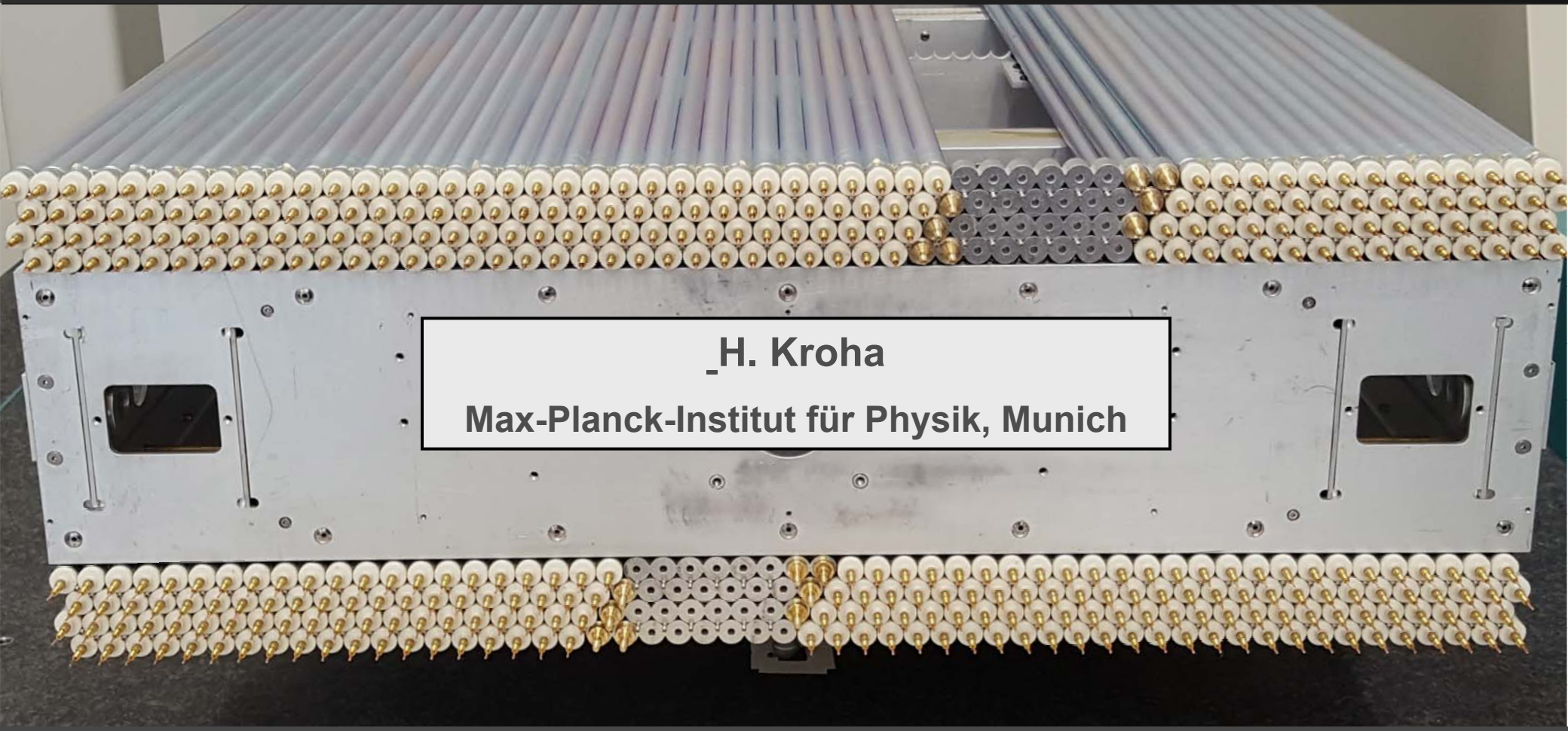
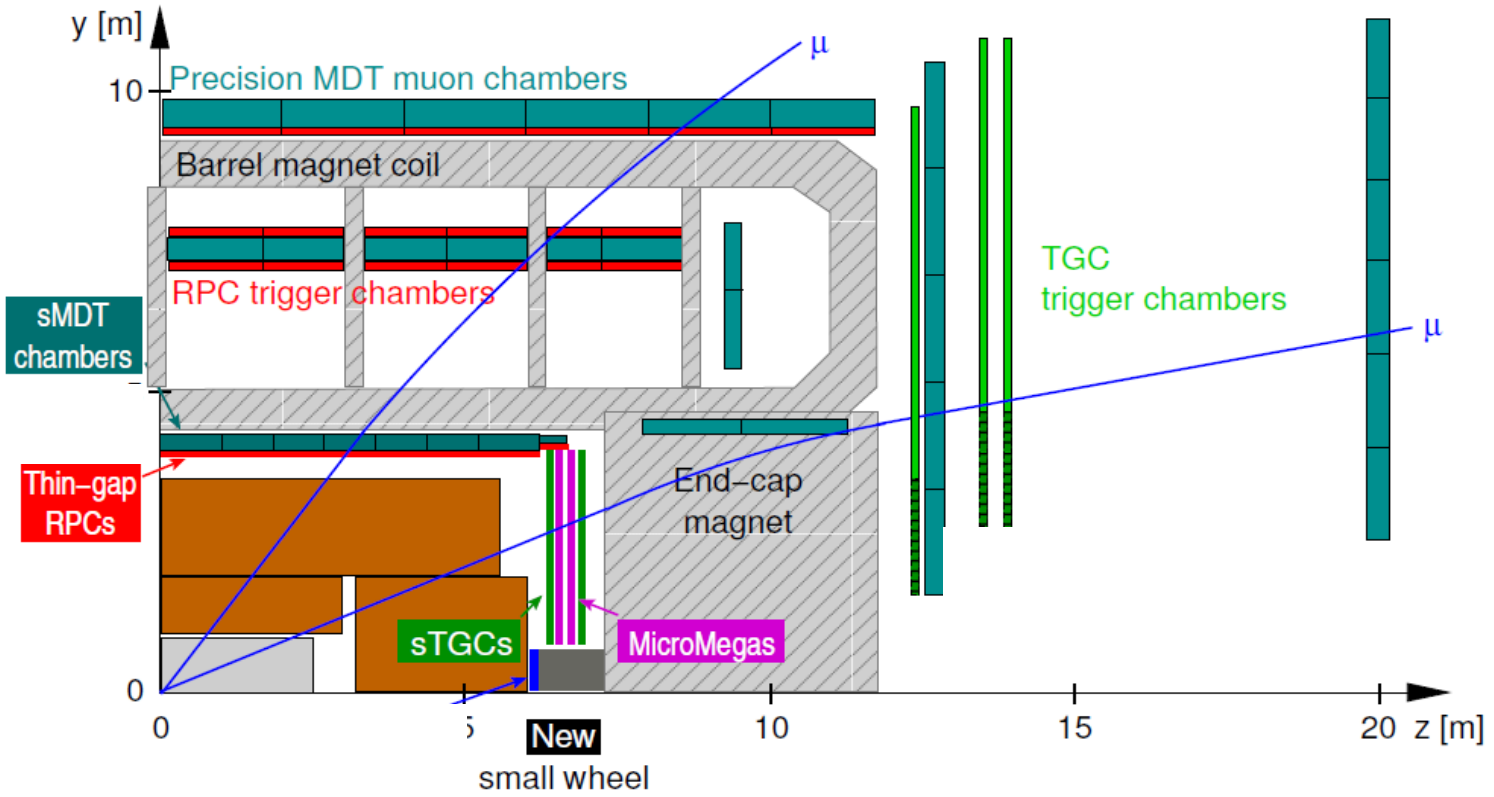
Status of sMDT Chambers for ATLAS



