The Formation of Dwarf Spheroidal Galaxies

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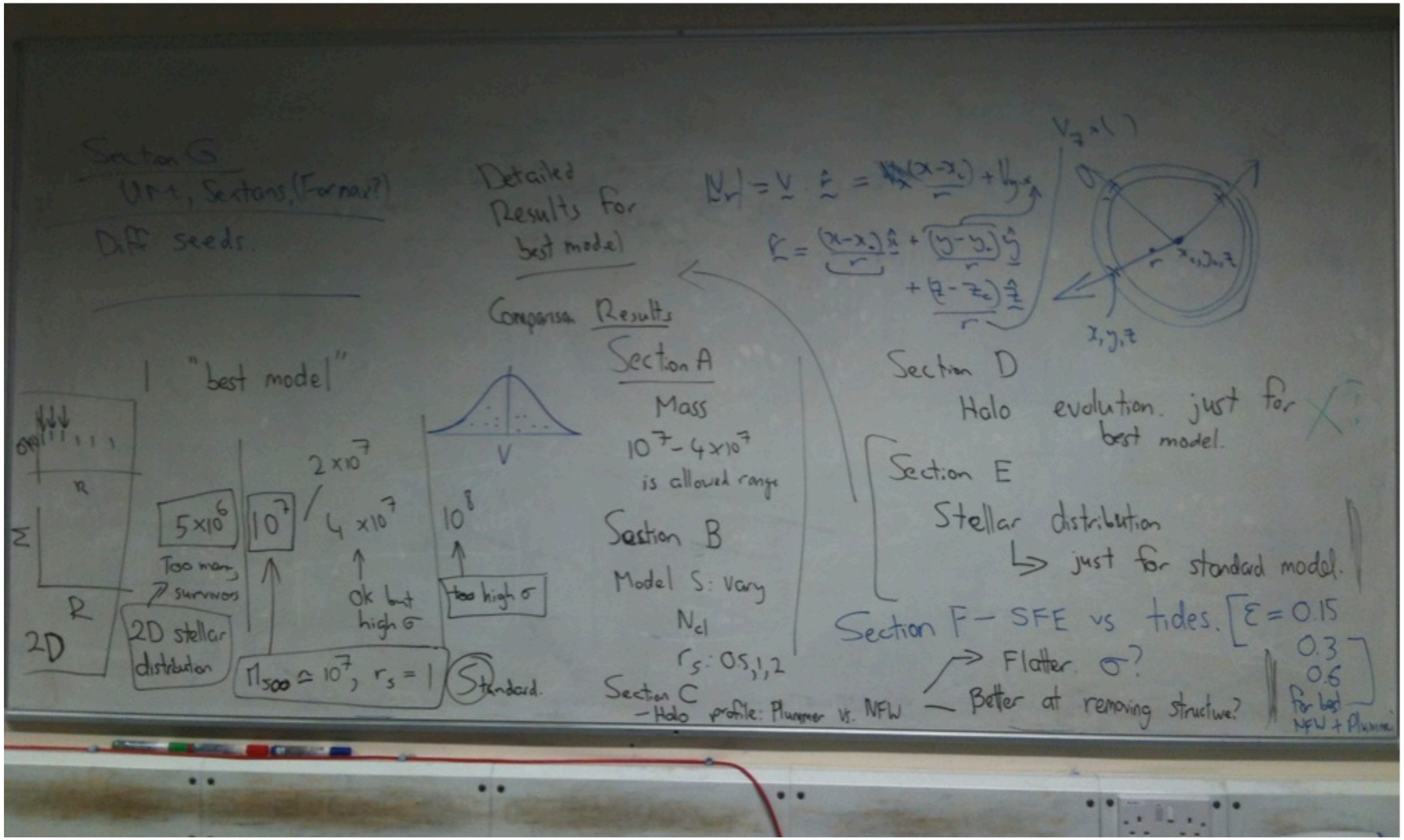
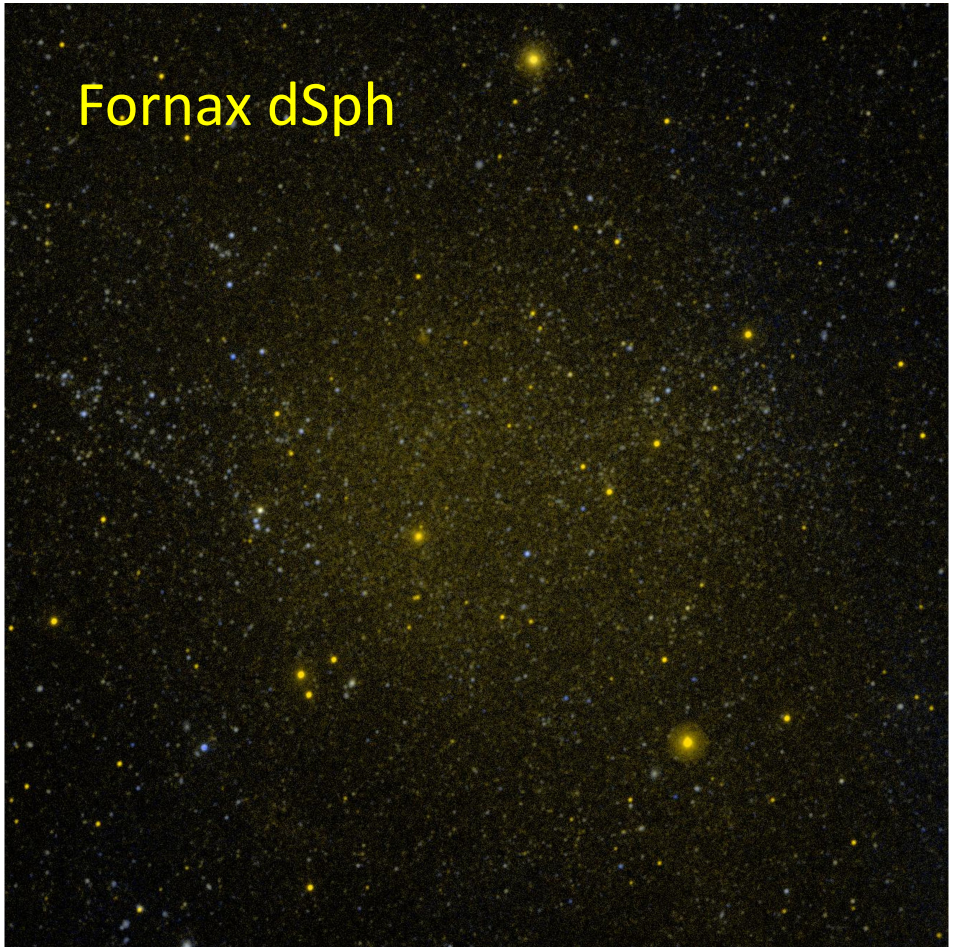
VT·VITAM HABEANT

