The SPD setup update report
(answers to the “Detector Technology” section)

Alexander Korzenev, JINR LHEP

Meeting with the Detector Advisory Committee
October 1, 2021

Outline

- Experimental hall news
- Magnet & ECal development update
- Vertex Detector (DSSD vs MAPS)
- Straw development update
- DAQ and Online Filter
- ZDC development update


Aerial view of NICA in July 2021
SPD


View of SPD from the courtyard


View of SPD from the outside

- All interior work in the SPD hall will be completed this year
- Under-rail plates and rails will be installed early next year
- The concrete block wall (biological protection) and the bridge between two balconies will be installed by the end of winter. Thus the accelerator tunnel will be isolated from the hall

The SPD experimental hall in September 2021

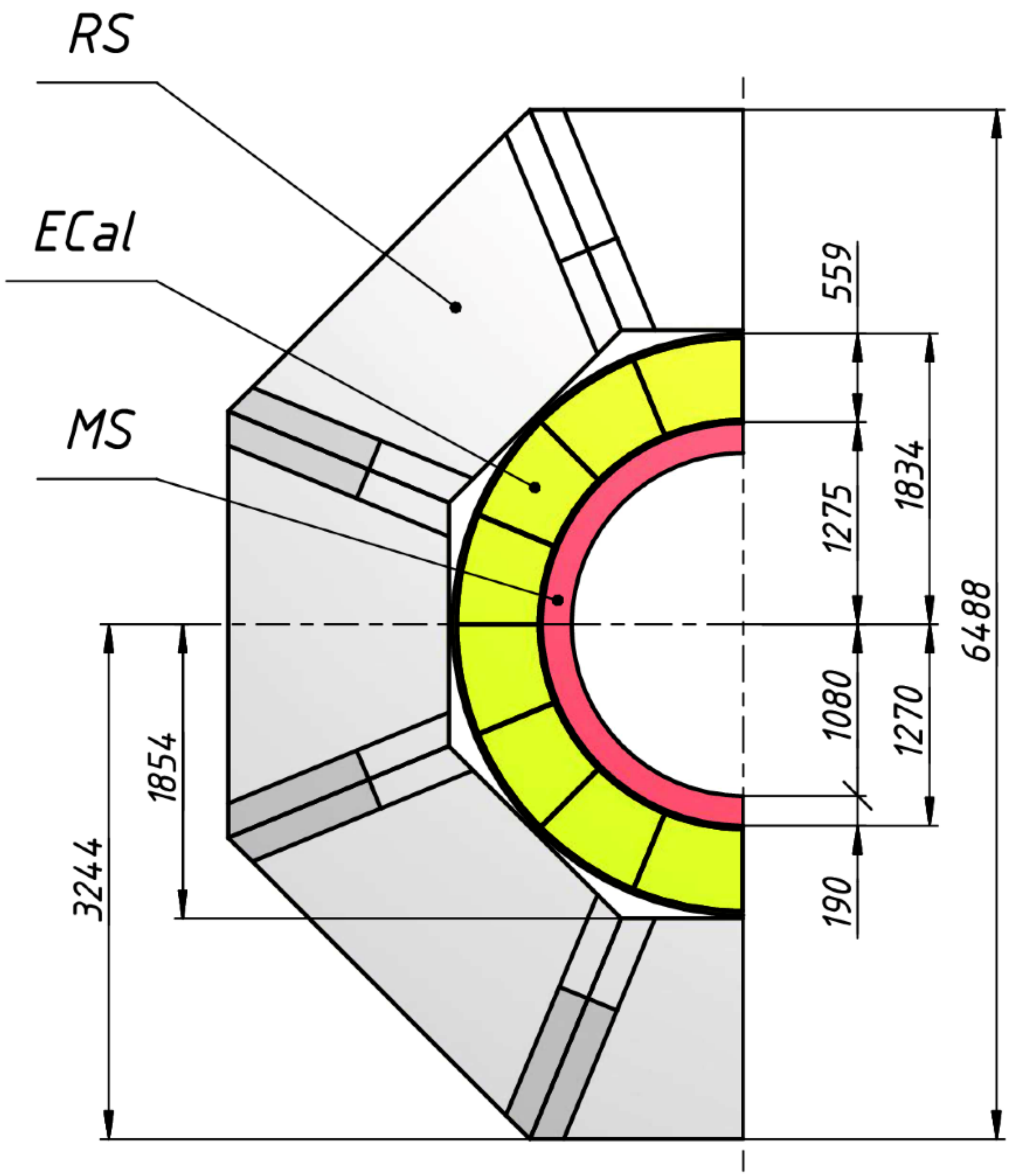
Magnetic system and ECal

Q8 The discussion on solenoid or individual coils and ECAL before or after the magnet is very recent. We would like to have updates on the issue given the impact on the detector performance vs relevant physics channels like the prompt photons. We also ask for an estimation of the material budget of the coils/solenoid.

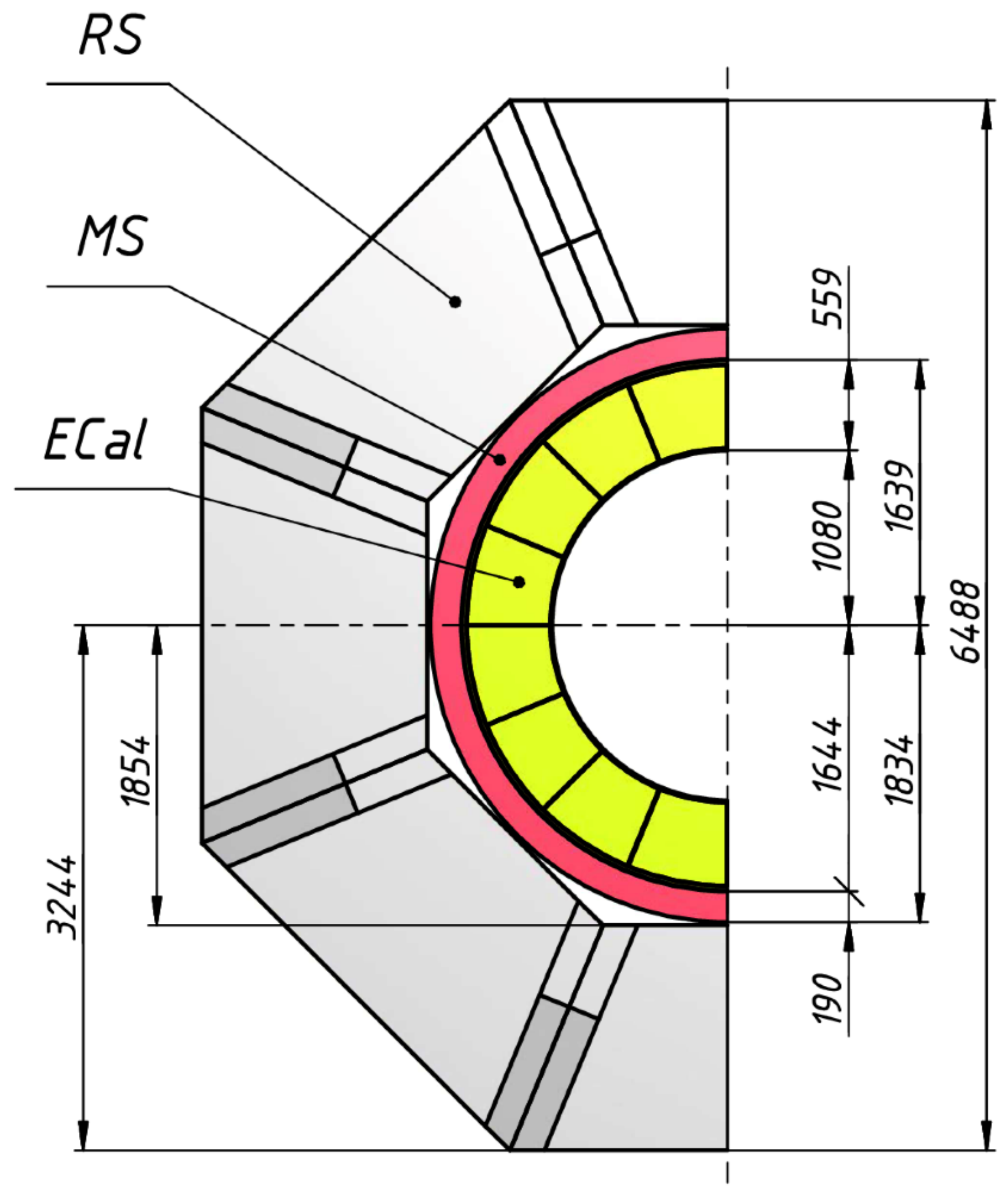
A8 We are aware of the extraordinary importance of this estimation and are working on it.

