31st International Seminar on Interaction of Neutrons with Nuclei(ISINN-31)

Development Status of the neutron detectors for instruments at China Spallation Neutron Source

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China Spallation Neutron Source, IHEP, CAS

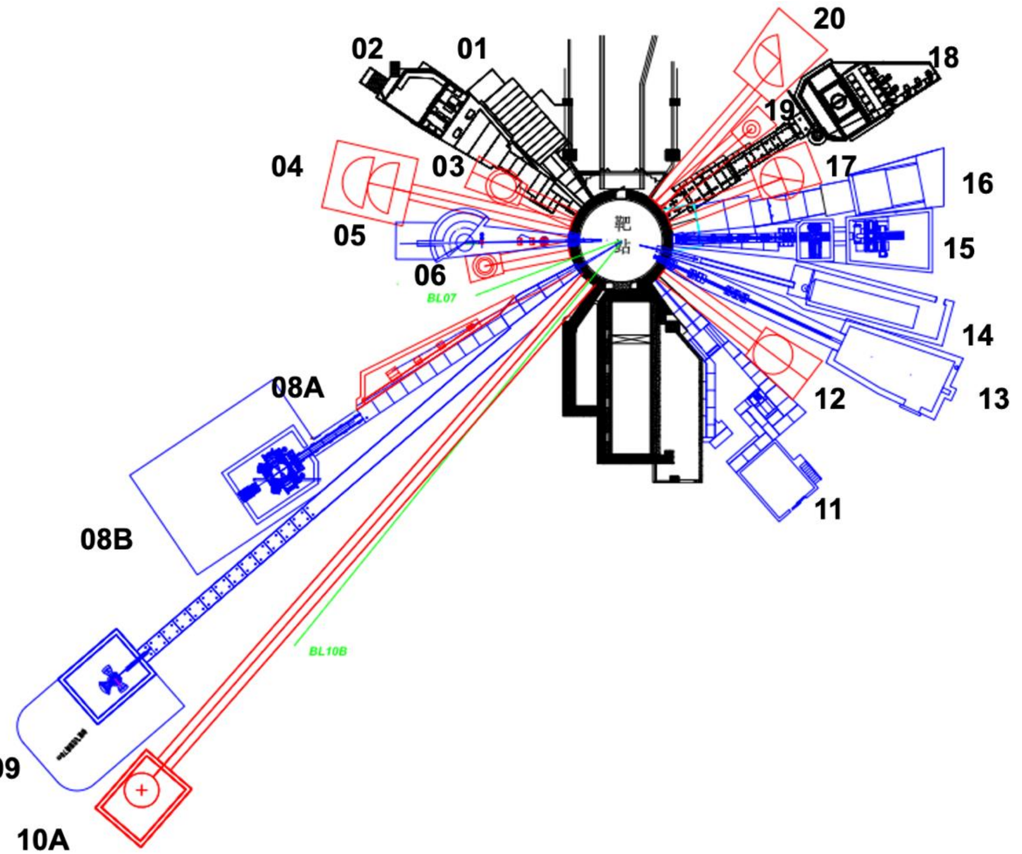
May 29 2025, Dongguan

Contents

Outline

Introduction to the group

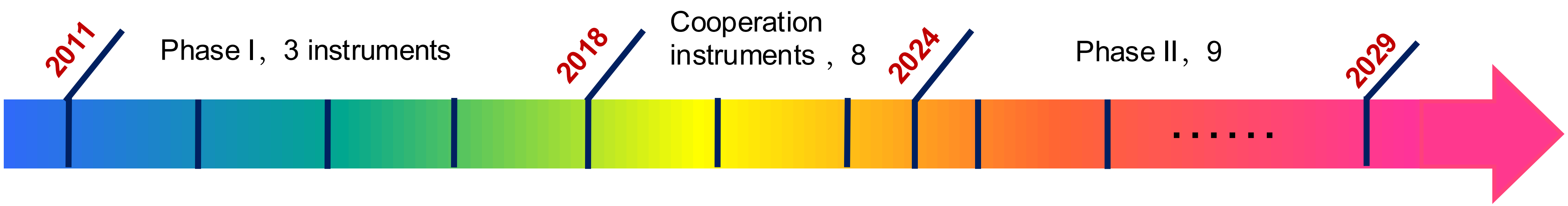
- **Mission:**
  - **Focusing on the requirements of the CSNS neutron Instruments**
  - **Developing advanced neutron detection system**



- **Composition:**
  - **Professors: 3, Senior Researchers: 11**
  - **Total Number of Members: 40+**
  - **Expertise: Detection Physics , Electronics, Data Acquisition, Mechanics, and Engineering Processes**
  - **Average Age: ~36 years old**

Roadmap

Develop detectors "family" for neutron instruments at CSNS



Detector

- **Neutron Scattering experiments**
  - Diffraction, Inelastic; Large area coverage ($>1m^2$， Res ~cm) → ^{3}He tube array detector; Scintillation detector
  - SANS, Reflection; High spatial resolution ($<1m^2$, Res ~ mm) → GEM neutron detector; Beam monitor
- **Neutron imaging experiments**
  - Large FOV or High spatial resolution (20cm*20cm, Res ~ μm) → Scintillator coupled with CCD camera
  - Timing resolution for energy resolution (Timing Res ~1μs, Res ~10 μm) → nMCP detector; Scintillator coupled with TPXCamera

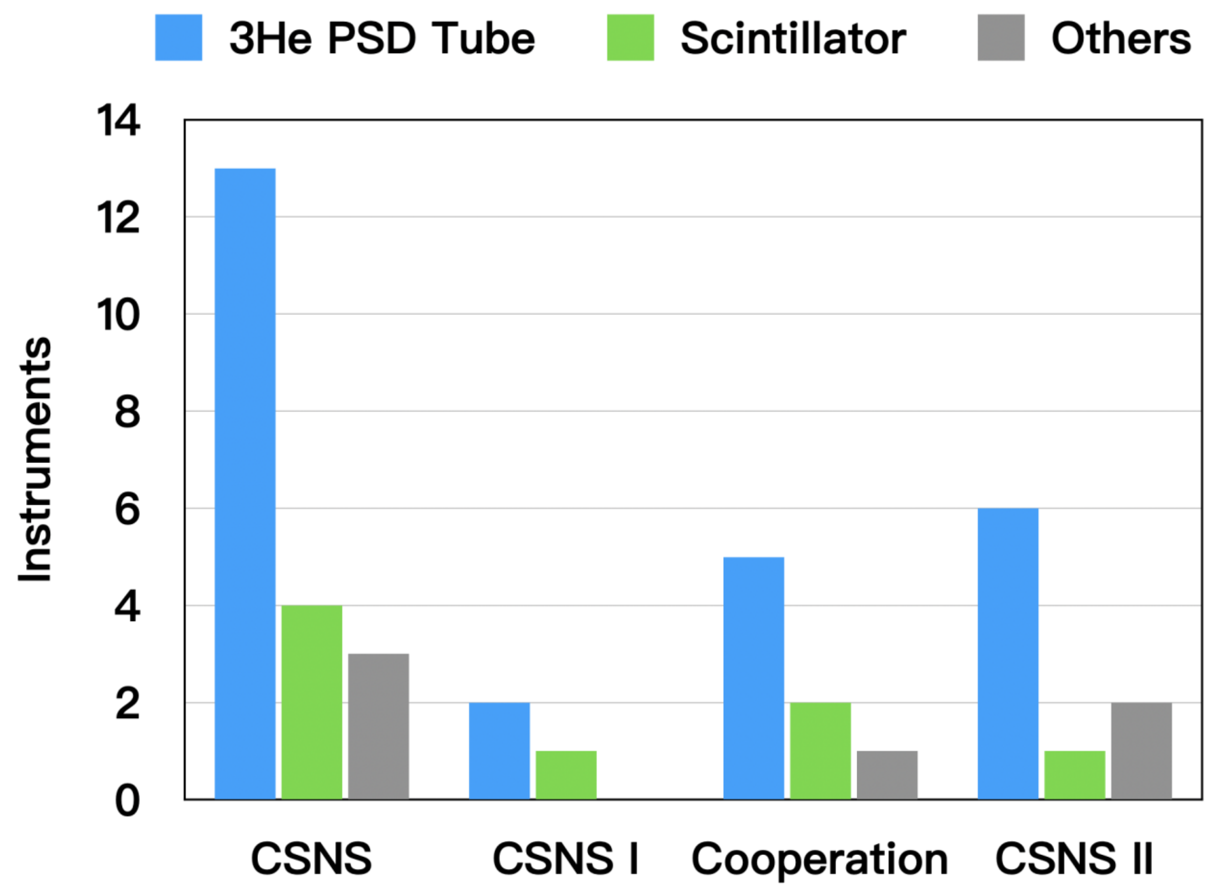
Detector status of instruments

NO.	Instrument	Detector Type	Detection Area	Technical specifications	Installation	Status
1	GPPD (BL18)	Scintillator	6 m^2	Eff. ≥40% @ 2Å, Res. ≤4mm×4mm	2017	Running
2	SANS (BL01)	^{3}He LPSD	1 m^2	Eff. ≥80% @ 2Å, Res. ≤8mm	2017	
3	MR (BL02)	^{3}He MWPC	0.2 m×0.2 m	Eff.≥60% @2Å, Res. ≤ 2mm×2mm	2017	
4	MPI (BL16)	^{3}He LPSD	3 m^2	Eff.≥90% @ 2Å, Res. ≤ 10mm	2020	
5	ERNI (BL13)	Scintillator	4 m^2	Eff. ≥40% @ 1Å, Res. ≤ 3mm×50mm, CCD 6.6μm-200μm	2023	
6	VSANS (BL14)	^{3}He LPSD	3.6 m^2	Eff. ≥80% @ 2Å, Res. ≤8mm	2023	
7	ANIS (BL11)	GEM, Ion. Chamber	0.1m×0.1mm	Eff. ~10^{-4}@1.0 MeV, Res. ≤ 5 mm	2022	Commissioning
8	EMD (BL08)	Scintillator	3m^2	Eff. ≥40% @ 1Å, Res. ≤ 3mm×180mm	2022	
9	HD (BL05)	^{3}He LPSD	20 m^2	Eff. ≥90% @ 2Å, Res. ≤25mm	2022	
10	HPND (BL15)	^{3}He LPSD Scintillator	5.7 m^2 1.75m^2	^{3}He Tube: Eff. ≥80% @ 2Å, Res. ≤8mm Sci.: Eff. ≥40% @ 2Å, Res. ≤4mm×4mm	2024	
11	HRD (BL09)	^{3}He LPSD	8.77 m^2	Eff. ≥80% @ 2Å, Res. ≤8mm	2024	
12	NTDS (BL08A)	^{3}He LPSD	0.03m×0.3m	Eff. ≥80% @ 2Å, Res. ≤ 8mm	2025	CSNS-II
13	NPAI (BL12)	HPGe, Si	TBD	Energy Res. ≤0.5%	2026	
14	IMVS (BL06)	^{3}He LPSD	0.36 m^2	Eff. ≥80% @ 2Å, Res. ≤ 8mm	2026	
15	NUBS (BL10)	^{3}He LPSD	0.44 m^2	Eff. ≥85% @ 6.3Å, Res. ≤12 mm	2026	
16	EDS (BL17)	Scintillator	12m^2	Eff. ≥60% @ 2Å, Res. ≤ 3.5mm×7mm	2026	
17	CNIS (BL04)	^{3}He LPSD	15.2 m^2	Eff. ≥80% @ 2Å, Res. ≤25mm	2027	
18	PACS (BL20)	^{3}He LPSD	12.2 m^2	Eff. ≥80% @ 2Å, Res. ≤25mm	2027	
19	SCND (BL19)	Scintillator	1.2 m^2	Eff. ≥40% @ 2Å, Res. ≤1mm×1mm	2027	
20	LNR (BL03)	GEM	0.6m×1m	Eff. ≥80% @ 2Å, Res. ≤ 2mm×2mm	2028	

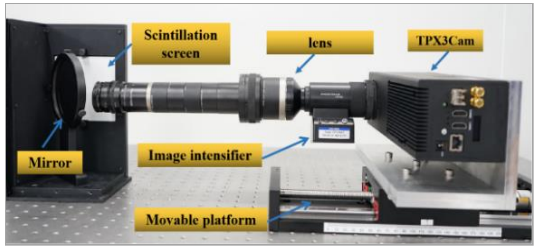
Contents

Outline

Detector requirements for instruments at CSNS



- The **present engineering approach** is based on the technology developed over the past 5-10 years.
- The **ongoing research** aims to provide the solution for the neutron instruments in the future.

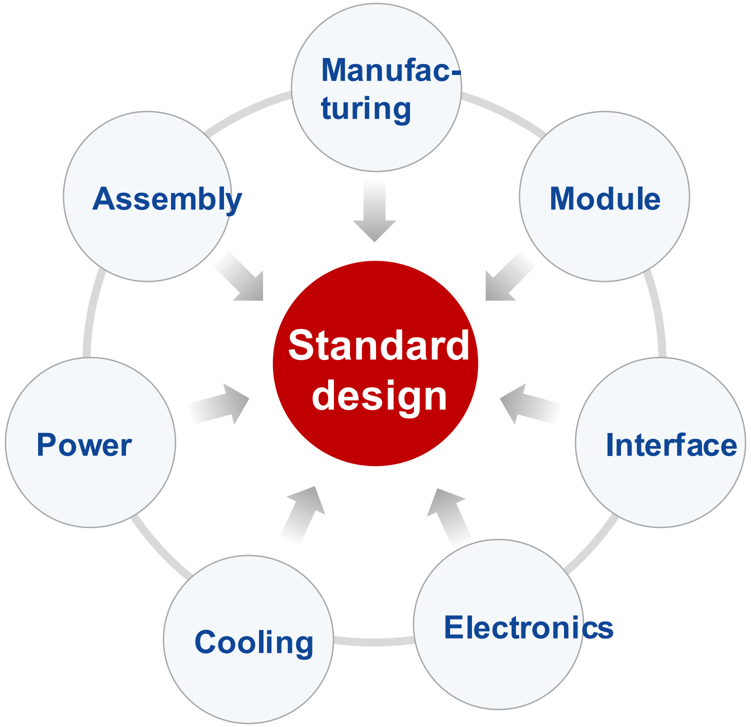


Large-Area ^{3}He Tube Array Detector - Standardization

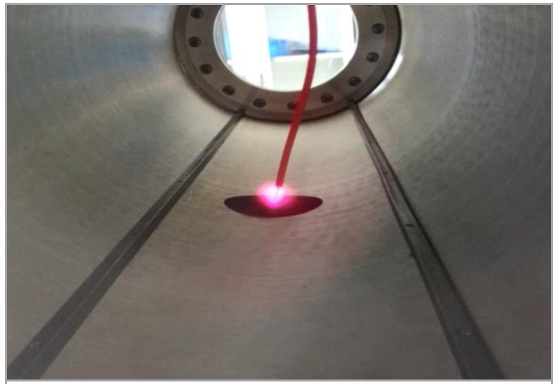
A continuously optimized and Standardized Engineering Design

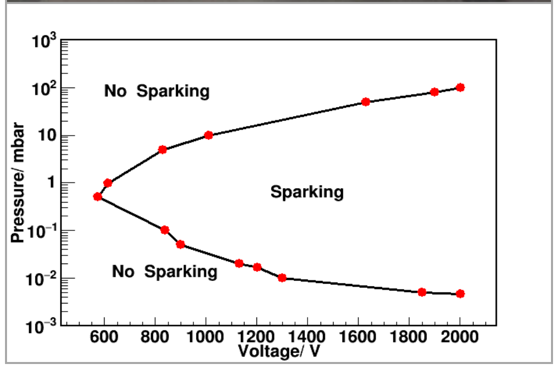
- Three technical solutions for atmosphere, high vacuum (~10^{-4}Pa) and low vacuum(~10Pa)
- Solve vacuum discharge, electronics cooling, space limitation, system noise and channel consistency.

