WIMP halo around the Sun and prospects for gamma ray detection

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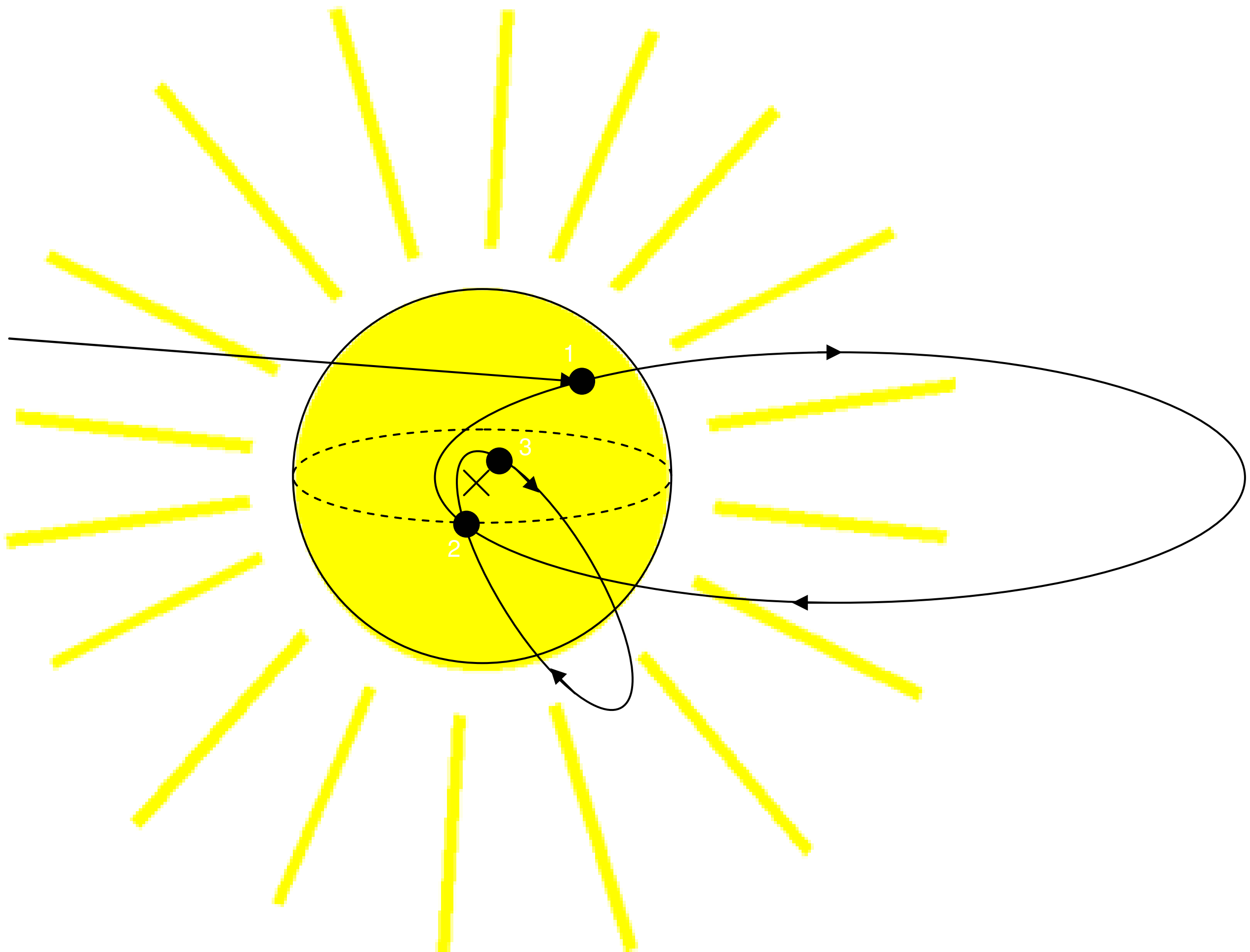
The Milky Way WIMP halo

- The Milky Way has a halo of Dark Matter, here assumed to consist of WIMPs.
- These WIMPs in the Milky Way halo are assumed to have Maxwell-Boltzmann distributed velocities.
- The Sun moves in this WIMP distribution, hence viewing the WIMP distribution from a moving reference system.
- Some of these Milky Way halo WIMPs will scatter in the Sun and be captured in the Sun's gravitational well.

