Summary of WG2 (Detector)

Shoji Uno (KEK)

AFAD

2023.4.14

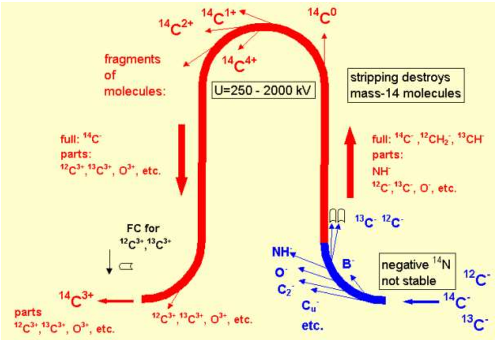
12 talks (8 in person + 4 remote) + 1 talk (canceled)

- Australia : 2
- China : 5
- Japan : 3
- Russia : 2

Topics

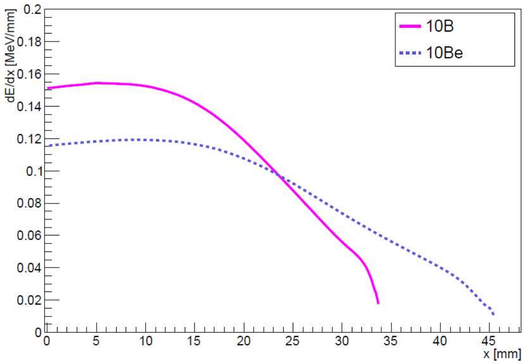
- TPC : 4
  - Small : low pressure gas + GEM : Ion identification
  - Middle : Thin inner material + micromegas : new particle search
  - Large : VU laser calibration system : CEPC
  - Huge : Liquid Xenon : Dark matter search
- Neutron detector : 2
  - Ceramic GEM
  - Several detectors (He-3 + GEM + Scintillator) in China
- Photon (+ Charged particle) senser : 3
  - Flat Panel MT with MCP : High time resolution
  - Electron Multiplier Tube (EMT) :same structure with PMT: Muon monitor
  - Plastic scintillator with SiPM : COMET trigger counter
- Radiation tolerance : 2
  - Neutron irradiation system in BINP
  - FPGA tolerance in neutron irradiation : Belle II CDC electronics
- Dose monitor : 1
  - Various radiation therapies and dose monitors

NEW TECHNIQUE OF ION IDENTIFICATION IN AMS USING LOW-PRESSURE TPC WITH GEM READOUT (A. SOKOLOV)

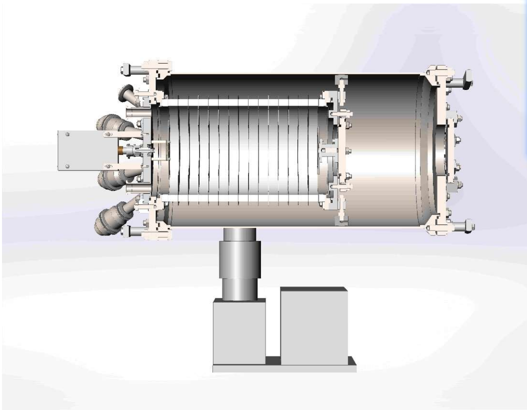


BINP AMS provides reliable separation of a pure beam of radiocarbon ions from the accompanying ion background. But that technique can't separate the isobars - different chemical elements having the same atomic mass. The typical example are radioactive isotopes ^{10}Be and ^{10}B.

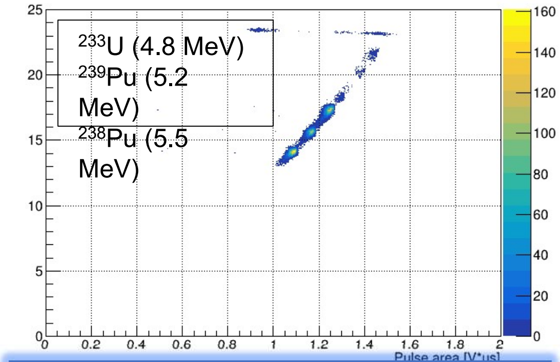
We built the prototype of the TPC and successfully tested it with the triple alpha-source. TPC was filled by the isobutan at 50 Torr pressure.

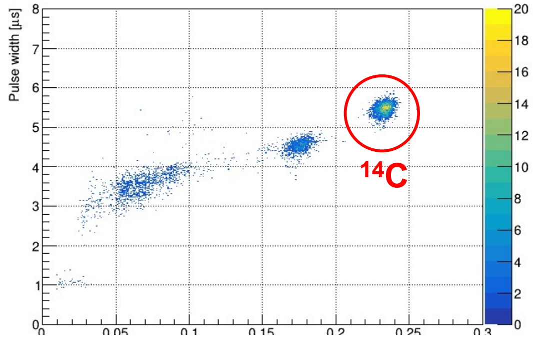


The idea is to use the TPC with low pressure gas filling to measure track ranges from different ion species.

