Triplet assembly and certification of the new generation of RPC for the ATLAS phase-2 upgrade at Max Planck Institute

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Outline

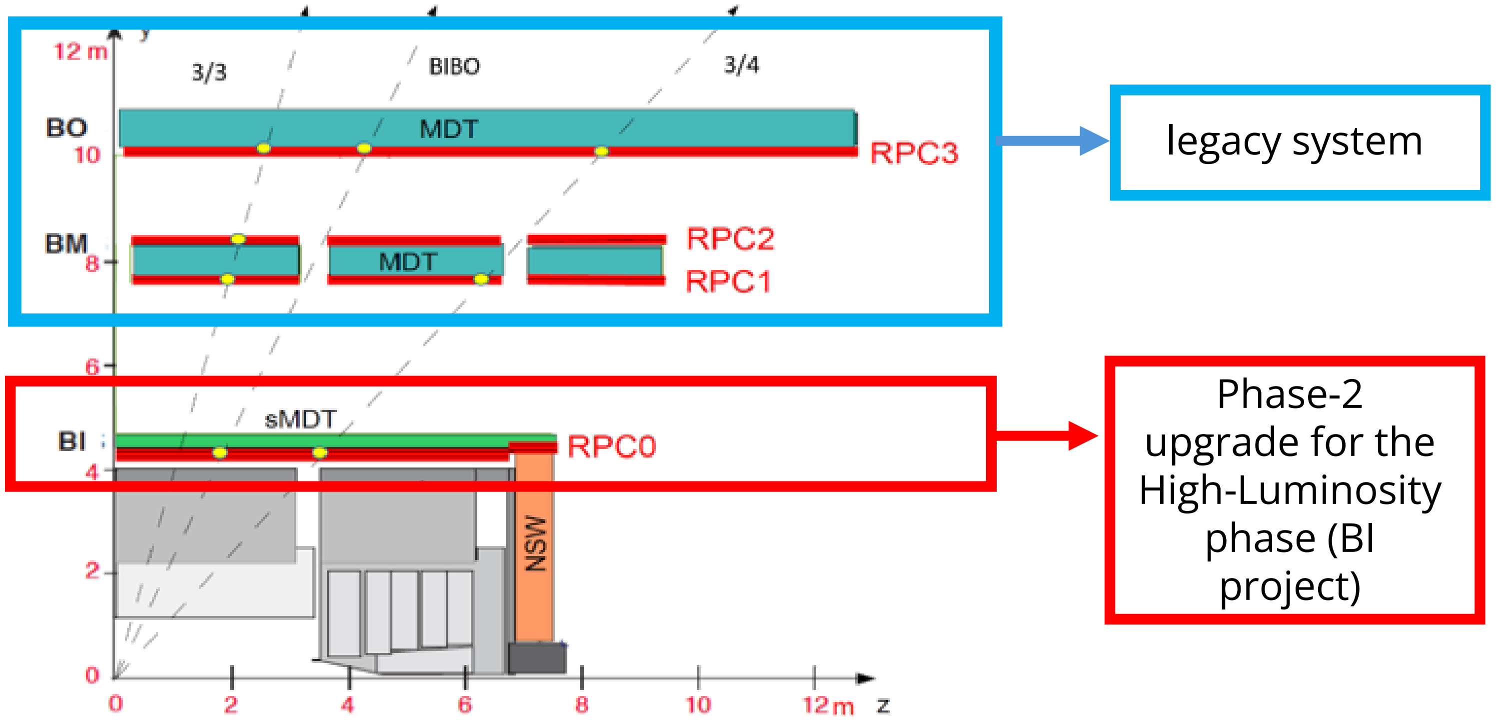
- Introduction ATLAS RPC phase-2 upgrade
- MPI Responsibility in the ATLAS RPC phase 2-upgrade
- Triplet assembly
- Cosmic rays test stand
- Conclusions

ATLAS Phase-2 upgrade

In sight of the High-Luminosity LHC program the ATLAS Muon Spectrometer (MS) must be able to operate at instantaneous luminosity L of 7.5 x $10^{34}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$.

RPC system upgrade : improvement of the acceptance, redundancy and selectivity of the trigger

BI project (2022-2028): entire coverage of the inner layer of the MS with a new generation of RPC



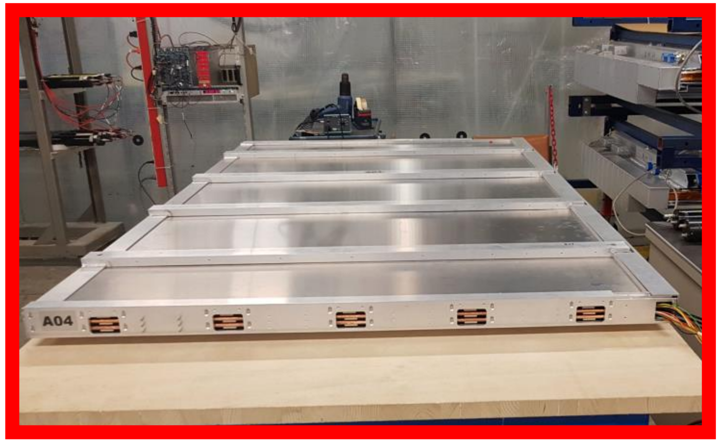
- Three gas gaps in the same mechanical structure;
- 1 mm gas gap + 2x(1.3 mm) electrode
- Two panels of parallel strips (η1-η1)
- Si & SiGe FE electronics technology (1-6 fC threshold on the electronic signal)→see L. Pizzimento's talk
- Intrinsic time resolution ~ 400 ps
- 500 Hz/cm^2 over 10 years of LHC operation

