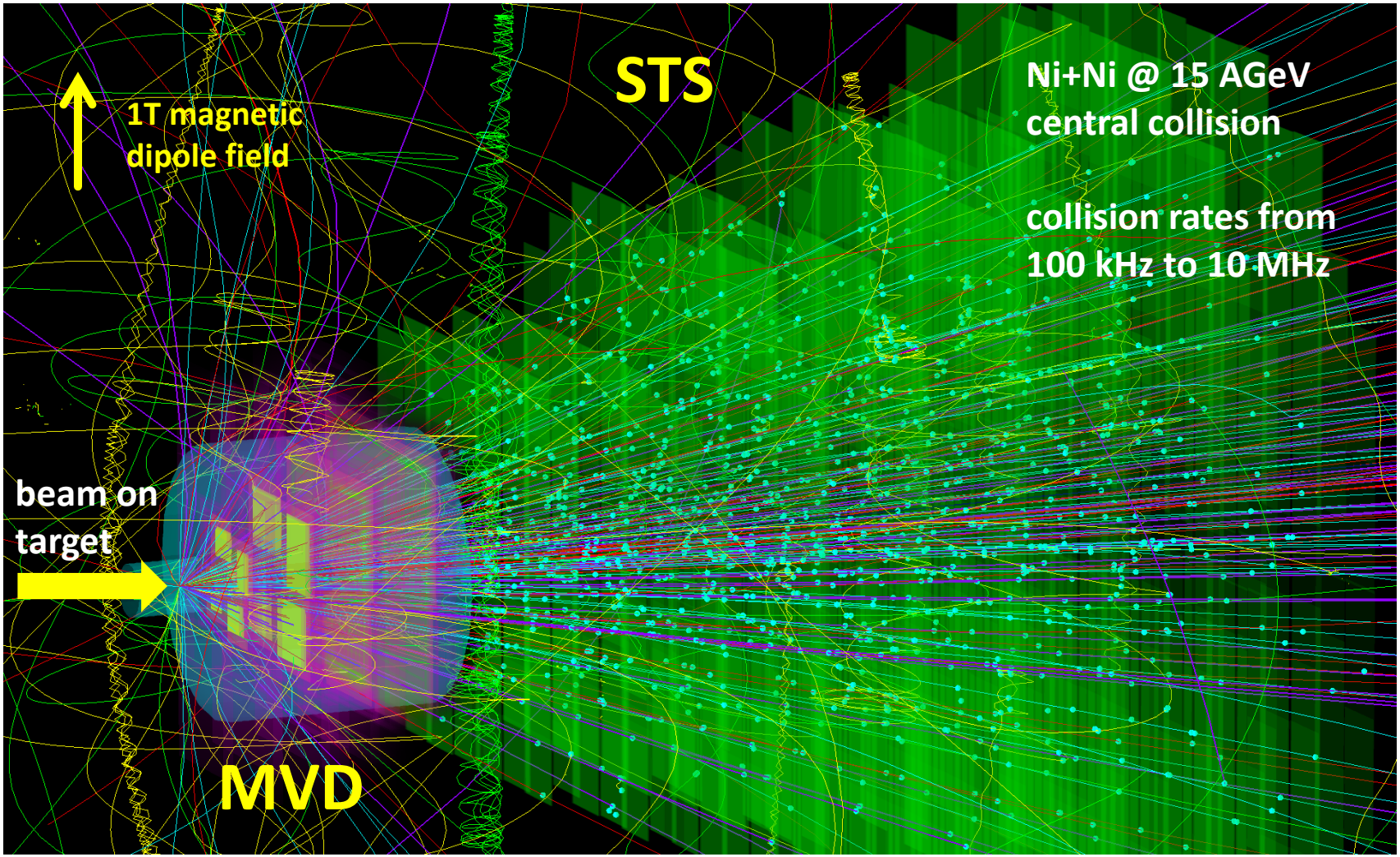
Status of the CBM Silicon Tracking System

- *Brief overview of the CBM-STS*
- *Development of components*
- *Project plan, production, tasks within CREMLIN*

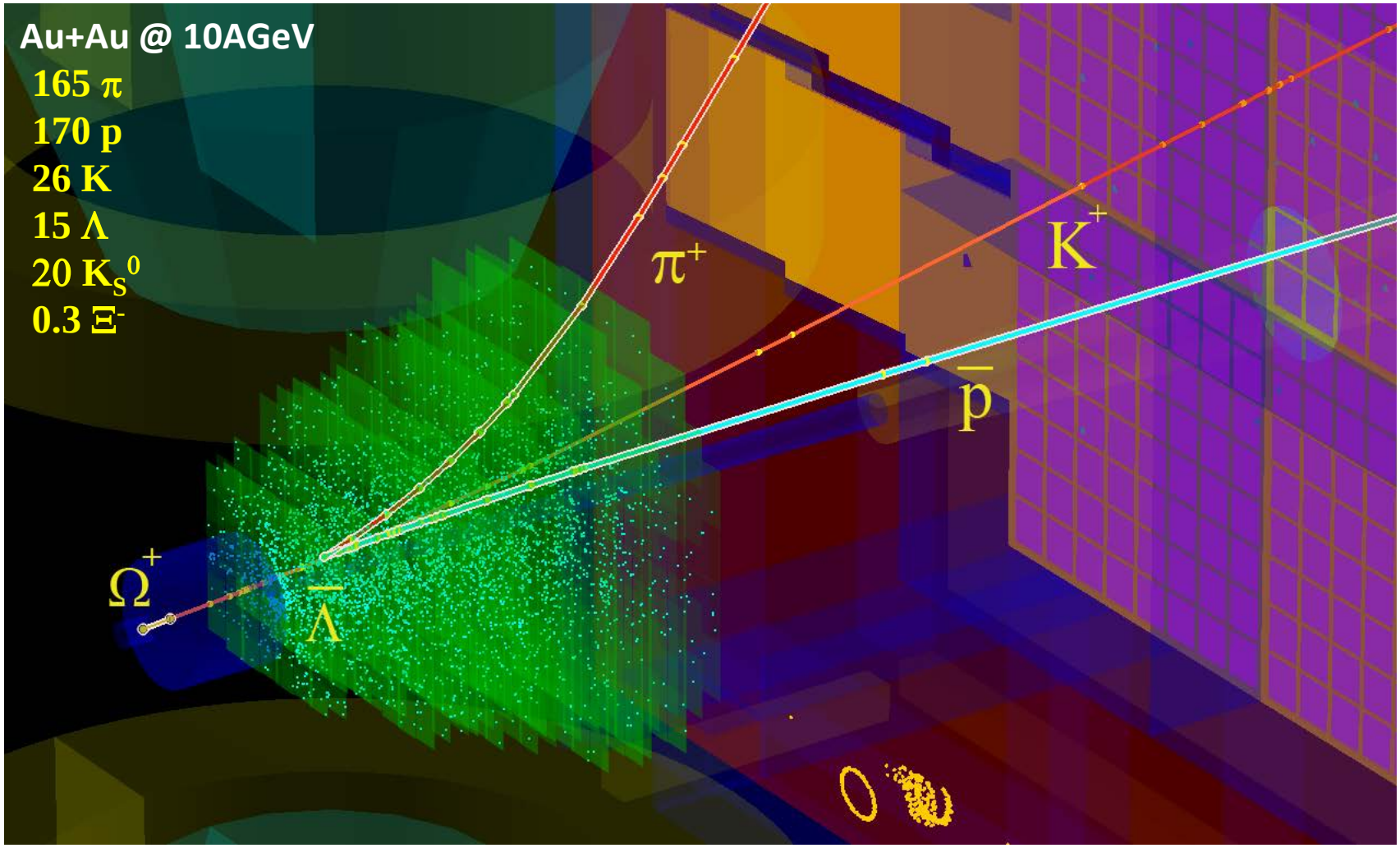
Johann M. Heuser, GSI
CBM-STS Project Technical Coordinator

