Ramses User Meeting - Lyon - 2018

Cosmological Milky-way like galaxies: trying different baryonic physics schemes

The (french) astroparticles and Dark matter connexion

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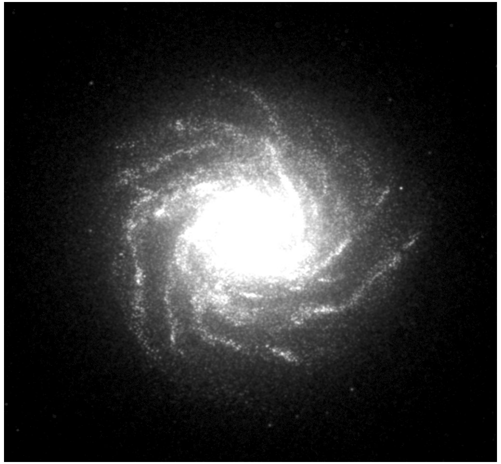
Pol Mollitor (Luxembourg)
Martin Stref (Montpellier)

Motivation

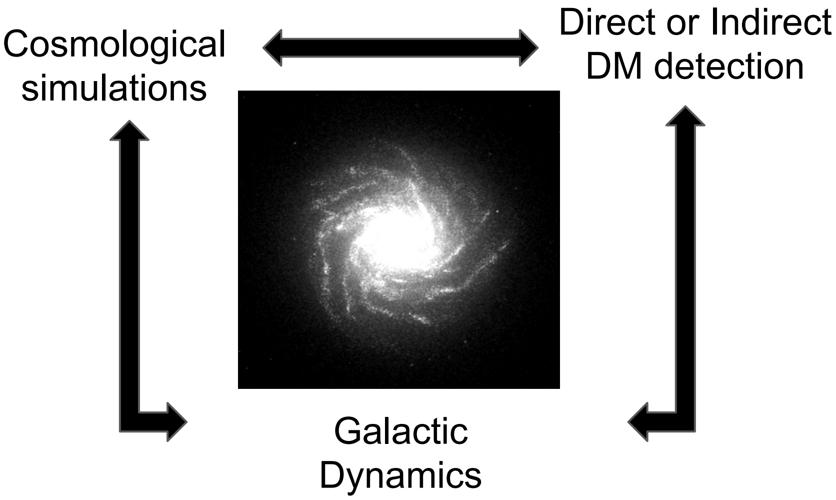
Cosmological simulations

Direct or Indirect DM detection



Galactic Dynamics

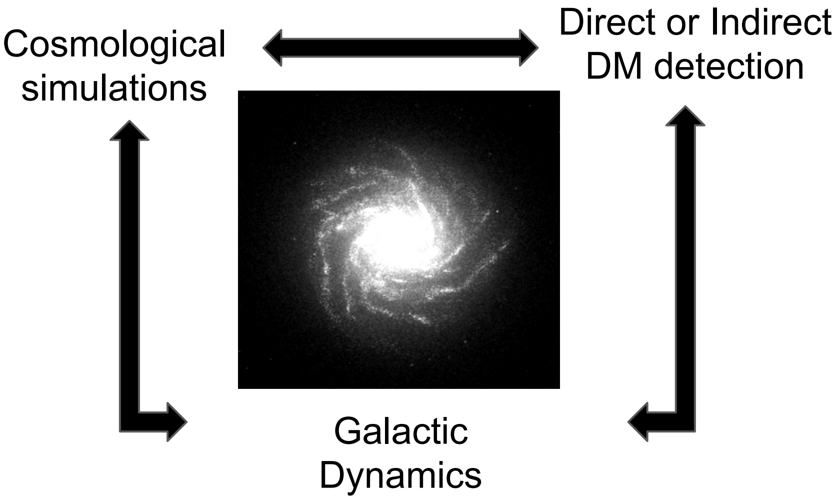
Motivation



What we need:

The Milky Way Cosmological Simulation

Motivation



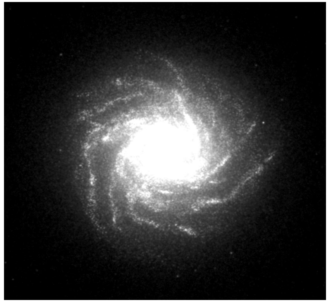
What we need:

