Dwarf galaxy observations as a test to CDM and SIDM

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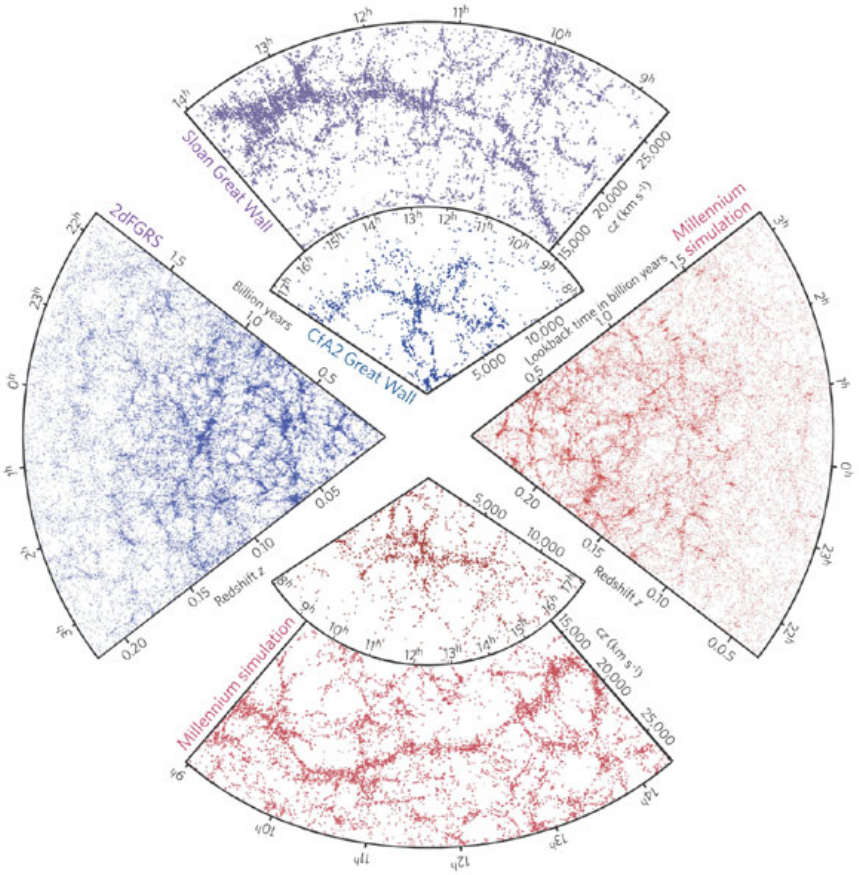
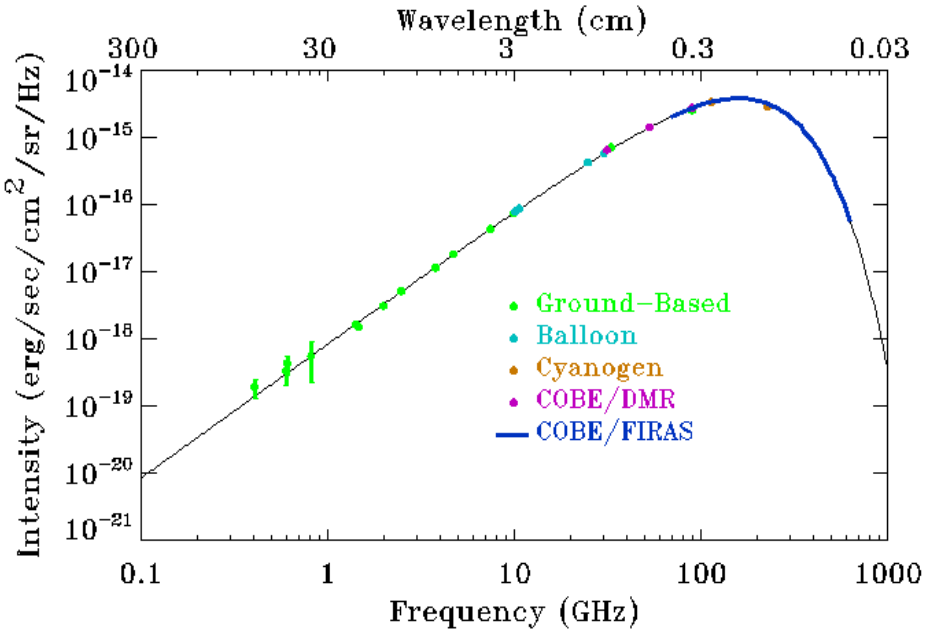
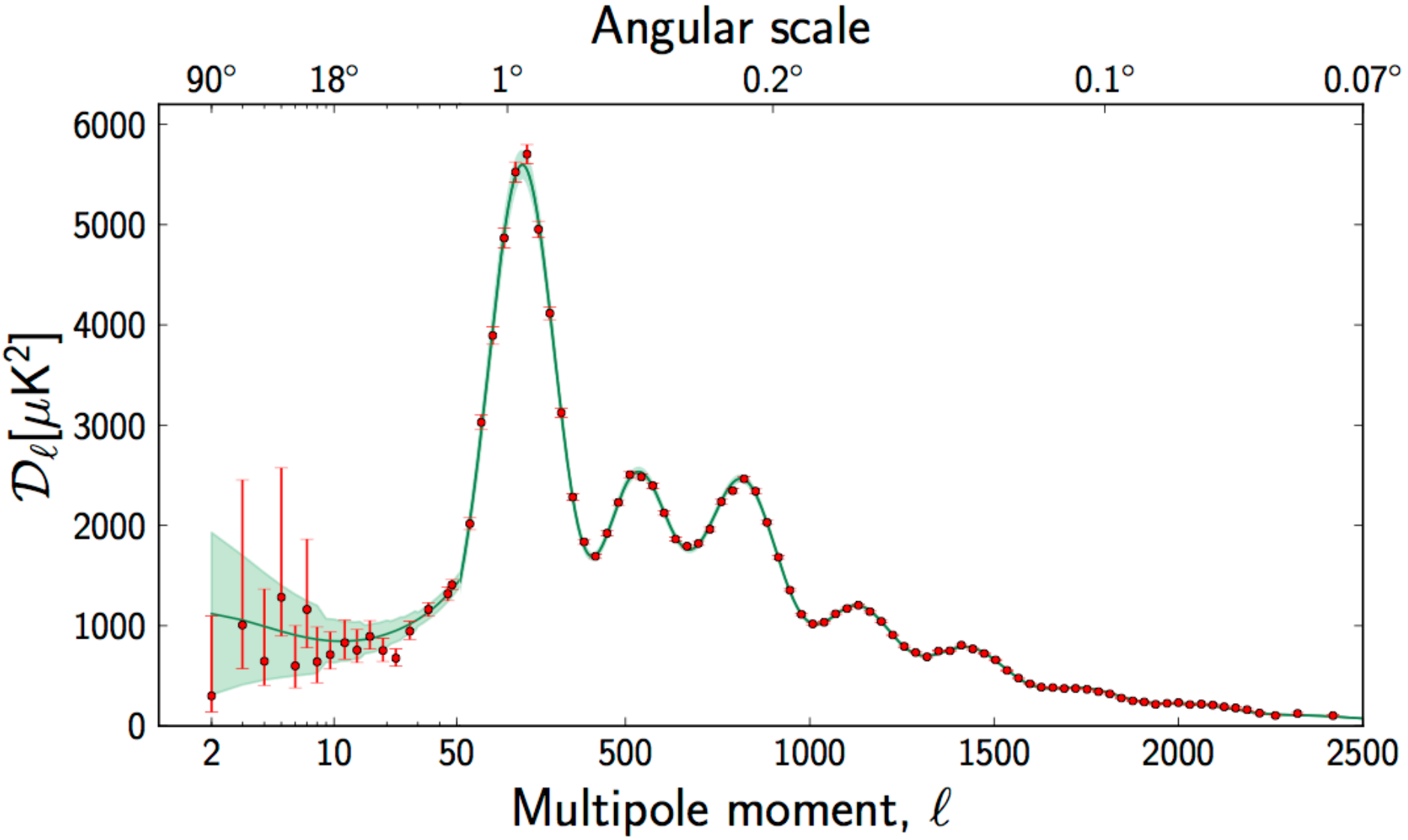
ΛCDM model

