



R&D of High pressure gaseous TPC for double beta decay



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Outline

一

$0\nu\beta\beta$ and High pressure gaseous TPC

二

Prototype TPC commissioning

三

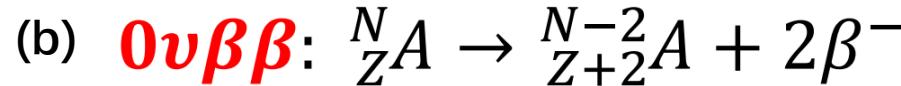
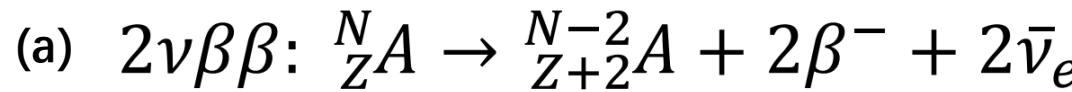
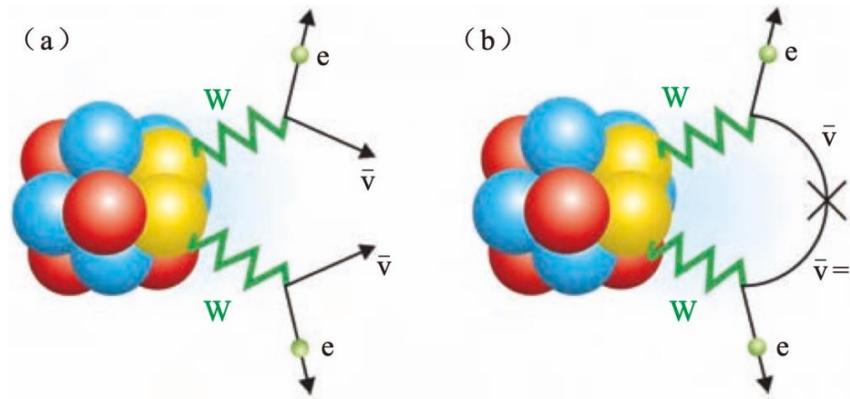
PandaX-III full detector progress

四

Summary



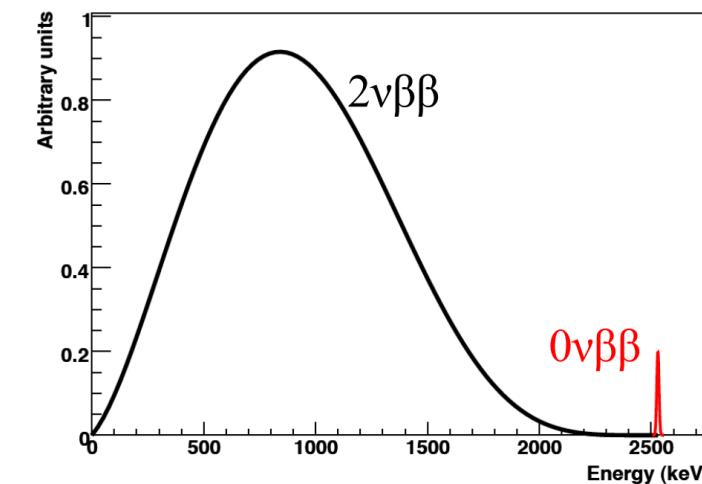
Dirac vs Majorana



- Majorana neutrino?
- Lepton number violation?



$$\bar{\nu} = \nu$$



${}^{136}\text{Xe}$

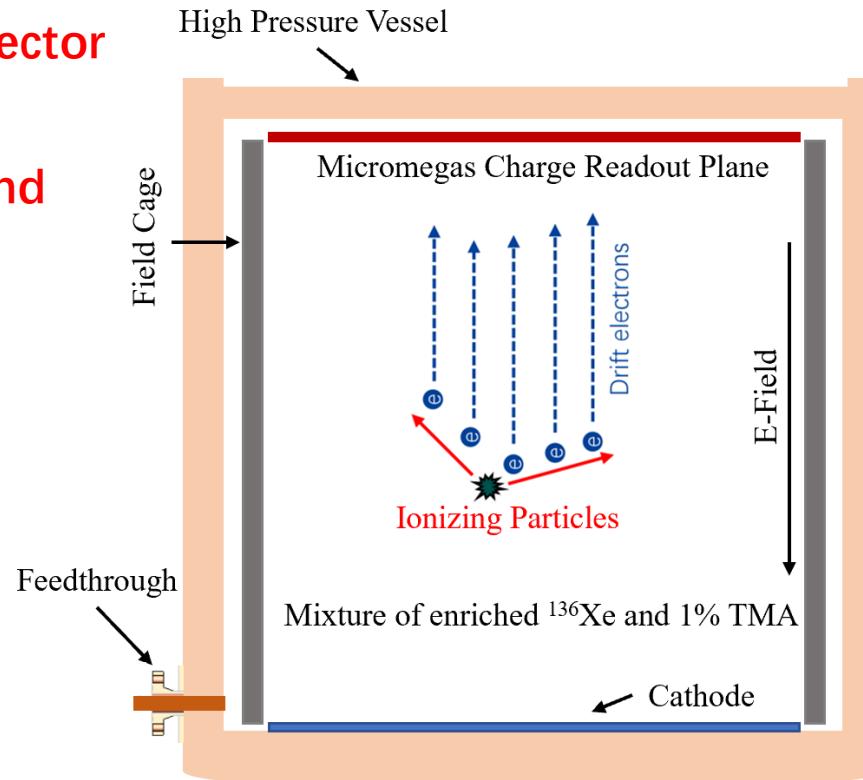
$Q=2458 \text{ keV}$

Sum of two electrons Energy

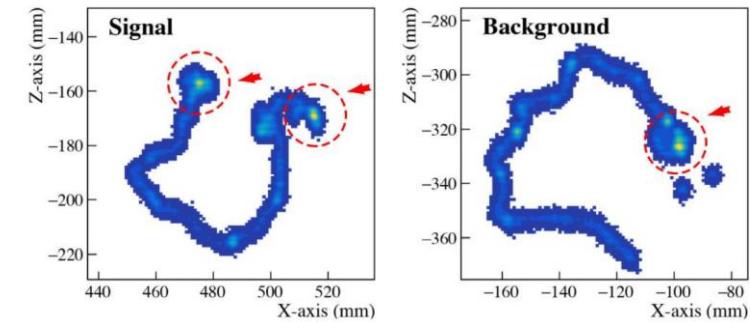
High pressure gaseous TPC (Time Projection Chamber)

PandaX-III detector

- Large mass
- Low background
- Good energy resolution



- 140 kg of enriched ^{136}Xe + 1%TMA at 10 bar
- Charge readout with 52 Micromegas → Amplification region
- Shaped drift-field with cathode, cage and MM → Drift region

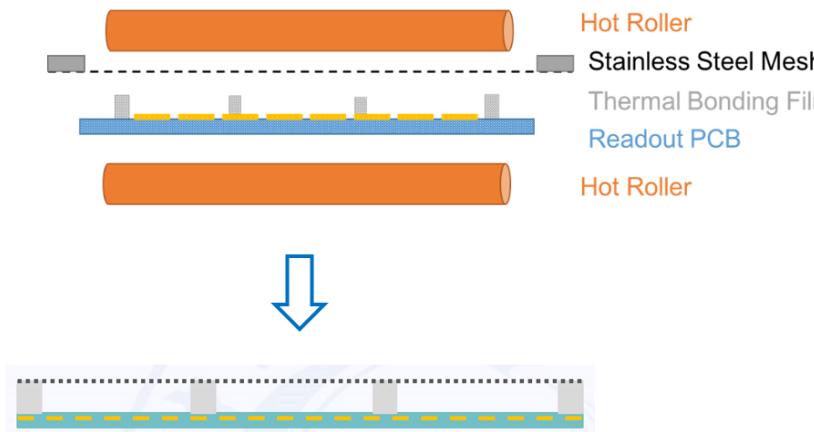


- Signal: two electrons, two Bragg peaks
- Background: one electron, one Bragg peak