SC magnet location with respect to ECal

<u>CDR version (**obsolete**)</u>
6 separated coils inside ECal



<u>Option under development</u>
A single cryostat with several coils



Two options for the SC coil technology

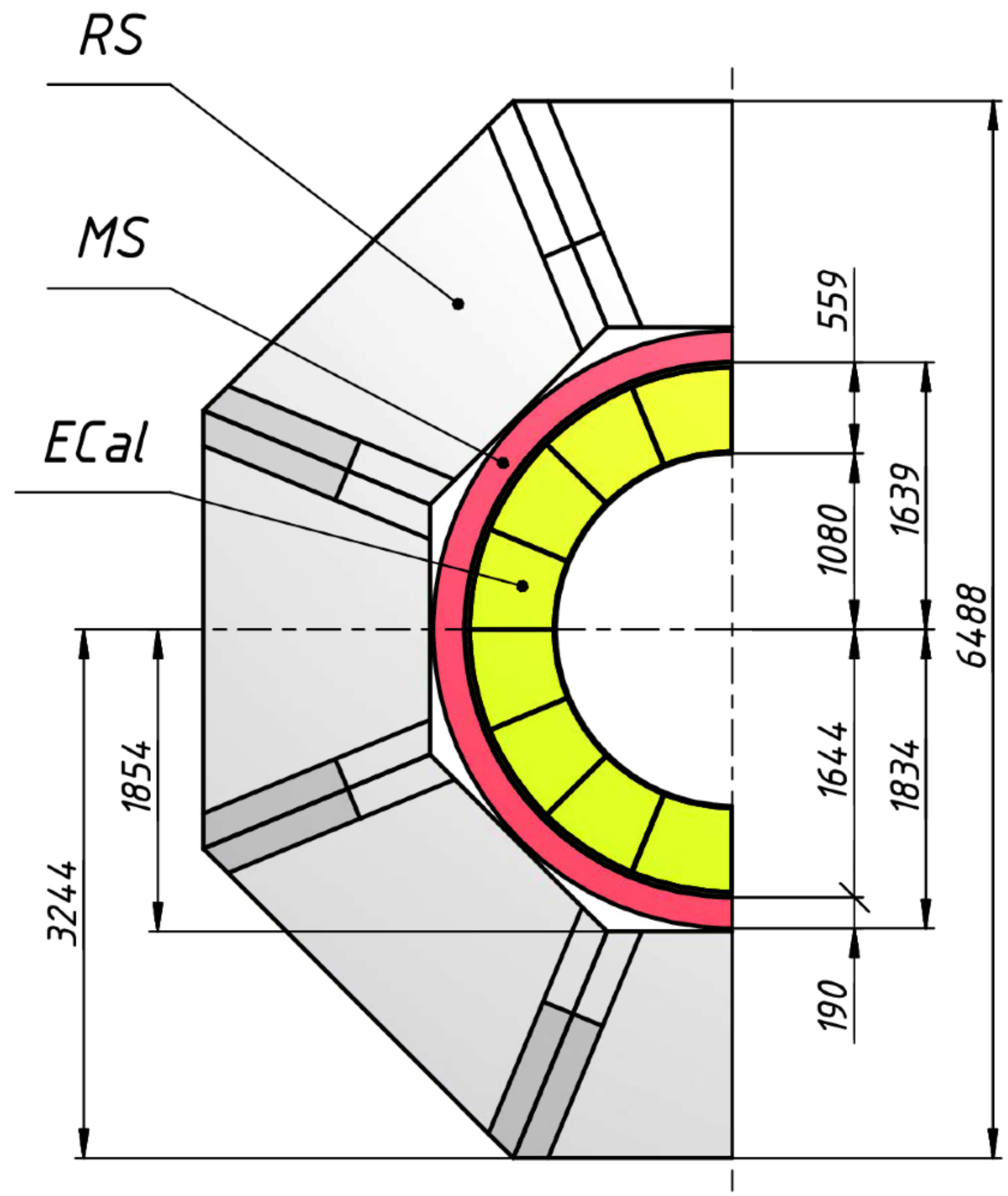
Option based on the NICA cable

- Coil construction similar to one used for the NICA magnets (produced in JINR)
- Two layers of NbTi/CuNi cable. The same cable as used in Nuclotron magnets: hollow superconductor with the helium flows inside (~4 K)
- Design of cryogenic system (refrigerator, pipelines and so on) in JINR

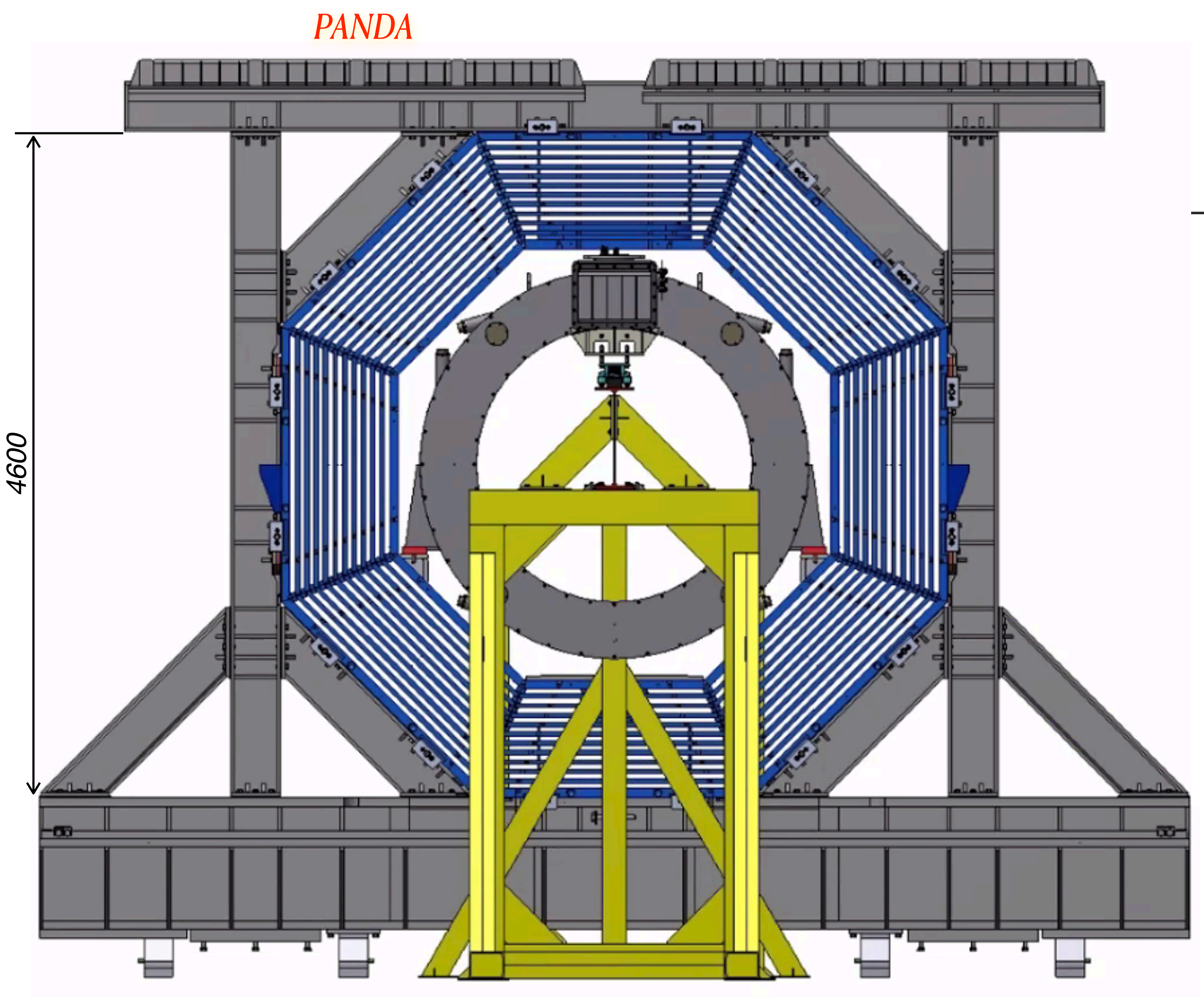
Option based on the PANDA cable

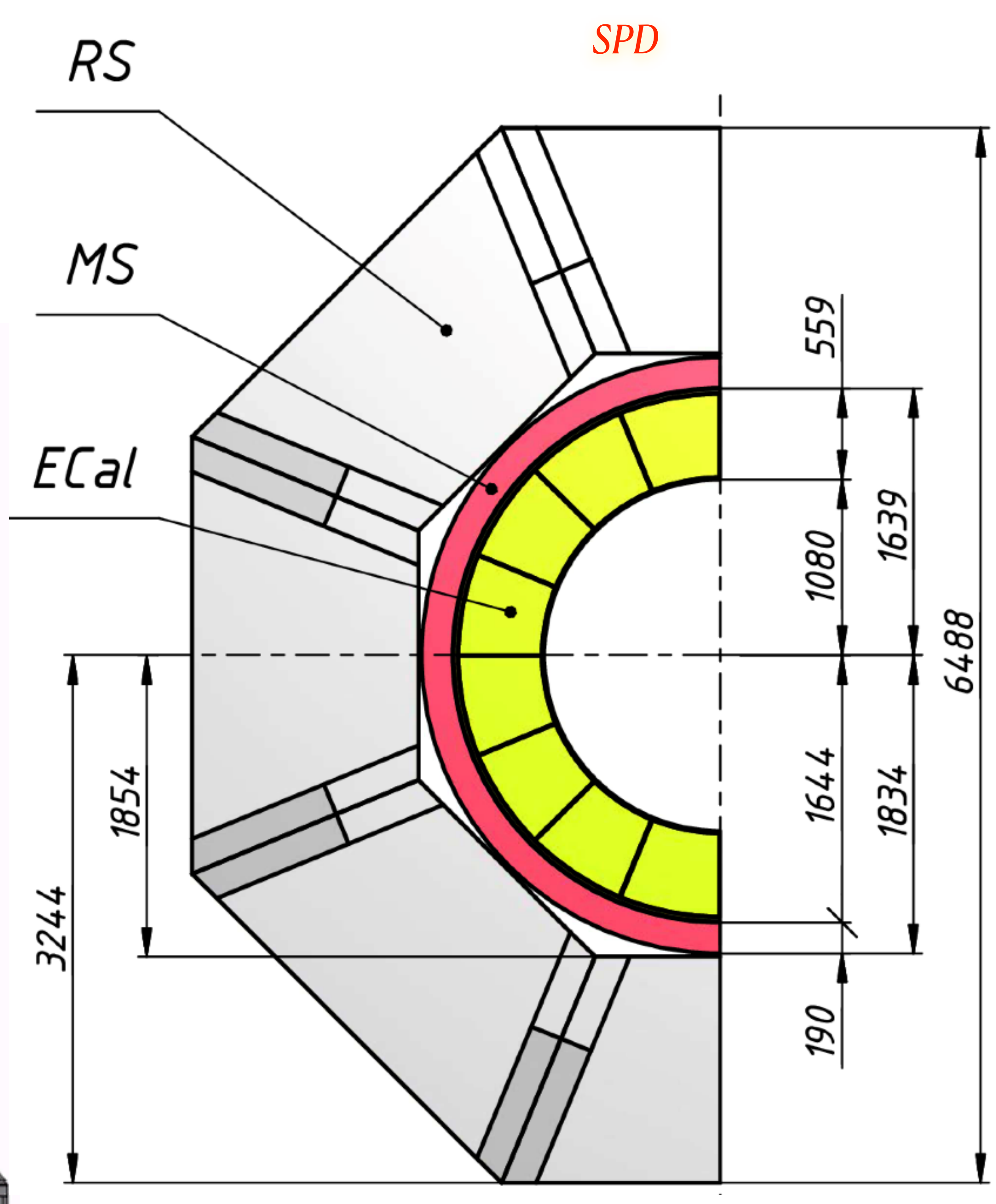
- The team of the Budker Institute of Nuclear Physics / Novosibirsk.
- The PANDA magnet will be moved to GSI in 2024 for final tests
- The Rutherford cable with 8 strands extruded in Al matrix
- Design of cryogenic system (refrigerator, pipelines and so on) in JINR

