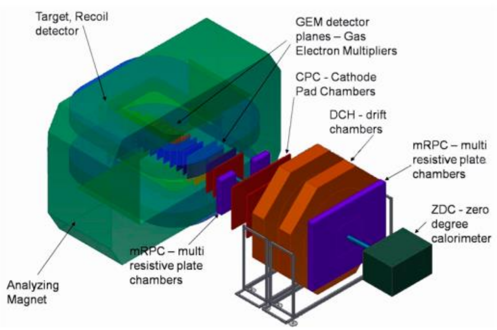
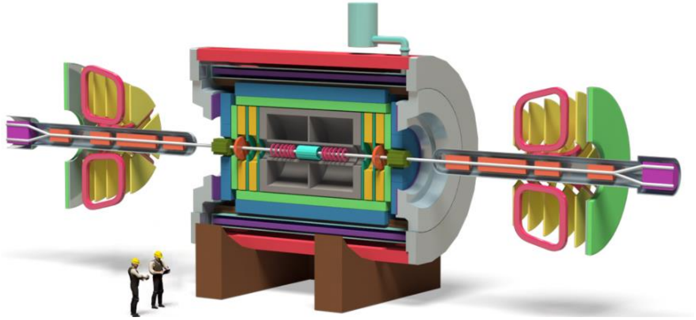
Large Aperture Silicon Tracking Systems for NICA with emphasis on the MPD/ITS



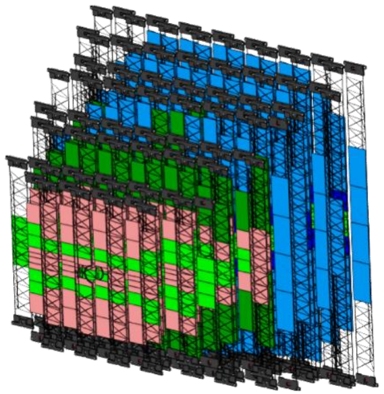


Yu. Murin / D.Dementev
for JINR STS team
JINR LHEP

SPD Pow-Wow
VB LHEP, 03/07/ 2018

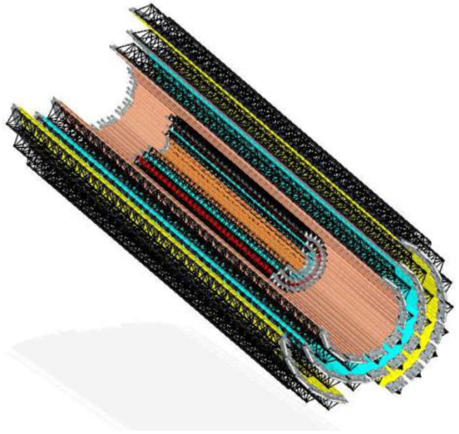
Three pillars of the STS Department

Today



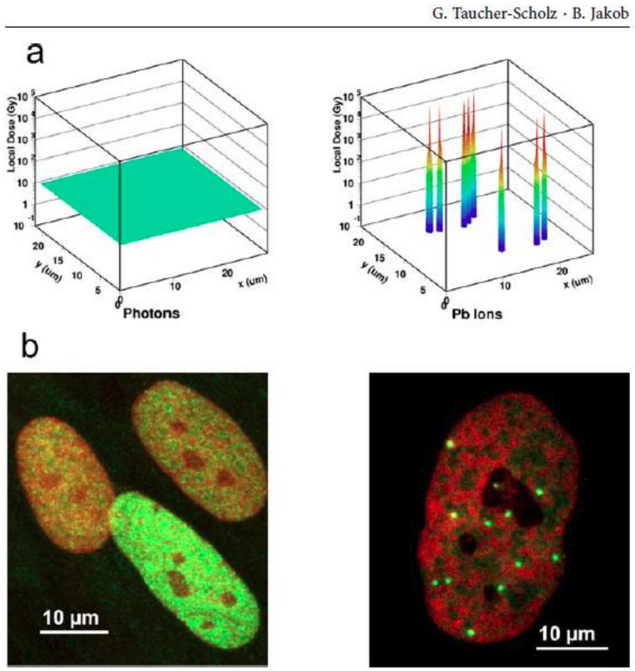
BM@N-2 / CBM

Tomorow



MPD/ITS

Day after



„Innovative“ projects

At the start three years ago

Status as today….

- **Silicon Tracking Systems (BM@N-STS and MPD-ITS)**
  - **Assembly of modules and super-modules (5): A. Sheremetev, Elsha,Sukhov, Semchukova,Andreeva**
  - **Mechanics of Composite Materials(1): A. Voronin**
  - **Bench and in-beam testing group (3): Dementyev, Kolozhvari, Shitenkow**
  - **Quality assurance of sensors (4): Zamiatin, Merkin (SINP), Sheremeteva, Streletskaya**

- **Administration, civil construction and procurements support(4): Murin, Gaganova, V. Penkin , S.Udovenko**
- **Industry partners(3): LTU (Kharkov), Planar enterprise (Minsk), NIIKAM(Pereslavl-Zalesky)**

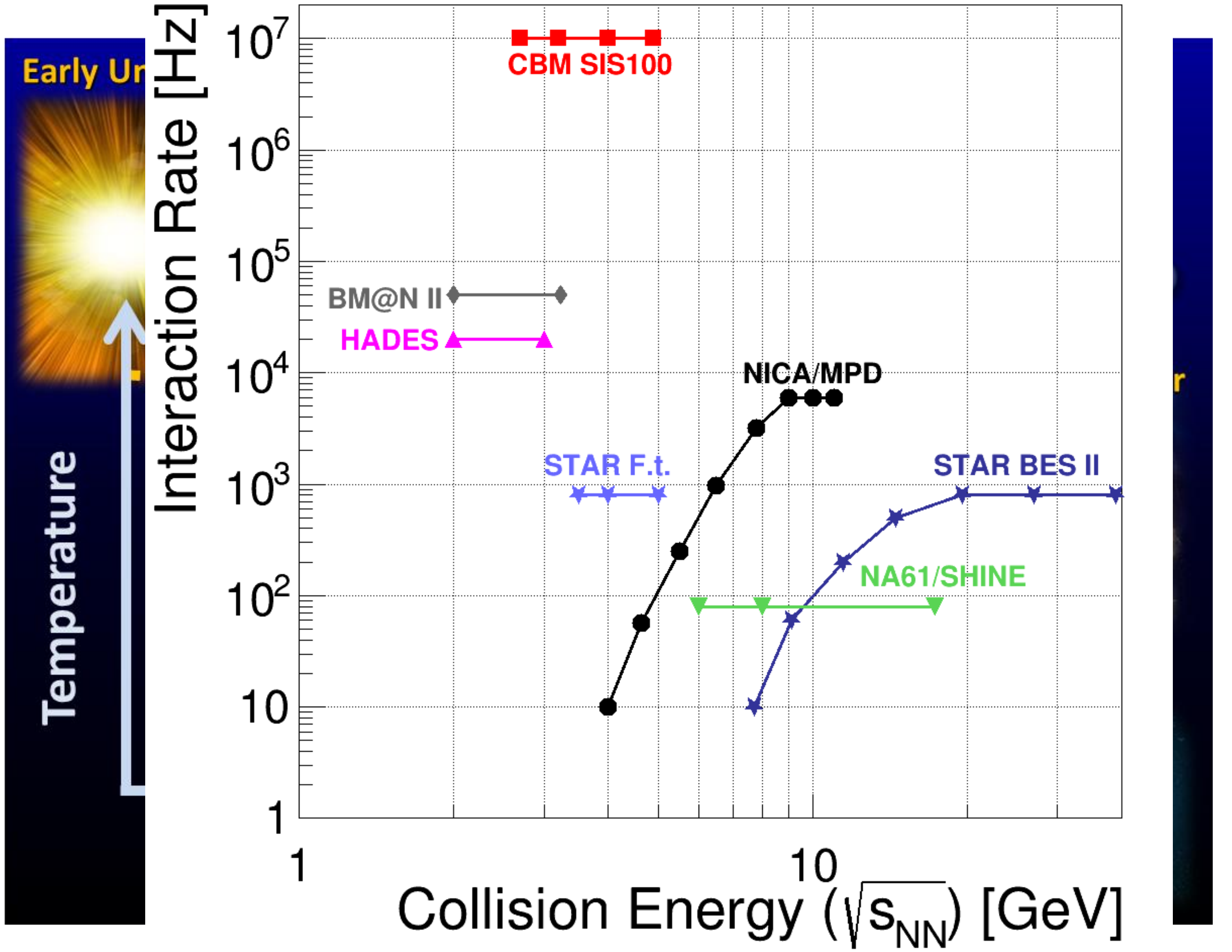
Physics case

main goal

study of hot baryonic matter at the region of max baryonic density

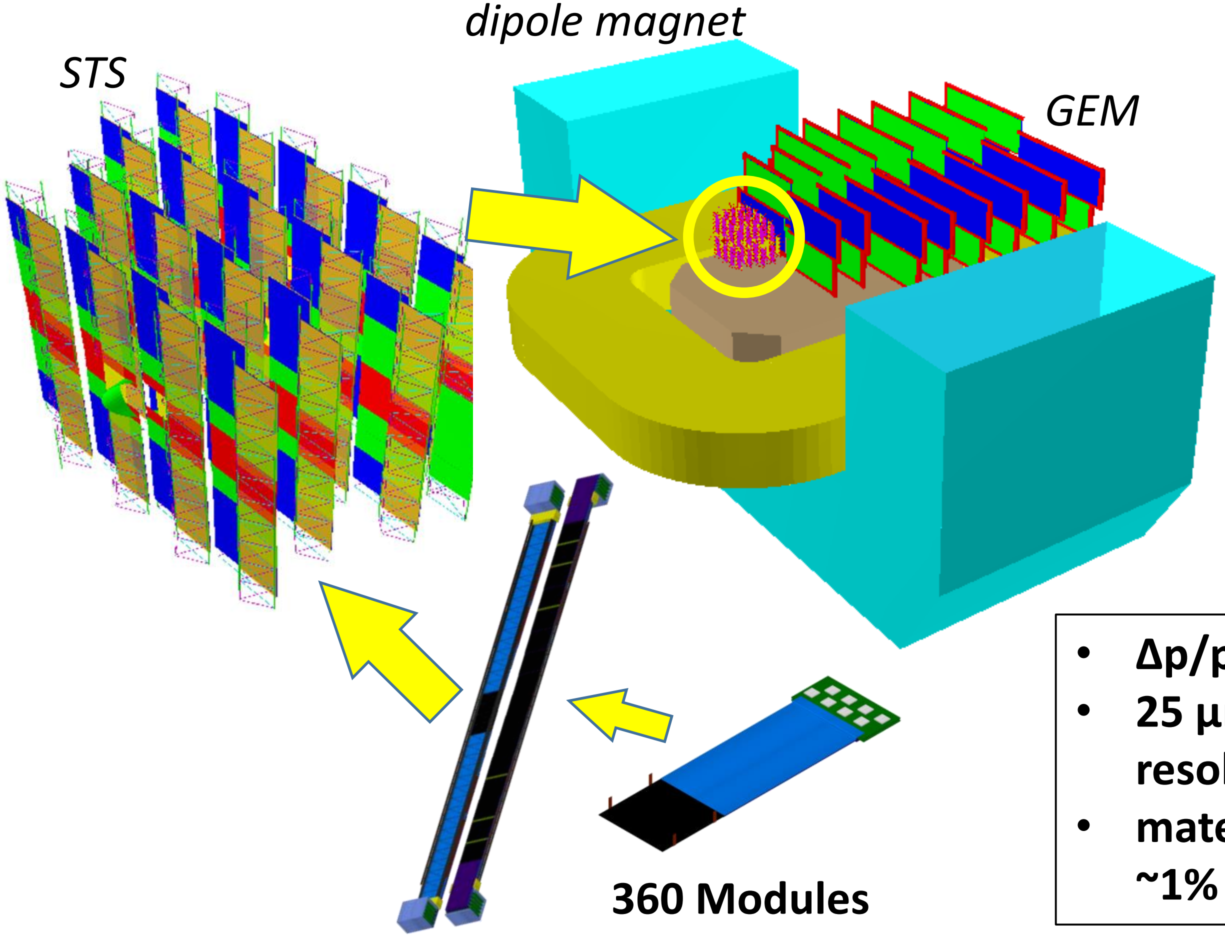
through the tasks

- *equation of state*
- *onset of deconfinement*
- *onset of chiral symmetry restoration*
- *first order phase transition observation*
- *search for critical end-point*
- *polarization phenomena*