Micromegas detector

- Collaborate with USTC to develop TBMM, since early 2020
 - Version 6 is being tested now in SJTU
- (See next report from USTC for more details)

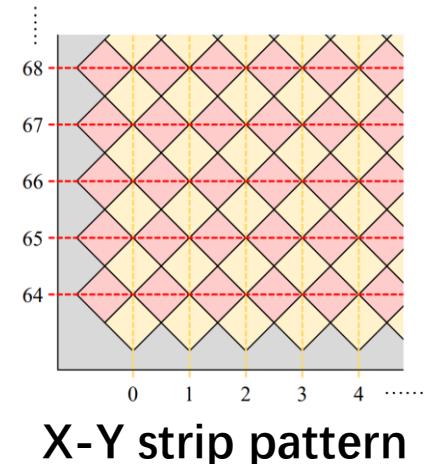


Thermal bonding method

- Amplification gap: 0.1 mm



**Micromegas Module
(Version 6, 20*20 cm²)**

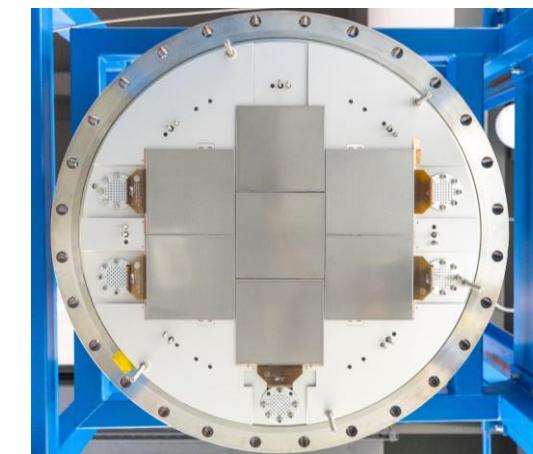
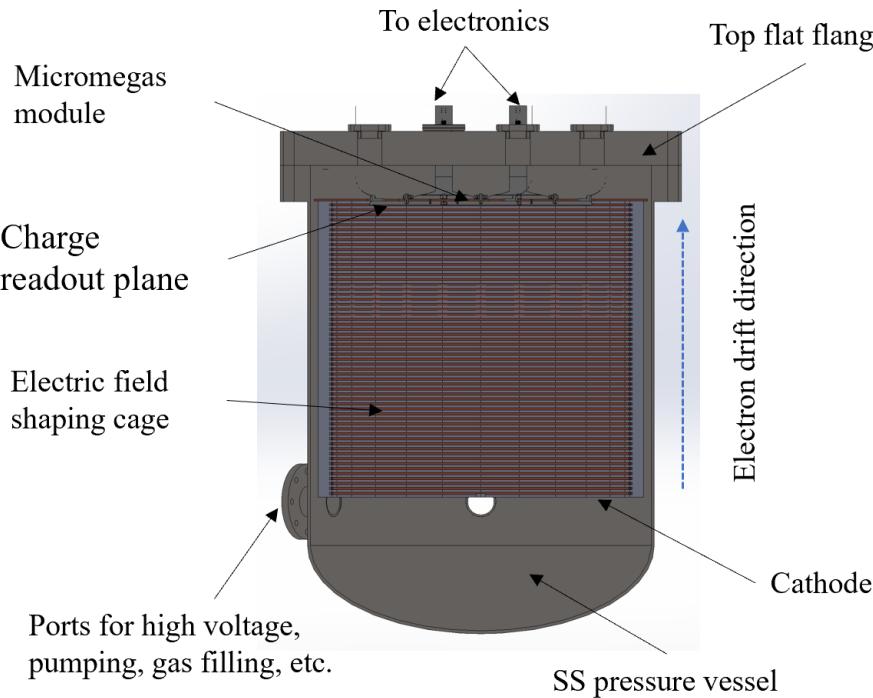


X-Y strip pattern

- Good energy resolution
- Mass production

二 Prototype TPC commissioning

Prototype TPC



CoBo_Asad electronics

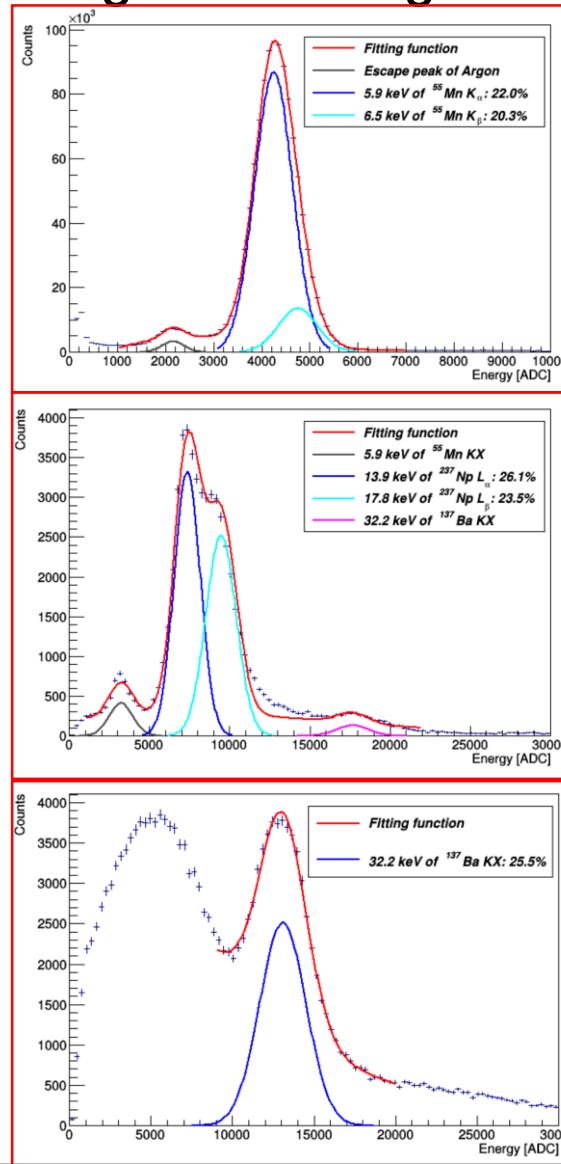


- 270 L of active volume and 780 mm drift length
- SS pressure vessel with a design of 15 bar upper limit
- Acrylic field cage with flexible PCB
- 7 Micromegas modules

