

Construction of small-diameter monitored drift tube (sMDT) chambers for the ATLAS muon spectrometer at the HL-LHC



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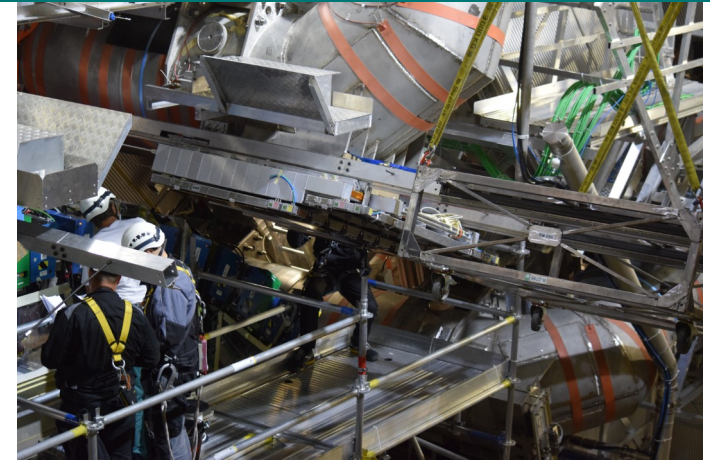
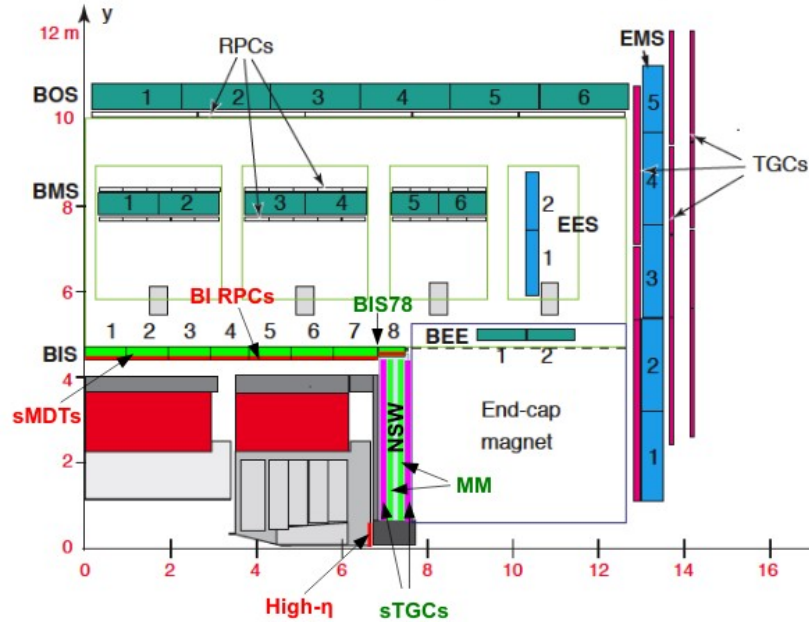


FSP ATLAS

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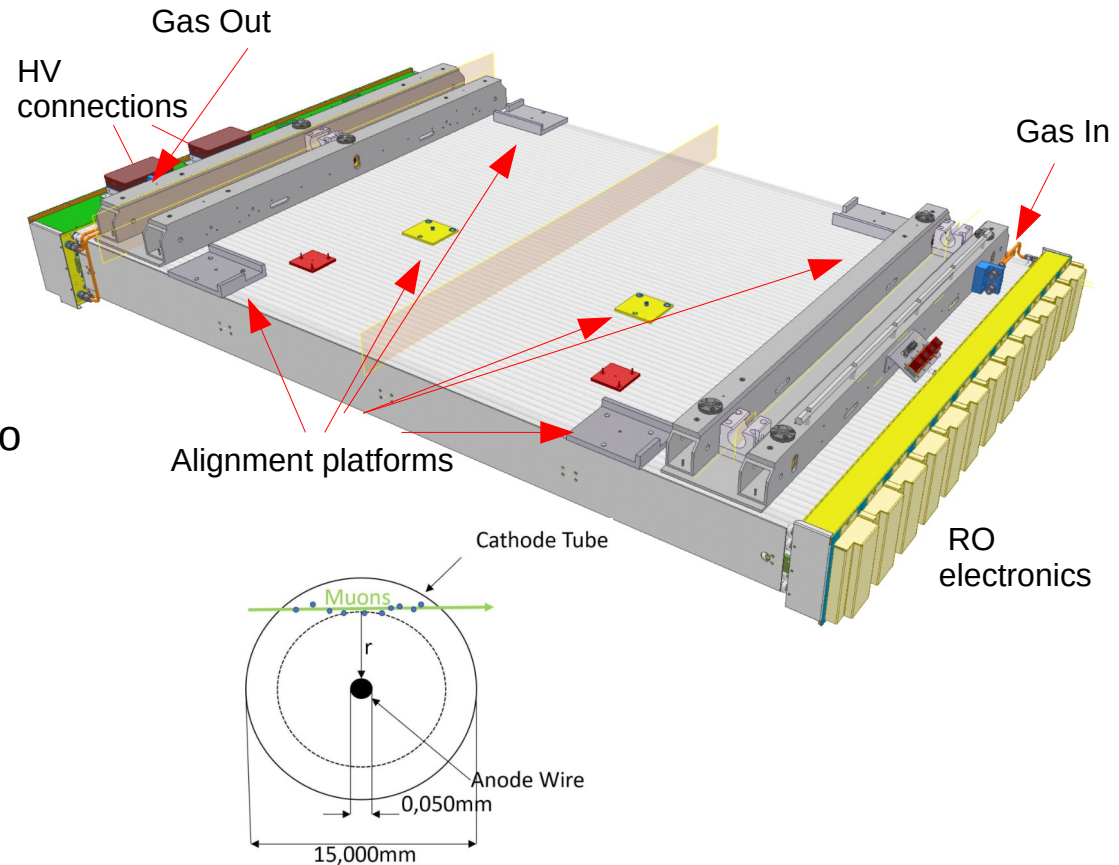
Pilot project BIS78: new sMDTs+RPCs were installed in 2020

