NIT Sensitivity evaluation with 290MeV/n carbon

Nagoya University

tada

29,30 May ,2018 NEWSdm collaboration meeting @ Capli

The motivation for heavy ion beam analysis

1.Motivation
For NEWSdm experiment

- ✓dE/dx is similar to C recoil
  → good to check the sensitivity test
  → fading stability

- ✓Very clear straight tracks
  → easy recognition

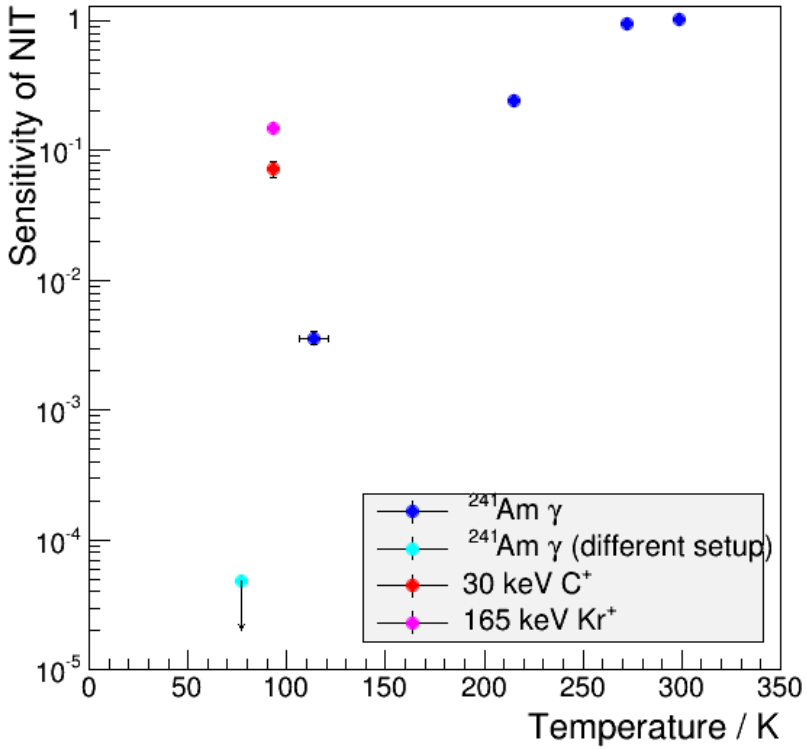
2.Motivation
Application of NIT

- ✓Analysis for high dE/dx cosmic ray events
- ✓Application NIT for heavy ion collision experiment

NIT has high spatial resolution and very wide dynamic range of charge ID for high dE/dx particle.

Sensitivity check at low temperature

Motivation



M. Kimura *et al., NIMA (VCI2016) 2016*

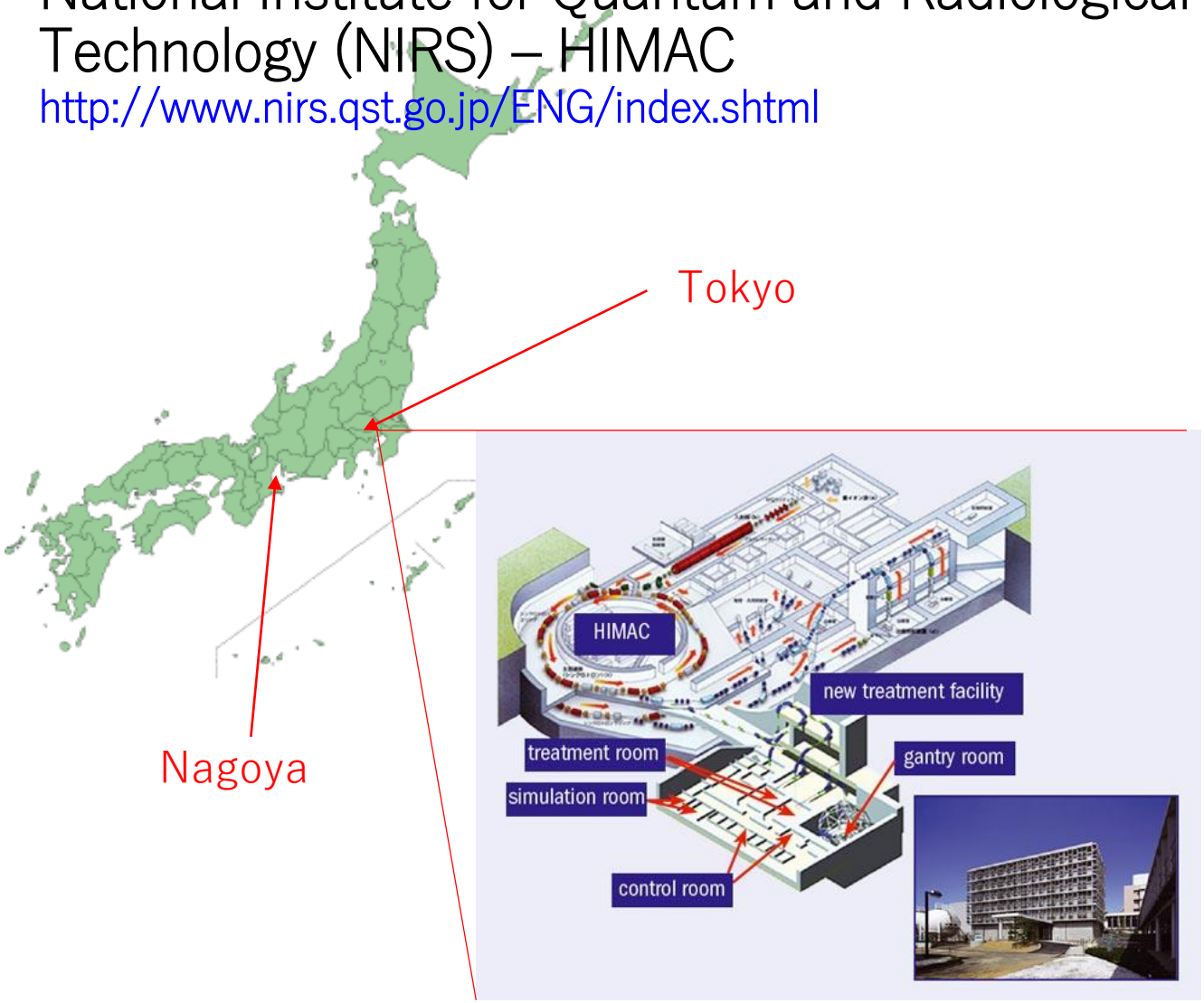
High dE/dx particle	Low dE/dx particle
Recover sensitivity loss	**Sensitivity decrease**

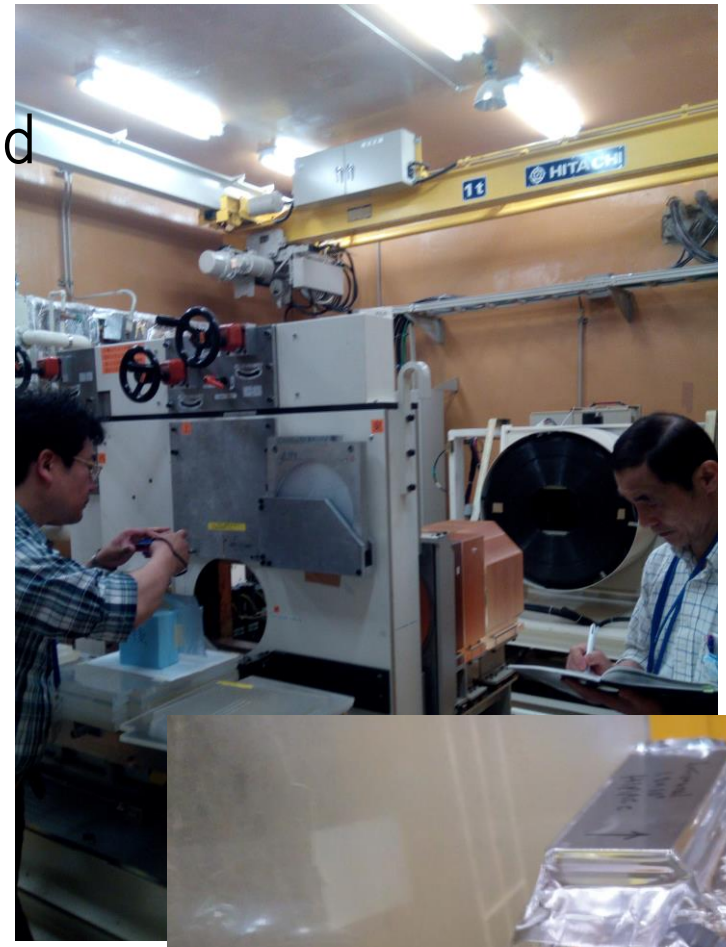
Evaluate the sensitivity by dE/dx

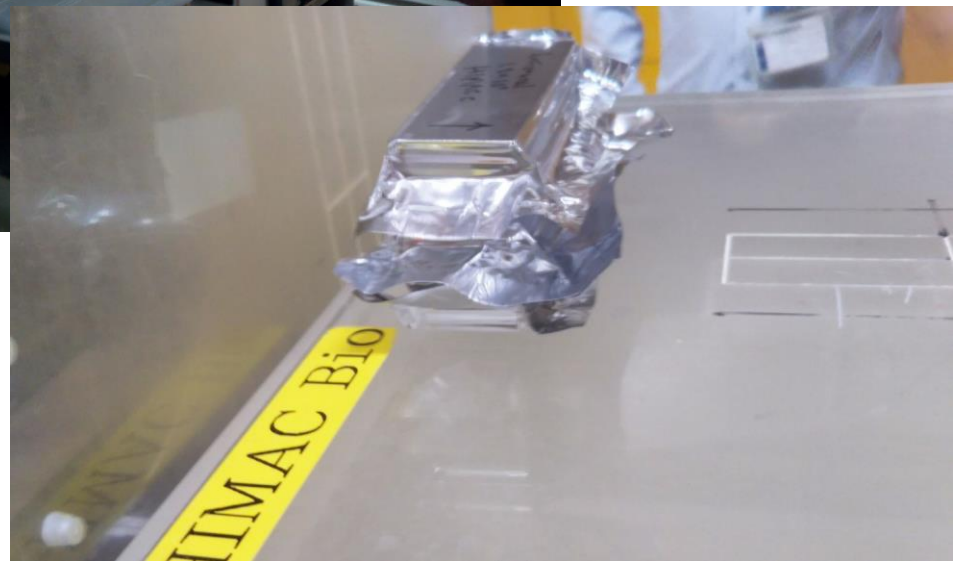
→We can determine best S/N temperature for NEWSdm experiment

