

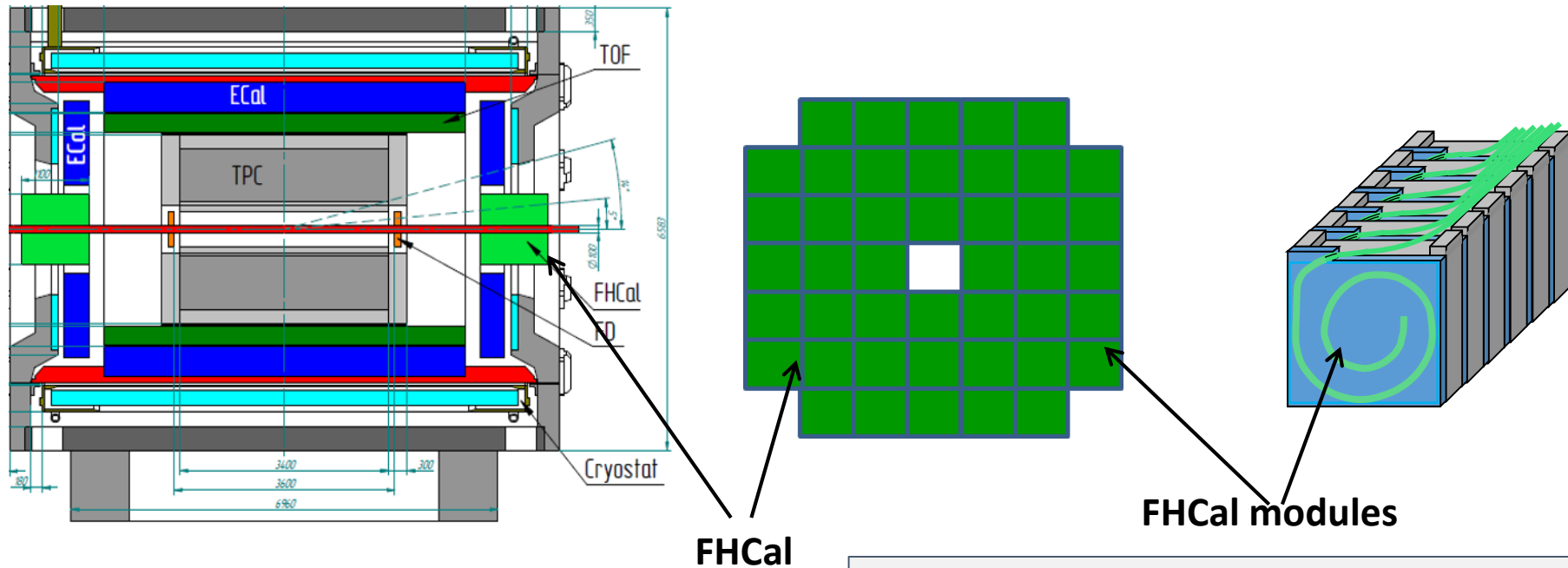
Status of Forward Hadron Calorimeter (FHCAL)

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on behalf of the FHCAL group**

- **FHCAL overview;**
- **Status of FHCAL modules;**
- **FHCAL subsystems;**
- **Integration to MPD;**
- **Mechanical support.**

FHCal in MPD



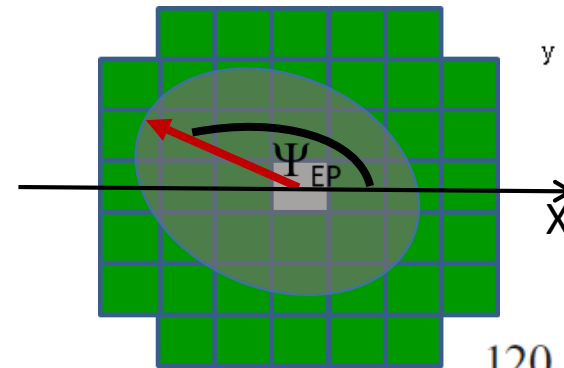
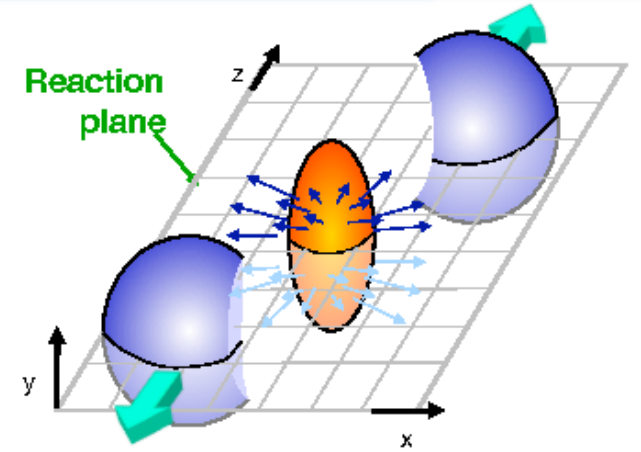
- Two arms of hadron calorimeter at opposite sides in forward regions.
- At the distance 3.2 meters from the interaction point.
- Available acceptance corresponds to pseudorapidity $2.0 < \eta < 5.0$

- FHCal consists of 2x44 modules.
- $\sim 1 \times 1 \text{ m}^2$ each part.
- Beam hole $15 \times 15 \text{ cm}^2$.
- Lead/scintillator sampling calorimeter.
- Longitudinal segmentation;
- Light readout- WLS-fibers;
- 7 sections/photodetectors in each module.