H. Kroha

Max-Planck-Institut für Physik, Munich

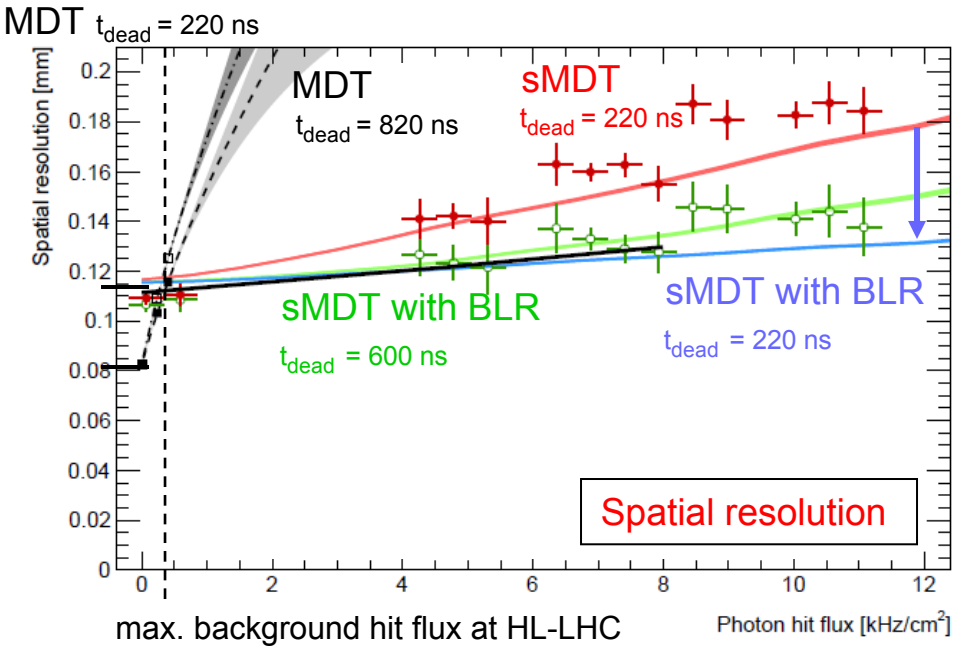
ATLAS Muon Trigger Upgrades for HL-LHC

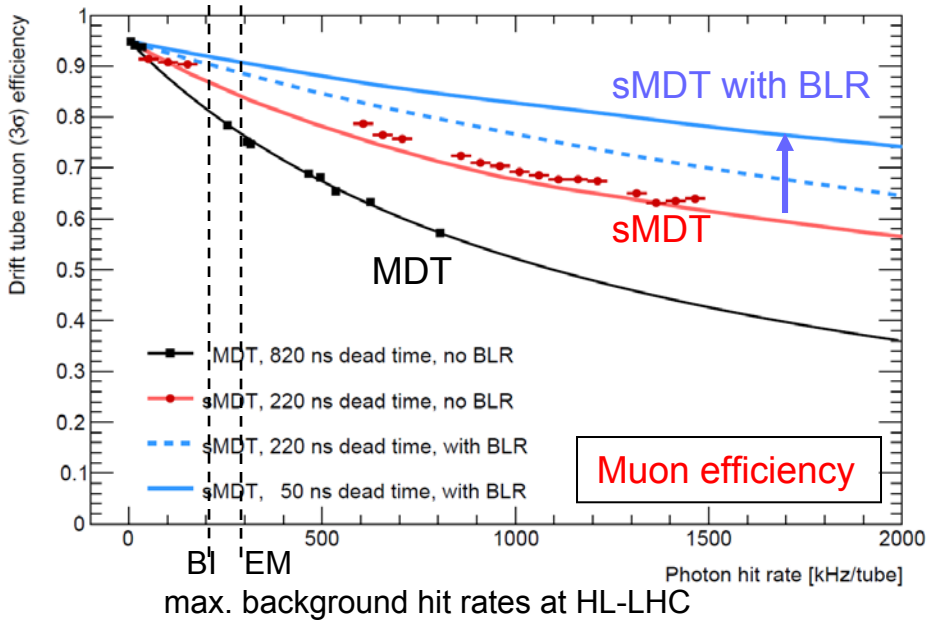


- New inner endcap layer (small wheel) with high-resolution sTGC trigger chambers to reject fake muon triggers and improve momentum resolution at trigger level.
- New thin-gap RPCs to close acceptance gaps of the barrel muon trigger.
- Use of the Monitored Drift-Tube (MDT) precision tracking chambers in the 1st level muon trigger to improve the momentum resolution to the maximum level.
- New MDT on- and off-chamber electronics for new read-out and trigger architecture.

