WG2: Detector technology development

Summary

B.Shwartz, BINP

General remarks

In total 19 talks

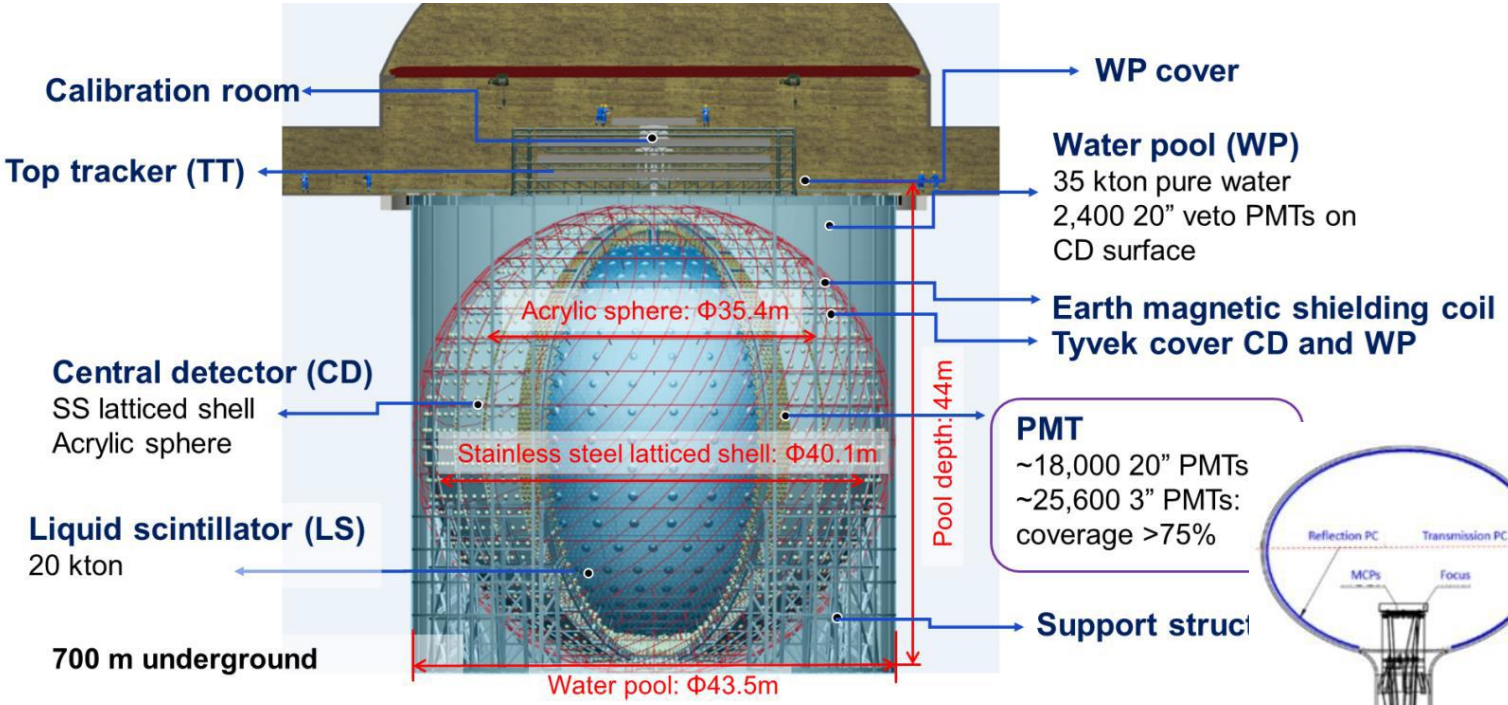
Australia	1
India	2
Taiwan	2
Japan	3
Russsia	3
Korea	4
China	4

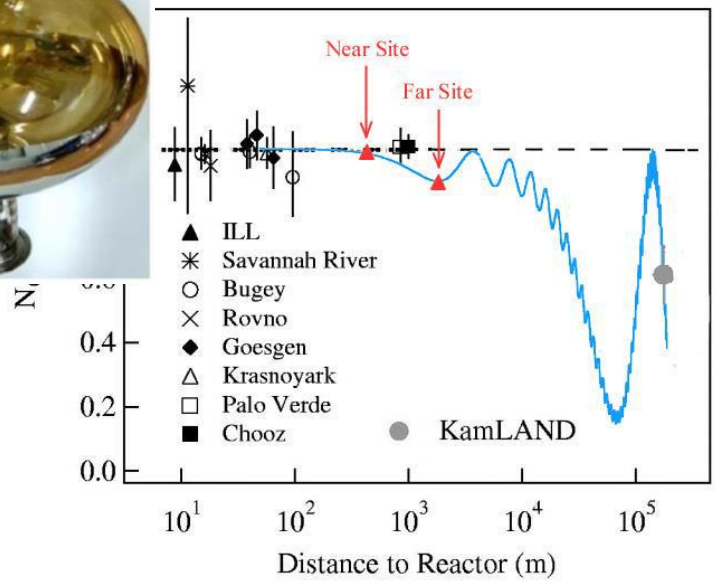
- **Reviews of big projects (for non-accelerator physics) neutrino mixing parameters and neutrino astrophysics**
- **Developments of technologies and subsystems for big experiments**
- **Technologies for wide range of applications**

Reviews of big projects (for non-accelerator physics) neutrino mixing parameters and neutrino astrophysics

1. Status of the JUNO experiment Haoqi Lu
2. Hyper-Kamiokande Kimihiro OKUMURA (ICRR, Univ. of Tokyo)
3. Cygnus, and directional DM detection, Ciaran O'Hare University of Sydney

Status of the JUNO experiment (Haoqi Lu)



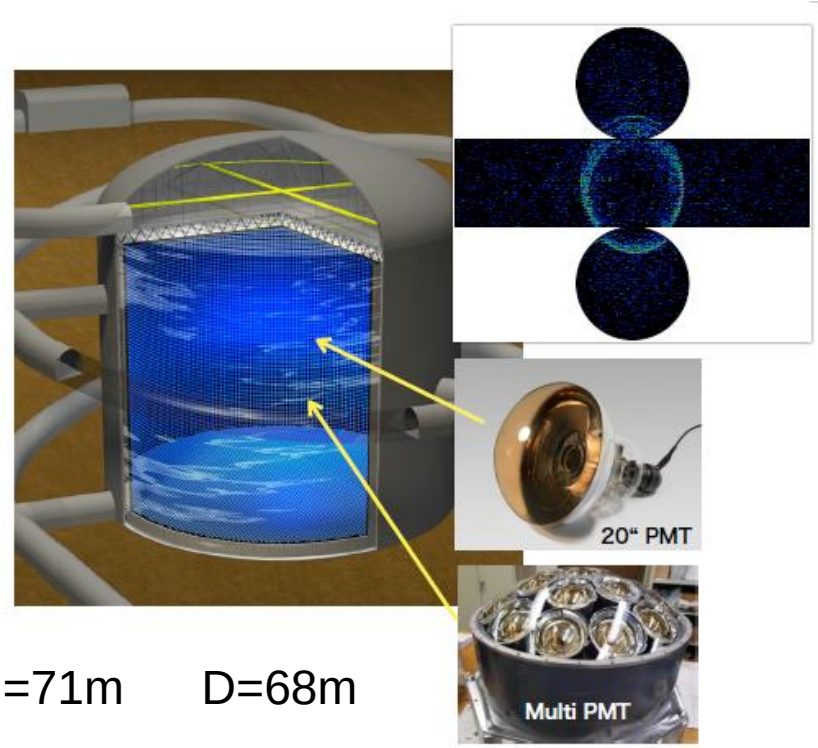


Precision of three parameters ($\Delta m^2 21$, $\Delta m^2 32$ and $\sin^2 \theta 12$) will reach sub-percent level, several times improvement compared with current precision.

