The shape of intracluster gas at high redshift

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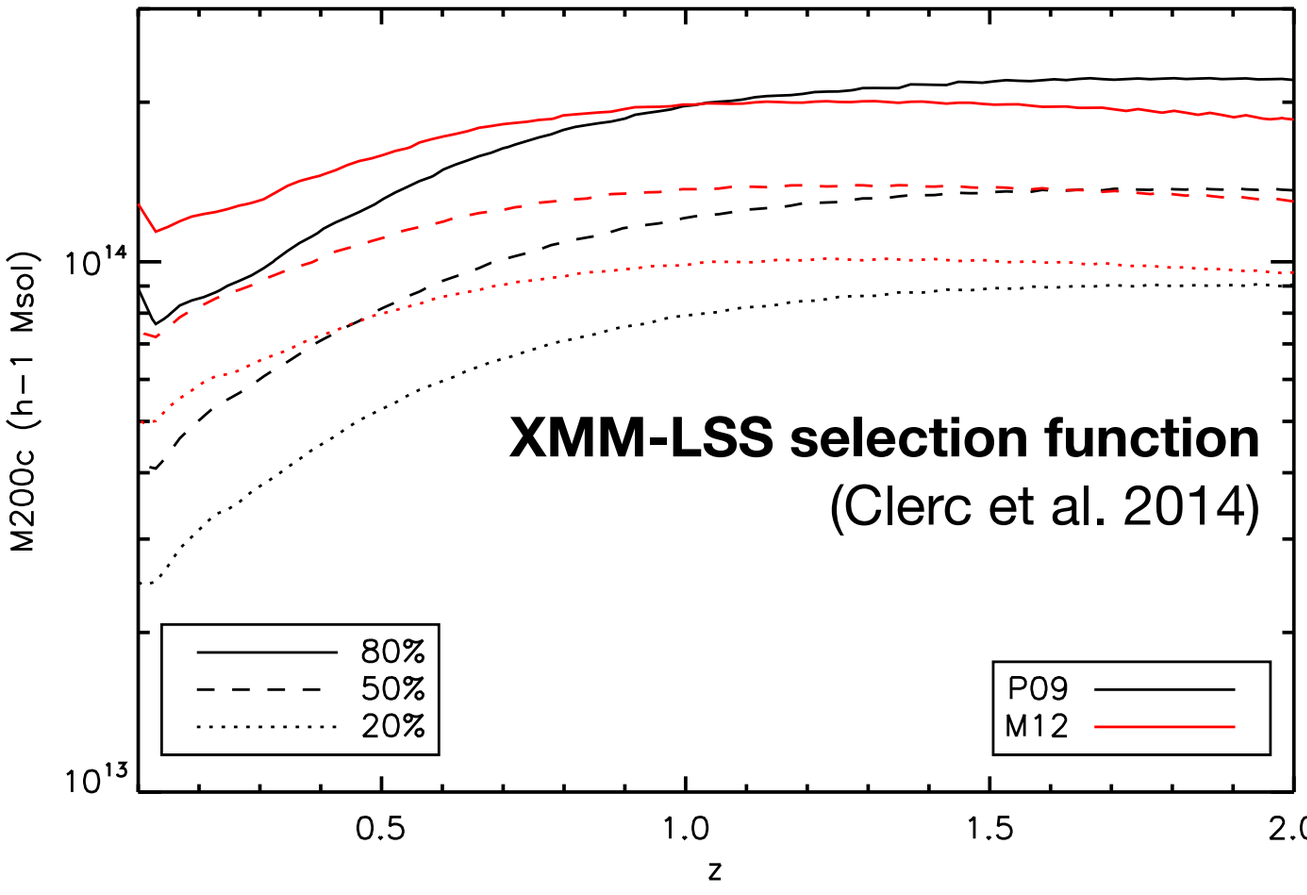
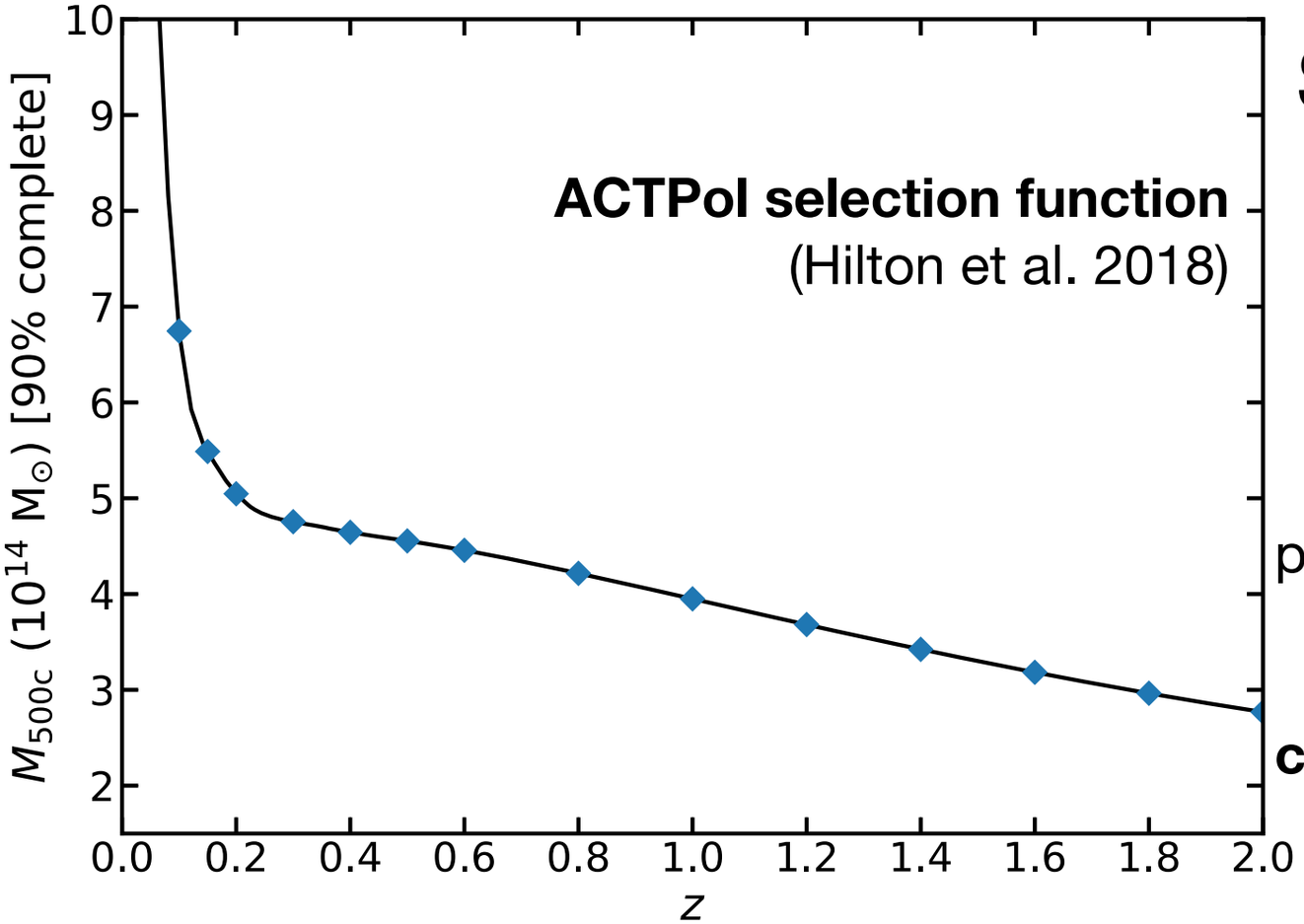


