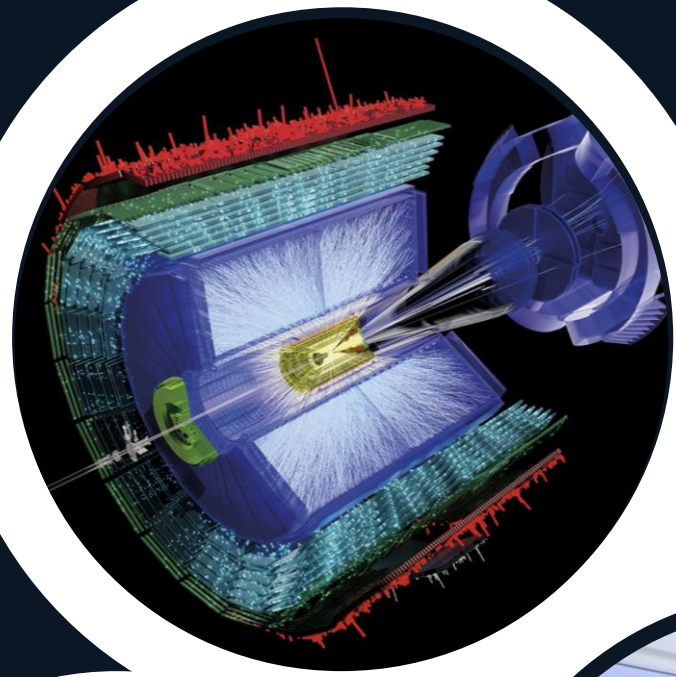
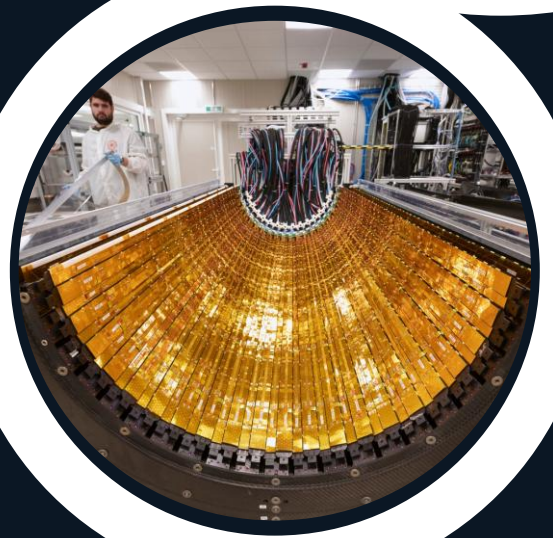
The 7th Sino-Thai Symposium on High Energy Physics,
Astrophysics, Materials Science and Beyond

# From Particle Physics to Particle Therapy at SUT


*Chinorat Kobdaj*

Suranaree University of Technology






DATE
12th October 2026

VENUE
Guilin Bravo Hotel, No. 14, Ronghu South Road, Guilin, Guangxi 541002, China.

# Outlines

1. Royal Support
2. International Collaboration
3. ALICE
4. Silicon Sensor
5. Proton Therapy and Proton computed tomography (pCT)
6. Boron neutron capture therapy (BNCT)
7. Radiobiology
8. Future Research



# 1) Royal Support

## HRH Princess Maha Chakri Sirindhorn

Support for scientific exchanges and international collaborations



BESIII at IHEP, Beijing • 6 April 2011



MoU between JUNIO and Thai Institutes at IHEP Beijing • 2 April 2017

## Precise over at signing ceremonies

Memory of Understanding (MoU) with International Laboratories



GSI/FAIR MoU, Darmstadt • 1 July 2017




HRH visited KATRIN (KArlsruhe TRItium Neutrino experiment) Germany • 28 June 2019

# SUT is a full member of ALICE since 2012

## A long-term research connection

SUT has joined the ALICE collaboration since 2012.



SUT–ALICE MoU • Bangkok, 13 December 2012

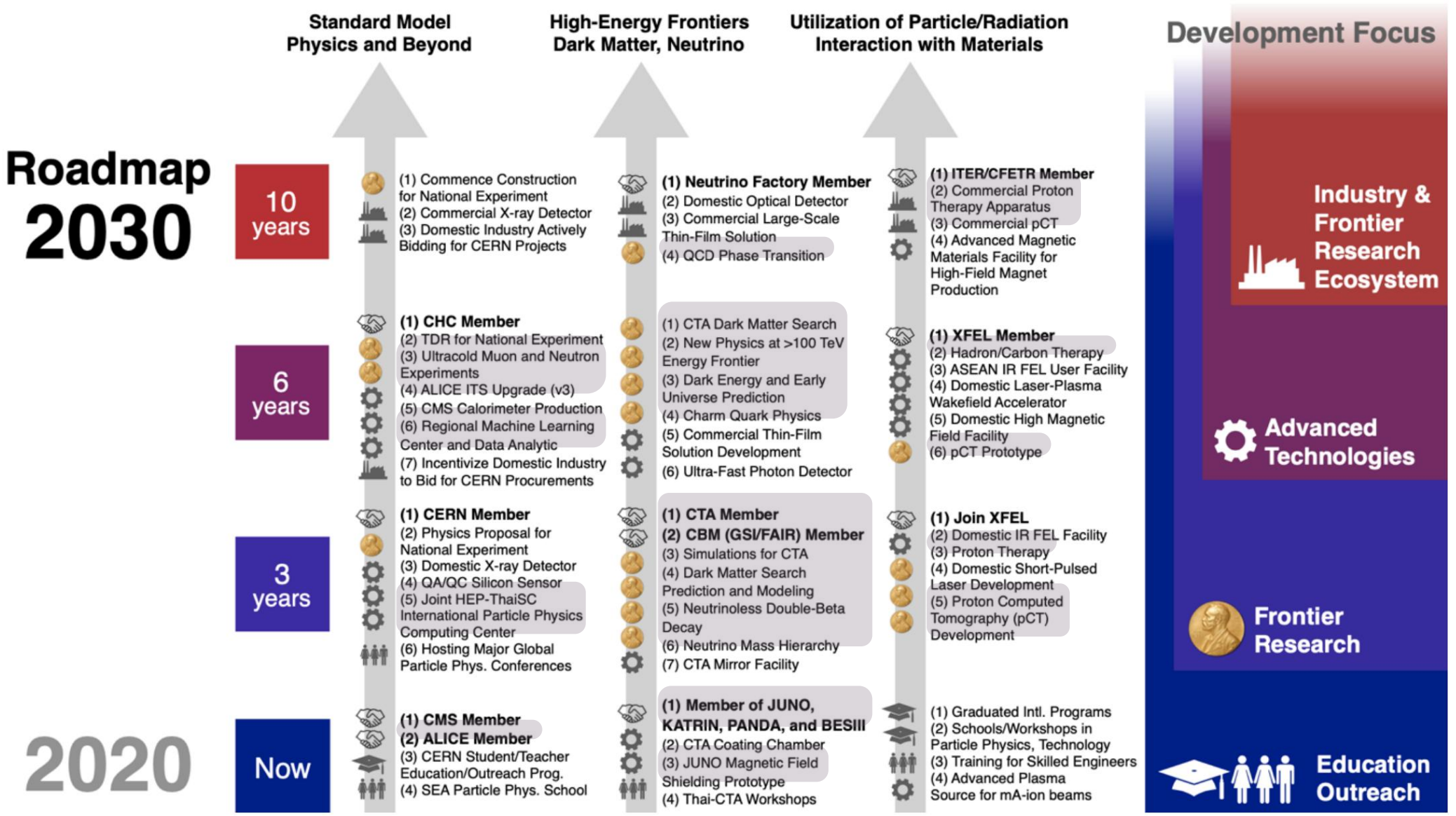
## A foundation for detector research

Silicon pixel sensors  simulations and characterization.



Royal visit to ALICE • CERN, 4 September 2019

# Thai High Energy Physics Roadmap



# Suranaree University of Technology (SUT)



- Founded in 1990
- First Public Autonomous University (PAU) in Thailand
- One of 9 National Research Universities (NRU)
- 2nd Largest Campus Area in Thailand





