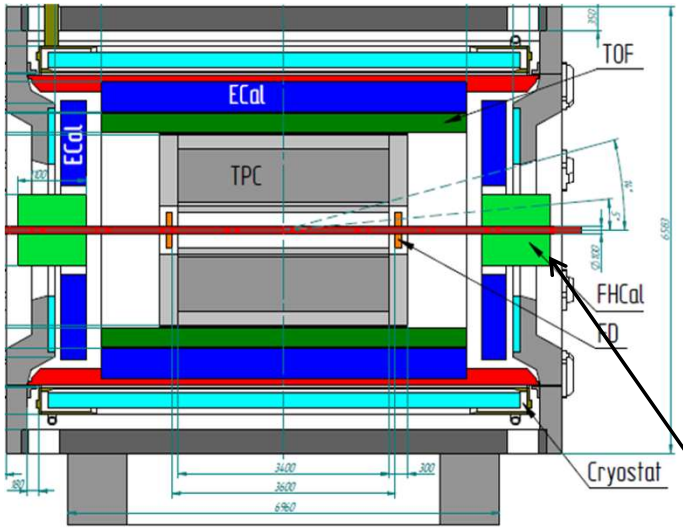
Status of Forward Hadron Calorimeter (FHCal)

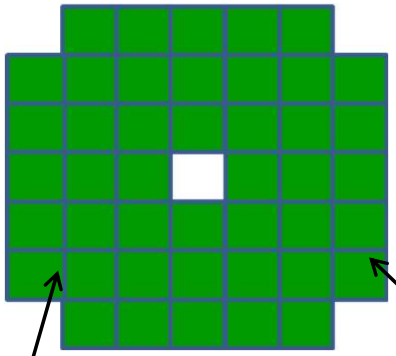
A.Strizhak
Institute for Nuclear Research RAS, Moscow

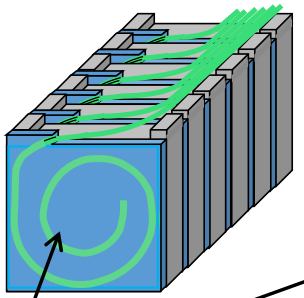
- **FHCal overview;**
- **Installation in magnet pole;**
- **FHCal readout;**
- **FHCal in trigger;**
- **Integration into MPD;**

15th MPD collaboration meeting, April, 2025

FHCal in MPD







FHCal

FHCal modules

- <u>Two arms of hadron calorimeter</u> at opposite sides in forward regions.
- At the distance 3.2 meters from the interaction point.
- Available acceptance corresponds to pseudorapidity $2.0<\eta<5.0$

- FHCAL consists of 2x44 modules.
- ~1x1 m^2 each part.
- Beam hole 15x15 cm^2.
- Lead/scintillator sampling calorimeter.
- Longitudinal segmentation;
- Light readout- WLS-fibers;
- 7 sections/photodetectors in each module.

Tasks of FHCal :

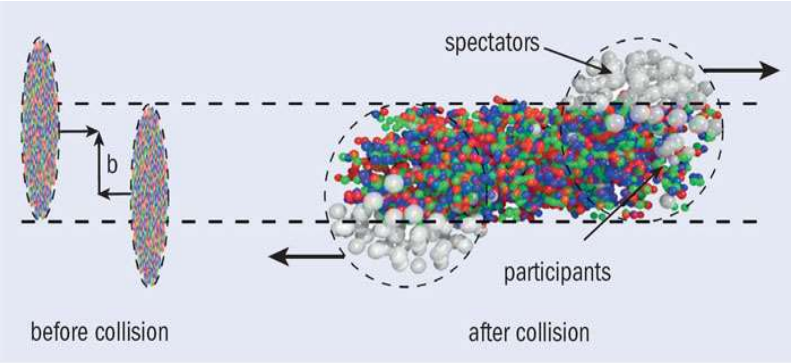
Detection of spectators:

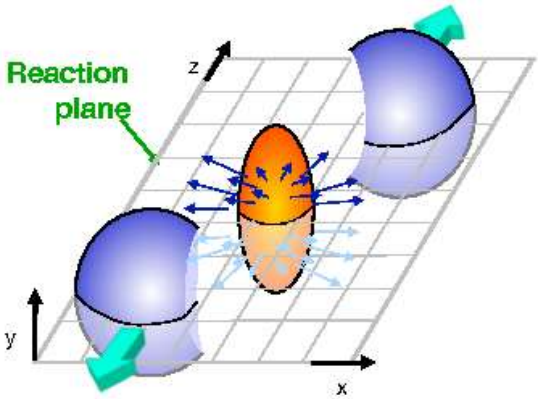
a) The centrality of the collision;

b) The reaction plane orientation;

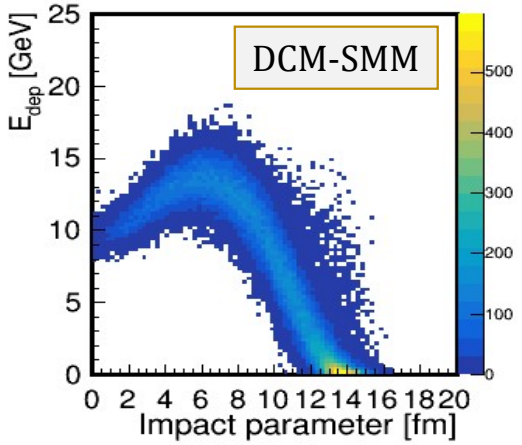
c) Minimum bias trigger;

d) Physics in forward rapidity.



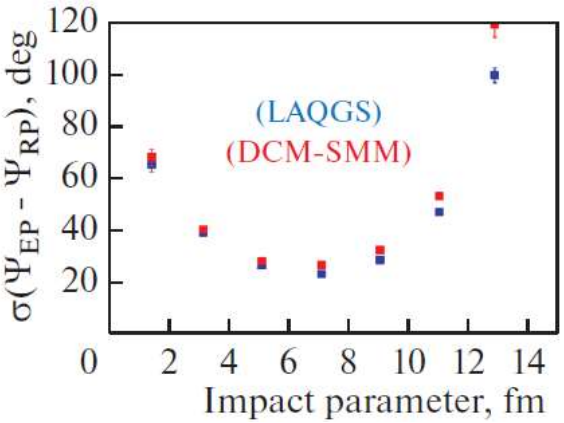


Centrality:
From energy distributions in FHCal and ECal (?).
First sections of FHCal may function as ECal too.

