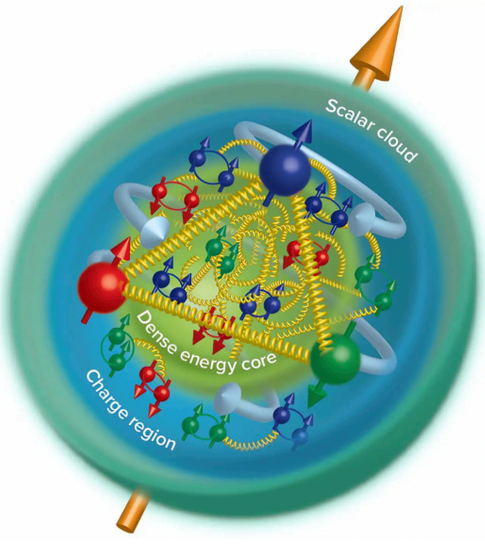
Implementation of the SPD project

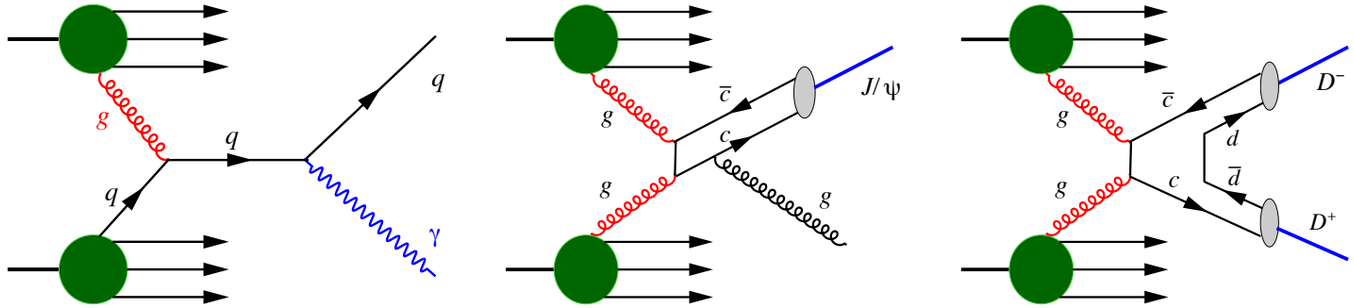
A. Guskov

15.6.2026

SPD project



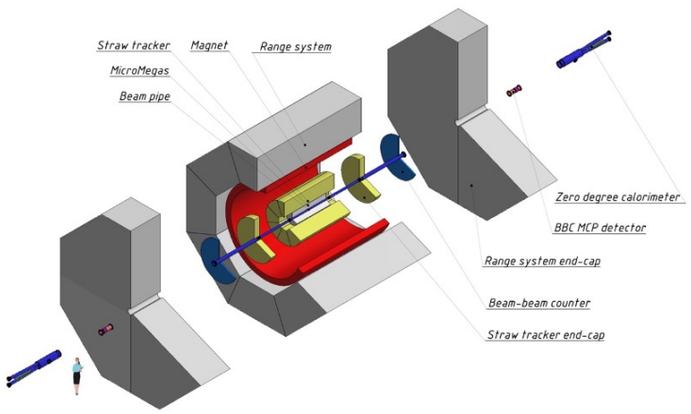
The purpose of the SPD experiment is the study of the nucleon spin structure in collisions of polarized protons and deuterons and other spin-related as well as unpolarized phenomena at $\sqrt{s}$ up to 27 GeV and luminosity up to $10^{32} cm^{-2} s^{-1}$

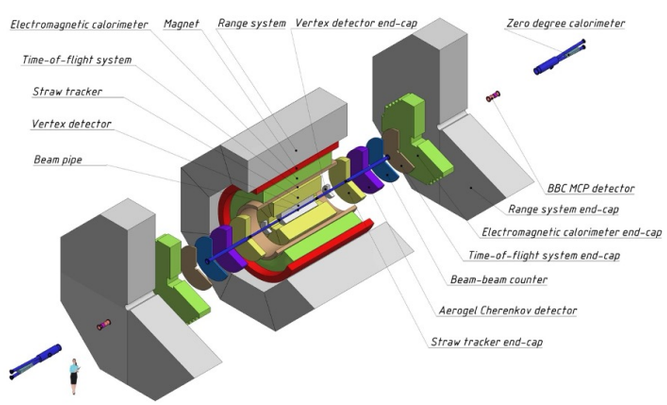


Gluon TMD PDFs will be accessed via 3 complementary processes.

$\sqrt{s}$

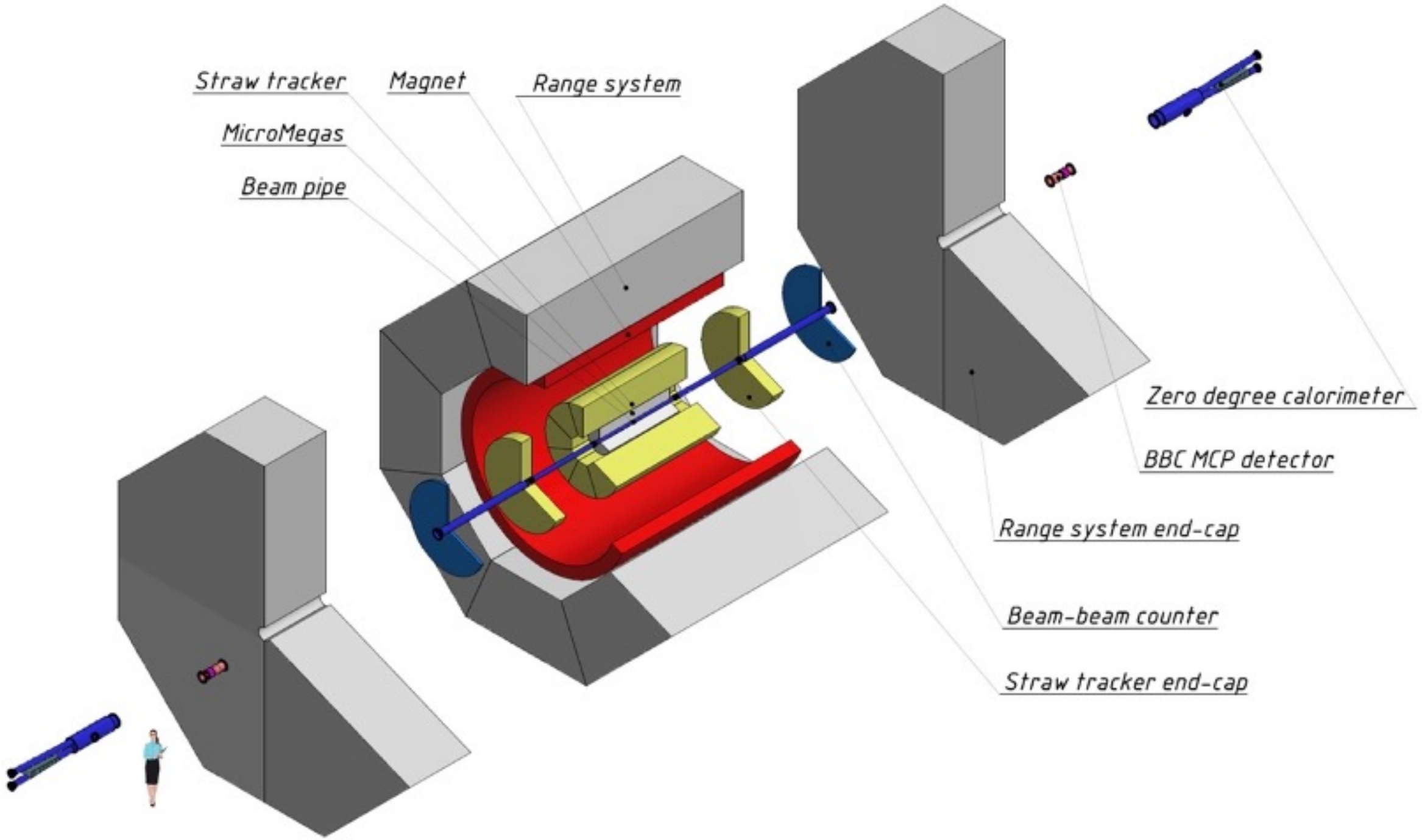
Non-perturbative QCD — *Perturbative QCD*





