Update on J-PARC detector development efforts

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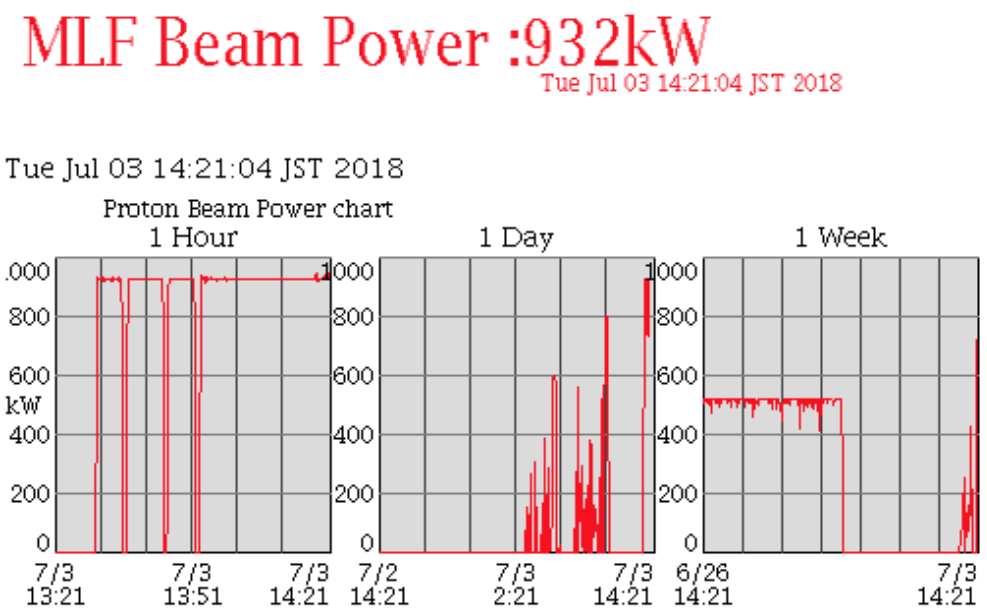
J-PARC Center

MLF Beam Power Status

- MLF beam power: 500 kW and very stable
- ~1MW operation achieved last year (1 hour) and this year (almost 1 day)
- Our mercury target vessel works well

MLF mercury target



MLF beam power, as of July 3, 2018

Outline

1. Introduction of our installed detectors at J-PARC MLF

2. Upgrading of the installed detector

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1. Introduction of our installed detectors at J-PARC MLF

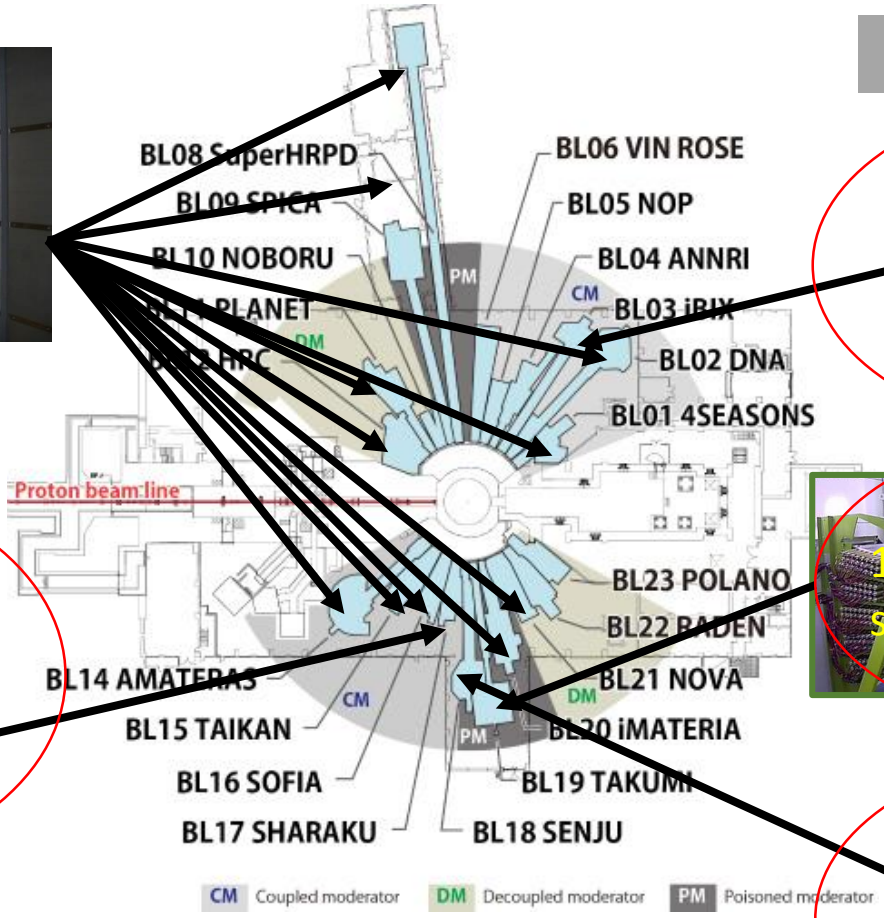
2. Upgrading of the installed detector

Current Status of Neutron Detectors at the MLF

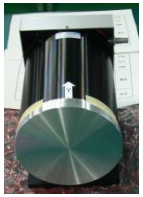
Commercially available
He-3 detectors

BL01, BL02, BL08, BL09, BL11, BL12
BL14, BL15, BL16, BL17, BL20, BL21

BL17



BL04
Germanium detector



BL16, BL17
RPMT

Scintillator detectors

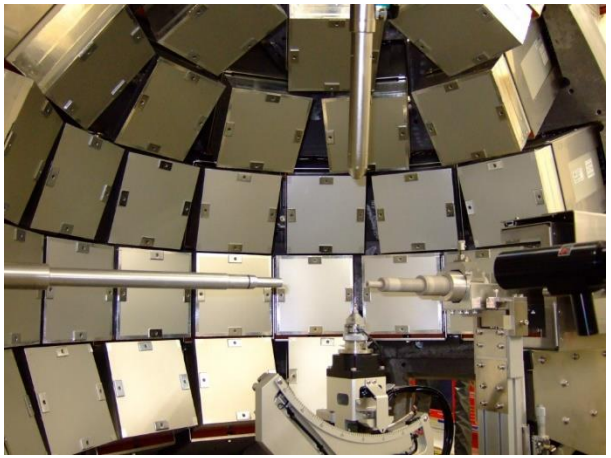
BL03

BL19

BL18, BL17

Our Scintillator detectors installed at the MLF

iBIX (BL03): Bio-single crystal diffractometer



High spatial resolution detector

- **WLS Fiber technology**
- **pixel size : 0.5 x 0.5 mm^2**
- **sensitive area : 133 x 133 mm^2**
- **detection efficiency: ~50% for 1.8Å**
- **gamma sensitivity: ~1 x 10^{-6}**

Preinstalled 14 detectors are re-newed, and other 16 detectors are produced.

