R&D status of the NEWAGE experiment

(New generation WIMP search with an advanced gaseous tracking device)

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1 Direction Sensitive WIMP Search
2 $\mu$-TPC, the advanced gaseous device
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5 Summary
Proving the existence of WIMPs and the monster...

Observing the annual modulation might be taking the picture

In order to “catch the monster and put it one’s head”

Detect the recoil tracks.

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Kentaro Miuchi @ IDM2004
1. Direction Sensitive WIMP Search

WIMP-wind (previous talks)

WIMP-wind

Advantages over the DRIFT project:
- advanced gaseous device ($\mu$-TPC)
- fine pitch (400 $\mu$m), 3D tracking

Simulation conditions:
- Kamioka 50 water shield
- $\gamma$-ray BG 100% rejected
- CF$_4$ 20Torr
- track > 3mm
- Eth = 25keV

$M_{\text{WIMP}}$ = 80 GeV, $\sigma_{p,\text{WIMP}}$ = 0.1 pb

Expected recoil "assymetry"

PLB 578 (2004) 241
2. $\mu$-TPC, the advanced gaseous device

**Key device:** $\mu$-PIC (micro pixel chamber)
- 1st prototype ($3\times3\,\text{cm}^2$): 1999 by Tanimori et al.
- 2001~ practical size ($10\times10\,\text{cm}^2$): working well
- 2003~ large size ($30\times30\,\text{cm}^2$): being manufactured

**$\mu$-PIC Properties**
- Simple structure
- Large area (PCB tech.)
- Stable operation
- Fine pitch (400 $\mu\text{m}$)
- 2D detector (x-y symmetry)
Performance of the $\mu$-PIC

- Gas gain uniformity $\sigma \sim 4.5\%$

- Practical size $\mu$-PIC

- Position resolution $\sim 120\mu m$

Gain map

X-ray image

0.5mm slits

1cm

10cm
Prototype $\mu$-TPC

- $10 \times 10 \times 10 \text{cm}^3$ detection volume

- 0.2mm copper wires

- $E = 500 \text{V/cm}$

- 15cm
Digital Electronics (of 10cm $\mu$-PIC)

- Amplifier Shaper Discriminator
  - ATLAS ASD chip ($\tau \sim 16$ns) $\rightarrow$ $\mu$-PIC ($\tau \sim 80$ns)
  - redesigned at the mask-level

- Position Encoder (FPGA-based)
  - anode-cathode coincidence ("hit") @ 50MHz
  - 256ch + 256ch $\rightarrow$ 32bit / hit
Performance as of shown in PLB 578 (2004) 241

Ar + C\textsubscript{2}H\textsubscript{6} 1atm

Proton tracks

\begin{align*}
\text{dE/dX} \quad [\text{keV/cm}] \\
\chi^2/\text{d.o.f.} \\
\text{dE/dX} \quad [\text{keV/cm}]
\end{align*}

\text{Gamma rejection}

\text{\(252\text{Cf} (n+\gamma)\)}

\text{\(22\text{Na} (\gamma)\)}
3. R&D status

Operation with low-pressure gas

- required operation pressure: 0.05~0.2 atm
- First test with “all-in-the-vessel…”

Signals were observed down to 0.1 atm

Out-gas should be suppressed
3-D Tracking

- neutrons from $^{252}$Cf

tracks of recoil protons

3-D tracking & Bragg curves

length v.s. charge roughly agrees with SRIM

FADC “Bragg curves”

proton tracks

0.2 atm Ar–C$_2$H$_8$ (9:1)
Tracking performance

- neutrons from $^{252}$Cf

Carbon candidate

350 keV $= 8$ mm (SRIM)

Carbon candidate

(350 keV)

0.2 atm Ar–C$_2$H$_6$ (9:1)

350 keV $= 8$ mm (SRIM)
4. Road to the NEWAGE

NEWAGE eve (R&D with 30cm cube)
- Low pressure operation
- $\gamma$-ray BG rejection
- Diffusion
- Gas selection (CF$_4$ for SD?)

NEWAGE (1m$^3$)

30cm $\mu$-PIC (test production)

BRAND-NEWAGE (1m$^3\times$

micro-TPC 27m$^3$

WATER 50cm
5. Summary

- μ-TPC, readout electronics working
- Study with 10cm-size detector
  - Low pressure operation (0.2 atm)
  - Proton and carbon 3-D tracks
  - Gamma-ray rejection
- 30cm-size TPC will be ready at the end of 2004
Applications of the $\mu$-PIC

- X-ray crystallography / polarimetry
- $\mu$-TPC for collider experiments
- MeV gamma-ray camera
- Astronomy / nuclear medicine
- Time-resolved neutron imaging
µ-PIC fabrication

1. Electroless plating
2. Via-fill plating
3. Surface etching
4. Electrode etching

Substrate
Anode
Cathode
Background rejection

- **Particle I.D.** (DM: nucleus BG-gamma: electron)
  - >95% gamma-ray rejection (very preliminary study)

Experimental results

- Simulations
  - (25keV F ion in 20 Torr CF₄ )

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μ-PIC as an X-ray detector

Gain uniformity (σ) 4.5%

$^{55}$Fe spectrum @ 10cm × 10cm

FWHM 30%

Position resolution \( σ = 120 \, \mu m \)

Counts

Length along the edge [mm]

Test chart image

Knife edge test

0.5mm slits
“head or tail” are important
- dotted line: track shape only
- solid line: track shape + direction
Sensitivities

- “Detection” by Forward/Backward 3σ asymmetry
- Simple and reliable

Xe for Spin-Dependent
CF₄ for Spin-Independent