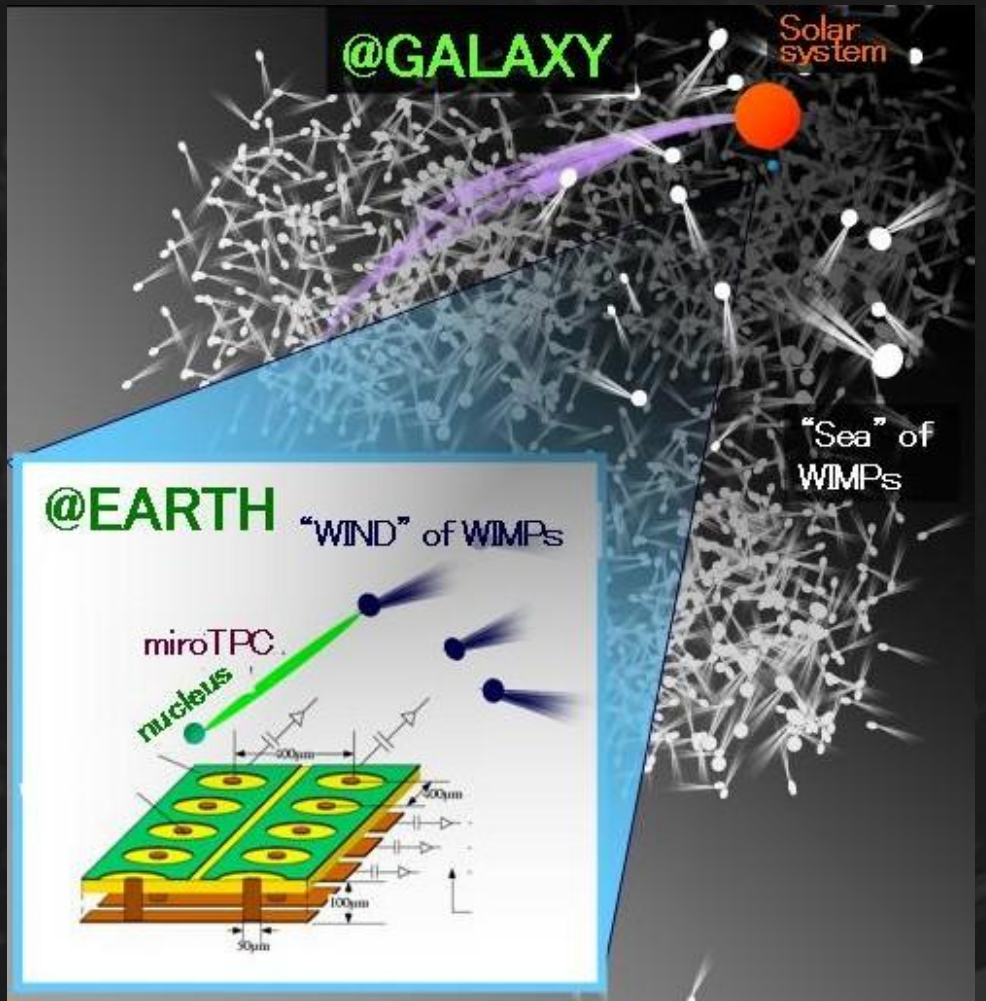
Direction-Sensitive Dark Matter Search
--NEWAGE--

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

Kentaro Miuchi
(Kobe University)