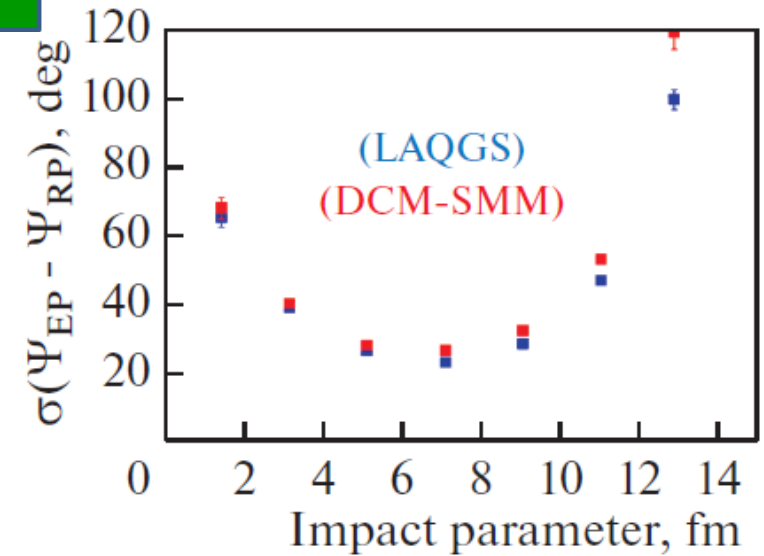
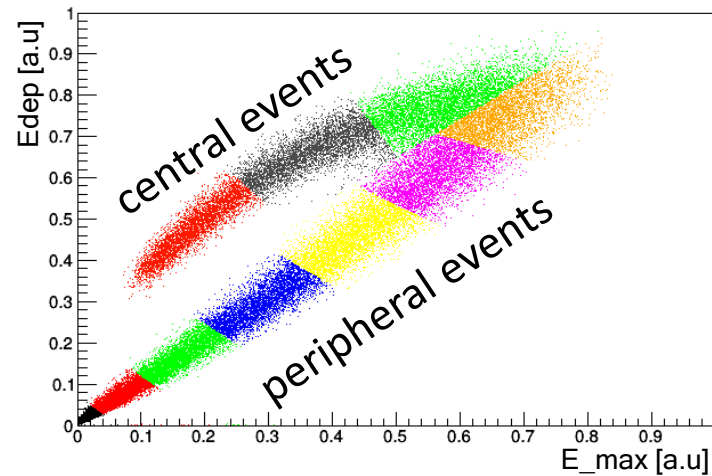
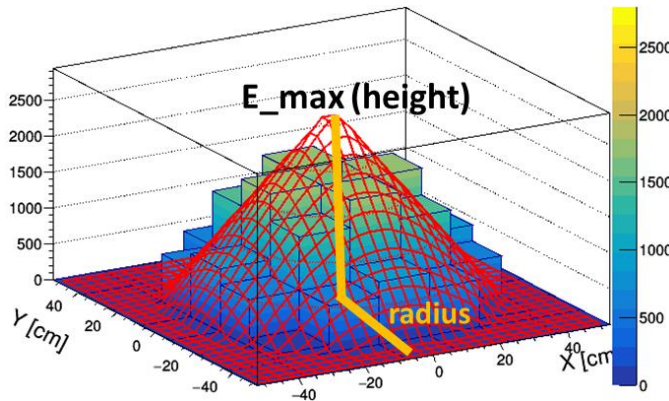
FHCal detects spectators to measure:

- 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

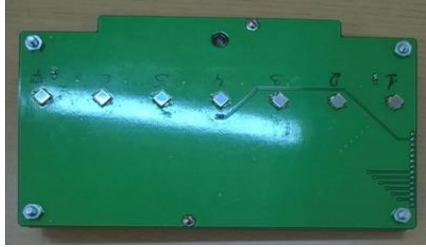
- All (90+spare) FHCal modules are assembled and tested with cosmic rays.
- 100 Front-End-Electronics (FEE) boards are produced and tested.
- Modules are ready for the delivery at MPD site.



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



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

Two PCBs in each module with:

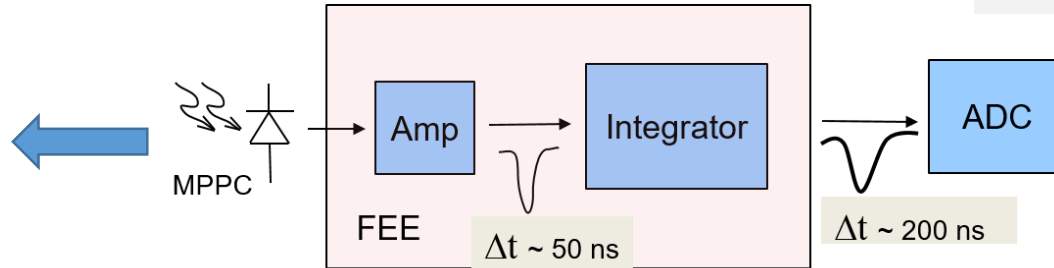
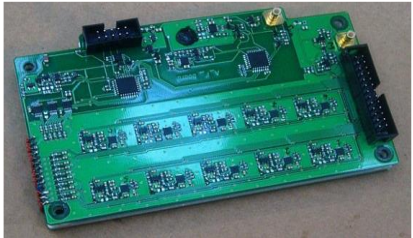
7 photodetectors ;

Photodetectors – MPPCs;

two-stage amplifiers;

HV channels;

LED calibration source.

