

R&D status of the NEWAGE experiment

(New generation WIMP search with

an advanced gaseous tracking device)

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for the NEWAGE group

- 1 Direction Sensitive WIMP Search
- 2 μ -TPC, the advanced gaseous device
- 3 R&D status
- 4 Road to the NEWAGE
- 5 Summary

Sep. 8th 2004

Kentaro Miuchi @ IDM2004



Proving the existence of WIMPs and the monster...

Observing the annual modulation

might be



taking the picture

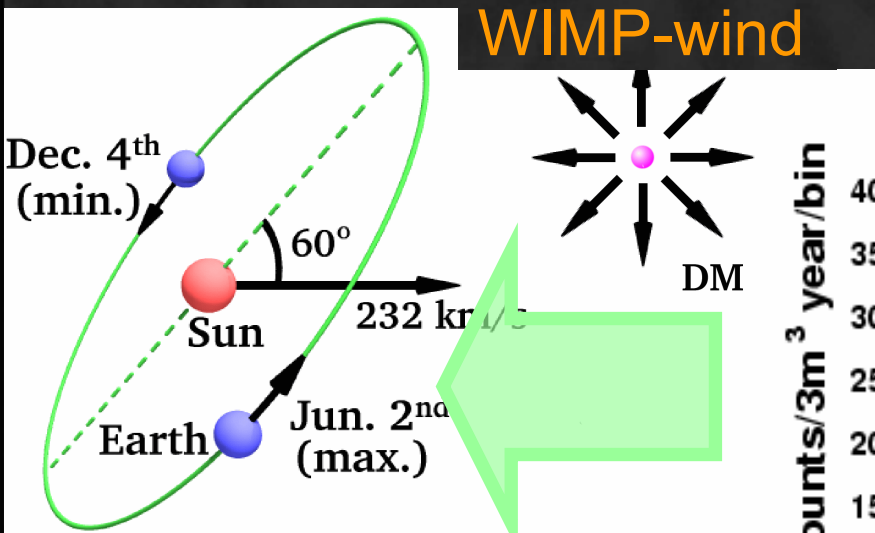
In order to

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

Detect the recoil tracks.

1. Direction Sensitive WIMP Search

◆ WIMP-wind (previous talks)

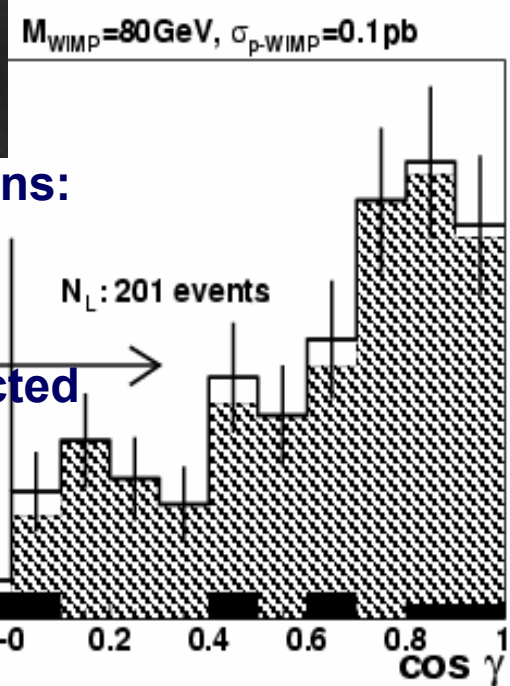


expected recoil
"assymetry"

counts/3m³ year/bin

Simulation conditions:

- Kamioka $N_S: 12$ events
- 50 water shield
- γ -ray BG 100% rejected
- CF₄ 20Torr
- track > 3mm
- E_{th} = 25keV



PLB 578 (2004) 241

◆ Advantages over the DRIFT project

: advanced gaseous device (μ -TPC)

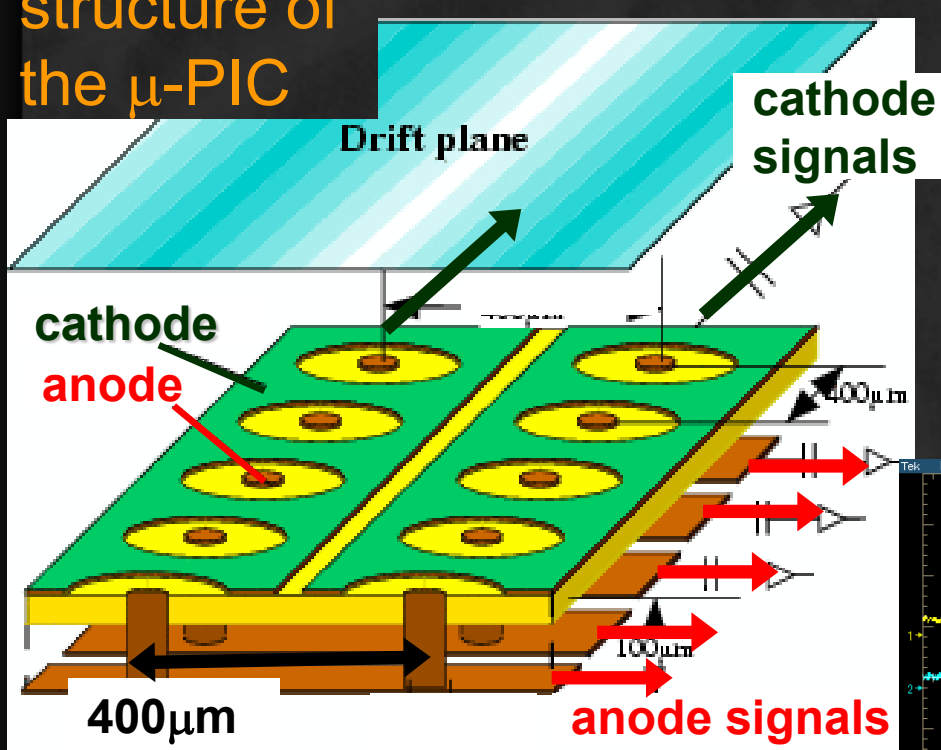
fine pitch (400 μ m), 3D tracking



2. μ -TPC, the advanced gaseous device

- ◆ **Key device: μ -PIC (micro pixel chamber)**
 - 1st prototype ($3 \times 3\text{cm}^2$): 1999 by Tanimori et al.
 - 2001~ practical size ($10 \times 10\text{cm}^2$) : working well
NIM A 525 (2004) 20
 - 2003~ large size ($30 \times 30\text{cm}^2$) : being manufactured

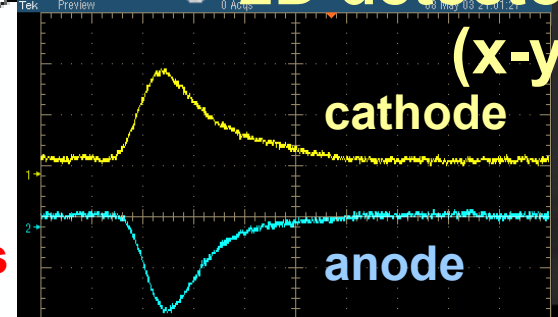
structure of the μ -PIC



◆ μ -PIC Properties

- Simple structure
- large area (PCB tech.)
- stable operation
- fine pitch ($400 \mu\text{m}$)
- 2D detector

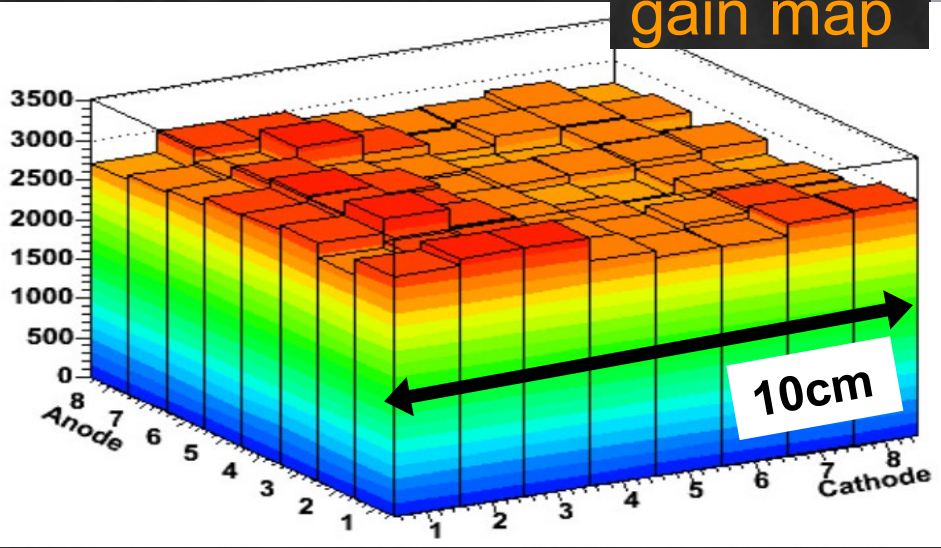
(x-y symmetry)



