

Low BG TPC for direction-sensitive dark matter search

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9th TPC conference @ Paris

NEWAGE

SR TPC

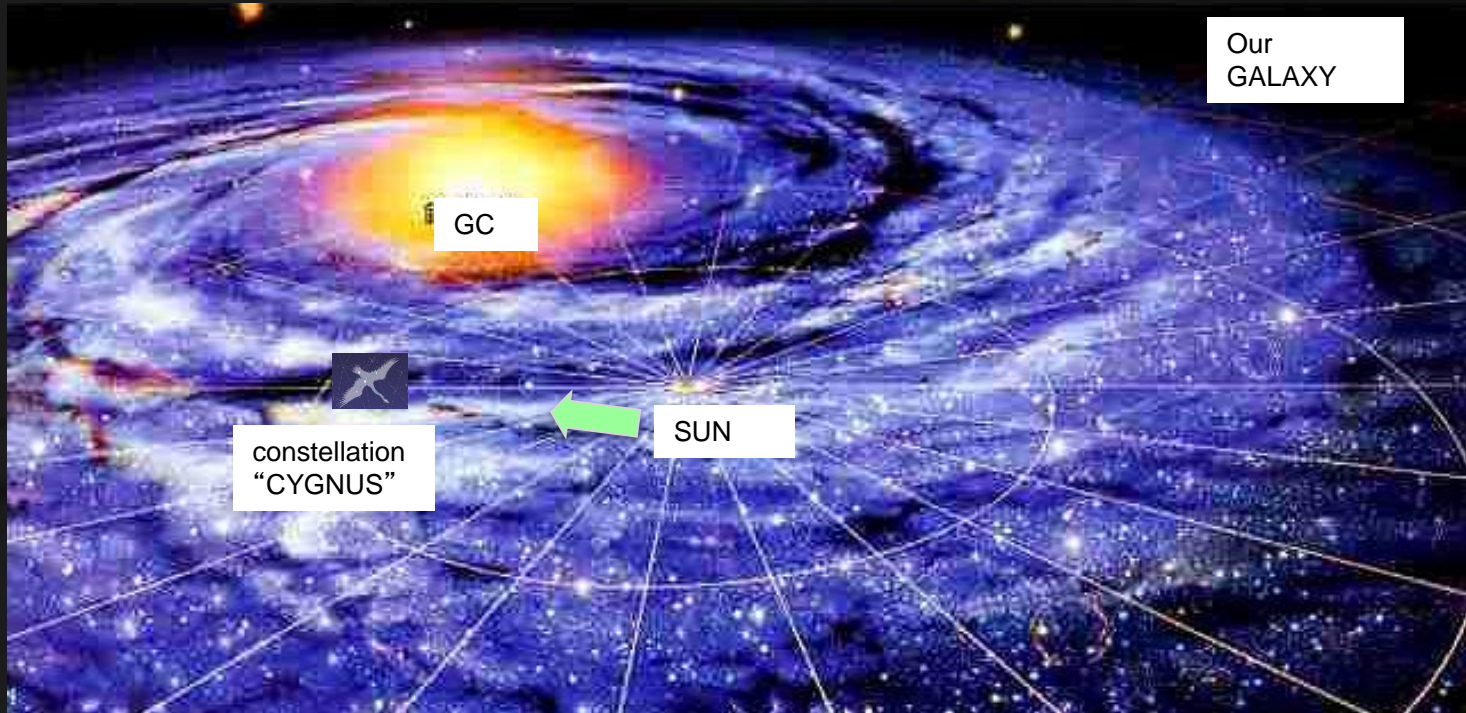
negative ION TPC



*Direction Sensitive
WIMP-search*
NEWAGE

NEWAGE

Direction-Sensitive Dark Matter Search concept “CYGNUS”



WIMP-WIND from “CYGNUS”

NEWAGE

New general WIMP search with an Advanced Gaseous tracker Experiment

μ-PIC(MPGD) based TPC

- 3-D tracks SKYMAP

CF4 gas for SD search

Proposal PLB 578 (2004) 241

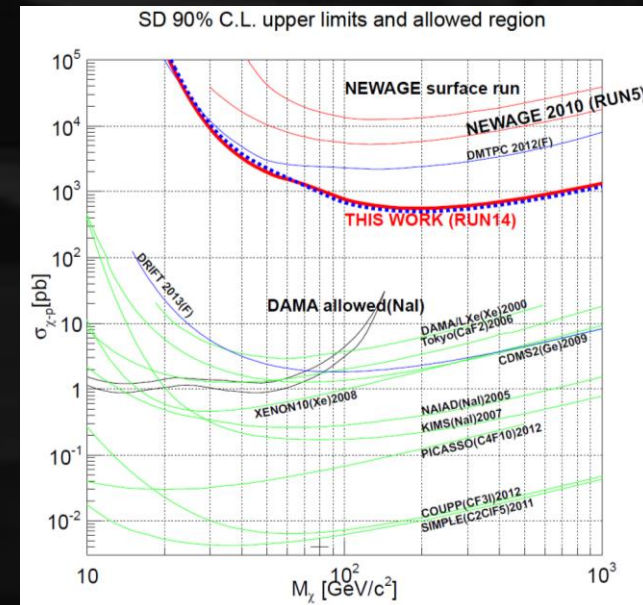
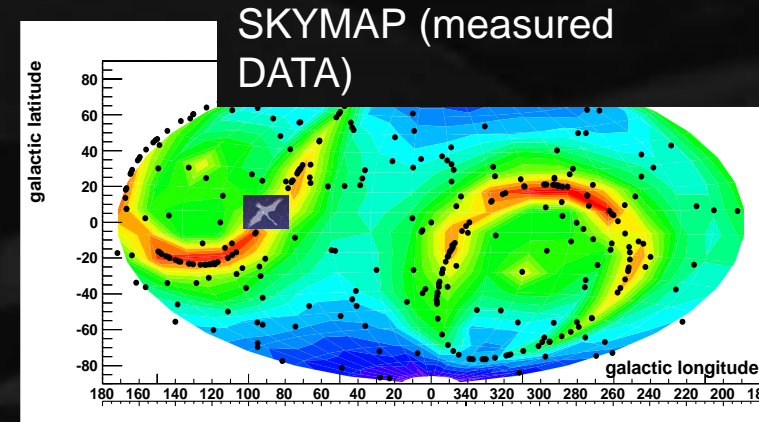
First direction-sensitive limits