Accurate description at large scales



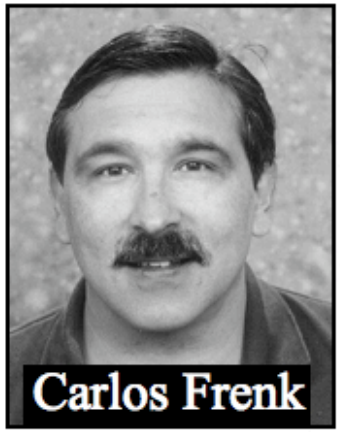


LSS,CMB, Angular Power Spectrum etc.

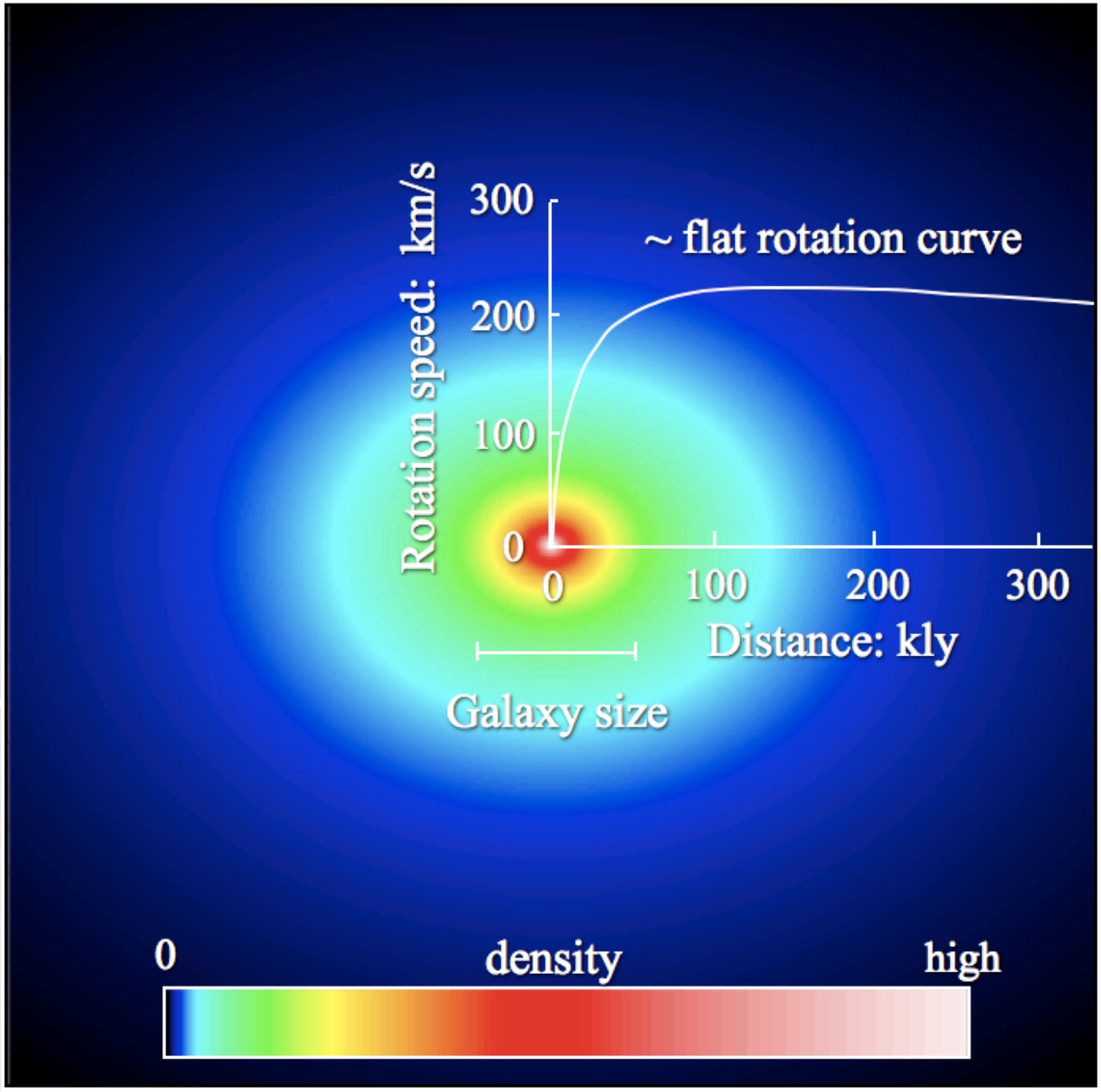

Angular scale
90°
18°
1°
0.2°
0.1°
0.07°
6000
5000
4000
3000
2000
1000
0
$\mathcal{D}_\ell[\mu K^2]$
2
10
50
500
1000
1500
2000
2500
Multipole moment, ℓ

The "NFW" form for dark matter halos


Julio Navarro


Carlos Frenk


Simon White



But there are some long standing issues

- Standard model of cosmology predicts ~26% of the matter in the Universe is DM.
- Nature of DM remains unknown(neutralino,WDM, axion,…)
- Three main unsolved issues
- Cusp/core problem
- Missing galaxy problem
- Too big to fail problem

Garrison-Kimmel(2013),Boylan-Kolchin, Michael; Bullock, James S.; Kaplinghat, Manoj(2013)

- Cusp/core problem
- Difficulties to describe observed central densities of dark halos in LSB

(cusp profiles predicted $\rho \approx r^{-1}$).