Overview



Section G
Diff seeds
Detailed Results for best model
Comparison Results
Section A
Mass
10^7 - 4x10^7 is allowed range
Section B
Model S: vary
N_cl
r_s: 0.5, 1, 2
Section C
- Halo profile: Plummer vs. NFW
Section D
Halo evolution. just for best model.
Section E
Stellar distribution
just for standard model.
Section F – SFE vs tides.
ε = 0.15
0.3
0.6
Flatter. σ?
Better at removing structure?
1 "best model"
5x10^6
10^7
2x10^7
4x10^7
10^8
Too many survivors
ok but high σ
too high σ
2D stellar distribution
Standard.
x, y, z

Why study dSph ?

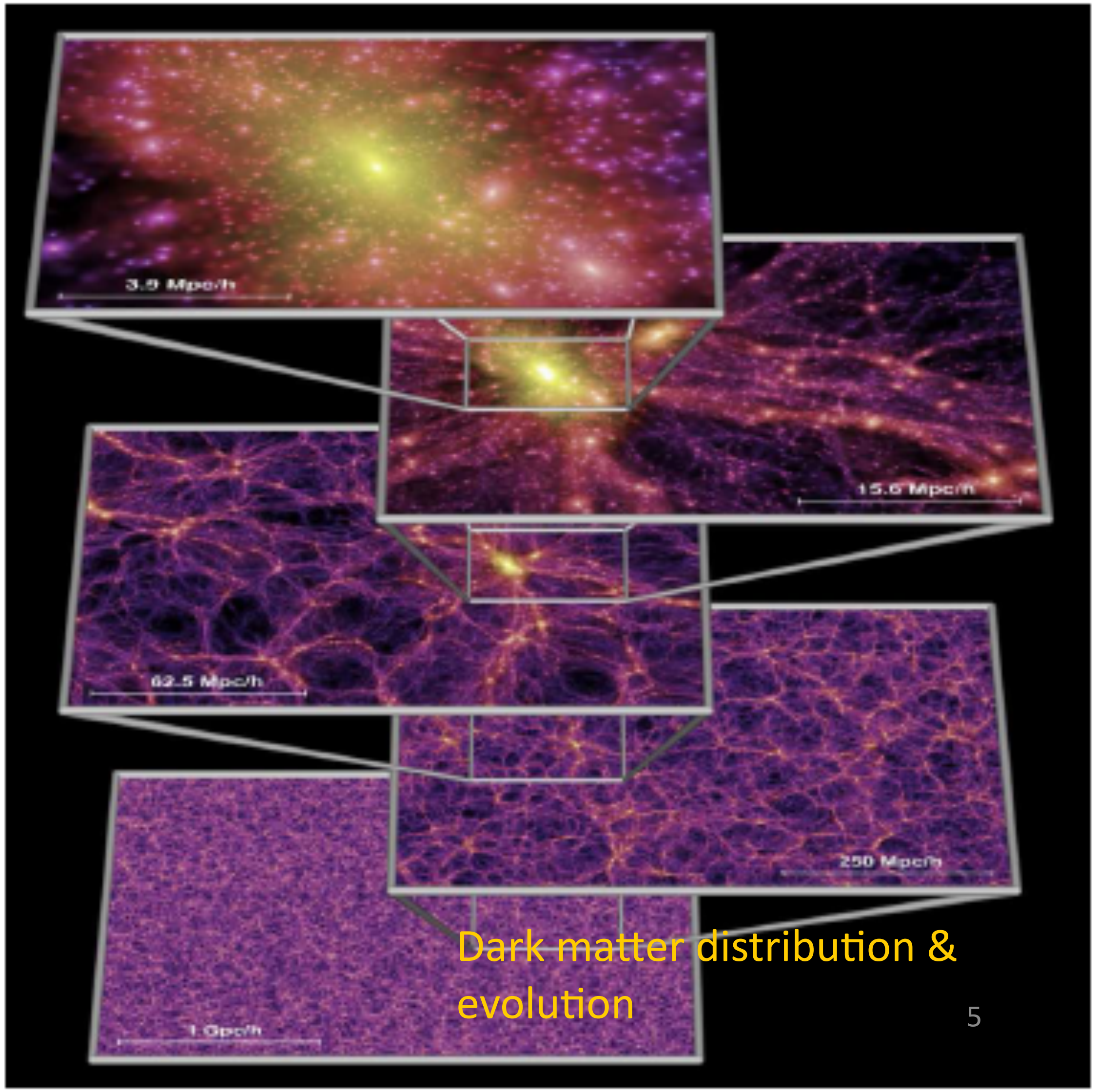


dSph are faint almost invisible blobs =
boring ???

