

# NEWAGE

(New generation WIMP search  
with an advanced gaseous tracker experiment)

**Kentaro Miuchi**  
**(Kyoto University)**

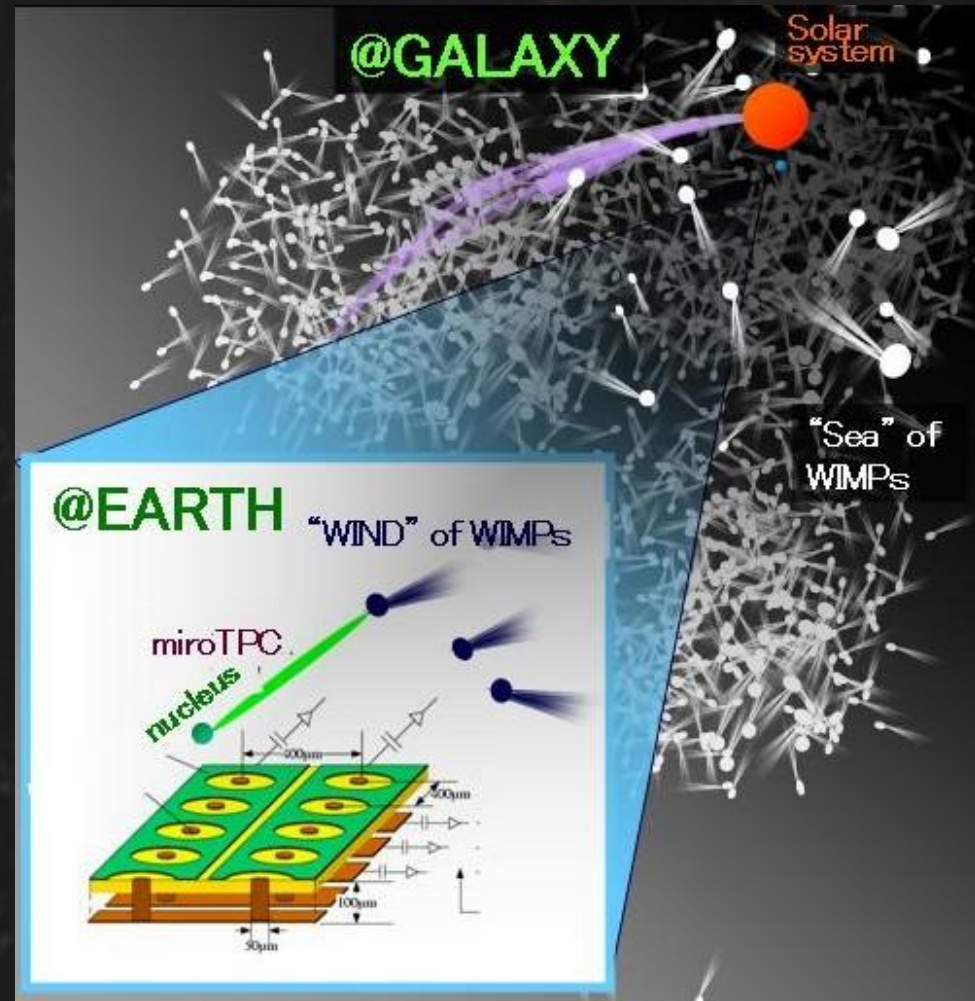
with

K. Nakamura, H. Nishimura  
T. Tanimori, H. Kubo,  
J. Parker, A. Takada,  
S. Iwaki, T. Sawano,  
Y. Matsuoka, Y. Sato, S. Komura  
(Kyoto)

A. Takeda, H. Sekiya  
(Kamioka)

A. Sugiyama, M. Tanaka,  
T. Fusayasu (QPIX)

K. Miuchi June 9, 2011 CYGNUS 11



# OUTLINE

## ◆ NEWAGE

- overview

## ◆ Since CYGNUS 2009

- sensitivity improvement :  
NEWAGE-0.3a(Kamioka)
- for next step: NEWAGE-0.3b(Kyoto)
- fundamental studies: NEWAGE-0.1a (Kyoto)
- R&D for future: QPIX(KEK)

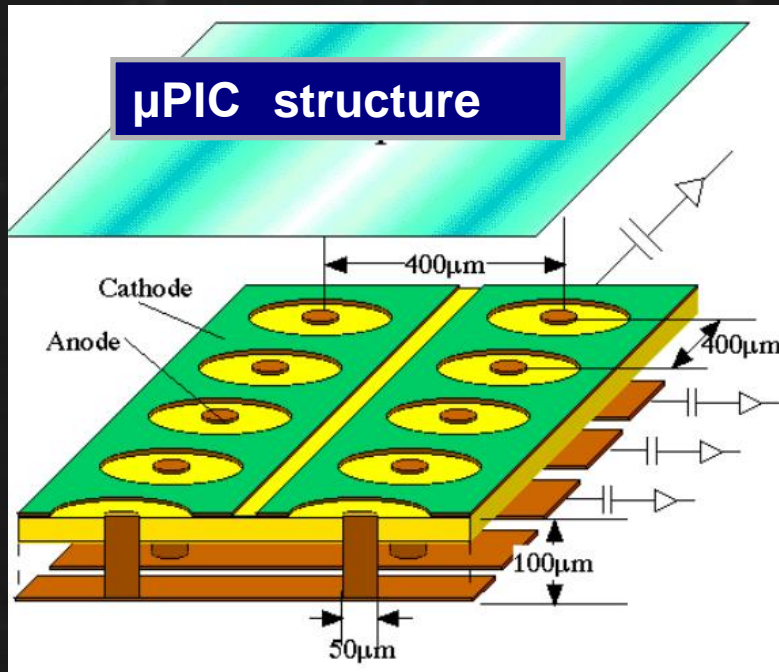
## ◆ Summary



# NEWAGE: overview

## μ PIC (developed in Kyoto)

( one of the Micro Patterned Gaseous Detectors )

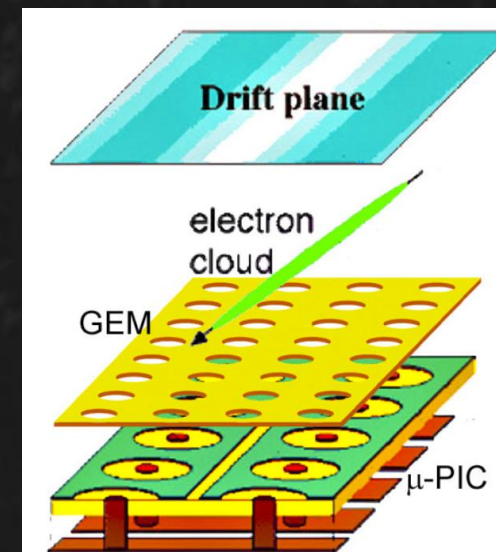


## μPIC SPECs

- ◆  $30 \times 30 \text{cm}^2$
- ◆ Gas amplification + readout
- ◆  $400 \mu\text{m}$  pitch
- ◆  $768 + 768$  readouts
- ◆ with GEM (sub amplifier)
- ◆ 3D tracks
- ◆  $\text{CF}_4$

## NEWGAE History

- ◆ Proposal PLB 578 (2004) 241
- ◆ first result PLB 654 (2007) 58
- ◆ underground result PLB 686 (2010) 11



# Readout electronics

## DIGITAL : Tracking

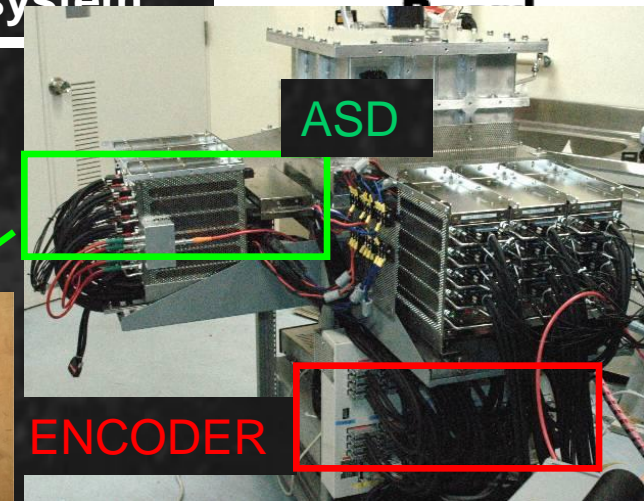
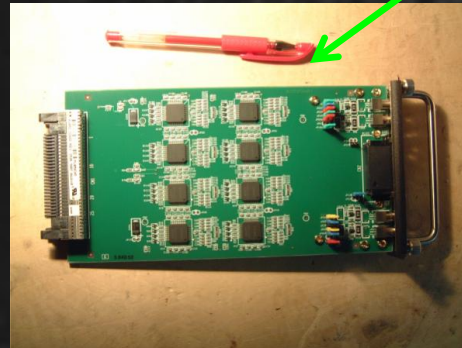
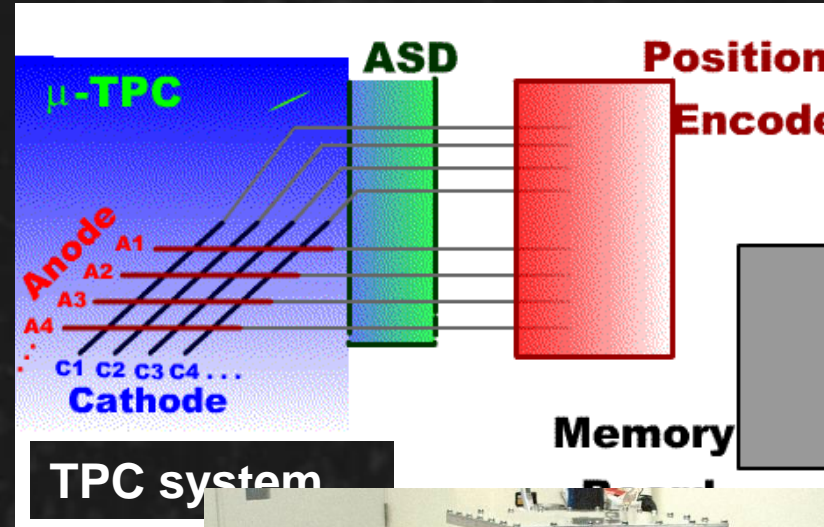
- 768 anode + 768 cathode
- Digital (LVDS) signals at ASD
- (X,Y,T) at the position encoder
- 100MHz pipeline

## ANALOG : energy

- 768 cathode –sum--> 4ch

## DATA size

- 16k byte /event
- ~ 20Gbyte /month @0.5Hz



# As of CYGNUS 2009

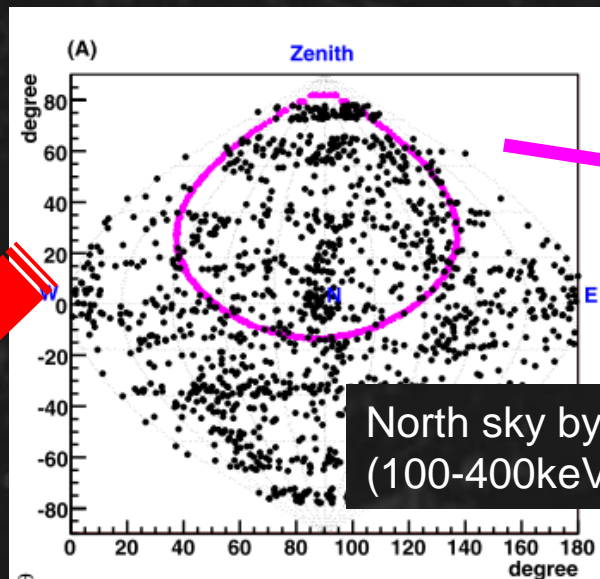
(PLB 686 (2010) 11)

