

Status of Forward Hadron Calorimeter (FHCAL)

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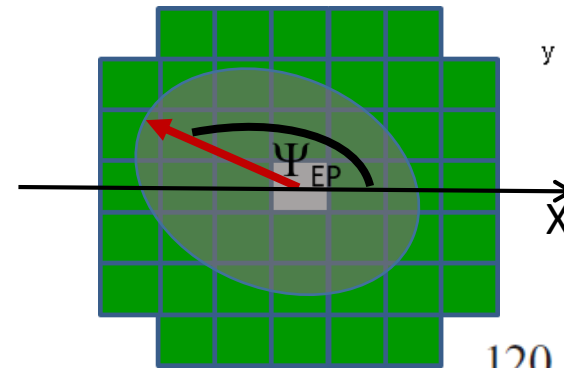
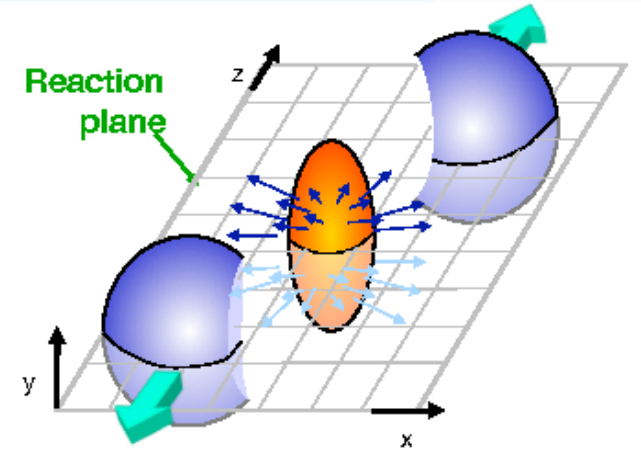
**Institute for Nuclear Research RAS, Moscow
on behalf of the FHCAL group**

- **FHCAL overview;**
- **FHCAL subsystems;**
- **FHCAL readout;**
- **Detector Control System;**
- **Monitoring System**
- **Energy calibration;**
- **Trigger with FHCAL;**
- **Integration to MPD;**
- **Summary.**

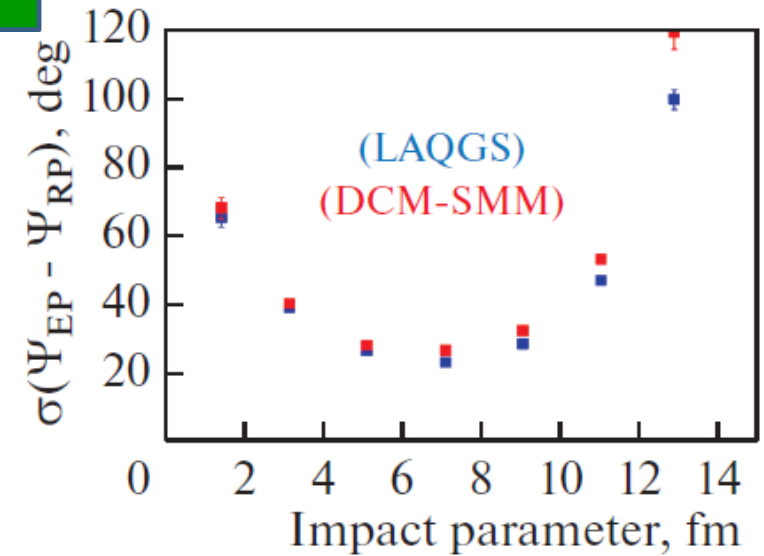
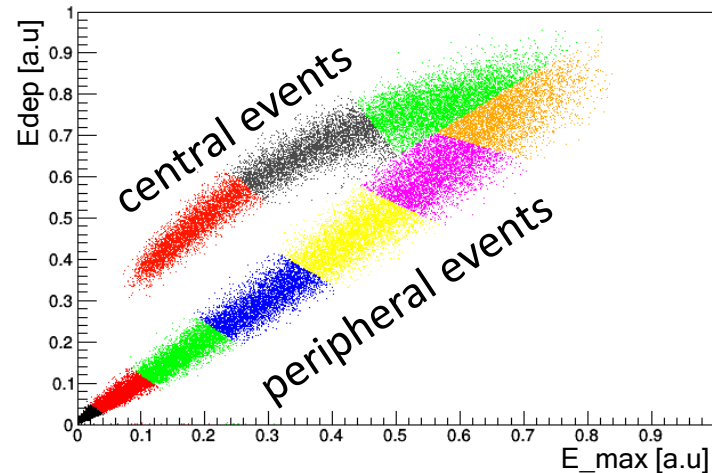
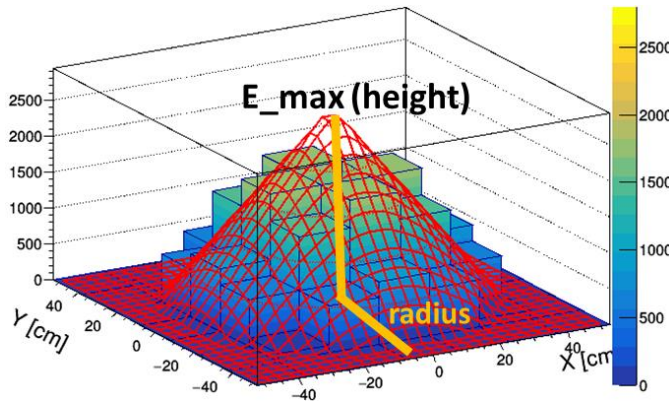
FHCal detects spectators to measure:

- a) The centrality of the collision;
- b) The reaction plane orientation;
- c) Physics in forward rapidity;
- d) Minimum bias trigger.