Standardized Engineering Design



HV Discharge in vacuum





Continuously upgrade solutions

- Module design with 8 or 16 tubes
- Key component from multiple supply, avoiding single source dependency.
- FEE close to detector to reduce noise
- Optical fiber connections between devices to prevent electromagnetic interference.
- Improve stability and real-time monitoring

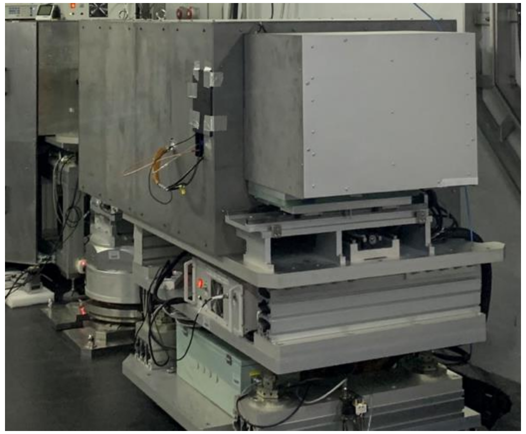
Large-Area ^{3}He Tube Array Detector

- **Totally 7 instruments with 3300 tubes**

SANS(~10Pa) @ 2018

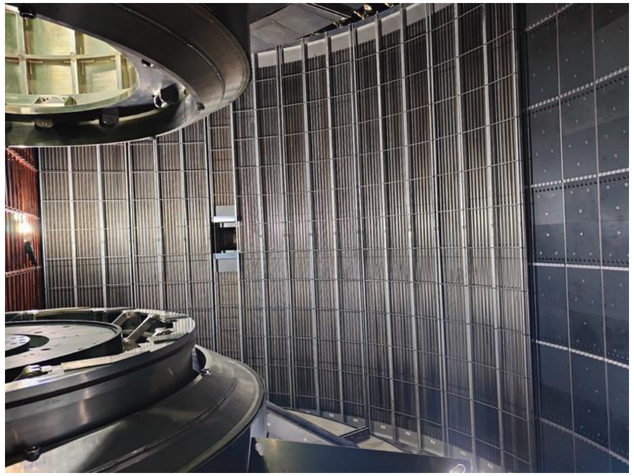
VSANS (~10Pa) @ 2023

MR (air) @ 2018

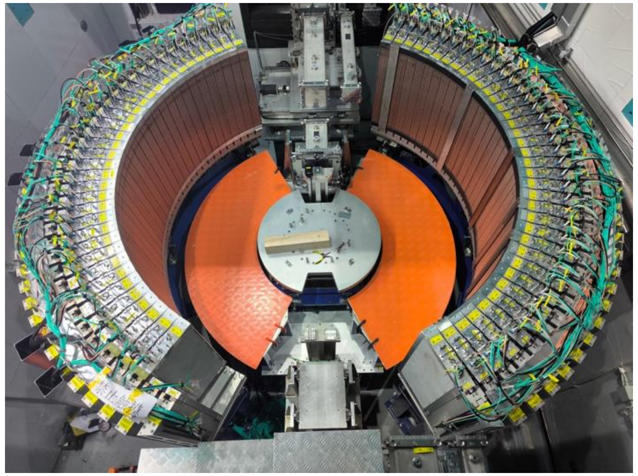


MPI (air) @ 2021

HD (~10^{-4}Pa) @ 2023



HP (air) @ 2024



HRD (air) @ 2024

Large-Area Scintillator Detector

Module design: front-end digital for fast readout, highly integration and easy assembly

2010~2018

First-generation

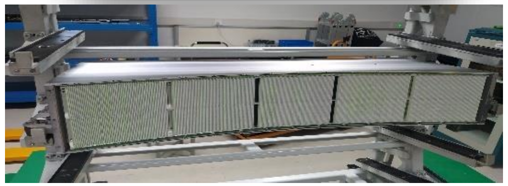
- **0-> 1 Breakthrough**
- **laboratory-level to engineering-level products**

- **Engineering application: GPPD spectrometer 6m^2 space coverage**

2018~2023

Second -generation

- **Performance further improved**
- **implementation of batch production**



- **High integration, low power consumption**
- **Engineering application: EMD, ERNI and other spectrometers 8m^2 area coverage**

2023~2029

Third -generation

- **More compact**

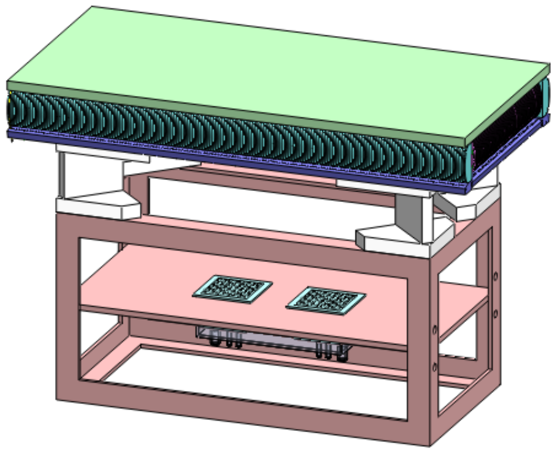
- **High spatial resolution: <1mm**
- **Can work in vacuum environment**
- **Domestic Key Components**
- **Engineering application: CSNS II**

Large-Area Scintillator Detector – 1st generation

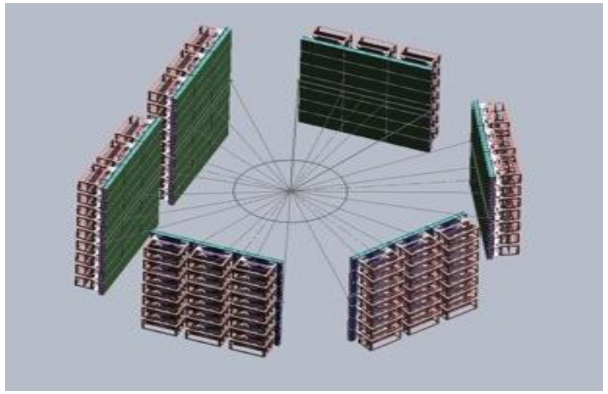
Flat Panel Scintillation Neutron Detector for GPPD

- Detection area 6m^2, ^{6}LiF/ZnS(Ag)+WLSF+MA-PMT
- Start operation from August 2018 and run stably for 6 years.

Detector module design

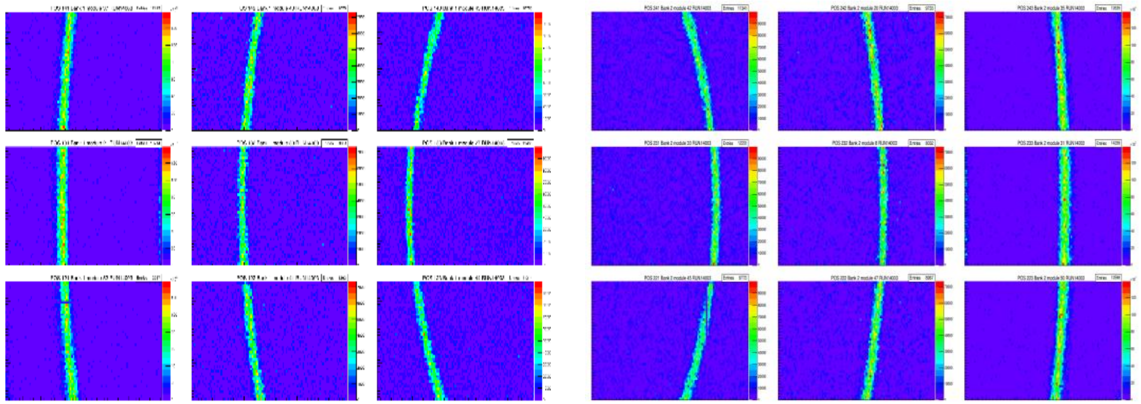


Detector array design

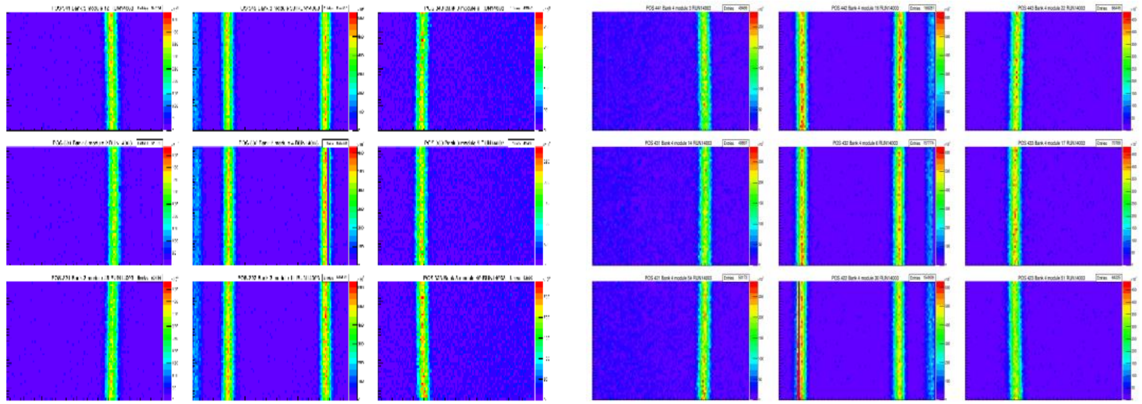


Sample experiments

Bank1 and Bank2



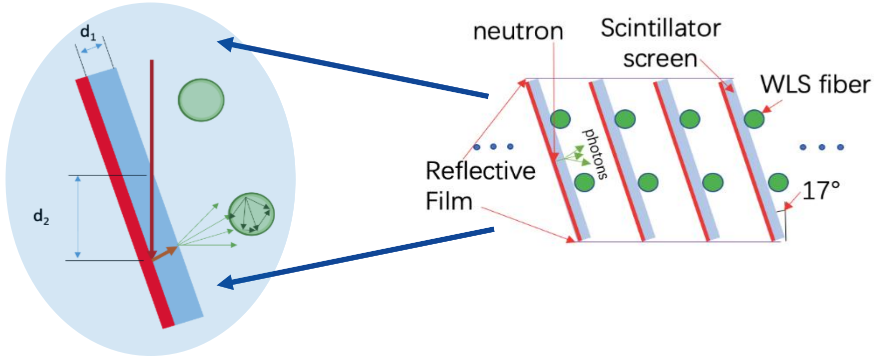
Bank3 and Bank4



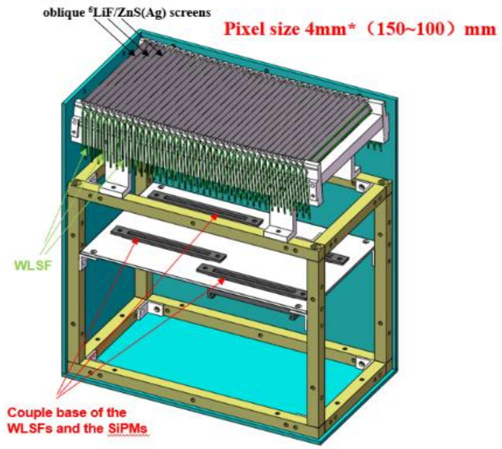
Large-Area Scintillator Detector – 2nd generation

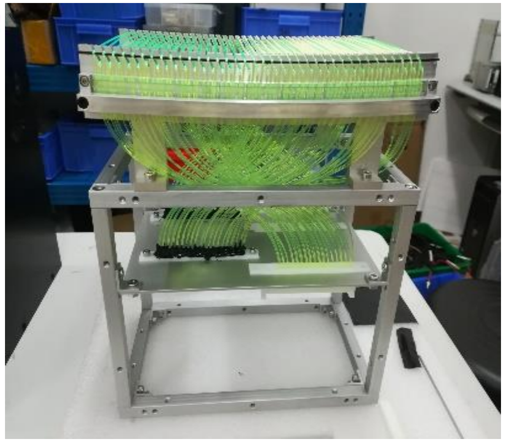
Oblique Incidence Scintillation Detector Based on SiPM

- Including scintillator, WLSF, electronics, SoC, power supply, temperature monitoring, temperature compensation modules.



$$n + {}^{6}\mathrm{Li} \rightarrow \alpha(2.05\mathrm{MeV}) + {}^{3}\mathrm{H}(2.72MeV)$$

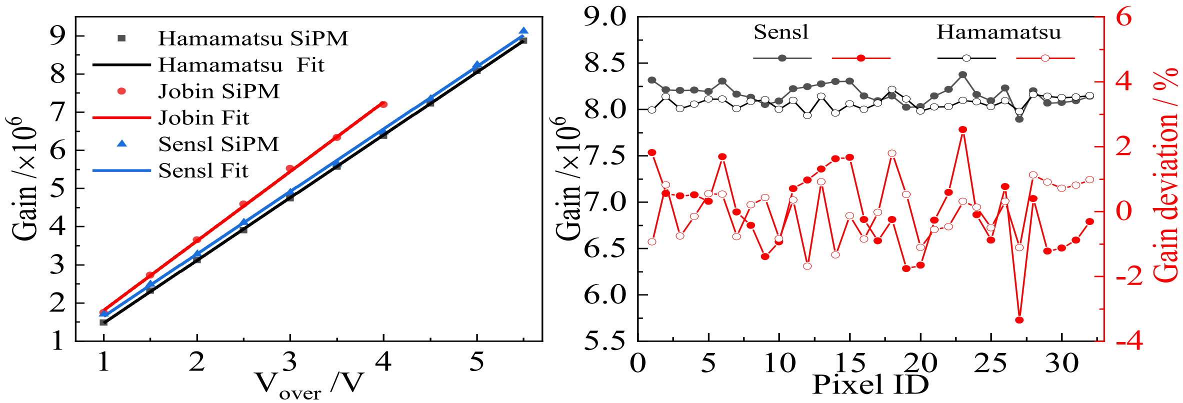




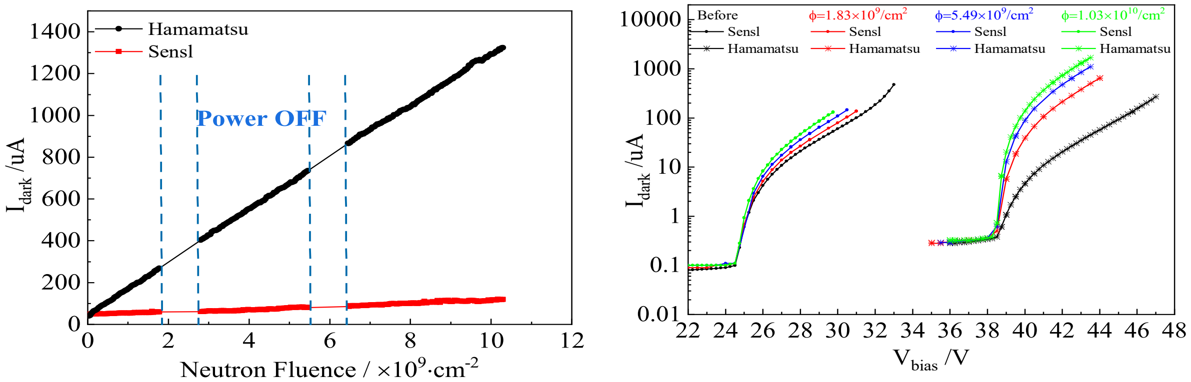
Detector module design

Solve problems of SIPM for large -scale engineering application

SiPM gain and gain uniformity comparison test



Thermal noise and I/V curve change before and after thermal neutron radiation

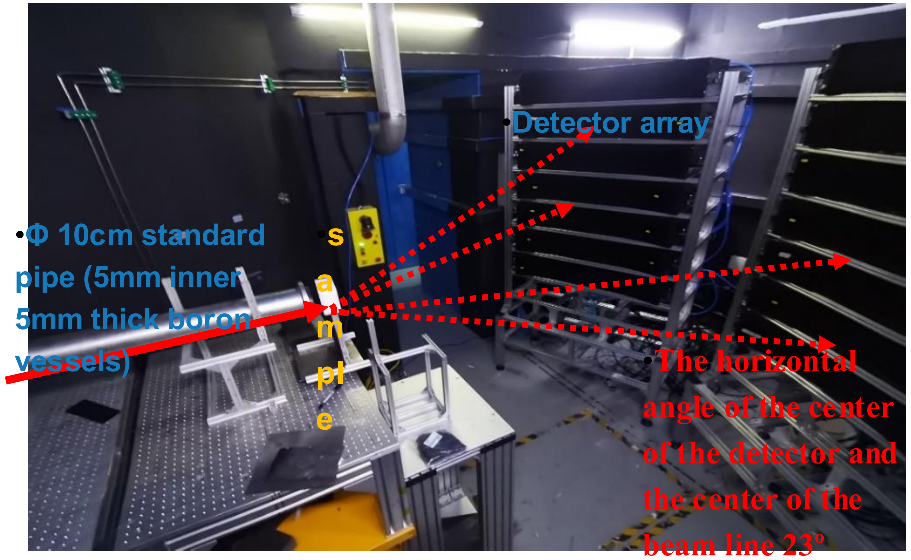


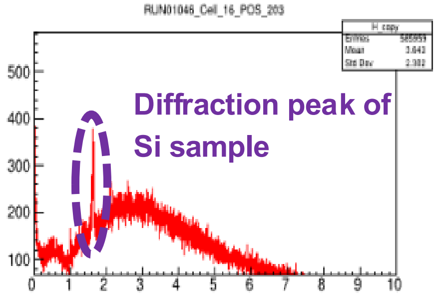
Large-Area Scintillator Detector

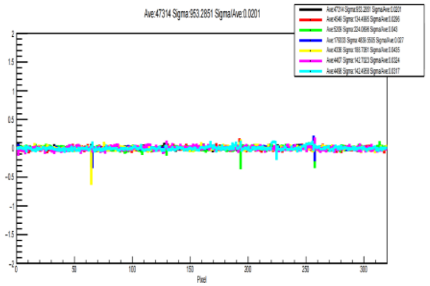
Applicated to Engineering Material Diffractometer (EMD) (100 units)

Batch calibration and optimization of the detector with neutron beam

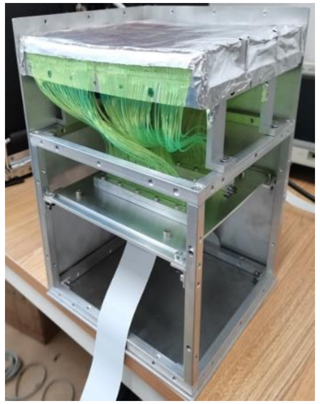
Beam Test

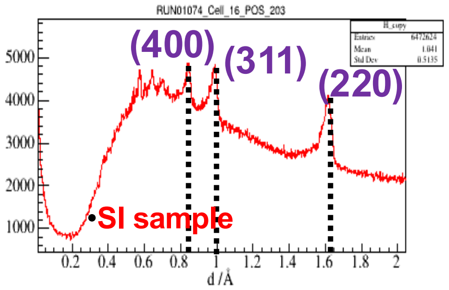


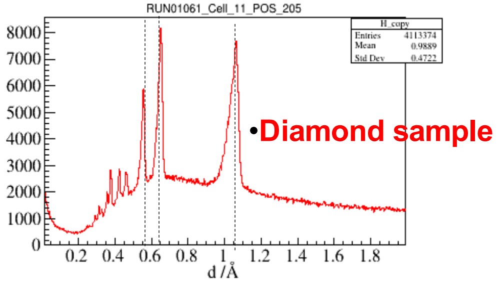




Uniformity of detection efficiency is better than 95%







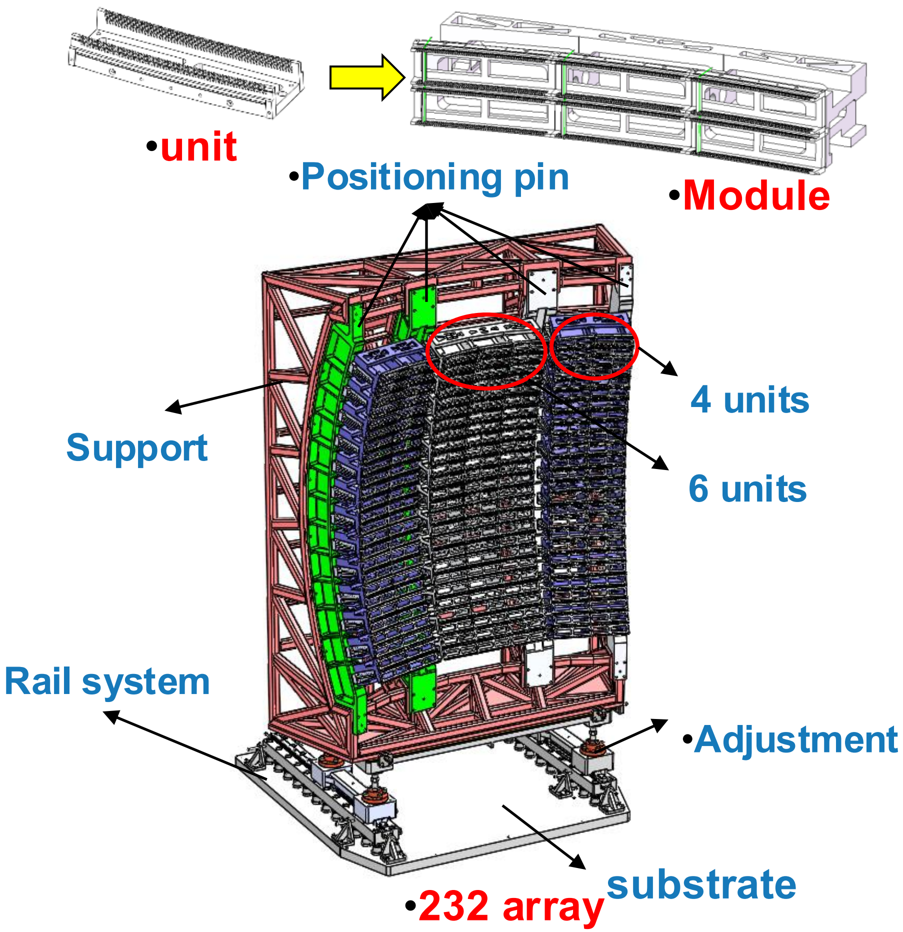
Characteristic diffraction peak of standard sample