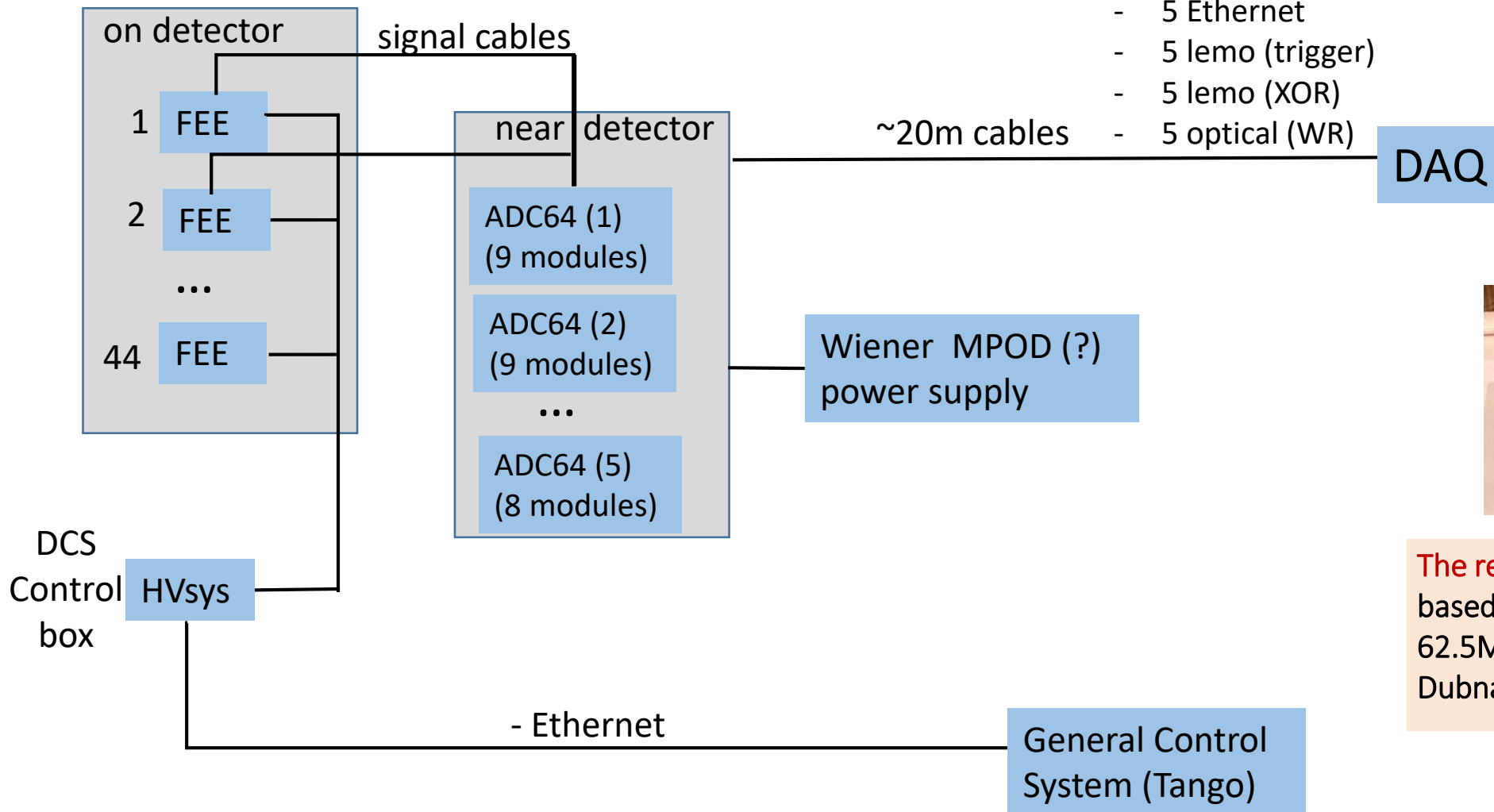


100 units of FEE were produced and tested.



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.

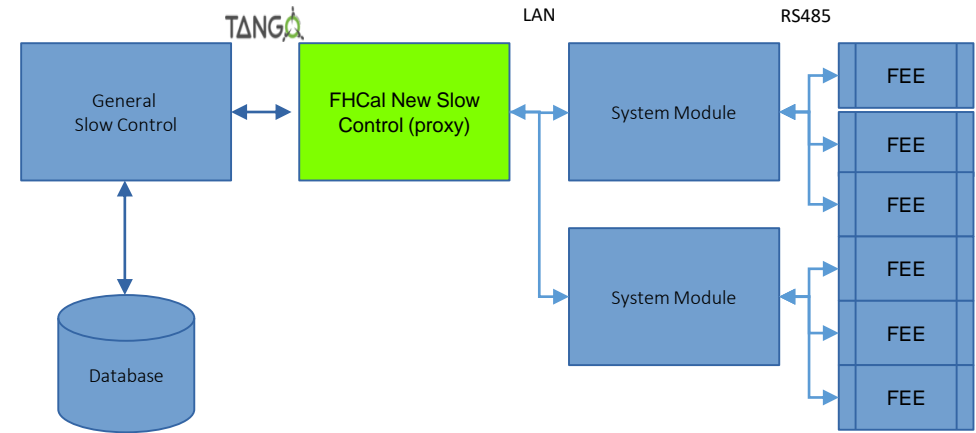
Detector Control System (DCS)

DCS Tasks:

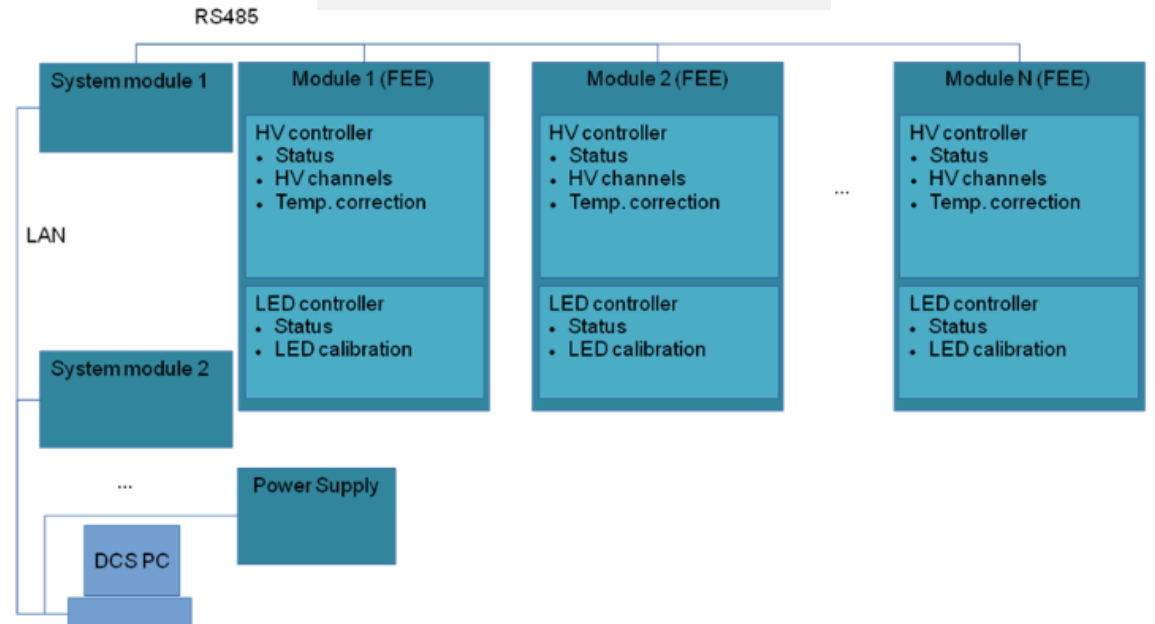
- Control of HV at photodetectors (MPPC's);
- Temperature control of photodetectors;
- Compensation of temperature drift of MPPC gain;
- Monitoring of MPPC gain with stabilized light source.