X-ray

surface brightness limited

completeness mass increases with z

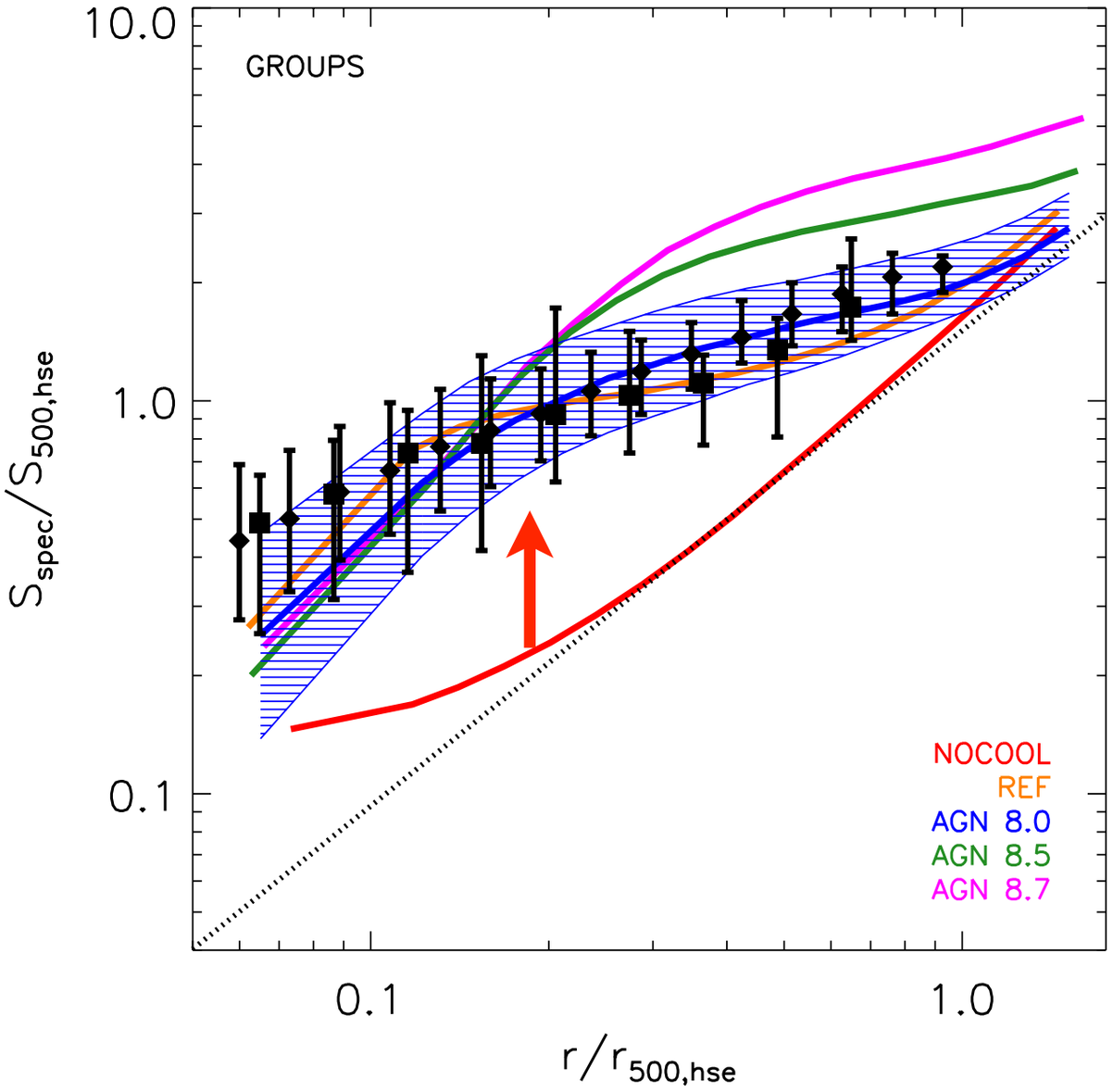


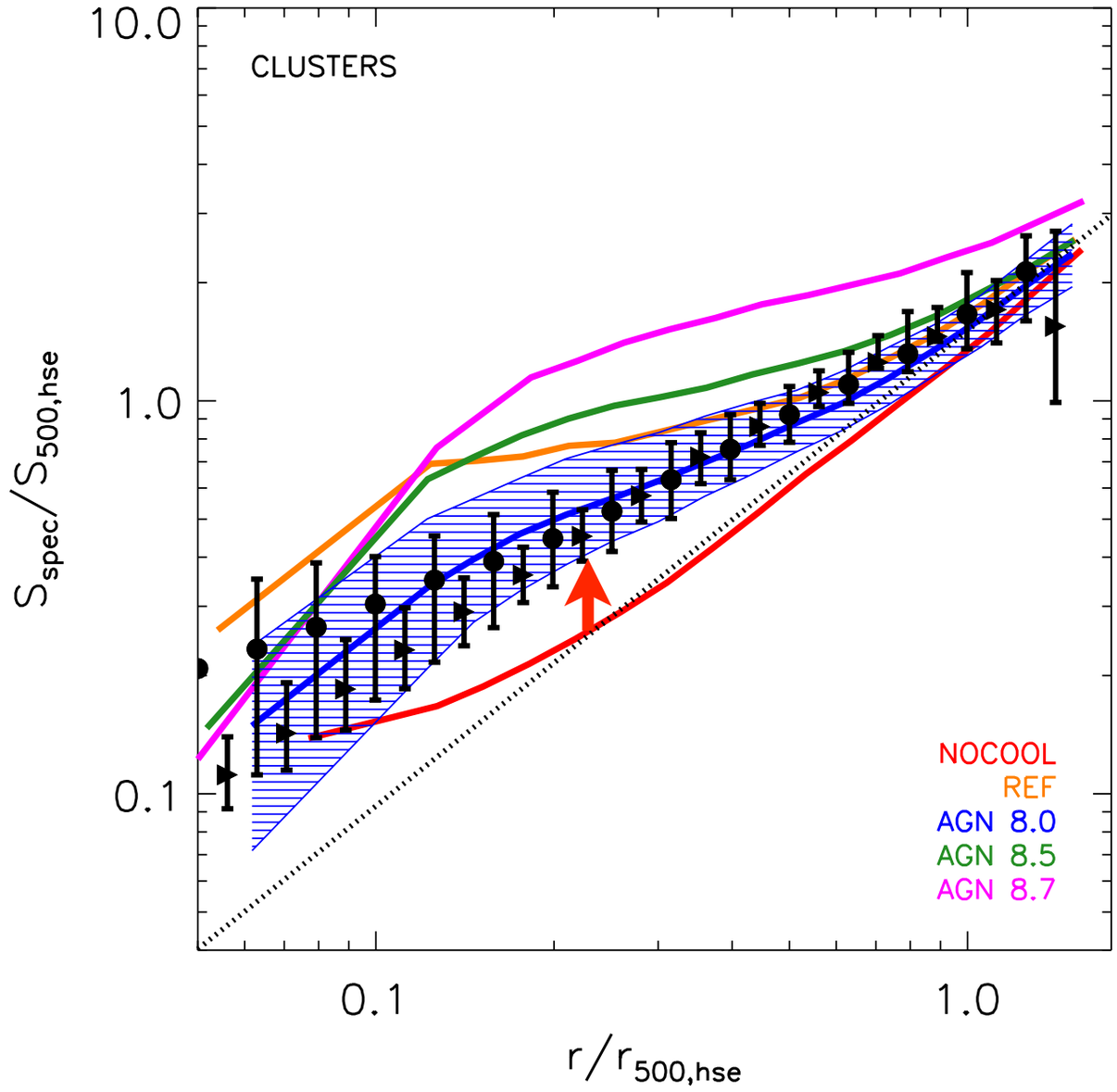
Sunyaev Zel’dovich

pressure (density×temperature) limited

completeness mass decreases with z

Le Brun et al. 2014





NOCOOL = no SF, no AGN, no cooling
REF = no AGN

Galaxies and AGNs will **inject energy** into the intracluster medium, especially at early times

(e.g., Kaiser 1991, Ponman et al. 1991, Valageas & Silk 1999, Tozzi & Norman 2001)

$t_{therm,Ly\alpha} < 10$ Myr

Estimated contribution of SF and AGN outflows:

~2 keV per particle

(Valentino et al. 2016)

Lyα emission

Chandra **(X-ray)**

AGN

ETGs

SF

$M_{200} \sim 6 \cdot 10^{13}\ M_{\odot}$

Cl J1449+0856 (z=1.99)

