Status of Forward Hadron Calorimeter (FHCal)

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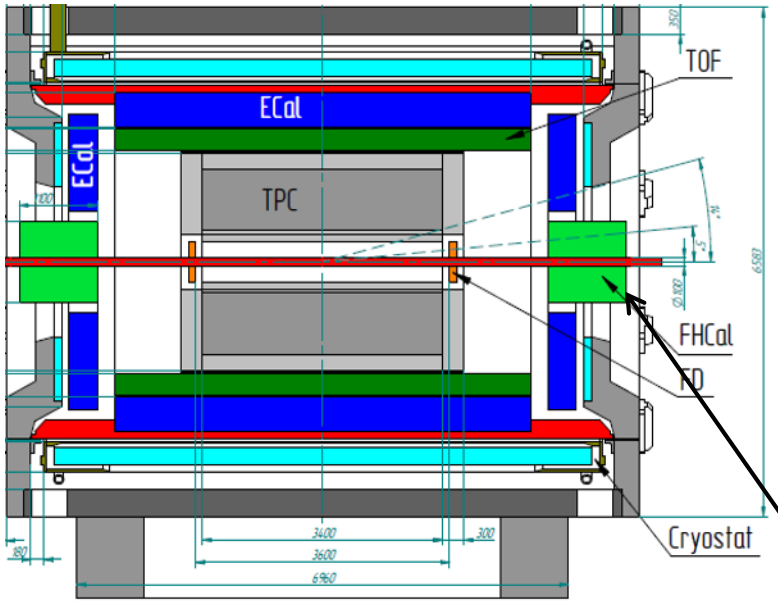
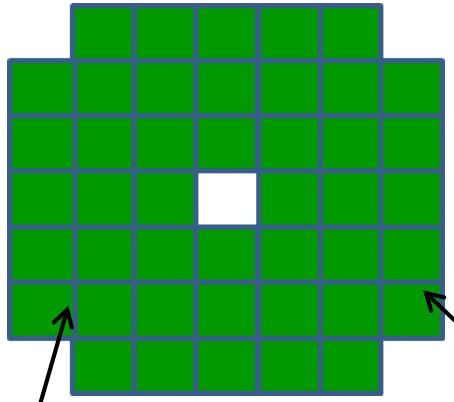
on behalf of the FHCal group

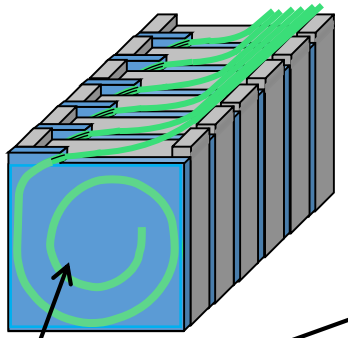
- **FHCal overview;**
- **Progress in integration;**
- **FHCal readout;**
- **FHCal in trigger;**
- **Open questions.**

13th MPD collaboration meeting, Apr., 2024.

FHCal in MPD







FHCal

FHCal modules

- 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.
- ~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 :

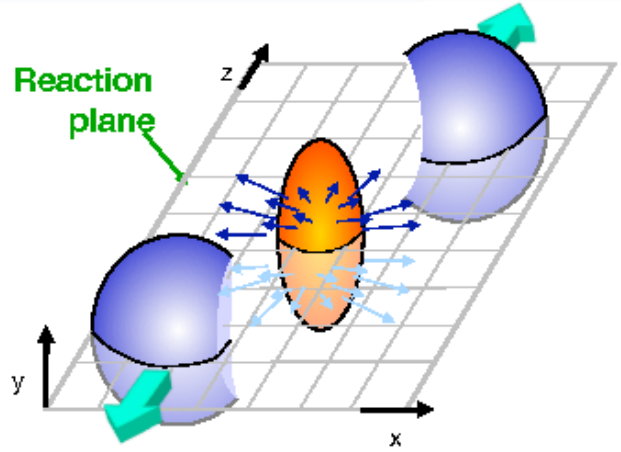
a) The centrality of the collision;

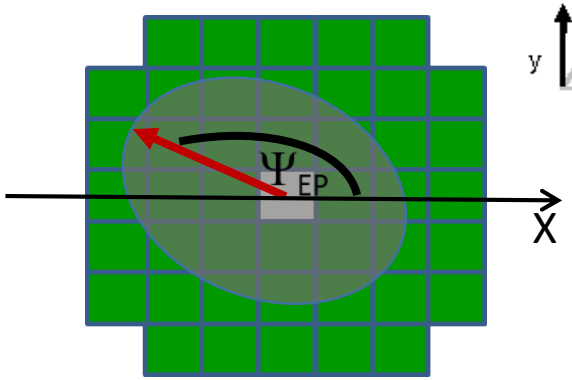
b) The reaction plane orientation;

c) Minimum bias trigger;

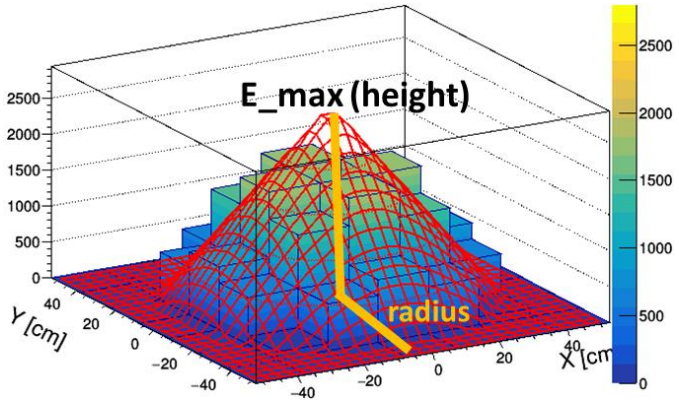
d) Physics in forward rapidity?

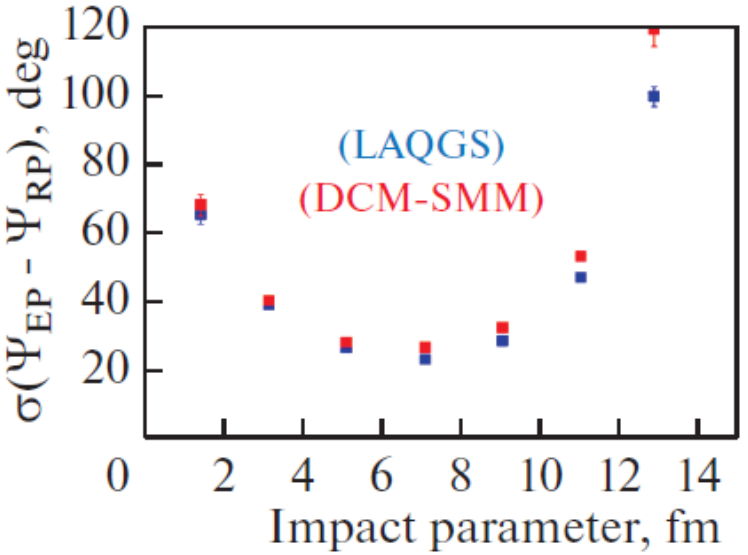
$$\Psi_{EP} = acrtg \frac{\sum E_i \sin(\varphi_i)}{\sum E_i \cos(\varphi_i)}$$