# Center of Excellence in High Energy Physics and Astrophysics



Director

Prof. Dr. Yupeng Yan



Assoc. Prof. Dr.Prapun Manyum



Assoc. Prof. Dr.Chinorat Kobdaj



Assoc. Prof. Dr. Ayut Limphirat



Asst. Prof. Dr. Khanchai Khosonthongkee



Asst. Prof. Dr. Warintorn Sreethawong



Assoc. Prof. Dr.Christoph Herold



Dr. Narongrit Ritjoho

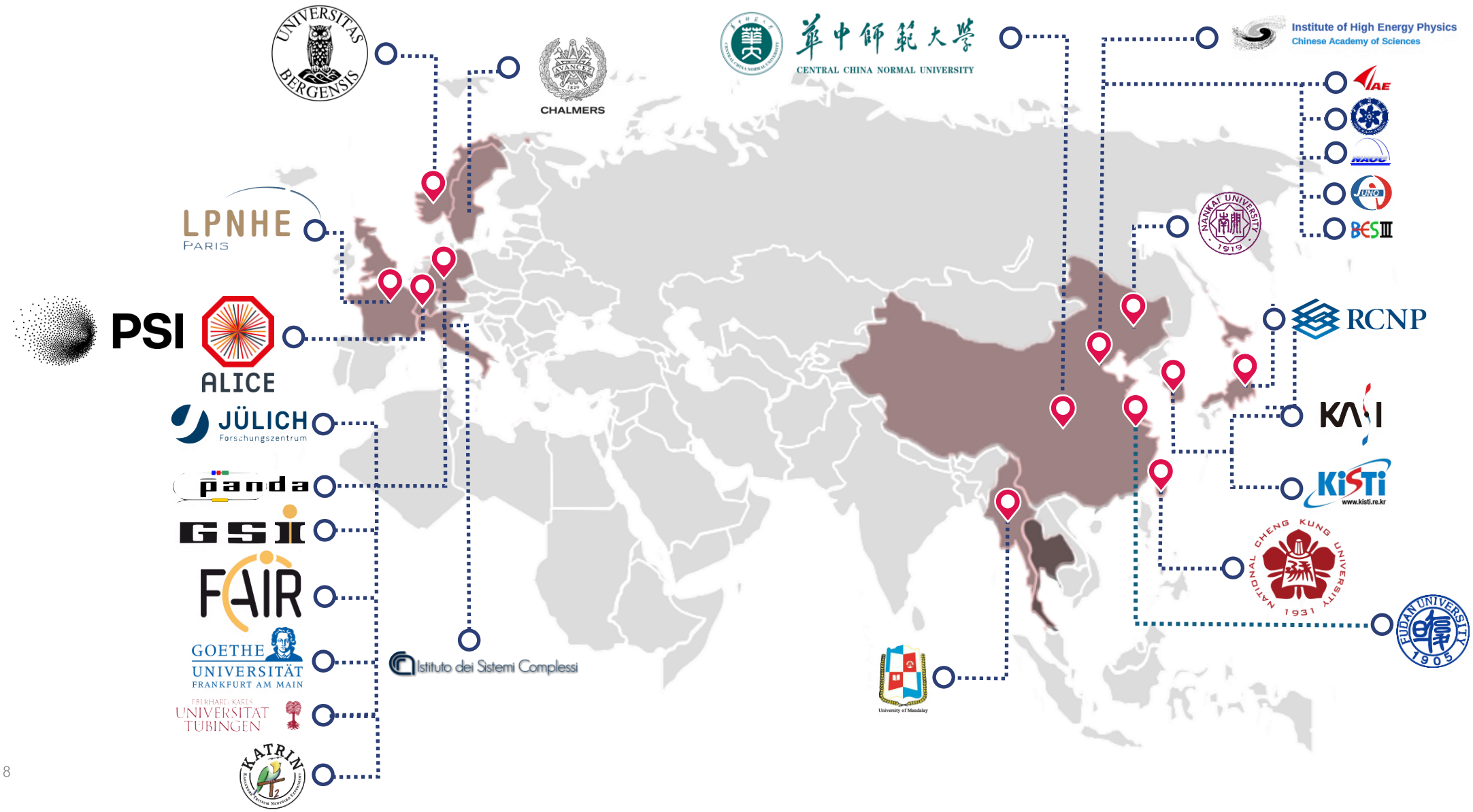


Assoc. Prof. Dr. Tirawut Worrakitpoonpon

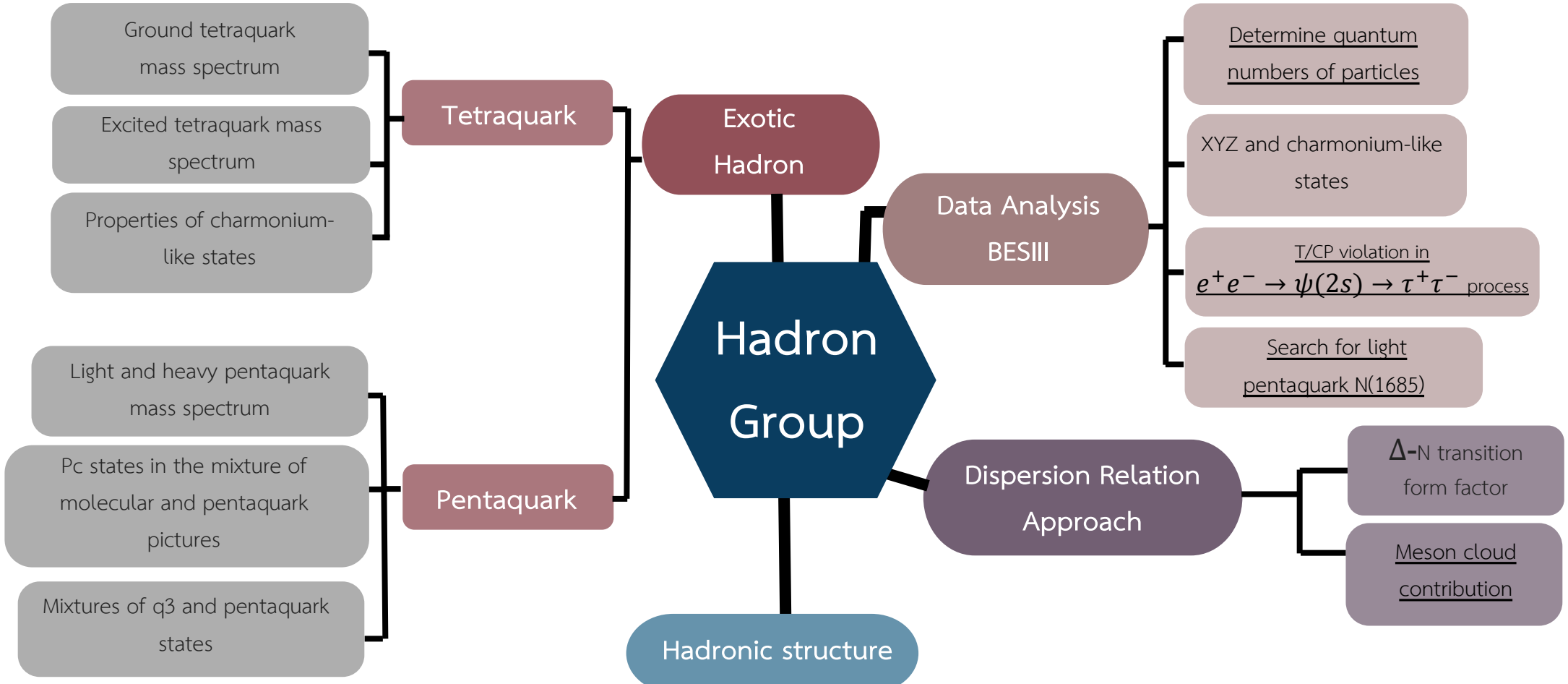





# 2) International Collaboration

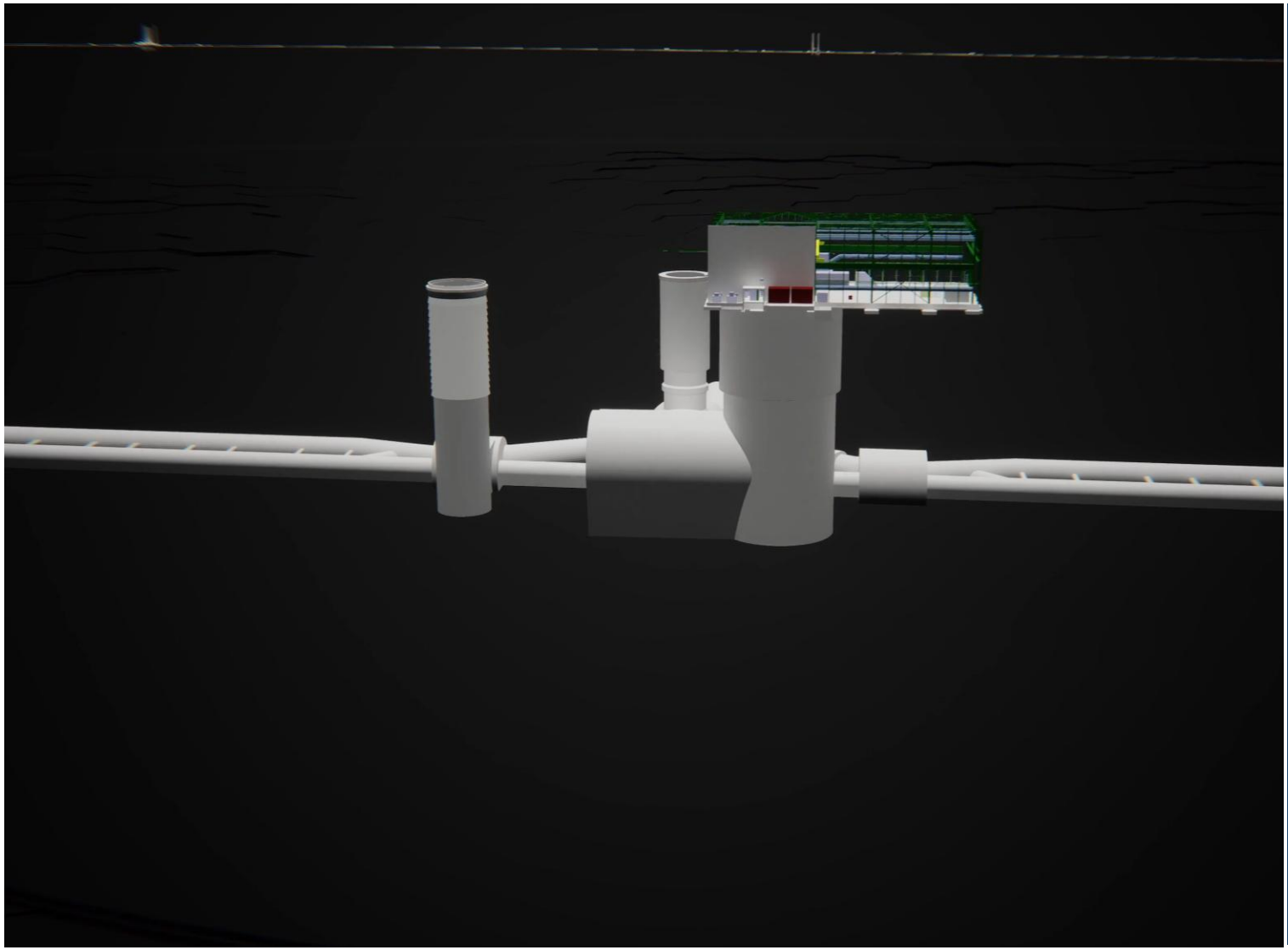


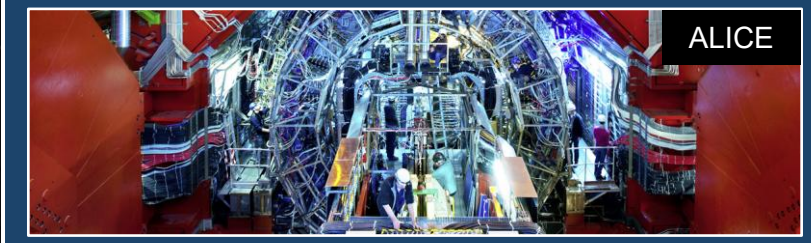
# SUT Hadron Physics Group

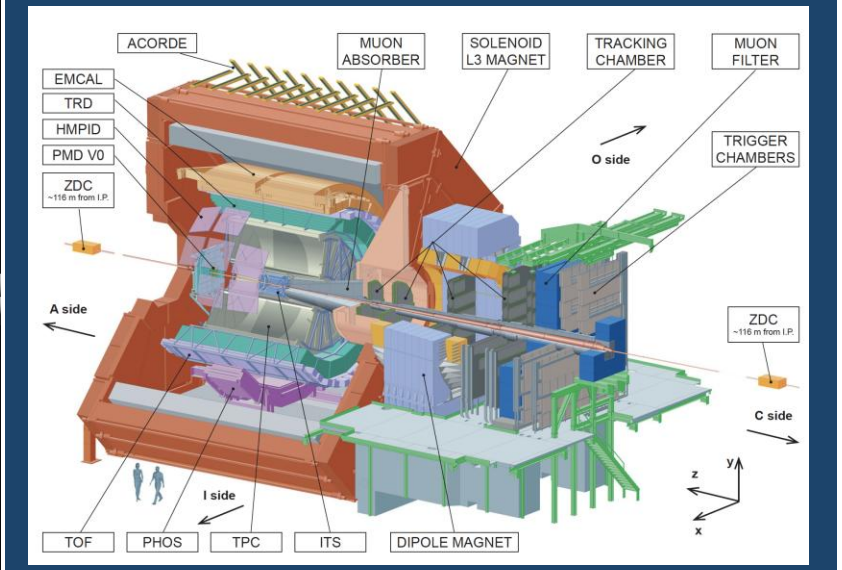



+ 3 Postdoc
+ 3 PhD, 3 master students
+ Research collaborations from BESIII, Nankai University, FIAS

# 3) ALICE: A Large Ion Collider Experiment





# Inner Tracking System (ITS)

## Physics need

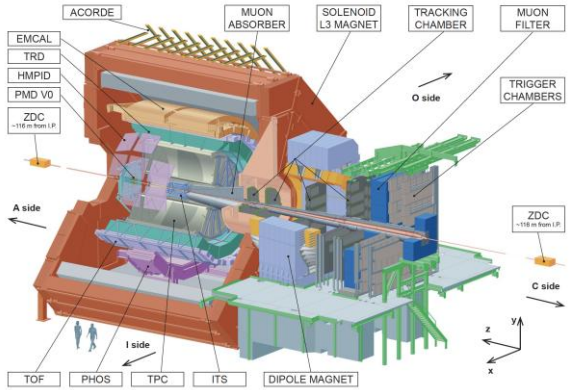
Reconstruct particle trajectories and locate decay vertices

## Detector challenge

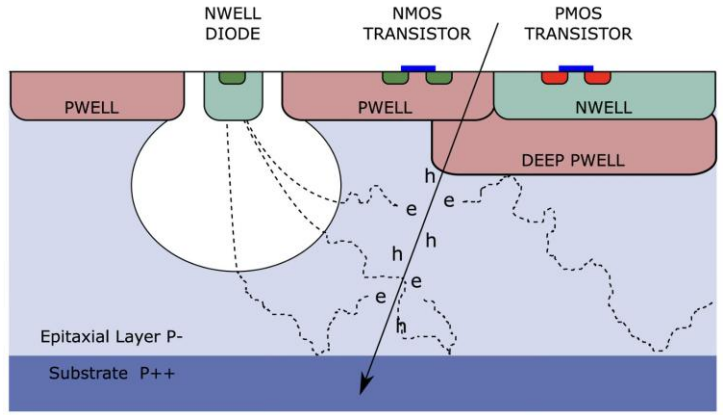
Precise measurements with low material budget

