Updates of the SPD experimental setup

Alexander Korzenev, JINR/LHEP

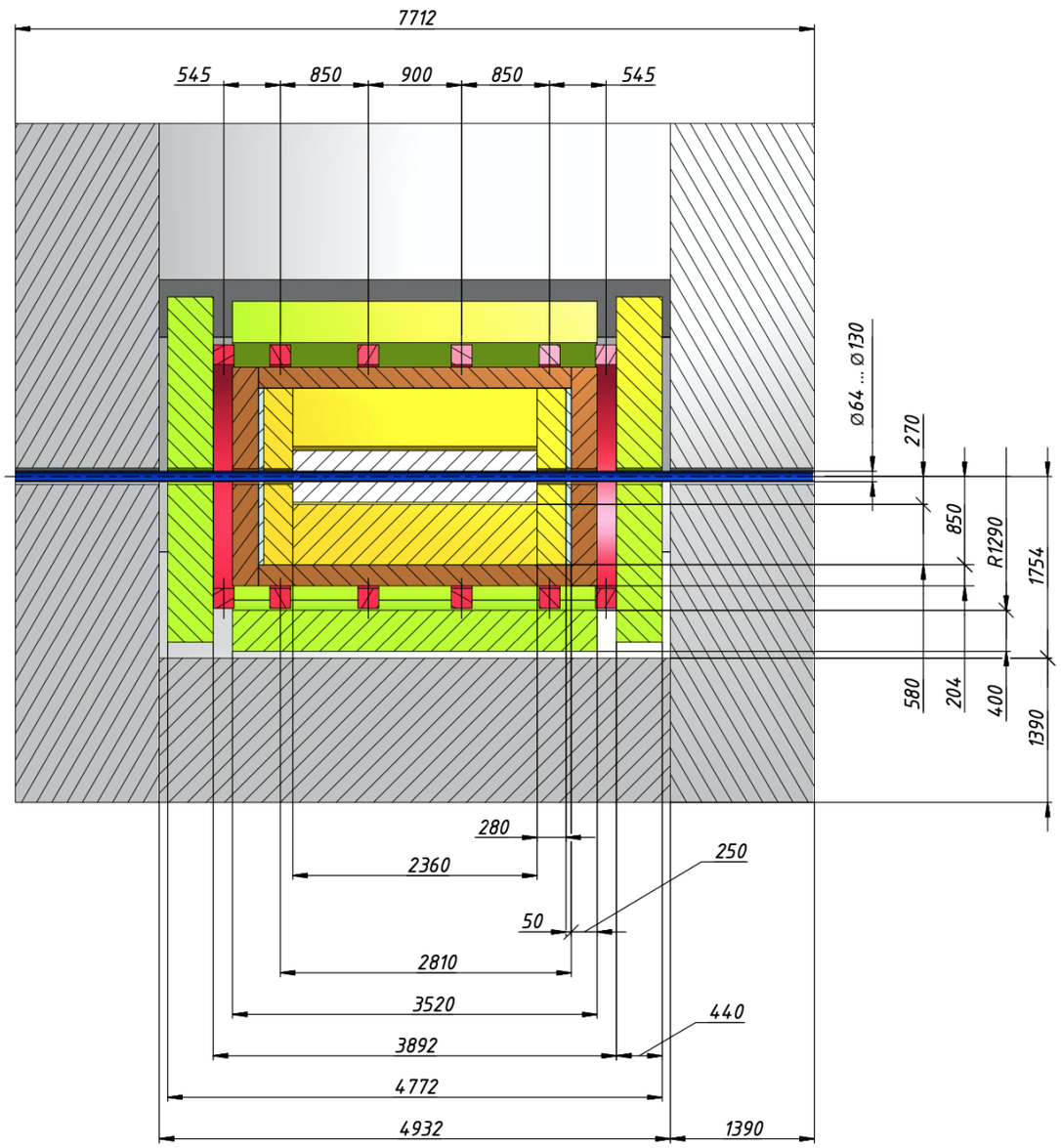
SPD TB #2 meeting
Dec 2, 2021

Outline

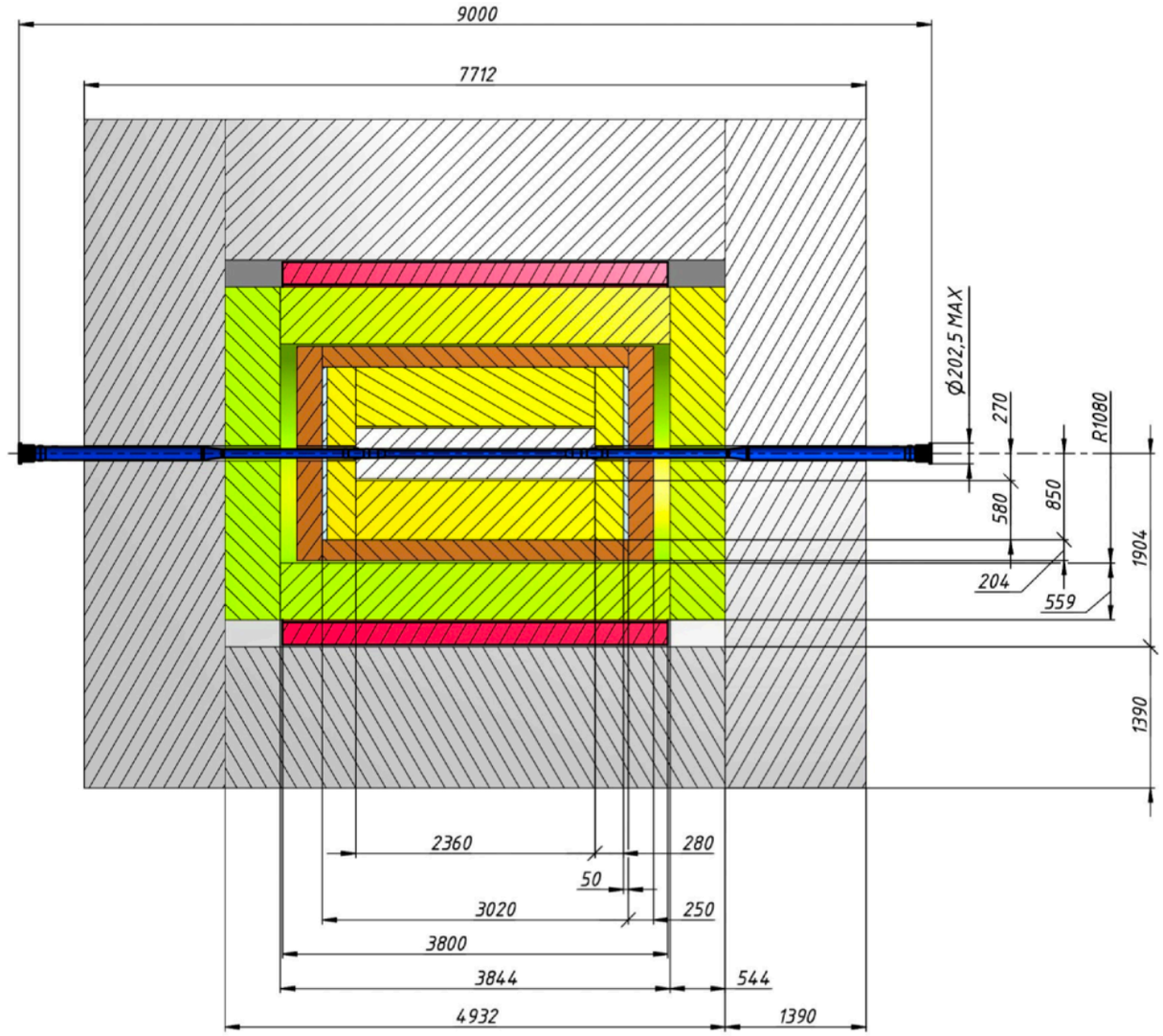
(news with respect to the previous meeting)

- Relative position of ECal and Magnet
- Two option for the magnet
  - Rutherford cable based (team of BINP Novosibirsk)
  - Nuclotron cable based (team of LHEP JINR)
- ECal construction options (power frame + baskets)
  - Half-sector approach (as in MPD)
  - Rim approach
- MRPC options for the Time-of-flight system
  - Tsinghua proposal
  - Protvino proposal
- MicroMegas proposal for the Vertex Detector (1-st stage of experiment)
- Priorities for subsystems in view of the construction stages of SPD
  - Release for the schematic views of the SPD setup
- Agreement for the detector nomenclature scheme
- Conclusions

CDR version (**obsolete**)
Magnet inside ECal

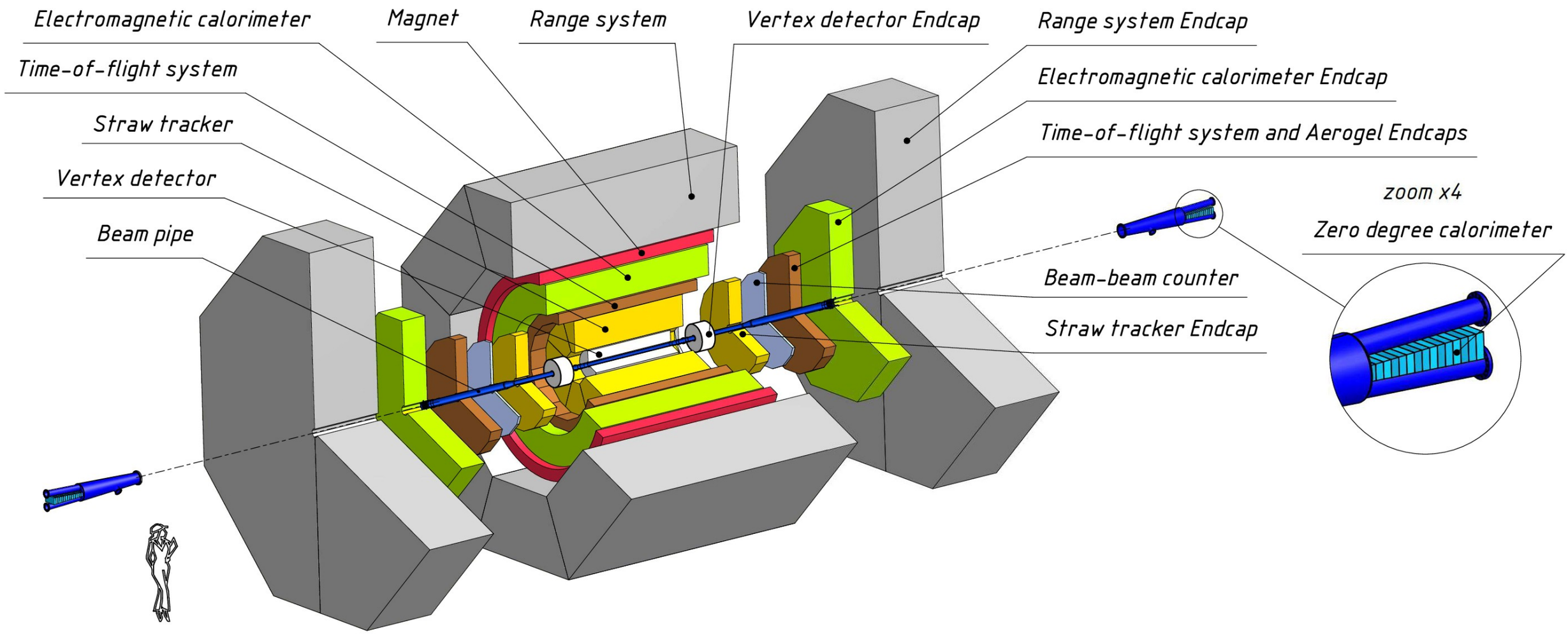


To be approved
ECal inside Magnet



+15 cm in radius w.r.t. CDR

Update for the schematic view of the SPD setup



- 6 coils inside ECal were replaced by a single cryostat outside ECal
- Final complete set of detectors

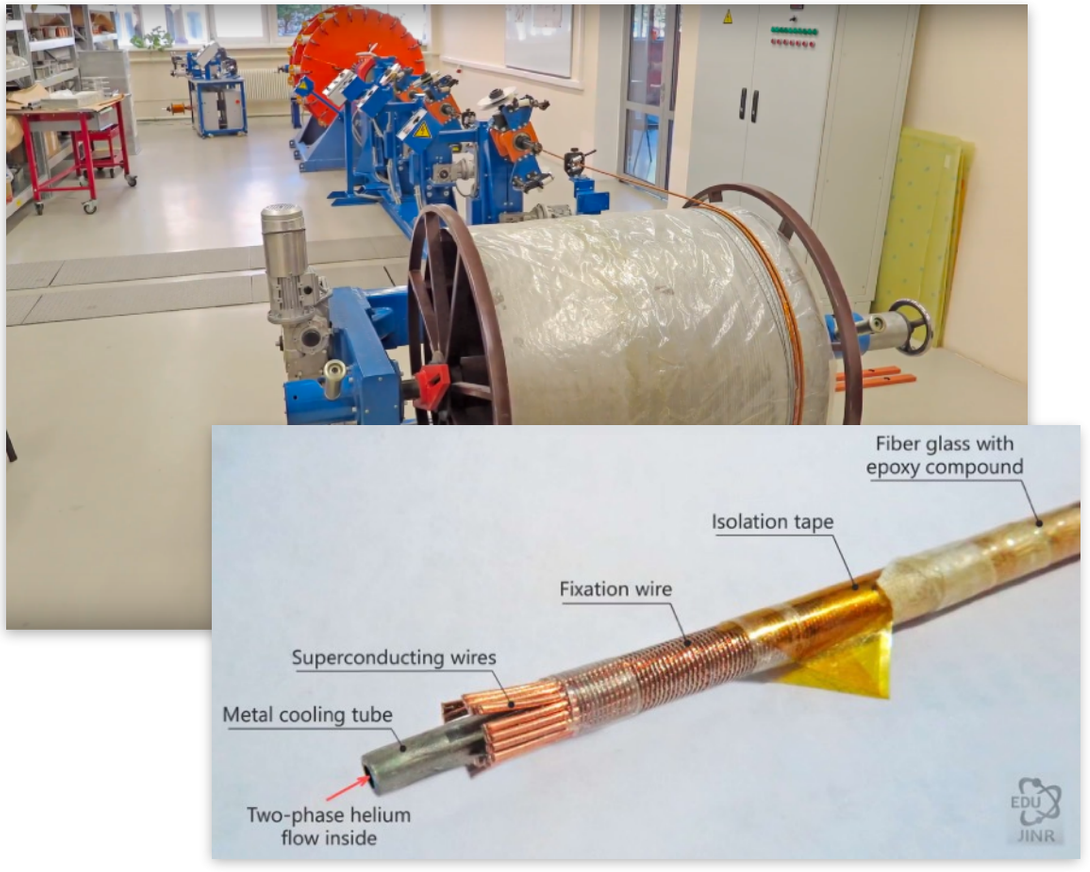
Two options for the SC magnet technology

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 based on the NICA cable

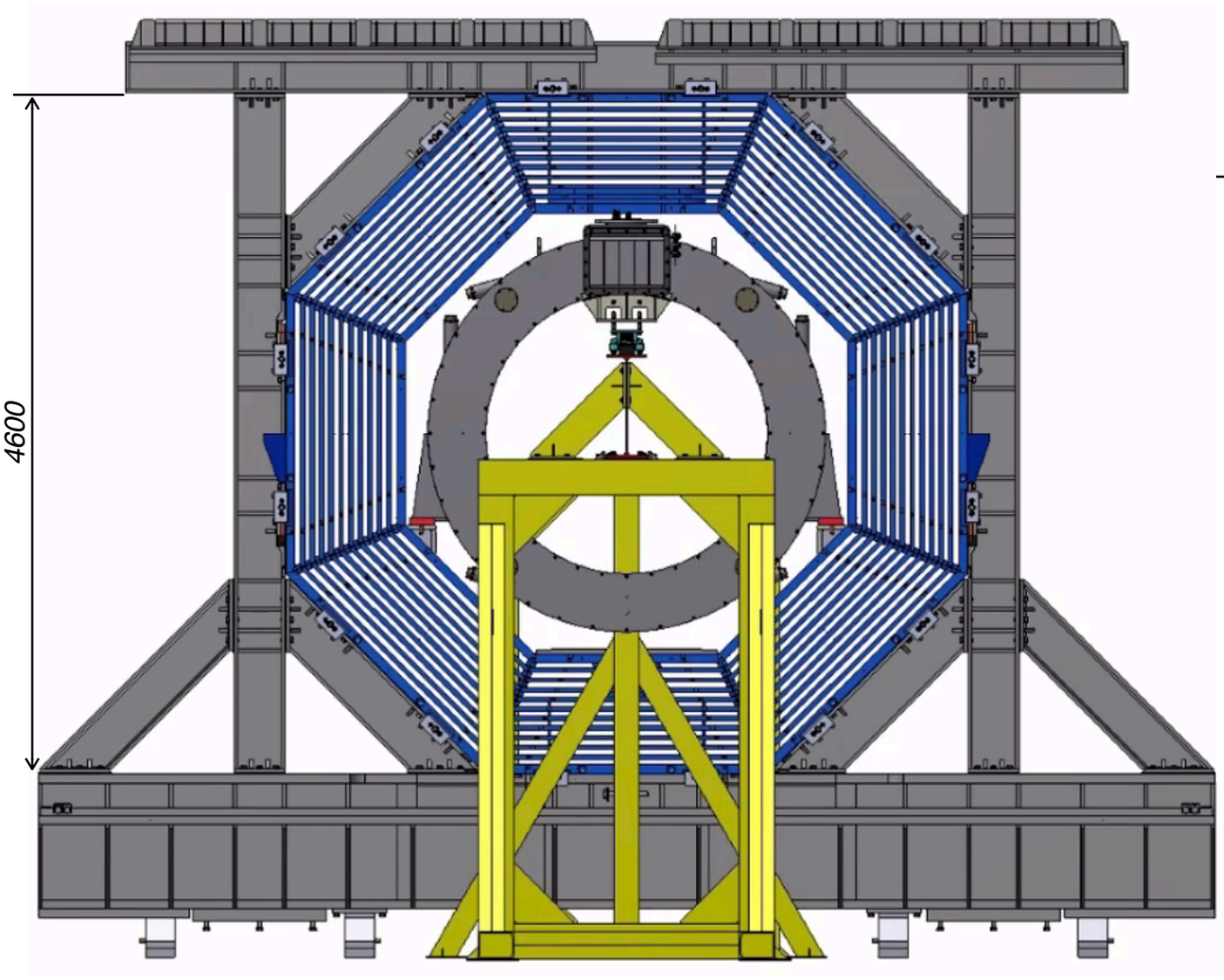
- Coil construction similar to one used for the NICA magnets (produced in JINR)
- Two layers of NbTi/CuNi cable. The same cable as used in Nuclotron magnets: hollow superconductor with the helium flows inside (~4 K)
- Design of cryogenic system (refrigerator, pipelines and so on) in JINR