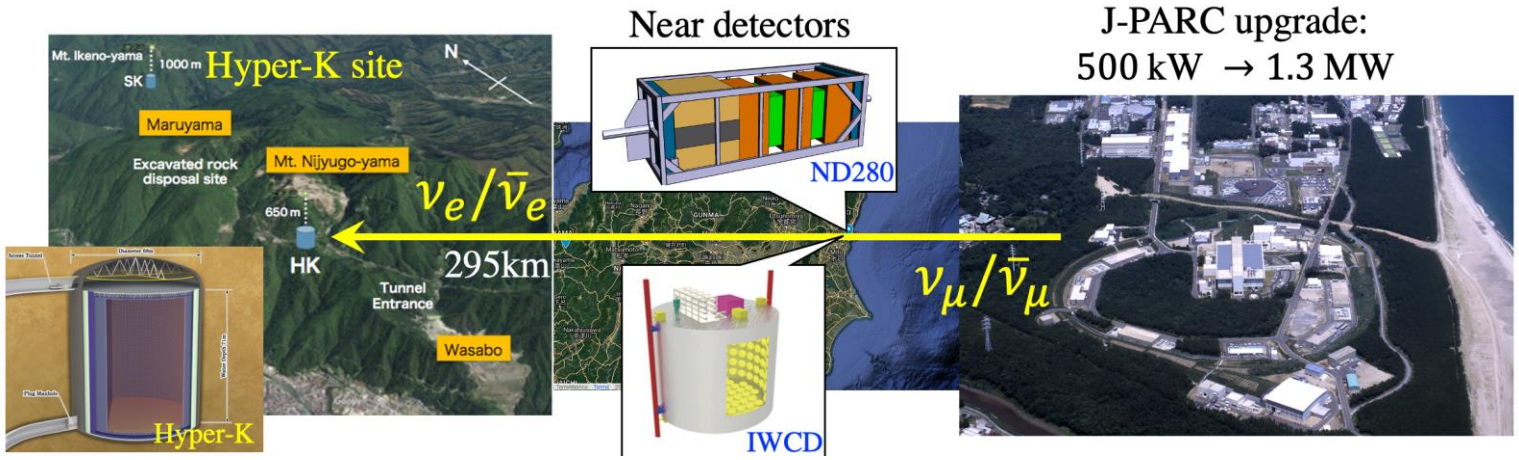
- **Supernova neutrinos(SN):**
- **Diffuse Supernova Neutrino Background**
- **Multi-messager astrophysics:**
- **Solar neutrinos**
- **Atmospheric neutrinos:**
- **Geo-neutrino**
- **Proton decay :**

complete the detector construction within 2022

Hyper-Kamiokande (K.OKUMURA, ICRR, Univ. of Tokyo)



H=71m D=68m



- ✓ Japan budget approved in 2020
- ✓ Construction has started
- ✓ Operation in 2027

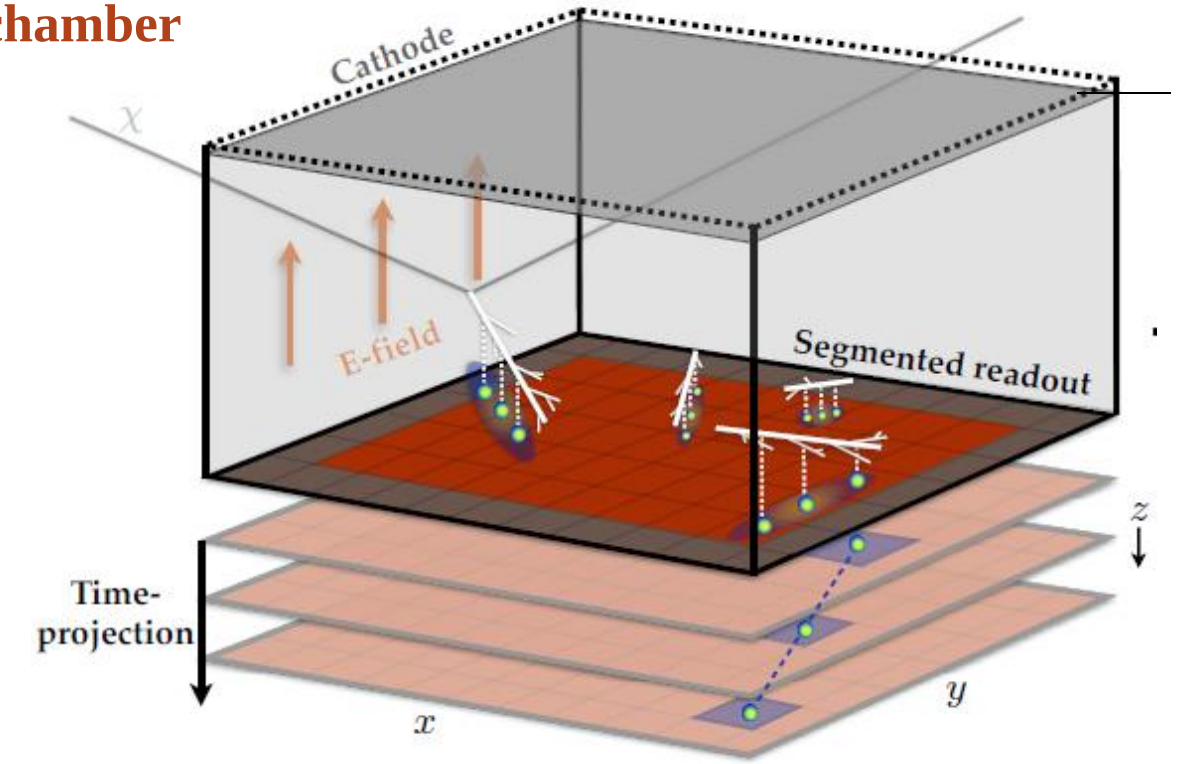
- Hyper-K will be the world's largest neutrino detector in MeV~TeV energies
- Multi purpose and rich physics with excellent discovery potential:
- LBL and atmospheric neutrinos for leptonic CP violation and mass hierarchy
- Proton decay
- Astrophysics (solar, supernova burst / relic neutrinos)