with

K. Nakamura, A. Takada
, T. Tanimori, H. Kubo, H. Nishimura
A. Takeda, H. Sekiya



OUTLINE

- Motivation
- Methods
- 1st underground result
- Latest activities
- Summary

Direction Sensitive WIMP-search NEWAGE

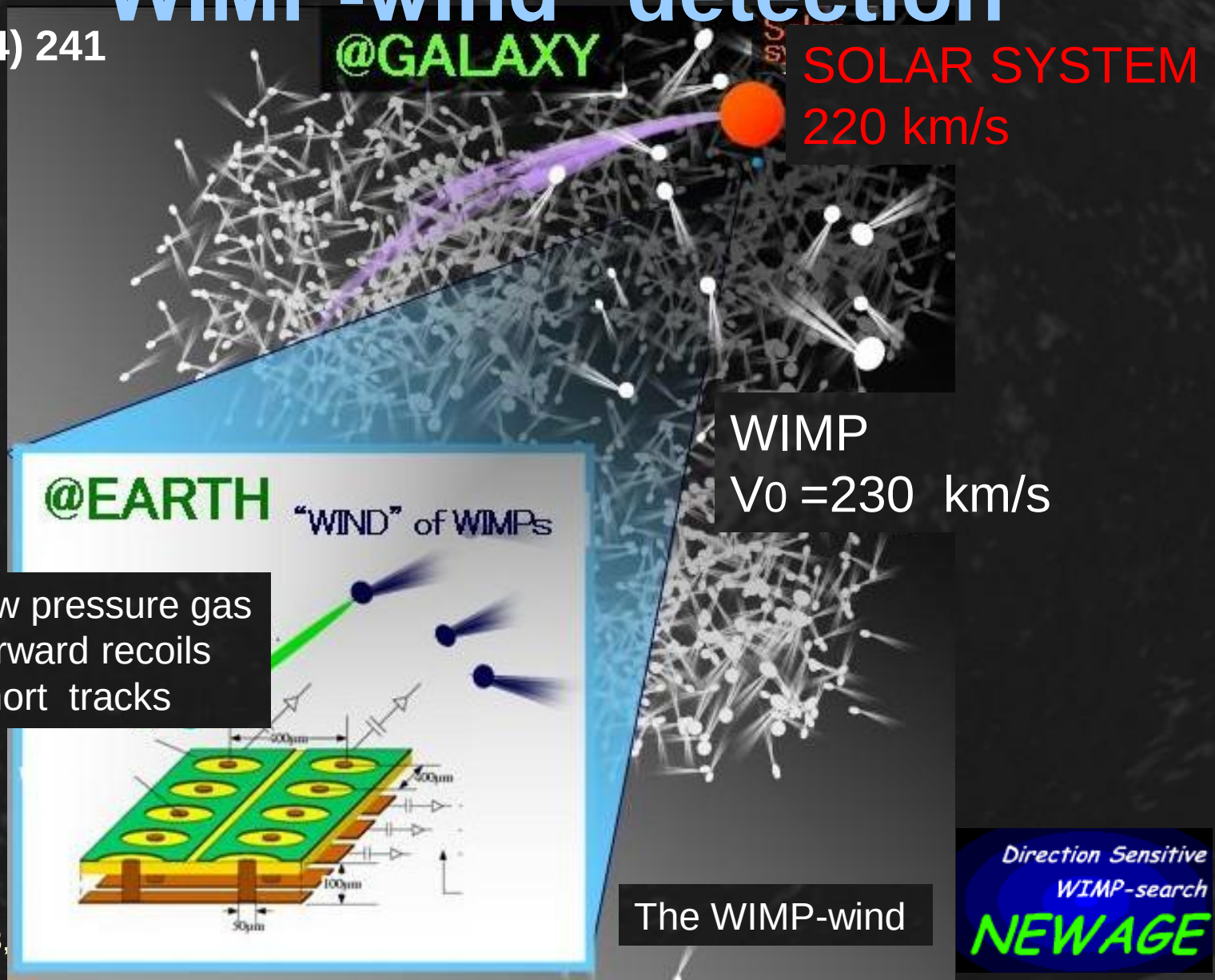
Motivation

Direction Sensitive WIMP-search NEWAGE

1. Motivation

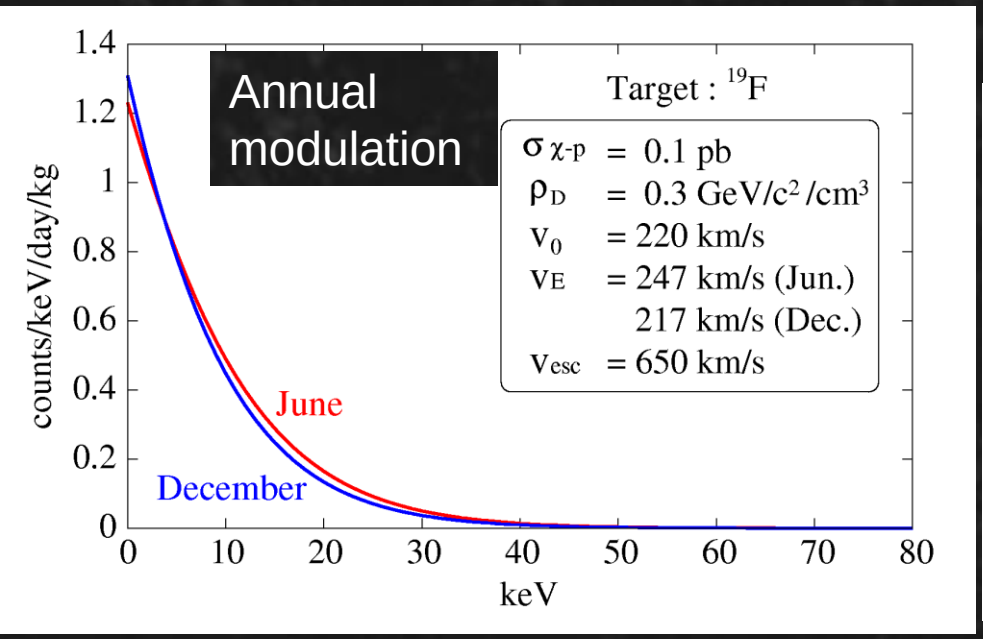
"WIMP-wind" detection

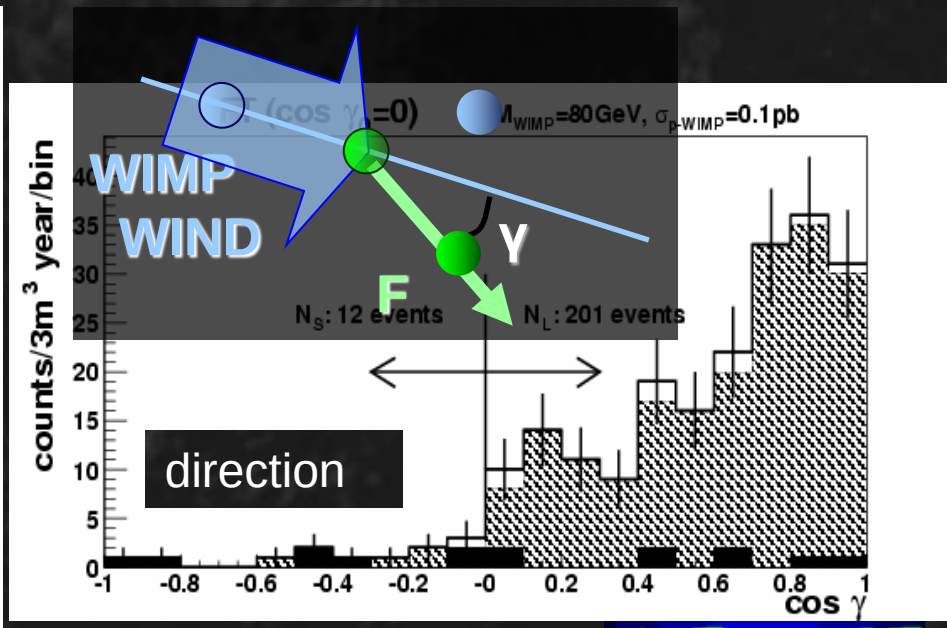
PLB 578 (2004) 241



WHY "Direction-sensitive" ?

- Large mass for exclusion (and indication)
- BUT Annual modulation is not enough…
- Direction-sensitive for a concrete evidence and further study of halo dark matter

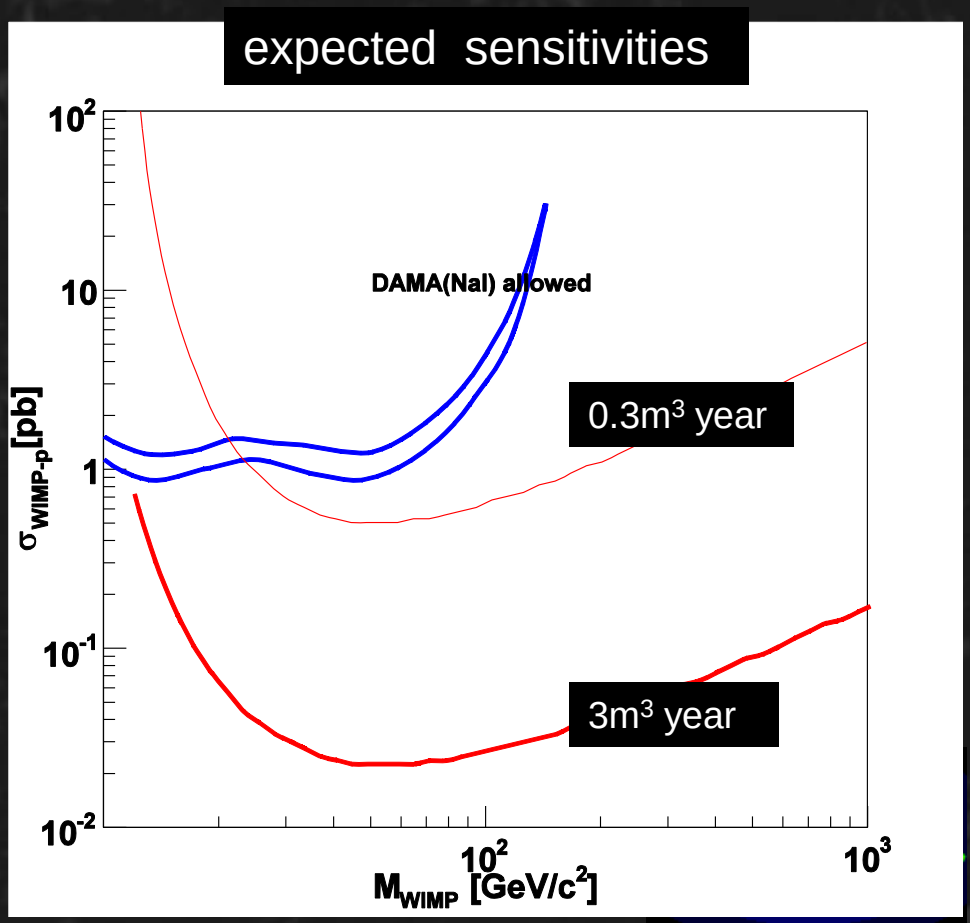




NEWAGE

Expected Sensitivities

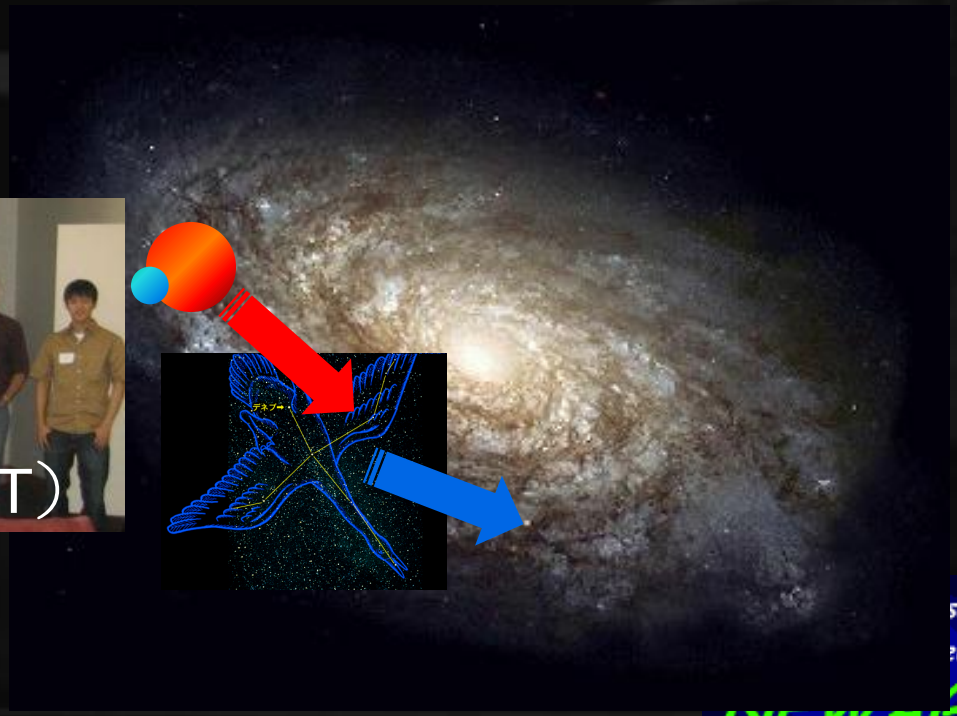
- **Goal: Detect the WIMP-wind**
  - low pressure (CF_4 0.05 bar)・large volume（$1m^3$ × N）・radio-pure materials
- **CURRENT: pilot run**
  - CF_4 0.2 bar ・$(0.3m)^3$
    ・normal materials



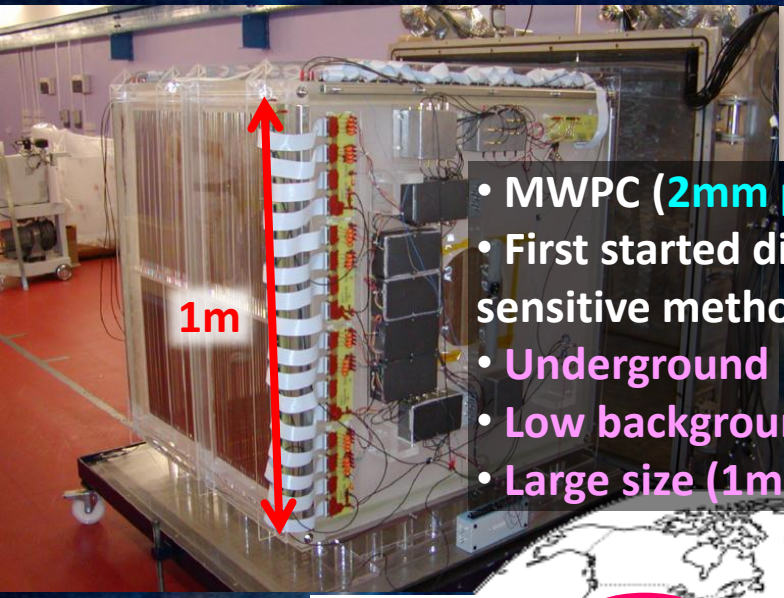
Community：CYGNUS

- direction-sensitive DM search workshop
  - 2007(UK)
  - 2009(US)
  - 2011(France)
  - 2013(Japan)