The project is planned to be implemented in two phases

SPD setup, phase 1

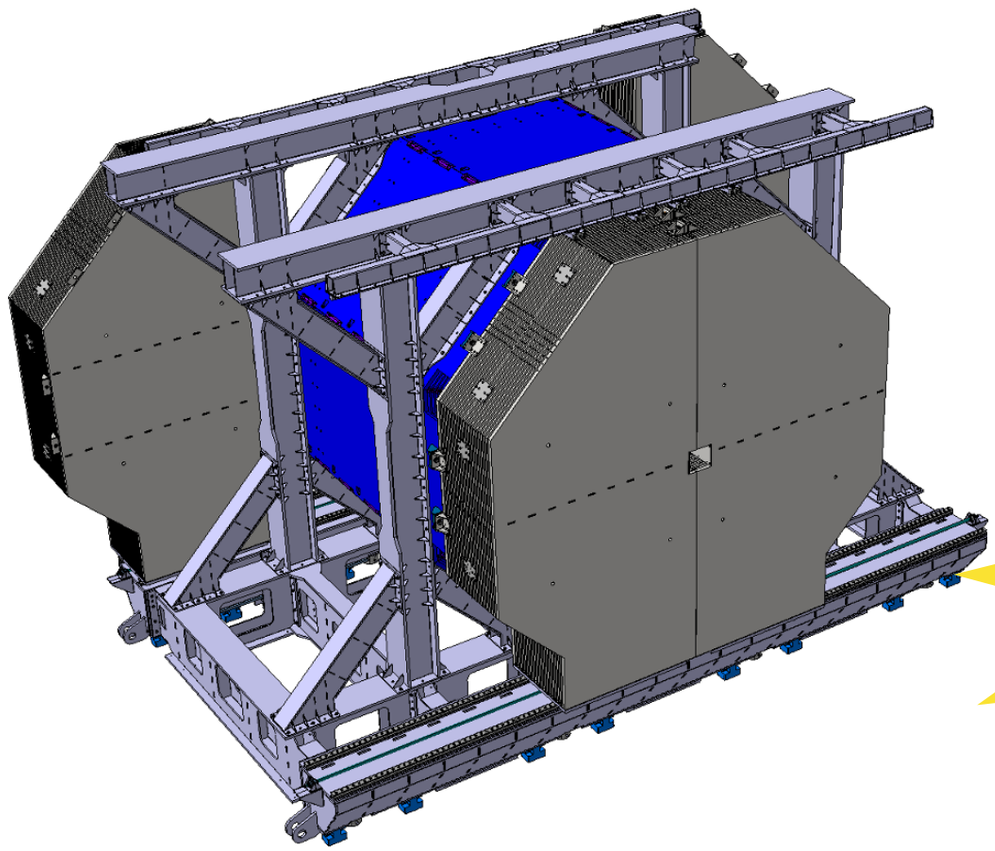


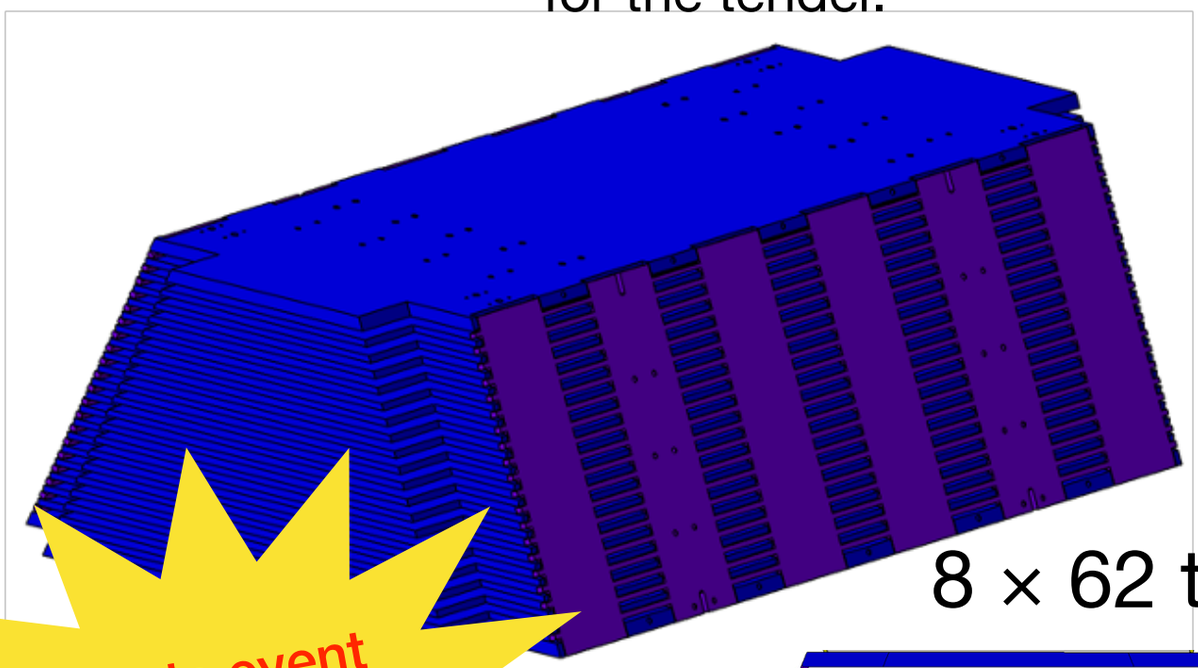
SPD yoke



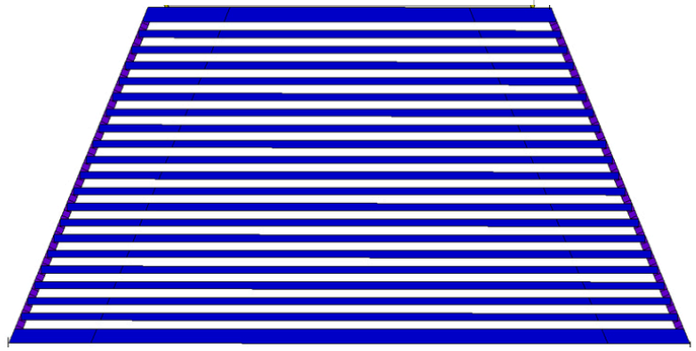
The SPD magnet yoke, integrated with the movement system, is a structure weighing 1074 tons, which forms the foundation of the entire SPD facility. It is also part of the detector's muon (range) system.

By February 2026, the staff of Design Bureau-2 (LHEP) had prepared a complete set of design documentation for the tender.





8 × 62 tons



Main event for SPD in 2026

SPD yoke

The tender is ongoing. The results should be available by the end of June.



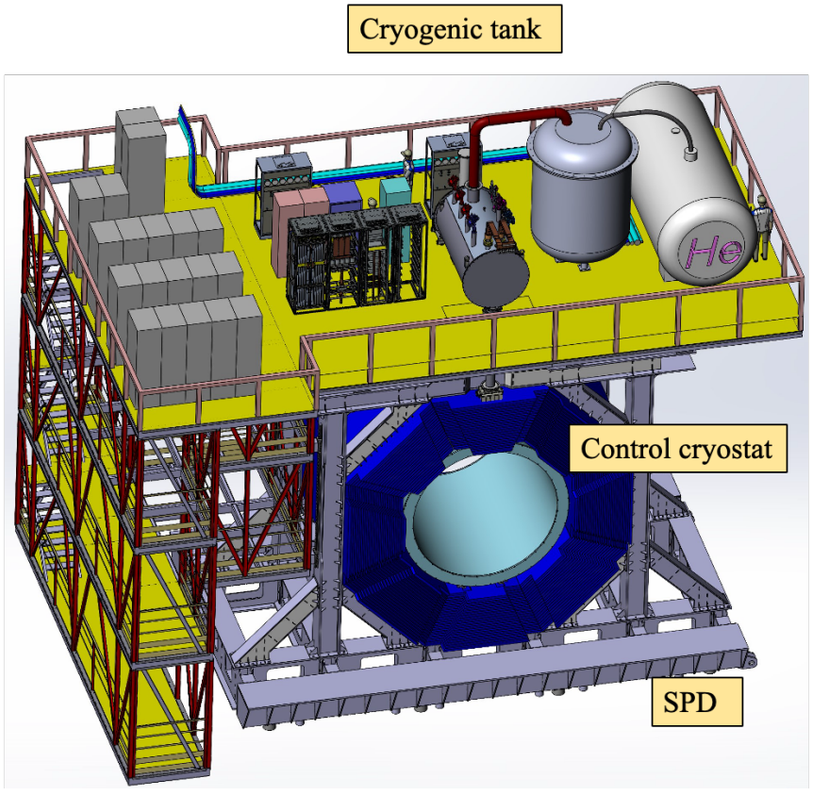


A group of engineers, led by the chief designer and technical coordinator, is visiting the candidate factories.

SPD magnet

A roadmap is being developed with the Budker institute for the construction of the SPD superconducting solenoid.