ATLAS Phase-2 -detector

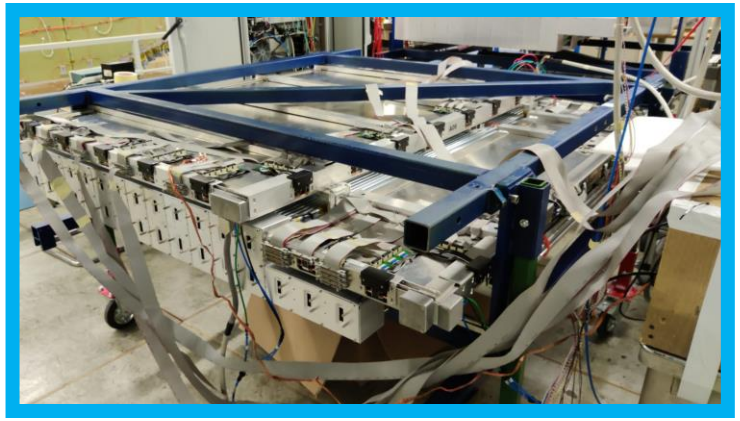
The BI RPCs are composed of three independent detectors ('**singlets**') in the same mechanical structure ('**triplet**')

Singlet

Triplet



BIS78 + sMDT



BIS + sMDT

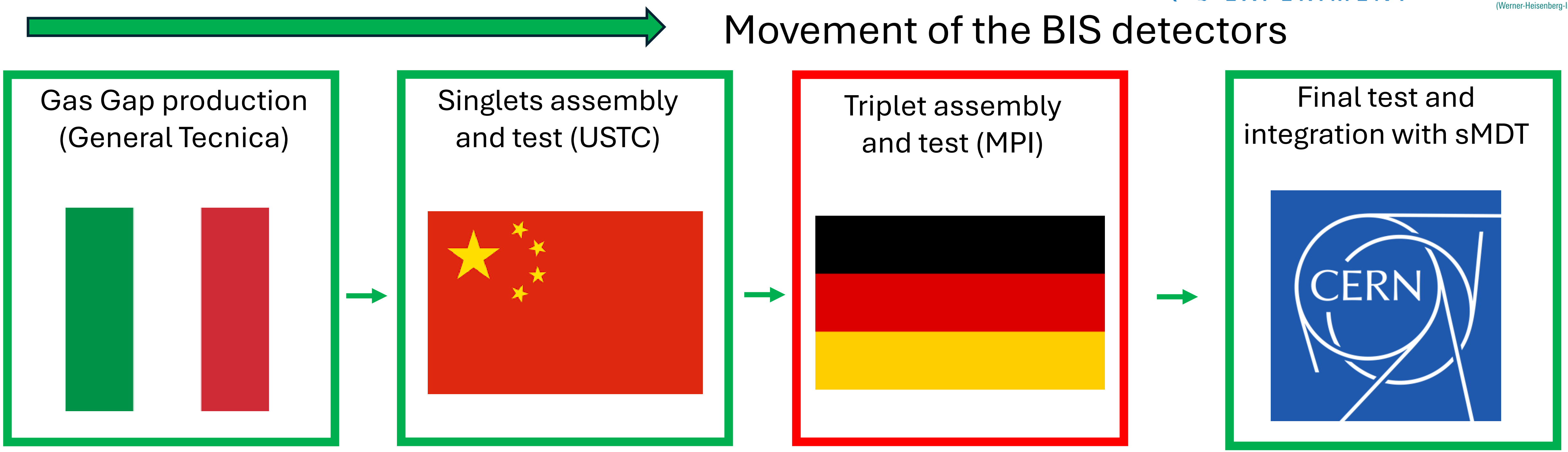
Two layouts of detectors depending on the ATLAS sector where they will be installed: BIL (Large sectors) and BIS (Small sectors)

BIL responsability of INFN group

BIS detectors are integrated with **s-MDT**, resulting in a mechanical structure different wrt the BIL

The mechanics layout of the BIS-type is designed to take into account the need of electrical and physical independence with the s-MDT

Max Planck Institute within the BI Project



The Max Planck Institute is responsible of:

1) Assembly and certification of the BIS-type triplets, for a total number of 96 triplets (288 singlets) →Topic of this presentation

2) Mechanics of the BIS-type RPC

3) Service boxes of the BIS-type RPC

4) Integration with s-MDT

5) Gas gap production of the BOR/BOM (see F.Fallavollita’s talk)

Timeline of the BIS assembly and certification

Expected 48 singlets/month from China → 16 triplets/month to be shipped at CERN

Day one: standard check of the singlets + assembly in the mechanical frame

-Visual inspection

-Check of the gas tightness;

-Flushing and HV-I curves;

-Check of the electronics ;

