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Dark Matter Annihilation from the Milky Way's halo

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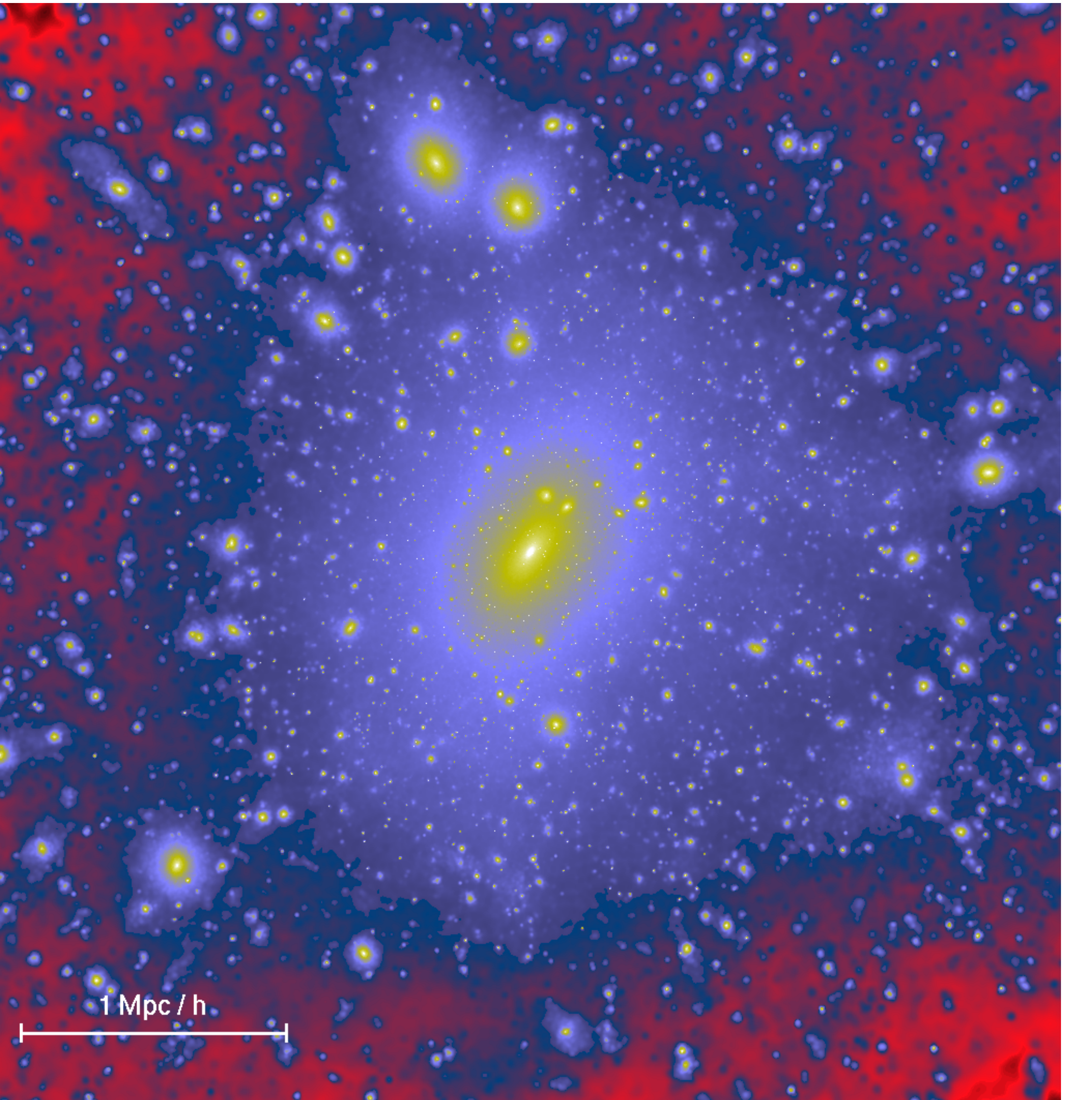
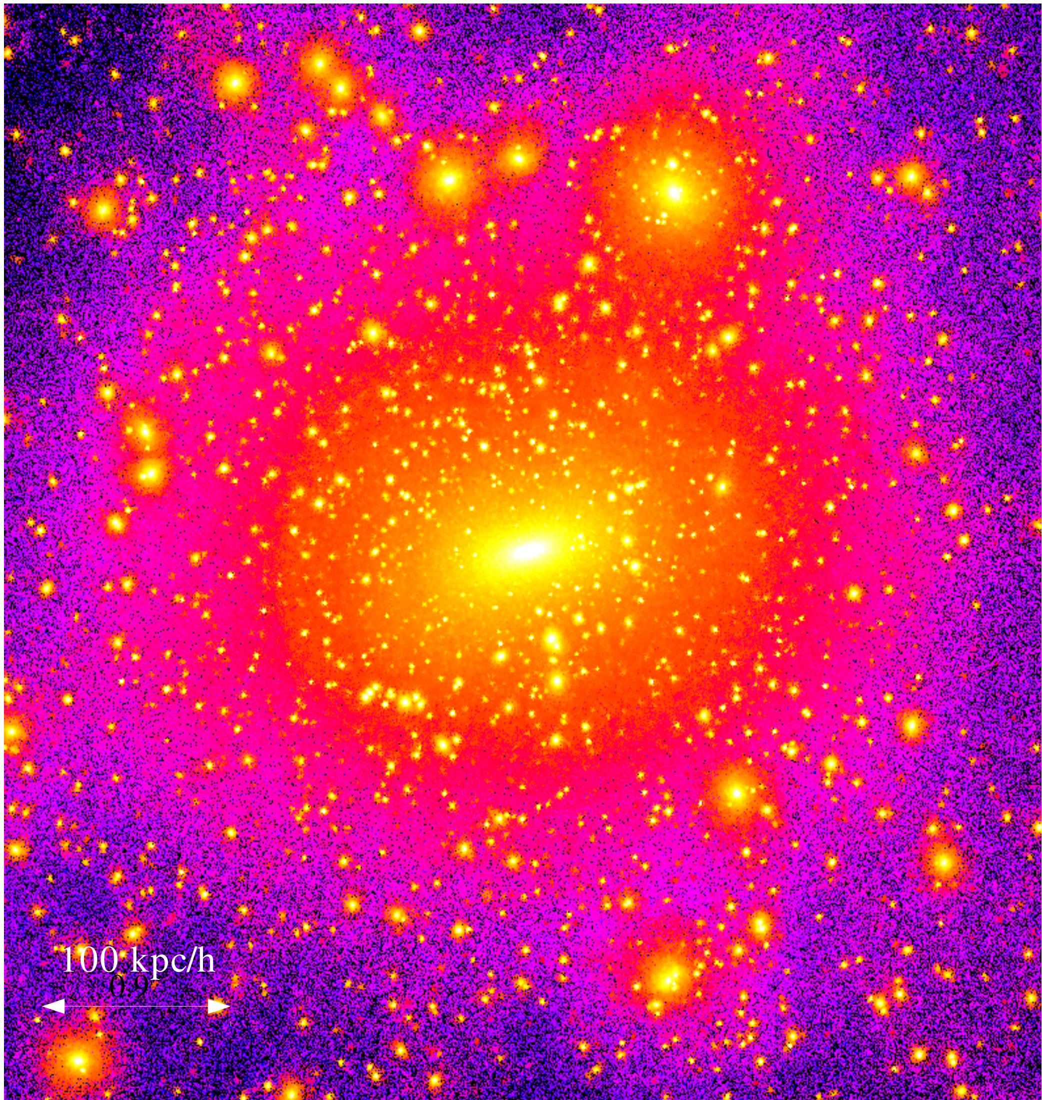
Small-scale structure in ΛCDM halos

