Constraining Feedback and Dust at z ≈ 1 using Microwave Observations

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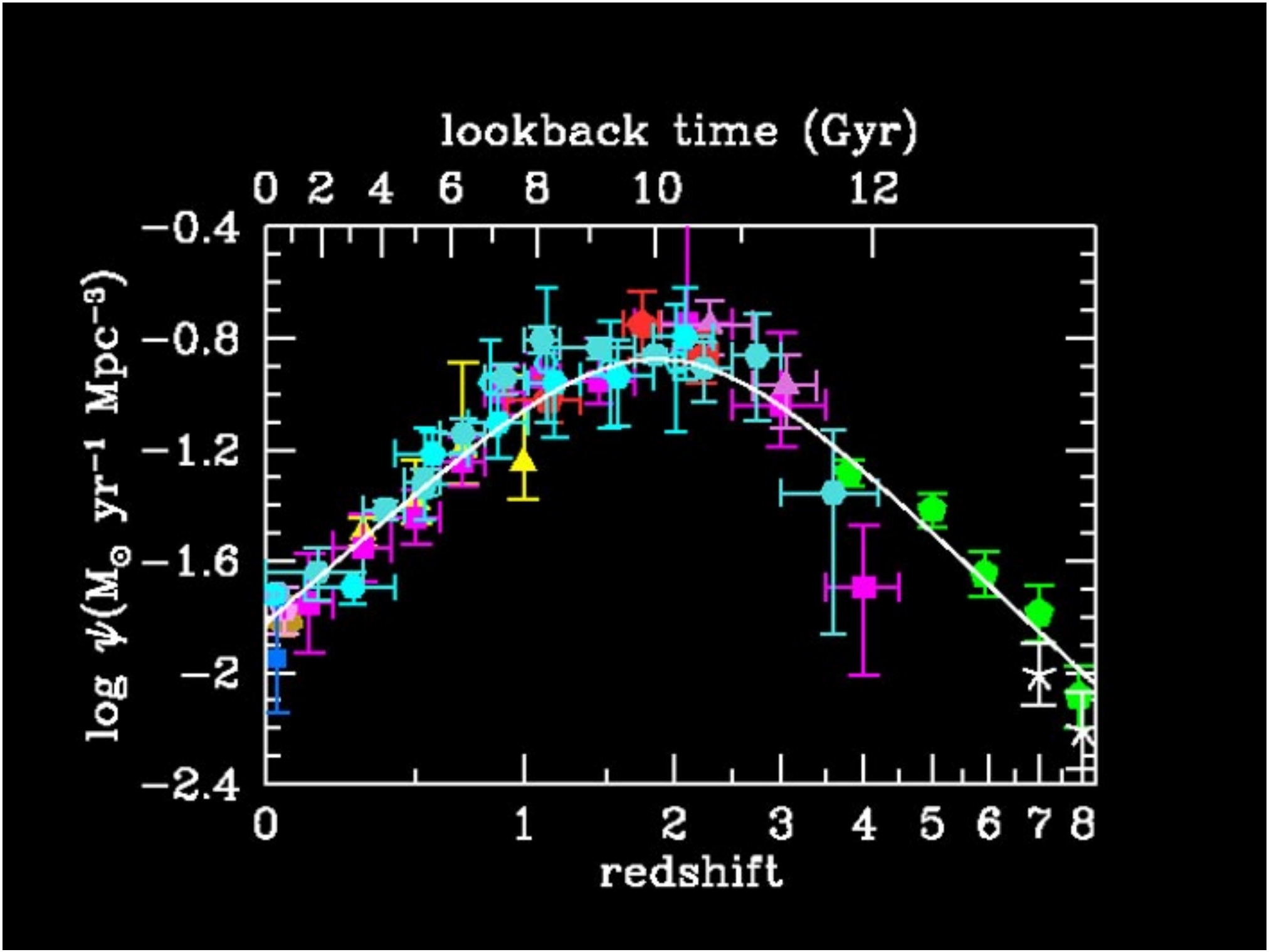
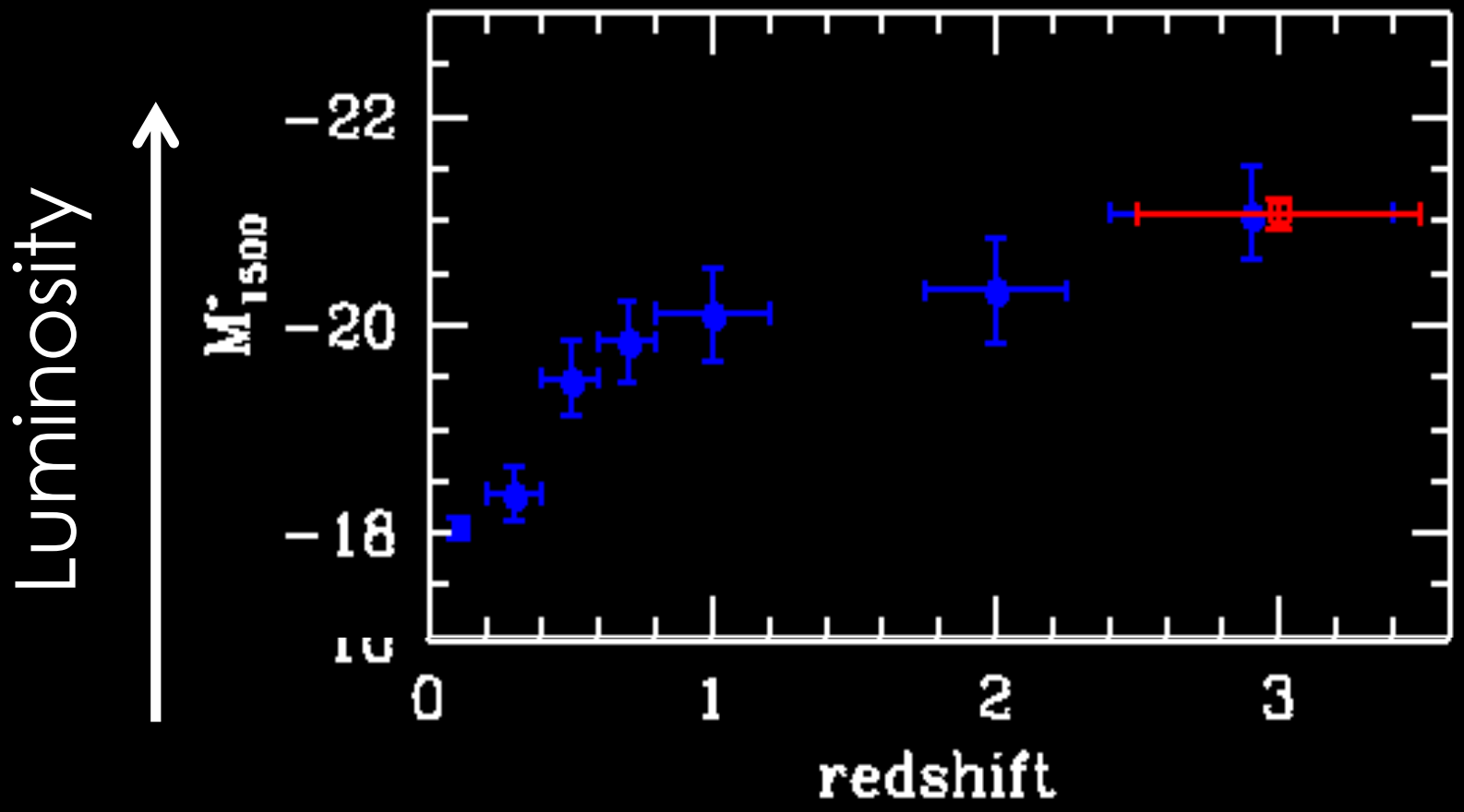
Arizona State University

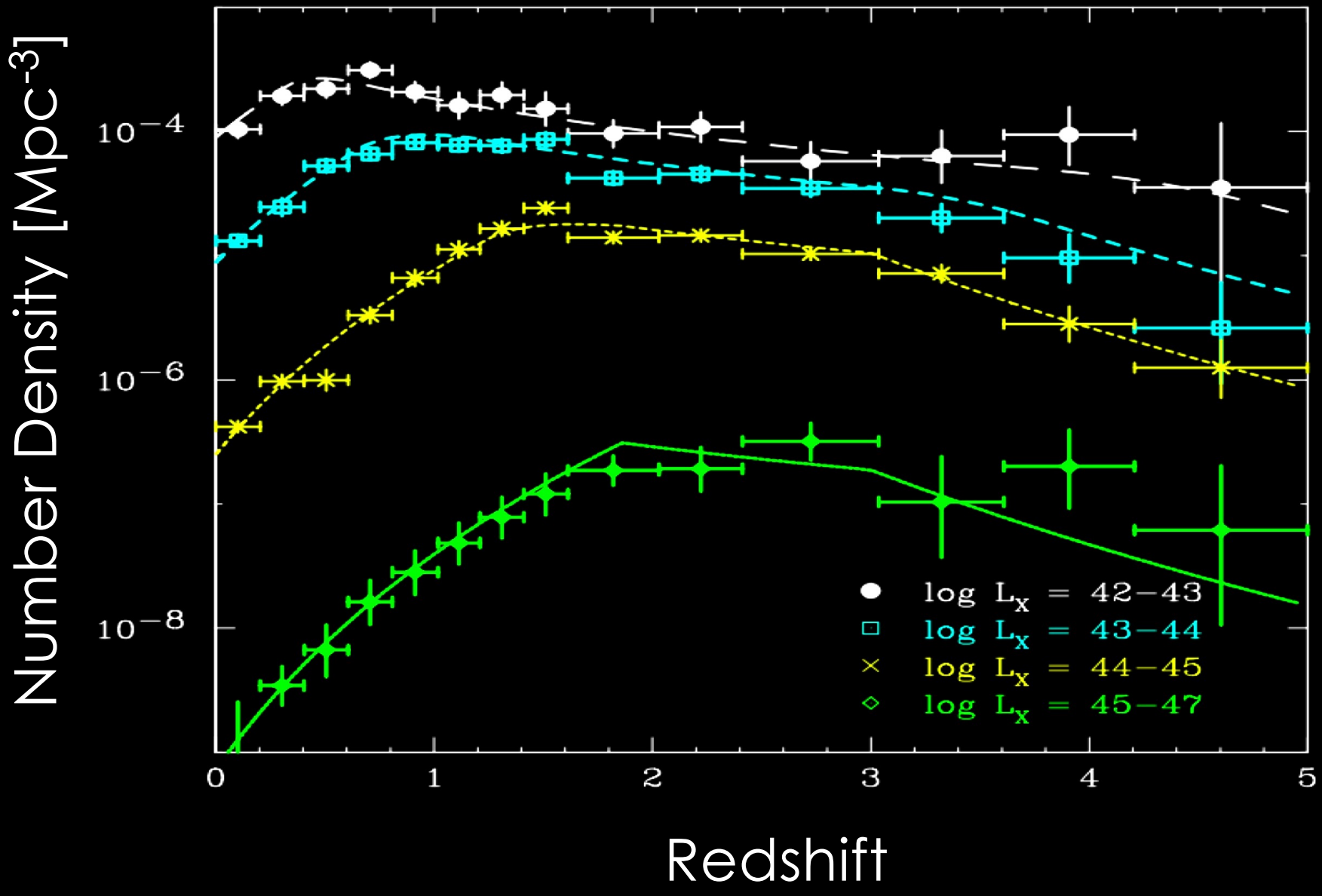

lookback time (Gyr)
0 2 4 6 8 10 12
−0.4
−0.8
−1.2
−1.6
−2
−2.4
log ψ(M⊙ yr⁻¹ Mpc⁻³)
0 1 2 3 4 5 6 7 8
redshift

Antihierarchical Evolution-"Downsizing"