PLB654 (2007) 58

Underground results

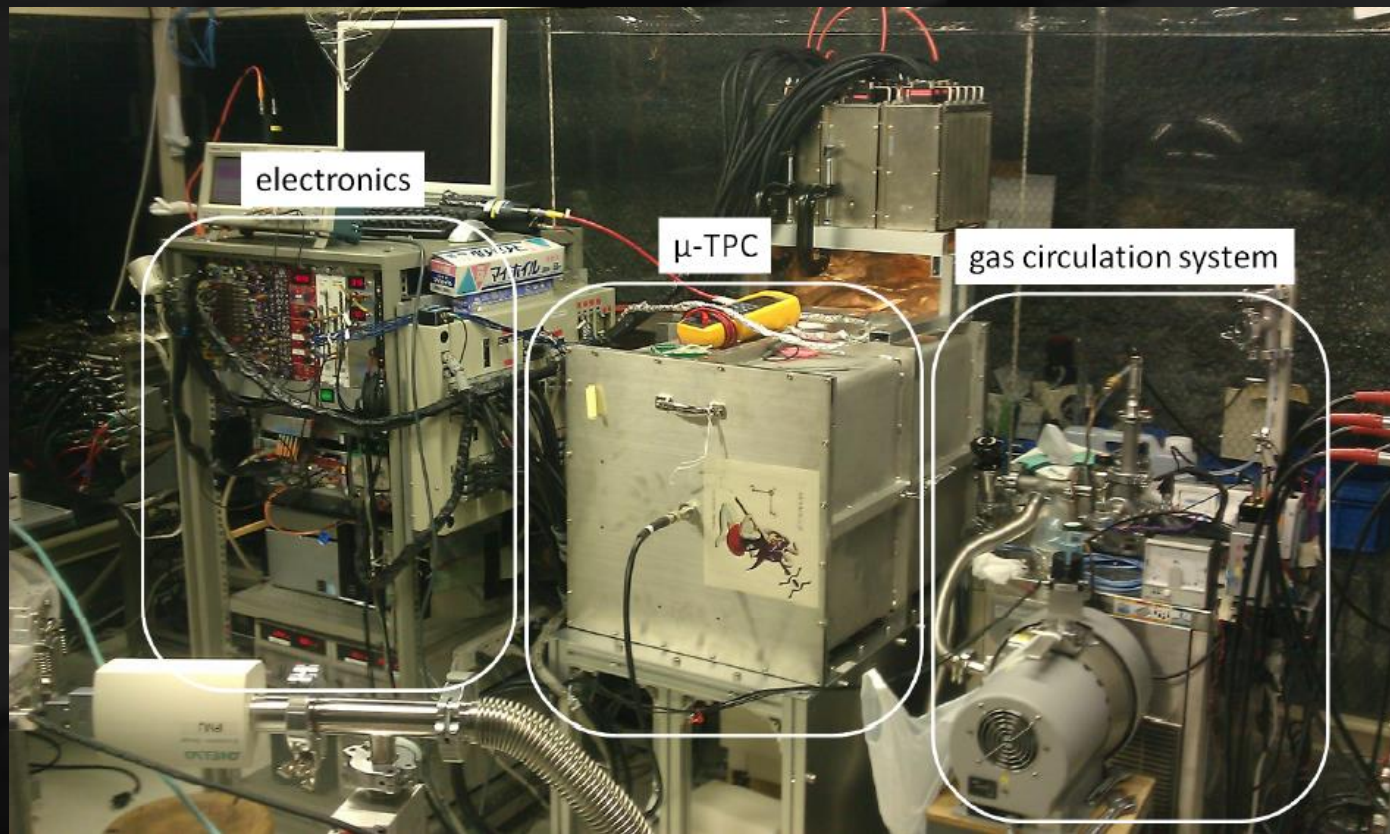
PLB686 (2010) 11, PTEP (2015) 043F01s

Phase for “low BG detector”



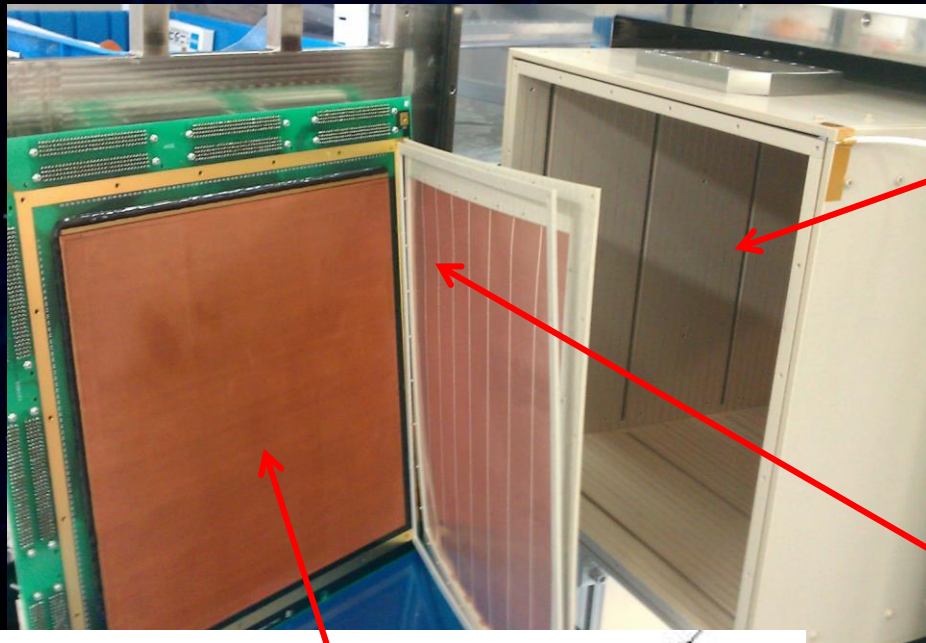
NEWAGE detector

- ✦ 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

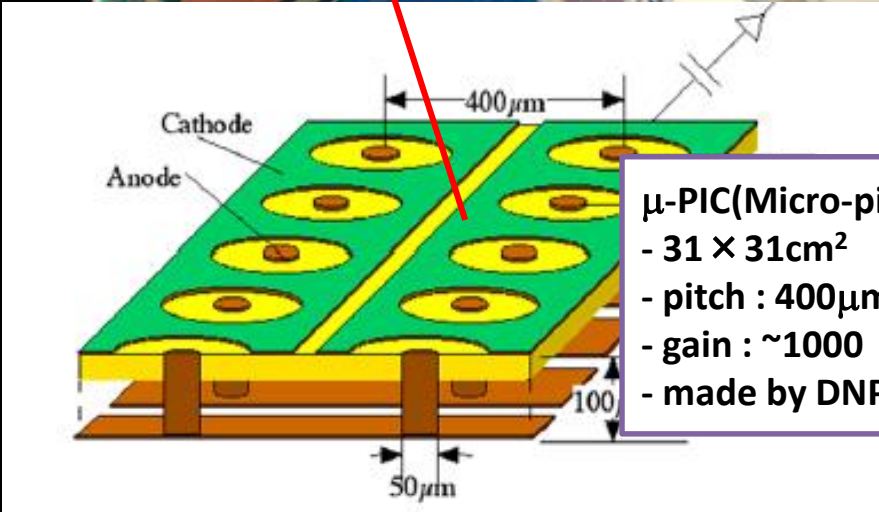
● Detection Volume: $30 \times 30 \times 41 \text{ cm}^3$



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 : ~ 5
- made by Scienergy, Japan

