Title: Earth mass microhalo survival at <10pc

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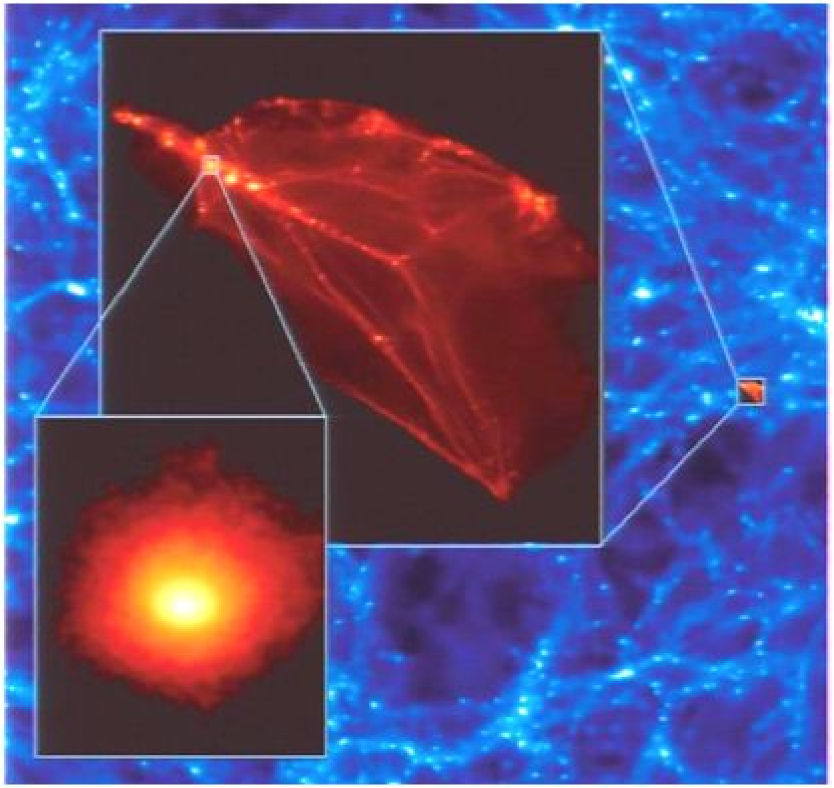
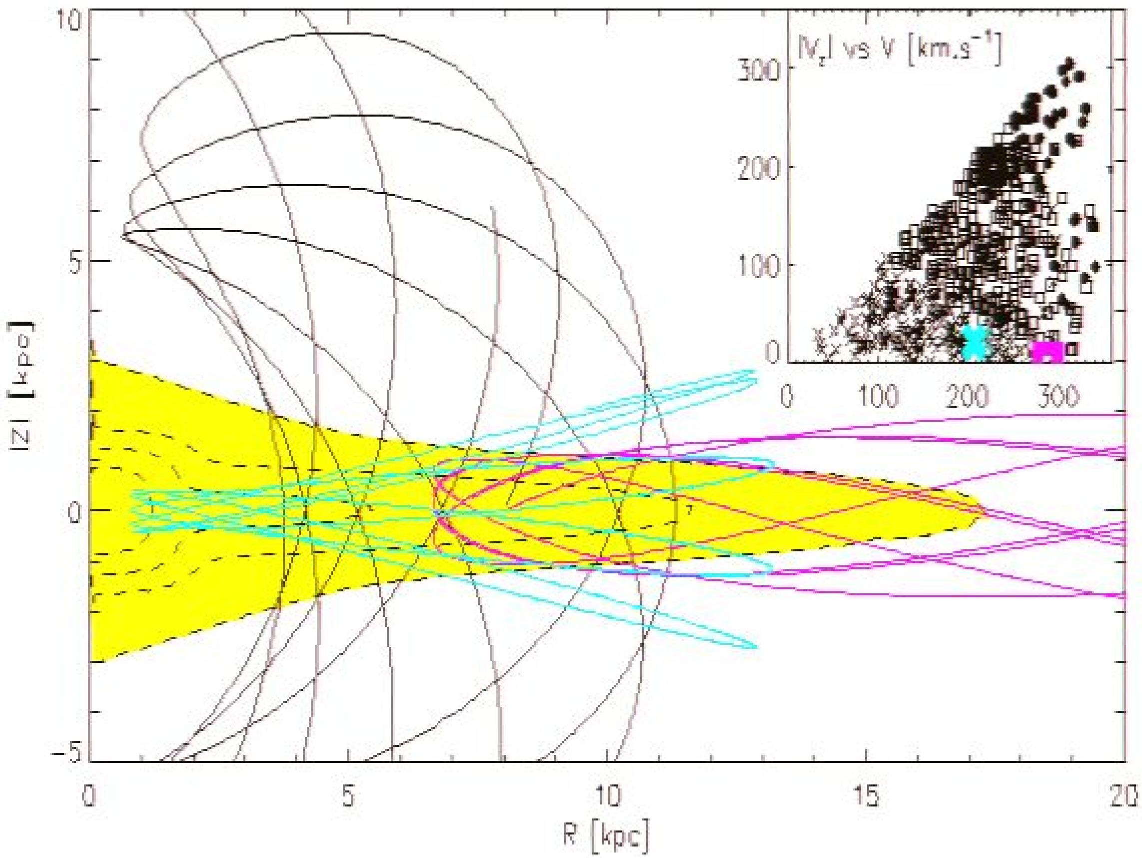
Abstract:

Earth Mass DM MicroHalo Survival At <10pc



From Diemand, Moore & Stadel (2005) Nature



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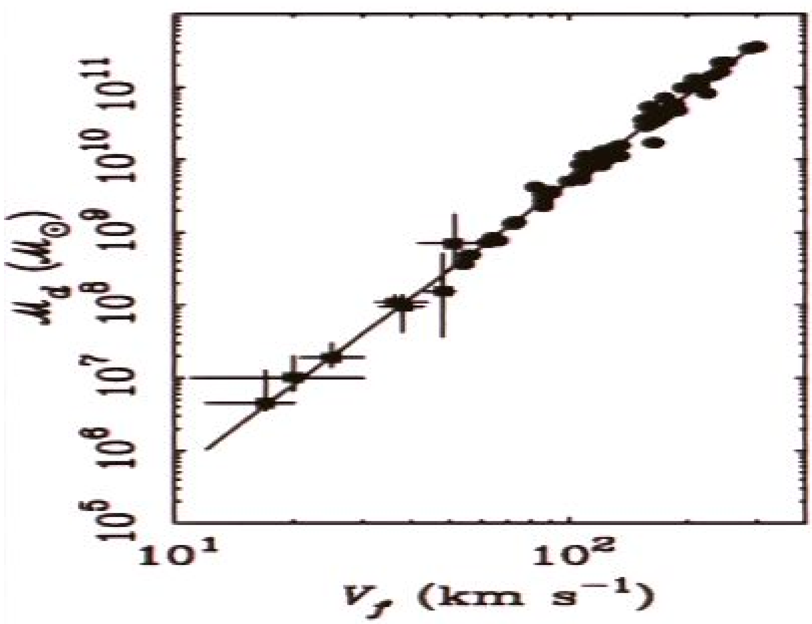
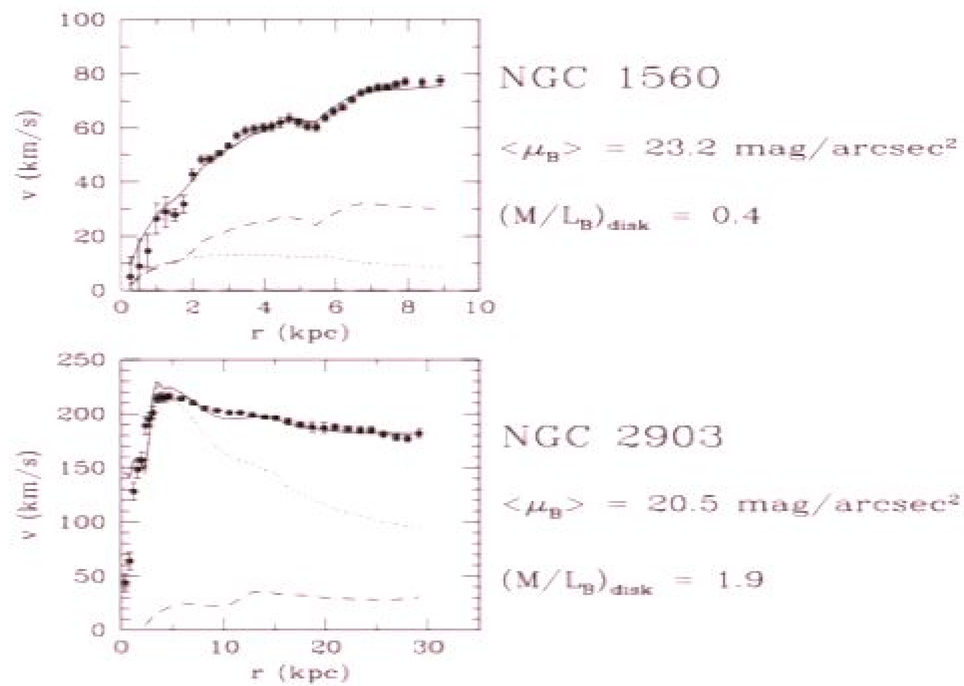
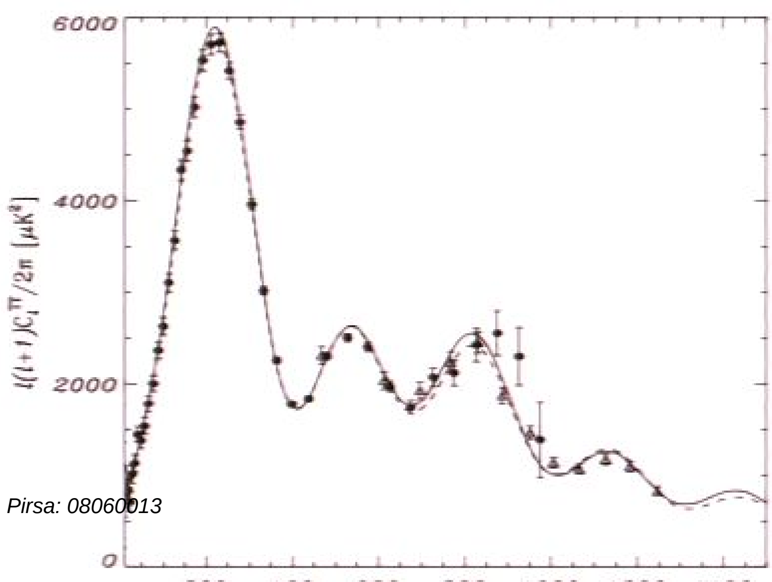
7^{th} June 2008