Missing galaxy problem

- Excess of satellite halos

predicted by N-body simulations Moore et al. (1999), Penny et al (2009).

- Too big to fail problem
- Why most massive subhalos around MW size hosts do not contain galaxies(Bullock & Kaplinghat 2013)

It is important to compare CDM simulations with dwarf satellites

- Feedback and baryonic physics are a viable solution but may require some degree of “fine-tuning”

Cusp profile

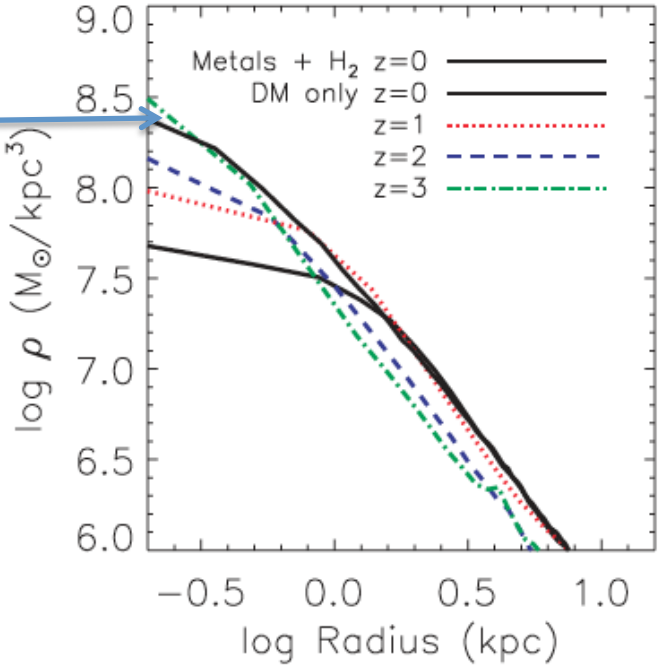


Figure 3. The DM density profile of a dwarf galaxy in our sample, at $z = 4, 3, 1, 0$. The prolonged process of cusp flattening due to many separate outflows results in a shallow inner profile at $z = 0$. For comparison, the density profile of the same galaxy, but simulated with DM only, is shown in the black dot–dashed line. In the DM only simulation, the DM maintains its cuspy density profile at all redshifts.

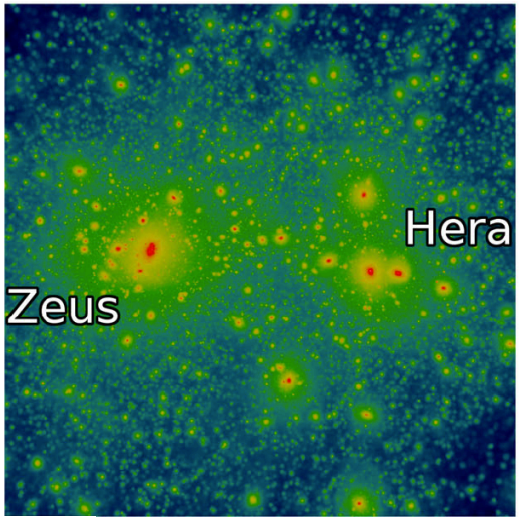
Cusp/Core problem

Low Surface Brightness (LSB) galaxies, dwarfs and UFD

Even if SN Feedback is able to remove cusps is some galaxies. Same FB recipe **unlikely to work in LSBs and dwarf galaxies, smaller halos have higher DM concentrations**

Cyclic gas blowouts essential to produce cores in galaxies !

