

# *The Inner Tracking System of the MPD*



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for the Russia-China MPD-ITS Collaboration



RFBR Grant No. 18-02-40119.



*RFBR grants for NICA, 20-23.10.2020*



# ***The outline***

- 1. The physics case and history in brief**
- 2. The two-stages project planning**
- 3. The major achievements of 2019 and 2020**
- 4. The work organization, bottlenecks ways to remedy**
- 5. Plans for 2021 and beyond**
- 6. Conclusions**

# The physics case and history in brief

## SUMMARY

### ONSET OF QGP (DECONFINEMENT):

- OBSERVED IN Pb+Pb/Au+Au AT  $\approx 8$  GEV (SPS, RHIC BES)
- RESULTS TO BE COMPLETED BY CHARM ( $\langle c\bar{c} \rangle$ ,  $J/\psi$ ) MEASUREMENTS (SPS, NICA, J-PARC?)

### CRITICAL POINT:

- INCONCLUSIVE INDICATIONS FR
- COMING RESULTS FROM NA61/SHOULD (AT LEAST PARTLY) REMI ALLOW TO DEFINE NEXT STEP

### ONSET OF FIREBALL:

- INDICATIONS FROM 2D SCAN A
- DETAILED SCAN ( $\sqrt{s_{NN}} \lesssim 20$  G) (NICA, SPS, SIS100, J-PARC)

## ALICE & NICA - Synergies and Cooperation

### Cooperation Agreement between CERN and JINR (2010)

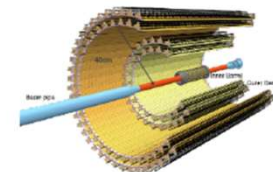
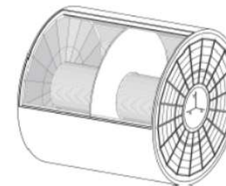
- Cooperate on reciprocal basis on: experimental and theoretical physics, accelerator and detector technologies and engineering, computing, ...

### ⇒ Protocol to the Cooperation Agreement between ALICE and MPD (2018)

- Cooperate on development of specific detector components: silicon detectors, time projection chamber, readout electronics, ...

### ⇒ Addenda to the Protocol

- TPC FEE
- Silicon pixels (ITS)
- Power regulation
- Readout electronics



Marek Gazdzicki , Luciano Musa, Adam Kisiel, others reports to the Conference.

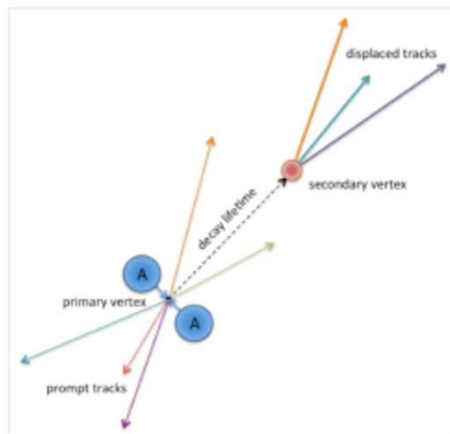
# Hunting for charm particles

## Secondary Vertex Determination



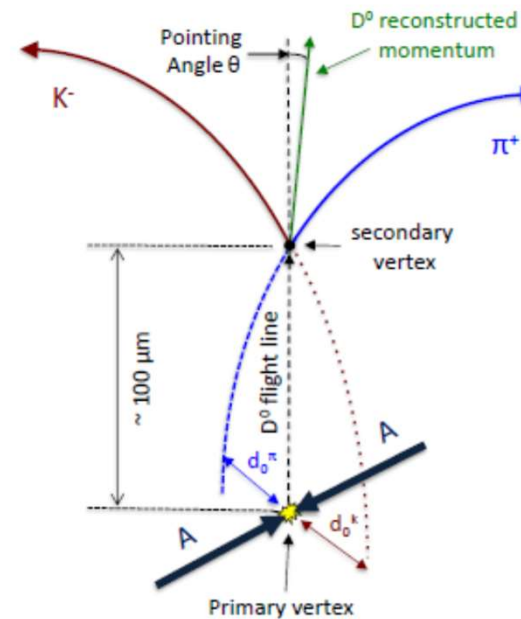
### Open charm

Particle	Decay Channel	$c\tau$ ( $\mu\text{m}$ )
$D^0$	$K^- \pi^+$ (3.8%)	123
$D^+$	$K^- \pi^+ \pi^+$ (9.5%)	312
$D_s^*$	$K^+ K^- \pi^+$ (5.2%)	150
$\Lambda_c^*$	$p K^- \pi^+$ (5.0%)	60



L. Musa (CERN) – International Winter Meeting on Nuclear Physics, Bormio, 8-11 Jan 2019

### Example: $D^0$ meson



Analysis based on invariant mass, PID and decay topology

Looking for a needle in a stack of hay.....