A ~~The~~ Milky Way-like Cosmological Simulation

Motivation

Cosmological simulations

Direct or Indirect DM detection



Galactic Dynamics

What we need:

~~The~~ SOME Milky Way-like

Cosmological Simulations

Observations

Low res (Δx=150-300 pc)
Delayed cooling
SF0

Stellar to Halo Mass Ratio

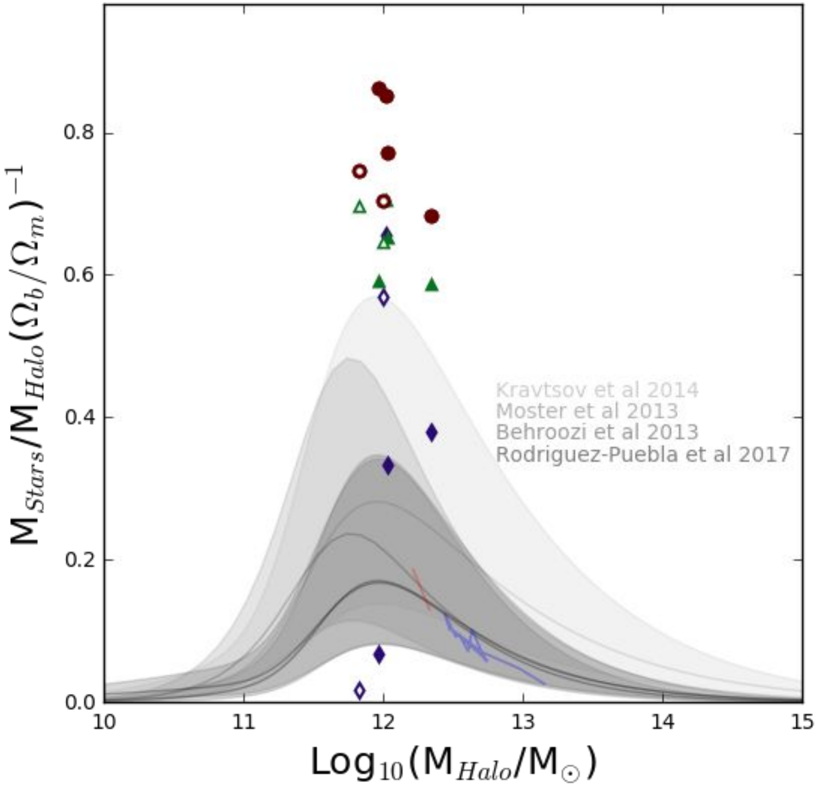
Total mass: **M(r<R$_{200}$)**

Mass inside 17 kpc : **M(r<17kpc)**

Fire2 recipe: M(r<r(M=M(3xr(M=M(r<R97)/2))/2))

Footnote 9: "We define central stellar mass as in Table 1 iteratively by first measuring the half-mass radius of all stars within a large cut (inside 15% of Rvir), then taking all stars within 3× this radius (and then re-defining the half-stellar mass radius on these stars)"

arxiv:1702.06148



Maybe selecting smaller halos than 1x10^12 Msun...

The same questions again

- Sub - grid physics:
    - Turbulent star formation (SF1) vs "Classical" star formation (SF0)
    - Mechanical Feedback (kimm et all 2015) vs Delayed Cooling (Teyssier et al 2013)
- Their effect in the final galaxy at z=0
    - SHMR
    - Rotation curves
    - Galaxy morphology
    - DM features ...

- Non-polytropic approach We do not impose a Temperature floor. **(Kravstov)**

So how do we search for the MW-like Haloes

With HAST...