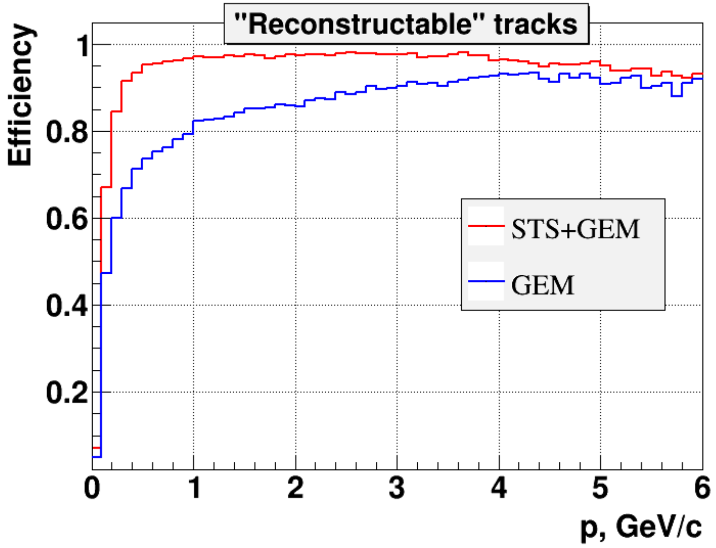


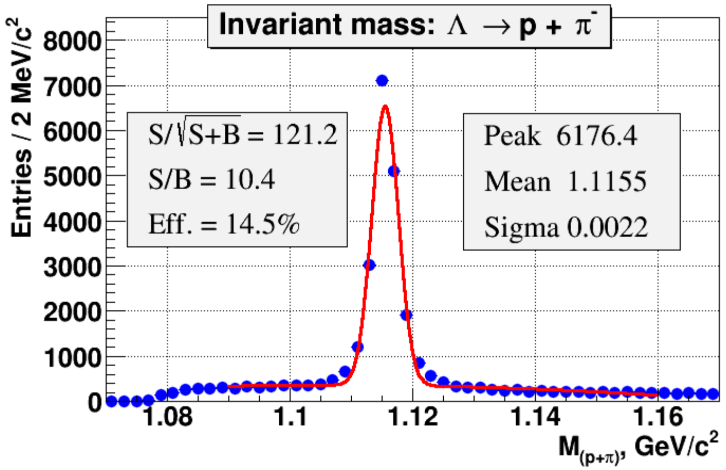
STS for BM@N experiment

Mutual interest by CBM groups from Germany and Russia to install, commission and use 4 CBM-like Silicon Tracking Stations in BM@N in 2020.



- **Δp/p ≈ 1%**
- **25 μm single-hit spatial resolution**
- **material budget per station ~1% X0**

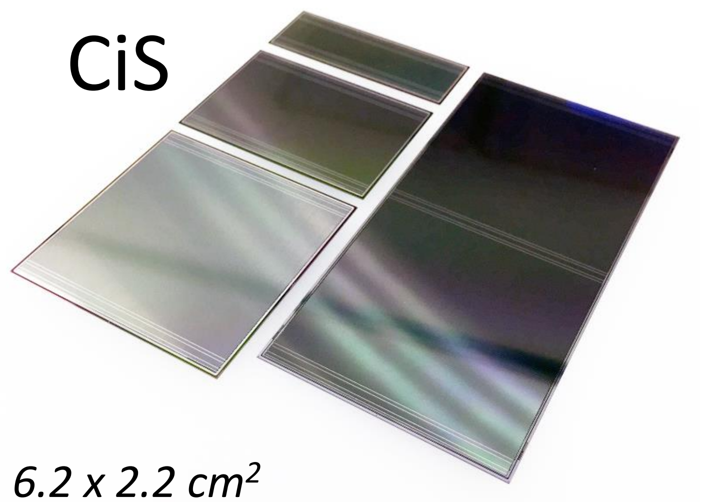




Slide by J. Heuser

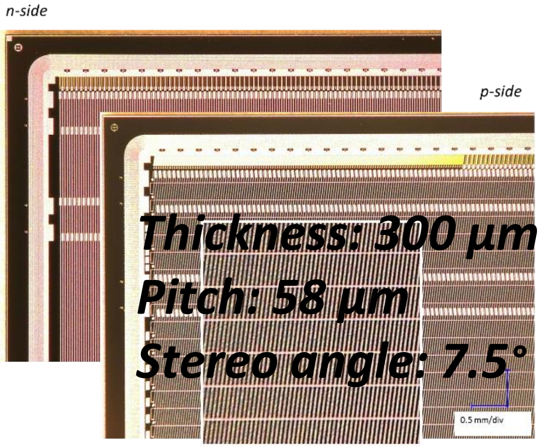
Sensors

CiS



6.2 x 2.2 cm²
6.2 x 4.2 cm²
6.2 x 6.2 cm²

Hamamatsu

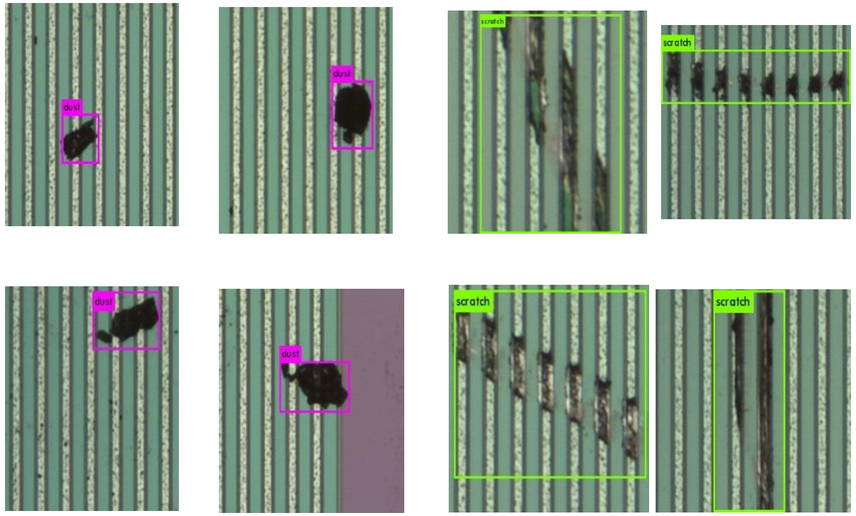


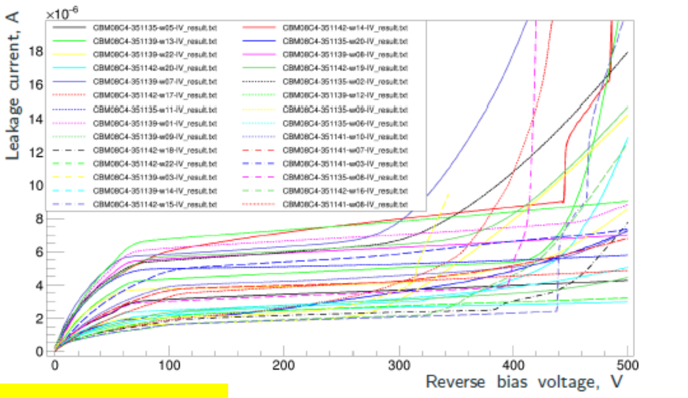
Quality assurance of the sensors

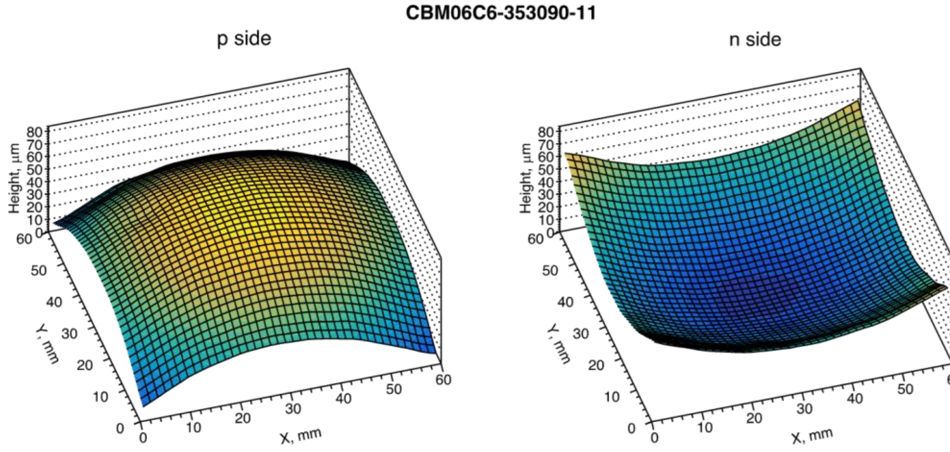
- Final product inspection at the vendors: detailed data
- Quality inspection at JINR has been advanced:

  full inspection during prototyping, sample tests during series production

  – *sophisticated optical and electrical methods established*
  – *charge collection tests before/after irradiation, S/N determination*



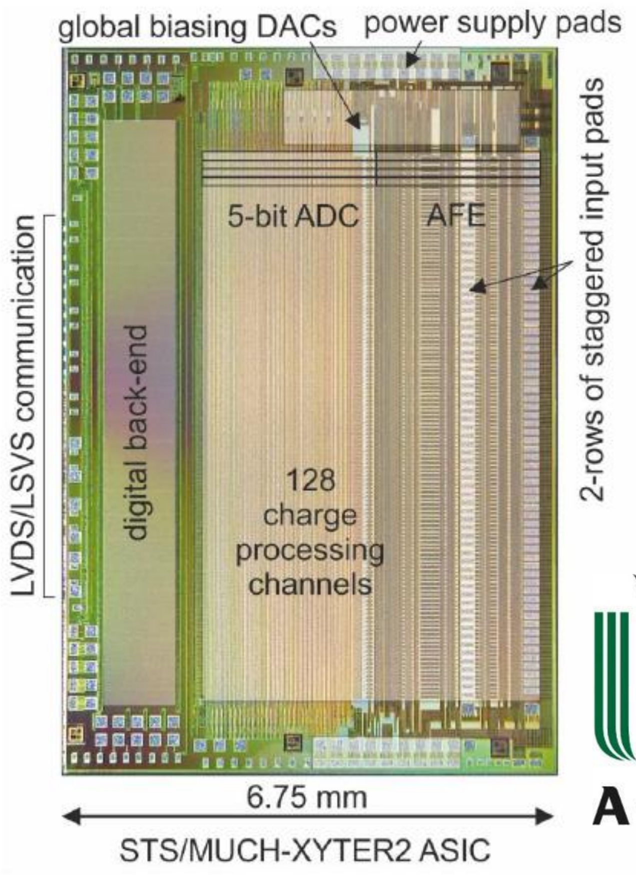




400 sensors are already ordered and arrived at JINR

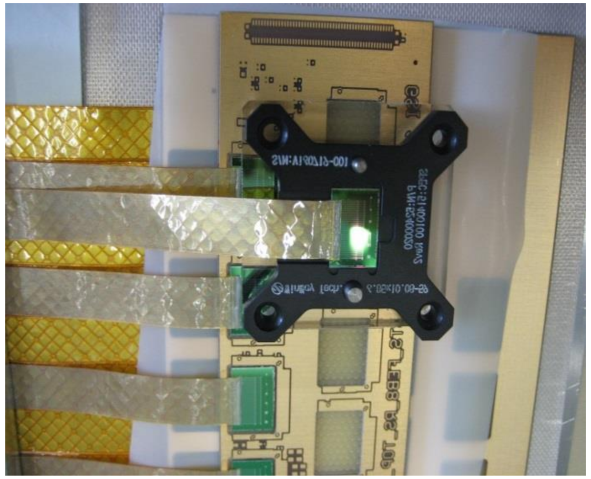
STSXYTER ASIC

produced in 9/2016



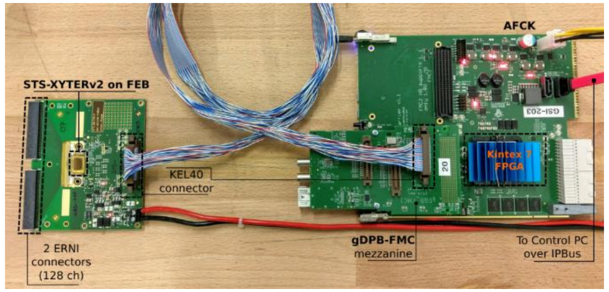
AGH

- 128 channels+ 2 test channels
- Self triggered architecture
- Maximum data rate: 250 kHz/channel
- 5-bit amplitude measurement
  - shaper_{slow}+ ADC
- time stamp measurement
  - shaper_{fast} + discriminator
- Dynamic range: 16 fQ at STS mode
- Noise performance: 1000 enc at 30 pF input
- Time stamp resolution: 1 ns

