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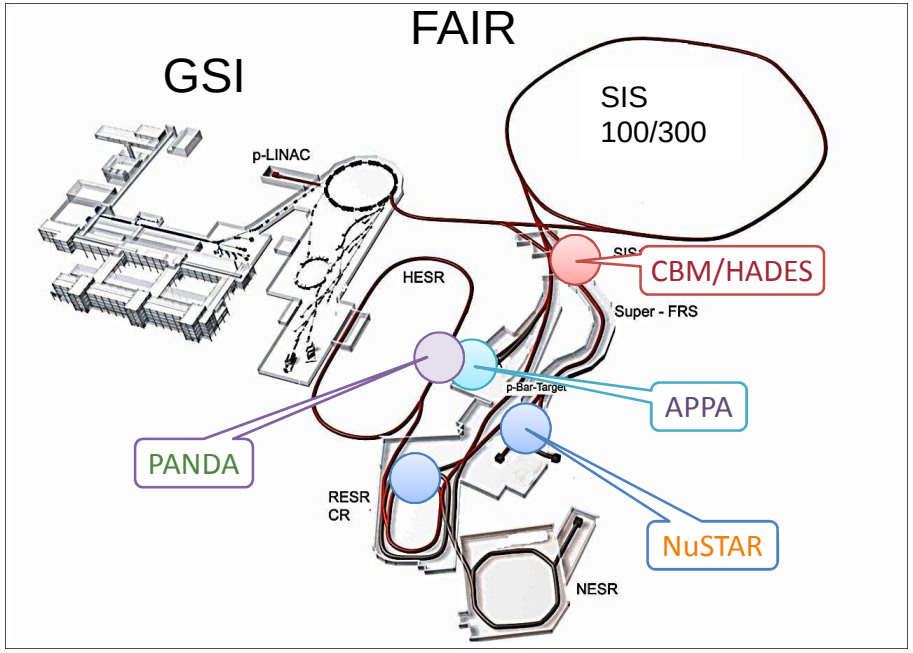
SINP MSU

MPD and SPD for NICA project

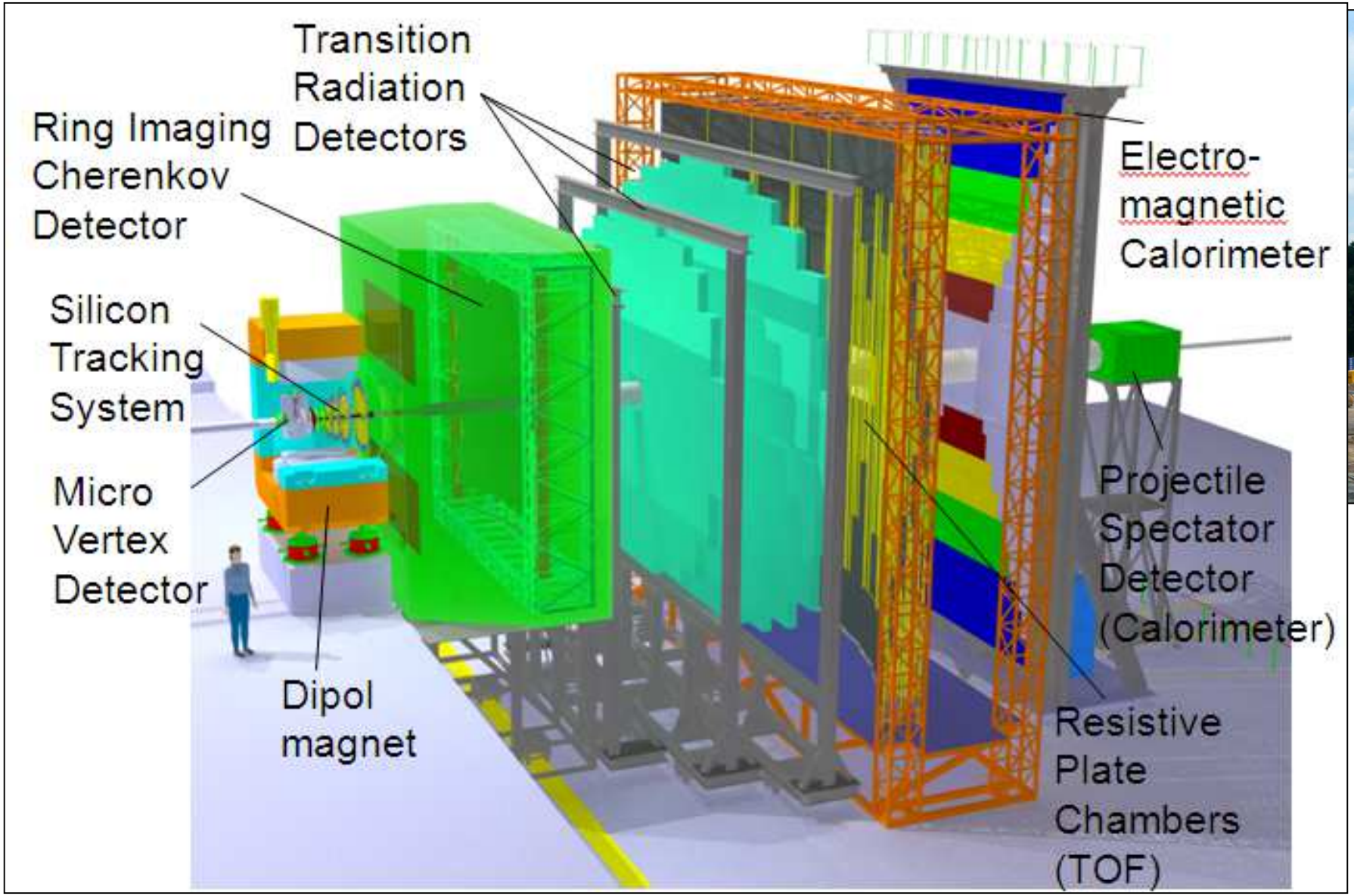
Questions and Answers

Advanced Studies Institute (ASI), SPIN-Praha-2014, 14 Feb, 2014

The CBM experiment at FAIR



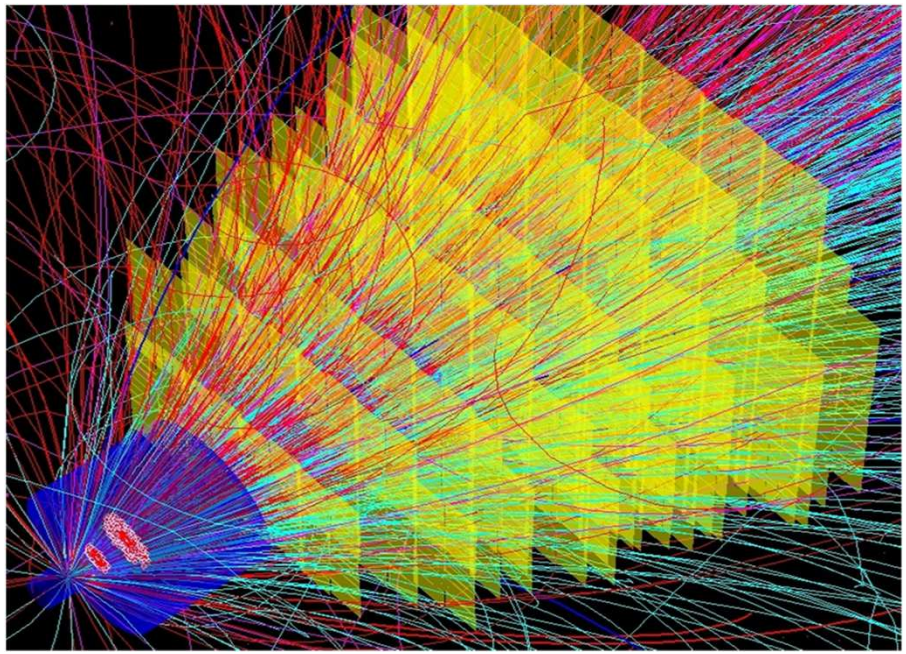
The CBM experiment at FAIR

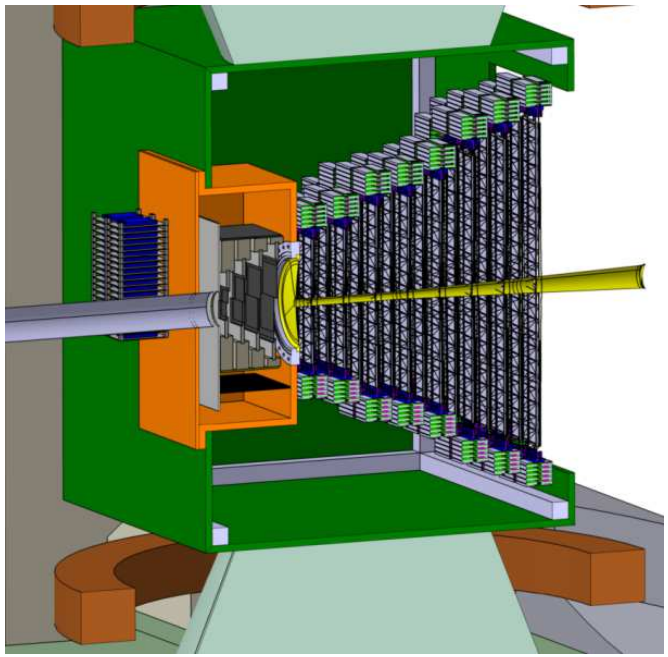


CBM Silicon Tracking System (STS)

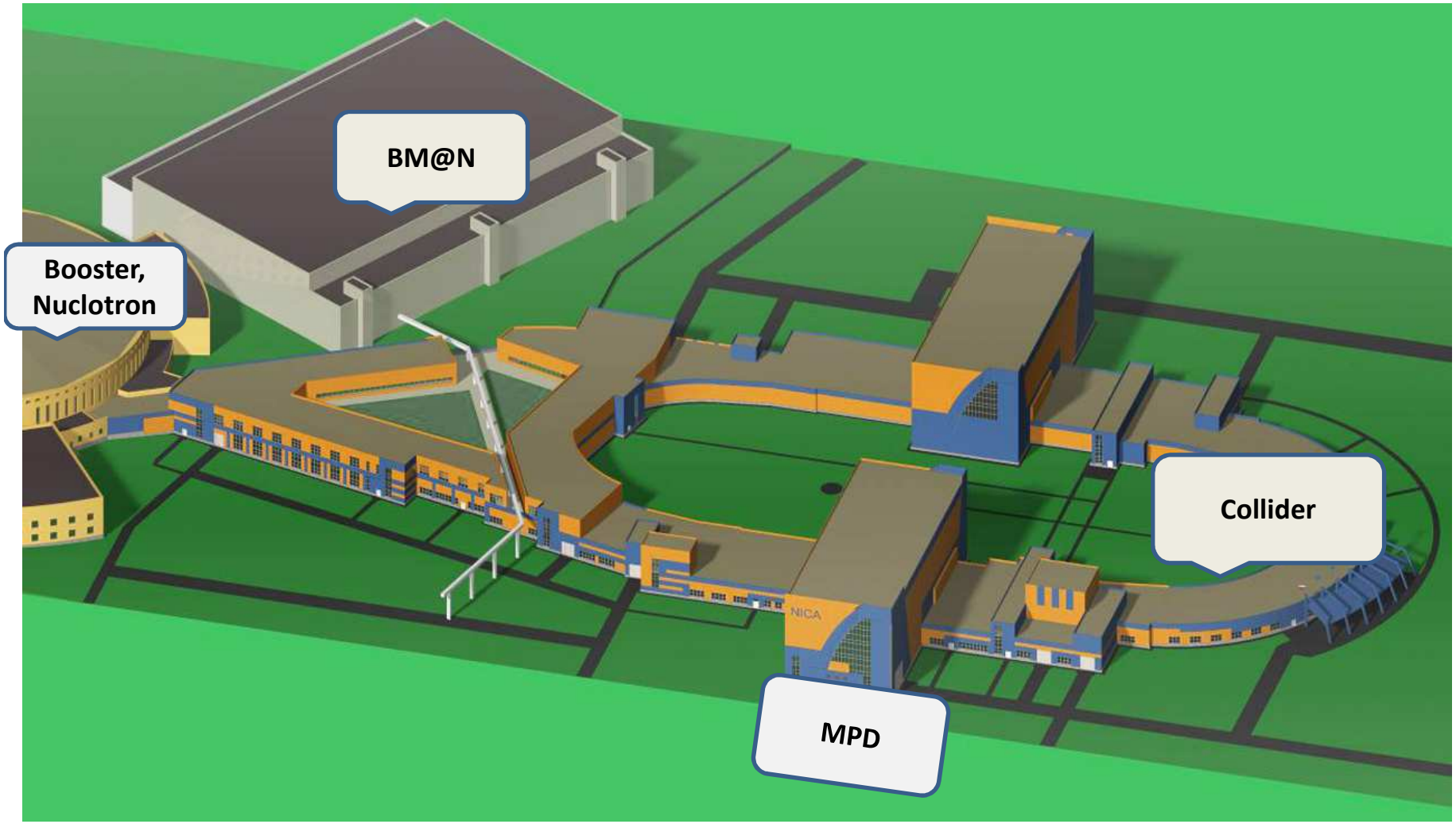
- CBM's central detector system
- largest detector project at GSI for FAIR
  - 8 high-tech tracking stations
  - 2 m^3 volume in dipole magnet
  - 2.5 M channels, 40 kW dissipation
  - 10 MHz event rate, 1 TB/s data

- International project:
  - 14 CBM member institutes from Germany, Russia, Poland, Ukraine
  - GSI has project leadership
  - partner project at JINR (BM@N)





