Development and Performance Evaluation of ECal Modules in China for the NICA-MPD

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for the MPD Collaboration

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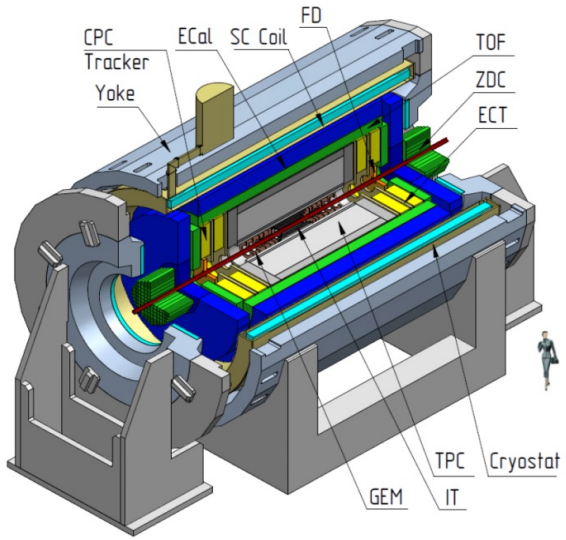
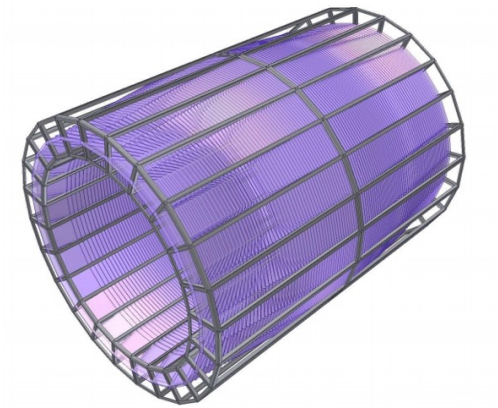
Outline

- **MPD-ECal introduction**
- **Fabrications and performance tests**
- **Cluster reconstruction**
- **Neutral mesons reconstruction with ECal**
- **Summary**

MPD-ECal introduction



Multi-Purpose Detector (MPD)



The Barrel of ECal

MPD aims to :

- **study the rich structure of the QCD diagram at high (net)baryon densities**

MPD-ECal :

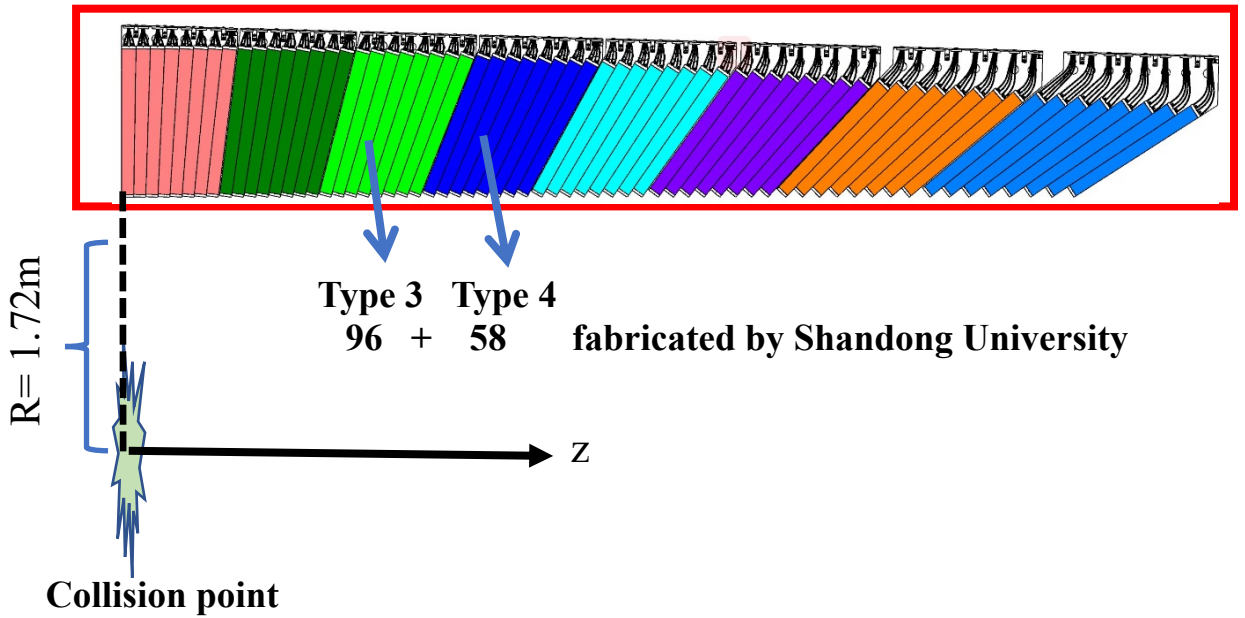
- **Measure the energy and position of photons, positrons and electrons**

- **Particle occupancy : ~ 70% at a threshold of 5 MeV in central collisions**
- **Time resolution : <1ns, ~ 500ps @ 1GeV**
- **Energy resolution : ~ 5% @ 1GeV in low multiplicity events**
- **Operate in the magnetic field : ~ 0.5T**
- **High segmentation and adequate space resolution**
- **Dense active medium with the small Moliere radius**
- **Good uniformity**

Requirements

ECal module production

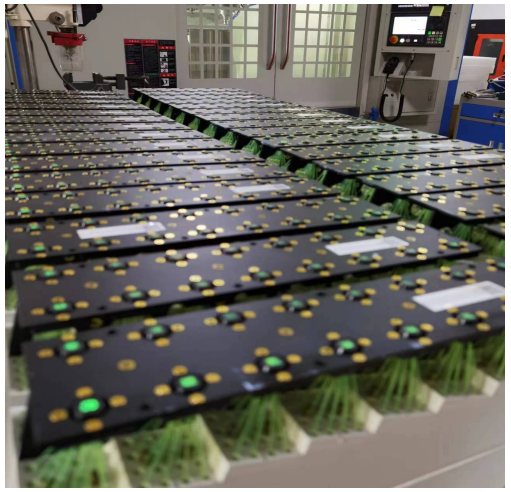
2400 Modules, 38400 Towers



768 modules produced in 4 universities of China

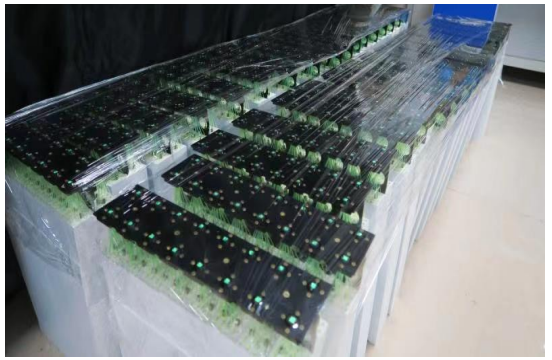
Type	1	2	3	4	5	6	7	8	Total
THU	19	19		38	96	96	96	96	460
SDU			96	58					154
FDU		77							77
USC	77								77