- For the HL-LHC the ATLAS detector will be upgraded:
 - New trigger and readout electronics, including L0 MDT trigger
 - New thin-gap resistive plate chambers (RPC) in the inner layer of the barrel increasing trigger efficiency and acceptance
 - Replacement of the current monitored drift tube chambers (MDT) in the small sectors of the inner layer with small-diameter monitored drift tube chambers (sMDT)

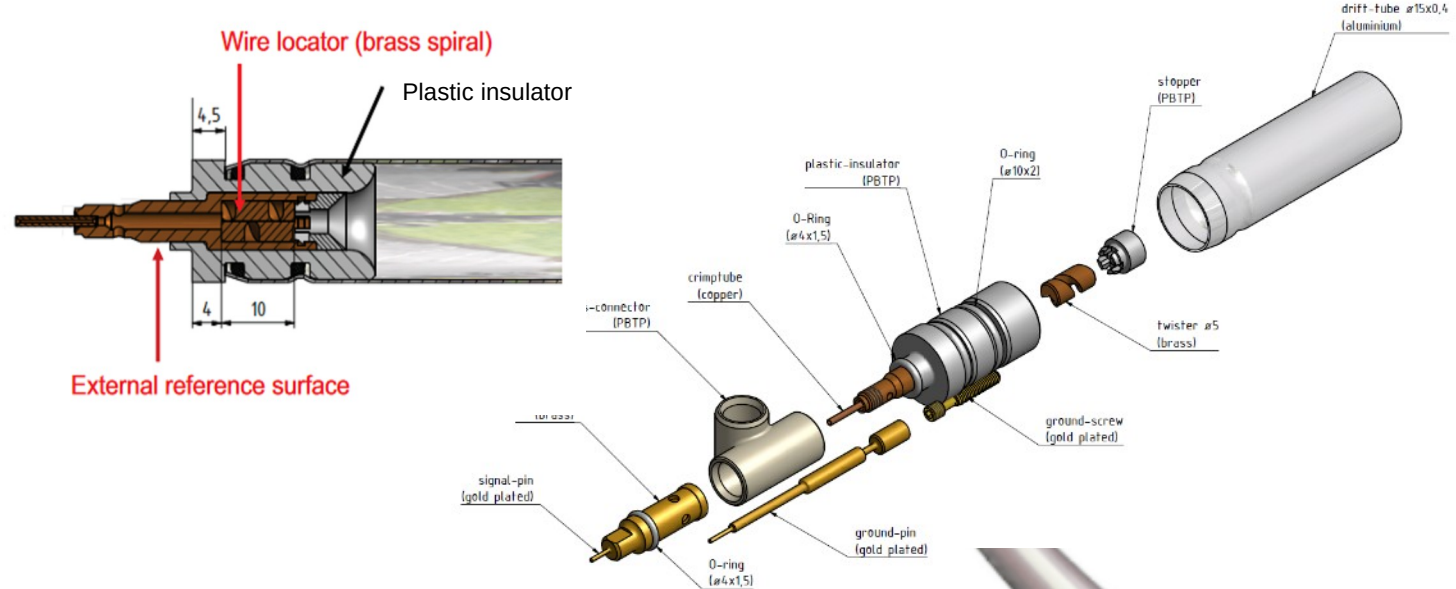
BIS 1-6 sMDT chambers



- 48 chambers are being built in Munich at MPI (mostly A-side) and 48 chambers in Michigan at MSU/UM (mostly C-side)
- Chamber design done at MPI
- Successful technology transfer to Michigan in 2020
- sMDTs consist of drift tubes with 15 mm diameter arranged in 8 layers separated into 2 multilayers
- One magnitude higher rate capability than MDT