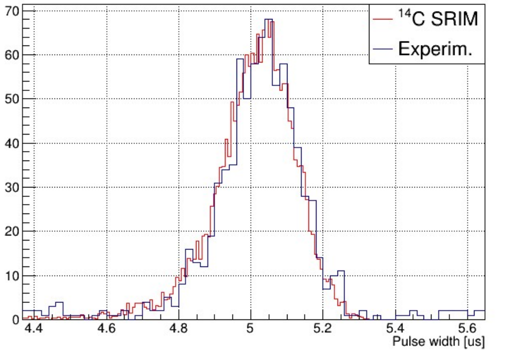


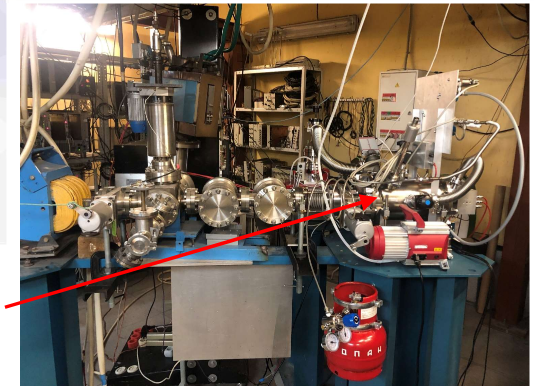
The TPC installation on BINP AMS





2D plot of pulse width versus pulse area and their axis projection spectra for alpha particles from ^{233}U (4.8 MeV), ^{239}Pu (5.2 MeV) and ^{238}Pu (5.5 MeV) source. The pulse width and pulse area spectra reflect those of the track range and energy. The separation between peaks are more than 8 sigma.





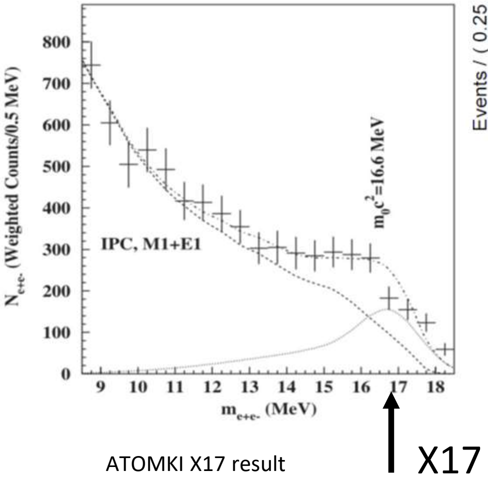
- A new concept of the detector for the AMS was proposed for identifying ions by their stopping range in gas;
- A low-pressure TPC prototype, based on this concept, have been made and successfully tested;
- The TPC have been installed on AMS;
- First results on ^{14}C beam are promising;
- We are preparing to the tests with ^{10}Be samples.

Martin Sevior

Particle and Nuclear Physics at the MeV scale in Australia, Martin Sevior University of Melbourne

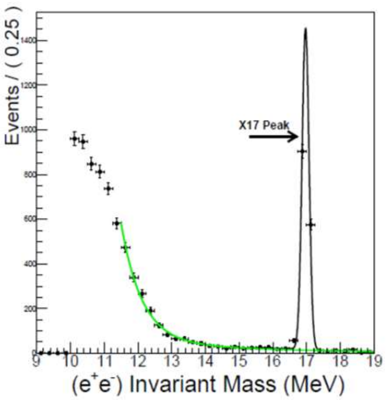
Initial anomaly: $p + 7Li \rightarrow 8Be + X17(\rightarrow e^+e^-)$

e^+e^- Invariant Mass



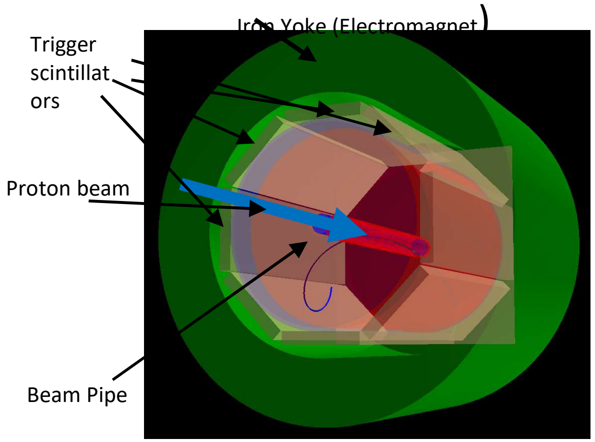
ATOMKI X17 result
For p + ^{7}Li→^{8}Be + e$^+$e$^-$

