NEWAGE

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7th SYMPOSIUM ON LARGE TPCs FOR LOW-ENERGY RARE EVENT DETECTION


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NEWAGE Overview

- μ-PIC based TPC with electronics
- 3-D tracks

- First direction-sensitive DM limits
  PLB654 (2007) 58

- Underground results
  PLB686 (2010) 11

- Phase for “low BG detector”
NEWAGE-0.3b’
Detection Volume: $31 \times 31 \times 41 \text{cm}^3$
Gas: CF4 at 0.1atm (50keVee threshold)
Gas circulation system with cooled charcoal
NEWAGE-0.3b’ inside view

Detection Volume: $30 \times 30 \times 41\text{cm}^3$

Field cage
- Drift length: 41cm
- PEEK + copper wires

GEM
- $31 \times 32\text{ cm}^2$
- 8-segmented
- hole pitch: $140\mu\text{m}$
- hole diameter: $70\mu\text{m}$
- insulator: LCP 100$\mu\text{m}$
- gain: $\sim5$
- made by Scienergy, Japan

µ-PIC (Micro-pixel chamber)
- $31 \times 31\text{cm}^2$
- pitch: $400\mu\text{m}$
- gain: $\sim1000$
- made by DNP, Japan
NEWAGE-0.3b’ readouts

- $\mu$-PIC is X-Y readout
- General purpose FPGA-based electronics since early 2000’s.
- Updates are still in progress

256ch connector

256ch ASD box

FPGAs

$\mu$-TPC

electronics

gas circulation system
NEWAGE-0.3b’ data

- TOT of every strip by FPGA (clock 100MHz)
  \(\Rightarrow\) 3D tracks, headtails in X,Y
  
  +

- Summed waveforms by FADC (100MHz)
  \(\Rightarrow\) energy, headtails in Z

combined \(\Rightarrow\) PID, absolute z
NEWAGE-0.3b’ performance

- Energy threshold: 50keV
- Energy resolution: 20% (dominated by gain non-uniformity)
- Nuclear track detection efficiency: 40% @50keVee
- Gamma rejection 2.5E-5@50keVee
- Angular resolution 40° @50keVee
NEWAGE-0.3b': calibration

- α's from $^{10}\text{B}(n,\alpha)^{7}\text{Li}$ reaction
- $^{10}\text{B}$ plate stays in the TCP
- Irradiated with thermalized neutrons

Linearity check: 1.5MeV + 5.9keV, 6MeV
length-cut (conventional gamma-ray cut)

dE/dx: nuclear ($^{252}$Cf) > electron ($^{137}$Cs)

track length: electron > nuclear
Event selection 2

**TOT-sum-cut** (new gamma-ray cut)

- Nuclear \(^{252}\text{Cf}\): TOT-sum is proportional to energy
- Electron \(^{137}\text{Cs}\): scratched track (small \(dE/dx\))

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**252\text{Cf RUN}**

- \(\text{ene}_{\text{low}}=100.783500 \text{ [keV]}\)
- \(\text{length}=0.689466 \text{ [cm]}\)
- TOT-sum=250
- \(\text{roundness}=0.055549\)

**137\text{Cs RUN}**

- \(\text{ene}_{\text{low}}=100.054500 \text{ [keV]}\)
- \(\text{length}=0.814168 \text{ [cm]}\)
- TOT-sum=55
- \(\text{roundness}=0.021144\)
**Event selection 3**

**roundness-cut (third cut)**

Remained $^{137}\text{Cs}$ events: straight track shape

**Diffusion (drift distance) affects roundness!**

(Aprilmost all electron events are cut)

(Remained events are BG $\alpha$ from $\mu$-PIC)

Roundness-cut works as “z-fiducial-cut”
After all cut, compare to Geant4

- **Nuclear (\(^{252}\text{Cf}\) neutron source)**
  Efficiency: 40\% @ 50\text{keV}

- **Electron (\(^{137}\text{Cs}\) \(\gamma\) source)**
  Rejection: \(2.5 \times 10^{-5}\) @ 50-100\text{keV}
NEWAGE underground run

RUN14
• period: 2013/7/20-8/11, 10/19-11/12
• live time: 31.6 days
• fiducial volume: 28x24x41cm³
• mass: 10.36g
• exposure: 0.327 kg·days

• Energy spectrum
  • Threshold: 100 => 50keV
  • BG rate: 1/10@100keV

• Skymap, cos θ distribution
  • Set limit by significant difference in 2-binned measured cos θ and DM-wind simulated cos θ
Direction-sensitive limit

Obtained limit: **557pb @200GeV**
(Best direction-sensitive limit)

Improved one order of magnitude from previous RUN5
NEWAGE to low-BG

BG sources

- BG source: α’s from polyimide for uPIC
- U $0.4 \times 10^{-6}$ g/g
- Th $1.8 \times 10^{-6}$ g/g

Measured by Ge detectors

- Low BG μPIC development started

Polyimide insulator 100μm-thick
NEWAGE with Garfield++

μPIC 3D simulations with free softwares (Takada)

- gmesh + elmer + garfiled
- For geometry designing, gas studies, electronics designing

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SUMMARY

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