二 Prototype TPC commissioning

Three gamma source wrapped by kapton

1. Running at 1 bar Argon + 3.5% iC₄H₁₀



Fe-55

- 22%@5.9 keV
- Gain: 6900

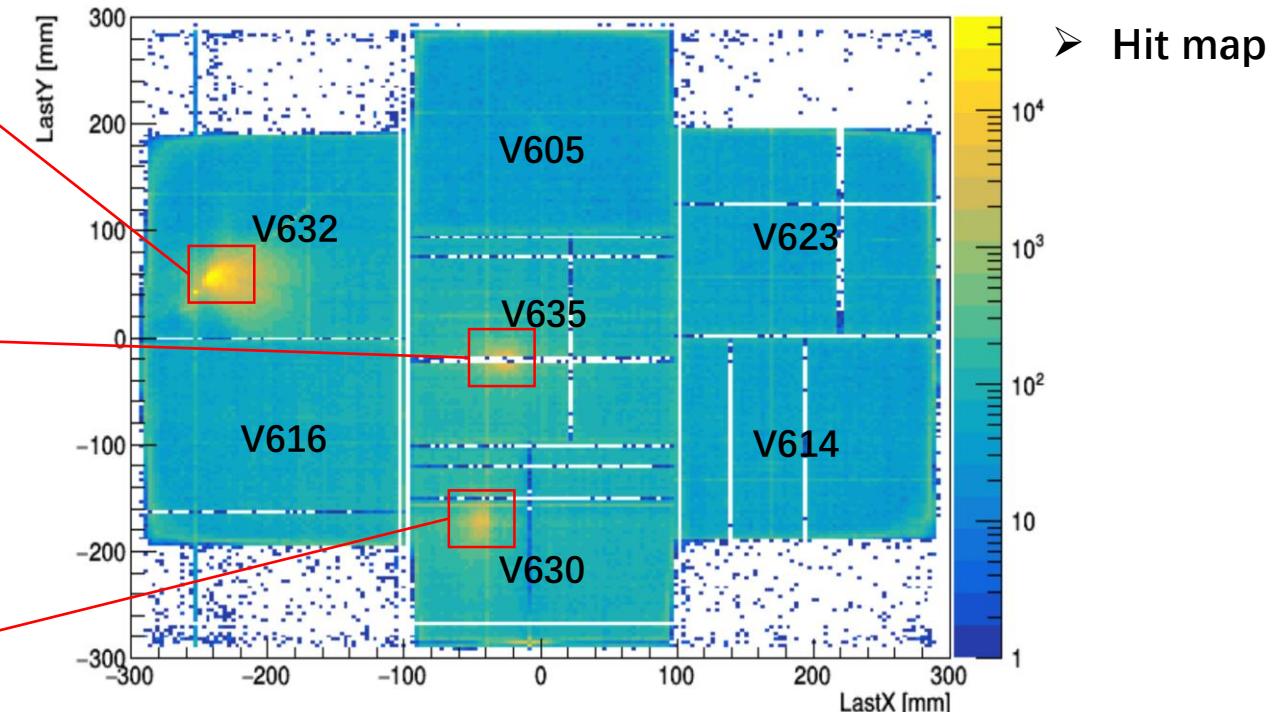
Am-241

- 26.1%@13.9 keV
- Gain: 5019

Cs-137

- 25.5%@32.2 keV
- Gain: 3898

- VMesh_400V VDrift_15kV 240fc
- Data taking with 7 MM for 7 hours
- 60*60 mm² region in the red box



➤ Hit map

1. Gain variance
2. Uniformity
3. Electron lifetime

二 Prototype TPC commissioning

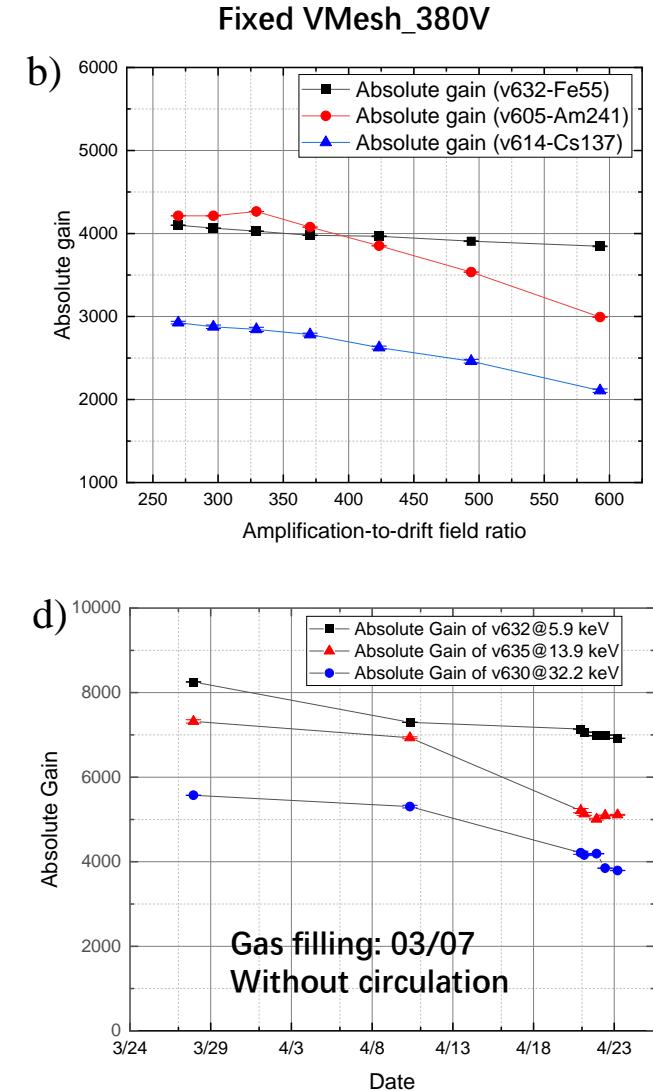
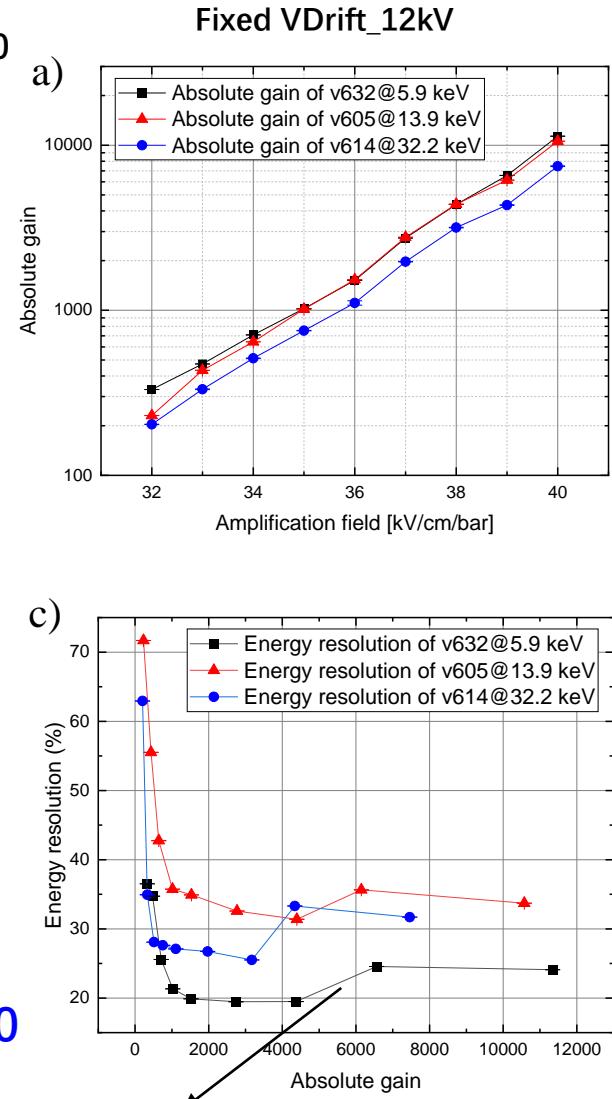
1. Running at 1 bar Argon + 3.5% iC₄H₁₀

Detector performance

V632(Fe-55), v605(Am-241), v614(Cs137)

- a) Gain curve
- b) Electron transmission
- c) Energy resolution
- d) Gain stability

