Evaluating the astrophysical uncertainties on dark matter direct detection

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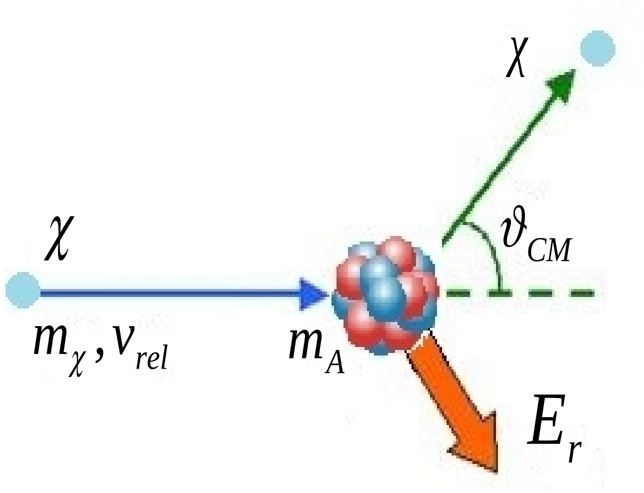
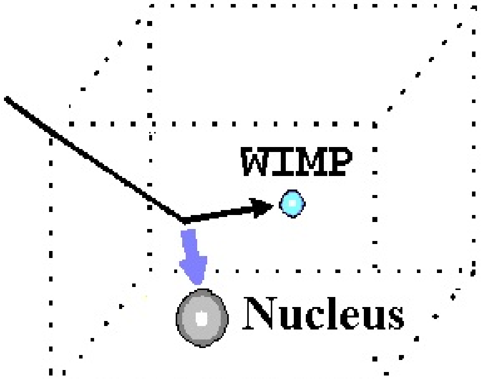
Direct Detection aims at detecting WIMPs via their scattering over nucleai



• **WIMPs** should be able to undergo **scattering** (elastic or inelastic) over **nucleai**.

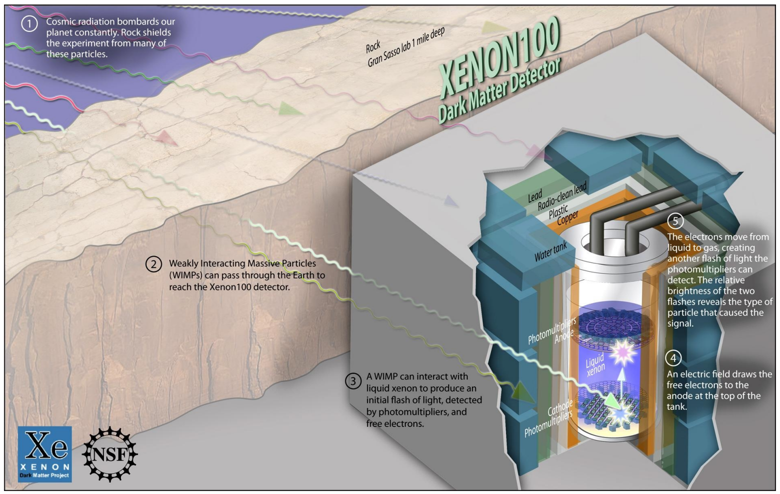
• From **kinematics** only you can predict the **recoil energy** of the nucleus:

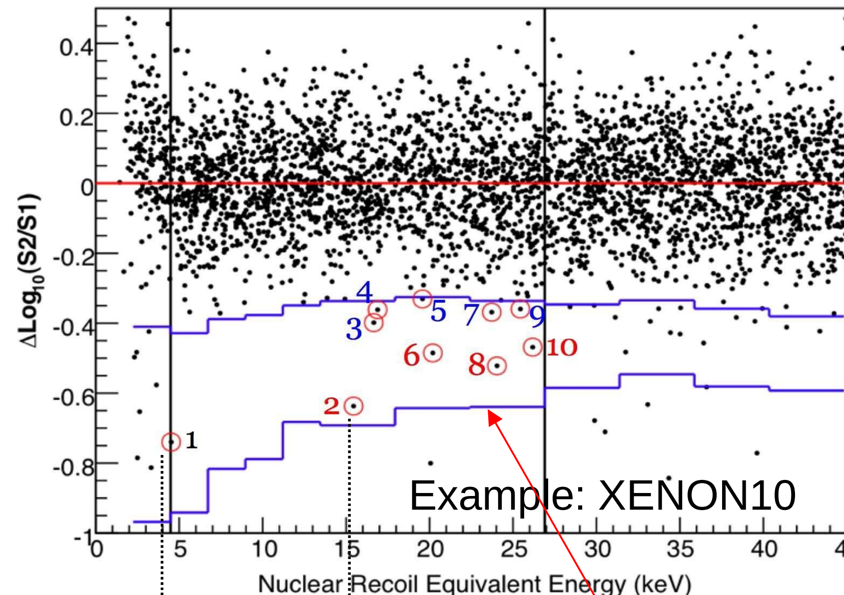
$$E_r = \frac{m_{red}^2 v_{rel}^2 (1 - \cos\vartheta_{CM})}{m_A}$$