Total 30 detectors are working now at BL03

SENJU (BL18): Single crystal diffractometer

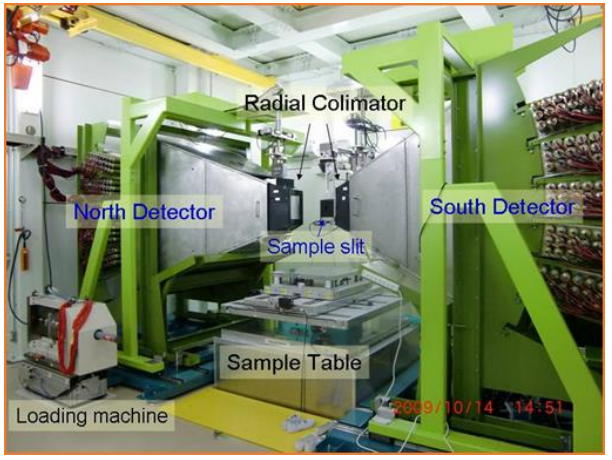
Large area detector

- **WLS Fiber technology**
- **pixel size : 4 x 4 mm^2**
- **sensitive area : 256 x 256 mm^2**
- **detection efficiency: ~40% for 1.8Å**
- **gamma sensitivity: ~ 3 x 10^{-6}**

The last 6 detectors are installed to complete the detector system.

Total 37 detectors are working now at BL18

TAKUMI (BL19): Residual Stress diffractometer



One dimensional large area detector

- **Coded fiber technology (with ISIS)**
- **pixel size : 3 x 200 mm^2**
- **sensitive area : 200 x 1000 mm^2**
- **detection efficiency: >50% for 1.0Å**
- **gamma sensitivity: < 1 x 10^{-6}**

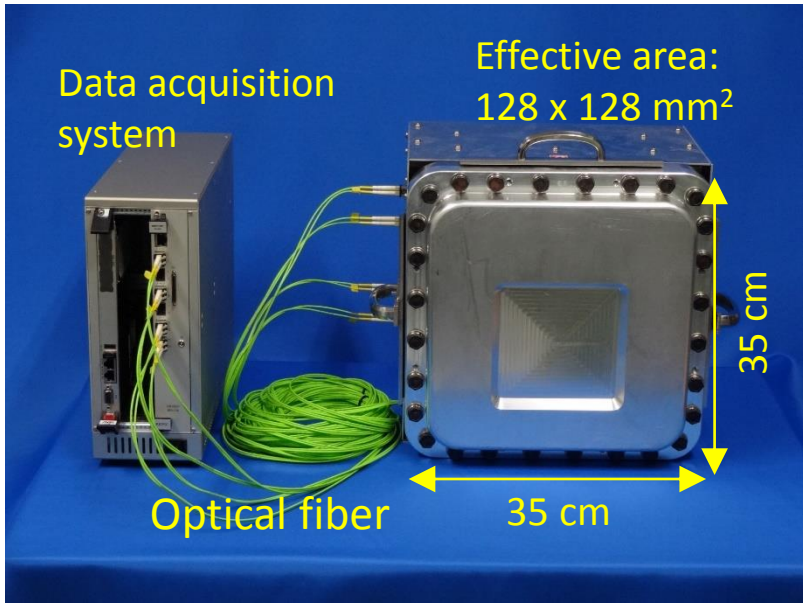
10 detectors firstly installed, 2 detectors were added.
2016 JAEA president's award

Total 12 detectors are working now at BL19

Unique instruments using WLS fiber detector in the world

Special thanks to ISIS det. group

Gas-based Detector System for BL17



2D neutron detector (MWPC) system

Installed in MLF/BL17

- **Multiwire-type detector element**
  Wire pitch: 1 mm
  Sensitive area: 128 x 128 mm²
- **Pressure vessel withstanding up to 8 atm**
- **Individual line readout**
- **Optical signal transmission**

Sharaku(BL17):

polarized neutron reflectometer

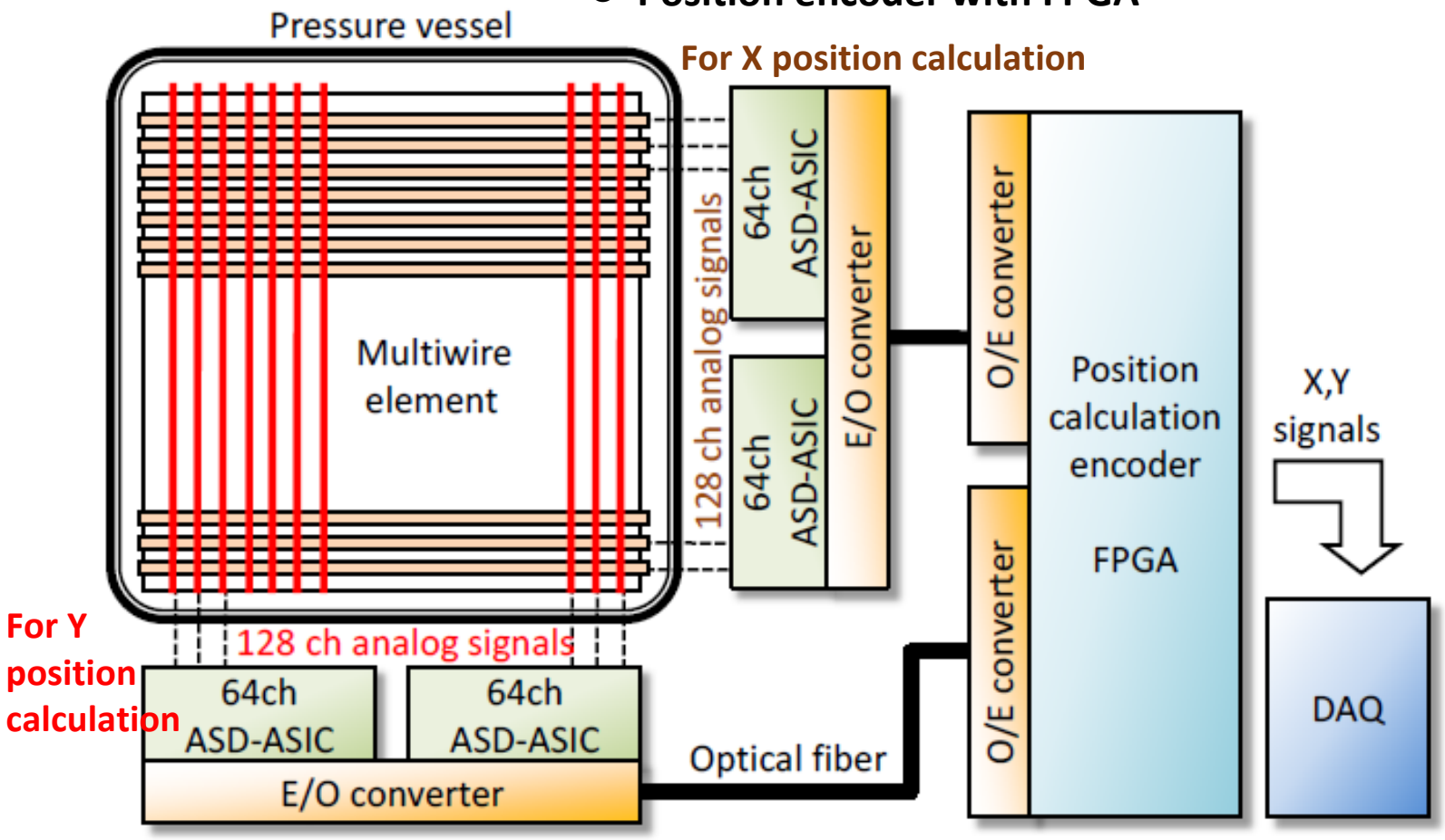
Specifications of MWPC

- Position resolution: 1.8mm FWHM
- 2D Uniformity: 8.3% deviation
- Counting Linearity: >5 decades (> 2 x 10^5 cps)
- Position linearity error: <0.5%
- Gamma sensitivity: <10^{-7}
- Neutron detection efficiency: >80%