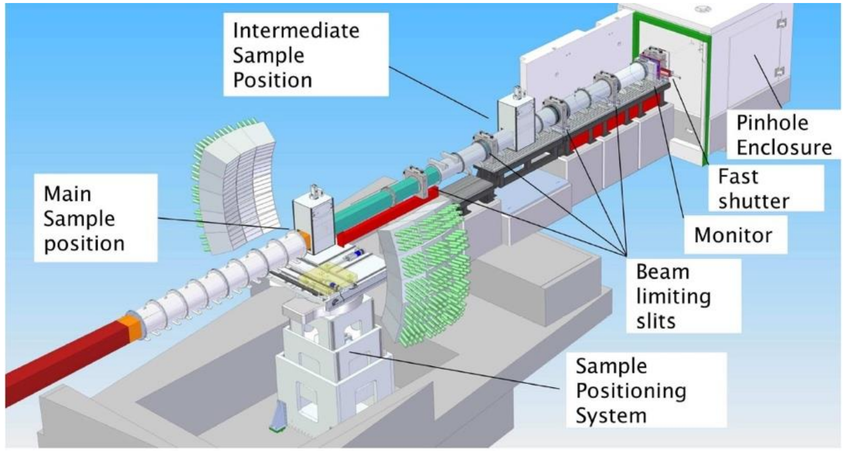
On-site installation and commissioning

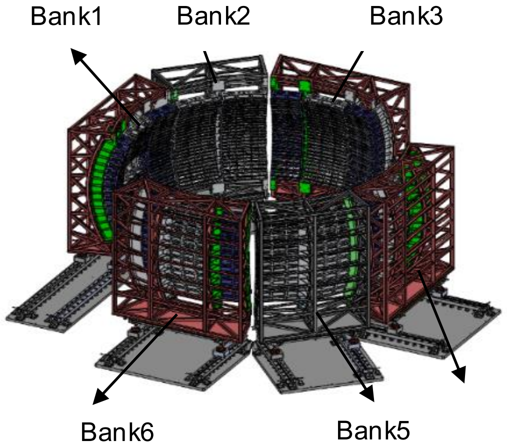
Large-Area Scintillator Detector

Applicated to Energy-Resolved Neutron Imaging instrument (ERNI) (400 units)

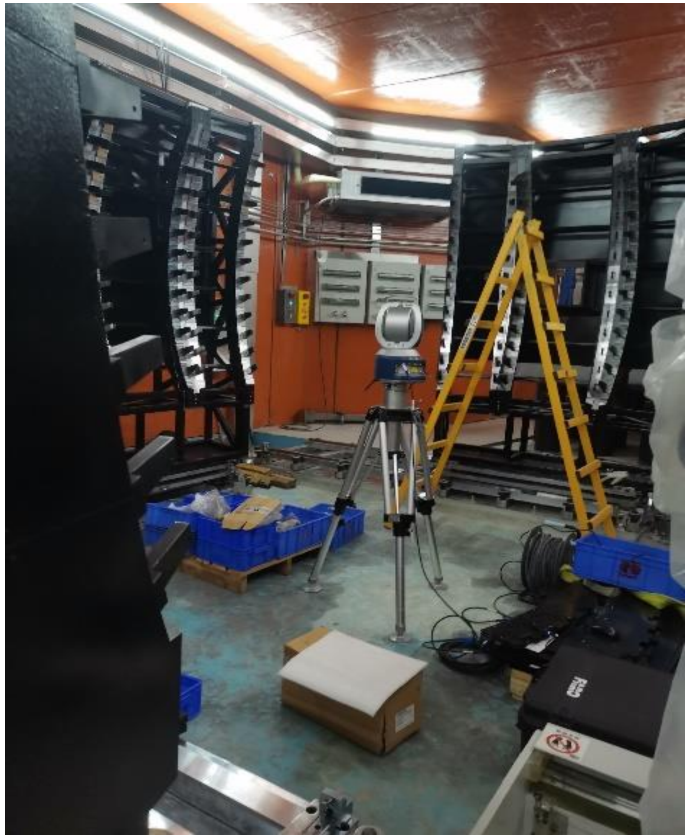
- **Detection area: ~ 3m^2, 25,000 channels of electronics, solved the problem of power consumption and heat dissipation. Operating stably for 1 year.**







Detector engineering design



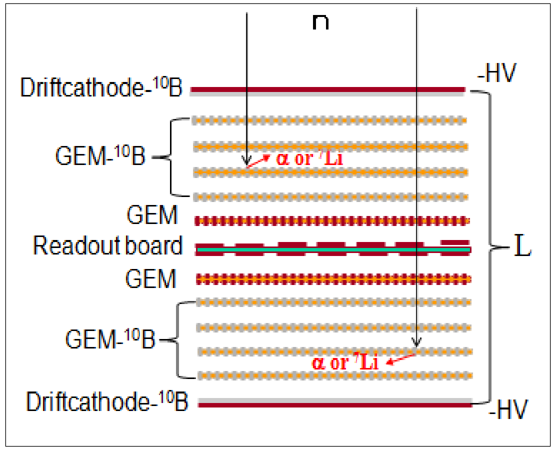
on-site installation and commissioning

Ceramic GEM Neutron Detector

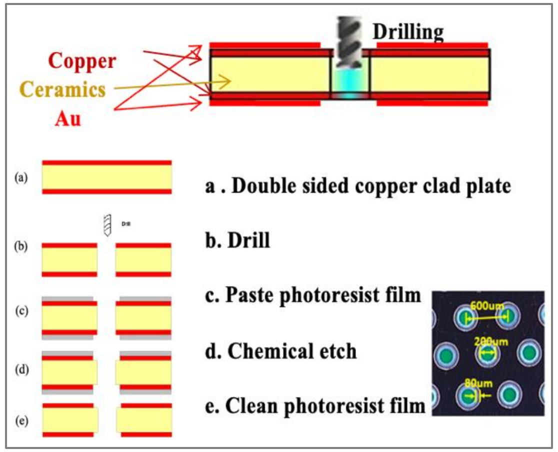
In 2013 the ceramic GEM was invented to reduce hydrogen containing materials with low neutron scattering, high radiation resistance and high temperature resistance

Aiming at engineering applications，ceramic GEM based detector design and key technology development

Detector design



Ceramic GEM development



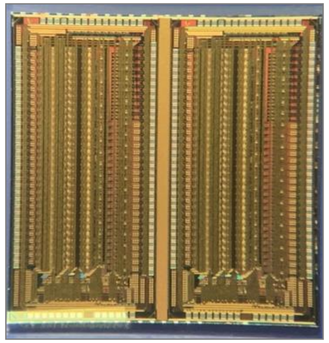
CPC, 40(7):076002,2016

Large-area boron coating by magnetron sputtering

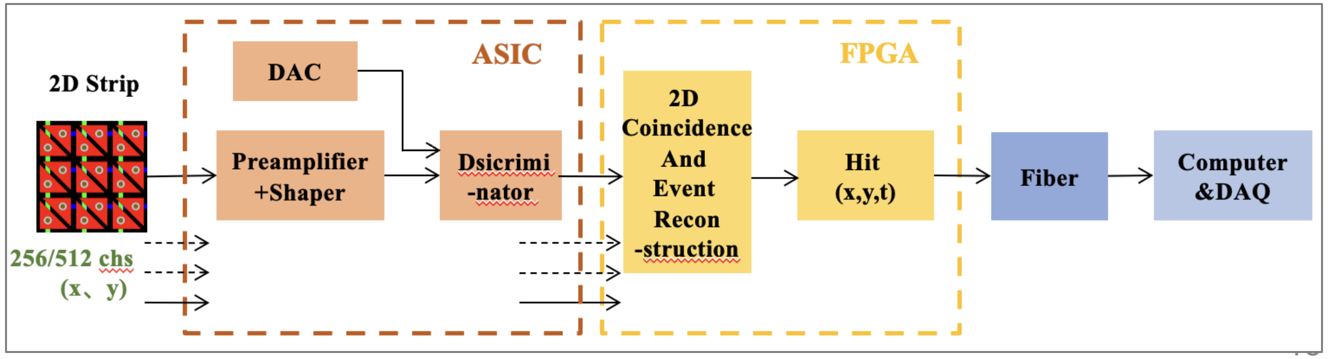
Rev. Sci. Instrum. 94, 093901, 2023

R&D of multi-channel ASIC chip

Parameter	Specification
Input charge	±10fC ~ ±400fC
Counting rate	1MHz/ ch
Channels	32*2
Output	2.5V TTL
Threshold	DAC adjustable



Fast digital readout electronics



Ceramic GEM - Beam Monitor

High flux 2D position sensitive neutron beam monitor

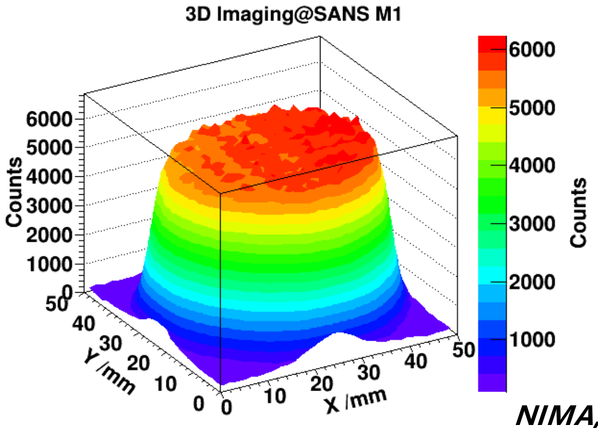
6 monitors were installed in CSNS I, operating stably for 6 years. 21 monitors totally used for instruments

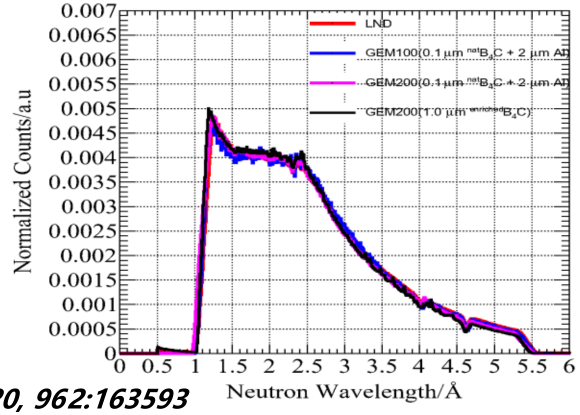
Monitor design parameters

Indicators	Specifications
Conversion layer	B_4C、C_2H_4, U
Effective area	50mm*50mm, 100mm*100mm, 200mm*200mm
Detection Efficiency @1.8Å	10^{-4}~10^{-2}
Counting rate	1 MHz
Neutron flux	10^{10} n/s

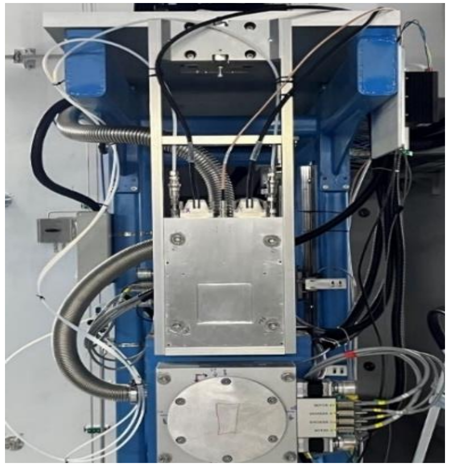
30 monitors have been mass-produced

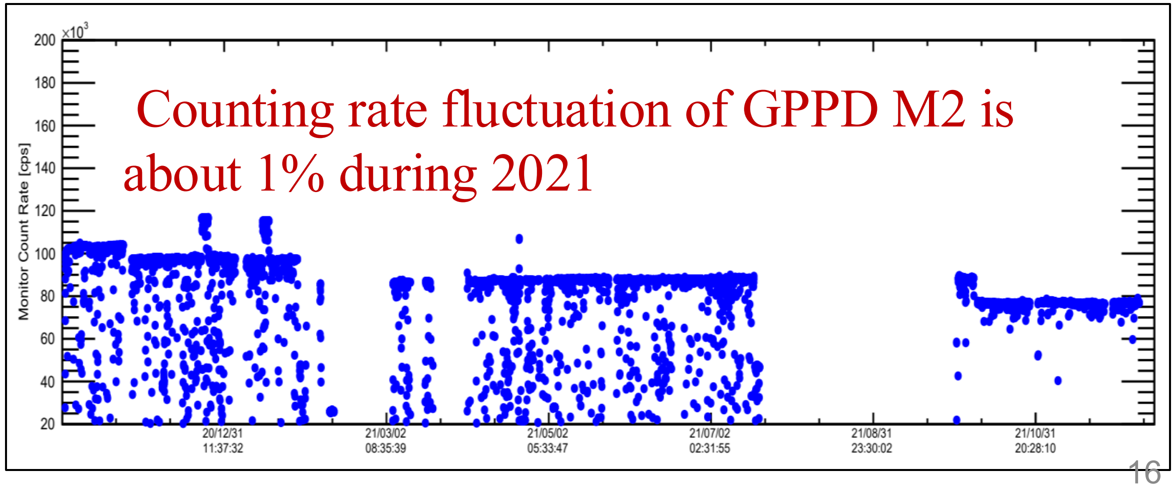
Monitor Operation Test Results





NIMA, 2020, 962:163593



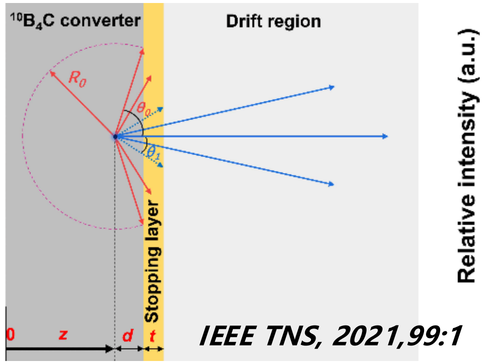


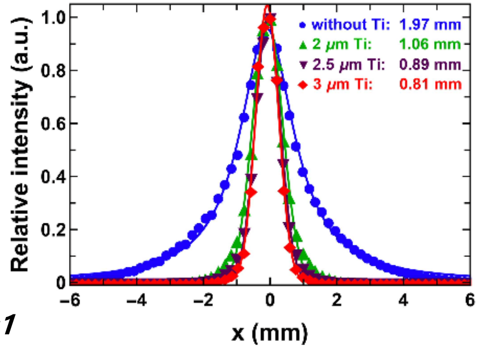
Ceramic GEM - Imaging Detector

Large FOV GEM neutron detector for ERNI

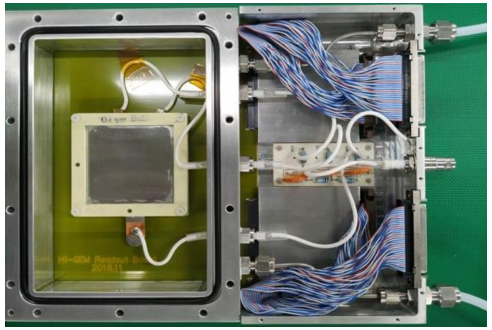
Al/Ti film is used as a stop layer. Spatial resolution is improved to 0.8mm, and it has been installed at ERNI for bragg-edge imaging experiment.