@CYGNUS2009（MIT）



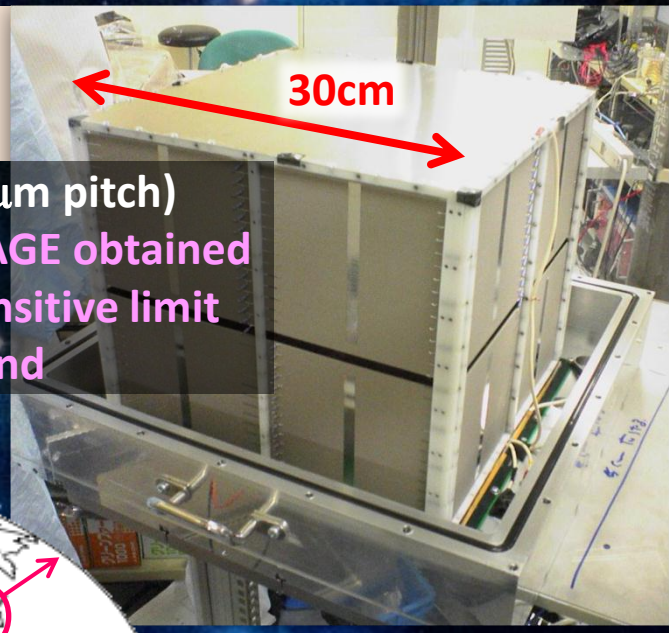
Direction-sensitive DM search



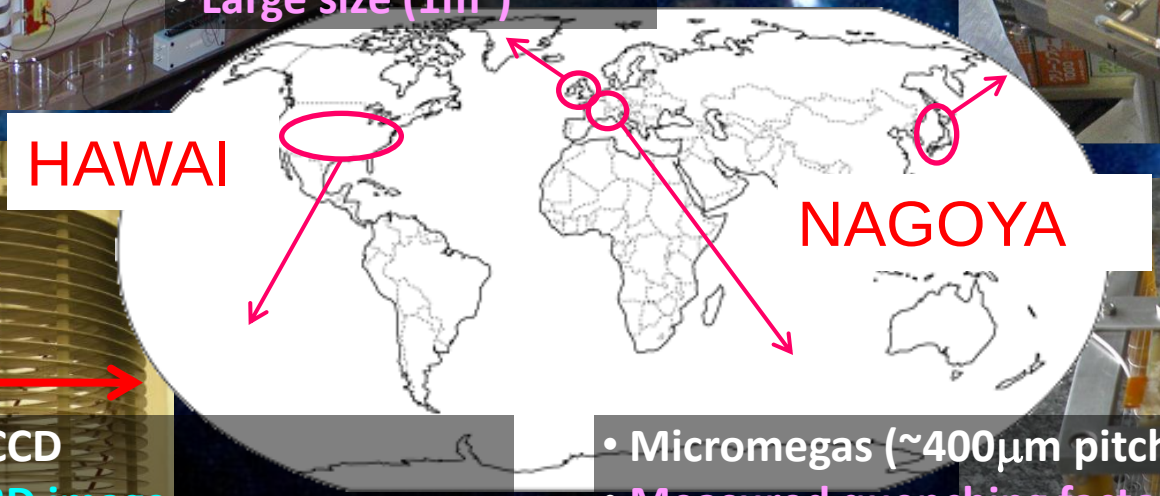
DRIFT
[UK]

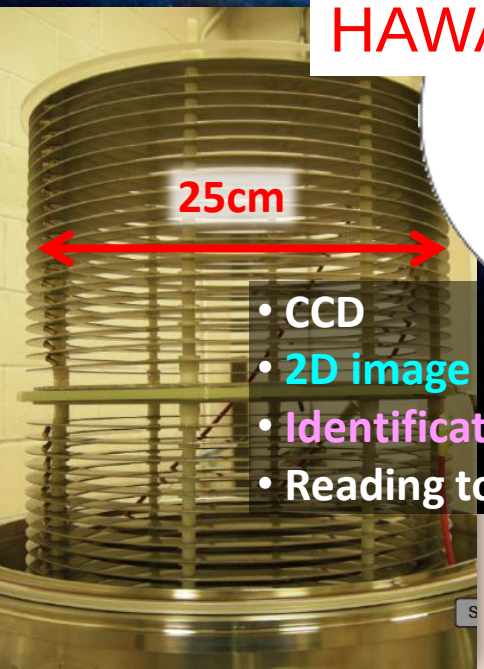
- MWPC (2mm pitch)
- First started direction-sensitive method
- Underground
- Low background
- Large size ($1m^3$)

NEWAGE
[Japan]



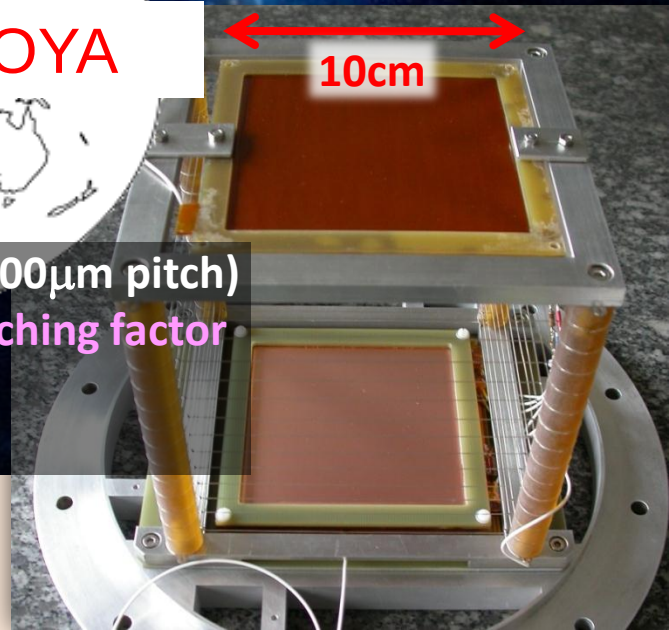
- μ-PIC (400μm pitch)
- Only NEWAGE obtained direction-sensitive limit
- Underground





- CCD
- 2D image
- Identification of head-tail
- Reading to underground

DMTPC
[USA]



- Micromegas (~400μm pitch)
- Measured quenching factor in detail
- R&D at surface

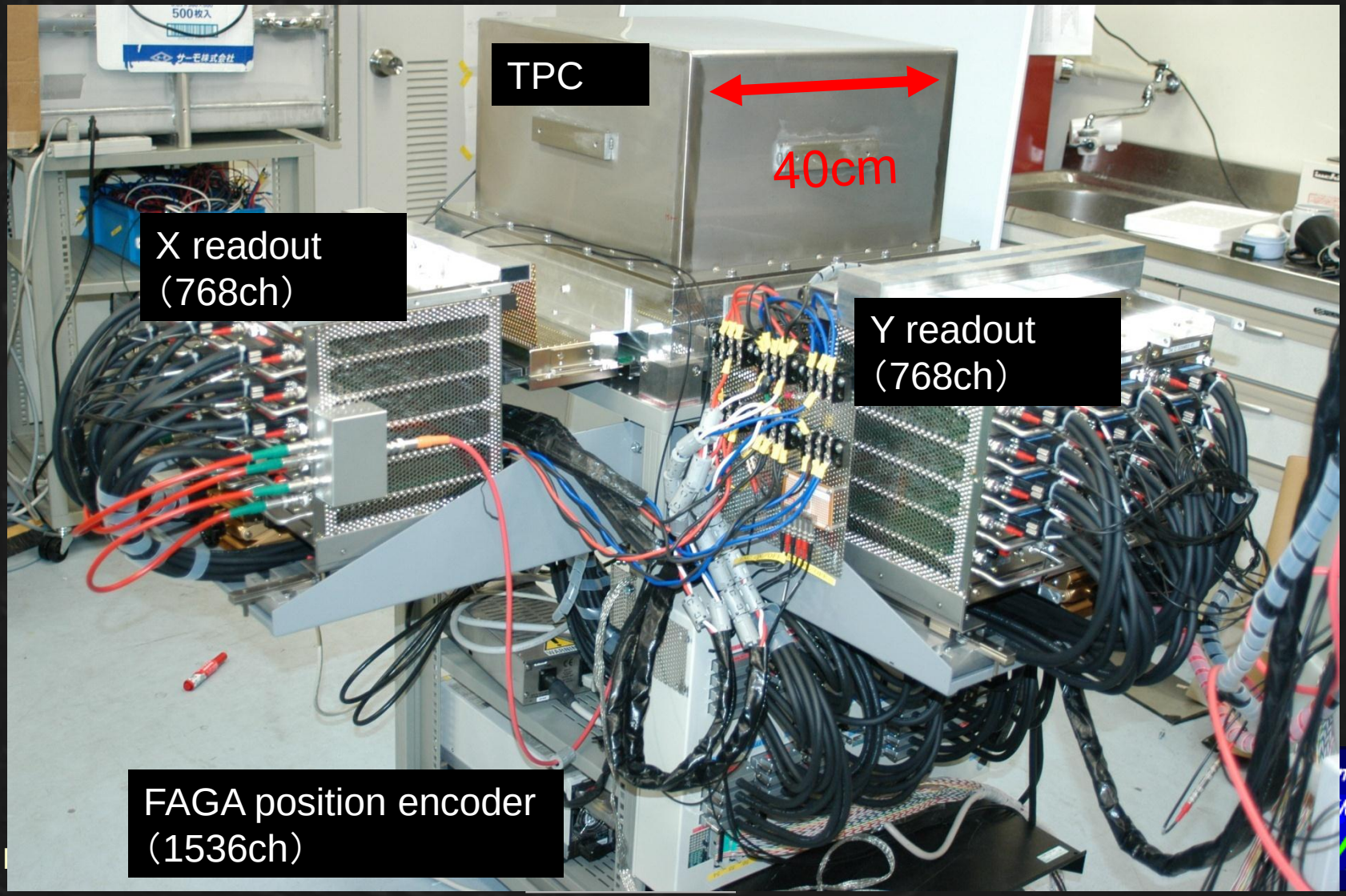
MIMAC
[France]