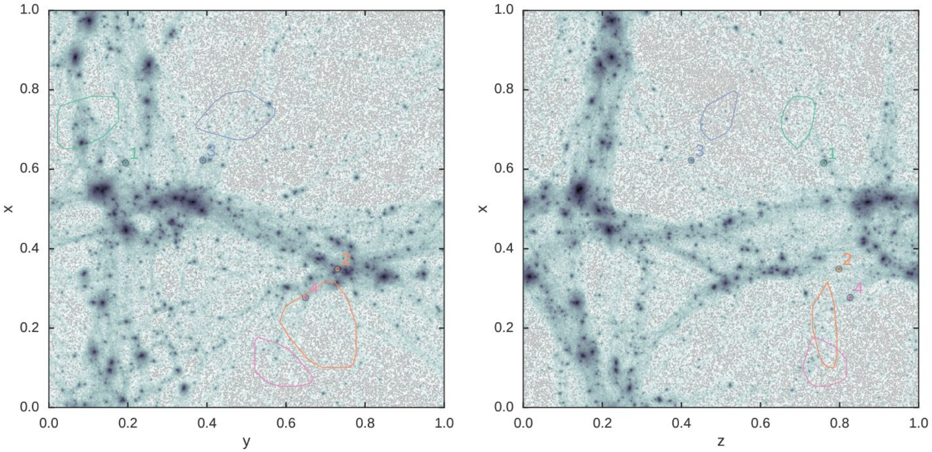
HAST is a python rutine writen by
Valentin Perret

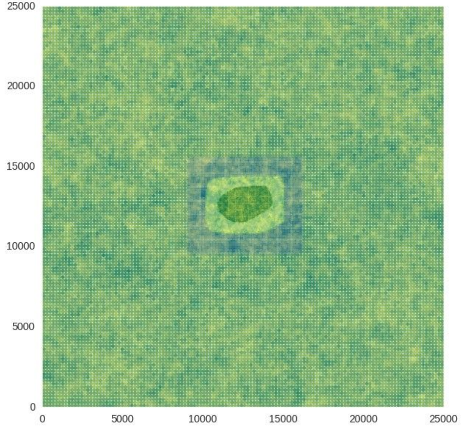
https://bitbucket.org/vperret/hast/

Ramses Unigrid

MUSIC
Zoomed initial conditions

Ramses
Zoom in
DMO or hydro

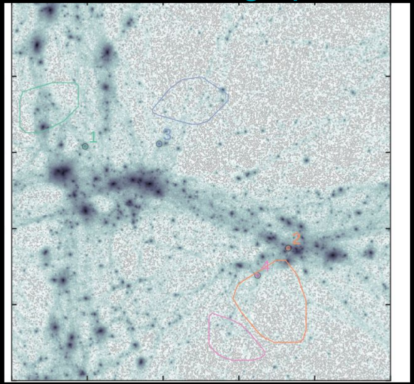




So how do we search for the MW-like Haloes

With HAST...

https://bitbucket.org/vperret/hast/

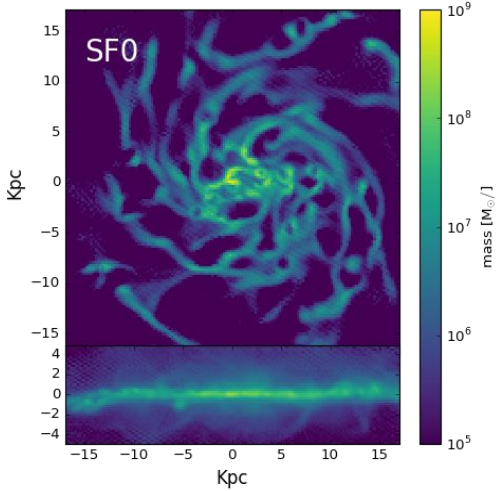


- Mass (0.5-1 x 10^12 Msun)
- Environment
- Merger history

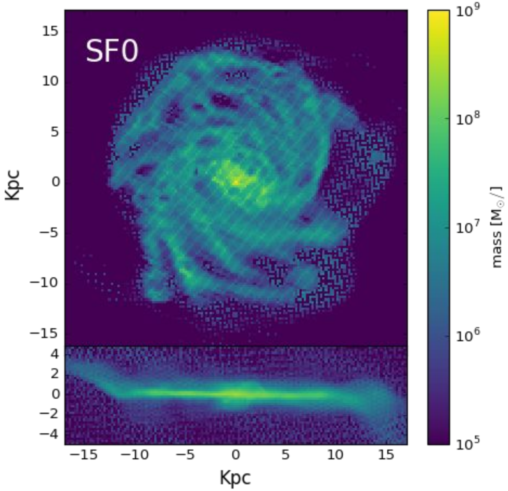
All this you can do before adding gas and subgrid physics… and realizing is not a disc

Preliminary results (Low resolution)