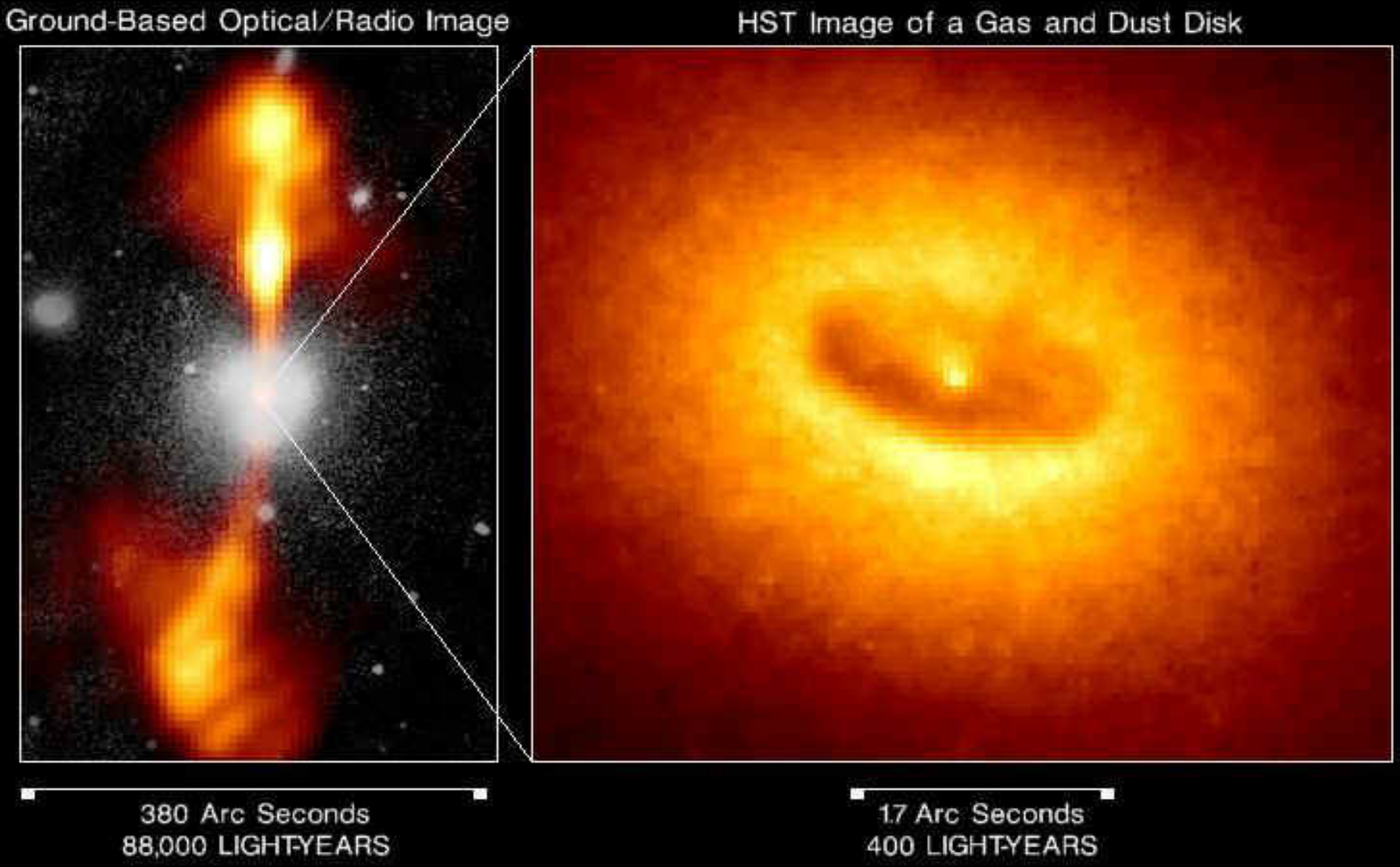


Arnouts etal (2005)

Active Black Hole Evolution Over Time



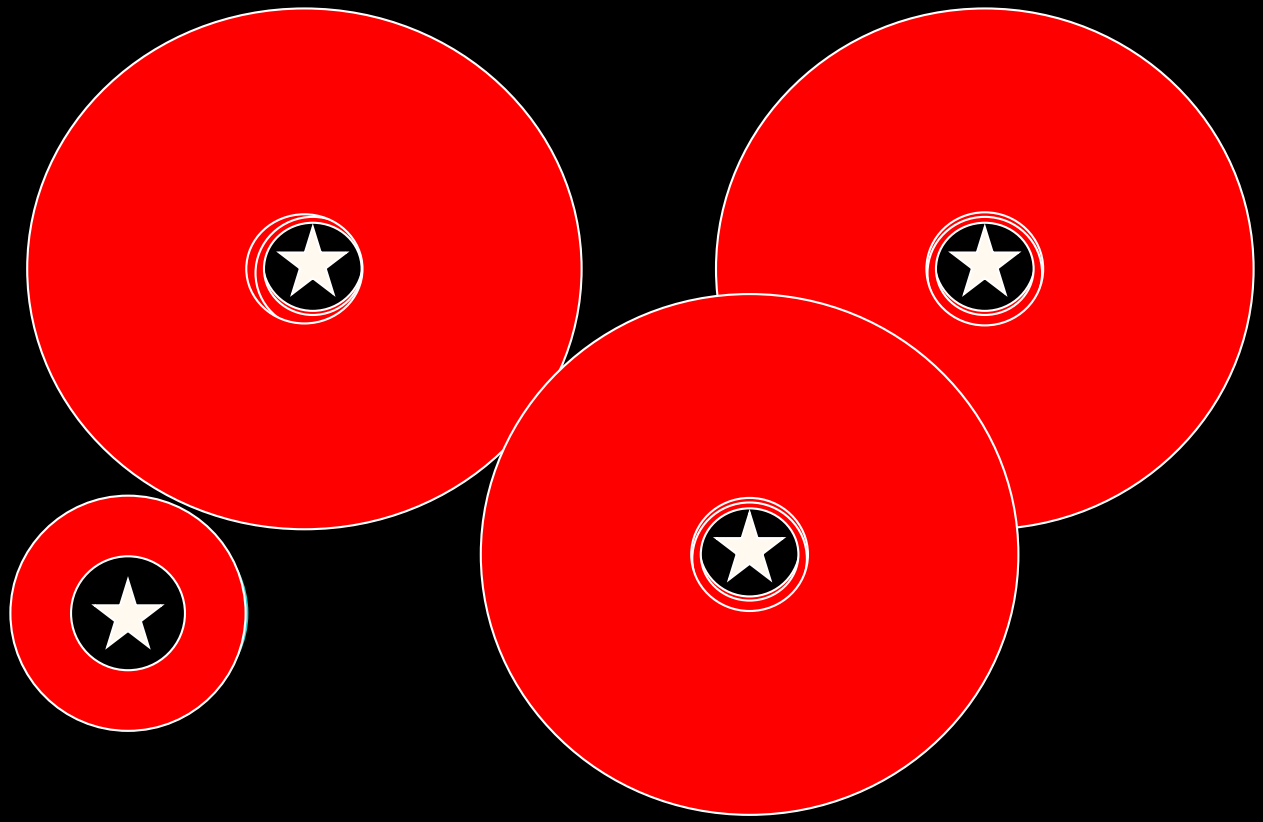
AGN host jets and winds, but overall energy Input history is still largely unknown



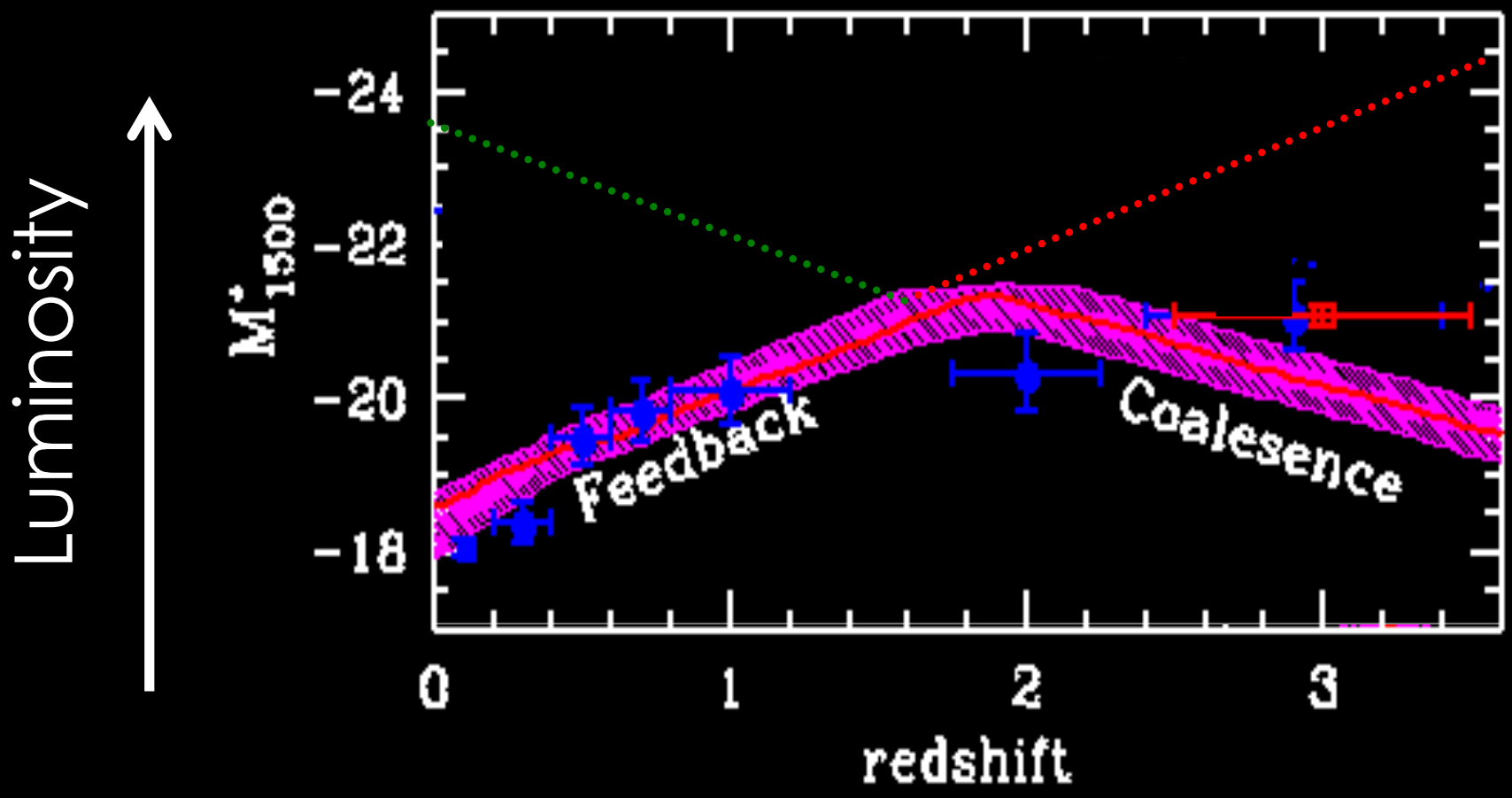
ES & Oh (2004) model

- Assume some small fraction, ε_k=0.05 of an active black hole's luminosity is converted to mechanical input
- Energy deposited as heat into surrounding medium (Sedov-Taylor blast wave).
- Clustering between halos from Scannapieco & Barkana (2002) extension of Kaiser (1984), Bond et al. (1991), Lacey & Cole (1993), Mo & White (1996), etc..
- Post-shock entropy of the IGM directly impacts growth of further generations.