Horizon2020-CREMLIN Kick-off Meeting, Moscow, 6 October 2015

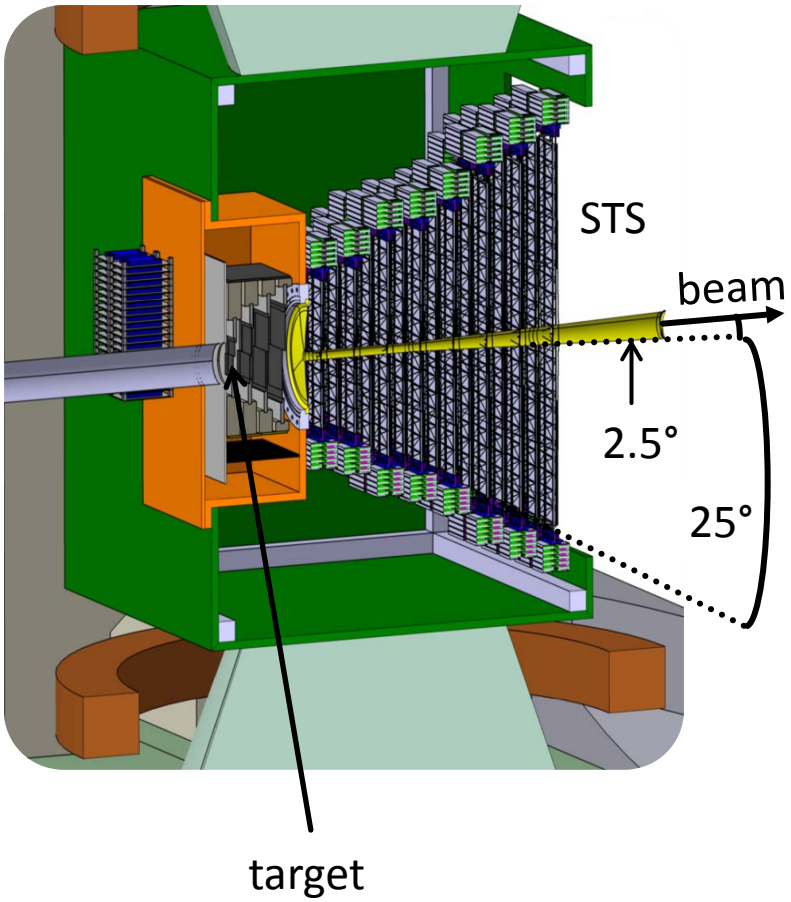
Tracking nuclear collisions

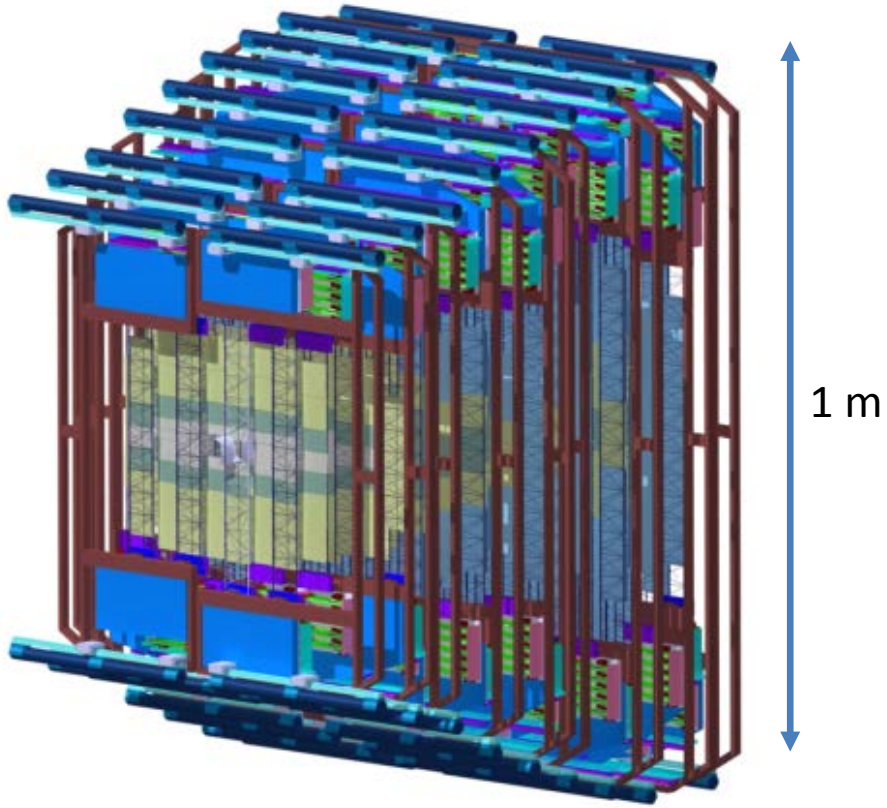


Physics signatures



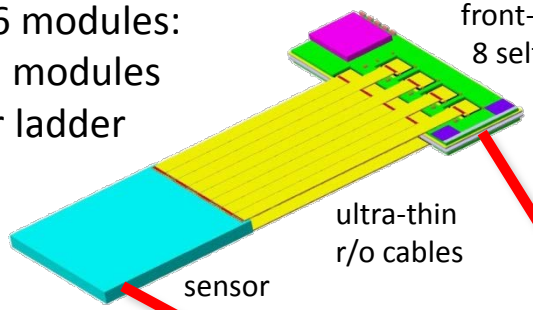
Silicon Tracking System



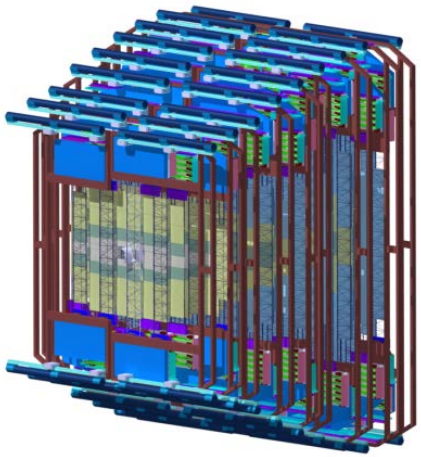


STS integration

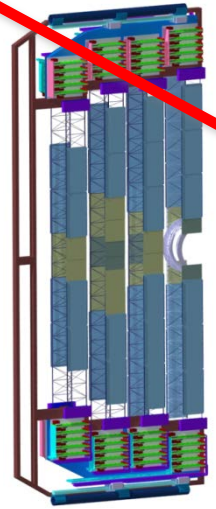
896 modules:
4-5 modules
per ladder



- 8 stations, volume 2 m^3, area 4 m^2
- 896 detector modules
  - 1220 double-sided microstrip sensors
  - ~ 1.8 million read-out channels
  - ~ 16 000 r/o STS-XYTER ASICs
  - ~ 58 000 ultra-thin r/o cables
- 106 detector ladders with 4-5 modules
- power dissipation: 42 kW (CO_2 cooling)

