The small scale crisis of LCDM cosmology

Arianna Di Cintio[1*] *arianna.dicintio@dark-cosmology.dk

collaborators
C. B. Brook[2] A. V. Macciò[3] , A. A. Dutton[3], G. S. Stinson[3] , A.Knebe[1]
[1] DARK FELLOW, Dark Cosmology Centre, Copenhagen
[2] Universidad Autonoma de Madrid
[3] MPIA Heidelberg

Dark Cosmology Centre

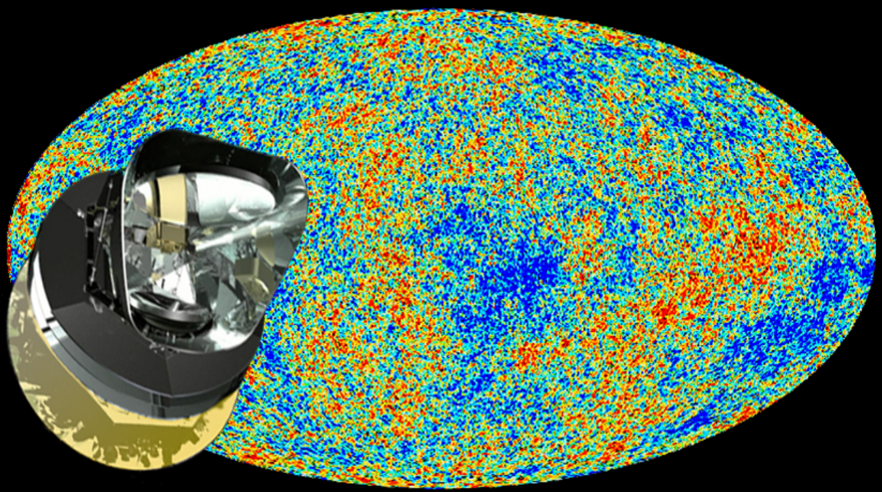
Roma, 22/09/15

Outline

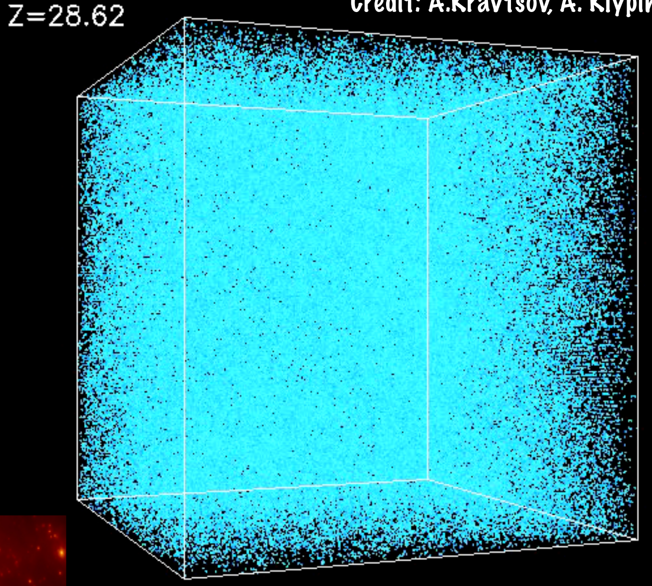
- Galaxy formation with cosmological simulations
- The LCDM small scale crisis -cusp/core problem
- Mass dependent density profile
- Application to observations