Methods

Direction Sensitive WIMP-search NEWAGE

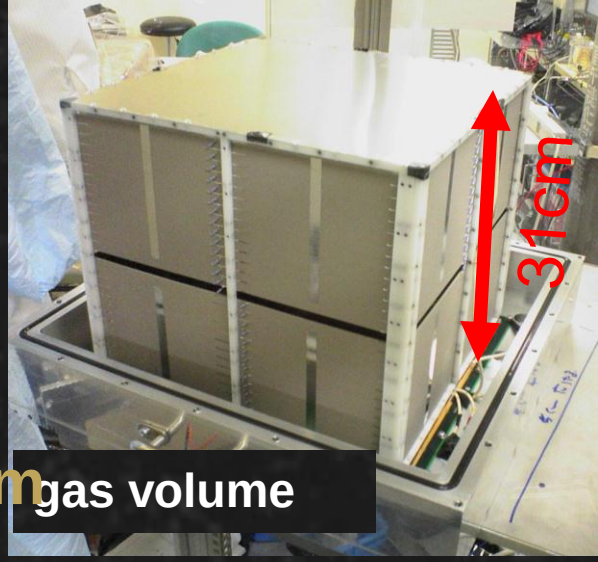
Methods (3D tracking device)

- NEWAGE-0.3a : $23 \times 28 \times 31 cm^3$

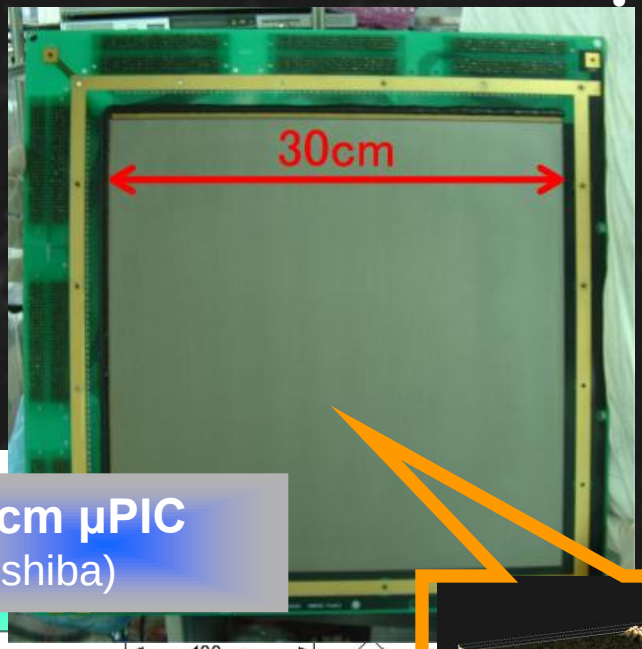


3D tracking device: microTPC

- 2D imaging device:
  μ-PIC (gas gain 5000)
  - 400mm pitch
  - 30×30cm²
- Gas volume
  - DRIFT length 31cm

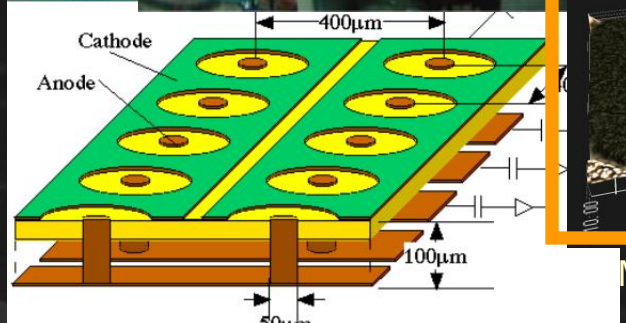


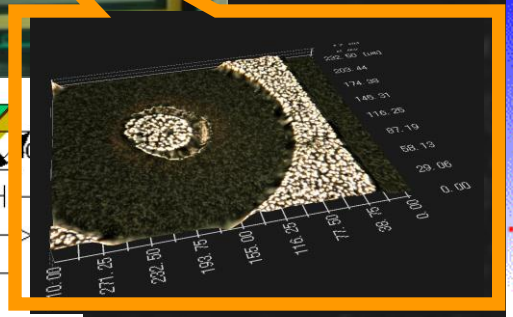
gas volume



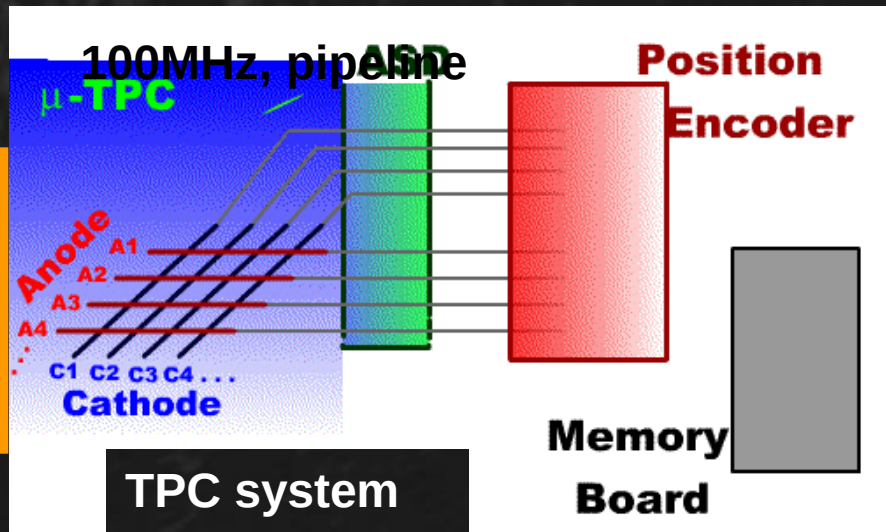
- Readout electronics
  - Digital ”3D-HIT” (track)
    +charge (energy)

30cm μPIC
(Toshiba)





M

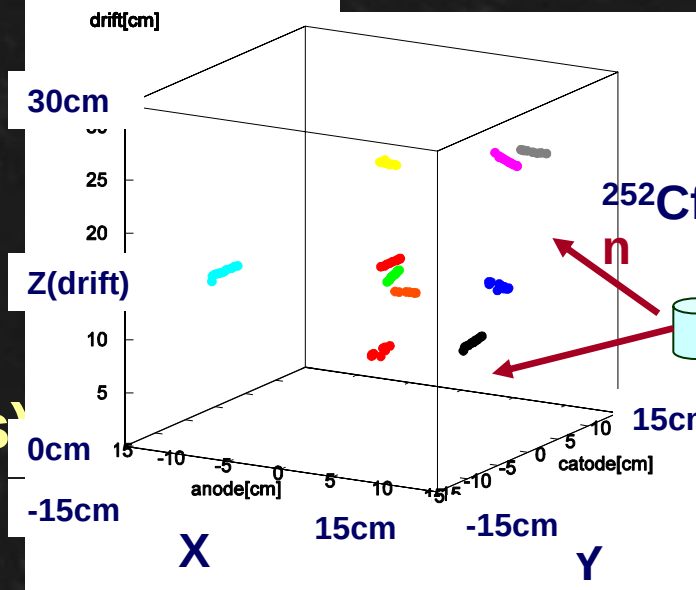


TPC system

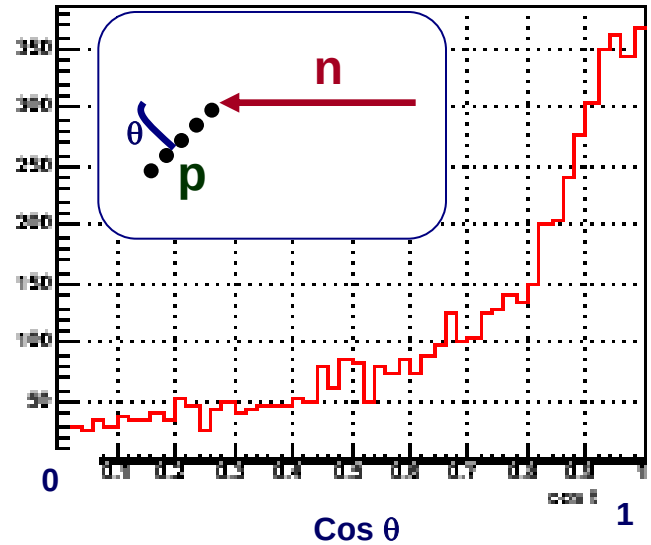
TPC Performance
①nuclear tracking

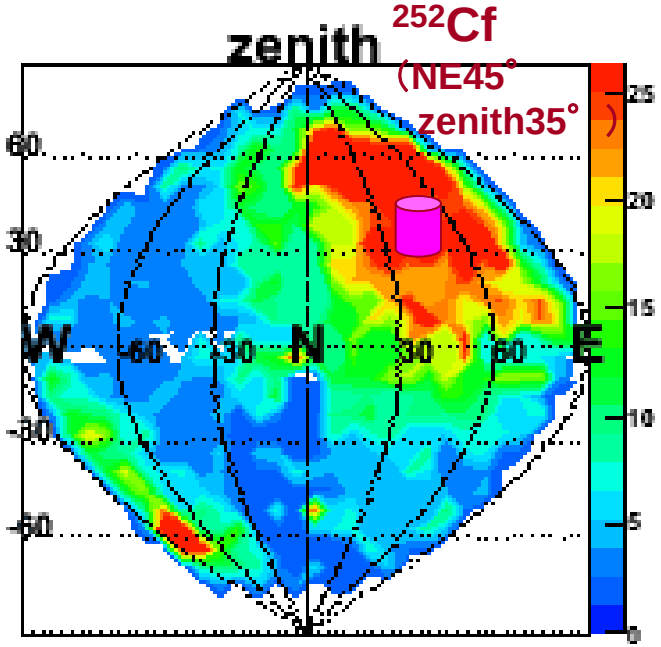
- CF_4+C_4H_{10} (9:1) 0.2 atm
- n -> p forward scattering
  (emulation of WIMP -> F scatterings)

