Galactic archaeology with direct(ional)-detection experiments

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Based on Samuel Lee & AP, arXiv:1202.5035
Directional detection

MIMAC experiment; Billard TAUP 11 talk
Directional detection and the Milky Way

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\frac{dR}{dQd\Omega_{lab}} \propto \int_{v_{cut}} d^3v_{rel} f(r,v)v_{rel} \frac{d\sigma}{dQd\Omega_{lab}}
\]

1. Smooth Milky Way halo properties?
2. Large-scale features from assembly history (Kuhlen et al. 2010, Vogelsberger et al. 2009)?
3. Small-scale features from tiny subhalos?
4. Dark disk?
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Goal

Local velocity distribution of WIMPs

WIMP mass
Cross sections
The power of complementarity

5-50 keV in 10 bins, 768 angular bins
50 GeV WIMP scattering off $^{19}$F
100 events, no backgrounds
Simulation for the standard halo model
Direction of lab’s motion wrt Maxwell-Boltzmann fixed
Maxwell-Boltzmann velocity distribution

Key parameters:
$v_{\text{lab}}$: speed of lab wrt center of the MB distribution
$\sigma_H$: MB velocity dispersion
Characterizing the halo

100 signal events
100 background events
Finding a stream (650 signal events)

\[ M_\chi \text{ [GeV]} \quad \text{Signal fraction} \quad l_{\text{lab}} \text{ [degrees]} \quad b_{\text{lab}} \text{ [degrees]} \quad \sigma_H \text{ [km/s]} \]

\[ \text{Stream fraction} \quad l_s \text{ [degrees]} \quad b_s \text{ [degrees]} \quad v_s \text{ [km/s]} \quad \sigma_s \text{ [km/s]} \]
Dark disk prospects (650 signal events)

- $M_\chi$ [GeV]
- Signal fraction
- $l_{\text{lab}}$ [degrees]
- $b_{\text{lab}}$ [degrees]
- $\sigma_H$ [km/s]

- Disk fraction
- $l_D$ [degrees]
- $b_D$ [degrees]
- $v_D$ [km/s]
- $\sigma_D$ [km/s]
Future directions

Non-parametric velocity reconstruction

Joint likelihood analysis w/solid-state and liquid-noble experiments and solar WIMP neutrinos