ΛCDM Cosmology

Predicts:

- Dwarf Galaxies form first in large quantities
- Are the basic building blocks of all larger galaxies
- Are the most dark matter dominated objects (M/L from several tens to >1000)

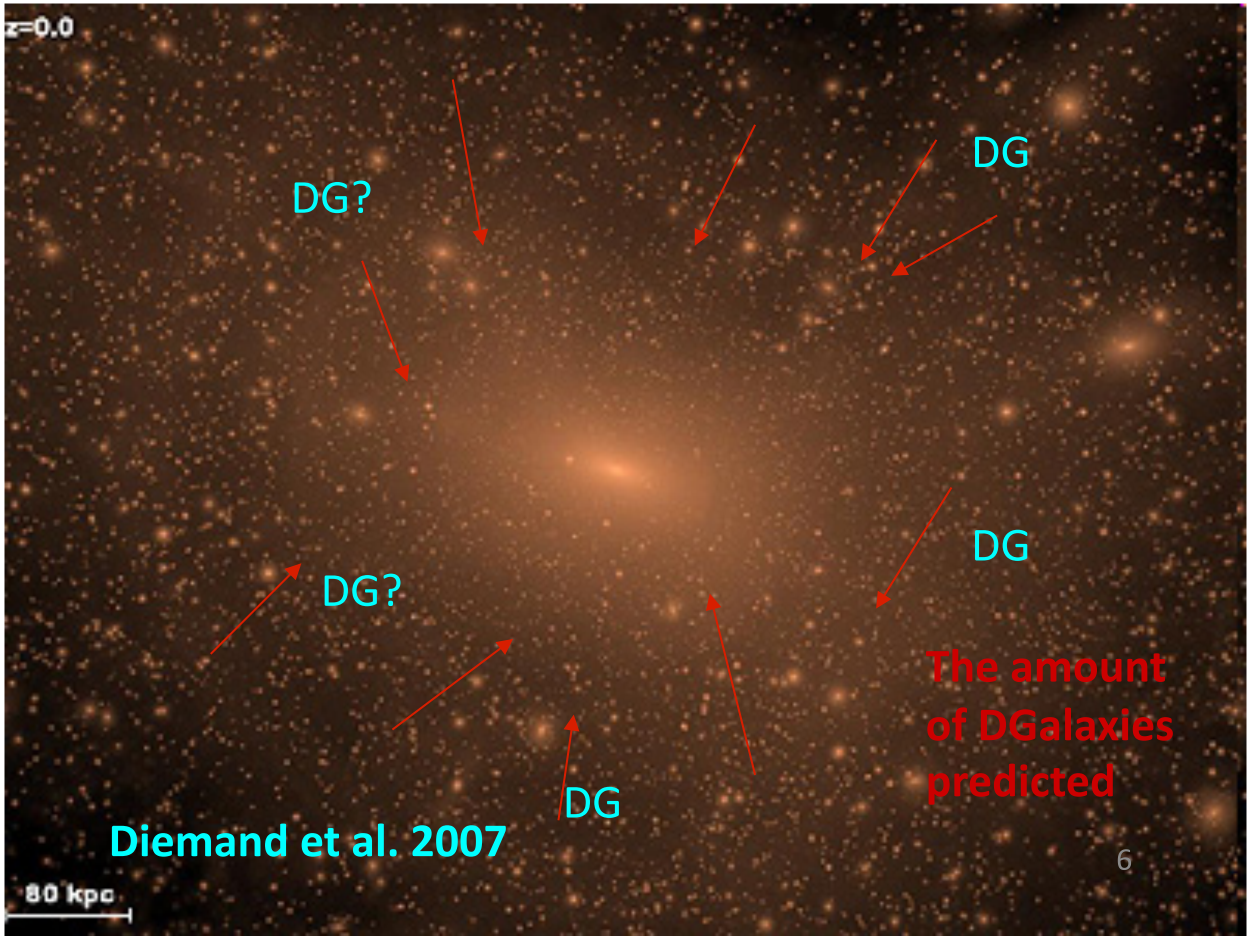


Dark matter distribution & evolution

Problem 1 : N° of Dwarf Galaxies around Large Galaxies

The Vía Lactea Simulation

- simulations predict thousands of dwarf galaxies around the MW
- With the detection of the faint and ultra-faint population this problem seems to be solved ?



Problem 2 : Shape of the dark matter halo Cusped or Cored ?

