ATLAS RPCs@ GIF++

Annual User meeting

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ATLAS BIS78 Module 0 in 2021

- BIS78 chambers represent a new generation of RPC with respect to the ones installed in ATLAS
- The BIS78 module 0 has been installed at the GIF++ in summer
- It is a triplet detector with 2D readout, strip pitch 26 mm
- Total 318 channels
- Gas gap 1; mm electrodes 1.2 mm surface 180 x 110 cm^2
- FE electronics includes preamp + discriminator chip with LVDS output
  - IHP BiCMOS SiGe technology 1000 e- noise
  - Operated with an equivalent threshold between 6 and 2 pC/count of total charge for MIPS at > 95% efficiency
- Fully readout with the BIS78 vertical slice made of a set of HPTDC connected to a FPGA capable of self trigger on track, triggerless and external trigger modes

Test Setup

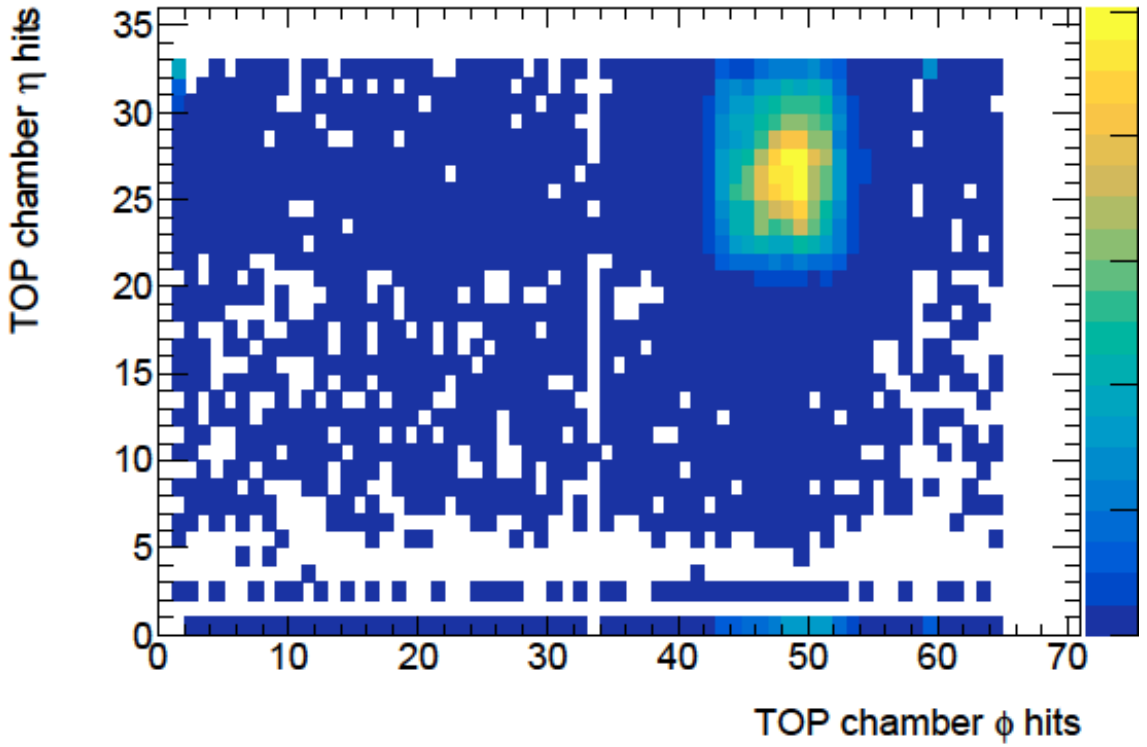
Two test beam sessions

- September focused on performance measurement for the chamber and for the readout system, in presence of HL-LHC radiation background
- October focused on performance comparisor between the standard gas mixture and various eco-compatible alternatives (ECO2 and ECO3). This last test is performed with the support of the ECO-Gas collaboration