Cryogenic system

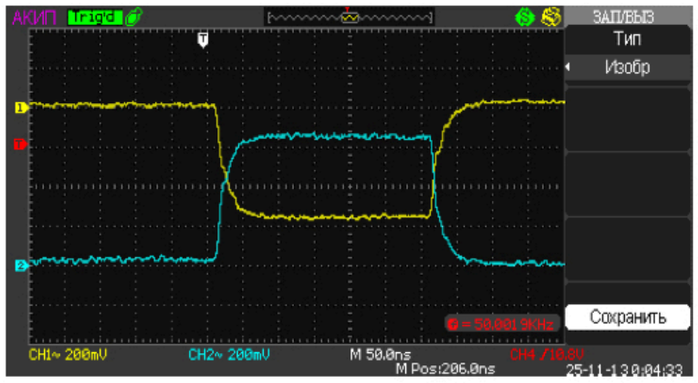


Steps of creation																
SPD	2026				2027				2028				2029			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Cryogenic plant																
Helium system																
Nitrogen system																
Vacuum system																
Pneumatic system																
Cryogenic system control																
Cryogenic tests																

Technical design
Technical task
Contract execution
Assembly & Test
Commissioning

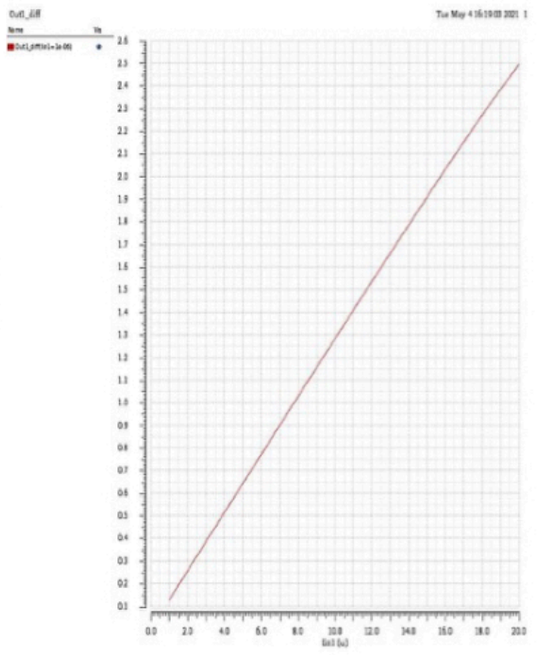
- A model has been prepared to coordinate with the route of cryogenic communications.
- The production contract for 2 cryogenic tanks for liquid helium and 2 cryogenic tanks for liquid nitrogen has been agreed upon and is under execution.
- The technical specification for 1 cryogenic tank for liquid argon has been prepared, the technical specification is at the stage of approval with the manufacturer.
- A technical specification for a cryogenic liquid CO2 storage tank is being prepared.
- The technical specification for a satellite refrigerator is in the final stage of preparation. An updated scheme of communications and the main components of the installation has been prepared.
- The cooling scheme of the heat shields and the upper part of the current leads has been changed. Previously, they were cooled with helium at a temperature of 50K, now they will be cooled with liquid nitrogen at a temperature of 80K.
- A company is being selected for the production and installation of helium pipelines.

Muon system



Main results:

1. The final design of amplifier chip Ampl-8.53 is ready and being tested, see test pulse (left) and linearity curve up to 20 μA / input current (right)
2. The contract on preamplifier (Ampl-8.11R-G5) and discriminator (Disc-8.17) designs is signed

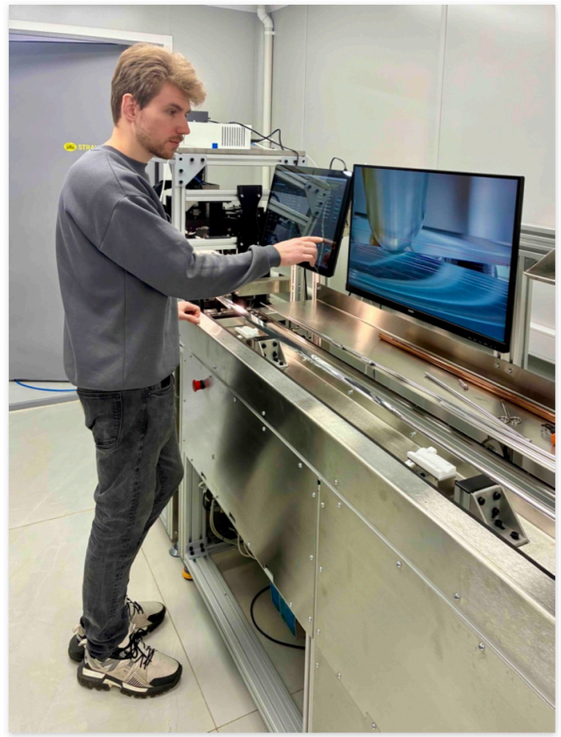


Current activity

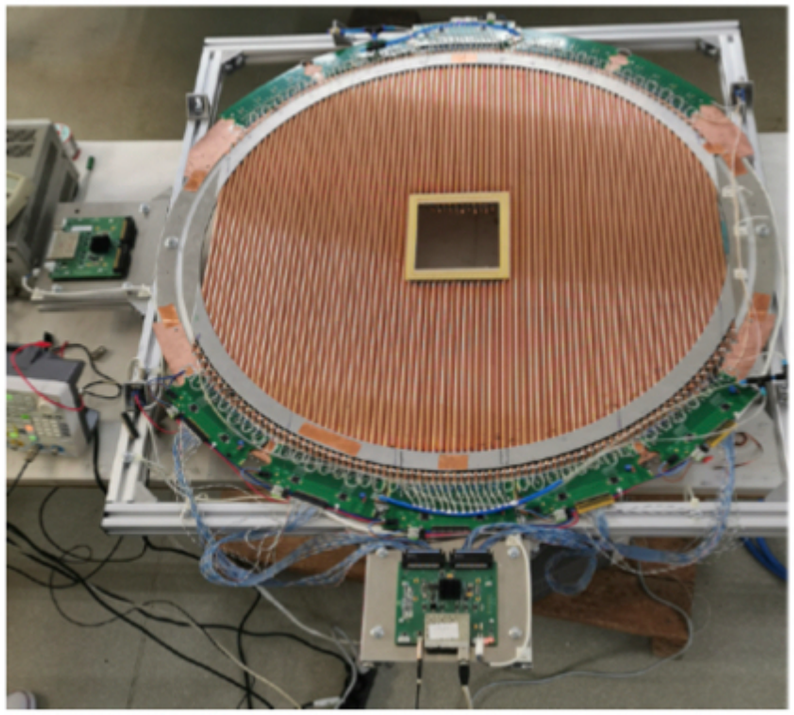
- **Preparation for MDT detectors mass production in progress:** continue the MDT's assembly line reconstruction in temporary hall at DLNP and start of workshop design for the final place in building 42 at VBLHEP; finalizing the choice for producers of MDT detector components
- **Analog FEE:** contract on final amplifier design is fulfilled/closed, pilot chips are being tested; contract for final (we hope) design of preamplifier and discriminator is signed/prepaid, pilot chips are expected by March 2027
- **Digital FEE:** contract on second version of digital unit (FDM-192) continued till autumn 2026
- **RS prototype tests:** study of temperature effects under heating by FEE electronics started at SPD test beam zone
- **Software:** 3D models for both, mechanical and physical deployment of MDTs are ready for final engineering RS design

Straw-tracker

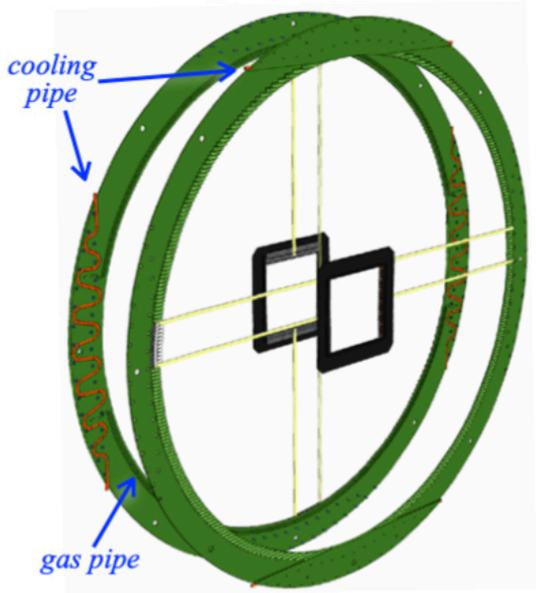
- New 12 m production line at JINR + 5 m line in Almaty
- R&D and optimization of individual elements
- Prototyping and general geometry optimization
- Beam tests at CERN and PNPI
- Two options for FFE: Two options:
  1.”Solin” –base line
  2.VMM3A-backup solution
- HV and LV power supply
- SPD DCS prototype
- Gas system