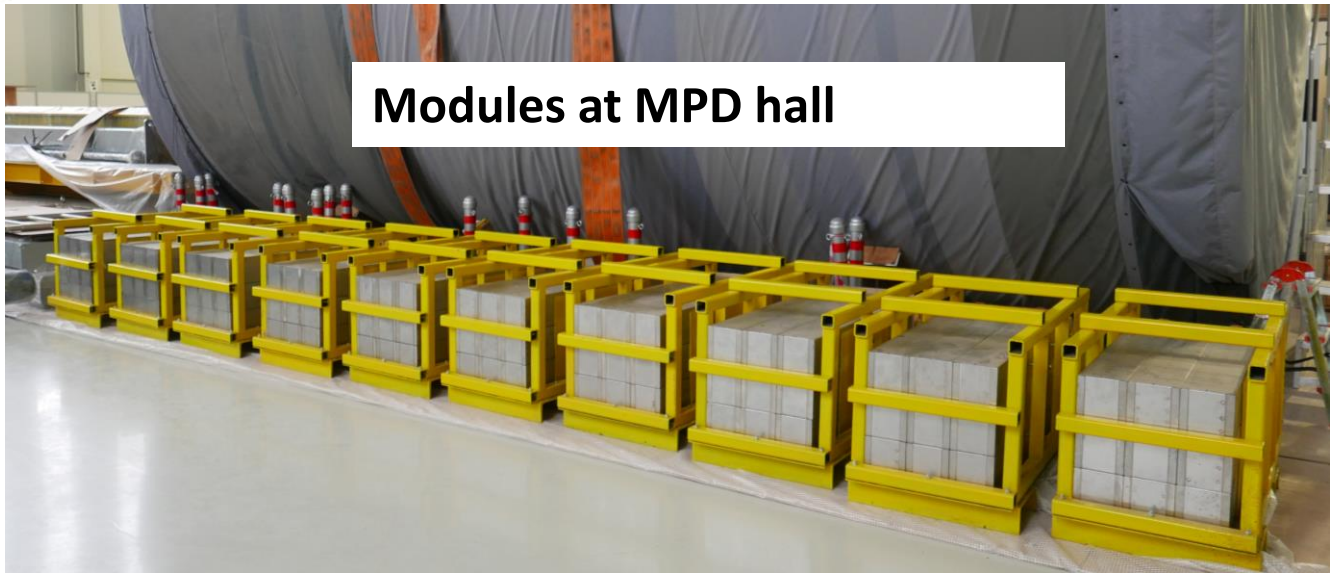
Centrality:
2D-Fit of energy distributions in FHCal modules





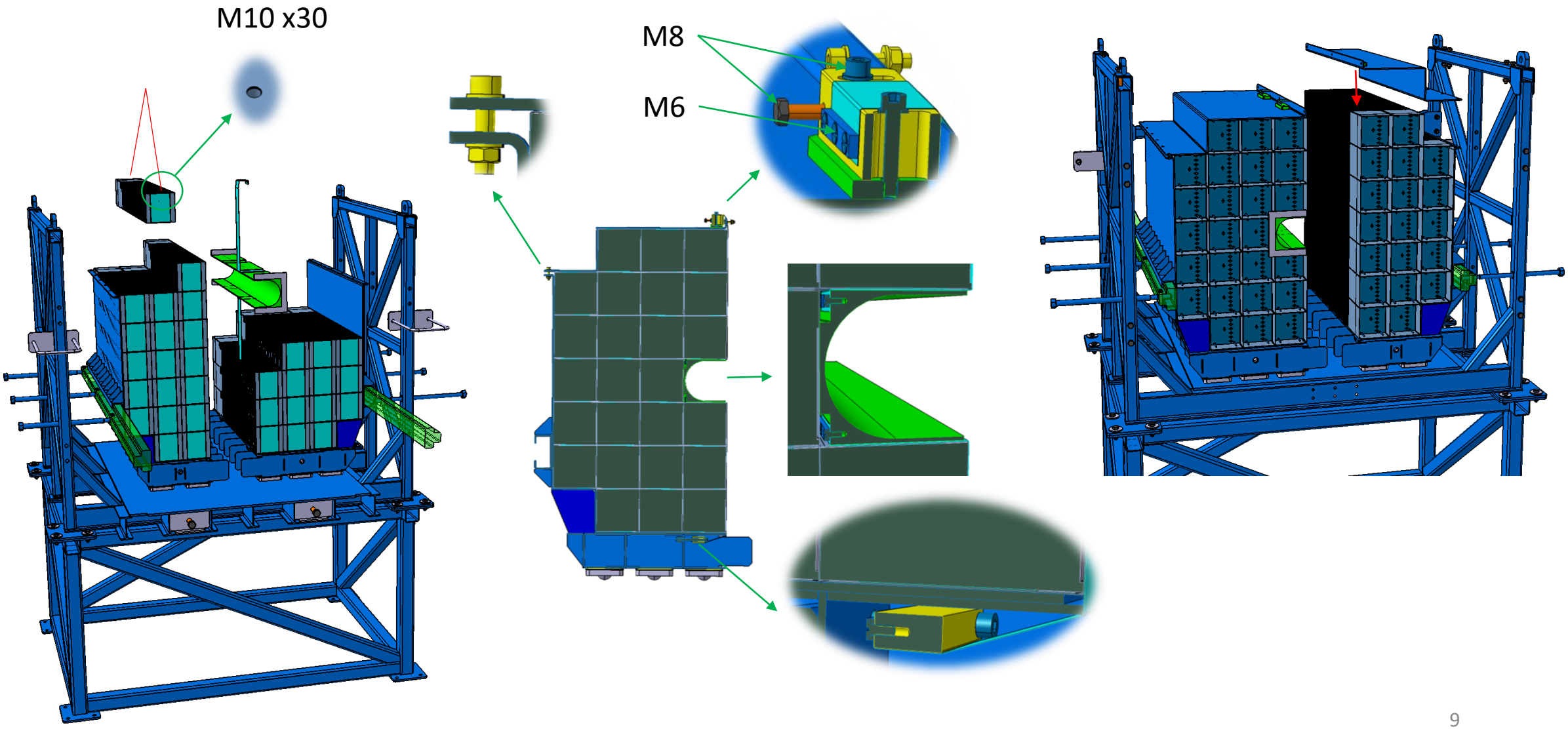
FHCal modules are at MPD hall now!

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



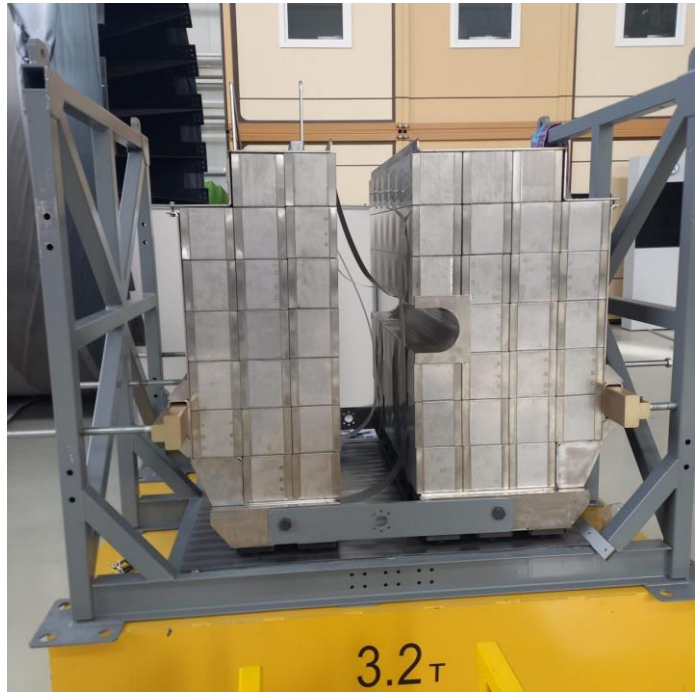
Step 1: Assembling of FHCal modules in basket