Rate Capability of sMDT vs MDT Drift Tubes

Measurements at the CERN Gamma Irradiation Facility (GIF) with 0.5 TBq ^{137}Cs source and cosmic muons using standard MDT readout electronics (bipolar shaping, 220 ns mininium adjustable deadtime, Wilkinson ADC for time slewing corrections applied here):

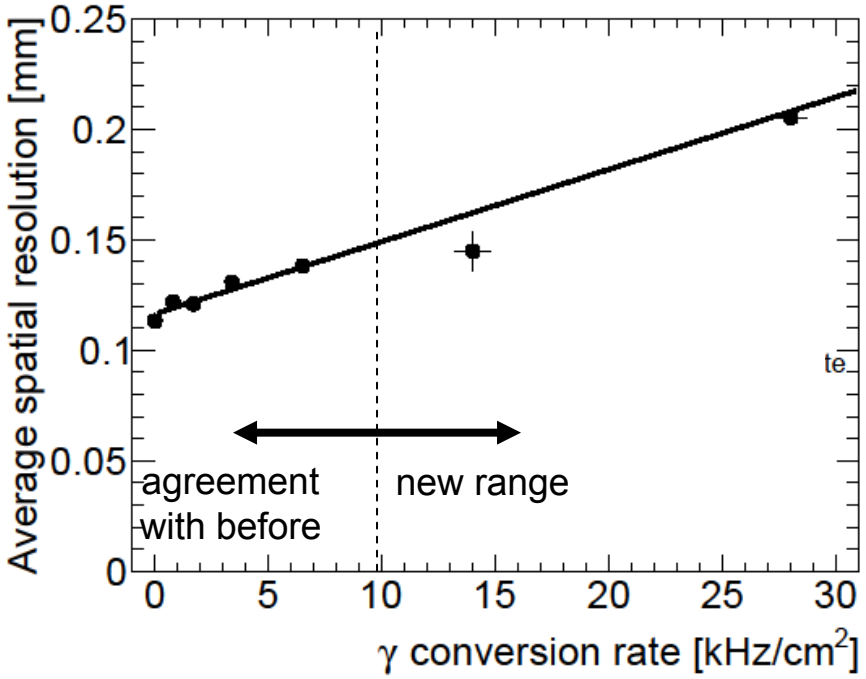


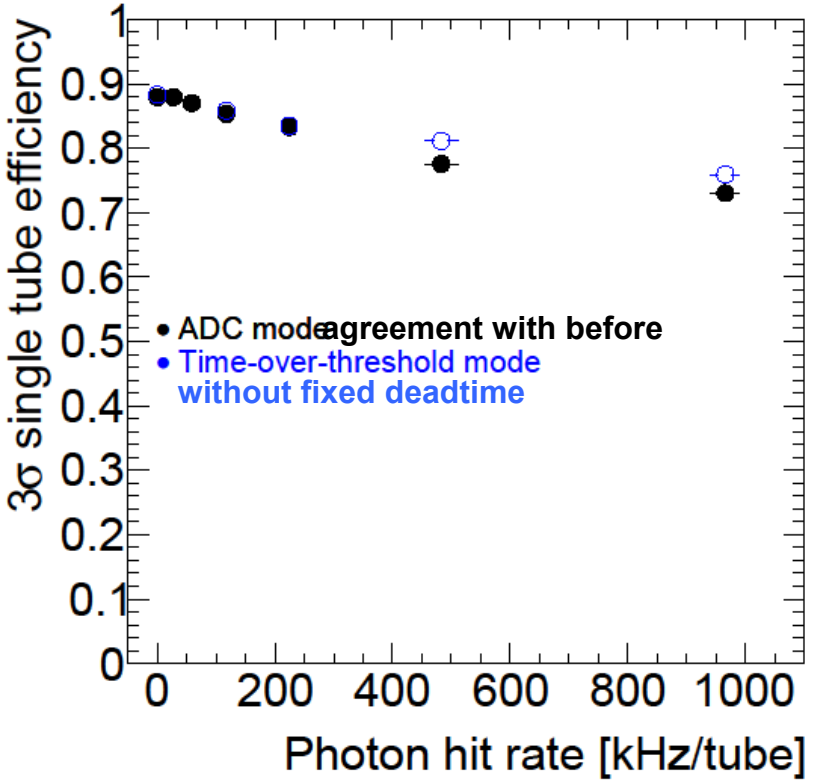


Active baseline restoration (BLR) in FE chip desirable for very high background counting rates, e.g. at FCC-hh. Not needed for ATLAS at HL-LHC.

Rate Capability of sMDT Drift Tubes

Update from 2016 measurements in GIF++ with 14 Tbq 137Cs γ source and high-energy muon beam with new stacked boards:





ATLAS Muon Chamber Upgrades

LHC / HL-LHC Plan

2014 (LS1):
2 sMDT + 4 RPC chambers
to improve acceptance and momentum resolution (by factor 2 – 4 at 1 TeV) in the bottom barrel sector.
Pilot project for phase 1.
In operation since Run 2.

Jan.– Mar. 2017:
12 sMDT chambers
to improve the momentum resolution (by factor of 2 at 1 TeV) in the regions of the detector feet.

4500 drift tubes.
1.1 m x 0.9 m.

2019/20 (LS2):
16 sMDT + 16 RPC chambers
to improve the trigger selectivity and the rate capability in the barrel inner layer.
Pilot project for phase 2.

9600 drift tubes.
1.7 m x 1.4 m.

2024-26 (LS3):
96 sMDT + 276 RPC chambers
for the barrel inner layer
to increase the robustness of the barrel muon trigger system.