A rich galaxy cluster halo
Springel et al 2001

A 'Milky Way' halo
Power et al 2002





ΛCDM galaxy halos (without galaxies!)

- Halos extend to ~10 times the 'visible' radius of galaxies and contain ~10 times the mass in the visible regions

- Equidensity surfaces approximate triaxial ellipsoids
  -- more prolate than oblate
  -- axial ratios greater than two are common

- "Cuspy" density profiles with outwardly increasing slopes
  -- $d \ln \varrho / d \ln r = \gamma$ with $\gamma < -2.5$ at large r
  $\gamma > -1.2$ at small r

- Substantial numbers of self-bound substructures containing ~10% of the mass and with $d N / d M \sim M^{-1.8}$

→ Most substructure mass is in most massive subhaloes

Dark Matter Annihilation

If the dark matter WIMP's are Majorana particles

→ Self-annihilation is possible
Annihilation products will typically include γ-rays

The luminosity density of annihilation emission is

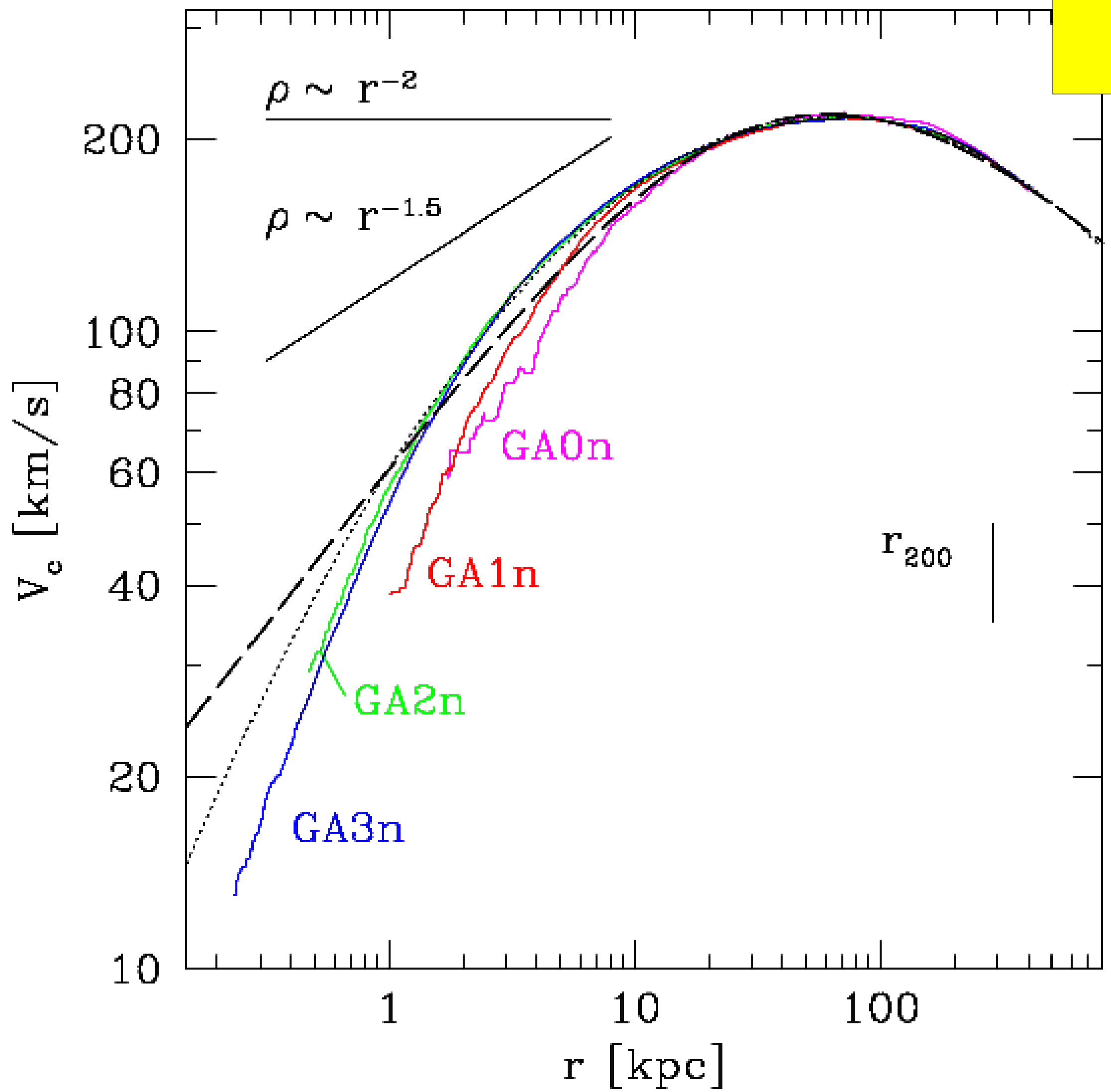
$$\mathscr{L}(\mathbf{x}) \propto n_{\mathrm{DM}}(\mathbf{x})^2 \langle \sigma \, \mathrm{v} \rangle$$

Thus the γ-ray luminosity of an object is

$$L \propto \langle \sigma \, \mathrm{v} \rangle \int \rho^2 \, \mathrm{dV} \propto \langle \sigma \, \mathrm{v} \rangle \int \rho^2 r^2 \, \mathrm{d}r$$