Atacama Compact Array

short baselines
large spatial scales

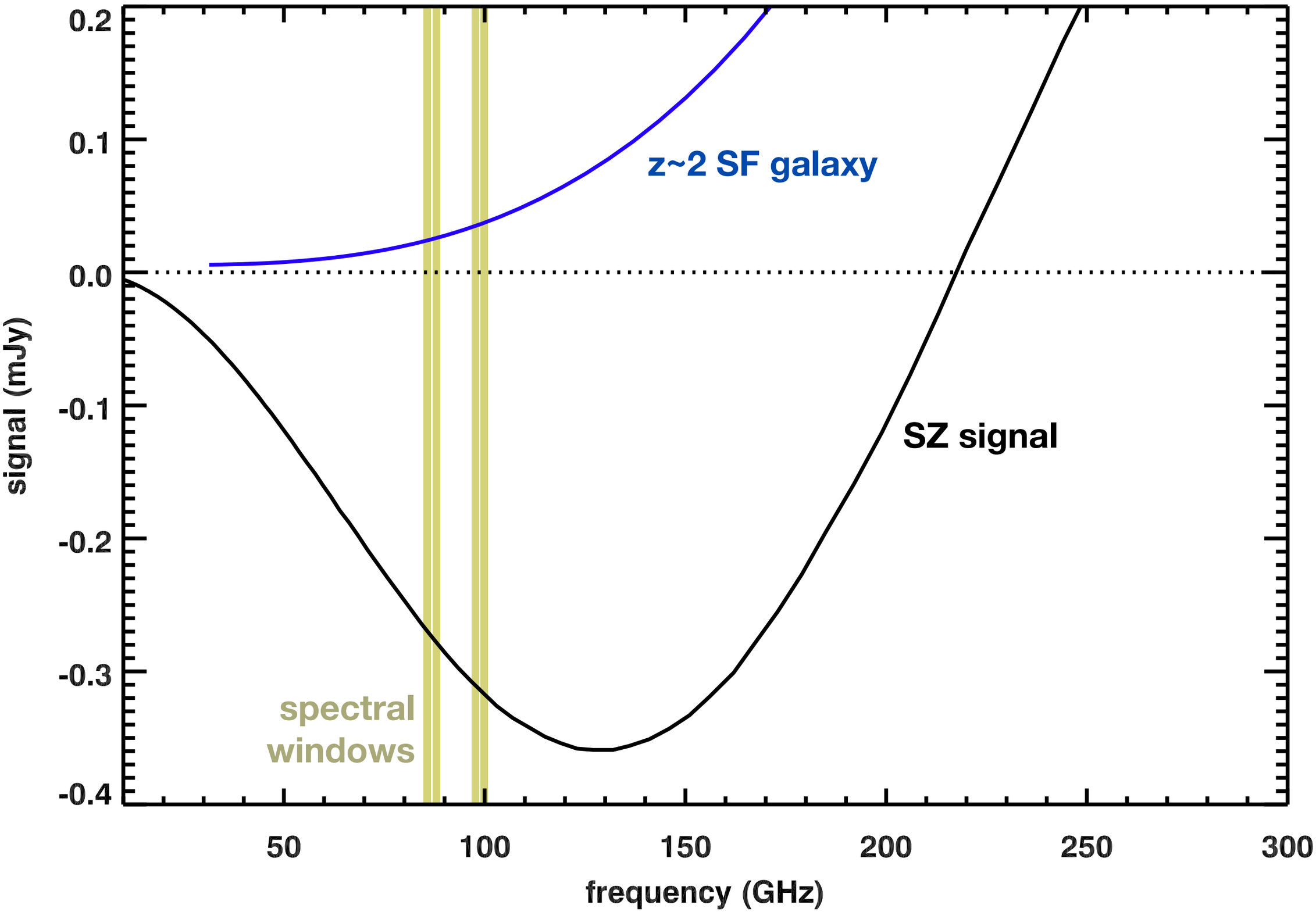
long baselines
short spatial scales

Atacama Large Millimeter Array

ALMA 850 μm

cluster galaxies

interlopers


0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
signal (mJy)
z~2 SF galaxy
SZ signal
spectral
windows
50
100
150
200
250
300
frequency (GHz)

synthesized beam

Combined ACA + ALMA

after subtracting point sources

~176 μJy @ 92 GHz

5.1σ detection

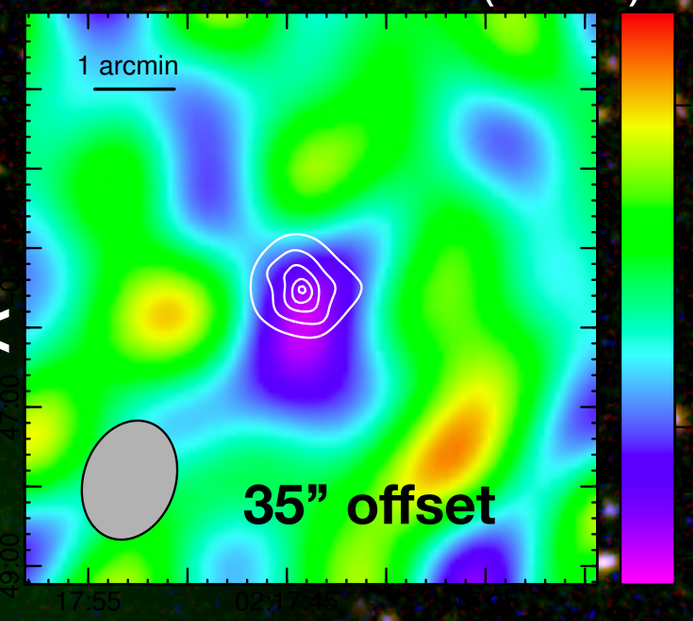
(Gobat et al., in prep)

