Progress with System Integration of the CBM Silicon Tracking Detector

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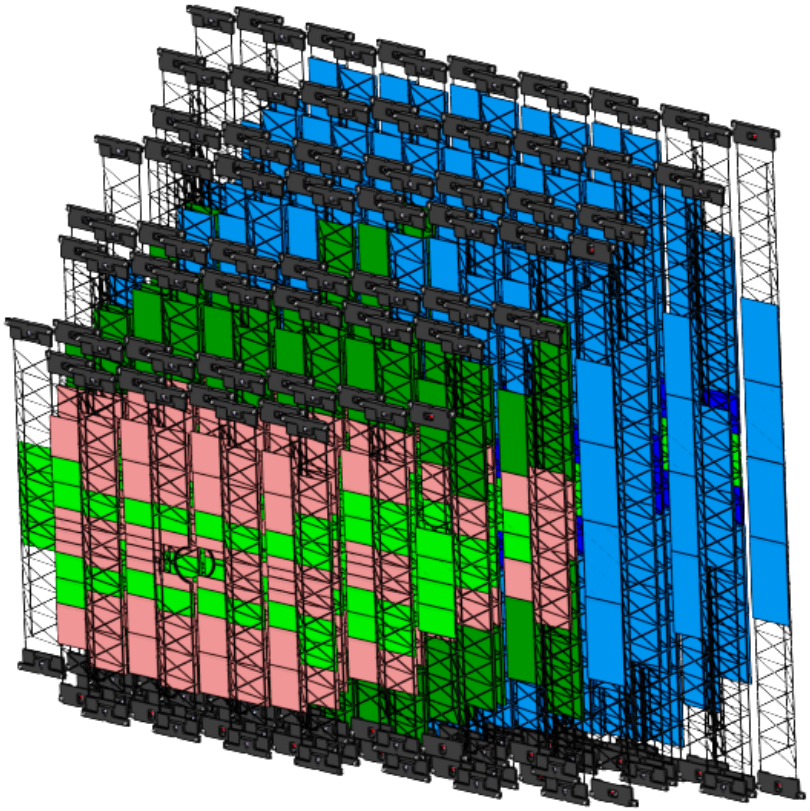
for the CBM Collaboration

DPG Frühjahrstagung,
Münster, Germany, 27 March 2017

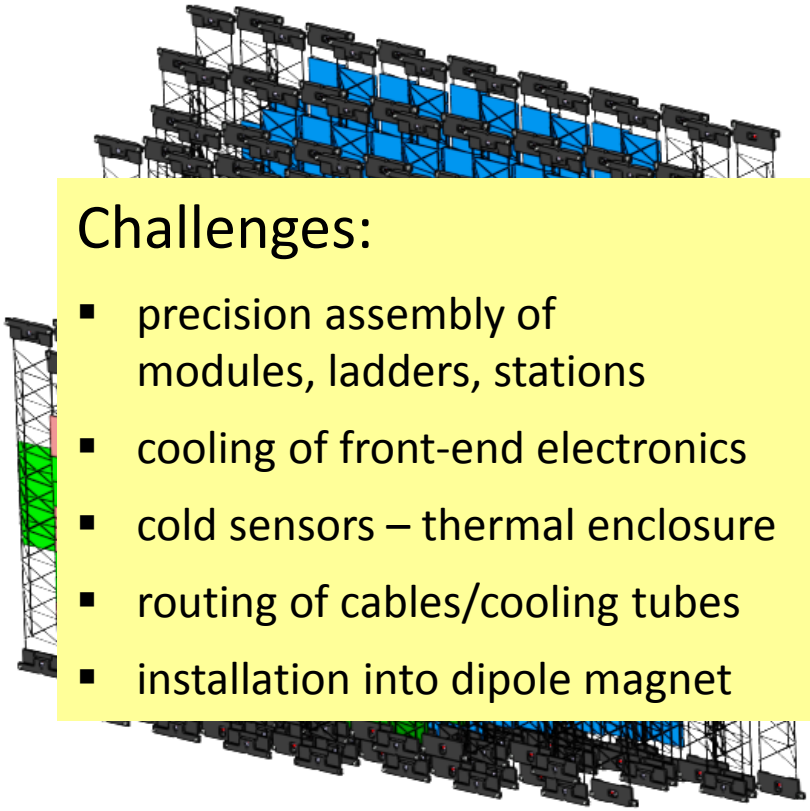
STS - Task & integration challenges



STS ladder arrangement

- pile-up free track point determination in high-rate collision environment:
  - *$10^5 - 10^7$/s (A+A), up to 10^9/s (p+A), track multiplicities up to 700/collision*
  - *momentum resolution $\Delta p/p \approx$ 1-2%*
- physics aperture : $2.5° \leq \Theta \leq 25°$
- 8 tracking stations: 0.3 m $\leq z \leq$ 1.0 m
  - *material : $\approx$ 0.3 % – 1% X_0 per station*
  - *896 detector modules , 106 ladders*
- double-sided silicon microstrip sensors
  - *hit spatial resolution $\approx$ 25 µm*
  - *operation at T = -5 °C (radiation field)*
- 1.8 million r/o channels, 14 000 r/o ASICs
  - *time-stamp resolution $\approx$ 5 ns*
  - *power dissipation: $\approx$ 40 kW*

STS - Task & integration challenges



STS ladder arrangement

Challenges:

- precision assembly of modules, ladders, stations
- cooling of front-end electronics
- cold sensors – thermal enclosure
- routing of cables/cooling tubes
- installation into dipole magnet