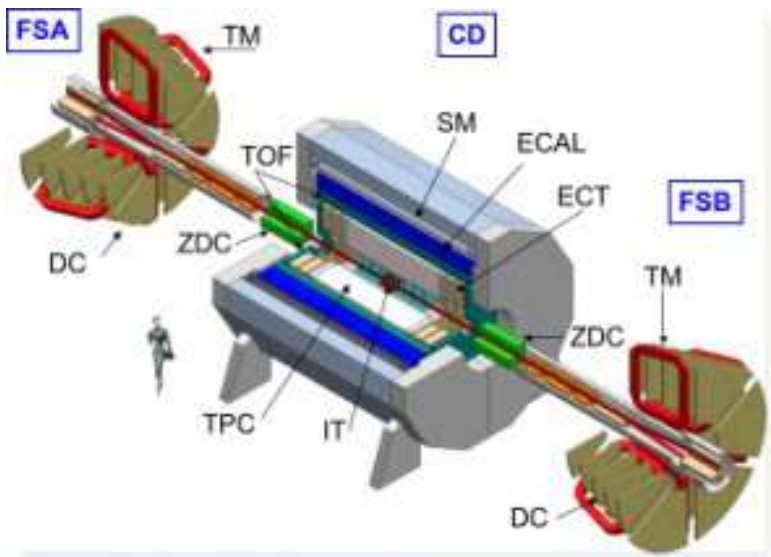
NICA megaproject

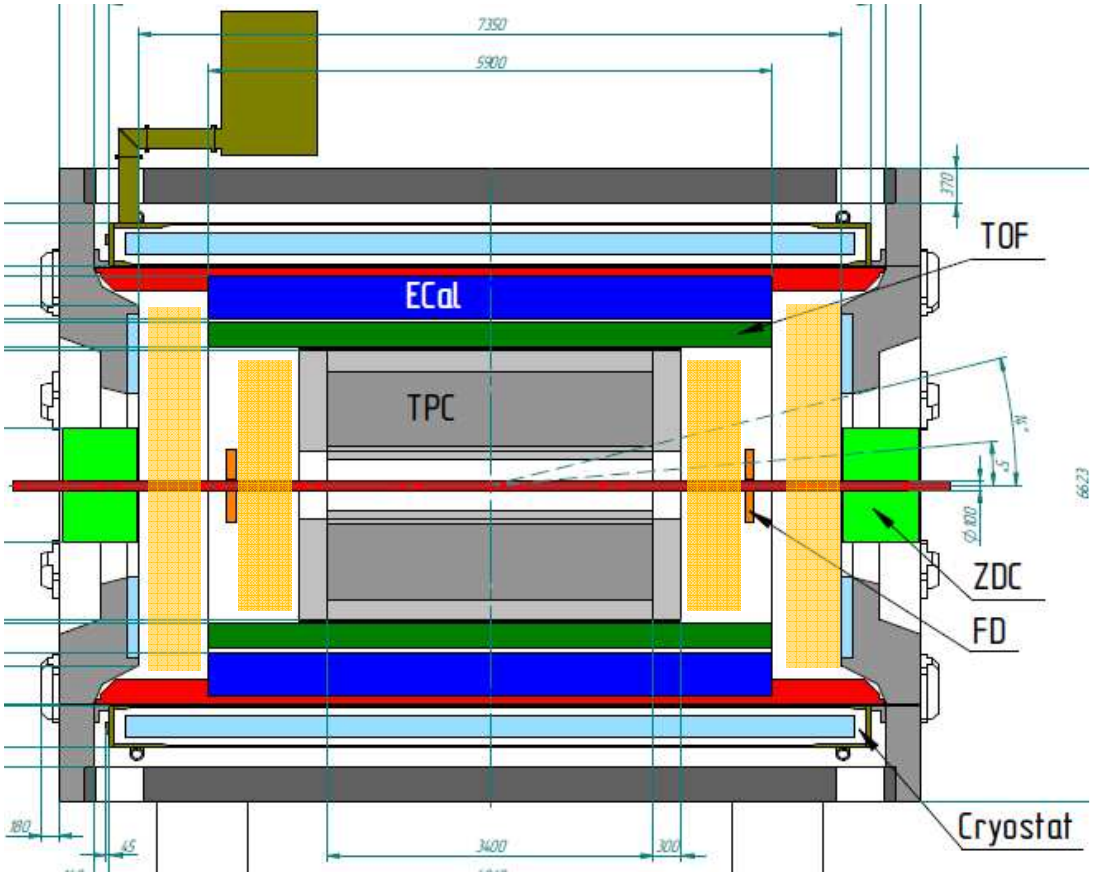


MPD detector at NICA

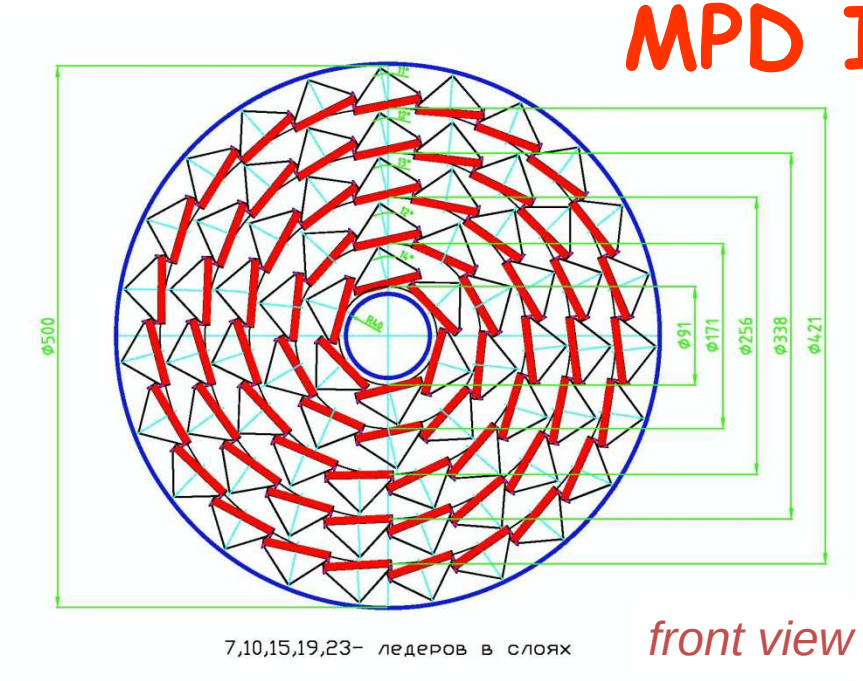
Magnet : 0.5 T
T0, Trigger : FFD
Centrality &
Event plane : ZDC
Tracking (|η|<2): TPC
PID: TOF, TPC, ECAL

Stage 1 (2017)
TPC, Barrel TOF & ECAL, ZDC, FFD
Stage 2: IT + Endcaps(tracker,TOF,ECAL)

