Determination of the sensitivity of an ATLAS RPC to gamma and neutrons with Geant4

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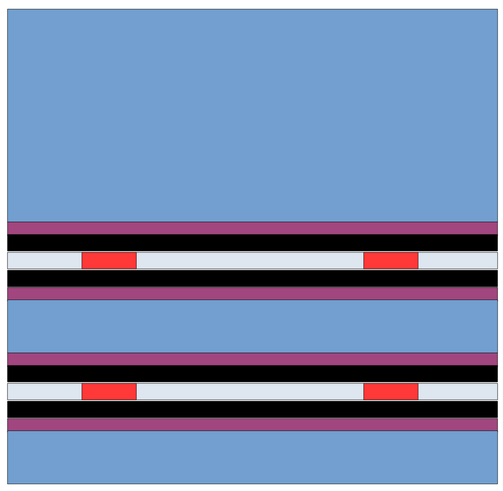
RPCs are fast and cost-effective devices widely adopted to instrument large area detectors, such as muon spectrometers.
The experiments at the Large Hadron Collider (LHC) operate in a large radiation background. With the increase of the luminosity of the LHC, the signal rate caused by neutral radiation originated from collisions in the beam-pipe, magnets, or from the activation of materials in the experimental area, should be estimated and cannot be determined from collision data.

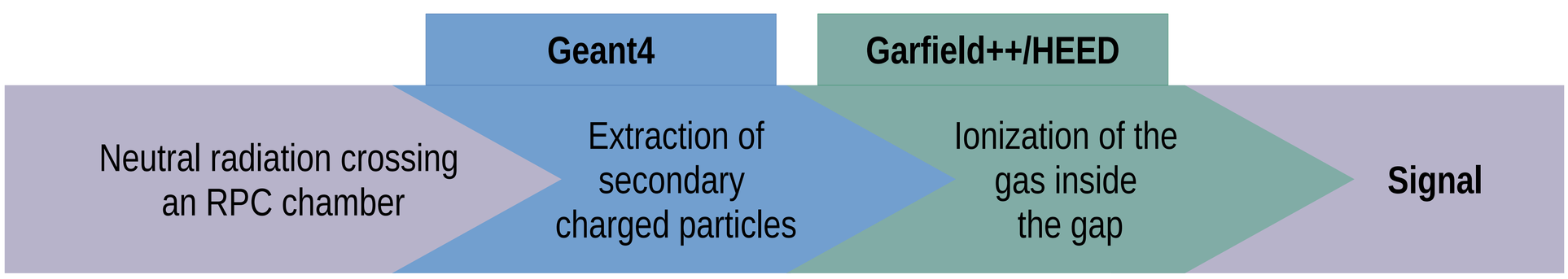
Schematic representation of the section of an ATLAS double-gap RPC



Material	Density (g/cm^3)	Composition (weight fraction)
Honeycomb	0.042	$C_6H_{10}O_5$
Foam	0.155	C_1H_1
Bakelite	1.25	H(0.0574) C(0.7746) O(0.1680)
Polycarbonate	1.20	$C_{16}H_{14}O_3$
Gas	0.006	$C_2H_2F_4$(0.947) C_4H_{10}(0.050) S_1F_6(0.003)

ATLAS RPCs: double gas gap with 2 mm thickness operated in the avalanche regime
Sizes in the drawing are not to scale