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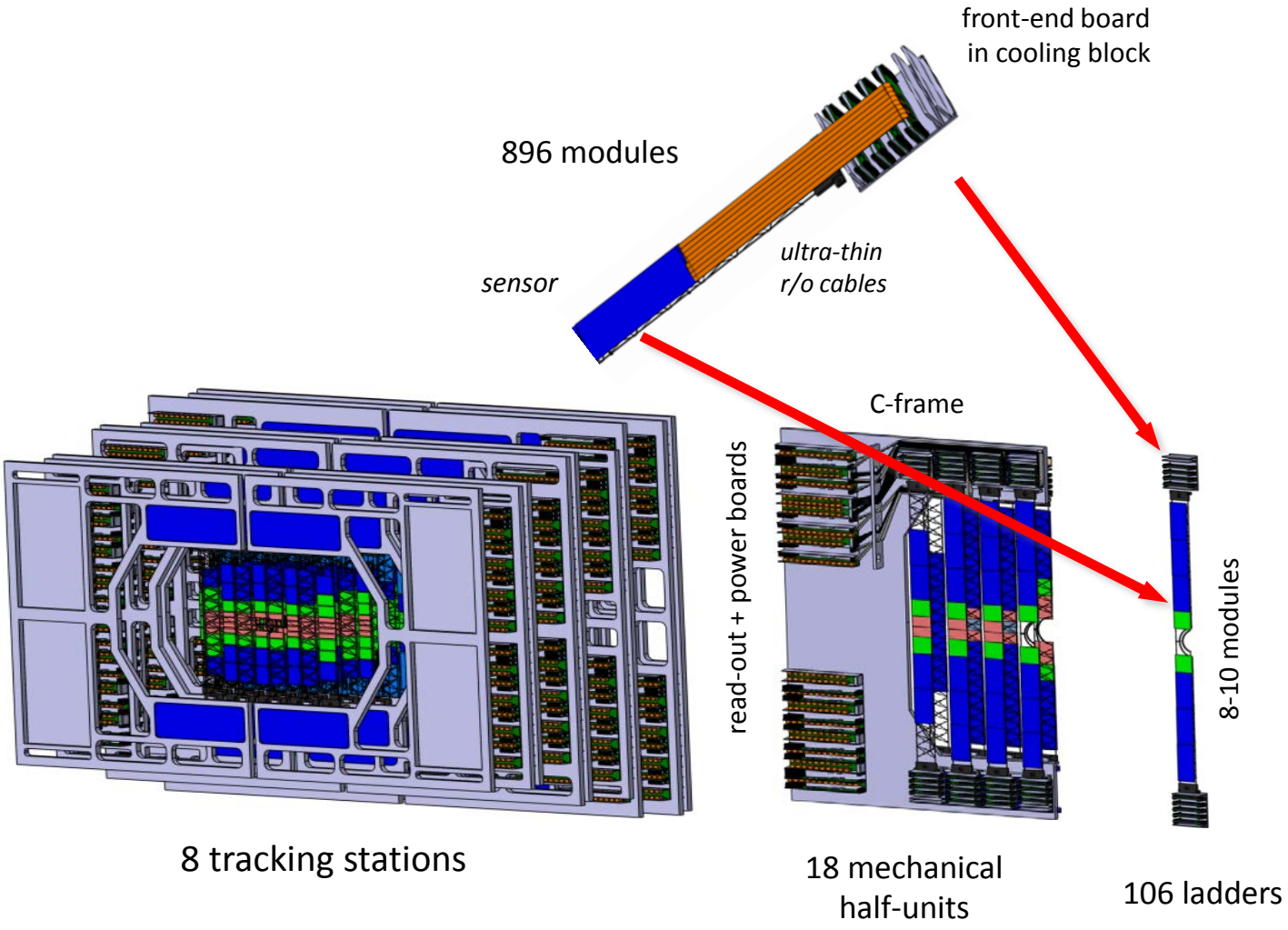
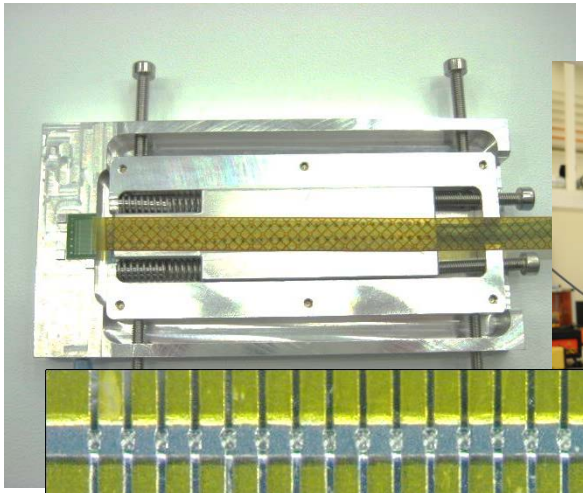
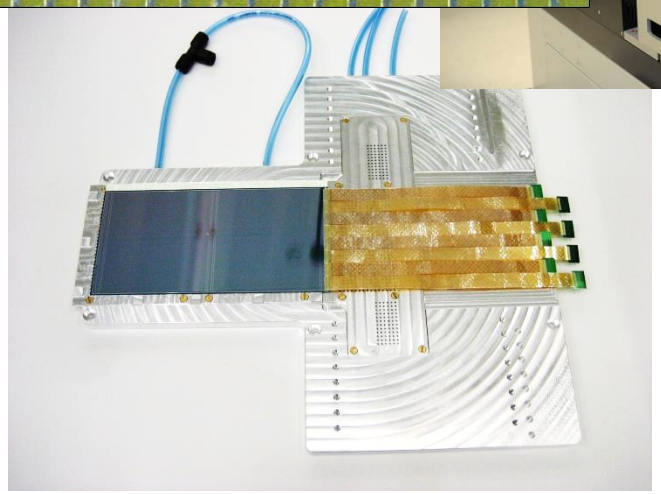
Integration – from modules to stations



Progress with module assembly

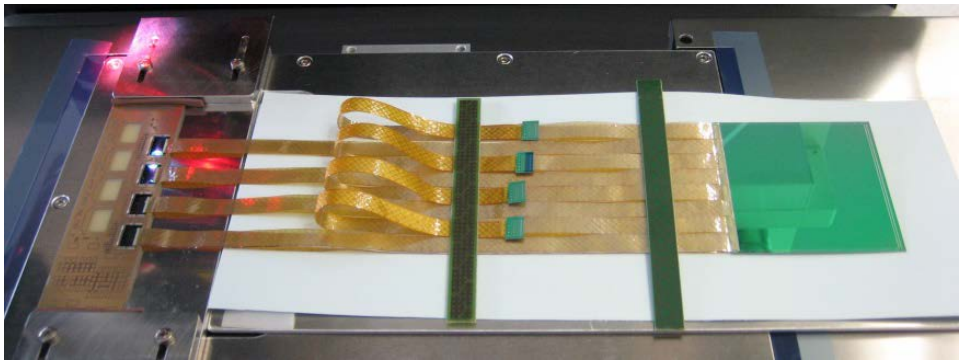
GSI-Detector Lab



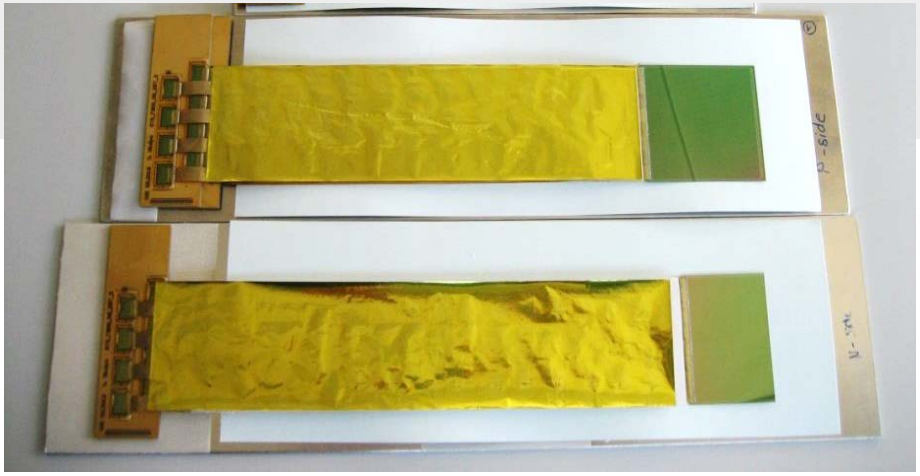


Work flow, per side:

1. TAB bonding of microcables to ASICs
2. TAB bonding of microcables to silicon sensor
3. die- and wire-bonding of ASICs to FEB
4. gluing of shielding layers and spacers

