# Status report
# Electromagnetic calorimeter for the SPD
# 10 June 2021

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**WAS Done:**

- EC prototype #1 with Sampling of 220x(1.5 Scint.+ 0.3Pb) – **11.7 $X_0$**

  cell 55x55 mm was tested in cosmic rays to estimate response for MIP;
- Moliere Radius = **5.2** cm (https://arxiv.org/abs/1710.08470);
- EC integration was performed in SPD setup;
- Monte Carlo calculations the impact of materials at the input of EC on energy resolution was done by Andriy Maltsev;
- EC prototype #2 with Sampling of 180x(1.5 Scint.+ 0.3Pb) – **16.0 $X_0$**

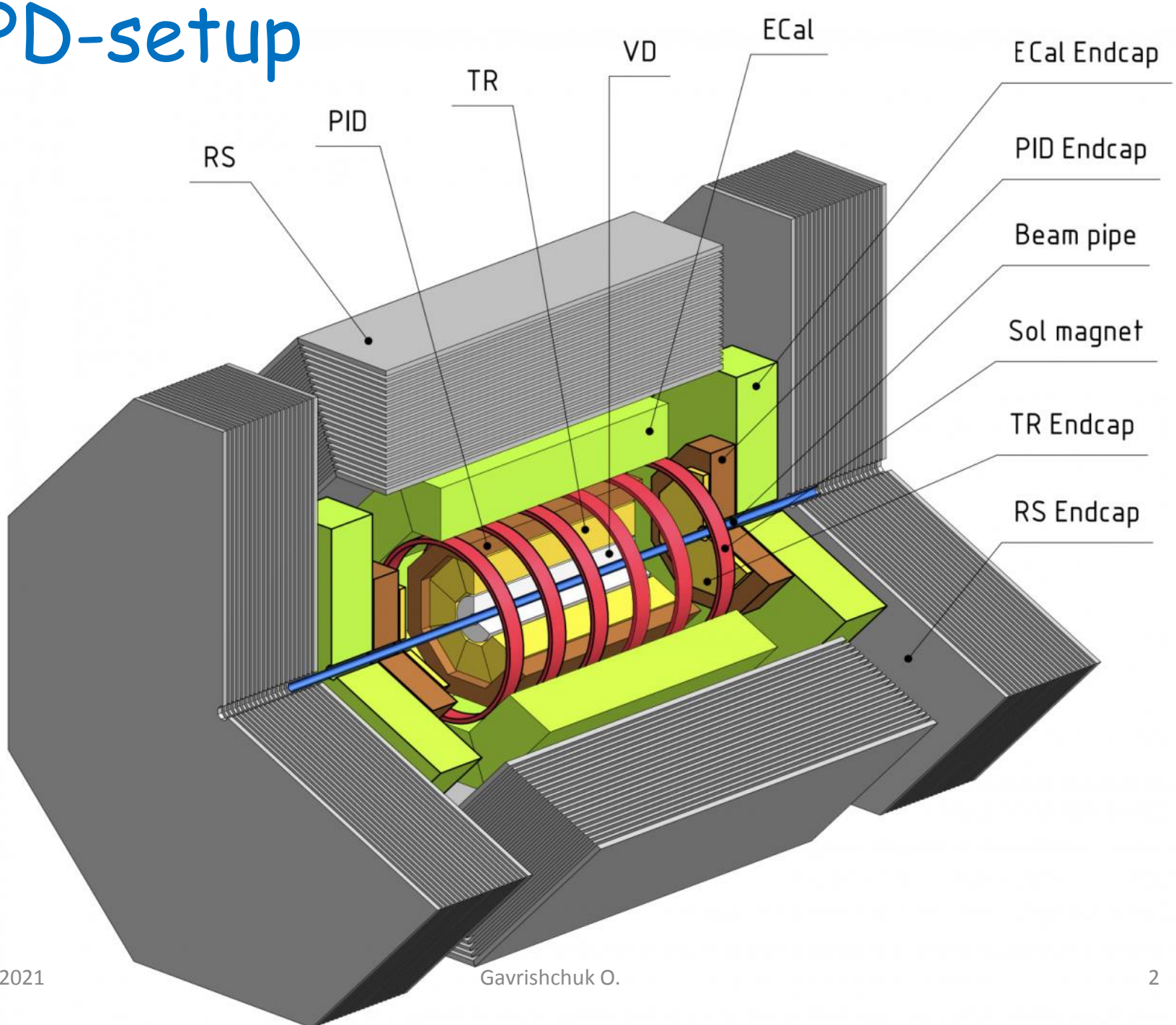
  cell 55x55 mm was tested in cosmic rays to estimate response for MIP;
- Moliere Radius = **4.2** cm (https://arxiv.org/abs/1710.08470).

**Planned for 2021**

- Beam test would be performed in electron beam in LHEP and LNP with

  EC porotypes #1 and #2.

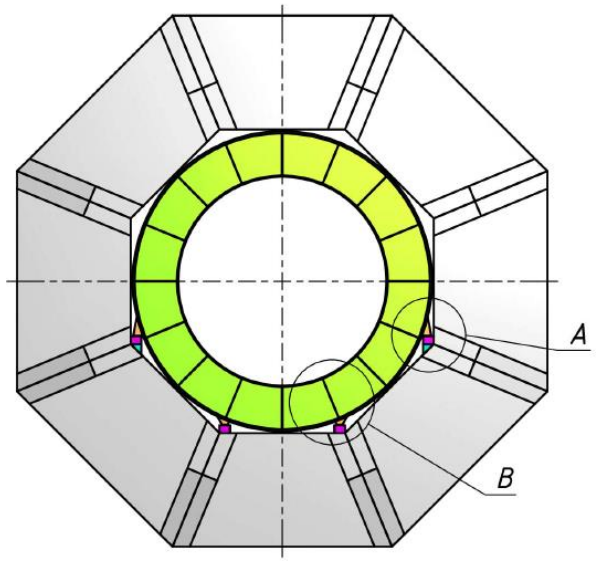
# SPD-setup

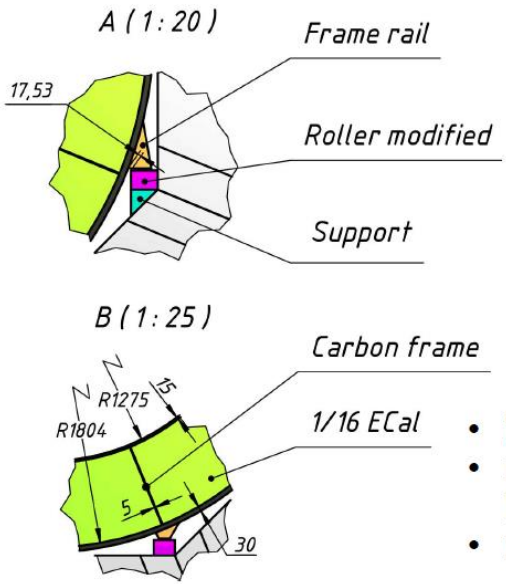

RS
PID
TR
VD
ECal
ECal Endcap
PID Endcap
Beam pipe
Sol magnet
TR Endcap
RS Endcap

# ECAL barrel part integration in carbon frame

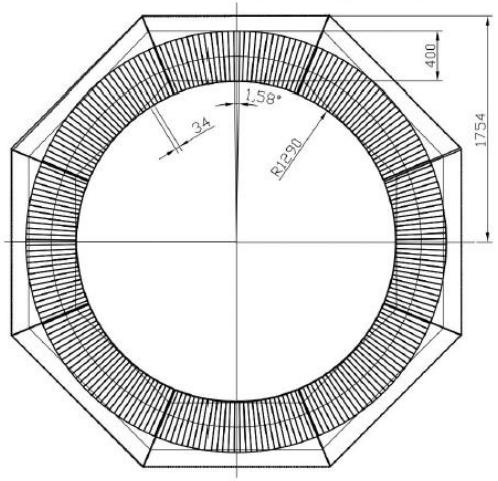
## Geometry options (carbon frame)

Proposed option (TDR)




Differences to CDR geomery:

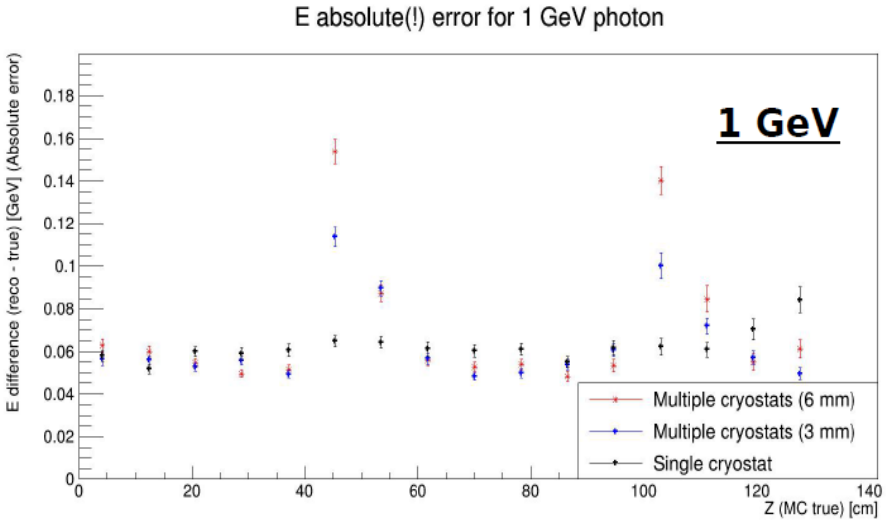


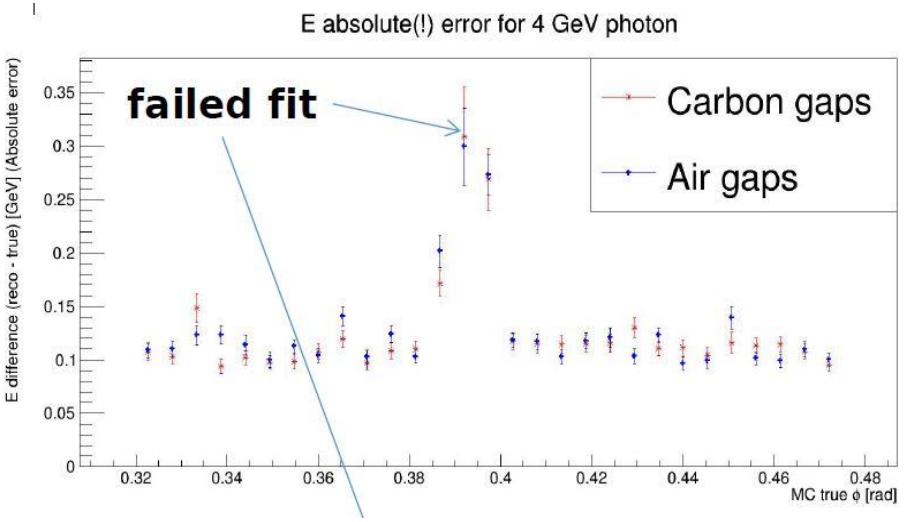

- 16 “baskets” instead of 8
- no gaps between “baskets”, but: 5 mm carbon frame in between
- 15 mm carbon frame in front

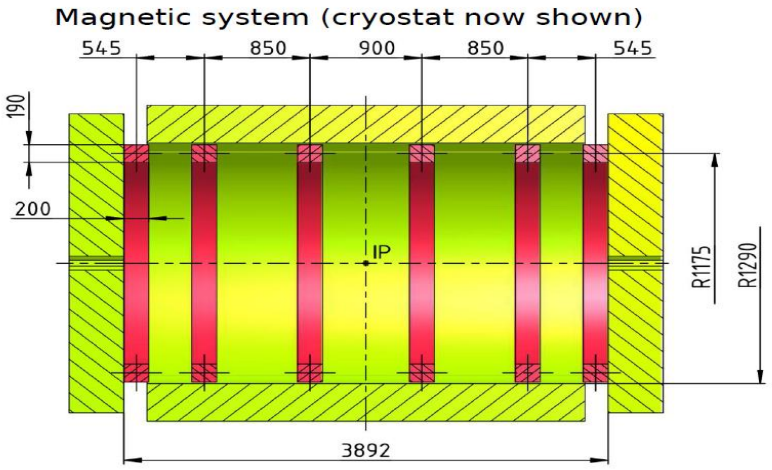
Will it impact the performance?

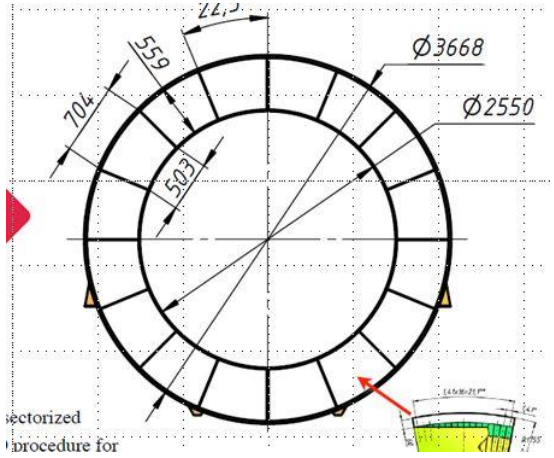
2

# Impact of Magnetic coils and carbon frame on energy resolution



# ECAL module design 2019-2021

Module has trapezoidal shape
With angles about $2^0$ and
consist of 4 cells 50x50mm$^2$.