SZ

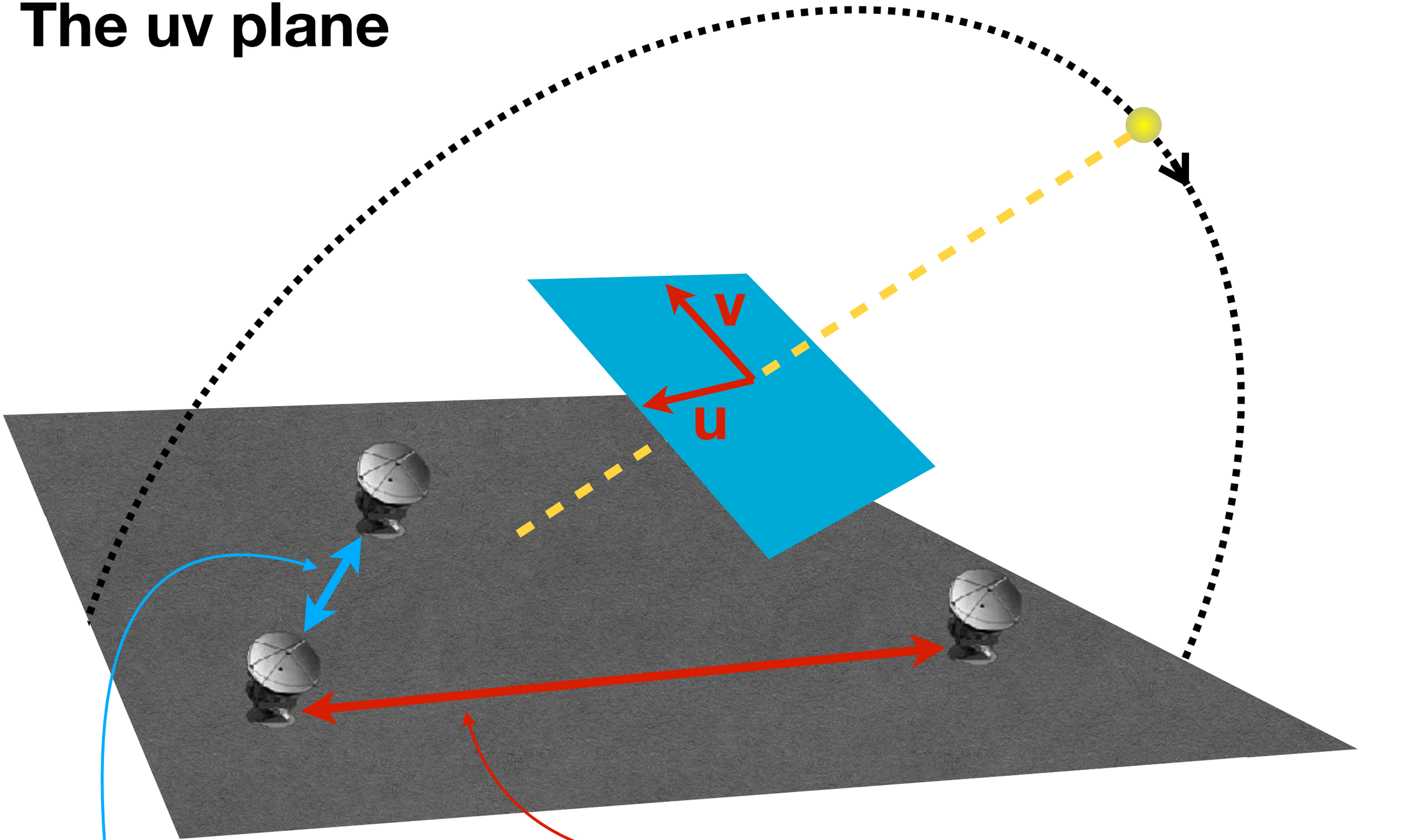
X-ray

~5” offset (2σ) w.r.t. (putative) mass center ≪

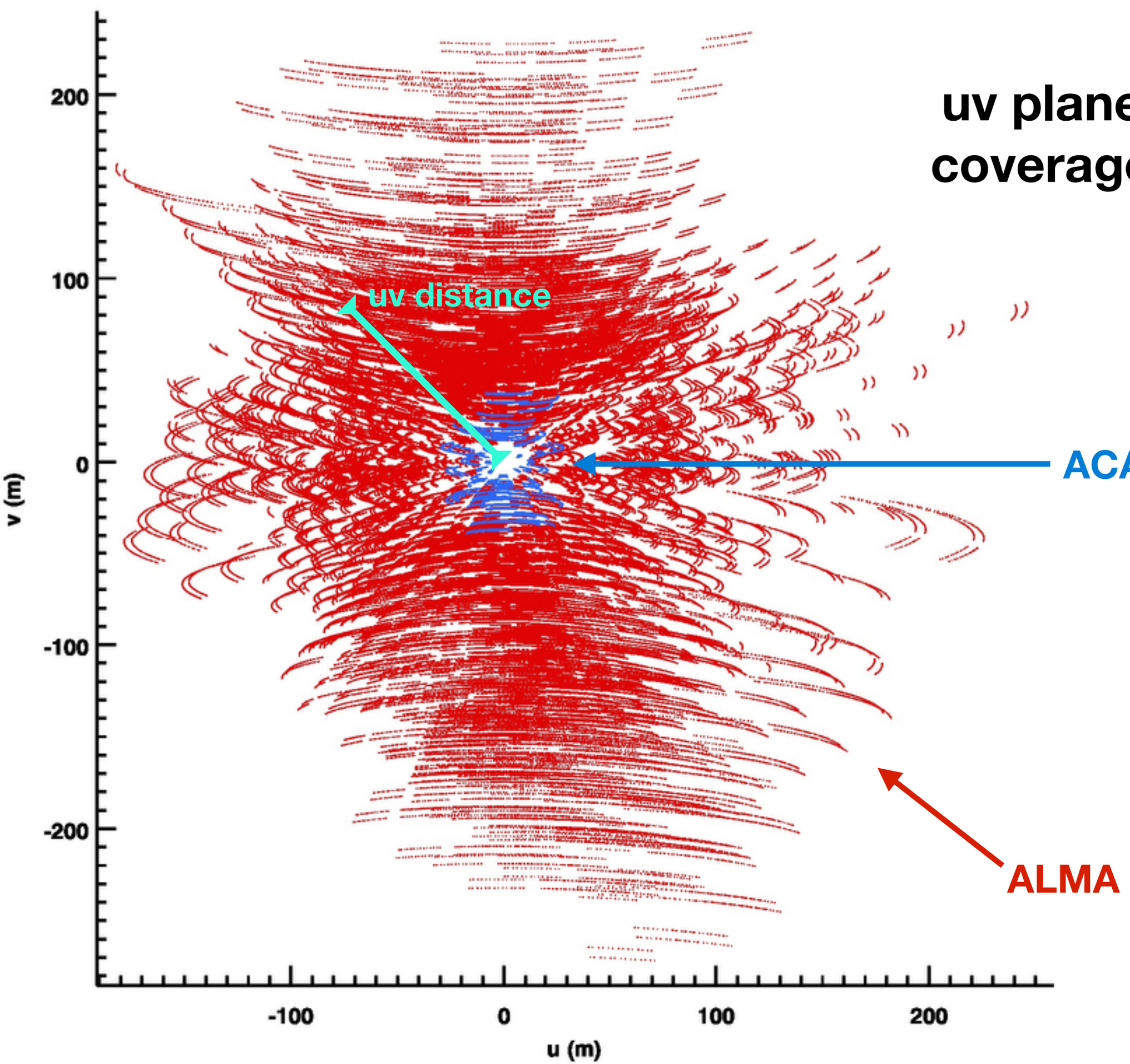
Mantz et al. 2017 (z=1.9)