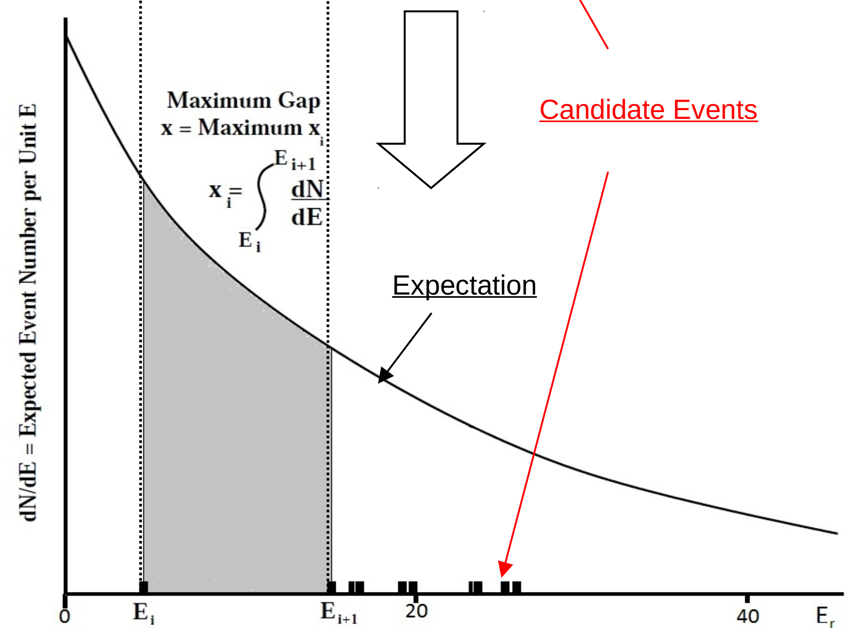


• You can build **detectors** able to observe such events, and to **measure the recoil energy** of the hit nucleus.

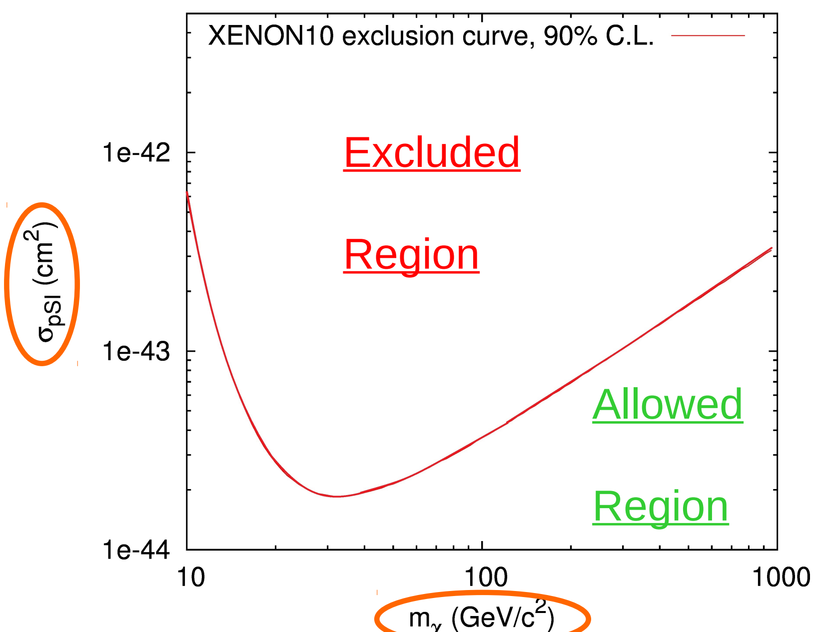
Experiments which detect few (or no) events can constrain the parameter space