Proton tracks



CF_4+C_4H_{10}
^{252}Cf run



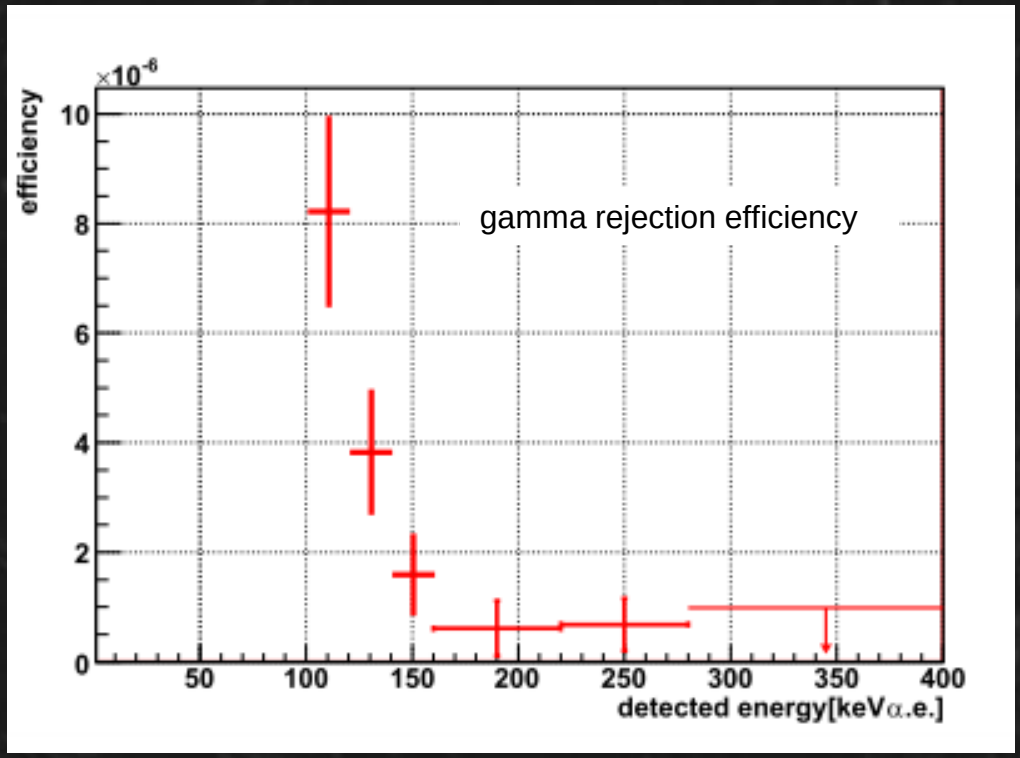


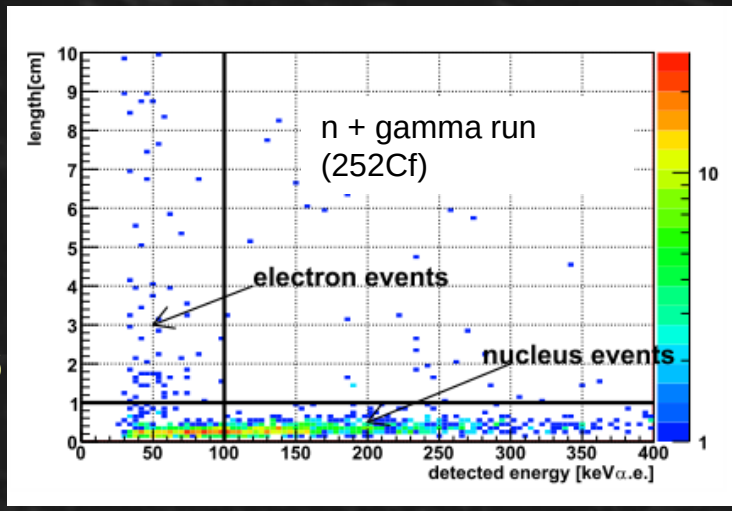
Recoil direction image

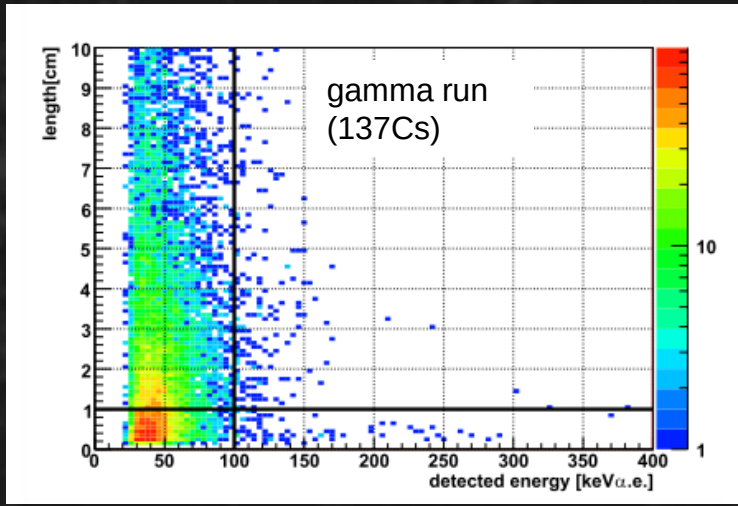
Direction Sensitive
WIMP-search
NEWAGE

TPC Performance
②gamma rejection

- energy vs length cut
- gamma rejection efficiency† 8.1×10^{-6}







† gamma rejection efficiency=electron detection efficiency

Direction Sensitive WIMP-search NEWAGE

1st underground result =NEWAGE-0.3a Kamioka Run5

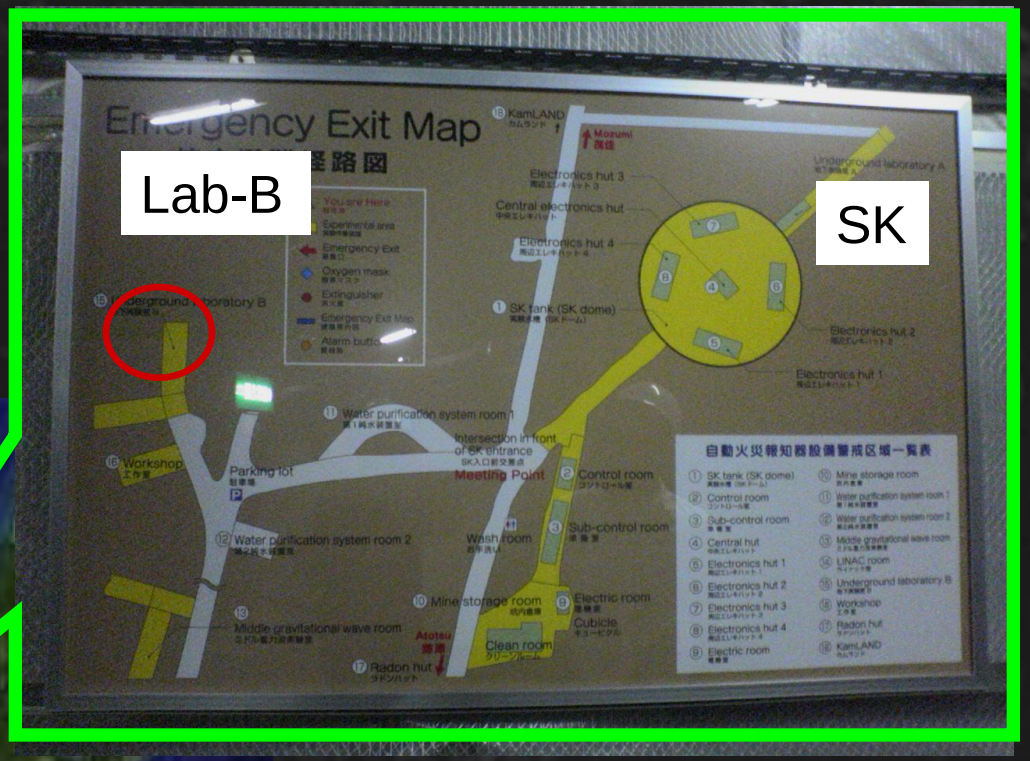
K.Miuchi+
PLB2010(686)11

Direction Sensitive WIMP-search NEWAGE

NEWAGE @ Kamioka

XMASS

- Kamioka mine
- 2700m w.e depth
  - DM measurement
  - Background Study



Direction Sensitive WIMP-search NEWAGE

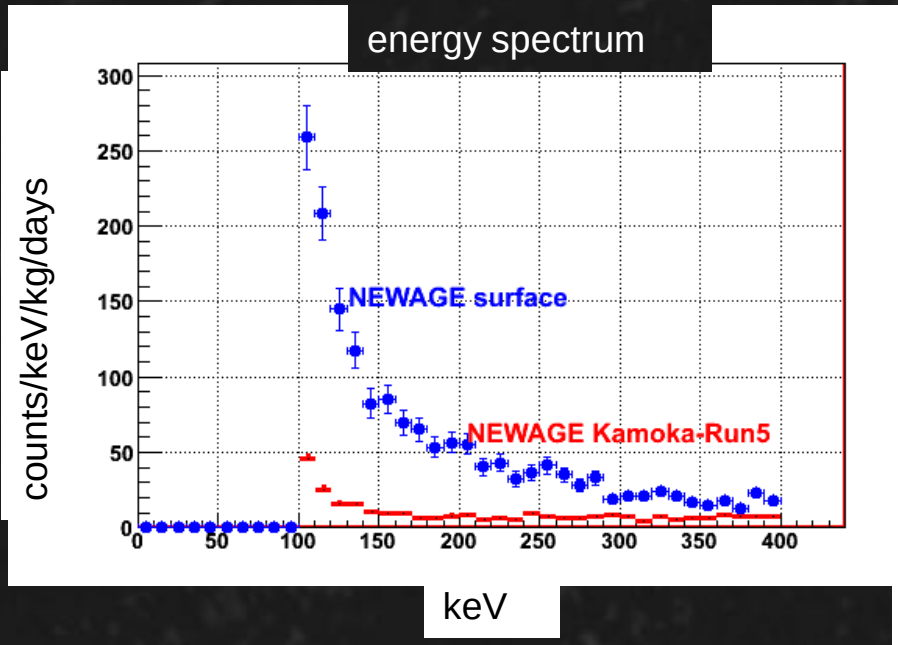
RUN5: Detector

- Target gas: CF4 0.2atm (0.0115kg)
- Exposure:0.524 kg･days
  (Sep. 2008 - Dec. 2008)