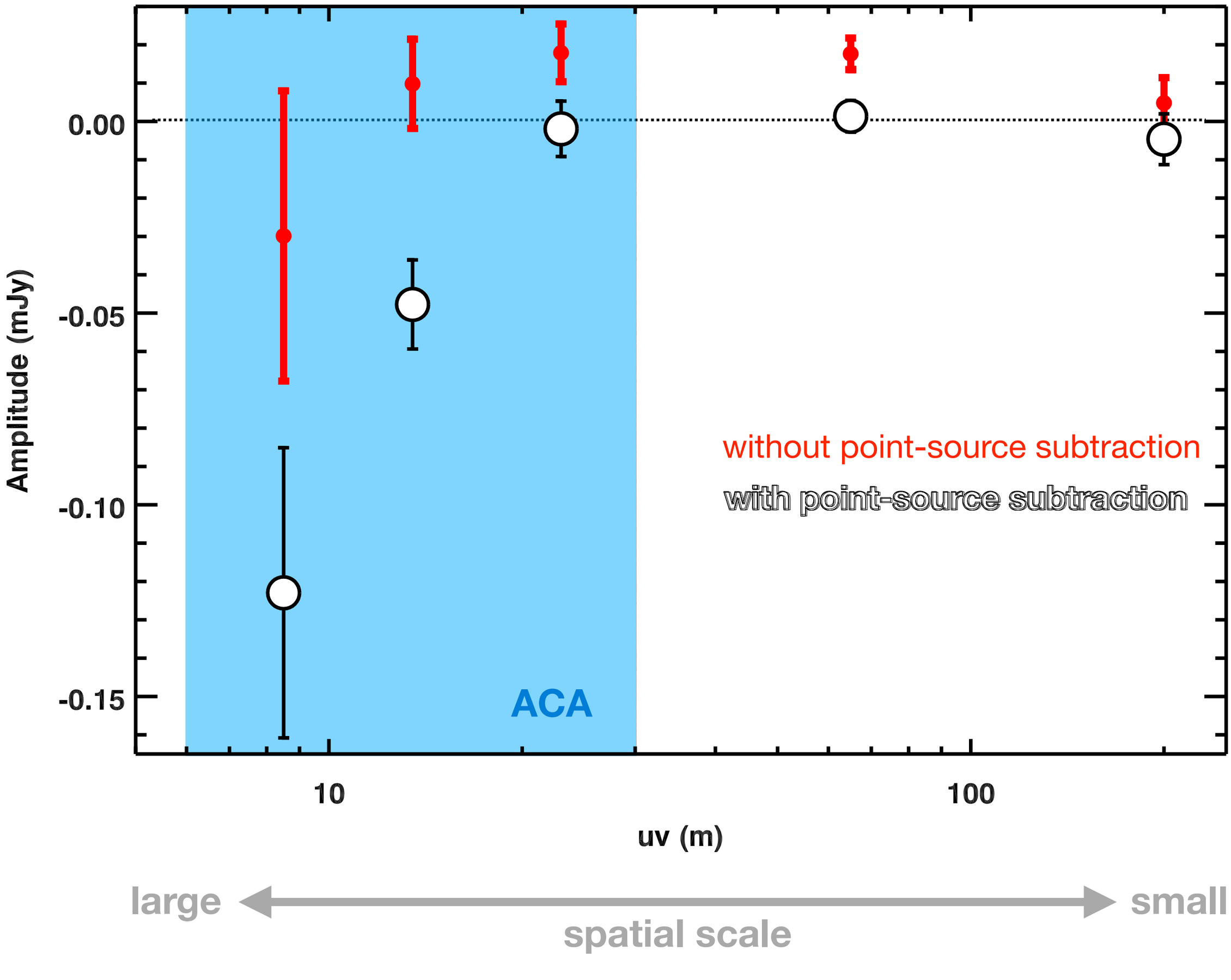


The uv plane


v
u
long baselines = short spatial scales
short baselines = large spatial scales

uv plane coverage



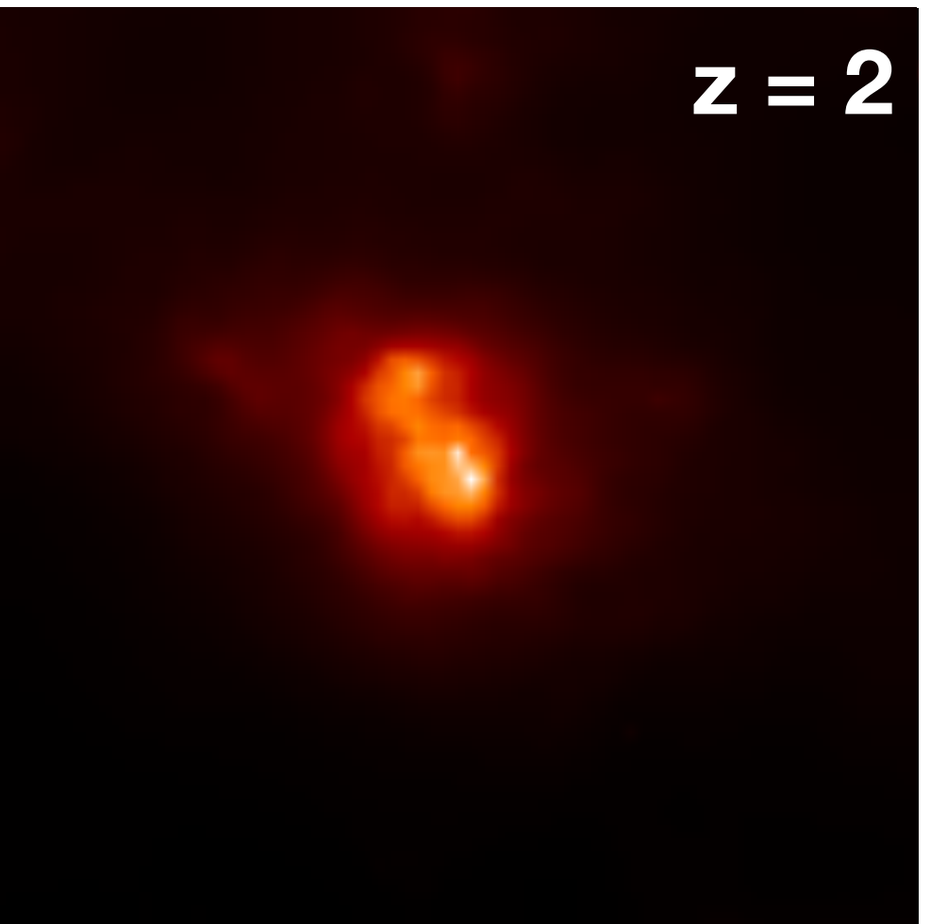

0.00
-0.05
-0.10
-0.15
Amplitude (mJy)
ACA
without point-source subtraction
with point-source subtraction
10
100
uv (m)
large
small
spatial scale

cosmo-OWLS

(400h^{-1} Mpc)

zoom-in on 4 clusters
with ~10^{14} $M_\odot$

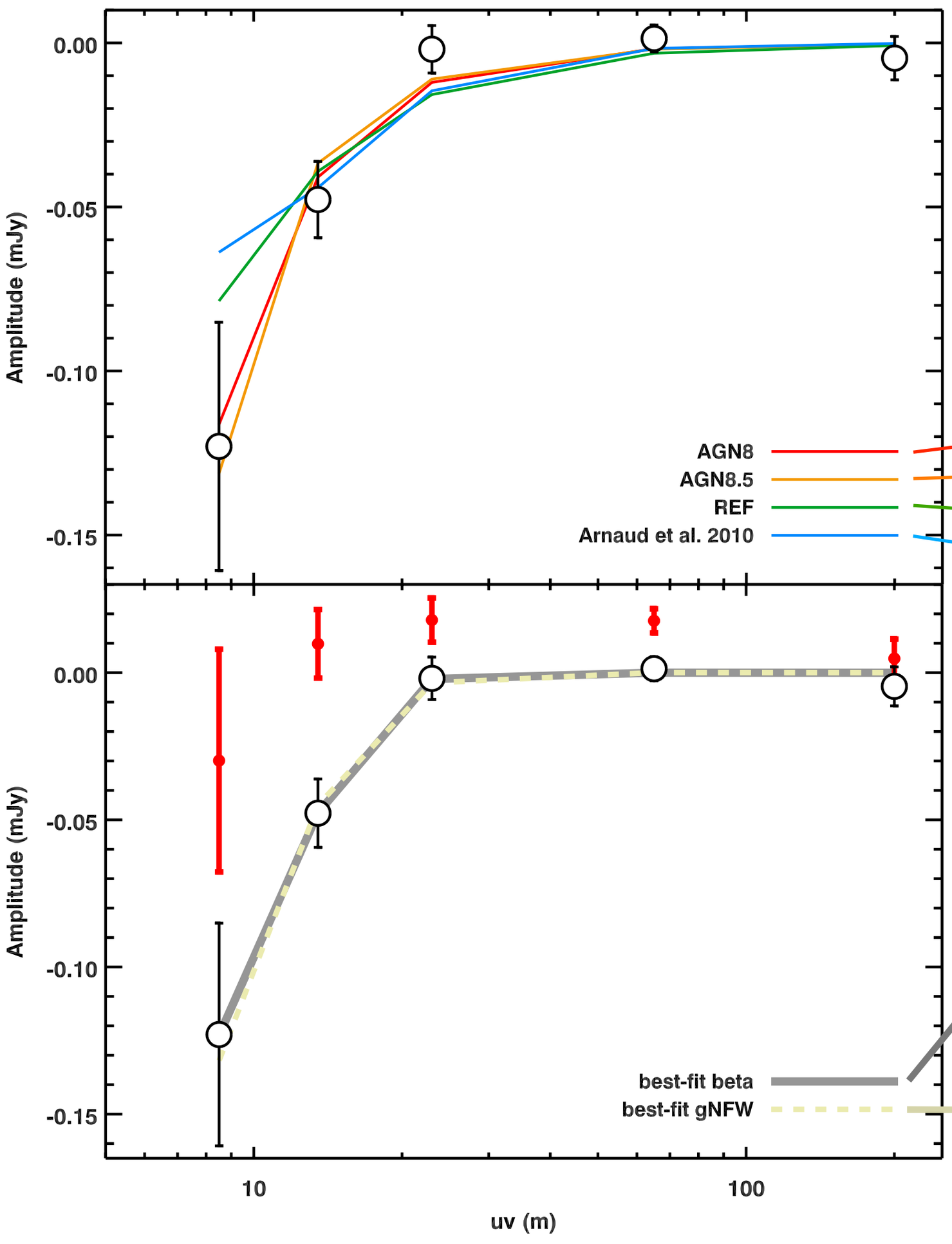
Le Brun et al. 2015



$$P(r) = \frac{P_0 P_{500}}{\left(\frac{c_{500} r}{r_{500}}\right)^{\gamma} \left[1 + \left(\frac{c_{500} r}{r_{500}}\right)^{\alpha}\right]^{\frac{\beta-\gamma}{\alpha}}}$$

Modeling the pressure profile

(Gobat et al., in prep.)



