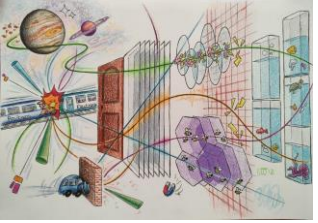



# WG3: Radiation Damage & Extreme Fluences

## General Radiation Damage Studies – Device and System level

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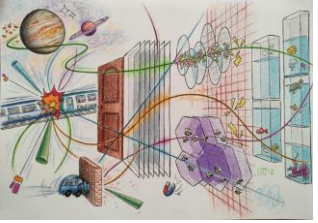
on behalf of the DRD3 proposal writing team



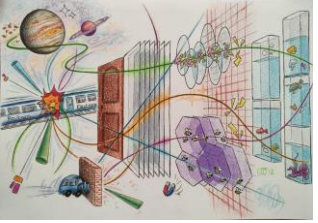
# General radiation damage studies - the interests of the experiments

- Tracking/timing (many flavors of LGADs, 3D,..) - aimed at the *earliest* upgrades will continue to need regular irradiations with various particle species up to ~5 x $10^{16}$ $n_{eq}/cm^2$.

- New efforts e.g. in high-granularity calorimetry. Large area and thick Si devices, applications for LHCb Upstream Tracker, Electron-Ion Collider, space-based detectors will need radiation testing and radiation damage modeling.

- Later upgrades need radiation damage studies already now, for evaluation of MAPS, monolithic CMOS, ASICs. Calls are made for facilities able to provide up to $10^{18}$ $n_{eq}/cm^2$, with multiple beam energies […see talk of Marko].

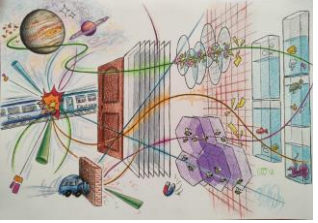
- TCAD/MC/Geant4/… simulations are ongoing for new structures and need benchmark data.