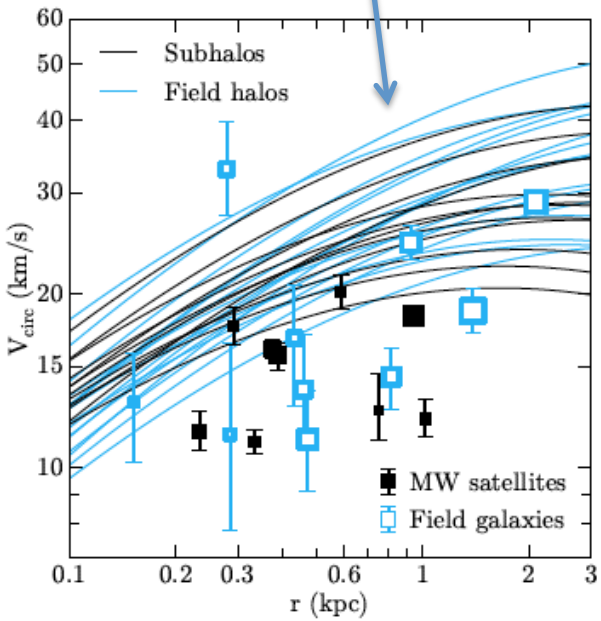
Too Big to Fail problem

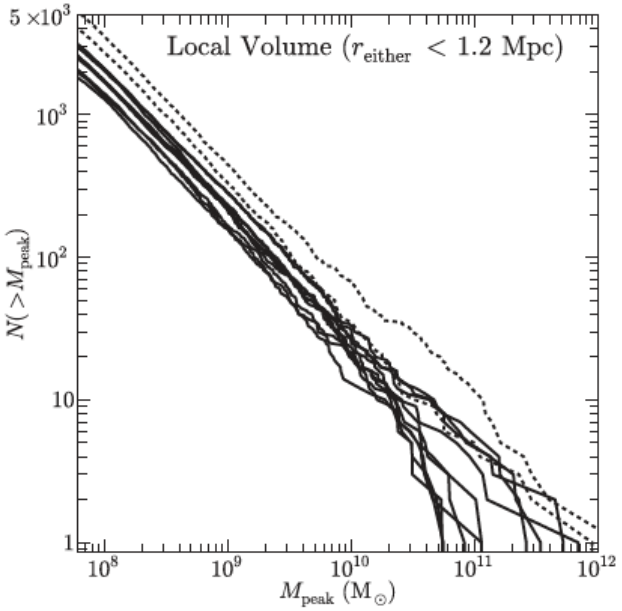


- Too many small mass satellite halos in the Local Group

Massive failures in all ELVIS pairs

Halos with no observed galaxy

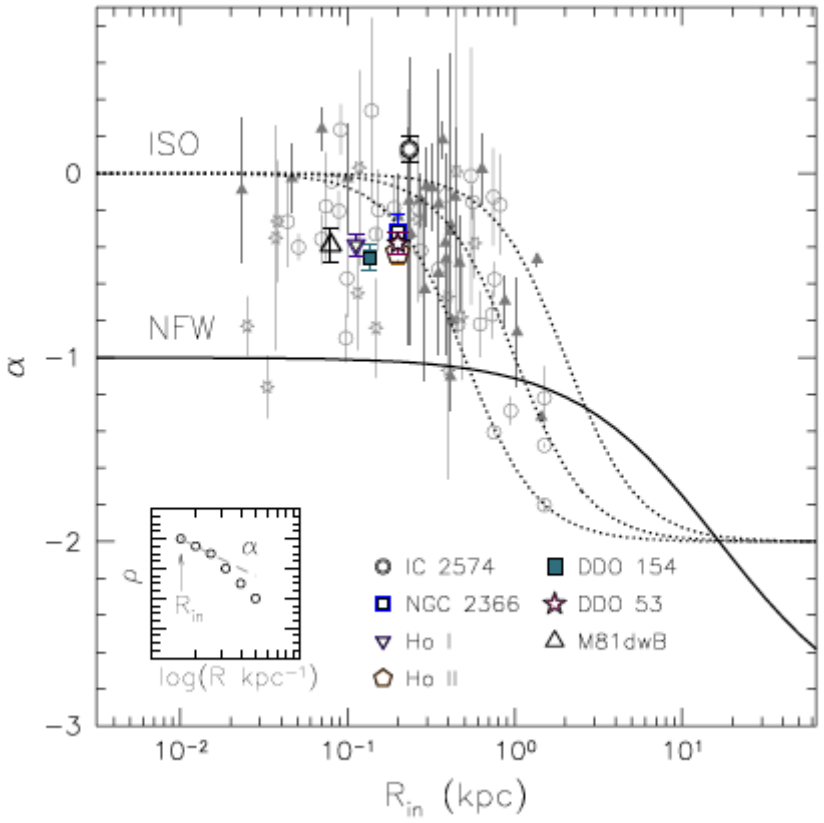




Garrison-Kimmel et al 2014