95%
92%
67%
80%

confidence

r_c ~ 0.4 Mpc

β ~ 1.1

c_{500} ~ 1.1

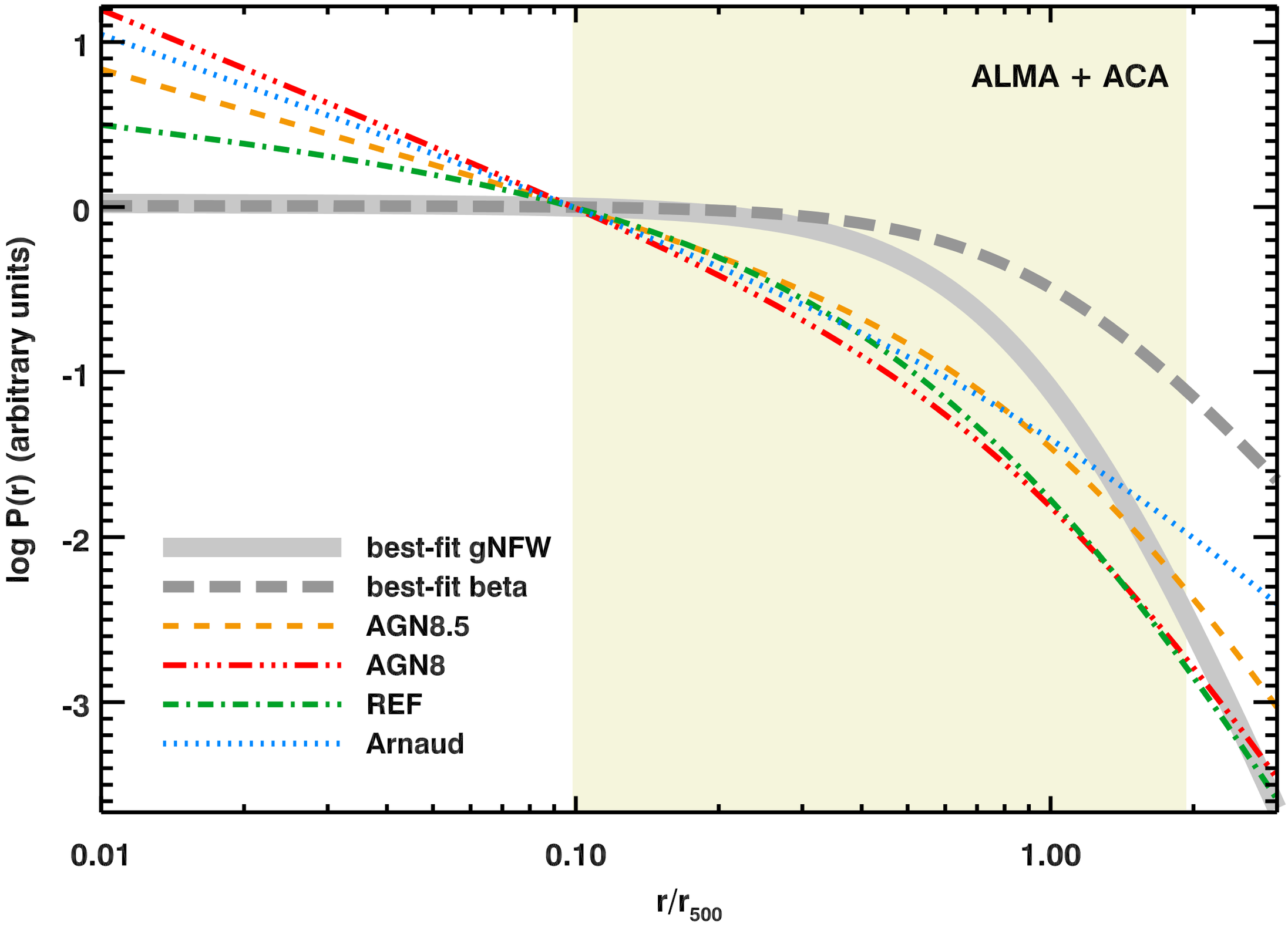
α ~ 2.1

β ~ 7

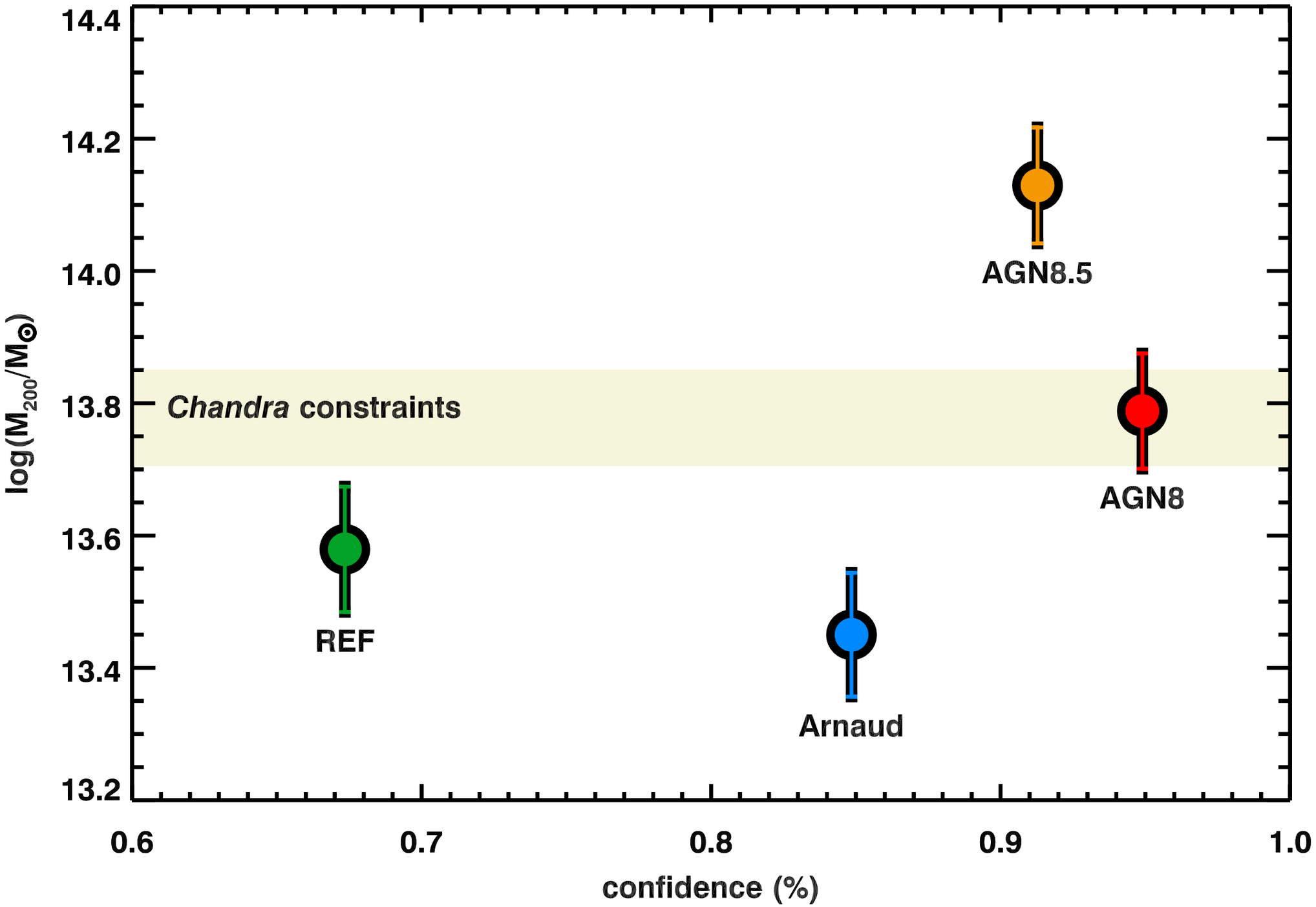
γ ~ 0.01

pressure, not DM