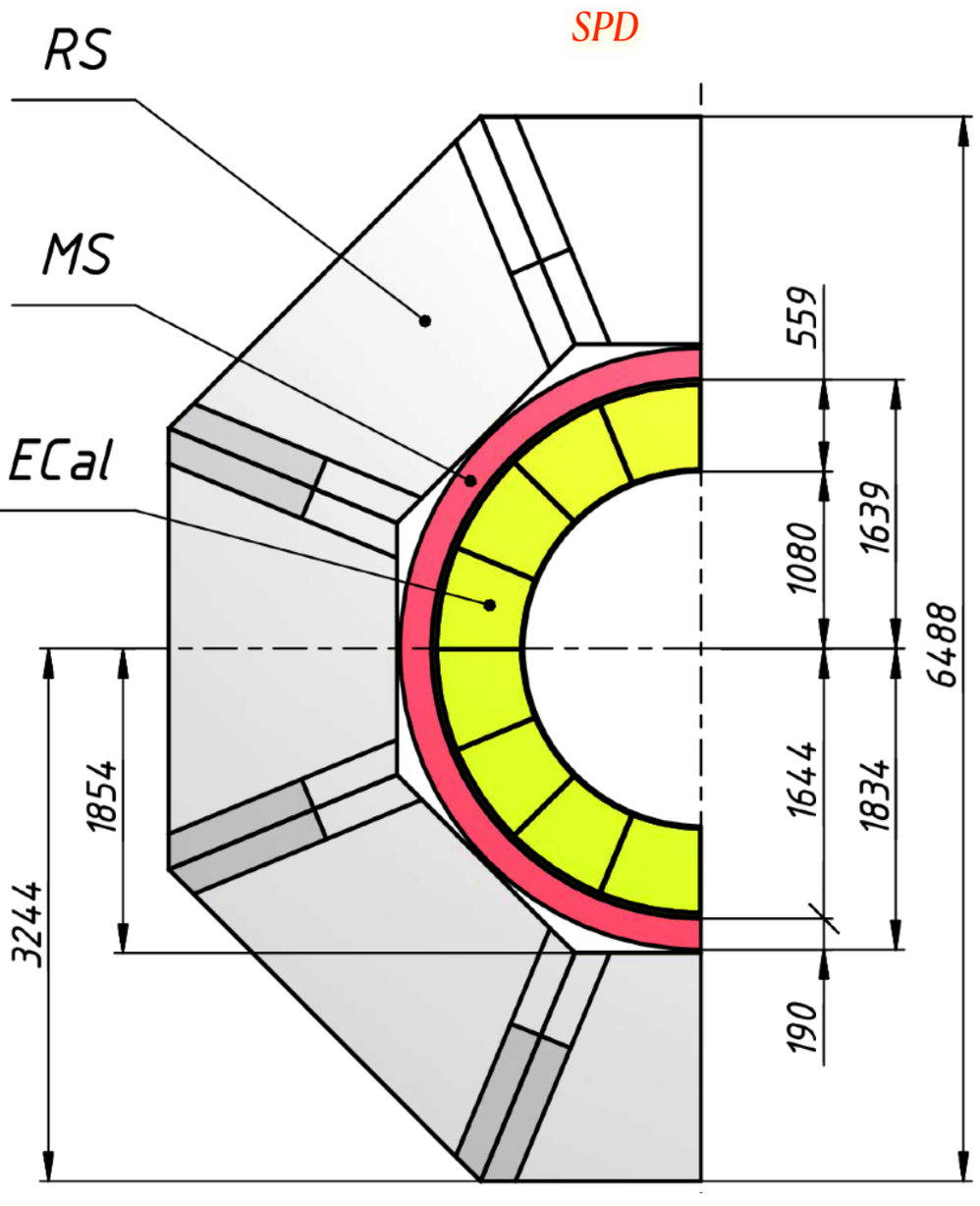
E.Pyata
S.Pivovarov
A.Krasnov

PANDA compared to SPD
(scale 1:1)

PANDA



SPD

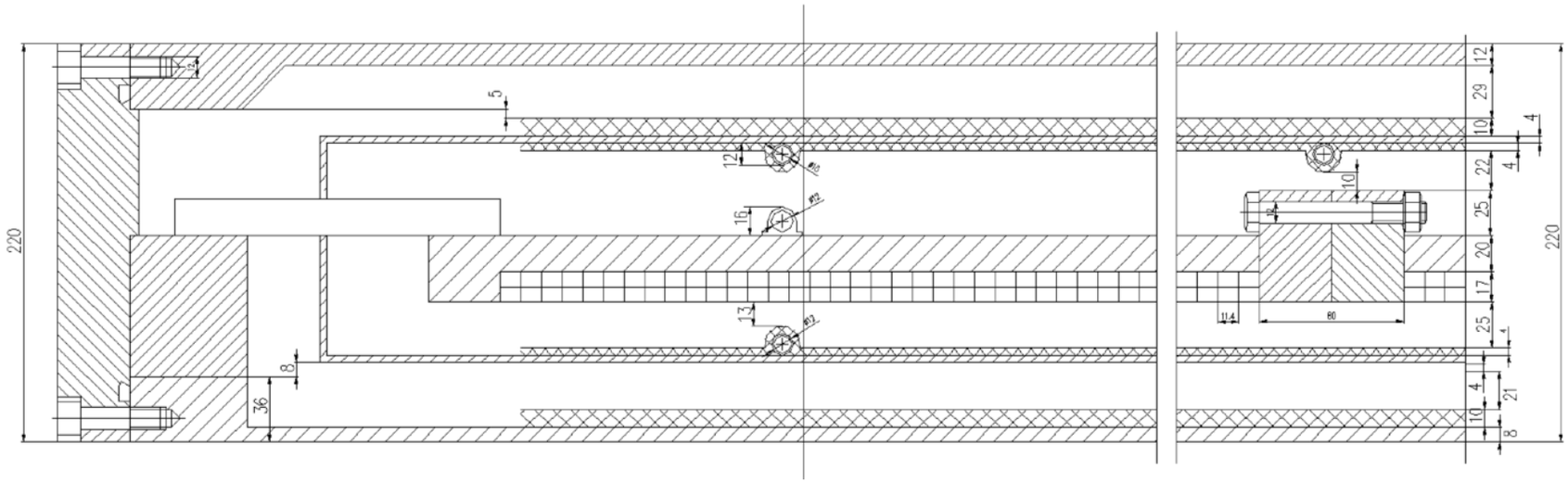


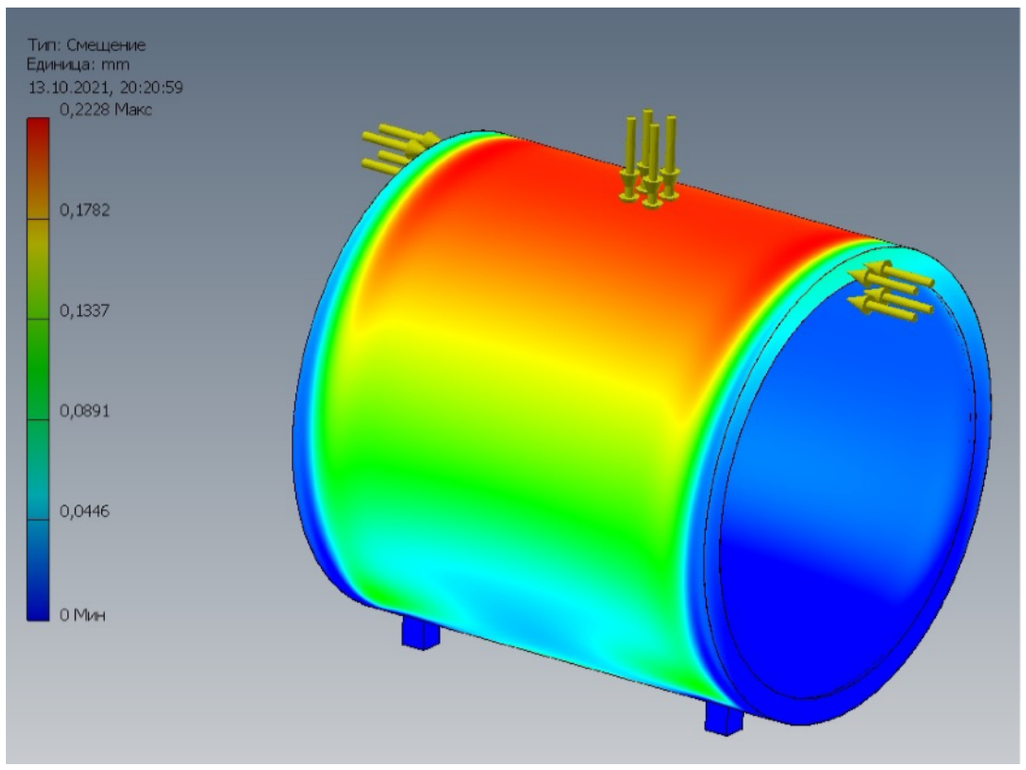
- Radial thickness of cryostat will have to reduced from ~40 cm (PANDA) to ~20 cm
- Example: solenoid of KEDR is 22.5 см thick

E.Pyata
S.Pivovarov
A.Krasnov

Option based on the PANDA cable

- The Rutherford cable with 8 strands extruded in Al matrix
- Cooling provided by liquid helium which circulates in pipes welded to the outside of the coil former

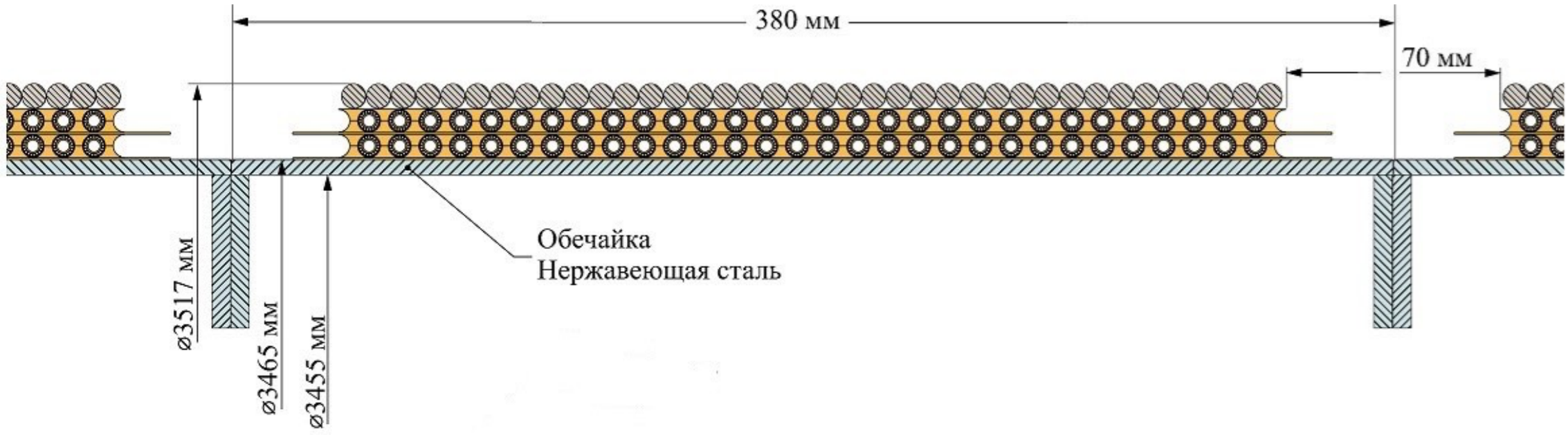




- Preliminary estimates for deformations shows satisfactory results
- The BINP team visited JINR for one week in October
- The PANDA magnet will be moved to GSI in 2024 for final tests. Engineers will be available for the SPD magnet in 2023-2024

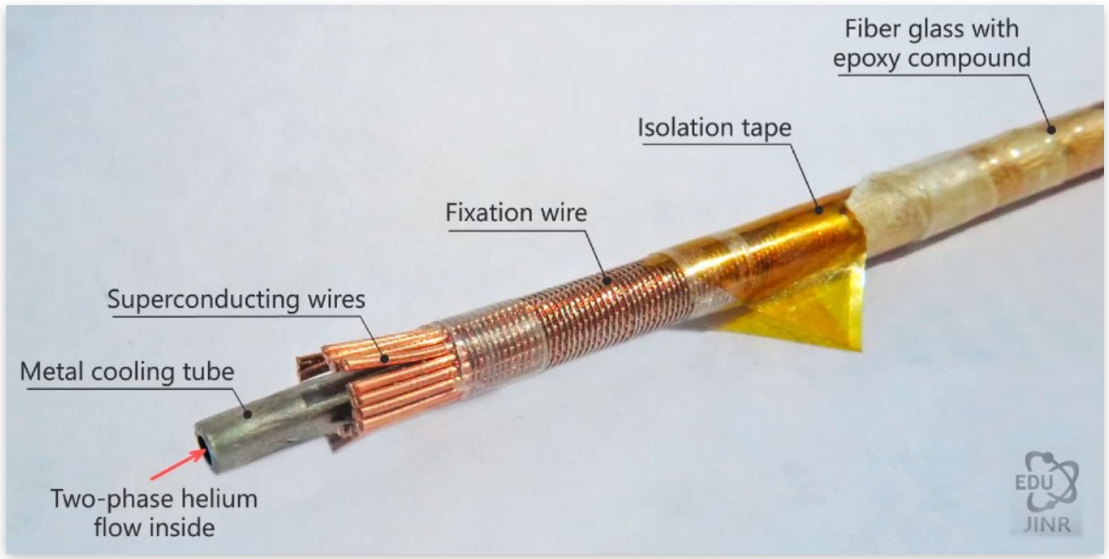
H.Khodzhibagiyan et al.

Option based on the NICA cable



- Two layers of NbTi/CuNi cable. The same cable as used in Nuclotron magnets: hollow superconductor with the helium flows inside (~4 K)
- Will require an intensive R&D since coils of large size made of Nuclotron-type cable has never been constructed before
- Main issue is a quench handling

Cable used for magnets of Nuclotron



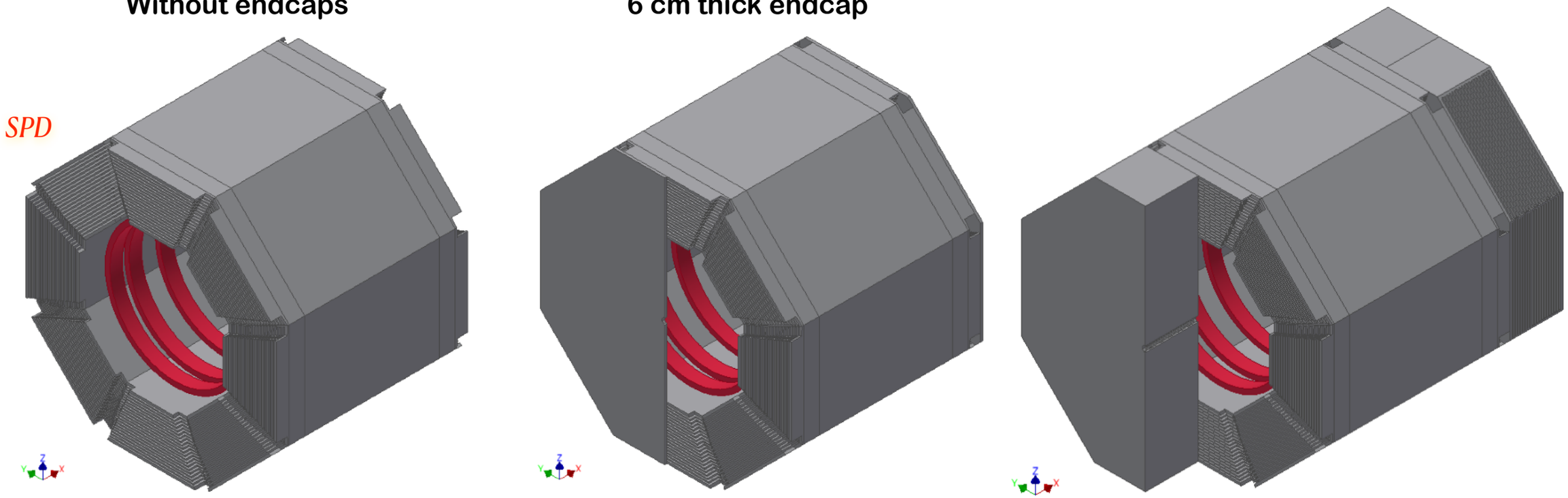
I.Moshkovsky

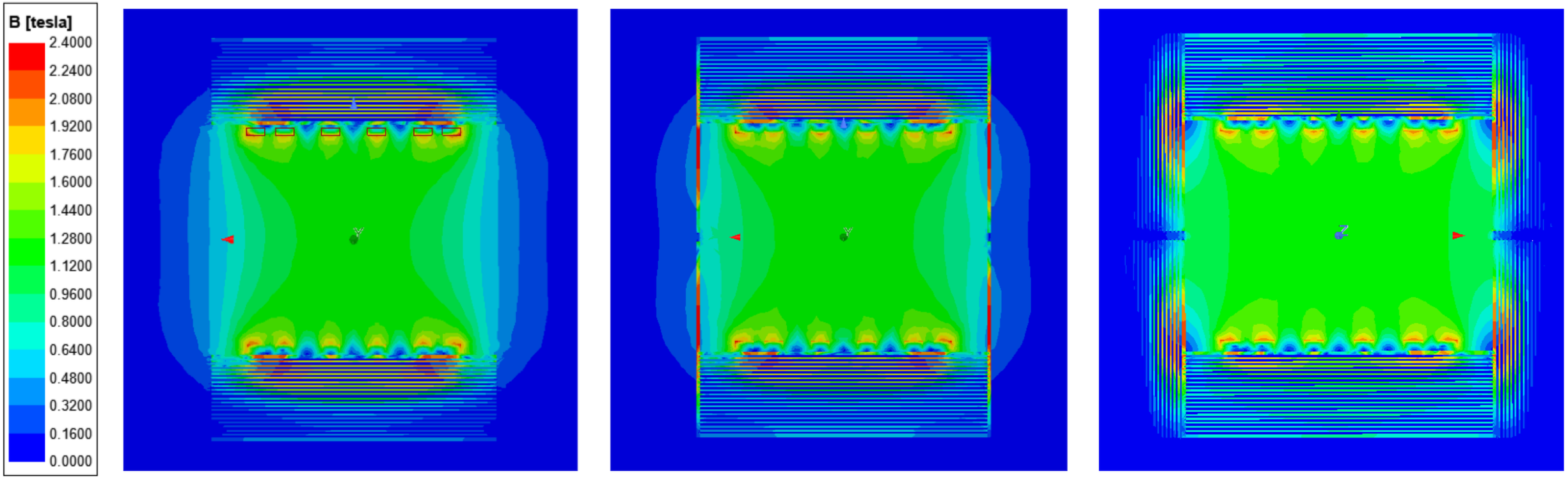
Magnetic field calculation (cryostat outside ECal)