- ΛCDM cosmology predicts cusped profiles.
- Observations favour cored profiles

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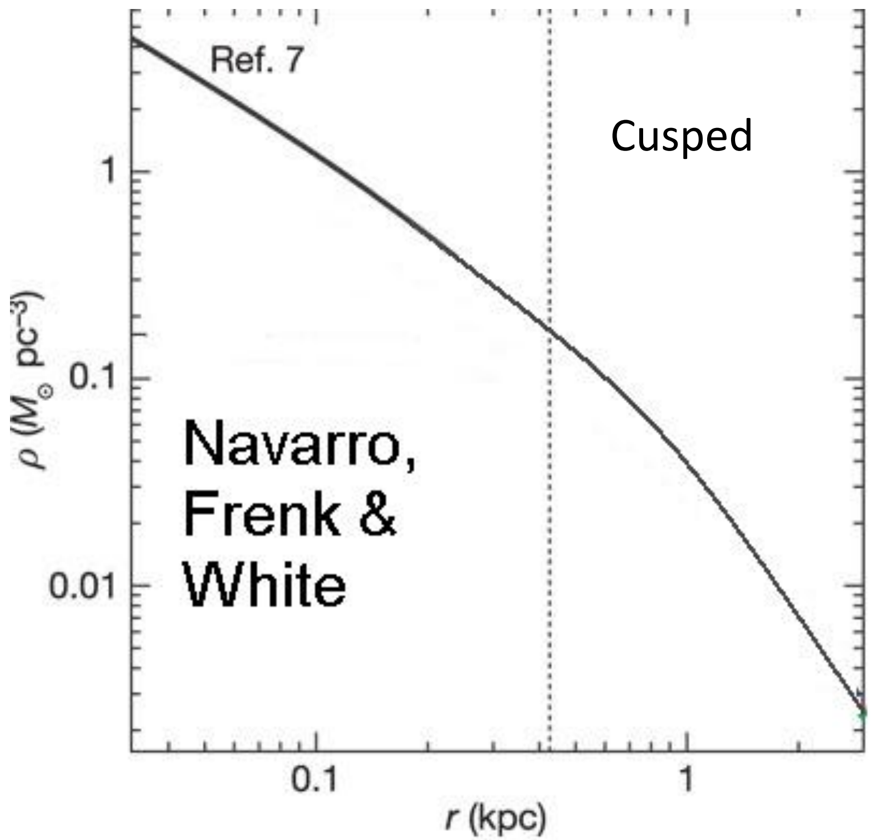
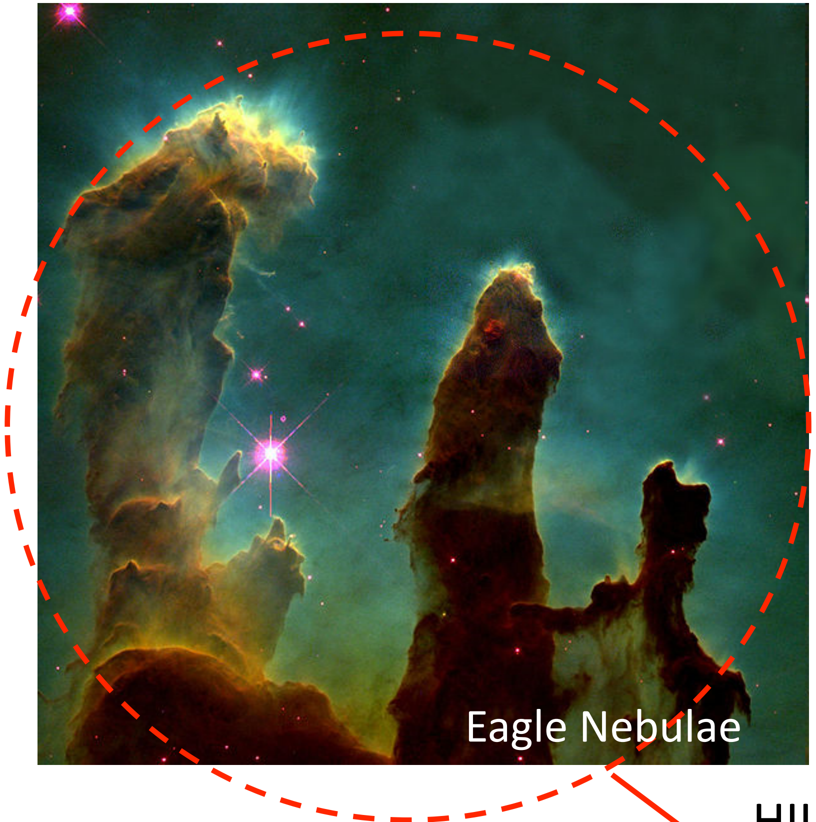
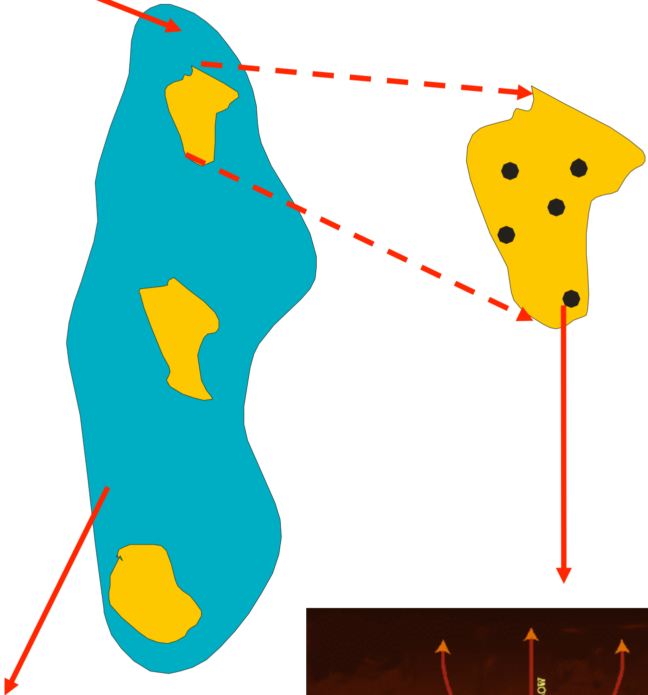


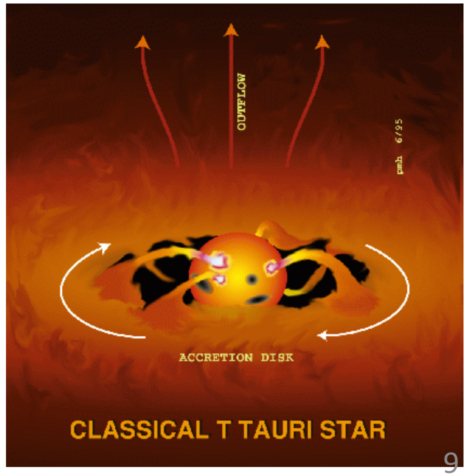
What do we know about star formation ?

