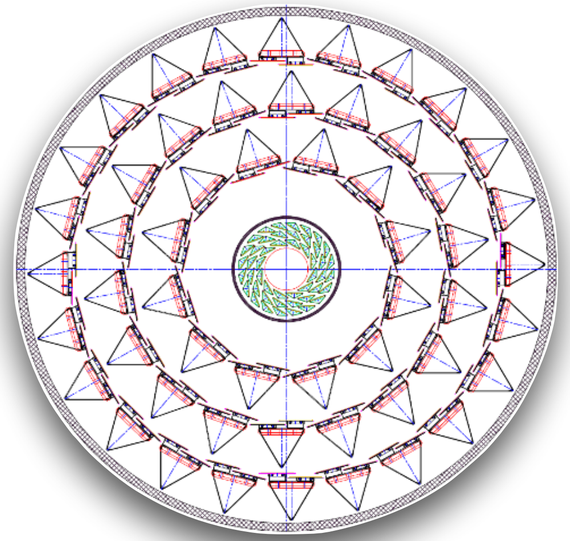
MPD-ITS Current Status.

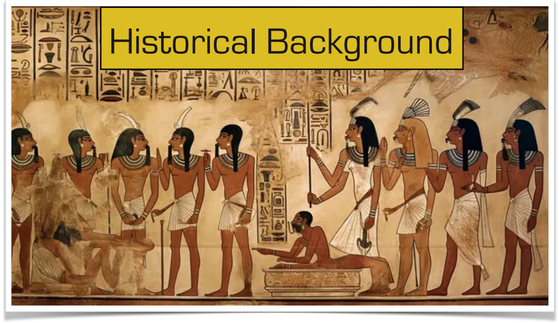
César Ceballos Sánchez (JINR) for the MPD-ITS Collaboration.



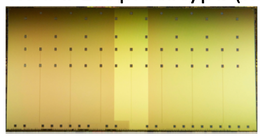
LXXIV International conference Nucleus-2024: Fundamental problems and applications

1–5 Jul 2024 Dubna, Russia

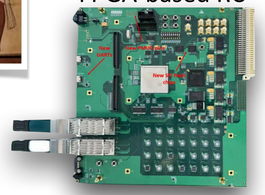
OUTLINE



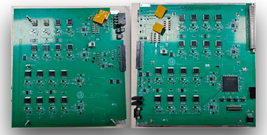
MAPS 1st prototype (financed by JINR)



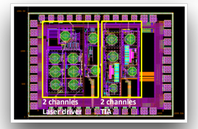
FPGA-based RU

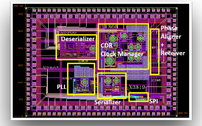


PB prototype



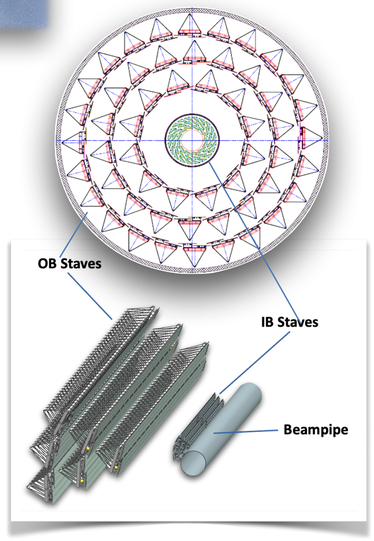
ASICs-based RU



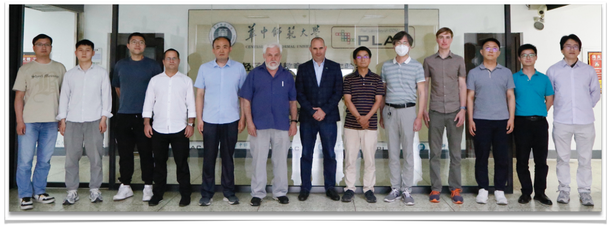


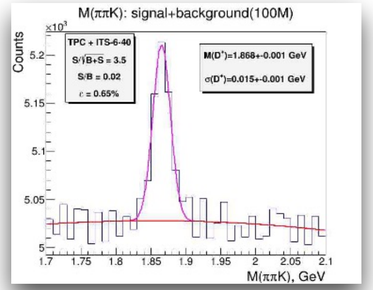
Site for Assembly and QA tests at CCNU

NICA's MPD-ITS project:



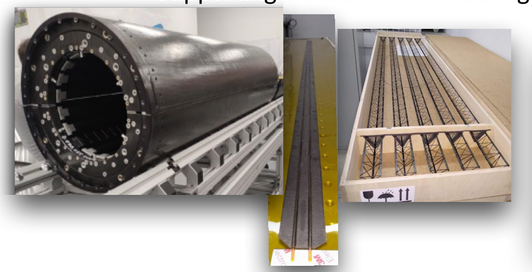
MPD-ITS International Collaboration

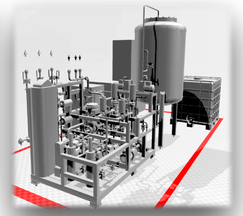




Computer simulations

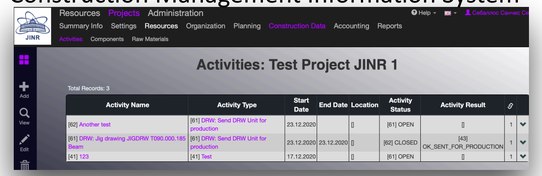
Supporting mechanics and cooling





Site for Assembly and QA tests at JINR

Construction Management Information System



"Monolithic Si-Pixel Detector for Collider Experiments and Other Applications"

	2024	2025	2026	2027	2028	2029
MICA R&D	R&D and testing			Preseries run		
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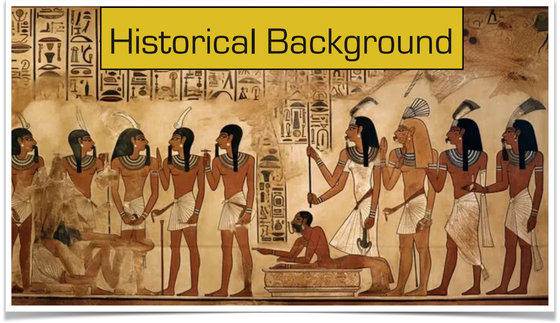
OUTLINE



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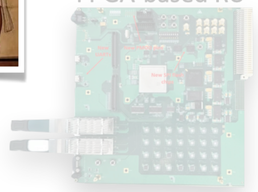
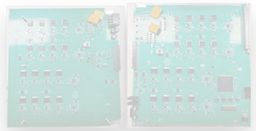
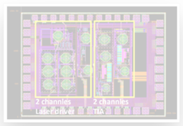
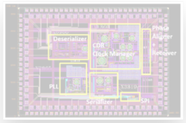


PB prototype



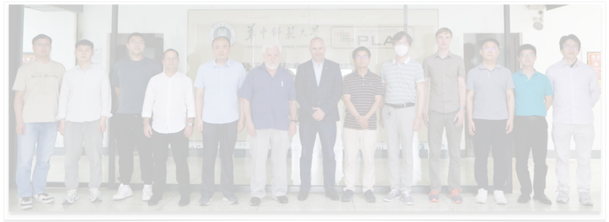
ASICs-based RU



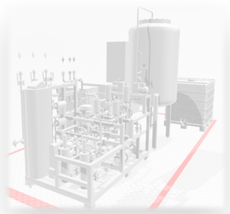


Site for Assembly and QA tests at CCNU

MPD-ITS International Collaboration

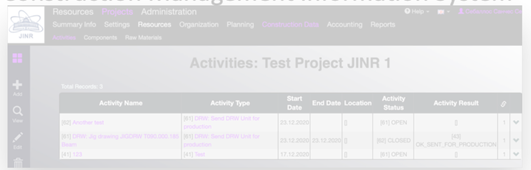


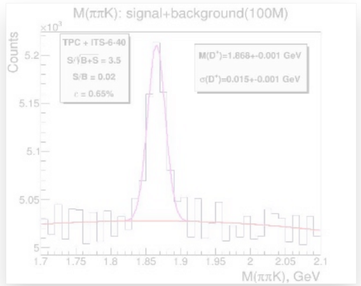
Supporting mechanics and cooling



Site for Assembly and QA tests at JINR

Construction Management Information System





Computer simulations

“Monolithic Si-Pixel Detector for Collider Experiments and Other Applications”

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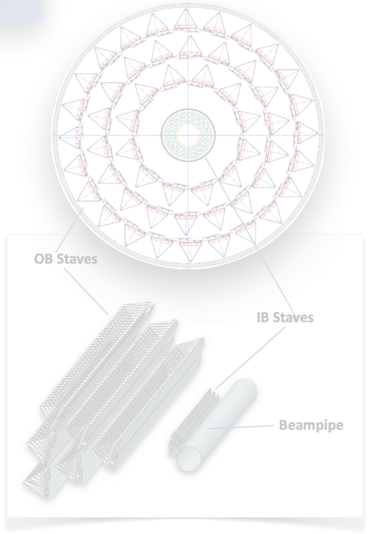
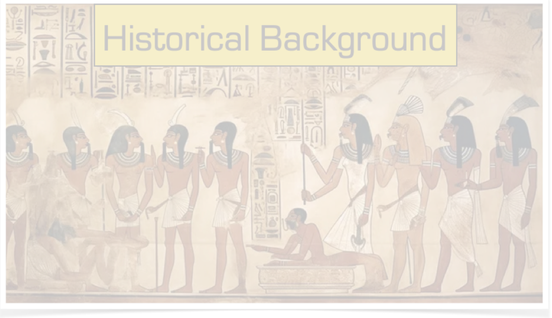
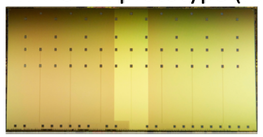


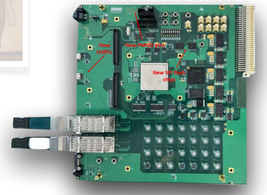
OUTLINE



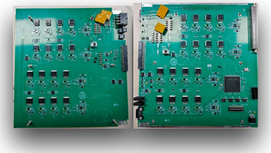
MAPS 1st prototype (financed by JINR)



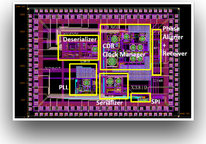
FPGA-based RU



PB prototype



ASICs-based RU



Site for Assembly and QA tests at CCNU

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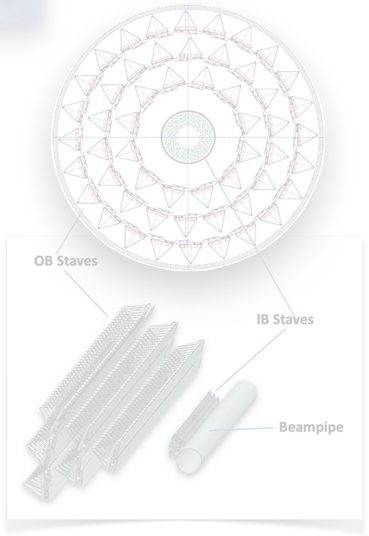
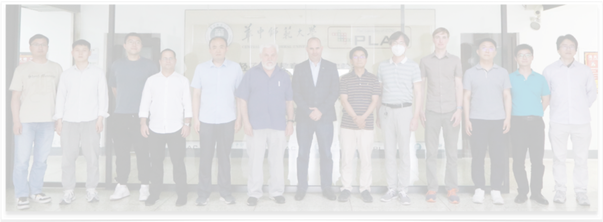
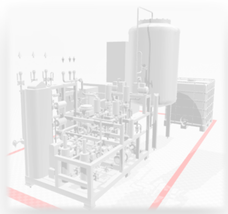


MPD-ITS International Collaboration

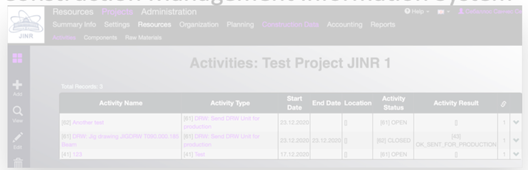


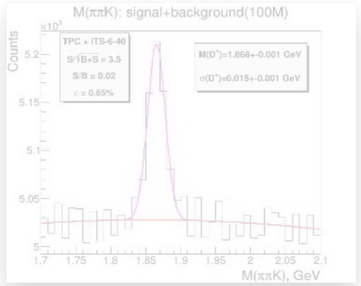
Supporting mechanics and cooling



Site for Assembly and QA tests at JINR

Construction Management Information System





Computer simulations

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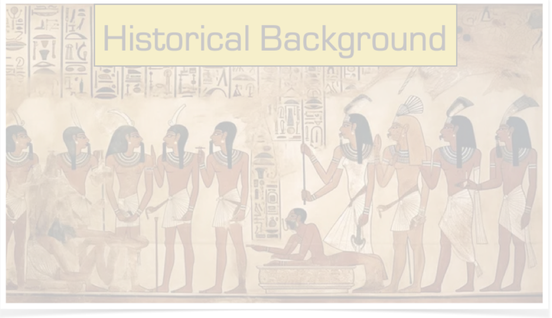

MAPS 1st prototype (financed by JINR)

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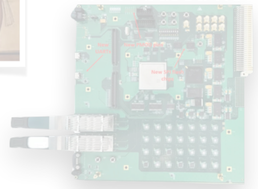
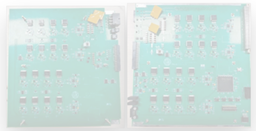
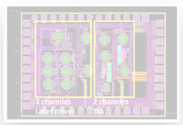
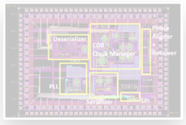


PB prototype



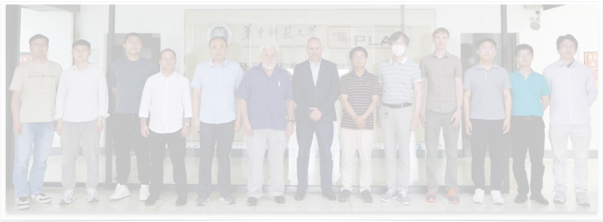
ASICs-based RU



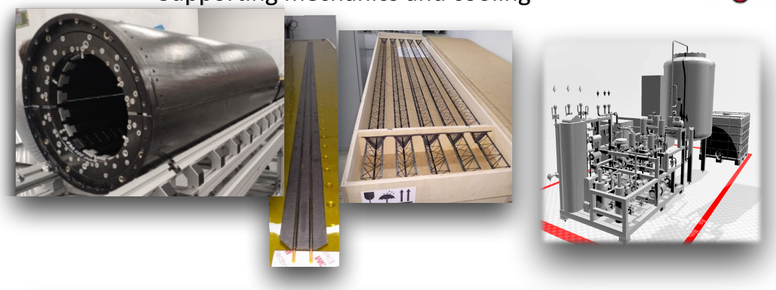


Site for Assembly and QA tests at CCNU

MPD-ITS International Collaboration

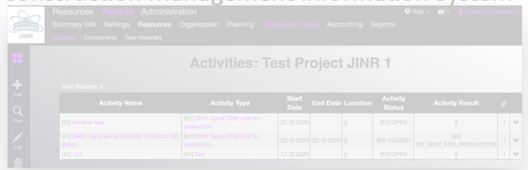


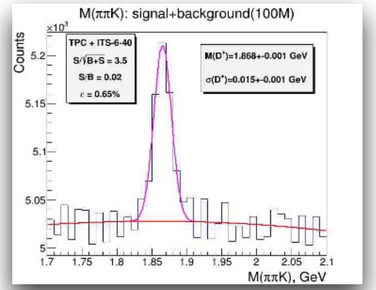
Supporting mechanics and cooling



Site for Assembly and QA tests at JINR

Construction Management Information System





Computer simulations

"Monolithic Si-Pixel Detector for Collider Experiments and Other Applications"

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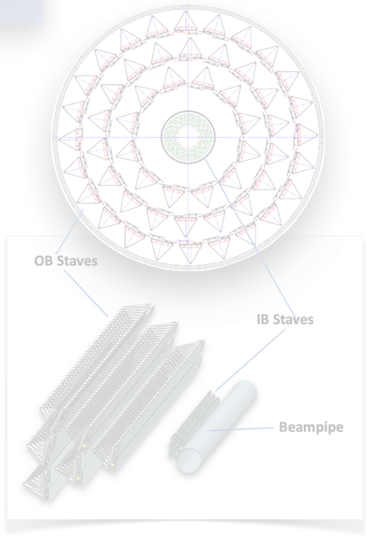

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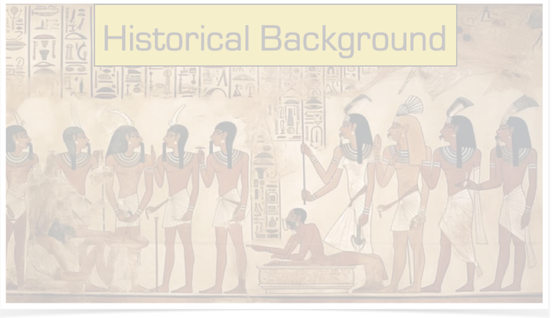

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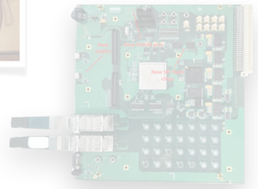
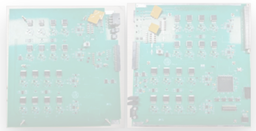
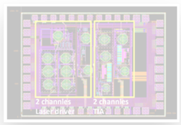
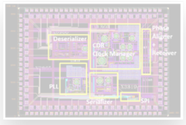


PB prototype



ASICs-based RU





Site for Assembly and QA tests at CCNU

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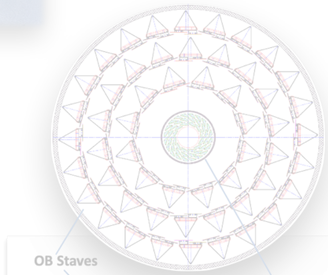
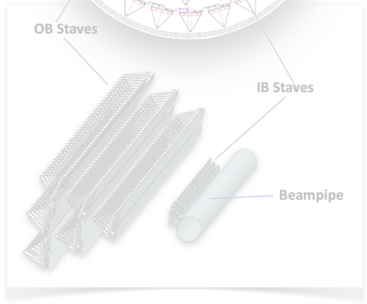
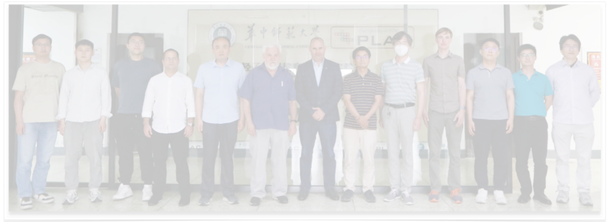




MPD-ITS International Collaboration



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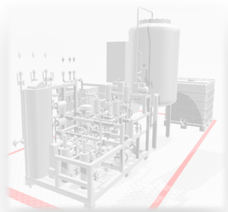

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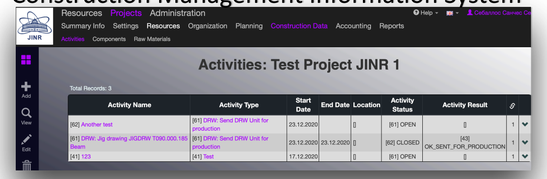
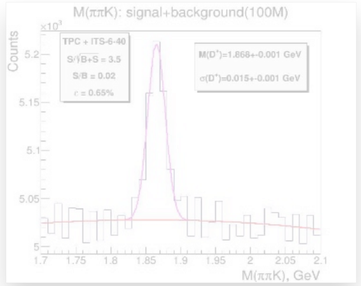
Construction Management Information System



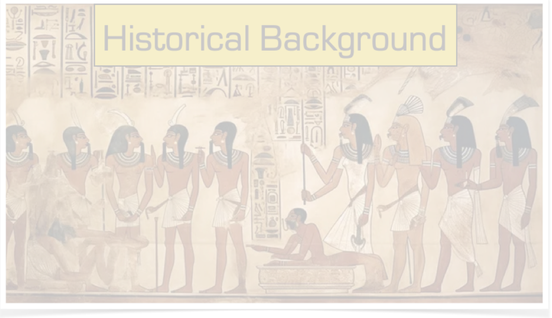


Computer simulations

"Monolithic Si-Pixel Detector for Collider Experiments and Other Applications"

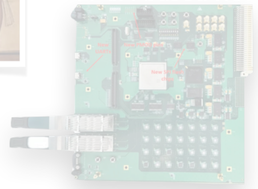
	2024	2025	2026	2027	2028	2029
MICA R&D	R&D and testing			Preseries run		
Readout	PU &FPGA version RU R&D complete		ASIC version RU R&D complete			
GBTx & ROC	R&D complete					
Assembly	R&D and Setup assembly line at CCNU and IMP		R&D, Assemble HICs/staves and testing at CCNU, IMP and JINR	Assembly 1/12 of the tracker including Readout	Assembly the full tracker (IB, OB) and test at the experimental site. Ready to take data in 2030	

OUTLINE

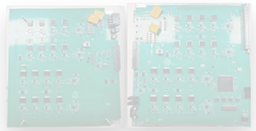


MAPS 1st prototype (financed by JINR)

