Report of the technical coordinator

Alexander Korzenev, JINR LHEP

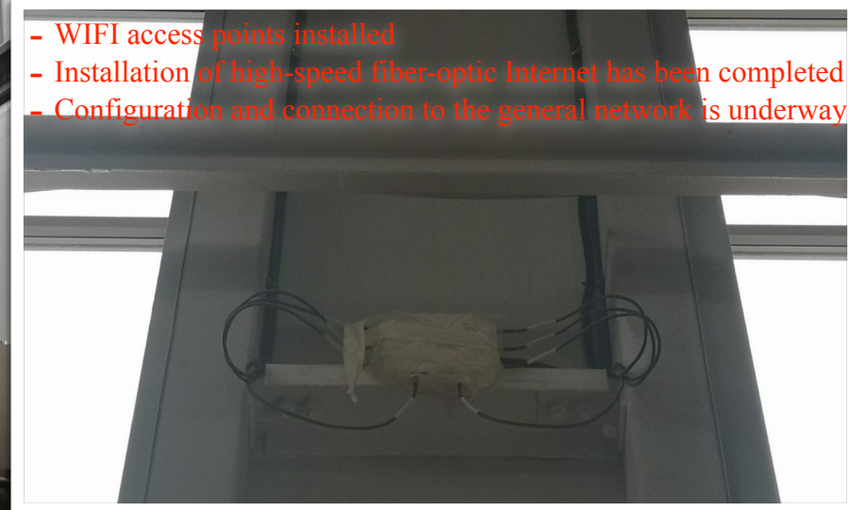
SPD Collaboration Meeting
Samara, Oct 24, 2023

Outline

- Infrastructure
  - Construction work in the SPD hall
  - Installation of bio protection walls
  - Location of DAQ and control rooms
- SC solenoid magnet
- Progress on detectors
  - Range System (RS)
  - EM calorimeter (ECal)
  - Straw Tracker (ST)
  - Time-of-Flight (TOF)
  - Focusing Aerogel RICH (FARICH)
  - MicroMegas (MM)
  - Beam-beam-counter (BBC)
  - Zero Degree Calorimeter (ZDC)
- Conclusion

SPD experimental hall

Installation of climate control equipment has been completed

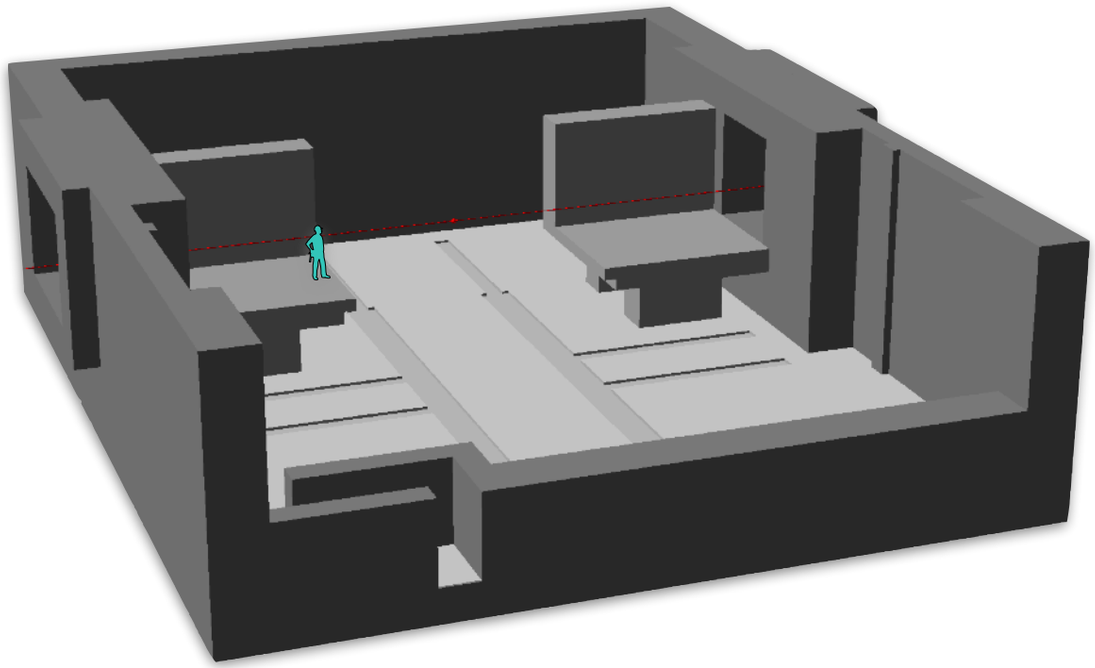


- WIFI access points installed
- Installation of high-speed fiber-optic Internet has been completed
- Configuration and connection to the general network is underway

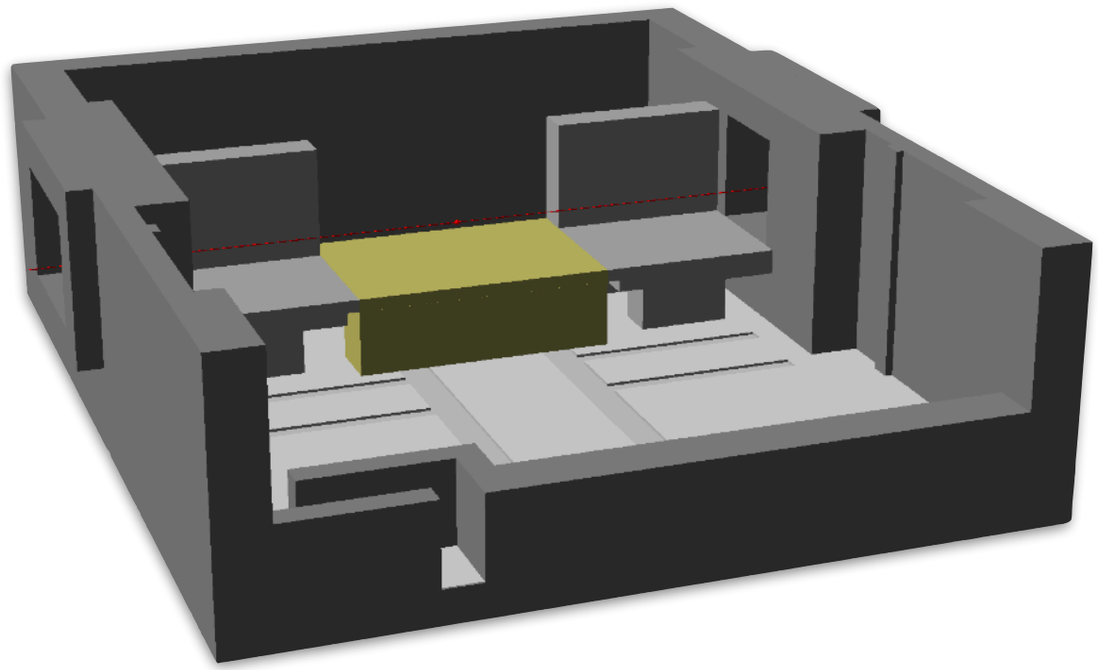
- Electrical panels and sockets have been installed
- Electrical wiring is being laid
- The hall itself is currently used for storing concrete blocks of biological protection and collider elements

Installation of bioprotection in the SPD experimental area

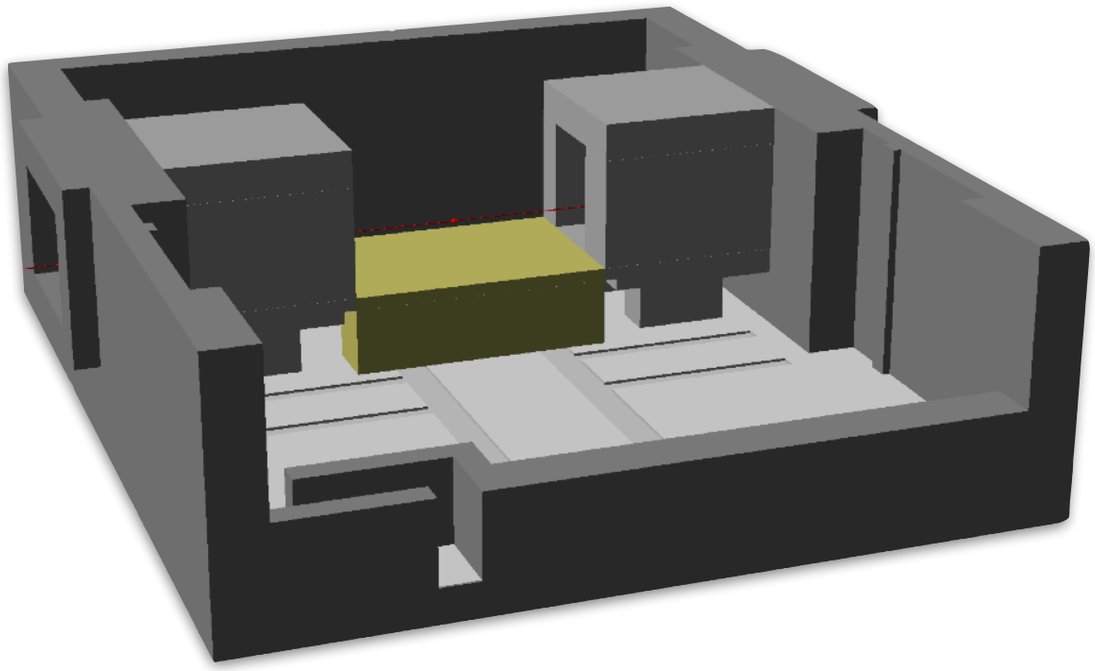
Current state (2023)



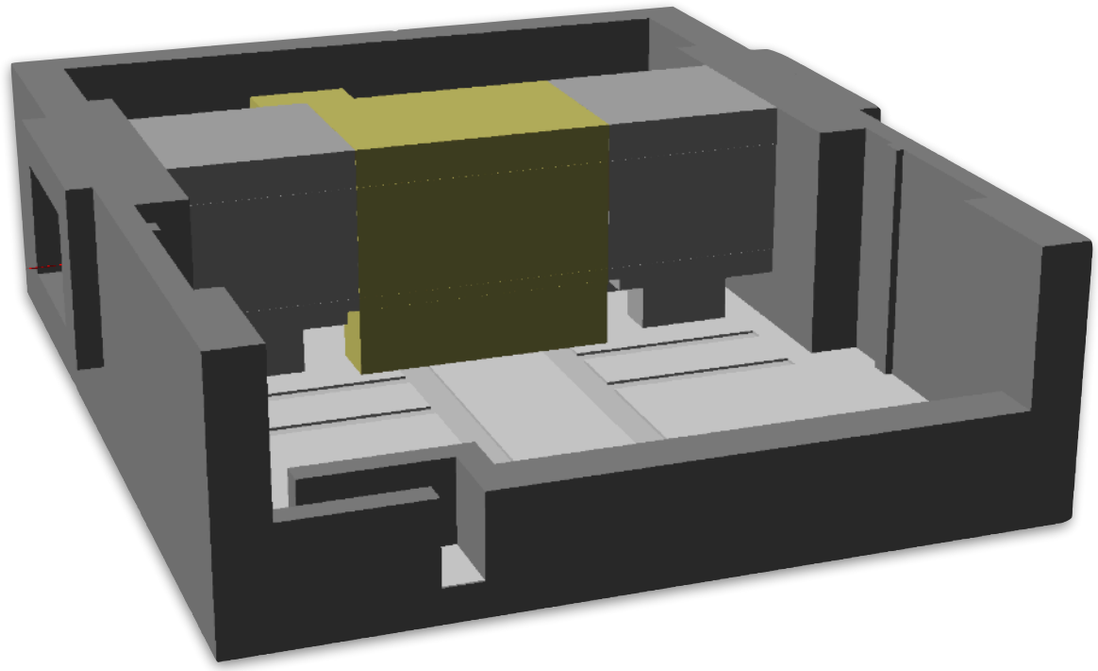
1-st quoter of 2024



Next step in 2024



End of 2024 (till ~2030)

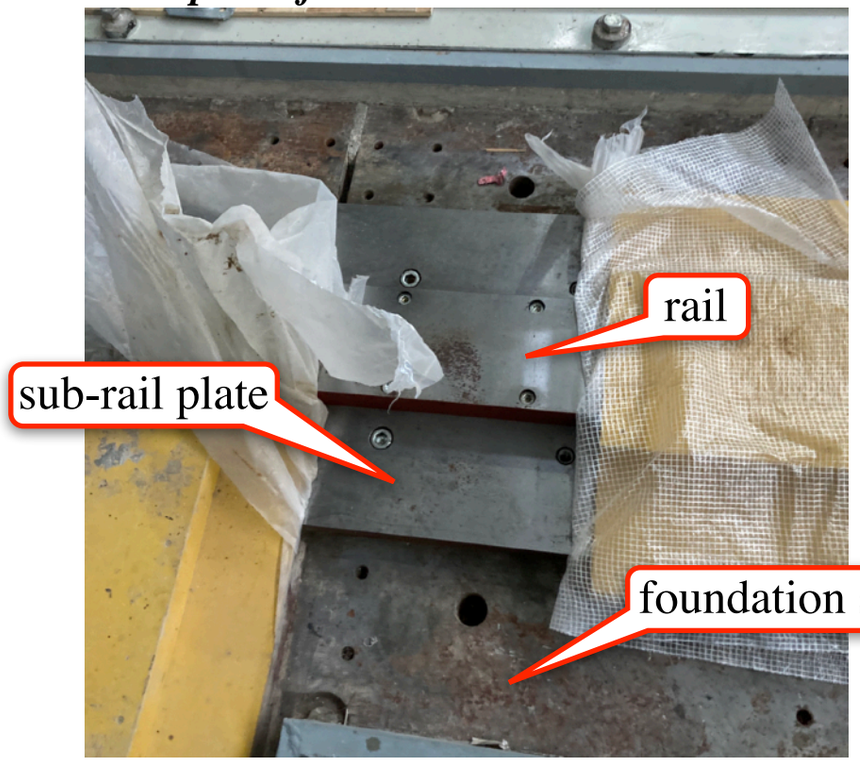


according to a meeting with the accelerator teem in June

Installation of sub-rail plates and rails

- Meeting with the accelerator teem in June -> insisting on installing the concrete bridge ASAP
- Mounting sub-rails and rails will have to be done before installation of bioprotection blocks
- (Sub-)Rail mounting procedure will take ~1 month and will be done by “Pelkom”

photo from MPD hall



Sub-rail plates were delivered in 2022.