- Resolution get stable when Gain>2000

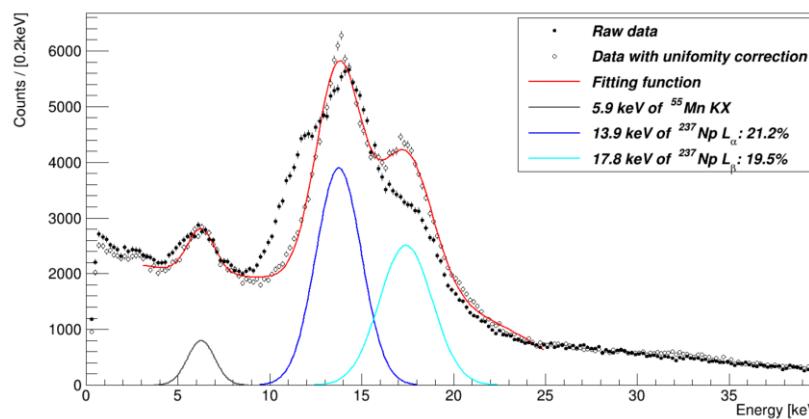


二 Prototype TPC commissioning

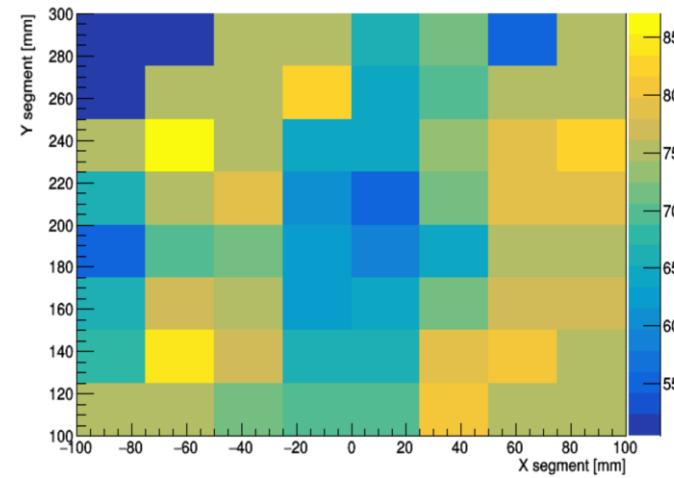
1. Running at 1 bar Argon + 3.5% iC₄H₁₀

Uniformity Correction

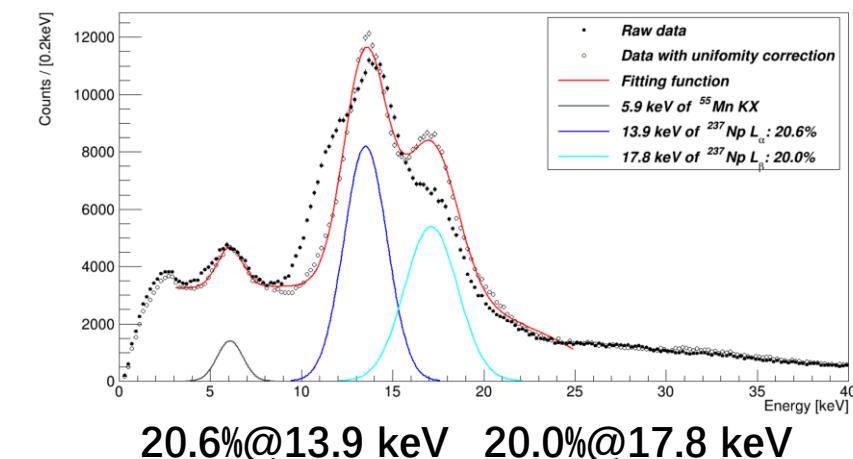
run8589



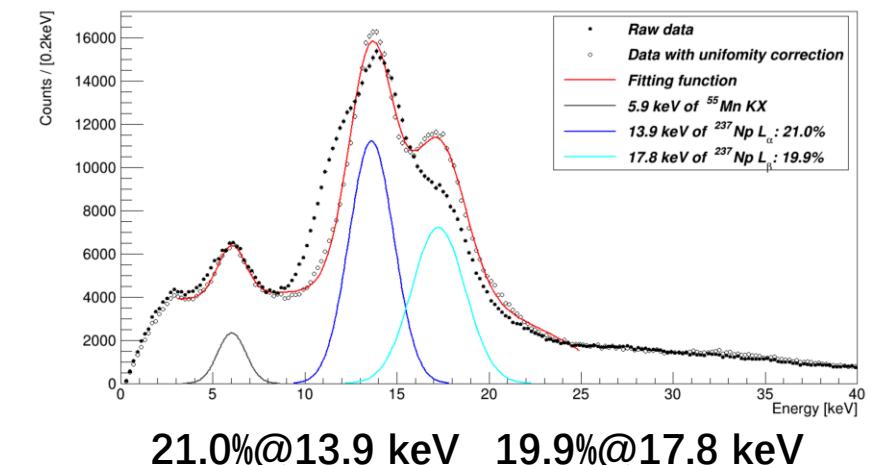
Spectrum of single MM (v605)



run8609



run8649



- Uniformity correction with Am-241 source
- Gain map accessible to different run data for same MM

