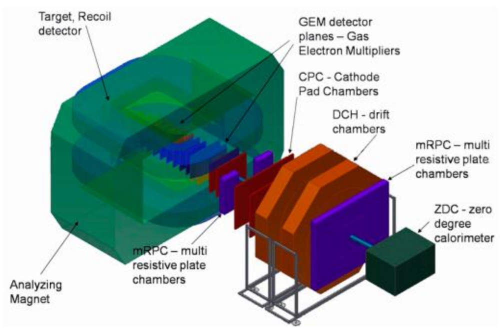
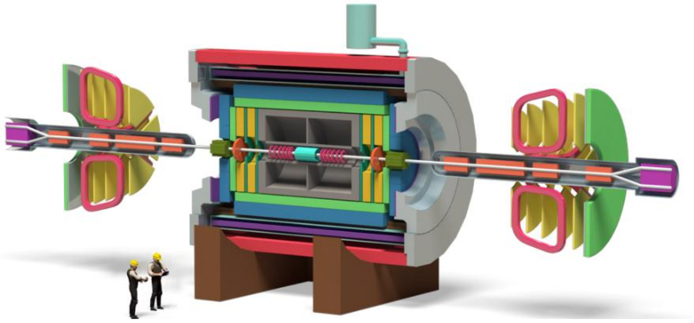
Silicon Tracking Systems for BM@N and MPD experiments at NICA



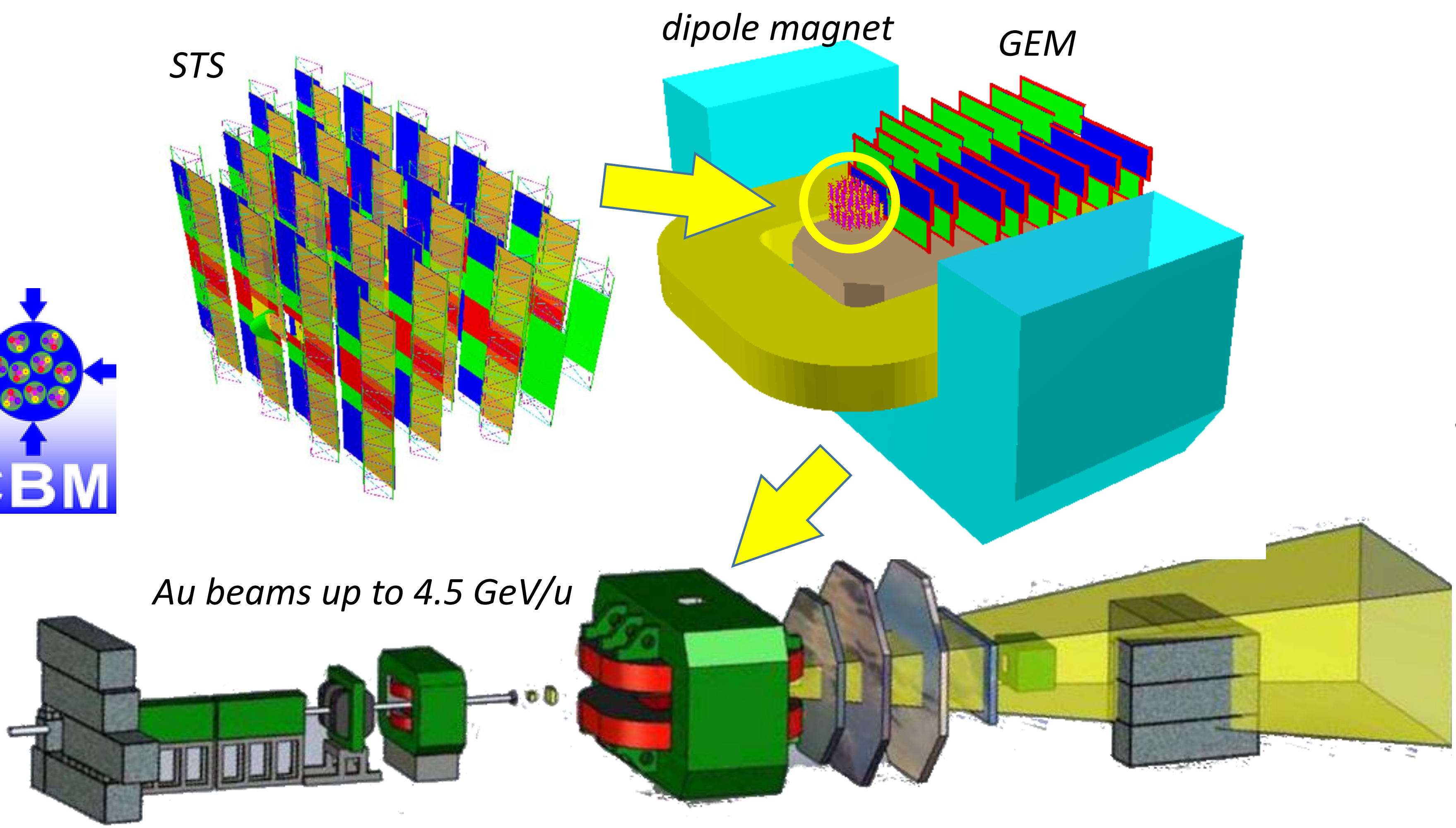


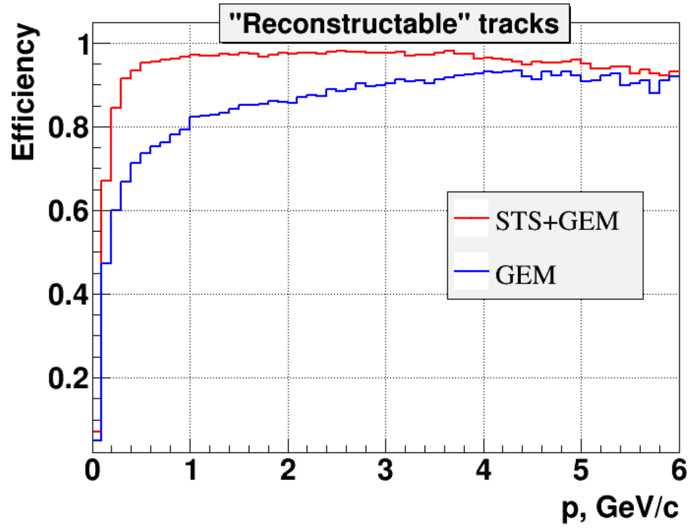
Dementev Dmitrii
For JINR STS team & CBM Collaboration
JINR LHEP

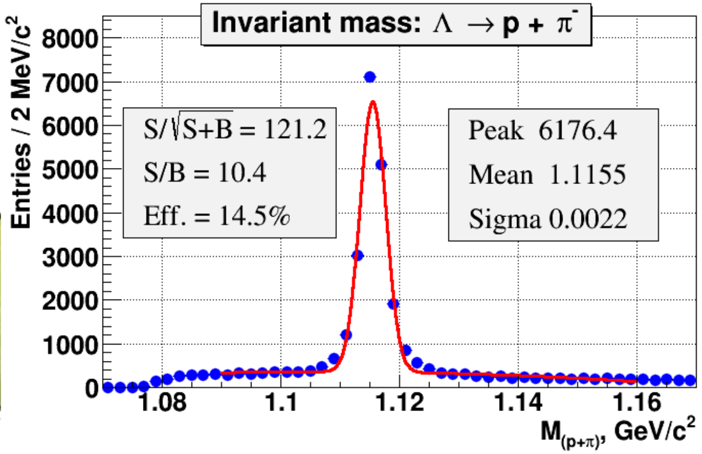
International Session-Conference of SNP PSD RAS “Physics of Fundamental Interactions”

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.

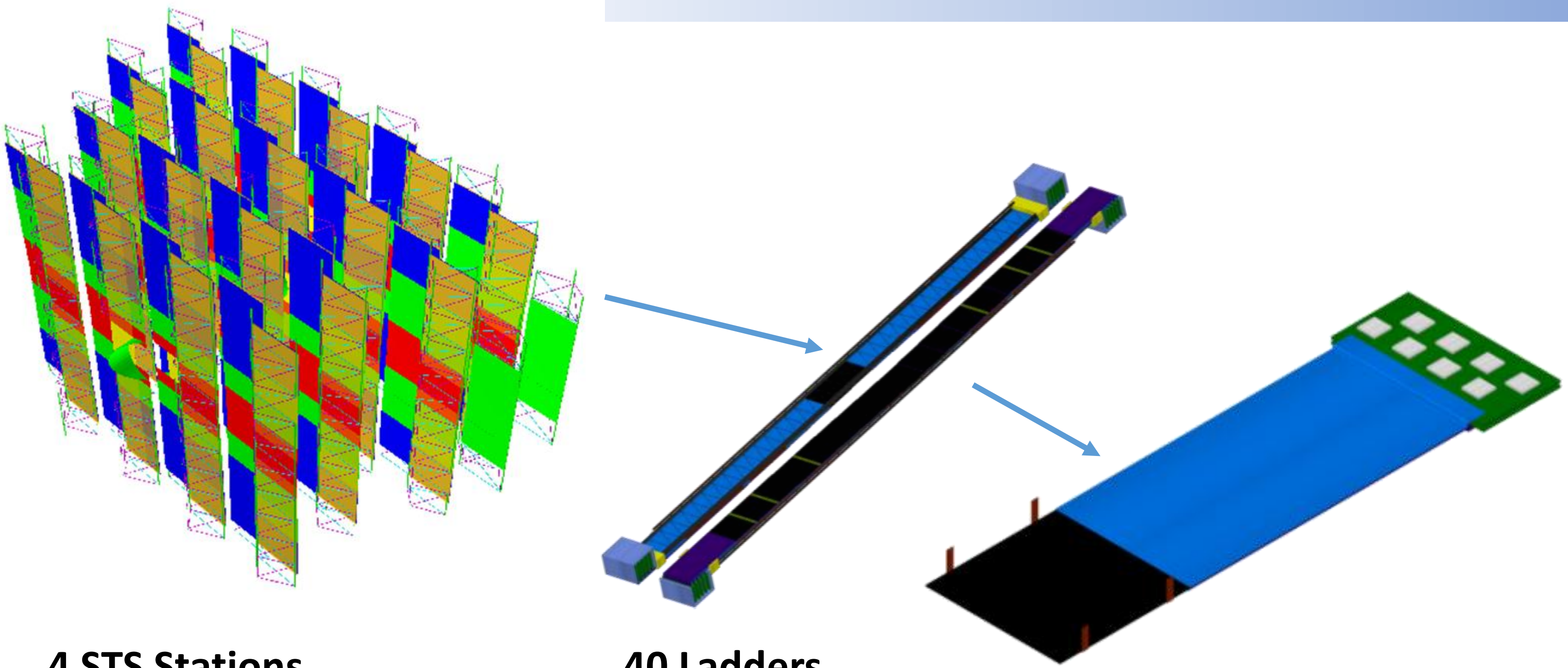






Slide by J. Heuser

STS Setup



4 STS Stations **40 Ladders**

360 Modules

~730 k Channels

Material budget per station ~1% X_0

At the maximum design luminosity, the event rate in the BM@N interaction region is about **10 MHz** with 1%X target; the total charged particle multiplicity exceeds 500 in the most central Au+Au collisions at E = 4,65 GeV/n.