SDU



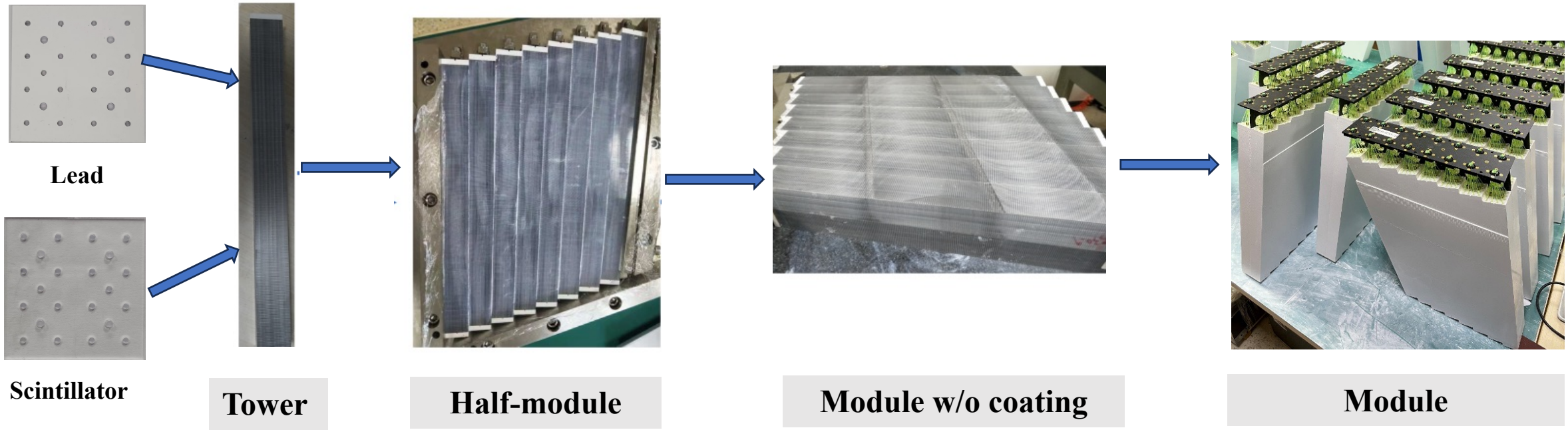
THU

USC



FDU

Fabrications of ECal module

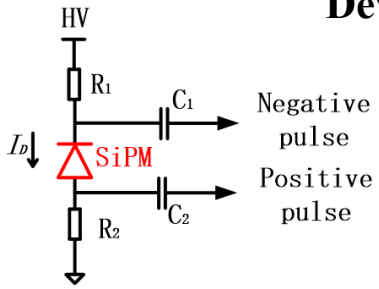


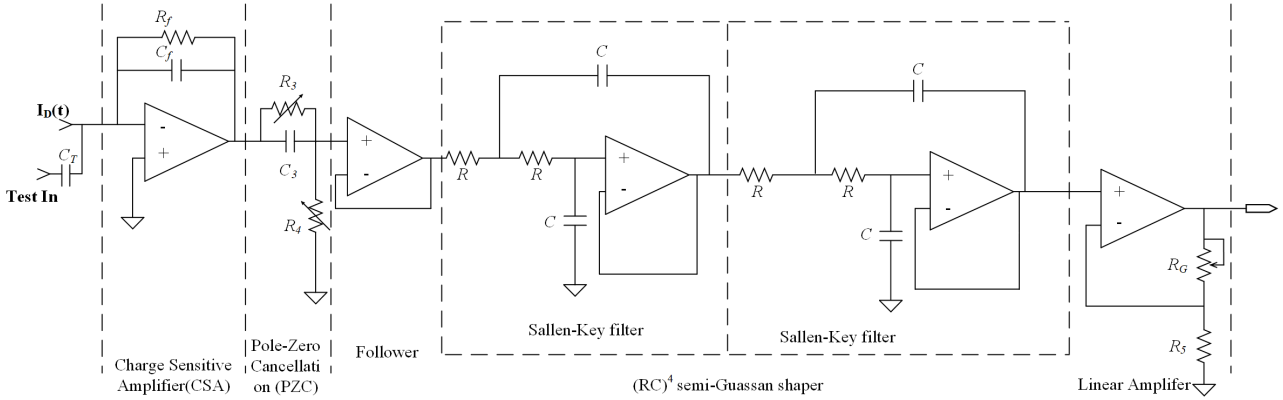
Parameters of main module			
Transverse size, mm^2	40 x 40	Scintillator thickness, mm	1.5
WLS fibers	16	Moliere radius, mm	62
Number of layers	440	Radiation length, X_0	11.8
Lead absorber thickness, mm	0.3	Effective radiation length, mm	32.4

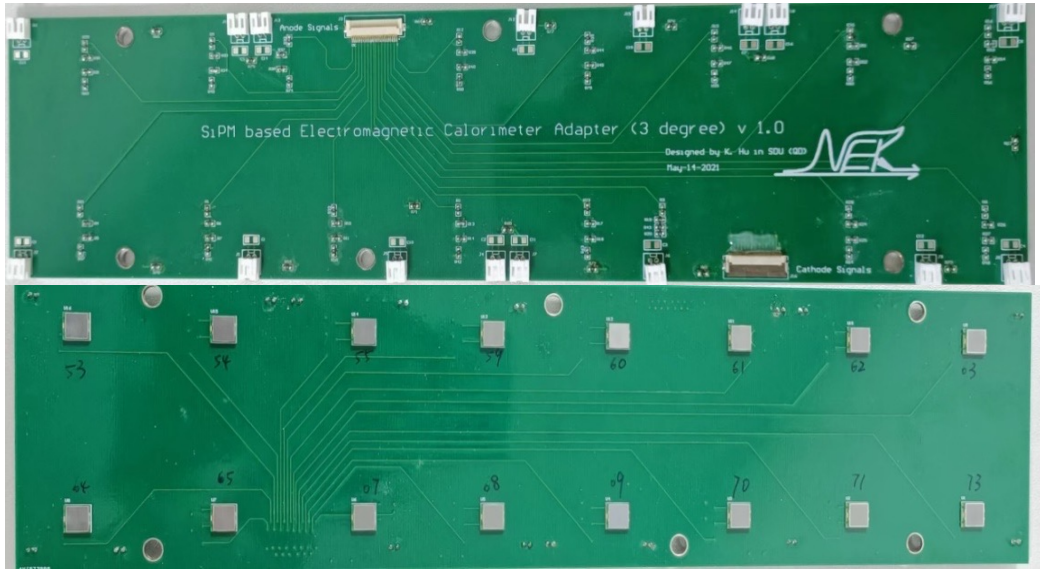
Readout electronics designed for local test

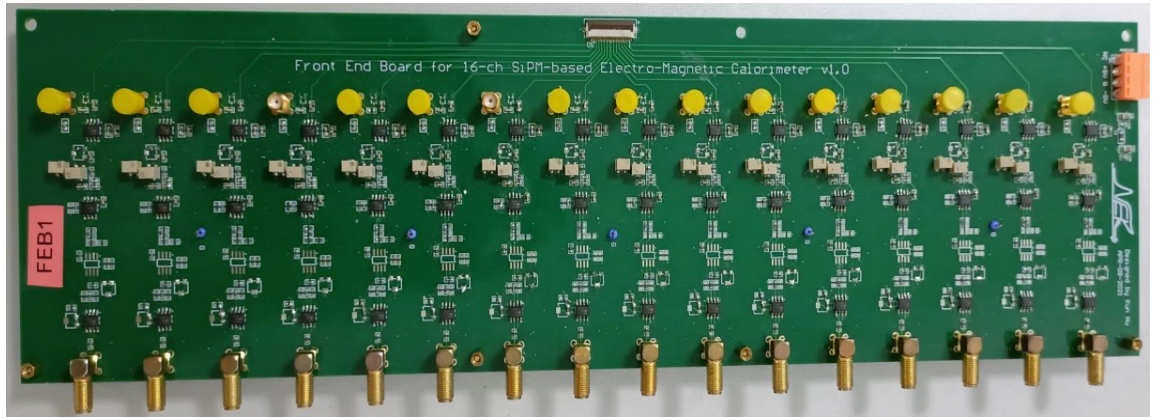
Developed by Kun Hu, Yonghong Wang and Chi Yang at SDU

*K. Hu et al 2016 JINST **11** T03002*









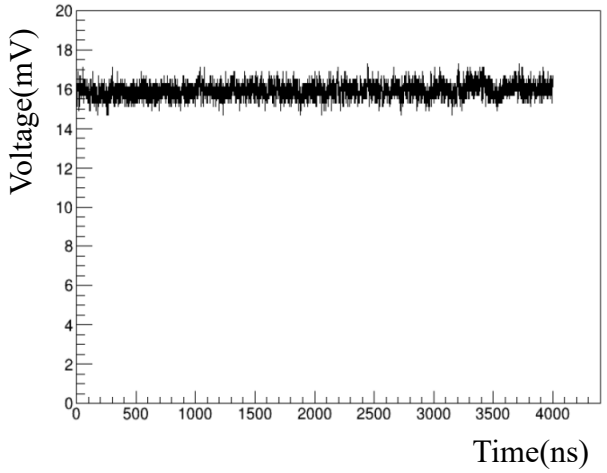
The SiPM-based adapter is used to collect the light from WLS fibers.