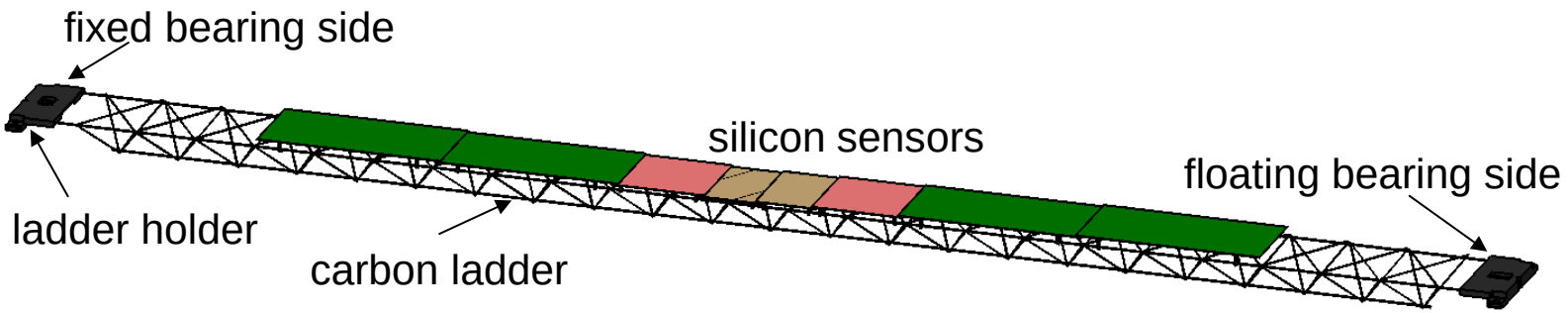


Progress with module assembly

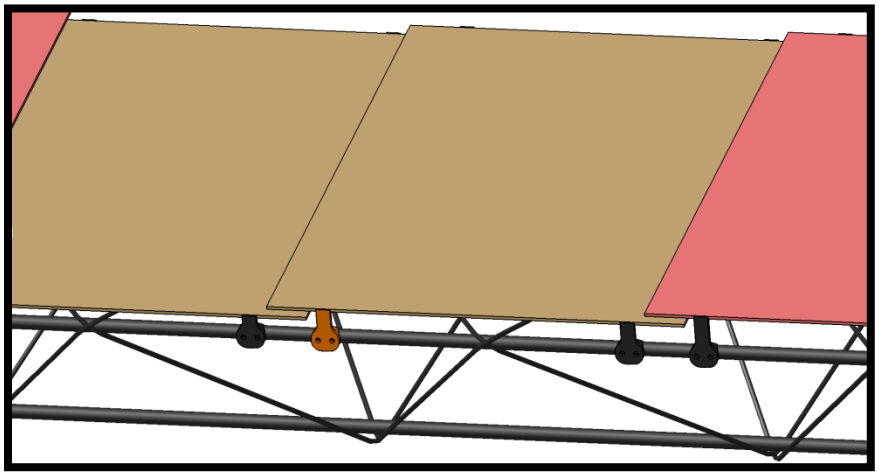


dummy modules
produced during set-up of assembly line

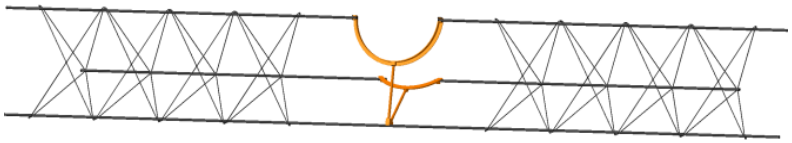
Detector ladders



sensor mounting with “L-legs”

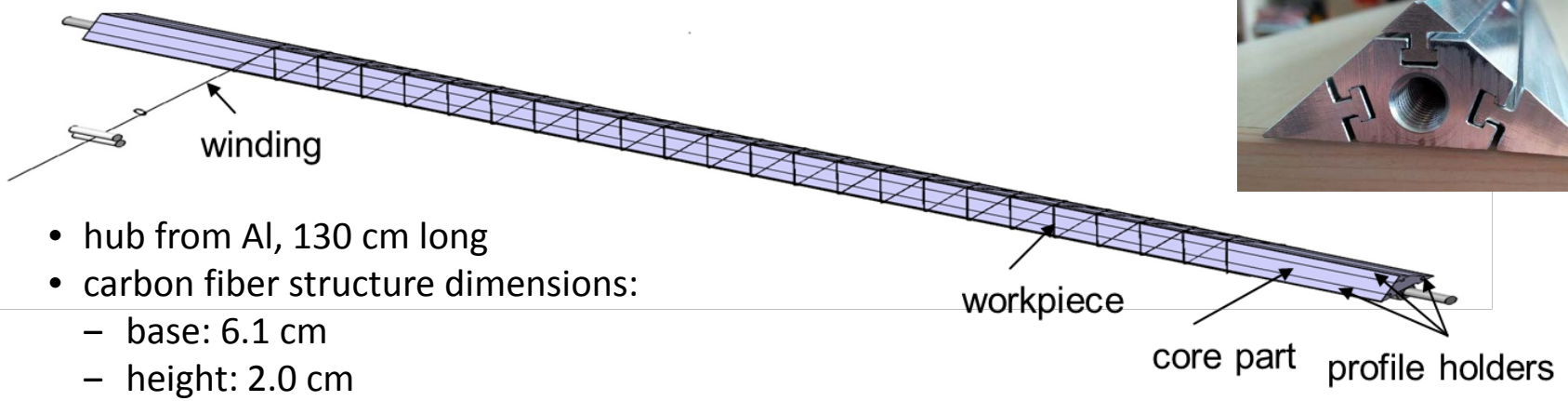


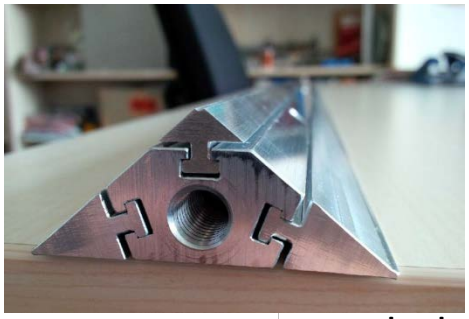
Beampipe cut-out for central ladders



Carbon fiber ladders

prototypes made in aerospace industry, Germany

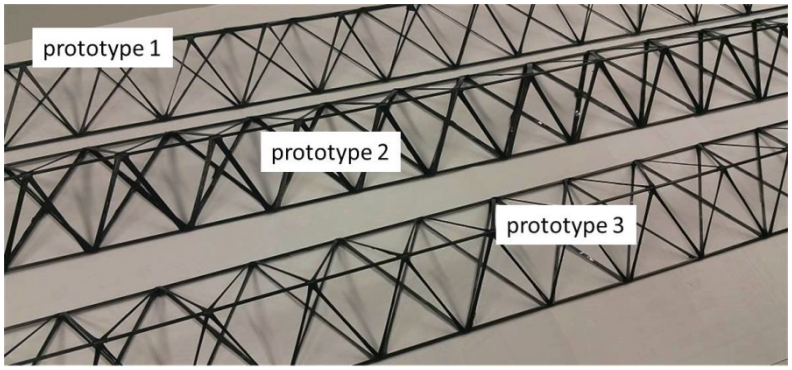




hub

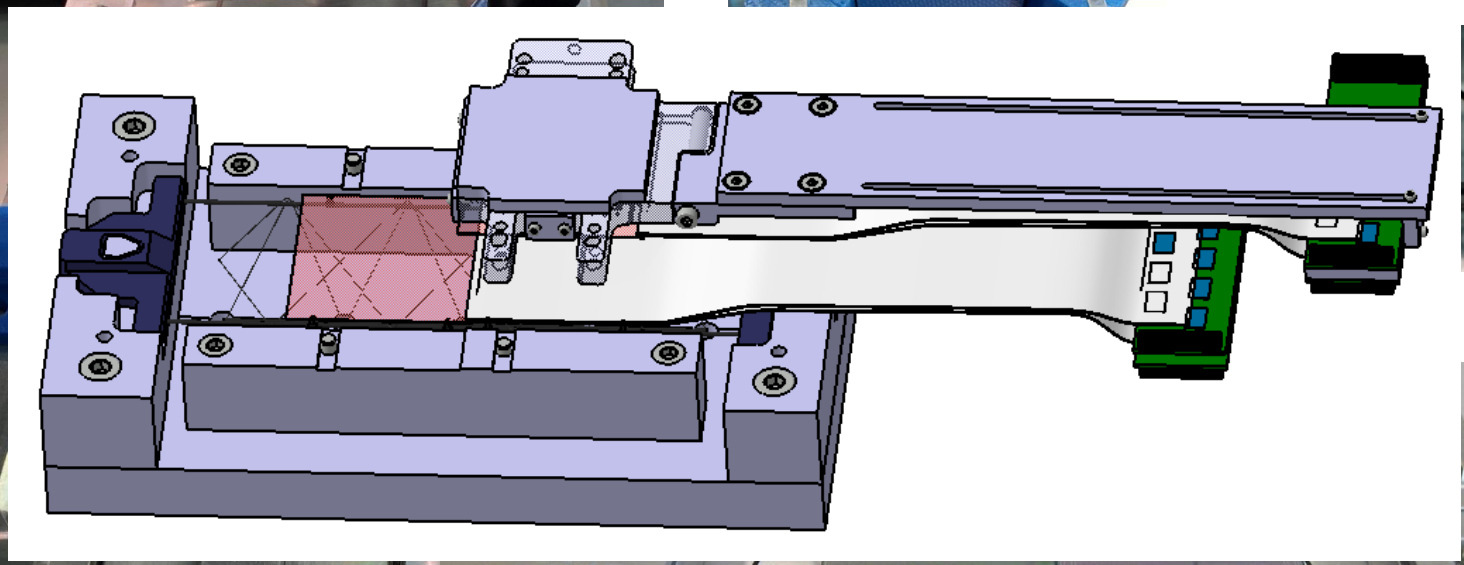
- hub from Al, 130 cm long
- carbon fiber structure dimensions:
  - base: 6.1 cm
  - height: 2.0 cm
  - length: 120 cm
  - tube supports: 1.5/0.5 mm ∅