# General radiation damage studies - the interests of the experiments, continued

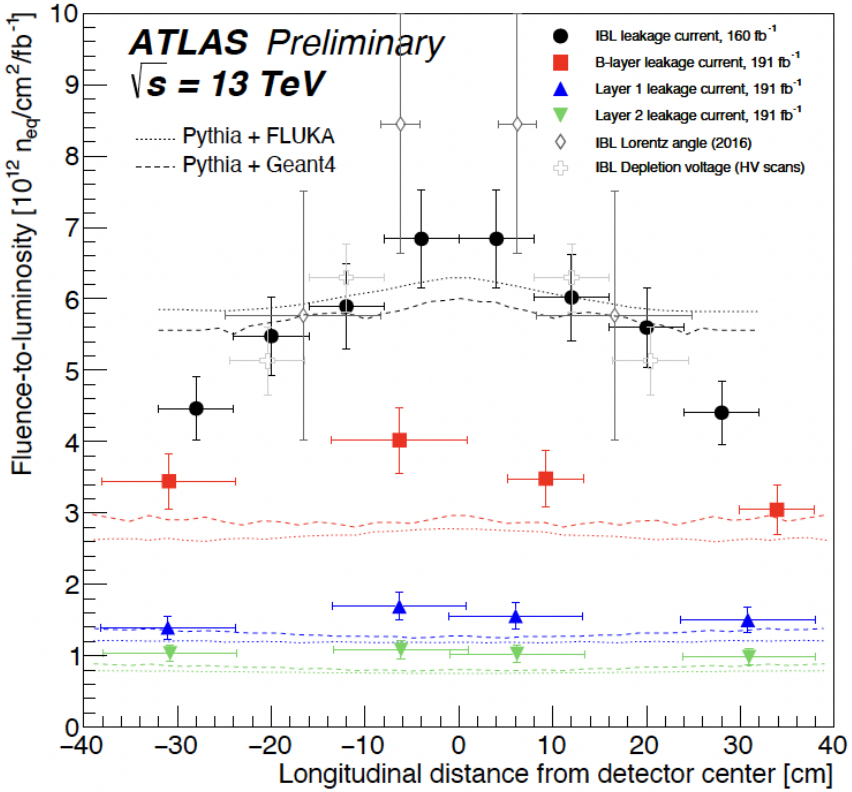
DRD3

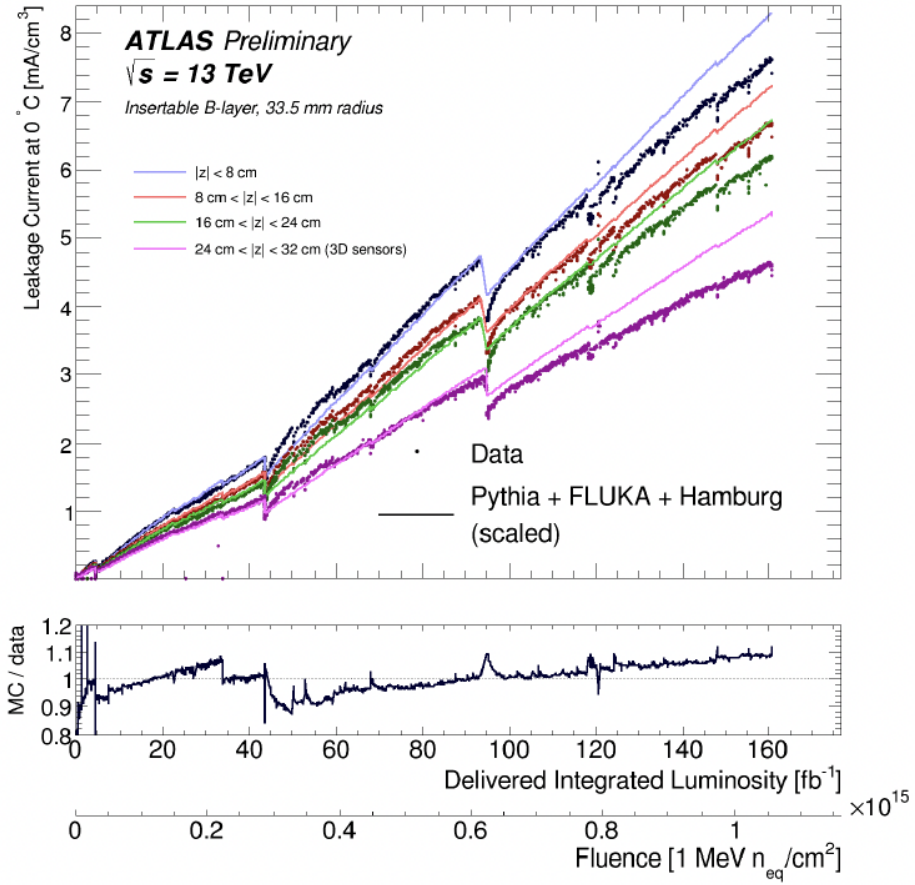
- New materials are under exploration – wide bandgap semiconductors, may reduce cooling requirements. New efforts in SiC, GaN, CdTe, CIGS, GaO, GaAs, diamond, silicon- and polymer-based conformal detectors. New or extended parametrized models for these materials are needed.
- New vertical and heterogeneous integration techniques directly connected to materials improvements.
- Ongoing work to understand how fundamental material properties – mobility, effective dopant concentrations, carrier lifetimes, etc. - evolve with dose.
- Motivations for tech transfer beyond HEP, for example medical imaging, dosimetry, nuclear safety and security – require rigorous radiation validation.
- Data are urgently needed – TCT and test beam – combined with dedicated data collected by the LHC experiments for leakage current and depletion.
- Need to understand the limit of validity of the current Hamburg Model – where NIEL fails – and best directions in defect engineering.



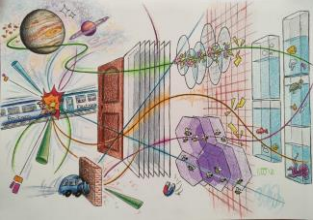
# LHC Experiments: Reaching the limits in modeling

- The “Hamburg Model” has worked very well but is reaching its limit: higher fluence basic data are needed.




Figures take from: CERN Yellow Reports: Monographs, CERN-2021-001



# The milestones

Expertise on radiation damage/hardening is essential in the coming years and should be kept in the community. Training of young researchers is an essential part to keep this knowledge.

- Milestones for 3 years
  - improved and/or new models for new materials and extreme radiation conditions based on a large set of experimental data
  - transfer of information from models to simulations
  - sufficient test beam support for this diverse program is required

- Milestone for 6 years
  - reliable availability of facilities for $10^{18}$ integrated fluence, charged and neutral.