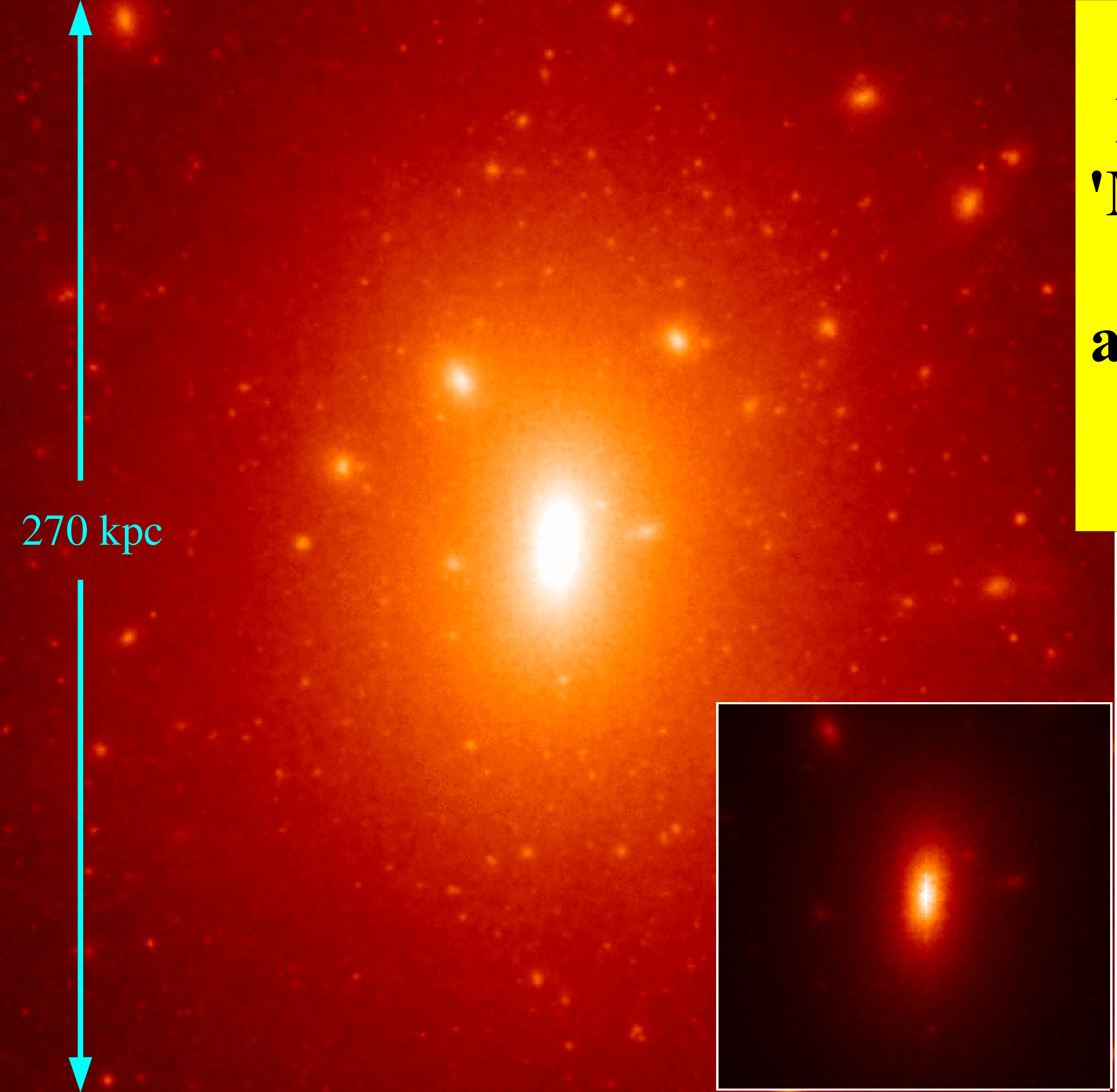
→ critical density exponent for convergence is $\rho \propto r^{-1.5}$

Inner density structure of a Milky Way halo



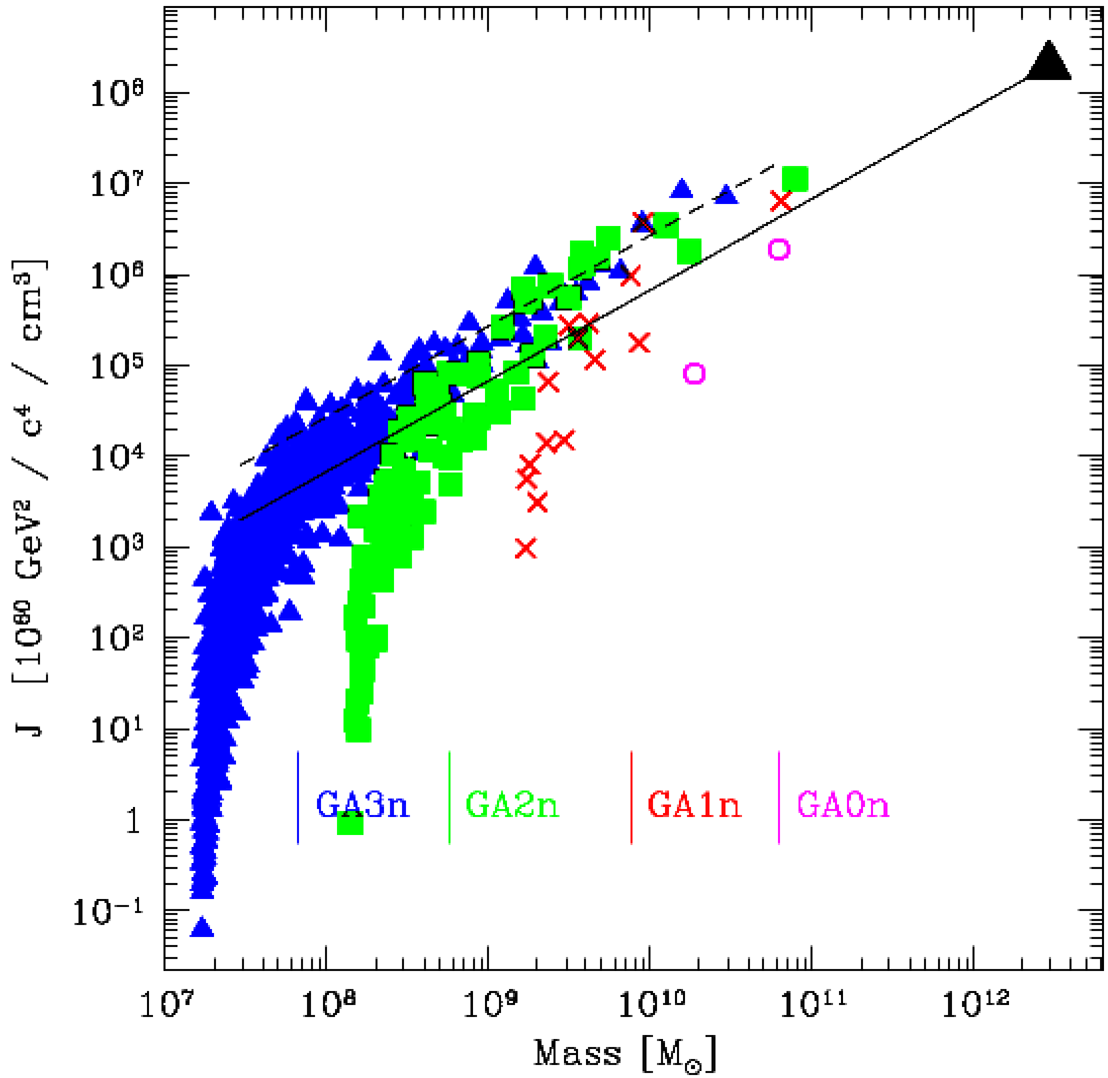
- Four simulations from the same initial conditions but with differing resolution N_{200} = 14,000, 130,000, 1,200,000, 10,100,000
- Inner structure converges down to about 1 kpc
- Slope is $\rho \propto r^{-1.5}$ at 7 kpc