Procedure for the calculation of the RPC sensitivity to neutral particles

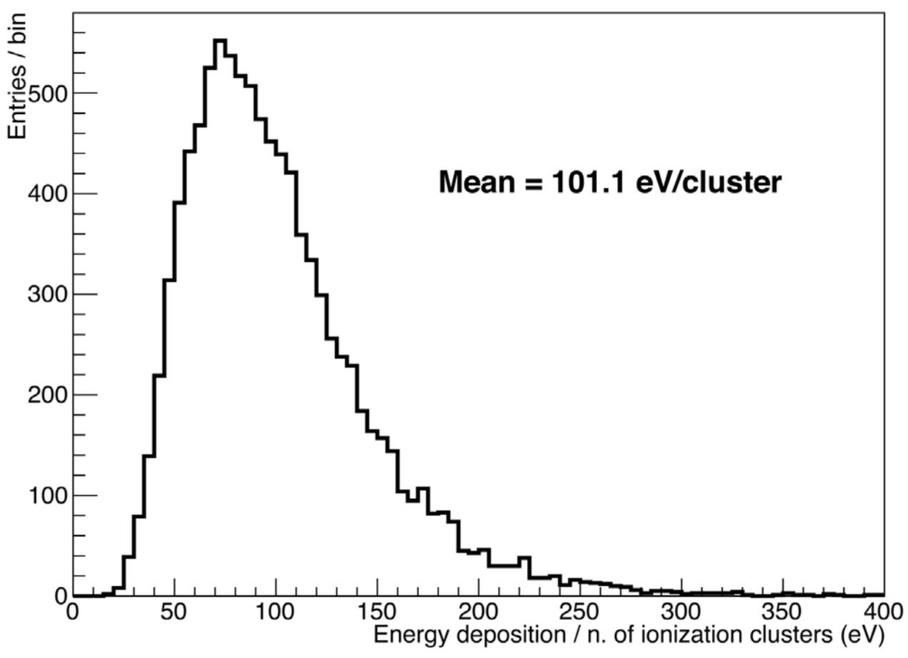


Sensitivity = N_{sig} / N_0

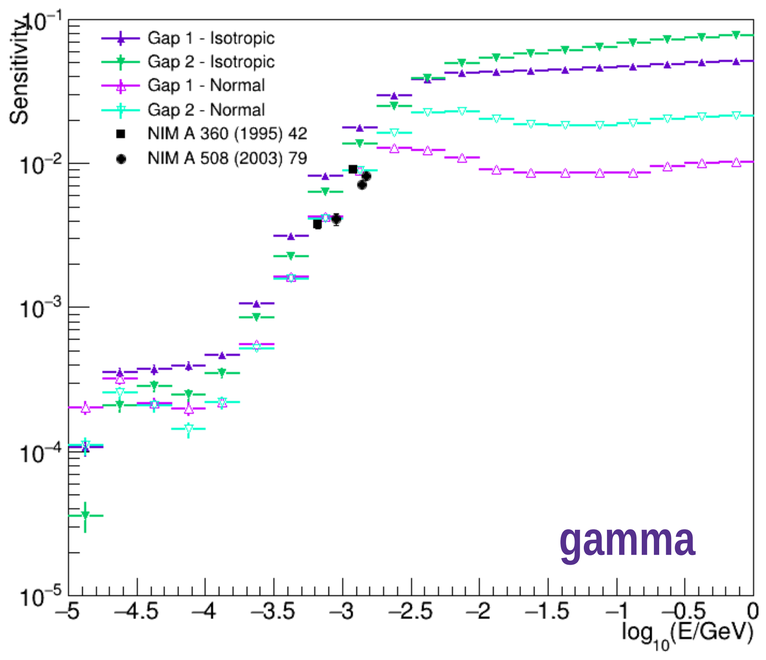
N_0: number of single particle events generated
N_{sig}: number of events with signal in a gas gap

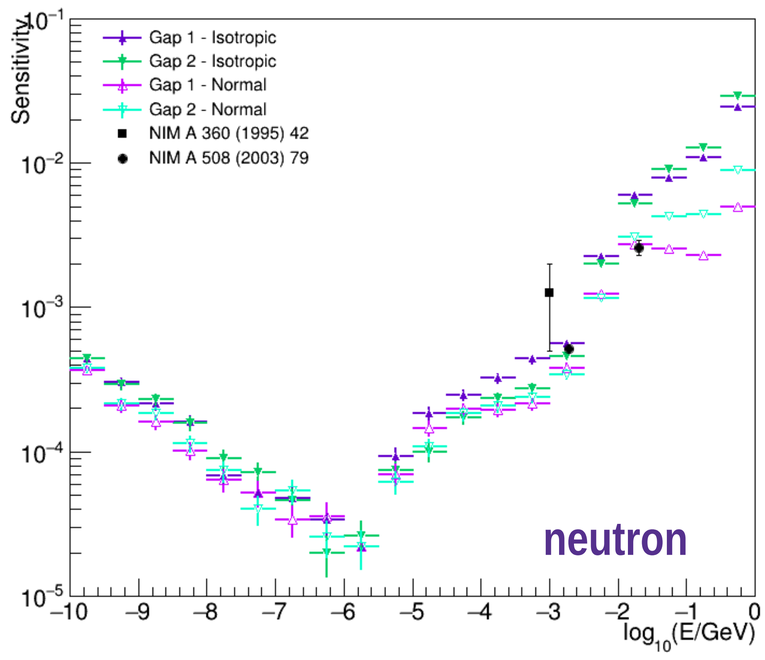
Geant4 is used to evaluate ionization energy deposition by secondary charged particles inside the gas gap. However, because of possible electron attachment or electron-ion recombination, not all the ionizations can produce a visible signal in the RPC.
A **Garfield++/HEED** simulation of the gas gap with the electric field allowed to extract the average energy deposition per ionization cluster, which is approximately 100 eV.
The RPC sensitivity is calculated assuming that the signal in the chamber is present if at least one ionization cluster is simulated.

This and other assumptions are made to extract the result. The detailed discussion of their impact on the sensitivity can be found in the paper.



Estimated sensitivity of an ATLAS double-gap RPC to gammas and neutrons





Results in the MeV region are in agreement with the measurements available in the literature [1,2].

In comparison with a previous estimate [3], which does not include the gas ionization effects, the sensitivity obtained with this method is consistent for gammas, while it is significantly smaller for neutrons with energy <1 MeV.

[1] Acitelli et al., NIM A 360 (1995) 42
[2] Abbrescia et al., NIM A 508 (2003) 79
[3] Jamil et al., Radiat. Meas. 43 (2008) 1554

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Detailed discussion of the results in the paper: *NIM A 953 (2020) 163122*