We have so far 2 candidates plus 1 galaxy previously simulated:



Mollitor et al.
Arxiv:1405.4318
M_{dm} = 2.3x10^5 MSun
Δx=150 pc
20Mpc box



Low Res
Current runs
M_{dm} =1.x10^6 MSun
Δx=300 pc
36Mpc box

Current High resolution Runs:

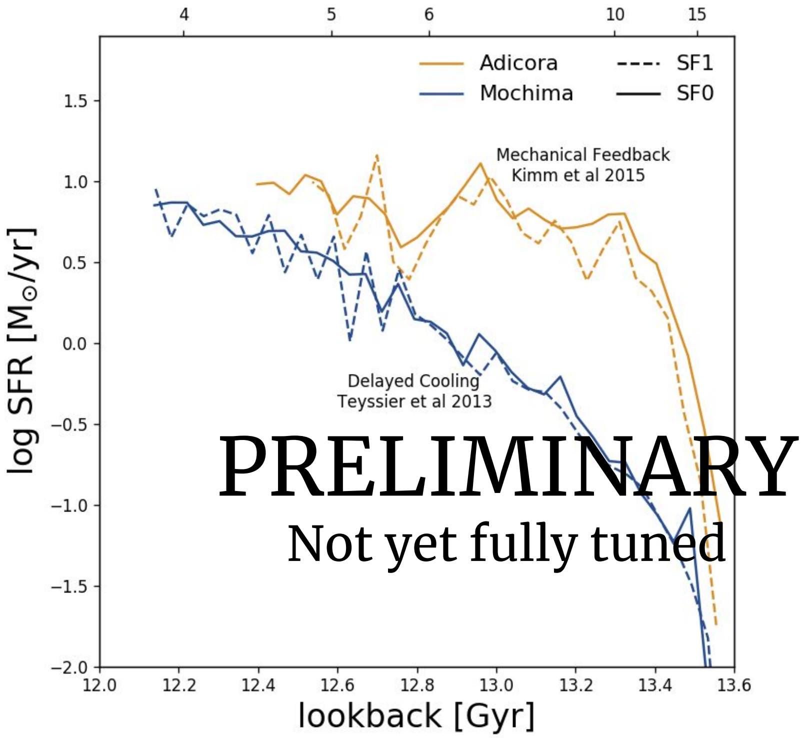
- **M_{dm} = 1.6x10^5 MSun**
- Δx=30 pc

Implementing

- SF0 (classical) / SF1 (turbulent)
- Mechanical Feedback / Delayed Cooling

On the way to redshift z = 0

Preliminary results (High res)



We aim to:

- At least three candidates..more to come
- Δx=30 pc
- Boxsize = 12-36 Mpc
- Halo M_{200} = 0.5-1 x 10^{12} Msun
- Mdm = 1.6 x 10^5
- Chabrier IMF

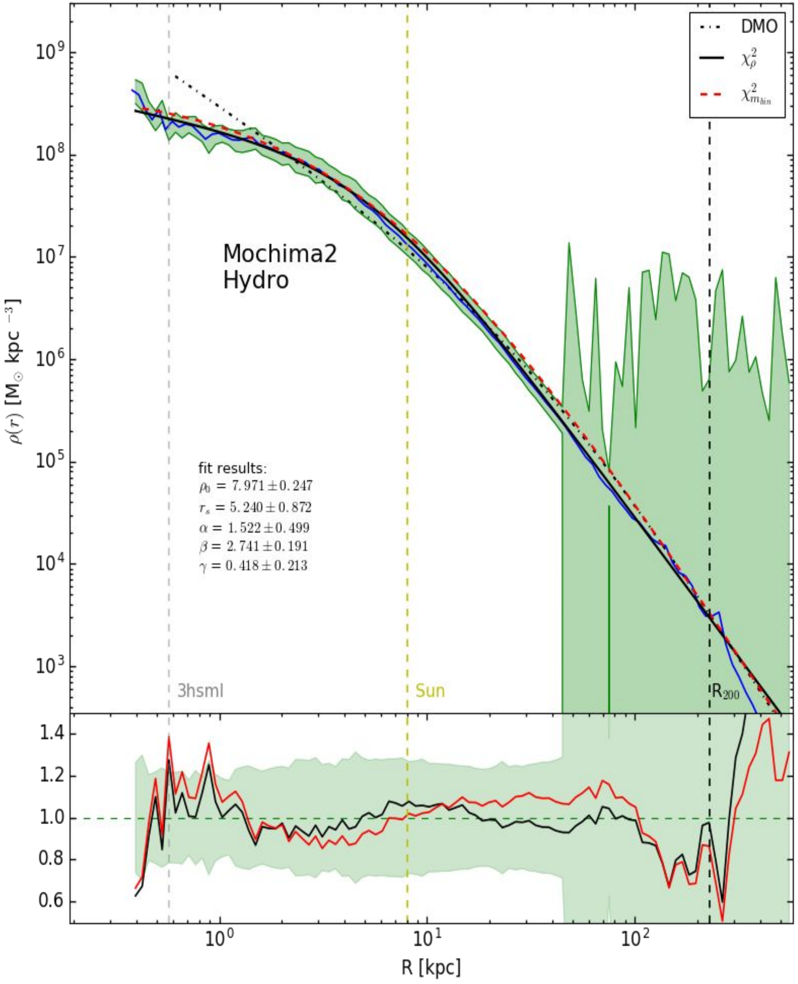
All the combinations of turbulent star formation, classical star formation, with Mechanical feedback or Delayed cooling