SiPM：S13360-6050PE

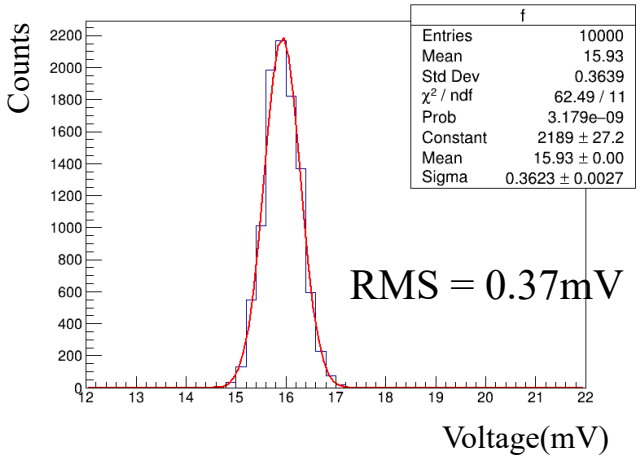
The FEB is designed to integrate and amplify the weak current pulse from the SiPM.

Calibration of the readout electronics

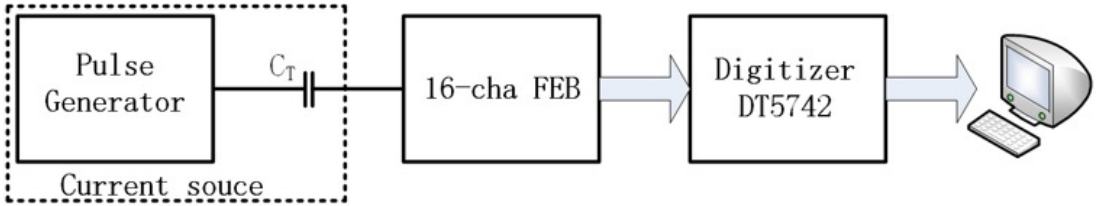
Noise vs. Time



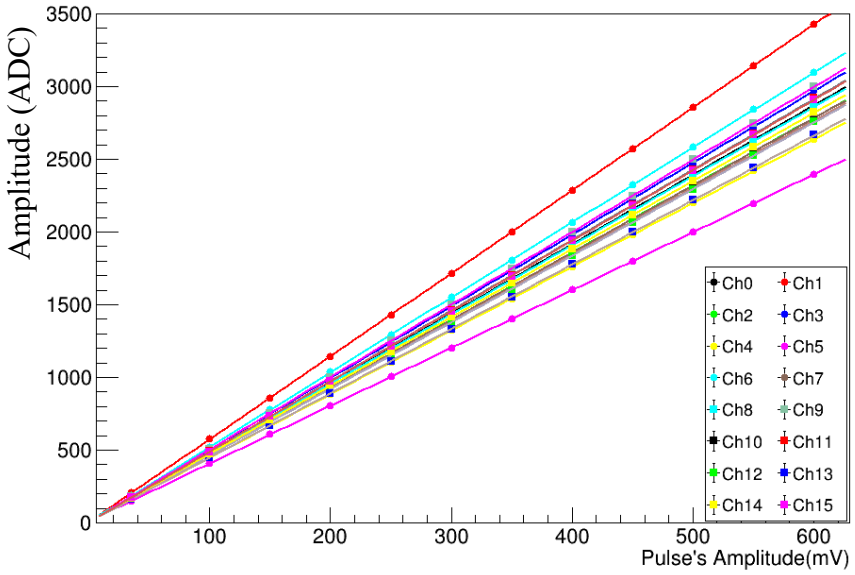
Noise Distribution



Baseline in the test is stable.

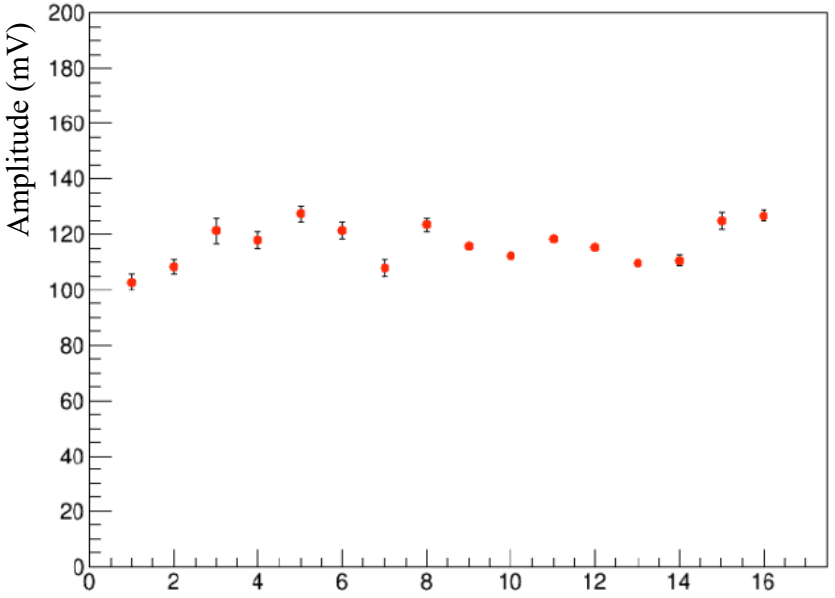


Calibrate the differences between FEB channels



Pulse Wave's Amplitude(mV)

