The SPD setup and its elements

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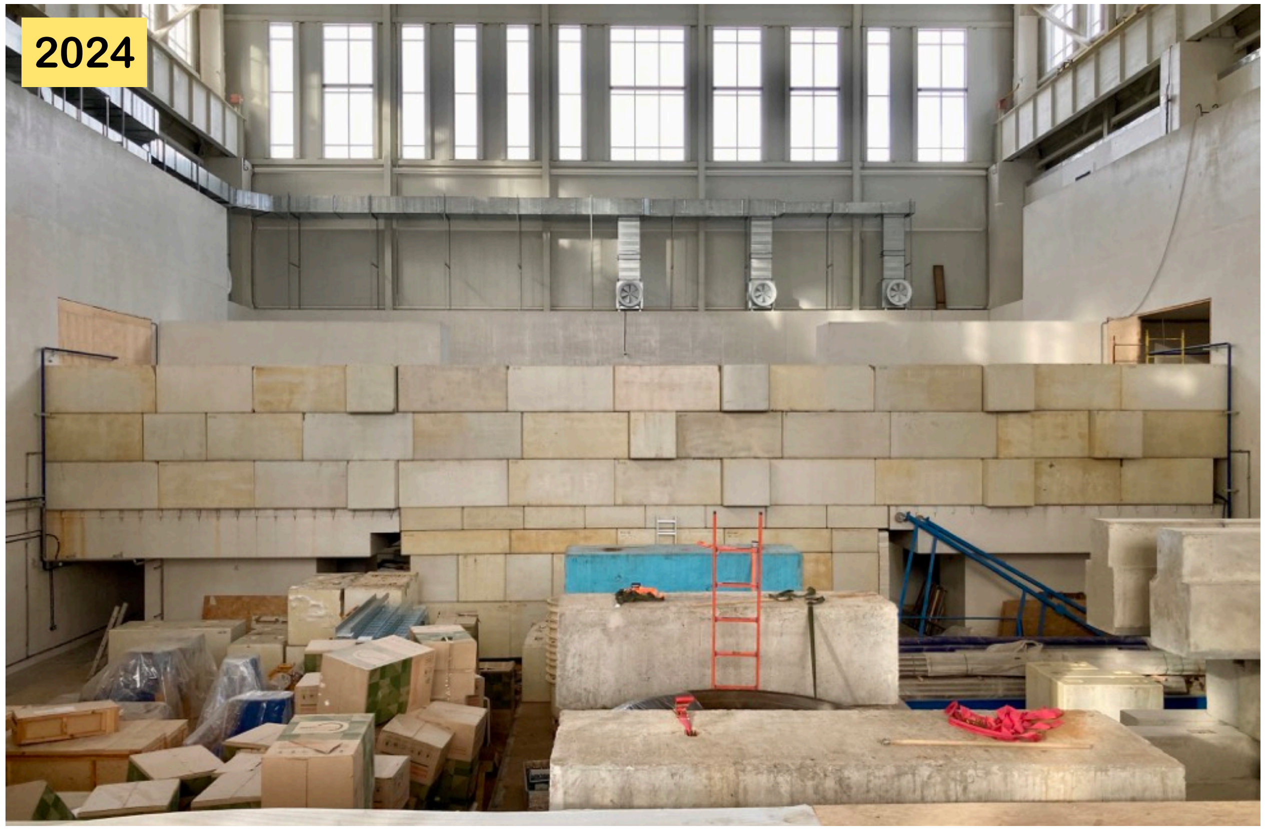
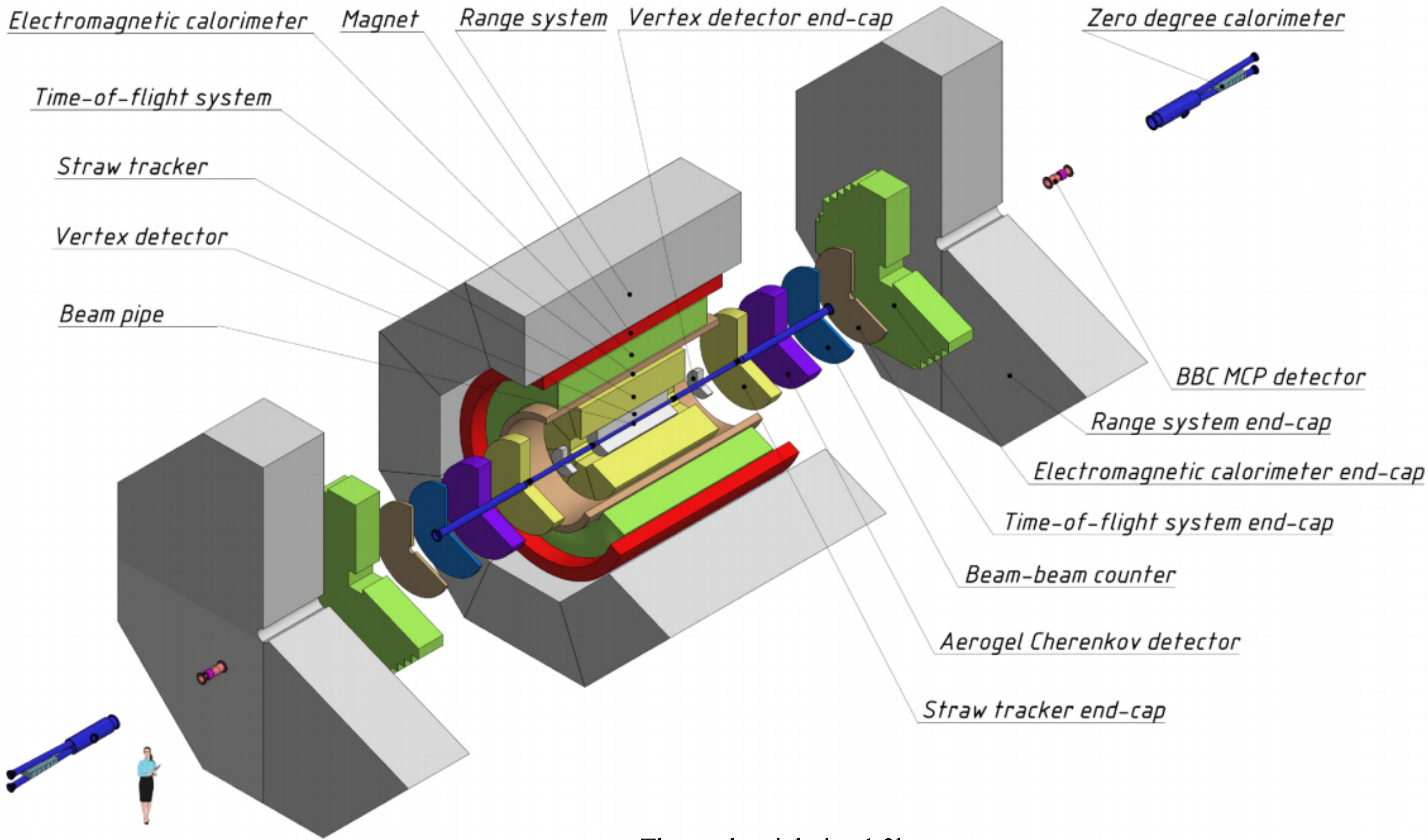
Meeting with DAC
Feb 27, 2024

Experimental area of SPD

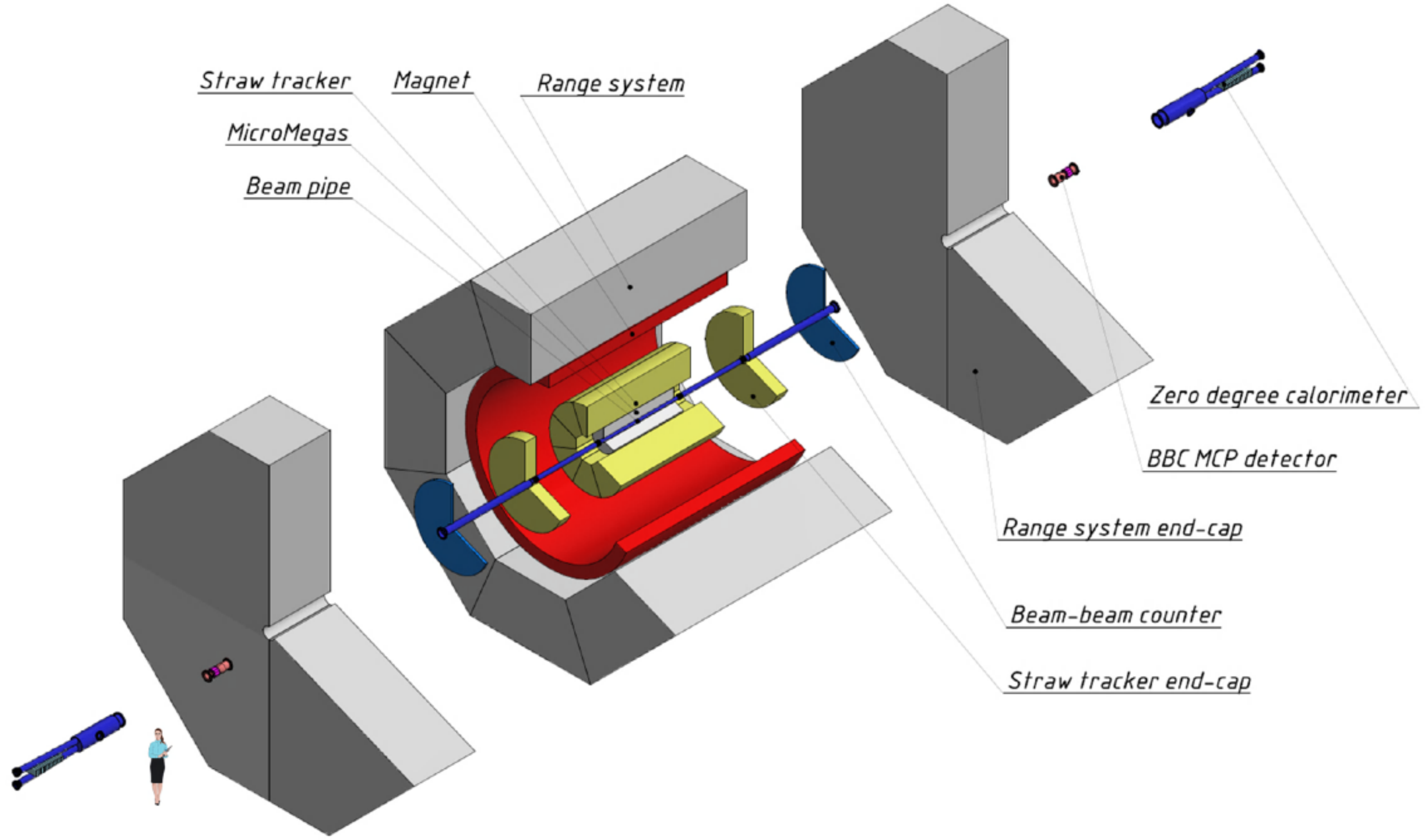
- All interior work (painting, ventilation, electricity, Wi-Fi and so on) in the SPD hall has been completed.
- The accelerator tunnel was isolated from the hall by concrete blocks (biological protection) in 2024.
- The trial run of the NICA accelerator is scheduled for early 2025.



Schematic view of the SPD setup



The total weight is ~1.3k tons

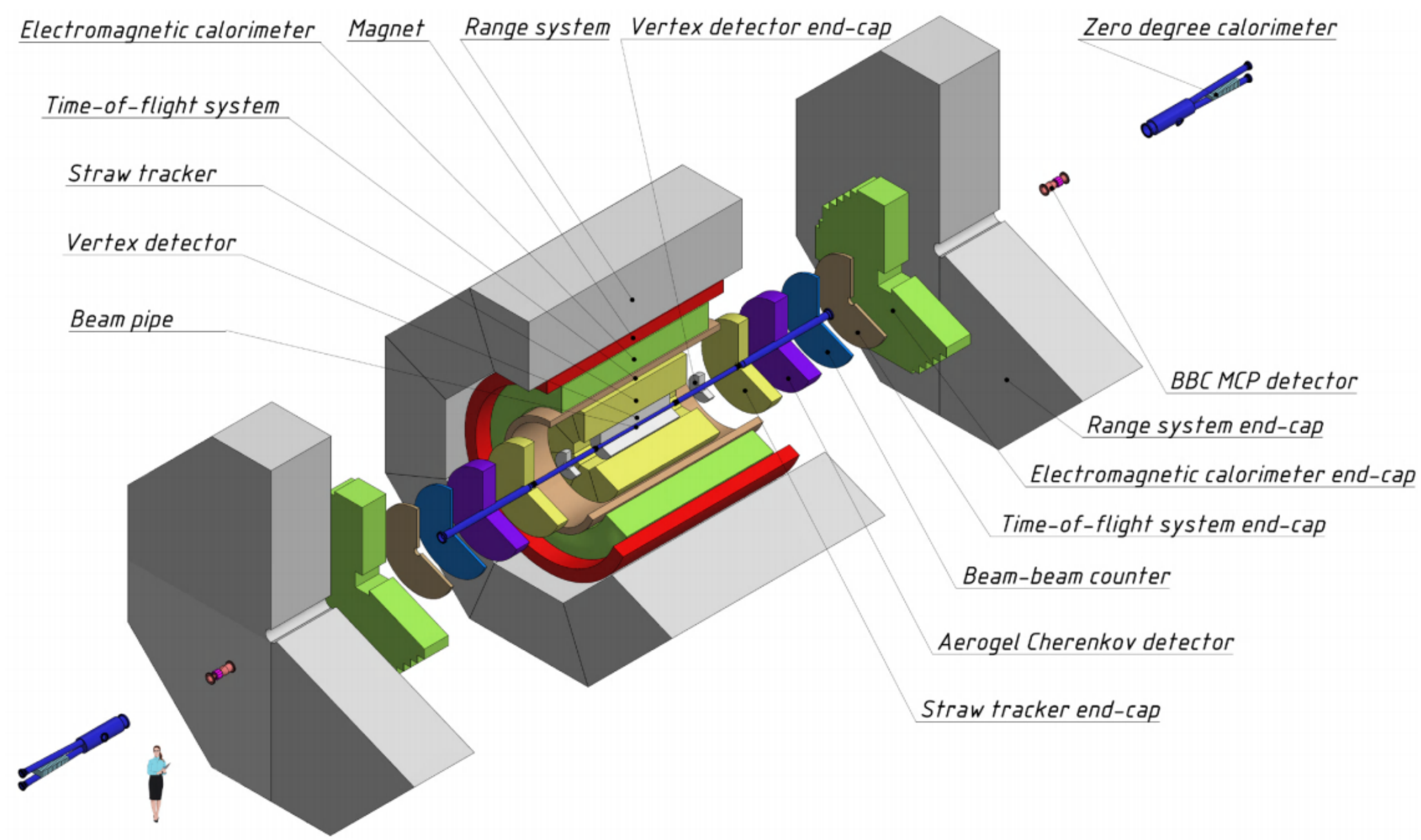


Stage I of experiment

- Basic set of subsystems
  - Magnet, RS, Straw
  - MM, BBC, BBC-MCP, ZDC
  - Maybe central of part of ECal-endcap
- p-beam: $\sqrt{s} \lesssim 15$ GeV, $\mathcal{L} \lesssim 10^{30}$ s^{-1}cm^{-2}

Stage II: Fully assembled setup

- PID detector: TOF, FARICH
- ECal
- Silicone VD
- p-beam: $\sqrt{s}$=27 GeV, $\mathcal{L}$=10^{32} s^{-1}cm^{-2} with interaction rate of ~4 MHz



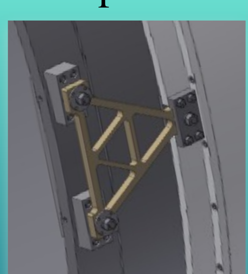
Superconductive solenoid magnet

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

Linear guides used for positioning an electro-magnetic calorimeter

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

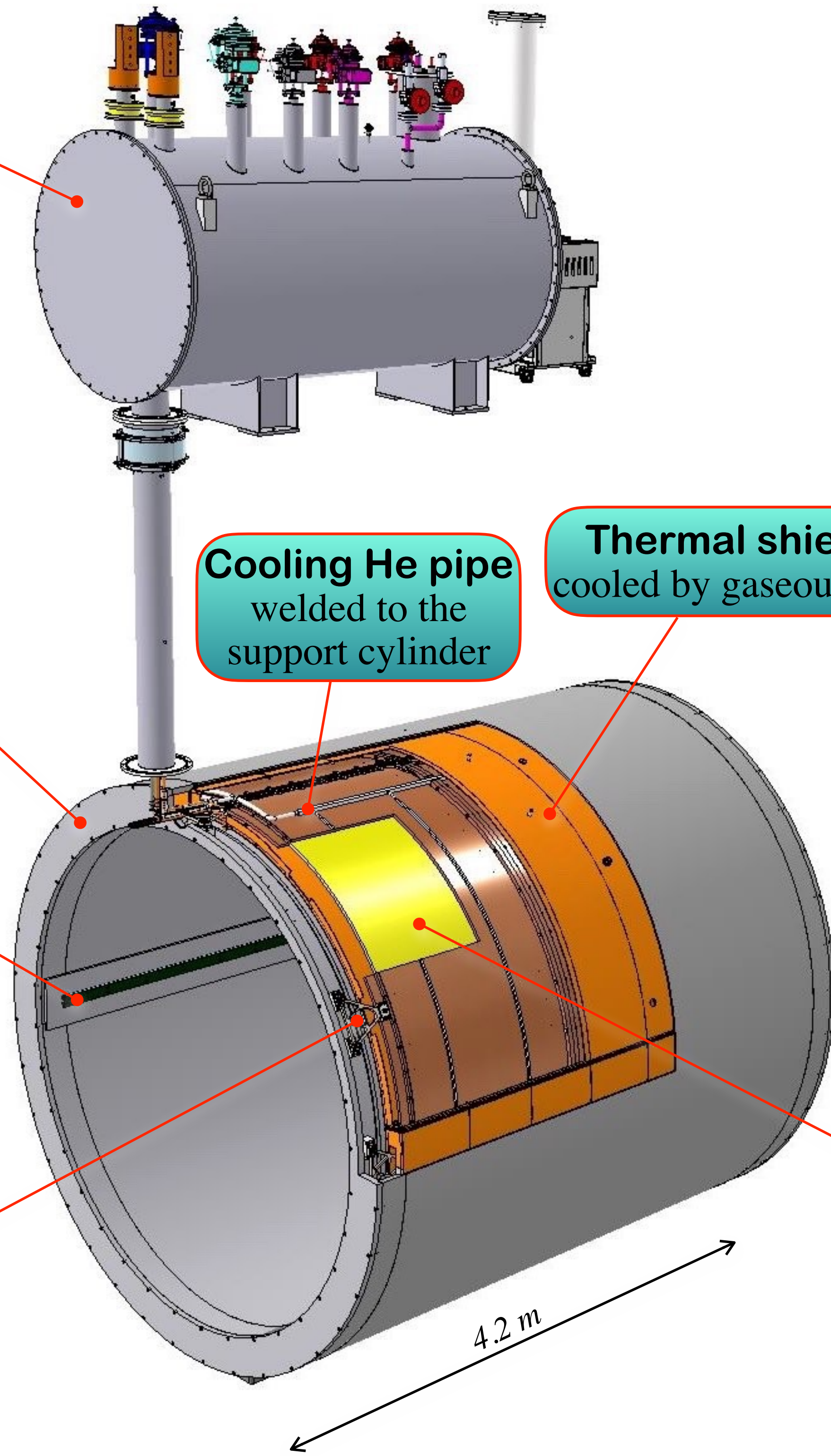


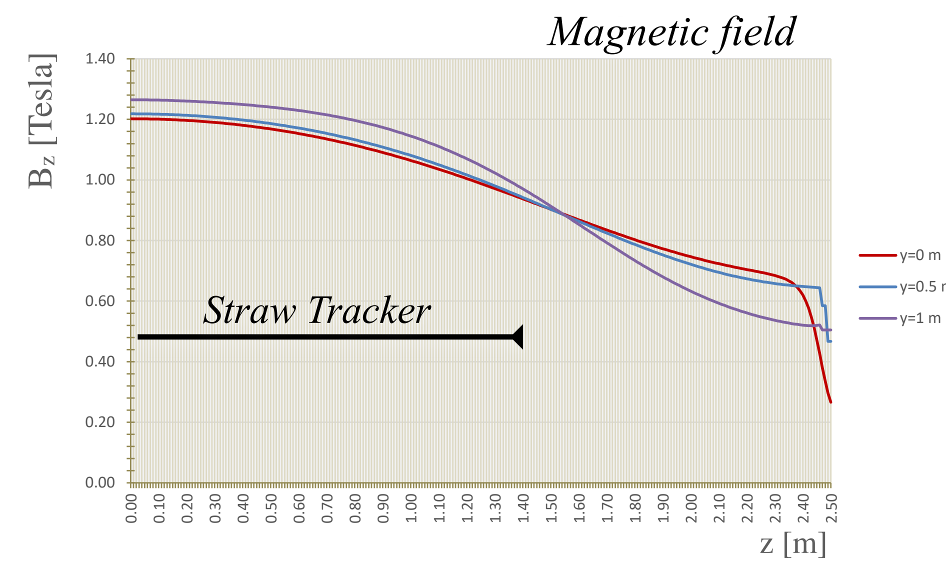
12 pieces on each side.

Made of fiberglass.

Cooling He pipe welded to the support cylinder

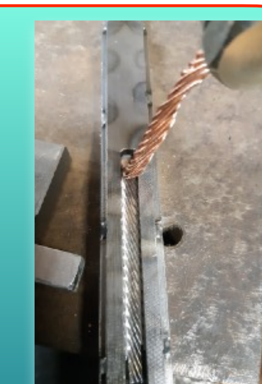
Thermal shield cooled by gaseous He



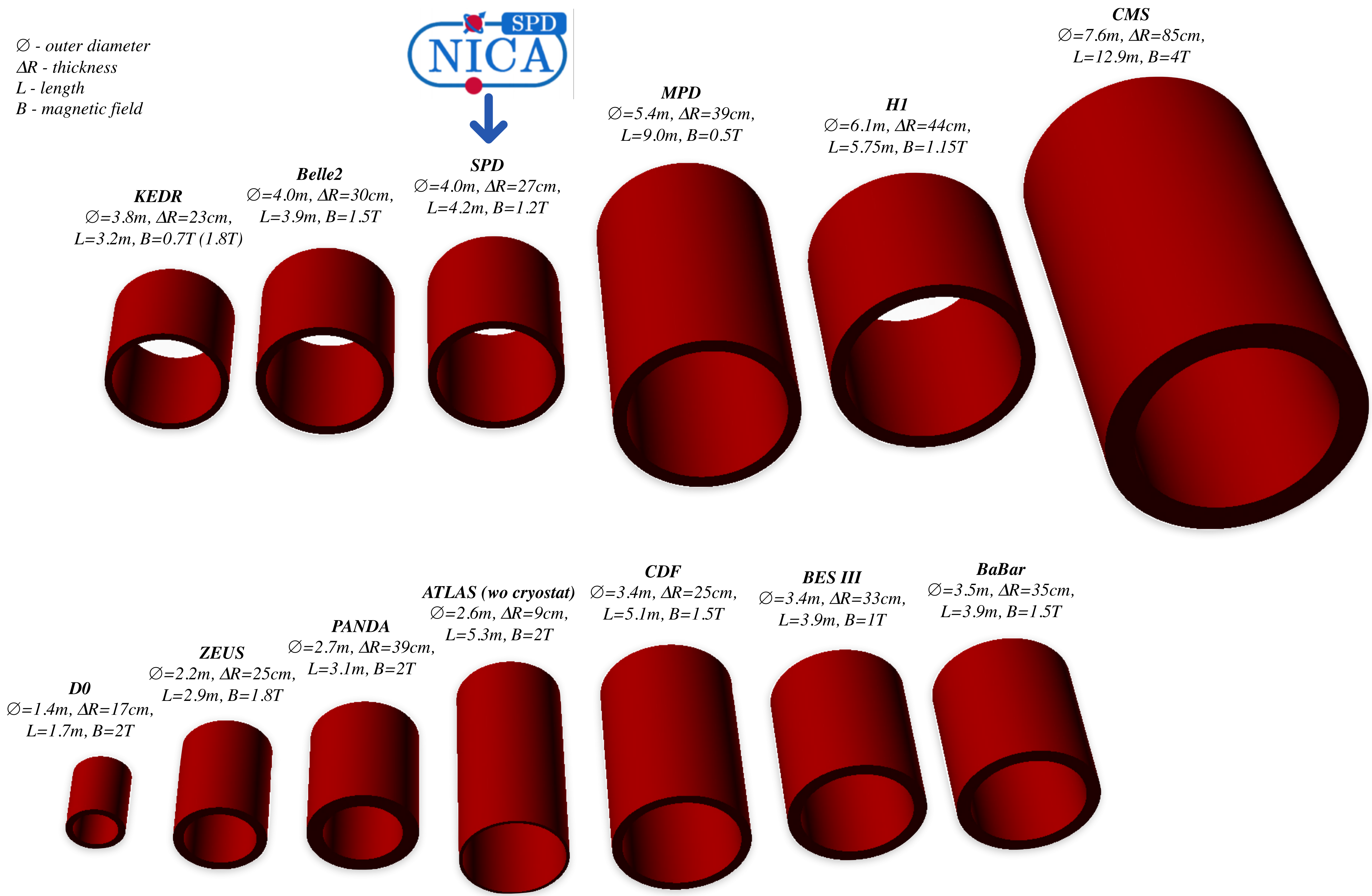


- 1.1 Tesla field with ±10% uniformity within ±1.4 m distance from center (tracking det.)
- Solenoid consists of 3 coils with 750 turns in total (two layer edge-wise winding)
  - central coil with 2×75=150 turns
  - 2 side coils with 2×150=300 turns
- The use of the *thermosyphon method* for cooling the superconducting coils (natural convection of two-phase helium at 4.5K)
- It will be constructed in 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.

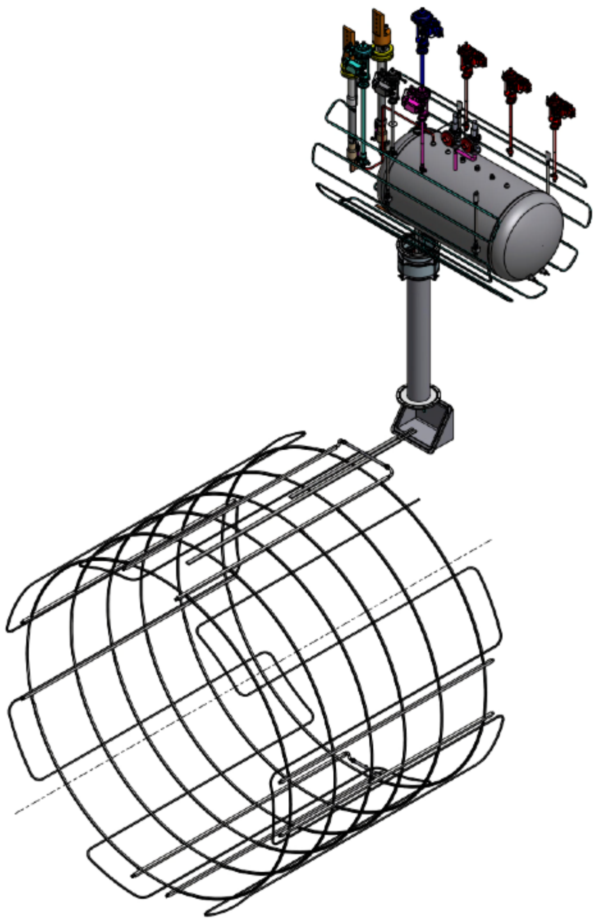


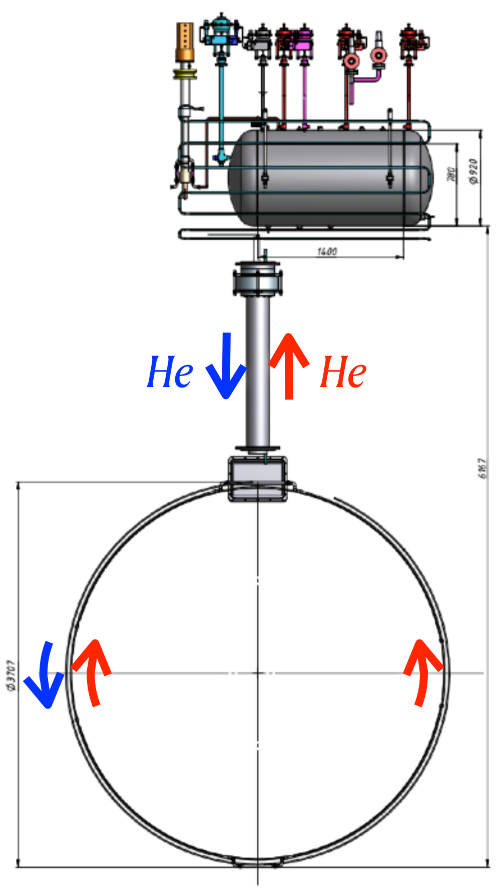
Cryostats of superconducting magnets of HEP experiments