Heavy Ion Beam Test

National Institute for Quantum and Radiological and Technology (NIRS) – HIMAC
http://www.nirs.qst.go.jp/ENG/index.shtml







http://cerncourier.com/cws/article/cern/42717

Property of Heavy Ion Beam

	Energy loss [keV/μm] by SRIM
C (290 MeV/n)	~ 28
Fe (500 MeV/n)	~ 400
α -ray (5 MeV)	~ 150

Low-velocity C ion	ESP [keV/μm]	NSP [keV/μm]
50 keV	~150	~58
100 keV	~220	~40

- ESP : electron stopping power
- NSP : nuclear stopping power

We can test the similar region of energy loss

Available ions at HIMAC :

Nuclei	Energy [MeV/n]	Z/β
H	160	2.0
He	150	4.1
C	135	13
	290	9.5
	350	8.9
	400	8.6
Ne	230	17
	400	14
Si	135	30
	490	19
Ar	500	24
Fe	200	47
	500	35

11 May, 2018 →

7 July, 2018 →

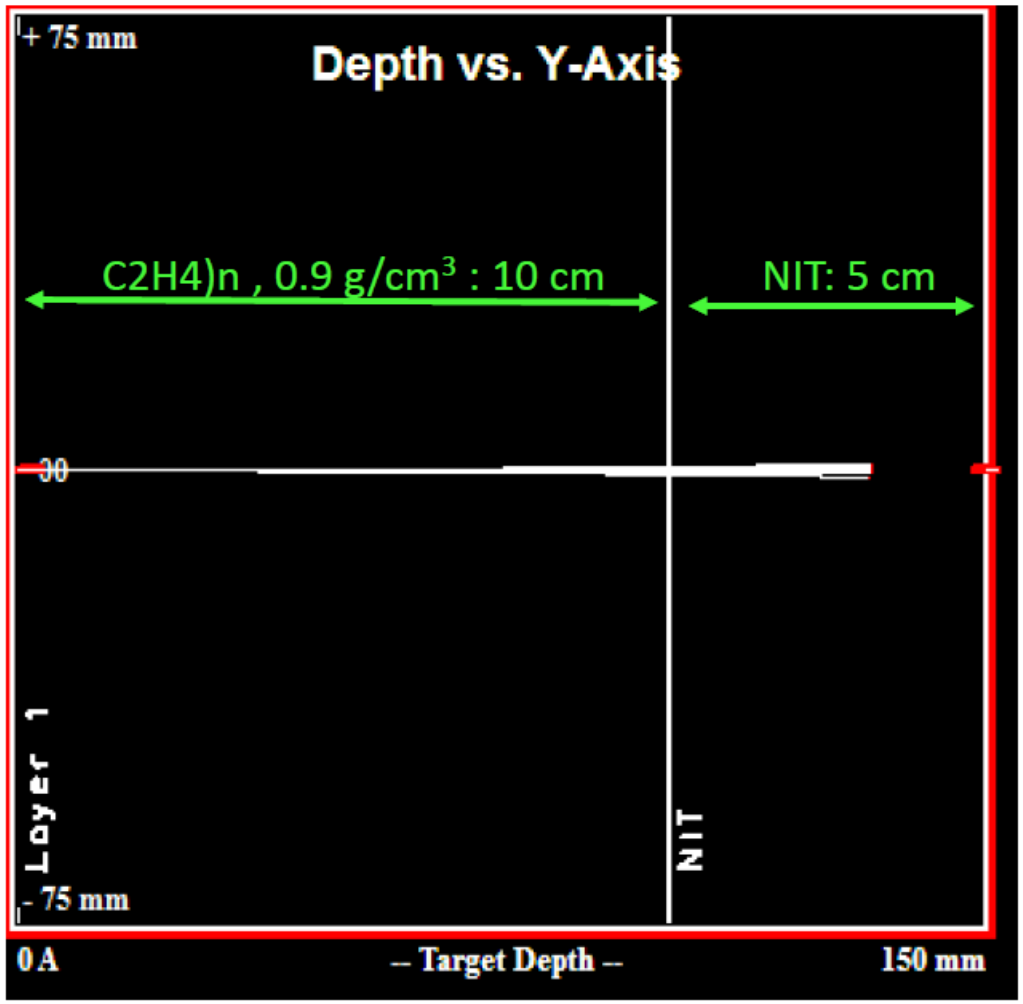
Sample

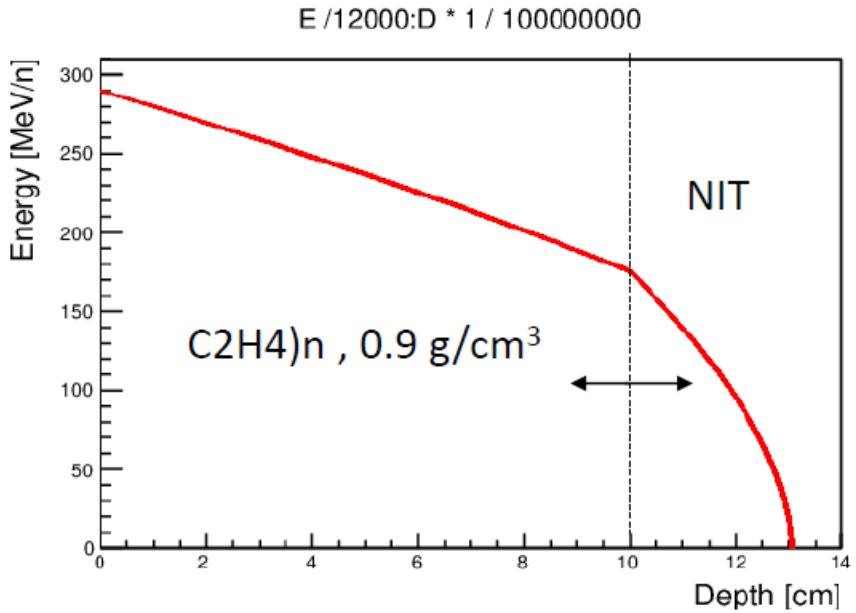
Emulsion batch	Structure	Sensitization
FAN102gf	Slide glass base (2cc application)	Na2SO3 (standard)
FAN104gf	Slide glass base (2cc application	Na2SO3 (standard)

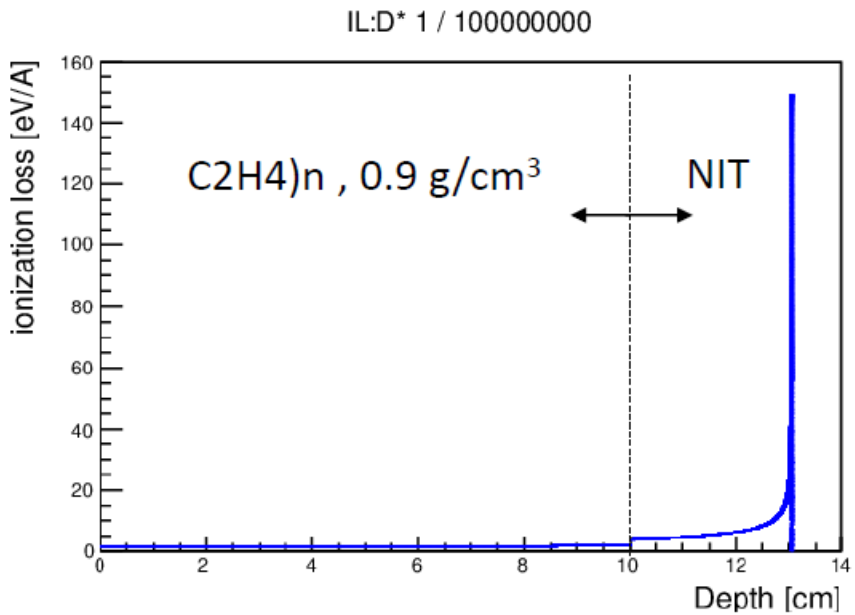
Target Temperature[℃]	Energy(MeV/n)	Cooling Method
20	290, 190(Bragg peak)	Room temperature
-20	190(Bragg peak)	Dry ice + ethanol
-68	290, 190(Bragg peak)	Dry ice + ethanol
-170	290, 190(Bragg peak)	Liquid N_2

