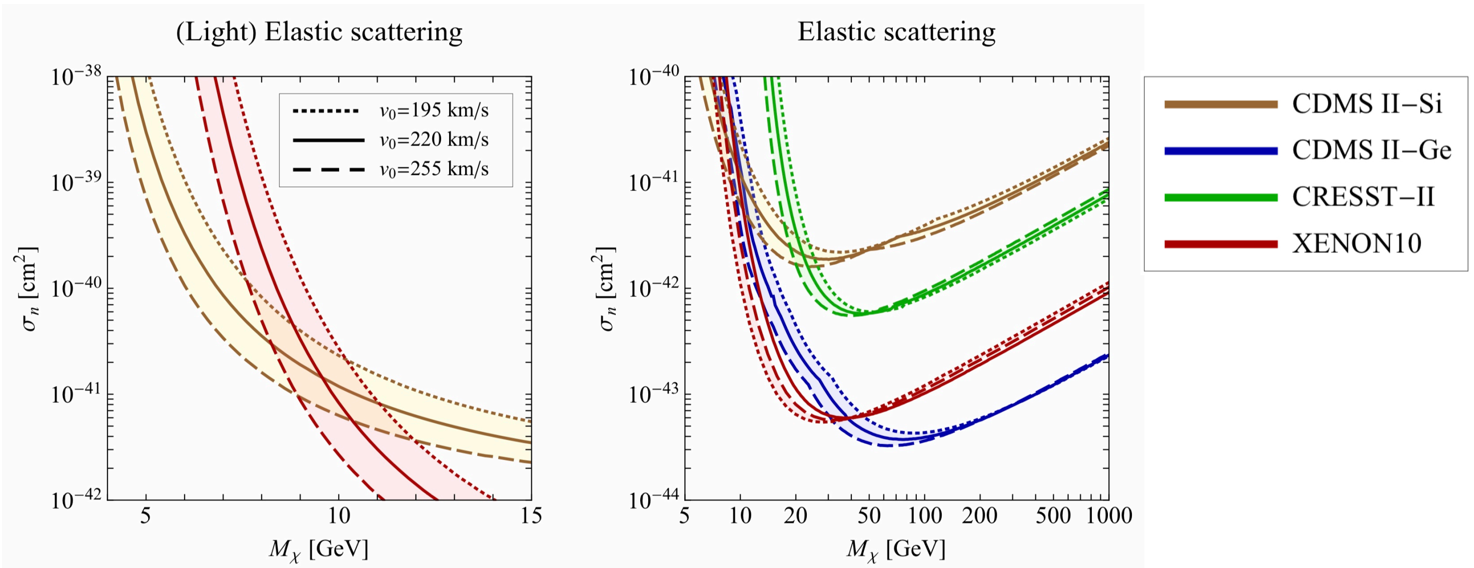
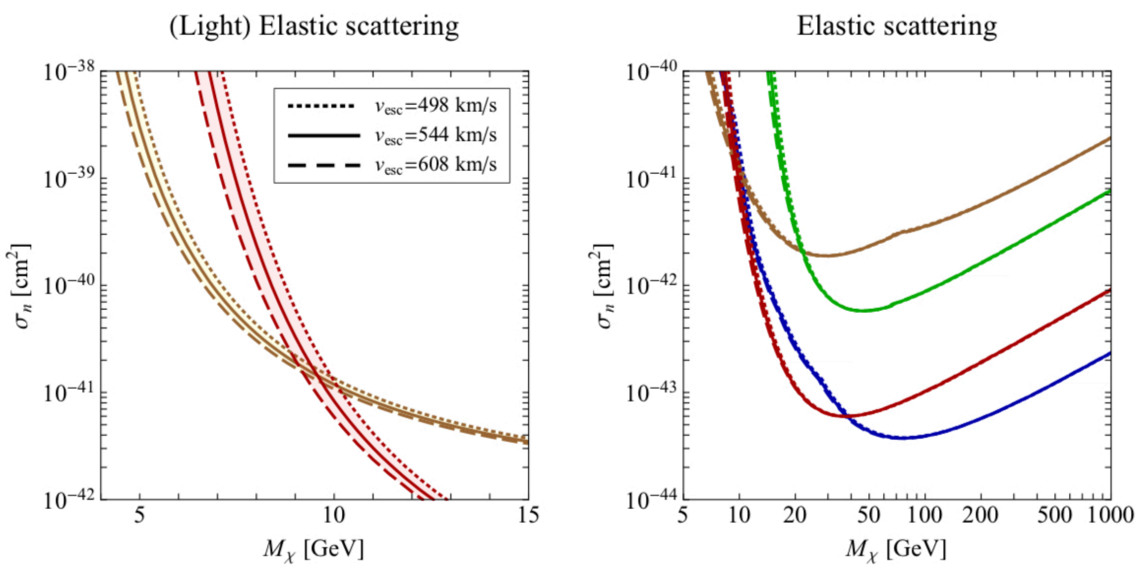
Sun's circular velocity