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



Centrality:
2D-Fit of energy distributions in FHCal modules



FHCal modules

- All (90+spare) FHCal modules are assembled and tested with cosmic rays.
- 100 Front-End-Electronics (FEE) boards are produced and tested.
- Modules are ready for the delivery at MPD site.



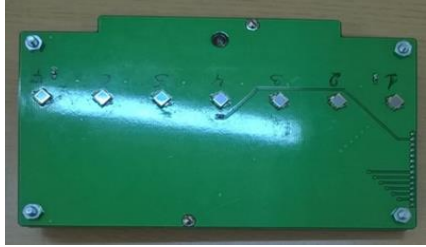
The activities with modules:

- Calibration with cosmic muons;
- Development of readout;
- Development of FHCal trigger;
- Development of Detector Control System;
- Monitoring system.

Front-End-Electronics

100 units of FEE were produced and tested.

MPPC: new type
S14160-3010PS
size – 3x3 mm²;
pixel -10x10 μm²;
PDE~18%.



Two PCBs in each module with:

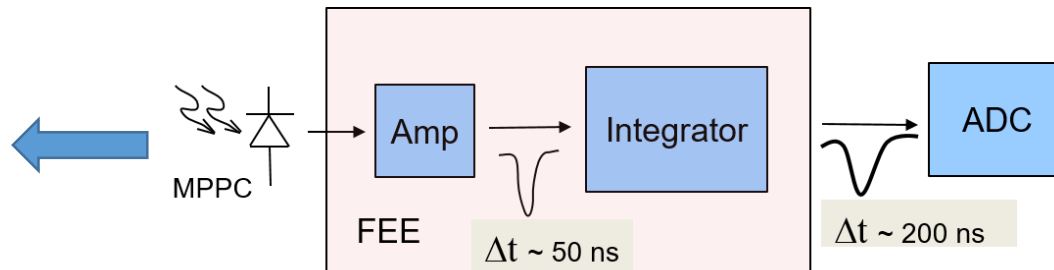
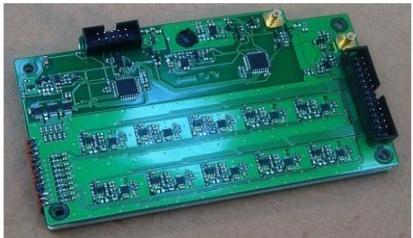
7 photodetectors ;

Photodetectors – MPPCs;

two-stage amplifiers;

HV channels;

LED calibration source.