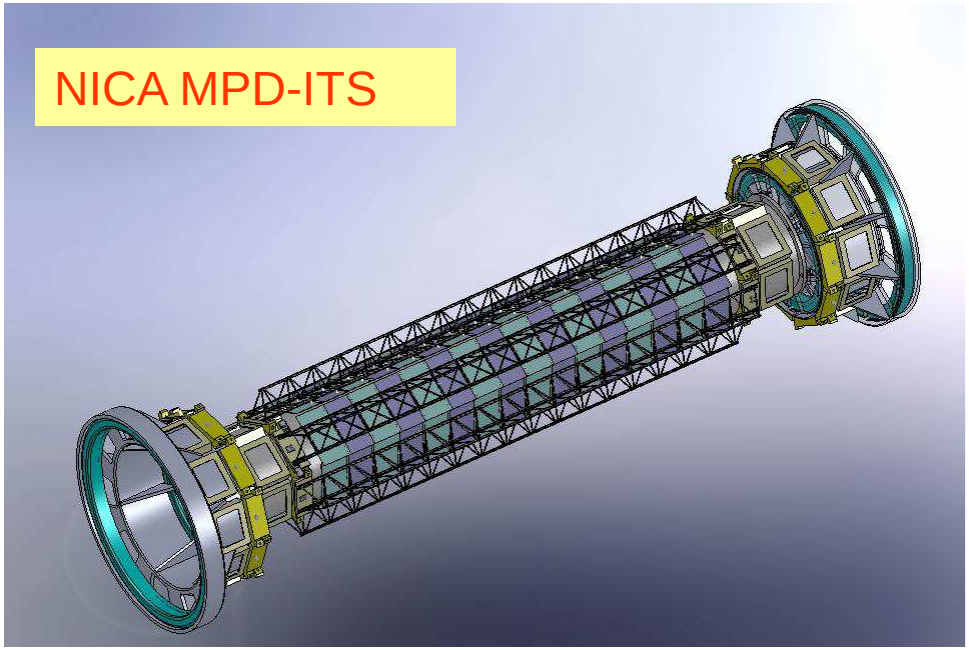


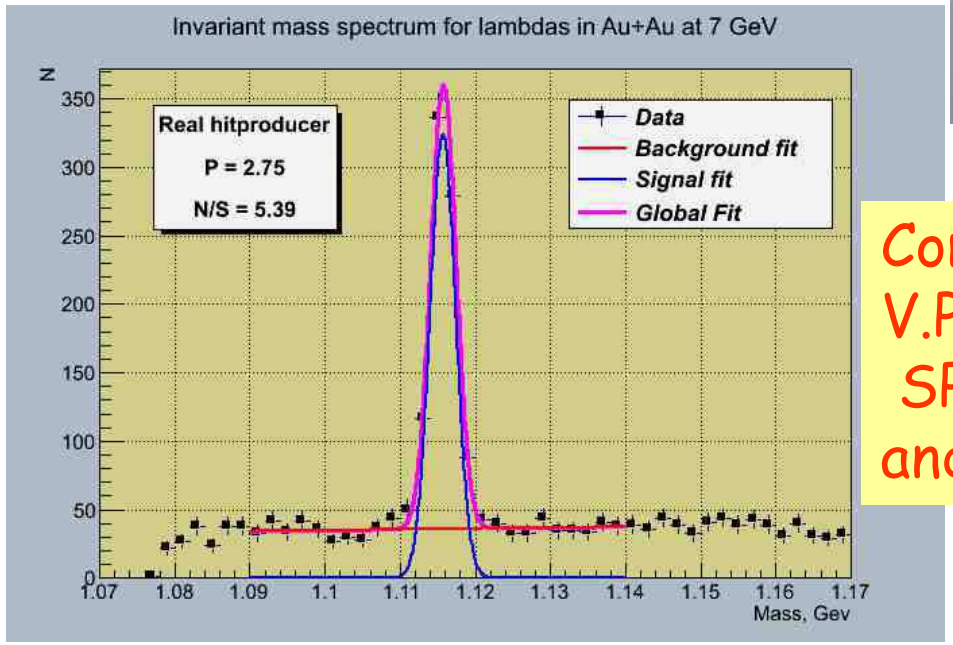


MPD ITS status



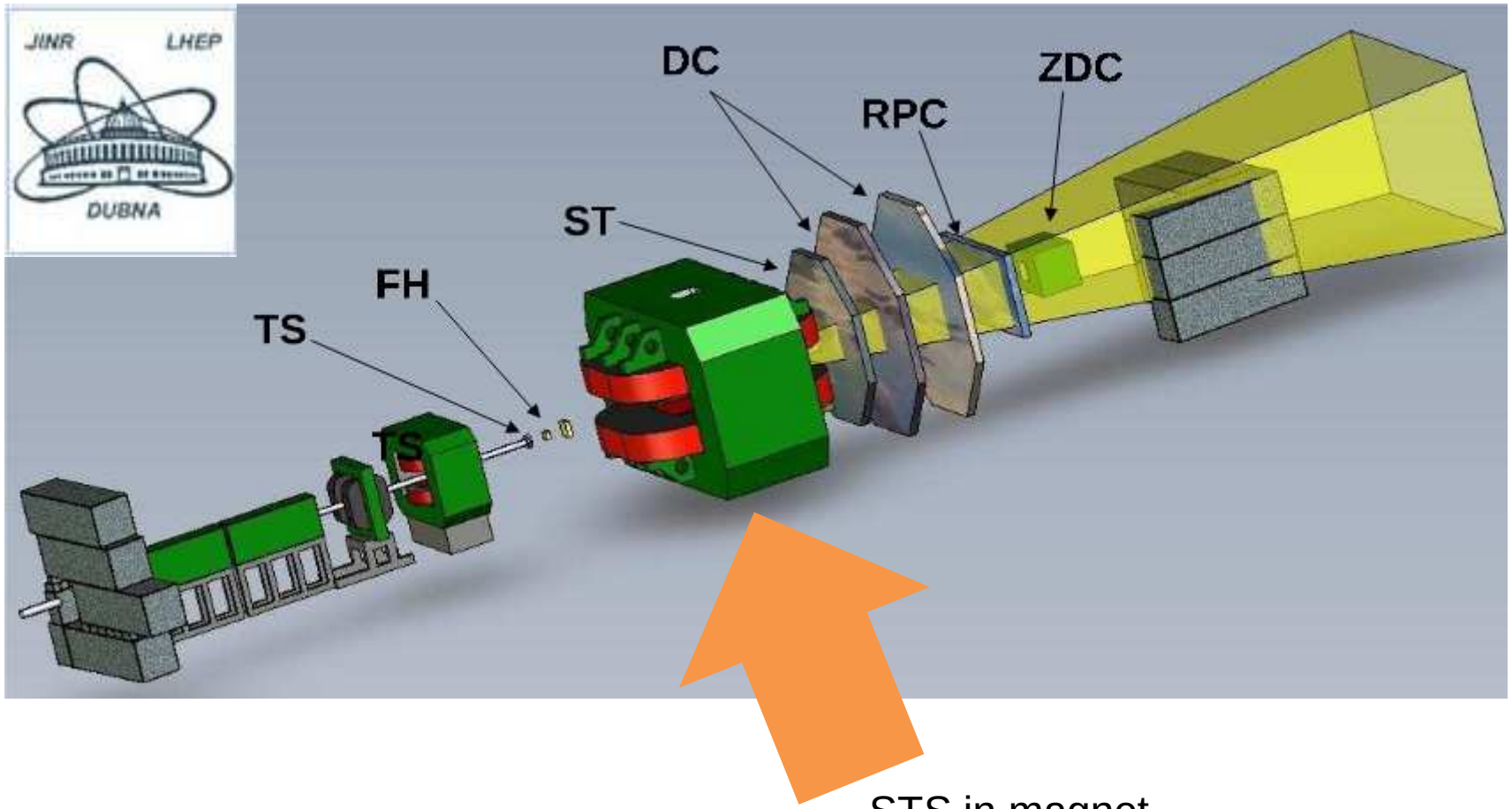
front view





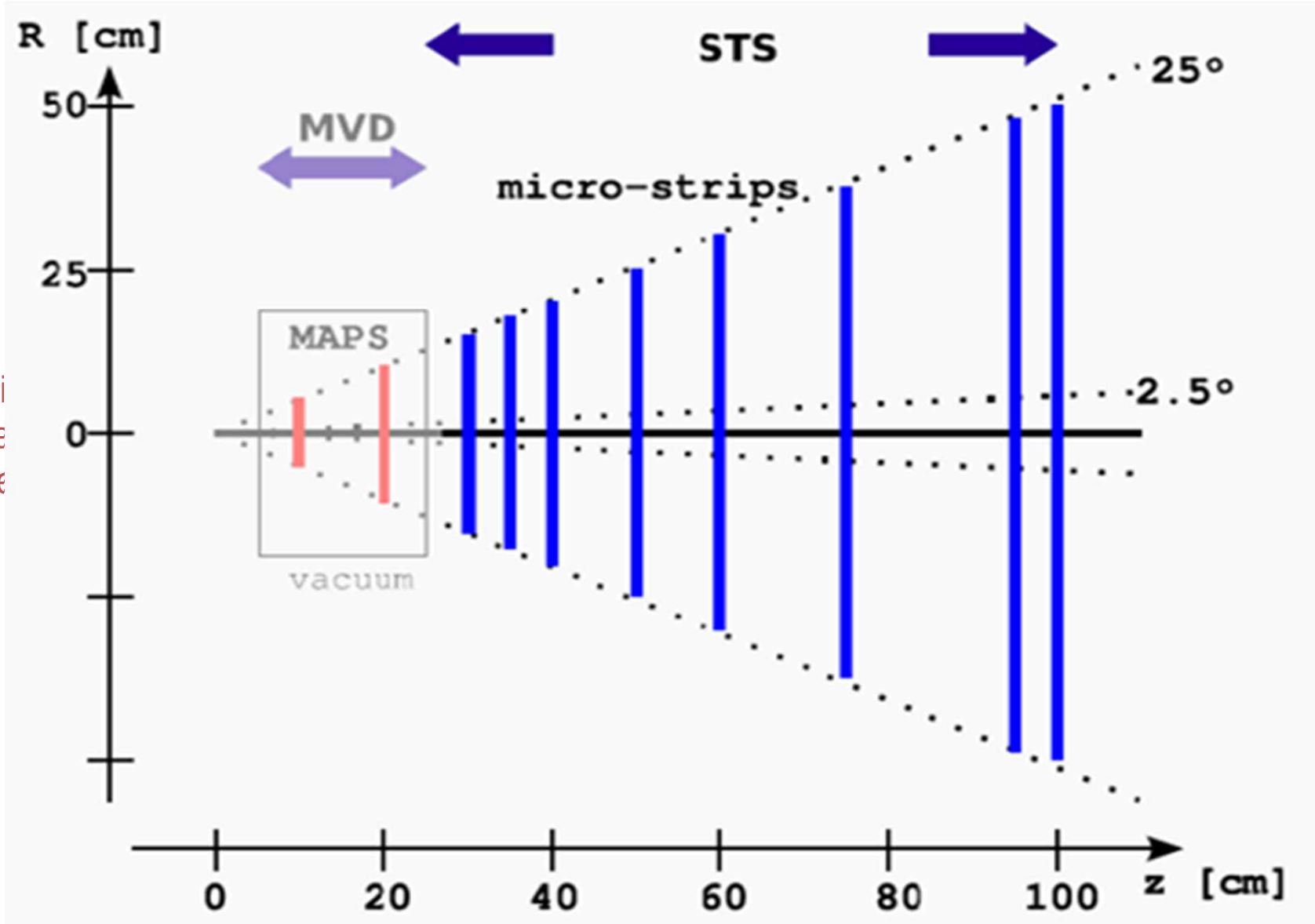
Computer model simulations by V.P.Kondratiev and N.Prokofiev, SPbSU together with A.I.Zinchenko and V.A.Vasendina

BM@N Silicon Tracking System



STS in magnet

The CBM experiment at FAIR



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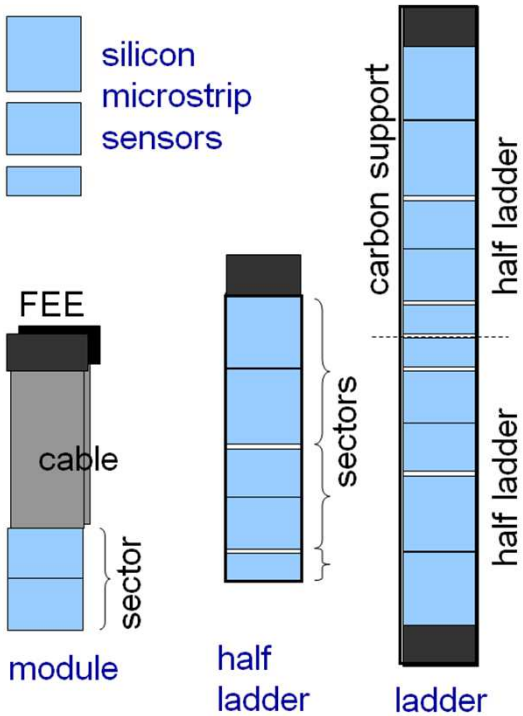
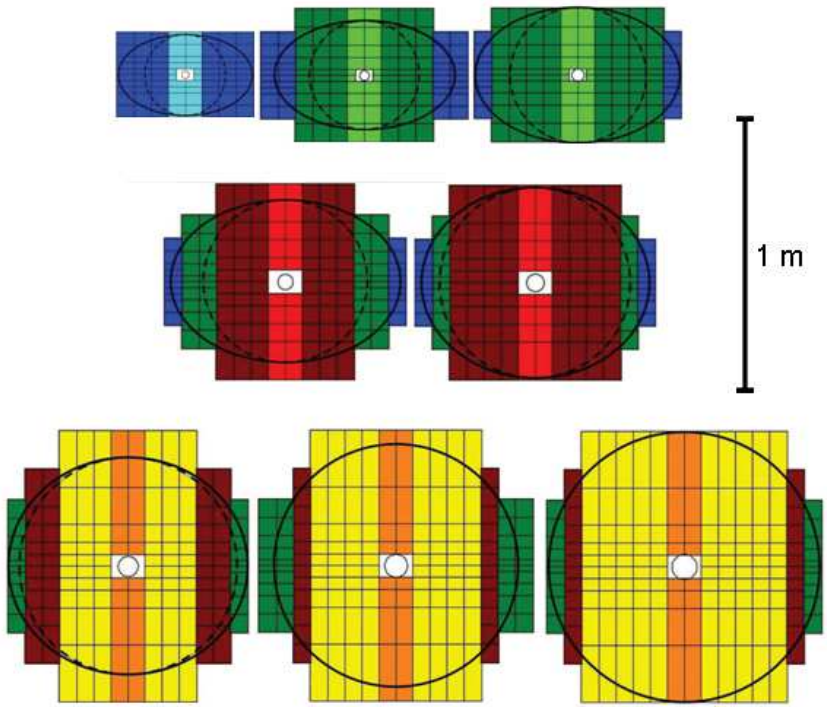
STS design constraints

- **Coverage:**
  - rapitidies from center-of mass to close to beam
  - *aperture 2.5° < Θ < 25° (less for BM_N)*
- **Momentum resolution**
  - $\delta p/p \cong 1\%$
  - *field integral 1 Tm, 8 tracking stations*
  - *25 μm single-hit spatial resolution*
  - *material budget per station ~1% X_0*
- **No event pile-up**
  - *10 MHz interaction rates*
  - *self-triggering read-out*
  - *signal shaping time < 20 ns*
- **Efficient hit & track reconstruction**
  - close to 100% hit eff.
  - > 95% track eff. for momenta >1 GeV/c
- **Minimum granularity**
  @ hit rates < 20 MHz/cm^2
  - *maximum strip length compatible with hit occupancy and S/N performance*
  - *largest read-out pitch compatible with the required spatial resolution*
- **Radiation hard sensors**
  compatible with the CBM physics program
  - 1×10^{13} n_{eq}/cm^2 (SIS100)
  - 1×10^{14} n_{eq}/cm^2 (SIS300)
- **Integration, operation, maintenance**
  - compatible with the confined space in the dipole magnet

STS concept

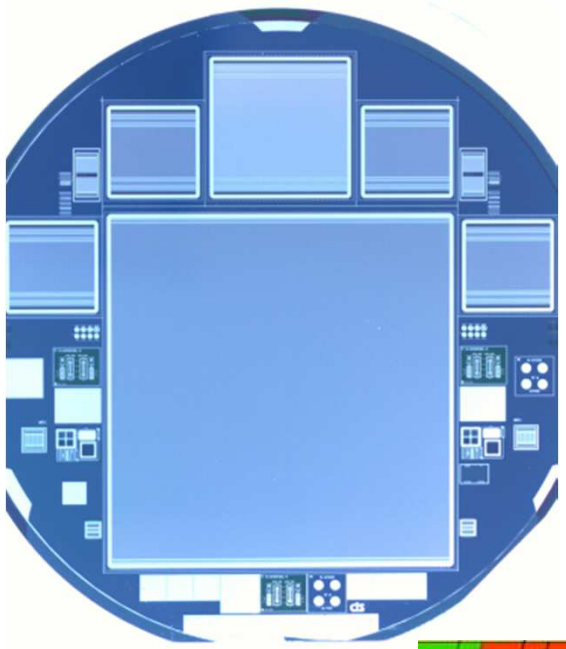
- Aperture: 2.5° < Θ < 25° (some stations up to 38°).
- 8 tracking stations between 0.3 m and 1 m downstream the target.
- Built from double-sided silicon microstrip sensors in 3 sizes, arranged in modules on a small number of different detector ladders.
- Readout electronics outside of the physics aperture.

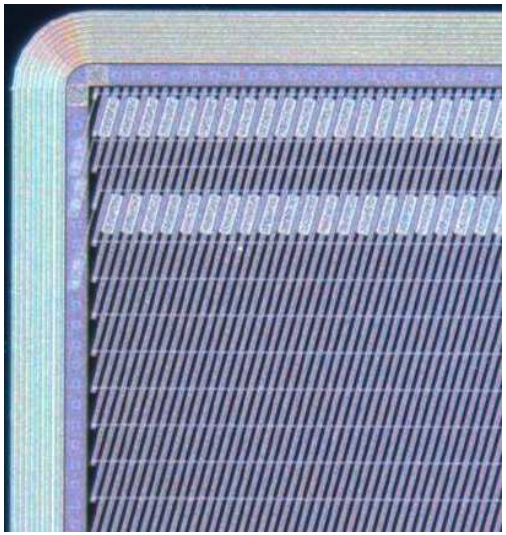


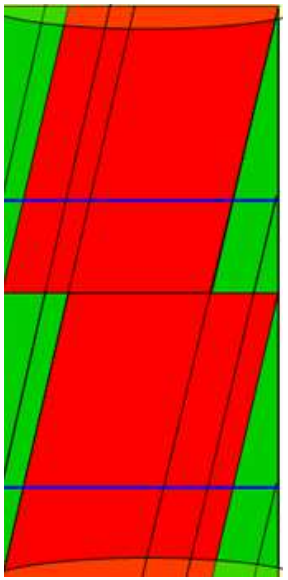


Microstrip sensors

- double-sided, p-n-n structure
- width: 6.2 cm
- 1024 strips at 58 μm pitch
- three types, strip lengths: 2, 4, 6 cm, 4 cm
- stereo angle front-back-sides 7.5°
- integrated AC-coupled read-out
- double metal interconnects on p-side, or replacement with an external micro cable
- operation voltage up to few hundred volts
- radiation hardness up to 1×10^{14} n_{eq}/cm^2