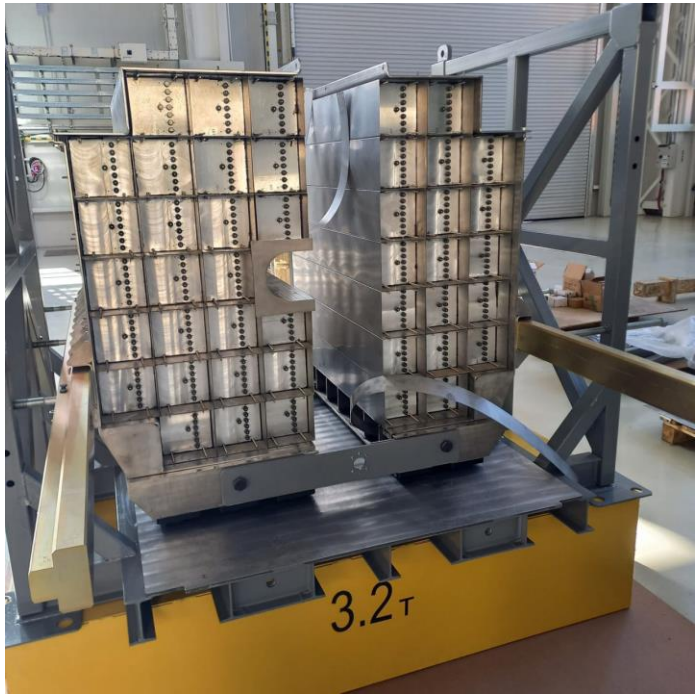
Drawings



Step 1: **Assembling of FHCal modules in basket**

Photos from MPD hall



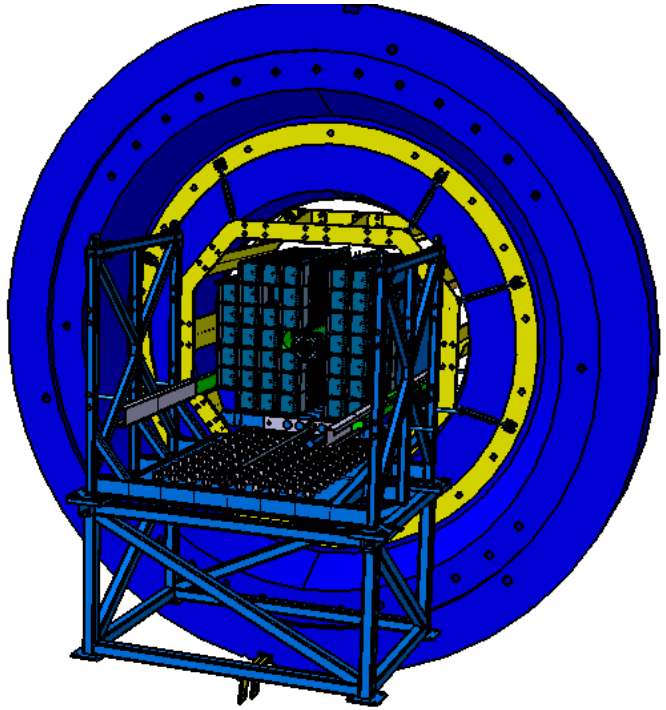


One FHCal arm already assembled in basket !

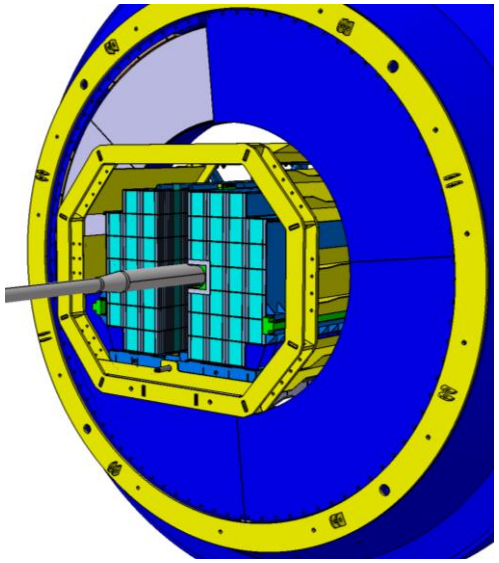
Step 2: **FHCal installation into support frame (in pole)**

Drawings

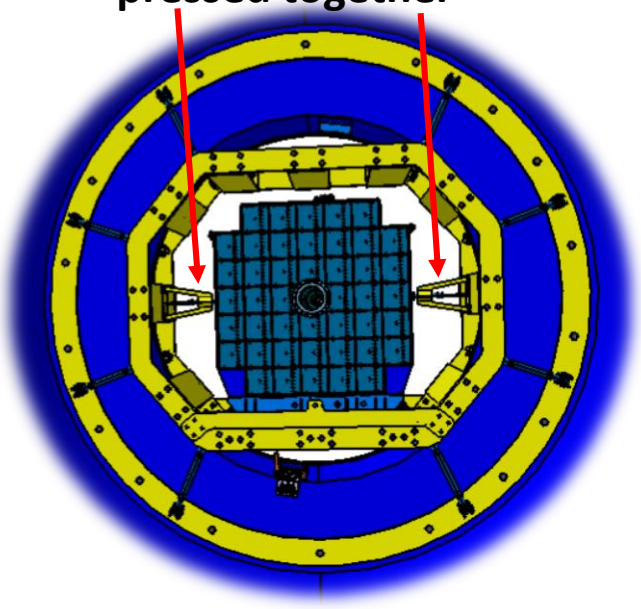
FHCal inserted into pole from inner side



Main problem: beam pipe between two FHCal halves

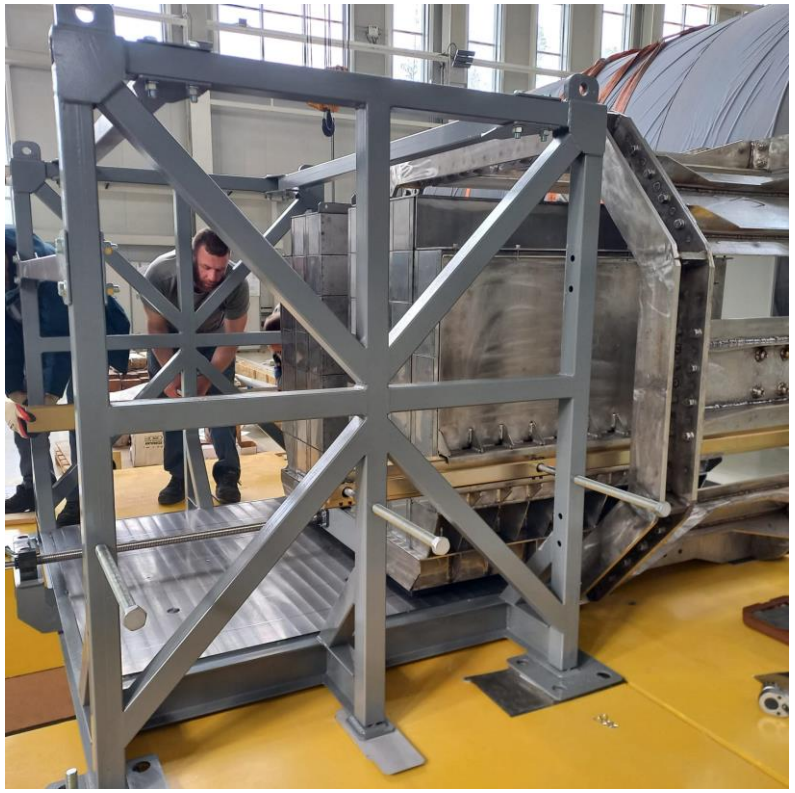


Two FHCal halves pressed together



Step 2: **FHCal installation into support frame (at floor)**

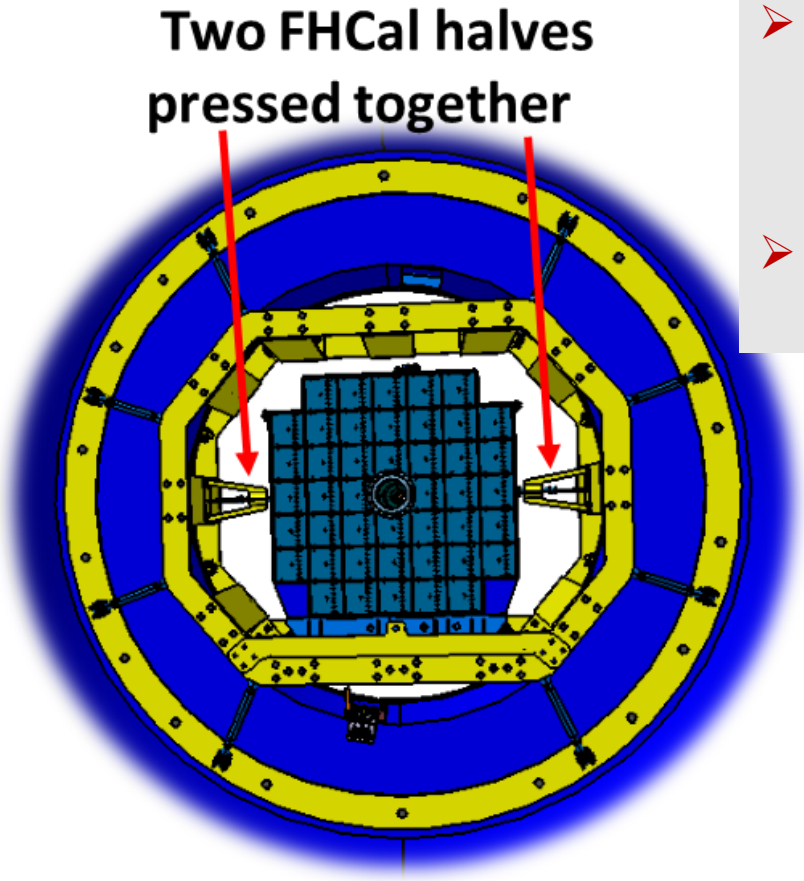
Photos from MPD hall



FHCal arm already moved into support frame!