-Assembly within the mechanics and mounting of the service boxes

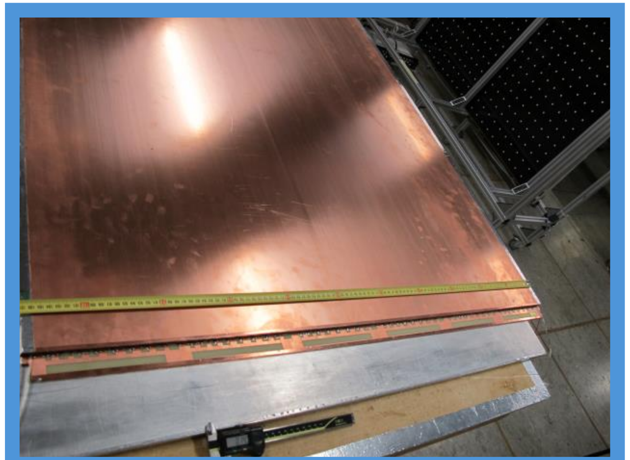
Day two: Test with cosmic rays

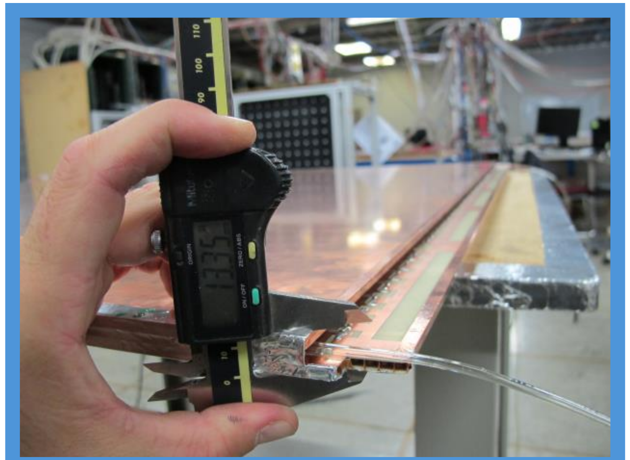
-Low noise

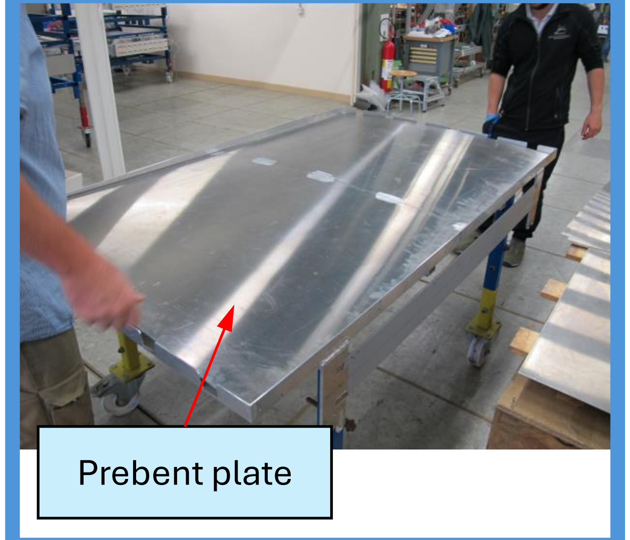
-Study of the main RPC parameters: efficiency, cluster size, time over threshold

-expected rate of 1 triplet/day

Triplet assembly : Step 1





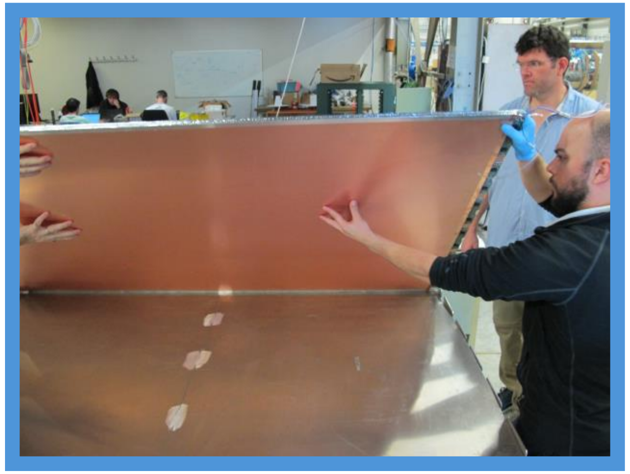


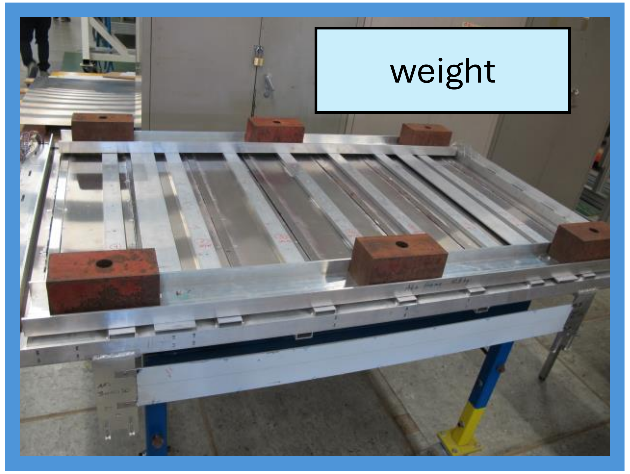
Check of the singlets

Goal : see if the singlets have been damaged during movement

1. **Visual check for the singlets (FE electronics boards and services)**
2. **Check the outer dimensions (tape, caliper)**
3. **Fast acquisition to check FE dead channels**
4. **Place the lower frame + prebent plates on movable table**