N-body simulations

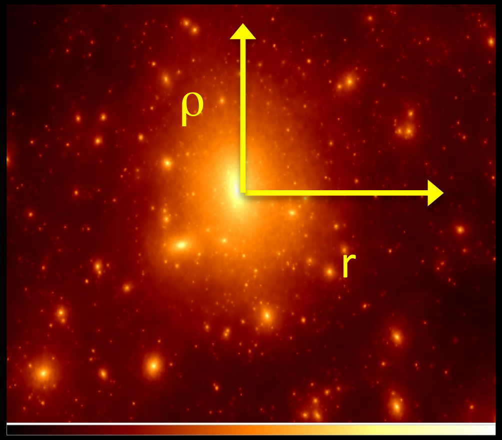
Credit: Planck collaboration



Credit: A.Kravtsov, A. Klypin

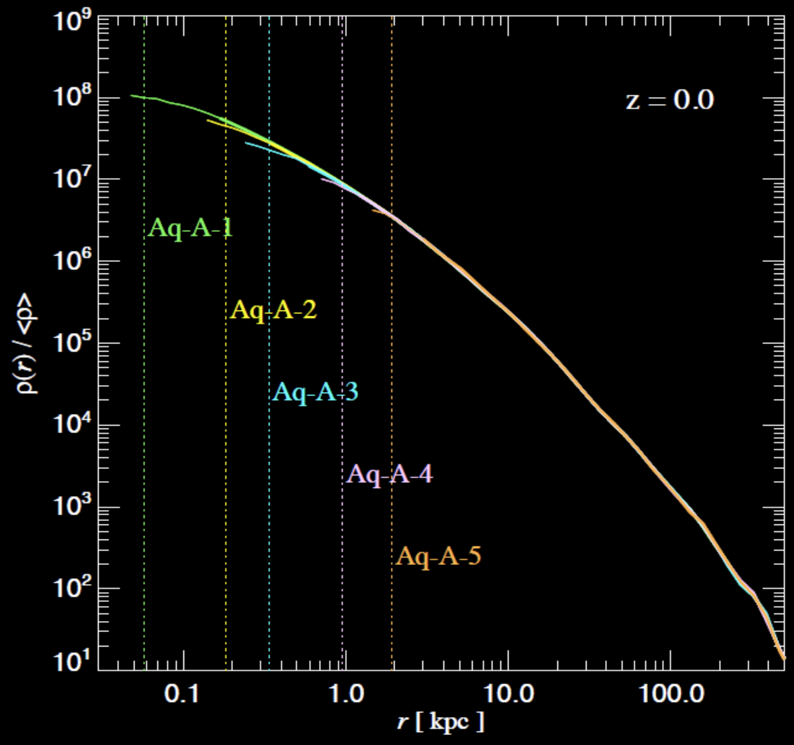


MW halo
Credit: CLUES project

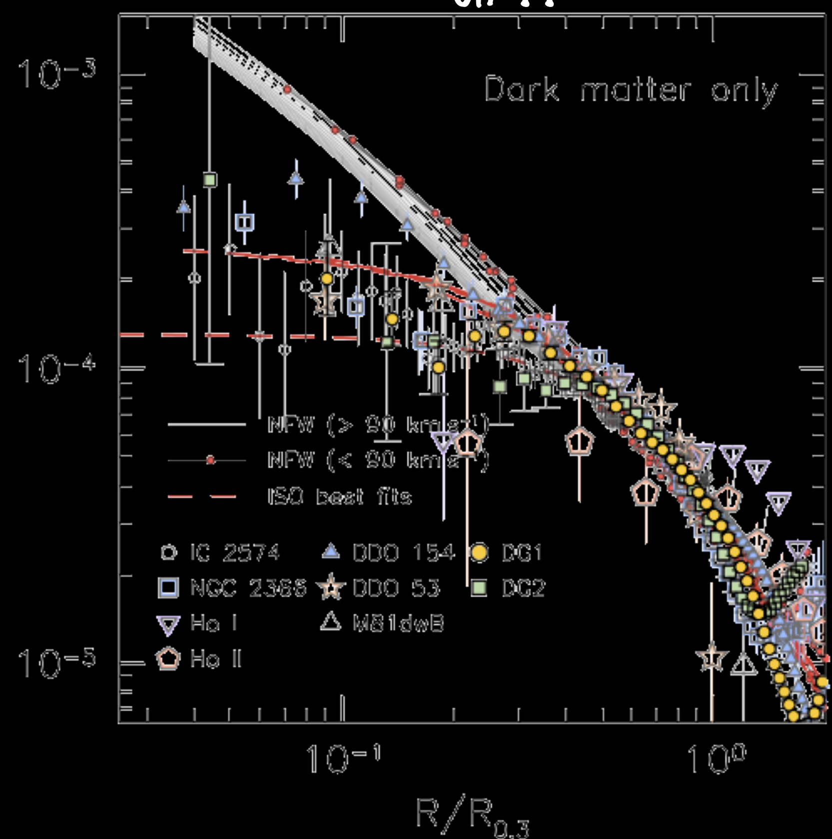


Problem: CUSP-CORE discrepancy

Springel+05



Oh+11



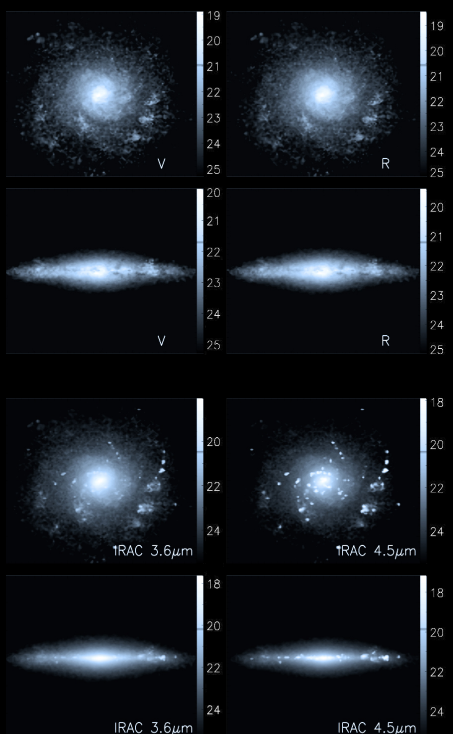
Simulations find 'CUSPY' profiles
Inner slope $\gamma \geq 1$