Rails and roller skates have been produced. Waiting for delivery.

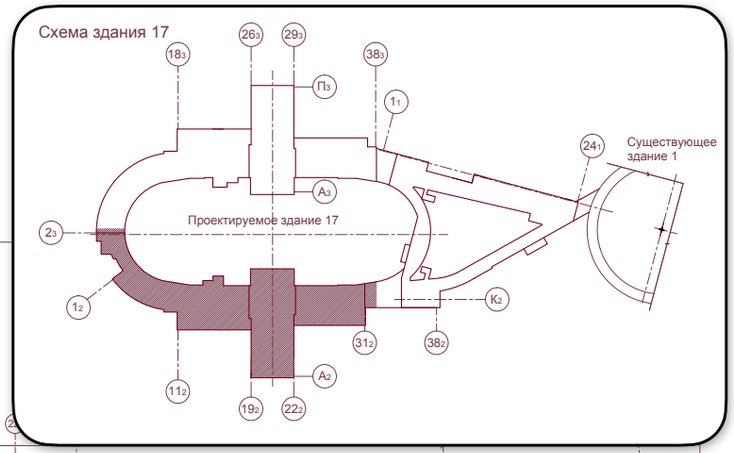
Allocation of DAQ electronics

- Inside the detector itself
- Side and top platforms of detector
- Two rooms for SPD control and DAQ in bld. 17
- Perhaps rooms in the STARABAG building
- Bld. 14 for the online filter farm (or LIT, as an option)

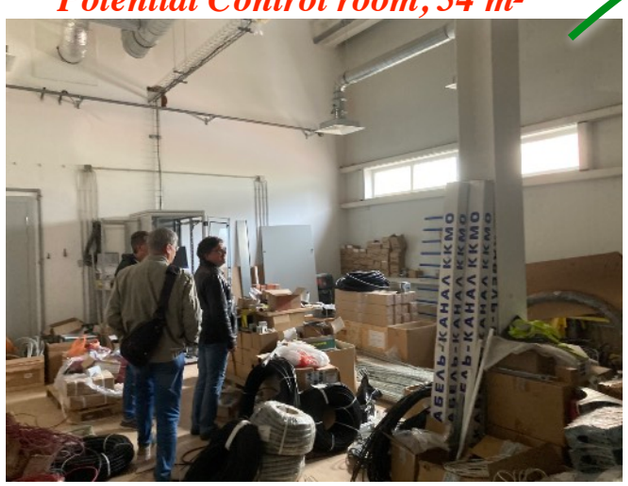
Building 14: for server equipment, data storage and transmission systems (300 kW)

Building of STRABAG

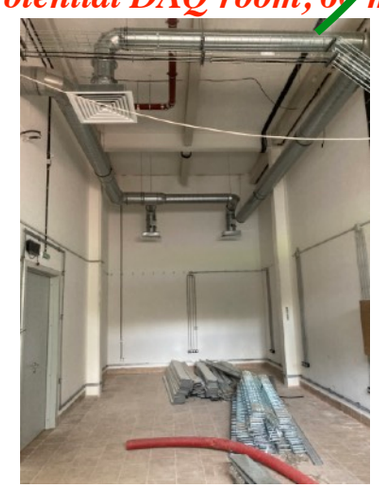
Plan of building 17 from the side of SPD



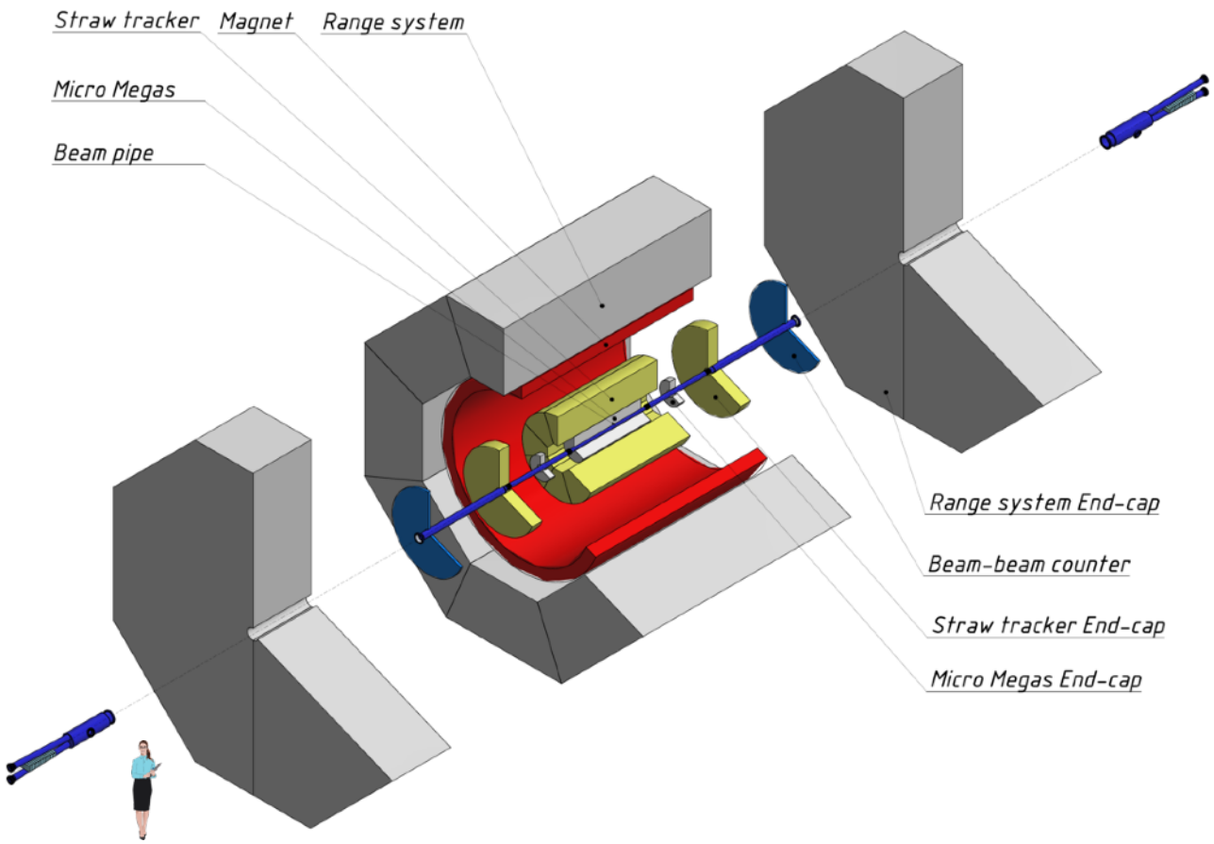
Potential Control room, 54 m²



Potential DAQ room, 60 m²



The territory assigned to SPD

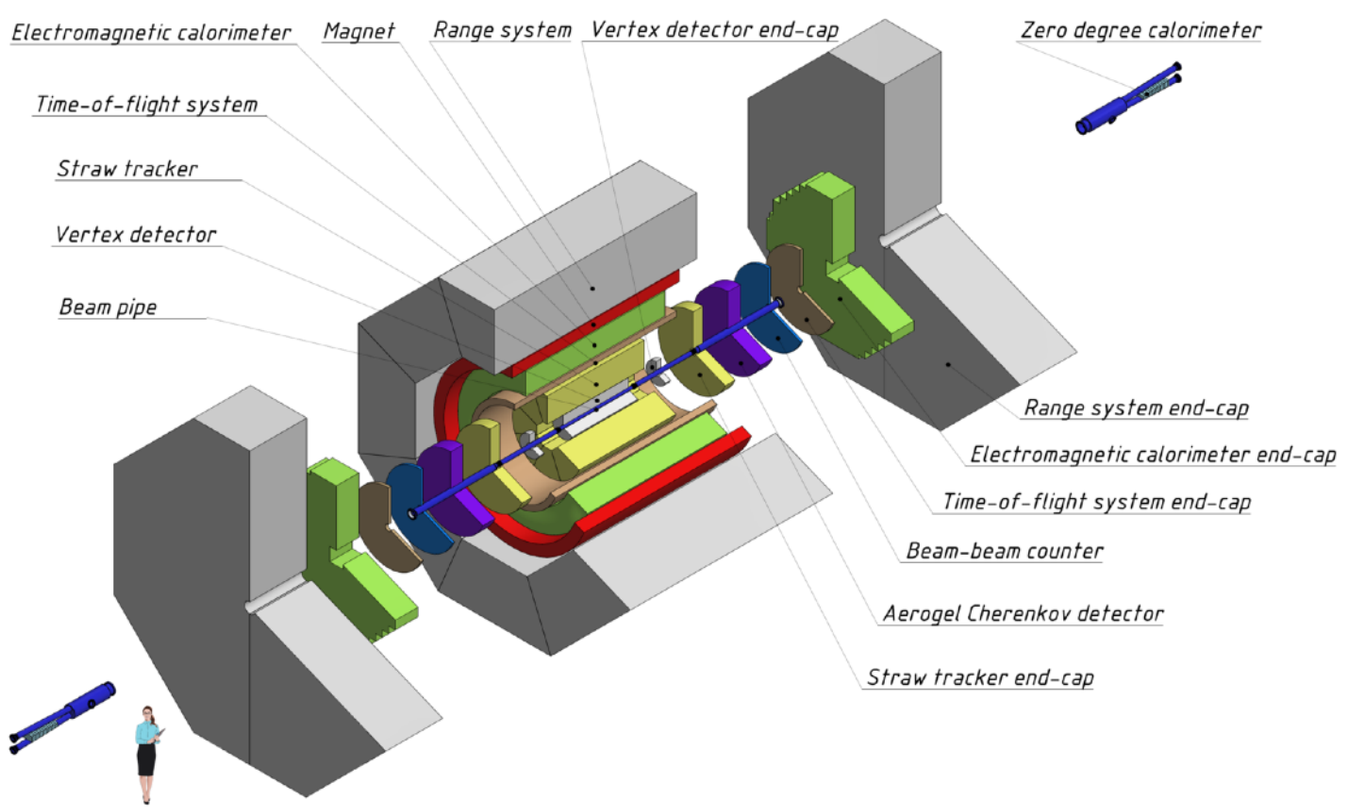


First stage of experiment (2028+)

- Basic set of subsystems
  - Magnet, RS, Straw
  - MM and ECal-endcaps (central)
  - BBC, MCP, ZDC
- No PID detector (TOF, FARICH), no ECal, no SVD
- p-beam: $\sqrt{s} \lesssim 15$ GeV, $\mathcal{L} \lesssim 10^{30}$ s^{-1}cm^{-2}

Fully assembled setup

- p-beam: $\sqrt{s}=27$ GeV, $\mathcal{L}=10^{32}$ s^{-1}cm^{-2} with interaction rate of ~3 MHz



Superconductive solenoid magnet

Control Dewar
The volume of the Dewar tank is enough to cool the magnet offline for about a day without an influx of helium from the outside

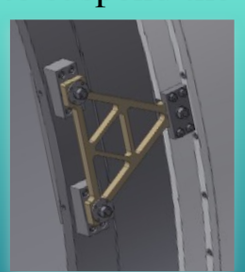
Steel cryostat
Outer diameter 4.01 m
Inner diameter 3.47 m
Thickness 27 cm
Length 4.2 m
Weight 22 tons

Cooling He pipe
welded to the support cylinder

Thermal shield
cooled by gaseous He

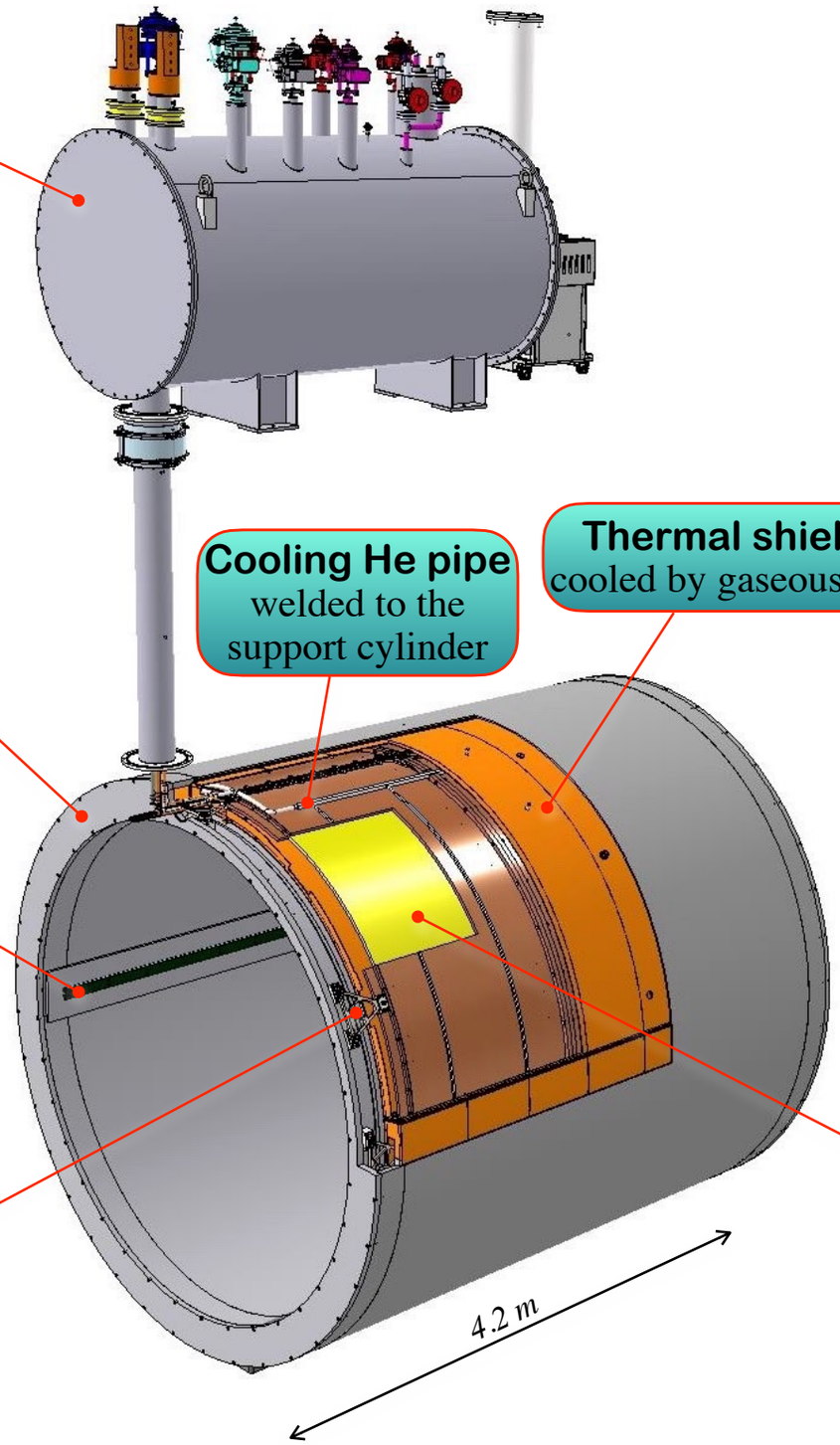
Linear guides used for positioning an electro-magnetic calorimeter