Illustration of the WIMP capture process



Gamma ray production

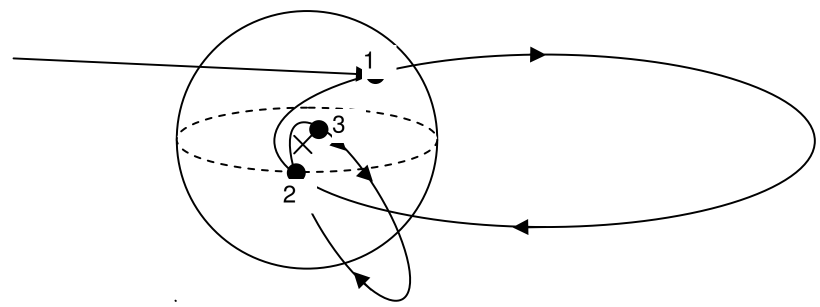
- In the capture process these bound WIMPs produce an overdensity of WIMPs, *i.e.* a WIMP halo, around the Sun.
- WIMP annihilations within the Sun's dark matter halo produce a gamma ray signal.
- This signal has low background since the Sun itself does not produce gamma rays.
- Such gamma rays can be detected by Cherenkov telescopes, such as the Milagro detector.

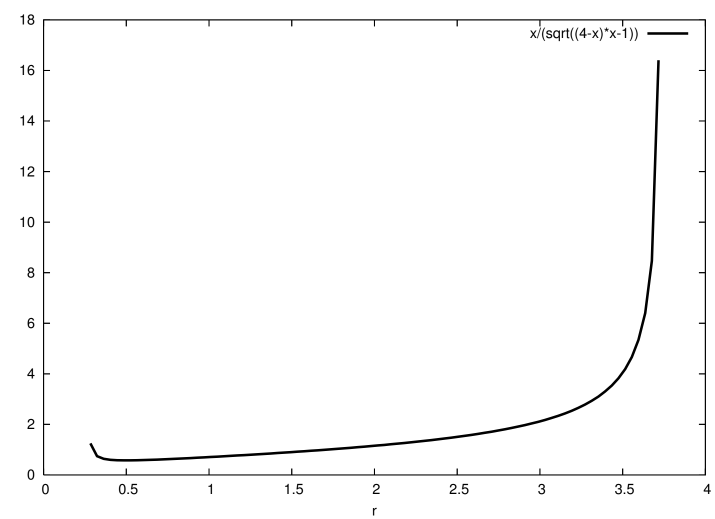
Previous work

- There are two previous estimates of the gamma radiation from the Sun's WIMP halo by Strausz and Hooper.
- Strausz comes to the conclusion that the gamma ray signal should be measurable or constrain parameters of the WIMP model. Phys. Rev. **D59**, 023504 (1999)
- Hooper comes to the conclusion that the gamma ray signal is too weak to be detected. arXiv:hep-ph/0103277 (2001)
- The Milagro collaboration have tried to measure this signal without any success. Phys. Rev. **D70**, 083516 (2004)
- The aim of this project was to make a more accurate calculation of this gamma ray signal.