Naka san Slide
@Univ.Chiba skype meeting

SRIM simulation to see the Bragg peak in the NIT layer

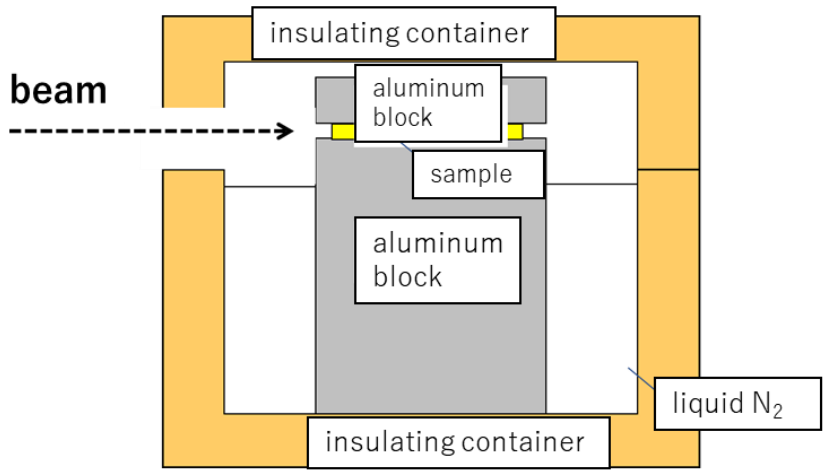


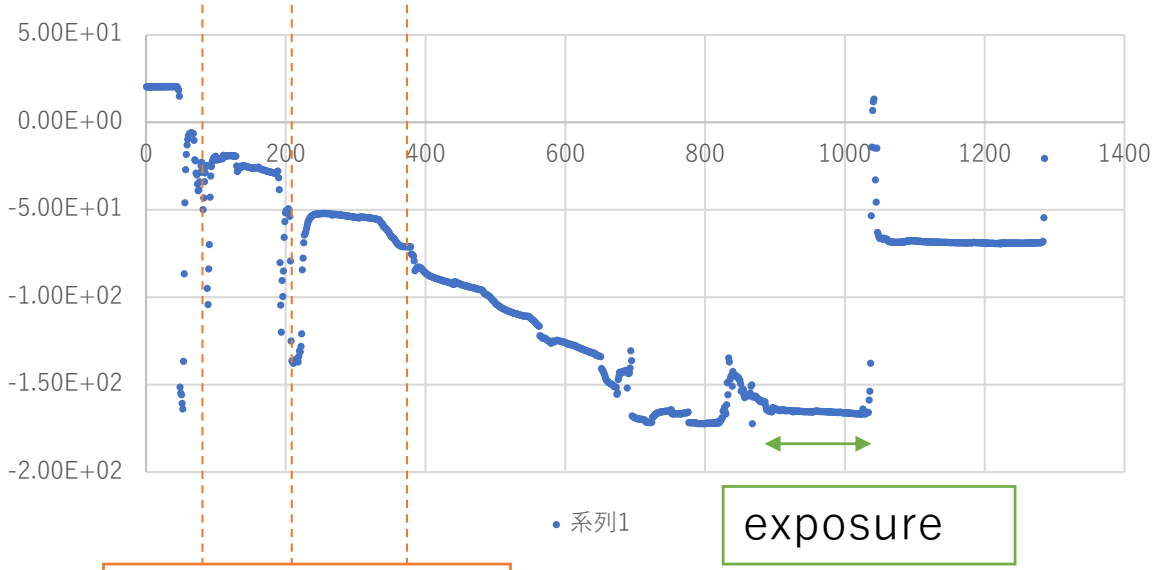




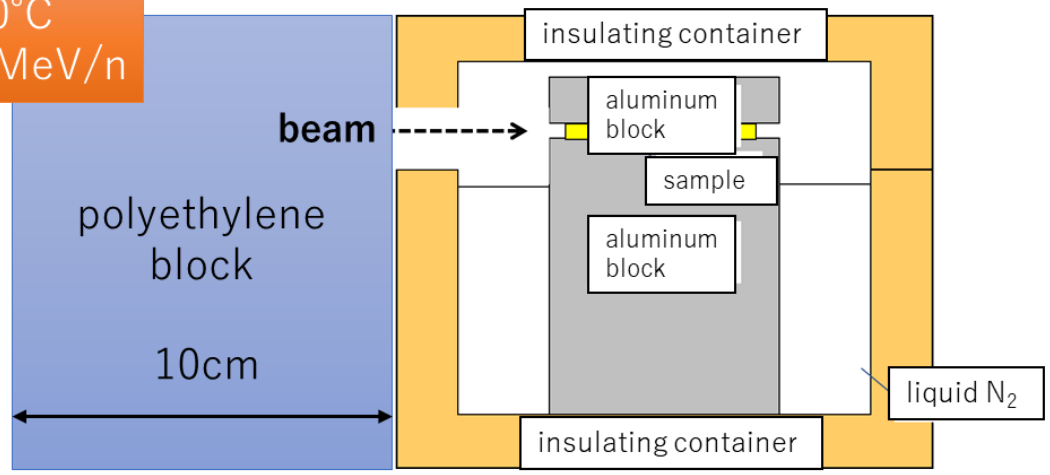
-170°C experiment

-170°C
290MeV/n

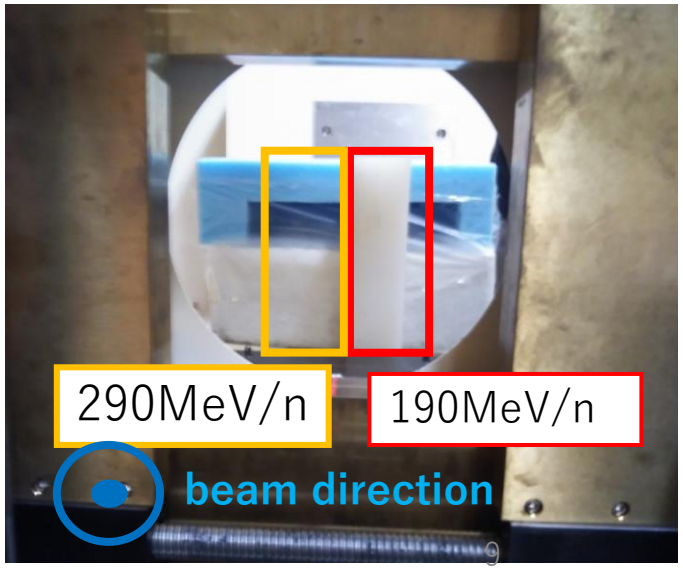




-170°C
190MeV/n

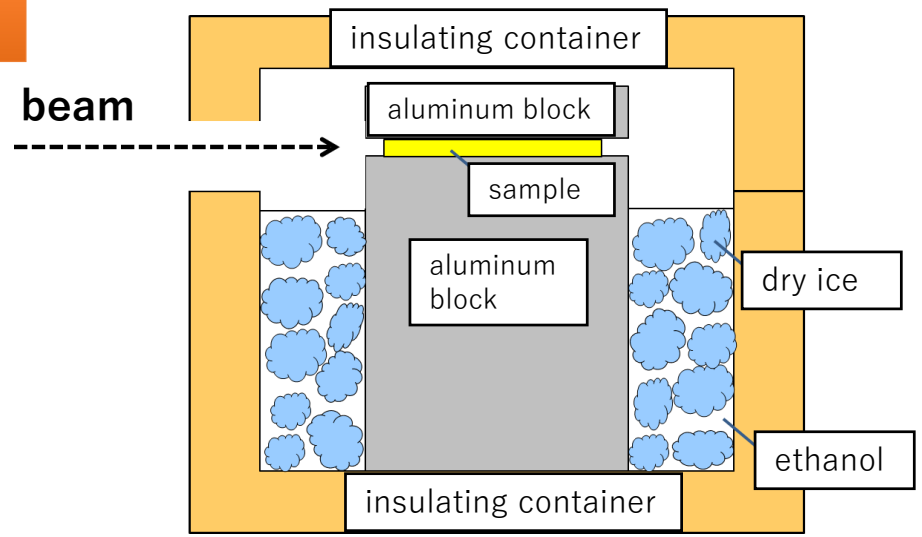


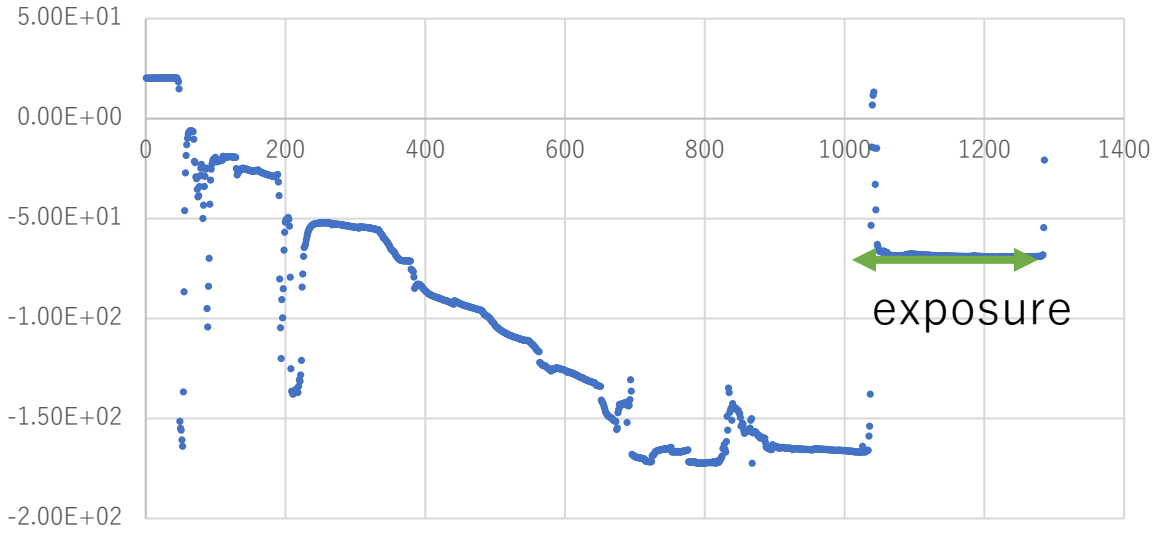
density :$4*10^6(/cm^2)$
$1*10^7(/cm^2)$