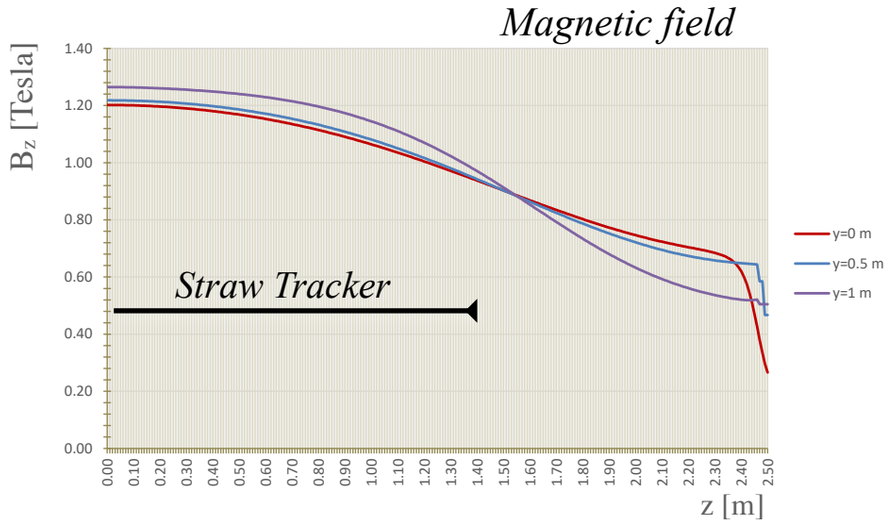
Triangular **supports** are used to suspend the "cold mass".



12 pieces on each side.

Made of fiberglass.





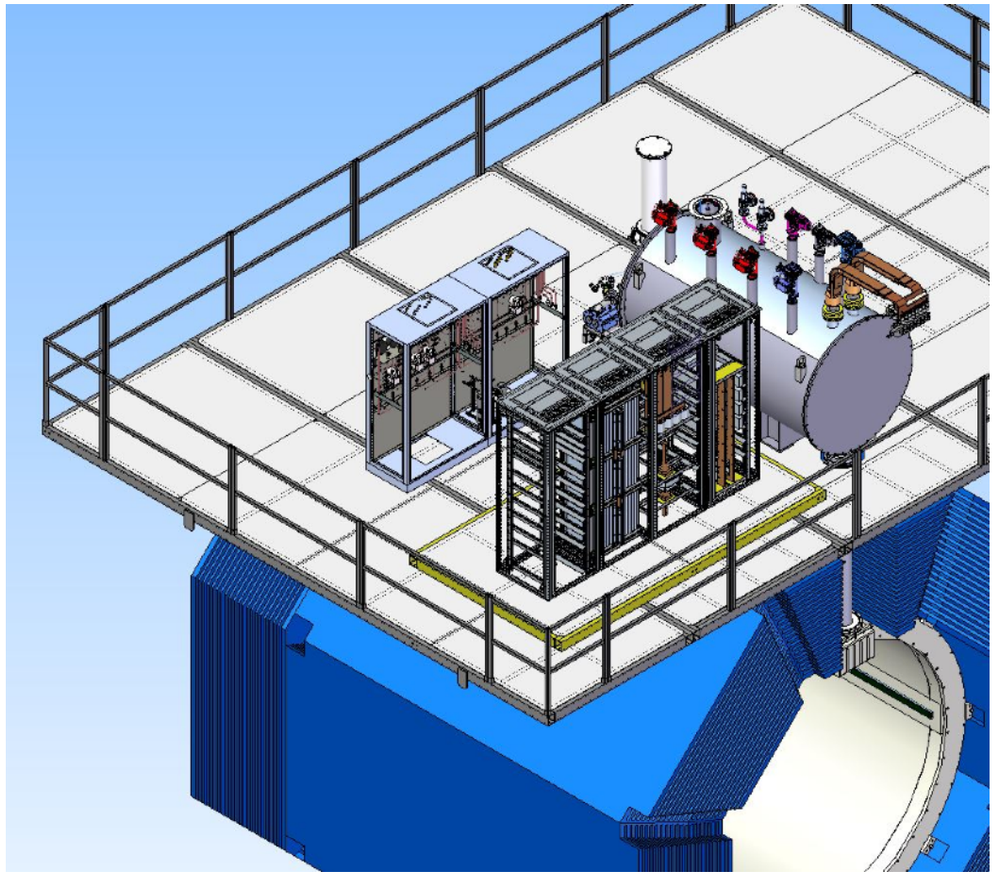
- 1.1 Tesla field with ±9% uniformity within ±1.4 m distance from center (tracking det.)
- Solenoid consists of 3 coils with 750 turns in total (two layer edge-wise winding)
  - central coil with 2×75=150 turns
  - 2 side coils with 2×150=300 turns
- The use of the *thermosyphon method* for cooling the superconducting coils (natural convection of two-phase helium at 4.5K)
- It will be constructed by **BINP Novosibirsk**

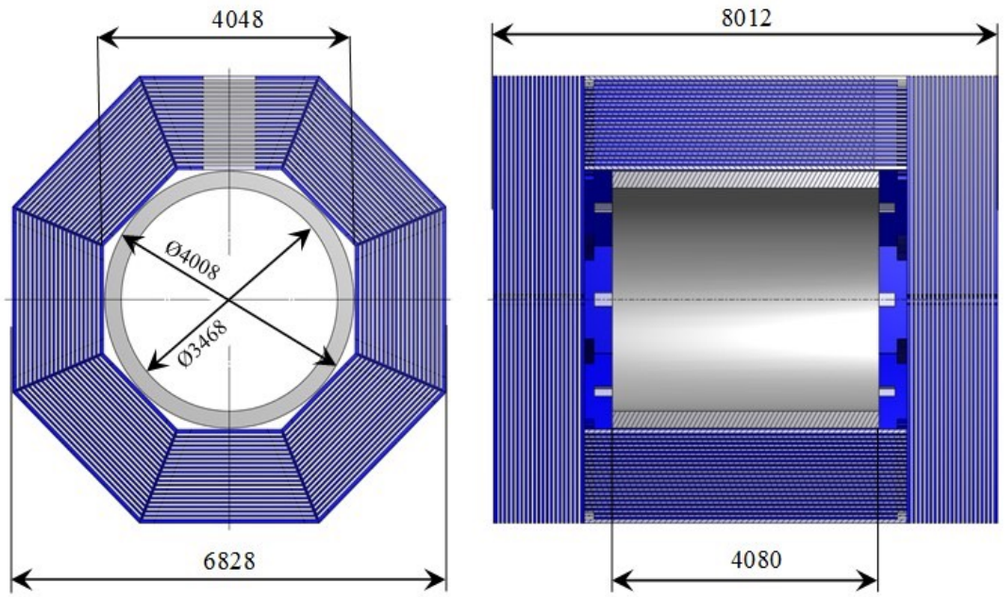
Rutherford-type cable made of 8-strands NbTi/Cu superconductor. The cable will be encased in an aluminum stabilizer using a co-extrusion process that provides a good bond between aluminum and superconductor in order to ensure quench protection during operation.

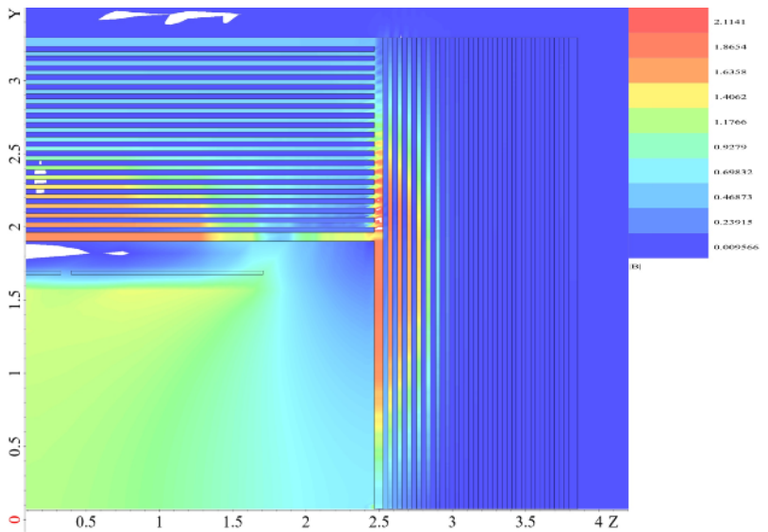
E.Pyata
S.Pivovarov

Progress on development of the SPD solenoid

- The placement of control racks and instrumentation frame on the top platform of the magnet is determined.
- Preparations are underway for production and testing of the Rutherford type cryogenic cable.
- A complete calculation of magnetic fields and forces is being prepared. The results of the calculations will be presented at a seminar at JINR in November 2023.



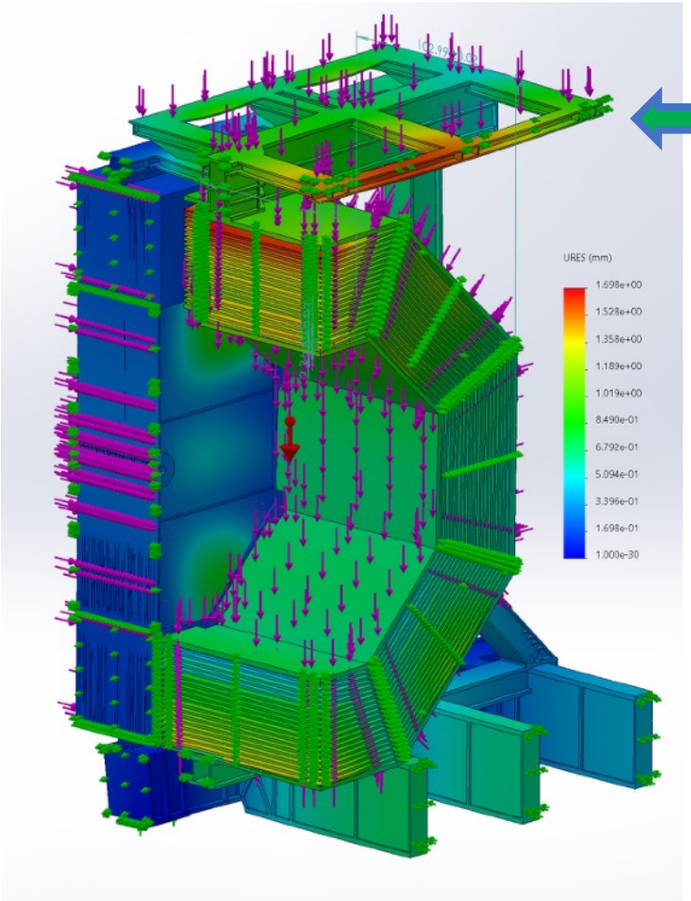




2D calculations of the magnetic field of the basic version of the solenoid with three coils were performed. After their optimization in terms of length and number of turns, 3D calculations were performed taking into account the real geometry of the magnetic coils.