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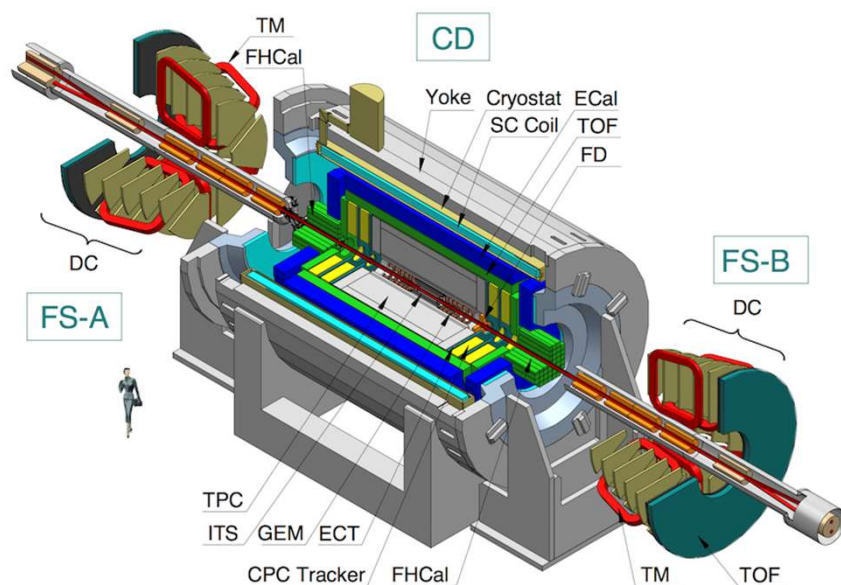




# The MPD-ITS structure and goals

**MPD-ITS structure:** 3-layers Inner Barrel + 2-layers Outer Barrel.

It will supplement the TPC for the precise tracking, momentum determination and vertex reconstruction for **hyperons** ( $\Lambda$ ,  $\Xi$ ,  $\Omega$ ) and **D-mesons**.



## Some of the MPD-ITS requirements:

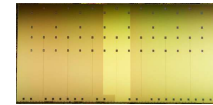
- Fast, high granularity CMOS pixel sensors with low noise level.
- Spatial resolution of track coordinate registration at the level of  $\sim 5\text{--}10\ \mu\text{m}$ .
- Material budget as low as possible.

*Difficulty to install an ITS into very narrow bore of the MPD ITS*

# ***Ingredients of ALICE ITS2 technology transferred to the MPD ITS***

**Developed by ALICE ITS2 Collaboration:**

- ALPIDE MAPS providing a 5  $\mu\text{m}$  resolution of a hit with fast in-built readout of the dataHigh speed Priority encoding readout



Concept of MAPS integration to large area system through model-to-supermodel-tracker roadmap

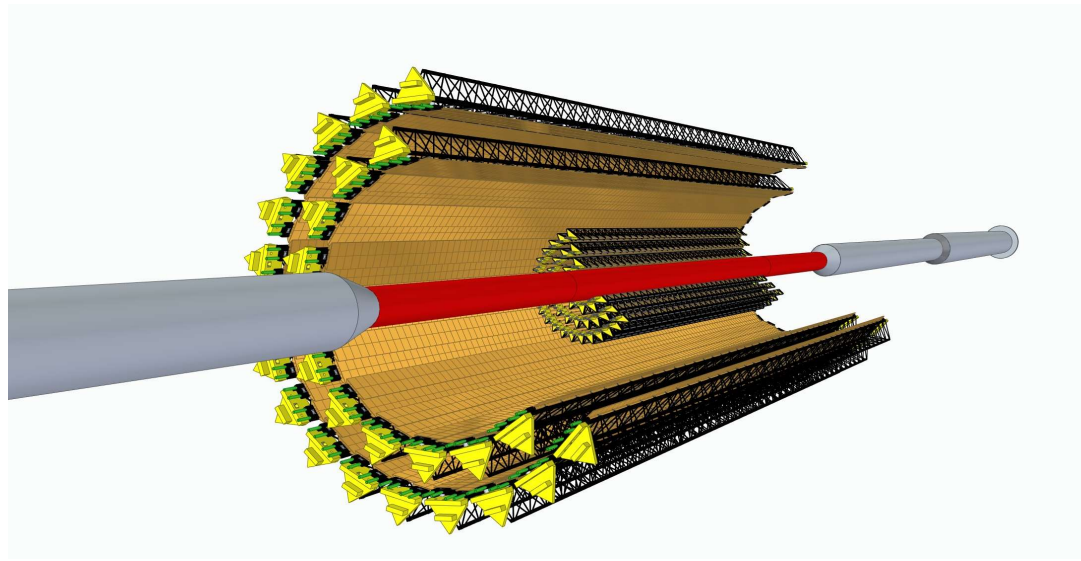
- 
- HIC design, the technology of assembly and QA testing
- OB stave design, the technology of assembly and QA testing
- LV- and HV power supplies connectivity
- *Technology for production of ultralight support CF trusses and cooling plates \*\**
- *for the OB \*)*
- *CMIS for monitoring the construction in of the ITS in Russia and China*



*\*) With strong Russian contribution (S.N.Igolkin for the SPbSU G.Feofilov's ALICE team)*