Garry Angus
SUPA, University of St. Andrews – Universita di Torino

The only way to dispel MOND

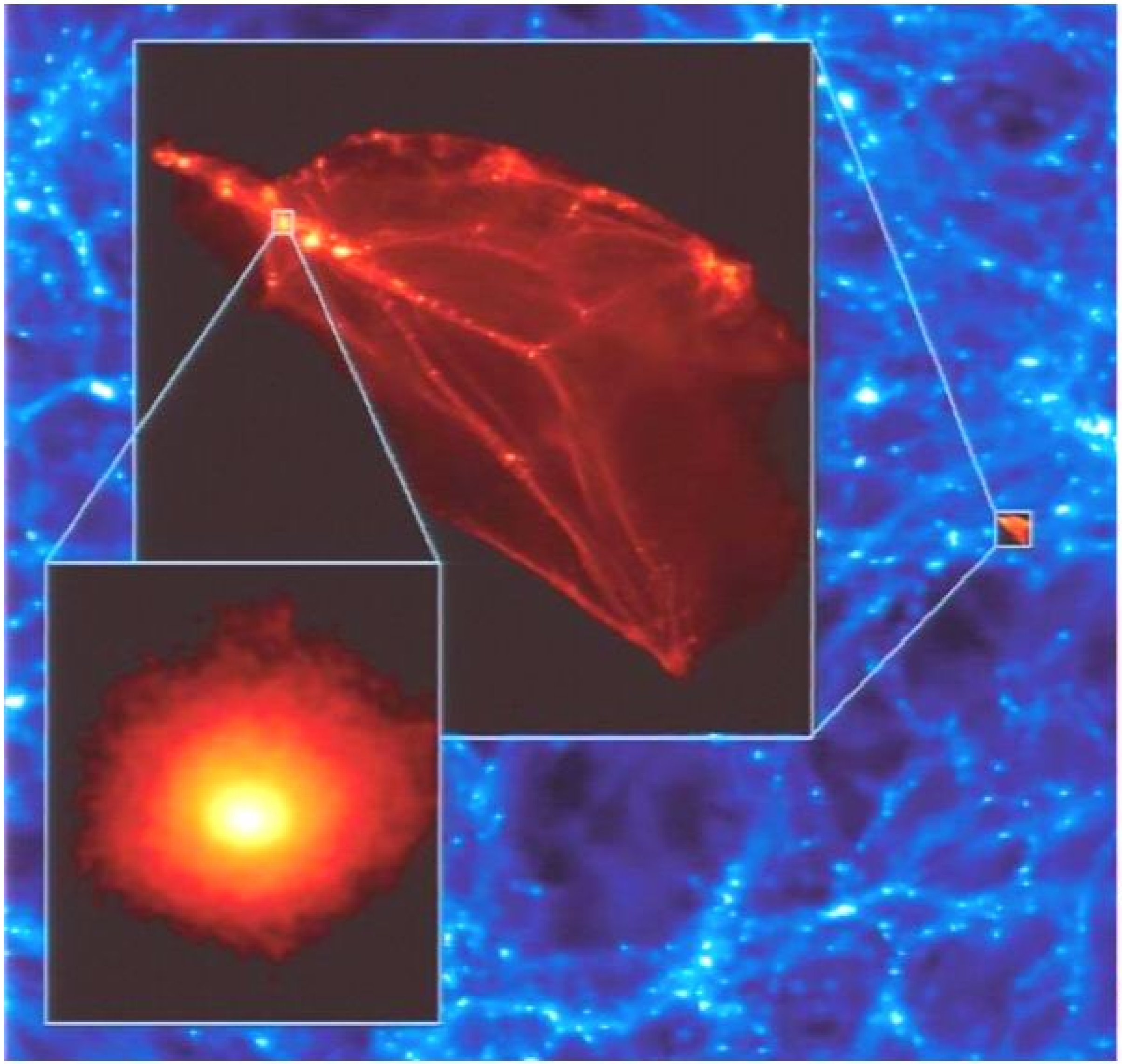


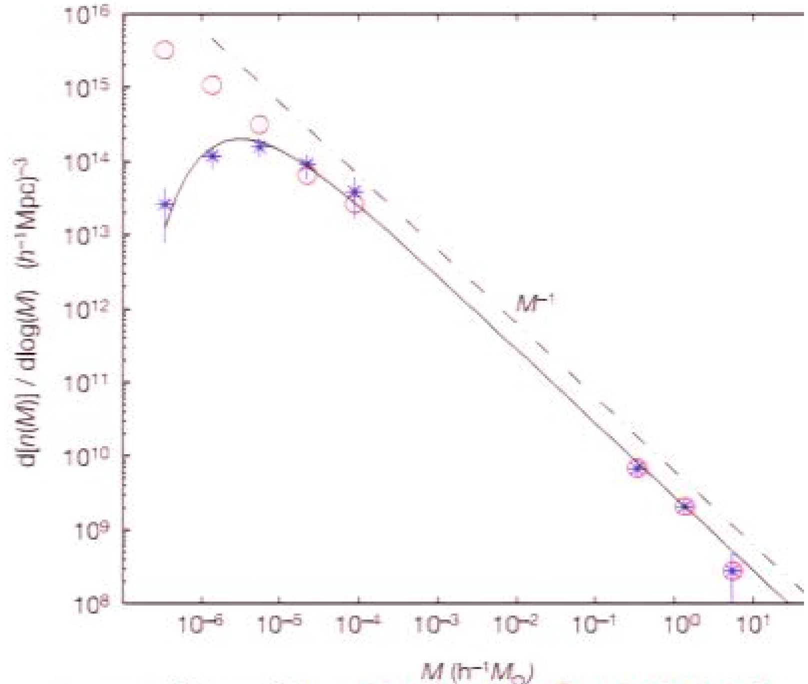




- MOND can exactly reproduce the baryonic Tully Fisher relation (**McGaugh 0506750**), rotation curve shapes and with an 11eV sterile neutrino can match clusters and the CMB (**Angus 08054014 or http://www-star.st-and.ac.uk/~gwa2/thesis.pdf**).
- No DM substructure! Free streaming scale of 11eV v_s is about 50kpc within a Milky Way type galaxy.
- Even if the LHC finds evidence for WIMPs, it will not tell us if they exist in galaxies.
- Must find conclusive evidence for CDM from substructure or we are wasting our time when studying galaxy formation.

