Galaxy Clusters and Cosmology
When there is light, there is also shadow

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University of Heidelberg

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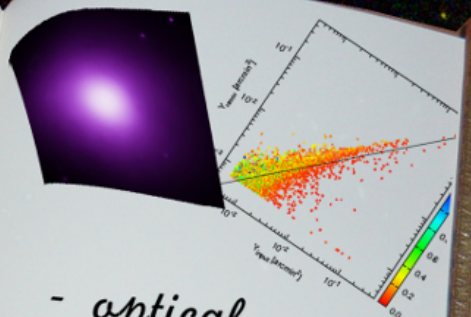
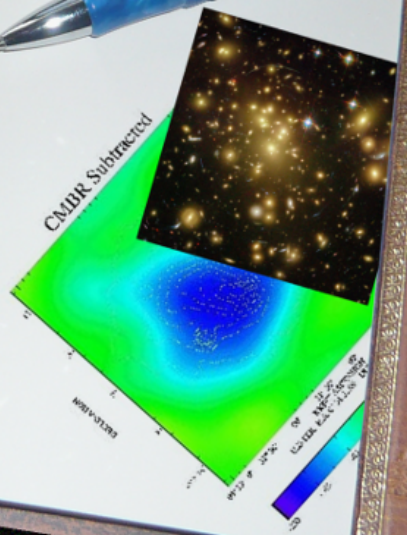
outline

The Book of clusters

The most massive gravitationally bound systems in the Universe ...



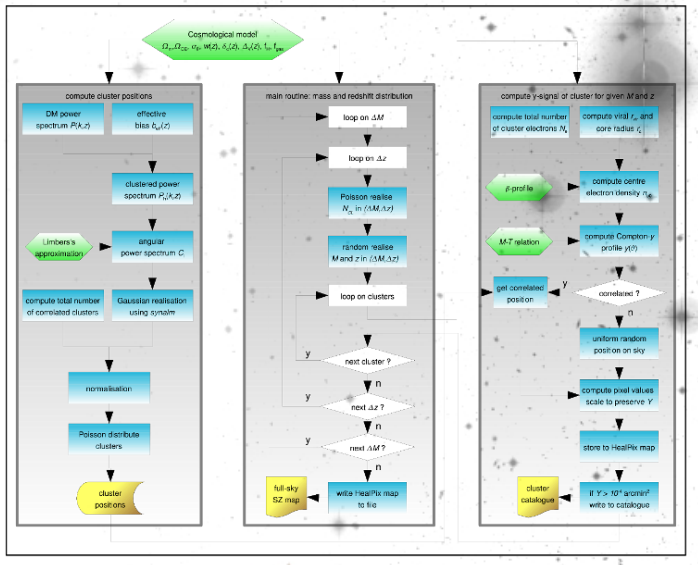
- optical
- X-ray
- SZ

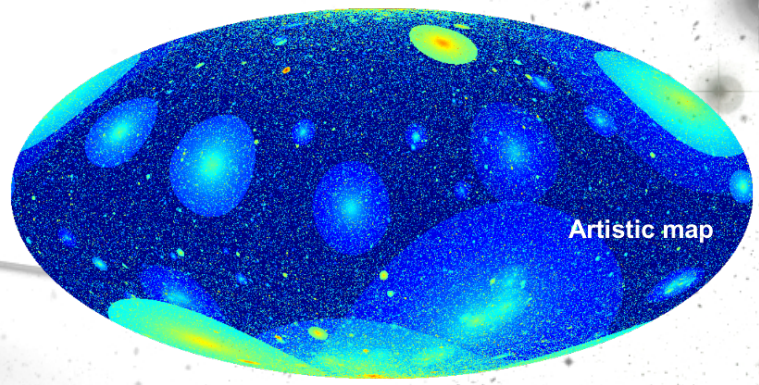


Constructing a full-sky tSZ-map (Waizmann & Bartelmann 2009)

In a nutshell

- Works also for $w(z)$ models
- Method is fast compared to numerical simulations
- Assume hydrostatic equilibrium (M-T relation)
- Model clusters as β-profiles
- Constructed observed sky maps including foregrounds and instrumental noise
- Fed observations into our filtering pipeline





