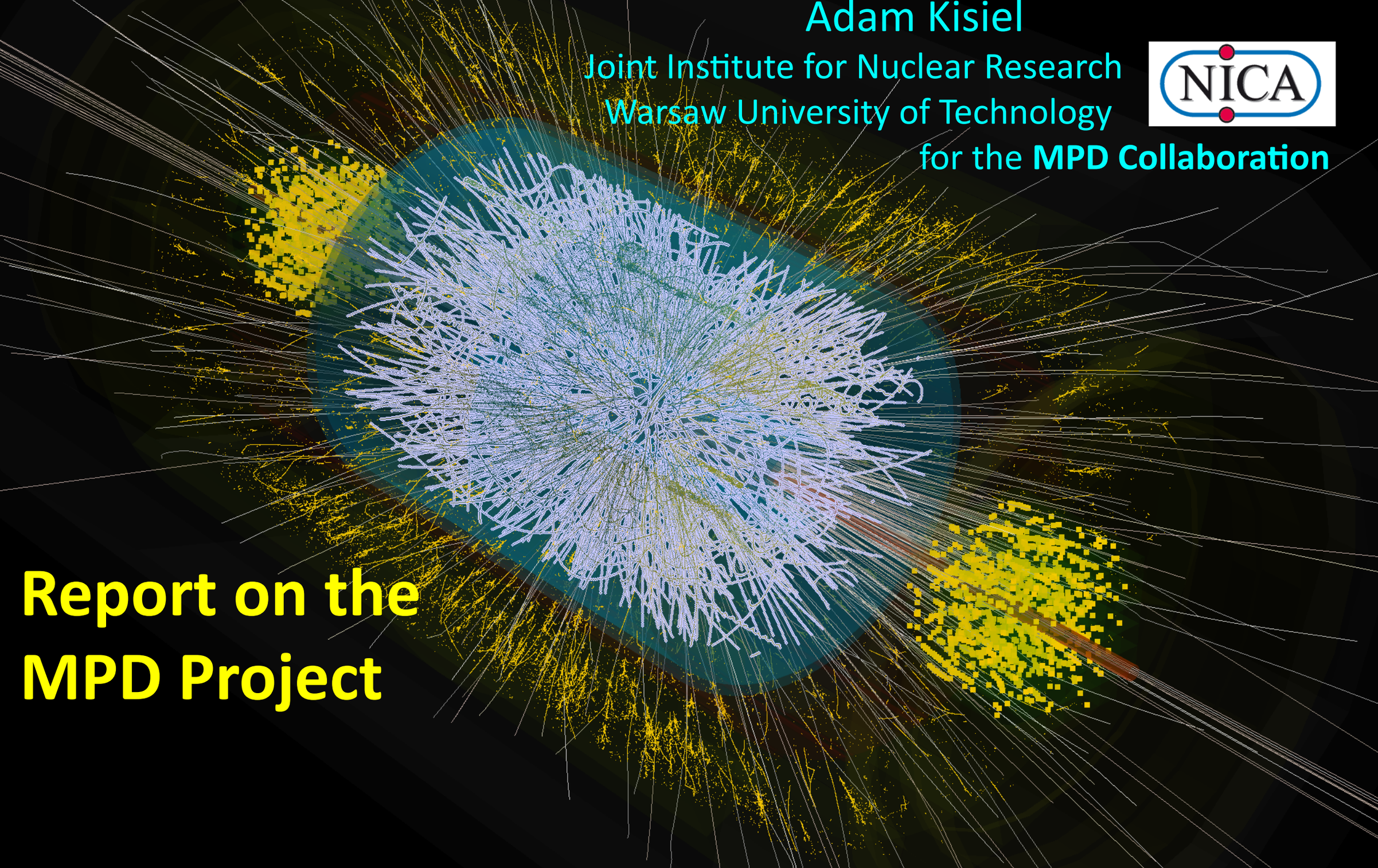
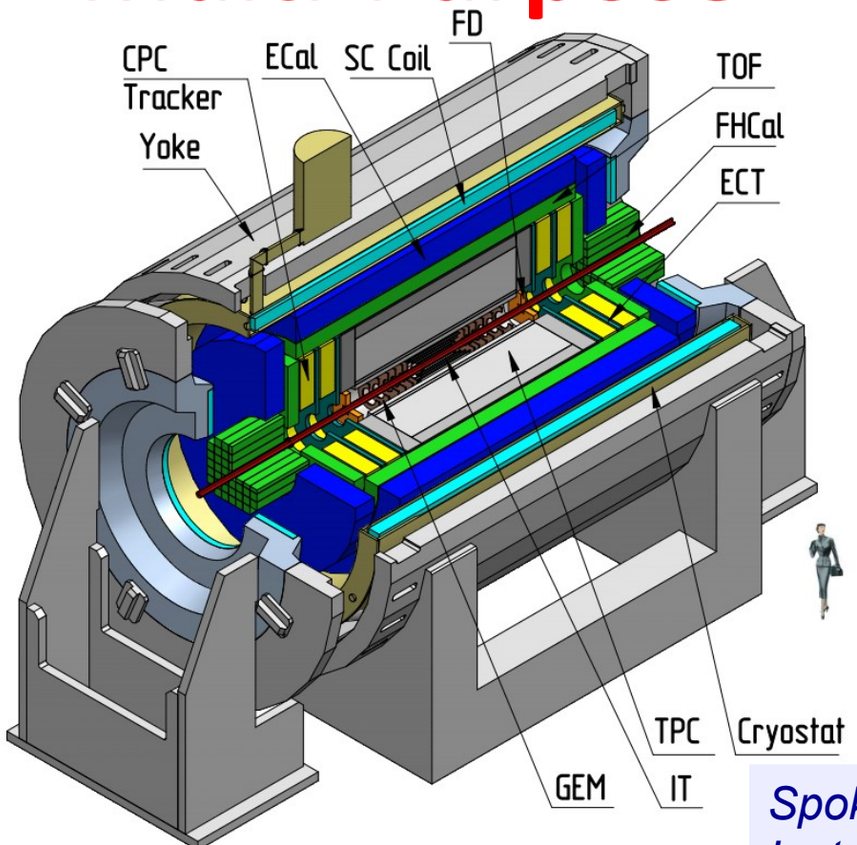