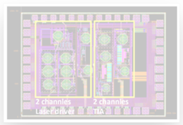
FPGA-based RU

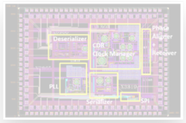


PB prototype



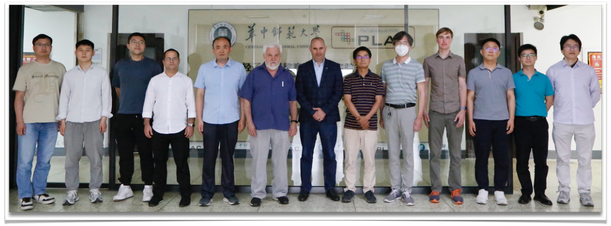
ASICs-based RU



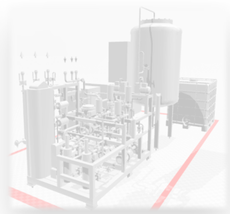


Site for Assembly and QA tests at CCNU

MPD-ITS International Collaboration

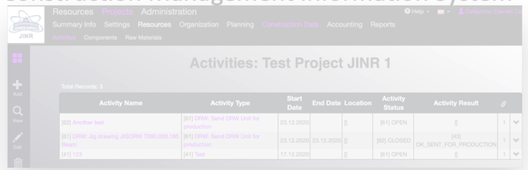


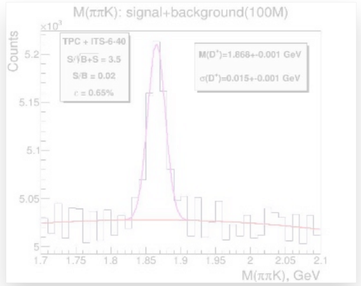
Supporting mechanics and cooling



Site for Assembly and QA tests at JINR

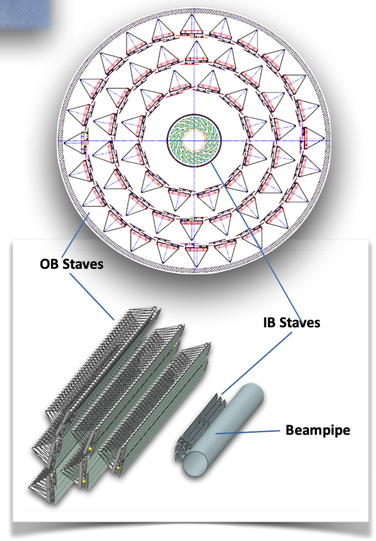
Construction Management Information System





Computer simulations

NICA's MPD-ITS project:



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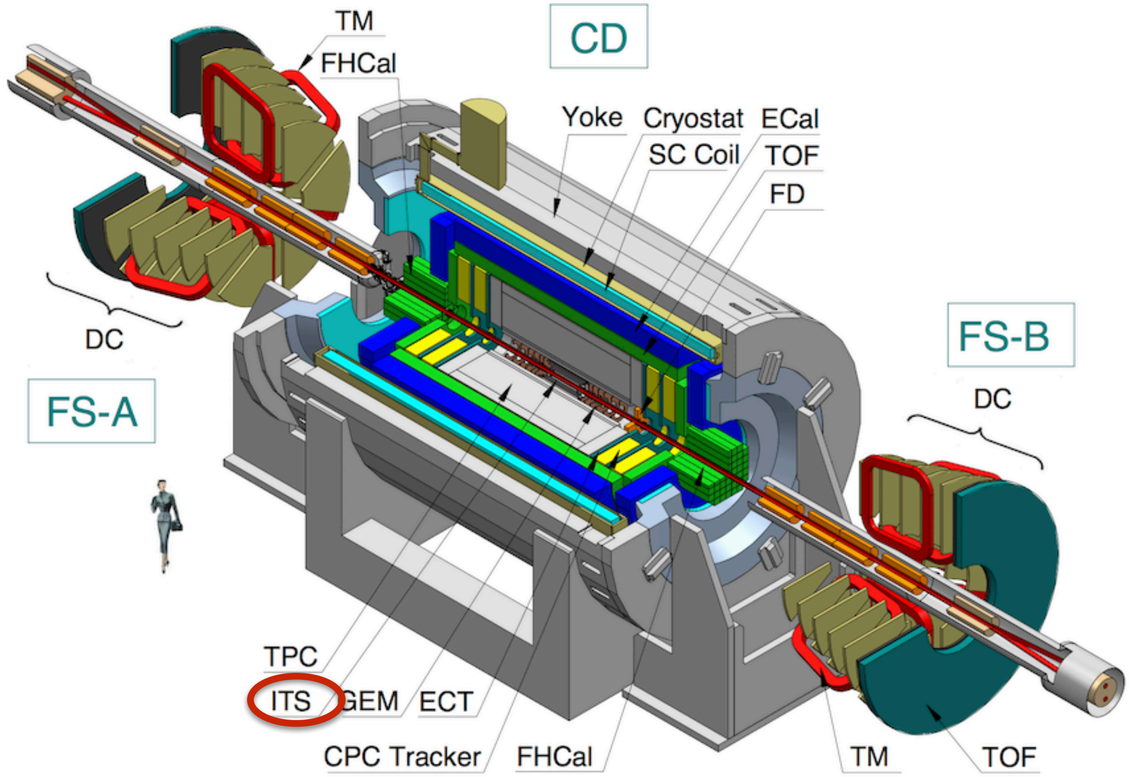
NICA's MPD-Inner Tracking System.

MPD-ITS structure: 3-layers Inner Barrel + 3-layers Outer Barrel.

It will supplement the TPC for the precise tracking, momentum determination and vertex reconstruction for **hyperons** (Λ, Ξ, Ω) and **D-mesons.**

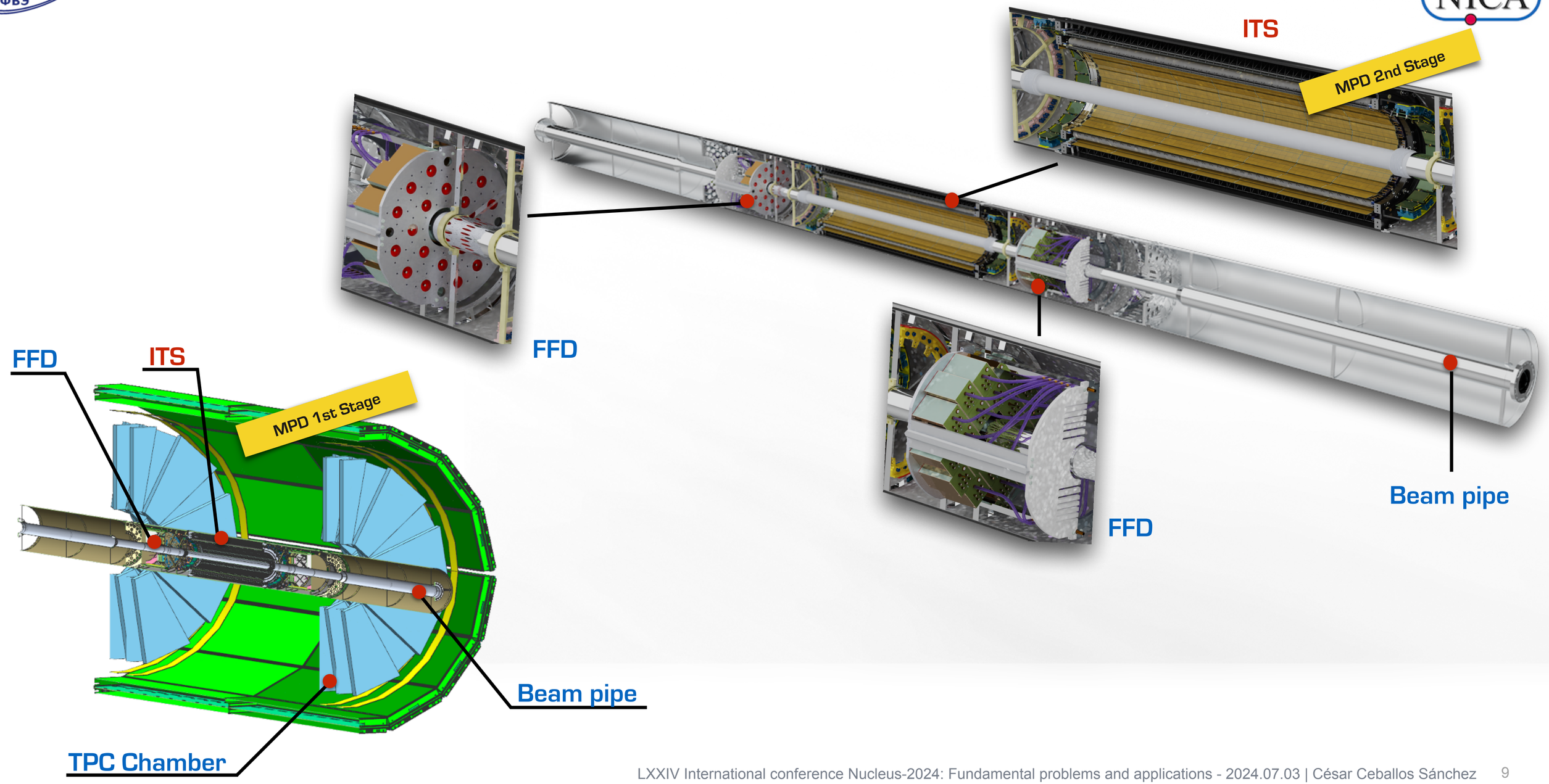


Some of the MPD-ITS requirements:

- **Fast, high granularity CMOS pixel sensors with low noise level.**
- **Spatial resolution of track coordinate registration at the level of ~5–10 μm.**
- **Material budget as low as possible.**

Yu. A. Murin and C. Ceballos, ***"The Inner Tracking System for the MPD Setup of the NICA Collider"***, Phys. Part. Nuclei 52, 742–751 (2021).

ITS and MPD Stages



Historical background - by 2021

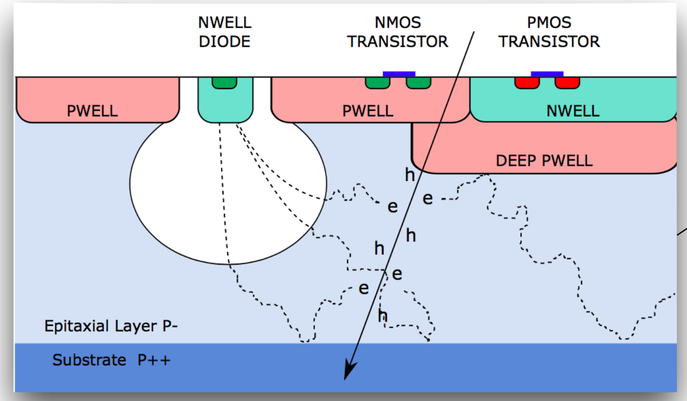
The MAPS chip - ALPIDE

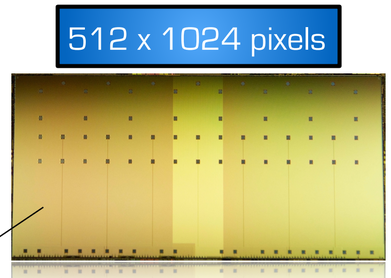
TowerJazz 0.18 µm CMOS pixel sensor

» High-resistivity (> 1kΩ cm) p-type epitaxial layer (20µm - 40µm thick) on p-type substrate.

» Small n-well diode (2-3 µm diameter), ~100 times smaller than pixel => low capacitance.

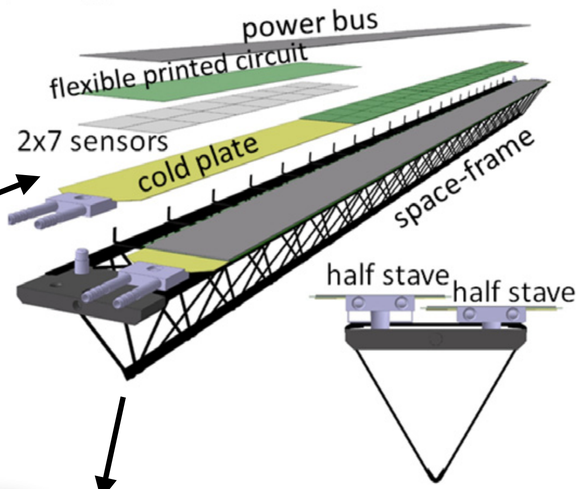
» Deep PWELL shields NWELL of PMOS transistors, allowing for full CMOS circuitry within active area.

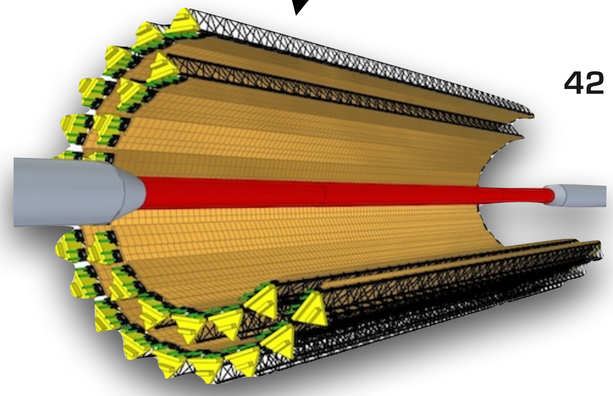




Sensor architecture

Size: 15mm x 30mm
Pixel pitch: 28µm x 28µm
Event time resolution: < 2µs
Power consumption: 39mW/cm^2
Dead area 1.1mm x 30mm





42 Staves

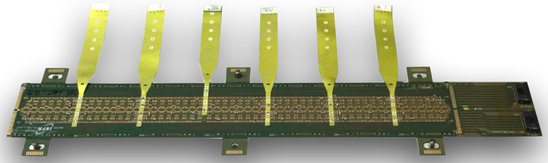
Historical background - by 2021

Full technological transfer from ALICE to MPD

- Complete Knowhow
- Detector assembly and testing hardware/software
- Supervision and support from ALICE specialists

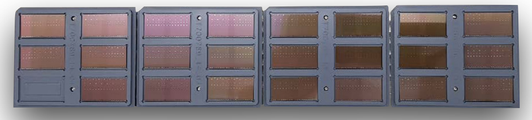
Setup at JINR of the full detector assembly line from chips to detector layers

FPC

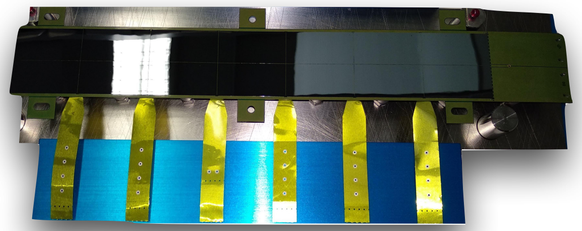


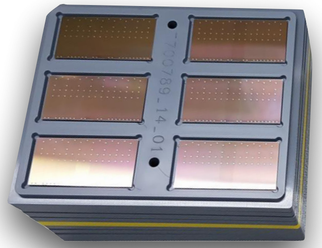
+

MAPS



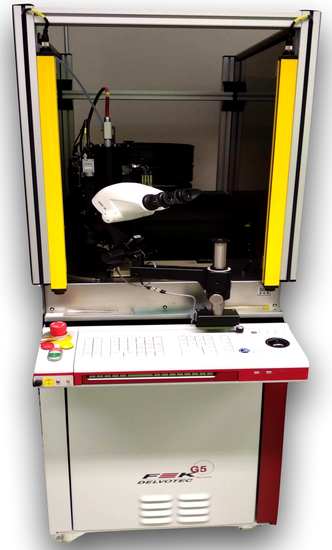
HIC



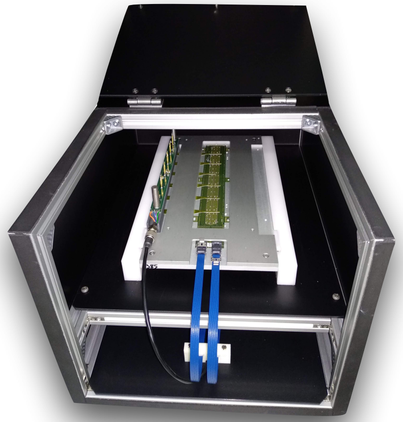


Chips selection

Chips alignment and gluing



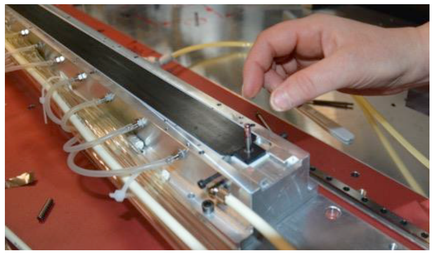
Ultrasonic bonding Chips - FPC



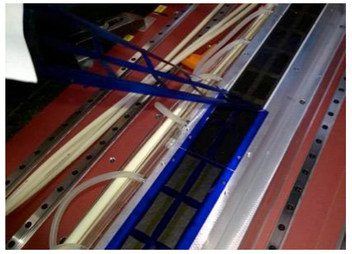
HIC testing

Historical background - by 2021

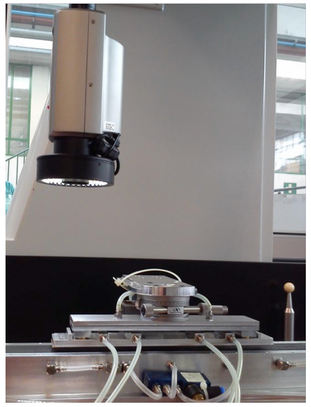
Full technological transfer from ALICE to MPD



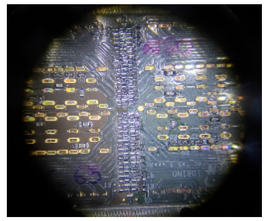
Cold Plate positioning



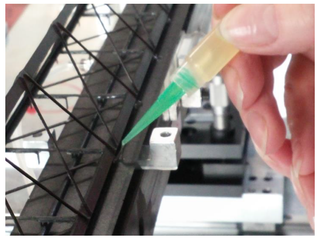
Glue deposition



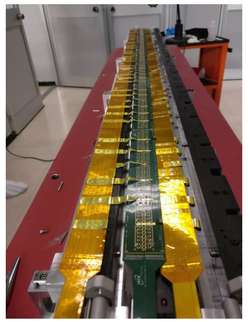
HIC positioning



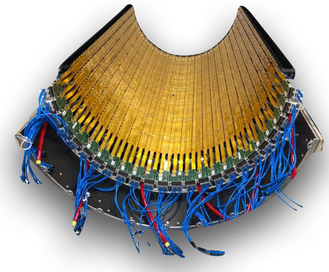
HIC to HIC interconnection



Space frame on CP



Power Bus position & folding



Historical background - by 2021

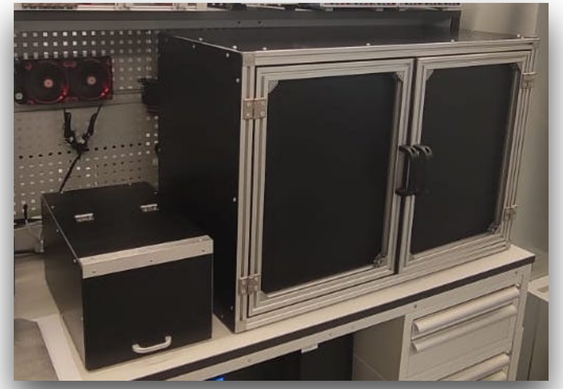
Full technological transfer from ALICE to MPD