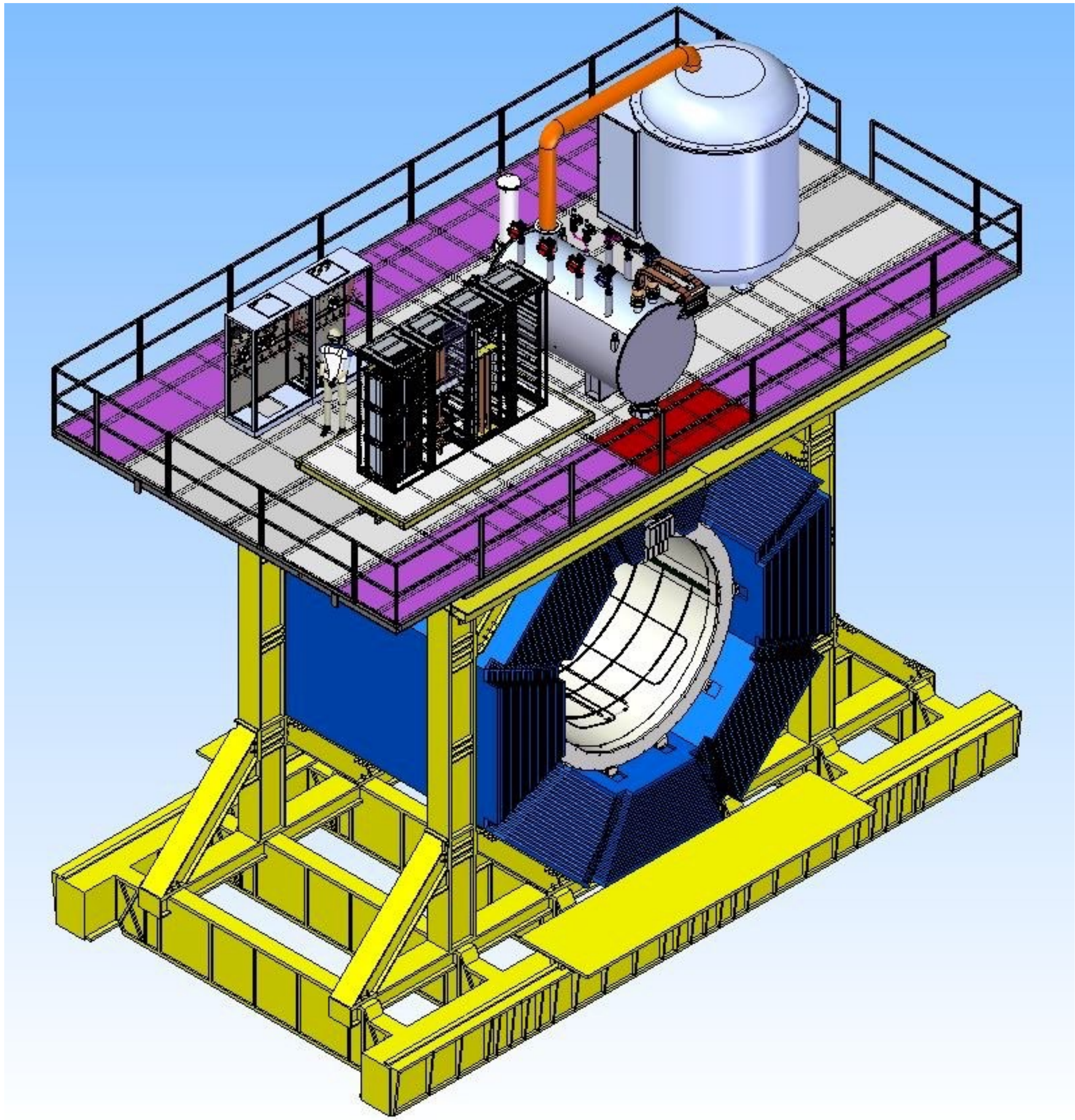


Helium system

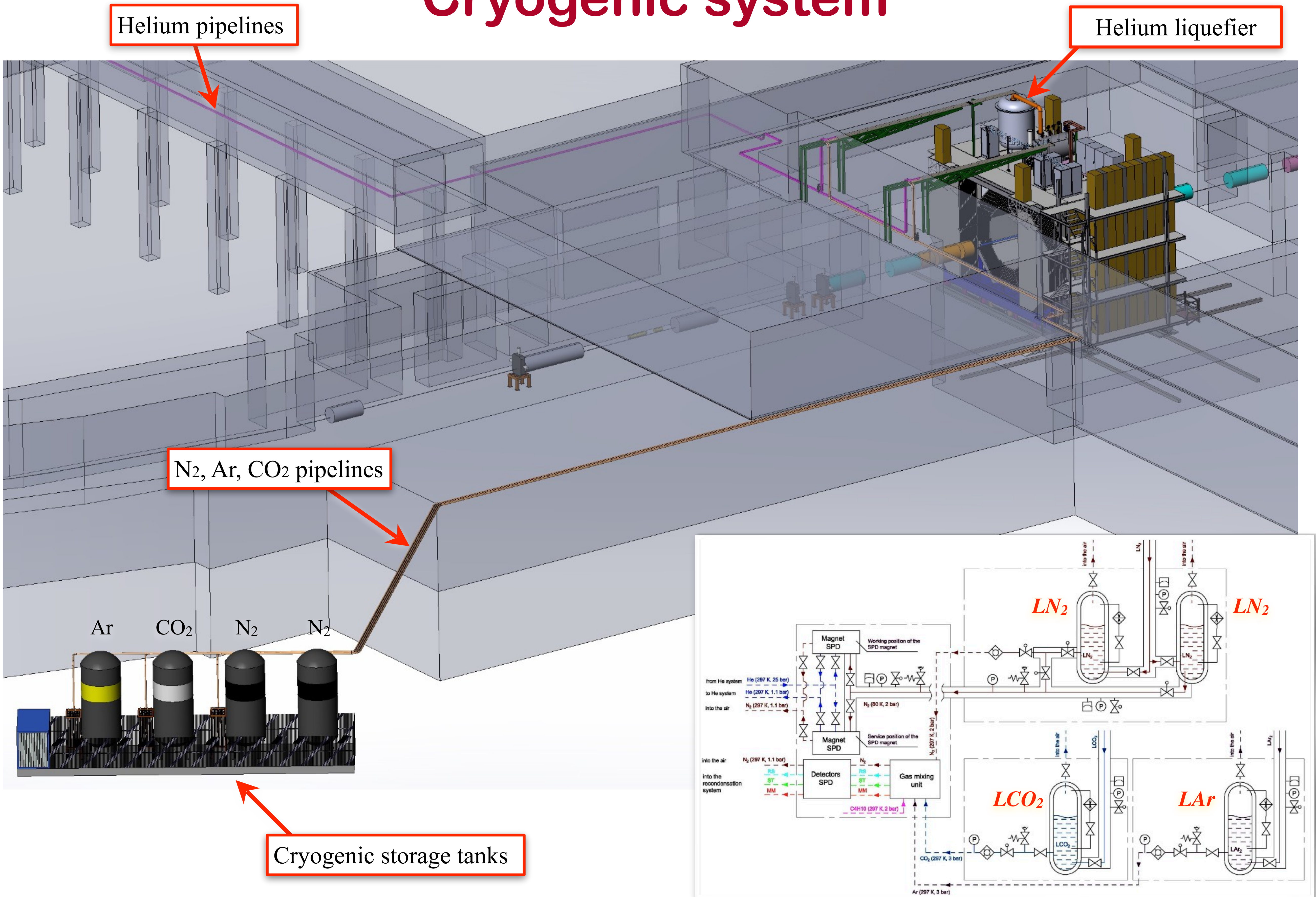
	Operating parameters	Unit
1	Cooling capacity (for 4.5 K)	100 - 130 l/h
	Cooling capacity (for 50 K)	150 W
2	Temperature of outlet flow	4.3 K (1.05 bar)
3	Temperature of inlet flow	4.5 K (1.15 bar)
4	Hydraulic resistance of the SC coil	0.1 bar
5	Cold weight	4000 kg
6	Maximum pressure in pipe	5 MPa
7	Heat load	60 – 80 W





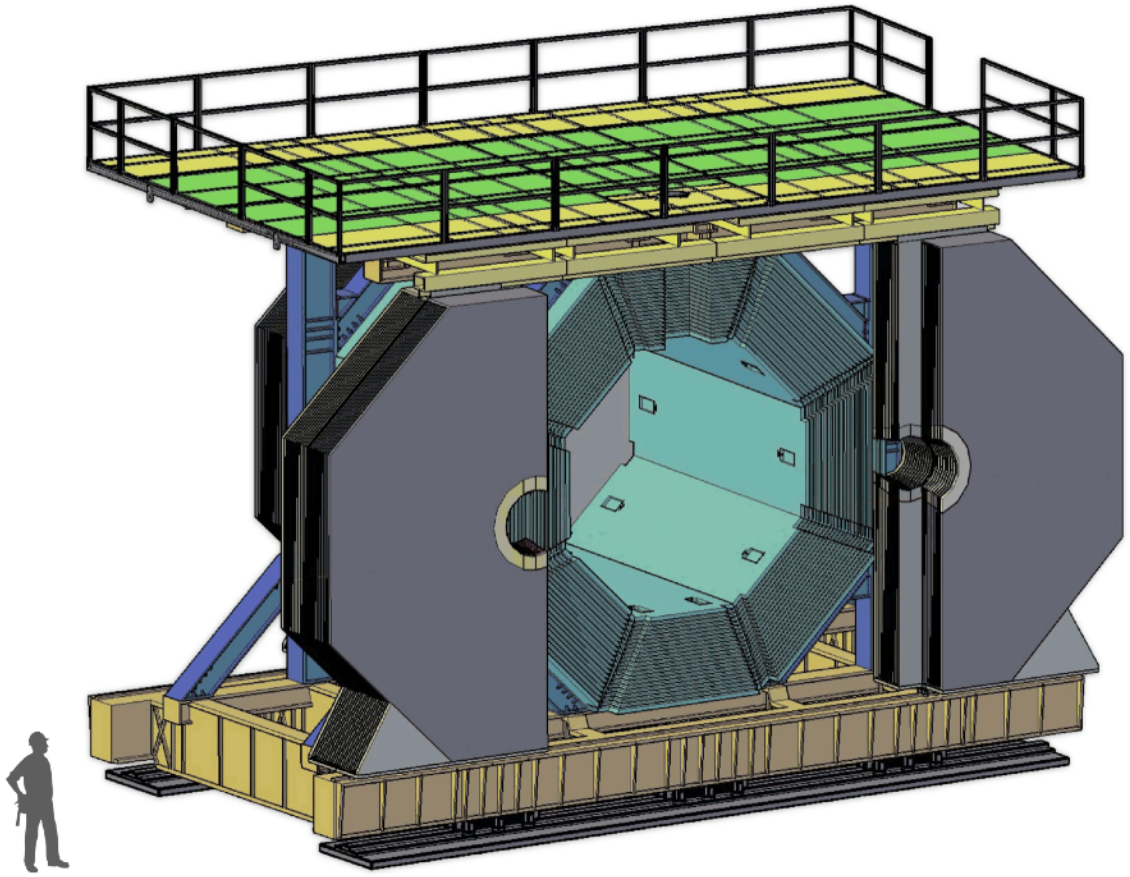


Cryogenic system

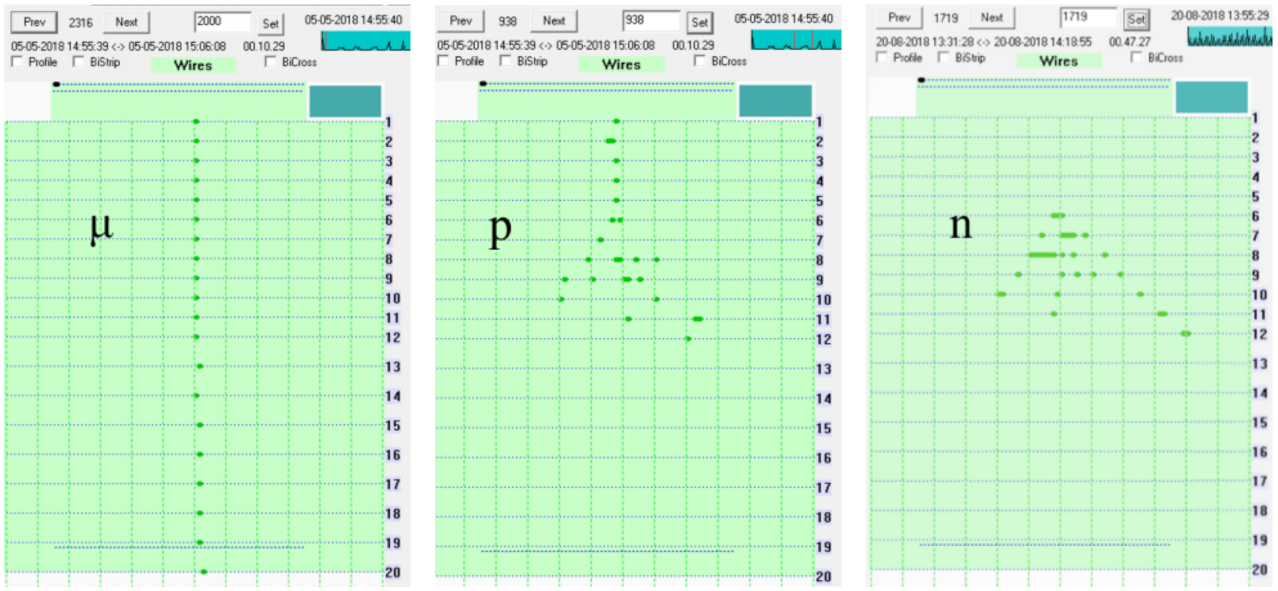


Range System (RS)

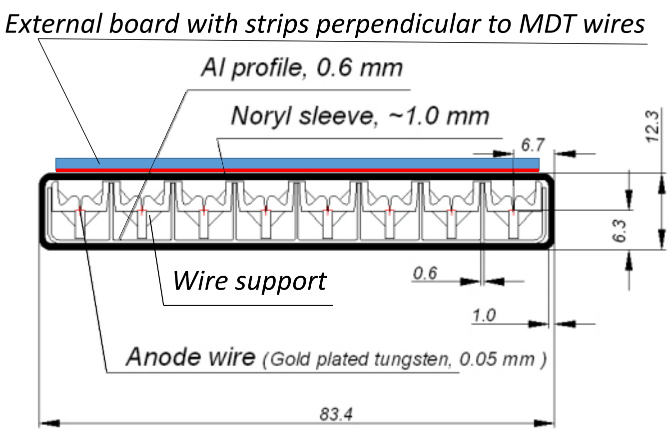
- Purposes: μ identification, rough hadron calorimetry, iron return yoke of the magnet, mechanical support structure of the overall detector
- 20 layers of Fe (3-6 cm) interleaved with gaps for Mini Drift Tube (MDT) detectors
- The endcaps must withstand the ~100 tonne magnetic force
- Total mass ~1000 tons, at least $4\lambda_I$
- The design will follow closely the one of PANDA
- MDT provide 2 coordinate readout (~140 kch)
    - Al extruded comb-like 8-cell profile with anode wires + external electrodes (strips) perpendicular to the wires

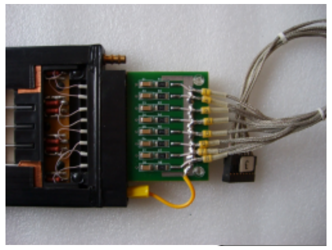


Results of beam tests of RS prototype (10 ton, 4k ch)

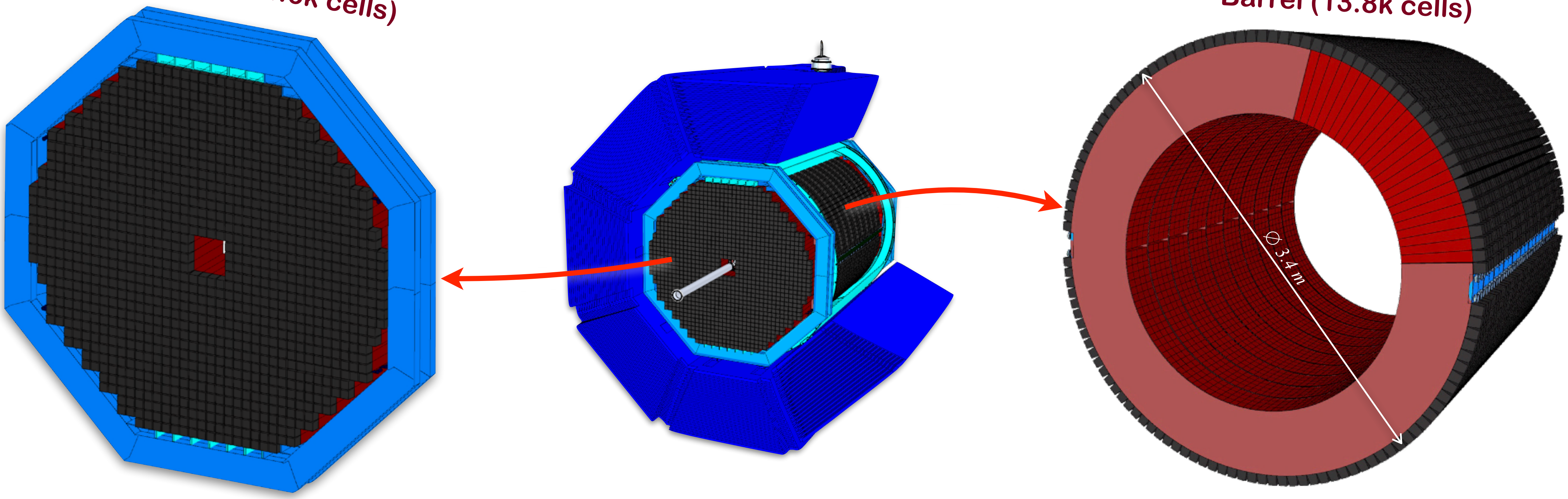


Mini Drift Tubes (MTD)

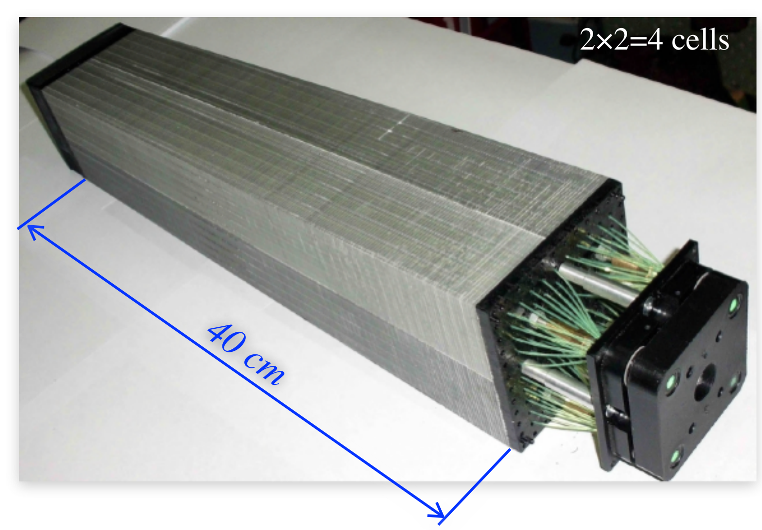




Electromagnetic Calorimeter (ECal)



- Purpose: detection of prompt photons and photons from π^0, η and χ_c decays
- Identification of electrons and positrons
- Number of radiation lengths $18.6X_0$
- Total weight is 40t (barrel) + 28t (endcap) = 68t
- Total number of channels is ~23k
- Energy resolution is ~5% / $\sqrt{E}$
- Low energy threshold is ~50 MeV
- Time resolution is ~0.5 ns

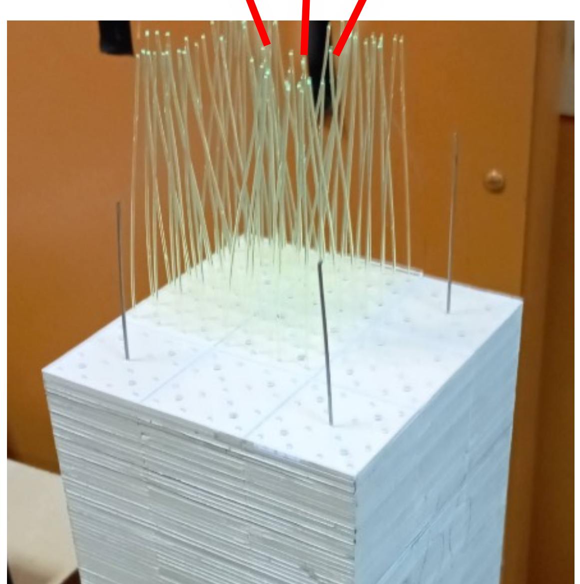


- 200 layers of lead (0.5 mm) and scintillator (1.5mm)
- 36 fibers of one cell transmit light to 6×6 mm^2 SiPM
- Moliere radius is ~2.4 cm

Test results with cosmic particles

Setup of 4 modules

- Each module consist of 9 cells of 4x4 cm^2
- All 36 cells were fully tested



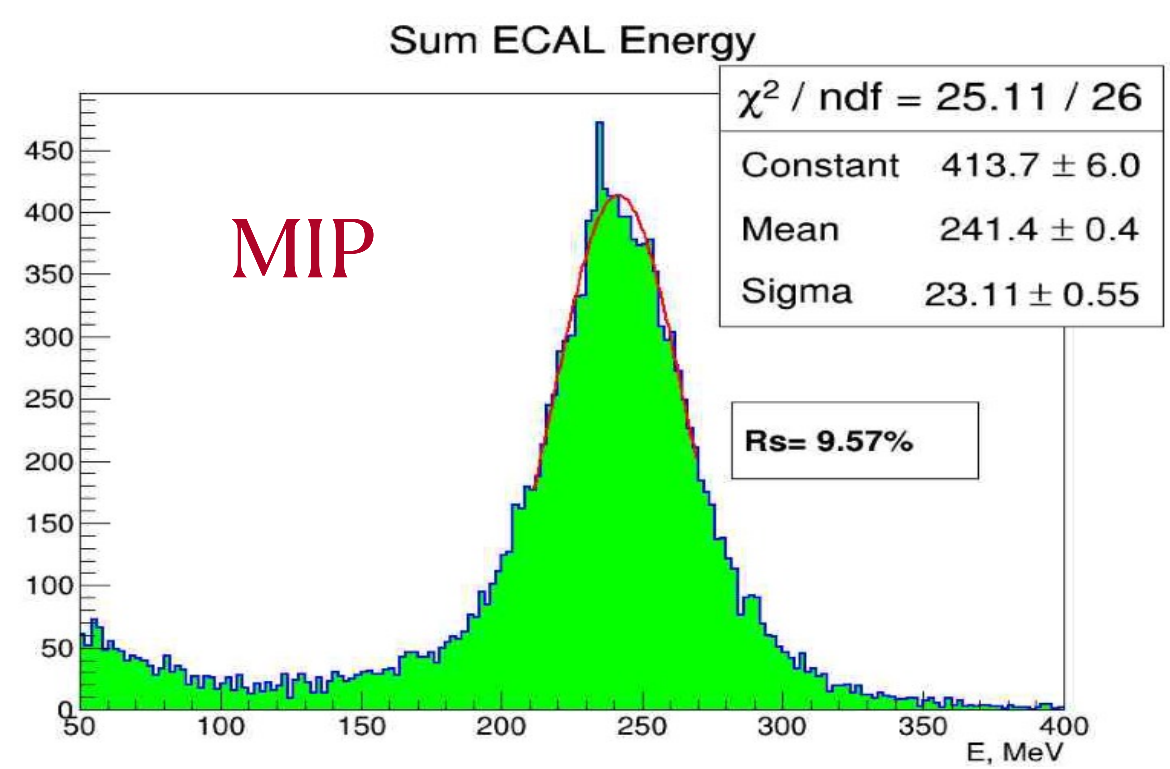
Cell assembled of:

- 1.5 mm Scintillator
- 0.3 mm Lead
- 200 layers

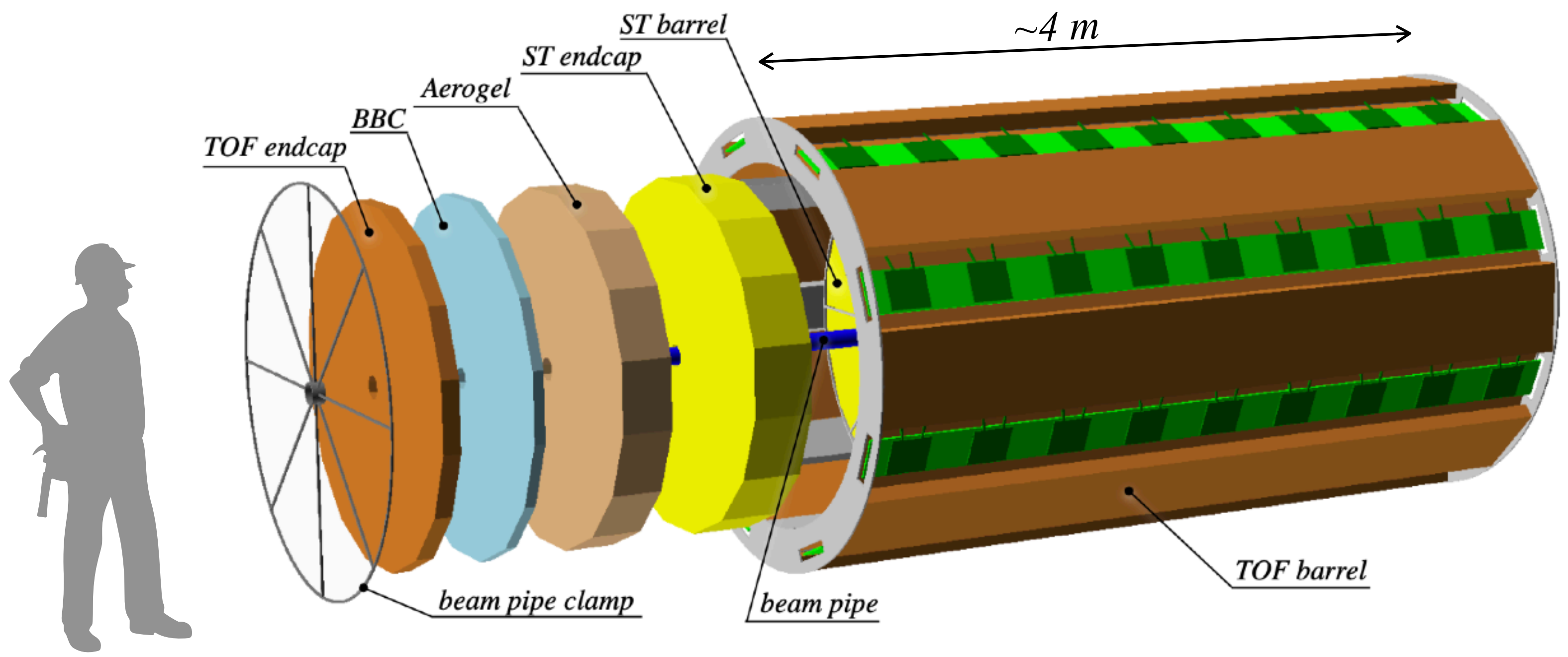
Scintillator composition:

- Polysterene
- 1.5% Paterphenyle
- 0.05% POPOP

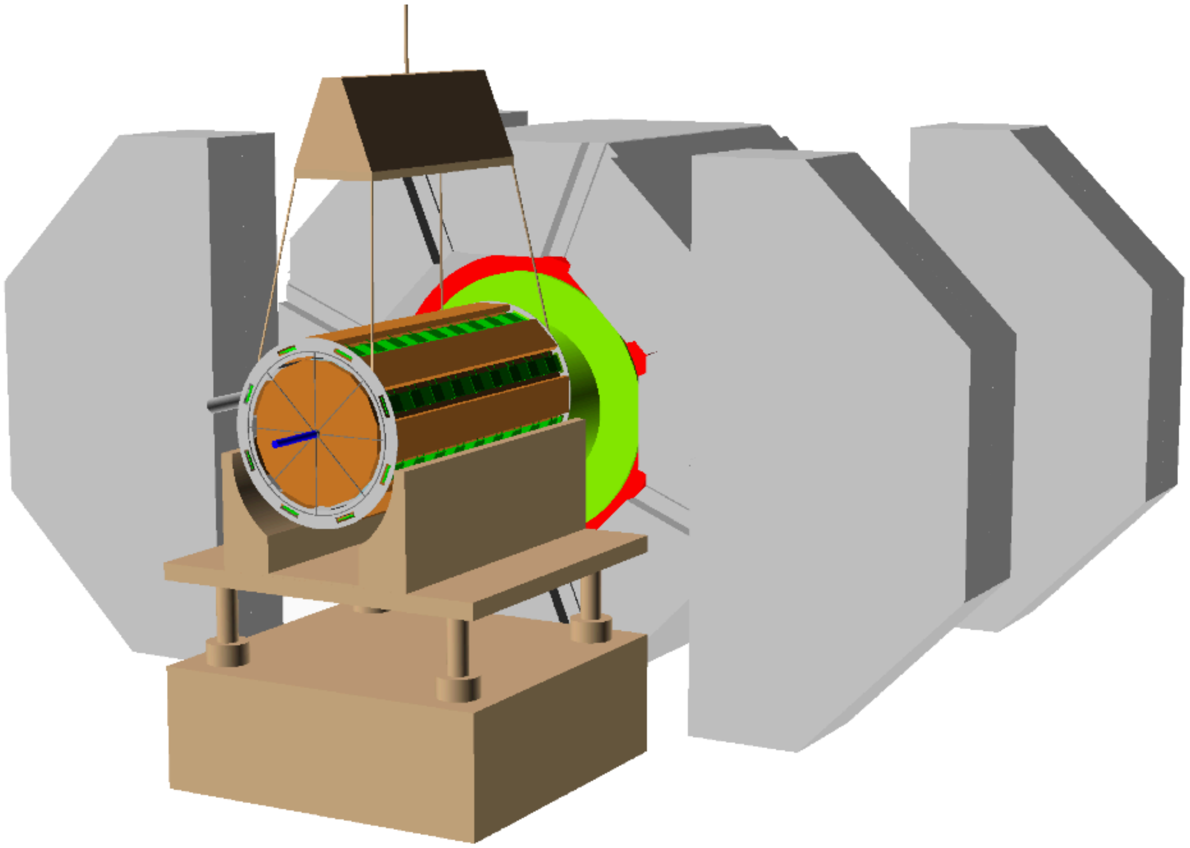
- Light detection by new NDL SiPm Series EQR15 (intrinsic epitaxial layer as a quenching resistor (EQR))
- For now, old modules with a cross section of 4×4 cm^2, left over from MPD production, are being used
- A matrix form for new scintillator production (40×40×1.5 mm^3) was ordered. A 4-set mold will 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.



Detectors inside ECal (tracking + PID)

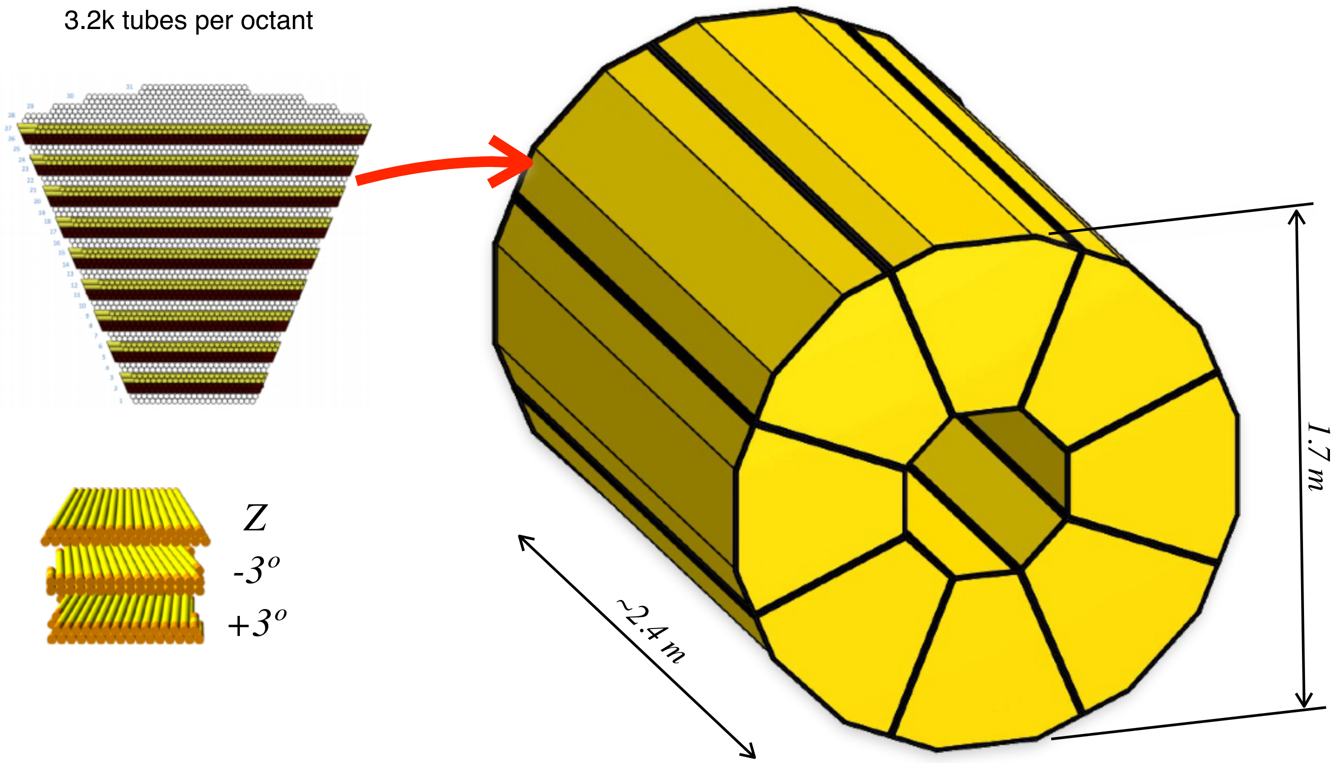


- All endcaps are loaded one-by-one presumably by hand
- No need to divide the endcap detectors into two halves



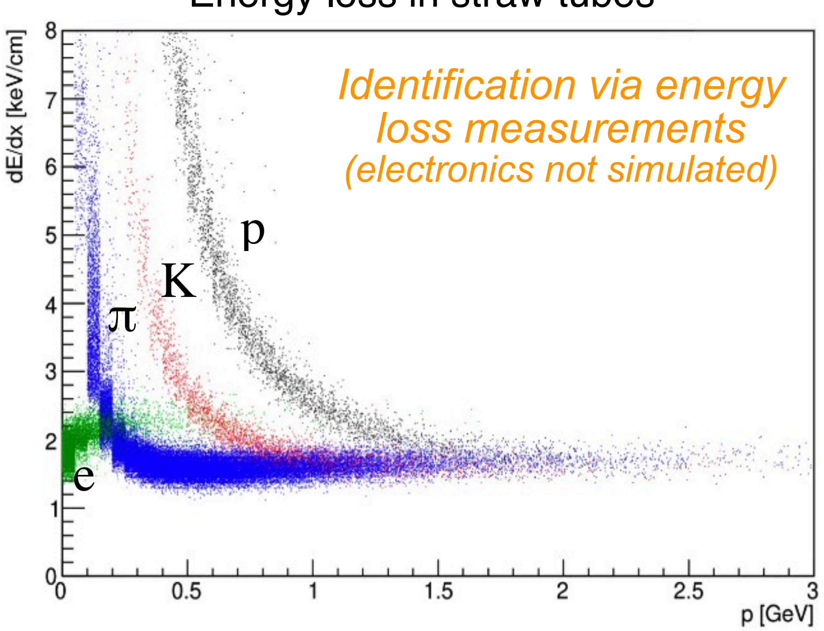
For the case when **assembling will not be allowed** in the experimental hall due to MPD runs, it can be done outside the aria.