-68°C, -20°C　experiment

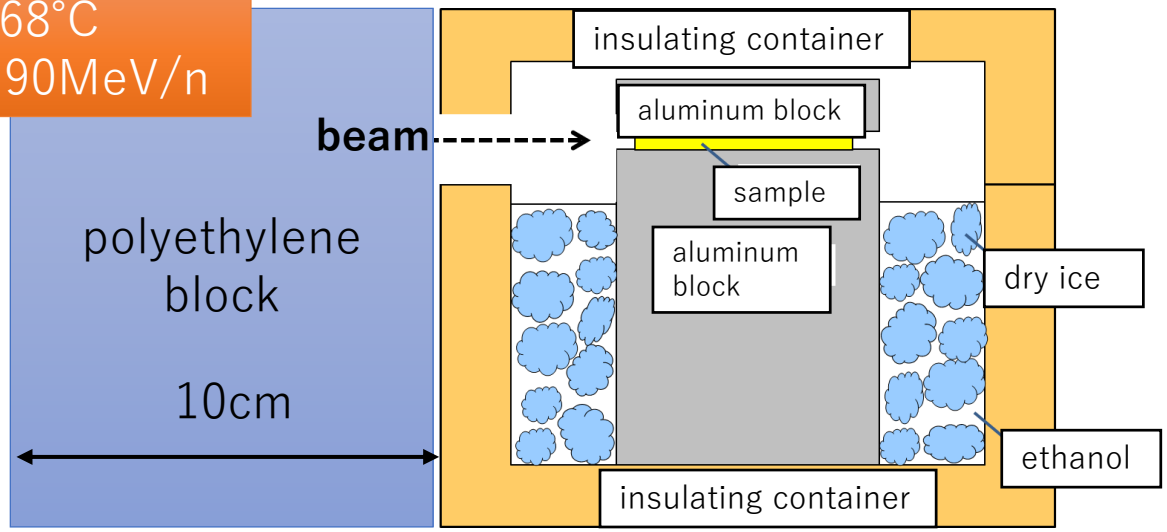
-68°C
290MeV/n

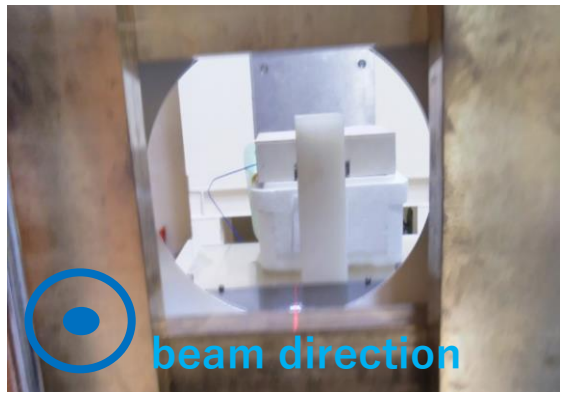




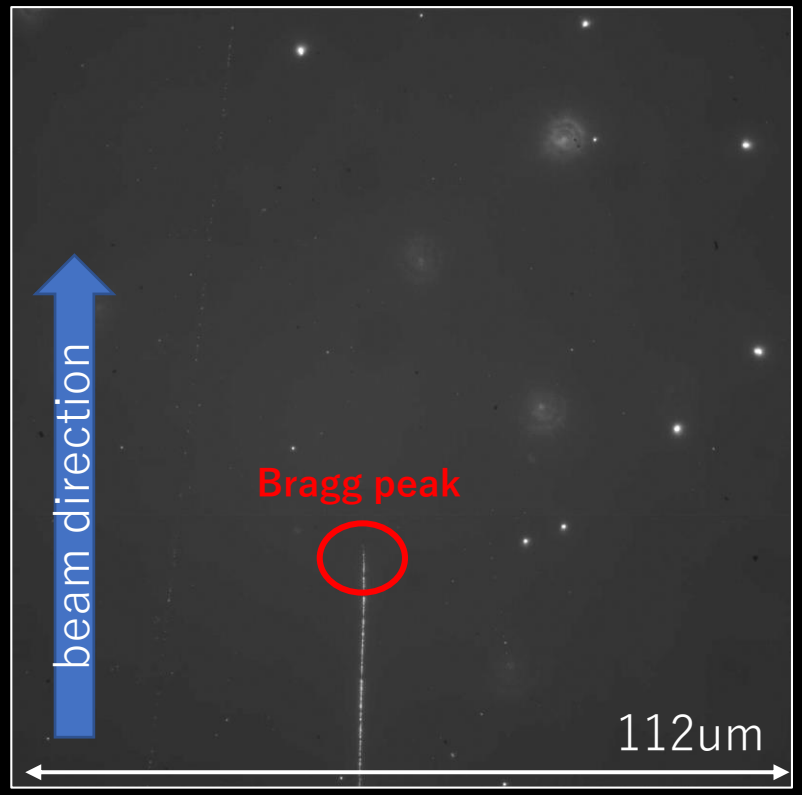
density　：4.0*10^6(/cm^2)
1.4*10^5(/cm^2)