M.C. simulation

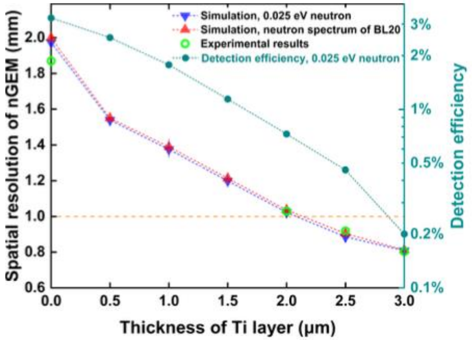


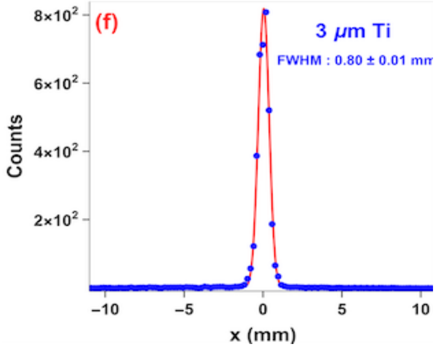


Prototype development



Test results of neutron beam test

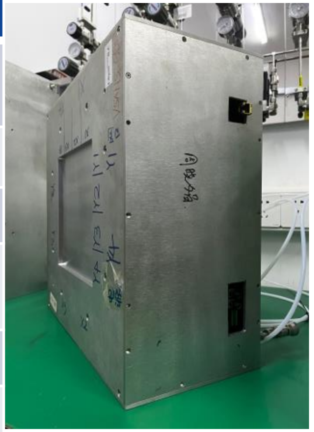




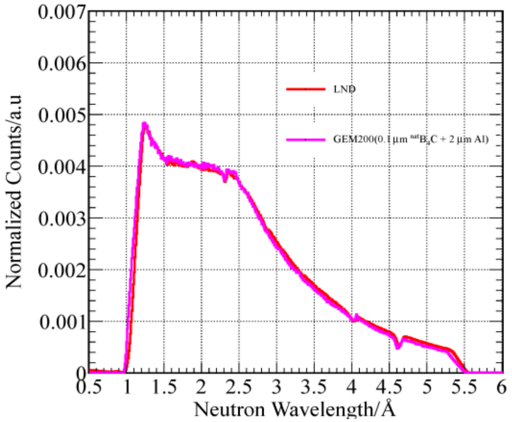
Detector design

Indicators	Specifications
Conversion layer	0.1μm ^{nat}B4C+2μm Al
Effective area	200mm*200mm
Pixel size	0.8mm
Detection Efficiency@1.8Å	10^{-4}
Counting rate	1 MHz
Neutron flux	10^{10} n/s

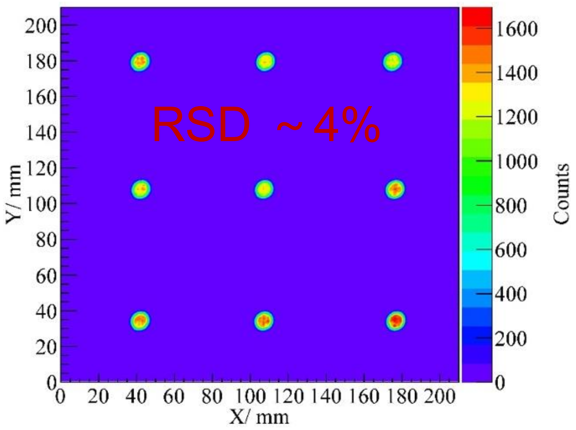
Detector photo



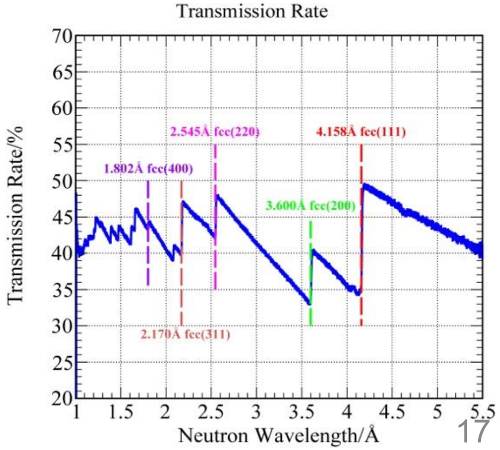
Neutron wavelength



Detecting surface uniformity



Bragg-Edge Neutron Imaging



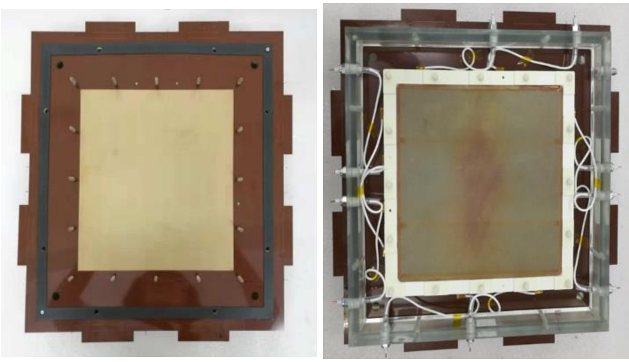
Ceramic GEM - High Resolution Detector

High Resolution Detector for VSANS

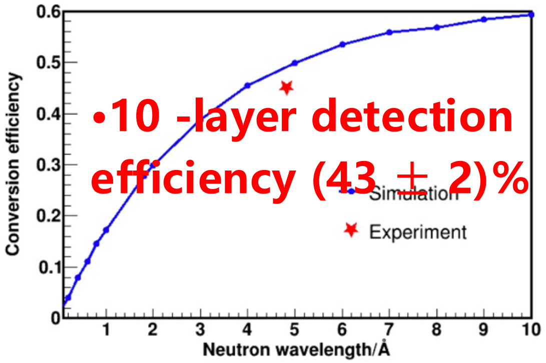
Multi-layer BGEM structure is used to improve the detection efficiency, and it has been installed at VSANS for very small angle neutron scattering experiment.

Detector design

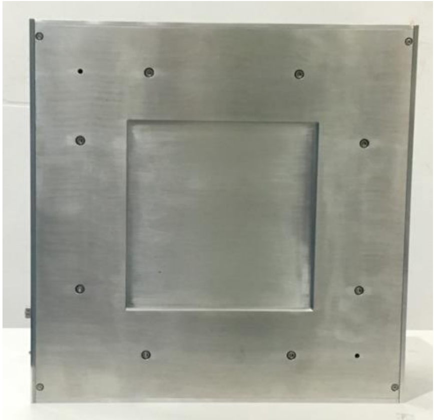
Detector prototype development



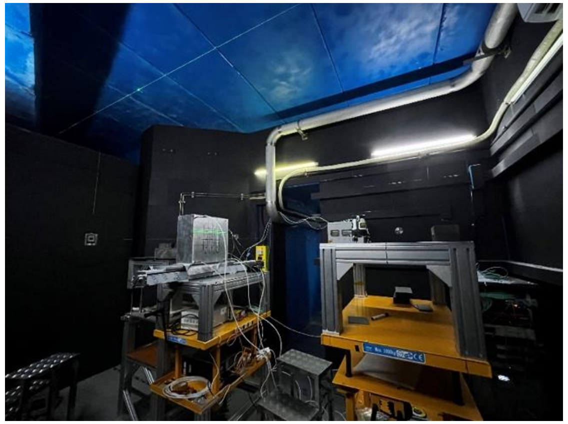
Project Acceptance by CAS@2019



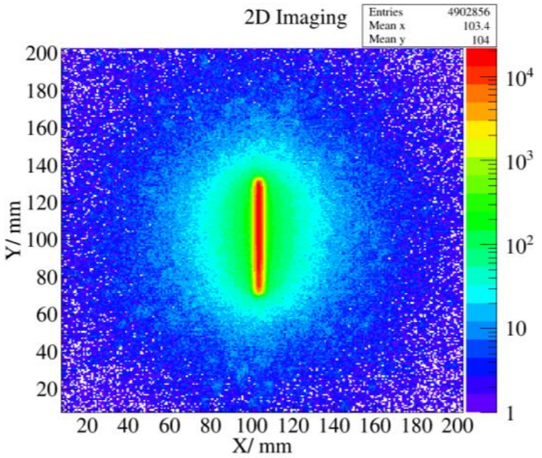
Detector photo



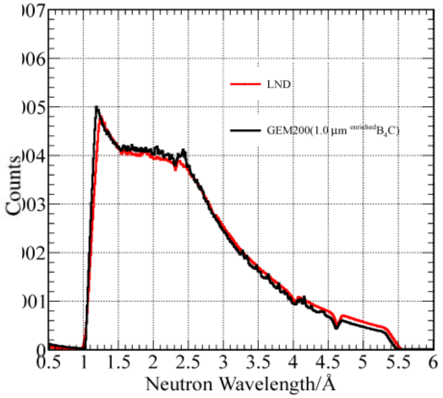
Neutron beam test



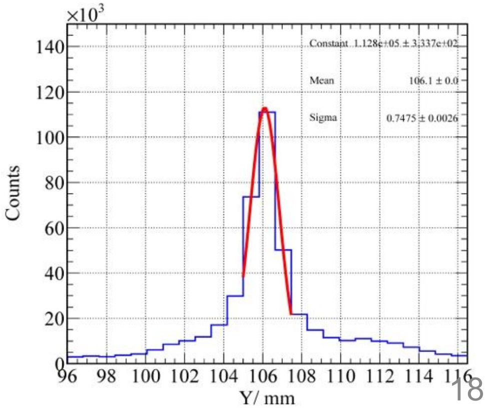
2D beam profile



Neutron wavelength



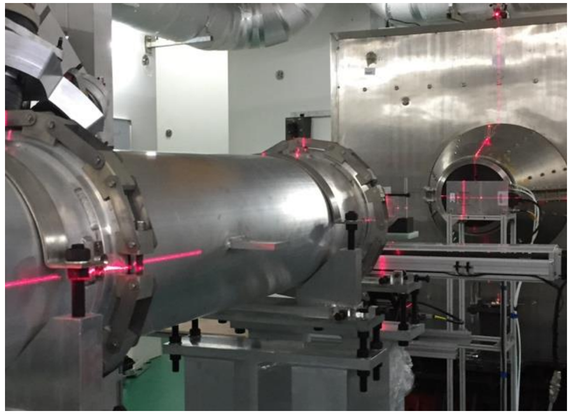
Spatial resolution

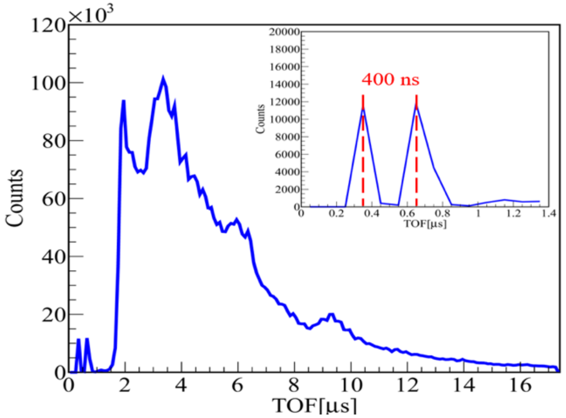


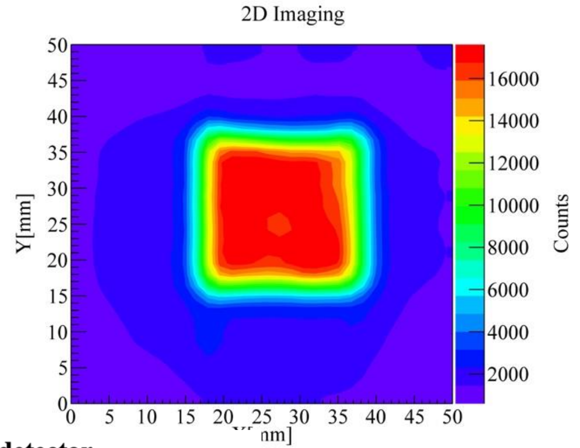
Ceramic GEM - Fast Neutron Detector

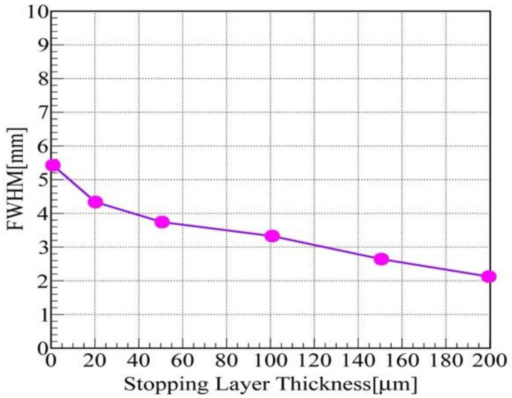
Atmospheric Neutron Irradiation Spectrometer 2D position sensitive detector

Use aluminum as stop layer and spatial resolution of fast neutron improved from 5mm to 2.1mm, has been installed at ANIS for fast and thermal neutron beam monitoring



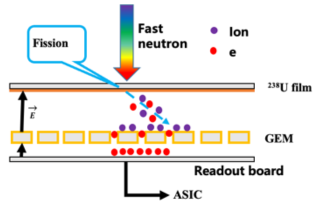




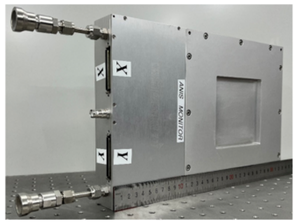


1. ^{238}U-GEM fast neutron detector

Schematic diagram



Detector photo

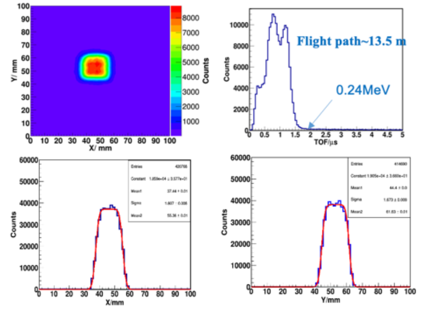


Spatial resolution 4.3 mm (FWHM)

Specifications

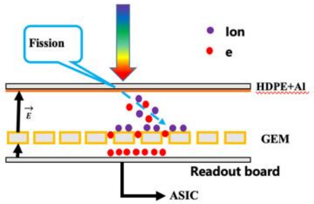
- Active area： 100mm×100mm
- Readout chanels： 64(X)+64(Y) = 128
- Pixel： 1.56mm×1.56mm
- Convertor： ~1 mg/cm^2 ^{238}U镀层
- Spatial resolution： 5 mm (FWHM)，HV= - 700V
- Energy range： Above 0.1MeV，Efficiency~10^{-5}

Beam test@BL20，20mm collimator @2021.11.15-21

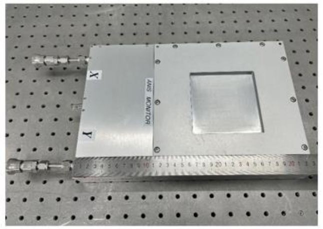


2. C_2H_4-GEM fast neutron detector

Schematic diagram



Detector photo

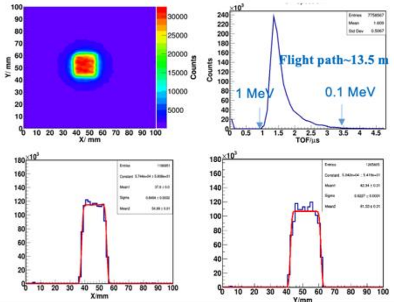


Spatial resolution 2.1 mm (FWHM)

Specifications

- Active area： 100mm×100mm
- Readout chanels： 64(X)+64(Y) = 128
- Pixel： 1.56mm×1.56mm
- Convertor： 2 mm C_2H_4+0.2mm Al
- Spatial resolution： 2 mm， HV= -1500V
- Energy range： Above 0.1MeV， Efficiency~10^{-4}

Beam test@BL20，20mm collimator @2021.11.15-21



Ceramic GEM – Frontier Exploration

Sealed GEM neutron detector.

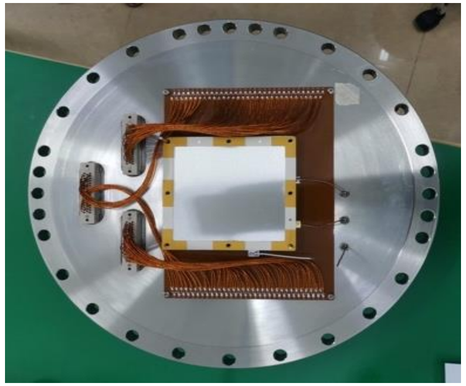
NIMA, 2021,995:165129

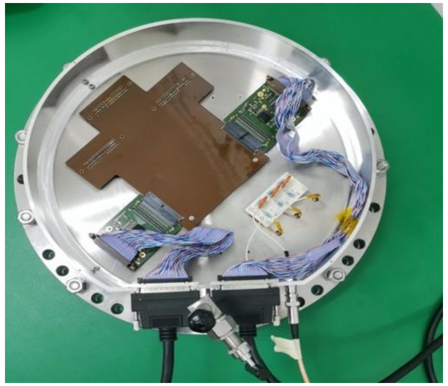
- **Developed high-temperature resistant (100°C) ceramic GEM to meet baking outgassing.**
- **Enhancing detector stability, suitable for vacuum environments, future direction.**

Detector design

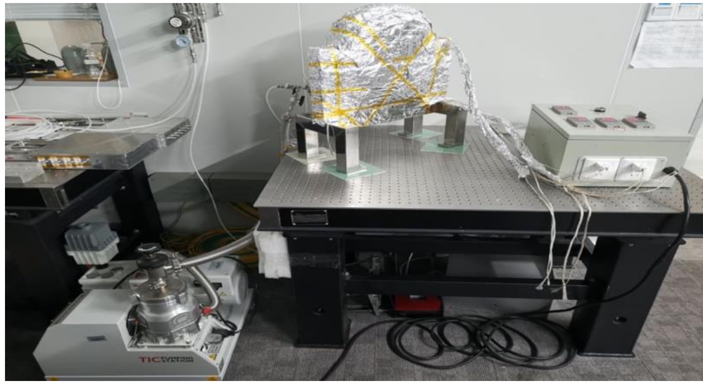
Indicators	Specifications
Conversion layer	1μm B4C
Effective area	100mm*100mm
Pixel size	1.56mm
Detection Efficiency@1.8Å	~3%
Counting rate	1 MHz