*\*\* ) A need for modifications*

# The Conceptual Design : from 7 to 5 layers



## Constraints:

**Number of layers:** MAPS size (30x15 mm), diameter of the TPC bore (50 cm), the beampipe diameter (64 mm)

**Length of sensitive line:** stability of supporting truss ( less than 150 cm)

**S.N.Igolkin (SPbSU)**

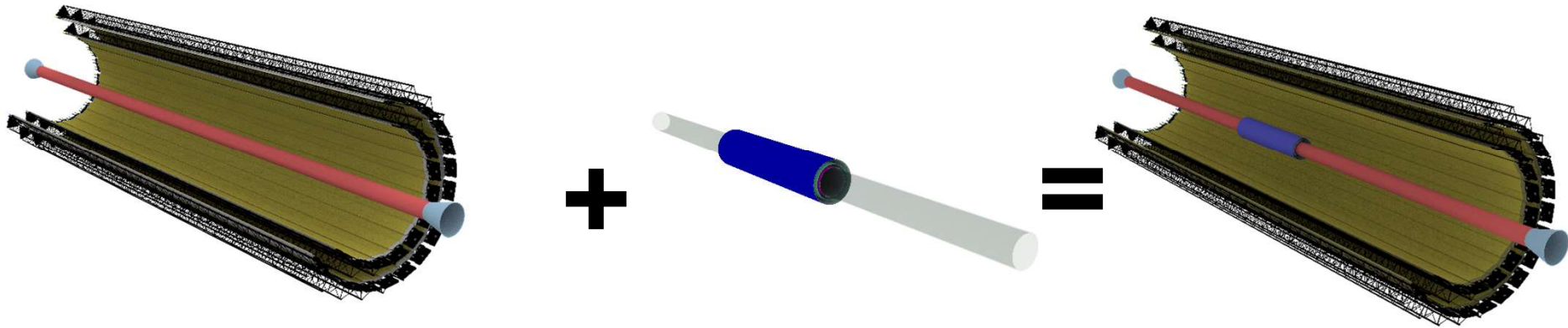
*described also in reports of V.Kondratiev, V.Zherebchevsky and A.Voronin to this Conference*

# The two-stages of the MPD-ITS production

**2020-2023**

**2020-2024**

**2025**



## Participants Russia:

*JINR (Dubna), SPbSU(St.Petersburg), SINP MSU(Moscow)*

## Participants China:

*CCNU(Wuhan), IMP CAS(Lanzhou), USTC(Hefei), HZU(Huzhou)*

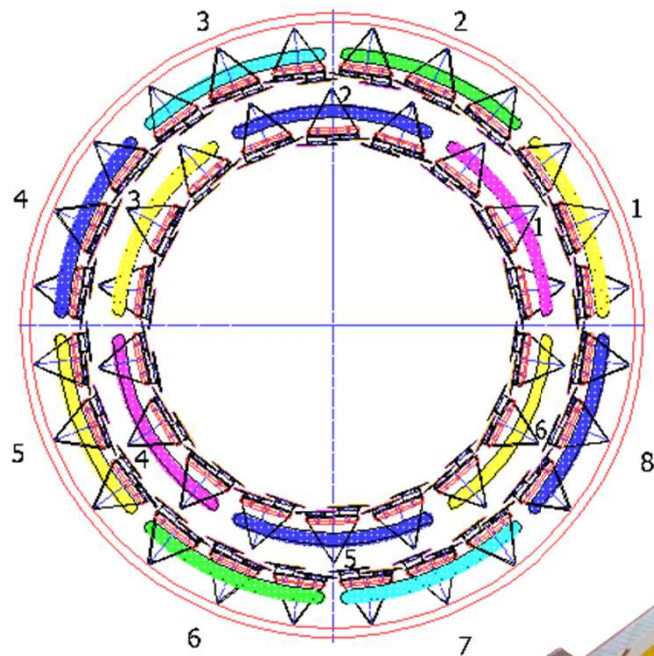
## Potential participants:

*GSI(Darmstadt), WUT(Warsaw)*



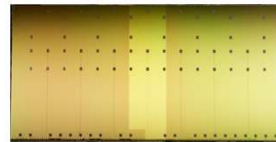
# The two Stages Construction Scenario

## Stage 1: The Outer Barrel (by 2022/2023).

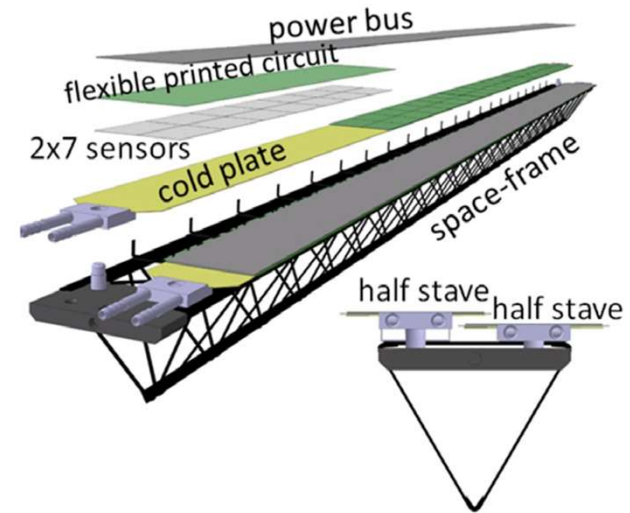
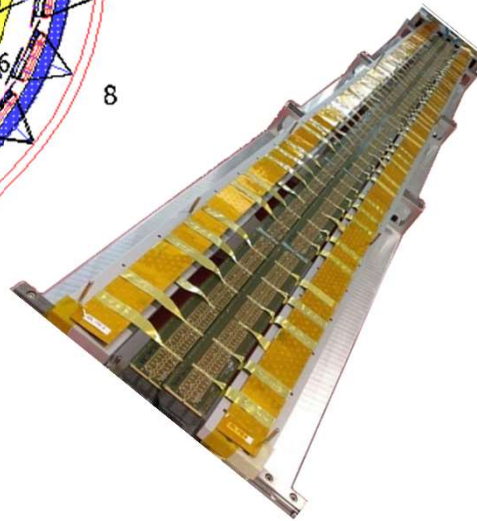