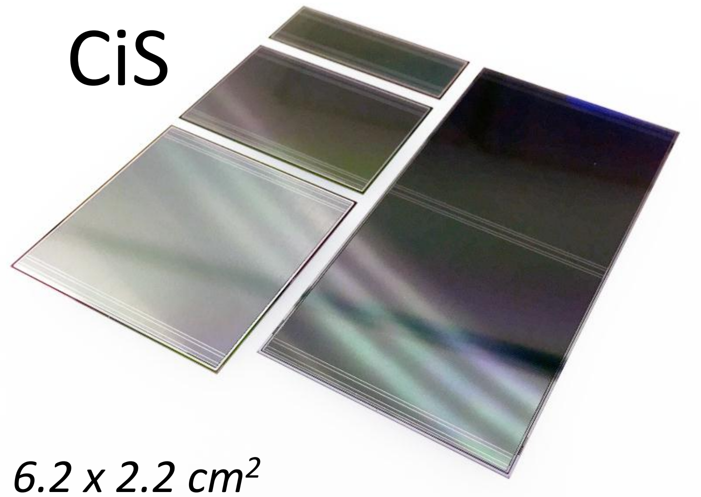
As the average momentum of the particles produced in a collision at Nuclotron energies is below 1.5 GeV/c, the detector design requires a **low material budget.**

Maximum occupancy less than 8%

In 2015 MoU of CBM STS participation in BM@N experiment at Nuclotron (4 STS CBM-like stations by 2020) as a "Phase 0" CBM STS experiment

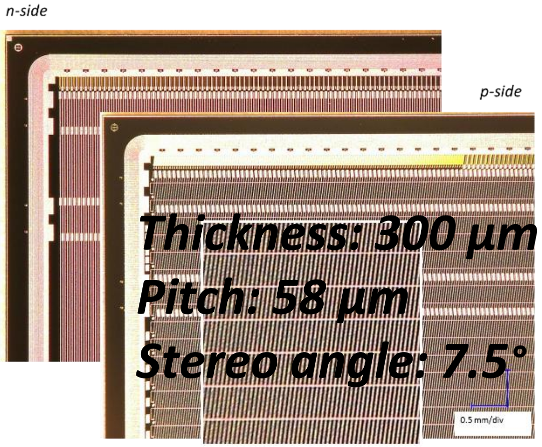
Sensors

CiS



6.2 x 2.2 cm^2
6.2 x 4.2 cm^2
6.2 x 6.2 cm^2

Hamamatsu



400 sensors are already ordered and arrived at JINR

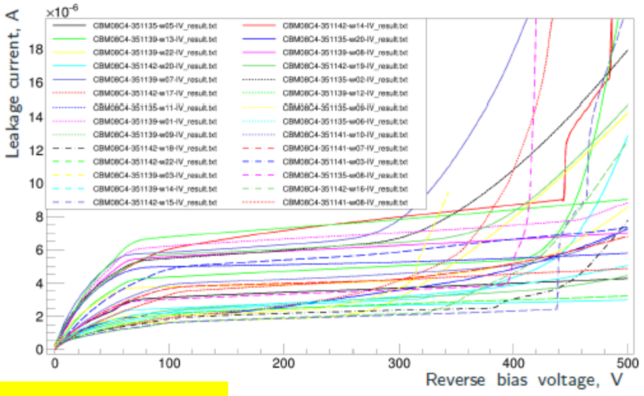
Quality assurance of the sensors

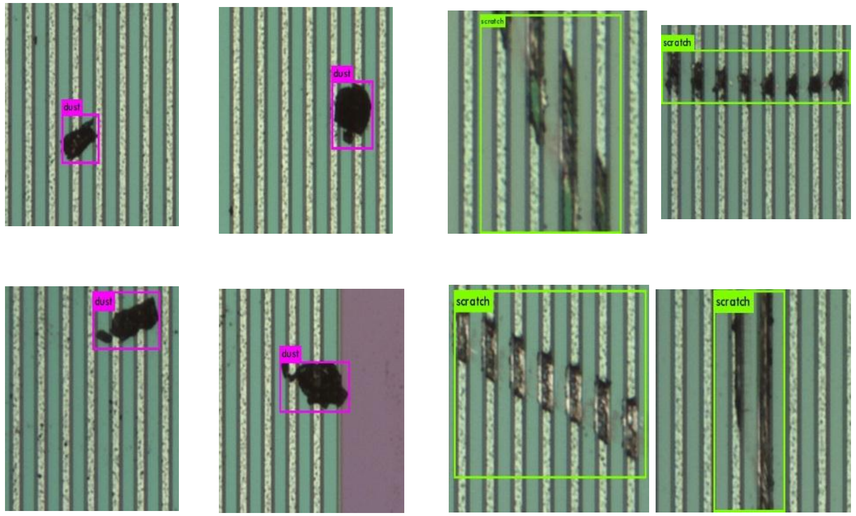
- Final product inspection at the vendors: detailed data
- Quality inspection at JINR has been advanced:

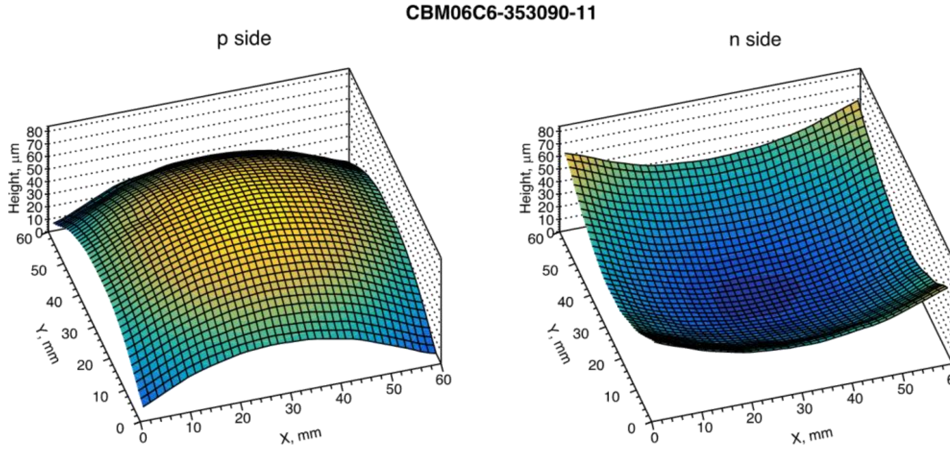
  full inspection during prototyping, sample tests during series production

  – *sophisticated optical and electrical methods established*

  – *charge collection tests before/after irradiation, S/N determination*



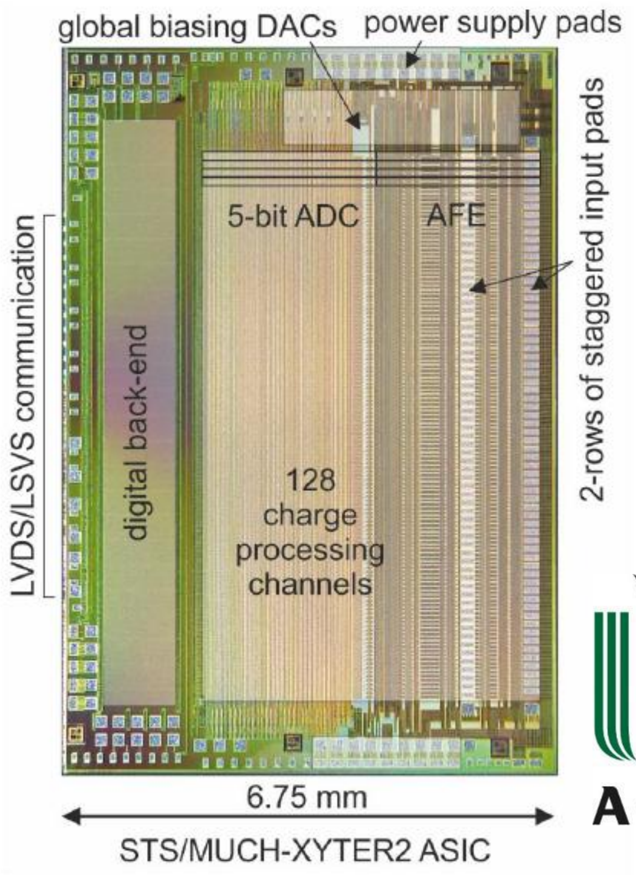




By E. Lavrik (Universität Tübingen)

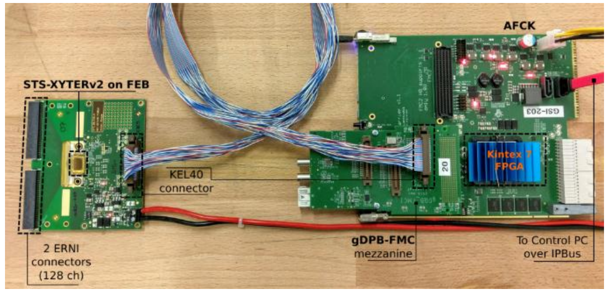
STSXYTER ASIC

produced in 9/2016

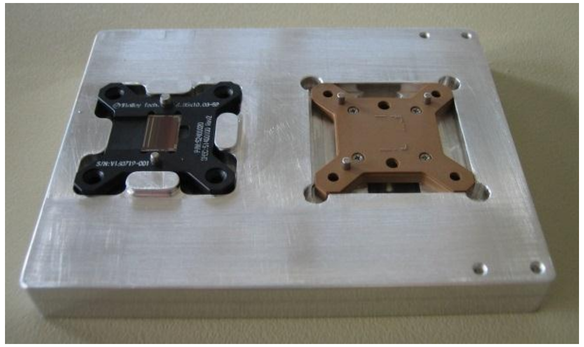


- 128 channels+ 2 test channels
- Self triggered architecture
- Maximum data rate: 250 kHz/channel
- 5-bit amplitude measurement
  - shaper$_{slow}$+ ADC
- time stamp measurement
  - shaper$_{fast}$ + discriminator
- Dynamic range: 16 fQ
- Noise performance: 1000 enc at 30 pF input
- Time stamp resolution: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

