SPD ECAL (End Cup part)

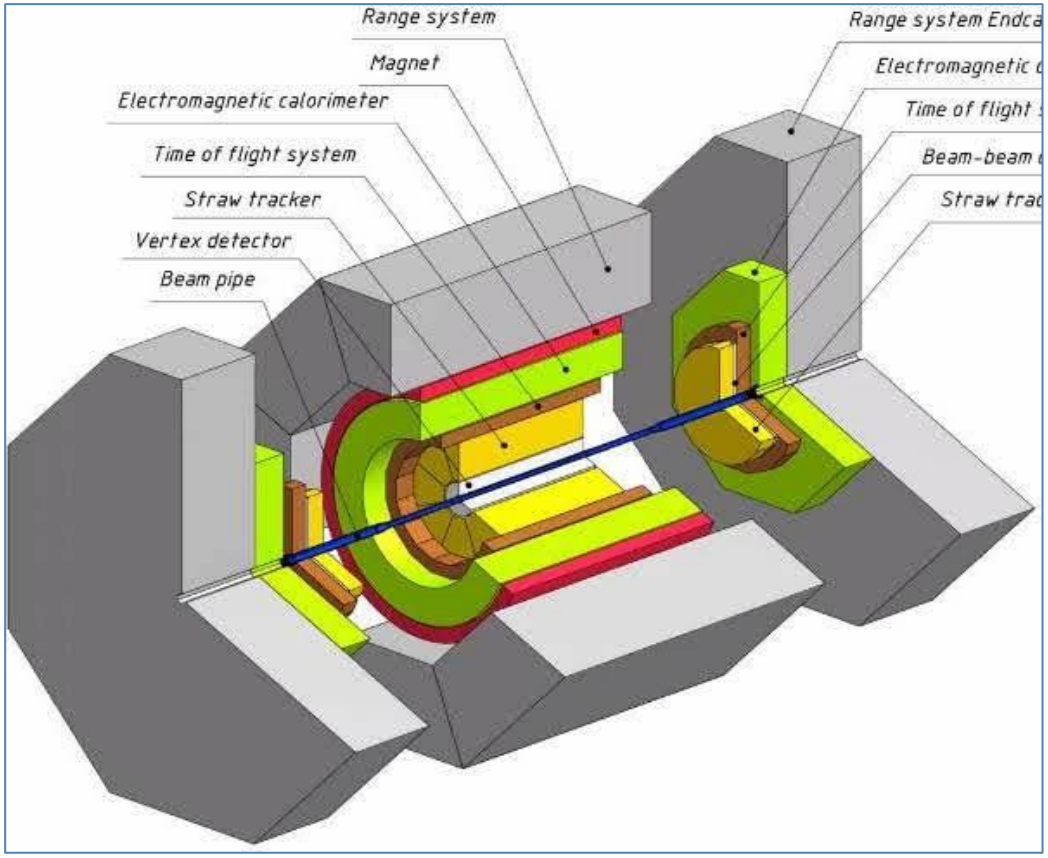
Particle physics at medium and high energies

Protvino, June 5 , 2026

Oleg Gavrishuk, Laboratory of High Energy Physics, Dubna
On behalf of SPD collaboration

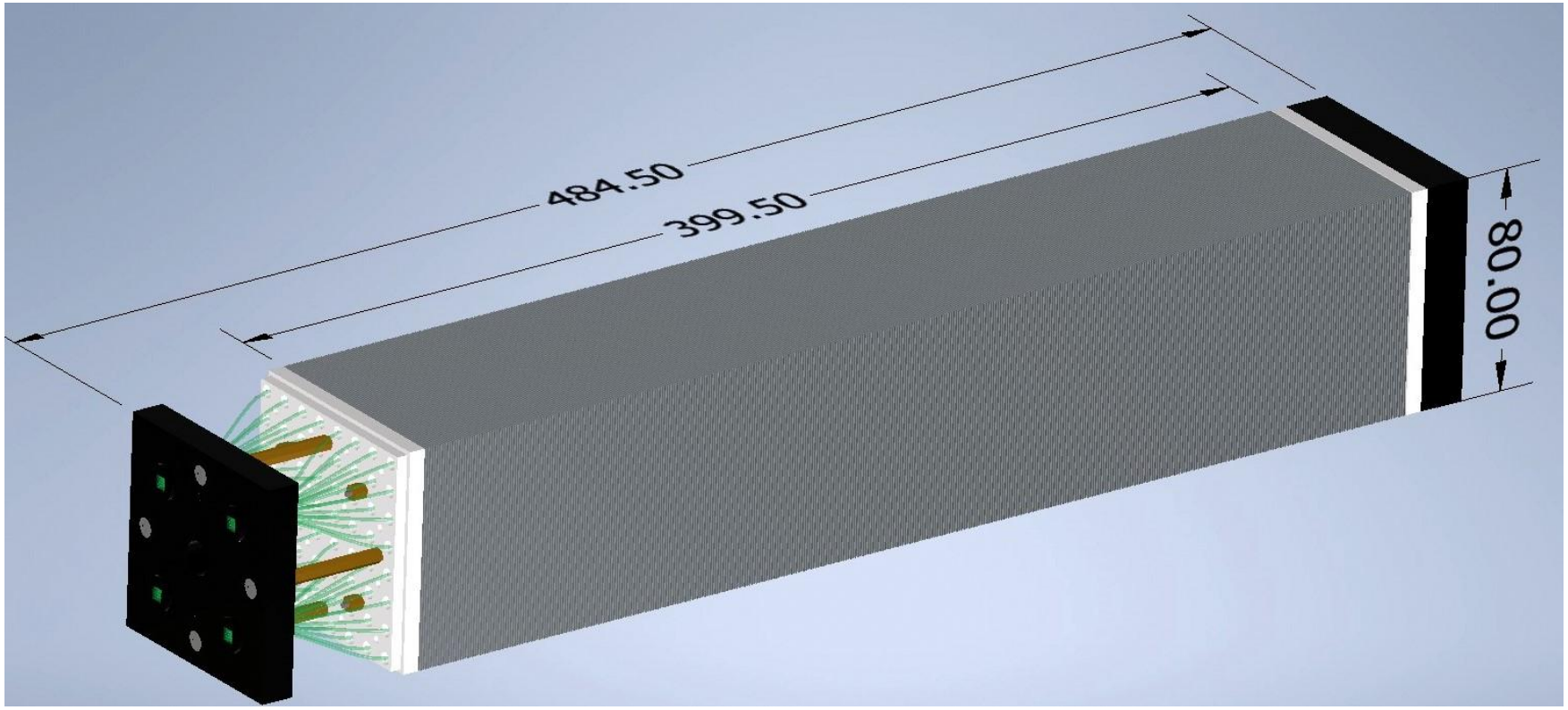
SPD ECAL inside of Criostat

1. **The calorimeter (Green) placed inside of the Cryostat (Red).**
2. **The calorimeter designed for efficient registration of electrons and gamma in the energy range up to 10 GeV.**
3. **Transverse cell size should be on the order to Moliere radius of the calorimeter medium: ~58 mm.**
4. **The End-Cup cells have a rectangular shape 40x40 mm^2.**
5. **The Barrel cells has a trapezoidal shape in the azimuthall direction with vertex angle equal 1.87^0 and 40 mm in beam direction.**



Calorimeters Module and cells composition

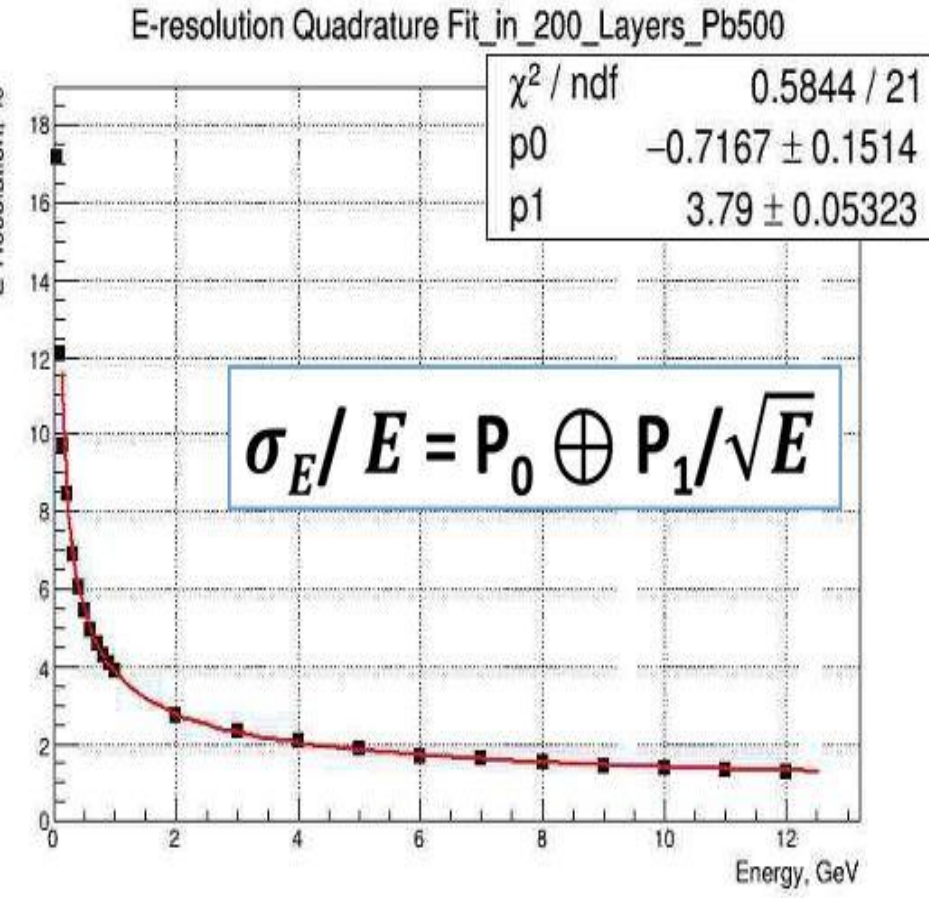
1. **Calorimeter has shashlik sampling structure of 200 layers of 1.5-mm polystyrene scintillator and 0.5-mm lead.**
2. **Active part length is ~400 mm, which corresponds to ~17X0.**
3. **The Cells size in the End-Cup is equal to 40x40 mm^2.**
4. **The Module size composed from 4 Cells is equal to 80x80 mm^2.**
5. **64 WLS fibers collect light onto the SiPm of 6x6 mm^2 .**
6. **SiPm EQR15 11-6060D-S - it is a novel China design of NDL technology**

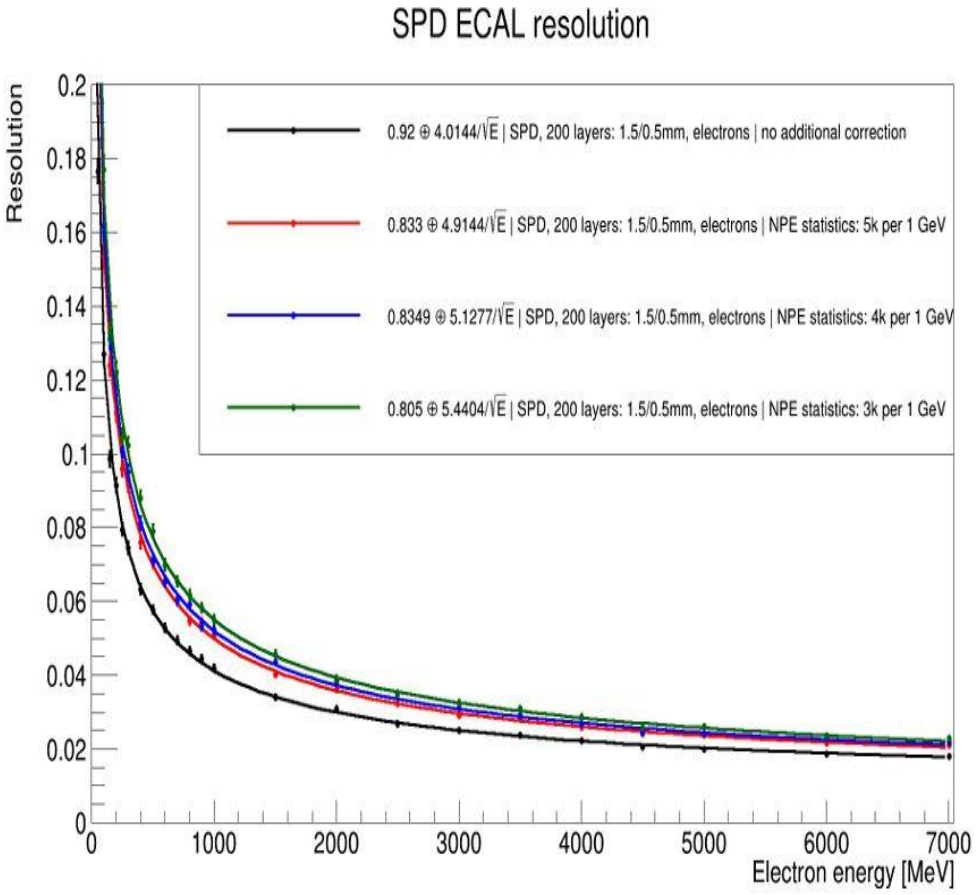


E-resolution without take in account the NPE per GeV
3.8% - Stoh/ part
~0% - const term at WLS L_{att}>10m

