

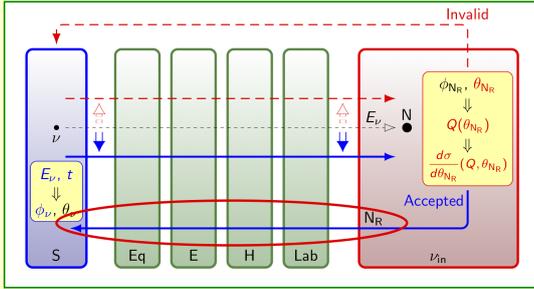
Numerical Simulations of 3D Recoil Responses of Solar B-8 Neutrinos in Directional Direct Dark Matter Detectors

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Simulation workflow



Recoil-direction validation in the incoming- ν frame

- Uniform azimuthal angle $\phi_{NR, \nu_{in}} \in (-\pi, \pi]$.
- Equivalent recoil angle dependence of the recoil energy

$$Q(\theta_{NR, \nu_{in}}) = \frac{2m_N E_\nu^2 \sin^2(\theta_{NR, \nu_{in}})}{(m_N + E_\nu)^2 - E_\nu^2 \sin^2(\theta_{NR, \nu_{in}})}$$

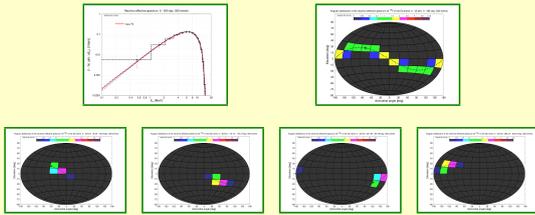
- Validation criterion of the equivalent recoil angle

$$\frac{d\sigma_{\nu-N, SM}}{d\theta_{NR, \nu_{in}}} \propto \left[g_v^2 \left(1 - \frac{m_N Q}{2E_\nu^2} \right) F_{SI}^2(Q) + g_a^2 \left(1 + \frac{m_N Q}{2E_\nu^2} \right) F_{SD}^2(Q) \right] \sin(2\theta_{NR, \nu_{in}})$$

for $\theta_{NR, \nu_{in}} \in [0, \pi/2]$.

Event generation in the Ecliptic frame

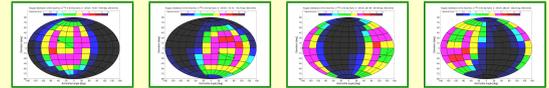
- Numerical Solar B-8 neutrino spectrum for $E_\nu \leq 16.36$ MeV.



- Uniform probability for the observing time $t \in [t_{start}, t_{end}]$.
- 500 events in each 60-day observation period of four advanced seasons

Solar B-8 neutrinos off ^{19}F target

- Nuclear recoil flux observed in the Equatorial frame

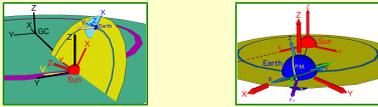


- Recoil energy observed in the Equatorial frame

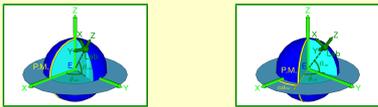


Definitions of our celestial coordinate systems

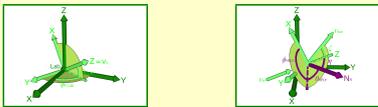
- Laboratory-independent (Galactic, Ecliptic, Equatorial and Earth) frames



- Laboratory-dependent (horizontal and laboratory) frames

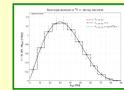


- Incoming- ν frame

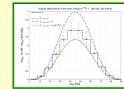


Discussions

- Most "frequent" recoil angle around 30° (interaction dependent)



- Most "energetic" recoil angle around 45° (interaction dependent)



- With $\mathcal{O}(500)$ events (per season), the "ring-like" recoil (energy) flux patterns would be observable