Earth Mass MicroHalos

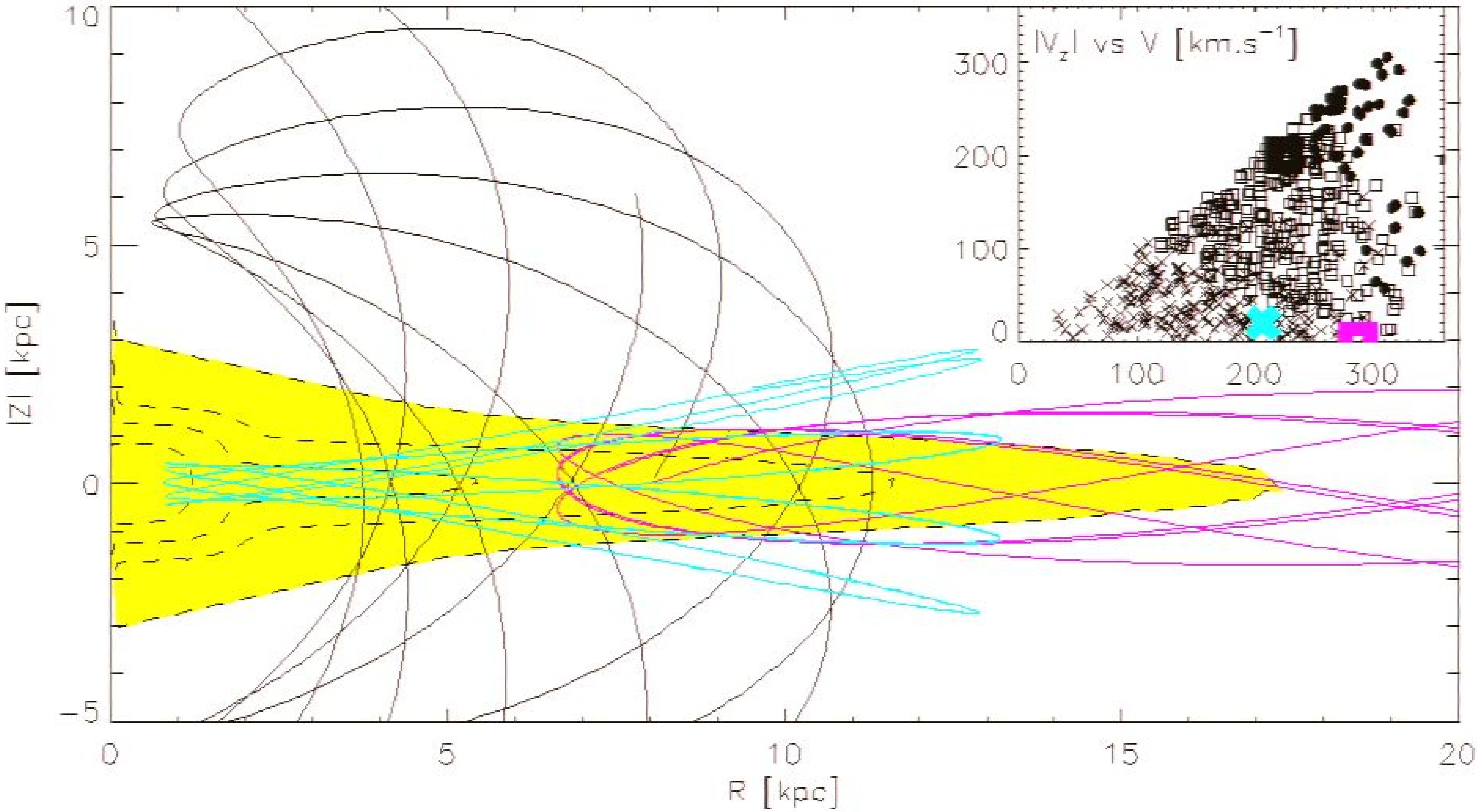




- As predicted by **Green et al. (0309621, 0503387)** for neutralino like CDM; **Diemand, Moore & Stadel (0501589)** showed that ~10^{15} of these Earth mass (~$10^{-6} M_{\odot}$) MHs could survive clustering and make ~0.1% of the Galaxy's dark halo mass.
- Excellent indirect detection candidates high proper motion γ−ray sources.
- **Zhao et al. (0508215)** demonstrated they are sensitive to encounters with stars in the Galactic disk.

Angus & Zhao (0608580), Green & Goodwin (0604142), Goerdt et al. (0608495)

MH survival is crucially dependent on orbital history



Zhao, Hooper, Angus, Taylor & Silk, 0508215

Generating orbital ICs for MHs

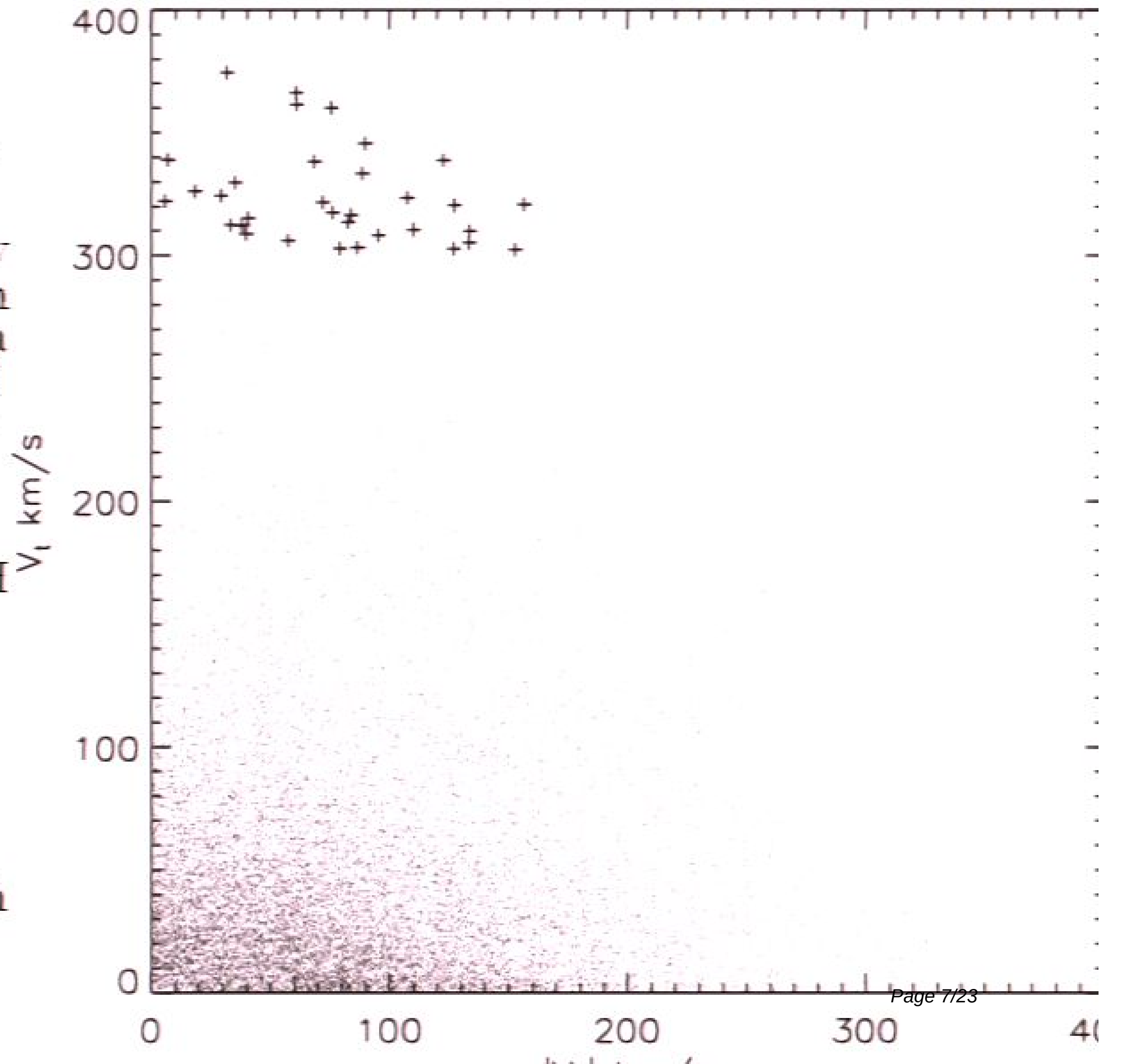
- Took the 10^{15} MHs of $10^{-6}M_\odot$ and distributed them within a typical NFW MW DM halo.
- NFW: r_{200}~250kpc, $M_{200}=10^{12}M_\odot$, c=12.

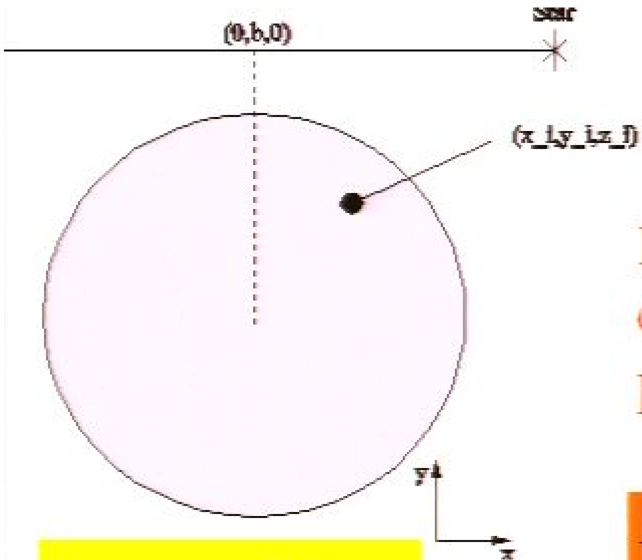
- Within a $V=(10pc)^3$ around Sun → N~19000MHs.

- Took the NFW distribution function $f(x=8kpc, y=0, z=0, V_x, V_y, V_z)$ at the Sun's position and numerically generated the orbital velocities of the 19000MHs.

Orbital distribution of MHs near the Sun

- Fig shows the velocity distribution of the 19000 MHs at the Sun's position.
- Crosses highlight the 33/19000 orbits which have tangential components greater than 300km/s.
- For the 33 orbits, we need to follow the their Galactic orbits for 7Gyr in a realistic MW potential given by a MN disk, Hernquist bulge and DM halo consistent with the RC of the MW.
- Crossing time of a star across a MH is ~ 2x0.01pc/200kms^{-1} ~ 100yrs.
- Dynamical time is ~ 10Myr.
- Orbital period 0.5-3Gyr.
- Must have orbital simulations with time steps a fraction of dynamical time, not crossing time!