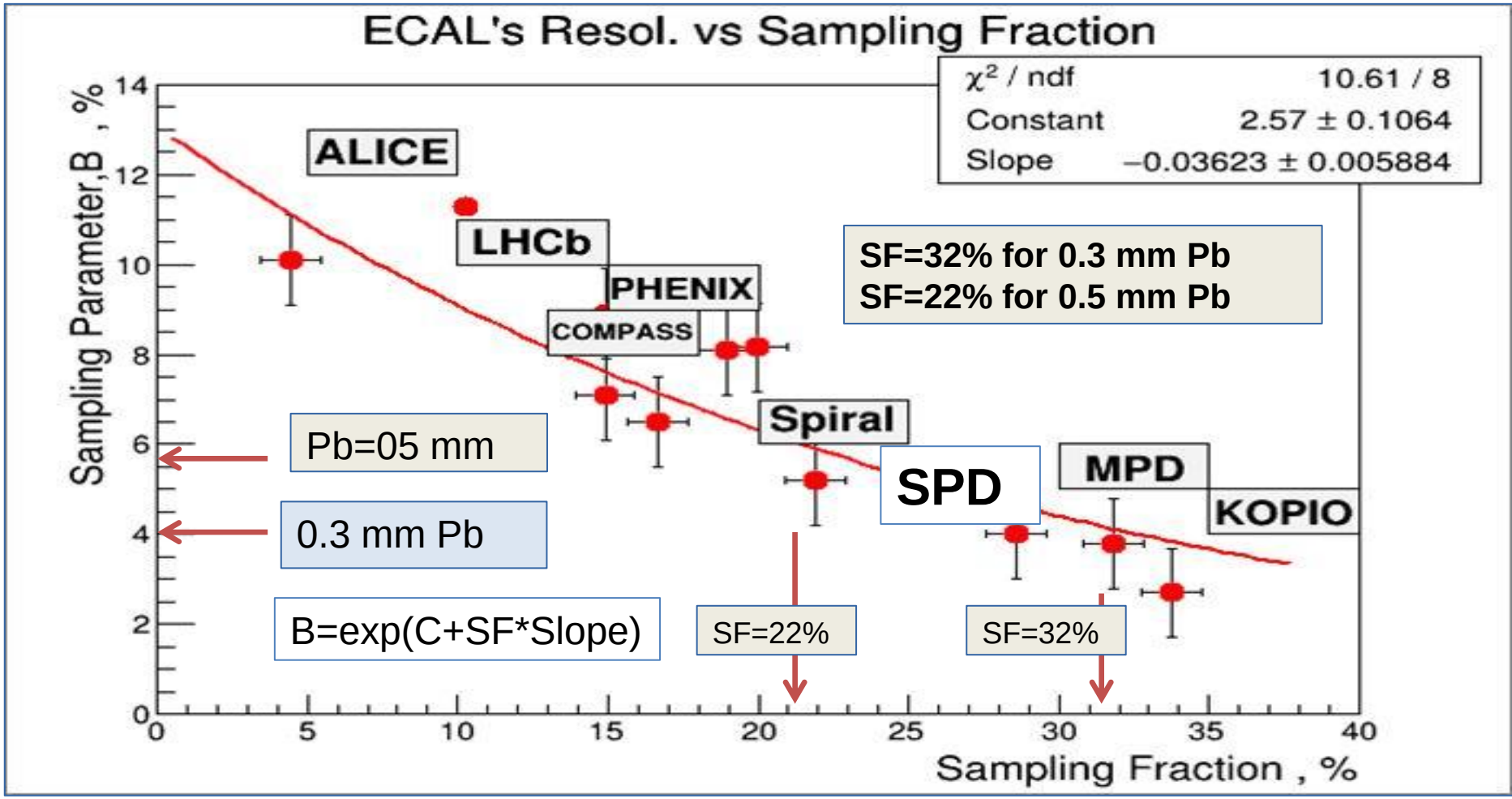
E-resolution vs NPE per GeV
1- >10k - 3.9% - Stohast. part
2 – 3k NPE/GeV – 5.4%
2 – 4k - 5.1%
4 – 5 k - 4.3 %
Const/ Frf ~ 0.9% < WLS L_{att}>10m

0.5 mm Pb + 1.5 mm Sc, 200 layers, e-
(Result of O.Gavrishchuk)

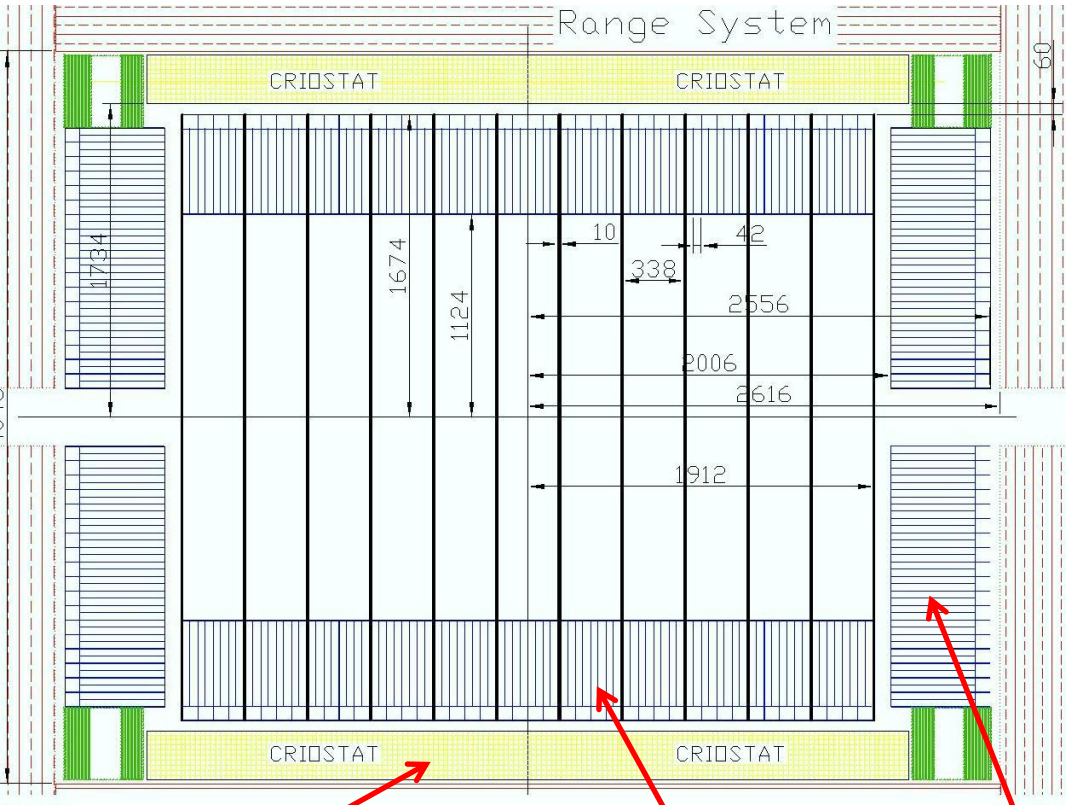


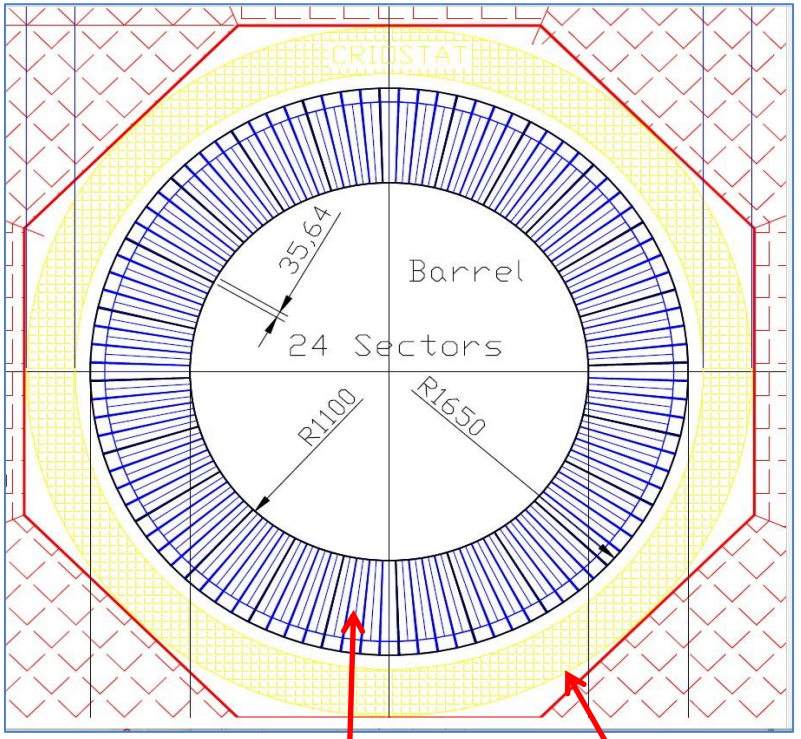


ECAL energy resolution vs sampling fraction.