e^+e^- Invariant Mass

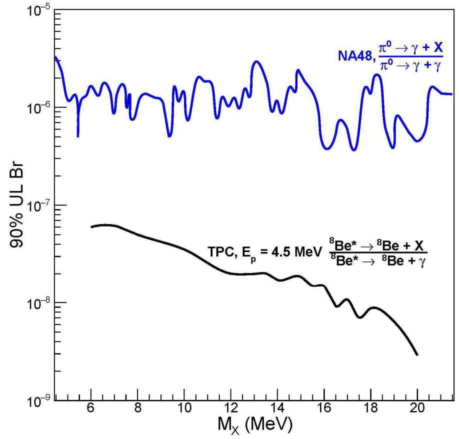


Our expectation from TPC
If the X17 exists

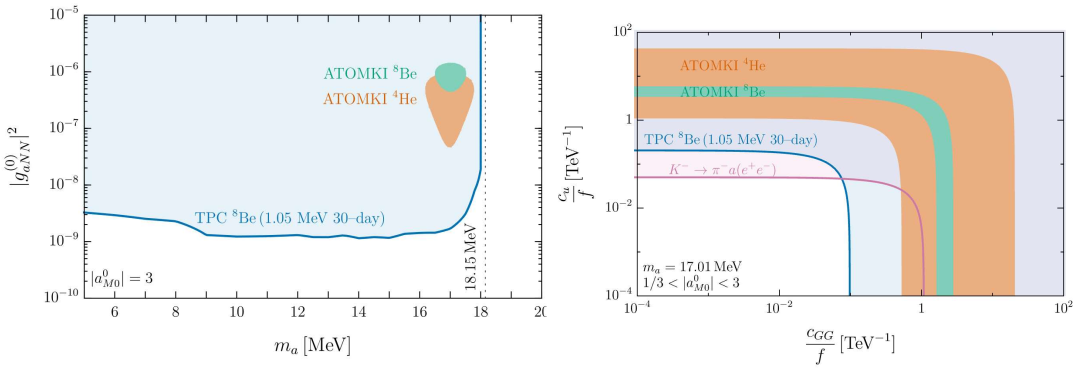
Time Projection Chamber



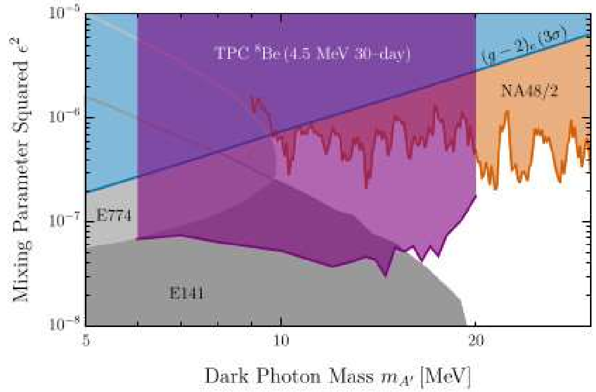
Upper Limit for X boson production



World-best limit for ALP Parameters



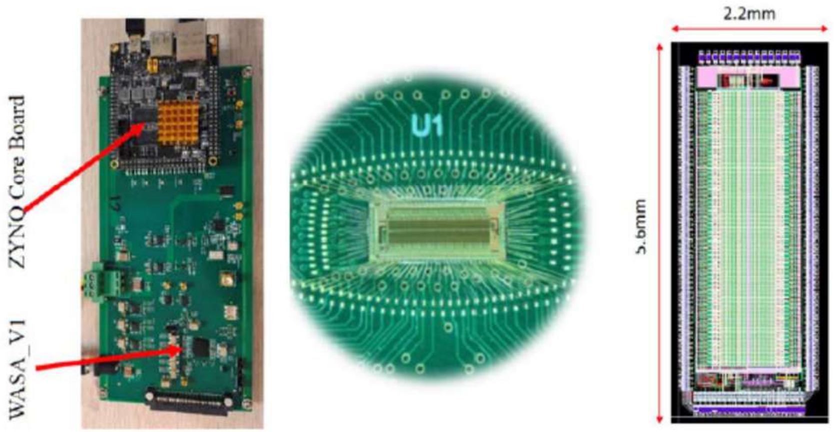
World-best limit on Dark Photon production

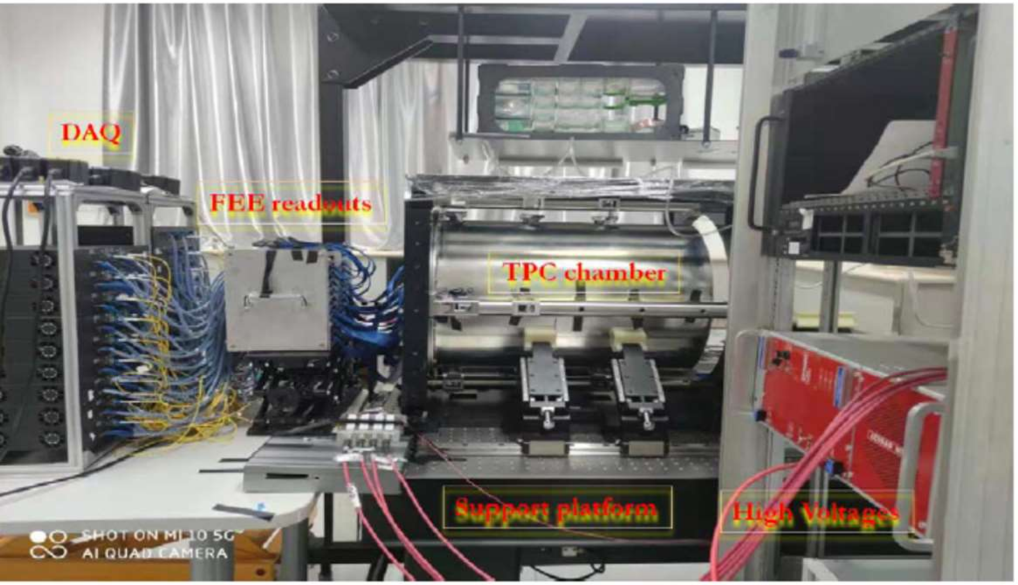


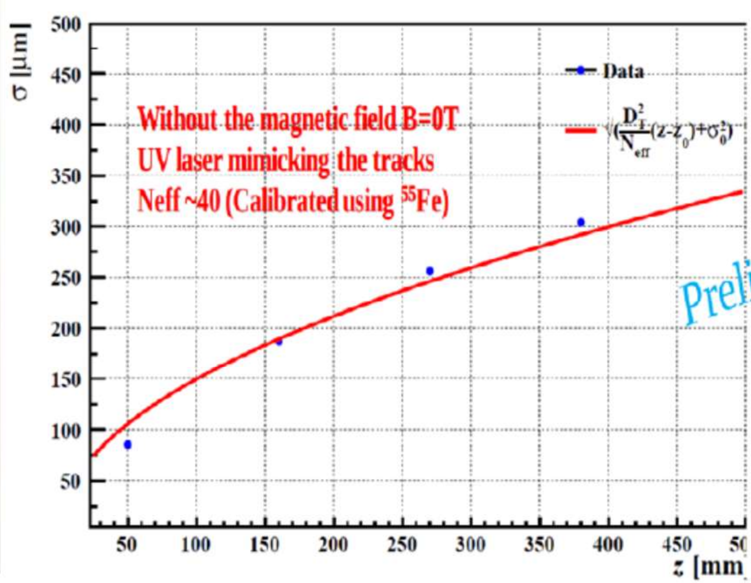
Full Details: Sevior et al. https://arxiv.org/abs/2302.13281