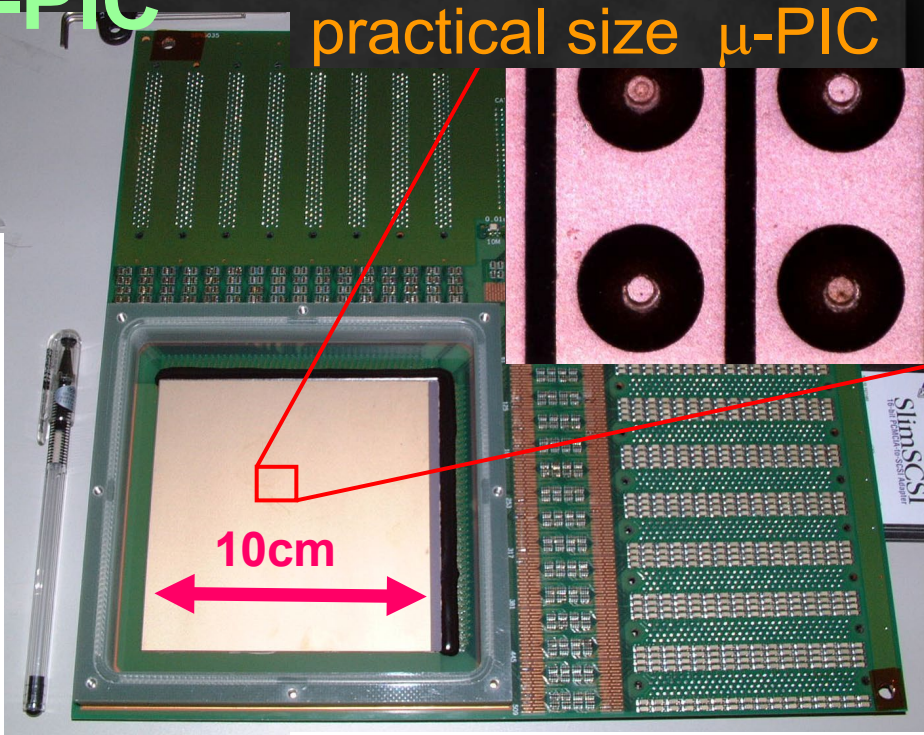
◆ Performance of the μ -PIC

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

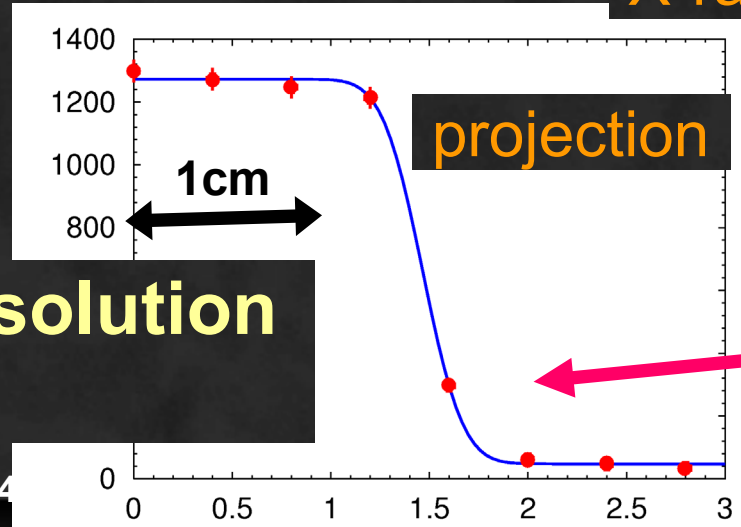
gain map



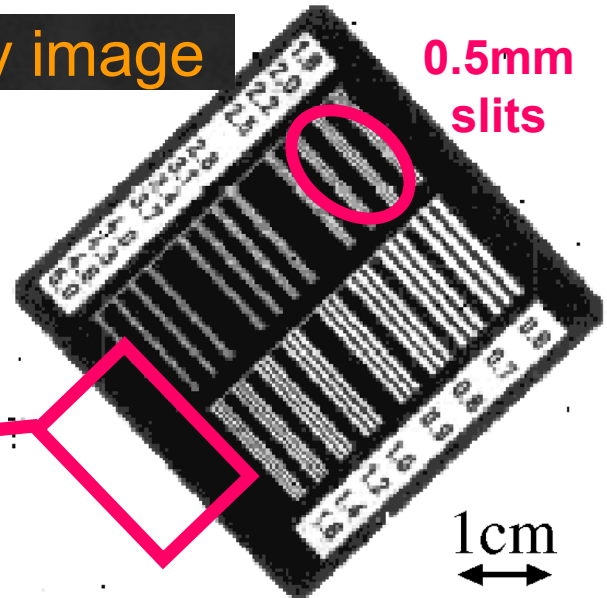
practical size μ -PIC



X-ray image



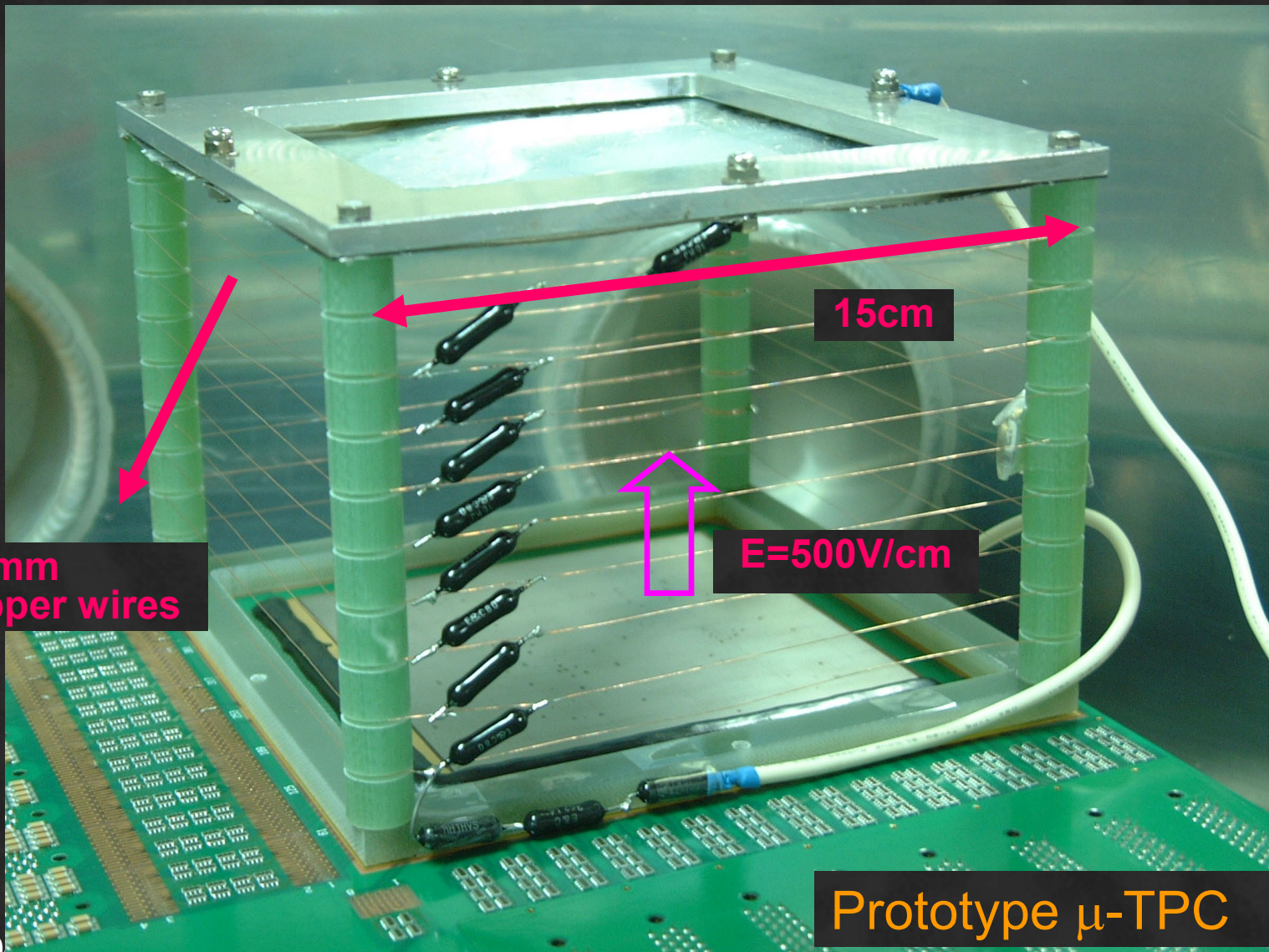
0.5mm slits



- position resolution
 $\sim 120\mu\text{m}$

◆ Prototype μ -TPC

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



0.2mm copper wires

15cm

E=500V/cm

Prototype μ -TPC

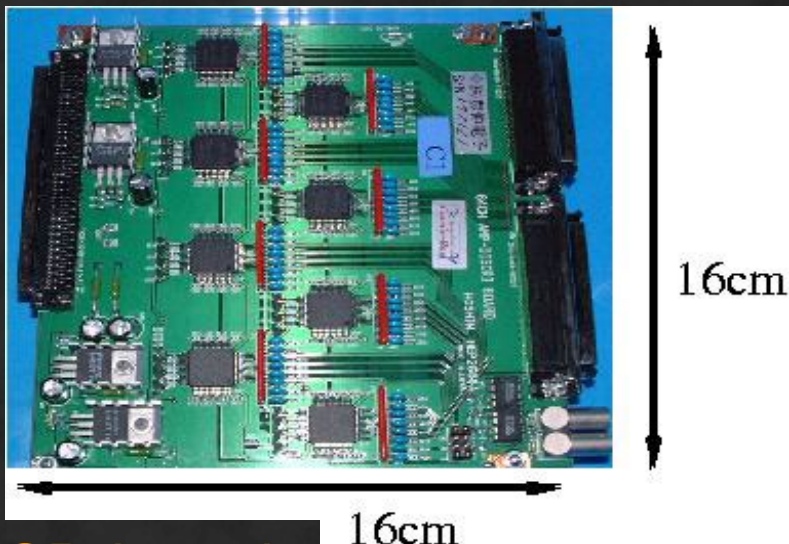
◆ Digital Electronics (of 10cm μ -PIC)