Without endcaps

6 cm thick endcap

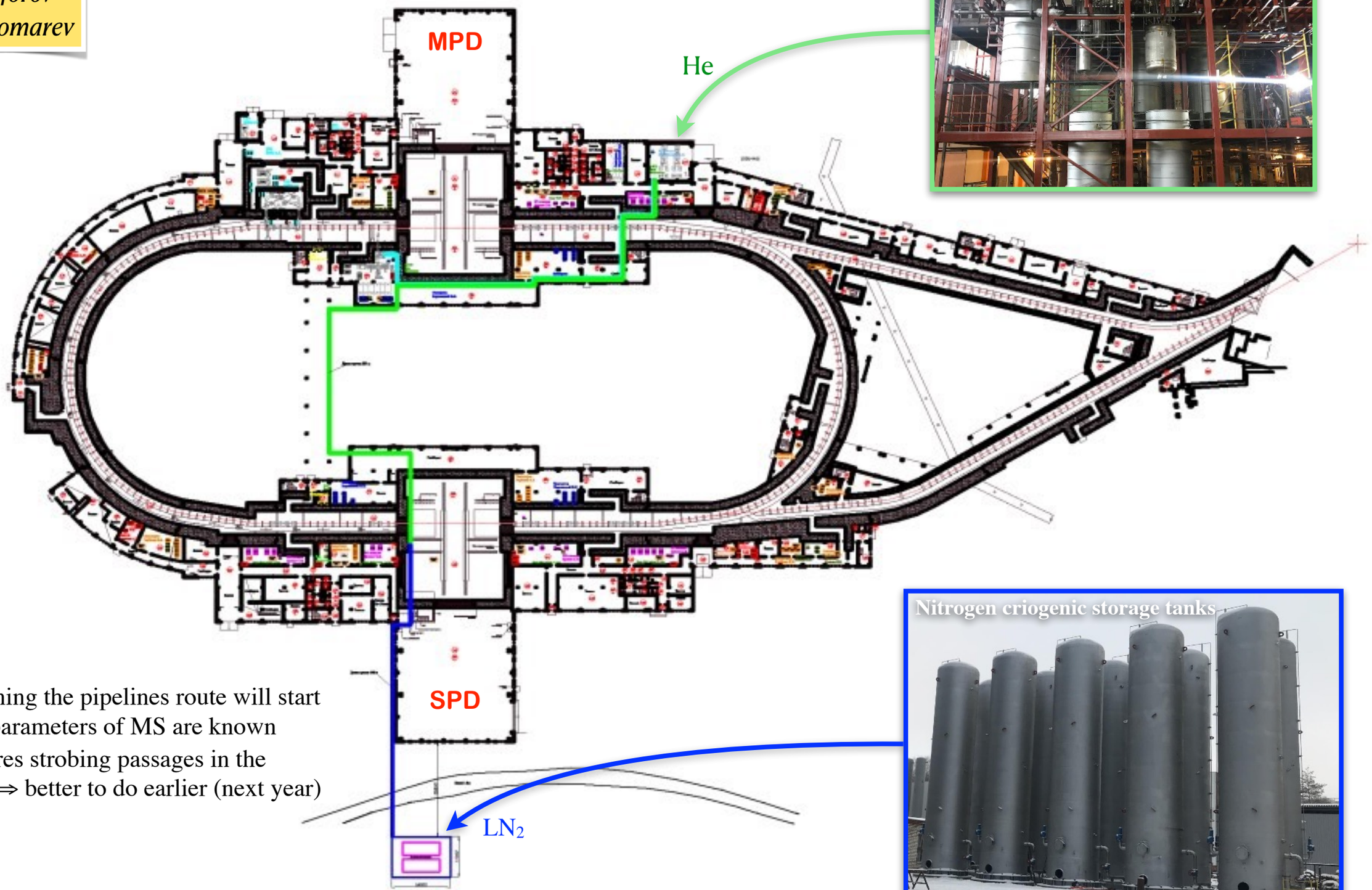
Full construction





Infrastructure for the cryogenic system

D.Nikiforov
A.Ponomarev



- Designing the pipelines route will start once parameters of MS are known
- Requires strobing passages in the walls ⇒ better to do earlier (next year)

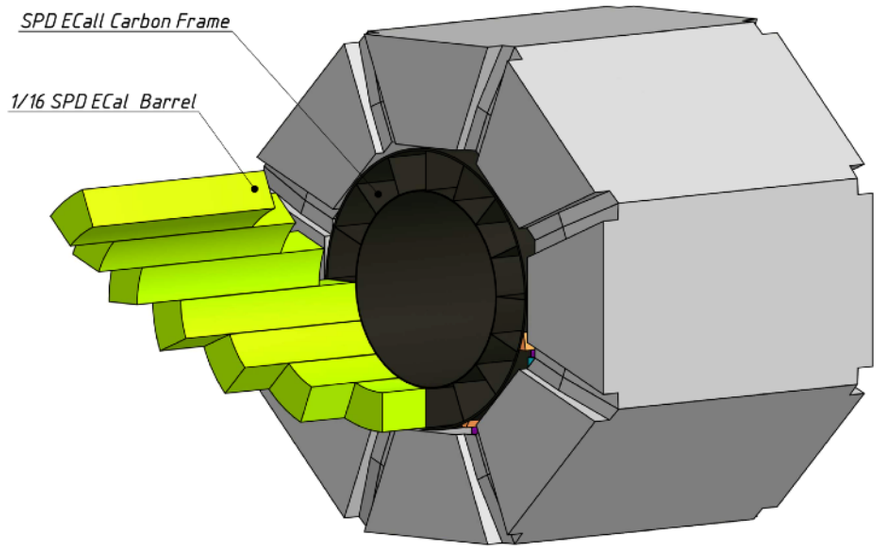
O.Gavrischuk

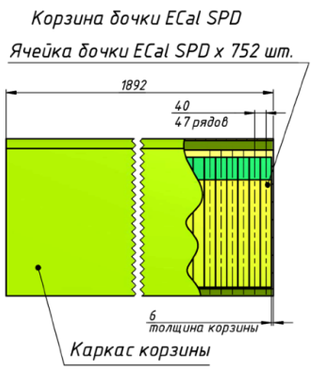
Electromagnetic Calorimeter (ECal)

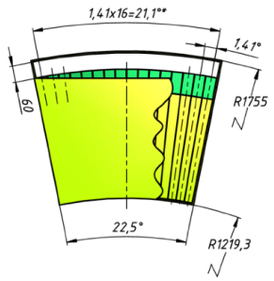
CDR

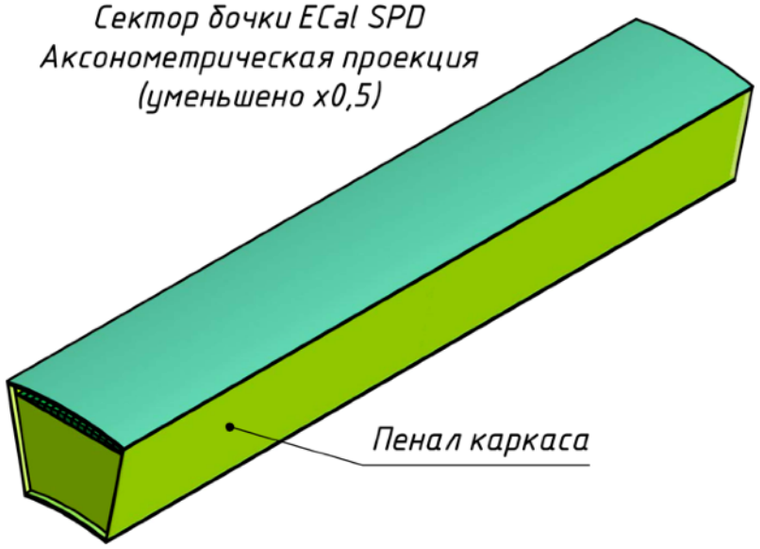
Half-sector approach

Similarly as it is employed in the MPD experiment



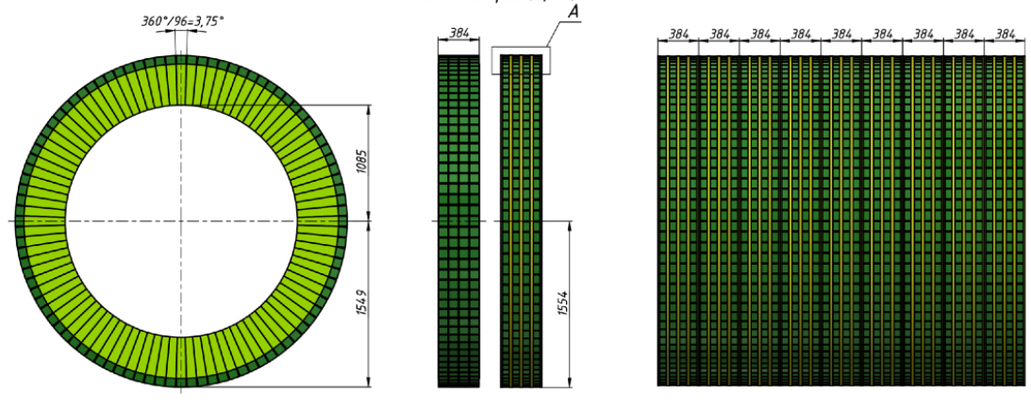


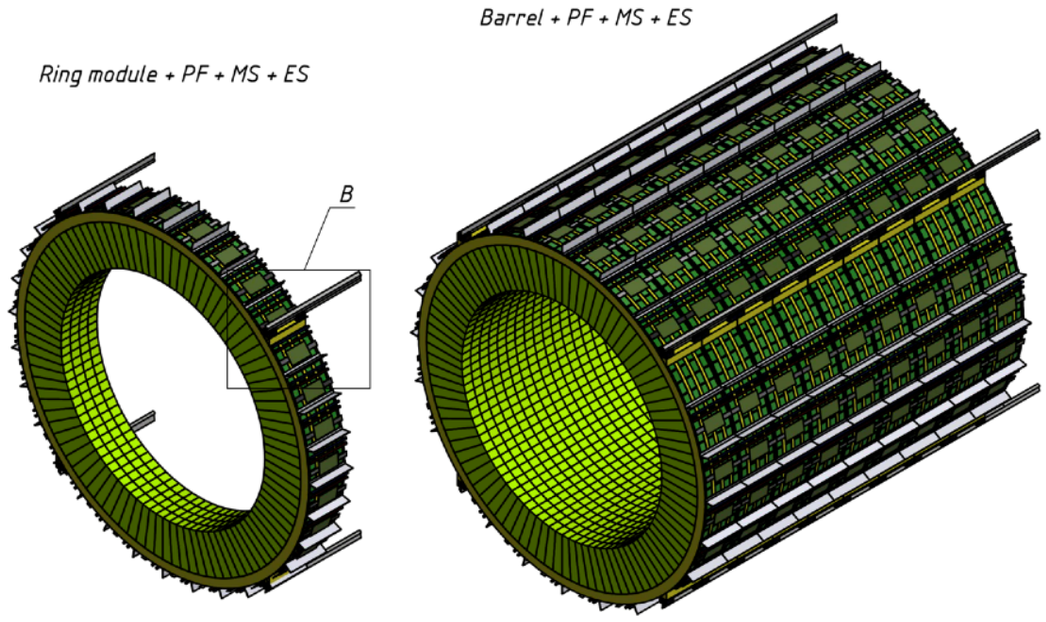




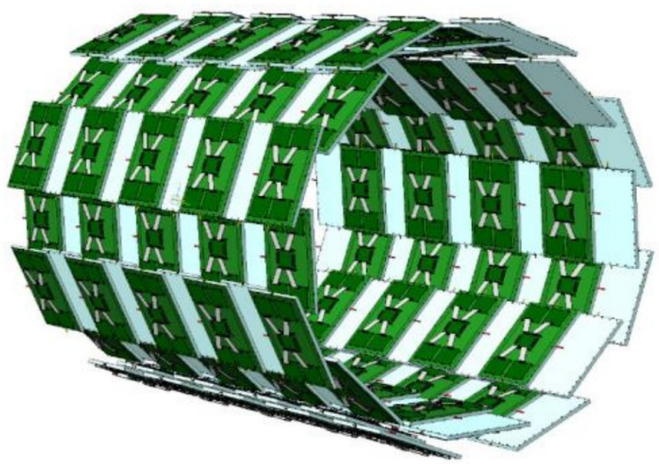
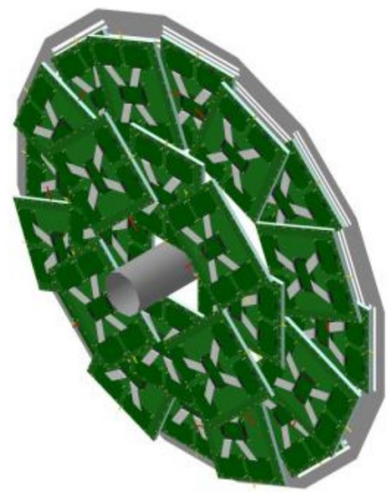
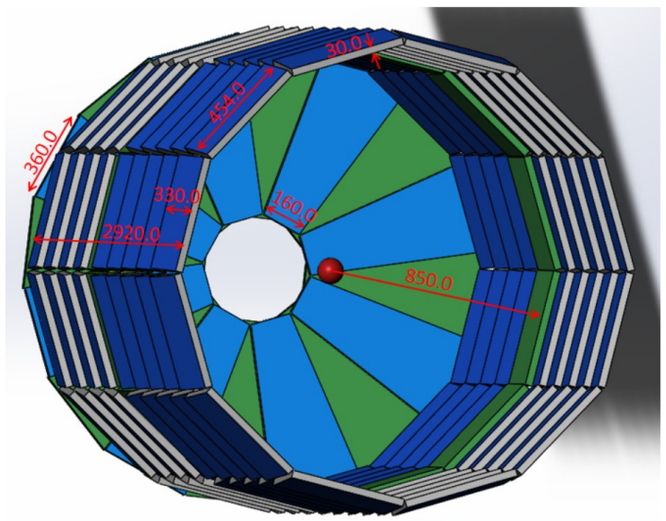
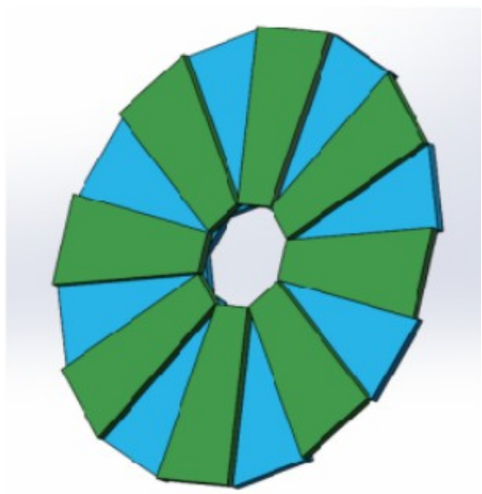
Rim approach