Carrier Plates

HIC testing

Same technology as ALICE-ITS

Peel test station

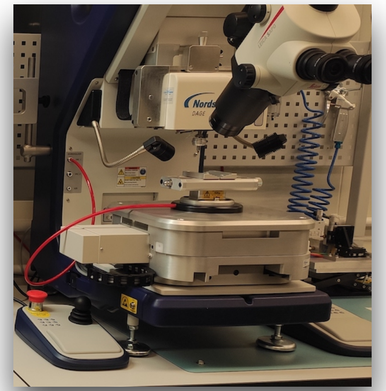


Qualification and Endurance test boxes

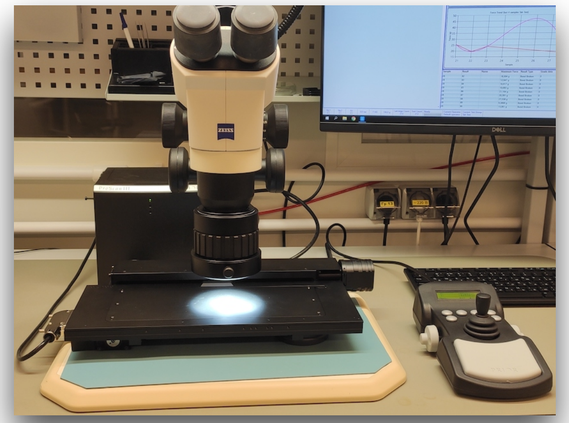
MOSAIC boards

Power boards

[*] Power Boards BoB to be produced



Pull test station



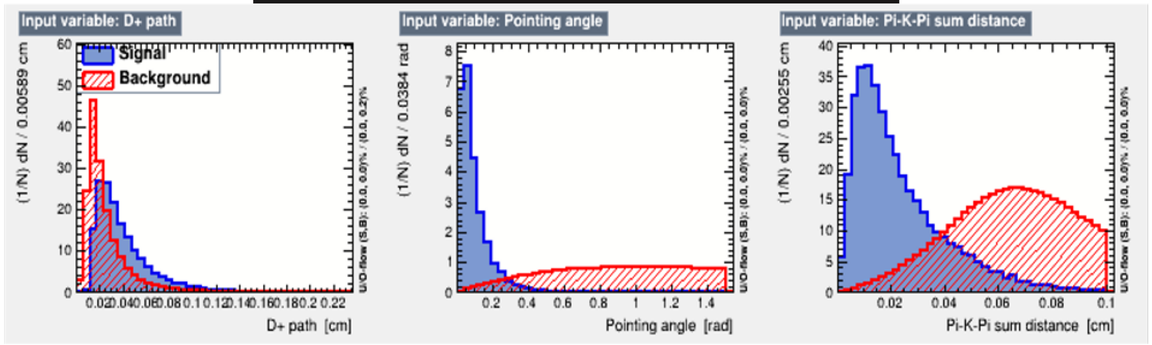
Visual inspection Station

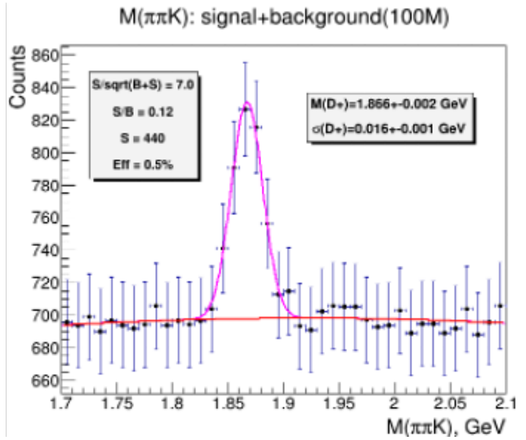
Historical background - by 2021

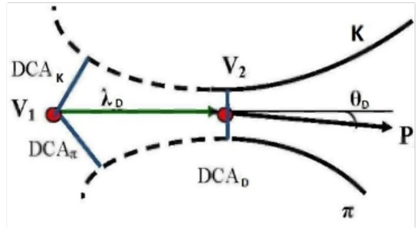
Simulations

D^+ and D^0 reconstruction using KF

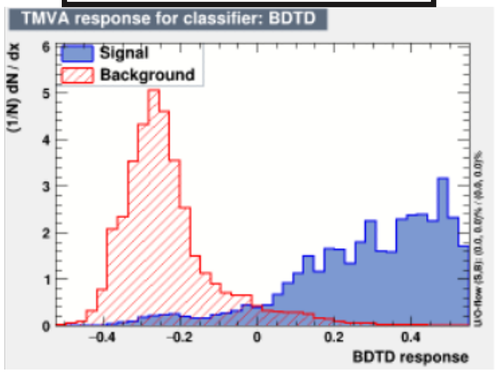
TC: dca(π), dca(K), dca(πK), λ(D), θ(D) cuts

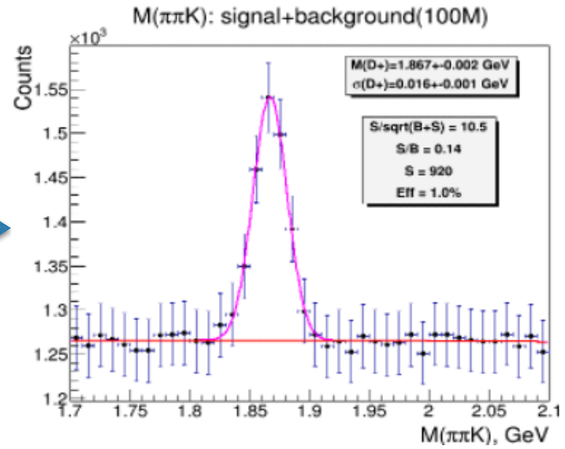






MVA: BDT classifier cuts





Particle	D^0	D^+
Method	MVA	MVA
Efficiency, %	0.85	1.0
Significance	5.5	10.5
S/B(2σ) ratio	0.10	0.14

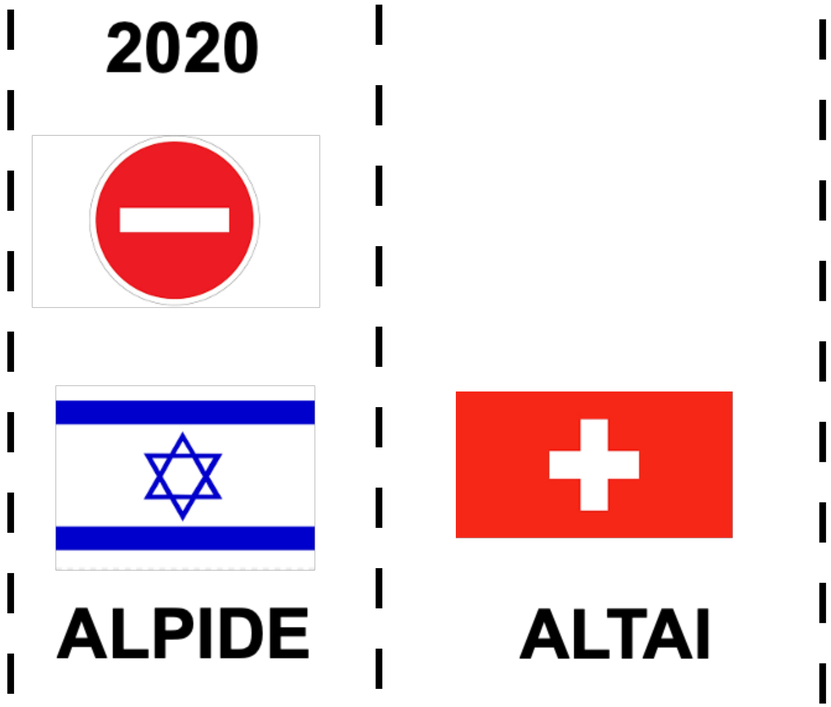
Using the topological cuts allows to reconstruct D^0 and D^+ decays with an efficiency of 0.8% and 0.5% respectively. Using the optimal BDT cut allows to reconstruct D^0 and D^+ with an efficiency of 0.85% and 1.0% respectively.

V. Kondratiev, C. Ceballos, S. Igolkin, A. Kolozhvari, Y. Murin, A. Sheremetiev, ***"Detection of D+-meson decays in the tracking system of NICA-MPD"***, Acta Physica Polonica B, 14 (3), 2021.

The MAPS case

By 2021we had been fighting for a year for receiving the already paid ALPIDE MAPS (~ 1.8 MCHF).

CERN agreed to create a non radiation-hard version: the ALTAI.



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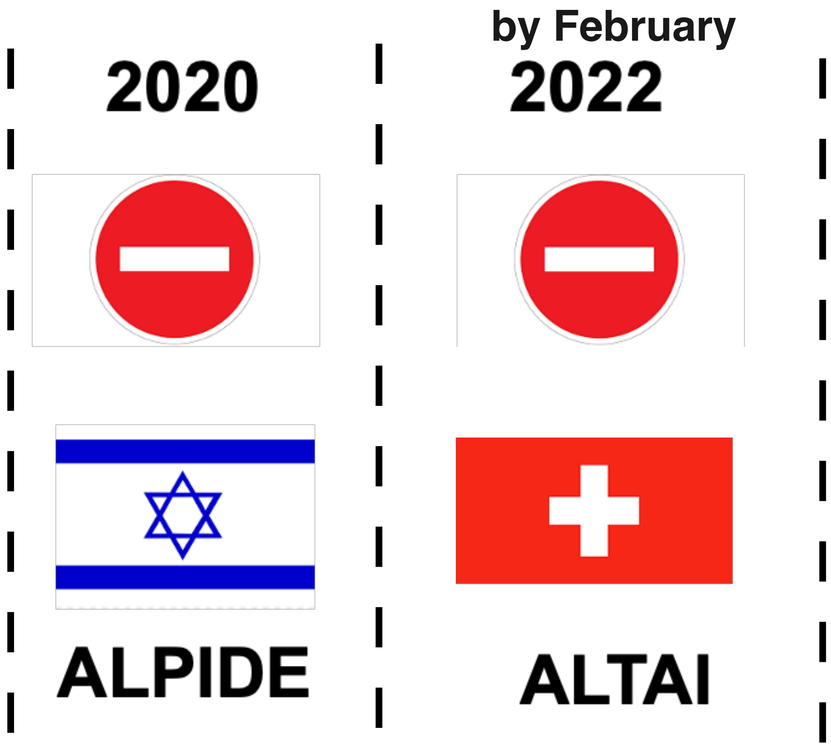

We fought for another year trying to get the ALTAI chips...and failed

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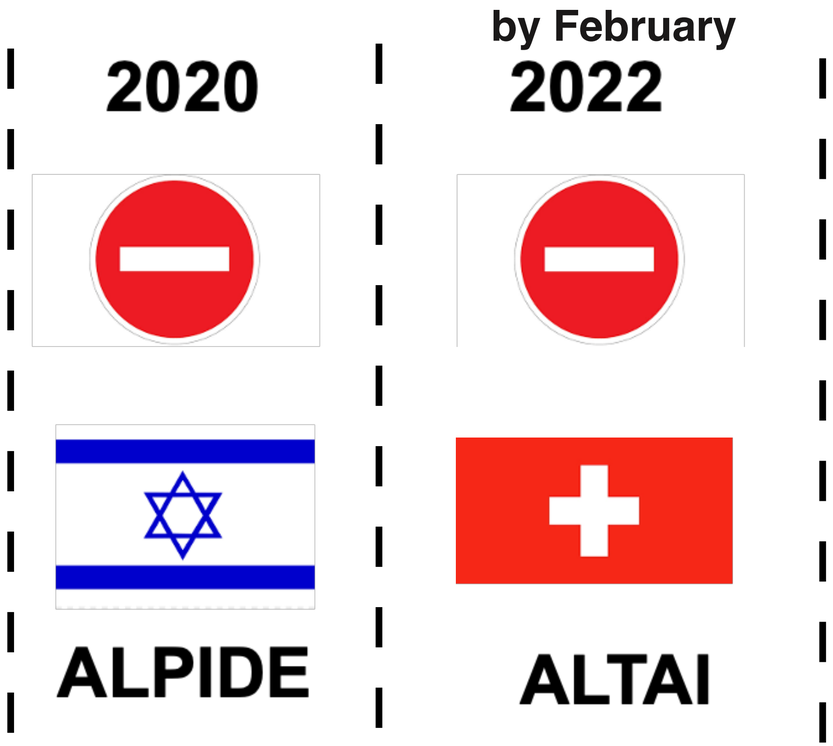


We fought for another year trying to get the ALTAI chips…and failed

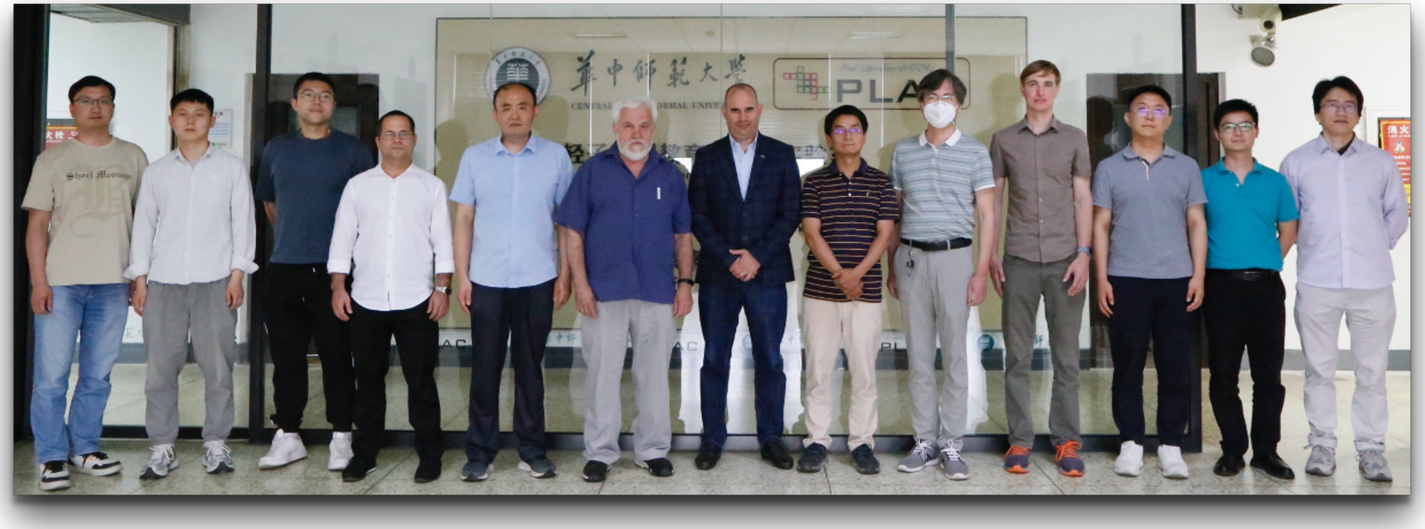
Highly prioritised tasks:

- Strengthen the international cooperation (Specially with China).
- Solve the microelectronic limitations (due to sanctions).
- Finish the mechanics in time for the commissioning of MPD.

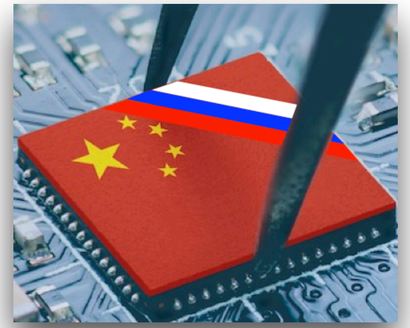
Historical background

The long-term sustainable proposal

NICA-MPD/ITS Seminar on China-Russia Cooperation, Wuhan, 2023.06.15-16



2023



MICA

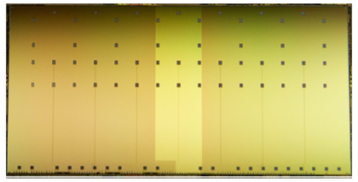
Participants: JINR, CCNU, USTC, IHEP and IMP.

It was agreed: A joint development and construction of Monolithic Active Pixel Sensors **(MAPS)** for fundamental and applied science experiments **including front-end electronics** to make this technology **freely accessible** to China and Russia.

Yu. A. Murin, C. Ceballos Sanchez for the MPD-ITS Collaboration, ***"Modern Microelectronics for MPD-ITS. Monolithic Active Pixel Sensors and Readout System"***, accepted for publication in the 4th issue of Phys. Part. and Nucl. in 2024

Electronics

Monolithic Active Pixel Sensors



MICA

- Domestic process (in China)
- Pixel Size: 27x31um^2
- Pixel Array: 512x980
- Front-end peaking time: < 2us
- Pulse discrimination time: 5-10 us
- ENC < 10e-
- Power consumption < 40mW/cm^2

12 wafers (~ 500 chips) of MICA MAPS first prototype already ordered !

The tape-out of the MICA chip prototype sent to the foundry at the end of February. Chips will be ready by July 2024.

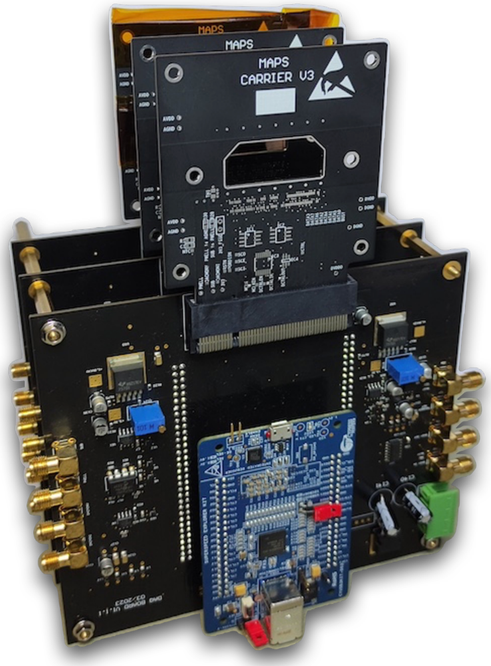
The the first batch of 300 chips to be received at JINR by the end of 2024.

The current status of the project

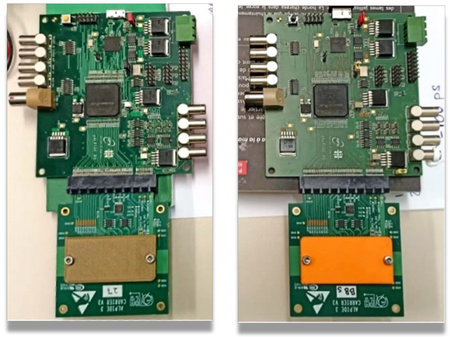
Preparation for sensor bench & beam test

Electronics

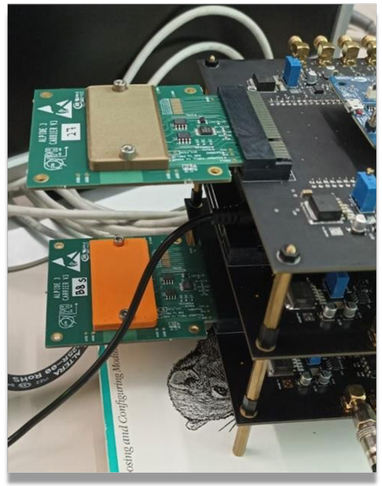
CERN-Equivalent DAQ boards and MAPS carrier-plates
Made in JINR



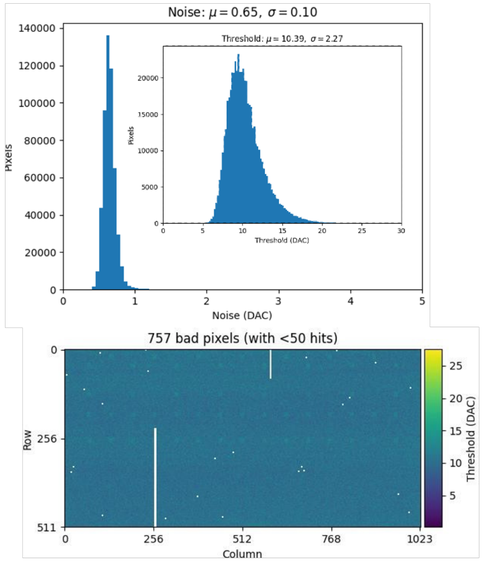
DAQ boards and MAPS carrier-plates
Made in CERN