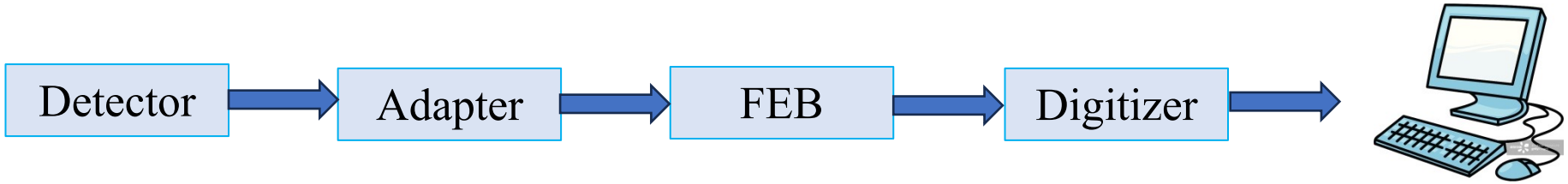
Calibrate the differences between SiPMs

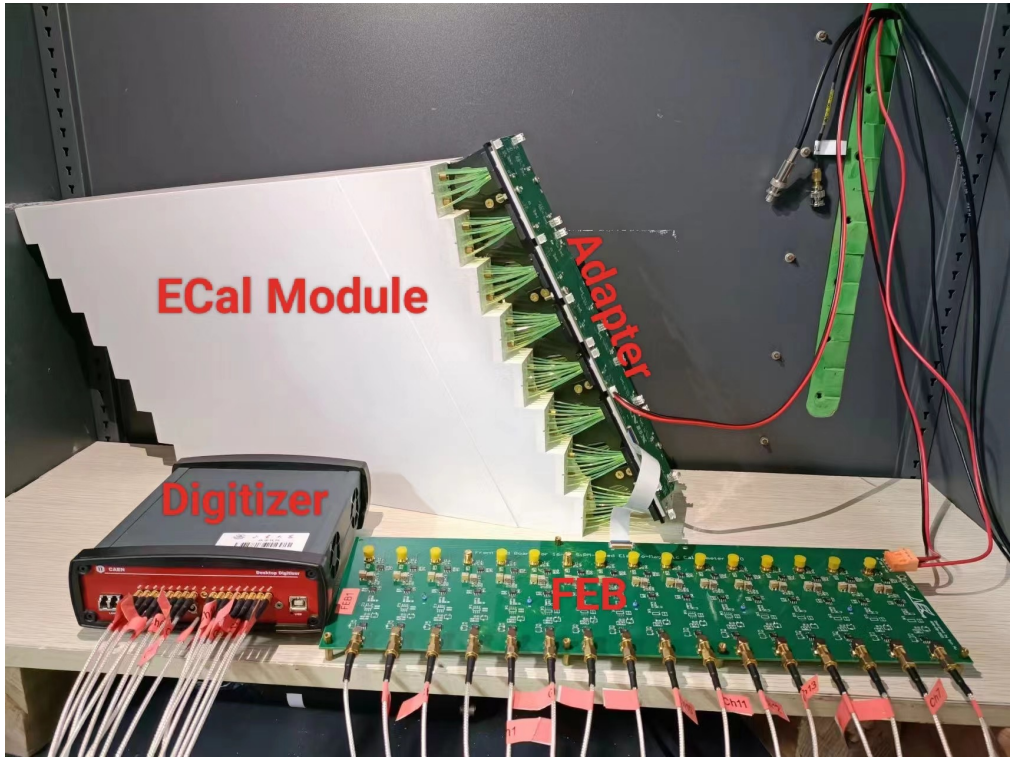


The channel differences in DAQ have been corrected:

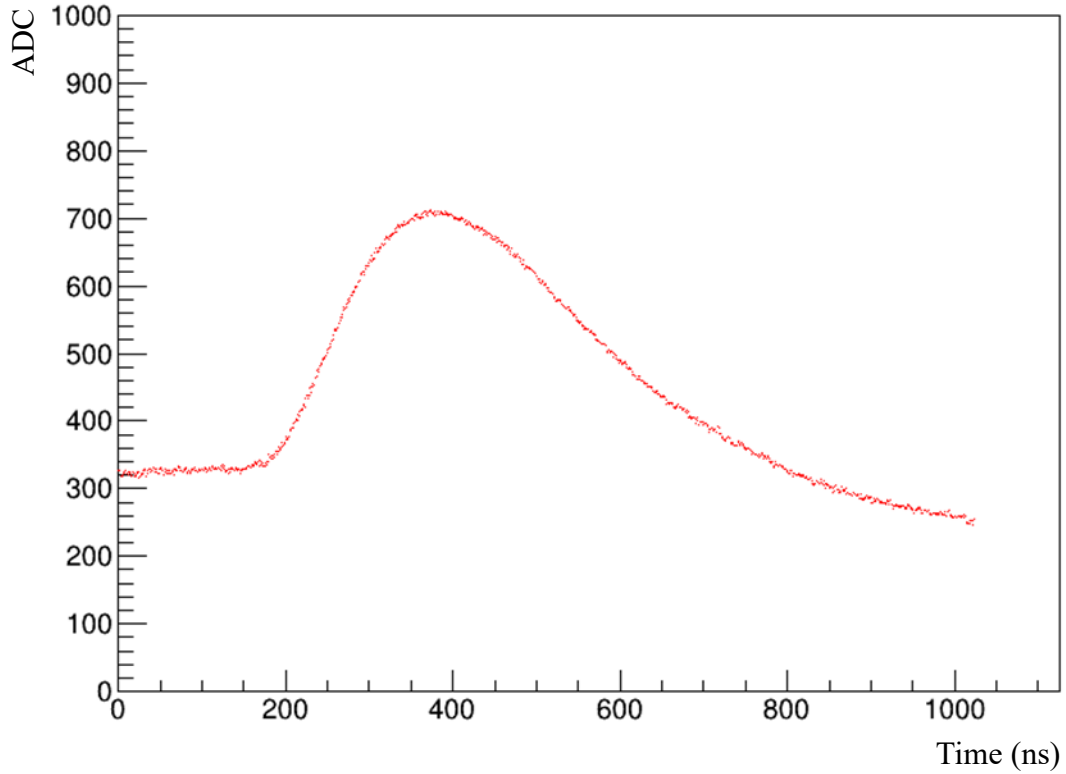
- **Different FEB channels**
- **Different SiPMs at same bias voltage**

The test system



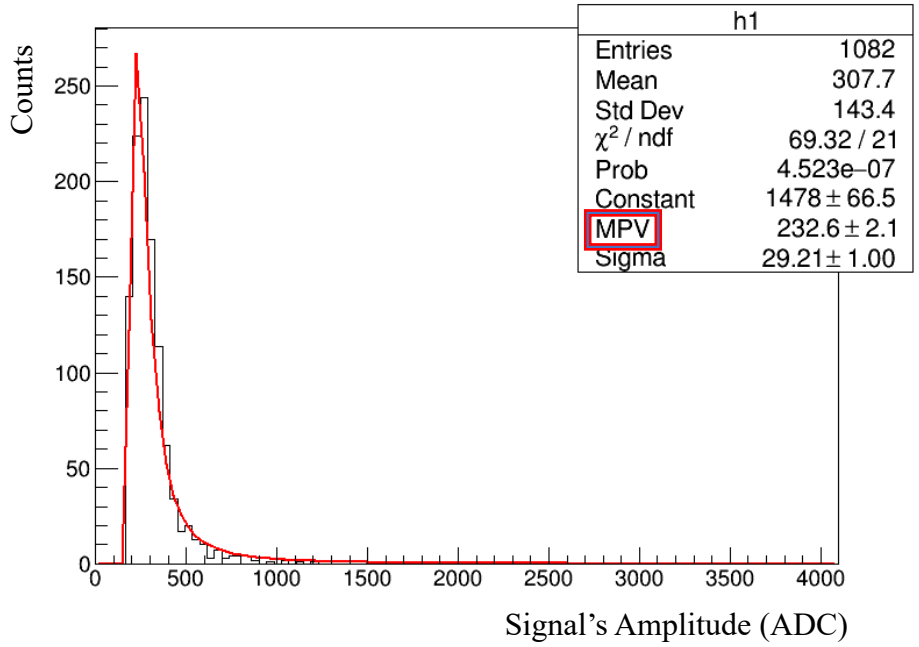


Signal of ECal cosmic ray test

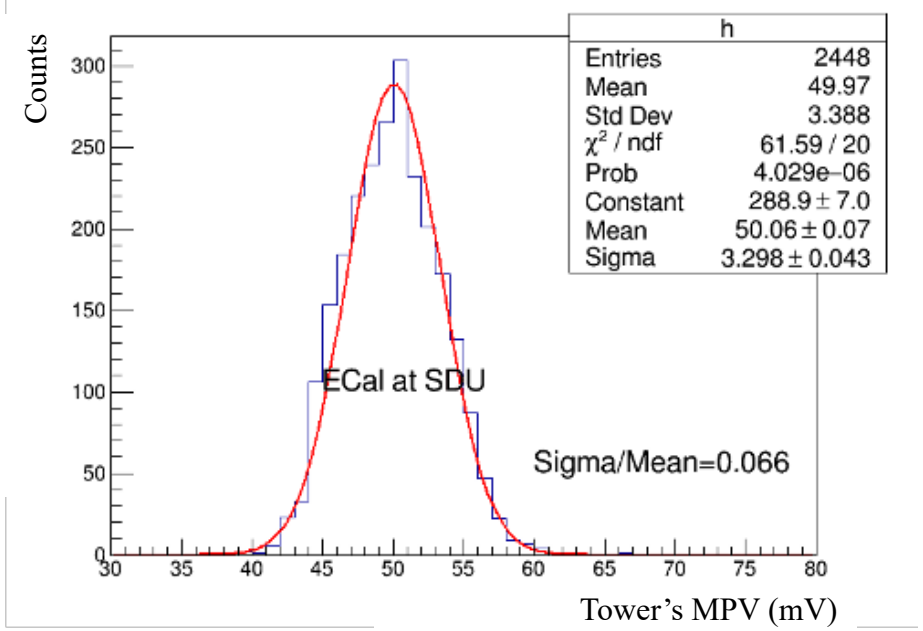


Uniformity test results

Amplitude Distribution



Amplitude Distribution After Correction



Air coupling effect differences from WLSFs to SiPMs are not corrected.