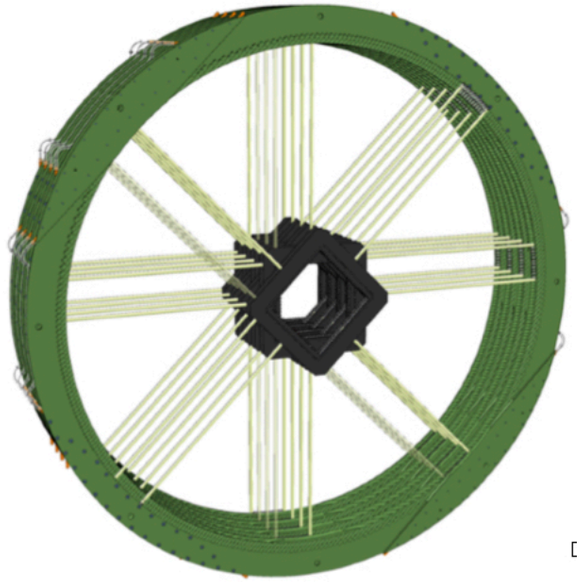




A single module with a double layer of straw-tubes X/Y



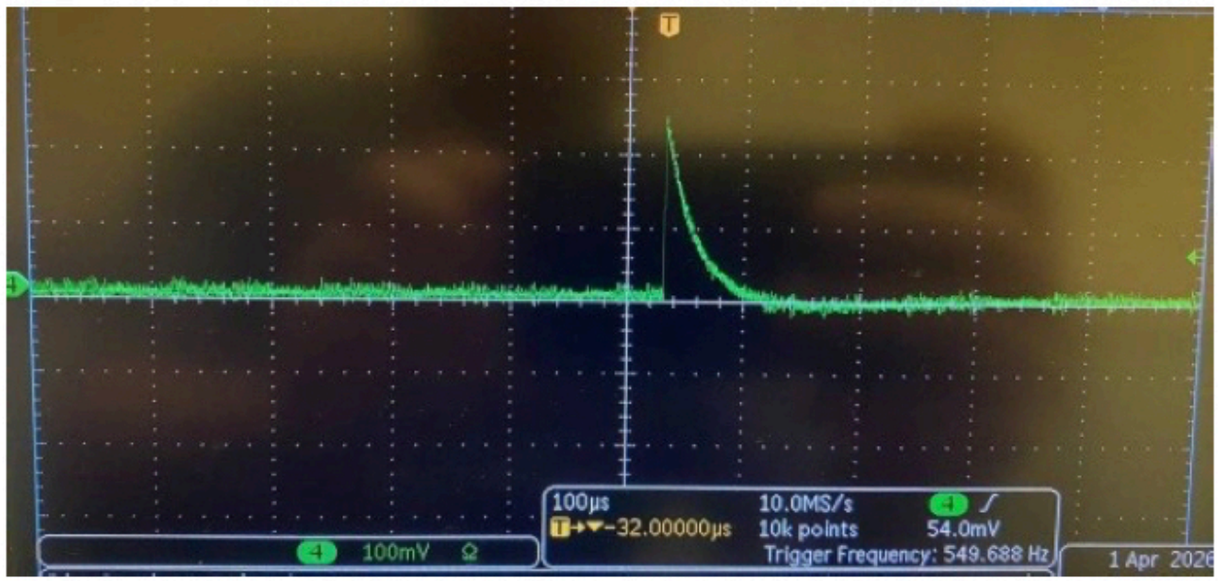
Stack of 8 modules



Micromegas-based central tracker

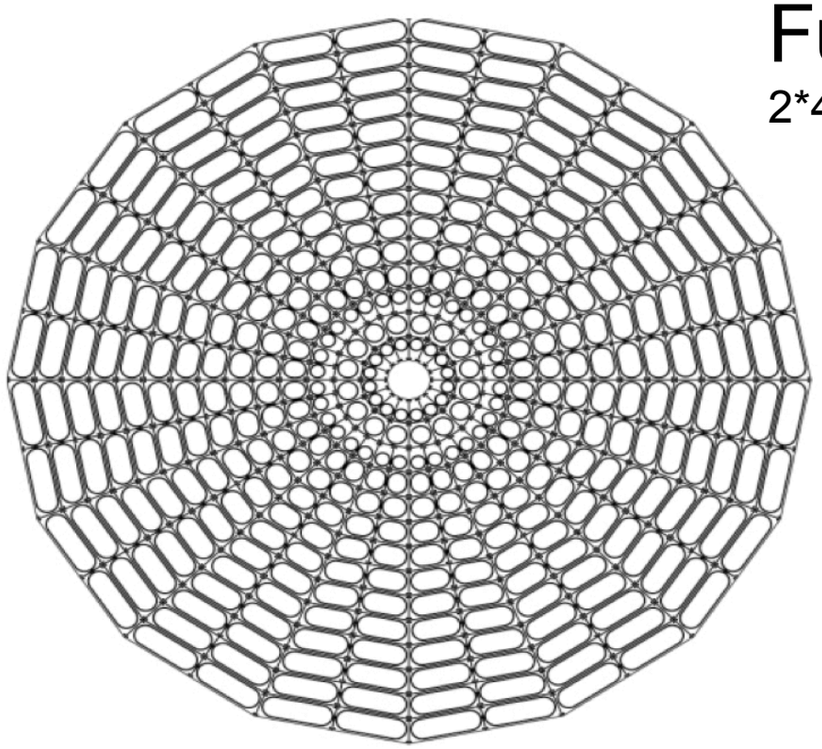


- Inner radius: 50mm
- Strip pitch: 0.6mm
- 200 mm working area (½ of full)
- Dead area width: 6 mm
- Gain: up to 2×10^4 (planned working gain is 0.75×10^4)
- Excellent gain uniformity: 7% ⇒ no sizable gap variations
- 0.34% of X0 within working area (0.4% specified in TDR)
- 2.2% of X0 within 3 mm from edge
- The assembly procedure is established. No problems are expected
- FEE based on WMM3a chip is about to be ready
- Preliminary calculations of the water cooling system has been preformed by Belorussian colleagues





Beam-Beam Counters



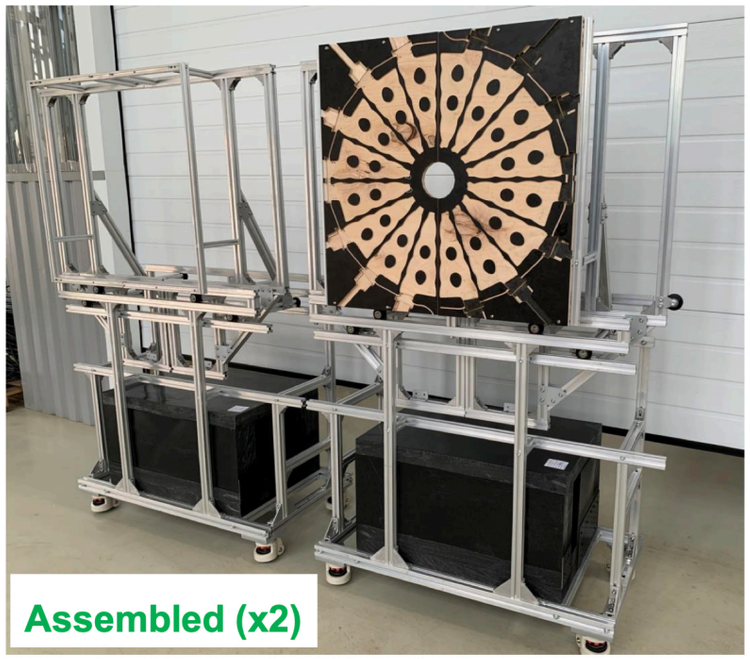
Full scale:

2*416 tiles wheels

- The main components and assembly technology have been selected and tested.
- The electronics have been tested in triggered and triggerless modes.
- Prototypes of the BBC for Phase-0 are ready.
- Tests on the internal target of the Nuclotron.

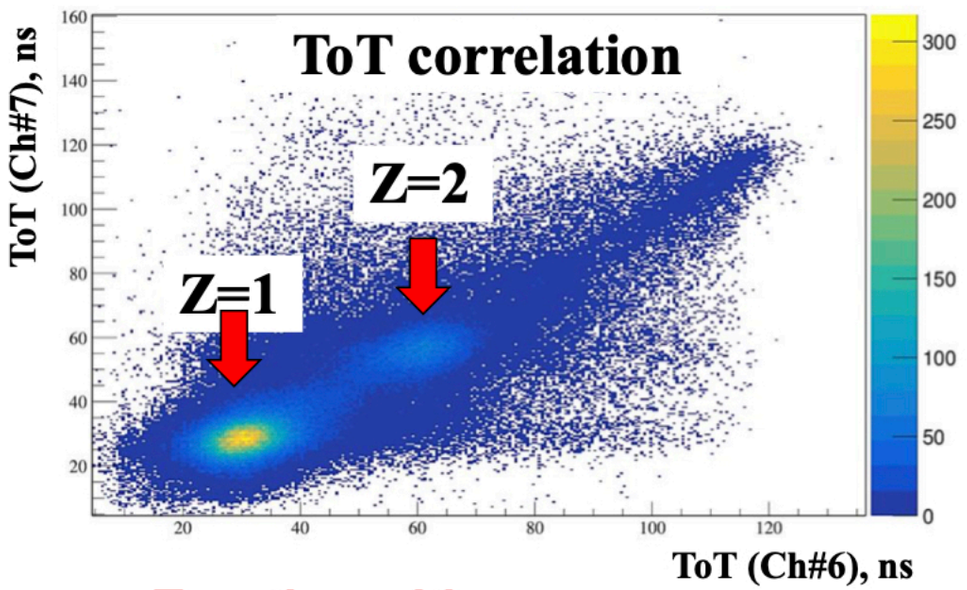
Prototype:

2*128 tiles wheels



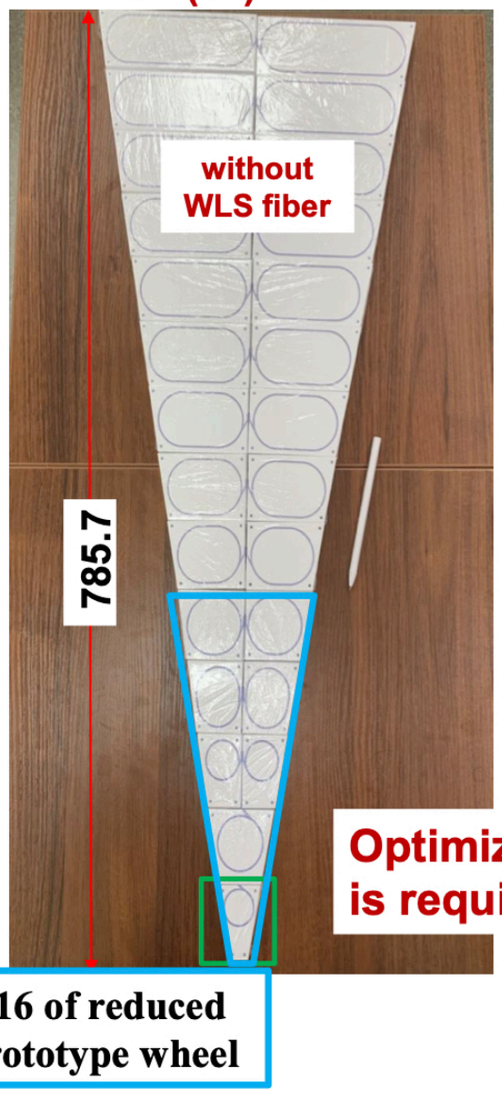
Internal Target at Nuclotron: Run-2026

Preliminary results ^{124}Xe+Ag



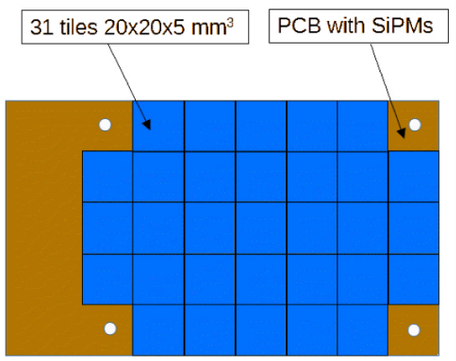
BBC Sector (1/16 of wheel) design

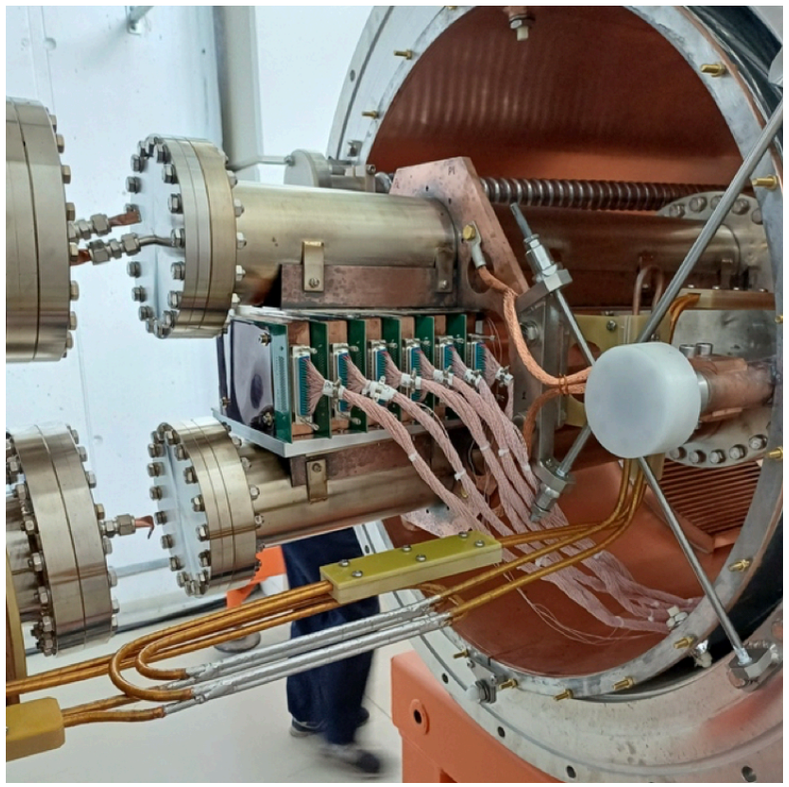
24 (26) - tiles



Zero Degree Calorimeter







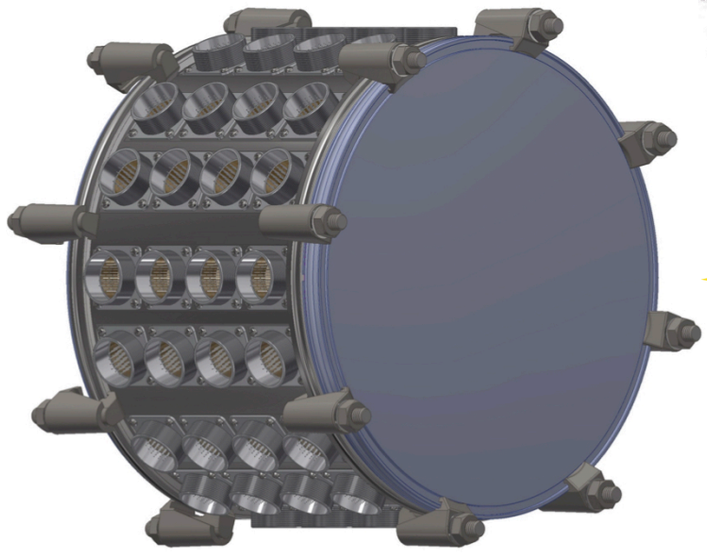
Installation of a ZDC prototype on both sides is completed. The prototype on one side was cabled inside the cryostat. Everything for the other side was ready, but it is still not cabled.

CAEN FERS system is purchased and checked. It should suit well to the tasks of the first few years of operation. All cables are prepared. **We need to install them and we need ethernet and AC power.**

DAQ and front-end from the DANSS experiment could be used for another prototype with connection to SPD DAQ system. DANSS-I is decommissioned and we have some spare hardware for tests.

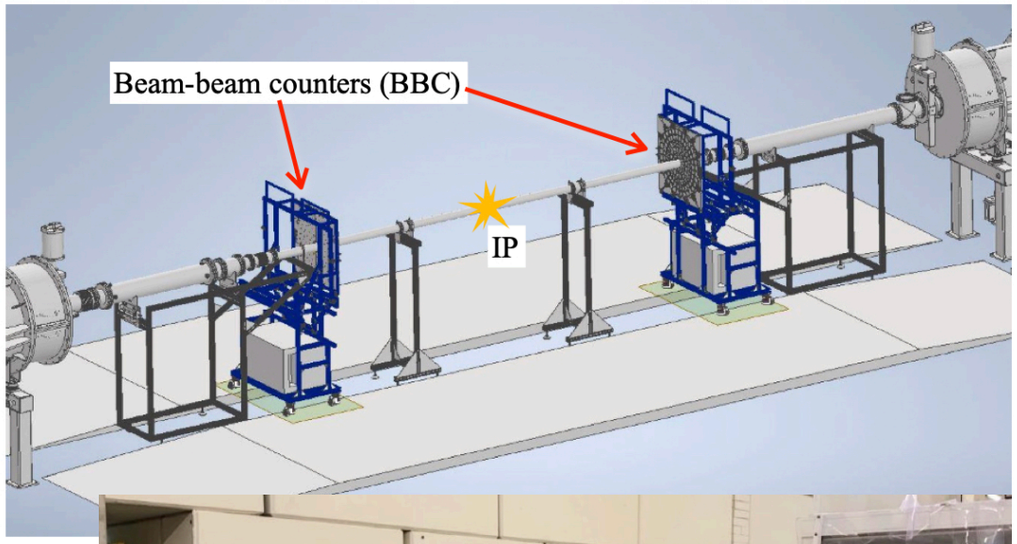
Framework for ZDC MC simulations and analysis has been developed. A NN architecture for the diferentiated identification between photons and neutrons has been created (Cuban group)

Barrel with 64*32 pin RSGSP connectors for the full-scale ZDC is received and tested for vacuum.



Our ZDC prototypes are ready to detect first collisions in SPD IP!