ES & Oh (2004) model



Downsizing

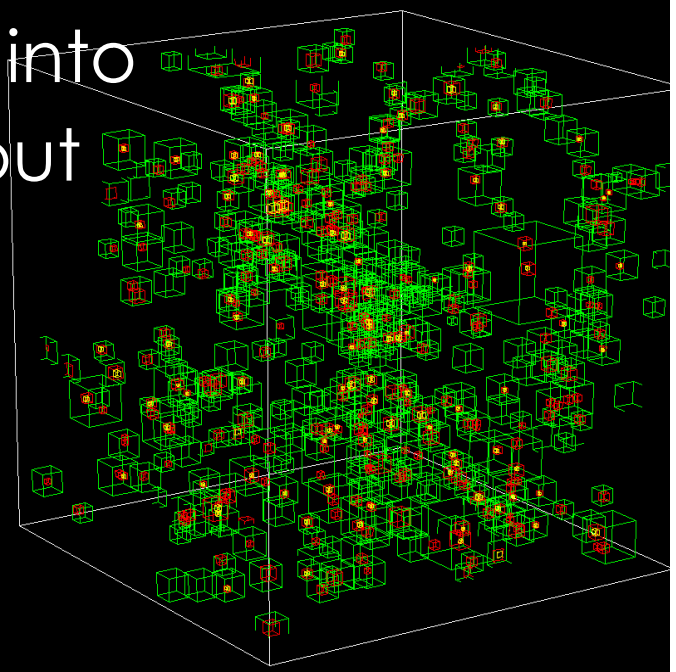


ES & Oh (2004)

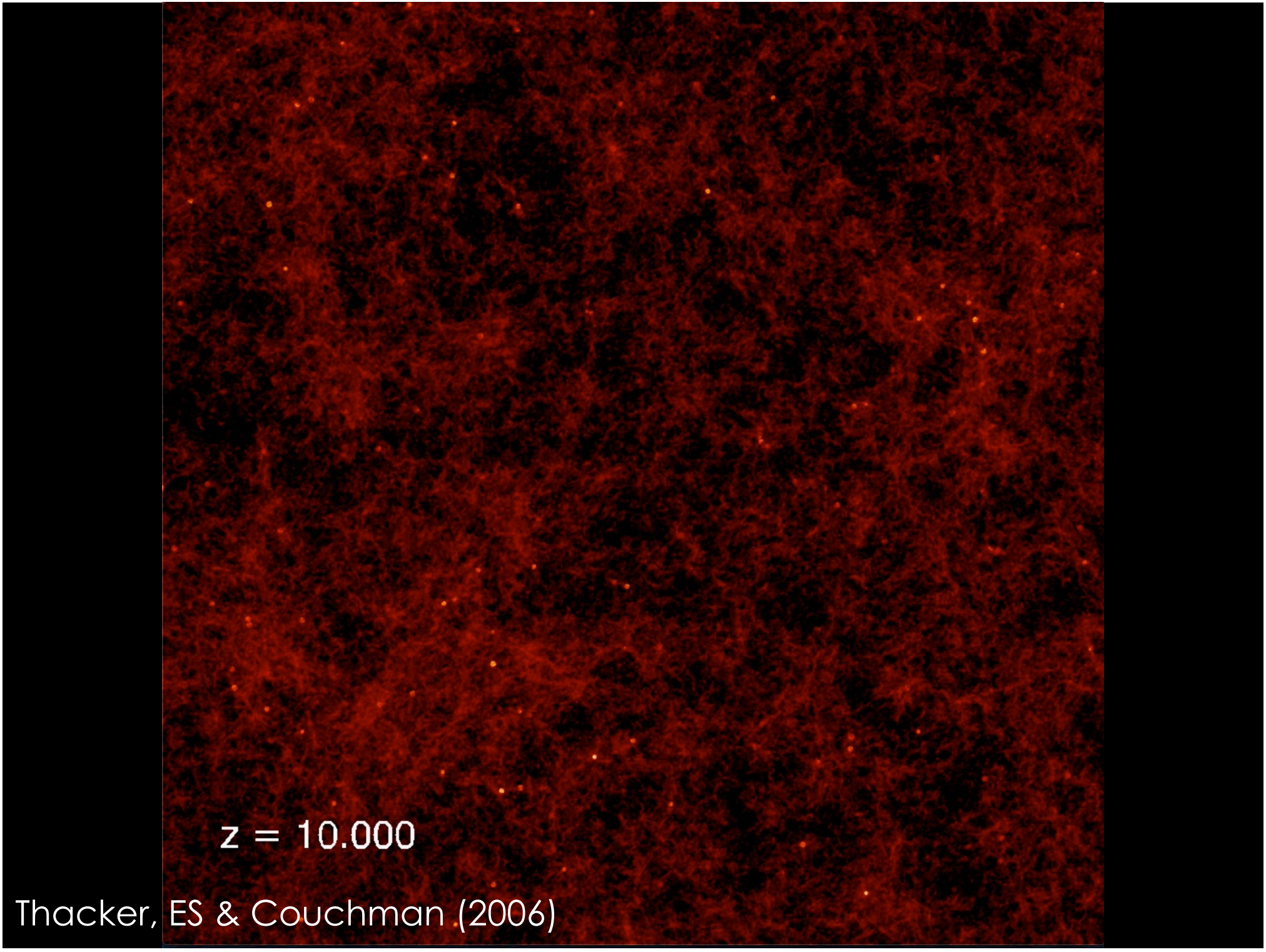
ES, Silk, & Bouwens (2005)

Full Numerical Simulation

- OpenMP version of the 'Hydra' SPH code
- 146 cMpc/h box, $2x640^3$ particles, to z=1.2
- $2x\ 640^3$ particles (2E8 Msun baryonic mass)
- Largest SPH simulation ever carried out at that time
- AGN are associated with mergers,
- ASSUME 5% of energy in light goes into outflows =>bursty, high energy input

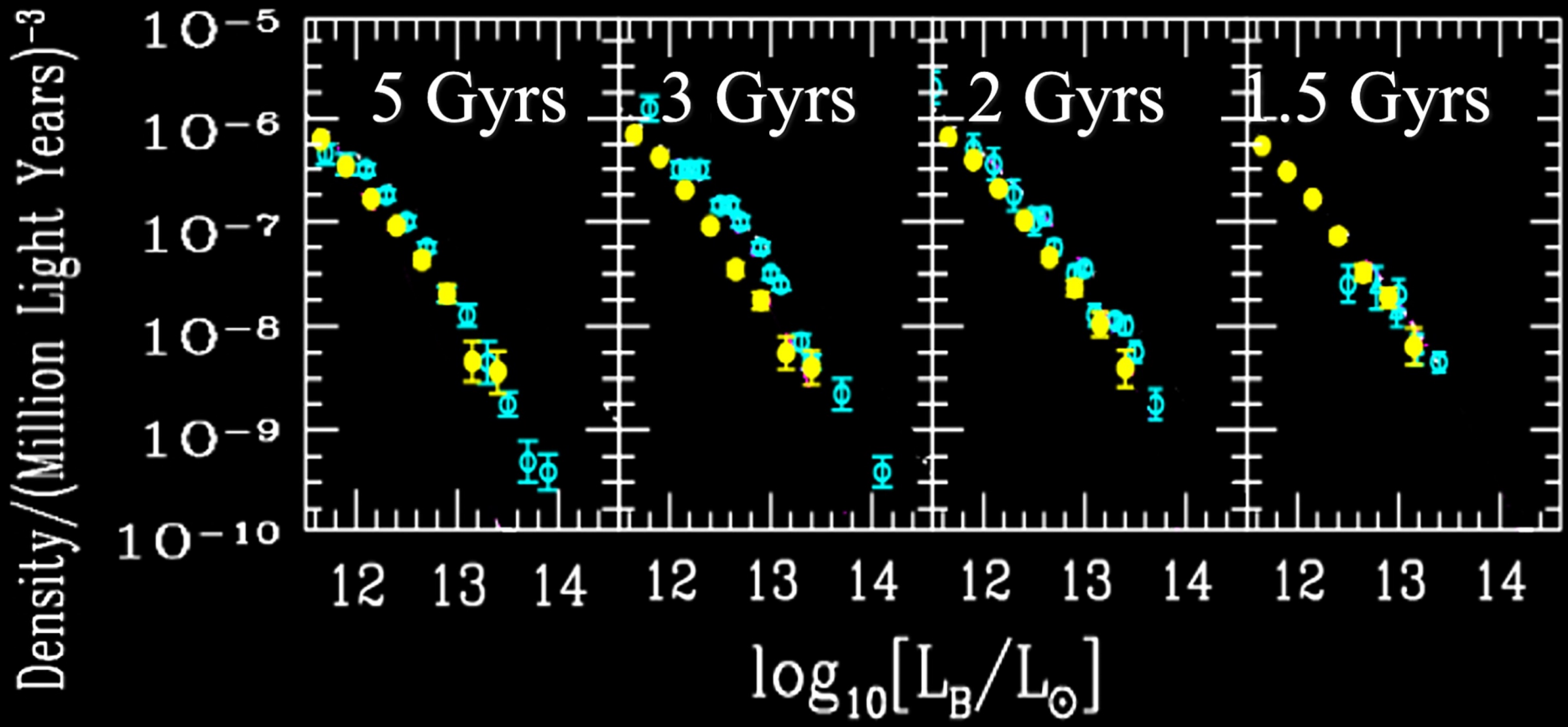


Thacker, ES & Couchman (2006)



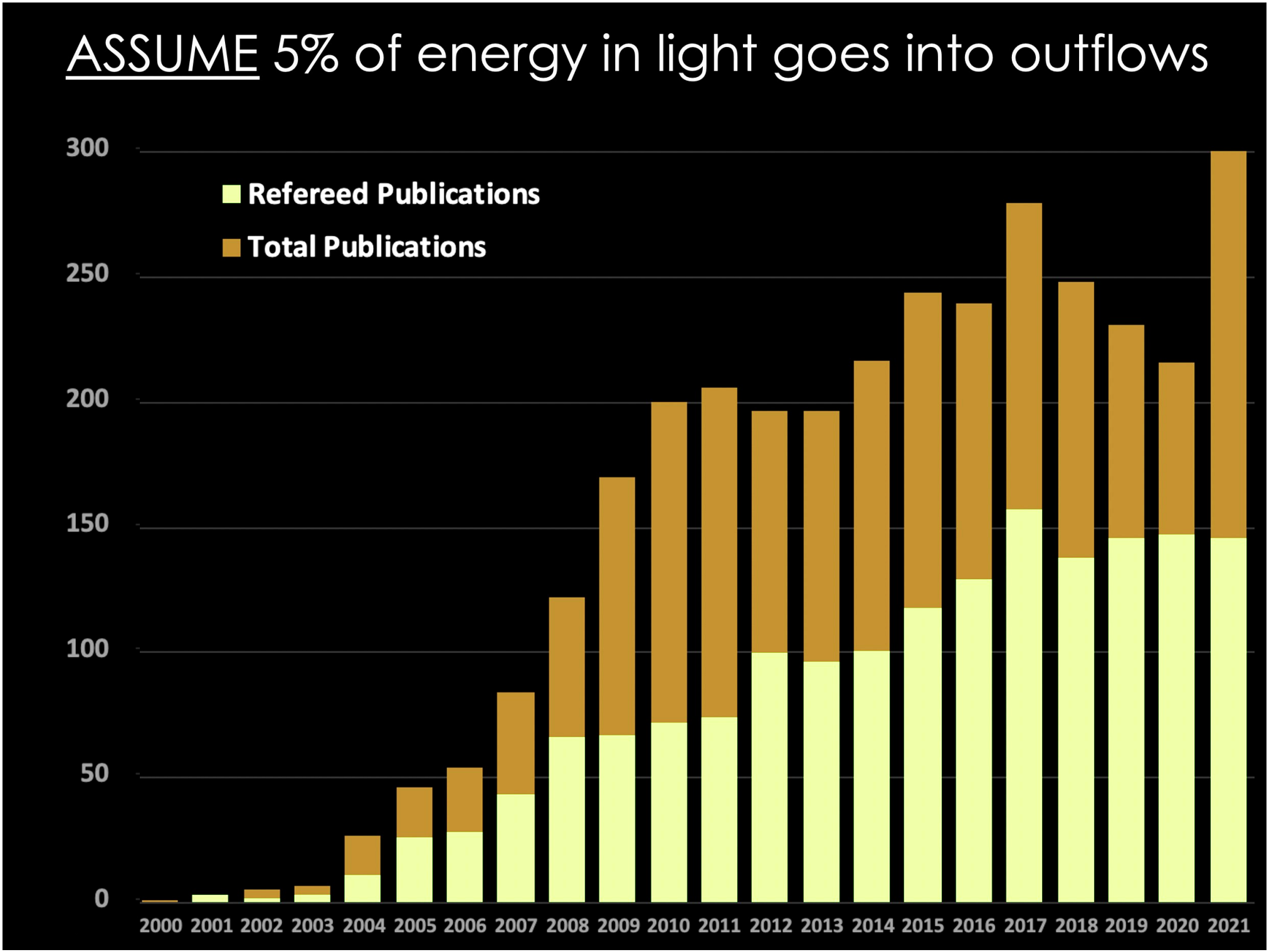
Thacker, ES & Couchman (2006)