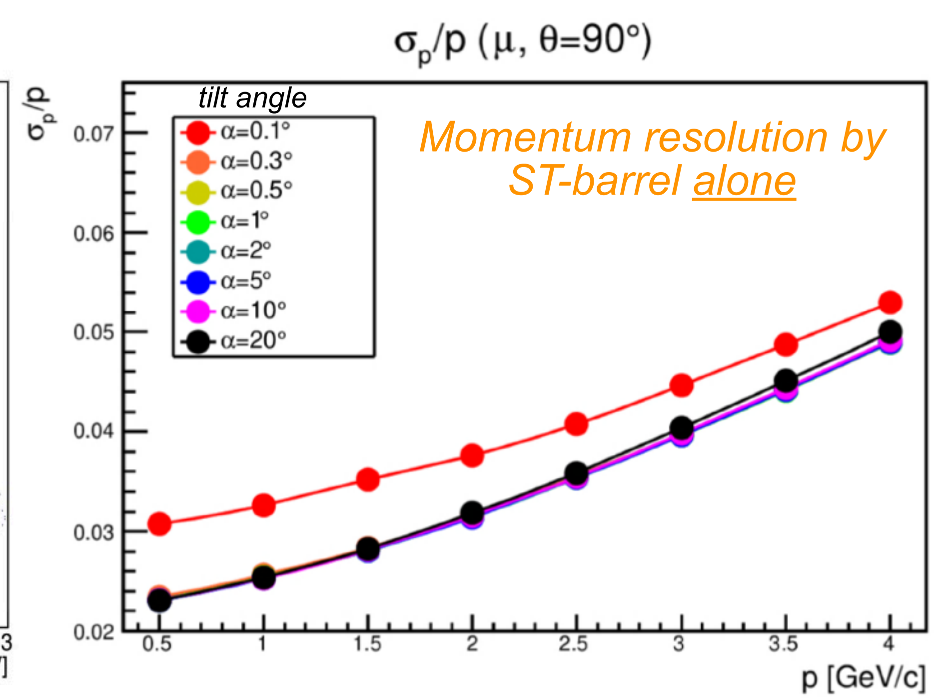
Barrel of Straw Tracker (ST)



- Main tracker system of SPD
- Barrel is made of 8 modules with 30 double-layers oriented as *z,+3°,-3°*
- Maximum drift time of 120 ns for ∅=10mm straw
- Straw tubes are made of a PET foil that is ultrasonic welded to form a tube
- Spatial resolution of 150 μm
- Expected DAQ rate up to several hundred MHz/tube (electronics is limiting factor)
- Number of readout channels ~26k
- Extensive experience in straw production in JINR for several experiments: ATLAS, NA58, NA62, NA64; prototypes for: COZY-TOF, CREAM, SHiP, COMET, DUNE.

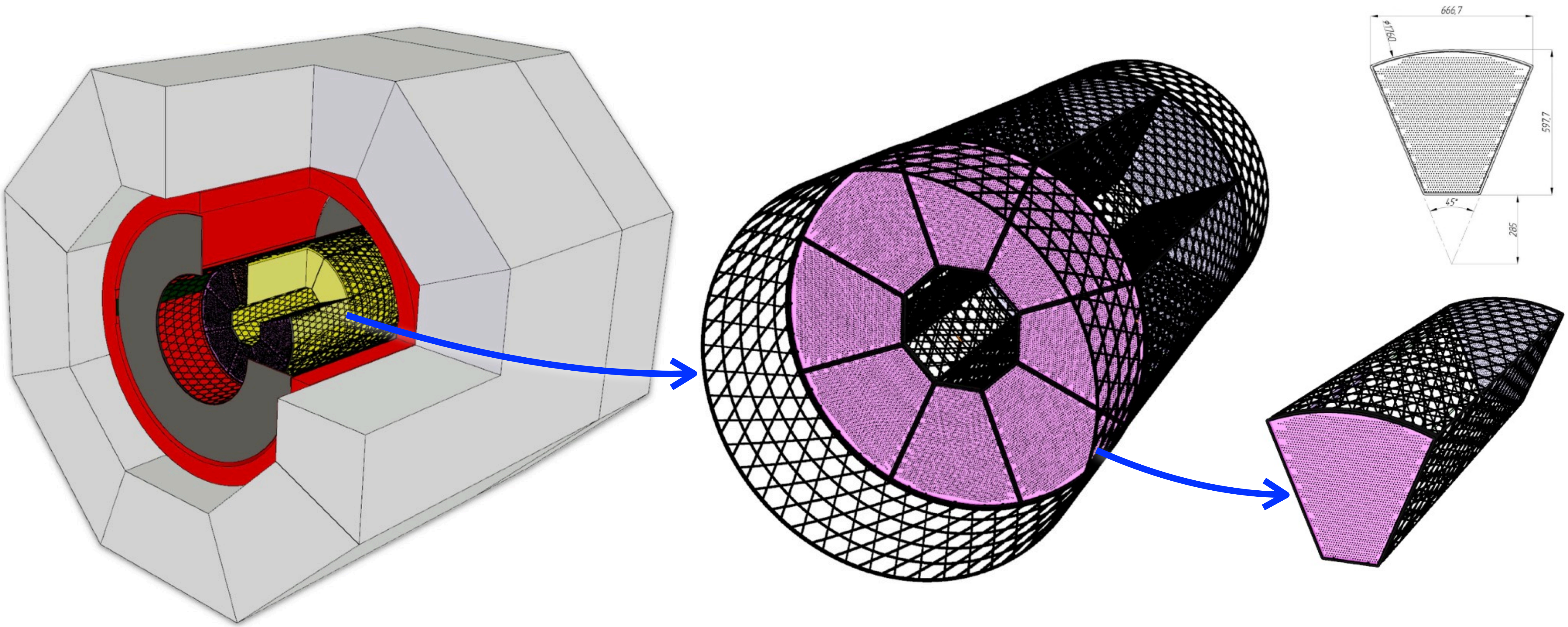
Energy loss in straw tubes





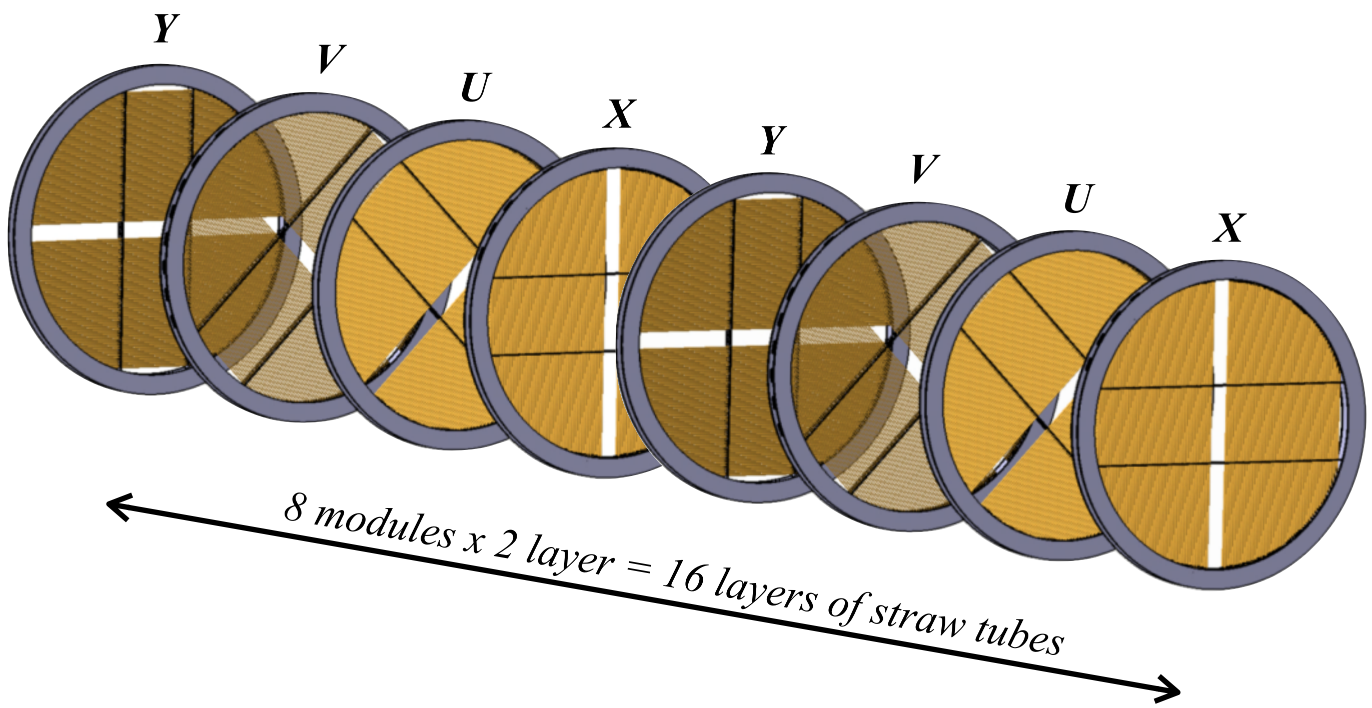
straw production for NA62 (~2010)

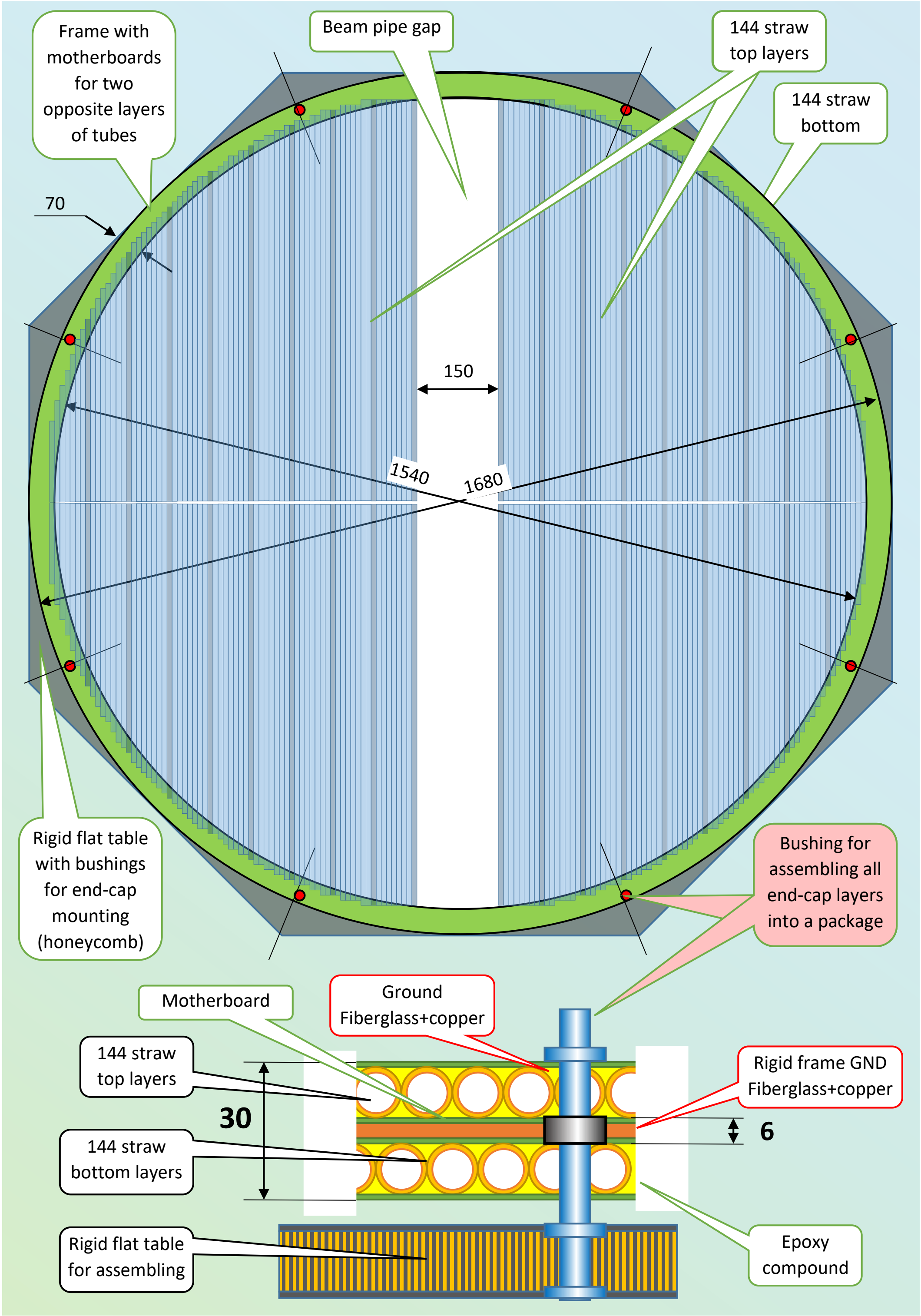
Power frame for the Straw-barrel



- Contract for the preparation of the conceptual design of the power frame was signed with CRISM earlier last 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 prepared

Endcap of Straw Tracker (ST)



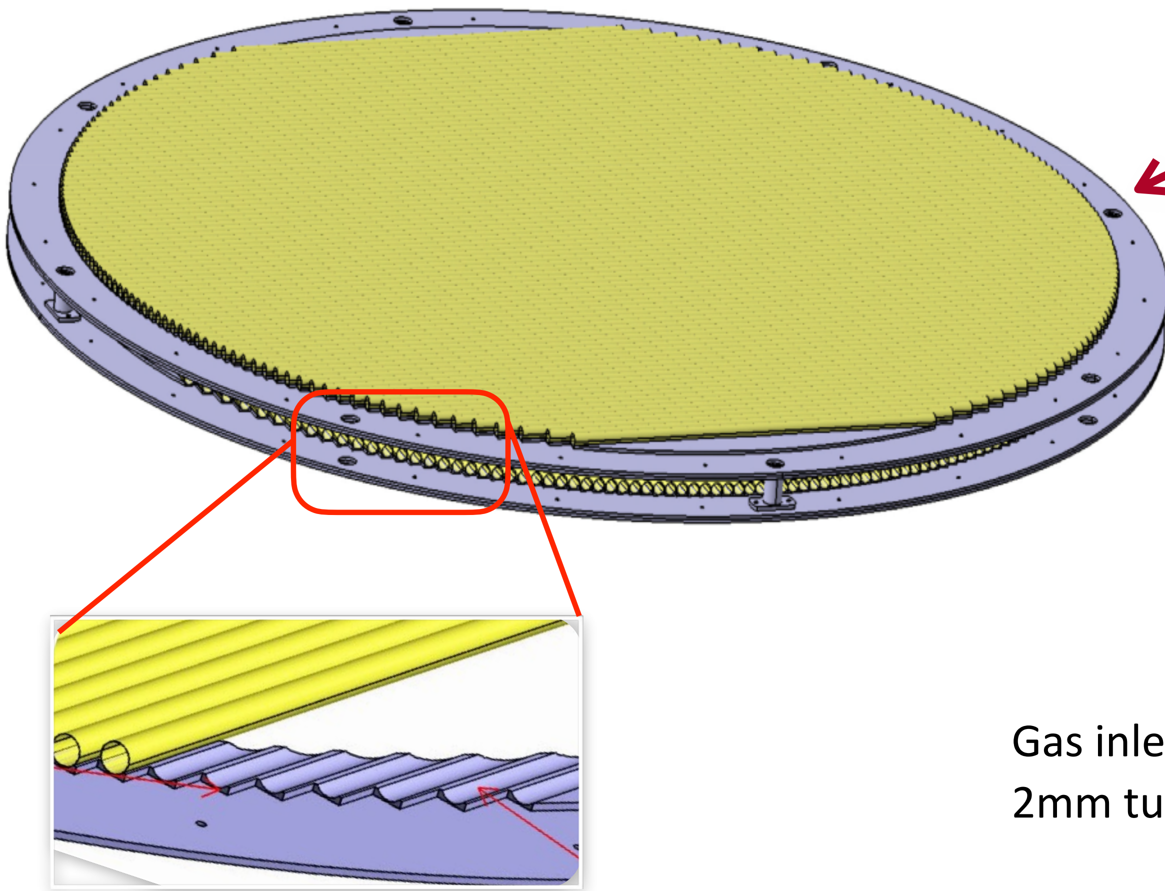


- One ST endcap contains 8 modules: *X*, *+45°*, *-45°*, *Y*
- One module contains 288 tubes in total, which are arranged in two layers shifted by half a tube
- Total number of tubes in two endcaps is

  $$288 \text{ tubes} \times 16 \text{ modules} \times 2 \text{ endcaps} = 9216 \text{ tubes}$$

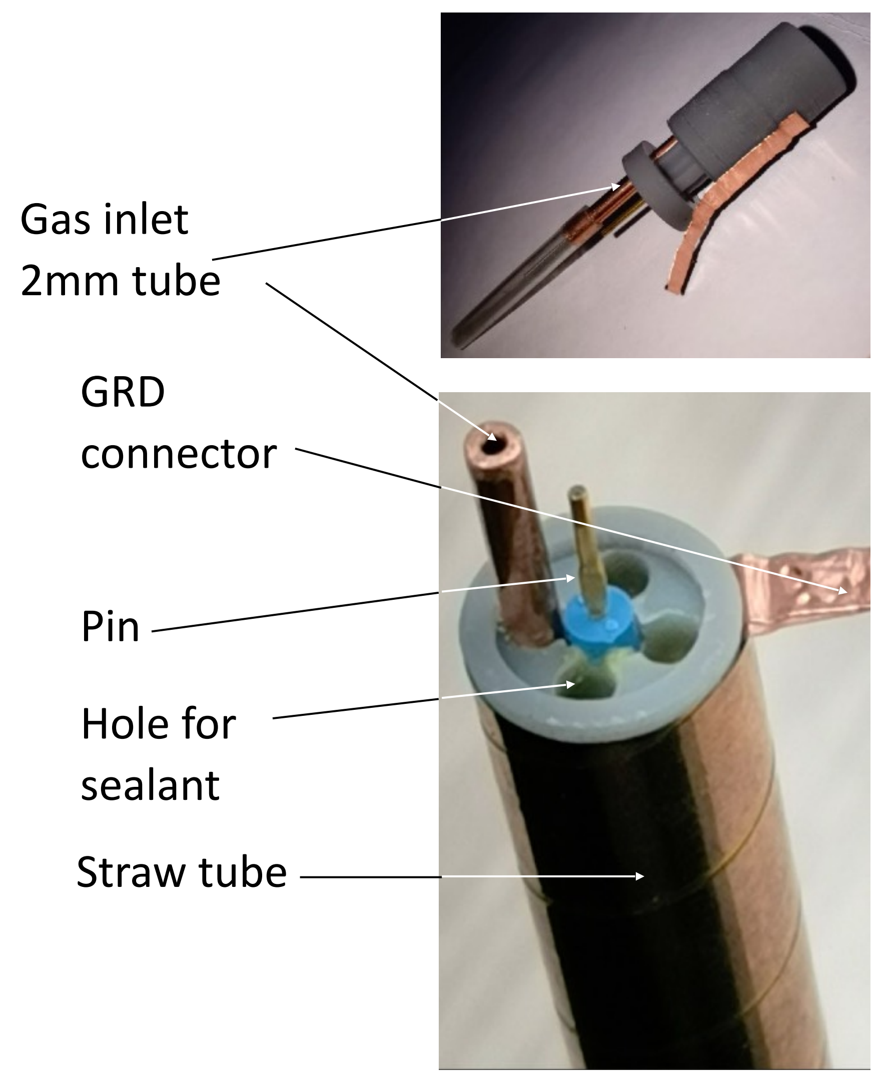
- The thickness of one module is 30 mm
- Eight coordinate planes are mounted together on a rigid flat table to form a 240 mm thick rigid block
- One straw is made by winding two "kapton" tapes forming a tube with $\varnothing = 9.56$ mm

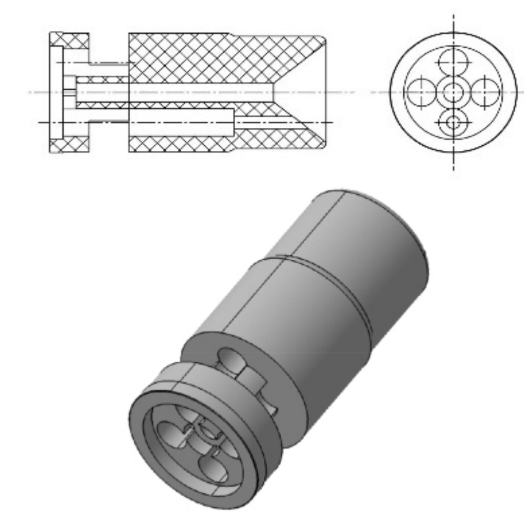
Progress on Straw-endcap prototype



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



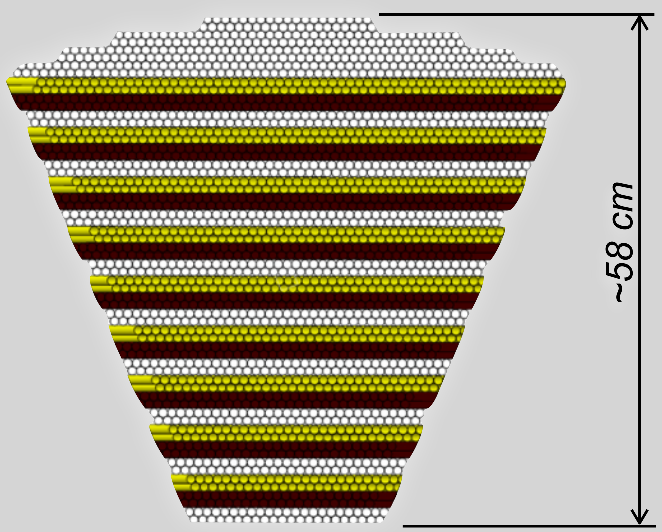


- The purpose of making the prototype is to test the assembly technology (stretching straws before gluing them to the frame)
- The circular Aluminum frame is being manufactured in LHEP workshop
- Starw-tubes of the required diameter have been manufactured
- The issue of electronics remains open

Application of ST for the dE/dx analysis (PID)

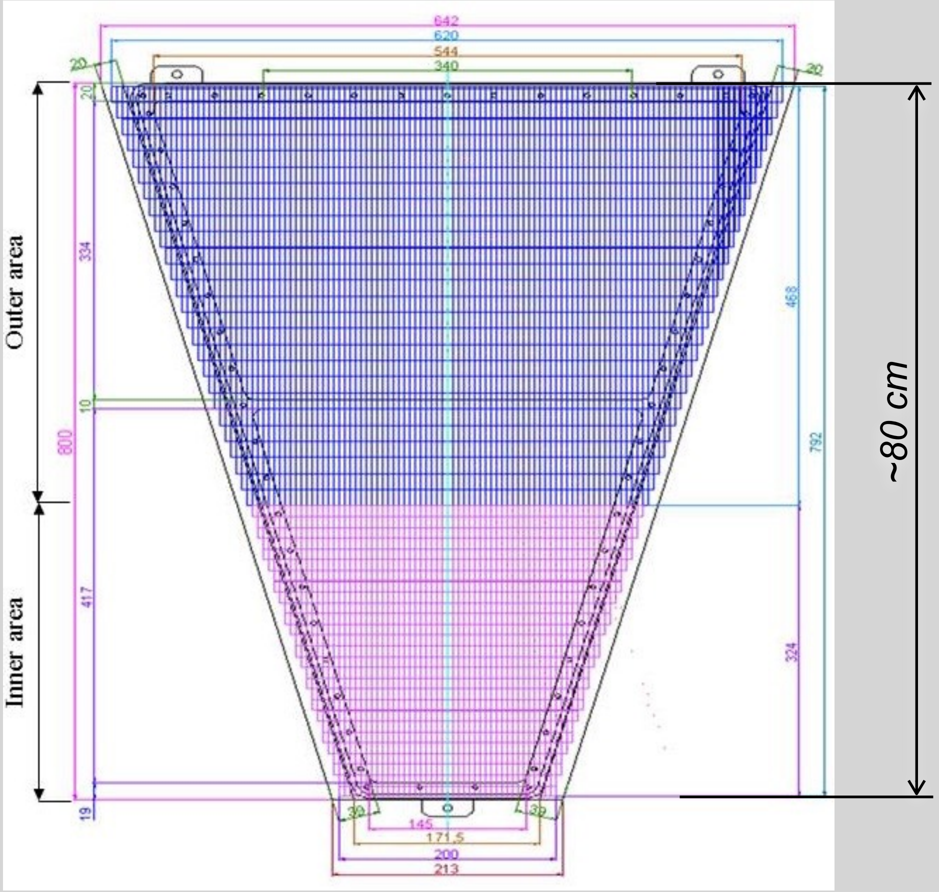
Straw of SPD

- Number of primary ionized e- per straw is about the same as per pad in TPC => similar abilities for identification
- Using TDC+ADC for readout. See VMM3 as an example

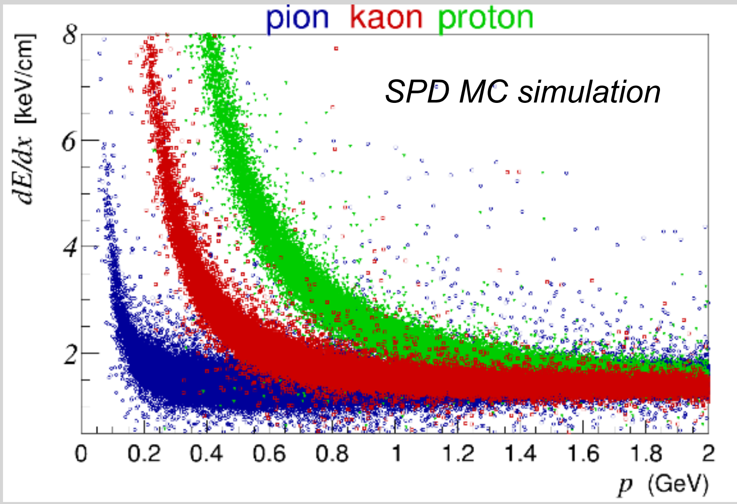


∅=10mm straw: S = **78 mm²**

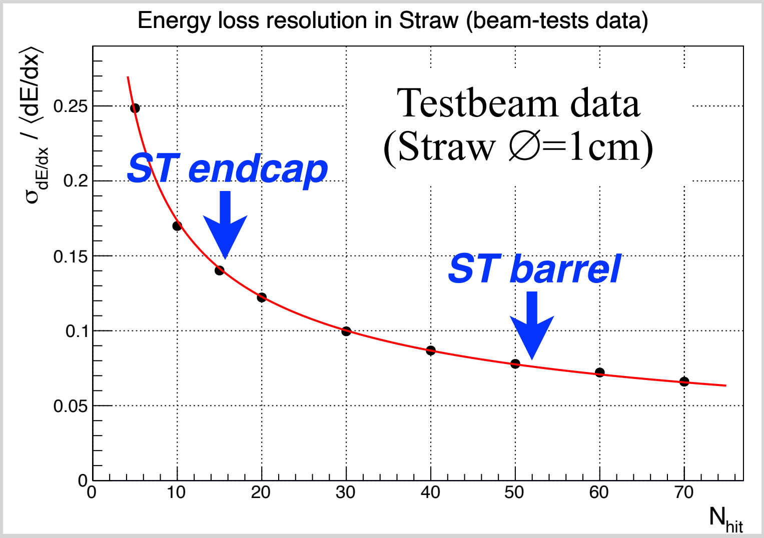
TPC of MPD (for comparison)



Inner pads: 5mm × 12mm = **60 mm²**, Outer pads: 5mm × 18mm = **90 mm²**



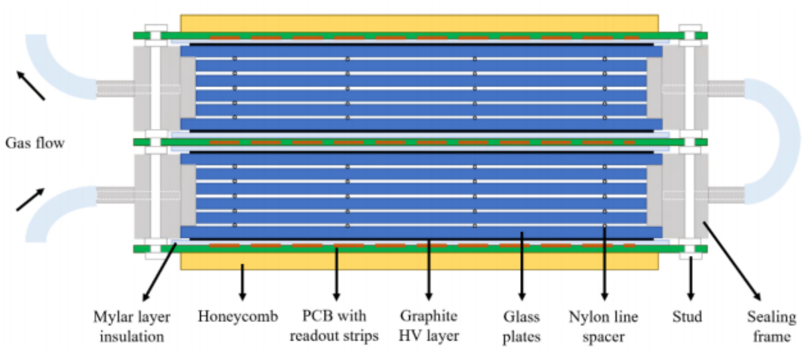
- For the 1-st stage of experiment ST will be the only PID detector in SPD for π/K/p.
- Only the low momentum region



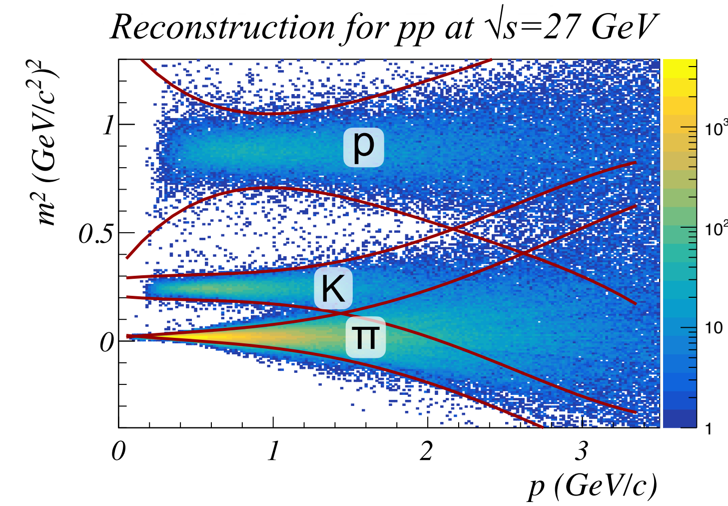
Time-of-flight (TOF) detector

Schematic view of sealed MRPC

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



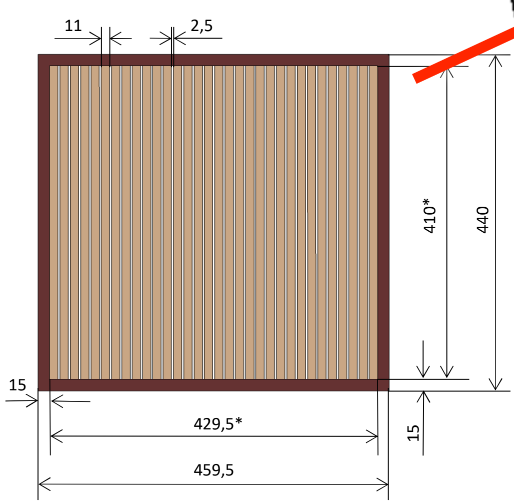
- Purpose: π/K/p discrimination for momenta ≲2 GeV, determination of t_0.
- Time resolution requirement <60 ps.
- Sealed Multigap Resistive Plate Chambers (MRPC) are the base option.
- DAQ electronics is under discussion. Analog of NINO chip v1 is in production.
- Number of readout channels is ~12.2k