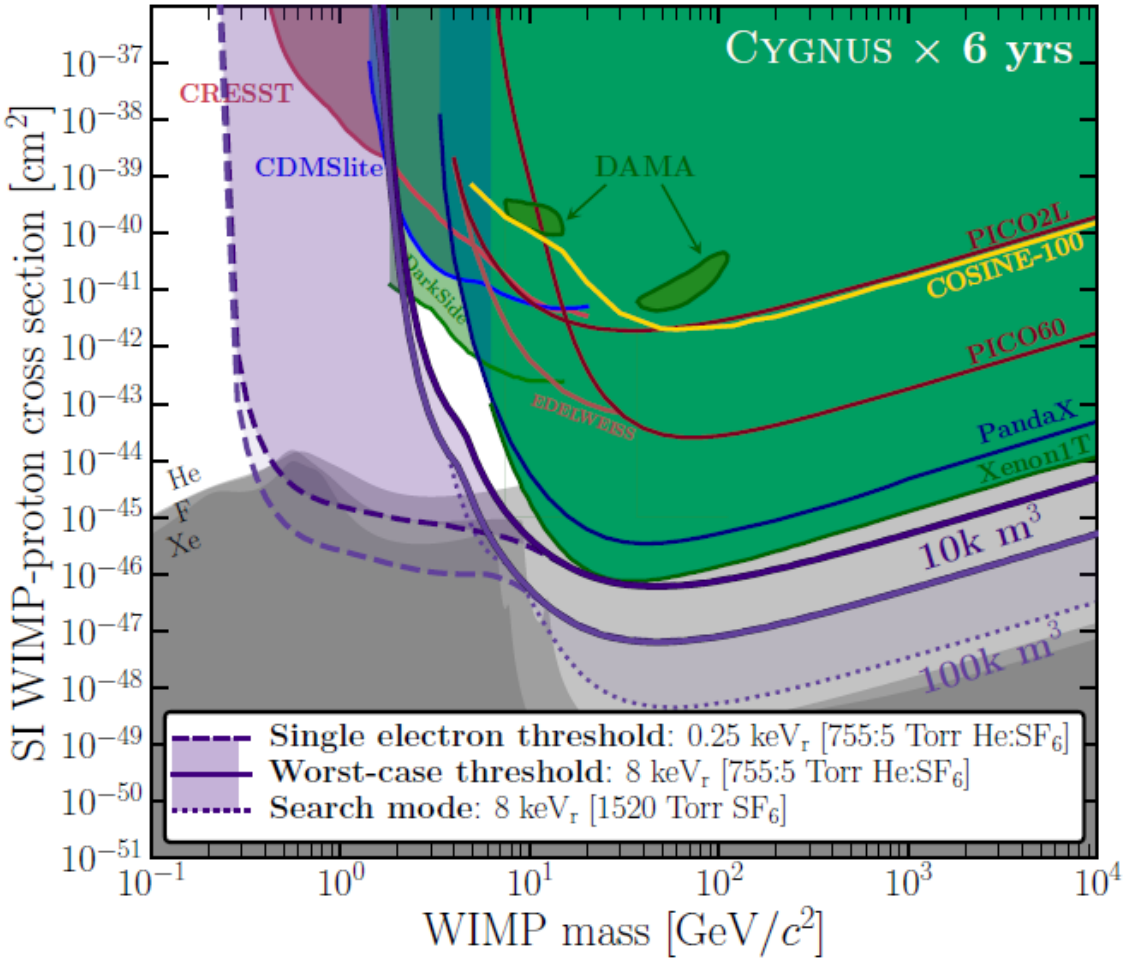
Cygnus, and directional DM detection (Ciaran O'Hare University of Sydney)

Tracks at mm-scale
Nuclear/Electronic tracks are easily distinguishable
Imaging in gas TPCs demonstrated since 1990s

Detecting the directions of low energy nuclear or electron recoils, as well as just their energies

Focus of Cygnus: High definition time projection chamber





Technologies for wide range applications

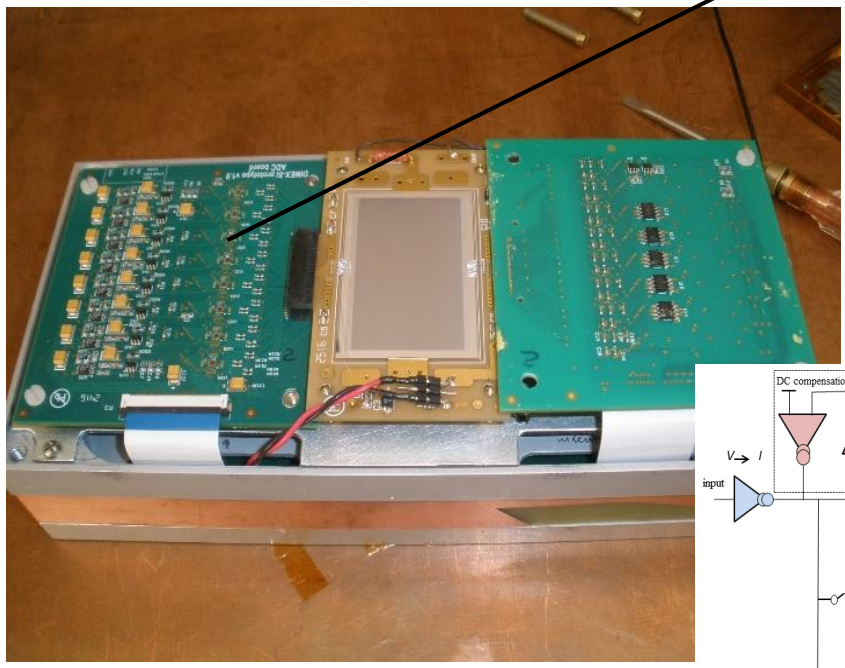
1. Detectors for dynamic experiments at Synchrotron Radiation beams at Budker INP, L. Shekhtman, BINP
2. Development of the X-ray Pixel Detectors for the High Energy Photon Source, Wei Wei, IHEP, CAS
3. Neutron detector with ceramic GEM, Shoji UNO (KEK)
4. Ion detector for Accelerator Mass Spectrometry based on low-pressure TPC with THGEM readout, T.Shakirova, BINP
5. Establishment of a Instrumentation Detector Consortium in Taiwan, Hsin-Yeh Wu (National Taiwan University)

Detectors for dynamic experiments at Synchrotron Radiation beams at Budker INP (*L.I.Shekhtman)*

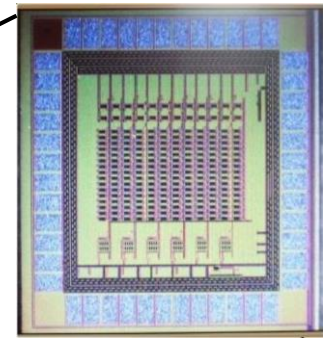
DIMEX-G

Gaseous 1D detector with new front-end ASIC DMXG64B(A)
Max frame rate - 10 MHz
Number of frames – 100
Maximum signal(electronics) – $2x10^6$ e (~3500 photons, 20 keV)
Noise - <~4000 e ~ 7 photons 20 keV (GEM attenuation)
Channel pitch – 100 μm
Number of channels - 512
Spatial resolution – 250 μm (FWHM, for 20 keV photons)
DQE ~ 40% (for 20 keV photons)
Maximum detected photon rate - ~1200 photons/chan x bunch (20 keV photons)

