BUFFALO meeting 2021:
Improving parametric mass modelling of lensing clusters through a perturbative approach

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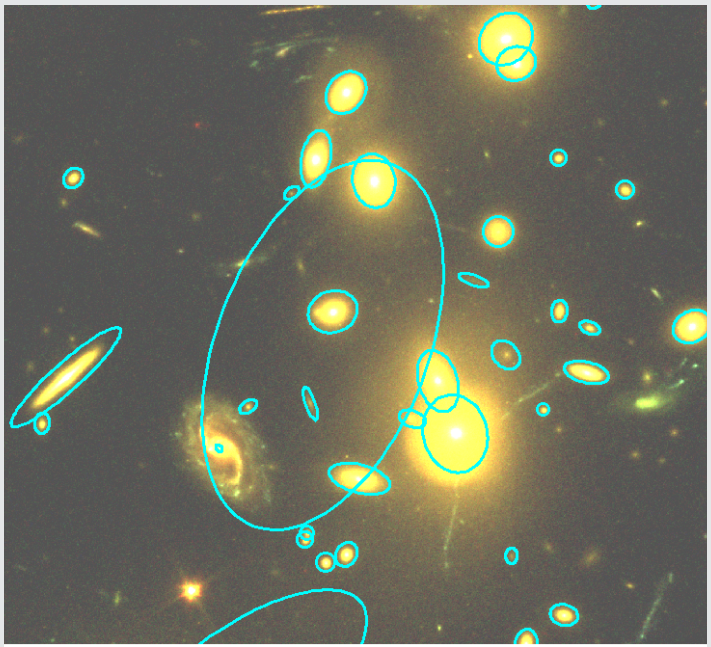
Beauchesne et al. (2021) [arxiv:2106.05029]

Galaxy cluster modelling

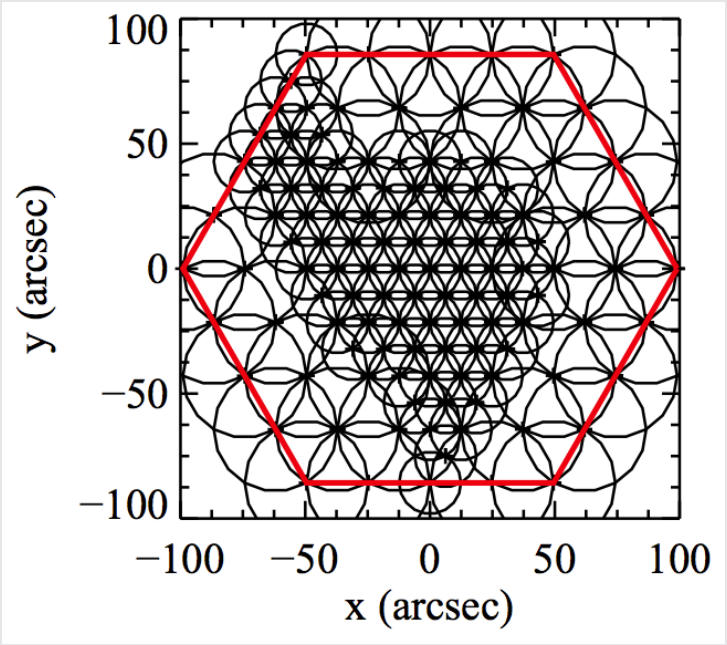
Model-based method



Mahler et al.(2018)

+ Physical solution (ex : isothermal sphere).
± Iterative work of modelling.
– Assumption on the shape of potential (symmetry,..).

Model-free method



Jullo et al.(2009)

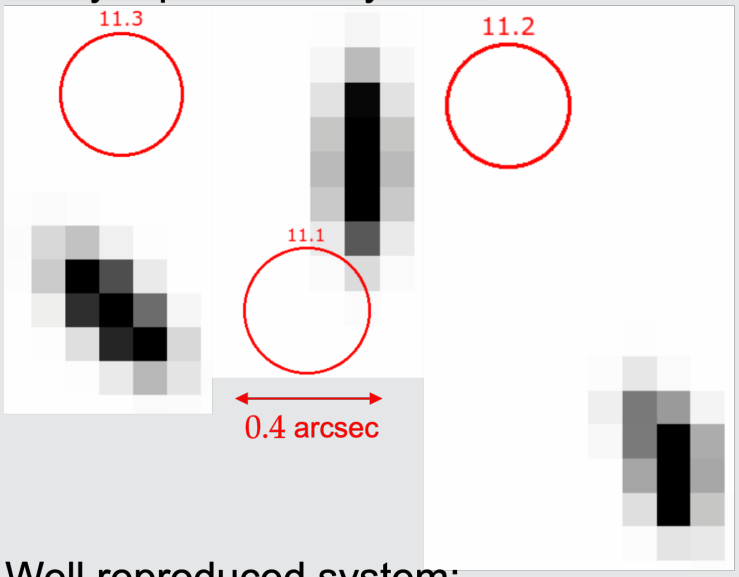
+ No assumption on the shape.
– Can lead to unphysical results.
– Models are strongly degenerated.