-68°C
190MeV/n

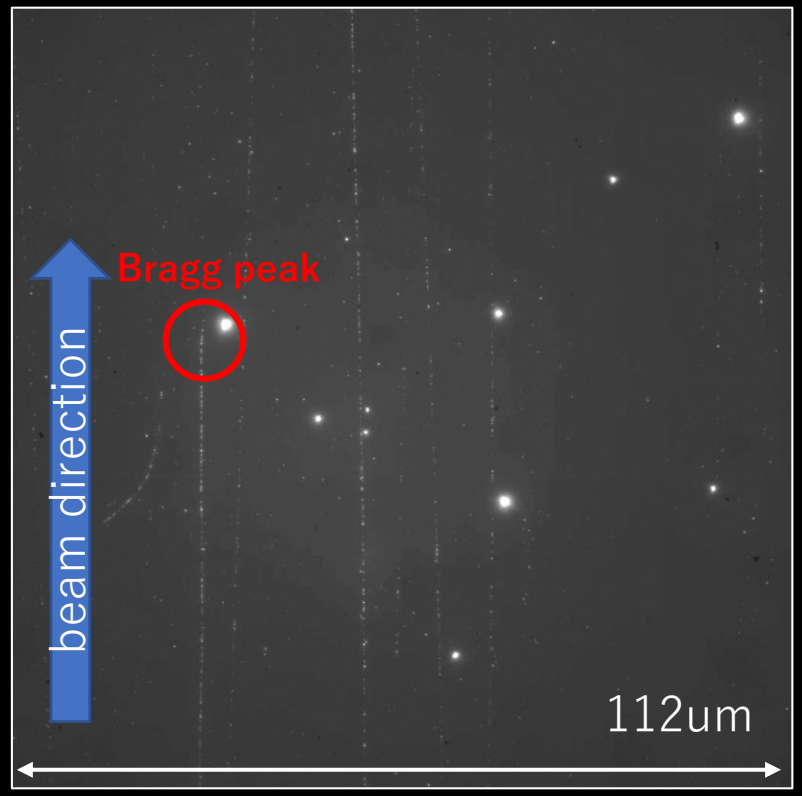




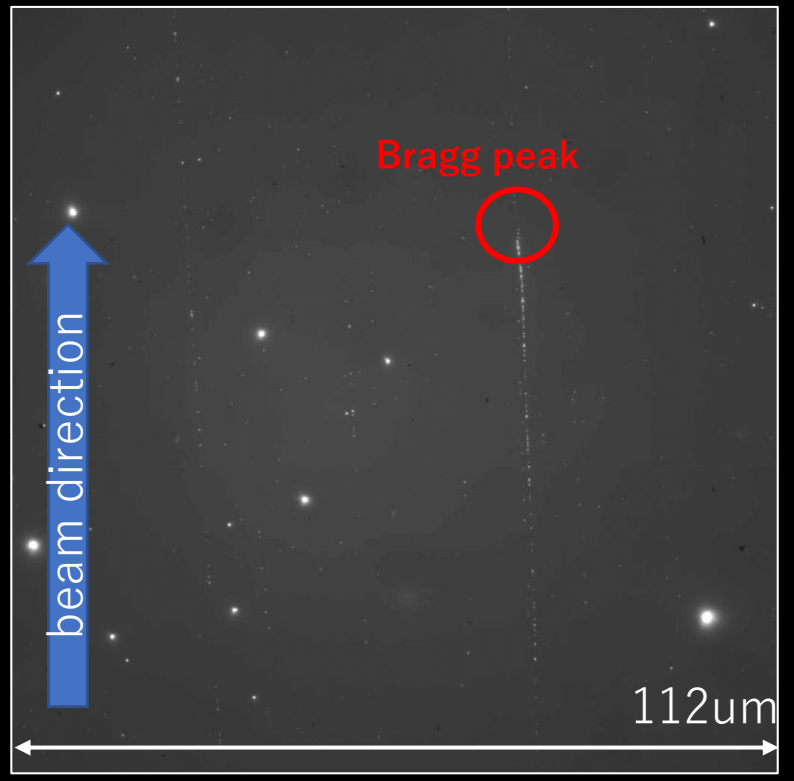
Bragg Peak



room temperature



-20°C

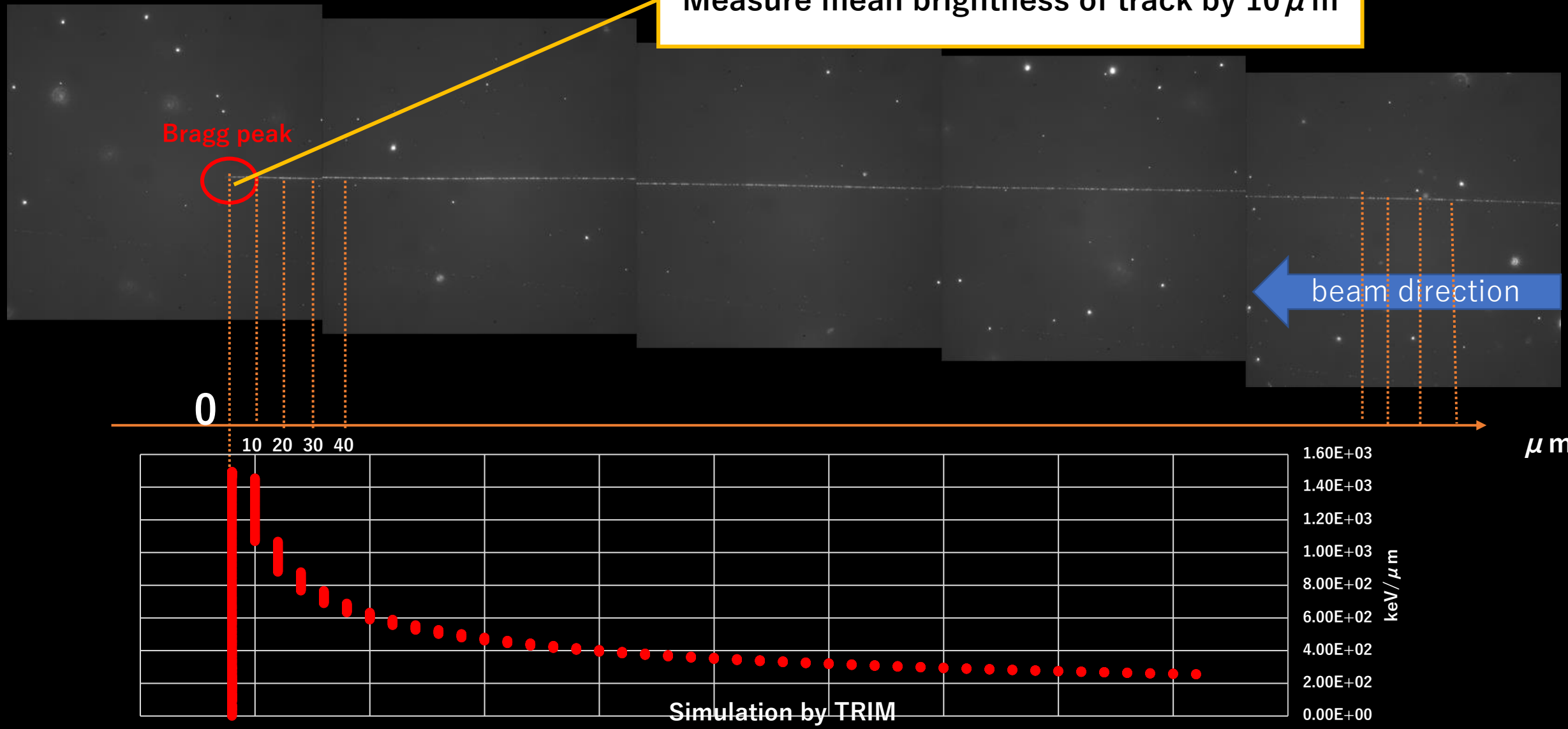


-68°C

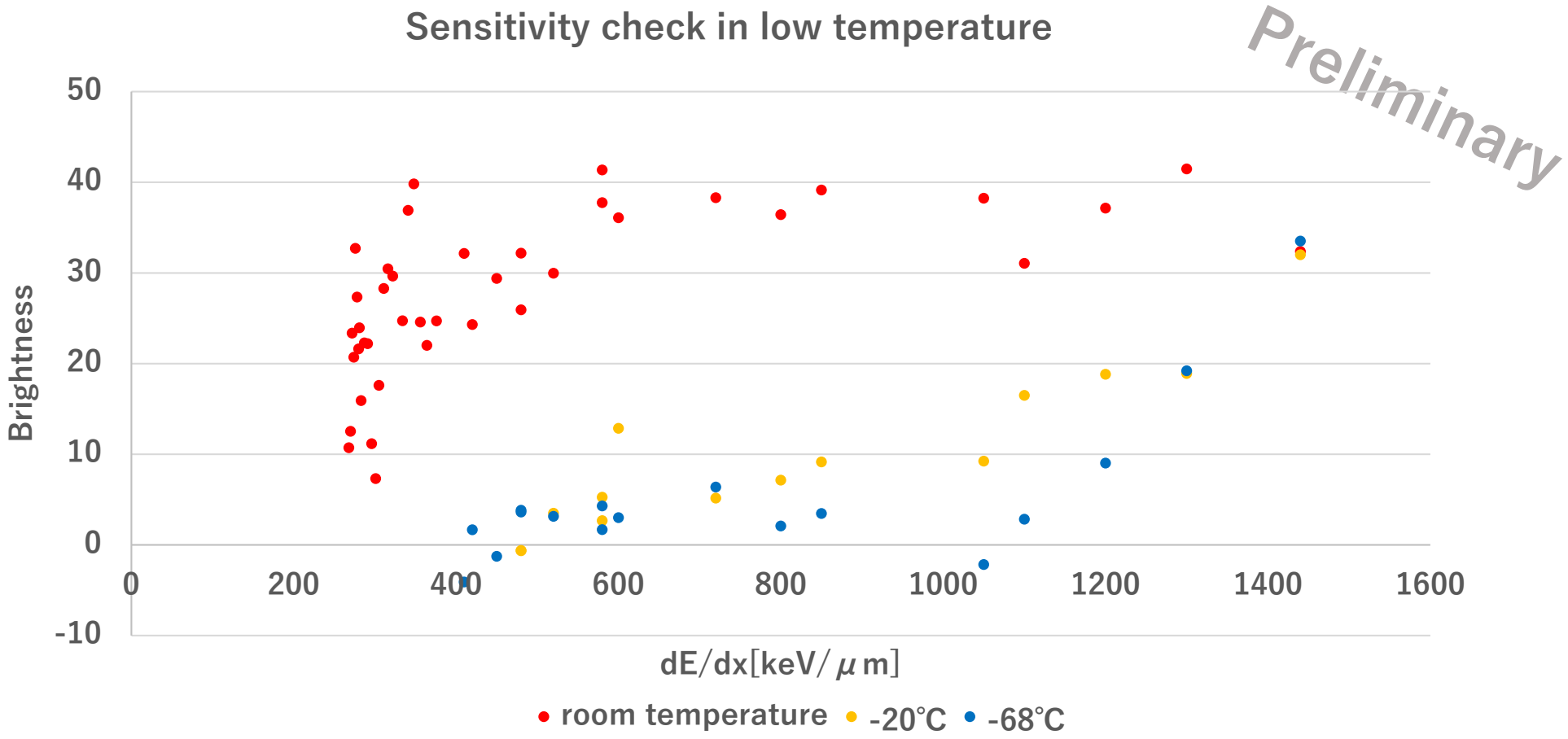
in -170°C exposure sample,
→not be seen

Analysis Method

Measure mean brightness of track by 10 μm



Result

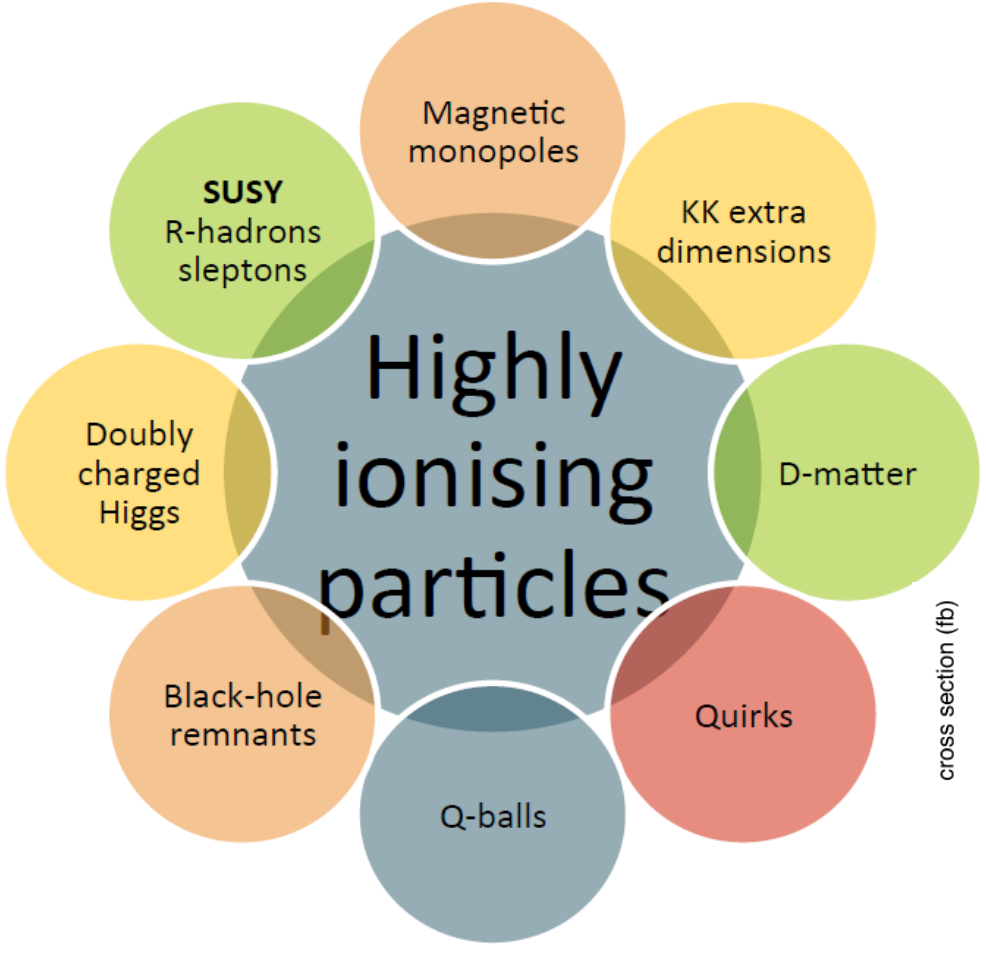

Sensitivity check in low temperature
Preliminary
Brightness
50
40
30
20
10
0
-10
0
200
400
600
800
1000
1200
1400
1600
dE/dx[keV/μm]
room temperature
-20℃
-68℃