Adam Kisiel
Joint Institute for Nuclear Research
Warsaw University of Technology
for the **MPD Collaboration**

Report on the MPD Project

Multi-Purpose Detector (MPD) Collaboration



11 *Countries,* ***>500*** *participants,*
39 *Institutes and* ***JINR***

NICA

Spokesperson: ***Adam Kisiel***
Inst. Board Chair: ***Fuqiang Wang***
Project Manager: ***Slava Golovatyuk***

Deputy Spokespersons:
Victor Riabov, Zebo Tang

AANL, Yerevan, ***Armenia;***
Baku State University, NNRC, ***Azerbaijan****;*
University of Plovdiv, ***Bulgaria;***
University Tecnica Federico Santa Maria, Valparaiso, ***Chile****;*
Tsinghua University, Beijing, ***China****;*
USTC, Hefei, ***China****;*
Huzhou University, Huizhou, ***China****;*
Institute of Nuclear and Applied Physics, CAS, Shanghai, ***China****;*
Central China Normal University, ***China****;*
Shandong University, Shandong, ***China****;*

IHEP, Beijing, ***China****;*
University of South China, ***China****;*
Three Gorges University, ***China****;*
Institute of Modern Physics of CAS, Lanzhou, ***China****;*
Palacky University, Olomouc, ***Czech Republic****;*
NPI CAS, Rez, ***Czech Republic****;*
Tbilisi State University, Tbilisi, ***Georgia****;*
Joint Institute for Nuclear Research*;*
FCFM-BUAP (Mario Rodriguez) Puebla, ***Mexico****;*
FC-UCOL (Maria Elena Tejeda), Colima, ***Mexico****;*
FCFM-UAS (Isabel Dominguez), Culiacán, ***Mexico****;*
ICN-UNAM (Alejandro Ayala), Mexico City, ***Mexico****;*
CINVESTAV (Luis Manuel Montaño), Mexico City, ***Mexico****;*
Institute of Applied Physics, Chisinev, ***Moldova****;*
WUT, Warsaw, ***Poland****;*
NCNR, Otwock – Świerk, ***Poland****;*
University of Wrocław, ***Poland****;*
University of Silesia, ***Poland;***
University of Warsaw, ***Poland****;*
Jan Kochanowski University, Kielce, ***Poland****;*
Belgorod National Research University, ***Russia****;*
INR RAS, Moscow, ***Russia****;*
MEPhI, Moscow, ***Russia****;*
Moscow Institute of Science and Technology, ***Russia****;*
North Osetian State University, ***Russia****;*
NRC Kurchatov Institute, ITEP, ***Russia****;*
Kurchatov Institute, Moscow, ***Russia****;*
St. Petersburg State University, ***Russia;***
SINP, Moscow, ***Russia****;*
PNPI, Gatchina, ***Russia****;*

Memorandum of Understanding

- Memorandum of Understanding formalizes the participation of the Institution in the Collaboration, defines its rights and obligations
- Currently MPD MoU ready for: **Mexican** Consortium MexNICA, **Poland**: WUT, NCBJ, Warsaw University, UJK in Kielce, University of Wrocław, **Czech Republic**: Palacky University, NPI CAS, **Azerbaijan**: NNRC Baku, **Bulgaria**: Plovdiv University, **Russian Federation**: SPSU, INR RAS, SINP MSU, Belgorod State University, MIPT Moscow, NRC „Kurchatov Institute" – ITEP
- Recently prepared MoUs: **Armenia:** A. Alikahnyan National Lab of Armenia, **Poland:** University of Silesia, **Czech Republic:** Palacki University, Olomouc
- Progress on the MoU with Chinese Institutions (agreement with Chineese MOST)

MPD Physics Programme

G. Feofilov, A. Ivashkin

Global observables

- Total event multiplicity
- Total event energy
- Centrality determination
- Total cross-section measurement
- Event plane measurement at all rapidities
- Spectator measurement

V. Kolesnikov, Xianglei Zhu

Spectra of light flavor and hypernuclei

- Light flavor spectra
- Hyperons and hypernuclei
- Total particle yields and yield ratios
- Kinematic and chemical properties of the event
- Mapping QCD Phase Diag.

K. Mikhailov, A. Taranenko

Correlations and Fluctuations

- Collective flow for hadrons
- Vorticity, Λ polarization
- E-by-E fluctuation of multiplicity, momentum and conserved quantities
- Femtoscopy
- Forward-Backward corr.
- Jet-like correlations

V. Riabov, Chi Yang

Electromagnetic probes

- Electromagnetic calorimeter meas.
- Photons in ECAL and central barrel
- Low mass dilepton spectra in-medium modification of resonances and intermediate mass region

Wangmei Zha, A. Zinchenko

Heavy flavor

- Study of open charm production
- Charmonium with ECAL and central barrel
- Charmed meson through secondary vertices in ITS and HF electrons
- Explore production at charm threshold

MPD First Physics Document

First Physics with MPD Experiment at the NICA Accelerator Complex*

Vladimir D. Kekelidze, Adam Kisiel,† and Viacheslav Golovatyuk‡
Joint Institute for Nuclear Research, Dubna, Moscow Region, Russian Federation

(MPD Collaboration)
(Dated: August 25, 2020)

The Nuclotron-based Ion Collider fAcility (NICA) is in construction at the Joint Institute for Nuclear Research (JINR). The accelerator complex will consists of several components, specifically the Nuclotron accelerator, the Booster support accelerator, two ion sources, as well as the NICA collider ring with the corresponding transfer lines from Nuclotron. The expected date of putting the NICA collider ring for commissionning is September of 2022. At the same time the Multi-Purpose Detector (MPD) has been designed to operate at NICA. Components of MPD are currently in production. The assembly of the detector on-site has started on July of 2020, while on November of 2021 the detector setup will start the commisioning, to be ready for datataking on first beam from NICA.

This documents details the preparation schedule for the construction and commisionning of MPD. It presents the plans for the first physics measurements at NICA and puts them into context of existing and planned physics experiments in the area of QCD phase diagram investigation.