Detector assembly

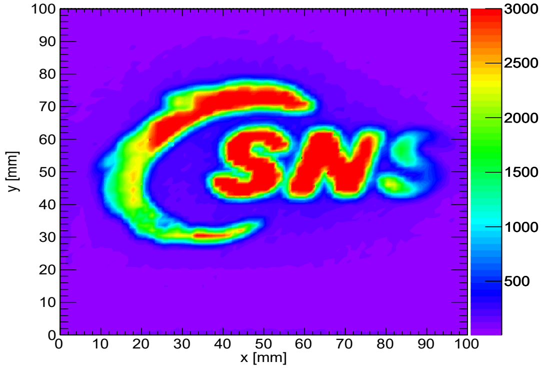




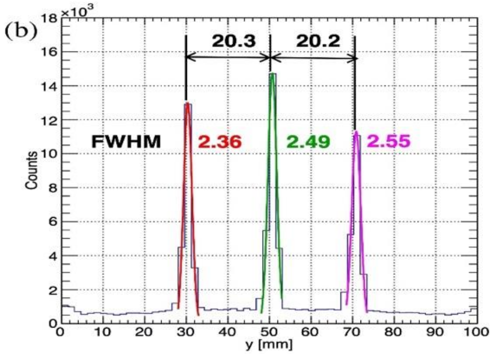
Detector baking outgassing system



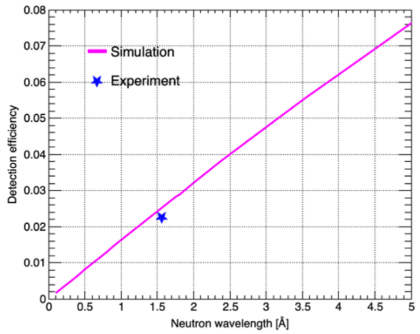
2D imaging



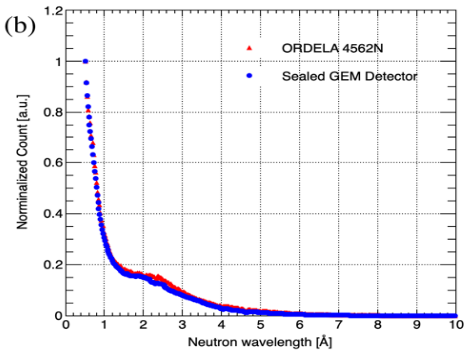
Spatial distortion



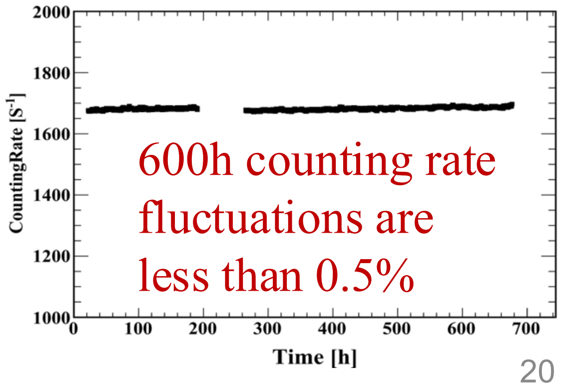
Detection efficiency



Neutron wavelength



Long-term stability



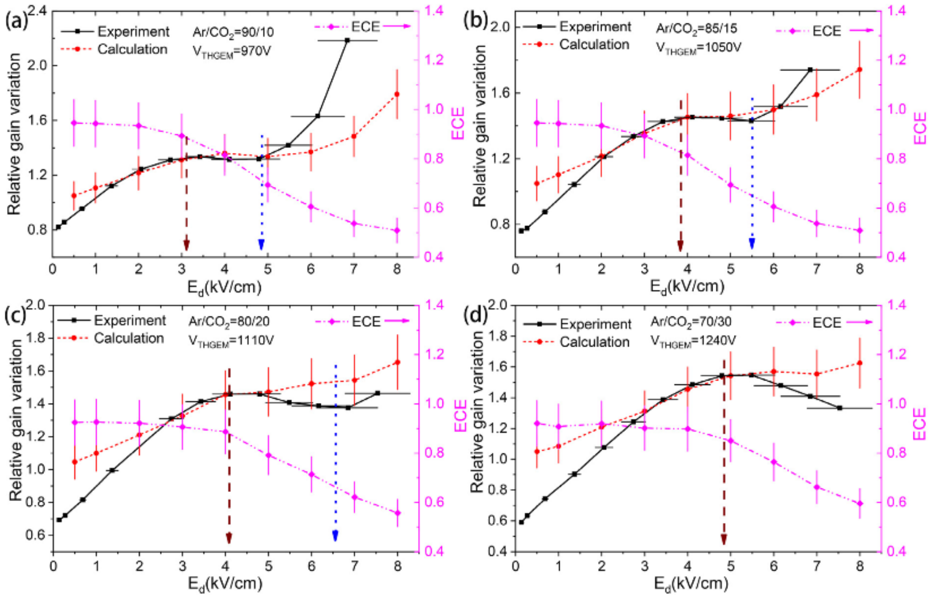
Ceramic GEM - International collaboration

Provided multiple batches of ceramic GEM detectors to several institutions abroad

Milano Uni. & INFN in Italy conducts research on the ceramic GEM and applications (NIMA, 2021, 988: 164907)

Ceramic GEM detector installed at ISIS VESUVIO instrument in UK (Jinst, 2021, 16: P06003)

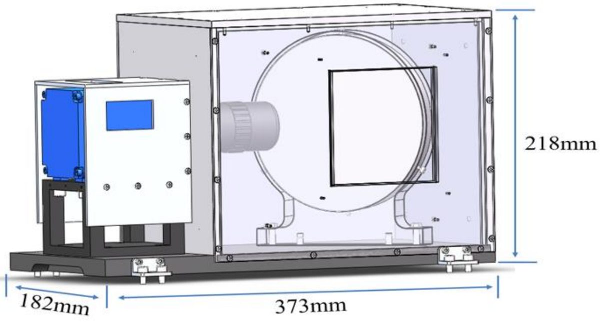
R&D of high-efficiency detector with GSI, German

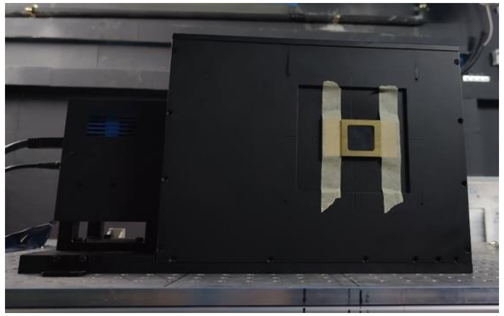


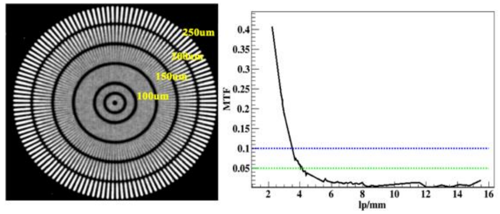
Neutron Imaging Detector

Aiming at the neutron imaging demands of CSNS and the frontiers, developing a variety of **high spatial resolution** and **high timing resolution** imaging detectors

Compact imaging detector



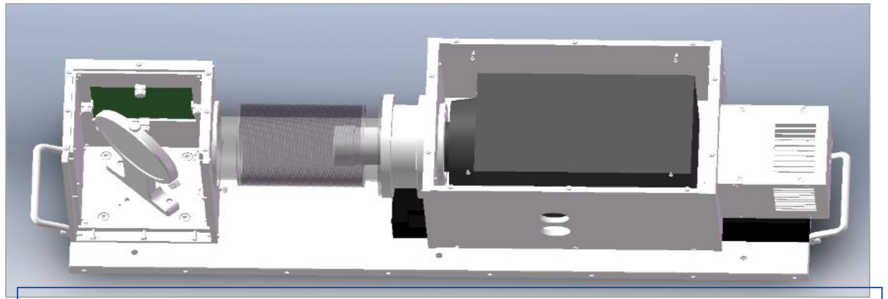




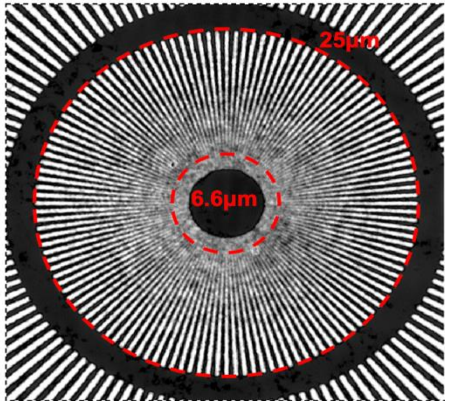
Latest beam test results: 122 μm@4.1LP/mm

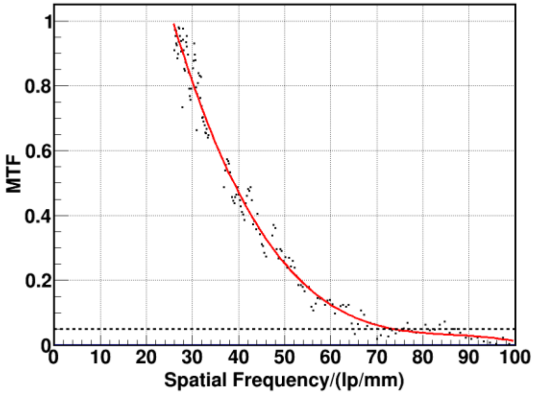
NET, 2021, 53(6):1942-1946

High-resolution imaging detector



Micrometer ultra-high resolution neutron imaging detector with ultra-thin GOS: Tb transparent ceramic scintillator

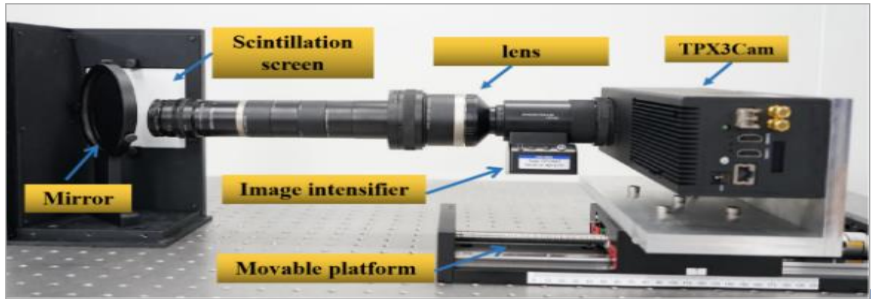




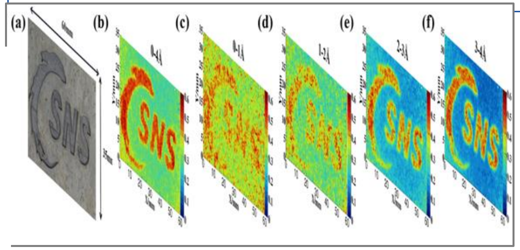
Latest beam test results: 6.6 μm @ 74 LP/mm

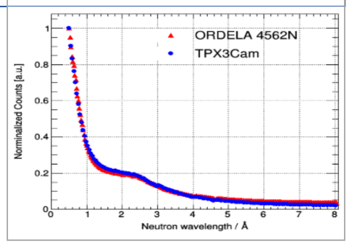
Optical Materials, 2020, 105: 10990 (cooperated with the Lijiang team of the Shanghai Institute of Ceramics)

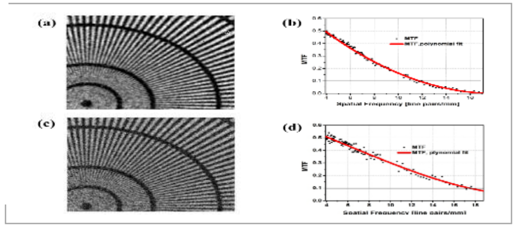
Energy resolution neutron imaging detector

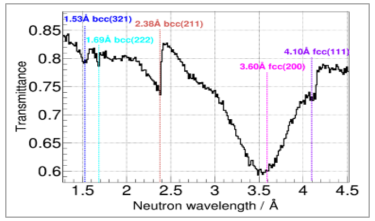


Energy resolution neutron imaging detectors can achieve high time resolution and high spatial resolution at the same time.









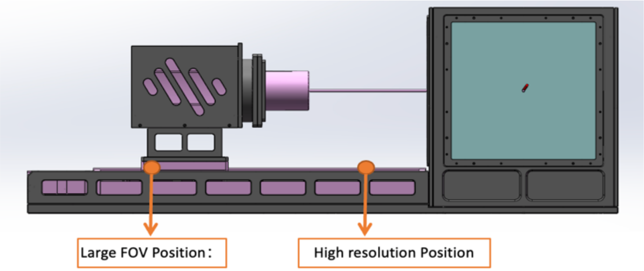
Latest beam test results: 20 μm (25 LP/mm), $\Delta\lambda/\lambda$= 0.2%

NIMA, 2021, 1003: 165322

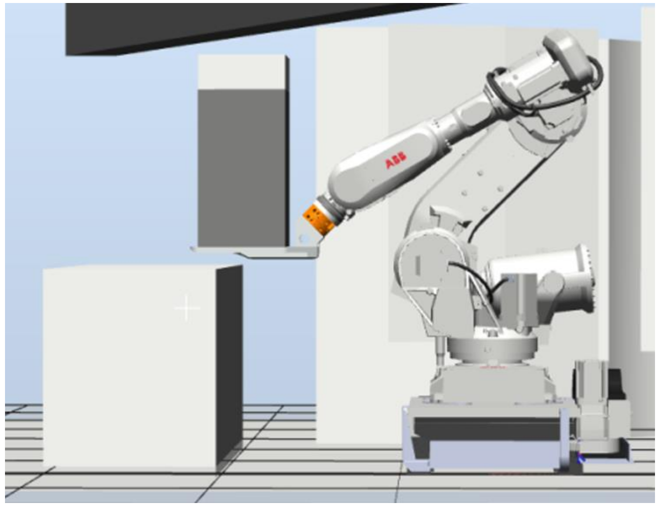
Neutron Imaging Detector - Large FOV

ERNI—Large FOV Imaging detector. Operating stably for 1 year.

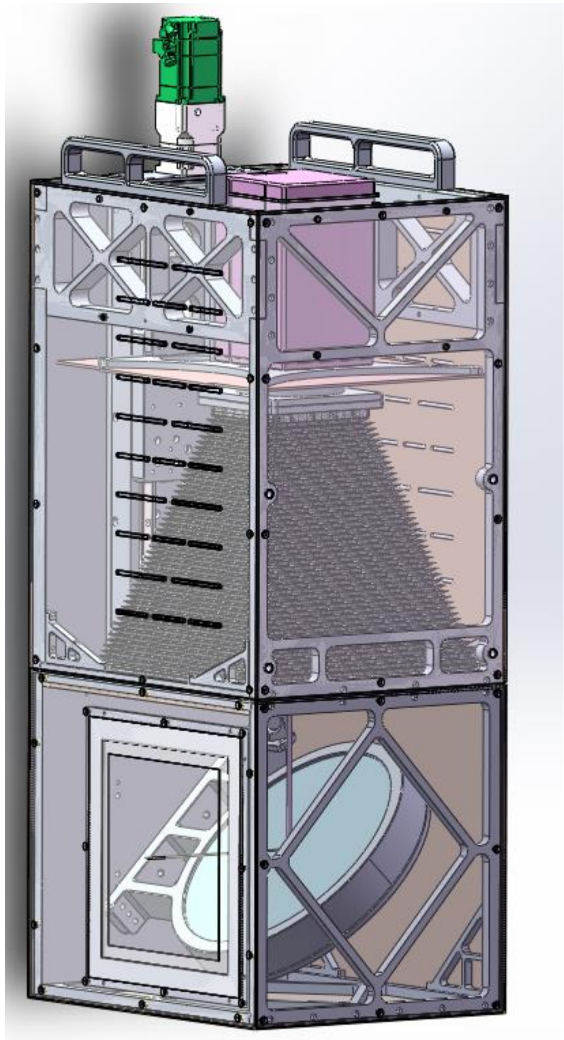
Detector engineering design



Lens	Magnification	FOV	Distance	Spatial resolution
Nikon AFSVRMICR O60_2.8	0.15	200mmX200mm	484mm	200μm
	0.3	100mmX100mm	242mm	100μm
Nikon AFSVRMICR O105_2.8	0.3	100mmX100mm	500mm	100μm
	0.5	60mmX60mm	423mm	60μm
	1	30mmX30mm	343mm	30μm

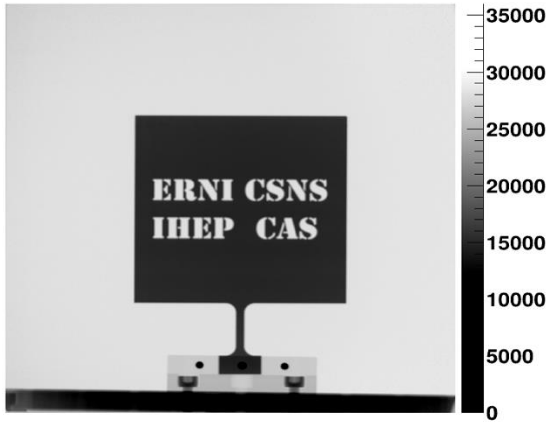


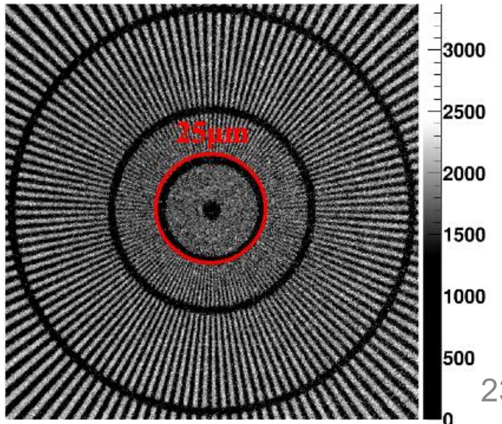
Large FOV Imaging detector



Neutron beam test @ ERNI

The maximum FOV is 220mm*210mm, and the best spatial resolution is 25 μm measured at ENRI

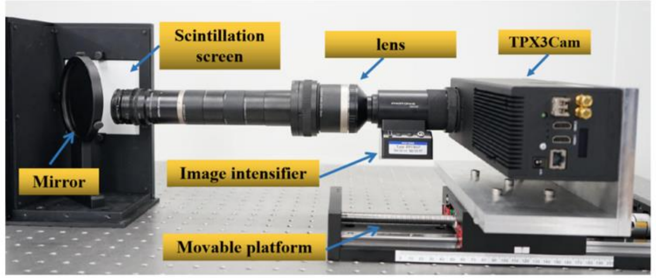




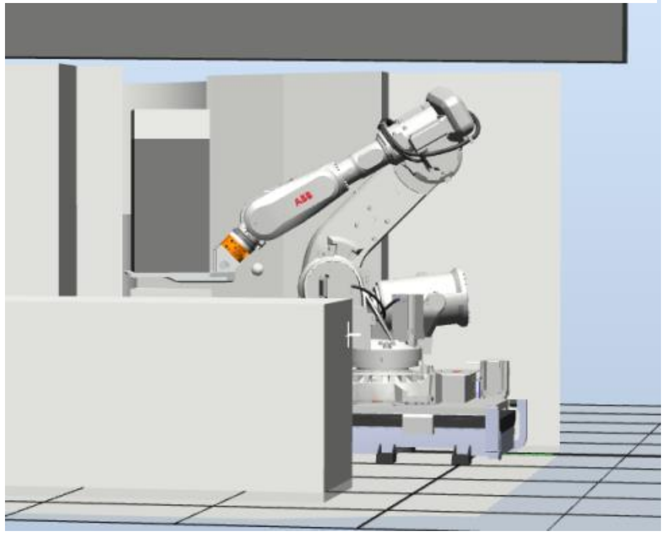
Neutron Imaging Detector-Energy Resolution (TOF)

Energy resolved imaging detector. Operating stably for 1 year.