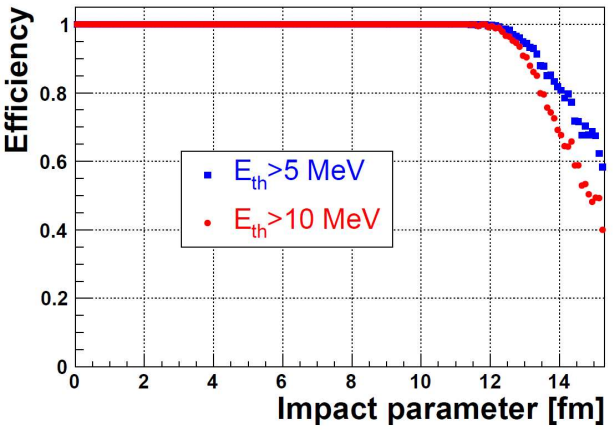


Reaction plane:

$$\Psi_{EP} = acrtg\frac{\sum E_i \sin(\varphi_i)}{\sum E_i \cos(\varphi_i)}$$



Trigger efficiency:

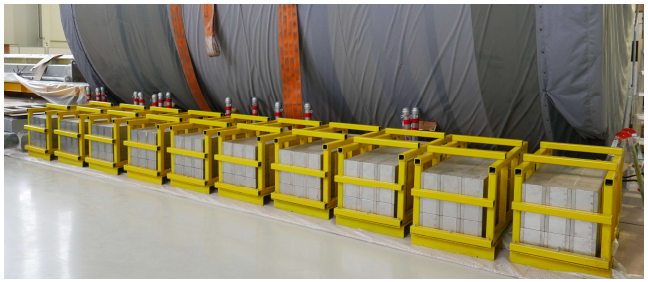


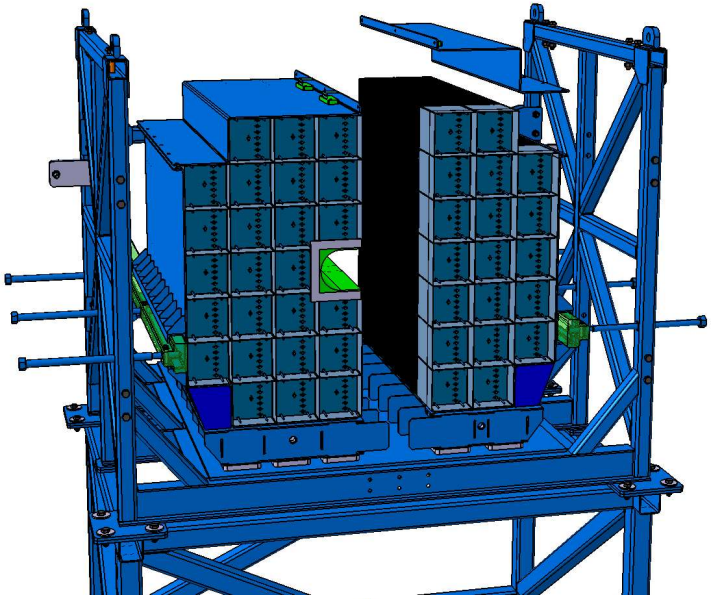
Installation of FHCal

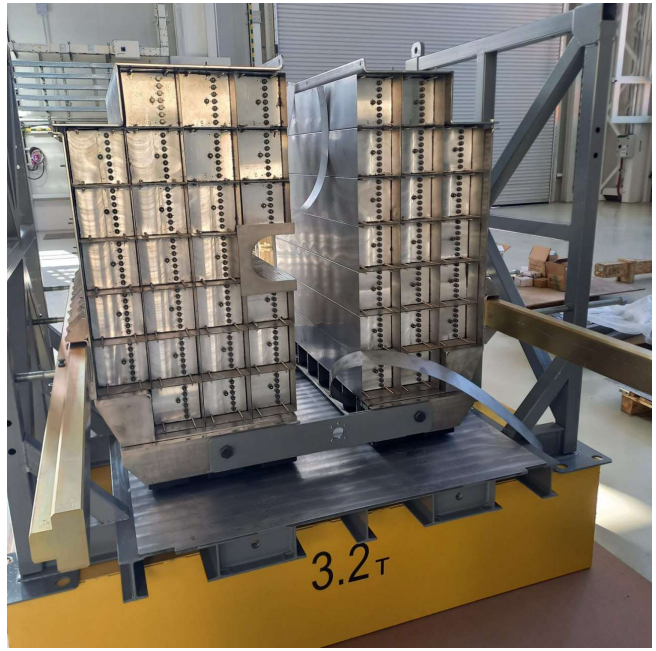
- **Assembling of modules;**
- **Installation into magnet pole;**
- **Adjusting final position.**

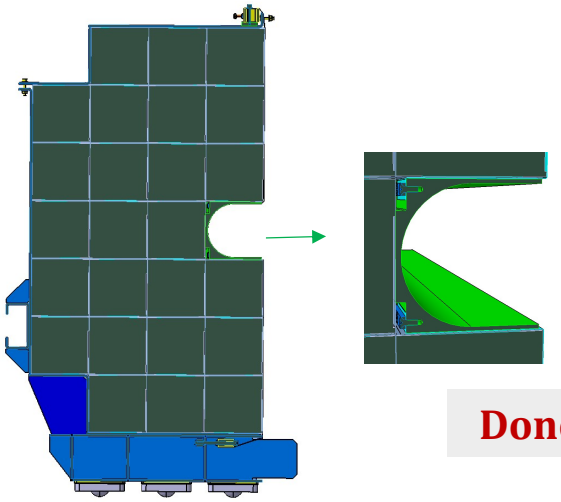
Step 1: Assembling of FHCal at the floor

In Nov'23
90 modules were delivered form INR to MPD hall



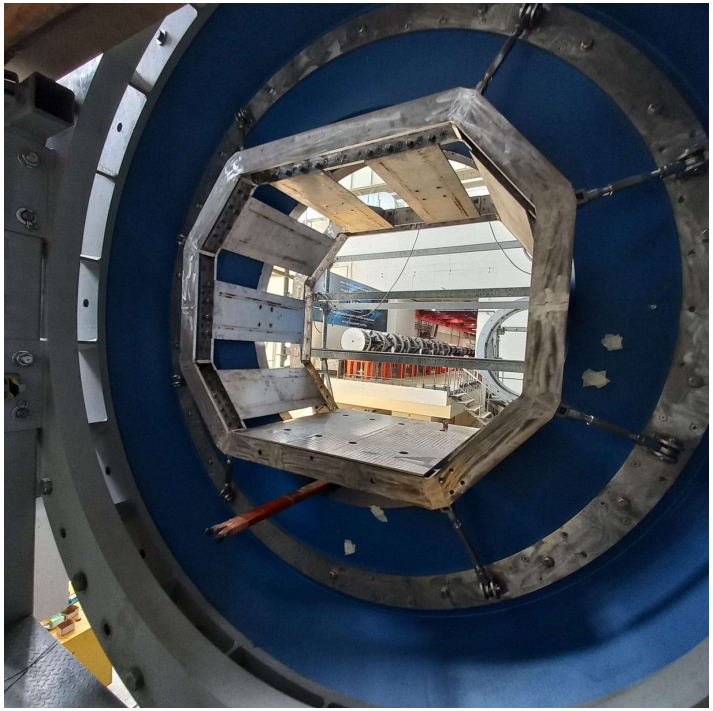






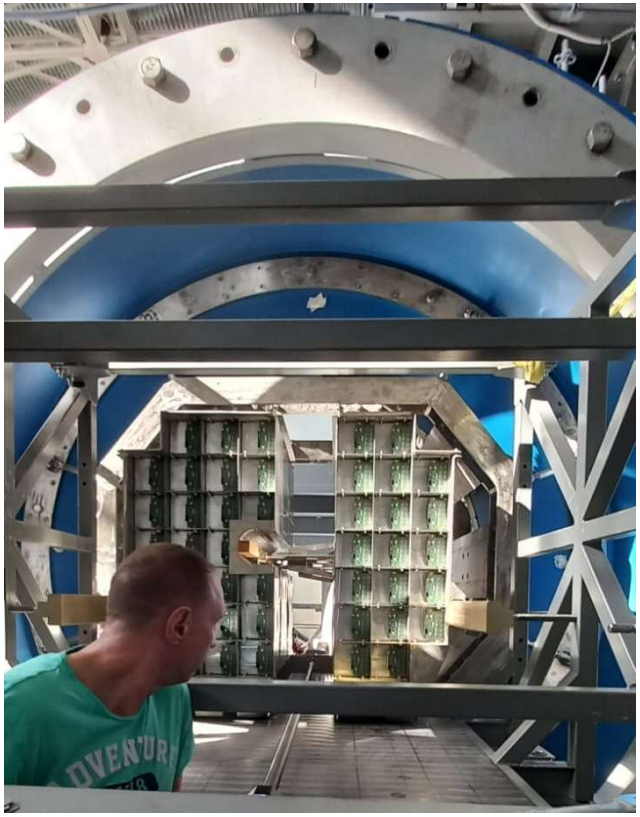
Done by S. Gerasimov and JINR technical group!