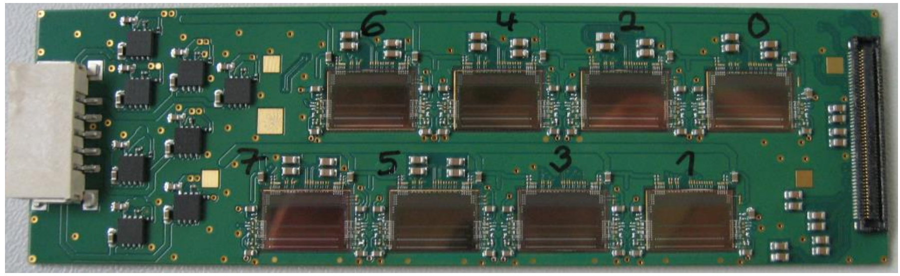


Test socket for the ASIC-tab-bonds

FEB board with 1 STSXYTER ASIC



Test bench for characterization of the ASIC

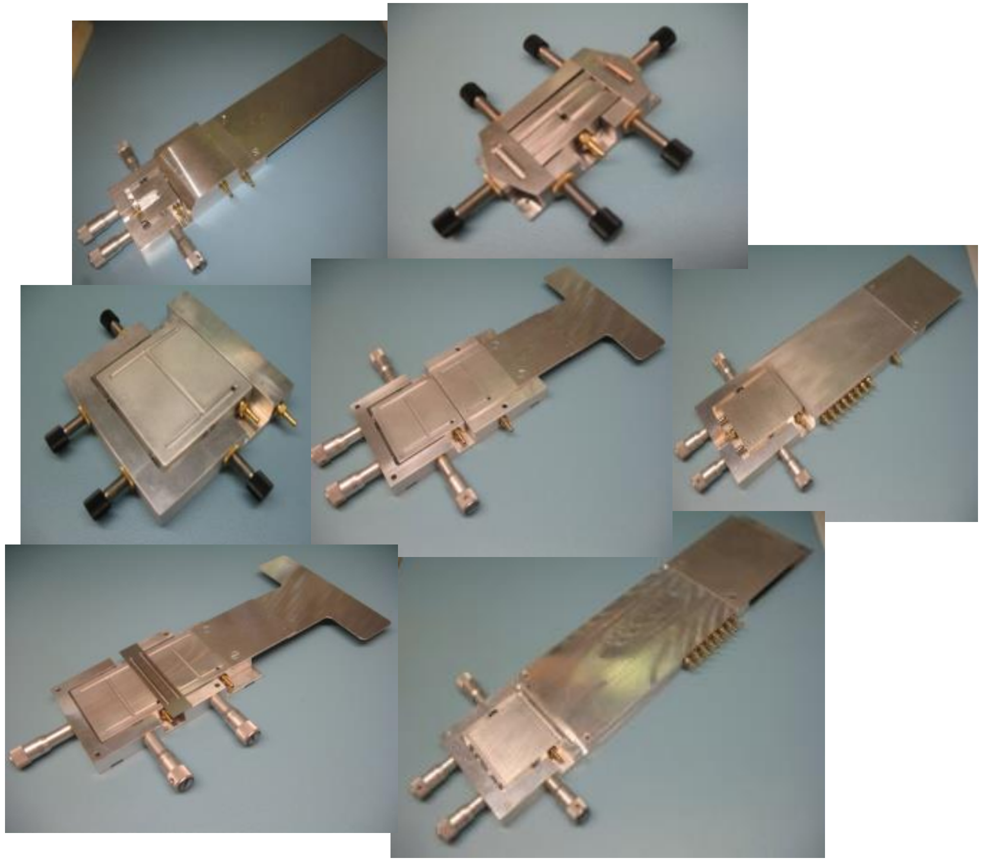


FEB board with 8 ASICs

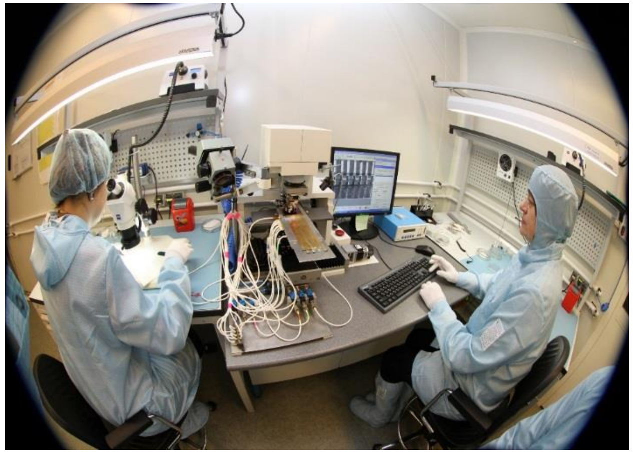
Module assembly site at JINR LHEP

The main room (90m^2) is class 7 ISO (less than 10 000 p/ft^3 < 0.5 mkm)

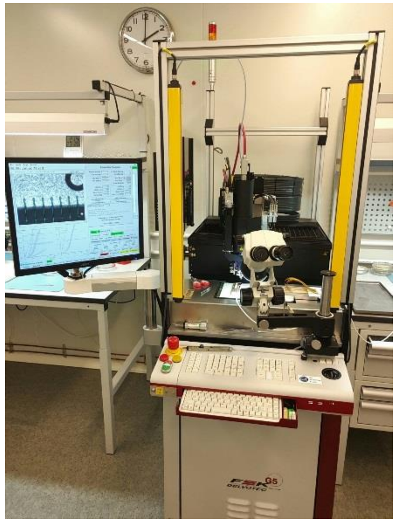
4 technicians are currently involved in module assembling



jigs for the module assembling

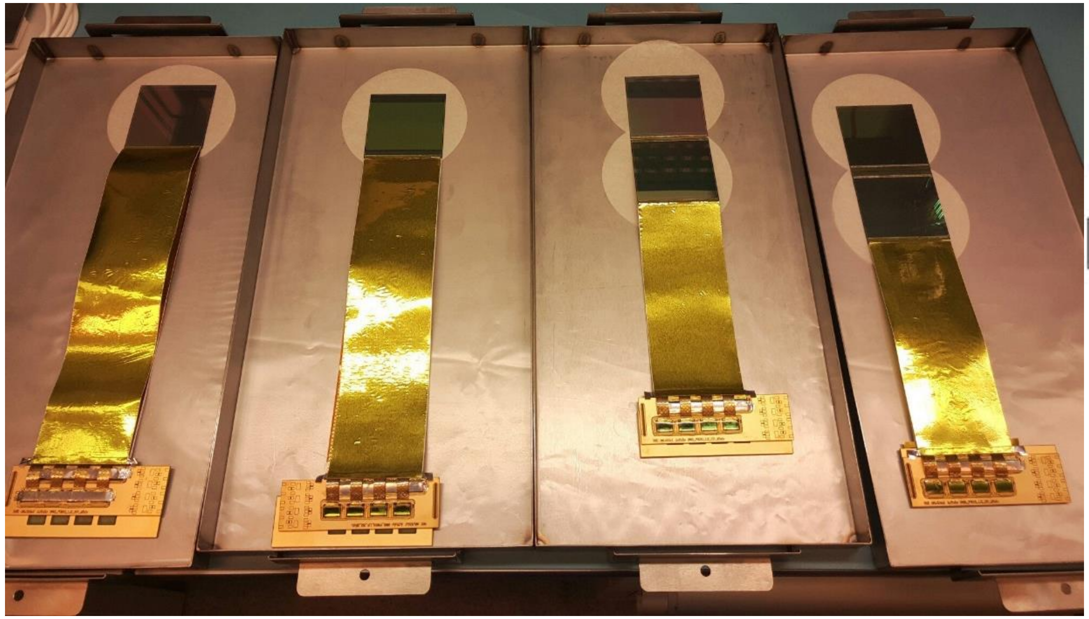


Modules



Wirebonder F&K Delvotec G5

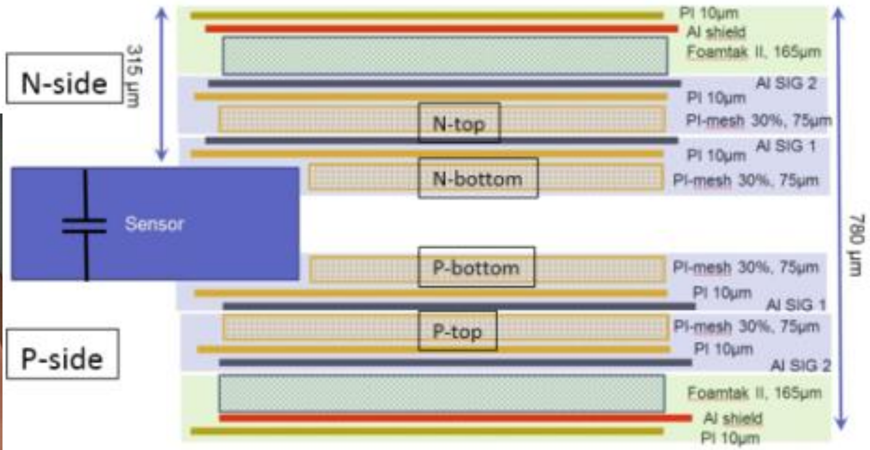
TabBonder Planar EM-437



Mockups of the STS modules

About 420 components are in assembly process at different stages

Microcables from Al-polyimide

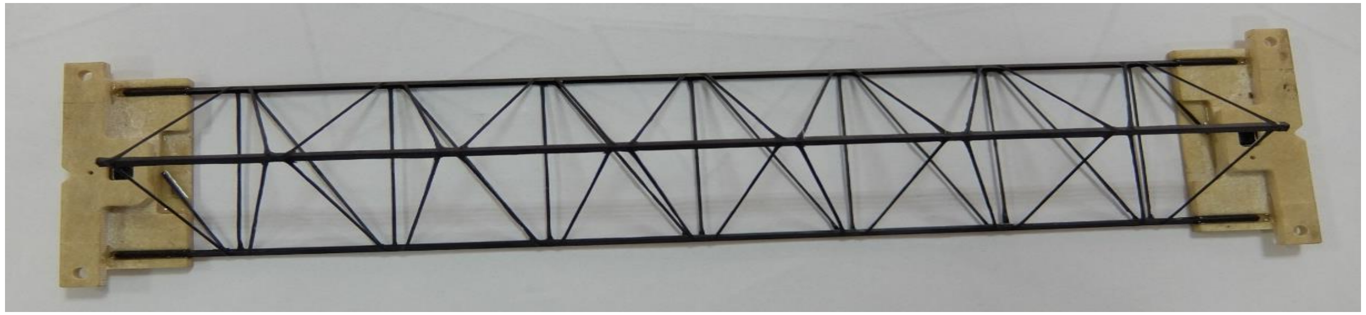


Measurement:

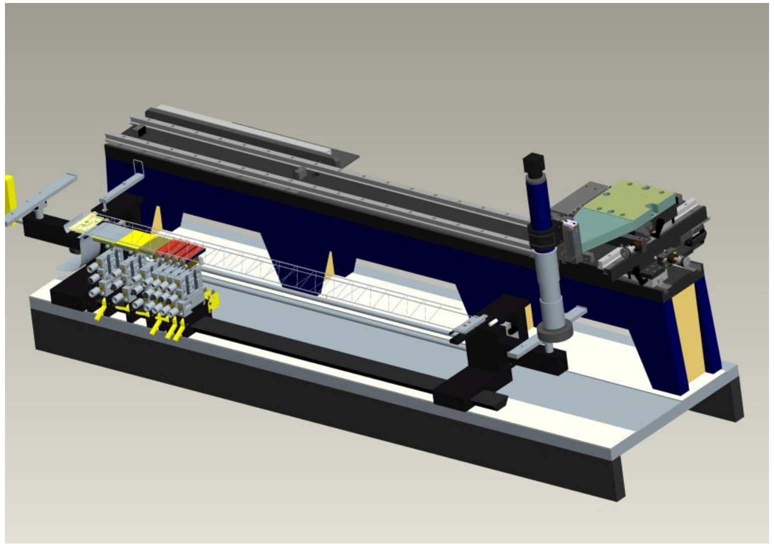
C_line = 0.38pF/cm

distance between traces varies from 74 to 82 µm

Ladder assembly



Design by S. Igolkin (CERN)