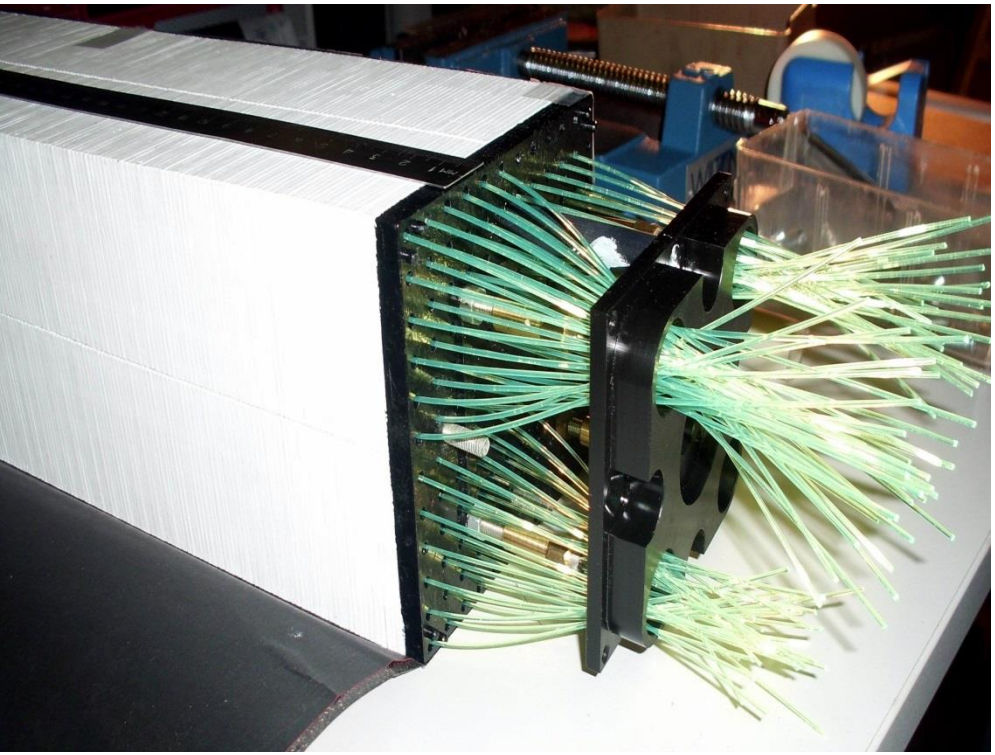
**Design of 2019:**

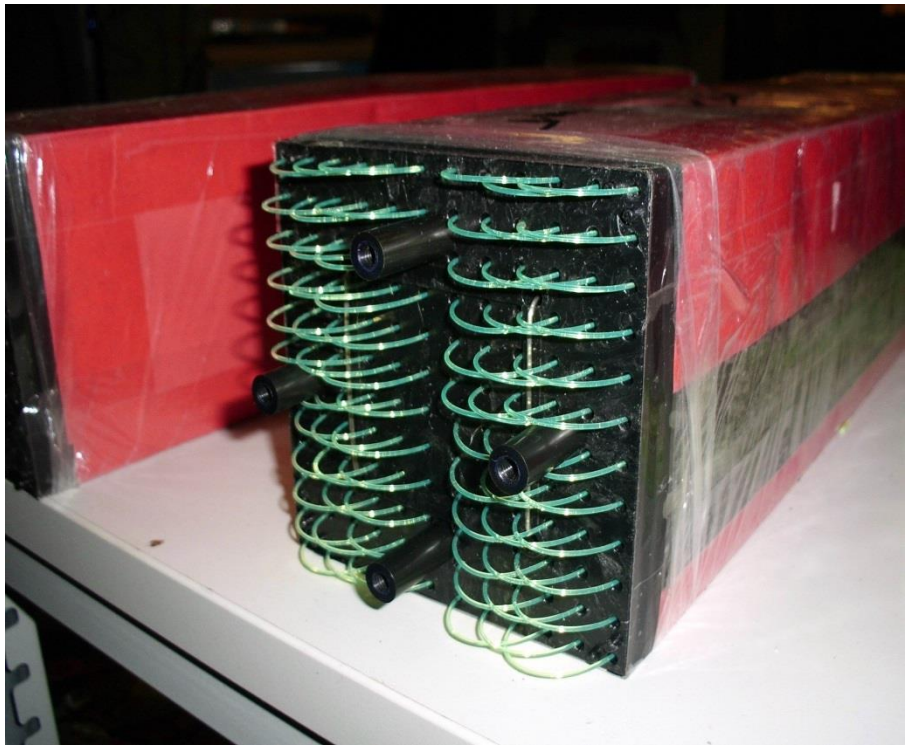
- 220 Layers Lead and Scintillator;
- 1.5 mm – Scintillator 55x55 mm$^2$ ;
- 0.3 mm - Lead 10x10 cm$^2$ plate;
- 440 mm length an active part;
- 560 mm length – totally;
- Radiation length - 11.7$X_0$;
- Moliere Radius = 5.2 cm.

**Design of 2021:**

- 180 Layers Lead and Scintillator;
- 1.5 mm – Scintillator 55x55 mm$^2$ ;
- 0.3 mm - Lead 10x10 cm$^2$ plate;
- 380 mm length an active part;
- 500 mm length - totally ;
- Radiation length - 16.0$X_0$;
- Moliere Radius = 4.2 cm.

WLS are pulled through module and have an U-loop End.
For light collection on MPPC used 4 bundles of 36 fibers each.

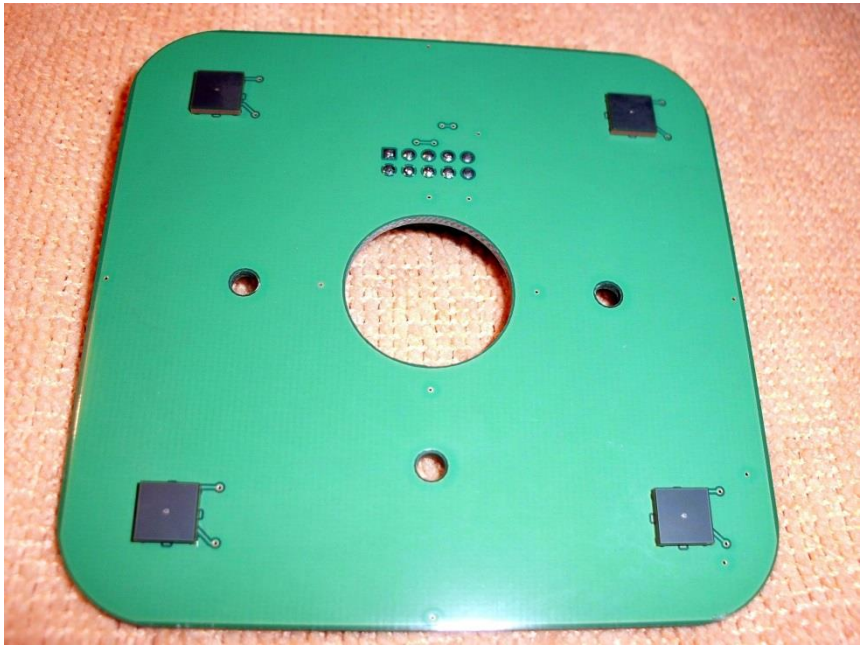


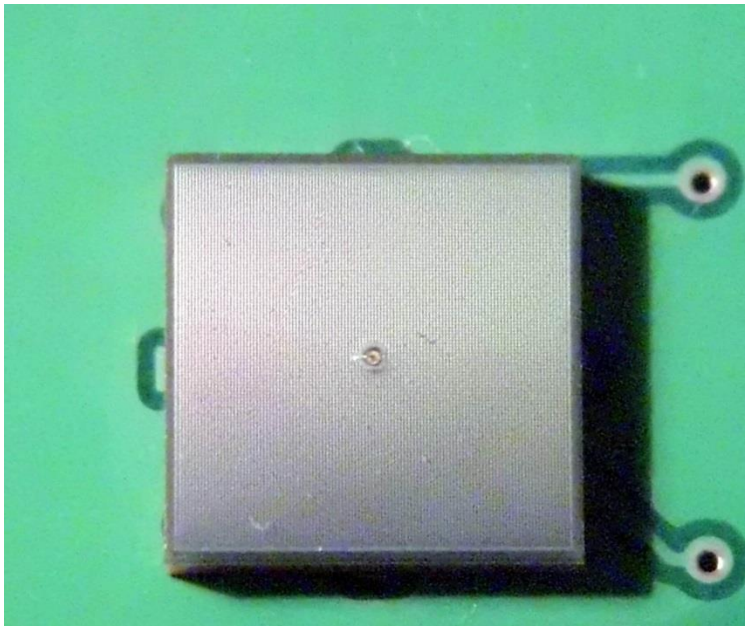


We used Y11-200 WLS Fibers with multi cladding of 1 mm in diameter.
144 Fiber are in through one Module.
Totally about 80 meters of WLS fiber is used to one module assembling.

# 9 ECAL modules produced in 2019
# IHEP – Protvino + JINR - production

# PCB board with 4 MPPC 6x6 mm2 (left) Single MPPS type S14160-6050





MPPC series of S14160-6050:

- Low Operation Power: 40 V
- Low temperature dependencies : 0.034 mv/$^0$C
- High PDE : 50% for 480 nm
- Pixel pitch = 50 mc
- Pixel Nuvber =14400