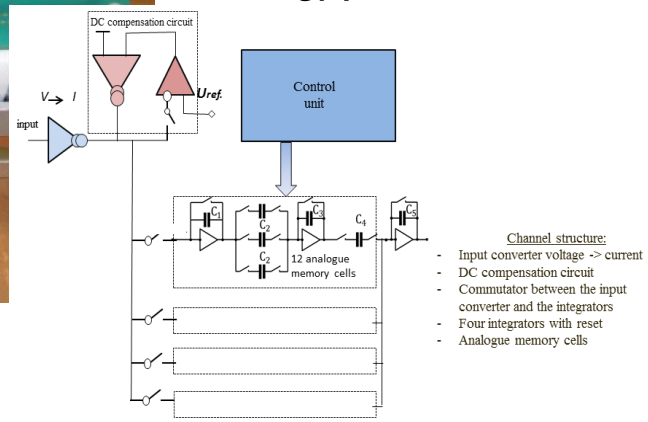
DIMEX-Si



96 channel prototype mounted



DMXS 6A



Development of the X-ray Pixel Detectors for the High Energy Photon Source (Wei Wei, Institute of High Energy Physics, CAS)

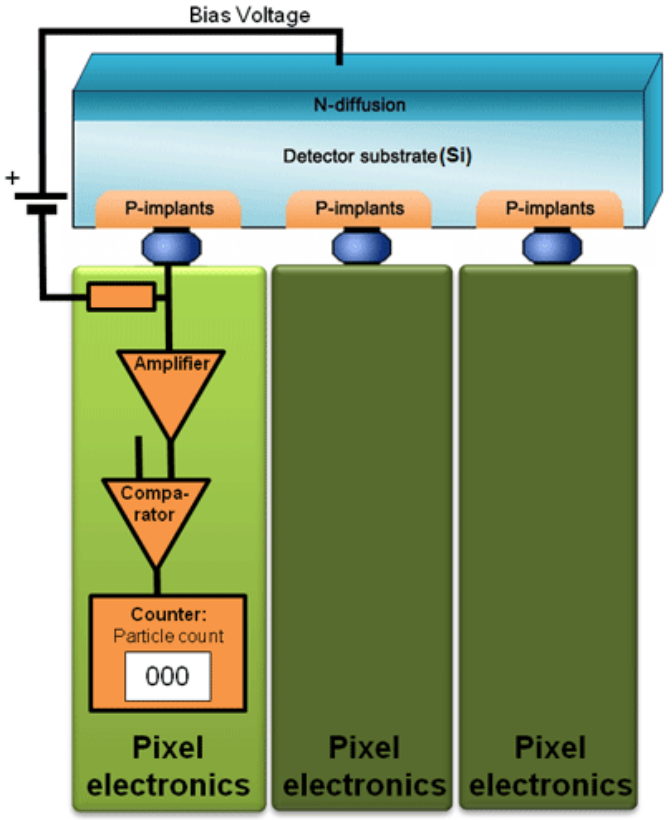
- **Application Specs**
  - **Modular design**
  - **High yield & rare defects**
  - **Portable & miniaturization**
  - **User friendly design**
  - **High robustness**

- **Project Specs**
  - **Area：8cm×8cm**
  - **Pixel size：150μm× 150μm**
  - **Frame rate：1kHz**
  - **Dynamic range：20bit**
  - **Energy range：8~20keV**

Major detector R&D for HEPS: BPIX system

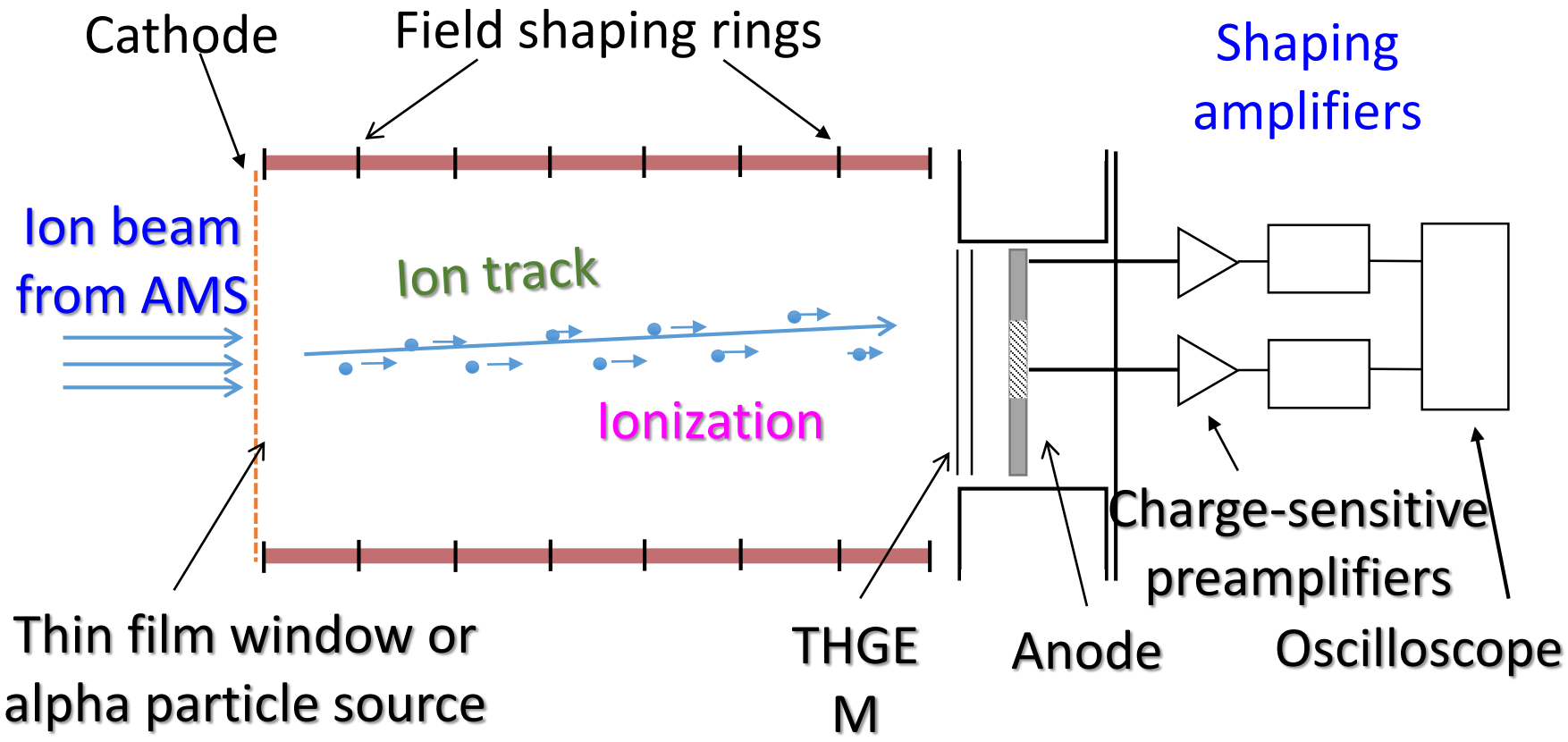
The pixel cell works in single photon counting mode, readout by frame refreshing.