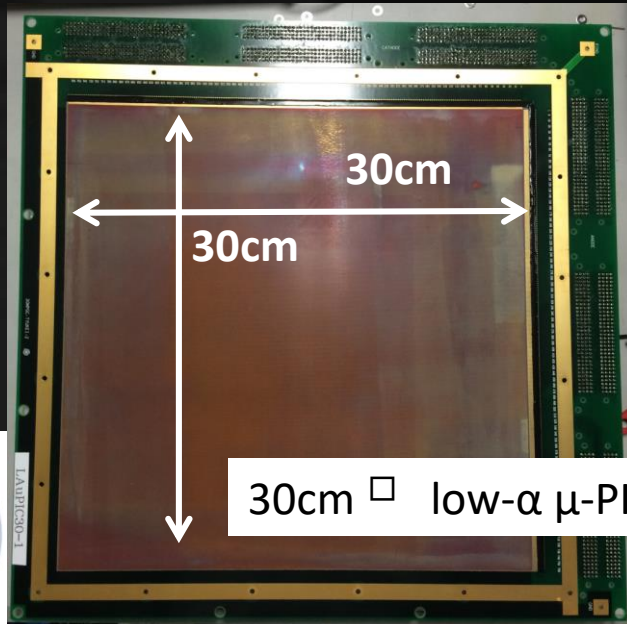
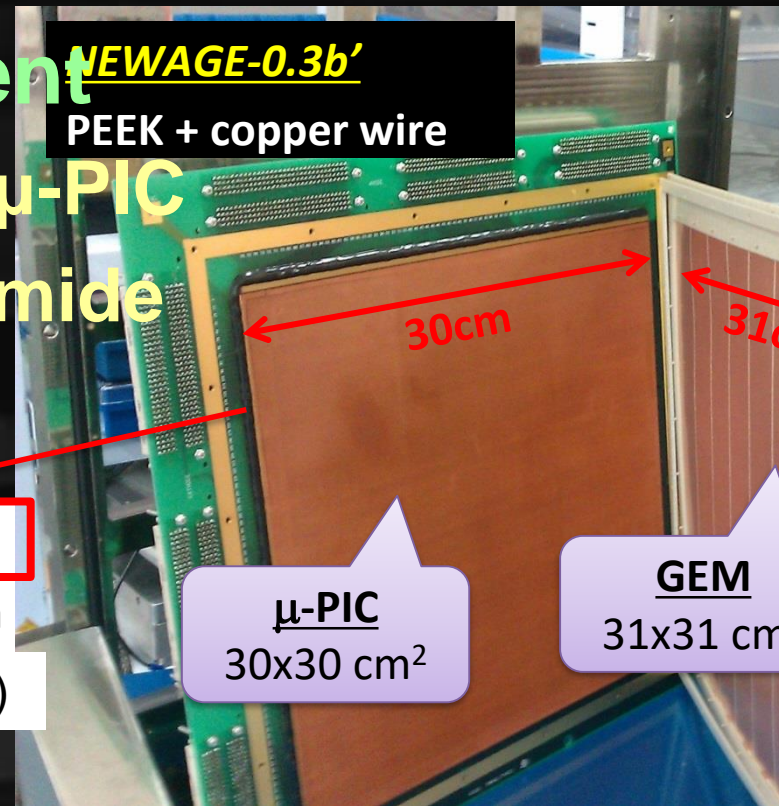
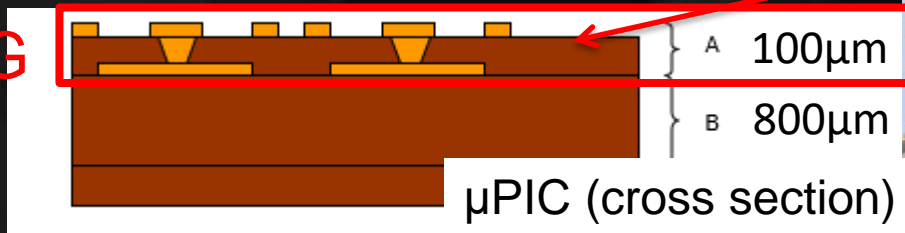


μ -PIC(Micro-pixel chamber)
- $31 \times 31 \text{ cm}^2$
- pitch : $400 \mu\text{m}$
- gain : ~ 1000
- made by DNP, Japan

low- α (LA) μ -PIC development

- main BG : α particles from μ -PIC
- “LA μ -PIC” with clean polyimide (U / Th $\times 1/100$)

low BG

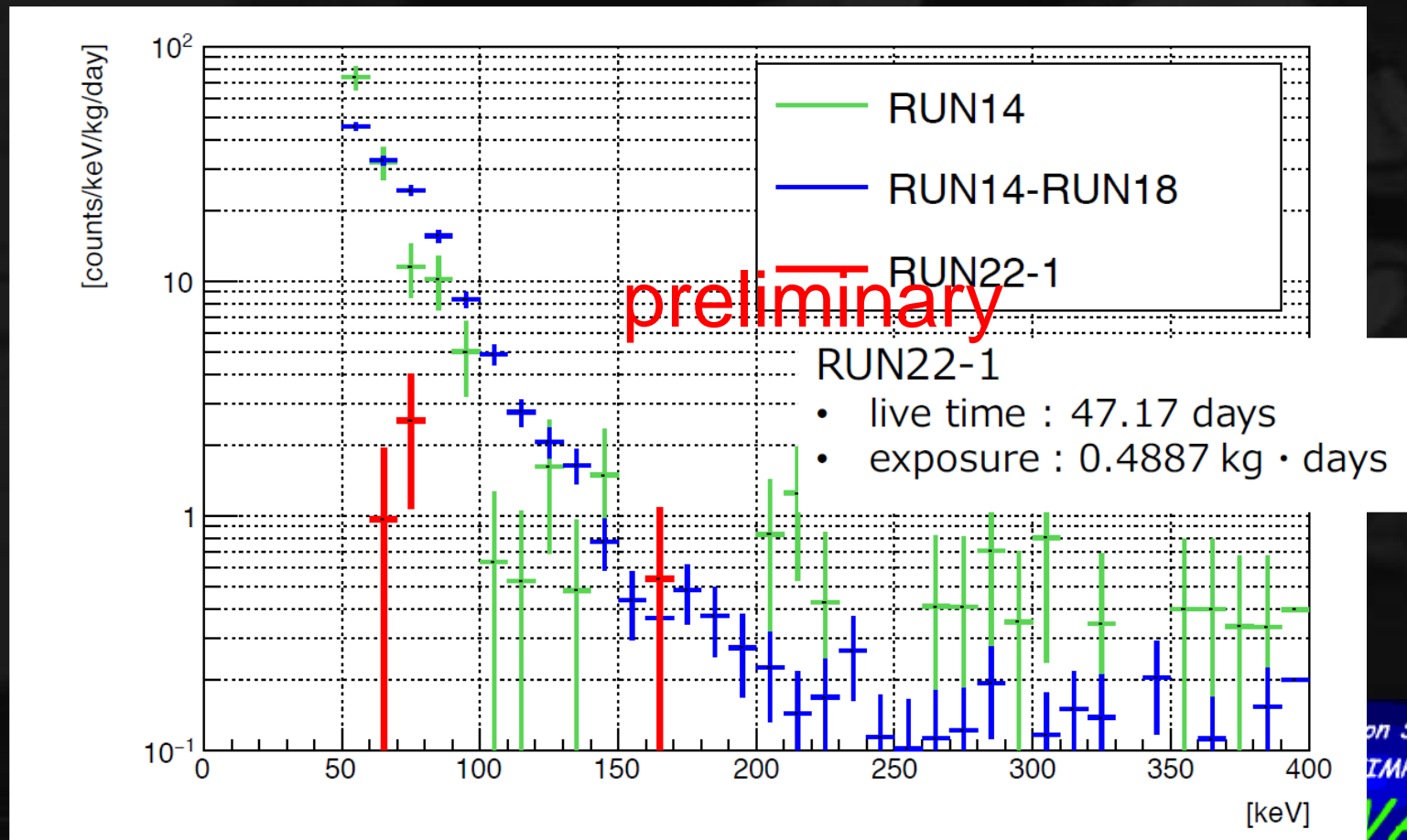


test (\sim Oct 2017)
underground measurement
(Nov 2017 \sim)