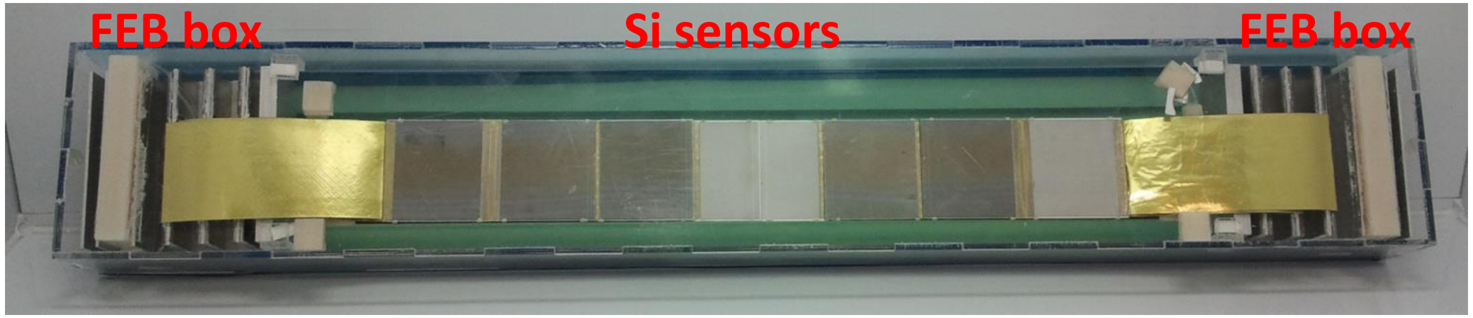


Ladder assembly device

Material: CF prepreg M55J/ 334EU
Modulus of composite 32800Gpa

Total weight: 10,4 g/m

40 CF frames were already produced (this is already enough for BM@N, production for the CBM@FAIR is under discussion)



Mockup of the ladder

The precision of the sensor orientation:

X coordinate	±50 mkm
Y coordinate	±15 mkm on 1200 mm base
	±12 mkm on 180 mm base
Z coordinate	±50 mkm

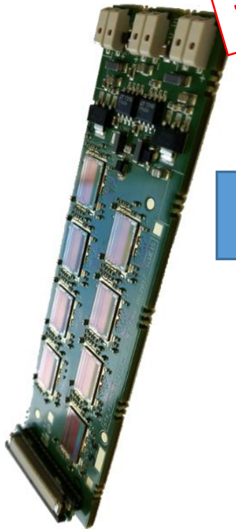
Detector readout chain

STS modules
8 STS-XYTER
v2.0 on FEB-8

Common GBTx Readout Board
- based on radiation hard GBT and Versatile Link comp
developed at C
→ all
currently
and commissioned
OB - larger than final board)

GBTx ASIC military graded by IBM! Banned for export to Russia

LES IN node with FLIBs



Copper link

Longer cables (~5 m)
80 Mbit/s per link
instead of 320 Mbit/s

Xilinx Artix 7 FPGA board

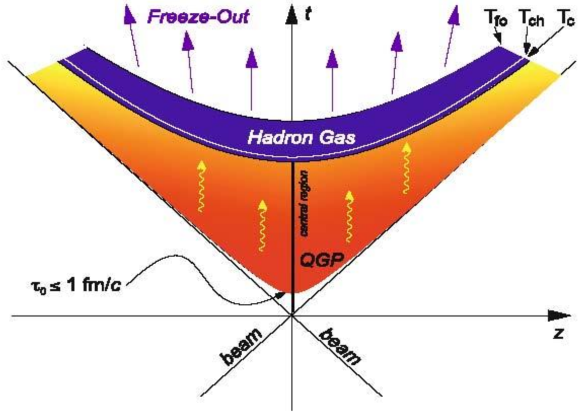
Optical link

on detector

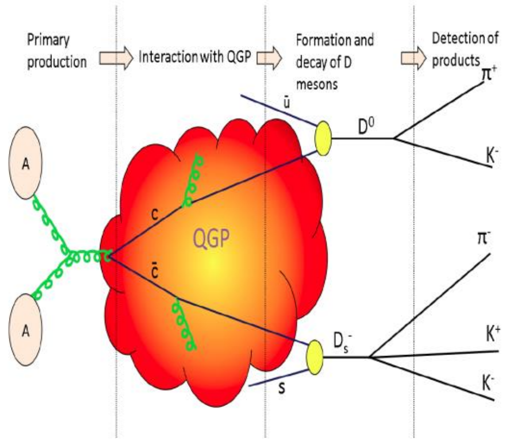
off detector

Physics motivation for a study of charm production at NICA

Heavy charm quarks are produced at the very initial stage of the collision of the heavy ions to witness the CBM(NICA,FAIR) or QGP (RHIC,CERN) . C-quarks re-scattering by CBM is the right way to study CBM at NICA

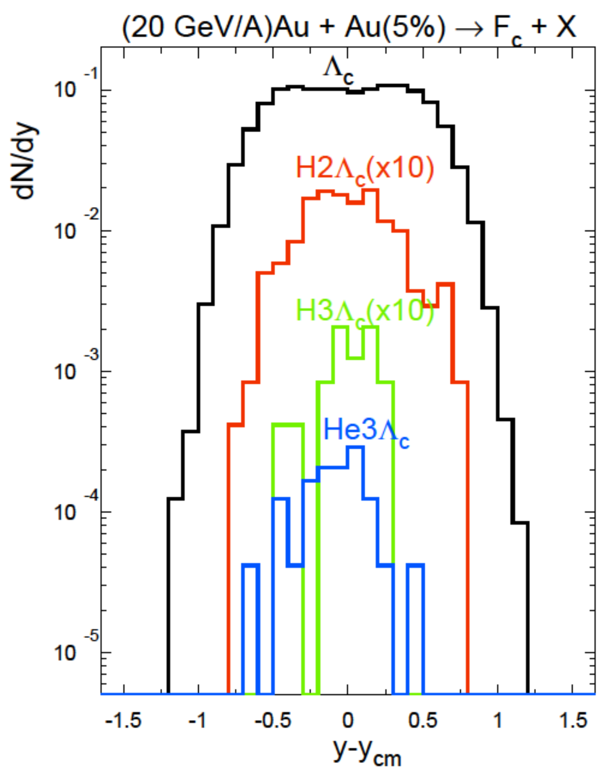


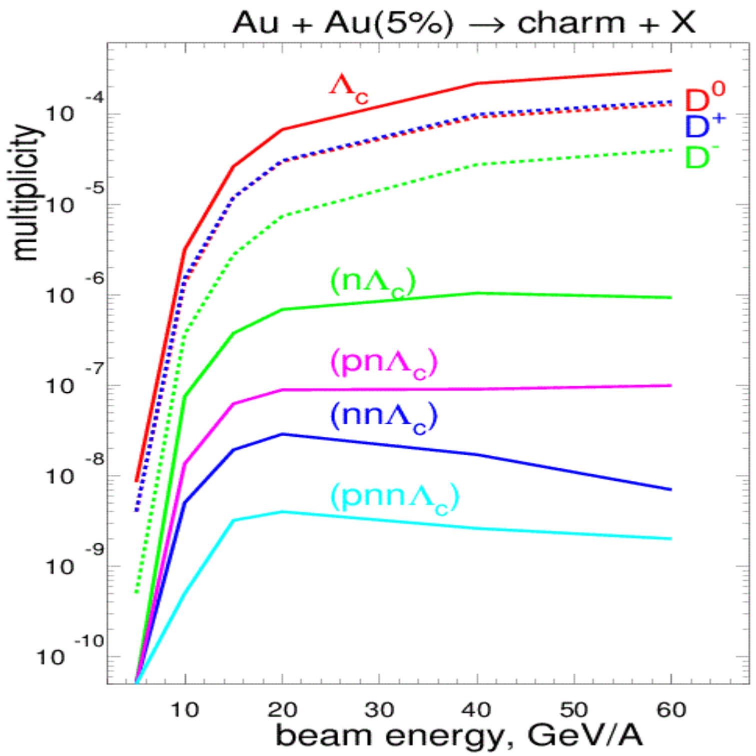
C-quarks interaction with cold nuclear matter has an exciting perspective at NICA since the estimated yields for the production of the hypothetical light supernuclei $_cHe^3$ and $_cHe^4$ indicated feasibility of the experimental search at NICA and not anywhere else at the moment



From the experimental point of view production of open-charm particles in the energy range of NICA is a complete *terra incognita*

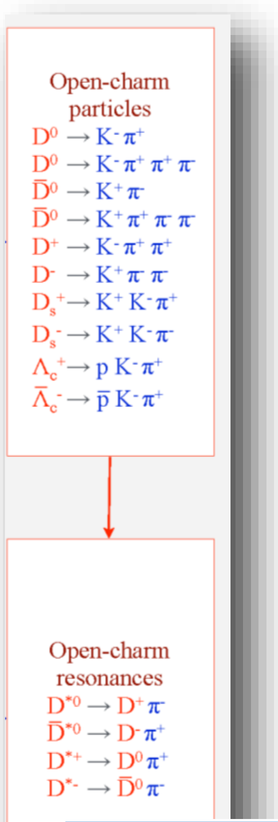
Physics motivation for a study of charm in cold nuclear matter

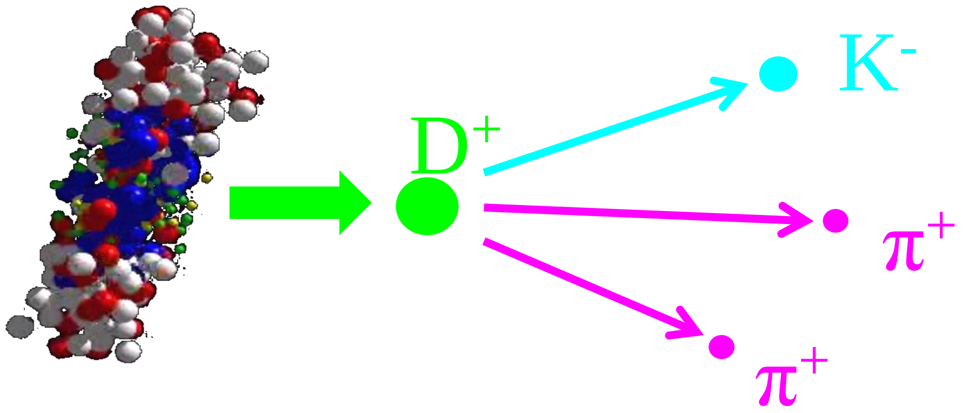




Dubna model and coalescense by late K.Gudima

Expected yields of the C-probes

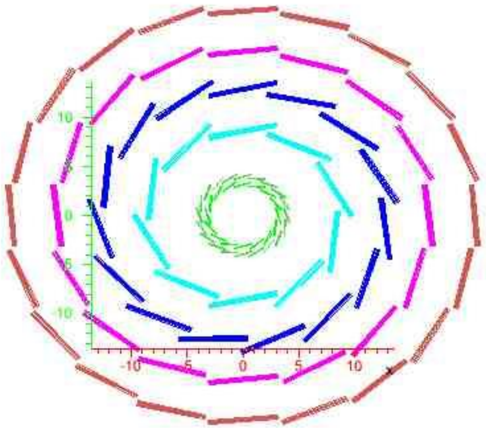




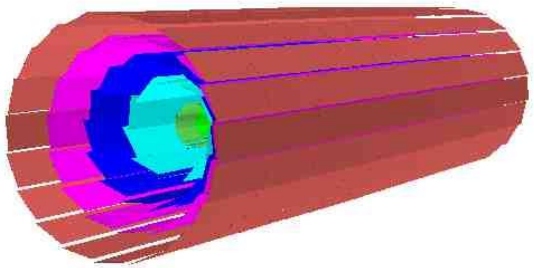
At the highest energies NICA luminosity will reach values of $L=10^{27}$ cm^2s^{-1} and the gold-gold collision rate of 5 kHz with the estimates for the number of registered open-charm particles in a two-week run of NICA/MPD as follows

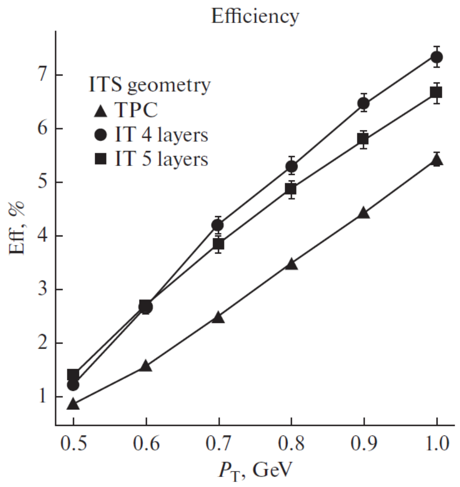
Decay	Multiplicity	cτ, μ	BR,%	Eff,%	Number of events
$D^0 \to K^+\pi^-$	0,1	123	4	2	48 10^3
$\bar{D}^0 \to K^-\pi^+$ (Dbar⁰->K⁻π+)	0,1	123	4	2	48 10^3
$D^+ \to K^+ \pi^-\pi^+$	0,1	312	7	1,5	63,5 10^3
$D^- \to K^- \pi^-\pi^+$	0,1	312	7	1,5	63,5 10^3
$D^+_s \to K^+ K^- \pi^+$	0,1	150	3	1,5	27,2 10^3
$\Lambda^+_c \to pK^+ \pi^-$	10^{-3}	60	6	0,1	363
Λbar^+_c-> pbarK$^-$ π+	10^{-3}	60	6	0,1	363
$_cHe^3 \to d+pK^+ \pi^-$	10^{-4}	60?	?	?	3,6 (?)
$_cHe^4 \to t+pK^+ \pi^-$	10^{-5}	60?	?	?	0,36 (?)