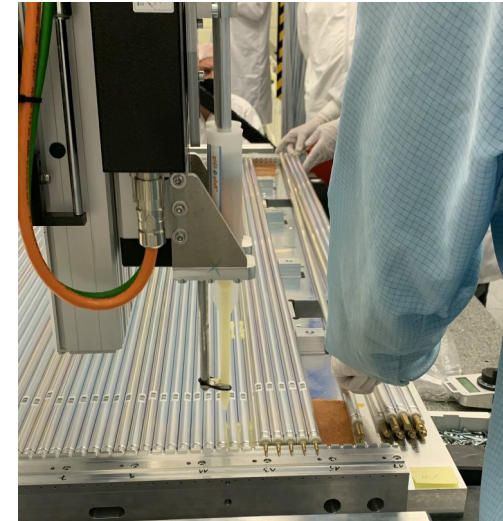


Drift tube production

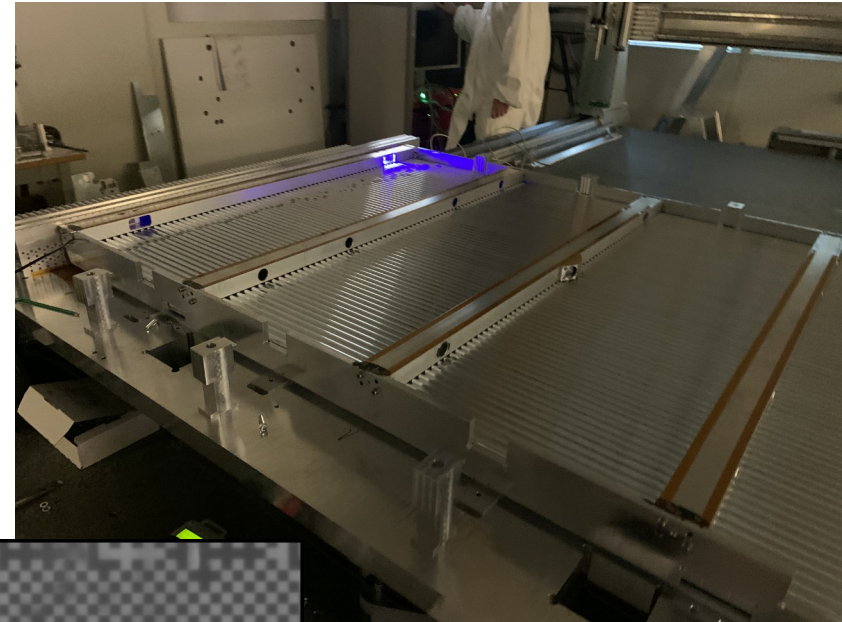
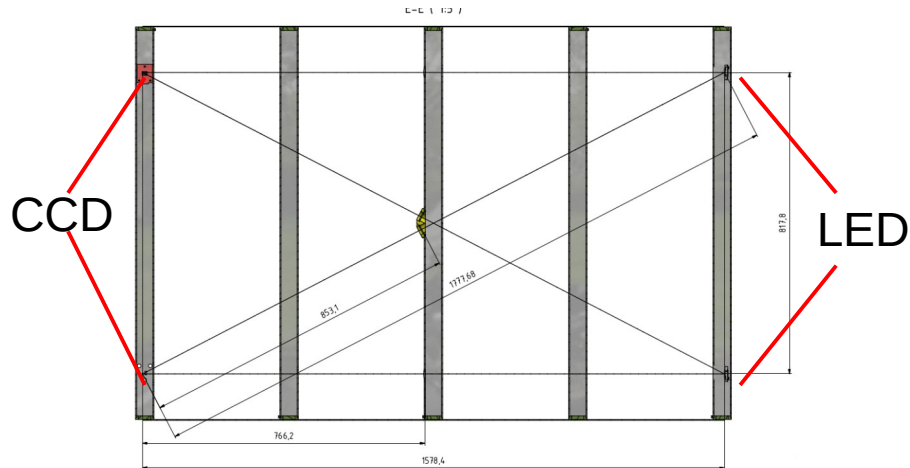


- Production of drift tubes is performed in a class 1000 clean room
- Endplug defines the wire position with a precision of 1 μm
- Each tube is tested for wire tension, dark current and gas leakage
- Sufficient production rate of 65 tubes per day