- First underground results

- The sky map

-->  $\cos\theta$  distribution

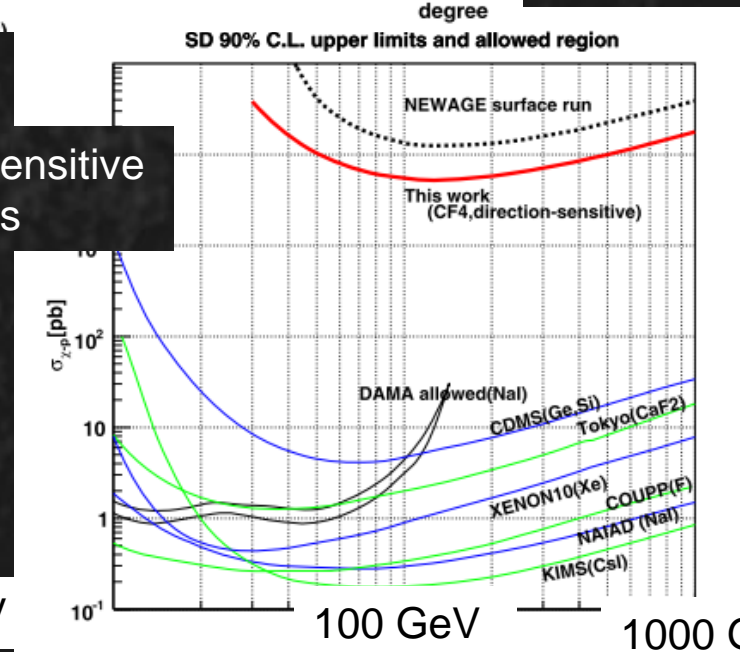
--> upper limits



DM direction

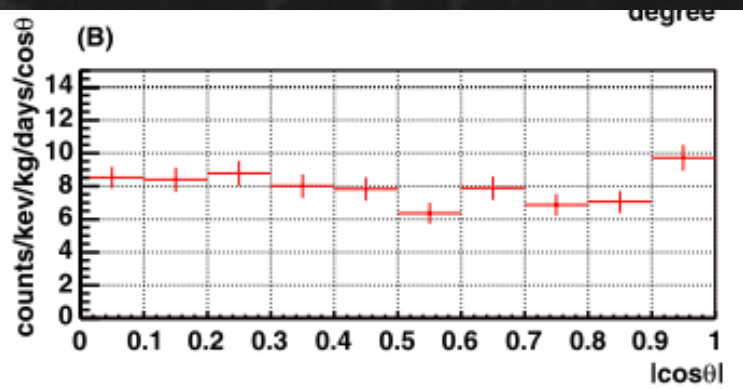
North sky by C and F nuclei (100-400keV)

direction-sensitive upper limits



Sensitive  
p-search  
ACE

10 GeV



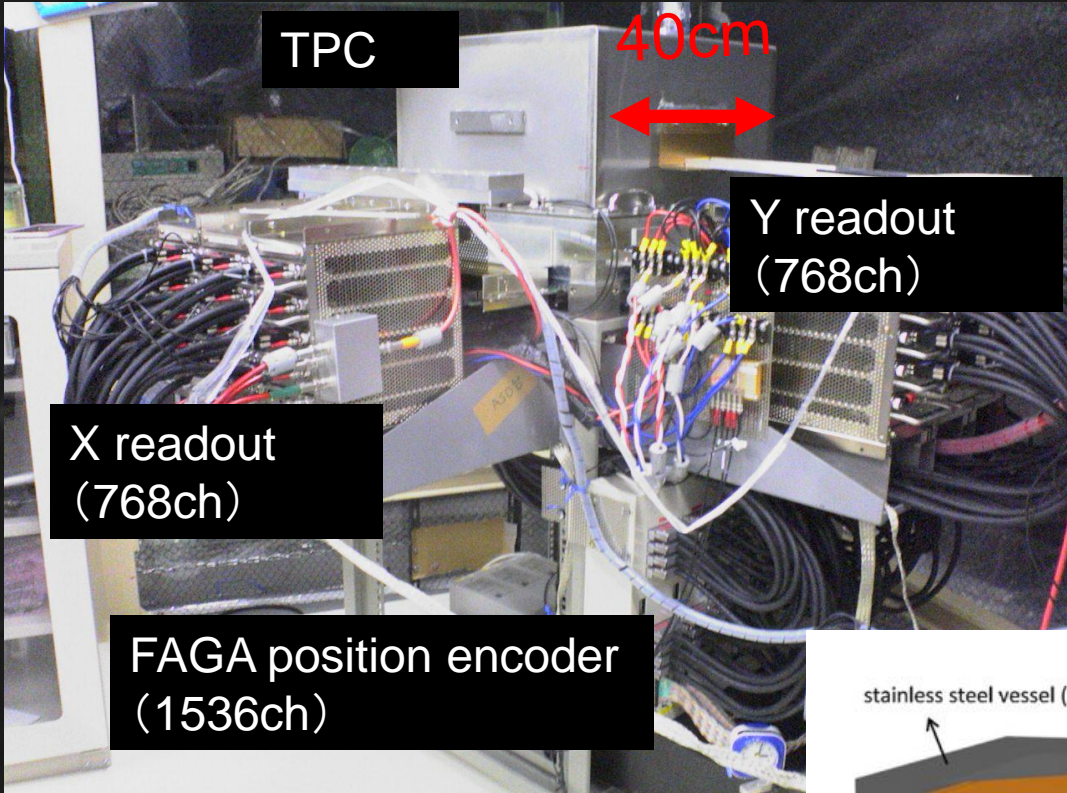
Cosθ distribution (100-400keV)

# first step BG $\times 10$

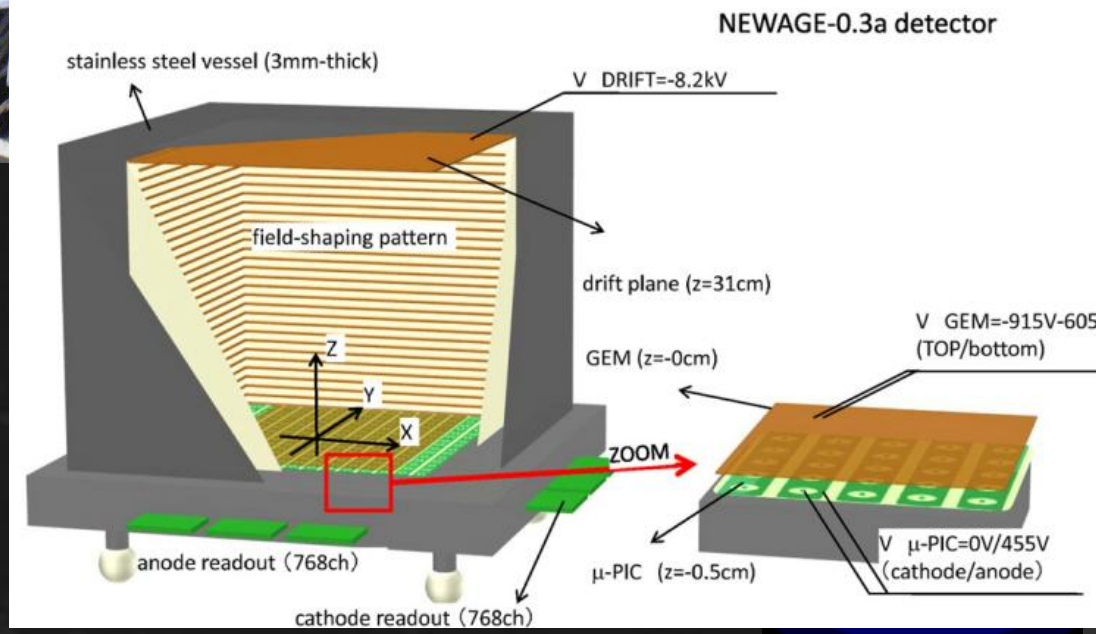
- ◆ **sensitivity improvement :**  
**NEWAGE-0.3a(Kamioka)**
- ◆ **for next step: NEWAGE-0.3b(Kyoto)**
- ◆ **fundamental studies: NEWAGE-0.1a (Kyoto)**
- ◆ **R&D for future: QPIX(KEK)**



# NEWAGE-0.3a (Kamioka)



- $23 \times 28 \times 31 \text{ cm}^3$
- 152torr  $\text{CF}_4 = 11.48\text{g}$



# Radon: charcoal

- gas circulation system
- monitor radon rate ( $\sim 6\text{MeV}$ )
- radon rate 1/10 after day 10

charcoal filter  $\sim 100\text{g}$

(TSURUMICOAL 2GS)

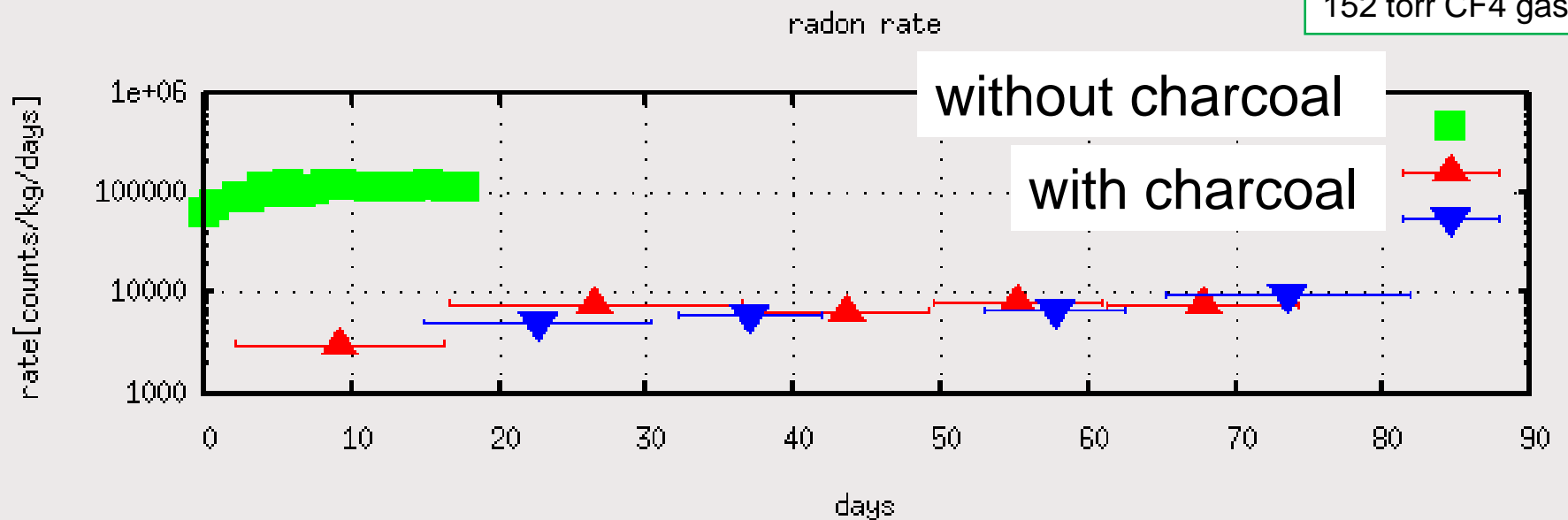
getter pump

(SAES GETTER C400-2DSK)

circulation

(Teflon bellows pump)