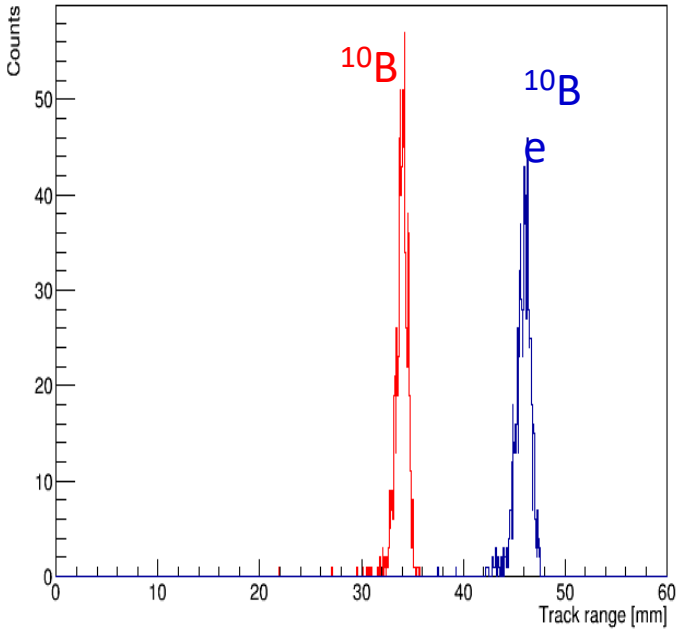
A hybrid pixel system: Si-PinN Sensor + Bump Bonding + ASIC



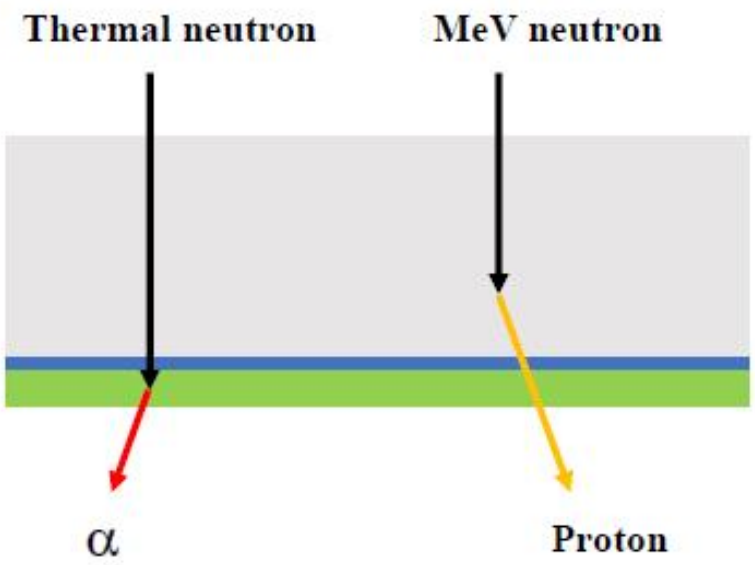
Ion detector for Accelerator Mass Spectrometry based on low-pressure TPC with THGEM readout (T. Shakirova, BINP)

Schematic layout of the low-pressure TPC



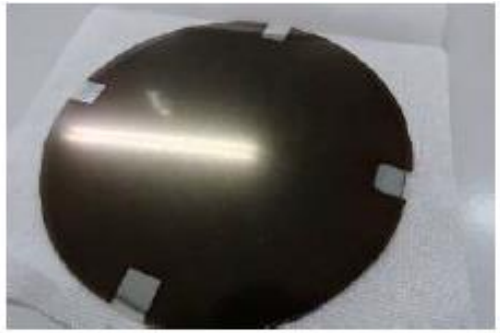


Neutron Detector with, Ceramic GEM, Shoji Uno (KEK)

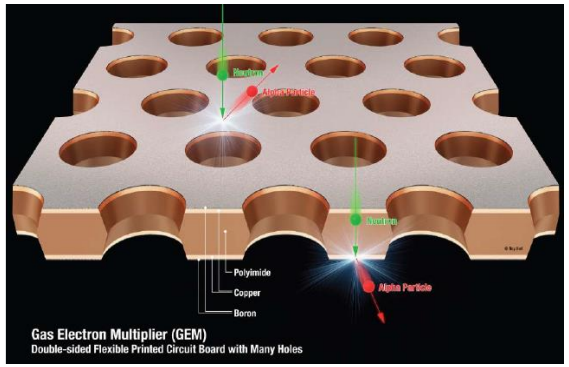


PET 0.5mm

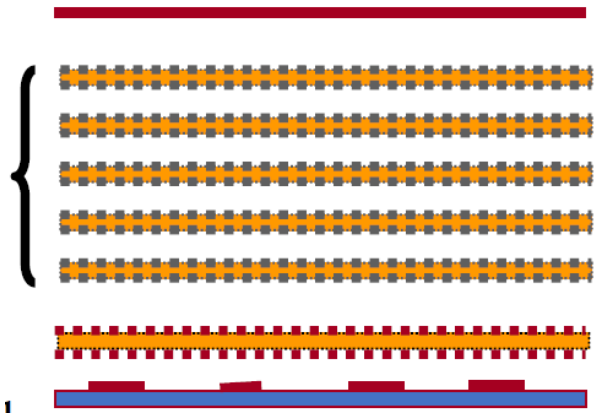
Aluminum 0.4 μm
Boron 1.0 μm



90$^{\phi}$ mm



Expensive 3He Gas is not necessary.
Free readout pattern, High resolution
Position and Time, Insensitive against g-ray
Capability against high counting rate