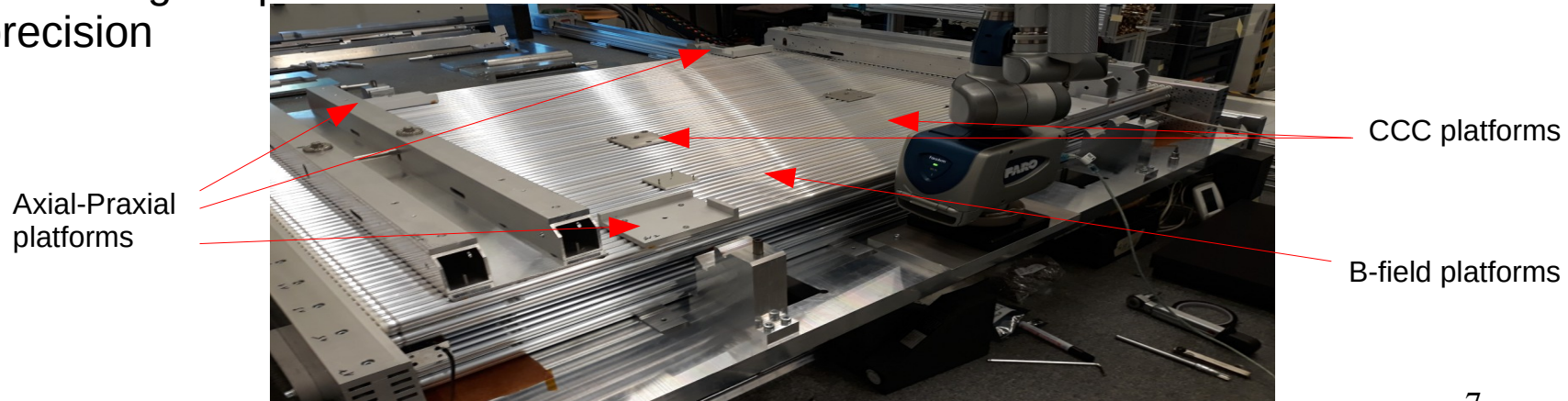
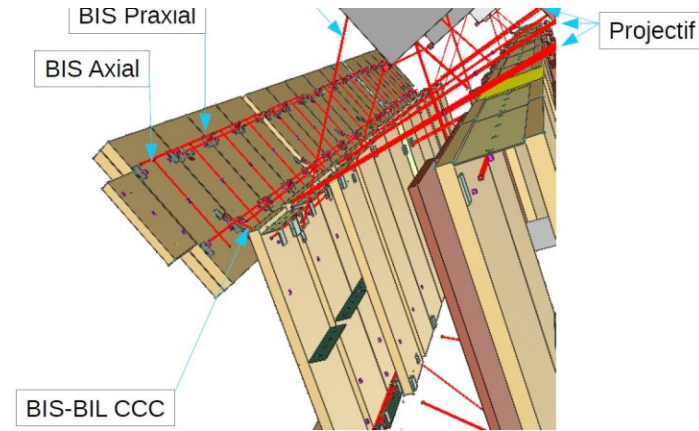
- The production of the chambers can be divided into 3 major steps:
 - Gluing of the chamber (9 days)
 - Assembling of the gas system (1 week)
 - Mounting of the electronics (2 days + 2 days test)
- Parallel work on 3 chambers
- Production rate is defined by the gluing step, which needs 9 working days (8 layers + platforms + measurement of platform positions)
- Geometry of the chamber is measured after the gluing using a Coordinate Measurement Machine (CMM)