(Maximum gap method, Yellin)



The velocity distribution of dark matter plays a fundamental role in determinig the shape of the exclusion curve

- For instance, the expected number of detected events (in the simplest case) looks like:

$$N = \Delta M \Delta t \int_{E_T}^{\infty} dE_r \frac{A^2 \sigma_{p,SI} F^2(E_r)}{2 m_{red,p}^2 m_\chi} \rho_0 \int_{|\vec{v}'| > v'_{min}(E_r)} d^3 \vec{v}' \frac{1}{v'} f(\vec{v}')$$

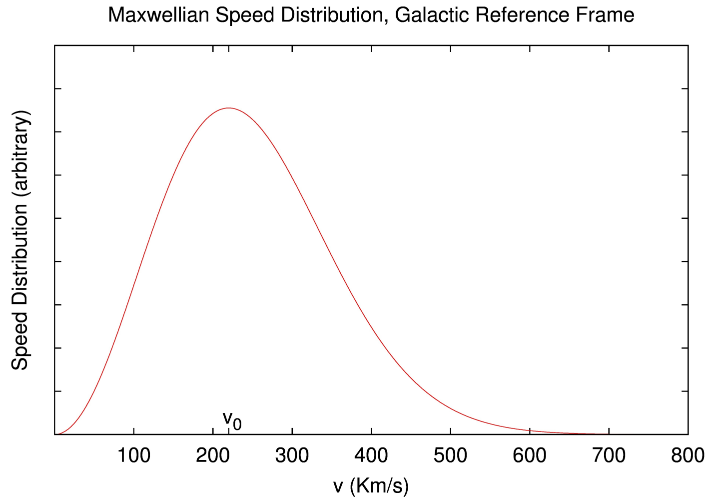
Intaraction with nucleus/detector

AstroPhysics

- Standard Halo Model

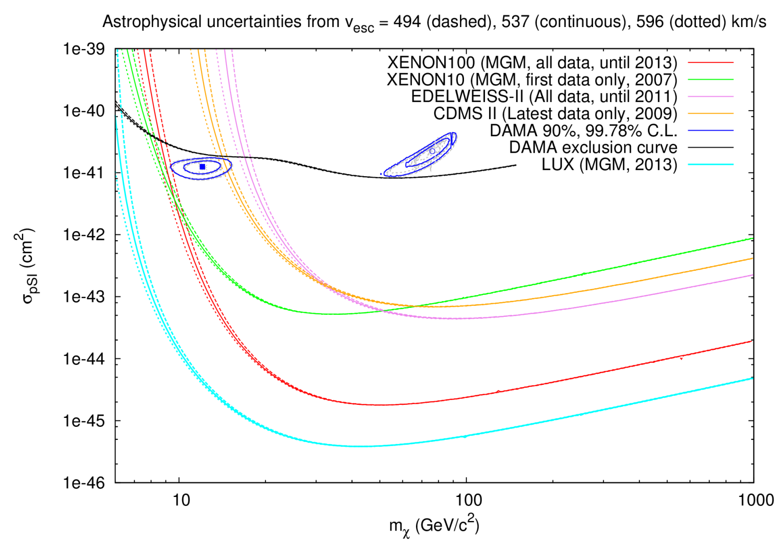
Maxwel-Boltzmann speed distribution

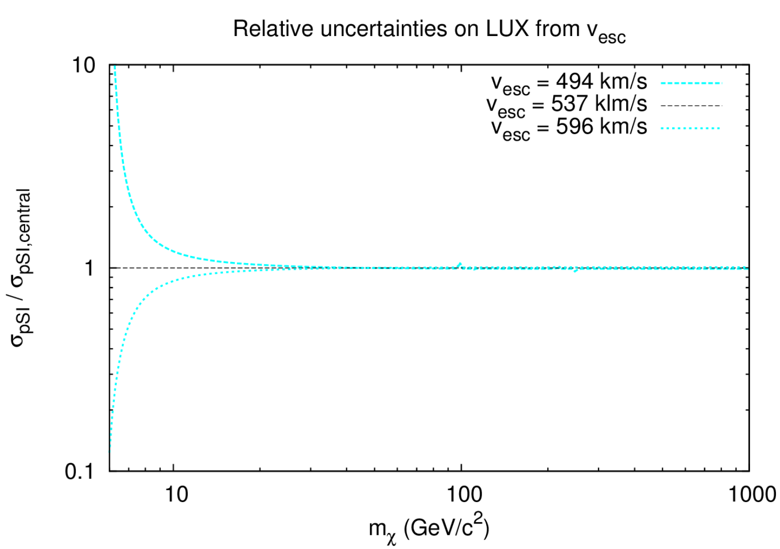
$$f(v) = \frac{4v^2}{\pi^{1/2} v_0^3} e^{-\left(\frac{v^2}{v_0^2}\right)}$$