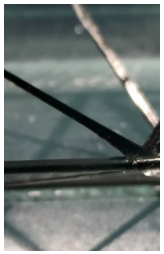
	prototype 1	prototype 2	prototype 3
support	CFK pipe 0.5/1.5 mm ∅	CFK pipe 0.5/1.5 mm ∅	CFK pipe 0.5/1.5 mm ∅
matrix	L20/EPH960	L20/EPH960	L20/EPH960
fiber	M55J/6K	M55J/6K	M60J/3K
roving	1	2	3
weight	11.2 g	14.8 g	11.2 g

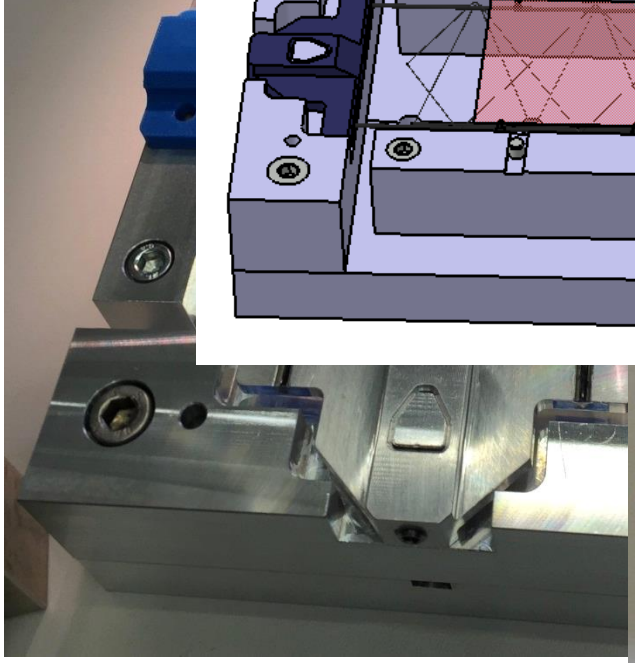


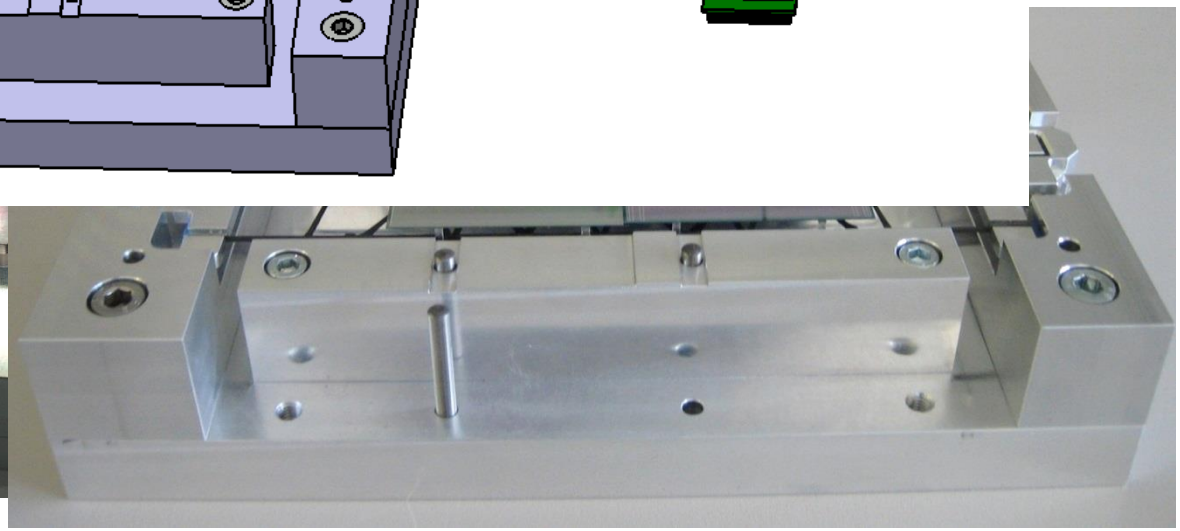
Progress with ladder assembly

concept tool









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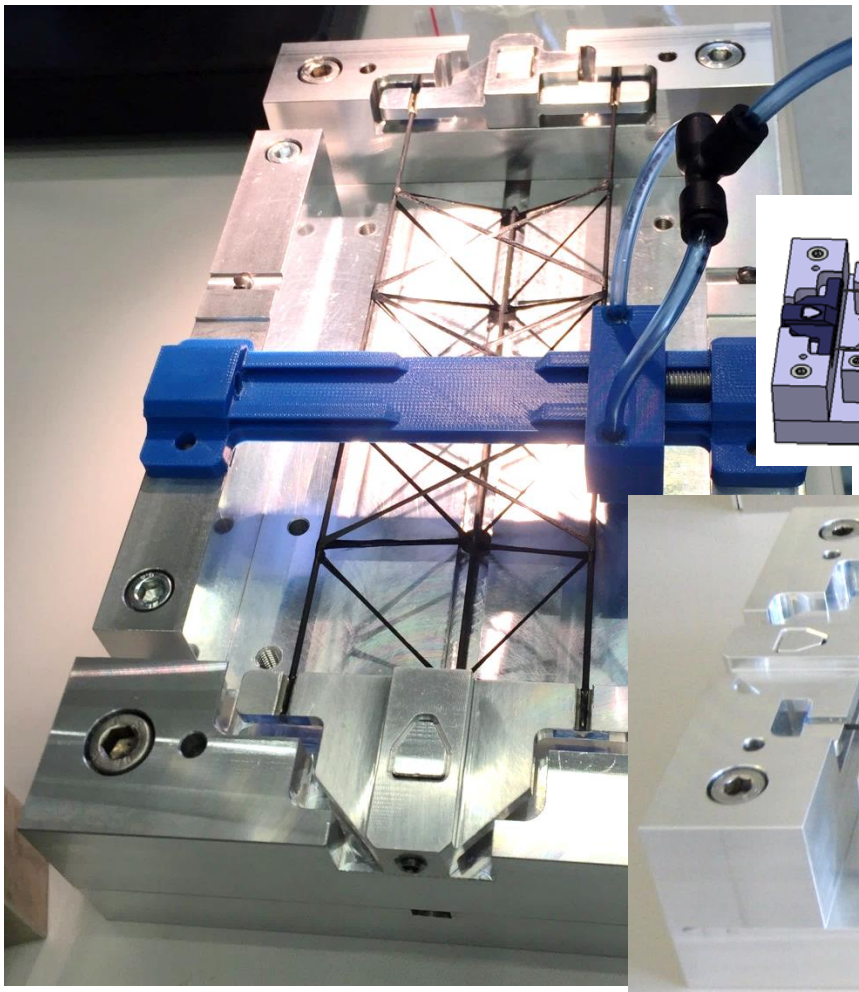

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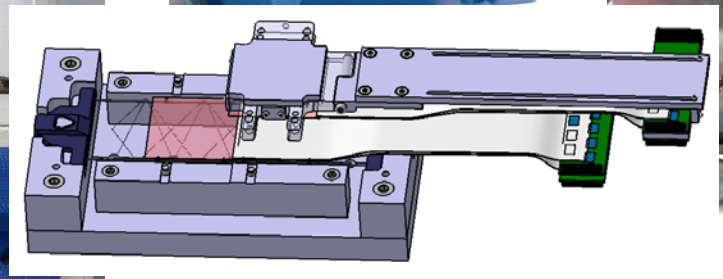