Step 2: FHCal installation into magnet pole



FHCal support frame in magnet pole

Outer view

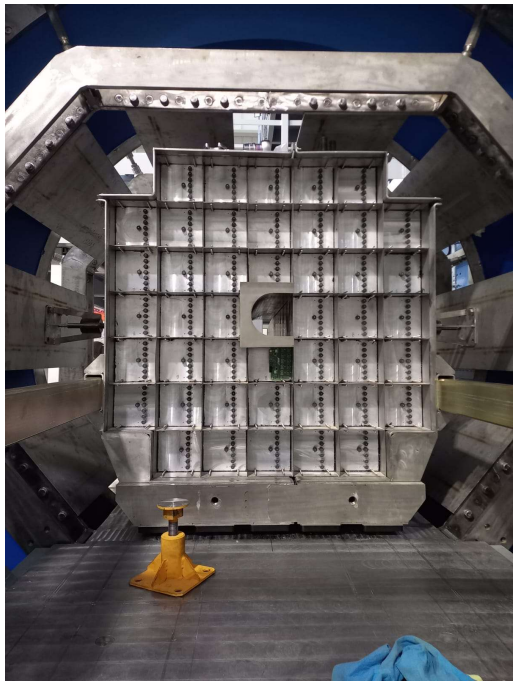


Inner (front) view

Done by S. Gerasimov and JINR technical group!

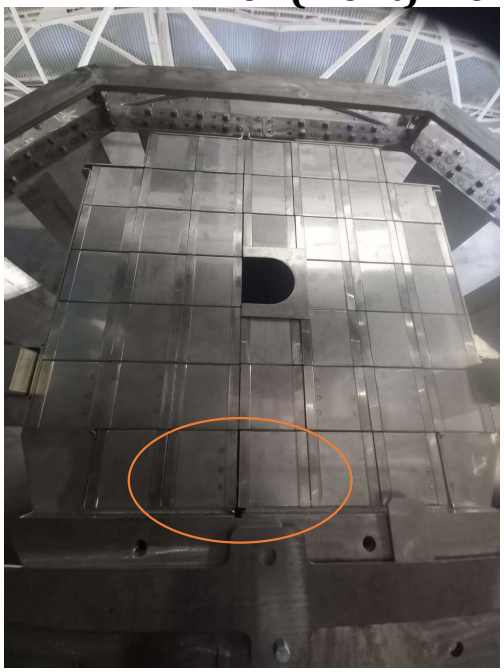
Step 3: Full assembling of FHCal in magnet pole

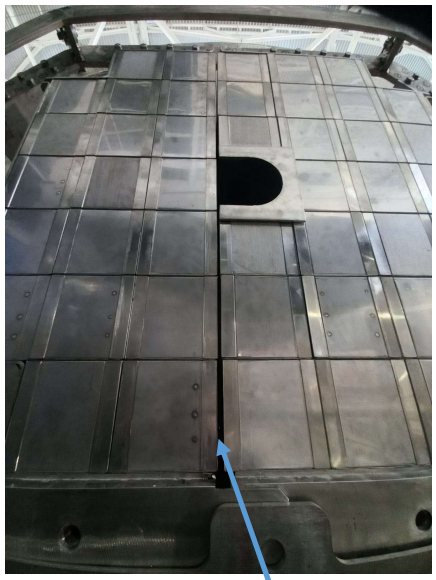
Outer view



Two FHCAL parts pressed together

Inner (front) view





2 mm gap between lowest modules of two parts. More accurate alignment is required!

All manipulations with FHCal modules were performed successfully!
Many thanks to S. Gerasimov and JINR technical group!

Next steps in construction of FHCal

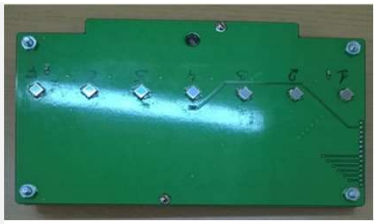
In February 2025 FHCal was moved back to the floor in MPD hall!

- **Installation of Front-End-Electronics;**
- **Installation of Detector Control System (DCS);**
- **Installation of readout;**
- **Development of FHCal trigger;**
- **Calibration with cosmic muons.**

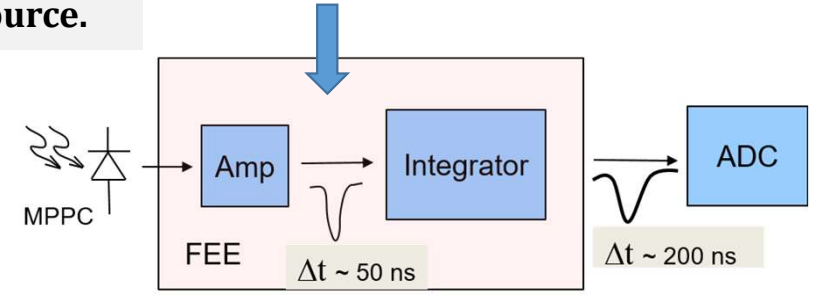
Front-End-Electronics (FEE)

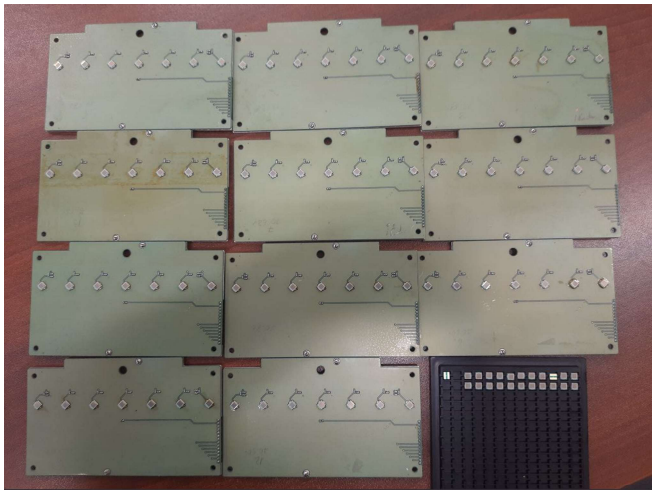
Two PCBs in each module with:

- **7 photodetectors ;**
- **Photodetectors – MPPCs;**
- **two-stage amplifiers;**
- **HV channels;**
- **LED calibration source.**



MPPC: S14160-3010PS
size – 3x3 mm^2;
pixel -10x10 μm^2;
PDE~18%.





