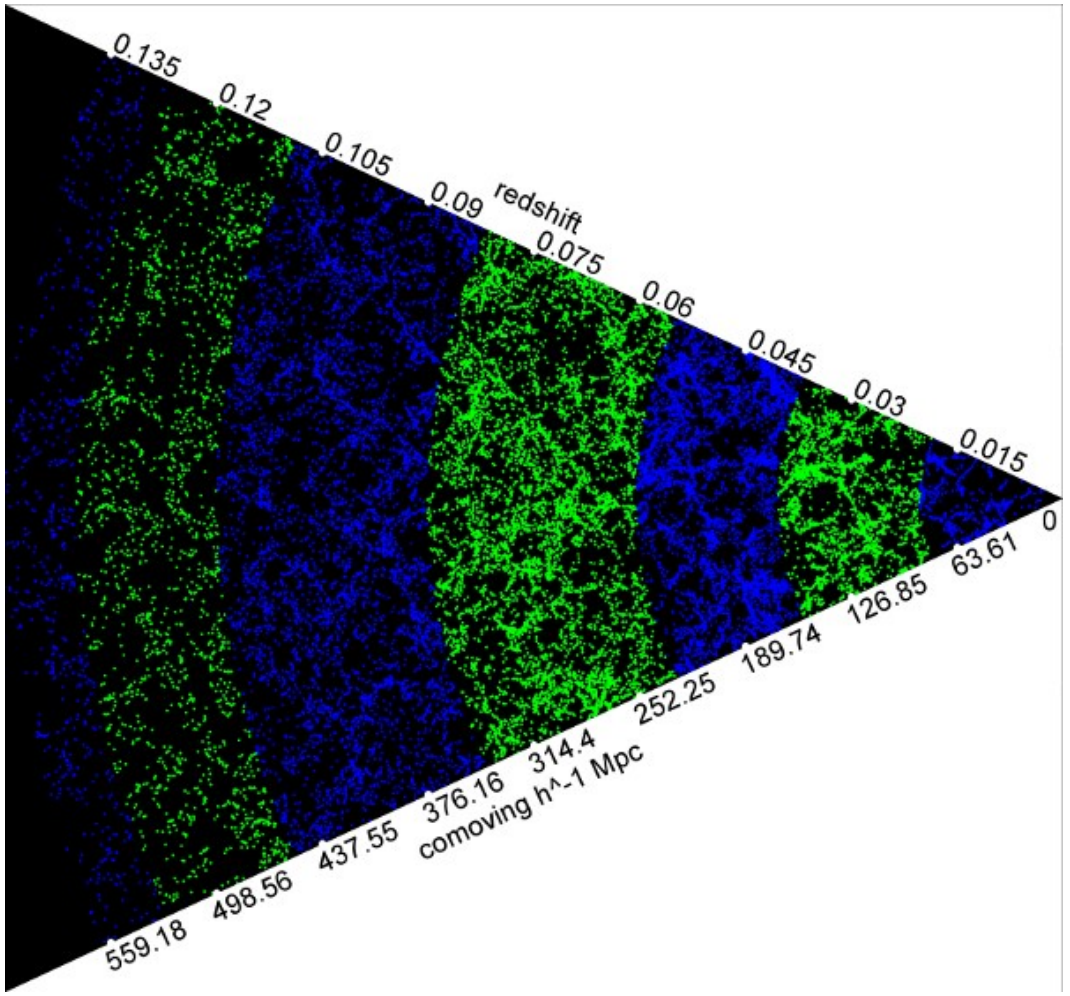
Using both techniques, and also extending Blaizot et al. 2004