Quasar Luminosity Function



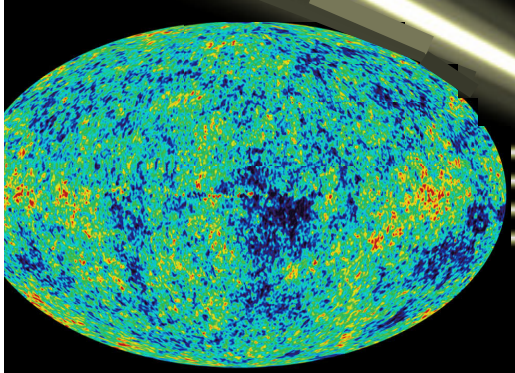
Thacker, ES & Couchman (2006)

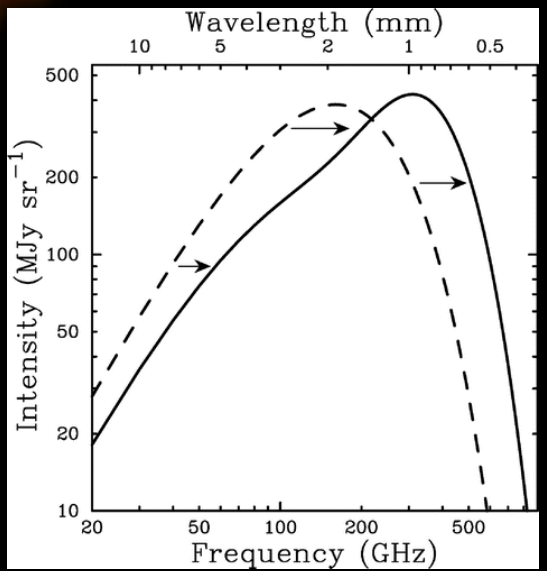
ASSUME 5% of energy in light goes into outflows



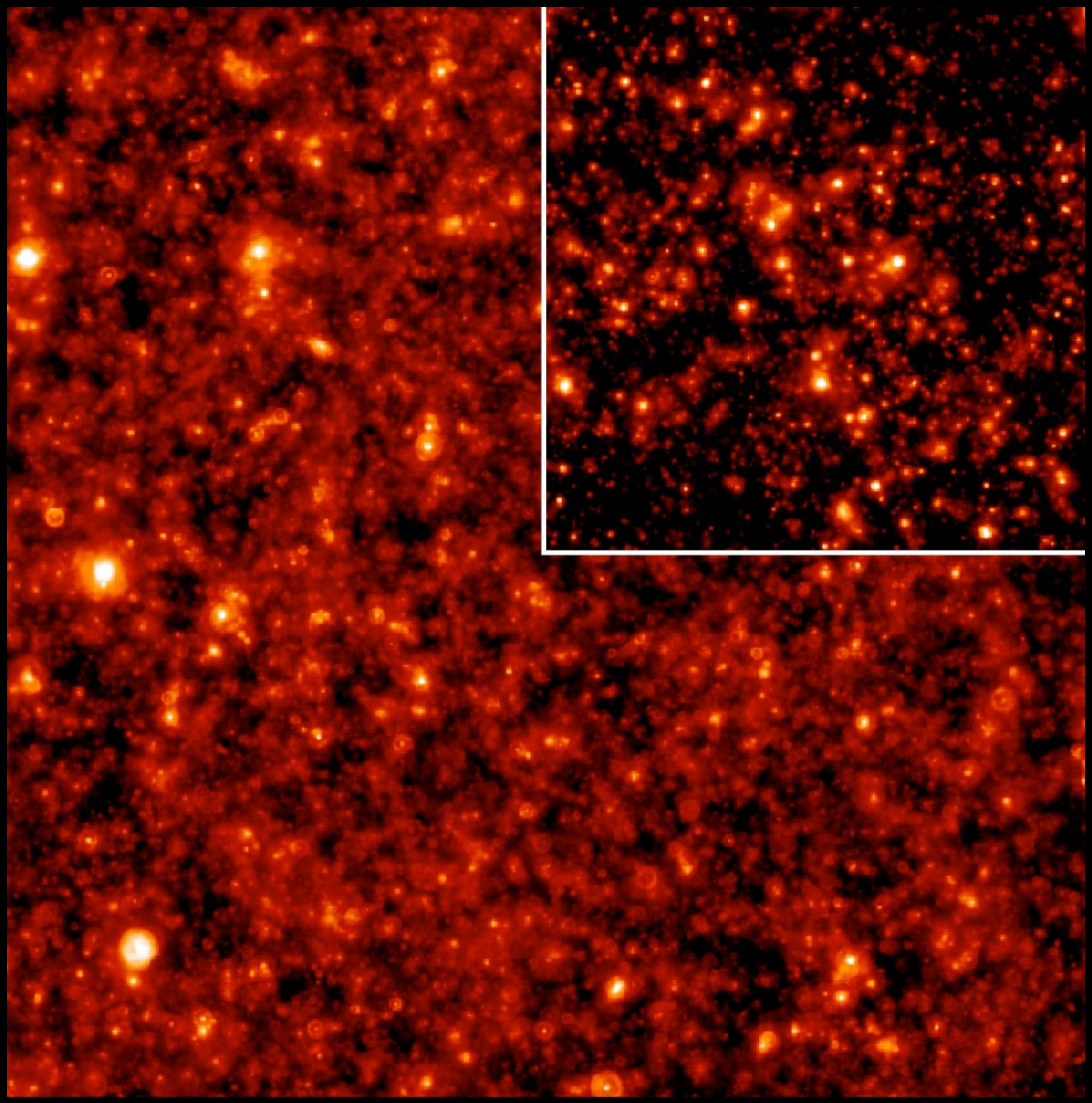
Thermal Sunyaev Zel'dovich Effect

Signal α Gas Density Along Sightline
× Temperature Along Sightline
= Pressure Along Sightline

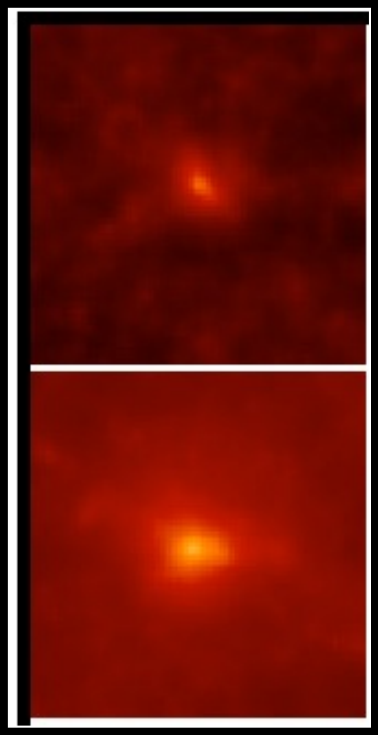




1.1 degree



6 arcmin

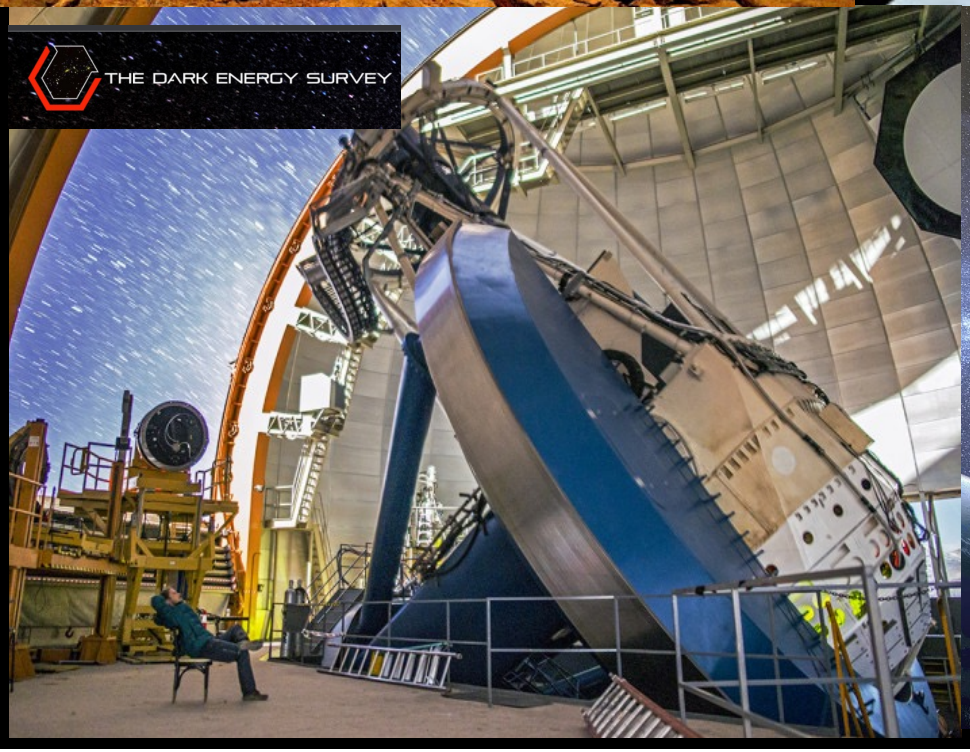


ES, Thacker, & Couchman (2008)