Underground run with LA μ -PIC

- **BG $< \times 1/10$**
- **promising start! data taking going on**

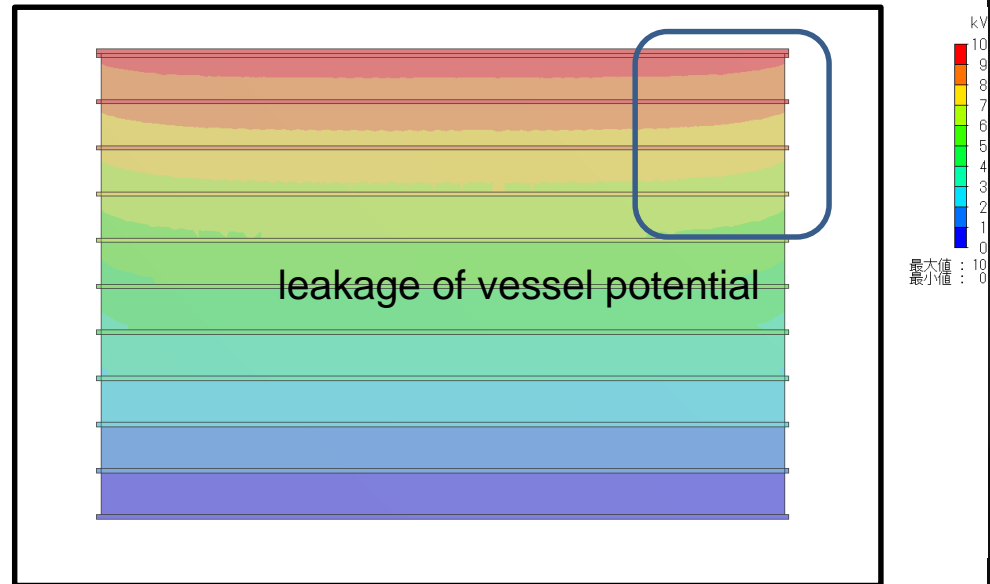
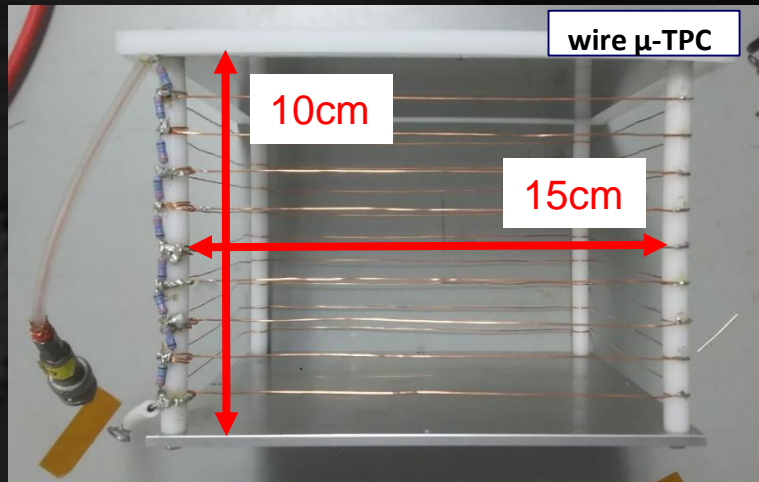


Sheet-Resistor (SR) μ -TPC

motivation

- to overcome potential problem of existing TPCs:
 - distortion of field cage or complicated design
 - radioactive background

⇒ Sheet Resistor (SR) μ -TPC



Vessel=GND

● Proof-of-concept SR μ -TPC ($\sim 10\text{G}\Omega/\square$)

ASONE通販

commercially available materials

The screenshot shows the ASONE website interface. The search results for '帯電防止PVCシート' (Anti-static PVC sheet) are highlighted with a red box. The results list three items:

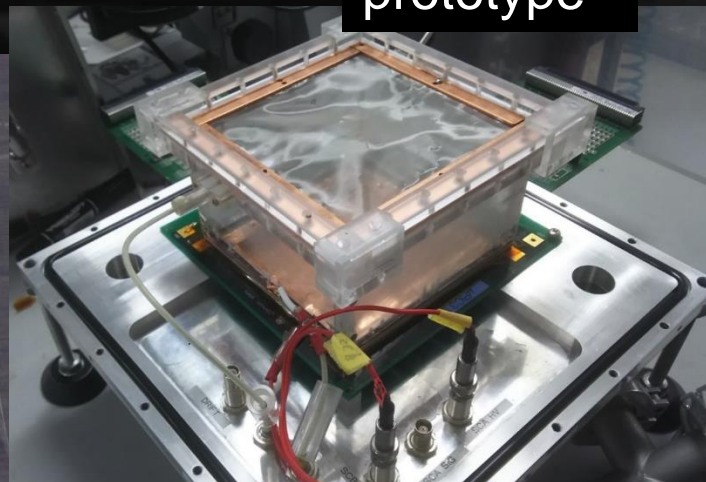
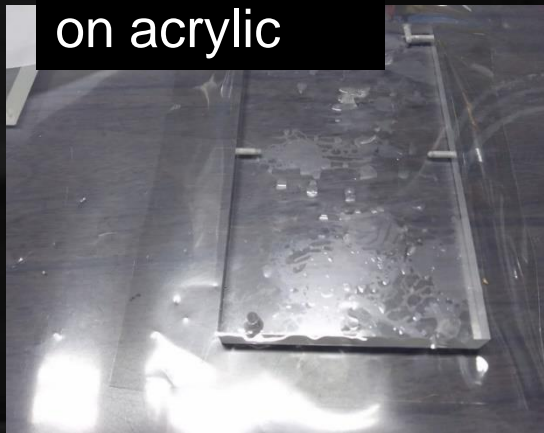
- 1種類の製品があります 標準価格: 9,700円
- 1種類の製品があります 標準価格: 14,200円
- 2種類の製品があります 標準価格: 60,600円~

chosen one : "Achilles Vynilas"
(in terms of) resistivity and
uniformity

thermal press

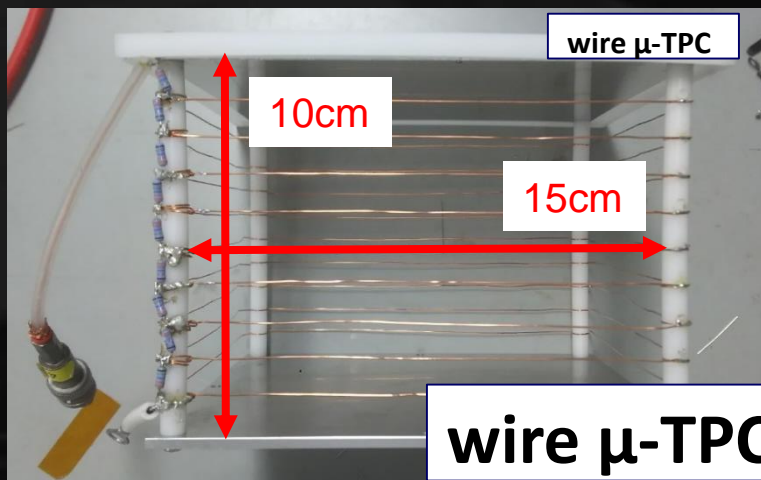
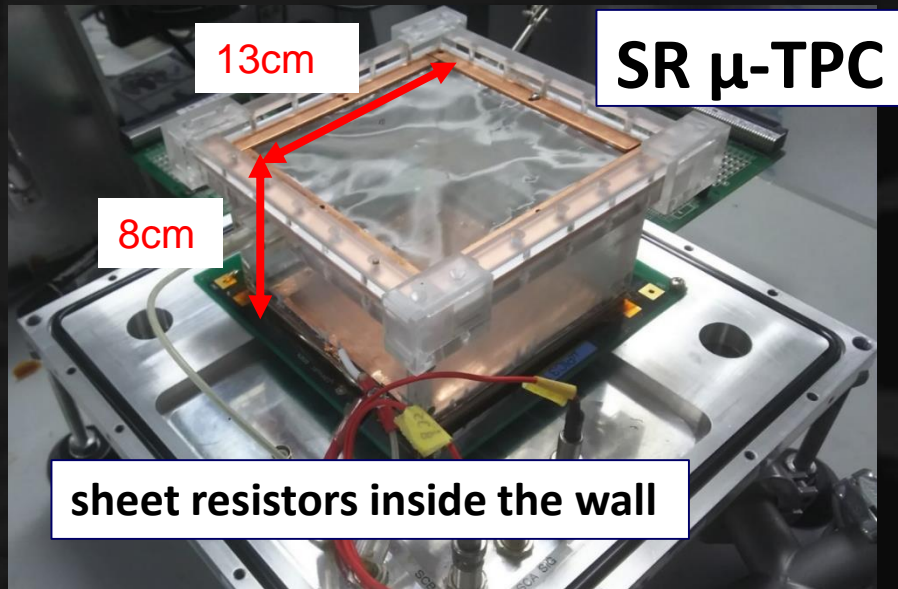
on acrylic