Step 3: **Put FHCal parts together**

Drawing



- Can we add additional metal in central hole to symmetrize interactions around beam pipe?
- Can it help in centrality reconstruction?

Photo from MPD hall

FHCal parts pressed together!

Up to now all manipulations with FHCal were performed at floor successfully!
Many thanks to S. Gerasimov and JINR technical group!

Next steps in development of FHCal

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

Front-End-Electronics

Two PCBs in each module with:

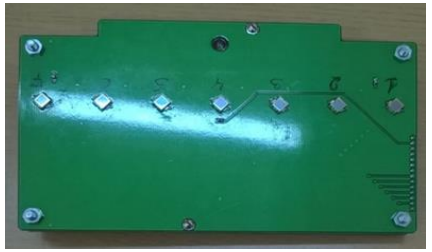
7 photodetectors ;

Photodetectors – MPPCs;

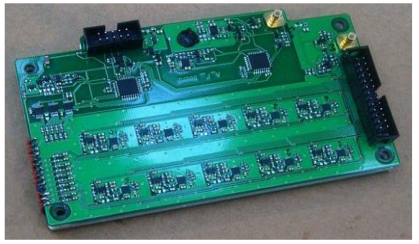
two-stage amplifiers;

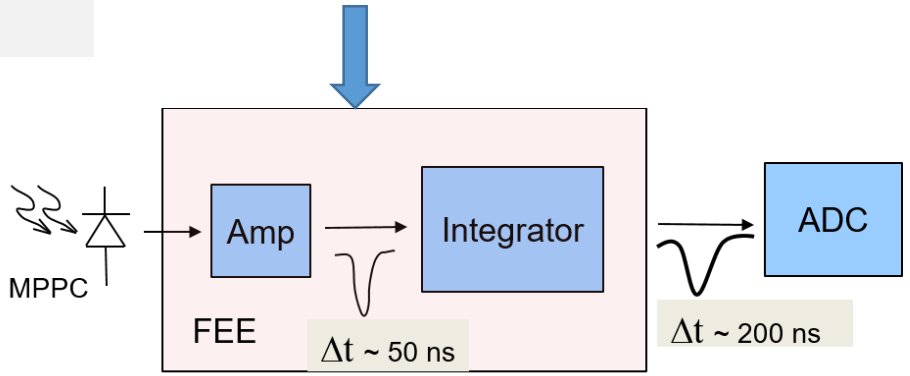
HV channels;

LED calibration source.



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





FHCal modules are currently equipped with FEE in the MPD hall.

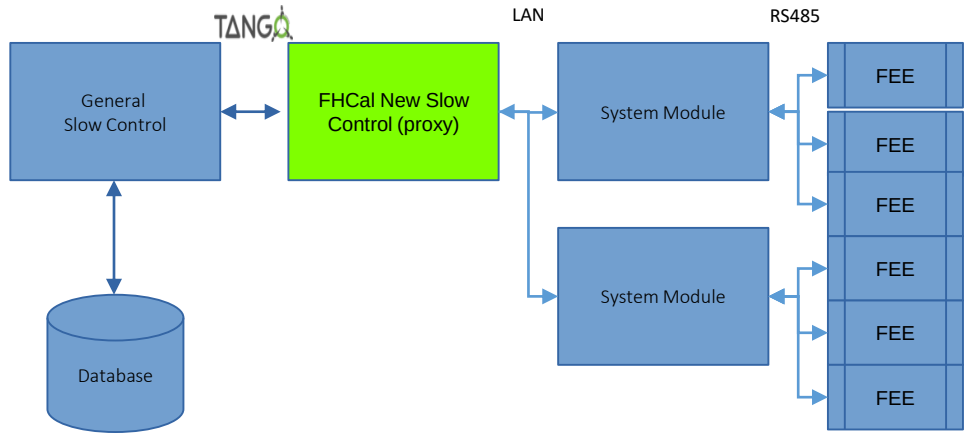
Detector Control System (DCS)

DCS Tasks:

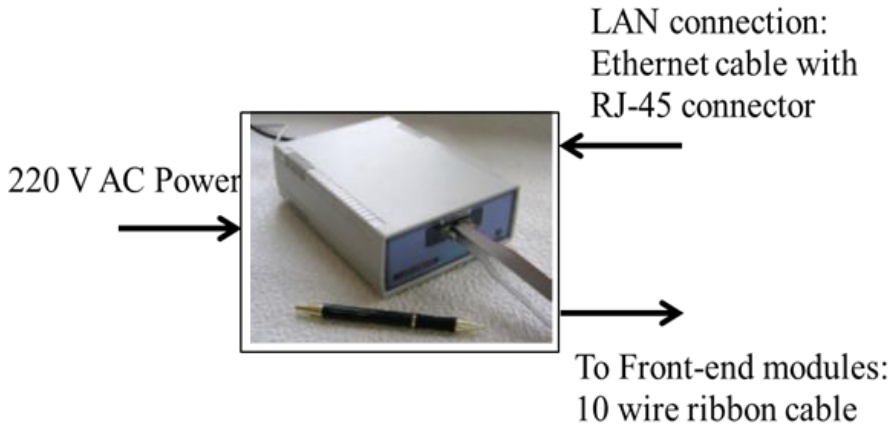
- Control of HV at photodetectors (MPPC's);
- Temperature control of photodetectors;
- Compensation of temperature drift of MPPC gain;
- Monitoring of MPPC gain with stabilized light source.

DCS open question:

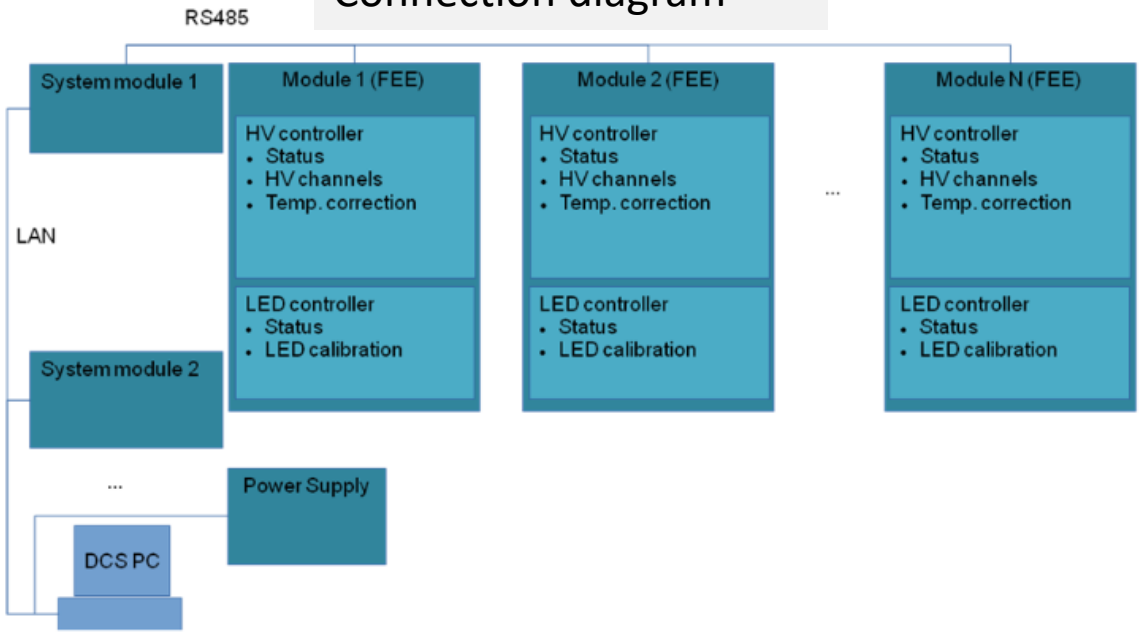
- Cabling for RS485 bus (now flat cables)?
- Pick up noises in real environment ?
- Place for System Module: near calorimeter or in Control Room?



Hardware:
System Module (HV sys. Co.)