Observations show 'CORED' profiles
Inner slope $\gamma < 1$

MaGICC simulations

Making Galaxies In a Cosmological Context
The MaGICC project

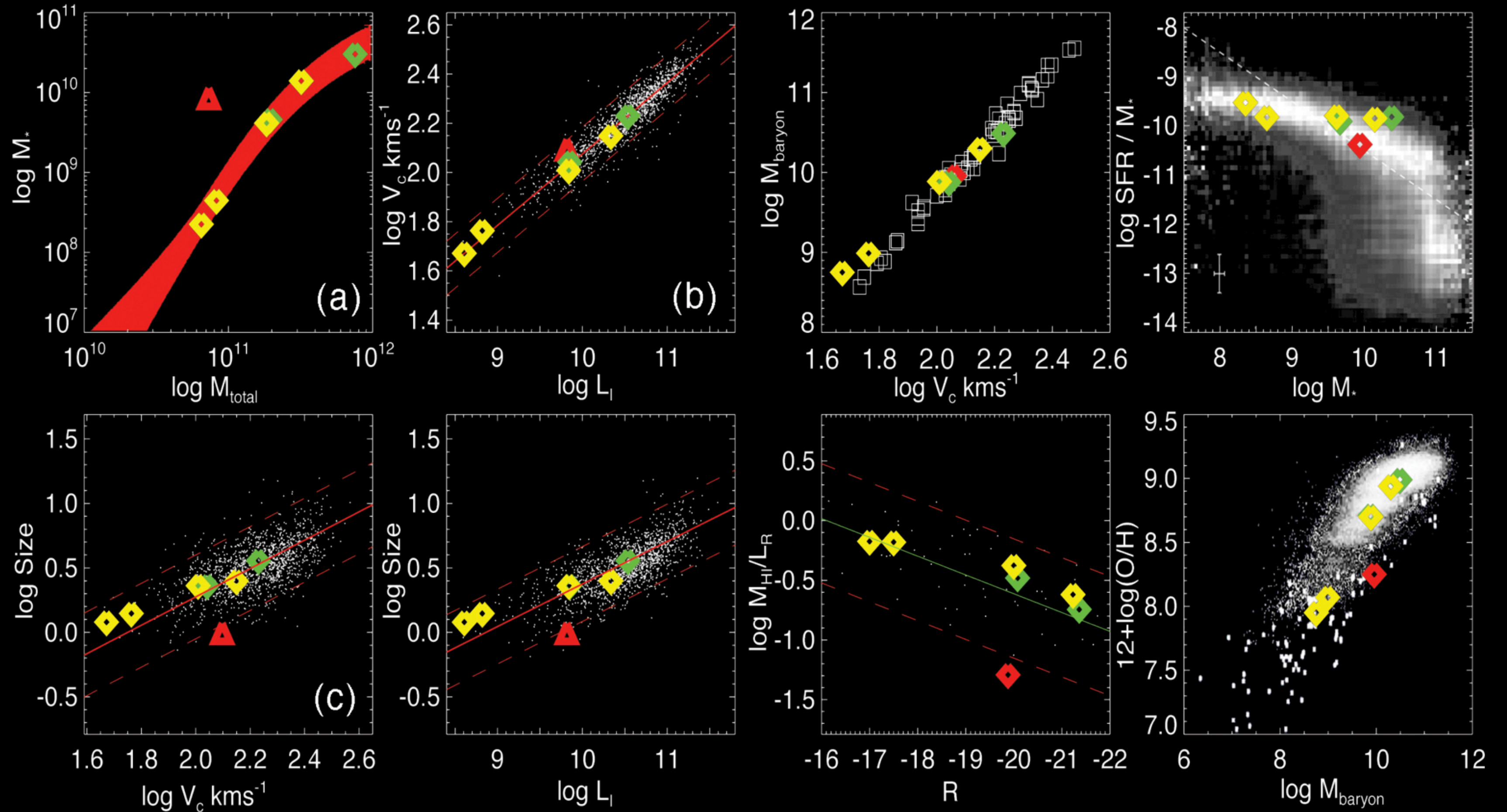
Stinson+13, Brook+12



Credit: Dominguez-Tenreiro, Obreja+13

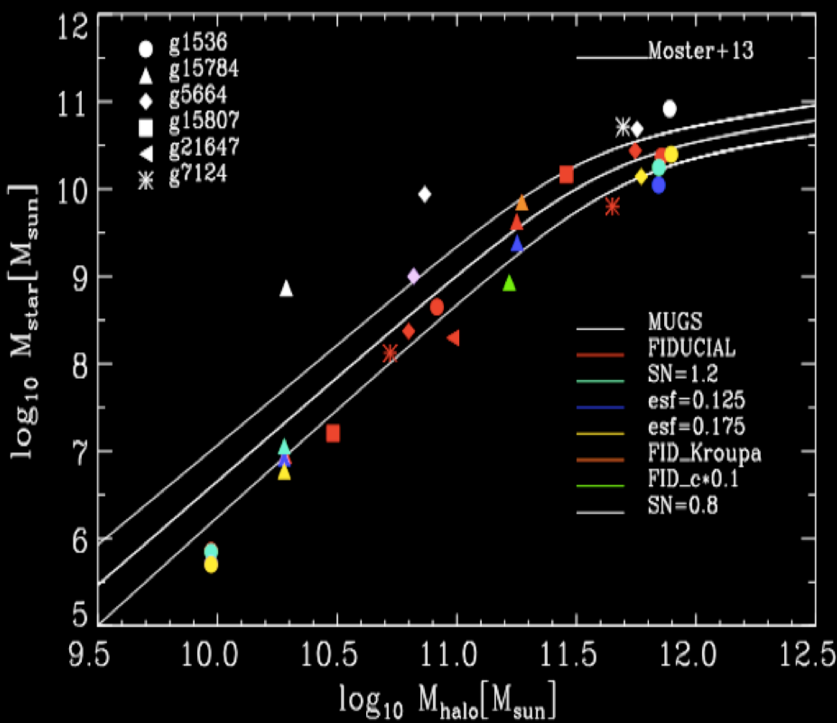
.. feedback from SNe and massive stars

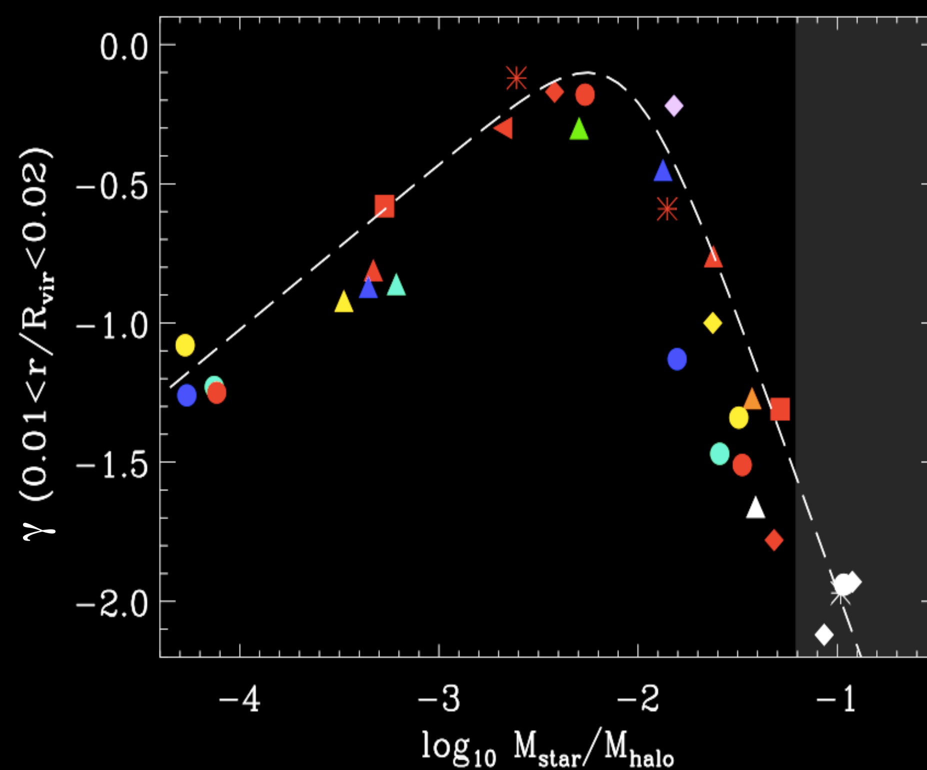
Stinson+06,+13



Brook +12

Inner slope dependence on $M_\star/M_{halo}$



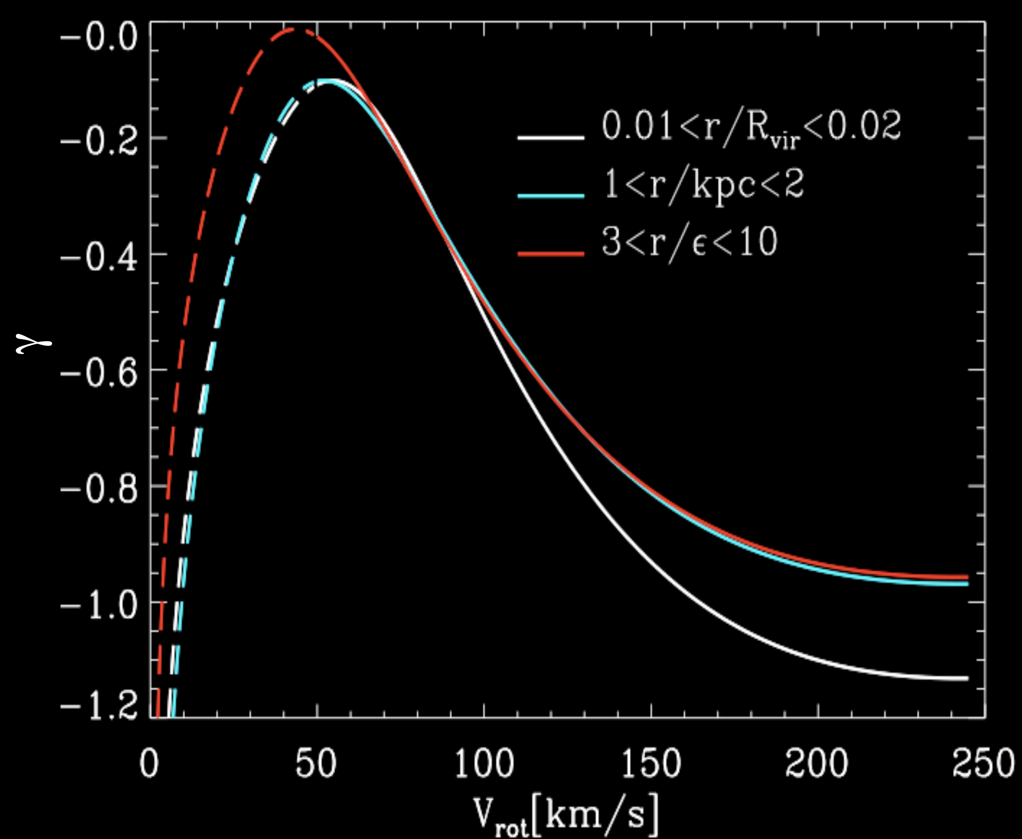