Astroparticle and DM

+LU+VE

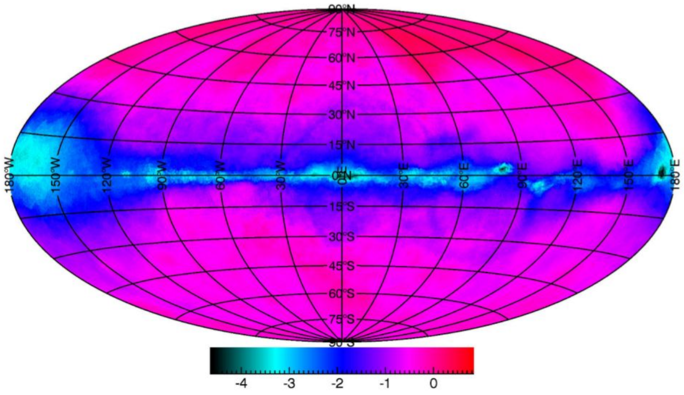
Astroparticles and Dark Matter connexion

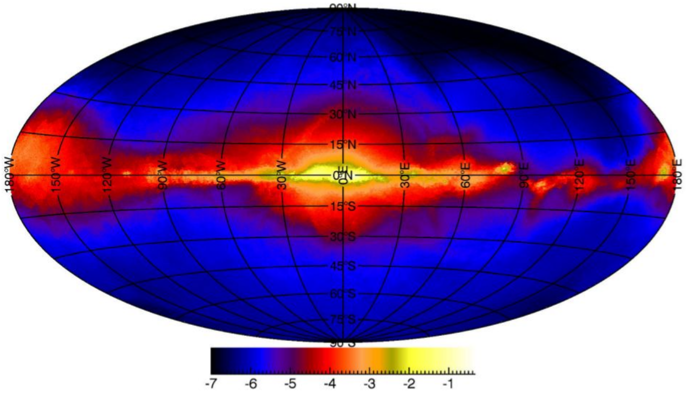
- Milky-way sized simulations = framework for astroParticle
- Need to have educated use (DM profile choice, DM phase space)



Astroparticles and Dark Matter connexion

- Gamma Rays and Cosmic Rays





Gamma Rays from DM-annihilations propagated through gas and CR Diffuse galactic emissions from SN-Feedback interaction with Gas in Halo B from Pol Mollitor PhD thesis 2014 at Laboratoire d'Astrophysique de Marseille. Coming soon with the new sims.