prototype

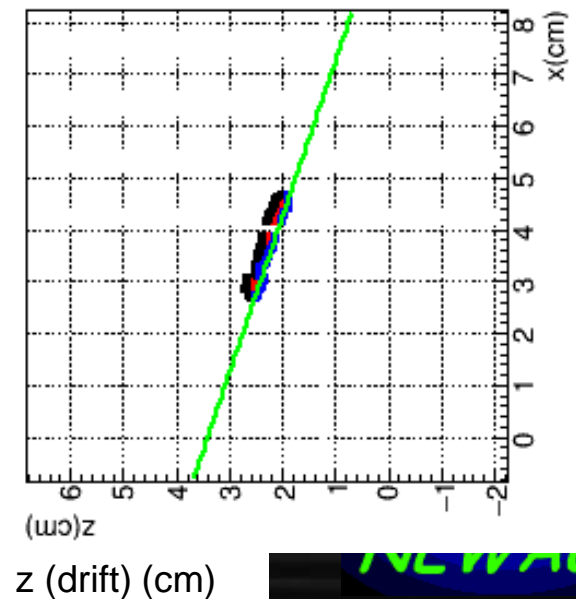
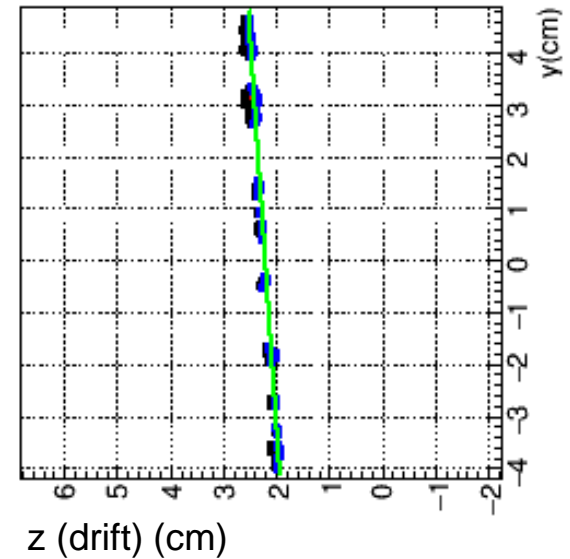


● performance test

- coupled with 10cm μ -PIC
- compared with wire μ -TPC



muon track
measured by SR μ -TPC

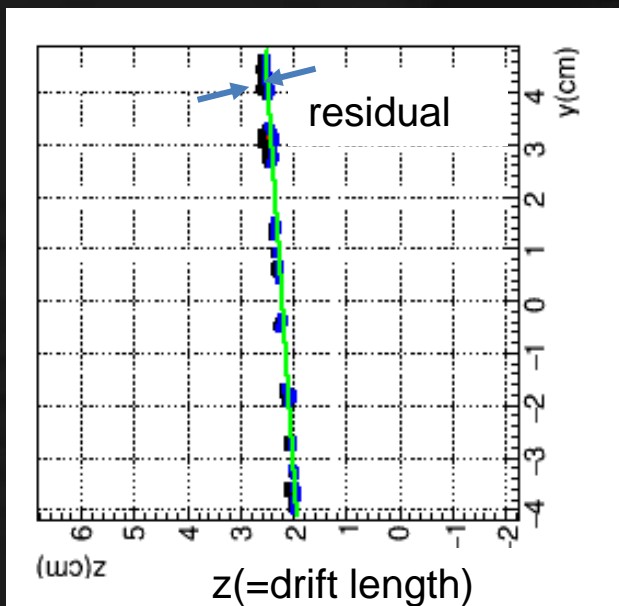


ive
rch

NEWAGE

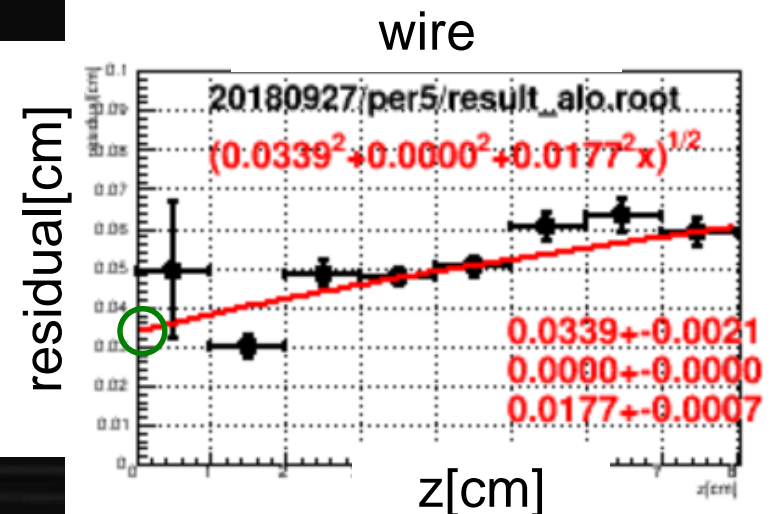
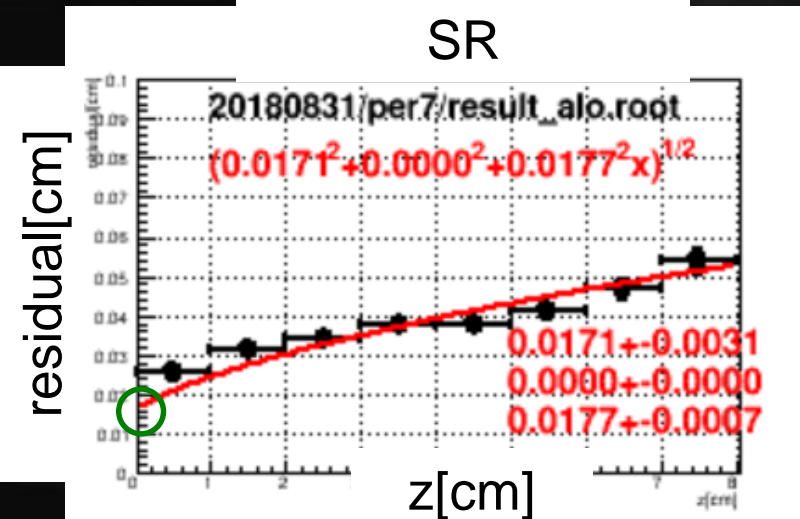
Result