Set-up for tests of FEE



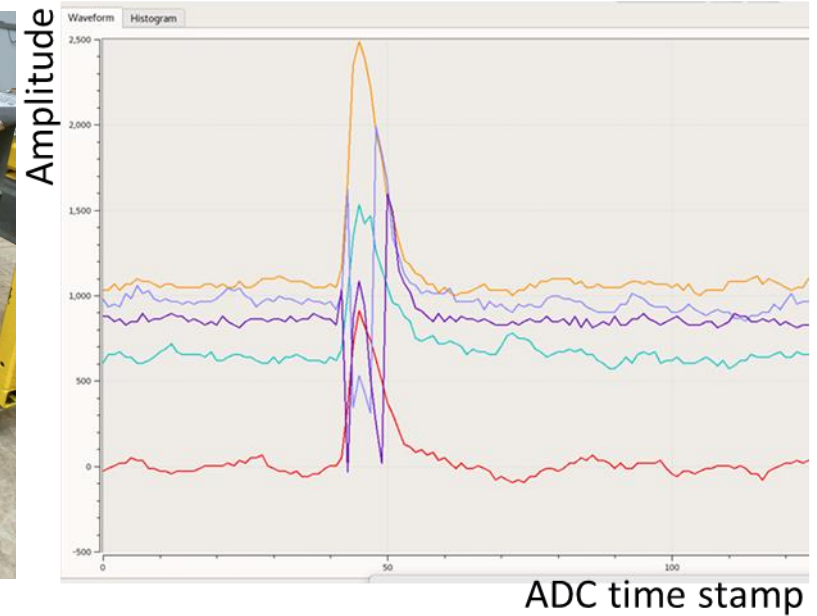
Readout - cabling

Effect of flat cables

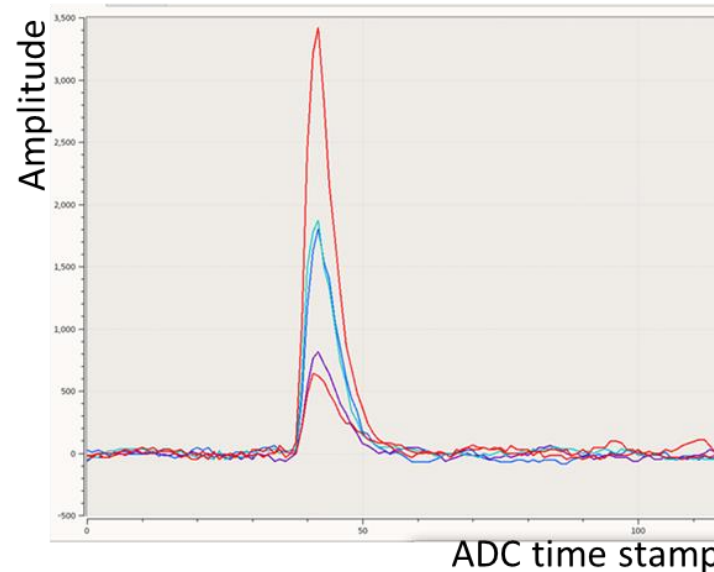
- At present, the signal flat cables are unshielded and are intended for LVDS signal.
- It lead to the pick-up noises and to instability of ADC base lines.
- It is visible during the tests with cosmic muons.
- To keep the best performance the cables must be shielded.



Before shielding:



After shielding:

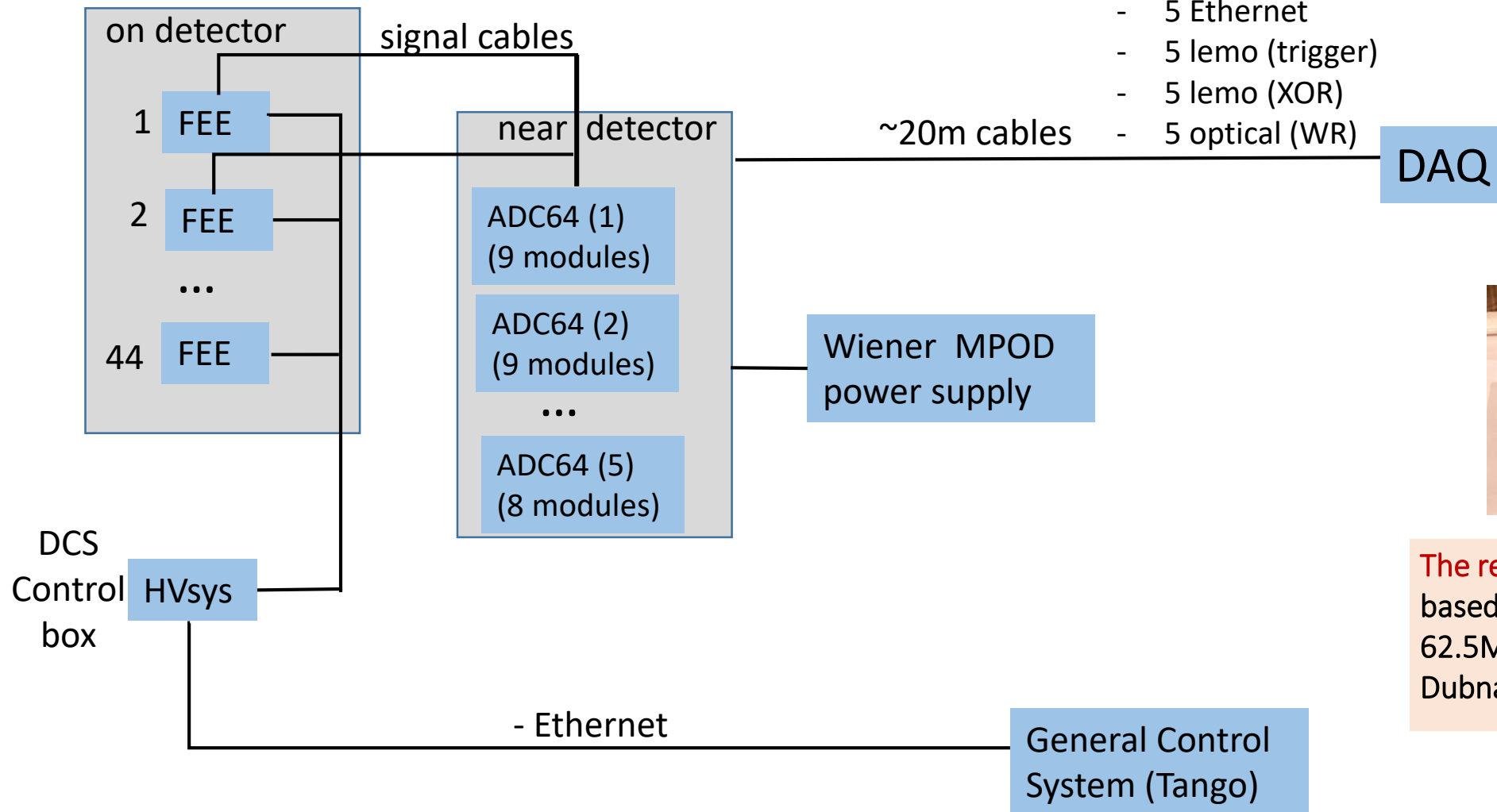


- After shielding the noises disappeared.
- Base lines are stable.
- Signal shapes are perfect.

One needs to get another type of flat cables or to use external shielding for present cables.

Diagram of FHCAL readout

Left (Right) FHCAL arm



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

Both FHCAL arms have the same readout scheme.