MPD ITS Version “DSSD” - now obsolete!

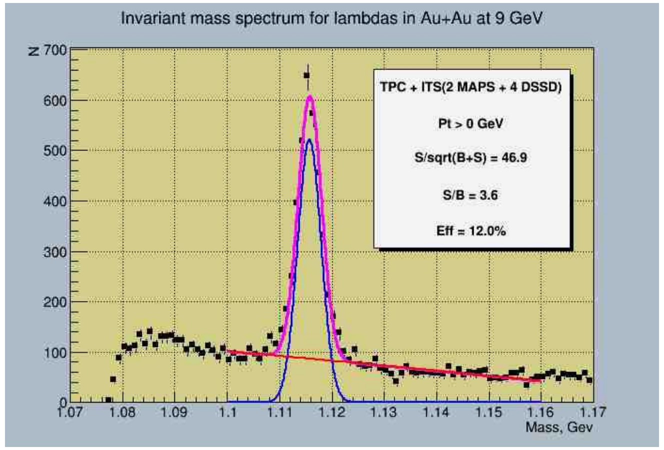


Six layers of CBM STS-like modules





Λ^0 -hyperon reconstruction efficiencies for different IT geometries

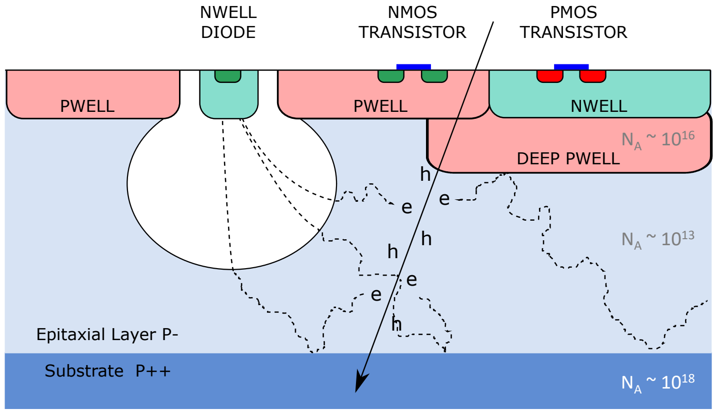


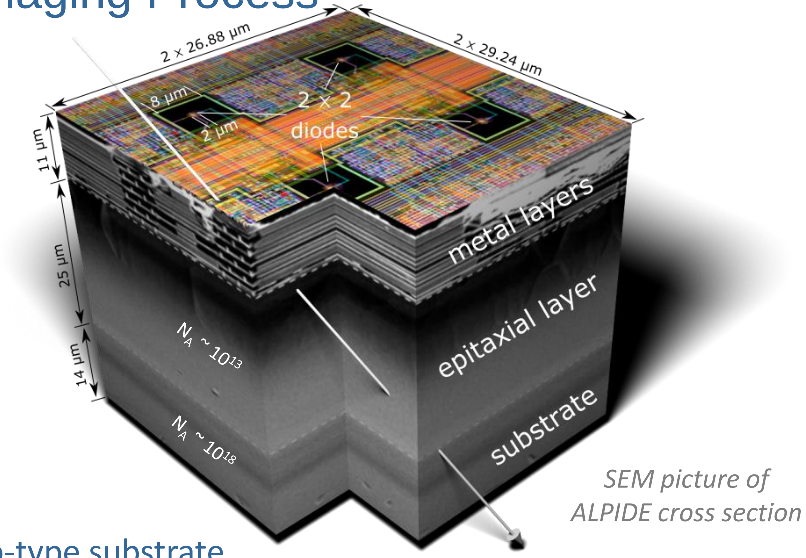
Reconstructed Λ-hyperon invariant mass spectrum
(p_t<0.6 Gev)

A. Zinchenko, V.Kondratiev et al.

ALICE Monolithic Pixel Detector

CMOS Pixel Sensor using 0.18μm CMOS Imaging Process



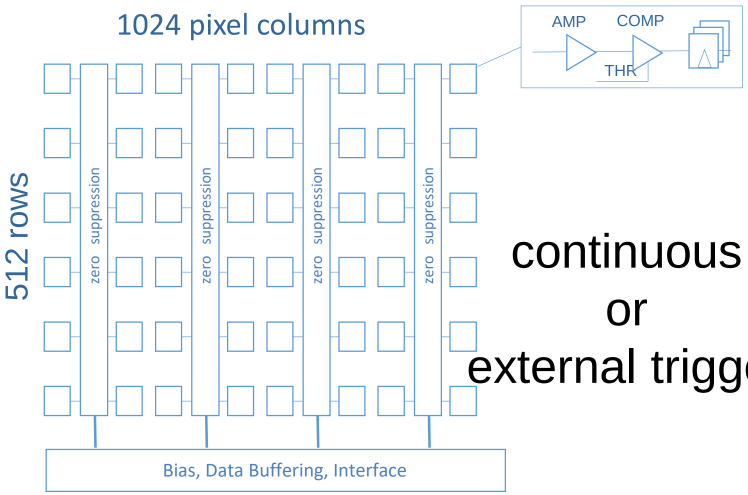


SEM picture of ALPIDE cross section

- High-resistivity (> 1kΩ cm) p-type epitaxial layer (25μm) on p-type substrate
- Small n-well diode (2 μm diameter), ~100 times smaller than pixel => low capacitance (~fF)
- Reverse bias voltage (-6V < V_{BB} < 0V) to substrate (contact from the top) to increase depletion zone around NWELL collection diode
- Deep PWELL shields NWELL of PMOS transistors

➔ full CMOS circuitry within active area

ALPIDE – **ALice PIxel DEtector**



continuous
or
external trigger

50μm thick

130,000 pixels / cm^2 O(30x30x30 μm^3)

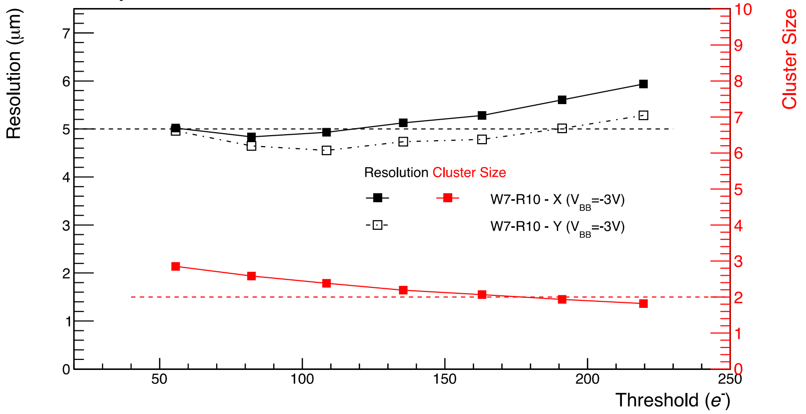
spatial resolution: ~ 5 μm (3-D)

Max particle rate: 100 MHz / cm^2

fake-hit rate: < 10^{-10} pixel / event

Power : ~ 300 nW /pixel

Spatial Resolution & Cluster Size



New ALICE ITS in a nutshell

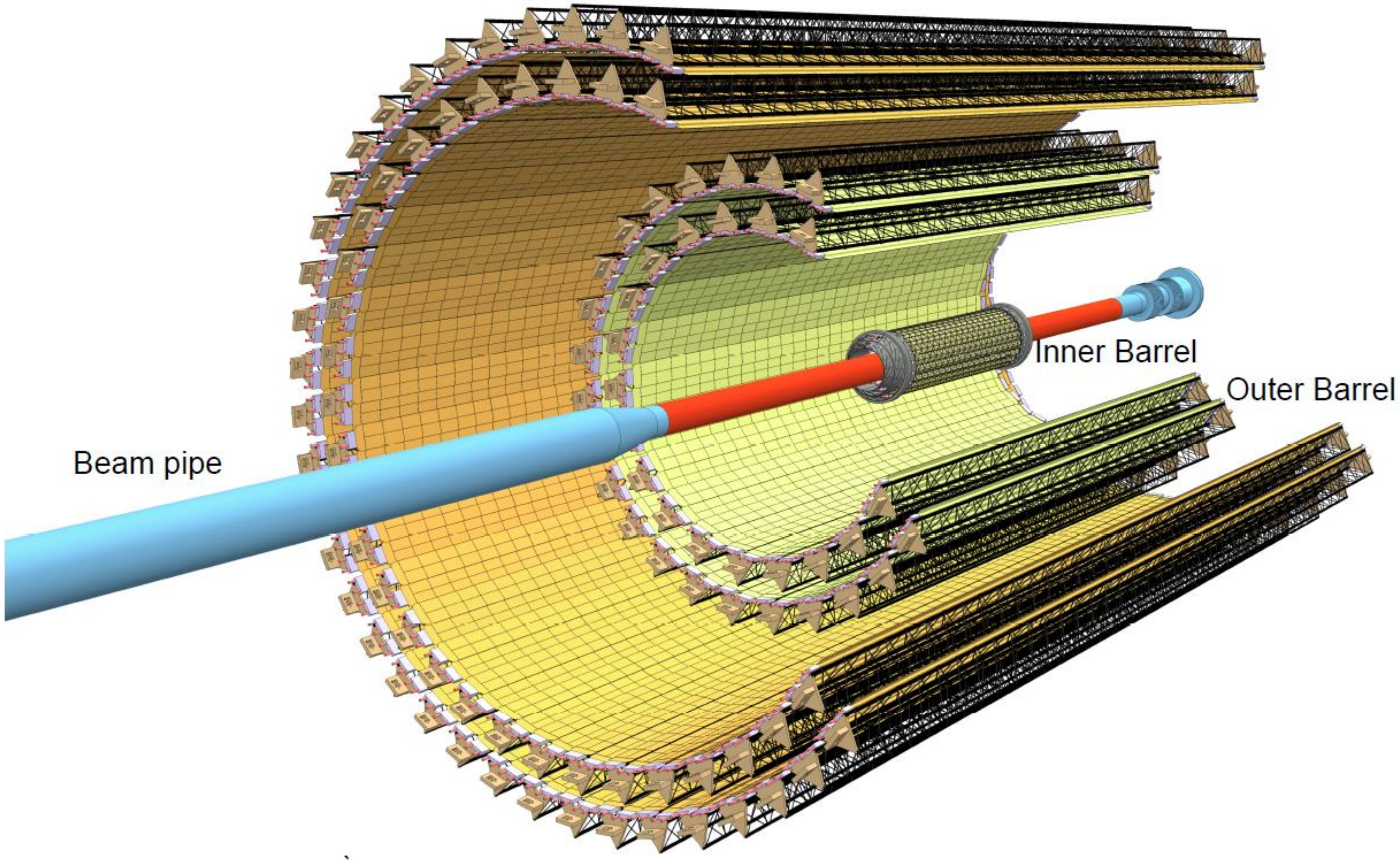


Figure 1.1: Layout of the new ITS detector.