- z-dependence of residual
- → calculate z-independent term



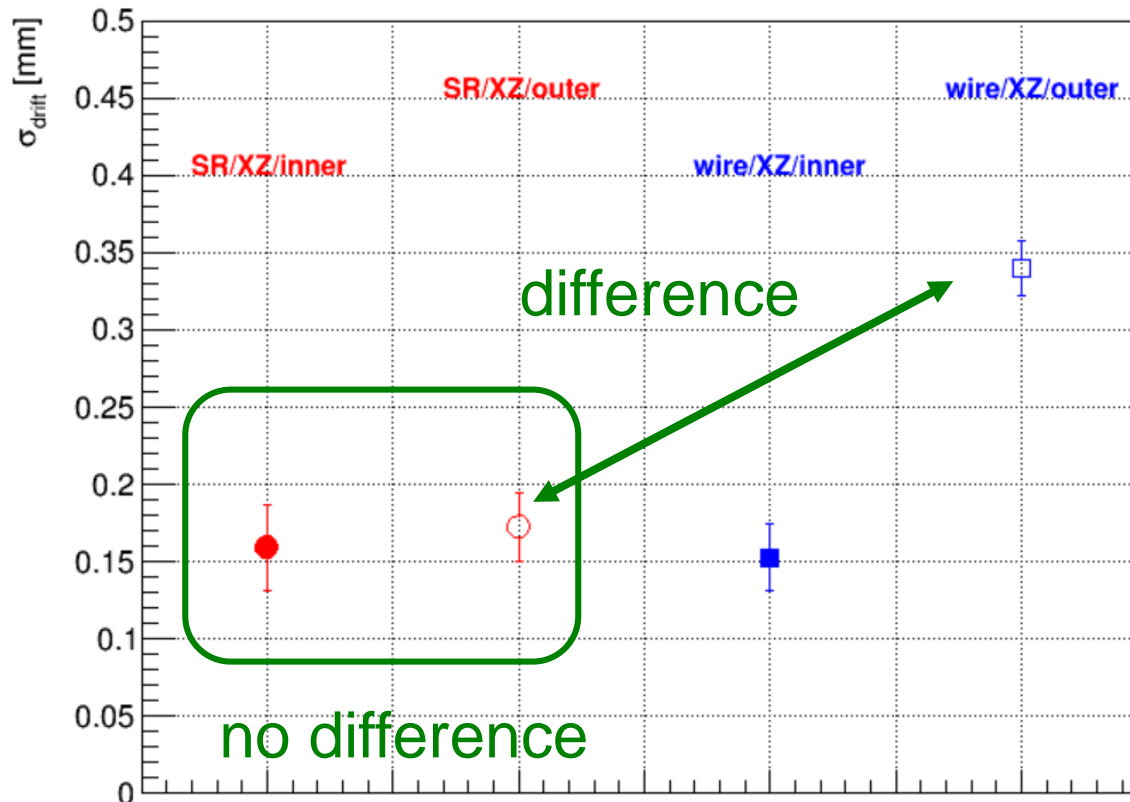
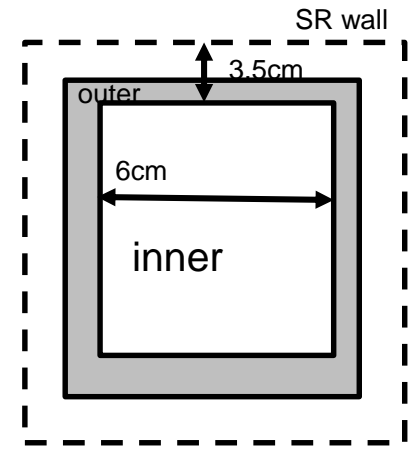
$$\sigma_{i,j,k}^2 = \sigma_{dd,i,j,k}^2 + \sigma_{diff,j}^2(z)$$

$$\sigma_{diff,(i,j,k)} = D_{diff,(j)} \sqrt{z}$$



Results (residual distributions)

- compare SR/wire \otimes inner/outer
- SR shows better position resolution @ outer than wire

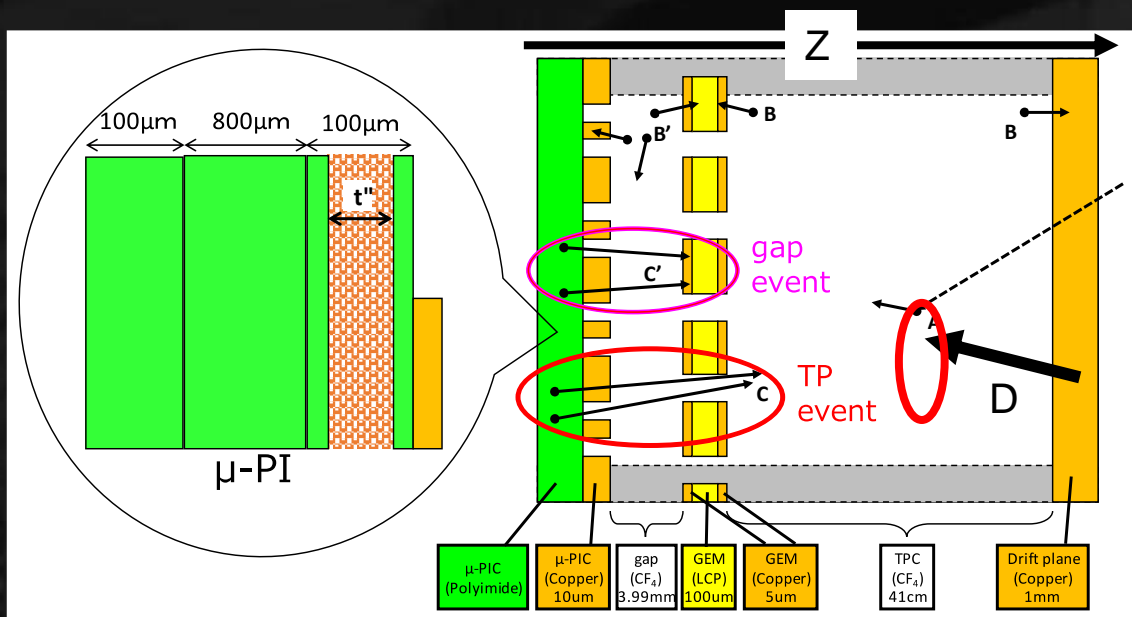


Negative ION TPC R&D

(originally assigned to N. Spooner)

Z-fiducialization

- For self-triggering TPC: t_0 cannot be detected
→ Z-fiducialization is (was) not possible



serious background:
- readout plane
- cathode (drift) plane

breakthrough for “z” detection

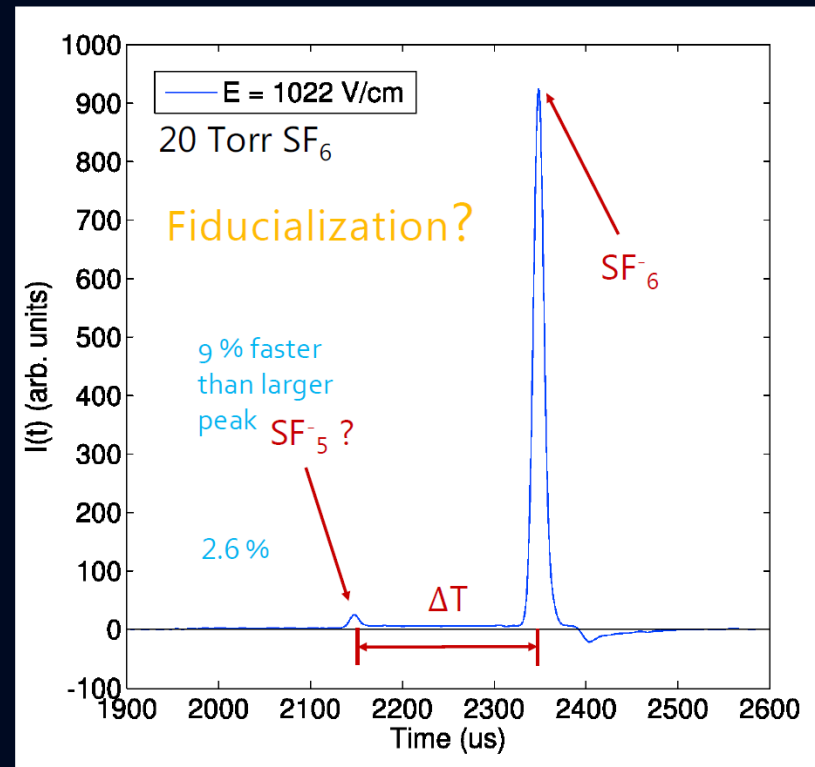
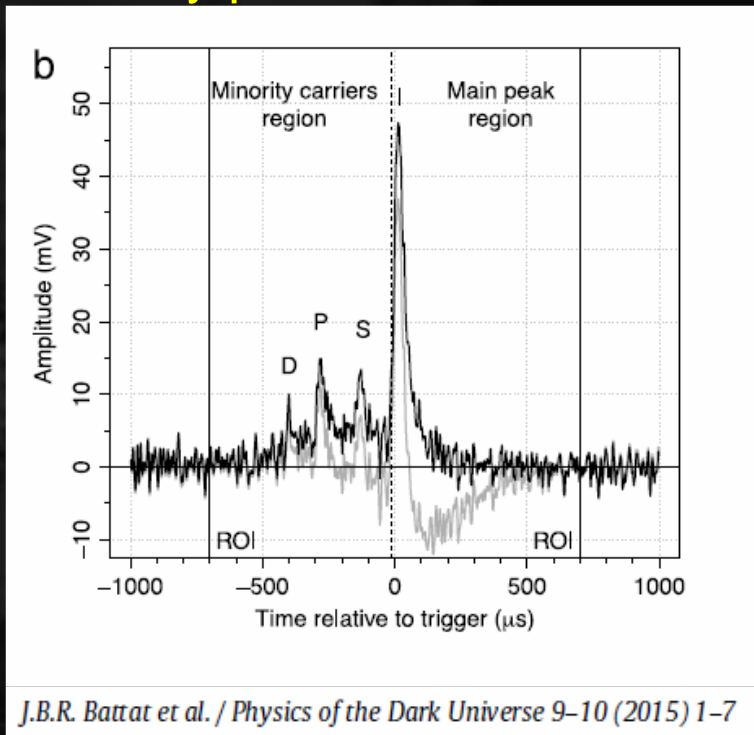
- minority peaks “discovery” (DRIFT group)
- O₂ addition to CS₂+CF₄ gas
- SF₆ gas