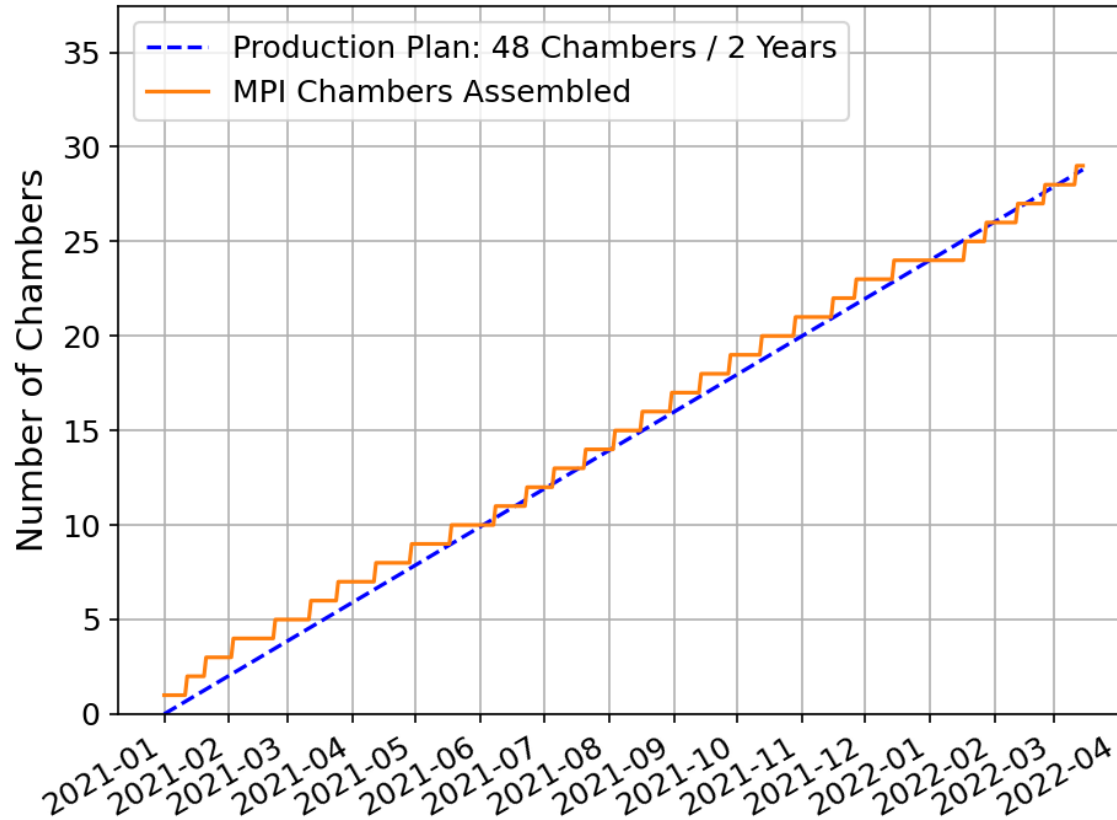
- Each chamber is equipped with an optical In-Plane Alignment System that allows monitoring the deformation of the chamber during operation
- The LEDs project a chess-like pattern onto the CCDs



- The positions of the chambers within the detector are monitored by an optical alignment system
- The optical sensors are mounted on platforms, glued on top of the chamber
- The positions of the platforms are measured during the production with 10 μm precision

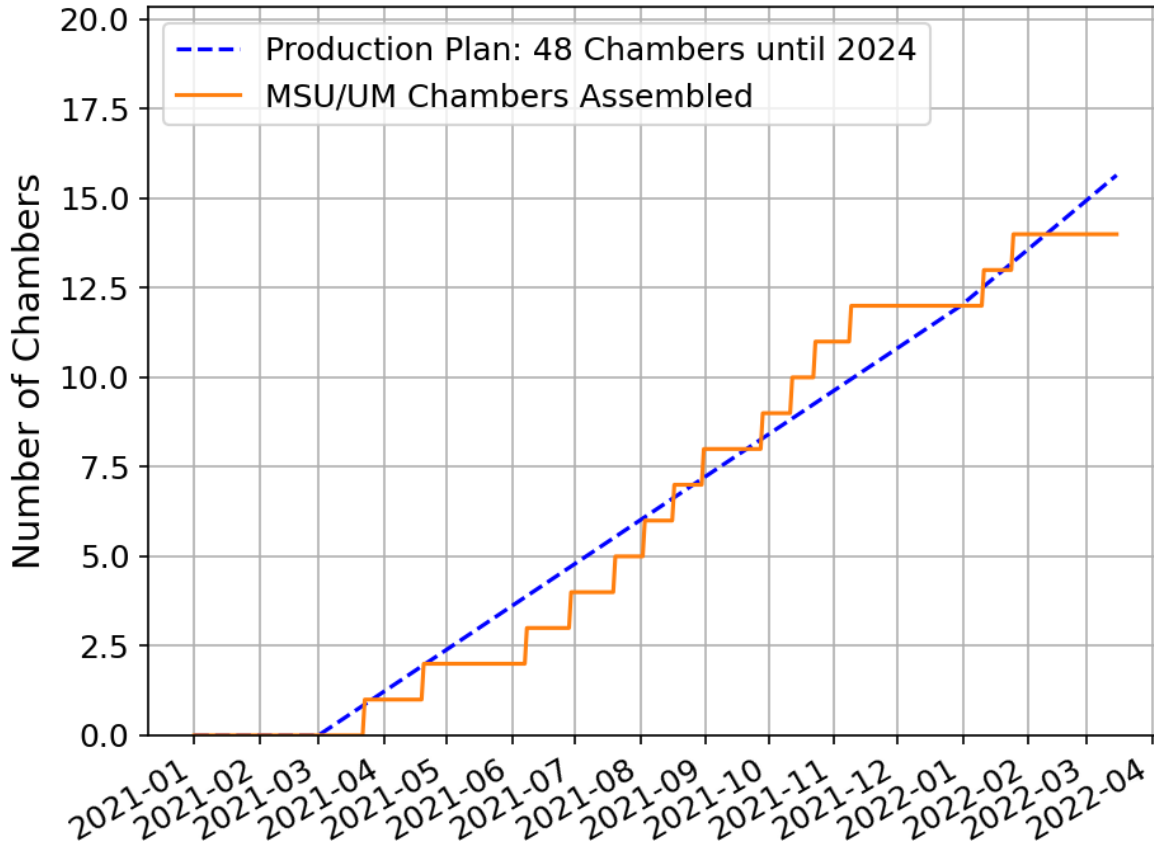


Production progress



- Producing one chamber every two weeks
- 29 chambers produced since beginning of 2021
- Goal: Finish chamber assembling until end of year

