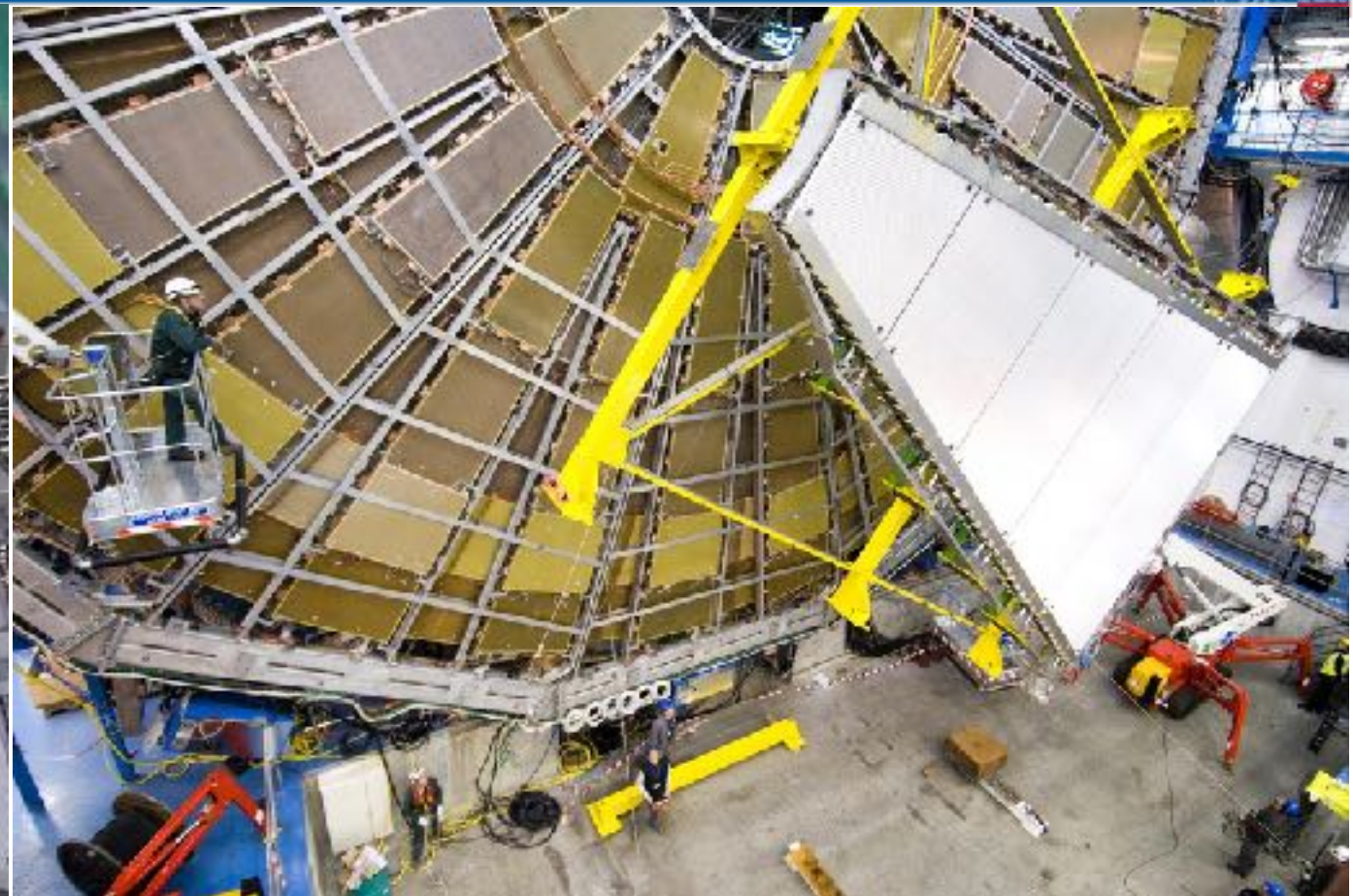
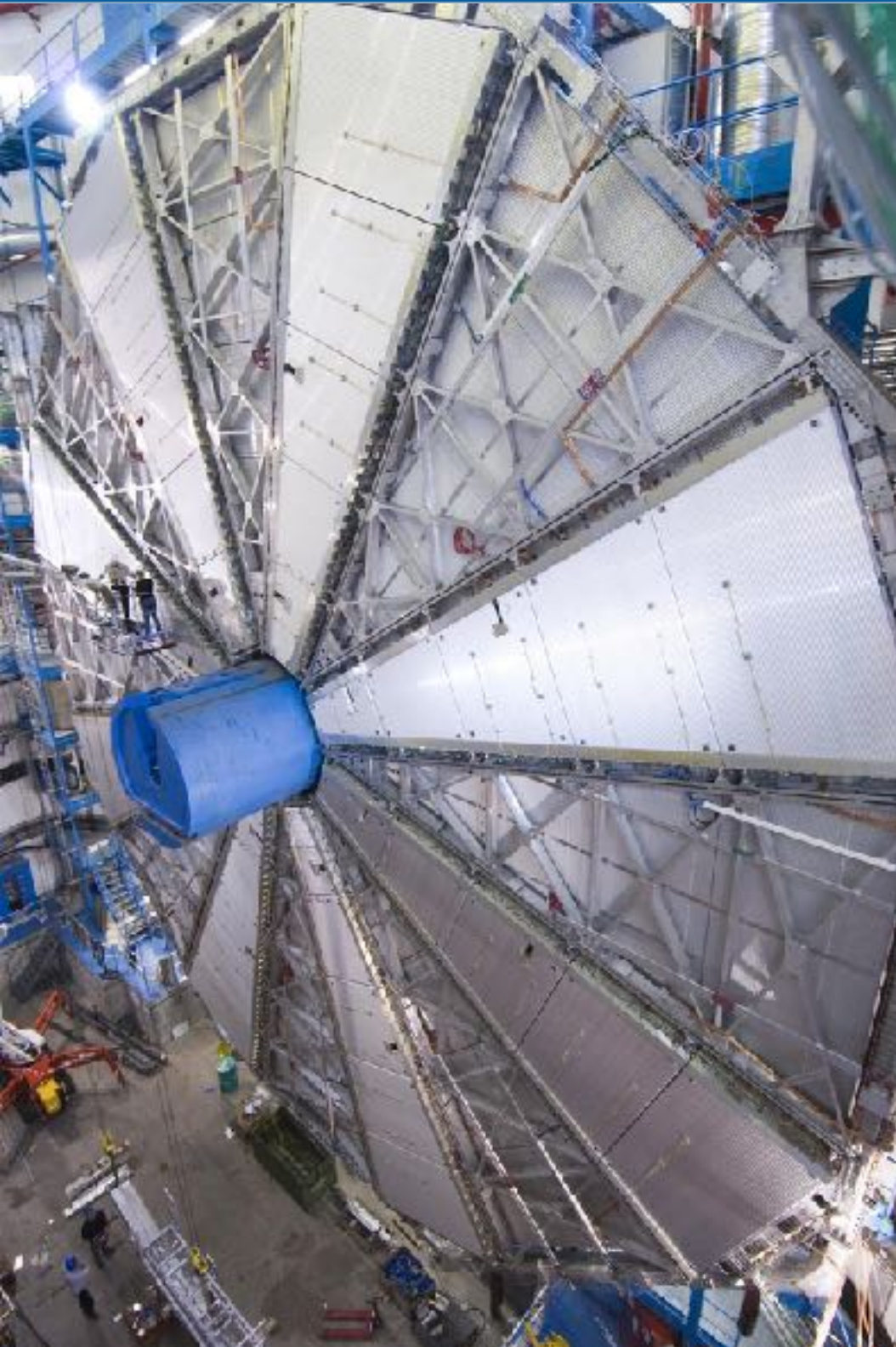


ATLAS Phase 1 Upgrade: Muons



GRK2044

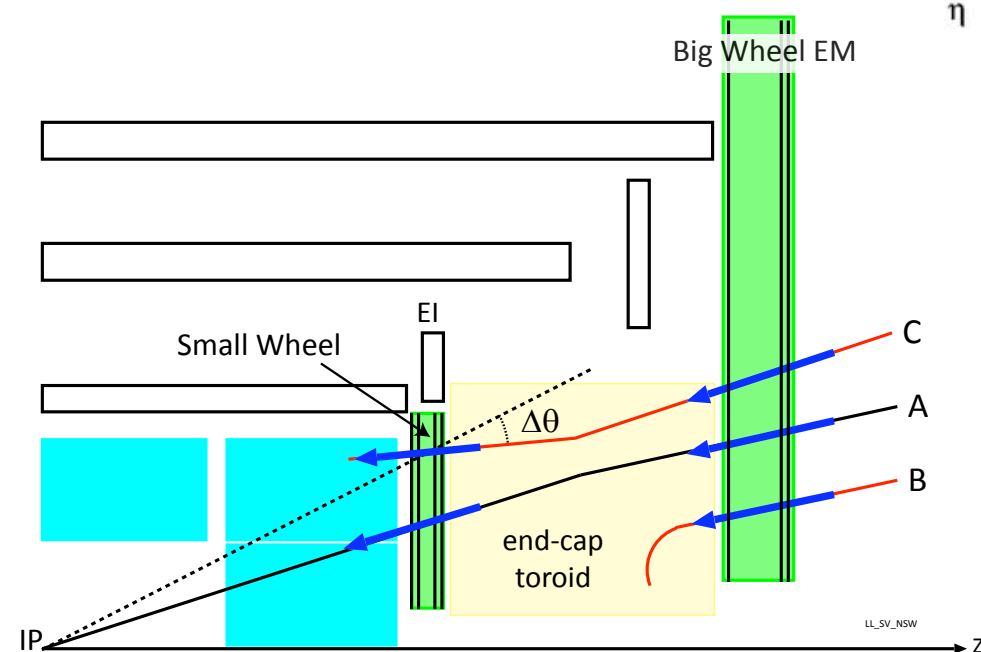
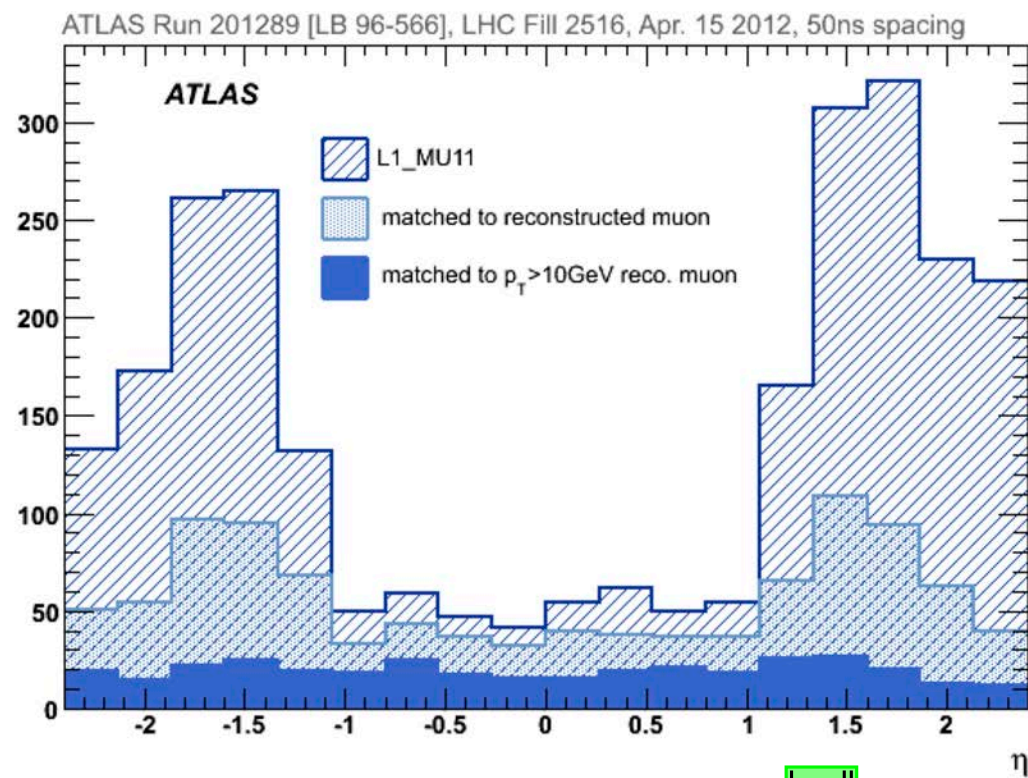
Overview

- Reasons for phase 1 upgrade
- Structure of New Small Wheel (NSW)
- Cooling system of NSW electronics
- Alignment system of NSW
- Micromegas operation: gas composition and HV