● Amplifier Shaper Discriminator

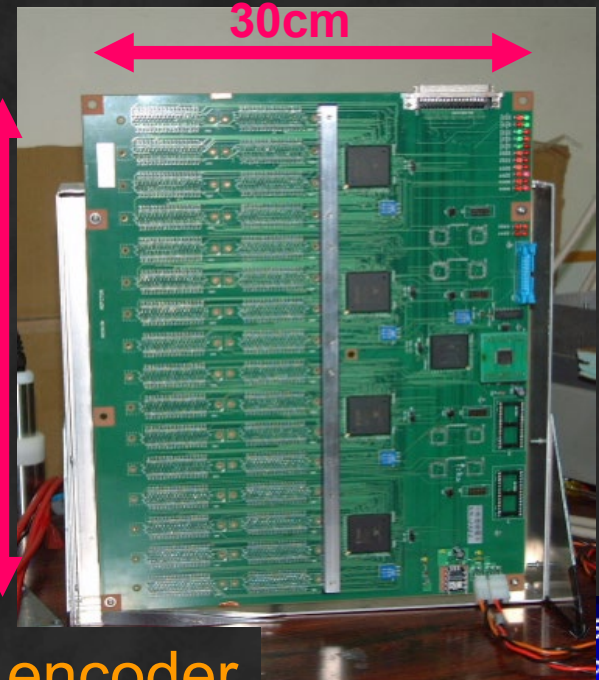
- ATLAS ASD chip ($\tau \sim 16\text{ns}$) \rightarrow μ -PIC ($\tau \sim 80\text{ns}$)
- redesigned at the mask-level

● Position Encoder (FPGA-based)

- anode-cathode coincidence (“hit”) @ 50MHz
- 256ch + 256ch \rightarrow 32bit / hit



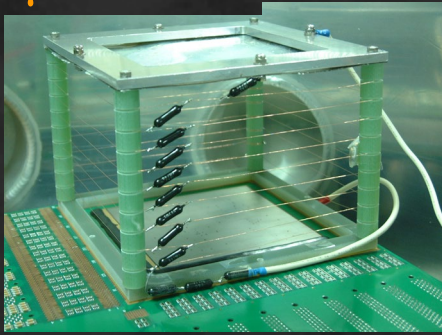
ASD board



encoder

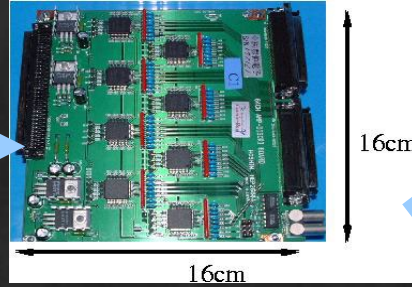
DAQ system

μ -TPC



512ch

ASD



512ch digital

Encoder

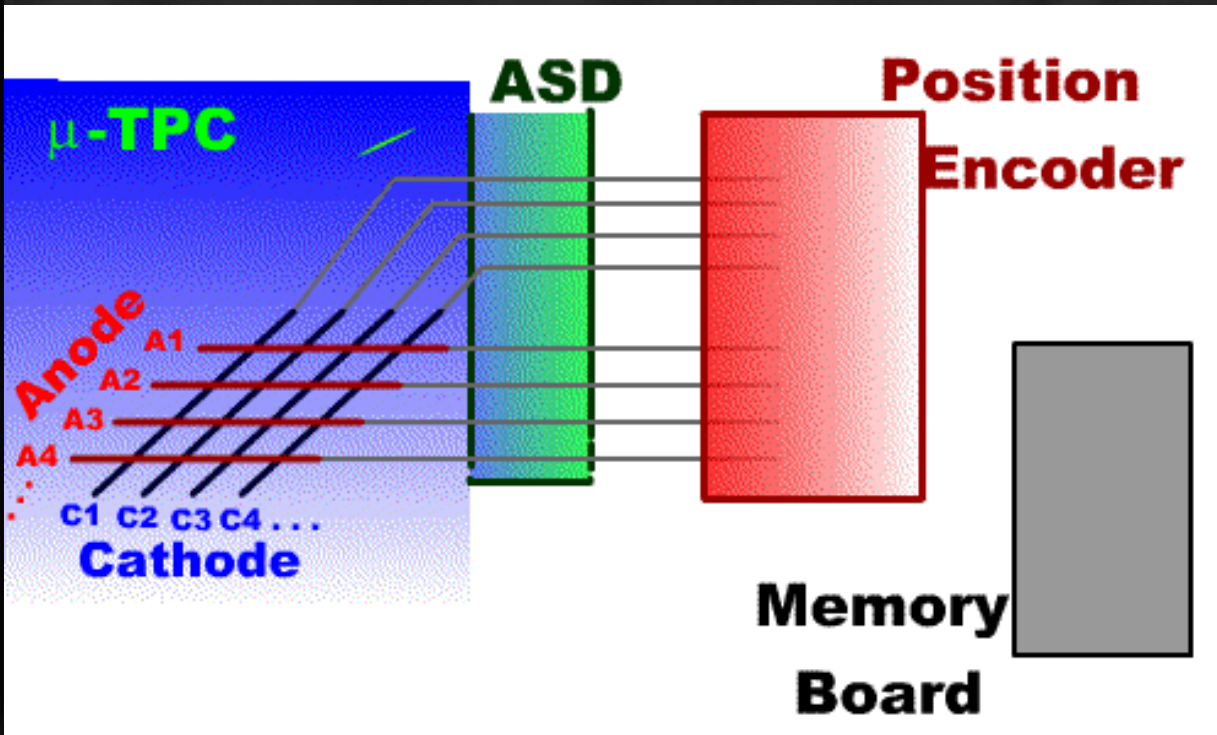


32bit

summed analog (8ch)

VME Memory Board

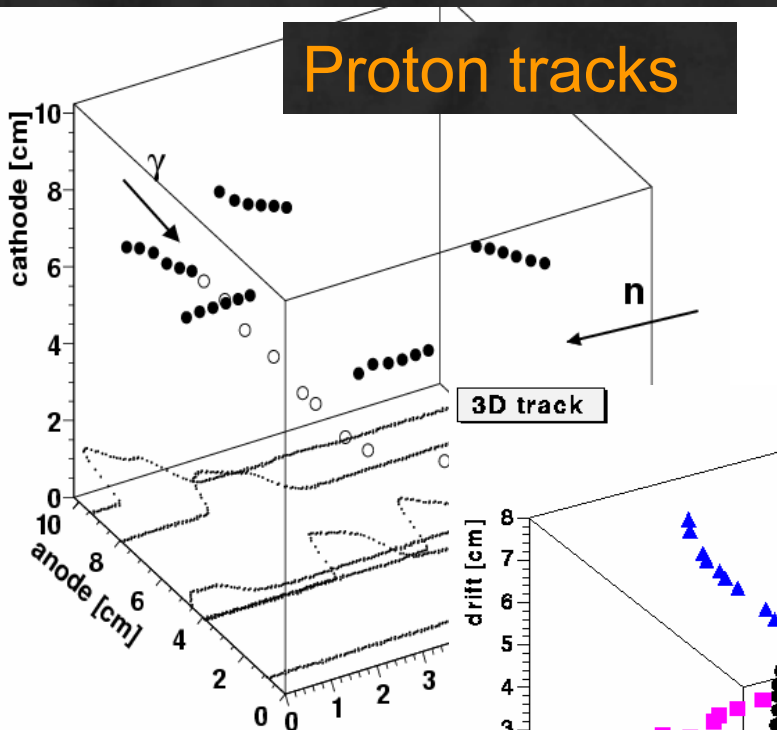
VME FADC
100MHz 8ch



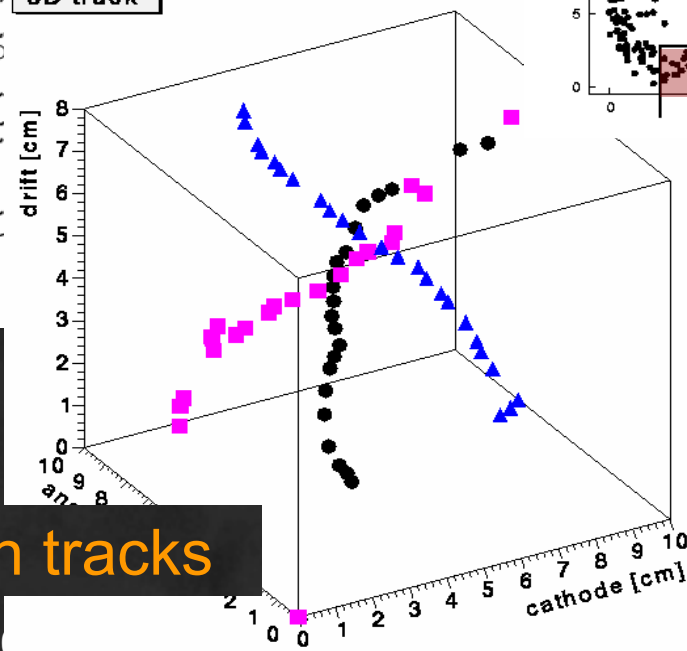
Performance as of shown in PLB 578 (2004) 241