Gas-based Detector System for BL17

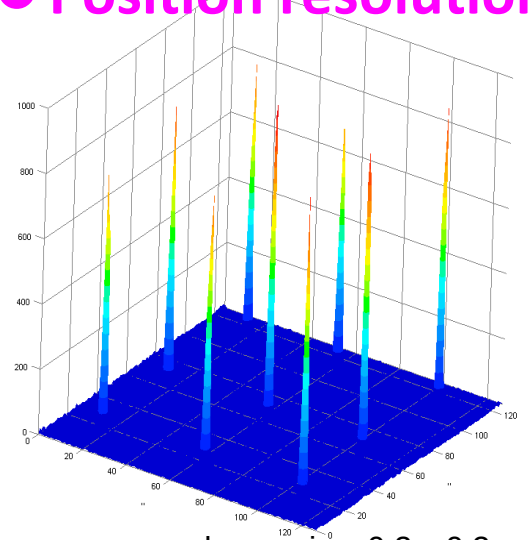
Signal processing scheme with individual line readout

- **ASD-ASICs for multi-channel signal processing**
- **Optical transmission from detector head to DAQ device**
- **Position encoder with FPGA**

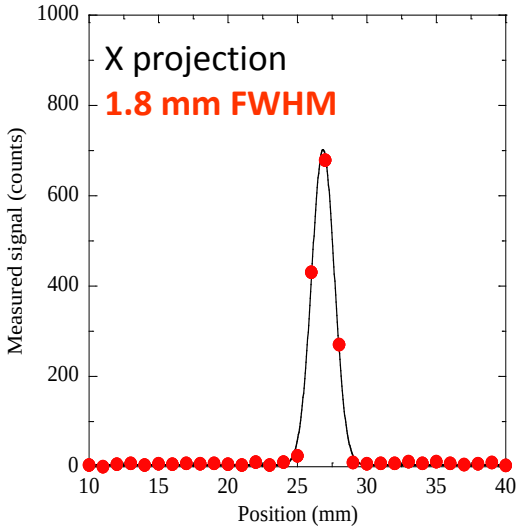


Some performances of MWPC

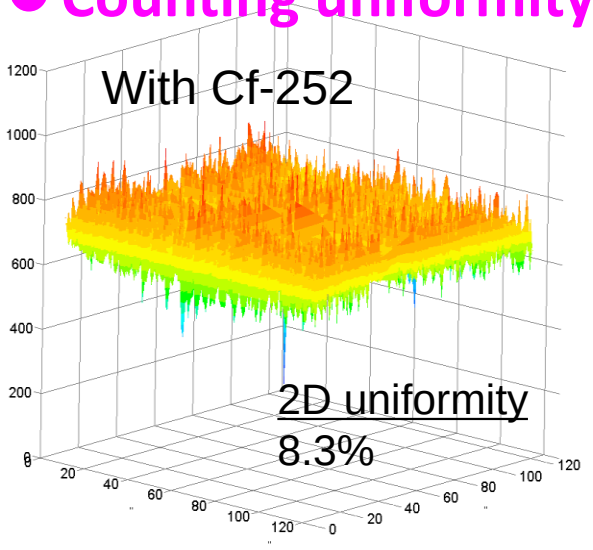
● Position resolution

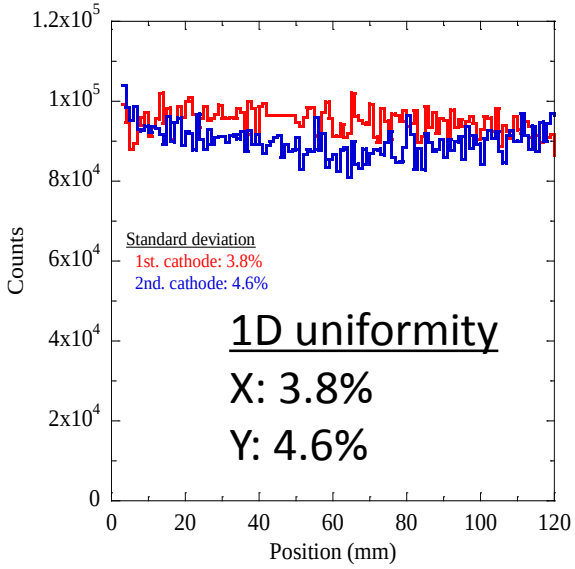


beam size: 0.3 x 0.3 mm^2

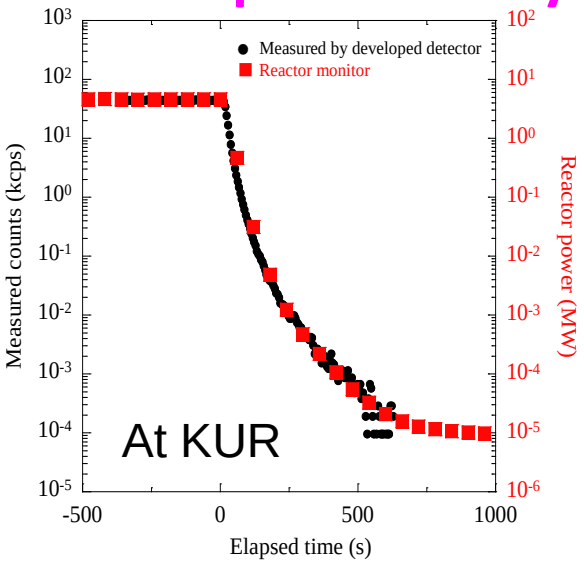


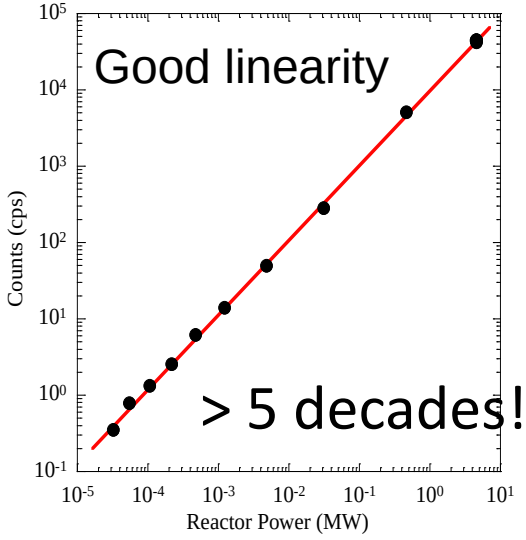
● Counting uniformity





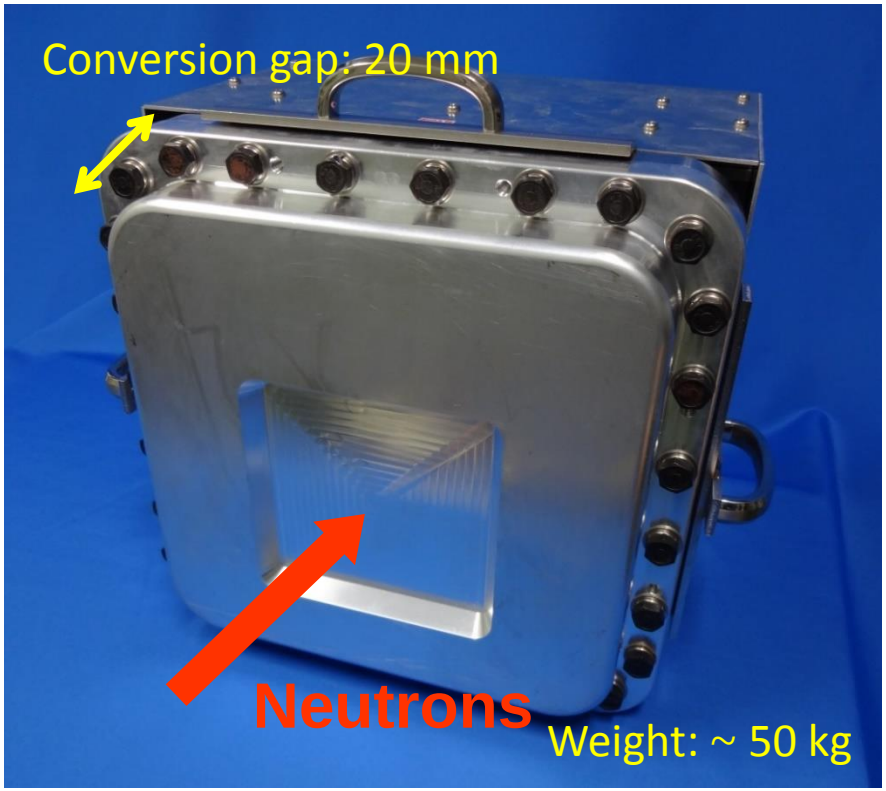
● Output Linearity





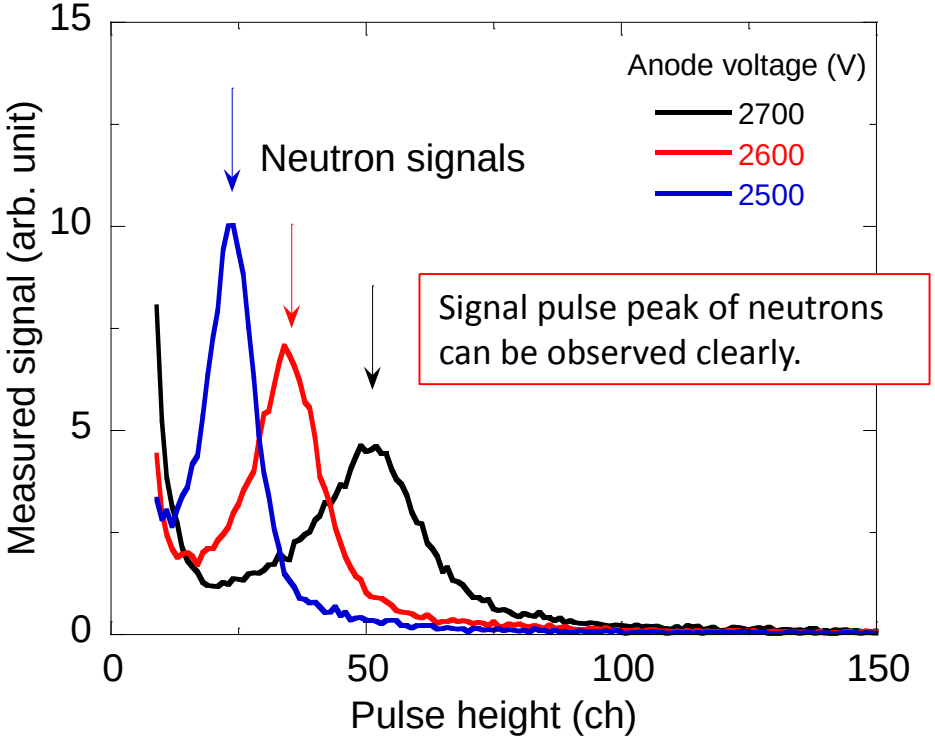
High pressure operation of MWPC

It is necessary to increase the gas pressure of MWPC to achieve high detection efficiency with a thin conversion gap. As a result of demonstration experiments, we have confirmed good operation of the MWPC with high gas pressure of 0.8 Mpa.