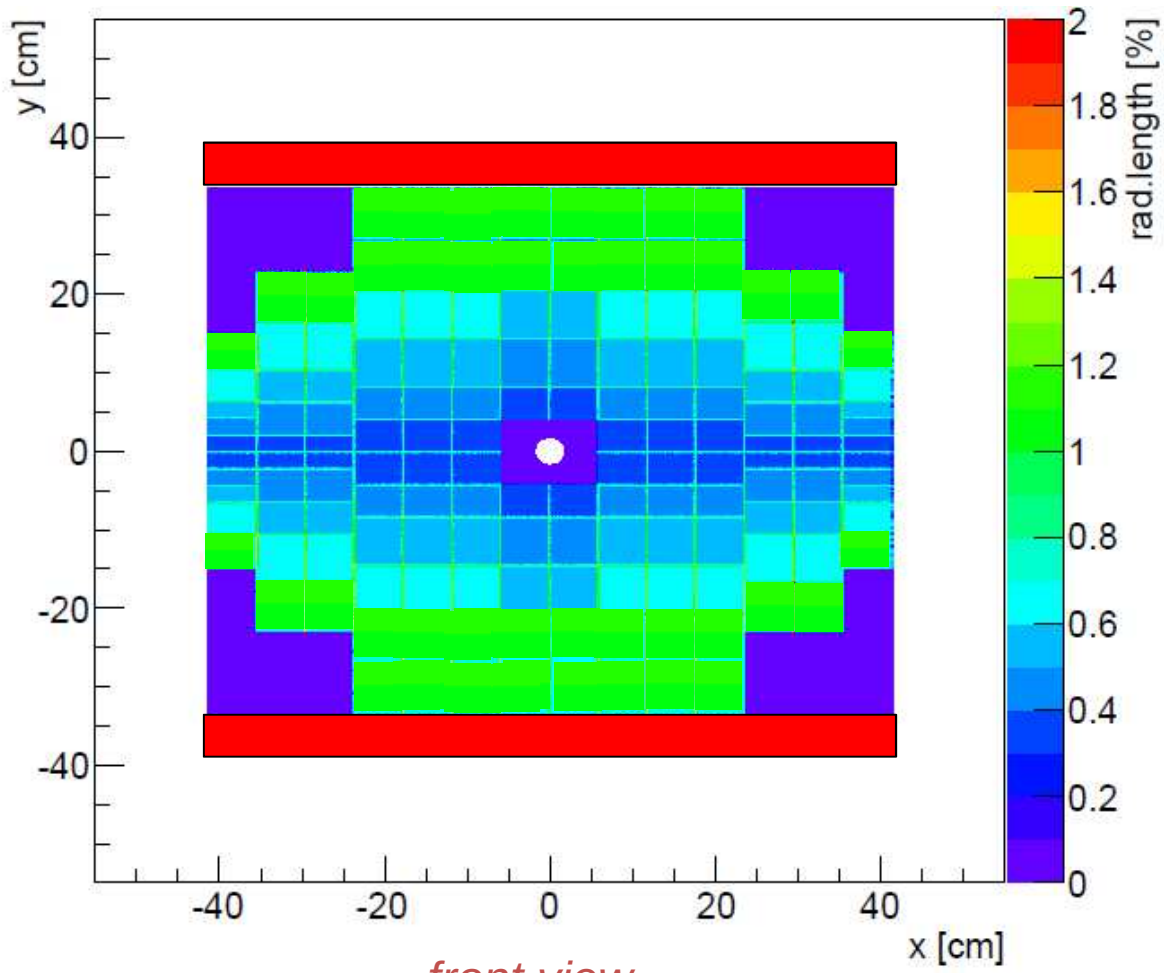




4” and 6” wafers, 300 μm thick
test and full-size sensors

Assessment of tracking stations – material budget

station 4



front view

electronics

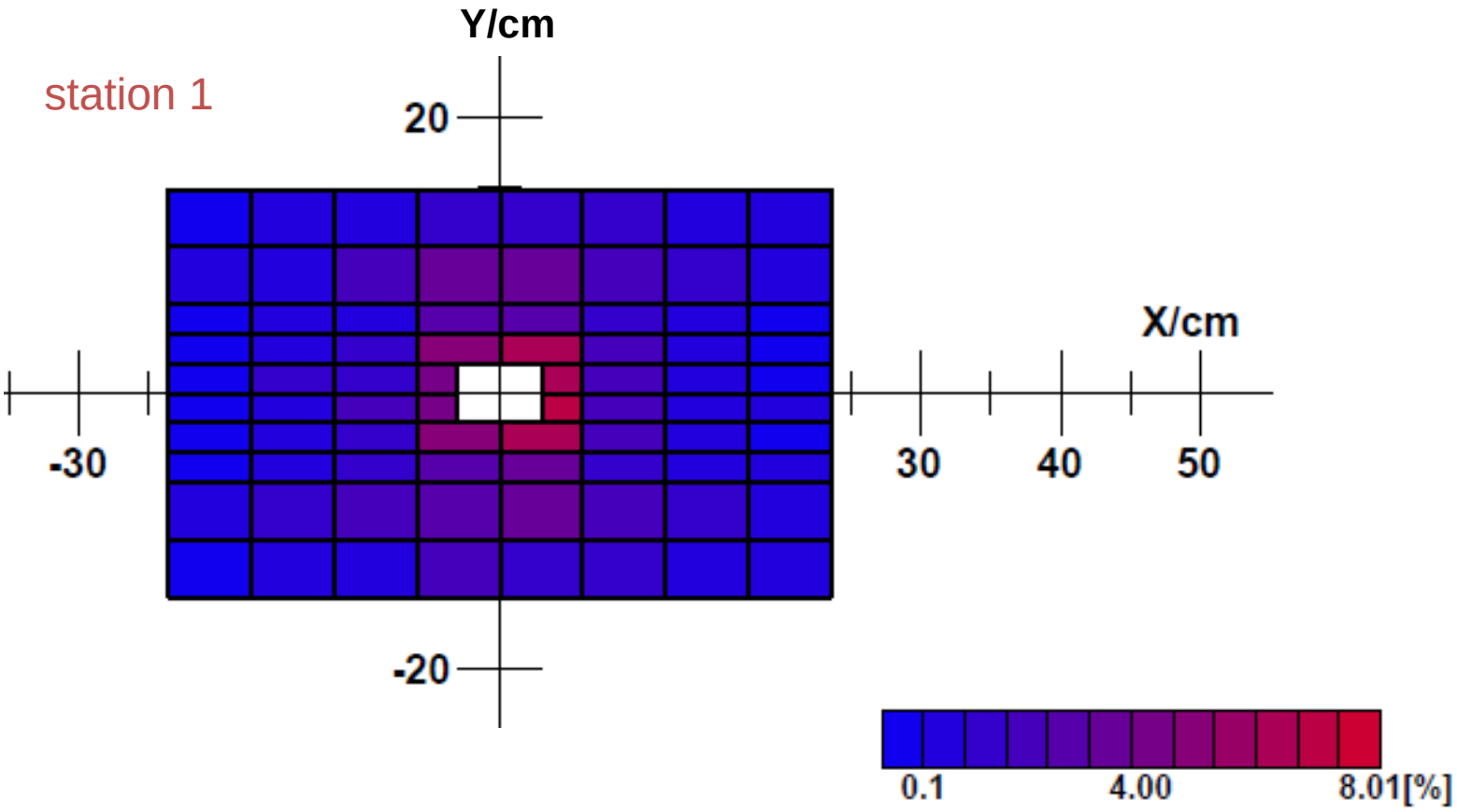
sensor:
0.3% X_0

r/o cables:
2×0.11% X_0

side view

Assessment of tracking stations – sensor occupancy

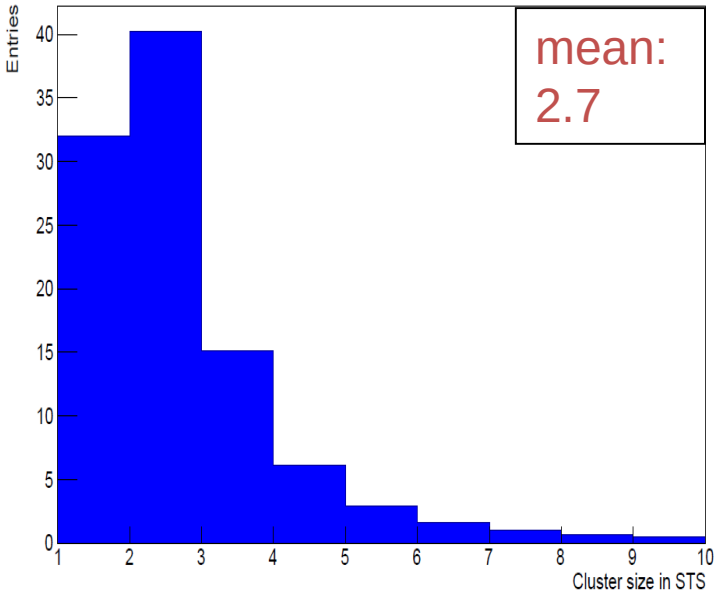
sensor occupancy := *ratio* *"nb. of hit strips : nb . of all strips"* *in a sensor*



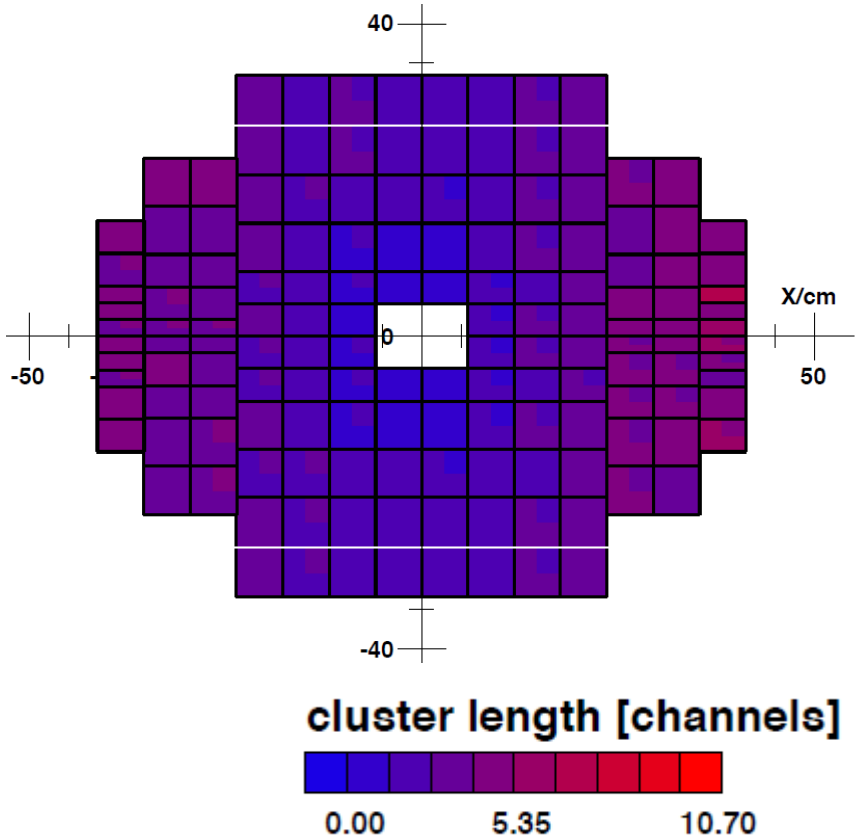
Assessment of tracking stations – hit cluster size

cluster of strips := *number of adjacent strips in a sensor that fire simultaneously*

distribution for full STS

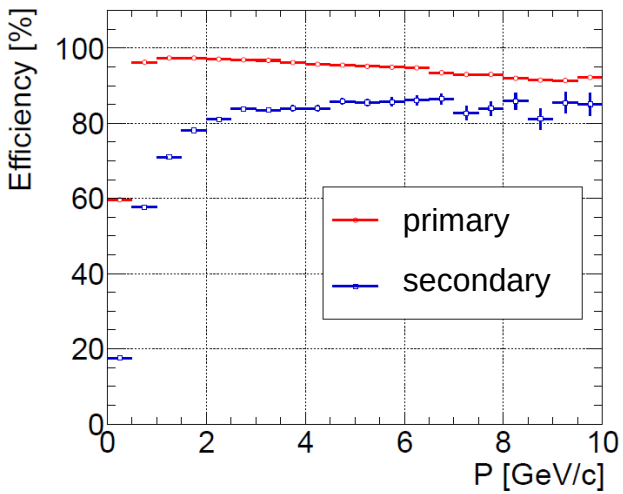


in station 4

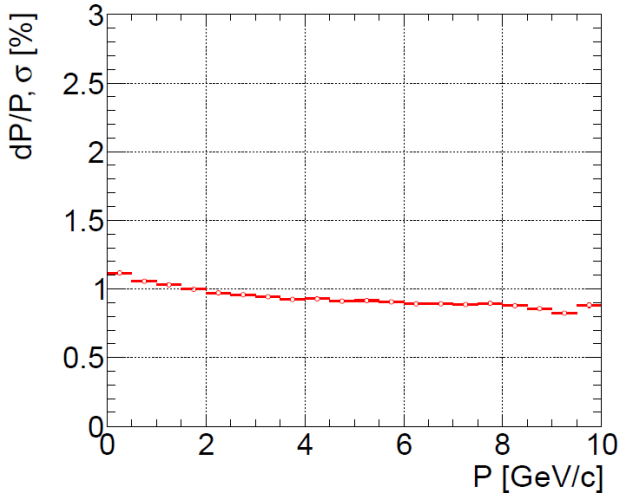


Track reconstruction performance studies

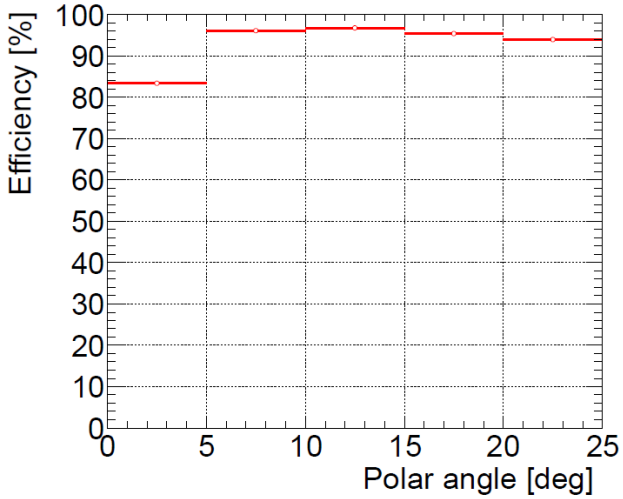
track reconstruction efficiency



momentum resolution



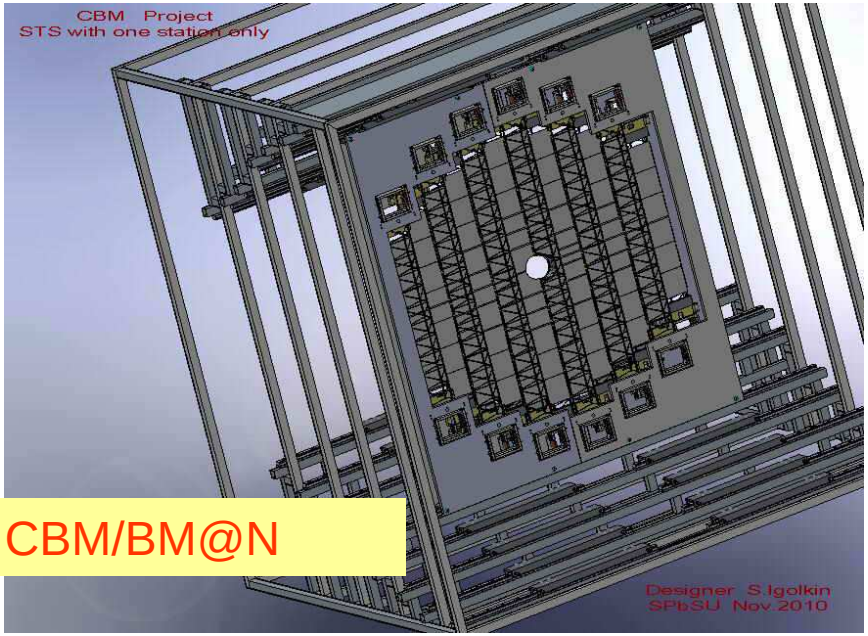
25 AGeV
Au+Au
central



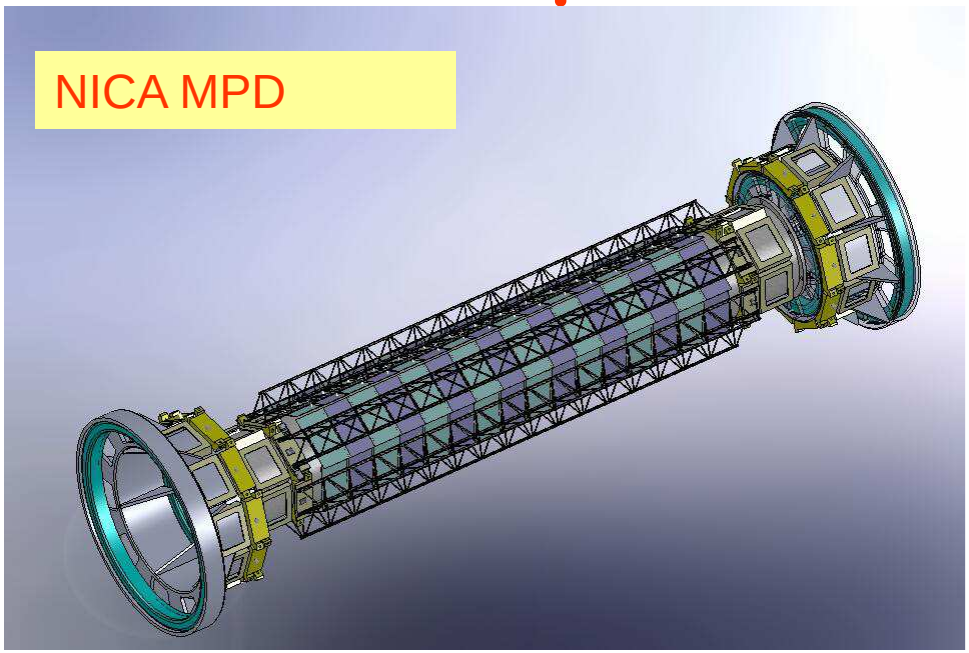
⇒ Ongoing layout improvements:

- *aperture improvements to be done in some of the stations: better coverage around beam pipe*
- *optimize number and type of modules and their deployment in the stations*