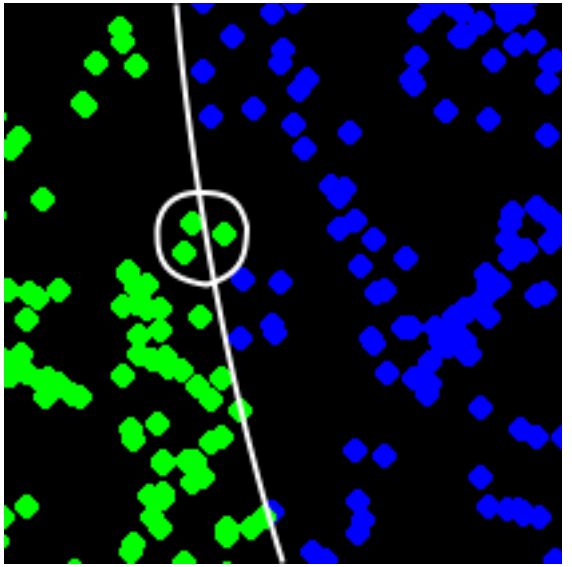
# Random rotation and shifting



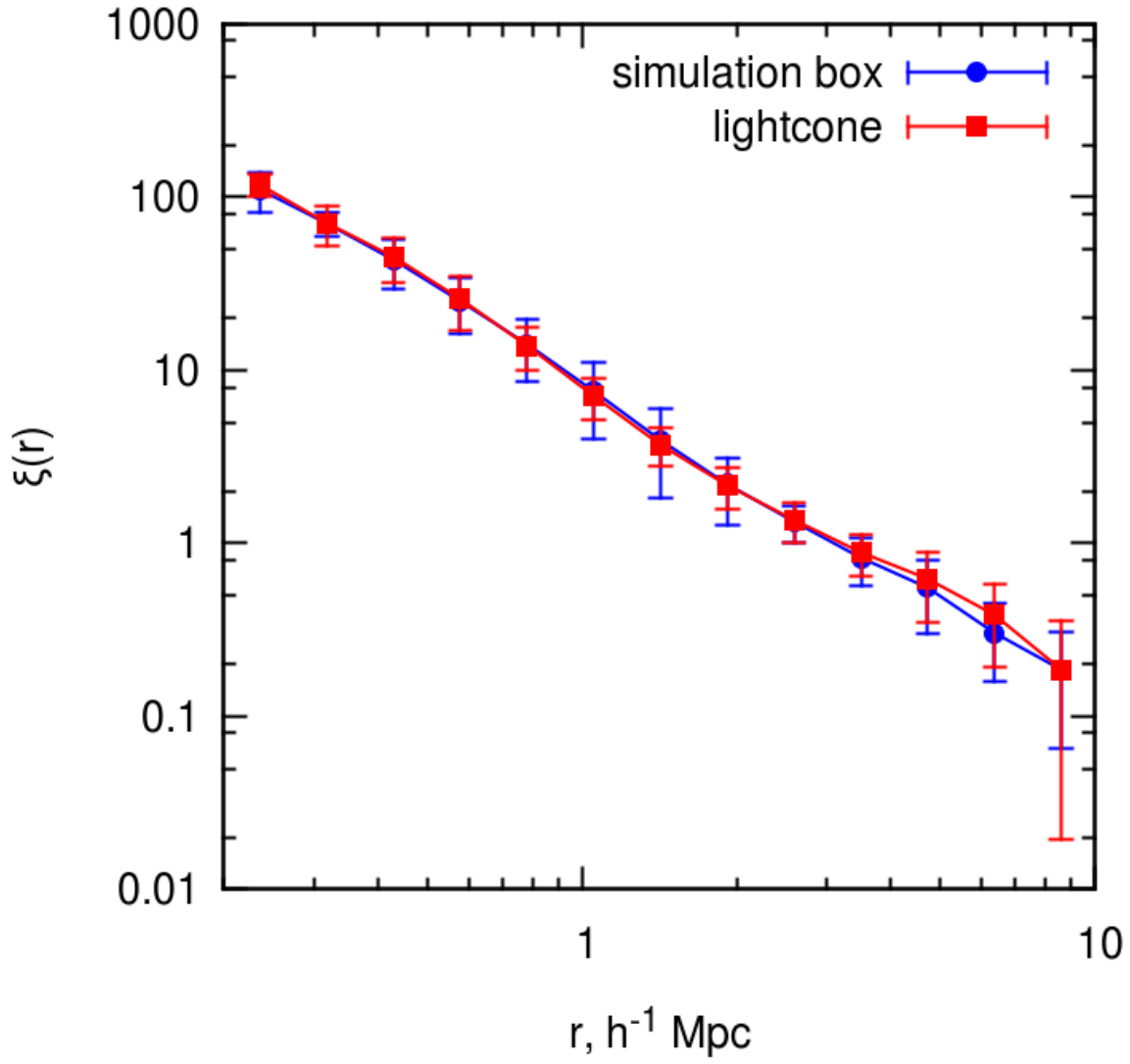



# Preserving Substructures



# Clustering Properties



# Mock Galaxy Factory
# http://tao.it.swin.edu.au

- Cosmological Dark Matter simulations
- Galaxy models
- Catalogue shape: lightcone or cube
- Structure: unique or random
- Pregenerated mock catalogues

# Mock Galaxy Factory

General -

| | |
|---|---|
| Catalogue Type: | Light cone |
| Simulation: | Full Millennium |
| Galaxy Model: | Croton et al. 2006 |
| Survey Preset: | Custom |
| Structure | Random - ○ Unique - ◉ |
| Observer ID | 0 |
| Number of cones (Total unique cones = 7) | 1 |

Parameters -

| | |
|---|---|
| Filter: B (abs mag) | brightest: |
| | faintest: |
| $Z_{min}$: | 0 |
| $Z_{max}$: | .8 |
| RA (arcmin, 0...5400): | 81 |
| Dec (arcmin, 0...5400): | 81 |