Conclusion and future plan

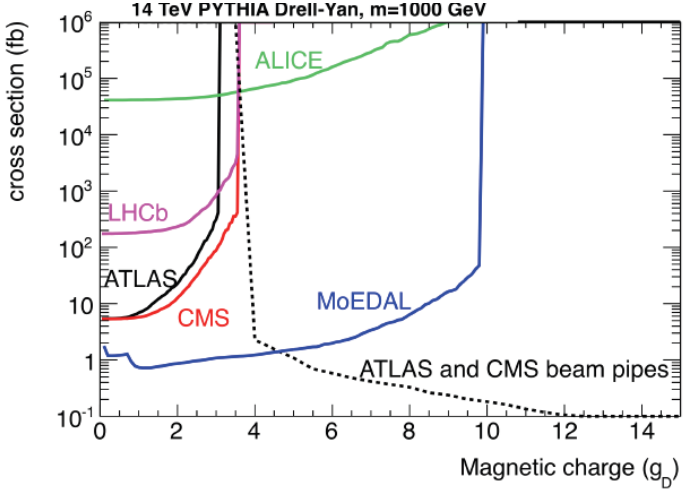
- Fe 500MeV/n　exposure(7 ,July 2018)

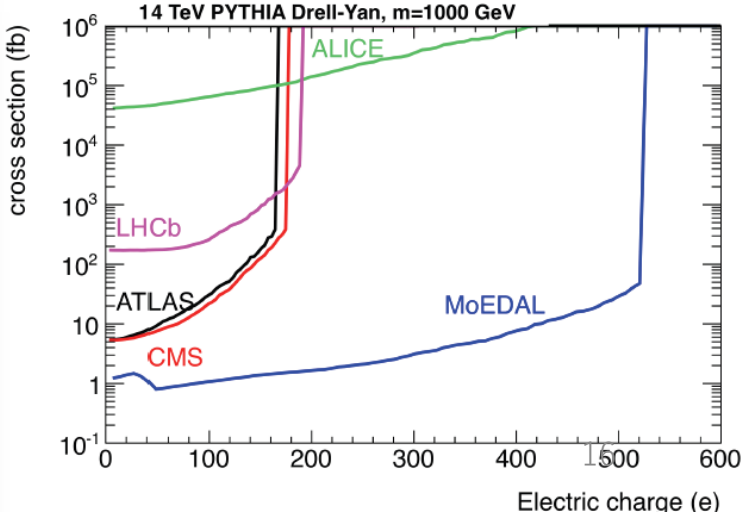
Application of NIT for high dE/dx particle search

Targets



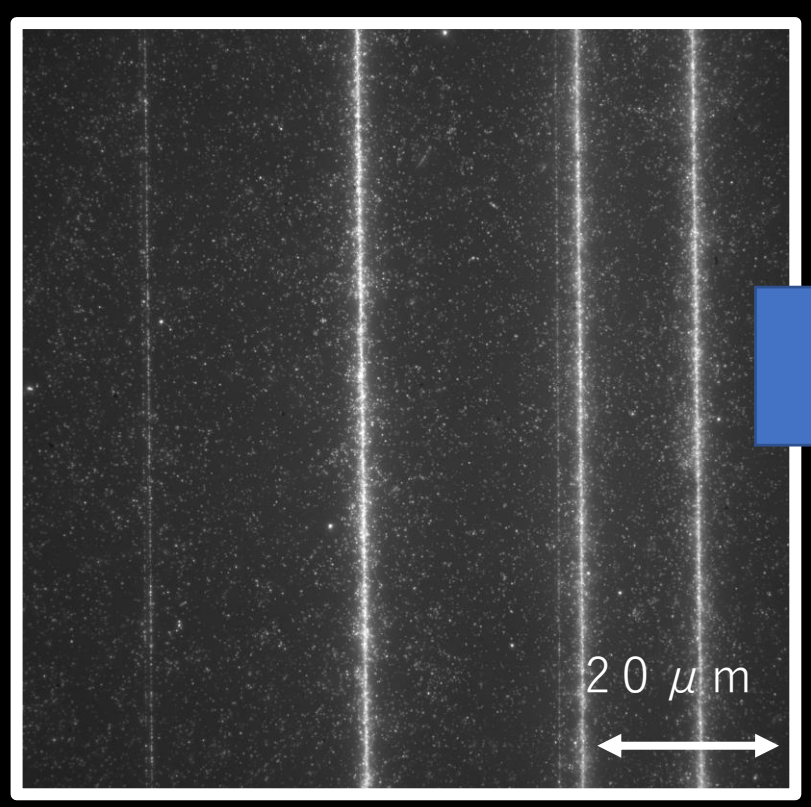
- **high dE/dx cosmic ray events**
- **massive , long-lived and highly ionizing particles**



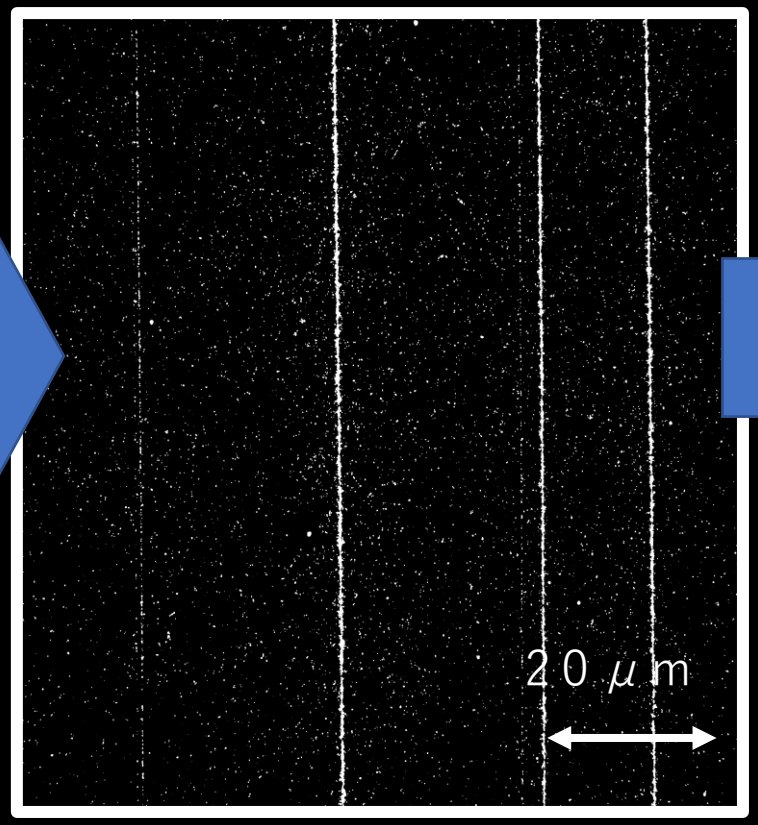


Tracks detection by using Hough transformation

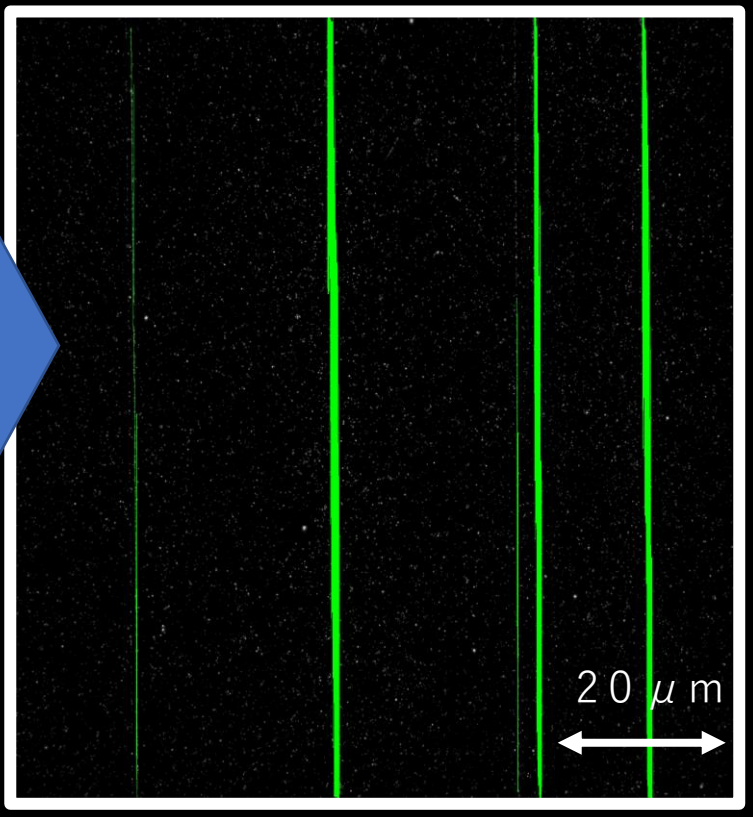
Image taking : PTS2 [wavelength: 300-500nm + x100 obj. lens with N.A. of 1.45]



Projection +
Cluster definition by the Gaussian filter and background subtraction