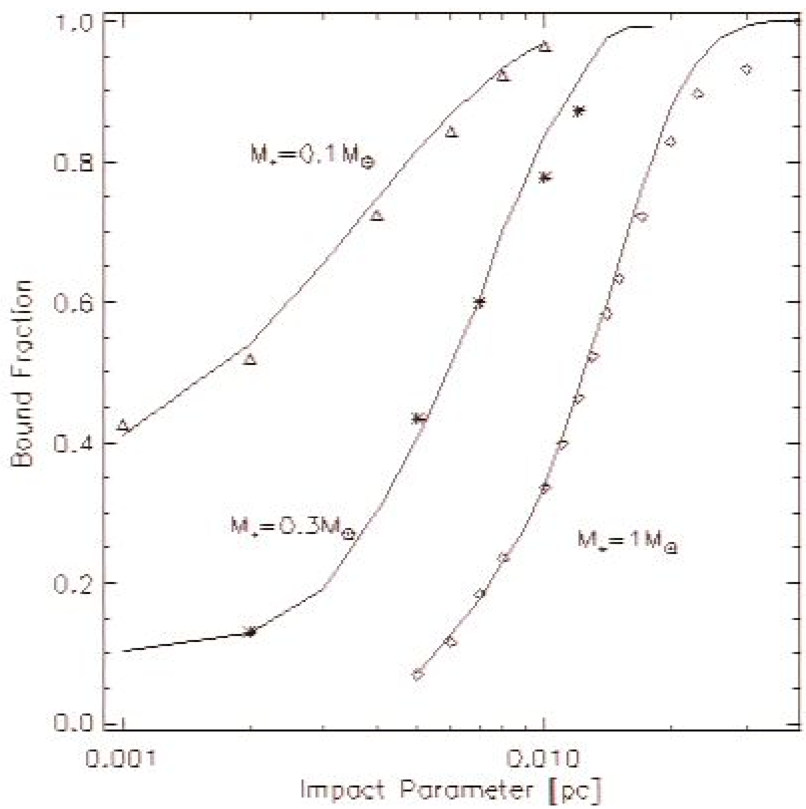
What happens when a MH meets a star?

Ran N-body simulations with 10^5 particles to investigate, b considering the bound fraction of particles after a star physically passes through a MH.

$$\rho = \frac{\rho_s}{r\left(r + r_s\right)^2}$$

$M = 10^{-6} M_{\odot}$
$r_s = 0.005\,pc$
$c = 2$
$N_p = 10^5$

$$v_i < v_{esc} = \sqrt{-2\phi_i(r)}$$



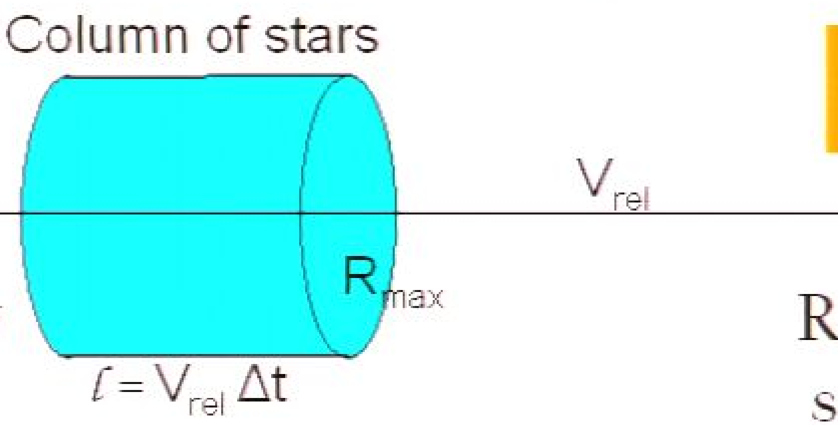
Symbols are for simulations. The lines are from the impulse approximation

$$\Delta v \propto \frac{M_*}{bV_{rel}}$$

Realistic simulations of orbits in a Galactic potential modelling stellar encounters

Use the Besançon model **(Robin et al. 0401052)** of stars in the Galaxy.

$M_{tot} = \rho(R,z)\pi R_{max}^2 V_{rel}\ell$



$\rho(R,z)$ $n(M_*)$

Randomly choose M_* from IMF $n(M_*)$ given for each component of the MW until $\Sigma M_i = M_{tot}$.

Randomly place the stars M_i in azimuth and R.

Analytically impose impulses on the MH particles from stars every time step (0.01Myrs) via the impulse approx from the created star distribution.

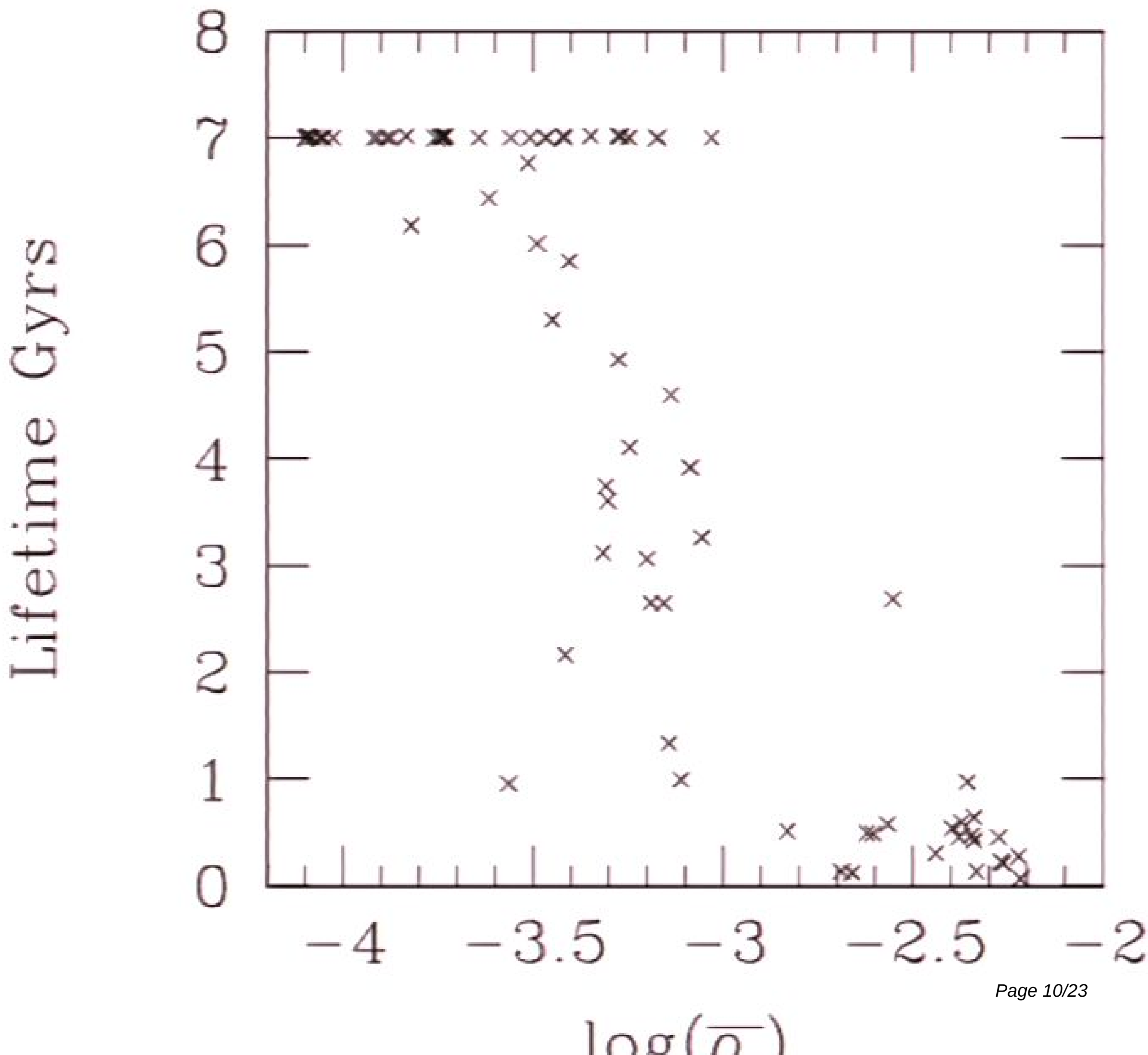
Preliminary Results

- There is a strong relationship between the average stellar density a MH encounters along its orbital path and the chance of MH survival.

- Fig shows the % of bound particles as a function of time for the sample of MHs with large tangential velocities.

- Each dip comes during a disk crossing where the number density of stars spikes and the probability of encountering one rockets.

- Clearly, most MHs are destroyed over a Hubble time, but there is hope that a few of the 19000MHs survive within 10pc of the Sun.