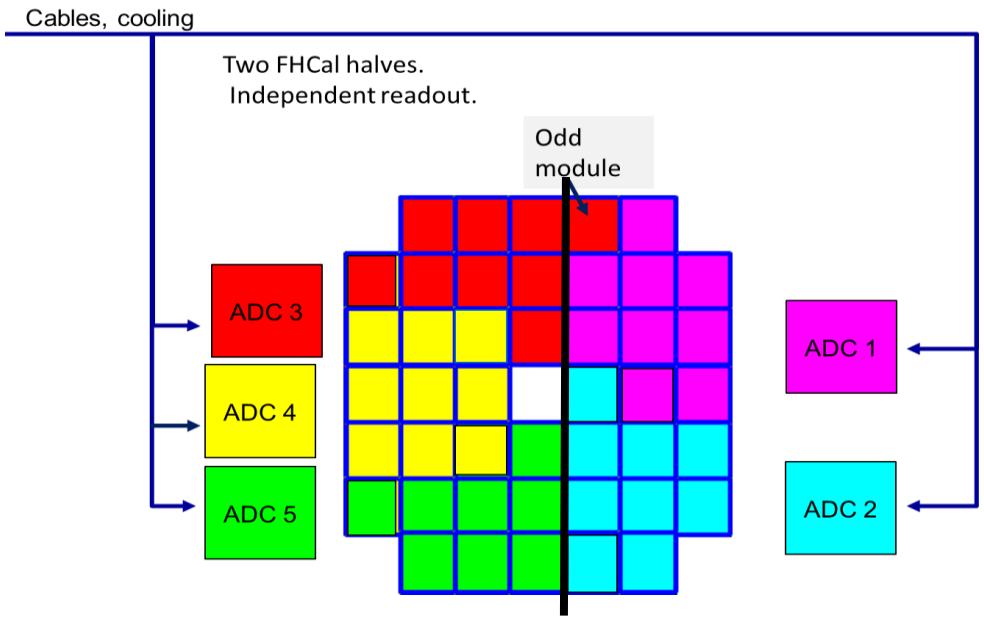
Connection diagram



ADC signal readout

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

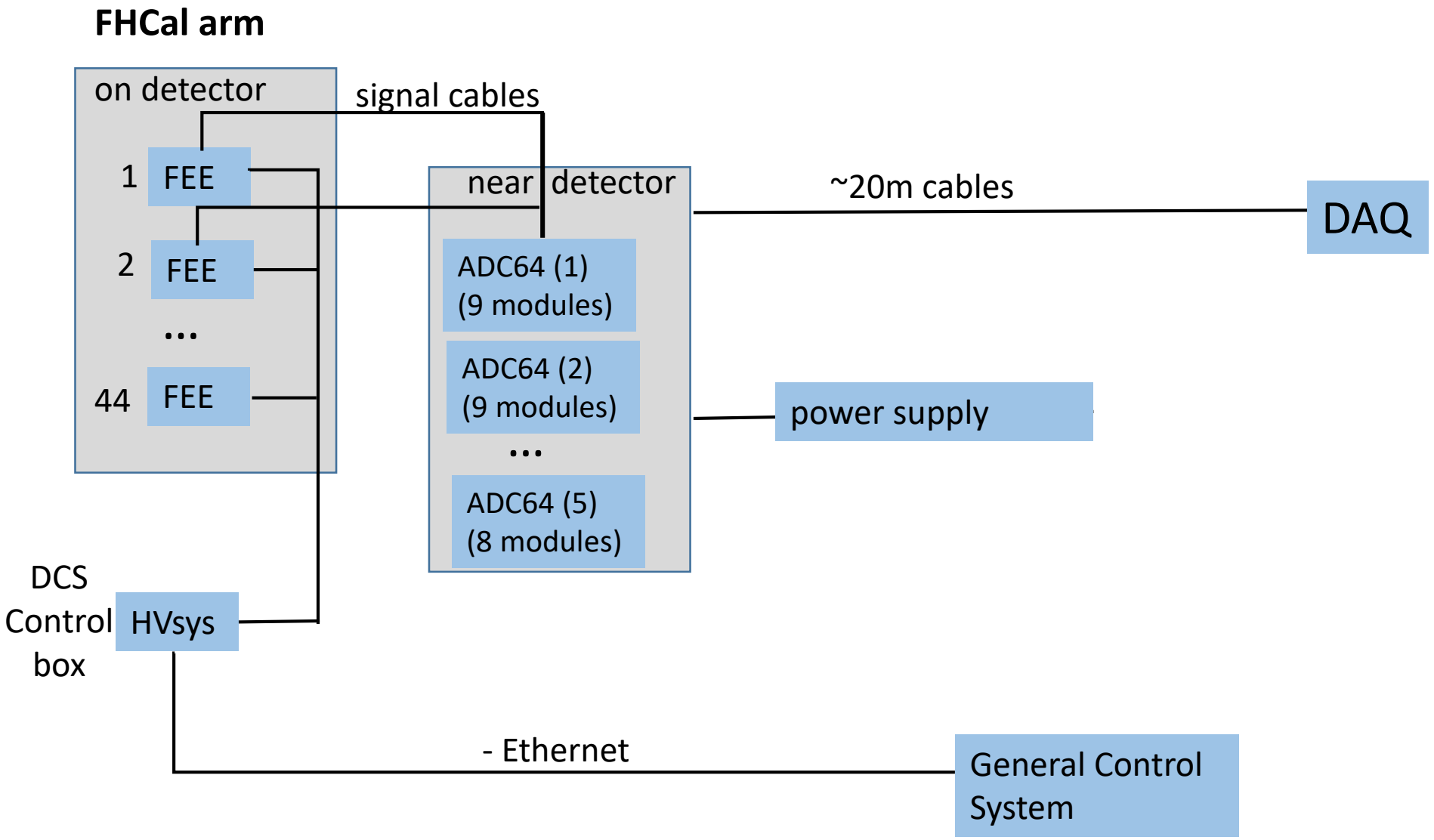
5 ADCs for each arm of FHCal



Two halves of FHCal.

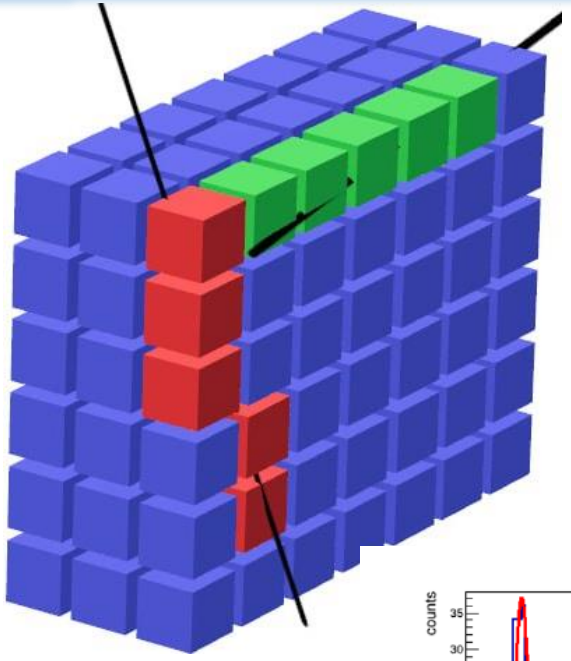
- **All 10 ADC boxes are tested and ready for installation.**
- **Open questions for readout:**
- **Would ADC be replaced by new ECAL-type modules? (Fast ADC for FHCal trigger)?**
- **ADC cooling? Pipes for air?**

FHCal readout and control



Both FHCal arms have the same readout scheme.