Phase-0





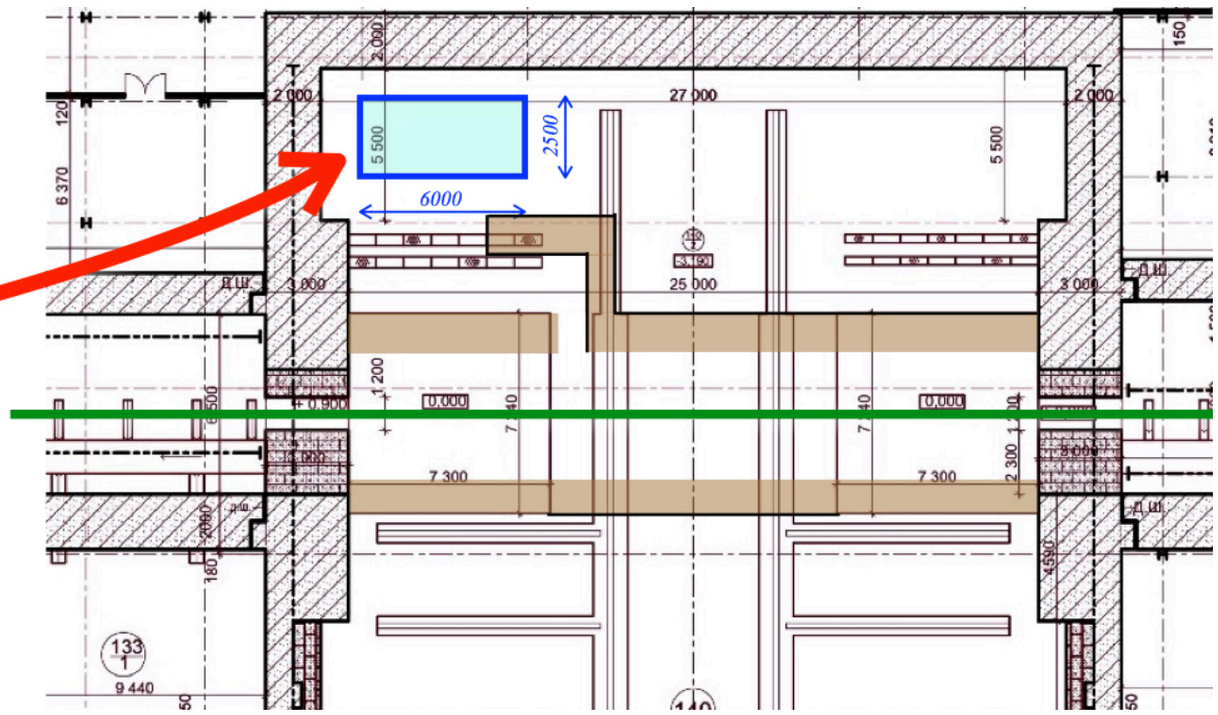


Goals:

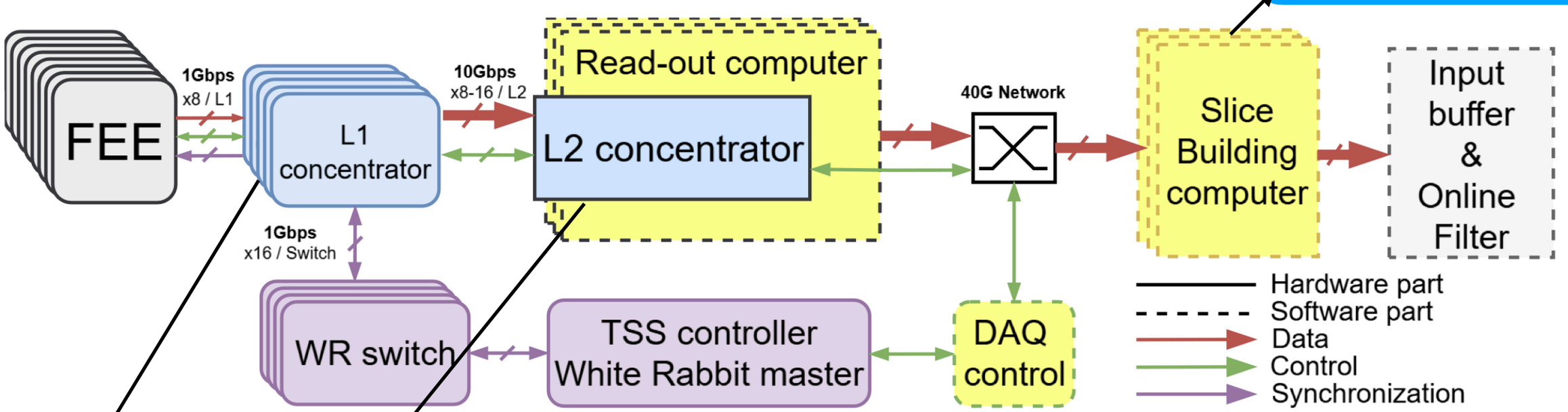
- Background conditions study
- Luminosity study and control
- Test of detector prototypes under realistic conditions

Detectors:

- BBC
- ZDC
- …
- Micromegas
- …



DAQ



JINR prototype

Prototyping by SPbTU

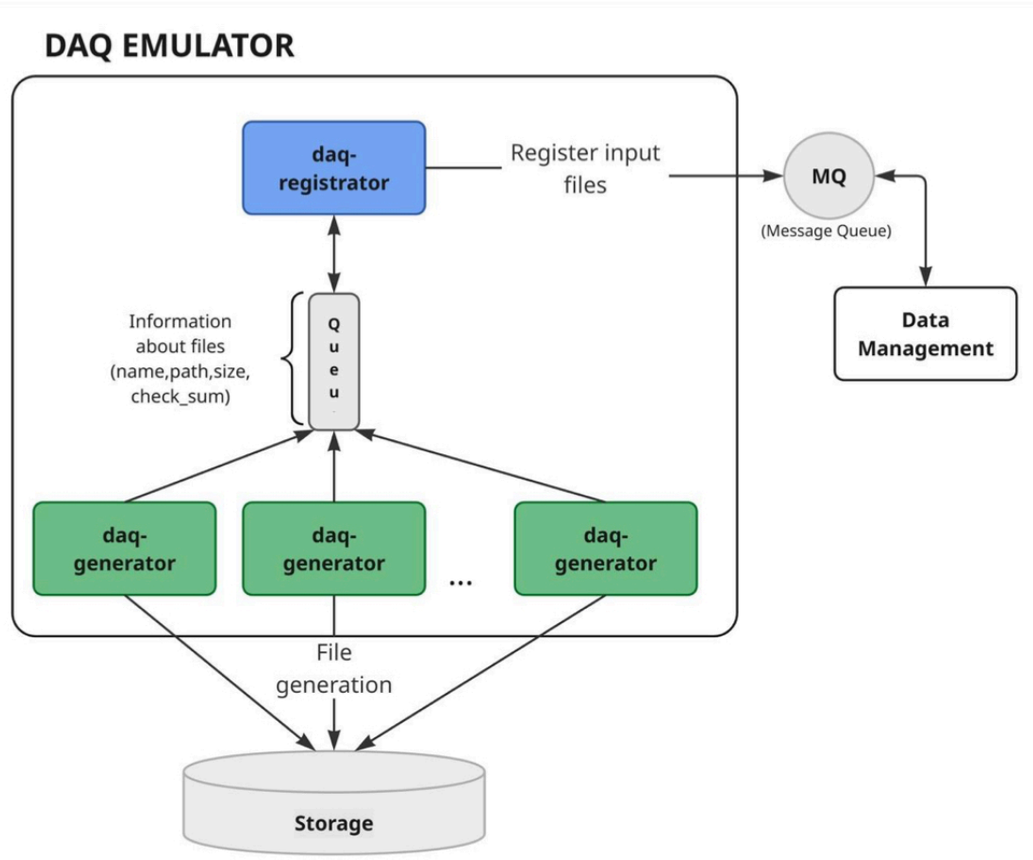
Prototyping by JINR+TSU

Communication with sub-detector groups

Communication level	Sub-detector	Num № Ch	Ch/FEE	Num FEE	Contact persons	Status of DAQ integration
0%	Vertex DSSD/MAPS	327680/12000	640/8	512/1500	(stage 2 ...)	0%
100%	Straw tracker (Barrel)	30512	128	425	Vitaly Bautin	80%
0%	Straw tracker (Endcap)				(stage 1)	0%
100%	Micromegas	5384	128	43	DAQ group	80%
30%	Calorimeter (Barrel)	27168	64	425	N.Anfimov (stage 2 ...)	0%
0%	Calorimeter (Endcap)				(stage 1 ?)	0%
20%	TOF	12228	8	1529	V.Chmil (stage 2 ...)	0%
0%	FARICH	70144	64	1096	(stage 2 ...)	0%
0%	BBC	1056	64	18	(stage 1)	0%
0%	BBC MCP	64	32	2	(stage 1)	0%
30%	Range system	137600	192	717	N.Zhuravlev & A.Anikeev	60%
30%	ZDC	210	64	34	I.Alekseev	10%

Online filter

- **Data Management System**
  - Data lifecycle support (data catalog, consistency check, cleanup, storage);
- **Workflow Management System**
  - Define and execute data processing chains by generating the required number of computational tasks;
- **Workload management System**
  - Create the required number of processing jobs to perform the task;
  - Control job execution through pilots working on compute nodes;
  - Handles efficient use of resources.



Parallel operation of standard event selection algorithms and ML algorithms is a key point for us. The former are reliable, the latter are fast. The hardware will also include CPUs and GPUs.