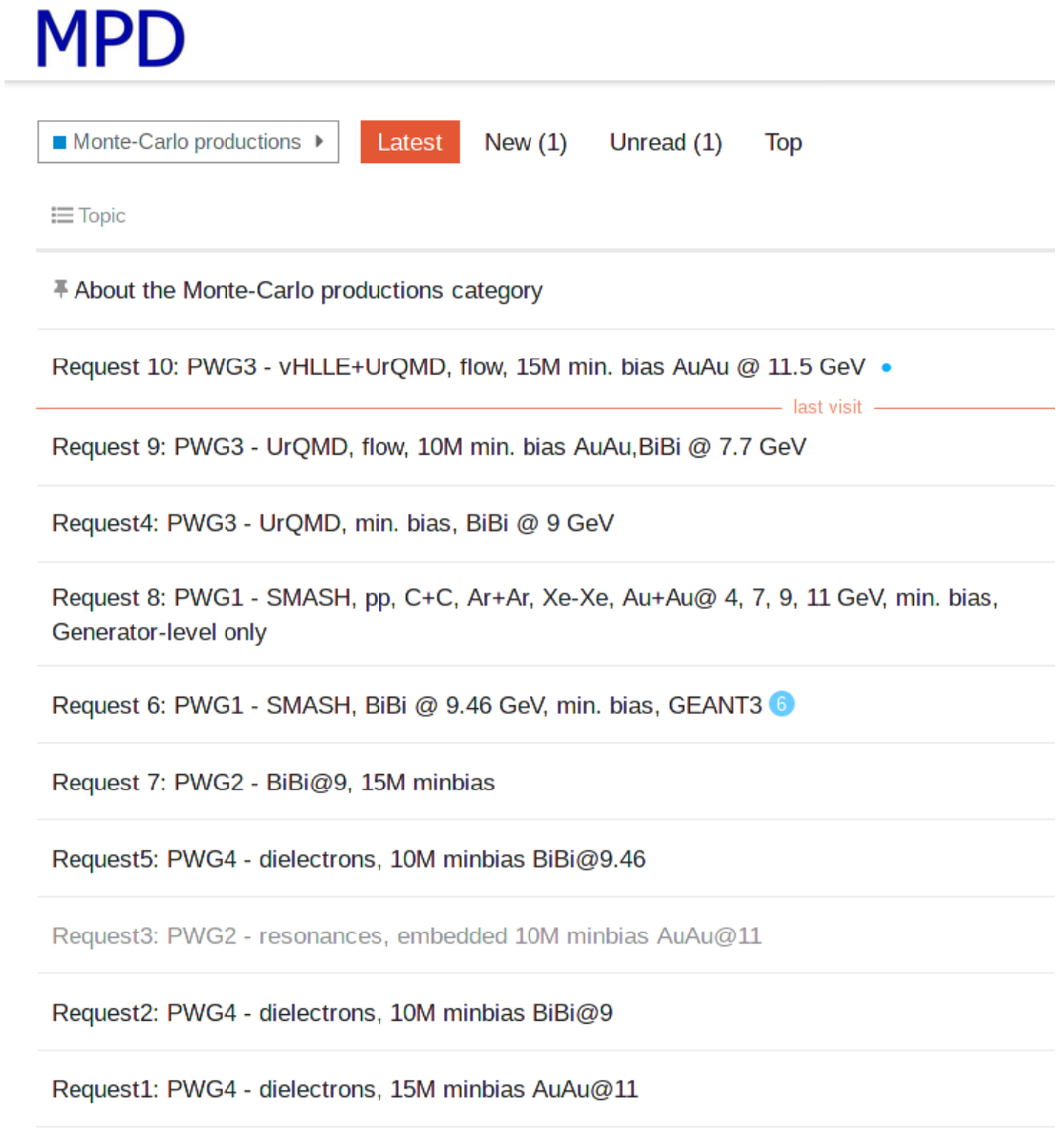
CONTENTS

* A report for the NICA Supervisory Board and the JINR Committee of Plenipotentiaries

† Also at Faculty of Physics, Warsaw University of Technology, Warsaw, Poland.
‡ Second.Author@institution.edu

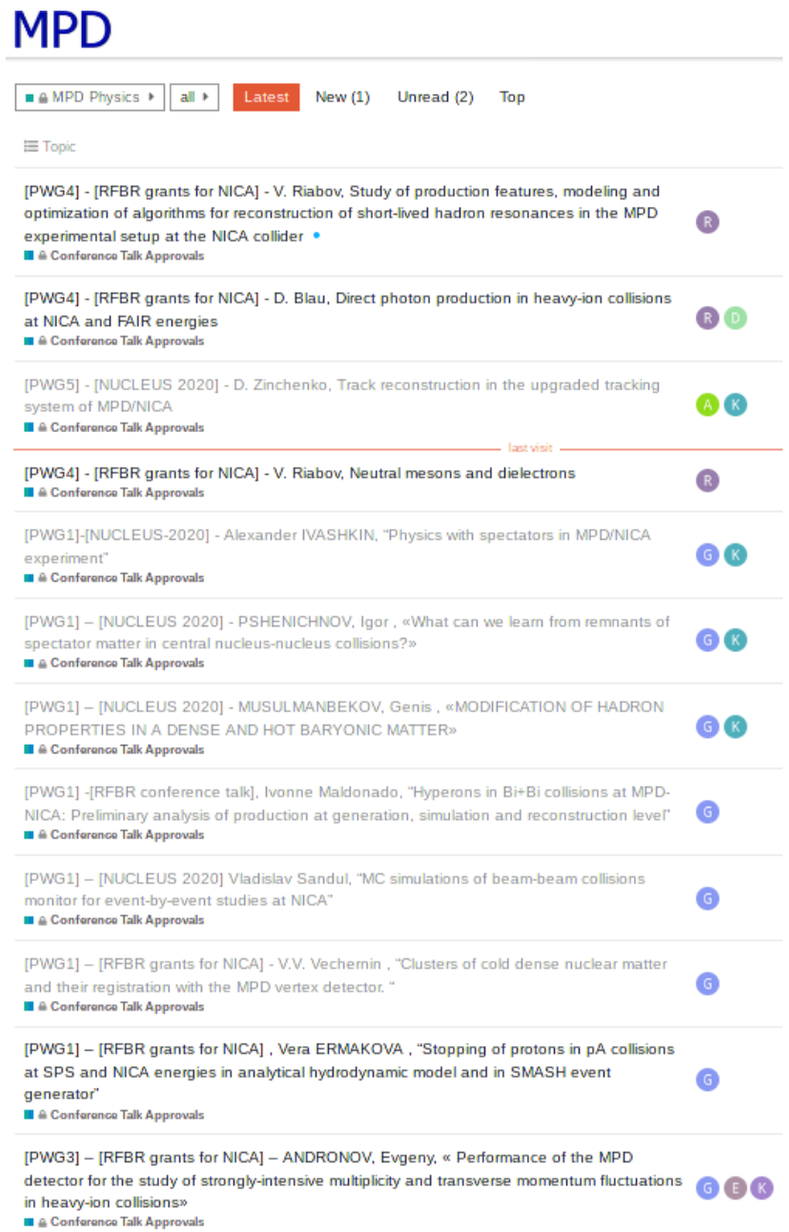
- Report on expected physics results on the first run of MPD
- Initial running plan for the NICA Complex (Bi+Bi@$\sqrt{s_{NN}}$=9.46 GeV, Au+Au up to 11 GeV)
- Status of the readiness of the MPD detector subsystems
- Calibration and computing readiness
- Selection of physics observables with largest discovery potential for the initial datasample
- Plan for preparation of first scientific publications from MPD data