NEWAGE0.3a  
152 torr CF<sub>4</sub> gas

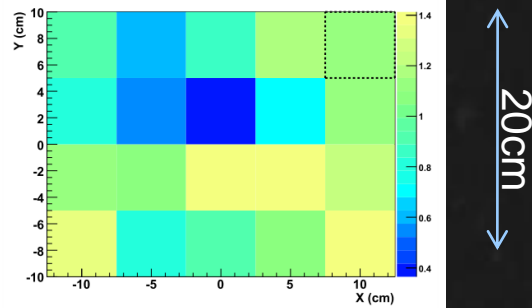


cf:  $1\text{e}5\text{counts/kg/days} \sim 1\text{Bq/m}^3$

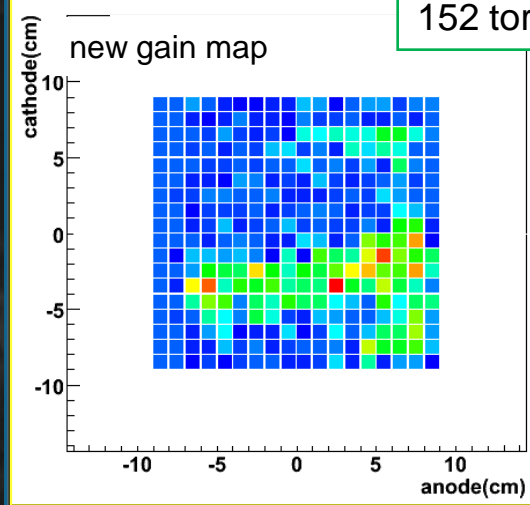


# gamma: precise gain map

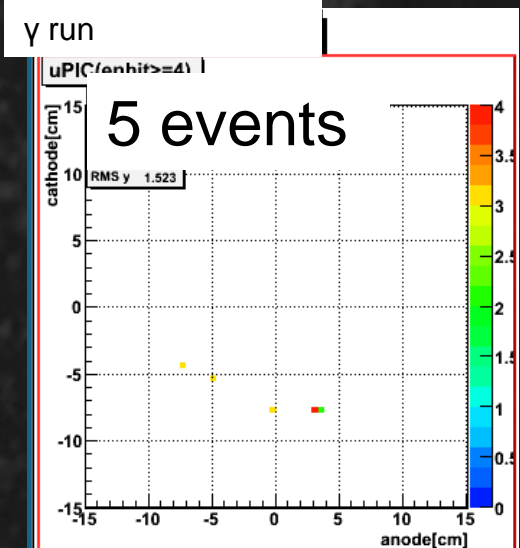
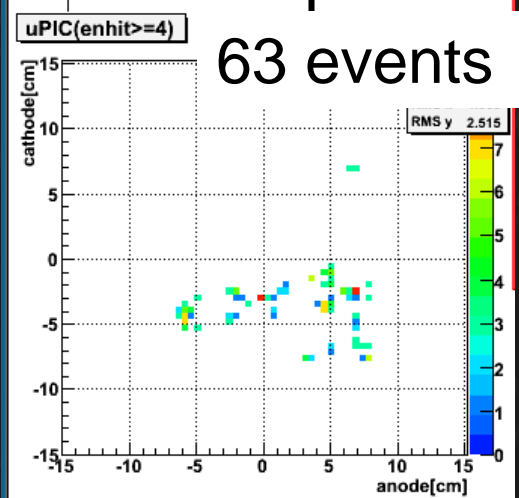
old gain map



NEWAGE0.3a  
152 torr CF4 gas

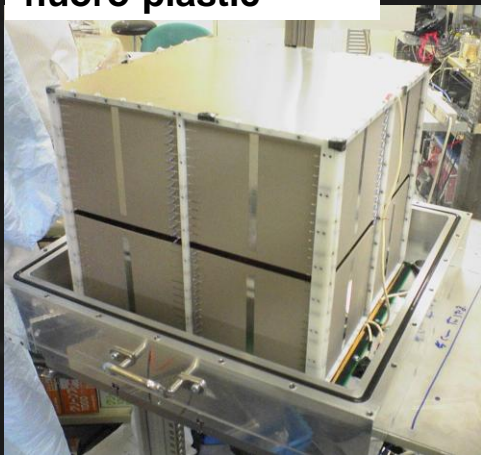


γ run

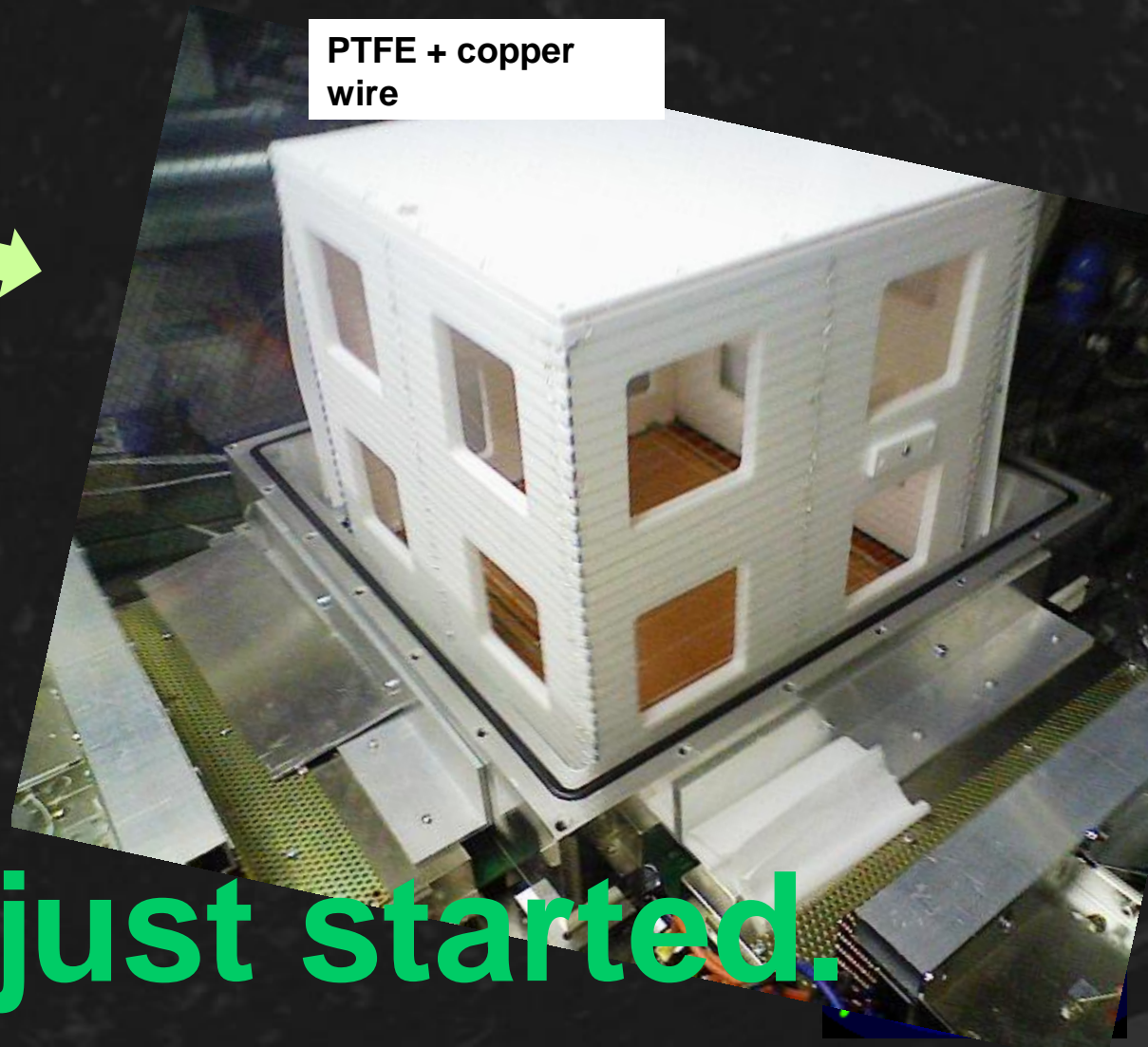


# radon, gamma, alpha: "clean" materials to $<1/10$ radon emanation level

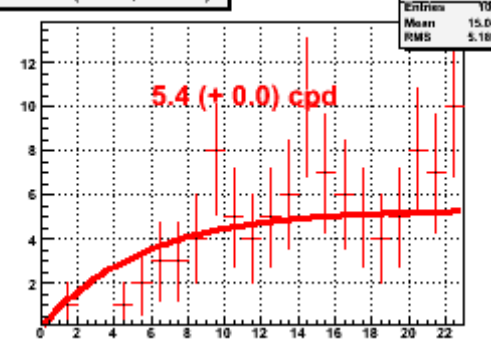
glass-reinforced  
fluoro-plastic



PTFE + copper  
wire



U-chain (6.0MeV, 7.83MeV)