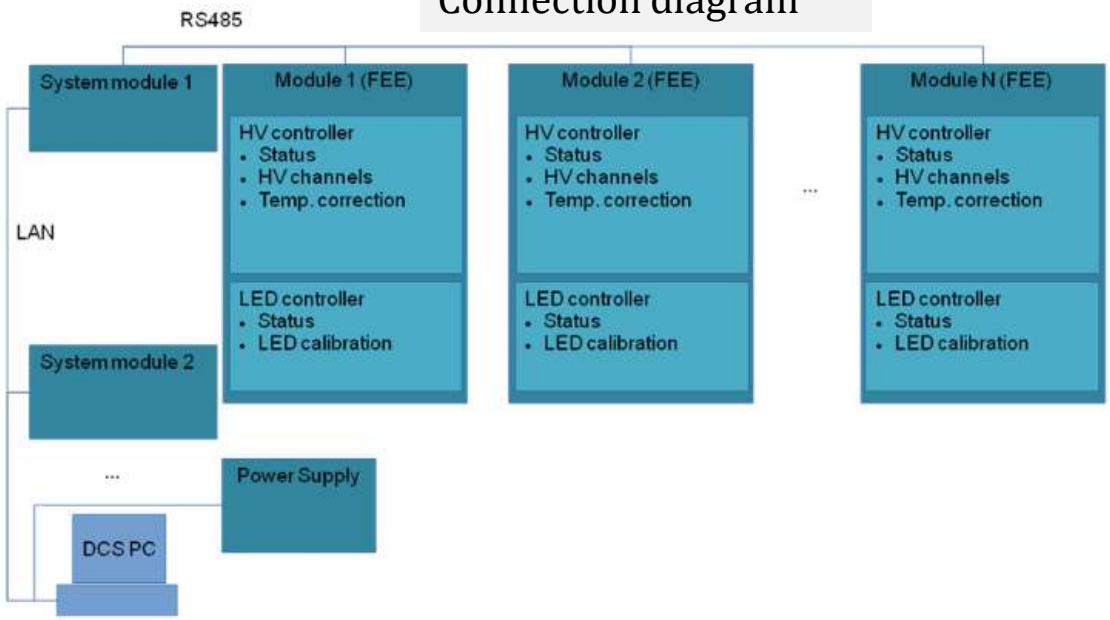
11 spare FEE boards were produced this year with new SiPMs

Detector Control System (DCS)

DCS Tasks:

- **Control of HV at photodetectors (MPPC's);**
- **Temperature control of photodetectors;**
- **Compensation of temperature drift of MPPC gain;**
- **Monitoring of MPPC gain with stabilized light source.**

Connection diagram

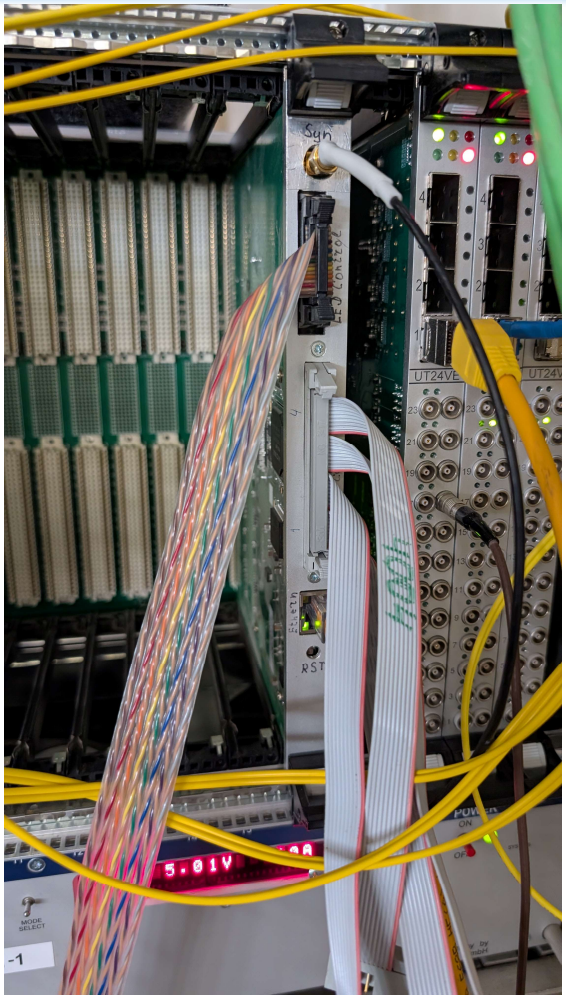


New system modules (boards) in VME crate format under production and will be installed in Control room.
(The design is similar to ECal boards).

FHCal FEE and DCS cabling

Feb'25

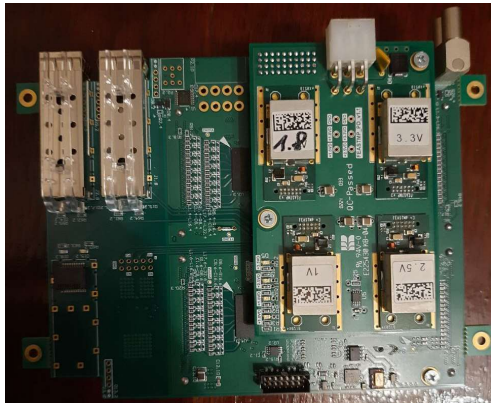
FEE boards were divided into two arrays – for left and right parts of FHCal.
One power cable for each array of modules.
Easily separable if FHCal is divided for maintenance.

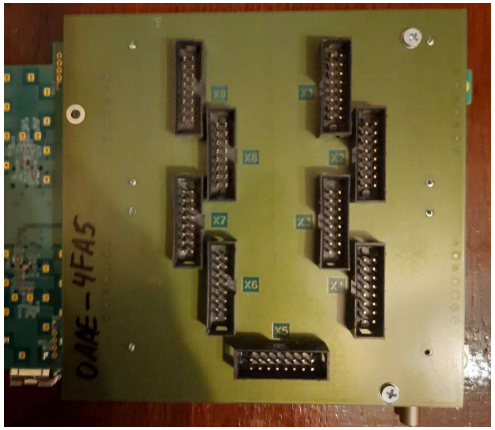


DCS module

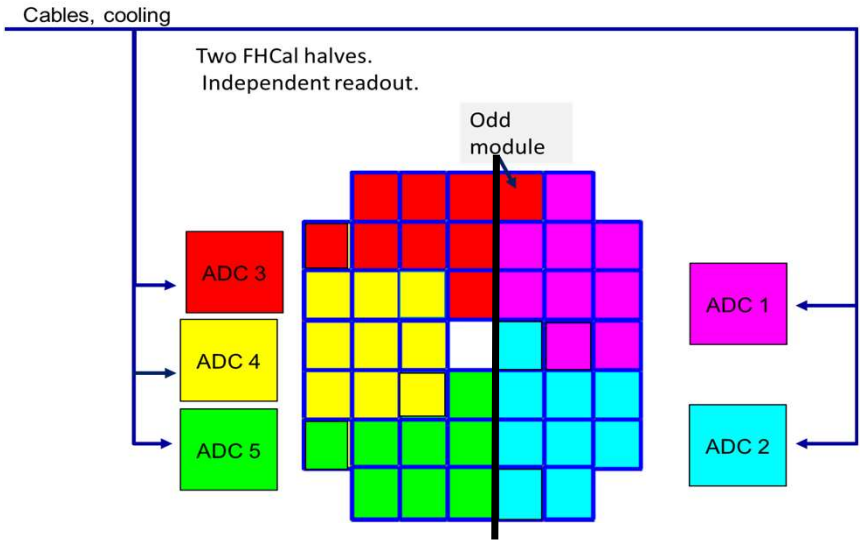
ADC signal readout

FPGA based 64 channel ADC64 board, 62.5MS/s (AFI Electronics, JINR, Dubna).