Production progress

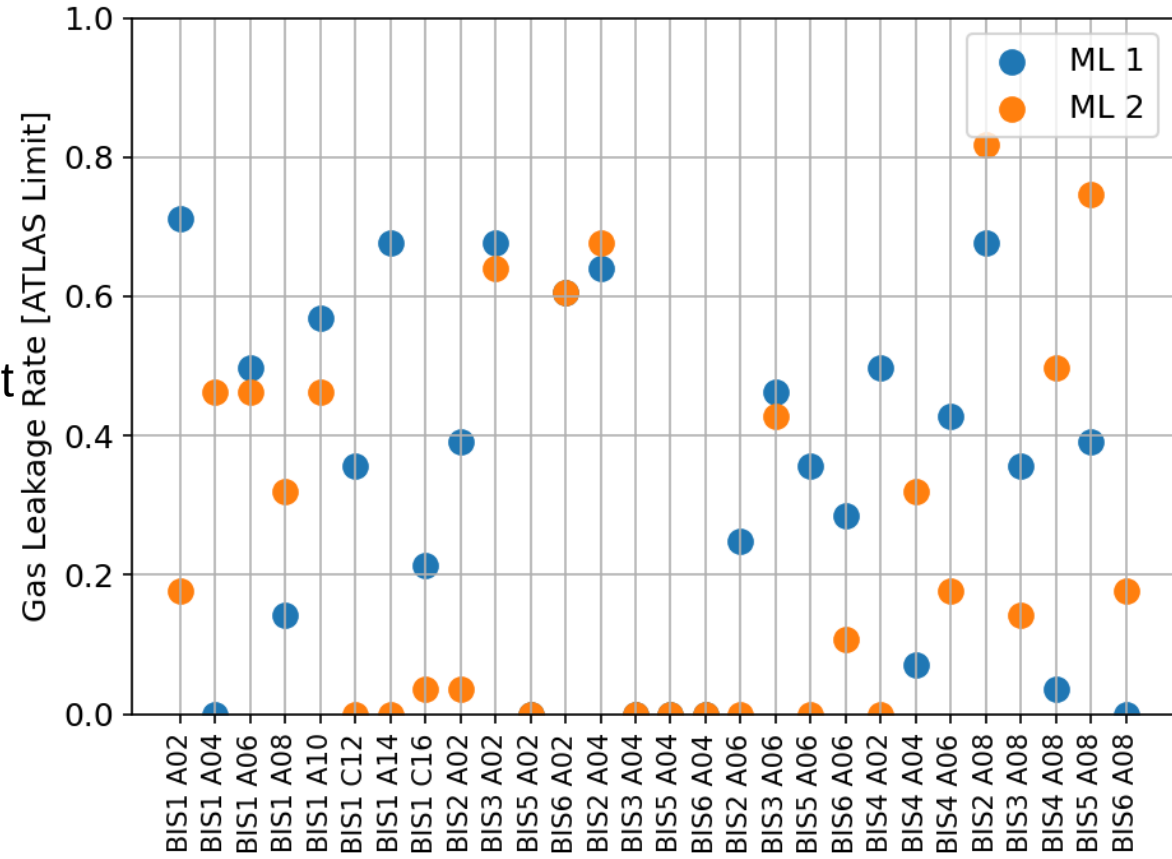


- 14 chambers produced since beginning of 2021
- Successful technology transfer to Michigan production site