The specially-fabricated pressure vessel with the conversion gap of 20 mm. The vessel can withstand pressures of up to 0.8 MPa.

Pulse-height distributions under neutron irradiation with pressure of 0.8 Mpa (He/CF4=0.71/0.09)



With pressure of 0.8 MPa (He/CF_4 = 0.71/0.09), detection efficiency for thermal neutron is 86.9%.

Outline

1. Introduction of our installed detectors at J-PARC MLF

2. Upgrading of the installed detector

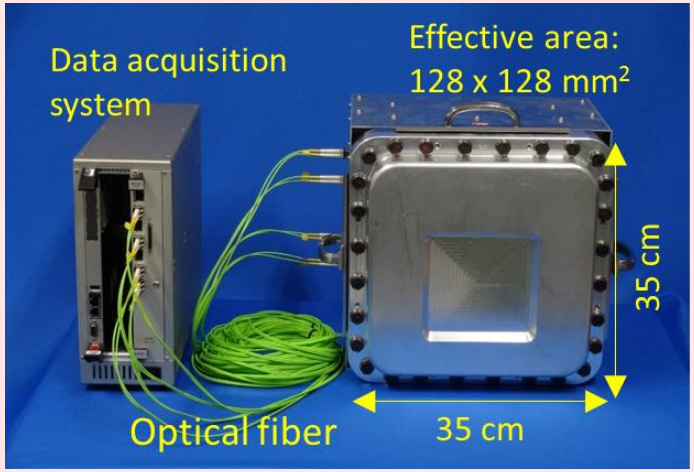
Our Mission for Neutron Instruments

Upgrading of our installed detectors

SHARAKU (BL17):

Polarized neutron reflectometer

Detector: MWPC



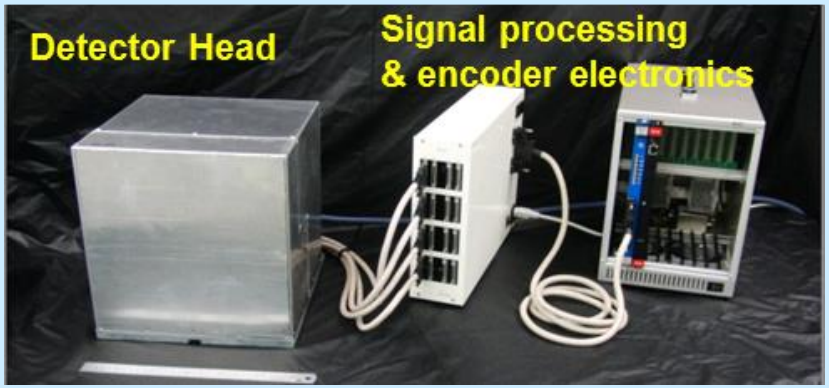
Under Improvement of the Detector Head

- high spatial resolution
- high count rate capability

SENJU (BL18):

Single crystal diffractometer

Detector: 2D scintillator WLSF detector

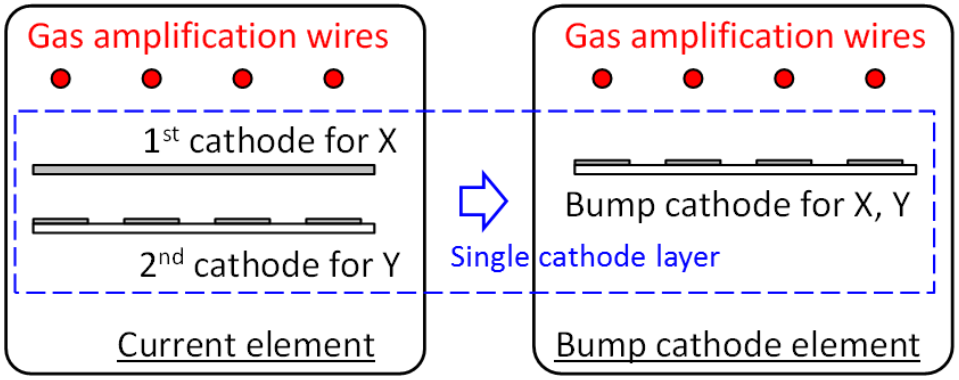


- Development of slim detectors and a large area detector for new vacuum vessel to be installed at BL18