5 ADCs for each arm of FHCal



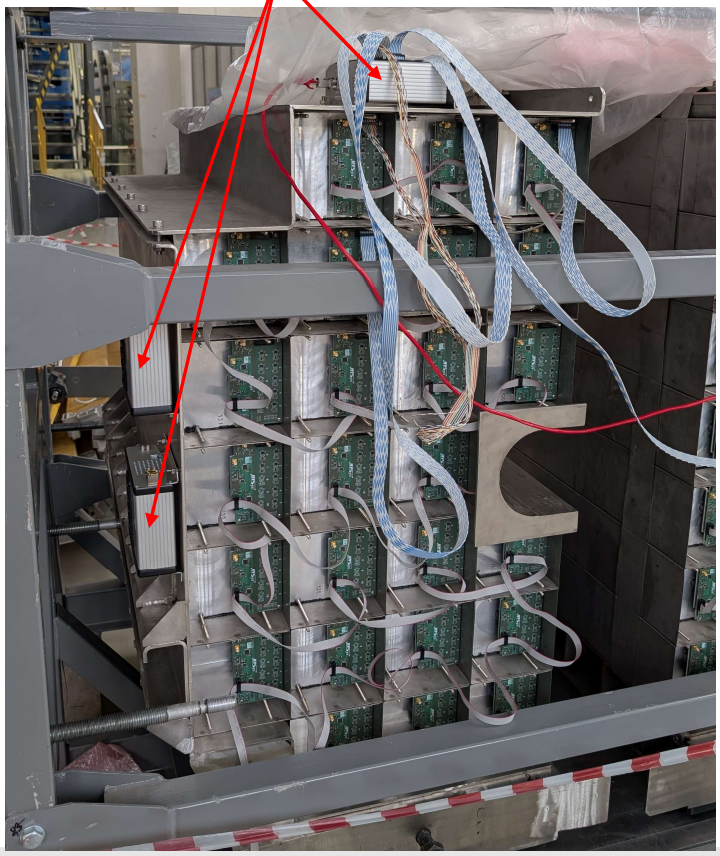
Two halves of FHCal.

New fast ADCs are already produced by S.Bazylev group and are ready for installation.

These ADCs will be used for arrangement of FHCal trigger.

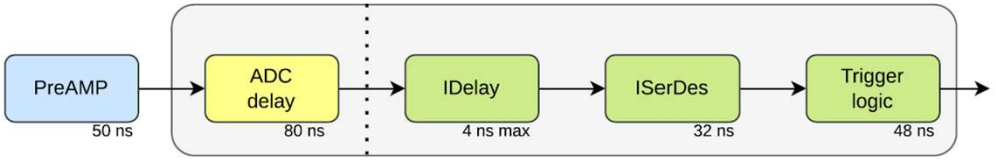
FHCal ADC and trigger

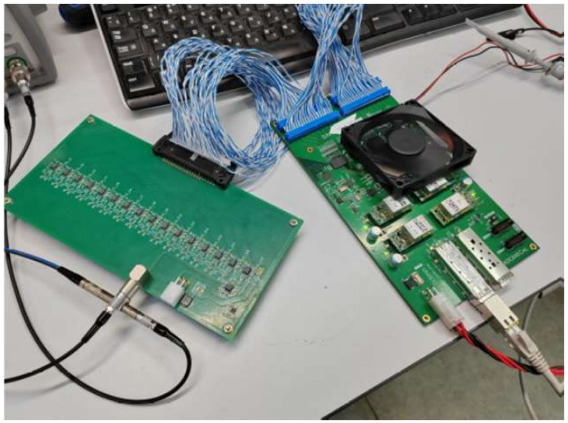
Photo ADC in FHCal



FHCal Trigger (S.Bazylev group solution): Digital trigger based on fast ADC

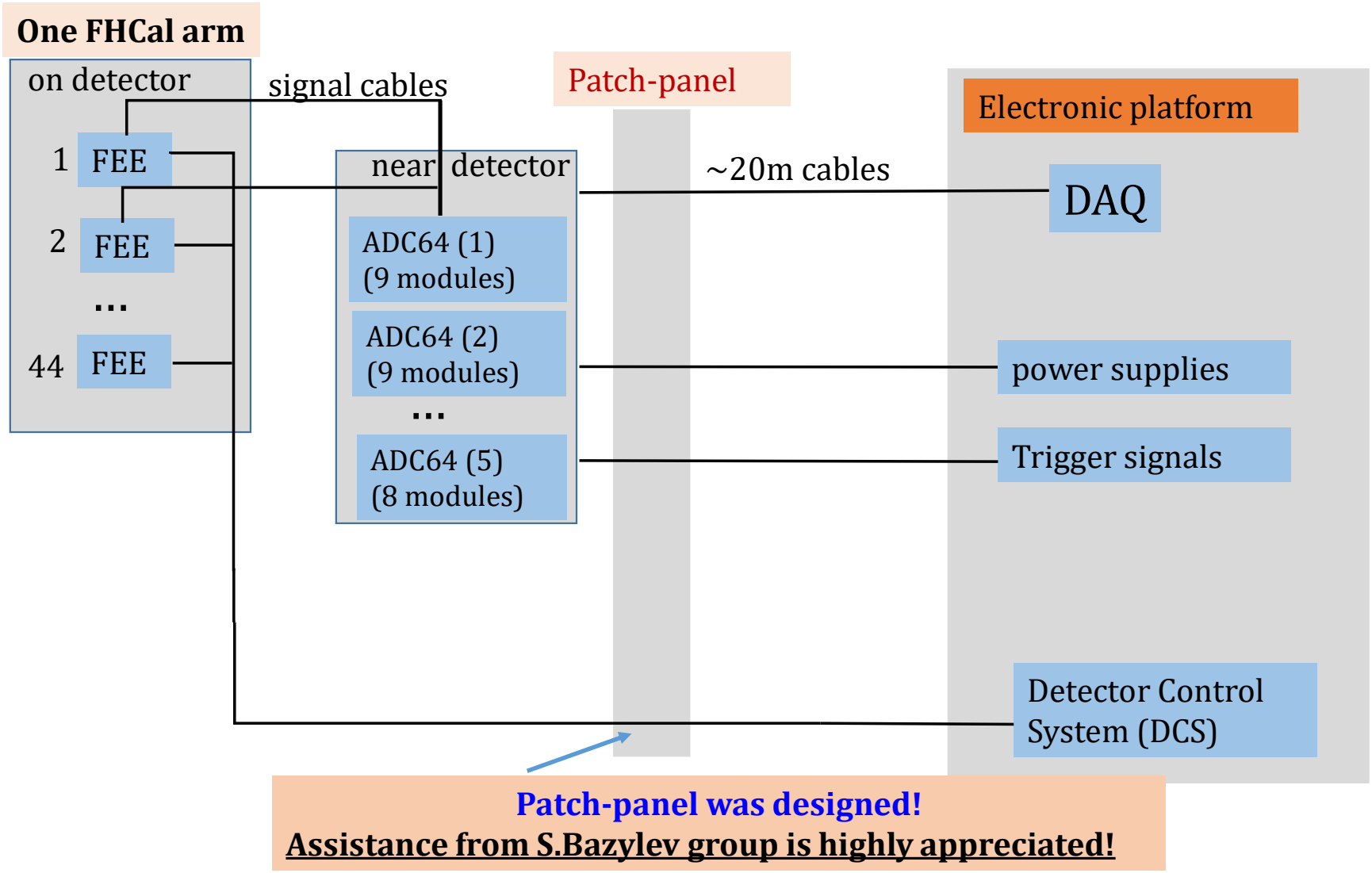
New ADC version is much faster with delay time 237 ns (150 ns shorter)





New ADC modules are available.
Practically any configuration of energy depositions in FHCal modules can be implemented in trigger!