## SUT involvement

Sensor development and characterization for ITS2 and ITS3 upgrades

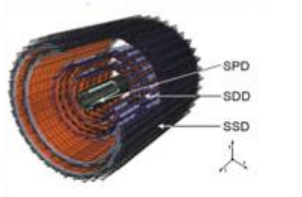



ALICE detector overview




Cross-section view of ALPIDE sensor

**ITS 1 (2008-2019)**

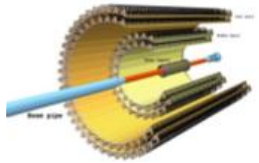



- 6 layers
- 2 SPD, 2 SDD, 2SSD
- innermost radius 39 mm

% Material Budget

- 1.14% for SPD
- 1.13% for SDD
- 0.83% for SSD

**ITS 2 (2021-2024)**

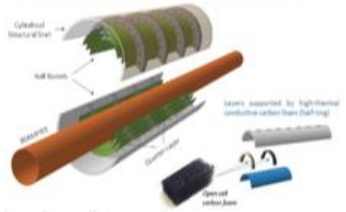


- 7 layers : SPD
- innermost radius 23 mm

% Material Budget

- 0.3% for layers 1-3
- 0.8% for layers 4-7

**ITS 3 (2027-2030)**

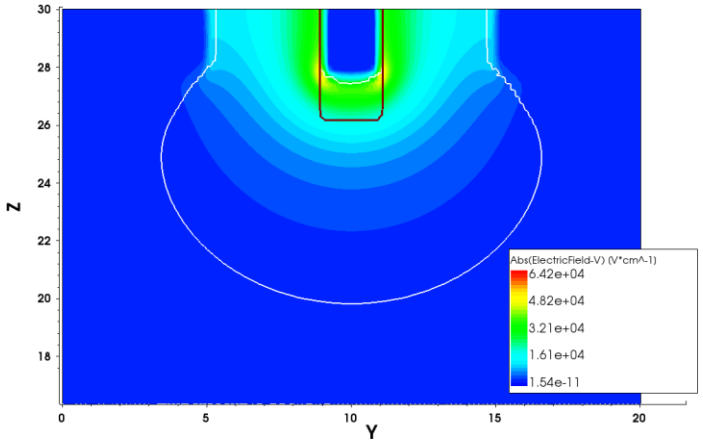


- 3 layers : bend sensors
- 4 layers : SPD remain unchanged
- innermost radius 16 mm

Curved silicon sensor shown in the COE report

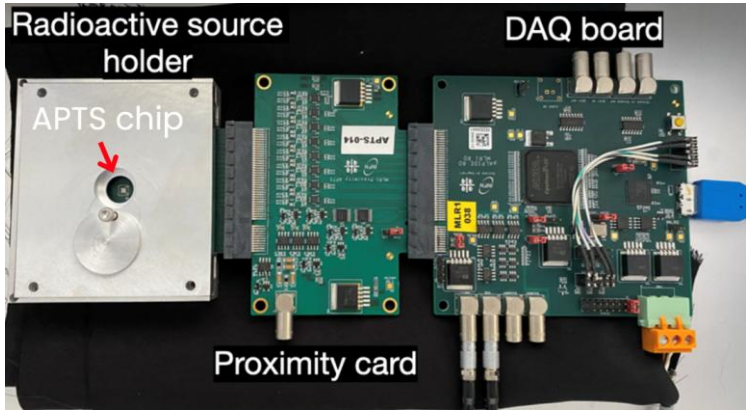
# 4) Silicon Pixel Sensor Research at SUT

## Sensor simulations



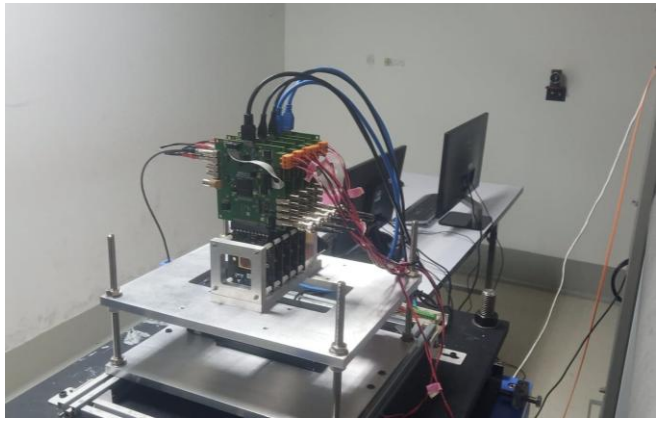

- Electric field and charge transport modeling using TCAD

## Laboratory Testing



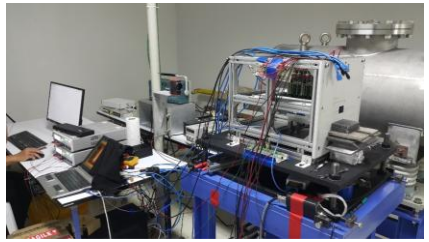

- Check sensor response and electronics readout

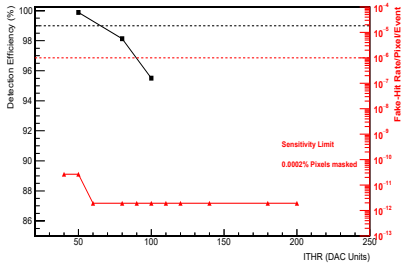
## Beam testing



- Measure response with beam of charged particles
- Hitmaps validation
- Hot and cold pixel detection
- Detection efficiency verification

# Silicon Pixel Sensor Research at SUT





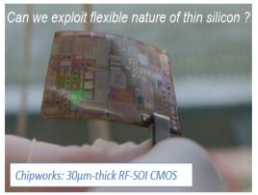

ITS2 Sensor Characterization at SLRI-BTF

ITS3 curved silicon sensors study

ALICE-SUT

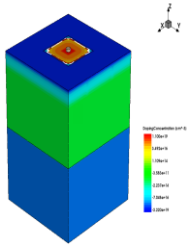
APTS chip Characterization

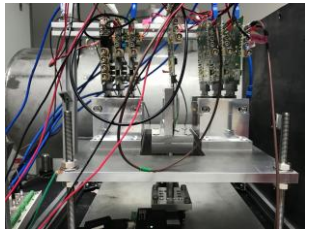
Simulate CMOS pixel sensor with TCAD

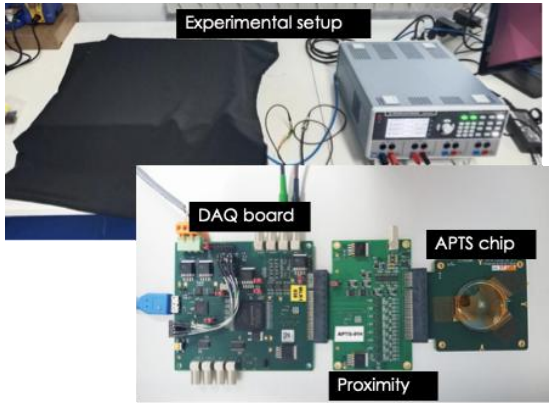




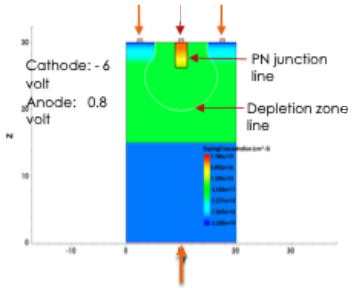


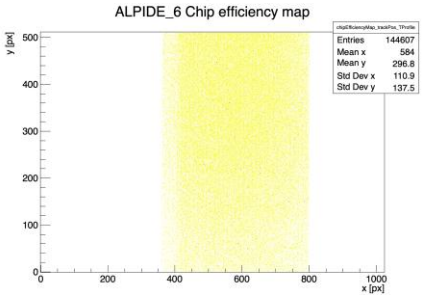






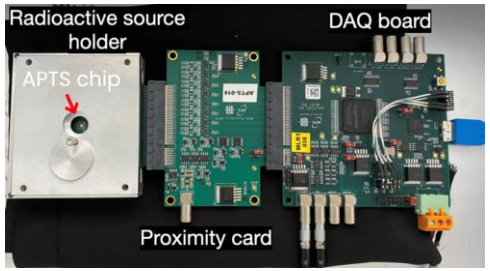


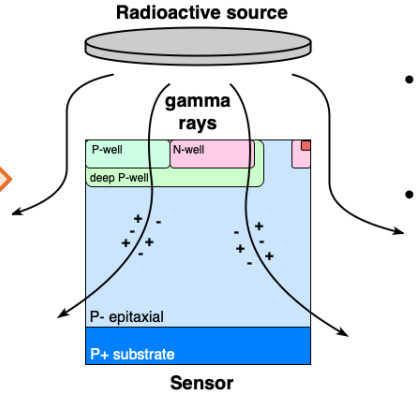



# Sensor characterization

## Single chip tests

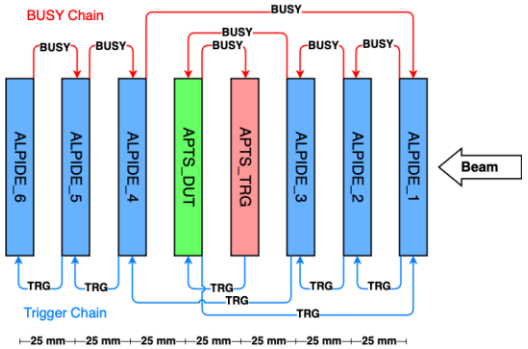



Sensor detects gamma decay from radioactive source

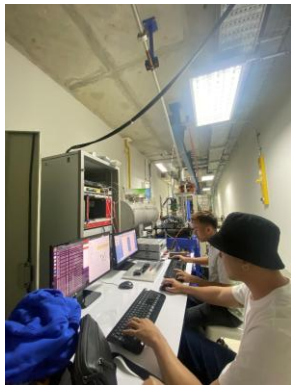



- observe functionality of sensor
- ensure sensor can detects particles

## Beam test

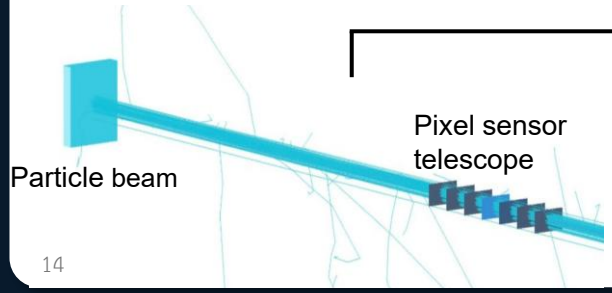



Pixel sensor telescope setup



Sensor characterization by using real particles, measure sensor's efficiency and resolution