Triplet assembly : Step 2

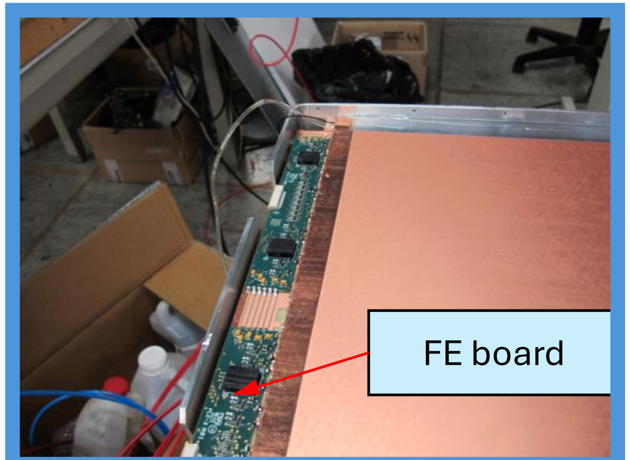


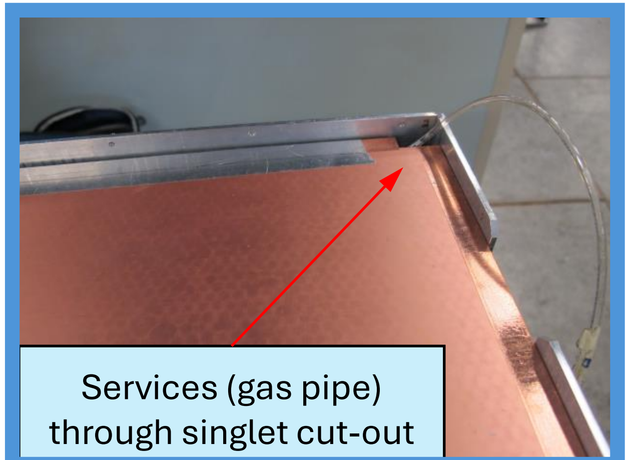


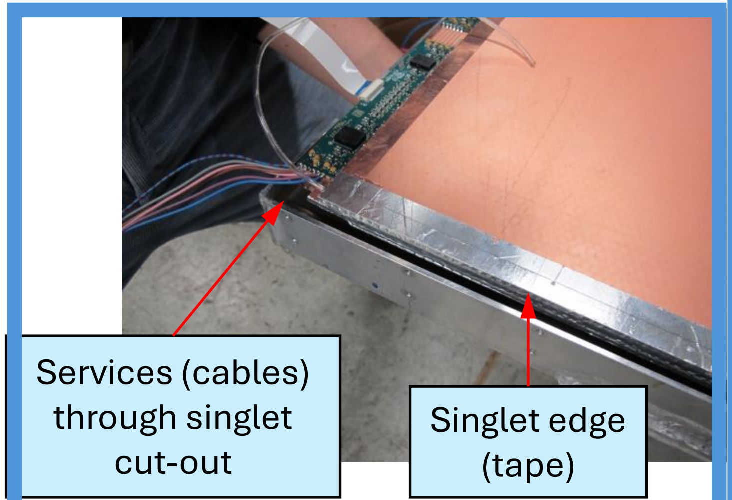
Assembly

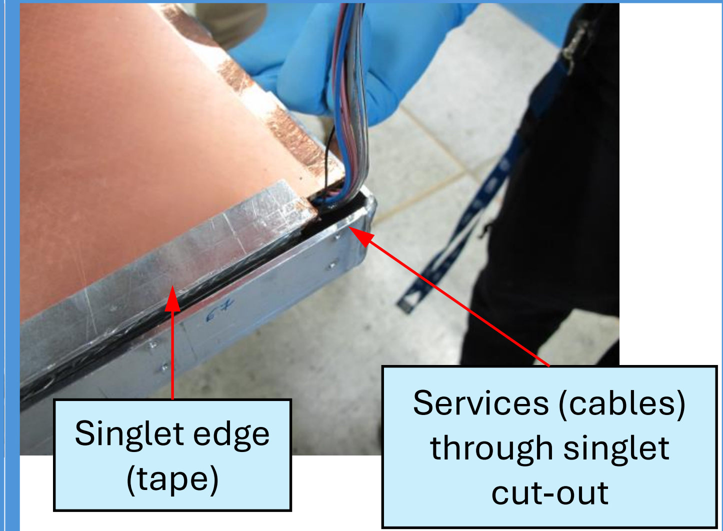
1. Place the first singlet vertically in the frame corner
2. Tilt the singlet into the lower frame housing
3. Check during/after placement (see next slide)
4. Repeat for the other two singlets
5. Close the mechanics using weights (80 kg corresponding to 4.3 mb)
6. Installation of the services

Triplet assembly : Checks









Checks (to be repeated for each singlet)

1. Singlet service (cables, gas pipe)
2. Singlet edges, tapes
3. FE boards connectors in the cut-outs lower frame

The mechanics is closed, the service are mounted and the triplet is ready to be tested