Option under development
A single cryostat with several coils



PANDA compared to SPD
(scale 1:1)

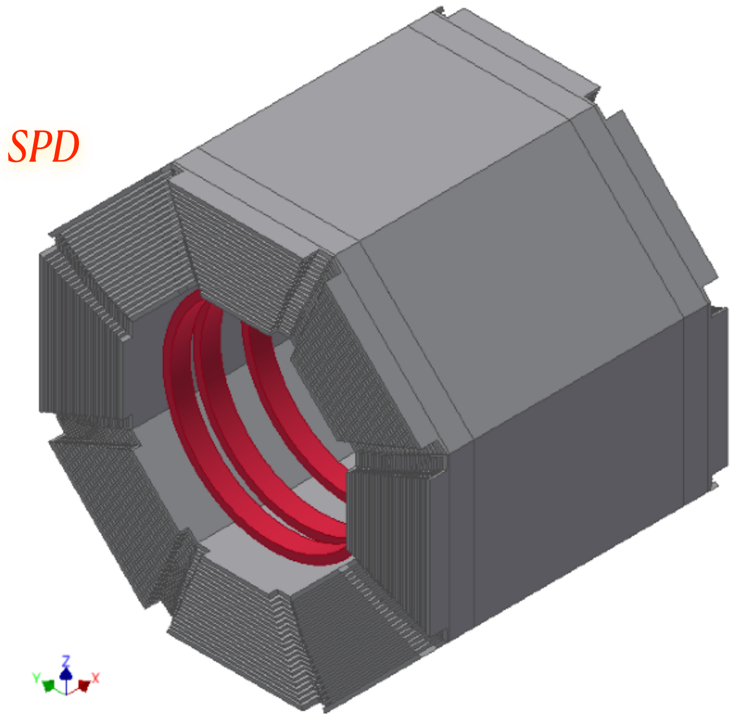




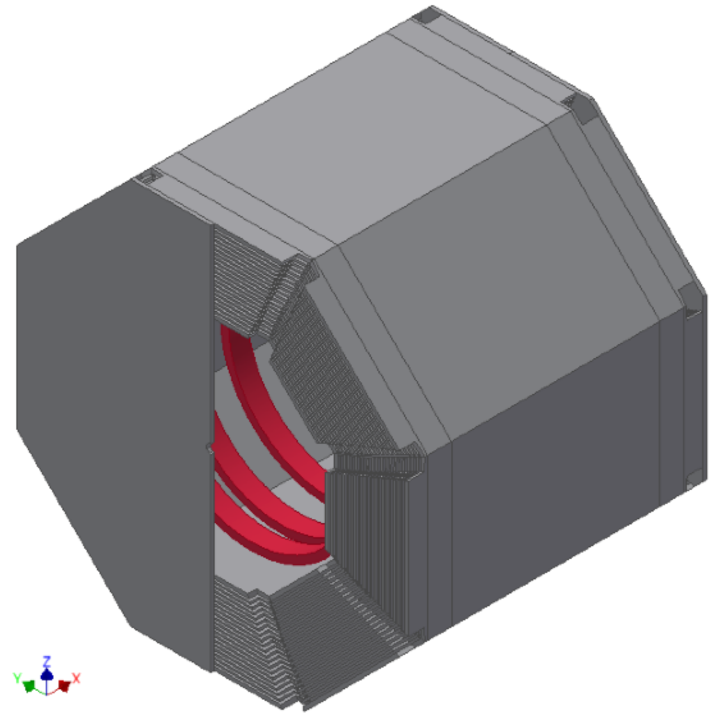
- Radial thickness of cryostat will have to reduced from ~40 cm (PANDA) to ~20 cm
- Example: solenoid of KEDR is 22.5 см thick

Magnetic field calculation (cryostat outside ECal)