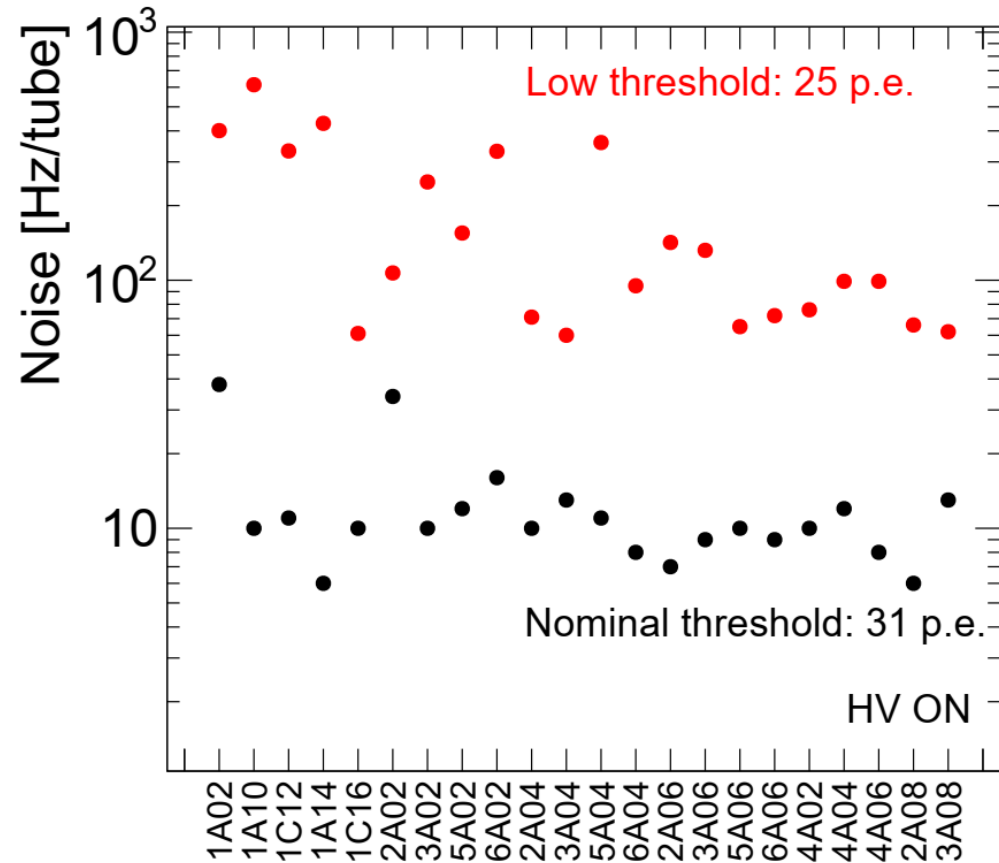
Gas Distribution System



- Getting the chamber gas-tight is challenging
- ~5000 O-rings per chamber
- Required gas leakage:
 $< 2N_{Tube} \cdot 10^{-8} \frac{\text{bar}\cdot\text{l}}{\text{s}}$
- Chambers are typically gas-tight without corrections needed



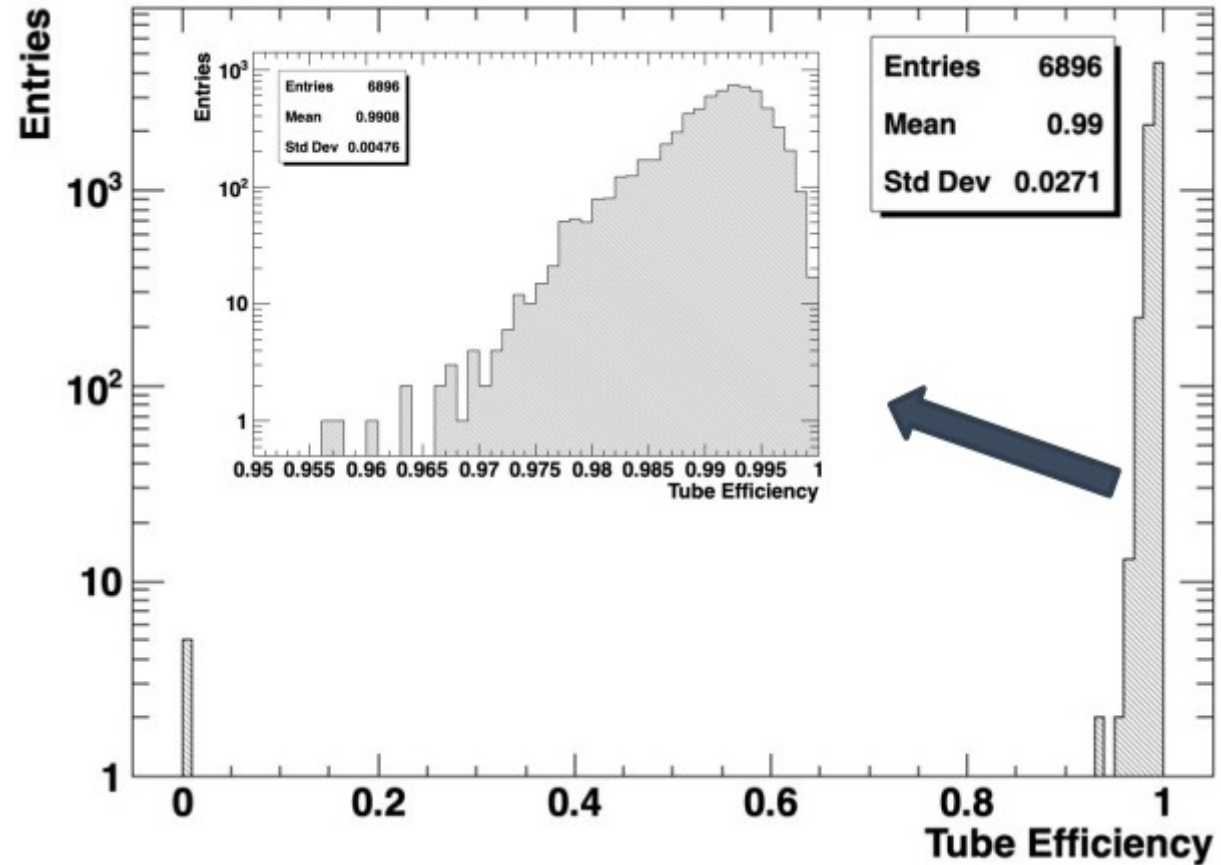
- Chambers are tested with cosmic muons
- Noise rates about 10 Hz/tube
- Noise rates is similar to the expected cosmic muon rate
- Required: < 1k Hz