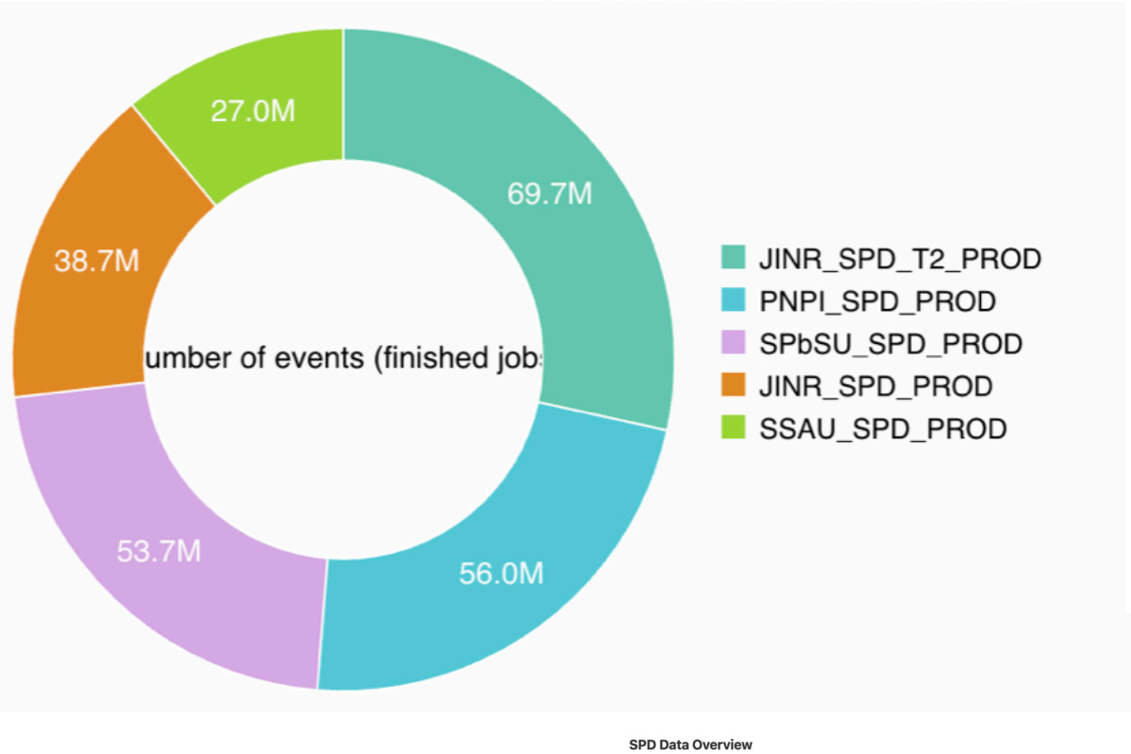
Server equipment has been purchased for the prototype of the 'classical' part of the offline system.

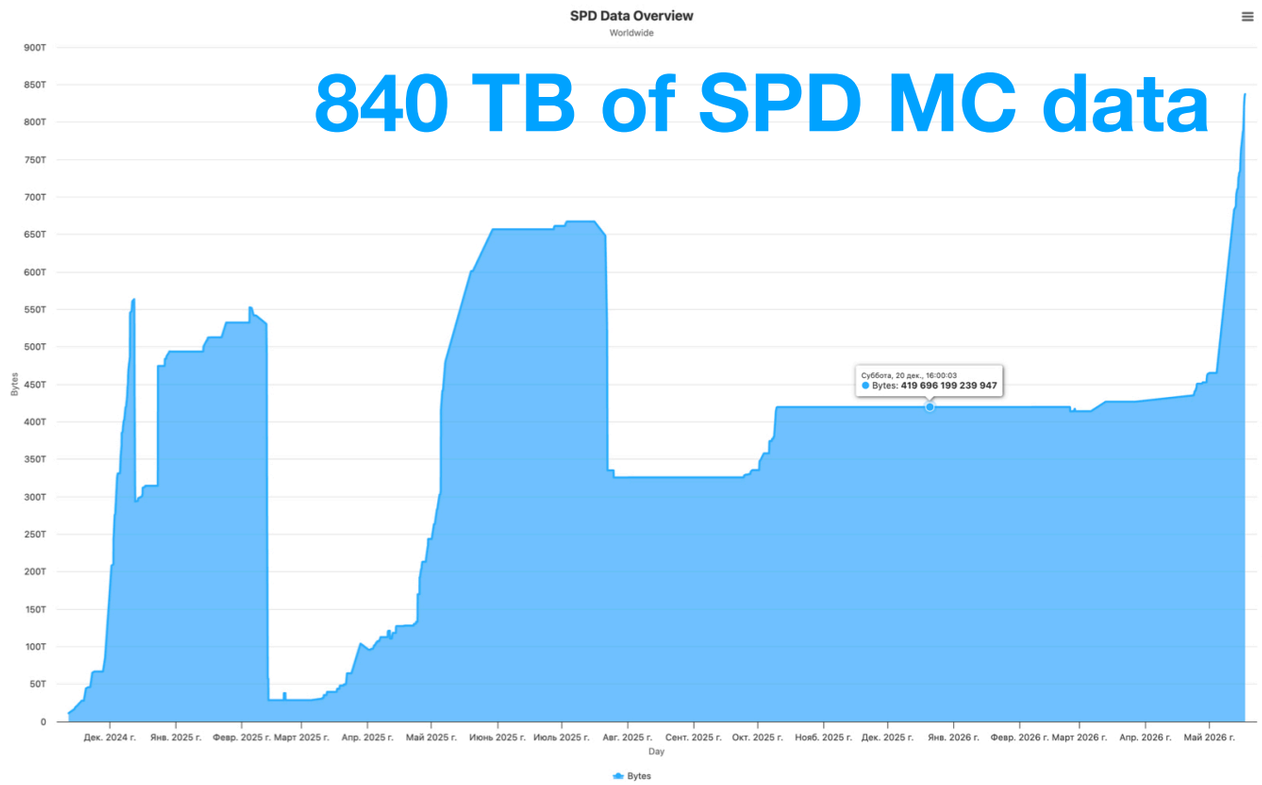
Work is underway to create a neural network prototype of the offline system.

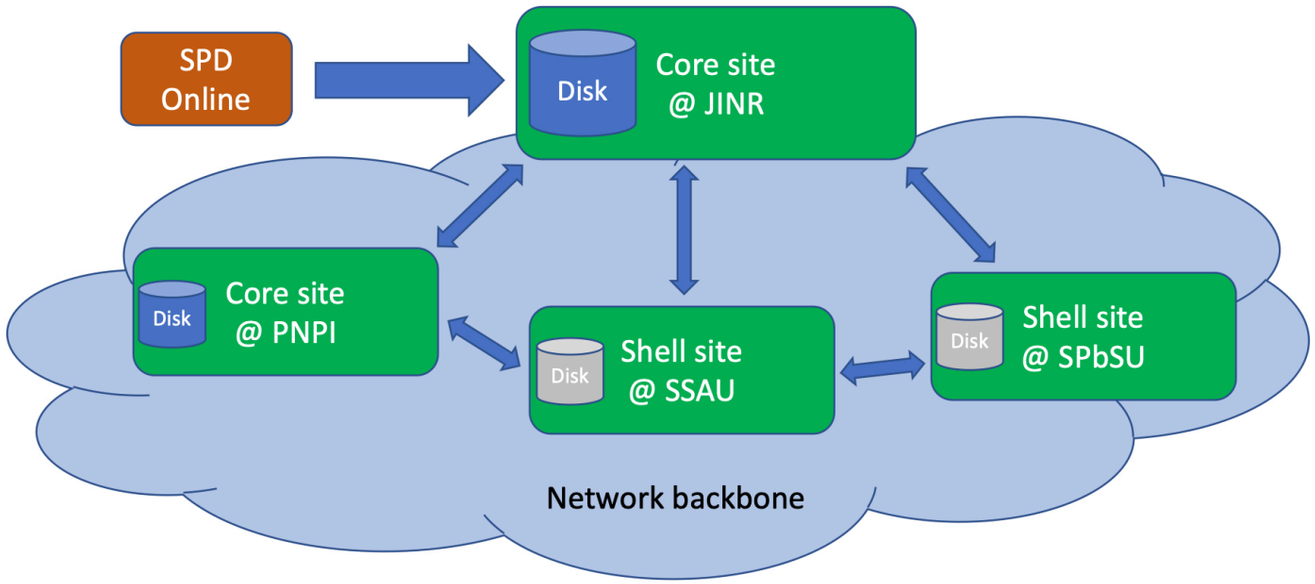


Computing

PanDA-based







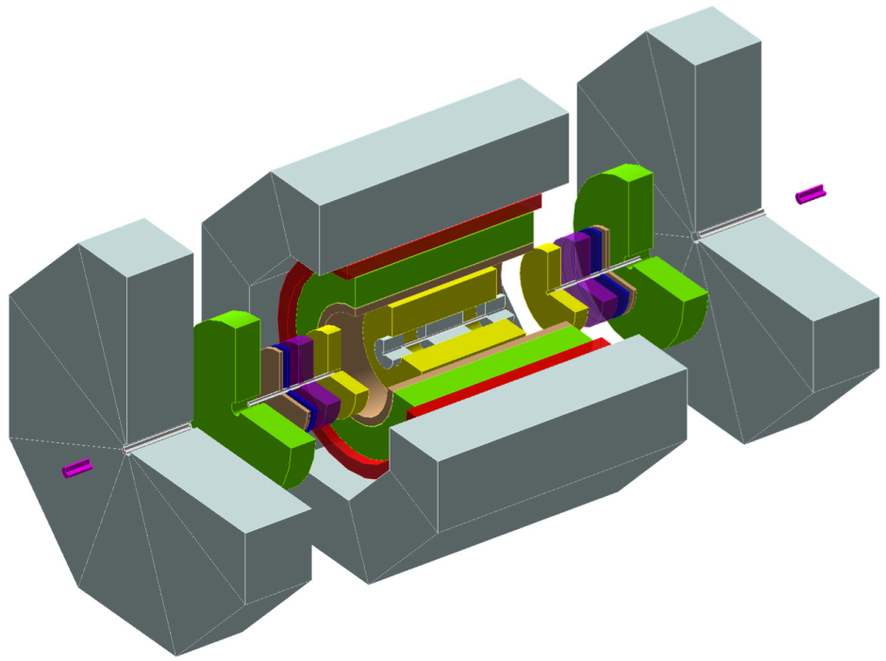
- Compute resources: Five sites are intergrated into production system:
  - JINR: around 1500 + 1500 CPUs on two different compute farms (total up to 3000)
  - PNPI: around 280 CPUs (most stable site)
  - SSAU (Samara): around 250 CPUs
  - SPbSU: around 250 CPUs
- Operational support increases step by step.
  - More monitoring and accounting tools would be desirable.
- Dedicated compute resources for SPD were acquired at JINR: approximately 3000 modern CPUs, each with up to 4 GB of RAM. These are expected to be available data production during the summer.