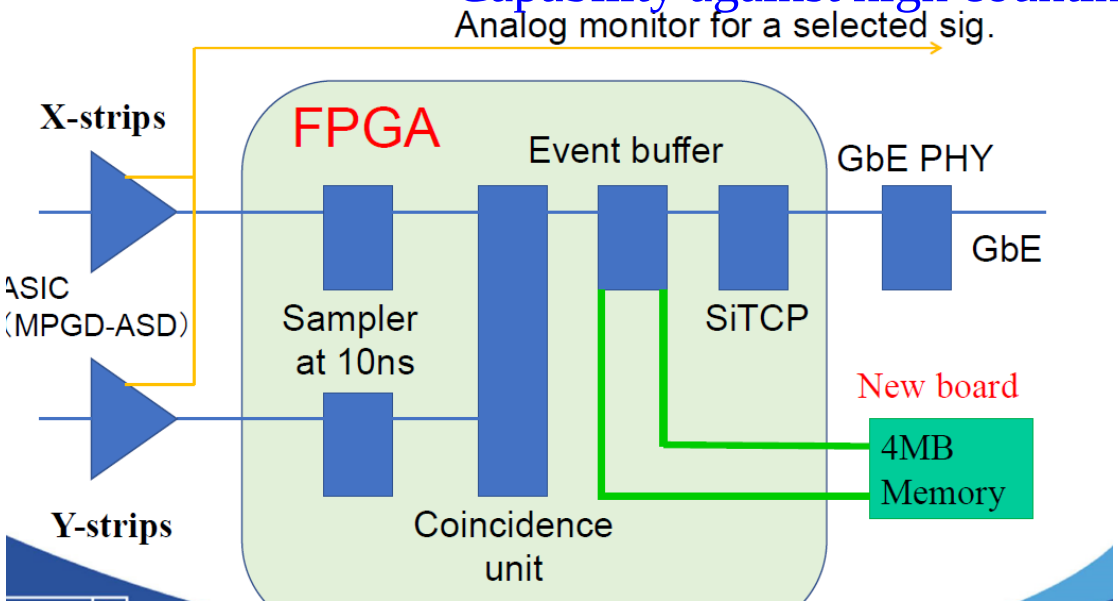


Cathode plate
With B10

B10 coated
GEMs

Normal GEM

Readout board



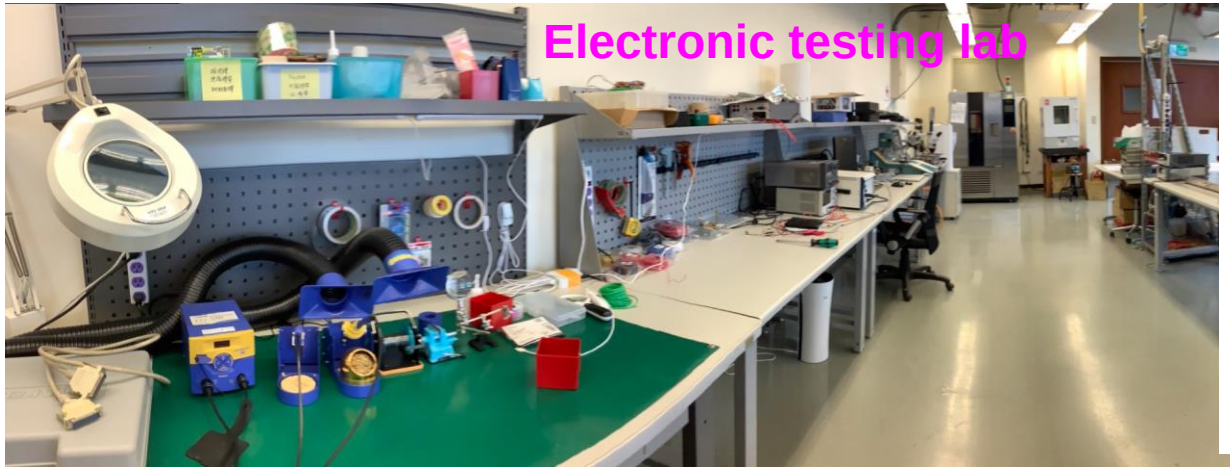
Establishment of an Instrumentation Detector Consortium in Taiwan (TIDC)

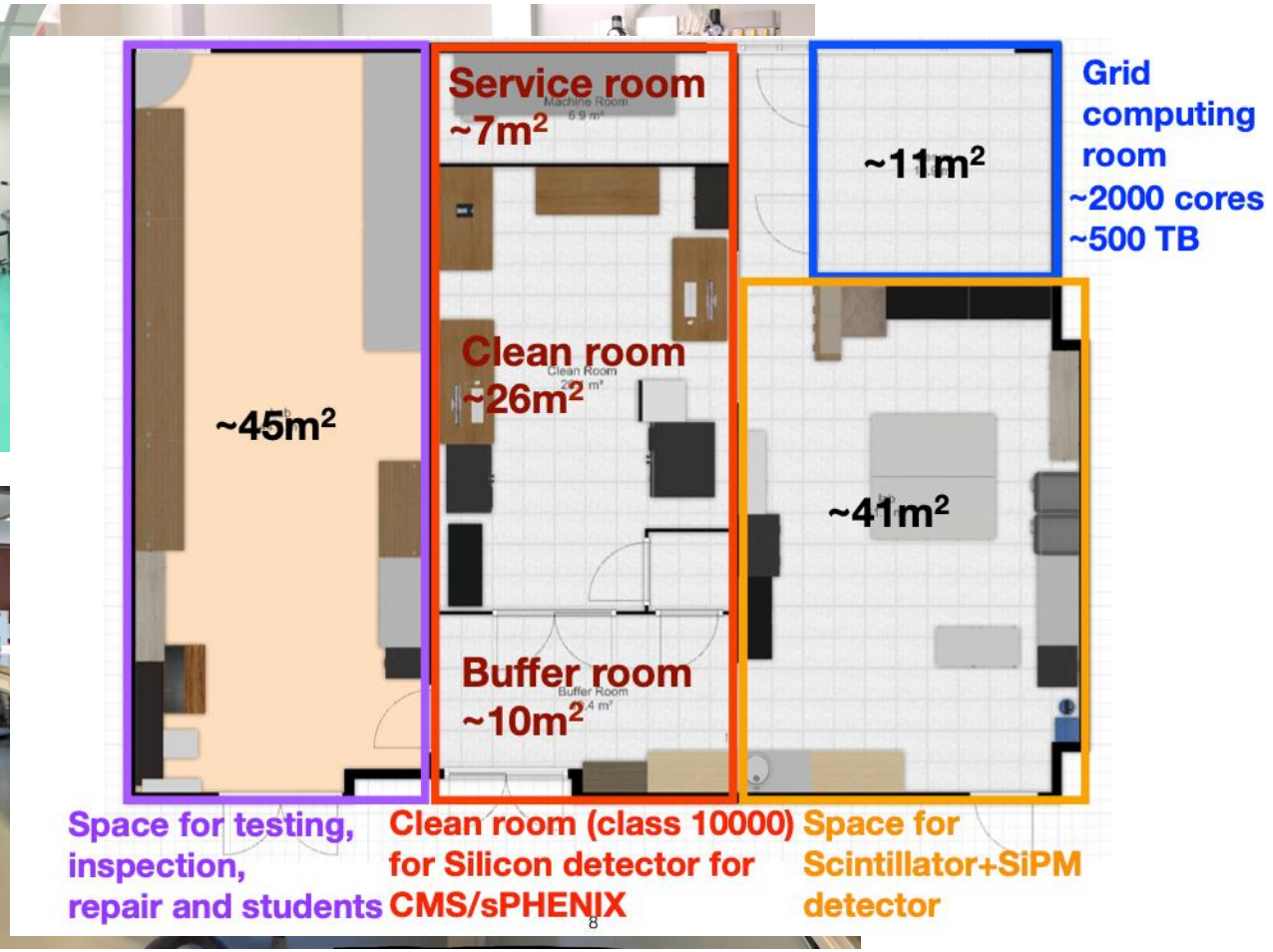
Hsin-Yeh Wu

5 participants -Seed Facility NTU

- TIDC started Nov 2020
- Share laboratories, resources and personnel among TIDC participating groups.
- Collaborate with local high-tech companies to provide high-quality custom-design parts for state-ofthe-art detectors

Clean room



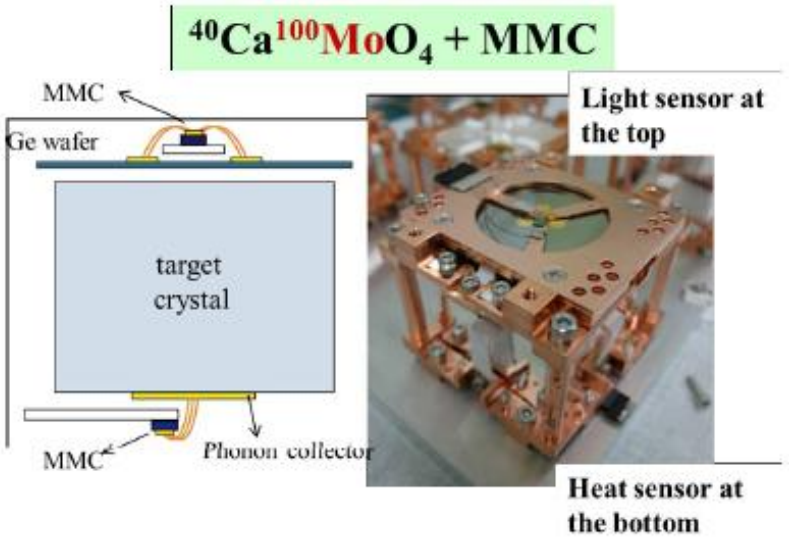


Developments of technologies and subsystems for big present and future experiments