FHCal cabling



FHCal patch-panel design

Optical data cables

FEE DCS power cable

FFA lemo for ADC trigger and busy signal cabling

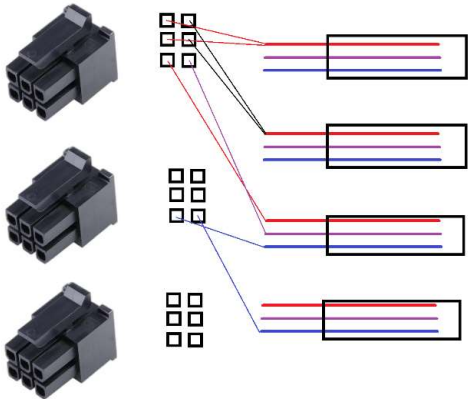
ADC power cables placement. Screwed to metal for common grounding with basket.

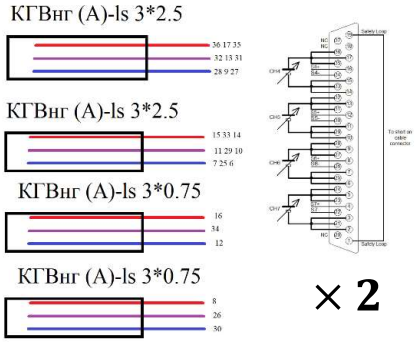
Cooling system for ADCs

$$Air\ flow \approx 40 \frac{liters}{minute}$$

Camozzi TPE 12/10, *polyethylene pipe*

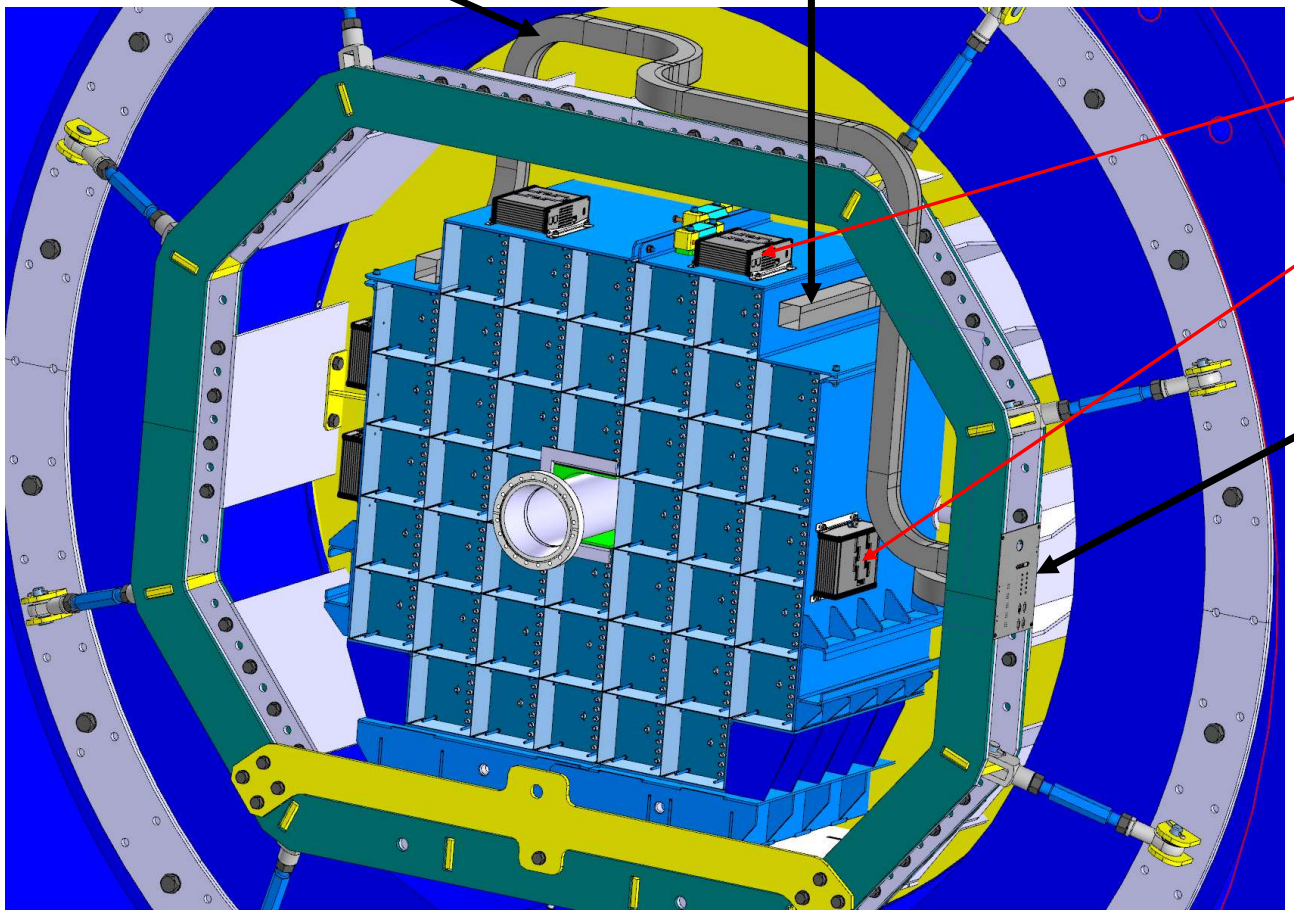
Camozzi TPE 8/6, *polyethylene pipes*





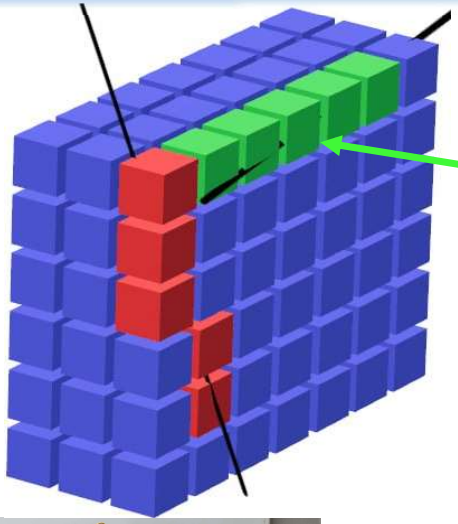
× 2

FHCal cable management



- **Patch-panel's design is final**
- **The panel is ready for production**

Energy calibration with cosmic muons



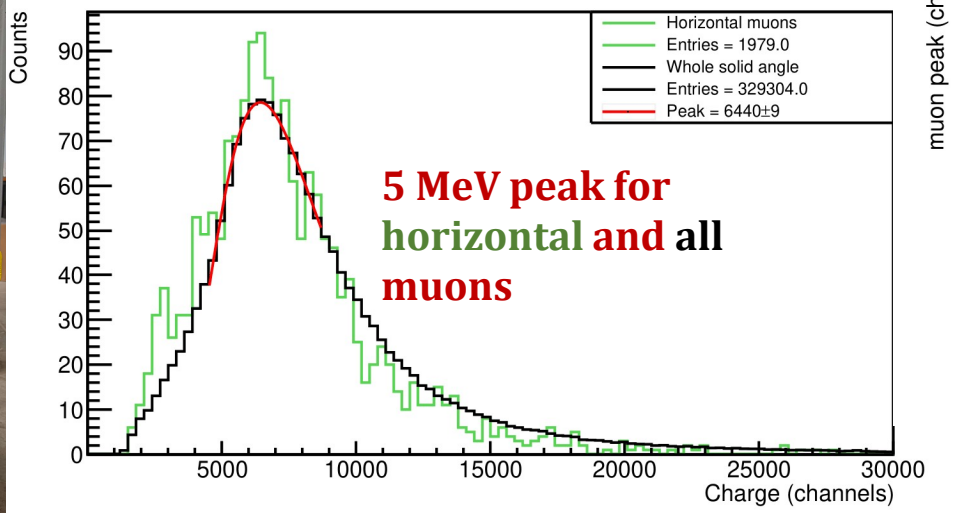
Response of FHCal modules to cosmic muons with different track geometries (4 days of data acquisition)