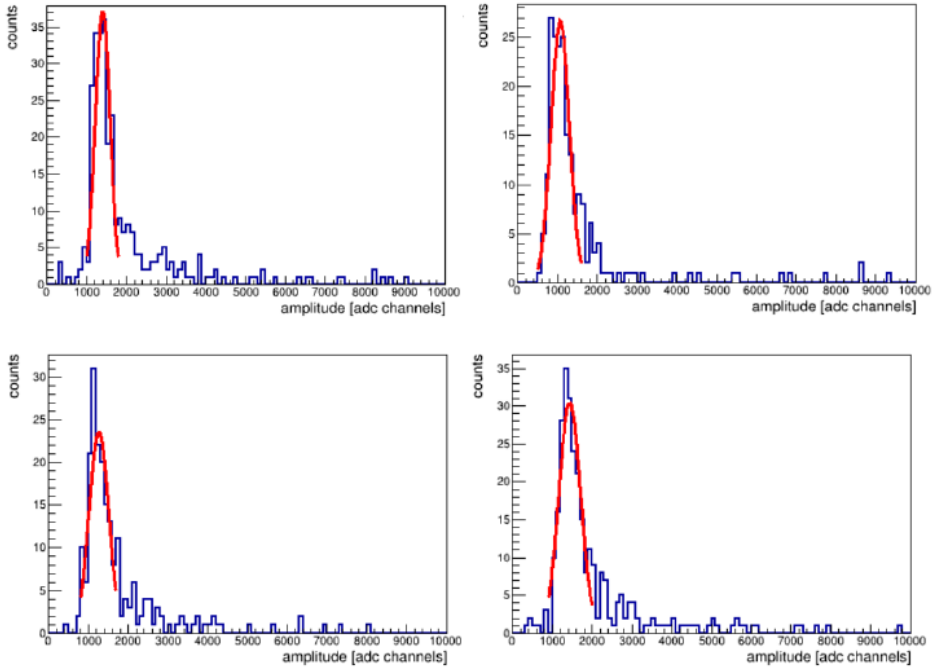
Energy calibration with cosmic nuons



Response of FHCal modules to cosmic muons with different track geometries.

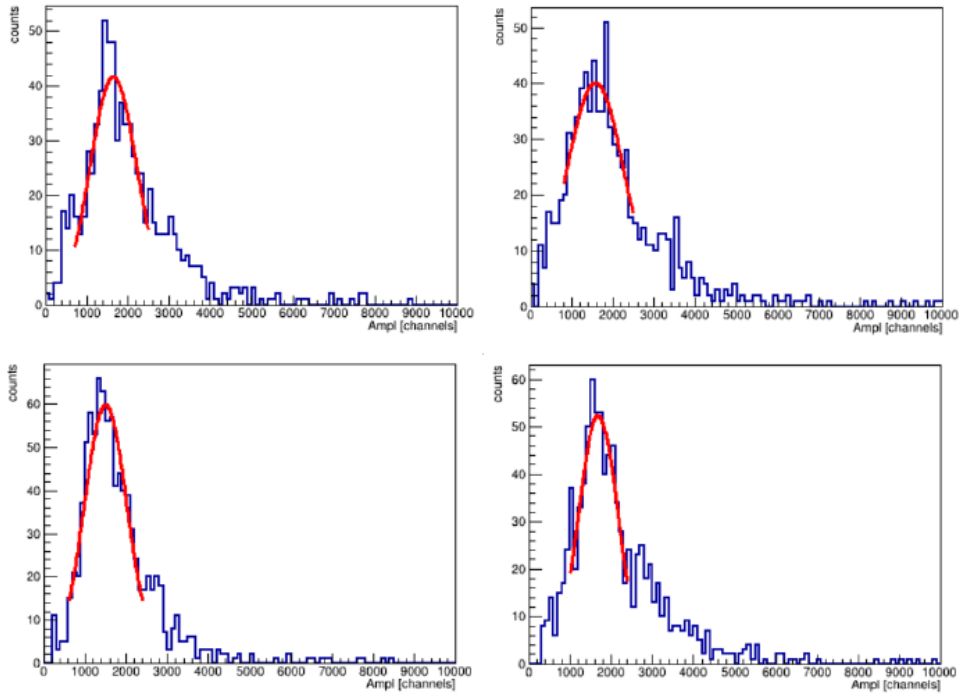
Horizontal muons

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



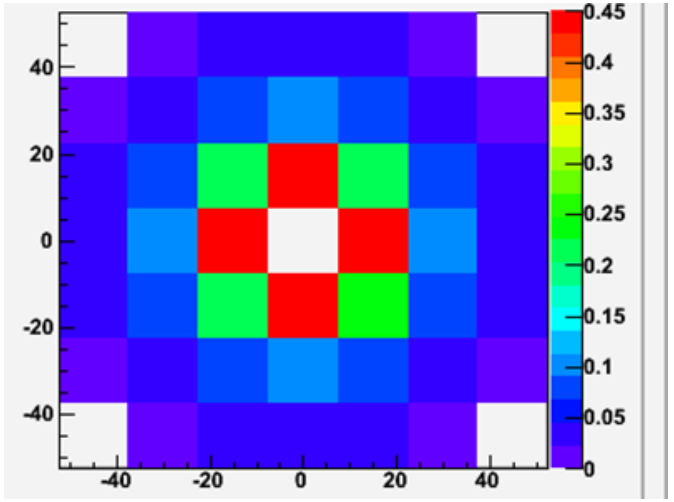
Vertical muons

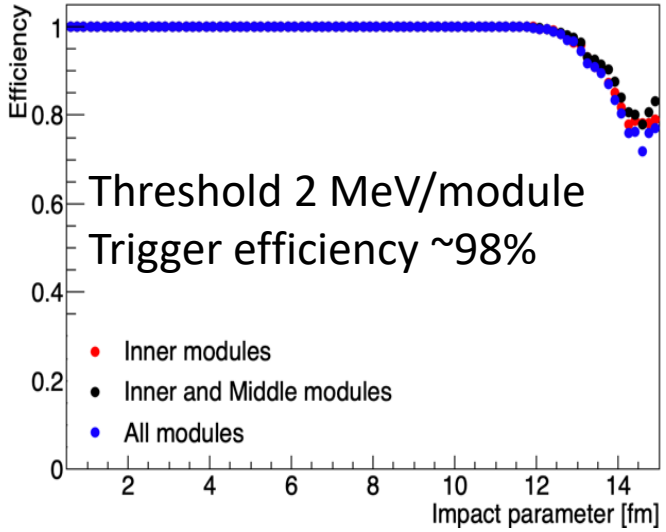
- Wide peaks;
- Short time for collection;
- (one day data acquisition);
- Energy deposition should be normalized for horizontal muons;



Tests done for FHCal prototype.
Must be done for full FHCal.

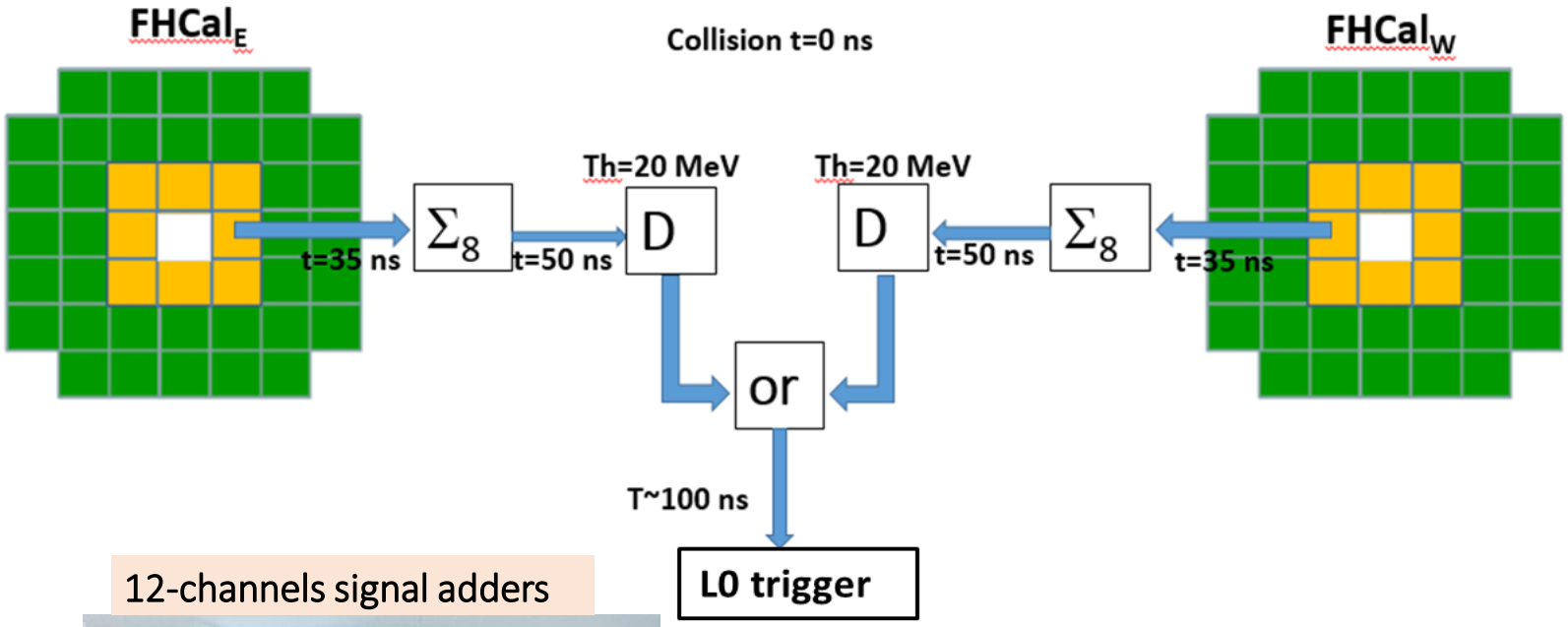
FHCal trigger (analog version)