ECAL Barrel & End Cup geometry





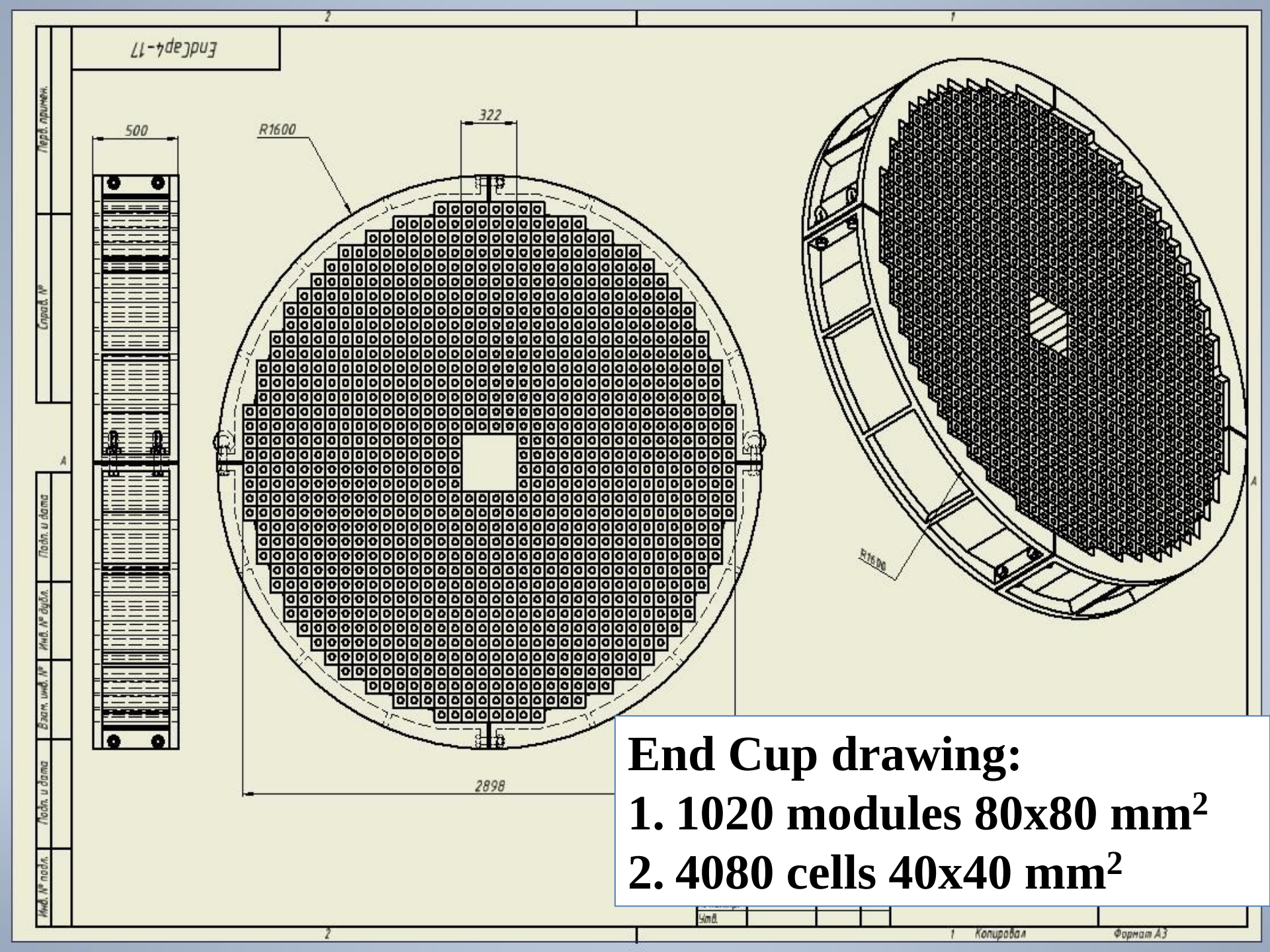
Criostat

Barrel

End-Cup

Barrel

Criostat

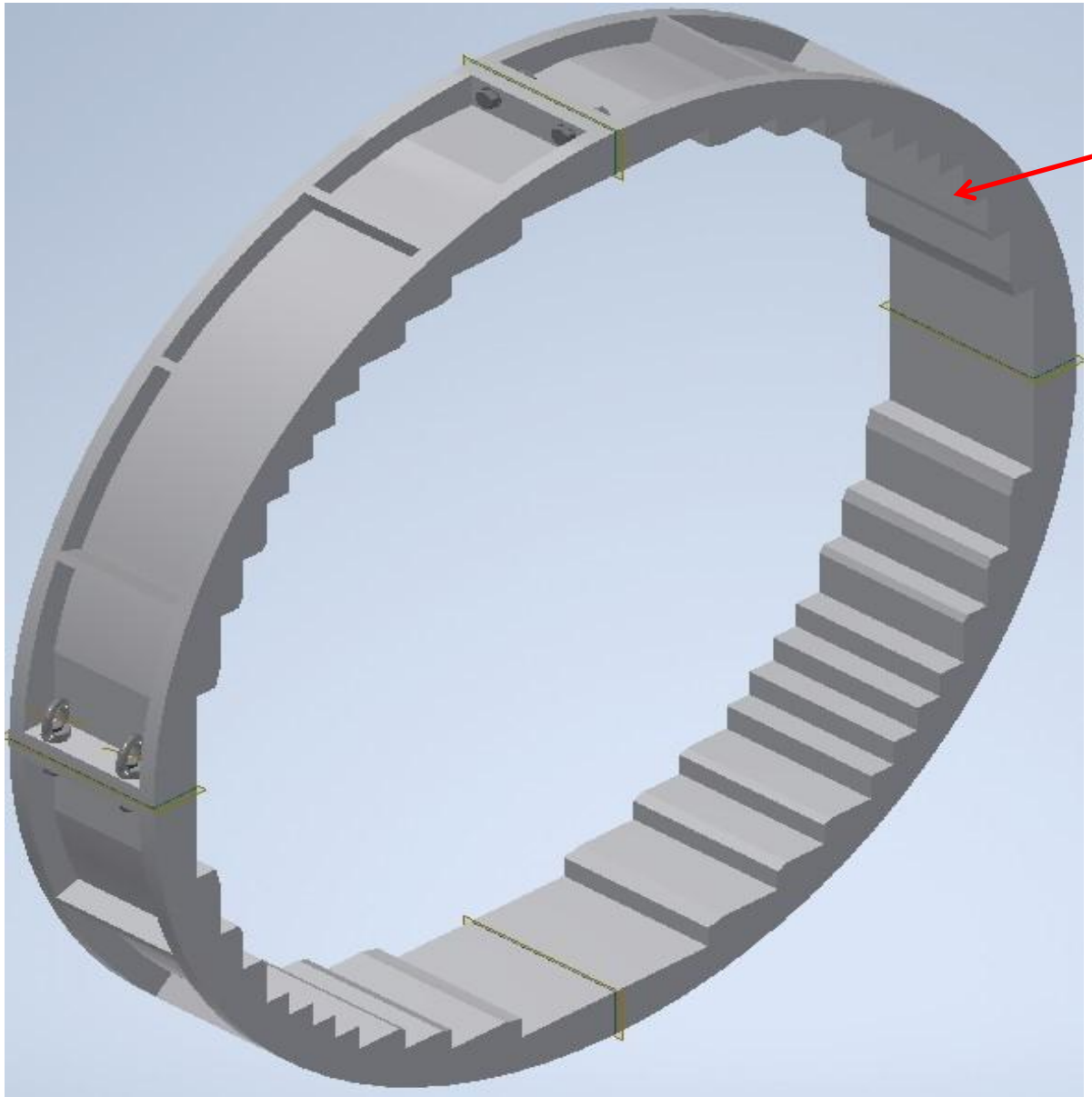


End Cup drawing:

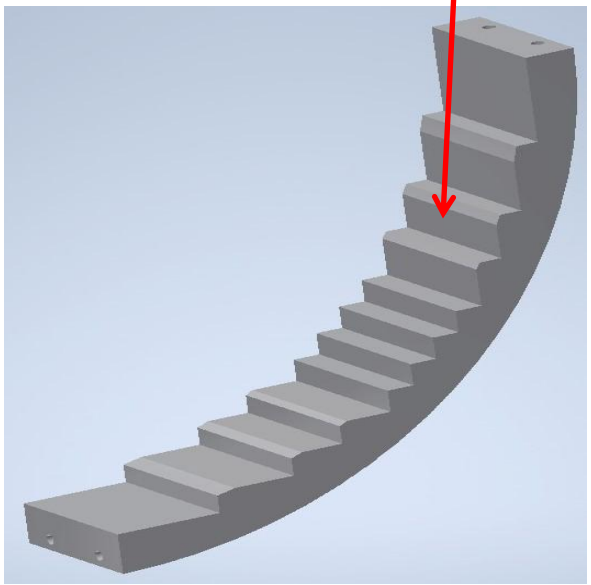
1. 1020 modules 80x80 mm^2

2. 4080 cells 40x40 mm^2

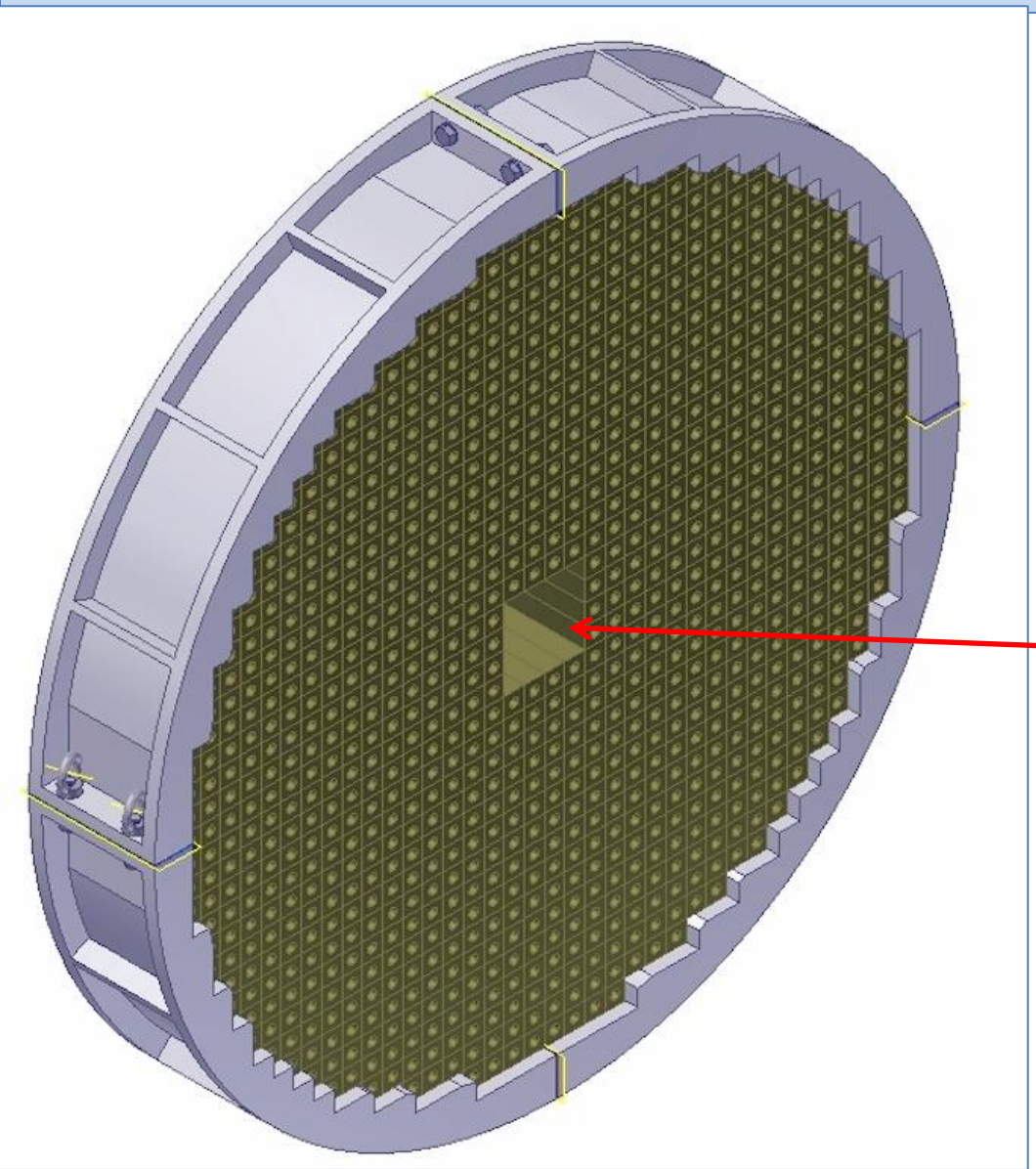
End-Cup calorimeter support:

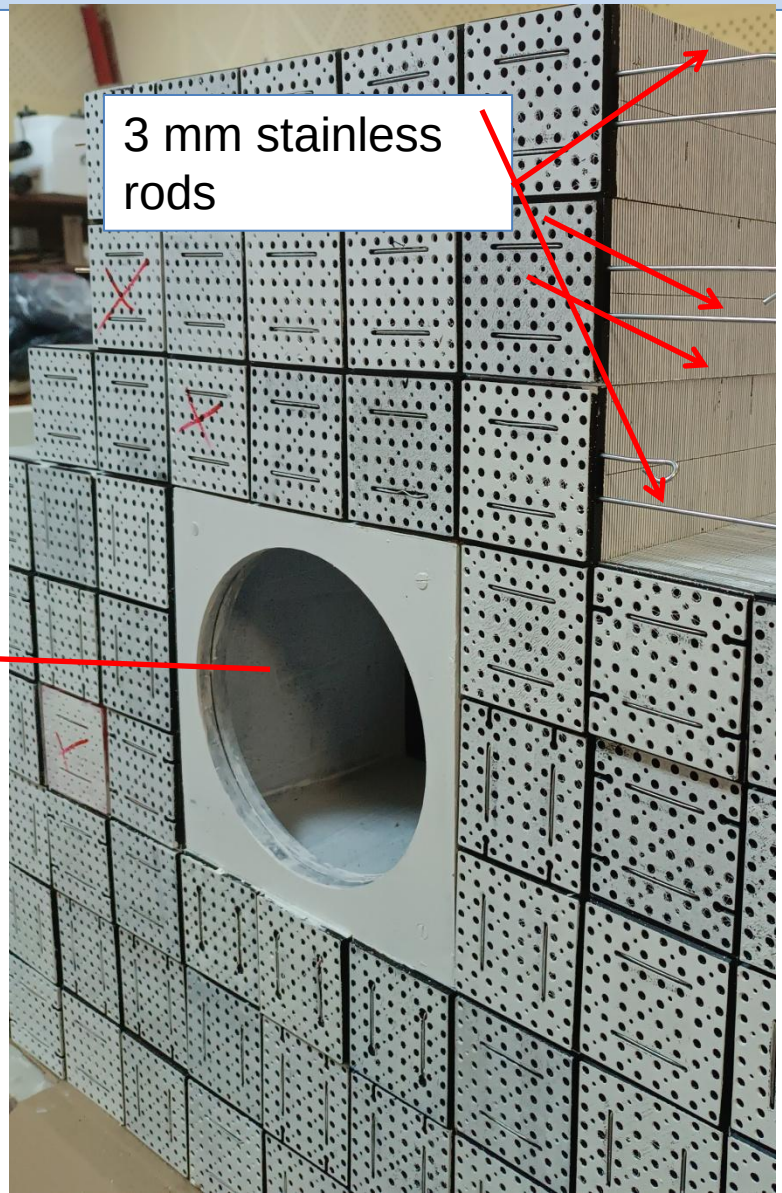


Aluminum frame composed from 4 details made by casting into a mold



End-Cup and central windows.