Dark matter profiles determined by two opposite effects: energy from Sne vs Increasing gravitational potential

$$\gamma(X) = n - \log_{10}\left[\left(\frac{X}{x_0}\right)^{-\beta} + \left(\frac{X}{x_0}\right)^{\kappa}\right]$$

Di Cintio+14a

Predictions for observed galaxies



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TF from Dutton+10

THINGS galaxy survey $10^7 < M^*/M_\odot < 10^9$, provides mean γ=-0.3 (Oh+08, Oh+11)

Flattest profiles in galaxies with V_{rot}~50km/s

Clear observations of cores in LSB galaxies with V_{rot}< 100km/s (de Blok+08, Kuzio de Naray+08,+09)

A double power law profile

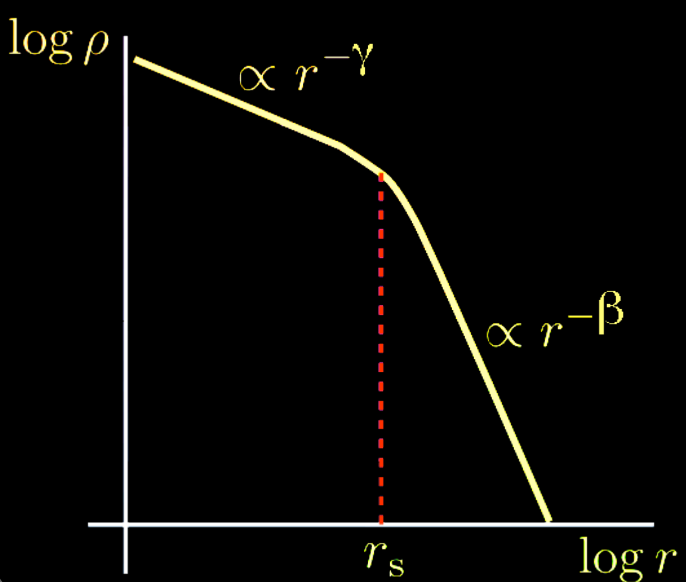
$$\rho(r) = \frac{\rho_s}{\left(\frac{r}{r_s}\right)^{\gamma}\left[1+\left(\frac{r}{r_s}\right)^{\alpha}\right]^{(\beta-\gamma)/\alpha}}$$

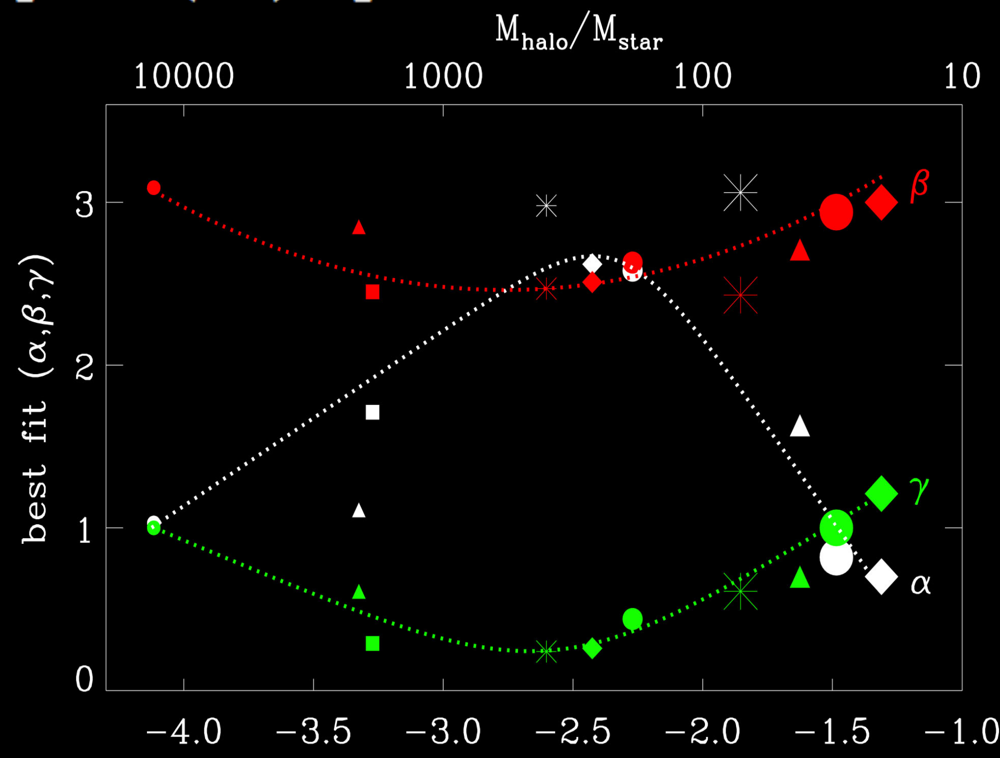
γ inner slope

β outer slope

α sharpness of transition

NFW: (α,β,γ)=(1,3,1)