It was proposed in order to avoid inefficiency regions distributed azimuthally





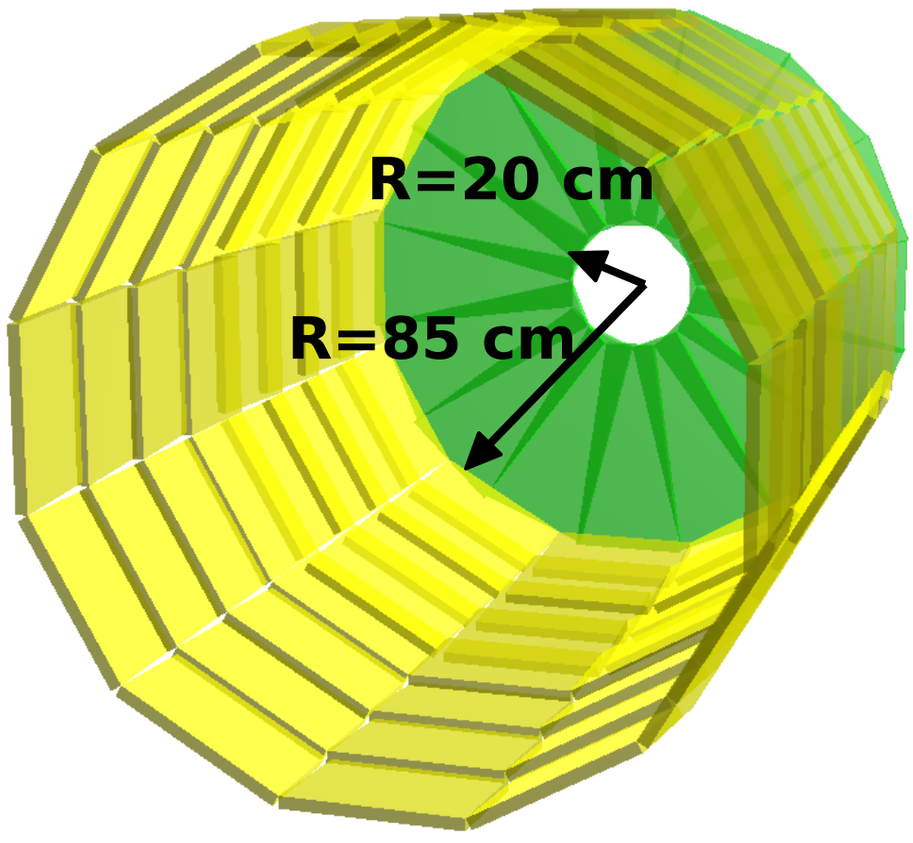
TOF system: Tsinghua and Protvino

geometry	Barrel	End-cap
A.Semak Protvino		
Yi Wang Tsinghua		

Presented by A.Ivanov at S&C meeting on 26.10.2021

Tsinghua TOF system: Barrel and End-cap

Proposal from Tsinghua

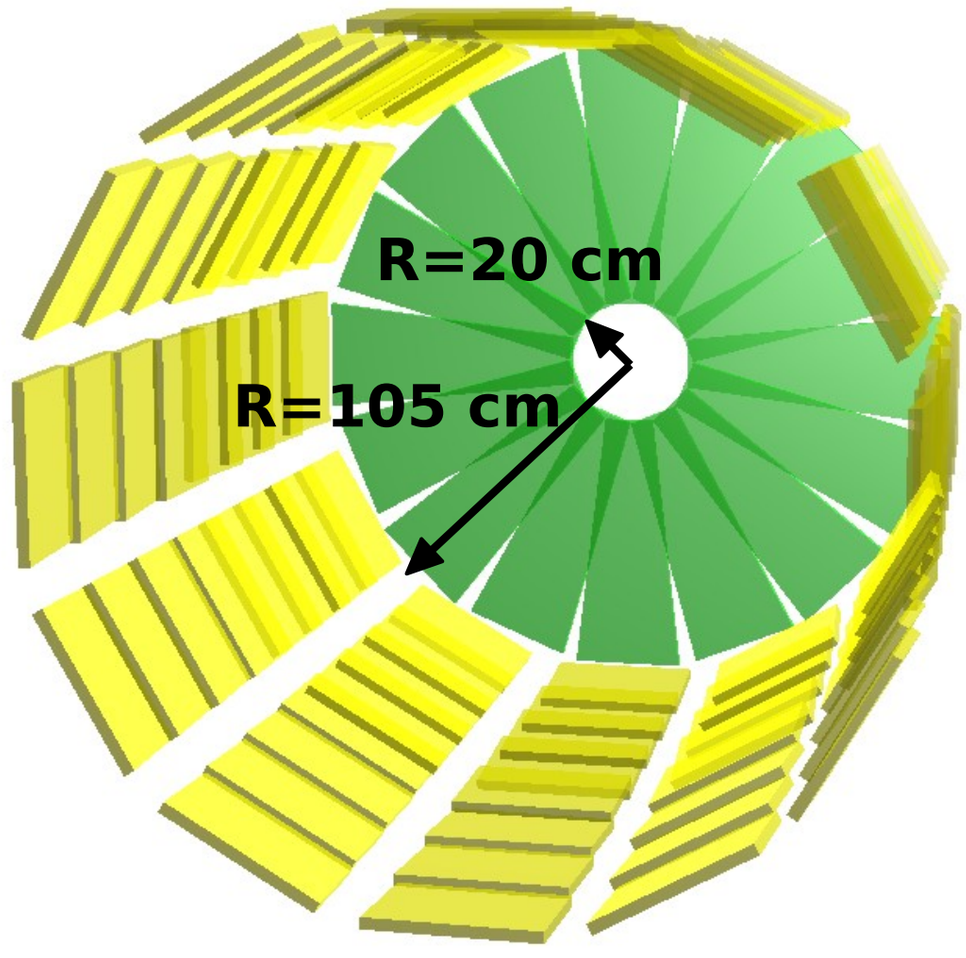


Module (Barrel)
Length=45.4 cm
Width=33 cm
Height=3.0 cm

Module (End-cap)
Width1=14.0 cm
Width2=34.0 cm
Length=70.0 cm
Height=3.0 cm

(95-115)

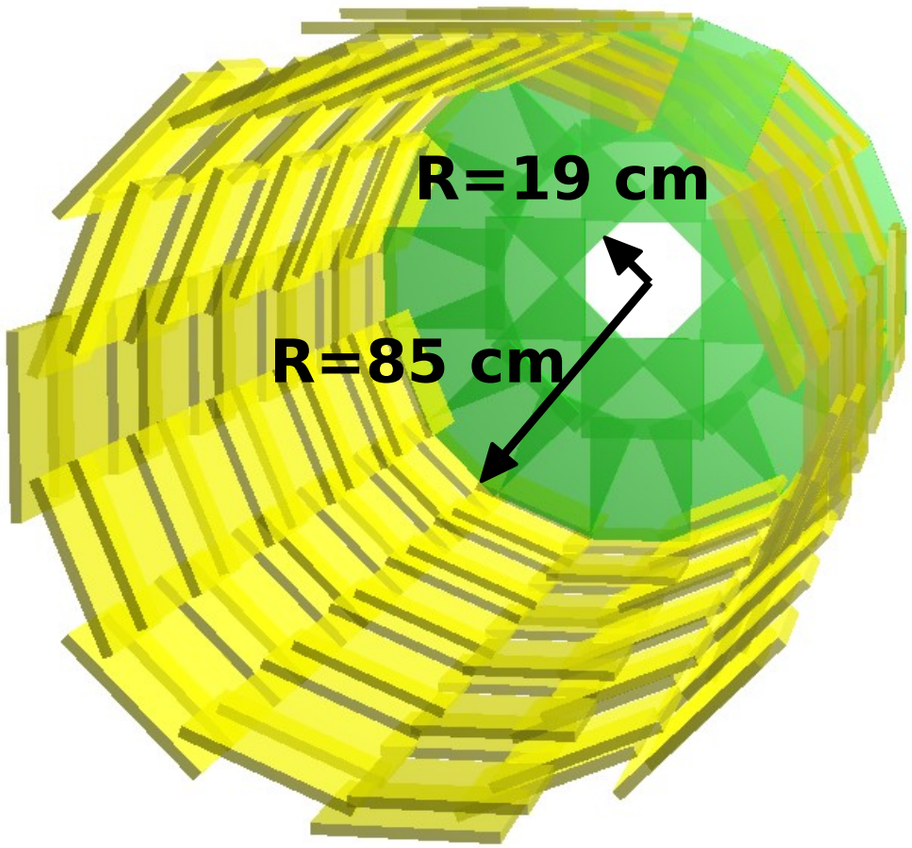
R=85 (proposal) → 105 as in SpdRoot



Size module as from proposal Wang

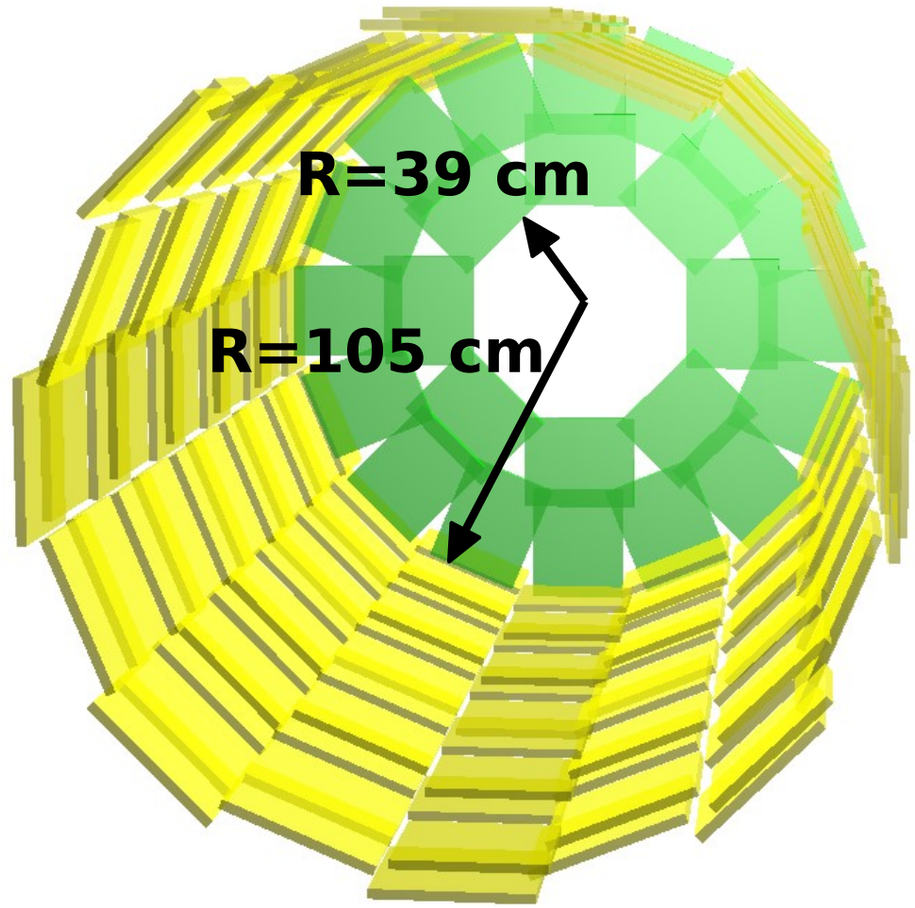
Protvino TOF system: Barrel and End-cap

Proposal from Protvino



module
Length=40 cm
Width=33 cm
Height=2.5 cm

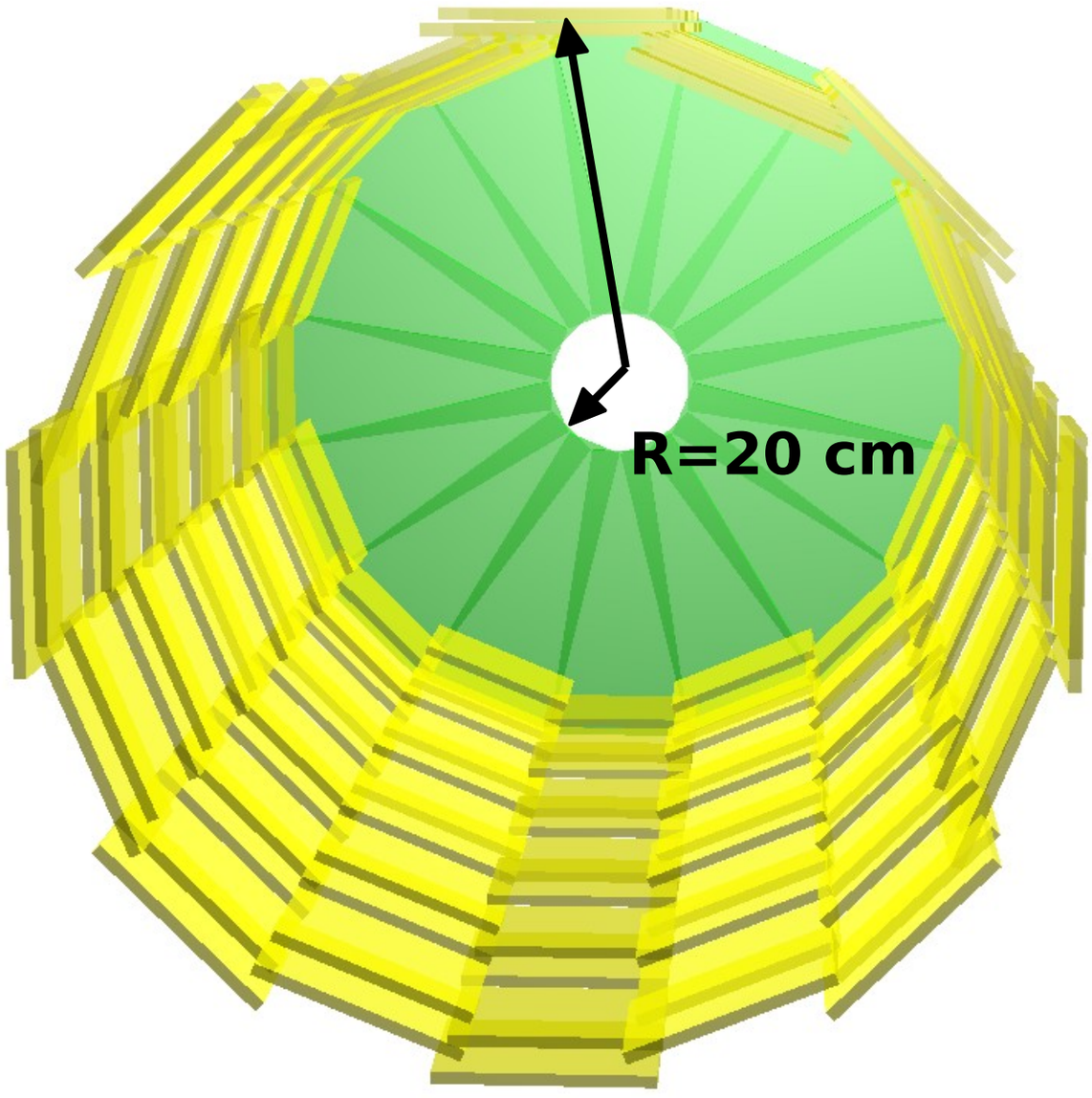
(95-115)
R=85 (proposal) → 105 in SpdRoot



Size module as from Protvino

Hybrid TOF system

R=85 → 105 cm



Barrel-module (Protvino)

Length=40 → 44 cm

Width=33 cm

Height=2.5 cm

Geometry Barrel as from Protvino

End-cap-module (Tsinghua)

Width1=14.0 cm

Width2=34.0 → 42 cm

Length=70 → 85.0 cm

Height=3.0 cm

Geometry End-Cap as from Tsinghua

18

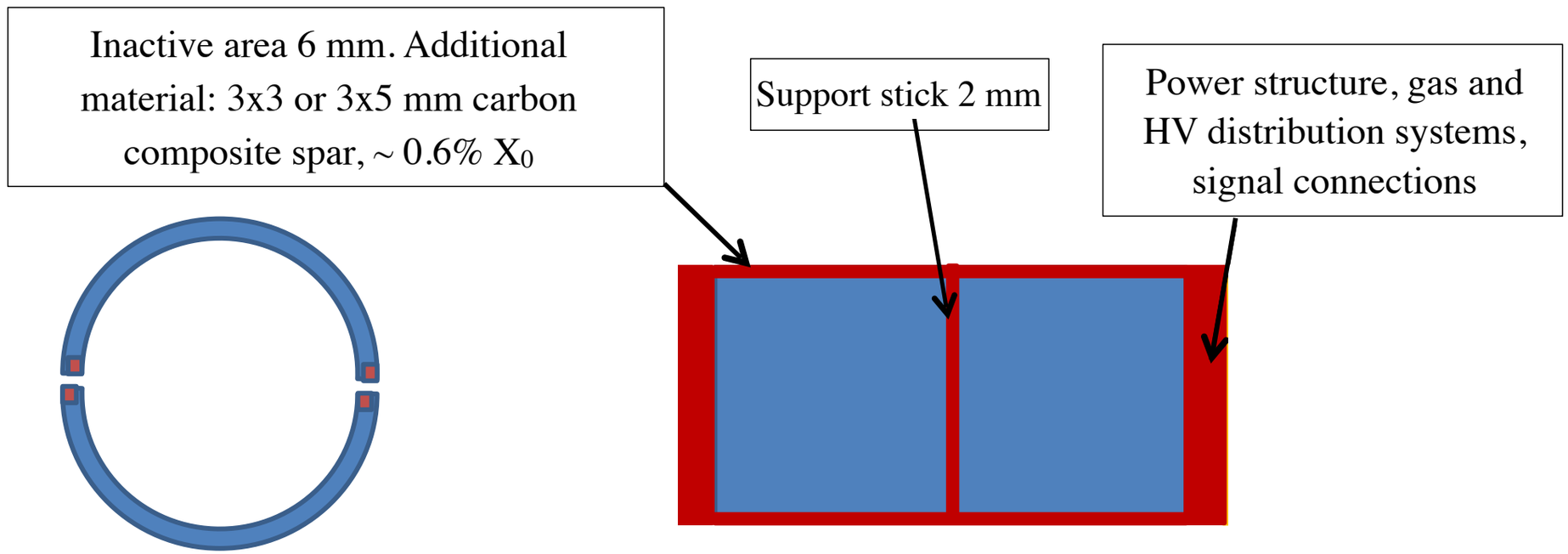
Presented by A.Ivanov at S&C meeting on 26.10.2021

D.Dedovich
A.Gongadze

MicroMegas proposal for the Vertex Detector

- For the first years of the experiment, it is proposed to replace the silicon vertex detector with a simpler and cheaper to manufacture MicroMegas
- It is assumed that MicroMegas for SPDs will be manufactured using bulk technology. Namely, PCB (~ 300 μm) with readout strips and a grid represent a single module made by photolithography methods. The cathode is glued to this module on a cylindrical frame. The gap and the shape of the detector are set by the power elements glued along the edges.
- A FE board based on the VMM3 chip is supposed to be used as the readout electronics. A convenient option for us is hybrid128 (2 VMM3 chips, 128 channels), developed by the RD51 collaboration. The size of one board is 50 x 80 mm, the price is ~ 1 to kCHF / pcs.

