Reconstruction and Particle Identification with CYGNO Experiment

A. Prajapati on behalf of CYGNO collaboration

Dark Matter and Background
- Our Galaxy is believed to reside in a halo of Dark Matter (DM)
- Direct Dark Matter detection measuring the recoiling nuclei in the elastic scattering of Dark Matter Particles
- Recoiling nuclei (Signal) and electrons (Background) produce different patterns in the detector medium
- WIMP interactions, at a rate as low as 0.1 events/kg/year, must be discriminated against the much higher background rate

Important background sources are:
- Neutrinos from sun and atmosphere
- Cosmic rays and cosmogenic activation of detector material, Natural radioactivity

Monte-Carlo Simulations
- Interaction of the particles with gas is simulated using either GEANT4 (for ER) or SRIM (for NR)
- Detector/readout effects are added to these track i.e. diffusion, camera noise, effective ionisation, gain fluctuations and geometrical acceptance etc.
- Tracks are reconstructed with algorithm used in [2][3]

CYGNO/INITIUM Approach
- CYGNO works with gas mixture of He:CF4 (60:40) at STP
- INITIUM is a part of CYGNO project which focuses on the development of gaseous TPC with negative ion drift using SF6 gas (Funded by ERC) [5][6].

CYGNO/INITIUM

Dark Matter and Background Approch

- Sensitive to track sense & direction
- Nuclear recoil track charge
- Tail
- Head

- sCOMS Camera
  - Single photon sensitivity
  - High granularity
  - Large area for detection
  - X-Y + Energy

- PMT
  - Fast
  - Integrated energy measurement
  - Z + Energy

- Project is already funded till phase 1.

Monte-Carlo Simulations

A. Undiffused & Diffused track
B. Reconstructed Clusters
C. LAPA
D. CylThick
E. Skeletonization

Particle Identification Studies
- It is very difficult to discriminate signal and background at very low energy [0-20 keV] with traditional approach
- Track’s topology variables were used to train three different deep learning models
- Three models are:
  - Random Forest Classifier (RFC)
  - Gradient Boosted Classifier (GBC)
  - Deep Neural Network (DNN)
- RFC performance is an order better in rejecting background than DNN in all the energy range between 1-40 keV for ER (background) & NR (signal)

C. Background with an efficiency of 50% and 40% on NR

Models

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<th>RFC</th>
<th>GBC</th>
<th>DNN</th>
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<tbody>
<tr>
<td>% ERFB</td>
<td>50%</td>
<td>40%</td>
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<tr>
<td>% GBCB</td>
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<td>% NRE</td>
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Bibliography

Daejeon, South Korea November 2021