Upgrading of gas-based detector at BL17

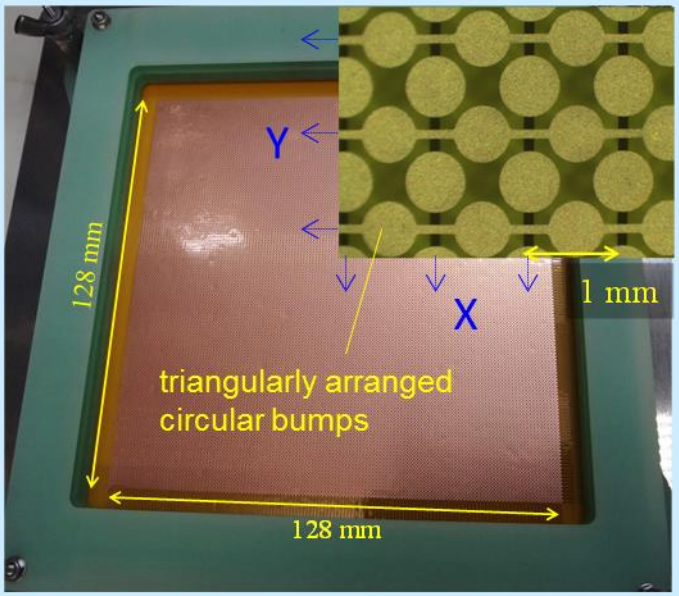
Improvement of charge collection element of MWPC

The charge collection element of MWPC is being improved to be a simple and efficient charge collection configuration for improvement of manufacturability and maintainability, and increase of detector signal, aiming to establish high detector performances



Comparison of new head consisting bump cathode elements with conventional one

Conventional head has two cathodes for X and Y, and is a little bit complicated. Newly developed head is simple and has good manufacturability

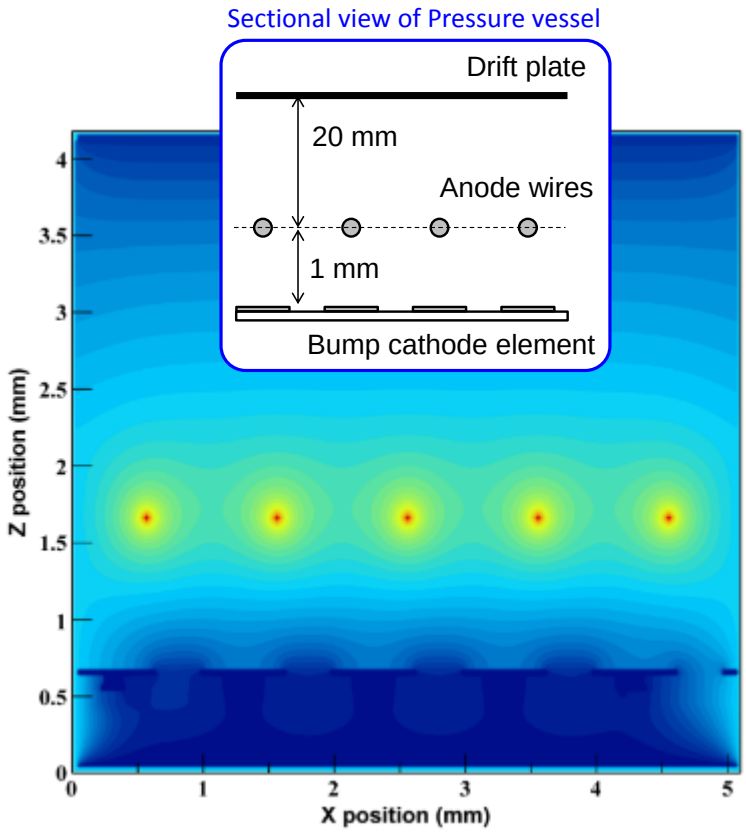


Entire and partially magnified photograph of a developed bump cathode element.

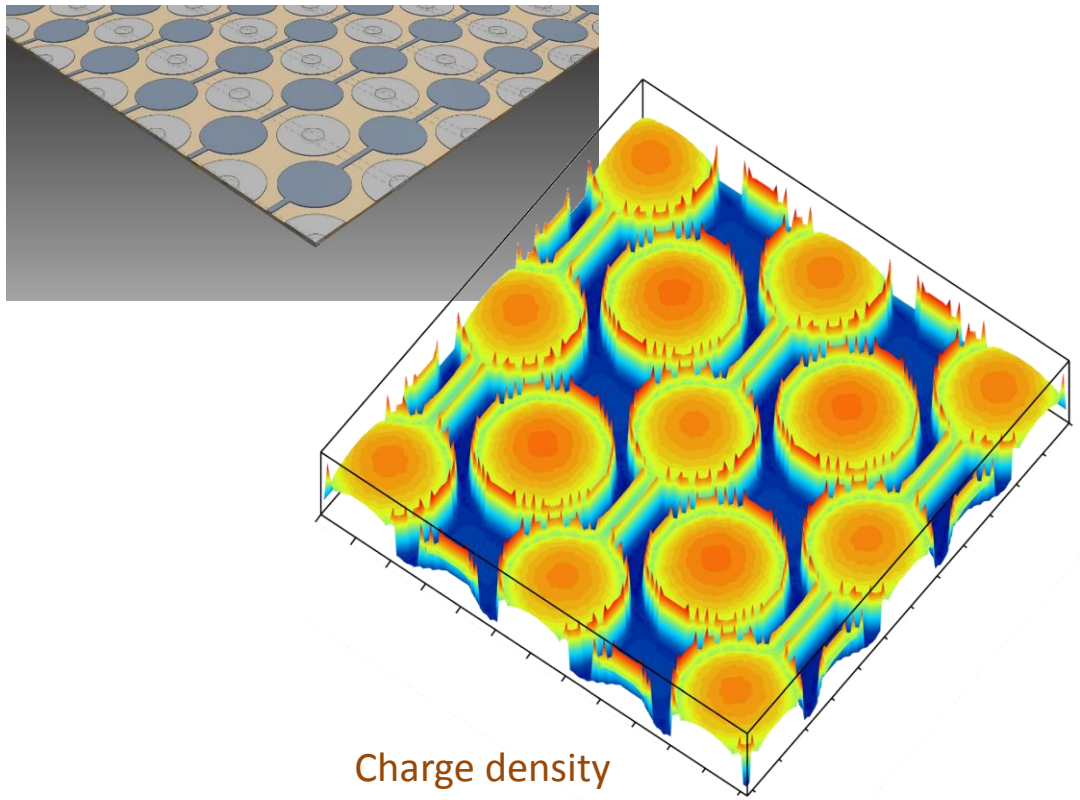
Upgrading of gas-based detector at BL17

Numerical Simulation for Bump cathode element head

Simulation was conducted to study the electric behavior of the detection system using the bump cathode element. The strong charge density was obtained at the center and the edge of the cathode bumps.