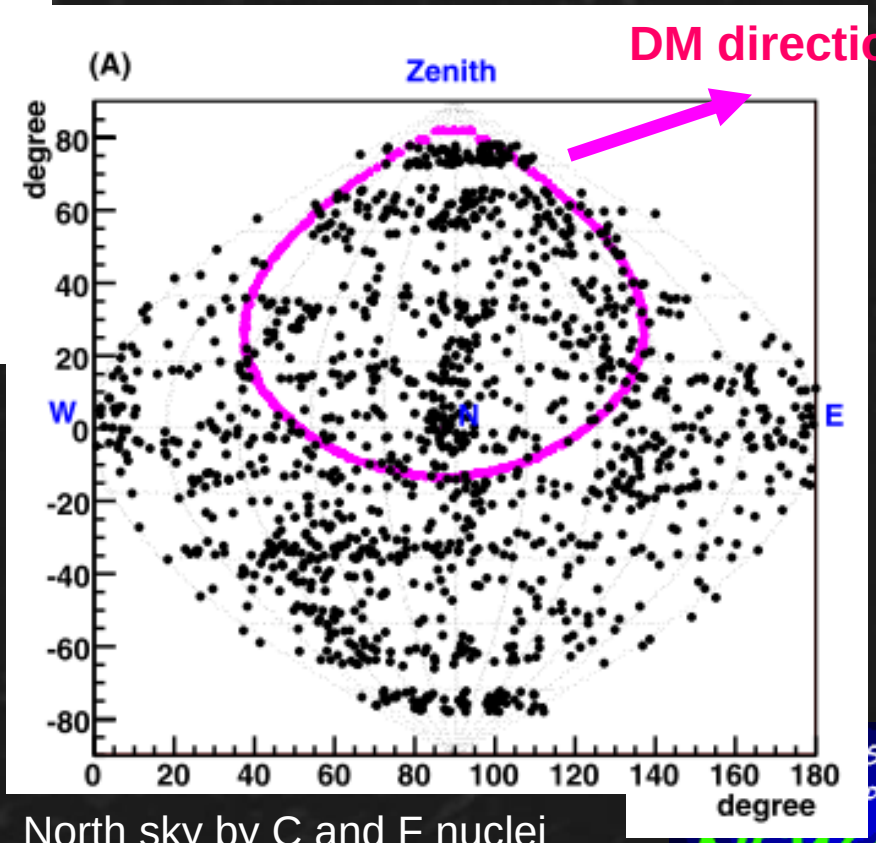
- Energy resolution
  70%@100keV(FWHM)
- Position resolution
  800μm (rms)
- angular resolution
  ~55° (RMS)

RUN5 results①

Energy spectrum 1/5 rate of the surface run



(PLB 686 (2010) 11)



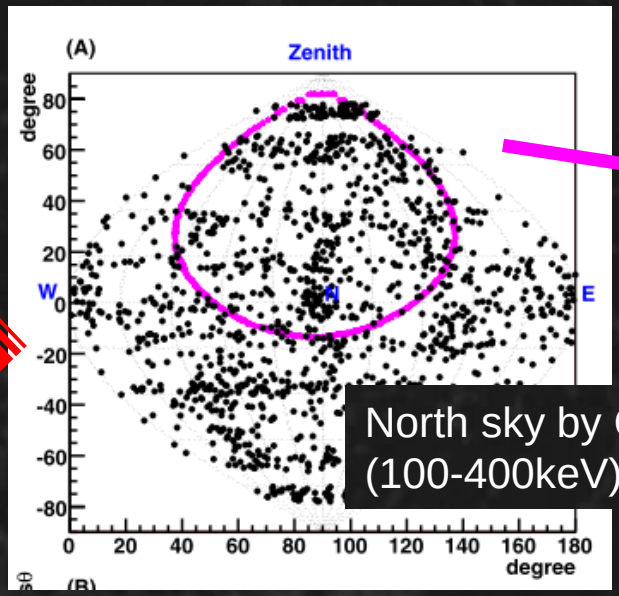
North sky by C and F nuclei (100-400keV)

RUN5 results②

(PLB 686 (2010) 11)

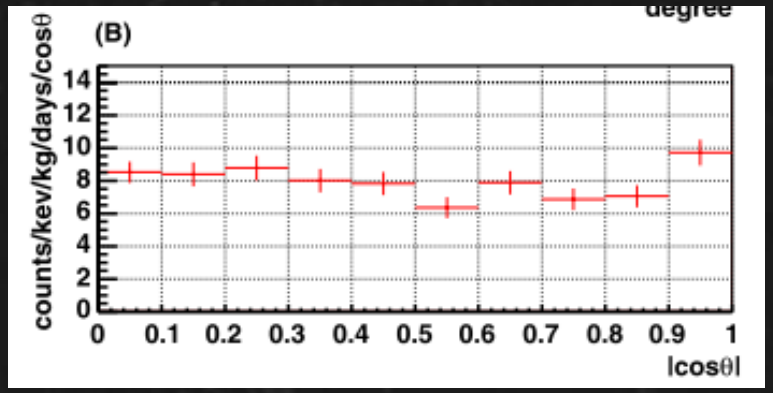
- The sky map
  - --> cosθ distribution
    - --> upper limits

new limits 5400pb
for 150GeV



DM direction

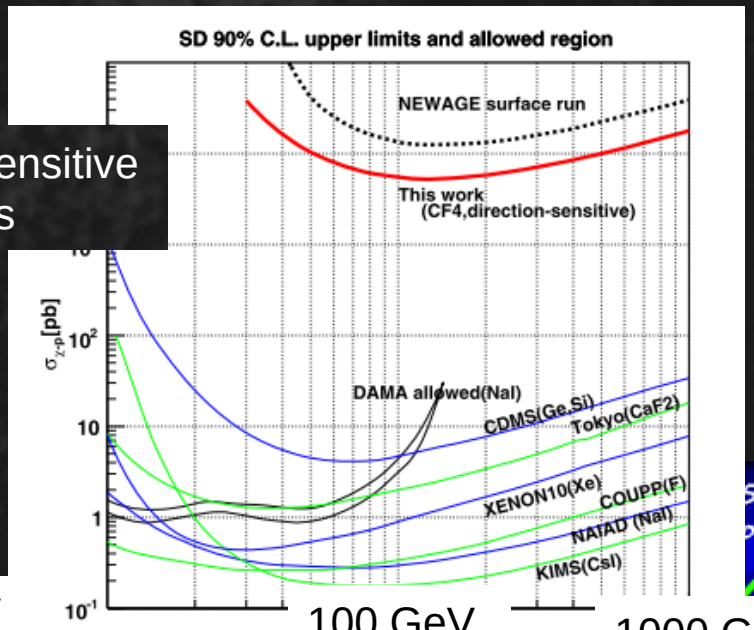
North sky by C and F nuclei
(100-400keV)



Cosθ distribution

(100-400keV)

direction-sensitive
upper limits



Recent activities

- Sensitivity improvement (underground updates)
- To go further (surface R&Ds)

Direction Sensitive WIMP-search NEWAGE

Sensitivity improvement

- radon gas
- gamma rays
- α particles

⇒ low background aiming 1/10

- DAQ upgrade

⇒ low threshold

- Kamioka RUN-13 TODAY
  - RUN13-1 : 2012 Jan. 23 – March 8
  - RUN13-2 : 2012 March 8 – May 24
  - RUN13-3 : 2012 May28-

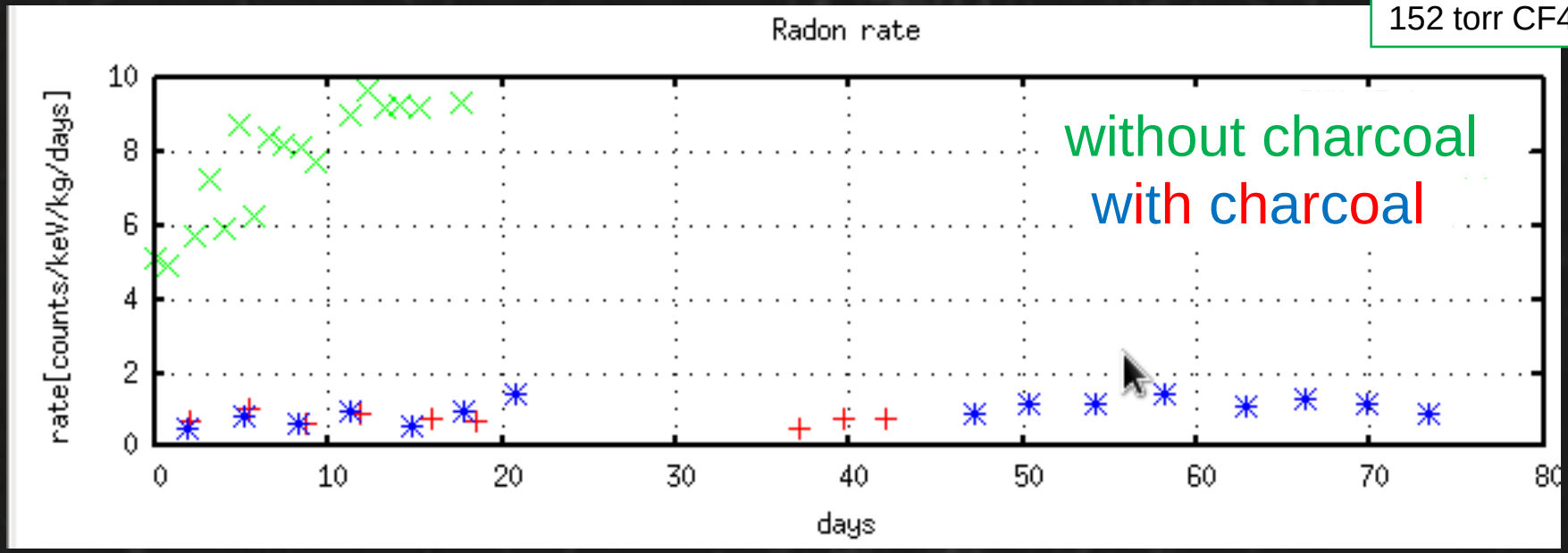
Direction Sensitive WIMP-search NEWAGE

Radon: charcoal

- gas circulation system
- monitor radon rate (~6MeV)
- radon rate ～1/10 after day10

