Simulations of large-scale structure with “AGN” feedback

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Jon Sievers, Debora Sijacki

arxiv:1003.4256

MS 0735.6 + 742
McNamara et al 05

Motivation

- Use galaxy clusters as cosmological tool (**SZ PS**)
- ACT, SPT & Planck (Chandra, XMM, RCs…)

$$C_l = g_\nu^2 \int_0^{z_{\max}} dz \frac{dV}{dz} \int dM \frac{dn(M,z)}{dM} \left| \tilde{y}_l(M,z) \right|^2$$

- Analytically (e.g KS…B10 in prep: fast CosmoMC plugin)
- SZ sky maps (e.g. Da Silva et al. 00, Springel et al., B02…)
- "Gastrophysics" correct

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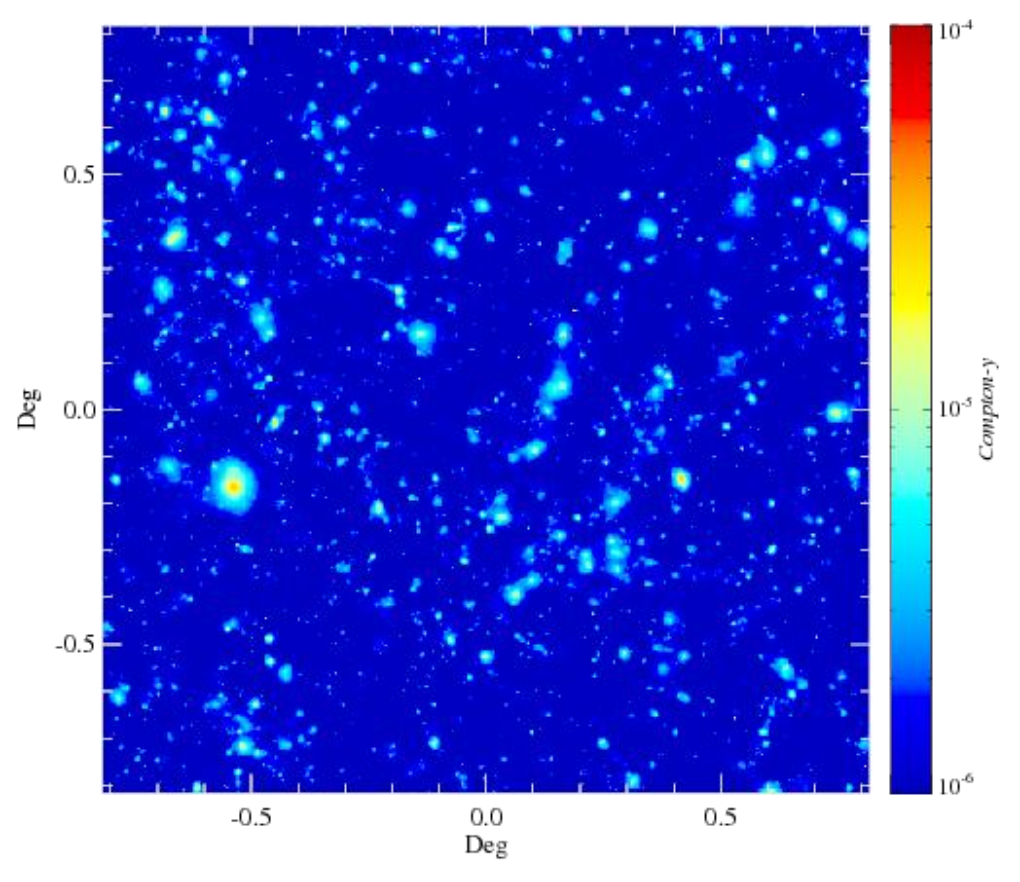
- SZ sky maps (e.g. Da Sil
- "Gastrophysics" correc



ICM Modeling

X-ray observations

- ❑ Match both aperture quantities / profiles / f_{gas}

Sunyaev – Zel'dovich observations

- ❑ Match both aperture quantities / PS / profiles
- ❑ f_{star} from optical observations

- Problems

Analytically: HSE, non-thermal....

Simulations: Sub-grid physics, Over-cooling!

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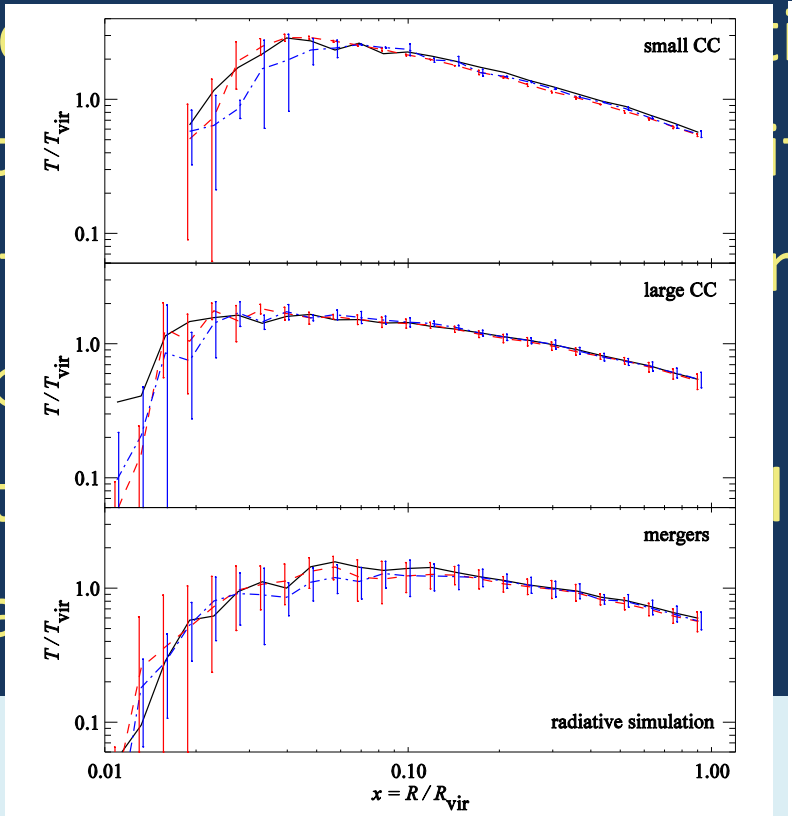
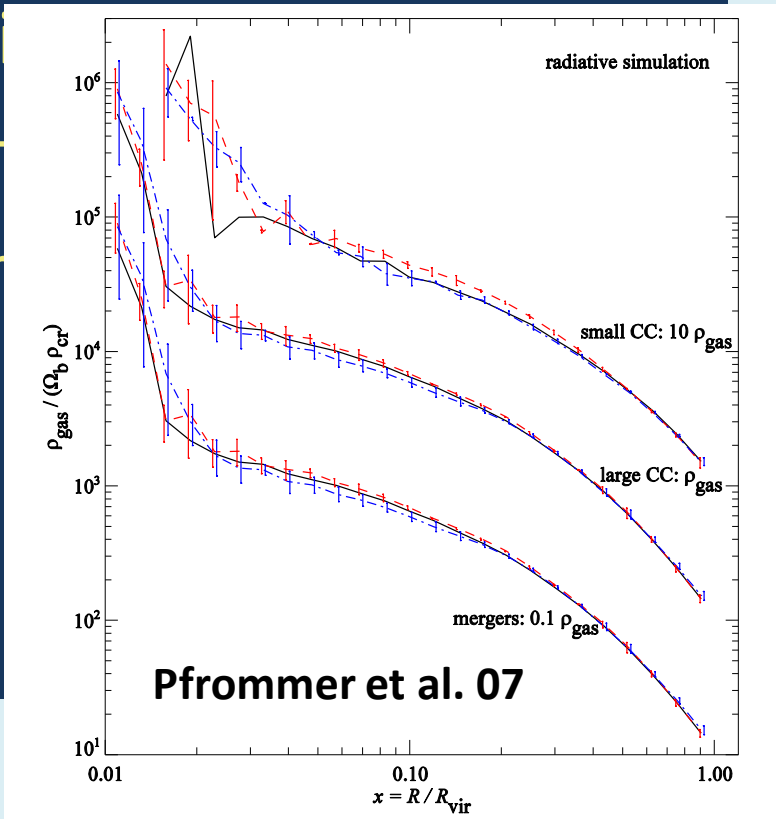
Sunya