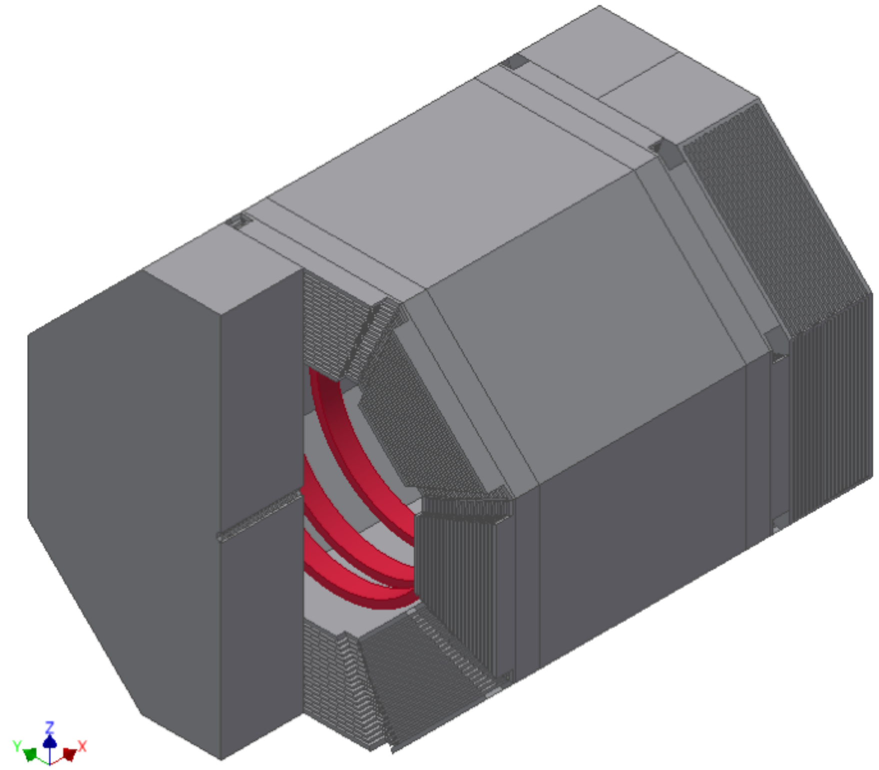
Without endcaps

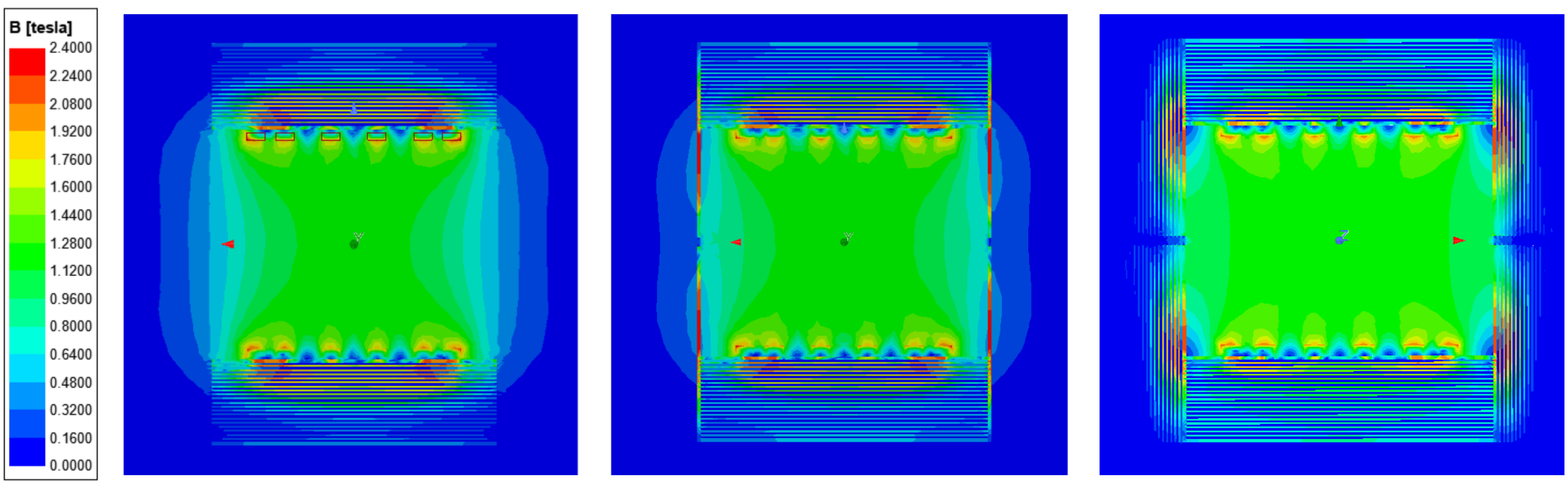


6 cm thick endcap



Full construction

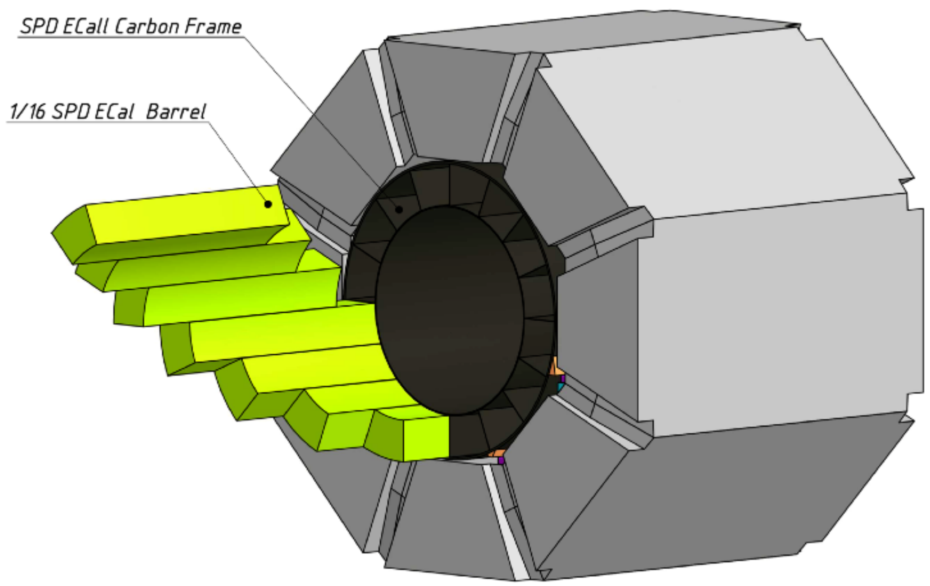


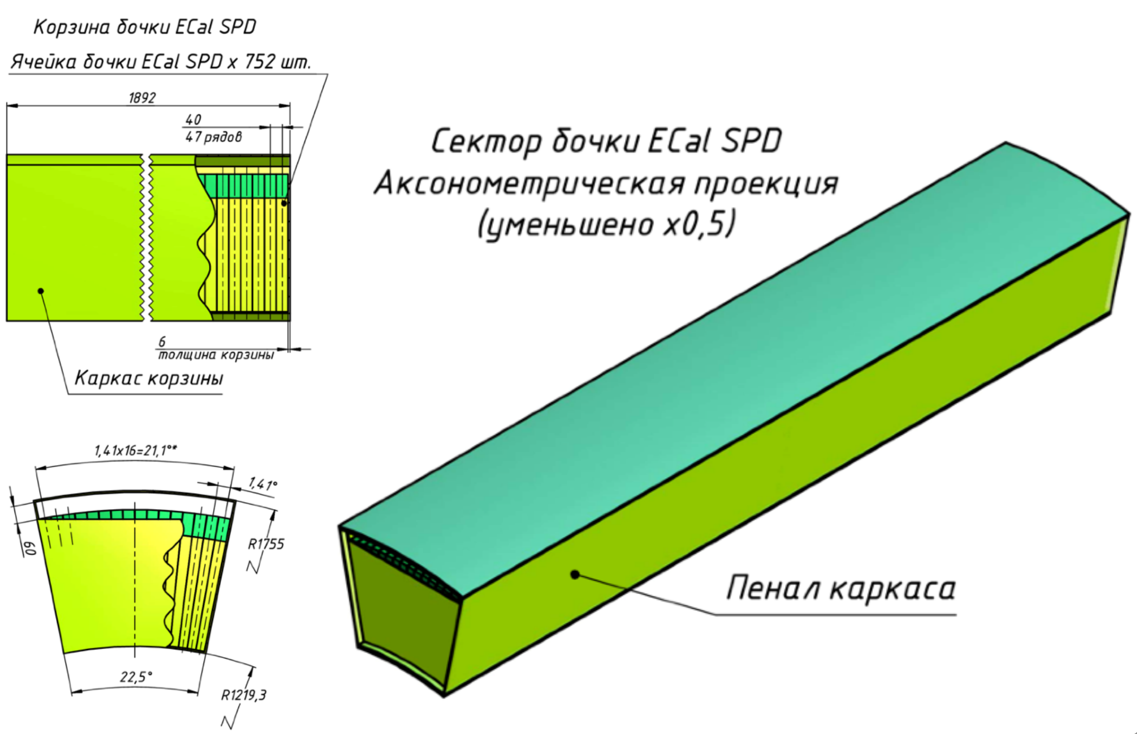


Electromagnetic Calorimeter (ECal)

Half-sector approach

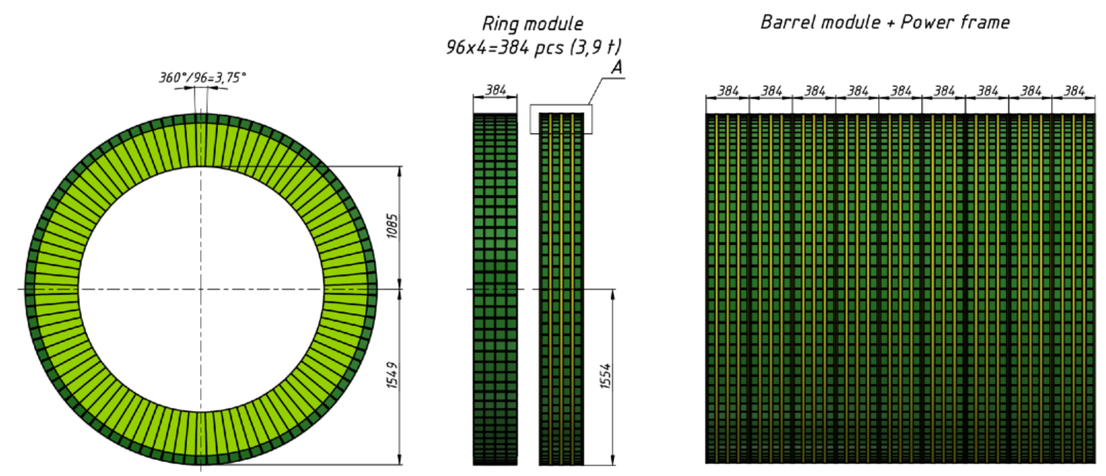
Similarly as it is employed in the MPD experiment

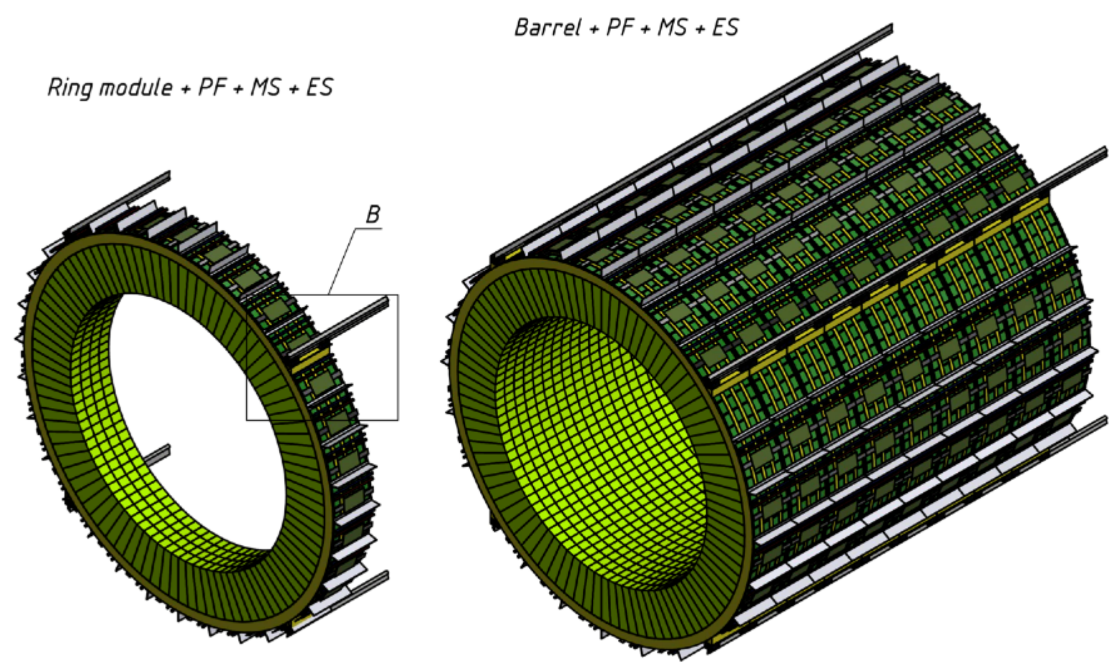




Rim approach

It was proposed in order to avoid inefficiency regions distributed azimuthally



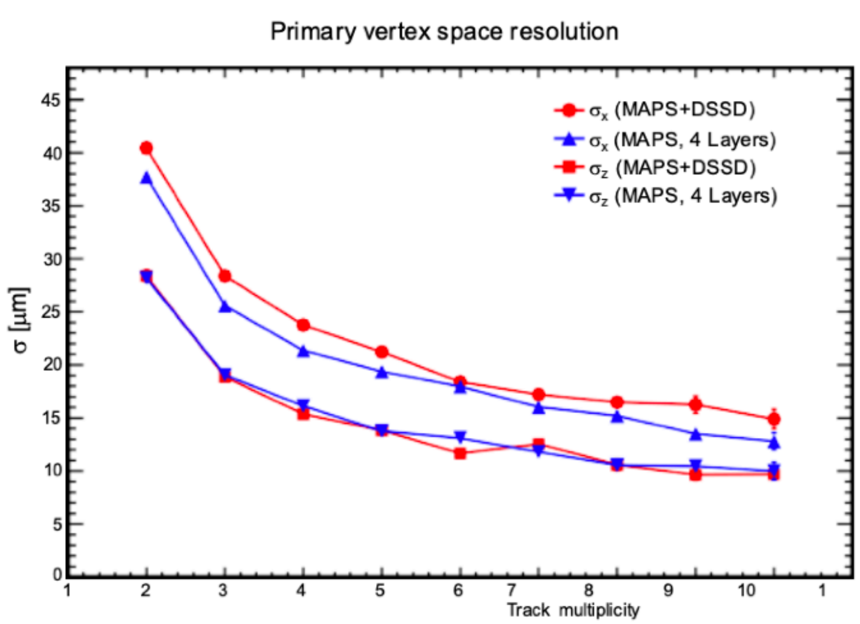


Vertex Detector (VD)