Ar + C₂H₆ 1atm

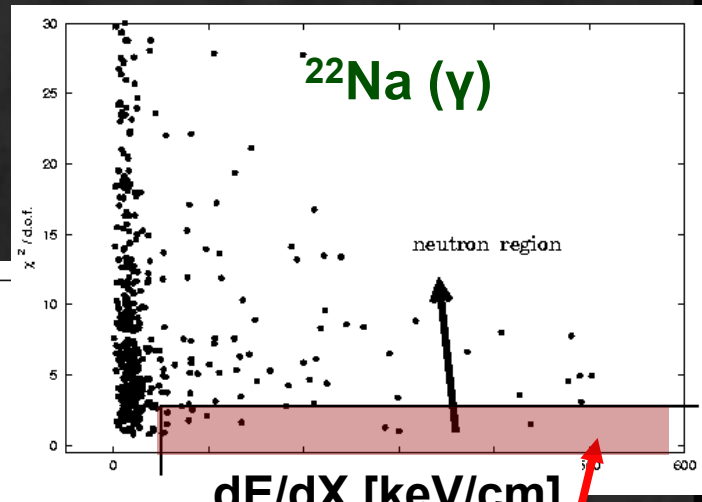
Proton tracks



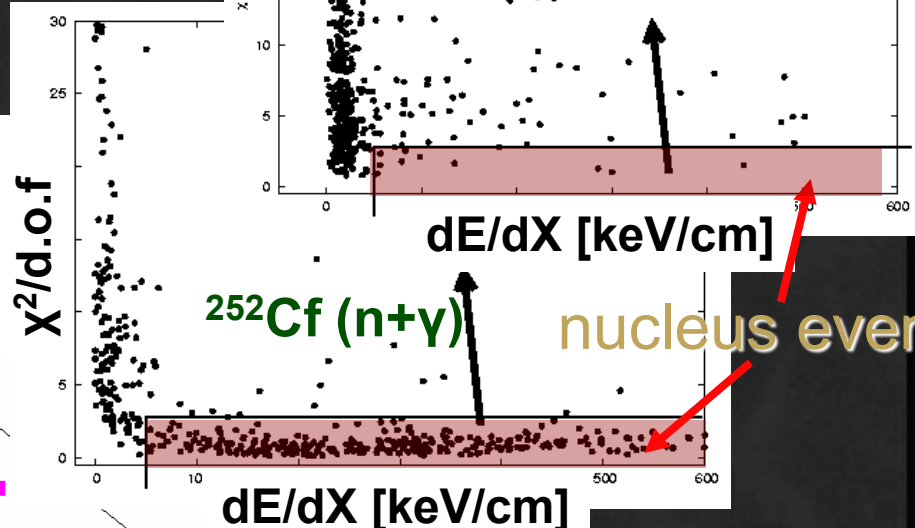
electron tracks



$\chi^2/\text{d.o.f}$



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

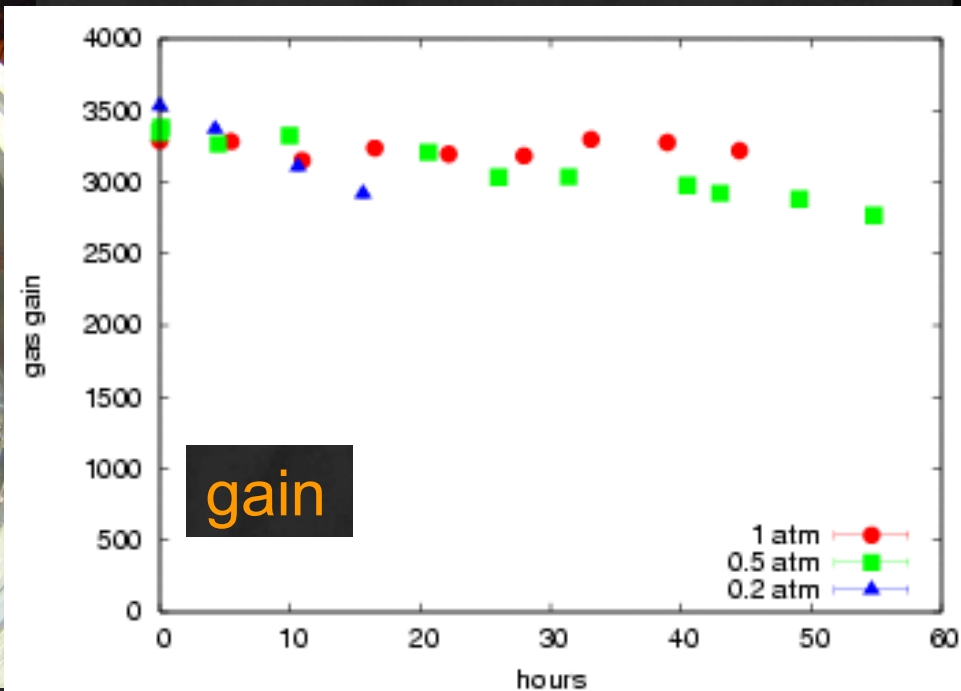
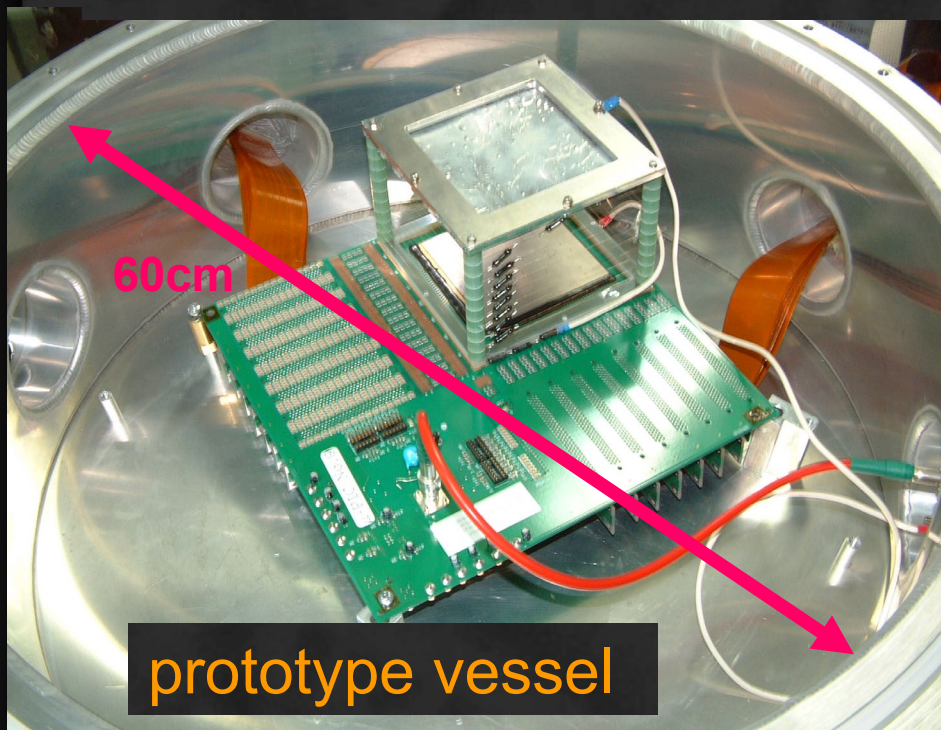