Monte-Carlo simulations, computing readiness



- Organized regular massive productions of Monte-Carlo simulations, using MPD computing resources
- Regular running of productions in HybryLIT (LIT laboratory cluster), use of DIRAC
- NICA Cluster at VBLHEP in routine operation for data analysis
- Established procedure for requests and validation of Monte-Carlo productions
- Extensive new requests in response to clarification of initial NICA beams

MPD Physics reports at Autumn conferences



- Three major conferences in Autumn 2020:
  - ICPPA 2020 (MePHI) Oct 5-9
  - Nucleus 2020 (SPSU) Oct 11-17
  - RFBR grants for NICA (JINR) Oct 20-23
- More than 40 reports (total) at the conferences, related to MPD
- Major effort to prepare up-to-date physics simulations for the talks
- Organized slides approval and talk rehearsals within MPD PWGs for the talks

Milestones of MPD assembling in 2020-2021

Year 2020

1. July 15th - MPD Hall and pit are ready to store and unpack Yoke parts
2. August - The first 13 plates of Magnet Yoke are assembled for alignment checks
3. Sept 15th - Oct 1st - Solenoid is ready for transportation from ASG (Italy)
4. November 10th - Solenoid is in Dubna
5. Nov-Dec - Assembling of Magnet Yoke and Solenoid at JINR

Year 2021

6. Jan- April - Preparation for switching on the Solenoid (Cryogenics, Power Supply et cet.)
7. May - June - Magnetic Field measurement
8. July - Installation of Support Frame
9. Jul- Dec - Installation of ECal and TOF, Electronics Platform, Cabling

Year 2022

11. Jan- Mar - Installation of TPC, Electronics Platform, Cabling
12. March - Installation of beam pipe, FHCal, Cosmic Ray test system
13. April-Dec - Cosmic Ray tests
14. December - Commissioning

Year 2023

15. March - Run on the beam

MPD Civil Construction status

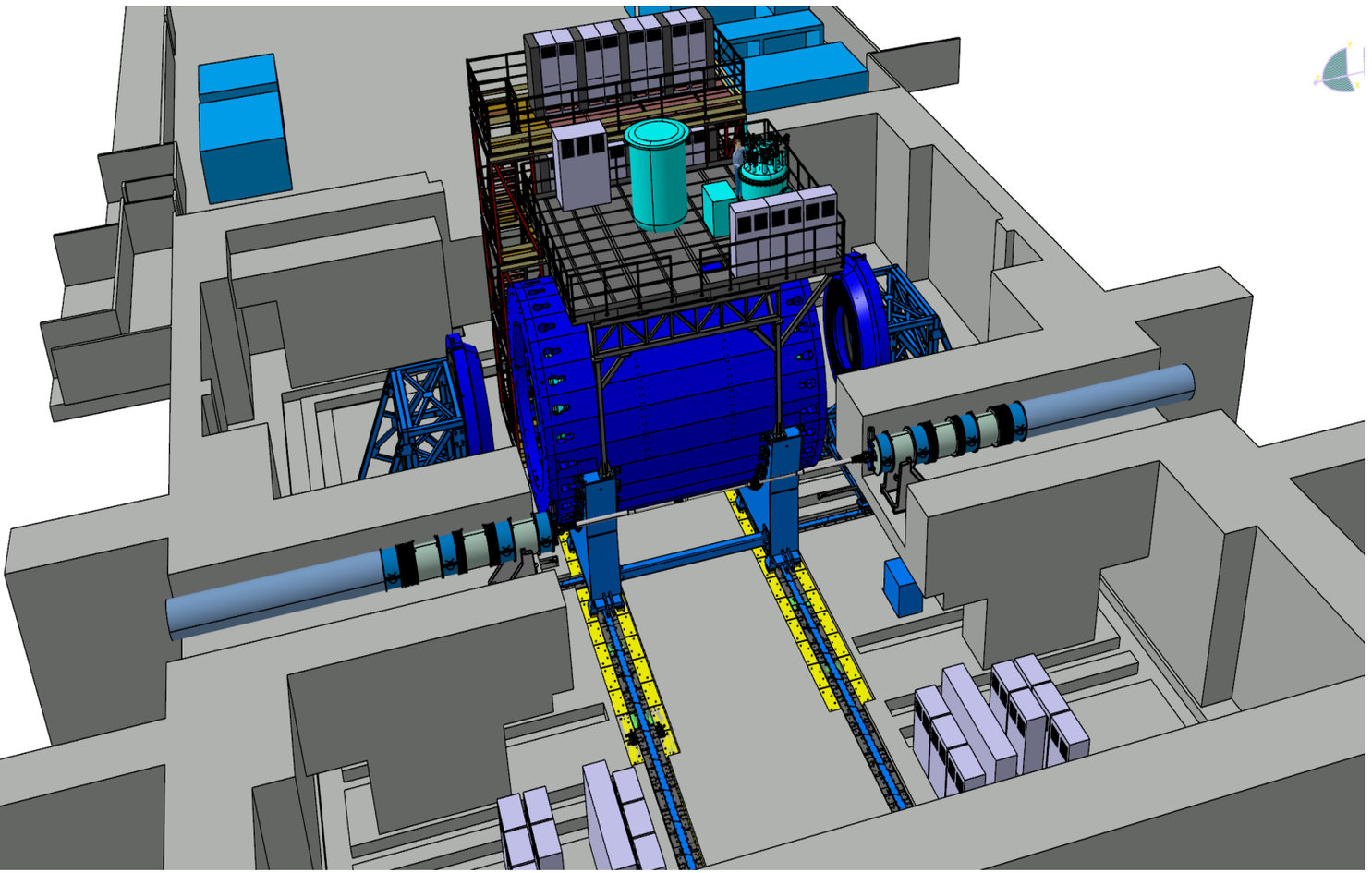
- MPD Hall ready for limited scope of equipment installation, remaining works still ongoing