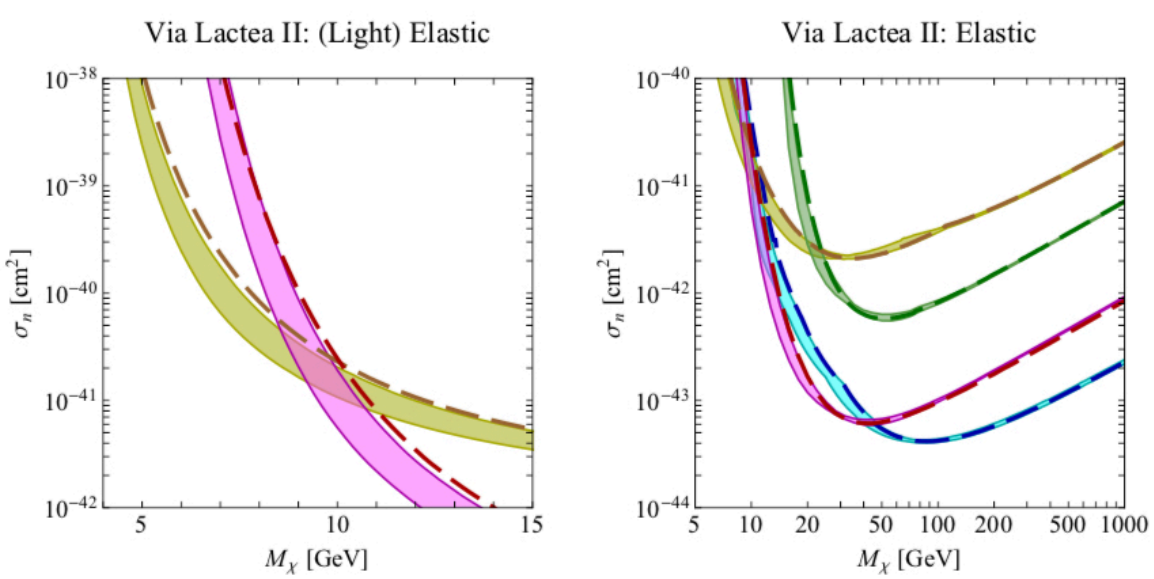
McCabe, arxiv:1005.0579



Escape velocity



Form of DM distribution



If we are to understand the nature of dark matter, it is vital that we have a full understanding of the astrophysical uncertainties affecting dark matter direct detection experiments. For spin-independent elastic and momentum dependent scattering with $M_\chi \gtrsim 50$ GeV, we have shown that the exclusion limits are robust against variations in the galactic escape velocity v_{esc} and the Sun's circular speed about the centre of the galaxy v_0 (right upper and left lower panels of Figs. 2 and 4) and under realistic variations in the form of the velocity distribution (middle and right panels of Fig. 6), with uncertainty $\sim 10\%$. The major uncertainty in this mass range arises from the error in the local dark matter density (a factor of 2).

In comparison, for lighter masses, we found that uncertainties in v_0 and v_{esc} and the velocity distributions from the numerical simulations can shift the exclusion curves horizontally by ~ 1 GeV at masses $M_\chi \sim 10$ GeV (upper left panels of Figs. 2, 4 and 6). Similarly for in-

elastically scattering dark matter, we found the vertical shift in the exclusion curves when varying v_0 or v_{esc} is large ($\sim 100\%$), with lighter target experiments such as CDMS II being particularly affected. Variations in the velocity distribution can also lead to significant changes, as we explicitly demonstrated in Fig. 7 for the CRESST-II experiment.

Inelastic and light dark matter are particularly sensitive to astrophysical uncertainties because the minimum speed needed to scatter is just below the galactic escape speed, so experiments only sample the tail of the velocity distribution. Even though the recoil spectrum for momentum dependent dark matter is different from elastically scattering dark matter (Fig. 1) they both respond to astrophysical uncertainties in a similar fashion for germanium, xenon and tungsten targets, because v_{min} remains far from v_{esc}. Therefore models which only sample the tail of the velocity distribution should carefully examine the effect of astrophysical uncertainties on their limits.

Typically:

For the WIMP energy spectrum we assume a standard isothermal WIMP halo with $v_0 = 220$ km/s, $\rho_{\rm DM} = 0.3$ GeV/cm^3, $v_{\rm esc} = 544$ km/s, and the Helm form factor for the nuclear cross section [30].

Uncertainties in the assumed dark matter halo are beyond the scope of this Letter but are reviewed in, e.g., [38].

In view of the white paper:

Should each experiment start accounting for uncertainties associated to astrophysical mismodeling? If yes we need a common recipe...

Should we continue putting under the rug these ‘common’ uncertainties but update their values?

What about the form factors?