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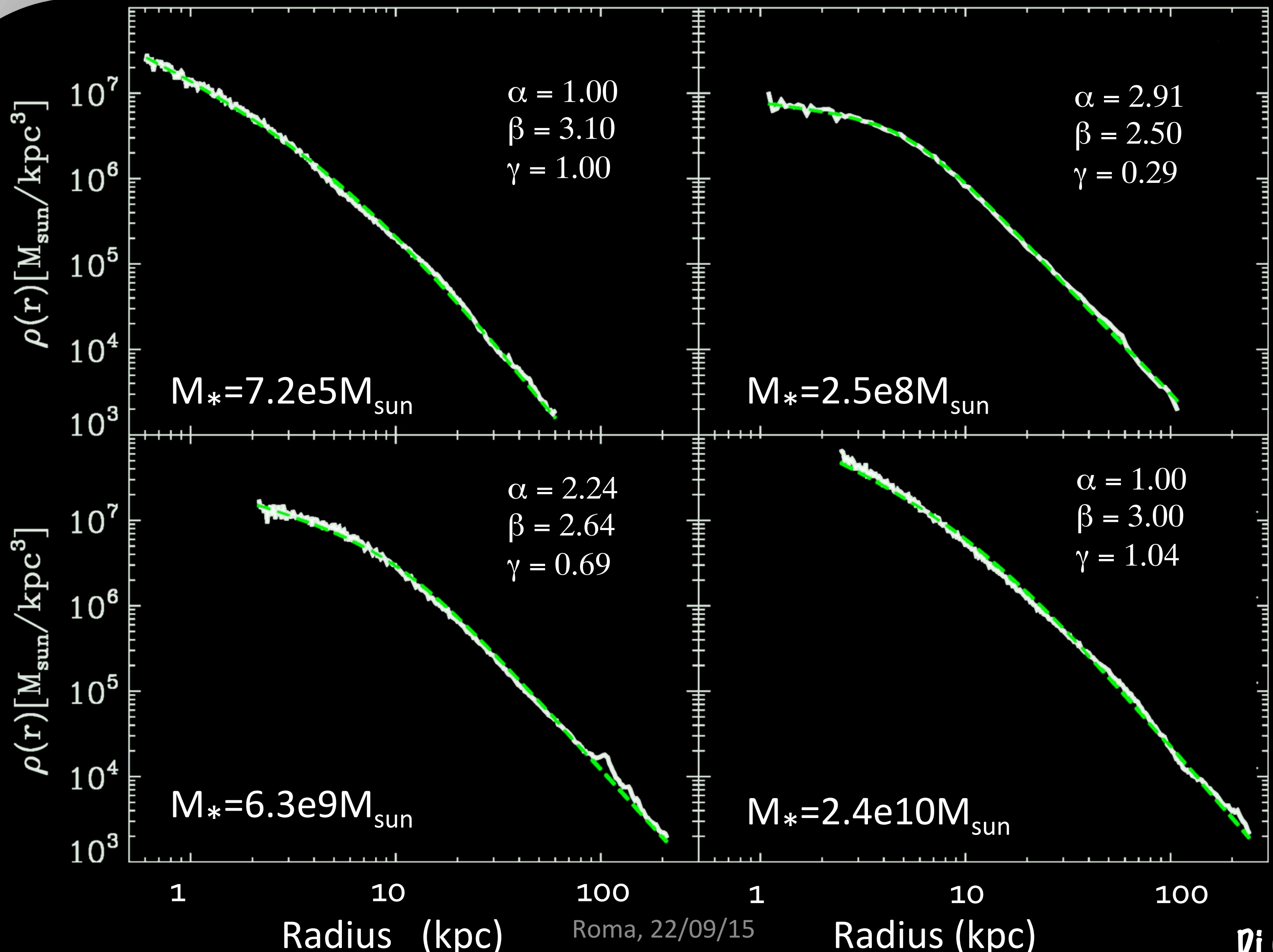
Mass dependent DM profile