- Layer 4 Staves (36 panels) :
- 6 Feed lines
  - 6 Return lines
- Layer 5 24 Staves (48 panels) :
- 8 Feed lines
  - 8 Return lines

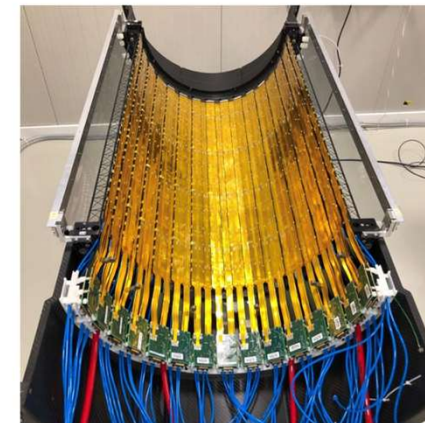
### Sensor



### OB Stave



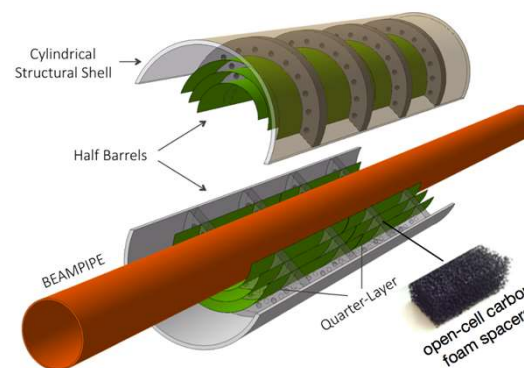
### 1/2 OB in a cage



# The two Stages Construction Scenario

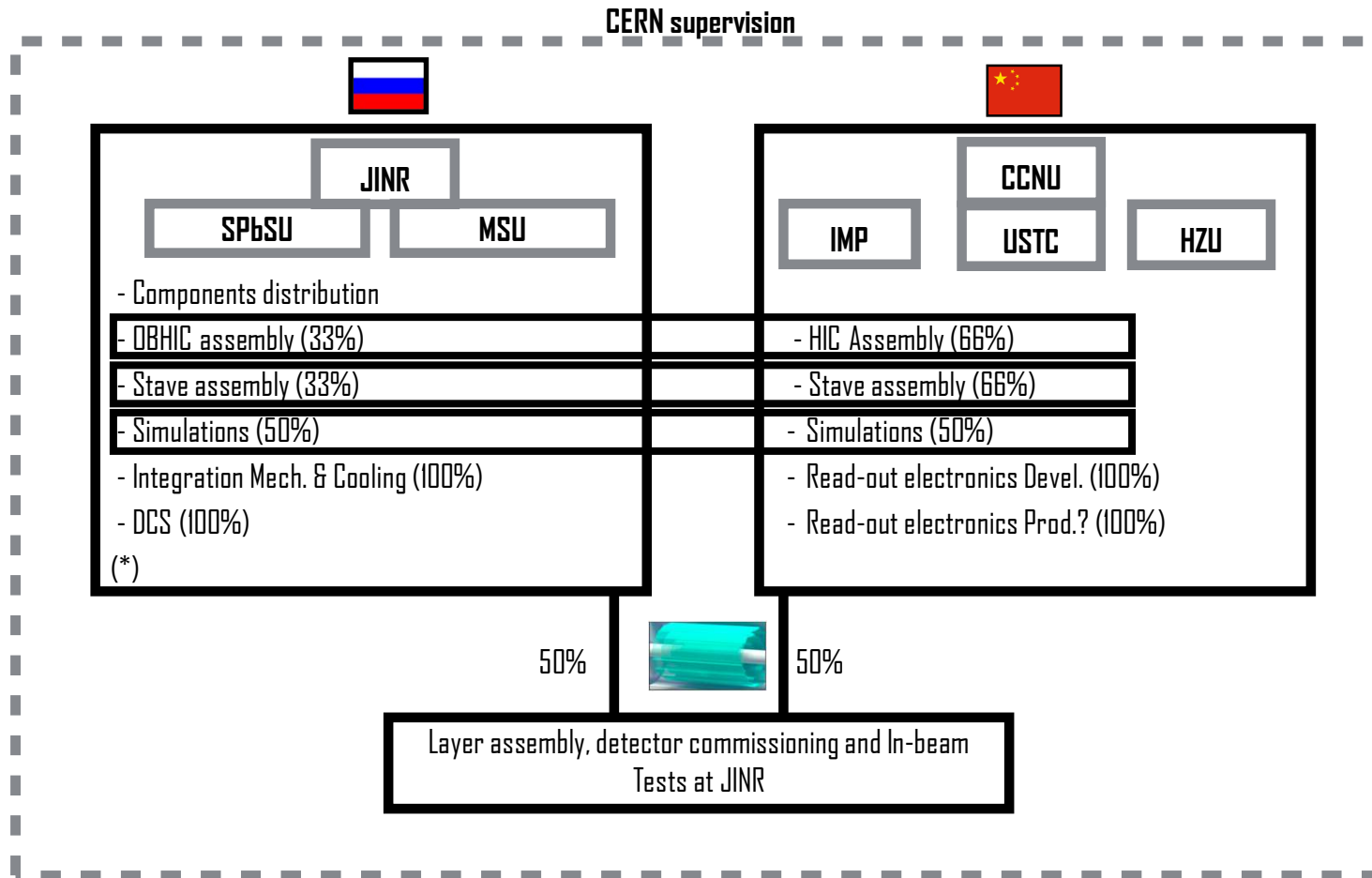
Stage 2: The Inner Barrel (by 2025/2026).