Limitation of the parametric modelling

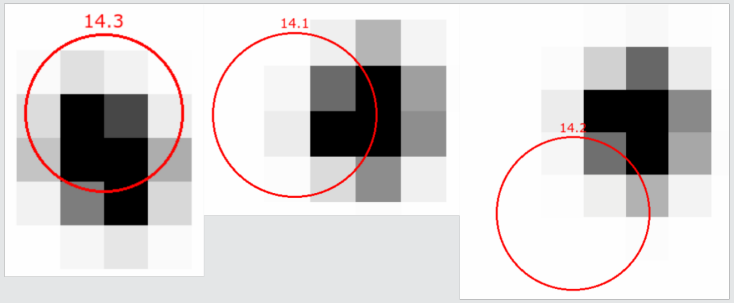
Many high-quality constraints

Models accuracy

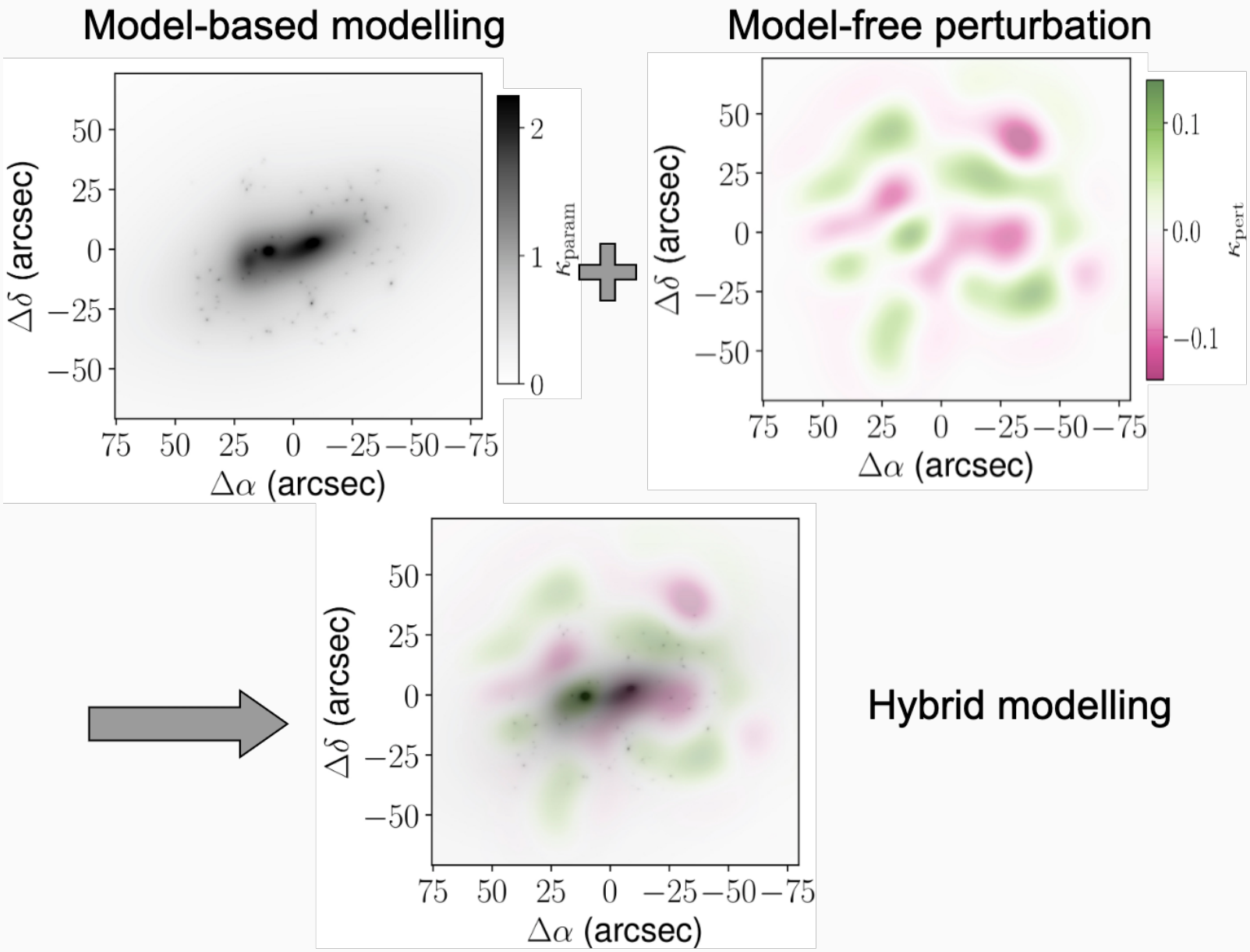
Badly reproduced system:



Well reproduced system:

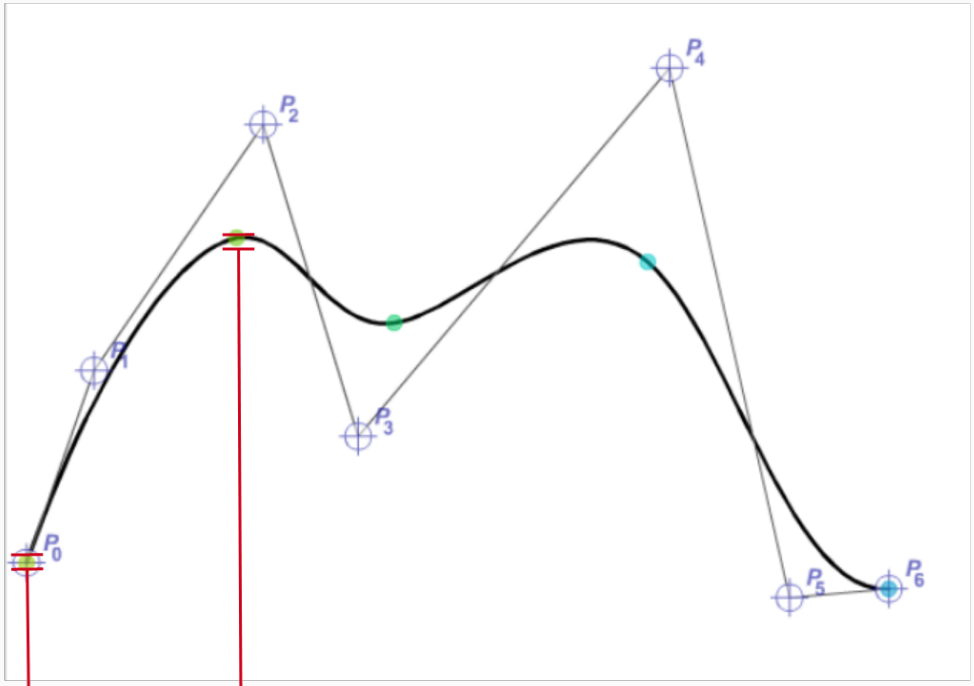


Hybrid approach

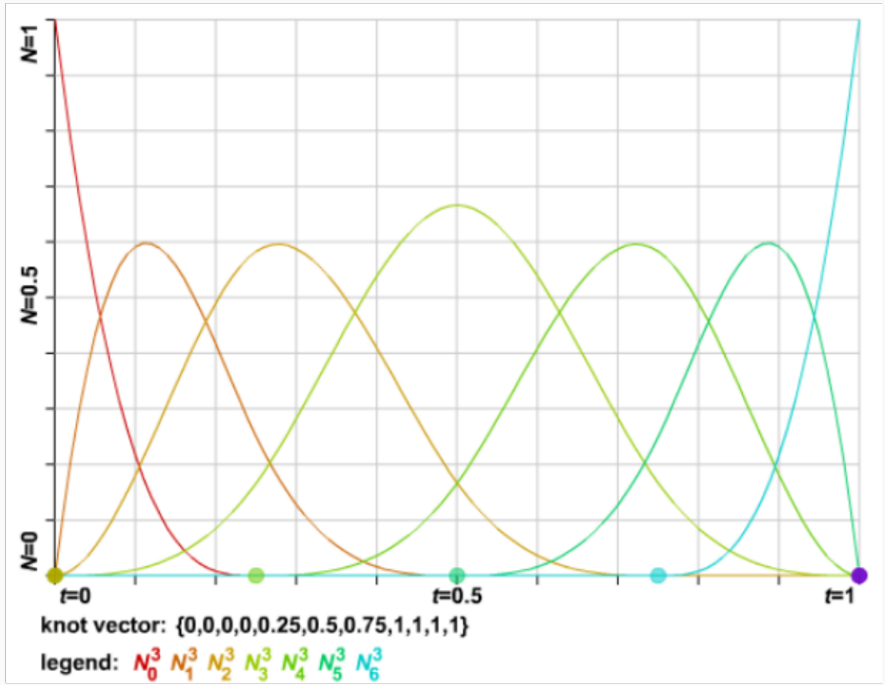


A B-spline perturbation

Spline function



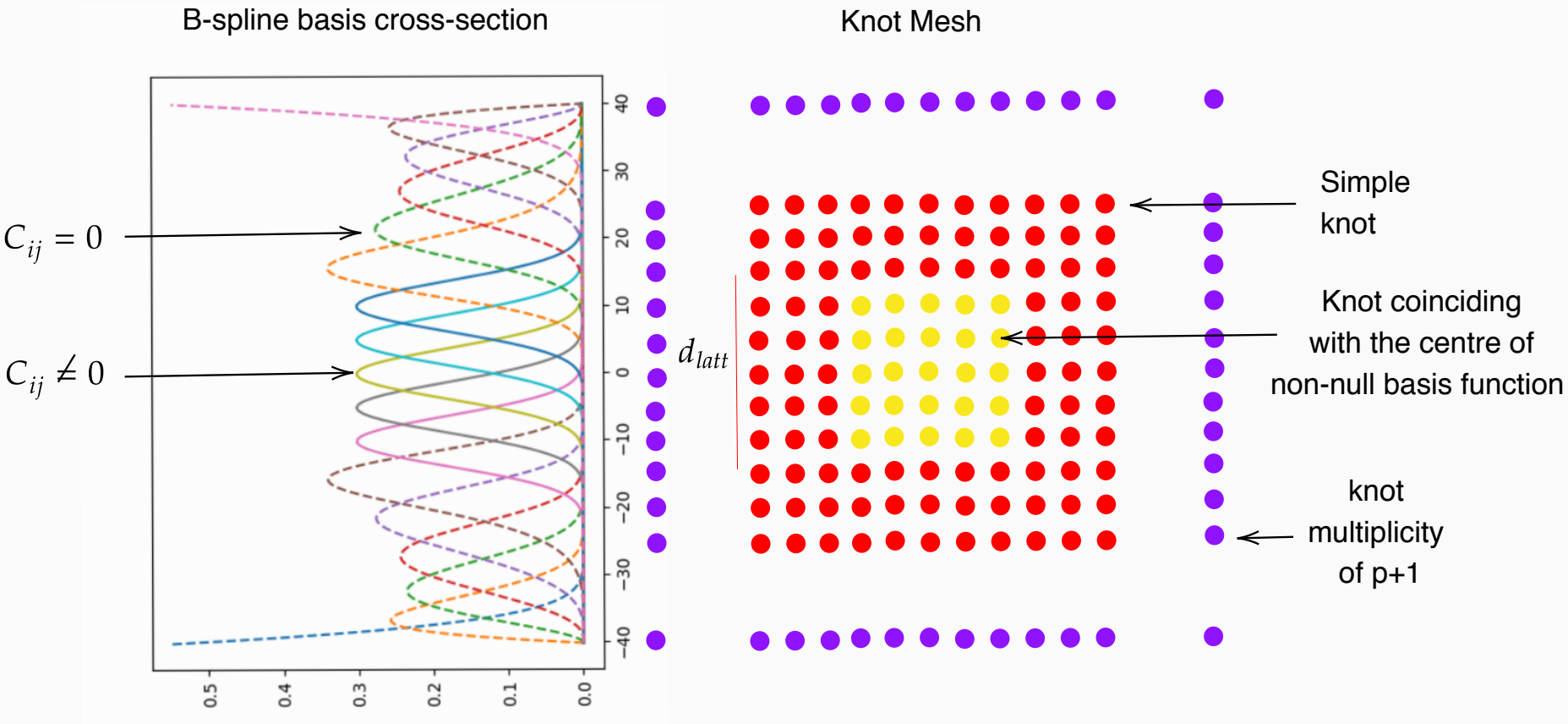
Basis functions: B-splines



Between knots ⇒ Polynomial functions

A B-spline perturbation : Surface definition

$$\Delta\psi(x,y) = \frac{D_{ls}}{D_s} \sum_{j,l=1}^{m} C_{j,l} B_{j,p,t_x}(x) B_{l,p,t_y}(y) \tag{1}$$