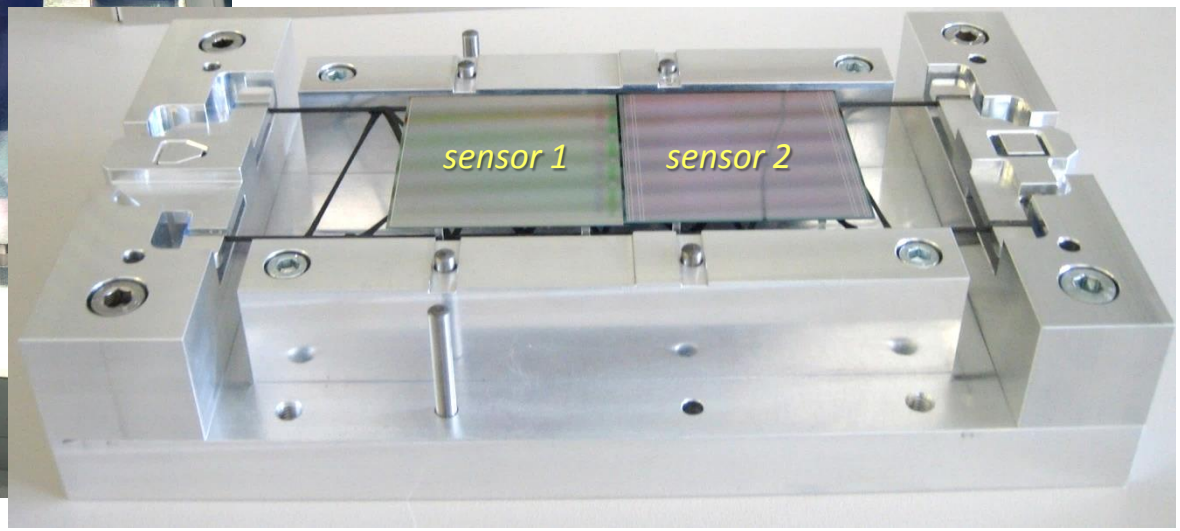

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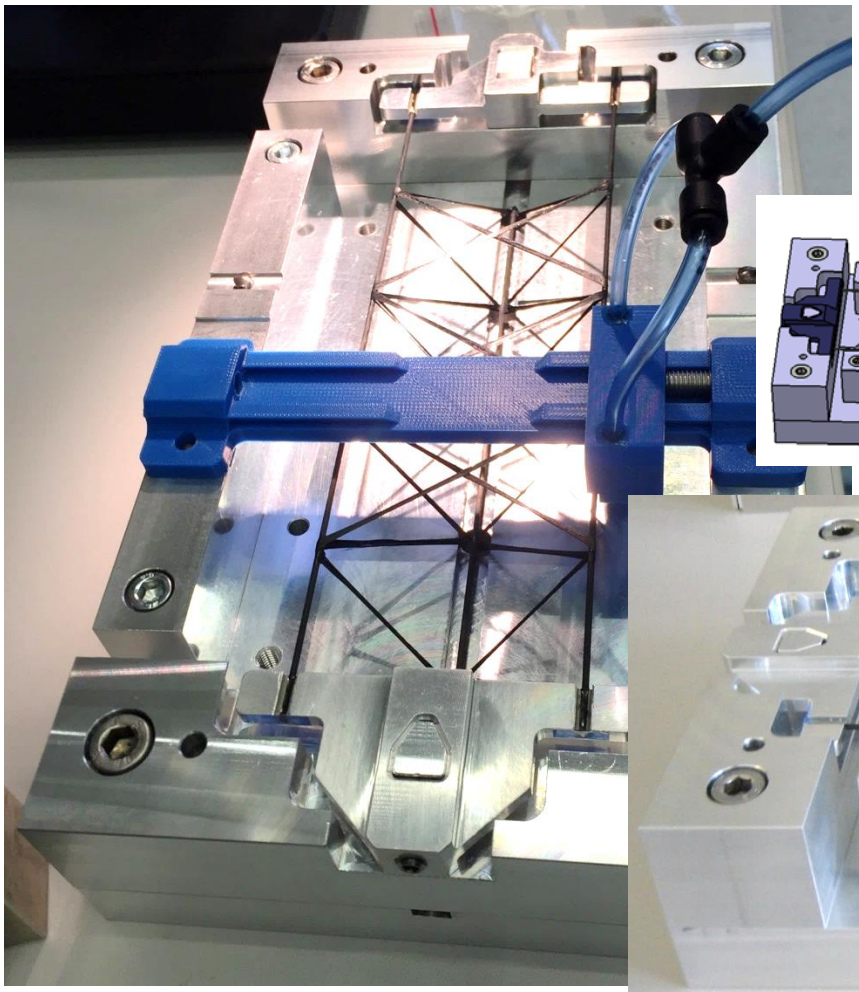

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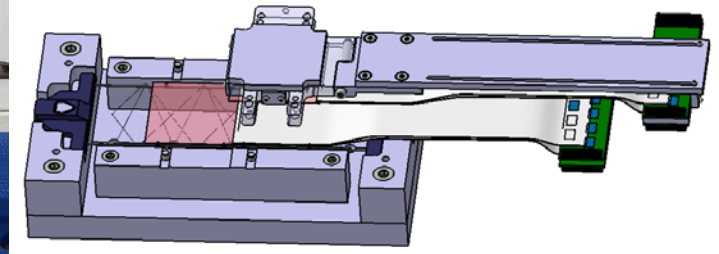
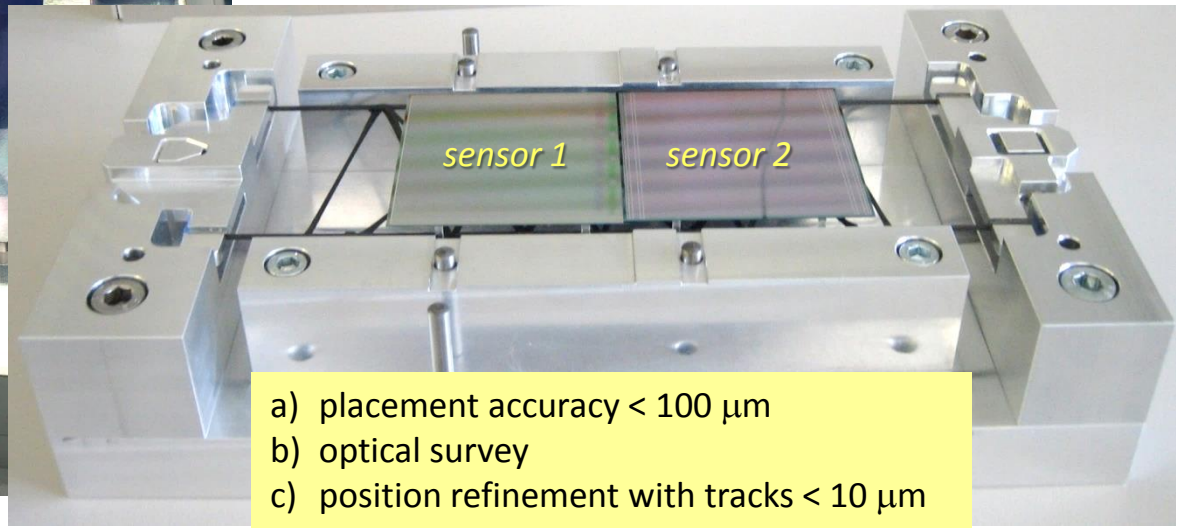
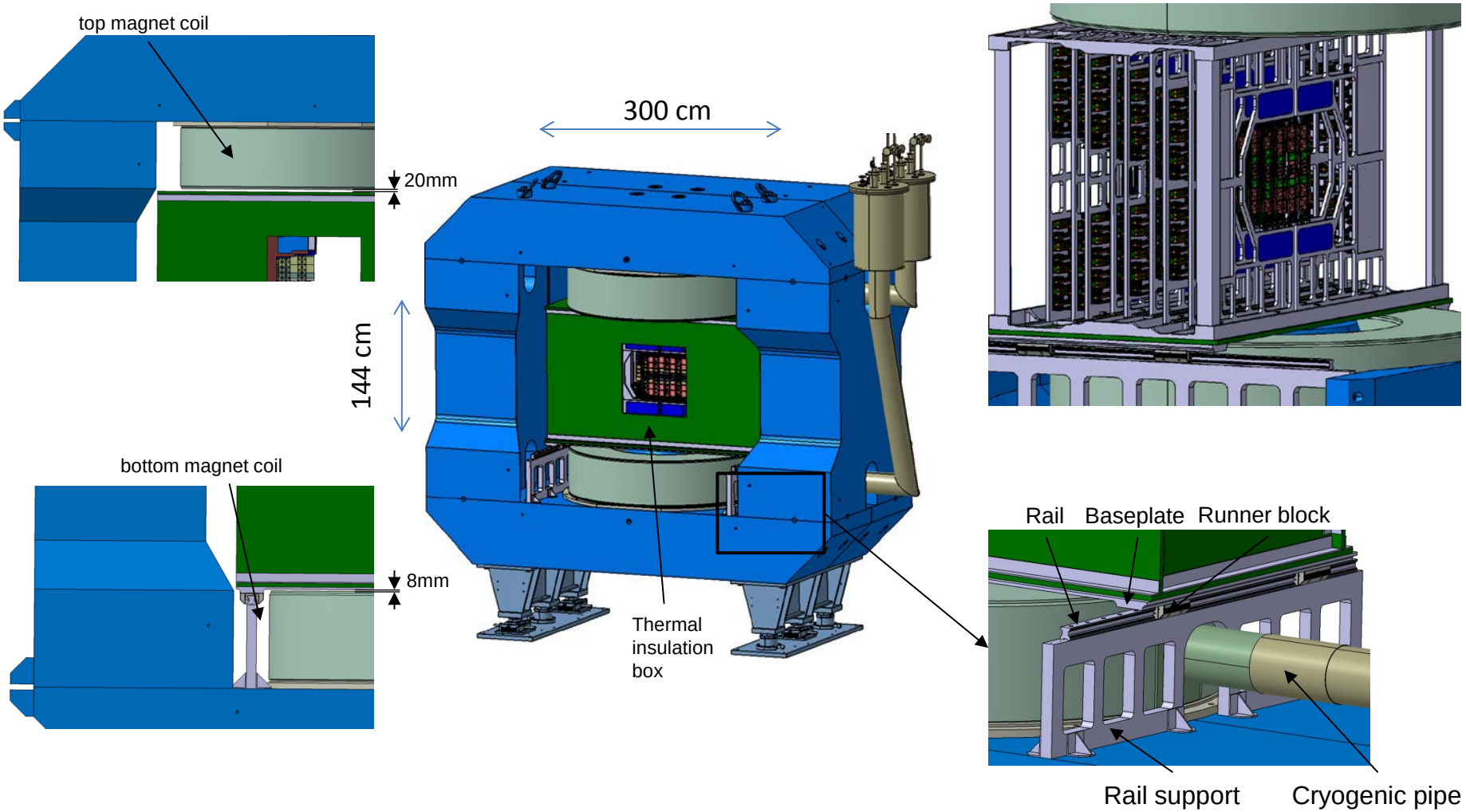