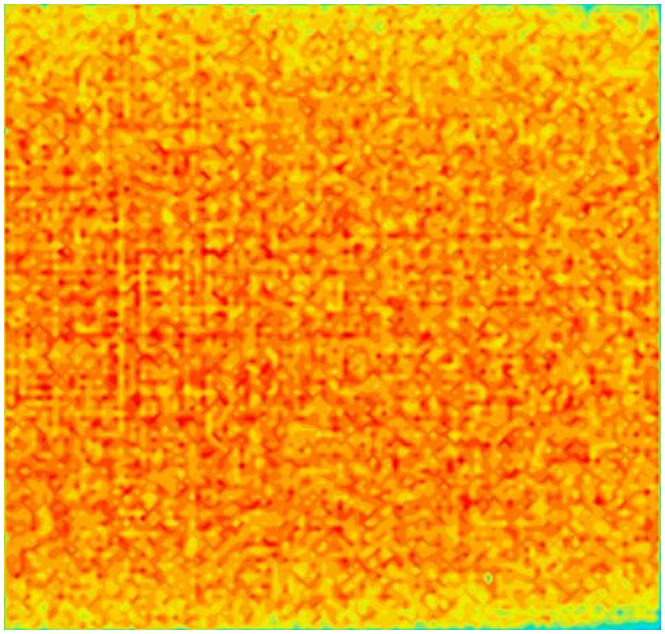
Electric potential distribution



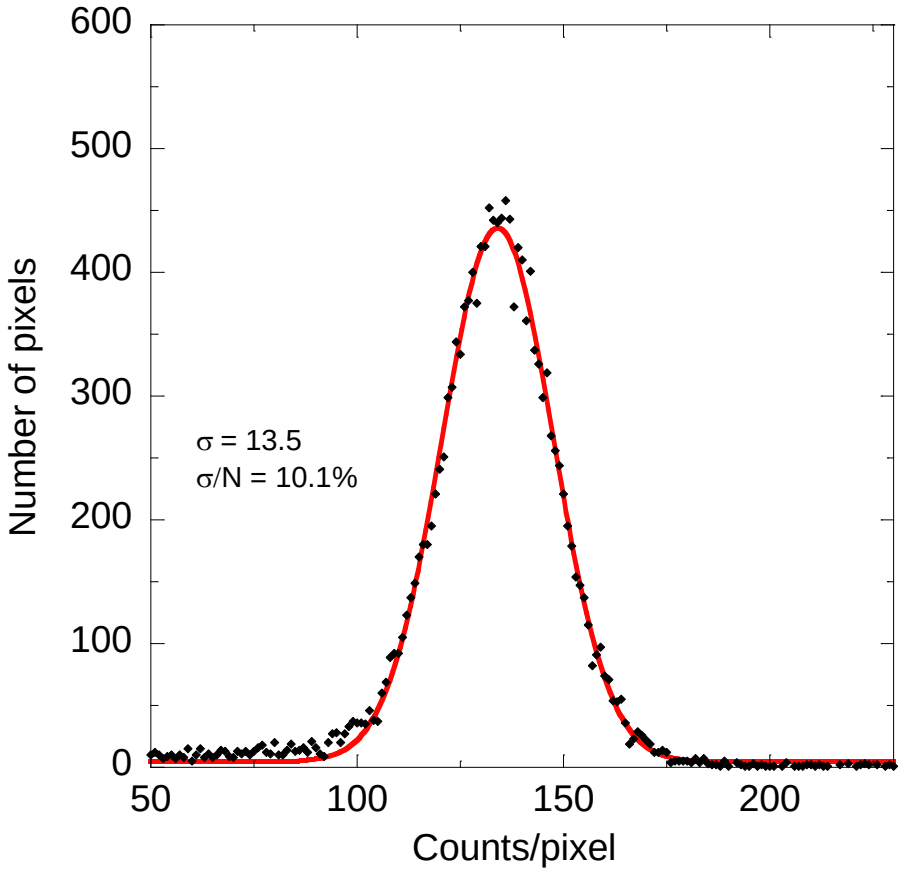
Charge density

Upgrading of gas-based detector at BL17

Uniformity measurement with Bump cathode element head



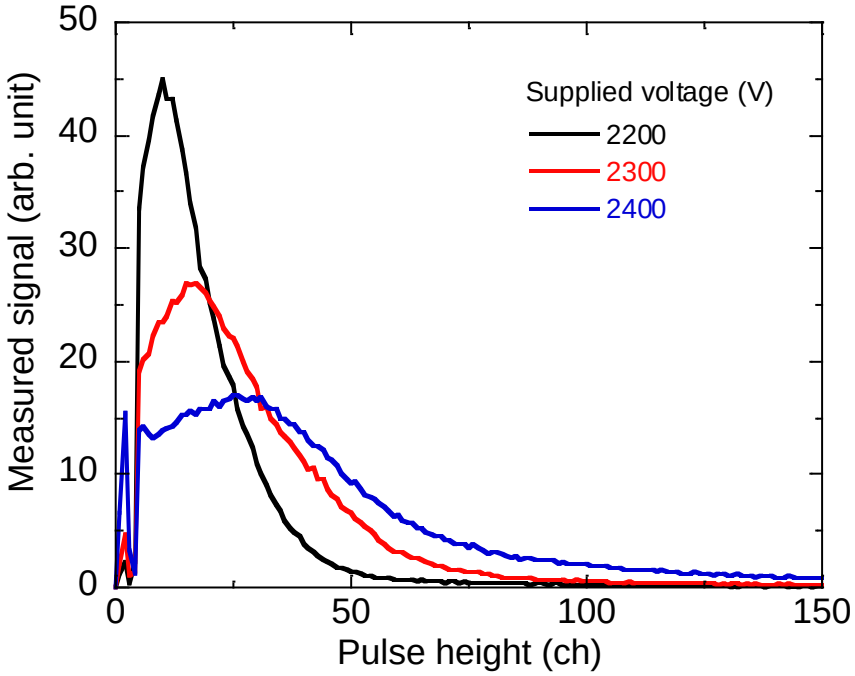
2D uniformity measurement results under neutron irradiation with Cf-252 source



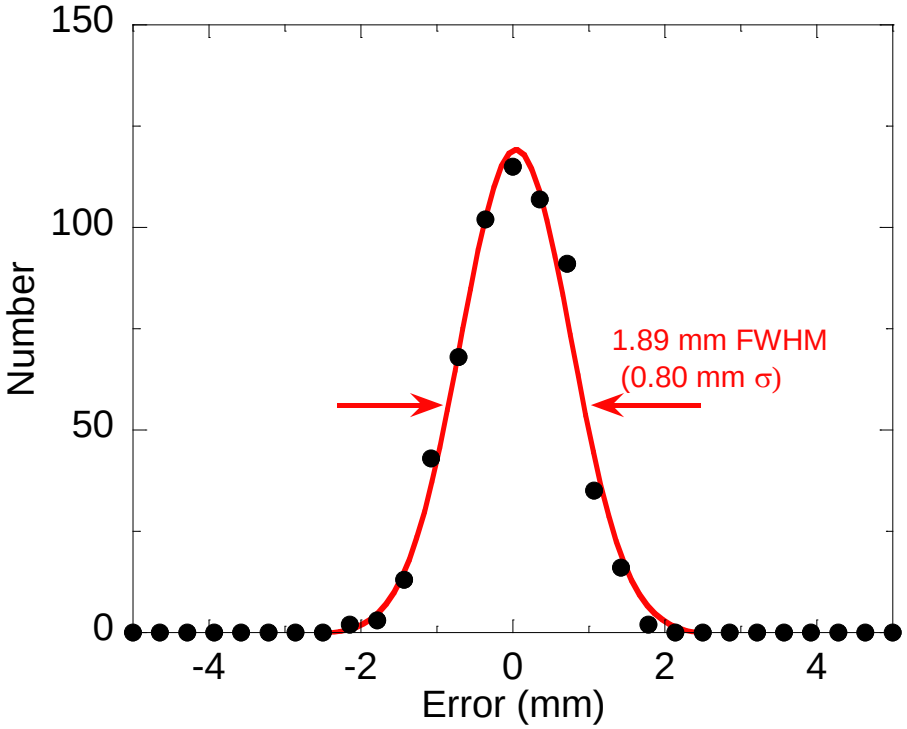
Histogram of all pixel contents.
Superior uniformity was obtained.