Star Formation & Star Clusters



Cloud core



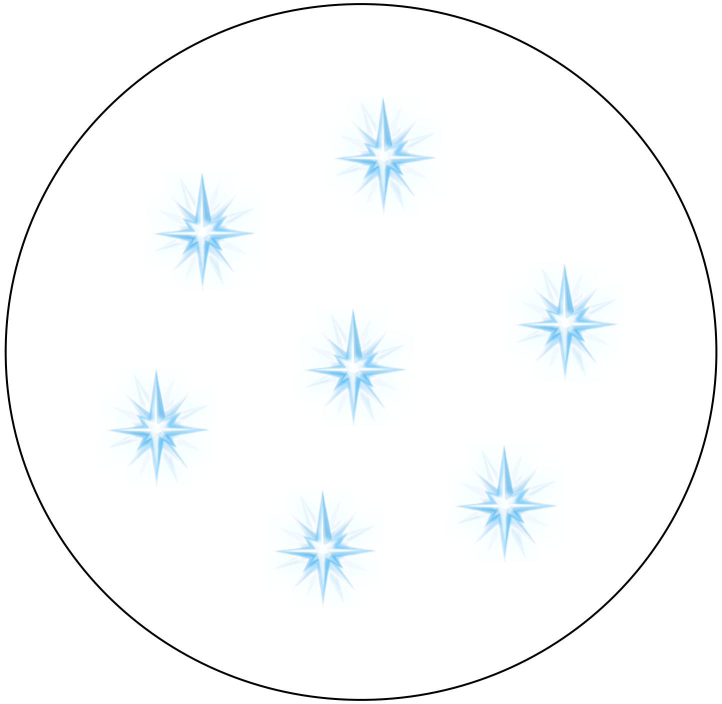


HII molecular cloud

Stars form in Star Clusters !

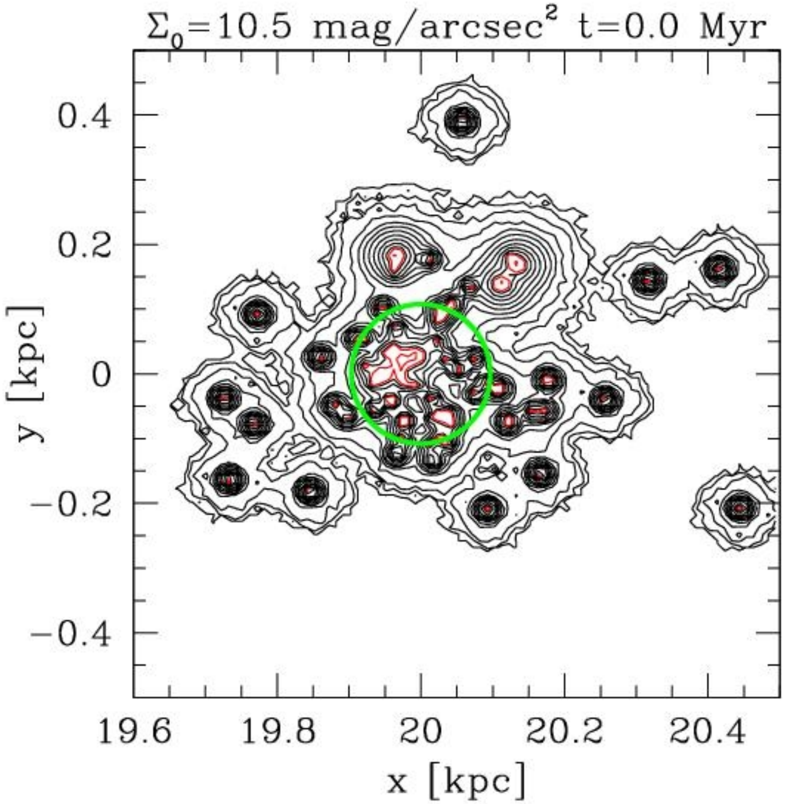
Final step of the star cluster formation