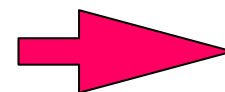
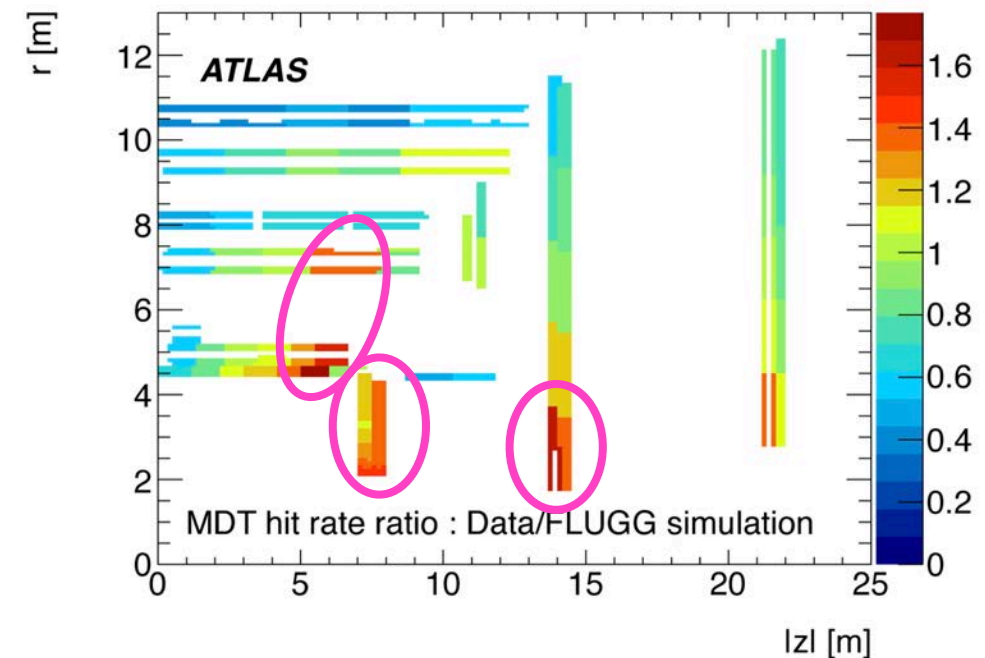
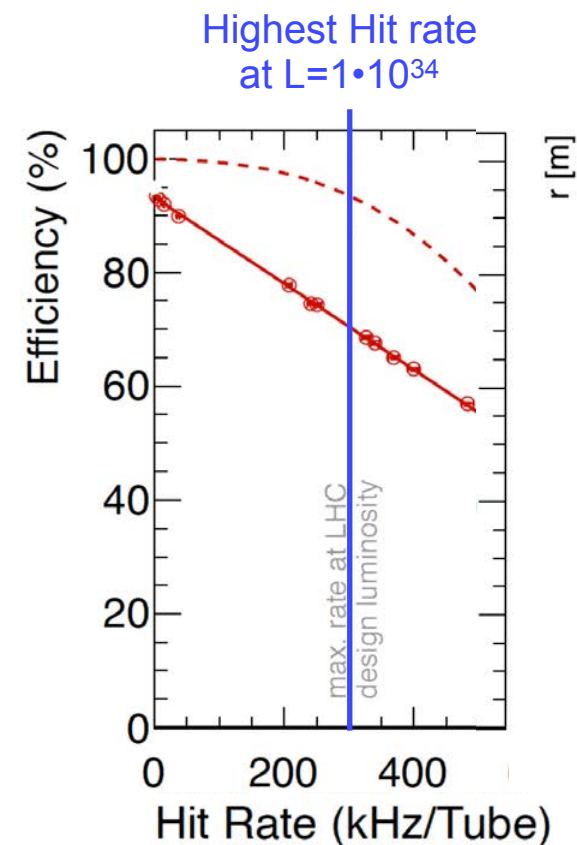
ATLAS Phase 1 Upgrade: Muons



End cap trigger not effective:



Muon tubes rate capability exceeded:



New Small Wheels needs:

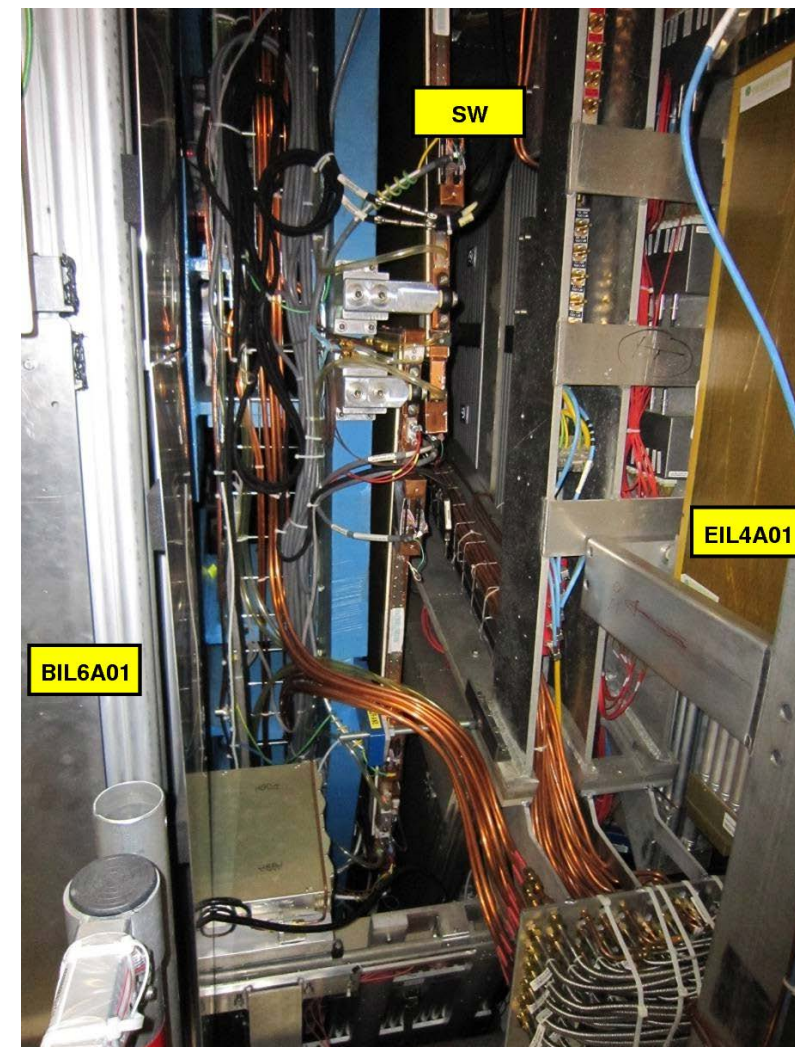
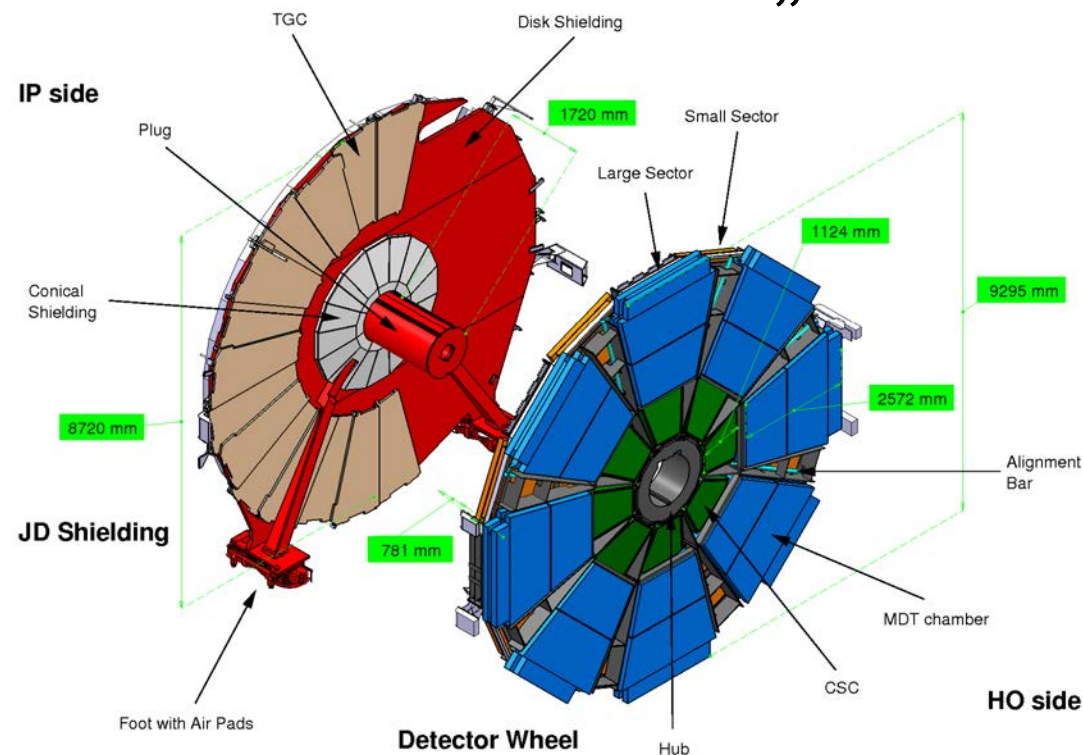
- finer granularity (ca. 0.5 mm)
- angle measurement (1 mrad)

ATLAS Phase 1 Upgrade: Muons



Current „Small“ wheel (10 m diameter)

Large - but delicate structure:
very thin and
almost inaccessible

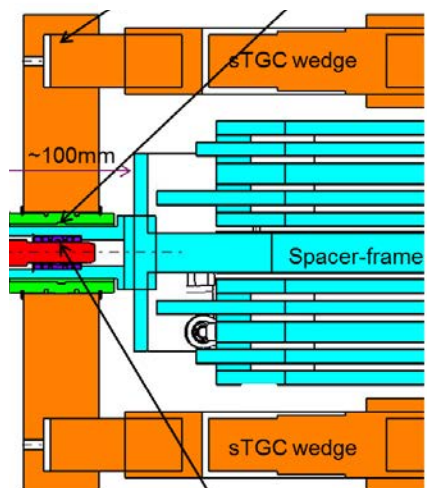
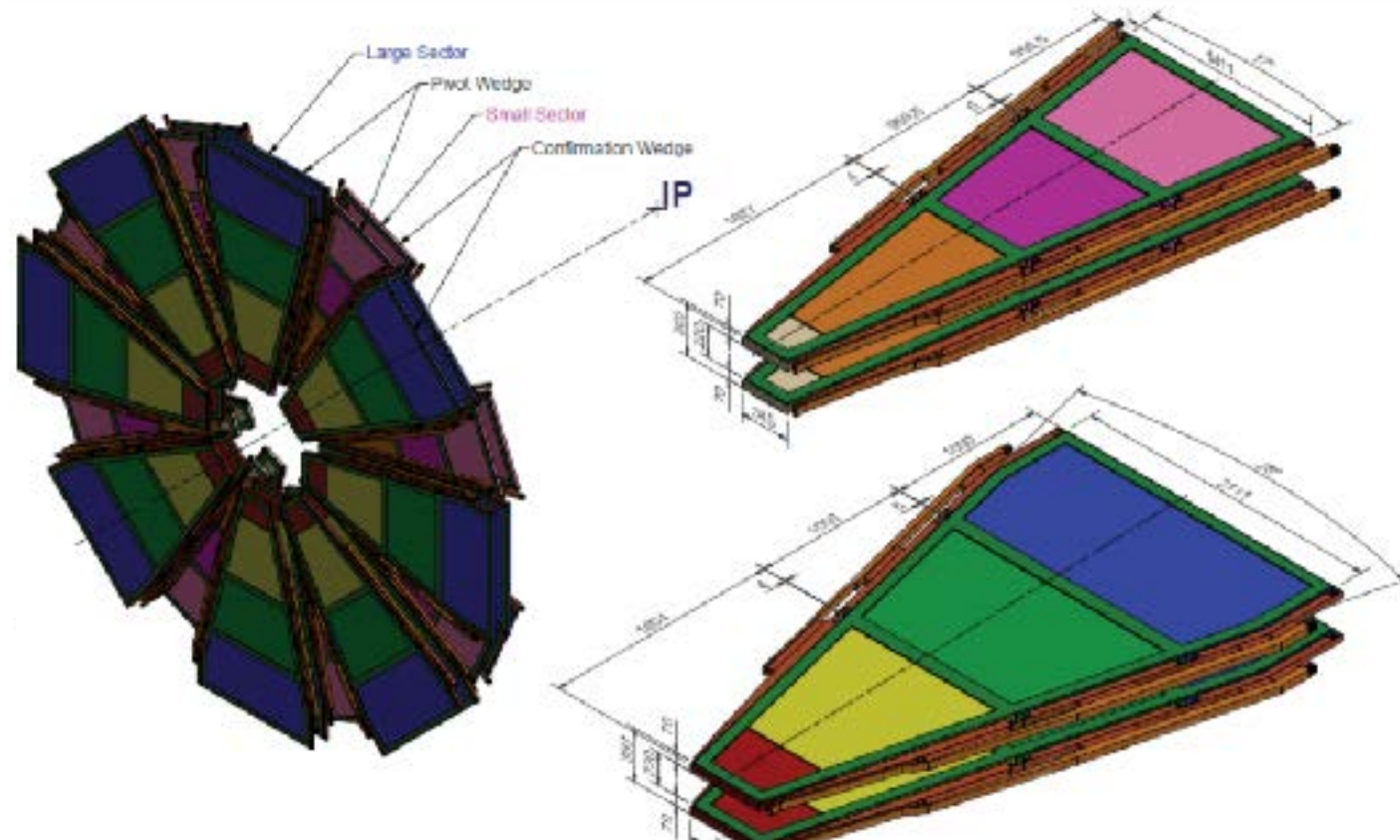