Upgrading of gas-based detector at BL17

Some results with Bump cathode element head



Pulse-height distribution under neutron irradiation. Neutron signal peak can be observed.

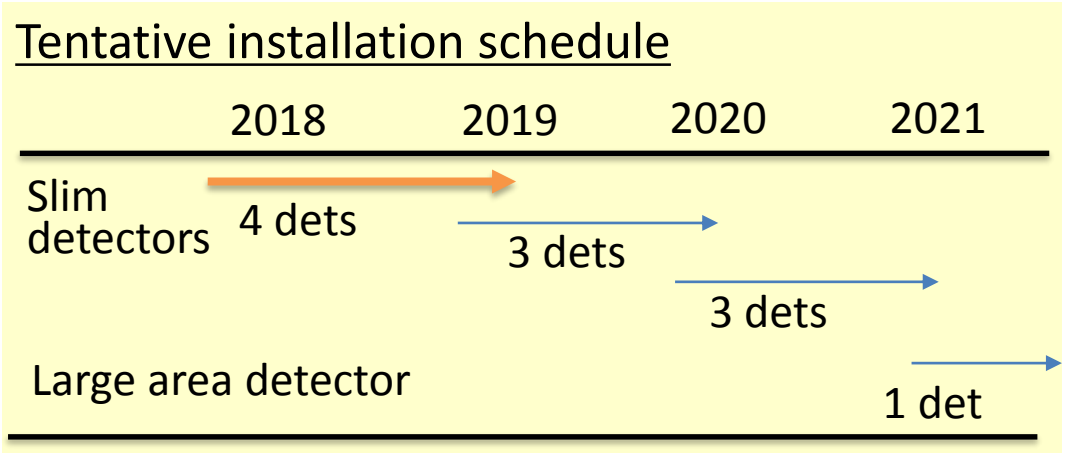


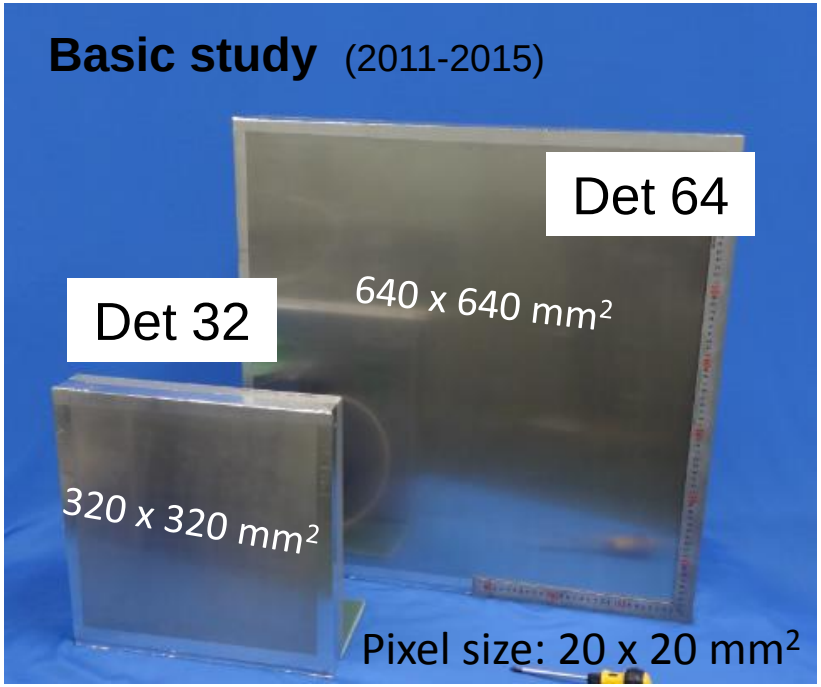
The estimated intrinsic position error caused by the difference of track lengths of proton and triton.

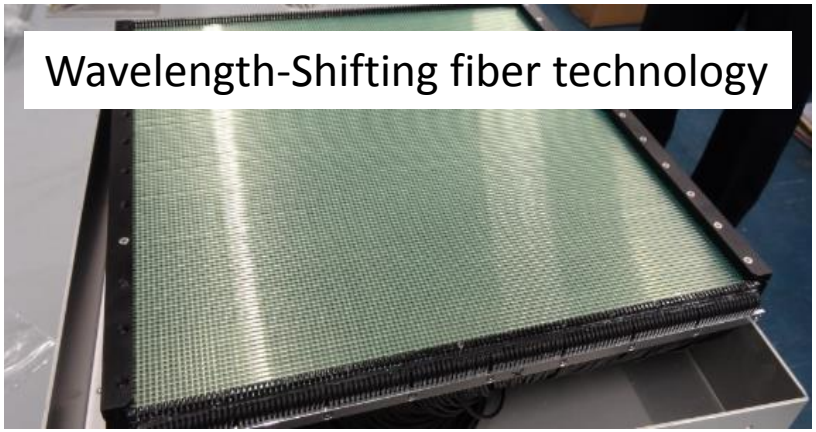
Upgrading of scintillator detector at BL18

Add-in two-dimensional scintillator detectors

New vacuum vessel to be installed,
More detectors are required.







Redesign of the detector

*detector size

*detector electronics

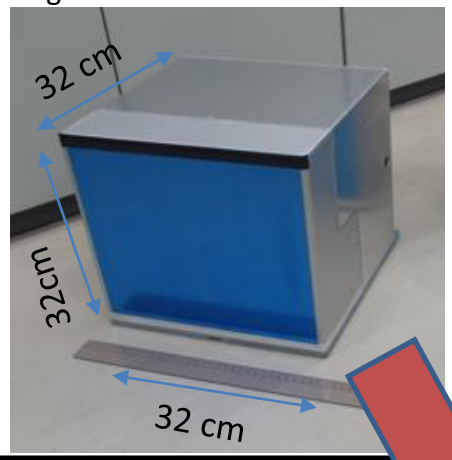
etc.

Upgrading of scintillator detector at BL18

Design and Fabrication of New 2D detector at BL18

BL18 (Senju)

Original detector

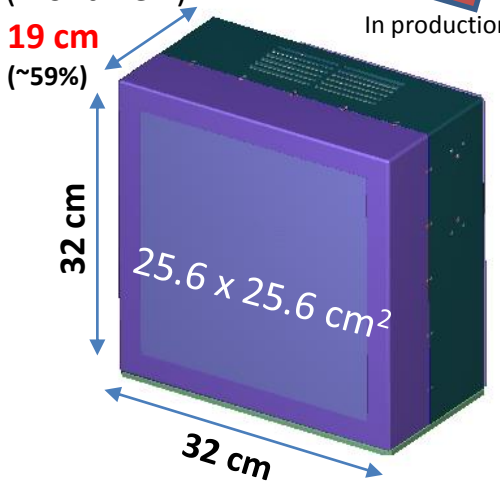


The detector has been redesigned as compact as possible because of space limitation.