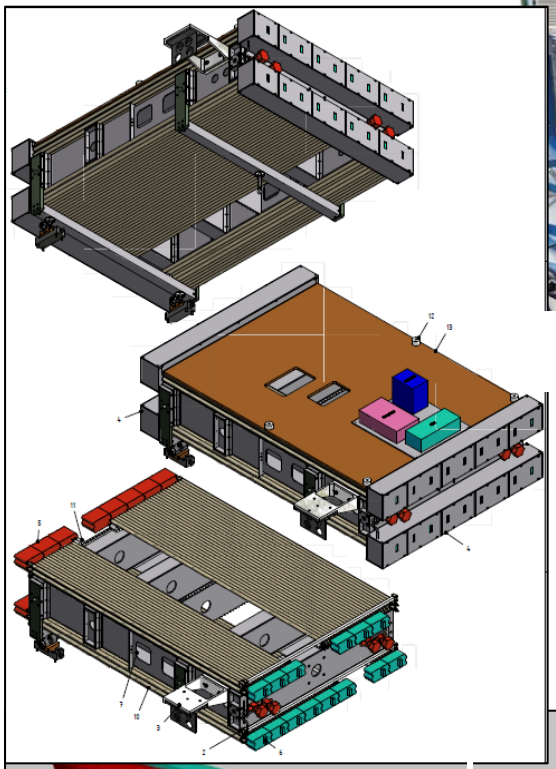
48000 drift tubes.

→

New MDT on-chamber electronics

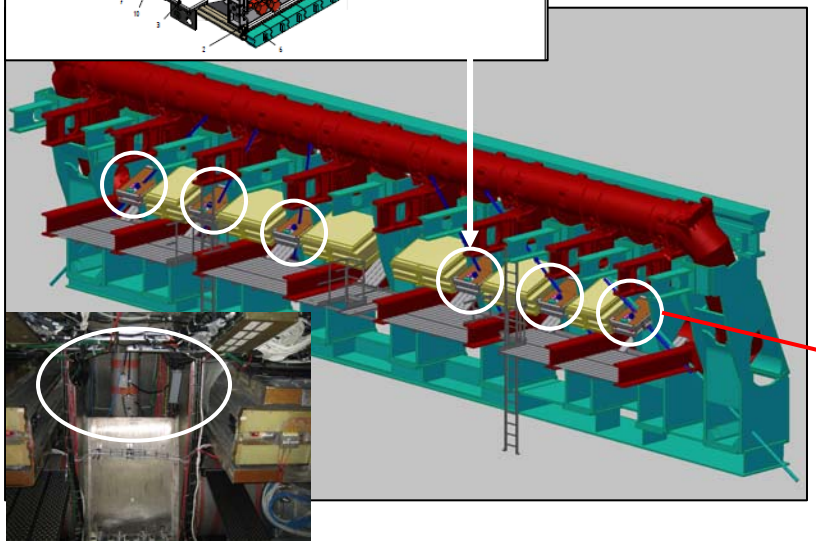
with triggerless RO for MDT based L0 μ trigger

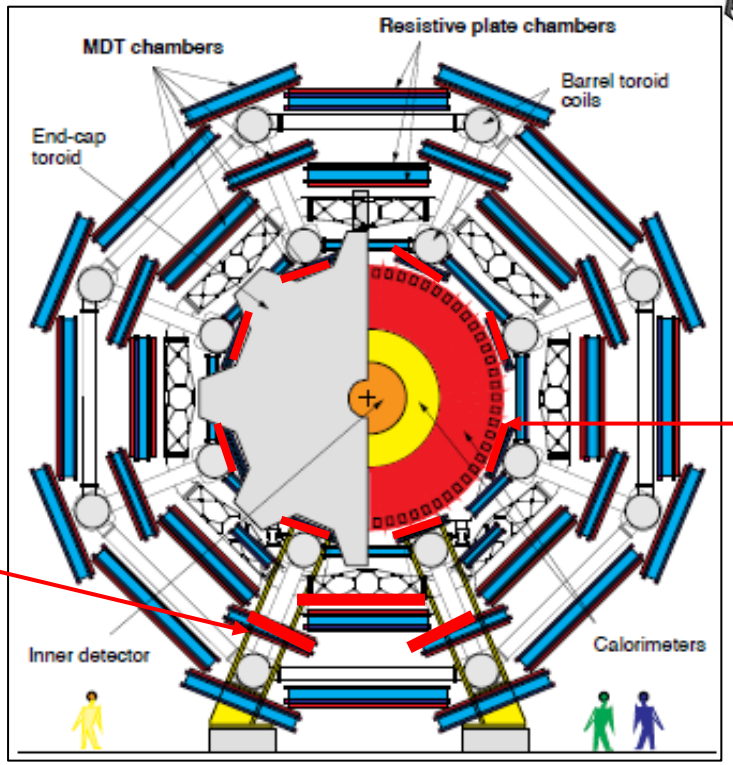
sMDT Chambers for ATLAS

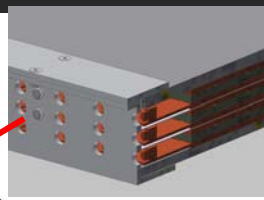


Construction of 12 chambers for the feet regions completed in 09/2015-07/2016 for installation in the first quarter of 2017.

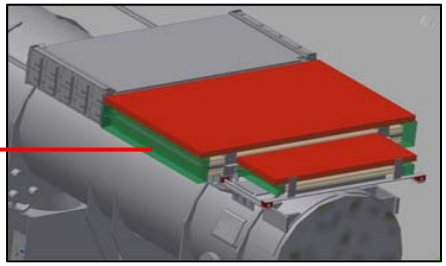
4500 tubes in total.