Sensitivity: ~10 μK
Beam: 1'-2' FWHM

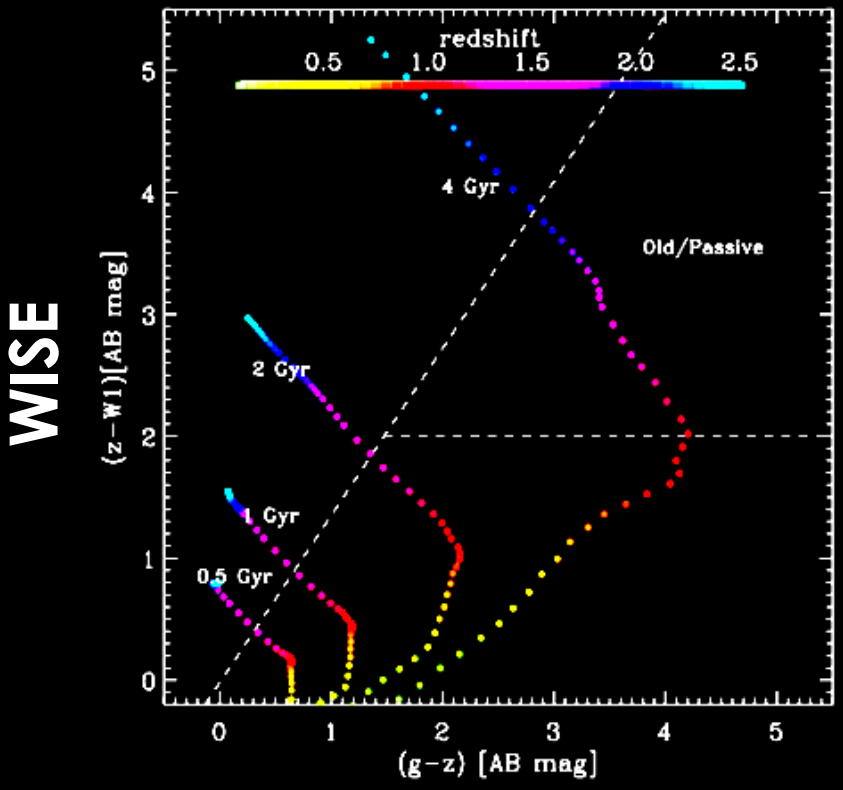
Atacama Cosmology Telescope

South Pole Telescope

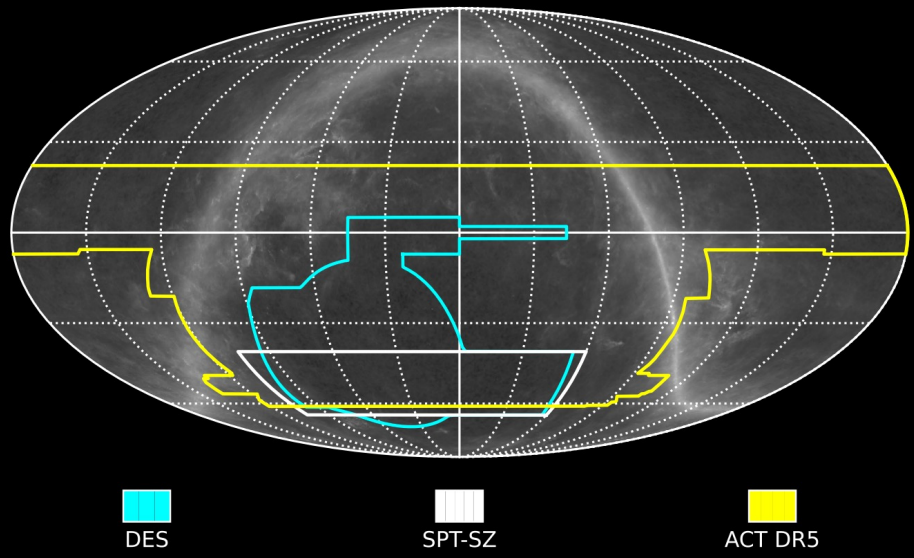


Selection and Sample

Seth Cohen



2,100 deg^2, 5,000 deg^2, 18,000 deg^2



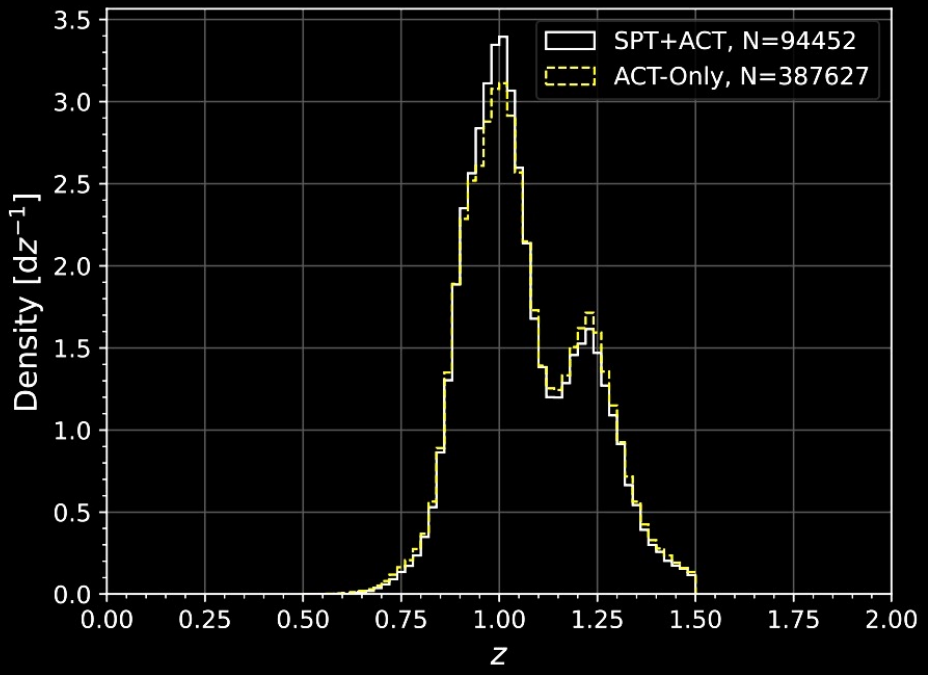
age > 1 Gyr , SSFR < 0.01 Gyr^{-1}

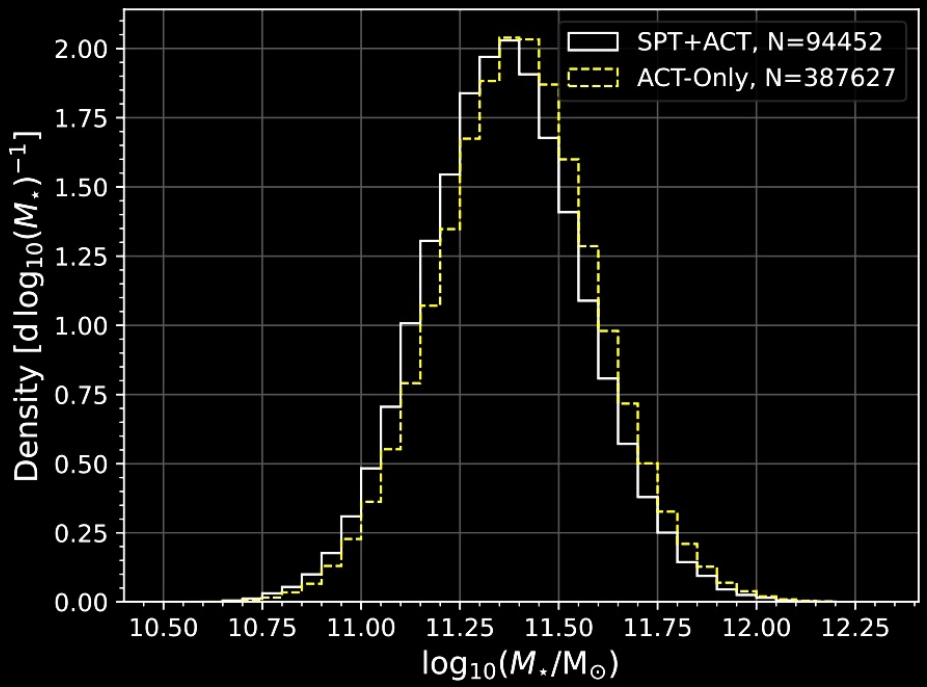
Catalog	N	z	$\log_{10}(\overline{M_\star}/M_\odot)$
SPT + ACT Overlap	94452	1.06	11.41
ACT Only	387627	1.07	11.44

J. Meinke et al. (2022)

Selection and Sample

Seth Cohen





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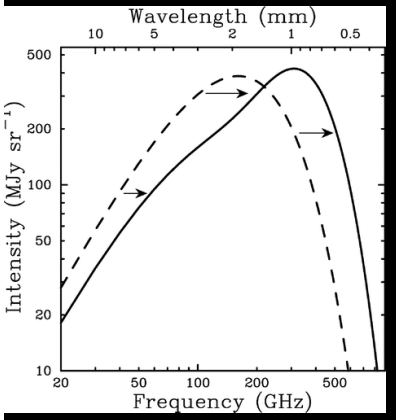
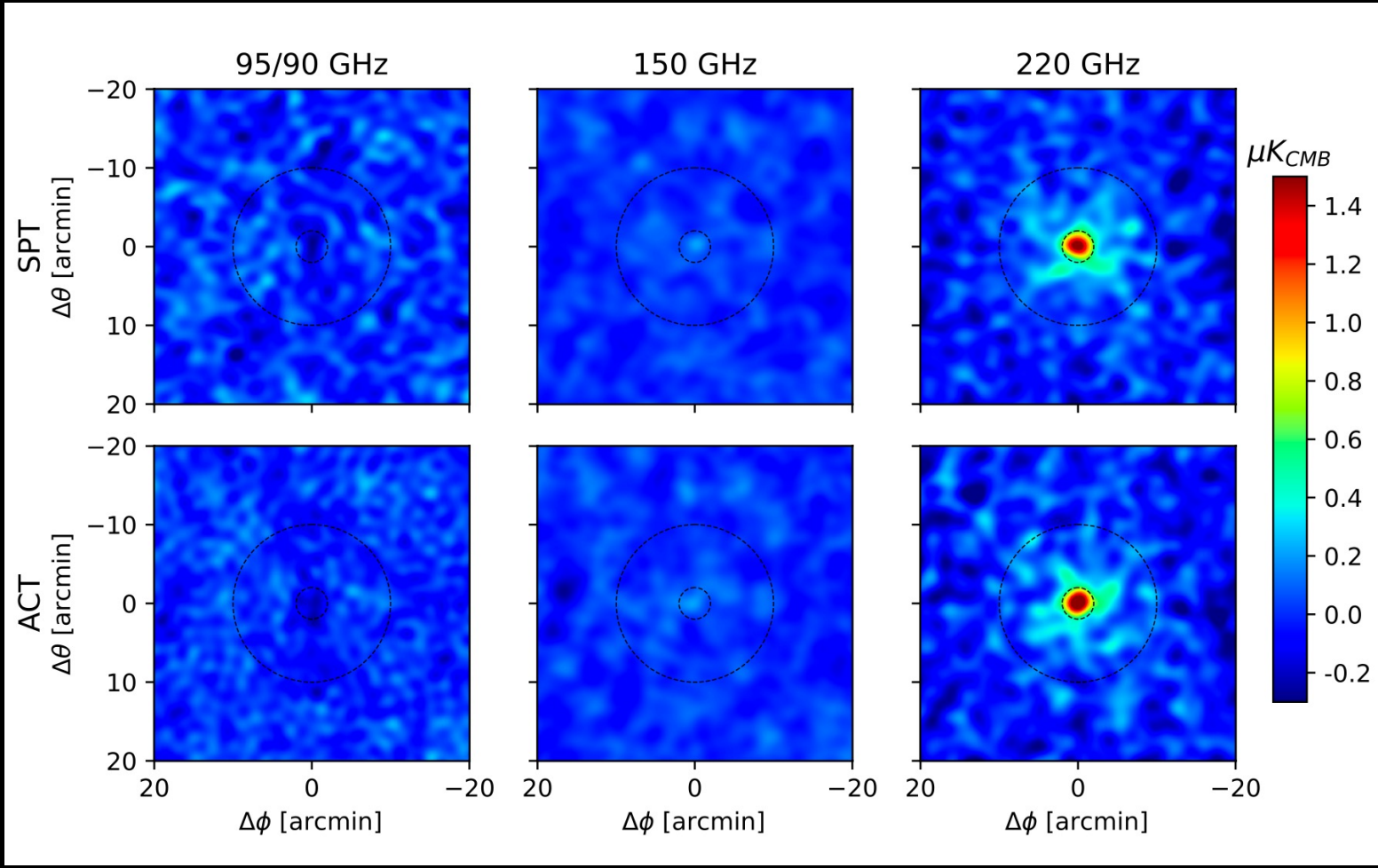
J. Meinke et al. (2022)