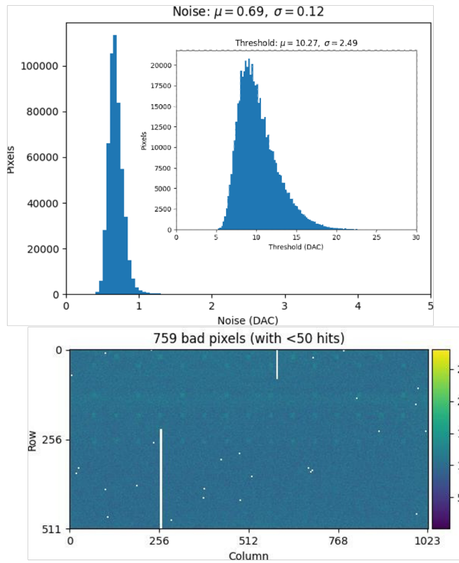
JINR-made DAQ boards test setup at CERN



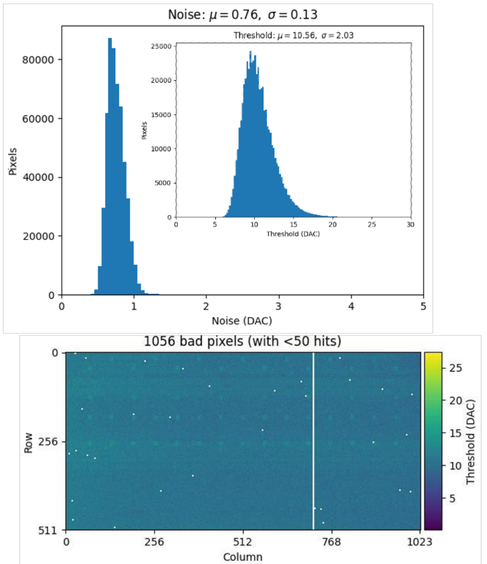
JINR DAQ



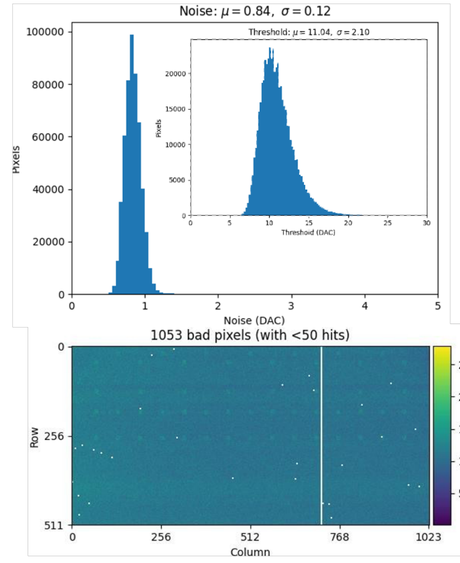
CERN DAQ



JINR DAQ



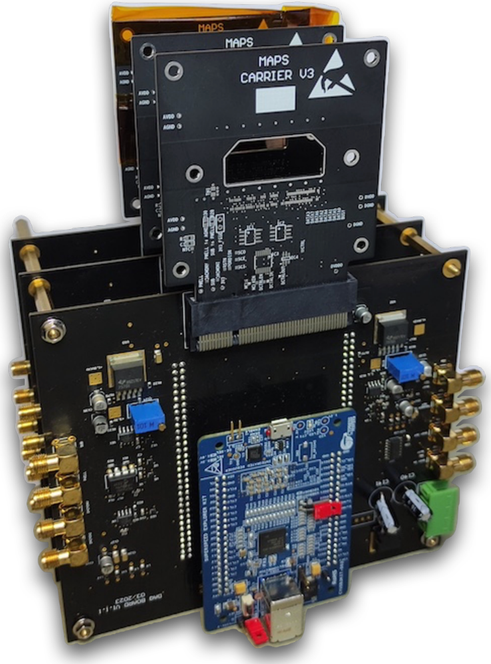
CERN DAQ



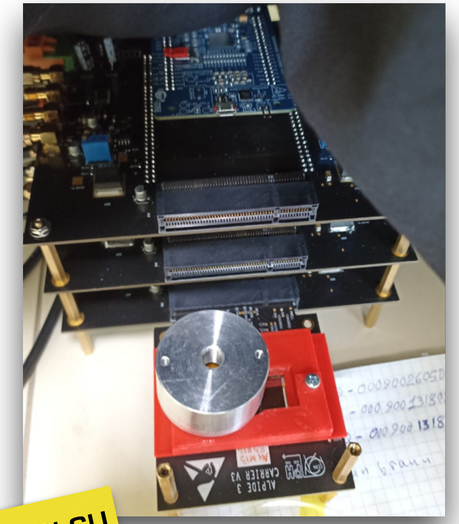
The current status of the project

Preparation for sensor bench & beam test

CERN-Equivalent DAQ boards and MAPS carrier-plates
Made in JINR

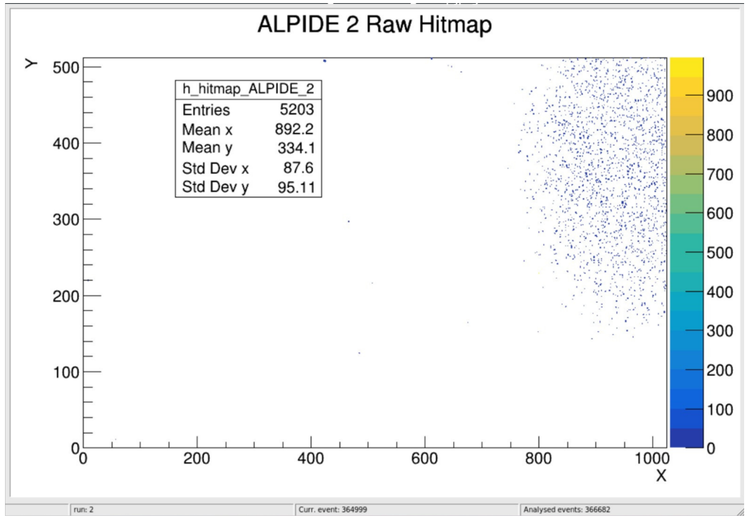


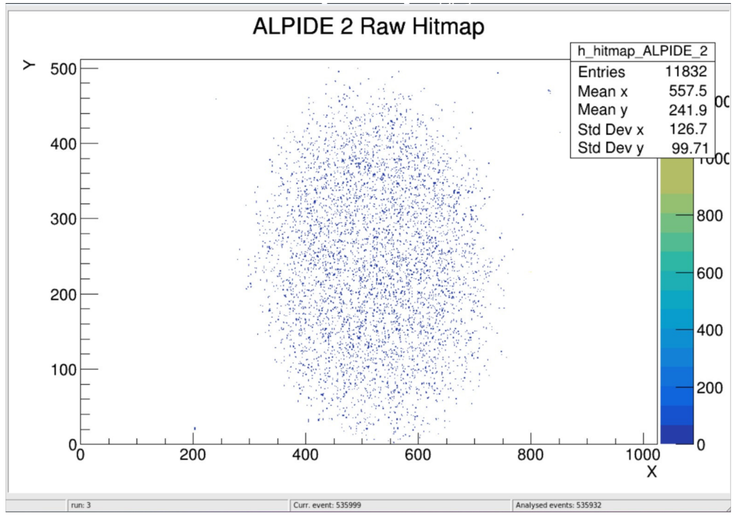
Electronics



MAPS courtesy of SPbSU

^{55}Fe source with Aluminum collimator

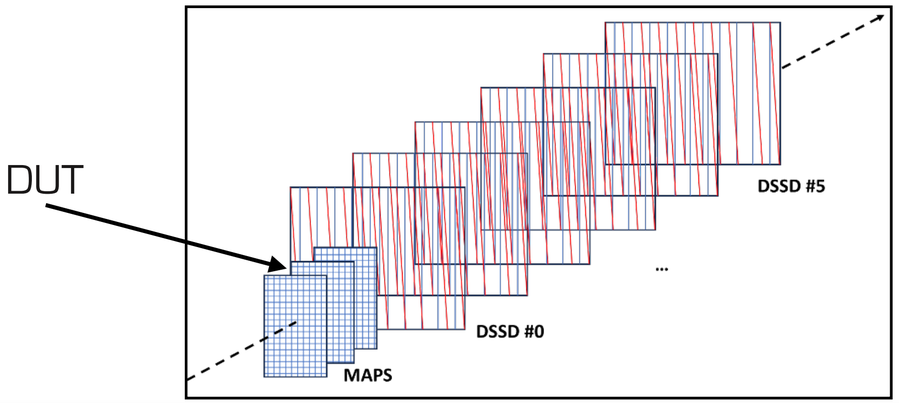


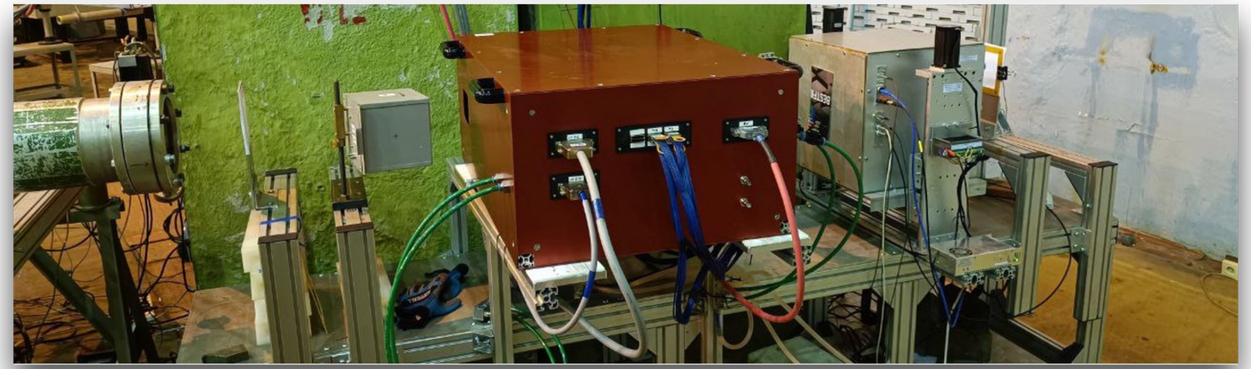


The current status of the project

Preparation for sensor bench & beam test

Tests with 1 GeV proton beam

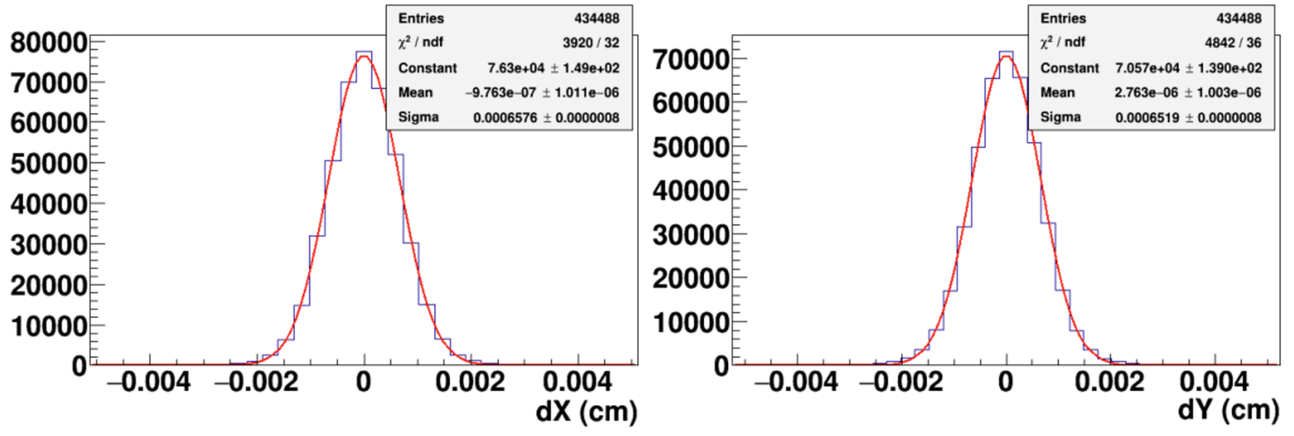




MAPS courtesy of SPbSU

Electronics

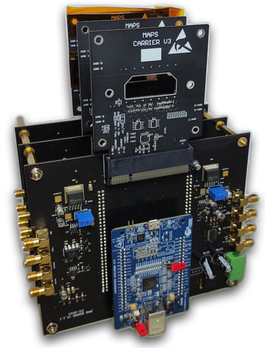
Residuals



Residual X/Y = 6.58 um / 6.52 um;

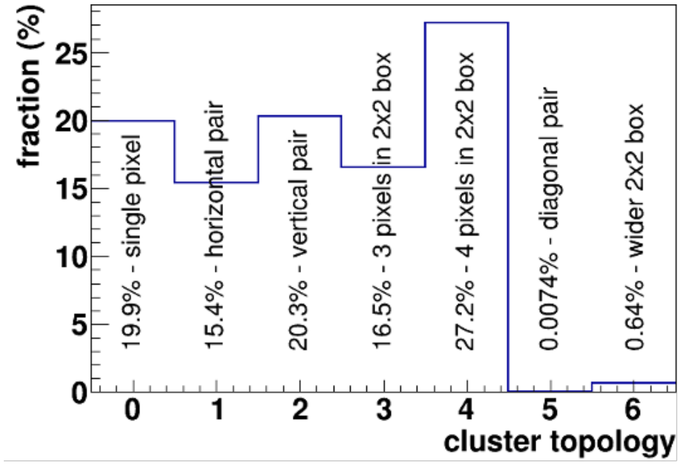
Spatial resolution X/Y = 4.1±0.4 um /4.06 ± 0.4 um;

Efficiency > 99 %

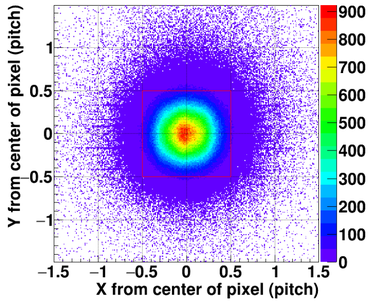


The current status of the project

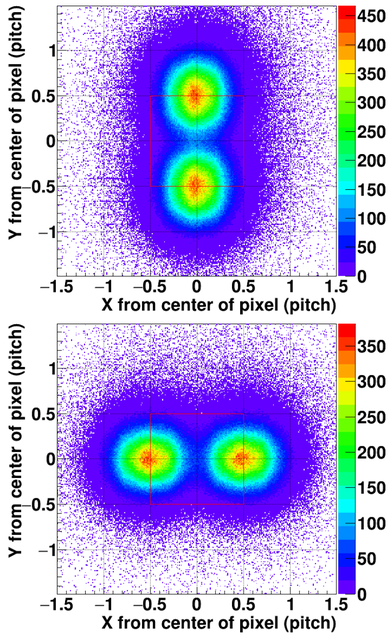
Electronics



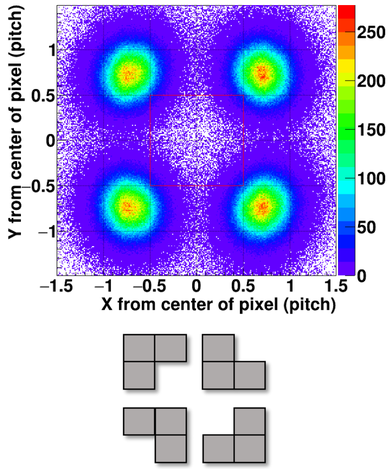
Cluster Topology



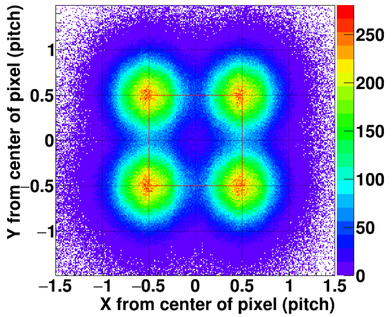
1-Pixel Clusters



2-Pixel Clusters



3-Pixel Clusters



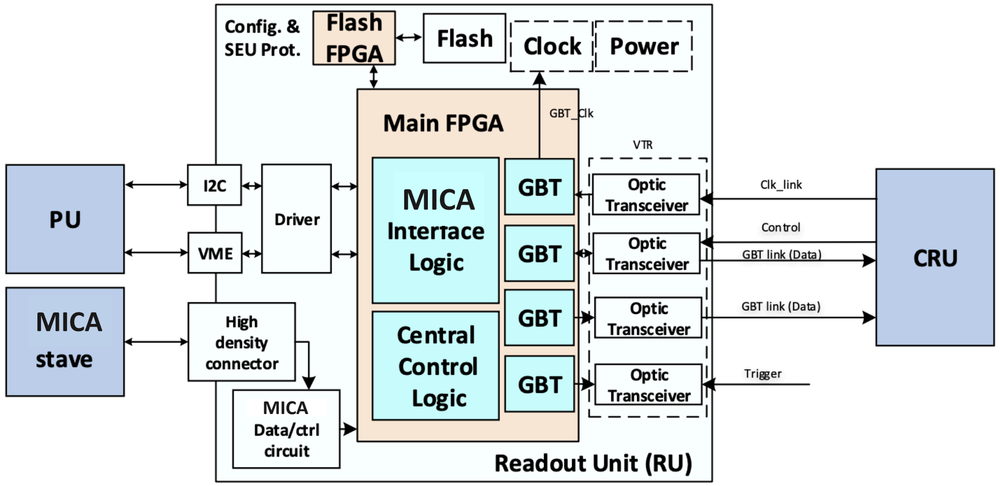
4-Pixel Clusters

The current status of the project

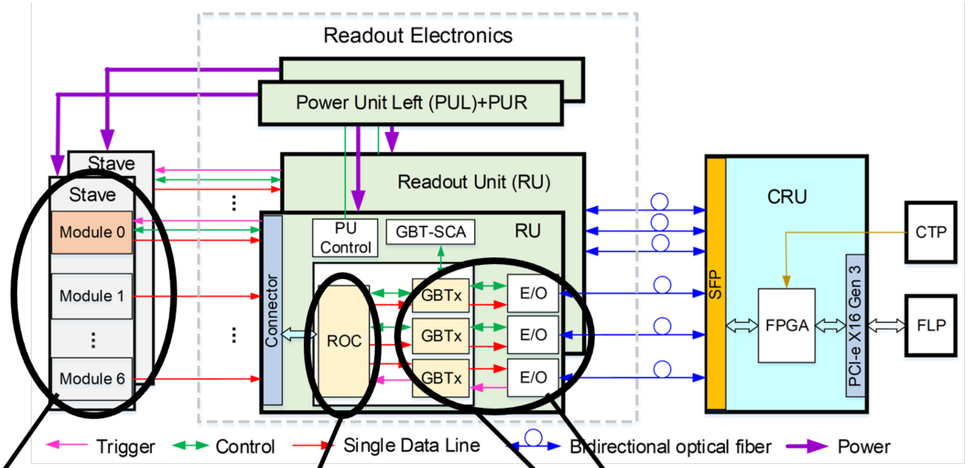
Readout and PU

Electronics

FPGA-based



ASIC-based



Monolithic Active Pixel Sensor (MAPS)

NICA_ROC:
Data collection and control distribution ASIC

NICA_GBT family (3 chips + optical module)
NICA_ LD : Laser Driver ASIC
NICA_TIA : Transimpedance Amplifier ASIC(Receiver)
NICA_GBTx: Bi-directional data interface ASIC
Note: NICA_LD and NICA_TIA are inside the optical module

Transfer data and control signals from/to MICA staves

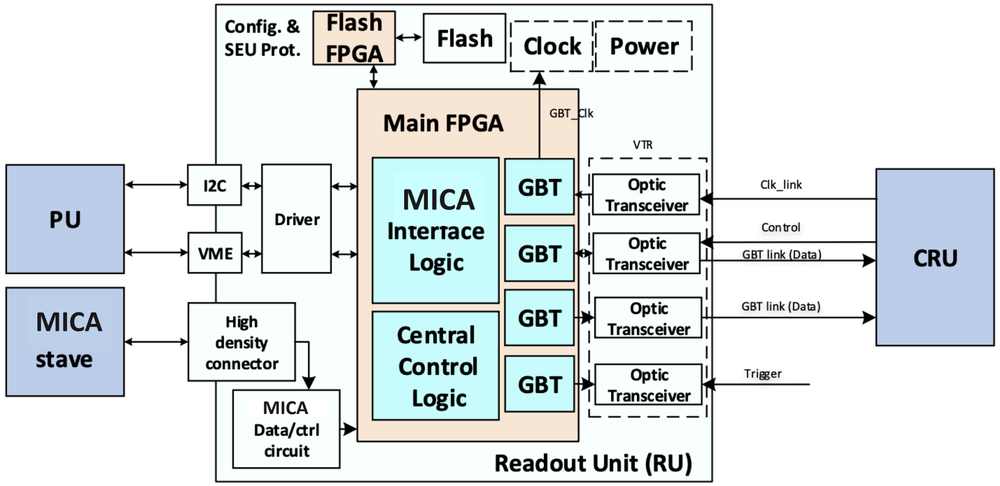
- FPGA implemented GBT protocol
- Protection from SEU based on logic scrubbing, with a flash based FPGA
- Power supply from VME backplane
- I2C interface is reserved on the front panel as an alternative path to communicate with PU

The current status of the project

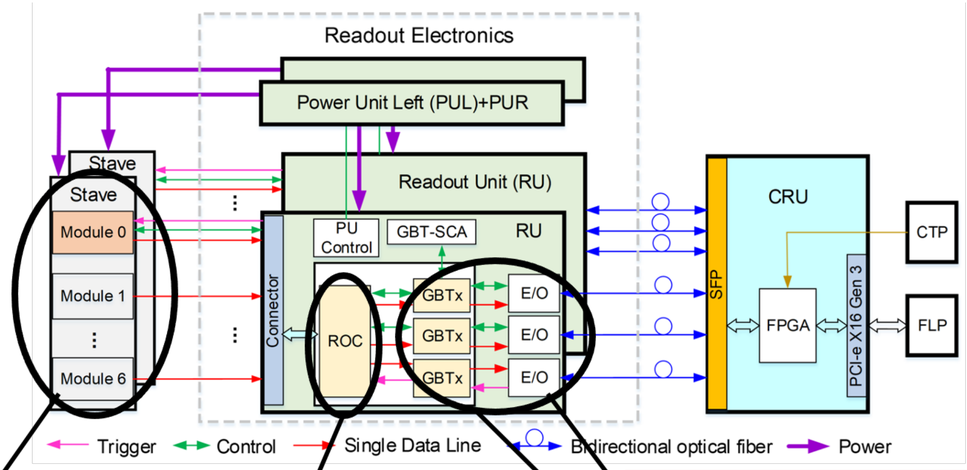
Readout and PU

Electronics

FPGA-based



ASIC-based



Monolithic Active Pixel Sensor (MAPS)

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Q. Chen, D. Guo, C. Zhao, R. Arteche, C. Ceballos, N. Fang, Y. Gan, Z. Guo, Y. Murin, X. Sun, and L. Yi for the MPD ITS collaboration, “LDLA14: a 14 Gbps optical transceiver ASIC in 55 nm for NICA multi purpose detector project”, JINST, 17, C01027, 2022

Q. Chen, D. Guo, C. Zhao, Z. Guo, R. Arteche, C. Ceballos, Y. Murin, L. Yi and X. Sun for the MPD ITS collaboration "*A 13 Gbps 1:16 deserializer ASIC for NICA multi purpose detector project*", JINST, 17 C08027, 2022

C. Zhao, Q. Chen, Z. Guo, R. Arteche, C. Ceballos, N. Fang, Y. Gan, Y. Murin, L. Yi, D. Guo and X. Sun for the MPD ITS collaboration, *“A 14 Gbps VCSEL driving ASIC in 55 nm for NICA multi purpose detector project”,* JINST, 17 C08021, 2022