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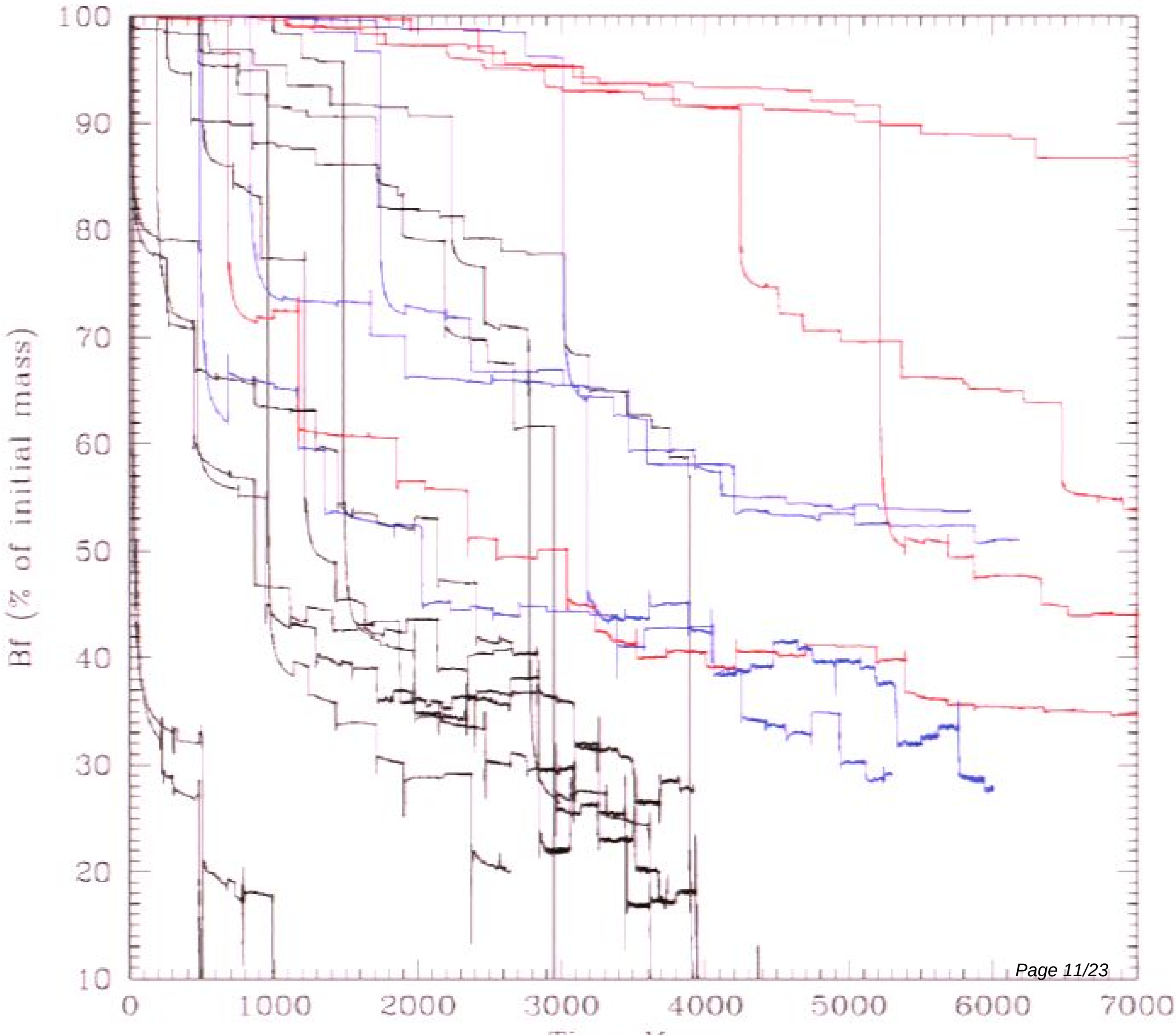
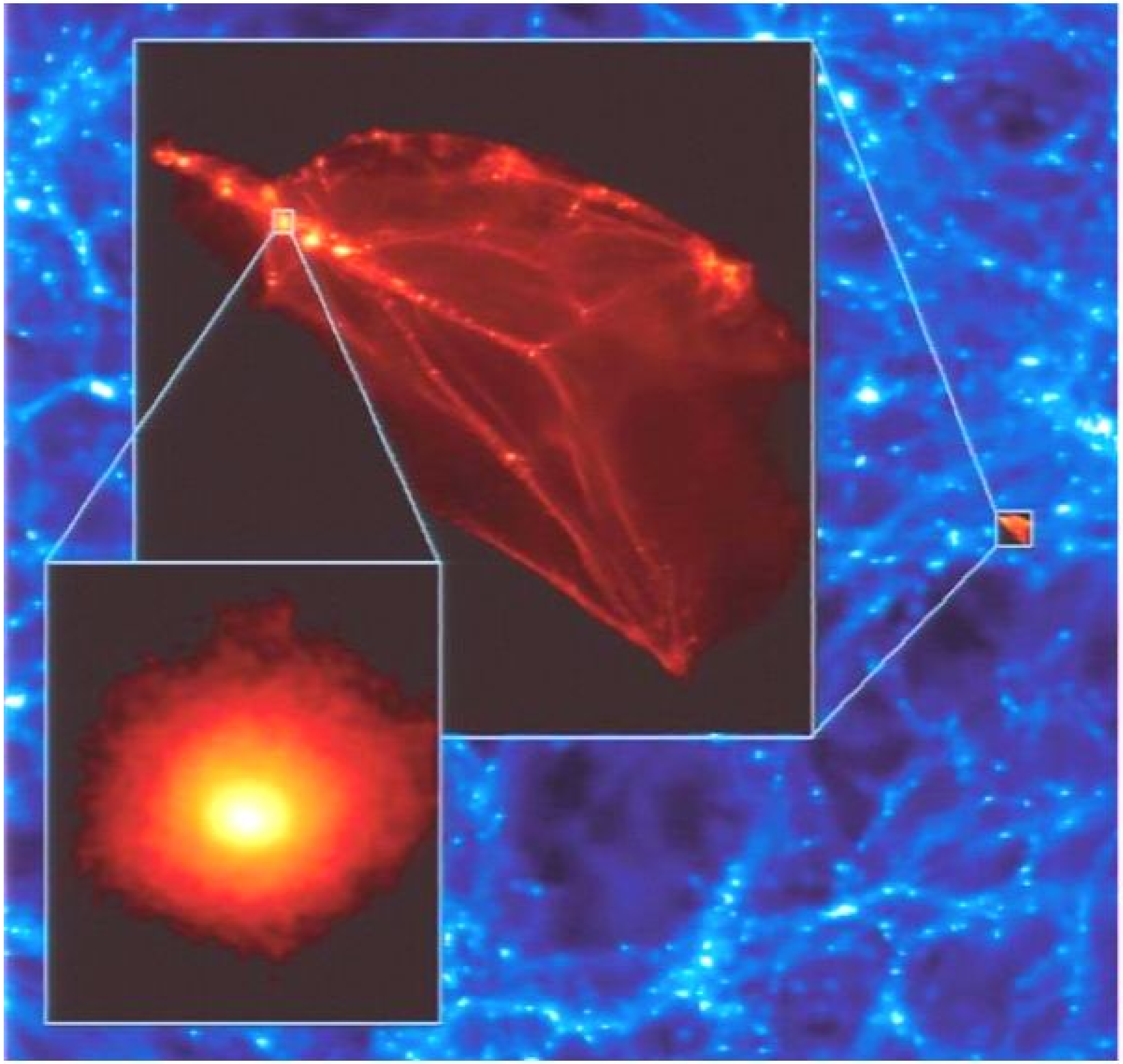
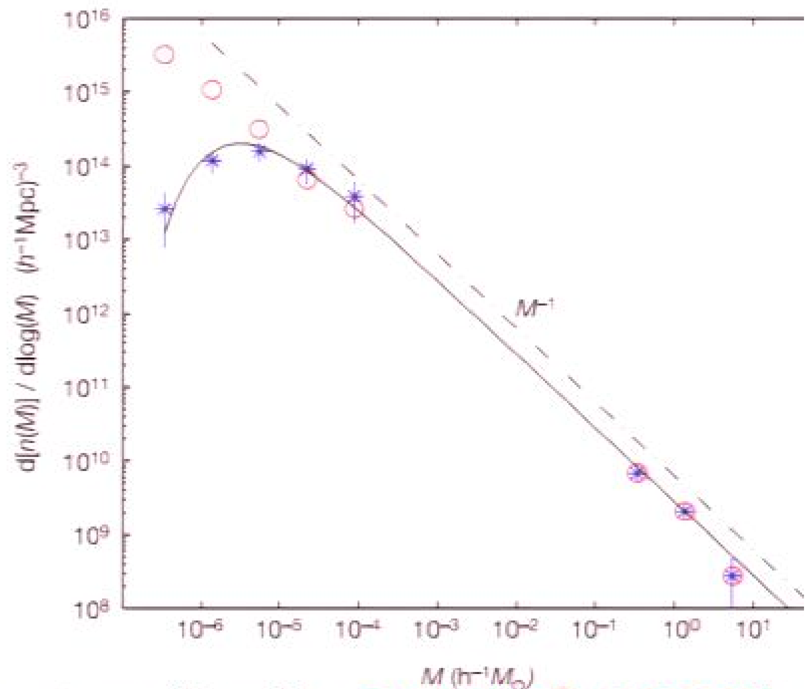


Conclusion - Detection with GLAST

- See talks by Kuhlen, Bertone & Pieri.
- Size of 0.01pc MH at 10pc: $\theta \sim 3'$.
- Takes ~50yrs to move outside overlap.
- If only the central 10% is visible, then $\theta \sim 21''$ and time ~ 5yrs.
- Try higher mass halos $10^{-5}M_{\odot}$, which might easily survive stellar encounters, although abundance drops.