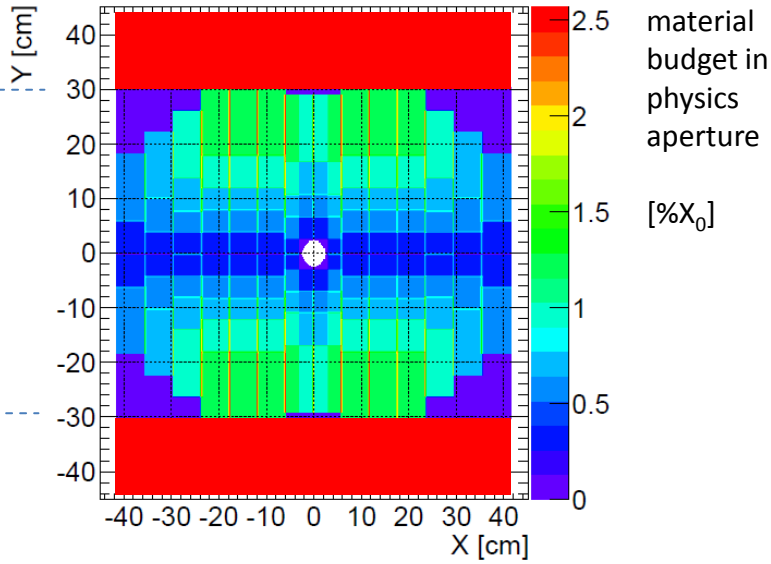


8 tracking stations



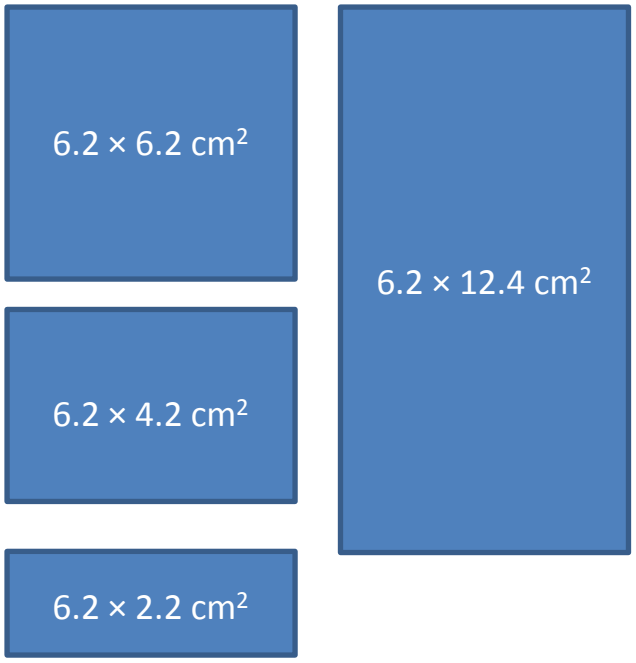
18 half-units

106 ladders



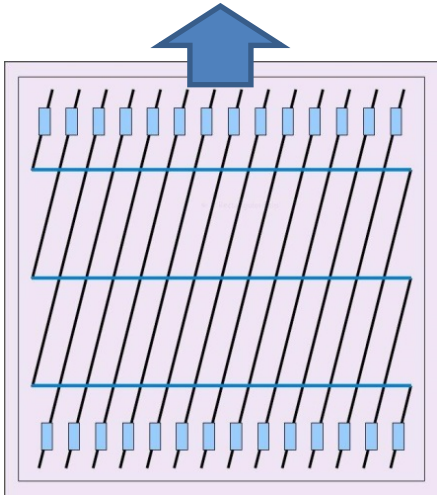
Silicon microstrip sensors

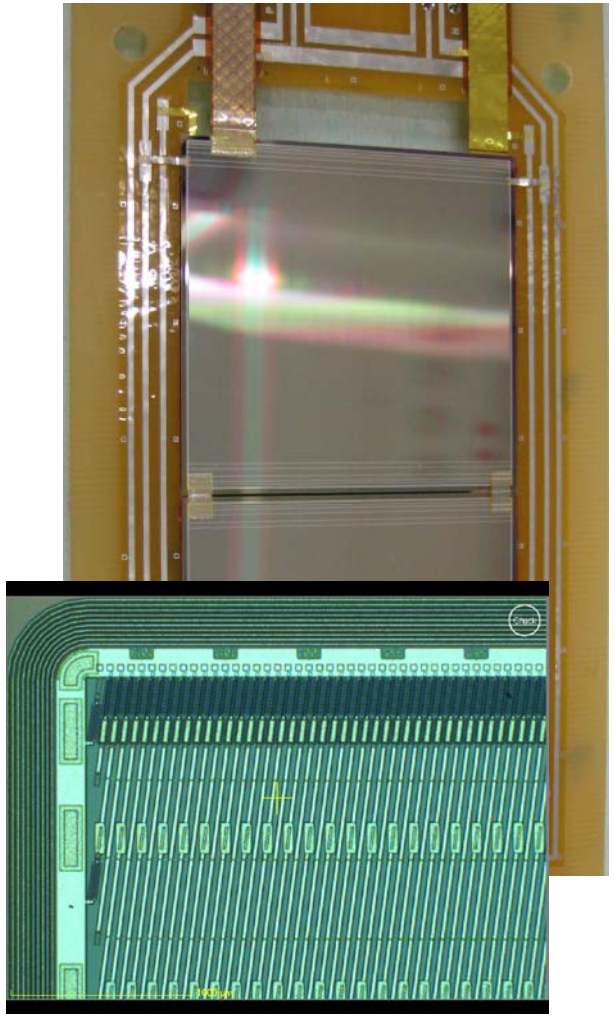
4 sensor shapes, differing only in strip length: short strips deployed in central part, long strips in outer part of the STS stations



sensor structure:

- 300 µm thick, n-type silicon
- double-sided segmentation
- 1024 strips of 58 µm pitch
- strip length 2/4/6/12 cm
- angle front/back: 7.5 deg
- read-out from top edge
- rad. tol. up to 10^{14} n_{eq}/cm^2