## Sensor simulation




Extract position and energy of particle's hit on sensors

↓

Calculate excited electrons and holes

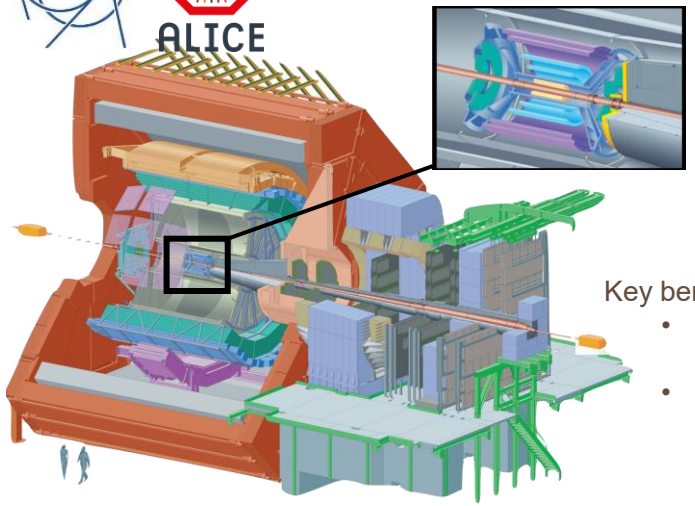
↓

Calculate cluster and hitmap



# ITS23 upgrade project

CERN ALICE

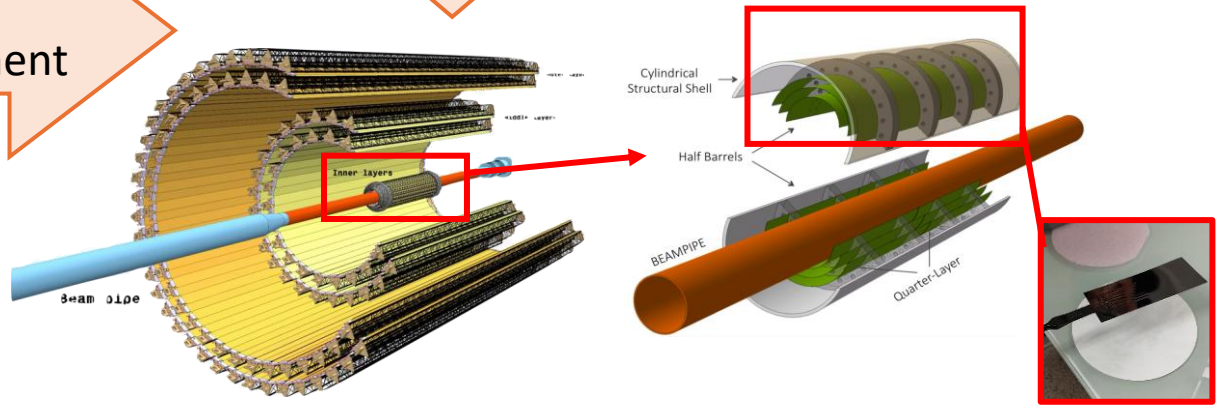


- Heavy particles have a short lifetime before they decay
- ITS aims at identifying decaying particles by measuring their location

Key benefits:

- Extremely low material budget: 0.02 - 0.04% X
- Better tracking performance, especially at low pT

Sensor development

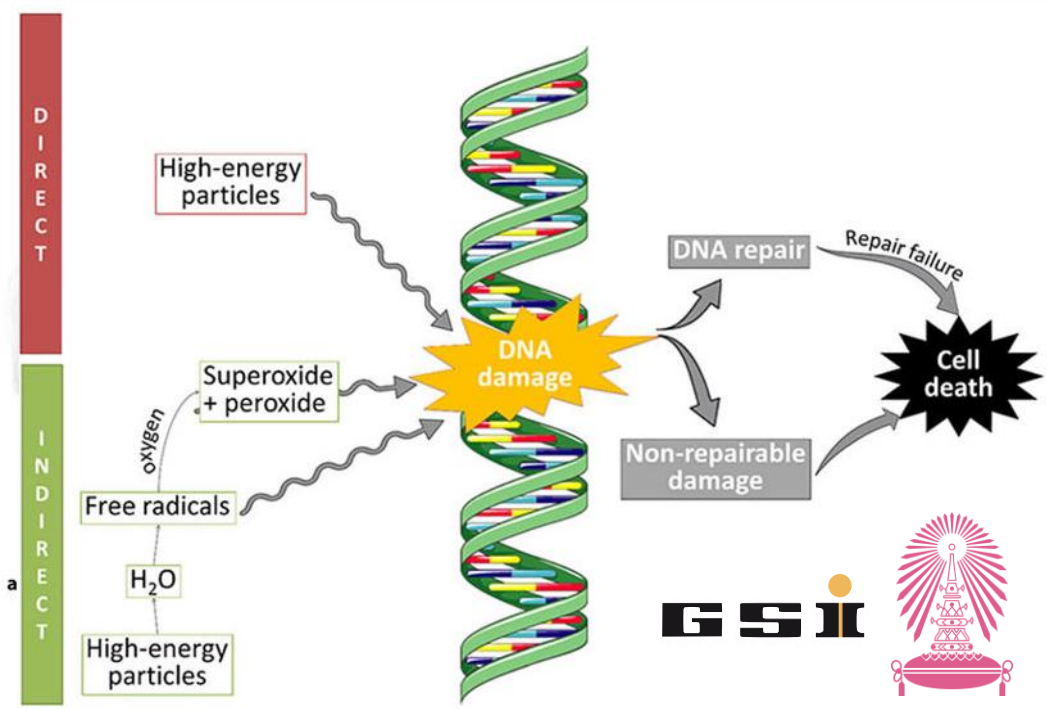



Three inner layers of ITS2 will replace by curve sensor

| | | |
|---|---|---|
| quantify low transverse momentum charmed hadrons | replace new sensors to improve vertexing and tracking performance | achieve interaction readout speeds faster than 50 kHz. |

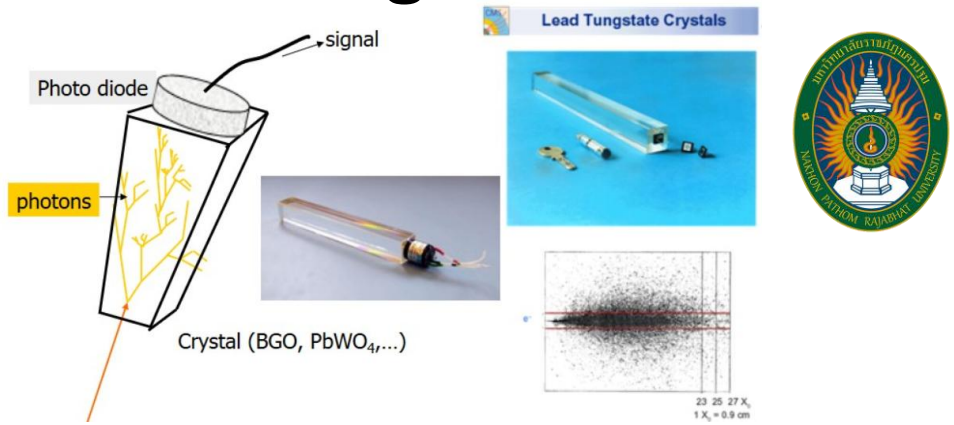
# Comparison between Particle detection and Particle Therapy

## Radiation Therapy

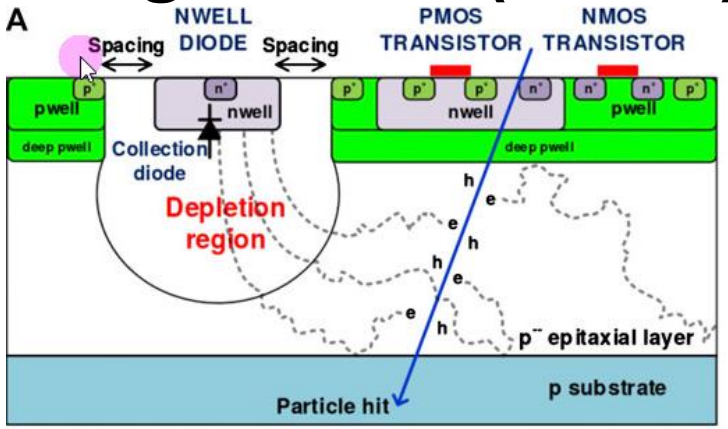



Radiation therapy can directly damage DNA or indirectly damage DNA through the creation of free radicals.
Credit: Adapted from Frontiers in Pharmacology. August 2019.
https://doi.org/10.3389/fphar.2019.00851. CC-BY-4.0
https://www.cancer.gov/news-events/cancer-currents-blog/2021/avasopasem-cancer-radiation-more-effective

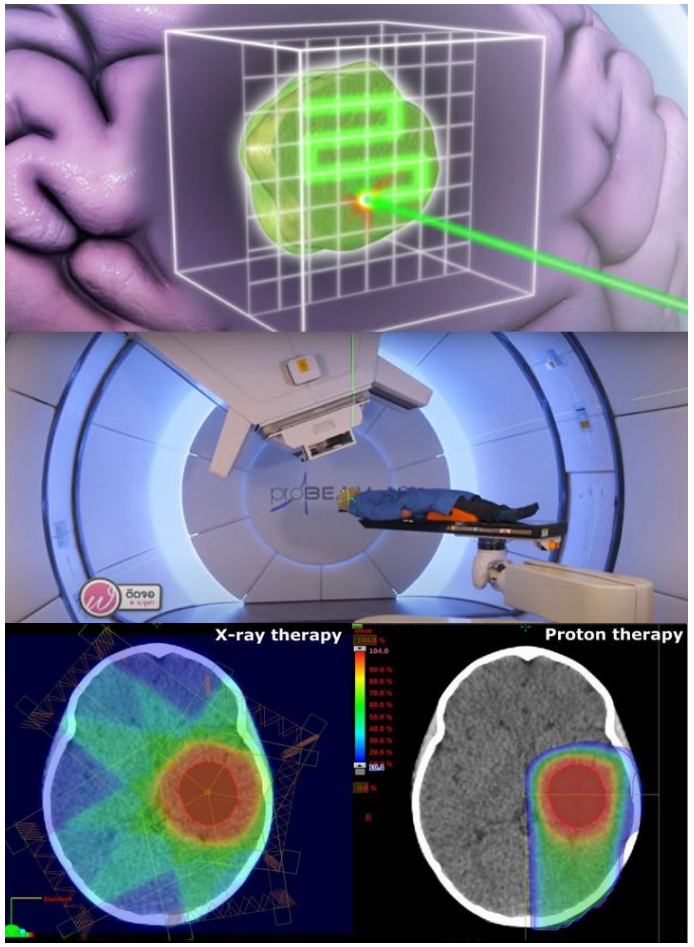
## Scintillating Materials

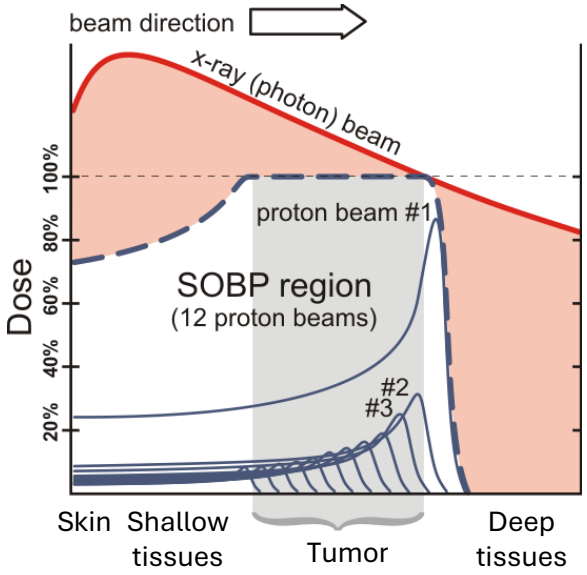


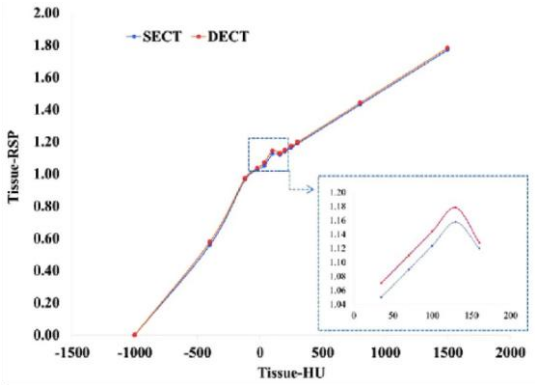

## Image sensor (CMOS)



# 5) Proton Therapy




HU-to-RSP conversion

- Proton therapy exploits the Bragg peak to maximize dose delivery to the tumor while sparing healthy tissue.
- Current treatment planning relies on X-ray CT.
- Conversion from HU to RSP introduces range uncertainties.
- Proton CT (pCT) can directly measure RSP and reduce these uncertainties.

| Diagnosis | Uncertainty |
|---|---|
| 2 – 4 weeks | 3 – 5% |

https://www.chulacancer.net/patient-knowledge-view.php?id=736
10.1016/j.critrevonc.2021.103415
https://doi.org/10.1038/sj.bjc.6602754