Cosmic rays (CR) test stand area

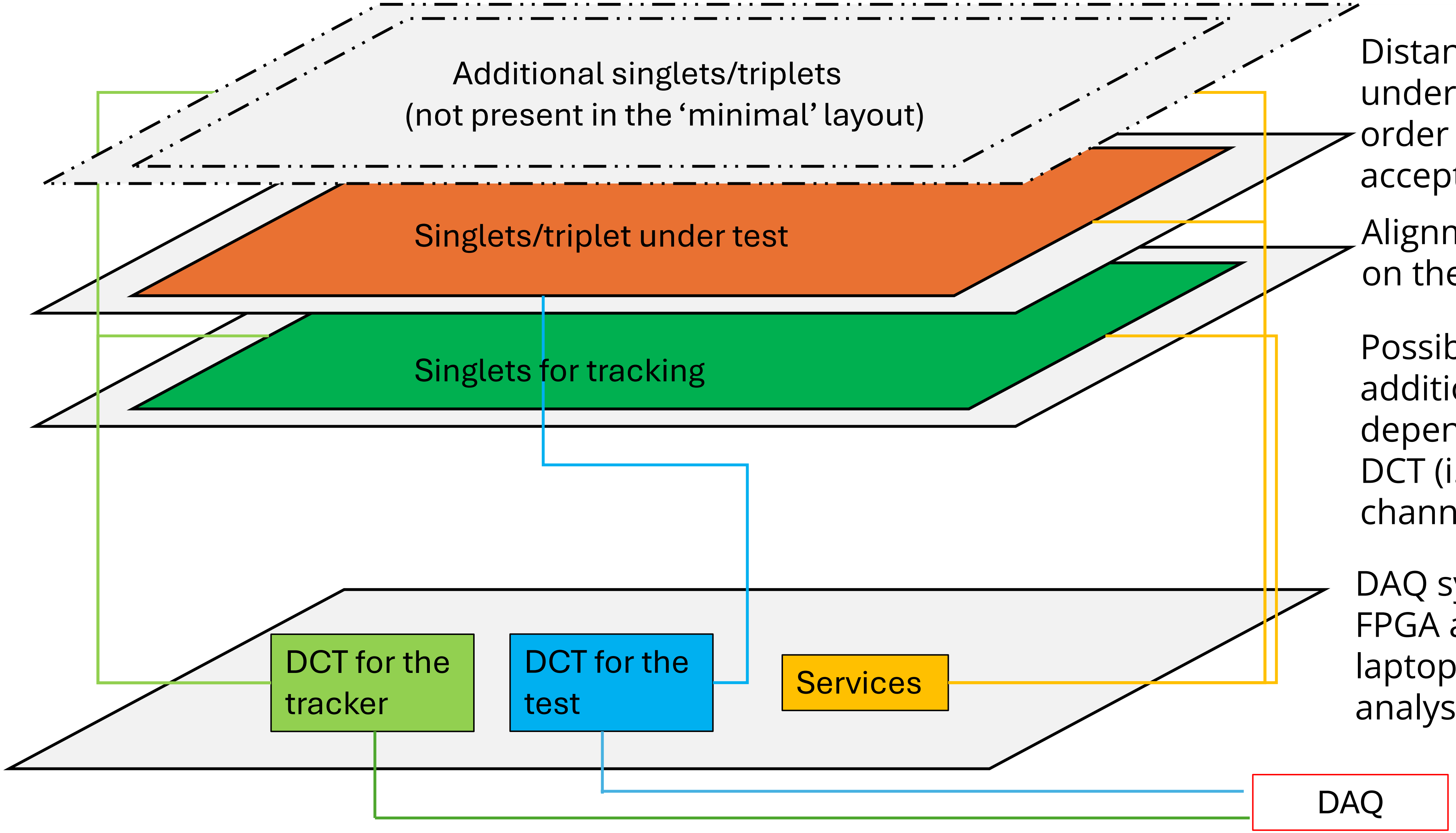
The cosmic rays test area is organized in 3 stations :

1. Assembly → Assembly of the triplet stations (see previous slide)

2. CR test stand → Test with cosmic rays for the certification of the triplets (topic of this presentation)

3. Infirmary → Used to debug problematic triplets. In this way it is possible to decouple the debug from the actual test and avoid delays

Cosmic rays test stand: set-up



Distance trigger- detector under test minimized in order to work with full acceptance

Alignment system mounted on the tables

Possibility to add an additional layer of triplets depending on the number of DCT (i.e. number of read-out channels available)

DAQ system composed of FPGA and acquisition laptop for the offline analysis

CR test stand:mechanical structure

3 movable layers that will host :

1. **Triplet under test → the number of triplets under test is limited by the number of read-out channels available;**
2. **Trigger : BIS-type triplet identical to the triplet under test (already certified and tested) with the function of external tracker and monitor;**
3. **Services : DCT(Data Transmission and Collection), LV system etc…→easier installation and fast test preparation**

Sensors are installed in order to measure the gas flow and environmental parameters(T, P, H)

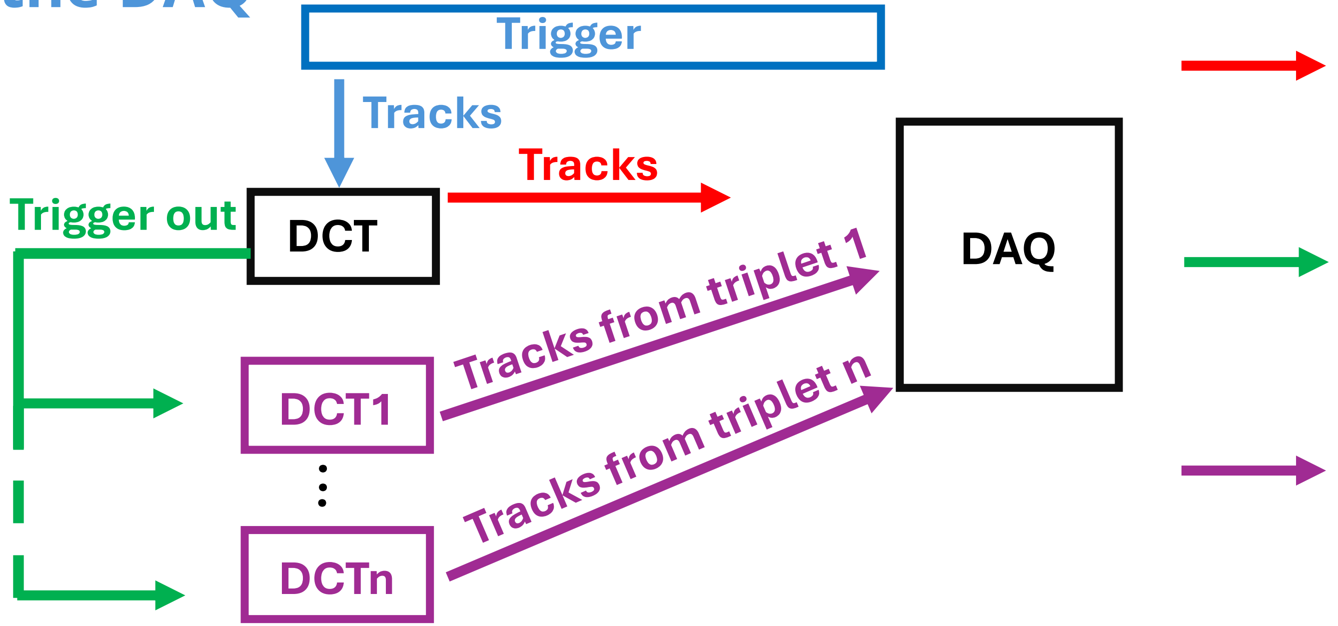
The gas flow, the environmental parameter, the HV and currents are continuously monitored and saved with an external system (DCS)