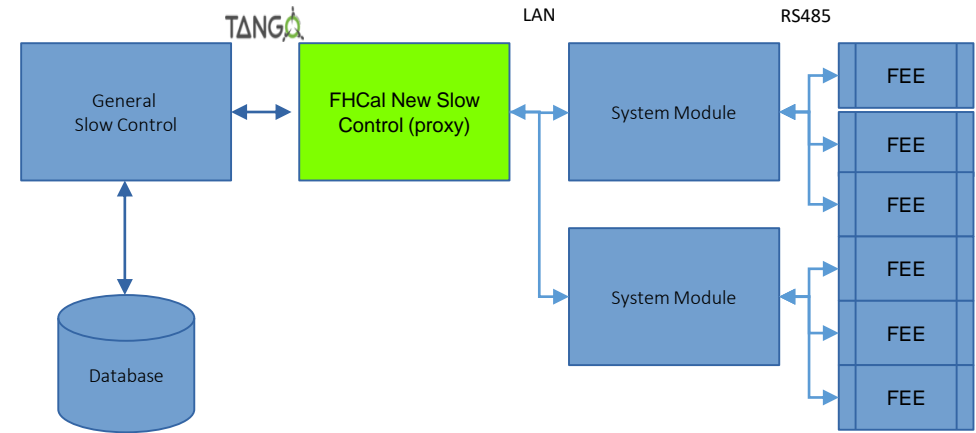
Detector Control System (DCS)

DCS Tasks:

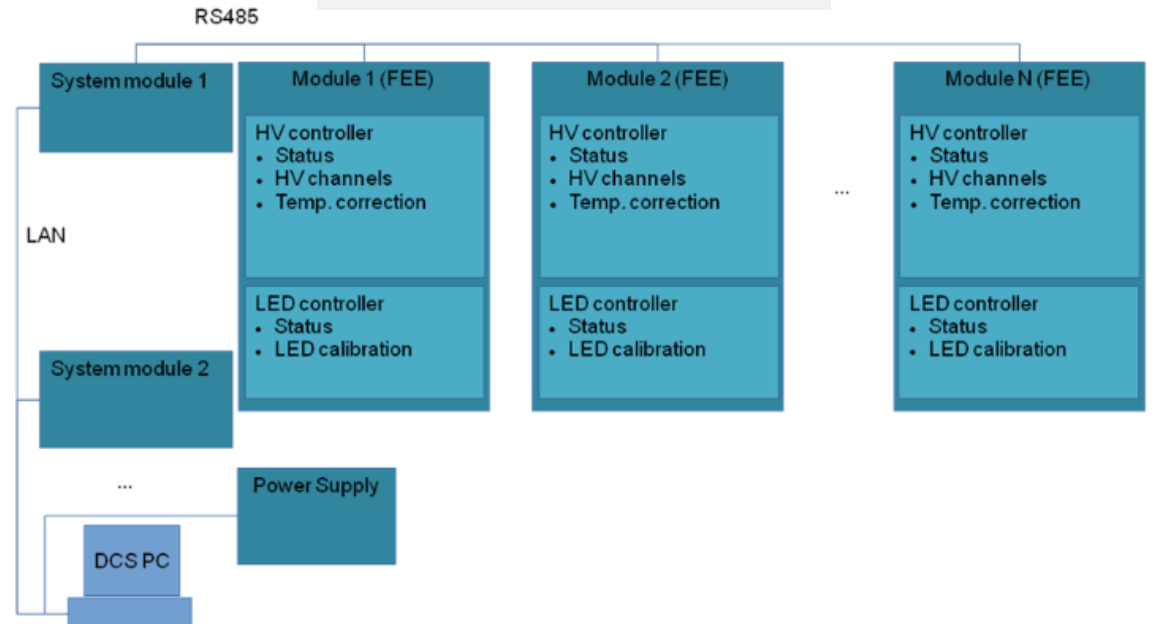
- Control of HV at photodetectors (MPPC's);
- Temperature control of photodetectors;
- Compensation of temperature drift of MPPC gain;
- Monitoring of MPPC gain with stabilized light source.

Status of DCS:

- It is working with one arm of FHCaI;
- Needs some debugging for full operation;
- Needs additional developments to work with two arms.