- **The amplitude of signals in a single tower follows the Landau distribution.**
- **About 6.6% (sigma/mean) uniformity was obtained in the cosmic ray test at SDU.**

Modules shipped from China to Russia

From SDU

http://www.jinr.ru/posts/equipment-for-nica-arrived-from-china/

Joint Institute for Nuclear Research

SCIENCE BRINGS NATIONS TOGETHER

New! DIGITAL JINR | JINR | SCIENCE | STUDENTS & EDUCATORS | PRES

ALL | World science | Organization | Education | Grants | Patents | Publications | Inter

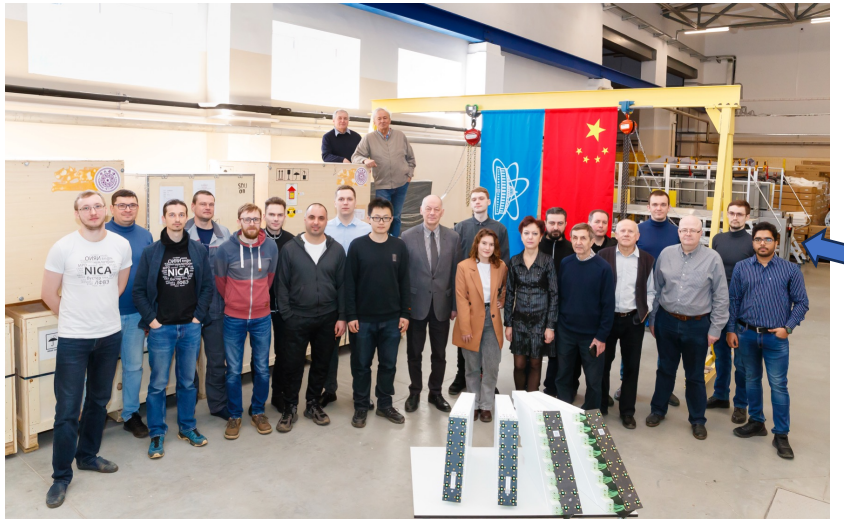
Equipment for NICA arrived from China

News, 31 March 2023

Today, about 300 modules of the electromagnetic calorimeter for the MPD Detector at NICA have been delivered to the Joint Institute for Nuclear Research from China. The current delivery was the last in a series of three. In total, 800 modules were produced in China.

From THU

From FDU



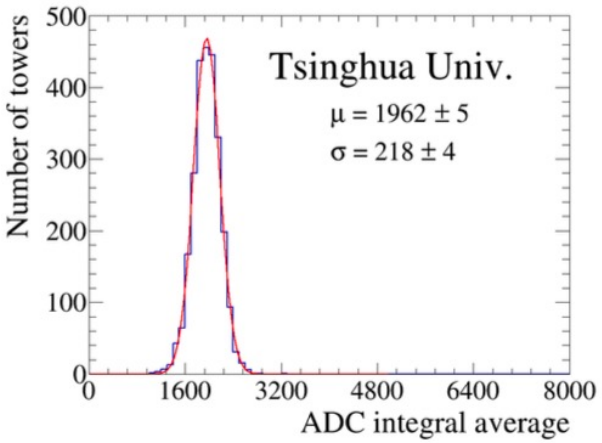
From USC

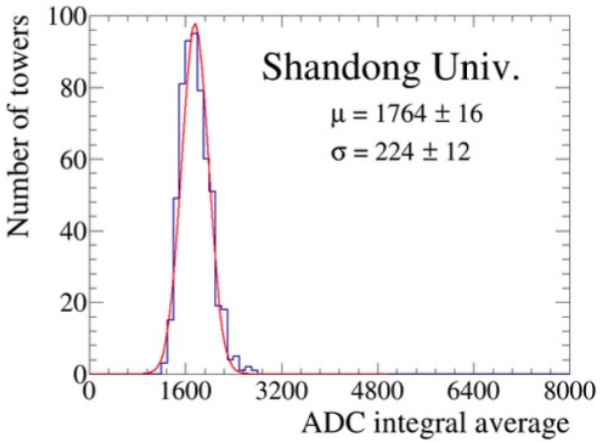
By March 31st 2023，all 768 modules have been delivered to the JINR from China.