**Goal:** Use double-size ALICE-ITS3-like sensors on a beam pipe of 40 mm in diameter  
**ALICE-ITS3 (Under R&D):** 20 um-thick (!!!) by 280 mm-long bent MAPS



**BackUp plan:** Built an ALICE-ITS2-like IB

# Ingredients: Organization and Management



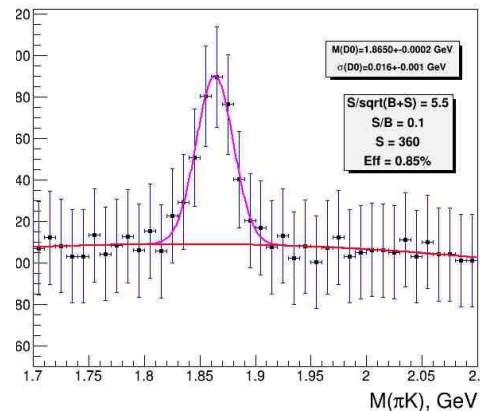
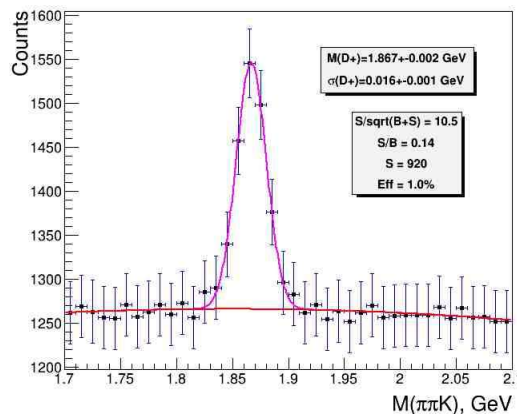
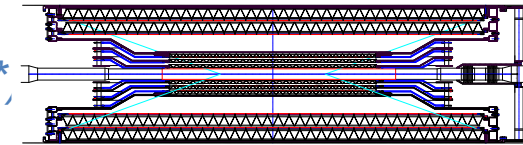
# Work packages (China proposal t.b.d.)

1. Simulations	1. Simulation	Russia	Kondratiev	Jiansong Wang, Yifei Zhang
2. Inner Barrel HIC	2. Wafer-scale MAPS		Kondratiev	Le Xiao, Yupeng Lu
3. Outer Barrel HIC	3. Outer Barrel Aassembling	Russia + China	Ceballos	Yaping Wang, Chengxin Zhao
4. Outer Barrel Staves		Russia + China	?	Yaping Wang, Chengxin Zhao
5. Mechanics & Cooling Design		Russia	Igolkin(**)	
6. Mechanics & Cooling Production		Russia		
7. Read-out and Electronics Devel.	4. Readout and transmission ASIC	China	?	Lei Zhao, Di Guo
	5. Readout Electronics			
8. Read-out Electronics Prod.		China		Lei Zhao, Di Guo
9. DCS		Russia		
10. In-beam Tests		Russia	Dementiev	Xiangming Sun
11. Services		Russia	Roslon	

# Ingredients: Mechanics Design

Achieved in 2019 – 2020 with support of RFBR grant:

- Design of the tracker mechanics - completed to 90%  
*More than 350 drawings of Tracker, Jigs and fixtures, Descriptions of production technology \**
- Physical computer simulations - *completed to 80%*



- Production of mechanics and cooling parts, jigs and fixtures - *just started \*\*\*)*