Stacked Signals in the Overlap Region

Jeremey Meinke

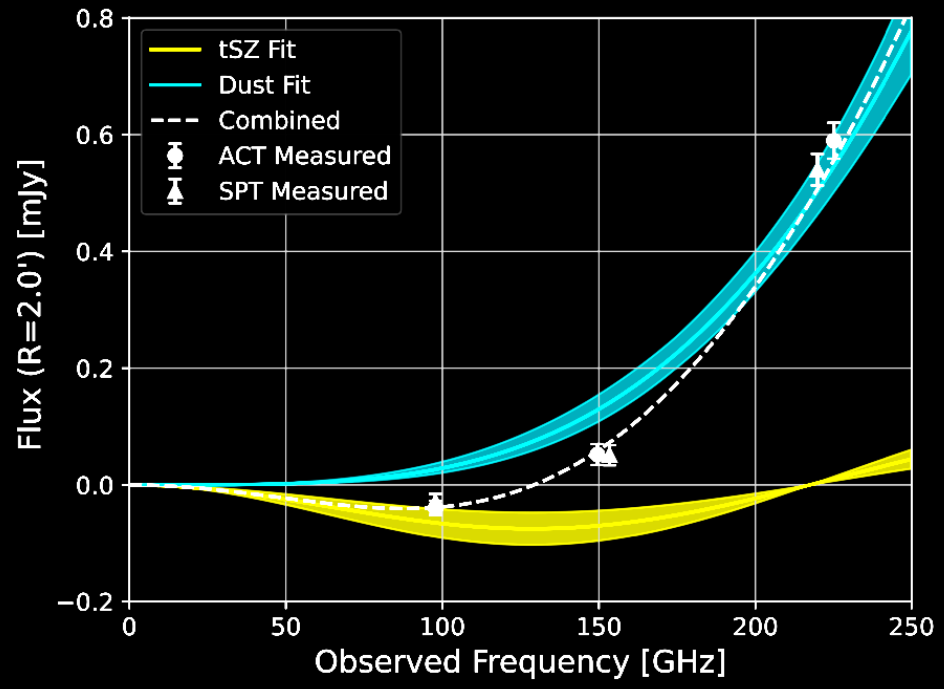


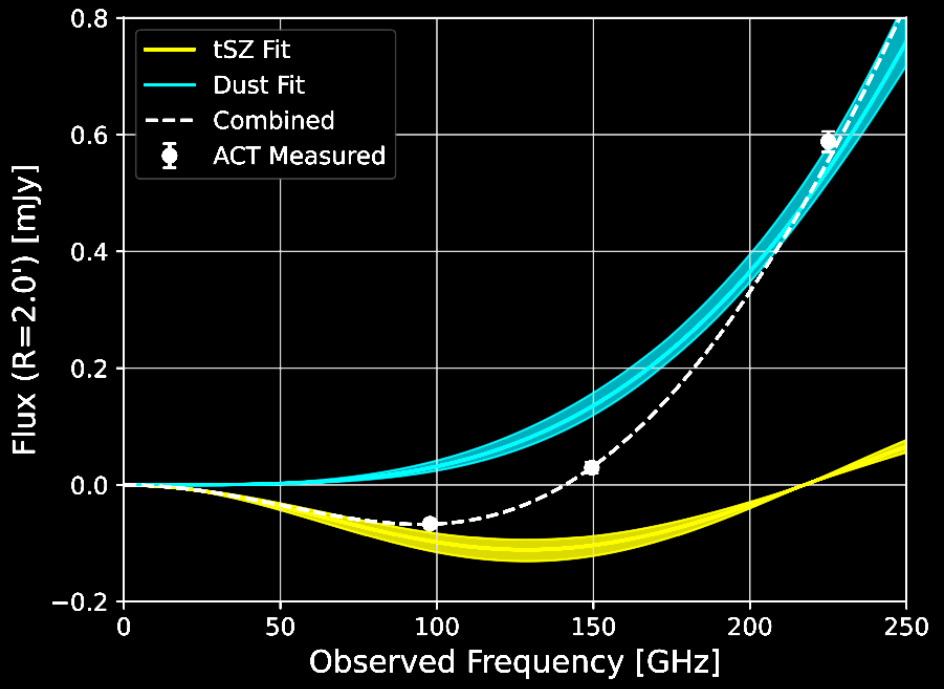


J. Meinke et al. (2022)

Two Component Fitting to Dust and tSZ

Jeremey Meinke



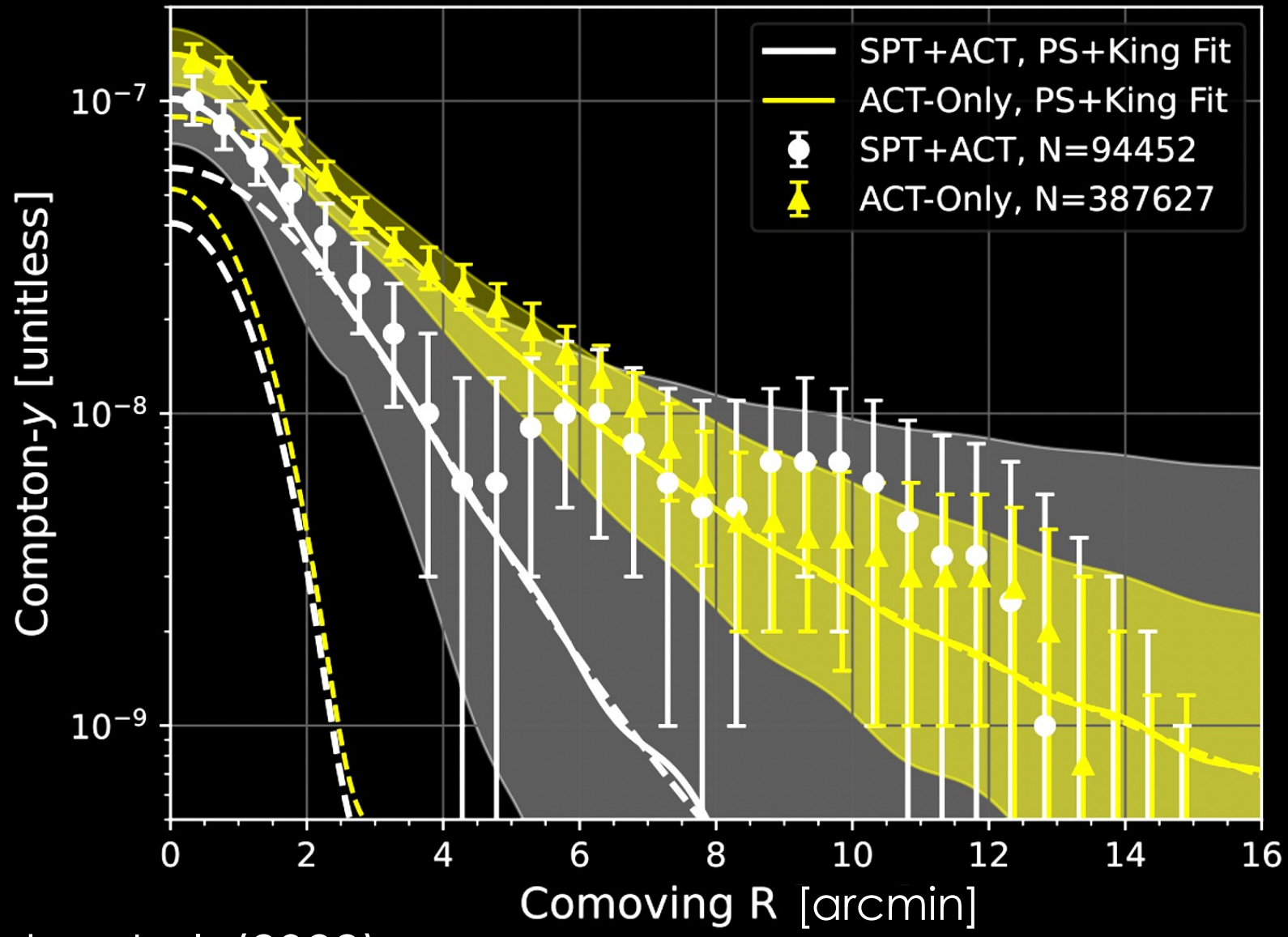


$$\beta = 1.75 \pm 0.25 \text{ and } T_{\text{dust}} = 20 \pm 5\text{K}$$

J. Meinke et al. (2022)

Stacked SZ Profiles

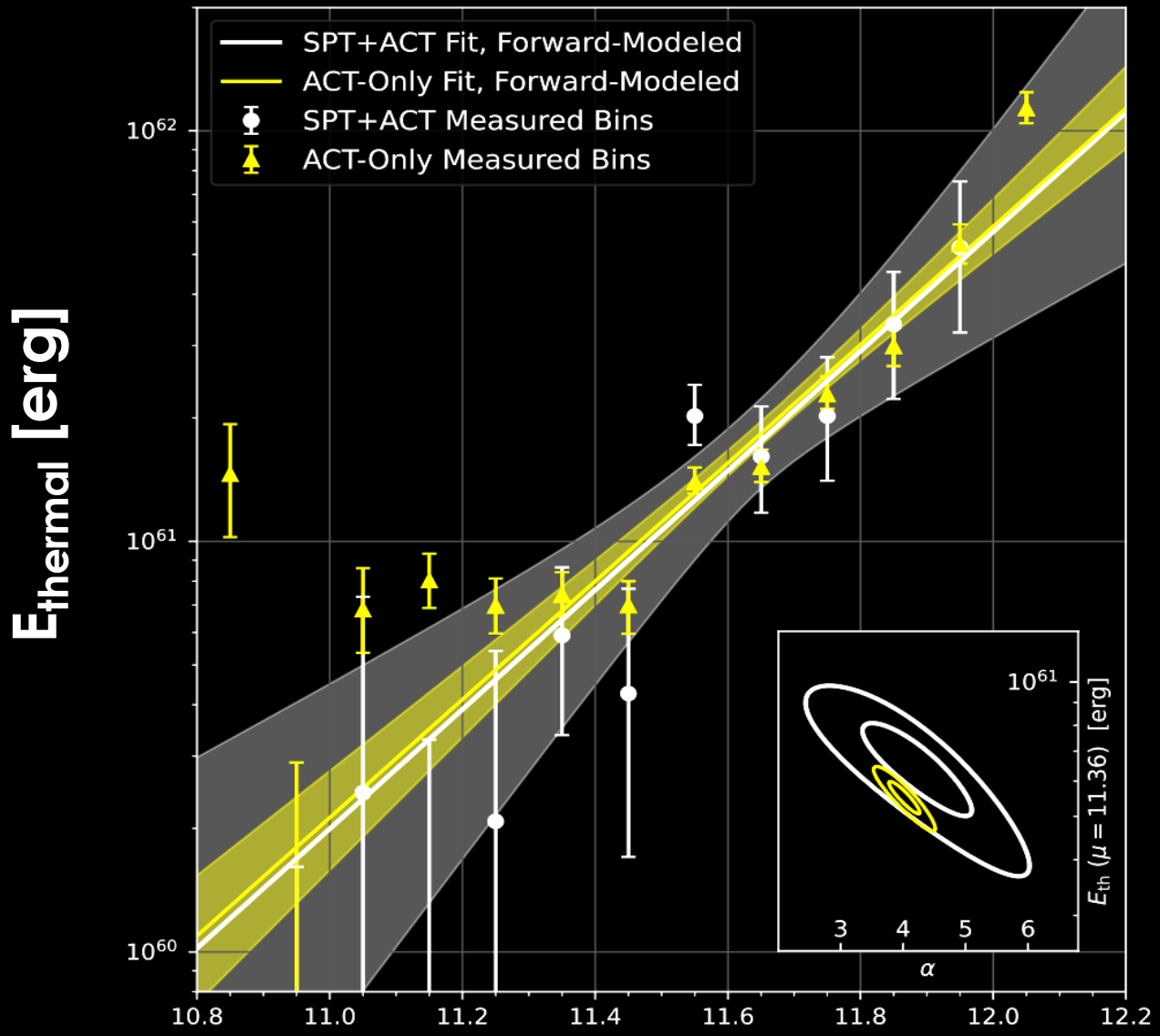
Jeremey Meinke



J. Meinke et al. (2022)

Jeremey Meinke

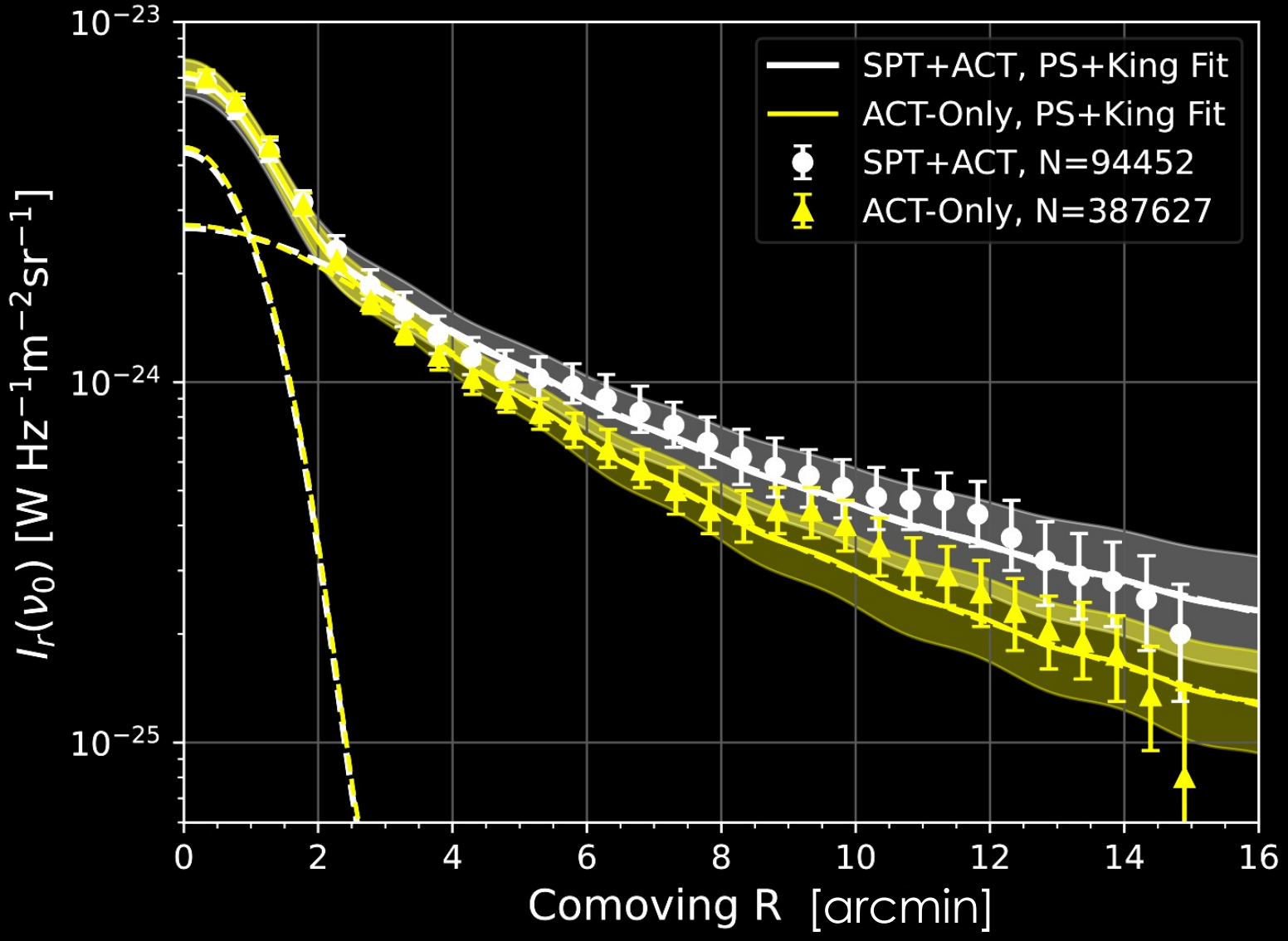
Total Thermal Energy (within R = 2.0′)



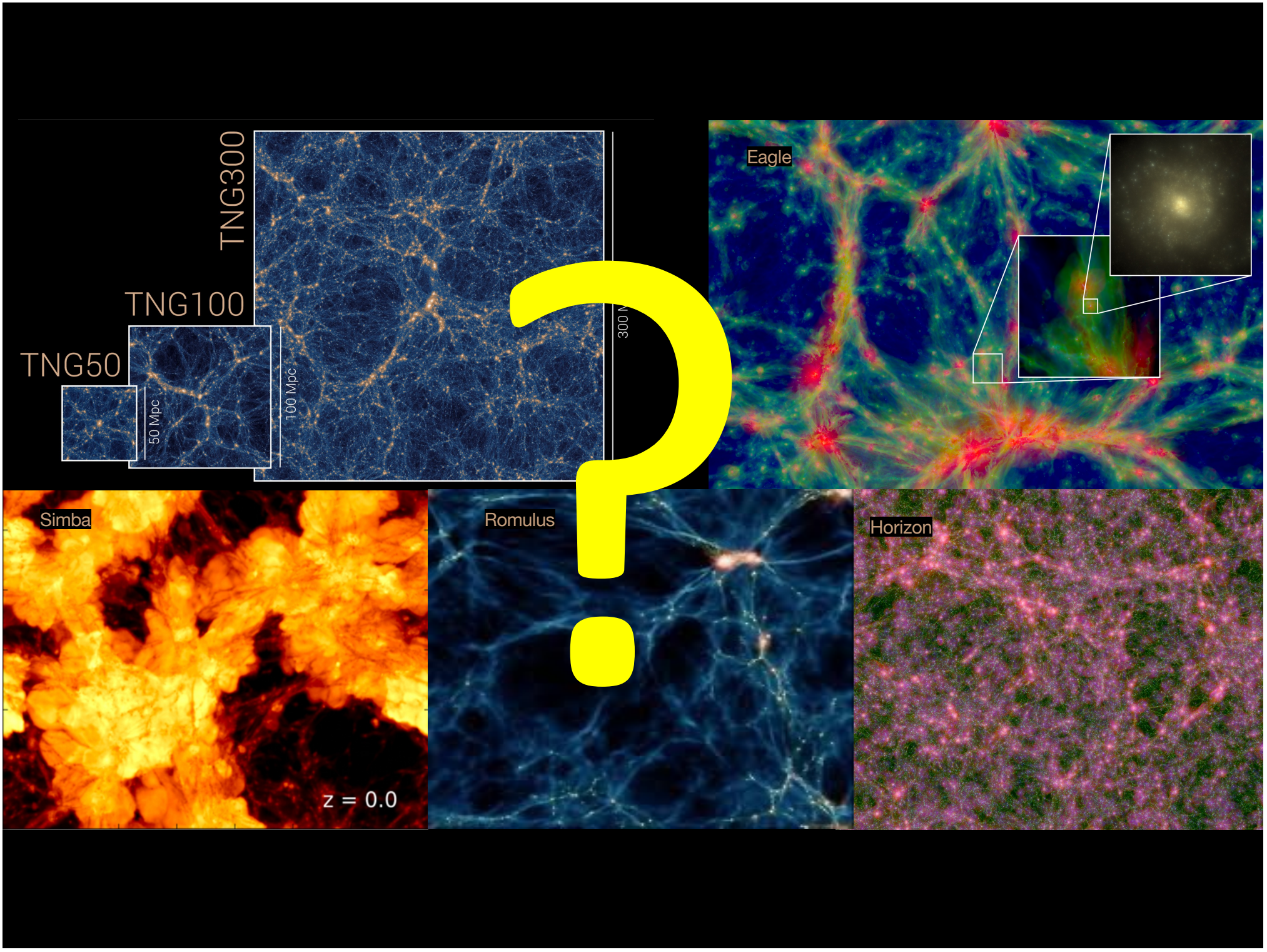