Alternative dark matter explanations : SIDM, SFDM, WDM…

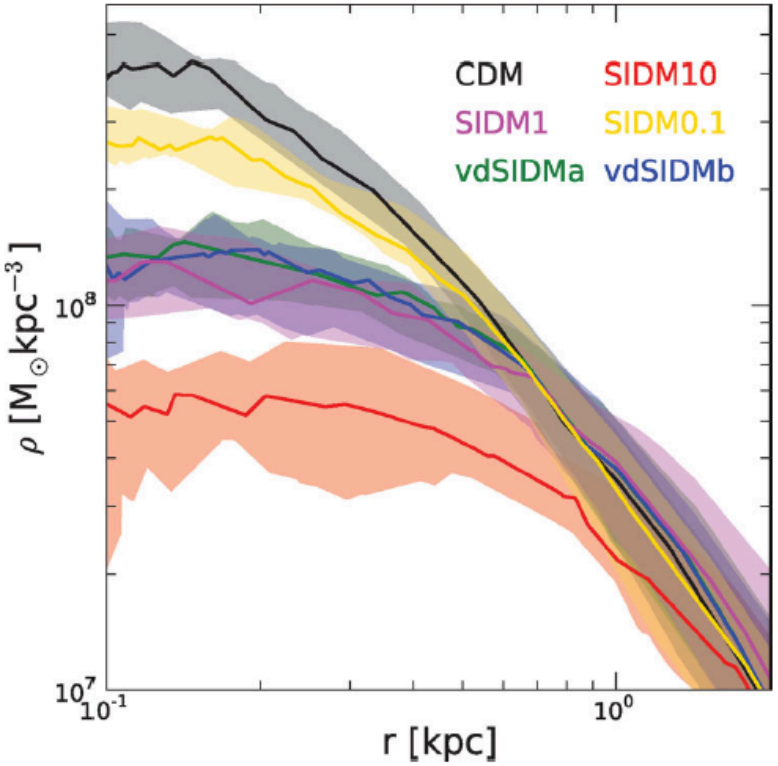
- **Observations in dSphs** consistent with core sizes of ~1kpc.
- Inner profile : $\rho \approx r^{-\alpha}$



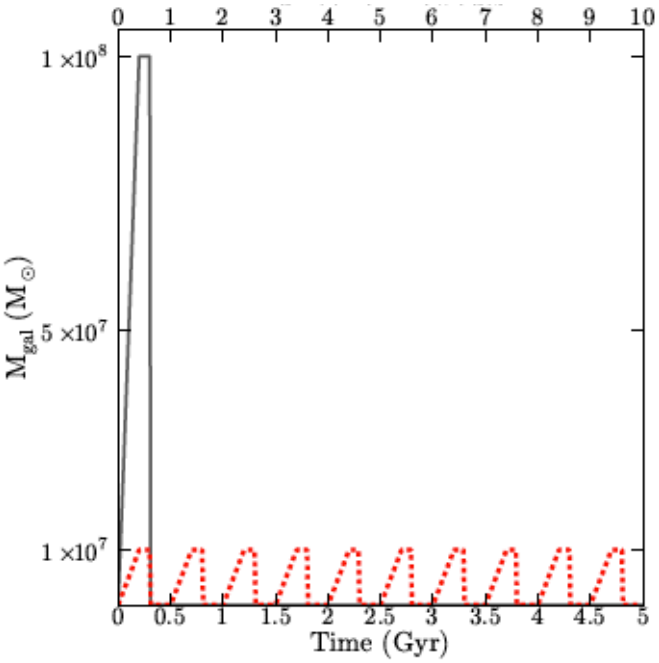
But we know SN feedback modifies CDM profiles! What about SN feedback in SIDM halos?