charcoal filter ~100g
(TSURUMICOAL 2GS)
getter pump
(SAES GETTER C400-2DSK)
circulation
(Teflon bellows pump)

NEWAGE0.3a
152 torr CF4 gas



cf: 1e5counts/kg/days～1Bq/m^3

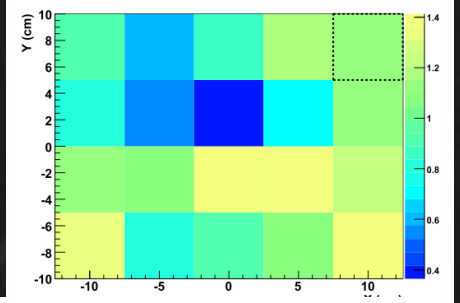
Direction Sensitive WIMP-search NEWAGE

gamma: precise gain map

- gas gain is not uniform in 30×30cm²

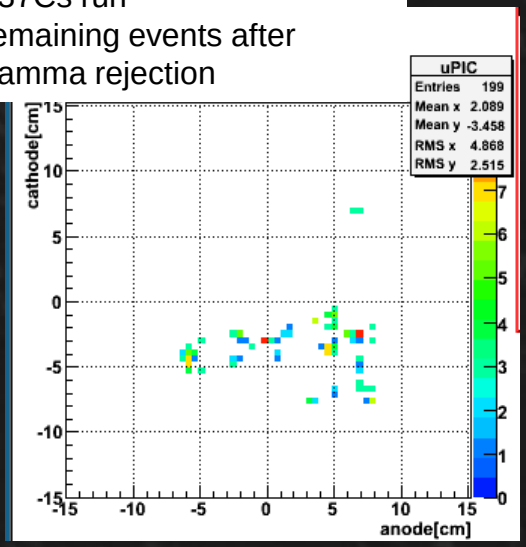
RUN5

old gain map



20cm

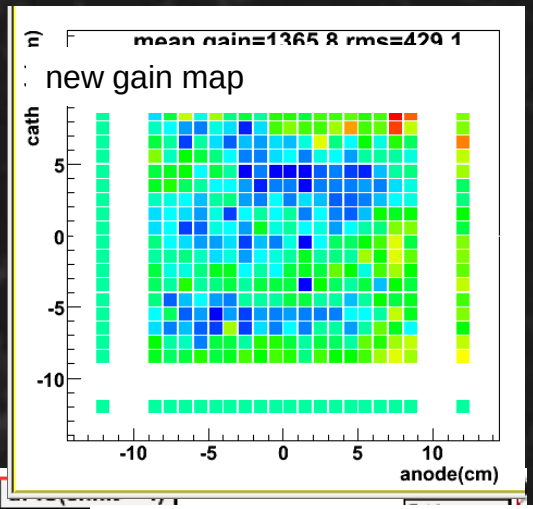
137Cs run
remaining events after
gamma rejection



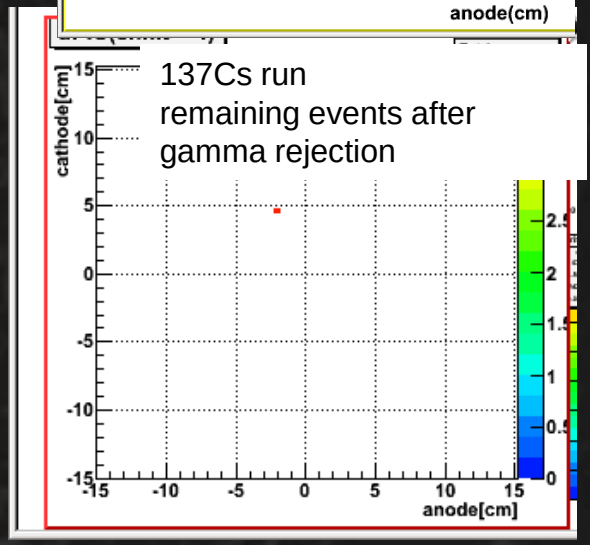
gamma rejection
8.1e-6

RUN13

new gain map



137Cs run
remaining events after
gamma rejection

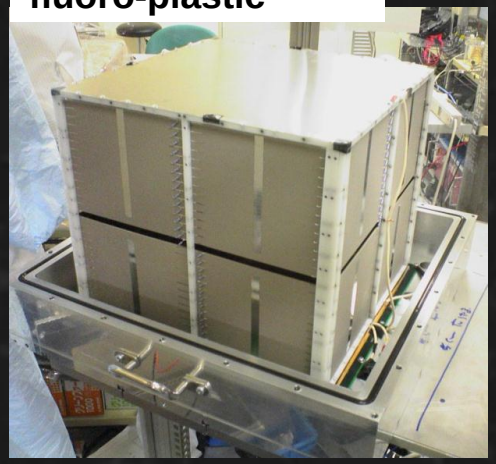


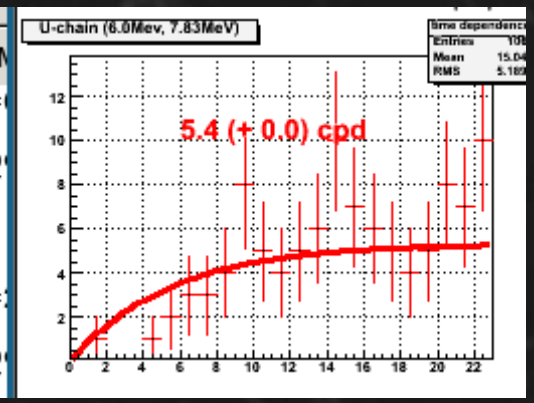
gamma rejection
1.0e-6>

Direction Sensitive WIMP-search NEWAGE

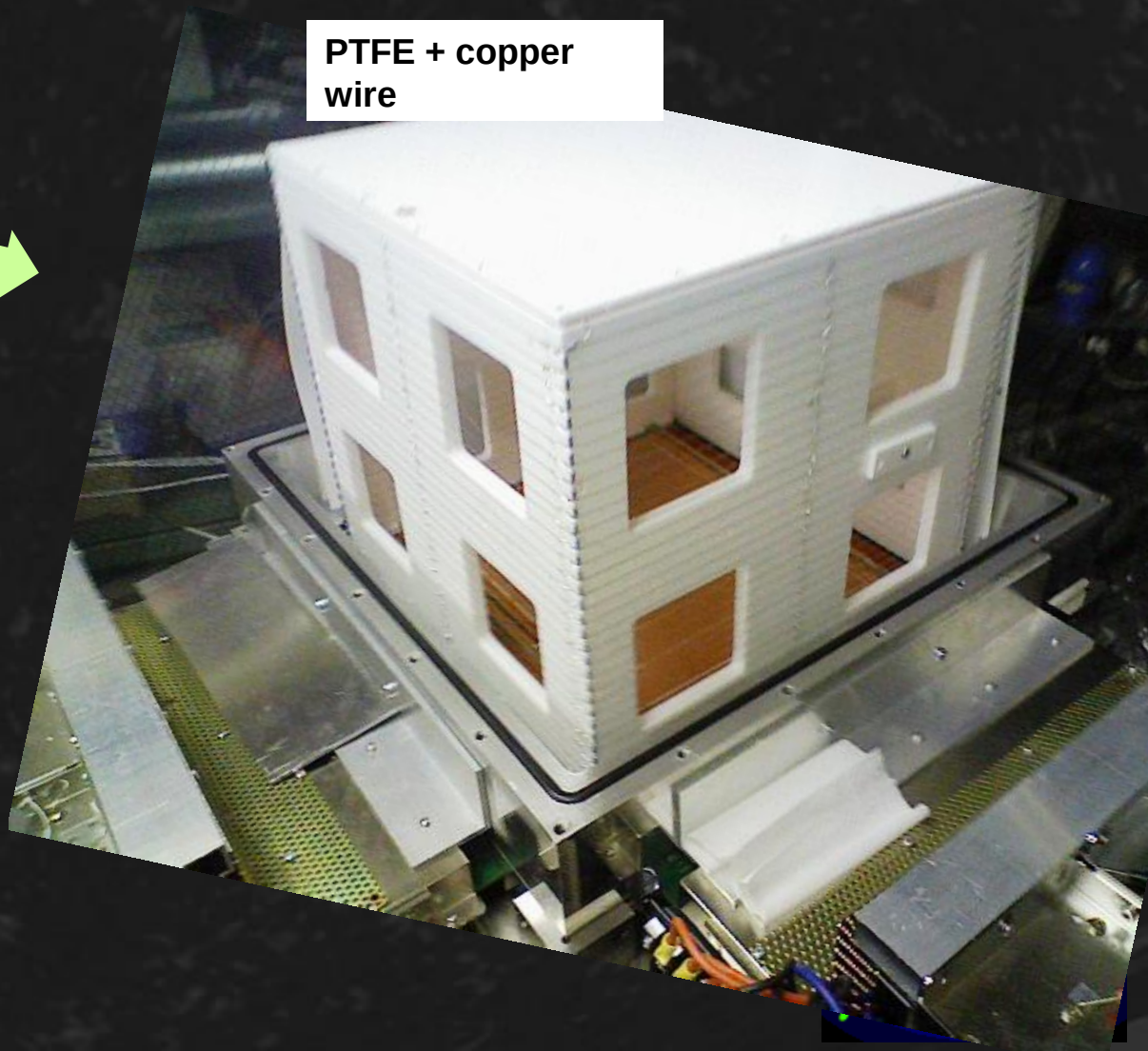
radon, gamma, alpha: "clean" materials to <1/10 radon emanation level