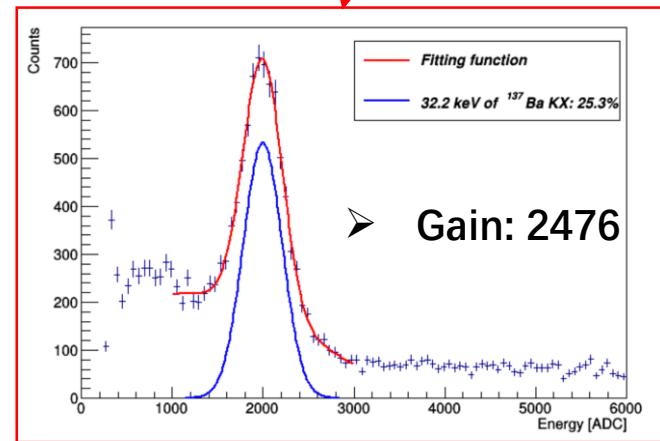
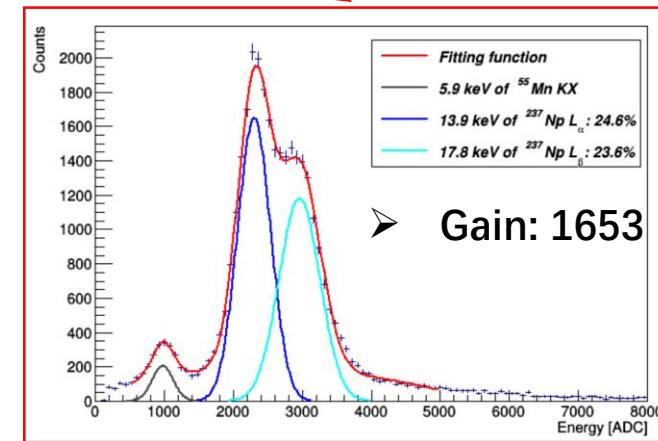
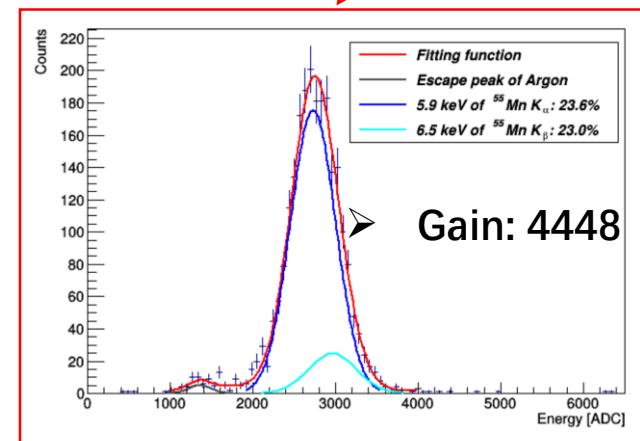
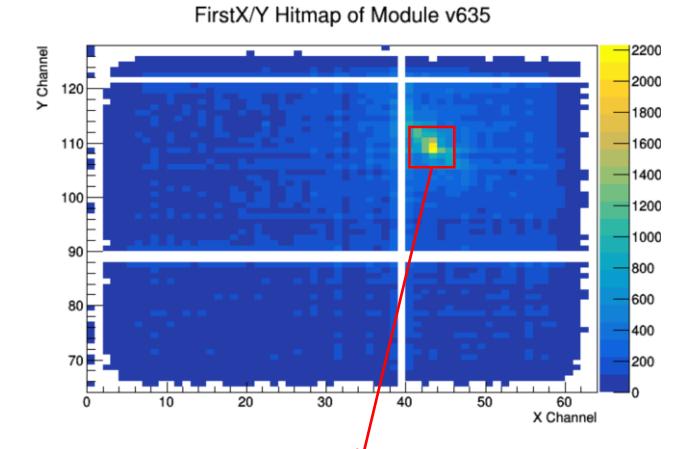
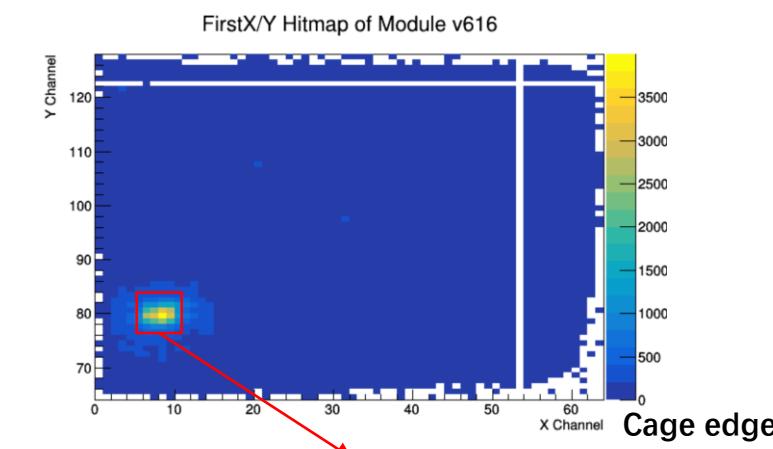
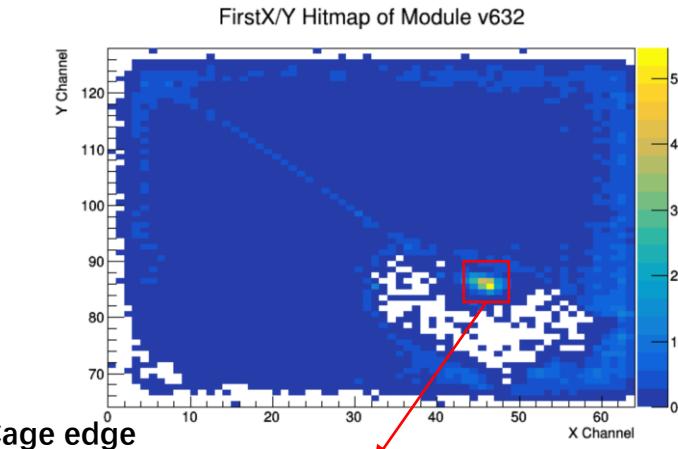
二 Prototype TPC commissioning

2. Running at 10 bar Argon + 2.5% $i\text{C}_4\text{H}_{10}$

➤ v632-Fe⁵⁵ (Hung from readout plane)

➤ v616-Am²⁴¹

➤ v635-Cs¹³⁷



- Spectrum in 10*10 mm² box around the source
- VMesh_1020V VDrift_35kV 240fc

二 Prototype TPC commissioning

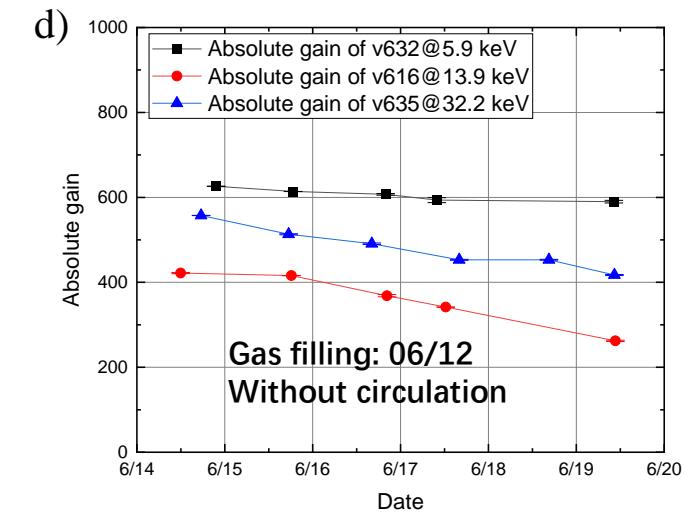
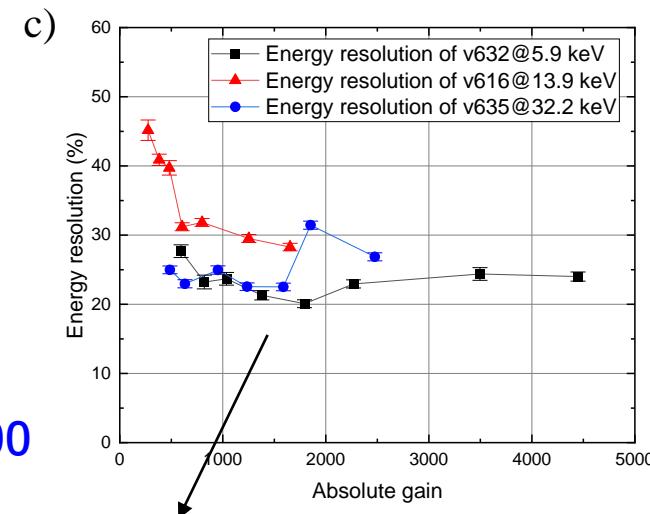
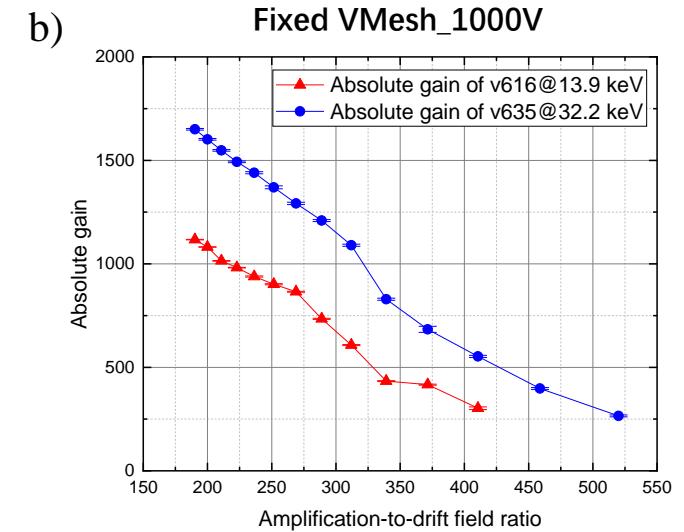
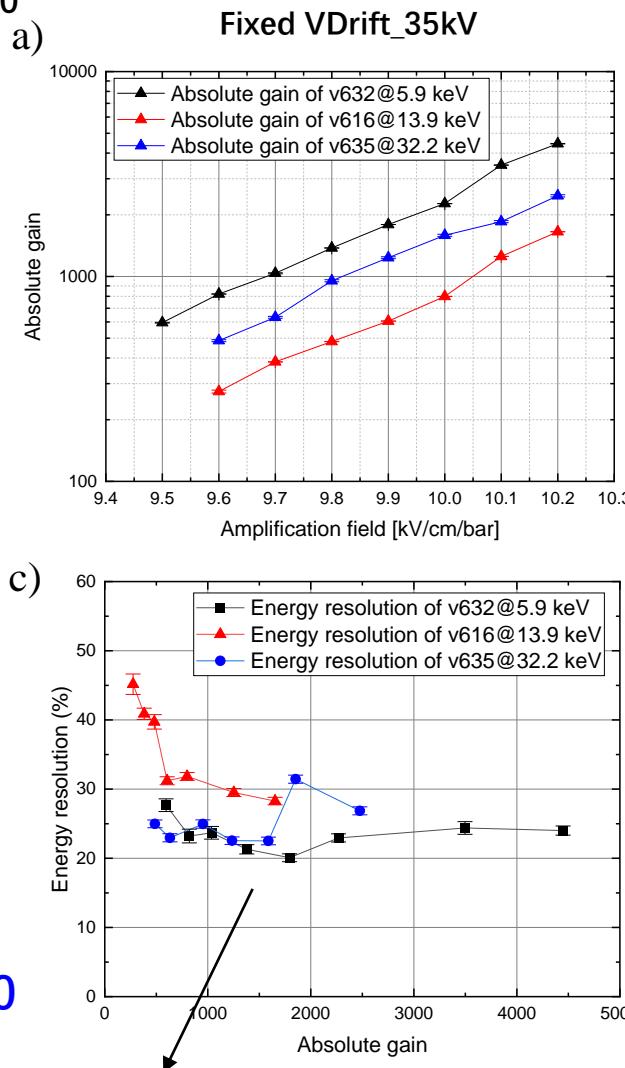
2. Running at 10 bar Argon + 2.5% $i\text{C}_4\text{H}_{10}$