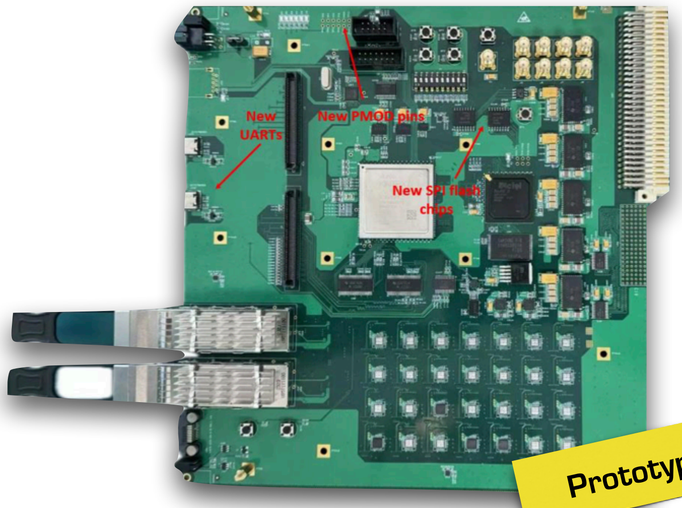
C. Zhao, D. Guo, Q. Chen, Z. Guo, R. Arteche, C. Ceballos, N. Fang, Y. Gan, Y. Murin, L. Yi and X. Sun for the MPD ITS collaboration, "A low noise 5.12 GHz PLL ASIC in 55 nm for NICA multi purpose detector project", JINST, 17 C09003, 2022

The current status of the project

Readout and PU

Electronics

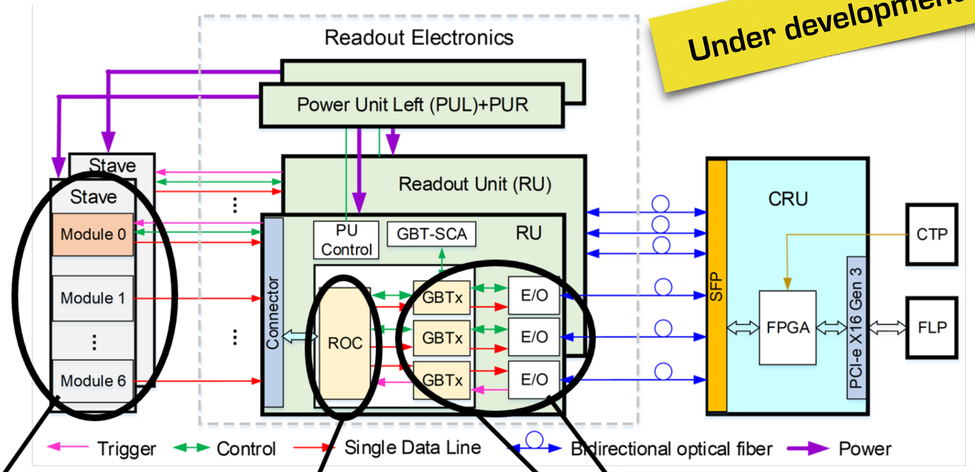
FPGA-based



Prototype Ready

ASIC-based

Under development

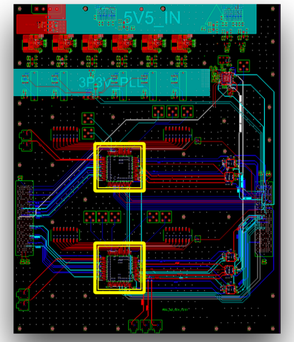


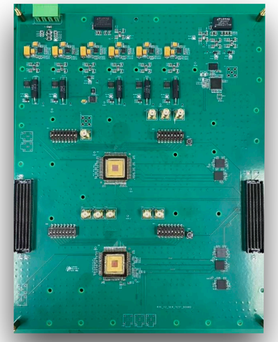
Monolithic Active Pixel Sensor (MAPS)

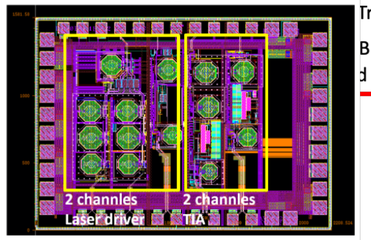
NICA_ROC:
Data collection and control distribution ASIC

NICA_GBT family (3 chips + optical module)
NICA_ LD : Laser Driver ASIC

NICA ROC V2: Finished PCB fabrication and soldering

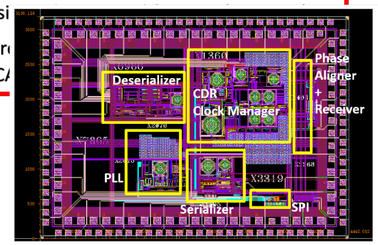






NICA_LD_v2 and NICA_TIA_v2

- NICA_LD and NICA_TIA designs are combined into one chip for further test and verification.
- Die size: 1400 * 2000 µm



NICA_GBTx_v2 layout

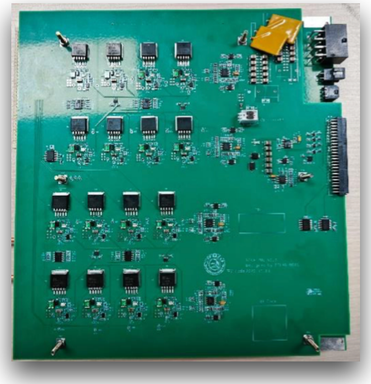
- Includes complete analog sub-modules
- Total pins: 166
- Chip size: 2880 x 4000 µm (Bare die)
- Dual-row wire-bonding pads used in this version for test

- R&D of ROC and GBT chipset prototype ASICs is ongoing.
- Finalisation of the engineering version ROC ASIC and GBT chipset ASICs is expected to be done by the end of 2026.
- Finalisation of the RU based on self-designed ASICs is expected to be done by July of 2027.

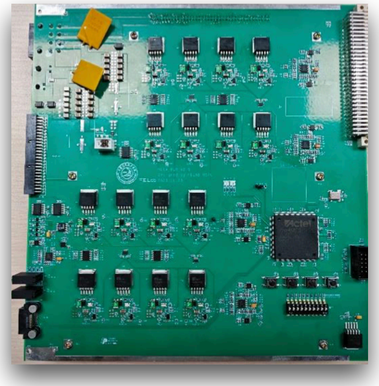
The current status of the project

Power Unit

PUL



PUR

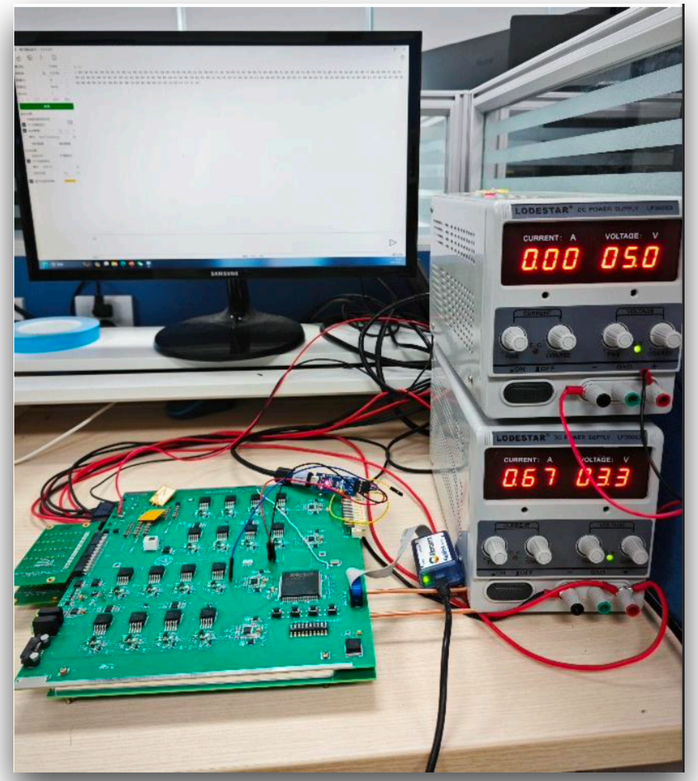


Cooling plate

Electronics

All functions of the PB have been tested successfully

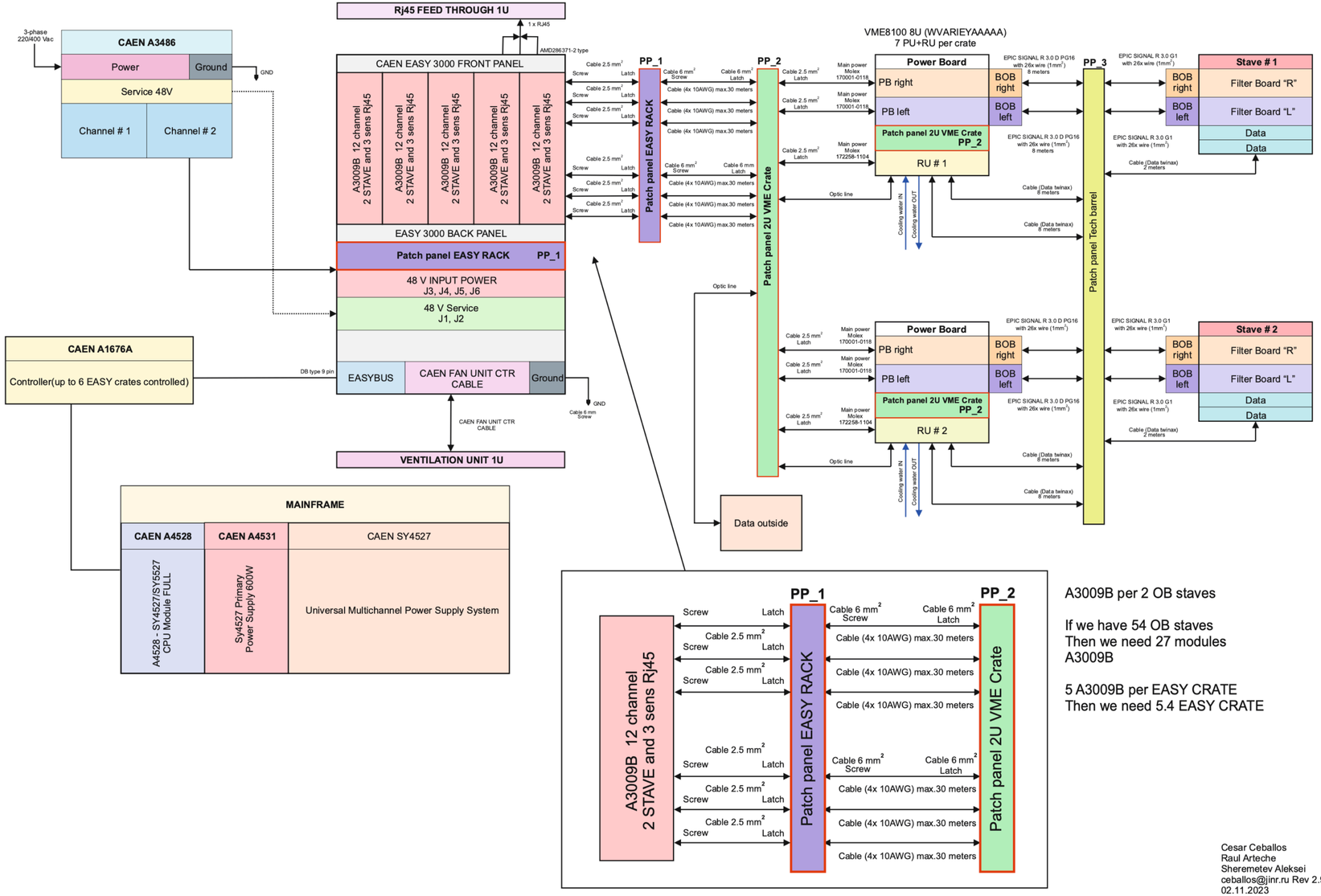
- Monitoring of voltages and currents
- Monitoring of temperature
- Adjustment of output voltages
- Communication with RU
- Monitoring of voltage and current of Bias output
- Adjustment of Bias output voltage



The current status of the project

Cabling

Electronics



Cesar Ceballos
Raul Arteche
Sheremetev Aleksei
ceballos@jinr.ru Rev 2.9
02.11.2023

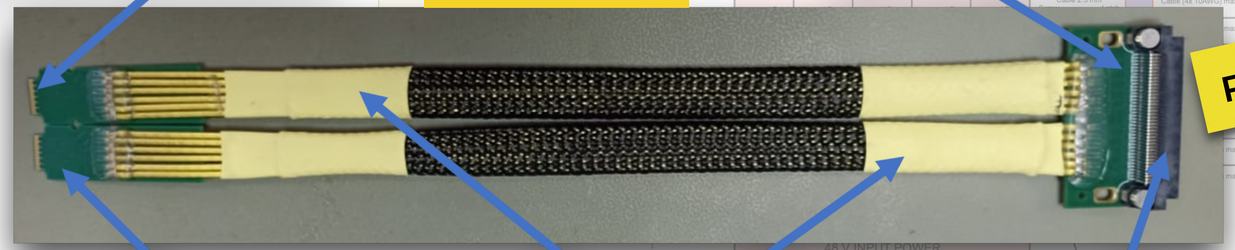
The current status of the project

Cabling

S-PCB-MOLEX-10006800107

Data Cable

ERF8-MOLEX-10006800107-V1-1



S-PCB-MOLEX-10006800107

Cables MOLEX-10006800107

ERF8-040-01-S-D-RA-L

Electronics

Ready for serial production

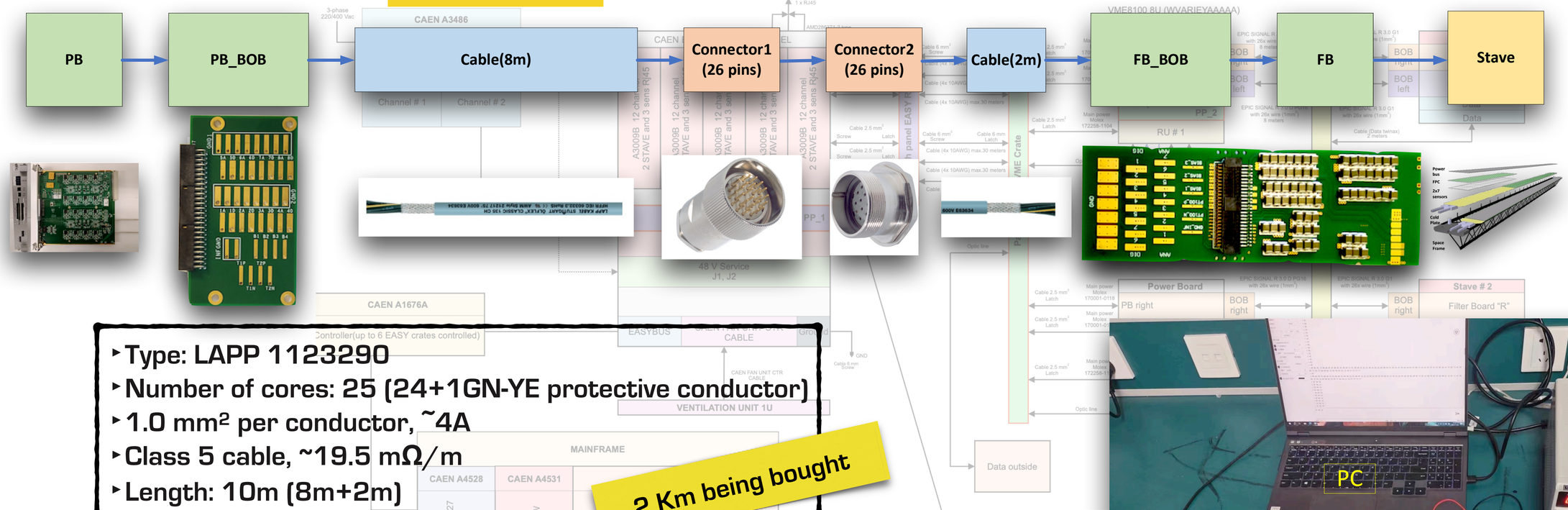
Test station

The current status of the project

Cabling

Power Cable

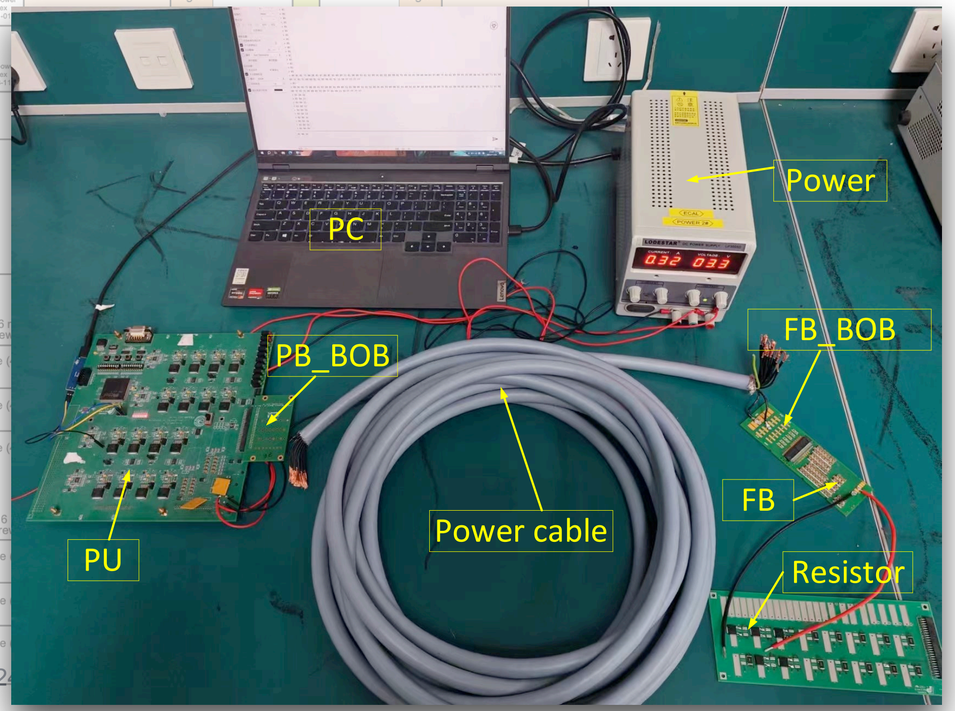
Electronics



- Type: LAPP 1123290
- Number of cores: 25 (24+1GN-YE protective conductor)
- 1.0 mm² per conductor, ~4A
- Class 5 cable, ~19.5 mΩ/m
- Length: 10m (8m+2m)

2 Km being bought

Test station



Load resistance(Ω)	Voltage at PU(V)	Voltage at load(V)	Current(A)	Voltage drop(V)	Resistance between PU and load(Ω)
1.2	1.805	1.313	1.094	0.492	0.450
1.8	1.802	1.442	0.801	0.360	0.449
4	1.798	1.617	0.404	0.181	0.448
5	1.798	1.649	0.330	0.149	0.452
7.5	1.798	1.696	0.226	0.102	0.451

The current status of the project

Mechanics

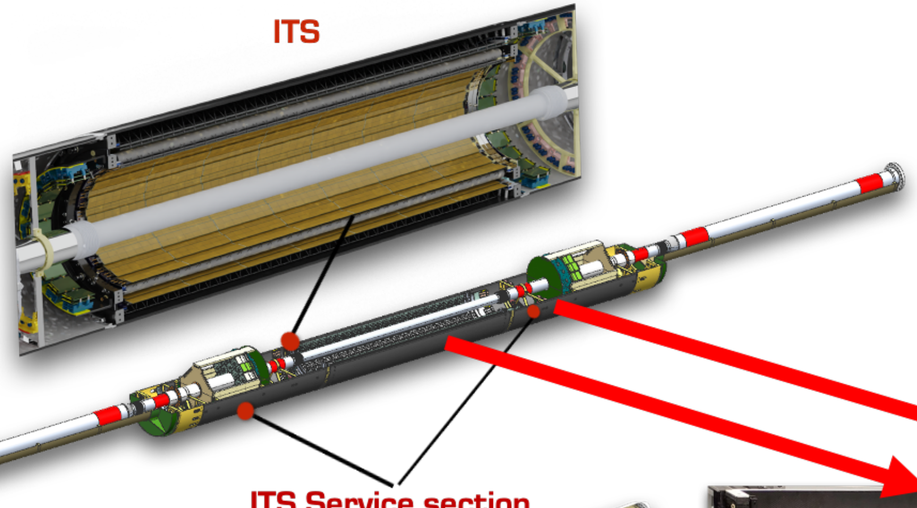
(To be finished by 2024)