Status of DCS:

- It is practically fully operational;
- The performance will be tested in the nearest BM@N runtime (nov'22).



Connection diagram

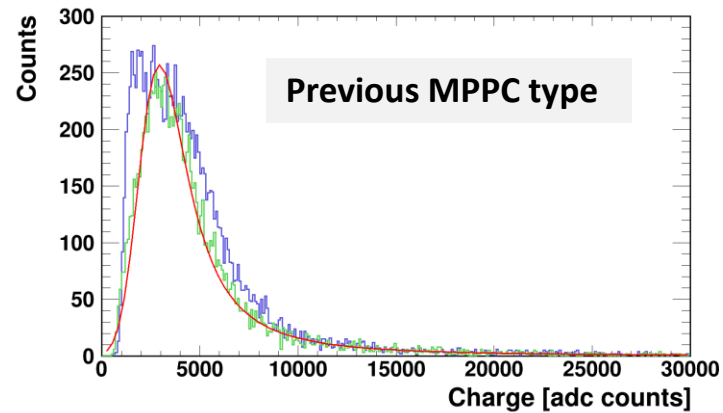


External LED generators for monitoring system were produced.
Synchronization and tests are ongoing!

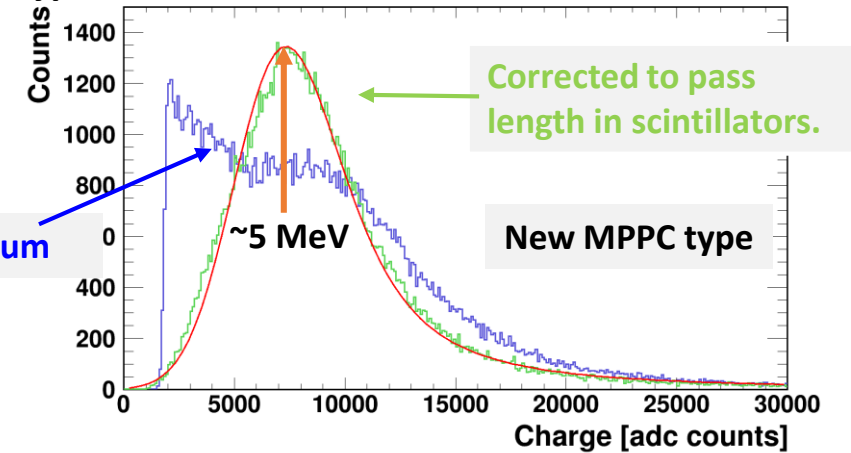
Energy calibration with cosmic muons

Response of FHCAL modules with different types of MPPC to cosmic muons .

μ



MPPC: S12572-010P
pixel -10x10 μm^2 ;
PDE~12%;
G~10⁵.

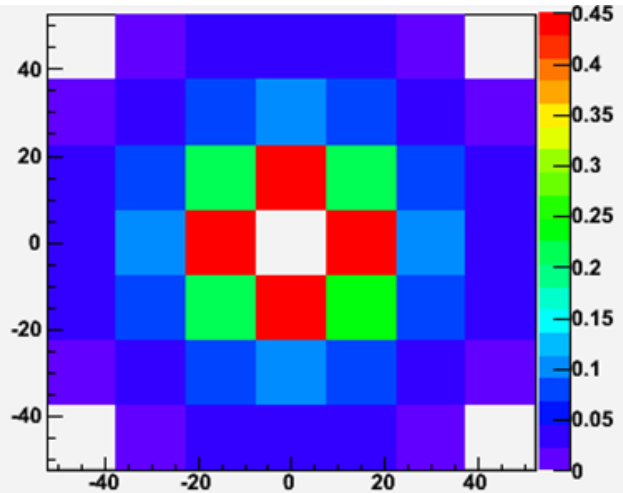


MPPC: S14160-3010PS
pixel -10x10 μm^2 ;
PDE~18%;
G~1.8x10⁵.

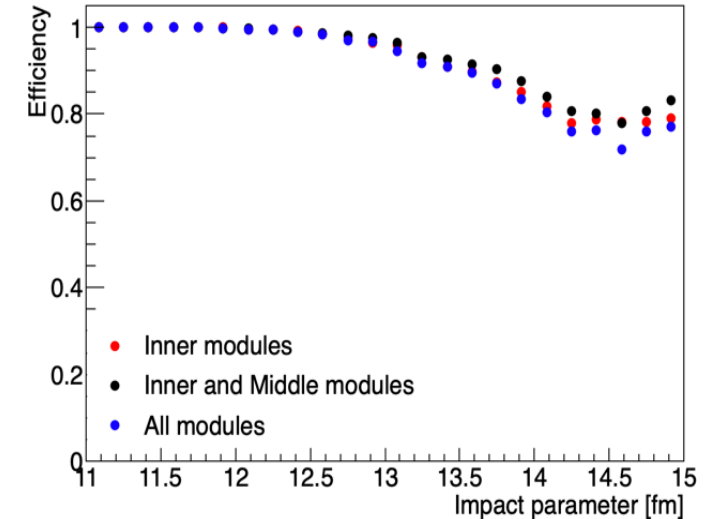
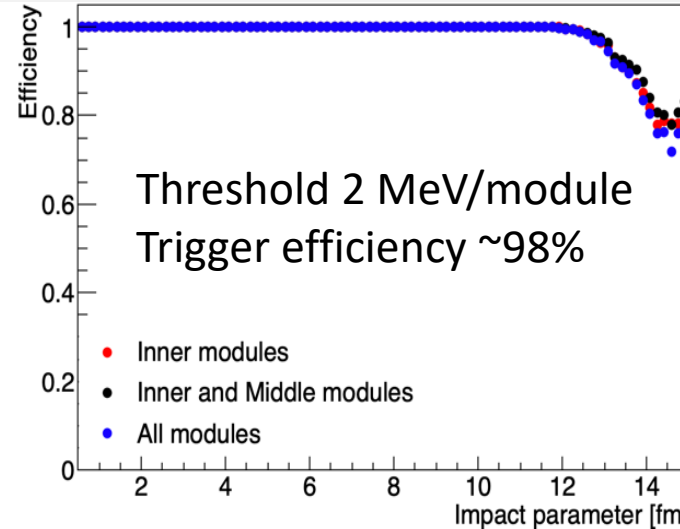


