Radiation Damage effects in the ATLAS Pixel detector: how to inject a new digitization model in ATLAS MC to describe/improve the Run 3 data and exploit radiation damage studies to anticipate operation and performance limitations.

The tracking performance of the ATLAS detector relies critically on its 4-layer Pixel detector. As the closest component to the interaction point, this detector is subjected to a significant amount of radiation over its lifetime. The inner layer (IBL), consisting of planar and 3D pixel sensors, has exceeded by 2022 an integrated fluence of 1 × 10**15 1 MeV n_{eq}/cm^2.

Signal reduction is the most important radiation damage effect on performance of silicon detectors. Adjusting sensor bias voltage and detection threshold can help in mitigating the effects but it is important to have simulated data that reproduce the evolution of performance with the accumulation of luminosity, hence fluence.

ATLAS collaboration developed and implemented an algorithm that reproduces signal loss and changes in Lorentz angle due to radiation damage. This algorithm is now the default for Run 3 simulations. In this talk the algorithm will be briefly presented and the results compared to first Run 3 data.

A few key operation and performance metrics of the ATLAS Pixel Detector are also summarised, showing an optimum data quality and data taking efficiency. A special emphasis is given to how consider the radiation damage experience from multiple perspectives (Leakage current, depletion voltage, charge collection efficiency, front-end detuning...) and how precious can be the feedback for the detector operation.