- ❑ Mat
- ❑ f_{star}
- • Prob

Analyt

Simula





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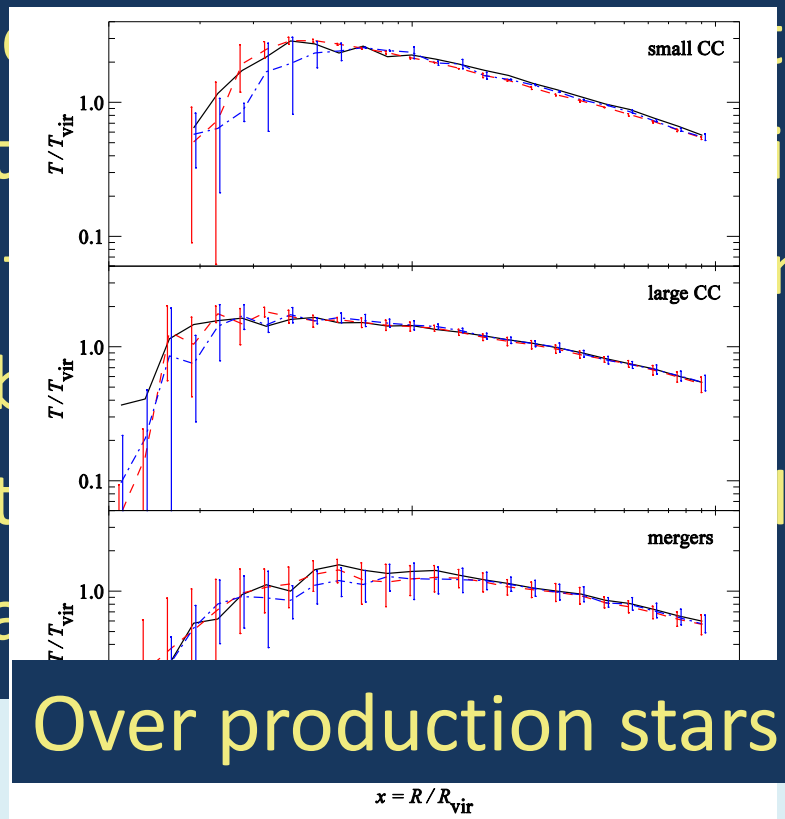
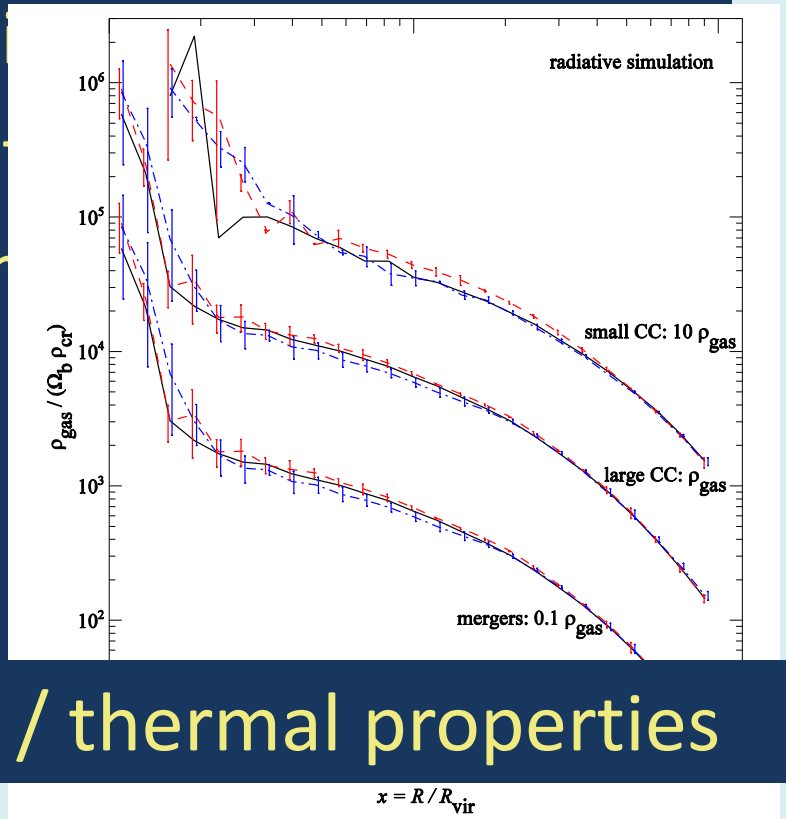




Over production stars / thermal properties

Our ICM Modeling

X-ray observations

✓ Match both aperture quantities / profiles / f_{gas}

Sunyaev – Zel'dovich observations

✓ Match both aperture quantities / PS / profiles

✓ f_{star} from optical observations

We introduce a form of "AGN" feedback

→ Does well to match current observations

Previous work on AGN feedback

- Magorrian relation $M_{BH} \propto \sigma^4, \dot{M}_{BH} \propto \dot{M}_{EDD}$

Thacker, Sijacki, Bhattacharya, Chatterjee….