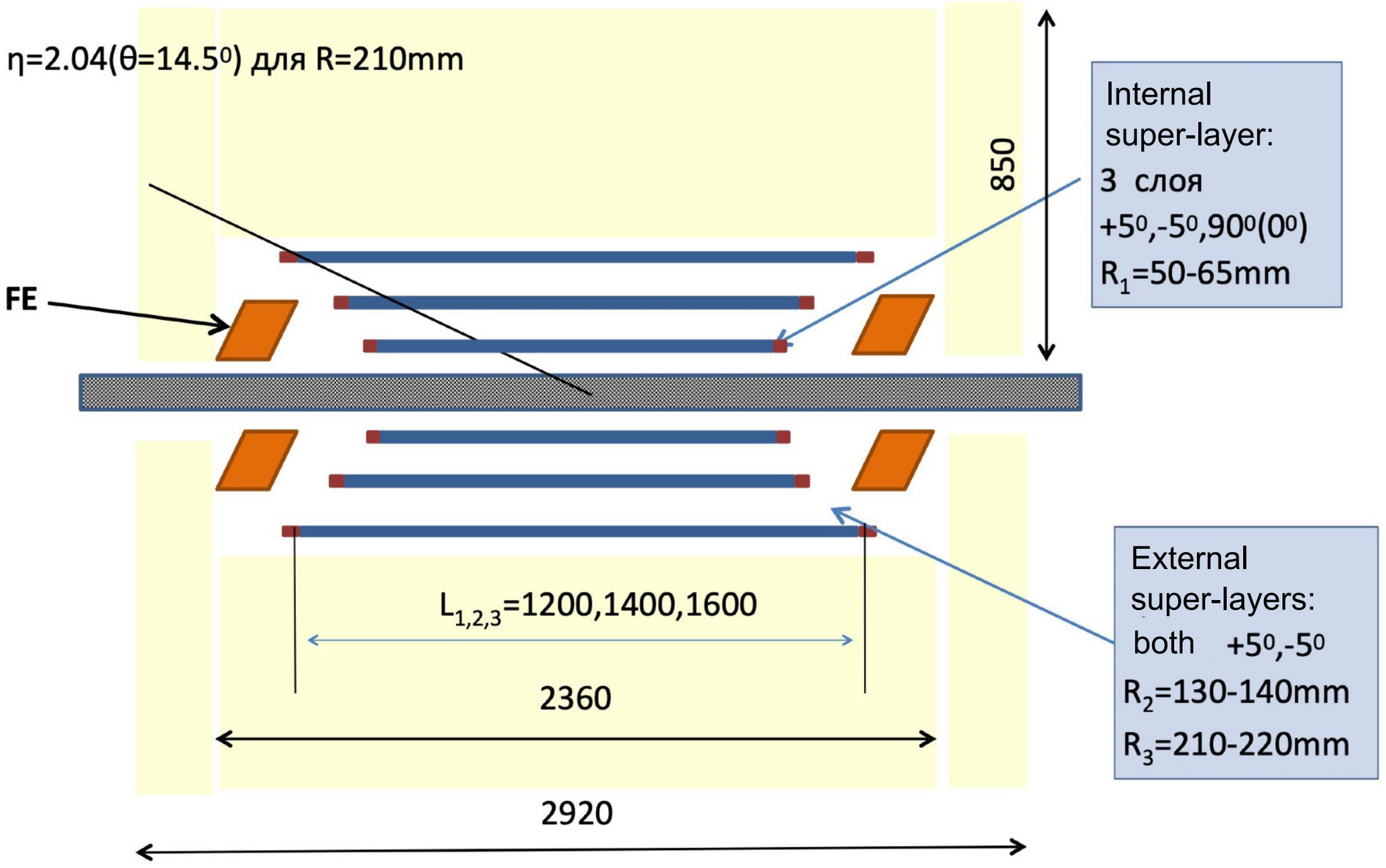
Cross section and developed views of one detector



D.Dedovich
A.Gongadze

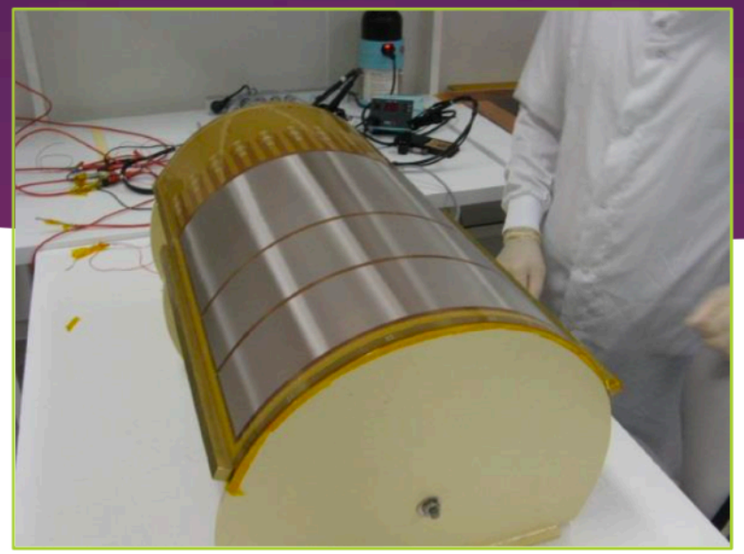
MicroMegas proposal for the Vertex Detector

- The number of channels is about 25 thousand (~ 200 boards, ~ 400 chips), power consumption ~ 2 kW. It is necessary to develop a cooling system

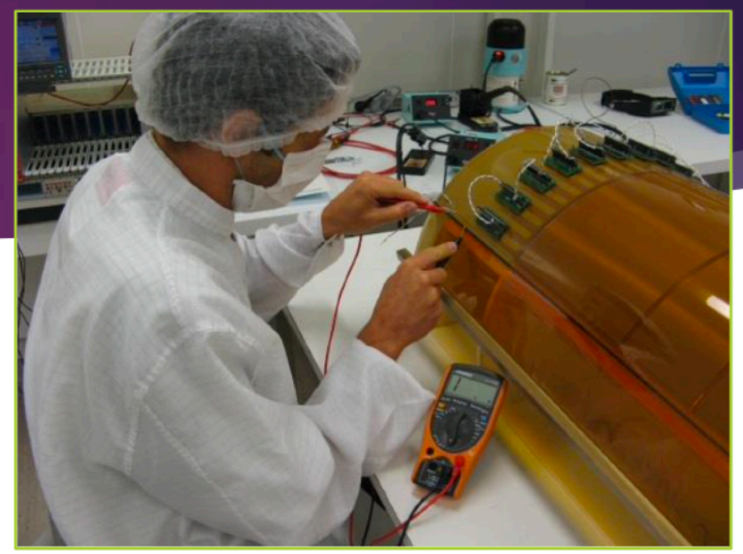


Cylindrical Micromegas

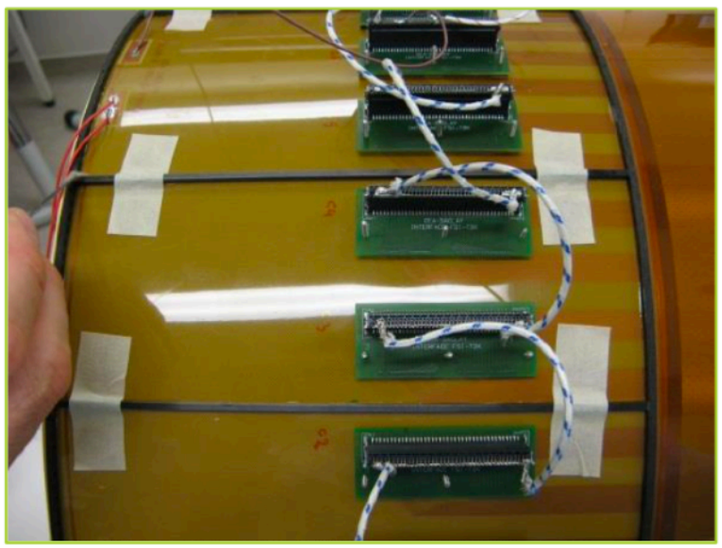
Segmentation and preparation



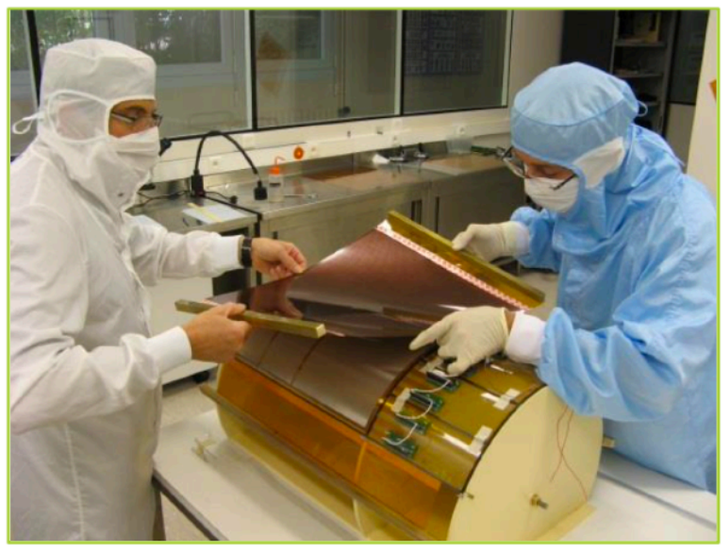
Gluing of the side carbon ribs on circular shape



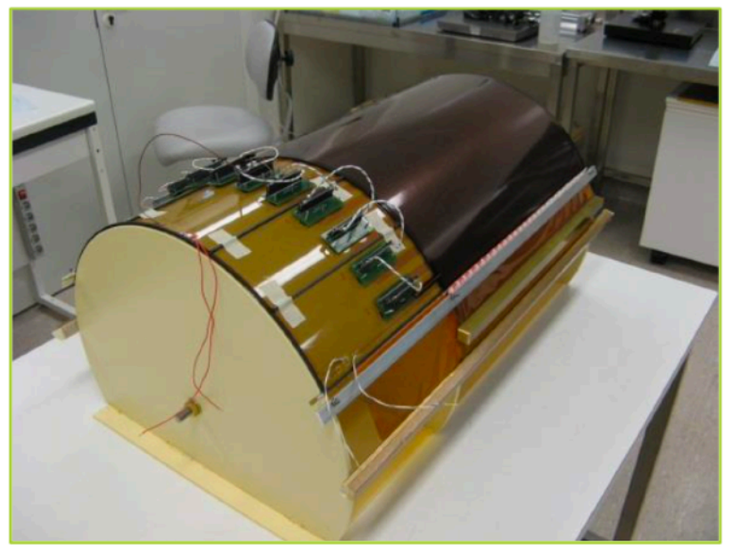
Electric leak test



Gluing of additional ribs



Setting drift plane



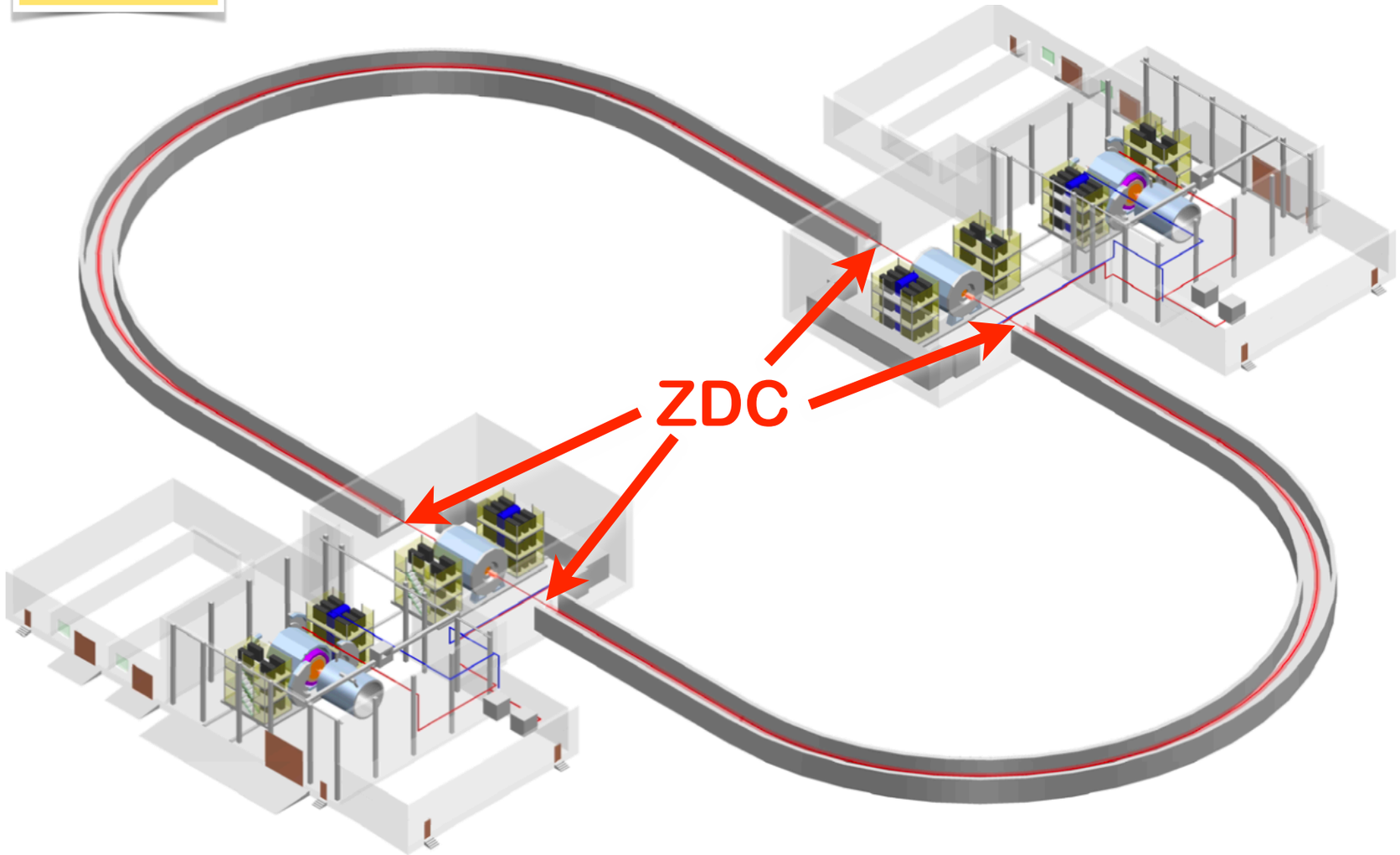
Gluing of the drift plane

CEA/IRFU - Maxence Vandenbroucke – RD51 – 12/2

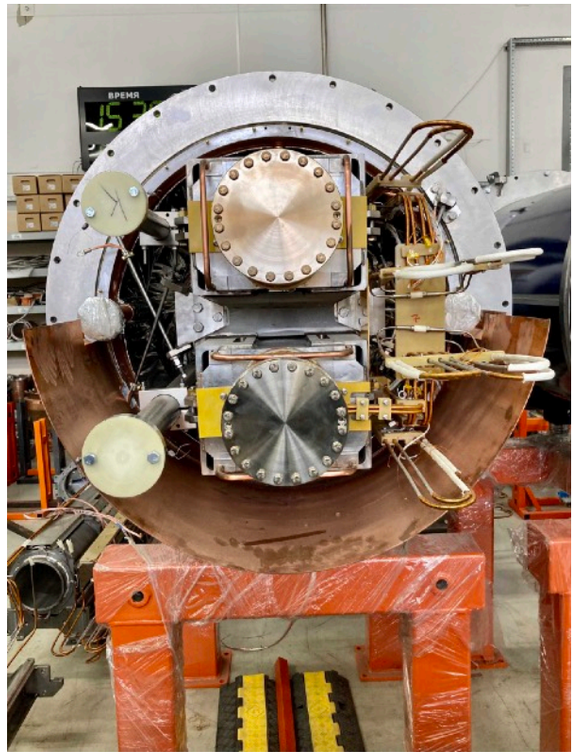
Negotiation with the team of CEA/Saclay is ongoing!