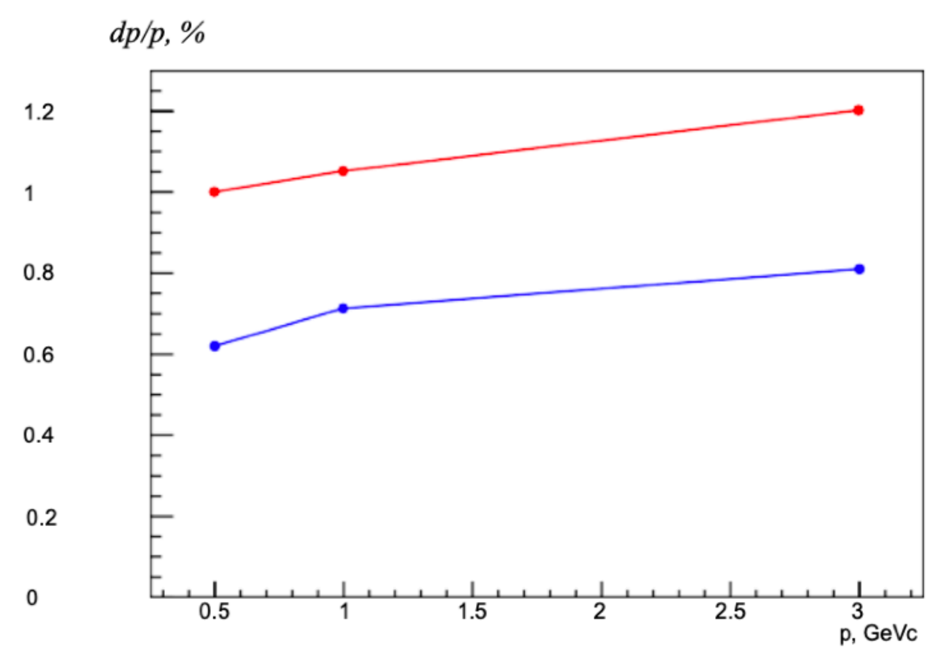
Q9 We would like to know if a vertex detector with 4 layers of MAPS, and no silicon strips was considered. It will be interesting to compare the performances of such vertex detector with the present options.

A9 The Monte Carlo simulation for a VD configuration with 4 equidistant layers of MAPS and no silicon strips was performed. There is no sizable impact to the spatial resolution of the vertex position in comparison with the option of 3 MAPS + 2 DSSD, while the momentum resolution was improved significantly, by the factor of ~1.5. The results of comparison are presented at Fig. 3. Such improvement in the momentum resolution should enlarge accordingly the significance of the J/ψ and D peaks.

C9: the answers outline the advantage of a pure 4MAPS layer. We advice the collaboration to take this into consideration.



(a)



(b)

Figure 3: (a) Vertex position resolution as a function of track multiplicity and (b) momentum resolution as a function of particle momentum for the VD consisting of 3 MAPS+2 DSSD and 4 MAPS, respectively.

Straw Tracker (ST)

Q10 We would like to know if the possibility to operate the straws in sizable over pressure, in order to increase stability (and primaries) was considered.

A10 At the moment we consider only small overpressure for tubes **100 mbar**. We agree that the performance of Straw tubes will improve with increasing pressure. However a large value of overpressure will unavoidably cause micodeformations of tubes and will increase probability for leaks. In view of the fact that we will have 50k tubes and no access to the detector during the run, we would like minimize those risks. Thus, for the time being only slight overpressure is considered.

C10: will be used the same technology as the one used for ATLAS TRT?

The straw tracker are using of in the different experiments.

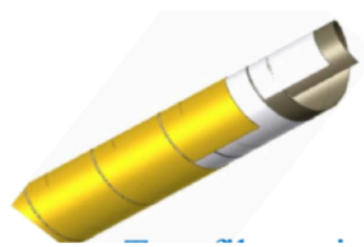
Straw winding

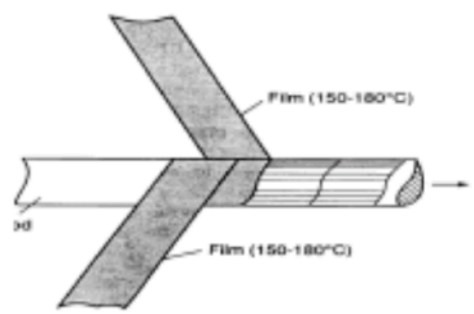
- ATLAS
- LHCb
- PANDA(overpressure)
- CBM
- COMPASS
- Mu2e(vacuum)
- NA64
- SVD-2
- GLUEX
- COZY-TOF
- ..

Straw welding

- NA62(vacuum)
- COMET(vacuum)
- SHiP(vacuum)
- DUNE(overpressure)
- ..

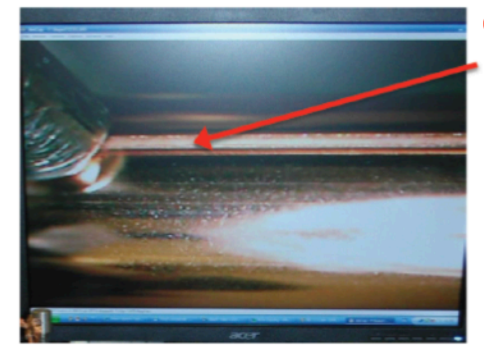
Two design of the straw-tube production



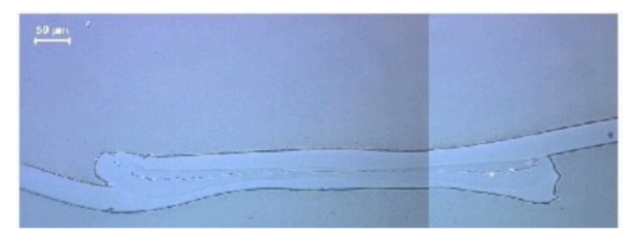


Straw winding. Two films revolve and stick together among themselves.

straw diameter from 2 mm to 18 mm



Weld seam (zoom x20 on a PC monitor)