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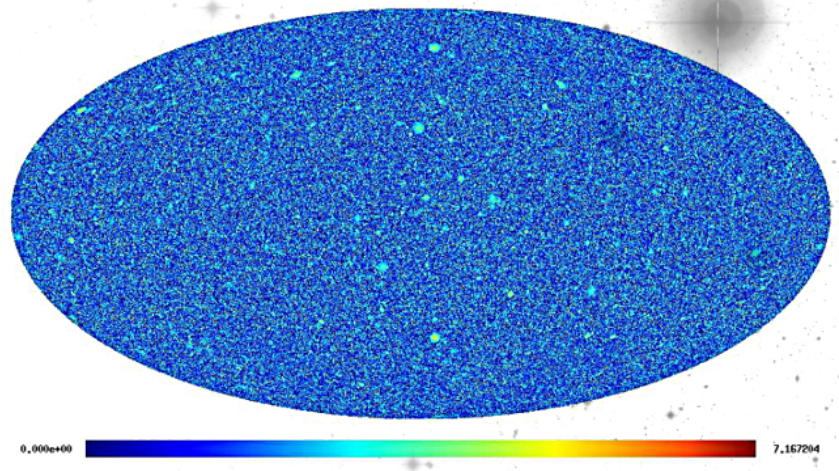
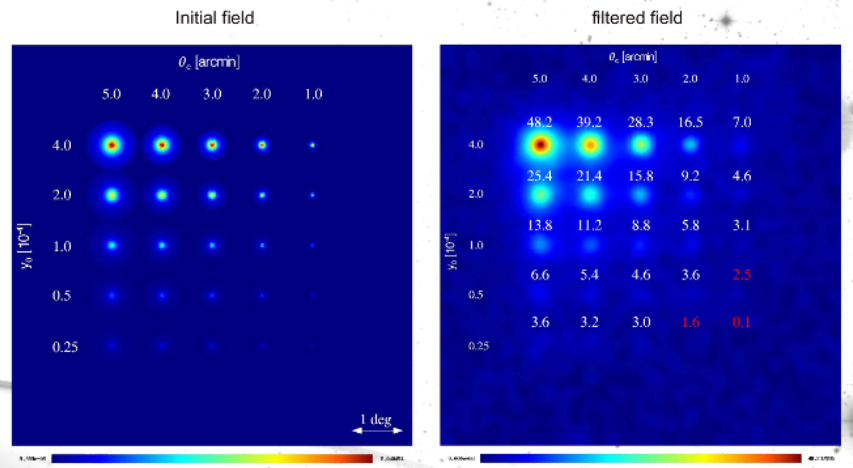
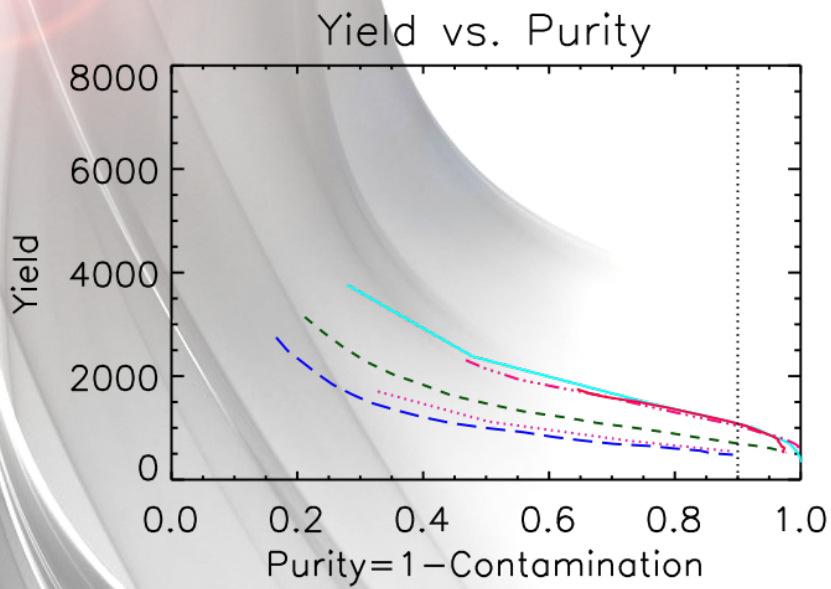
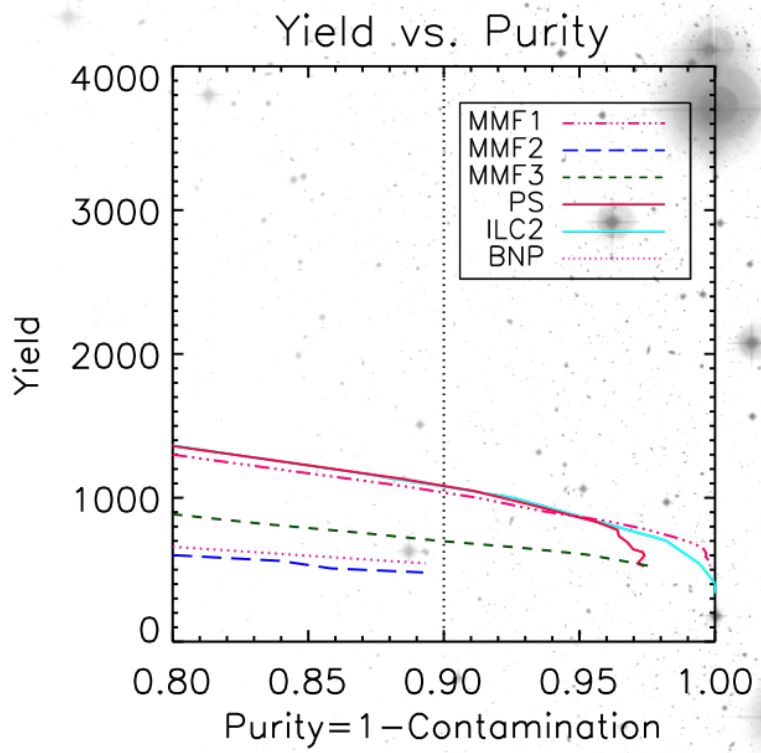




The Planck Cluster Catalogue (Melin et al. in prep.)





What can we expect of the PCC?

We can expect from Planck to detect 1000-2000 clusters at a purity of 90%. **Preliminary results!!! from WG5 cluster challenge**

Structure growth & dark energy

(Pace, Waizmann & Bartelmann in prep.)

How do structures grow when dark energy is present?

$$\delta'' + \left(\frac{3}{a} + \frac{E'(a)}{E(a)}\right)\delta' - \frac{4}{3}\frac{\delta'^2}{1+\delta} - \frac{3}{2}\frac{\Omega_\mathrm{m}}{a^5 E^2(a)}\delta(1+\delta) = 0$$

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IC: $a_\mathrm{i} = 5 \times 10^{-5}$, $\delta' = a_\mathrm{i}$, δ_i to be searched.