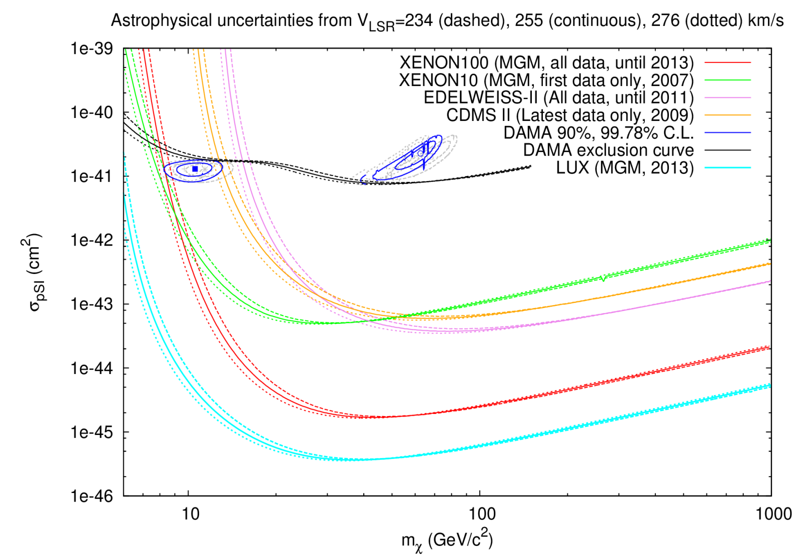
We have studied the effect of the uncertainties on the different astrophysical parameters of the Standard Halo Model