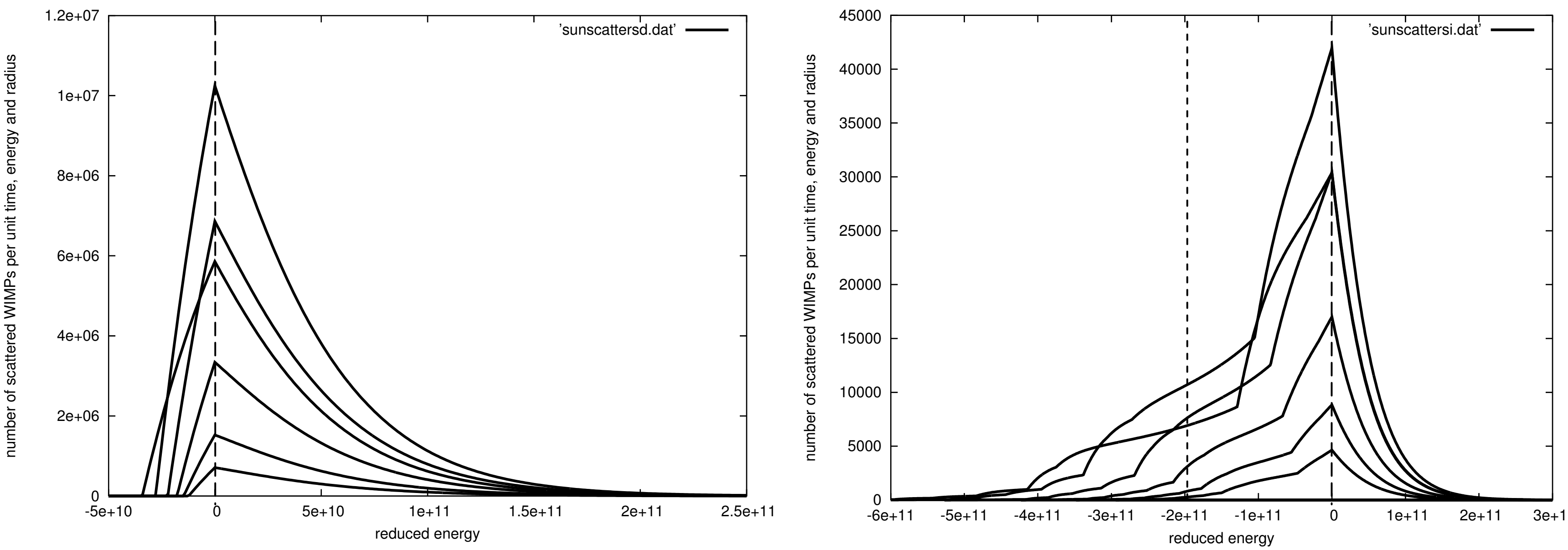
The WIMP capture process

- The WIMP-nucleus cross section is given by a spin independent and a less constrained spin dependent cross section.
- The spin dependent cross section effectively only couples to hydrogen.
- A 100 GeV WIMP which scatters only off hydrogen would have to scatter at least some 40 times before it is buried inside the Sun.





The WIMPs' distribution after their first scatter in the Sun



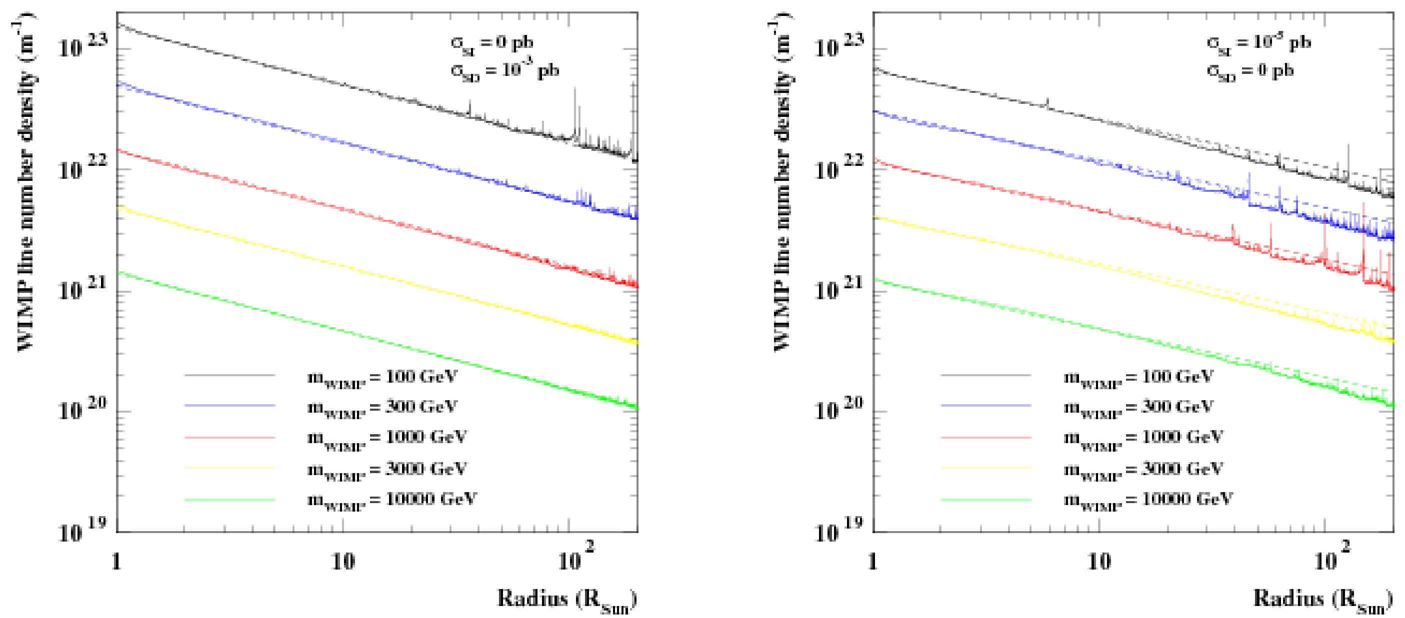
The energy distribution of 100 GeV WIMPs after their first solar scatter. The different lines show the distribution of WIMPs which have scattered at shells with radii 10%, 20%,…, 60% of the solar radius.