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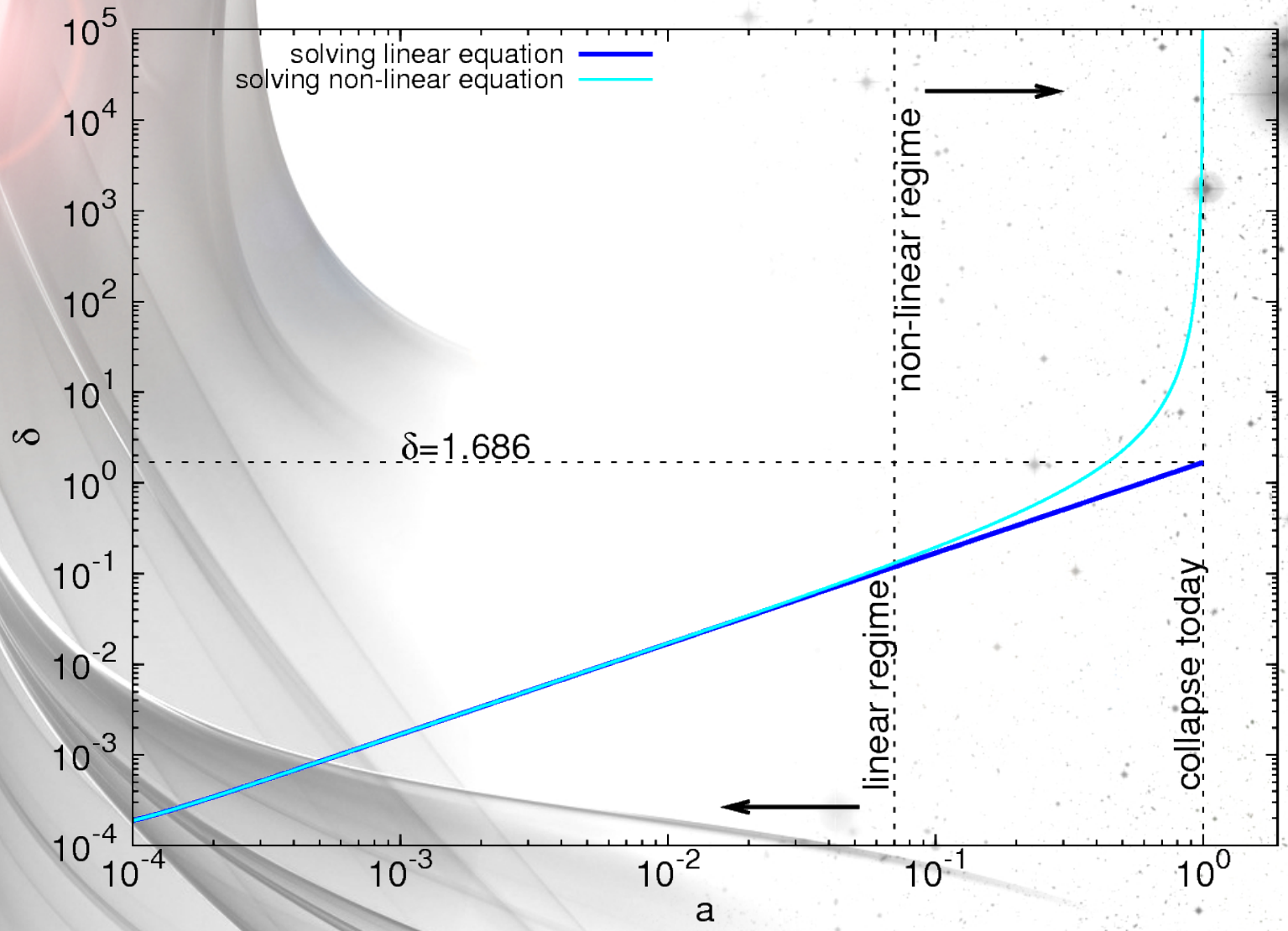
Getting δ_c for DE models

(Pace, Waizmann & Bartelmann in prep.)