Image of a 'Milky Way' halo in annihilation radiation



$$S(\theta) \propto \int \rho^2 \, dl$$

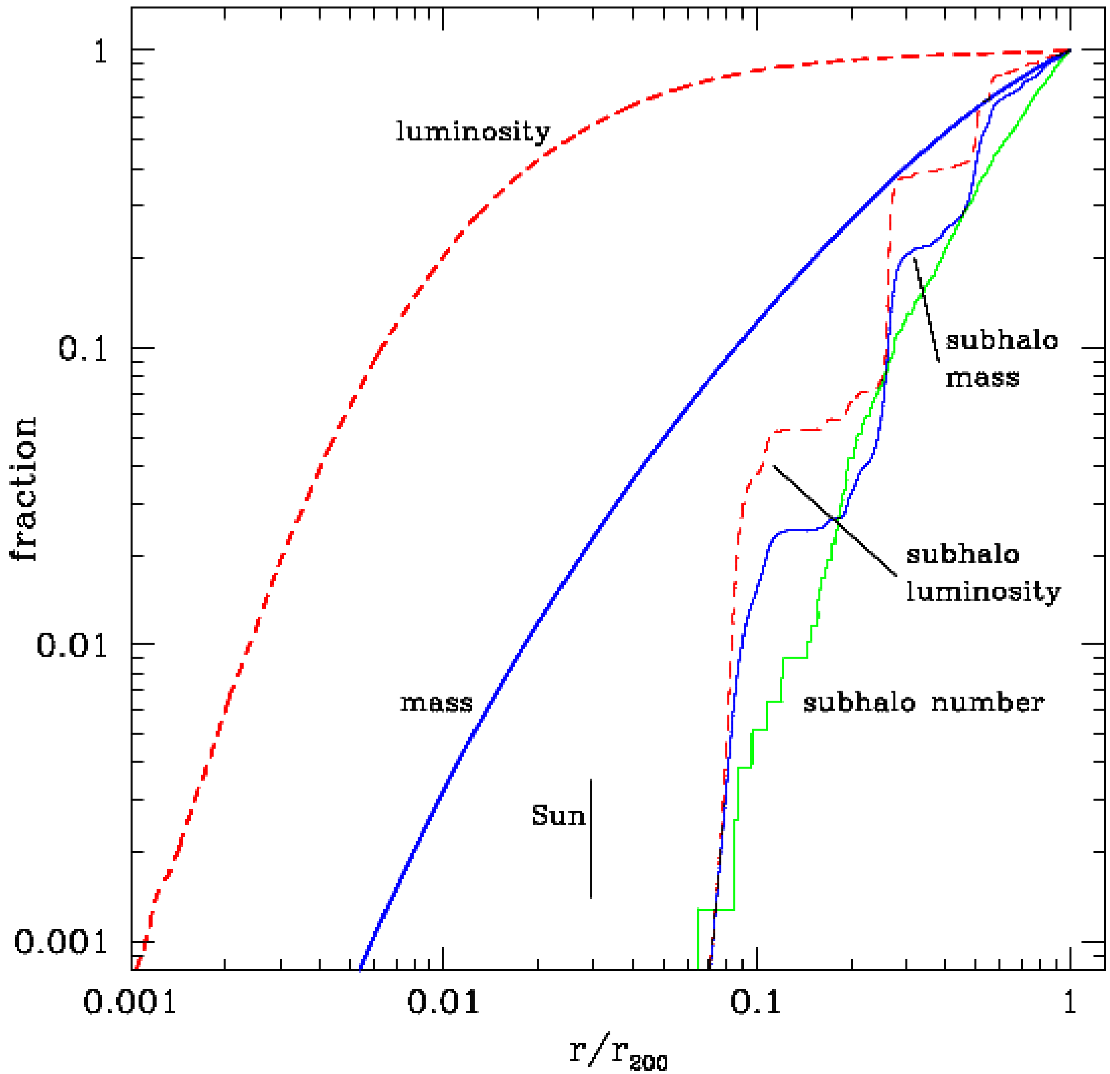
Substructure luminosity



- $J = \sum \rho_i m_i$ is proportional to the annihilation luminosity of an object