Gamma rejection

3. R&D status

◆ Operation with low-pressure gas

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

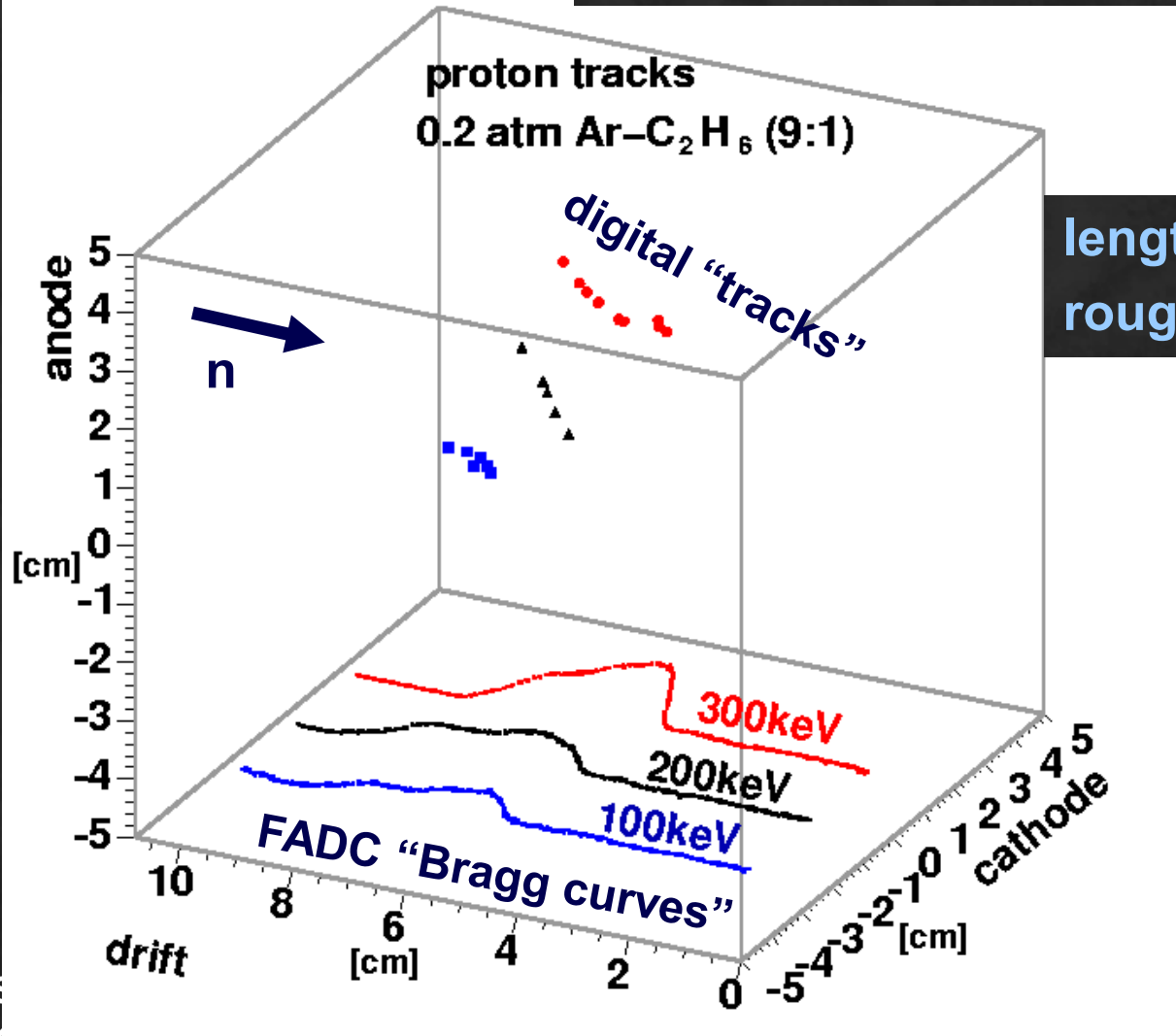


- Signals were observed down to 0.1 atm
- Out-gas should be suppressed

3-D Tracking

neutrons from ^{252}Cf

tracks of recoil protons



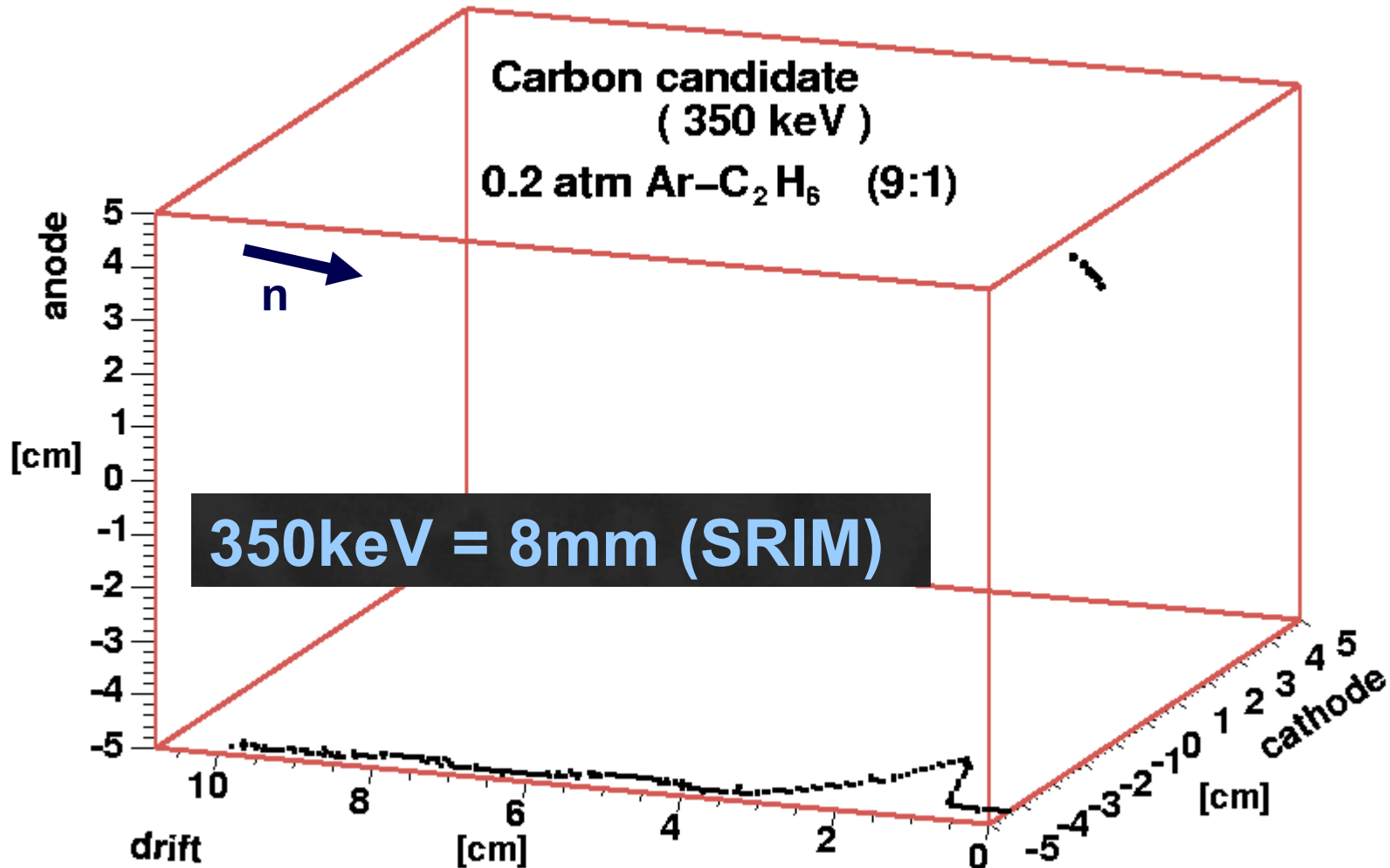
length v.s. charge roughly agrees with SRIM

3-D tracking & Bragg curves

Tracking performance

- neutrons from ^{252}Cf

carbon candidate



4. Road to the NEWAGE

2004 ▲ NEWAGE eve (R&D with 30cm cube)

- Low pressure operation
- γ -ray BG rejection
- Diffusion
- Gas selection (CF_4 for SD?)

2006 ▲ NEWAGE (1m³)

30cm μ -PIC
(test production)

2010 ▲ BRAND-NEWAGE (1m³ × 30)

micro-TPC 27m³

WATER 50cm

Reaction Sensitive
WIMP-search
NEWAGE

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**



Thank you

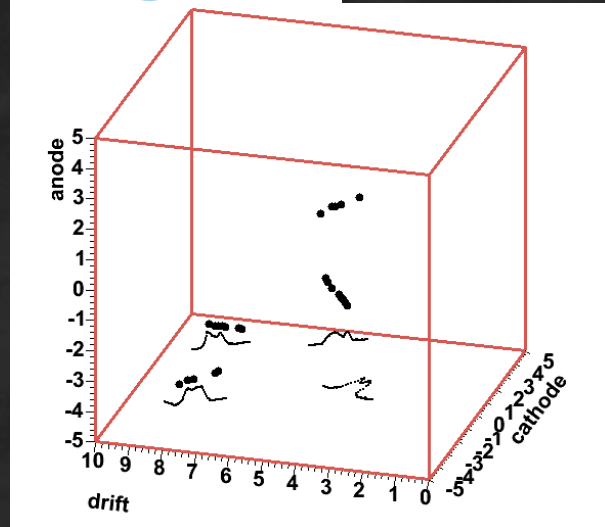


NEWAGE

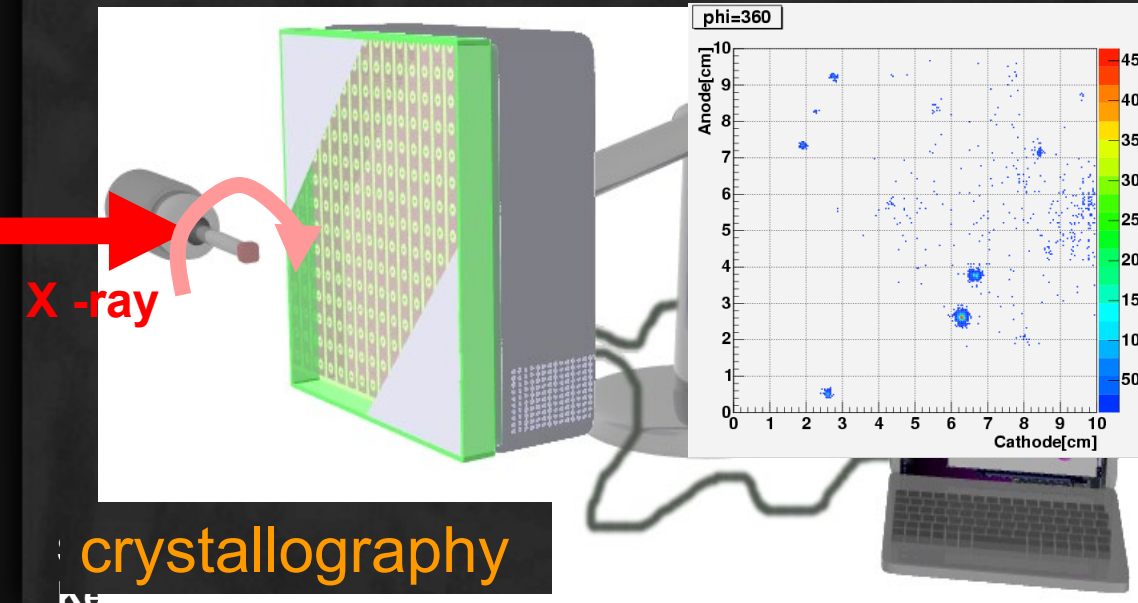
Applications of the μ -PIC

neutron

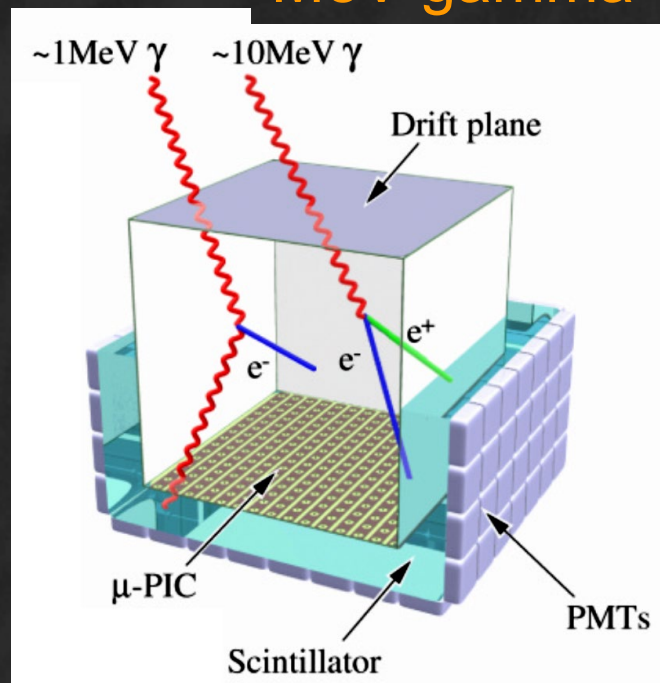
- ◆ X-ray crystallography / polarimetry
- ◆ μ -TPC for collider experiments
- ◆ MeV gamma-ray camera
 - Astronomy / nuclear medicine
- ◆ Time-resolved neutron imaging