glass-reinforced fluoro-plastic



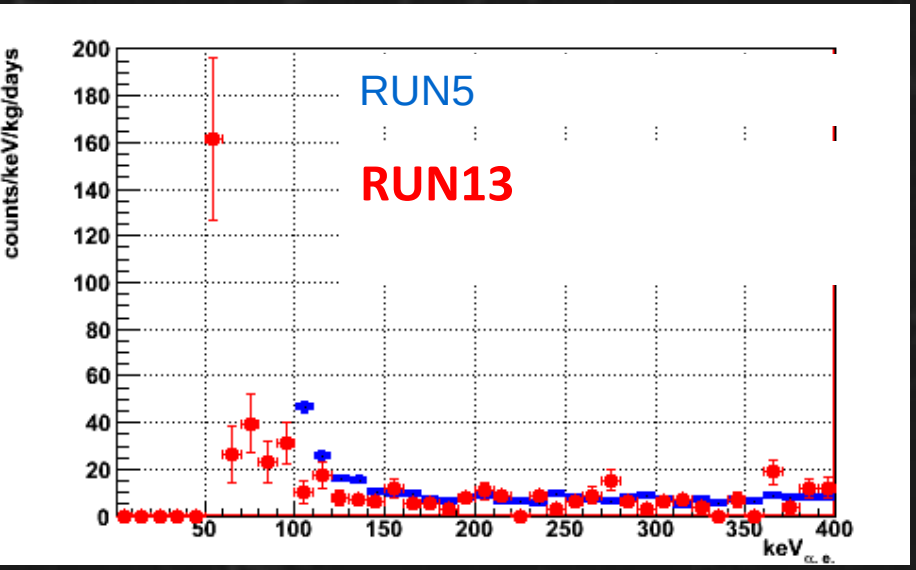


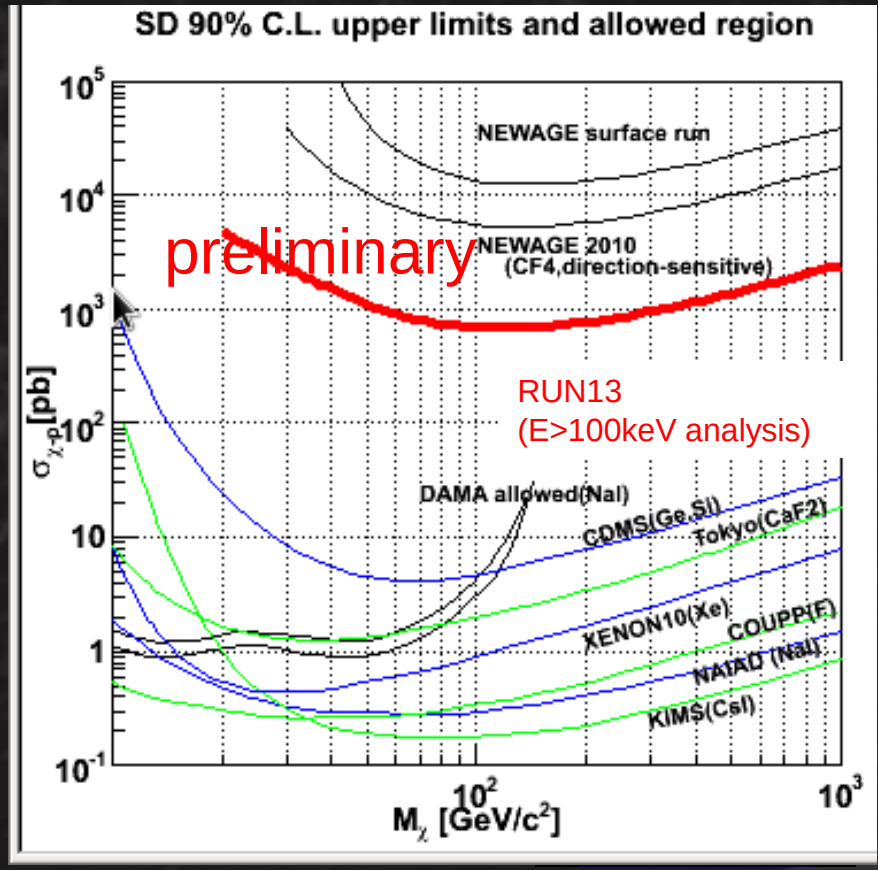
PTFE + copper wire



Results(preliminary)

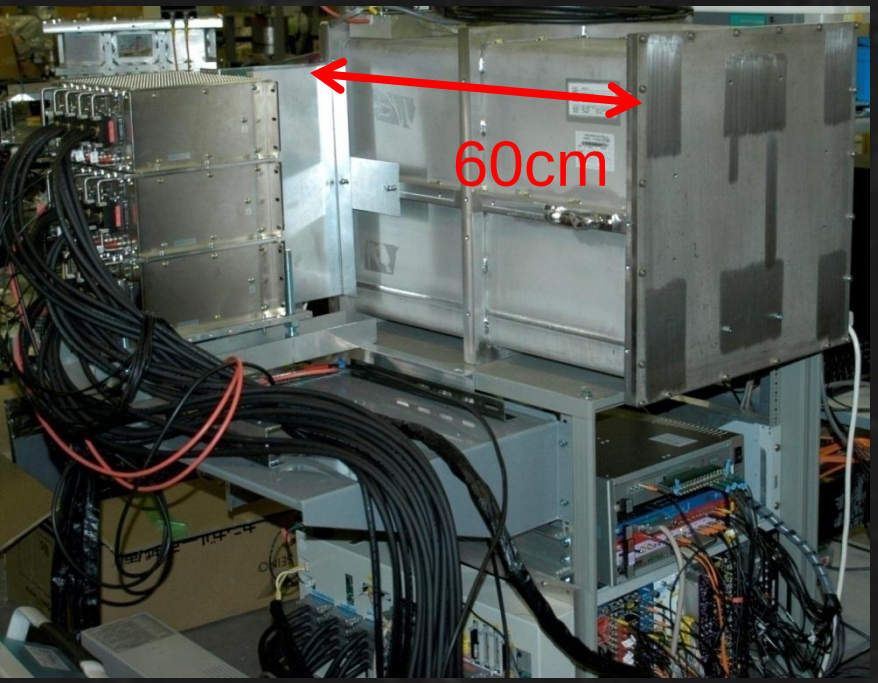
- exposure 0.140kg･days
- spectrum threshold 100keV⇒50keV
- rate: ～1/5 at 100keV
- direction-sensitive analysis: on-going



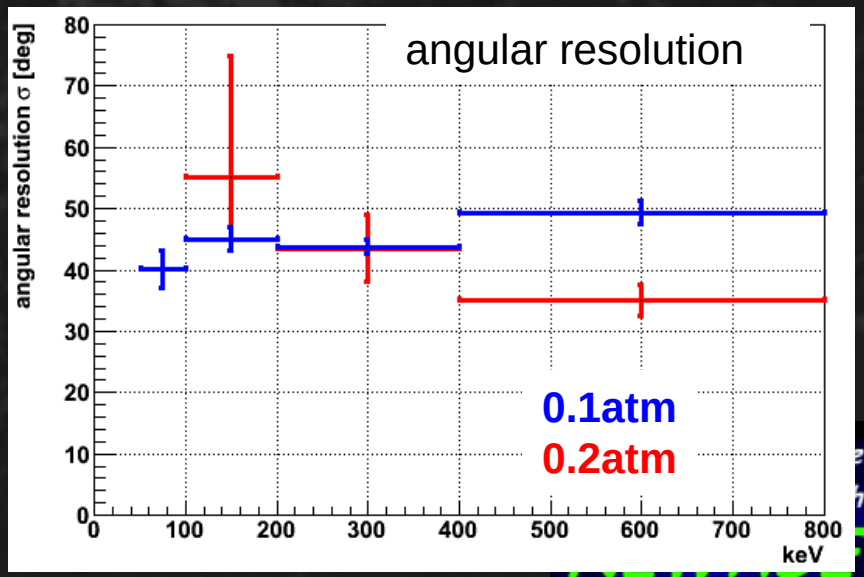


To go further…
(R&D in surface labo.)

- NEWAGE-0.3b detection volume $31 \times 31 \times 50 cm^3$
- Cold charcoal
- 0.2atm ⇒ 0.1atm CF4 gas for lower threshold



K.Nakamura
2012 JINST 7 C02023



SUMMARY

- NEWAGE: direction-sensitive DM exp.
- 1st underground run:
  updated direction-sensitive results

- underground and surface R&Ds are on-going

Direction Sensitive WIMP-search NEWAGE