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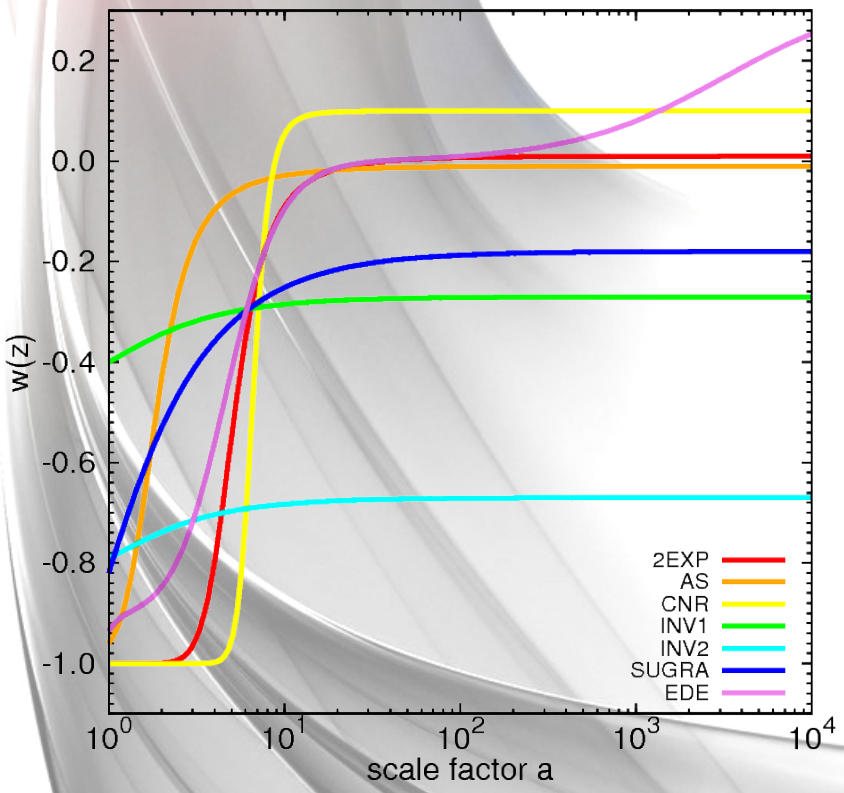
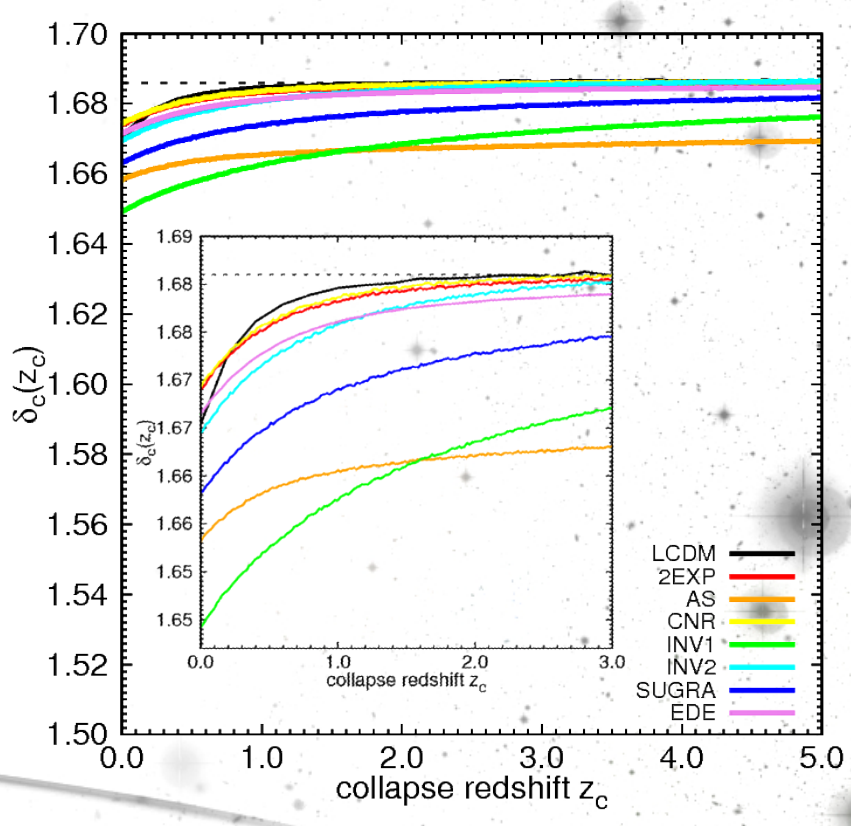
Equation of state