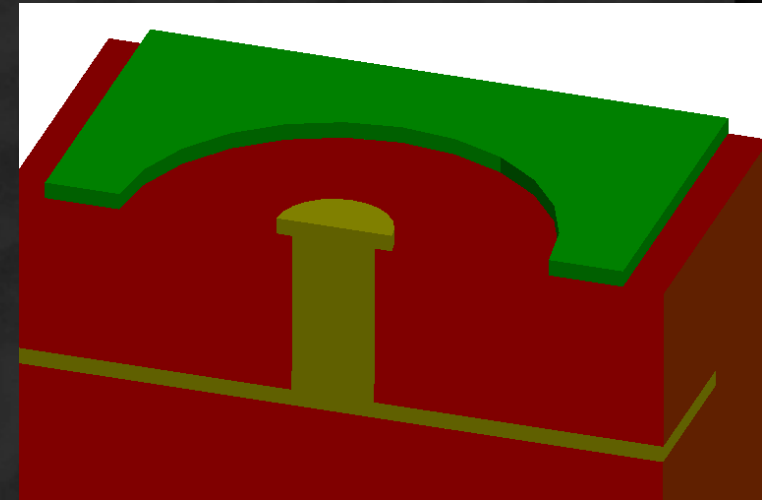
MeV-gamma



crystallography



μ -PIC fabrication



1. Electroless plating



3. Surface etching

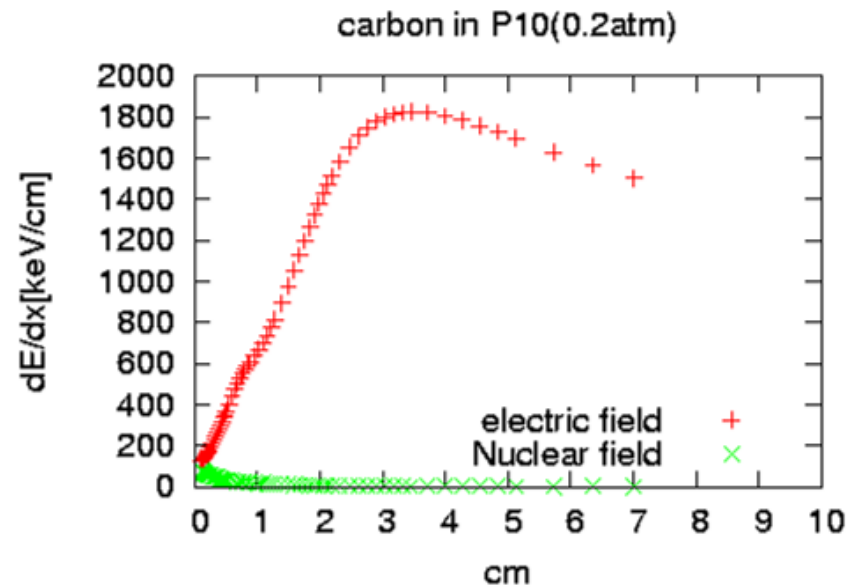
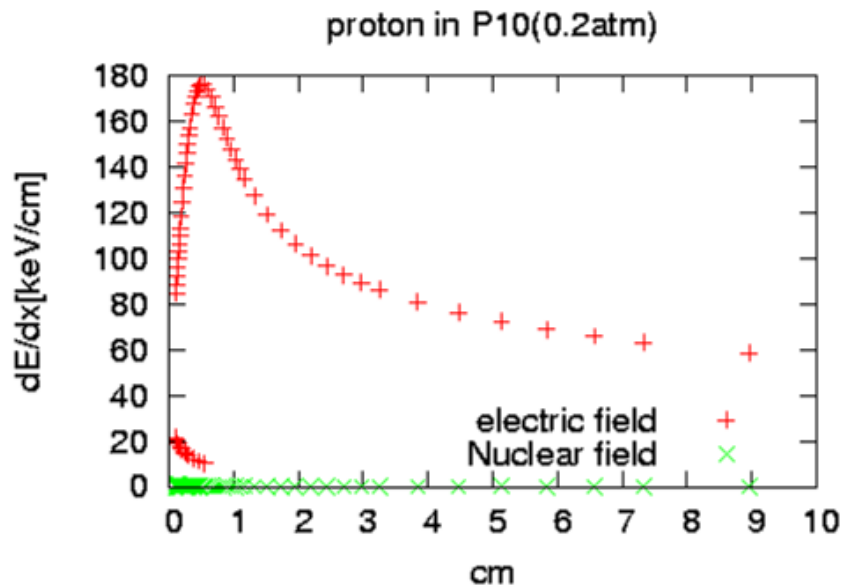
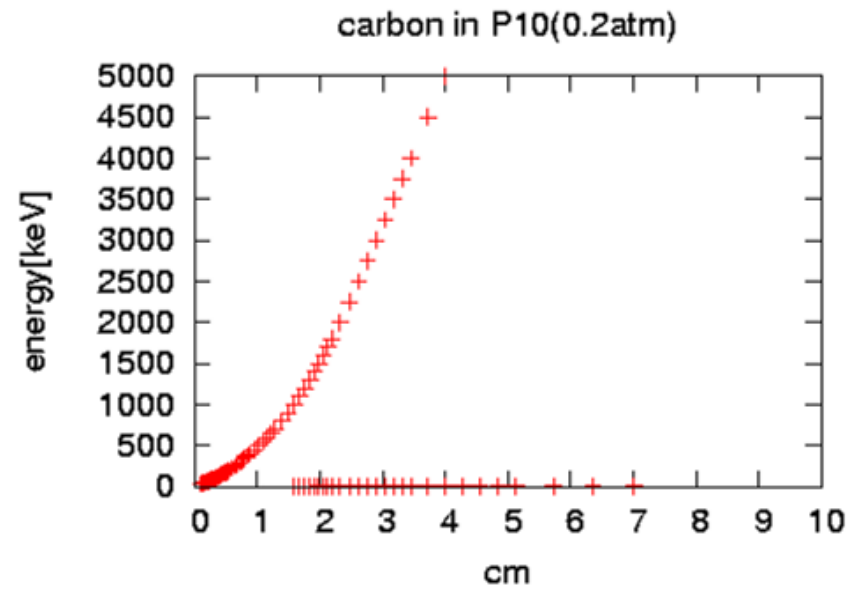
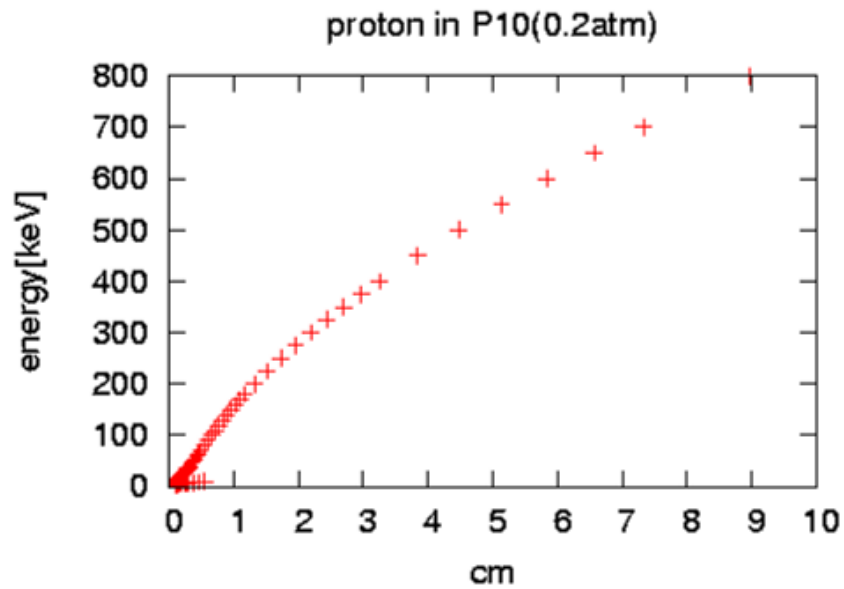