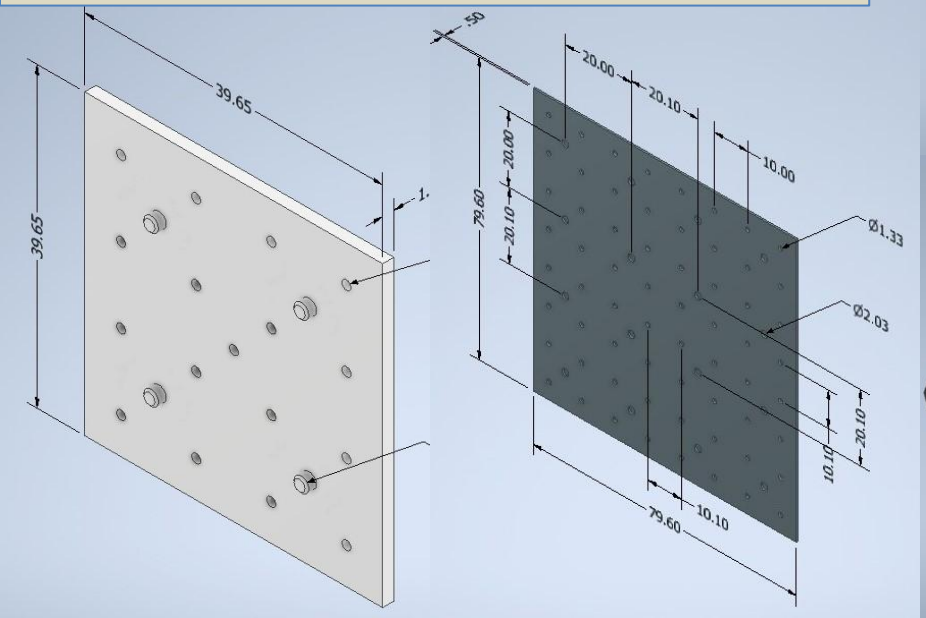




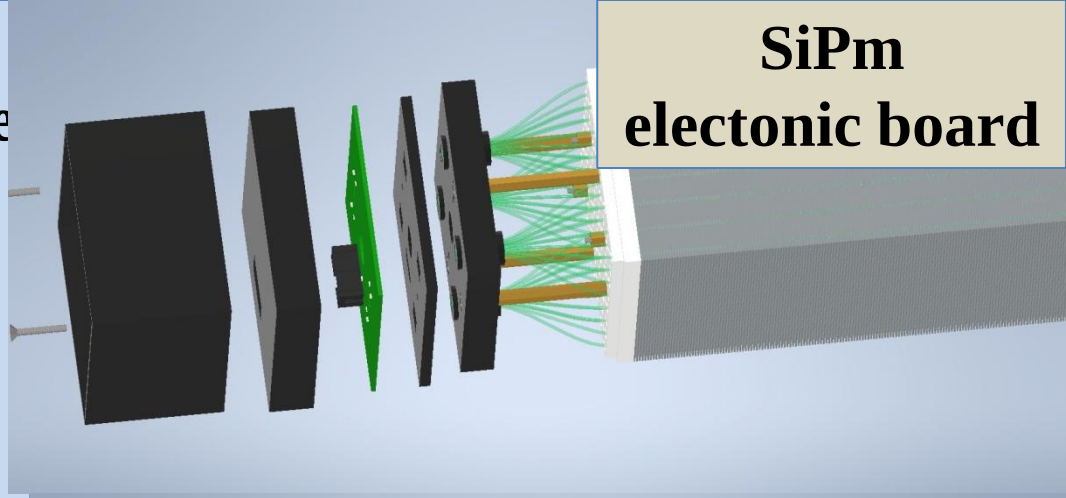
3-D Model
ECAL SPD END CUP module
3-D Design

3-D ECAL model should be implemented in SPD Data base by help of Valery Shvetsov

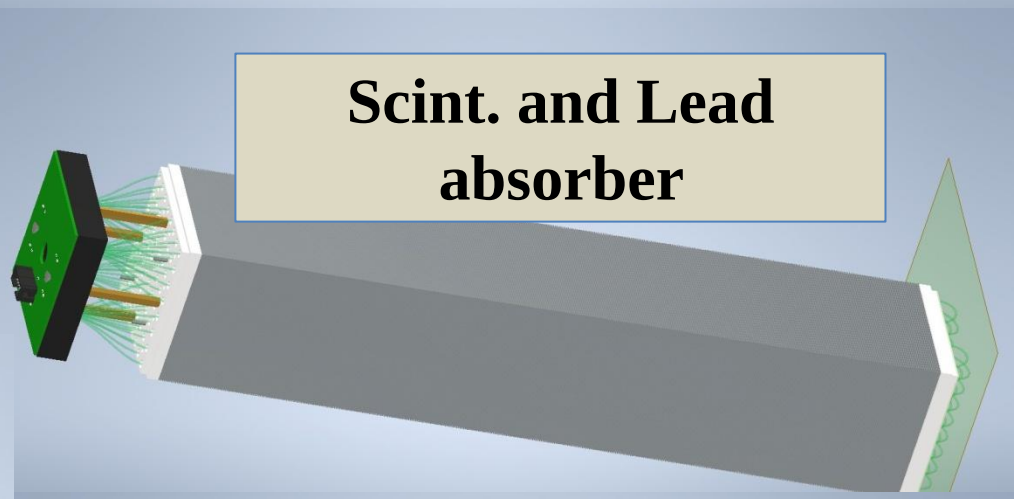
Scintillator and Led Plates



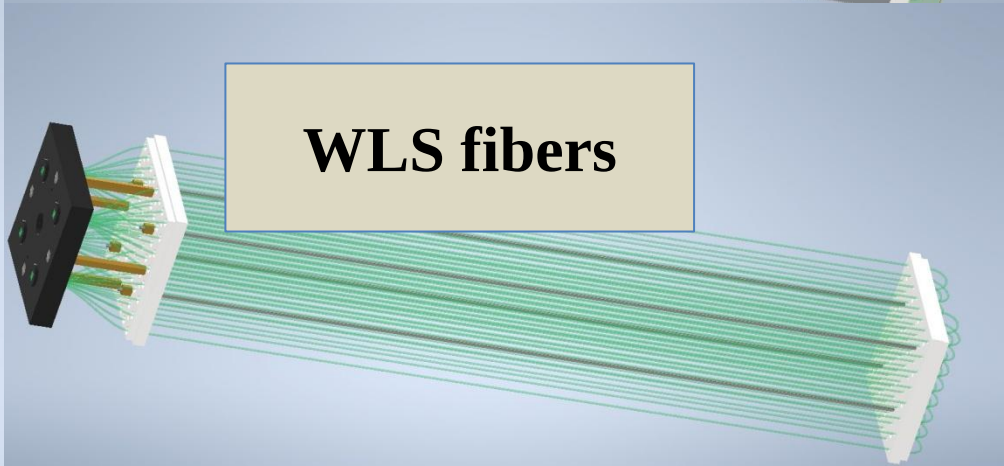
SiPm electonic board



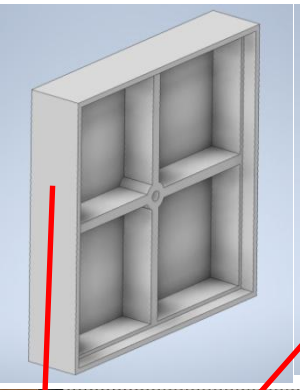
Scint. and Lead absorber

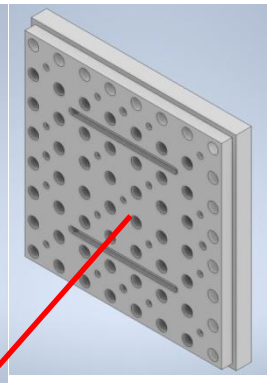


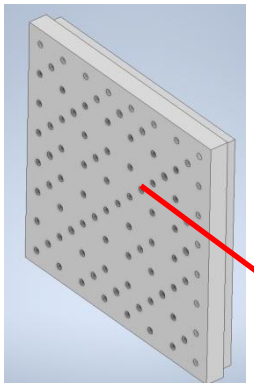
WLS fibers

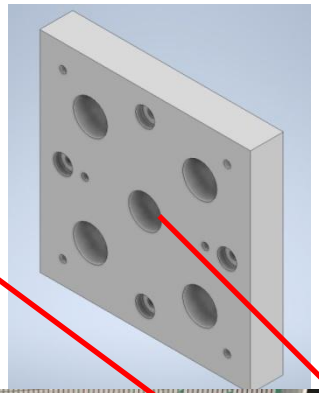


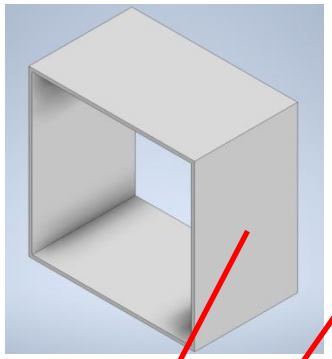
Assembling details: ABS, 3-D Printer, density=0.6 gr/cm^3