- J appears to have converged for the higher resolution models
- $J \propto M$ for subhaloes

→ total subhalo luminosity dominated by most massive objects

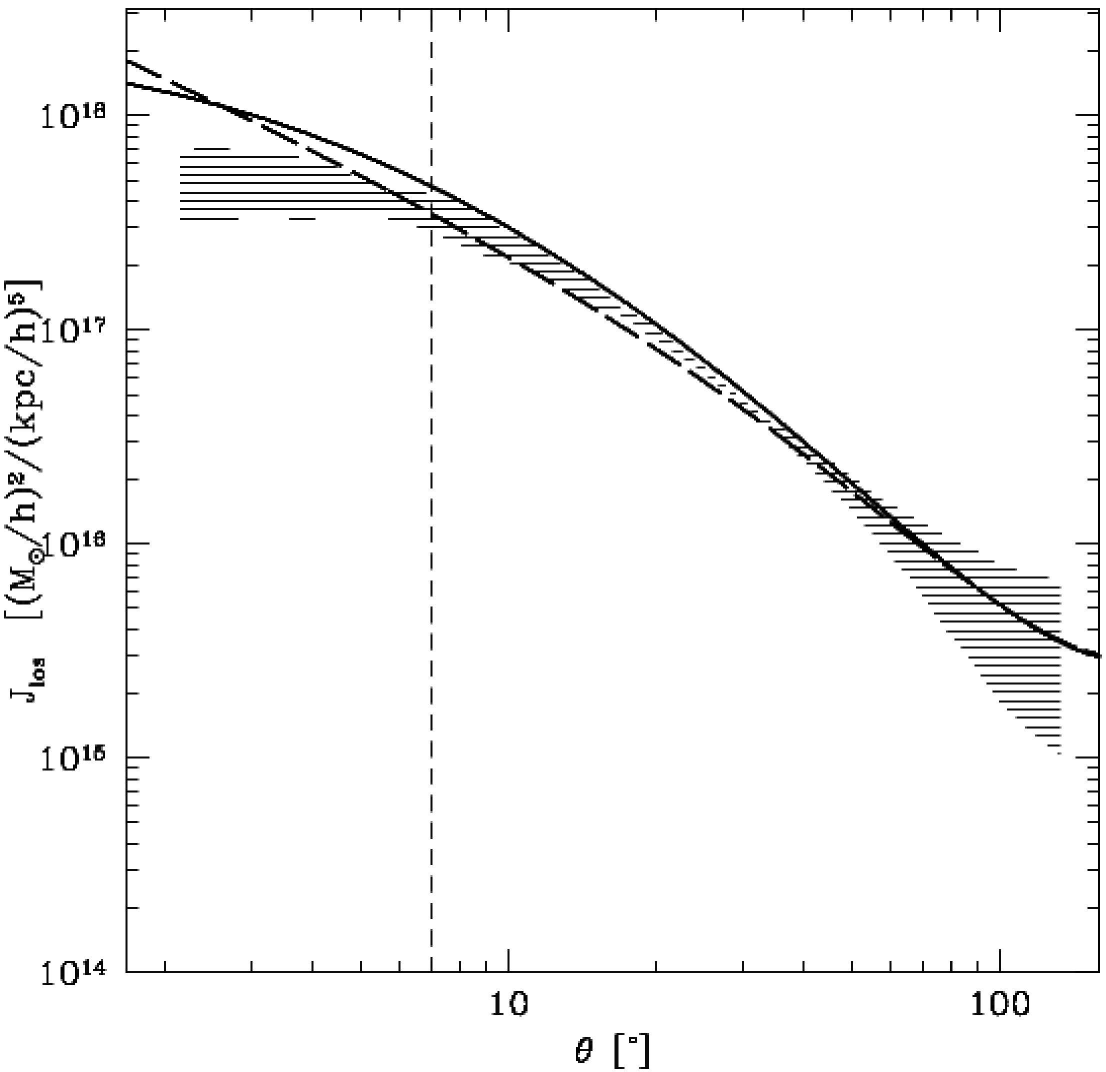
Cumulative radial distributions of mass and light