Modern fast and high precision instrumentation based on microstrip sensors



CBM/BM@N

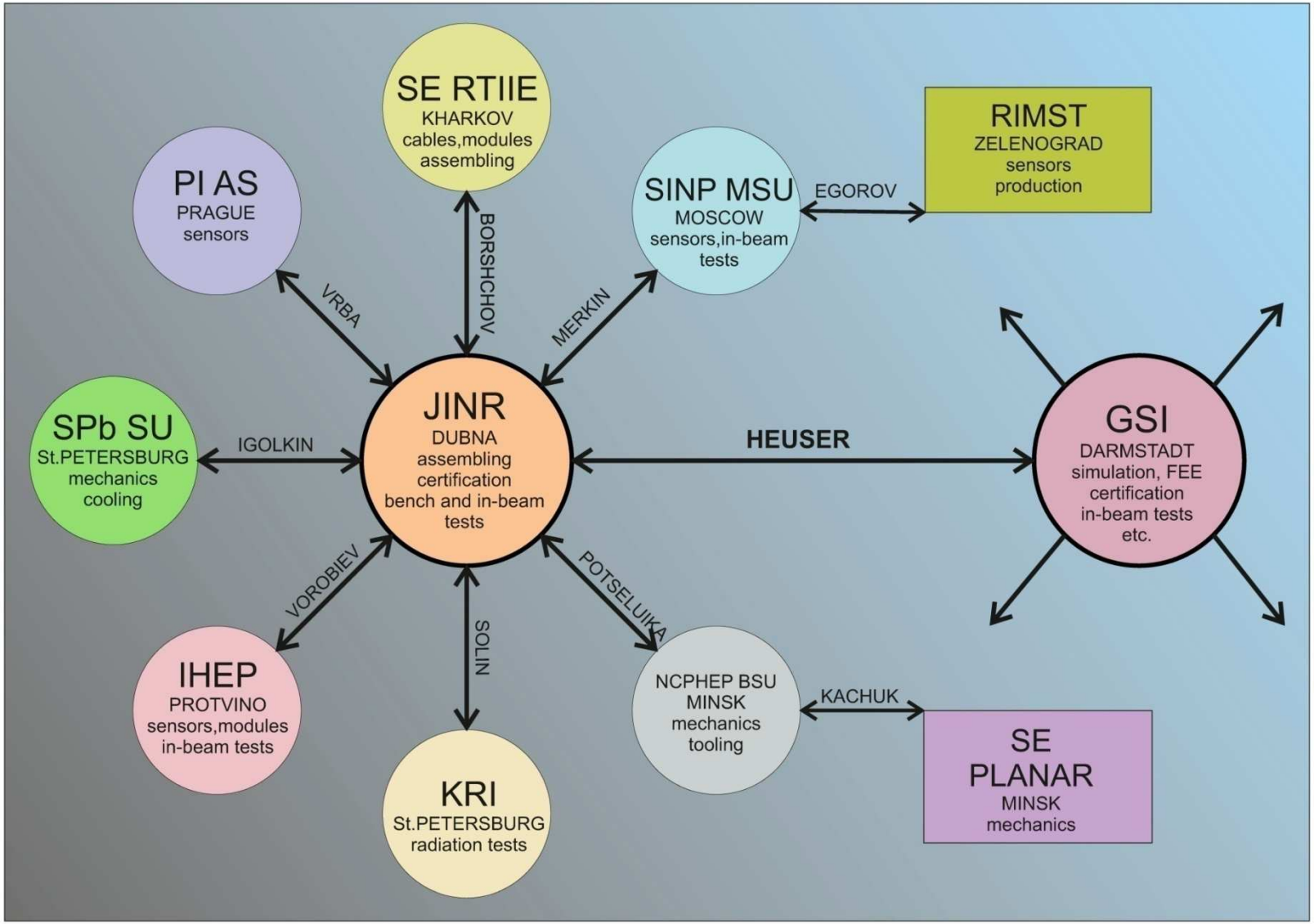


NICA MPD

The Ladder

Supermodule („the ladder“)= Sensitive modules on light weighed CF support frames with FEE in cooled containers at the rare ends

The CBM-MPD STS Consortium Since Nov 2008 till 2013



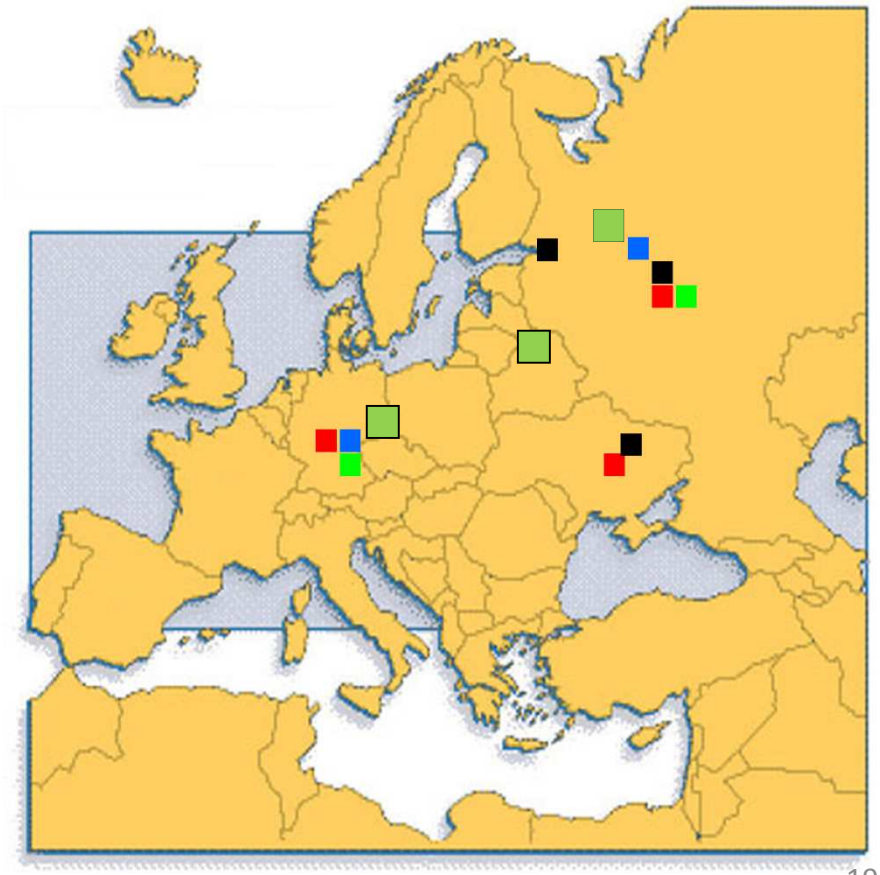
CBM-MPD STS Consortium

- 8 institutes
- 5 countries

- CBM in Darmstadt

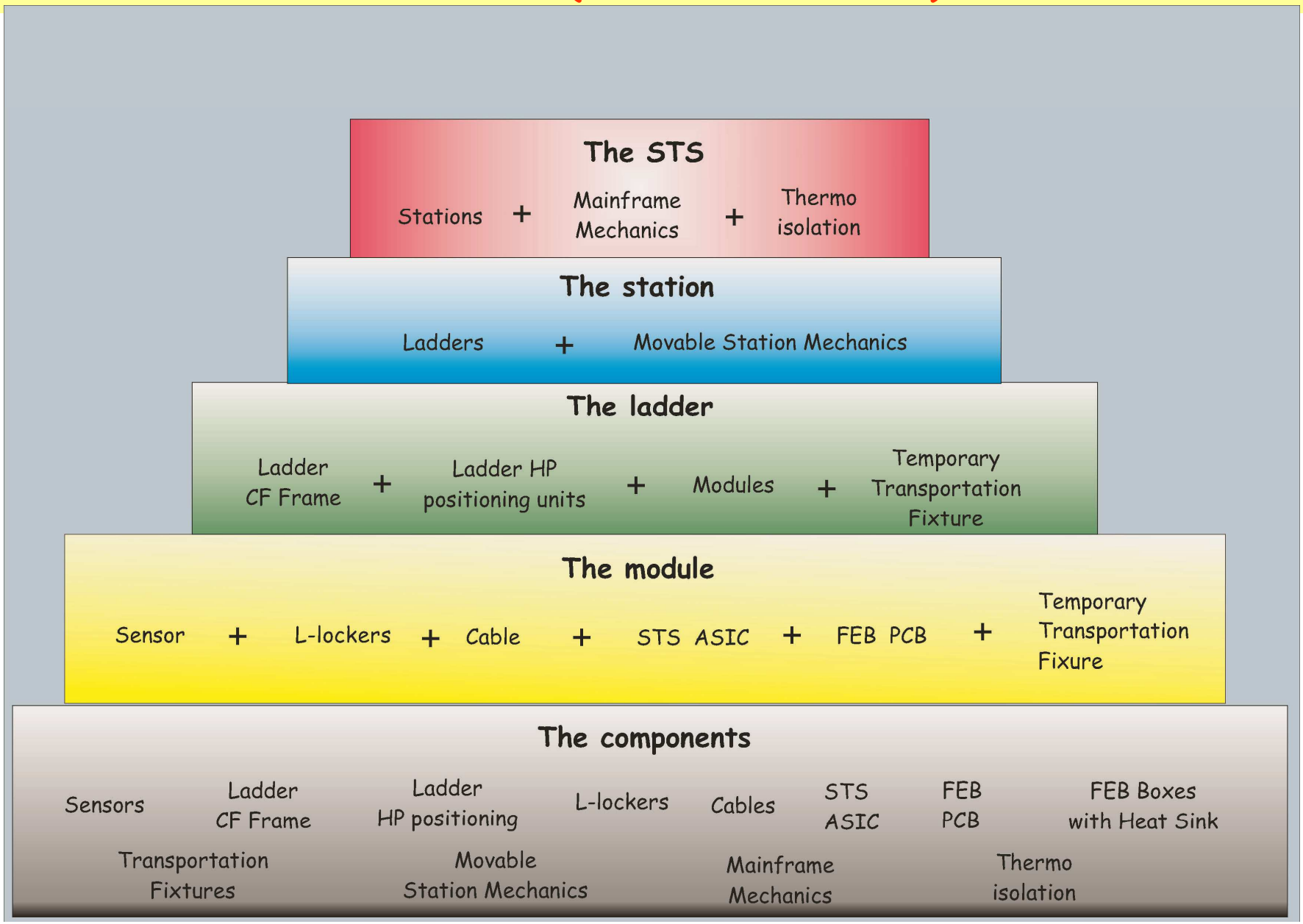
MPD and BM@N in Dubna

- **GSI, Darmstadt, Germany**
- **JINR, Dubna, Russia**
- IHEP, Protvino, Russia
- MSU, Moscow, Russia
- KRI, St.Petersburg, Russia
- SPbSU, St.Petersburg
- SE SRTIIE, Kharkov, Ukraine
- NCPHEP, Minck,Belarus Rep.
- PI AS, Prague,Czech Rep



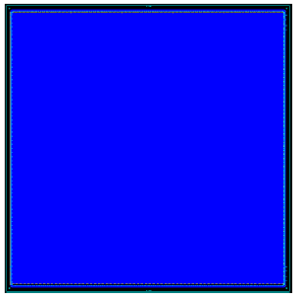
- **Components**
- **Sensors**
- **Modules assembly**
- **Ladder assembly**
- **Radiation tests**
- **In-beam tests**

STS (BM@N / ITS)

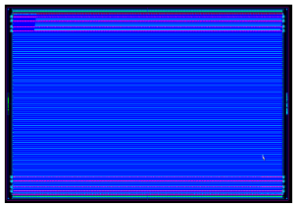

The STS
Stations + Mainframe Mechanics + Thermo isolation
The station
Ladders + Movable Station Mechanics
The ladder
Ladder CF Frame + Ladder HP positioning units + Modules + Temporary Transportation Fixture
The module
Sensor + L-lockers + Cable + STS ASIC + FEB PCB + Temporary Transportation Fixure
The components
Sensors
Ladder CF Frame
Ladder HP positioning
L-lockers
Cables
STS ASIC
FEB PCB
FEB Boxes with Heat Sink
Transportation Fixtures
Movable Station Mechanics
Mainframe Mechanics
Thermo isolation

Components Readiness: The sensors

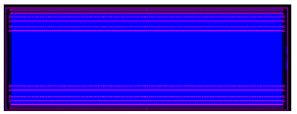
Prototype	Year	Vendor	Processing	Size [cm^2]	Description
CBM01	2007	CiS	double-sided	5.5×5.5	±7.5 deg
CBM03	2010	CiS	double-sided	6.2×6.2	±7.5 deg
CBM03'	2011	CiS	Single/CBM03	6.2×6.2	test for CBM05
CBM05	2013	CiS	double-sided	6.2×6.2	7.5/0 deg full-size
CBM05H4	2013	Hamamatsu for GSI	double-sided	6.2×4.2	7.5/0 deg full-size
CBM05H2	2013	Hamamatsu for JINR	single-sided	6.2×2.2	7.5/0 deg full-size



CBM05



CBM05H4

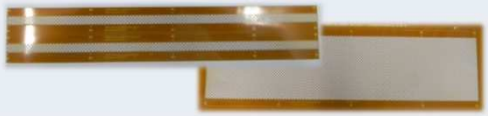


CBM05H2

under study: replacement for integrated 2nd metal layer

external on-sensor cable

Components Readiness: The Cables

Components type	Q-ty for STS (+20%), pcs	Material	View
Analog connecting layer	34400	FDI-A-24	
Meshed spacer	38700	Polyimide	
Shielding layer	2150	FDI-A-24	
Daisy –chain cable	778	FDI-A-20 (24)	
Interstrip cable	1464	FDI-A-24	

Components Readiness: Readout ASIC

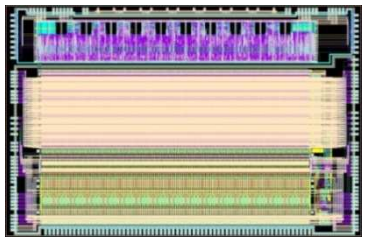
full-size prototype dedicated to signal detection from the double-sided microstrip sensors in the CBM environment

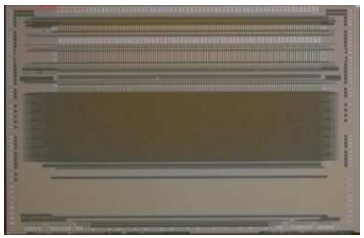
fast ⇔ low noise ⇔ low power dissipation