MPD Hall crane weight test

Exterior of the MPD Hall Building and high voltage connection housing

Epoxy floor finish ready in the MPD Hall

MPD Hall readiness

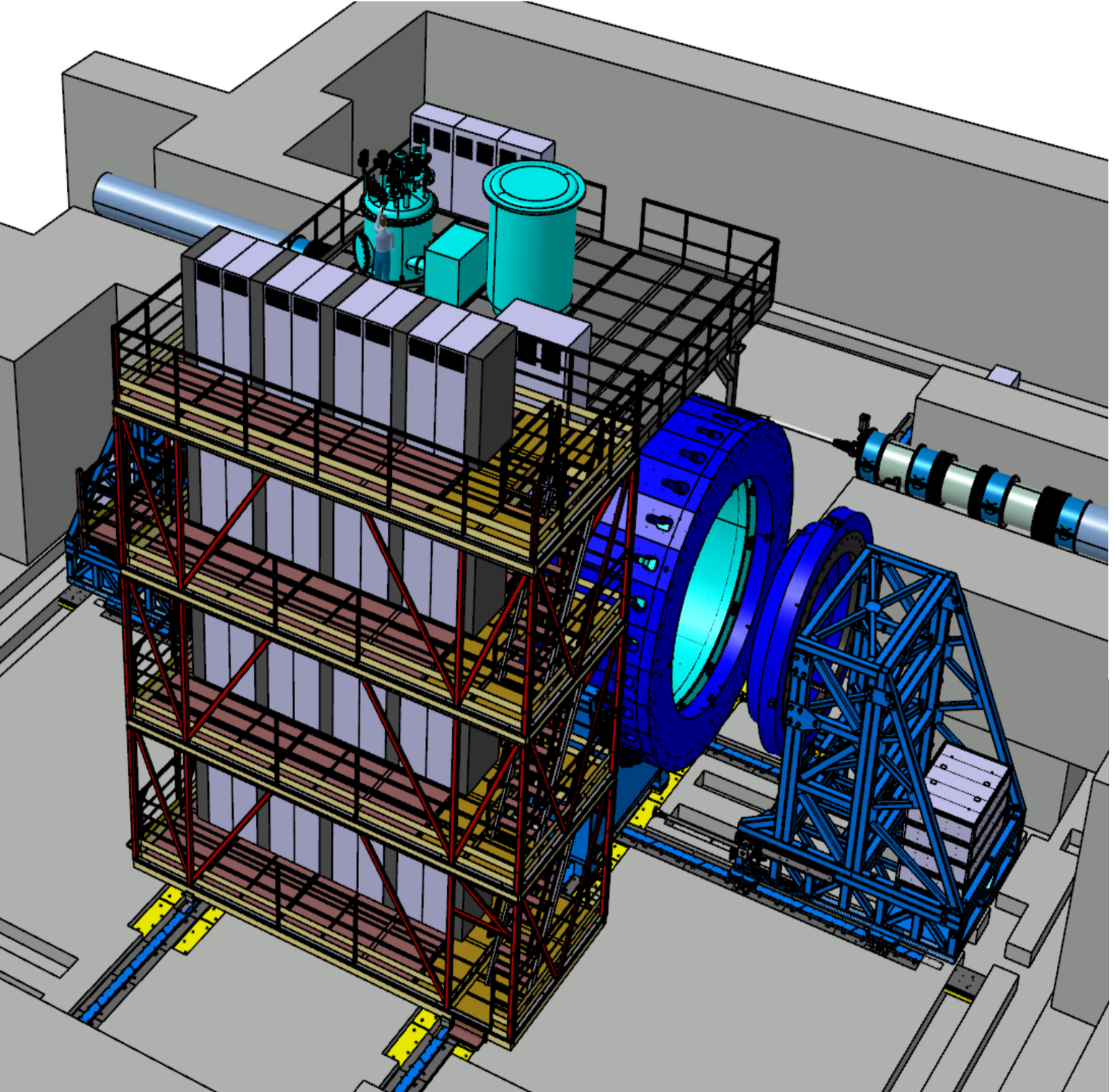


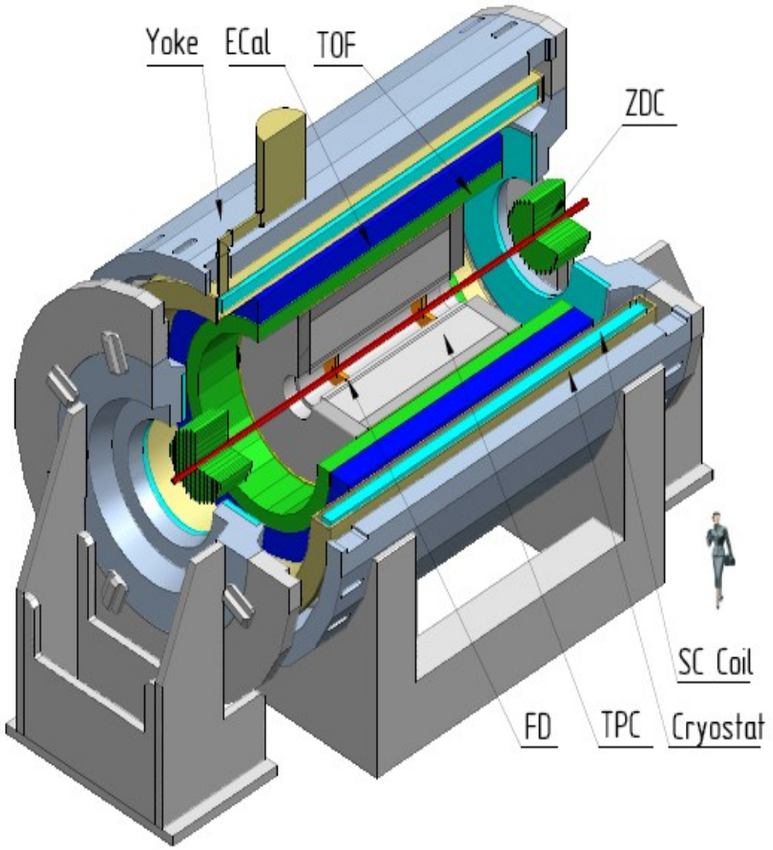
The MPD Hall readiness required for full-scale works
consits of:

- The Hall has to be clean – walls, ceiling and a floor
- Stable temperature – 20^0C
- Electric lines ready (1,2 MW)
- Grounding lines checked
- Gas pipe lines from gas systems location to the detector assembling dock ready and tested
- Cryogenic infrastructure for Solenoid (LN and LHe tanks and pipes)
- Cooling water lines ready and tested

Magnet Yoke assembly

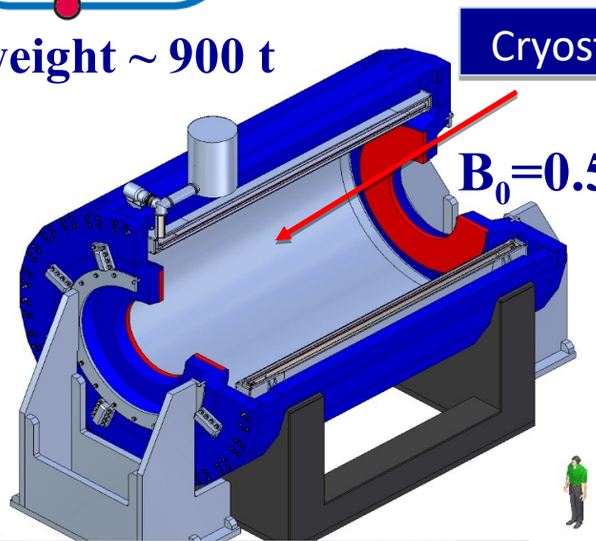
- MPD Hall, including MPD Pit delivered to MPD for selected MPD activities
- In parallel significant interior finishing works as well as major support facilities are still being installed by the contractor
- Important effort to finish the epoxy floor
- Assembly of the magnet yoke started – 13 modules (out of 28) installed with average 200 µm precision
- Awaiting delegation from Solenoid manufacturer to finish procedure
- Critical assembly path commenced