Ultrasonic welding of straws

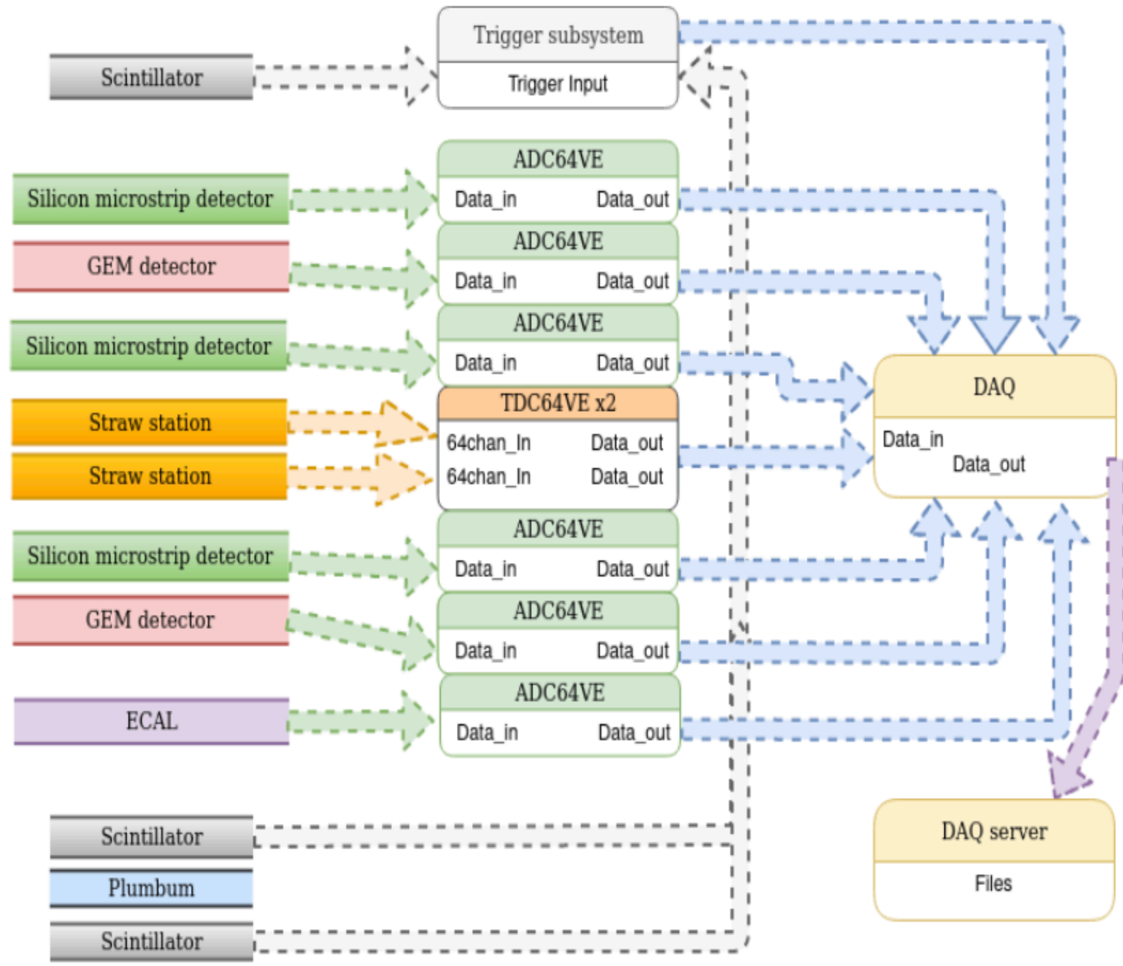
straw diameter from 5 mm to 20 mm

both of these technologies are well developed at JINR

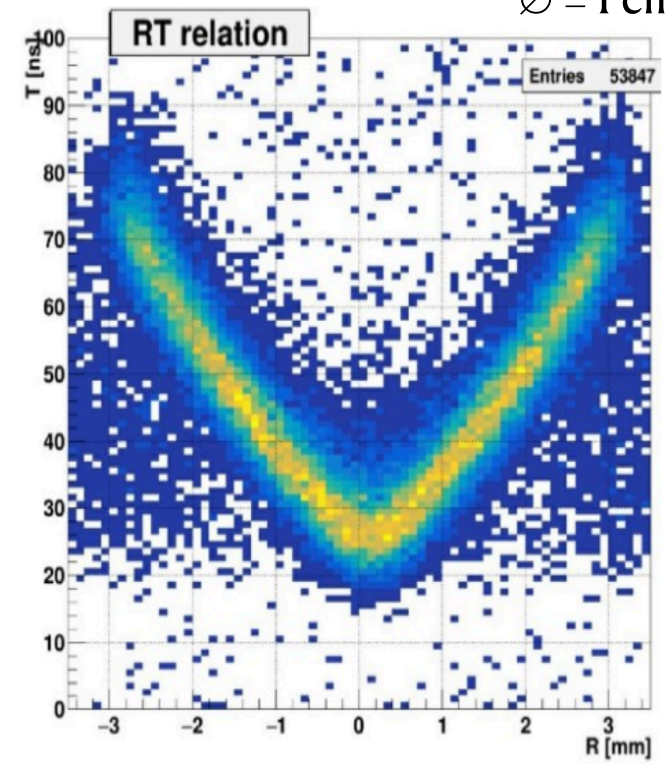
MiniSPD testing facility

DAQ BM&N and MPD

Straw+Vertex+Colorimeter

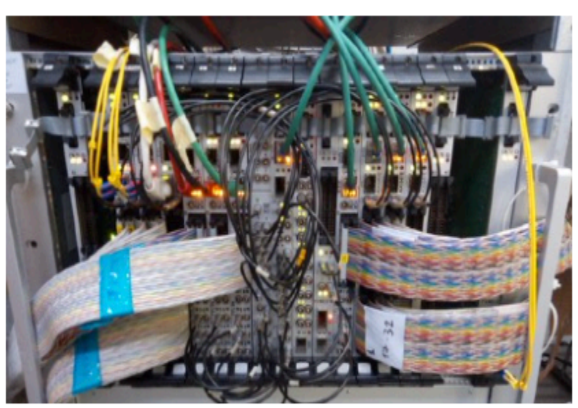


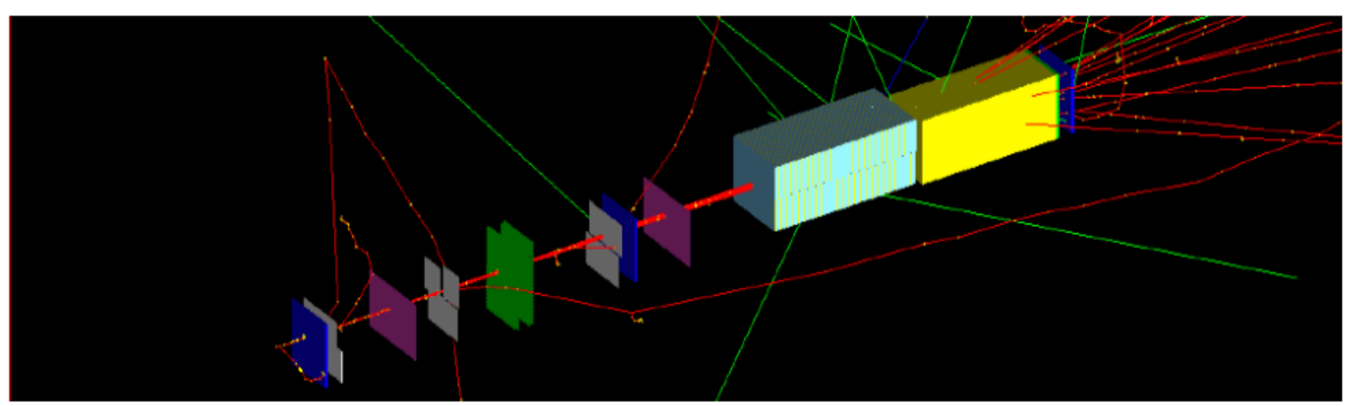
$\varnothing = 1$ cm



Spatial resolution 180mkm

(should be ~150 um for a single tube)





DAQ and Online Filter

Q11 We need more details on the model for data acquisition/reduction and on what will be finally written on tape.

A11 We expect the data *rate from the detector of 20 GB/s* (here and later all numbers are given for the maximum design luminosity and beam energy). The raw data are a byte stream organized in *files of ~4 GB each*. The raw data come to the online filter, which does data unpacking, fast reconstruction, and event unscrambling. Currently, we are working on the event selection criteria and already can count on the data *reduction by a factor of ~10 by removing events with low* p_T tracks only, and some other. We assume that we will finally be able to *reach the data reduction by a factor of 50 or so*. The online filter will output unpacked raw data, grouped by events (~400 MB/s) and fast reconstructed data (~20 MB/s) to verify the fast reconstruction and selection efficiency offline. These data are written on tape to be processed offline. Offline processing includes full reconstruction and we estimate it would provide data volume of about 20% of the unpacked raw data (these data will contain physics objects for the analysis and no low-level objects like hits etc). So, we end up with

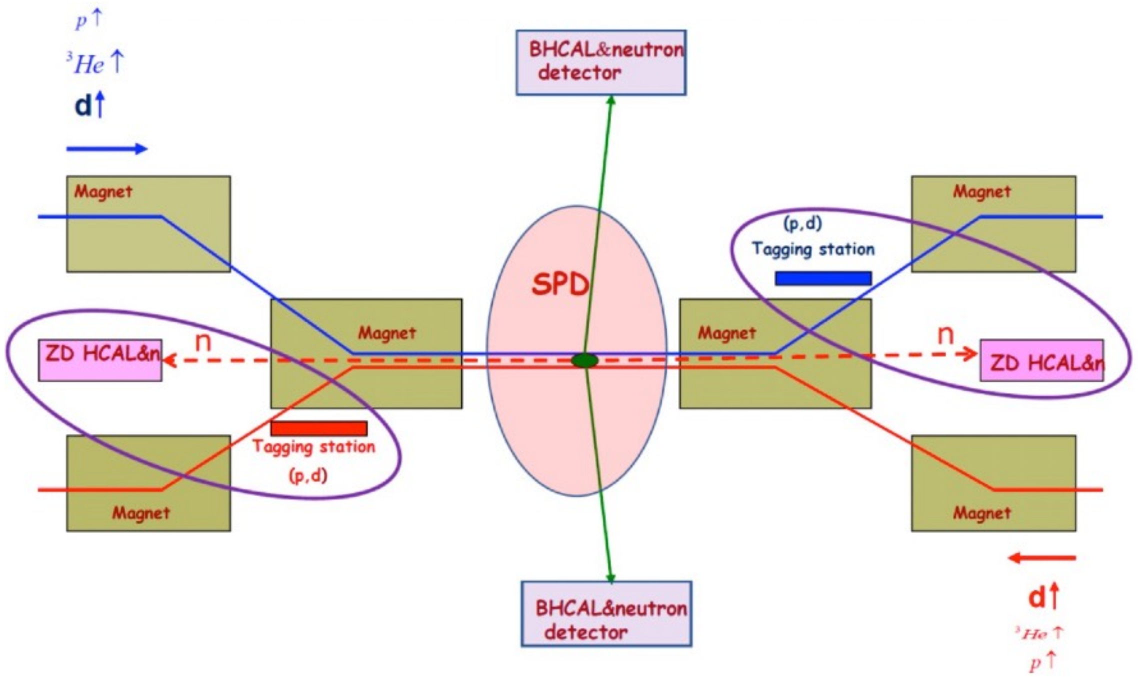
400 (unpacked raw) + 80 (full reco)+ 20 (fast reco) =500 MB per second

of data taking (= *5 PB/year*) written on tape. MC production will produce about the same amount of data data. Normally, the data analysis will use fully reconstructed data only. We foresee two rounds of data reconstruction, so that the fully reconstructed data will be superseded by a newer version and the obsolete data removed after quality checks of newer data. We may also consider removing the unpacked raw data at this point and keeping only physics objects for future analysis after the reprocessing. Of course, this data flow is tentative and should be verified by a simulation and finally tuned during the early years of the data taking at lower luminosity.