- Half mass/light radii of the diffuse halo component are 90 kpc and 7 kpc
- Half mass/light radii of the subhalo component are both 130 kpc
- Total light from subhalo component is 25% that from the diffuse component
- The Sun is *much* closer to the peak of the diffuse emissivity than to a subhalo

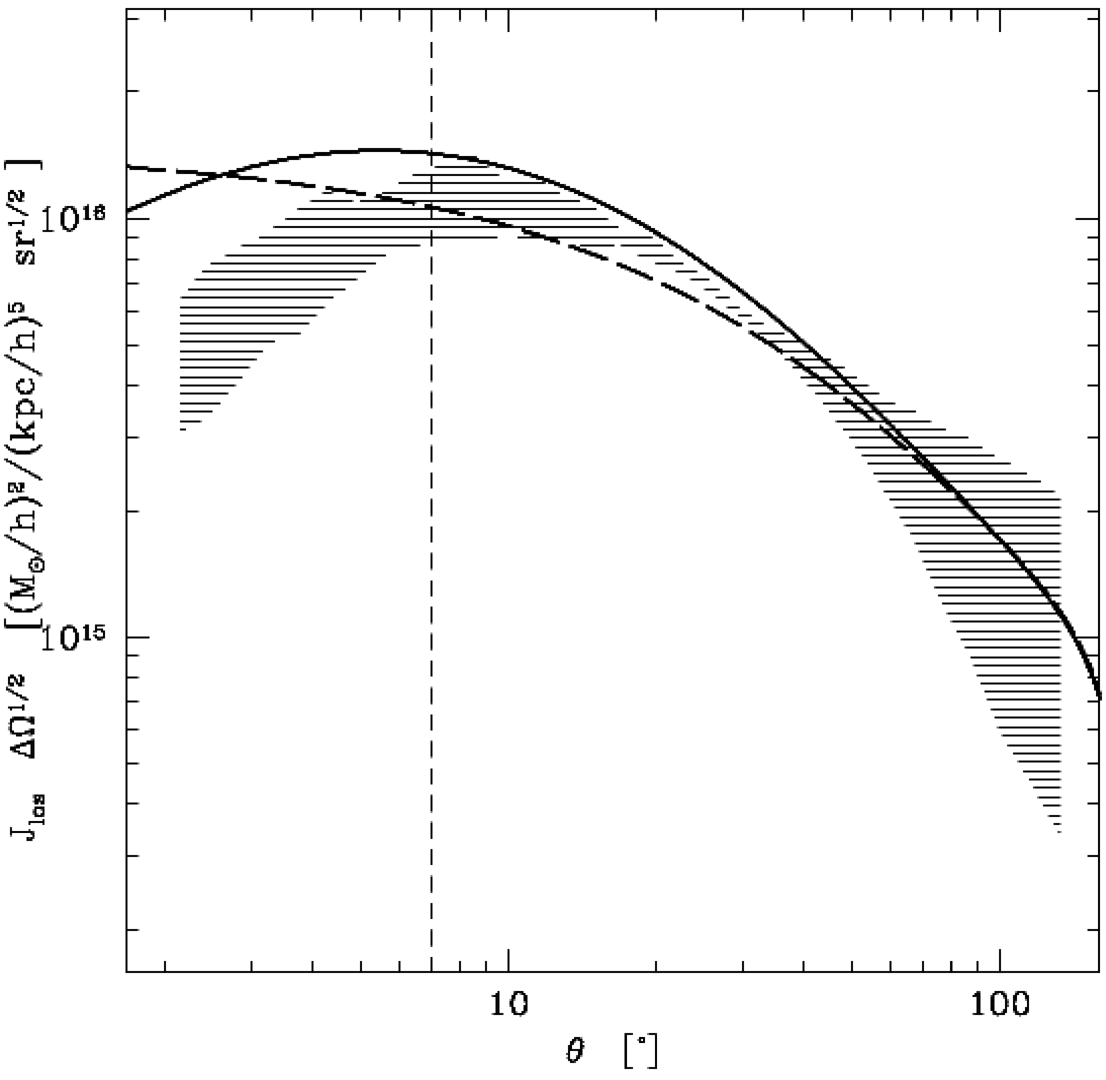
→ Observed flux dominated by diffuse emission from inner Galaxy