A B-spline perturbation : Pros and cons

Perturbation on the lensing potential

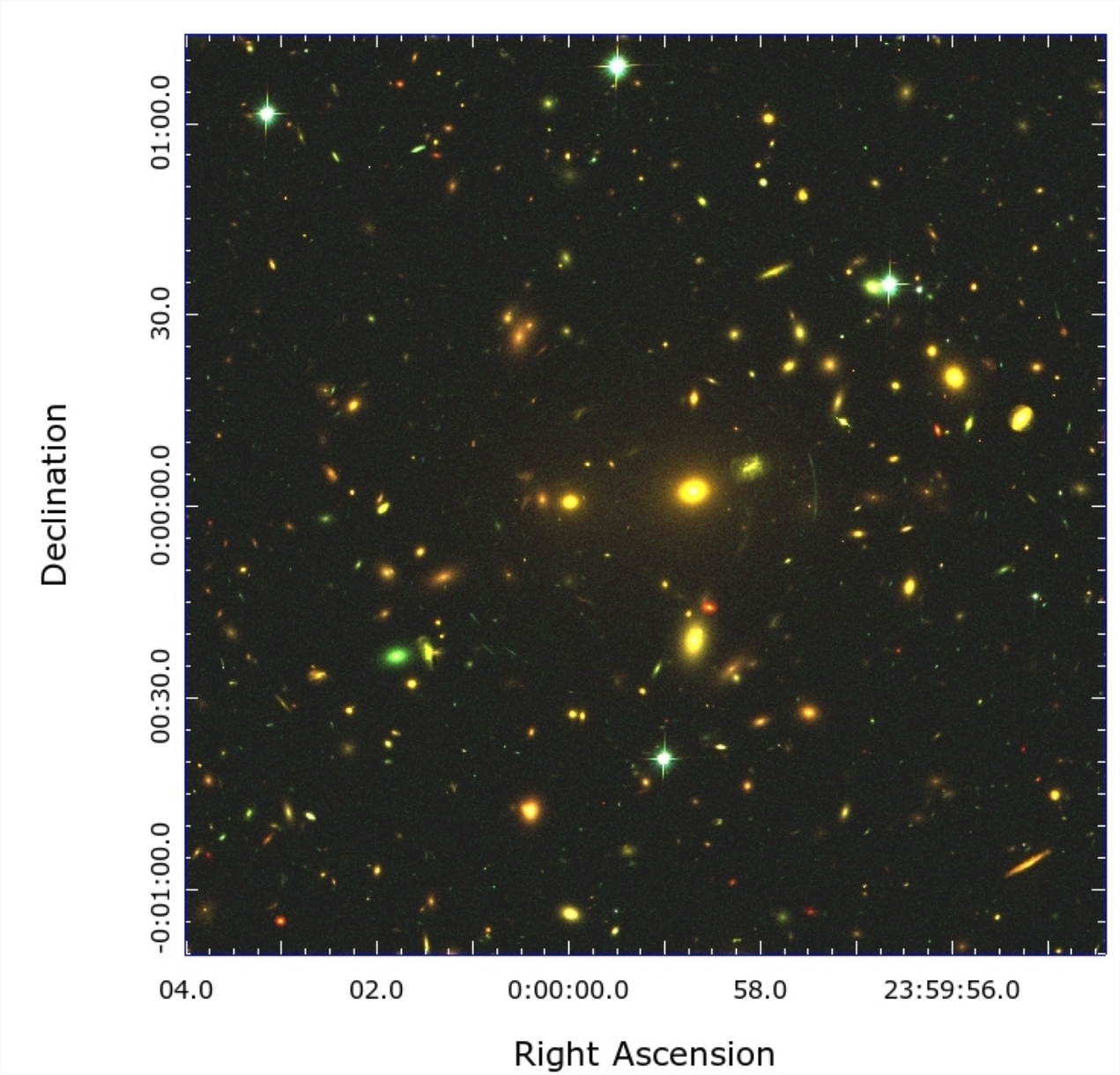
Pro

- Direct modification of the mass distribution
- Locality
- Easy to compute

Cons

- Redistributing the mass only