ATLAS Phase 1 Upgrade: Muons



NSW structure:

sTGC



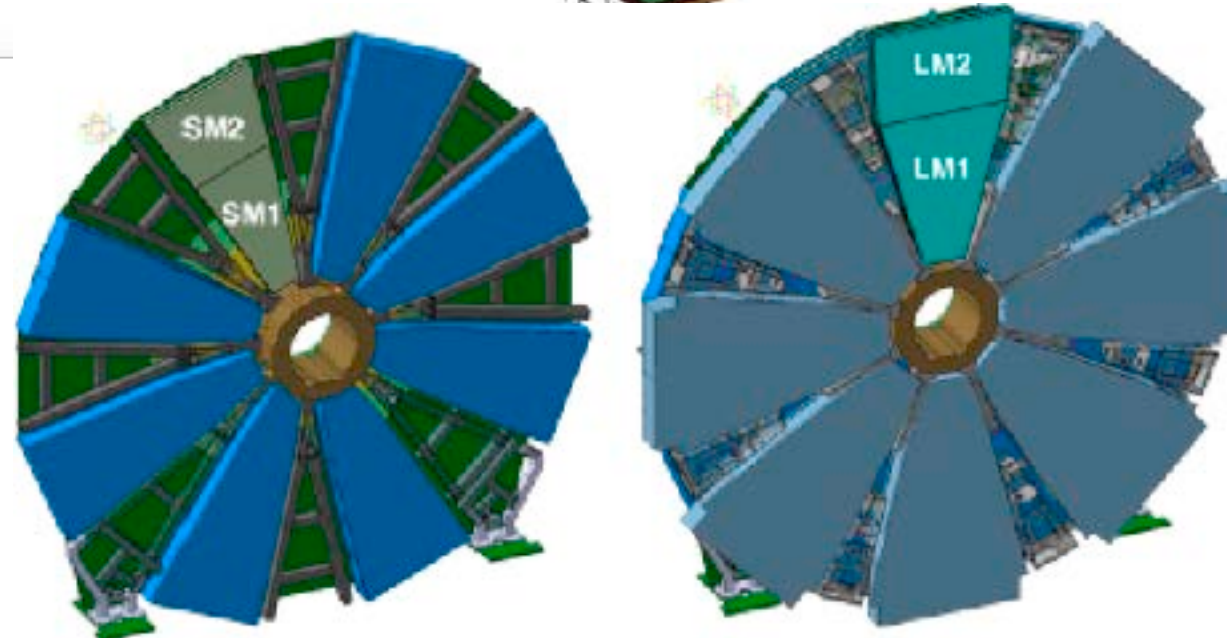
sTGC

Micromegas

Micromegas

sTGC

MM



„Small sector“, IP side

„Large sector“, HO side

ATLAS Phase 1 Upgrade: Muons



NSW Front End Electronics (on-detector):

$$\begin{aligned} \text{Micromegas: } & \underbrace{8 \text{ PCB} * 1024 \text{ channels}}_{\text{ca. 4m}} * 8 \text{ planes} \\ & * 16 \text{ sectors} * 2 \text{ wheels} \\ & = 2,097,152 \text{ readout channels à } 21 \text{ mW/channel} \\ & \Rightarrow \mathbf{50 \text{ kW}} \end{aligned}$$

- + Trigger cards + Concentrator cards \Rightarrow **58 kW**
- + inefficient LV conversion (65%!). \Rightarrow **89 kW** (*due to B-Field*)

sTGC (similar calculation):

40 kW

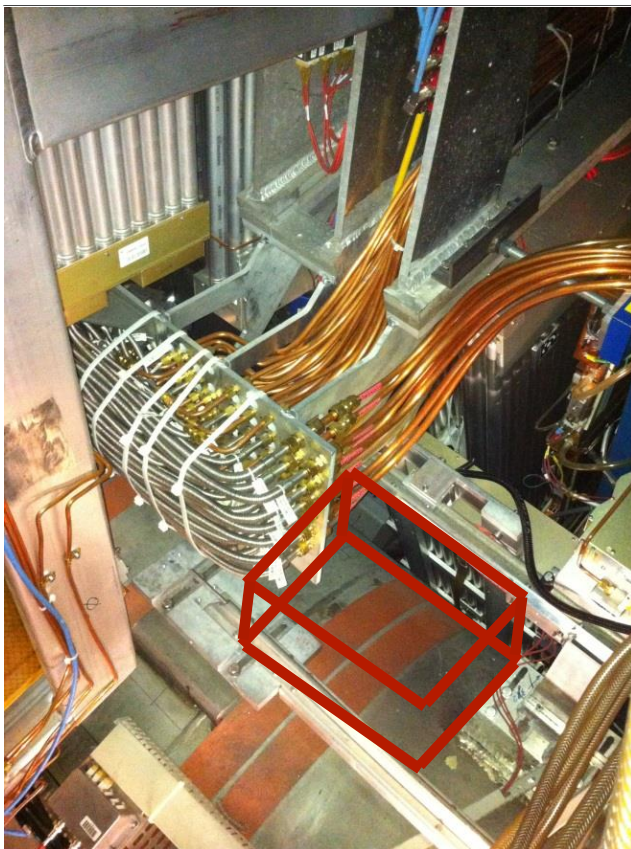
129 kW

\Rightarrow Need water cooling!

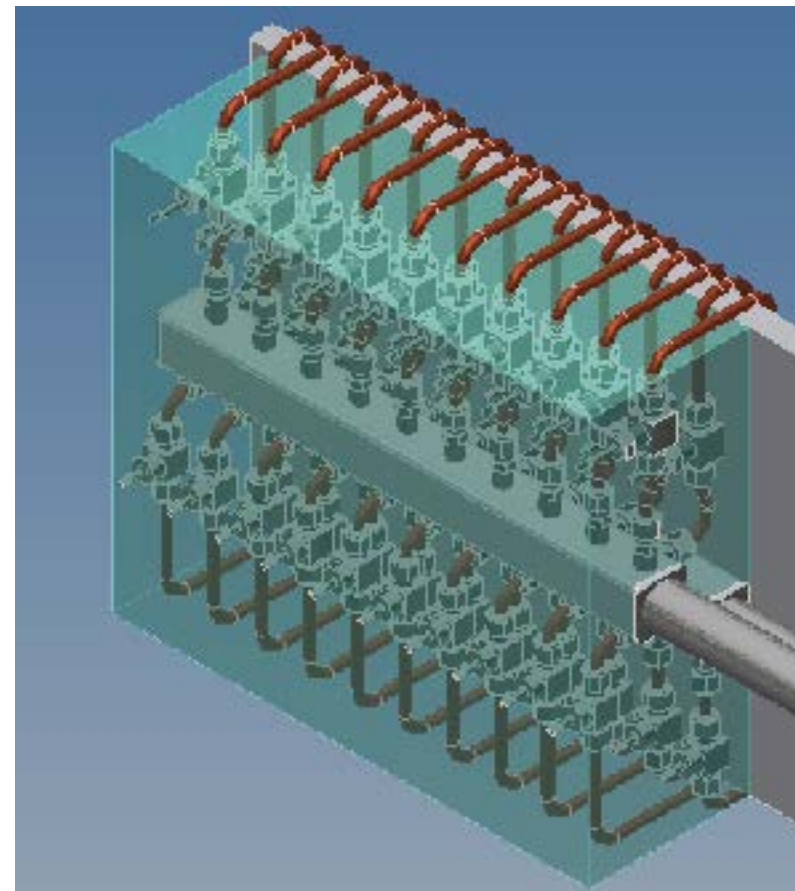
ATLAS Phase 1 Upgrade: Muons



- „Leakless cooling“ \Leftrightarrow underpressure cooling ($p < 1$ bar)
difficult with 10 m height (pressure loss with flow)
 - Very different tube lengths for each sector
 - Partly turbulent flow - nonlinear with pressure drop
- \Rightarrow need flow regulation for each sector!



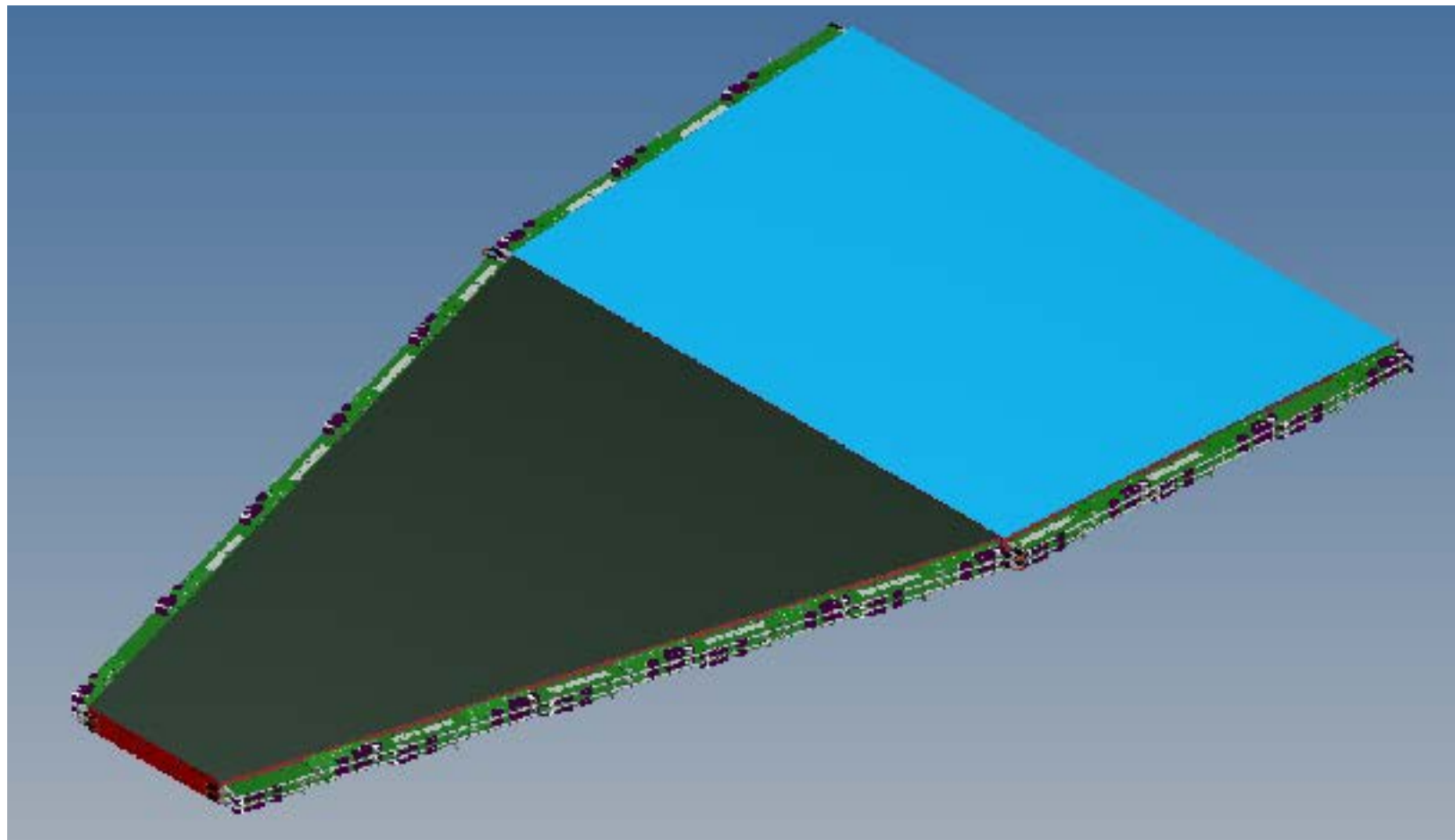
... in *very*
little space!