*\*) With strong contribution of S.N.Igolkin, SPbSU, SPb*

*\*\* ) V.Kondratiev et al. report to this conference*

*\*\*\*) See report of Alexey Voronin to the conference*



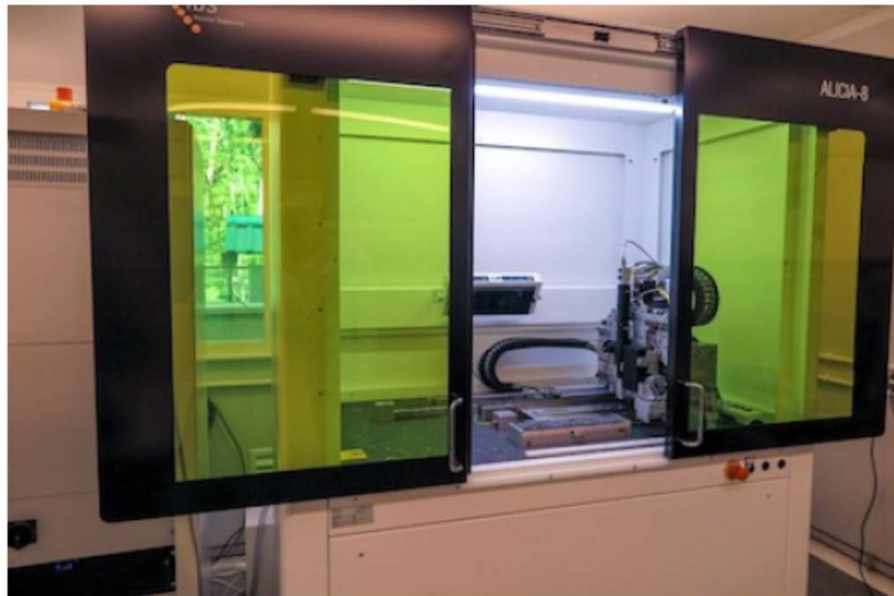
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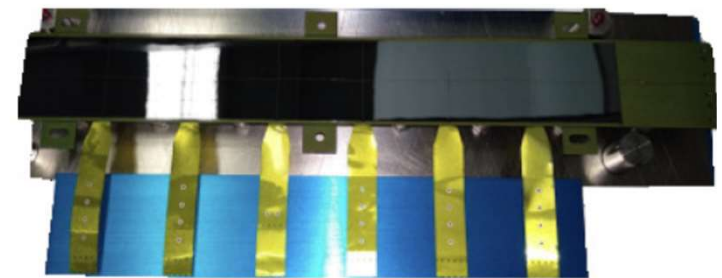


# ***Ingredients: Clean Rooms and Equipment for HIC assembly and QA test \*)***

**ALICIA-8**



**OB HIC**



*Assembly of HIC mockups with PAD-chips will start in January-February 2021 at JINR; CNUU is ready now*

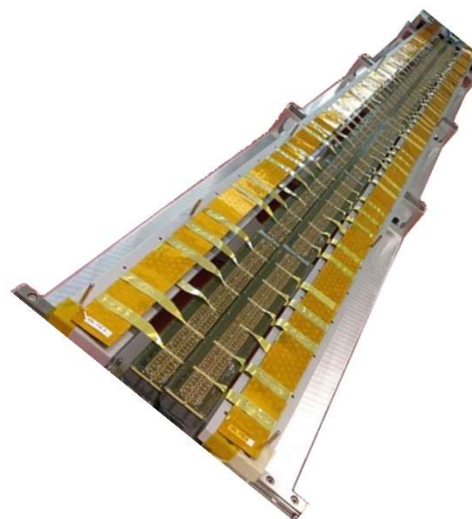
*\*) Aleksey Sheremetev et al. to this conference*

# ***Ingredients: Clean Rooms and Equipment for OB Stave assembly and QA test***

## ***Mitutoyo Crysta-Apex S9206***



## ***OB Stave***



***Assembly to start January 2022 after release of the TPC Assembly  
Clean Hall, basic equipment is in the house!***

Opened EC Grant “CREMLINPlus” position, additional training needed!

# ***Ingredients : qualified personal***



**The Dubna and Wuhan HIC Assembly teams**

# Monitoring the production of geographically separated sites

**KYBERNETIKA** s.r.o.  
Automatizované systémy riadenia

**Construction Management Information System**

**Customer** Joint Institute for Nuclear Research  
6 Joliot-Curie St  
Dubna  
Moscow Region  
Russia

**Contact person** Yuri Murin

**Date** 11. 11. 2019

**Authors** Ján Jadlovský  
Henrieta Telepovska  
Jakub Čerkala  
Vasil' Vančík

All-around multiple-projects handler.

It is composed of the following base modules:

- » Resources Module
  - » Members
  - » Institutes
- » Project Module
  - » Project Definition and Planning
  - » Project Management and Resources
  - » Construction Data
  - » Activities
  - » Finances
  - » Reports
- » Administration
- » Help

**Key persons:**  
**C.Ceballos, E.Tsapulina ,**  
**A.Kolzhvari**  
**+LIT team+KYBERNETIKA**

**Commissioning by the end 2020**

The Construction Management Information System (CMIS) adopted by the STS department and LIT for the NICA projects at JINR is an Oracle-based all-around project management database system that allows the organization and follow-up of every aspect of the project.

It will be hosted at LIT JINR and is the same one that is being used by the ALICE collaboration at CERN for the production of the ITS2 and MFT detectors.