Efficiency



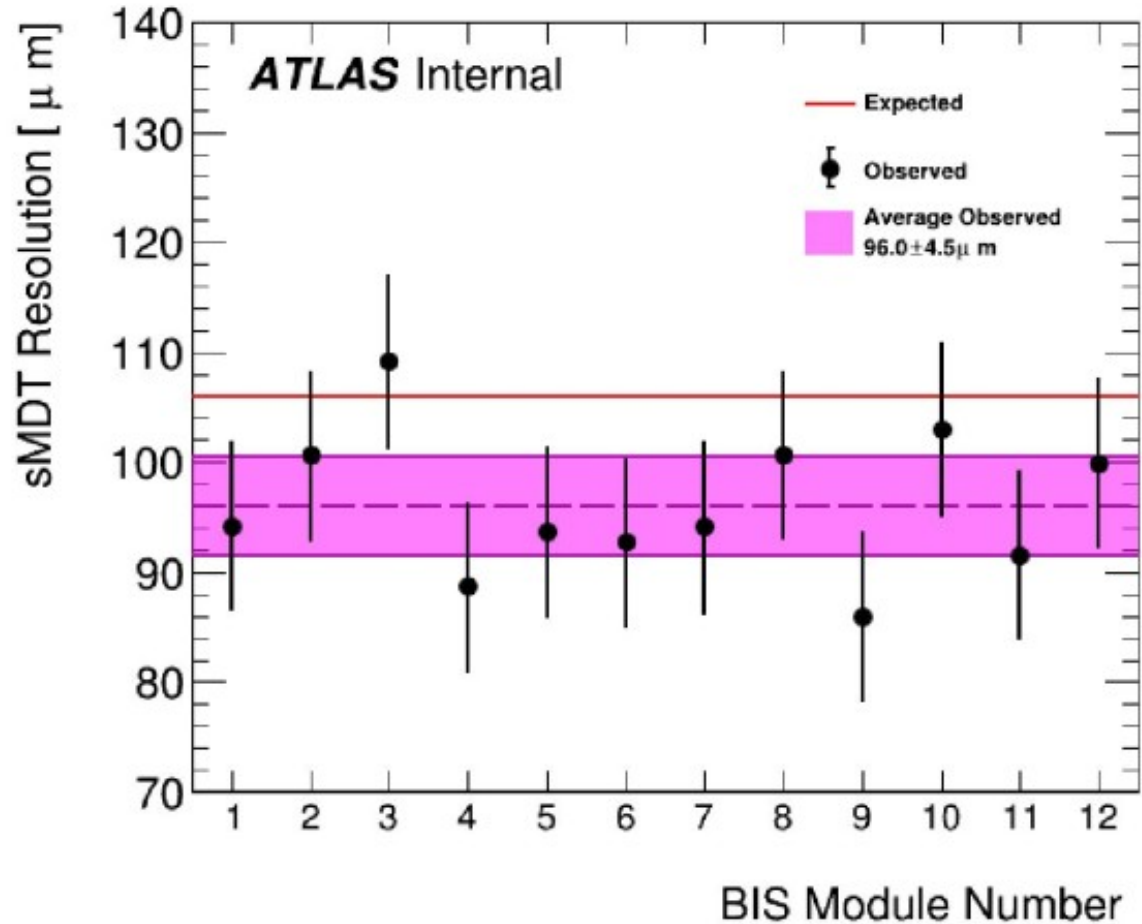
- Chambers are tested with cosmic muons
- 99% single tube efficiency observed



Resolution



- Chambers are tested with cosmic muons
- Single tube resolution of $\sim 100 \mu\text{m}$



- After transportation to CERN, all chambers are tested again
- Chambers will be equipped with new electronics (designed by MPI) in 2023
- Production of RPCs by MPI in 2023
- Integration of RPCs with sMDT in 2024
- Installation of Chambers in 2026/2027