Current pre-series prototype sensors

Prototype	Year	Vendor	Processing	Size [cm^2]	Bill	Comment
CBM06C2	2015	CiS	DSDM	6.2 × 2.2	GSI	BMBF-JINR funded
CBM06C4	2015	CiS	DSDM	6.2 × 4.2	JINR	
CBM06C6	2015	CiS	DSDM	6.2 × 6.2	GSI	
CBM06H6 CBM06H2	2015	Hamamatsu	DSDM DSSM	6.2 × 6.2 6.2 × 2.2	JINR	
CBM06C12	2015	CiS	DSDM	6.2 × 12.4	GSI	
CBM06H12 CBM06H2	2015	Hamamatsu	DSDM DSDM	6.2 × 12.4 6.2 × 2.2	GSI	

DSDM = double-sided, double-metal

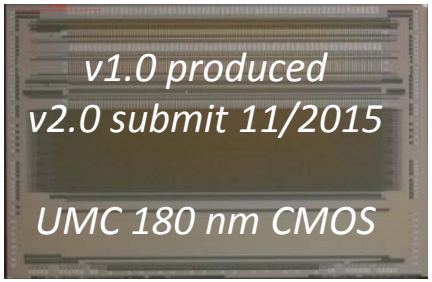
DSSM = double-sided, single-metal

Read-out electronics

- *purely data driven read-out*
- *time-stamped data elements*

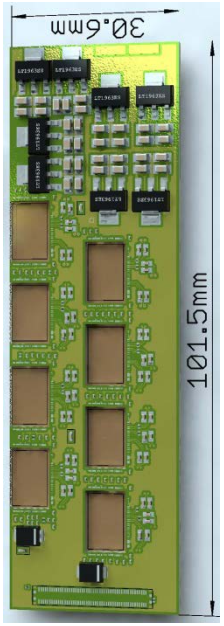
STS-XYTER ASIC

128 sensor channels



channels	128, polarity +/-
noise	< 1ke$^-$ at 20-50pF load
ADC range	linear up to12 fC, 5 bit
clock	250 MHz
power	< 10 mW/channel
timestamp	< 10 ns resolution
out interface	5 × 500 Mbit/s LVDS