# ***Flow of components and infrastructure readiness***

**Components, equipment, training of the personal completed or close to the completion**

- **Custom designed Items** are shipped from **CERN** in accordance with the Protocol
  - *will be completed by the end of 2020*
- **Procurement** all basic commercially available equipment - *completed to 95%* allows to start the assembly of HICs mockup at JINR in first Quarter of 2021.
- **CF lamination** workshop *is fully equipped and starts production* with three more engineers recruited for the EC CREMLINplus grant (WP7)
- **Training of two persons** at CERN assembly and CF lamination lab *completed*
- **CMIS** for monitoring the construction in of the ITS in Russia and China – *to be commissioned by the end of the year*

## **Still in need and planned for completion in 2021**

- Increase of clean rooms area needed for testing the HICs
- Release of large area ISO8 cleanroom by the TPC team and a start of staves assembly at LHEP – *planned for early 2022*
- Design of the staves Readout Scheme and start of its realization – *just started*





# ***Bottlenecks and ways for remedy***

## **“the dual-usage items problem”**

- 19'000 ALPIDE chips produced by TowerJazz in Israel were banned for export to Russia – our appeal failed, the question raised to the state diplomatic level for final statement of exception or final ban, preparations started for production of non-radiation hard NICA MAPS at Towers, proposal of China to develop the NICA-MAPS at the Chinese foundry
- MJ-55 TorayCA CF thread was banned for export to RUSSIA – solution found with NIIKAM
- EX1515 adhesive is banned for export to RUSSIA – solution found with NIIKAM
- K12D2U Mitsubishi thermo-conductive CF prepreg was banned for export to RUSSIA  
**An attempt to work out a substituting technical solution\*)**

***\*) A report of Alexey Voronin to the conference***



***RFBR grants for NICA, 20-23.10.2020***



# ***Achieved in 2019 – 2020 with support of RFBR grant***

## **Achieved in 2019 – 2020 with support of RFBR grant:**

- Design of the tracker mechanics - completed to 80% , production just started
- Physical computer simulations - completed to 95% (three papers, several reports)
- TDR draft written to 75% and will be delayed by half a year due to pandemic
- LV- and HV power supplies schemes developed, CAEN system procured to be used for DCS development bench
- CMIS for monitoring the construction in of the ITS in Russia and China is close to finalization

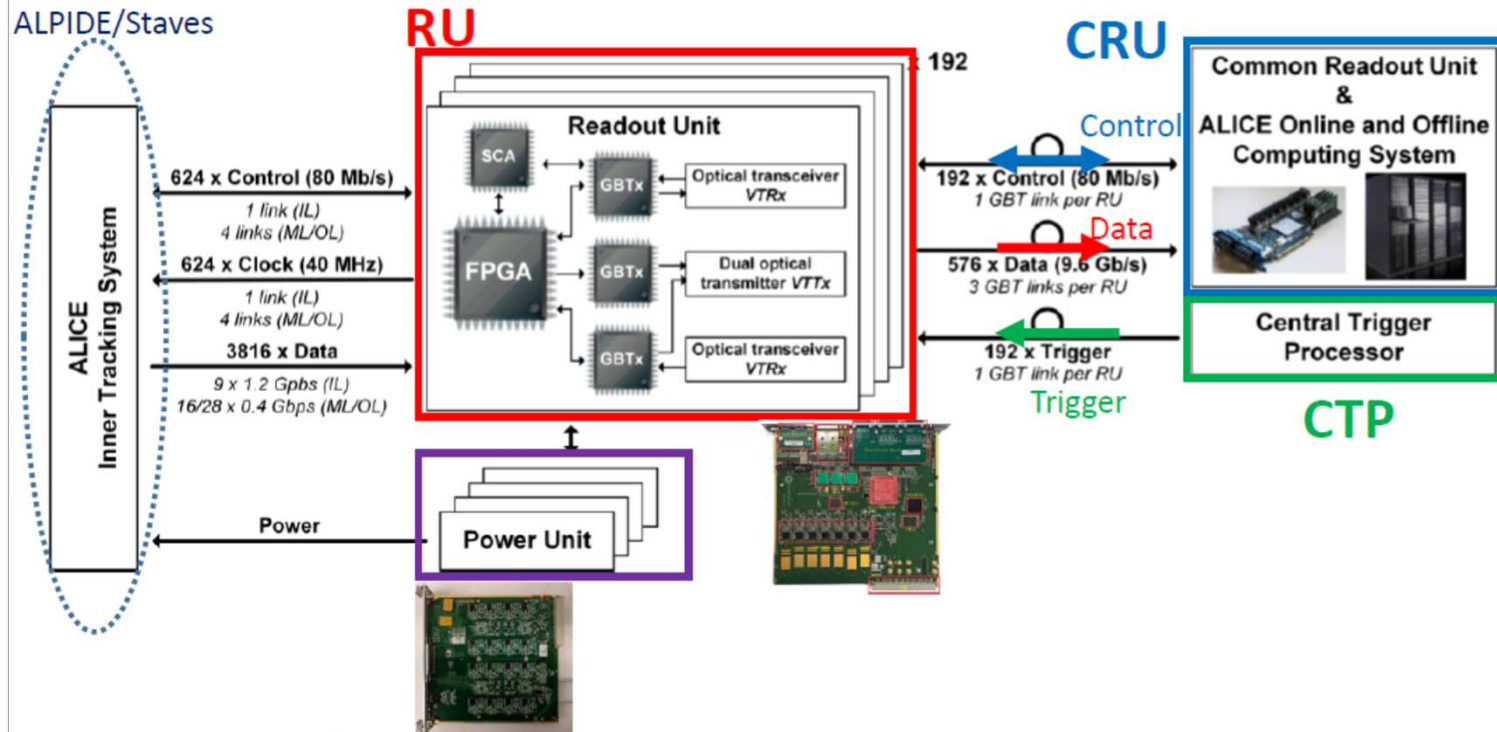
# ***Planned for 2021 with support of RFBR grant***