# KCMH proton treatment center

varian
A Siemens Healthineers Company

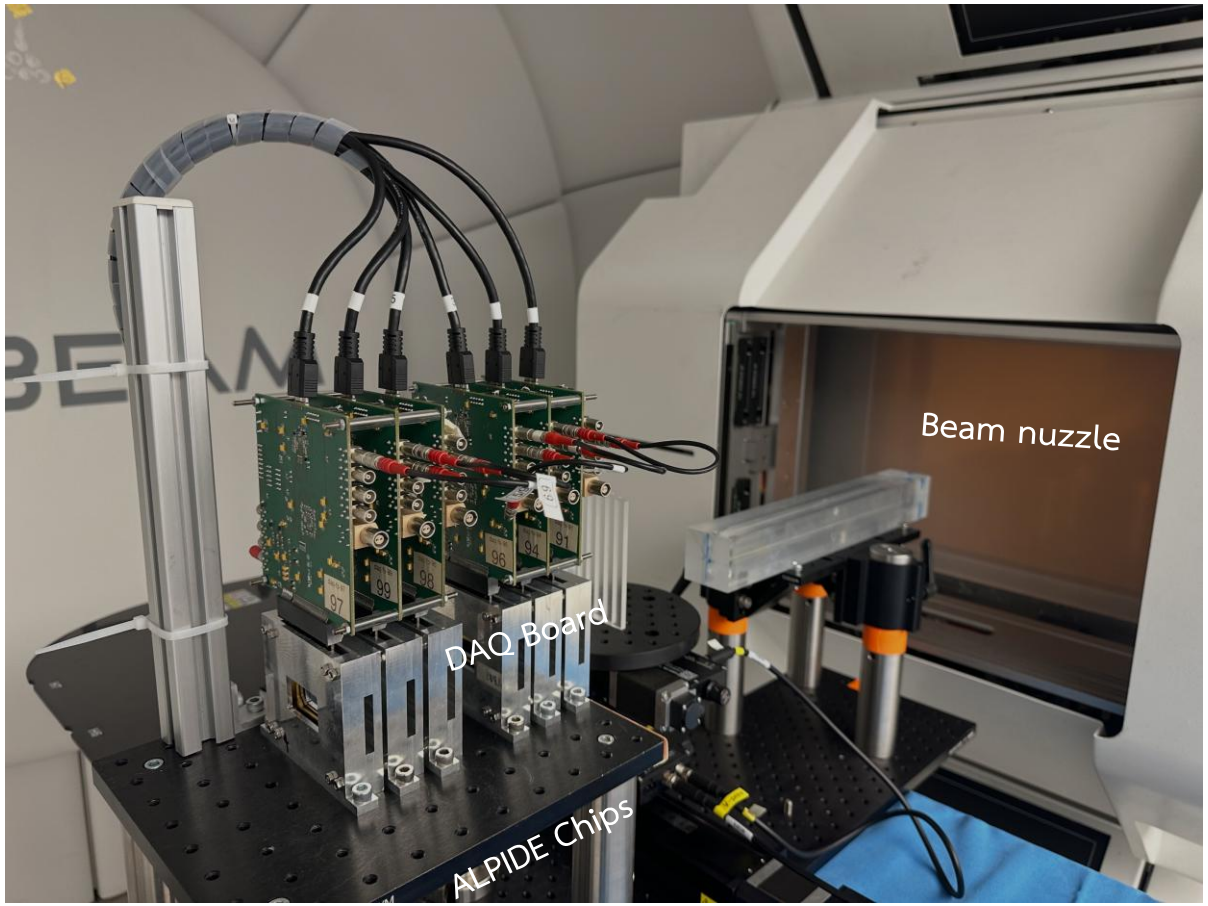
King Chulalongkorn Memorial Hospital
The Thai Red Cross Society

- First proton therapy center in Southeast Asia
- Located at KCMH, Bangkok
- Commissioned in 2019; treating patients since 2020
- Varian cyclotron-based accelerator (70-220 MeV)
- Pencil-beam scanning: 5-7 mm (1$\sigma$)
- Patient treatment and QA operation modes
- SUT-KCMH collaboration on proton therapy research
- NDA with Varian enabling access to selected beam-control electronics




https://www.bangkokbiznews.com/news/royal/1024965

# Proton Computed Tomography (pCT)

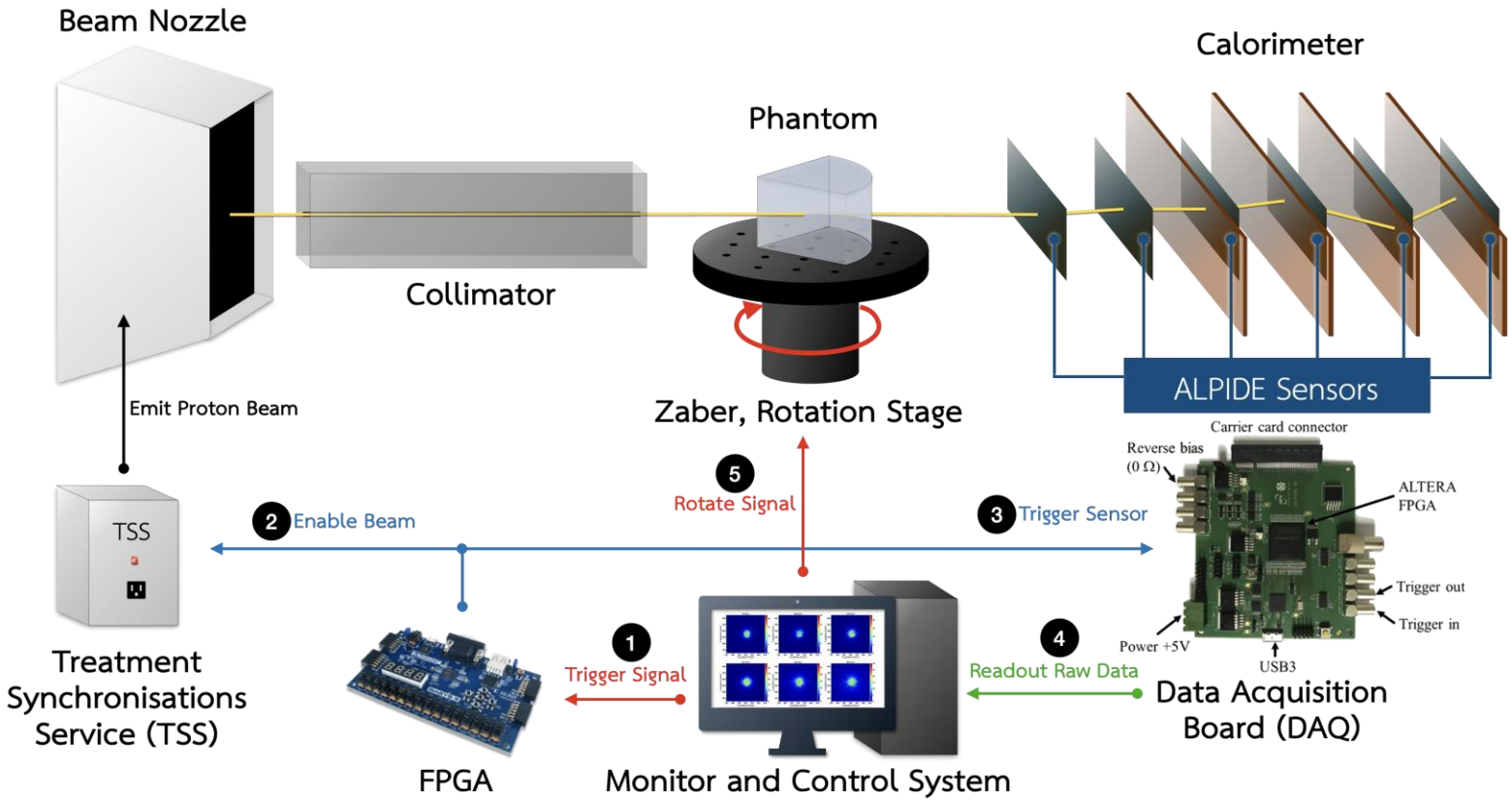



Proton CT directly reconstructs relative stopping power (RSP) images for more accurate proton therapy planning.

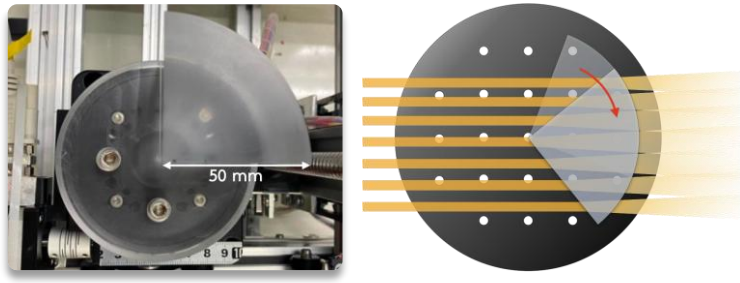
The pCT system employs ALPIDE silicon pixel sensors developed for the ALICE experiment at CERN.

Target Performace: Processing time < 10 minute Uncertainty < 1 %

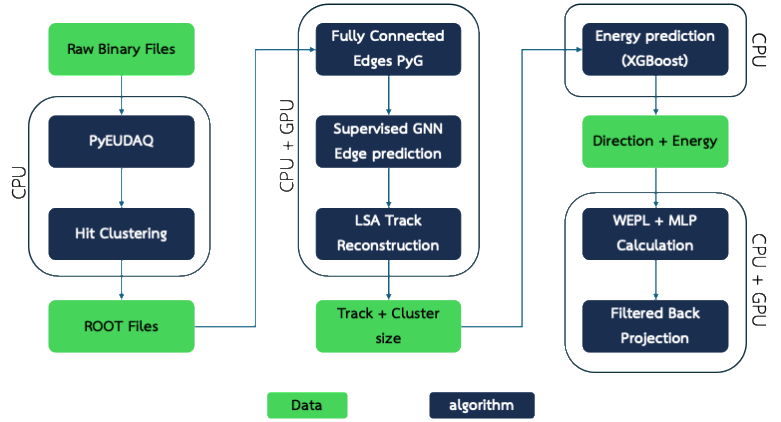
# SUT Prototype (System Components and Operating Principle)




Schematic of the pCT prototype control system: (1) the computer sends a signal to the trigger controller to initiate a measurement cycle; (2) the trigger controller sends an Enable Beam signal to the TSS to activate the proton beam; (3) a Trigger signal is sent to the ALPIDE sensor data acquisition (DAQ) system to begin recording data; (4) raw sensor data are read back to the computer; and (5) once the measurement is complete, the system signals the rotation stage to change the phantom angle before starting the next measurement cycle.




A quarter-cylinder PMMA phantom with a radius of 50 mm is translated transversely to the proton beam using a Zaber stage to scan the full area before being rotated to acquire data at the next angle.




Schematic of the RSP image reconstruction workflow using measurements from the pCT prototype, showing the data types, processing steps, and computing units.