-Run on smaller scales (Quasars/galaxies)

- Estimate Bondi-Hoyle accretion (BH particles)

Springel, Sijacki, Shaye

-Require high resolution

$$\dot{M}_{BH} = \frac{\alpha 4\pi G^2 M_{BH}^2 \rho}{(c_s^2 + v^2)^{3/2}}$$

AGN Model

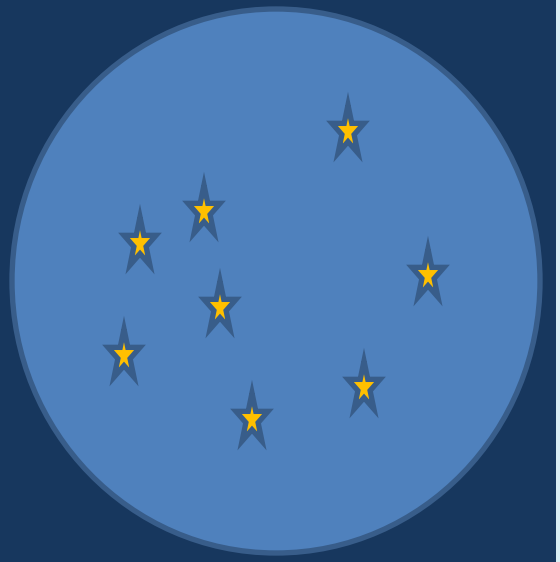
- Sub grid (~10^9 [OM]) (Thompson et al. 05)

$$\dot{M}_* \propto \dot{M}_{BH}$$

$$E_{inj} = \varepsilon_r \dot{M}_* c^2 \Delta t$$

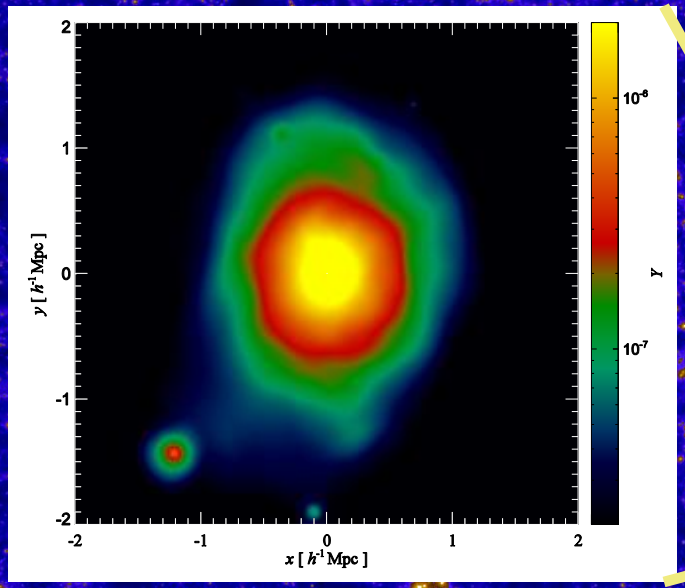
- Spherically injecting $E_{inj} \rightarrow R_{AGN}$
- Parameters: Δt, ε_r & R_{AGN}
- ε_r includes many #s

Match previous AGN models



Simulations (many of them)

- TreePM-SPH Gadget-2+
- Single cluster ‘g676’ (Zoom simulation)
- Cosmological box simulations (256^3 & 512^3)



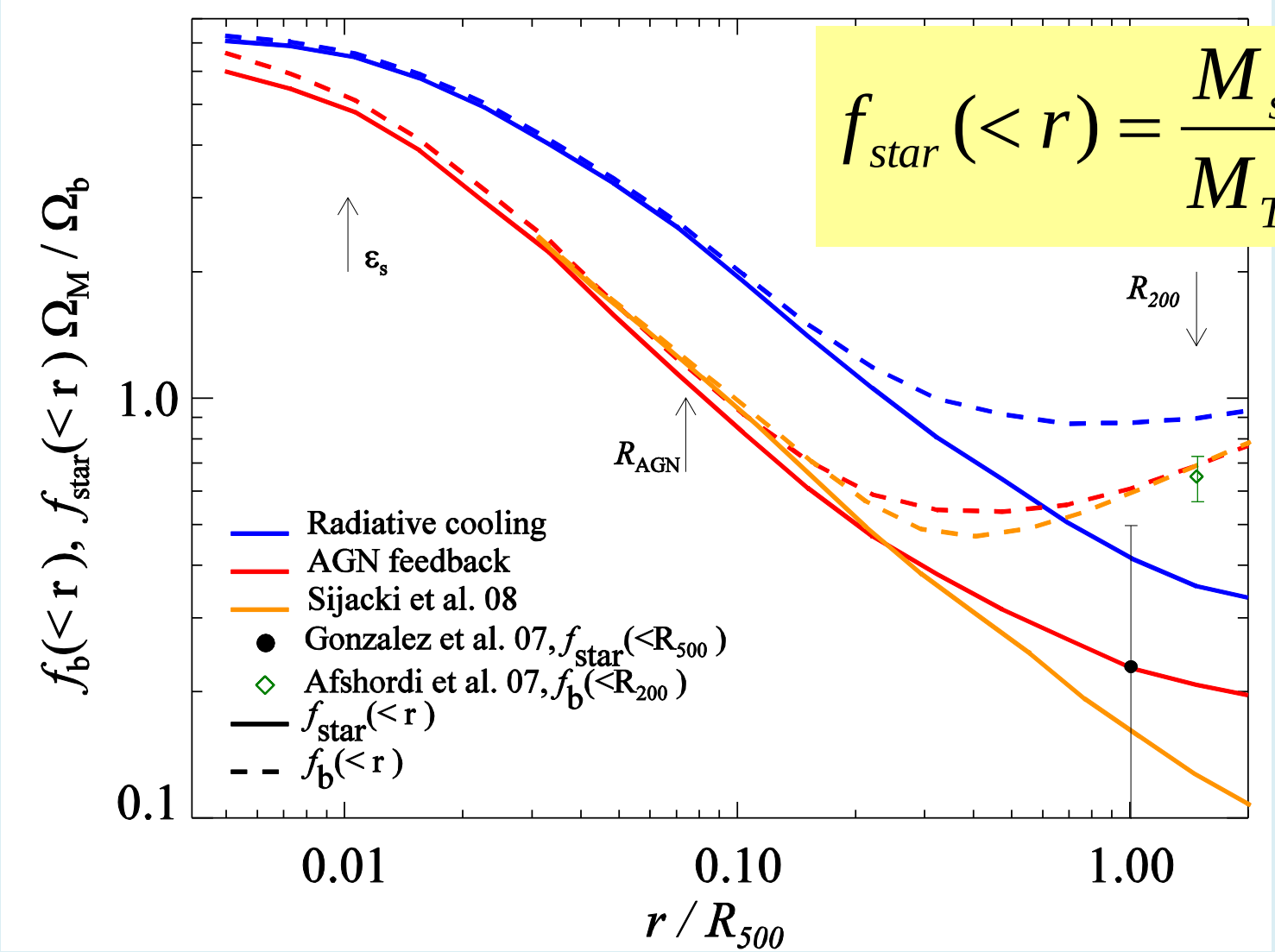
Models:

- “adiabatic”
- cooling + SF
- AGN feedback

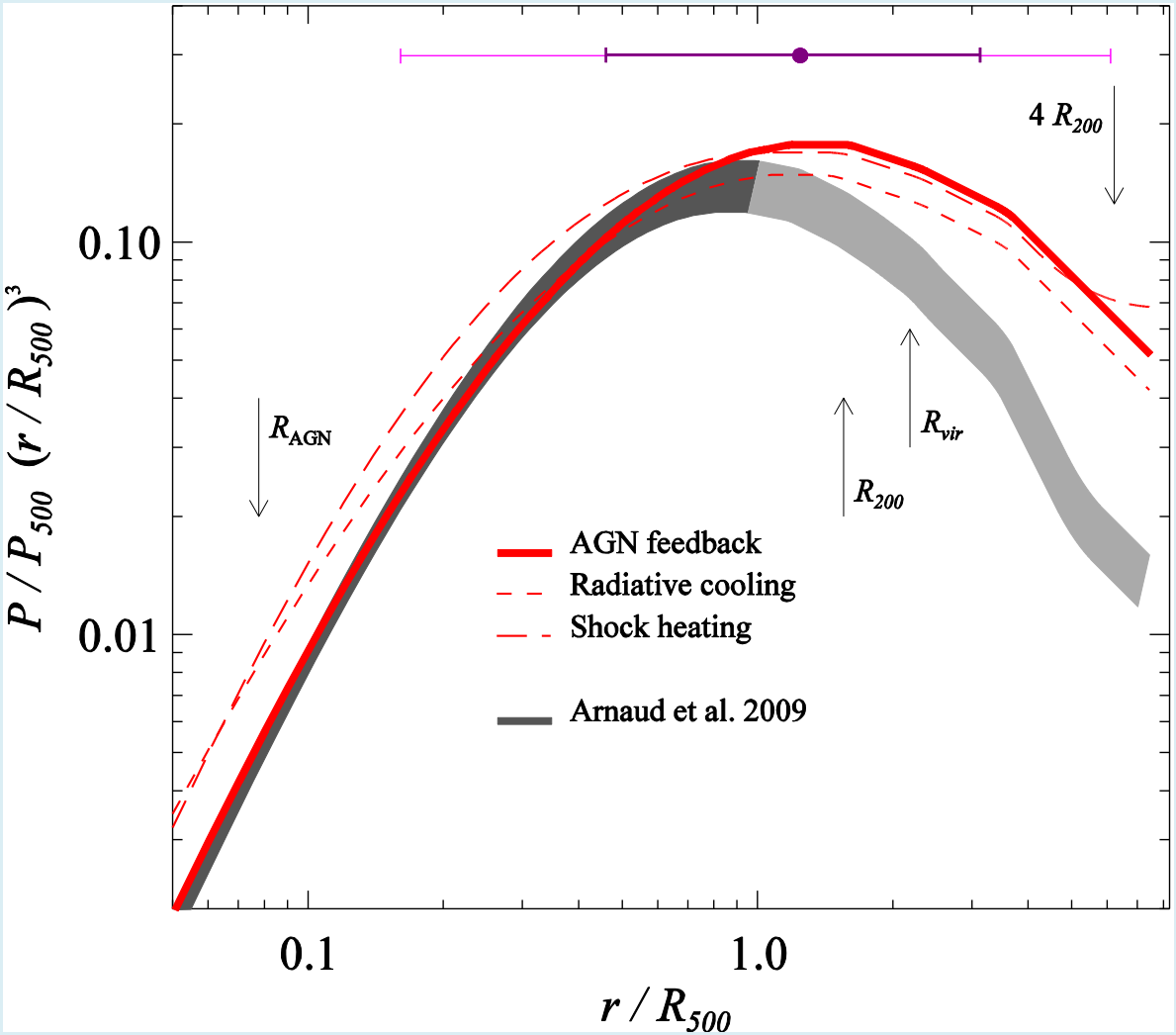
Thank you SciNET (30 k cores) & Sunnyvale