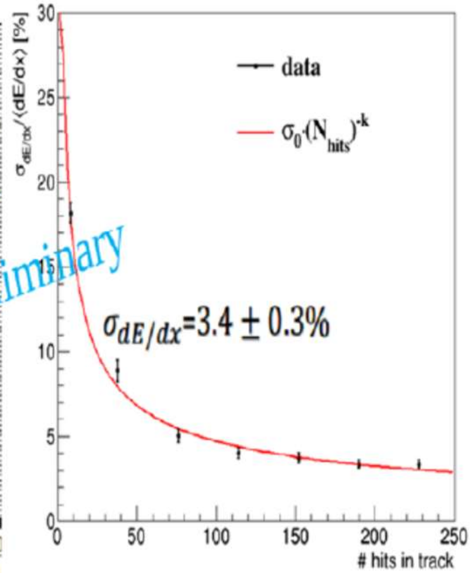
Highlight of CEPC TPC detector prototyping roadmap

- From TPC module to TPC prototype R&D for CEPC
  - Low power consumption FEE ASIC (**reach ~2.4mW/ch** including ADC)
- Achievement by far:
  - Supression ions: IBF × Gain **~1 at Gain=2000** validation with GEM/MM readout
  - Spatial resolution of **$\sigma_{r\varphi} \leq 100$ μm** by TPC prototype
  - dE/dx for PID: **<4%** (as expected for CEPC baseline detector concept)
  - PID requirements of Tera-Z: Pad TPC toward the pixelated TPC R&D for CEPC
    - 1mm × 6mm → 500μm × 500μm