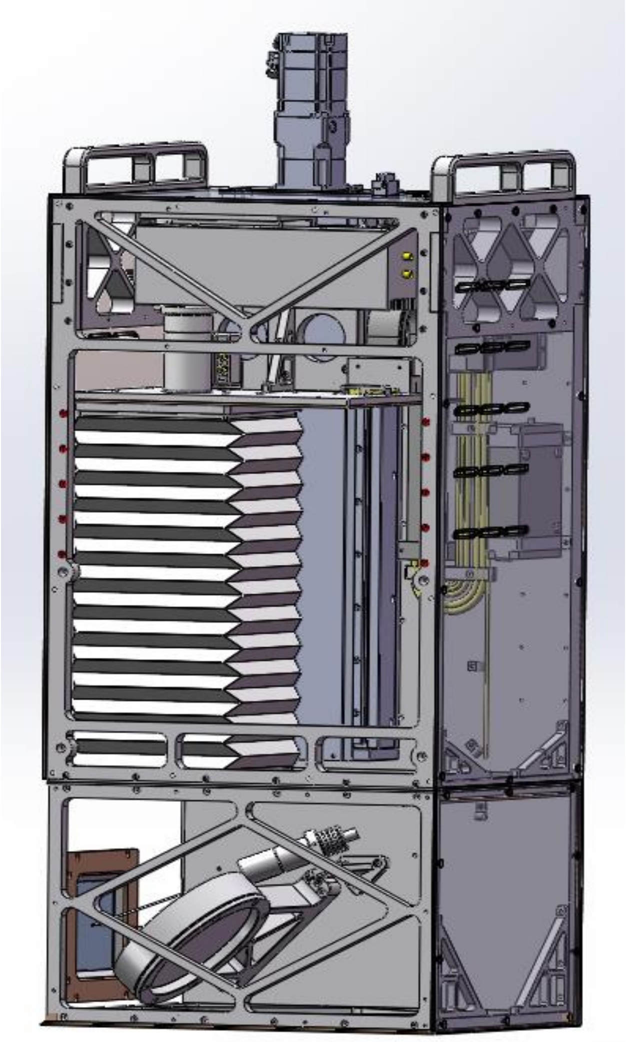
Detector engineering design



Lens	Magnification	FOV	Distance	Spatial resolution
Nikon AFSVRMIC RO60_2.8	0.12	100mmX100mm	622mm	458μm
	0.14	90mmX90mm	507mm	393μm
	0.3	42mmX42mm	302mm	183μm
Nikon AFSVRMIC RO105_2.8	0.3	42mmX42mm	519mm	183μm
	0.5	25mmX25mm	399mm	110μm
	1	12.7mmX12.7mm	299mm	55μm

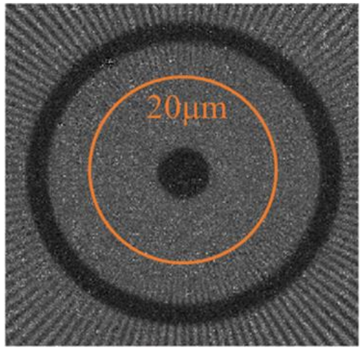


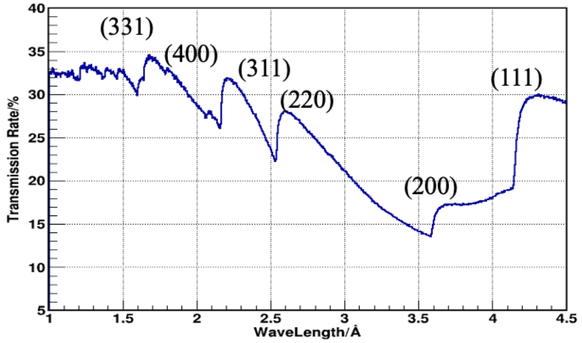
Energy resolved neutron imaging detector



Test and commissioning at the ERNI

Preliminary test results of ENRI





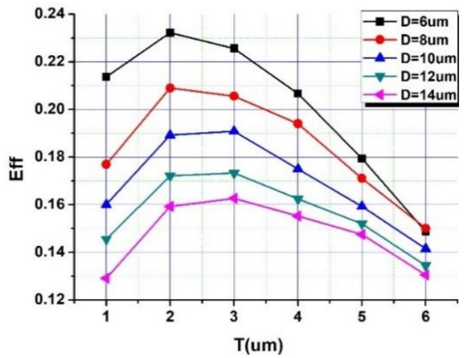
Neutron Imaging Detector-Energy Resolution (TOF)

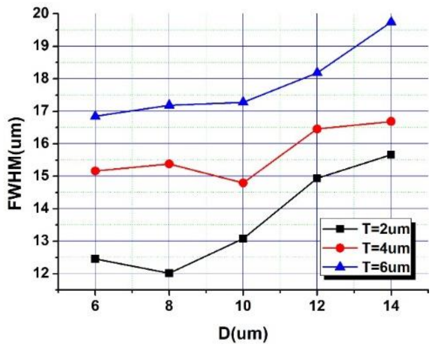
Development of neutron sensitive Micro Channel Plate (nMCP)

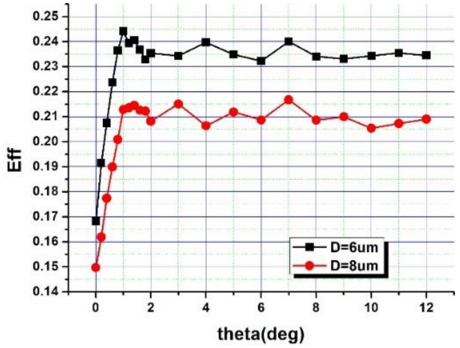
- Challenges: Low γ sensitivity and high boron-doped concentration in nMCP, reducing high Z materials.
- Achieved 20 mole% boron-doped nMCP, successfully applied in GPPD

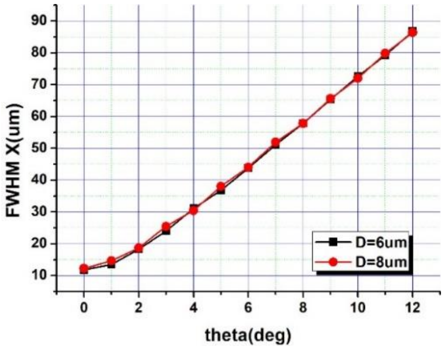
NIMA , 2022, 167828

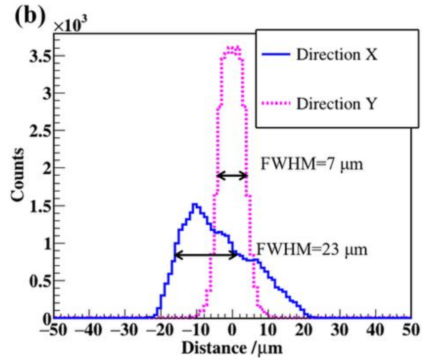
Design and optimization of nMCP based on Geant4 simulation



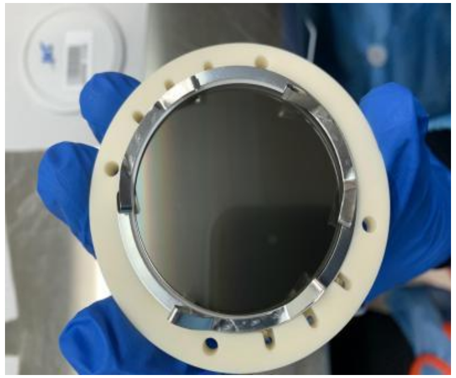




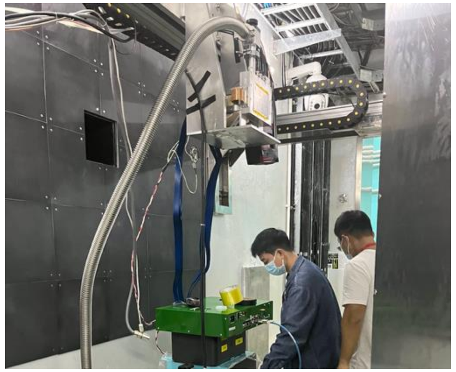




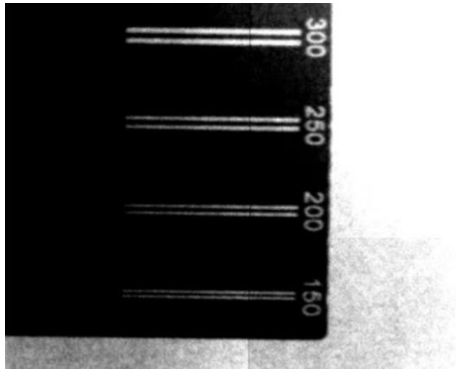
B-nMCP photo



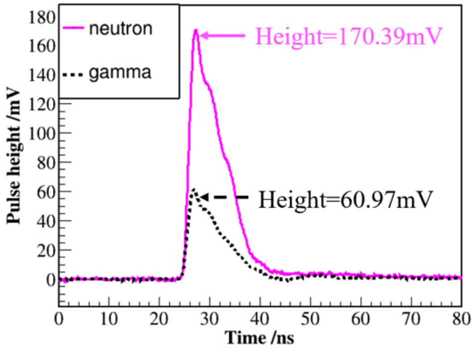
GPPD application



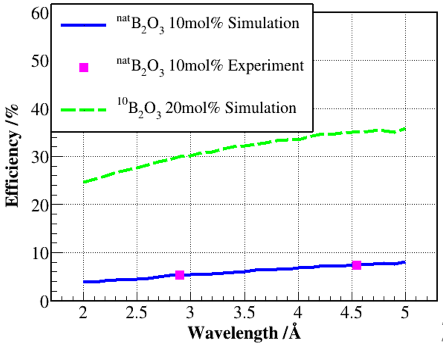
Spatial resolution



n/γ discrimination



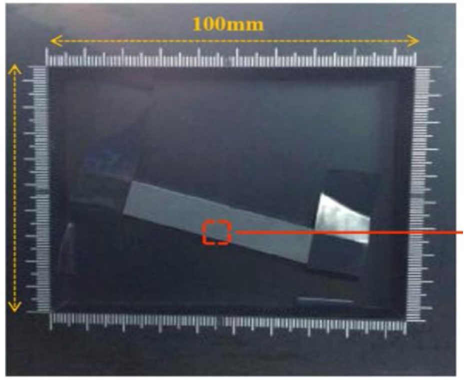
Detection efficiency

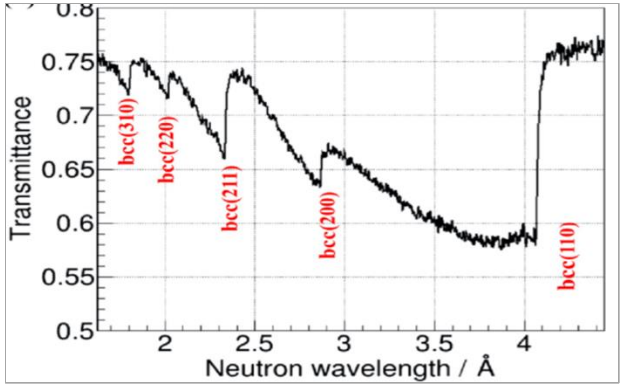


Neutron Imaging Detector-Applications

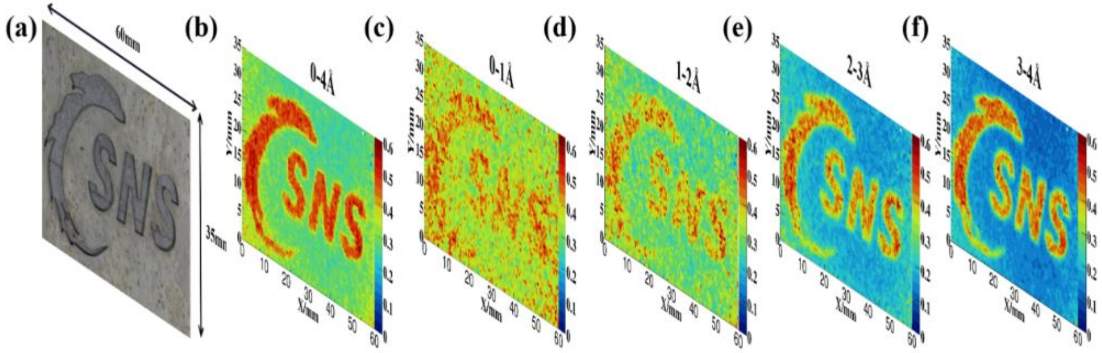
Successfully carried out several applications in multi fields at CSNS

Bragg Edge Neutron Imaging Experiment (Chen Jie)

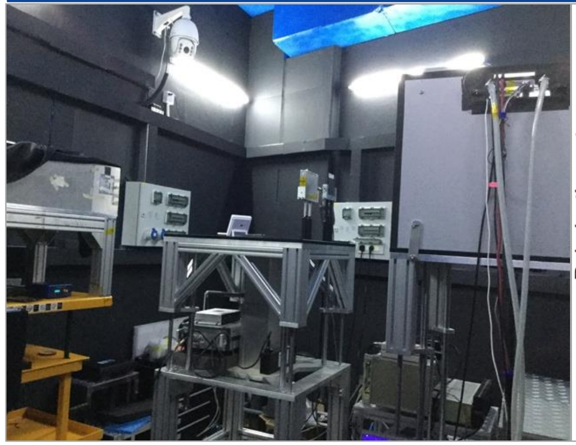


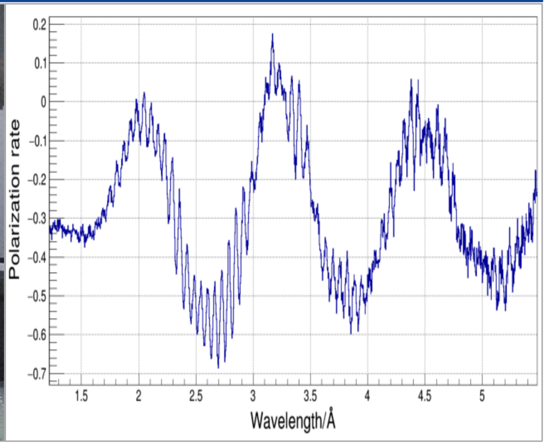


Energy Selective Neutron Imaging

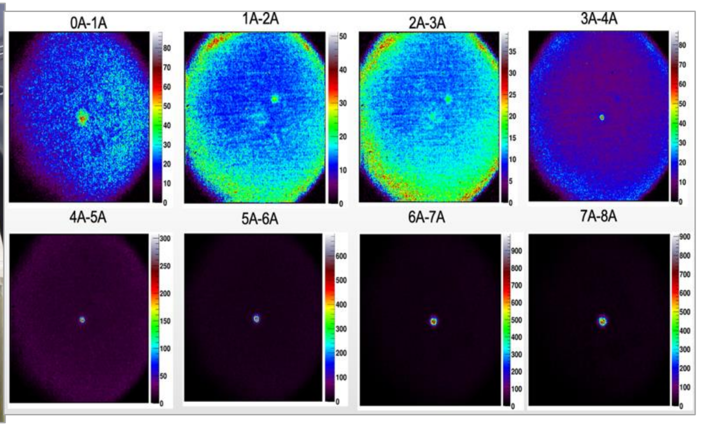


Polarized Neutron Imaging (Wang Tianhao)





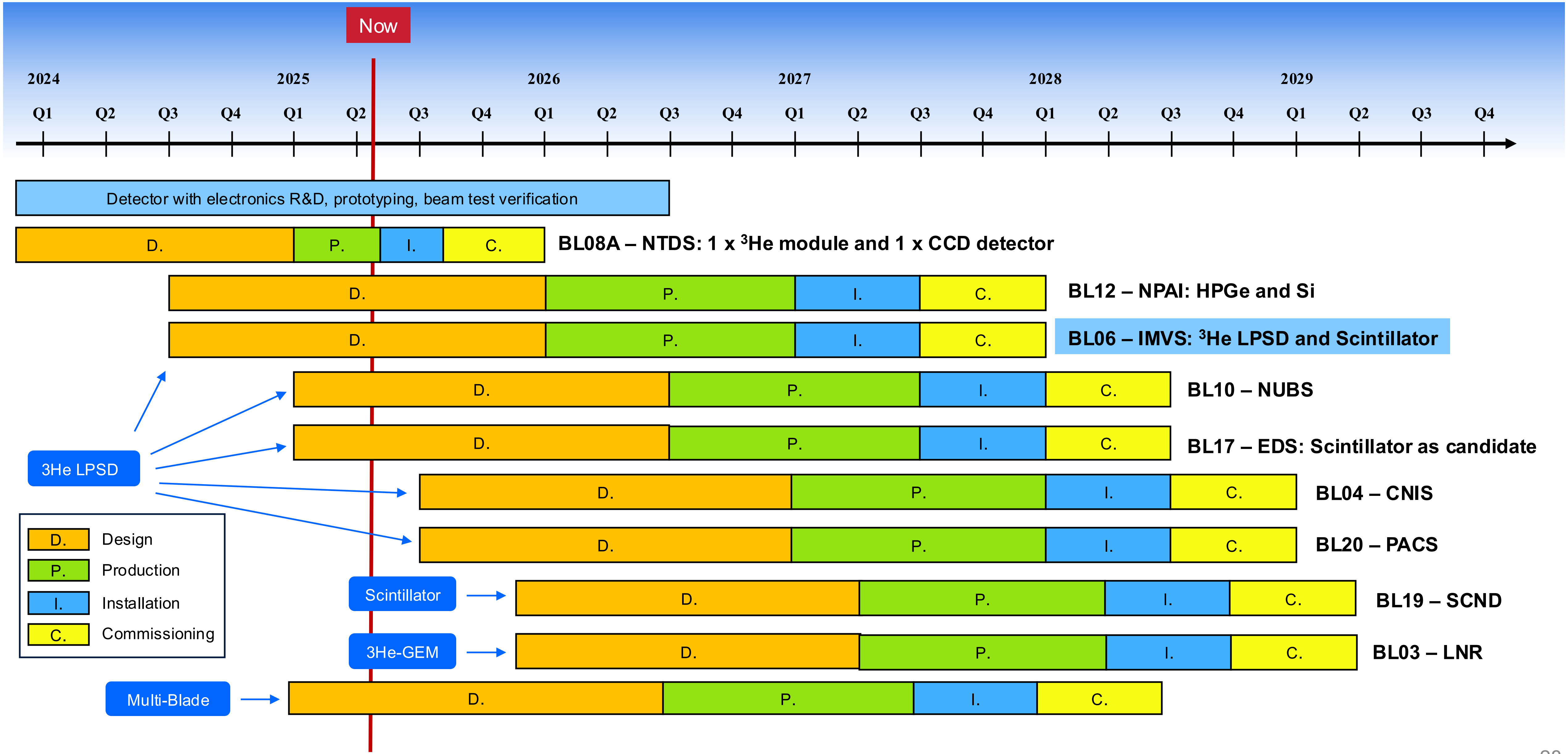
Polycapillary (Yi Tiancheng)



Contents

Outline

CPM and Requirements for CSNS-II Instruments



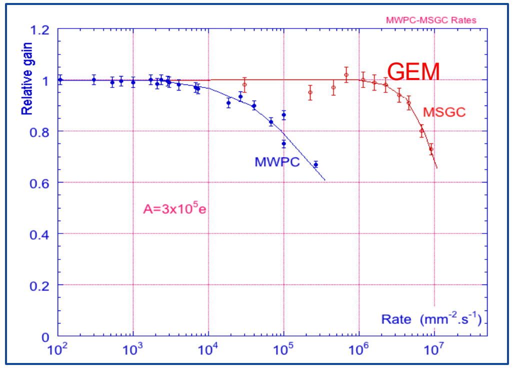
^{3}He based GEM neutron detector

Develop high count rate, high efficiency GEM detector to meet the requirements of liquid instrument