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

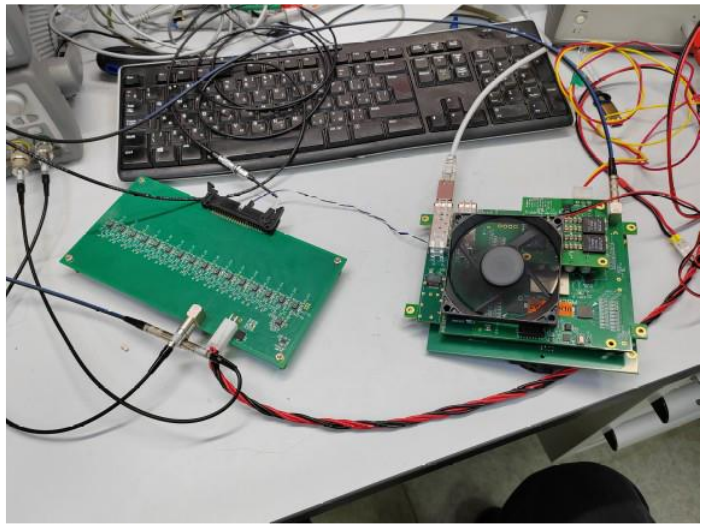
Scheme of FHCal trigger



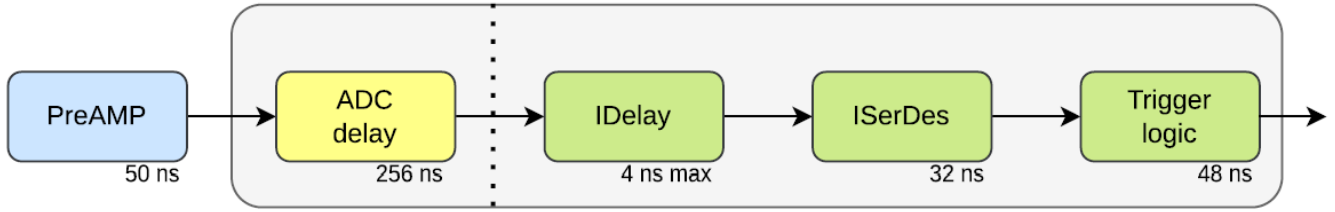
12-channels signal adders

- 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.

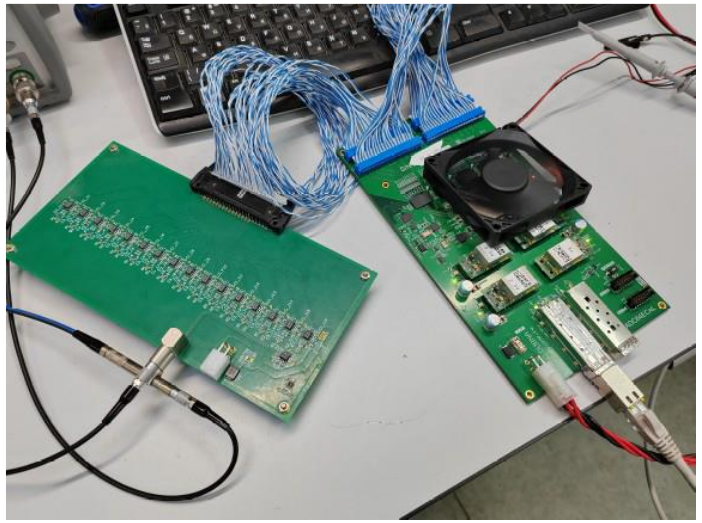
Digital FHCal trigger ? (Data from MPD trigger group)



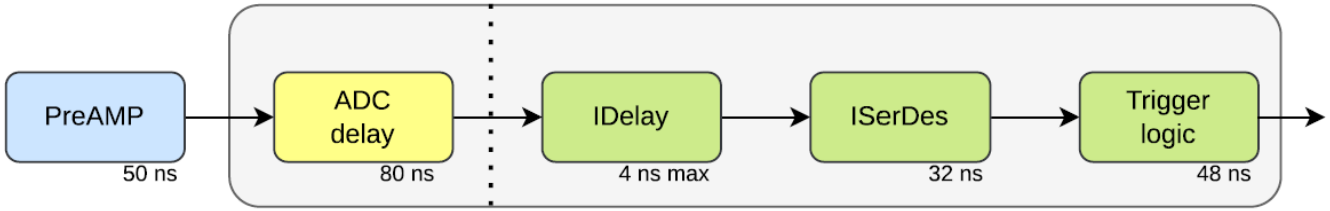
Version ADC64s2 V5.0 prepared for FHCal



Total delay time 387 ns



New version ADC64ECAL prepared for ECal



Total delay time 237 ns (150 ns shorter)

New ADC modules allow arrangement of FHCal trigger logic with digitized signals instead of analog adders!?

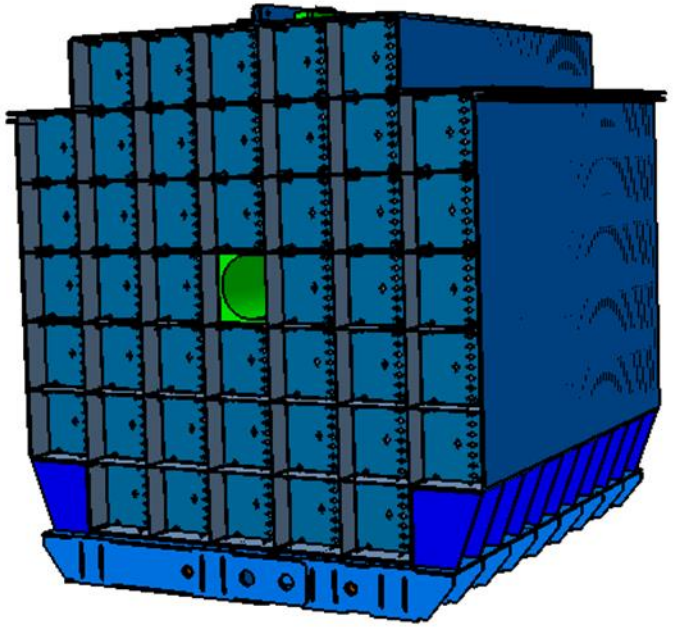
Summary (open questions)

- Timetable for FHCal installation?
- One or two FHCal arms at the beginning?
- Cabling for ADC and DCS?
- Place for DCS System Module?
- What ADCs (previous or new Ecal type)?
- What FHCal trigger (analog or digital)?
- Pipes with cooling air for ADCs?