Progress on Range System (RS)

G.Alexeev
A.Samartsev



- Quarter of SPD setup is shown
- Acting forces (gravity and magnetic) are indicated by violet arrows
- Displacements are shown by color: the slot gap is slightly decreased only in one down Barrel module and in few spots in End Caps (~ 1 mm). At present it does not look dangerous

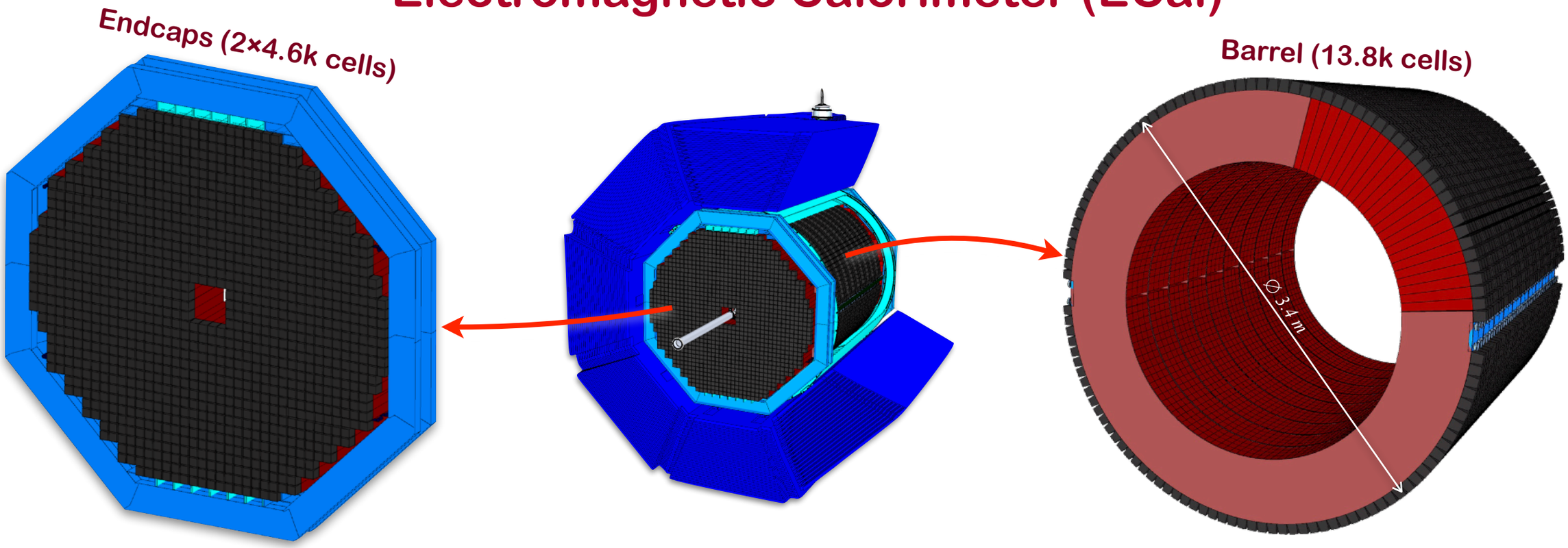
Main result: FEA analysis conducted for combined gravity and magnetic forces applied to the full SPD setup demonstrates no critical zones

Current activities:

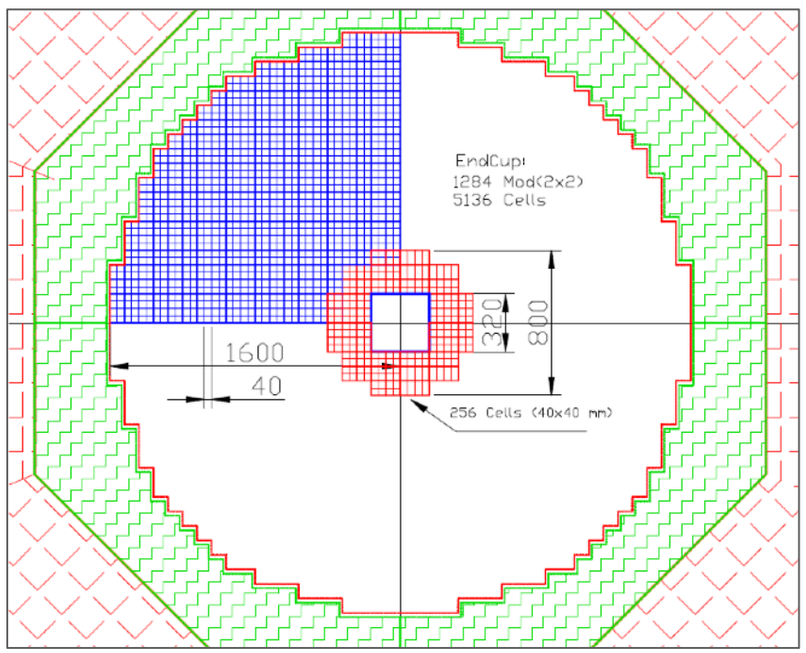
- Testing/tuning a new ”final” digital FDM-192 card (Moscow State University)
- Testing/tuning a DAQ system for the prototype readout (to be used at Nuclotron)
- Development of “local DAQ” for tests of small MDTs assemblies
- Development of the layout for detecting plane analog FEE, cables and power buses
- The contract on amplifier chip (Ampl-8.53) preproduction at INTEGRAL (Minsk) is close to be signed
- The AGRISOVGAS installed new equipment to be used for mass production of the main MDTs element – thin wall aluminum profile
- Development of PID algorithms for pion-to-muon separation

O.Gavrishuk

Electromagnetic Calorimeter (ECal)



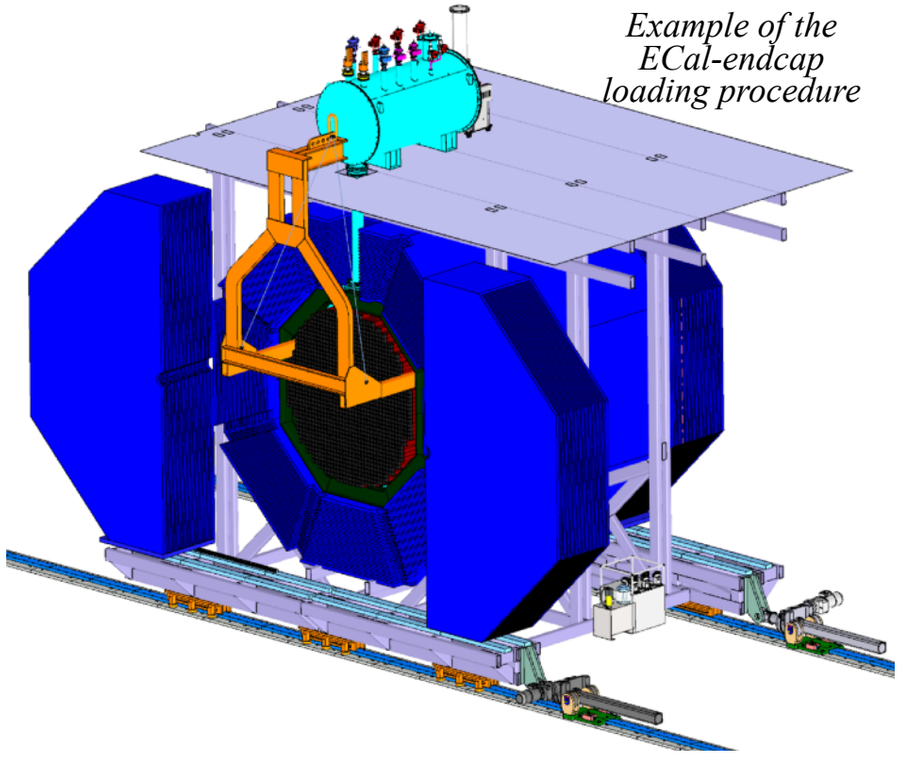
Proposal for the 1-st stage of SPD (256 cells)



This Figure shows in red 64 modules, consisting of 4 cells each. The weight of this assembly is 597 kg. This will require 130 kg of polystyrene, 465 kg of lead, as well as additives: 1.95 kg of P-terphenyl and 65 g. POPOP, and 2000 meters WLS fiber type Y-11.

It is 1/20 part of End Cup and taken time of 36 Days to prepared 51200 stintilator plates.

To read this setup, we need four ADC64 - 64-channel amplitude encoders, as well as 16 boards of 16-channel amplifiers and bias voltage regulators.



Example of the ECal-endcap loading procedure

O.Gavrishuk

Setup of 4 modules

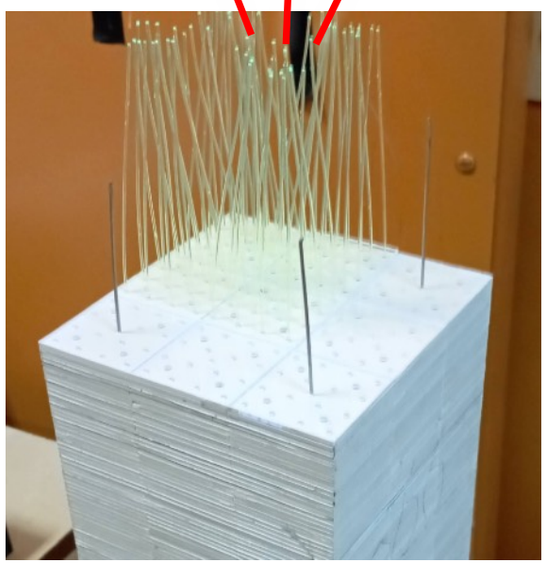
- Each module consist of 9 cells of 4x4 cm²
- All 36 cells were fully tested

Cell assembled of:

- 1.5 mm Scintillator
- 0.3 mm Lead
- 200 layers

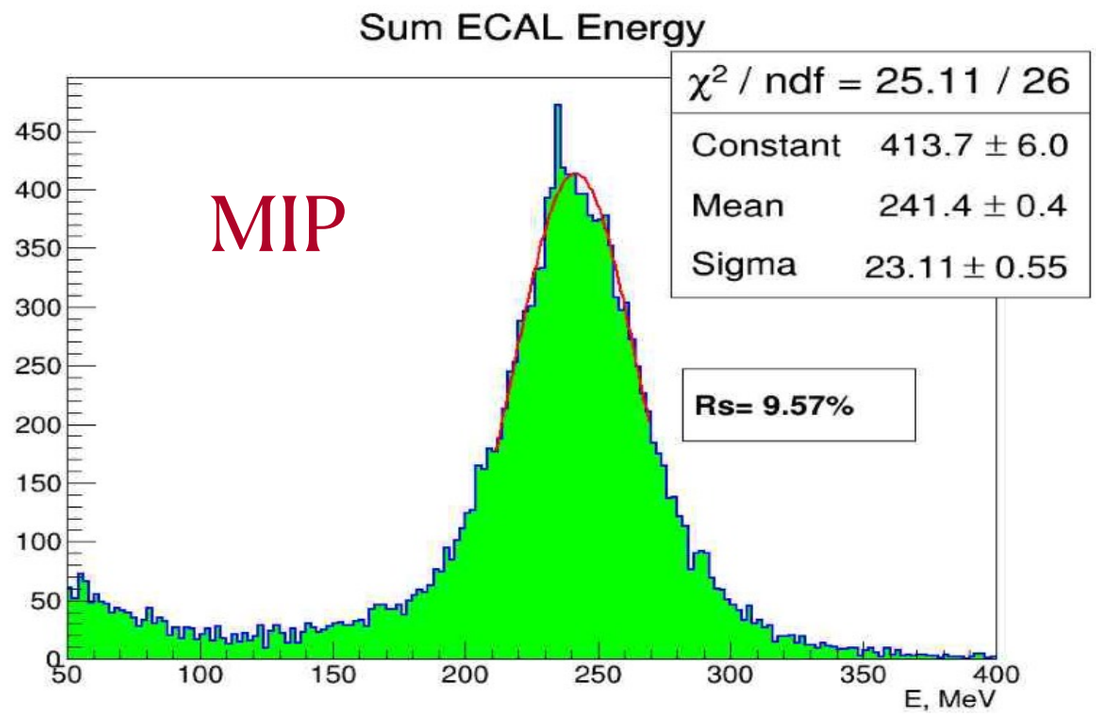
Scintillator composition:

- Polysterene
- 1.5% Paterphenyle
- 0.04% POPOP

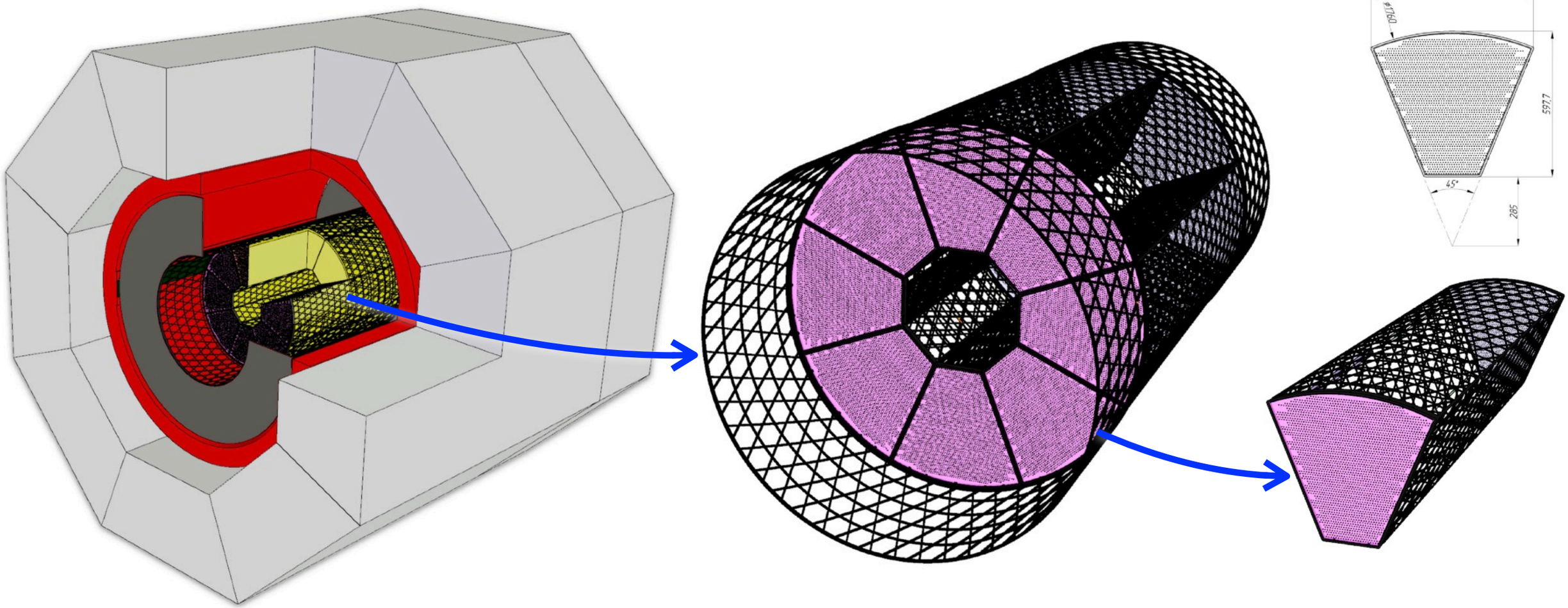


Test results with cosmic particles

- Light detection by new NDL SiPm Series EQR15 (intrinsic epitaxial layer as a quenching resistor (EQR))
- For now, old modules with a cross section of 4×4 cm², left over from MPD production, are being used
- A matrix form for new scintillator production (40×40×1.5 mm³) was ordered. A 4-set mold will produce 4 scintillator plate per minute.
- The relative energy resolution for MIP: dE/E=9.6% which corresponds to 240 MeV of electron signal and consistent with MC prediction
  - Spectra of all 36 cells were tested and give consistent results.