# ALPIDE high-resolution proton sensor




Proton Computed Tomography (pCT)

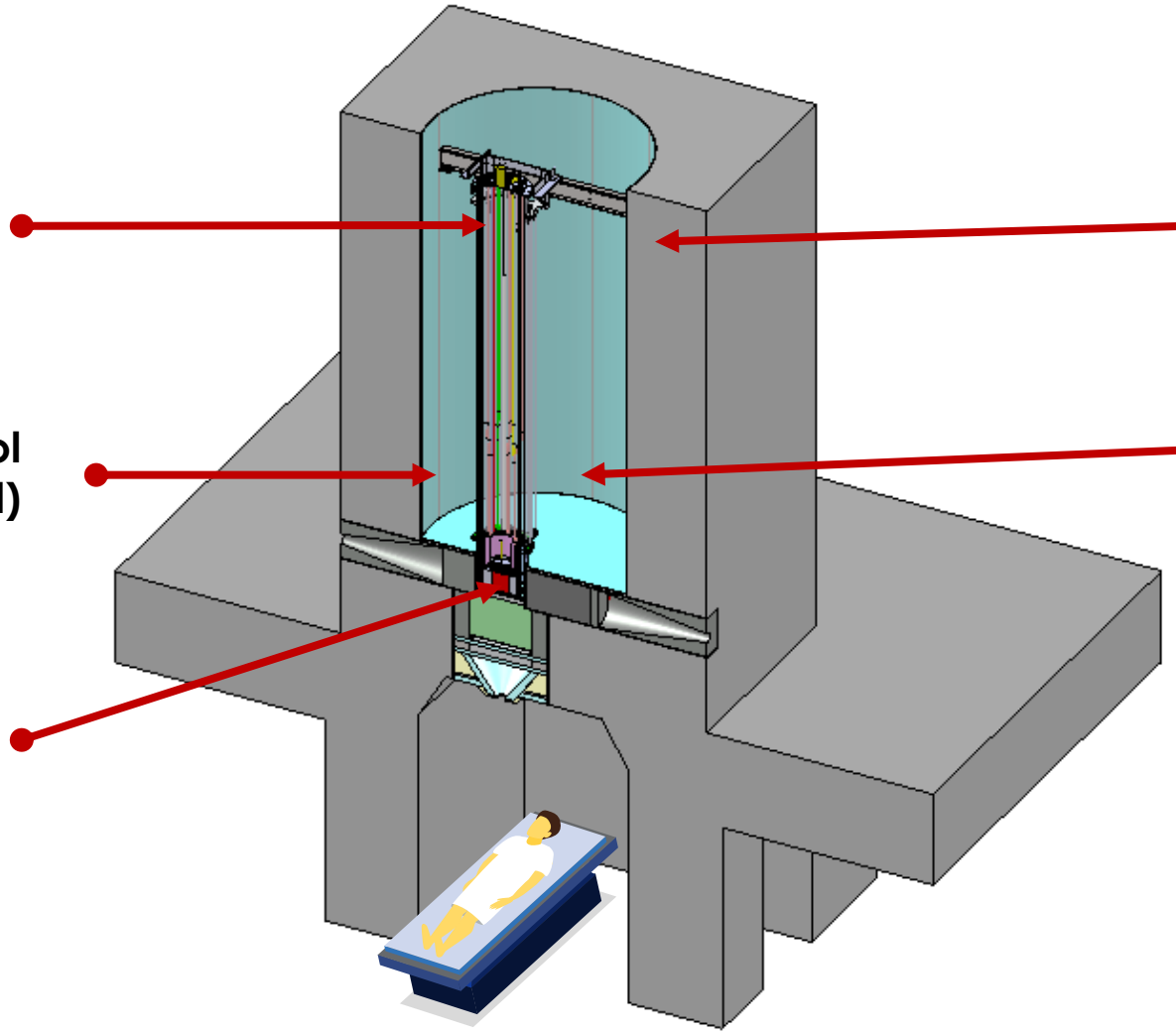
- Direct reconstruction of relative stopping power (RSP) images
- Improves proton range accuracy for proton therapy
- Uses ALPIDE silicon pixel sensors from the ALICE experiment at CERN

ALPIDE performance

- 28 × 28 μm² pixel pitch
- ~5 μm spatial resolution
- > 99% detection efficiency

# 6) Boron neutron capture therapy (BNCT)

**SUT-RR**



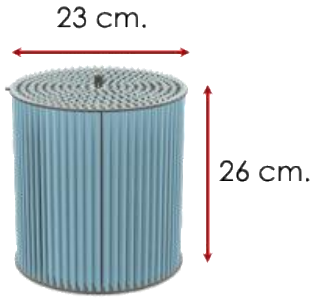
**Aluminum tank (Reactor vessel)**

**Stainless steel pool (Reactor pool)**

**Reactor core**

**Heavy concrete**

**Deionized water**

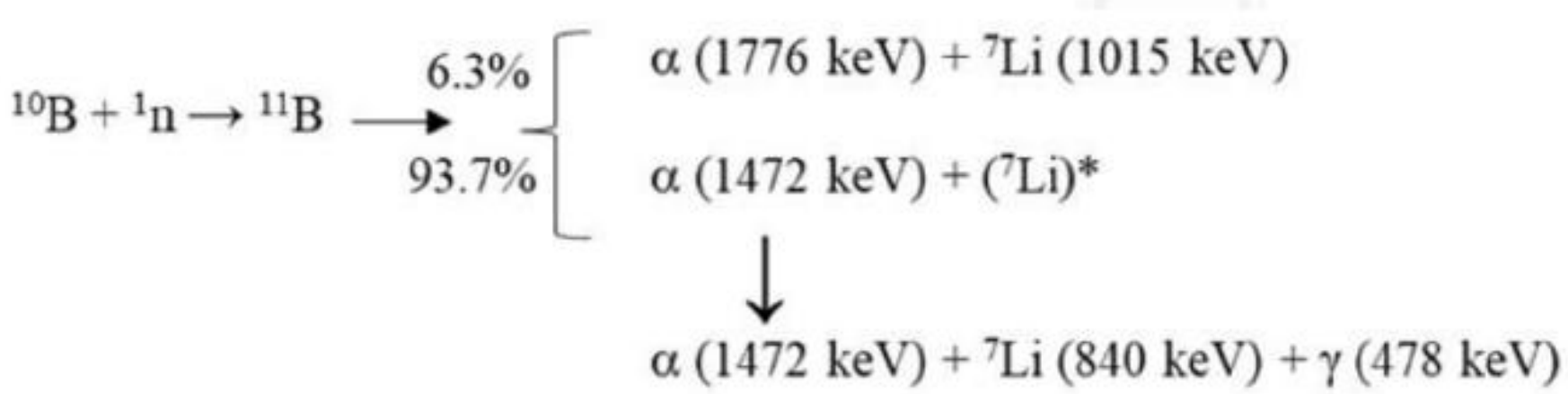



Reactor core

- 45 kW
- Uranium-235 enrichment : 19.75% (LEU), 1.7 kg.
- Use for cancer treatment and research purposes only.

# Principles and Applications of BNCT

The drug containing boron ($^{10}B$) compound is injected into the patient's body by Intravenous infusion method to allow it to accumulate in the cancer cells within the patient's body. Then, a low-energy thermal neutron of about 0.025 eV was irradiated and reacted with $^{10}B$ as in the reaction.

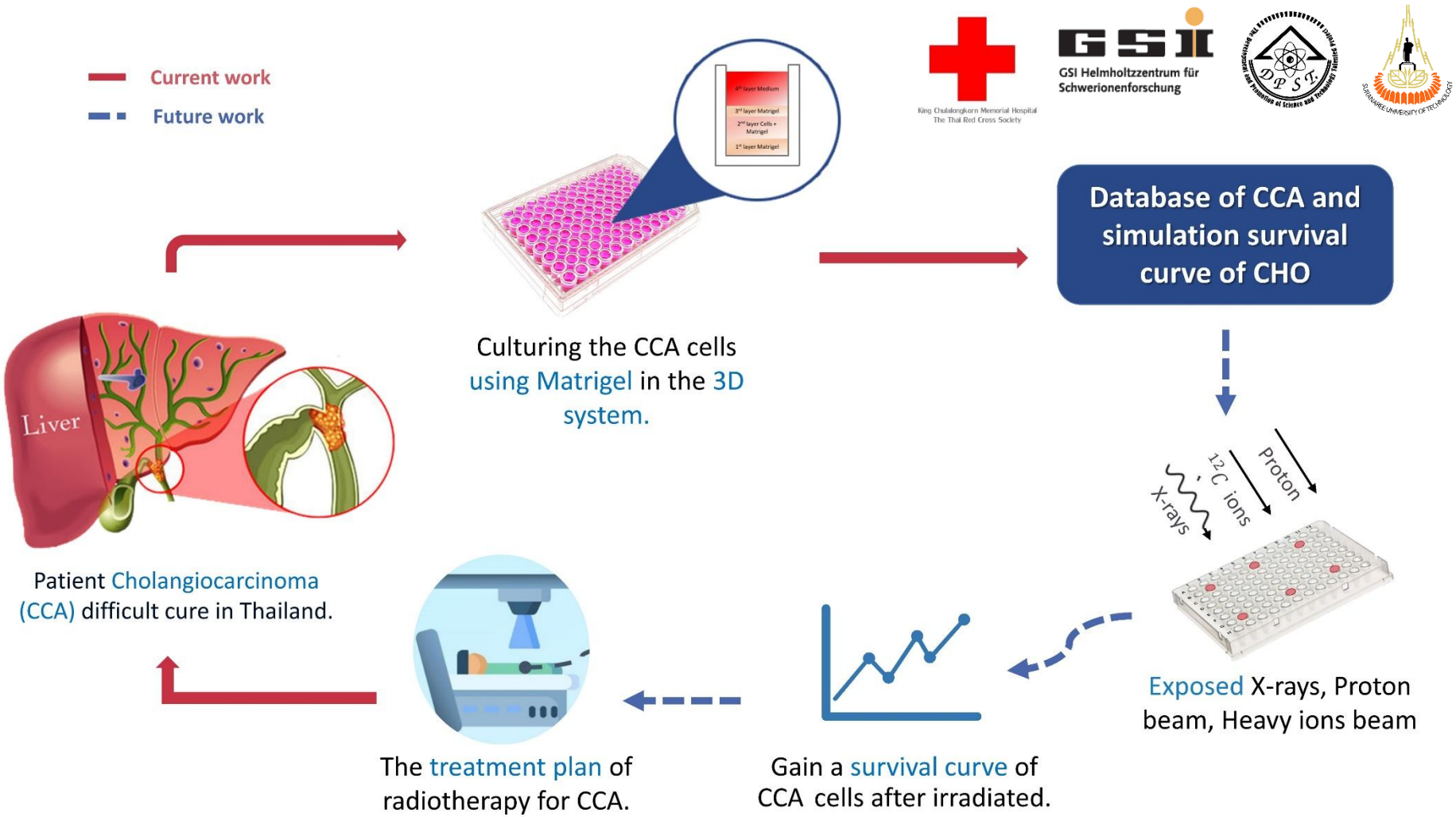



| Range name | Thermal | Epithermal | Fast |
|---|---|---|---|
| Neutron energy | <0.5 eV | 0.5eV–10 keV | > 10 keV |

IAEA BNCT TECDOC 2022

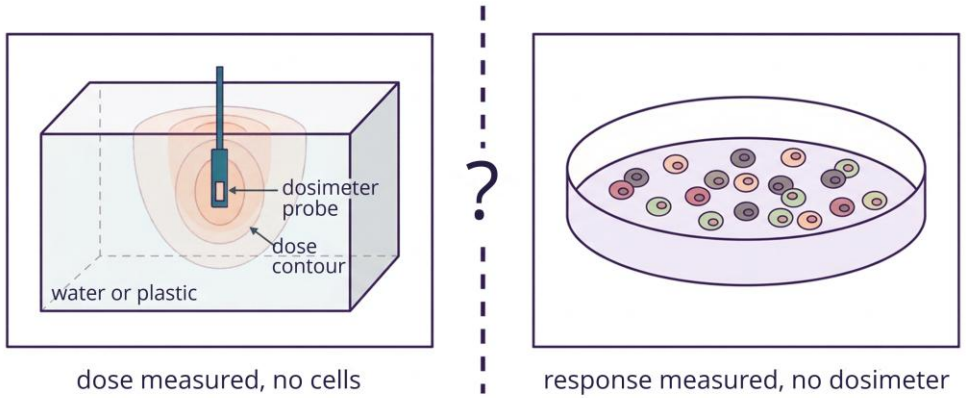
# BNCT for Cholangiocarcinoma (CCA) or bile duct cancer

- To investigate characteristics and behaviours of CCA cell lines in 2D and 3D culture systems.
- To obtain the survival curve of CCA cell lines.