Integrated design of sMDTs with triple thin-gap RPCs for barrel inner layer



Design very similar for complete BIS layer replacement

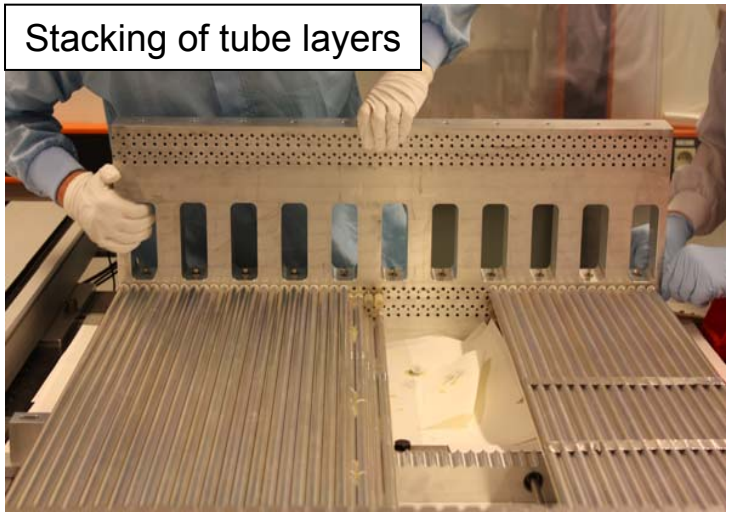
BMG sMDT Chamber Construction

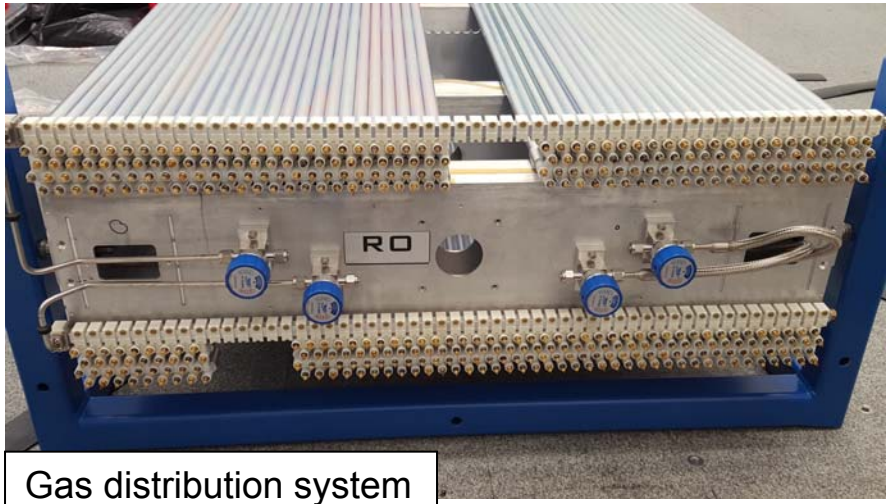
Design for mass production of chambers with large numbers of tube layers:

Assembly within one working day, independent of the number of layers.

Endplug insertion in jigging holes

Stacking of tube layers





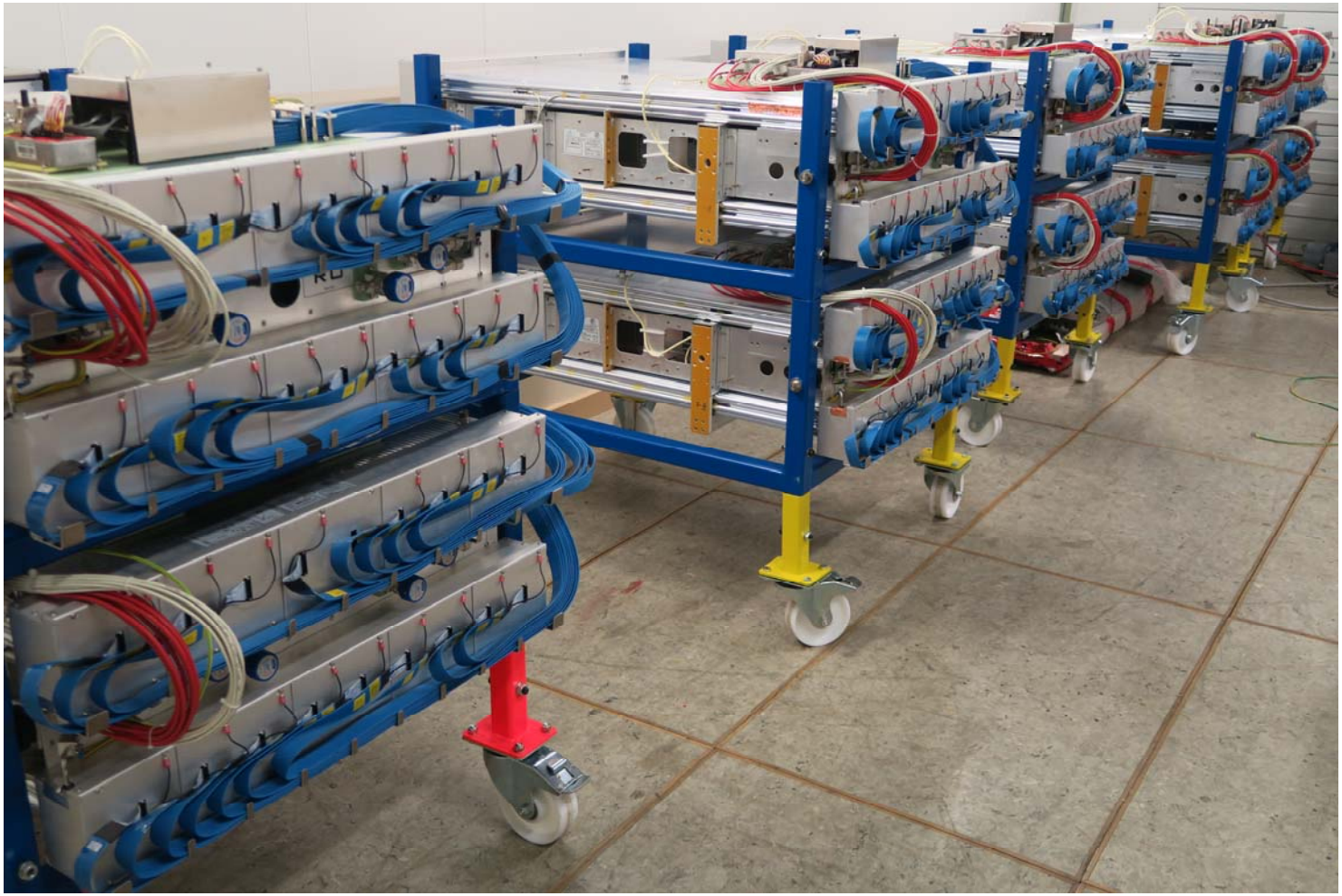
Gas distribution system

Completed BMG chambers for early 2017 installation

BMG Chamber Commissioning at CERN

Tests of all 12 BMG chambers at CERN completed in December 2016.