Horizontal muons

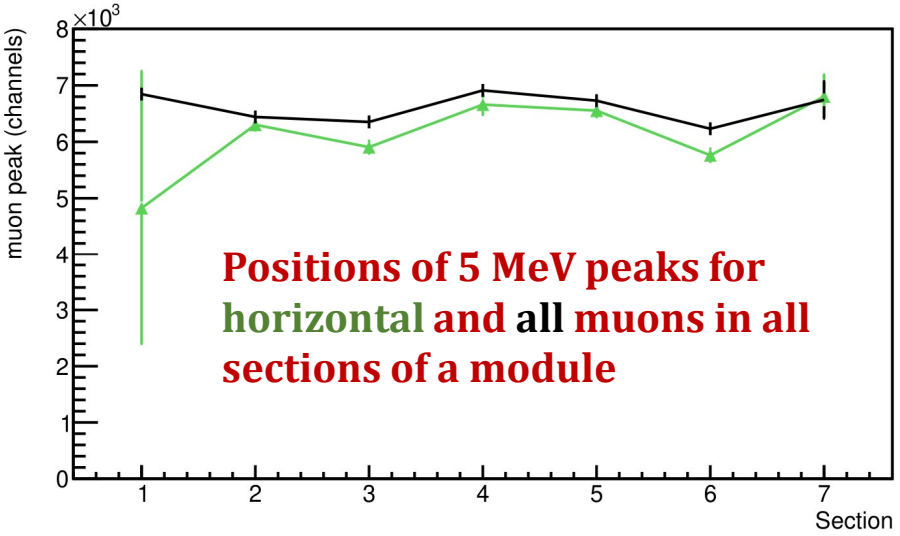
- **Energy deposition 5 MeV;**
- **Narrow peak;**
- **Long time for collection; (one week data acquisition);**
- **Required at least one time.**

All muons

- **Short time for collection; (one day data acquisition);**
- **Energy deposition should be normalized to horizontal muons;**
- **Big uncertainty for end sections;**



5 MeV peak for horizontal and all muons



Positions of 5 MeV peaks for horizontal and all muons in all sections of a module

Tests done for 3x6 modules test bench. Must be done for full FHCal.

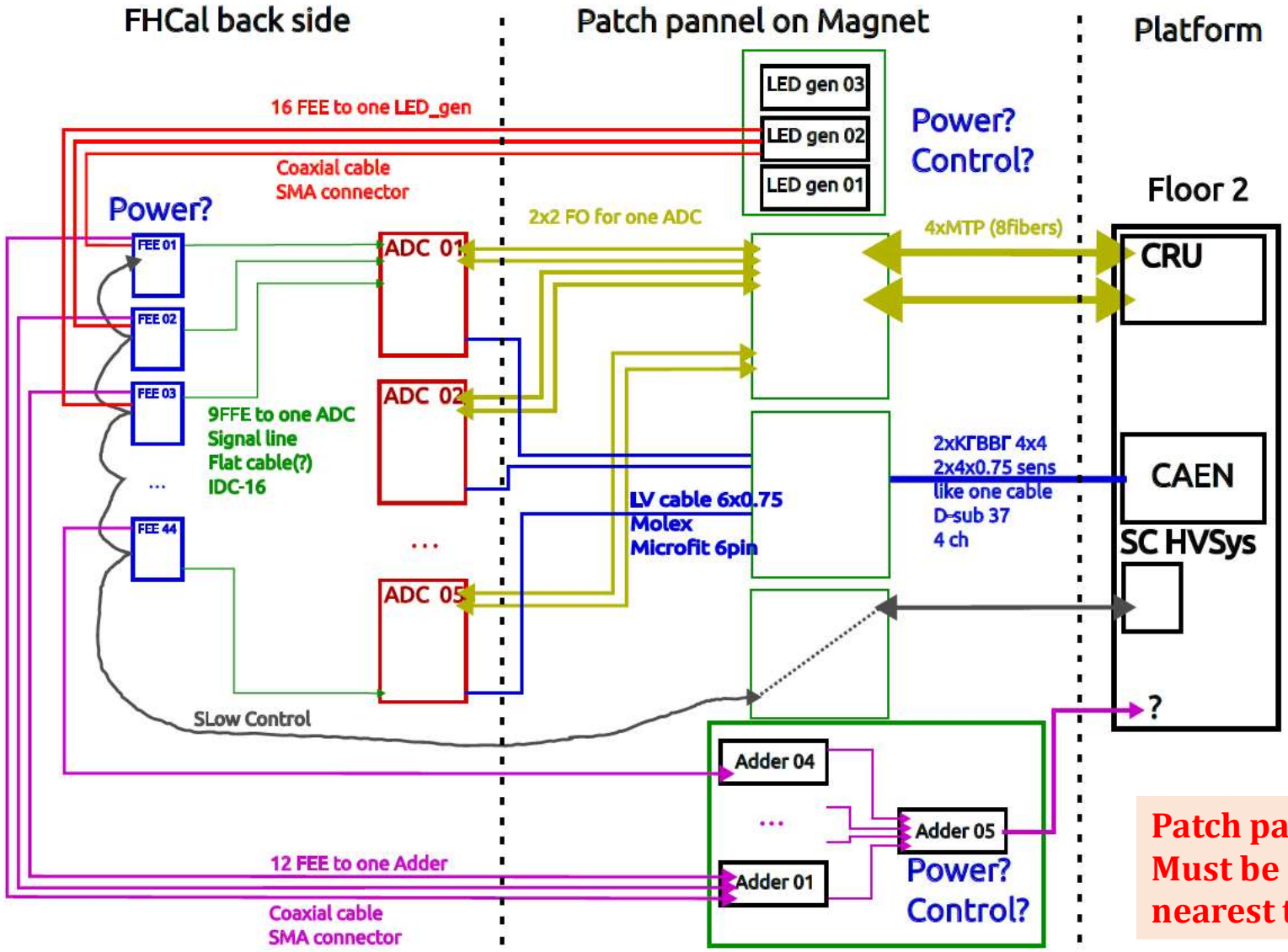
Schedule

- **Apr 2025 - ADC installation and readout (in progress)**
- **Apr-May 2025 - Test of FHCal readout**
- **May 2025 - Configuration of FHCal trigger for muon energy calibration**
- **May-June 2025 - Cosmic muon calibration of full FHCal arm**
- **June 2025 – Installation of the first FHCal arm into magnet**
- **August-September 2025 - Assembling of second FHCal arm**
- **August-September 2025 - Cabling, patch-panel production**
- **August-September 2025 - Pipes with cooling air for ADCs**
- **September 2025 – Installation of the second FHCal arm into magnet**