New ALICE ITS in a nutshell

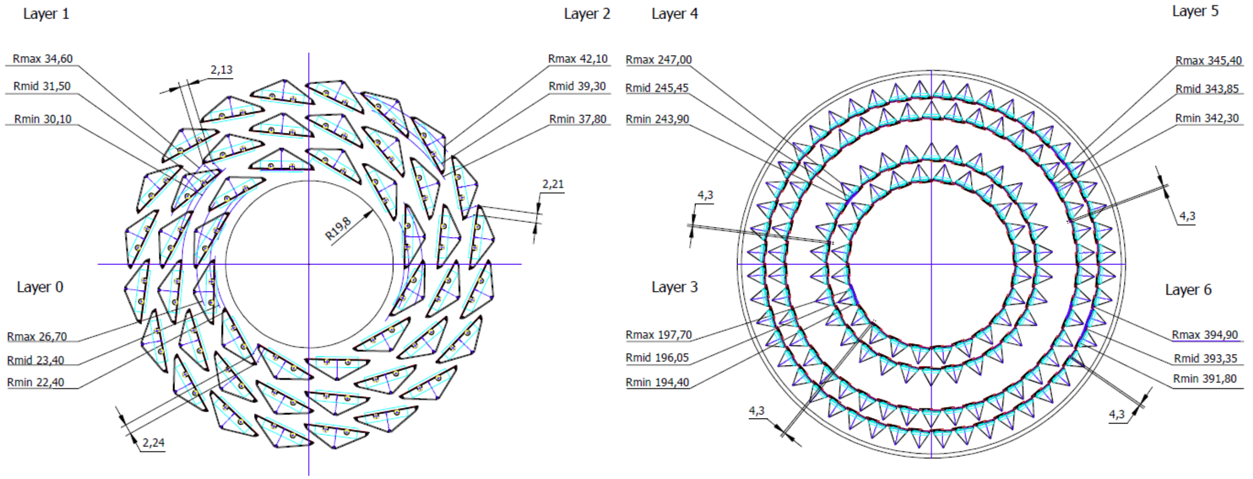
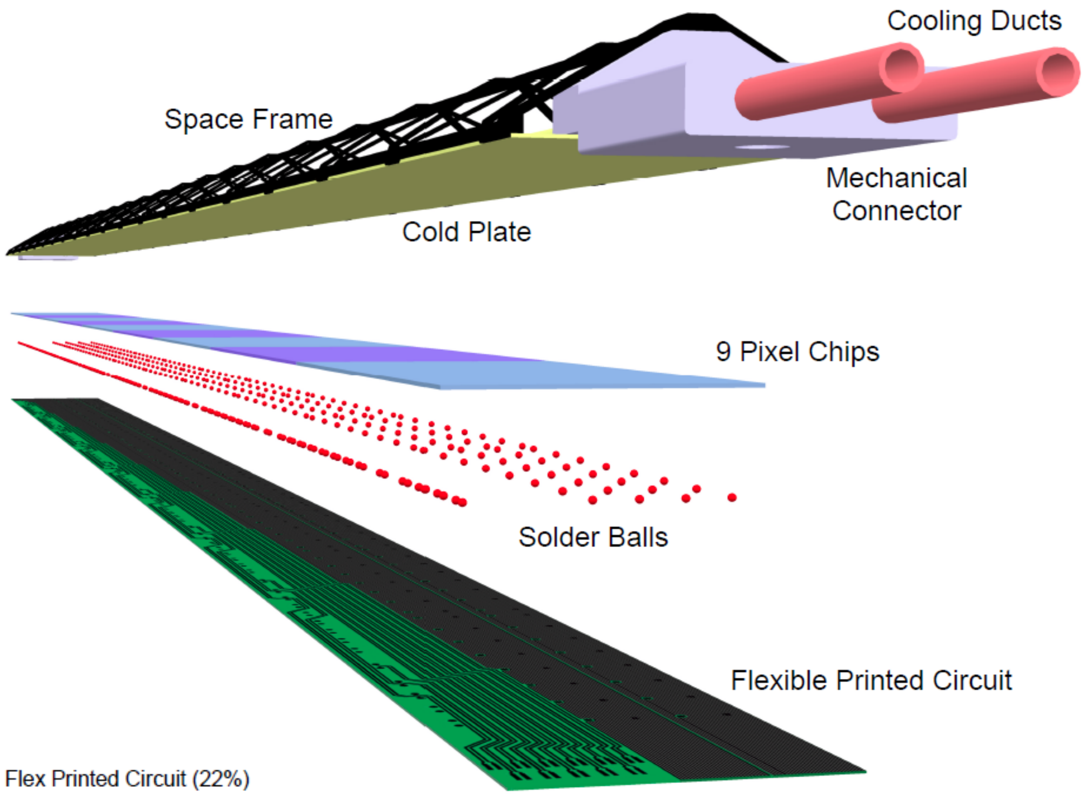
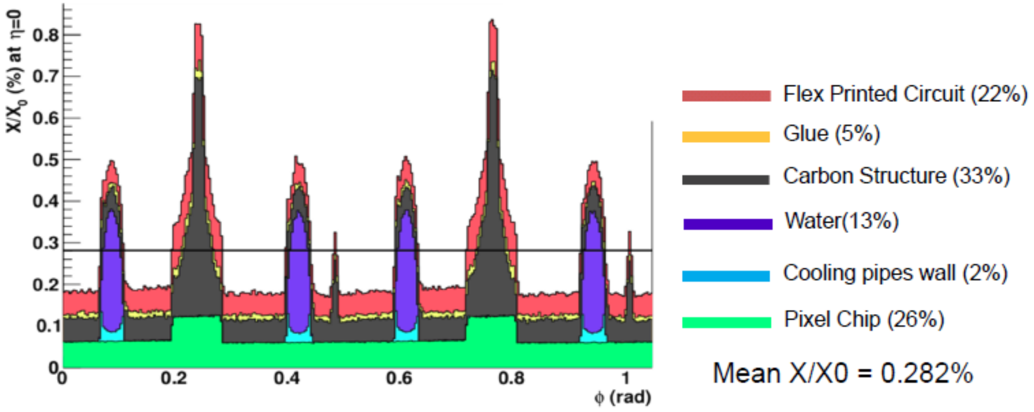


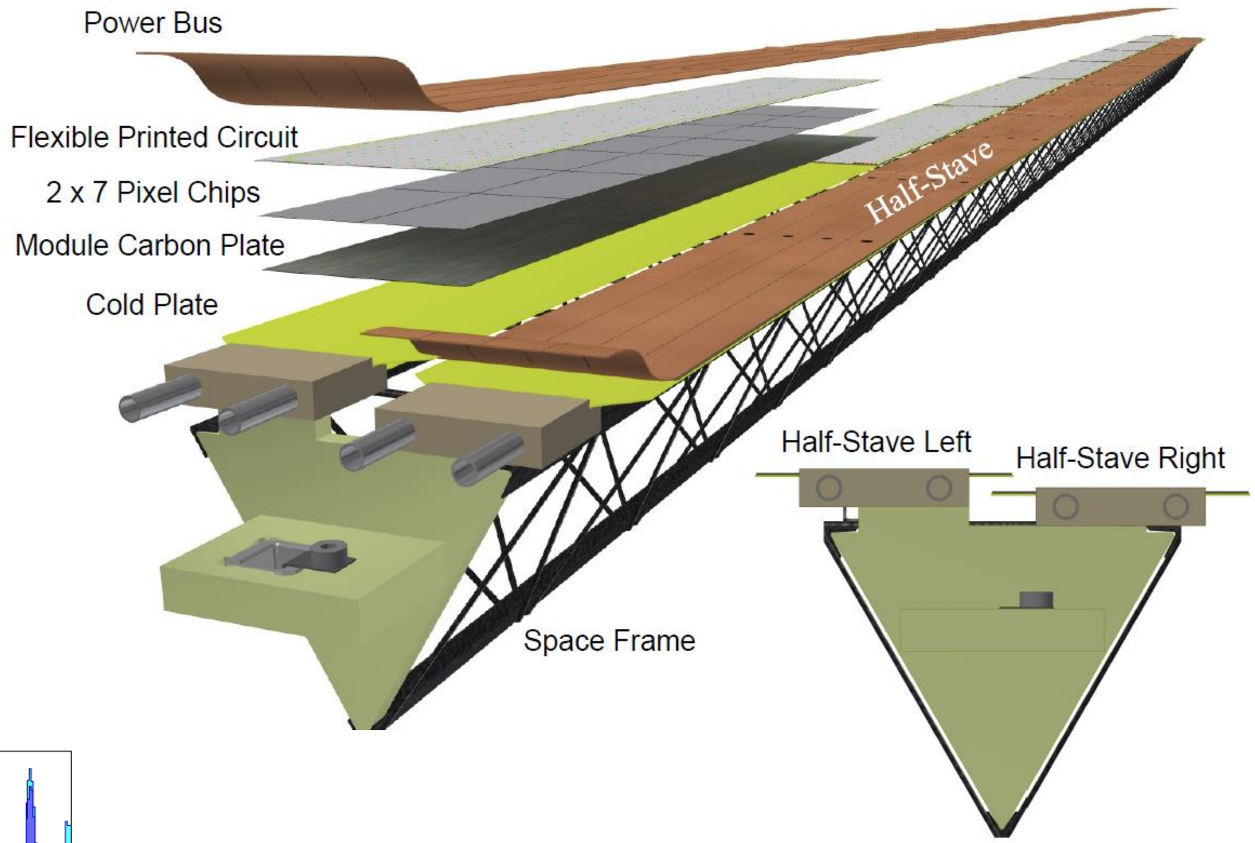
Figure 1.2: Schematic view of the cross section of the Inner Barrel (left) and Outer Barrel (right).

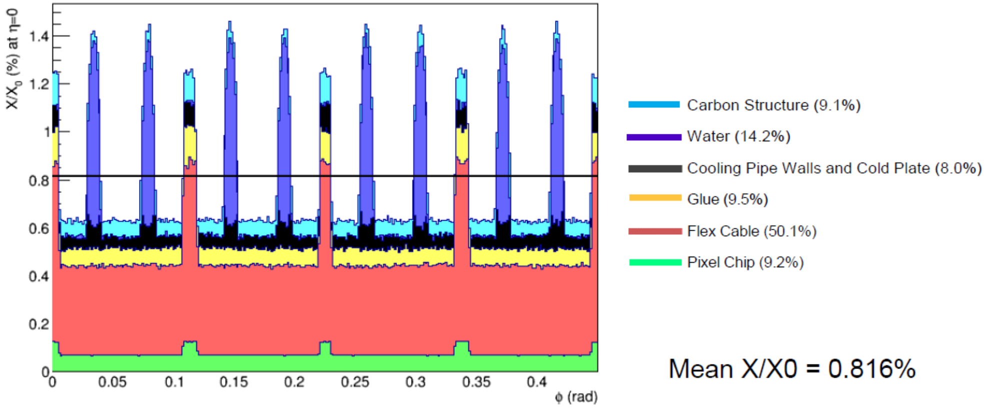
New ALICE ITS in a nutshell: IB stave





New ALICE ITS in a nutshell:OB





Mean X/X0 = 0.816%

Strategic work plan

- To transfer Know-How on MAPS ITS from CERN to NICA

- To design the ITS out of new ALICE ITS components with minimum changes and need for additional R&D

- To build the outer layer(s) with all mainframe and installation mechanics completed by the time of the MPD commissioning (2022)

- To complete MPD ITS by 2025-26 and install it during NICA LS1 together with Be-pipe of reduced diameter

The status of the MPD-ITS

PROTOCOL

to

THE CO-OPERATION AGREEMENT

between

THE JOINT INSTITUTE FOR NUCLEAR RESEARCH (JINR)

and

THE EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

concerning

The Development and Provision by CERN of Monolithic Pixel Detectors, TPC Front-end Electronics and other Items for the MPD Experiment at the NICA Facility at JINR

2018

8

third party without any confidentiality obligation; or has been developed by the receiving Party independently and outside the scope of the Collaboration.

ARTICLE 12
Relationship with other agreements

This Protocol, including any associated Addenda, sets out the exclusive understanding between the Parties on the subject matter.

ARTICLE 13
Entry into force, amendment and duration

13.1 This Protocol shall enter into force on the date of its signature by the Parties, it being understood that where it is subject to subsequent approval or ratification, it shall enter into force on the date on which the Party concerned has given written notification to the other Party that approval or ratification has taken place.

13.2 This Protocol shall remain in force for as long as required to give effect to its provisions.

13.3 The Parties may amend this Protocol at any time by agreement in writing.

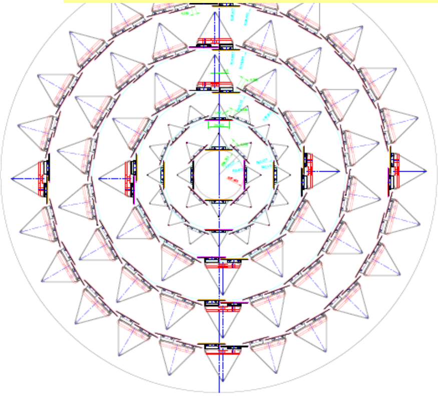
Done in two copies in the English language.