# DM run, just started.

◆ **sensitivity improvement :**  
**NEWAGE-0.3a(Kamioka)**

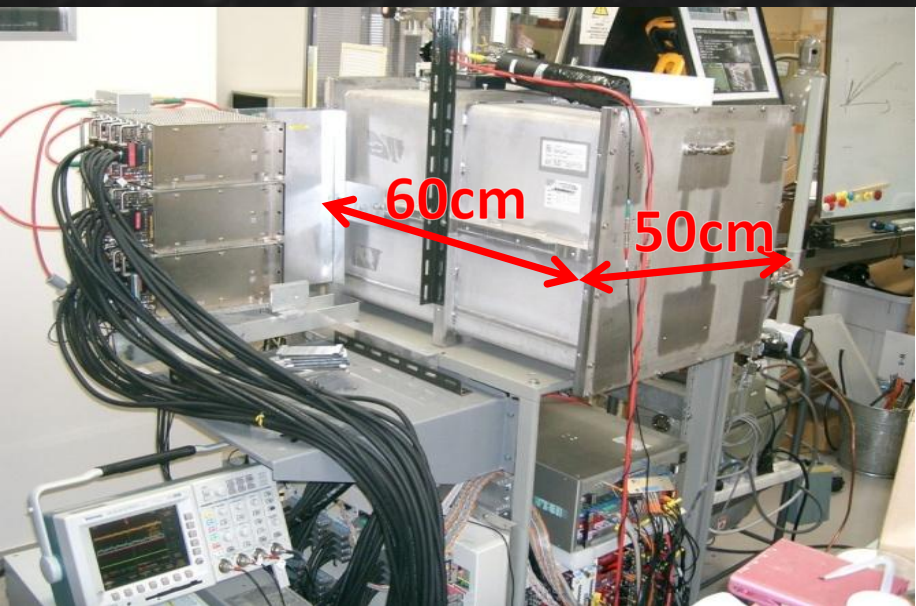
◆ **for next step: NEWAGE-0.3b(Kyoto)**

◆ **fundamental studies: NEWAGE-0.1a (Kyoto)**

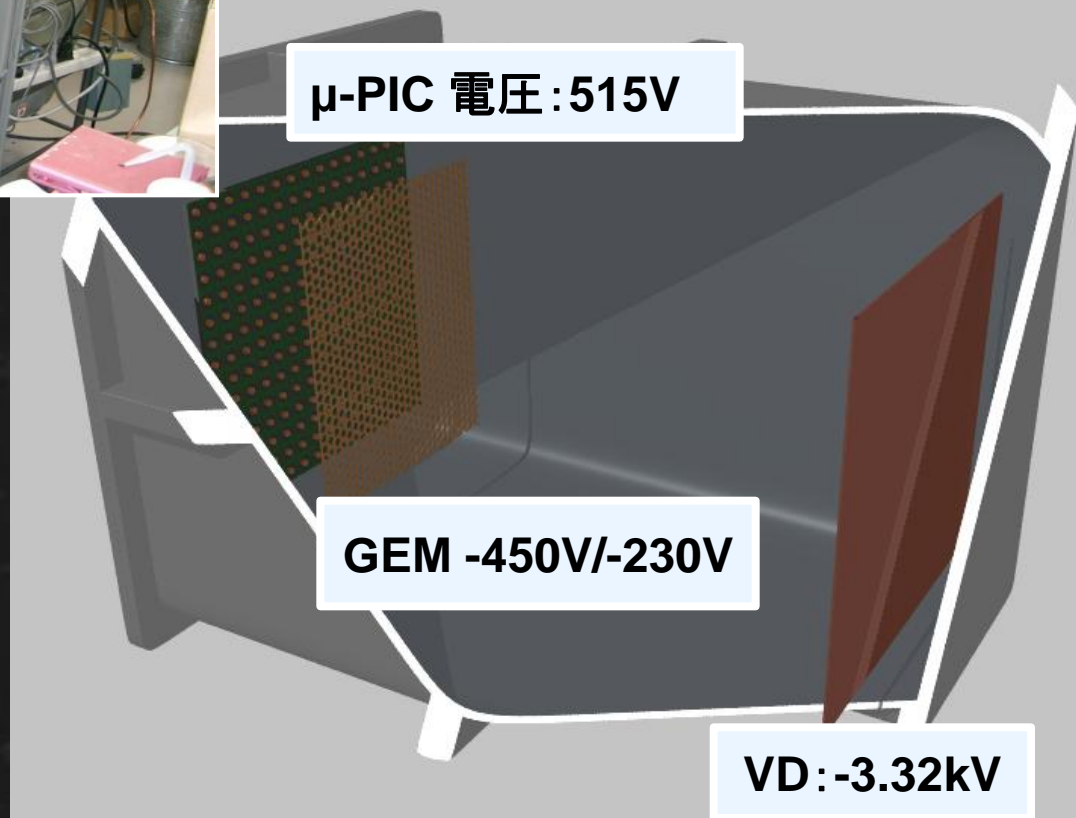
◆ **R&D for future: QPIX(KEK)**



# NEWAGE-0.3a (@Kyoto by K. Nakamura)



- $23 \times 28 \times 50\text{cm}^3$
- 76 torr  $\text{CF}_4$

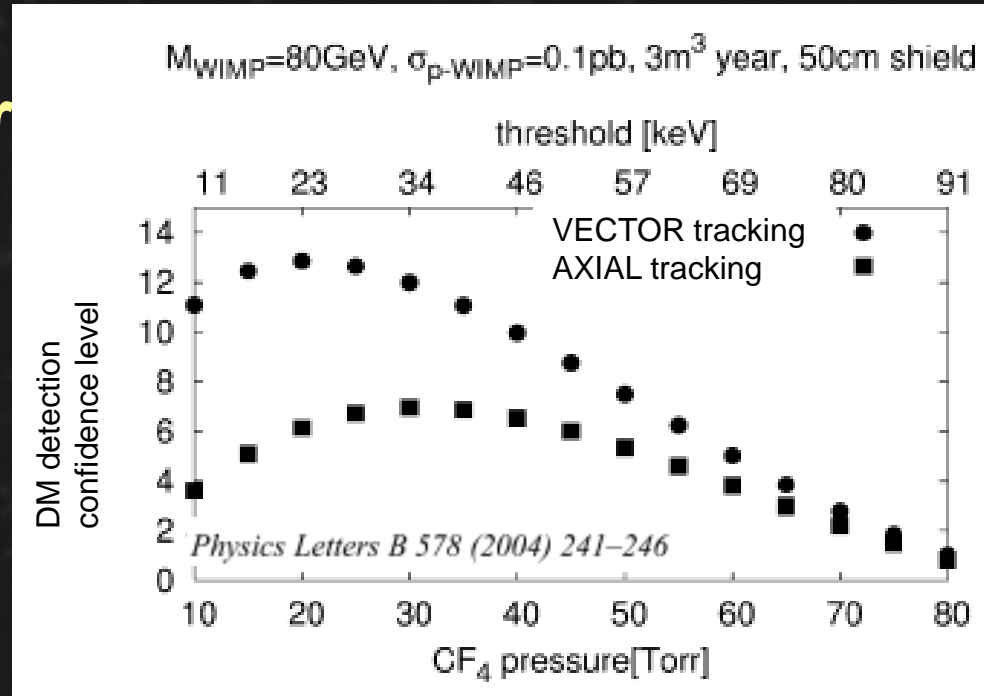


# Gas pressure

- energy threshold: limited by track length
- lower pressure for higher sensitivity

● optimum:  $\sim 30$  torr

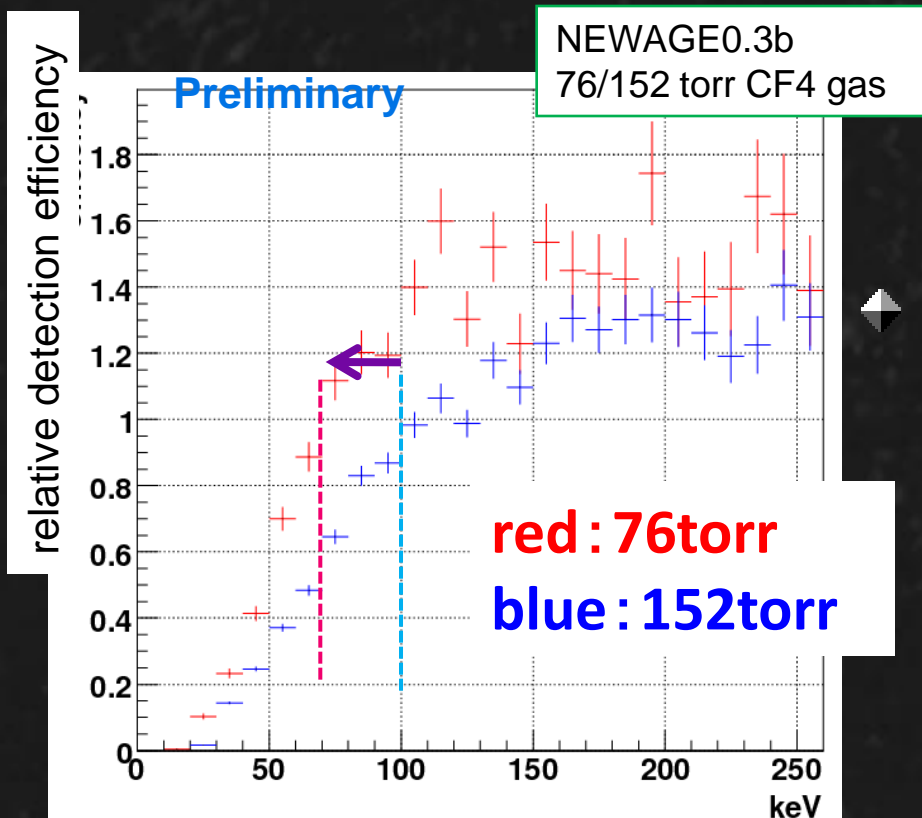
● NOW working on:  
156  $\rightarrow$  76 torr



- Measured  
detection efficiency  
angular resolution

# Detection efficiency for nuclear tracks

- $^{252}\text{Cf}$  run: fast neutron irradiation
- threshold 100keV  $\rightarrow$  70keV (expected 50keV)



## Angular resolution

- $50^{+7}_{-2}$  degree @100-200keV
- 55 degree with 152torr gas

- re-measure with higher gas gain



◆ **sensitivity improvement :**  
**NEWAGE-0.3a(Kamioka)**

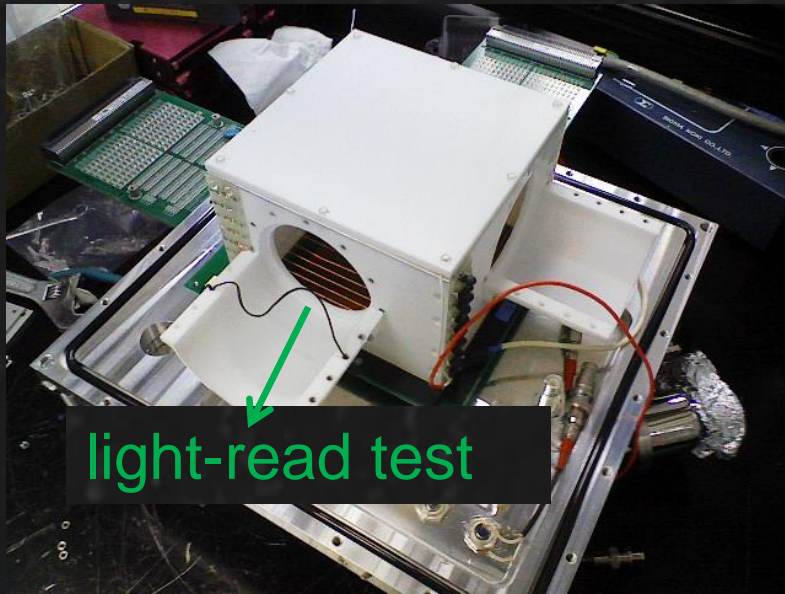
◆ **for next step: NEWAGE-0.3b(Kyoto)**

◆ **fundamental studies: NEWAGE-0.1a (Kyoto)**

◆ **R&D for future: QPIX(KEK)**



# NEWAGE-0.1a (@Kyoto)

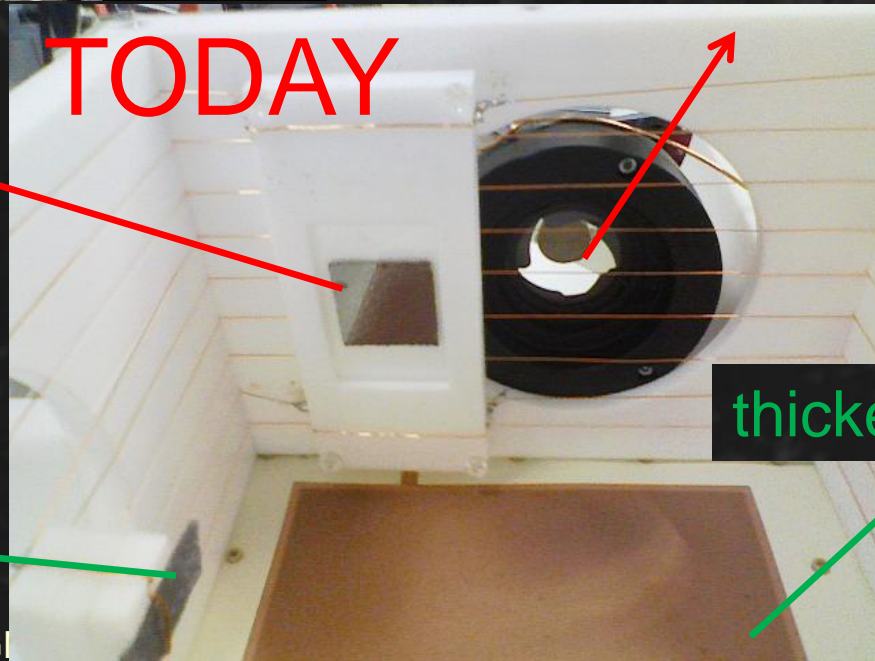


- $10 \times 10 \times 10 \text{cm}^3$
- for fundamental and challenging studies

$^{55}\text{Fe}$  source with shutter

$^{10}\text{B}$  coated glass

**TODAY**



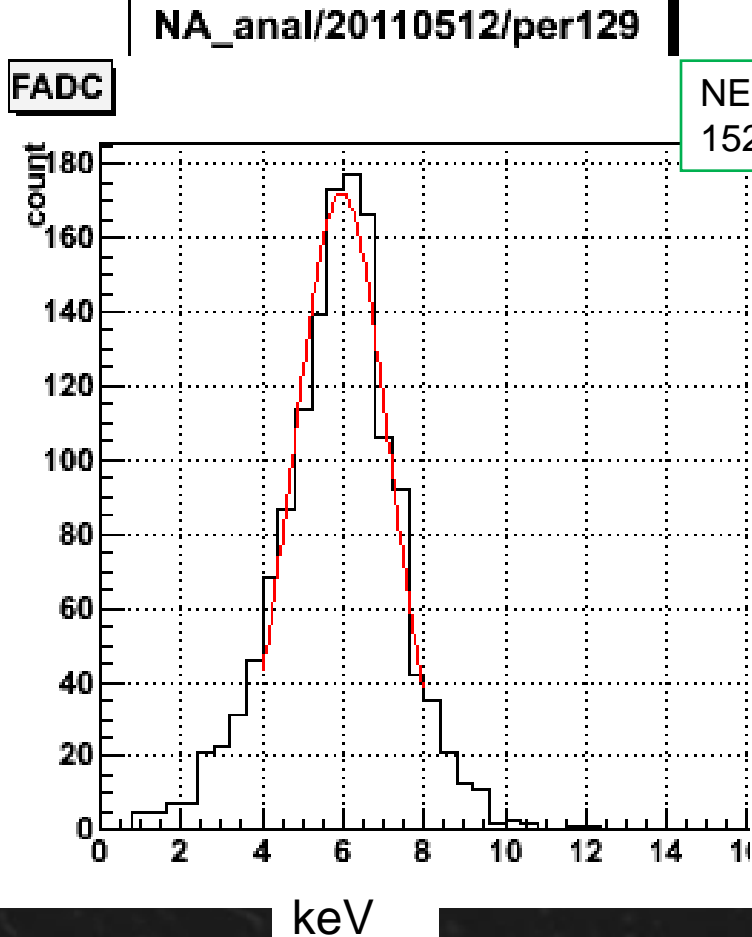
Samarium source

thicker GEM(100μm)