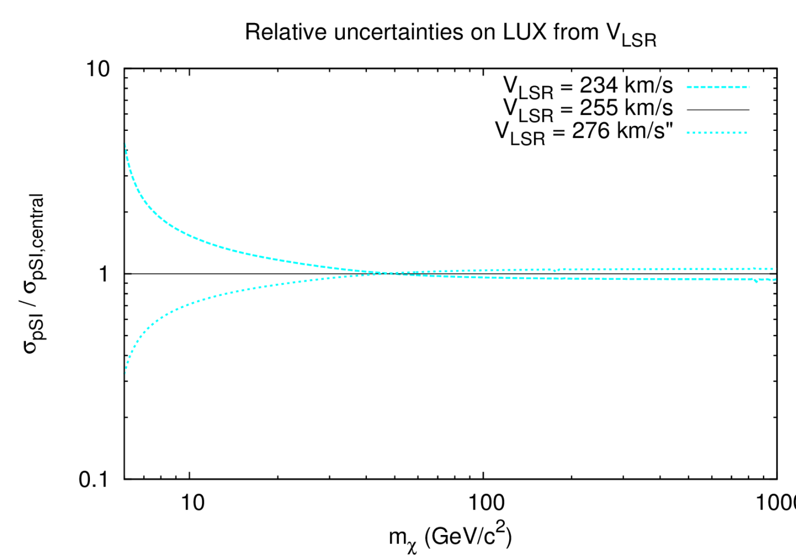
The effect of v_{esc}





The effect of v_0



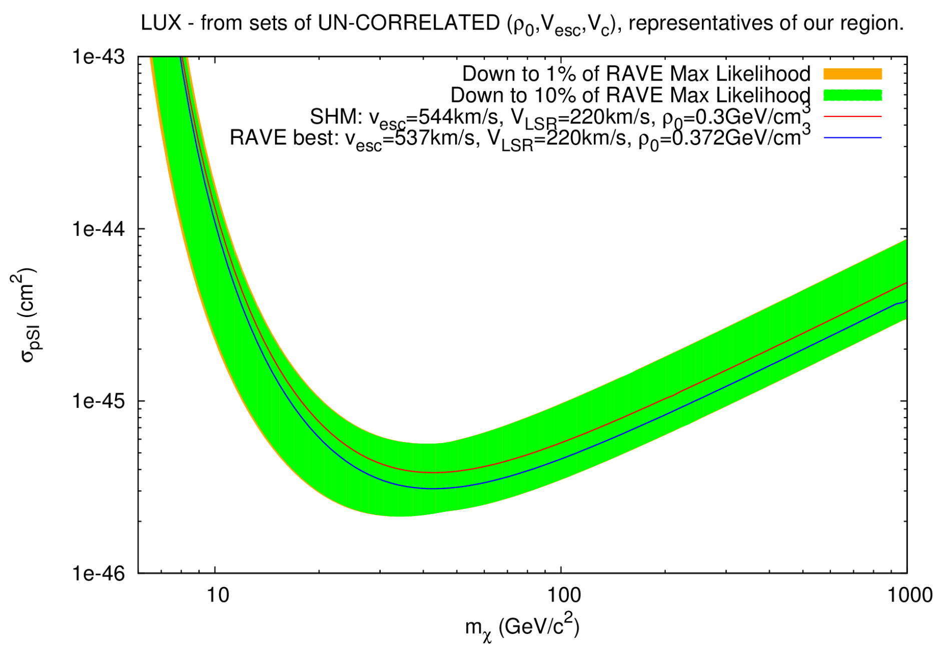


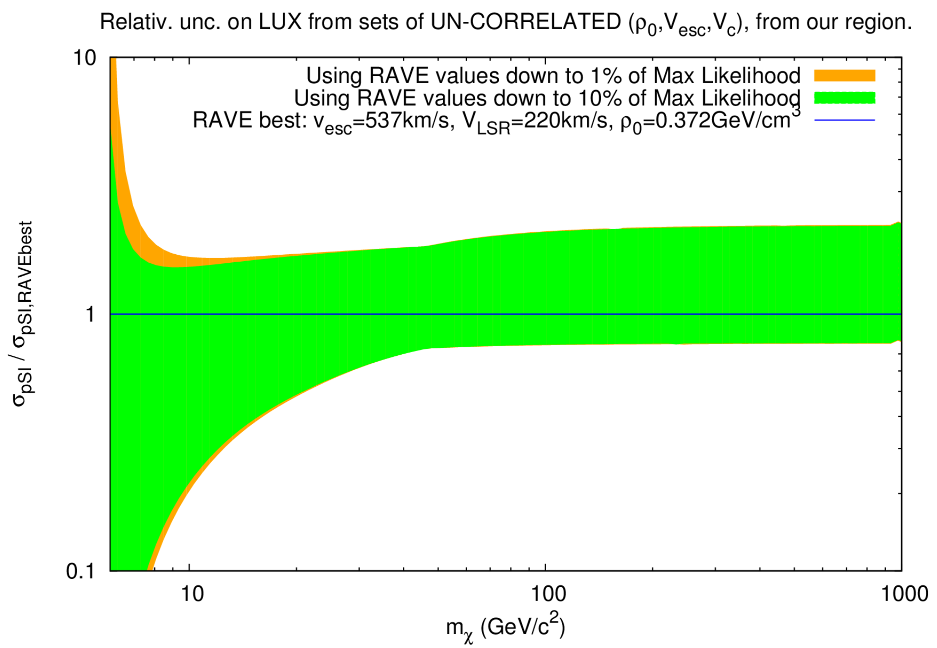
We have evaluated the astrophysical uncertainties on direct detection, using constraints from different observations

$$0.2\,GeV/cm^3 < \rho_0 < 0.4\,GeV/cm^3$$ (Bovy et al., 2012)

$$29.9 \pm 1.7 < v_{c0}/R_0 < 31.6 \pm 1.7\,km\,s^{-1}\,kpc^{-1}$$ (Mc Millan & Binney, 2009)

$$v_{esc}(\vec{r}_0) = 533^{+54}_{-41}\,km/s$$ (Piffl et al, the RAVE survey, 2013)





The uncertainties are reduced when we assume a mass model for the Milky Way, which correlates the astrophysical quantities