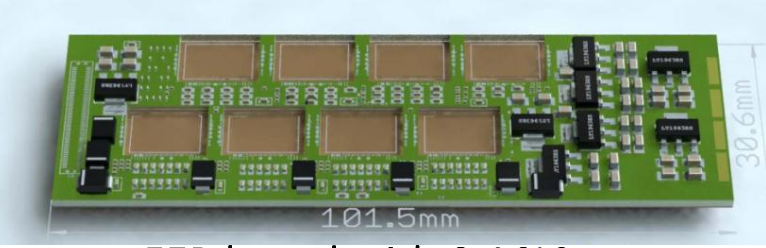
FEB board with 1 STSXYTER ASIC



Test bench for characterization of the ASIC

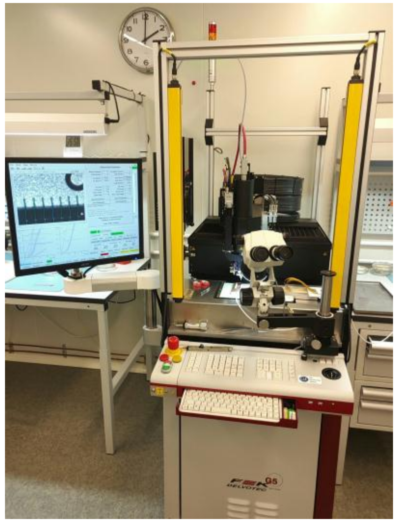


Test socket for the ASIC-tab-bonds



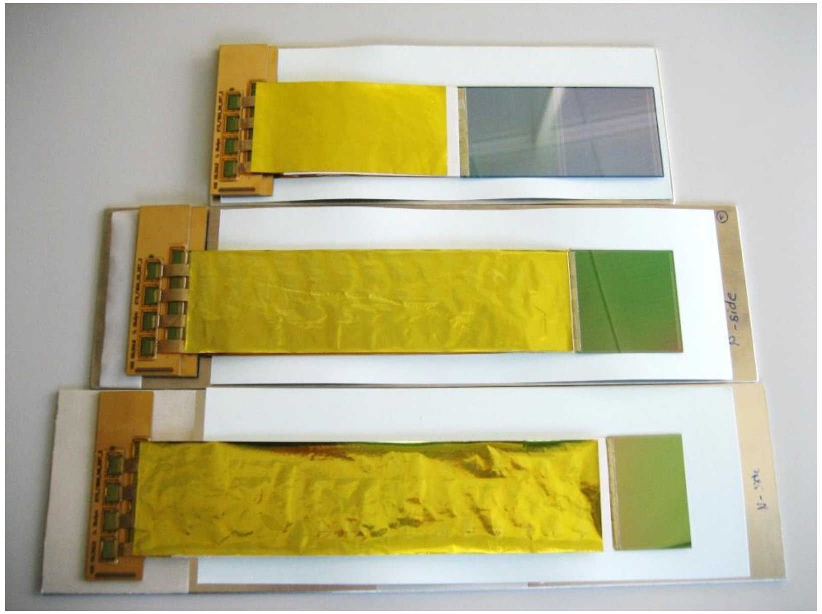
FEB board with 8 ASICs (3D-view, V.Kleipa)

Modules



Wirebonder F&K Delvotec G5

TabBonder Planar EM-437

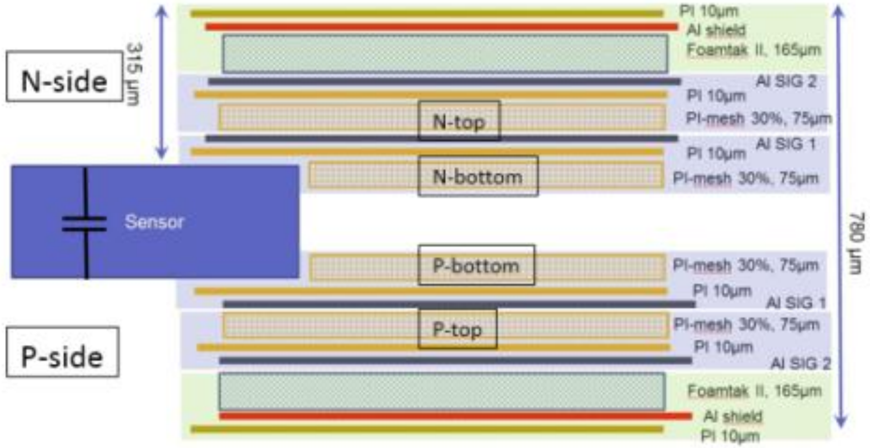


Mockups of the STS modules

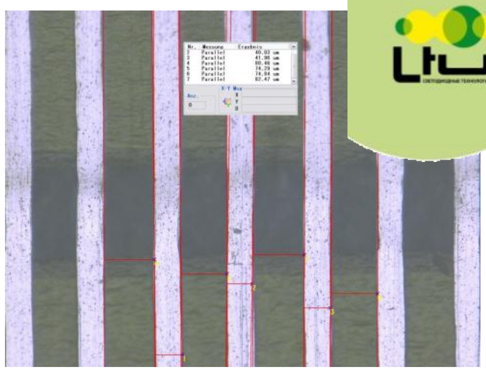
Operation time for 1 module mock-up ~ 3 - 3,5 person/day

About 420 components are in assembly process at different stages

Microcables from Al-polyimide



Measurement:
C_line = 0.38pF/cm

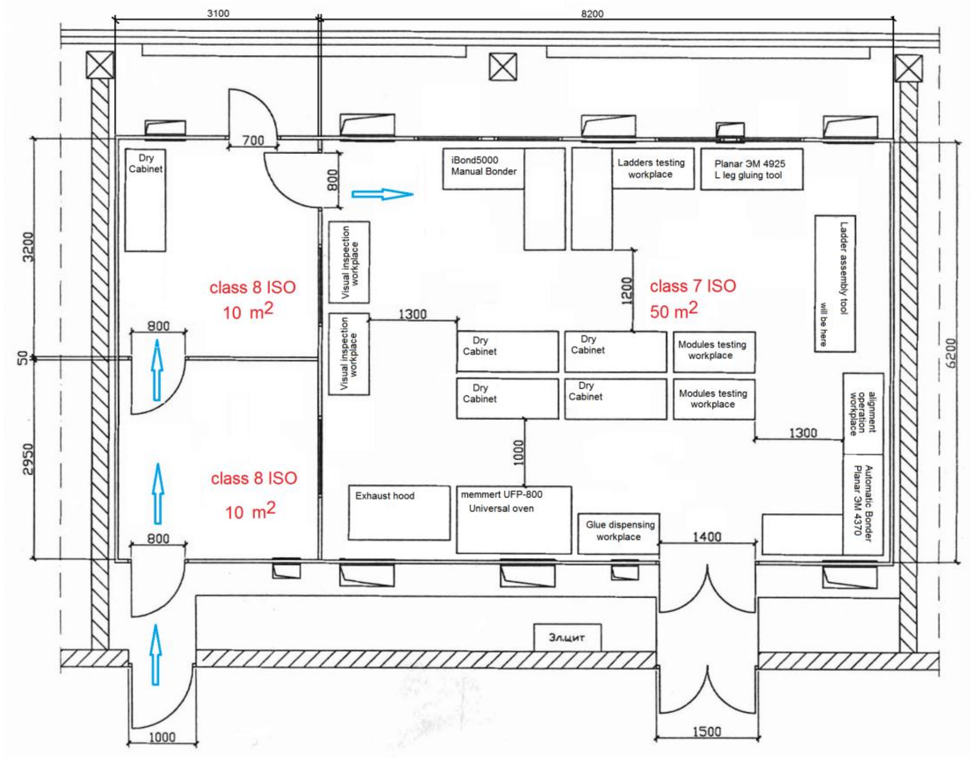


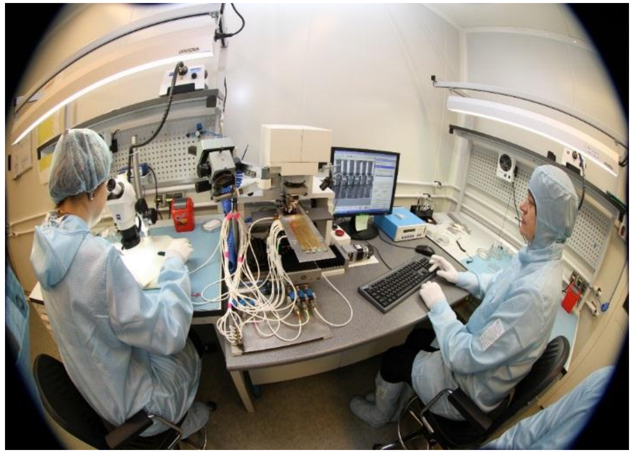
distance between traces varies from 74 to 82 µm

Module assembly site at JINR LHEP

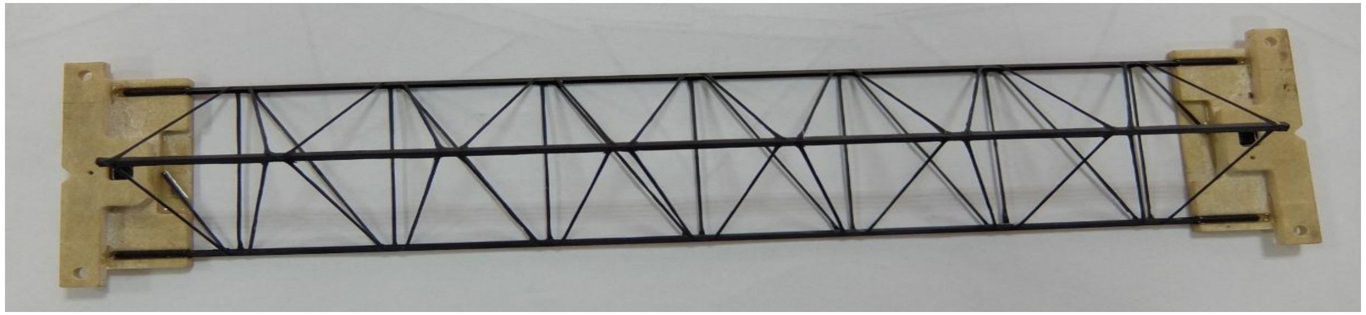
The main room (90m^2) is class 7 ISO (less than 10 000 p/ft^3 < 0.5 mkm)