2. Via-fill plating



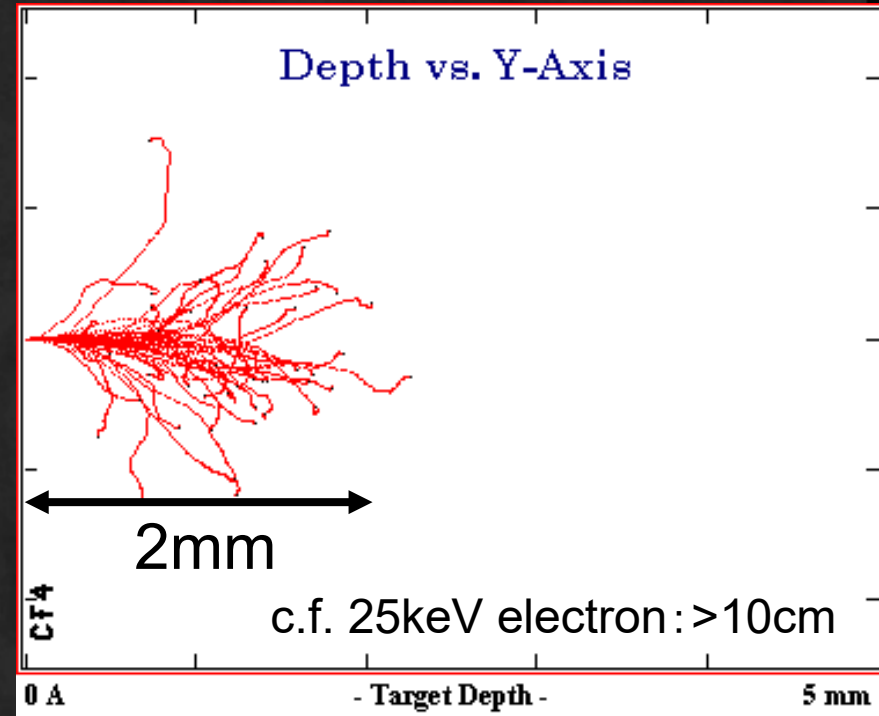
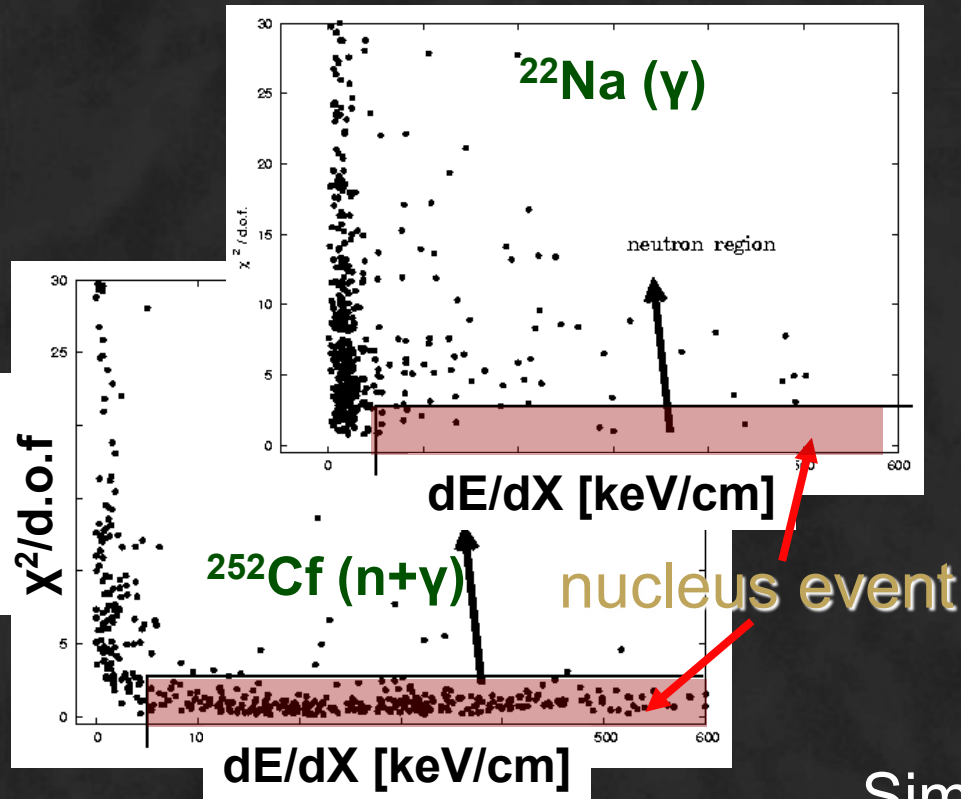
4. Electrode etching





Background rejection

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

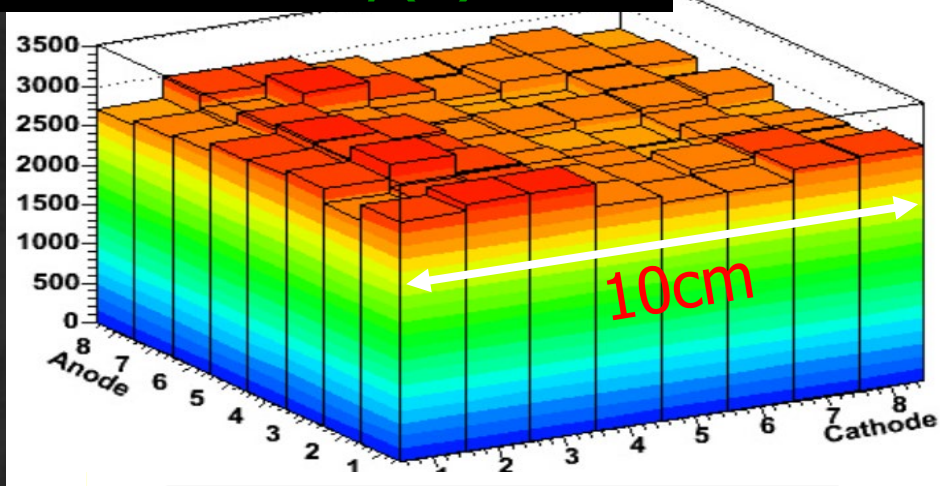


Experimental results

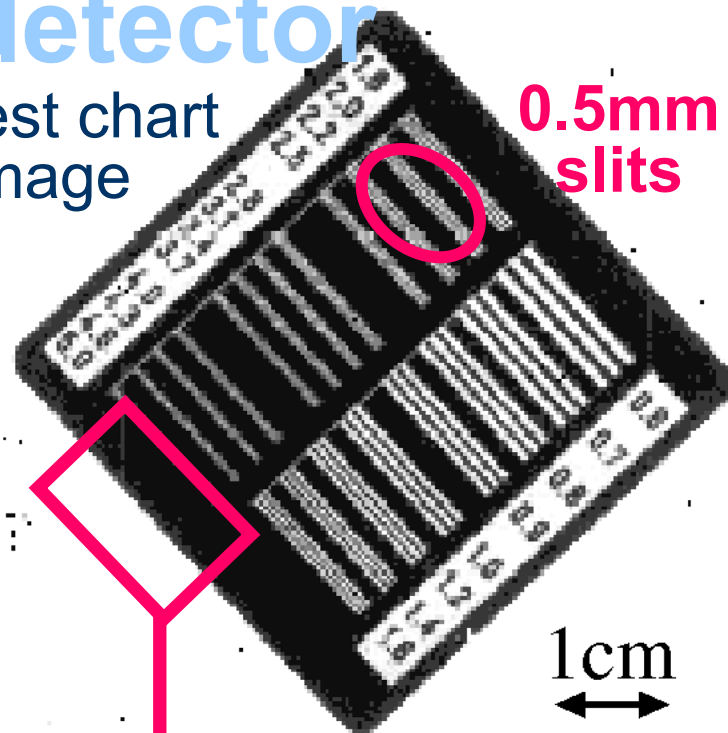
Simulations
(25keV F ion in 20 Torr CF₄)