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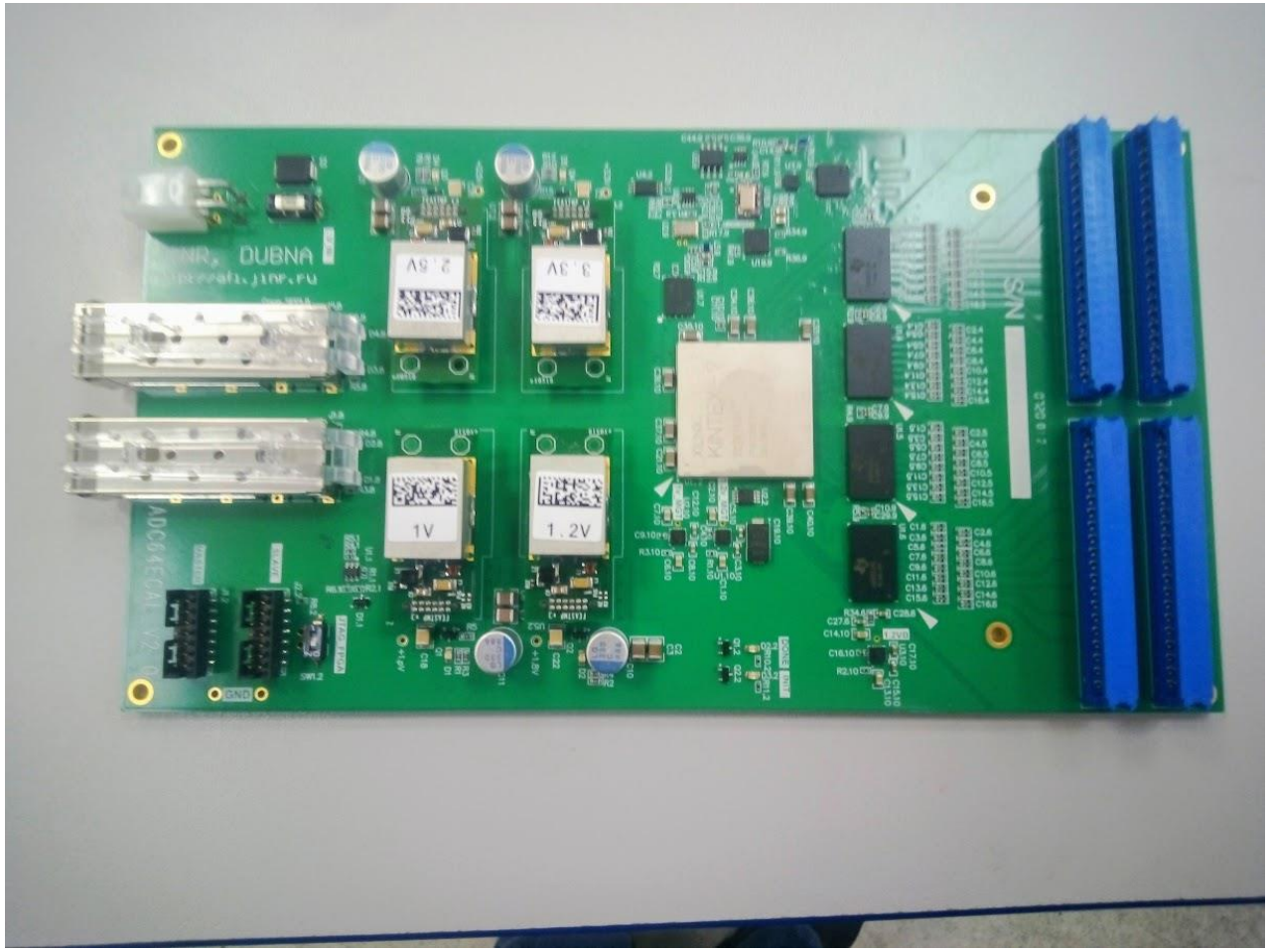
Hamamatsu promise produce
Such MPPC series type with
Pitch 15 mc
Pixel Number = 160000

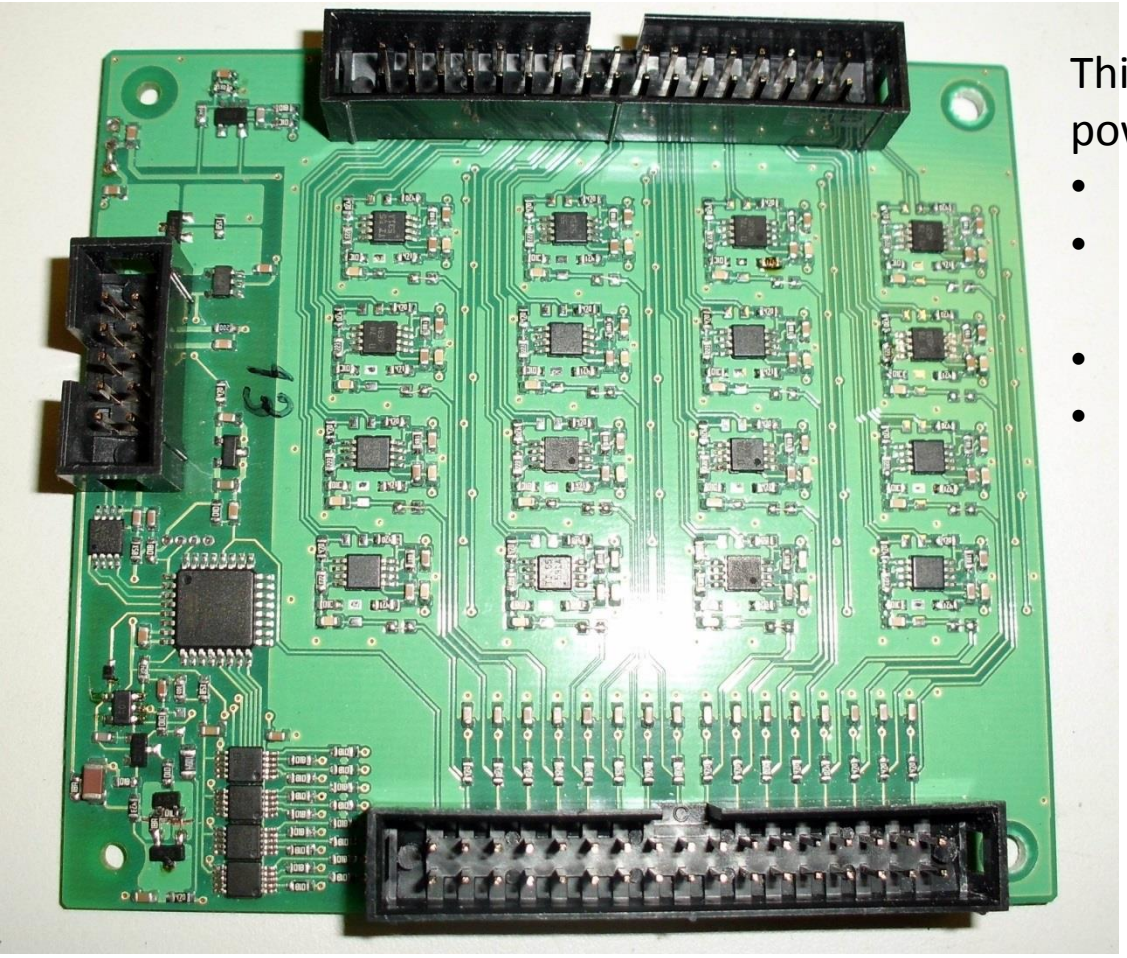
# 64 channel Wave form digitizer

## ADC_64 Ecal – produced in https://afi.jinr.ru




1. 64 MHz – samples frequency
2. 14 – bit/per sample
3. White Rabbit provides sub-nanosecond synchronization accuracy.
4. Can operate in Streamer mode – Trigger less DAQ

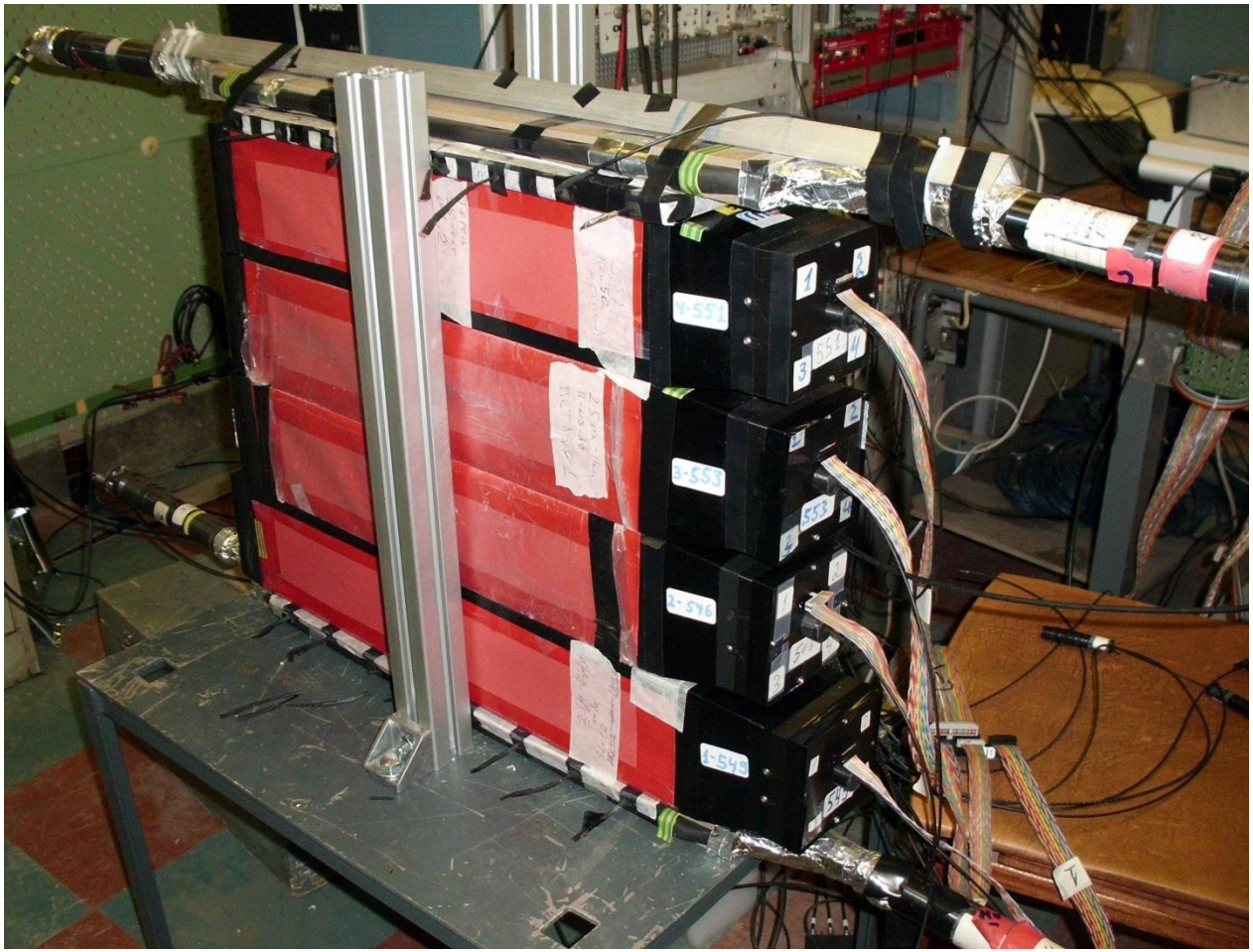
# 16 channels Front End – card Produced in http://hvsys.ru/en



