Beta spectrum shape measurements using backscatter recognition

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Why?

- High-energy frontier
- Low-energy frontier
  - Complementary constraints on Scalar(S) and Tensor(T) currents through Effective Field Theory (EFT)

What?

- Signal height versus voltage
  - \textsuperscript{114}In \rightarrow \textsuperscript{114}Sn
  - \textsuperscript{114}In \rightarrow \textsuperscript{114}Sn is a good candidate to probe WM

Challenges?

- \textsuperscript{114}In \rightarrow \textsuperscript{114}Sn is sensitive to both BSM physics \textsuperscript{Fierz} and uncharted SM physics \textsuperscript{Weak Magnetism}

How?

- Probing Beyond SM
- Probing SM
  - Influence of QCD on WI?
  - Why?

Scintillator

Plastic: EJ-204 (Ejen technology)
Cylinder: h=30mm, r=100mm
4 PMTs: XP3330 (Photonis)

Advantages
- Low backscattering coefficient (~2-7%)
- Low amount of bremsstrahlung (<10%)\textsuperscript{5}

Disadvantages
- Low energy resolution (~5-20%)
- High non-uniformity in light collection efficiency (~15-20%)

Multi-Wire Drift Chamber (MWDC)

- Recognize back-scattered electrons as V-tracks
- Reduce background from gamma's and cosmic muons
- Correct for gain non-uniformity by reconstructing the scintillator hit position

Tracking in X-Y plane

Monte-Carlo simulations

- Geant4
  - Detector geometry
  - Particle tracking
- Garfield++
  - Ionization and electron drift
  - Signal readout

Goal: Interface Geant4 and Garfield++
and fully simulate events in order to support the measurements\textsuperscript{[6]}

Results

2D-gain map
- Scintillator calibration with Blumth-207:
  - Conversion peaks at ~500 keV and 2 peaks at ~1 MeV
- Model of the detector response includes a linear term with offset, a noise resolution and a Fano factor:
  \[ ADC = a \cdot V + b \]
  \[ \sigma_{ADC}^2 = \sigma_n^2 + F_v \cdot E \]
- Divide scintillator surface in a grid of squares
- Fit experimental spectrum with simulated spectrum using a Markov Chain Monte Carlo (MCMC) method
- Extract gain for each location and map the detector surface

Signal height versus voltage
- Average signal height from muonic data for:
  - Different gas mixtures
  - Increasing Voltage
- Very good agreement with simulation
- Remaining discrepancy due to inaccuracies in Penning effect

Preliminary results
- Fairly good agreement between experiment and simulation but systematic effects arise at the % level
  - Origin: the track reconstruction algorithm is energy dependent!!!
  - Work in progress...

Conclusions

- The beta spectrum shape is sensitive to both BSM physics \textsuperscript{Fierz} and uncharted SM physics \textsuperscript{Weak Magnetism}
- \textsuperscript{114}In \rightarrow \textsuperscript{114}Sn is a good candidate to probe WM
- Back-scattering and non-uniform light collection efficiency are monitored by a MWDC
- Proof of principle: 2D gain map of the scintillator surface
- Preliminary comparison of the \textsuperscript{114}In spectrum with simulation: systematics at the % percent level due to the track reconstruction algorithm: requires further analysis

References

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