$$z = (t_a - t_b) \frac{v_a v_b}{(v_b - v_a)}$$

several species of ions with different velocities

SF₆ results

minority peaks



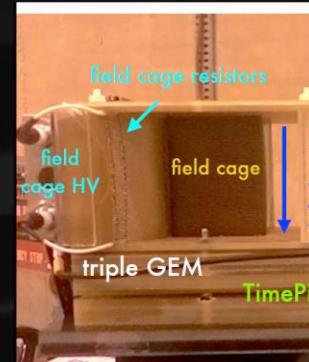
World-wide SF₆ activities (convener: Miuchi)

- Wide varieties of MPGD(micro patterned gaseous detectors)
- very active, new comers are welcome!

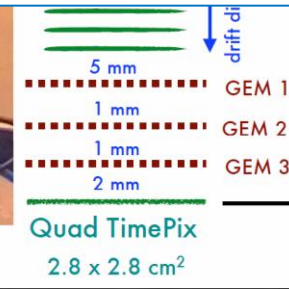


New Mexico
thick(400um) GEM (3 × 3cm²)
CERN 0.5mm pitch, Φ0.3mm

gas gain
2000@30Torr
30,40,(60) Torr

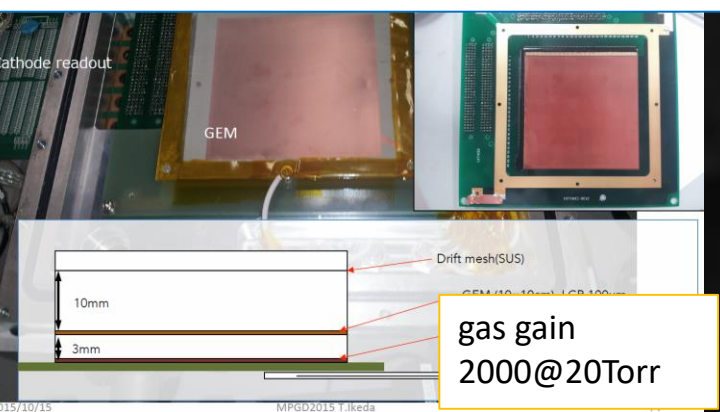


Italy
triple thin(50um) GEM (3 × 3cm²)
CERN, 50um pitch, Φ30um



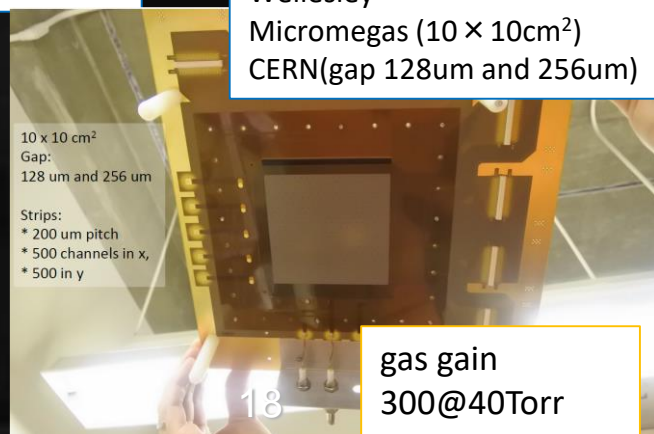
gas gain
5000@ 175Torr, 2000@370Torr

Kobe
thin(100um) GEM (10 × 10cm²) Scienergy, 140um pitch, Φ70um
+ μ-PIC(10 × 10cm²) DNP, 400um pitch strip readout
triple thin (100um) GEM Scienergy, 140um pitch, Φ70um



gas gain
2000@20Torr

Wellesley
Micromegas (10 × 10cm²)
CERN(gap 128um and 256um)



gas gain
300@40Torr

Sheffield
thick(400um) GEM(50 × 50cm²)
UK , 0.5 um pith Φ0.3mm

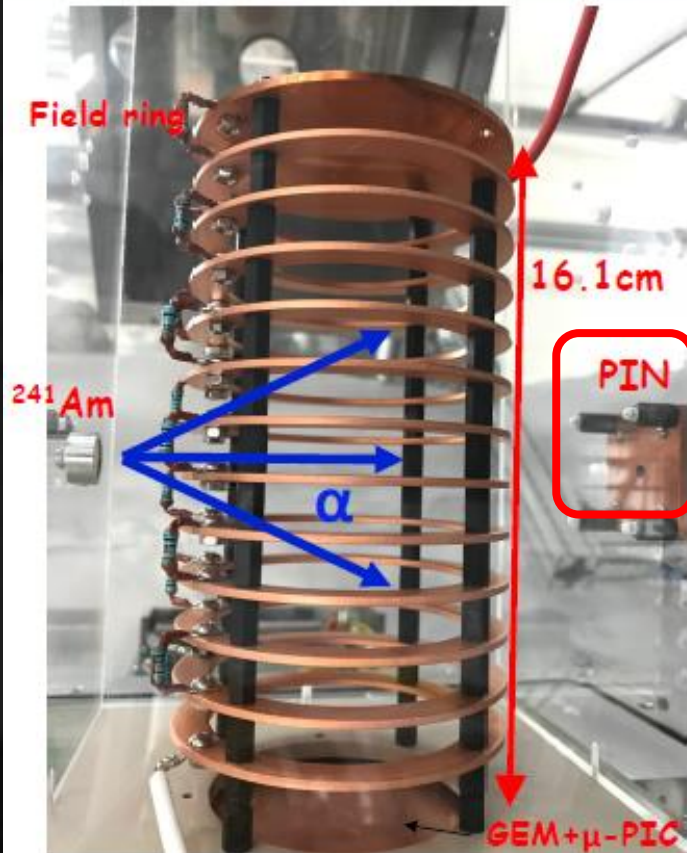


gas gain
6000@30,40Torr

◆ KOBE's activity μ -PIC in SF6

- tracking test (α -rays)
- ASIC development
- simulation (Garfield++)