Cold Plates

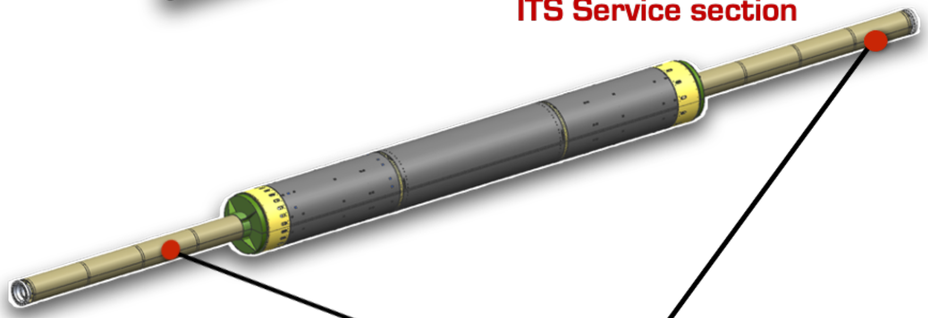
Space Frames

Irradiation effect to be studied

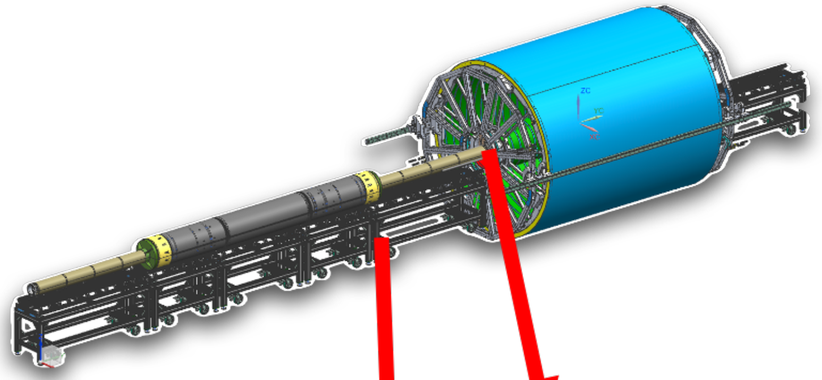
ITS

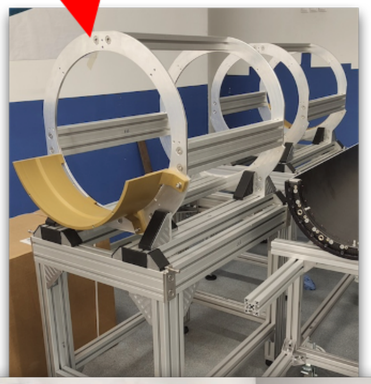


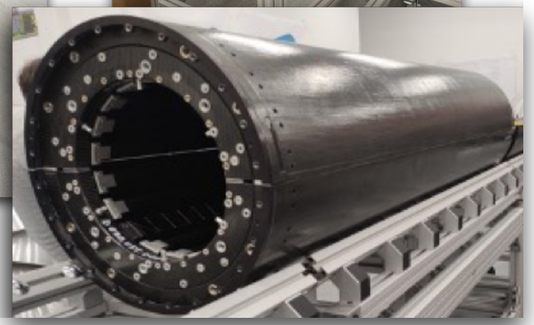
ITS Service section



ITS technical section







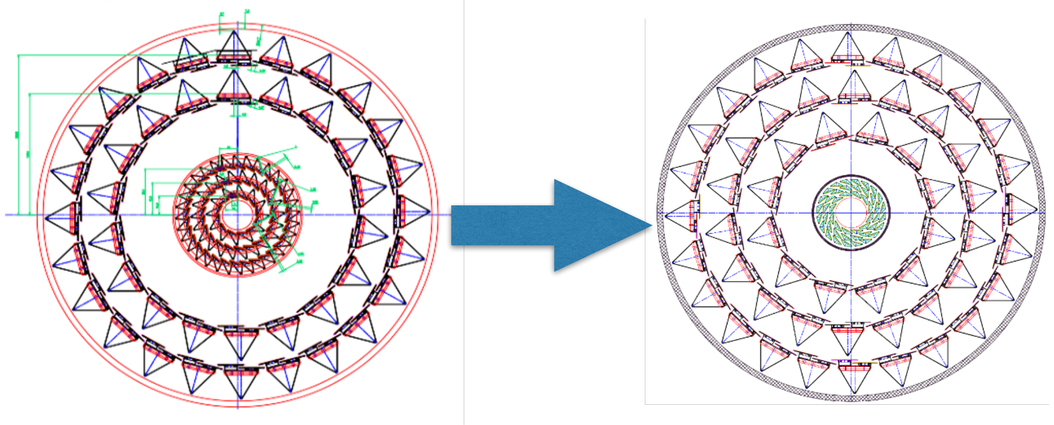
M. Herrera, T. Ligdenova, C. Ceballos, D. Dementev, S. Igolkin, V. Zherebchevsky, ***"Determination of the Natural Frequencies of Ultralight Carbon Fiber Trusses for Silicon Tracking Systems"***, accepted for publication in the Revista Mexicana de Física.

The current status of the project

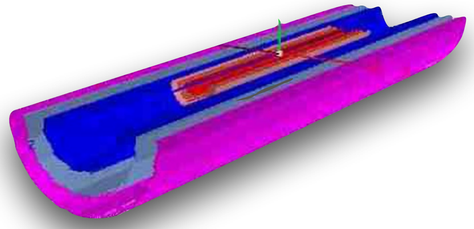
Simulations

5 layers in TDR - 2021

6 layers in TDR - 2024

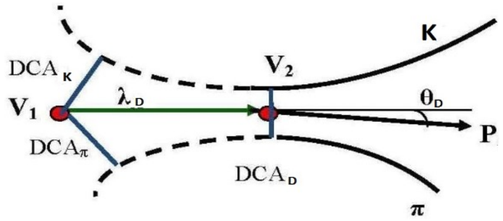


OB - 3 layers of ALPDE-like MAPS (15*30 mm^2) - effective thickness of 700 μm
IB - 3 layers of ALPIDE-like MAPS (15*30 mm^2) - effective thickness of 50 μm

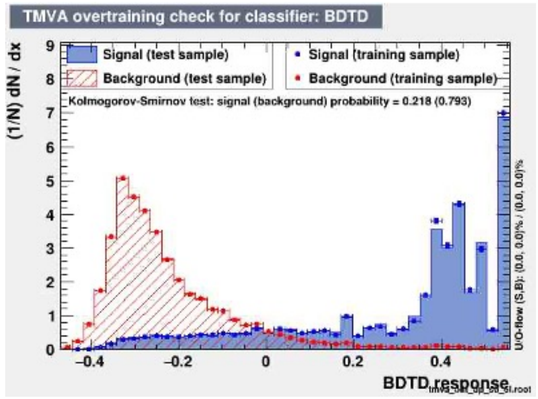


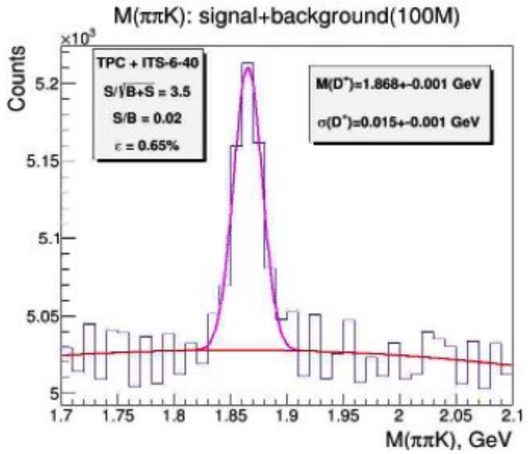
Beam pipe diameter – 40 mm

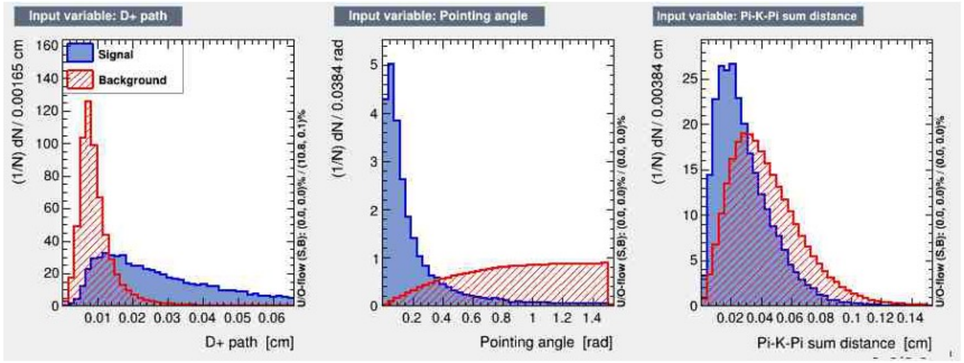
Layer	R_{min}, mm	R_{max}, mm	Length, mm
1	22.4	26.7	750
2	40.7	45.9	750
3	59.8	65.1	750
4	93.2	96.7	1526
5	144.5	147.9	1526
6	194.4	197.6	1526



Used methods :
1) Track finder: KF
2) Particle identification: TOF + dE/dx
3) Track analysis: ML (MVA)







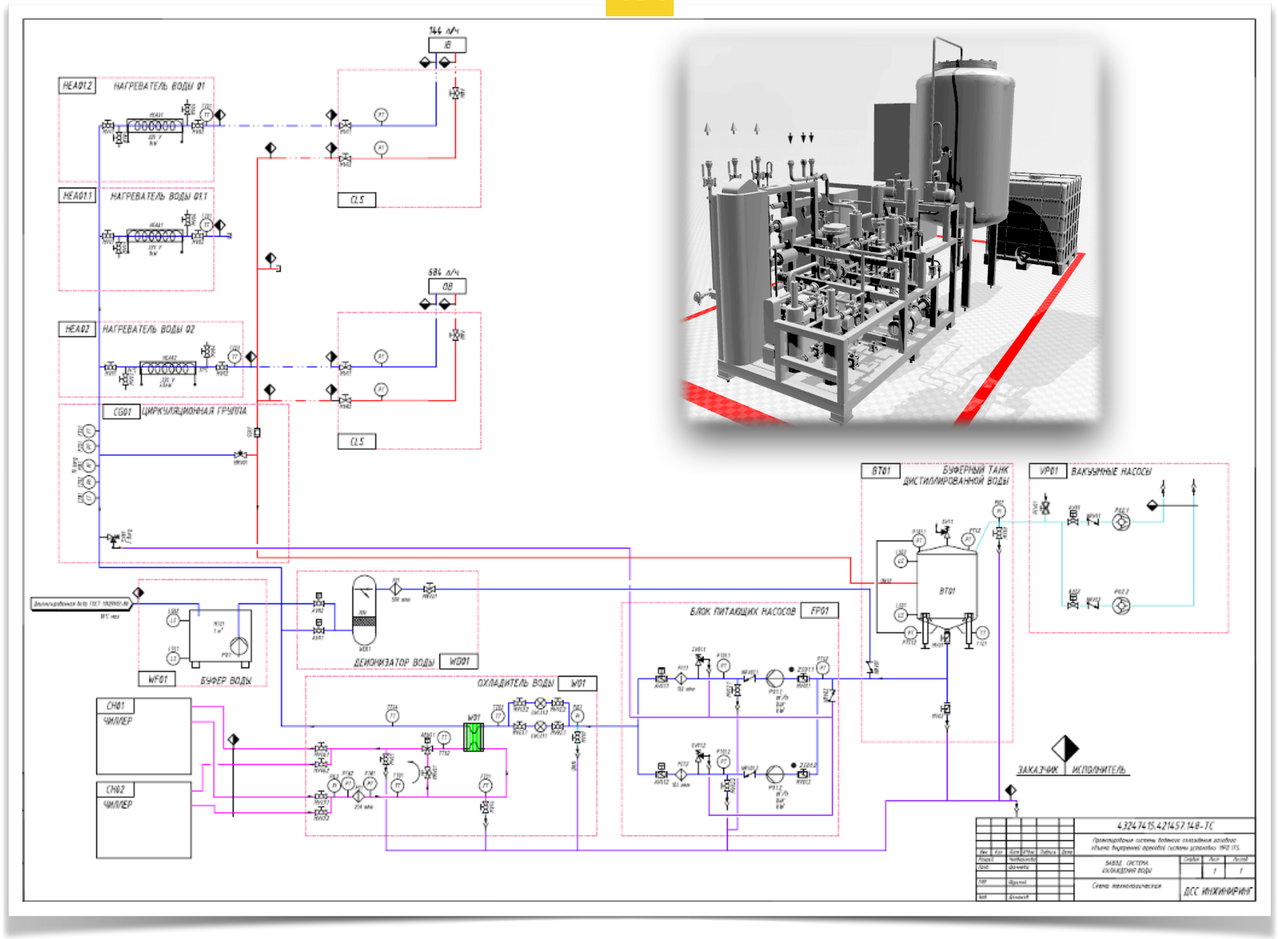
MVA input:
λ_D (D^+ path),
θ_D (pointing angle),
DCA_D (π-K-π sum distance)

Particle	D^+
Efficiency, %	0.65
Significance	3.5
S/B(2σ) ratio	0.02

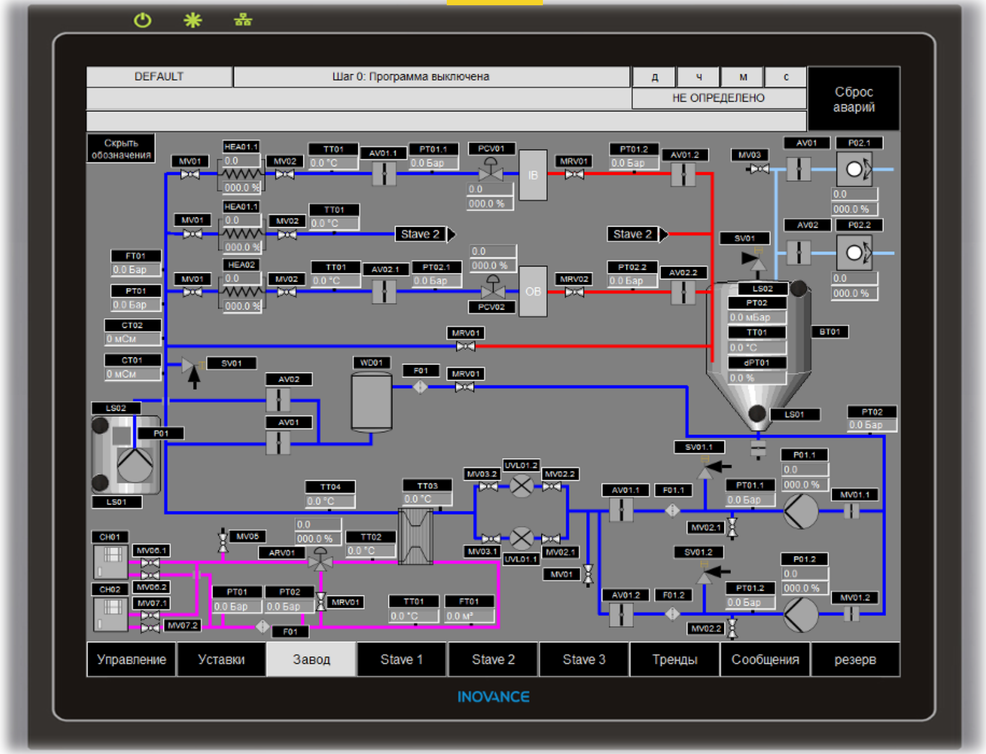
Cooling Plant by DSSE

(Leak-less)

TX



ATX

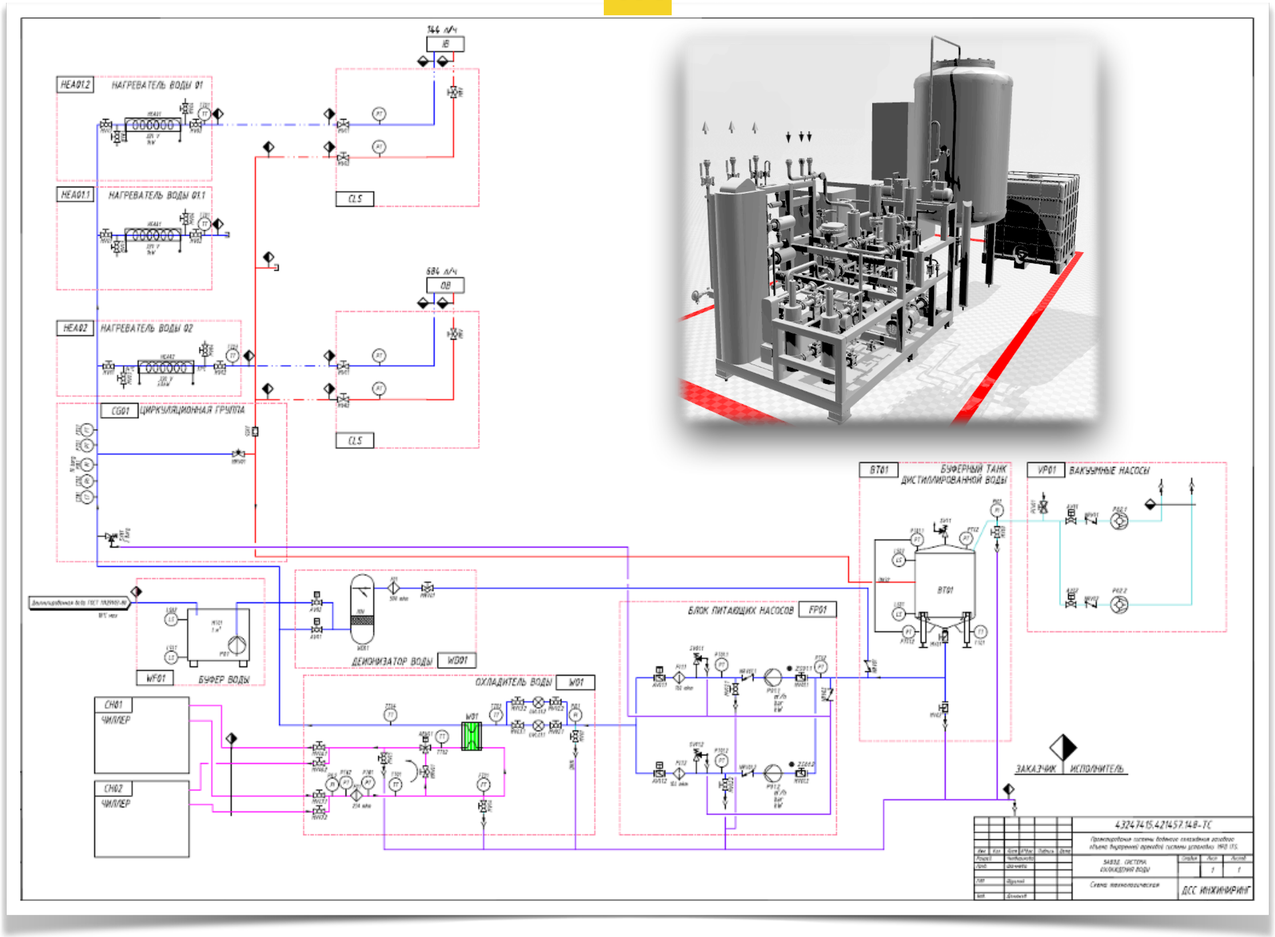


Barrel type	No. of Staves	No. of Panels	No. of Circuits	Power in the circuit [W]	Flow [l/h]
IB	96	96	24	240	288
OB	54	108	9	2187	684
Total ITS	150	204	33	2427	972

Cooling Plant by DSSE

(Leak-less)

TX



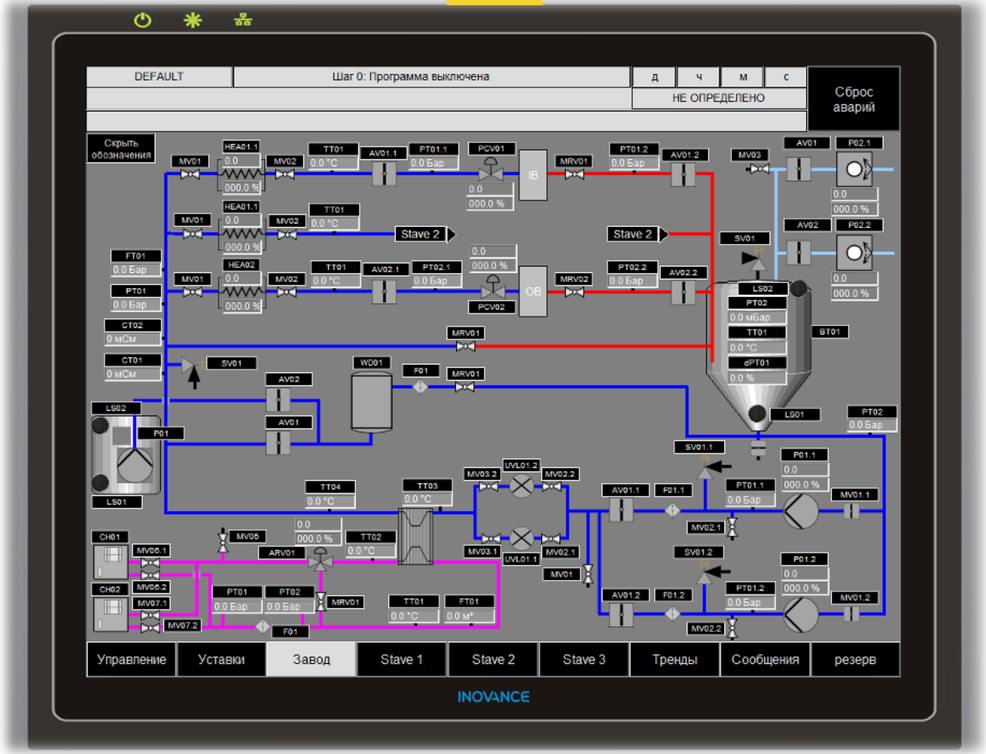
Done so far:

- Design according to ГОСТ 2.
- Confirmation of the possibility supplying under-sanctions equipment.
- Calculation of the operating parameters of the equipment.
- The beginning of the purchase of lengthy parts.