Astroparticles and Dark Matter connexion

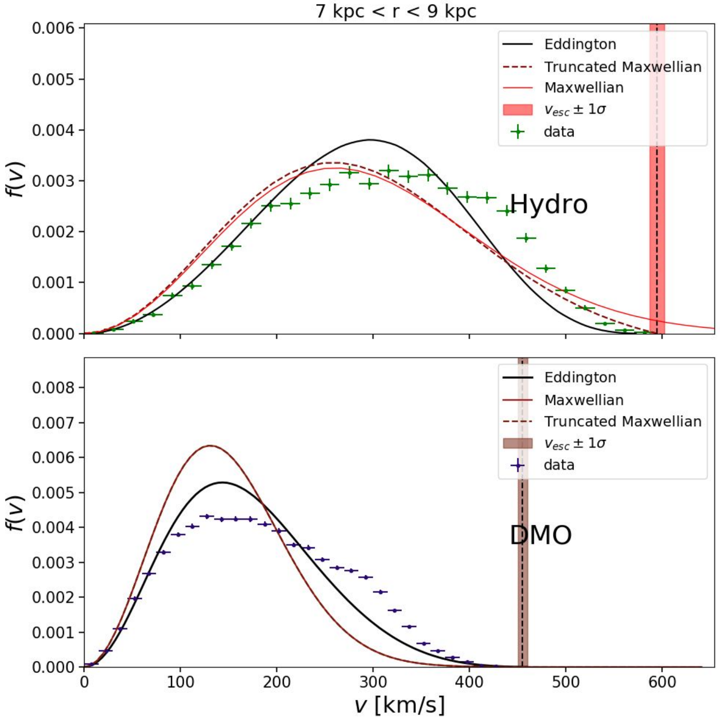
- Dark Matter direct detection

$$\frac{d\mathcal{R}}{dE} \propto \int_{vmin}^{v_{esc}} d^3\vec{v}\, \frac{f(v)}{v}$$

- Dark Matter indirect detection (Capture by the Sun)

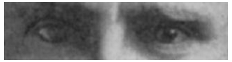
$$\frac{dC}{dV} \propto \int_0^{v_{esc}} du \frac{f(u)}{u} \Omega(Q)$$

You can compare with predictions Gal.Dynamics models. Upcoming publication on the Eddington inversion (see next slide) in collaboration with T. Lacroix , J. Lavalle , E. Nezri (in the room) and M. Stref



Again one halo might not be enough..

Astroparticles and Dark Matter connexion



- Eddington inversion (as in Lacroix et al 2018) and its validation with Cosmological Simulations from

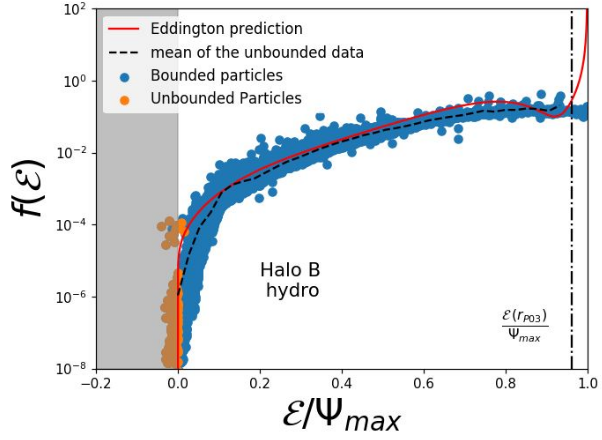
$$\rho_{DM}(r) + \rho_{baryons}(r) \qquad \frac{d\rho}{d\Psi}$$

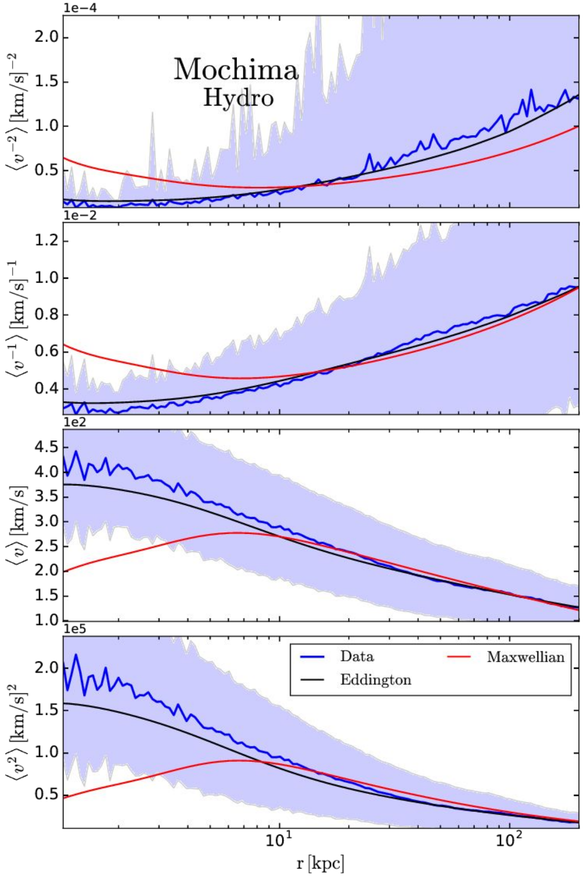
$$f(\mathcal{E}) = \frac{1}{\sqrt{8}\pi^2}\left(\frac{1}{\sqrt{\mathcal{E}}}\left[\frac{d\rho}{\Psi}\right]_{\Psi=0} + \int_0^{\mathcal{E}} \frac{d\Psi}{\sqrt{\mathcal{E}-\Psi}}\frac{d^3\rho}{d\Psi^3}\right)$$