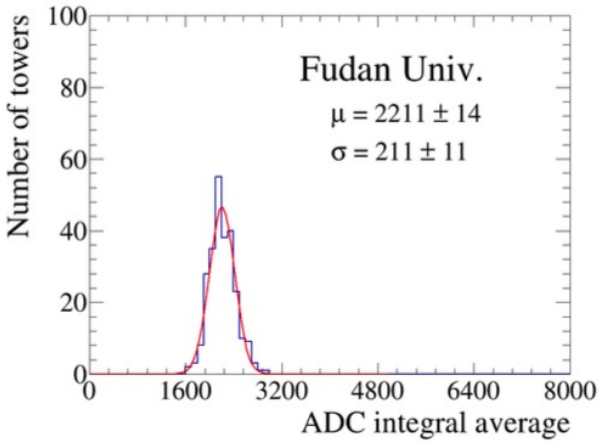
Testing of Modules at JINR

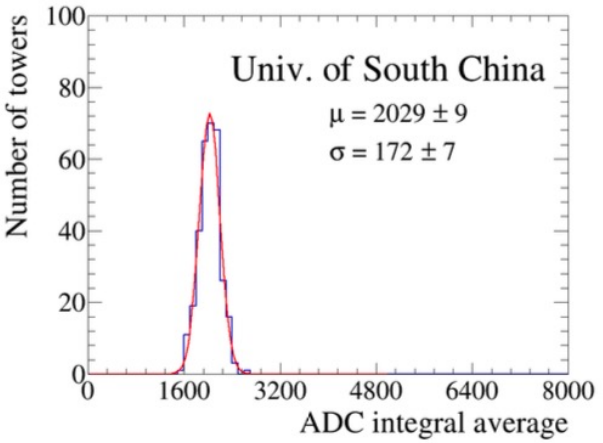
Signals amplitude distributions

From different institutions

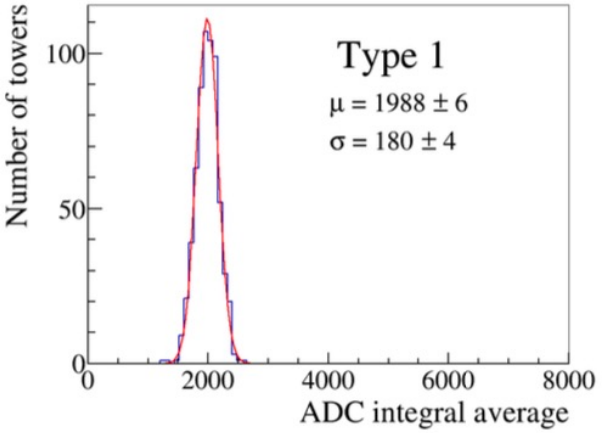


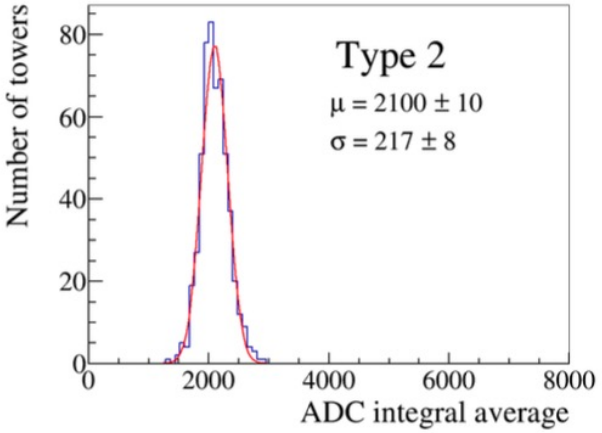


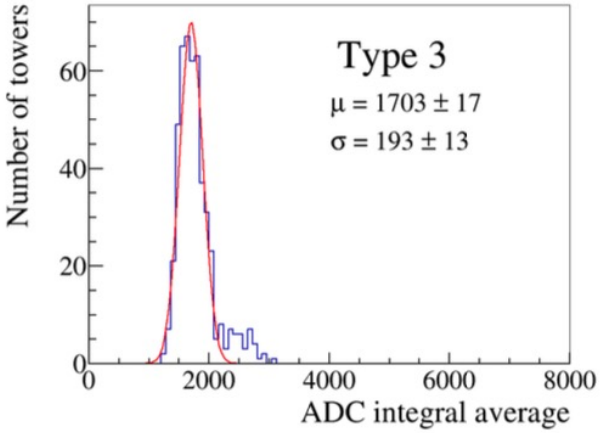


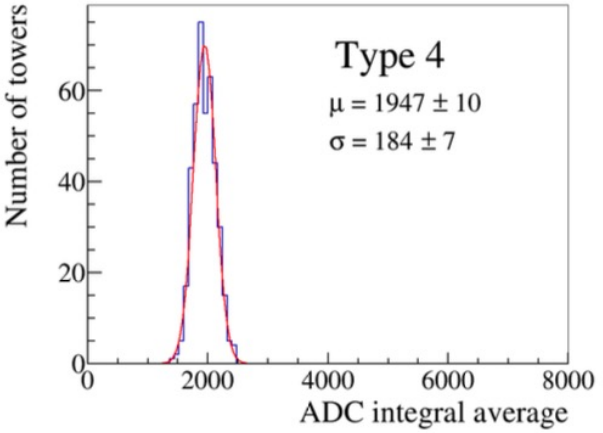


From different types





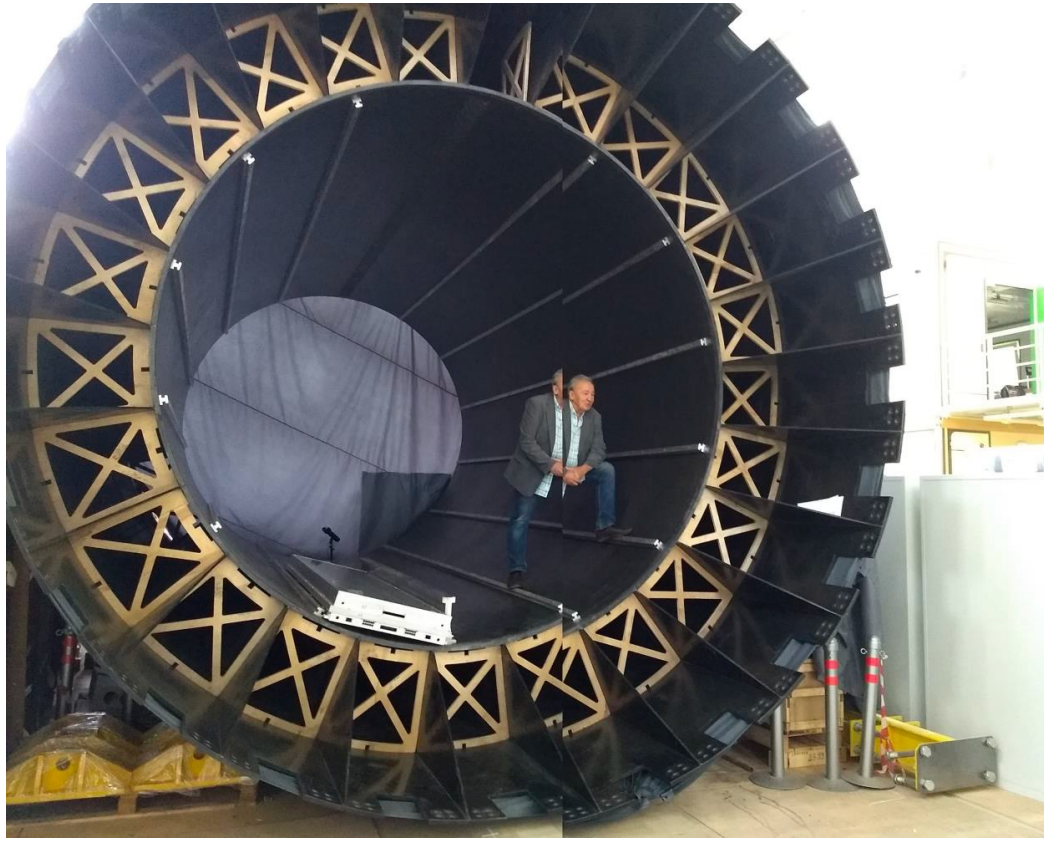




These modules work as expected.

From M. Bhattacharjee's talk
@ XI NICA-MPD collaboration meeting

The status of ECal



From Igor Tyapkin's talk
@ XV NICA-MPD collaboration meeting

First 40 baskets of ECal are ready to be assembled to the MPD.

Photon’s energy resolution in ECal

Event cut: Primary vertex of event reconstructed and vertex_z cut < |100| cm.

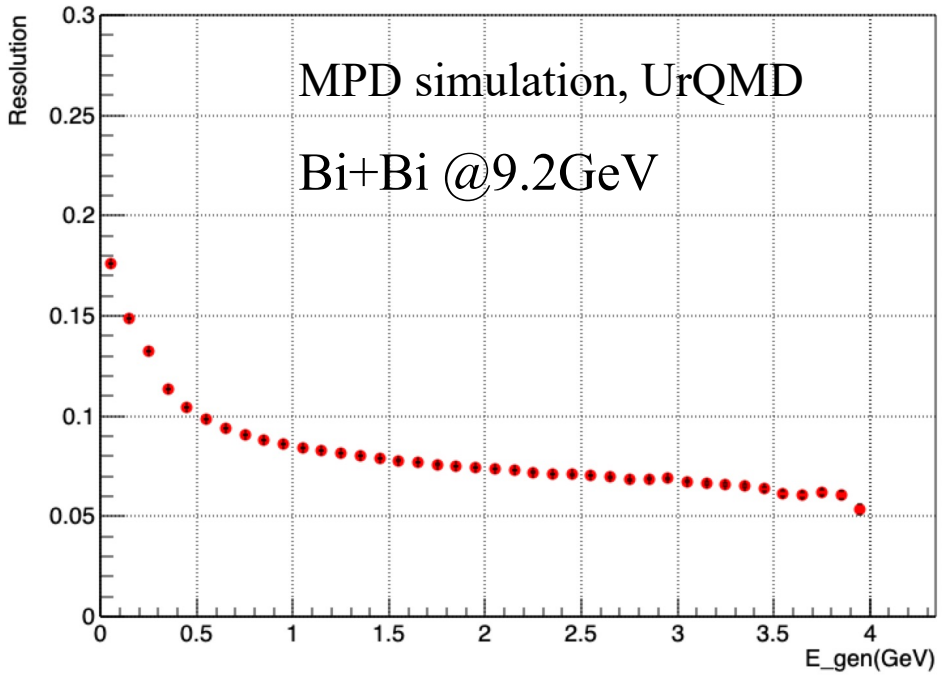
1、number of towers in the shower/cluster ≥ 2

2、reconstructed energy ≥ 75MeV

3、χ^2/NDF ≤4(This variable says how close the cluster shape to the one expected for electromagnetic shower.)