J. Meinke et al. (2022)

Jeremey Meinke

Stacked Dust Profiles

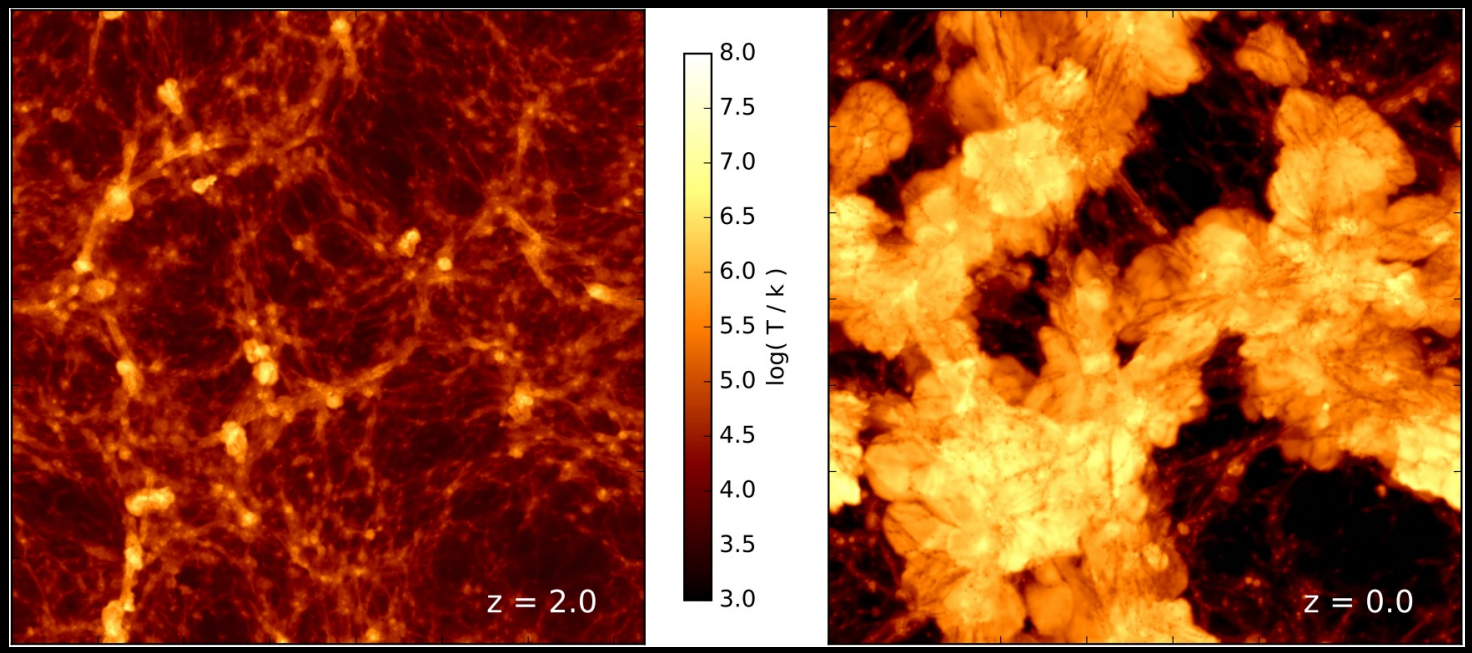


J. Meinke et al. (2022)


TNG300
TNG100
TNG50
50 Mpc
100 Mpc
300 M
Eagle
Simba
z = 0.0
Romulus
Horizon

SIMBA

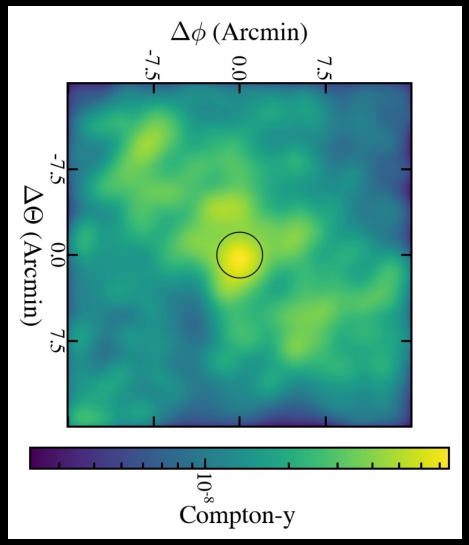
- MPI version of the GIZMO meshless code
- 100 cMpc/h box, 2 x1024^3 particles, to z=0 (2E7 Msun)
- Includes updates to Mufasa's sub-resolution star formation and feedback prescriptions.
- AGN are associated torque limited accretion (cold) / Bondi accretion (hot).
- 3-25% of energy in light goes into outflows depending L_{edd}