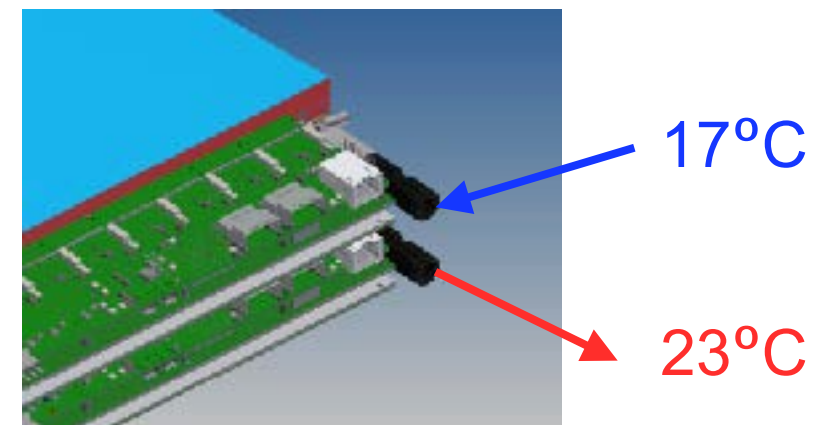
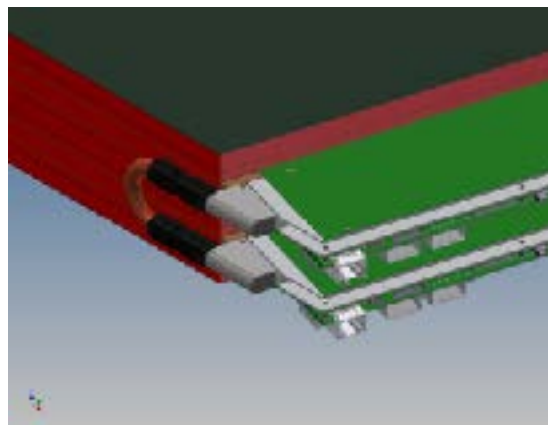
ATLAS Phase 1 Upgrade: Muons



Cooling channels on a Micromegas wedge



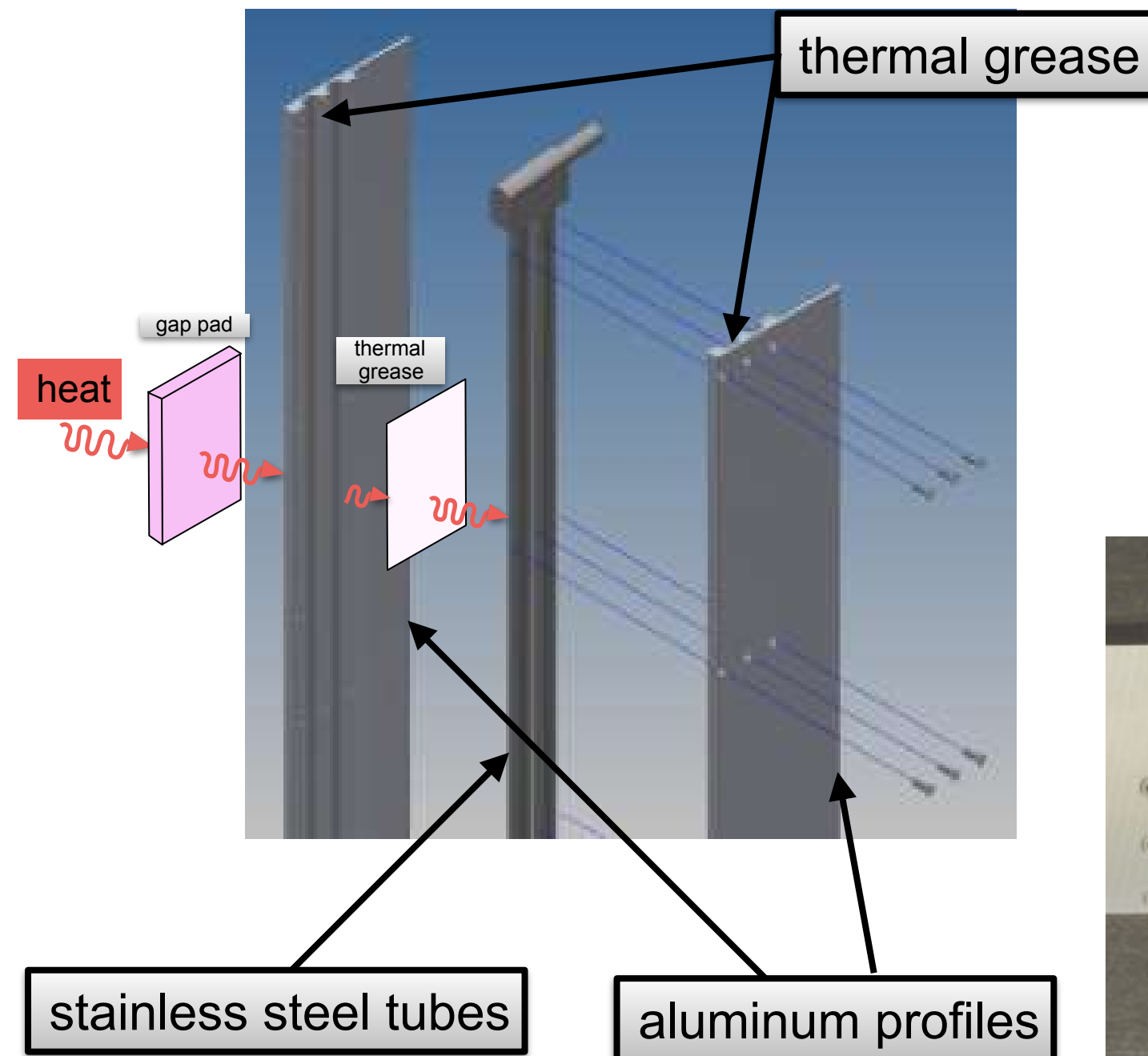
- integrated into each Micromegas chamber
- corrosion resistant
- precision part
(tolerance < 0.1 mm)
- has to support front end cards
- 1024 channels needed
- low weight required
 \Rightarrow no copper!



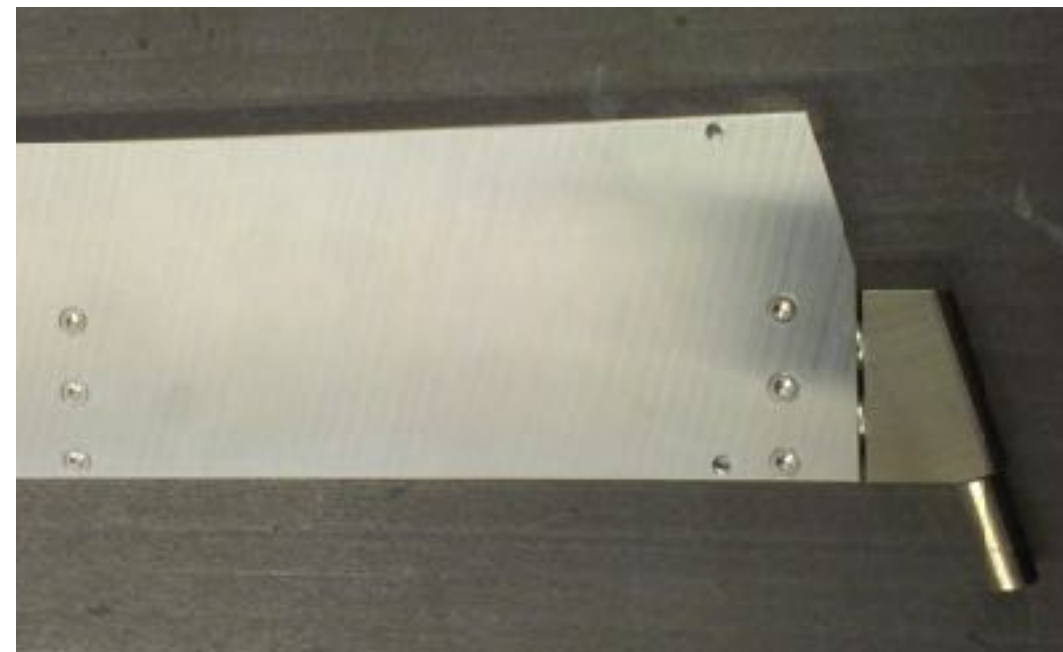
ATLAS Phase 1 Upgrade: Muons



Micromegas cooling channels

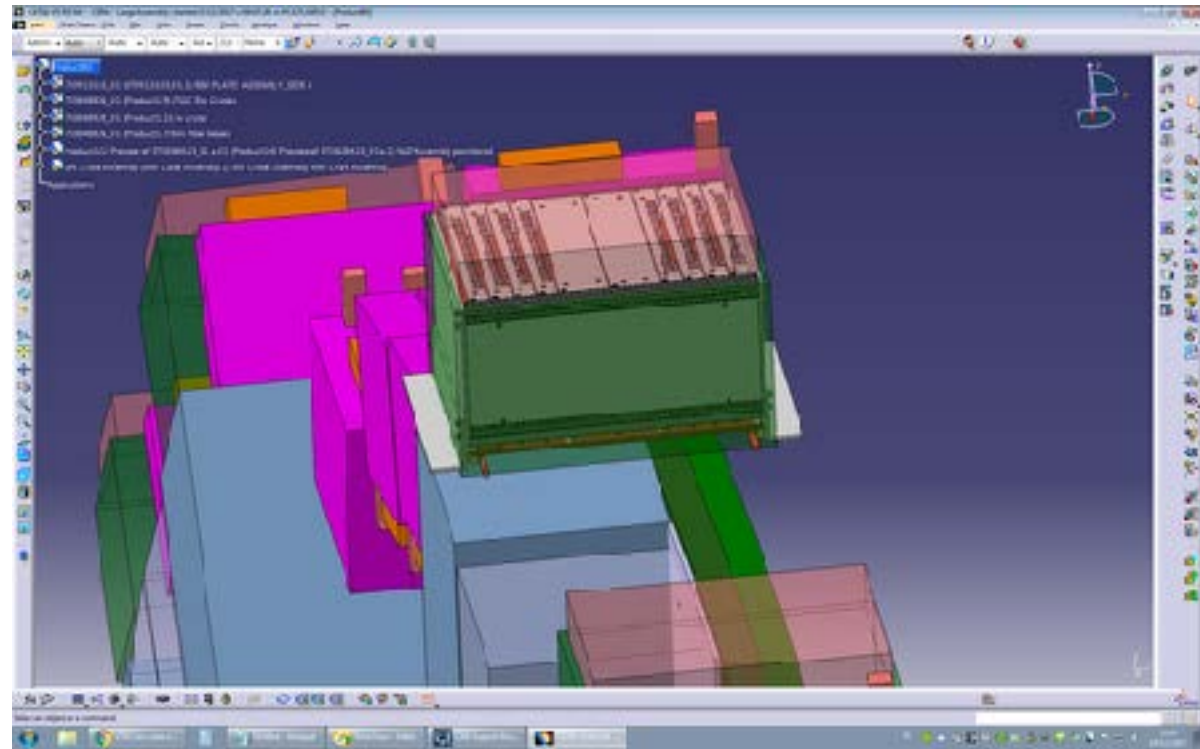
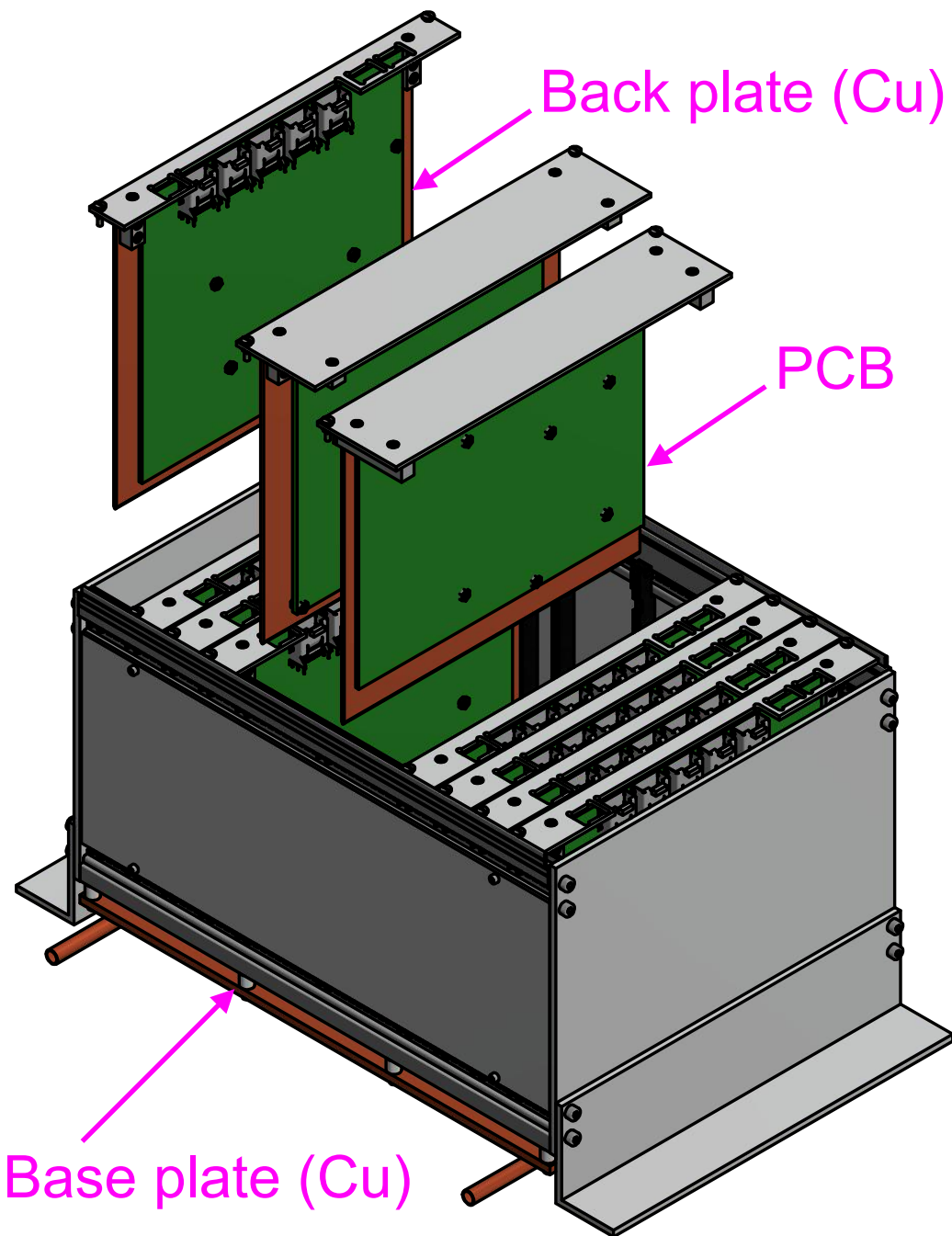


- ▶ water flows through stainless steel tubes
- ▶ soldered stainless steel end pieces
- ▶ heat transfer to aluminum profiles by thermal grease
- ▶ heat transfer from profiles to electronics via gap pads