I.Alekseev
S.Shimansky

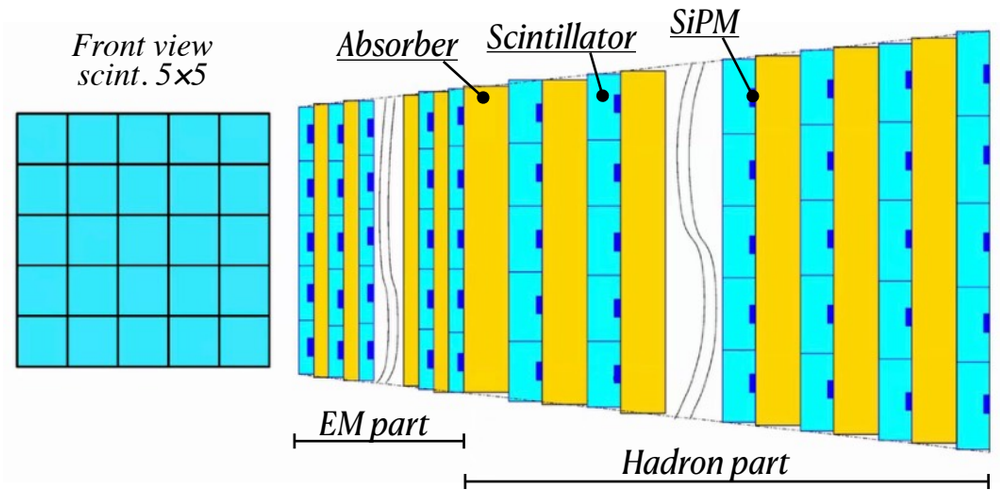
Zero Degree Calorimeter (ZDC)



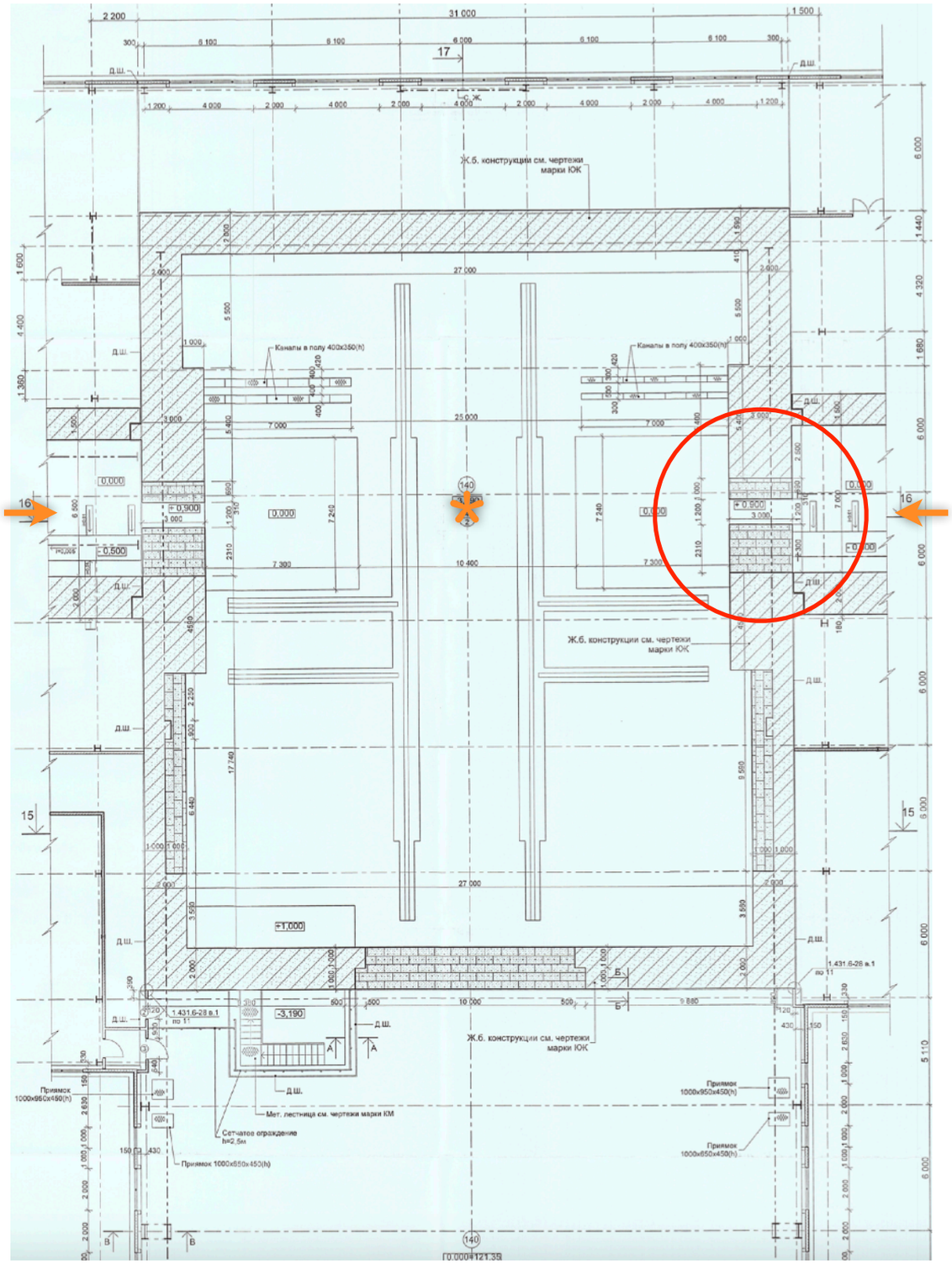
ZDC will be locates in ‘cold’ zone between two beampipes

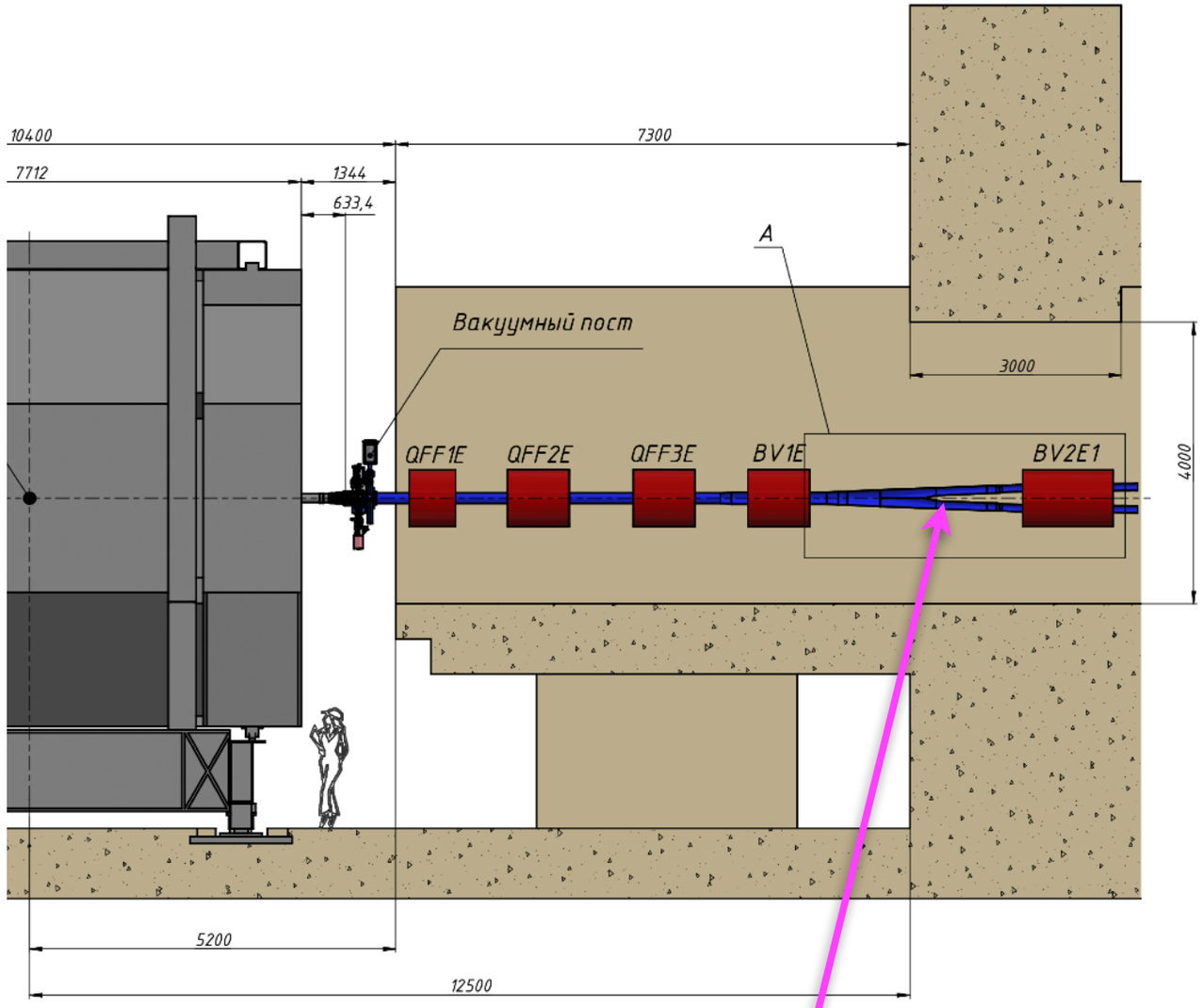


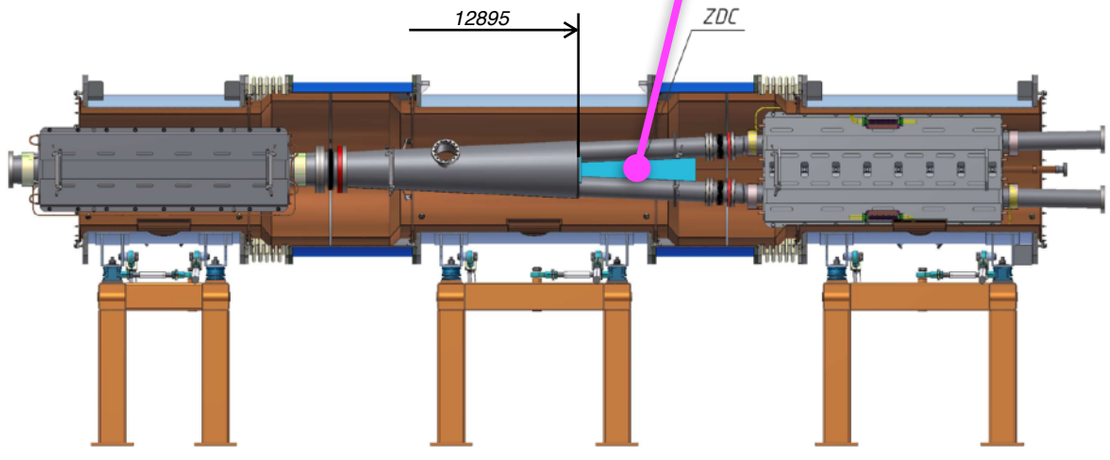
- Discussion with accelerator people (Syresin, Meshkov, Butenko) on 27.10.2021.
- Agreed on: 4 identical zones in the region of beampipe merging to be allocated for ZDC
- Funds to be shared in equal proportion between SPD, MPD and Accelerator teams.
- Two ZDC prototypes to be ready by the end of Oct 2022



Location of ZDC in the SPD hall

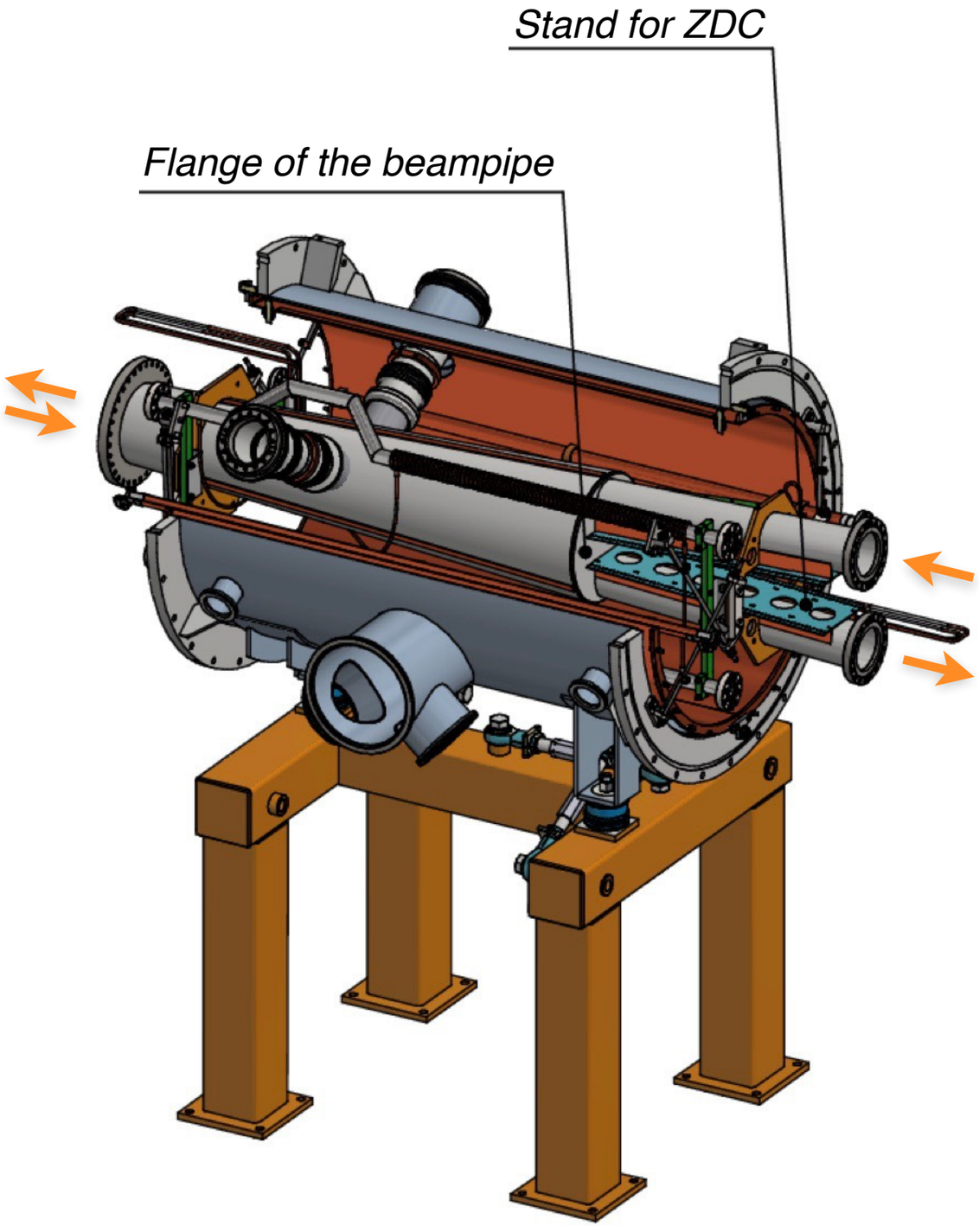


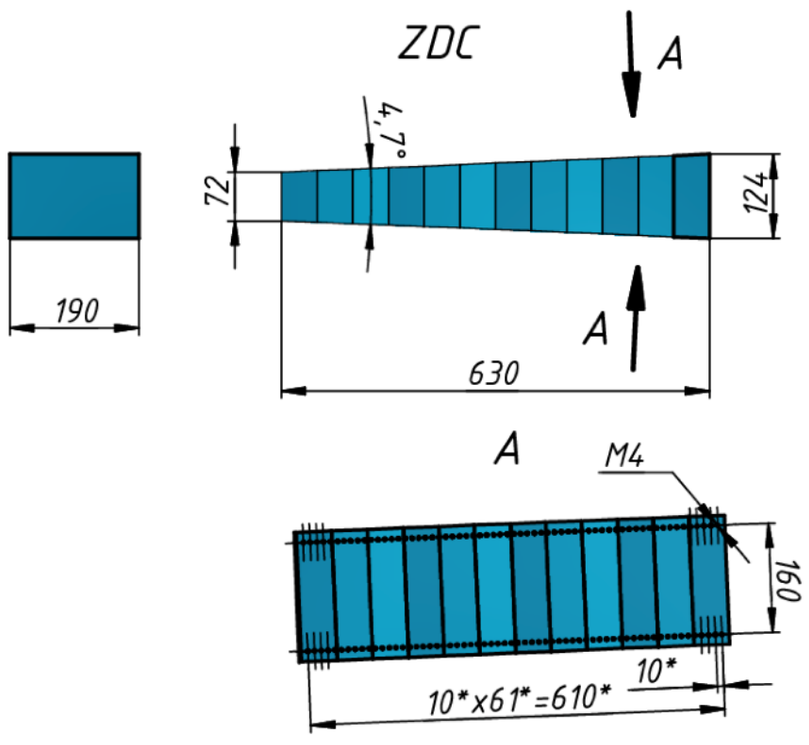




Yu. Gusakov

Zero Degree Calorimeter (ZDC)





- Weight is ~100 kg
- Located inside the cryostat (vacuum, about -200 ˚C)
- To be loaded section-by-section
- About 1000 DAQ channels
- Two few-section ZDC prototypes to be ready by the end of Oct 2022

Subsystems in view of the construction stages of SPD

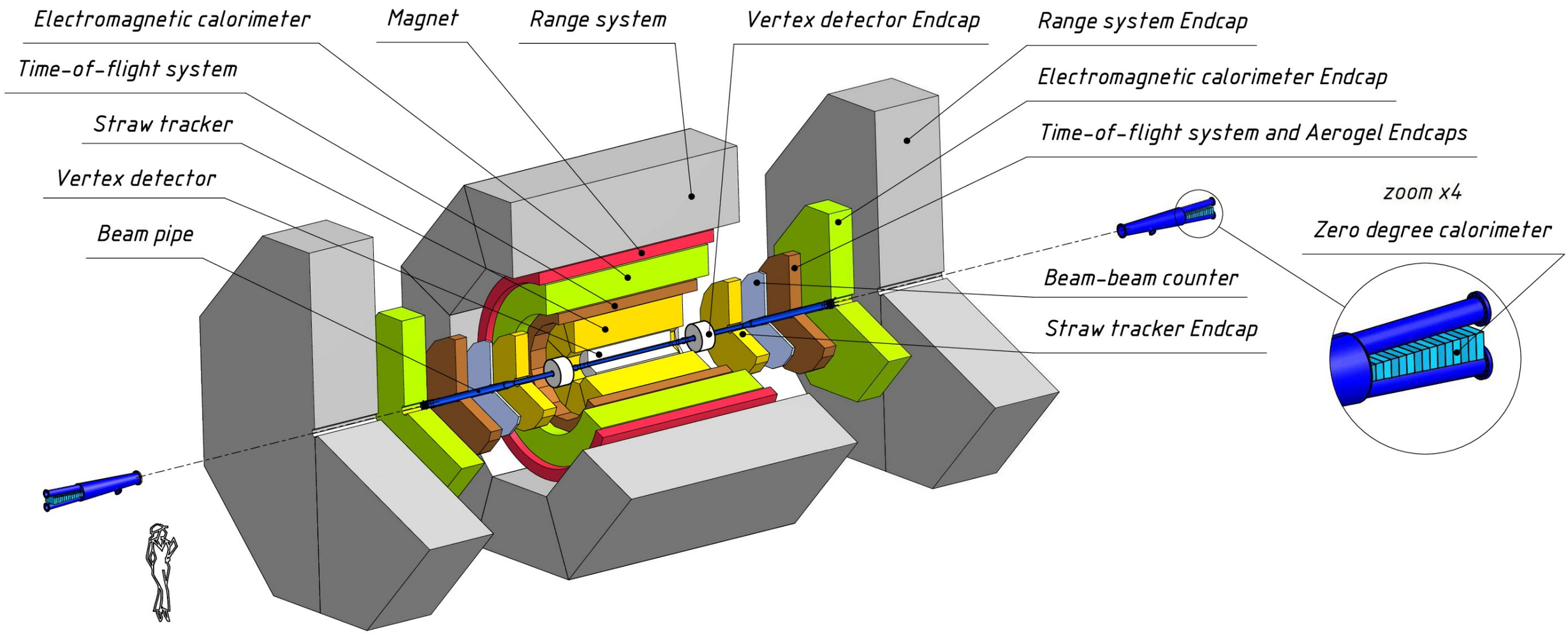
Systems employed before start of physics programme	First stage of experiment	Following stages of experiment
ZDC, MCP, BBC	Magnet, RS, ST, MM (a.k.a. VD)	VD, TOF, ECal, Aerogel
• Detectors for local polarimetry and luminosity control • Elastic scattering	• Charmonia • SSA for π and K • Light vector mesons	• Open charm • Prompt photon • $\bar{p}$ production • Physics with light ions

CDR

Table 4.1: Required setup configuration for each point of the SPD physics program. (+++) - absolutely needed, (++) - extremely useful, (+) - useful, (-) - not needed.