- Squared shapes
- Boundary effect

Hera Cluster : A realistic simulation of galaxy cluster

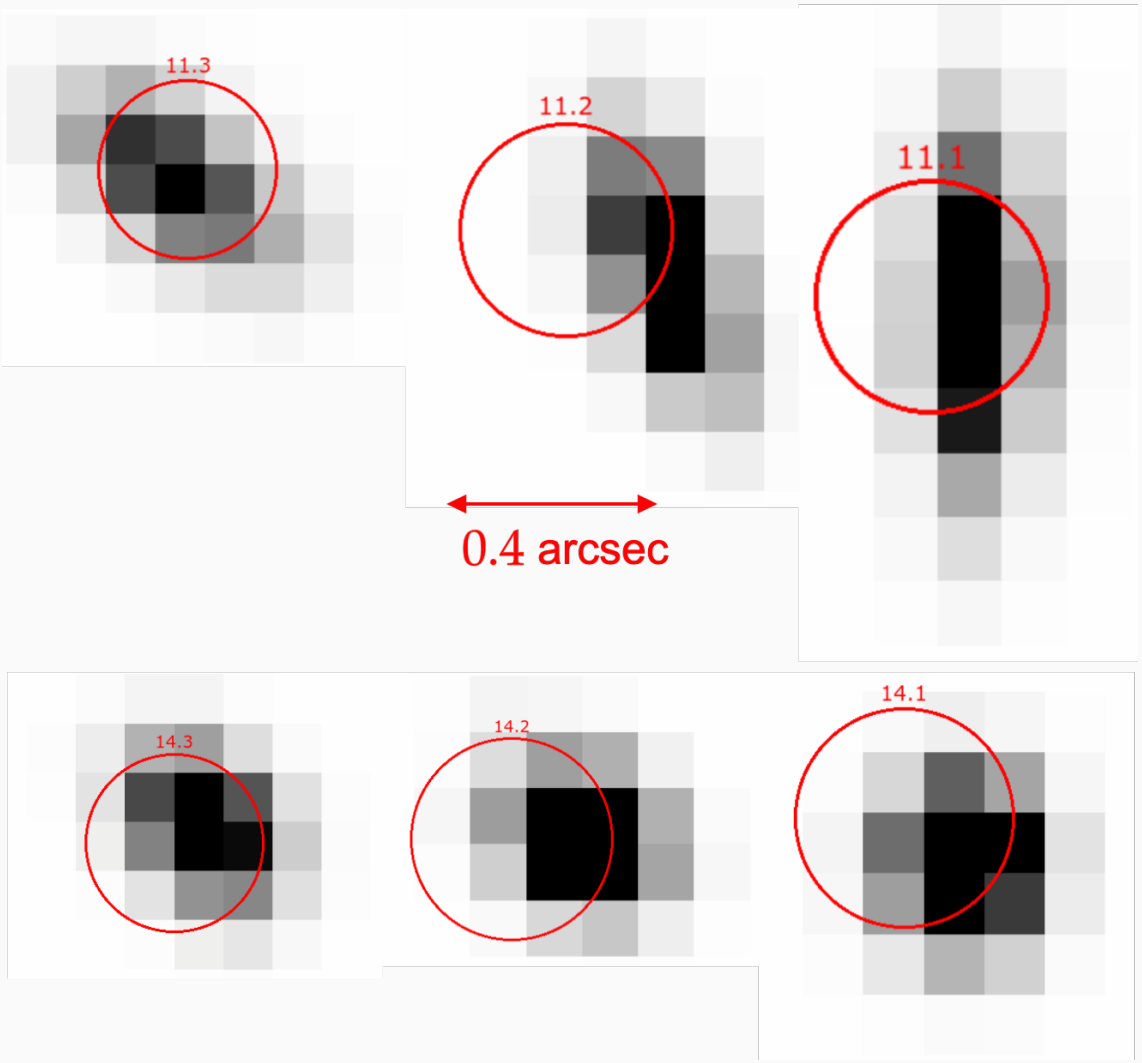


Hera Cluster

- Large scale N-body simulation
- Similar to HFF clusters

Meneghetti et al. (2017)