Fullfill the specifications and are ready for installation starting on 16 January.

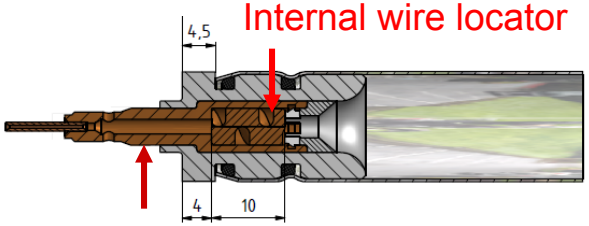


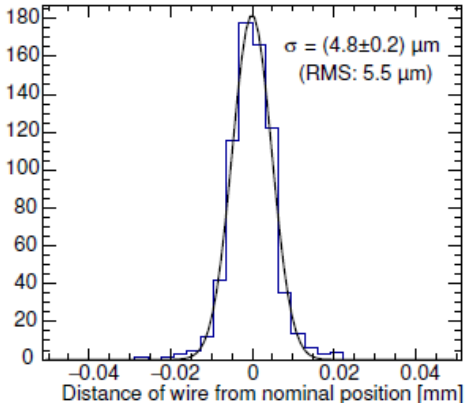
Wire Position Measurement in sMDT Chambers

- Measurement of individual sense wire positions and of global deformations (torsion around tube axis) with with 3D coordinate measuring machine.

- Wire positioning accuracy of better than 5 µm achieved,

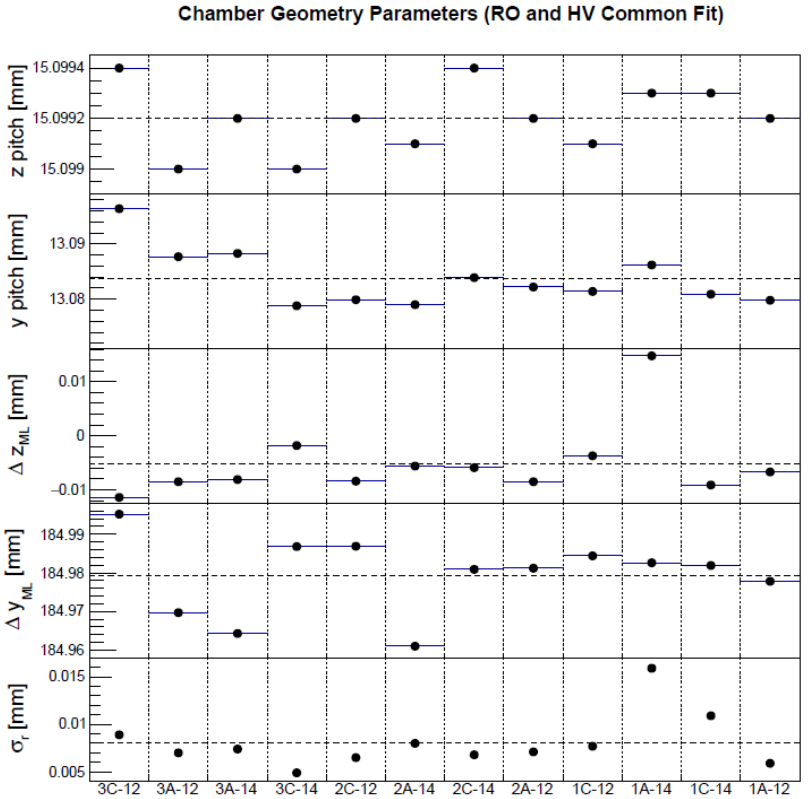
  at the limit of the jigging precision.





3D position measurement of the optical alignment sensor mounting platforms with respect to the wires.

Essential for absolute optical alignment monitoring with accuracy on the order of the chamber resolution.