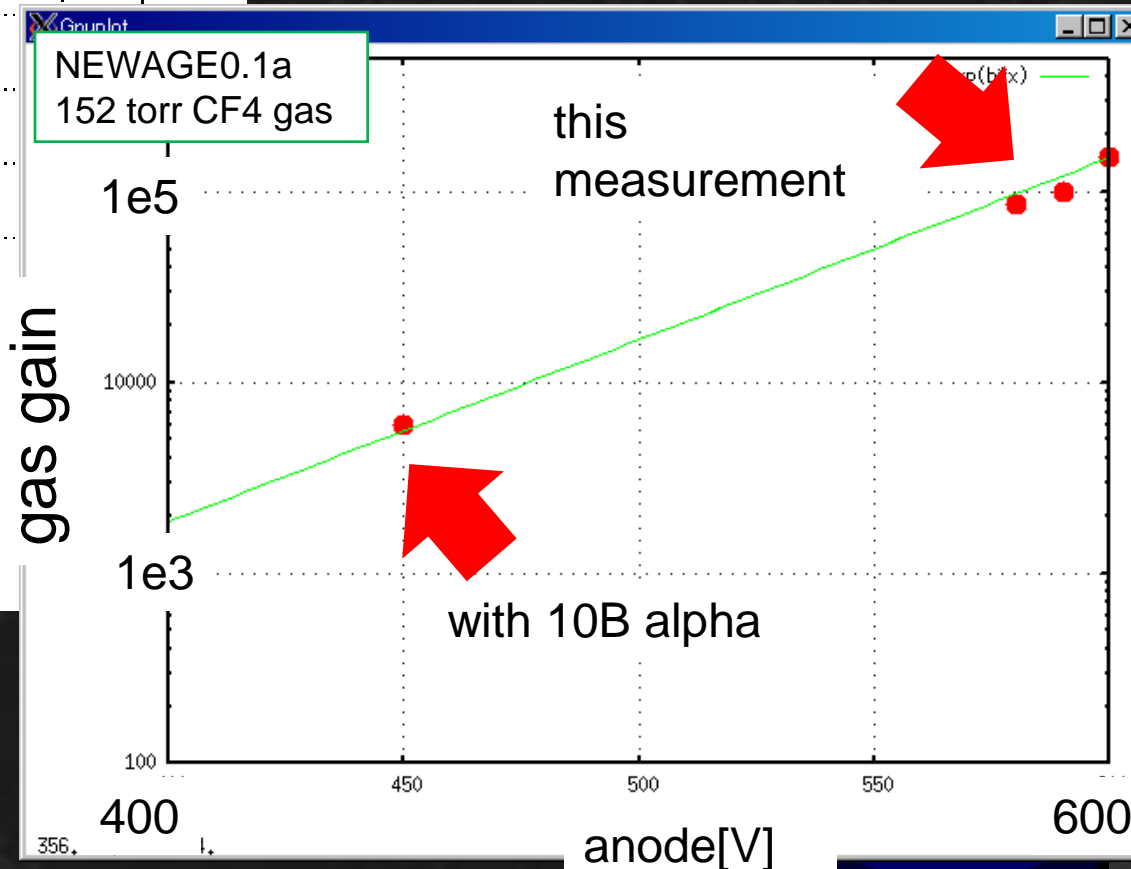


# 55Fe calibration

● 40% FWHM @5.9keV



gain curve



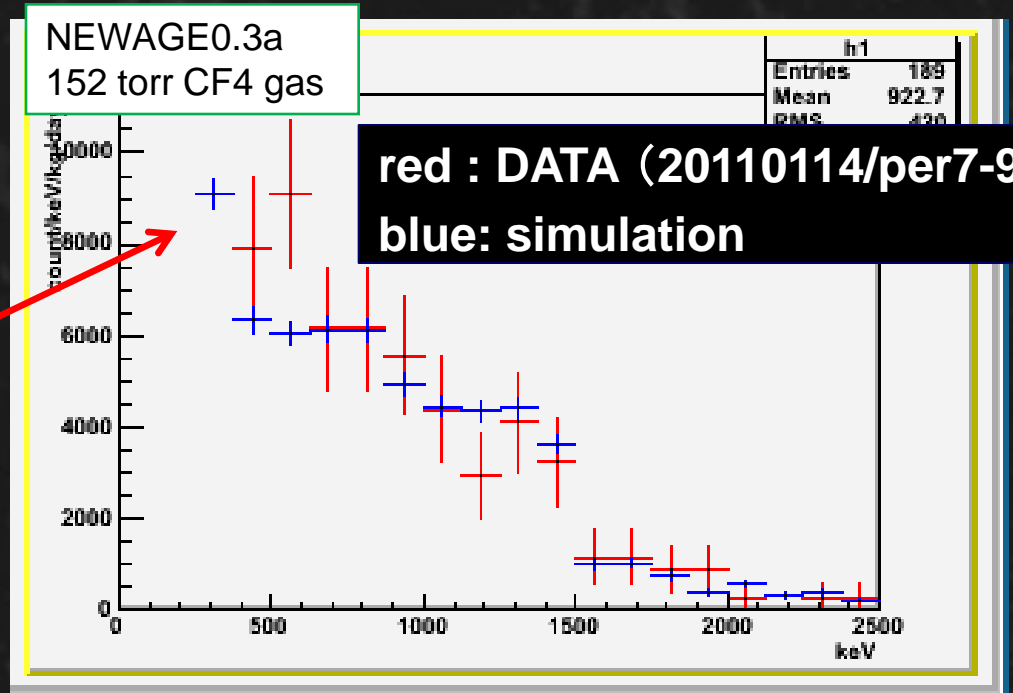
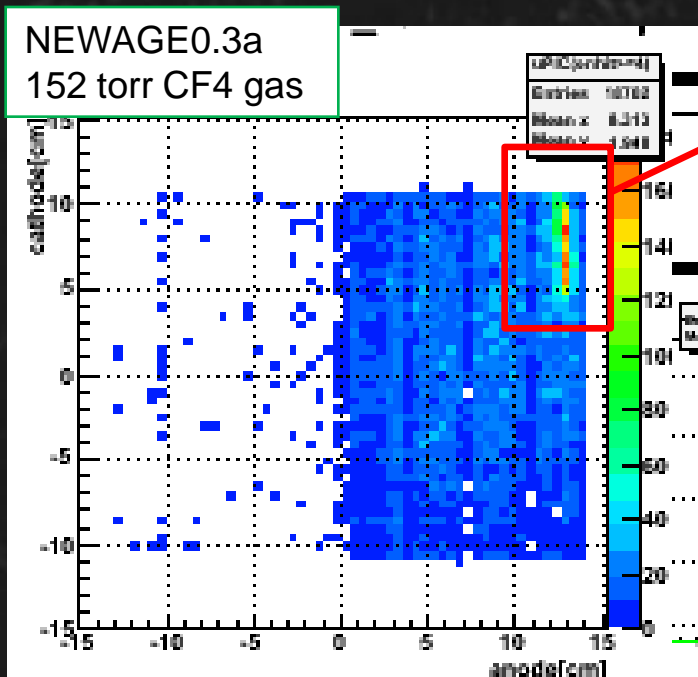
# Calibration with $^{10}\text{B}$

- $^{10}\text{B}(n,\alpha)^7\text{Li}$  reaction ( $Q=2.70\text{MeV}$   $\sim 1.5\text{MeV}$   $\alpha$ )



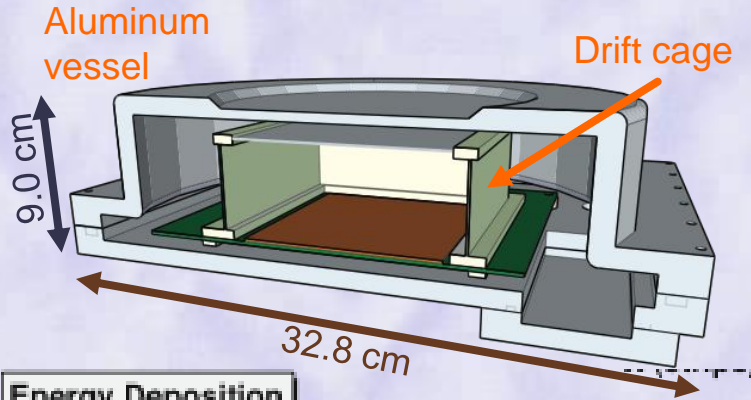
$^{10}\text{B}$  (  $1.5\mu\text{m}$  thickness ) coated glass

irradiate with thermalized neutrons

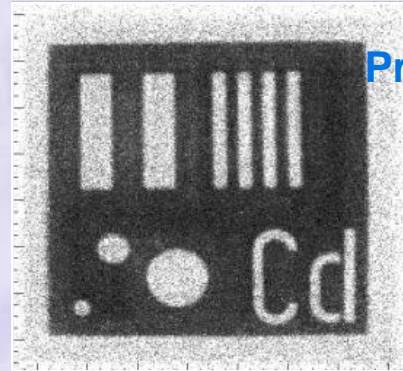
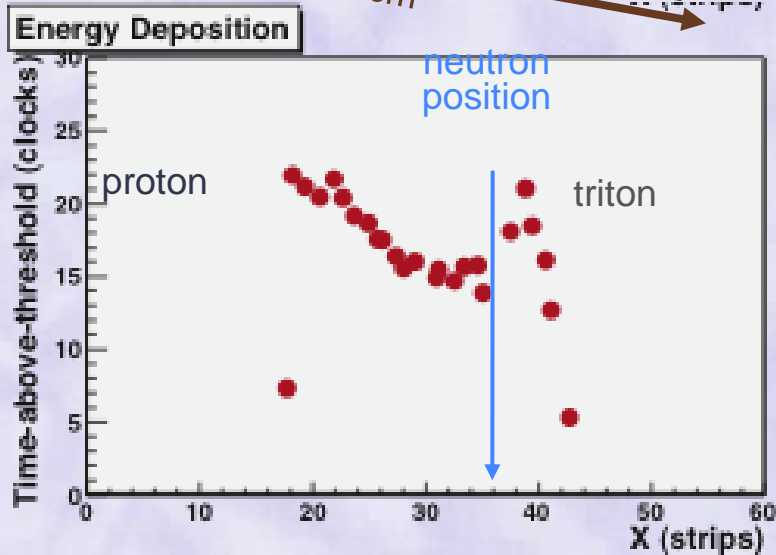