4 technicians are currently involved in module assembling

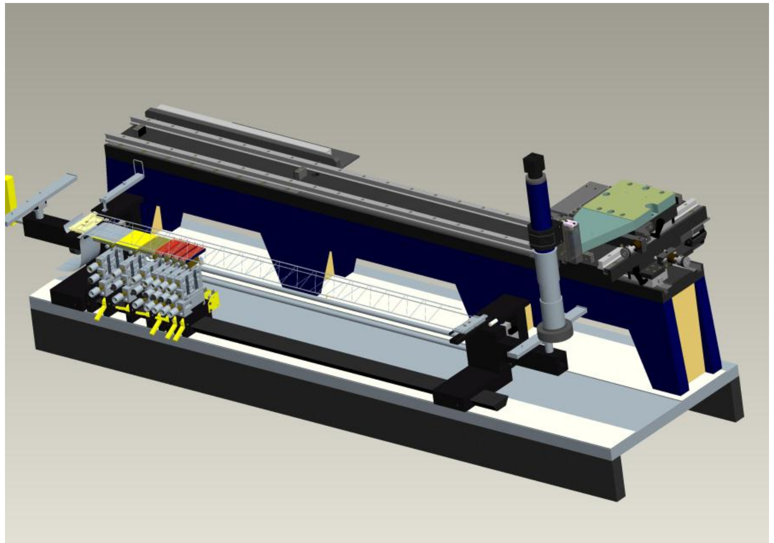




Ladder assembly



Design by S. Igolkin (CERN)

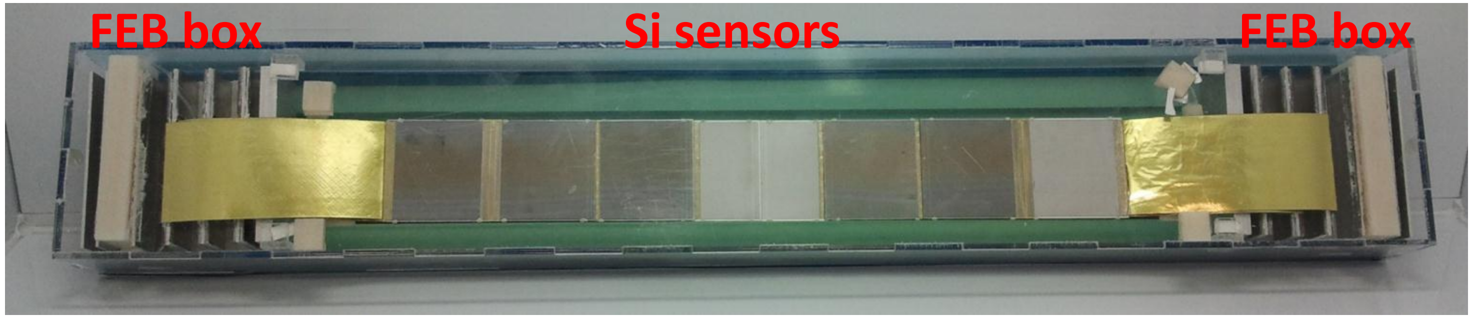


Ladder assembly device

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)



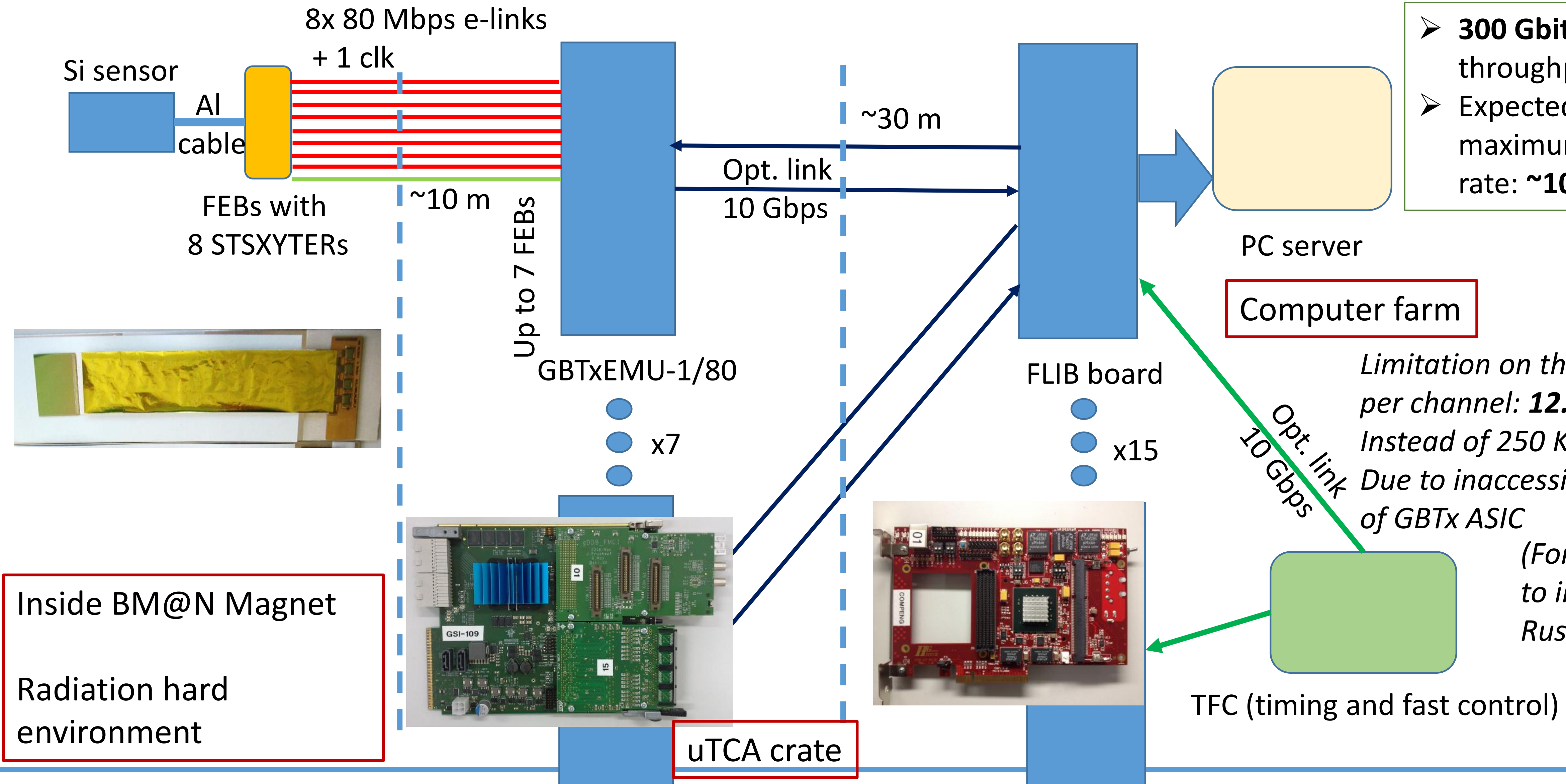
Mockup of the ladder

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

DAQ scheme

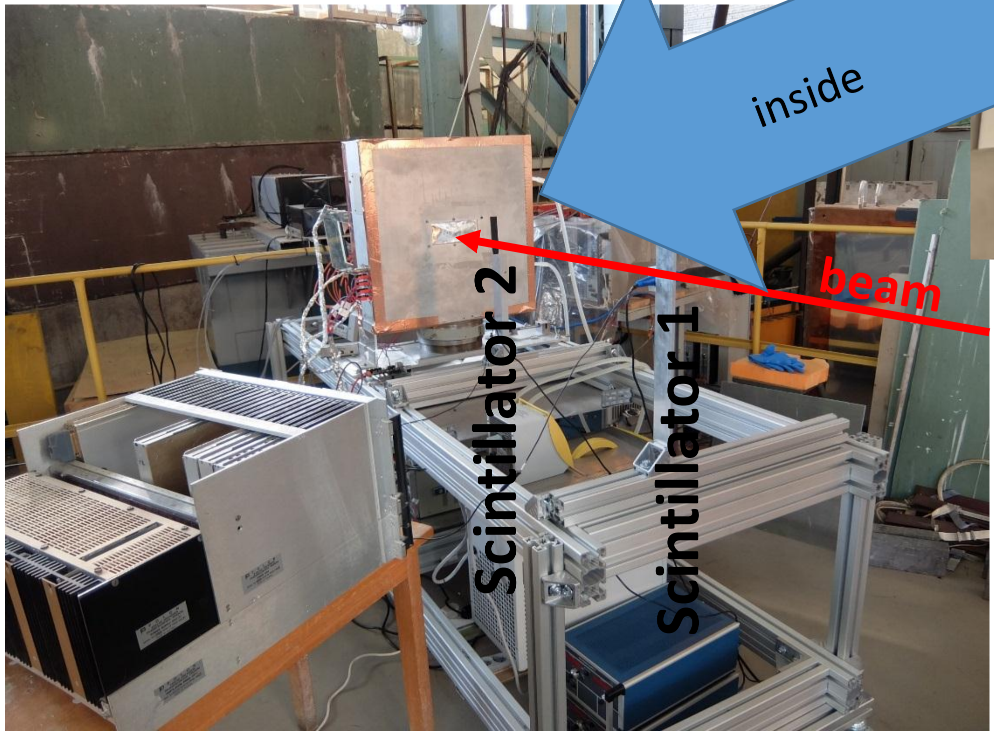
Proposed by Dr. C.J. Schmidt and Dr. D. Emschermann (GSI)