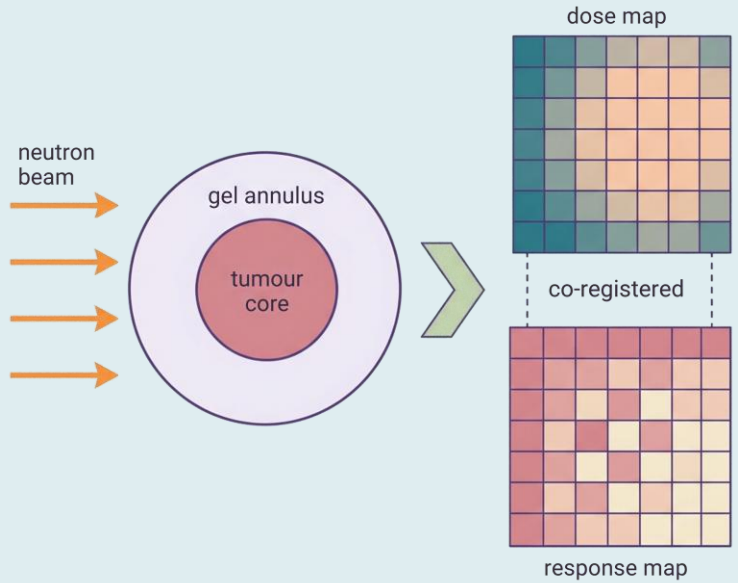
# Spatial Dose Mapping and Radiobiological Assessment of Boron Neutron Capture Therapy (BNCT)

## Two objects, one untested assumption




The dose assigned to a biological experiment is carried across from a different object, measured at a different time, in a different geometry. **In a steeply attenuating, spectrally mixed epithermal beam, that transfer has never been measured.**

## One specimen, one geometry, one exposure




co-registered pixel by pixel - one absorbed dose, one measured response

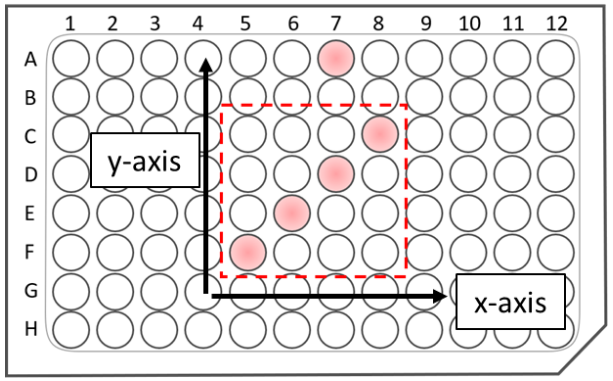
The gel sits beside - then inside - a living, geometrically defined 3D construct, and is irradiated **in the same shot**.

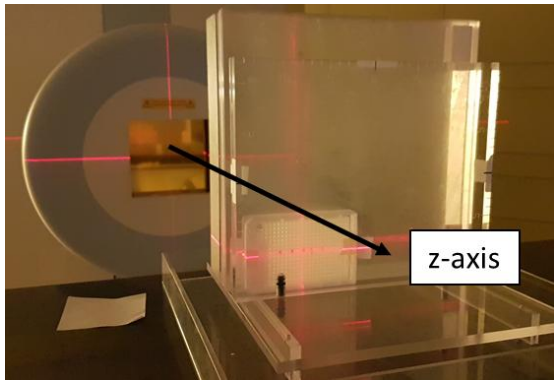
**Preclinical BNCT dose** reporting stops depending **on a phantom that contains no cells.**

Tumor and normal compartments compared at the **same measured absorbed dose, in one specimen**.

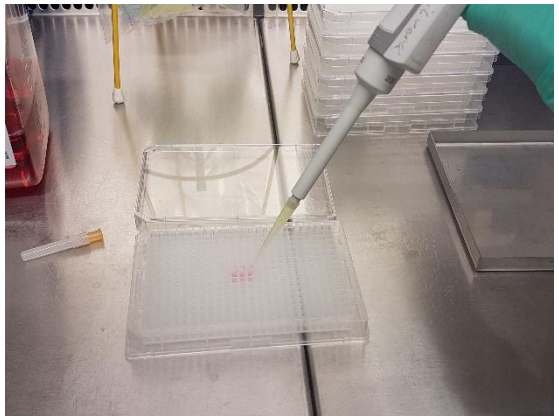
Once the unloaded field is calibrated, any carrier can be scored against the same baseline.

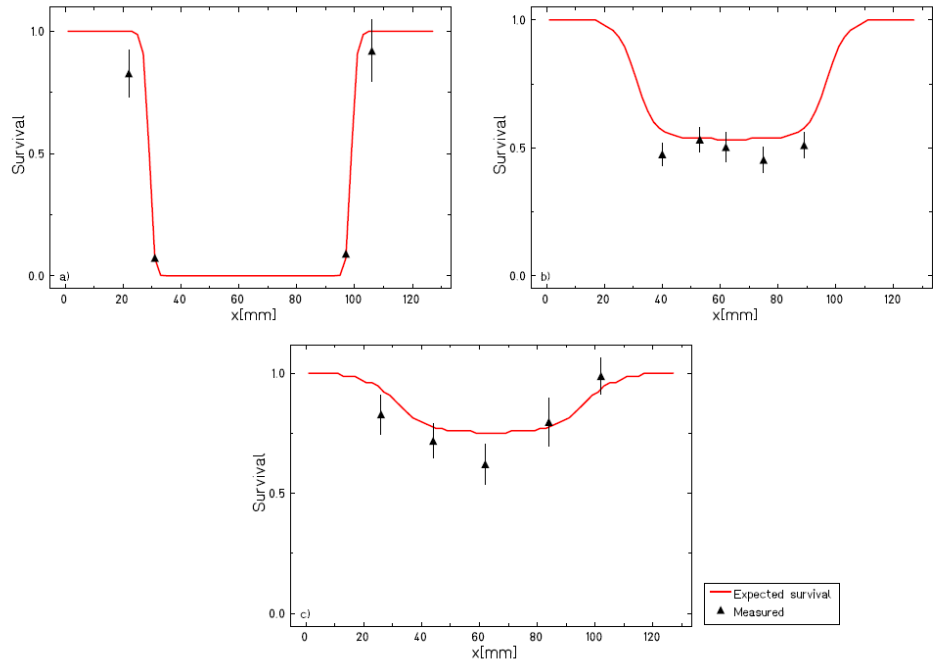
# 7) Radiobiology: Benchmarking with Carbon Ion beams




Growing cells **in Matrigel** inside micro-well plate and measuring cell response to **radiation in 3D**



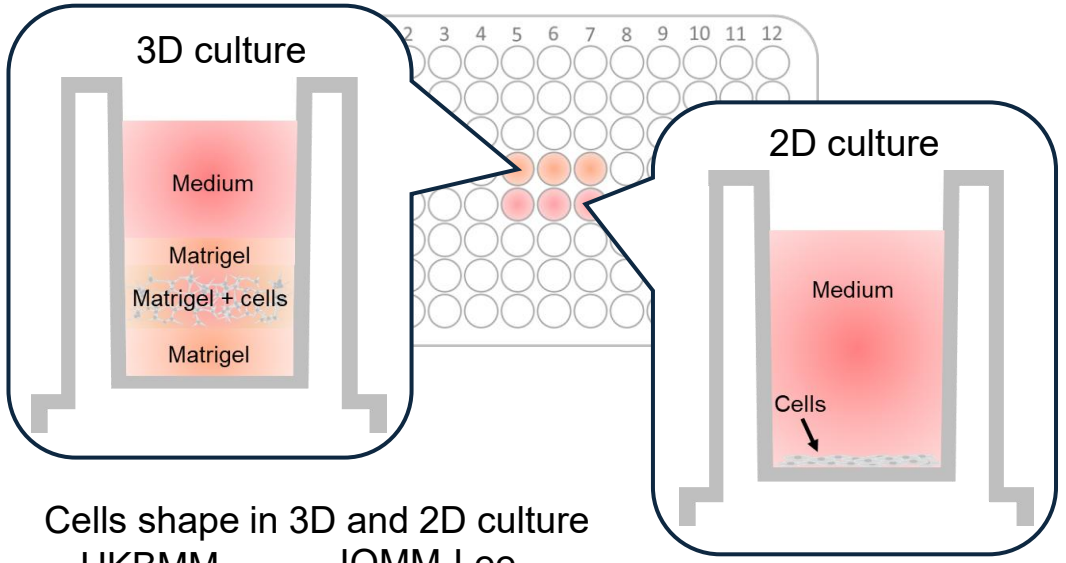



Biological verification of **carbon ion irradiation** plan outside the target field utilizing refined 3D bio-phantom

# Benchmarking with x-ray and proton beams

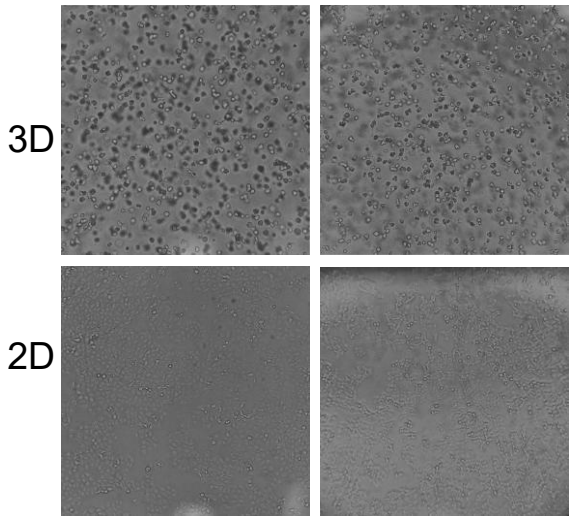
## Sample preparation

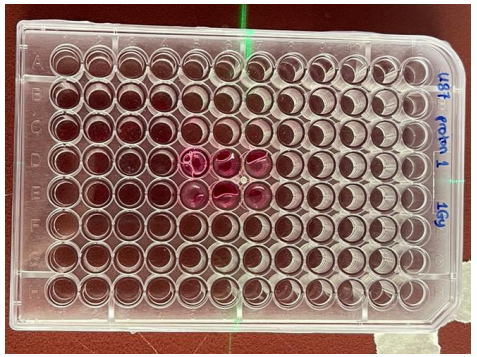
1




Cells shape in 3D and 2D culture

HKBMM IOMM-Lee



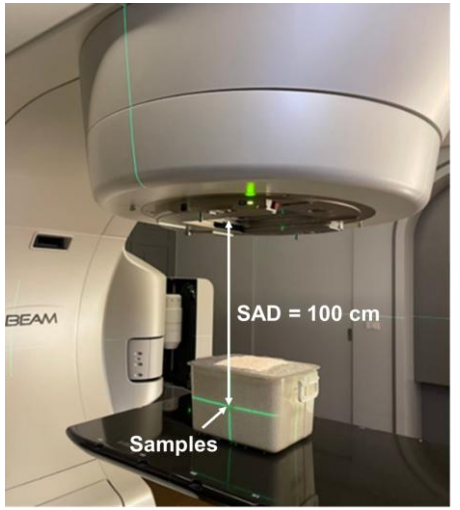



## Irradiation setup

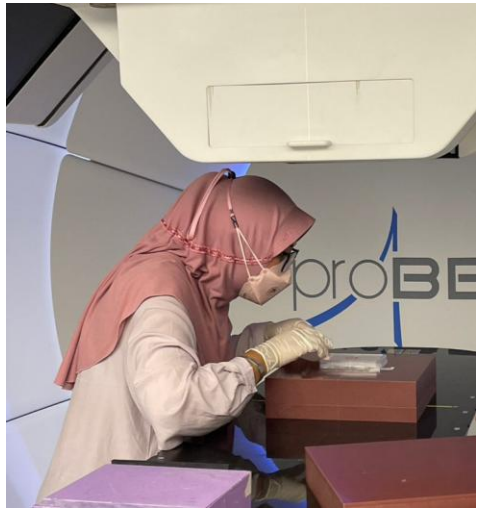
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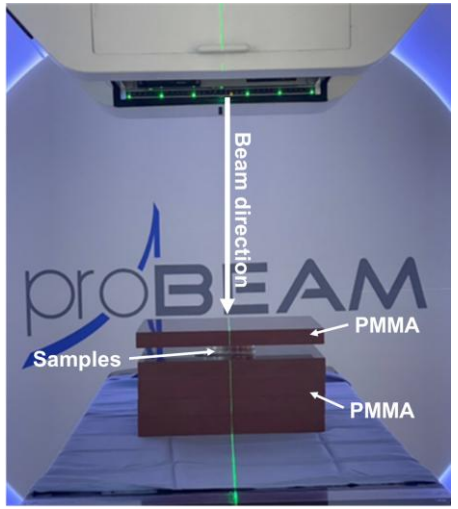
X-ray irradiation