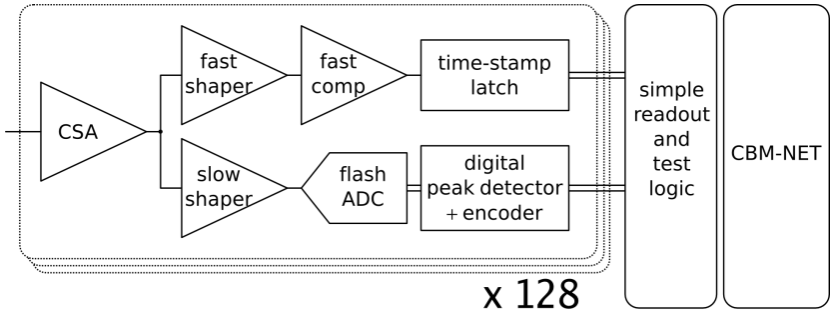
new w.r.t. n-XYTER architecture:
effective two-level discriminator scheme

design V1.0 @ AGH Kraków
UMC 180 nm CMOS

produced 2012
die size 6.5 mm × 10 mm
second round planned
forfall 2014



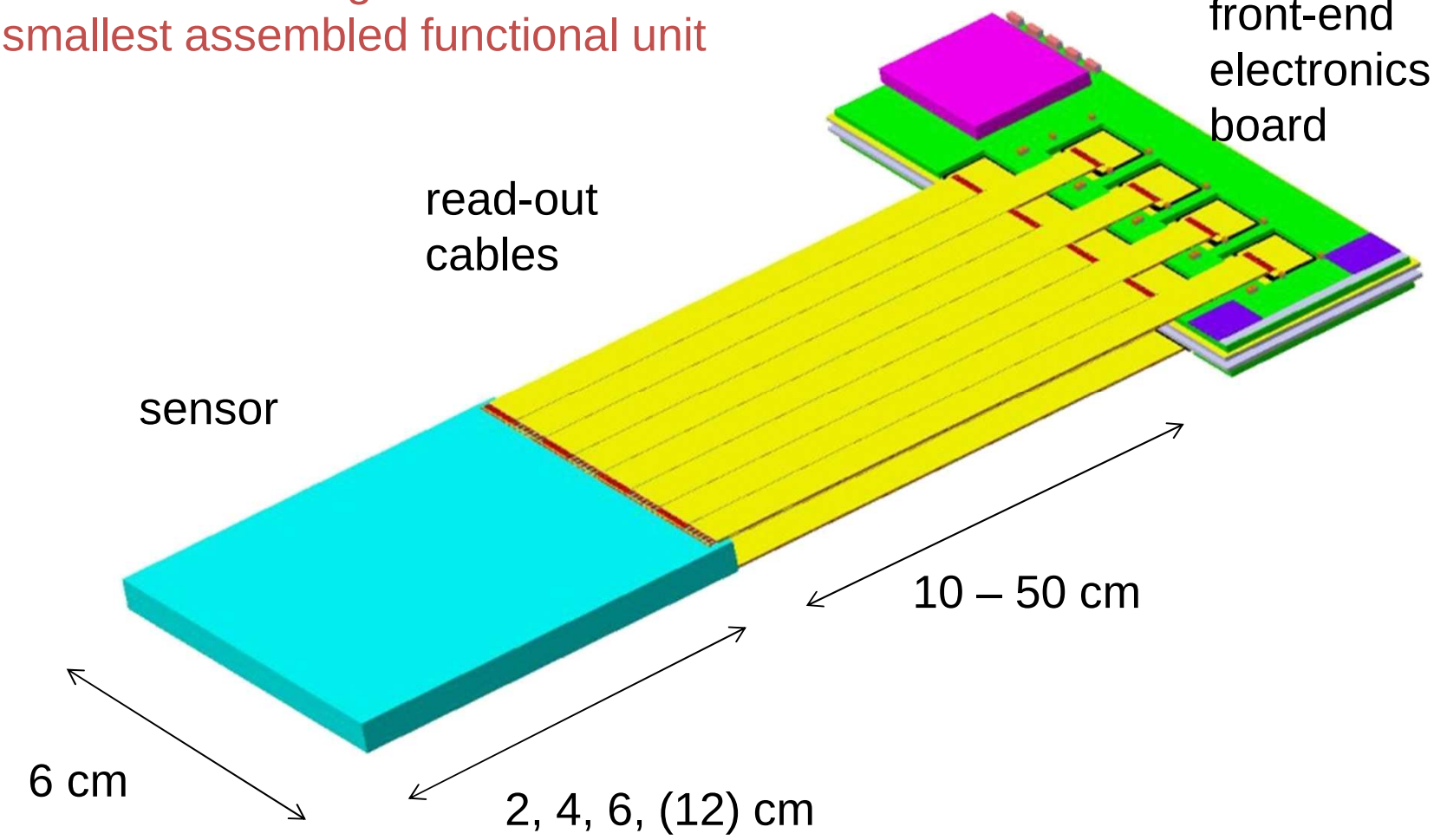




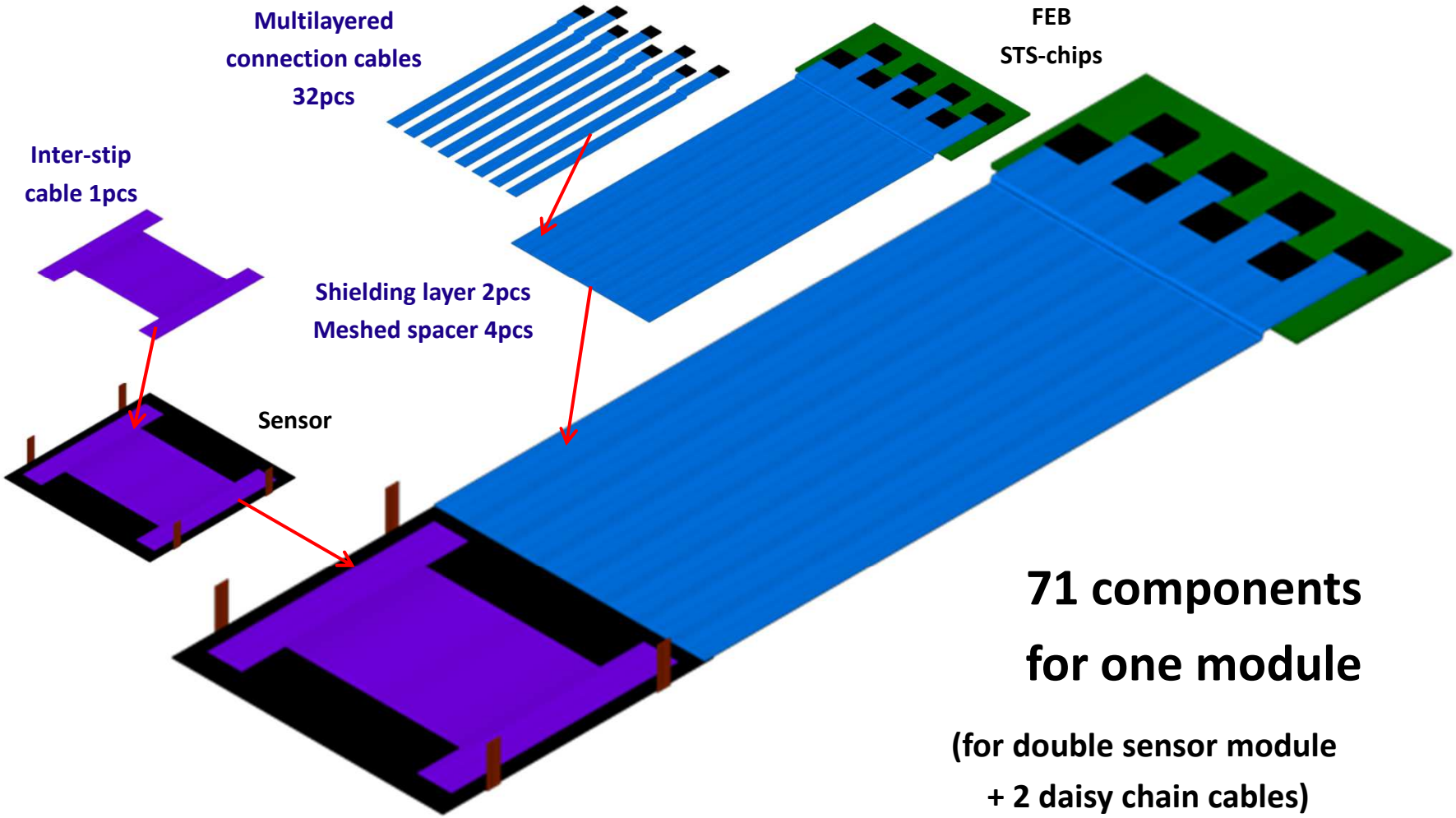
Channels, pitch	128 + 2 test
Channel pitch	58
Input signal polarity	+ and -
Input current	10 nA
Noise at 30 pF load	900 e^-
ADC range	16 fC, 5 bit
Clock	250 MHz
Power dissipation	< 10 mW/channel
Timestamp resolution	< 10 ns
output interface	4 × 500 Mbit/s LVDS

STS module concept

module is building block of ladders
smallest assembled functional unit



Detector module composition



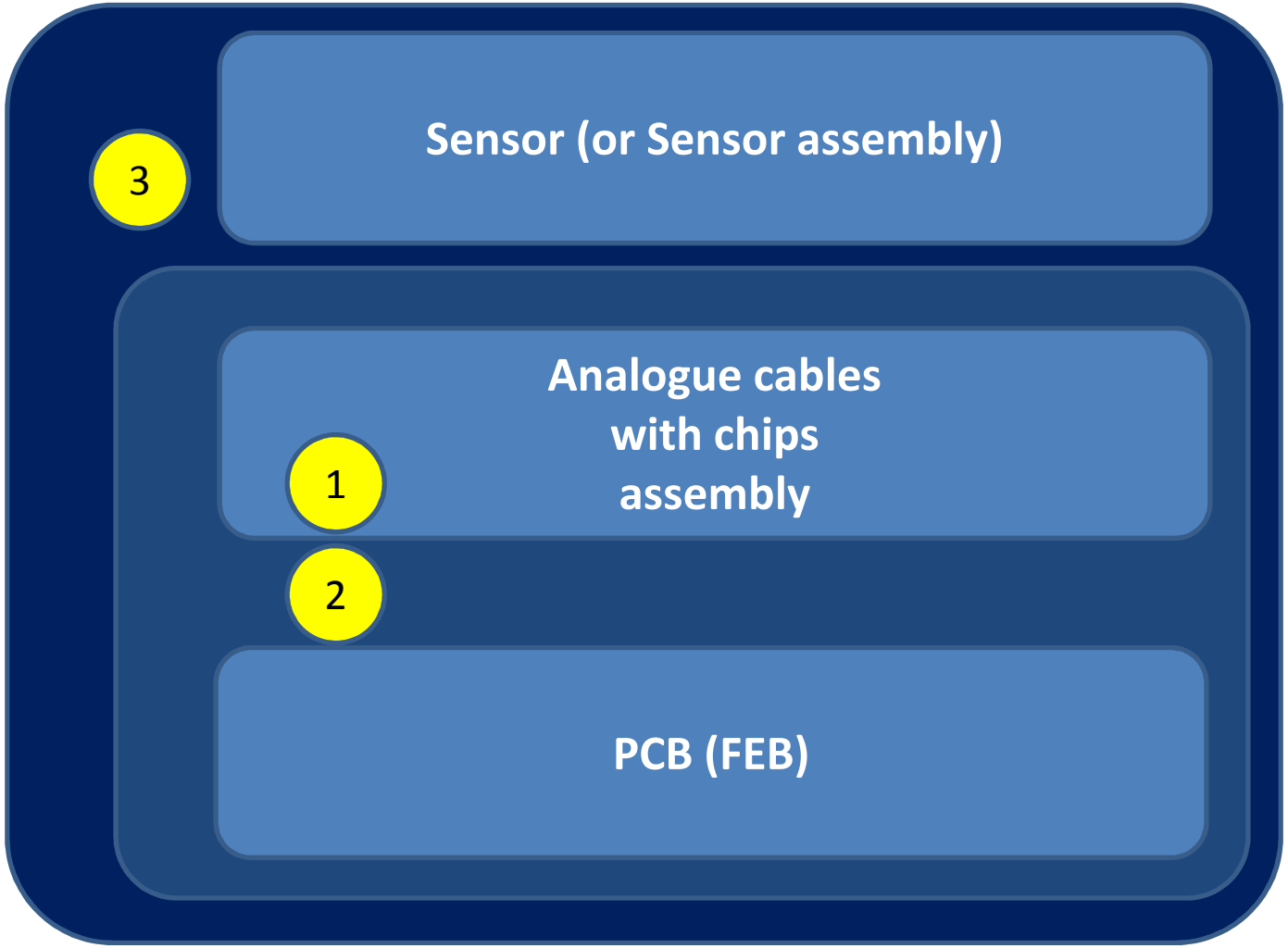
71 components

for one module

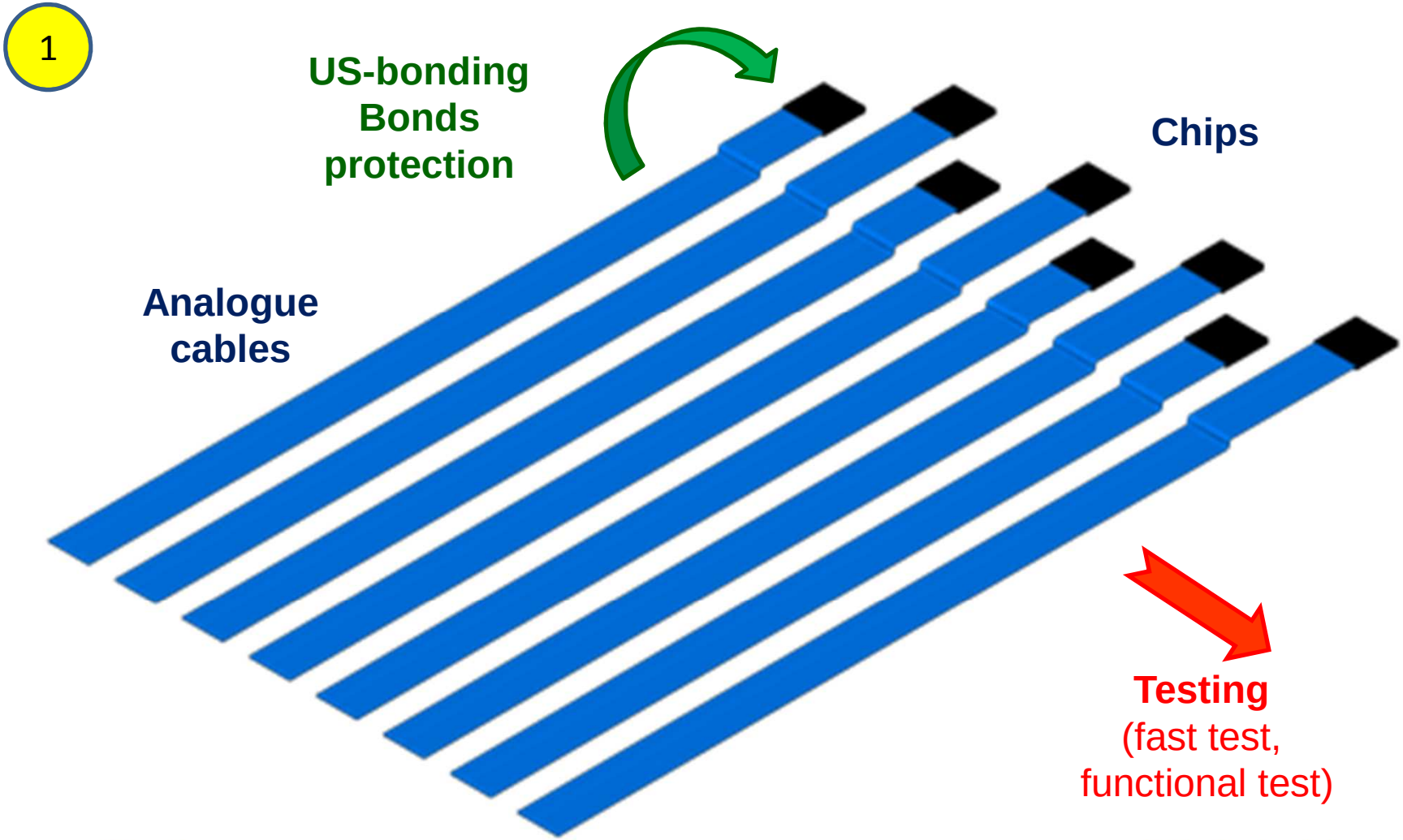
(for double sensor module

+ 2 daisy chain cables)