Di Cintio+14b

Derived rotation curves

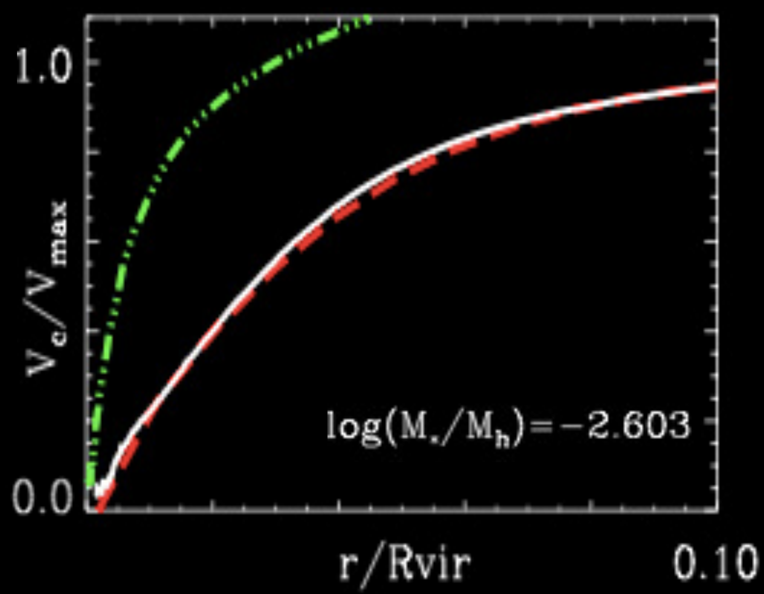
$$M_{\rm halo} = \frac{4}{3}\pi R_{vir}^3 \Delta\rho_{crit}$$

$$c = R_{vir}/r_s$$

$$M(r) = 4\pi\rho_s \int_0^r \frac{r'^2}{\left(\frac{r'}{r_s}\right)^{\gamma}\left[1+\left(\frac{r'}{r_s}\right)^{\alpha}\right]^{(\beta-\gamma)/\alpha}} dr'$$

$$V(r) = \sqrt{GM(r)/r}$$

Rotation curve of expanded halo



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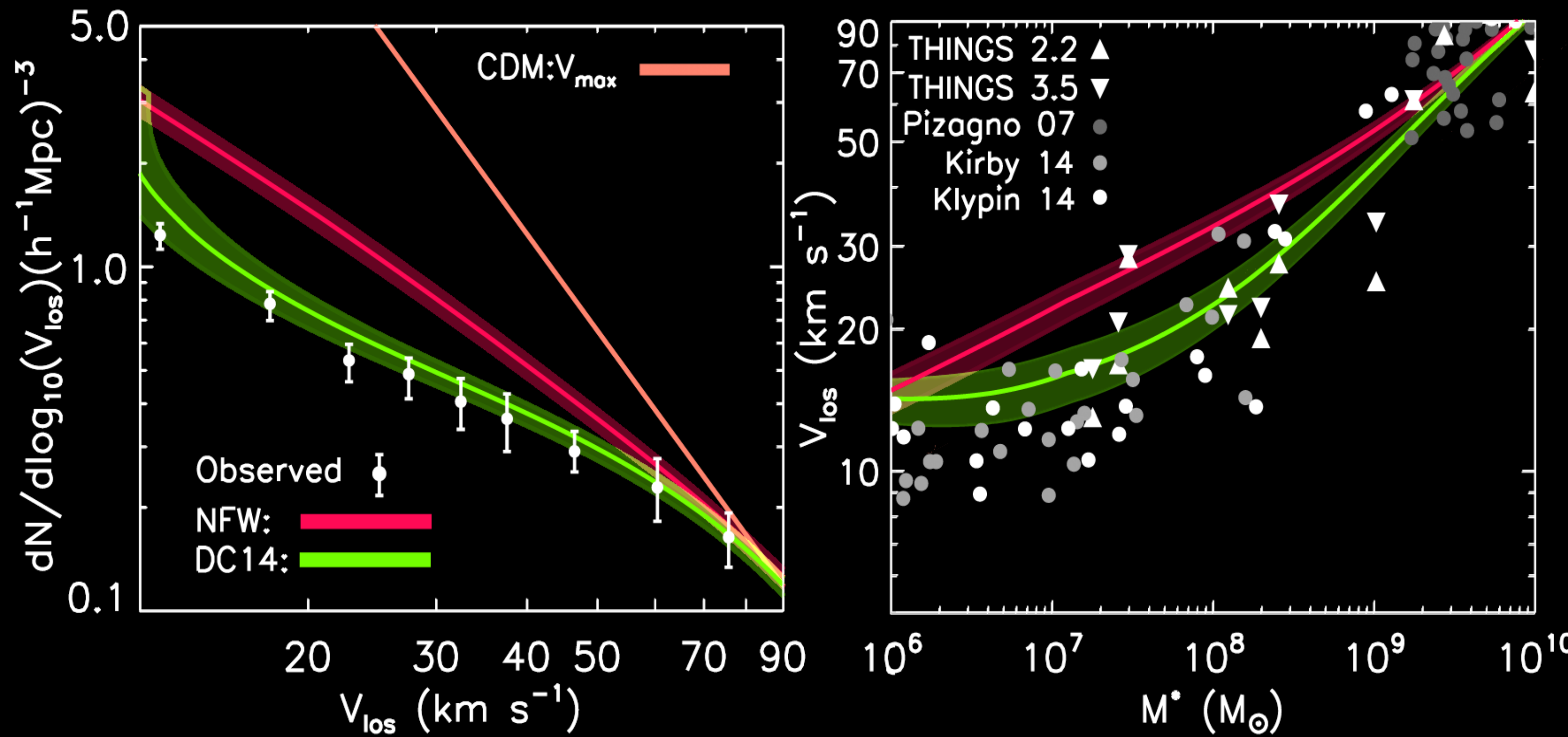
Velocity function and TF relation