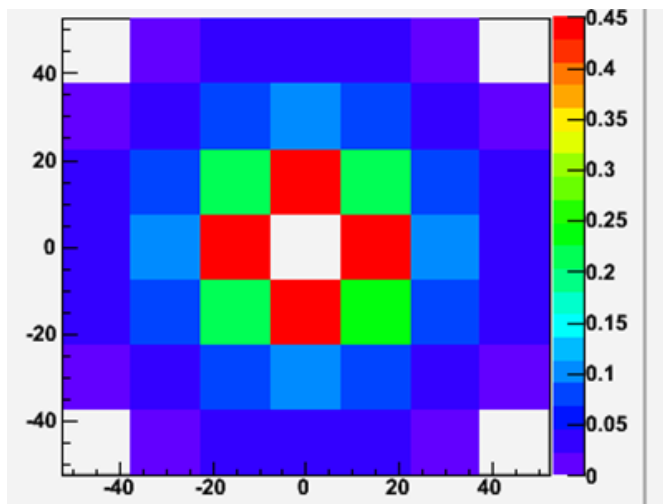


Connection diagram

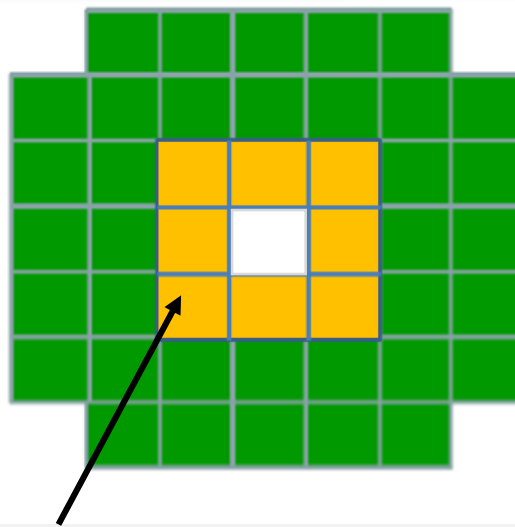


External LED generators for monitoring system were produced.
Synchronization and tests are ongoing!

Preparations for FHCAL trigger

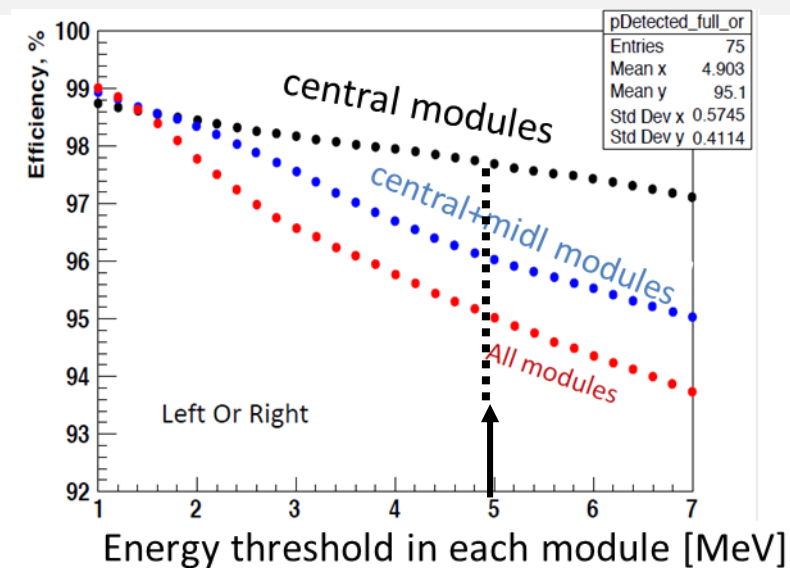


In peripheral collision the energies are mainly deposited in central modules.



In the simplest case only the central modules can be used in trigger.

Dependence of trigger efficiency on the energy threshold and on the number of modules.



Simulation of V.Ryabov shows that all modules must be included in trigger.

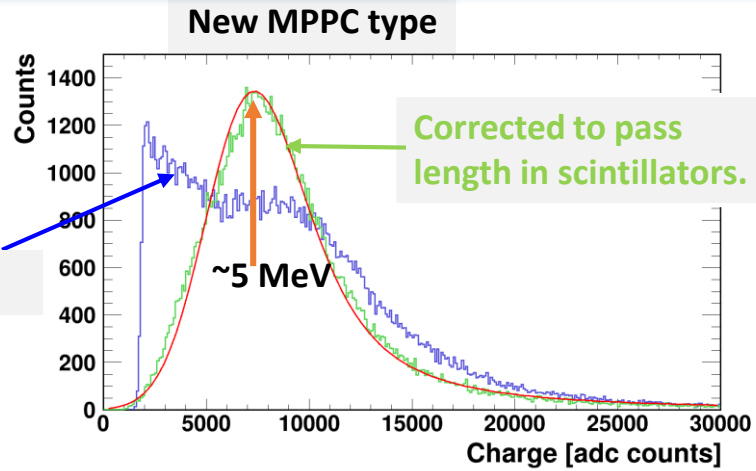
- Adders of analog signals from individual modules were produced for part of FHCAL.
- For all modules a few additional adders must be produced!
- The configuration of modules in trigger would depend on FEE and correlation noises. Flexible configuration is to be developed.



Energy calibration with cosmic muons



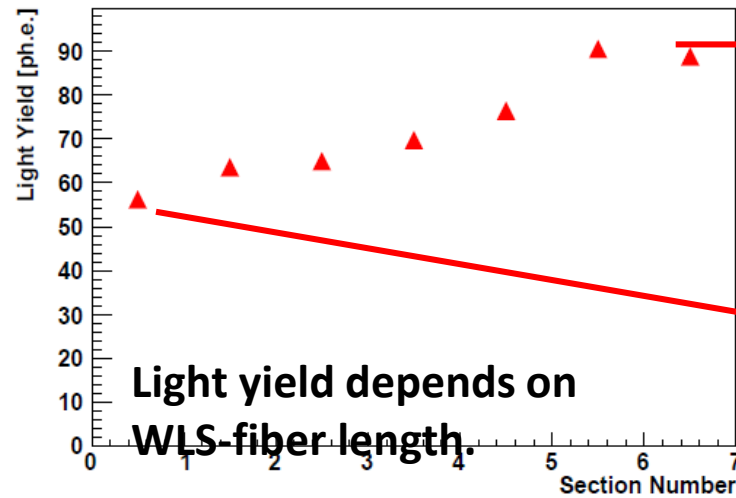
Raw spectrum



Clear amplitude spectra from cosmic muons allow the energy calibration in self-triggering mode (without external muon trigger).