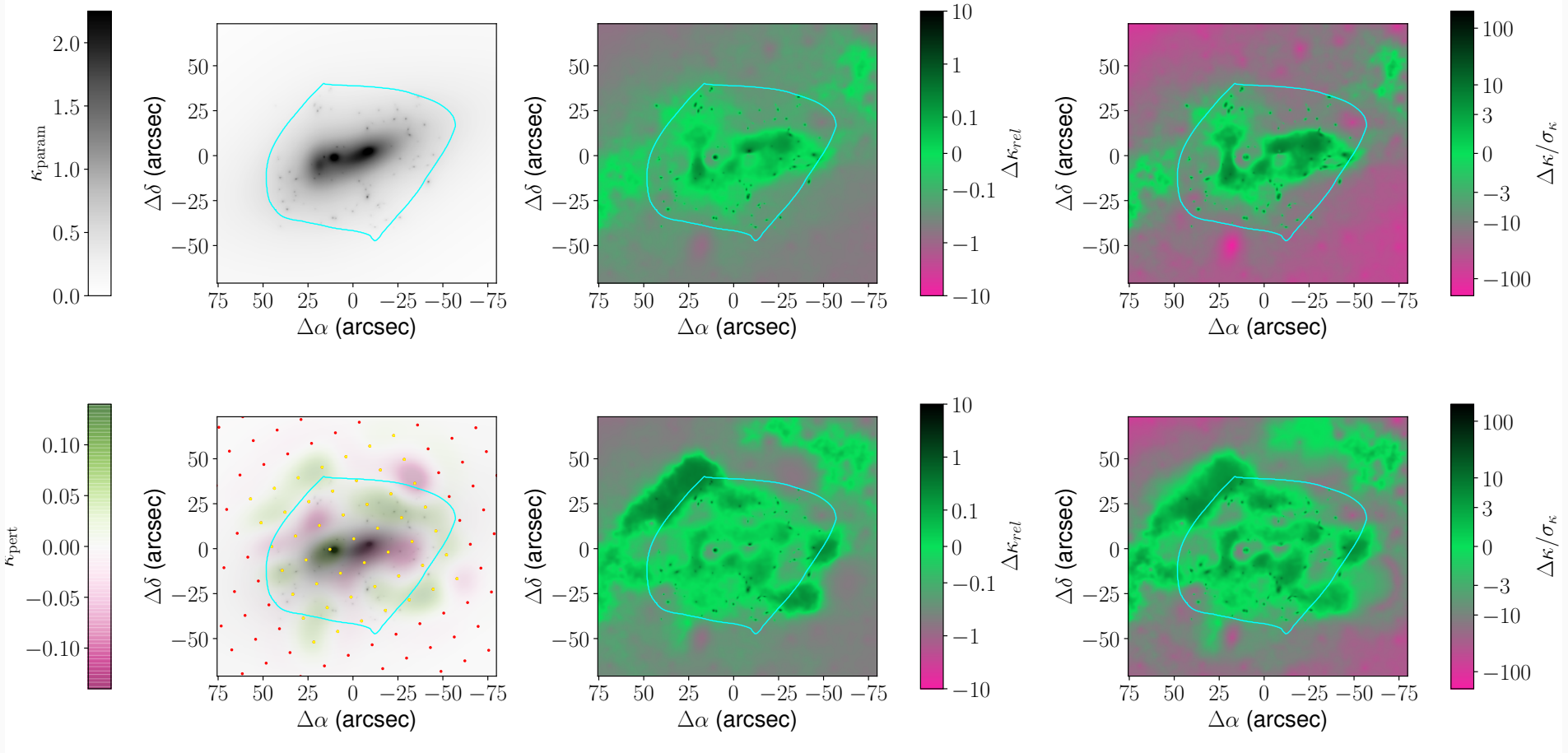
Deflection angle field



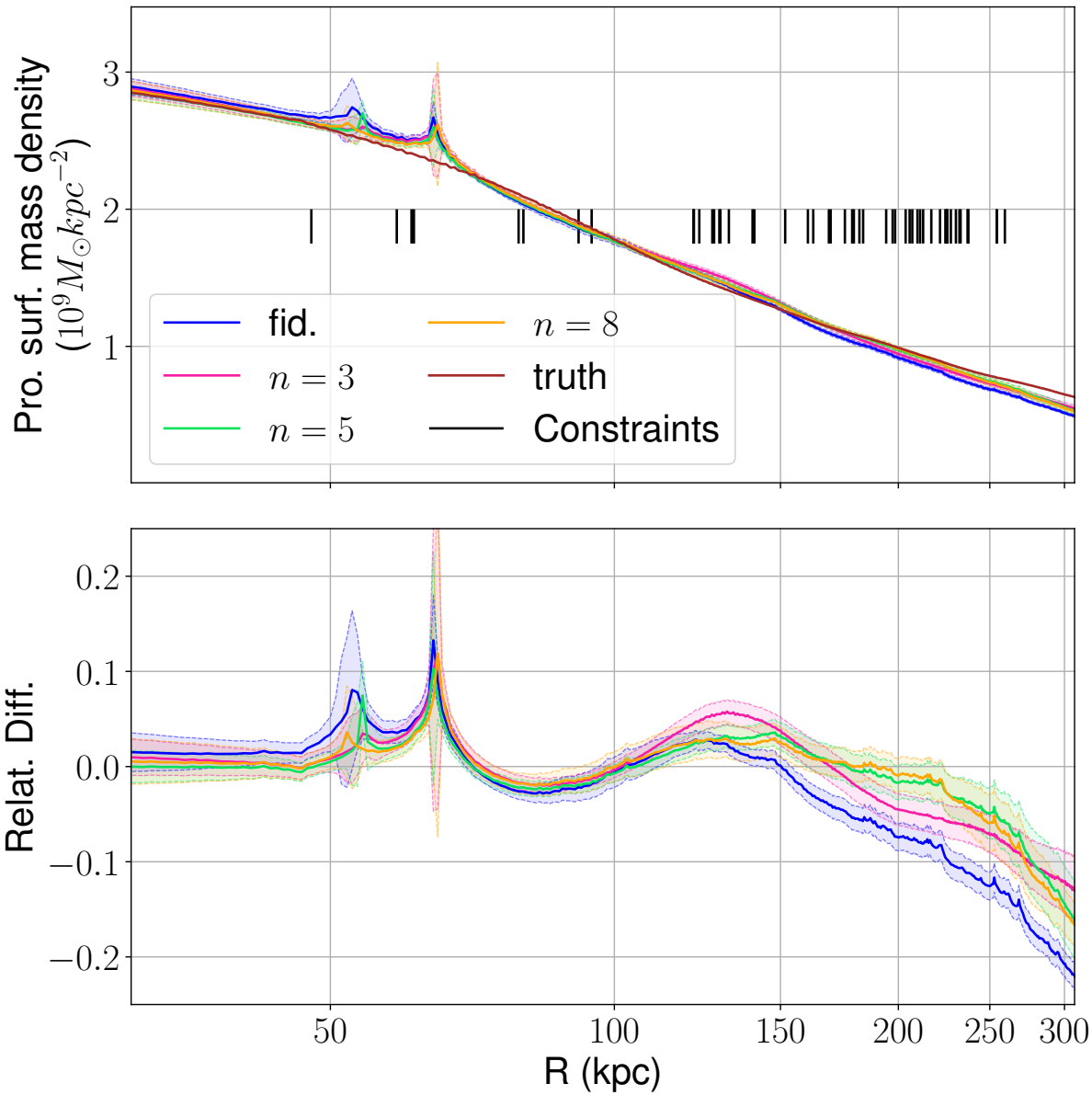
Root-mean-squared Error

- Decrease by a factor $\sim 3 - 4$.
- Reduction of the RMS spreading among all systems.