Monte Carlo simulation

- The WIMP density in the Sun's WIMP halo is calculated through constructing a Monte Carlo.
- The Monte Carlo picks WIMPs randomly according to the previously shown distribution and then simulates the WIMPs' life until complete solar entrapment.
- MC uses the average orbit life time.
- The WIMP orbit is not entirely elliptical inside the Sun, which decreases scatter probability and increases WIMP density in Sun's halo by approx. 20%.
- The cross section for scatter off heavier nuclei depends on the energy loss, which complicates calculations.

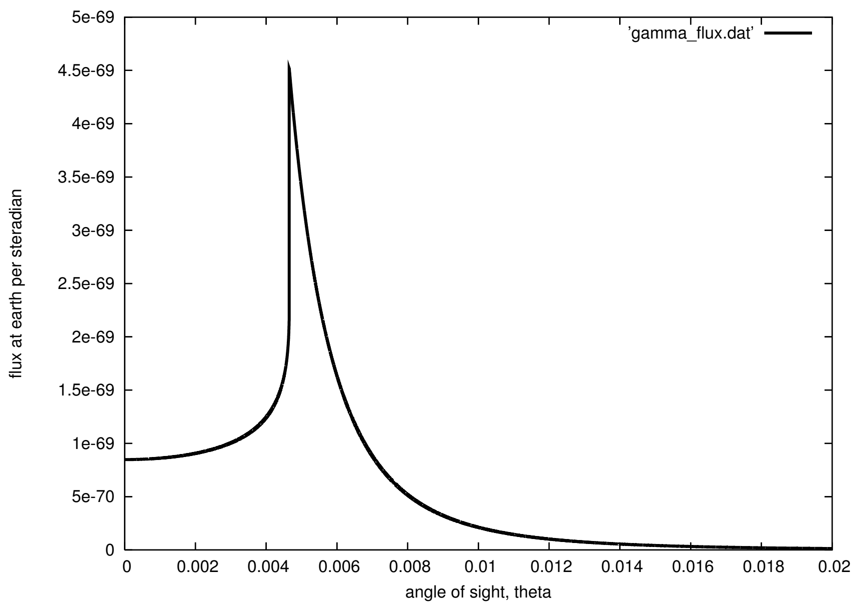
Monte Carlo simulation

- The line number density of WIMPs around the Sun is then calculated for different configurations of the cross sections and WIMP mass.
- The WIMP density is effectively independent of the scale of the cross section.



The gamma ray flux at earth

- Knowing the WIMP density distribution, the gamma ray flux profile from the WIMP halo can be calculated.



Result

- The total gamma ray flux at Earth from the Sun's WIMP halo can then easily be estimated for simple WIMP annihilation models.
- The flux at earth per square meter per second for different WIMP mass and cross sections: $\sigma v = 10^{-32}\,\mathrm{m^3 s^{-1}}$ $\quad N_\gamma = 20$

	$M = 10^2 m_p$	$M = 10^3 m_p$	$M = 10^4 m_p$
$\sigma_{sd} = 10^{-3}$ pb, $\sigma_{sd} = 0$	$5 \cdot 10^{-19}$	$7 \cdot 10^{-21}$	$3 \cdot 10^{-23}$
$\sigma_{sd} = 0,\ \sigma_{si} = 10^{-5}$ pb	$1 \cdot 10^{-19}$	$4 \cdot 10^{-21}$	$6 \cdot 10^{-23}$

The End