Radiation Damage Modeling for 3D Pixel Sensors in the ATLAS Detector

Veronica Wallängen\textsuperscript{1,2} on behalf of the ATLAS Collaboration
\textsuperscript{1} Stockholm University \textsuperscript{2} Lawrence Berkeley National Laboratory

Radiation Damage in 3D Pixel Sensors

- Pixel sensors subject to extreme radiation environment result in decreased signal efficiency by causing charge carrier trapping in silicon bulk.
- 3D sensors reduce charge collection time to lower risk of trapping, making them suitable for innermost pixel layer for HL-LHC upgrade, expected to receive fluence above \( \Phi = 10^{16} \text{ n/cm}^2 \) during its lifetime.
- ATLAS pixel detector first high-energy physics application to use 3D sensors.

Charge Collection Model

Collectively propagating several charge carriers (~10) as "chunks" results in increased fluctuations of induced charge that are corrected for using the pre-calculated mean charge \( \langle Q \rangle \) and number of fundamental charges in each chunk \( \phi_i \):

\[
Q \rightarrow Q + \frac{1}{N} (Q - \langle Q \rangle)
\]

Charge contributions from all chunks added and converted to Time-over-Threshold (ToT) value, or "digit".

Results

Predictions from 3D digitizer model proved to agree with experimental data.