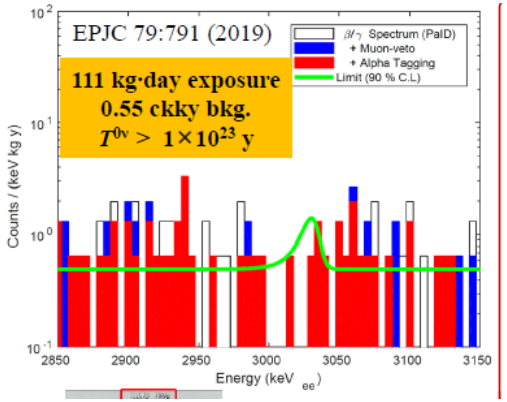
1. Low-temperature thermal calorimeters for neutrinoless double beta decay experiments, Yong-Hamb Kim
2. Development of GEM chambers for high rate CBM experiment, Anand Kumar Dubey, VECC-Kolkata
3. Development of photo-detector utilizing photocathode, scintillator and SiPM, Jik Lee, Kyungpook National University
4. Development of single-gap RPC for the INO-ICAL, B. SatyaNarayan, TIFR-Mumbai Satyanarayana Bheesette
5. Combined LXe/Crystal calorimeter for low energy e+e- experiments, K.Mikhailov, BINP
6. Development of SOI pixel sensors, Toru TSUBOYAMA (KEK)
7. A Large Tracking System with Novel HV-CMOS Sensors for the CEPC, Hongbo Zhu, (Institute of High Energy Physics)
8. Investigation of TPC prototype using 266nm UV laser tracks for CEPC, HUIRONG QI (Institute of High Energy Physics, CAS)
9. Meet requirements for detectors in CMS MTD: LYSO Scintillator, Lin Wei Chang (Taiwan Applied Crystal Co)
10. LGAD Based Endcap Timing Layer for CMS phase-2 upgrade, Sunil Dogra, Kyungpook National University
11. Dual-Readout Calorimeter R&D in Korea for future e+e- colliders, Hwidong Yoo (Yonsei University)

Low-Temperature Thermal Calorimeters for 0νββexperiments (Yong-Hamb Kim)

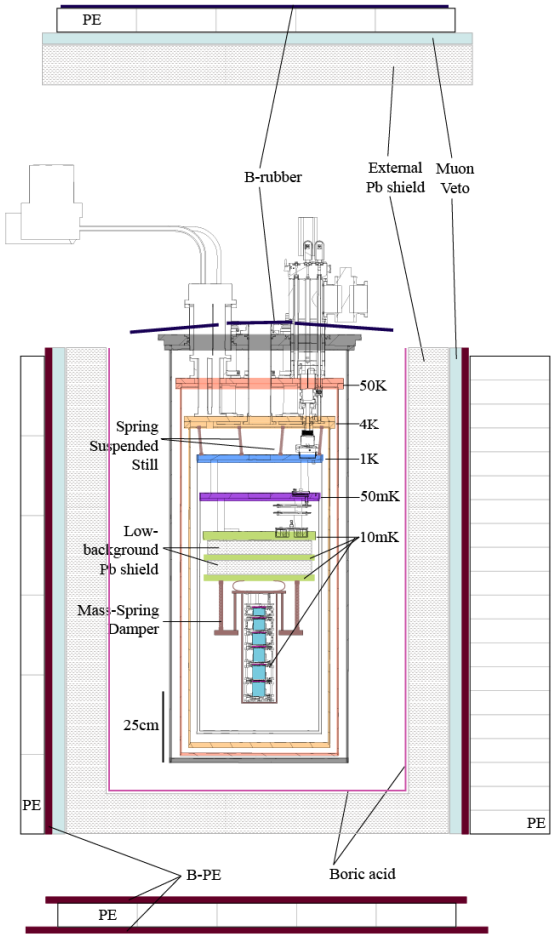
AMoRE: Advanced Mo-based Rare process Experiment

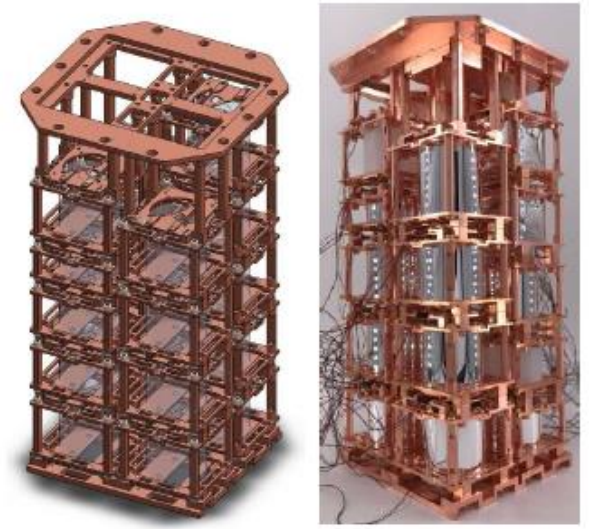


Ø4cmx4cm
CaMoO4 crystal



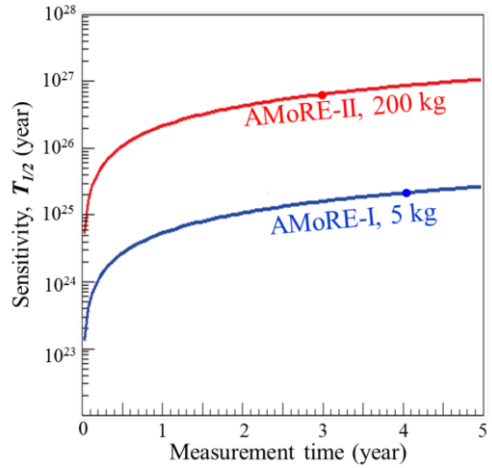
First Pilot result





~3.1 kg of 100Mo

Science run began Dec. 2020.