- Clear amplitude spectra from cosmic muons allow the energy calibration in self-triggering mode (without external muon trigger).
- This is due to high light yield in the longitudinal sections in modules.
- With new photodiodes effect of electronic noise is rather small.
- A new simplified version of energy calibration is under development.

Preparations for FHCAL trigger

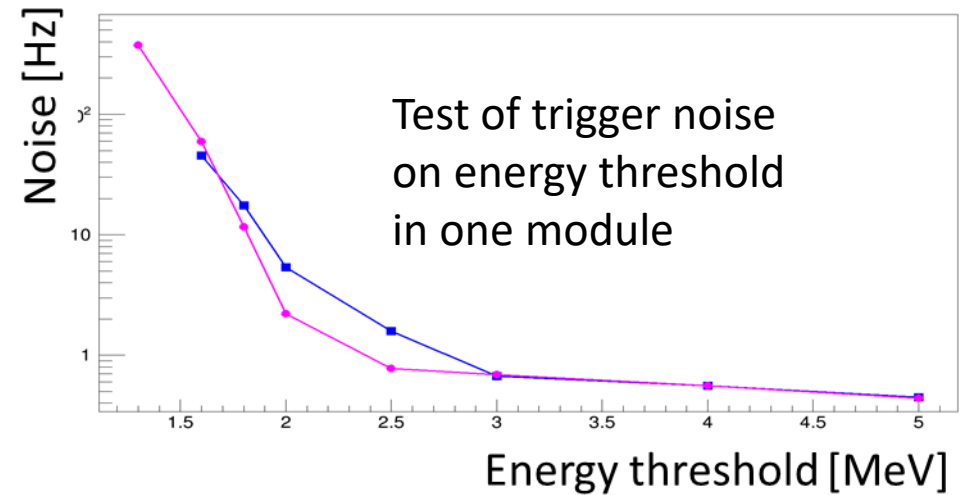


In peripheral collision the energies are mainly deposited in central modules.

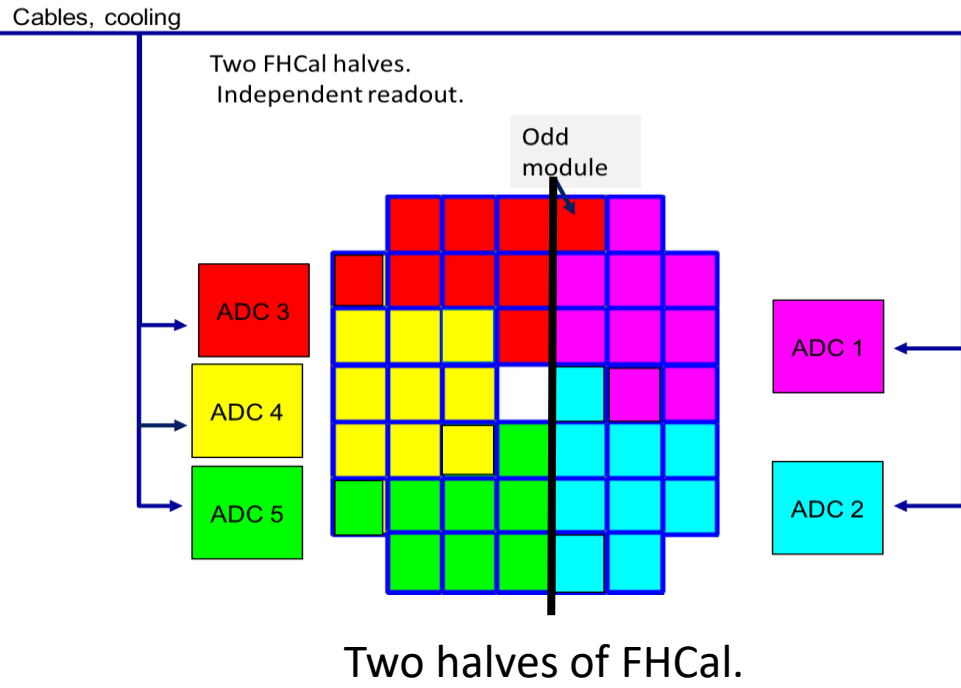


Dependence of trigger efficiency on the configuration of modules (Au-Au 11 GeV).

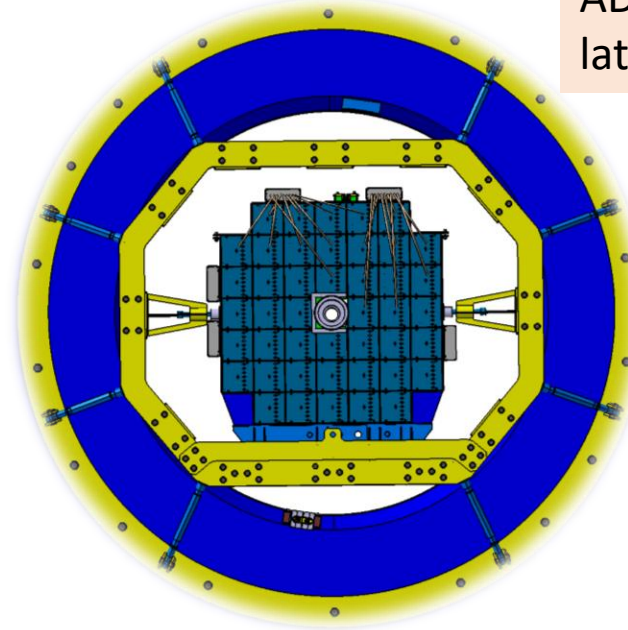
- Adders of analog signals from individual modules were produced for part of FHCAL.
- For all modules a few additional adders must be produced!
- The configuration of modules in trigger would depend on FEE and correlation noises. Flexible configuration is to be developed.