DAQ system

DCTs dedicated to the acquisition of both monitor and triplet(s) under test

Monitor triplet : a DCT will give both tracks and trigger out (depending on the test)

Triplet under test: the DCT receive the trigger out from the DCT and sent data of the chambers to the DAQ



Tracks are sent to the DAQ system for the offline analysis

The trigger out is sent to the DCT(s) that acquires the triplet(s) under test

The tracks of the detector under test corresponding to the triggered event are sent to the DAQ

This system allows to maintain the independence between trigger and triplet under test and among triplets under test

→ **Robust test**

→ **Easy debugging**

Test overview

The layout of the cosmic rays test stand allows to perform all the tests needed in order to fully characterize the triplet under test before the installation in the ATLAS cavern and fastly debug the system.

Random trigger → Study of the detector and electronics noise

External tracker → Characterization and certification of the triplet (performance) →
- -Low noise
- -Efficiency
- -Cluster size
- -Time over threshold

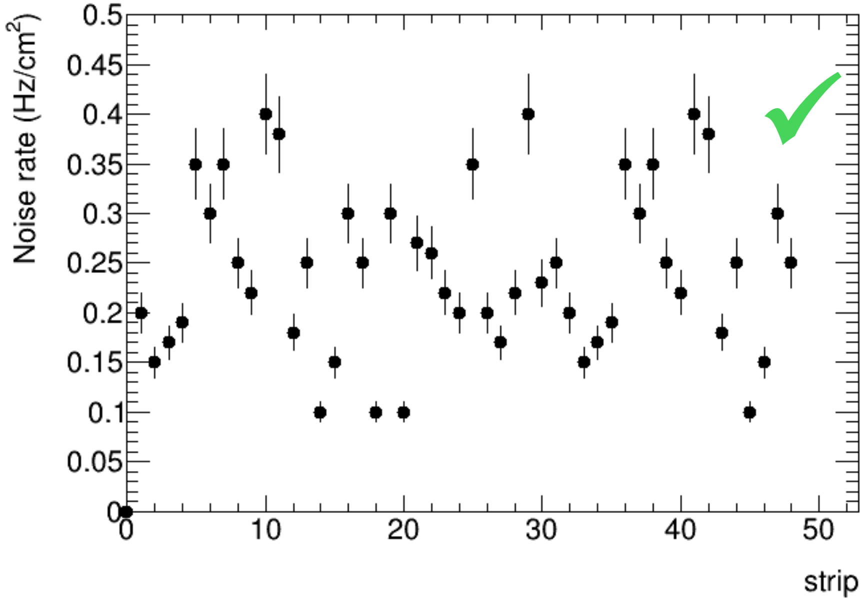
Autotrigger → Study of the correlated noise among singlets within the same triplet (self-induced noise)

The tests have been selected in order to study the main RPC characteristic as similar as possible to the final layout, avoid further troubles during and/or after the installation in cavern.

Tests with random trigger

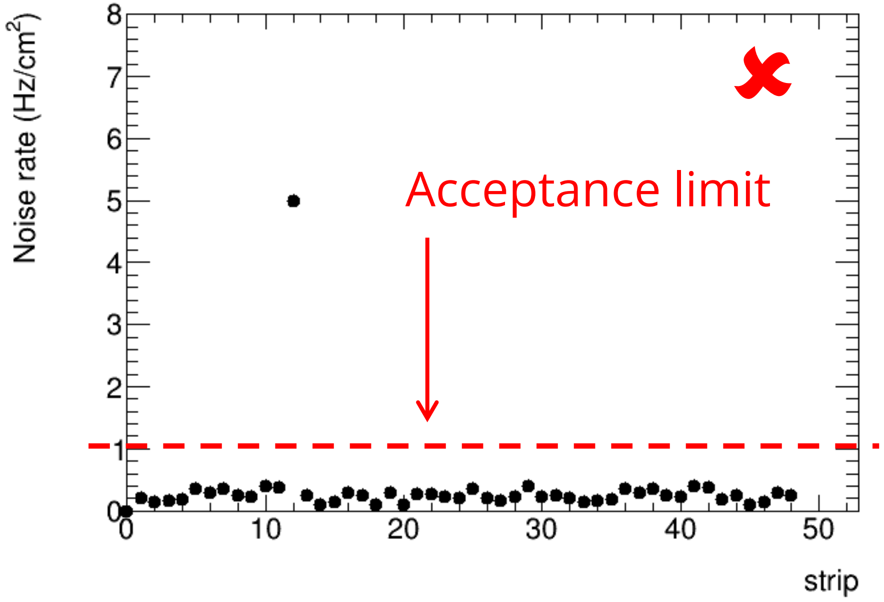
1. RPC detectors OFF : FE electronics noise