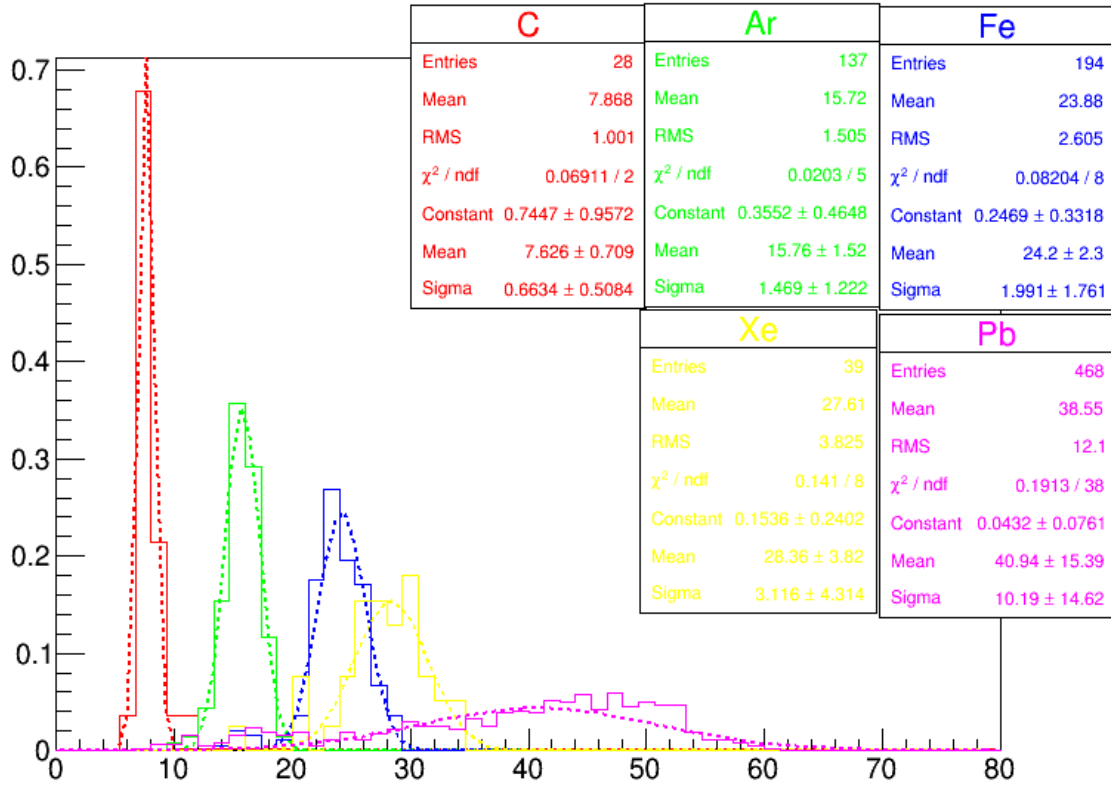
Binarization (threshold40)

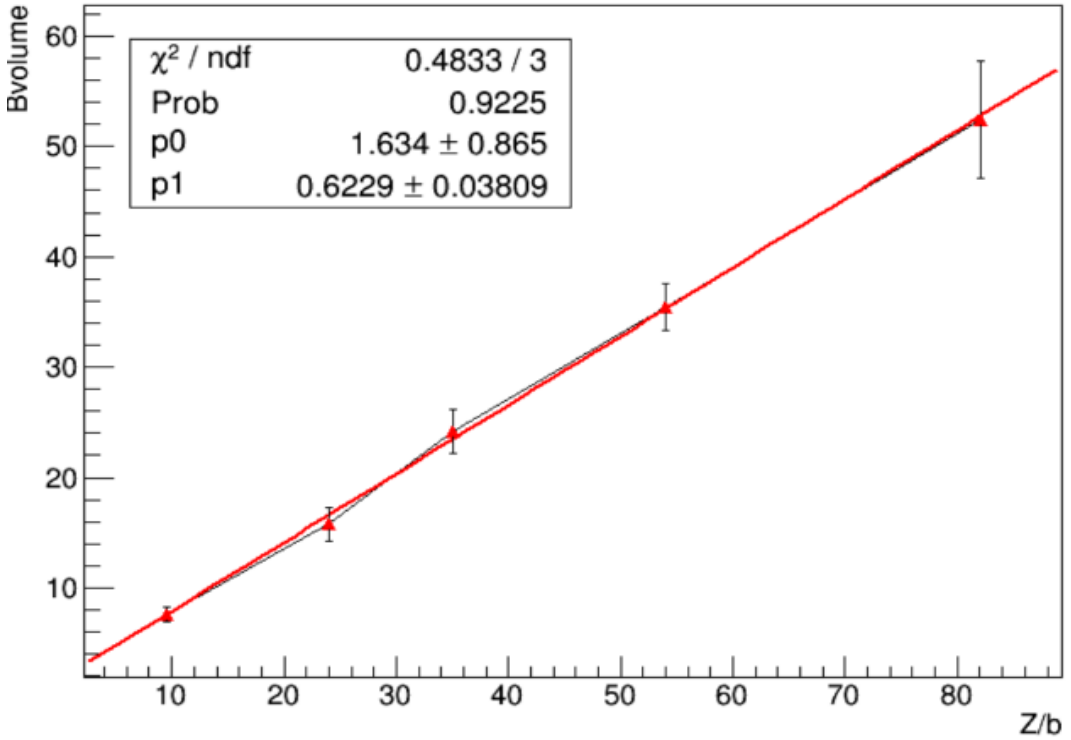


Line recognition by the Hough Transform

Z/β resolution

Nuclei	Energy(/n)
C	290MeV
Fe	500MeV
Ar	500MeV
Xe	150GeV
Pb	150GeV





$$\delta Z(Z,\beta)=\frac{\delta A_Z}{A_Z - A_{Z-1}}$$

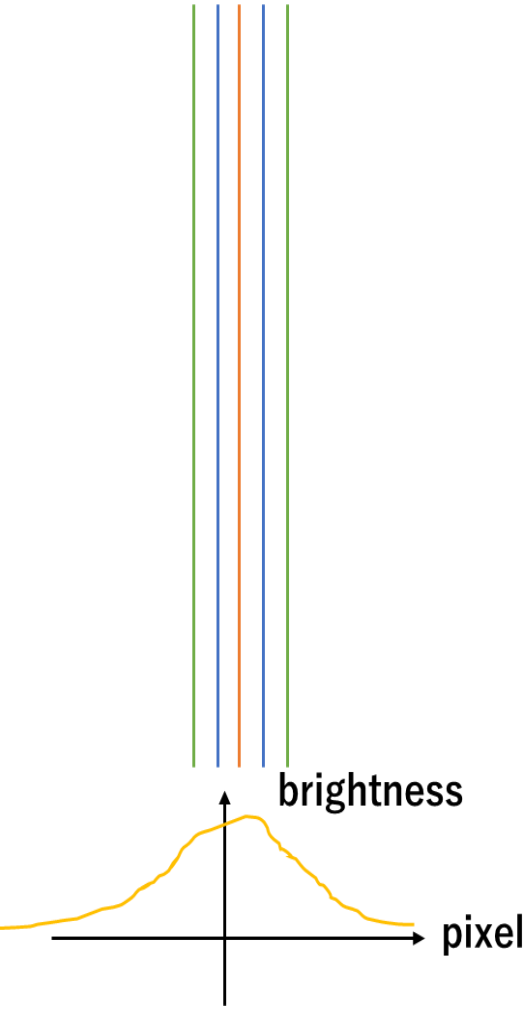
$$\delta Z(Z,\beta)=\frac{1.469}{24.2-15.76}\times(26-18)\sim 1.4$$

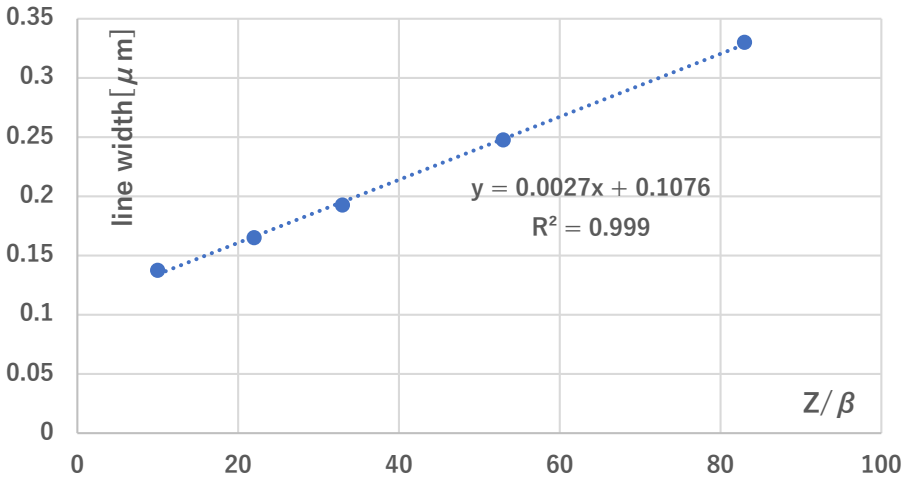
Compare with other detector

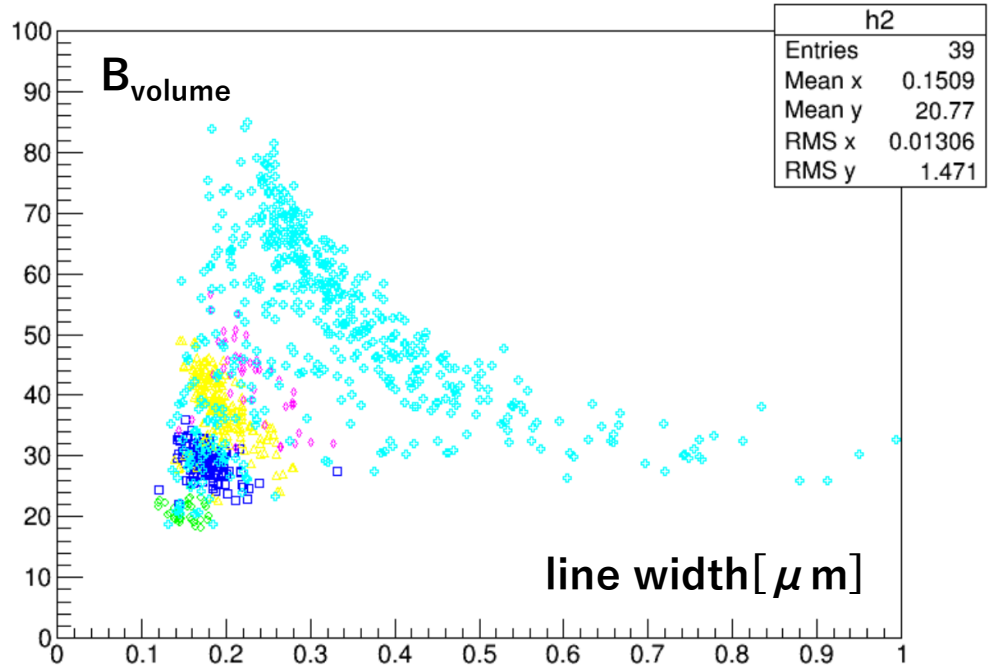
	TD-1(CR39)	BARYOTRAK (CR39)	OPERA film	MUSIC (gas chamber)	NIT
Two tracks resolution	~100 μm	~100 μm	5~10 μm	~1cm	~0.5 μm
Time resolution	×	×	×	2 μs	×
Z/β resolution	<0.15	No data	No data	<0.2	<1.4
Z/β Dynamic range	$5<Z/\beta<16$	$53<Z/\beta<100$	$Z/\beta<6$	$7<Z/\beta<79$	$9<Z/\beta<82$