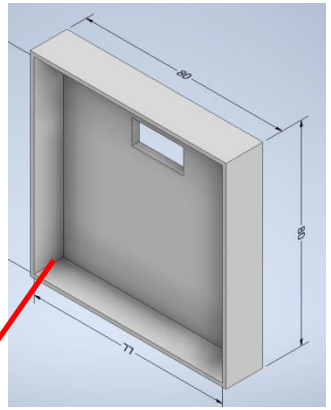








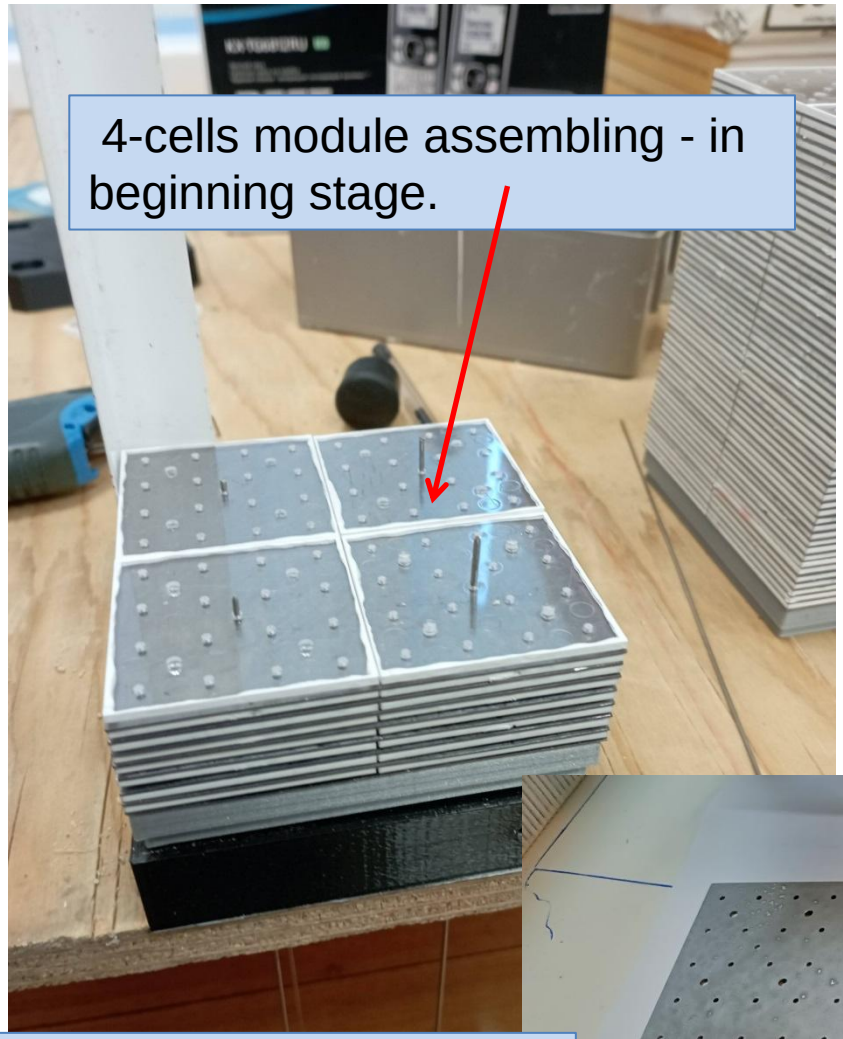




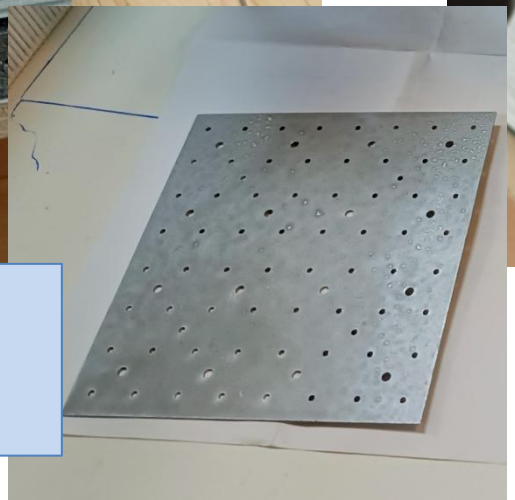
200 layers: 1.5/0.5 mm Scint/Lead

ECAL Front side: WLS loop

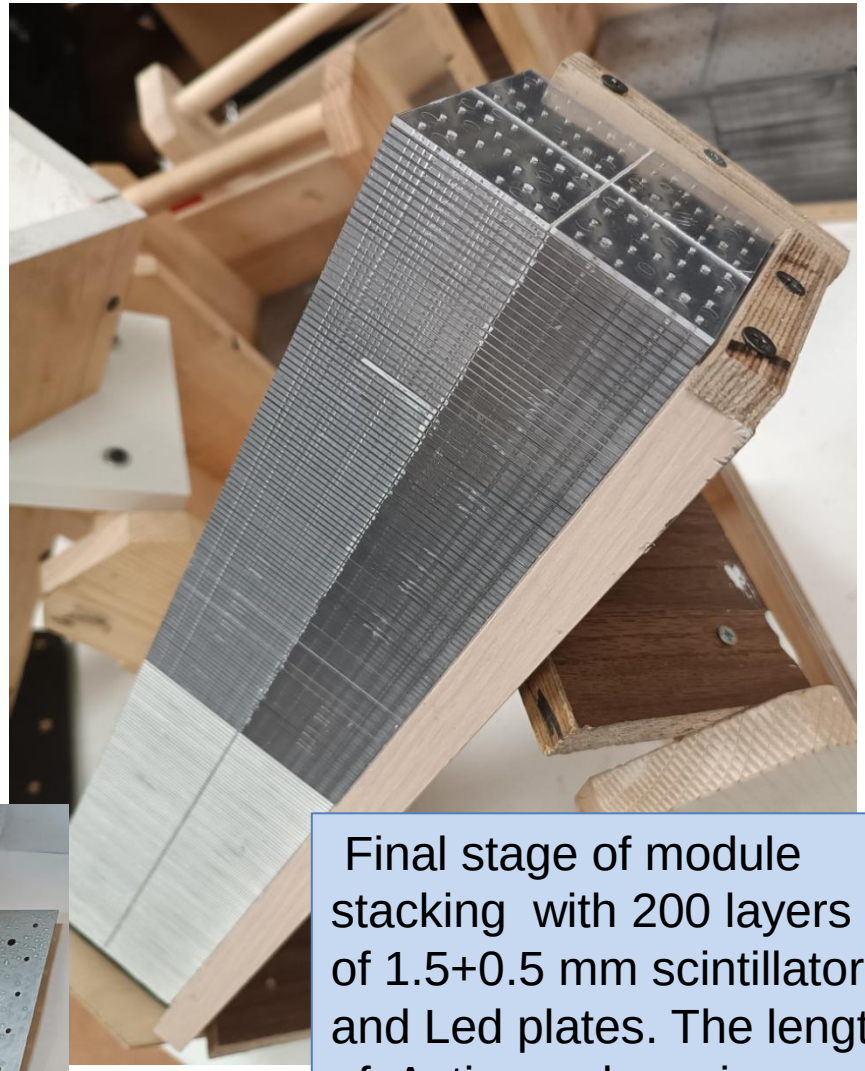
Modules assembling procedure



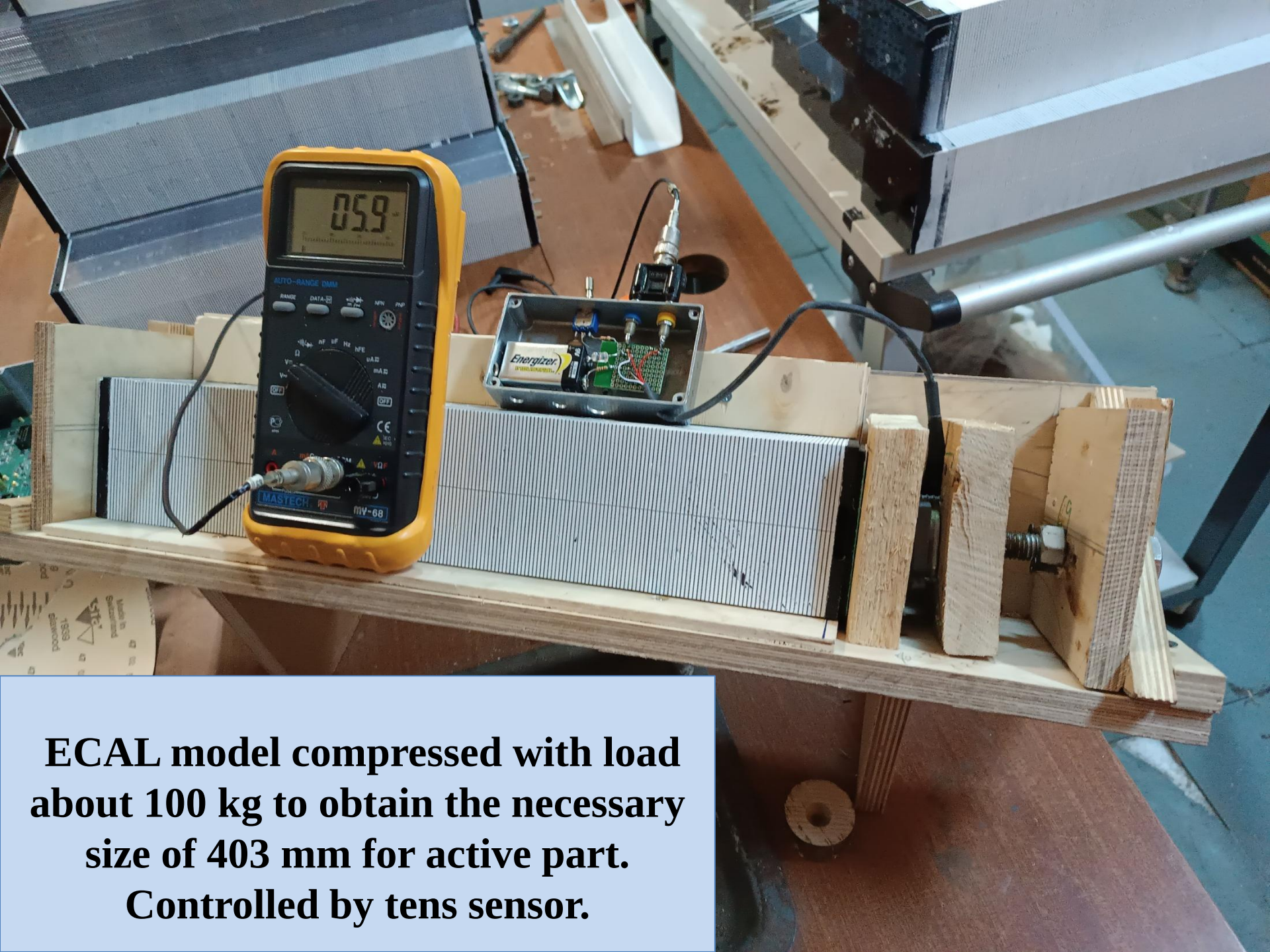
4-cells module assembling - in beginning stage.



Led plate 80x80 mm^2 to joint 4 Scintillator plates 40x40 mm^2.



Final stage of module stacking with 200 layers of 1.5+0.5 mm scintillators and Led plates. The length of Active volume is equal 403 mm , that corresponded to the estimated period 2.02 mm



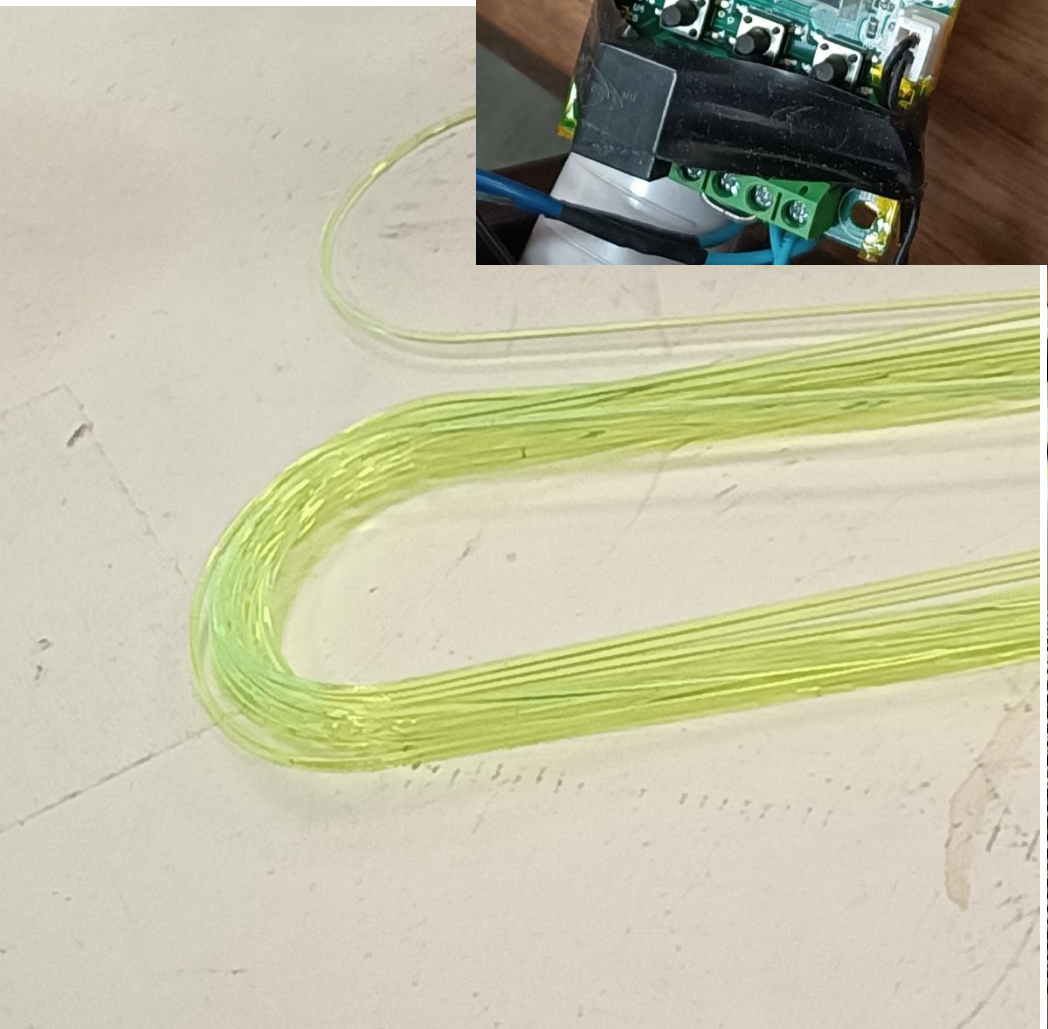
ECAL model compressed with load about 100 kg to obtain the necessary size of 403 mm for active part. Controlled by tens sensor.

Modules Assembling in JINR LHEP.
500 modules was assembled in 2025 .