Front-end Board



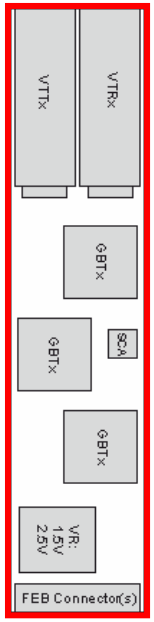
time-stamped data

8 STS-XYTER chips
1/2/5 LVDS links out

in development

copper link

Read-Out Board



data combining

GBTx chip-set (CERN):
3 GBTx, 1 VTRx, 1 VTTx, 1 SCA

42 E-links à 320 Mb/s
3 GBT optical uplinks à 4.48 Gb/s

in development /production

optical link

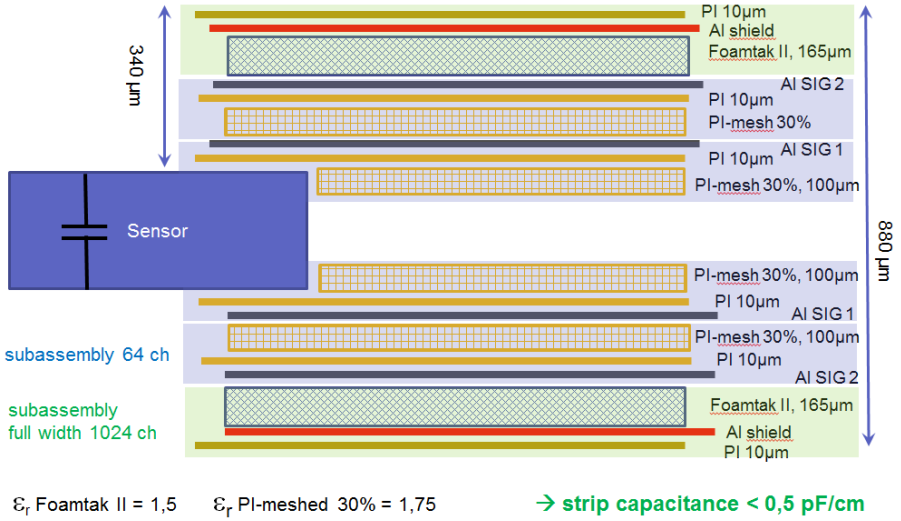
Data Processing Board
time-slicing

FLES farm
online event computing

Ultra-thin read-out cables

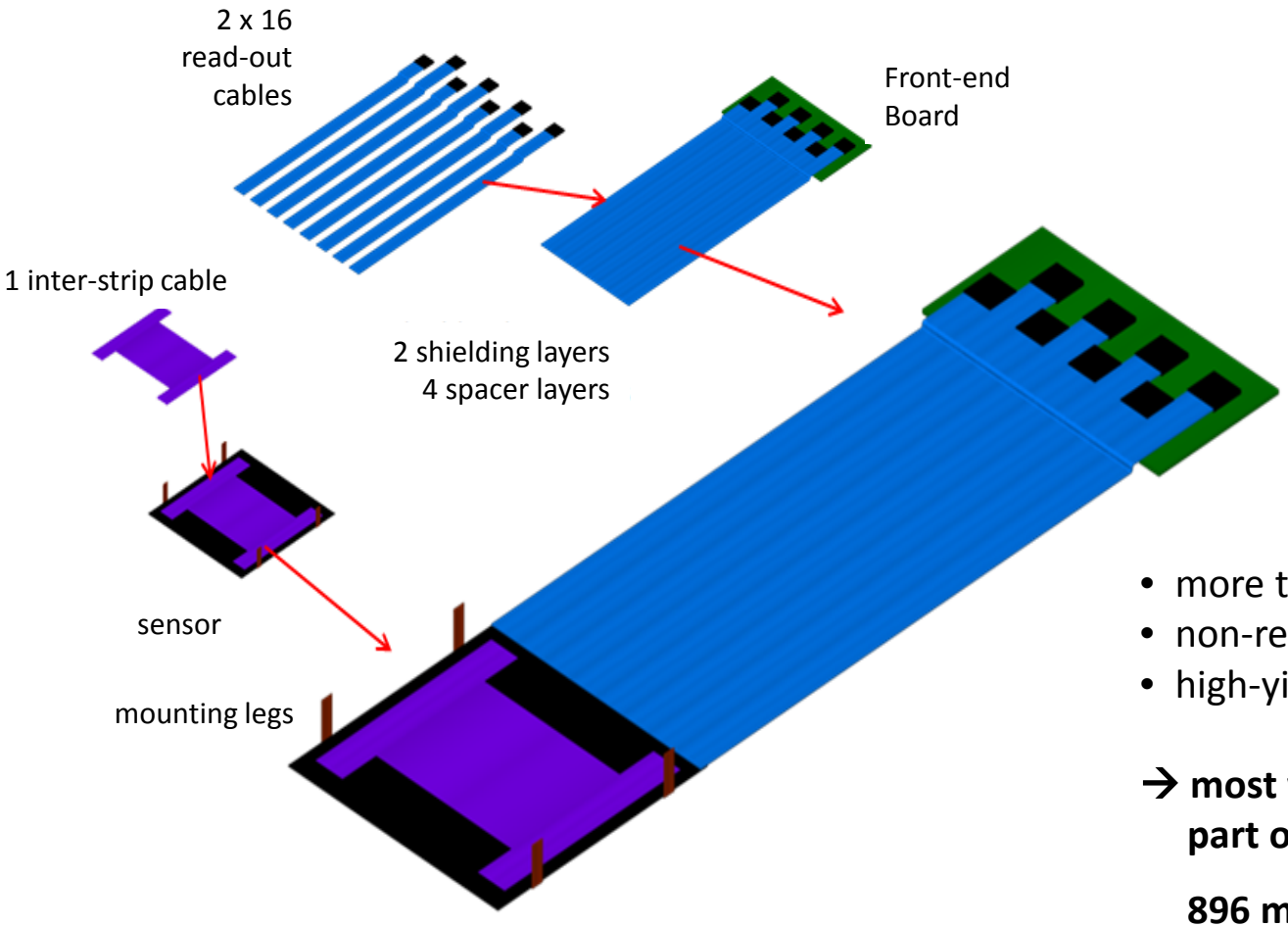
Aluminum-Polyimide technology

signal layer: *64 Al lines of 116 µm pitch, 10 µm thick on 14 µm polyimide, lengths up to 55 cm*



- optimized cable stack-up
- batches of hundreds of cable sets produced, cooperation GSI-JINR with company LTU in Ukraine
- current focus: determination and optimization of production yields
- connectivity via TAB-bonding

Module assembly



Integration of:

- *silicon sensors,*
- *front-end electronics,*
- *read-out cables*

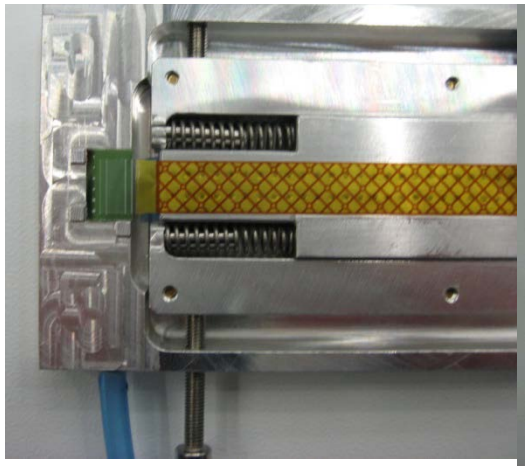
→ functional building block of the STS.

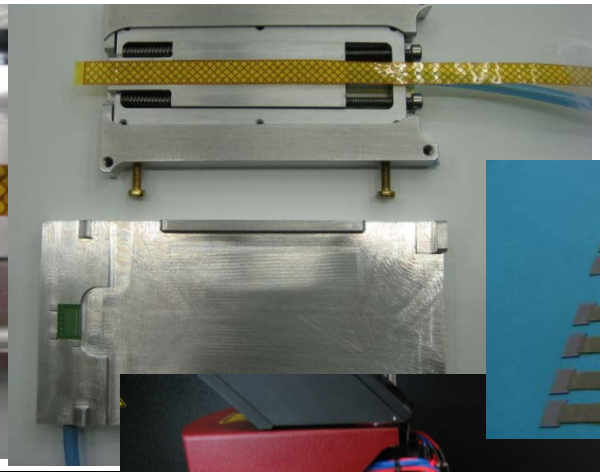
- more than 70 components/module
- non-reworkable assembly
- high-yield components essential

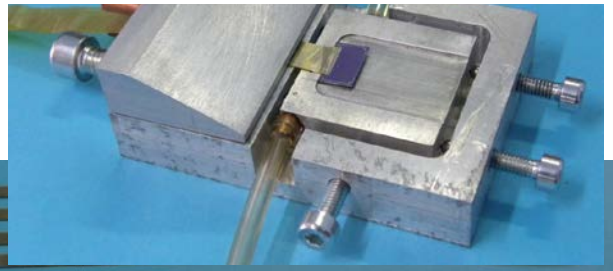
→ **most work-intensive and critical part of STS construction effort:**

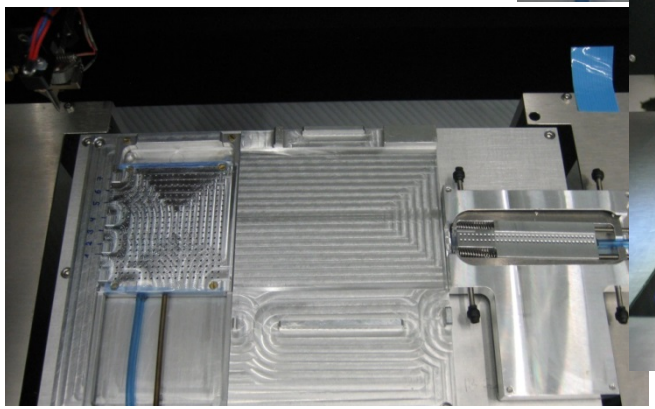
896 modules required

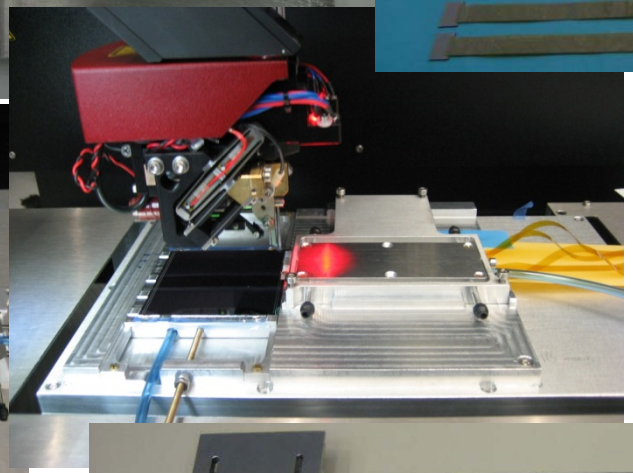
Tooling/procedures for module assembly under development: GSI + LTU