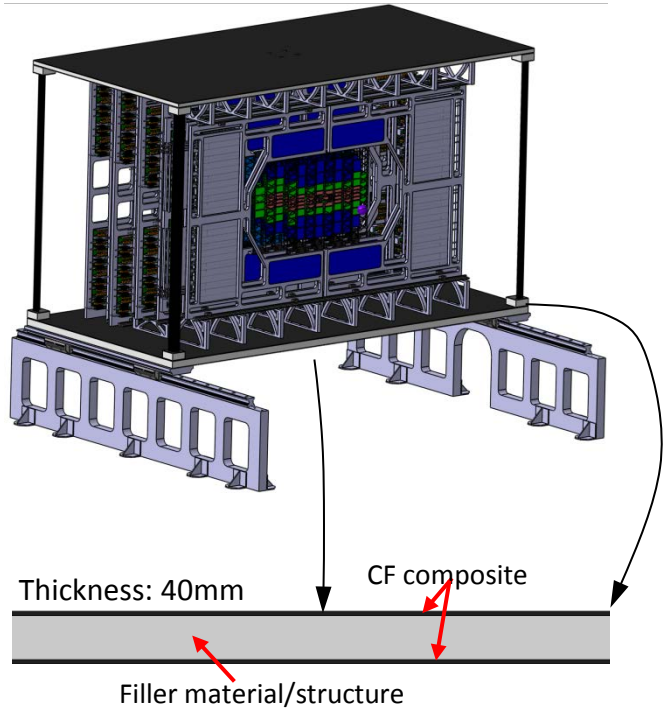


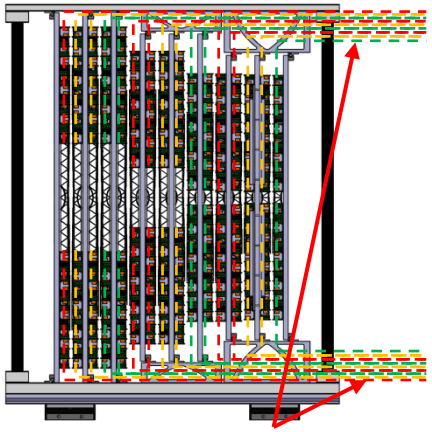
a) placement accuracy < 100 µm
b) optical survey
c) position refinement with tracks < 10 µm