# thermal neutron imaging

Parker+



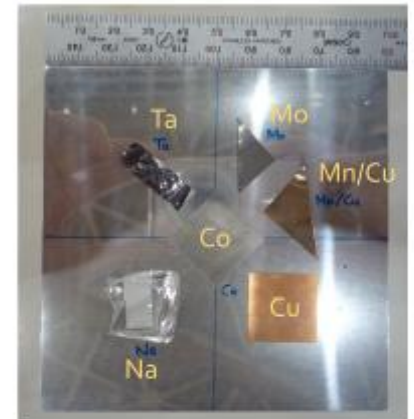
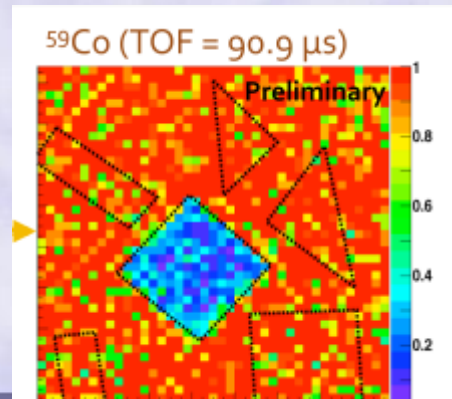
- ▶  $^3\text{He}(n,p)t$  reaction
- ▶ Ar-C<sub>2</sub>H<sub>6</sub>- $^3\text{He}$ (30%) gas 2atm
- ▶ detection efficiency ~30%
- ▶ Time resolution ~1  $\mu\text{s}$  for each neutron interaction.



Preliminary

position resolution  
<150 $\mu\text{m}$

resonance imaging by TOF



Assorted metals

DAQ rate: 1.48 MHz

Exposure time: 5.5 min

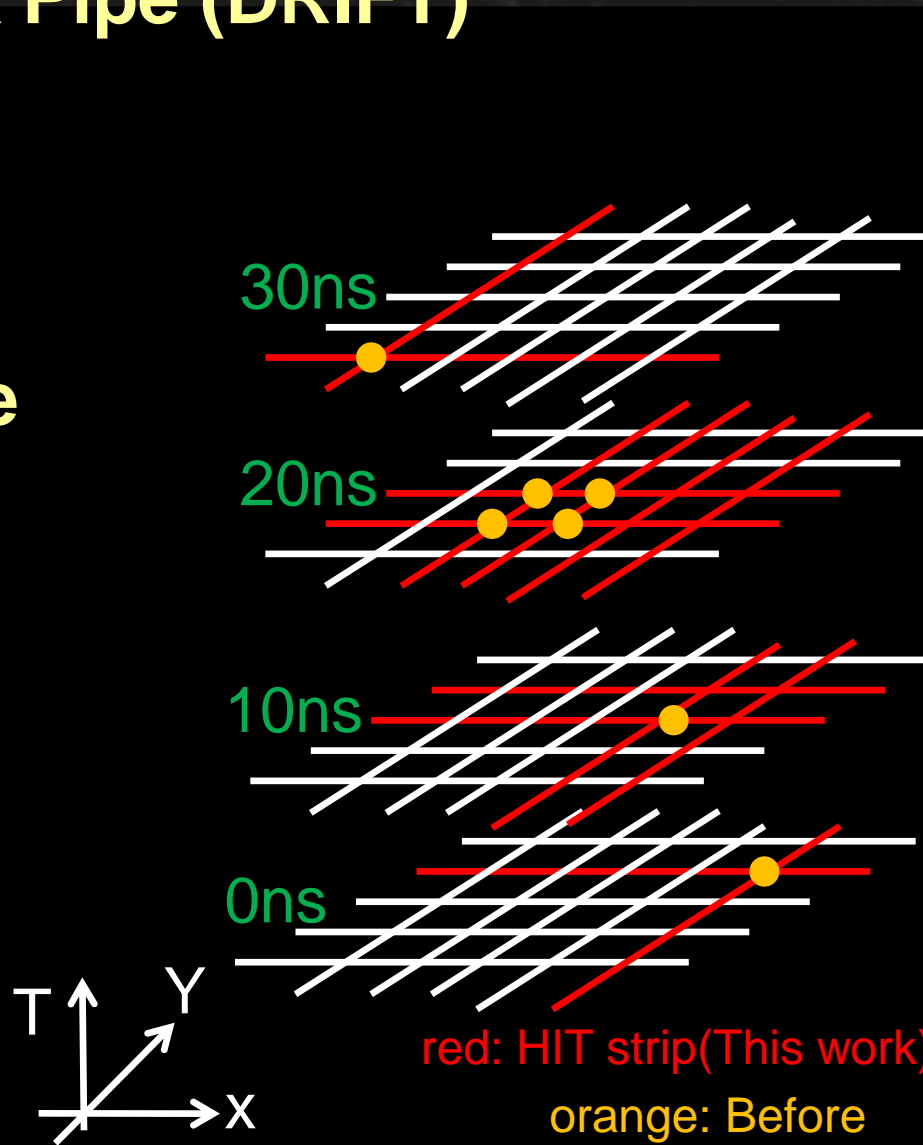
# FPGA firmware update

- wrote from scratch (by A. Takada)
- Analysis code by Mark Pipe (DRIFT)

- record **all HIT-STRIP** with **100MHz**  
~ **charge data** by pulse duration

Before: online reduction for high-rate acquisition

- Head/tail discrimination**



# 55Fe electron track

NA\_anal 20110512 per32

file 2 event 8

nhit : 4 (1 front, 3 back)

distance(f-f) = 0.34 cm

path length = 0.42 cm

FADCsum = 350.3

anode hitsum = 21

mean = -1.014

sk3/sk2=-0.000/0.00

skewness = -0.104

cathode hitsum = 37

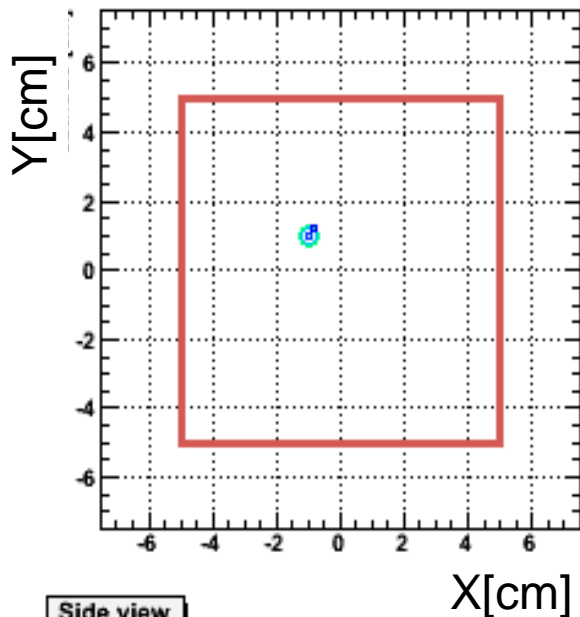
mean = 1.004

sk3/sk2=0.004/0.02

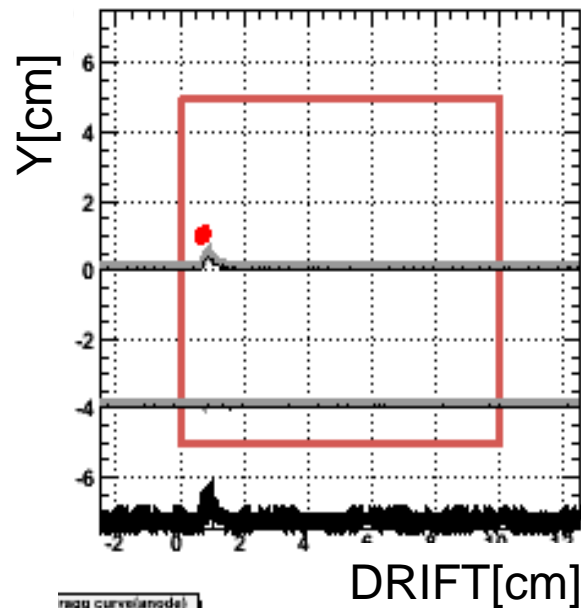
skewness = 0.249

drift velocity = 6.0cm/us

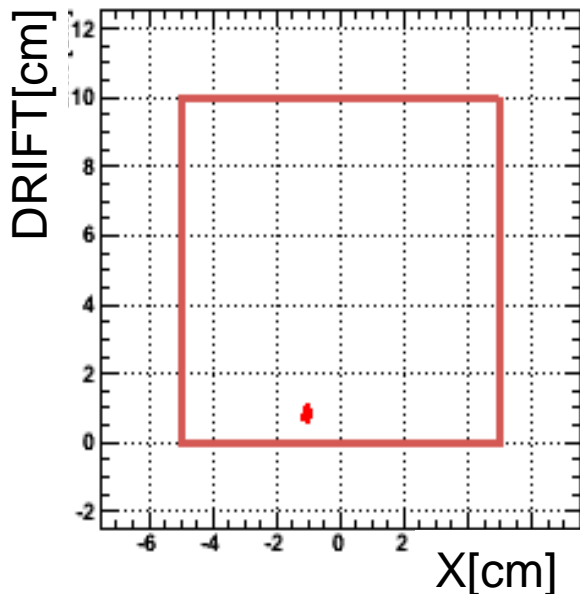
Top view



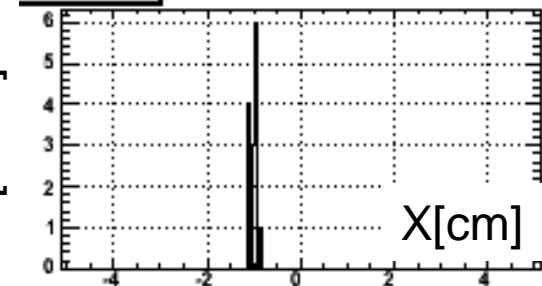
Side view



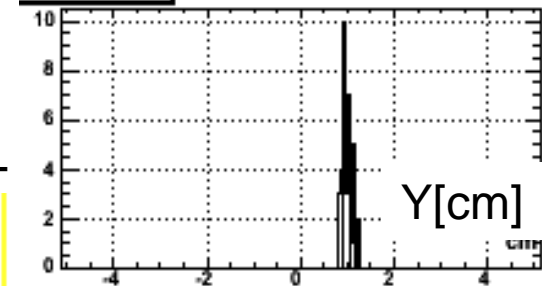
Side view



regg curve(anode)



regg curve(cathode)