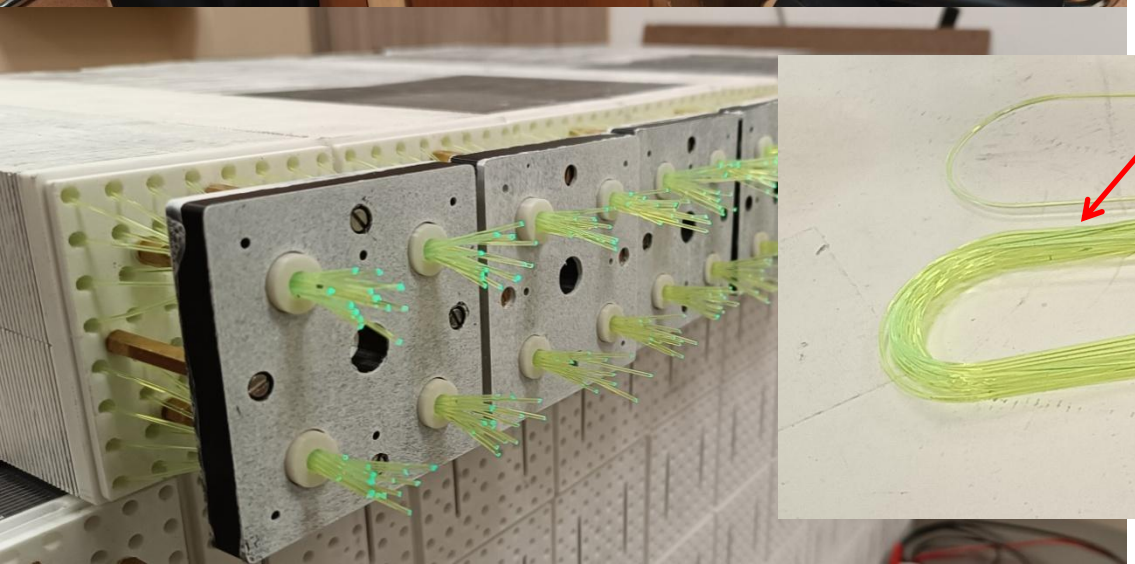
The preparation of fibers in the form of U-shaped loops is done by heating to 70-75 ^{O}C.

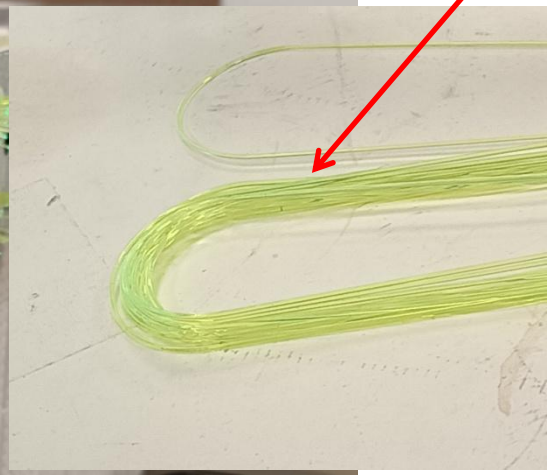
Thermo-sensor + Relay

30 mm Diameter



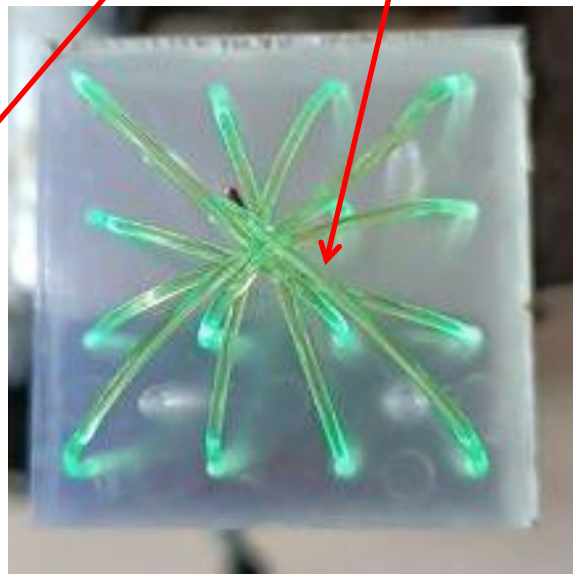
WLS fiber installation in LHEP JINR.
250 modules was assembled with WLS Y11 in 2026.

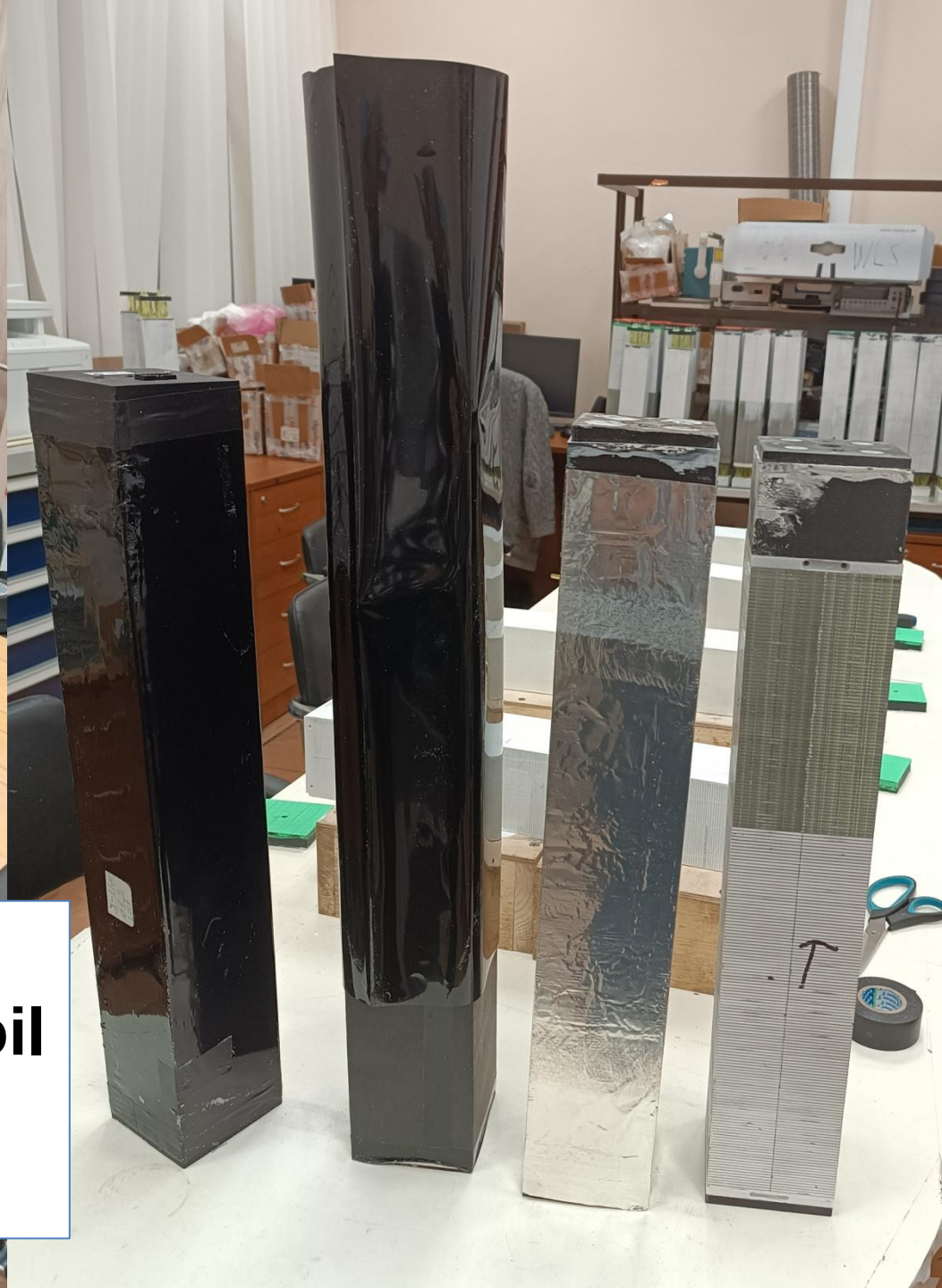




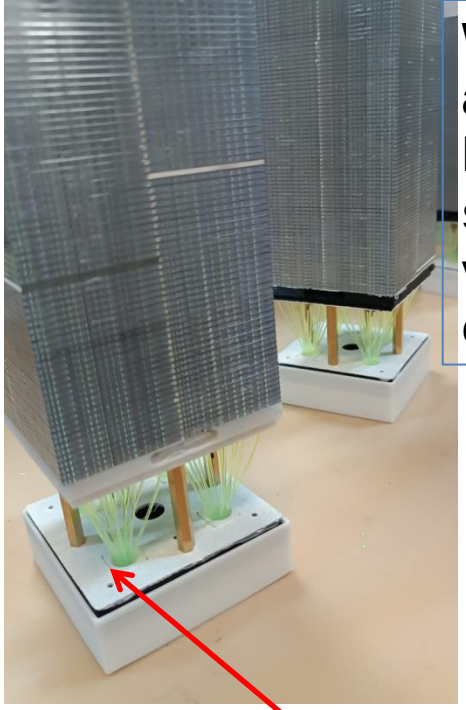
Each module contains 64 fibers. The WLS have U-shape installed in 32 U-shaped loops.

The fiber installation pattern provides a curvature diameter of approximately 30 mm

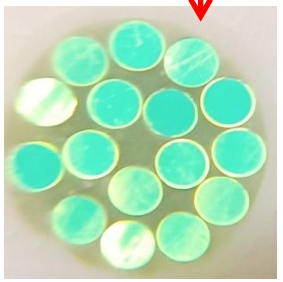




Finally, the modules are wrapped in aluminum foil and covered with heat-shrinkable black film.



WLS bundle after cutting has good surface – are visible outer cladding ring



WLS bundles are glued into modules in this modules position,

WLS Ends cutting was done on a milling machine.

Its take time ~1 min/mod.

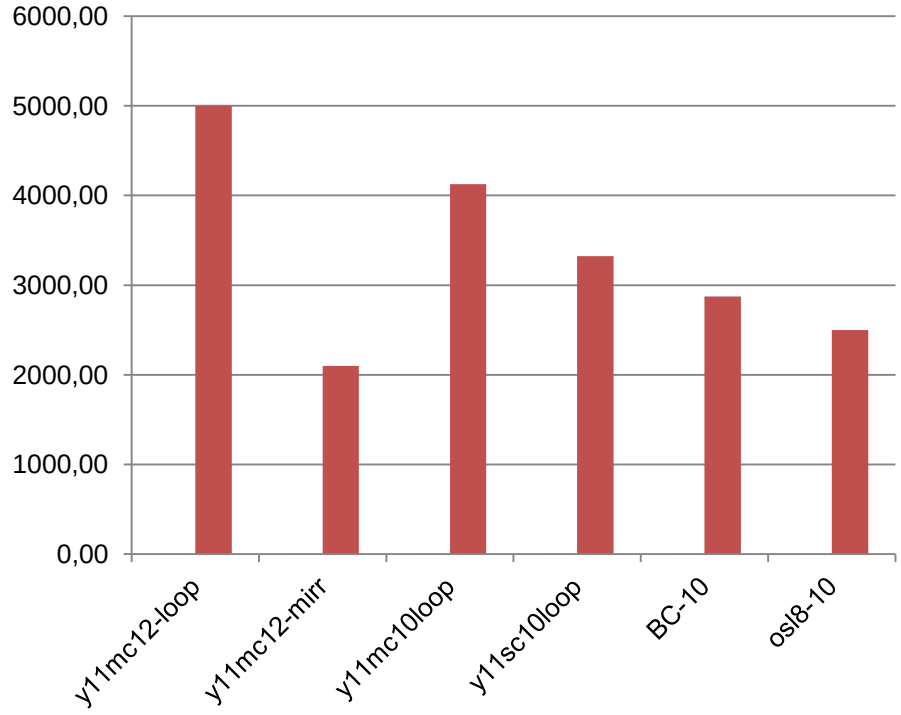
After assembly, the modules are transported to storage.