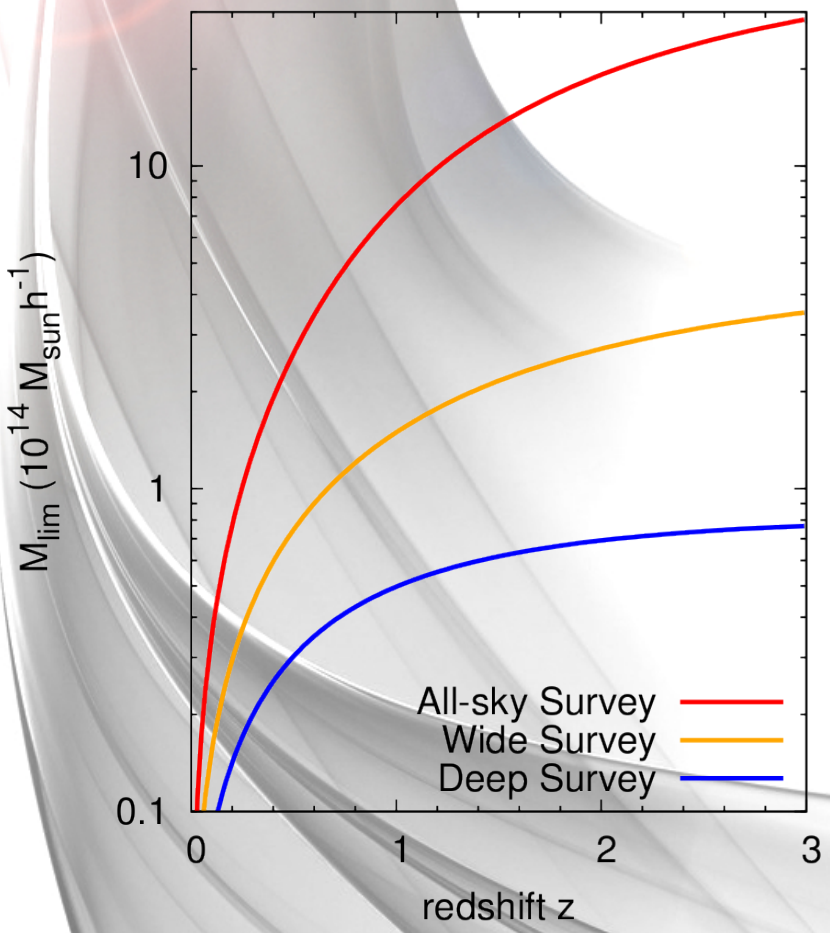


Linear density contrast

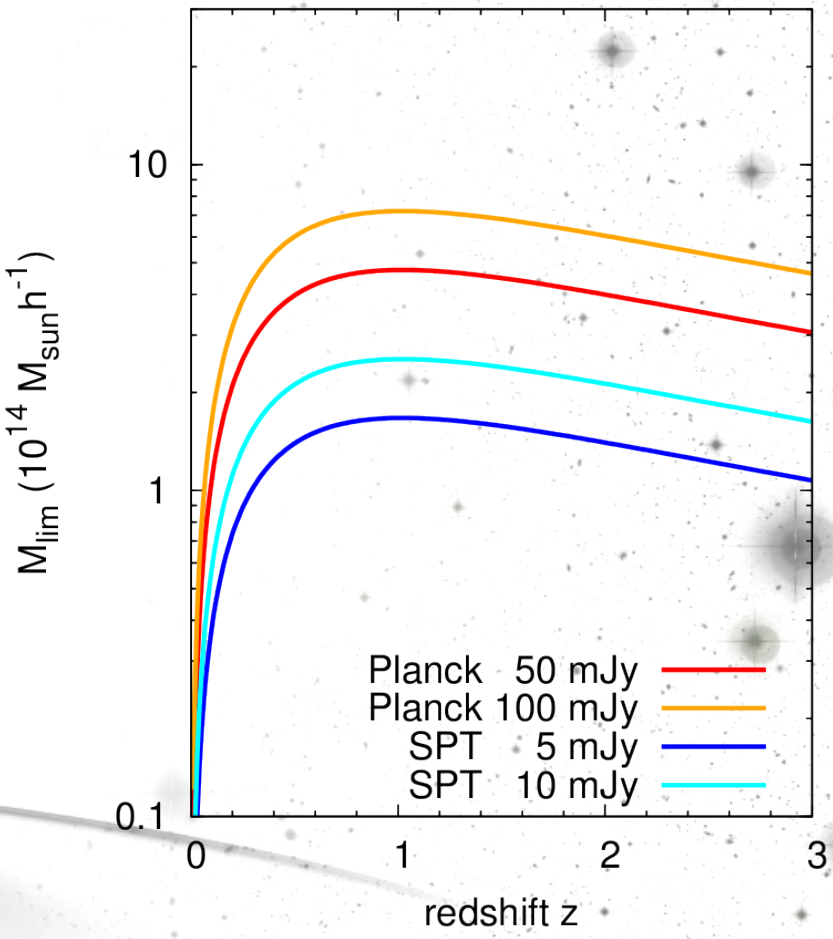


Cluster Cosmology in our Dreams

X-ray (eROSITA)

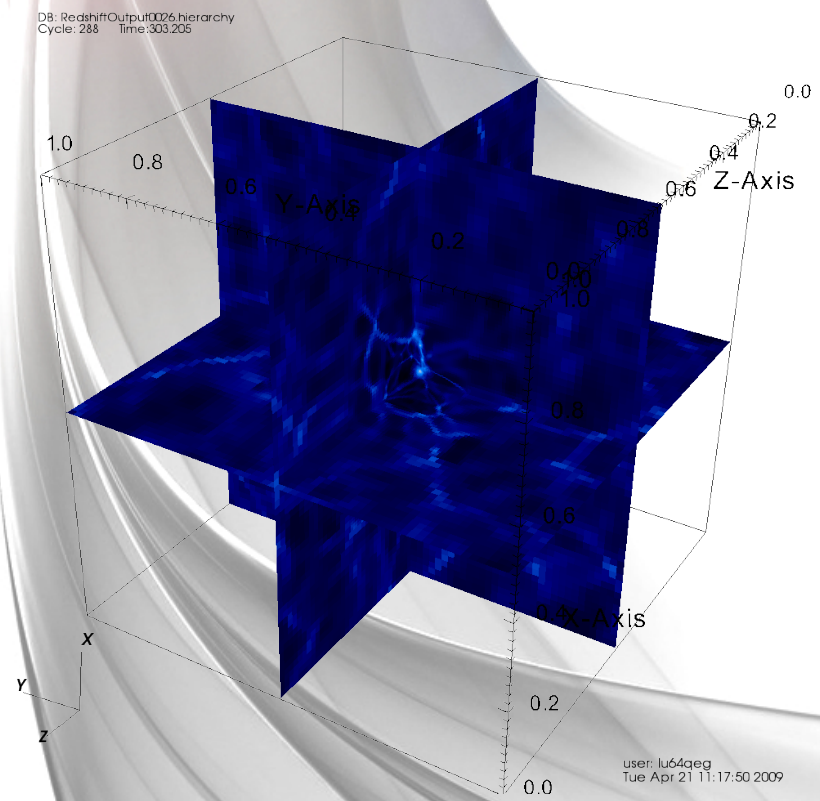


SZ (Planck, SPT)