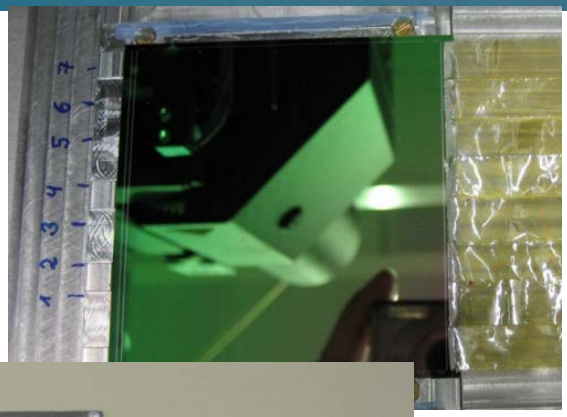


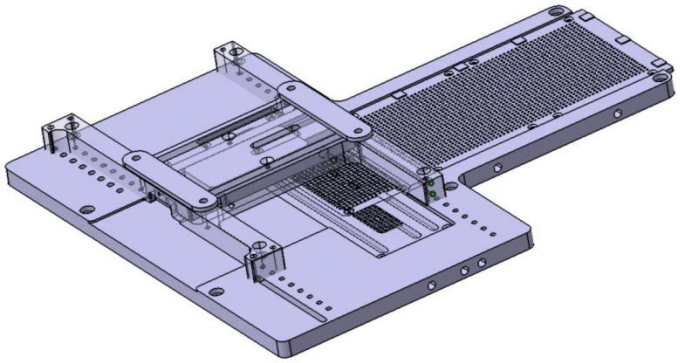




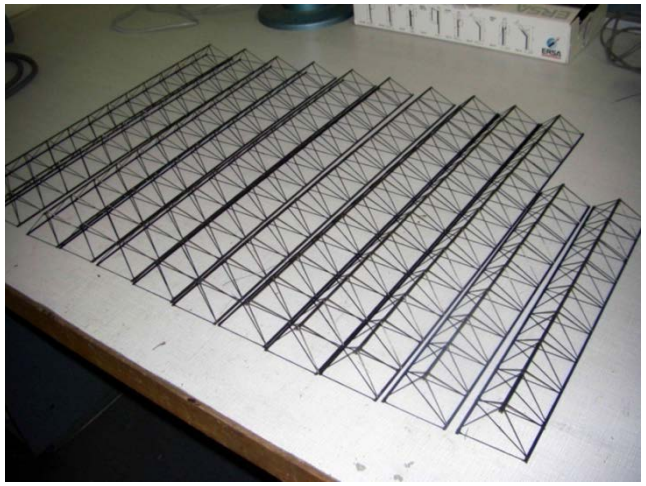




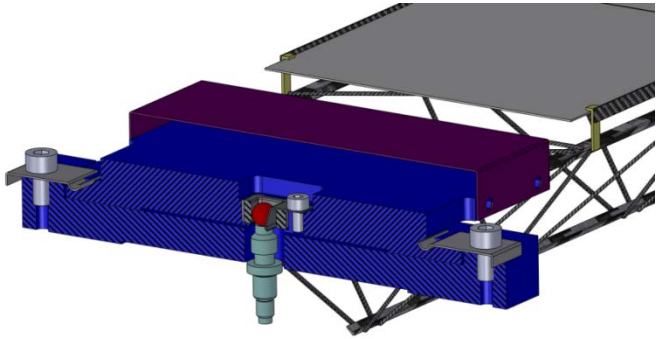


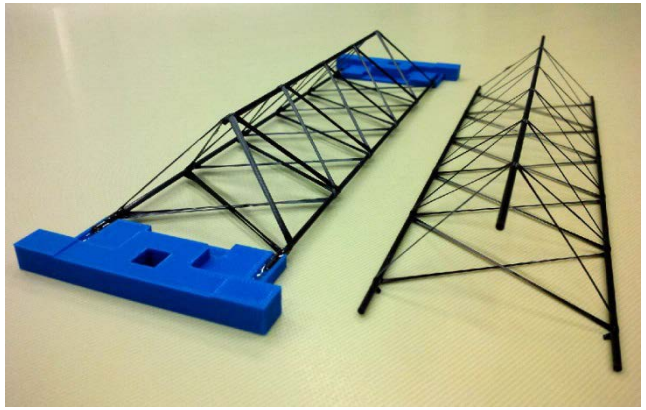


Ladder assembly



pre-series CF ladders, JINR team @CERN





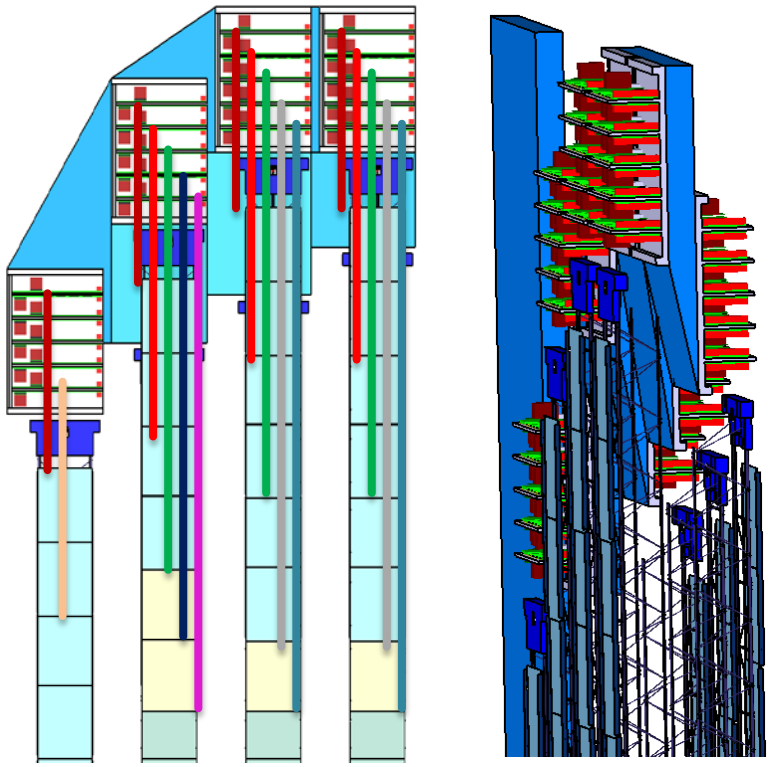
prototype CF ladders, GSI

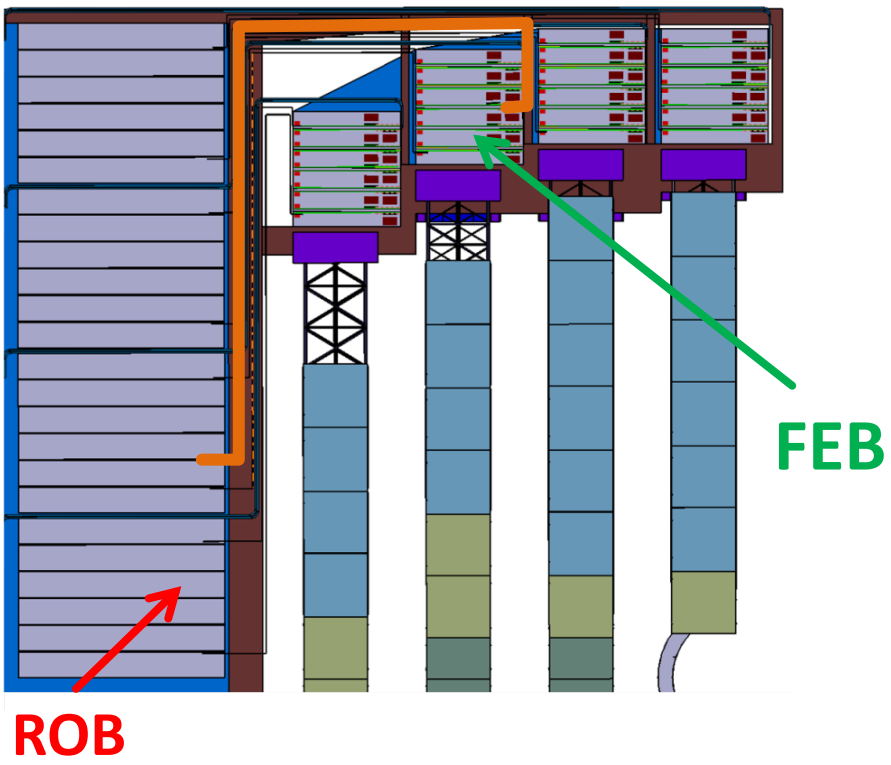
assembled mechanical prototype ladder, JINR-LTU