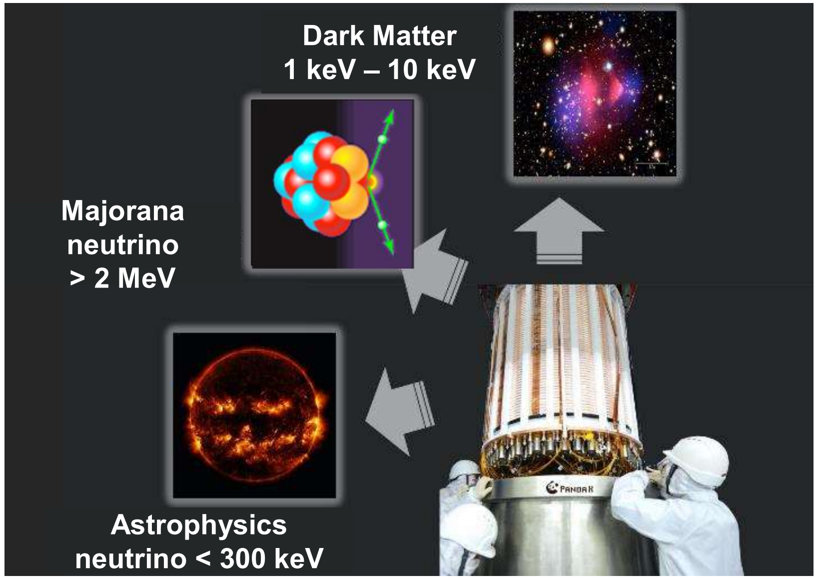


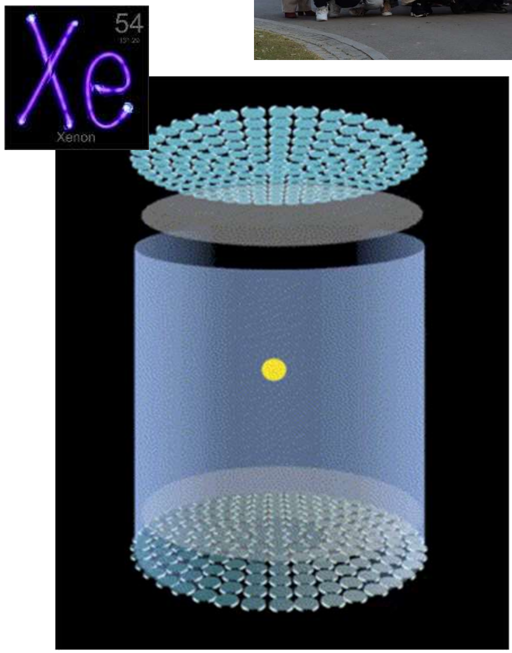


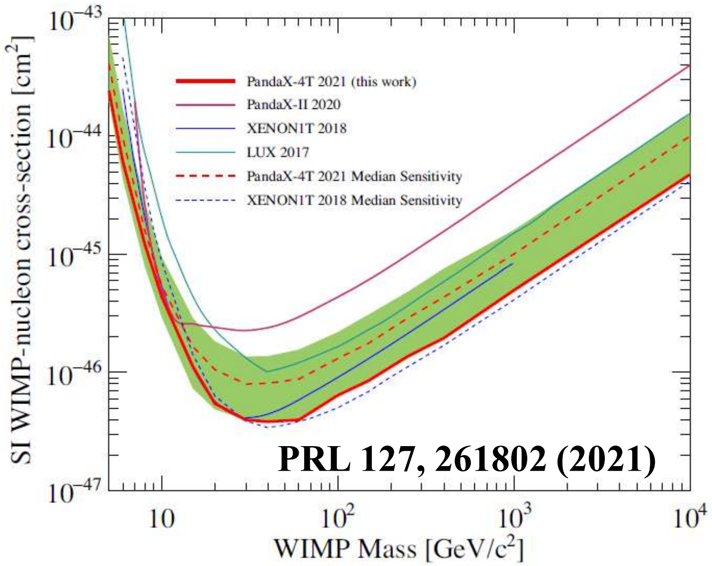


CEPC TPC prototype detector R&D

PandaX Dark Matter Direct Detection Experiment



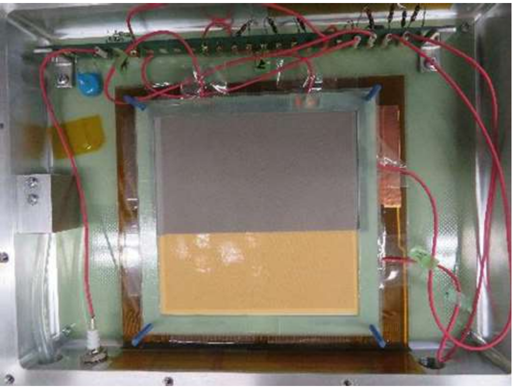


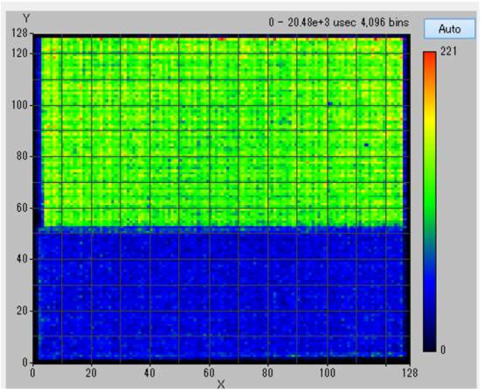


- PandaX-4T, one of the new generation multi-tonne xenon experiments, finished the commissioning (operation until 2025);
- Intense searches for various types of physics, including DMs and neutrinos;
- In parallel, improved technologies are studied for the next generation experiment;

Neutron detector with ceramic GEM

Shoji Uno (KEK)



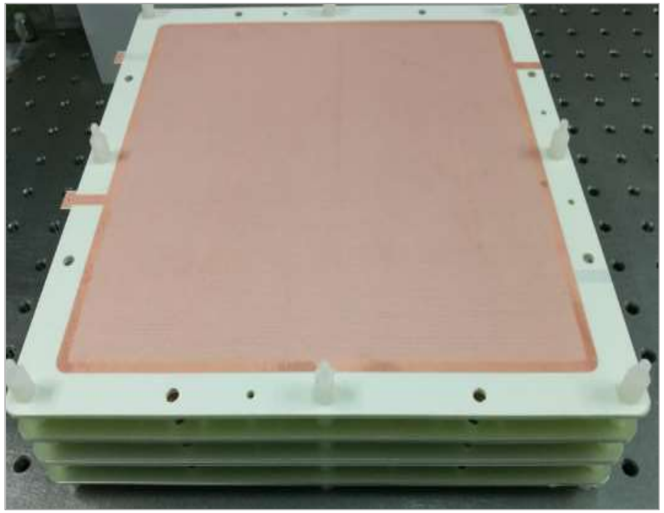


- Ceramic GEM is working fine without serious damage.
- Our detector system is compact and simple.
  - Neutron beam monitor is a good application.
- Boron coated GEM comes soon.
  - A test sample is working.
  - B10 is also available for sputtering.
- A new test beam line (a few GeV electron) is available for users in KEK from this year.

Detectors alternative to ^{3}He @ CSNS

Yuekun Heng and Zhijia Sun

Ceramic GEM for neutron detection with high spatial and high counting rate



Large-area scintillation detector (^{6}LiF/ZnS(Ag))

High flux 2D beam monitor

High efficiency (43%) large area(20cm*20cm)

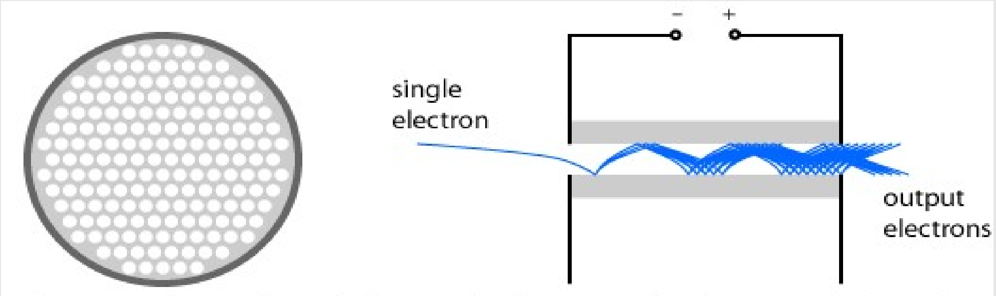
Sealed GEM detector

Spatial resolution improvement with a stopping layer to 0.8mm (thermal) and 2.1mm(fast)

R&D of MCP-PMTs for High Energy Physics Detectors

Sen QIAN

➢ The Microchannel Plate MCP



a) front view of microchannel plate　　b) electron avalanche in a single channel

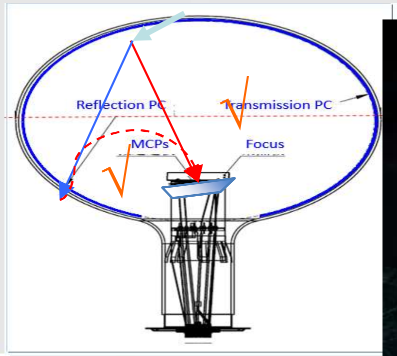
performance of the MCP:

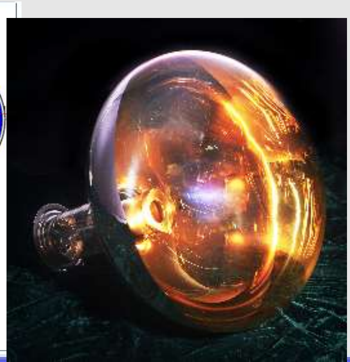
- **High Gain： $1X10^4$ / 1 pic**
- **Small Size: Diameter=50mm**
- **Fast Signal：Rise time < 1ns**
- **TTS@SPE：~30ps**

MCP-FPMTs（LPMT，FPMT） developed in IHEP+NNVT in China

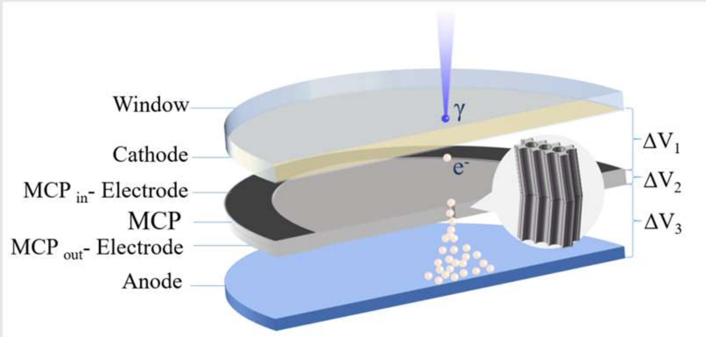
	Period	Gain	P/V	Amp(SPE)	RT	Width	TTS@SPE	TTS@MPE	Application
LPMT	2010-2020	1.0E7	**>5**	~8mV	1.4 ns	10 ns	20 ns	--	JUNO,LHAASO
FPMT	2020-2023	2.0E6	**>5**	~60 mV	150 ps	500 ps	**50 ps**	**10 ps**	TOF-PET

➢ 20 inch LPMT for Large Detector





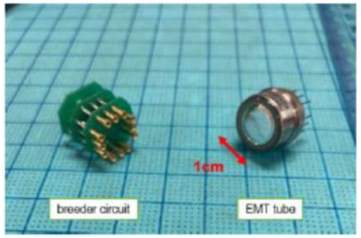
➢ 2 inch FPMT for Collider Detector



Development of Electron Multiplier Tube as muon monitor

Kiseki NAKAMURA

Summary



- T2K experiment
  - long baseline neutrino oscillation experiment with off-axis method
  - beam direction monitor is important

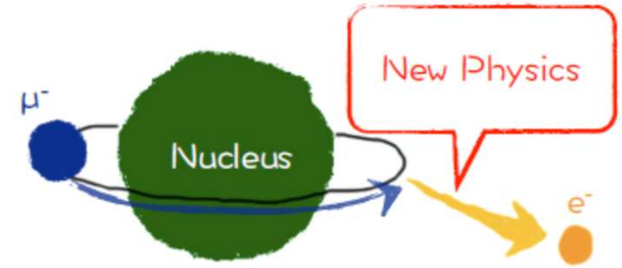
- EMT as a MUMON sensor
  - MUMON sensor must be upgraded together with the beam power upgrade
  - EMT (electron multiplier tube) is promising candidate for the new sensor
  - Good linearity, good radiation tolerance

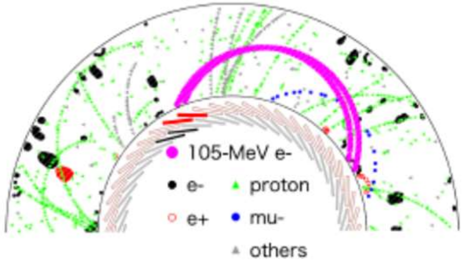
- ELPH beam test (3rd, 4th)
  - Radiation-damaged component seems dynodes (antimony deposited)
  - Temperature dependence exist, and may have affected in the previous J-PARC measurement (outside of enclosure)

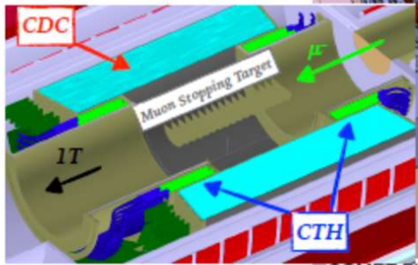
- Next T2K beam (RUN12 will be start from 4/17)
  - We will measure 1 dimensional beam profile by 7 EMTs
  - Check the temperature dependence with 2 EMTs at outside of the enclosure