Model comparison/calibration

$$f_{star}(<r) = \frac{M_{star}(<r)}{M_{TOT}(<r)}$$

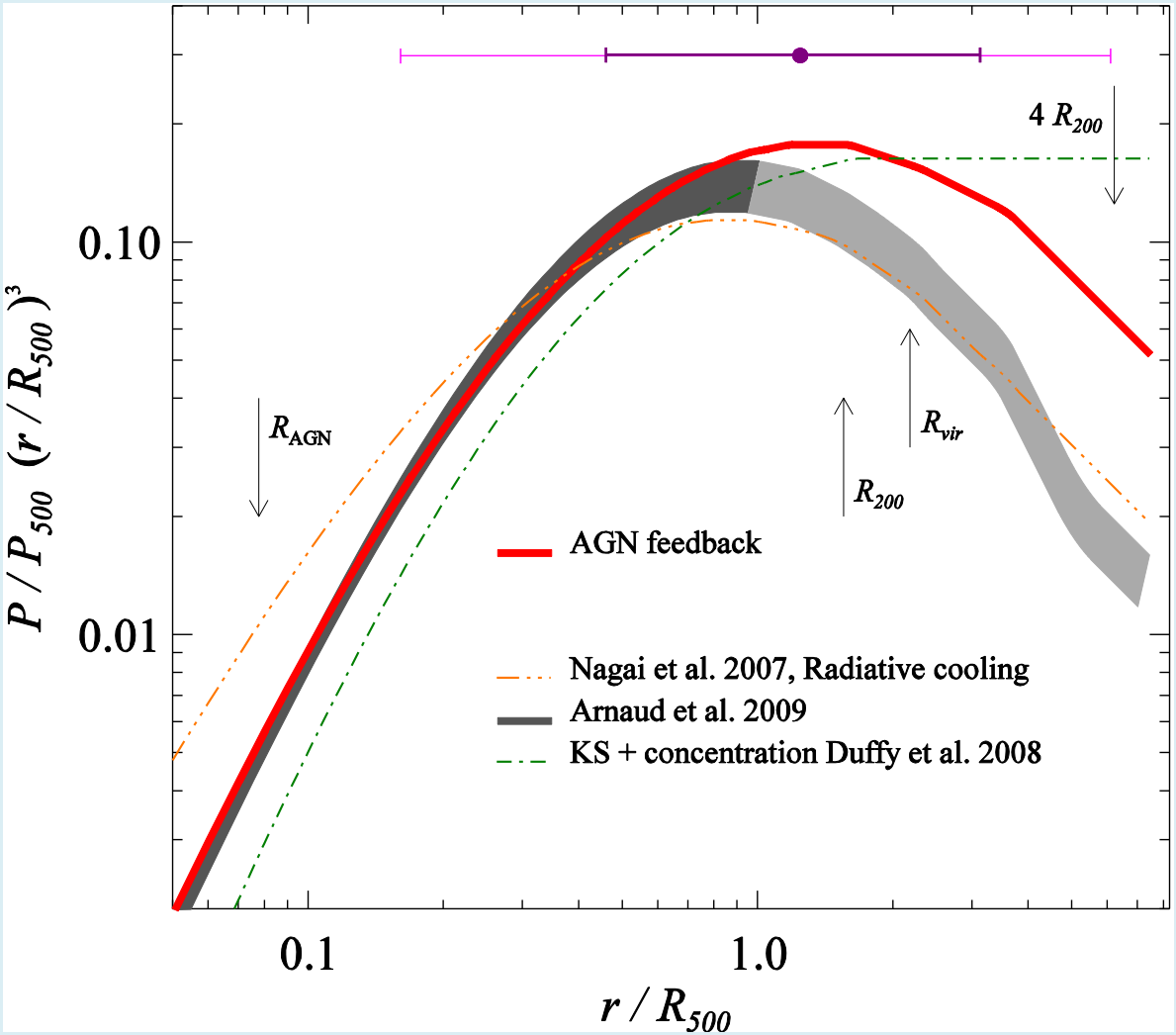


Observational comparisons



Bonus:
We match Recent X-ray results
•Stacked pressure profiles

Observational comparisons



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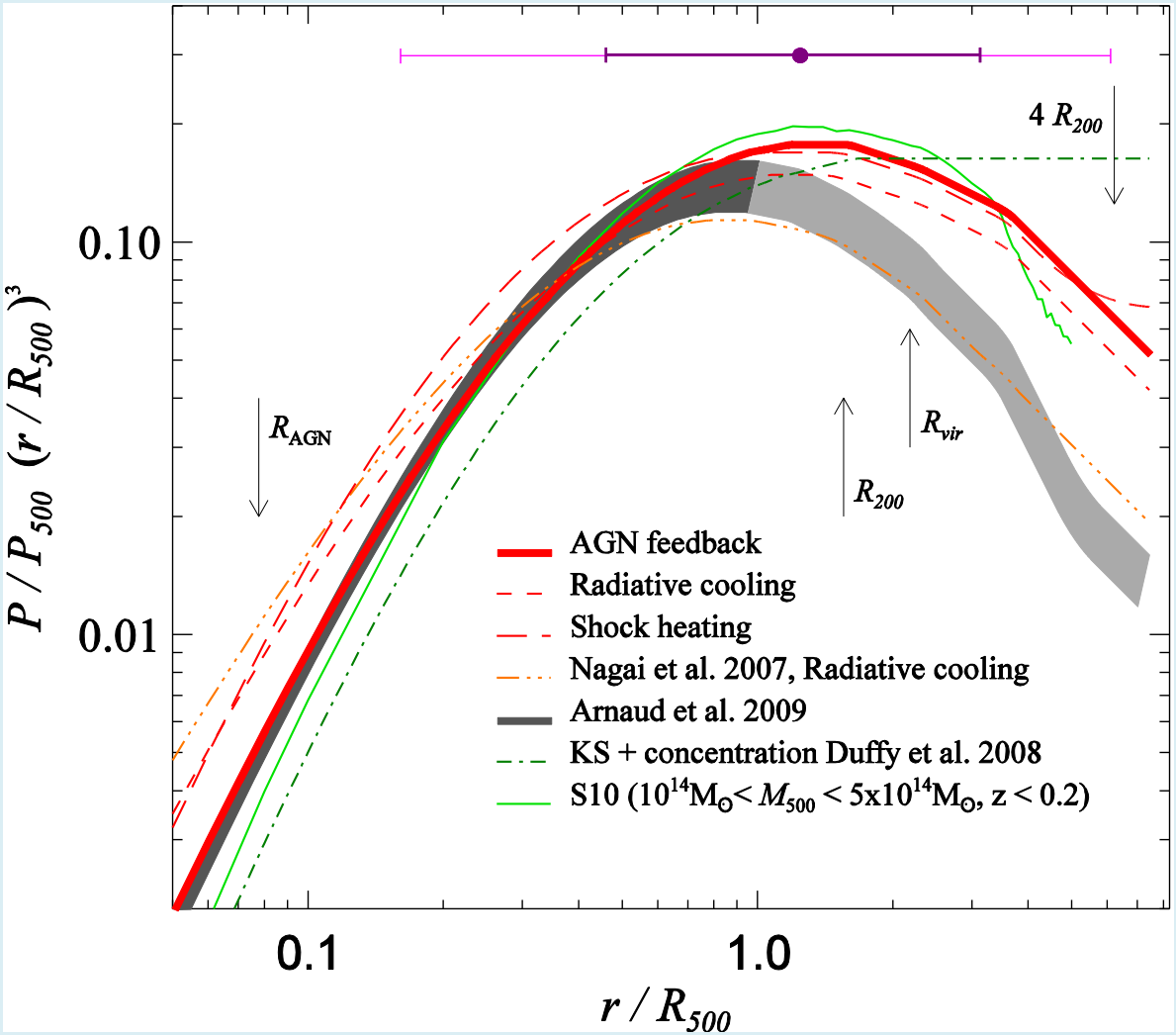