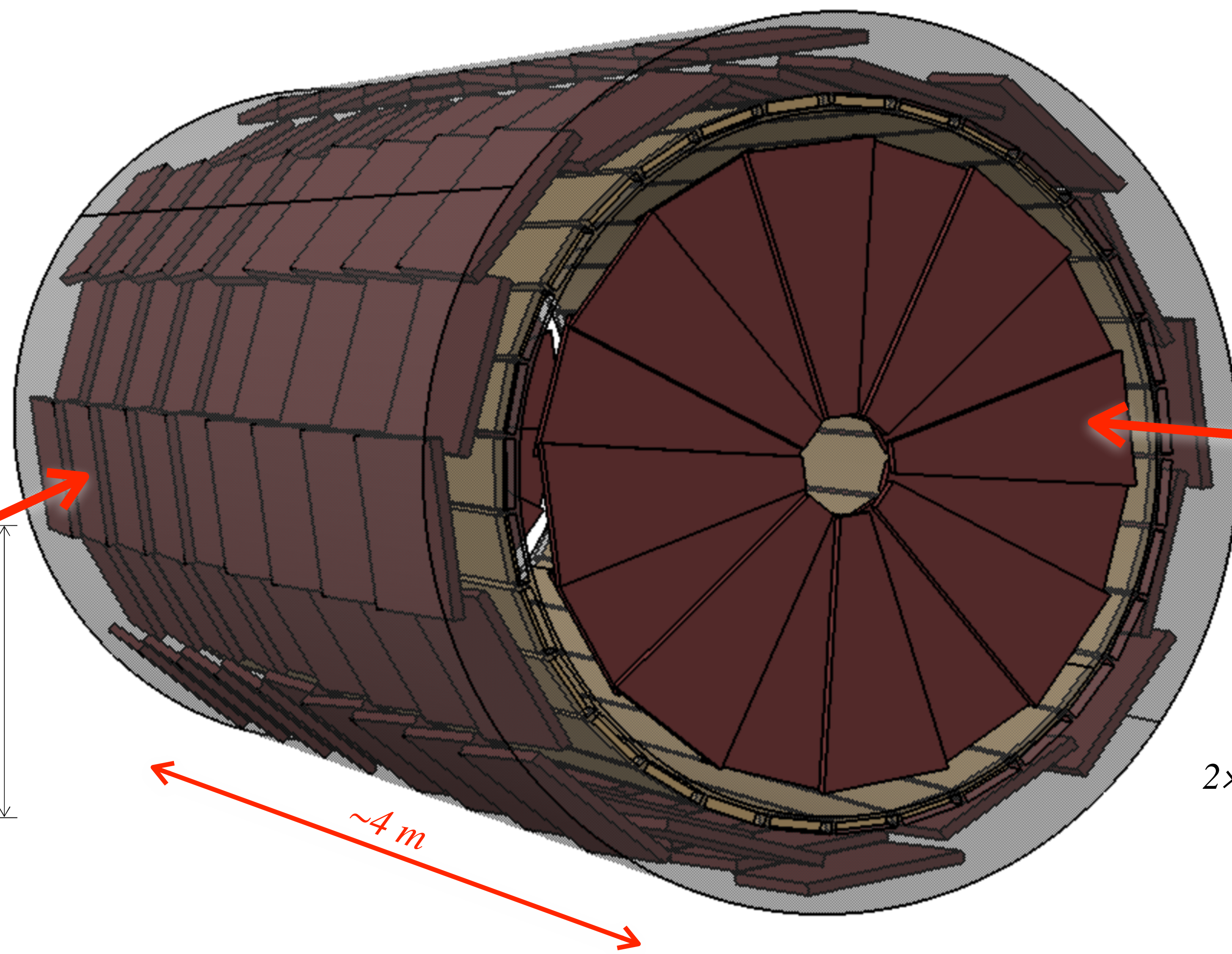


TOF Chambers for Barrel
(overlap in 2 dimensions)

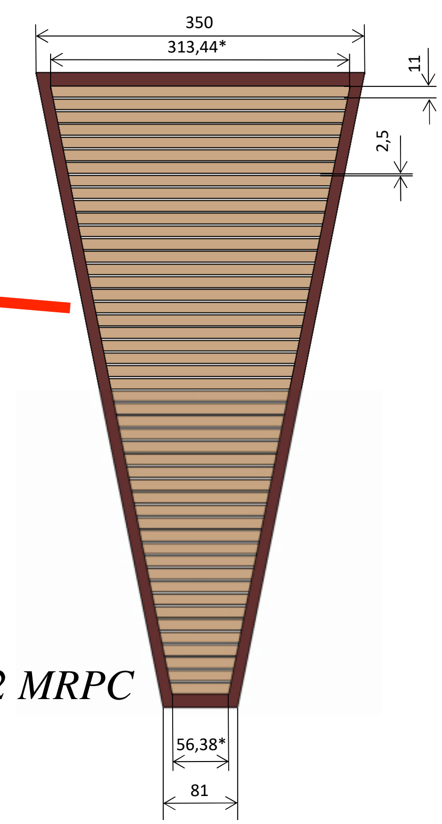
16×9=144 MRPC

TOF Chamder
32 strips





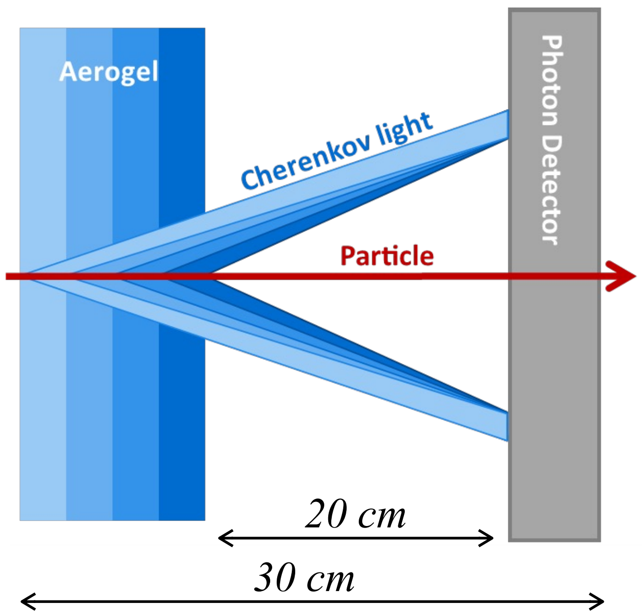
TOF Chambers for Endcap
48 strips



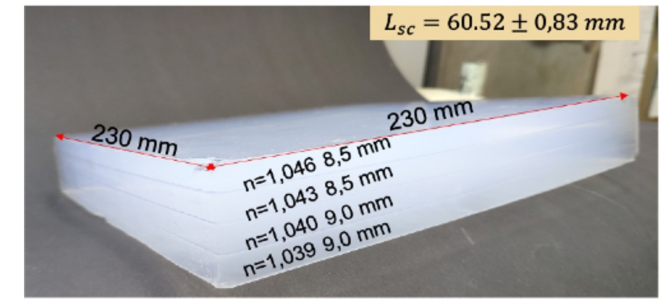
2×16=32 MRPC

Focusing Aerogel RICH (FARICH) detector

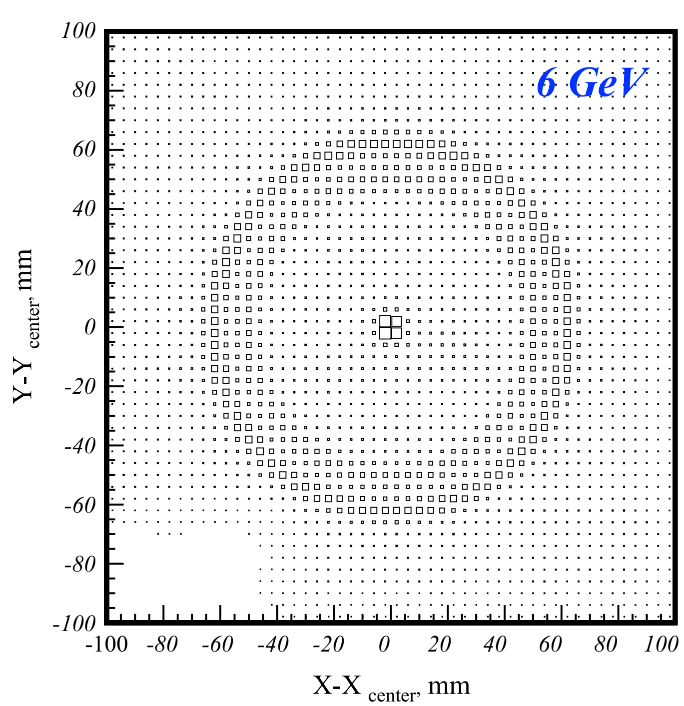
Principle of detector operation



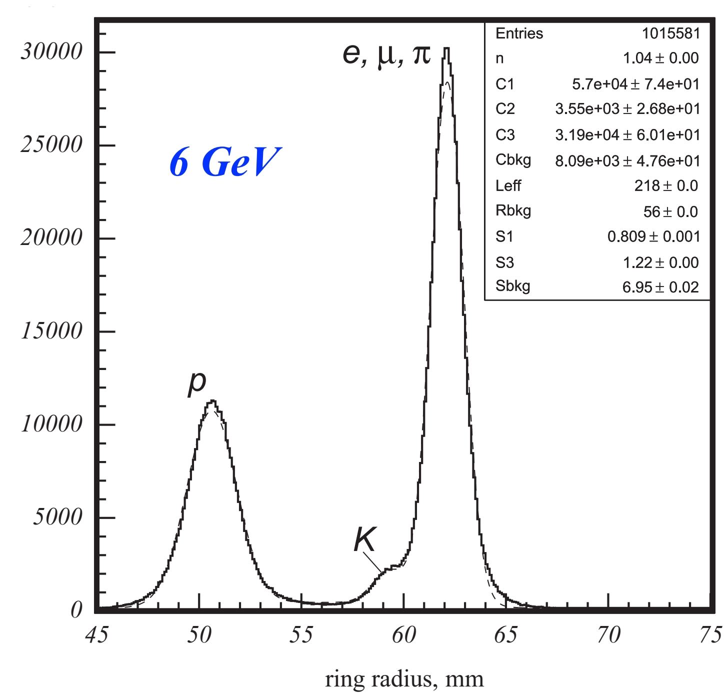
- Purpose: identification of high momentum particles ($p \gtrsim 1.5$ GeV) which cannot be discriminated by TOF
- Requirement: π/K separation at 6 GeV/c up to 3.5σ
- Disk-shaped detector in endcap with an area of 2 m²
- Multilayer focusing aerogel radiator produced in BINP
- Development of Multi-anode MCP-PMT is ongoing in Russia. So far PMT of Hamamatsu, Photonis, NNVT…
- The FARICH concept was published in 2005
- It was realized as a detector in Belle-II (KEK) in 2017



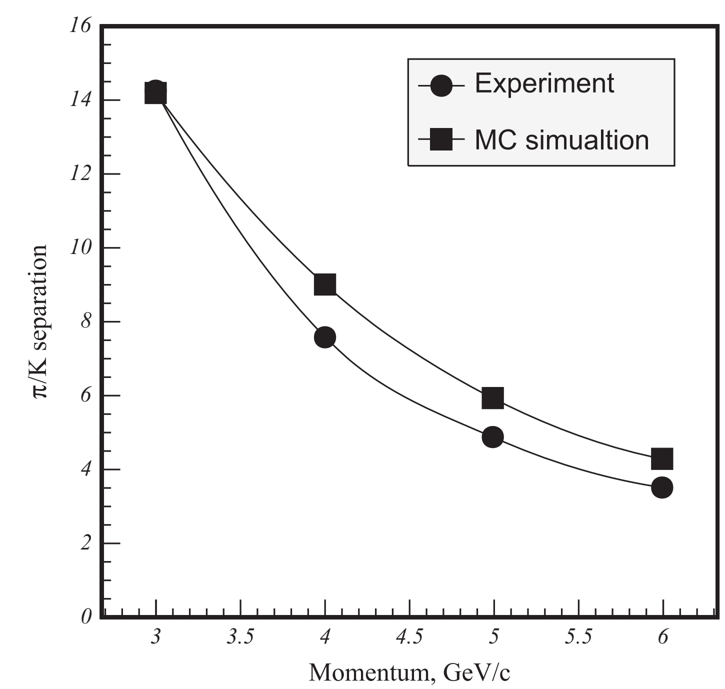
Accumulated *xy* distribution of hits



Ring radius distribution of γ



Ability to distinguish between π and K



A.Barnyakov et al, NIMA732(2013)352

Inner Tracker System of SPD

Micro pattern gaseous detector for the 1-st phase of SPD

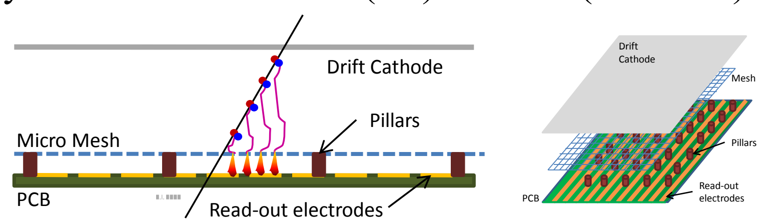
(commissioning by ~2028)

Silicon Vertex Detectors (SVD) for the 2-nd phase of SPD

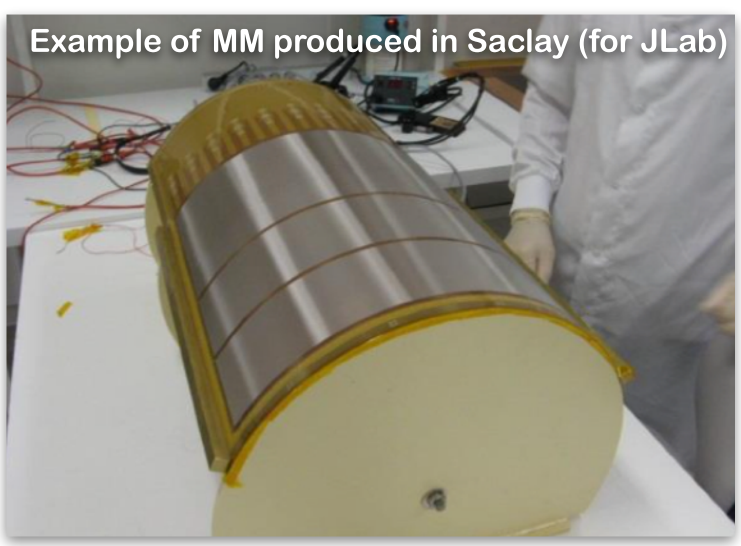
(one of two options, commissioning by ~2035)

Cylindrical MicroMegas (MM)

Purpose: temporary replacement for SVD, it serves to improve momentum resolution of tracks by about 2 times 3.5% (ST) →1.7% (ST+MM).



Ionization gap 3 mm, amplification gap 120 μm, gas mixture $Ar{:}C_4H_{10}$ = 90:10, gas gain 10^4, pitch size 450 μm, will be manufactured in LNP JINR, ***spatial resolution ~150 μm***.

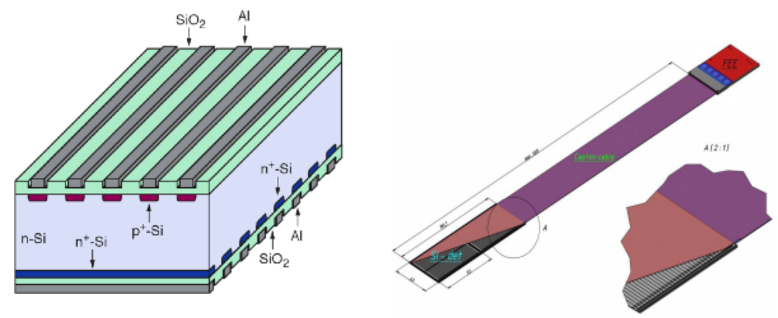


Example of MM produced in Saclay (for JLab)

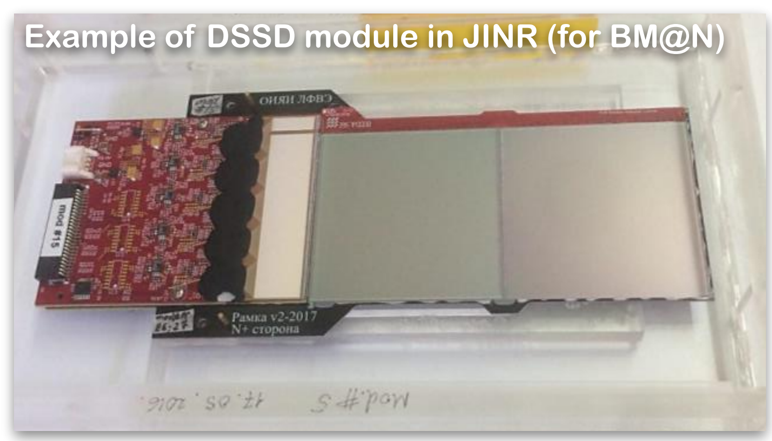
Bulk technology, cylindrically bent, 1 super-layer at R = 5 cm with strip tilt angles 0º, ±5º and length of 90 cm, readout electronics at two ends, ~5.4k channels.

Double-Sided Silicon Detector (DSSD)

Main purpose of the detector is to reconstruct the position of D-meson decay vertices (σ_z=76 μm).



Silicon wafer size 63×93 mm², thickness 300 μm, orthogonal strips on p^+ and n^+ sides, p^+ pitch 95 μm, n^+ pitch 282 μm, produced by ZNTC Russia, ***spatial resolution 27 (81) μm*** for p^+ (n^+) side.

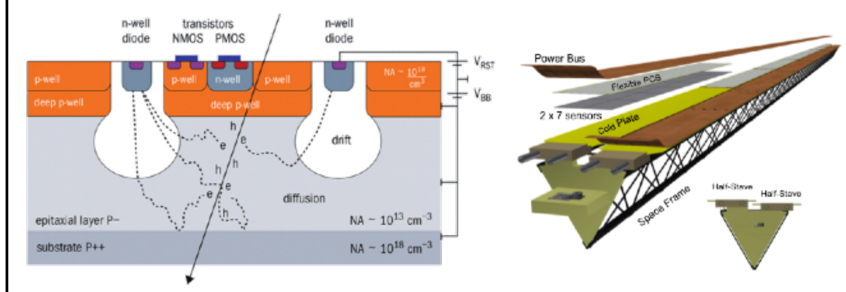


Example of DSSD module in JINR (for BM@N)

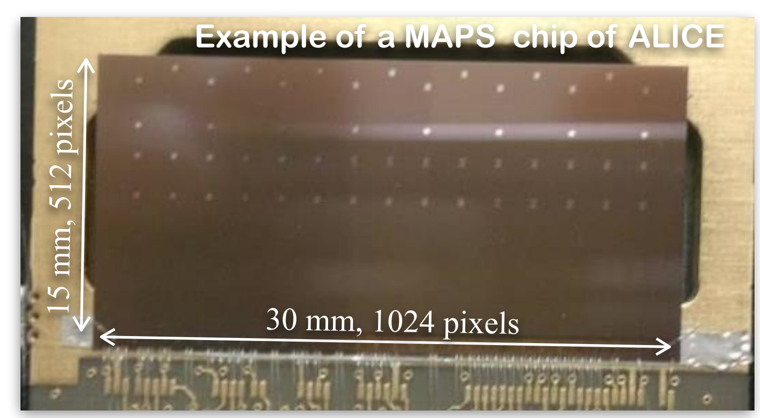
DSSD modules are assembled in ladders with carbon fiber support, 3 layers (R=5, 13, 21 cm) in barrel 74 cm long, 3 layers in each endcap, readout electronics at two ends, ~108k channels.

Monolithic Active Pixel Sensors (MAPS)

Main purpose of the detector is to reconstruct the position of D-meson decay vertices (σ_z=51 μm).



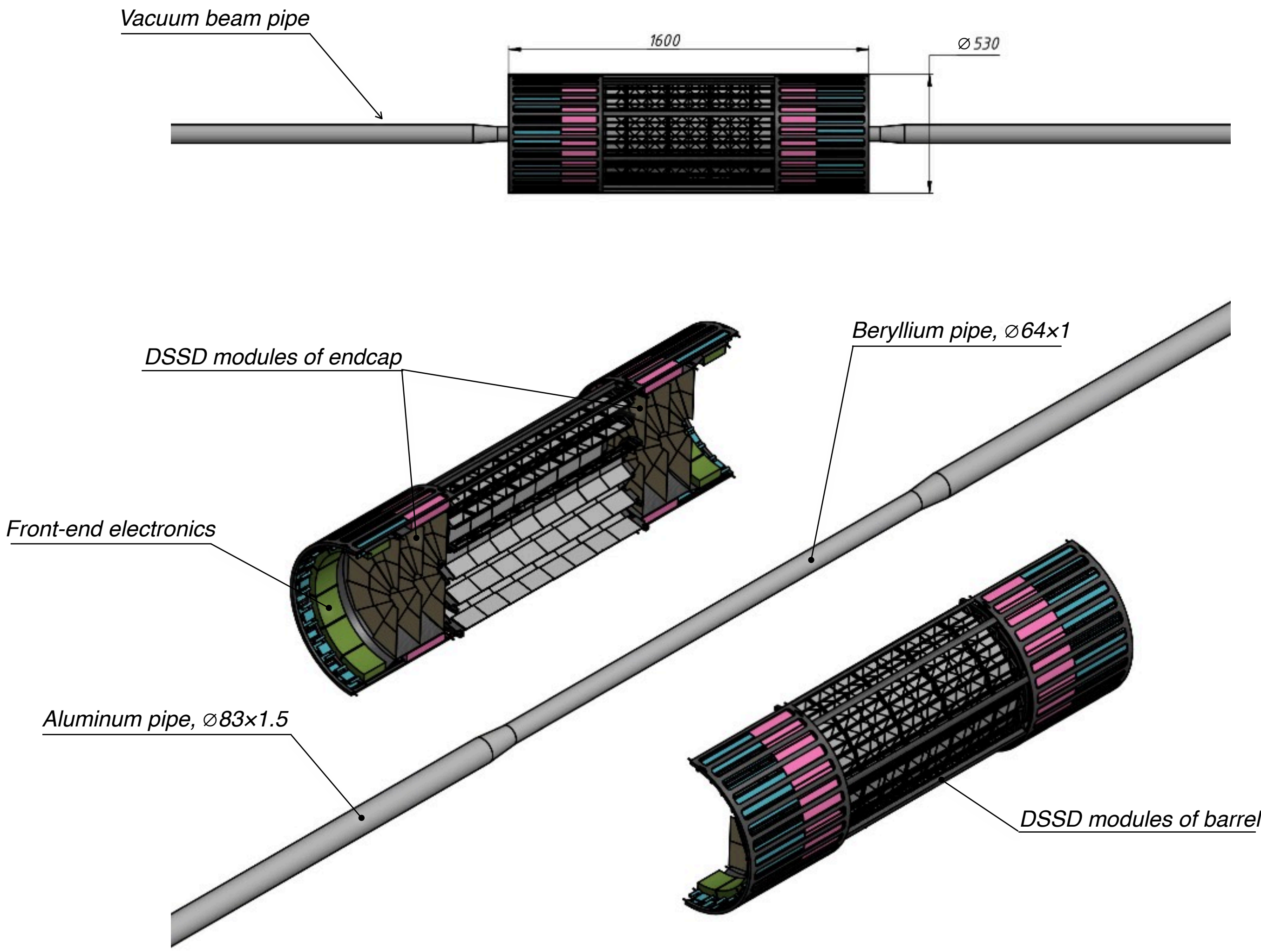
Silicon wafer size 30×15 mm², thickness 50 μm, pitch 28 μm, 512×1024 pixels, sensor and FEE sections are integrated in a single chip, so far is not produced in Russia, ***spatial resolution 5 μm***.

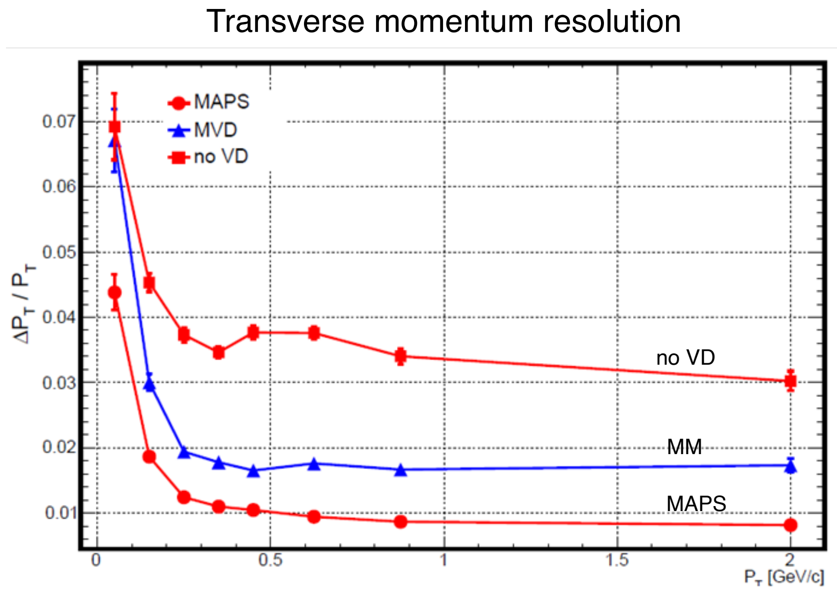


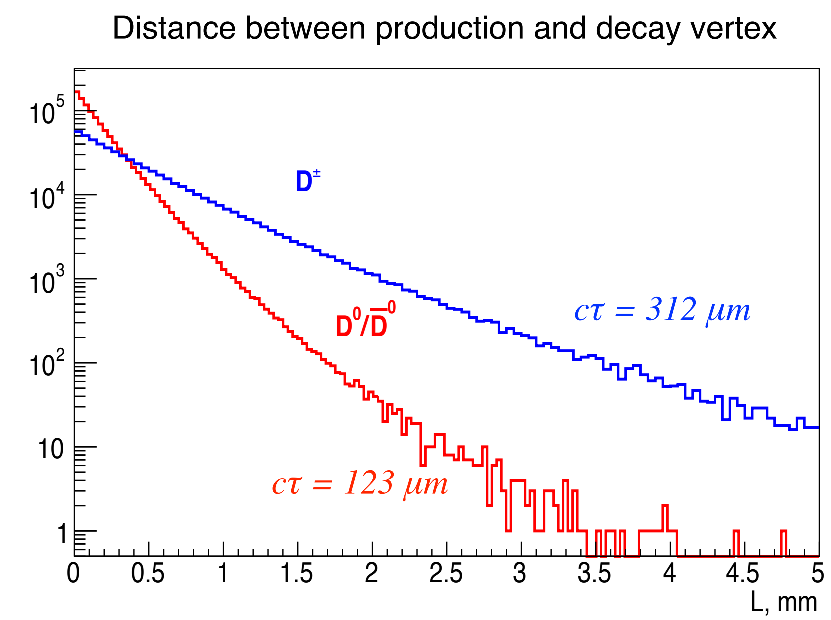
Example of a MAPS chip of ALICE

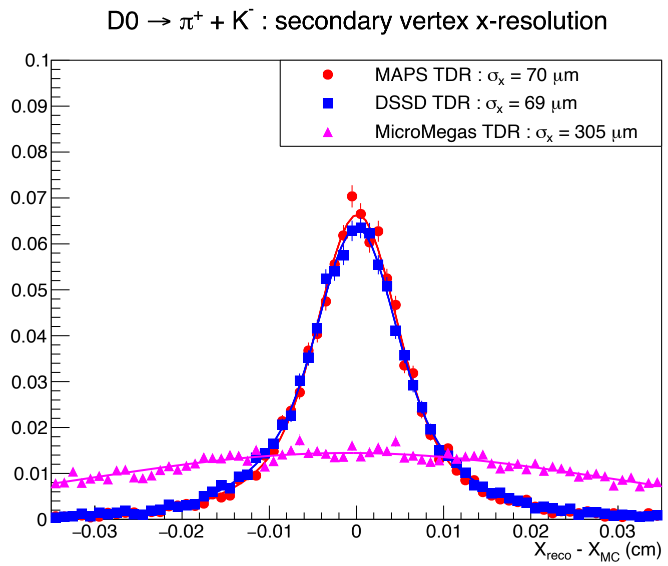
MAPS chips are assembled in staves with carbon fiber support, 4 layers (R=4, 10, 15, 21 cm) with the external layer 127 cm long, FE electronics is part of the chip, ~10^9 pixels for readout.