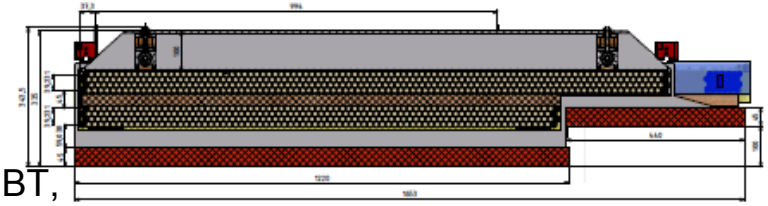


Constructed chambers

BIS 7/8 sMDT + Thin-Gap RPC Chamber Design

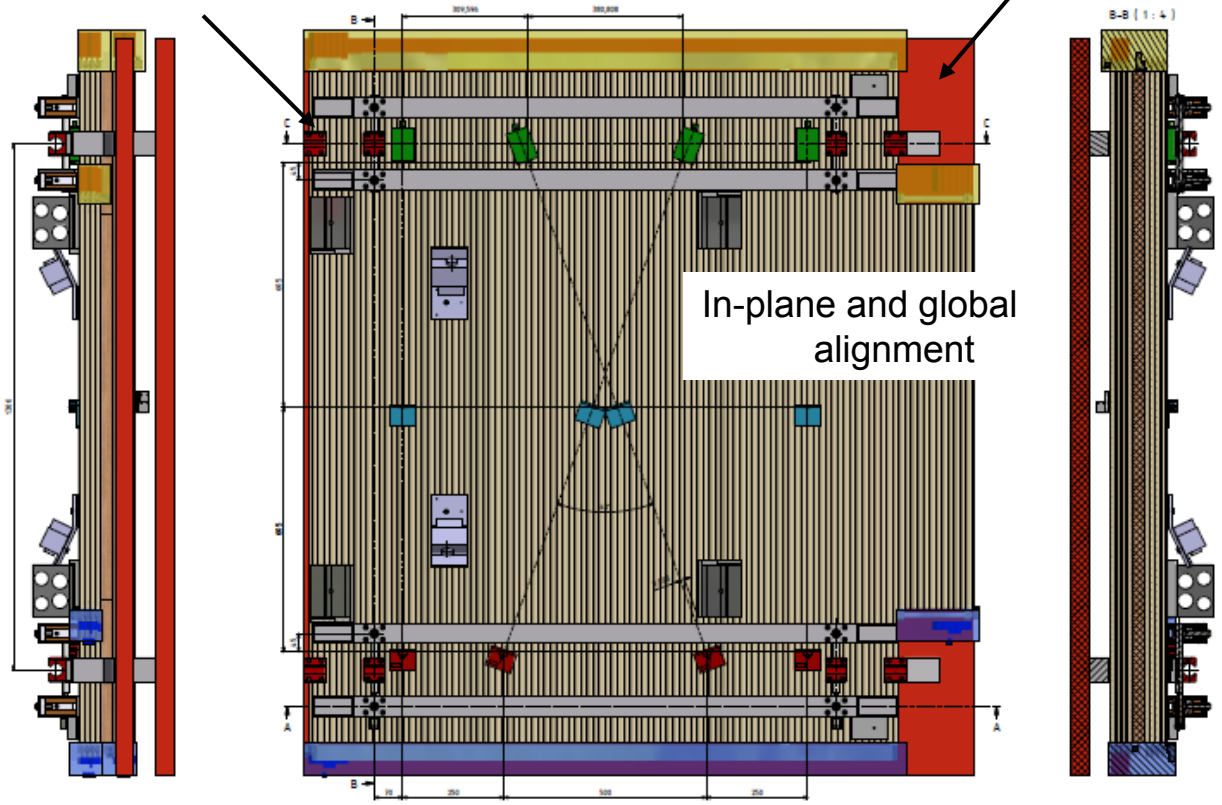
Integrated BIS 7/8 sMDT and RPC design with alignment connections to NSW.

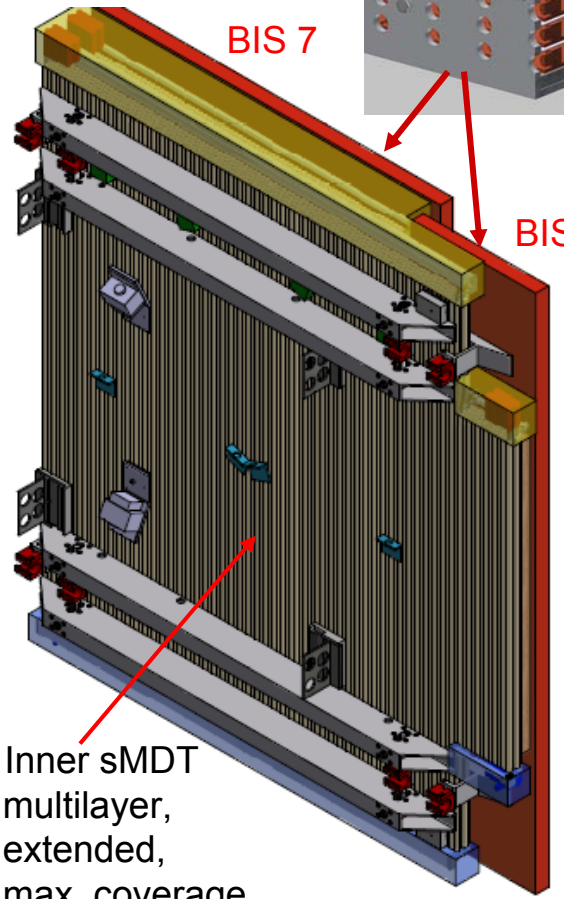
sMDT design close to final. Module 0 March 2017. Model for Phase II BI layer upgrade.



Rail bearings on BT, separate for sMDT and RPC

Cutouts for NSW support brackets



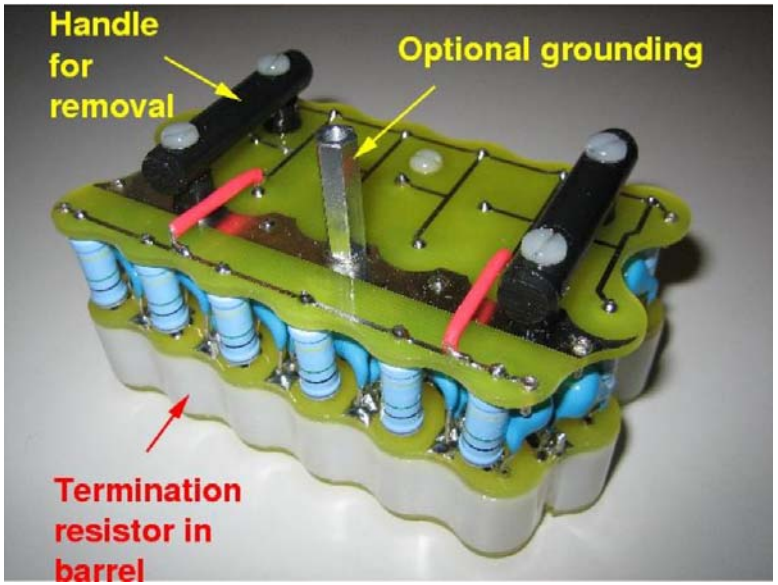


Inner sMDT multilayer, extended, max. coverage

Mechanical RPC design ongoing.
Plan for a prototype early 2017.