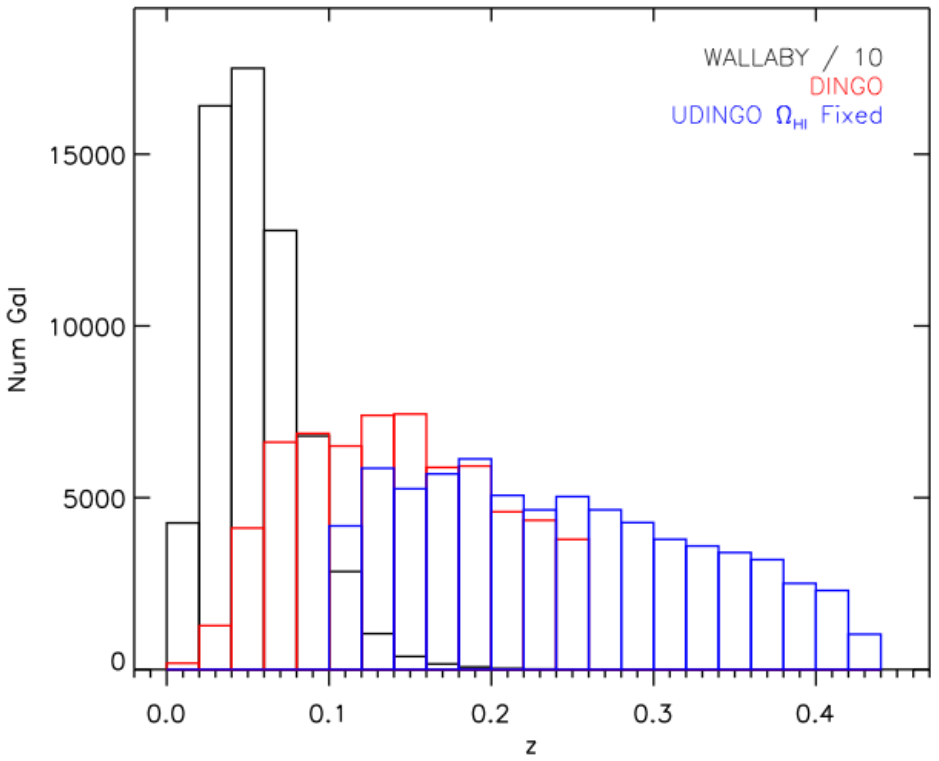
Selected simulation details:

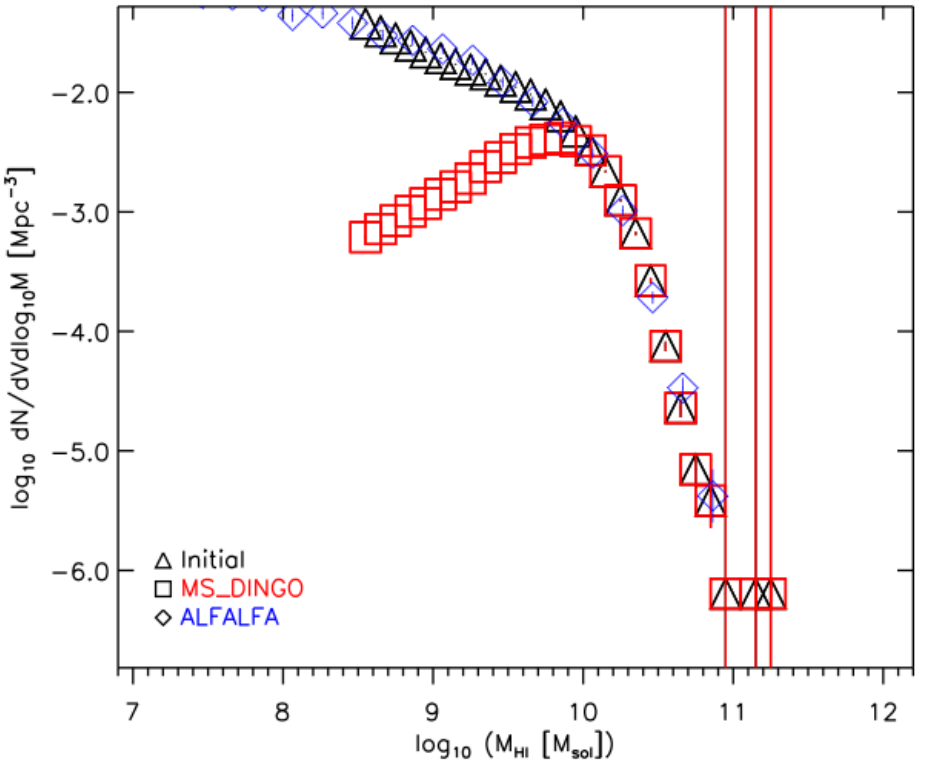
- **Full Millennium**
Paper: Springel et al. 2005
External link: http://www.mpa-garching.mpg.de/galform/millennium/
Cosmology: WMAP-1
Cosmological parameters: Ωm = 0.25, Ωb = 0.045, h = 0.73, ΩΛ = 0.75, n = 1, σ8 = 0.9
Box size: 500Mpc

Selected galaxy model details:

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

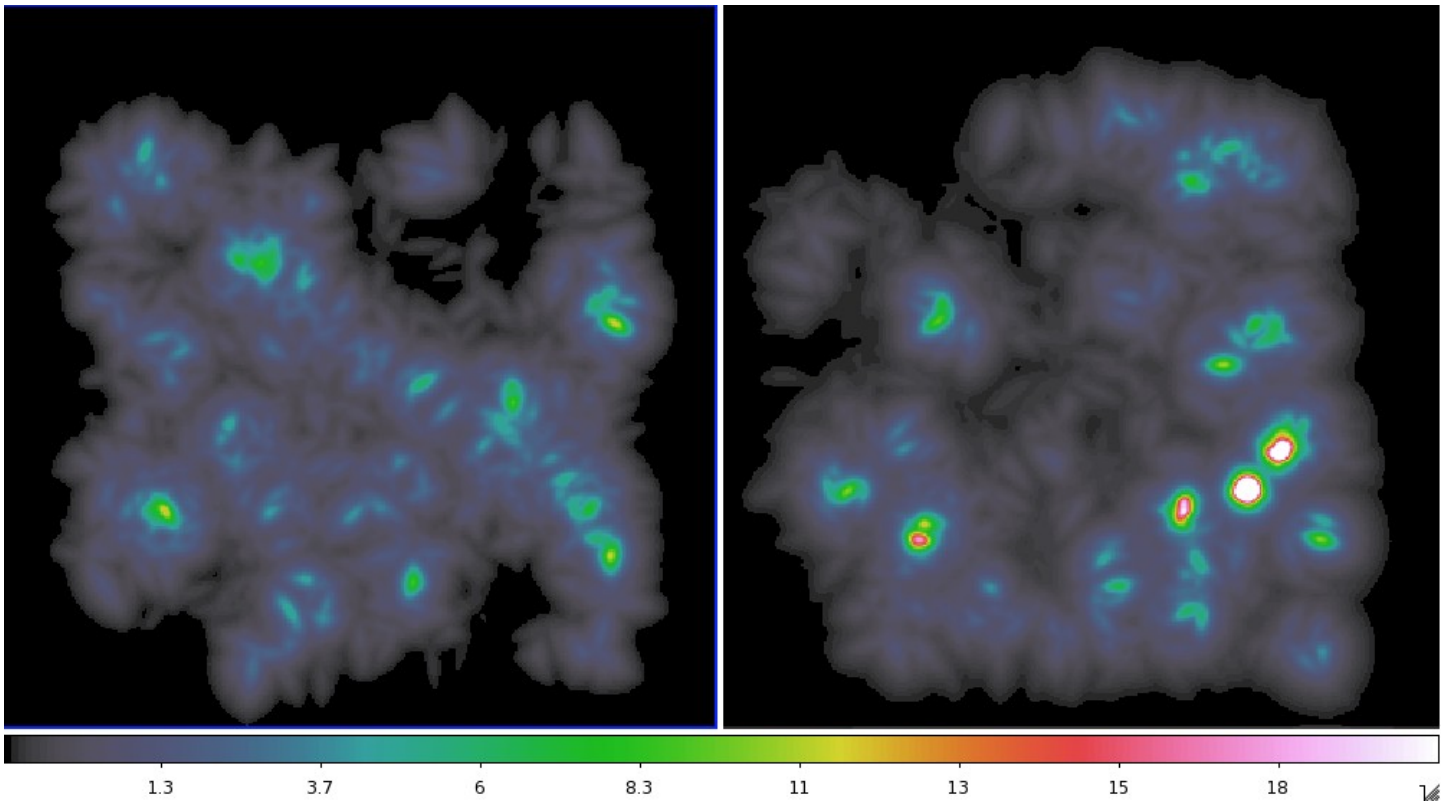
# Predictions for ASKAP Neutral Hydrogen Surveys




Duffy et al. - submitted

# First results FourStar: discovery of a candidate galaxy supercluster at z ~ 2.2




Spitler et al. in prep.