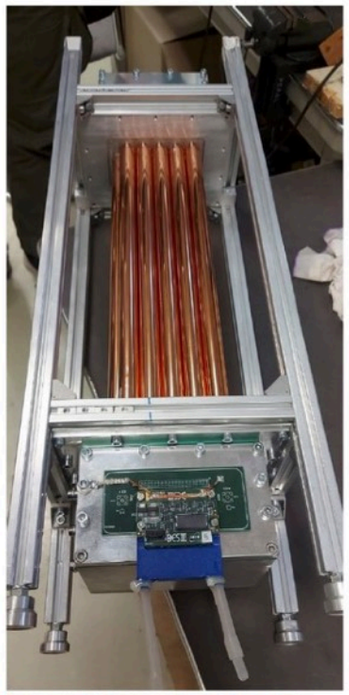
Power frame for the Straw-barrel

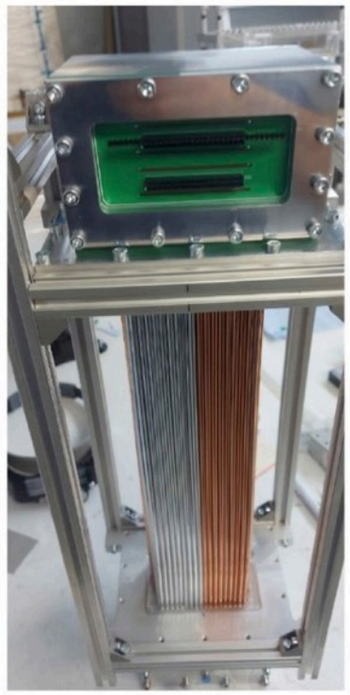


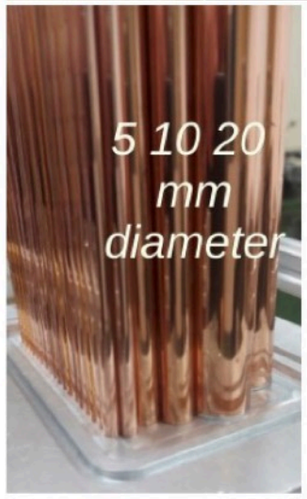
- Contract for the preparation of the conceptual design of the power frame was signed with CRISM earlier this year
- Engineers of CRISM were in charge for the development and production of the ECal power frame in MPD

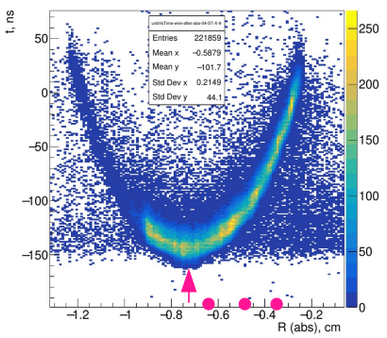
- The frame will be made of carbon fiber composite material UMT49-12K-EP (Rosatom)
- A preliminary design, which takes into account all the tolerances imposed by the Technical Assignment, was presented in April
- A request was submitted to expand the frame to allocate space for all end cap detectors.

Straw prototyping activity & test-beams in CERN









Combined prototype

E.Kuznetsova, Sep 28

Straw and wire diameters:

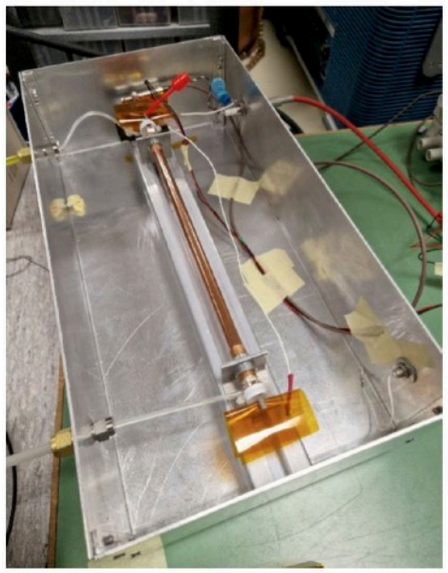
20mm / 30um : SHiP type

10mm / 30um : SPD type

5mm / 20um :

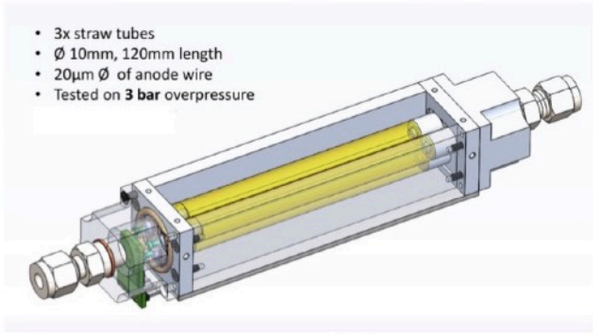
NA62 upgrade (Cu/Au coating)

DUNE (Al metallisation)



- Dedicated small size prototype for testbeam measurements and alignment control studies
- Good for x-check with existing measurements (NA62, SHiP)
- Tests of x-talks, impedance measurements etc
- Lessons learned
  - Calibration/termination connector from opposite side
  - ….

Various single straw or small assembly setups



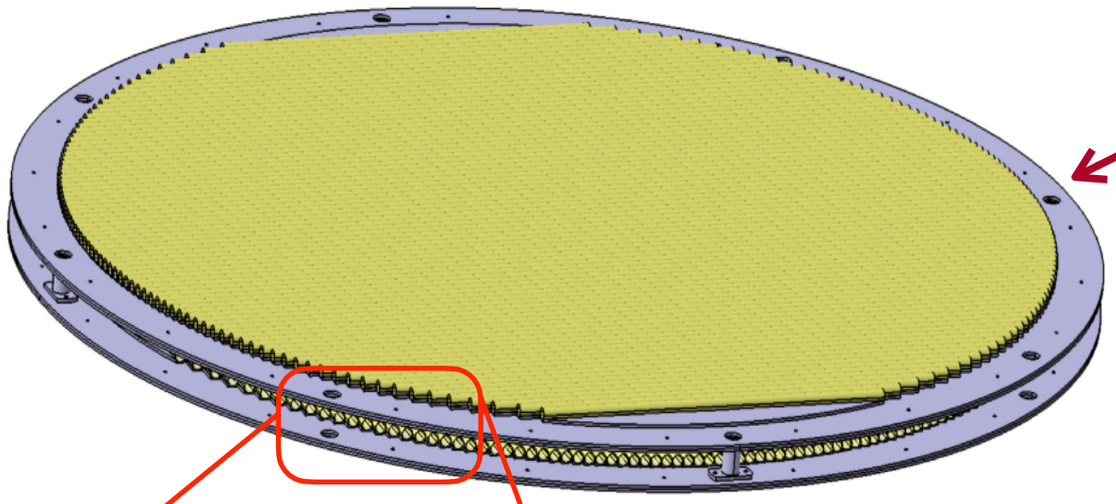
Laboratory tests with sources:

- Gas gain measurements
- Tests with different custom readout
- Tests with different gas mixtures

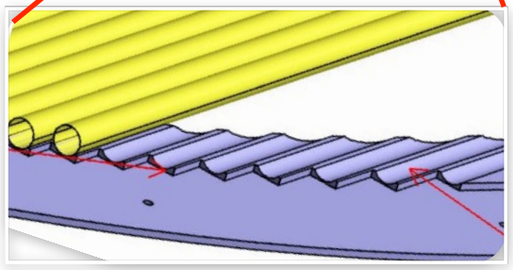
	VMM3	TIGER
Number of channels	64	64
Clock frequency	10…80 MHz	160…200 MHz
Input capacitance	<300 pF	<100 pF
Dynamic range	Linearity within ±2% up to 2 pC	50 fC
Gain	0.5, 1, 3, 6, 9, 12, 16 mV/fC	12 mV/fC
ENC (energy branch)	<3000	<1500
TDC binning	~1 ns	50 ps
Maximum event rate	140 kHz/ch	60 kHz/ch
Consumption	15 mW/ch	12 mW/ch

Progress on Straw-endcap

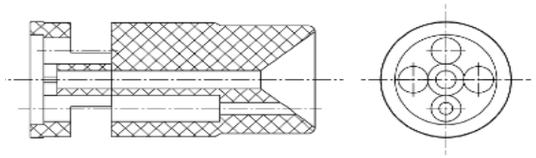
G.Kekelidze
V.Kramorenko

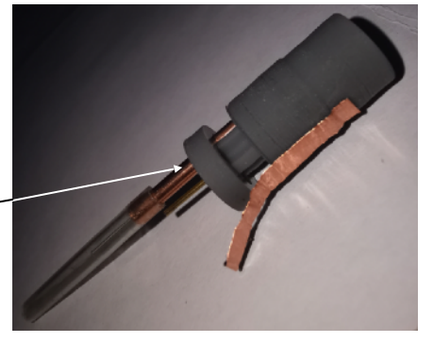


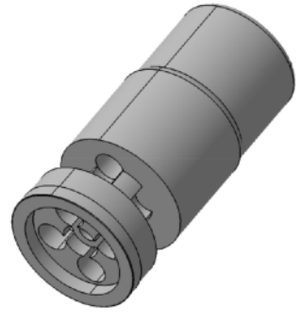
Prototype of ∅=1m with two layers of tubes rotated 90 degrees relative to each other



End-plugs for ∅=9.54 mm tubes were designed and a 400 of them were manufactured using a 3D printer







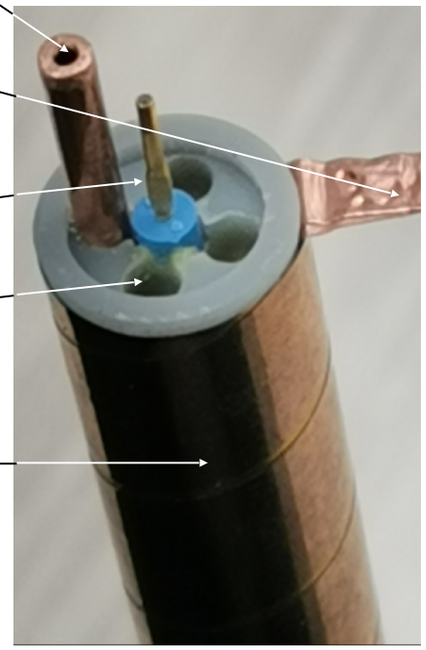
Gas inlet 2mm tube

GRD connector

Pin

Hole for sealant

Straw tube

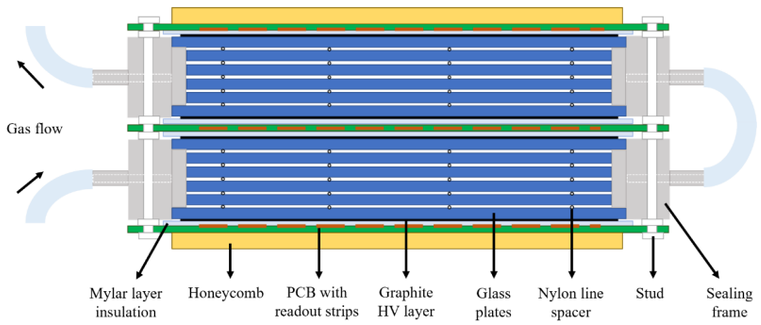


- The purpose of making the prototype is to test the assembly technology (stretching straws before gluing them to the frame)
- Aluminum sheets were purchased in the spring. The frame is being manufactured in LHEP workshop
- Tubes of the required diameter have been manufactured
- The issue of electronics remains open

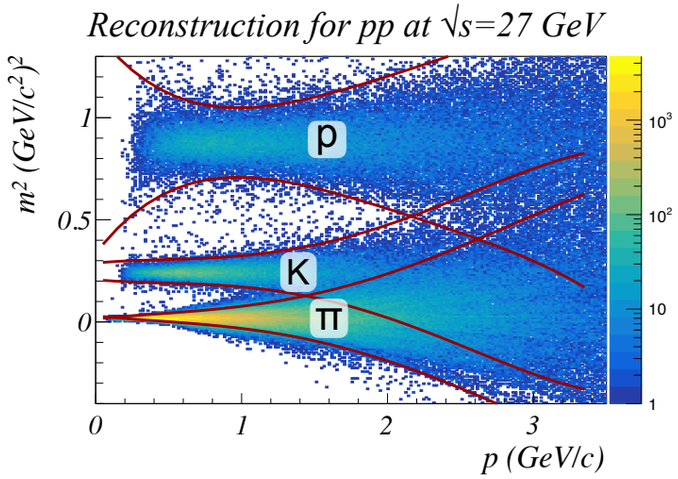
Time-of-flight (TOF) detector

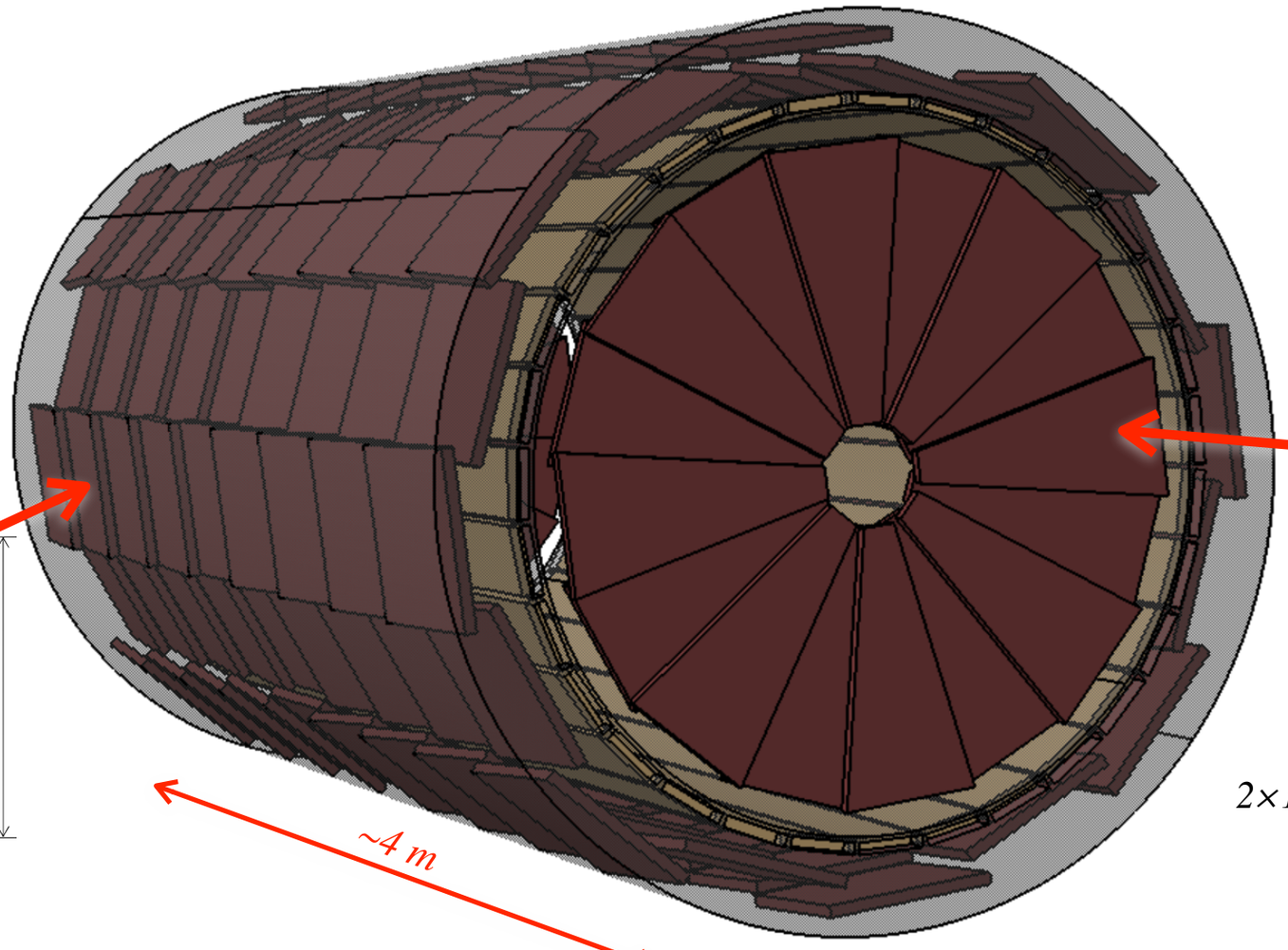
Schematic view of sealed MRPC

(B.Wang et al, JINST 15 (2020) 08, C08022)



