

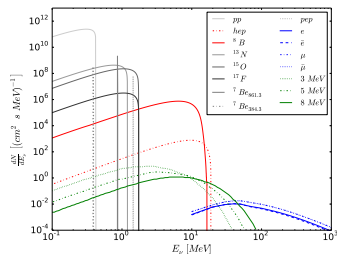
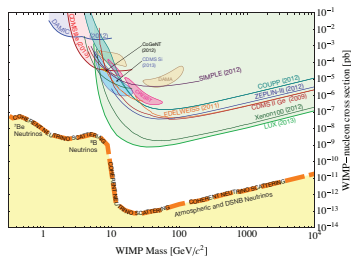
Directional Dark Matter Detection Beyond the Neutrino Bound

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based on 1407.****

June 9th 2014
DMUK Meeting
Durham

WIMP Discovery Limit



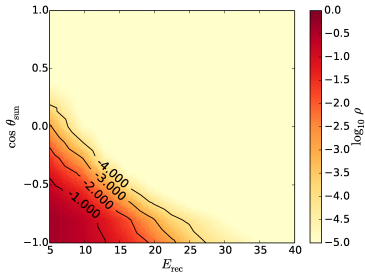
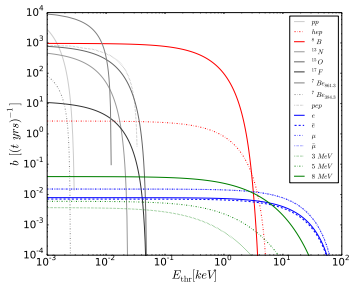
discovery limit if:

- ▶ energy spectra of neutrino and dark matter match (e.g. 6 GeV WIMP, 8B solar neutrino)
- ▶ uncertainty in neutrino fluxes

Billard et al. (arXiv: 1307.5458)

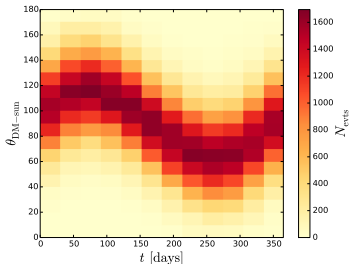
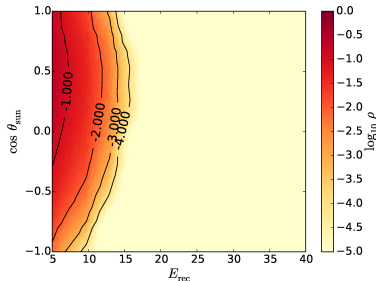
What if **directional information** is included?

Neutrino Event Distribution



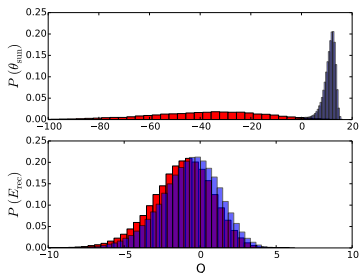
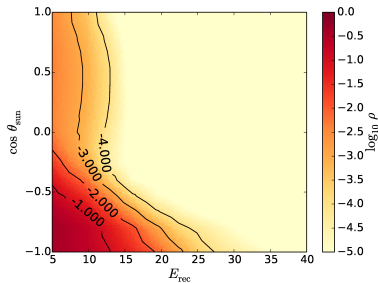
- ▶ fit events in recoil energy and event angle (also time information, but small compared to directionality)
- ▶ event angle θ_{sun} defined as projection of recoiling nucleus track onto the earth-sun direction
- ▶ solar ν 's scatter away from sun, non-solar ν 's form isotropic background

Dark Matter Event Distribution



- ▶ DM comes approximately from Cygnus A
- ▶ $E_{\text{rec}} = E_{\text{DM}} r (1 - \cos \theta) / 2$, $r = 4m_{\text{DM}} m_T / (m_{\text{DM}} + m_T)^2$
- ▶ relative angle between sun and Cygnus A varies over the year
- ▶ heavy DM give events with less directional character

Hypotheses Test

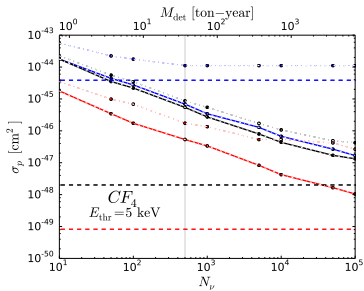
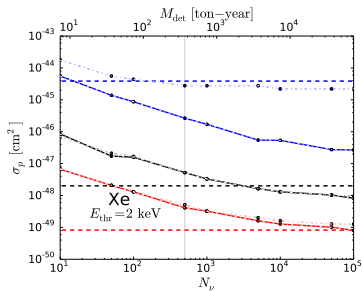


- ▶ simulate both situations for a given detector set-up:
 - events are background only (blue)
 - events contain a signal (red)

$$\tilde{Q} = \frac{p_{b+s}(n)}{p_b(n)} \frac{\prod_{j=1}^n \frac{sS_t(t_j) + bB_t(t_j)}{s+b}}{\prod_{j=1}^n B_t(t_j)} \frac{sS_{\theta,E}^{(t)}(\theta_j, E_j) + bB_{\theta,E}(\theta_j, E_j)}{s+b}$$

- ▶ overlap of both distributions quantifies significance

Projected Sensitivities



- ▶ **no solar neutrino floor with directionality**
- ▶ need approx. 5 ton-year CF₄, 10 ton-year Xenon detector
- ▶ directionality most helpful for light DM
- ▶ to reach non-solar neutrino floor, extremely large exposures are necessary

Conclusions

- ▶ investigated neutrino backgrounds in DM searches
- ▶ used directional information to separate signal from background
- ▶ **directional direct dark matter detectors have no solar neutrino floor**
- ▶ reaching non-solar bound requires extremely large exposures