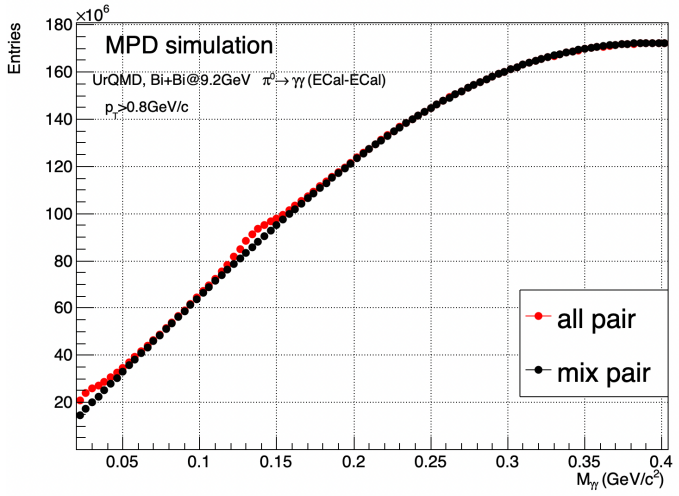
4、tof<2ns(tof of the cluster, assumed ECal time resolution dt = 0.5 ns)

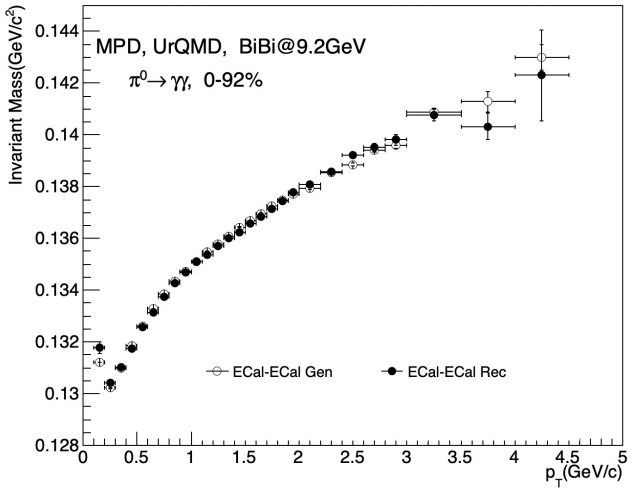
Photon’s Energy Resolution

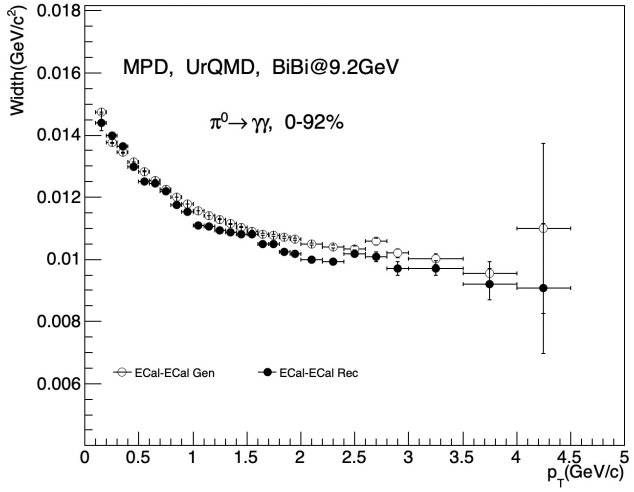


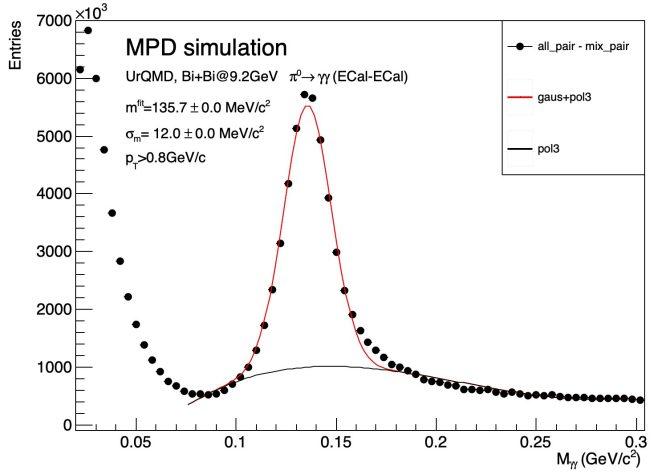
The energy resolution of photon is about 8% at 1GeV.
The clusters are reconstructed in high multiplicity events.