# Other Mock Surveys in progress

- PRIMUS
- GAMA
- CANDELS

- WiggleZ – coming early 2012

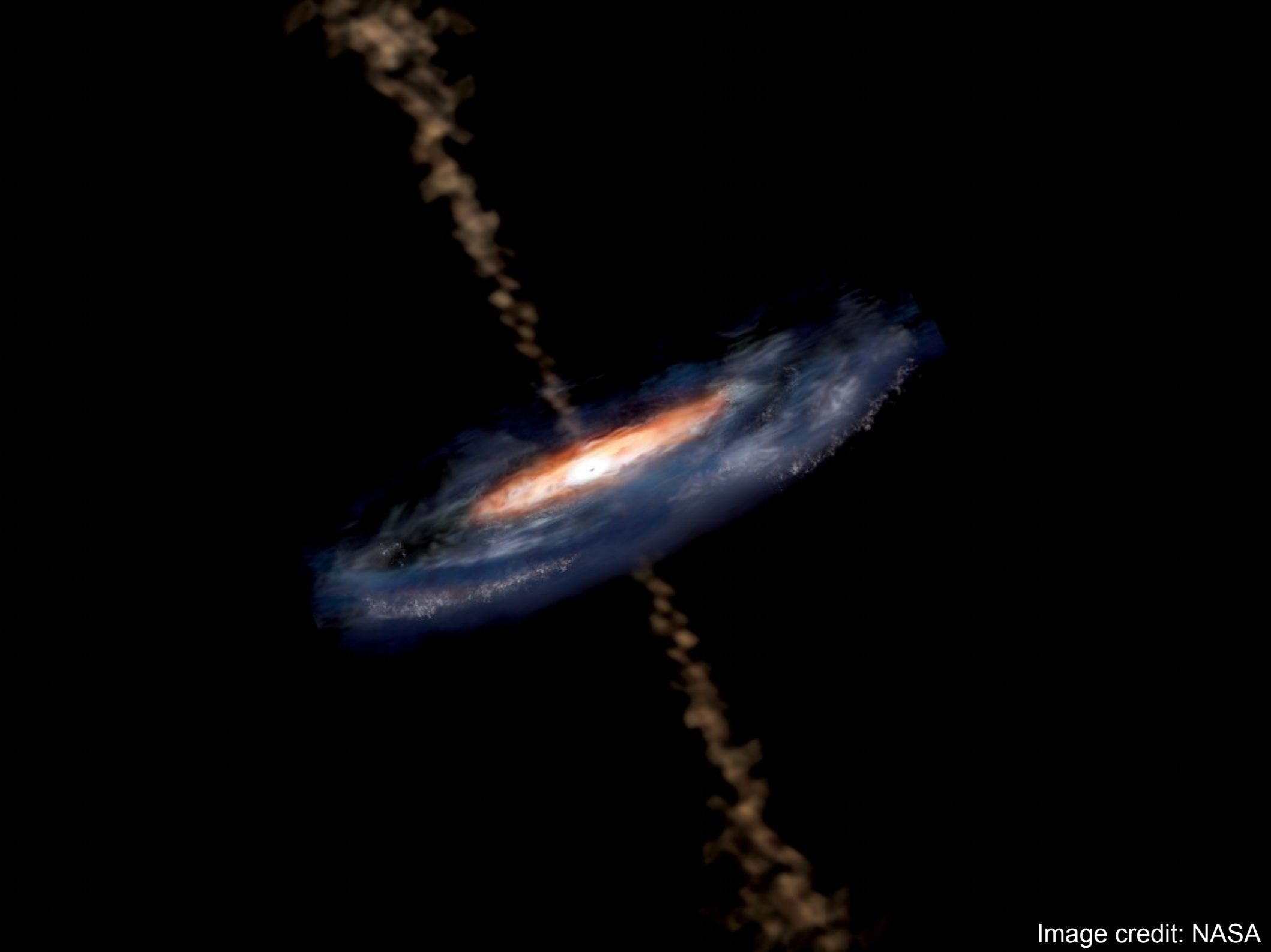


Image credit: NASA

# Types of AGN

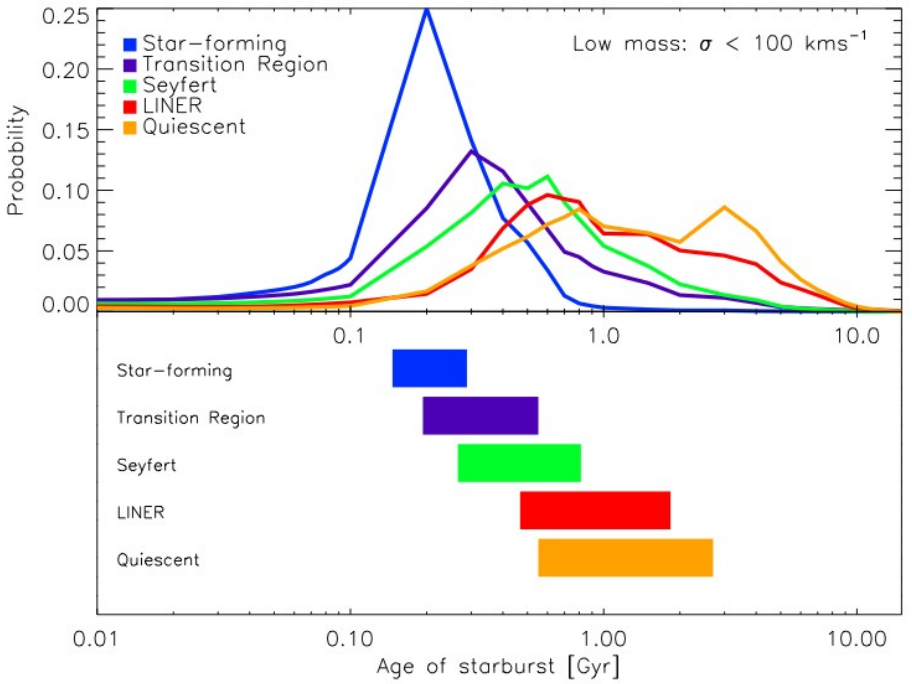
| Galaxy Type | Emission Lines | | X-rays | Excess of | | Strong Radio | Jets | Variable | Radio loud |
|---|---|---|---|---|---|---|---|---|---|
| | Narrow | Broad | | UV | Far-IR | | | | |
| **Seyfert I** | yes | yes | some | some | yes | few | no | yes | no |
| **Seyfert II** | yes | no | some | some | yes | few | yes | yes | no |
| **Quasar** | yes | yes | some | yes | yes | some | some | yes | 10% |
| **Blazar** | no | some | yes | yes | no | yes | yes | yes | yes |
| **BL Lac** | no | none/faint | yes | yes | no | yes | yes | yes | yes |
| **OVV** | no | stronger than BL Lac | yes | yes | no | yes | yes | yes | yes |
| **Radio galaxy** | some | some | some | some | yes | yes | yes | yes | yes |