$$f(\vec{r},\vec{v}) = f(\mathcal{E}, L)$$

$$\Psi = \Phi(r) - \Phi(r_{max})$$

$$\mathcal{E} = \Psi(r) - \frac{v^2}{2}$$





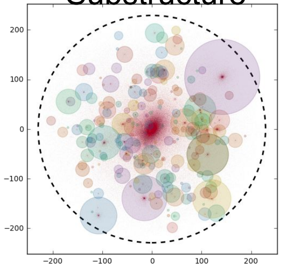
Conclusions

No conclusions yet, results are on the ways..

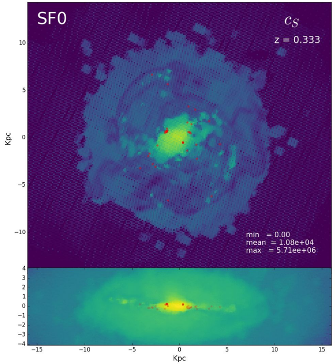
- Educated use of Simulations and the extrapolations of its results to experiments

WKBL, a python library for post-processing Cosmological Zoom-in Ramses Simulation focusing on DM distributions.

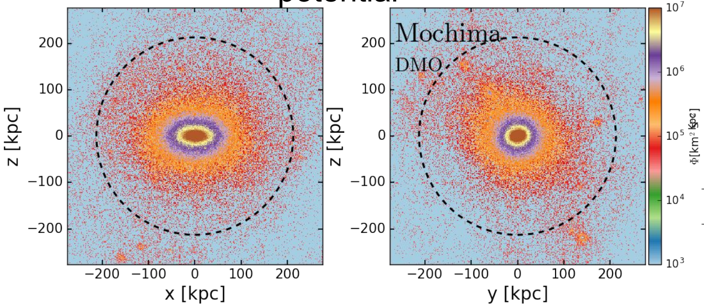
Substructure



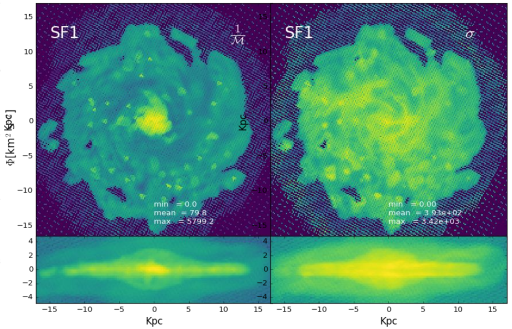
Sound-speed and new stars



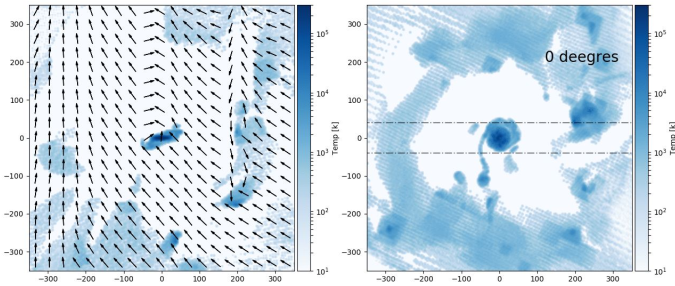
Gravitational potential



Mach and V_{rms} number per cell



Cold-gas



Thanks..

Mochima

Adicora