Comparison of pressure profiles



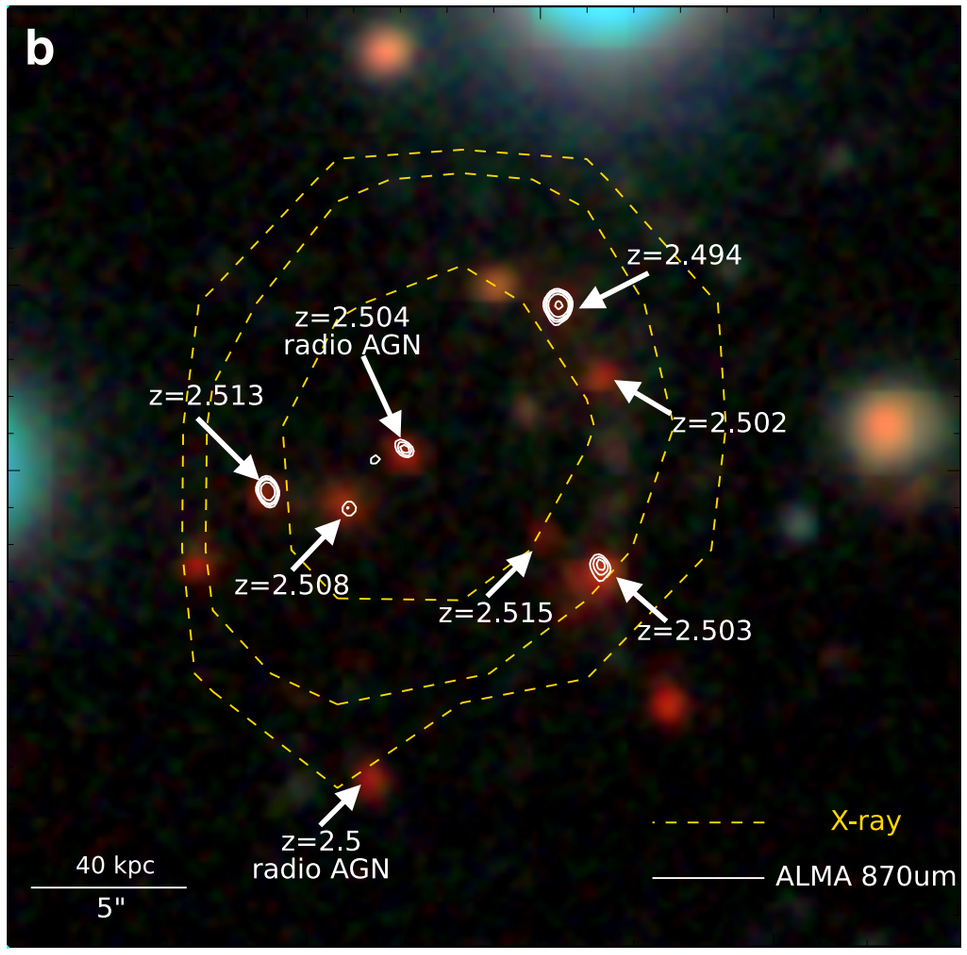
SZ vs X-ray mass constraints



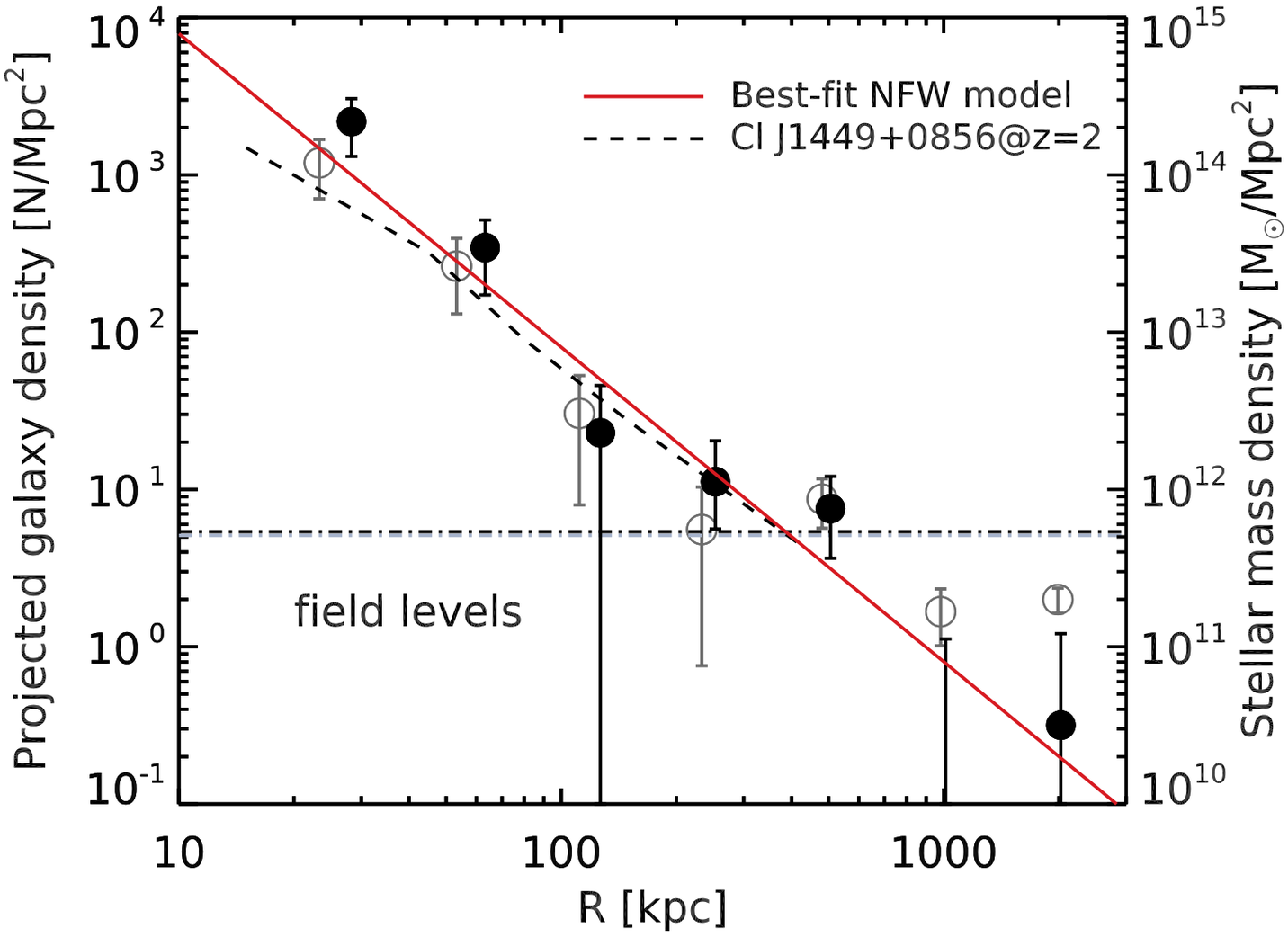
Higher redshift: star forming cluster core at z=2.5