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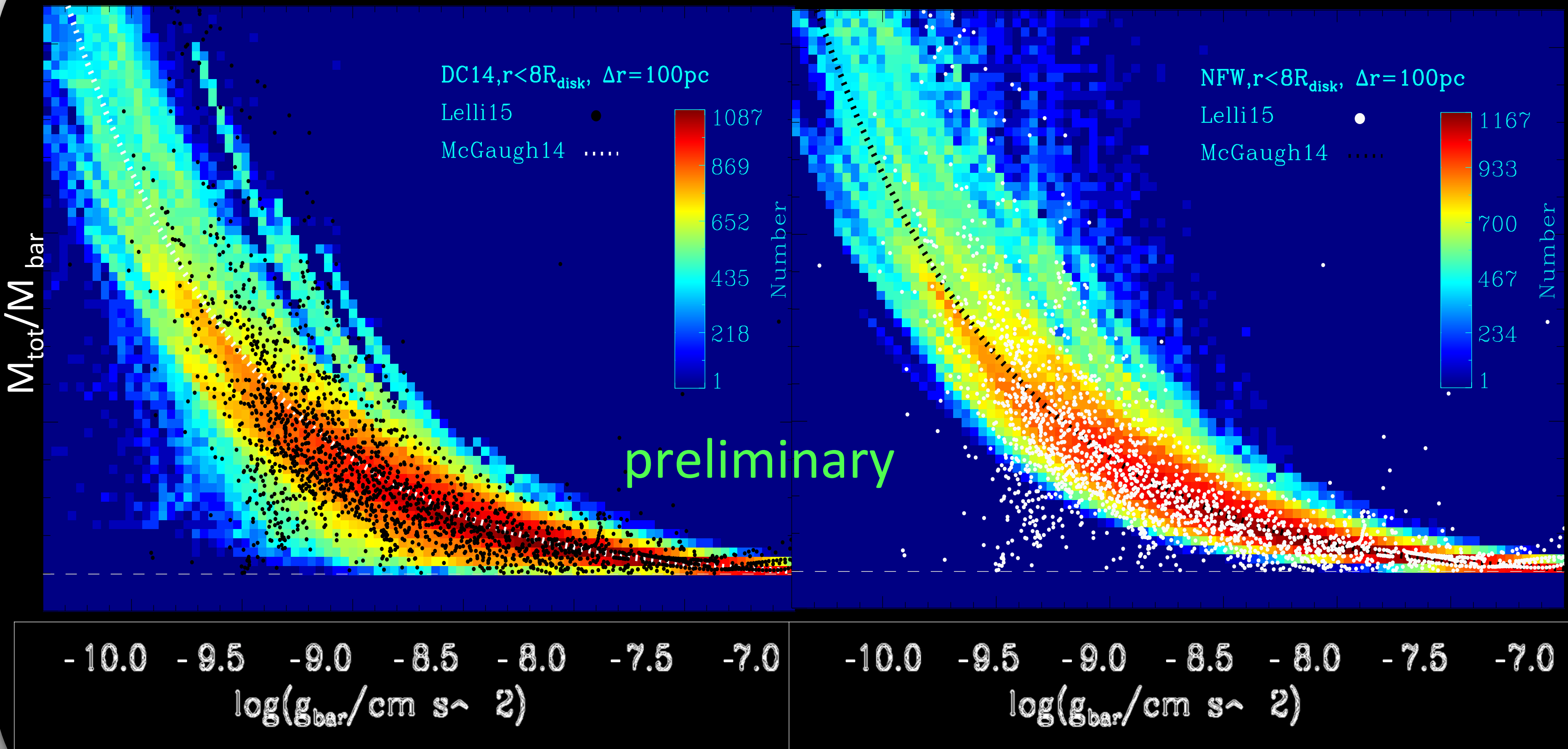
Brook & Di Cintio 2015b

Mass Discrepancy acceleration relation



Di Cintio & Lelli 2015 (in prep)

Conclusions

TAKE HOME POINT #1: Baryonic physic affects dark matter profiles in galaxies: peak in core formation efficiency at $M^* \approx 10^{8.5}$ Msun

TAKE HOME POINT #2: Mass dependent dark matter profile can be used in observations and semi-empirical models to fit galaxy RCs and test LCDM theory

Thank you!

Di Cintio, Brook +14a, MNRAS, 437, 415

Di Cintio, Brook +14b, MNRAS, 441, 2986

Brook C. B. & Di Cintio A., 2015a, MNRAS, 450, 3920

Brook C. B., Di Cintio A., 2015b, MNRAS, 453, 2133

Di Cintio & Lelli 15 (in prep)