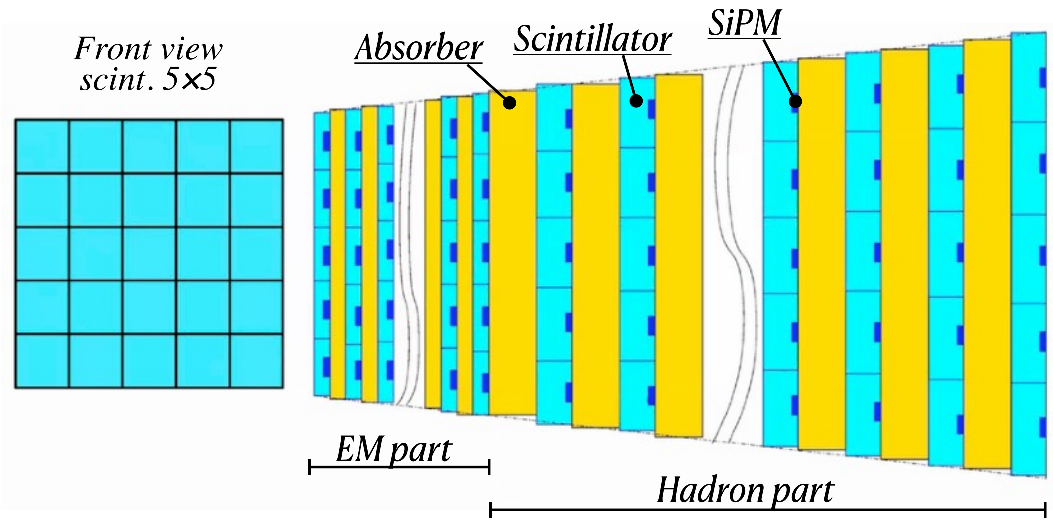
Zero Degree Calorimeter (ZDC)

Q12 We have not seen the impact of the ZDC on physics. May you elaborate on this point.

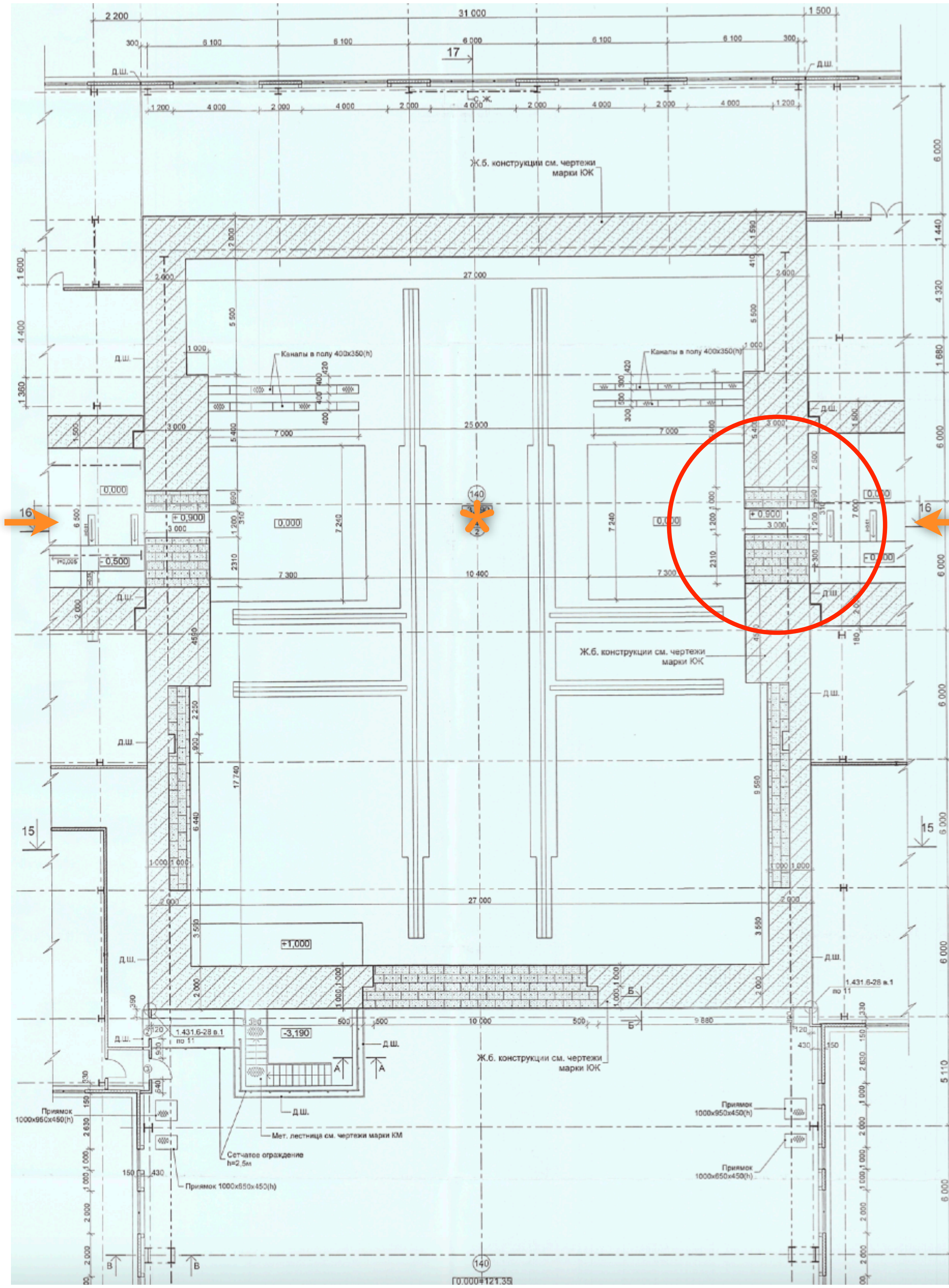
The Zero Degree Calorimeter is especially important for physics with deuteron beams at low energies. We could be able to study tagged p-p and p-d interactions (ZDCs detect 1+1 and 1+0 neutron, respectively). To be able to tag also n-n interaction, installation of spectator proton detectors on the beam line during possible upgrade of the NICA collider could be discussed (there is no free space for them now).