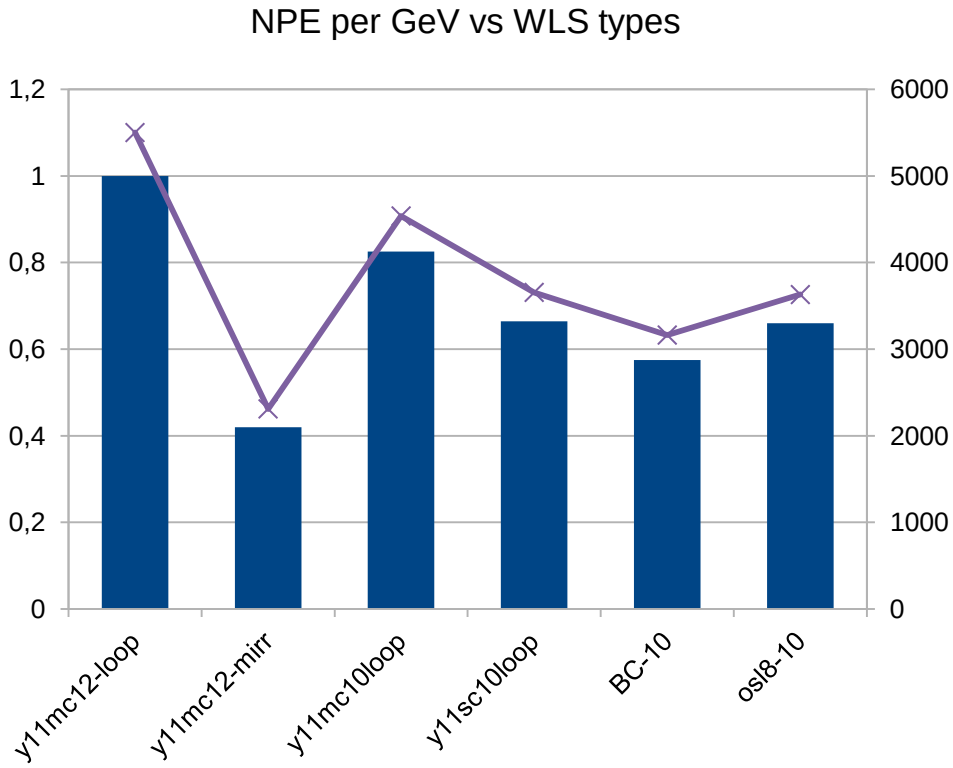
NICA SPD clean room in Hall 17.
To store ECAL modules.

1. **Test in Cosmic beam**
2. **MIP – position in cells**
3. **NPE per MIP**
4. **NPE per GeV**

4 Modules setup
16 cell 40x40 mm^2.

1. **Test in Cosmic beam**
2. **NPE per GeV**

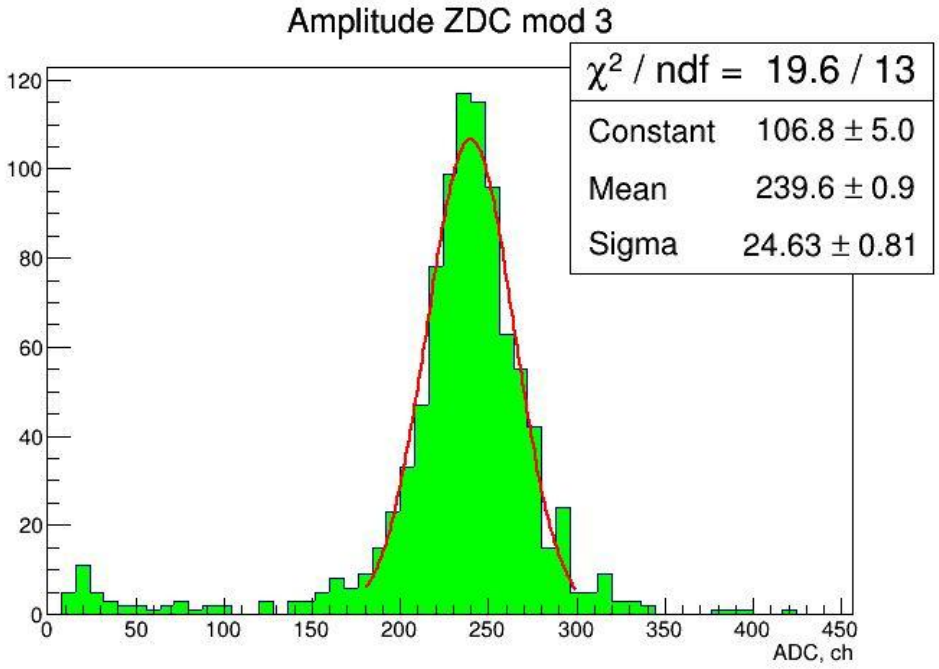


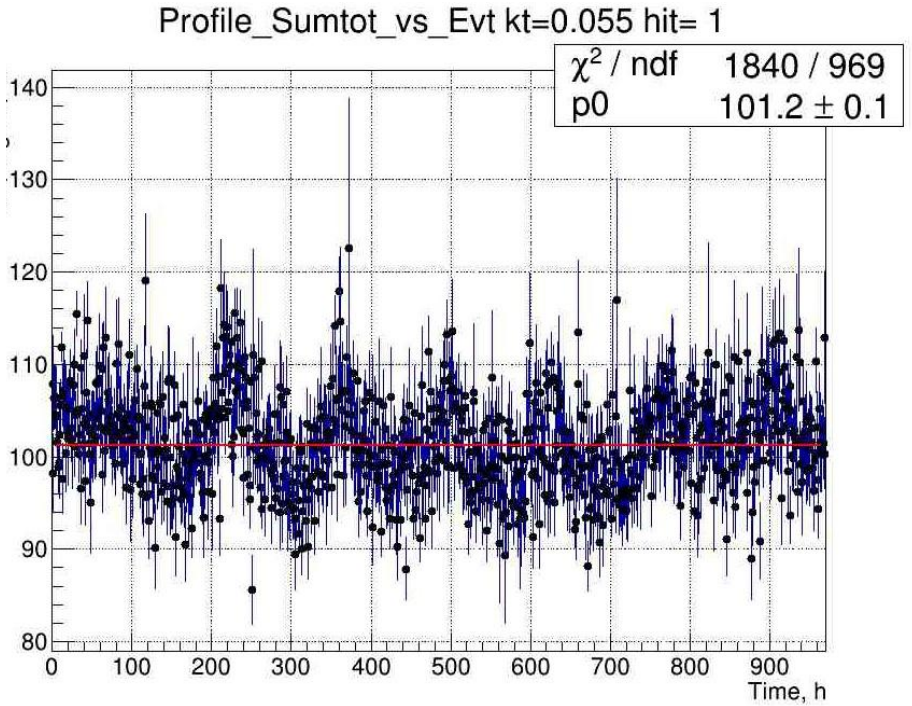


NPE per GeV vs WLS Types, normalized to Y11-MC-1.2 mm

1. Y11-MC-1.2 mm – Loop SPD
2. Y11-MC-1.2 mm – Mirror, Silver Shine – COMPASS (20 Year old)
3. Y11-MC-1.0 mm – Loop SPD
4. Y11-SC-1.0 mm – Loop SPD
5. BC-MC-1.0 mm – Loop SPD
6. OSL8-SC-1.0 – Loop SPD

1. **Test in Cosmic beam**
2. **Total E-spectra from MIP for all 16 cells of 40[40 mm^2 - left**
3. **Amplitude MIP vs time (right). Show signal daily fluctuation.**



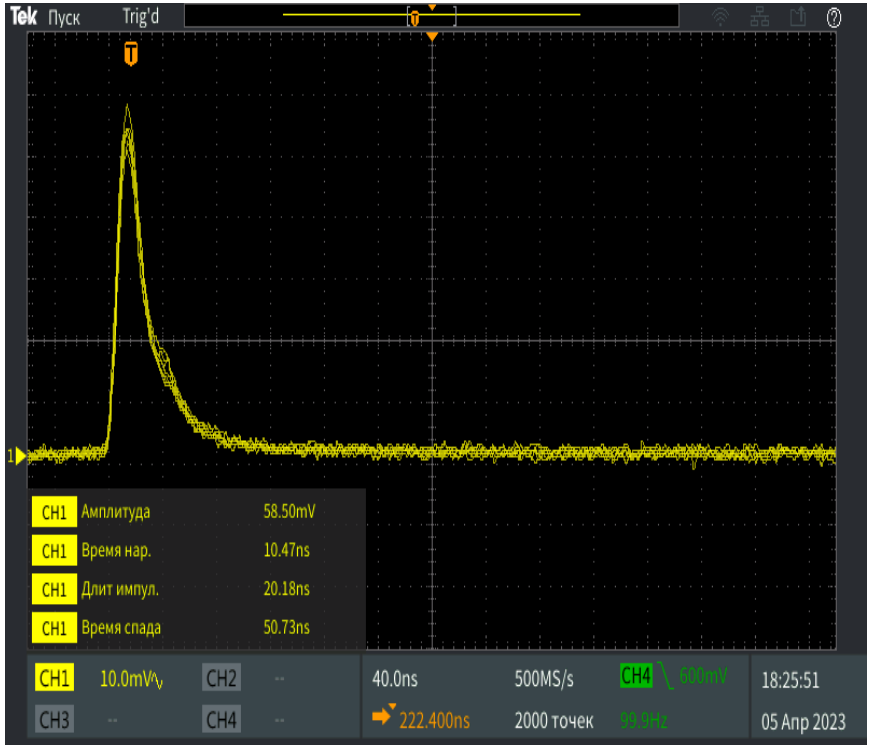


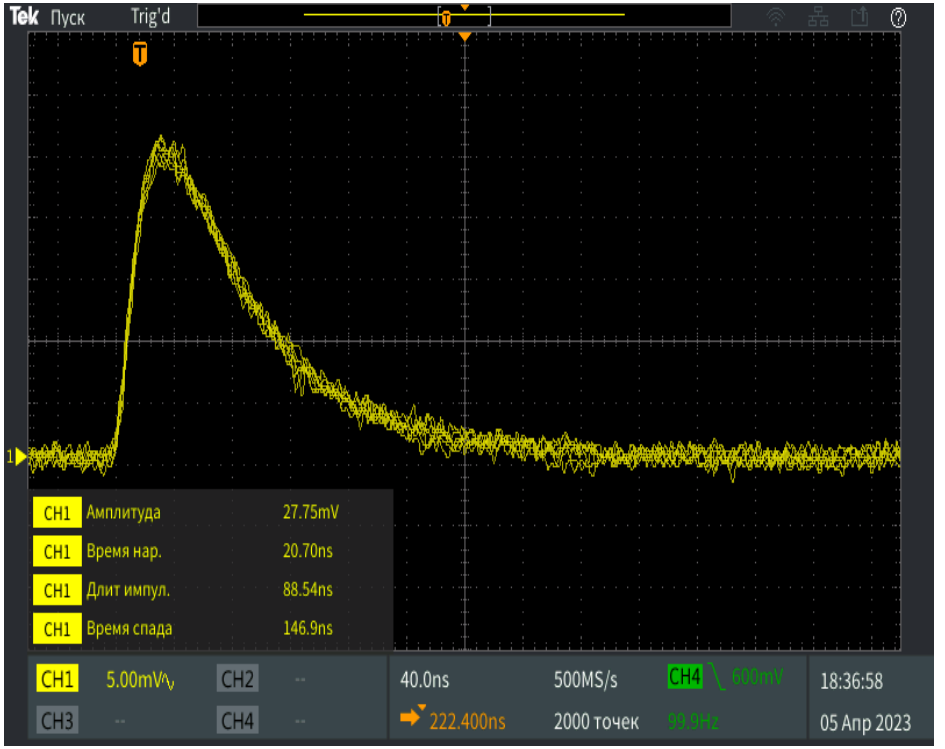
1. Y11-MC-1.0 mm – Loop SPD
2. E resolution for 240 MeV (MIP equivalent response in Ecal = 11.05%
3. For 1 GeV electron it should be 5.5% - according dep. 1/sqrt(E).
4. It is in agreement from MC for SPD Ecal