Cyclic explosion might not be enough to solve TBTF (Garrison-Kimmel et al. 2013, Brooks&Zolotov 2013

Core sizes typically of ~1kpc SIDM with constant cross section per unit mass $\sigma_T/m \approx 1 cm^2/g$ (Rocha et al.2013, Zavala et al. 2013)



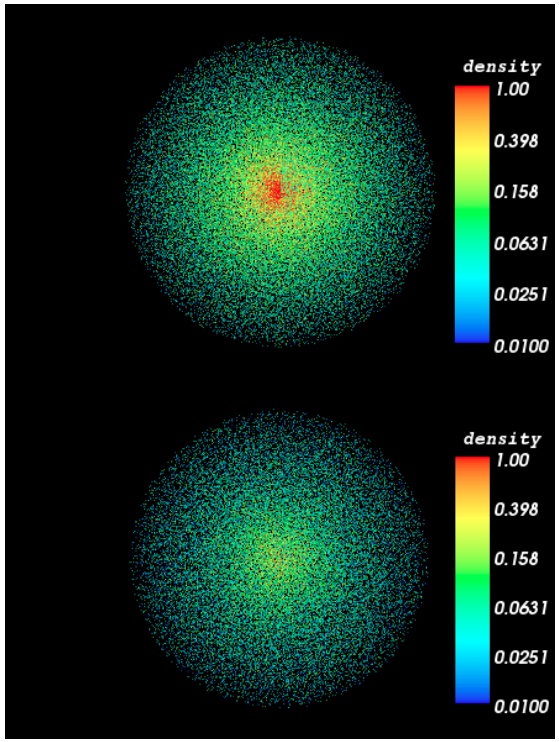
Blowout feedback



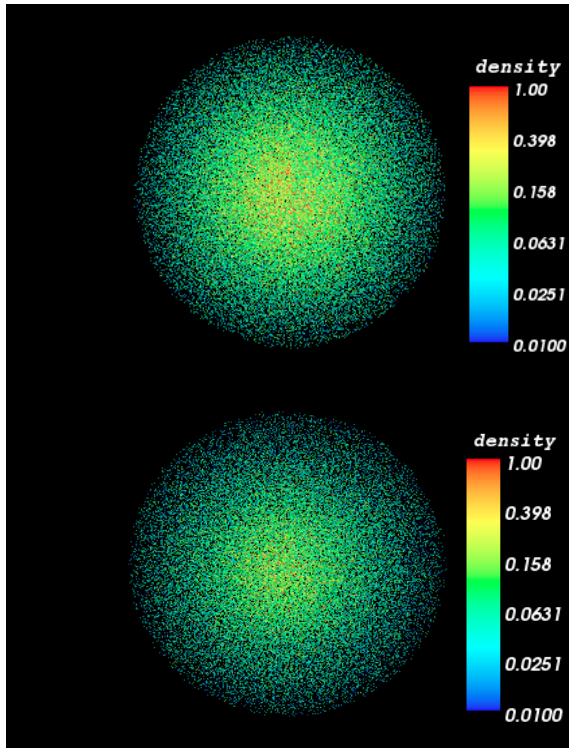
A representative example of our blowout scheme. A single cycle takes 500 Myr.

Mass evolution for a single blowout with: $\mathbf{M}_{max} = 10^8 \mathbf{M}_\odot$;

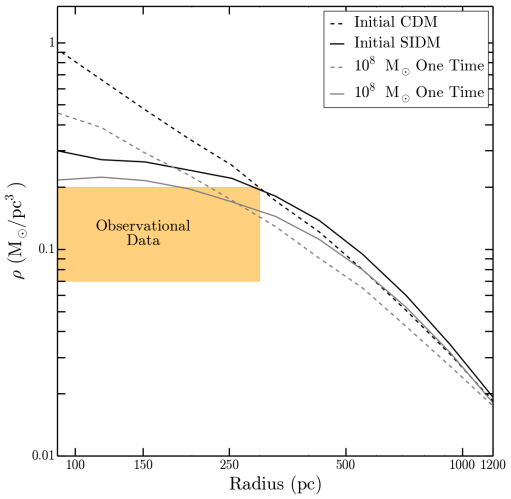
Red dotted line shows the same for repeated blowouts with $\mathbf{M}_{max} = 10^7 \mathbf{M}_\odot$