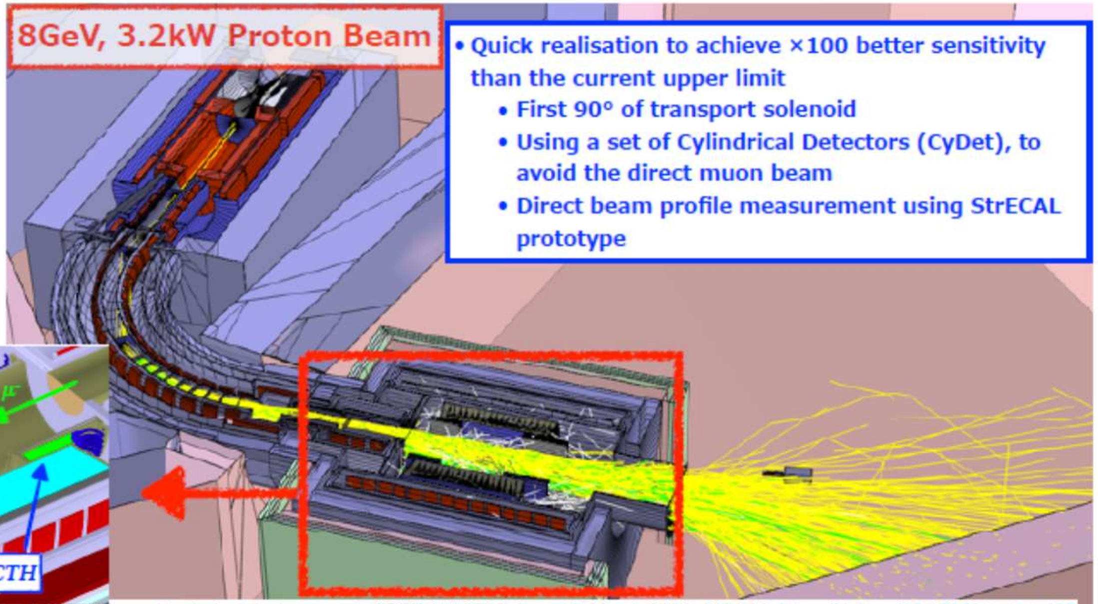
A Cylindrical Trigger Hodoscope System for the COMET Phase-I

Y. Fujii (Monash University)



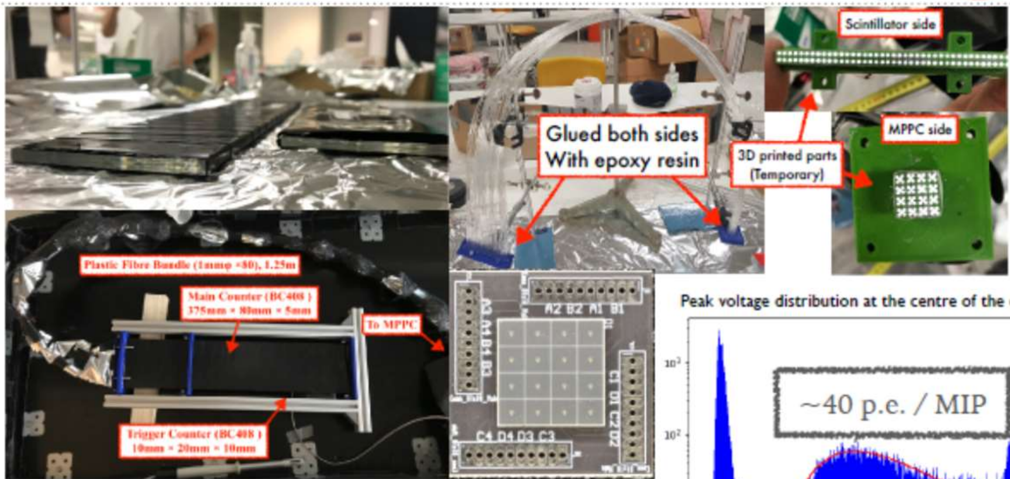




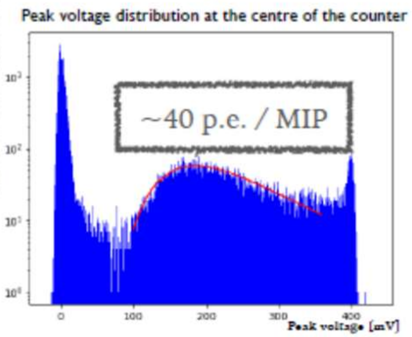


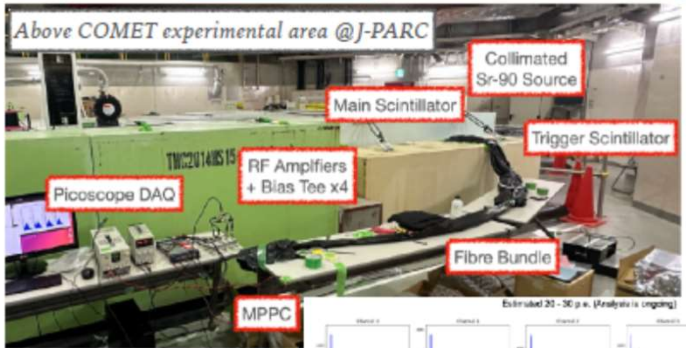
COMET Phase-I technical design report, *PTEP*, Vol 2020, Issue 3, March 2020, 033C01, https://doi.org/10.1093/ptep/ptz125

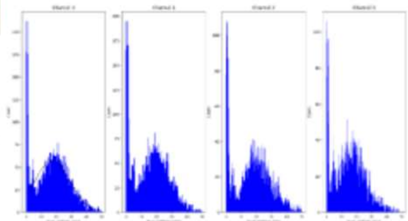
A Small Prototype



Yuki Fujii, AFAD, April 2023







Real scale 5m fibre bundle + plastic scintillator

Many studies are ongoing!