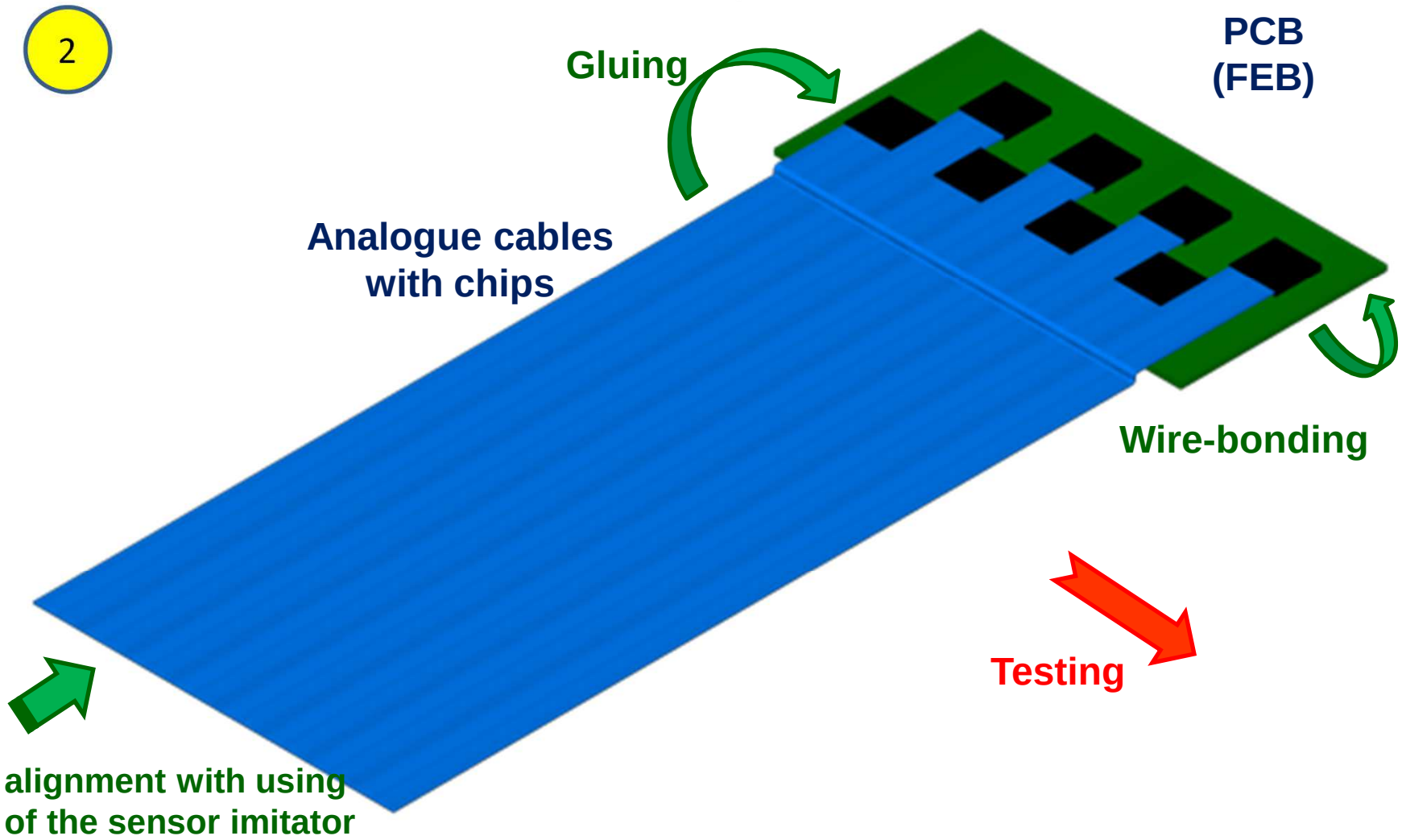
Technological scheme of single-sensor module assembly



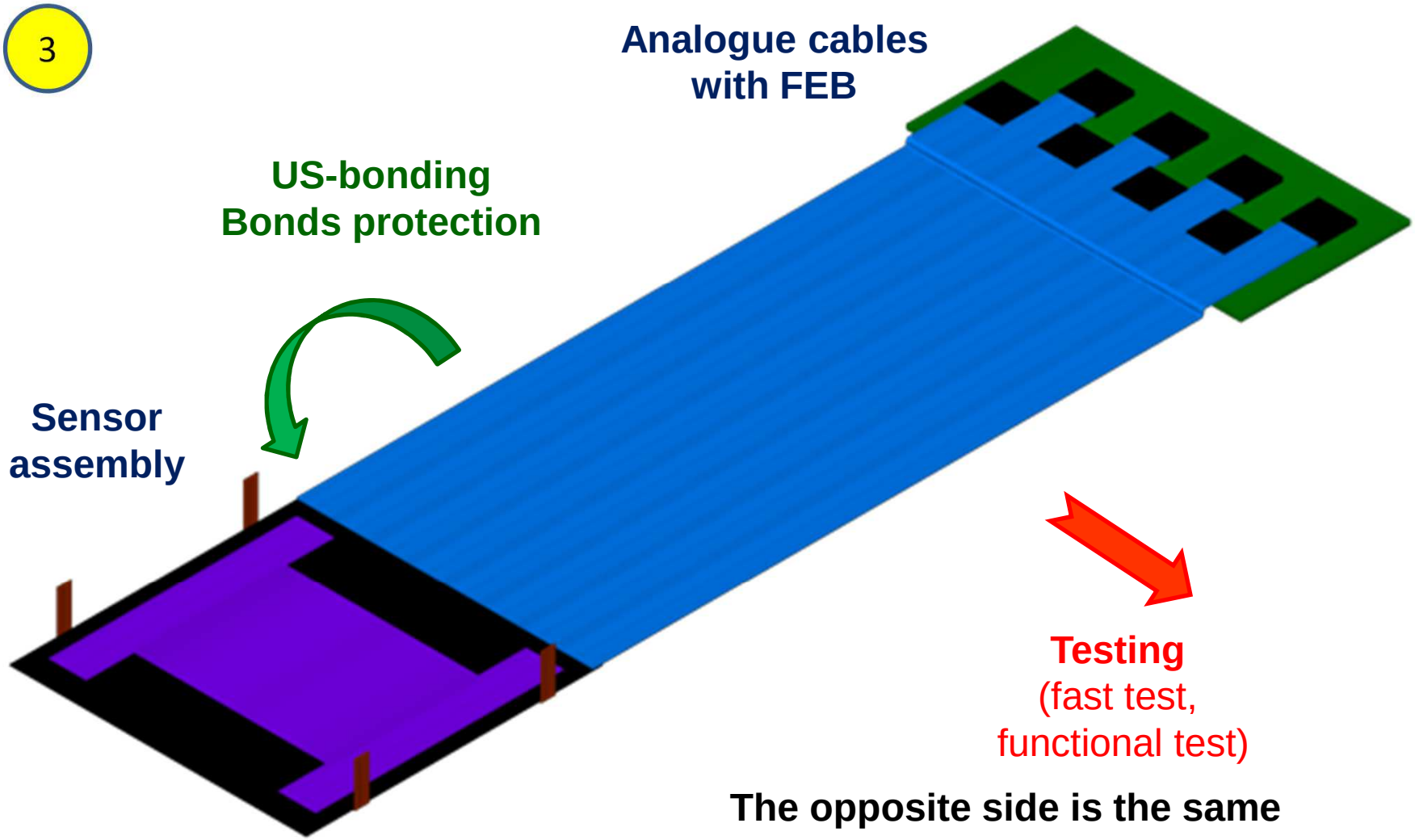
Technological scheme of chip with analogue cable assembling



Technological scheme of analogue cables with PCB assembling

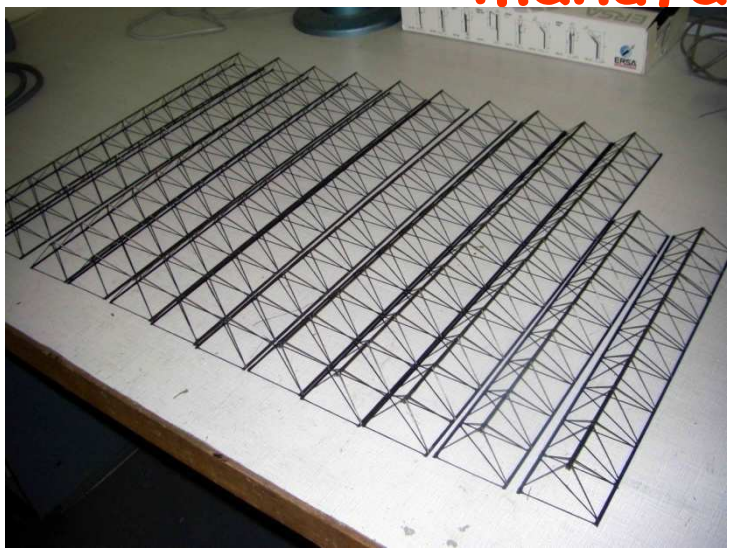


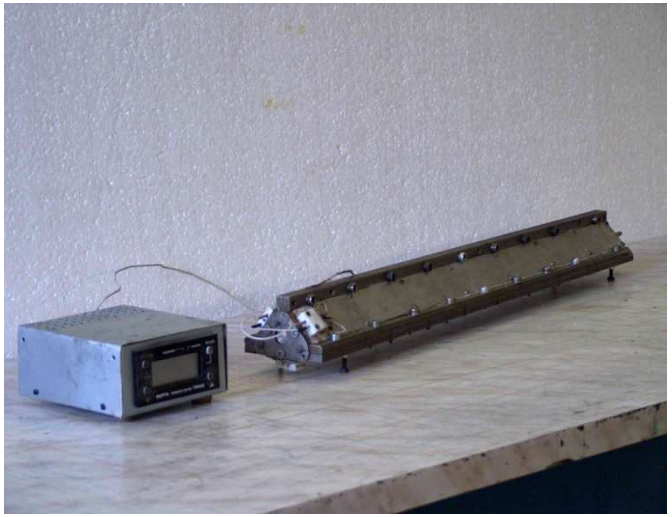
Technological scheme of analogue cables with sensor assembling

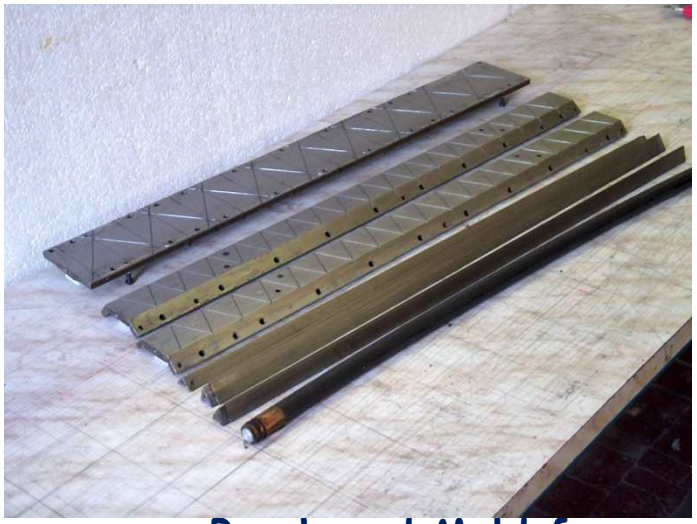


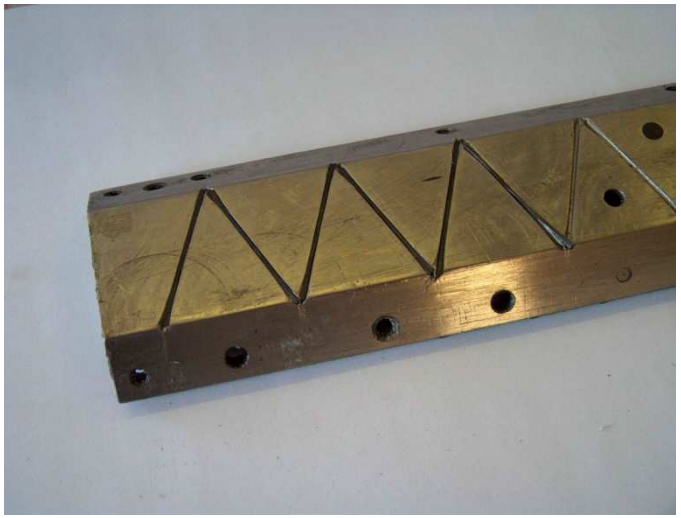
The opposite side is the same

CF Mechanics Readiness :Punch@Mould Produced in SPb with ten CF space frames manufactured @ CERN