Wang et al. 2016, ApJ 828, 56

X-ray detection



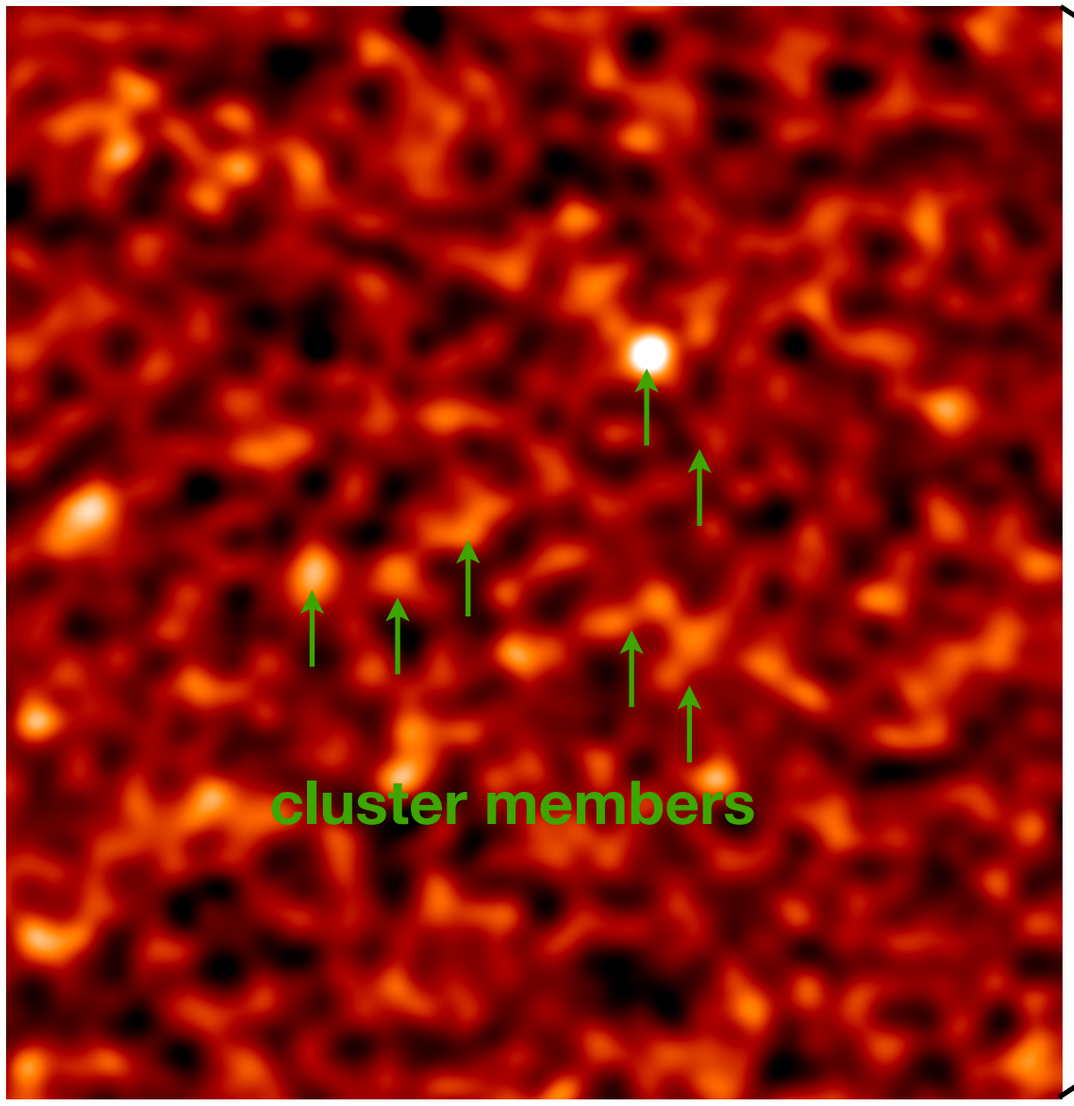
Cluster-like mass/density profile



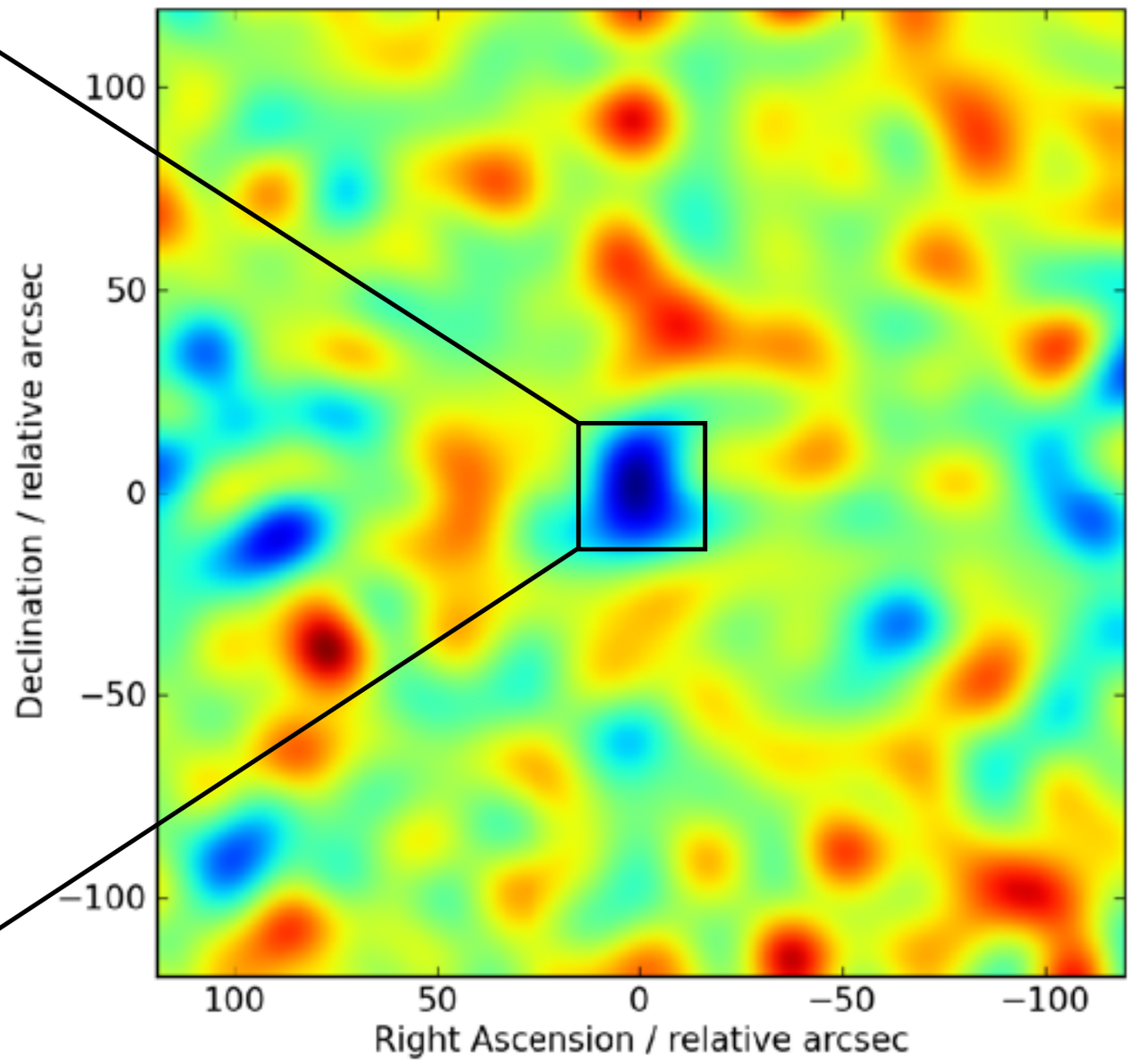
M_{tot}(Cl J1001+0220) ~ M_{tot}(Cl J1449+0856)

Δage ~ 670 Myr

Existing 93 GHz ALMA data



Simulated 93 GHz ACA image



55h ACA observation approved in Cycle 6

Summary

- ~180 μJy SZ signal at z = 2 with 5σ confidence
- signal (almost) entirely **filled** by point-source emission
- best-fitting pressure model has $\mathbf{M_{SZ} \approx M_X}$
- pressure models from simulations still have too much power at small/intermediate scales
- ⇒ actual **profile is flatter** in the center (more feedback ?)