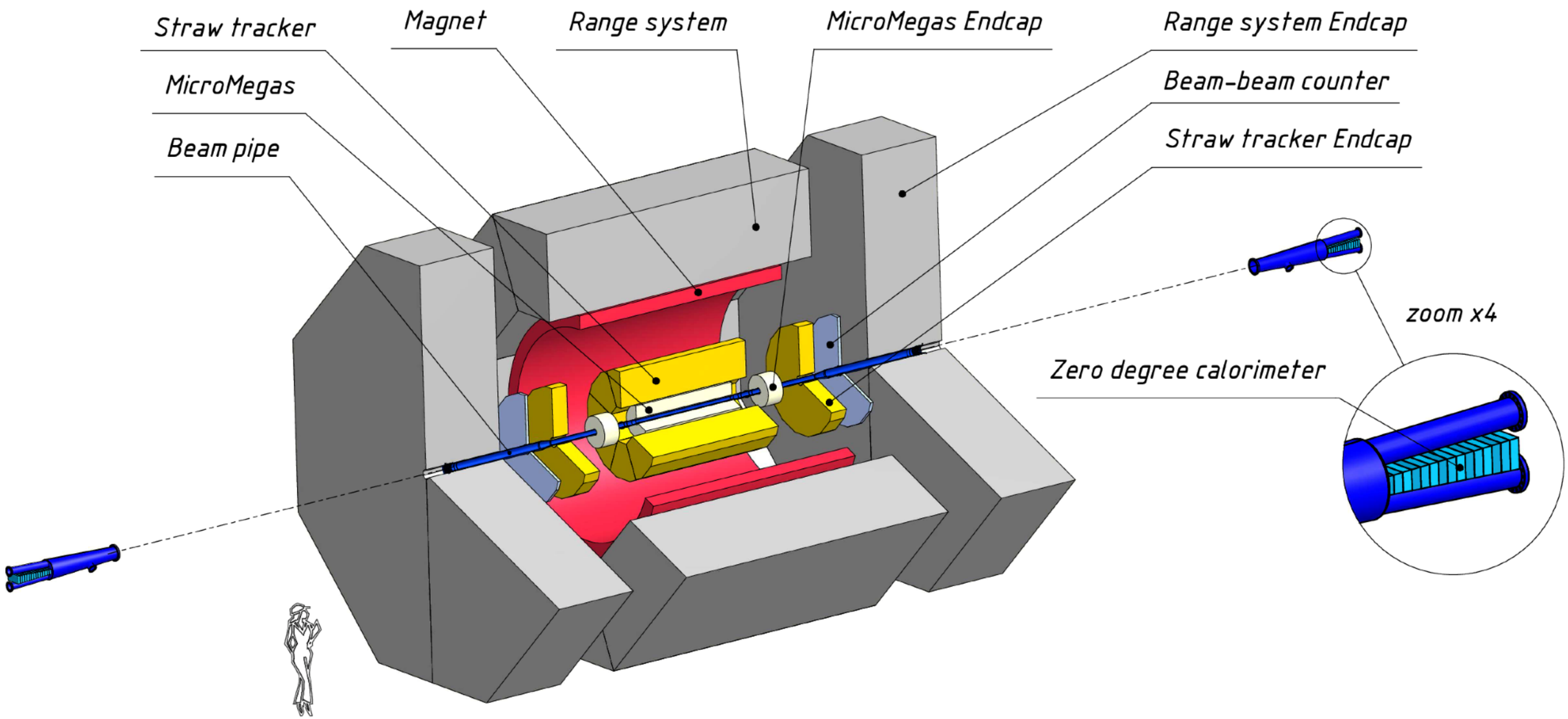
Program	Vertex detector	Straw tracker	PID system	Electromagnetic calorimeter	Beam-beam counter	Range system
Gluon content with:						
charmonia	+	++	+	++	+	+++
open charm	+++	++	++	+	+	++
prompt photons	+	+	-	+++	+	-
SSA for π and K	+	++	+++	++	+	-
Light vector meson production	+	++	-	+	+	-
Elastic scattering	+	++	-	-	+++	-
$\bar{p}$ production	+	++	+++	++	+	-
Physics with light ions	++	+++	+	++	++	+

Update for the schematic view of the SPD setup



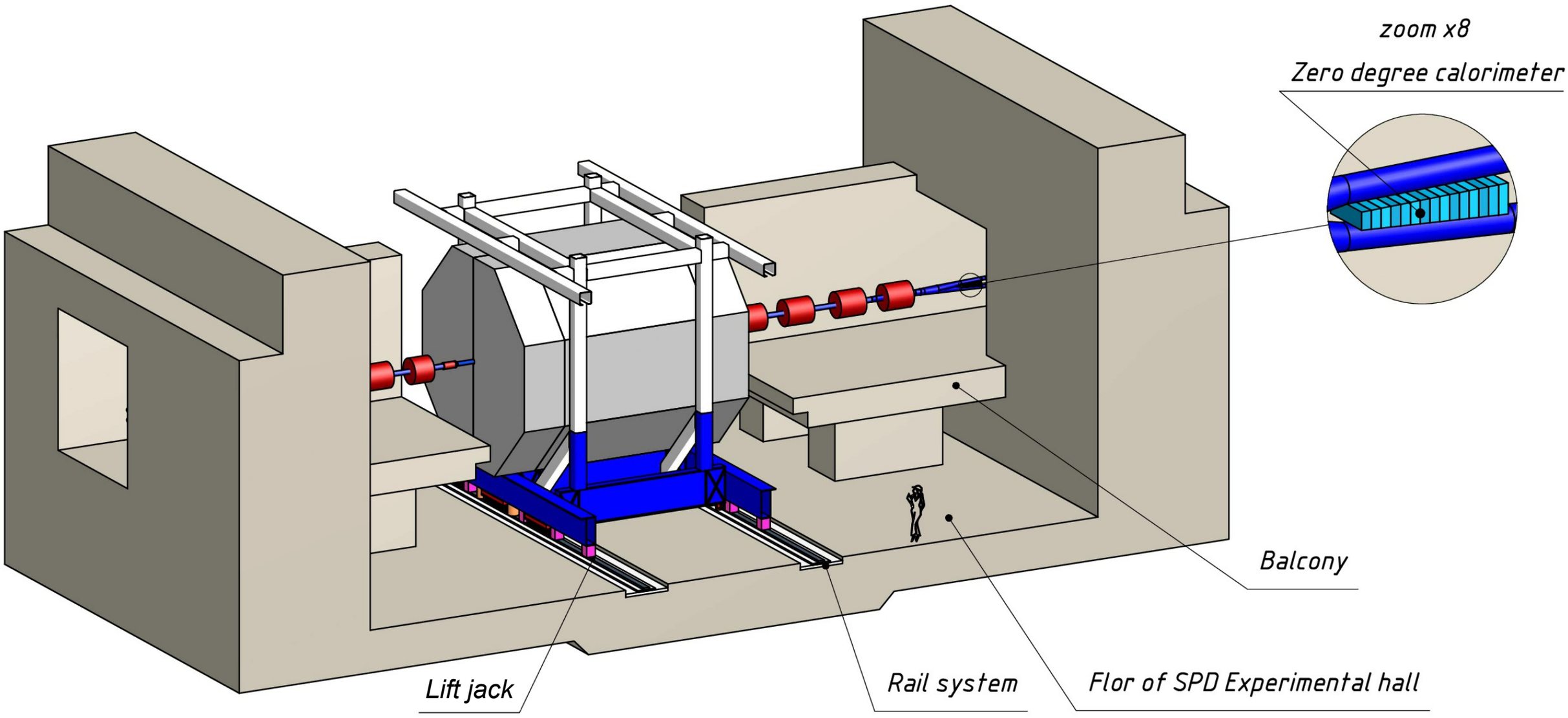
- 6 coils inside ECal were replaced by a single cryostat outside ECal
- Final whole set of detectors

Update for the schematic view of the SPD setup



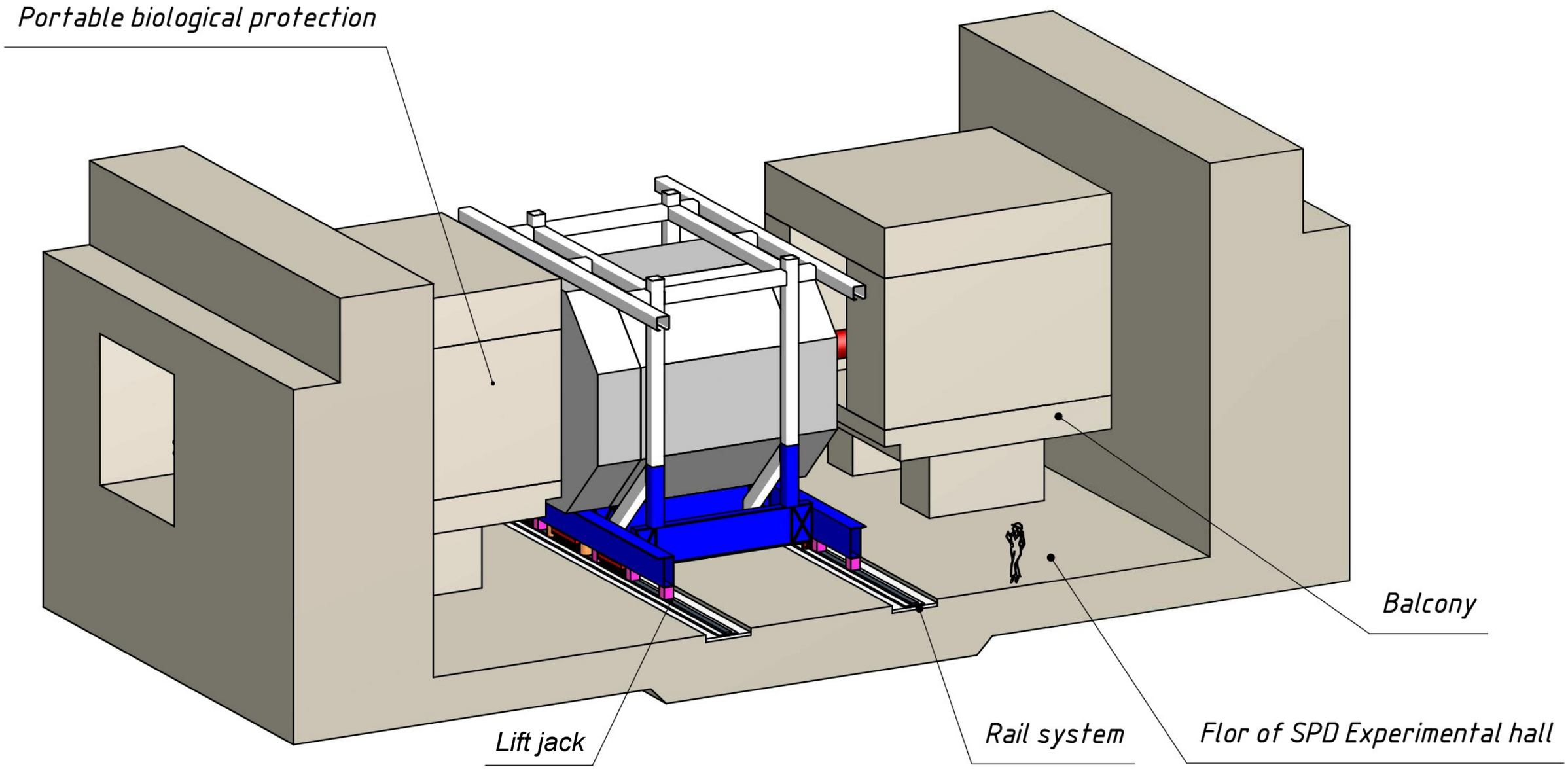
- First stage of experiment: without ECal and PID

Update for the schematic view of the SPD setup



… Few more figures for technical presentations …

Update for the schematic view of the SPD setup



… Few more figures for technical presentations …

S.Sukhovarov

Agreement for the detector nomenclature scheme

1065.000.000.000 - **NICA**

1065.100.000.000 - **Инжекционный комплекс**

1065.110.000.000 - Источники лёгких ионов

1065.120.000.000 - Лазерный источник

1065.130.000.000 - ИТИ «КРИОН»

1065.131.000.000 - Магнитно-криостатная система источника

1065.133.000.000 - Источники питания, АСУ

1065.134.000.000 - Вакуумная система

1065.135.000.000 - Инженерные системы КРИОН

1065.140.000.000 - Источник поляризованных частиц

1065.141.000.000 - Источник поляризованных атомов

1065.142.000.000 - Зарядово-плазменный нонизатор

1065.143.000.000 - Система управления и питания SPI

1065.144.000.000 - Инженерные системы SPI

1065.150.000.000 - Линак ЛУ-20М

1065.151.000.000 - Основная ускоряюще-фокусирующая структура

1065.152.000.000 – Форинжектор

1065.153.000.000 - Высоковольтный терминал

1065.154.000.000 - Вакуумная система и диагностика

1065.155.000.000 - Высокочастотный генератор

1065.156.000.000 - Система автоматизированного управления

1065.157.000.000 - Система питания

1065.160.000.000 - Линейный ускоритель тяжёлых ионов

1065.161.000.000 - Основная ускоряюще-фокусирующая структура

1065.162.000.000 - ВЧ генератор

1065.163.000.000 - Вакуумная система и диагностика

1065.164.000.000 - Форинжектор, LEBT

1065.165.000.000 - Система автоматизированного управления

1065.166.000.000 - Системы питания

1065.170.000.000 - Энерготехнологические и инженерные системы

1065.171.000.000 - Системы водоохлаждения

1065.172.000.000 - Системы энергообеспечения

1065.173.000.000 - Геодезическая сеть

1065.174.000.000 - Конструкционные и монтажные элементы

1065.190.000.000 - Линак ЛИЛУ

1065.191.000.000 – Форинжектор

1065.192.000.000 - Начальная часть на 7МэВ/и

1. 2. 3. 4.

1065.700.000.000 – Детектор MPD

1. 1065 – номер темы

2. 700 – идентификатор группы в структуре проекта

3. 000 – сборочные единицы

4. 000 – детали

1065.701.000.000 – детектор **TOF**

1065.702.000.000 – детектор **TPC**

1065.703.000.000 – детектор **ECAL**

1065.704.000.000 – детектор **ITS**

1065.705.000.000 – детектор **FFD**

1065.710.000.000 – система сбора данных

1065.711.000.000 – система медленного контроля

1065.712.000.000 – инженерная инфраструктура

1065.712.200.000 – ионопровод

1065.712.300.000 – платформа для электроники

1065.712.400.000 – система электропитания

1065.712.500.000 – система охлаждения детектора

1065.712.600.000 – инфраструктура MPD

1065.712.700.000 – система газового обеспечения MPD

1065.713.000.000 – тестовая экспериментальная зона

1065.800.000.000 – Детектор SPD

1065.801.000.000 – детекторы

1. 2. 3. 4.