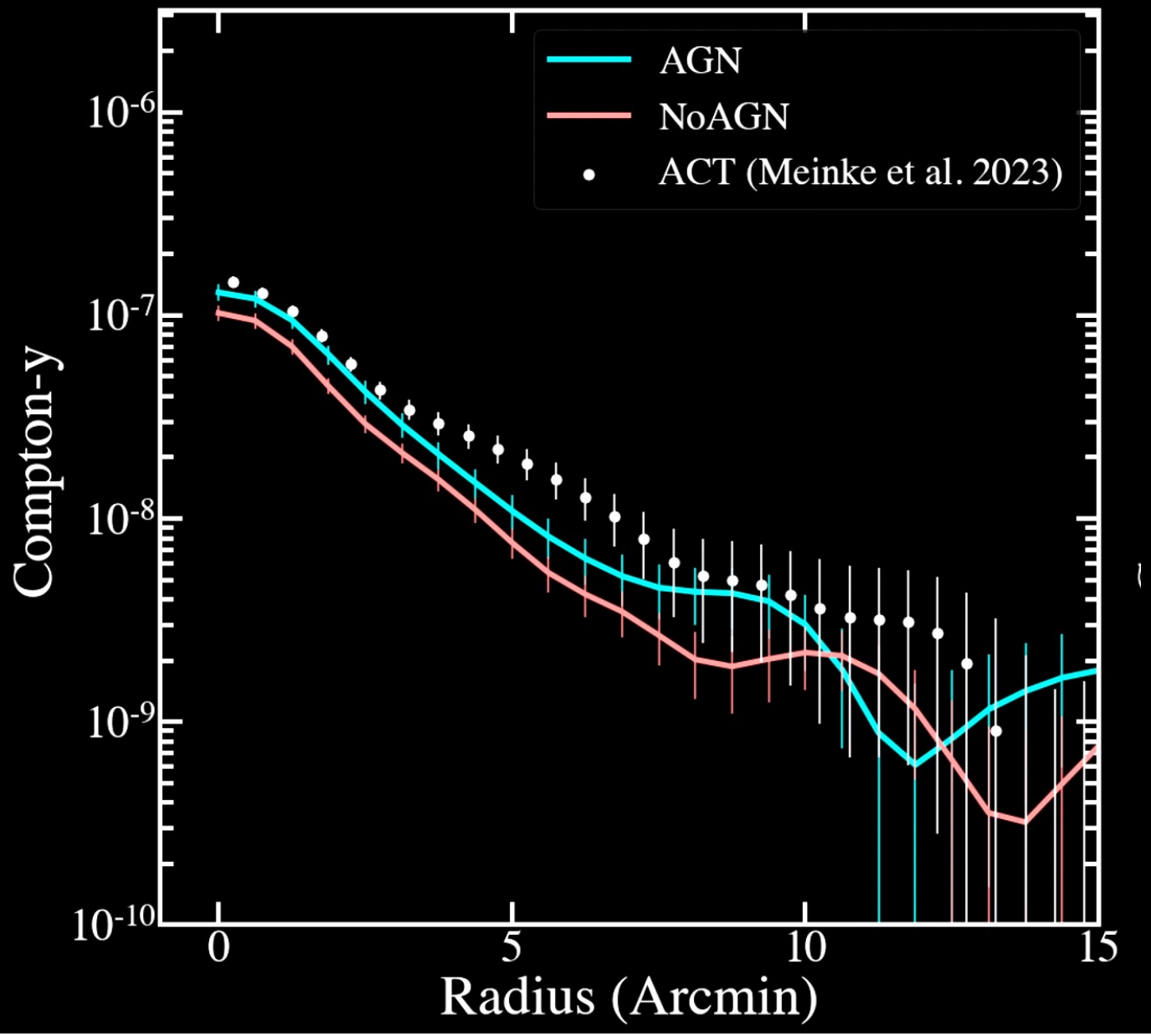


Davé et al (2019)

Stacking SZ Data from SIMBA

Skylar Grayson





TolTEC / Large Millimeter Telescope (LMT)

- 50-m diameter single dish telescope
- Located at 15,000 ft (4672 m)
  - Site on Sierra Negra in Puebla, MX
- Facility first light in 2011

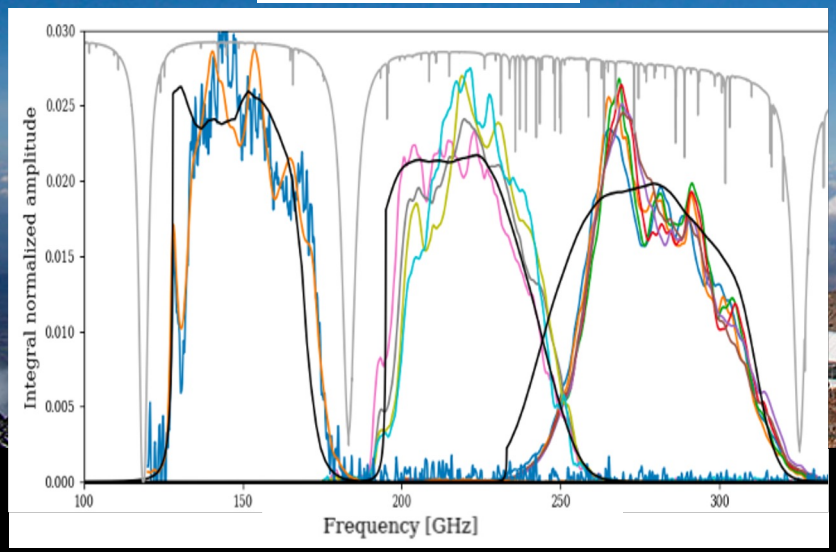
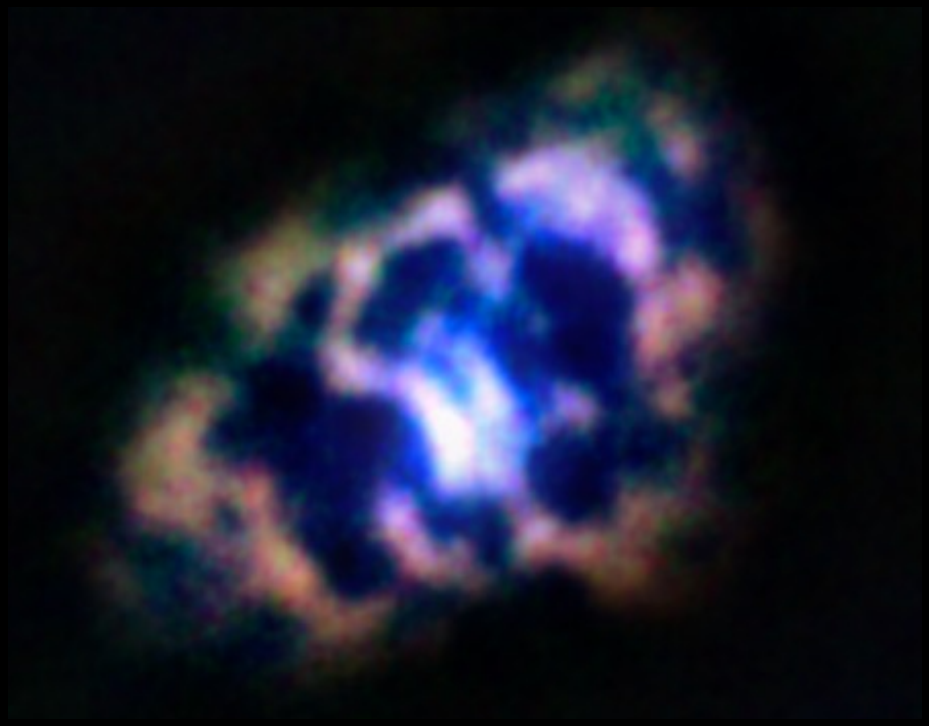


Image credit: Dario Lopez-Mills/AP PHOTO

Installing TolTEC



R. Gutermuth

N. Denigris

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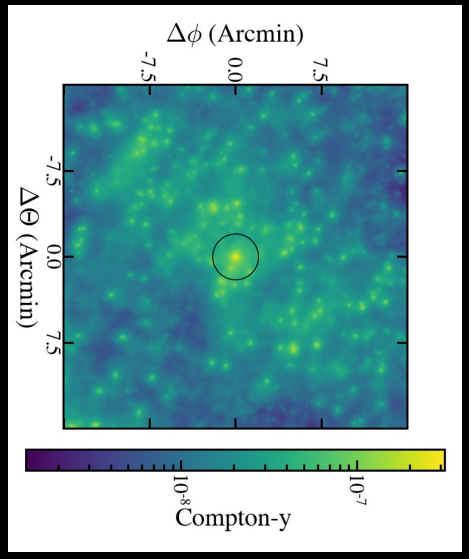

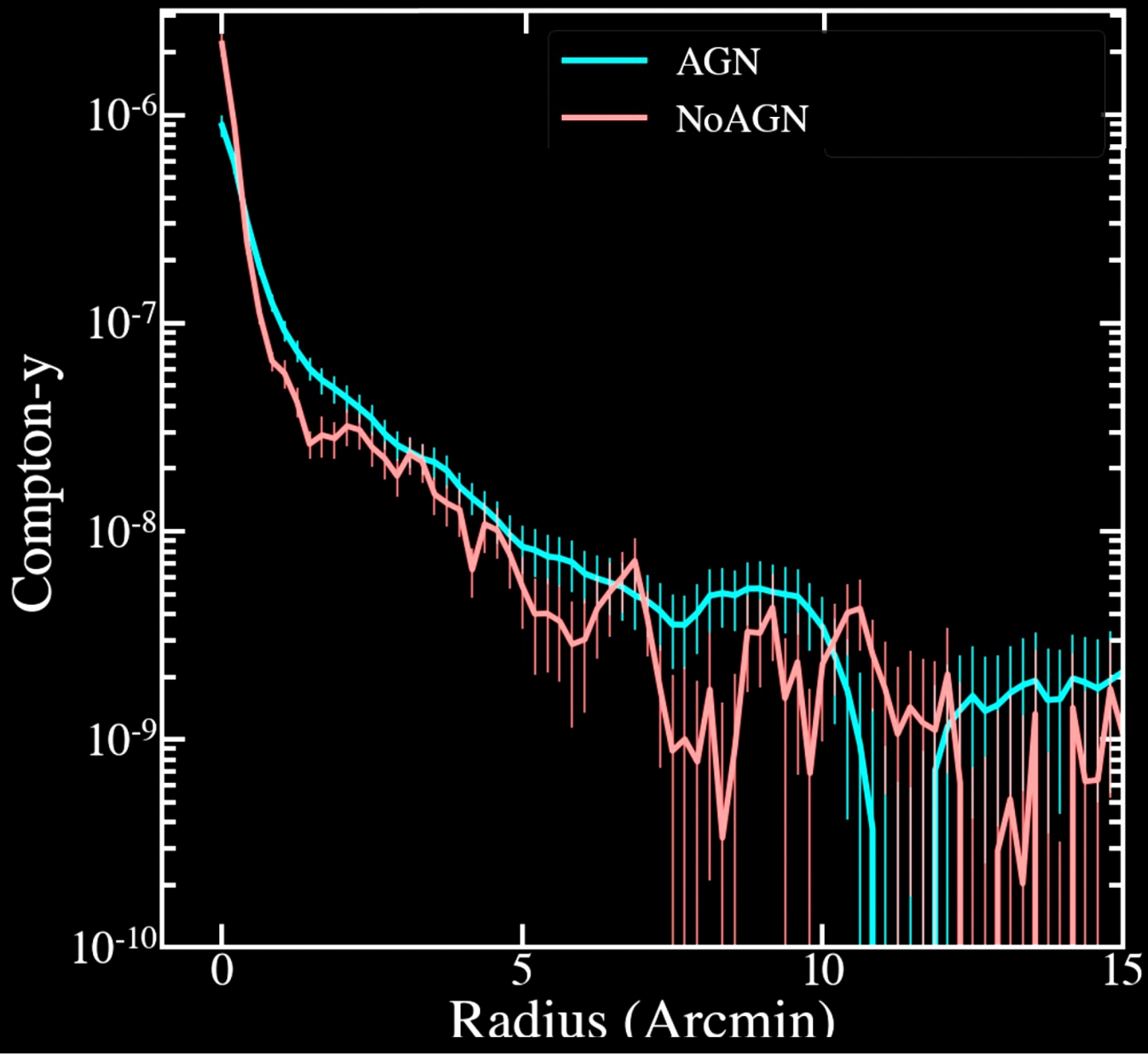

Conclusions