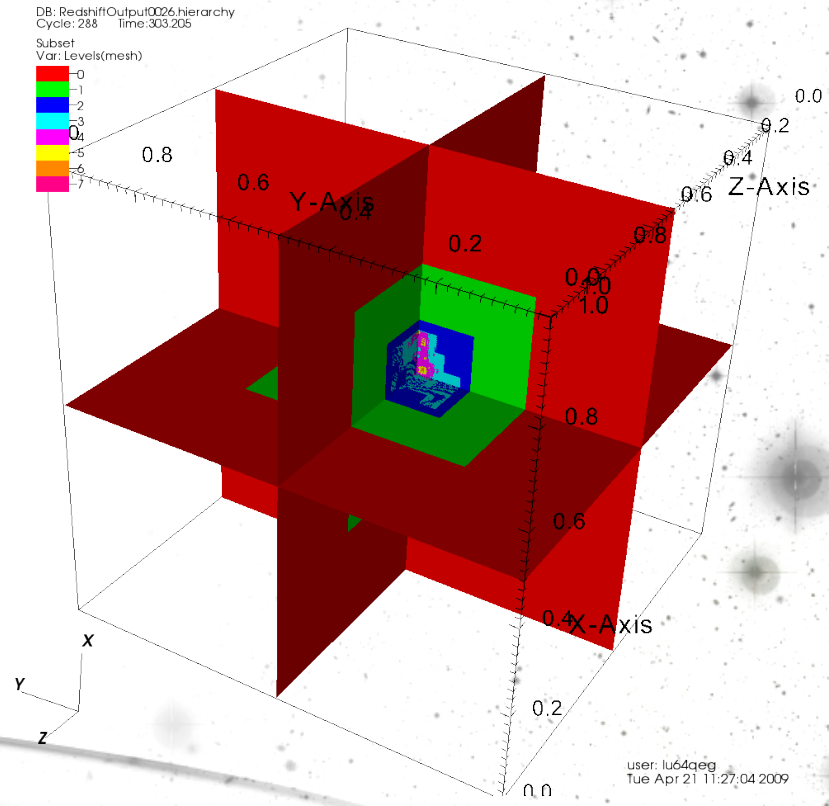


Using simulations to study cluster evolution

Density

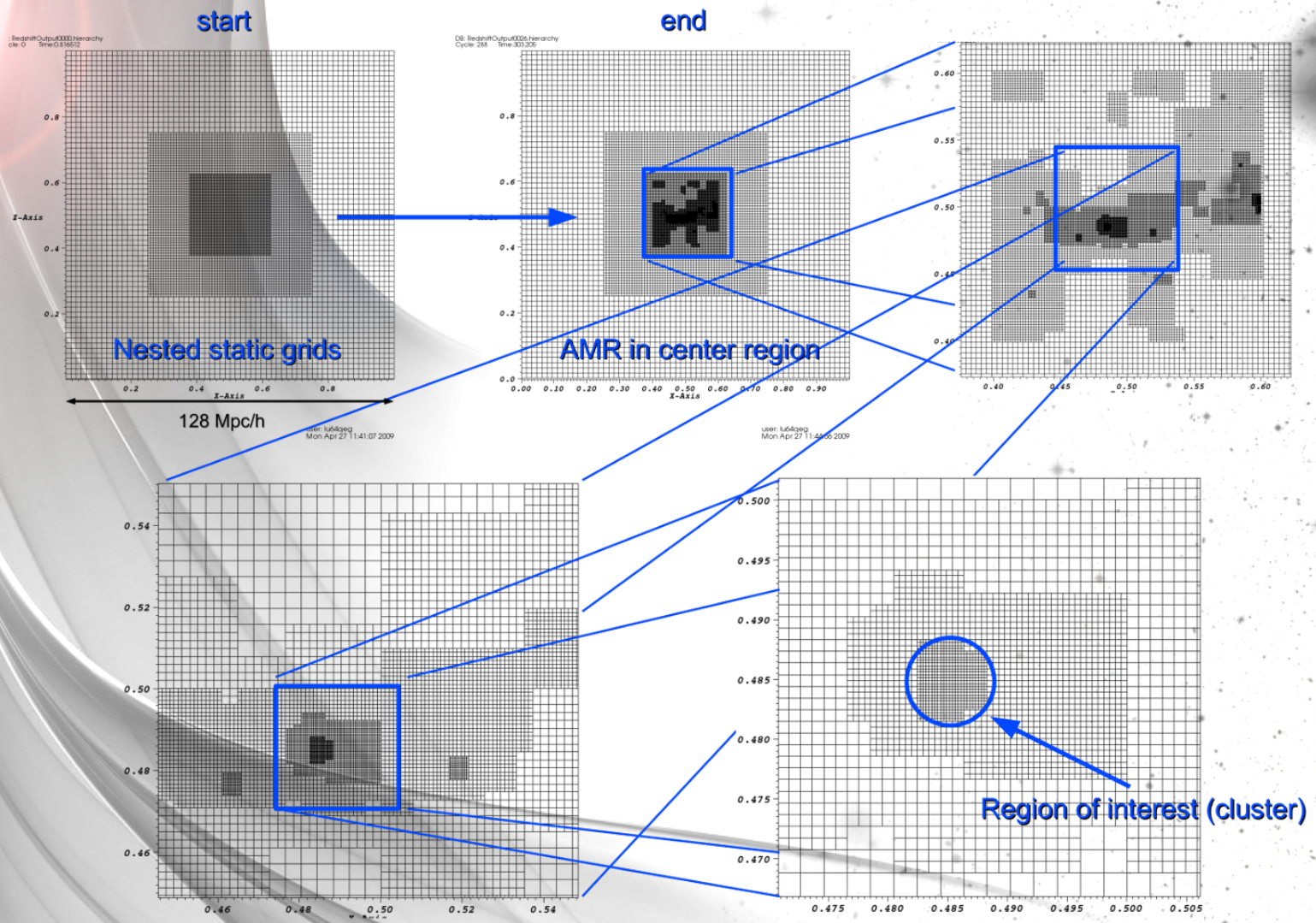


Grid Level



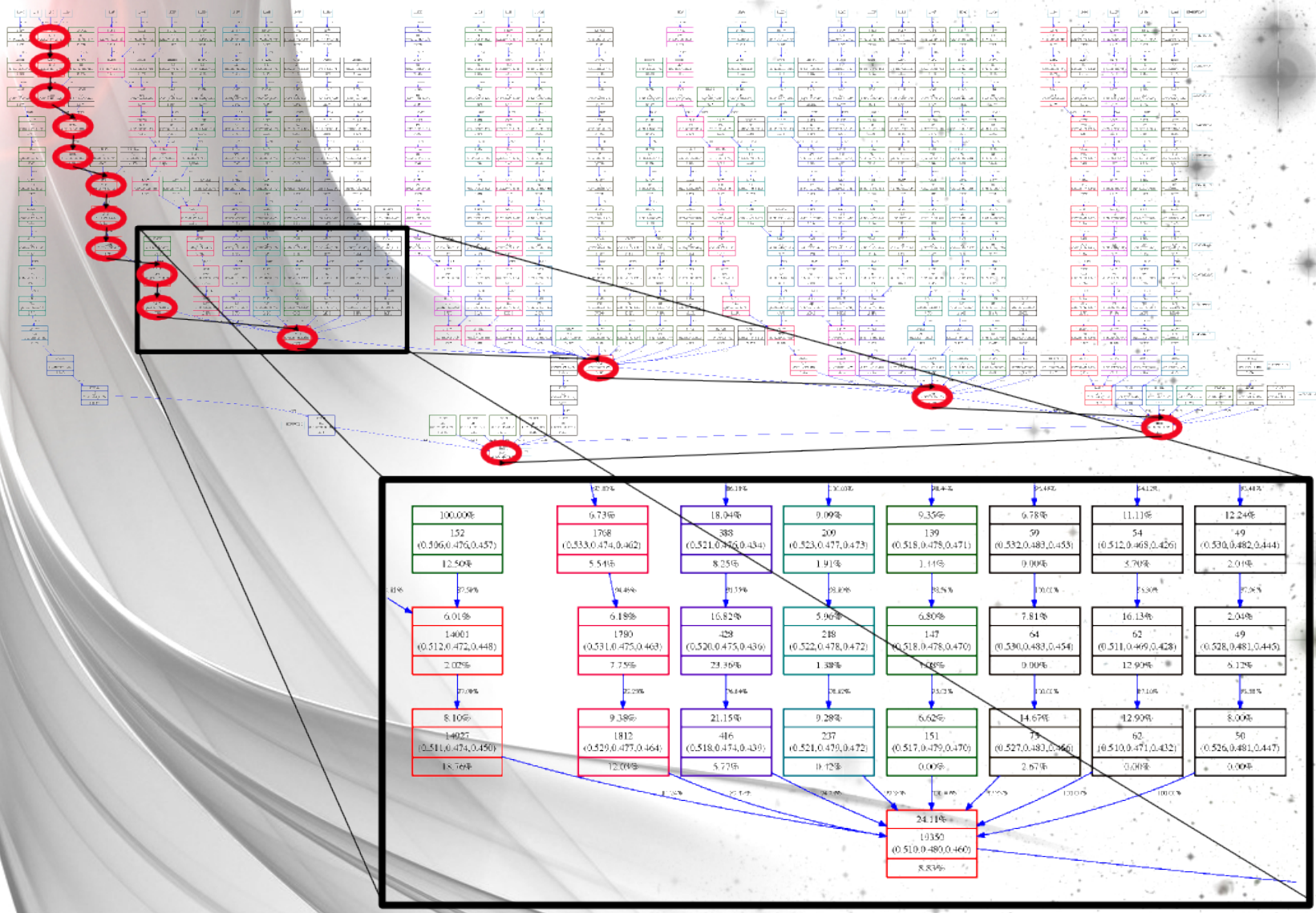
Refinement scheme