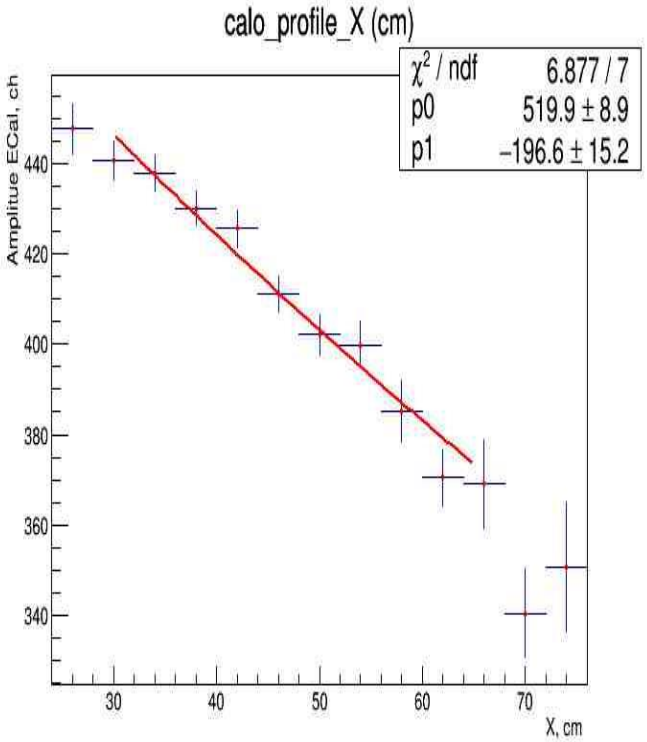
This board controlled of 16 MPPC H/V power:

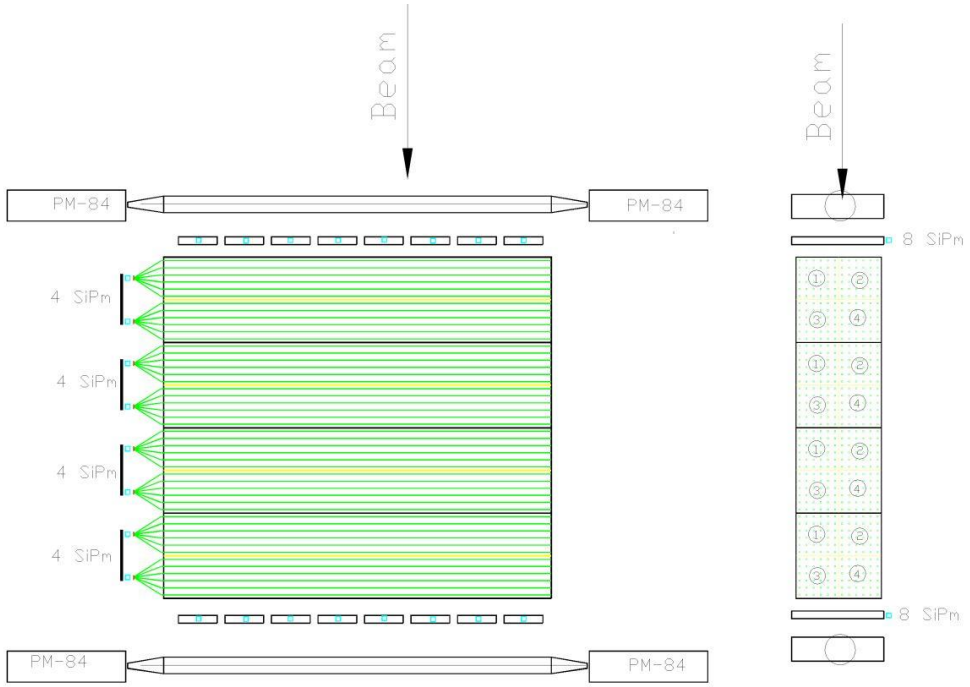
- Bias Voltage: 36 – 64 V;
- Transfer SiPm signals to ADC using twist pair flat cable up to 4 m length;
- Measurement the SiPm's temperature;
- H/V Temperature compensation done with software