- Purpose: π/K/p discrimination for momenta ≲2 GeV, determination of t_0.
- Time resolution requirement <60 ps.
- Sealed Multigap Resistive Plate Chambers (MRPC) are the base option.
- Eco-friendly gas is under discussion HFO-1234ze ($C_3H_2F_4$) 4-th generation.
- Number of readout channels is ~12.2k

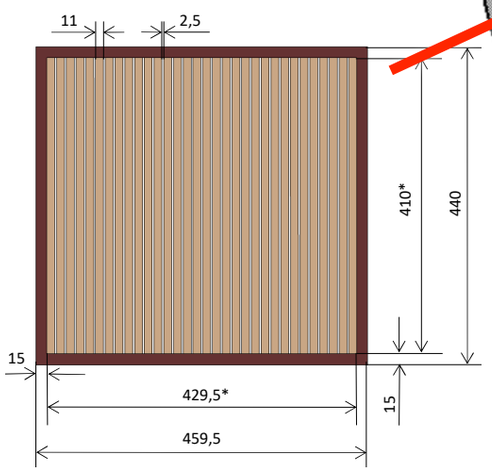




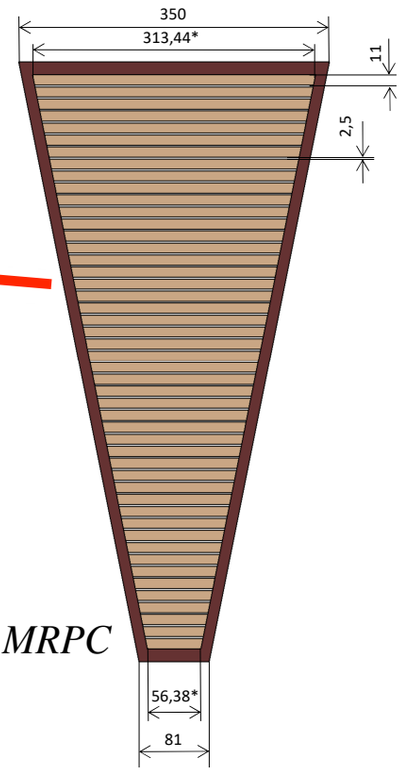
TOF Chambers for Barrel
(overlap in 2 dimensions)

16×9=144 MRPC

TOF Chamder
32 strips



TOF Chambers for Endcap
48 strips



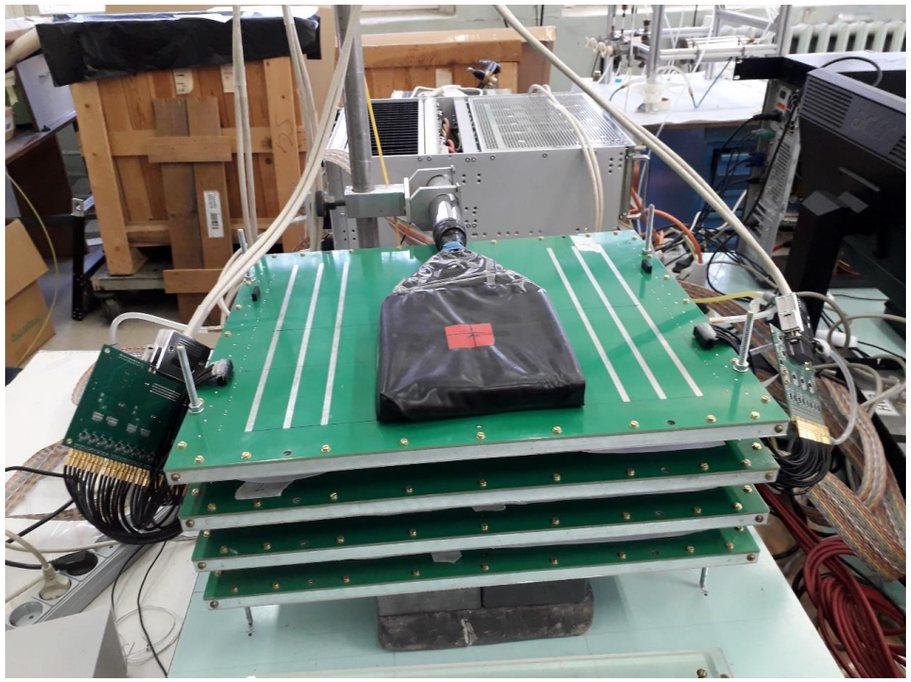
2×16=32 MRPC

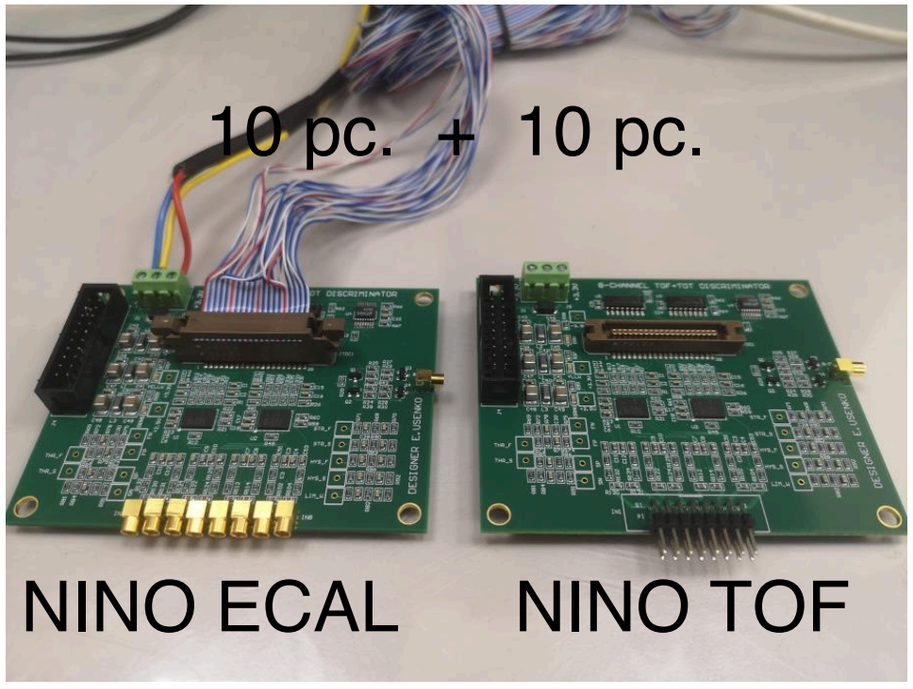
See talk of V.Chmill

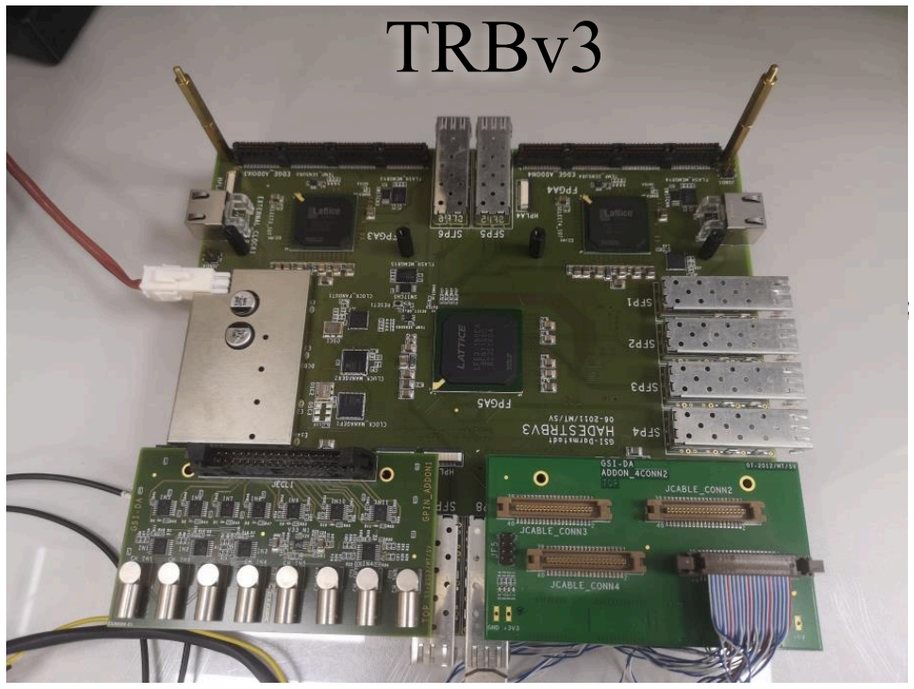
MRPC activity for TOF in JINR

- Three MRPC chambers were produced and tested in Protvino in 2021. They are waiting for electronics to be tested in JINR.
- 20 FEE cards based on NINO (10 for ECal + 10 for MRPC) were designed and produced by E.Usenko
- Digitization and control by TRBv3
- The MPD teem (V.Babkin) agreed to provide their test facility (gas, HV, cosmic trigger) for us
  - Plans for tests after the Samara meeting