STS in Dipole Magnet

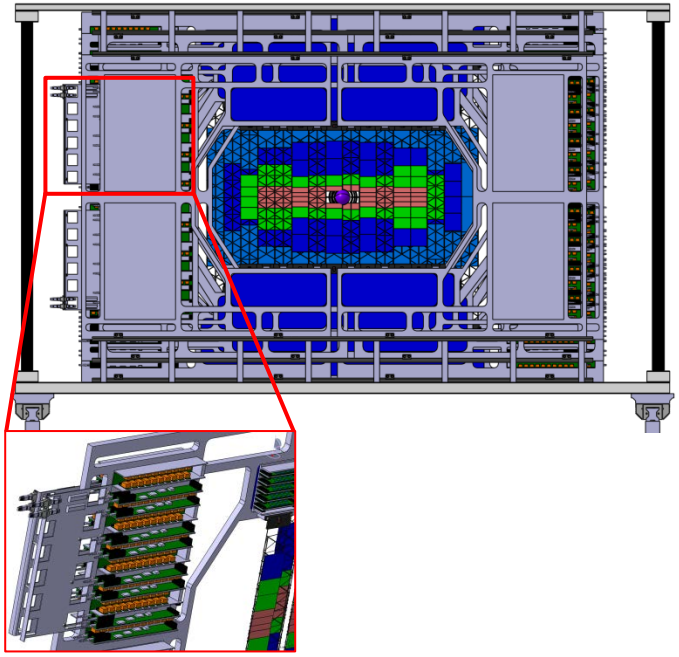


Progress with STS CAD model





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



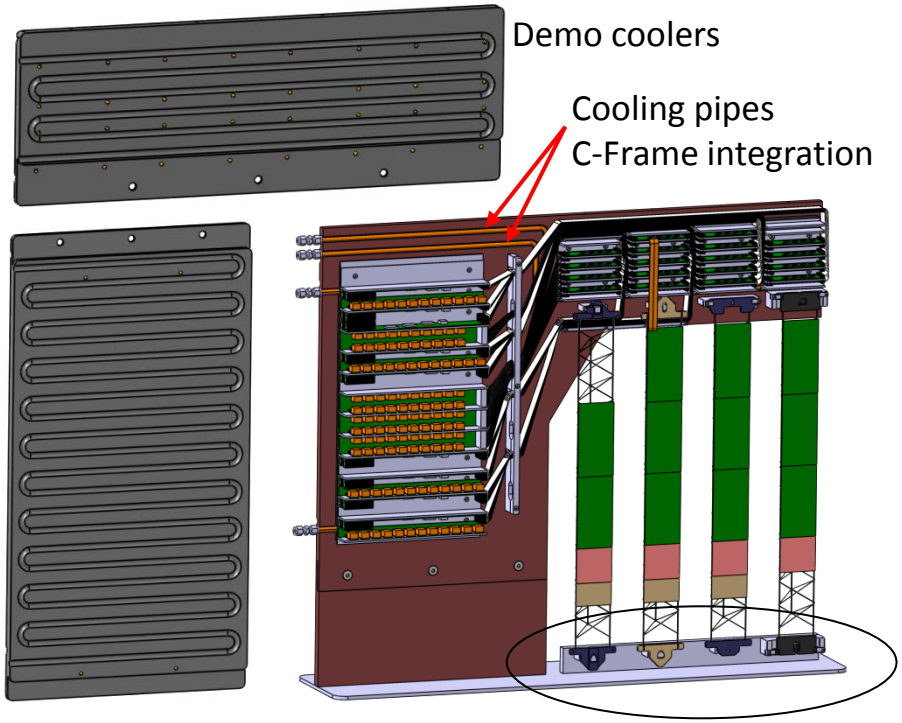
Sandwich concept:
- Lightweight and stiff
- Parameters depend on filler material
- Versatile configuration

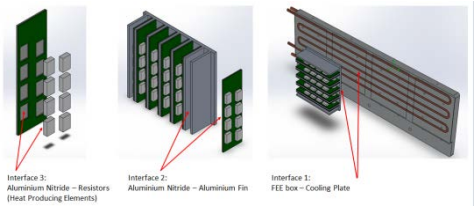
Further development requires:
- Thermal testing
- Requirement summary
- Coordination with industrial manufacturers

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

Construction of a mock-up STS

¼ Unit 07 – detailed CAD:

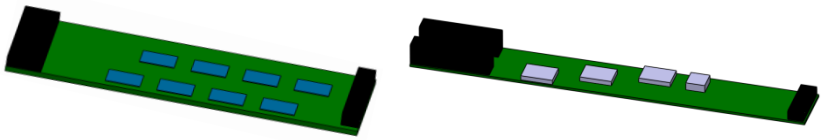




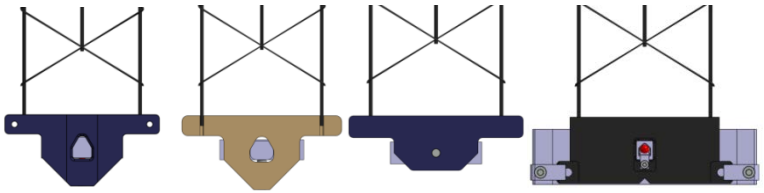
Set-up to study thermal management of FEE water cooling → CO2 cooling

Status:

- CAD finished
- Assembly ongoing
- Final parts manufacturing
  - FEB dummies
  - ROB/POB dummies

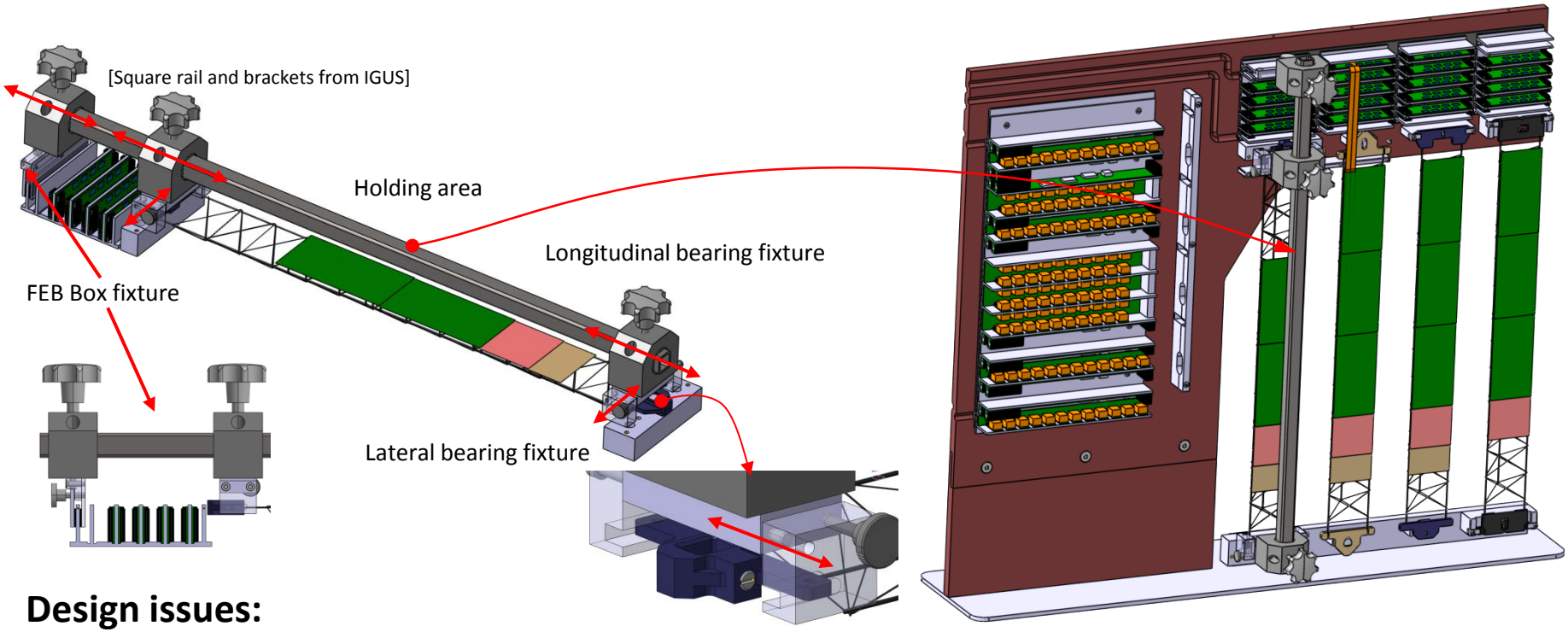


Testing of different types of ladder bearings:



CNC pin Al bearing	CNC pin Ceramic bearing	Dowel pin Al bearing	Ruby ball Fiberglas bearing

Development of ladder handling tool

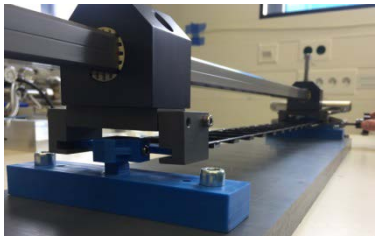


Design issues:

- Stress free ladder handling
- Variable length for multiple ladder types
- Mounting and dismounting from Master jig to C-Frame
- Sufficient precision
- Easy handling