Star cluster



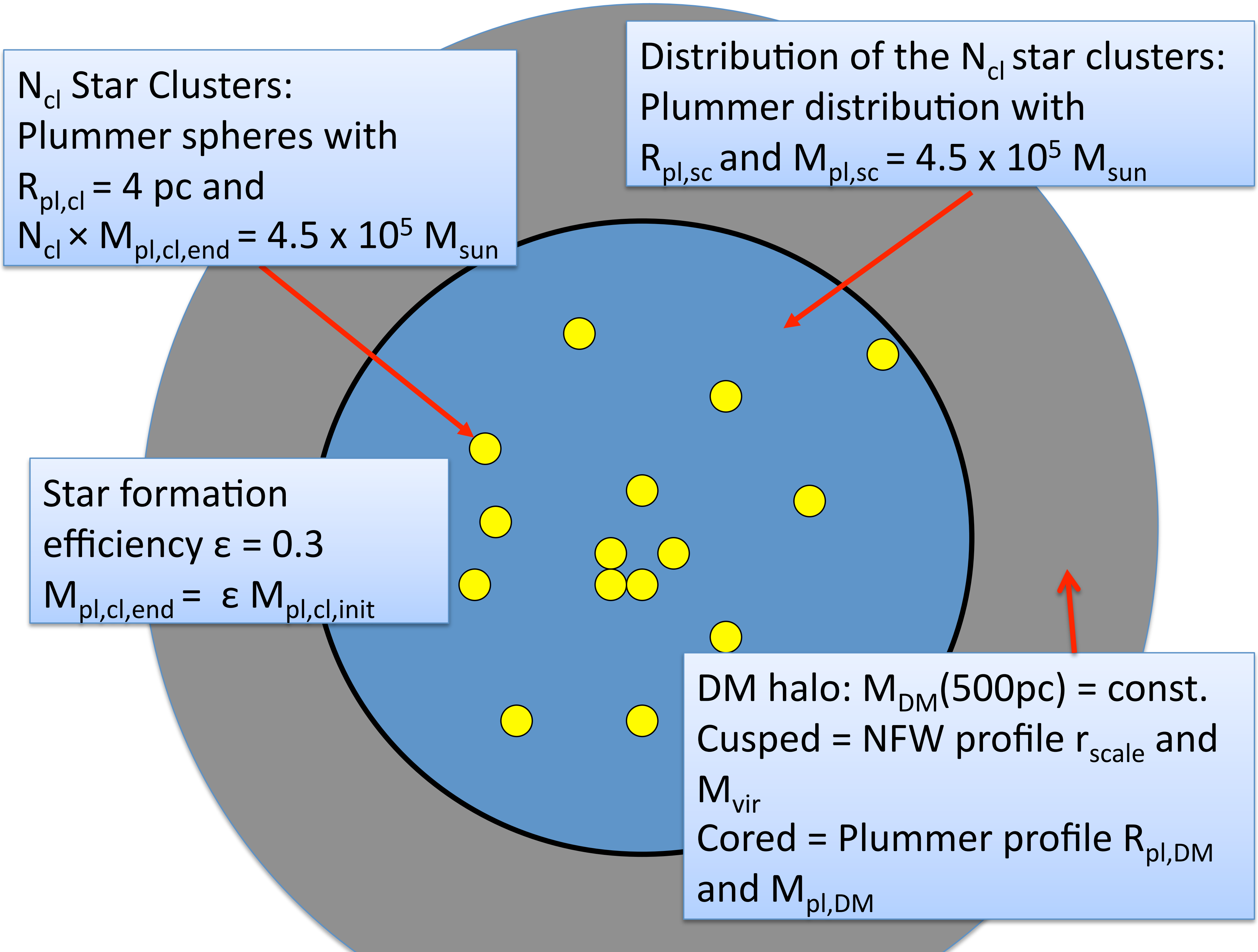
- Stars have formed in the embedded cluster phase
- Now the stars expell the remaining gas by stellar winds & super novae
- Leaving the cluster out of virial equilibrium and expanding
- If the SFE is around 30% the star cluster survives

Merging of Star Clusters



- The gas inside a dSph might form many star clusters
- Star clusters interact with each other and merge in the centre of the dark matter halo
- At the same time they expand and dissolve

So here we start with our models


N_{cl} Star Clusters:
Plummer spheres with
$R_{pl,cl}$ = 4 pc and
$N_{cl} \times M_{pl,cl,end} = 4.5 \times 10^5 M_{sun}$
Distribution of the N_{cl} star clusters:
Plummer distribution with
$R_{pl,sc}$ and $M_{pl,sc} = 4.5 \times 10^5 M_{sun}$
Star formation
efficiency ε = 0.3
$M_{pl,cl,end} = \varepsilon M_{pl,cl,init}$
DM halo: M_{DM}(500pc) = const.
Cusped = NFW profile r_{scale} and
M_{vir}
Cored = Plummer profile $R_{pl,DM}$
and $M_{pl,DM}$

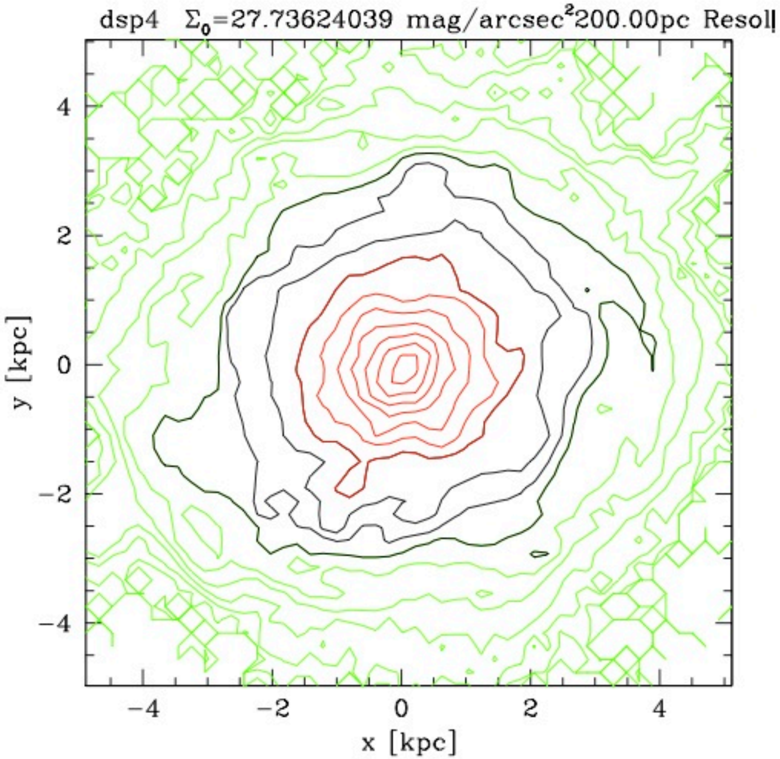
Our simulation-parameters

- M_{DM}(500pc) = 5x10^6, 10^7, 4x10^7 and 10^8 M_{sun}
- $R_{scale,DM}$ = 0.25, 0.5, 1.0, 2.0 kpc (Plummer or NFW)
- $R_{pl,sc}$ = 0.25 kpc
- N_{cl} = 15 and 30 star clusters
- ε = 0.3 (star clusters are dissolving)