Software

From SPDroot to Gaudi-based **SAMPO**

Current functionality:

- HepMC3 as main format for generators
- Pythia8 for events generation (MT)
- GeoModel for detector description
- Geant4 for simulation (MT)
- Magnetic field description features



SubSystem	GeoModel description	Sampo hit Algorithm	Sampo digi Algorithm
Micromegas Central Tracker	√	×	×
Double-Sided Silicon Vertex Detector	×	×	×
MAPS Vertex Detector	×	×	×
Straw Tracker	Barrel only	In progress	×
Inner Beam-Beam Counter	In progress	×	×
Outer Beam-Beam Counter	×	×	×
Range System	√	√	In progress
Zero-Degree Calorimeter	√	✗	×
Electromagnetic Calorimeter	√	√	√
Time-Of-Flight System	×	×	×
FARICH	In progress	×	×
Beam pipe	×		
Magnet	×		

Infrastructure for:
1. fiber optics cables
2. gas and cryoliquid pipelines
3. power cables

Cryogenic system

SC solenoid

Multi-storey platform for electronic equipment

Magnet yoke (supporting structure for the detectors)

Support and transportation system

SPD detector configuration for 2031

XI Collaboration meeting (Tomsk)

XI SPD collaboration meeting

18-22 May, TSU



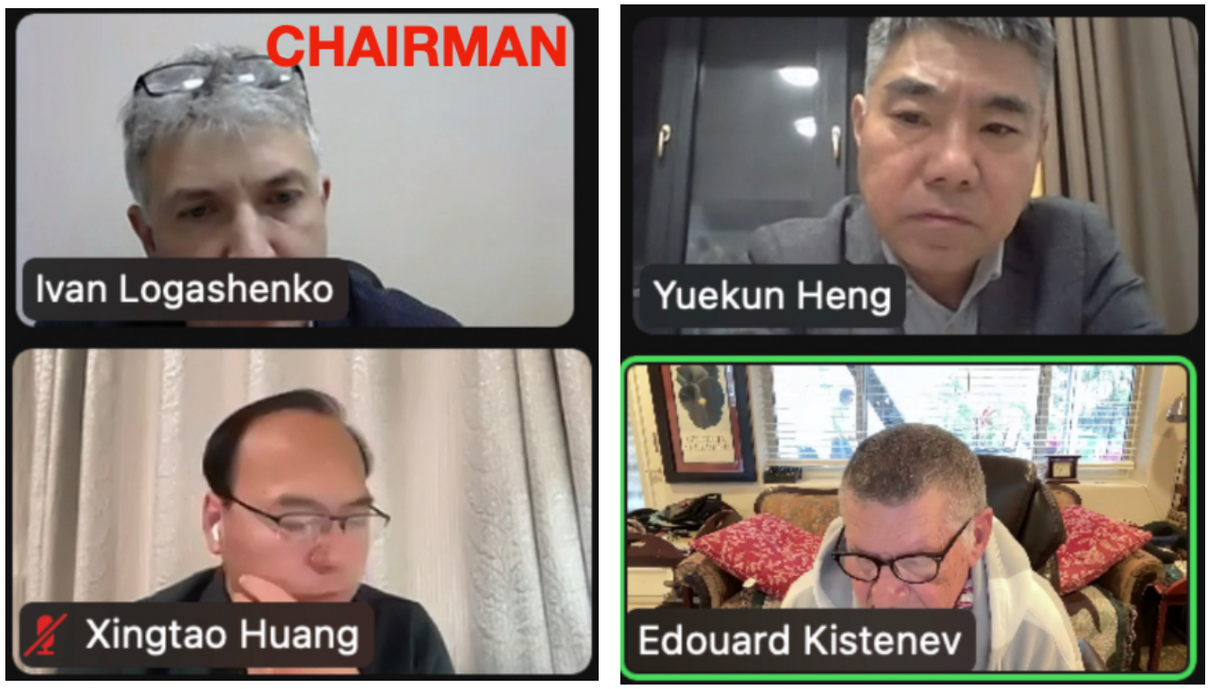
Participants:

Total: 175
In person: 84
from JINR: 36
foreigners: 6
local: 13

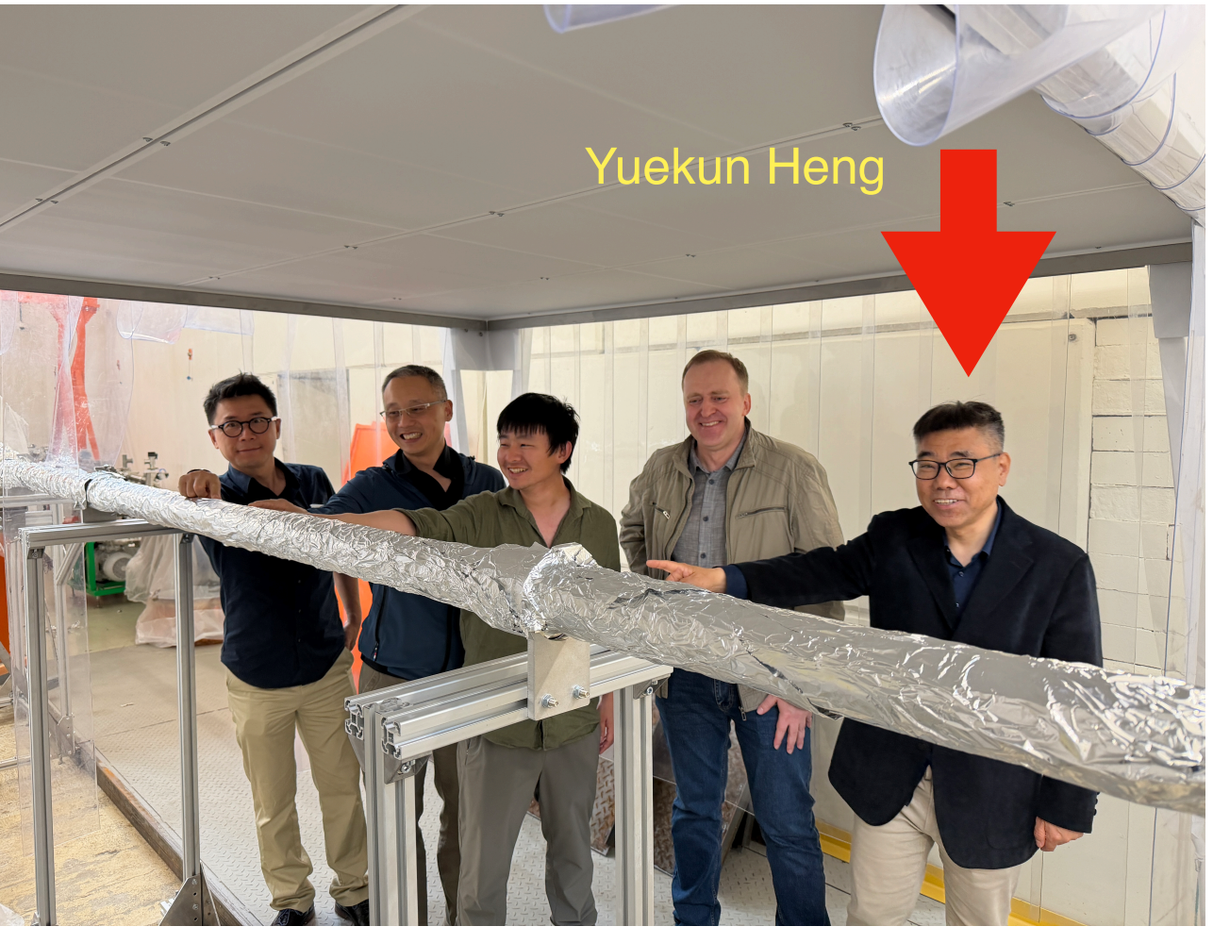
64 talks
by JINR: 30

An agreement has been reached to sign the MoU with USTC and the Shandong University

“Peek” mode of interaction with DAC



We agreed on the following mode of interaction: committee members 'peek' at our work, but do not actively interfere in it.





Summary

- We are focused on the construction of the detector and the corresponding infrastructure for the first phase of the experiment;

- The main priorities for us are: contracting of the SPD yoke, cryogenic infrastructure of the experiment and arranging production of the SC-cable for the SPD magnet;

- We are to place prototypes of our detectors in the SPD IP (phase-0) (BBC & ZDC)

- The SPD collaboration is in a good shape and developing dynamically.