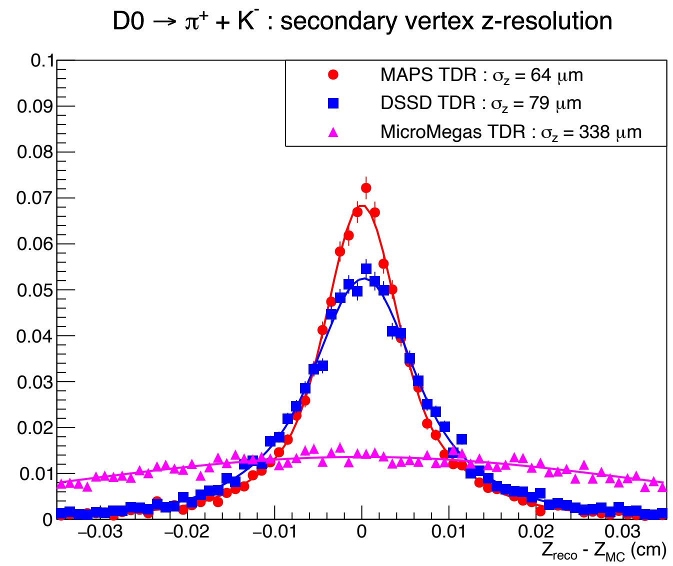
Silicon Vertex Detector (SVD)



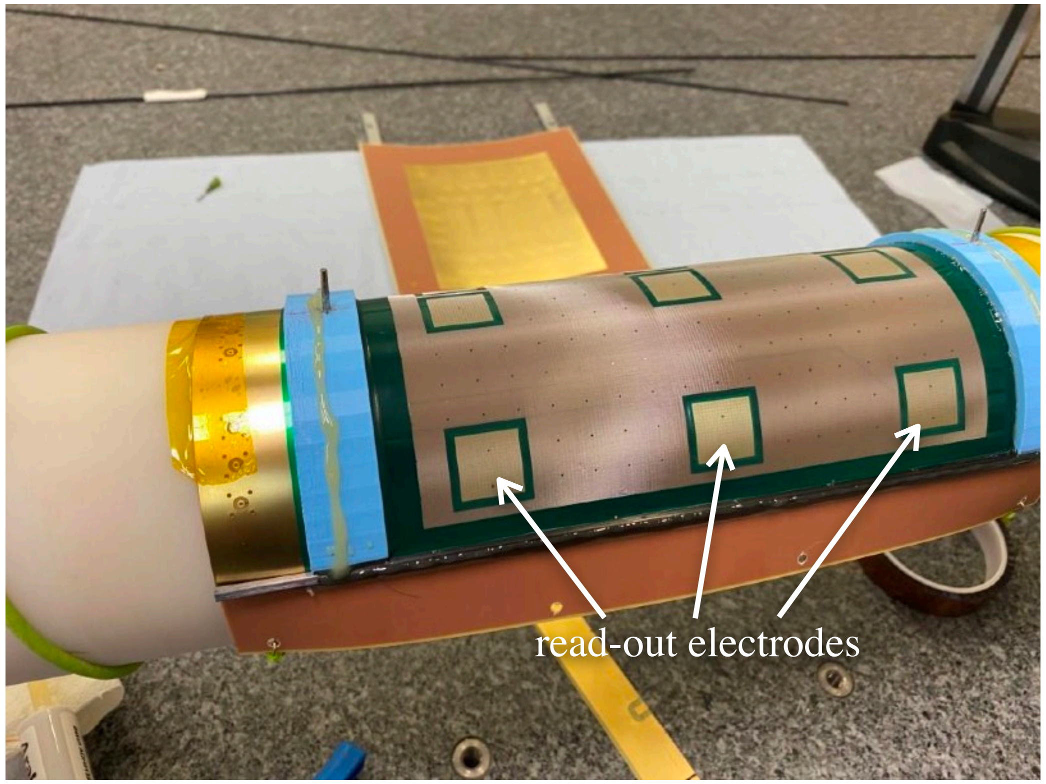




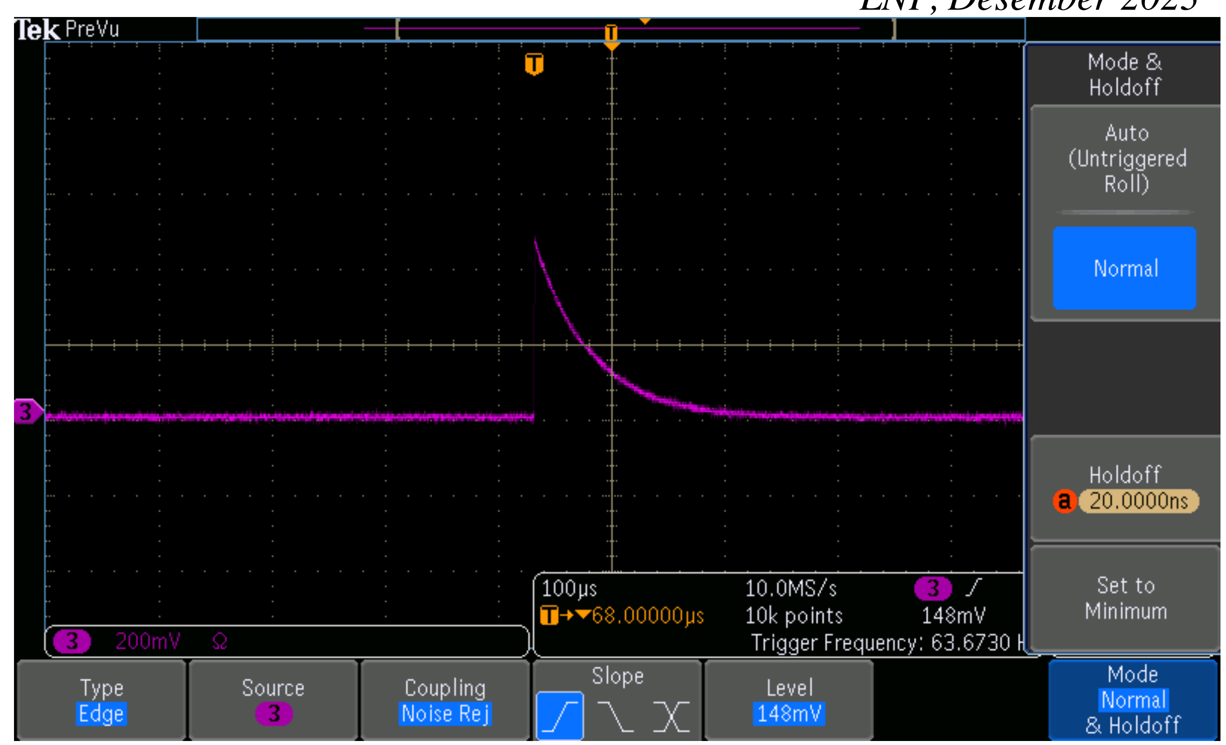




Progress in developing a cylindrical MM prototype in LNP

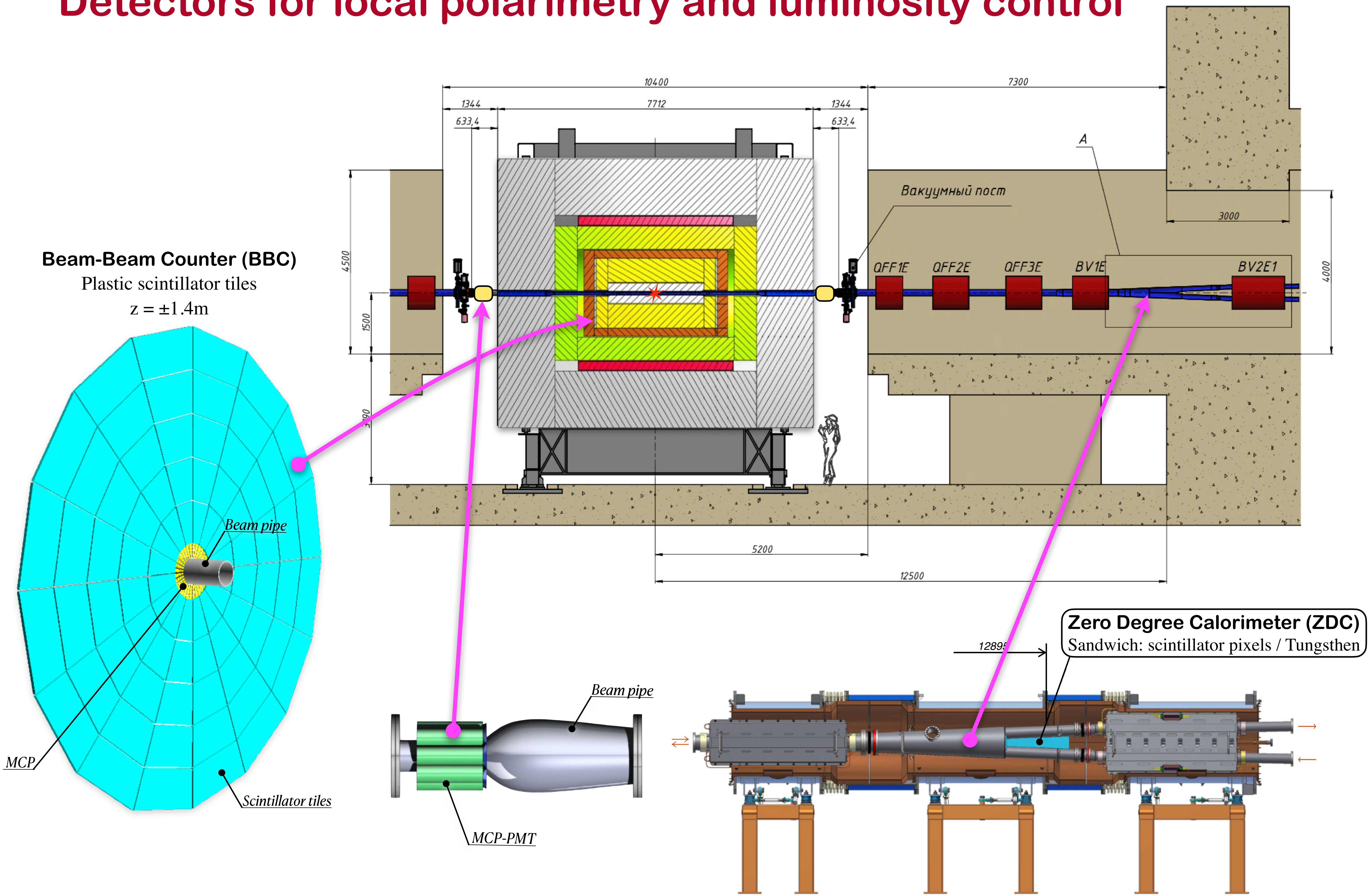


LNP, Desember 2023



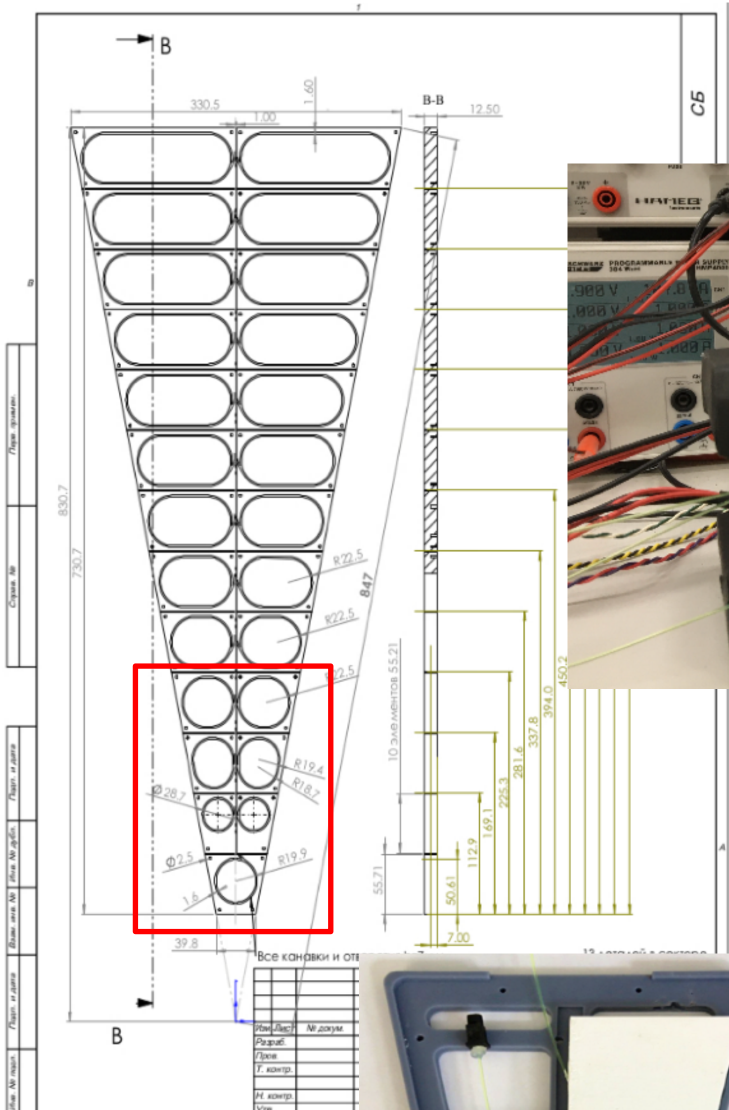
- Cylindrical MMs have so far been produced only in Saclay for CLASS12, R=10 cm.
- MM production stages for SPD (**R=5 cm**):
  - Photolithography to produce RO board
  - Bending and fixation on template
  - Gluing force elements (longbeams, arcs)
  - Gluing cathode plain and hermetization
  - Finalization (cut-out technological detail, add gas connectors, etc)
- Stable signal (U_{gain}=525V, G=10^4)

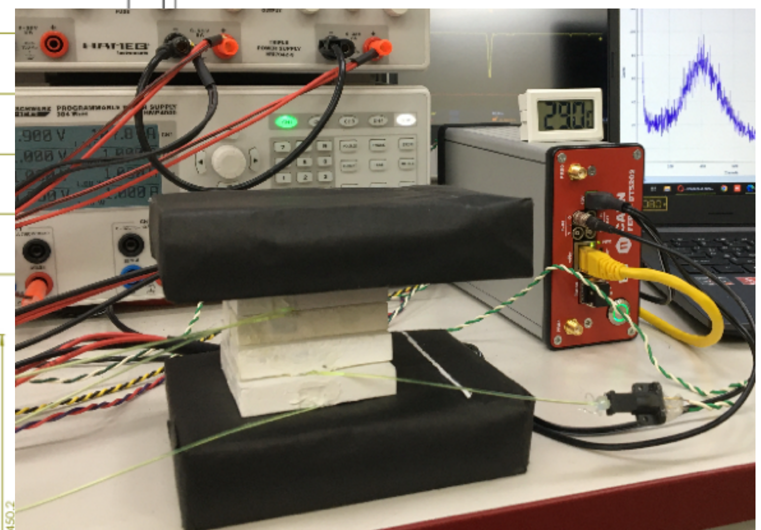
Detectors for local polarimetry and luminosity control



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

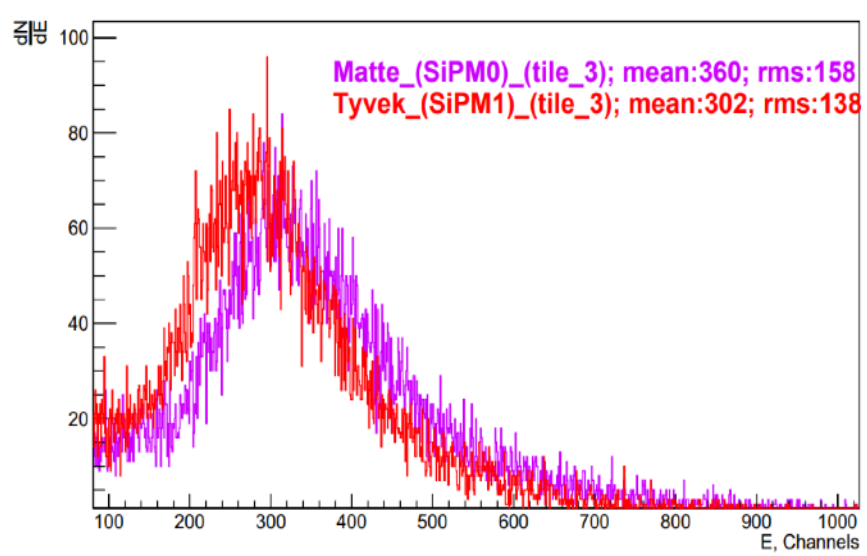
Progress on Beam-Beam-Counter (BBC)

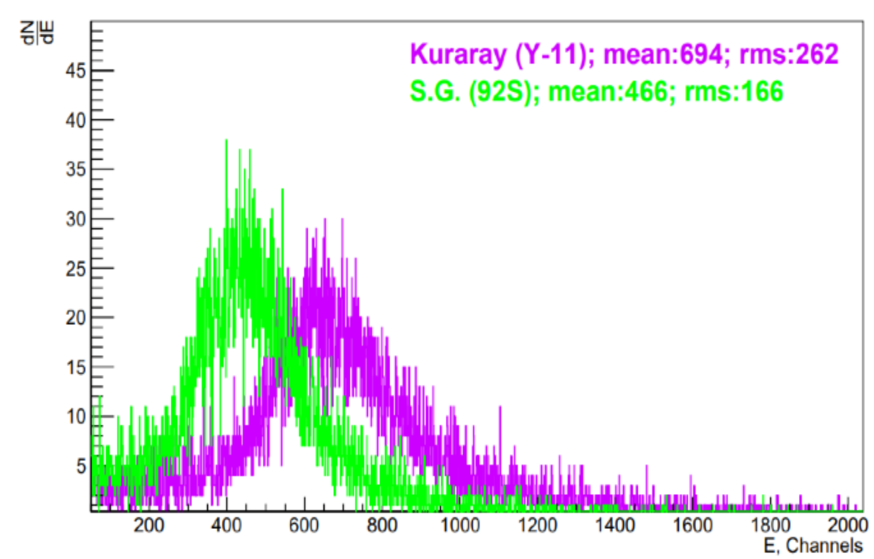




The BBC prototype options:

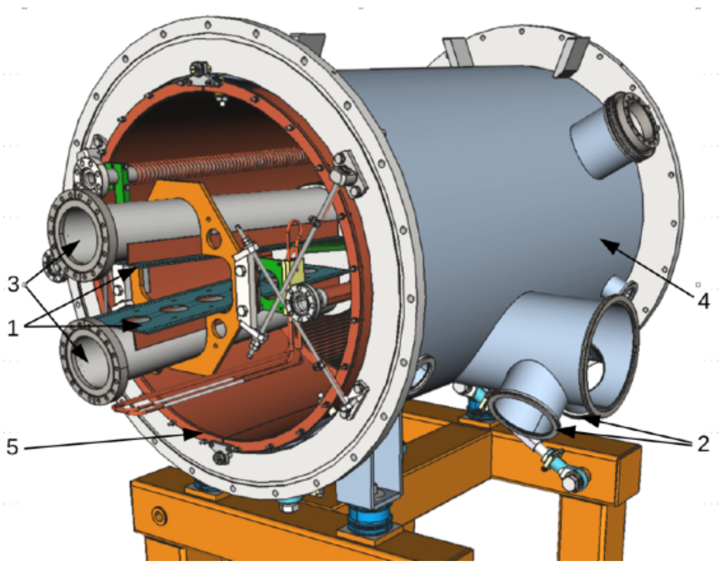
- ➢**CAEN FERS-5200 readout system**
- ➢scintillator prototype tiles (thickness 10 mm)
  - Tyvek covered vs **chemical mating**
- ➢scintillation optical fibers (WLS and clear)
  - KURARAY vs Saint-Gobain Crystals
- ➢optical cement
  - CKTN Med vs OK-72
- ➢SENSL SiPMs (MicroFC-x0035-SMT)
  - 3x3 mm² (for tests) vs **1x1 mm²**



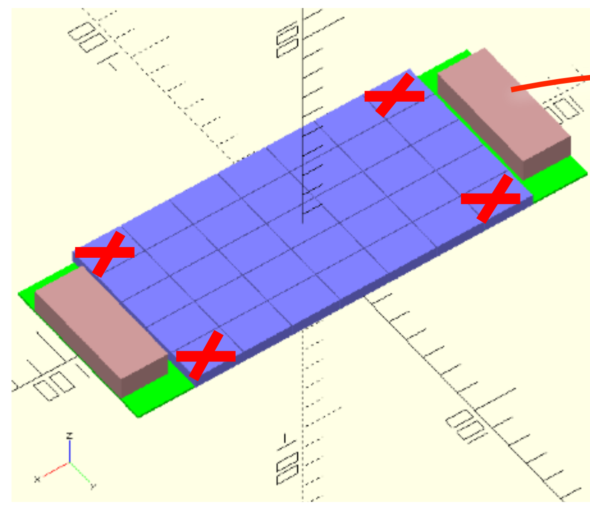


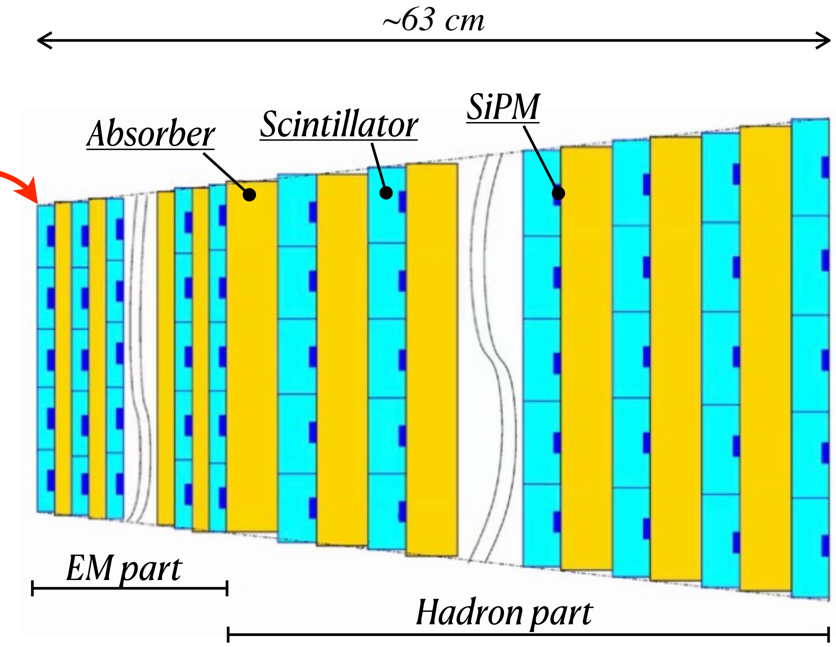
Currently, the selection of materials for the build of 7 detector prototype sector tiles is underway

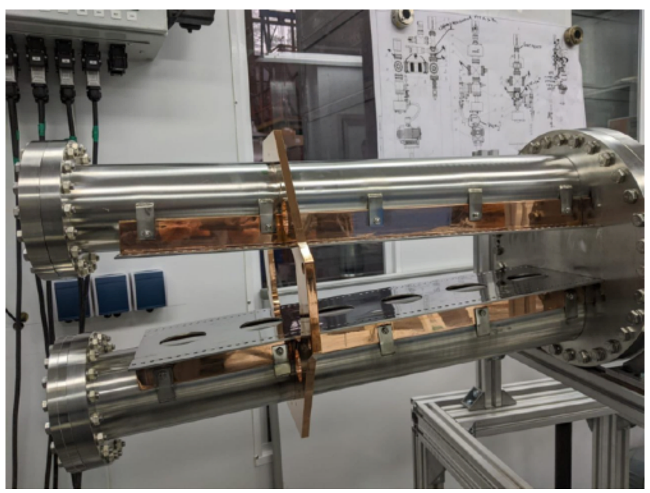
Progress on Zero Degree Calorimeter (ZDC)

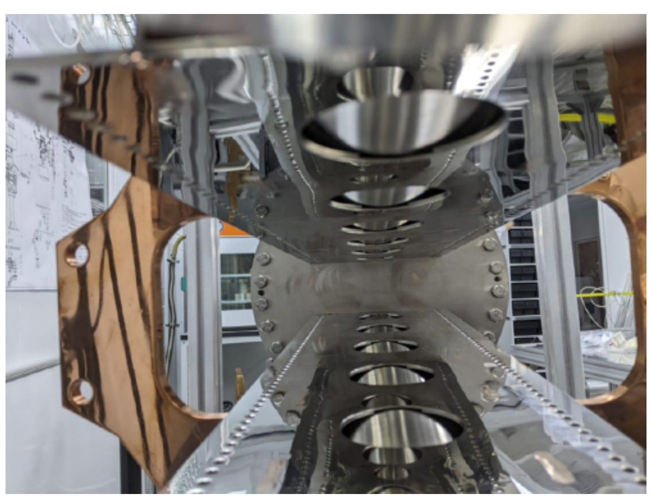


One plane of ZDC
(for initial tests)



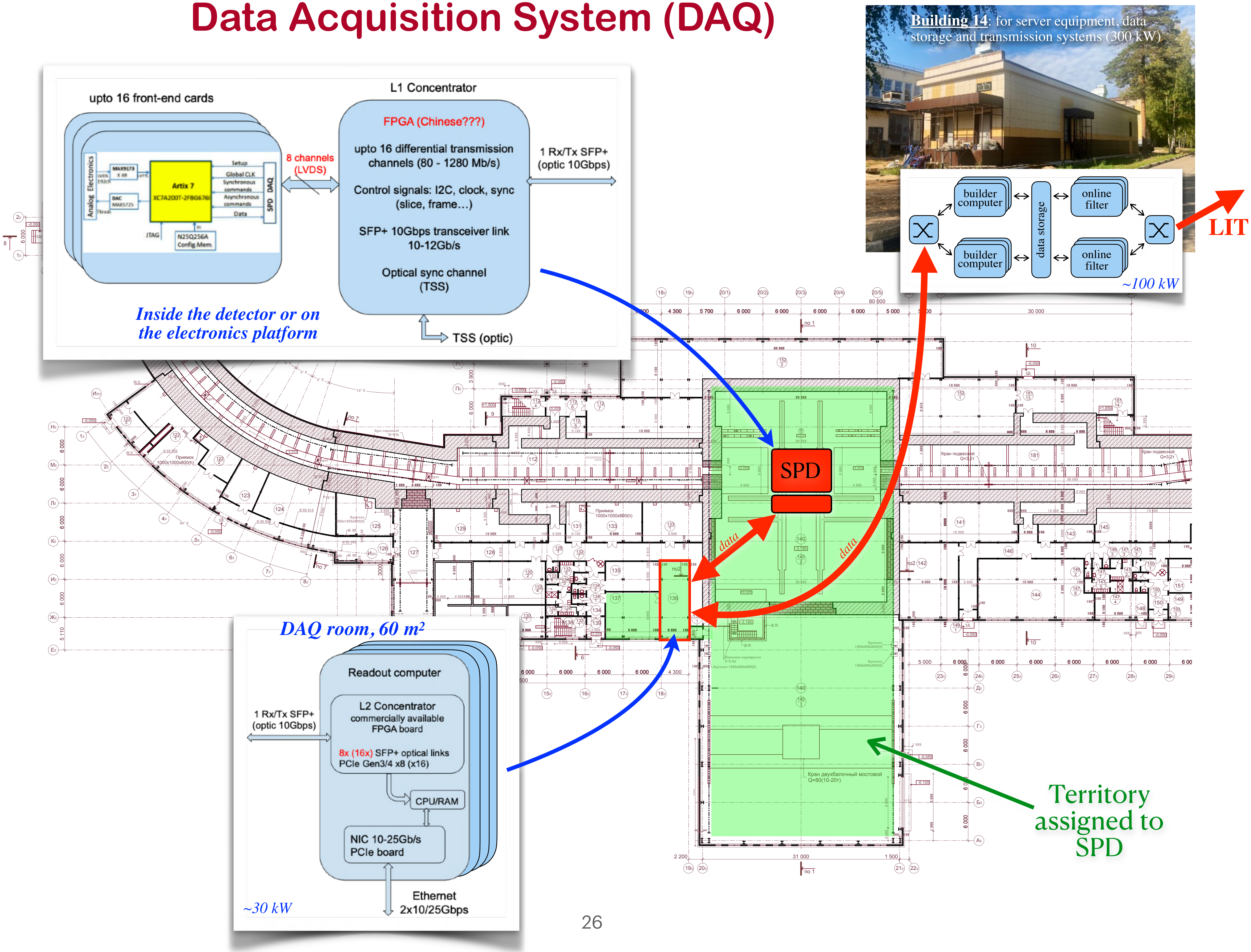






- Energy resolution for neutrons $(50 \div 60)\% \ / \ E \oplus (8 \div 10)\%$. Time resolution $150 \div 200$ ps. Neutron entry point spatial resolution 10 mm.
- Beam pipe sections for the ZDC cite are received in JINR October. Now under tests by vacuum group. The place for ZDC is fine and well acceptable for installation.
- For the initial test a single ZDC plane with 31 scintillator tile (no tiles in the corners) is being developed.
- DAQ electronics: A5202 based on Citiroc-1A chip produced by WeeROC (not available). Homemade discrete electronic board for the 1st stage.

Data Acquisition System (DAQ)



Status of the development

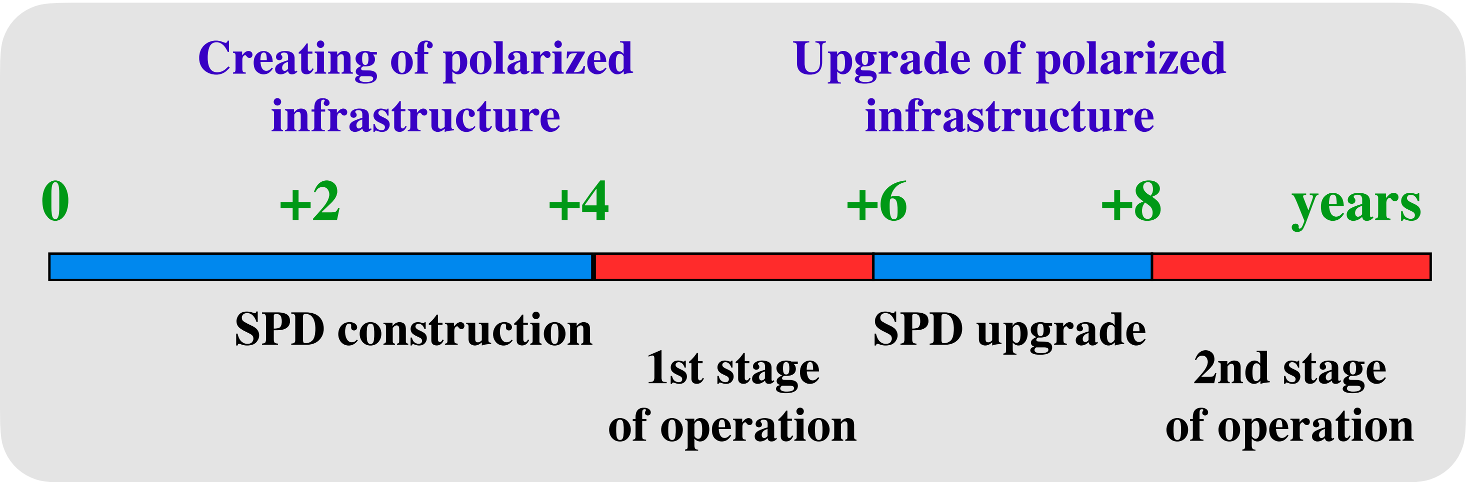
- Green: is ongoing well (proven technology or successful R&D)
- Red: open issue (to be defined or developed), at a conceptual level now

	Magnet (phase I)	RS (phase I)	ECal	Straw tracker (phase I)	TOF	FARICH
Power frame (mechanics)	contract for development of documentation	communication with manufacturer has begun		contract for development of conceptual design		
Active part of the detector	based on the PANDA magnet		interest from Tsinghua Uni		interest from Tsinghua Uni	
Readout & control electronics		final phase of development				

	MicoMegas (phase I)	DSSD	MAPS	BBC (phase I)	BBC-MCP (phase I)	ZDC (phase I)
Power frame (mechanics)		provided by the group			to be confirmed by accelerator team	
Active part of the detector	R&D in progress					R&D in progress
Readout & control electronics				purchased		

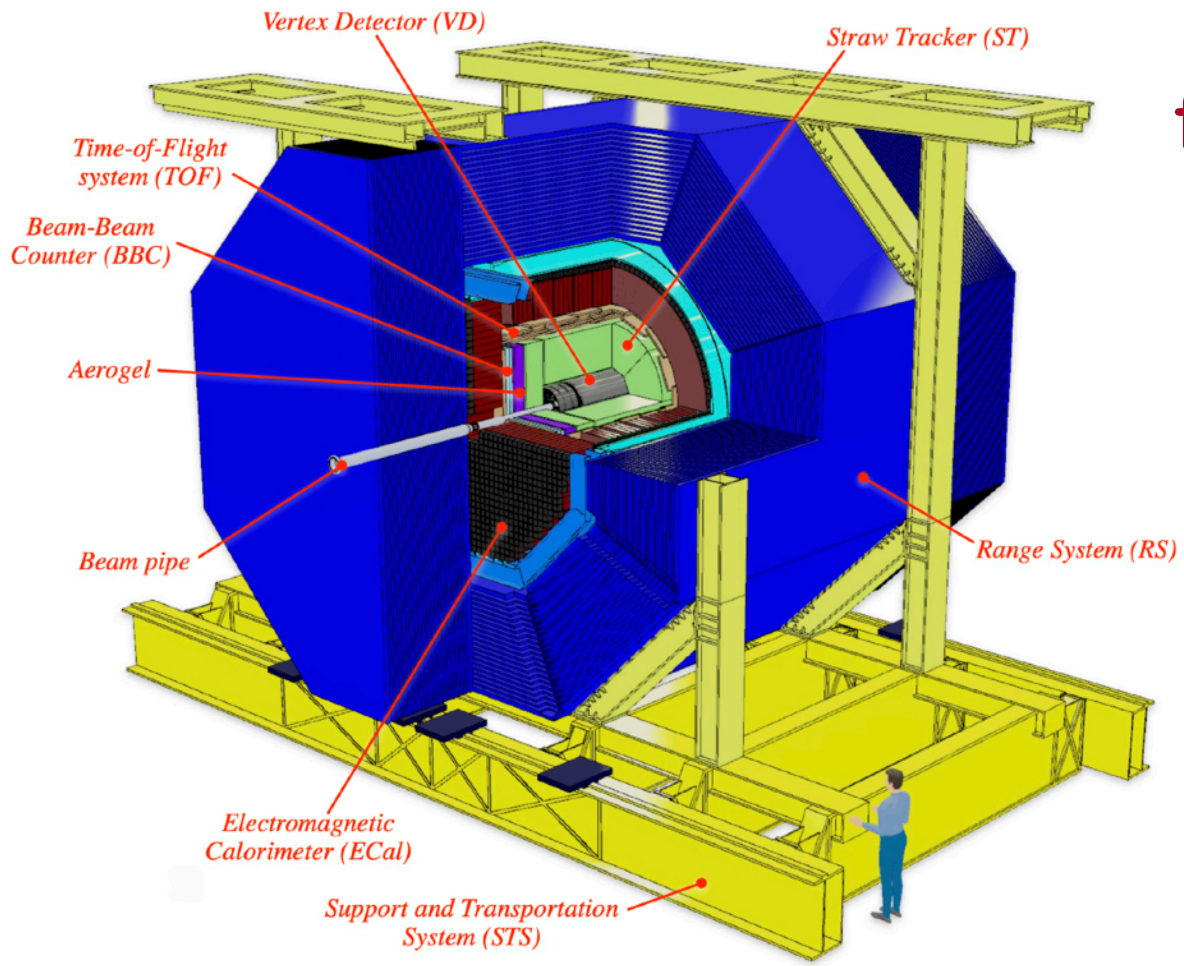
Conclusions

- NICA collider will start operation in heavy ion mode in early 2025
- Possibility of running (polarized) proton beams in NICA is currently being studied
- SPD (Spin Physics Detector) is a universal facility with the primary goal to study unpolarized and polarized gluon content of p and d
  - 4π detector will be equipped with silicon detector, straw tracker, TOF and FARICH for PID, calorimetry, muon system and monitoring detectors
- SPD Technical Design Report was released at the beginning of 2023
- More information could be found at http://spd.jinr.ru