AFAD 2023

Study of the radiation aging of materials at BINP SB RAS (V.Bobrovnikov)

BNCT facility at BINP as source of fast neutrons

- Deuteron beam is used to generate neutrons
- Nuclear reactions due the interaction of the beam with lithium target

  $$d + {}^7\mathrm{Li} \rightarrow {}^8\mathrm{Be} + n + 15.028\ \mathrm{MeV}$$

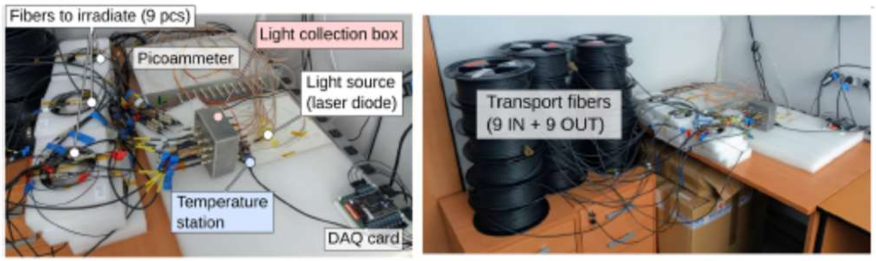
  $$d + {}^7\mathrm{Li} \rightarrow 2\,{}^4\mathrm{He} + n + 15.122\ \mathrm{MeV}$$

- For irradiation aging it was used beam with energy 1.5 MeV and current 1 mA

Experimental setup

- Vacuum chamber, neutron producing target and lead concentrator were done at BINP for the test
- Set of special studies was carried out on the residual activation of various materials to test possibility of their using in the concentrator construction and target

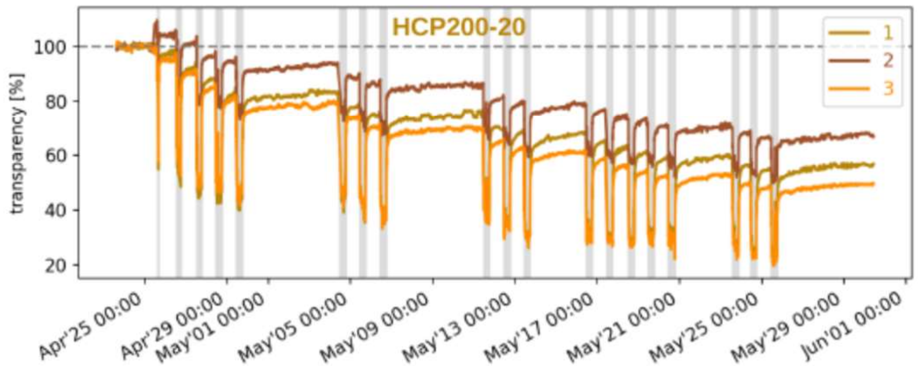
- Measuring equipment and materials were provided by the Saclay team



- Simulation on base FLUKA package was used for calculation of neutron fluence for high doses
- The difference between experimental data and simulation results is around 10%

Results

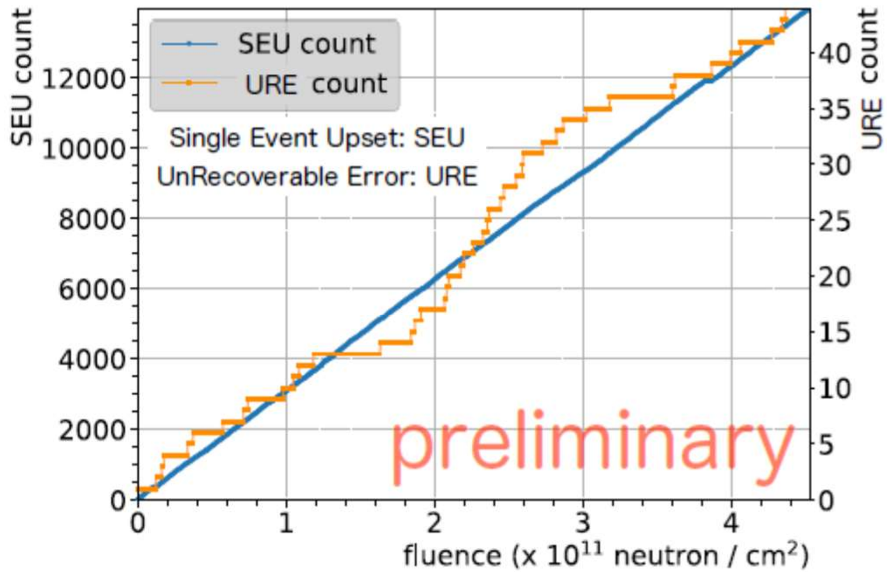
- Duration of the irradiation test was one month, 18 daily shifts per 7–8 hours
- Deuteron current fluence is 122 mAh
- Obtained doses are $(0.54 \div 2.37)\times 10^{14}$ neq/cm^2
- Example degradation of transparency for HCP200–20 fibers



- The degradation of transparency at level from 20% to 35% (over the full length of the fibres)
- BNCT facility at BINP SB RAS provides irradiation the dose at level **10^{14}** neq/cm2, this is quite enough to check the radiation resistance of materials, which proposed for use in the field of HEP
- The uniqueness of this radiation tests in contrast to irradiation in reactor is the precise control of the level of the accumulated dose with continuous measuring of degradation fiber transparency

Operation of electronics for the Belle II Central Drift Chamber

- SuperKEKB is steadily increasing beam current and luminosity.
- The biggest factor affecting the DAQ efficiency at Belle II is trouble in the CDC electronics.
- Neutron-induced soft errors in FPGAs can reduce the DAQ efficiency, and thus an auto-recovery scheme has been implemented to fix them.
- In the past physics runs, the soft errors were not corrected.
- After resolving the bug, we verified that the auto-recovery scheme successfully detected and corrected soft errors during neutron irradiation tests.



Yiwei Yang

FLASH-RT

- FLASH radiotherapy: ultrahigh dose-rate radiation (>40 Gy/s) enables tumor control to be maintained while reducing toxicity to surrounding non-malignant tissues.
- Electron, Proton and X ray

- Three monitors adopted on PARTER
  - **A**: Fast Current Transformer (FCT) monitoring electron beam
  - **B**: Diamond monitoring X-rays upstream
  - **C**: Scintillator monitoring X-rays downstream