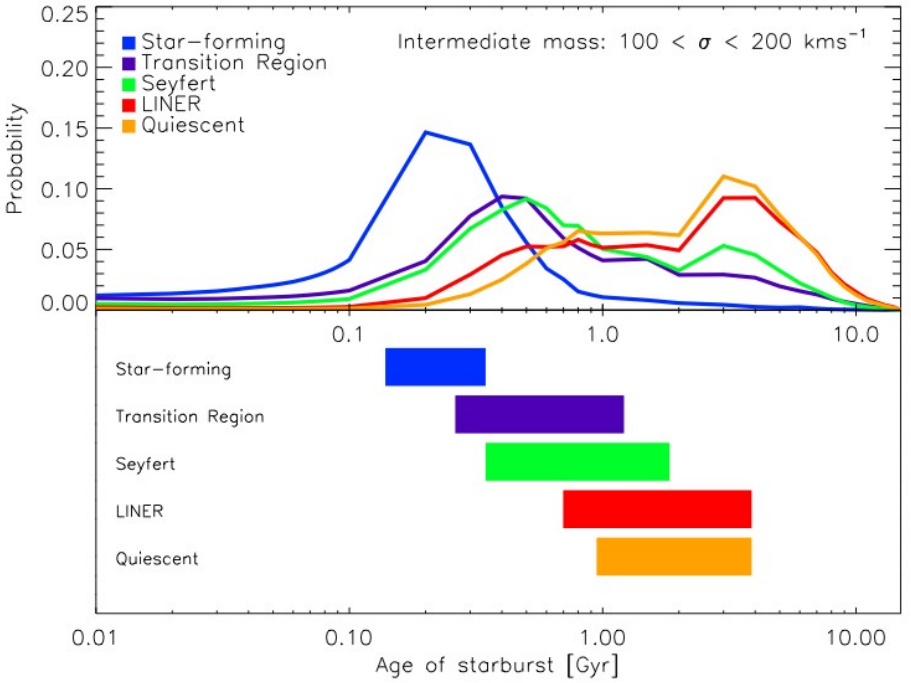
# AGN feedback

- Plays an important role in galaxy evolution
- No Galaxy Model which incorparates all types of AGN and accretion modes
- Observations are still at early stages

- Associate each major AGN class with a trigger and accretion model
- Couple this to the cosmological evolution of galaxies in the semi-analytic model