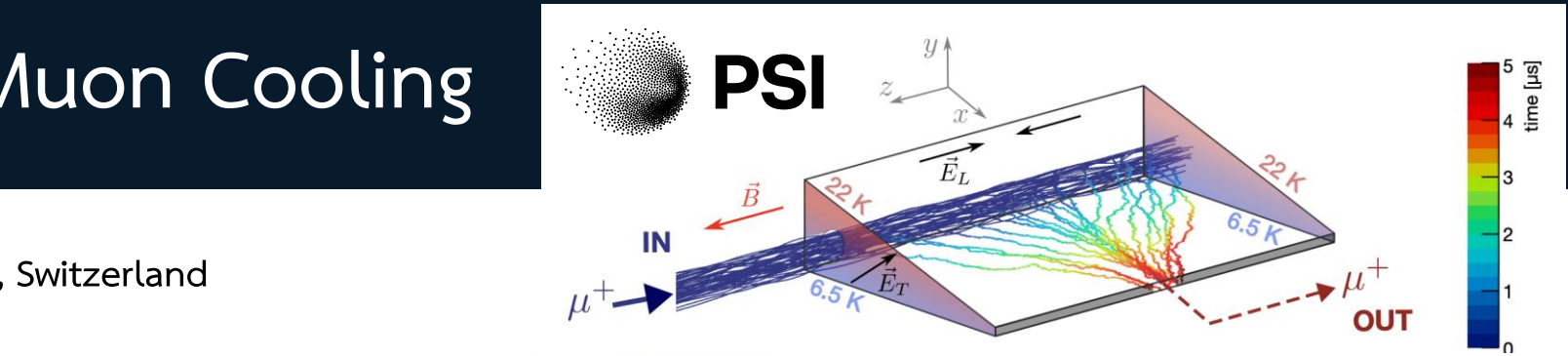

Proton irradiation

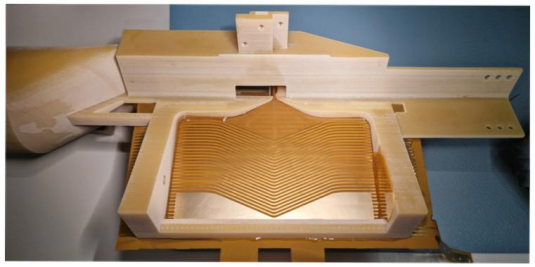




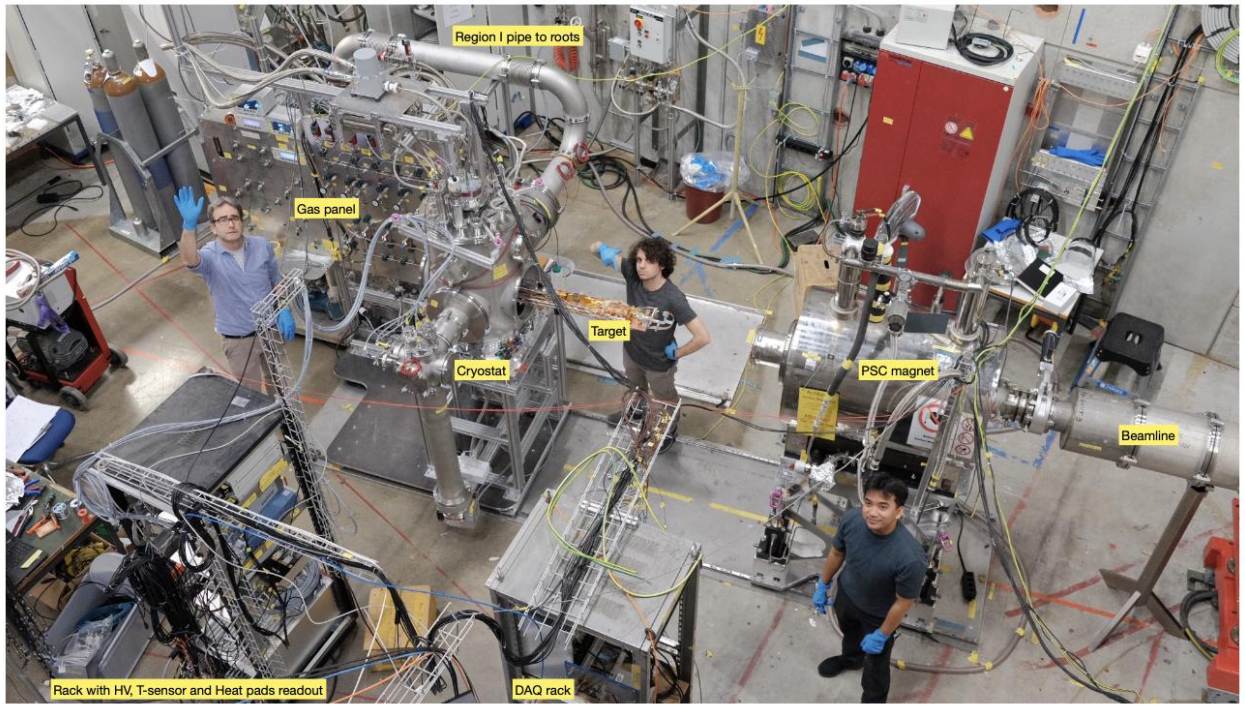
# 8) Future Research: Muon Cooling

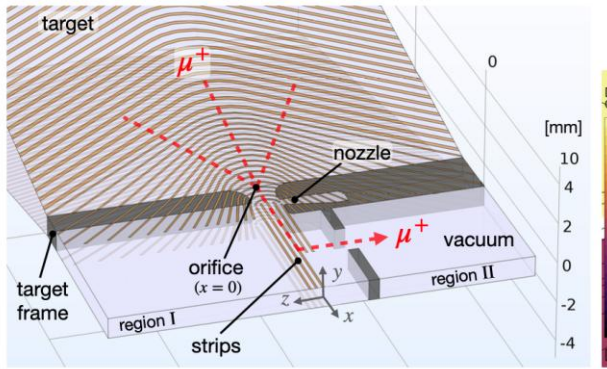
- Collaboration with Paul Scherrer Institute (PSI), Switzerland
- Develop high phase-space muon beamline
- Design the experiment setup by using Geant4 (G4Beamline) and CAD
- Design gas flow and vacuum systems by using ANSYS program
- Design electrodes and magnetic field configuration
- Design a new muon entrance detector

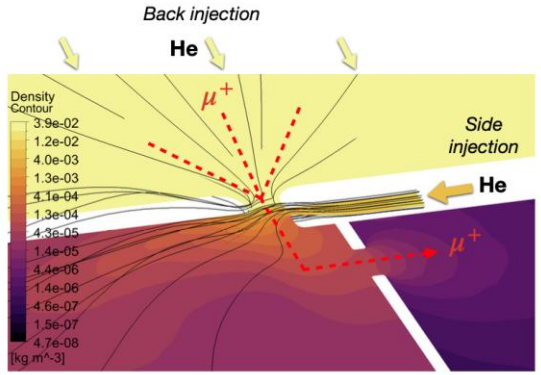


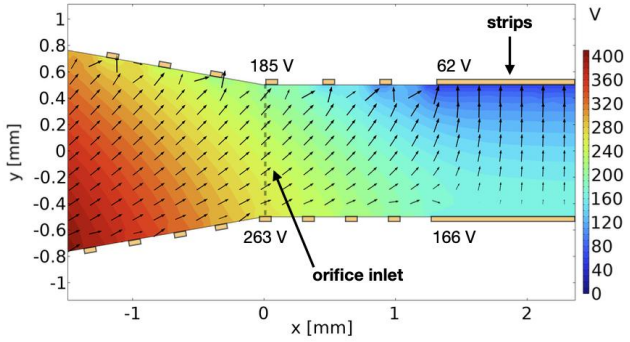



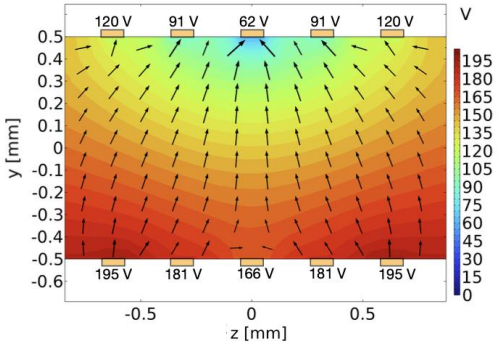




# Conclusions

**01** **International collaboration built SUT's research foundation**

Royal support and global partnerships have strengthened expertise in particle physics and detector technology.

**02** **Detector expertise is driving proton imaging innovation**

ALPIDE-based proton CT has been successfully validated with the clinical proton beam at KCMH.

**03** **SUT-RR enables future BNCT research**

New opportunities in dosimetry, radiobiology, and neutron-shielding studies.

**04** **Radiobiology studies support advanced particle therapy**

Comparative studies with X-ray, proton, and carbon-ion beams are ongoing.

# THANK YOU!

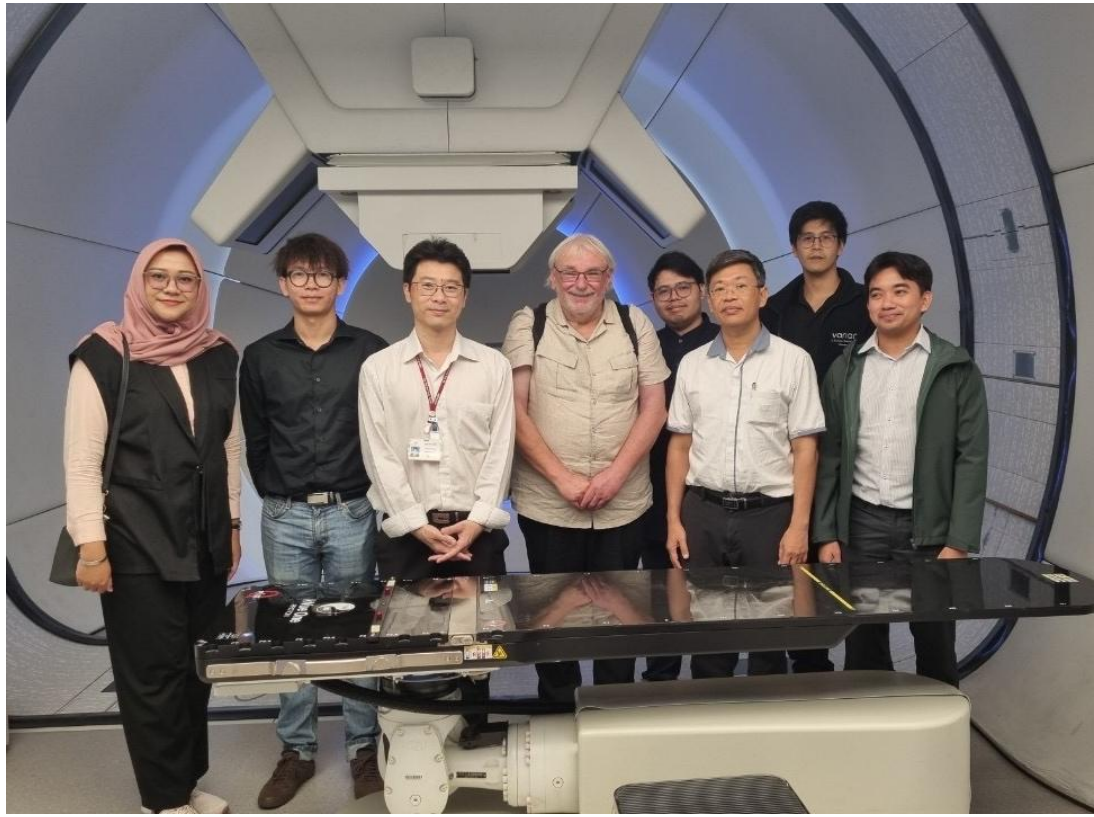



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从粒子到患者：基础研究驱动医学创新。