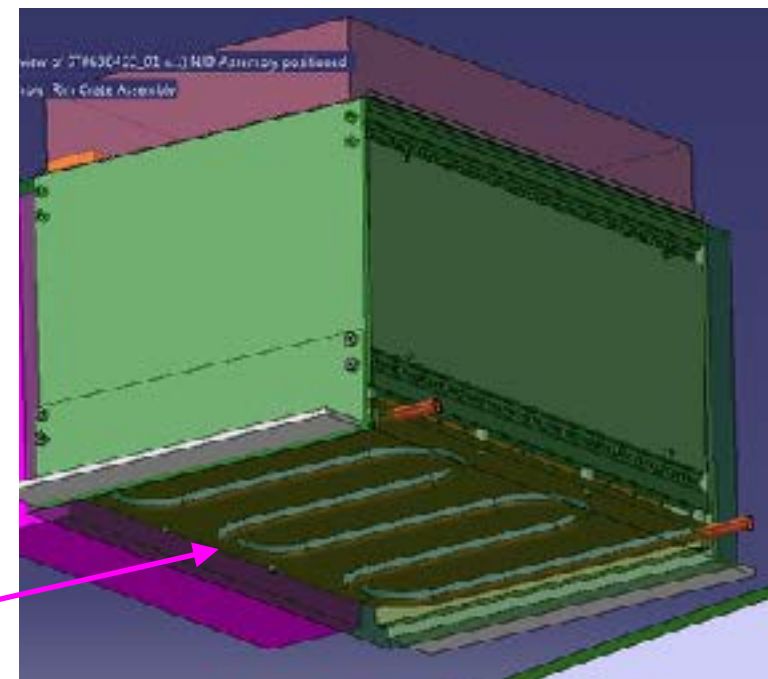
ATLAS Phase 1 Upgrade: Muons

sTGC Rim Electronics crate:



1 crate/sector
16 crates/wheel

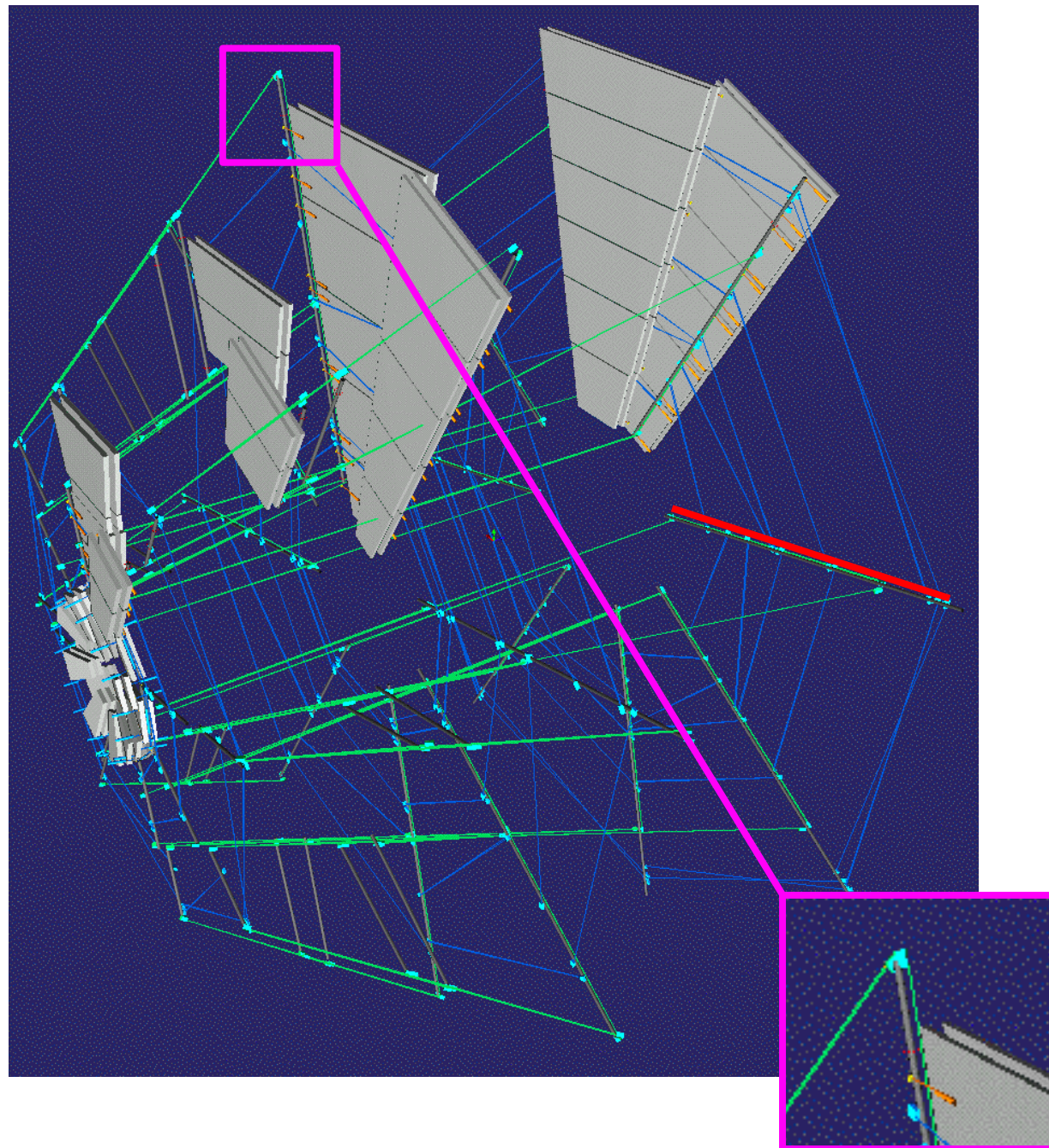
Cooling pipe



ATLAS Phase 1 Upgrade: Muons



End Cap Alignment System:



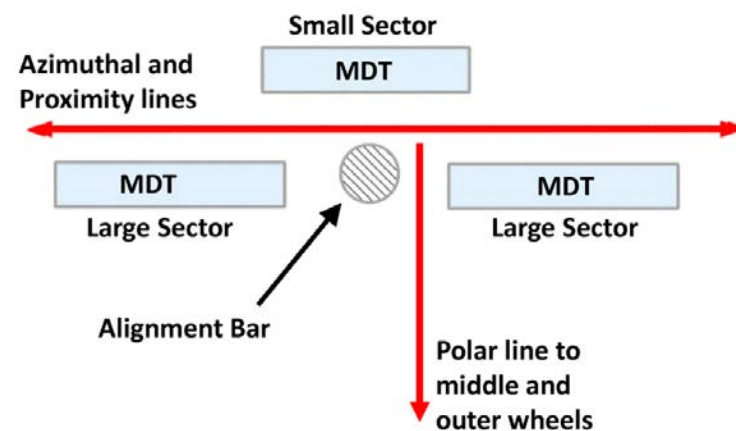
- Monitoring of relative muon chamber positions to 50 μm over distances up to 14 m
- Calibrated CCD cameras (BCAMs) look at point like light sources determining the angular direction of the sources
- BCAMs sit on precisely measured positions on alignment bars pointing in precisely measured directions
- Deformations of alignment bars are monitored and taken into account
- Bars connected by a grid of **azimuthal** and **polar** lines
- Chamber positions monitored by short **proximity** lines

ATLAS Phase 1 Upgrade: Muons

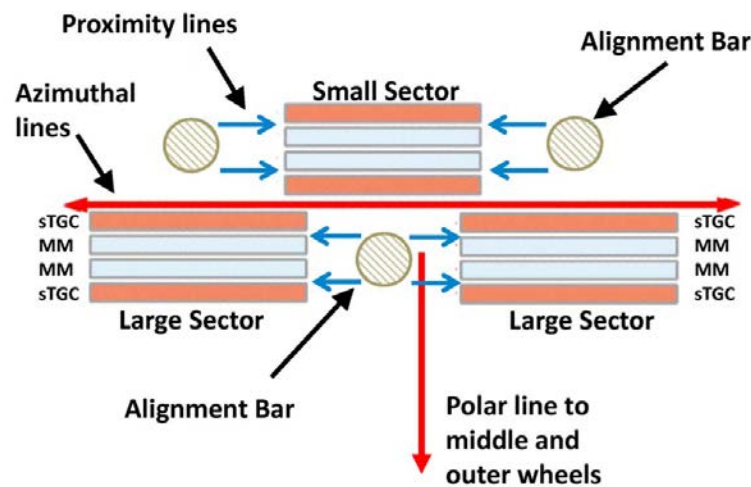


End Cap Alignment System:

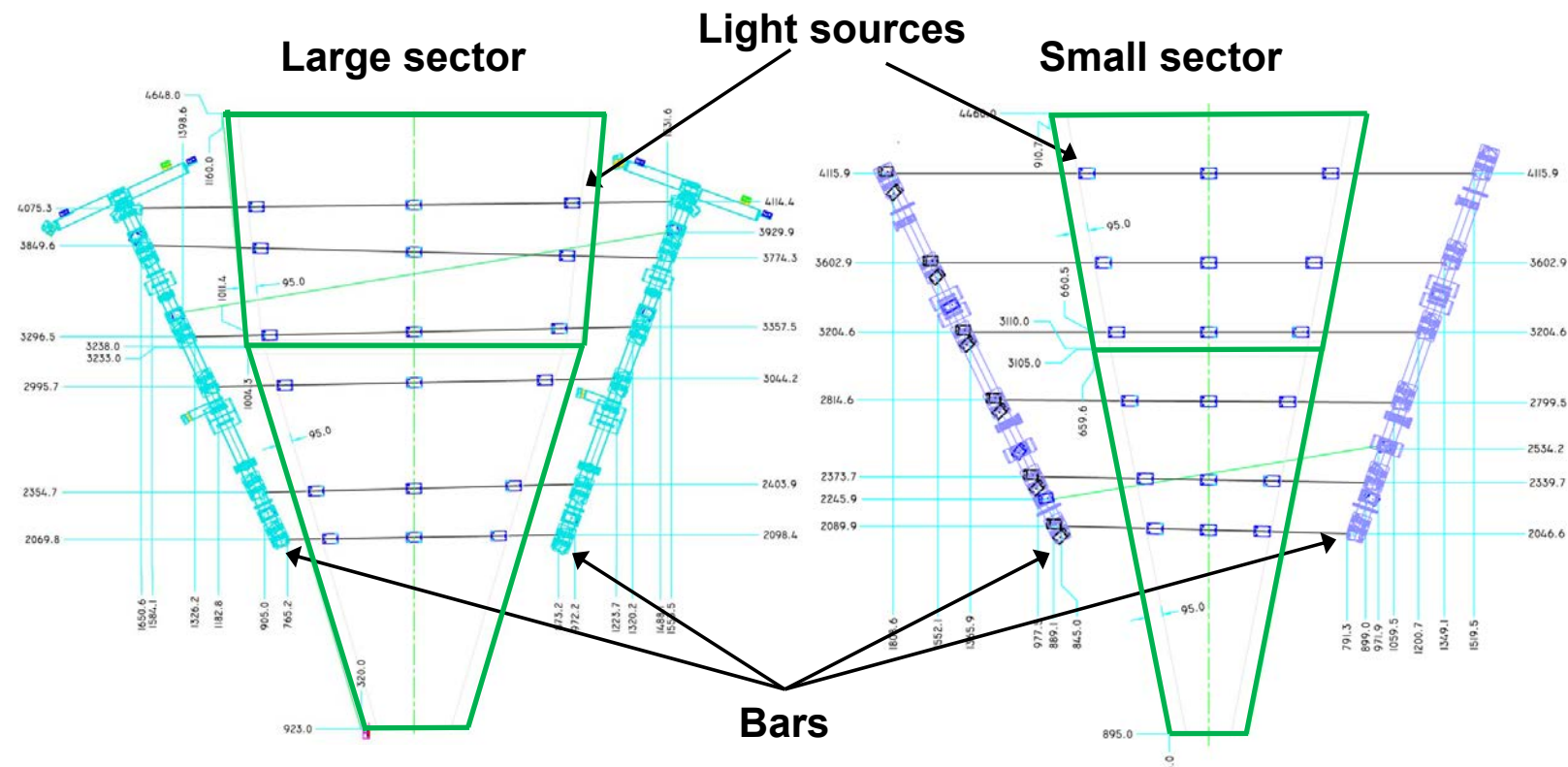
Present layout



nSW layout



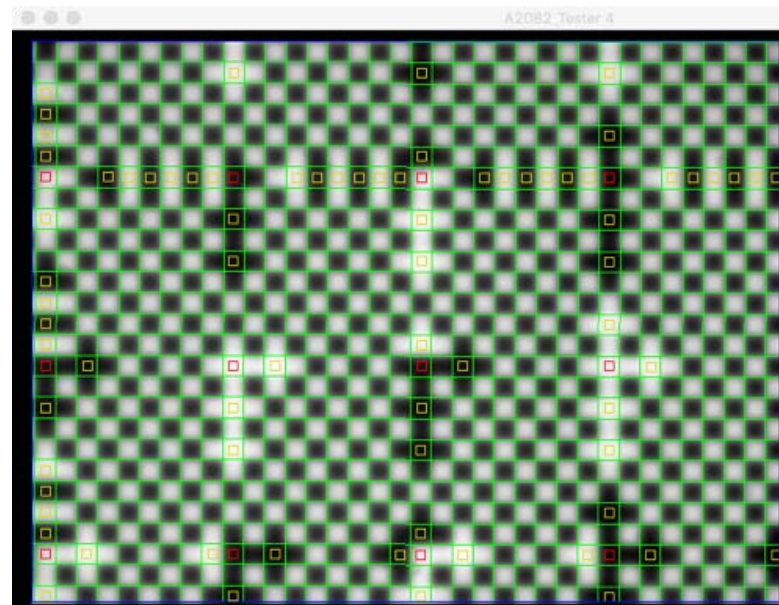
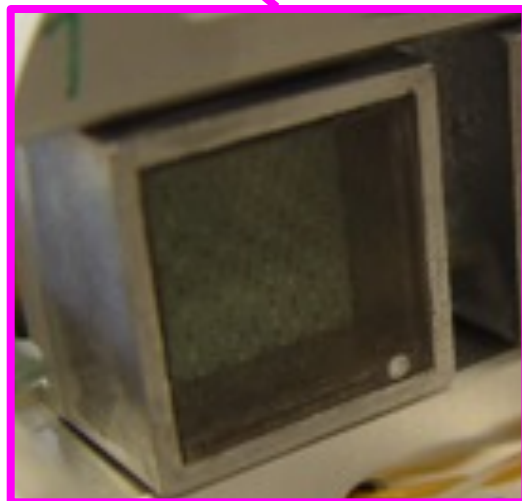
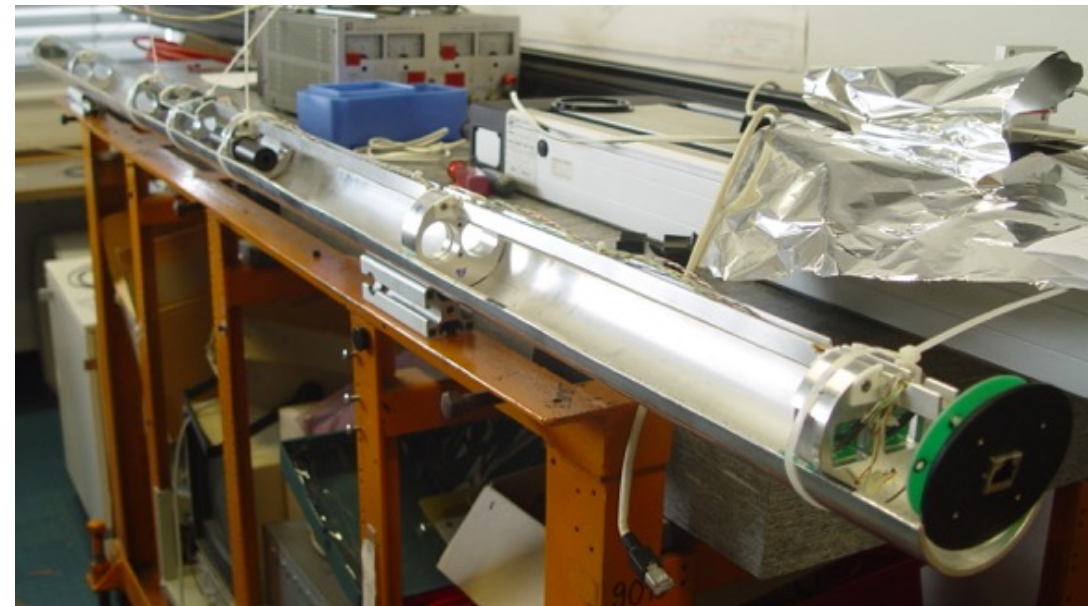
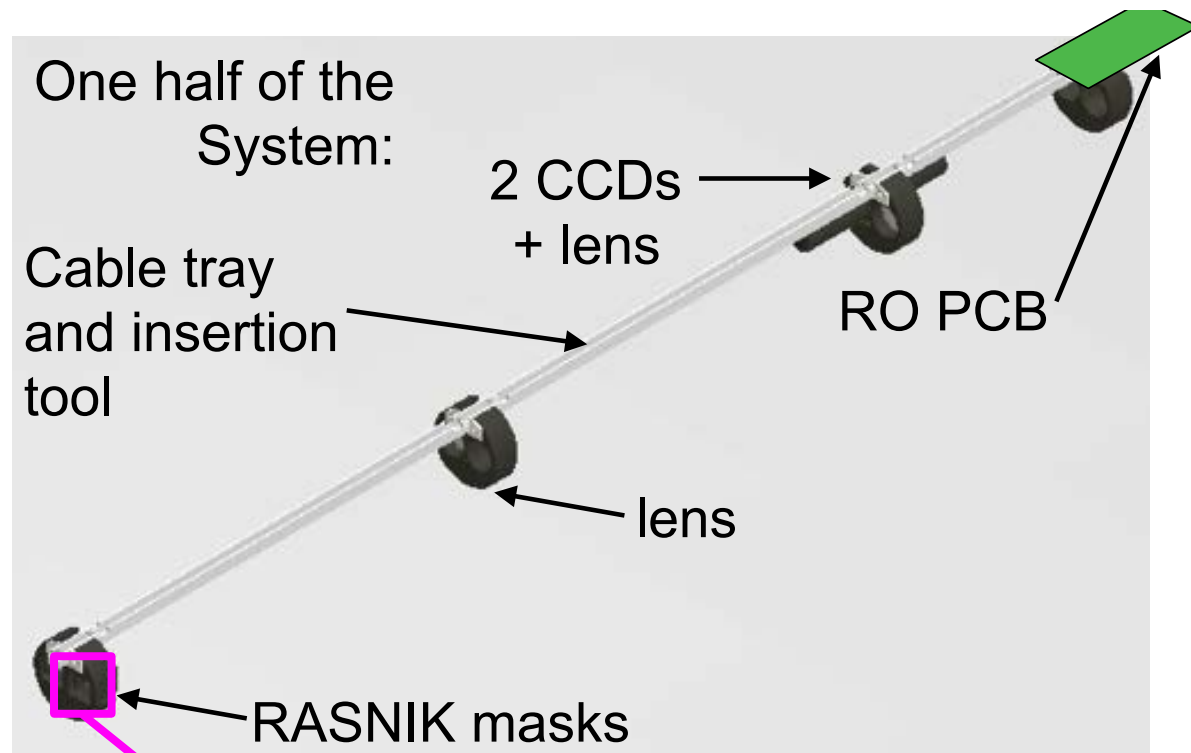
- 16 bars/wheel needed
- Four bar types (LA,SA) (LC,SC)
- Bars monitor also chamber deformations



ATLAS Phase 1 Upgrade: Muons



Monitoring bar deformations:



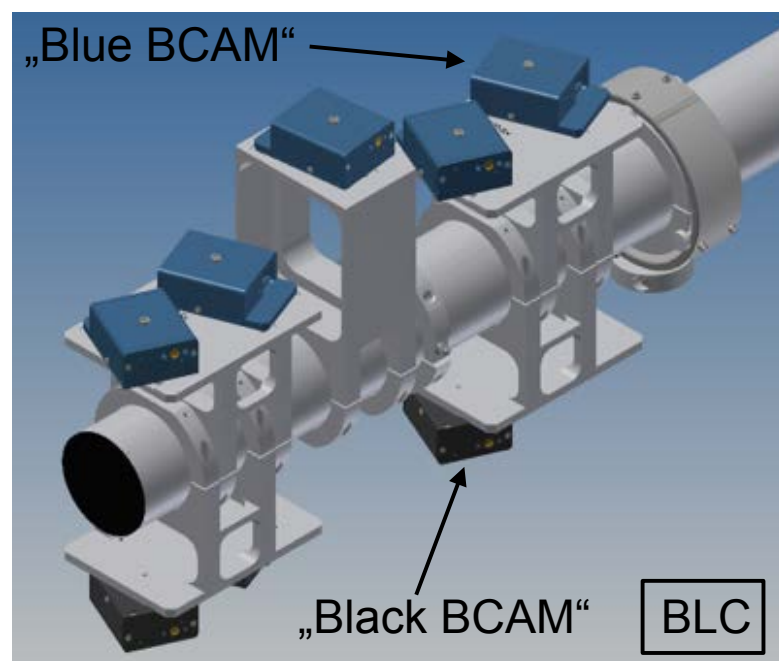
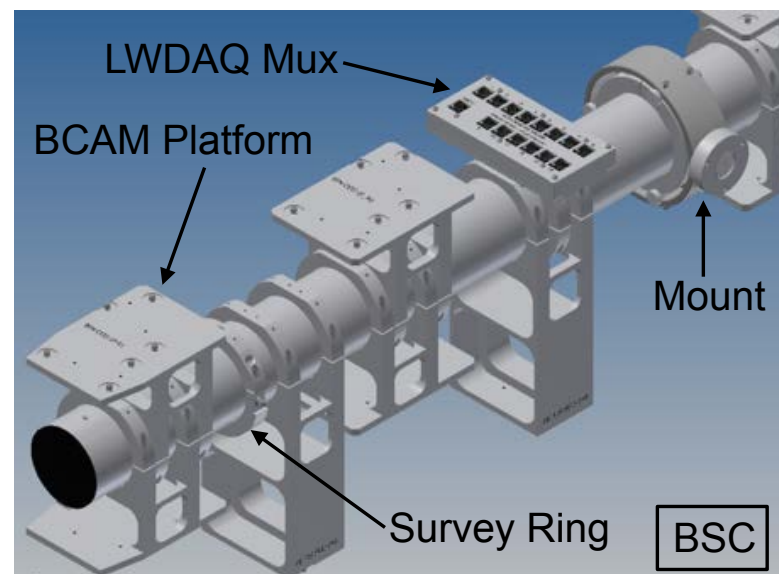
- Monitoring of bar deformations by 4 systems looking at encoded chess patterns
- Monitor position (x,y) to 0.1 μm and rotation angles

ATLAS Phase 1 Upgrade: Muons



Our tasks:

- Production of all alignment platforms



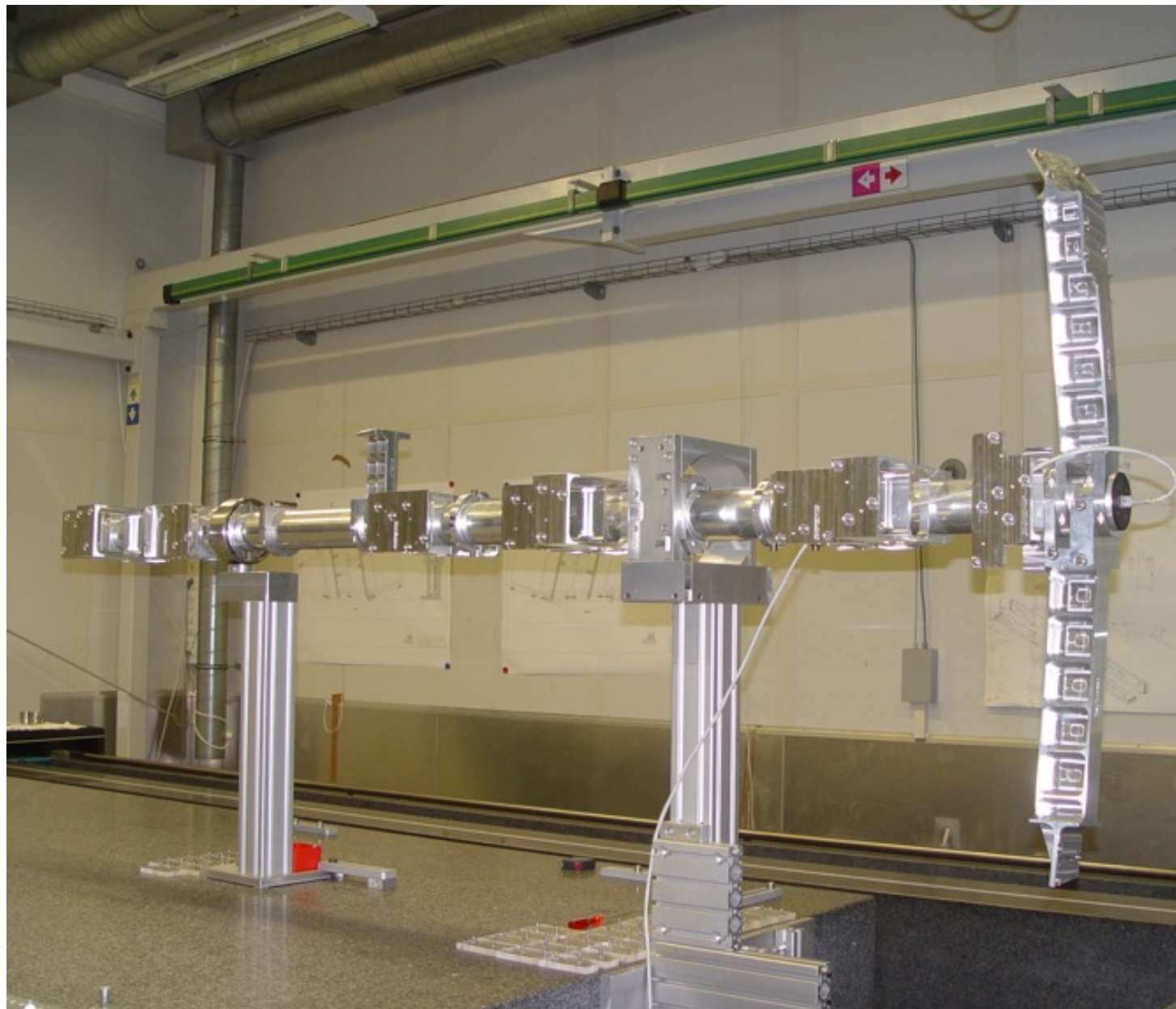
4 cup boards
of platforms!