- ladder assembly tools under development at JINR and GSI

STS system integration

- **GSI-led effort**





CBM-STS teams

17 groups
from
4 countries

- ***Darmstadt, Germany, GSI Helmholtz Center (GSI)***
- *Karlsruhe, Germany, Karlsruhe Institute of Technology (KIT)*
- *Tübingen, Germany, Eberhard Karls University (EKU)*

- *Katowice, Poland, University of Silesia (Usilesia)*
- *Krakow, Poland, AGH University of Science and Technology*
- *Krakow, Poland, Jagiellonian University (JU)*
- *Warsaw, Poland, Warsaw University of Technology (WUT)*
- *Warsaw, Poland, University of Warsaw (UWarsaw)*

- ***Dubna, Russia, Joint Institute for Nuclear Research (JINR)***
- *Moscow, Russia, Inst. for Theoretical and Exp. Physics (ITEP)*
- *Moscow, Russia, Moscow State University (SINP-MSU)*
- *Protvino, Russia, Institute for High Energy Physics (IHEP)*
- *St. Petersburg, Russia, Ioffe Physical-Technical Institute (Ioffe)*
- *St. Petersburg, Russia, Khlopin Radium Institute (KRI)*
- *St. Petersburg, Russia, St. Petersburg State Polytechnic Univ. (SPbSPU)*

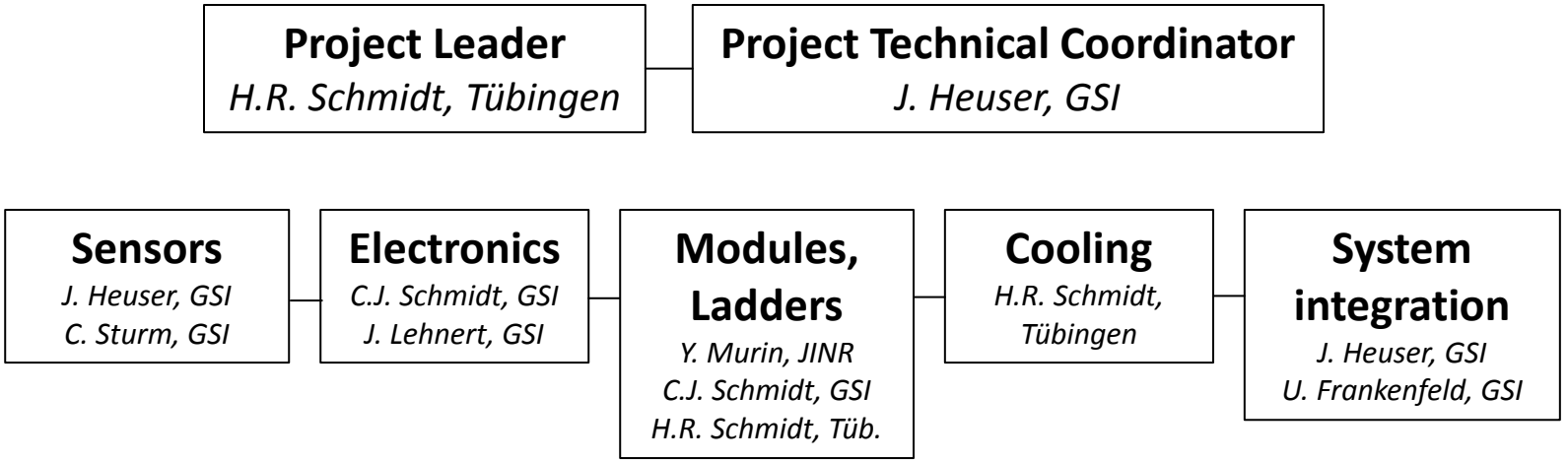
- *Kharkov, Ukraine, LED Technologies of Ukraine Ltd (LTU)* * *Partner*
- *Kiev, Ukraine, Kiev Institute for Nuclear Research (KINR)*