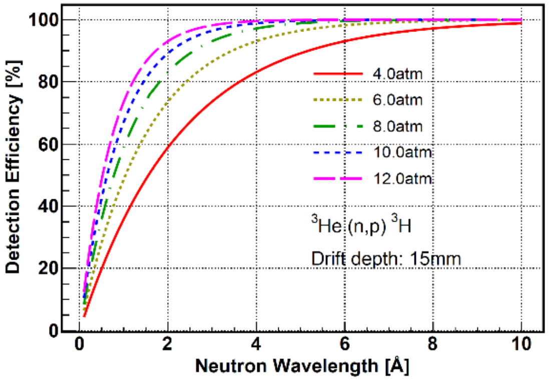
- Bottleneck: traditional detector based on wire chamber can't meet the high flux measurement
- ^{3}He + GEM may potentially achieve high efficiency and enhance high count rate by two orders of magnitude

Parameter	^{3}He MWPC	^{3}He GEM needed
Effective Area	200mm × 200mm	600mm × 1000mm
Spatial resolution	≤ 2mm (FWHM)	≤ 2mm (FWHM)
Detect efficiency	≥ 80% @ 1.8Å	≥ 80% @ 1.8Å
Counting rate	≤ 100kHz	≥ 1MHz
n/γ discrimination	10^{-6}	10^{-6}

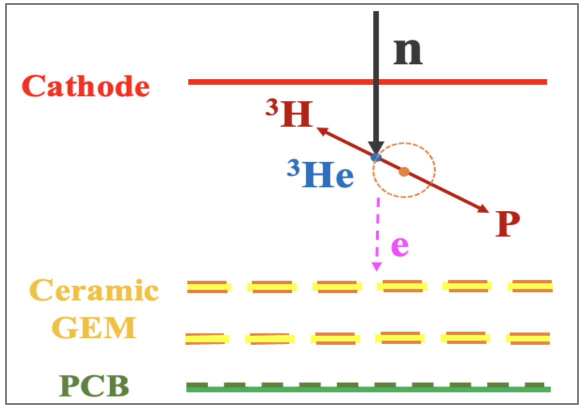
GEM counting rate 10 MHz



^{3}HE gas advantage

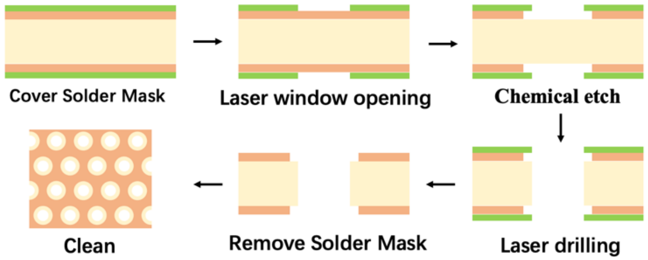


GEM neutron detector with ^{3}He

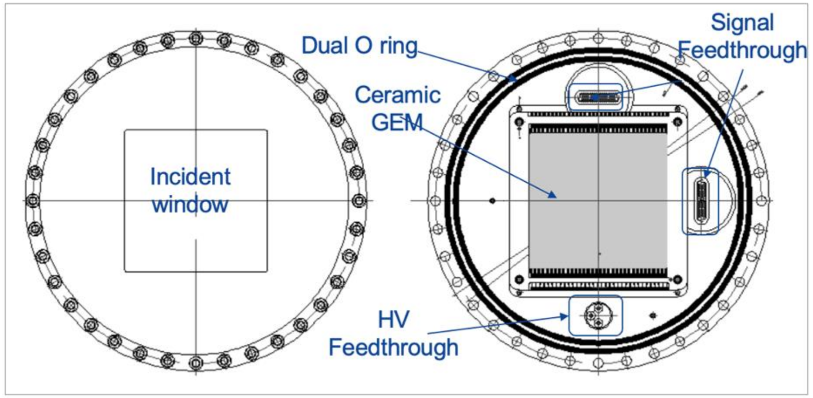


Laser drilling for ceramic GEM

- Laser preparation new technologies and methods
- Research ion feedback physics for new design



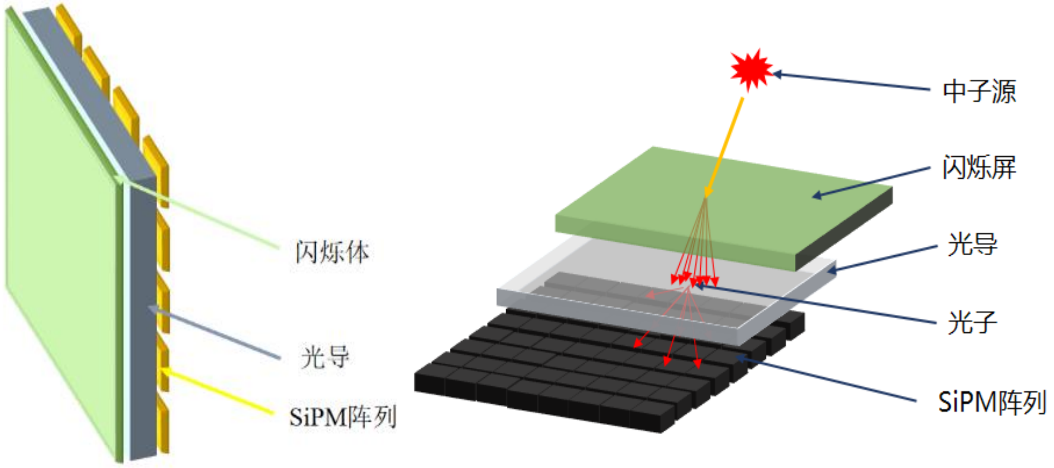
Detector high-pressure chamber design

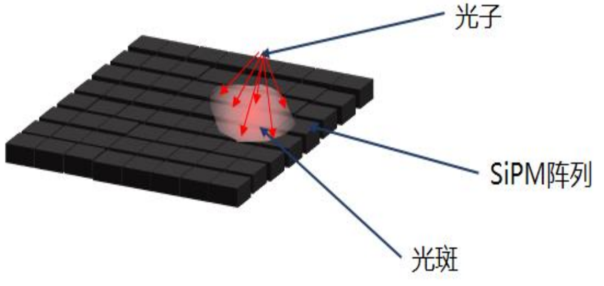


Large-Area Scintillator Detector – 3rd generation

High-Resolution Scintillation Detector, spatial resolution: ≤1mm×1mm

- Aiming at the urgent needs of high -performance neutron detector for CSNS II

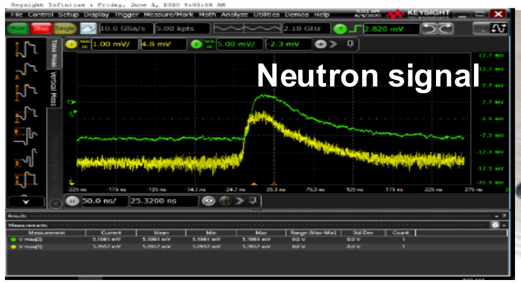


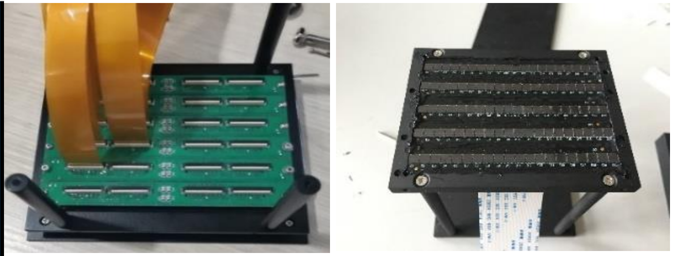


$$x = \frac{x_1 \times w_1 + x_2 \times w_2 + \cdots x_n \times w_n}{w_1 + w_2 + \cdots w_n}$$

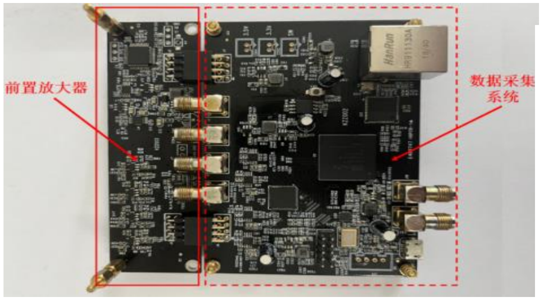
$$y = \frac{y_1 \times w_1 + y_2 \times w_2 + \cdots y_n \times w_n}{w_1 + w_2 + \cdots w_n}$$

Detector module design

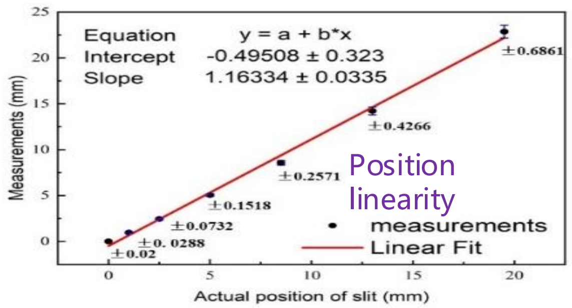


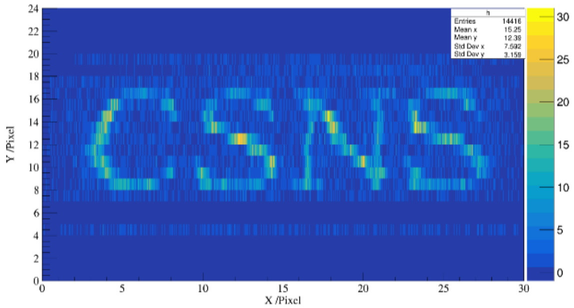


Prototype (10cm*10cm)

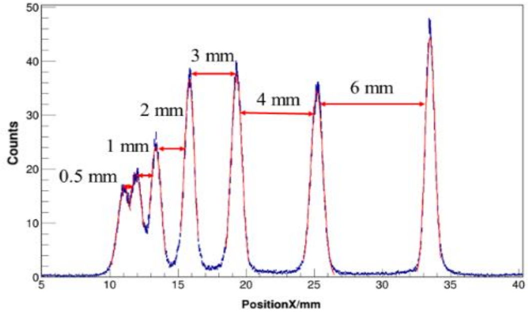


•Electronic readout system





2D imaging



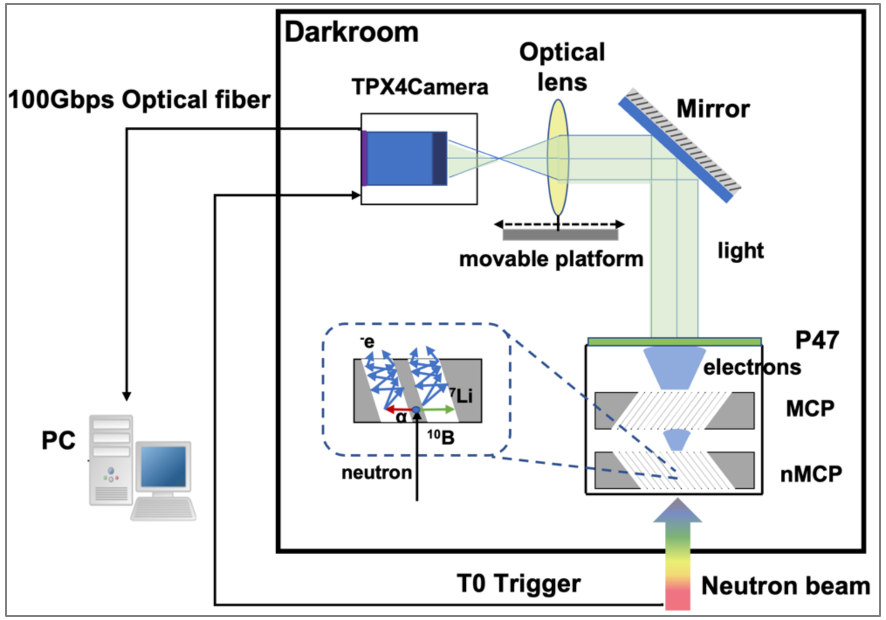
0.5mm position resolution

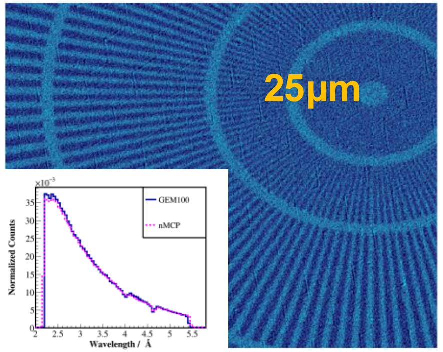
Neutron imaging detector with ultra high spatial resolution

Microsecond-level time resolution, and micron & even sub-micron level spatial resolution

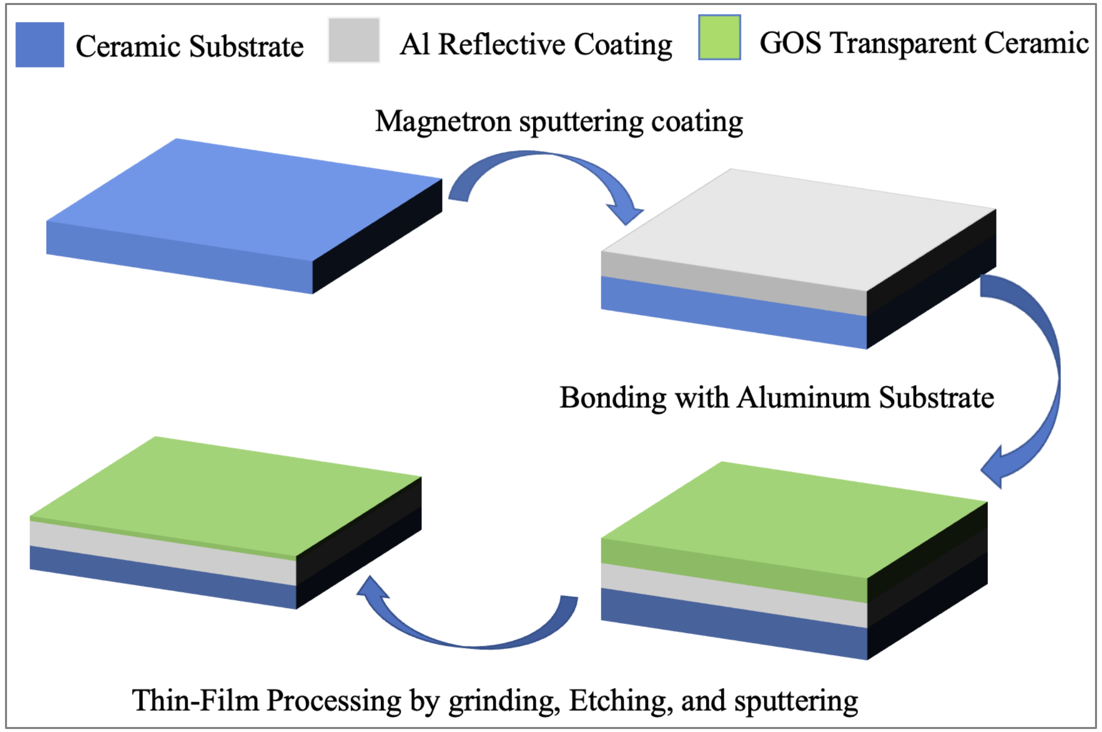
- Researching neutron image intensifiers, integrating neutron conversion and intensifier into a single vacuum device to improve integration.
- Developing ultra-thin transparent ceramic scintillators and TimePix4 cameras.

Neutron image intensifier



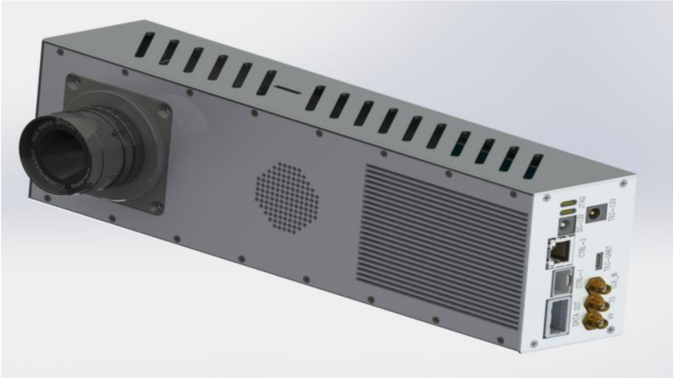


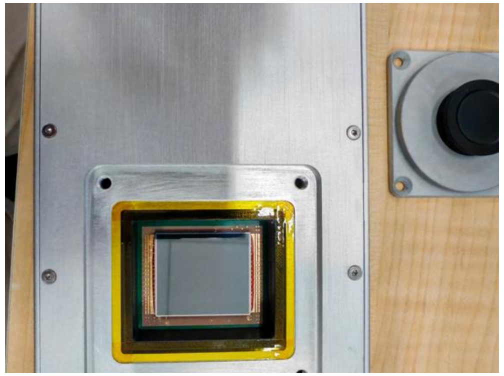
Ultra-thin transparent ceramic scintillator



Neutron imaging detector and the Timepix4 Camera

A prototype of neutron imaging detector based on Timepix4 Camera





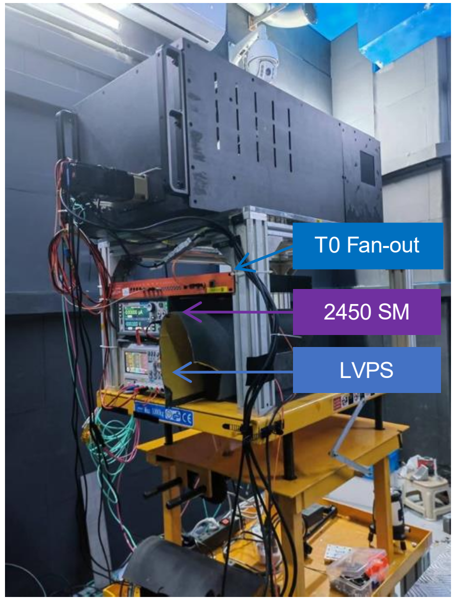
CSNS officially joined the Medipix4 international collaboration group in 2022.