Detector performance

- calibrated by single MM
- 10*10 mm² around the source

- a) Gain curve
- b) Electron transmission
- c) Energy resolution
- d) Gain stability

• Resolution get stable when Gain>1000

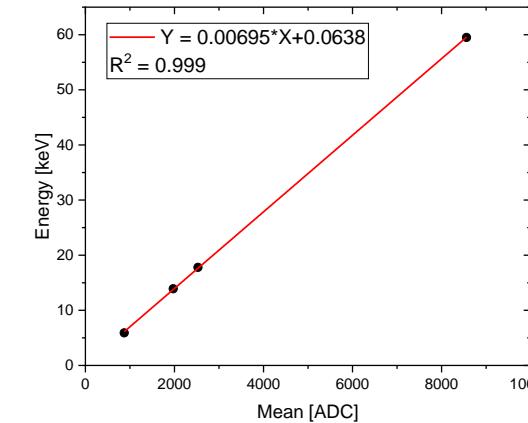
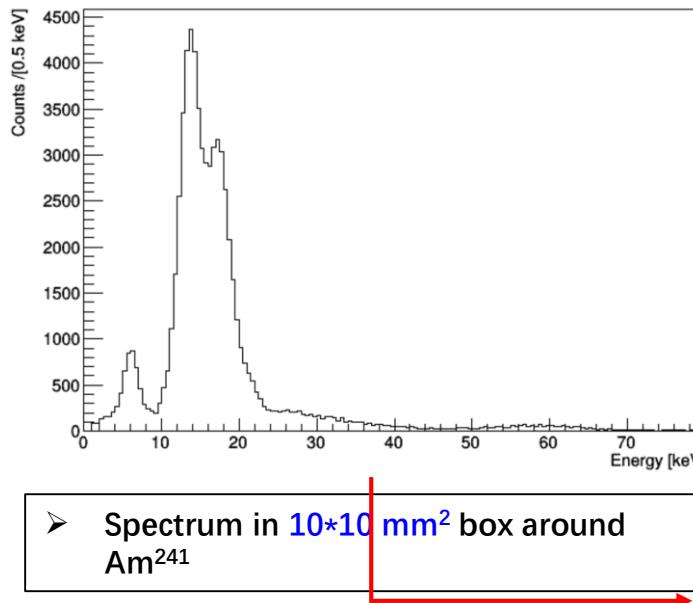


Last two points change dynamic range just for v635: 240 fc ->1 pc

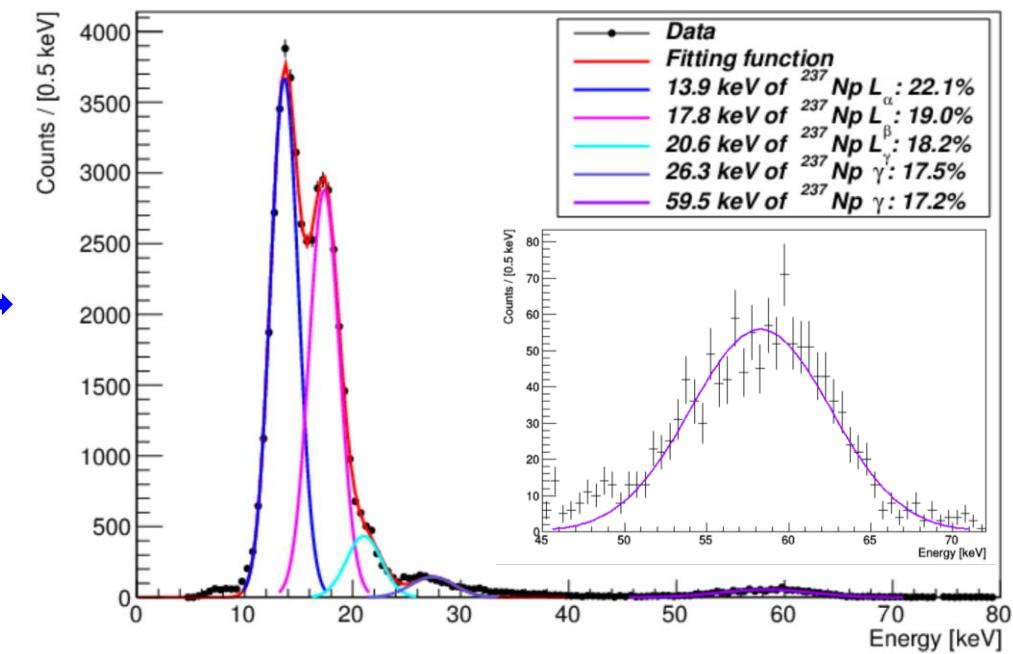
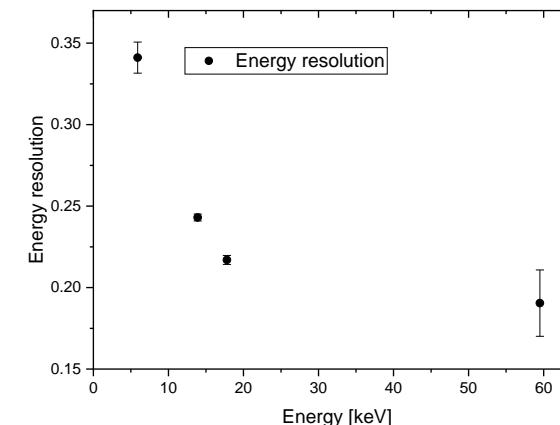
二 Prototype TPC commissioning