This is due to high light yield in the longitudinal sections in modules.

Average light yield for MIP's in longitudinal sections.

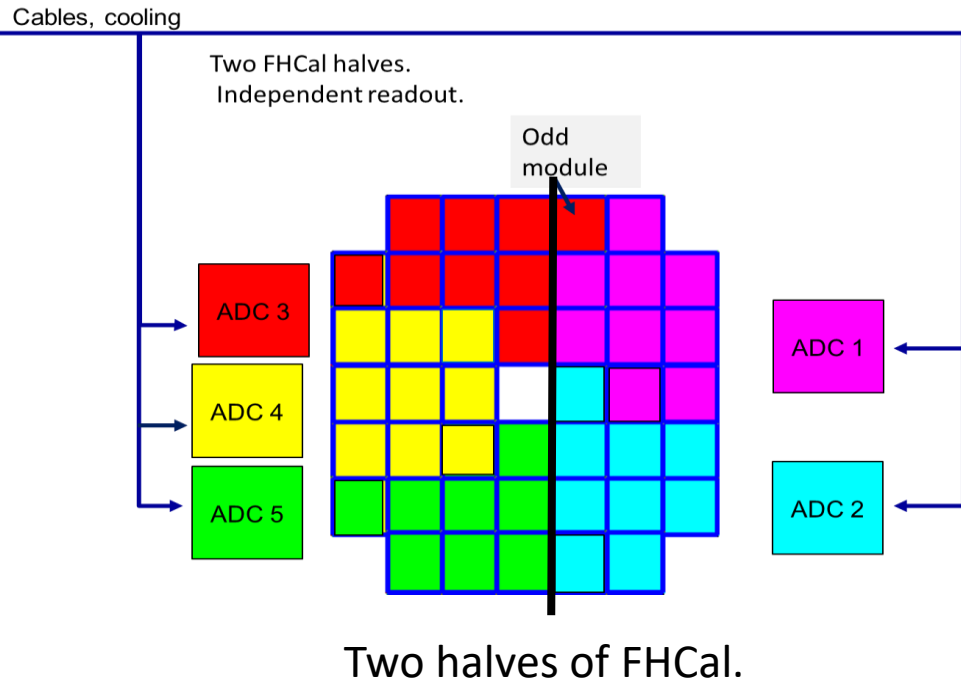


Light yield depends on WLS-fiber length.

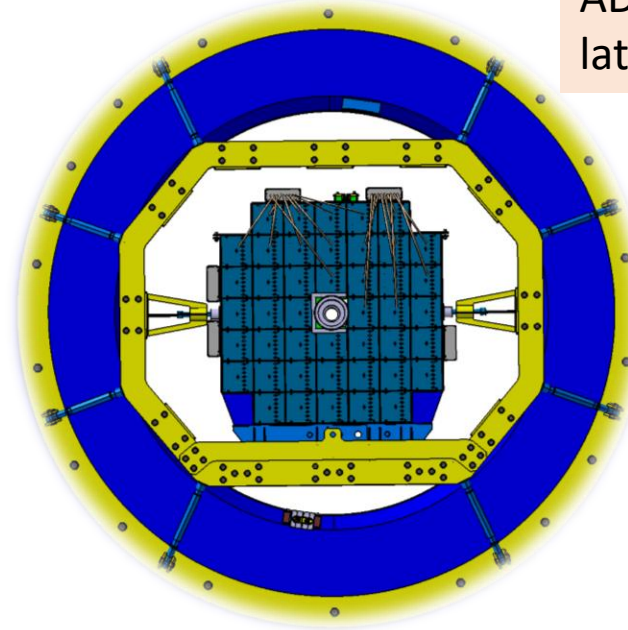
Light drops for ~40% for 1m fiber.



FHCal integration to MPD (ADC readout)



ADC boxes are placed at the lateral sides of FHCal support



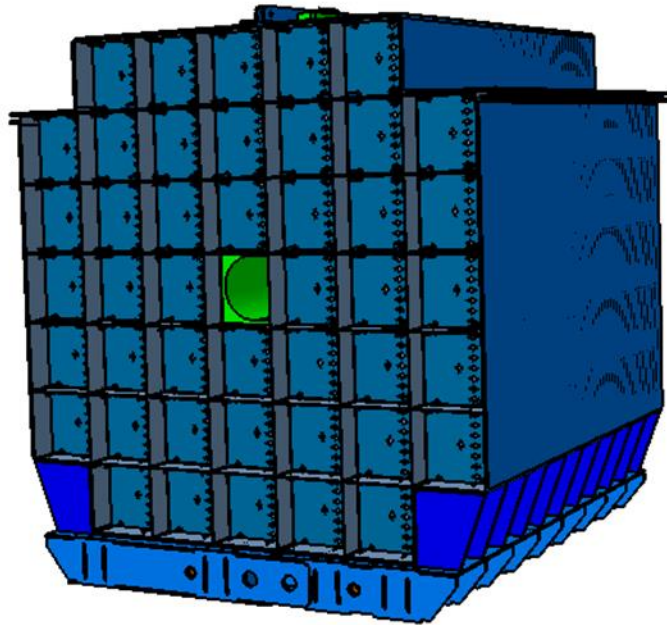
ADC boards – ready!
ADC boxes – in production.