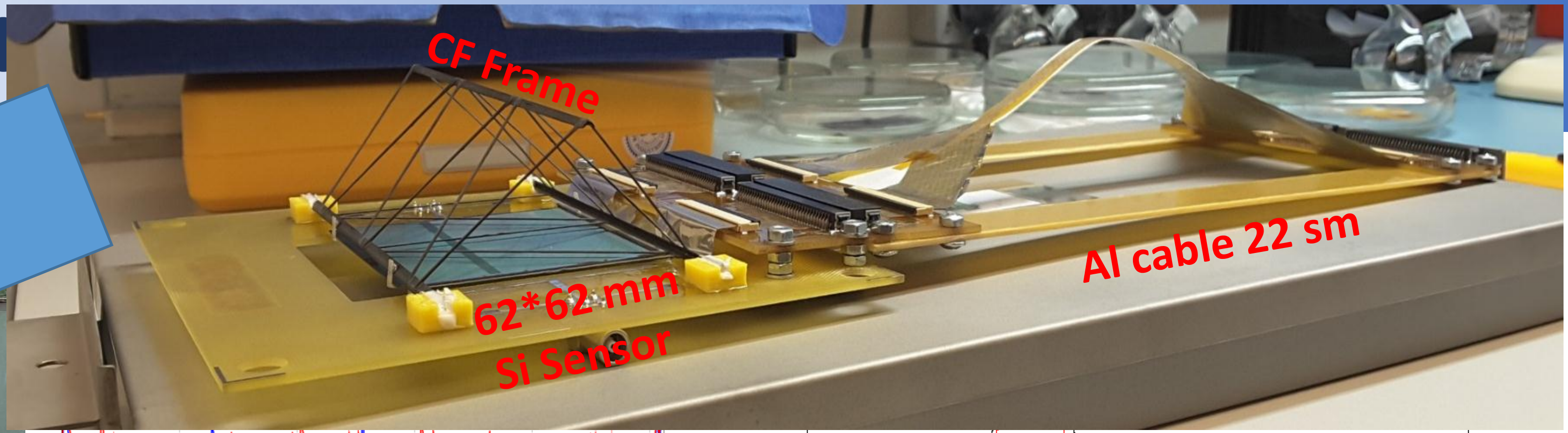


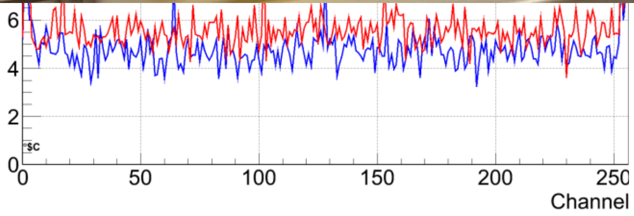
- **300 Gbit/s** data throughput
- Expected maximum data rate: **~100Gbit/s**

*Limitation on the data rate per channel: **12.5 KHz** Instead of 250 KHz Due to inaccessibility of GBTx ASIC (Forbidden to import in Russia)*

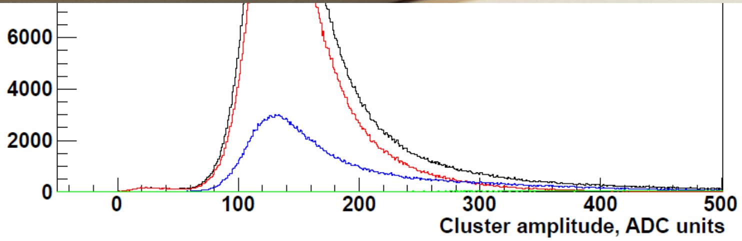
Test beam at Nuclotr







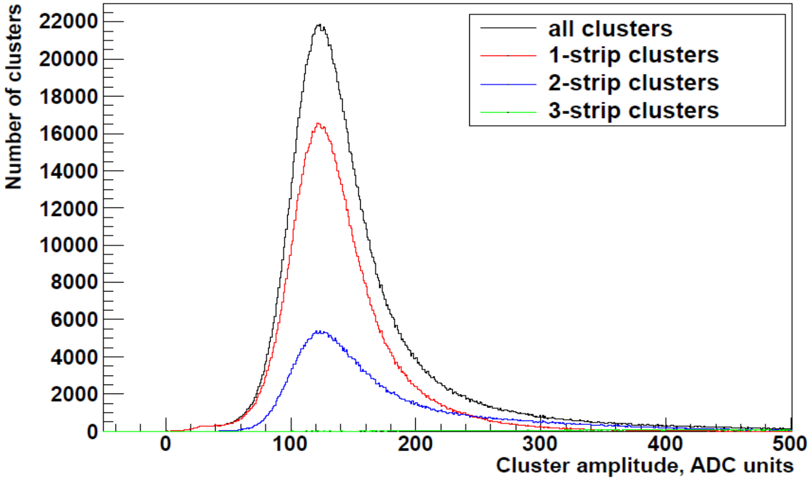
Noise per channel distribution



Clusters amplitudes on the **P side**

S/N for N side 23.4±0.5

S/N for P side 24.5±0.5

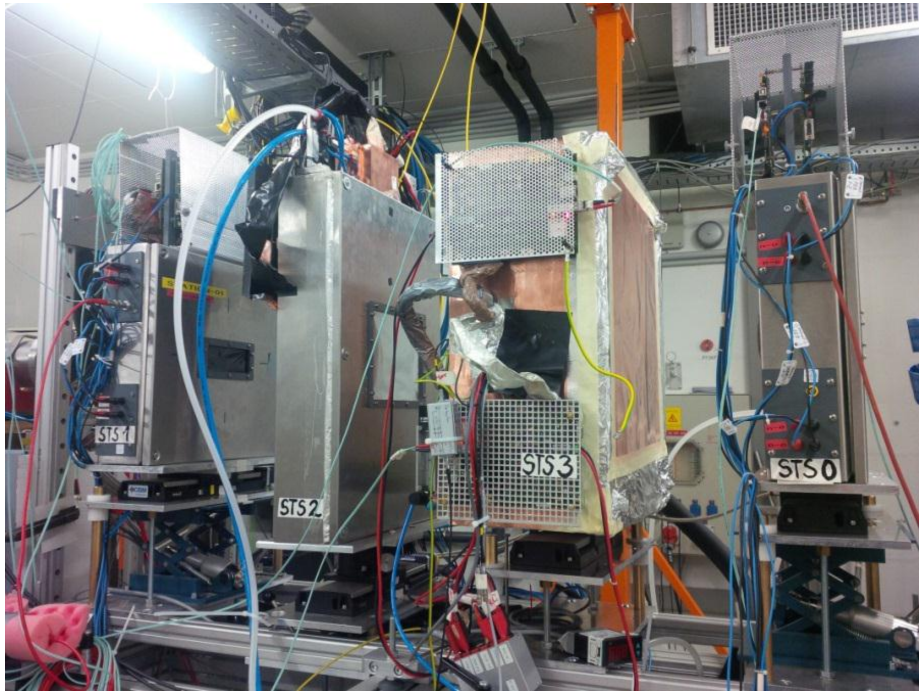


Clusters amplitudes on the **N side**

Beam properties:

- Deuteron beam with Ekin = 2.95 GeV/n
- Intensity: $2 * 10^5$ p/s

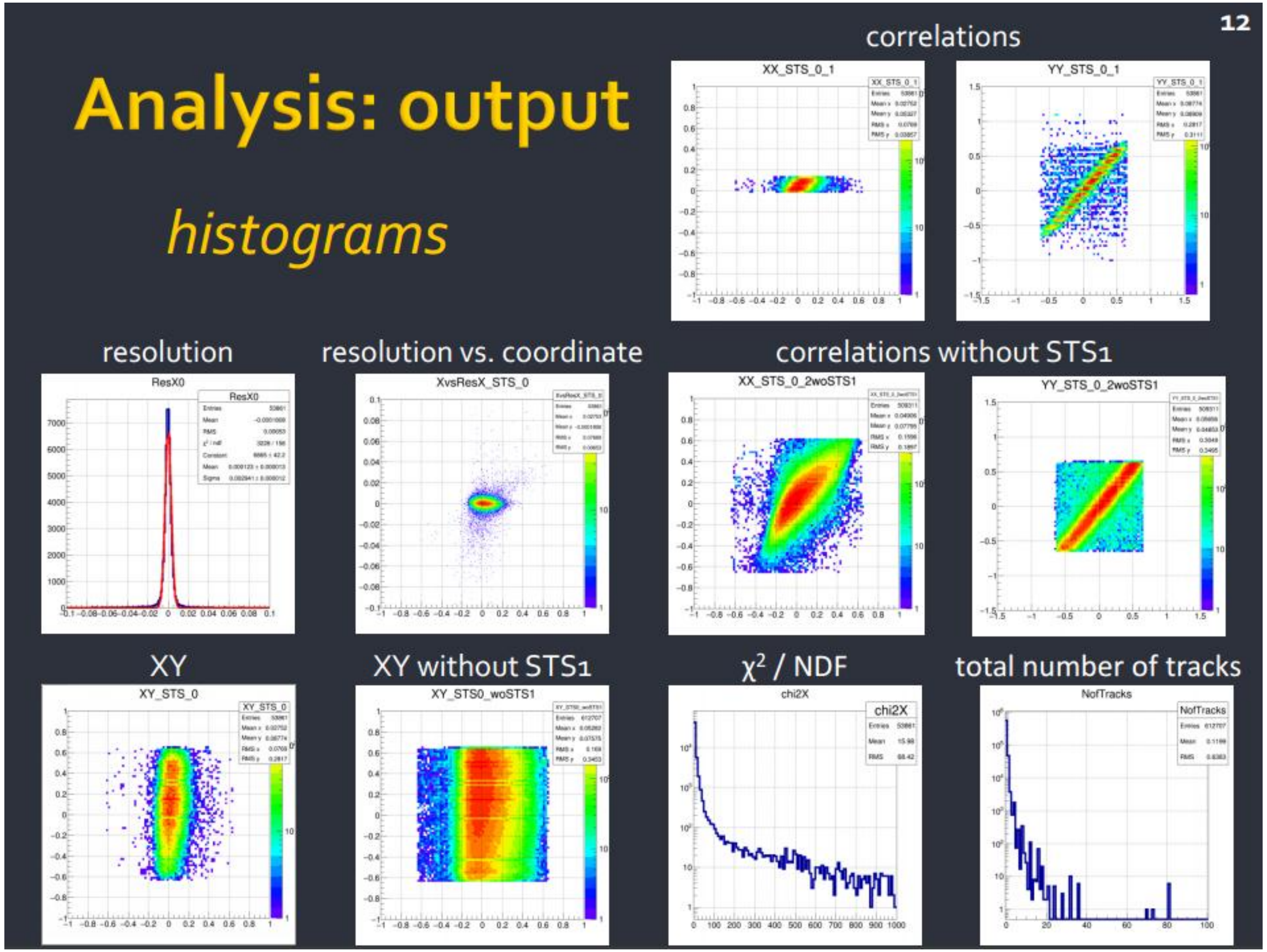
Test beam at COSY



COSY Dec 2014

Test bench setup:
2 hodoscopes + 4 STS stations
+ GEM set-up + electronics tests

2,4 GeV proton beam



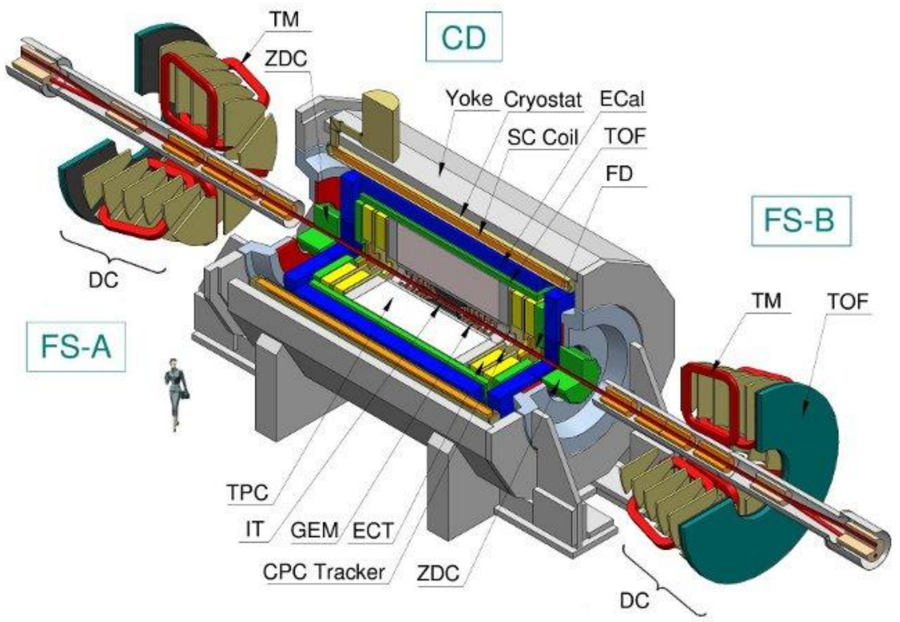
Anna Senger, 26th CBM Collaboration Meeting

ITS for MPD Experiment

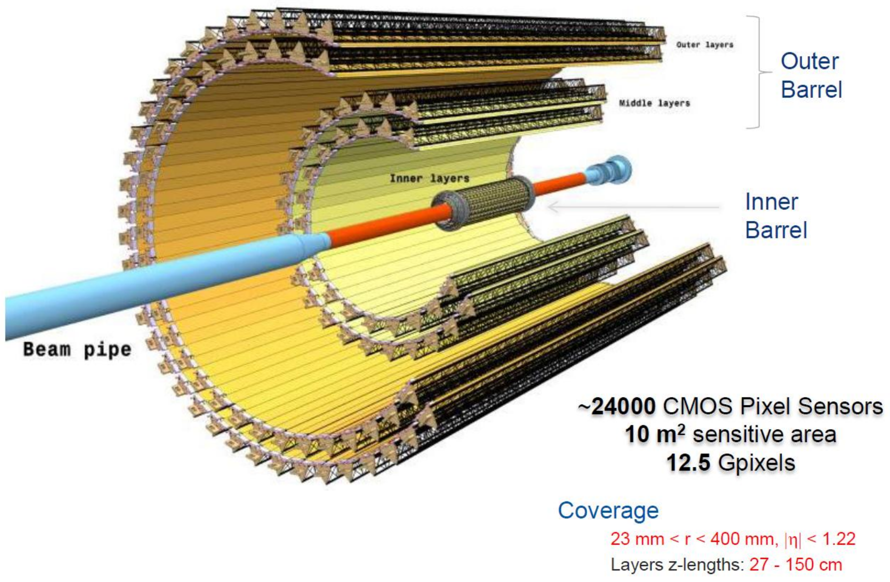
Stage 2: 2022-2023

Installation of ITS and thin wall Be beam pipe

JINR appeals for the Know-How transfer to build 6-layer ITS of the ALICE ITS Upgrade type with increased length of ladders to fit the NICA/MPD Interaction diamond parameters
MoU is on agreement

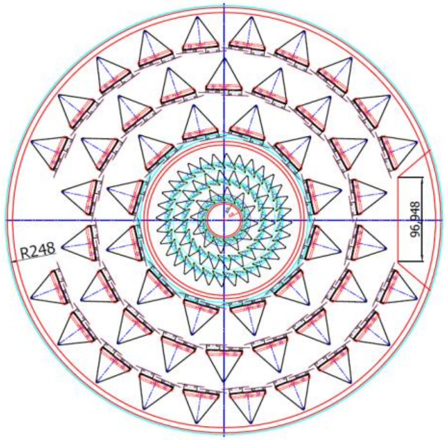


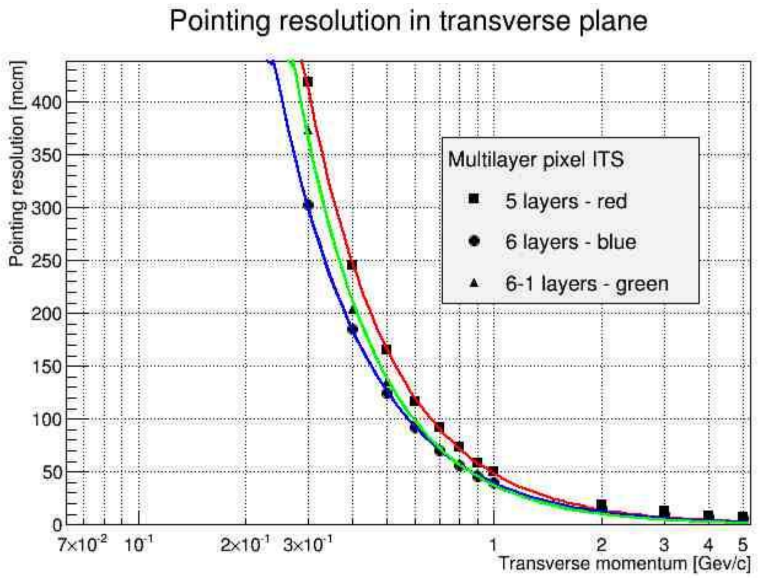
New ALICE ITS layout



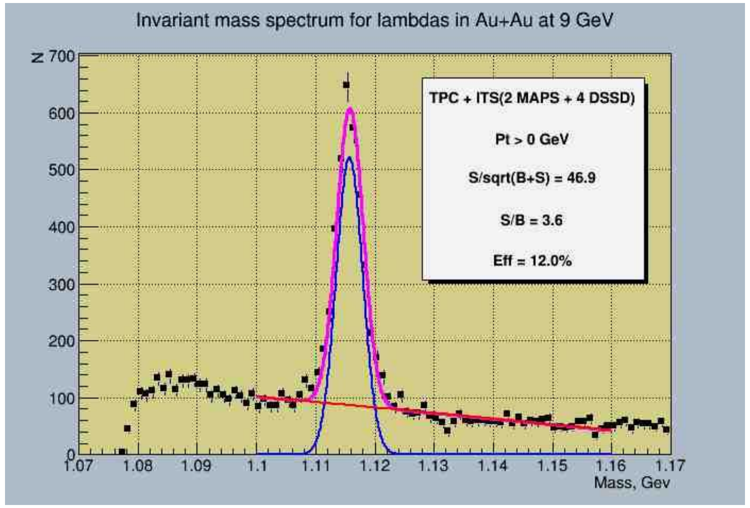
By Yu. Murin (JINR)

ITS for MPD Experiment

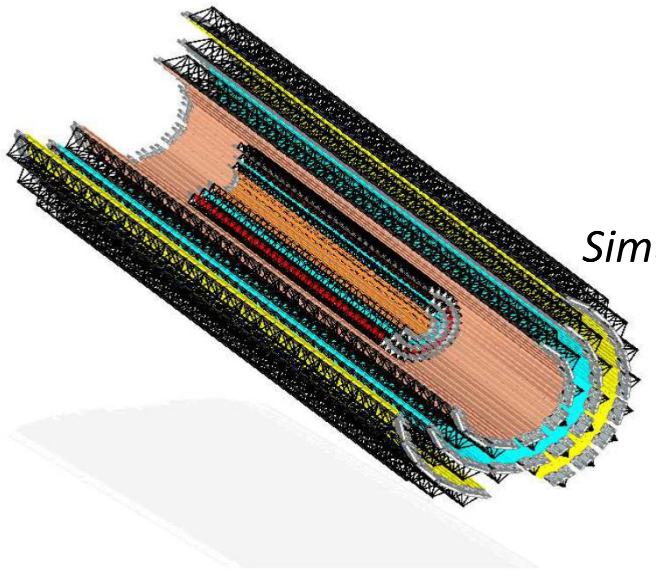




Pointing resolution
Simulations by Valery Kondratiev, SpBSU, SpB



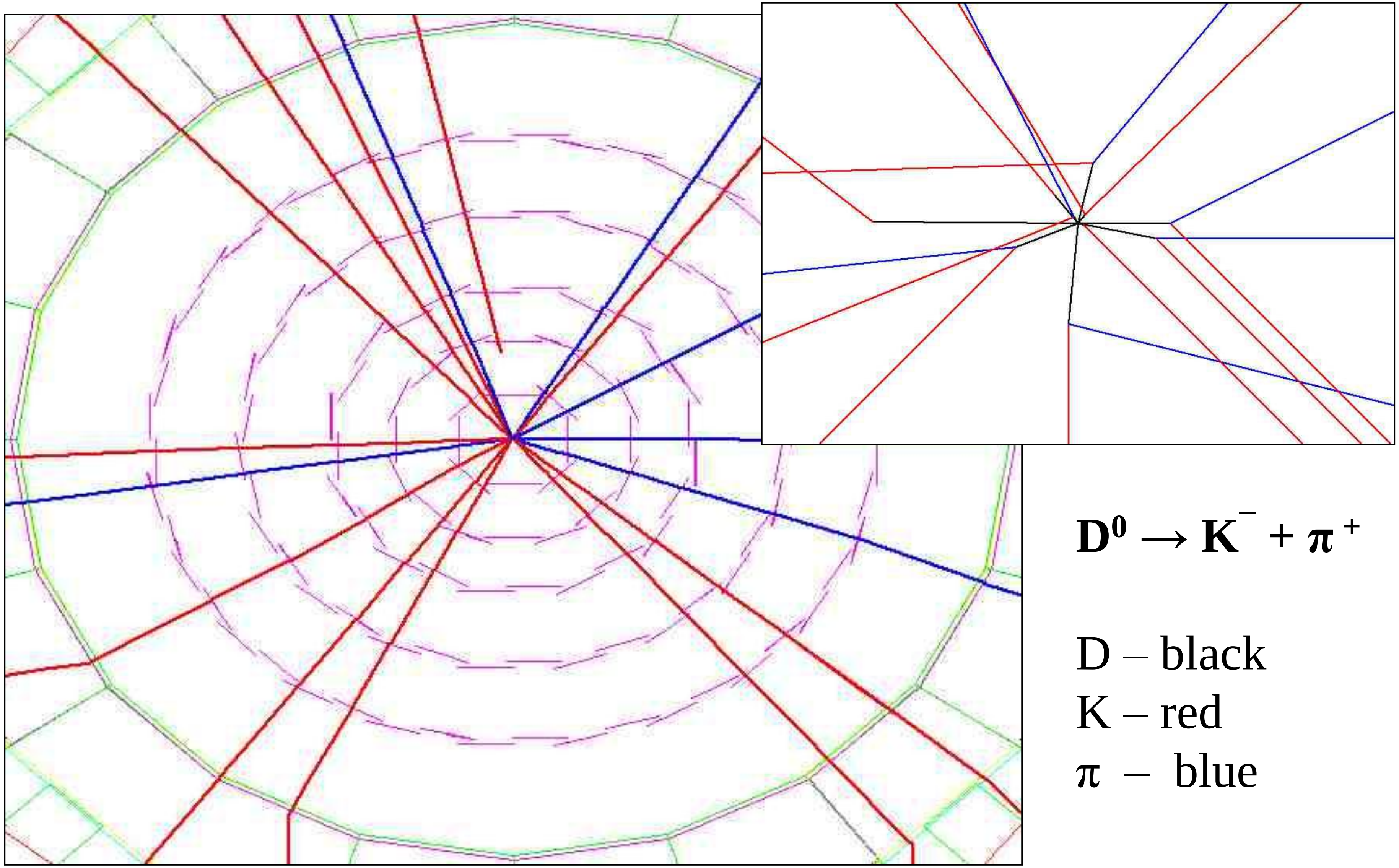
Reconstructed Λ-hyperon invariant mass spectrum (p_t<0.6 Gev)
A. Zinchenko et al