ATLAS Phase 1 Upgrade: Muons



Our tasks:

- Precise assembly of bars



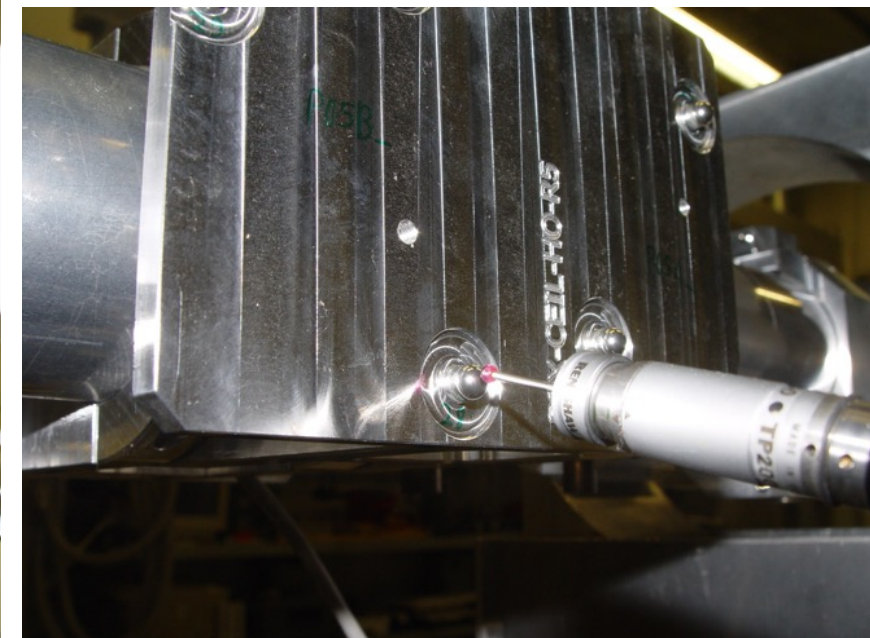
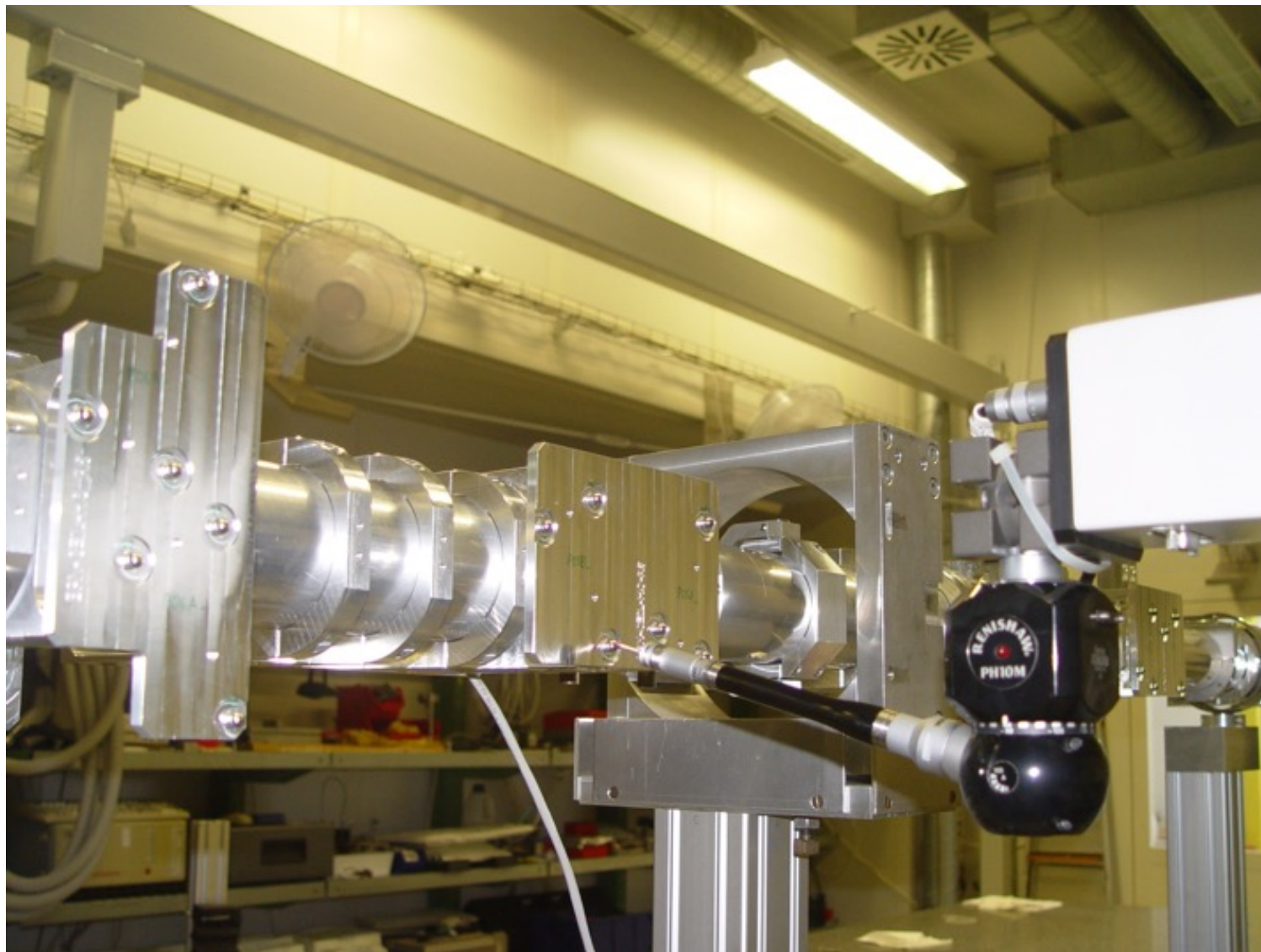
Cabling for the readout of BCAMS still missing here!

ATLAS Phase 1 Upgrade: Muons



Our tasks:

- Measurement of 3-sphere mounts for all BCAMS on our large CMM (6.5m x 1.4 m x 1.2 m; precision < 30 μ m)



ATLAS Phase 1 Upgrade: Muons



Our tasks:

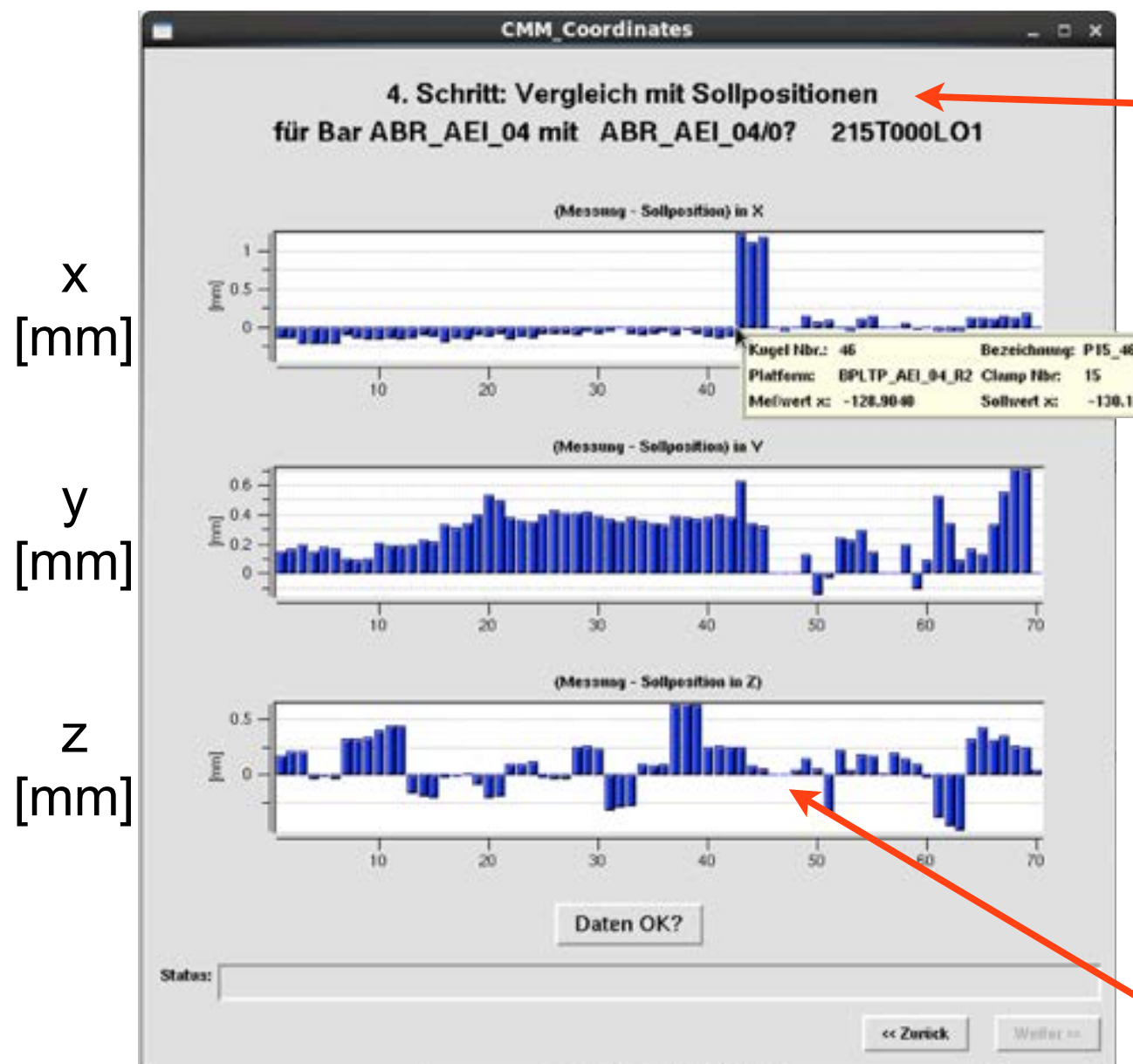
- 4 measurements for each bar
0°, 180°, with symmetrical load, with asymmetrical load
- Correlate RASNIK readings with measurements to be able to correct BCAM positions for bar deformations
- Correlate in-bar temperature sensors with bar distances to be able to correct for bar elongation in ATLAS (elongation of aluminum 23,1 $\mu\text{m/mK}$ well known)

ATLAS Phase 1 Upgrade: Muons



Our tasks:

- Quality control during bar measurement



Here e.g. comparison of measured sphere positions with nominal positions

ATLAS Phase 1 Upgrade: Muons



Micromegas Operation:

- Due to mechanical tolerances different parts of Micromegas will need different voltages to compensate $V = E \cdot d$; (gain grows exponentially with electric field)
- Operation of Micromegas at very small overpressure (some millibar) means gain variations with change of atmospheric pressure and ambient temperature (mean free path varies with density)
- Humidity of gas mixture influences drift velocity. FR4 material of Micromegas takes up/releases humidity on time scales of weeks.

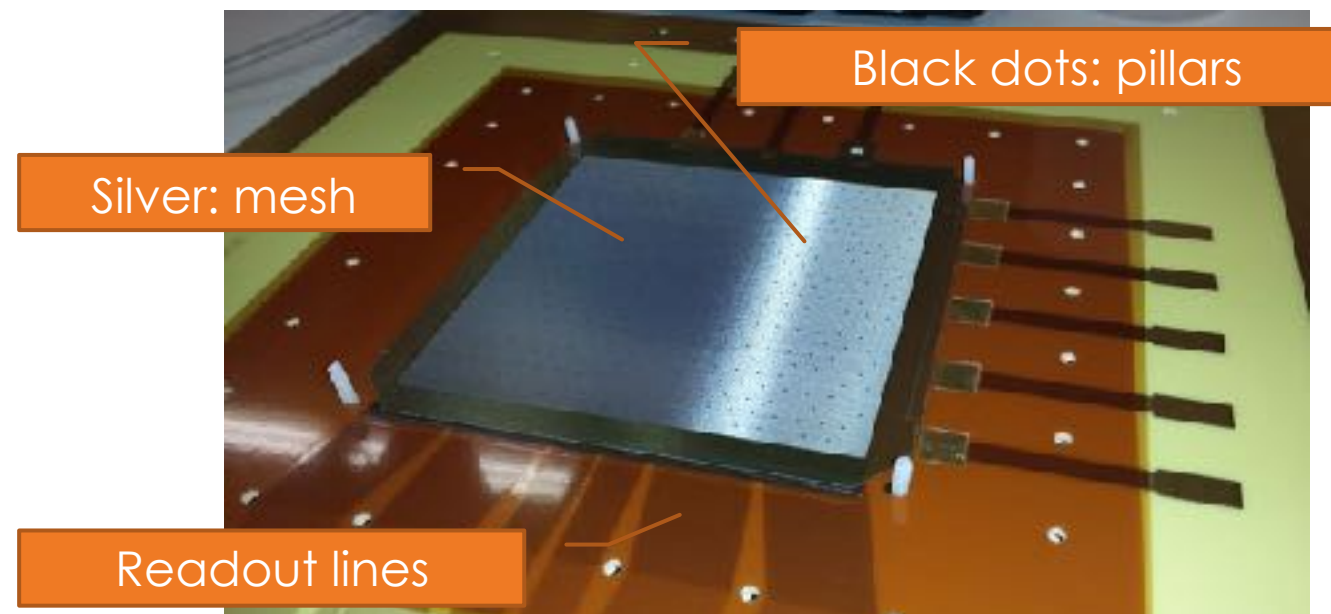
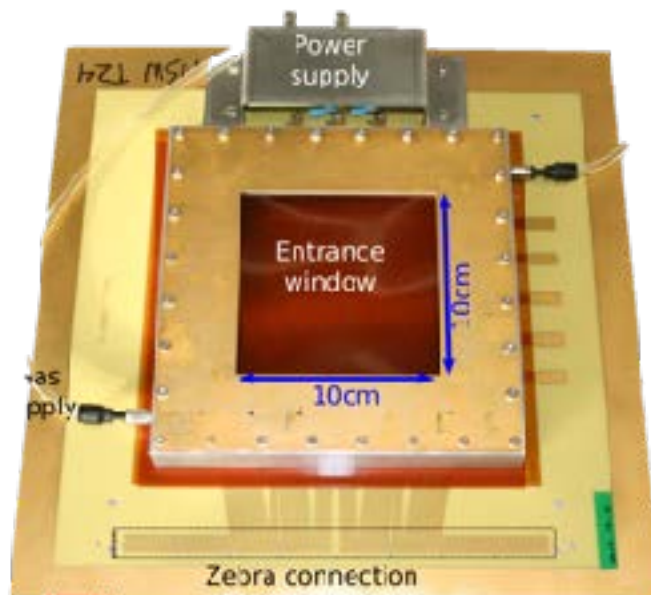
⇒ studies of operation conditions needed!