In this configuration both RPC and high voltage are off and the only noise that can be detected is due to the FE electronics



2. RPC detectors @ 4000 V : HV noise

In this configuration the RPC is off for what concerns the ionization of the gas, but the high voltage is applied.



3. RPC detectors @ Working Point (WP):Detector noise

In this configuration the detectors are at the WP high voltage. Since this step comes after 1. and 2., the noise can only be due to the detector itself.

Tests with external tracker

1. RPC detectors @ Working Point (WP) : Cable check

The data acquisition is performed with the RPCs fixed @ HV(WP)

2. 2 RPCs OFF, 1 ON : Independence test

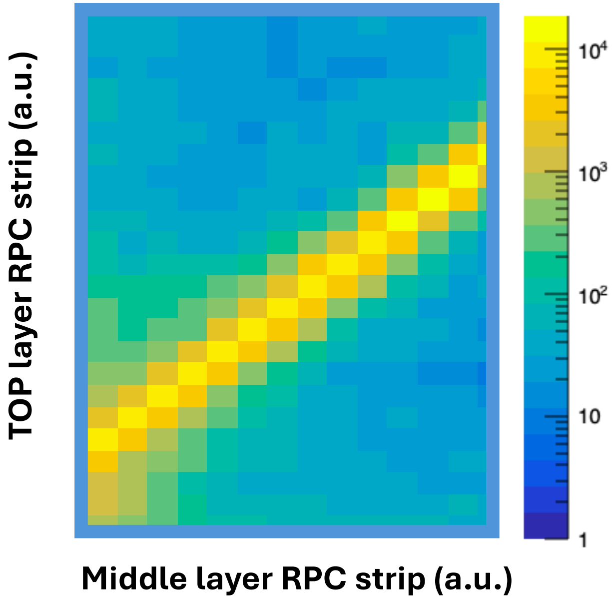
In this configuration one RPC is at HV(WP) and the acquisition is performed on the two that are OFF, but with the electronics switched on. This test allows to see if there is some correlated noise among singlets

3. Efficiency scan + performance @ WP

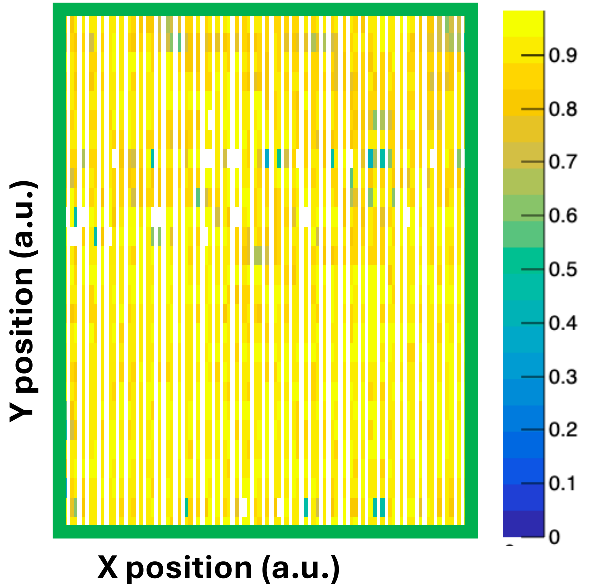
1. Efficiency scan: study of the RPC efficiency vs HV;

2. Performance at WP : Long acquisition (high statistics) aimed to the study of the main RPC parameter (efficiency map, cluster size, time over threshold…)