✓ highly spatial resolution
✓ wide dynamic range in charge resolution

Future Plan







- manuscript in preparation
- calculate the sensitivity for magnetic monopoles of NIT

back up

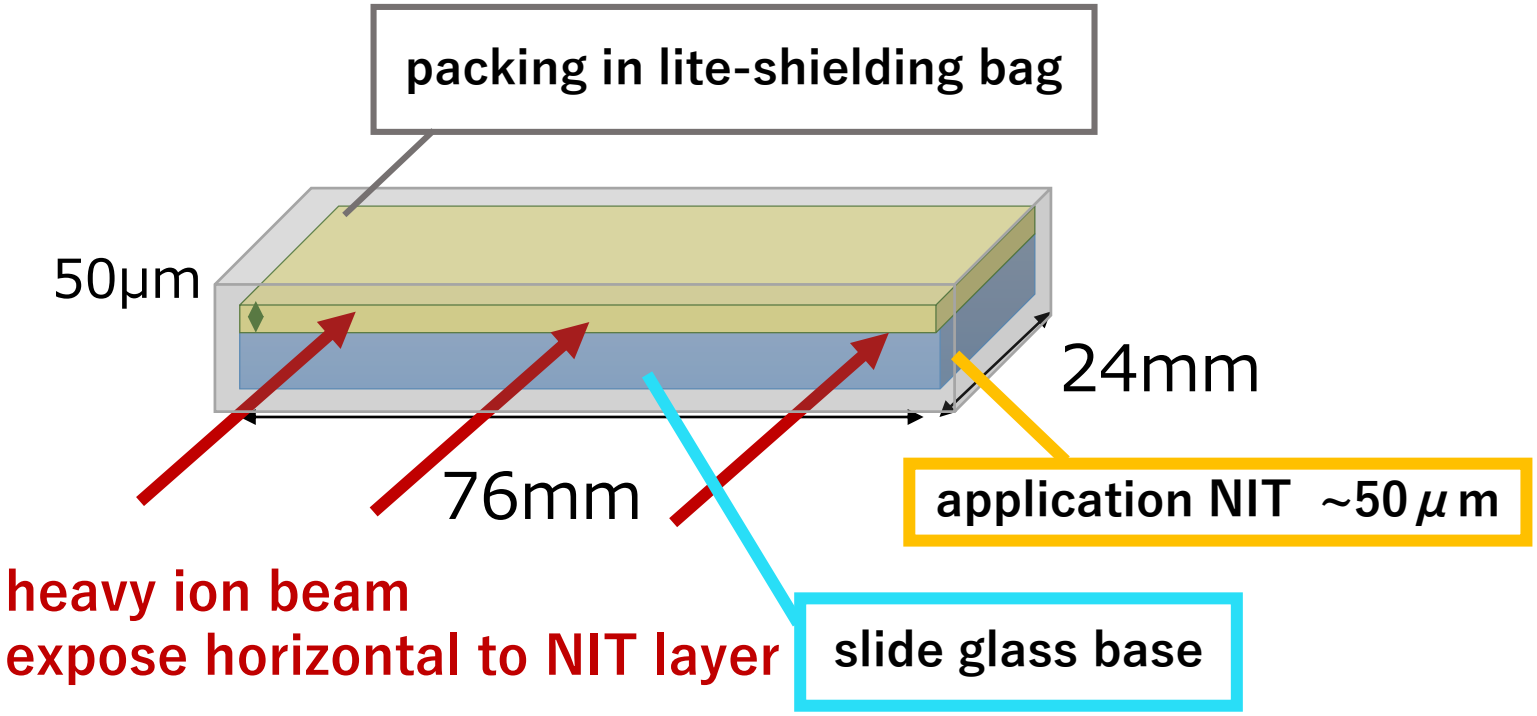
1.difference of HA sensitization

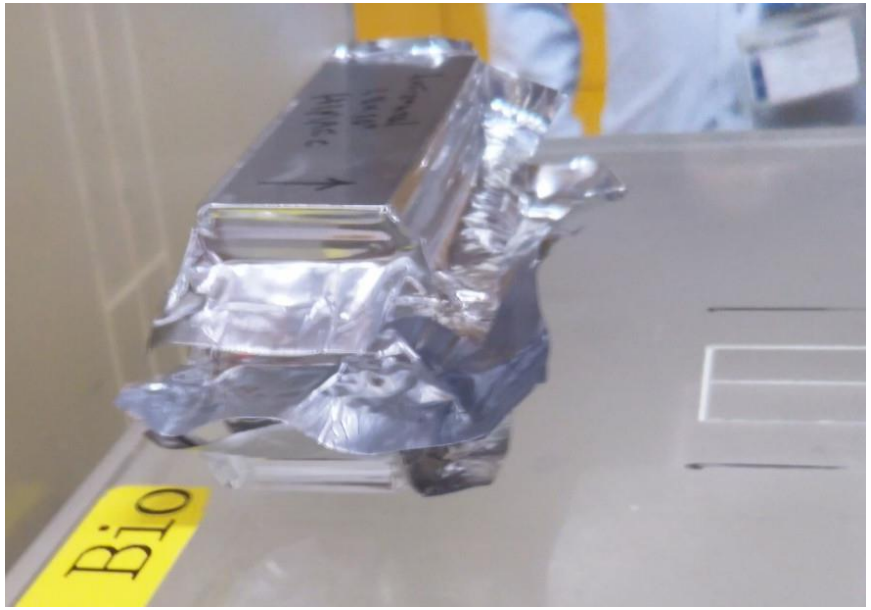
Type of sensitization	Consentraion	Tempareture[℃]	Soaking Time[min]
Na_2SO_3 (standard)	5g/L	20.0	15
Triethanolamine	0.5wt%	20.0	6.5
Water (check of low pAg)	-	20.0	15, 6.5

2.difference between standard NIT and low noise NIT

Emulsion batch	Structure	Sensitization
FAN096gf	Slide glass base (2cc application)	Na2SO3 (standard)
FAN102gf	Slide glass base (2cc application)	Na2SO3 (standard)
FAN104gf	Slide glass base (2cc application	Na2SO3 (standard)

Set up


packing in lite-shielding bag
50μm
24mm
76mm
application NIT ~50μm
heavy ion beam
expose horizontal to NIT layer
slide glass base

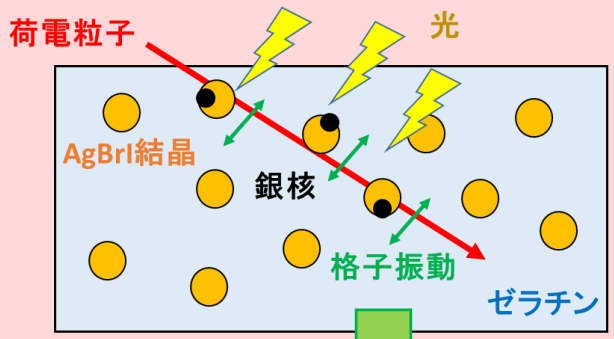

Bio

emulsion batch

- FAN096gf
- FAN102gf
- FAN104gf

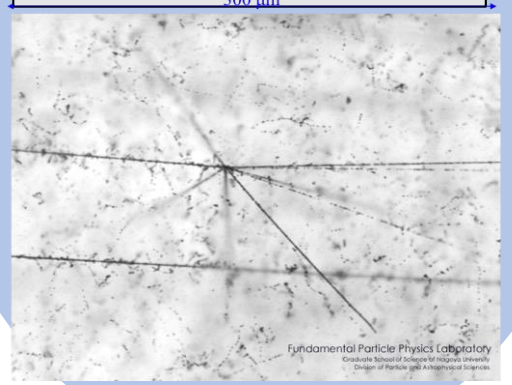
Shiraishi san Slide
@JPS meeting spring 2018

Energy deposit in Nuclear emulsion

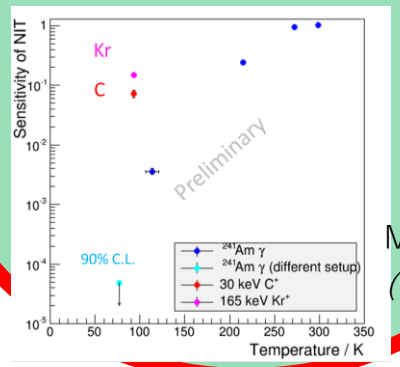


Energy Deposit

Ag core Development

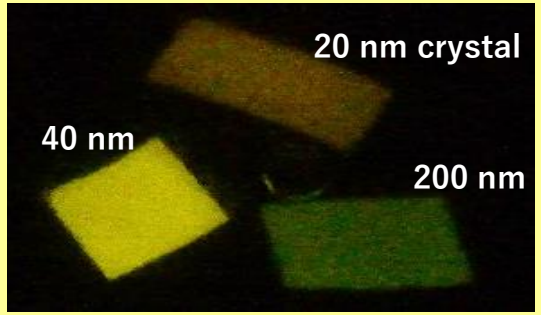


Phonons



M. Kimura *et al., NIMA (VCI2016) 2016*

Light



蛍光灯で露光後の発光

High dE/dx particle	Low dE/dx particle
Recover sensitivity loss	Sensitivity decrease

dE/dxごとの感度評価を行うことで、
NEWSdm実験として最もS/Nの高い温度を
決められる