# ECAL setup for horizontal cosmic test of 4 (16 cells)

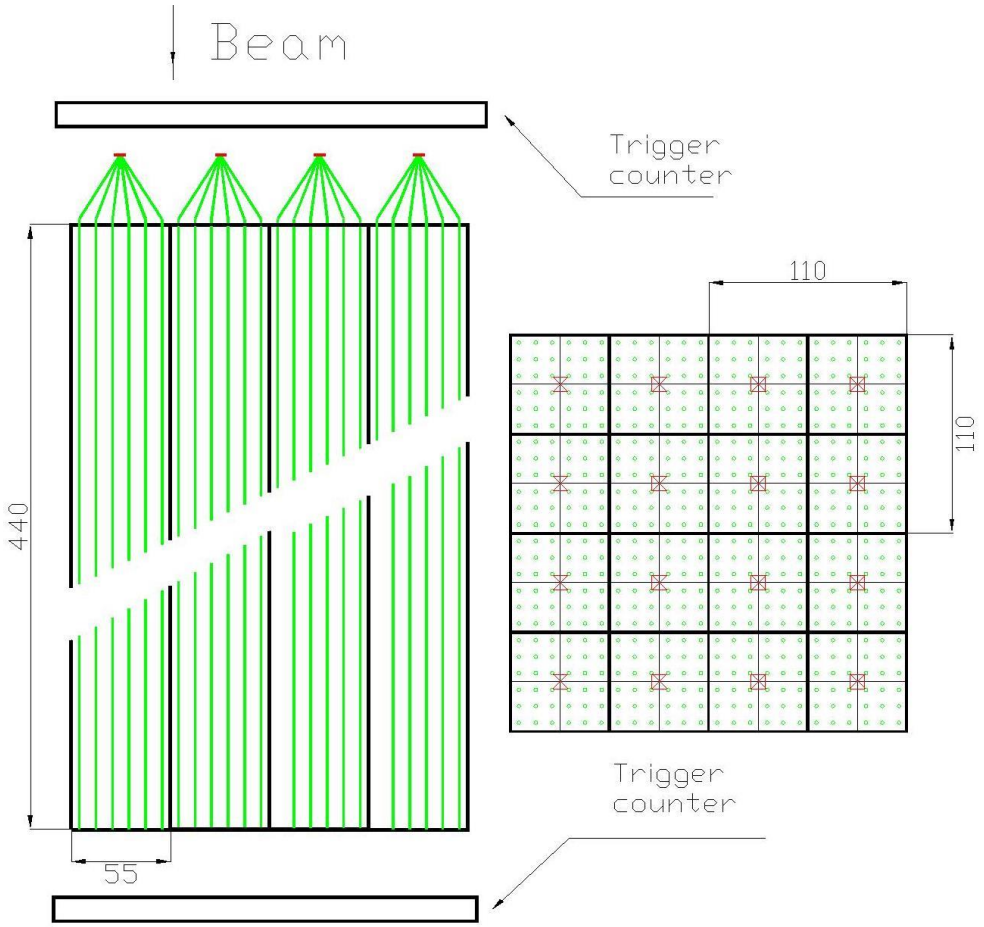


# Horizontal cosmic test – for measurement the attenuation length

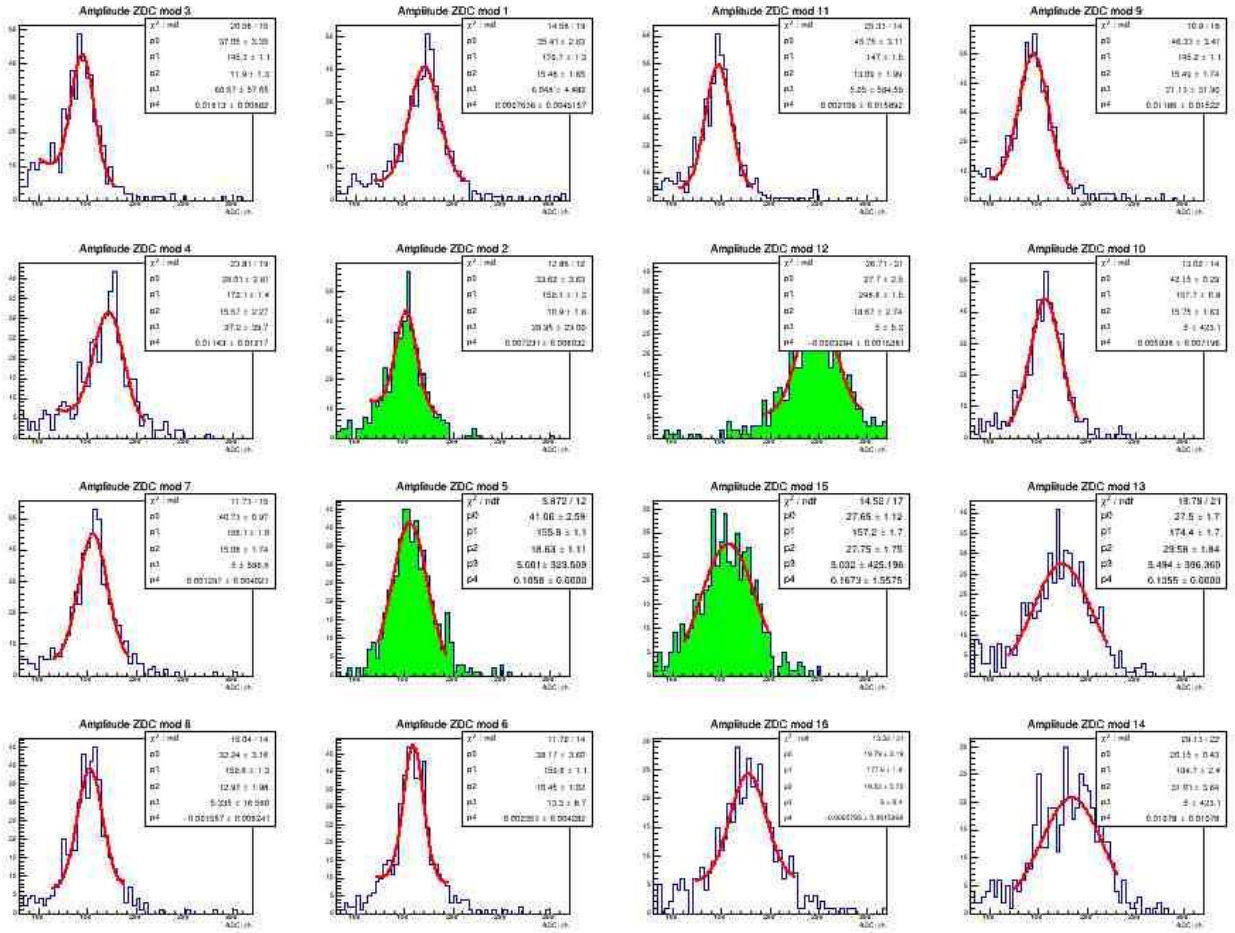


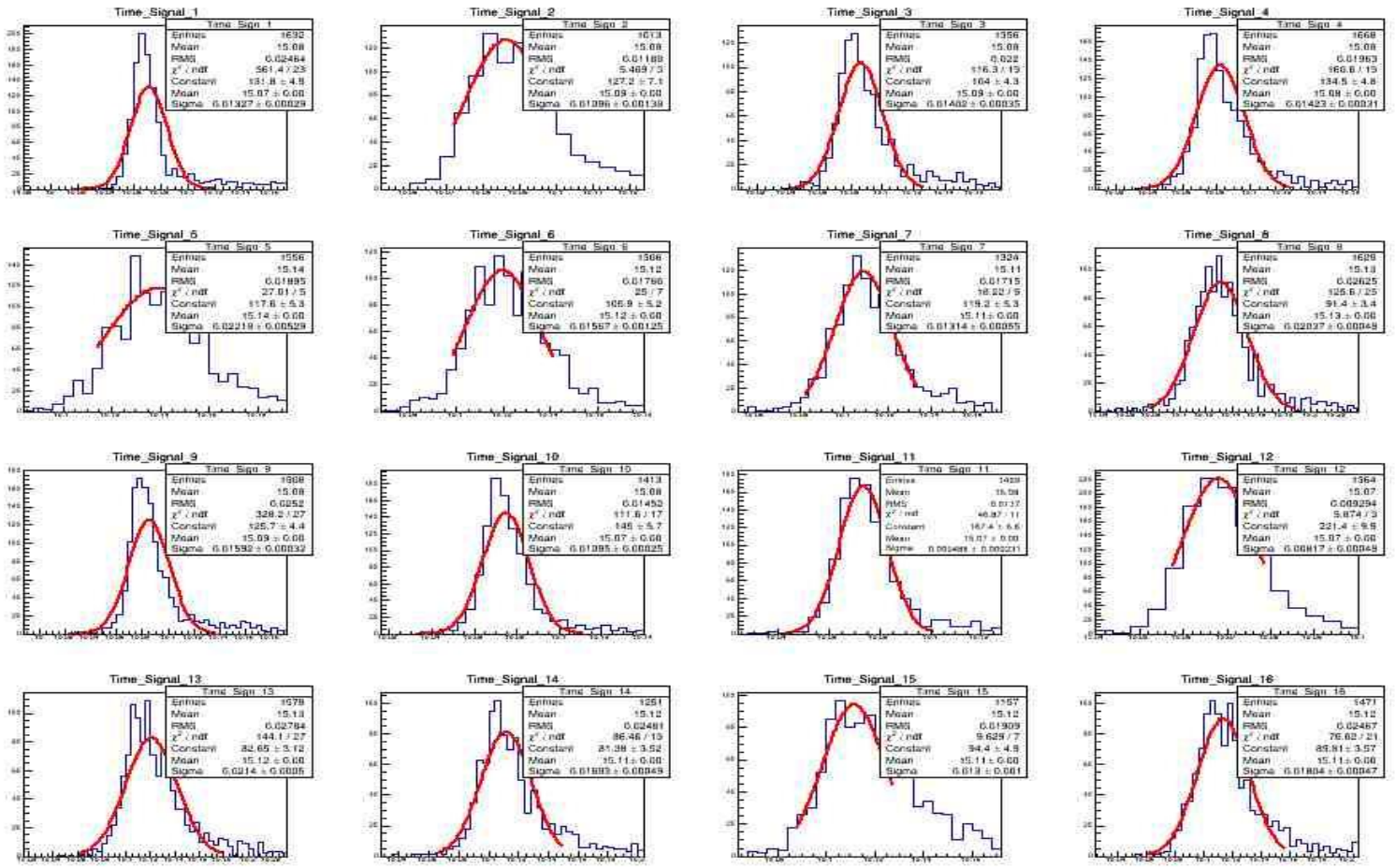
# ECAL setup for vertical cosmic test of 4 (16 cells)