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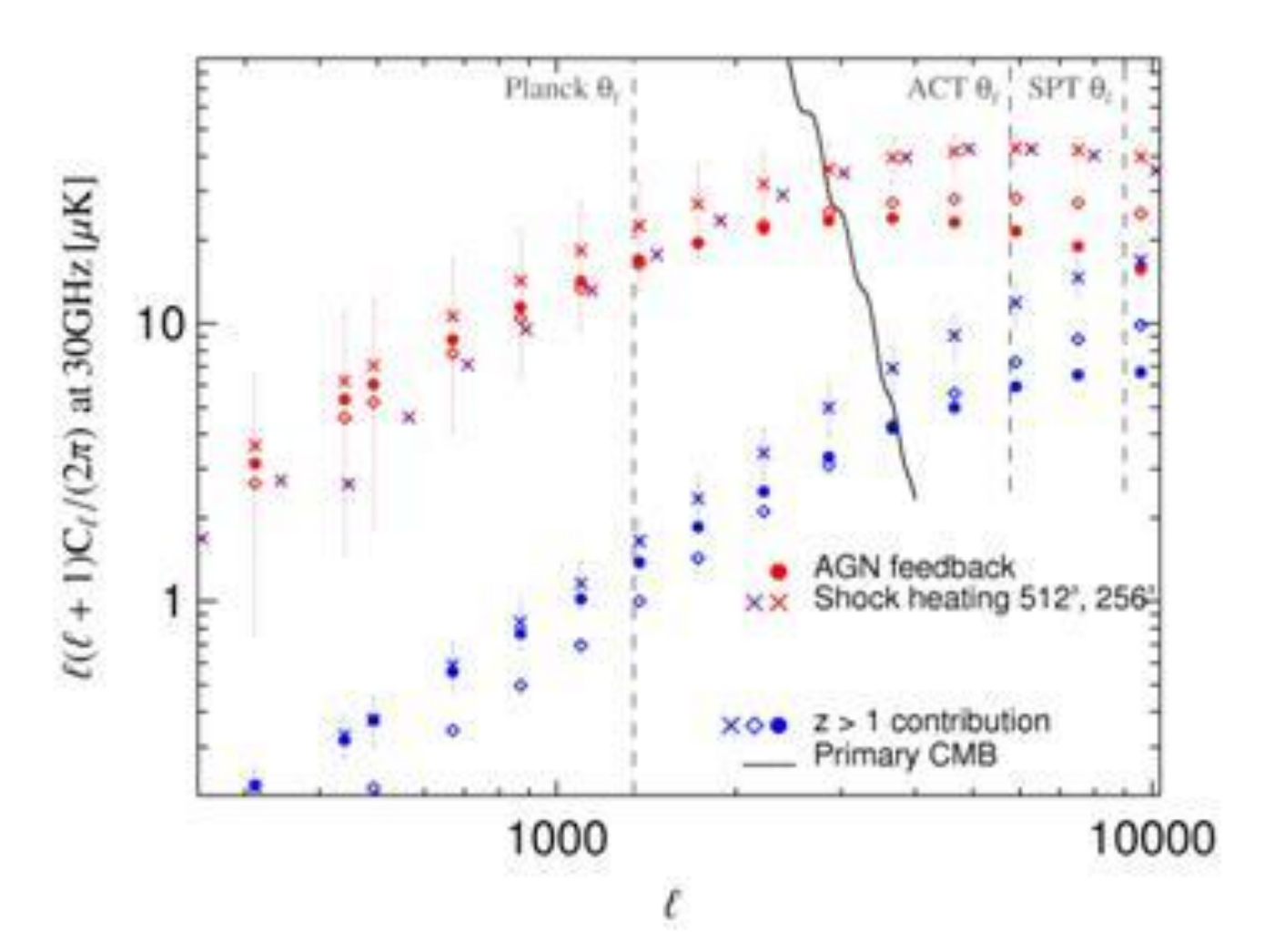
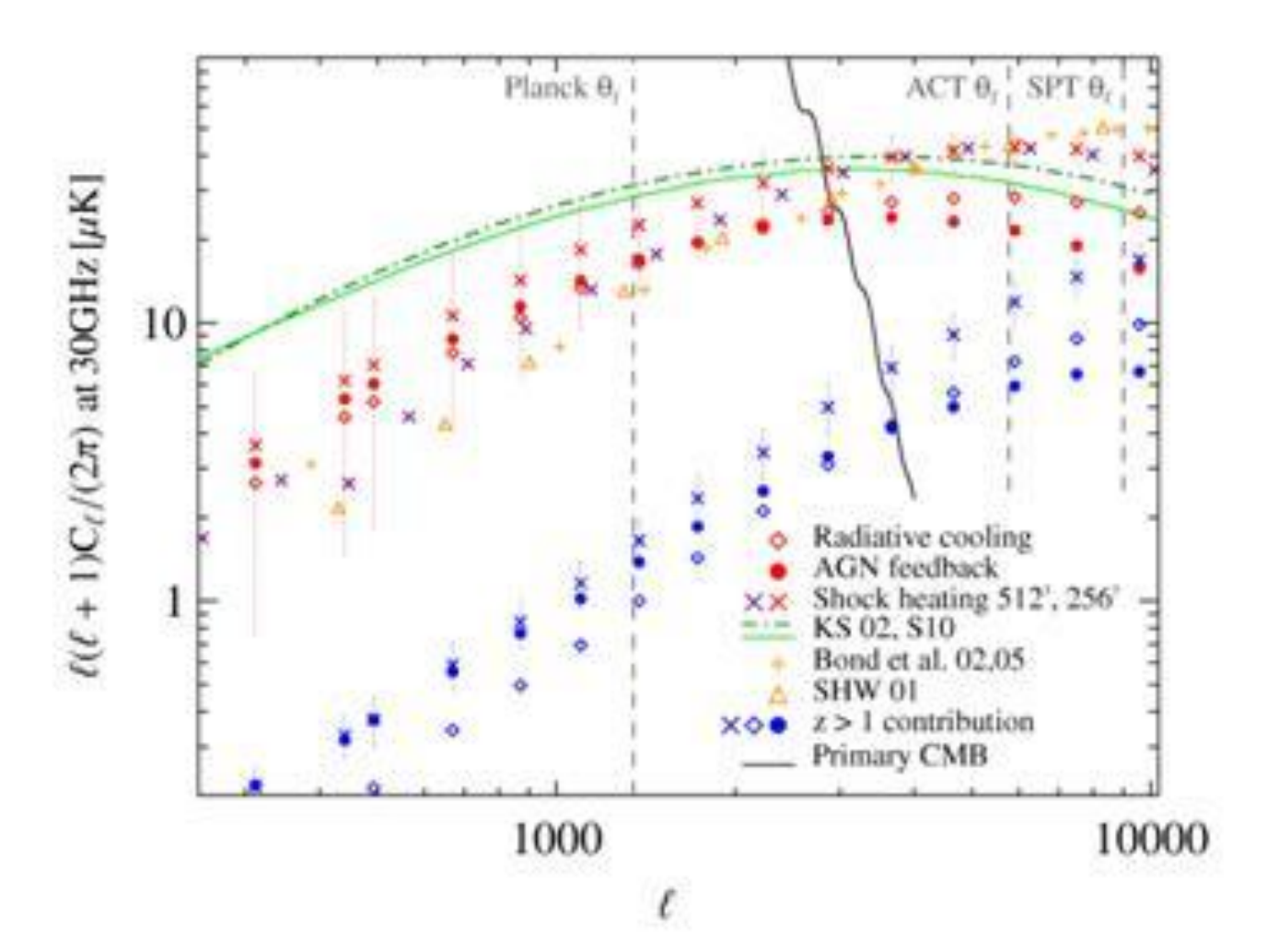