The MPD experimental Hall

Magnet fabrication



Assembled Solenoid

yoke control assembly at HM Vitkovice

- **Transportation**
- **The magnet is being transported via boat to Dubna**
- **Should arrive in St. Petersburg and then be delivered to Dubna via the Volga river**
- **Preparation for switching on the Solenoid at JINR**

To cool down the magnet the supply of LN and LHe from Collider lines was planned. However at the time of Solenoid cooling down the collider Cryogenics line will not have been yet available. Dedicated cryogenics needed

Cooling tests

We expect results of low temperature (LN) tests at JINR under supervision of ASG (ITALY). Some reparation after Cooling down procedure of the Solenoid Coils may be needed (coil isolation cracks). Specialized area in JINR is prepared in case repairs are needed

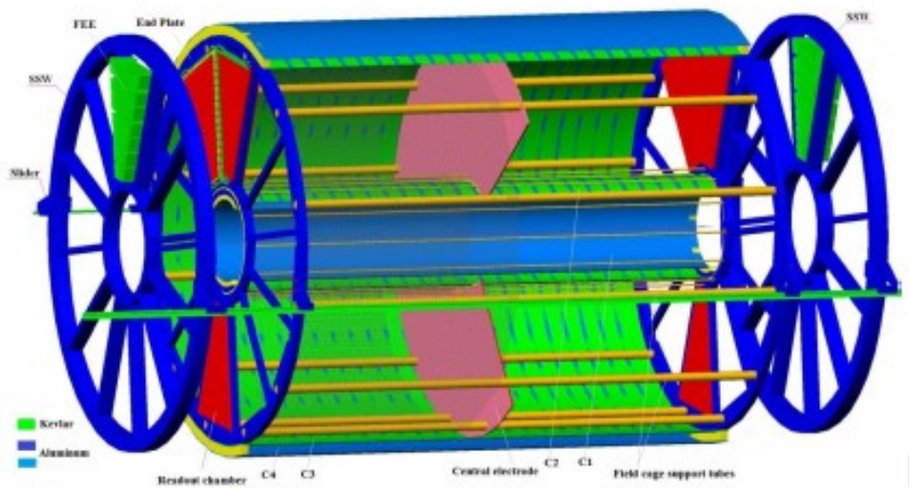
Current lead

ASG decided to use current leads with glued fiberglass vacuum seals. Our experts suggest this is not a reliable solution. Several cycles of warming and cooling may cause the leakage in the vacuum system of the solenoid. We plan to replace current leads from Cryomagnetic Inc. company with those of Mark&Wedel.