- And more to come…

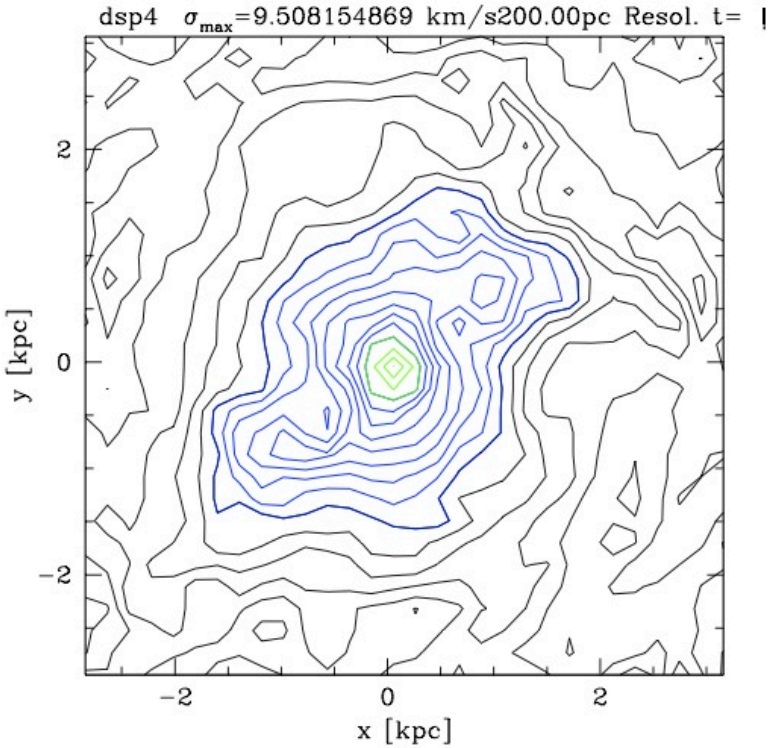
What are the results and what are the general trends ?

Results



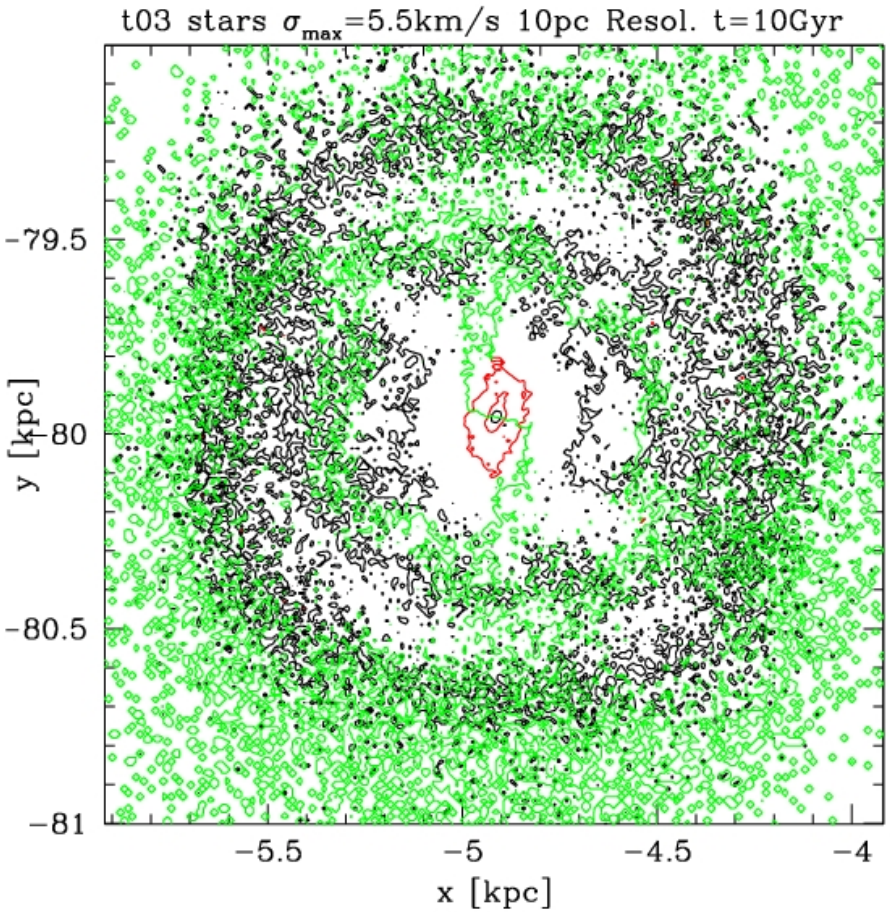
- Star clusters dissolve and form an extended luminous object which looks like a dSph galaxy
- Outer parts show faint remnants of dissolved star clusters even after 10 Gyr but these features are too faint to be observationally detectable