**With support of the RFBR (*support of young scientists*)  
and CREMLINplus grants (*hiring experts and technical personal*):**

- Production of major mechanical parts of the tracker, including jigs and fixtures
- Trying the integration procedure of the BP-ITS-2FFD cage with TPC mockup
- Infrastructure expansion – new clean rooms area, two Delvotecs for increasing the productivity of the HIC assembly sites
- Beginning of mass production of HICs in Russia and China under control of CMIS deployed at LIT
- *WinCC OA DCS development (together with WUT)*
- *Gas cooling system development and testing (together with WUT)*
- *Liquid leakless cooling plant*
- *Development of readout scheme (together with USTC, GSI and WUT)*

# Planned beyond .....

## Readout Electronics System

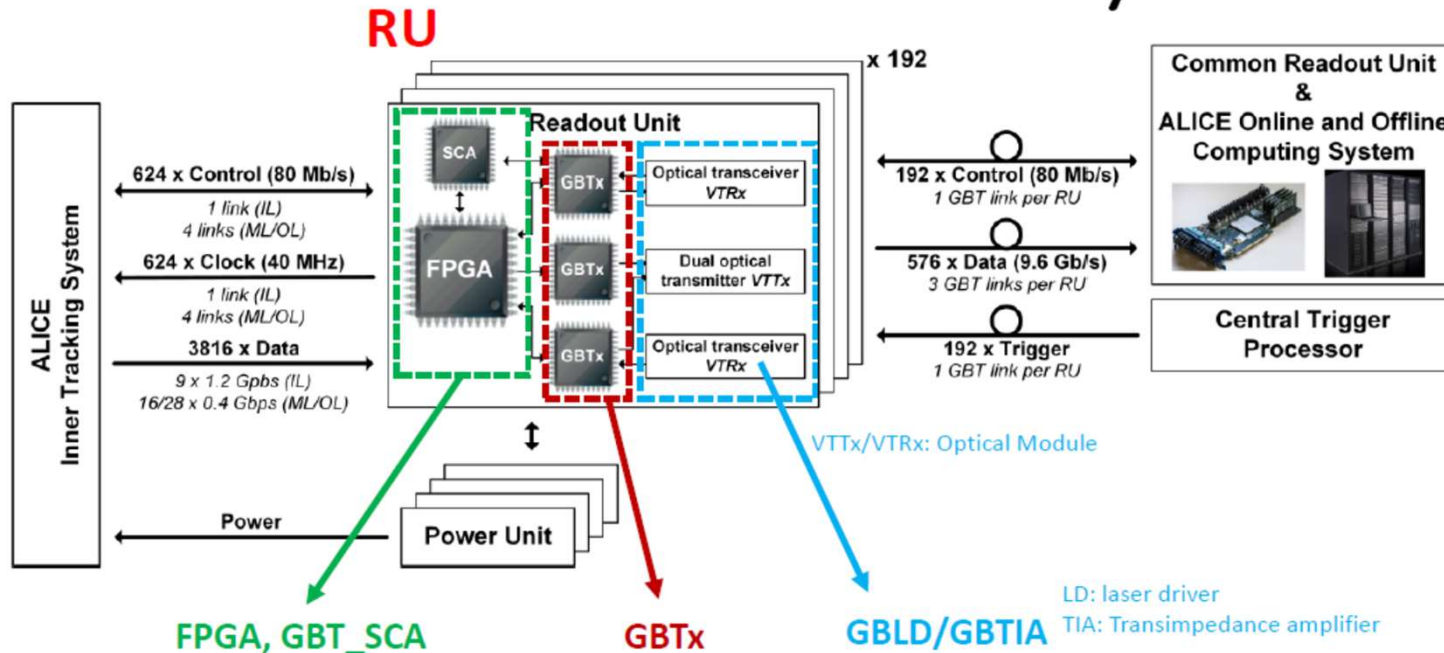


**RU, CRU, CTP boards.**

The **readout unit (RU)** board is located between the front-end and the back-end (CRU/CTP). It is tasked with controlling and gathering data from the front-end ALPIDE sensor chips on the staves. RU communicates with CRU and CTP through bidirectional optical links (GBT link).

# Planned beyond .....

## ASICs in Readout Electronics System



Related ASICs are located in RU boards as shown above.

- GBLD/GBTIA: driving and receiving ASICs for optical transceiver → NICA\_LD/TIA Optical modules
- GBTx: Bi-directional data interface ASIC → NICA\_GBT
- GBT\_SCA: slow control ASIC (SCA)
- FPGA: pre-process of the front-end data → NICA\_ROC





*Thank you for attention*