STS assembly centers: GSI and JINR

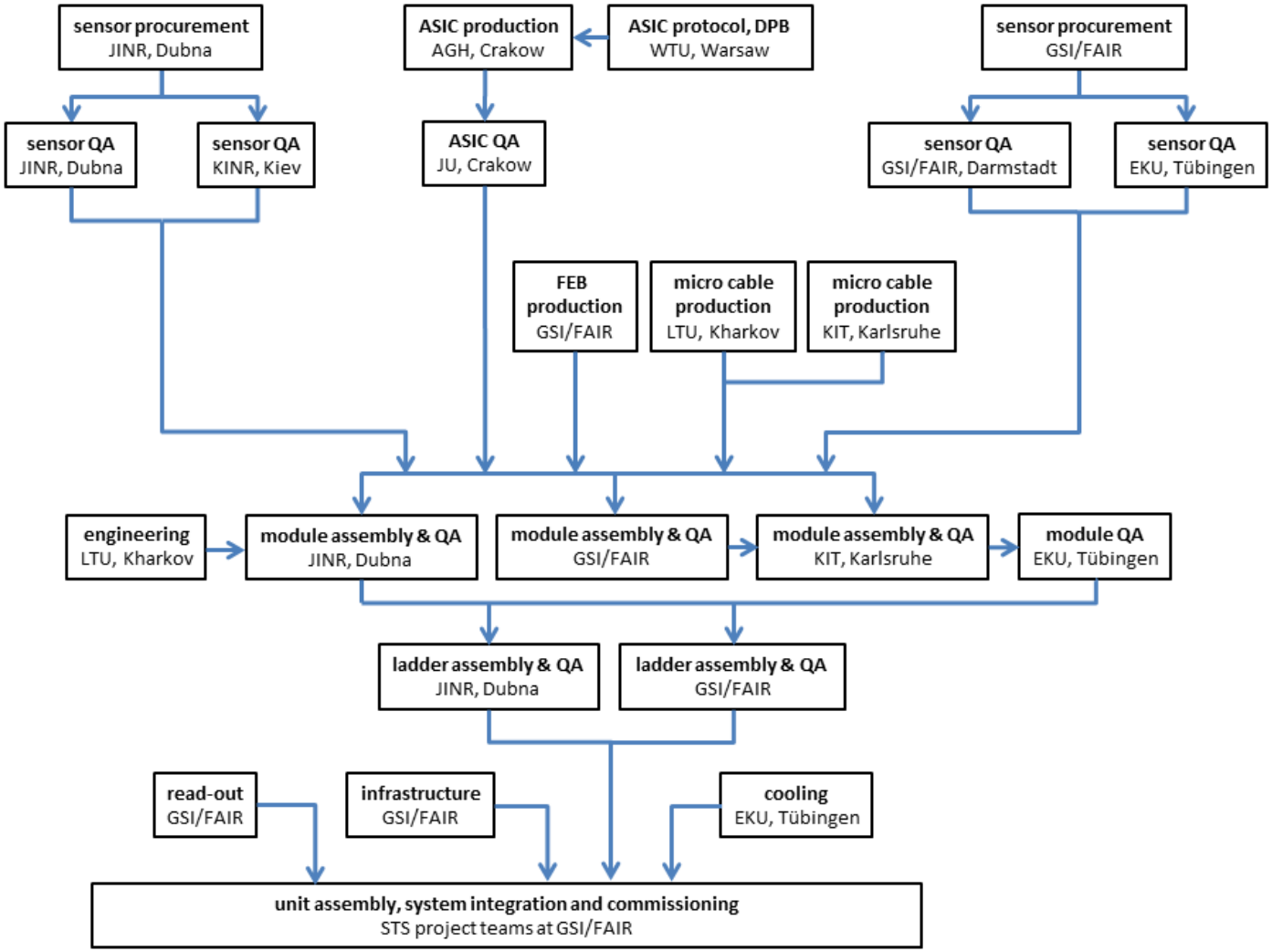

clean rooms, Solid State Section


realized in GSI + JINR cooperation with BMBF-JINR funding (2015)

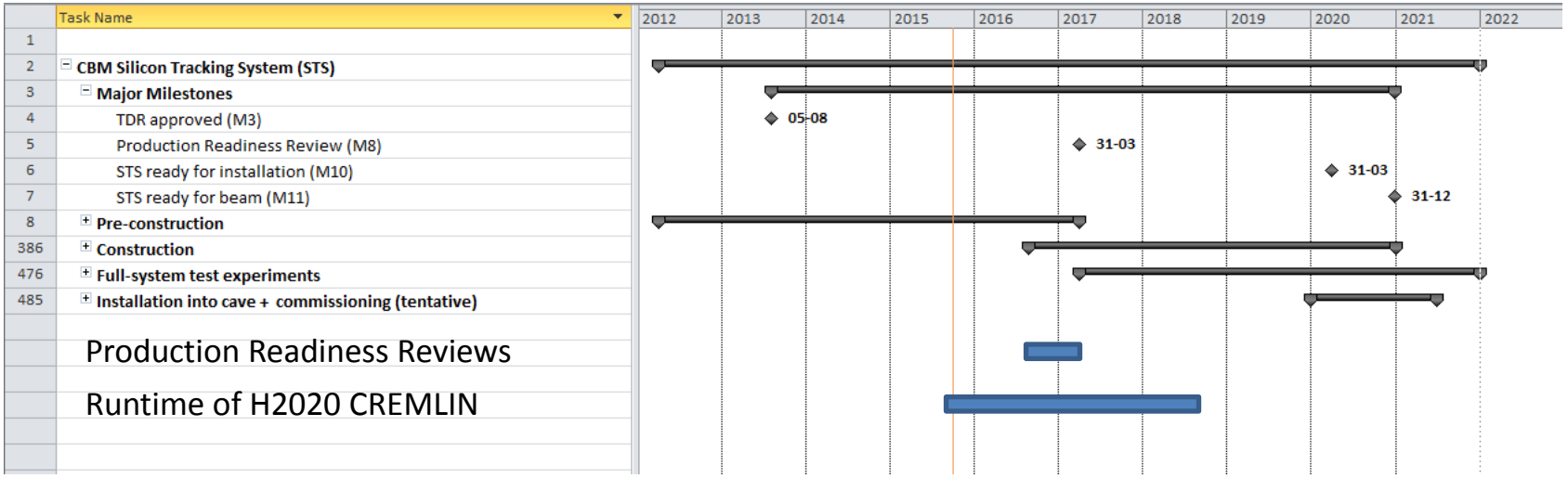
CBM-STS project structure



CBM-STS assembly flow



CBM-STS project plan



Impact of CREMLIN on the CBM-STS project:

Foster concrete cooperation of GSI-JINR to:

- *exercise, prove and start the production of STS modules and ladders for the CBM experiment at FAIR*
- *possible use of further ladders in the BM@N at JINR/Nuclotron (t.b.d.)*

Milestones towards production readiness:

Sensors:

- final prototypes produced: 3.2016
- technology decided: 5.2016
- QA procedures defined: 12.2015
- **production readiness sensors: 8.2016**

Modules:

- assembly tools and procedure proven: 03.2016
- final prototype module produced: 08.2016
- **production readiness modules: 3.2017**

Ladders:

- decision on CF ladder technique, ladder assembly tools and procedure: 3.2016
- **production readiness ladders: 3.2017**

Front-end electronics:

- STS-XYTERv2 sign-off review: 10.2015
- MPW production completed: 2.2016
- **production readiness electronics: 2.2017**

Micro cables

- cable production yield determined: 11.2015
- cable technology defined: 12.2015

Cooling / System Integration:

- cooling test performed: 6.2016
- system integration procedures verified: 9.2016
- **production readiness system integration: 3.2017**

GSI + JINR ← related to CREMLIN other CBM teams

preliminary, status 28.9.2015

CREMLIN WP3

Tasks related to the STS:

3.1: Coordination of joint developments of main components of the Silicon Tracking System
3.1.1: Technical management - development of STS modules/ladders
3.1.2: Organization of technical review meetings for each component and final Production Readiness Review
3.1.3: Initiation of expert training for the assembly of the components to modules and ladders
3.1.4: Organization of workshops for the joint development of experiment and accelerator components for NICA and FAIR
3.2: Lesson learned and internationalization of the NICA experiment collaborations

Organizational aspects:

- Which are the concrete objectives of the WP?
  - development of CBM-STS module and ladder assembly
  - preparation and passing of the CBM-STS Production Readiness Review
  - start of module and ladder production at the assembly centers GSI and JINR-VBLHEP
- Who will be responsible for the milestones and deliverables; workshops and meetings?
  - milestones and deliverables: GSI and JINR
  - meetings and workshops: weekly CBM-STS workgroups (GSI) , (semi)-annual workshops (GSI + JINR)
- What is the current status of the EU-Russian cooperation in the scientific field of the WP?
  - very active, years of cooperation embedded in CBM Collaboration and other FAIR-NICA contacts

CBM-STS Workshops

CBM-STS Workshops

Forthcoming meetings and workshops will be organized within the framework of CREMLIN.