ADC cooling with compressed air is planned.
5 pipes from each side are to be available!

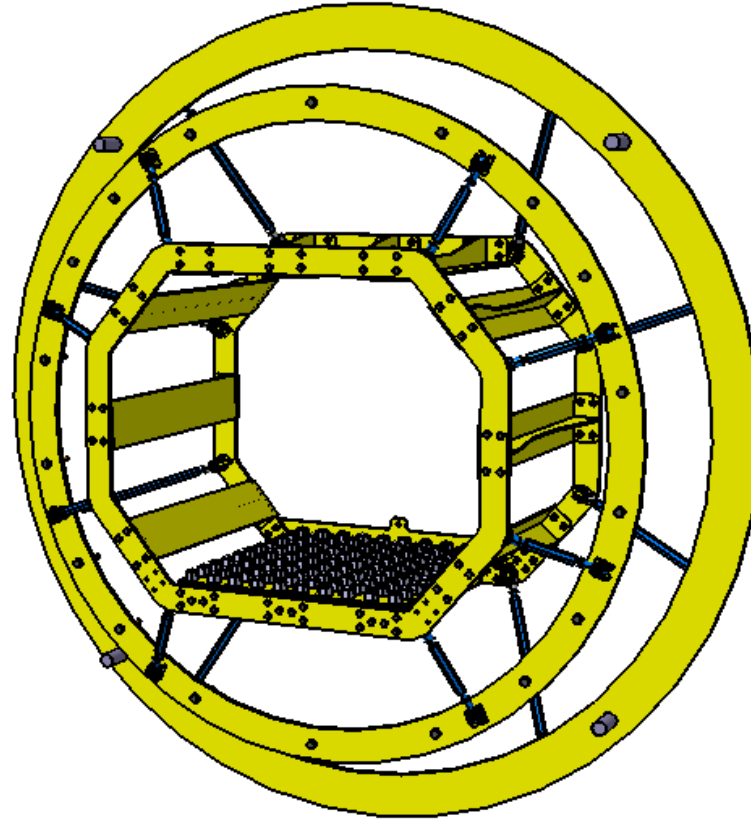
Mechanical support (main elements)

Basket of FHCAL modules



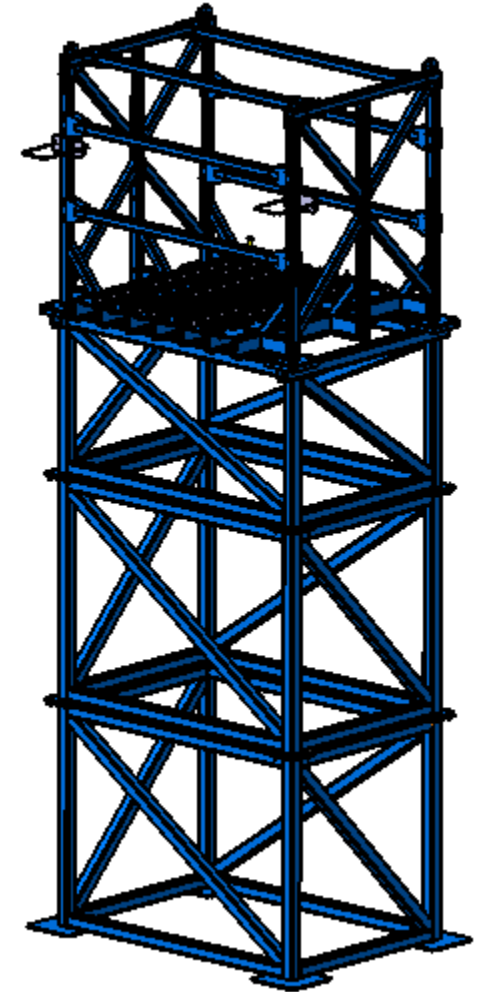
Design is practically finished!
Basket is very urgent for production
to start the FHCAL assembling near
MPD next year!

Support frame in magnet pole



First version of support was not
rigid enough.
Second version is more stable.
Design is at final stage!