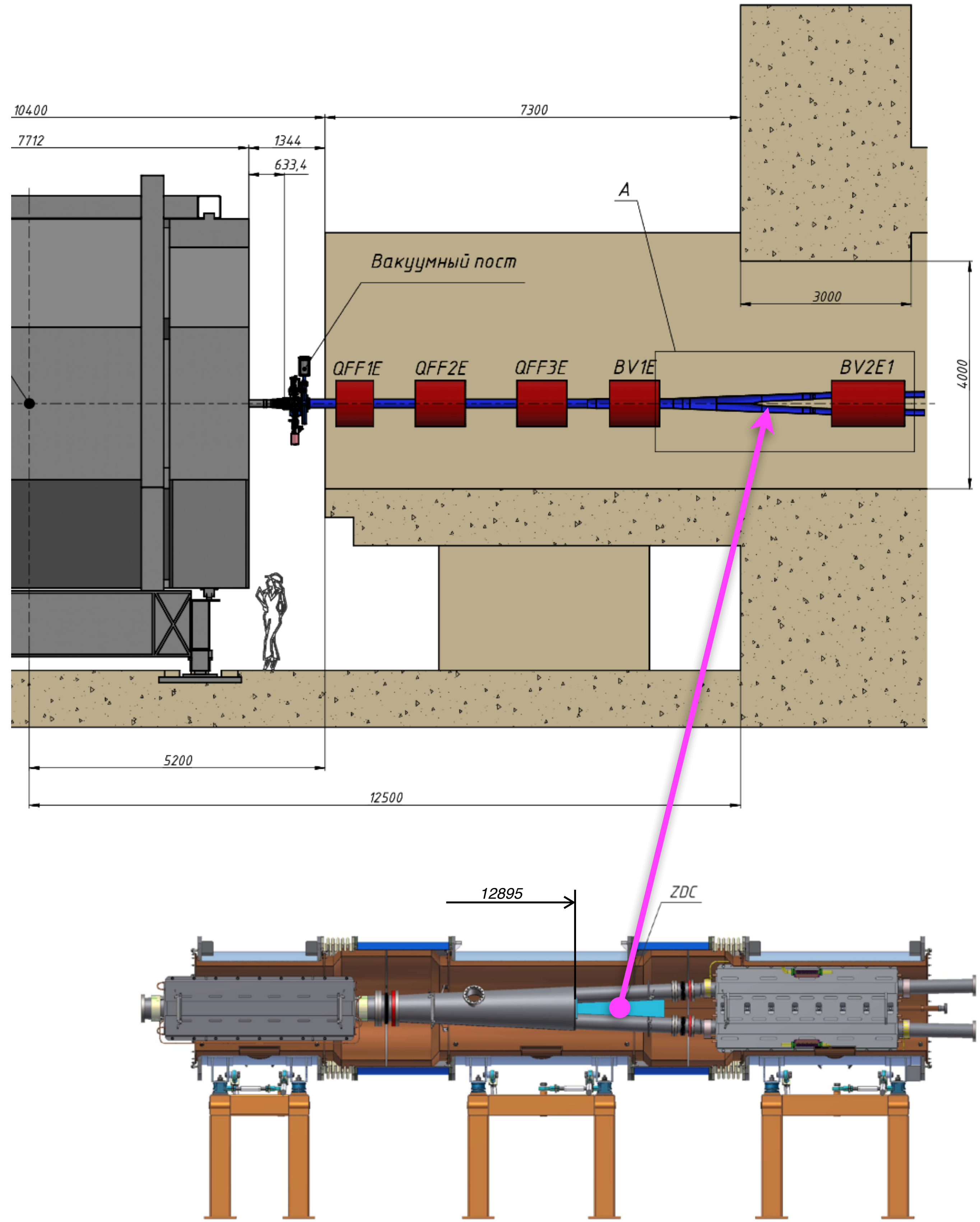


Schematic view of ZDC



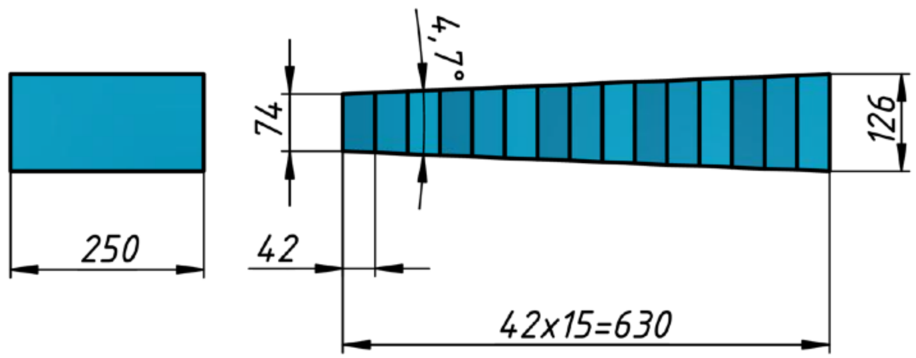
Location of ZDC in the SPD hall



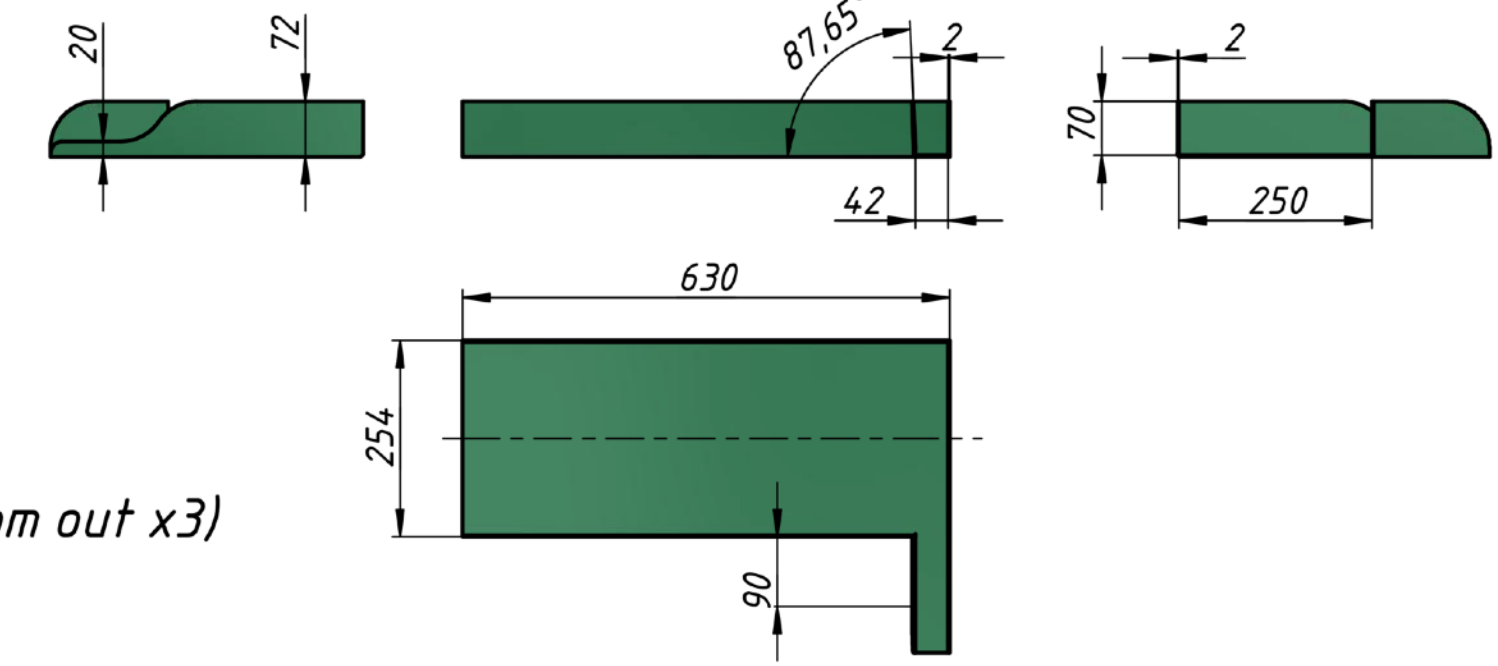


Zero Degree Calorimeter (ZDC)

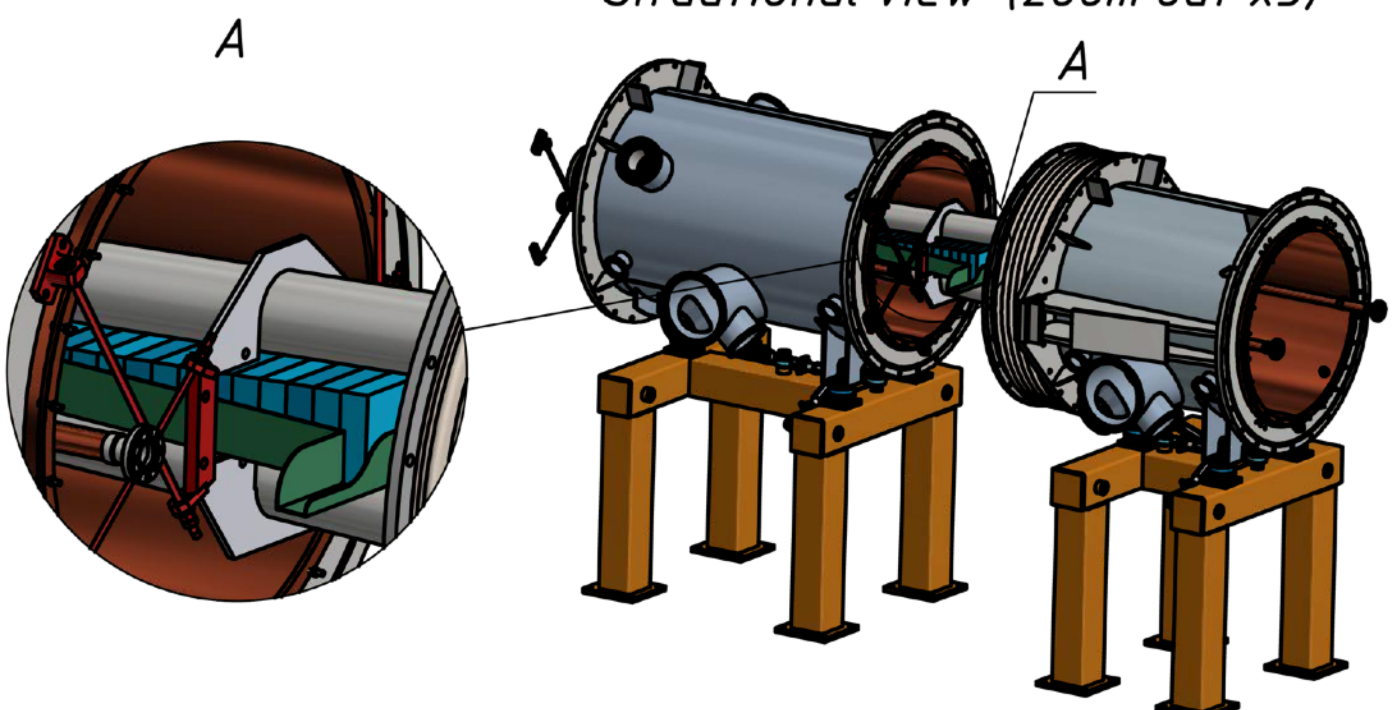
ZDC (15 slices)



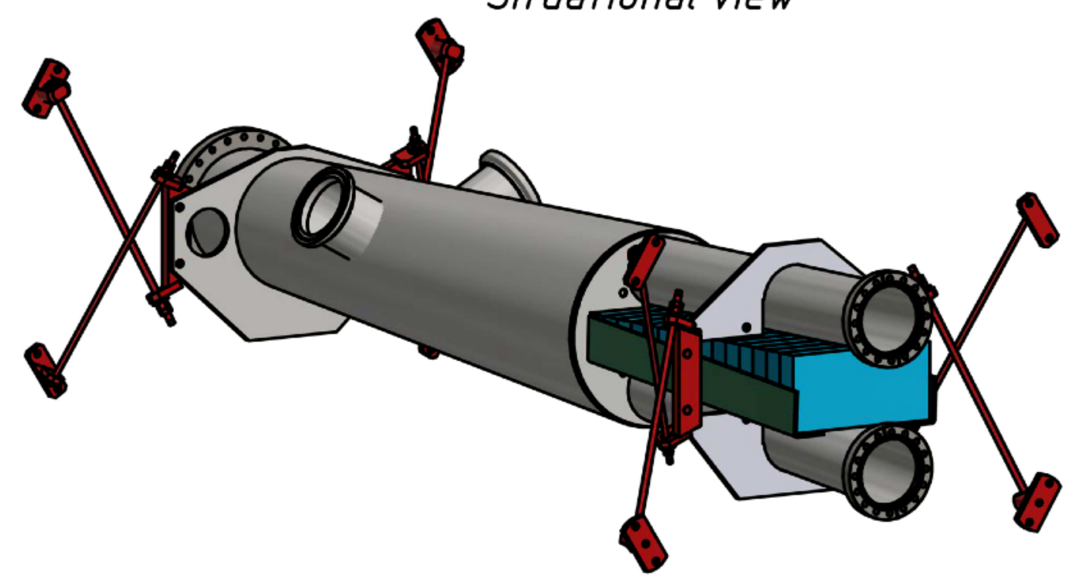
Feeder



Situational view (zoom out x3)



Situational view



- Weight is ~100 kg
- Located inside the cryostat (vacuum, about -200 ·C)
- Loaded section-by-section

Conclusions

- TDR preparation of is in the active phase
- The main obstacle for today is the absence of a magnet design. Several meetings with the local magnet team and the Novosibirsk team in October
- Beam tests for the detector prototypes potentially this or next year