ATLAS Phase 1 Upgrade: Muons



Micromegas Operation:

Thorwald Klapdor-Kleingrothaus uses small (10cm x 10cm) Micromegas to study and optimize the operation parameters under controlled conditions of pressure, temperature and humidity:

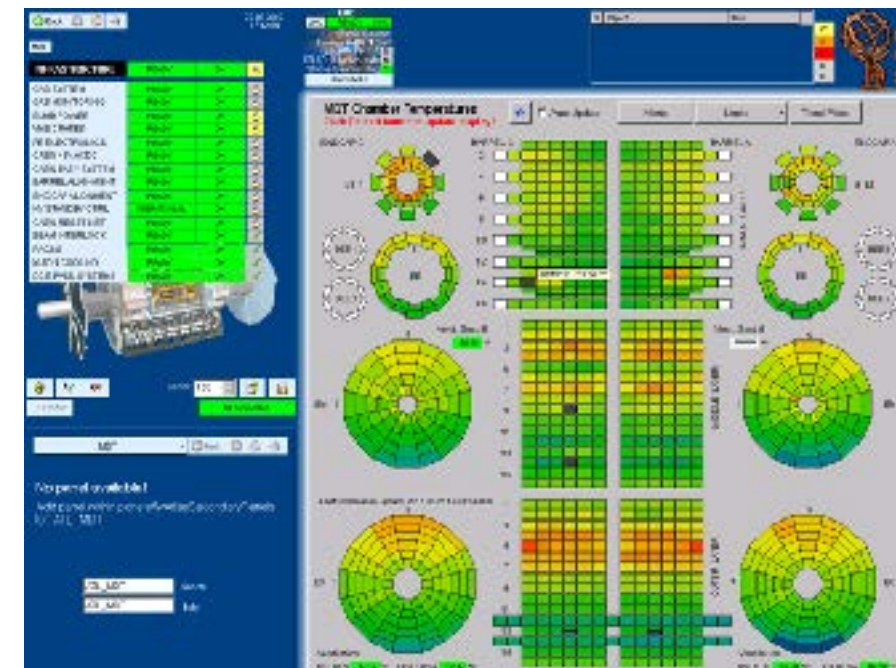


ATLAS Phase 1 Upgrade: Muons

Our tasks:

- Study operation conditions
- Test setup for new (and recycled) special HV supplies produced by CAEN which can be operated in magnetic fields
- Integrate HV operation of NSW (for Micromegas and sTGC) into ATLAS operation panels.

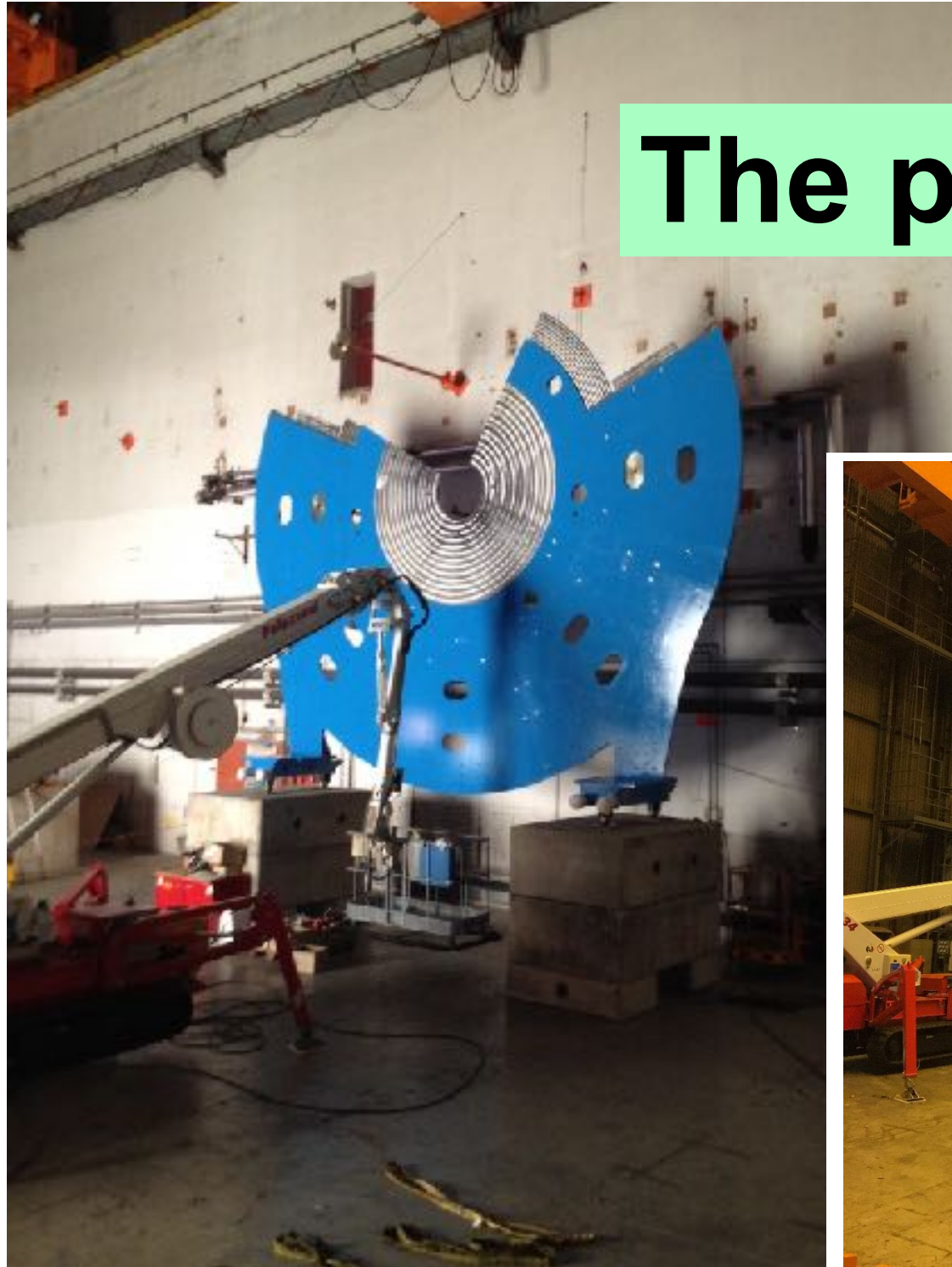
50 Modules à 32 channels
= 1600 HV channels



ATLAS Phase 1 Upgrade: Muons



The project has started!



ATLAS Phase 1 Upgrade: Muons



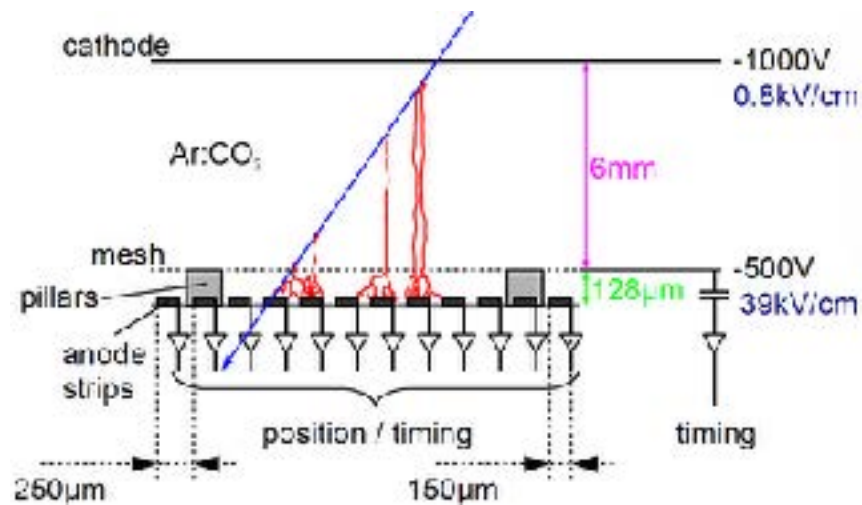
UNI
FREIBURG

Thank you!

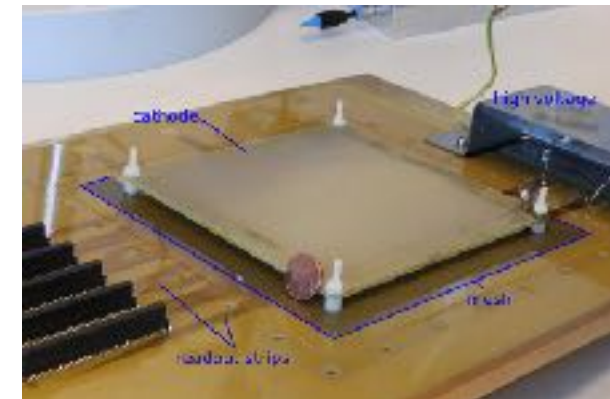
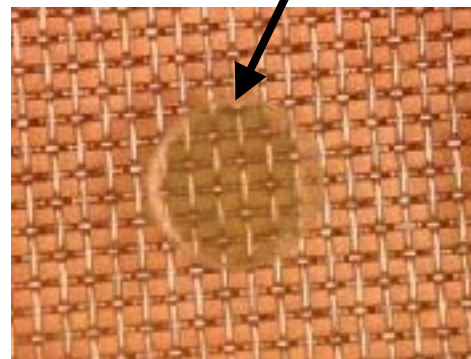
ATLAS Phase 1 Upgrade: Muons



Micro-Mesh-Gas-Chambers:



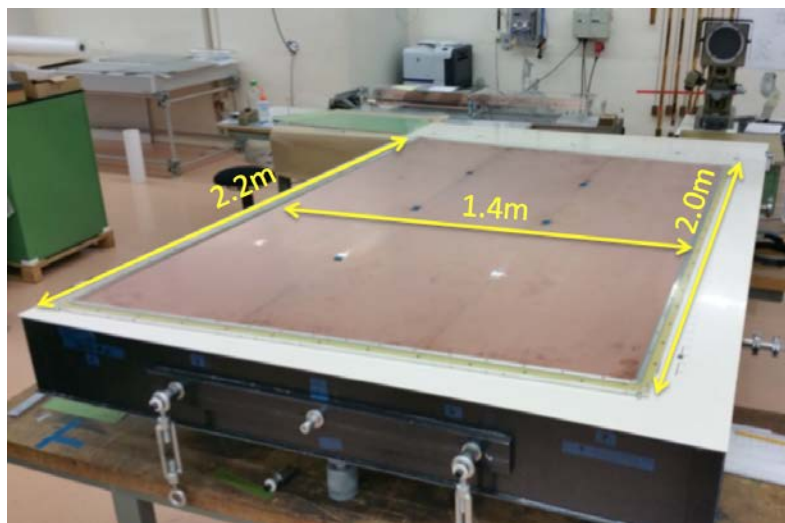
Pillar



- In ATLAS:
- size up to 3 m²
 - planarity < 80µm
 - precision < 40µm

Construction sites: France, Germany, Greece, Italy, Russia

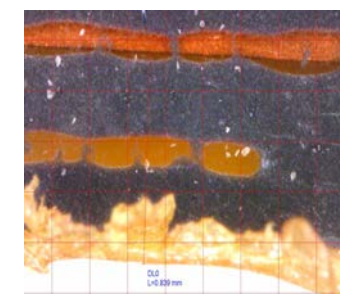
Initial problems with PCB quality from industry **solved:**



bubbles



bad strip repairs



bad cutting

ATLAS Phase 1 Upgrade: Muons



sTGC = small Thin Gap Chambers:

small strip width
- not small chamber!

- mature technology
- same sizes
- similar accuracy requirements

Construction sites:

Canada, Chile,
China, Israel