For the Joint Institute for Nuclear Research	For the European Organization for Nuclear Research (CERN)
Professor Victor A. Matveev	Dr. Fabiola Gianotti
Signed on 15th March 2018	Signed on 16th February 2018

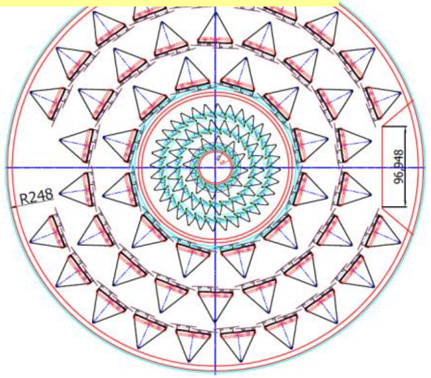
Work Plan for 2018

- To sign the Protocol on Agreement CERN -JINR
- **To send 3 key assembly persons to CERN**
- To write & sign Addendum for CERN delivery of ALPIDE,SAMPA, etc. and transfer the money to CERN to be able to start assembling of HICs OB at LHEP in 2019
- To write the Technical Proposal for MPD/ITS : (1) mechanical sketch design including jigs for ITS installation; (2) ITS optimization through computer simulations
- To procure/install the basic equipment for assembly of HIC (ALICIA-8)

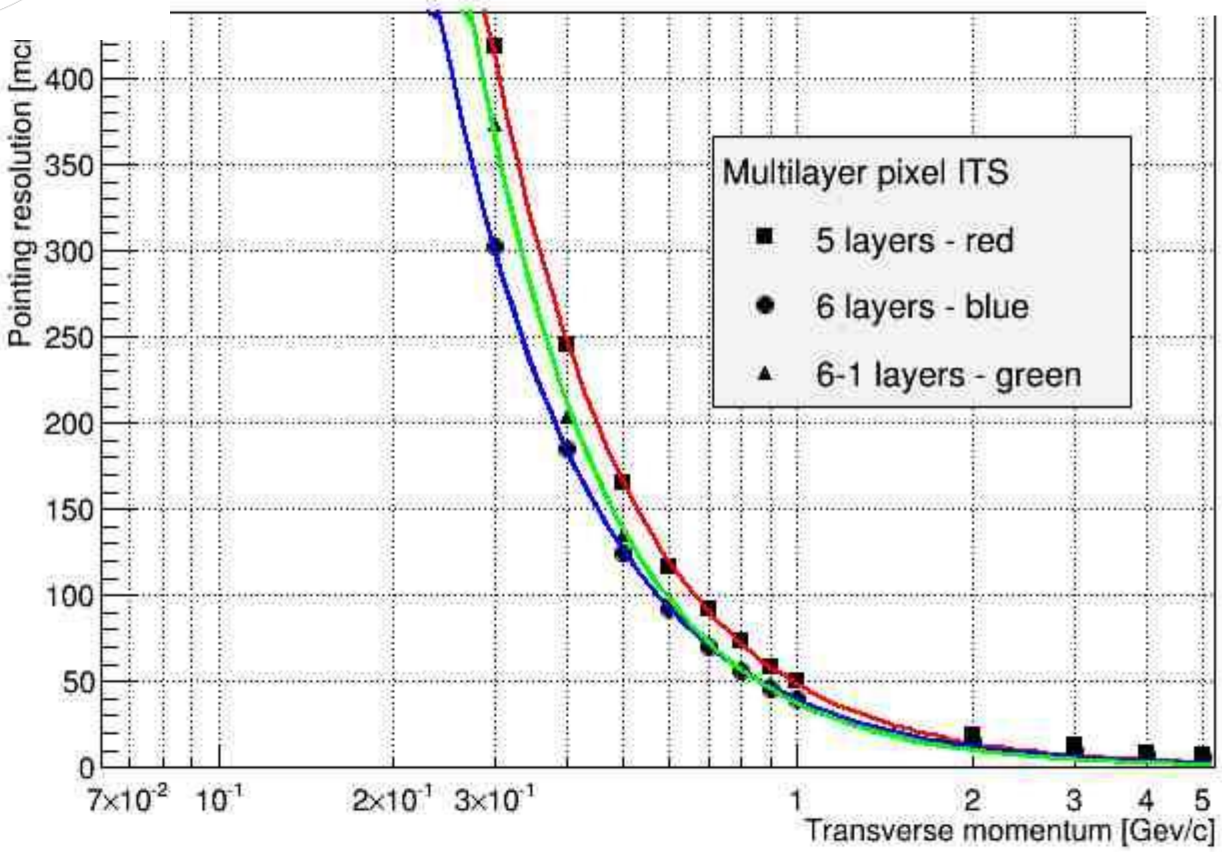
Towards Technical Proposal



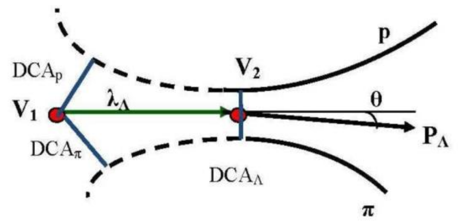
Pre-design!

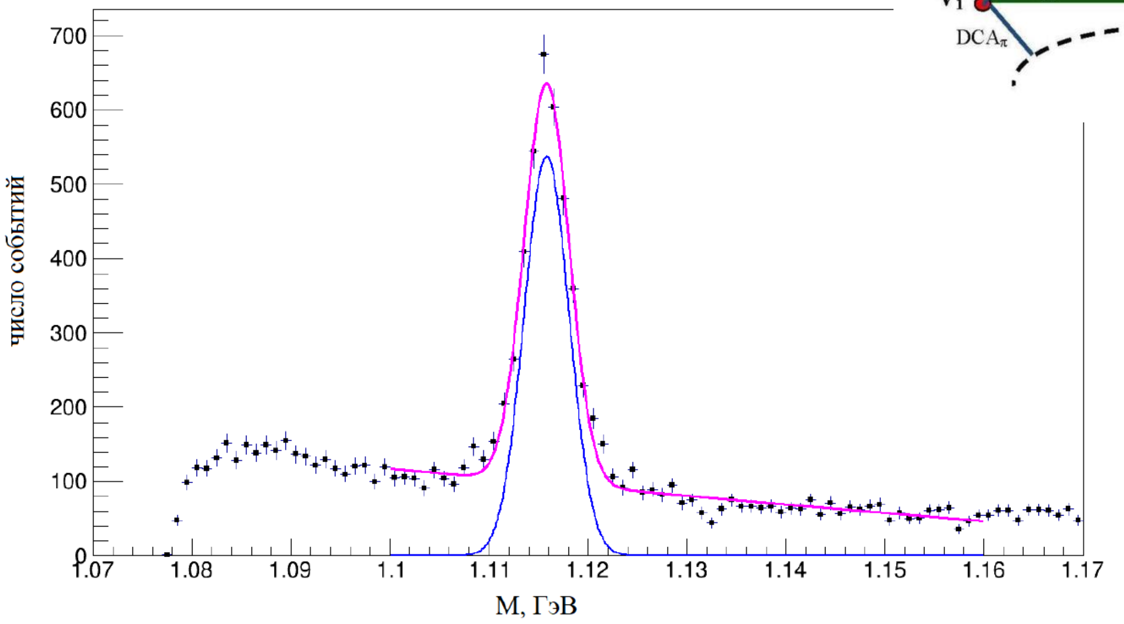


Pointing resolution in transverse plane



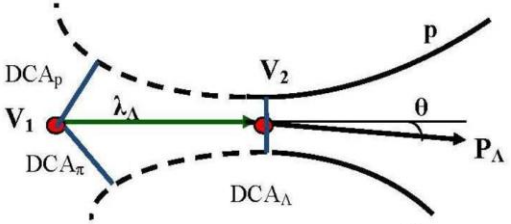
Towards Technical Proposal: Simulations

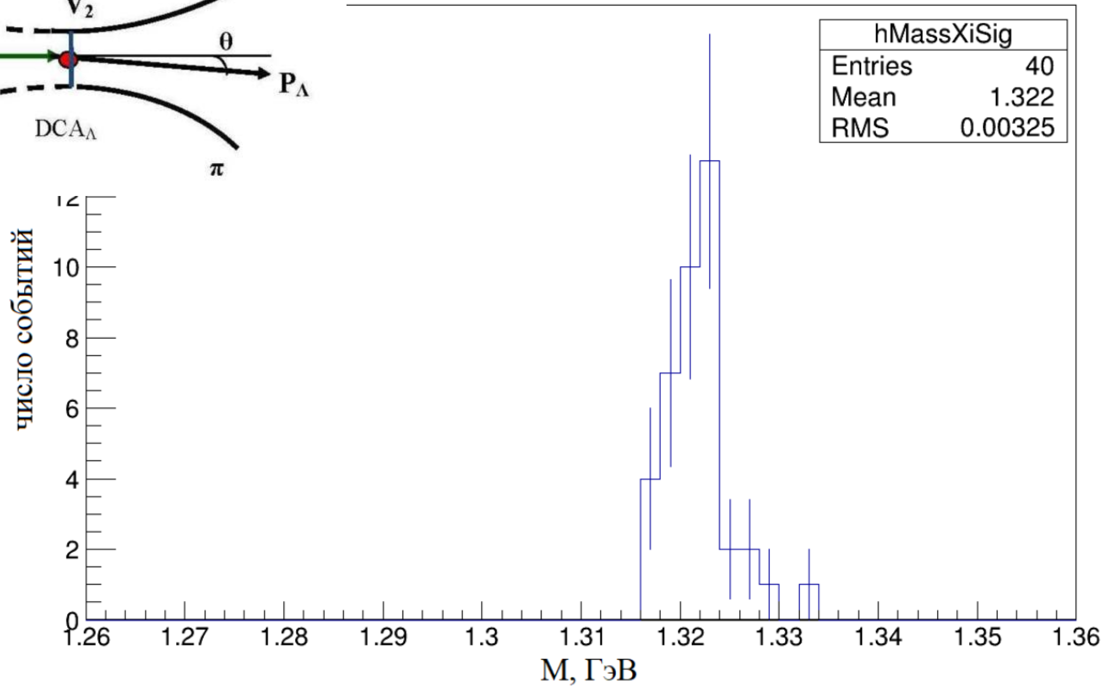




Strange hyperons identification (Λ_0)