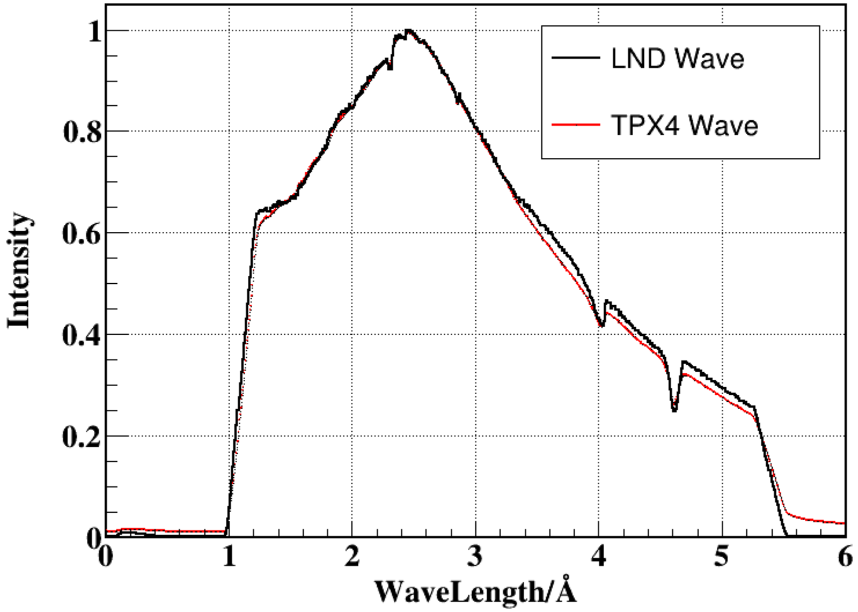
CSNS Timepix4 Camera

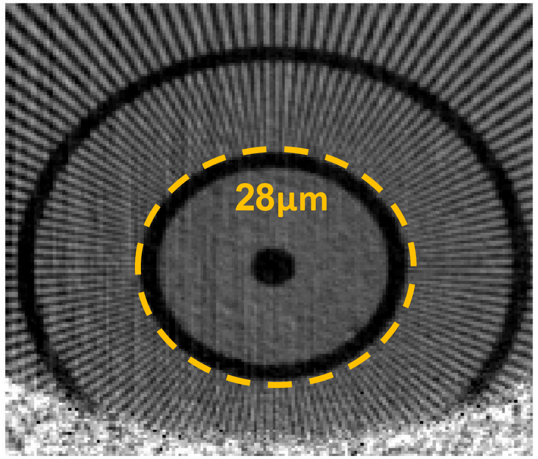
- 1 x Advafab 300um Si sensor with Al window
- CSNS Readout system (ZU15EG + 16 GWT)
- 10GbE/40GbE/64G custom link readout
- TEC cooler with PID controller
- Integrated HV generator and I/V monitor (being developed)

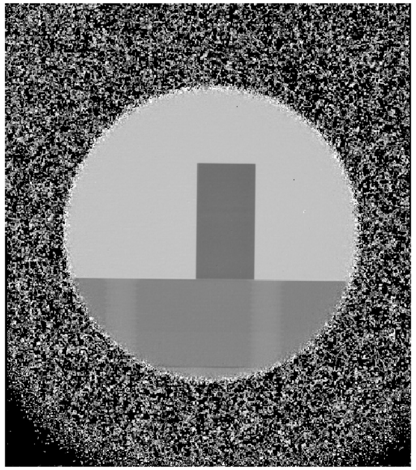
Neutron imaging detector and the Timepix4 Camera

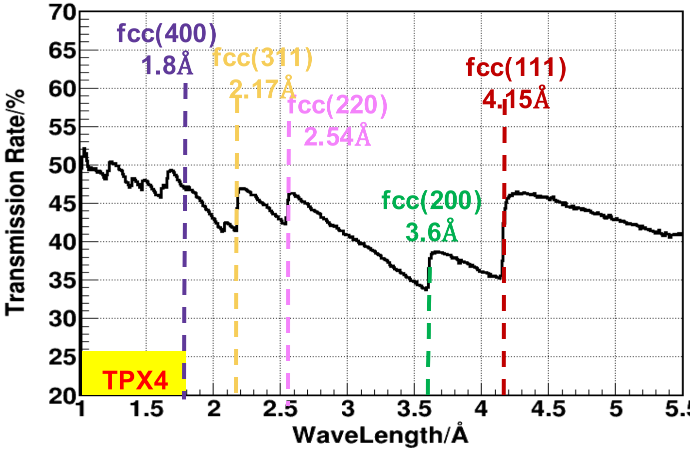
Maximum event rate measured at BL20 was 35.5M hits/s without saturation





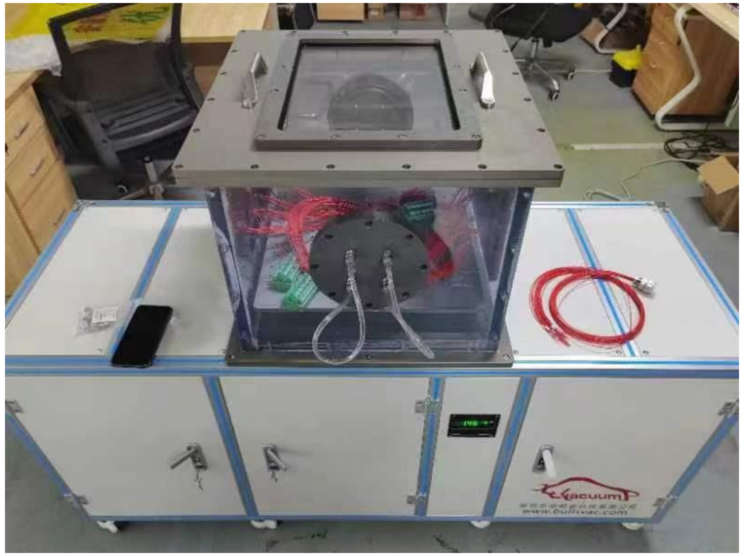


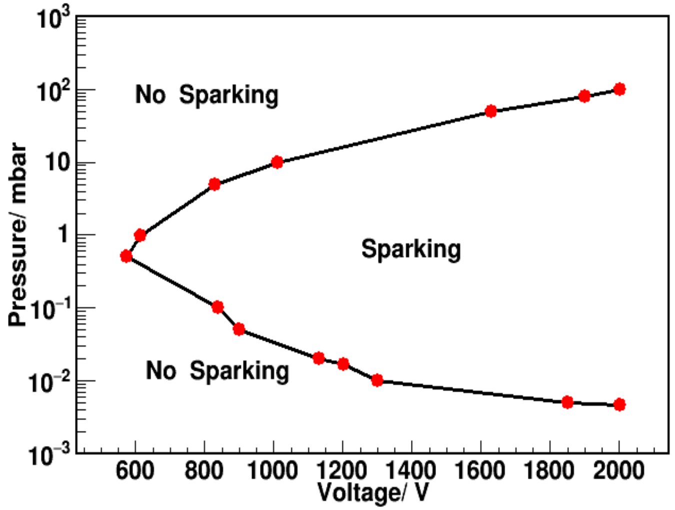




Environment Testing Platform

Vacuum environment

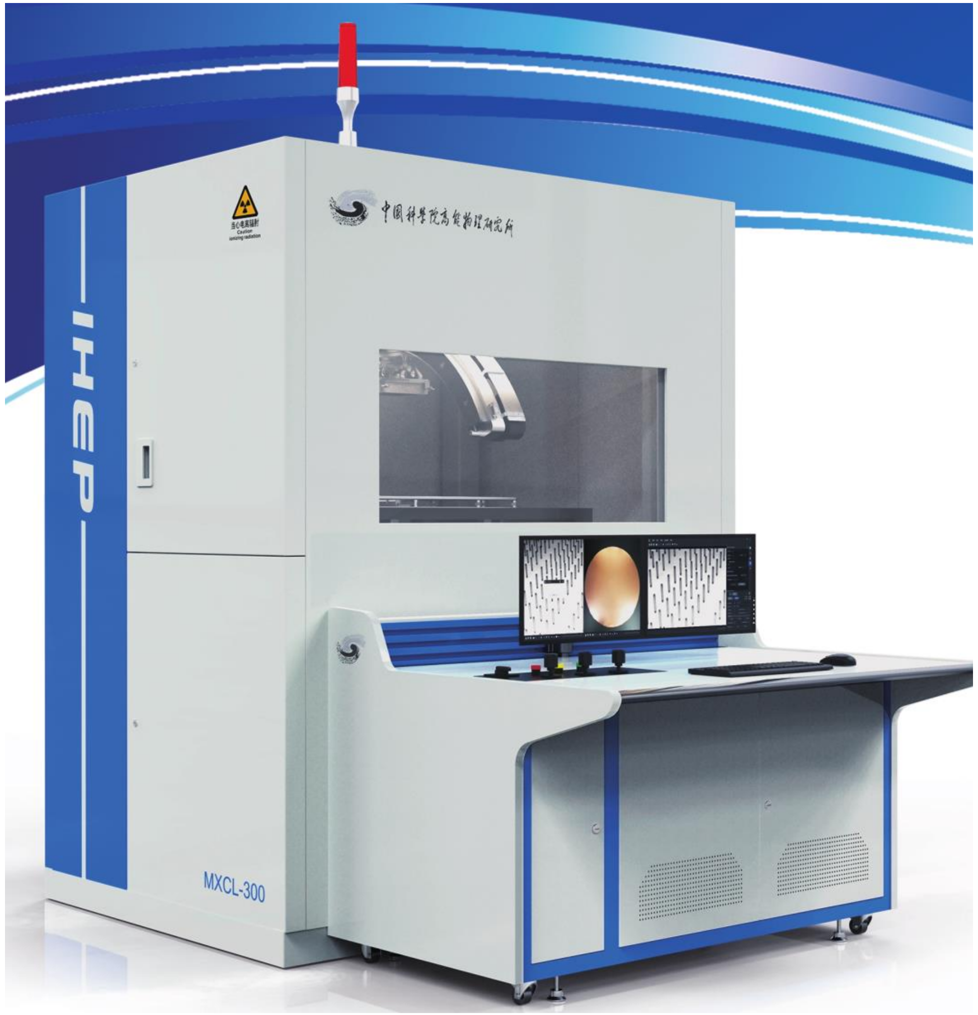




Magnetic environment

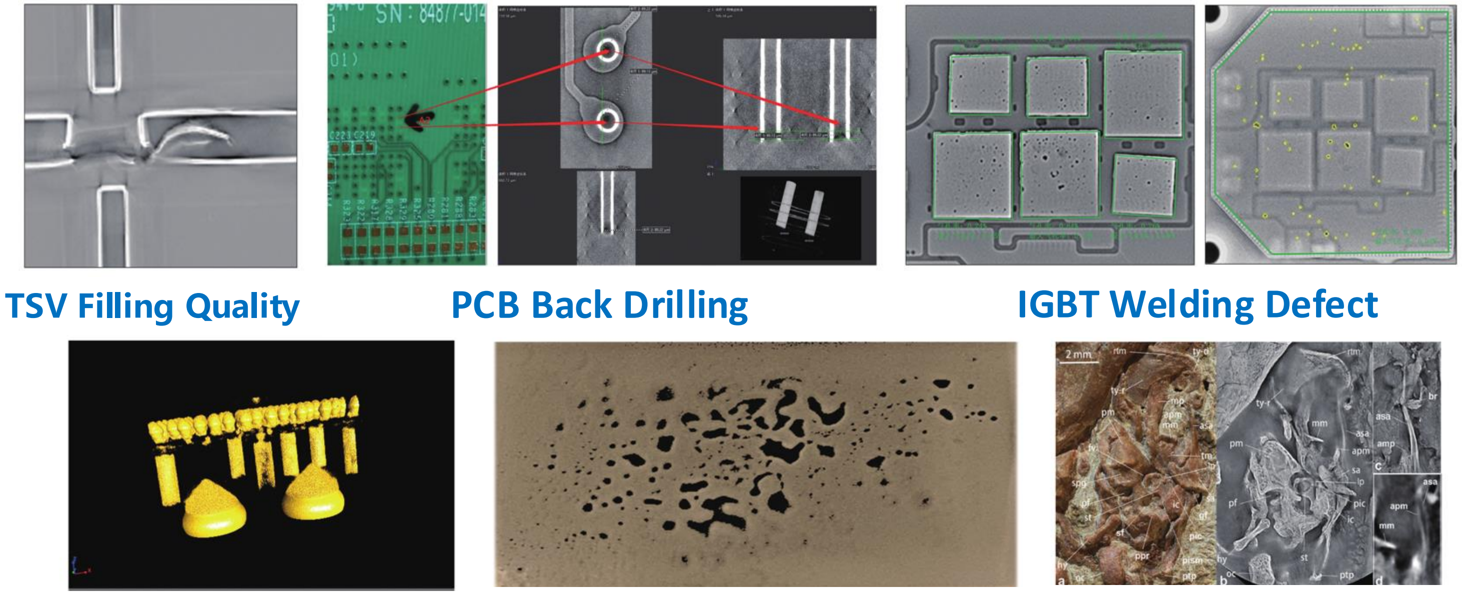
Magnetic Field Mapping	magnetic field mapping; 10^{-6} T – 1T; 0Hz – 1MHz; Accuracy: 1mm
Strong Magnetic Field Testing	Ambient/Superconducting magnet testing (≤9T)
Fixed Magnetic Field Testing	• Electromagnet: 100G 3D magnetic field • Electromagnet: 2T single-axis magnetic field • Permanent Magnet: 500G unidirectional magnetic field.
Zero Magnetic Field Testing	Multi-layer magnetic field shielding; ≤10^{-6} T (0.01G)

3D X-ray Tomographic Imaging Platform



- Developed independently by IHEP
- Main Functions:
  - 3D tomographic imaging of flat objects and small-sized samples like circuit boards, microdevices, fossils, etc.
- Technical Specifications:
  - Microfocus X-ray source, maximum voltage 160kV, maximum target power 50W, spatial resolution 2 microns.
  - Detection area 300mm x 300mm

应用案例



TSV Filling Quality

PCB Back Drilling

IGBT Welding Defect

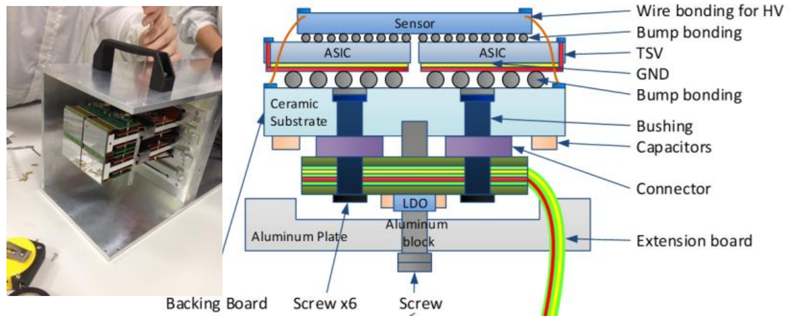
3D Stacked Packaging

Device Welding Defect

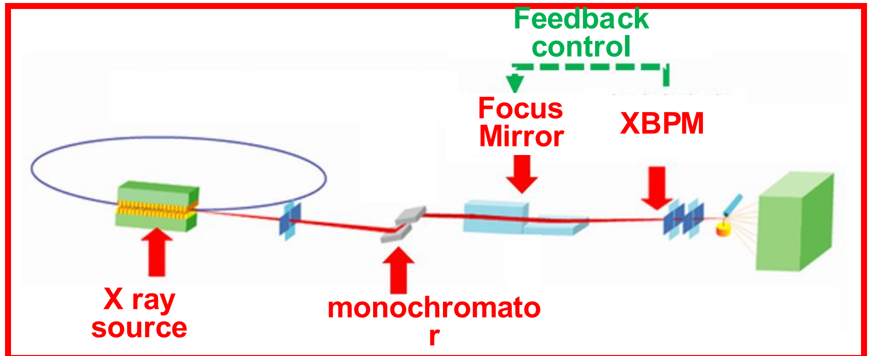
Flat Fossil Imaging

Nanofabrication Lab for Detector Development

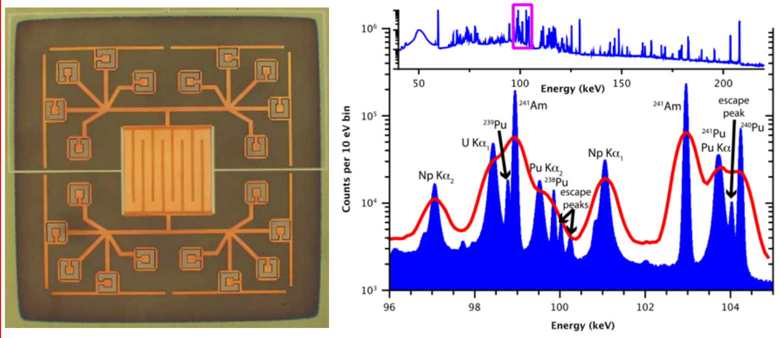
□ Research feilds:



Multi-threshold photon counting pixel array detector



Beam position stabilization system based on diamond detectors



Ultra-high energy resolution detector based on TES

□ Supporting Conditions:

Laser Direct Writing Lithography Machine

Magnetron Sputtering Coating machine

Reactive Ion Etching Machine

Wire bonding

Probe Station & Semiconductor Analyzer

Microscope

Micro-Nano Fabrication:

- Minimum critical dimension: 300nm
- Overlay alignment accuracy: 500nm
- Maximum substrate size： 6 inch

Packaging Integration：

- Maximum wire length： 8mm
- Bonding accuracy： 3μm
- Bonding Wire Range： 56mm*90mm

Testing and Calibration：

- I-V、C-V Curve, Voltage range： -210V~210V
- High-Bandwidth Oscilloscope, Bandwidth: 36GHz

Summary

- Tightly around the requirements of neutron instruments, establish a neutron detectors family, promote engineering construction and exploration of new technologies.
- Based on engineering and R&D requirements, establish various functional testing and development platforms.
- Set up a micro-nano structure detector R&D platform.
- In the future, will focus on the demands of major scientific projects:
  - Solve engineering challenge, conducting engineering technical R&D (vacuum, magnetic field, electromagnetic interference, background suppression).
  - Exploring new technologies to enhance the performance of instruments

Acknowledge

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State Key Laboratory of Particle Detection and Electronics

中物院中子物理学重点实验室
Key Laboratory of Neutron Physics,CAEP

中国科学院青年创新促进会
Youth Innovation Promotion Association CAS

中国原子能科学研究院
China Institute of Atomic Energy

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LANZHOU UNIVERSITY

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1953
HARBIN ENGINEERING UNIVERSITY

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Thanks for your attention !