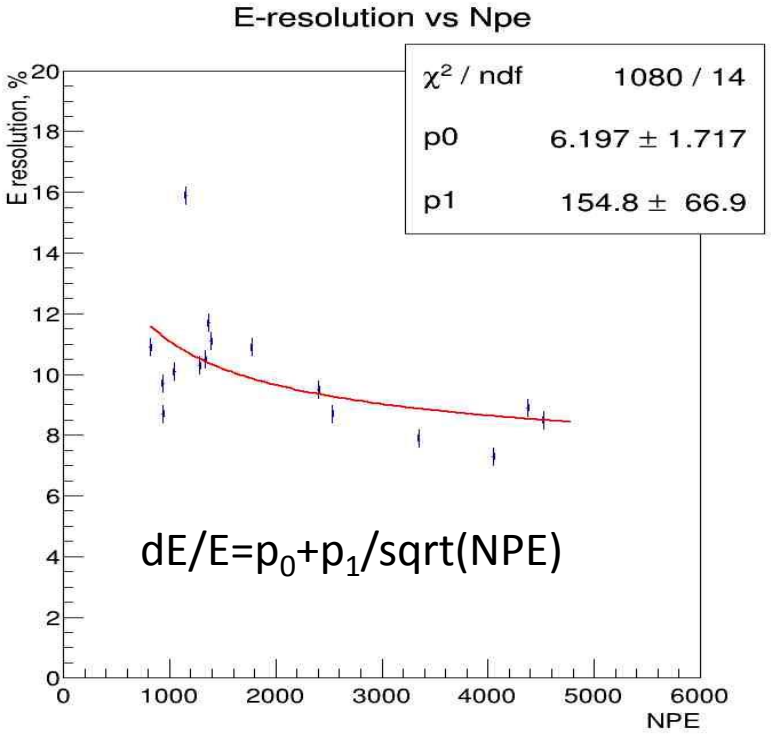
# 16 MIP ADC spectra with event selection as one hit per track