Average PS from our simulations -Rotate & Translate redshift slices

Power spectra comparisons



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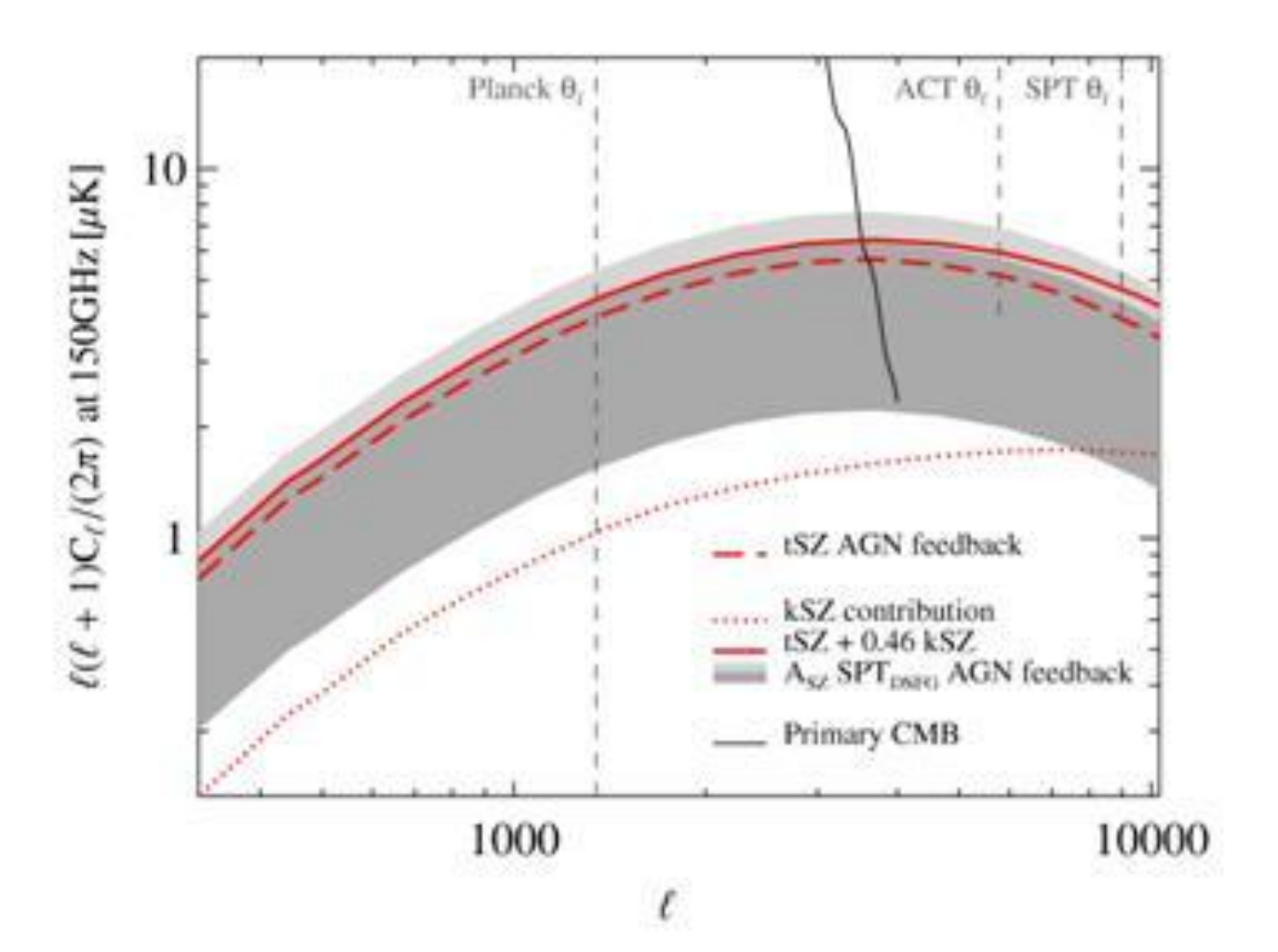
Cosmological constraints



-Included kSZ spectra
- Templates CosmoMC
-Constraints on A_{SZ} & σ_8
- Using SPT within WMAP7 values for σ_8