Results



- Velocity dispersion is similar to the ones found with dSph galaxies (around 10 km/s) and distributes a flat profile but shows some aspherical features in a 2D-plot

Results



- We also see streaming motions if we plot the 2D mean velocity calculated pixel by pixel, even after 10 Gyr of evolution
- We call these velocity signatures of the merging process "fossil remnants"

changing M_{DM}(500pc)

- With increasing dark matter mass we see:
  - naturally an increase the velocity dispersion σ
  - A trend to more extended luminous components (larger r_s)
  - An increase in the strength of fossil remnants (has to be verified if statistically significant)

Changing $R_{scale,DM}$

- If we increase the scale-length of the dark matter halo by keeping the mass within 500 pc constant (i.e. flatter profiles) we see:
  - The velocity dispersion stays constant when using a Plummer profile
  - The velocity dispersion increases in NFW haloes
  - A small increase in fossil remnants (maybe not statistically not significant)

Changing N_{cl}

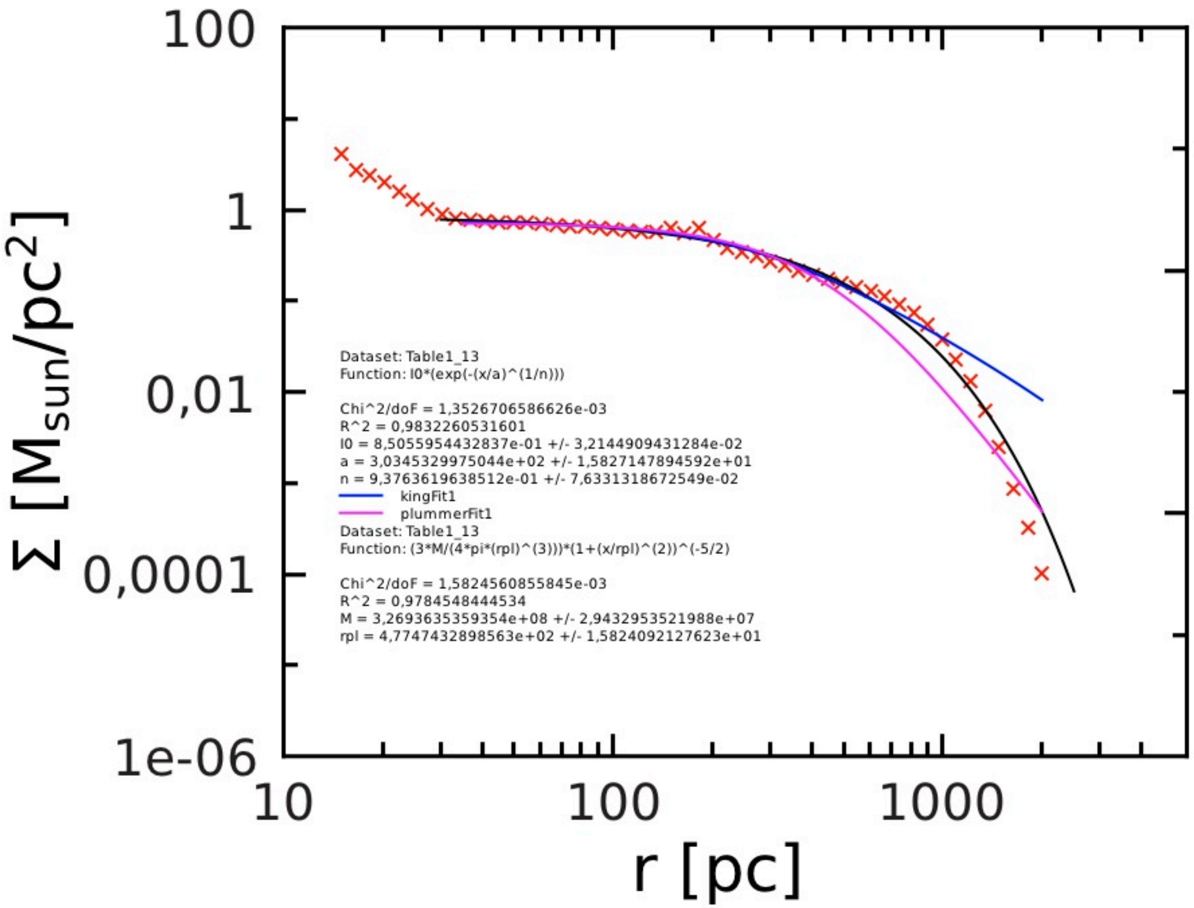
- When we distribute the luminous mass into more star clusters we see:
  - No changes in the velocity dispersions
  - A small increase in fossil remnants (maybe not statistically significant)

- If M_{DM}(500pc) is too high (~ 10^8 M_{sun}) we see a lot of unmerged star clusters
- If $R_{scale,DM}$ is too high (~ 2 kpc) we get unmerged SC as well
- Large scale-lengths not only favour flatter velocity dispersion profiles they also favour the fossil remnants
- High DM masses favour the remnants as well
- NFW profiles erase remnants better than Plummer profiles

"Best fit model"

- To get a velocity dispersion of 10 km/s in the centre, we need less M_{DM} than observations predict: only $M_{DM}(500pc) \sim 10^7\ M_{sun}$
- The velocity dispersion profile (i.e. flat profile) is best reproduced if the scale-length of the halo is 1 kpc
- Plummer and NFW fit equally well – Plummer shows more fossil remnants

One model fits Sextans



- Figures and pretty pictures are soon to be found in Assmann et al. (2011) in prep. – so please stay tuned…

Thanks!