MPD ITS based on ALICE type staves

Identification of open charm particles

Example of 10 D0-decays in 5 pixel layers ITS



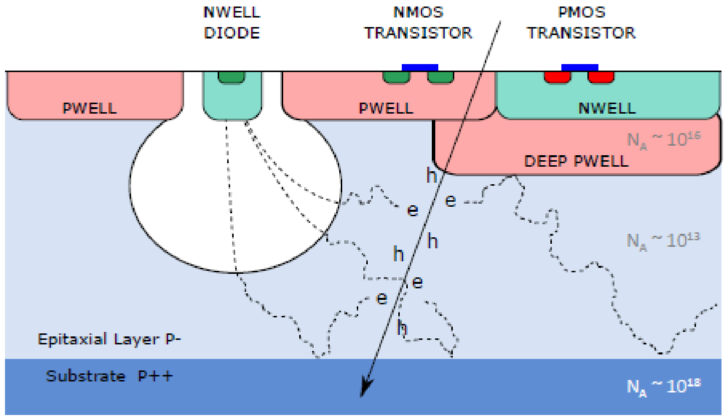
cτ = 123 μ
Eff 2%

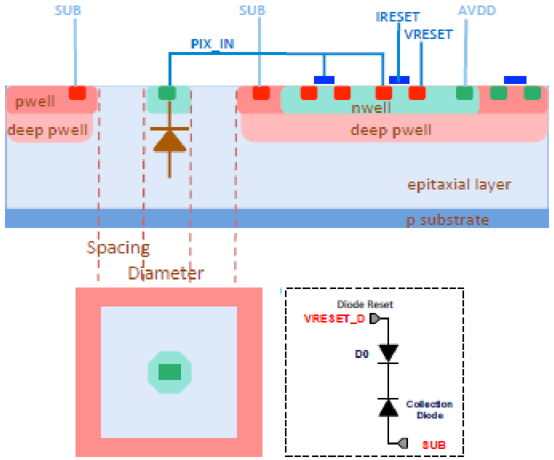
$\mathbf{D^0 \rightarrow K^- + \pi^+}$

D – black
K – red
π – blue

ALPIDE – Monolithic Active Pixel Sensor

CMOS Pixel Sensor using TowerJazz 0.18μm CMOS Imaging Process

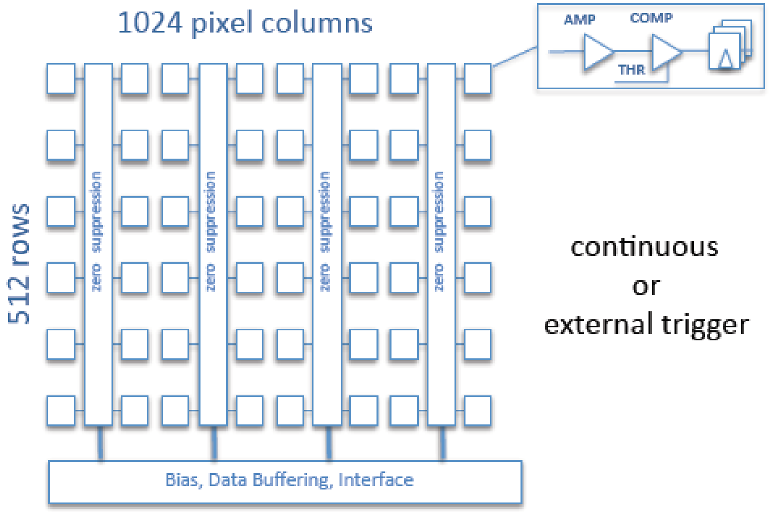




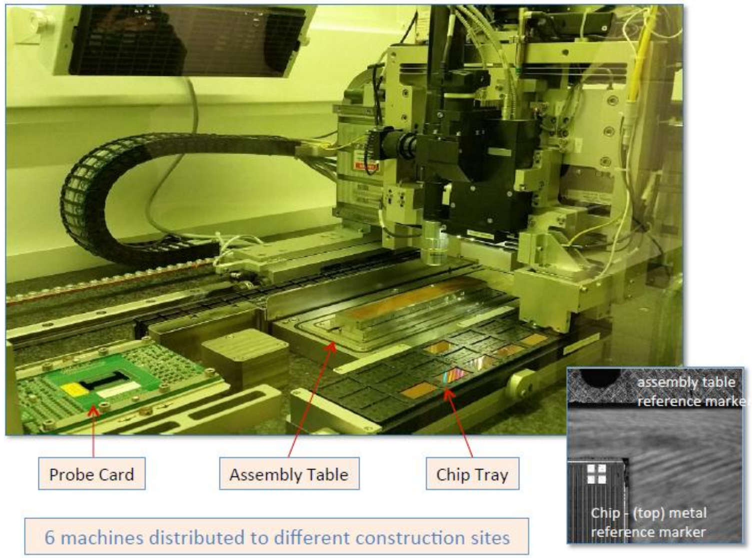
Monolithic PIXEL chip using

Tower Jazz CMOS 0.18 μm

- Chip size: 15mm x 30mm
- Pixel pitch ~ 30 μm
- Spatial resolution ~ 5 μm
- Power density < 100 mW/cm^2



Automated Module Assembly (custom-made machine)



Automated machine for module assembly

Our group already ordered one machine

By L. Musa (CERN)

Conclusion

- 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
- Our group is already close for production readiness for BM@N STS. Production will start at the end of 2018.
- We initiated contacts with ALICE ITS Upgrade team to build 6-layers ITS ALICE type based on a ALPIDE sensors.

First mini work meeting with the head of ALICE ITS team L. Musa was held at JINR 13-15 Apr 2017

Workshop at JINR dedicated to the BM@N and CBM STS setups. 22-23 May 2017

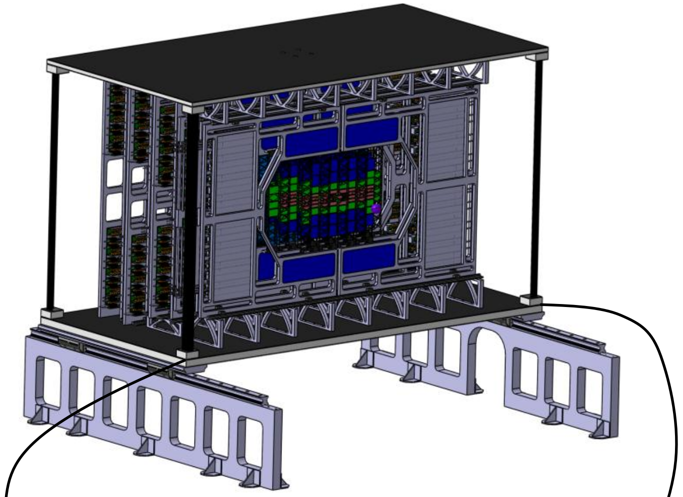
THANK YOU FOR YOUR ATTENTION!

BACKUP SLIDES

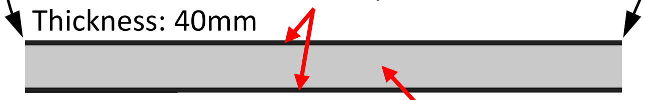
JINR STS Department

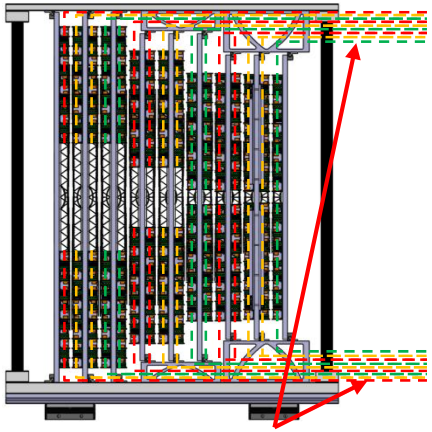
- **The head of the department is Yu. Murin**
- **Quality assurance of sensors: N. Zamyatin (LHEP)+ M. Merkin (SINP)**
- **Silicon Tracking Systems (STS+ITS)**
  - **Assembly of modules and super-modules: A. Sheremetev +4**
  - **Mechanics of Composite Materials: A. Voronin, Igolkin as a consultant (CERN)**
  - **Bench and in-beam testing group: D. Dementev + 2 students**
- **Administration, civil construction and procurements support: V. Penkin + S. Udovenko**
- **Industry partners: lrd. LTU (Kharkov), Planar enterprise (Minsk)**