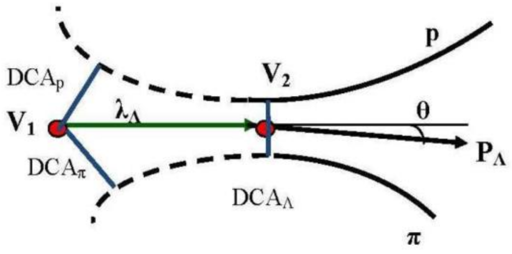
Towards Technical Proposal: Simulations

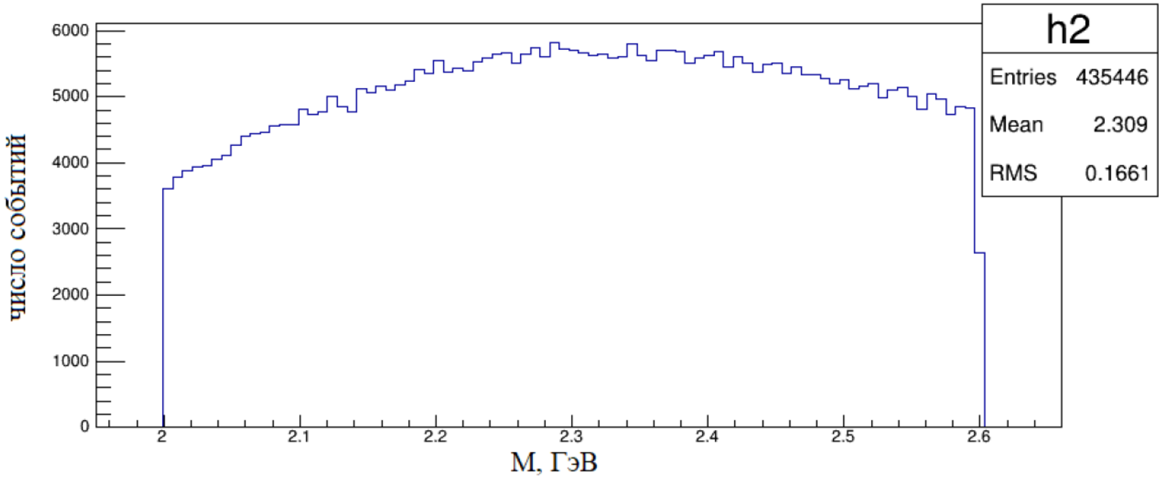


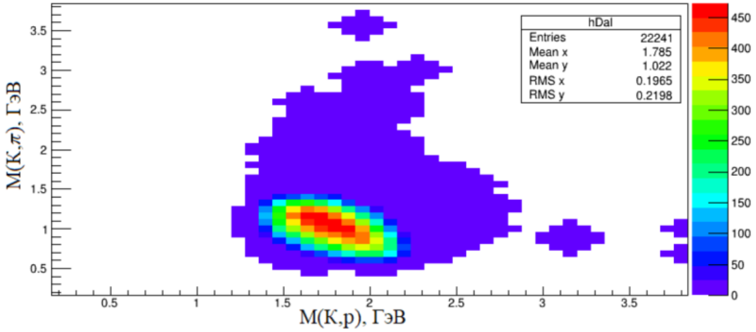


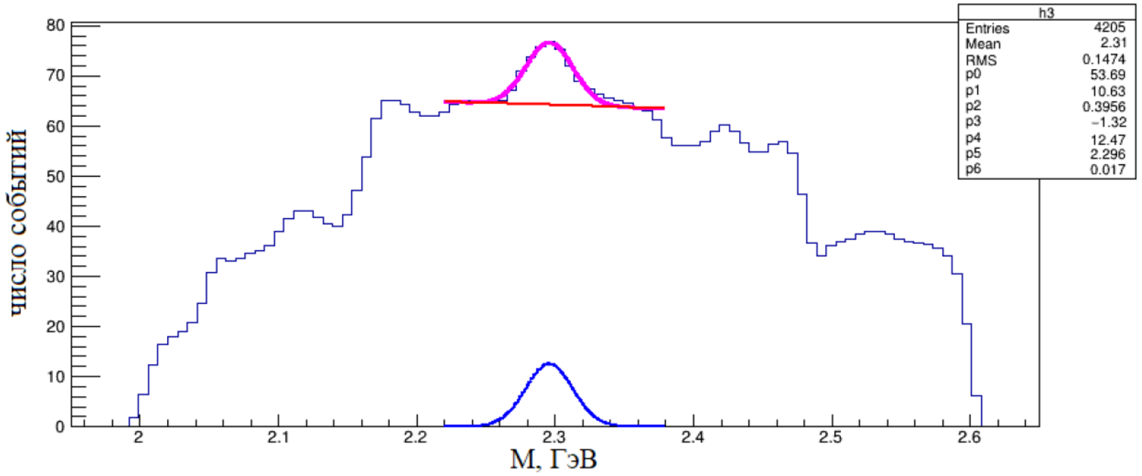
Cascades hyperons identification (Ξ^-)

Towards Technical Proposal: Simulations





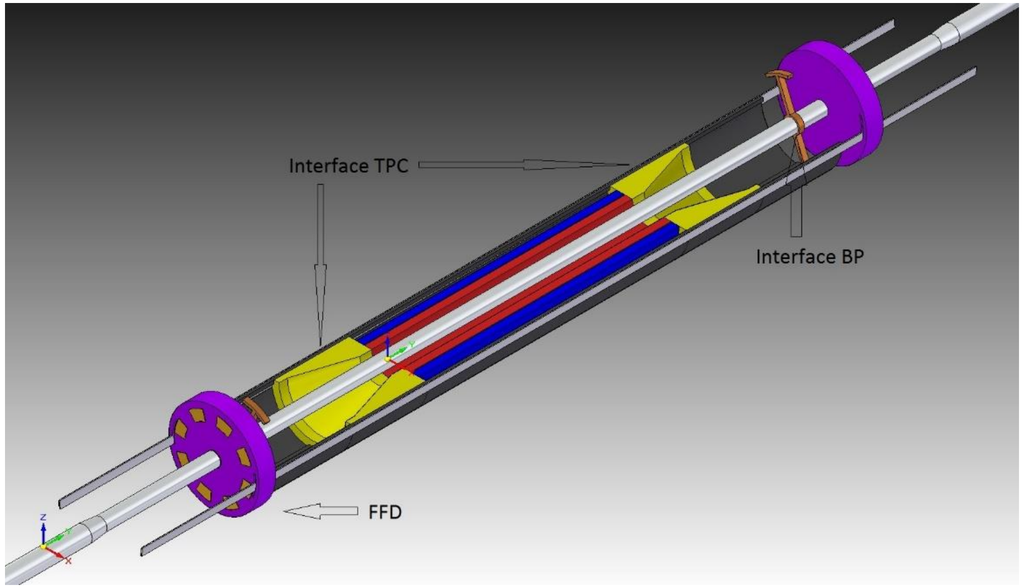




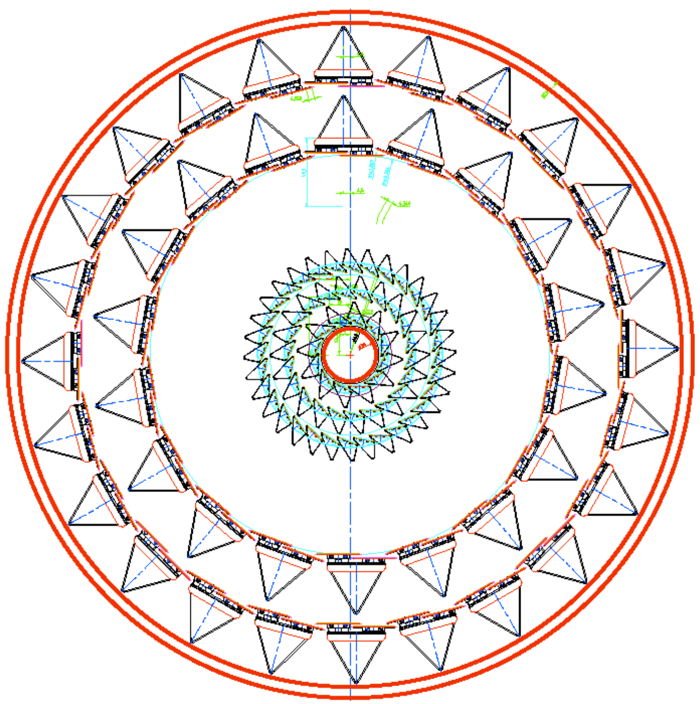
Strange hyperons identification Λ^+_c

Towards Technical Proposal: General Mechanical Layout

Sketch design by S.N.Igolkin will start September 2018



Вариант 1



Слой №	Количество линеек	R 1 установки	R 2 установки	Смещение	R min сенсора	R max сенсора	Длина линейки	Длина активной части	Разворот слоя для разъёма
1	12	24,4		7,0	22,4	26,7	810	502	-0,6
2	22	42,0		15,0	40,7	45,9	810	600	-3,5
3	32	60,0		22,0	59,8	65,1	810	700	-3,5
4	18	156,5		4,5	144,5	147,9	1554	1190	-1,6
5	24	206,5		4,5	194,4	197,6	1554	1468	-8,7

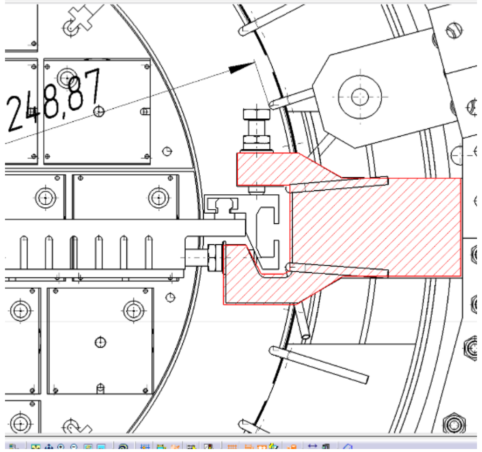
Key task: To design of the mainframe and jigs for its integration with TPC and BP within a year and tune the flow of components for assembly OB at JINR

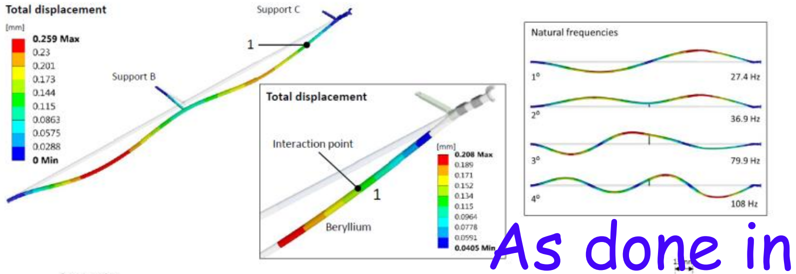
Towards Technical Proposal: Interfaces

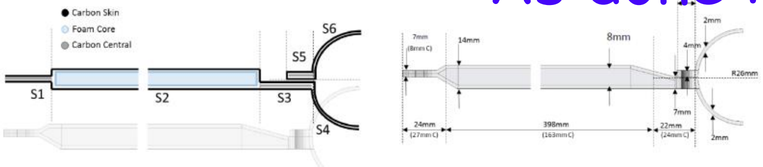
In TPC

?

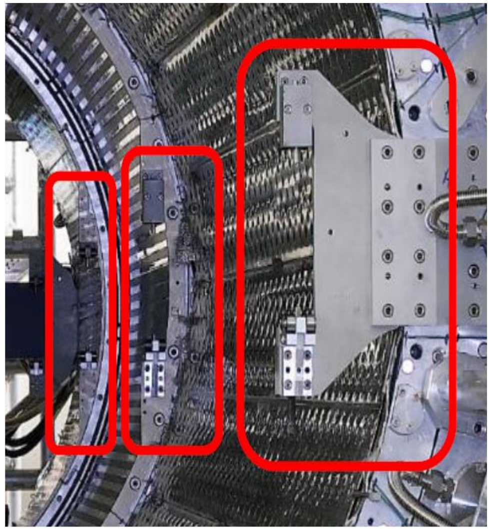
Proposed for MPD







As done in ALICE



Critical issues of the MPD/ITS project and ways for remedy

- Absense of 3 “leutenants” in the fields pointed by Musa

- Decision of JINR Director to overcome the standard flow of procurement and transfer the money without delay to CERN

- Getting an export license on ALPIDE (SAMPA?)

- Finding a Deputy for me of a rank of “a captain” to carry on the project after my retirement

Perspectives for Internationalization

- Italy, China, Germany, Poland, UK

- Hiring foreign postdocs with salary from CREMLIN+ (starting 2019)

- MPD/ITS physics case is well justified and has a potential of discovery of super nuclei
- After signing the Protocol with CERN the project got a ground for a start
- Strategic plan is worked and agreed with CERN
- However, the general status to the moment is "just started"
- THANK YOU FOR YOUR ATTENTION!

Forum on Tracker Detector Mechanics
25-27 June 2018

CERN EP R&D INITIATIVE
DETECTOR MECHANICS

EP R&D

Corrado Gargiulo and Antti Onnela
on behalf of Working Group 4 Detector Mechanics

https://indico.cern.ch/event/695767/overview

R&D ON EXPERIMENTAL TECHNOLOGIES

Source: Presentation by M. Krammer, CERN EP department head, in EP R&D kick-off meeting 20.11.2017

An initiative to define R&D on Experimental Technologies in CERN's Experimental Physics department for 2020 - 2025 (- 2030)

Scope:

- Define the R&D strategy for experimental technologies for future experiments: future colliders, fixed target experiments, future LHC experiment upgrades, new (unconventional) ideas
- R&D on Detectors, Electronics, Software
- Identification of key technologies (with CERN involvement)
- Definition of a roadmap with milestones and prototypes to be developed
- Define funding requirements
- Proposal for the organization of R&D within EP

Build on ongoing R&D, maintain and foster partnership with external research institutes and industrial partners

Why now?

- HL-LHC Phase 2 R&D nearing completion
- R&D for future colliders funded through FCC and CLIC studies – will be under one budget line as of 2020

PREPARING THE R&D PROPOSAL: TIME-LINE

Kick-off meeting

20 Nov 2017

R&D workshop I

16 March 2018

R&D workshop II

Early autumn 2018

Release R&D proposal document

November 2018

Working Groups	Convenors
WG 1: Silicon detectors	Heinz Pernegger, Luciano Musa, Petra Riedler, Dominik Dannheim
WG 2: Gas detectors	Christoph Rembser, Eraldo Oliveri
WG 3: Calorimetry and light based detectors	Martin Aleksa, Carmelo d'Ambrosio
WG 4: Detector Mechanics	Corrado Gargiulo, Antti Onnela
WG 5: Interconnection technologies	Federico Faccio, Michael Campbell
WG 6: High Speed Links	Paolo Moreira, Francois Vasey
WG 7: Software	Graeme Stewart, Jakob Blomer
WG 8: Detector Magnets	Herman Ten Kate, Benoit Cure

Хочешь накормить человека один раз — дай ему рыбу. Хочешь накормить его на всю [жизнь] — научи его рыбачить .

Три пути ведут к знанию: путь размышления — это путь самый благородный, путь подражания — это путь самый легкий и путь опыта — это путь самый горький.

Давай наставления только тому, кто ищет знаний, обнаружив свое невежество.