Density of matter

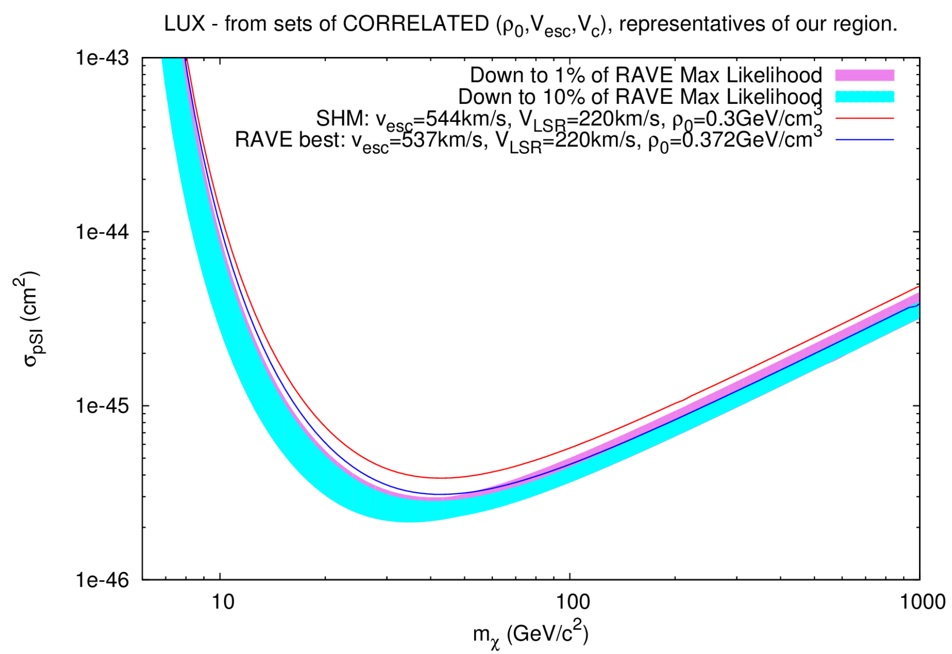
$$\rho(\vec{r}) = \rho_{DM}(\vec{r}) + \rho_{baryons}(\vec{r})$$

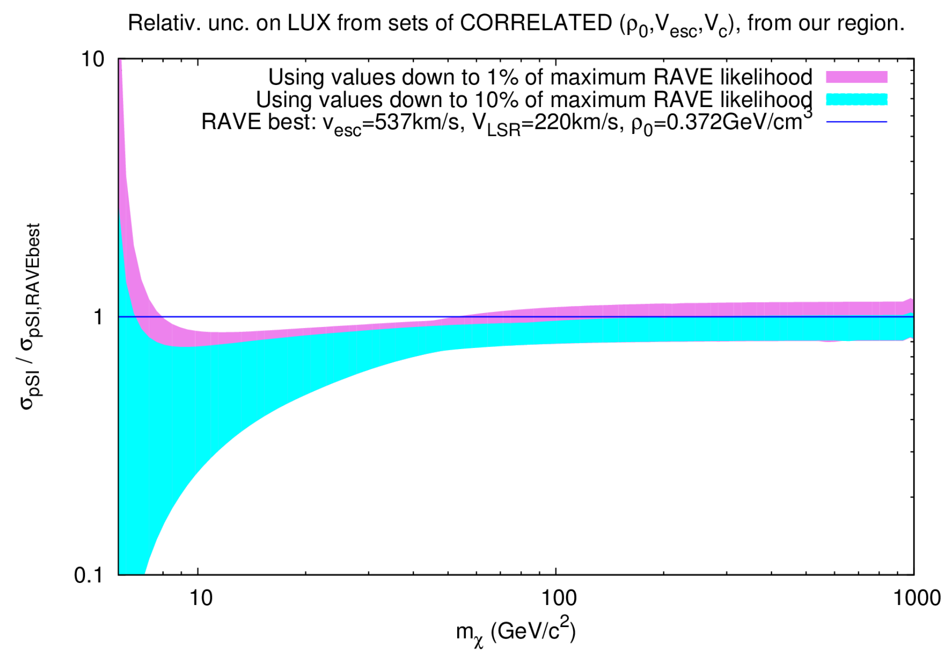
Gravitational Potential

$$\Phi(\vec{r}) = \Phi_{DM}(\vec{r}) + \Phi_{baryons}(\vec{r})$$

The potential in RAVE paper

$$\Phi_{MW}(R, z) = \Phi_{NFW}^{DM}(r) + \Phi_{MiNa}^{disk}(R) + \Phi_{Hernqvist}^{bulge}(r)$$





We are now studying the impact of assuming a different speed distribution, namely the one consistent with the assumed potential

$\rho_{DM}^{NFW}(\vec{r})$

inside

$\Phi_{MW}(\vec{r})$

Eddington equation