Tomonori Ikeda



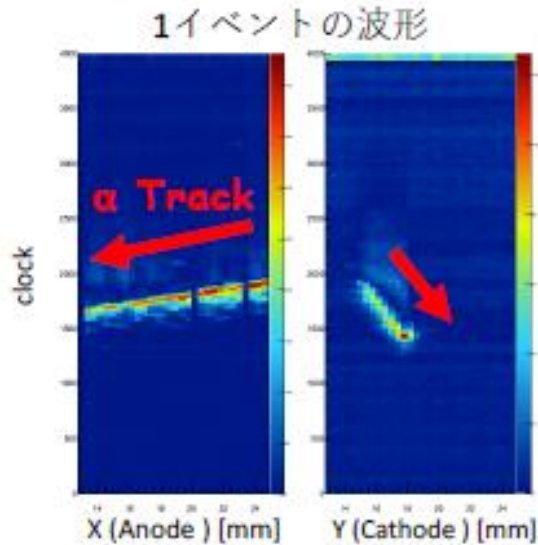
Liq argon electronics (LTARS2014)
GEM (LCP 100 μ m-thick)+ μ -PIC
PIN photodiode for trigger
detection volume

$1.28 \times 1.28 \times 16.1$ cm
anode(32ch) cathode(32ch)

SF6 20 Torr

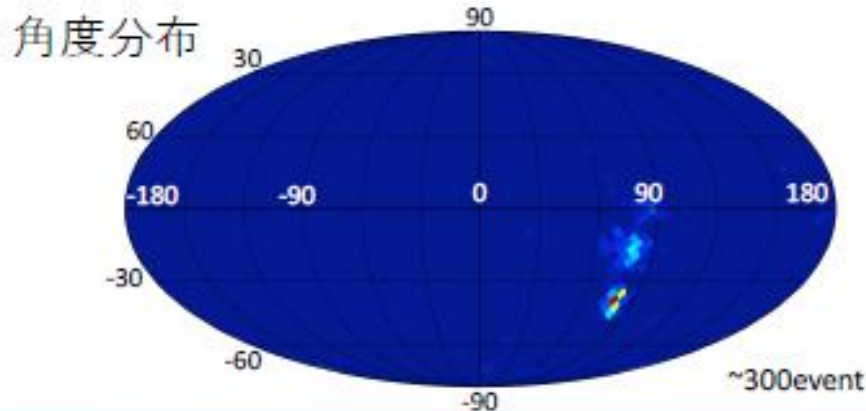
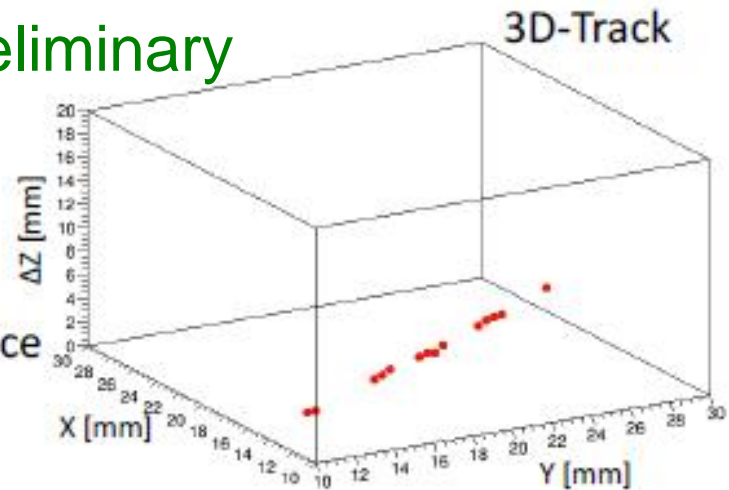
3D tracking + z-fiducialization (first!)

Tomonori Ikeda JPS
Mar2018



preliminary

coincidence



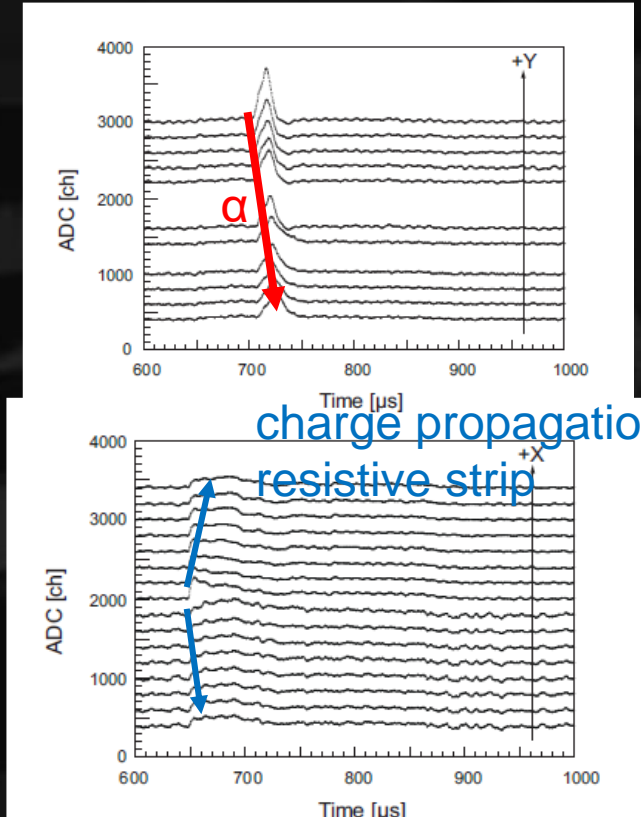
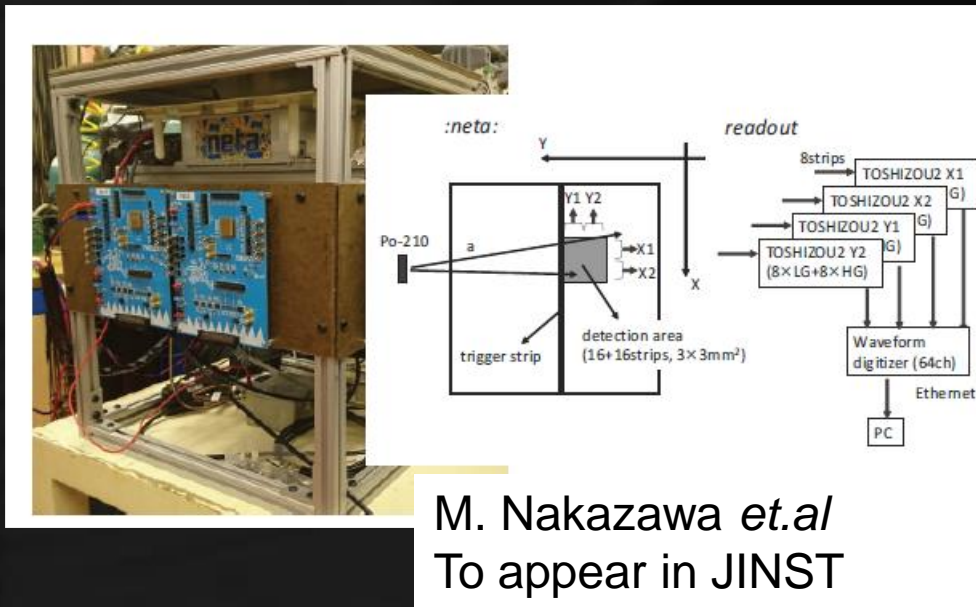
^{241}Am 配置図



paper in preparation

ASiC (cont'd)

- Test at Wellesley (Oct 2018) coupled with micromegas
- 16ch+16ch active area



2D tracking of α was confirmed
Test at Sheffield (Dec 2018) ongoing
LTARS 2018 being designed.

SUMMARY

- ◆ low BG μ -PIC developed
- ◆ SR TPC
- ◆ SF6: 3D track + fiducialization