MPD Time Projection Chamber

S.Movchan

- **Sensitive length: 326 cm**
- **Radius: 34/133 cm**

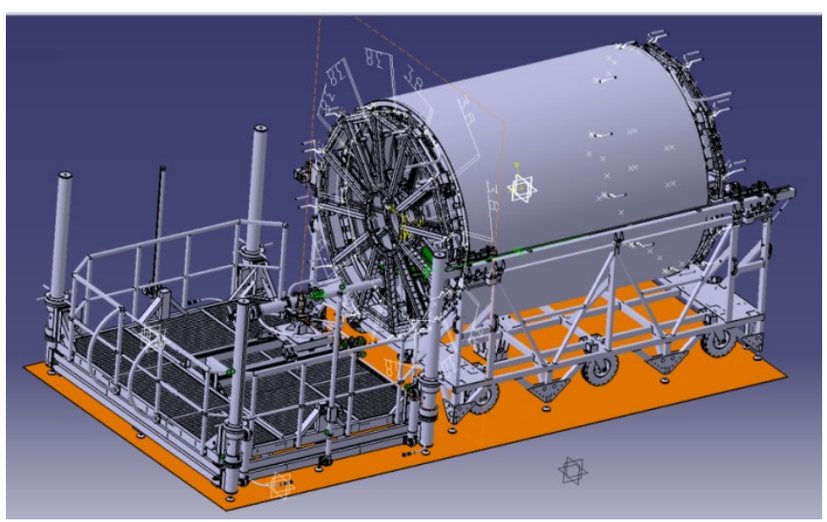


HV tests

Tests to control the leakage current when 30 kV is applied to the membrane of the TPC.

ROC chambers installation with a special Robot is foreseen

Robot for ROC installation



Item	Date	
Testing 512-channel system (FEC v1.0) finished	Jan. 2019	✓
Testing 256-channel system (FEC v2.0) finished	Feb. 2019	✓
Preproduction vervion FEC PCBs sent for fabrication	Mar. 2019	✓
Half-ROC readout system base design finished	Mar. 2019	✓
Receive SAMPA V4 chips at Dubna	Jul. 2019	✓
34 preproduction version FEC assembled and tested	Nov. 2019	✓
32 preprod. version FEC installed on Pilot 2048 ch. Syst.	Dec. 2019	✓
Instrumented Half ROC system testing	Feb. 2020	
Testing instrumented ROC finished	Apr. 2020	
Production vervion FEC PCBs ready	May 2020	
1st batch of prod.ver FEC (130 pcs) fabricated	Jul. 2020	
2nd batch of prod.ver FEC (800 pcs) fabricated	Sept. 2020	
3rd batch of prod.ver FEC (800 pcs) fabricated	Dec. 2020	

Test ROC with FECs (2048ch) –> Oct 2020

FECs mass-production –> 2021

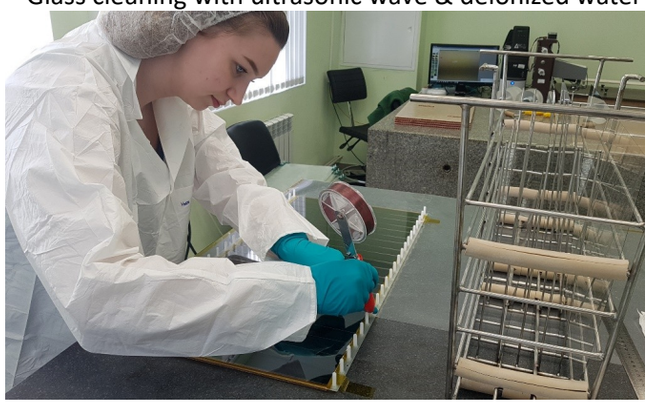
MPD Time-of-Flight

Mass production staff: 4 physicists, 4 technicians, 2 electronics engineers

Productivity: ~ 1 detector per day (1 module/2 weeks)

Glass cleaning with ultrasonic wave & deionized water

Automatic painting of the conductive layer on the glass



MRPC assembling

Soldering HV connector and readout pins

	Number of detectors	Number of readout strips	Sensitive area, m^2	Number of FEE cards	Number of FEE channels
MRPC	1	24	0.192	2	48
Module	10	240	1.848	20	480
Barrel	280	6720	51.8	560	**13440** (1680 chips)

The current design of mRPC was used for TOF-BM&N and showed excellent characteristics. Time resolution - 60 ps

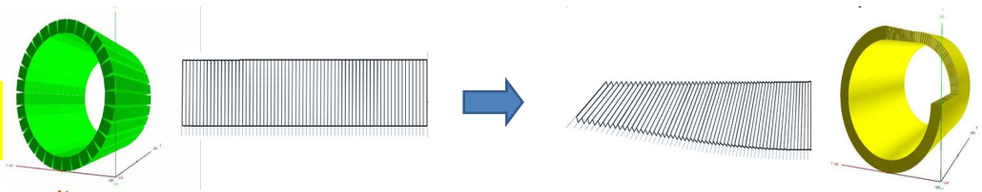
- However on the stage of mass production of RPCs for MPD we have observed a different electric properties of glass and higher dark current. Finding the problem and its solution required 4 months.
- Gas tightness of boxes requires a lot of effort. To lower the material budget we designed and produced low material-budget, non-enforced gas boxes.
- To diminish dead zones we left tight space between TOF modules in the MPD (5 mm). It may cause problems during installation.

Electromagnetic Calorimeter (ECAL)

ECal – THU – Tsinghua University., Yi Wang
SDU –Shandong University
HU- Huzhou University Fuqing Wang
JINR – production in IHEP (Protvino) and Tenzor (Dubna)

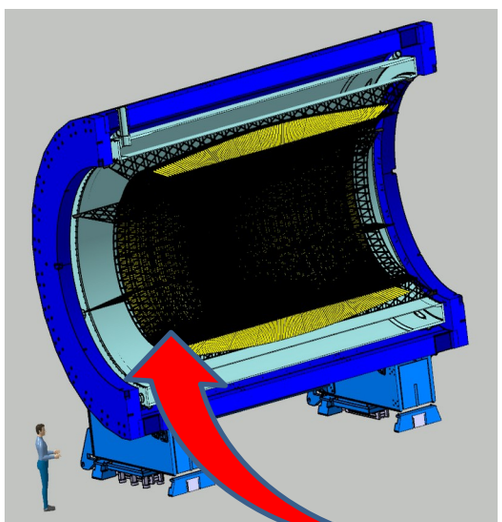
ECal is organized into 25 sectors (50 half-sectors). Each half-sector contains 48 modules.