MRPCs in Protvino

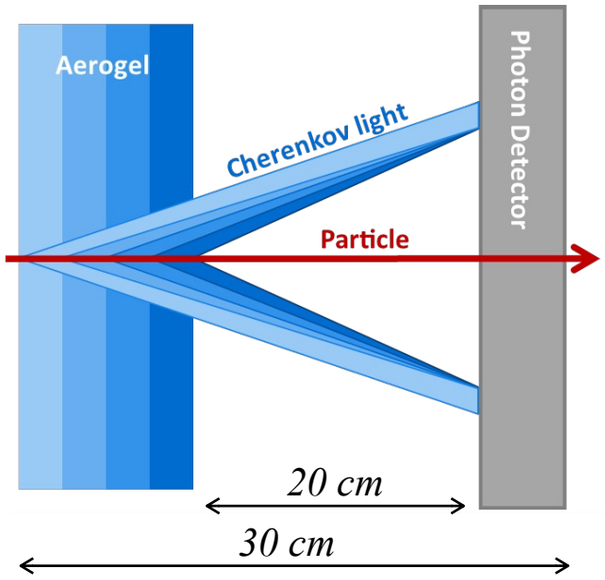




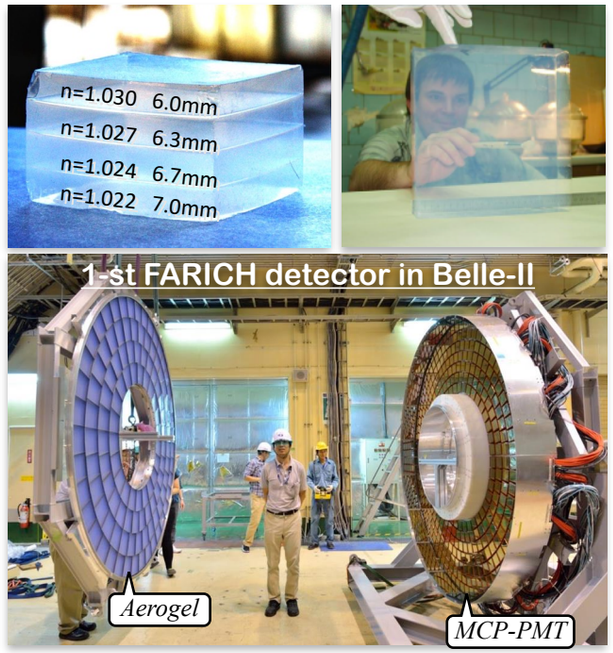


Focusing Aerogel RICH (FARICH) detector

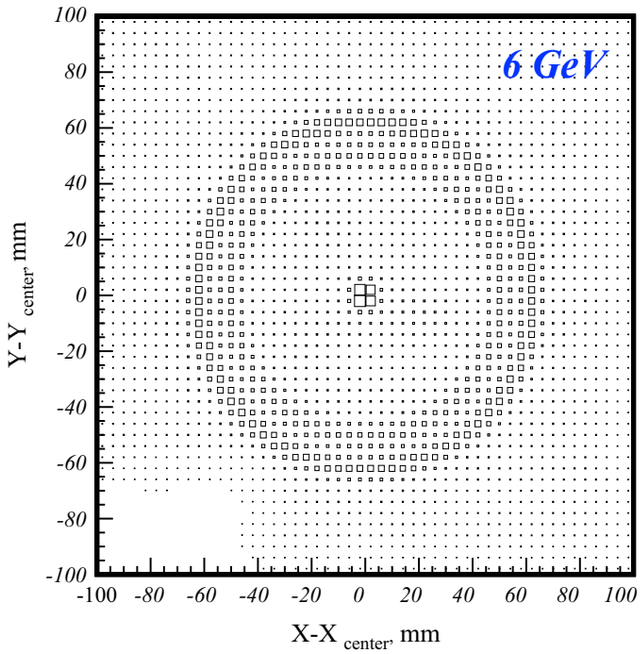
Principle of detector operation



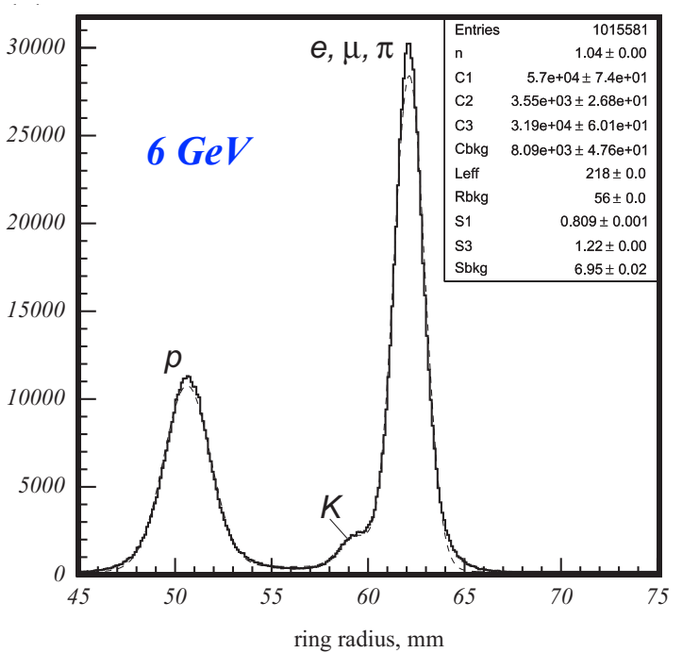
- Purpose: identification of high momentum particles ($p \gtrsim 1.5$ GeV) which cannot be discriminated by TOF
- Requirement: π/K separation at 6 GeV/c up to 3.5σ
- Disk-shaped detector in endcap with an area of 2 m^2
- Multilayer focusing aerogel radiator produced in BINP
- Development of Multi-anode MCP-PMT is ongoing in Russia (so far PMT of Hamamatsu, Photonis, Photek)
- The FARICH concept was published in 2005
- It was realized as a detector in Belle-II (KEK) in 2017



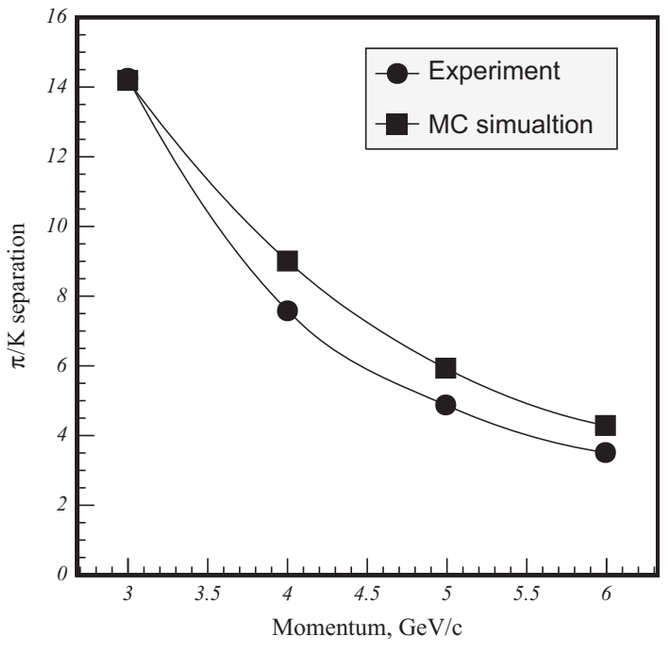
Accumulated *xy* distribution of hits



Ring radius distribution of γ



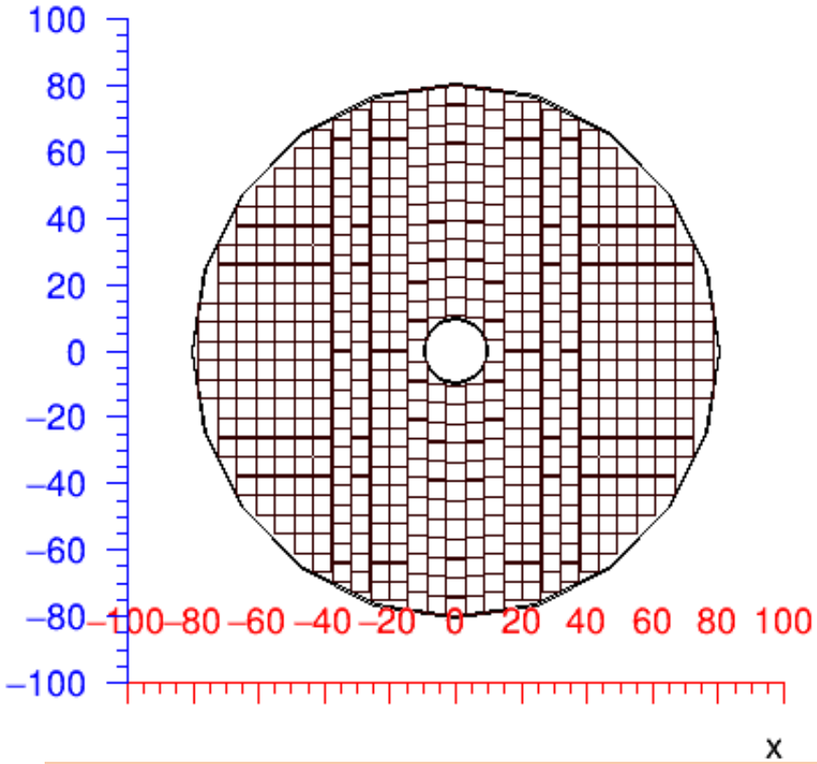
Ability to distinguish between π and K

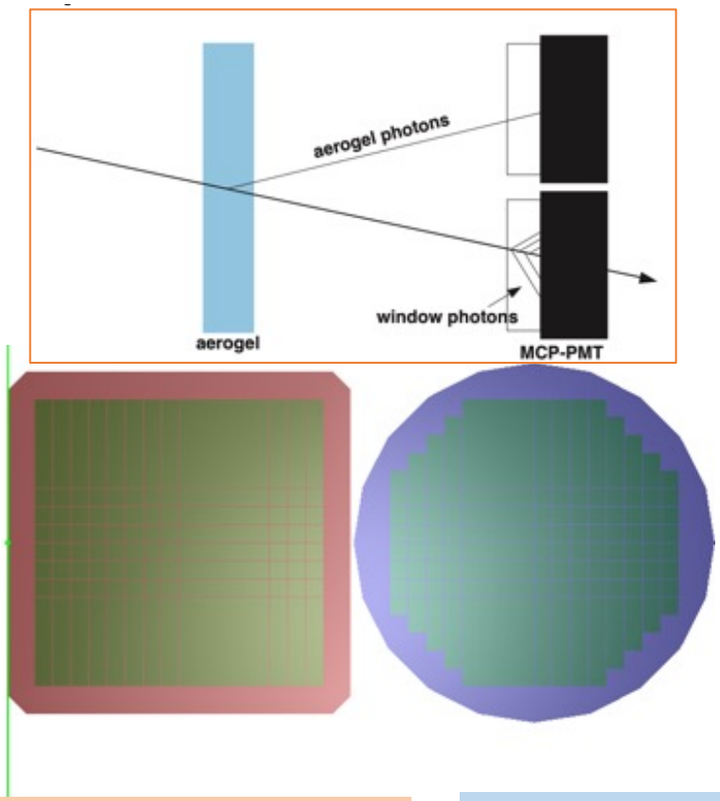


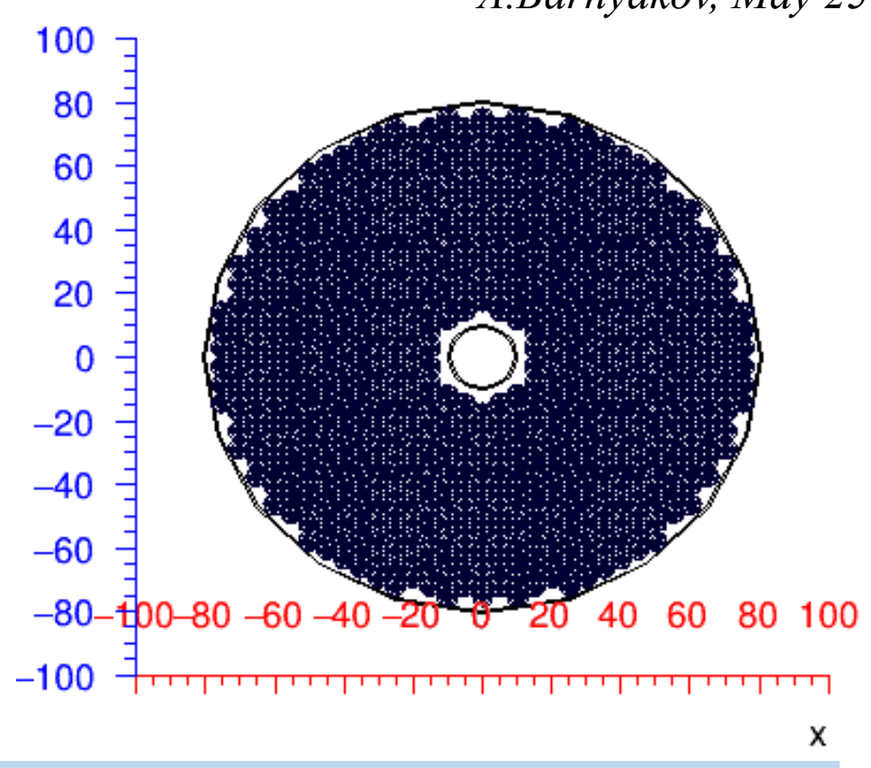
A.Barnyakov et al, NIMA732(2013)352

Round vs Square MCP-PMT for the FARICH

A.Barnyakov, May 25







548 PMTs ■58x58 mm (PC ■ 50x50 мм) –>

$$Eff = \frac{548 \cdot 5{\times}5}{S_{endcap}} = \frac{13700\ cm^2}{19792\ cm^2} \approx 0.69$$

16x16=256 pixels 2.9x2.9 mm

$$Eff = \frac{548 \cdot 256 \cdot 0.29{\times}0.29}{S_{endcap}} = \frac{11798\ cm^2}{19792\ cm^2} \approx 0.596$$

630 PMTs Ø58 mm (PC Ø50 mm) –>

$$Eff = \frac{630 \cdot \pi \cdot 2.5^2}{S_{endcap}} = \frac{12370\ cm^2}{19792\ cm^2} \approx 0.625$$

216 pixels 2.9x2.9 мм

$$Eff = \frac{630 \cdot 216 \cdot 0.29{\times}0.29}{S_{endcap}} = \frac{11444\ cm^2}{19792\ cm^2} \approx 0.58$$

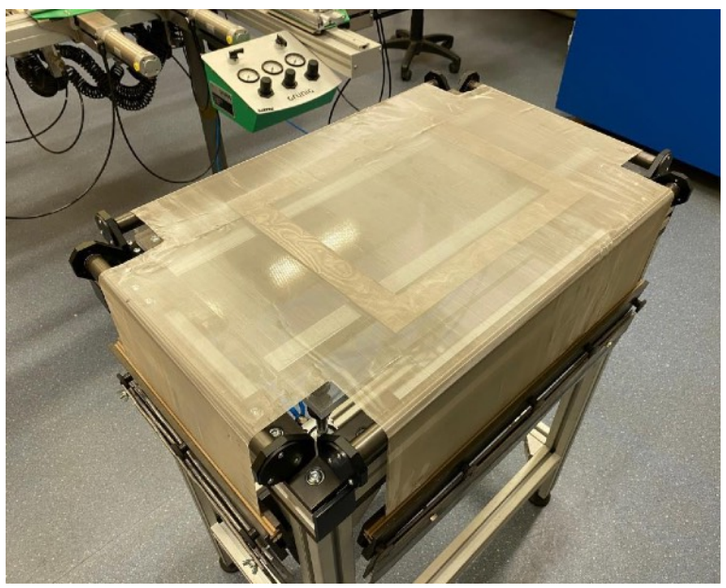
- The BINP group officially joined the SPD collaboration.
- For FARICH proposal see talk of A.Barnyakov on Tuesday.
- Start of implementation of FARICH in the SPDROOT software. See talk of A.Ivanov on Wednesday (+DIRC).

Progress on MicroMegas central tracker

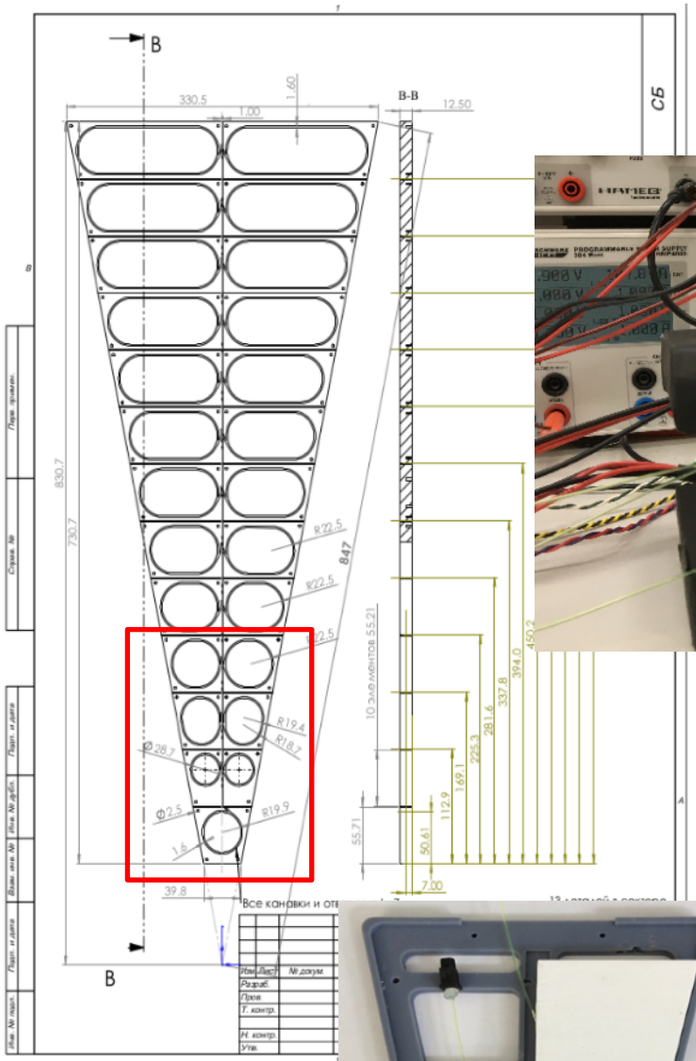
- Our Minsk colleagues can now produce DLC (diamond-like carbon) coating with resistance value within our specification. 1st batch of readout boards for new R&D programs is delivered to Dubna.