Earth Mass MicroHalos





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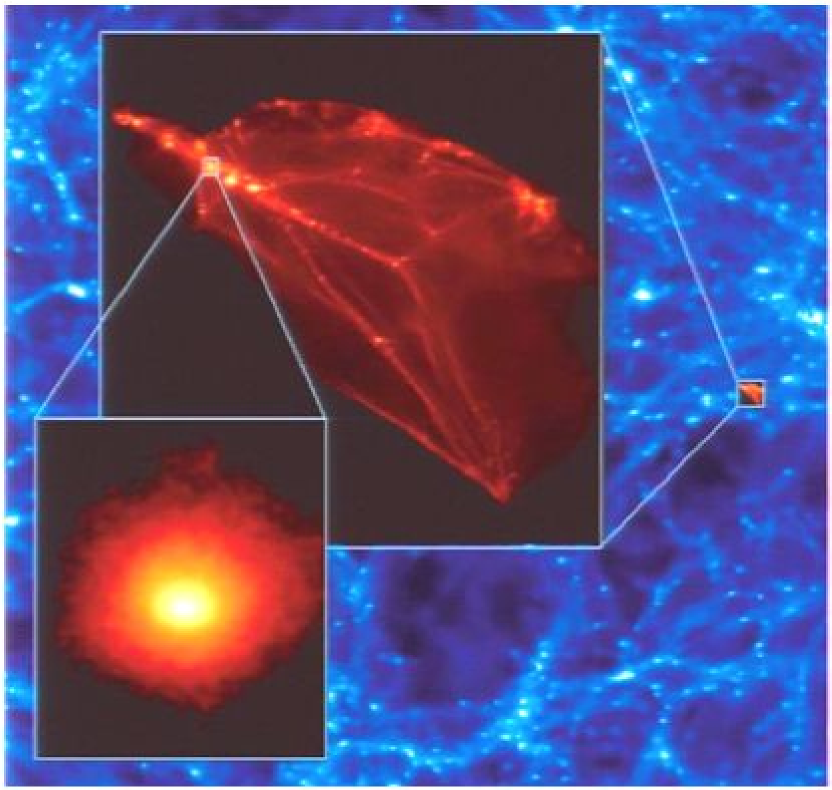

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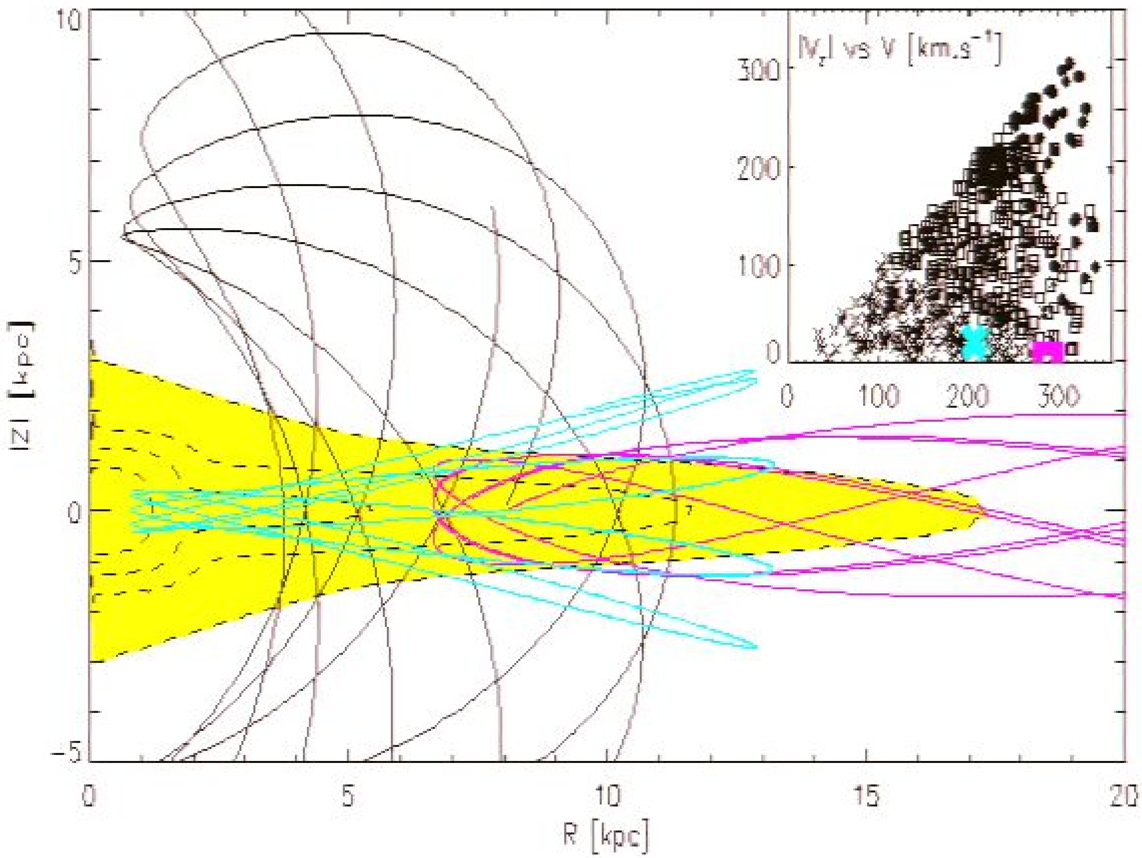

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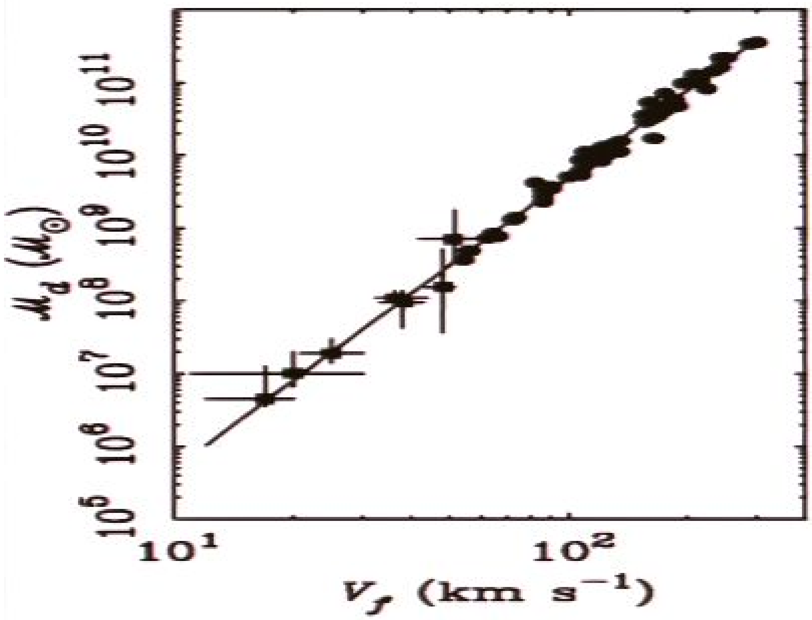