STD = $C_2H_2F_4$/i-C_4H_{10}/SF_6= 94,7 / 5/0,3

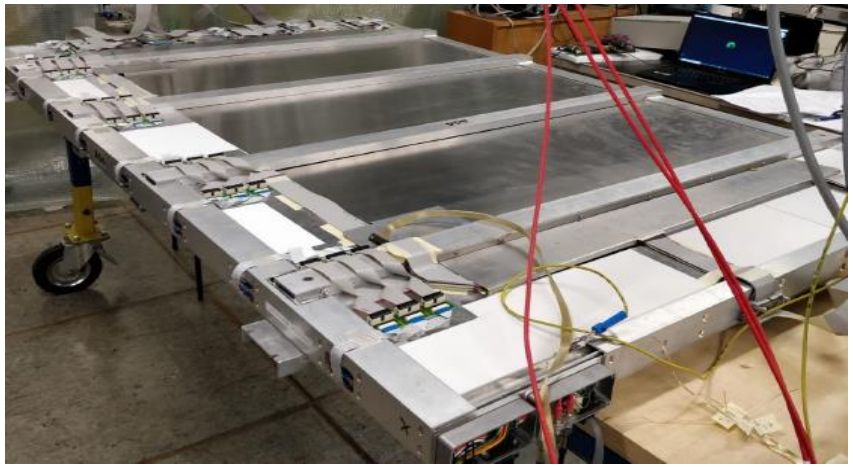
ECO2 = $C_3H_2F_4$/ CO_2 /i-C_4H_{10}/SF_6 = (35/59/5/1)

ECO3 = $C_3H_2F_4$/ CO_2 /i-C_4H_{10}/SF_6 = (25/69/5/1)



Detector features

- This chamber is a vide area 3 layers 3D+time tracker
- Can self trigger on CRs with a wide solid angle
- A good intrument to study both system performance and detector physics



Scope of the test

Test performed

a) Trigger and DAQ working at high rate

b) RPC performance vs. radiation background

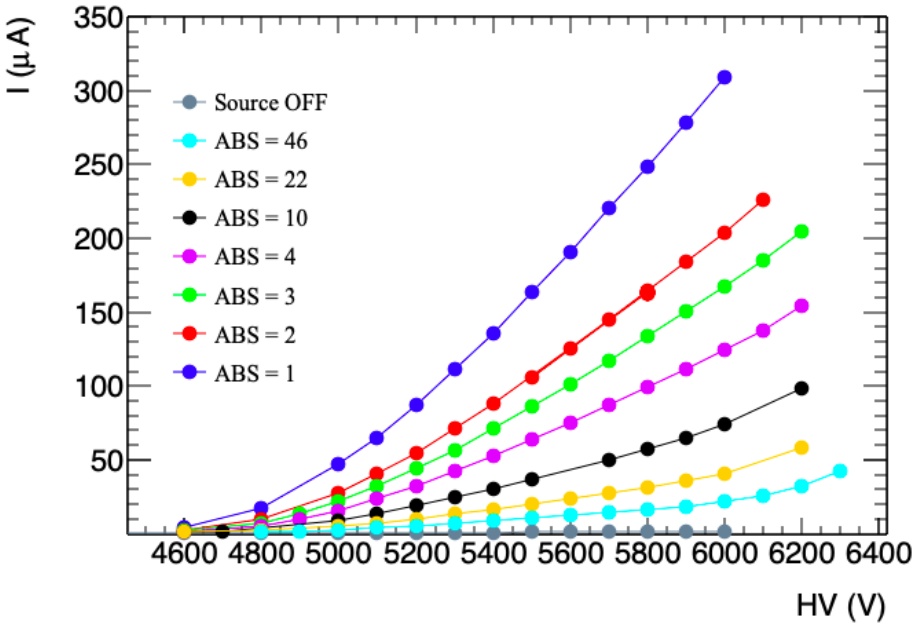
d) RPC Performance vs. Front-end threshold

e) Measurement of the average charge per count for gamma and MIPS vs. HV and FE threshold

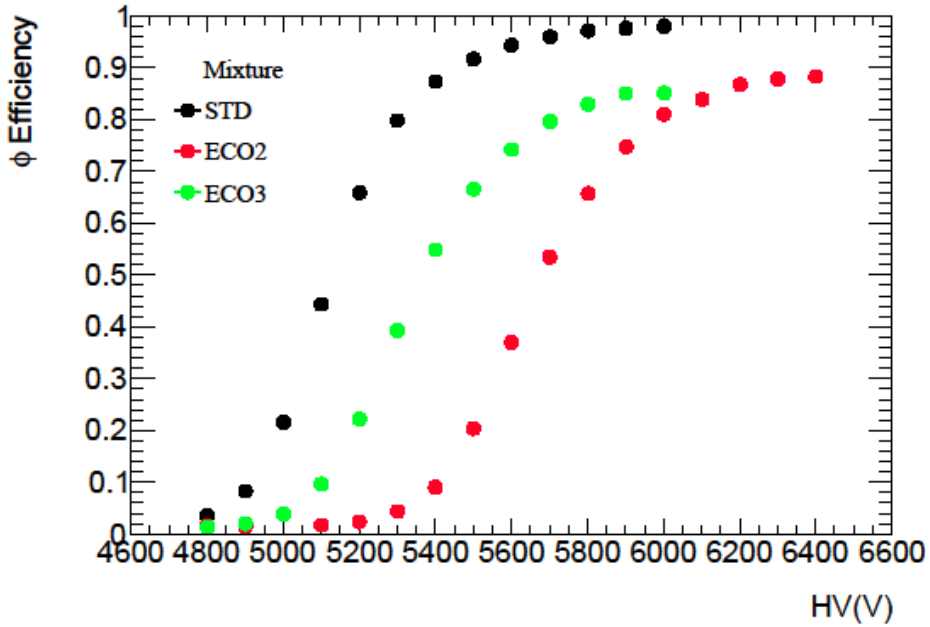
f) Timing performance through internal ToF