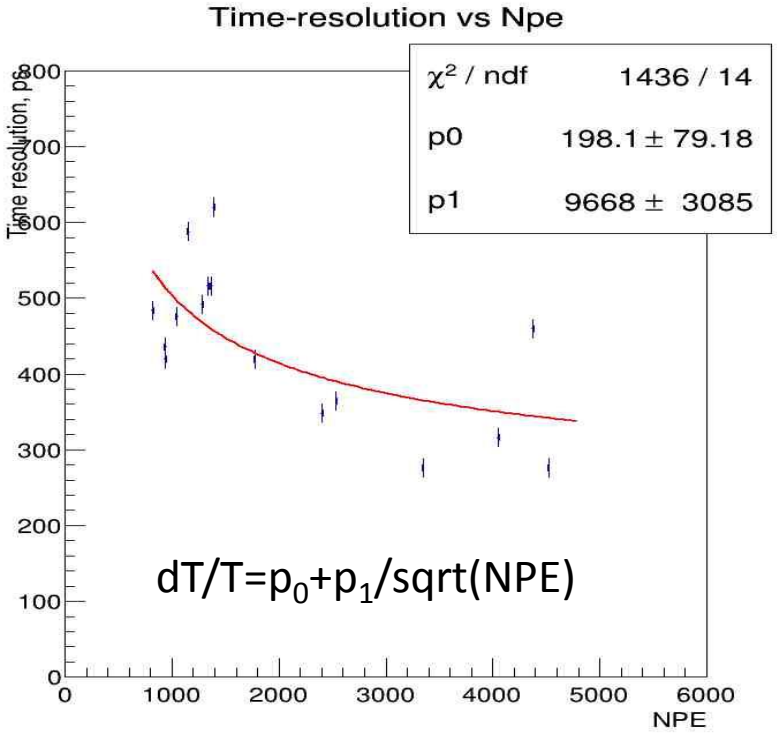


# Time signal for 16 ECAl cells for MIP signals with 1 hit per event



# Energy & Time resolution vs NPE in cosmic tests

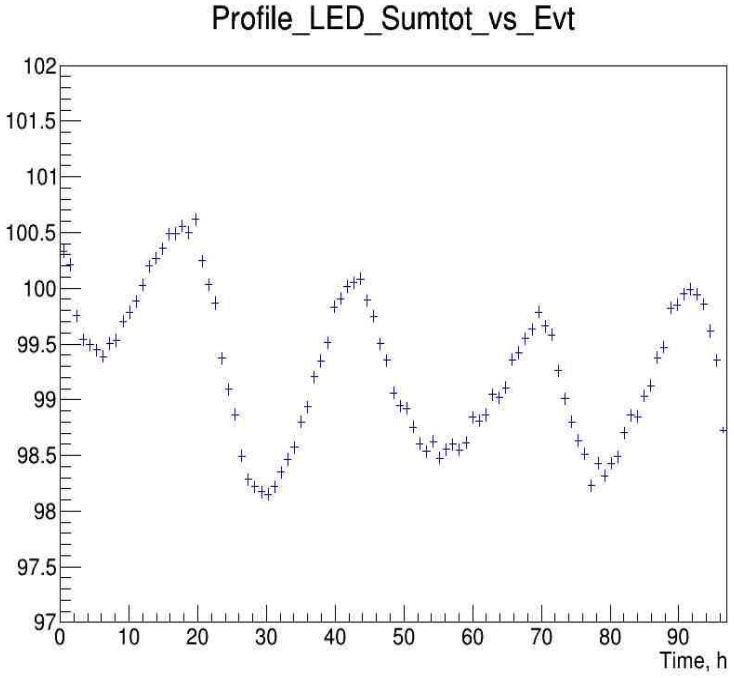


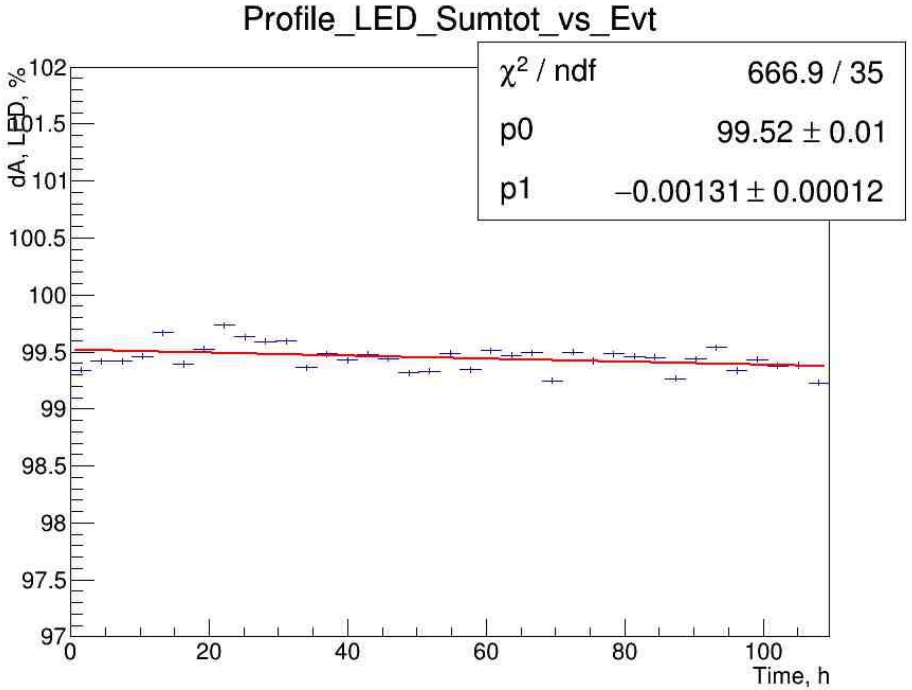

E – resoluvin limit equal to 6.2% for MIP as function of Light output

Time – resoluvin limit equal to 198 ps for MIP as function of Light output

# LED amplitude vs time (hours)



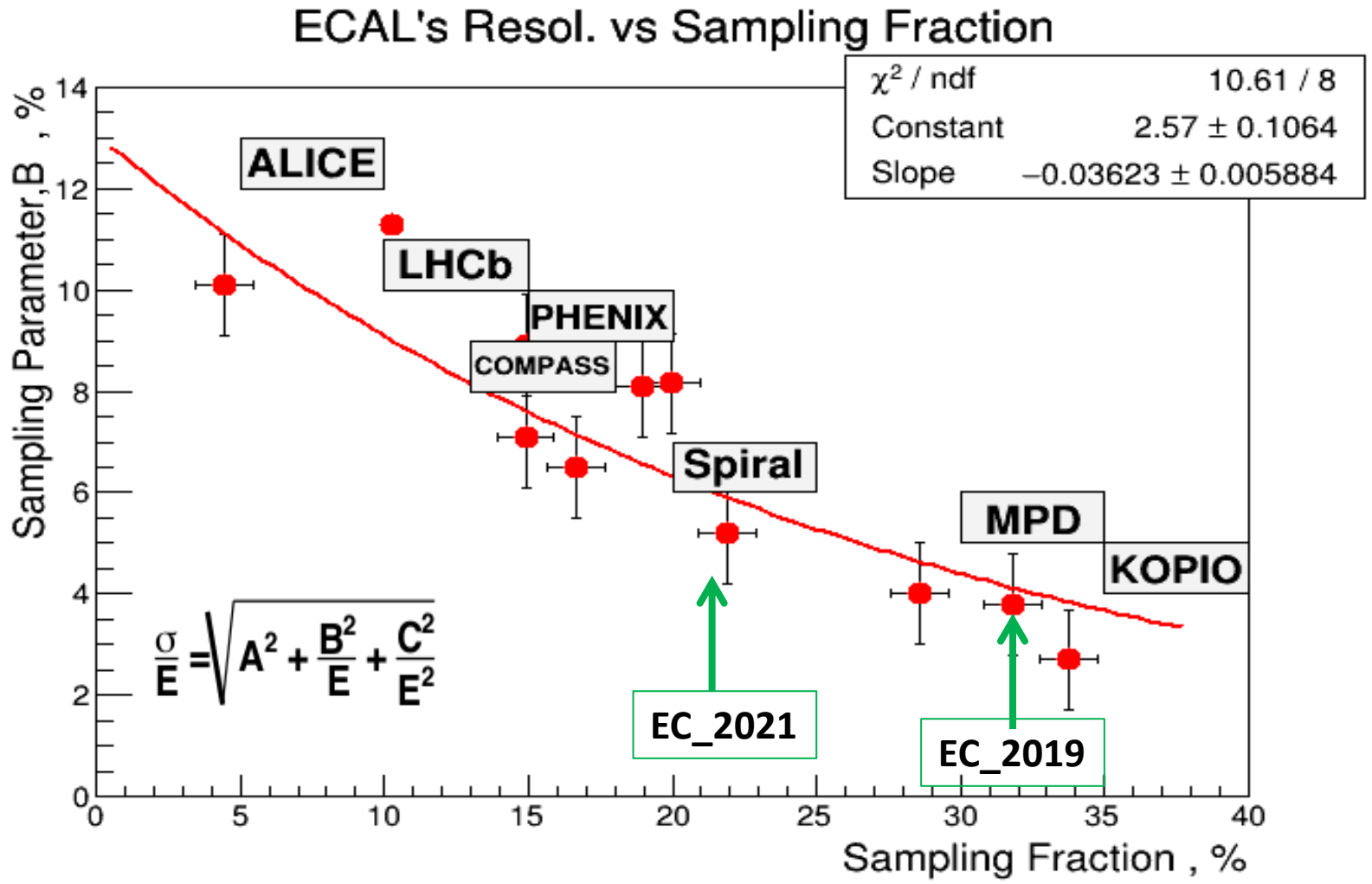

Without temperature compensation



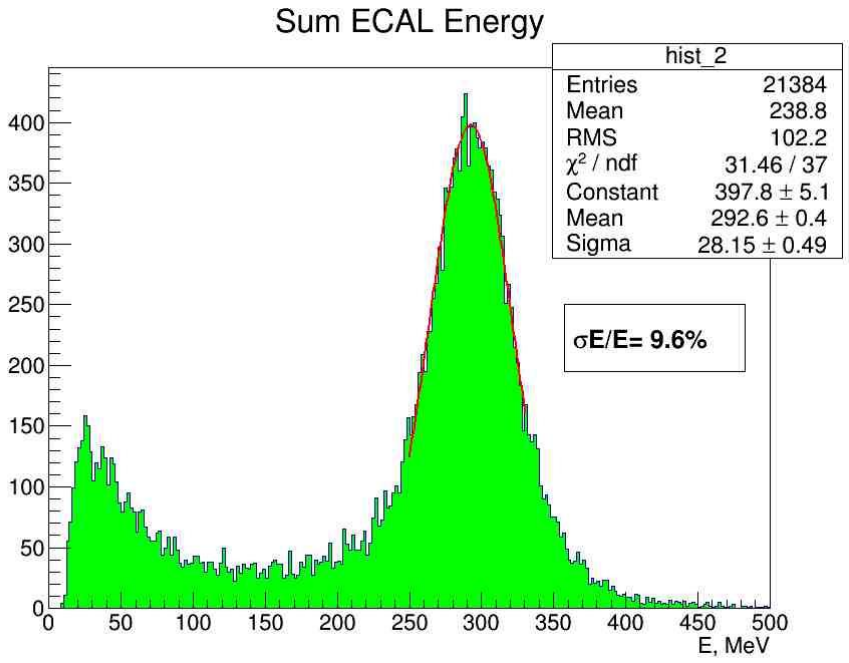

With temperature compensation

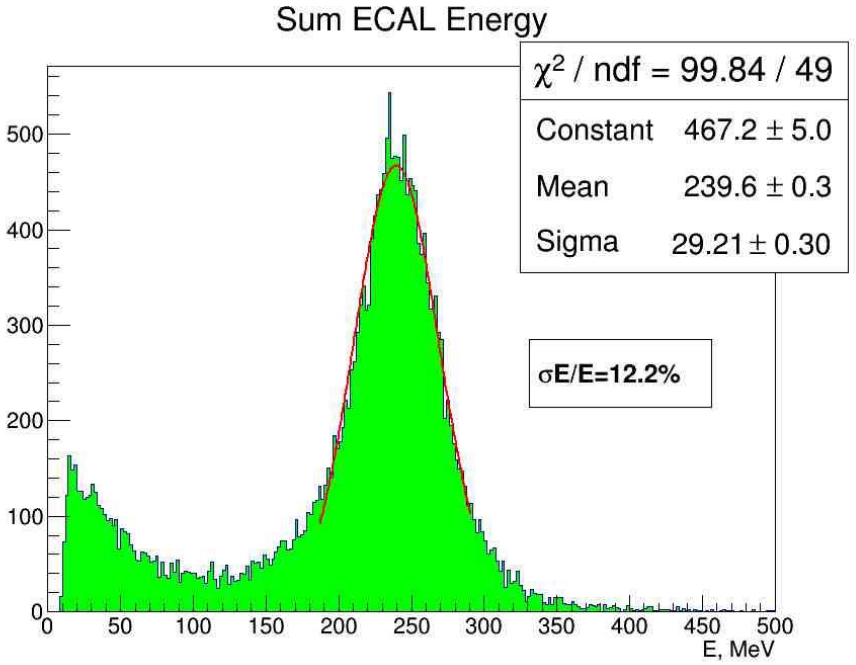
# Modules 2019 vs 2021

# Ecal's sampling resolution in experiments of last 20 years



# Test results for EC-2019 vs 2021




Const=sqrt(0.292)*9.6=5.18%

Const=sqrt(0.239)*12.2=5.96%

The difference of E-resolution vs sapling 0.3 – 0.5 Lead , Layers 22o vs 180:

1. dE/E (%) : 5.18 --------→ 5.9/ sqrt(E)
2. Moliere Radius: R=6.2 ------→ 4.2 cm

# Conclusions

- ECAL for SPD :
  - Total cells Number of 40x40 $mm^2$ =20.480 +9.600 ~ 30.000 (Barrel +2 End Cups)
  - ECAL total weight = 37 + 10 = 47 tons
  - Frame weight ~ 3 tons
- Integration preliminary option proposed:
  - Carbon frame using look like as for MPD
  - EC positon Out of Magnetic Coils
- EC prototype 2019 was tested with cosmic rays
- EC prototype 2021 is under investigation in cosmic rays
- Beam test with electrons **should** be performed during 2021-2022
- **Carbon frame optimization : pfi-gaps orientations ? – to decrease dead Aries;**
- **Magnet Coil : EC vs MC position – open question ?**

# End of Report

Thanks All for attention