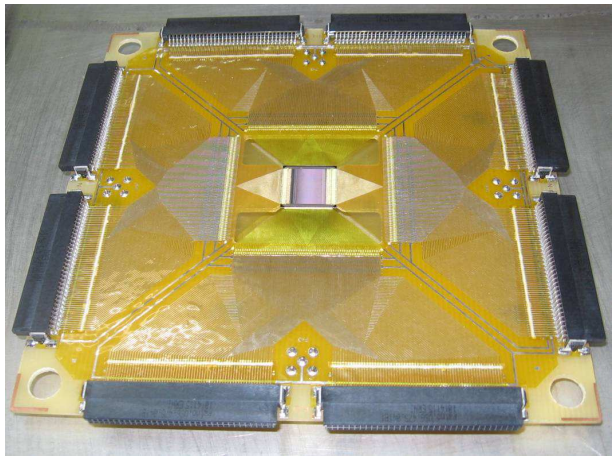


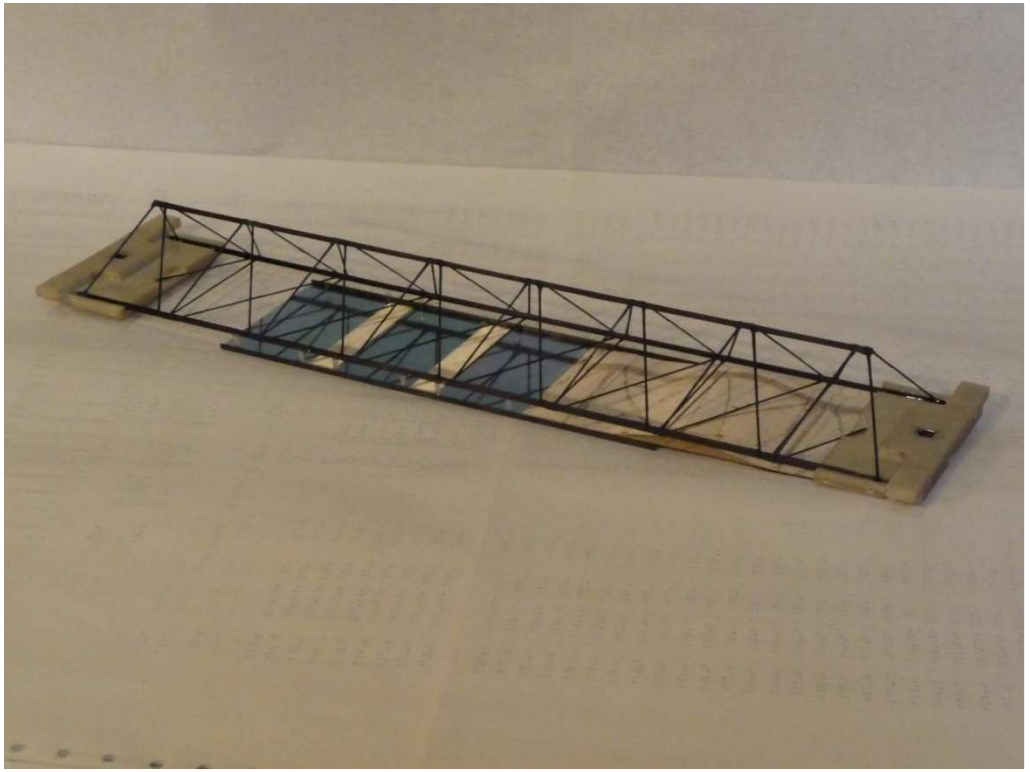




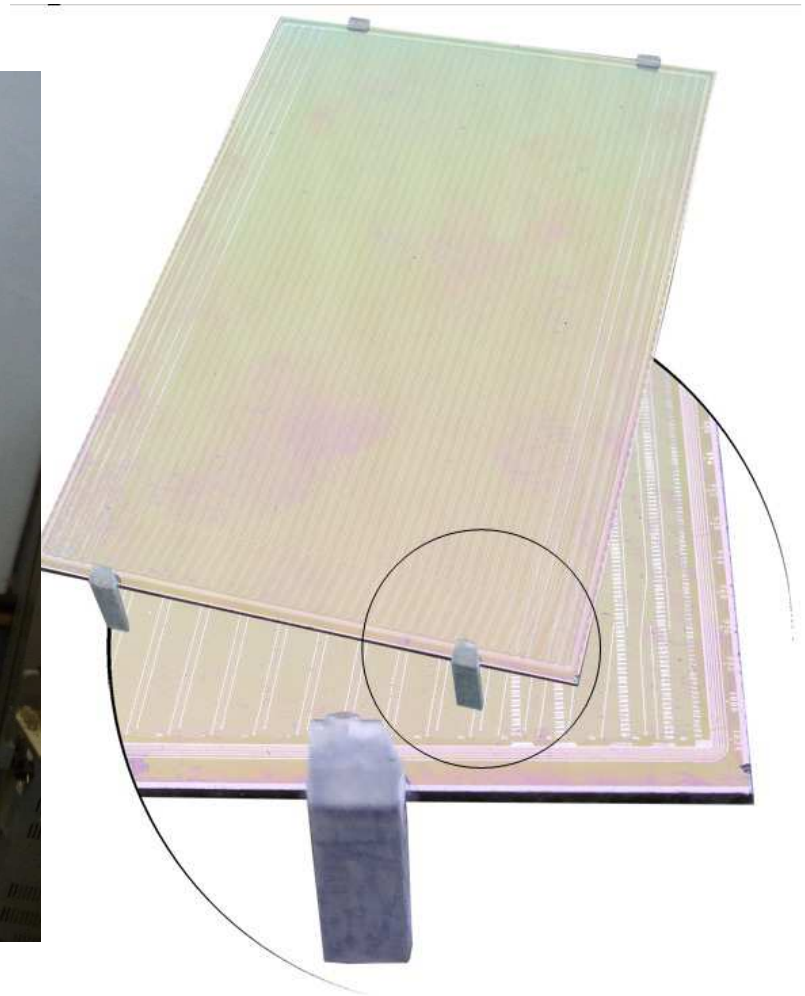
Punch and Mold for production of true CBM supporting frames

Demonstrators and prototypes



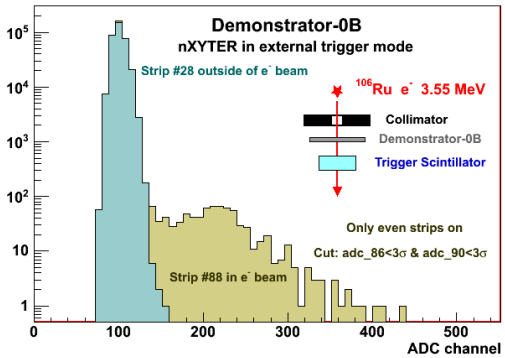


Prototype **Device for ladder assembling manufactured at PLANAR, Minsk , Rep. of Belarus, 2012**



Preparations for the in-beam tests at Nuclotron

•Equipment of JINR test bench with n-XYTER readout



•Mechanics preparation

•Slow Control for Protvino in-beam

•Logic Init for recording the external DAQ information into the ROC

Status: Preparations for the in-beam tests at Nuclotron

Timelines of CBM STS

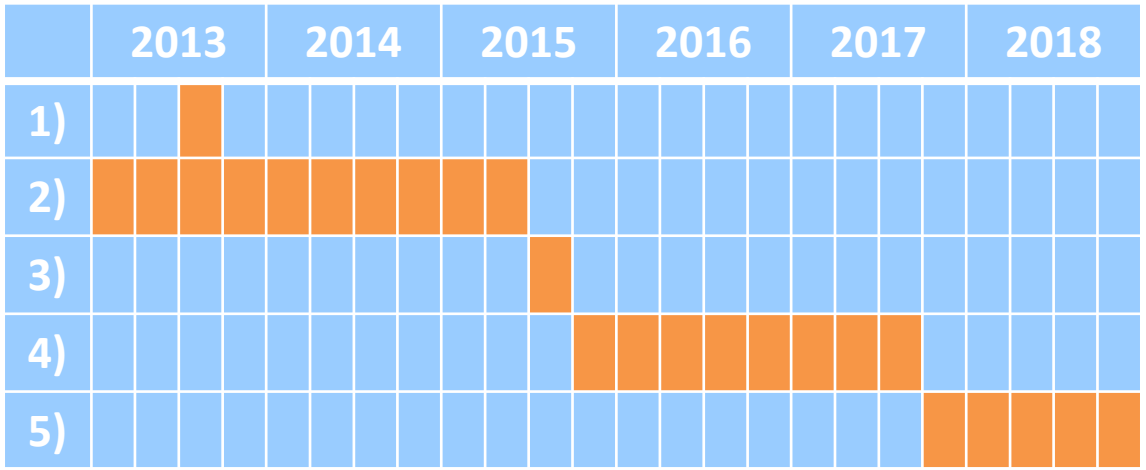
1) STS Technischer Design Report (approved 8/2013)

2) **Pre-production phase (2014): Technology decisions, module demonstrators**

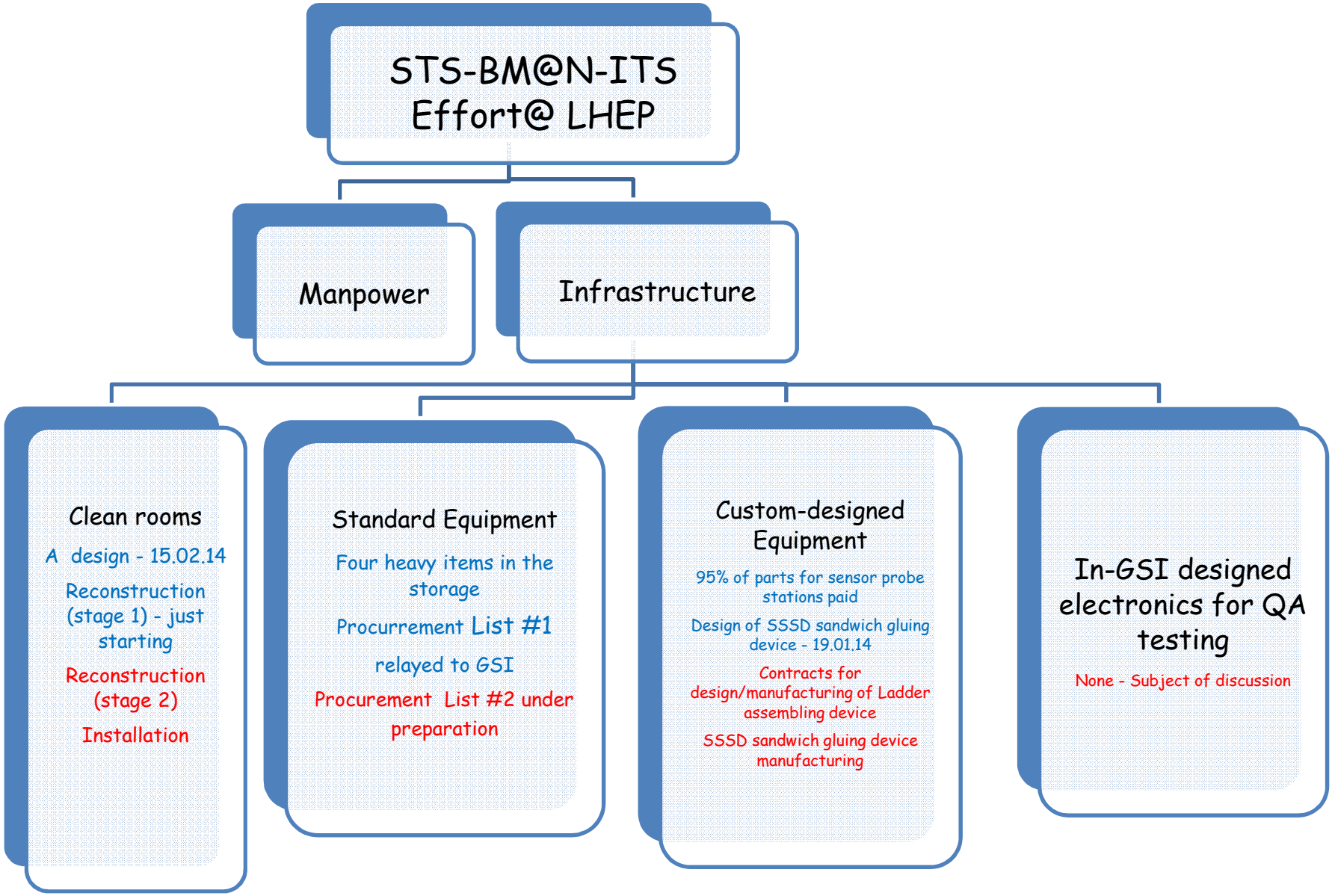
3) Production Readiness Review (7/2015)

4) Series production of sensors until ~ mid 2017:

5) STS commissioning (2018)



LHEP JINR STS-BM@N-ITS Effort Strategic Plan



STS and ITS FEE

CBM-xyter

- Self triggering
- High power consumption
- Too fast
- Not ready yet
- 5-bit ADC

Tentative Work Plan for 2014-15

STS
assembling
Lab Installation

MANAGEMENT
Murin Yu.A.
Asistants:
Penkin V.A.- civil enginering, procurement
Pavlyuk E.- bookkeeping

External EXPERTISE
Merkin M.M.
MSU

Composite material parts production	Cryogenic and radiation sensor QA testing	Modules and ladders assembling	Assembling QA testing	Nuclotron in-beam tests
CERN Igolkin S.N. + 2 technicians JINR Budilov V.A.	JINR Zamiatin N.I.+3 MSU sensor probe station Merkin M.M.+3	STU,Ltd Borschov V.N.+6 JINR Elsha V.V. Budilov V.A. Berezin G.S. +2 technicians IHEP 2/3 modules assembling	STU,Ltd Borschov V.N.+6 GSI Ch.Schmidt+3 JINR Bazylev S.N.+1 Dementyev D.V.	JINR Murin Yu.A.+3 MSU Merkin M.M.+3 GSI J.Heuser+5

The Conclusions

- Through years 2008-2013 the CBM-MPD STS Consortium has accomplished 80-90% of R&D activity which could be successfully accomplished by mid 2015
- In 2013 not only the targets but additional sources of budgeting of the common GSI-JINR project were indicated: GSI-JINR LHEP STS assembling Lab MoU signed with resources + draft of the FAIR-JINR-ROSATOM –CBM Contract for assembling four stations of CBM STS at LHEP is ready for signatures
- To resolve the "manpower crises" administrative decision have been taken to organize a department of STS for CBM, BM@N and ITS
- All young researchers are be in a joint working group which will built the core of team to yield the benefit of the STS being used at Nuclotron and NICA

Questions

Difference between MPD and SPD Inner Tracking System:

- Single hit resolution
- Tracking resolution
- Tracking efficiency
- Secondary vertex resolution
- Momentum resolution
- Material budget

Thank you for your attention!

Thanks for courtesy of using the slides to

J.Heuser, M.Protsenko,I.Tymchuk