Outer table

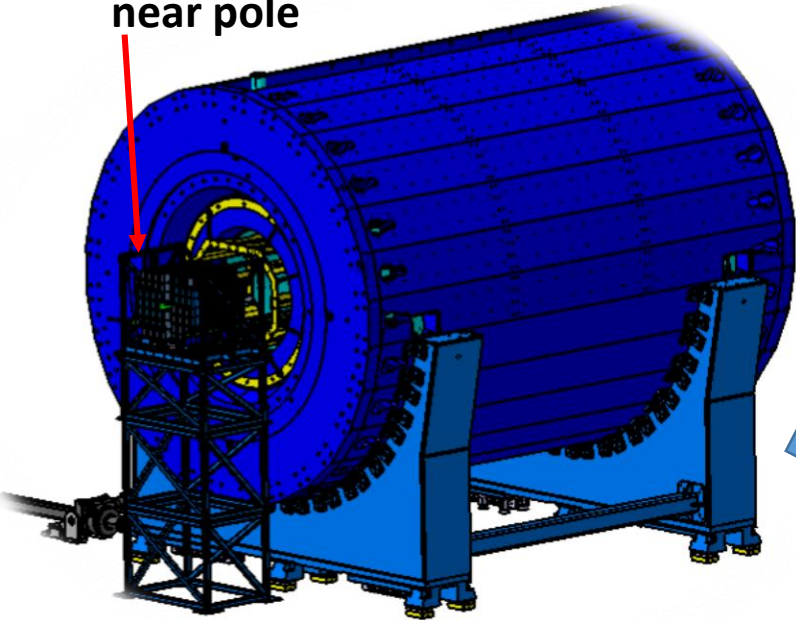


FHCal installation into magnet pole

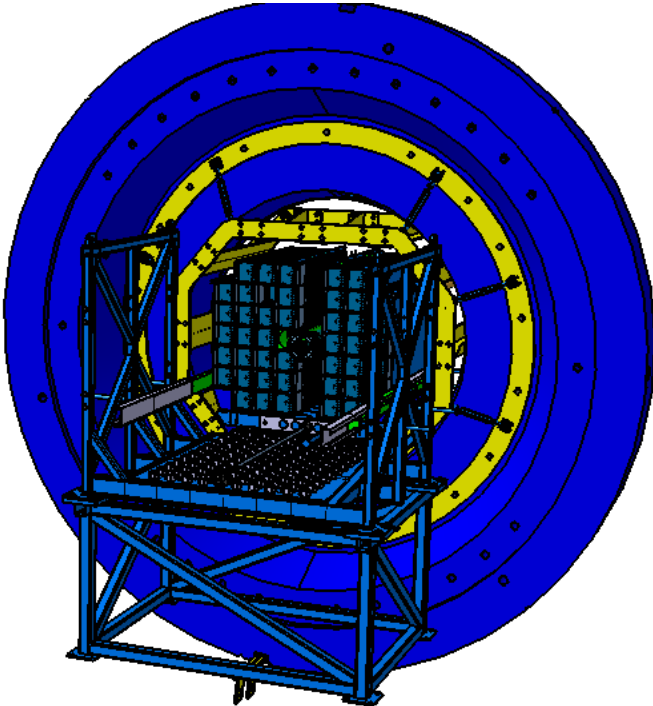
Design of FHCal support is at final stage!

Main problem: beam pipe between two FHCal halves

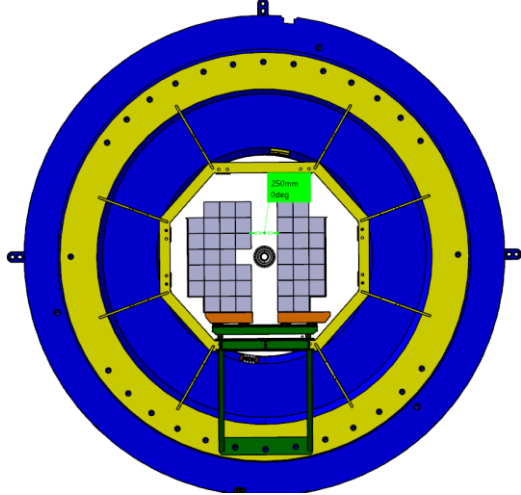
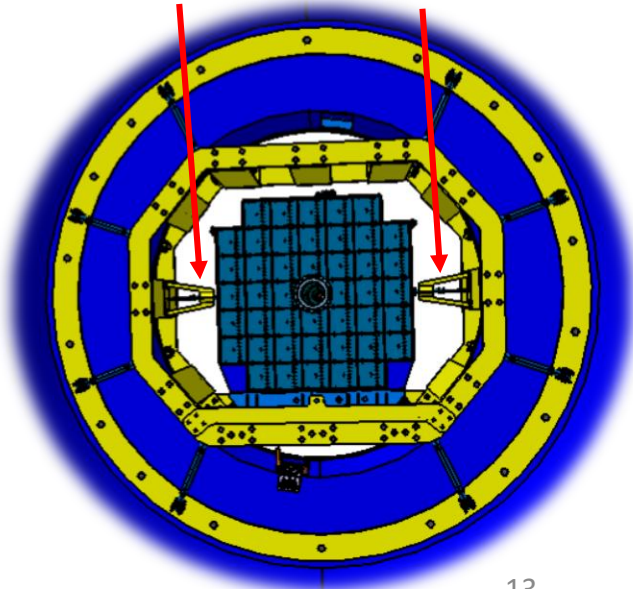
Table with FHCal near pole



FHCal inserted into pole



Two FHCal halves compressed together



Summary

- All FHCAL modules were tested and are ready for delivery at MPD site.
 - FEE was produced and tested.
 - Detector Control System is at the debugging stage.
 - Energy calibration procedure is well developed (needs optimization).
 - The FHCAL readout is under development. No serious problems are expected.
 - FHCAL trigger is under development. Flexible configuration of modules is considered.
 - The mechanical platform is at final stage of design.
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- We plan to be ready for the calorimeter assembling at MPD site in the second half of 2022.
 - The basket for FHCAL modules must be produced to this time!
 - The space and some infrastructure for FHCAL assembling must be available!

Thank you!