Cooling Plant by DSSE

(Leak-less)

ATX



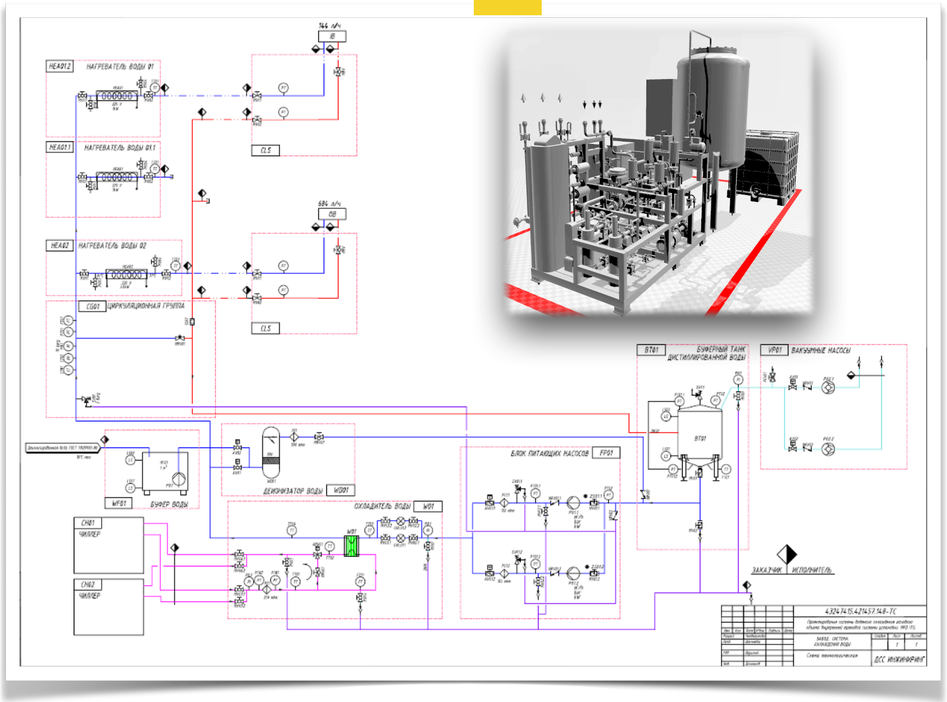
Done so far:

- **Development of project documentation for the Automation section**
  - Electrical schematic diagram.
  - Assembly drawing of the control cabinet.
  - Pneumatic schematic diagram.
  - Cable logbook.
  - Diagram of external connections and wiring.
  - Passport of the control cabinet.
  - User Manual.
- **Software development operation manual**
  - Main screen of the technological scheme.
  - Drivers for the control elements.
  - Screen for automatic control mode.
  - Screen of failures and charts of technological parameters

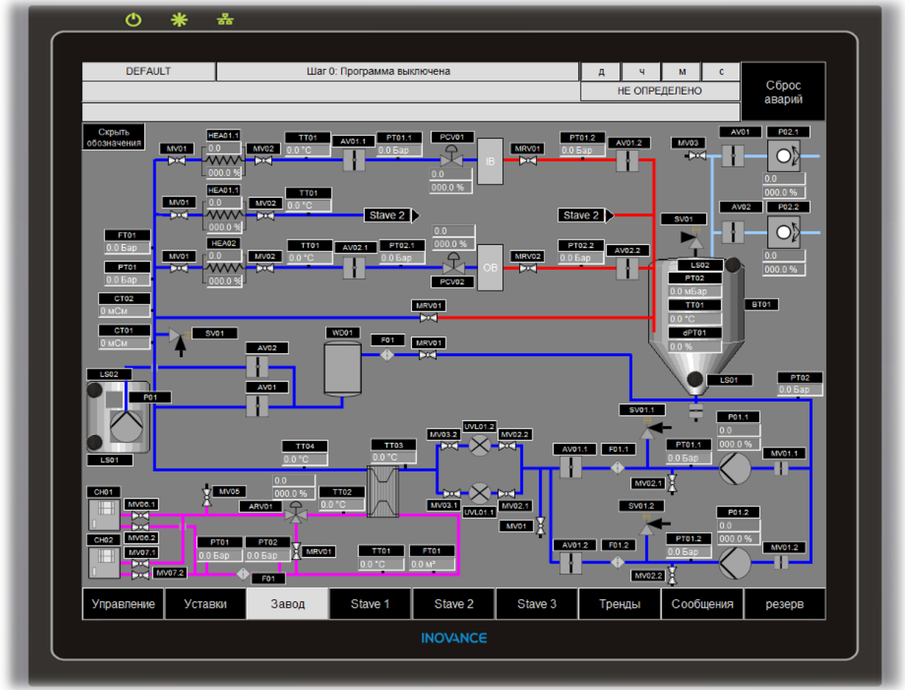
Cooling Plant by DSSE

(Leak-less)

TX



ATX



Next:

- Delivery of instrumentation and control equipment (Oct. 2024).
- Delivery of installation materials (Oct. 2024)
- Production and tests (Jan. 2025).

Cooling Plant by DSSE

(Leak-less)

Next:

- Delivery of instrumentation and control equipment (Oct. 2024).
- Delivery of installation materials (Oct. 2024)
- Production and tests (Jan. 2025).

The current status of the project

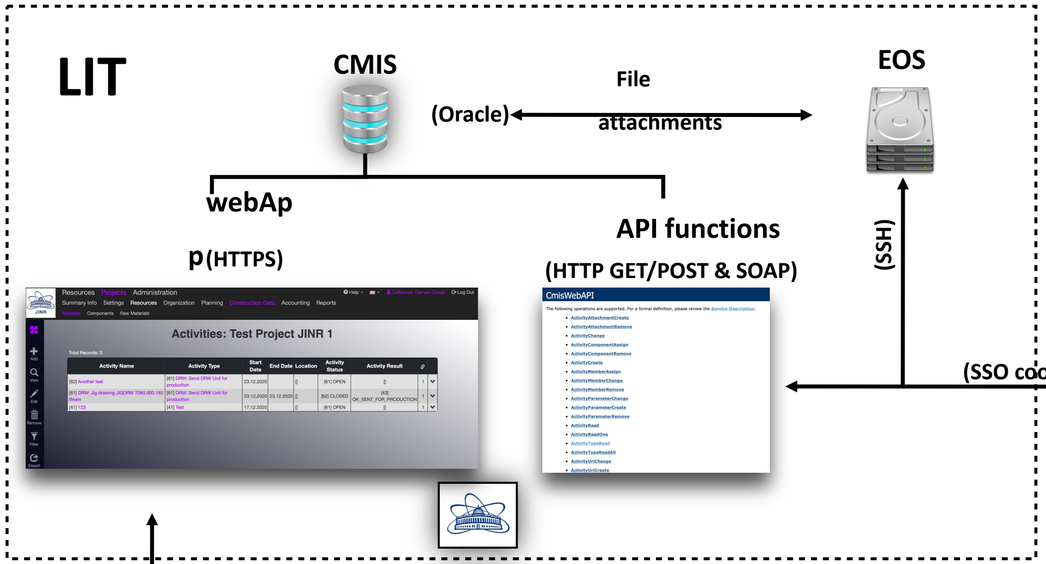
Construction Management Information System

(Commissioned)

An Oracle-based all-around project management database system that allows the organization and follow-up of every aspect of a hardware production project.

It is designed to be accessed by human users and interfaced hardware independently.

It is installed at LIT and might be accessed in real-time over the internet.



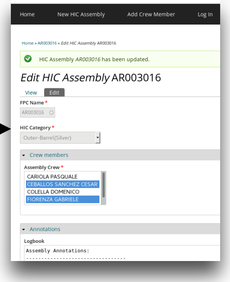
JINR SSO:

- Web access.
- Registered JINR-SSO users.
- Role-based access rights.

Custom Assembly & Testing programs

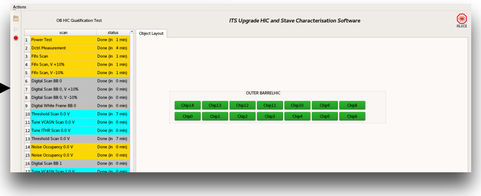
(Kerberos credentials automatically renewed)

Direct HW interface to DB



JINR SSO:

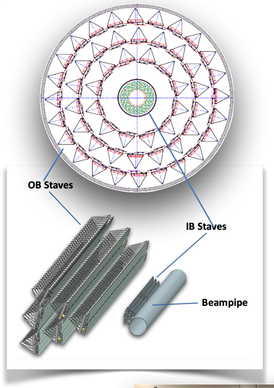
- Registered service accounts.
- Kerberos credentials.
- Access cookies acquired through ‘get-sso-cookie.py’.



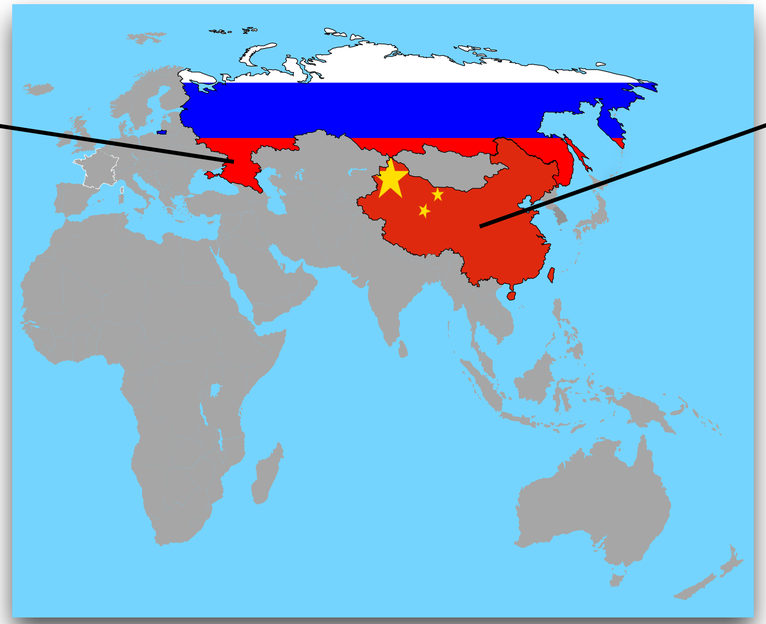
Used for the DSSD assembly

C. Ceballos, A. A. Kolozhvari, A. G. Dolbilov, R. N. Semenov, E. A. Tsapulina, A. Rodriguez, A. D. Sheremetiev, Yu. A. Murin (for the MPD-ITS Collaboration), *"Construction Management Information System at JINR"*, Phys. Part. and Nucl. Lett., 2023, Vol. 20, No. 5, pp. 981–987

The current status of the project



International Collaboration



Site for Assembly and QA tests at JINR

Site for Assembly and QA tests at CCNU

Proposal for joint JINR-China projects

Project: Monolithic Si-Pixel Detector for Collider Experiments and Other Applications

	2024	2025	2026	2027	2028	2029
MICA R&D	R&D and testing			Preseries run		
Readout	PU &FPGA version RU R&D complete	ASIC version RU R&D complete				
GBTx & ROC	R&D complete					
Assembly	R&D and Setup assembly line at CCNU and IMP	R&D, Assemble HICs/staves and testing at CCNU, IMP and JINR		Assembly 1/12 of the tracker including Readout	Assembly the full tracker (IB, OB) and test at the experimental site. Ready to take data in 2030	

- **6 layers vertex detector.**
- **Monolithic Active Pixel Sensors (MAPS) & ASICs-based Readout:**
  - **Developed and made in China.**
  - **Unrestricted access for China and Russia (Currently forbidden).**
  - **Applicable also to Space science and Medical Imaging.**
- **5μm spatial resolution.**
- **5.5 GPixels in total.**

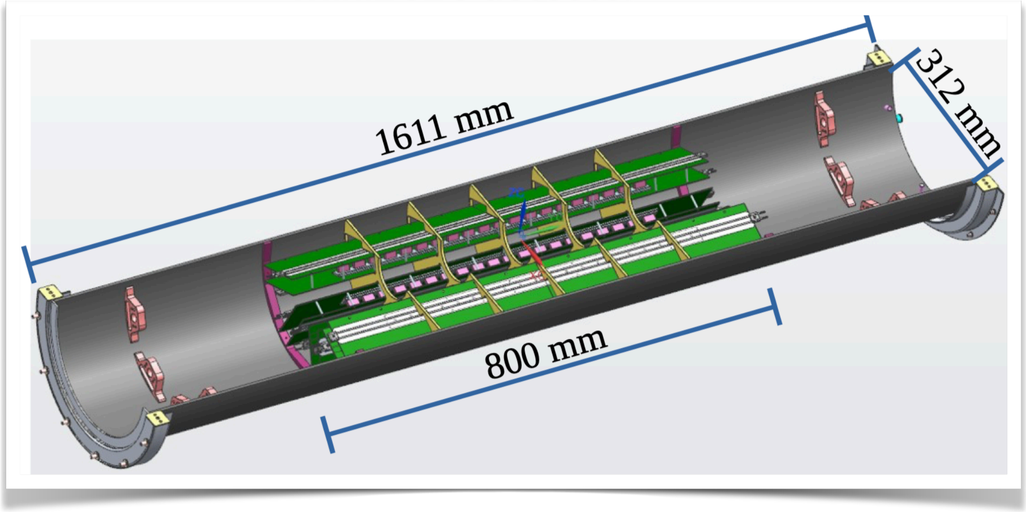
The current status of the project

International Collaboration

JINR

Universidad Nacional Autónoma de México

MiniBeBe detector



SPECIFIC AGREEMENT BETWEEN THE INSTITUTE OF NUCLEAR SCIENCES OF THE NATIONAL AUTONOMOUS UNIVERSITY OF MEXICO – ICN-UNAM AND THE JOINT INSTITUTE FOR NUCLEAR RESEARCH – JINR

SPECIFIC COLLABORATION AGREEMENT FOR RESEARCH ACTIVITIES RELATED TO THE MULTI-PURPOSE DETECTOR (MPD) EXPERIMENT CELEBRATED BY THE NATIONAL AUTONOMOUS UNIVERSITY OF MEXICO, HEREAFTER REFERRED TO AS "UNAM", REPRESENTED BY DR. MARÍA SOLEDAD FUNES ARGÜELLO AS SCIENTIFIC RESEARCH COORDINATOR, WITH THE ASSISTANCE OF DRA. MARIA DEL PILAR CARREÓN CASTRO AS DIRECTOR OF THE NUCLEAR SCIENCES INSTITUTE, AND THE JOINT INSTITUTE FOR NUCLEAR REEARCH, HEREAFTER REFERRED TO AS "JINR", REPRESENTED BY DR. GRIGORY VLADIMIROVICH TRUBNIKOV, AS GENERAL DIRECTOR, IN ACCORDANCE WITH THE FOLLOWING DECLARATIONS AND CLAUSES:

BACKGROUND:

1. On September 29, 2006, "JINR" and "UNAM" signed a general agreement for cultural, educational and scientific cooperation, with registration number 18492-777-13-VI-06, the purpose of which is to promote collaboration between THE PARTIES. to carry out scientific and academic activities in areas of common interest.

RECITALS

I. "UNAM" STATES THAT:

1.1 In accordance with article 1 of its Organic Law, published in the Official Gazette of the Federation on January 6, 1945, it is a public decentralized entity of the State, with full legal capacity, whose purpose is that of providing higher education to form professionals, researchers, university faculty and technicians that are useful to society, as well as of organizing and conducting research dealing mainly with national issues and conditions and to disseminate to the greatest possible extent the benefits of culture.

1.2 Its legal representation is vested in its Rector, Dr. Leonardo Lomelí Vanegas, as provided in articles 9 of its Organic Law and in the 30 first paragraph of its General Statutes, being vested with powers of delegation pursuant to section of article 34 of said Statutes.

1.3 Dra. Patricia Dolores Dávila Aranda, as General Secretary and Dra. María Soledad Funes Argüello, as Scientific Research Coordinator, who are authorized to sign consensual instruments, according with the Agreement that delegates and distributes the legal authority to the signing of agreements, contracts and other consensual instruments in which the University takes part, published in Gaceta UNAM, on September 5, 2011.

Going through the final round for approval

Credits

ОИЯИ

Мурин Юрий
Себаллос Сесар
Дементьев Дмитрий
Артече Рауль
Родригес Алехандро
Цапулина Екатерина
Шитенков Михаил
Гореликов Илья
Лыгденова Туяна
Рейес Солне
Эррера Марибель
Гаганова Мария
Перес Маргарита
Удовенко Светлана
Леонтьев Владимир
Шереметьев Алексей
Андреева Татьяна
Семчукова Татьяна
Елша Владимир
Андреев Денис
Бокова Татьяна
Воронин Алексей
Коложвари Анатолий
Патронова Светлана
Игор Руфанов

Жеребчевский Владимир
Иголкин Сергей
Кондратьев Валерий

孙向明 [Sun Xiangming] (CCNU)
小乐 [Xiao Le] (CCNU)
王亚平 [Wang Yaping] (CCNU)
赵磊 [Zhao Lei] (USTC)
陆云鹏 [Lu Yunpeng] (IHEP)
赵晨新 [Zhao Chenxin] (IMP)
郭迪 [Guo Di] (CCNU)
高超松 [Gao Chaosong] (CCNU)
钱家俊 [Qin Jiajun] (USTC)
周扬 [Zhou Yang] (IHEP)

Musa Luciano
Di Mauro Antonello

Ayala Alejandro (UNAM)
Herrera Maribel (Univ. de Colima)
Maldonado Ivonne (JINR)
Rayas Alfredo (Univ. Michoacana)

Thank you!

V. Kondratiev, C. Ceballos, S. Igolkin, A. Kolozhvari, Y. Murin, A. Sheremetiev, *"Detection of D+-meson decays in the tracking system of NICA-MPD"*, Acta Physica Polonica B, 14 (3), **2021**.

Yu. A. Murin and C. Ceballos, *"The Inner Tracking System for the MPD Setup of the NICA Collider"*, Phys. Part. Nuclei 52, 742–751 (**2021**).

Q. Chen, D. Guo, C. Zhao, R. Arteche, C. Ceballos, N. Fang, Y. Gan, Z. Guo, Y. Murin, X. Sun, and L. Yi for the MPD ITS collaboration, *"LDLA14: a 14 Gbps optical transceiver ASIC in 55 nm for NICA multi purpose detector project"*, JINST, 17, C01027, **2022**

Q. Chen, D. Guo, C. Zhao, Z. Guo, R. Arteche, C. Ceballos, Y. Murin, L. Yi and X. Sun for the MPD ITS collaboration "*A 13 Gbps 1:16 deserializer ASIC for NICA multi purpose detector project*", JINST, 17 C08027, **2022**

C. Zhao, Q. Chen, Z. Guo, R. Arteche, C. Ceballos, N. Fang, Y. Gan, Y. Murin, L. Yi, D. Guo and X. Sun for the MPD ITS collaboration, *"A 14 Gbps VCSEL driving ASIC in 55 nm for NICA multi purpose detector project",* JINST, 17 C08021, **2022**

C. Zhao, D. Guo, Q. Chen, Z. Guo, R. Arteche, C. Ceballos, N. Fang, Y. Gan, Y. Murin, L. Yi and X. Sun for the MPD ITS collaboration, "A low noise 5.12 GHz PLL ASIC in 55 nm for NICA multi purpose detector project", JINST, 17 C09003, **2022**

C. Ceballos, A. A. Kolozhvari, A. G. Dolbilov, R. N. Semenov, E. A. Tsapulina, A. Rodriguez, A. D. Sheremetiev, Yu. A. Murin (for the MPD-ITS Collaboration), *"Construction Management Information System at JINR"*, Phys. Part. and Nucl. Lett., **2023**, Vol. 20, No. 5, pp. 981–987

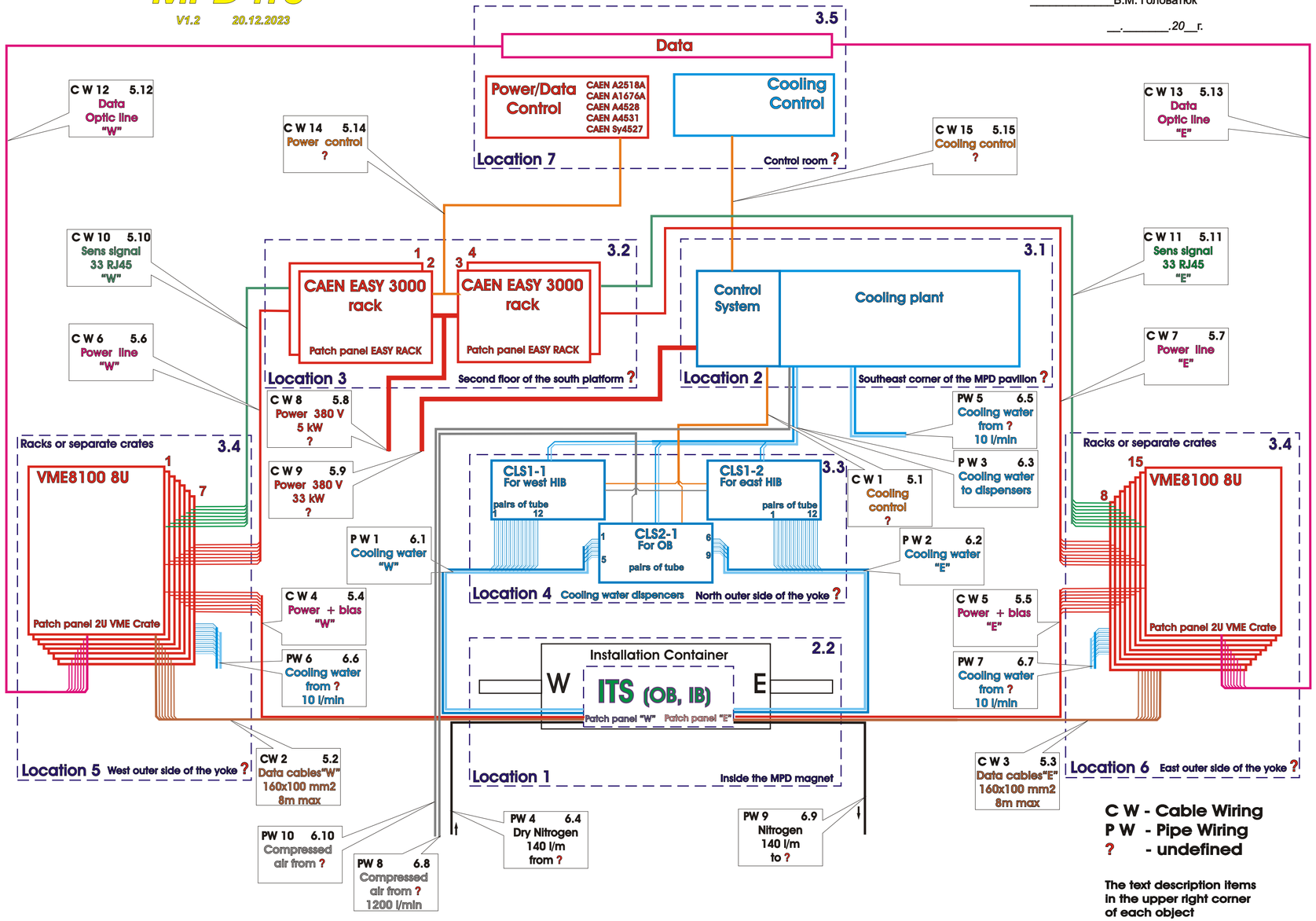
Yu. A. Murin, C. Ceballos Sanchez for the MPD-ITS Collaboration, *"Modern Microelectronics for MPD-ITS. Monolithic Active Pixel Sensors and Readout System"*, accepted for publication in the 4th issue of Phys. Part. and Nucl in **2024**

M. Herrera, T. Ligdenova, C. Ceballos, D. Dementev, S. Igolkin, V. Zherebchevsky, *"Determination of the Natural Frequencies of Ultralight Carbon Fiber Trusses for Silicon Tracking Systems"*, accepted for publication in the Revista Mexicana de Física.