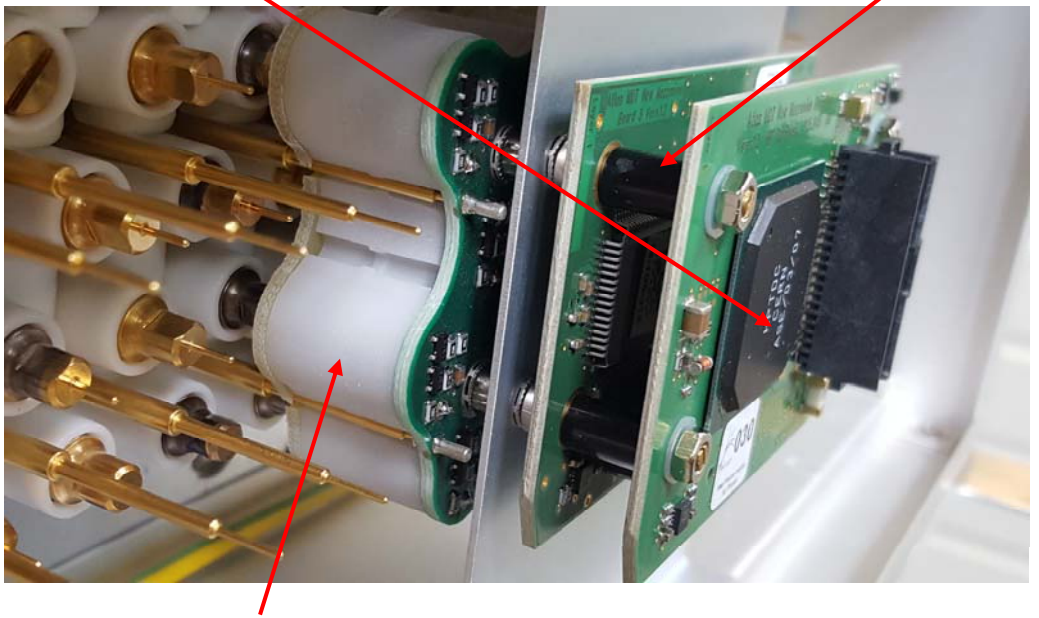
sMDT Readout Electronics

High-voltage distribution boards
(24 channels),



Signal distribution and readout boards (24 channels)

with three 8-channel amplifier-shaper-discriminator (ASD) chips
and one TDC chip (CERN HPTDC).



4 x denser electronics: stacked boards and HV protection.

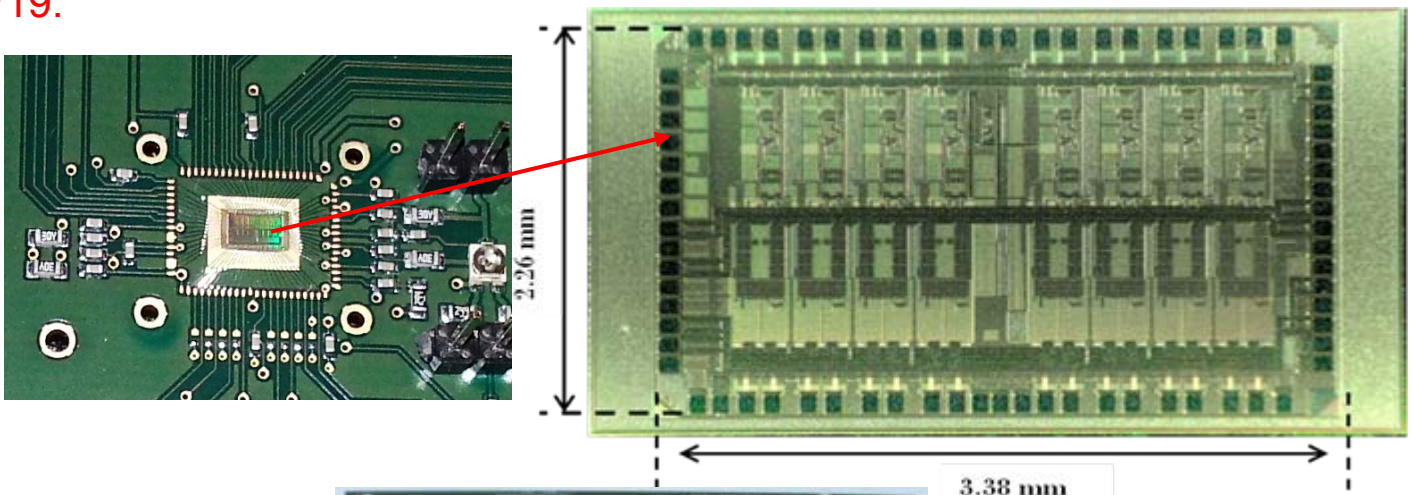
New ASD and TDC chips in 130 nm CMOS technology are under development
both for existing ATLAS MDT and new sMDT chambers at HL-LHC.

New TDCs with higher bandwidth and new trigger-less readout
for (s)MDT-based Level-0 muon trigger for HL-LHC with offline momentum
resolution and thus much sharper trigger threshold.

New (s)MDT Front-end Chips for Phase 2

New ASD and TDC chips in 130 nm CMOS technology are under development both for existing ATLAS MDT and new sMDT chambers at HL-LHC.
Plan for procurement in 2018/19.

First test results of new ASD chips from the latest submission received in November 2016 are very promising.



Mezzanine card design also well advanced.
Ready for early fabrication and installation in winter shutdowns from 2021/22.

New TDCs with new trigger-less readout, but also compatible with current triggered readout, for (s)MDT-based Level-0 muon trigger for HL-LHC providing full offline momentum resolution and thus much sharper trigger threshold.

Conclusions

- 12 BMG sMDT chambers completed for installation in the winter shutdown 2016/17.

- Design of BIS7/8 sMDT chambers close to completion.
  BIS7/8 RPC design in progress.
  Module 0 construction in spring 2017. Production of 16 chambers 2017-2018.

- BIS7/8 sMDT and RPC design model for new BI layer for Phase 2.

- New front-end electronics chip and board design for (s)MDT chambers for Phase 2 with additional triggerless readout mode for MDT based L0 muon trigger well advanced. Will be compatible with present triggered readout.
  Will be ready for early installation starting from 2021/22.