NA\_anal 20110512 per32

file 2 event 7

# $\mu$ track

nhit : 22 (9 front, 13 back)

distance(f-f) = 7.17 cm

path length = 7.86 cm

FADCsum = 677.2

anode hitsum = 87

mean = -2.265

sk3/sk2=4.804/11.35

skewness = 0.423

cathode hitsum = 107

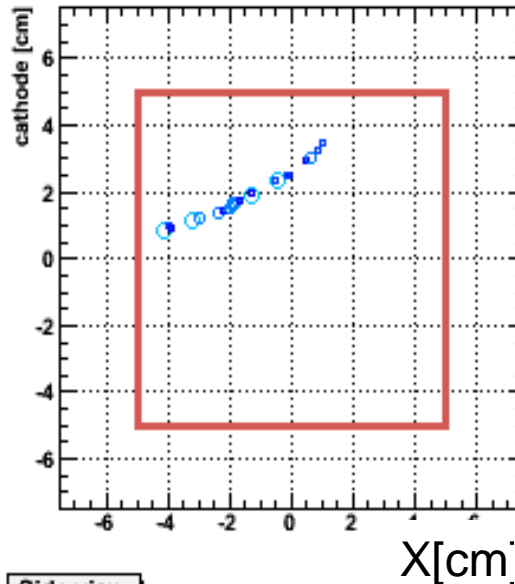
mean = 1.867

sk3/sk2=0.990/2.45

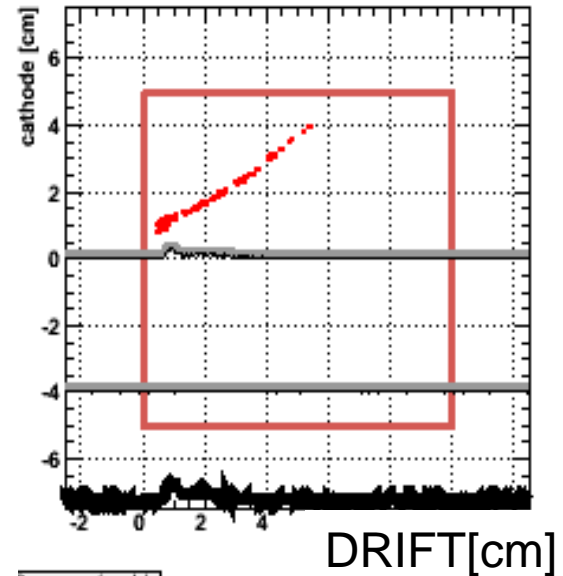
skewness = 0.404

drift velocity = 6.0cm/us

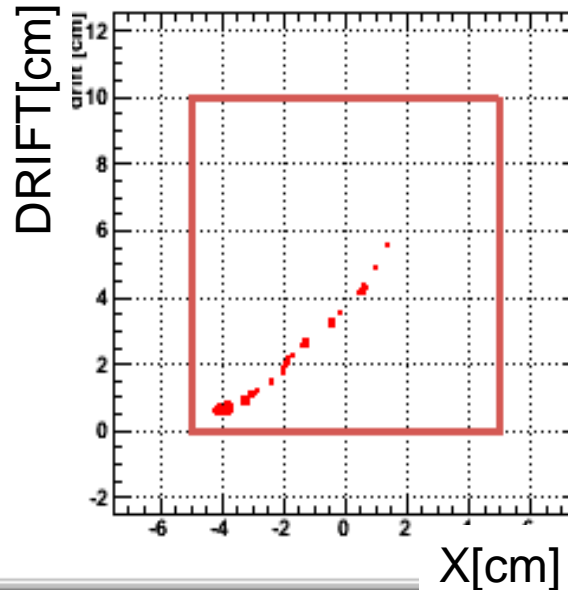
Top view



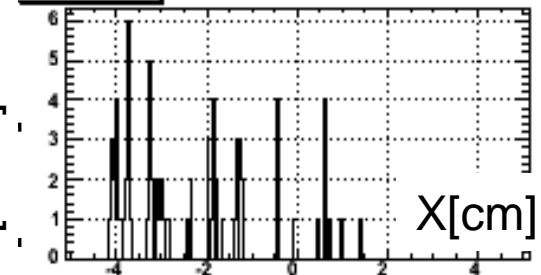
Side view



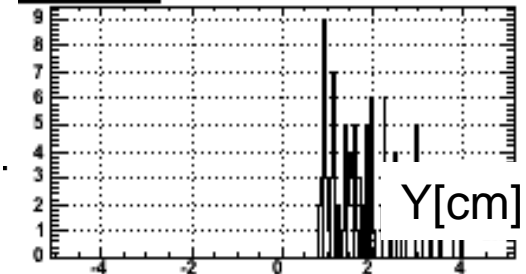
Side view



bragg curve(anode)



agg curve(cathode)



NA\_anal 20110512 per167

file 92 event 2

# nuclear track

nhit : 4 (2 front, 2 back)

distance(f-f) = 0.48 cm

path length = 0.93 cm

FADCsum = 494.1

anode hitsum = 40

mean = -2.816

sk3/sk2=0.015/0.09

skewness = 0.178

cathode hitsum = 54

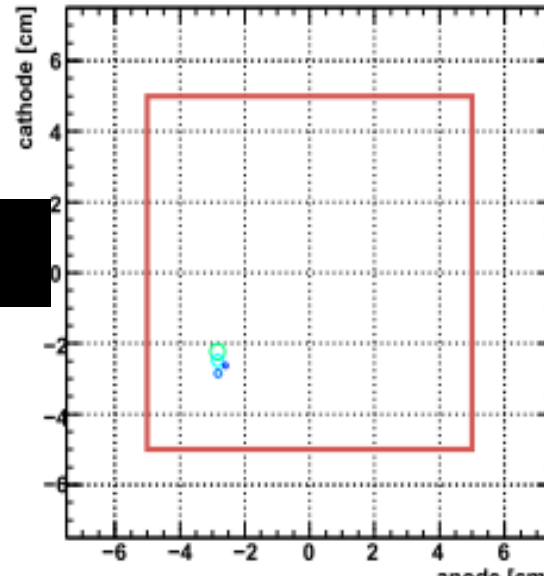
mean = -2.547

sk3/sk2=0.278/0.55

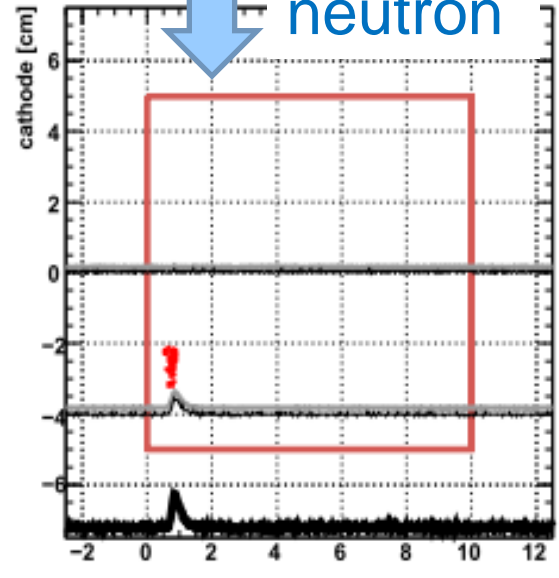
skewness = 0.502

drift velocity = 6.0cm/us

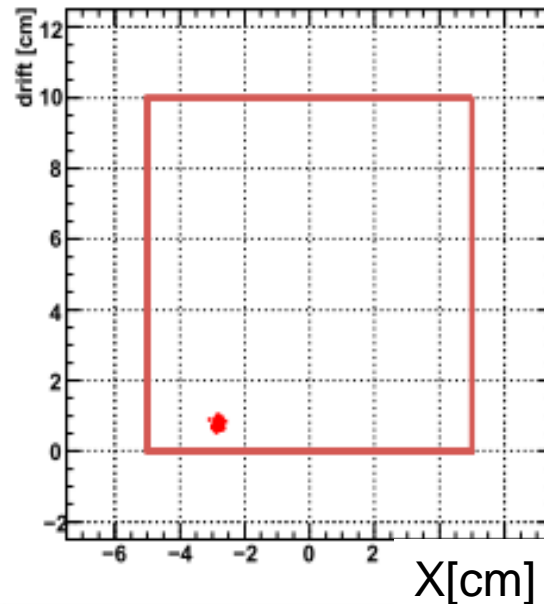
Top view



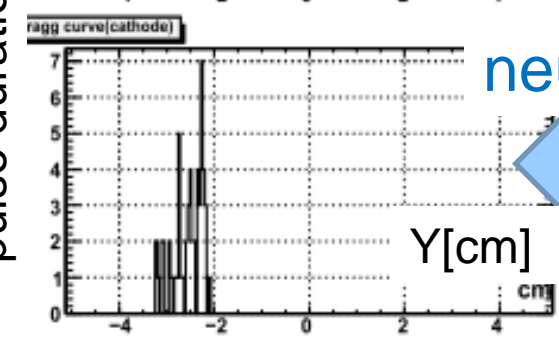
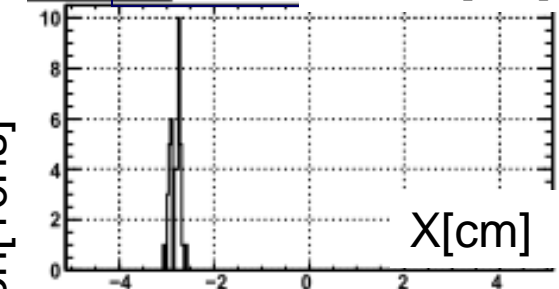
Side view



Side view



DRIFT[cm]



NA\_anal 20110512 per171

file 83 event 82

data file:forEventView

nhit : 3 (1 front, 2 back)