μ -PIC as an X-ray detector

Gain uniformity(σ) 4.5%



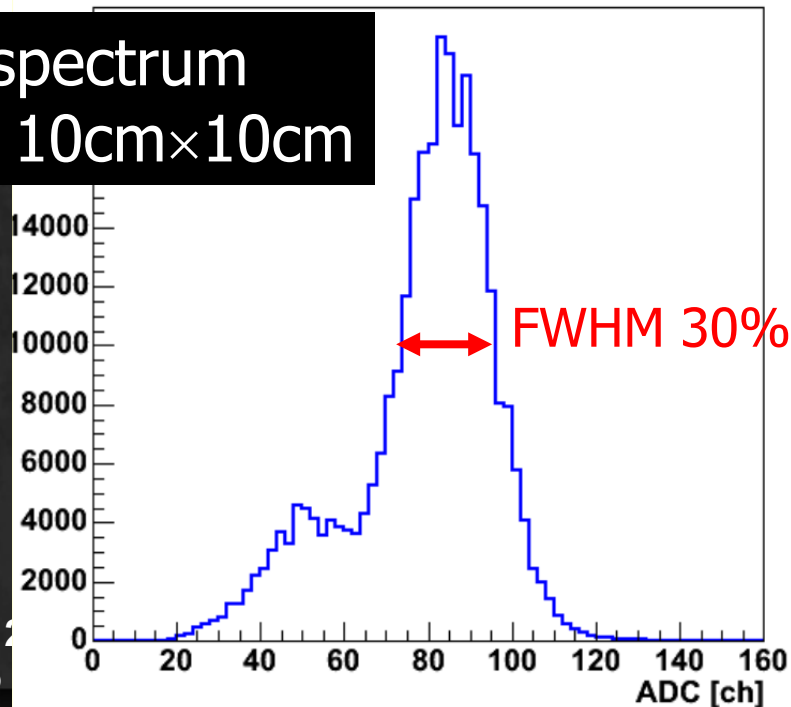
Test chart image



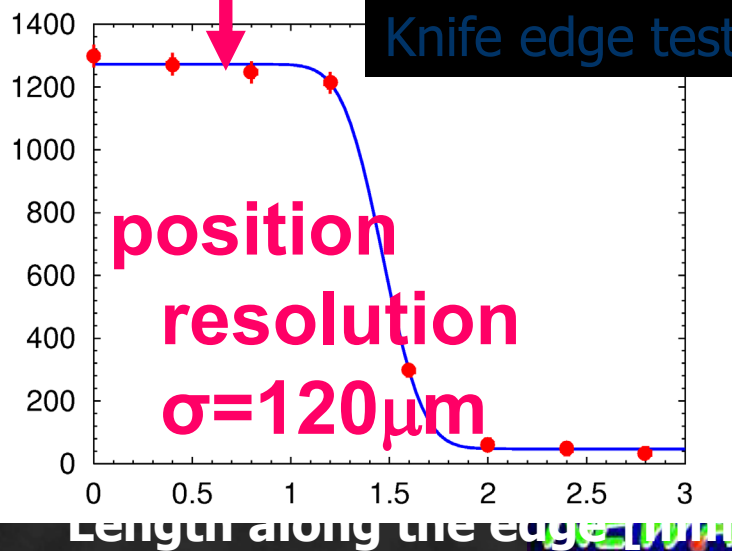
0.5mm slits

1cm

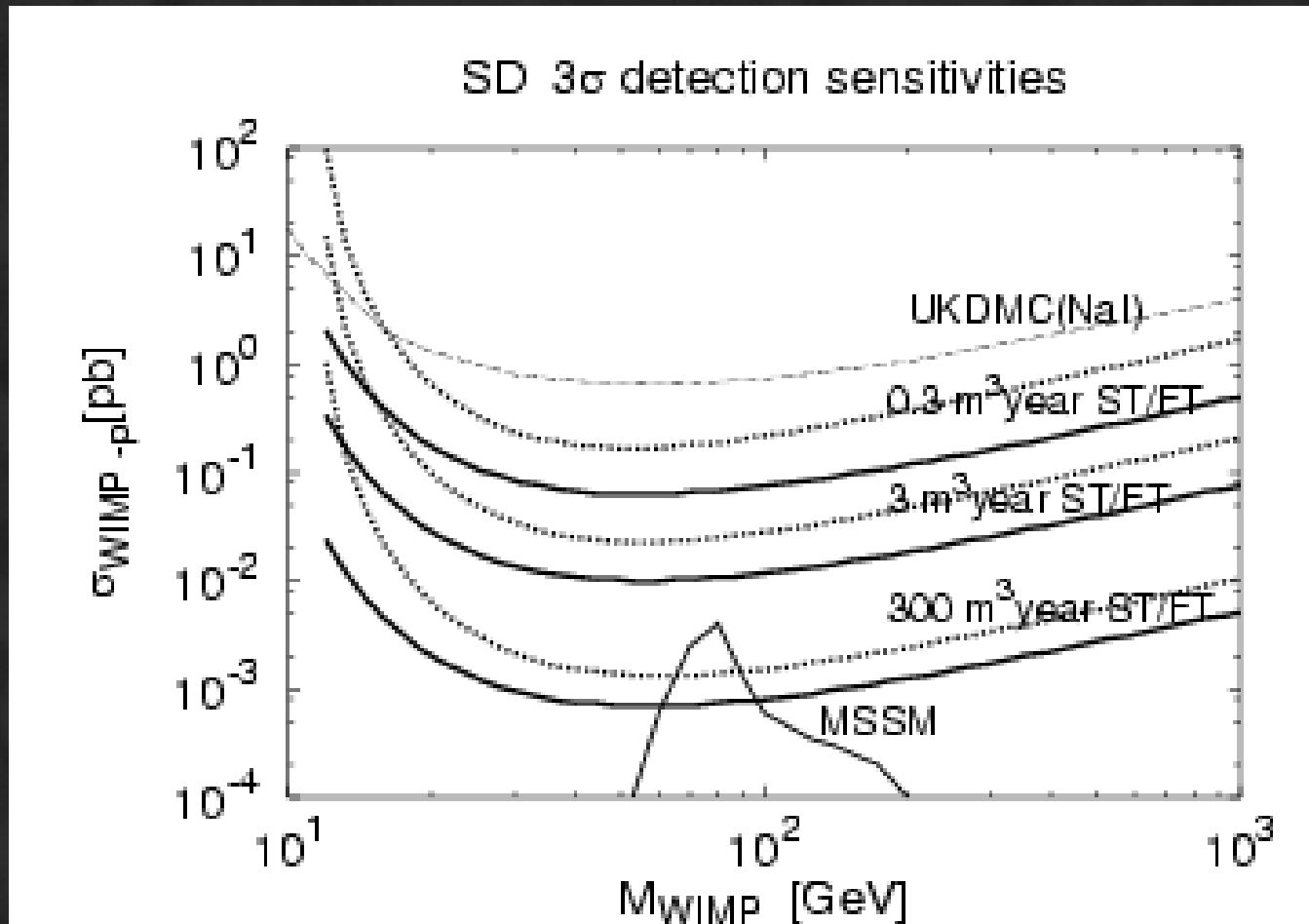
^{55}Fe spectrum
@ 10cm \times 10cm



Knife edge test



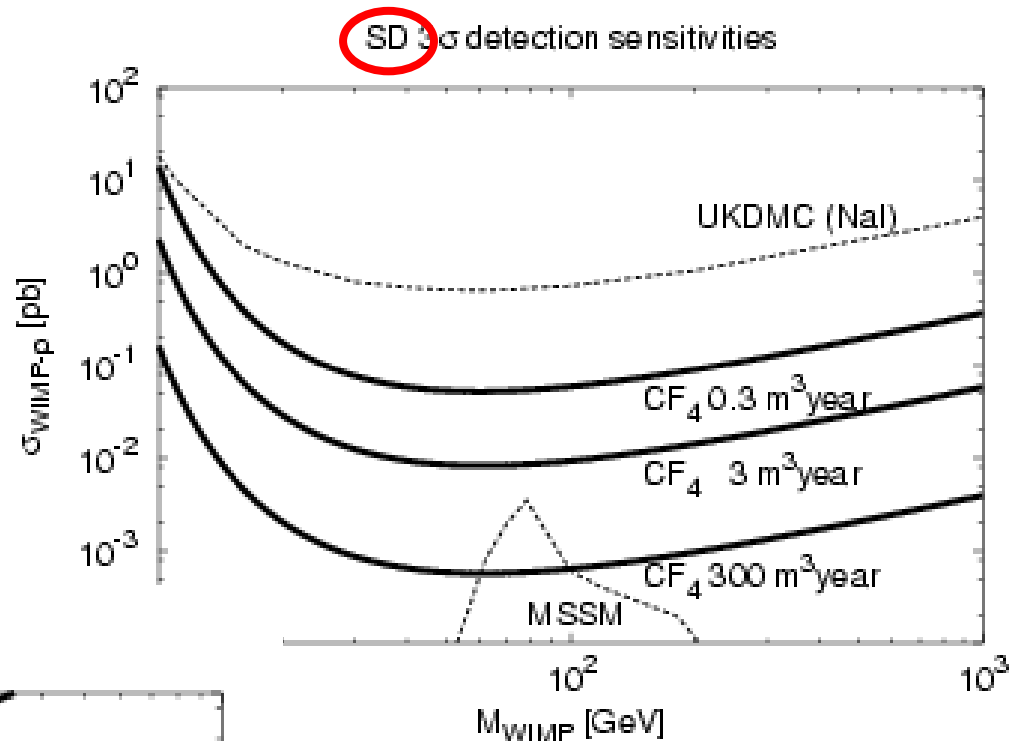
- ◆ “head or tail” are important
 - dotted line: track shape only
 - solid line: track shape + direction



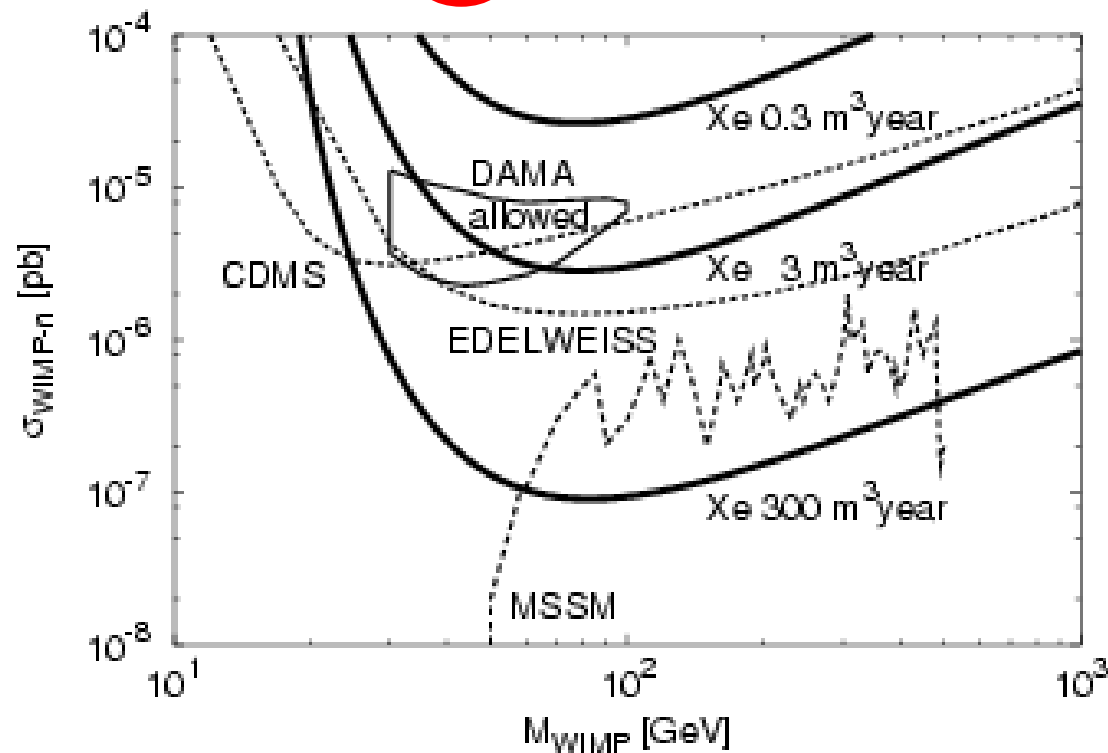
Sensitivities

- “Detection” by Forward/Backward 3σ asymmetry

Simple and reliable



SI 3σ detection sensitivities



**Xe for Spin-Dependent
CF₄ for Spin-Independent**

New Journal of Phys.2(2000)14