2. Running at 10 bar Argon + 2.5%iC4H10

Energy resolution



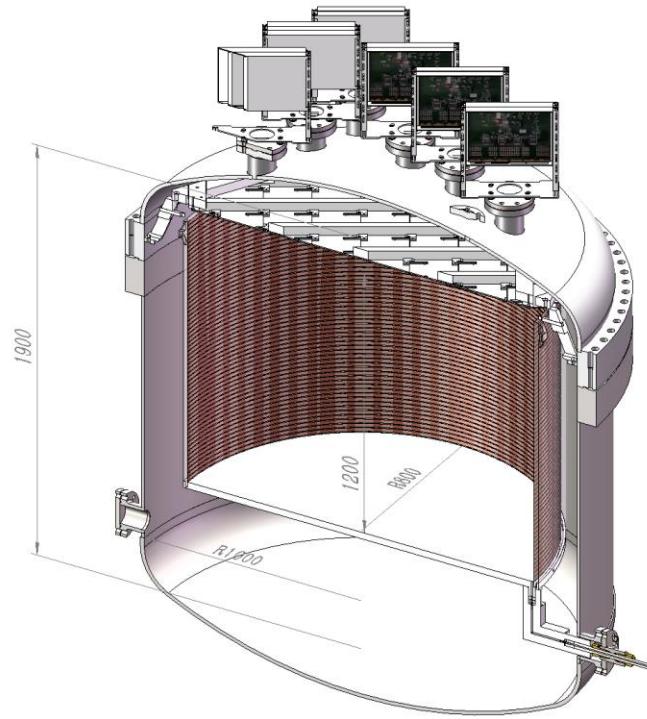
Quality-cut



- Gain: 1385
- 17.2%@59.5 keV
- Extrapolation to 2.458 MeV: 2.7%

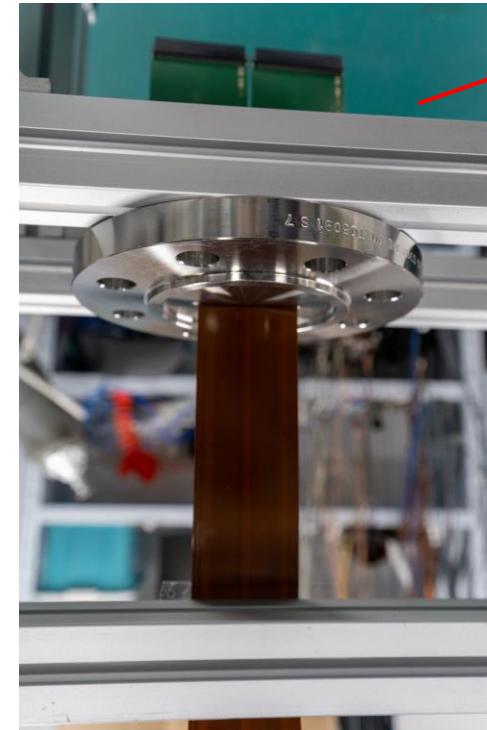
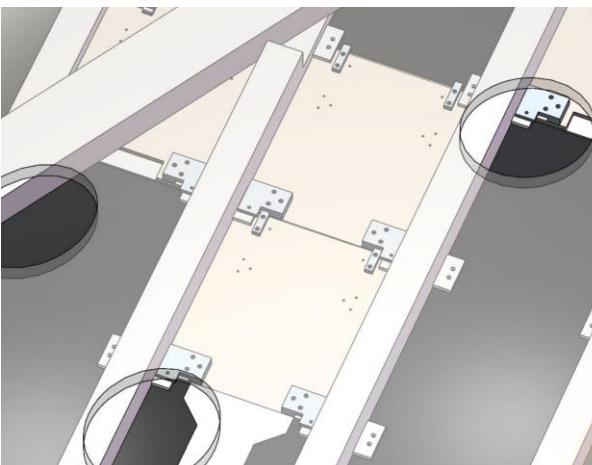
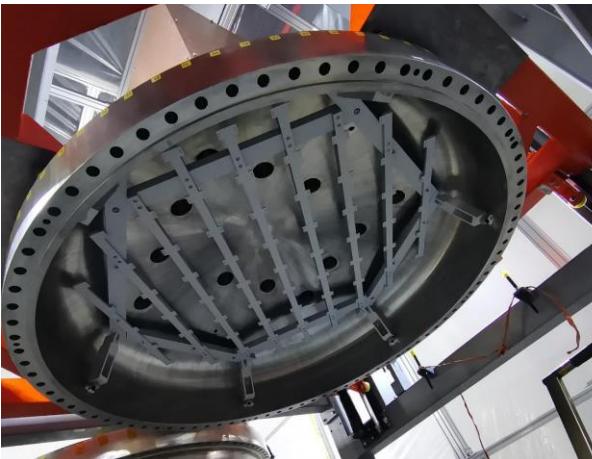
三 PandaX-III full detector progress

- SS vessel (Vacuum and pressure-holding test)
 - ~10 mPa at far end of the pump
 - Leak rate < 0.01 L.bar/h at 10 bar
- Acrylic field cage (high voltage test)
 - 120 kV stable for 24 h
- Gas circulation system



三 PandaX-III full detector progress

- 52 TBMM installation
- MM Readout plane (Plug-in design)
- Face-to-Face design and Extension line glued



Extension line



MM

三 PandaX-III full detector progress

- Electronics(USTC): FEC + TDCM + Midas
 - 4 AGET chips on FEC , 64 channels per chip
- Detector data taking
- FEC batch testing: 21 + 6
 - Noise level of AGET chips, pulse and gain

Midas

Run Status

Run 235	Start: Thu Aug 4 18:06:44 2022	Stop: Thu Aug 4 18:07:30 2022
Stopped	Alarms: On	Restart: Off
Start	Data dir: /home/midas/midasforpandax3/data/	