FHCal integration to MPD (ADC readout)



ADC boxes are placed at the lateral sides of FHCal support



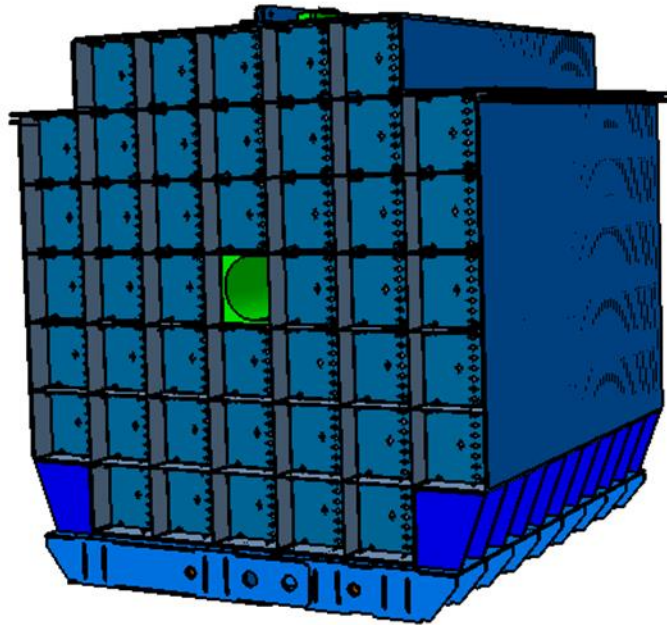
ADC boards and boxes are ready.
Tests are planned in the nearest time.



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

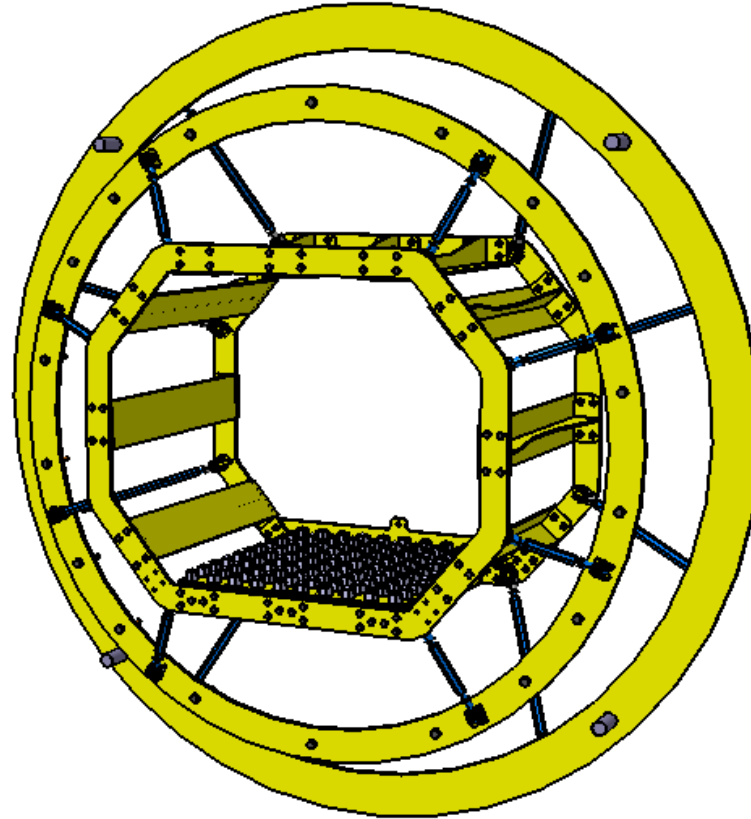
Mechanical support (main elements)

Basket of FHCAL modules



Design is finished!
Basket is urgent for production to start the FHCAL assembling near MPD.

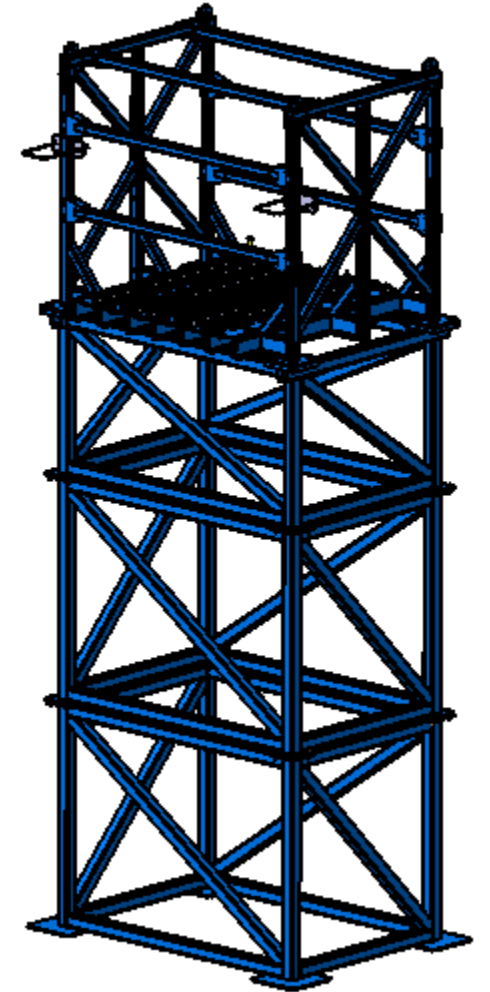
Support frame in magnet pole



Design is at final stage!

Start of production is planned next year.