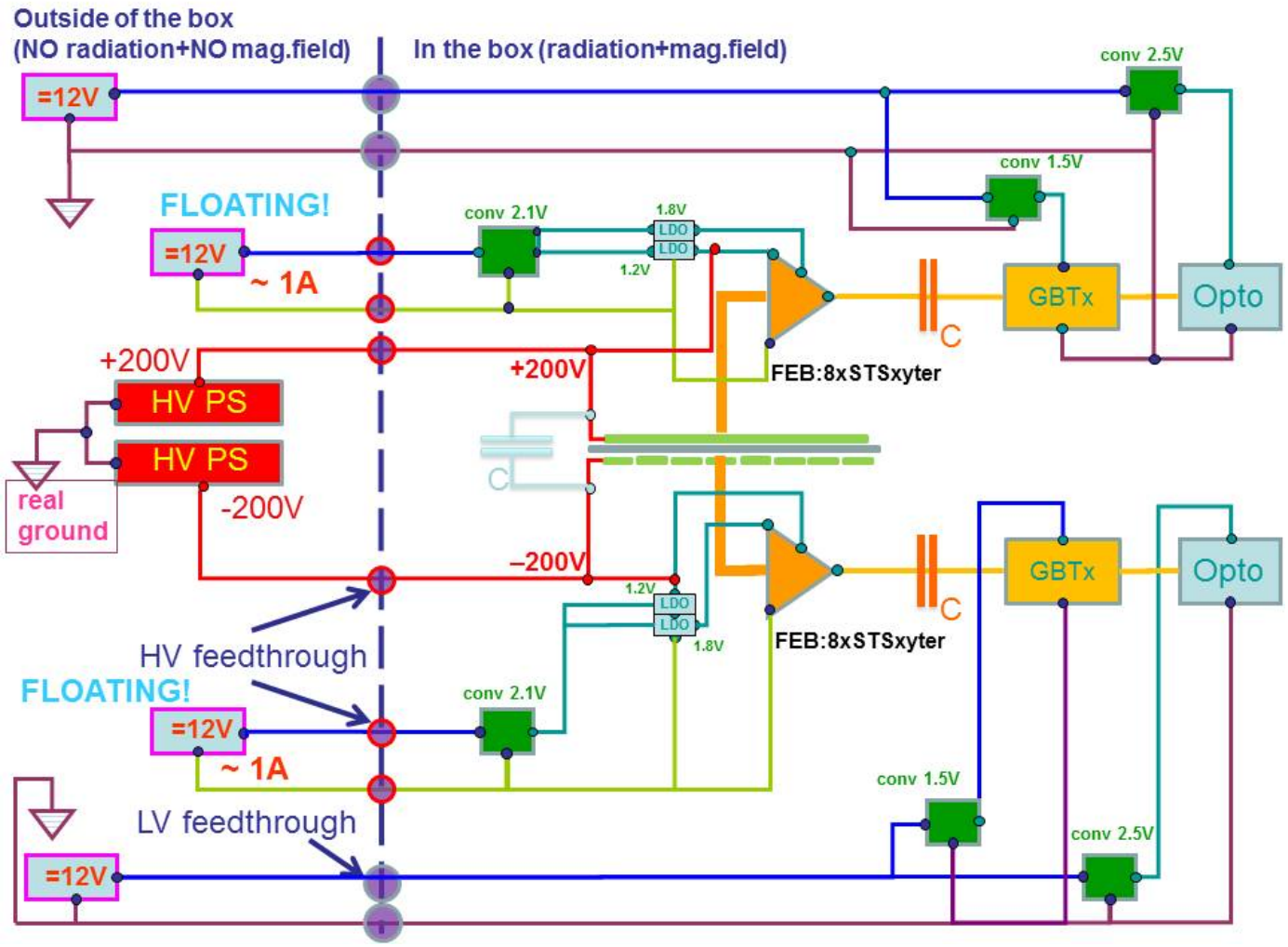
Status

- First prototype assembled
- Tests ongoing
- Mounting of Mock-up ladders planned



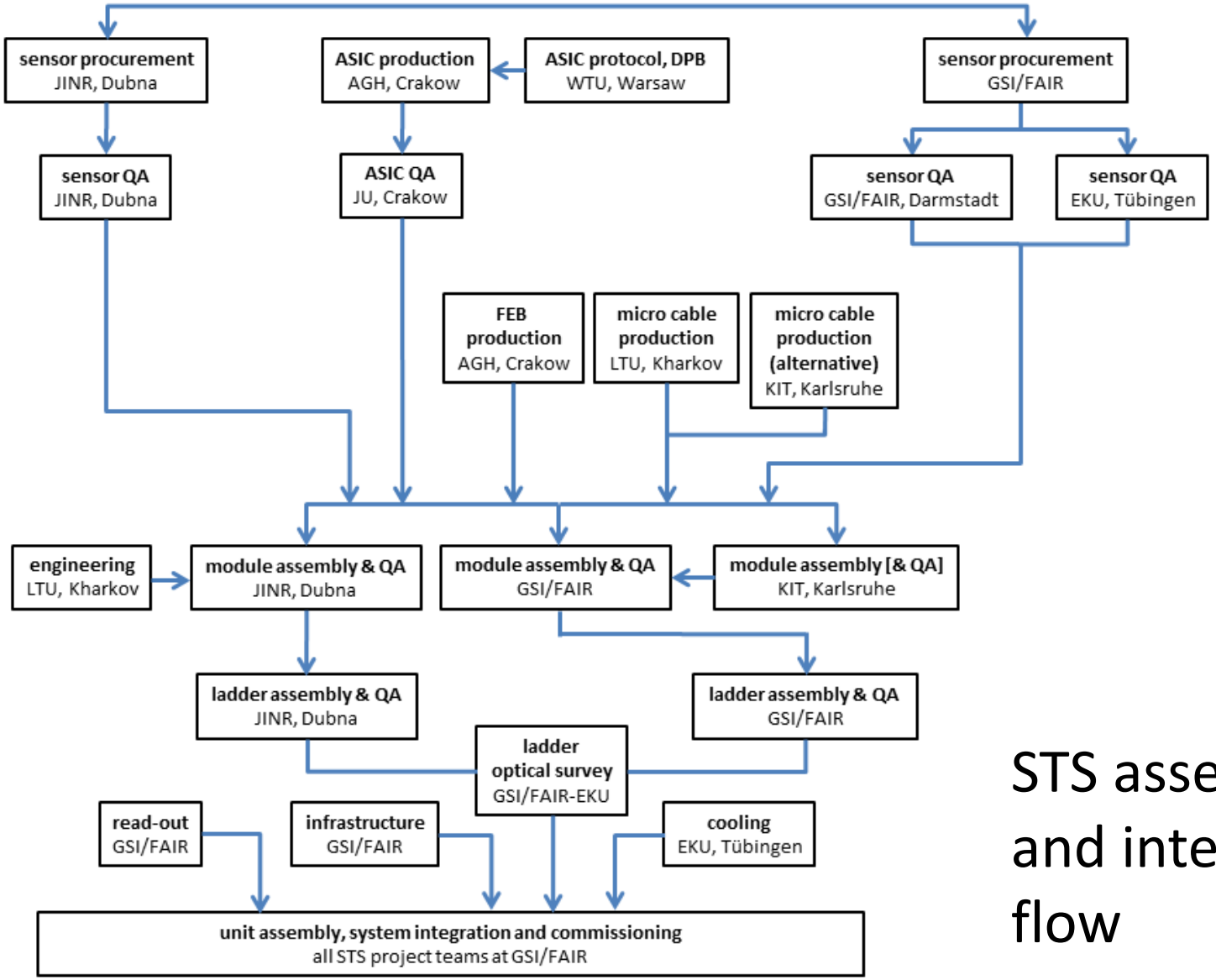
LV/HV powering scheme

- Sensor bias: ± 200 V, common ground
- FEE floating
- ASIC powering: ~ 2.2 V, ca. 4 A (per FEB) by a FEAST DC/DC converter
- Two LDOs convert to 1.8 V (digital) and 1.2 V (analog)
- 12 V, ca. 1 A, and HV are delivered from outside STS



Summary

- Challenges of CBM-STS system integration:
  - *precision assembly and mounting of its components, to yield the final spatial resolution*
  - *fast front-end electronics requires efficient cooling (CO2)*
  - *cold operation of sensors requires thermal enclosure*
  - *routing of services*
  - *installation in dipole magnet*
- Module assembly: fully developed, dummy modules produced.
  - *FEB under development for functional modules*
- Ladder assembly: procedure and tooling under development
- System integration:
  - *CAD well advanced, in concept and detail*
  - *¼ unit demonstrator and cooling demonstrators under construction*
  - *electronics & powering components being produced*
  - *open topic: beam pipe section in STS*
- Aim to advance system integration towards production readiness in 2018.



STS assembly and integration flow

Key project institutes:

- GSI-FAIR, Darmstadt, Germany
- JINR, Dubna, Russia
- Univ. Tübingen, Germany
- KIT, Karlsruhe, Germany
- AGH, Cracow, Poland; JU, Cracow, Poland; WUT, Warsaw, Poland
- *Assembly Centers: GSI-FAIR, JINR -VBLHEP*