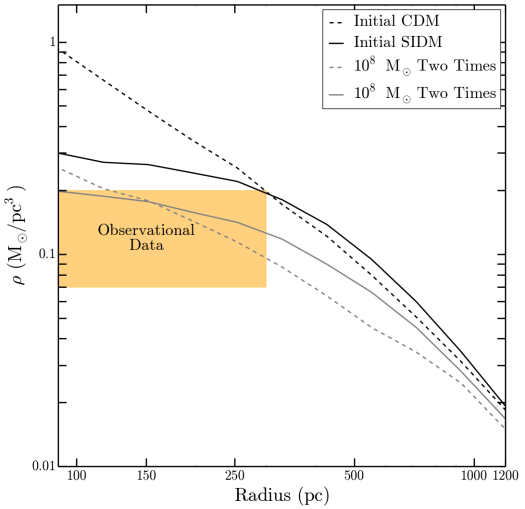


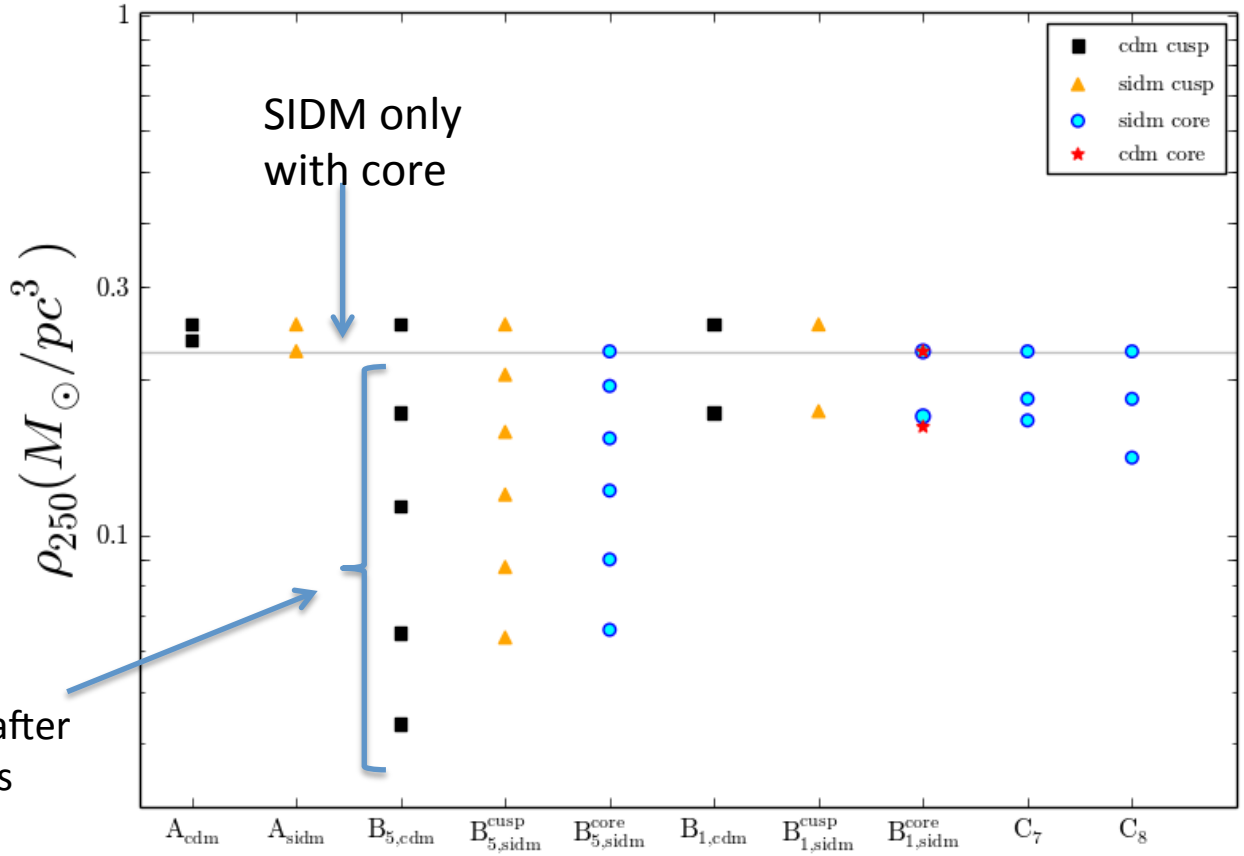
CDM



SIDM







Baryons must ALSO be consider in Self Interacting dark matter models for a fair comparison with observations.

RESULTS

- Less massive cyclic blowouts with $M_{max} = 10^7 M_\odot$ create a core (~300 pc) , but does not do better than CDM to account for the TBTF problem.
- Massive blowouts of $M_{max} = 10^8 M_\odot$ explain the Too big to fail in both CDM and SIDM

BUT a larger number of blowouts are needed for SIDM ("shielding" due to self interactions) and NONE of the models ends with a core.

Go to my poster or to me for more details