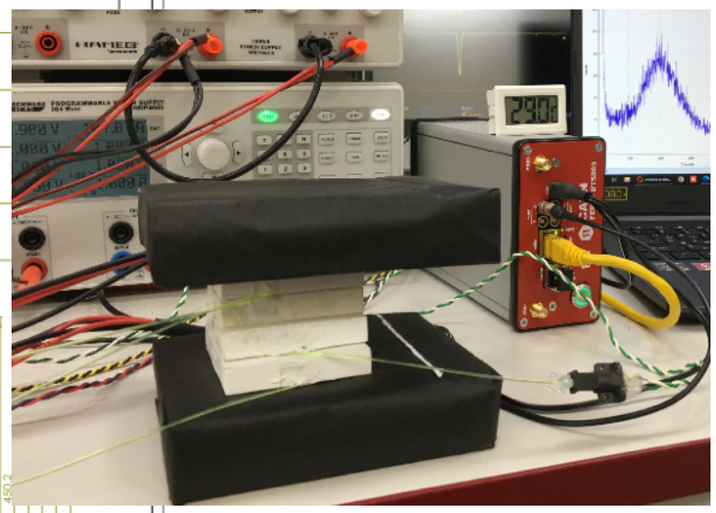
- Two new test program started:
  - DLC degradation due to discharge. 2 special chamber (planar) are assembled, test is started
  - Strip pitch and resistance optimization. 4 Boards for new chamber are produced. Each board have sensitive zones with 450μ and 600μ pitch, DLC resistance vary 0.7 to 15 MOhm. All components for chambers are available, assembling is in progress.

- New mesh tension machine for cylindrical chambers is produced. Turning & test now in progress. All components for 1st bended prototype are ready, we hope to build it this year



Tile height 55.7 mm
25 tiles in sector (similar to STAR EPD)





Progress on Beam-Beam-Counter (BBC)

The BBC prototype options:

➢**CAEN FERS-5200 readout system**

➢scintillator prototype tiles (thickness 10 mm)

• Tyvek covered vs **chemical mating**

➢scintillation optical fibers (WLS and clear)

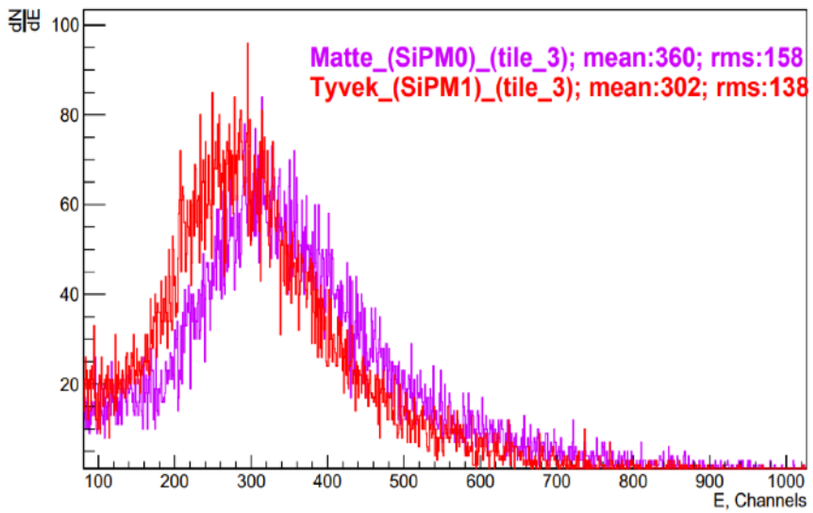
•KURARAY vs Saint-Gobain Crystals

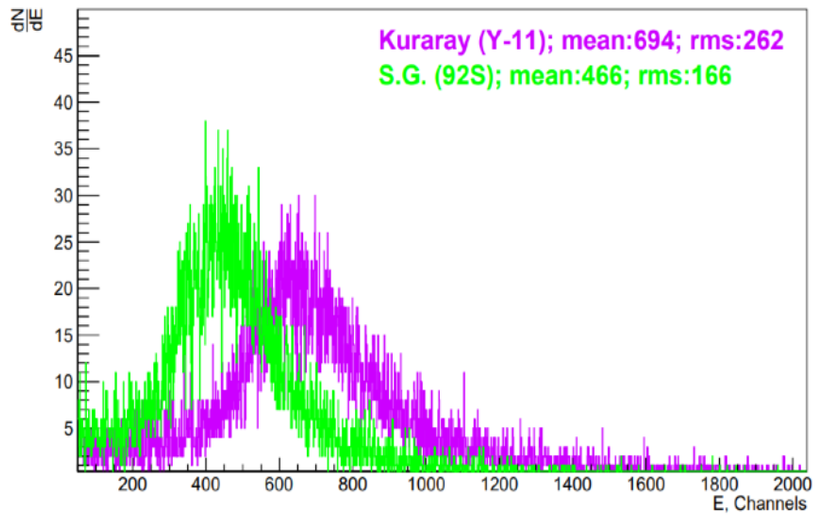
➢optical cement

•CKTN Med vs OK-72

➢SENSL SiPMs (MicroFC-x0035-SMT)

• 3x3 mm^2 (for tests) vs **1x1 mm^2**





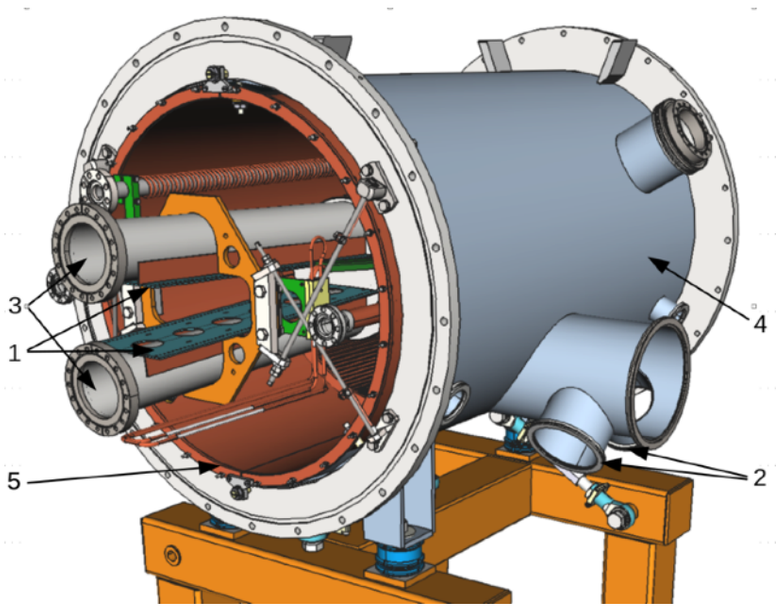
Currently, the selection of materials for the build of 7 detector prototype sector tiles is underway

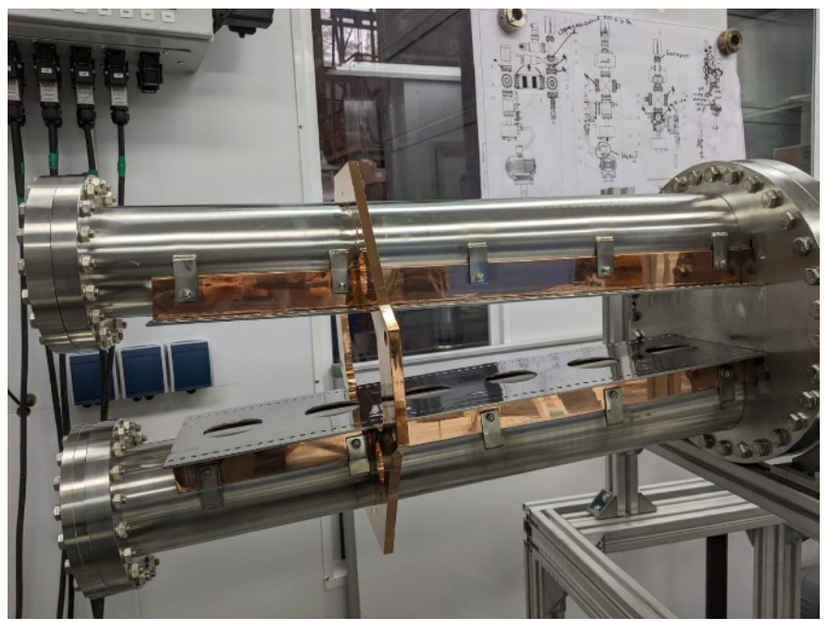
BBC status report (A.V.Tishevsky)

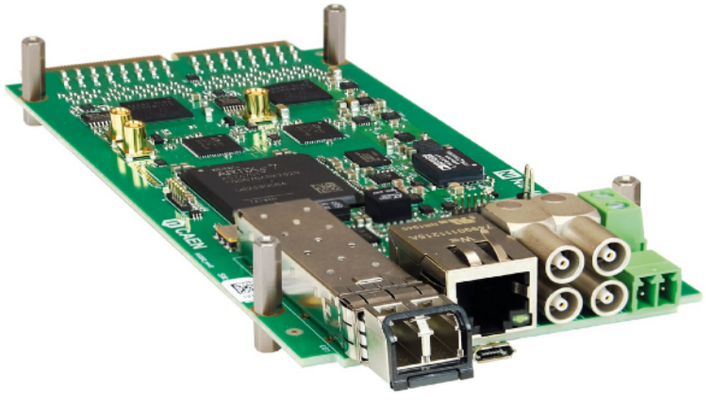
(see talk at this meeting)

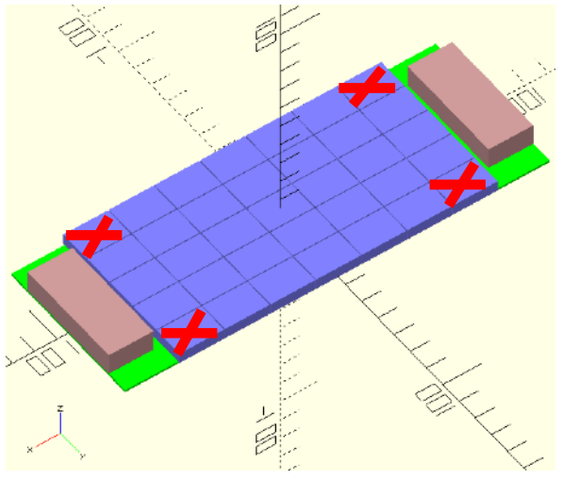
I.Alekseev

Progress on Zero Degree Calorimeter (ZDC)









- Beam pipe sections for the ZDC cite are received in JINR early October. Now under tests by vacuum group. As it looks now the place for ZDC is fine and well acceptable for installation. It is not sure when there will be the cryostat and other communications.
- We think of testing CAEN FERS 5200 system for SiPM control and readout. 7 A5202 modules are ordered for the 1st NICA run. They will cover DAQ for two 6 planes ZDC (3 modules for each ZDC and 1 spare). A5202 is based on Citiroc-1A chip produced by WeeROC. It has 64 channels which provide SiPM bias, amplification and readout.
- For the initial test a single ZDC plane with 31 scintillator tile (no tiles in the corners) is being developed.

Hardware session in Samara

10:00	**Status of SPD Solenoid Magnet Development** — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Evgeniy Pyata* 10:00 - 10:30
	Cryogenic system — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Dmidry Nikiforov* 10:30 - 10:50
	RS status report — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Guennadi Alexeev* 10:50 - 11:10
11:00	**ECal status report** — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Dr Oleg Gavrishchuk* 11:10 - 11:30
	Coffee break — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	11:30 - 12:00
12:00	**Straw Tracker R&D: ongoing activities and further steps** — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Ekaterina Kuznetsova* 12:00 - 12:20
	TOF status report — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Valery Chmill* 12:20 - 12:40
	FARICH option for the PID system of the SPD experiment. — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Alexander Barnyakov* 12:40 - 13:00
13:00	**BBC status report** — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Aleksey Tishevsky* 13:00 - 13:20
	Lunch break — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	13:20 - 14:20
14:00		

SC magnet & detectors
on Tuesday before lunch

FEE, DAQ & ASIC
on Tuesday after lunch

15:00	**DAQ status report** — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Dr Leonid Afanasyev* 14:20 - 14:40
	Status-quo of the L1, L2 concentrators — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Vyacheslav Tereschenko* 14:40 - 15:00
	White-rabbit evaluation device for SPD TSS prototyping — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Dmitry Ryabikov* 15:00 - 15:20
	Slice forming system. Status and plans. — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Konstantin Gritsay* 15:20 - 15:40
16:00	**Coffee break** — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	15:40 - 16:10
	Progress report on the development of a beam-beam collision monitor on microchannel plates — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Farkhat Valiev et al.* 16:10 - 16:30
	Development of an ASIC for Straw and MicroMegaS detectors of SPD NICA — *Auditorium L11, Building 22B, Samara University, Academician Pavlov str., 1, Samara*	*Alexander Solin* 16:30 - 16:50

Concluding remarks

- There is some progress in many subsystems ⇒ update your section of TDR before November
- Special attention should be paid to the detectors of the 1st stage of the experiment
  - Lack of qualified engineering personnel capable of doing the work
- According to original plans, only 5 years left before the datataking starts. Clear planning required from corresponding groups. Financial support will certainly be matter.