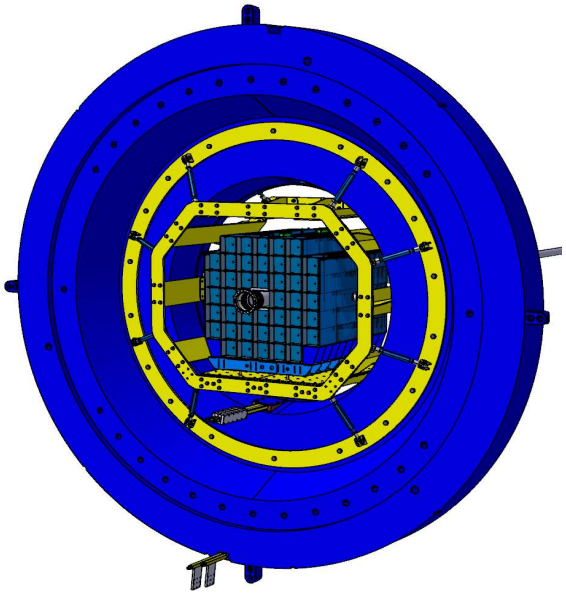
Many thanks to S. Bazylev group, V. Astakhov, S. Gerasimov and M. Rumyantsev !

Thank you!

FHCal cabling



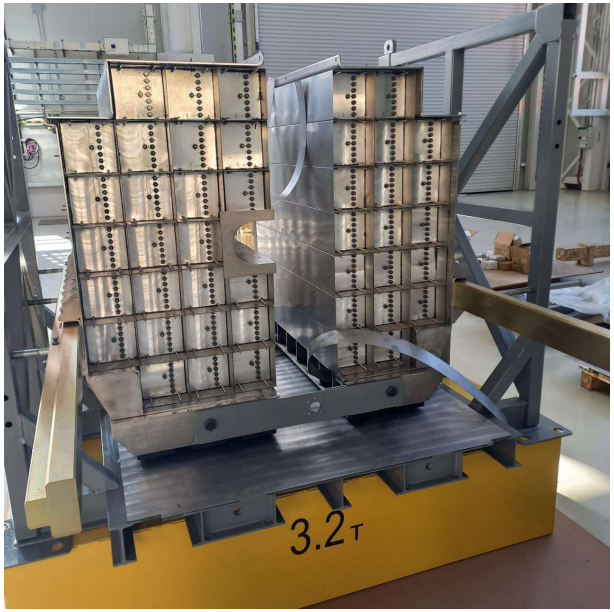
Prepared by M. Rumyantsev



Patch panel is not ready. Must be constructed in nearest time

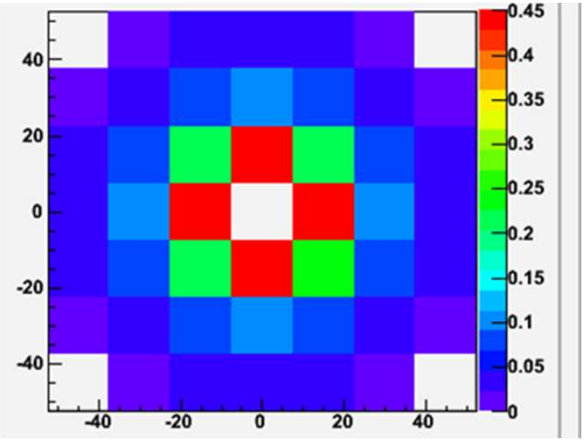
Assembling of FHCal modules in basket

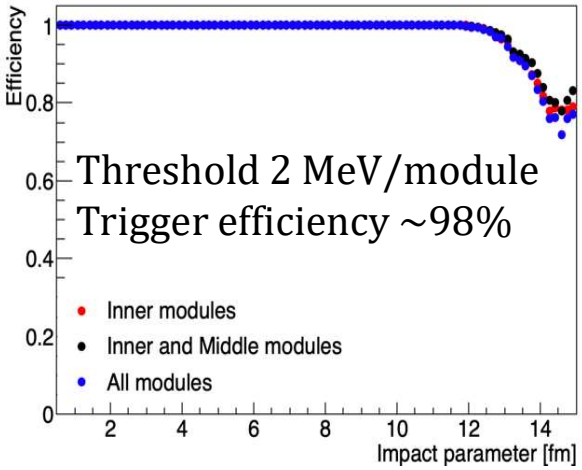
Photos from MPD hall



One FHCal arm already assembled in basket !

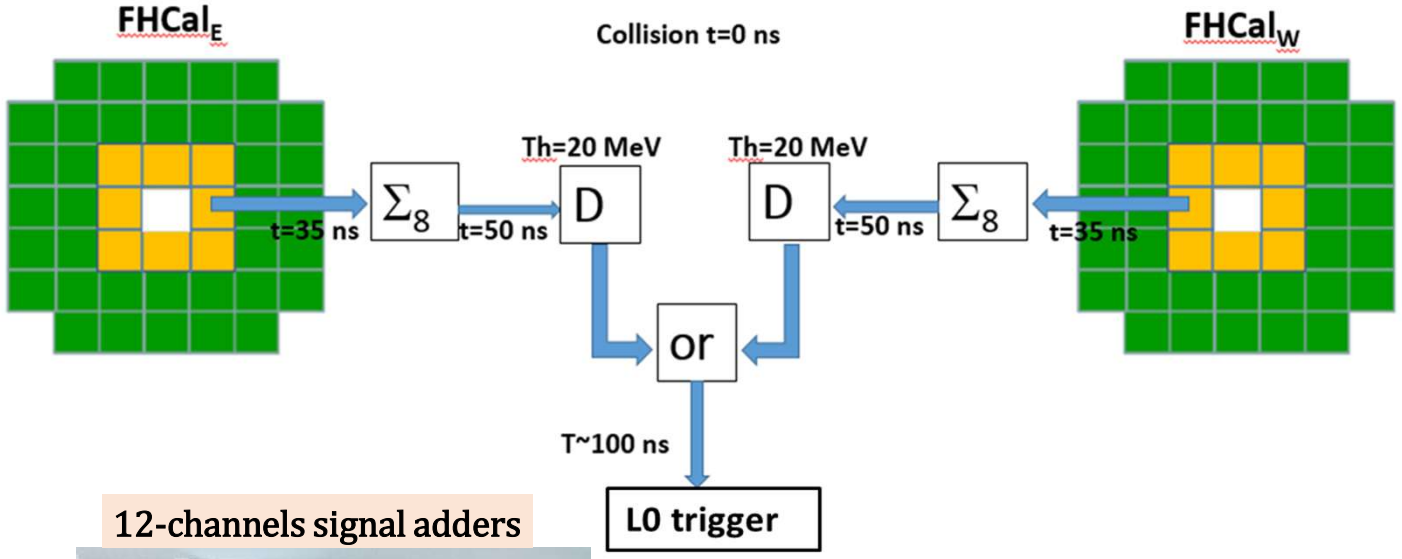
FHCal trigger (analog version)





Dependence of trigger efficiency on the configuration of modules (Au-Au 11 GeV).

Scheme of FHCal trigger



12-channels signal adders

- Adders of analog signals from individual modules were produces for full FHCal.
- The configuration of modules in trigger would depend on FEE and correlation noises. Flexible configuration is to be developed.