1065.700.000.000 – Детектор MPD

1. 1065 – номер темы

2. 700 – идентификатор группы в структуре проекта

3. 000 – сборочные единицы

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1065.701.000.000 – детектор **TOF**

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1065.703.000.000 – детектор **ECAL**

1065.704.000.000 – детектор **ITS**

1065.705.000.000 – детектор **FFD**

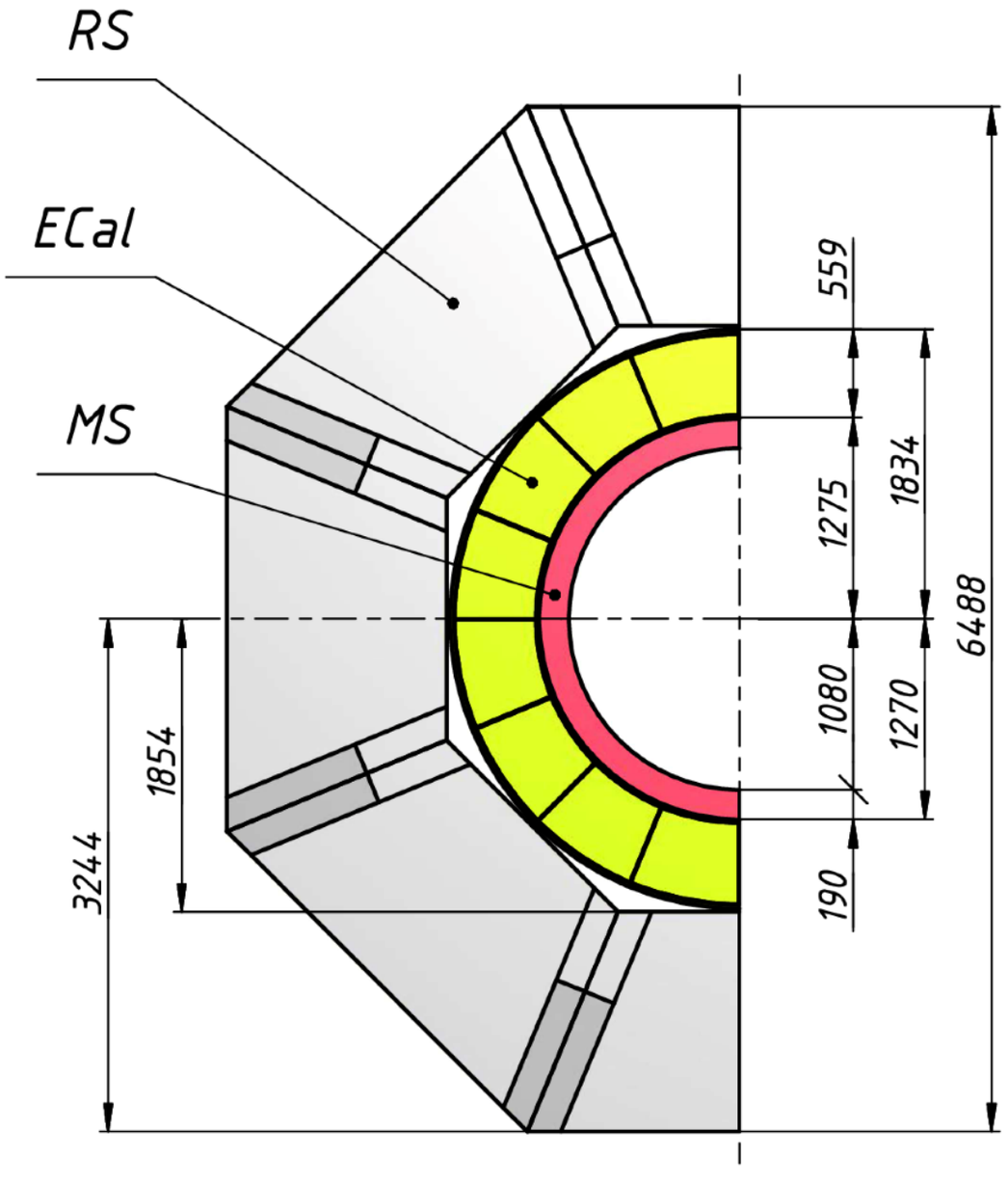
Conclusions

- Major update in the detector layout: magnet coils are outside ECal
- Good development progress in the SC magnet design. Several meetings with the local magnet team and the Novosibirsk team recently
- Discussion ongoing about layout and dimensions of ECal, TOF
- Agreement on ZDC location has been concluded
- MM detector in place of silicon VD for the 1-st stage of SPD
- TDR preparation is in active phase

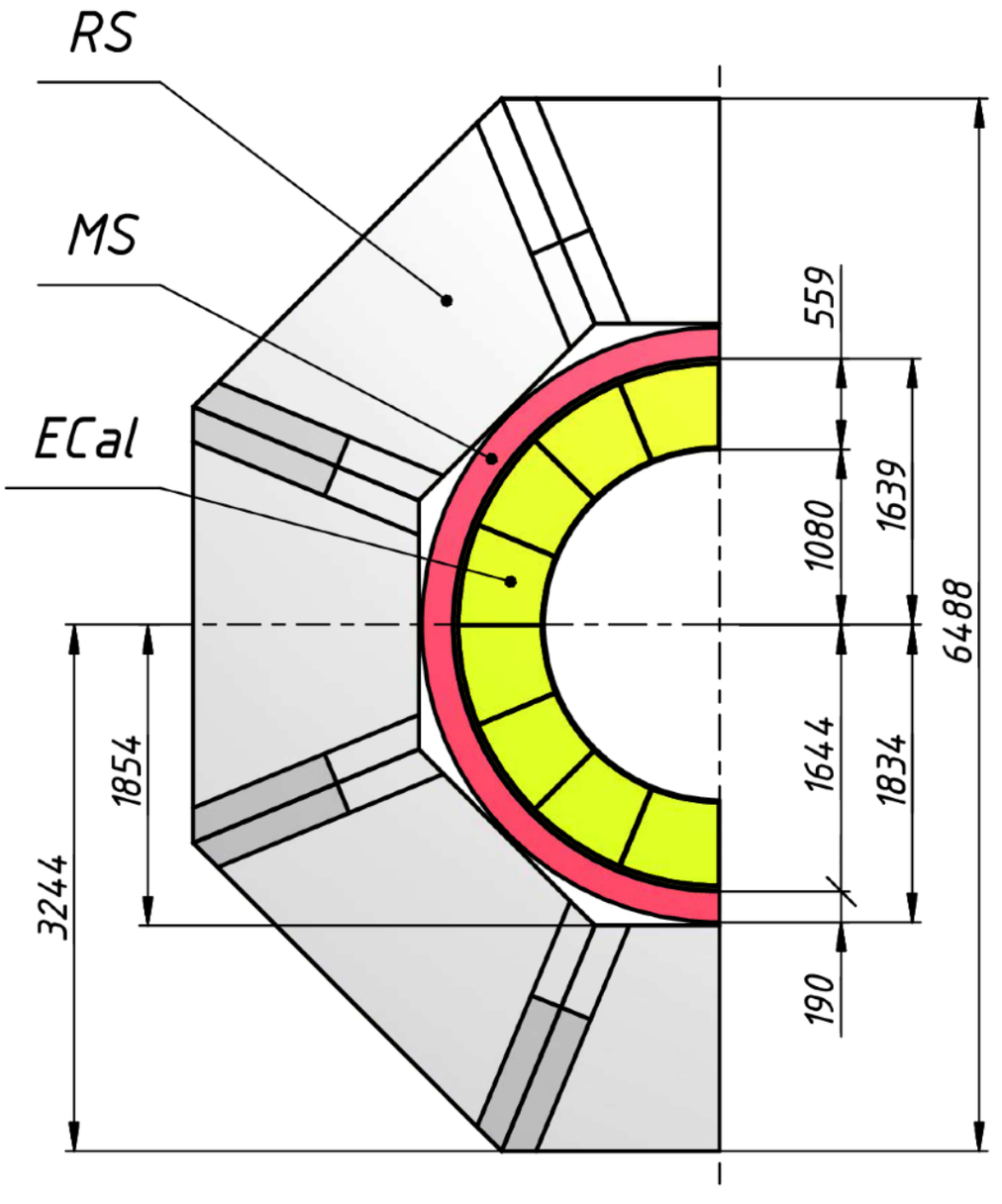
Backup slides

SC magnet location with respect to ECal

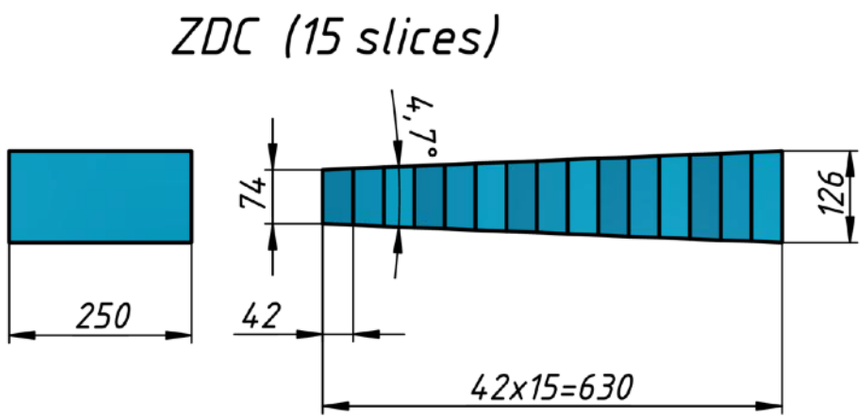
CDR version (**obsolete**)
6 separated coils inside ECal

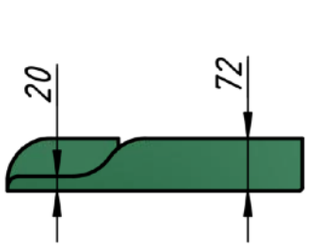


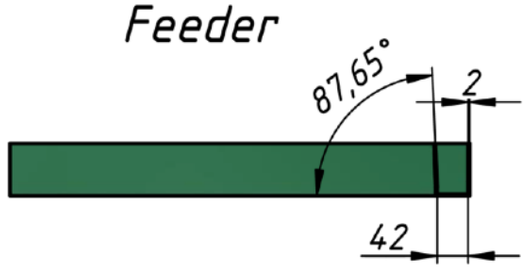
Option under development
A single cryostat with several coils

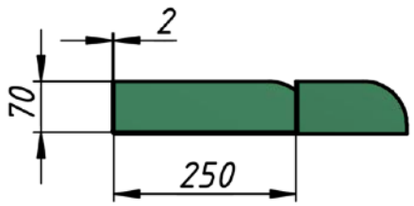


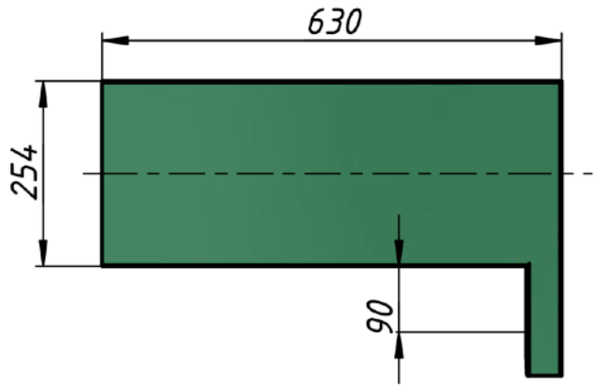
Zero Degree Calorimeter (ZDC)



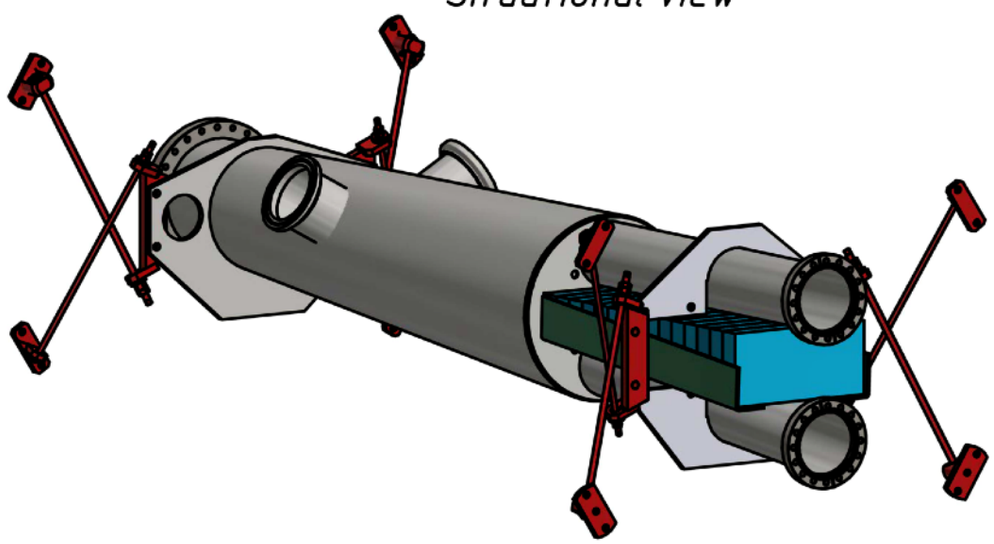




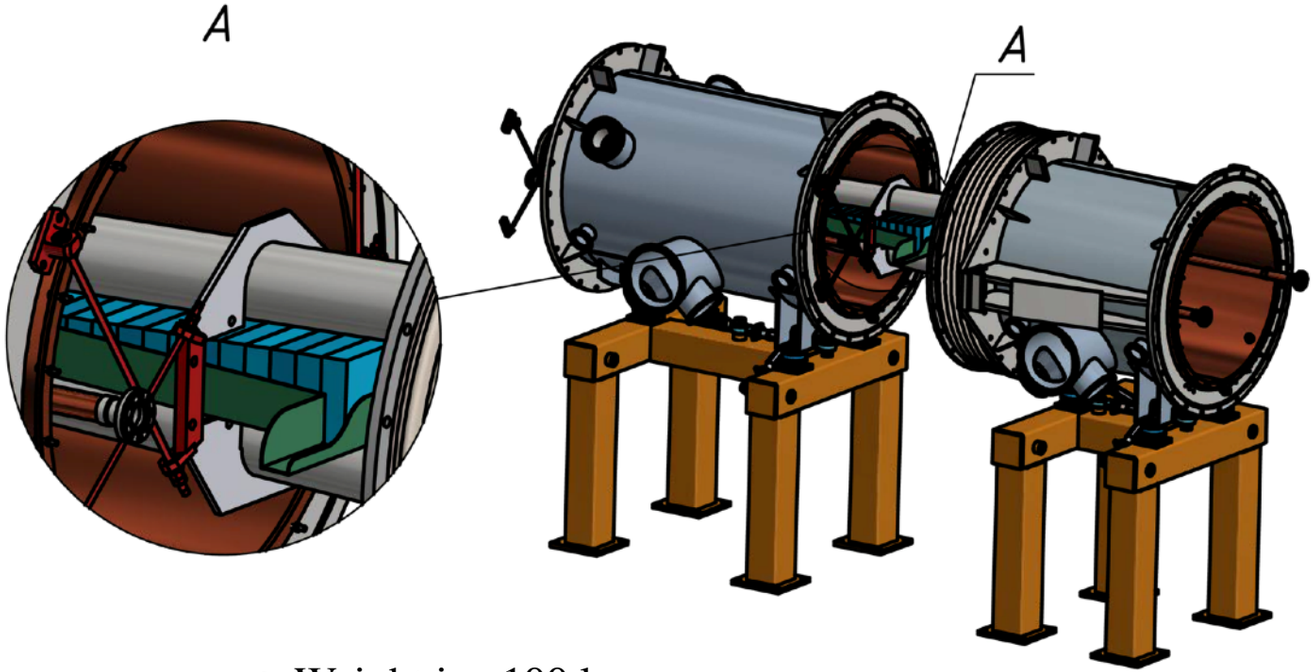




Situational view

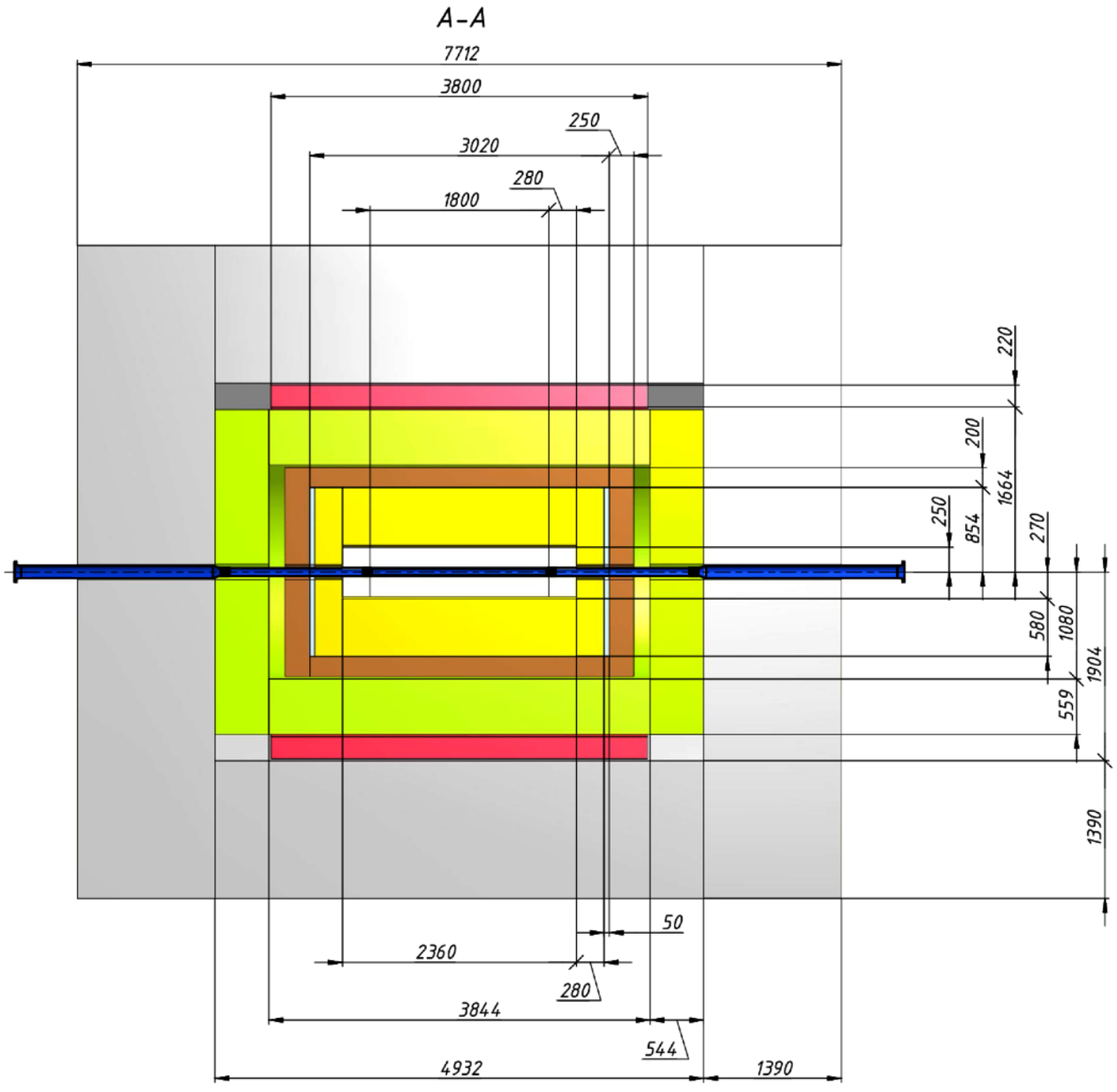


Situational view (zoom out x3)



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

Complete setup



1-st stage of experiment