distance(f-f) = 0.36 cm

path length = 0.44 cm

FADCsum = 391.8

anode hitsum = 29

mean = -1.781

sk3/sk2=0.041/0.09

skewness = 0.463

cathode hitsum = 45

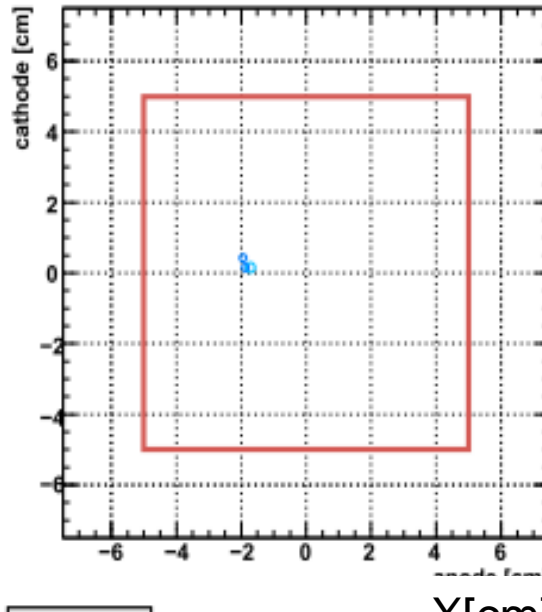
mean = 0.283

sk3/sk2=-0.167/0.35

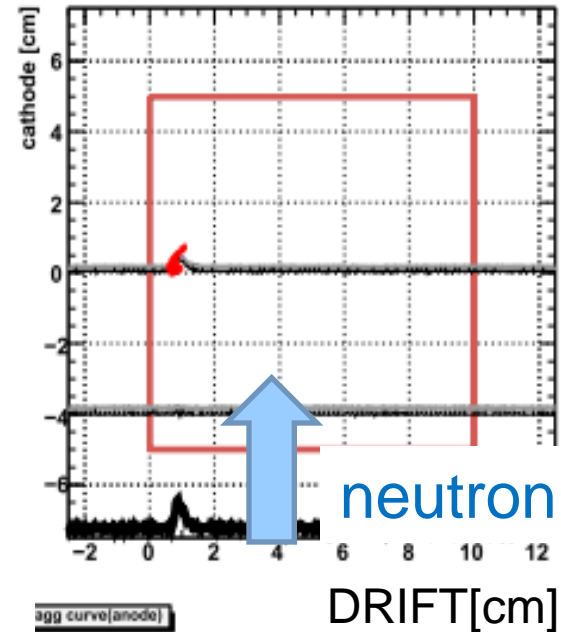
skewness = -0.478

drift velocity = 6.0cm/us

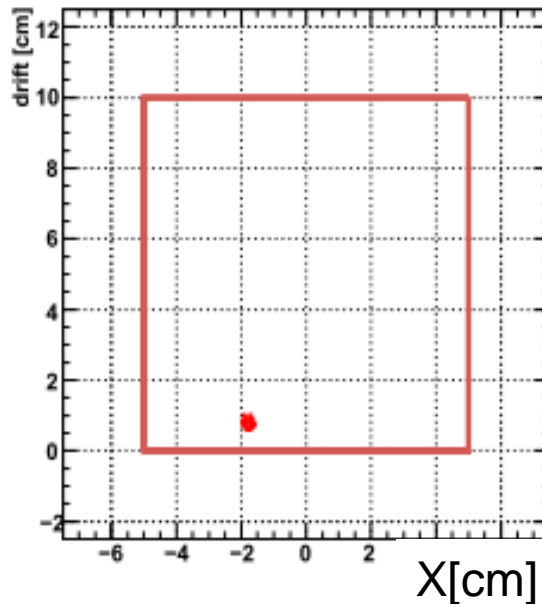
Top view



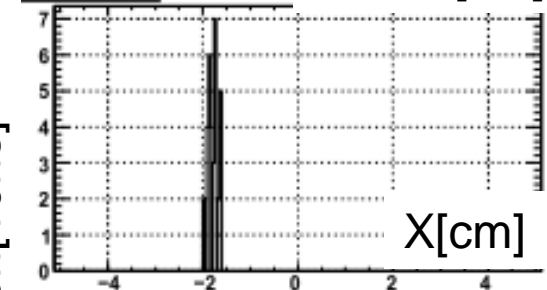
Side view



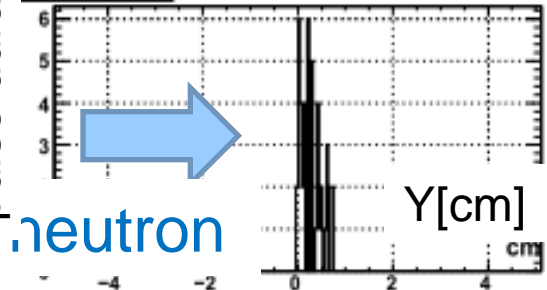
Side view



agg curve(anode)



agg curve(cathode)



pulse duration[10ns]

neutron

sensitive search



- ◆ **sensitivity improvement :**  
**NEWAGE-0.3a(Kamioka)**
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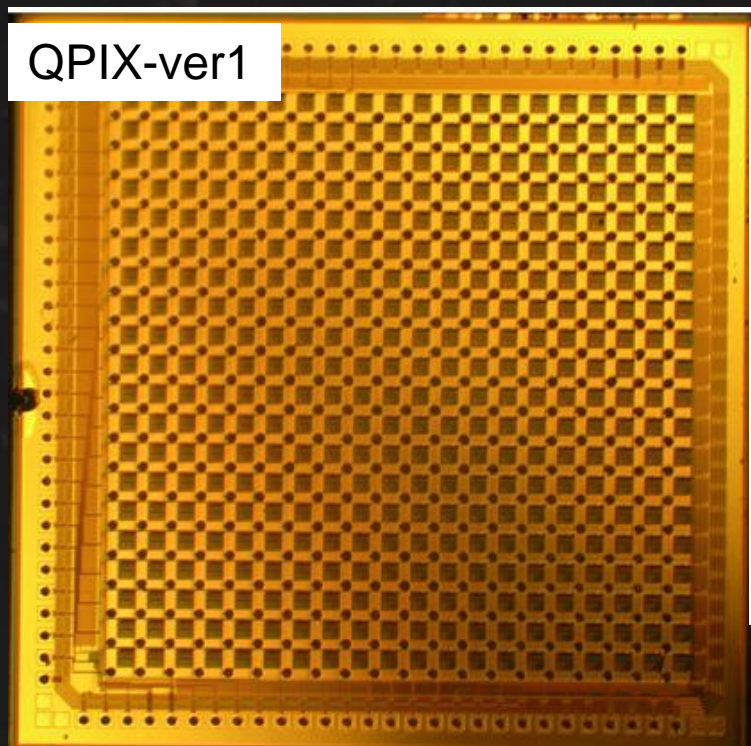


# QPIX (@KEK)

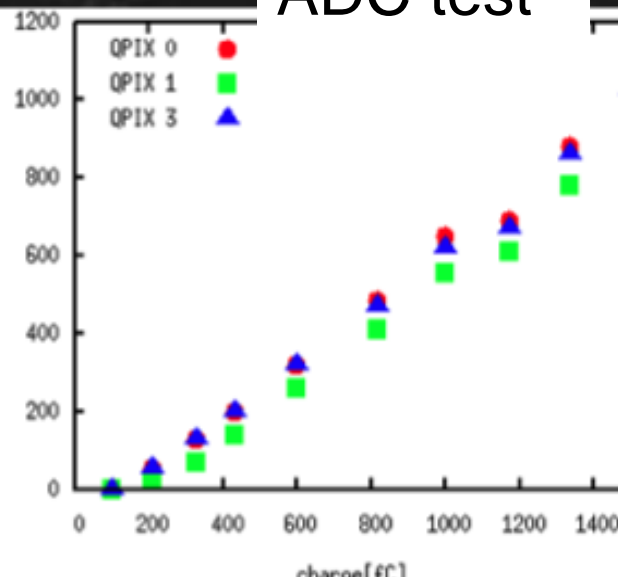
## PIXEL readout ASIC

- "ultimate"  $\mu$ TPC

QPIX-ver1



ADC test



QPIX.v.1 SPECS

channel size 200 x 200 $\mu$ m<sup>2</sup>

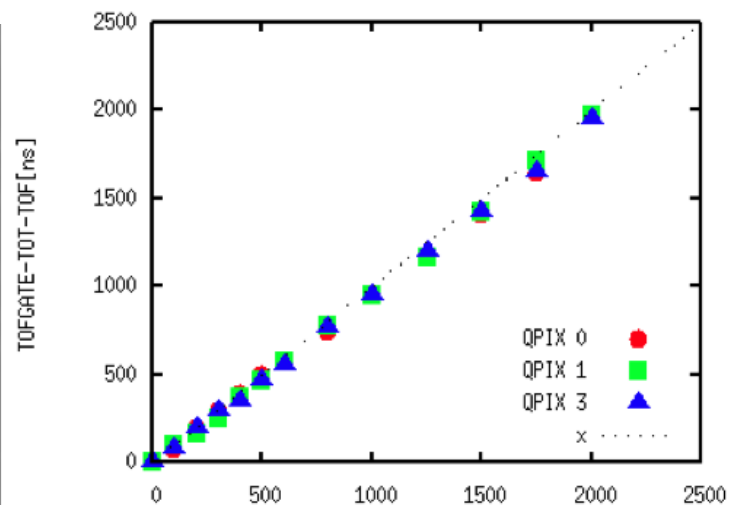
20 x 20ch/chip

TOF: 14 bits

TOT: 8 bits

ADC: 10 bits, 10Mps  
1.5fC~1.5pC

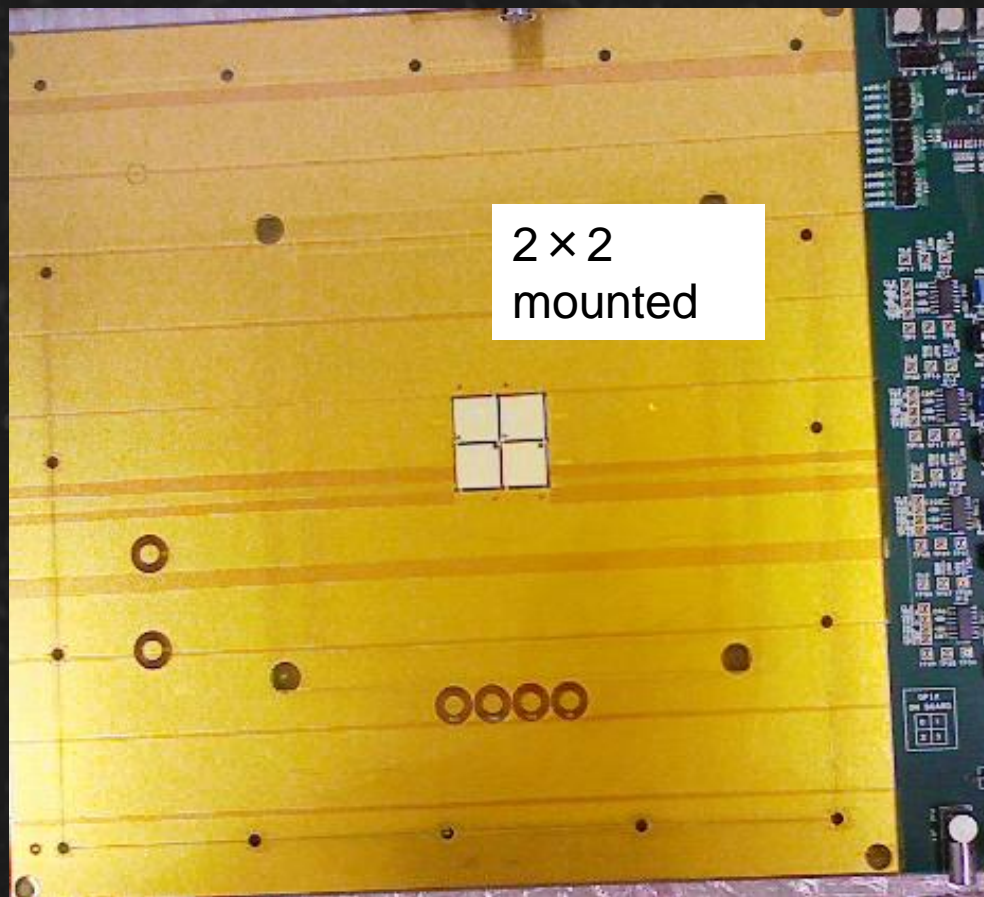
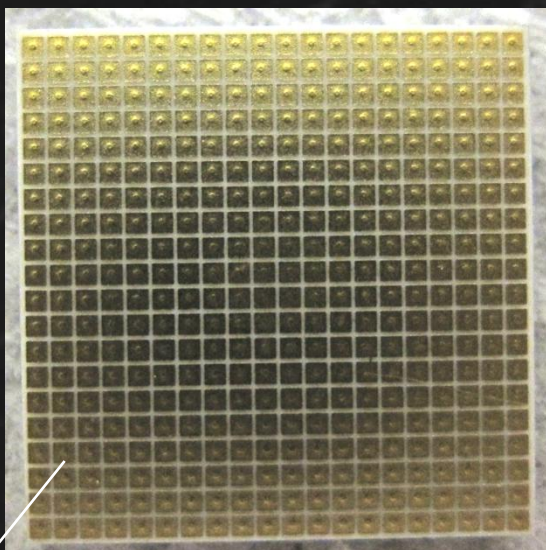
TOF test



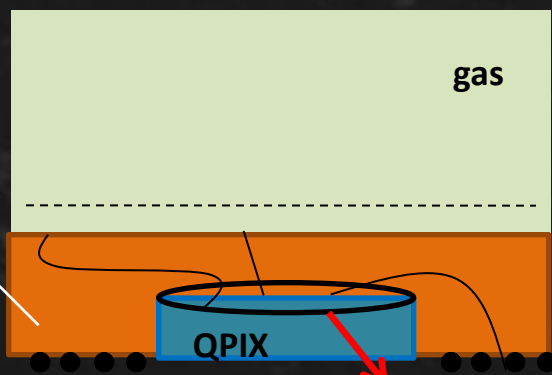
- functions: mostly OK

# Mounting

- all pixel-type ASIC suffers from gaps (dead area) between chips



ceramic board



bump bonding

- "whole chain" confirmed  
→ to fix details



# SUMMARY

- **NEWAGE-0.3a:**  
**BGs  $\times$  1/10 DM run just started**
- **NEWAGE-0.3b:**  
**76torr test going on**
- **NEWAGE-0.1a:**  
 **$^{55}\text{Fe}$  spectrum, head-tail test**
- **QPIX:**  
**20  $\times$  20test chip, gas less mounting**