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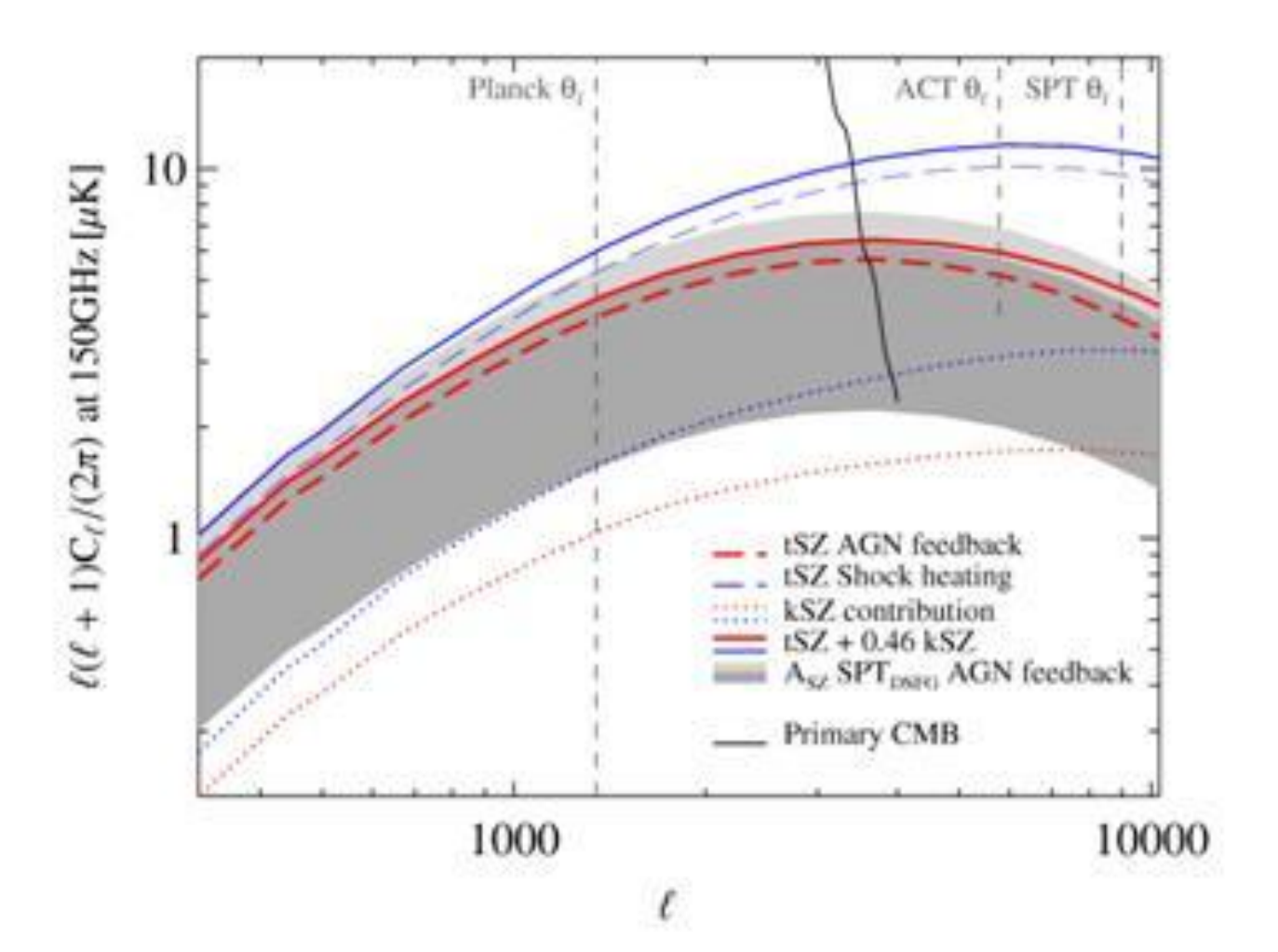

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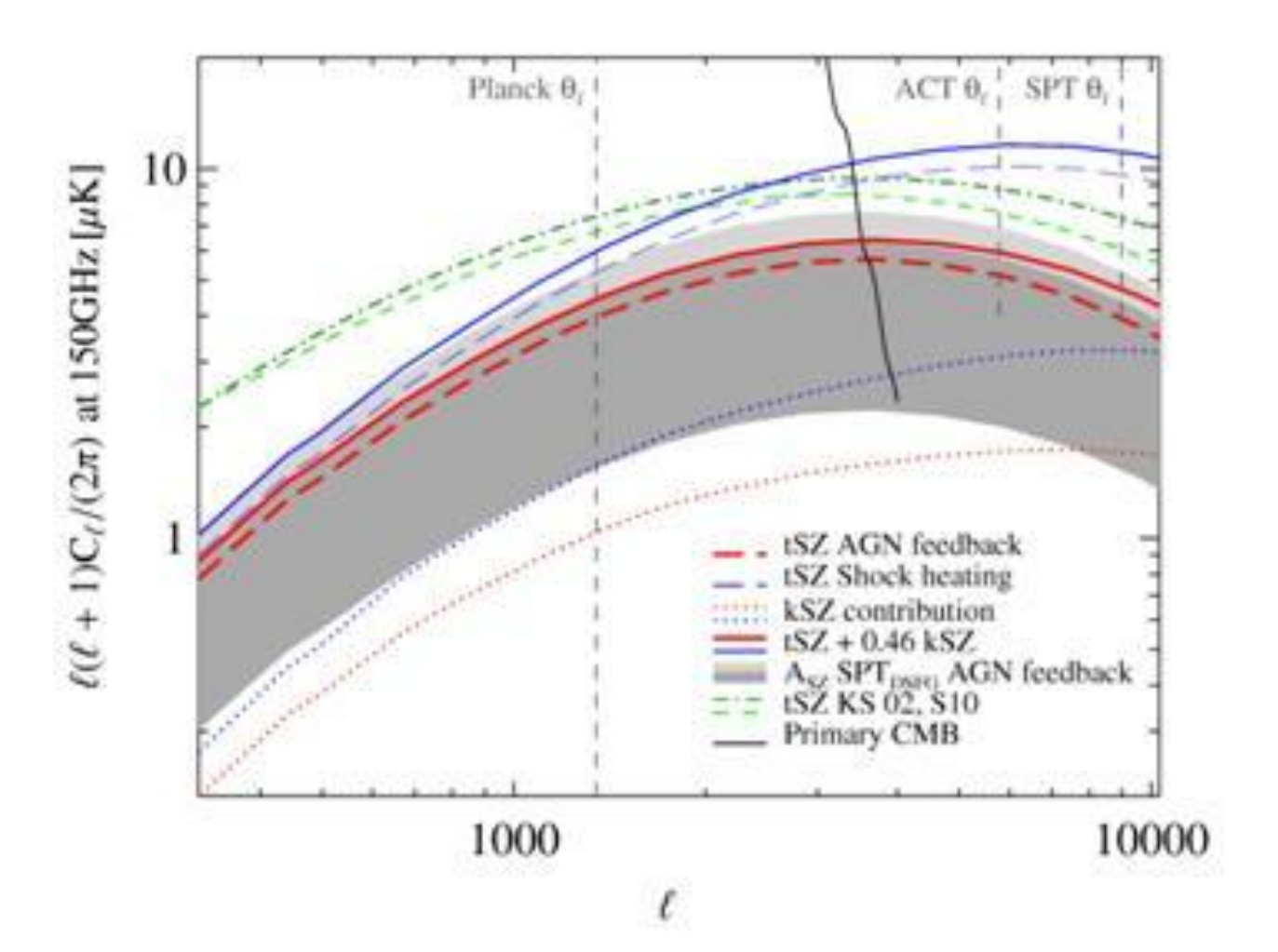

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Conclusions

”AGN” feedback does well

✓ X-ray observations

✓ Sunyaev – Zel’dovich observations

✓ f_{star} from optical observations

✓ Consistent with WMAP7 σ_8

Much more to be done!