Согласовано
Технический координатор *MPD*
_____В.М. Головатюк
__._____.20__г.

MPD ITS

V1.2 20.12.2023



C W - Cable Wiring
P W - Pipe Wiring
? - undefined

The text description items in the upper right corner of each object

Cooling Plant

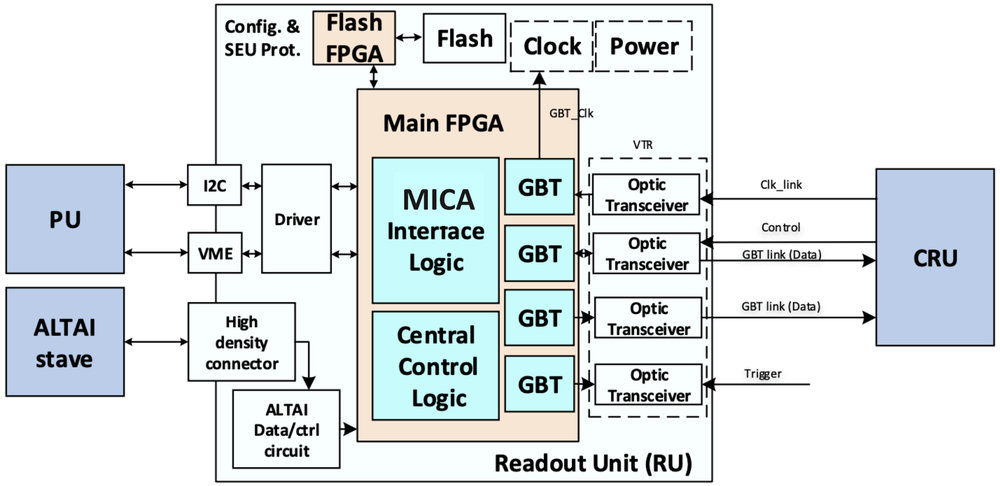
1. Water treatment unit:
- Storage tank for ready deionized water;
- A pump for pumping water into the cooling system.
2. Water cooler assembly, including:
- Heat exchanger;
- Control of temperature, pressure at the inlet and outlet of the heat exchanger (cold and hot parts);
- UV disinfection;
- Flow control.
3. The unit of the feeding pumps, including:
- Pressure monitoring at the inlet and outlet of pumps;
- Duplication of pumps for redundancy;
- Filters for each pump unit;
- Bypass valves on each pump block to protect against high pressure;
- Shut-off valves at the inlet and outlet of the pumps.
4. Buffer tank assembly, including:
- Maximum upper and maximum low level sensors;
- Differential level sensor;
- Temperature and pressure sensor in the container.
5. Vacuum pump assembly, including:
- 2 backup vacuum pumps;
- Shut-off valves at the inlet.
6. Circulation group, including:
- Flow Meter, Pressure sensor, Pressure Gauge, Ph sensor, Conductivity sensor;
- Bypass valve for protection against high pressure;
- Sight glasses.
7. Water heater assembly, including:
- Water heater of at least 1 kW – 2 sets;
- Water heater of at least 3 kW – 1 set;
- Shut-off valves at the inlet and outlet of heaters;
- Temperature control at the outlet of the heaters.
8. Distribution node (simulators of 2 circuits), including:
- Control valve for flow rate of 12 x12 l/h =144 l/h;
- Flow control valve 9 x 76 l/h =684 l/h;
- Shut-off valves;
- Pressure sensors;
- A transparent fragment of the pipeline for monitoring the flow of refrigerant.
- Other necessary equipment.

The current status of the project

Readout and PU

Electronics

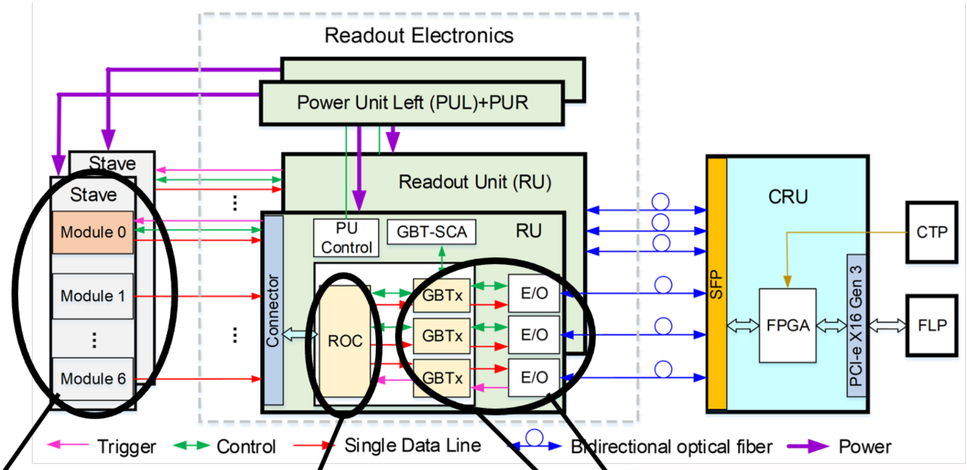
FPGA-based



Transfer data and control signals from/to ALTAI staves

- FPGA implemented GBT protocol
- Protection from SEU based on logic scrubbing, with a flash based FPGA
- Power supply from VME backplane
- I2C interface is reserved on the front panel as an alternative path to communicate with PU

ASIC-based



Monolithic Active Pixel Sensor (MAPS)

NICA_ROC:
Data collection and control distribution ASIC

NICA_GBT family (3 chips + optical module)
NICA_ LD : Laser Driver ASIC
NICA_TIA : Transimpedance Amplifier ASIC(Receiver)
NICA_GBTx: Bi-directional data interface ASIC
Note: NICA_LD and NICA_TIA are inside the optical module

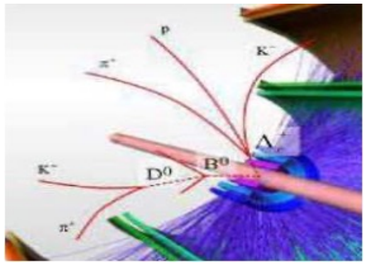
- **NICA_ROC:** Concentrates the output data of front-end ALPIDE chips and transfer the packaged data to the following NICA_GBTx ASIC. It also receives control commands, clocks, and trigger signals from the backend and distributes them to ALPIDE chips.
- **NICA_GBTx:** A high-speed bidirectional data interface ASIC for optical links.
  - It receives multichannel data from the front-end (NICA_ROC), performs scrambling, encoding, frame building and serializing as the main function for the up-link direction.
  - It receives high-speed serial data from the back-end, performs CDR (Clock and Data Recovery), deserializing, decoding and distributing to the front-end as the main function for the down-link direction.
- **NICA_LD (Laser Driver) and NICA_TIA (Transimpedance Amplifier):** Are two analog ASICs that would be integrated together with the laser and PD (Pin Diode) in the customized optical transceiver module.
  - NICA_LD receives the high-speed up-link serial data from NICA_GBTx and amplifies the signal to driver the laser.
  - NICA_TIA receives the down-link serial signal from the pin diode, and amplifies the signal to NICA_GBTx, so that the data can be furthered processed in NICA_GBTx.

WP1 - Simulations

Goal: To asses the identification ability of the MPD tracking system (**ITS + TPC**) for the reconstruction of the decays of strange (Λ^--, Ξ^--, and Ω^--hyperons) and charmed (D^0- and D^+-mesons) particles produced in central Au + Au collisions at $\sqrt{S_{NN}}$ = 9 GeV.

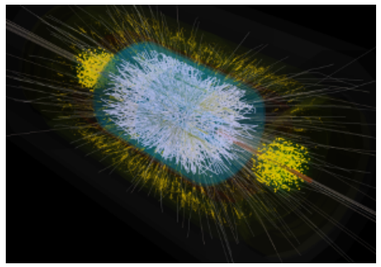
MpdRoot

Signal



Thermal Generator tuned to the energy range of NICA collider.

Background

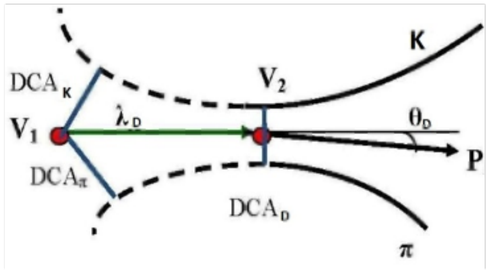


QGSM event generator.

The decay channels of strange and charmed particles used for their reconstruction in the MPD tracking system.

Hadron	Mass ($\mathrm{MeV/cm^2}$)	Average path length $c\tau$(mm)	Decay channel	BR (%)
Λ	1115.68 ± 0.01	78.9	$\pi^- + \mathrm{p}$	63.9
Ξ^-	1321.71 ± 0.07	49.1	$\pi^- + \Lambda^0$	99.9
Ω^-	1672.45 ± 0.29	24.6	$K^- + \Lambda^0$	67.8
D^+	1869.62 ± 0.20	0.312	$\pi^+ + \pi^+ + K^-$	9.13
D^0	1864.84 ± 0.17	0.123	$\pi^+ + K^-$	3.89

Simulations



Track Reconstruction Methods:

- Kalman filter (**KF**).
- Vector Finder (**VF**)*

Signal selection criteria:

- Cuts[**] on the topology of the decay of the short-lived particles (**TC**):

  dca (tracks of decay products, primary vertex of interaction).

  distance (between tracks of daughter particles) @ vertex of the decay of the parent particle.

  path length of the parent particle (point of its formation, decay point).

  angle (vector connecting the primary and secondary vertex, vector of the reconstructed momentum of the parent particle).

  [**]cut-off level for the specified selection parameters is based on the maximum value of the significance function Sg(C_i) for each parameter C_i

- Multivariate Data Analysis (**MVA**)

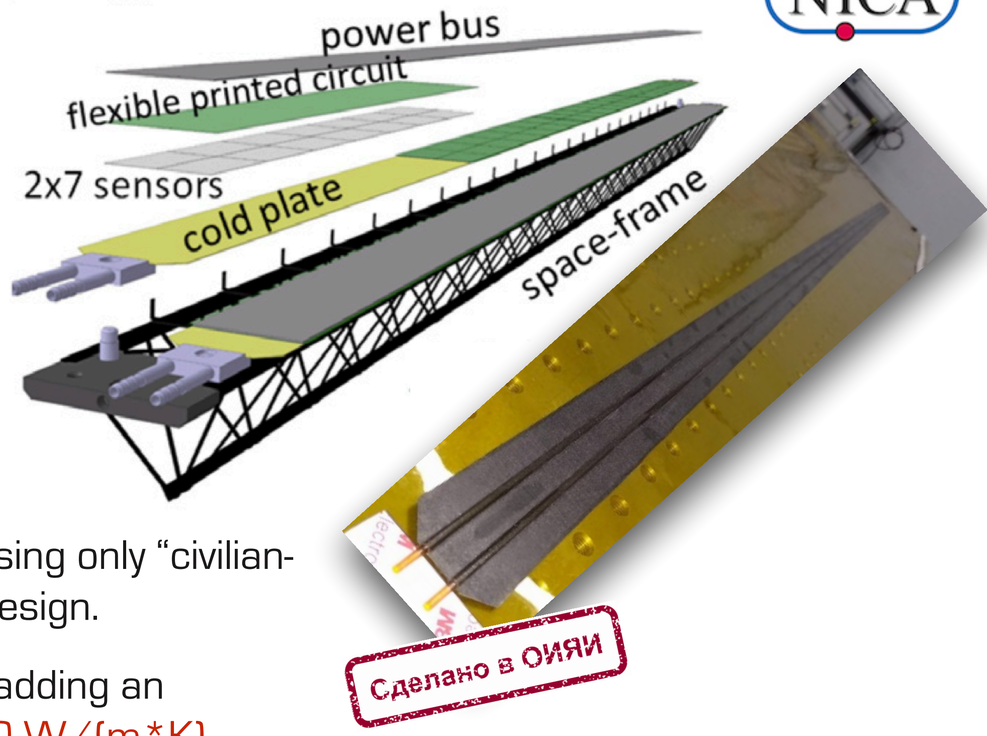
  [*]$V^N \rightarrow R$ (classifier response) @ training phase, BDT (boosted decision tree classifier) @ analysis phase using the same topological parameters from TC

The pointing resolution of the vertex detector is defined as the r.m.s value of the closest approach distance of the reconstructed particle track to the vertex.

(*)*D.A. Zinchenko, A. I. Zinchenko, E. G. Nikonov. «Vector Finder — a toolkit for track finding in the MPD experiment» Письма в ЭЧАЯ. 2021. Т. 18, No 1(233). С. 134*

WP5/6 - Mechanics & Cooling Design/Production

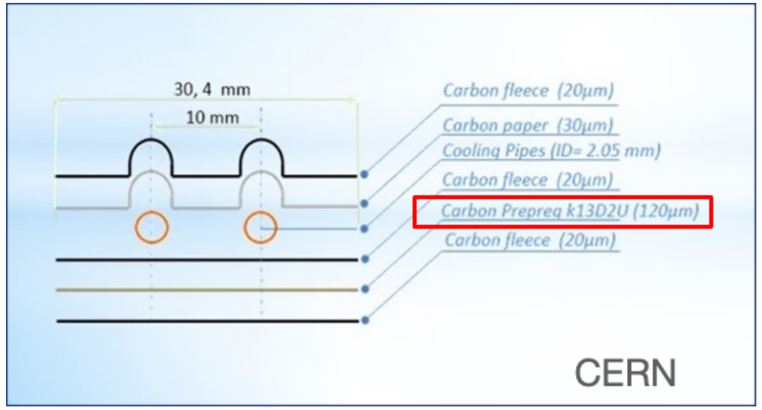
- **Design, Produce[*] and Assembly all parts for:**
  - **MPD-ITS Mechanics and Cooling**
  - **MPD-ITS integrations with the beam pipe, the TPC and the FFD**

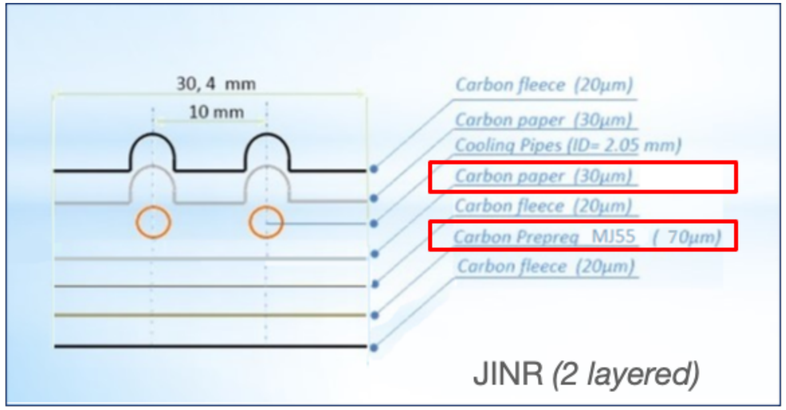


Cold Plates: Water-cooled large-area (30 mm x 1502 mm) for dissipating a total of 20W each with a power density of 40mW/cm^2 (CERN technology).

Task: To produce Cold Plates with a similar performance as the ones form CERN but using only "civilian-grade " materials instead of the double-use **prepreg k13d2u** included on the original design.

A new version of the CP was produced substitution the prepreg k13d2u to **MJ55** and adding an **additional layer of carbon paper**, with a planar high-thermal conductivity rated to 1500 W/(m*K) .

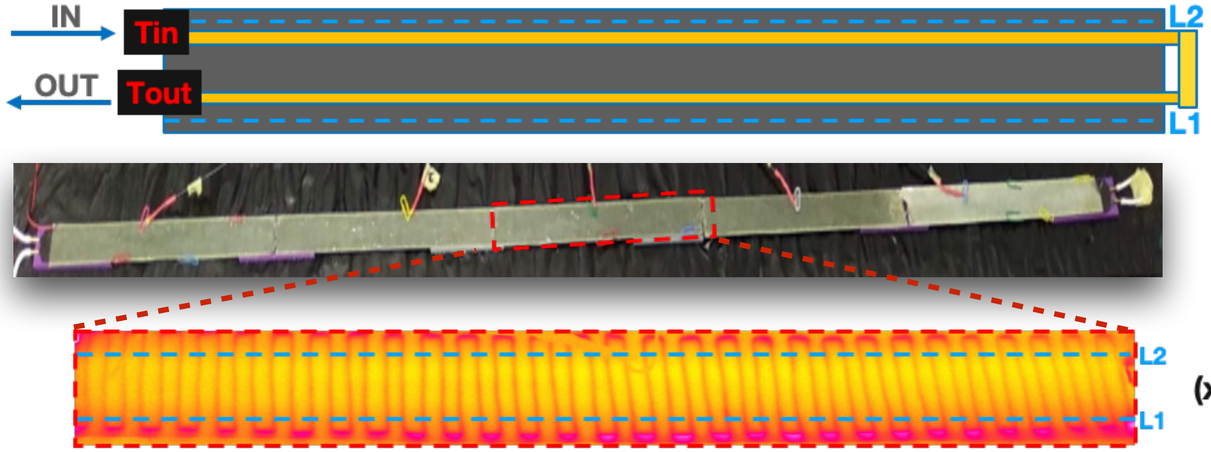




[*] Almost all carbon fiber structures for the mechanics are produced at LHEP

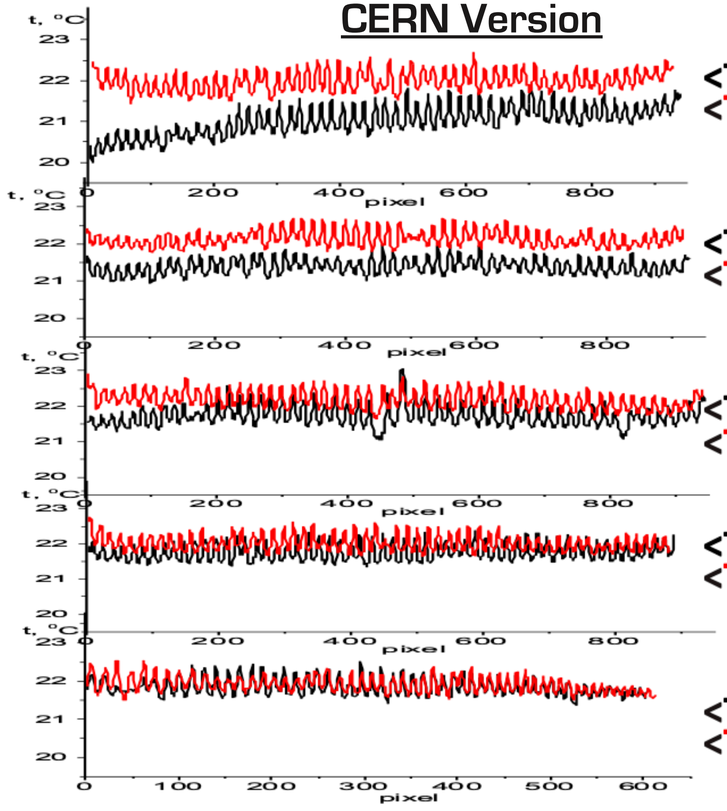
WP5/6 - Mechanics & Cooling Design/Production

water supply temperature 18°C
water flow rate 4-6 l/h



[T] = ° C

CERN Version



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JINR Version