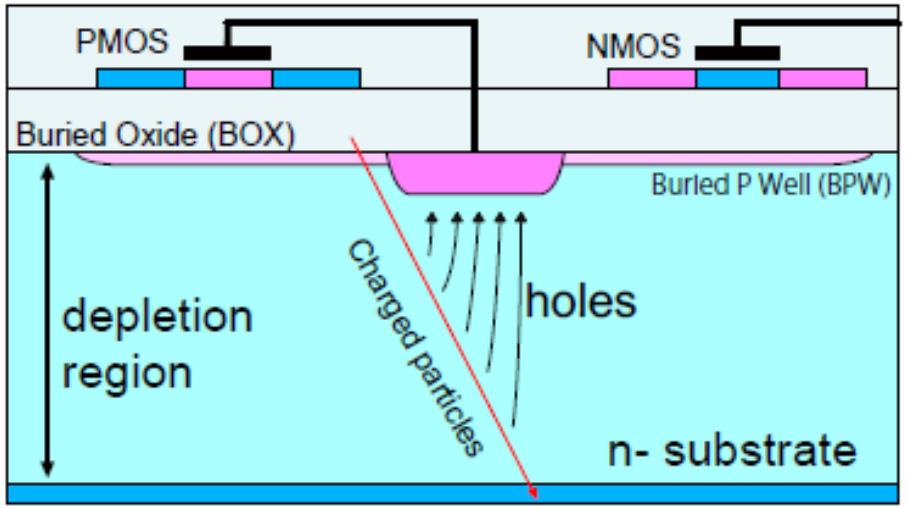


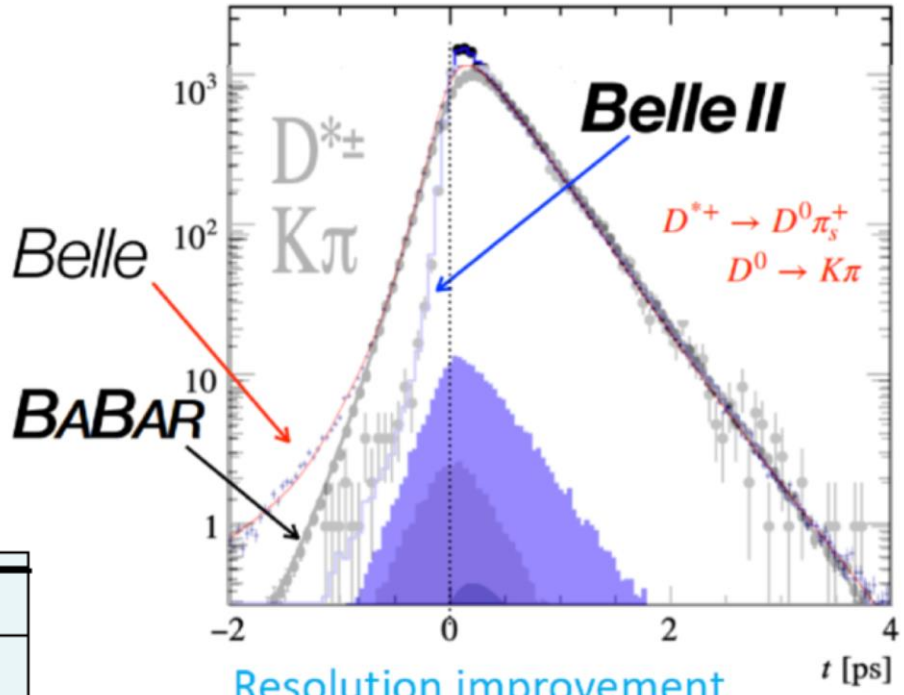
SOI pixel detector (Toru Tsuboyama (KEK IPNS, Sokendai))

SOI/ Silicon on insulator

Belle-II vertex detector

Charge collection Fast because the sensor is depleted with bias voltage.
Monolithic The signal in the wafer is directly connected to the MOSFET
Radiation hard
CMOS circuit Complex circuit can be implemented by using standard ASIC tools.



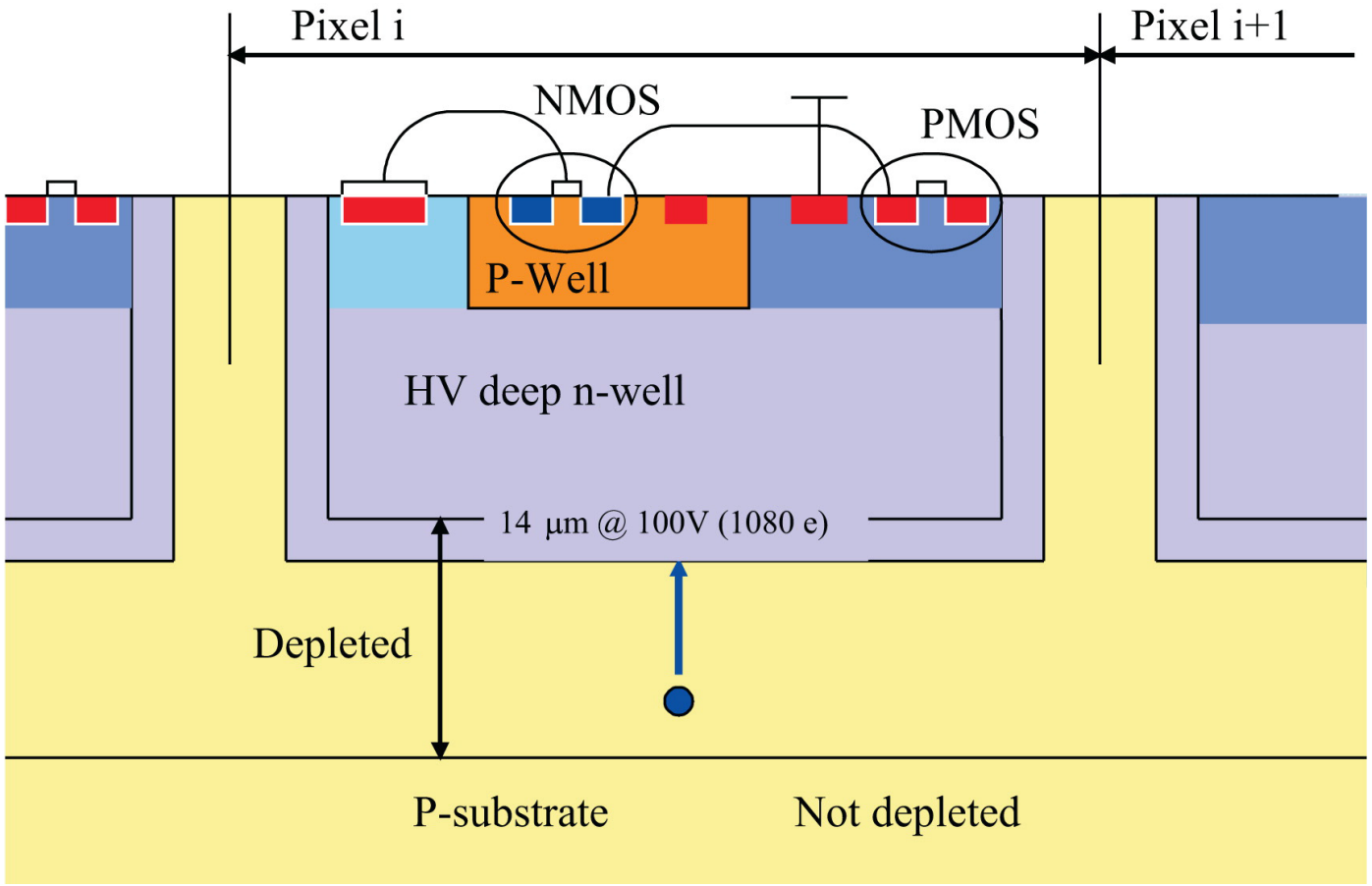


Resolution improvement visible at $t < 0$

A LARGE TRACKING SYSTEM WITH NOVEL HV-CMOS SENSORS FOR THE CEPC (Hongbo Zhu (IHEP))

TRACKING REQUIREMENT

- Large area tracking system to deliver high track momentum resolution
- Silicon Tracker: multiple high precision measurements along the track particle trajectory;
- Spatial resolution $\sigma r\varphi$~7 μm; time resolution σt~10 ns;
- low material budget, low cost



Conclusion

- At WG2 sessions many (19) very interesting and highly promising detector technologies were presented
- I would like to thank speakers for excellent presentations and very sorry that I could not mention all of then in my short summary
- Many thanks to colleagues attended and actively participated in WG-2 sessions.