1659607652 18:07:32.345 2022/08/04 [mhttpd,INFO] Run #235 stopped

Equipment

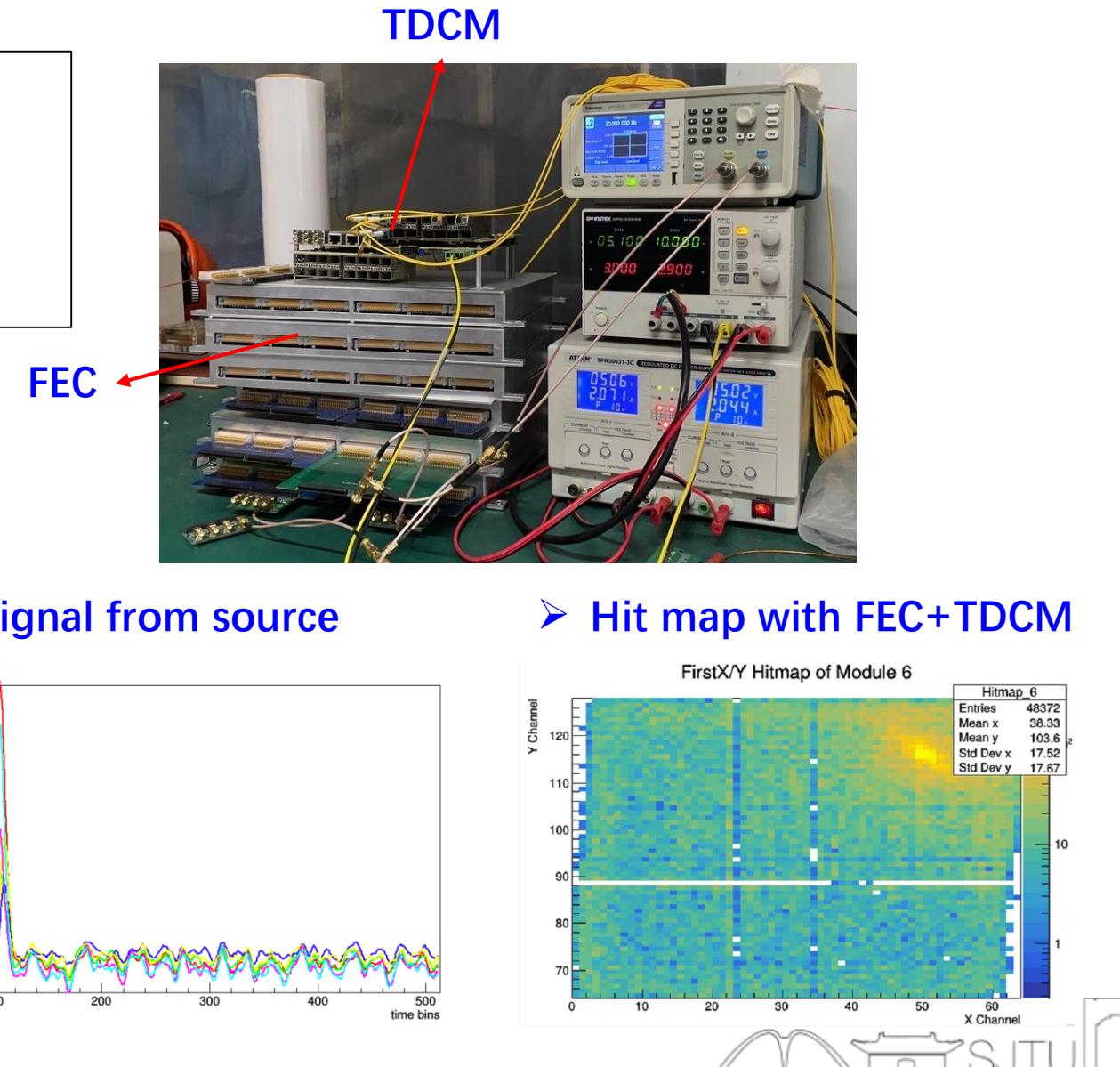
Equipment +	Status	Events	Events [s]	Data[MB/s]
Tdcmsc_Control	tdcmsgc@localhost	0	0.0	0.000
Tdcmsc_Daq	tdcmdaq@localhost	1114	0.0	0.000

Logging Channels

Channel	Events	MB written	Compr.	Disk Level
#0: run00235.mid.lz4	1114	212.107	67.8%	88.4%
Lazy Label	Progress	File Name	# Files	Total

Clients

mhttpd [localhost]	tdcmsgc [localhost]	tdcmdaq [localhost]
Logger [localhost]		





四 Summary

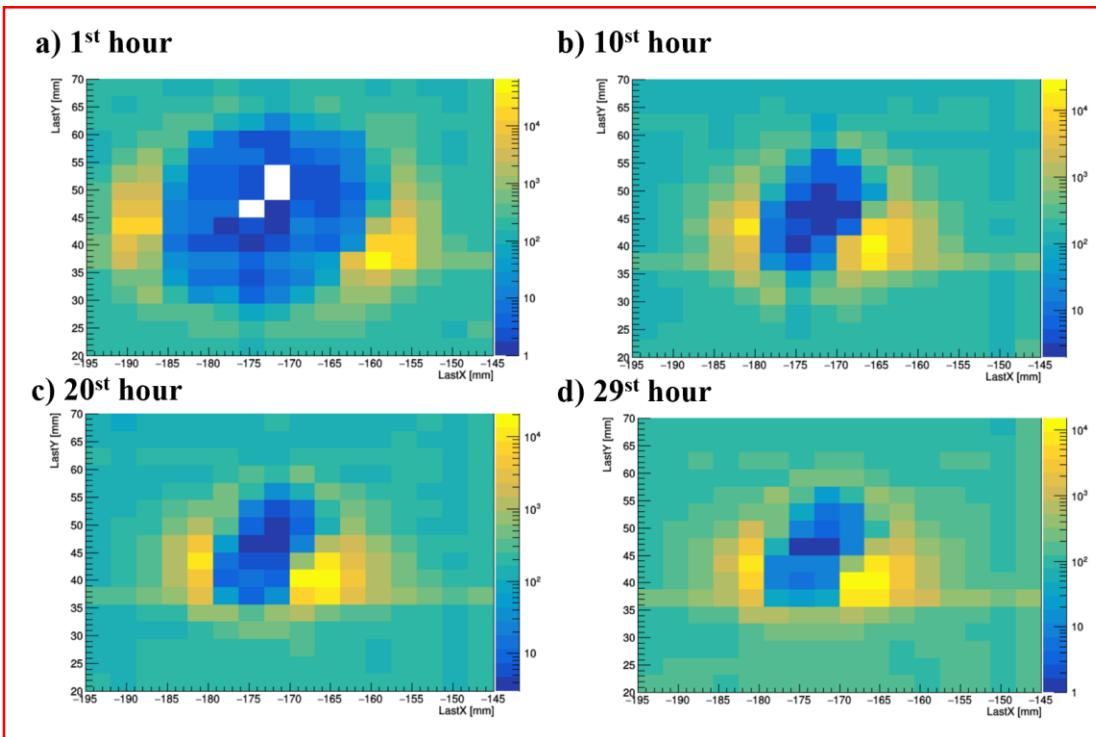
- 0νββ experiment
 - exciting physics and hard experiment
- Prototype TPC commissioning
 - Works well in different pressure gas mixture (gain curve, stability and energy resolution, etc)
- PandaX-III detector progress
 - Several subsystem installation in progress



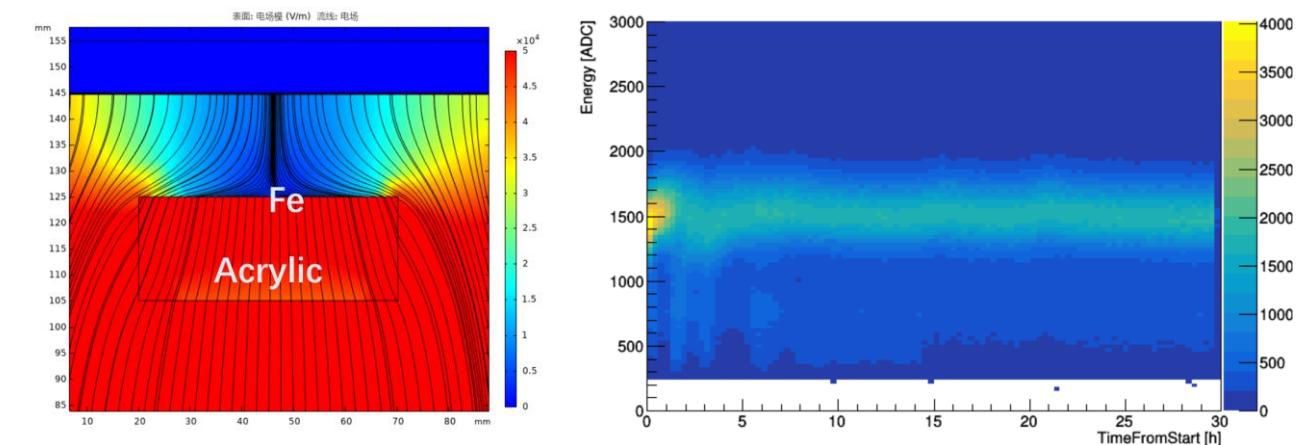
Thanks



Ion piled-up evolves with time



Fe-55
wrapped with kapton



- Event rate [Hz] in the region:
241.8->210.0->211.5->211.9
- 10 bar Argon + 2.5% iC₄H₁₀

- About 30 hours stable run (v632-Fe55)
40*40 mm² around the source