Surface brightness of the simulated Milky Way as seen from the Sun's position



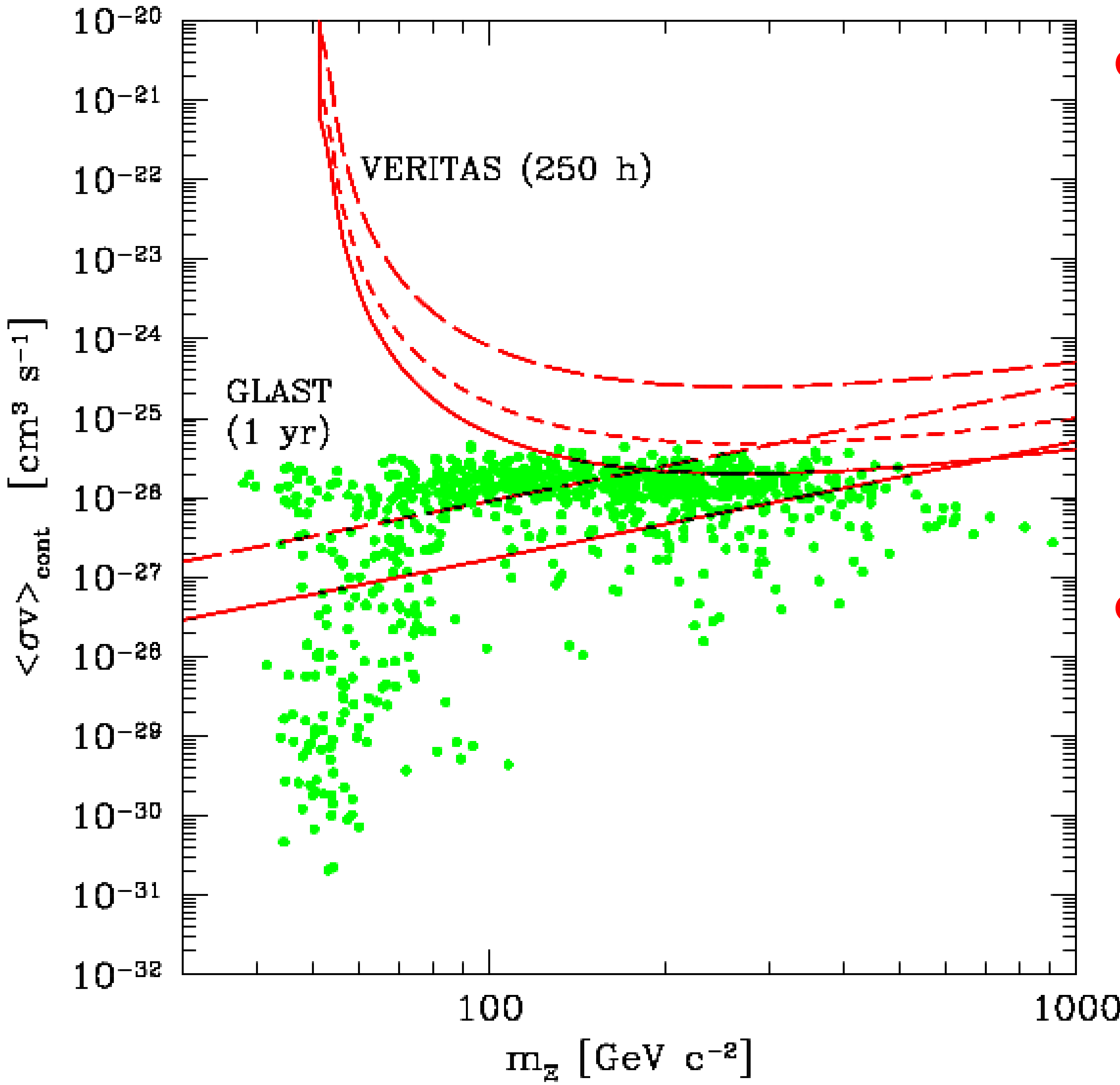
- Hatched area is scatter in circularly averaged surface brightness profiles for 8 artificial skies constructed directly from the simulation
- Heavy lines are from analytic fits to the density profile
- Vertical line is resolution limit of simulation at Galactic Centre

Signal-to-noise of the simulated Milky Way as seen from the Sun's position



- Hatched area is scatter in circularly averaged signal-to-noise profiles for *wide beam* observation of 8 artificial skies assuming *uniform* background
- Heavy lines from analytic fits to the density profile
- Best S/N is achieved about at a radius of 10 degrees
- At this radius simulation is secure and backgr'd is *lower*

Could GLAST or VERITAS see the Signal?



Possible MSSM params from Darksusy

- For VERITAS (a Cerenkov detector with 1.75° FOV) the detectability of the G.C. depends on poorly resolved regions of the simulation and is marginal
- For GLAST (a satellite with 3 sterad. FOV) detection should be possible 20° to 30° from the G.C. in a very long integration and for most MSSM parameters. This does *not* depend on poorly resolved regions of the simulation