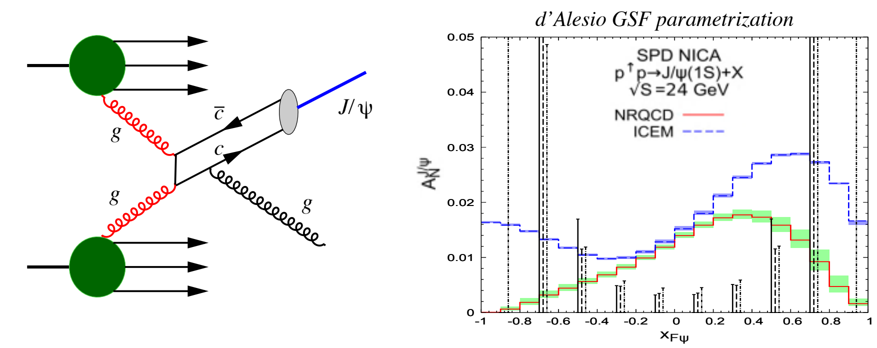


backup

Detector requirements for the SSA/TMD measurement

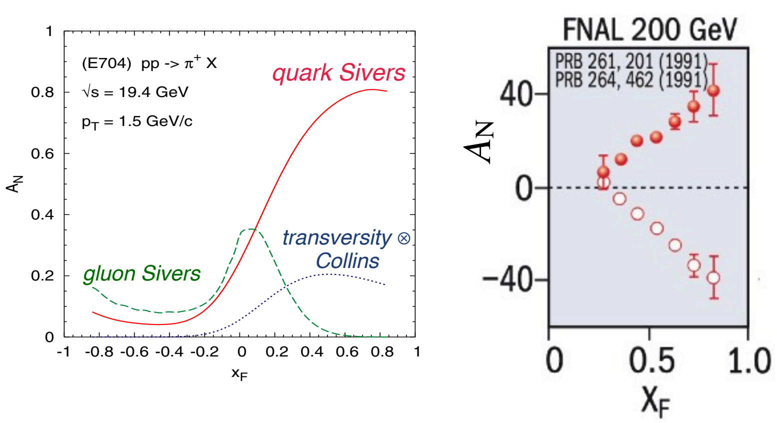


Gluon TMD: Charmonia (J/ψ) production



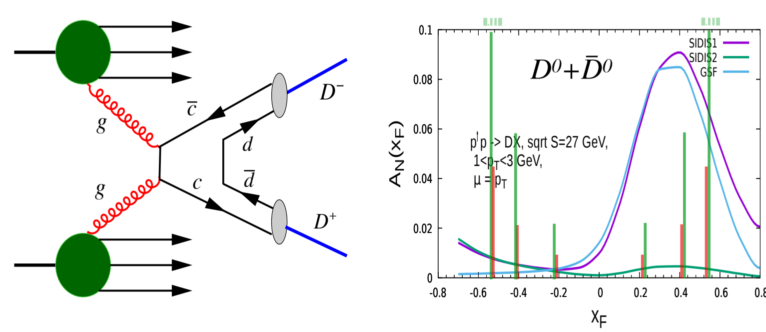
- Pair of muons from primary vertex to be identified
- **Range System** (iron interleaved by MDT detectors)
  - Thickness of $4\lambda_I$ or $4.5\lambda_I$ with ECal

Quark TMD: Light hadron π,K,p production



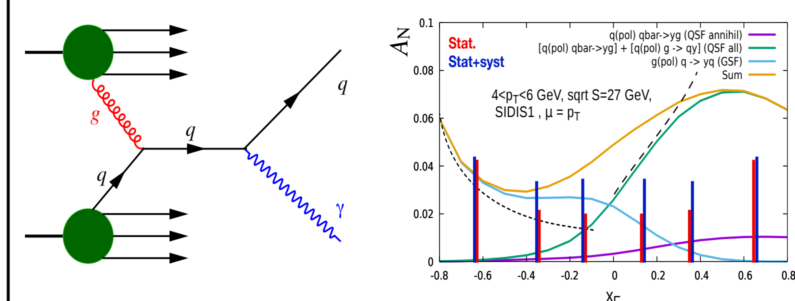
- High energy hadron identification (x_F>0.3)
- **FARICH** (Cherenkov photon detector)
  - Better than 3σ separation up to 6 GeV

Gluon TMD: Open charm ($D^{0,\pm}$) production



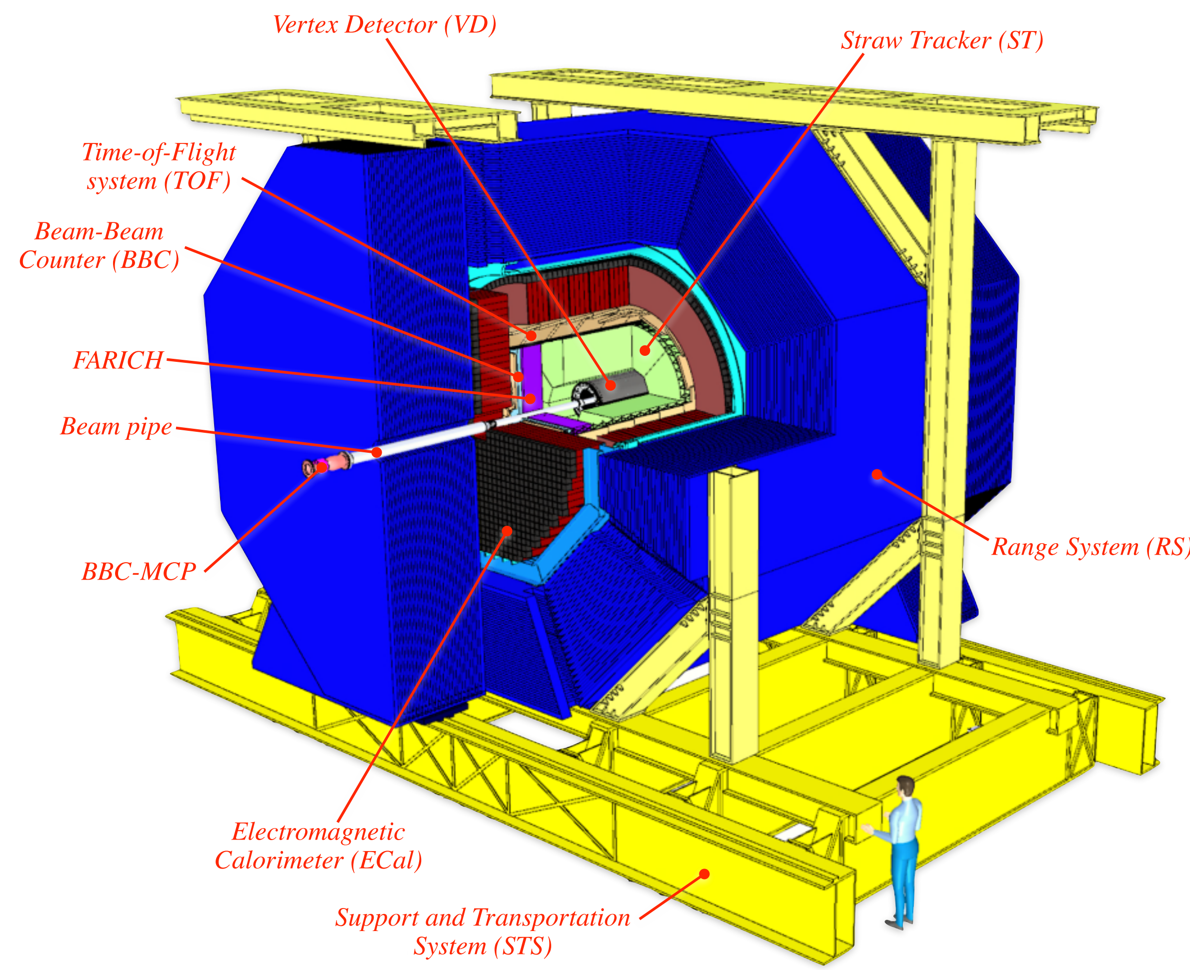
- Distinction of D-decay from primary vertex
  - Silicon detector (**DSSD** or **MAPS**)
- Identification of kaon from D-decay
  - **TOF** and **FARICH**

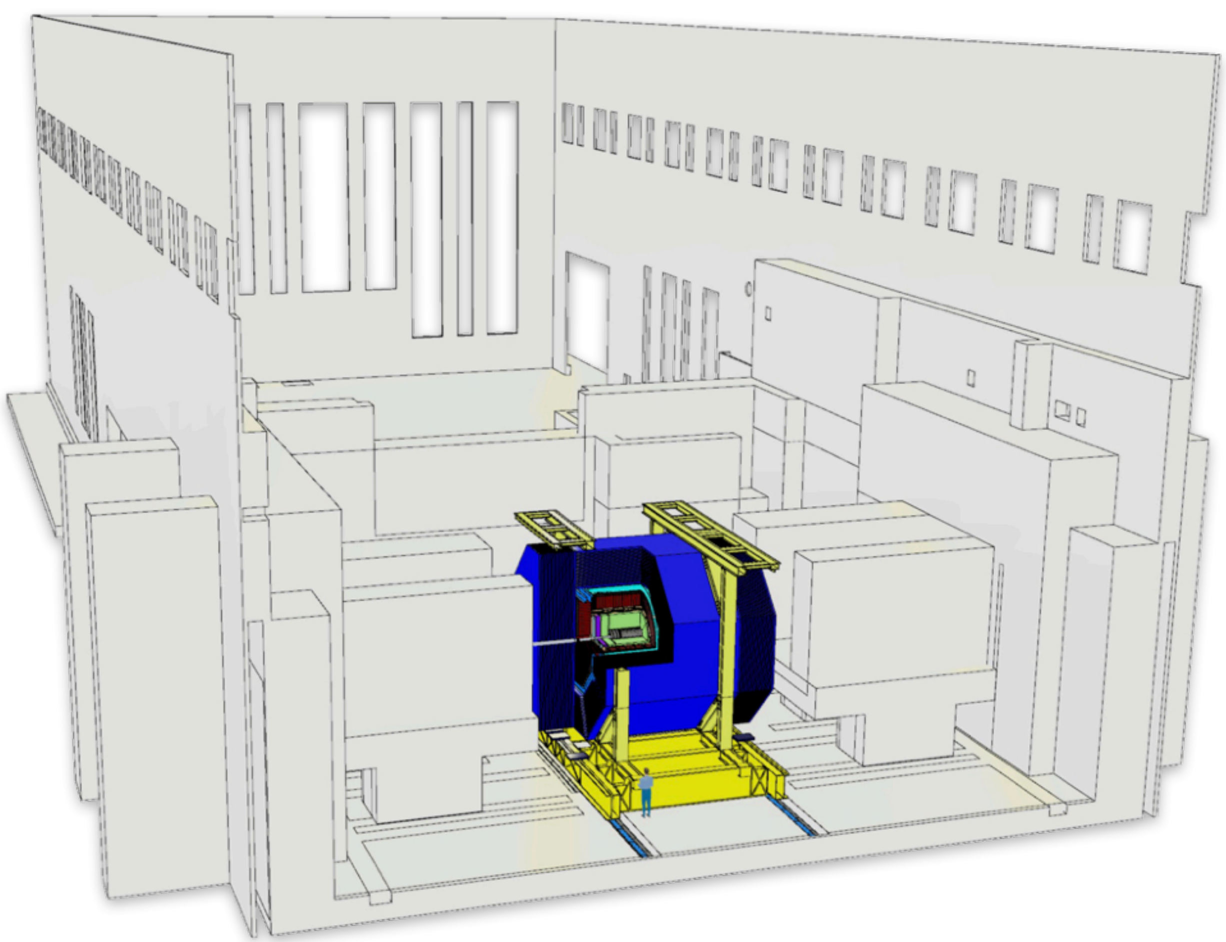
Gluon TMD: Prompt photon production



- High energy photons E>4 GeV to be detected
- **Electromagnetic calorimeter (ECal)**
  - 40 cm long cell = 200 layers of lead and scintillator
  - Thickness of $18.6X_0$

- Universal 4π detector 6.6 m high and 7.7 m long
- Superconductive solenoid providing 1T field
- Tracking and vertexing provided by Silicon Vertex Detector and Straw Tracker
- Hadron PID by TOF and Aerogel detectors
- Photon and $e^{\pm}$ selection by ECal
- Muon identification by Range System
- Local polarimetry and luminosity control by BBC, MCP and ZDC detectors
- Luminosity of 10^{32} $cm^{-2}s^{-1}$ at $\sqrt{s}$=27 GeV results in interaction rate of 4 MHz for protons

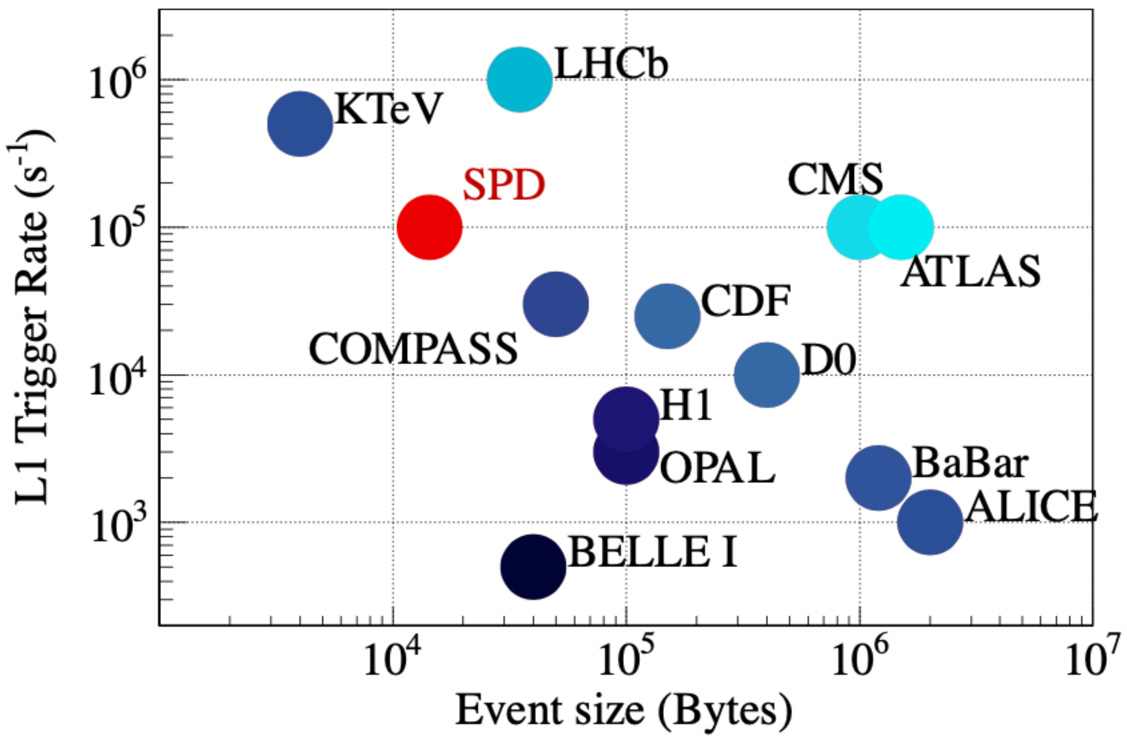




- Single-span building with overall dimensions of 32 × 72 m^2, which is divided into
  - unloading and production area located at ground level.
  - concrete-protected experimental area located 3.2 m below ground level.
- One-pipe-section of 30 m long, where 9 m of this section can be allocated for detectors.
- Weight of the experimental setup is limited to 1200 tons.

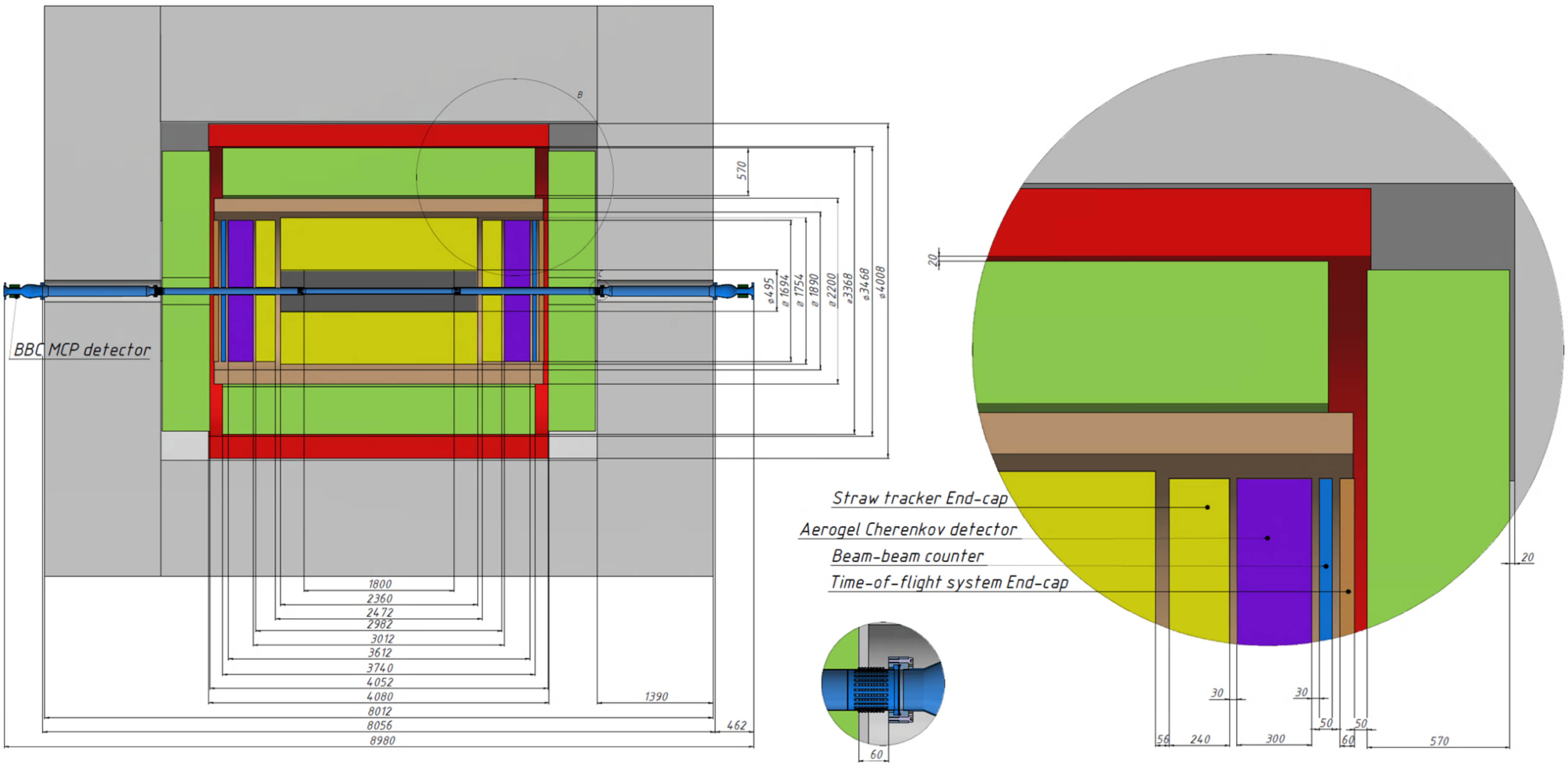
Data Acquisition System (DAQ)

- Bunch crossing every 76 ns → crossing rate 12.5 MHz
- At maximum luminosity of 10^{32} $cm^{-2}s^{-1}$ the interaction rate is 4 MHz
- No hardware trigger to avoid possible biases
- Raw data stream 20 GB/s or 200 PB/year
- Online filter to reduce data by oder of magnitude to ~10 PB/year

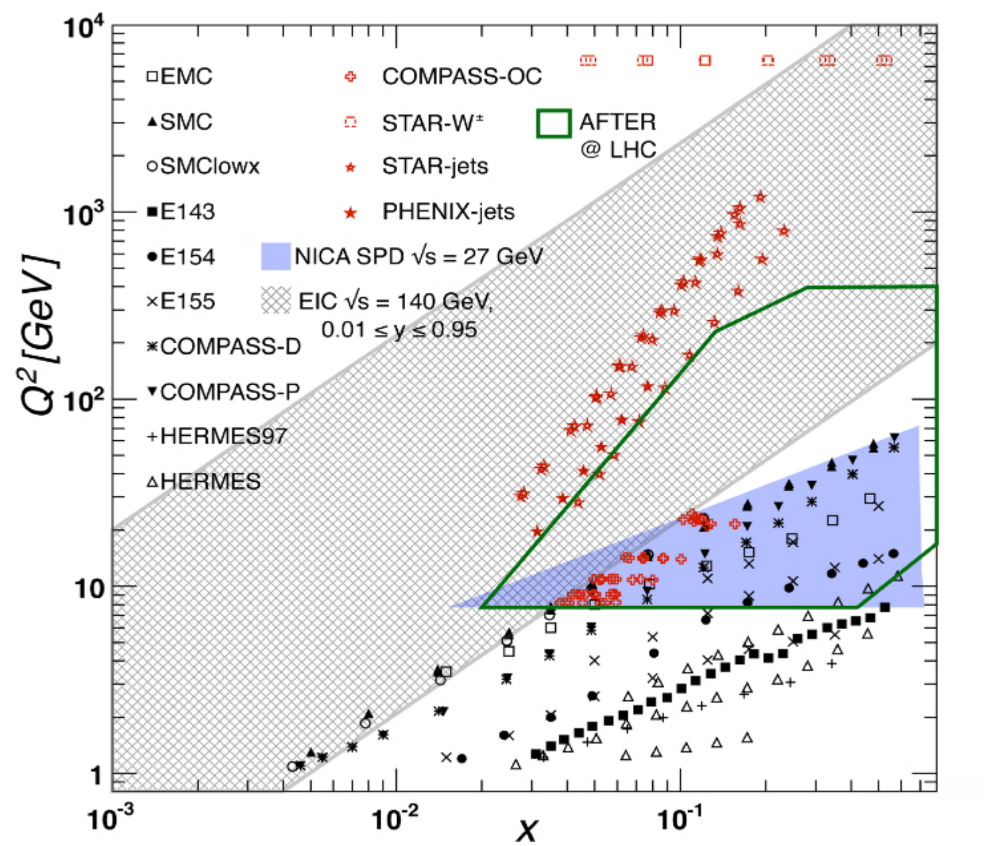


Data volume vs time

- ***Preparation for the experiment.*** Monte Carlo simulation from 2024 to 2028 will provide 2 PB per year. Total per stage: ***10 PB***.
- ***Stage I:*** running at low luminosity of the NICA collider. Monte Carlo simulation and real data taking from 2028 to 2030 will provide 4 PB per year. Reprocessing: 2 PB per year. Total per stage: ***18 PB***.
- ***Upgrade of the setup*** for operation at high luminosity. Monte Carlo simulation from 2031 to 2032 will provide 2 PB per year. Reprocessing: 2 PB per year. Total per stage: ***8 PB***.
- ***Stage II:*** running at maximum design luminosity of the NICA collider. Monte Carlo simulation and real data taking from 2033 to 2036 will provide 20 PB per year. Reprocessing: 10 PB per year. Total per stage: ***120 PB***.

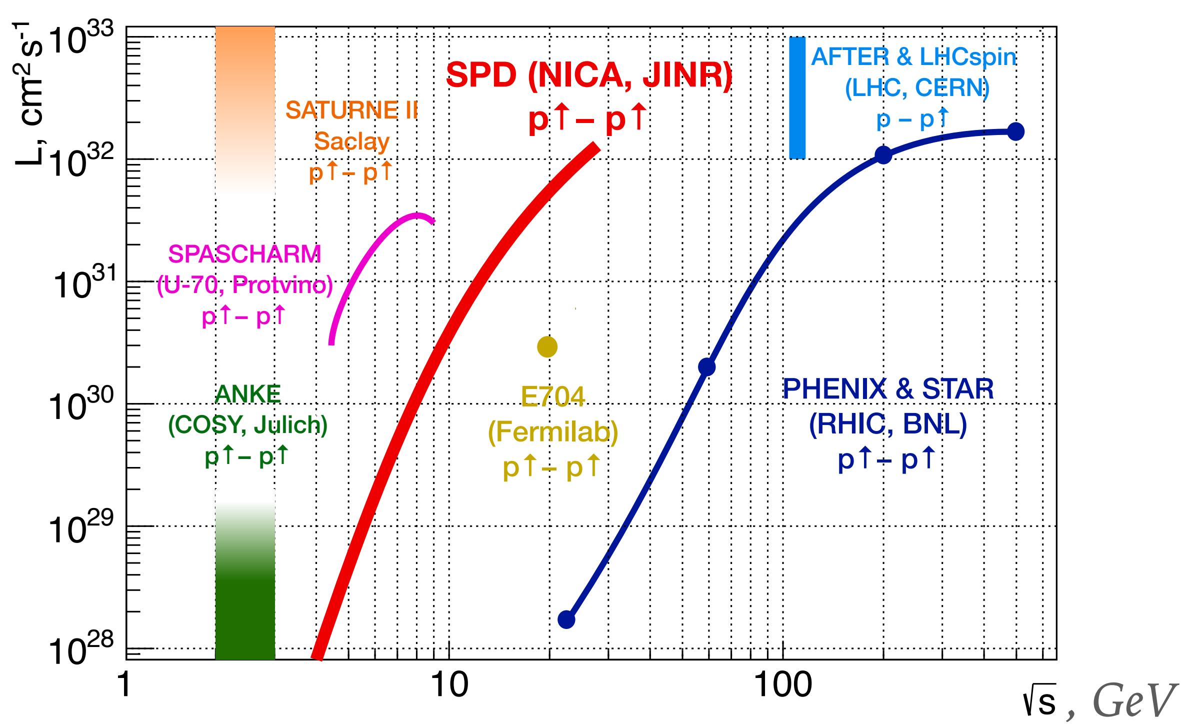

BBC MCP detector
570
ø495
ø 1694
ø 1754
ø 1890
ø 2200
ø3368
ø3468
ø4008
1800
2360
2472
2982
3012
3612
3740
4052
4080
8012
8056
8980
1390
462
60
Straw tracker End-cap
Aerogel Cherenkov detector
Beam-beam counter
Time-of-flight system End-cap
20
20
30
30
50
50
56
240
300
60
570

SPD compared to other spin experiments



Main present and future gluon-spin-physics experiments

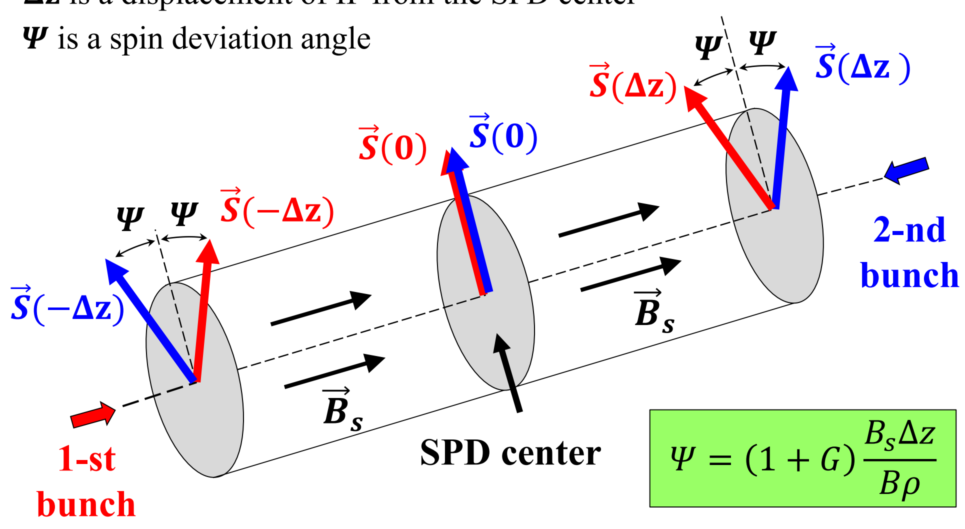
Experimental facility	SPD @NICA	RHIC	EIC	AFTER @LHC	LHCspin
Scientific center	JINR	BNL	BNL	CERN	CERN
Operation mode	collider	collider	collider	fixed target	fixed target
Colliding particles & polarization	$p^\uparrow$-$p^\uparrow$ $d^\uparrow$-$d^\uparrow$ $p^\uparrow$-d, p-$d^\uparrow$	$p^\uparrow$-$p^\uparrow$	$e^\uparrow$-$p^\uparrow$, $d^\uparrow$,^{3}He$^\uparrow$	p-$p^\uparrow$,$d^\uparrow$	p-$p^\uparrow$
Center-of-mass energy $\sqrt{s_{NN}}$, GeV	≤27 (p-p) ≤13.5 (d-d) ≤19 (p-d)	63, 200, 500	20-140 (ep)	115	115
Max. luminosity, 10^{32} cm^{-2} s^{-1}	~1 (p-p) ~0.1 (d-d)	2	1000	up to ~10 (p-p)	4.7
Physics run	>2025	running	>2030	>2025	>2025



- Access to intermediate and high values of x
- Low energy but collider experiment (compared to fixed target). Nearly 4π coverage
- Two injector complexes available ⇒ mixed combinations p↑-d and p-d↑ are possible

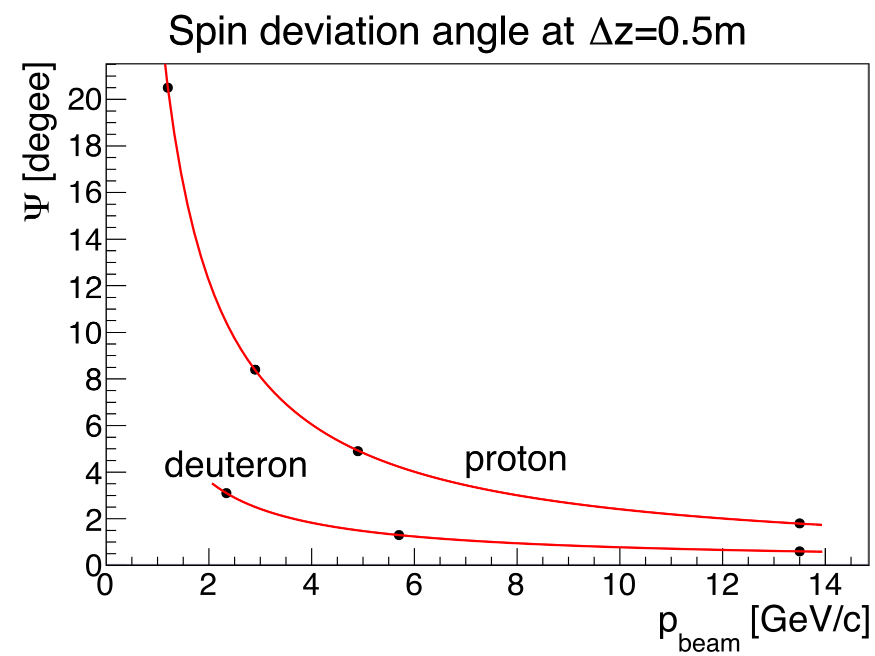
Spin dynamics in the SPD solenoidal field 1T

Δz is a displacement of IP from the SPD center
Ψ is a spin deviation angle



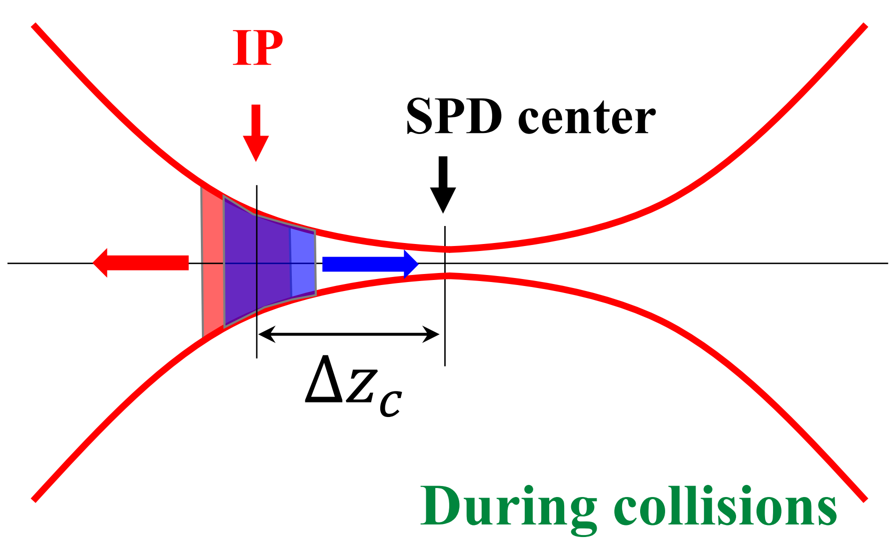
$$\Psi = (1+G)\frac{B_s \Delta z}{B\rho}$$