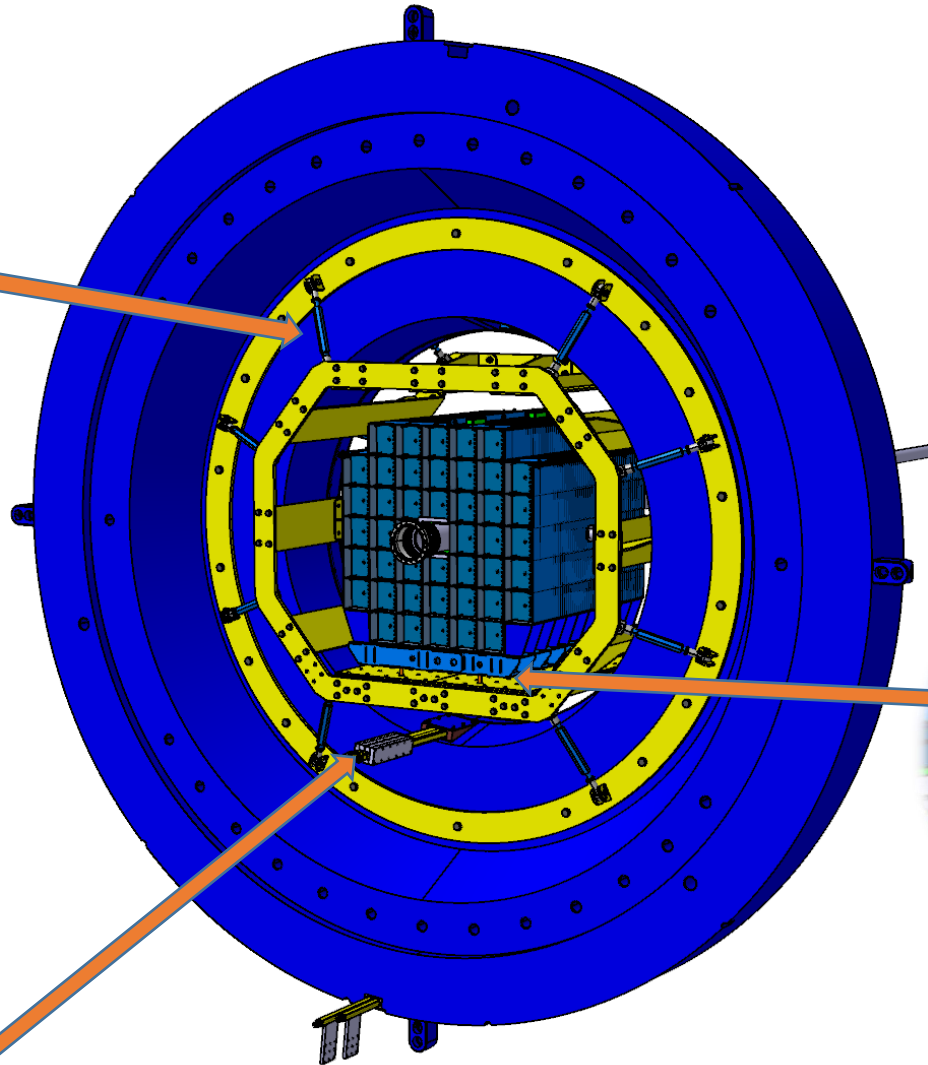
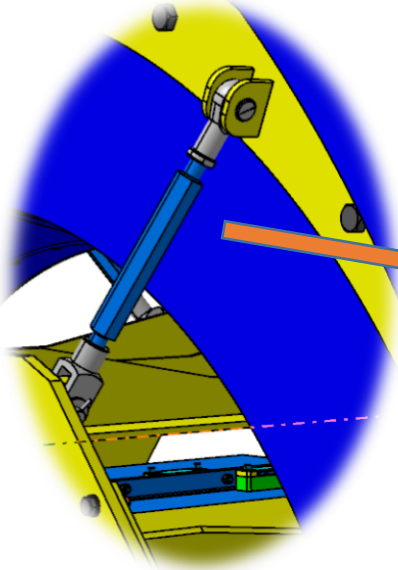
Outer table



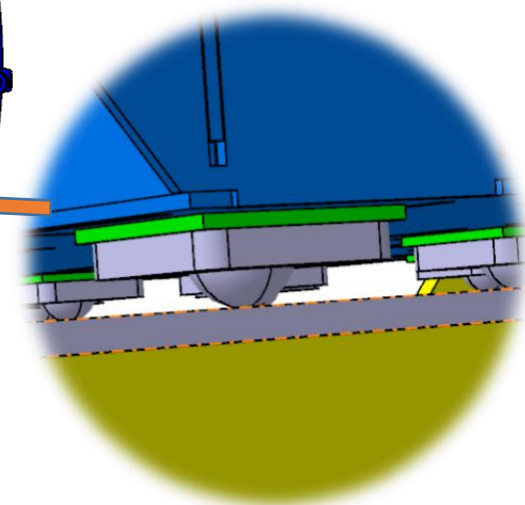
Design is finished!

Mechanical support (sensitive parts)