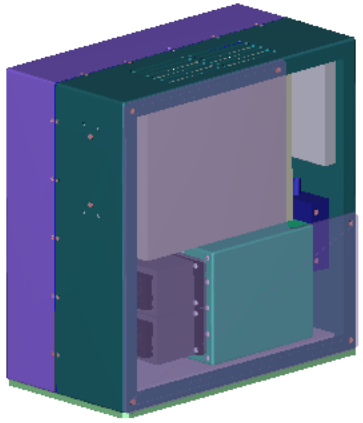
(Detector spec.)
- Pixel size: 4 x 4 mm^2
- Area: 256 x 256 mm^2
- Physical size: 32 x 32 x 19 cm^3
- Weight: <20kg

In production

(Front view)



(Rear view)

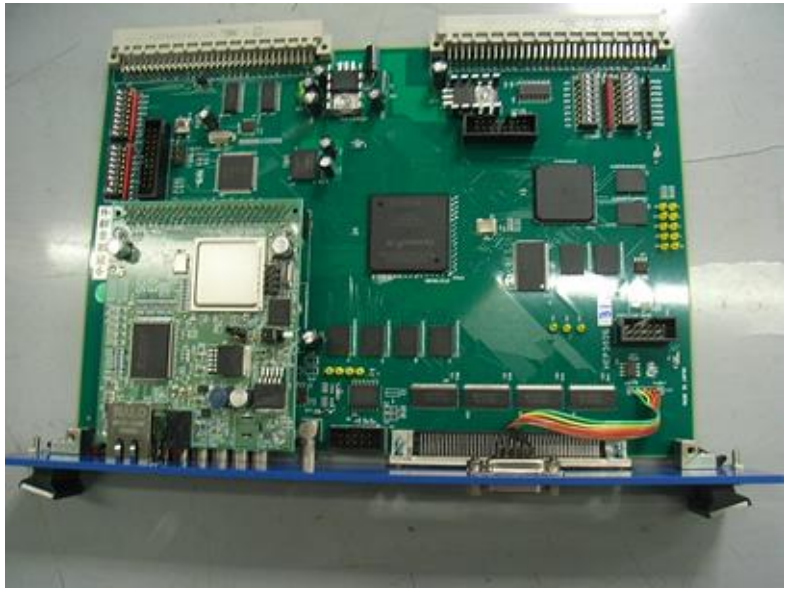


The new 2-d detector for SENJU has been designed. Four detectors are produced and under checking.

Upgrading of scintillator detector at BL18

Preparation for installation of four detectors at BL18

All DAQ boards used at BL18 were upgraded and checked (2019.7-10)

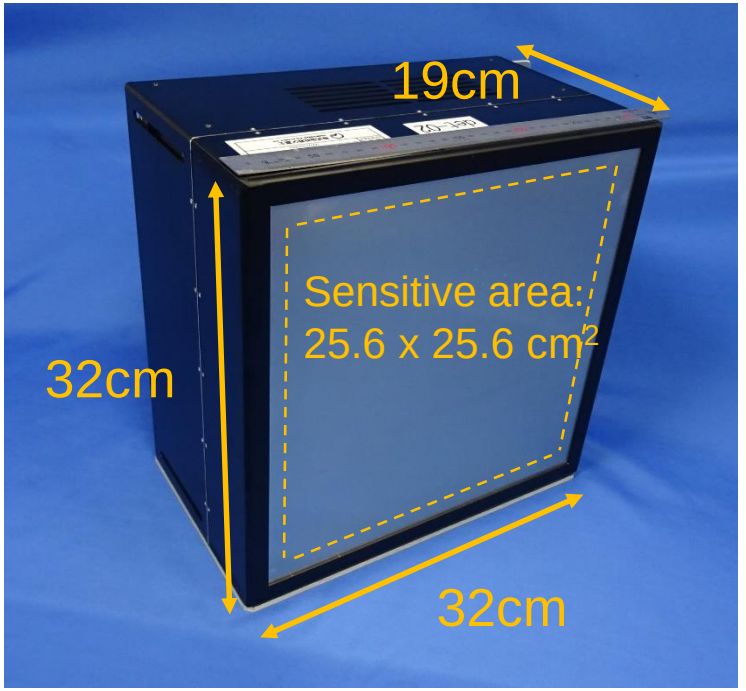


Upgraded DAQ board
(e.g., FPGA program renewed)

Upgrading of scintillator detector at BL18

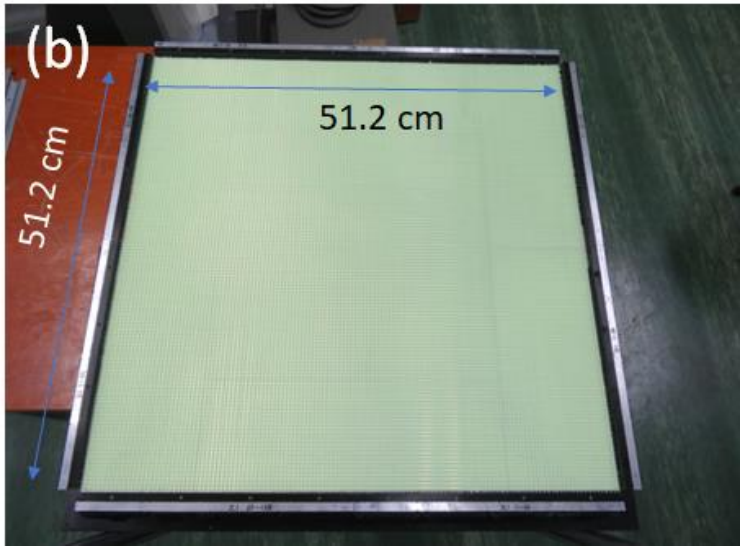
Preparation for installation of four detectors at BL18

After checking with MLF BL10 and Cf-252 Source (2019. 6-10), the four detectors were set at BL18 and being checked this October



Upgrading of scintillator detector at BL18

A Prototype large area detector at BL18



DETECTOR SPECIFICATIONS

Detector efficiency	: 45% (@1.8 Å)
^{60}Co gamma sensitivity	: 2 x 10^{-6}
Pulse pair resolution	: 5 us
Fiber channel number	: 128 x2
Neutron-sensitive area	: 51.2 x 51.2 cm^2 (~0.26 m^2)
Pixel size	: 4 x 4 mm^2
Physical size	: 60 x 60 x 20^d cm^3
Weight	: 30 kg

No degradation in fiber alignment position and in neutron sensitivity has been observed over one year after production.

For details, please visit our poster presentation;

NSS poster session II
Date & Time: Wed. 10:20-12:10
Poster ID: 236
Poster Number: N-19-236
Location: Central 1

Title: “A Large Area Position-Sensitive Scintillation Neutron Detector for Upgrading SENJU Diffractometer”

Summary

- Developed and installed three scintillator detectors and one gas-based detector at J-PARC MLF.
- Installed detectors:
  - WLSF 2D scintillator detector at BL03 and BL18
  - 1D fiber-coded scintillator detector at BL19
  - Gas-based 2D detector at BL17
- These detectors have been working well since their commissioning.
- Detector upgrade:
  - Newly developed head well demonstrated at BL17
  - Slim detectors produced and being installed at BL18
  - A prototype large area detector for BL18 fabricated and tested

Thank you for your attention