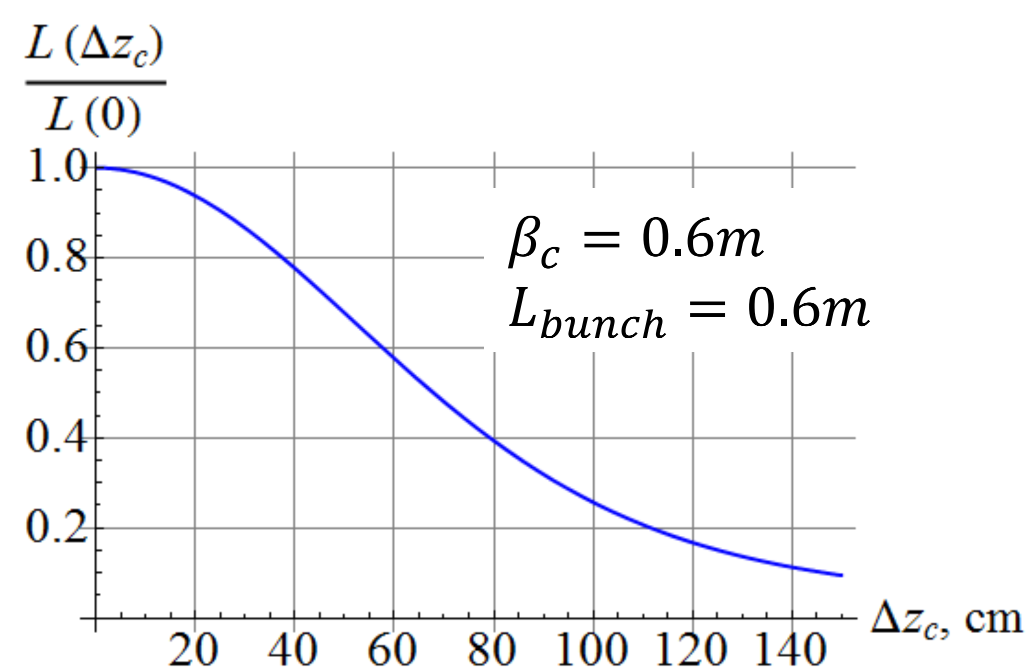
$B\rho$ is a magnetic rigidity

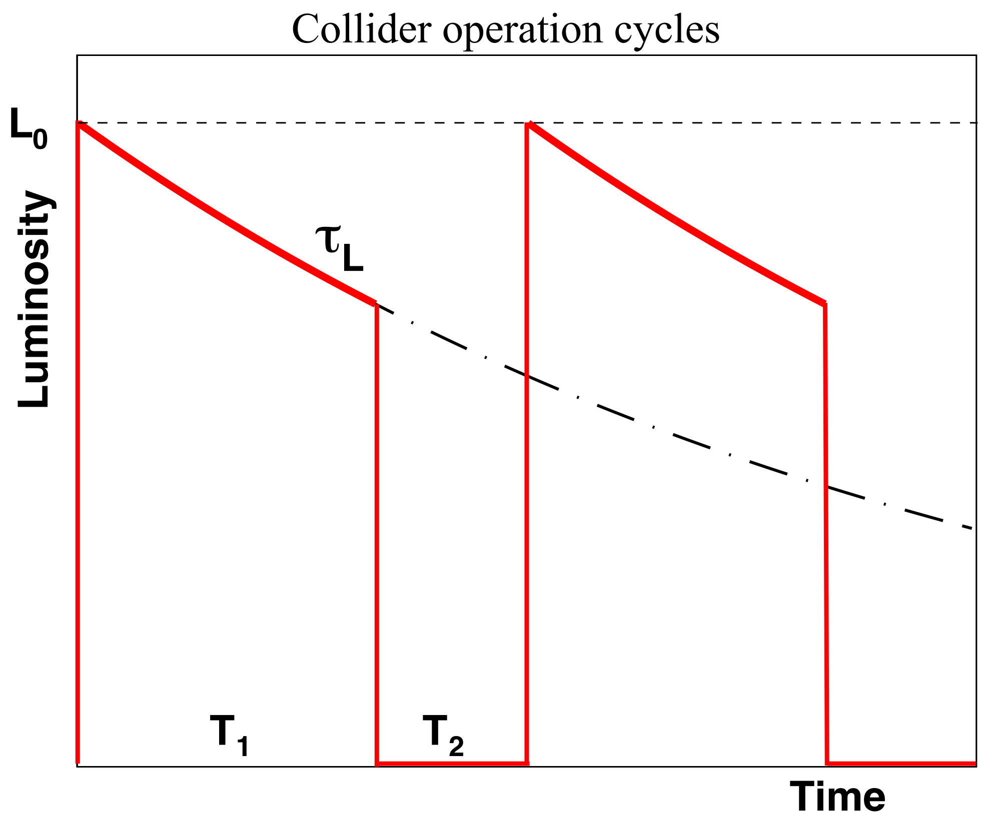


Luminosity reduction due to displacement of IP from the SPD center

IP is displaced from the SPD center







- Formation of polarized proton beams in the NICA collider is presently under study
  - $T_1 \approx 2h$, $T_2 \approx 1h$, $\tau_L \approx 6h$, $\tau_P \approx 3day$
  - Effective luminosity $L_{eff} \approx 0.6L_0$, maximum luminosity $L_0 \approx 10^{23}\ cm^{-2}s^{-1}$

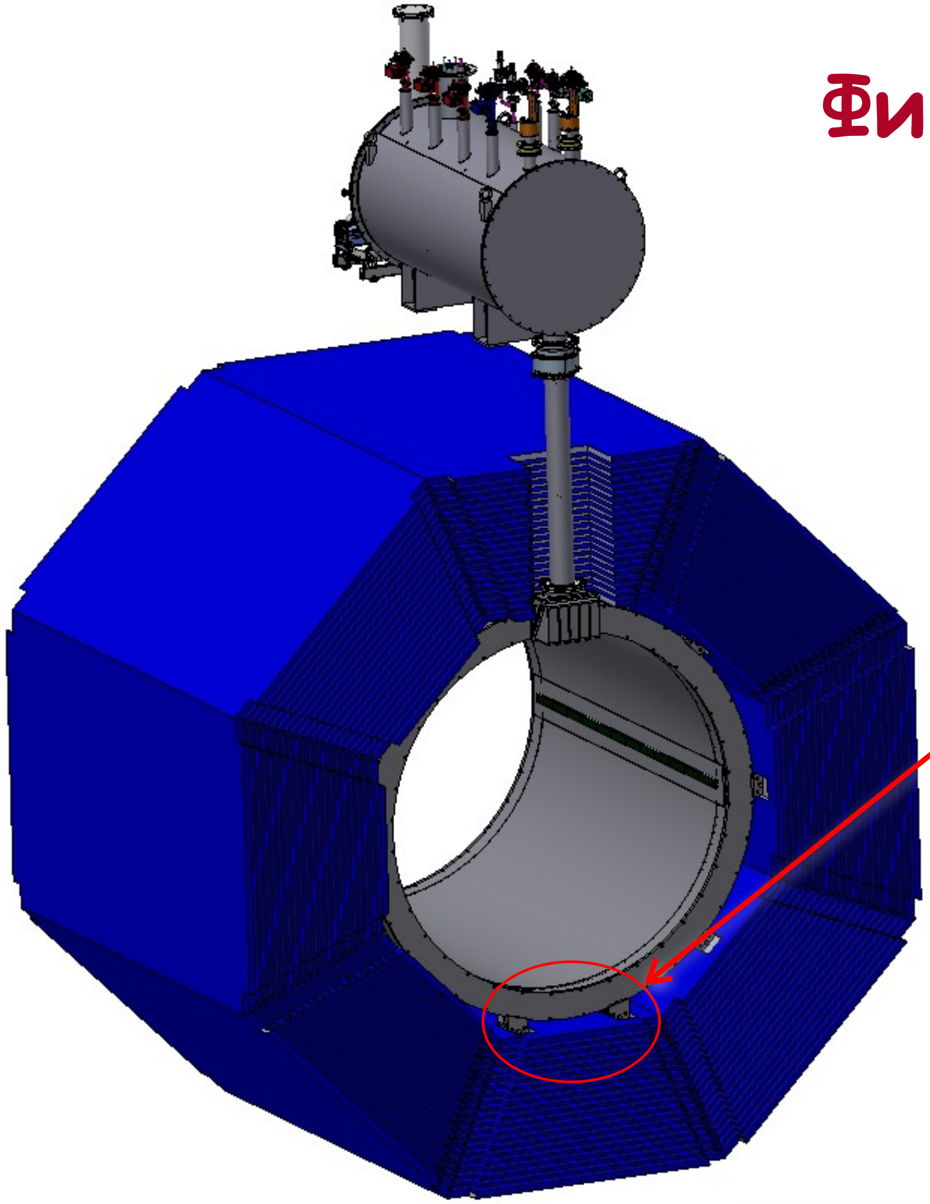
- All bunches in one ring will have the same polarization (~70%)
- Spin navigator (SN) is based on weak solenoids with $BL \leq 0.6Tm$
- It takes ~1s for Spin-Flipper based on SN to reverse the polarization

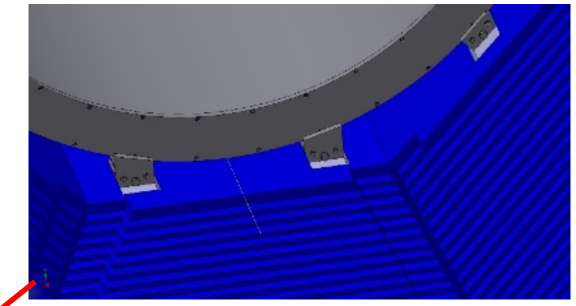
Operation mode with spin flippers

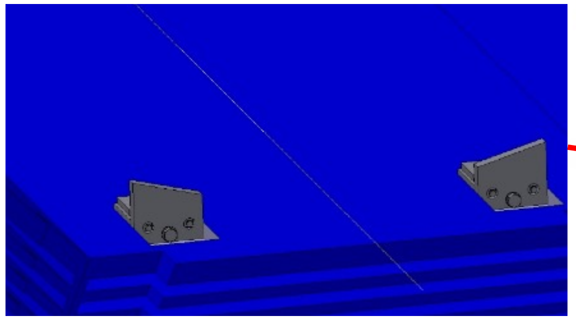
1st ring +++… |xxx| - - -… | | - - -… |xxx| +++ …| | +++…
2nd ring +++… | | +++…|xxx| - - -… | | - - - … |xxx| +++…
(+ +) (- +) (- -) (+ -) (+ +)

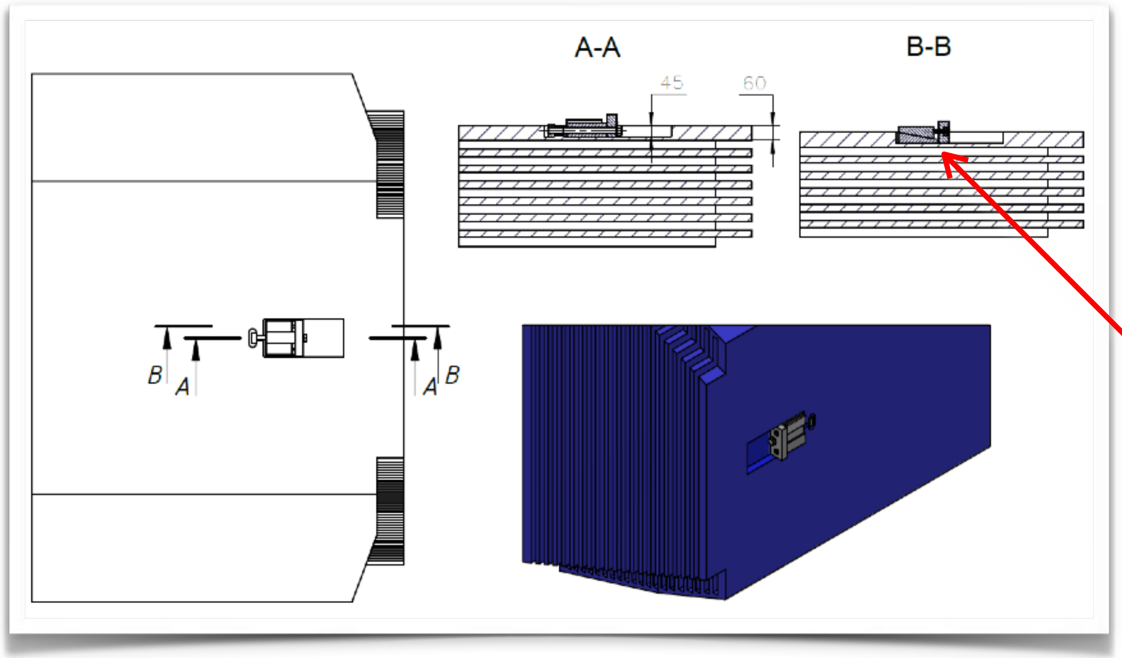
|xxx| - spin-flipper switching-on, no data taking
| | - spin-flipper switching-off, no data taking

Фиксация магнита на ярме

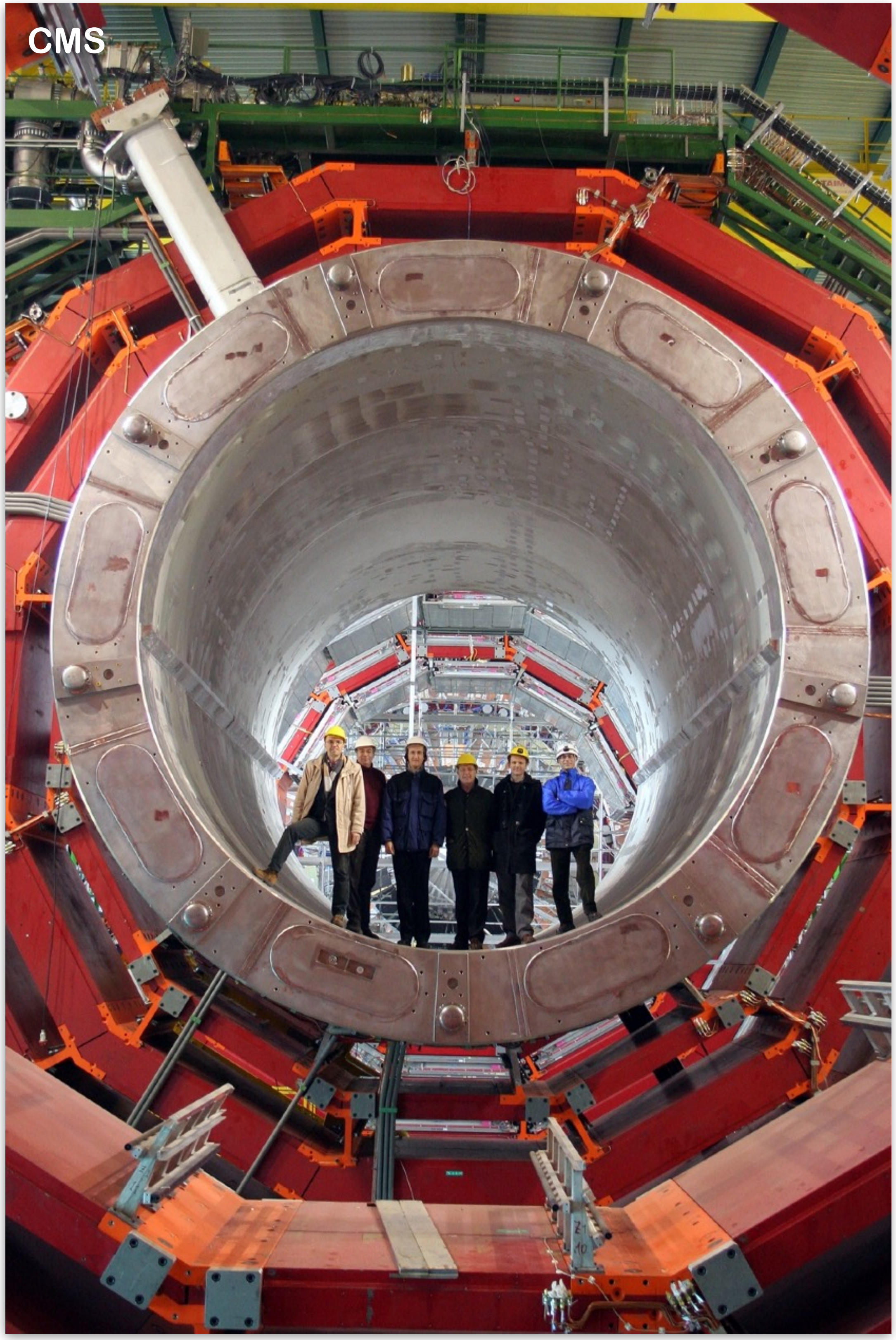


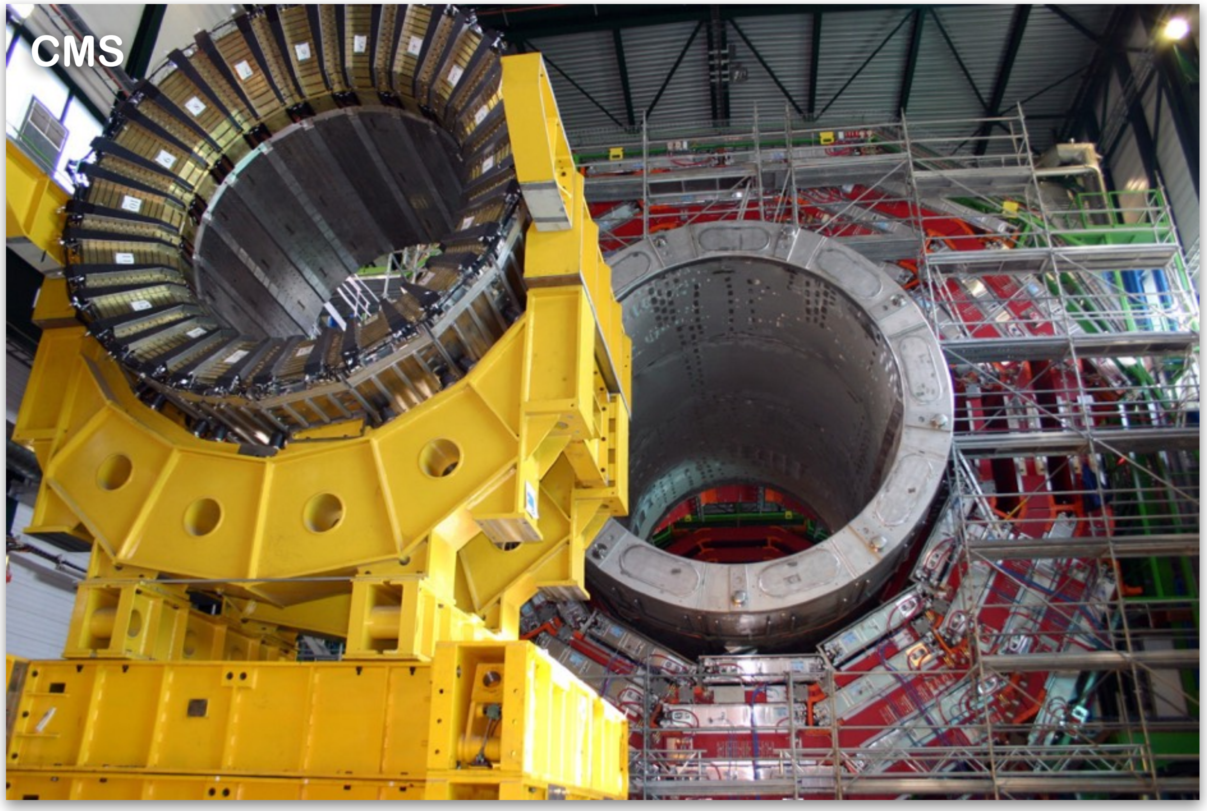


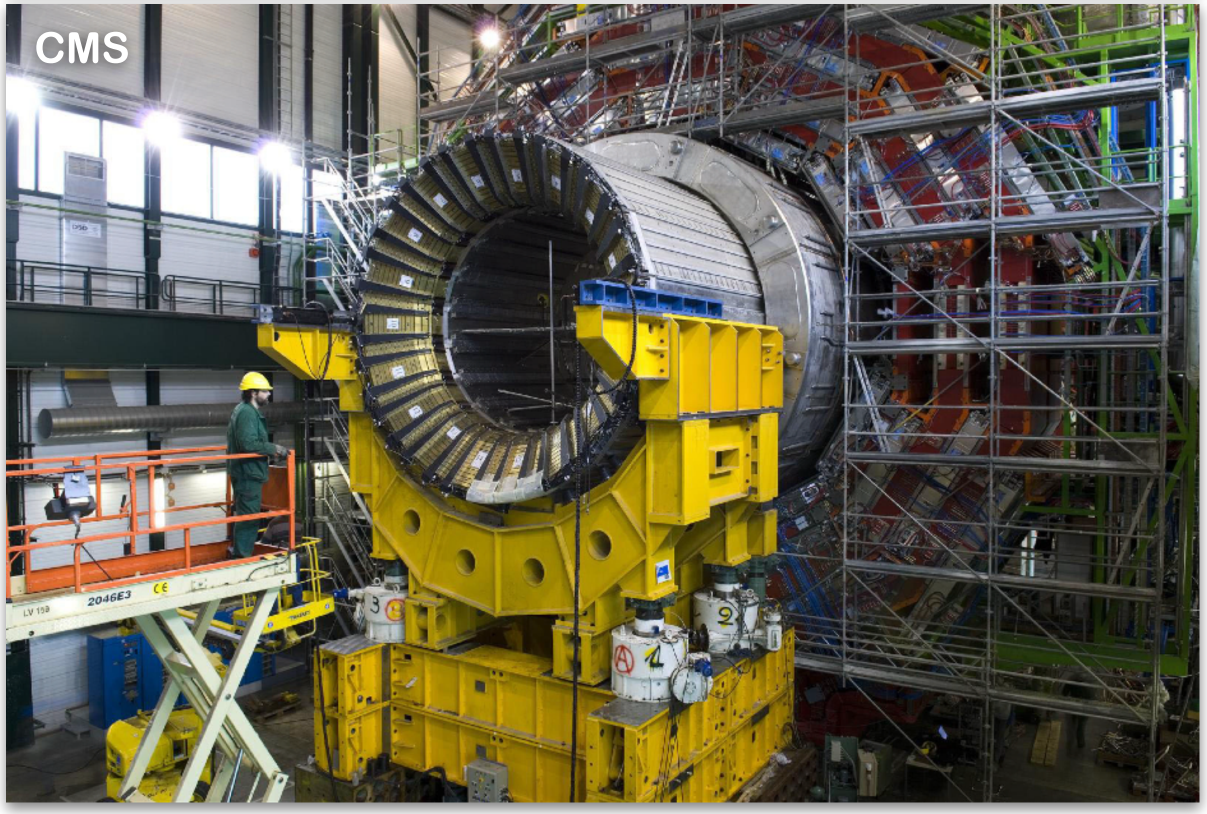




Calorimeter suspension scheme in CMS/LHC

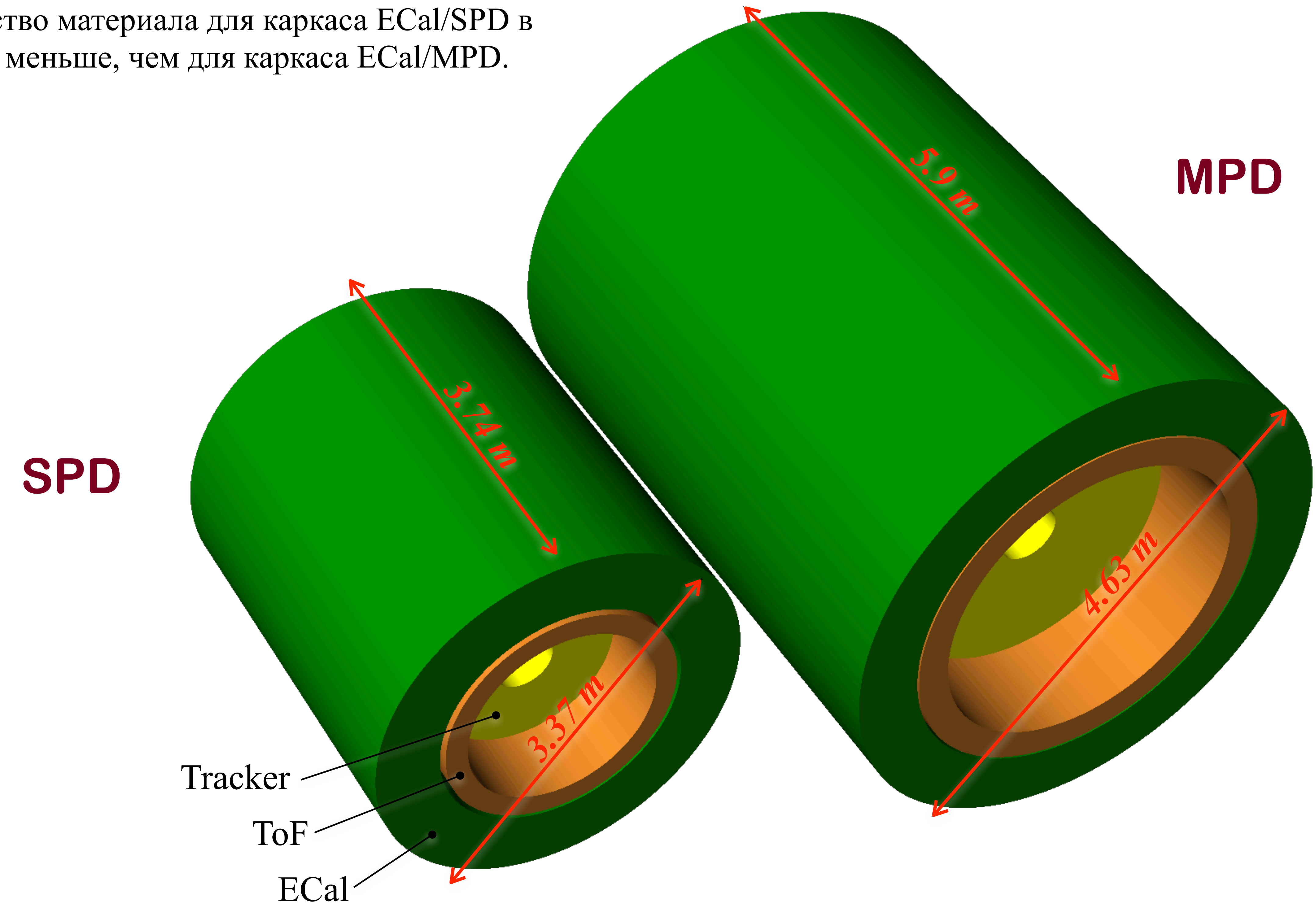






Сравнение размеров установок **SPD** и **MPD**

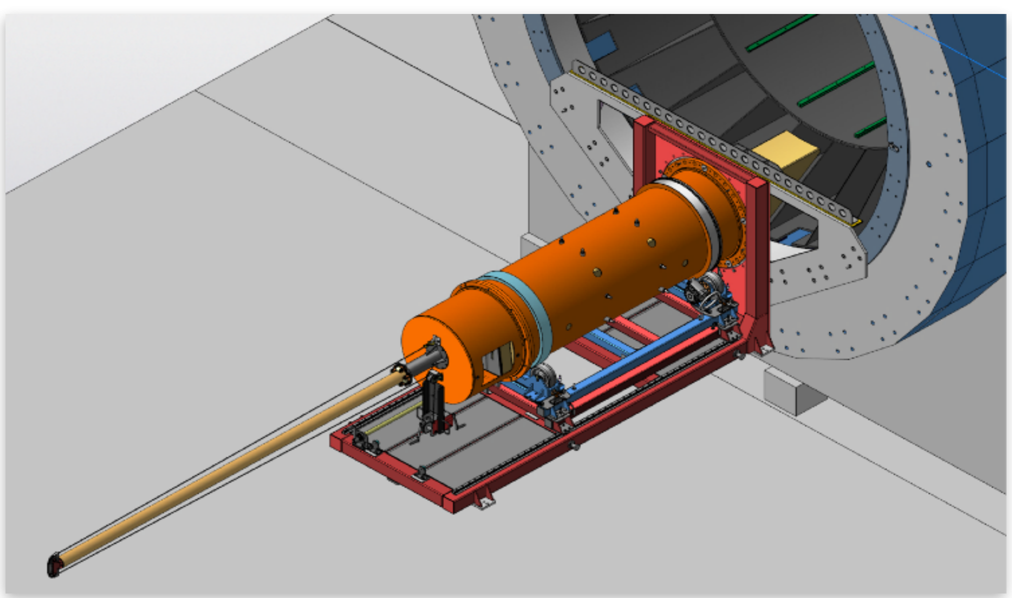
Количество материала для каркаса ECal/SPD в 2-3 раза меньше, чем для каркаса ECal/MPD.