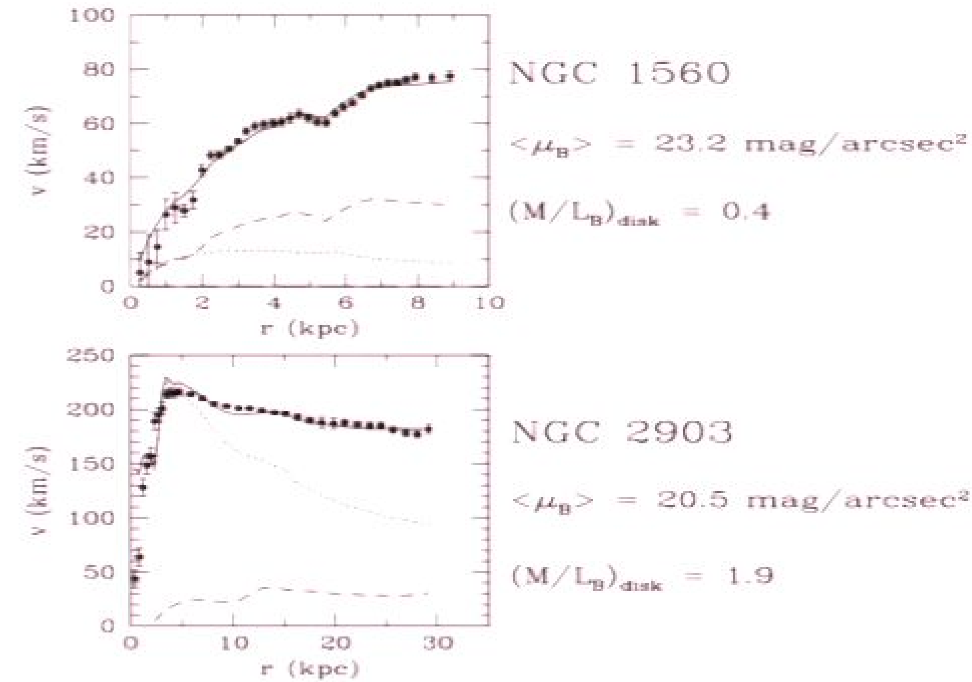

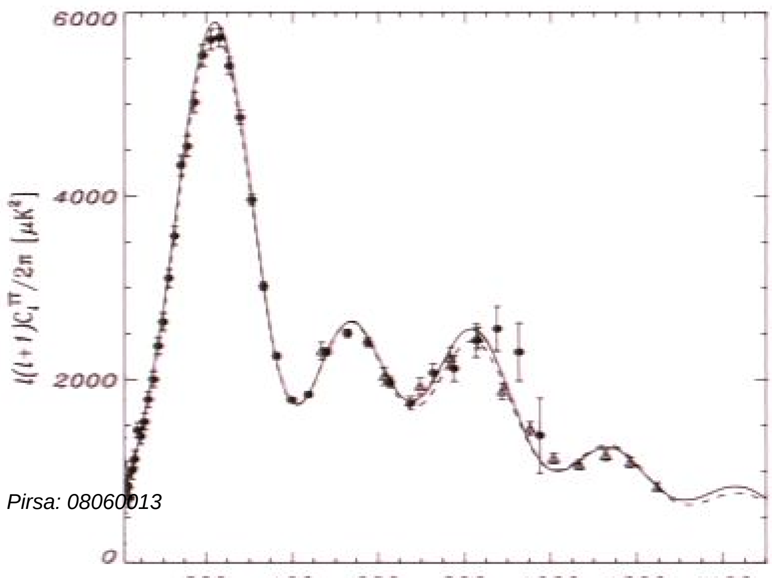

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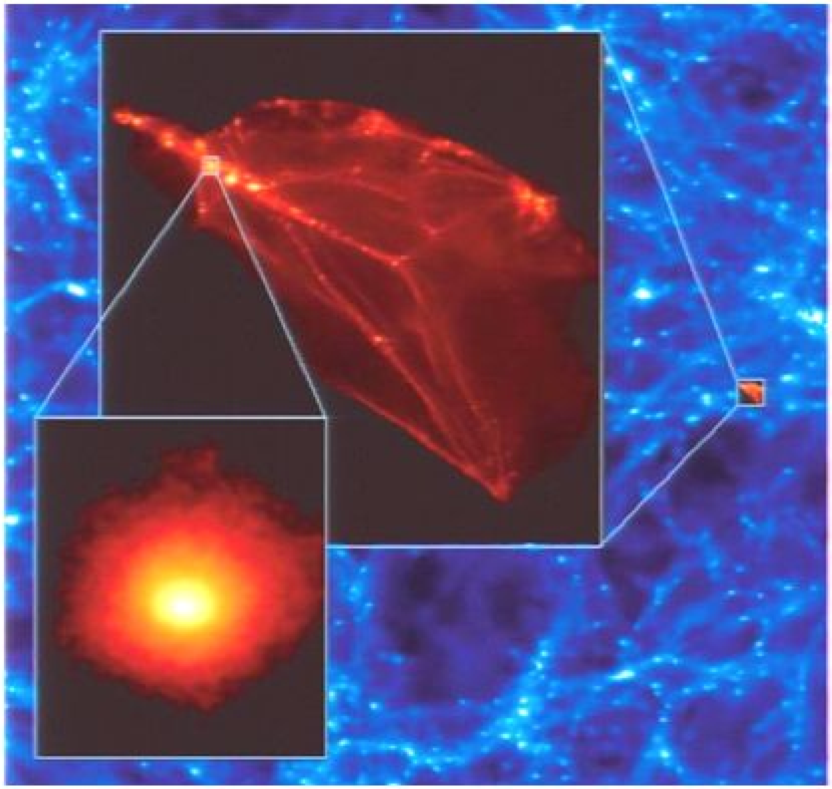

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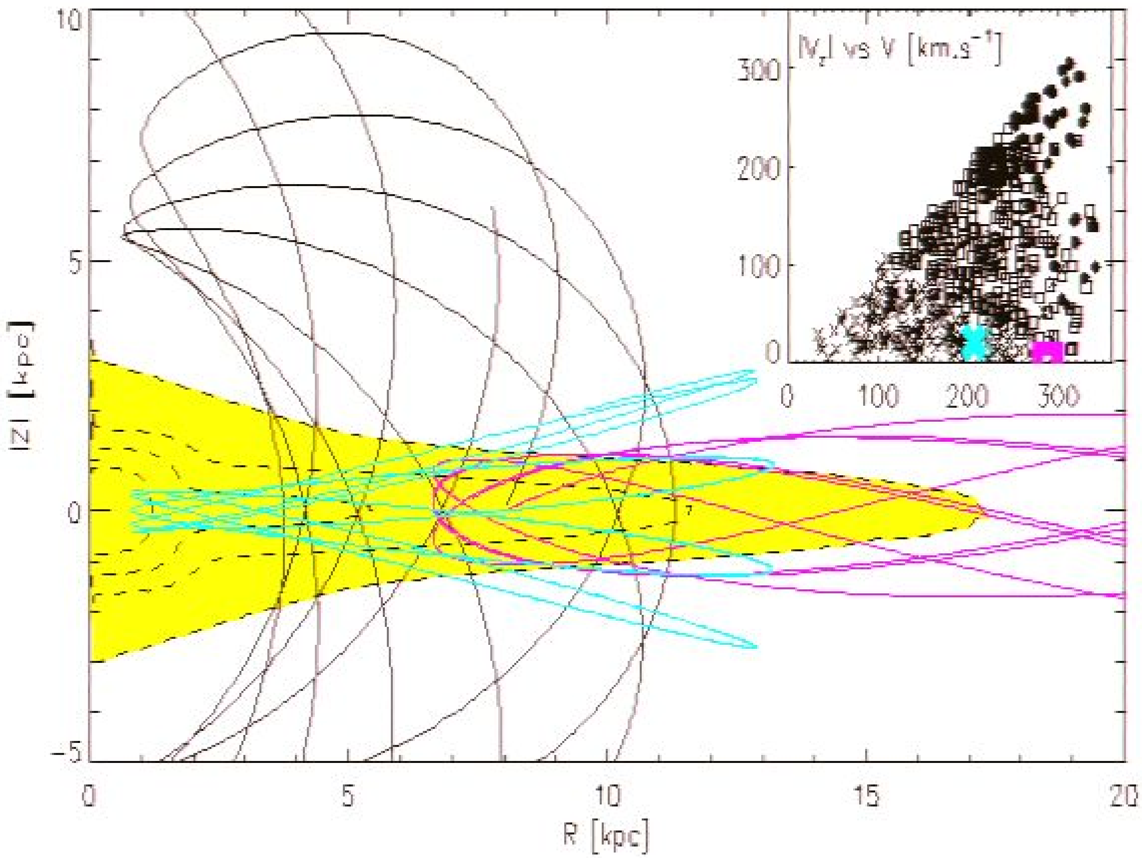