- Time resolution as a function of HV, FE threshold and gas mixture
- Estimate of the drift velocity for different gases

Current vs. HV for different source intensities



Efficiency of 1 mm gas gap for different gas mixtures



ATLAS RPC Plans for 2022

Ageing test program

- Period: end 2021 + 2022 + 2023
- Detectors to be tested:
  - BIS78 mod. 0
  - small size ATLAS like doublet
  - Phase-2 real size prototypes
- Test mode: performance vs. Integrated charge
- Performance measured periodically with CRs and muon beam
- Longevity target with standard mixture:
  - Legacy RPCs → 30 pc/count @ 150 Hz/cm^2 x 15 HL-LHC years → 700 mC/cm^2
  - New gen. RPCs → 5 pc/count @ 300 Hz/cm^2 x 15 HL-LHC years → 225 mC/cm^2
- Longevity target with eco-gas mixture:
  - The average charge per count is higher with HFO but is very much mis dependent
  - charge/count of different mixtures must be measured in advance
  - The charge/count is specific of a given detector layout so targets may vary alot

Goal of the test:

- Assessment of legacy ATLAS detectors (2 mm gas gaps) longevity with eco-gas mixtures using minimal amount of HFO to determine the maximum safely operable w.p.
- Assessment of new generation RPC (advanced FE + 1 mm gas gap) longevity with
  - standard mixture
  - Eco-friendly mixture (ensuring full efficiency operation) may need higher HFO fractions or additions of R134A)
- Eco gas Mixtures for legacy and new generation RPC are likely not the same
- Additional flexibility in the gas system will be needed to test different detectors at the same time
- We will need to operate the new gen. RPCs at 2 pc/count to gain a further margin with higher fractions of HFO → detector integration challenge

Characterization of the ATLAS detectors ageing properties with different gases

- The ATLAS standard gas mixture has been characterized several years ago by measuring the fluoride concentration as a function of
  - Working point
  - Radiation background
  - Lenght of exposition time window
- It was also studied for relative variation of the main components
- The results are still applicable to the new generation RPCs
- What is missing is the equivalent characterization for a HFO based gas mixtures used with legacy and new gen. RPCs.
- We are planning to setup such a measurement set in collaboration with the CERN gas group
- Time schedule would be after the RUN3 start for man power conflicts...

Charachterization of recirculation systems

- Not an ATLAS specific activity
- Done with joint funds of ATLAS and CMS technical coordination and in collaboration with CERN gas group
- A dedicated recycling gas system will be installed in 2022

Some history

- The ability of present recycing systems to purify RPC mixtures has been measured several years ago at the old GIF facility
- The result was given in terms of the fraction of fresh gas needed over the recirculated volume and empirical values among 5% and 10% have been estabilshed
- The result is certainly significant but is system dependent under several aspects
- The main limit is that in this formulation the result would negatively depend on the recycling speed while it should be independent on it

PROPOSAL of a new measurement to find the limits of recycling systems

- Relevant to reduce the gas waste
- The limits on the fresh gas needs should depend on
  - Necessity to dilute the the polluting radicals not filtered by the filter system which are proportional to the total operating current
  - Necessity to dilute air intake proportional to time, and system tightness.
- The system will use an irrdiated ATLAS RPC set to provide an empirical assessment the gas quality, as a function of recycling parameters by watching both current and charge distribution maps obtained with photon hits and CRs
- CERN gas group will perform gas analysis to provide a quantitative gas quality assessment

ATLAS Phase-2 project gas gap validation test

- ATLAS Inner Barrell chamber production expected to start in the 1° quarter of 2022
- Total production is about 1000 gas gaps lasting more than 2 years
- Tested in batches of 24 each irradiated vertically on special trolleys (similar to the ones used for BIS78) → about 40 test cycles
- Need HV, gas and current readout, position flexible in the downstream area
- Cycle duration wed to wed
- In 2022 we expect 30% to 40% of production