ECal installation

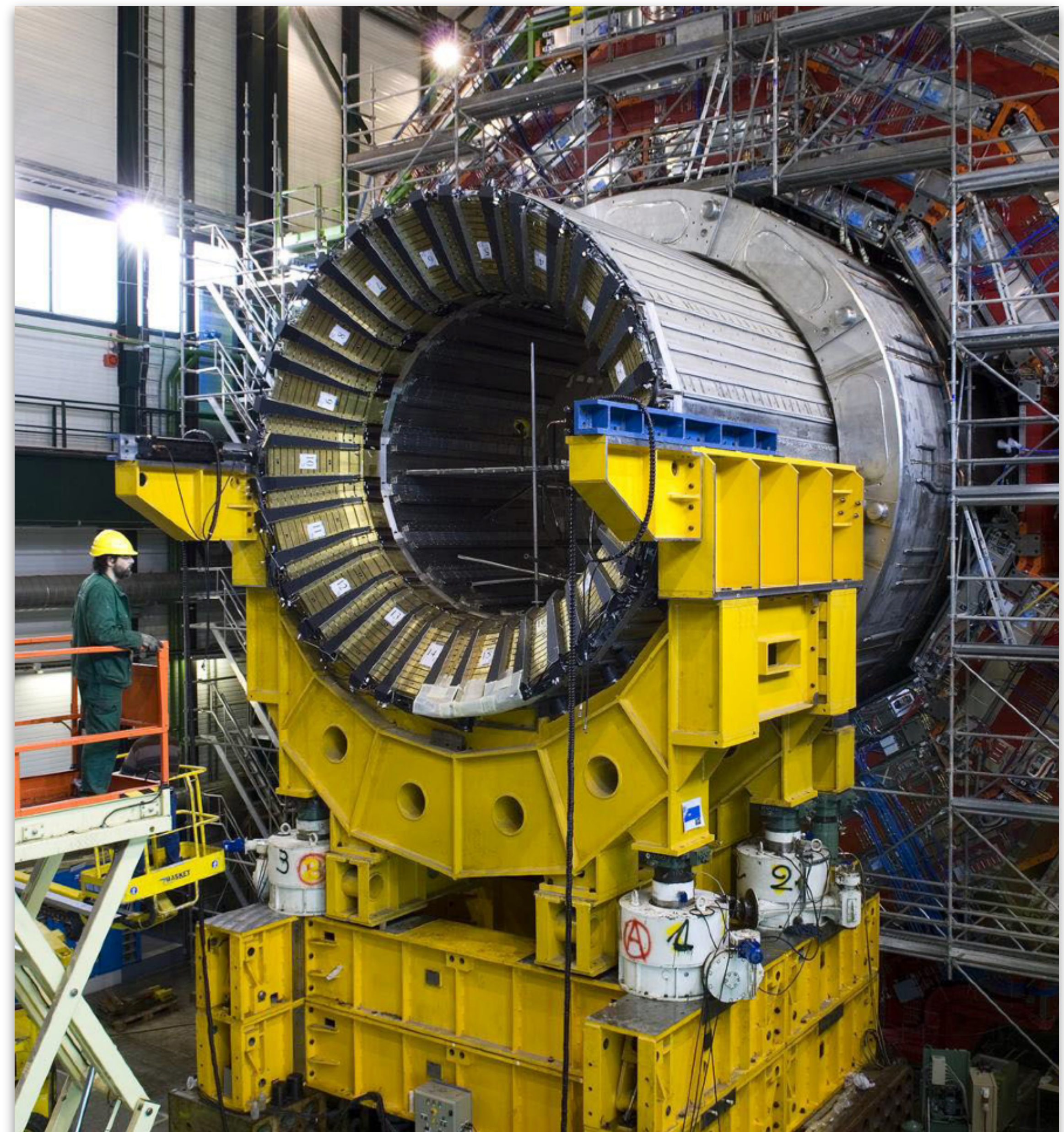
Example of MPD experiment

First, the housing is installed, and then the cells are installed one by one



Example of CMS experiment

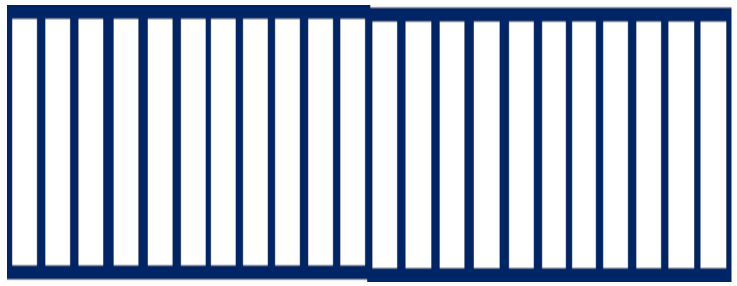
The housing and cells are rolled up as a single unit



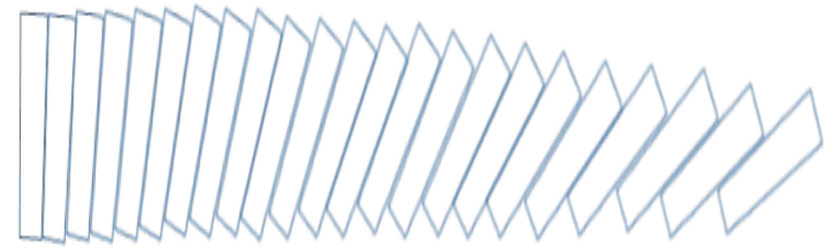
Electromagnetic Calorimeter at NICA/MPD

Igor Tyapkin, Boyana Dabrowska

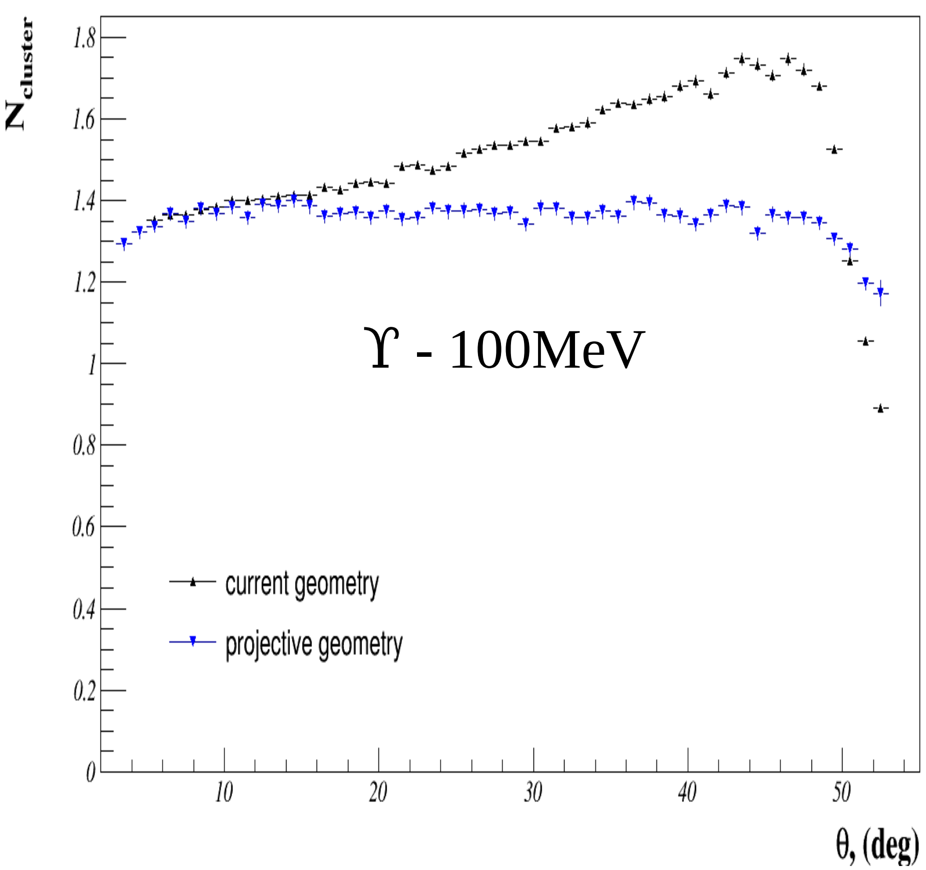
CHEF 2017, Lyon, France 03/10/2017



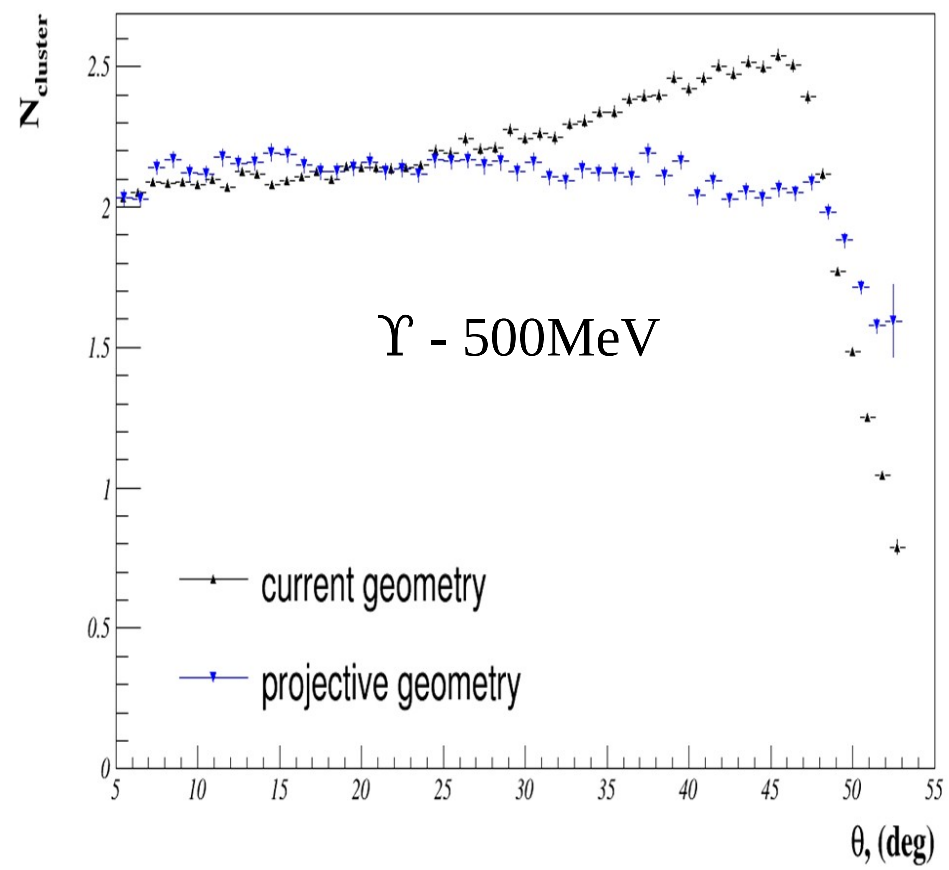
View of the some modules of the no projective geometry in the Z plane



View of the some modules of the projective geometry in the Z plane.



Distribution of the number of clusters vs angle θ (Photons beam with energy 100MeV).

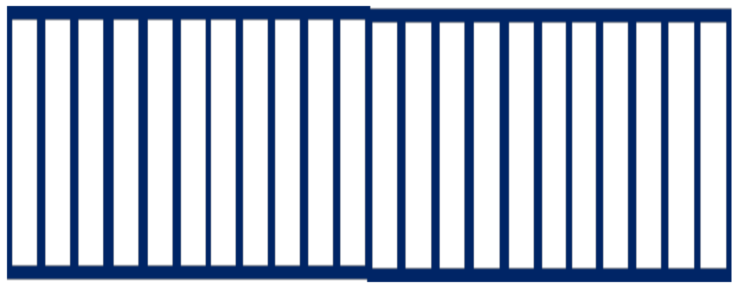


Distribution of the number of clusters vs angle θ (Photons beam with energy 500MeV).

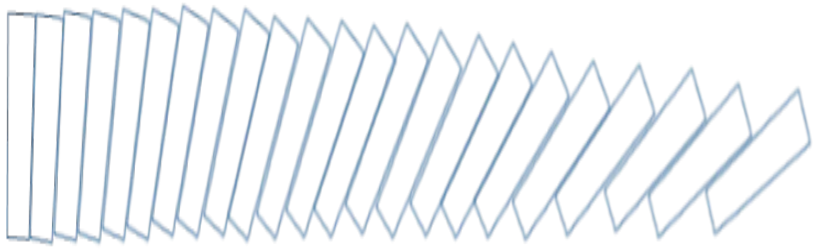
Electromagnetic Calorimeter at NICA/MPD

Igor Tyapkin, Boyana Dabrowska

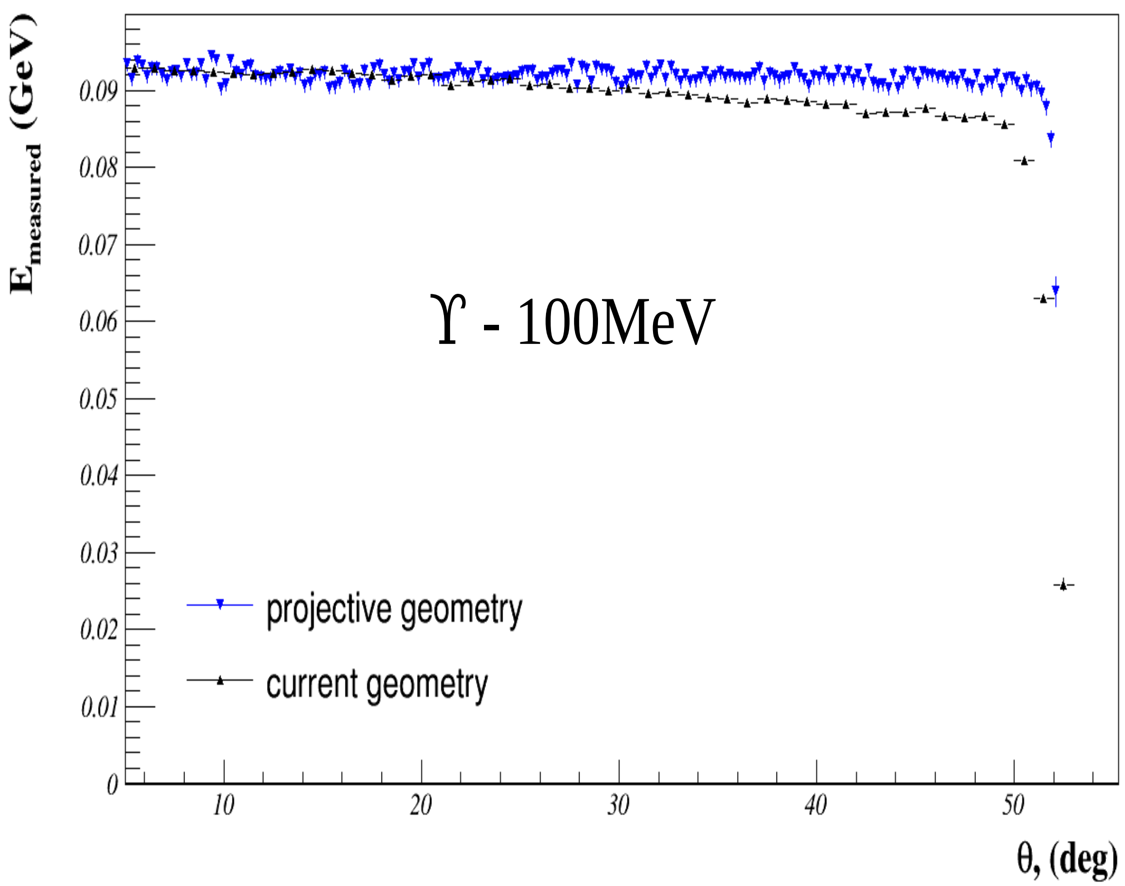
CHEF 2017, Lyon, France 03/10/2017

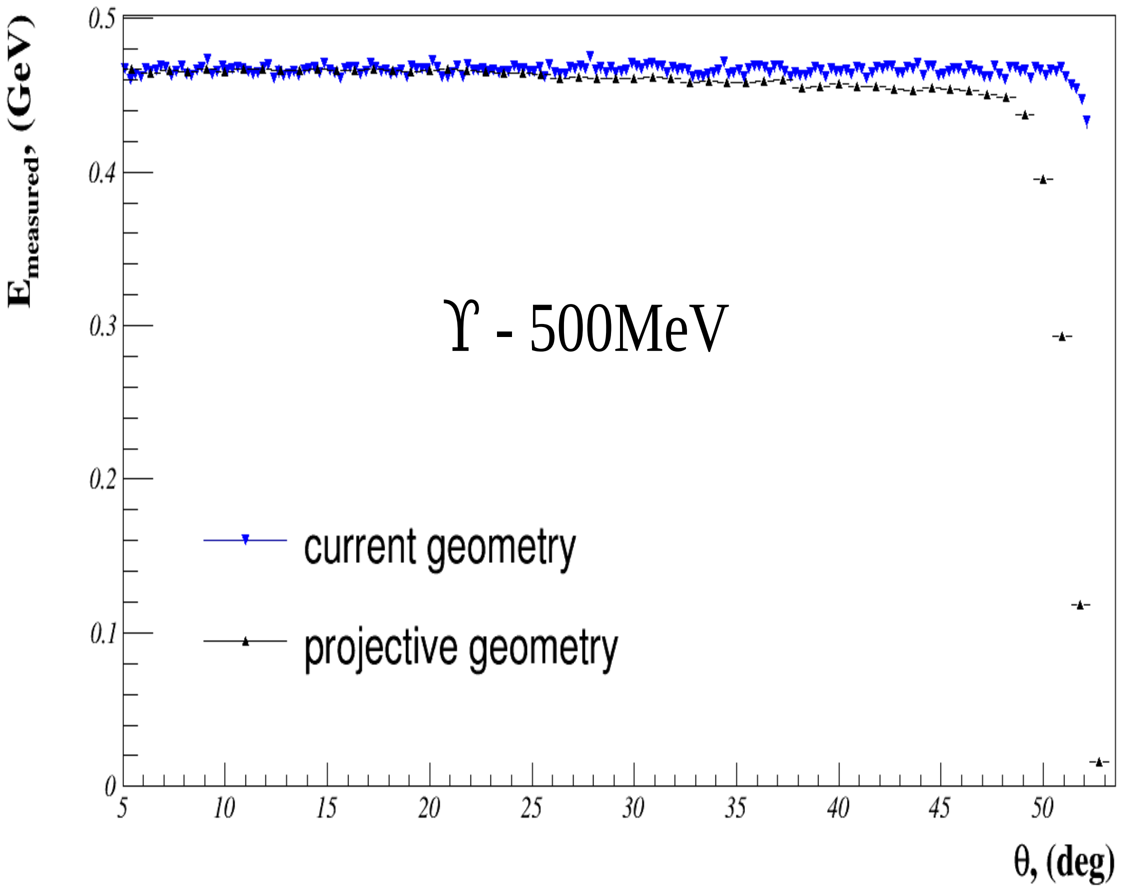


View of the some modules of the no projective geometry in the Z plane



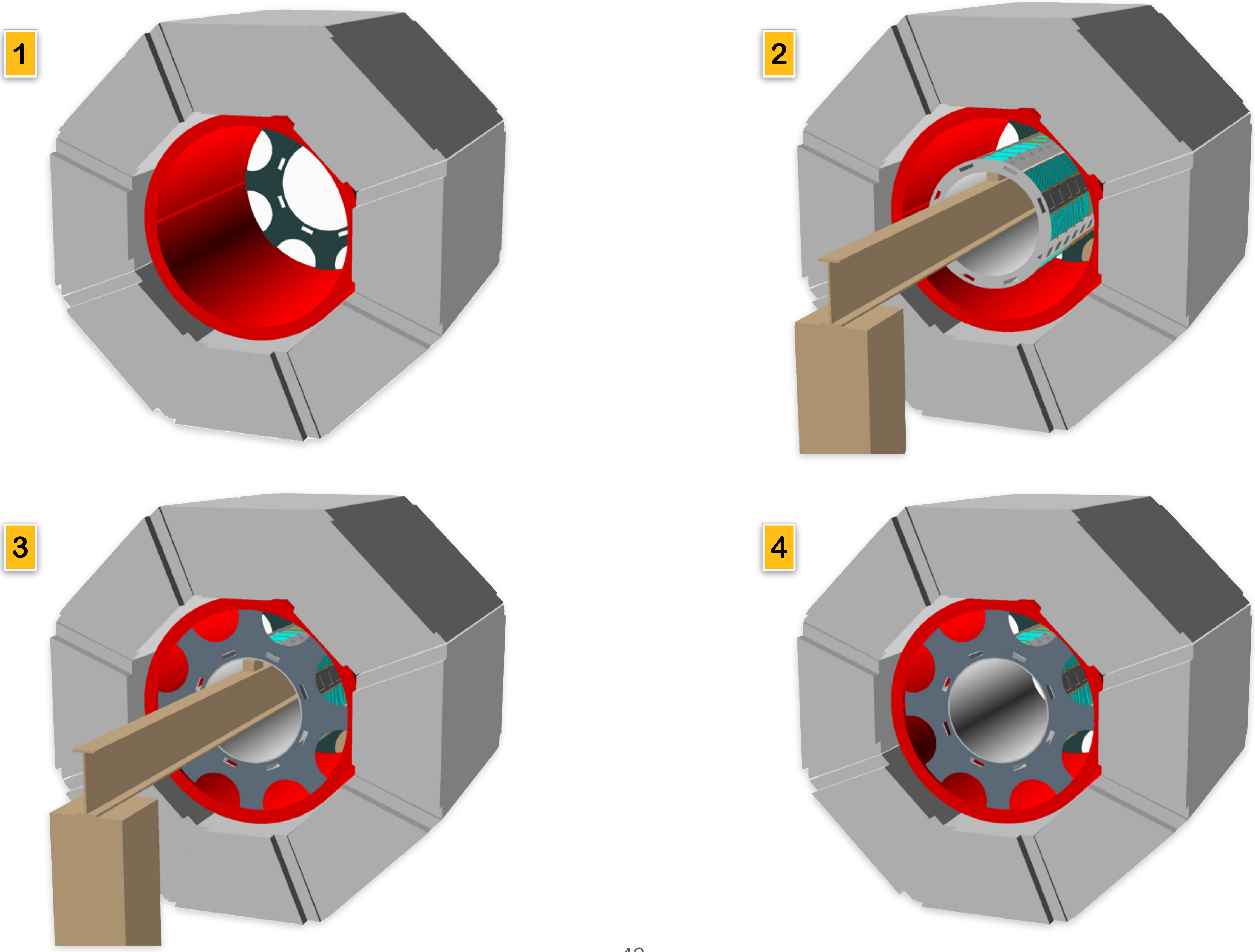
View of the some modules of the projective geometry in the Z plane.



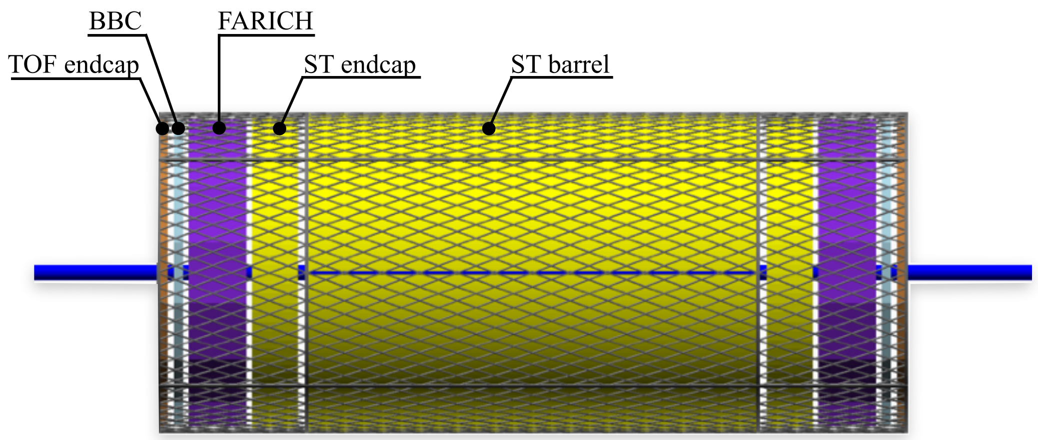


Монтаж **TOF** по аналогии с магнитом

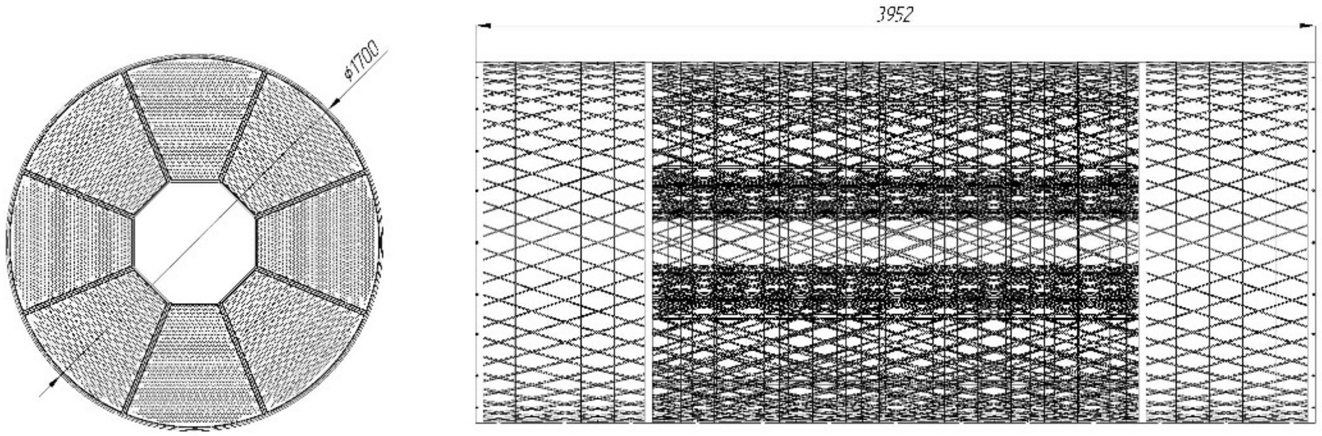
(не зависит от наличия ECal)



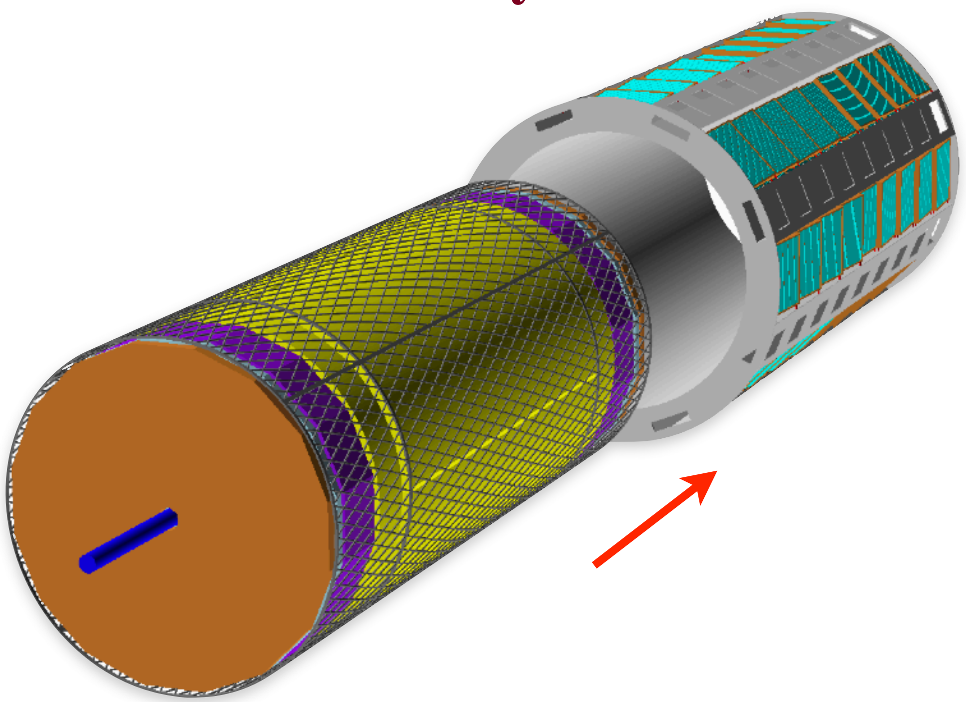
Монтаж бочки **Straw**



Подготовили в ЦНИИСМ в прошлом году

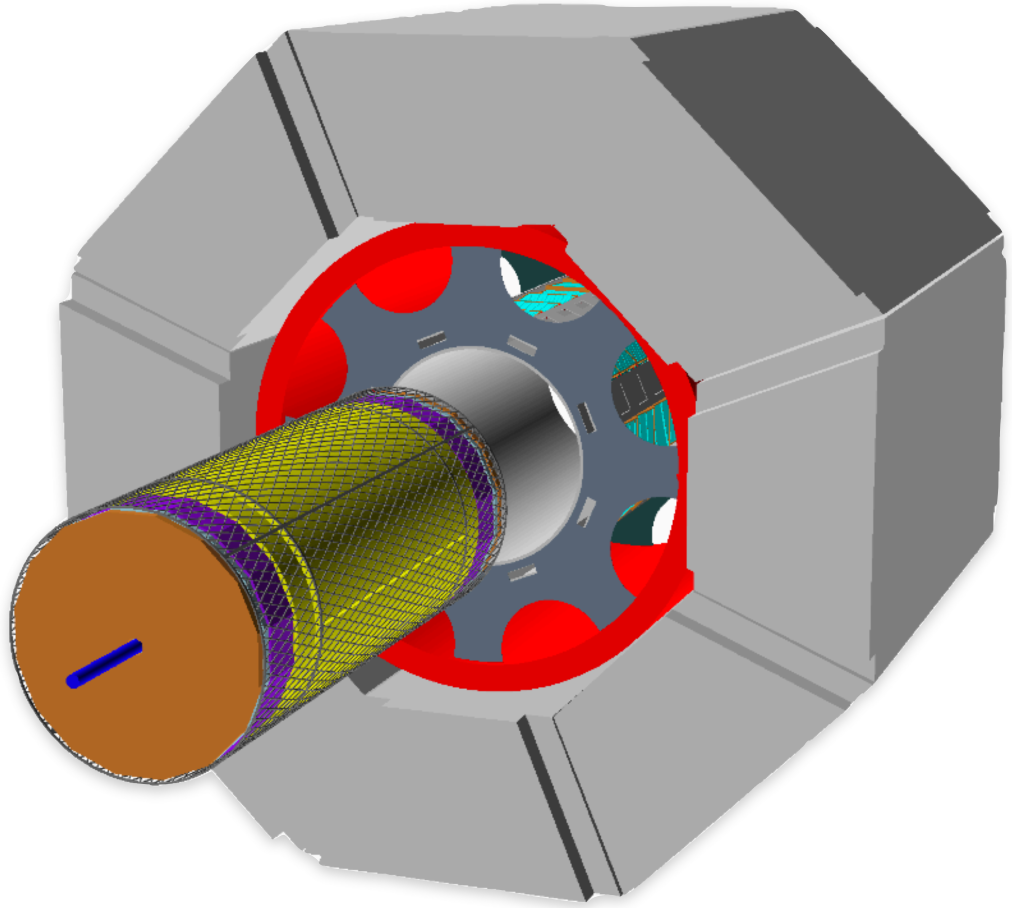


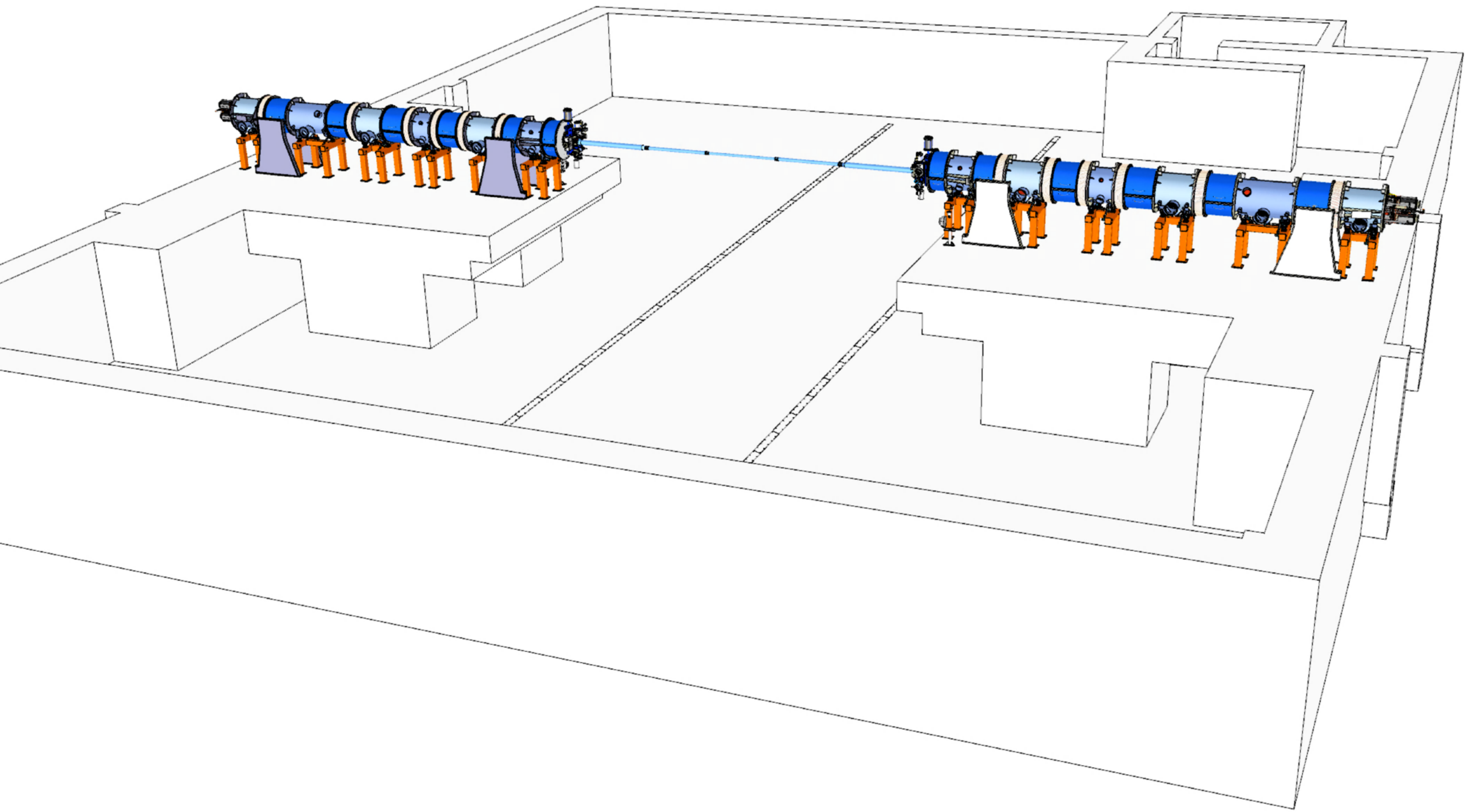
Монтаж в бочку TOF



Нужны направляющие, ролики и т.д.

Монтаж в бочку TOF





Прямолинейный участок SPD, который можно будет использовать для тестирования детекторов

MoU signed

1 A.I. Alikhanyan National Science Laboratory (Yerevan Physics Institute), Yerevan
2 NRC “Kurchatov Institute” - PNPI, Gatchina
3 Samara National Research University (Samara University), Samara
4 Saint Petersburg Polytechnic University St. Petersburg
5 Saint Petersburg State University, St. Petersburg
6 Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow
7 Tomsk State University, Tomsk
8 Belgorod State University, Belgorod
9 Lebedev Physical Institute of RAS, Moscow
10 Institute for Nuclear Research of the RAS, Moscow
11 National Research Nuclear University MEPhI, Moscow
12 Institute of Nuclear Physics (INP RK), Almaty
13 Institute for Nuclear Problems of BSU, Minsk

14 NRC “Kurchatov Institute”, Moscow (NRC KI)
15 Higher Institute of Technologies and Applied Sciences, Havana