AXEL—a high pressure xenon gas TPC for 0νββ search

AXEL

- A Xenon ElectroLuminescence detector (AXEL) is a high pressure xenon gas TPC to search for 0νββ of 136Xe.
- The project is now in R&D phase.
  - 10-L prototype: Demonstration of our original detection method, ELCC
  - 180-L prototype: Evaluation of energy resolution near Q-value (2.458 MeV)

- Large mass
  - high pressure up to 10 bar
- Good scalability with solid structure
- Targeting 0.5% FWHM @Q-value
- Background rejection by tracking

Feature

ELCC ElectroLuminescence Light Collection Cell (ELCC) is our original device to detect ionization electrons via EL process.

Energy resolution (10-L prototype)

For 180-L prototype & a future larger detector

Cockcroft-Walton voltage multiplier

- The voltage of the drift top electrode will be 65 kV for 180-L prototype, and few hundred kV for future detector.

- Applying relatively low AC voltage (few kV) and convert it to DC high voltage in the pressure vessel with Cockcroft-Walton (CW) voltage multiplier.

- Polymide-based Flexible Print Circuit (FPC)
- Electrically conductive epoxy

- 100-nF capacitors
- 100-MΩ resistors; two for each stage

We achieved output of 10.3 kV with input amplitude of 540 V.

The output voltage was stable for at least 12 hours.

Higher voltage is expected to be generated with higher input or more stages.

- Electric discharge on the feedthrough will become a severe problem!!

Drift field cage

- The drift field cage for a larger detector must
  - form a strong and uniform field (100 V/cm/bar ±5%) over a large volume.
  - prevent an electric discharge between the vessel and an electrode of the cage.
  - reflect scintillation photons (VUV; l=175 nm) on PMTs.

- Strip electrodes of two different radius with a little overlaps.

- Good uniformity of electric field even on the surface of the cage.

- The structure of stacking PTFE rings is based on the field cage of LZ experiment.

A test of this structure in 10-L prototype is ongoing!!

Other developments

- Front end board
- Calibration system for more than 1,000 MPPCs
- Background rejection by tracking with deep learning technique
- Positive ion detection for less diffusional tracking

Cockcroft-Walton Voltage multiplier for HV generation

ELCC energy measurement & tracking

PMTs for time-zero signal of TPC

Energy resolution (10-L prototype)

Number of photons

Number of photons

Conditions

- Gas: Xe 8 bar
- EL: 2.375 kV/cm/bar
- E_d= 83 V/cm/bar
- Source 137Ba

After several cuts (fiducial cut, FADC saturation cut, ...) and corrections (cell by cell gain correction, MPPC saturation correction, ...)

Extrapolating the energy resolution to Q-value (2.458 MeV)

by $\Delta E$ (only statistics): 0.82% FWHM

by $\Delta E + B E^2$ (with any other causes): 1.74% FWHM

It is required to evaluate the energy resolution near Q-value.

It is required to evaluate the energy resolution near Q-value.

180-L prototype!!