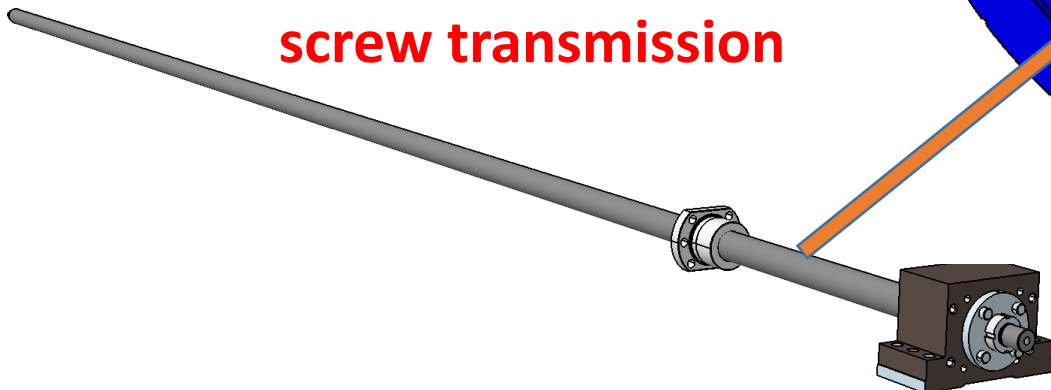
Ball heads and holders



Ball joints



screw transmission

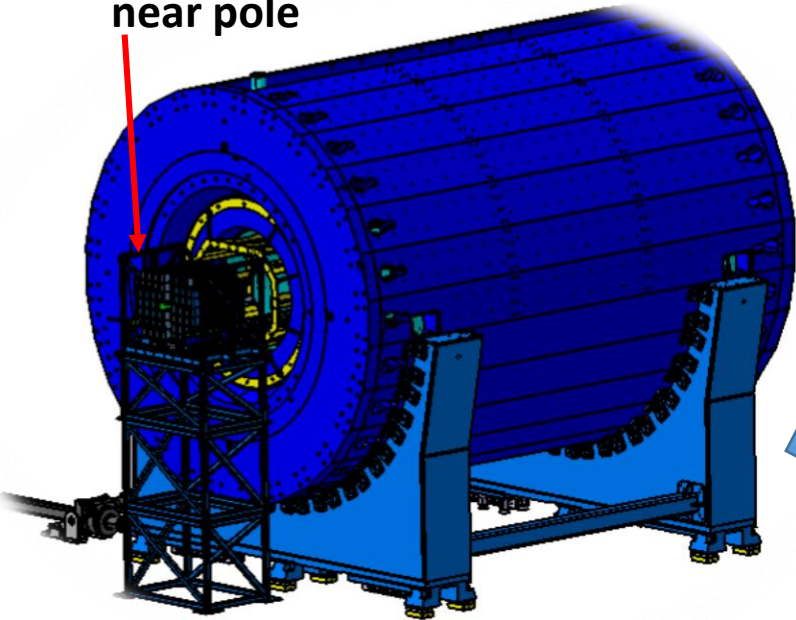


These parts are already ordered!

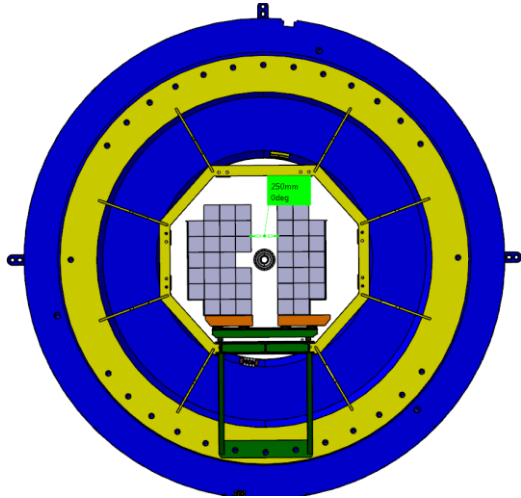
FHCal installation into magnet pole

Design of FHCal support is at final stage!

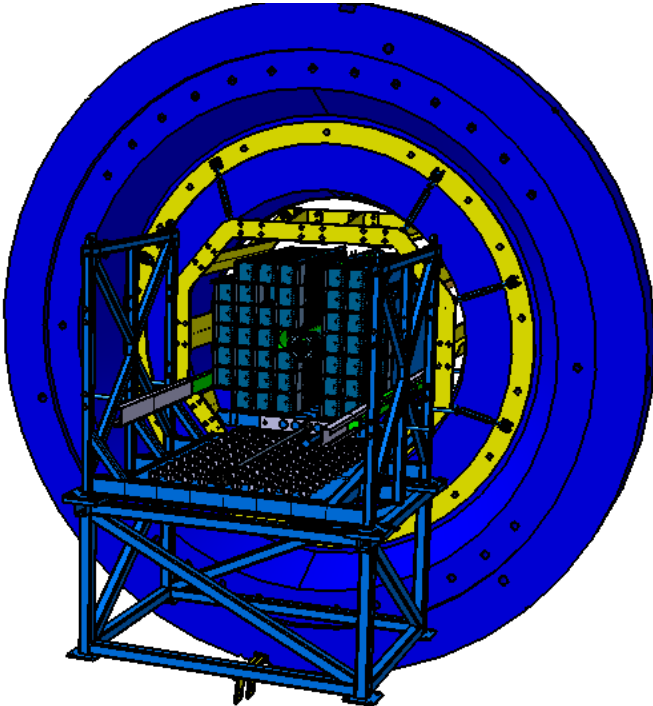
Table with FHCal near pole



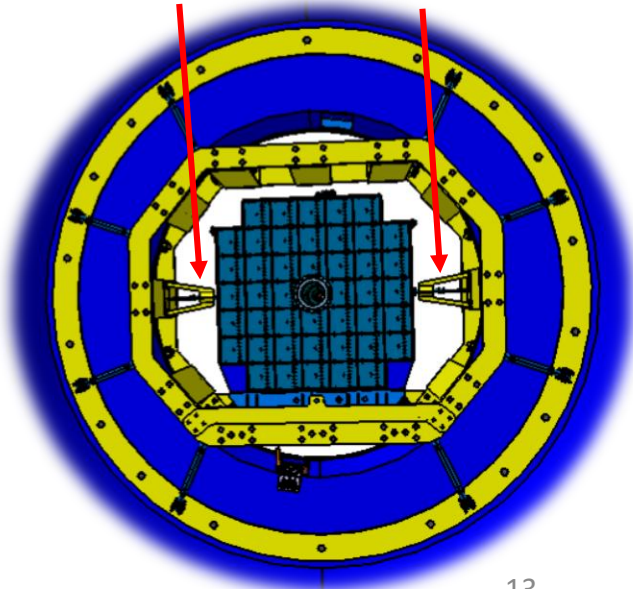
Main problem: beam pipe between two FHCal halves



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. (Power supplies for ADC?)**
- **Detector Control System is ready and will be tested at nearest BM@N runtime.**
- **Energy calibration procedure is under optimization.**
- **FHCAL trigger is under development. Flexible configuration of modules is considered.**
- **The mechanical platform is at final stage of design. The production of FHCAL baskets is urgent!**

- **We plan to be ready for the calorimeter assembling at MPD site in the middle of 2023.**
- **The baskets for FHCAL modules must be produced to this time!**
- **The space and some infrastructure for FHCAL assembling must be available!**

Thank you!