(Waizmann, Iapichino & Bartelmann in prep.)



Follow the leader

(Waizmann, Iapichino & Bartelmann in prep.)



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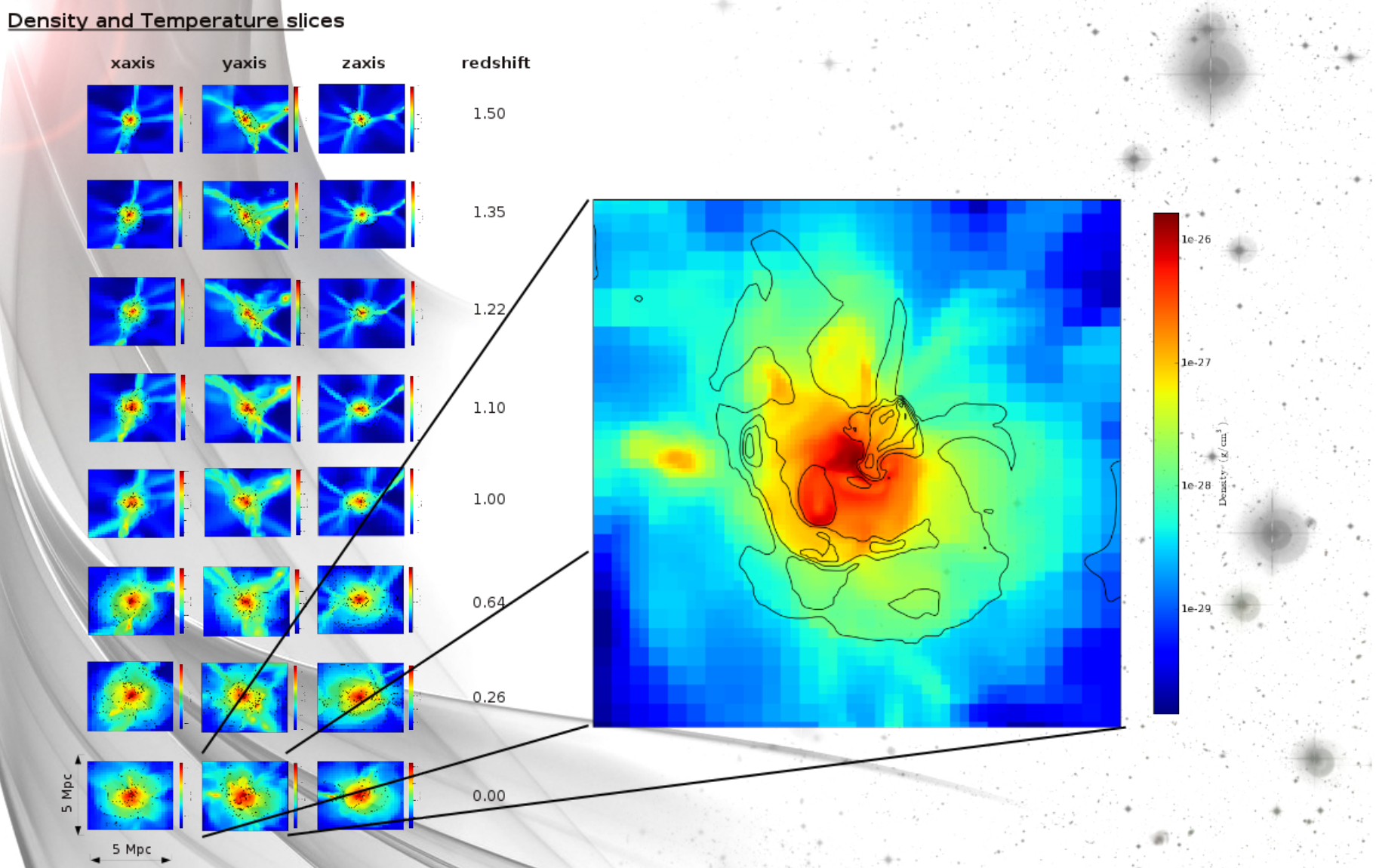