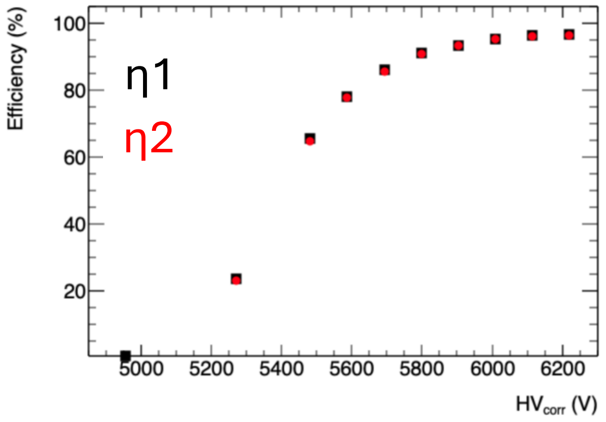
Cabling check



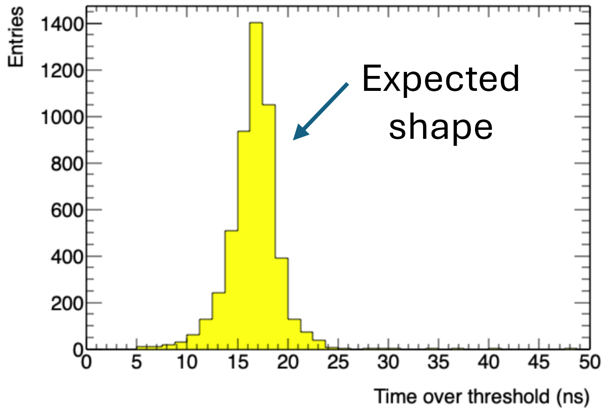
Efficiency map



Efficiency scan



Time over threshold



Tests with autotrigger

1 RPC OFF and two ON @ HV(WP)

1. BI RPCs will be used as trigger chambers→ Study of the performance in this configuration

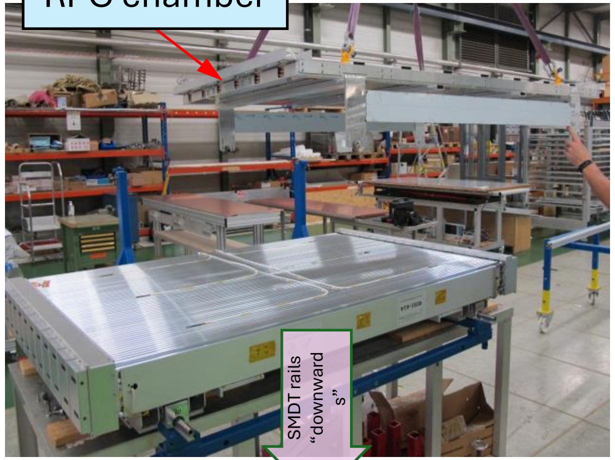
2. Study of correlated noise (‘fake muons’ due to self-induced correlated noise)

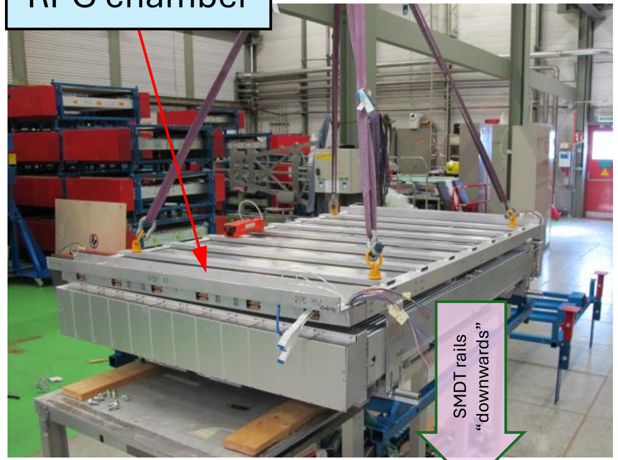
→ No discriminating variable found to tag these events with an external trigger or with all detectors switched on

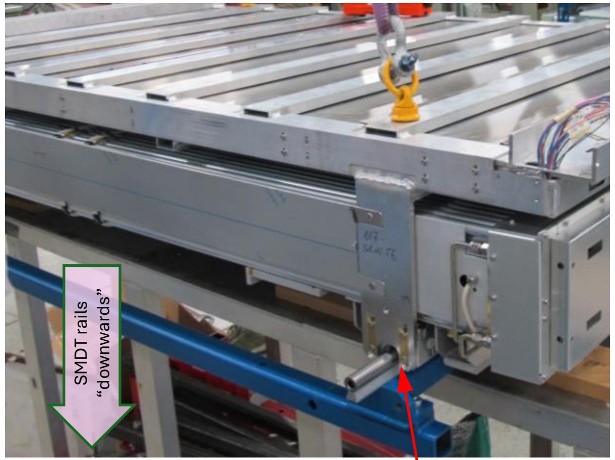
→ This kind of events is consistent with the expected behaviour of a muon signal from both timing (within 1 ns) and space (same n1-n2 strip) point of view

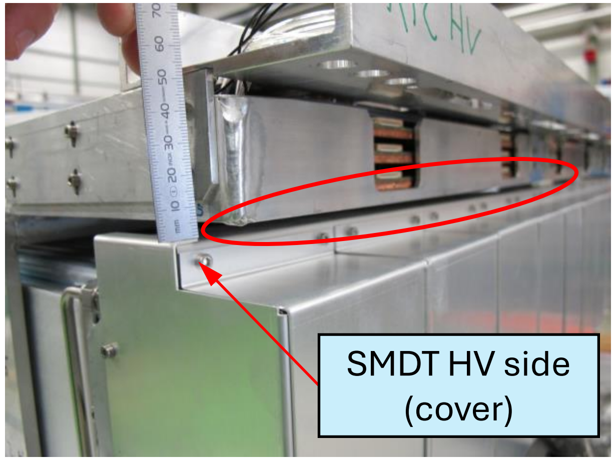
→ Not uniformly distributed among singlets and/or triplets→ possible loss in efficiency

Integration with s-MDT









1. Place the RPC chamber on the s-MDT chamber
2. Install the sliding plates on the RPC frame feet
3. Set and fix the position of the RPC(4 RPC frame feet)
4. Check the RPC position (envelope check)
5. Check the gaps between RPC and sMDT chamber (NO mechanical contact)
6. Independence test

Ready for the installation in the ATLAS cavern! ✓

Conclusions

The Max Planck Institute plays a pivotal role within the BI project, being responsible of the assembly and certification of the BIS-type triples, upholding the highest standards of accuracy and quality throughout the process

- Project of the CR test stand done
- Structure of the stations designed to efficiently test the triplets and minimize any delay due to problematic detectors
- Tests in order to guarantee the performance required for the ATLAS experiment, producing triplets with low-noise and full efficient

Max-Planck-Institut für Physik
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Thank you!
Questions are welcome

BACK UP