EQR15 Series SiPMs

Specifications subject to change without notice

Pulse shape of SiPm with 15 μ pitch and 6x6 mm^2 size

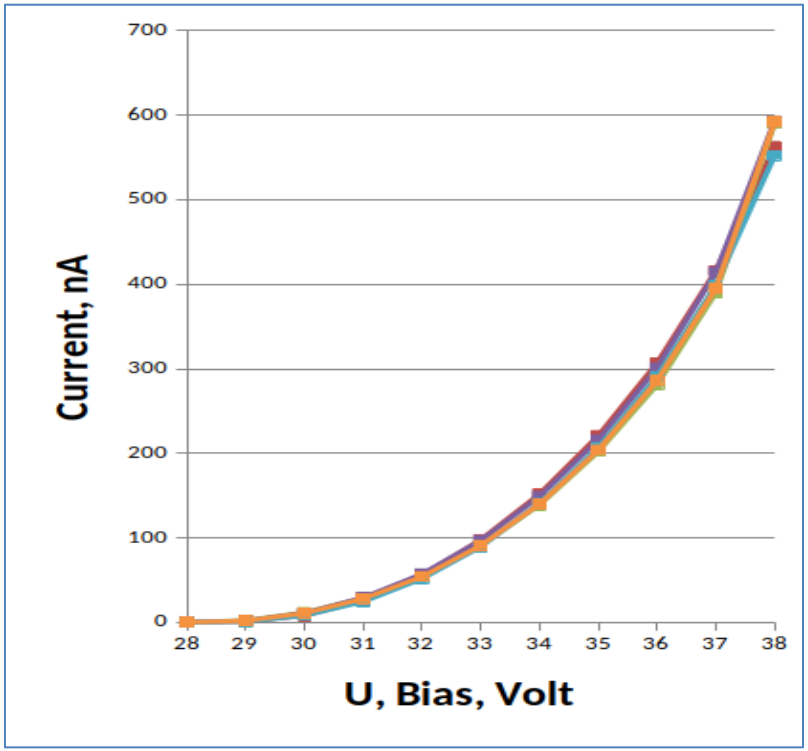


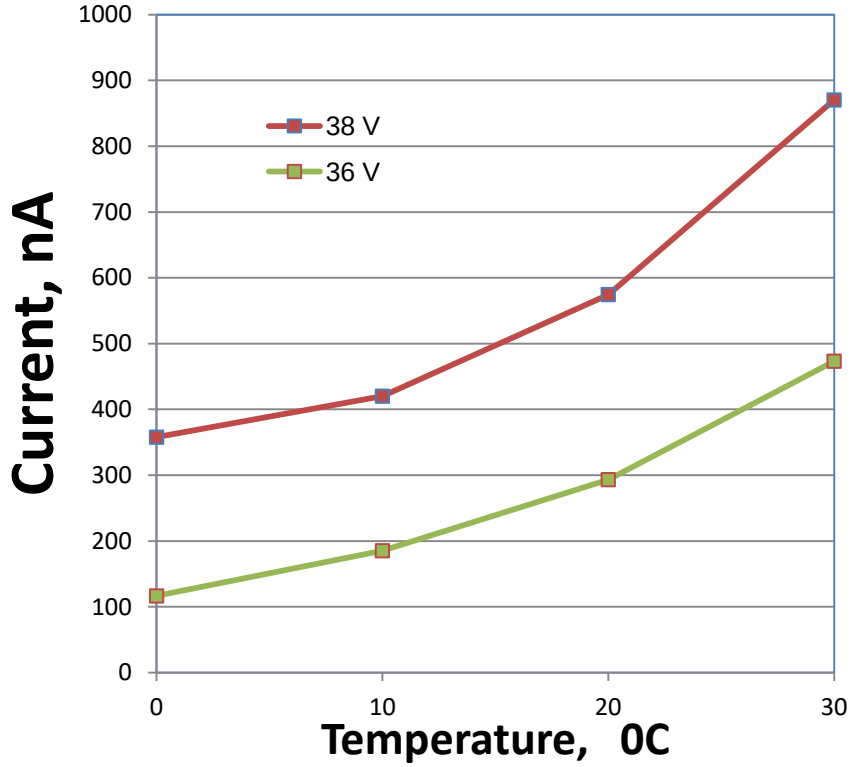


EQR-15-60
Front – 10 ns
Length – 20 ns

HAMAMATSU S14160-6015
Front – 21 ns
Length – 89 ns

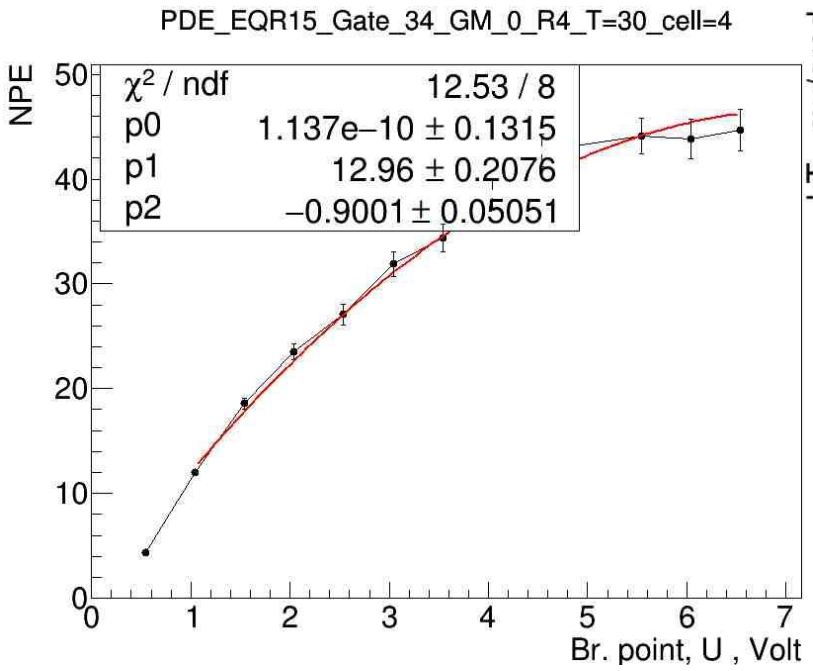
EQR15-60 Dark Current vs Bias voltage and its temperature dependences around operate Voltage

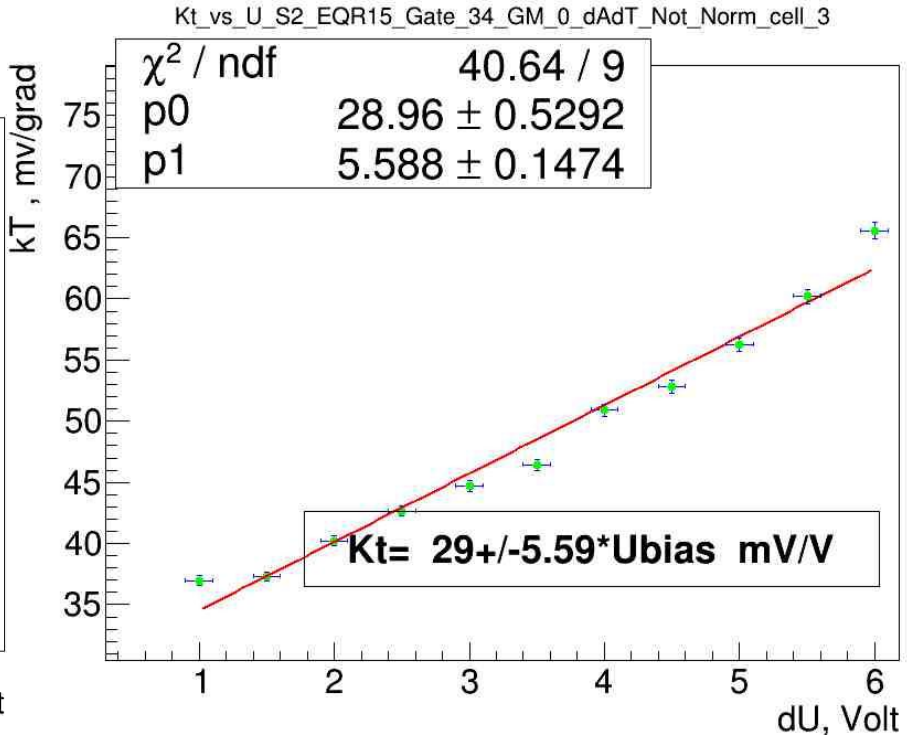




Dark Current vs Operation Bias (36-37 V) at room temperature (20 ^{0}C) is equal to 300-400 nA. Its are corresponded to the factory data and is similar HAMAMATSU too.

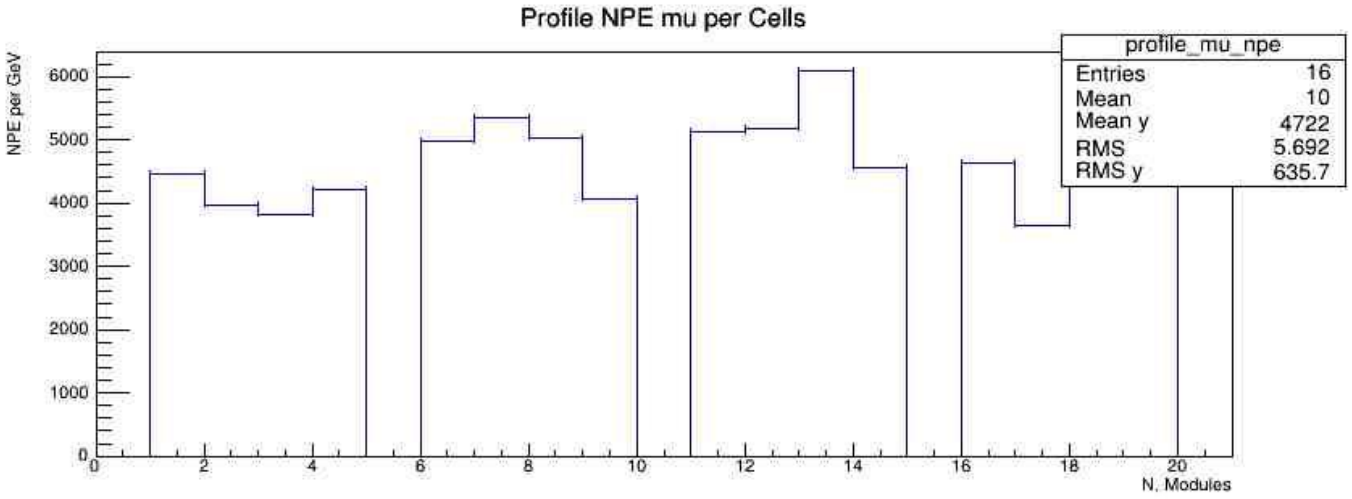
1. **SiPm EQR-11-15-6060, Break poin U=31 V, Bias Ub=5 V**
2. **6x6 mm^2 , pixel size = 15 mikron**
3. **160.000 Pixel number**



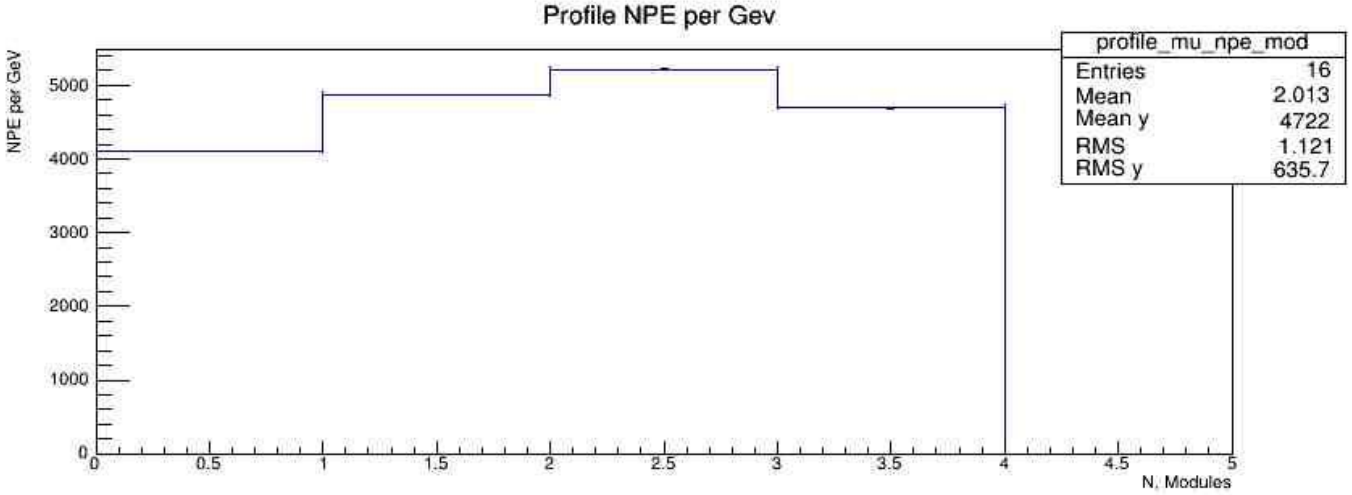


PDE vs U-Bias
U_b=5V → PDE~40%

K_t vs U-bias
U_b=5V → K_t=60 mV/^{0}C



NPE/GeV for Cels from 4 Modules



NPE/GeV for 4 Modules

1. Y11-MC-1.0 mm – Loop SPD
2. E resolution for 240 MeV (MIP equivalent response in Ecal = 10%
3. For 1 GeV electron it should be 5.0% - according dep. 1/sqrt(E).
4. It is in agreement from MC for SPD Ecal

1. **Scintillated tiles production in Vladimir, UNIPLAST:**
2. **Lead absorber plates production in Vladimir , MARAL:**
3. **Modules assembling in LHEP JINR:**
    1. **500 – JINR VBLHE – 2025 – assembled.**
    2. **~250 Modules arranged with WLS .**
    3. **Assembly last 500 modules will be completed in 2026-2027**
4. **Ecal test in Cosmic beam wad dome:**
    1. **Light output ~ 5000 NPE /GeV**
    2. **E-resolution for MIP ~ 11.05%**
    3. **Long time stability vs Temperature – shown ~1% fluctuation**

End of Report

Thanks for attention to All