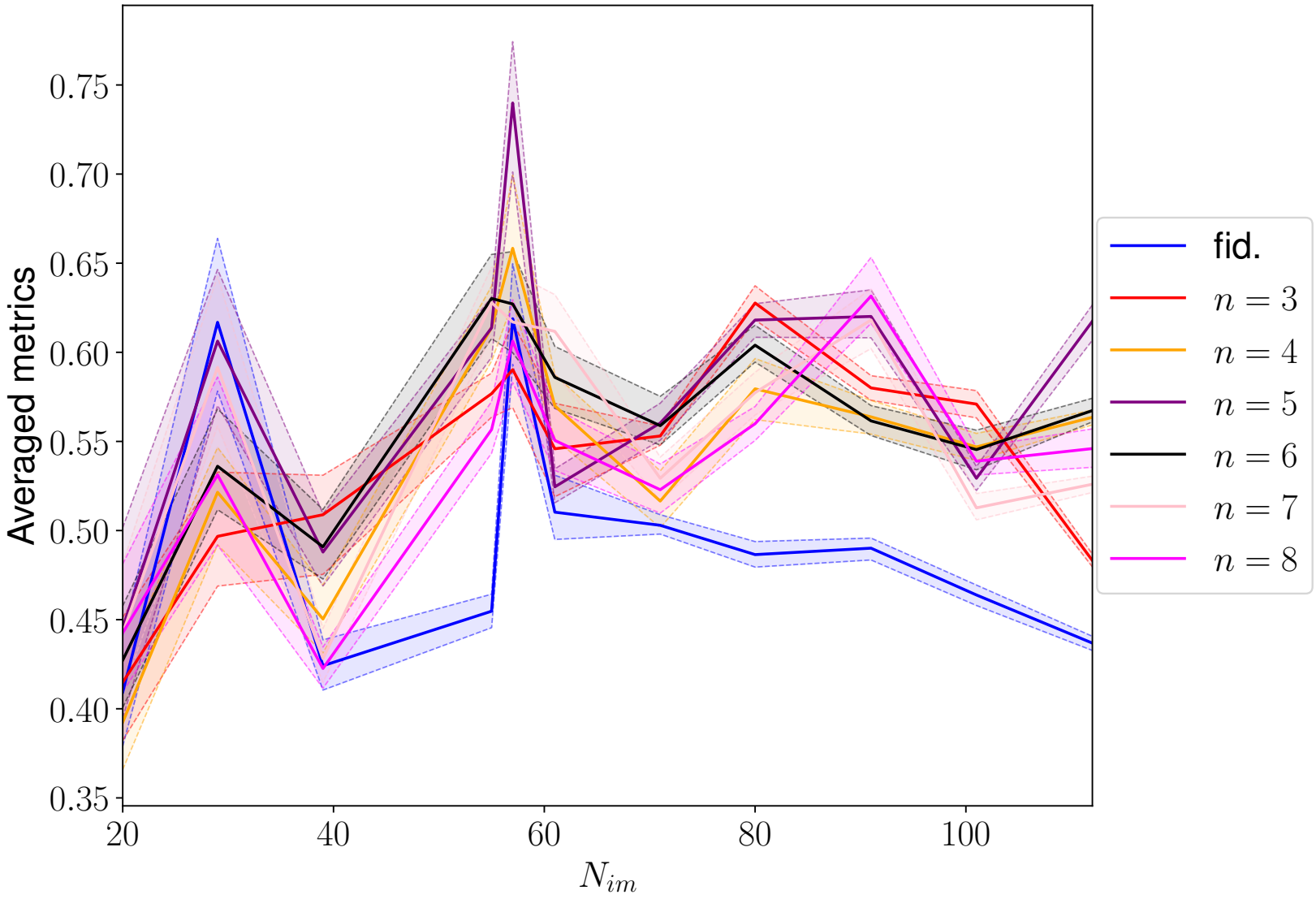
Mass distribution : 2D field



Mass distribution : Profiles



Evolution with the number of constraints



Conclusion

Key points :

Modelling :

- A hybrid modelling : Benefits from both approaches.

Results :

- Better fit of the deflection angle field.
- More accurate reconstruction of the projected mass distribution.

Thank you for listening