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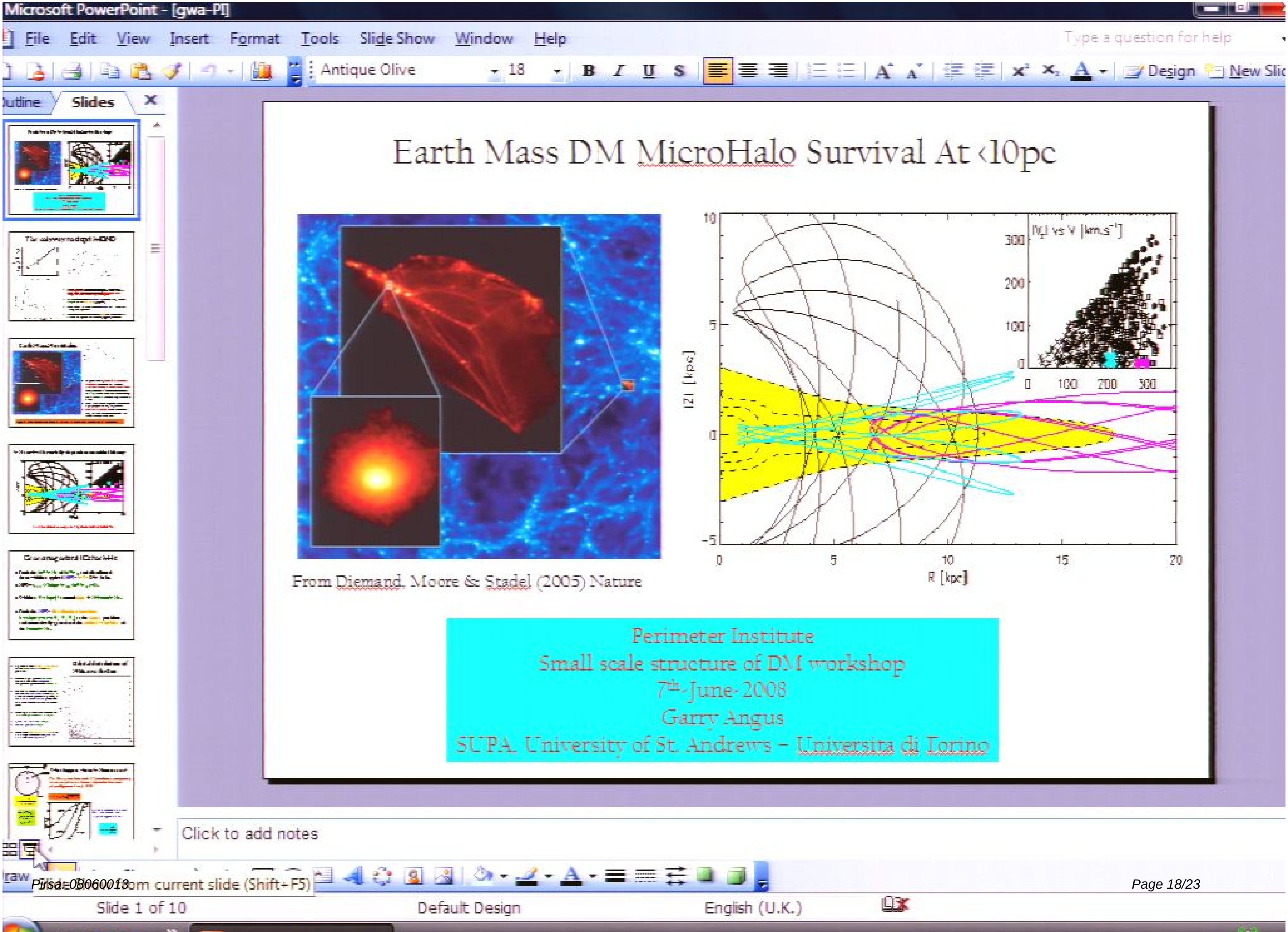
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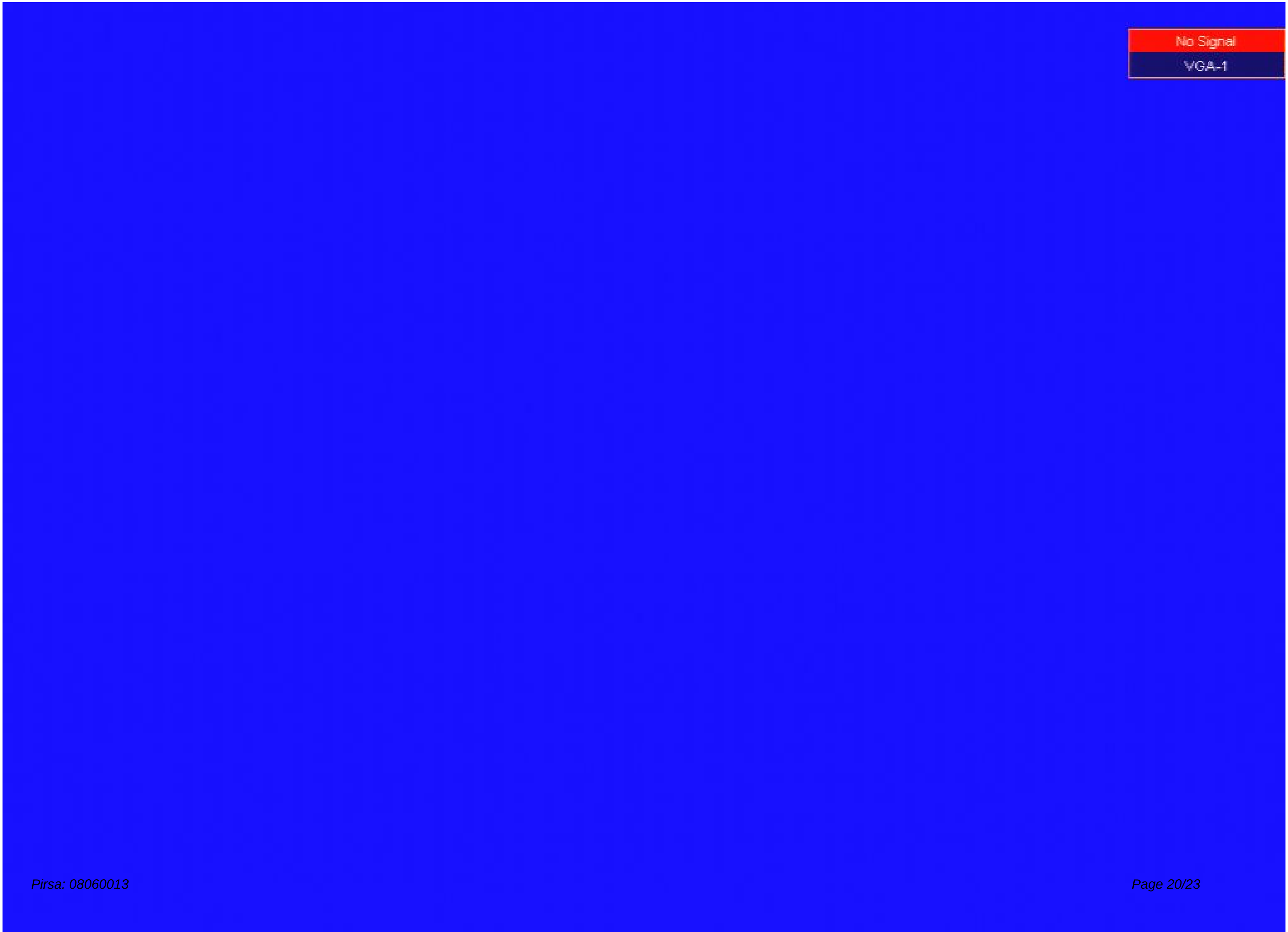
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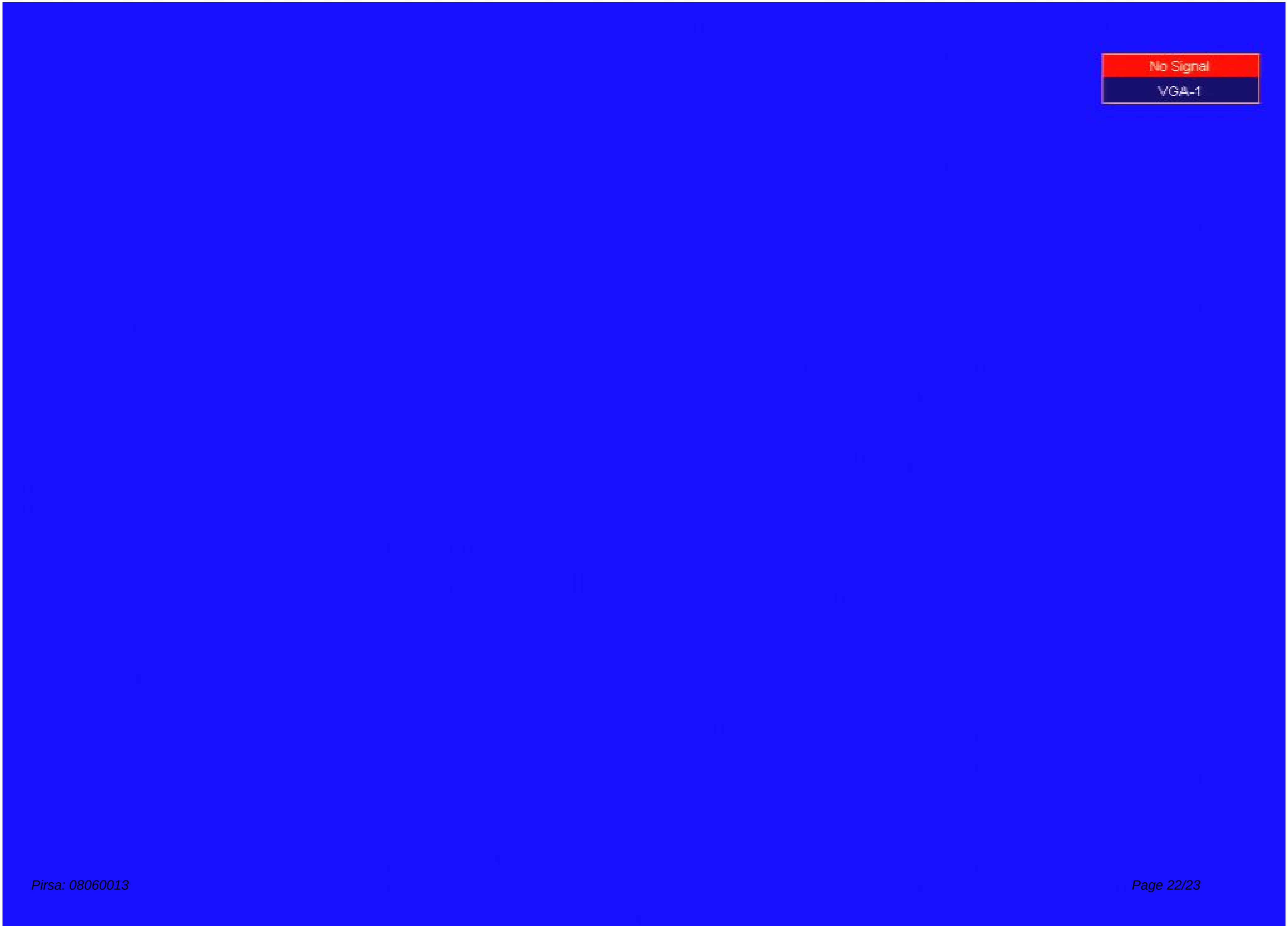
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