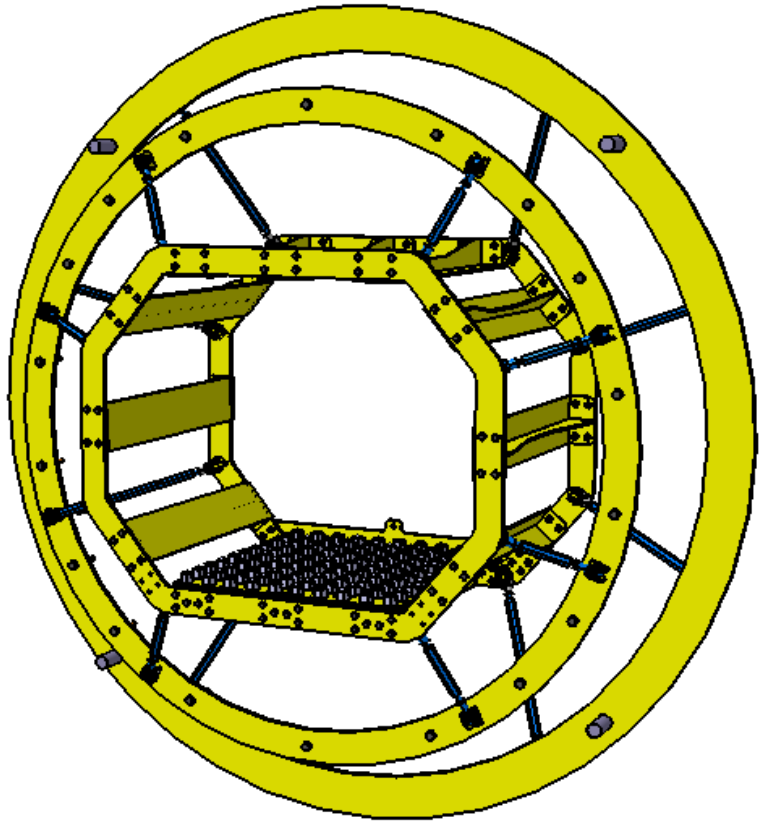
Thank you!

Mechanical support (main elements)

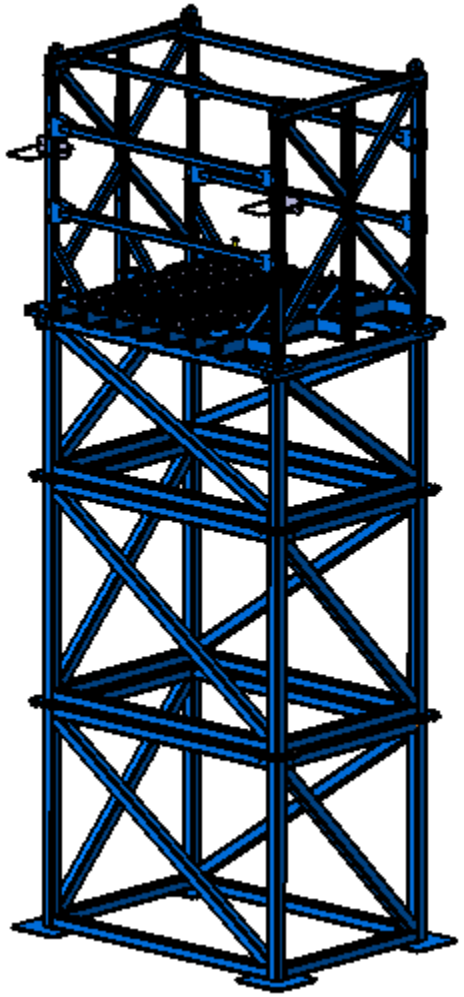
Basket of FHCal modules



Support frame in magnet pole

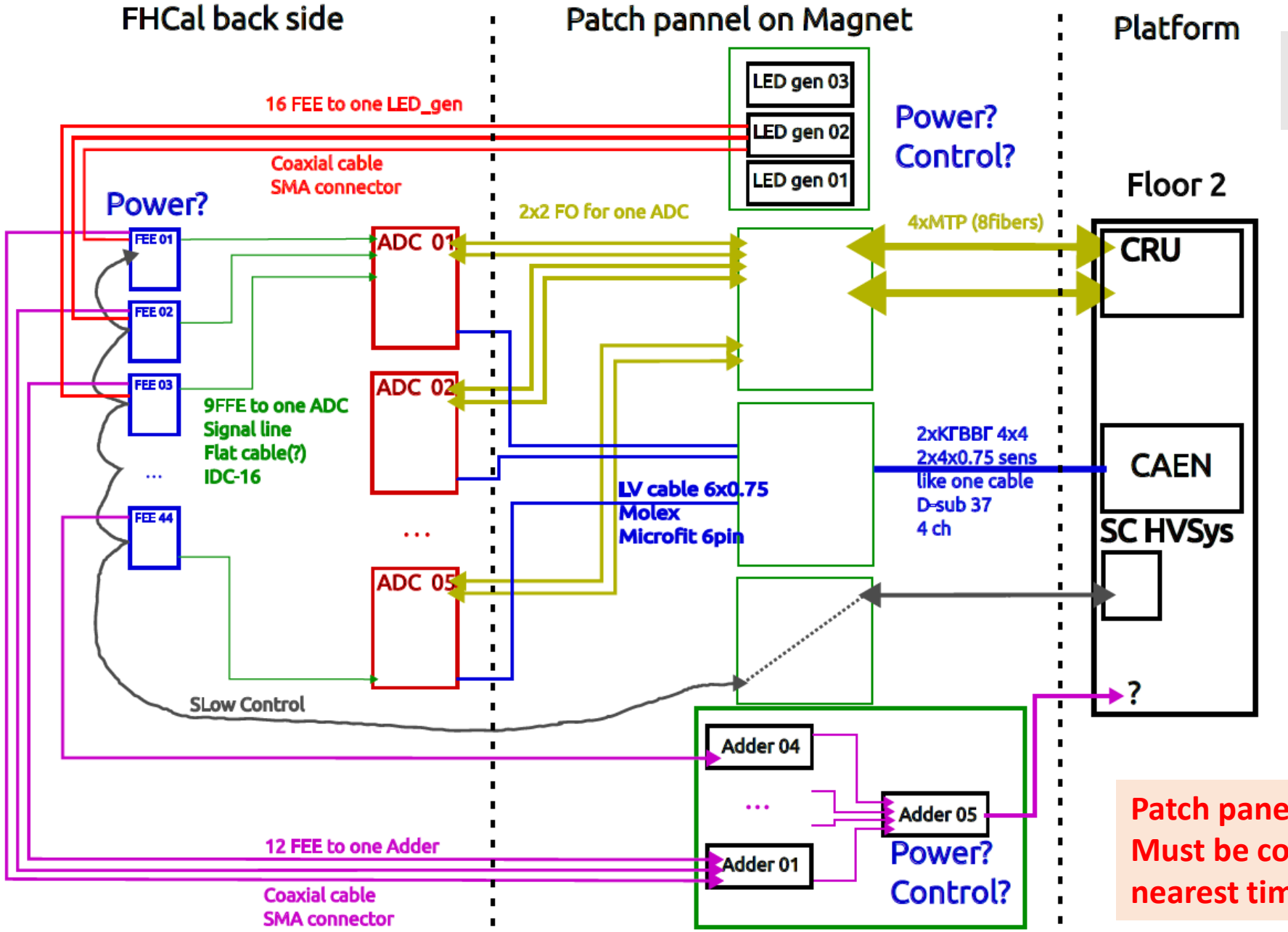


Outer table

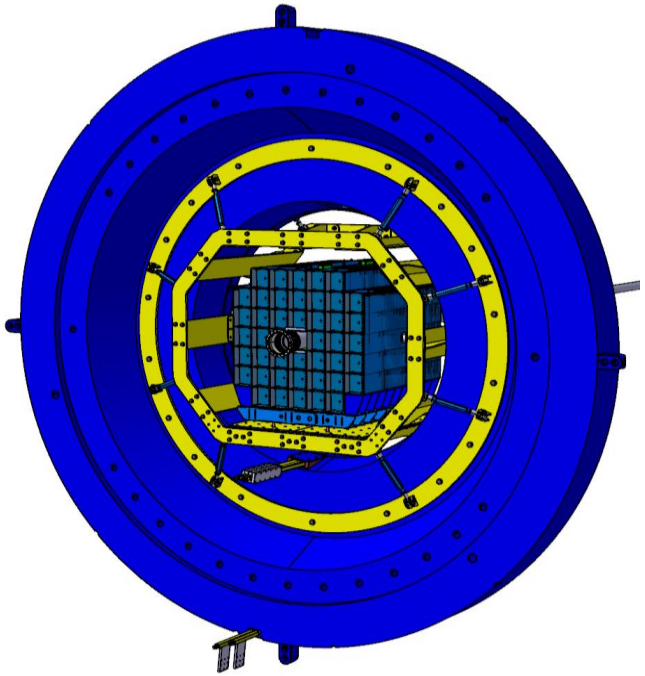


- Design of all elements was finished!
- The production starts now!

FHCal cabling



Prepared by
M. Rumyantsev



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