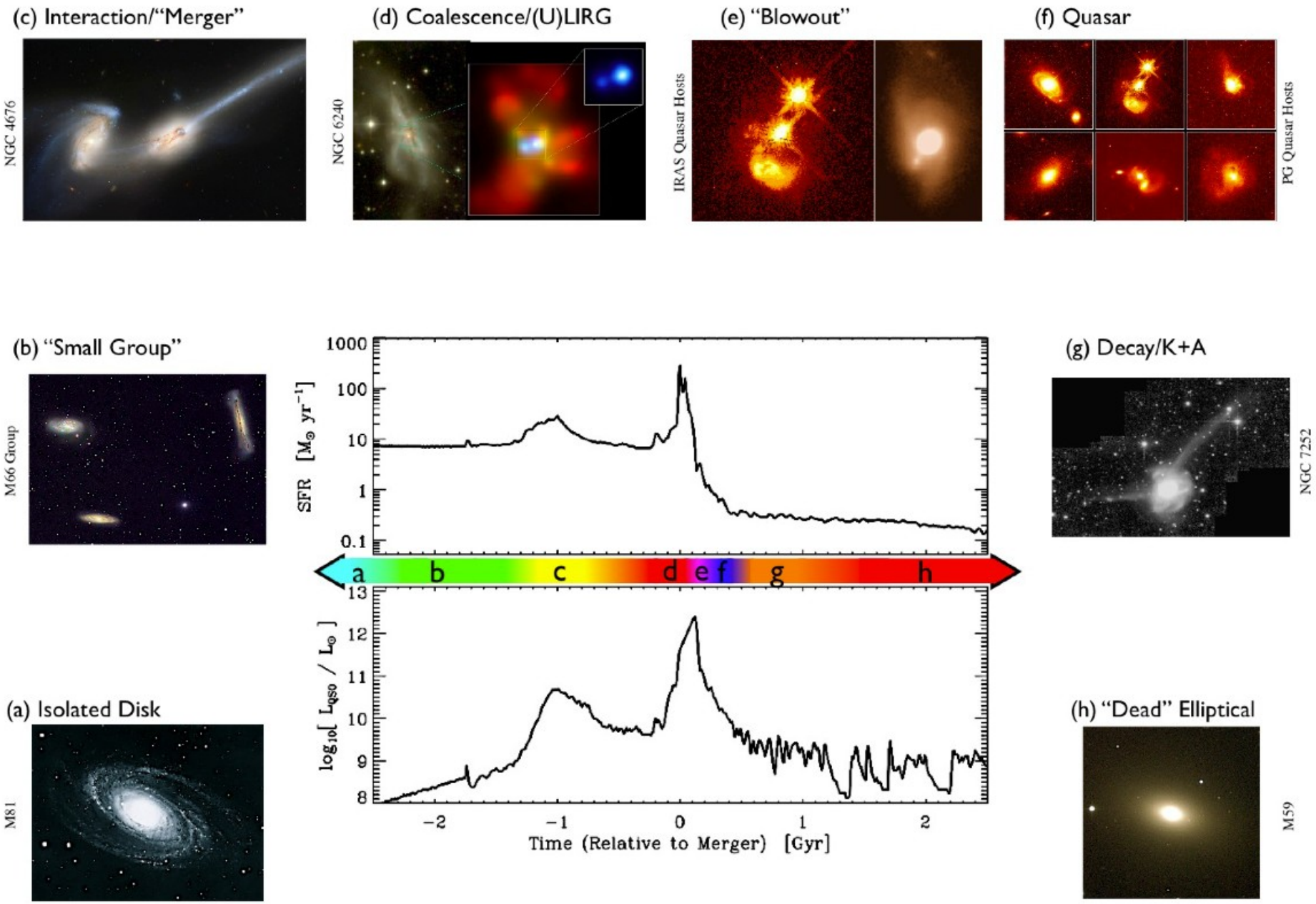
# Unified AGN model




Schawinski et al. 2008

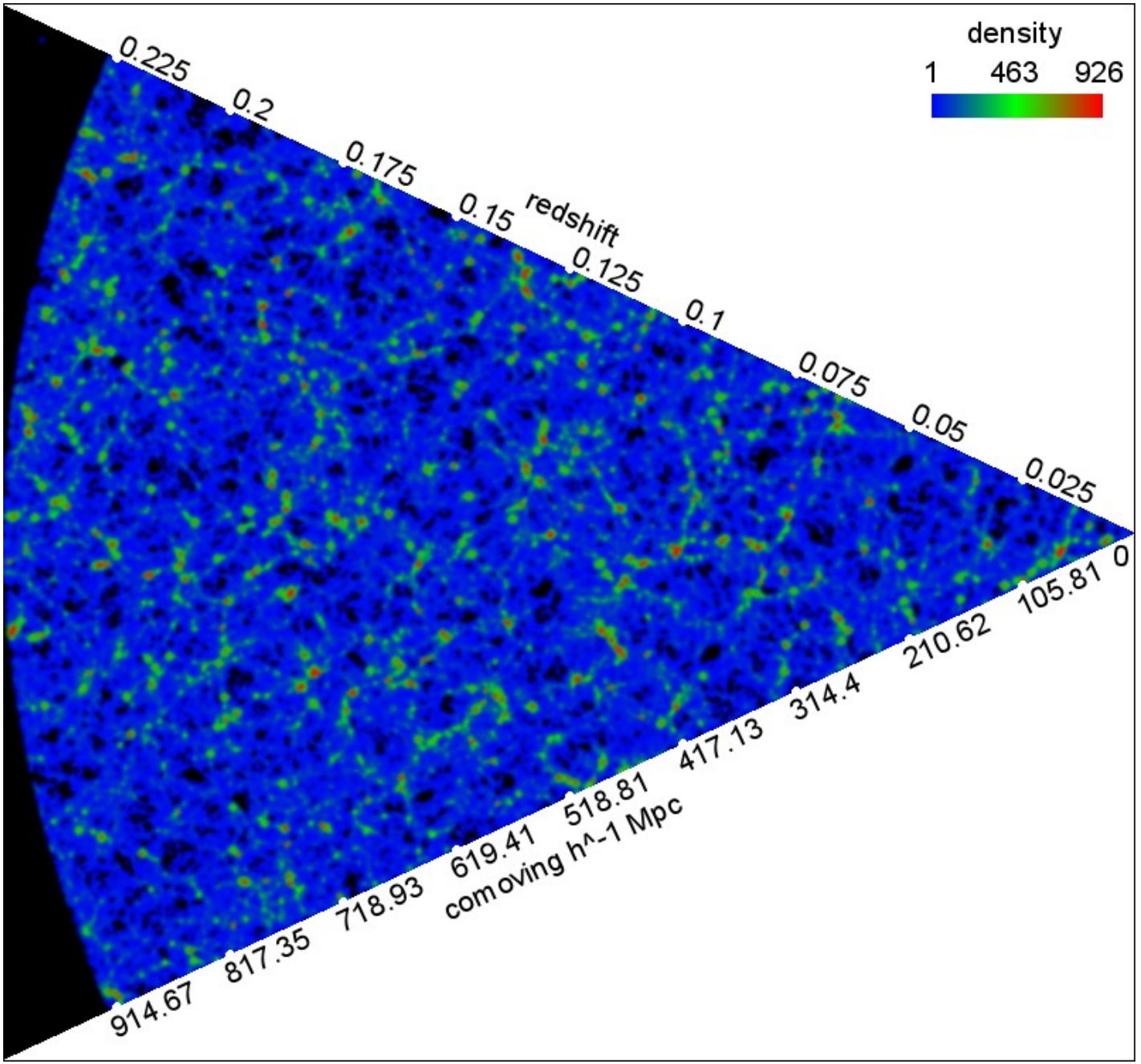
# Quasar light curve



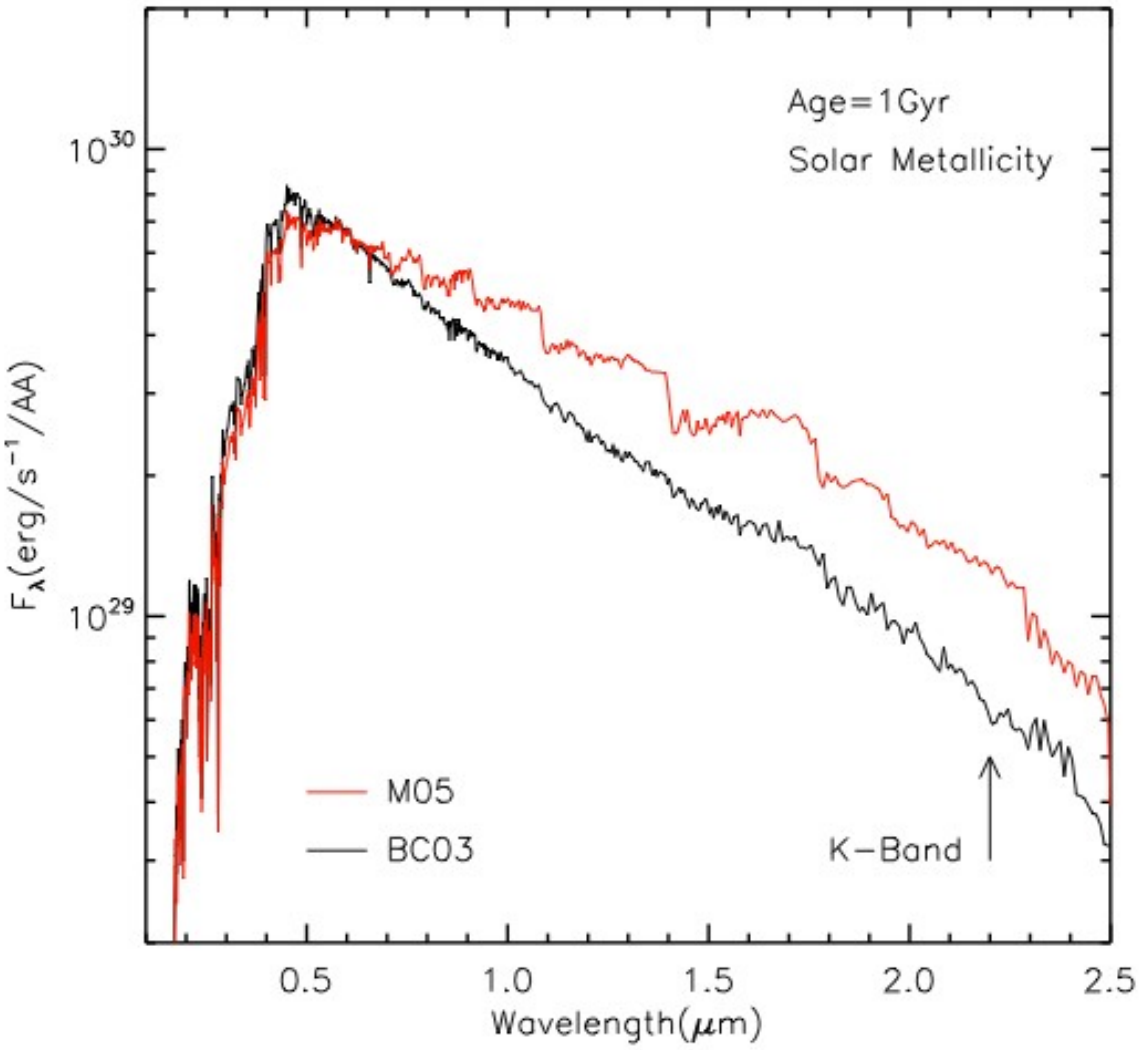

Hopkins et al. 2008

- The Mock Galaxy Factory is public
- SEDs are in progress
- More DM simulations and Galaxy Models are in progress

- Unified semi-analytic prescription for different AGN regimes is required for better understanding of the SMBH and galaxy co-evolution


density
1
463
926
0.225
0.2
0.175
0.15
redshift
0.125
0.1
0.075
0.05
0.025
0
105.81
210.62
314.4
417.13
518.81
619.41
718.93
817.35
914.67
comoving h^-1 Mpc

# SSP SED with and without TP-AGB evolutionary phase



Output -

Core Properties:

- [x] Redshift real
- [ ] Redshift observed
- [x] Coordinates (RA, Dec)

Halo Properties:

- [ ] Central Halo Mvir
- [ ] Halo Mvir
- [ ] Halo Vvir
- [ ] Halo Velocity dispersion

Intrinsic Galaxy Properties:

- [ ] Galaxy Type
- [ ] Stellar Mass
- [ ] Bulge mass
- [ ] DiskRadius

Galaxy Luminosities:

- [ ] B (abs mag)
- [ ] V (abs mag)

select / deselect all

Miscellaneous -

Output format: HDF5

Email results to:

Submit