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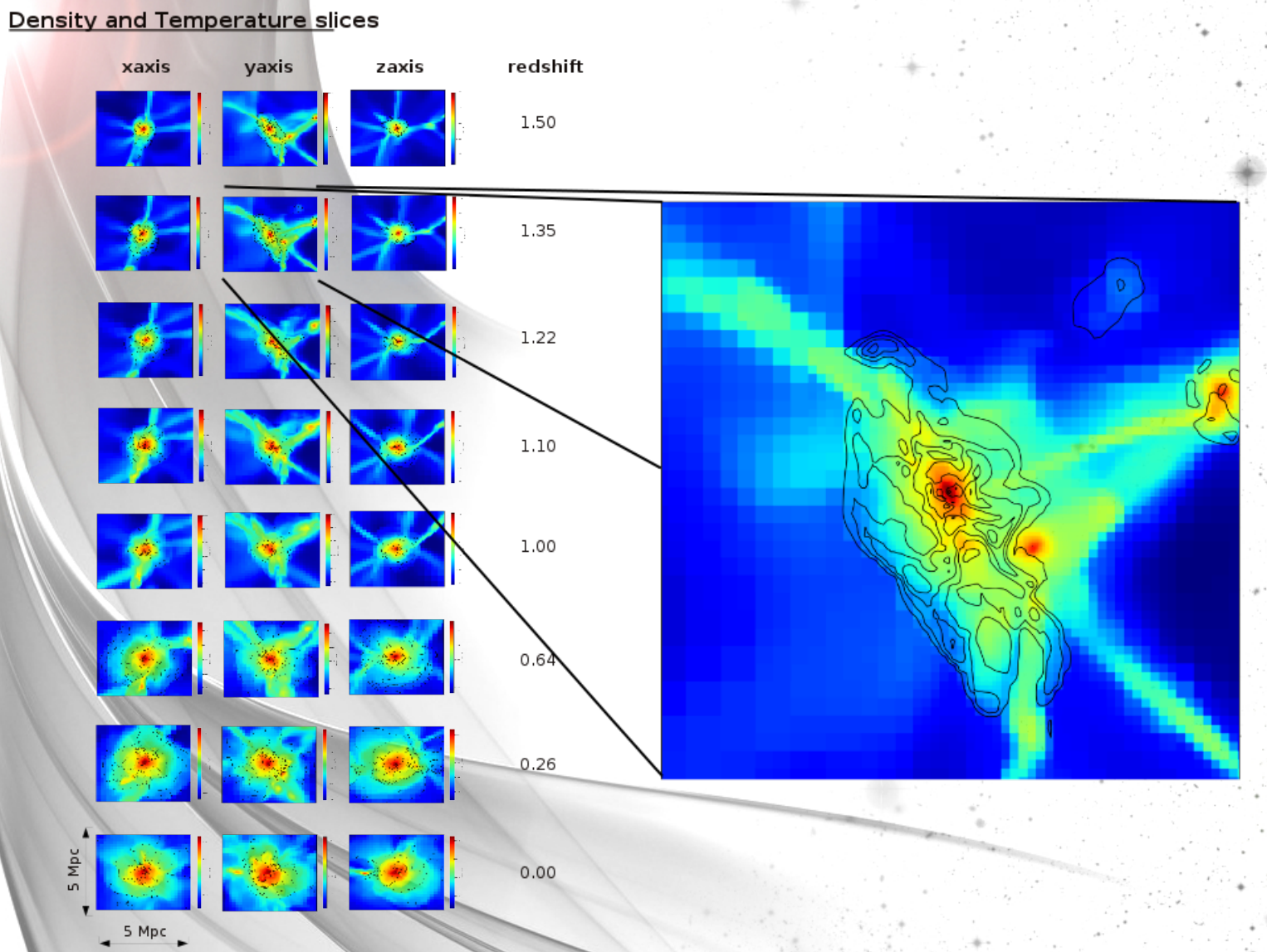

Summary & Conclusions

Structure formation and Dark Energy

- We can compute δ_c for a range of DE models
- Impact on non-linear structure formation is neglible
- Probably modified gravity and/or clustered DE change this

SZ cluster sample & mapmaking

- We expect 1000-2000 clusters from Planck
- Foregrounds & point source contamination make life hard
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Cluster cosmology

- We need many clusters for cosmology
- Future missions will probe high-redshift clusters
- Better understanding of high-z cluster evolution is needed

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