CBM STS Cad model

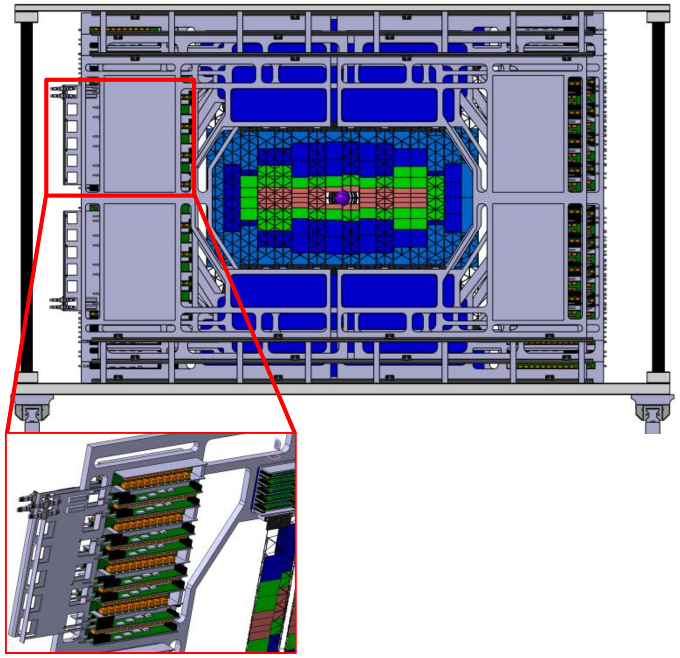


[Sandwich concept by M. Faul and W. Niebur]





Design concept update:
- Cable routing
- Unit disassembly
- Integrated design



Peripheral cabling design

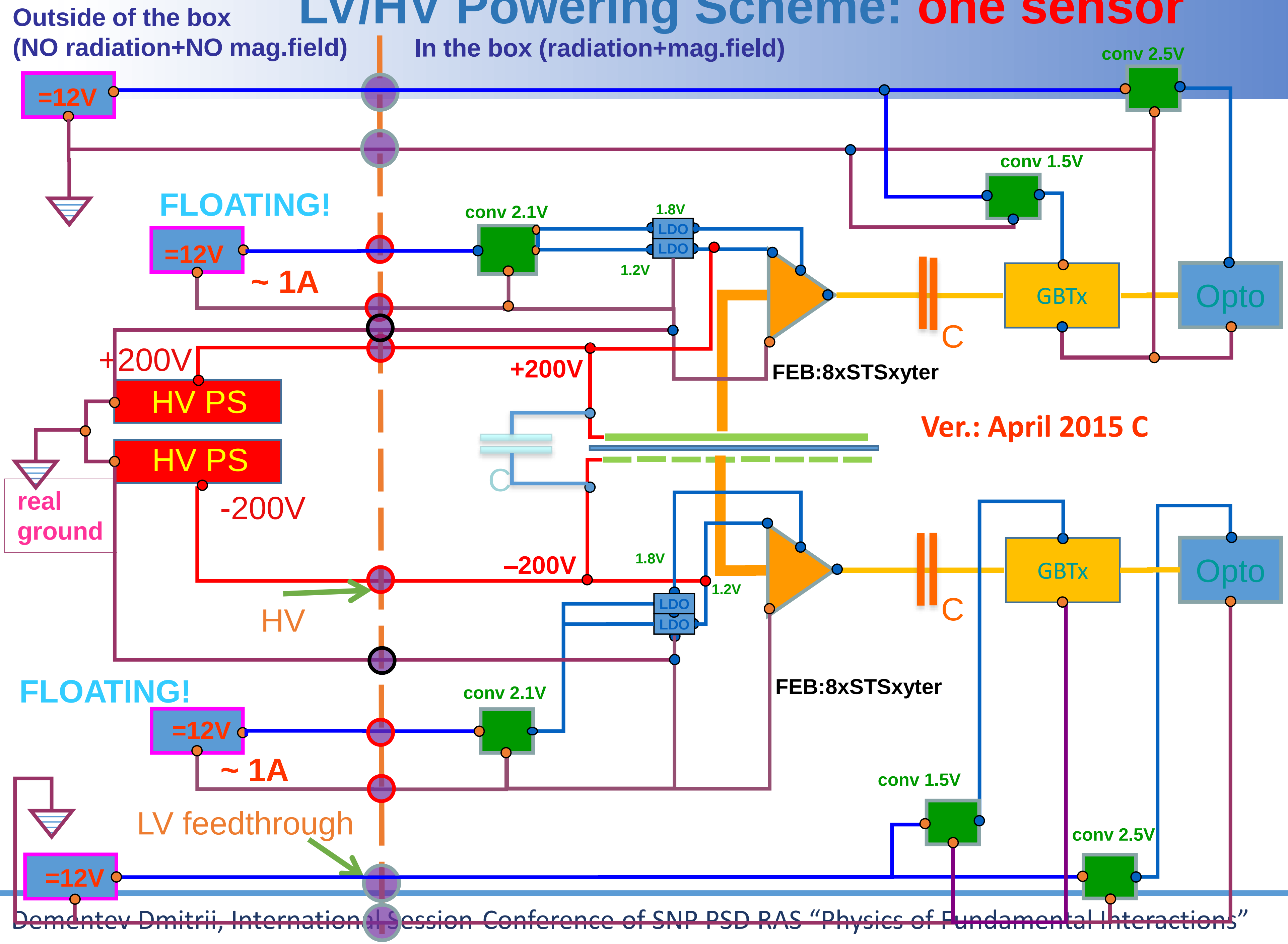
Sandwich concept:
- Lightweight and stiff
- Parameters depend on filler material
- Versatile configuration

Further development requires:
- Thermal testing
- Requirement summary
- Coordination with industrial manufacturers

Further CAD development:
- Finalize cabling concept
- Schematic cable routing
- Integrated design

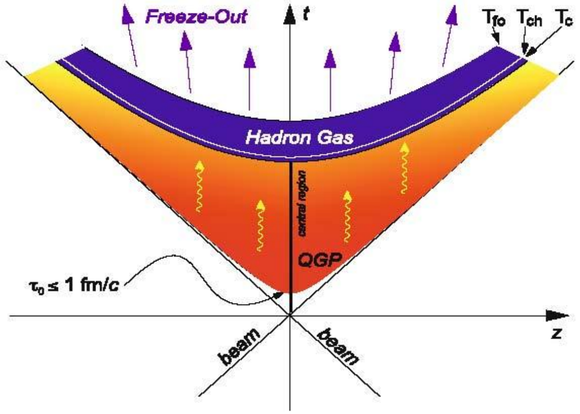
By J. HEUSER

LV/HV Powering Scheme: one sensor

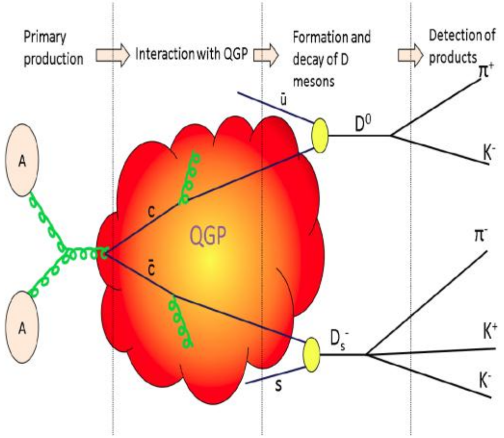


Physics motivation for a study of charm production at NICA

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

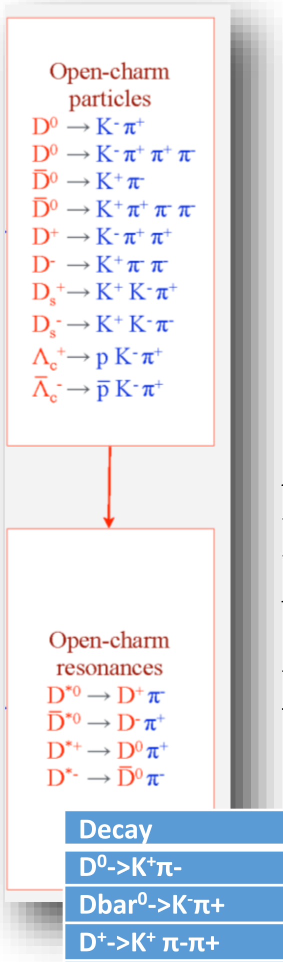


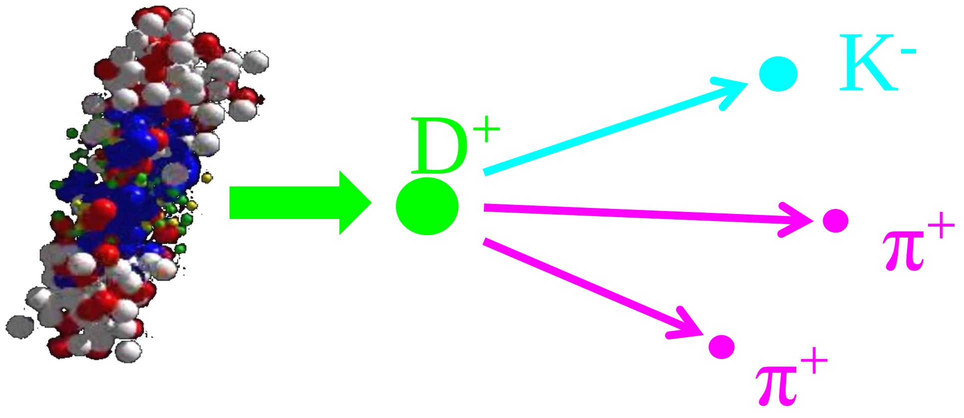
C-quarks interaction with cold nuclear matter has an exciting perspective at NICA since the estimated yields for the production of the hypothetical light supernuclei $_{c}He^{3}$ and $_{c}He^{4}$ indicated feasibility of the experimental search at NICA and not anywhere else at the moment



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

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->K^+π-	0,1	123	4	2	48 10^3
$Dbar^0$->K^-π+	0,1	123	4	2	48 10^3
D^+->K^+ π-π+	0,1	312	7	1,5	63,5 10^3
D^-->K^- π-π+	0,1	312	7	1,5	63,5 10^3
D^+_s-> K^+ K^- π+	0,1	150	3	1,5	27,2 10^3
$Λ^+_c$-> pK^+ π-	10^{-3}	60	6	0,1	363
$Λbar^+_c$-> pbarK^- π+	10^{-3}	60	6	0,1	363
$_cHe^3$-> d+pK^+ π-	10^{-4}	60?	?	?	3,6 (?)
$_cHe^4$-> t+pK^+ π-	10^{-5}	60?	?	?	0,36 (?)