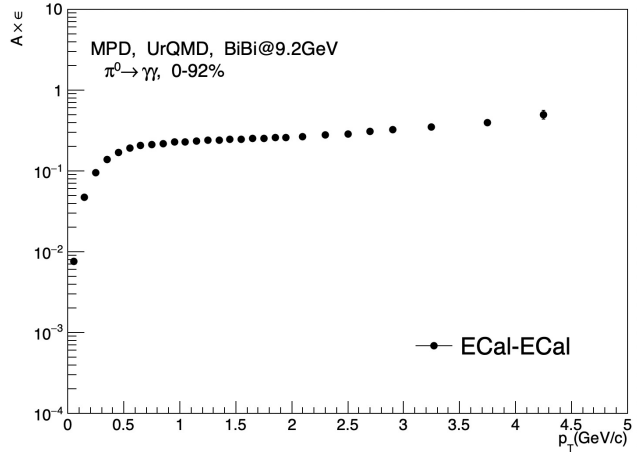
π^0 reconstruction with ECal

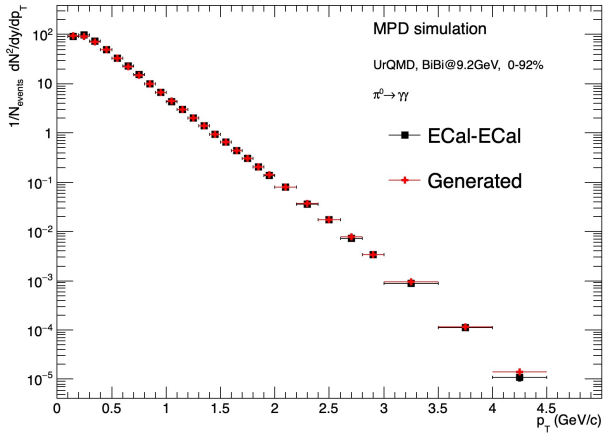






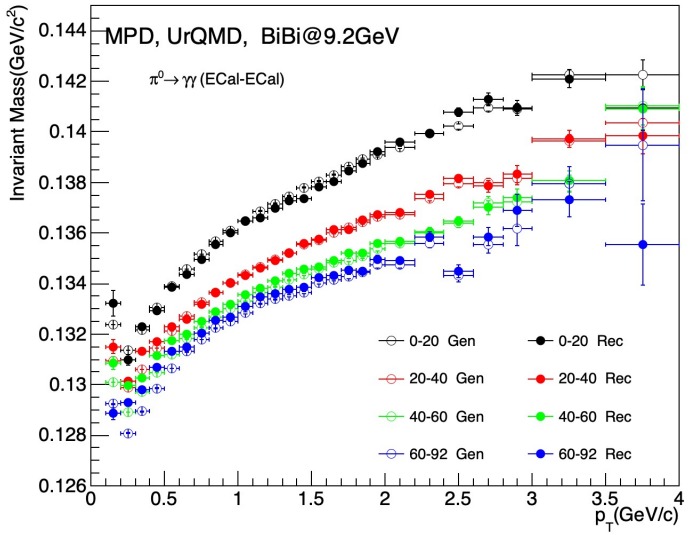


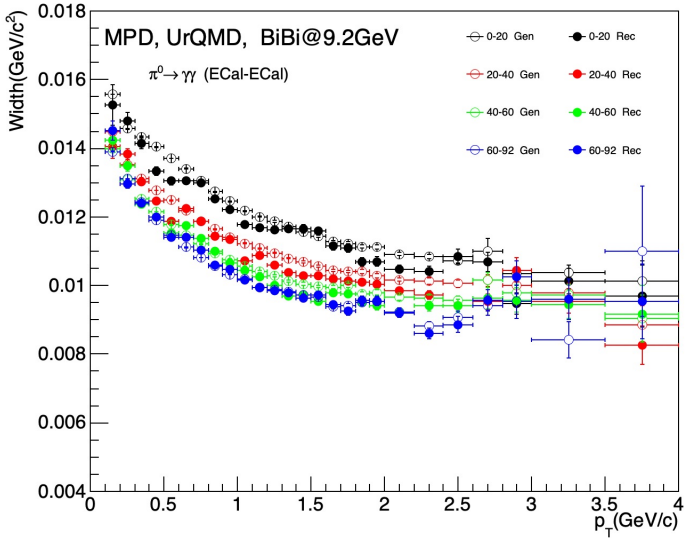


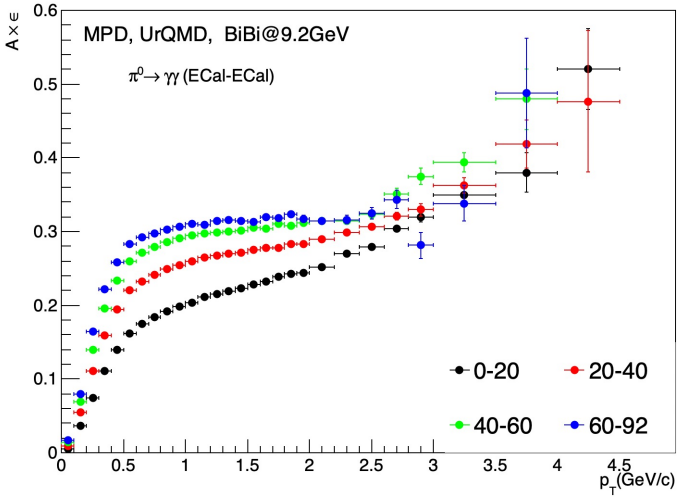


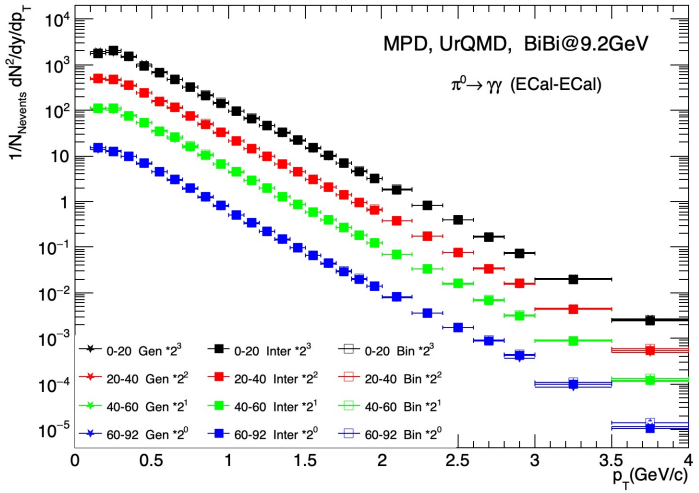
A clear excess is visible in distributions close to the nominal meson mass of 135 MeV/c² for the π^0. The variables reconstructed for π^0 are consistent with truly MC generated.

Centrality dependence of π^0 in ECal-ECal





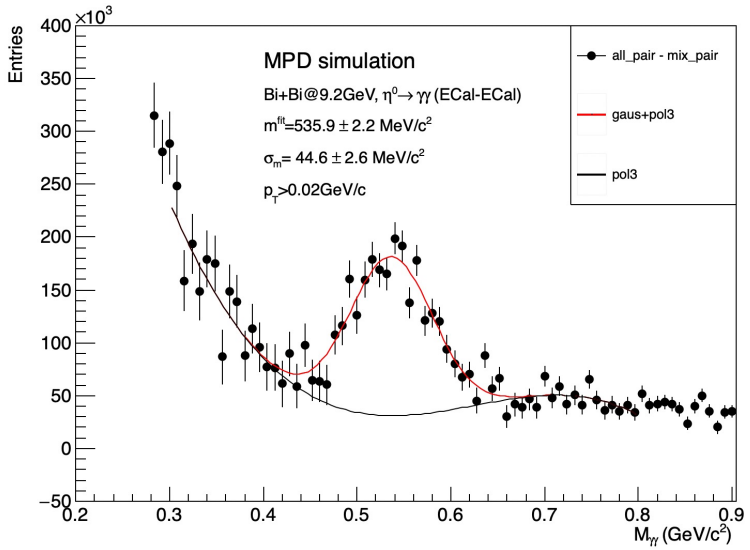


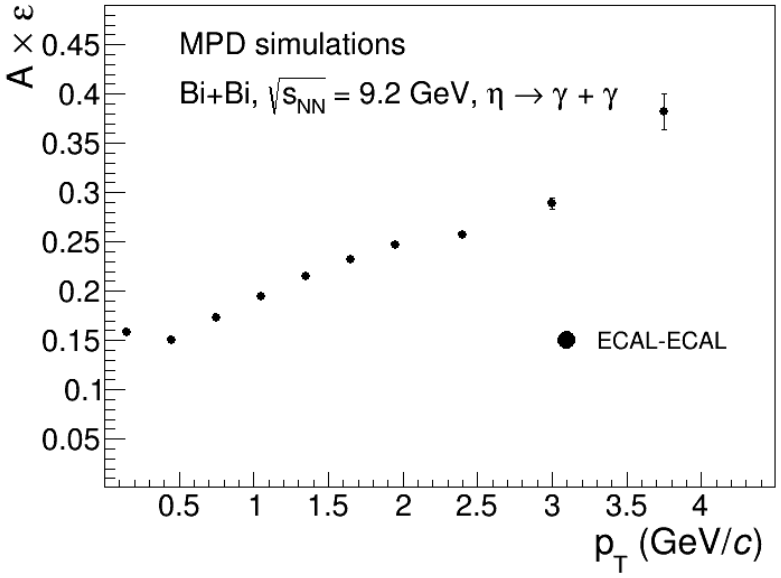


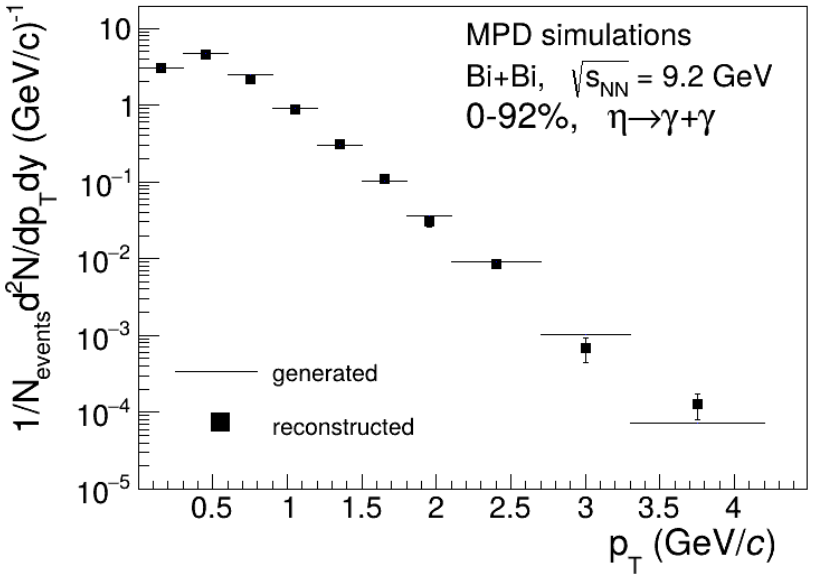
The invariant mass, peak width and corrected yield of π^0 reconstructed and MC generated via two photons from ECal decrease as centrality increases within the same p_T range.

The corrected yields for π^0 are agree with truly generated ones in each centrality interval.

η reconstruction with ECal







A clear excess is visible in distributions close to the nominal meson mass of 548 MeV/c^2 for the η.

The reconstructed yield is consistent with the truly generated for η.

Summary

- **The first-stage mass production of ECal modules was completed in China, culminating in 768 modules delivered to JINR by March 2023.**
- **About 6.6% (sigma/mean) uniformity was obtained in the cosmic ray test at SDU with air coupling between WLSF and SiPM.**
- **Assembled half-sectors are under long term tests. It is estimated that 46 (92%) baskets will be ready by the end of August 2025.**
- **The neutral mesons reconstructed with ECal are consistent with the generated ones in the simulation.**

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Thank You !