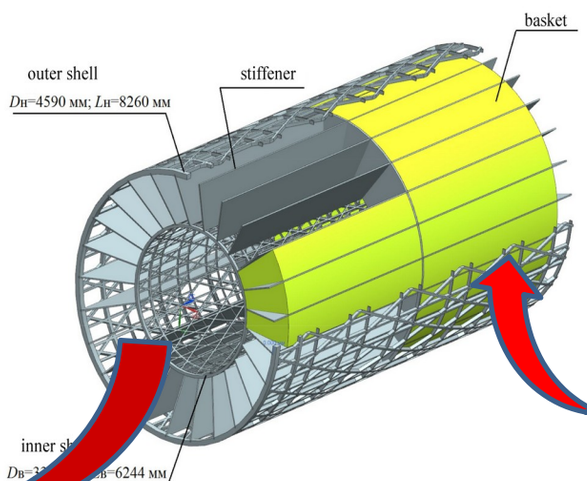
Barrel ECAL ~ 38400 ECAL modules

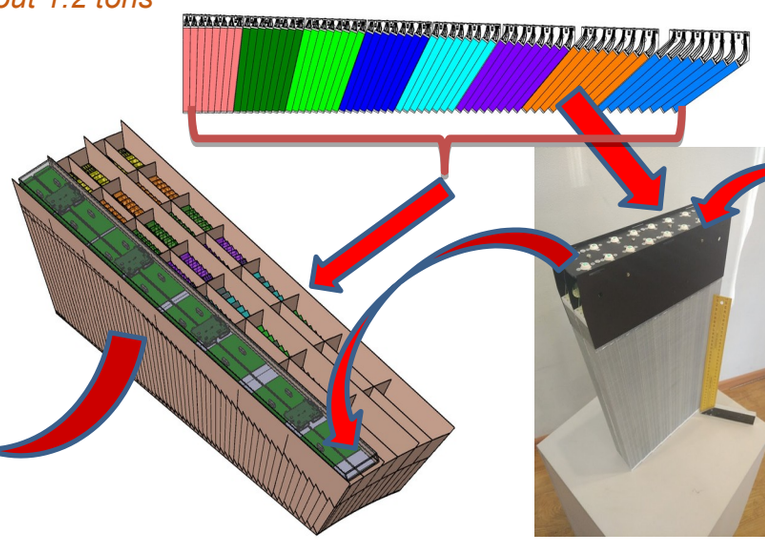


Container is made of Carbon composite

Total load of about 1.2 tons







We need Containers for sectors

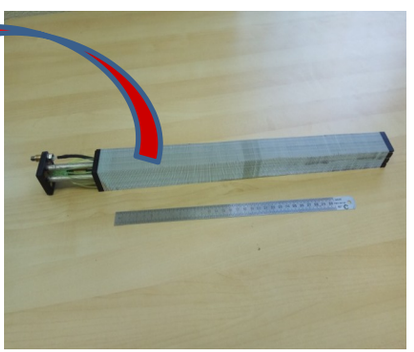


Photo of one element

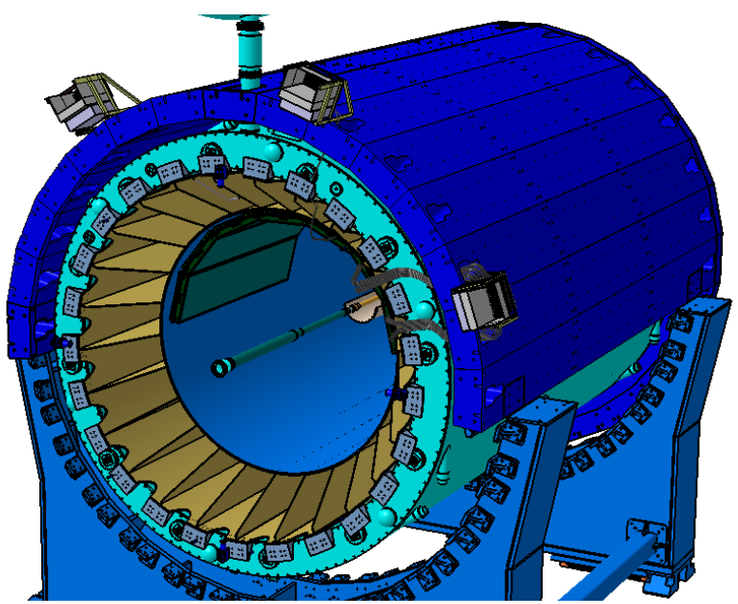
There was preliminary agreement that 25% of all modules are produced by JINR (production area in Protvino) and the rest - 75% in China. 3 sites are prepared for that in China Universities.
However at the beginning of this year the Ministry of Science and Education of China allocated funds for only for 25% all modules and electronics for them. We have to postpone the production of other 50% of Ecal modules to Stage II.
The positive news is that China Universities received funds in August 2020.

Support Frame for detectors inside Solenoid

S.Sukhovarov

The structure of the Support Frame is made of carbon fiber which allows for deformation of less than 3 mm under the load with detectors (~80 T). The thickness of the walls is 2-4 mm.

Producer - The Central Research Institute for Special Machinery, Khotkovo, Moscow region is a leading Russian enterprise in design and production of structures on the basis of advanced polymer composite materials for rocket & space engineering, transport, power, petrochemical machinery and other industries.



- design is almost ready, we have to control the space for cabling
- the contract with the Company on the construction of the Support Frame is signed
- according to schedule the Frame will be transported to Dubna in April 2021
- Representatives of the Company will participate in the process of installation of Support Frame into MPD and its alignment

- **The rigs and tools for the installation of ECAl and TOF are still in the design stage.**

Summary

- Increased effort on the preparation of the MPD Physics Programme, with connection to detector readiness
- Definition of formal deadlines for MPD project milestones
- All components of the MPD 1st stage detector advanced in production, commissioning expected for 2021