TID study of ABCstar Chips for the ATLAS Upgrade Silicon Strip Tracker at the HL-LHC

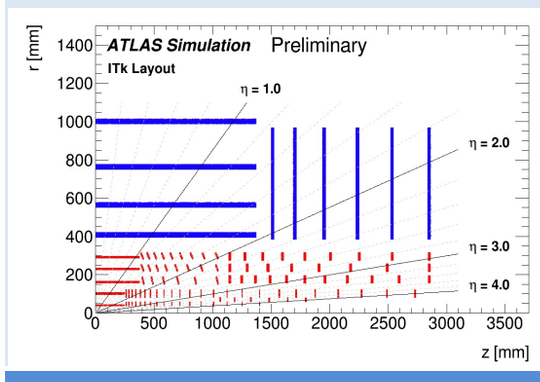
QINGDAO2021, 15th-20th August

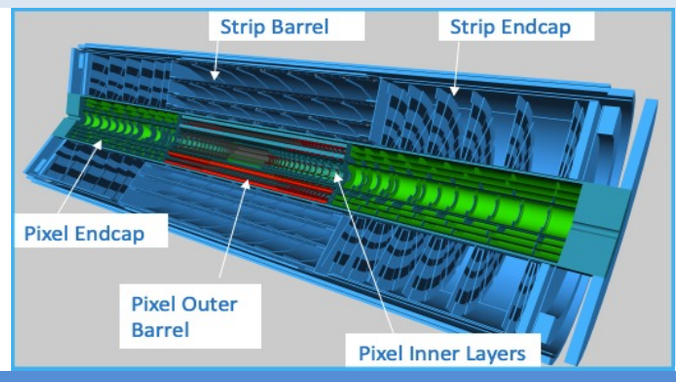
The increase of the leakage current of ABCstar chips for the upgrade of ATLAS inner tracker detector during exposure to ionizing radiation will lead to power consumption. Dedicated irradiation experiments for ABC130 chips(predecessor of ABCstar chips) have been performed at BNL and RAL. A dramatic increase of digital current with Total Ionizing Dose (TID) has been observed. Research regarding ABCstar chips is been conducting at RAL, IHEP is also involved in the study. This poster will focus on the latest results from IHEP TID research.

Upgrade of Inner Tracker of the ATLAS experiment for the HL-LHC

Introduction

- HL-LHC is aiming at delivering a total integrated luminosity of 4000 fb^{-1} to the ATLAS experiment. To cope with the high particle fluence and reliable readout, the current ATLAS Inner Detector will be replaced by an all-silicon system, the Inner Tracker (ITk), targeting on providing increased tracking coverage up to $|\eta| = 4$.
- The ITk consists of an inner pixel and an outer strip detector. The total surface area of silicon in the new pixel system measures about 13 m^2, the strip detector will compromise to 190 m^2 of silicon.

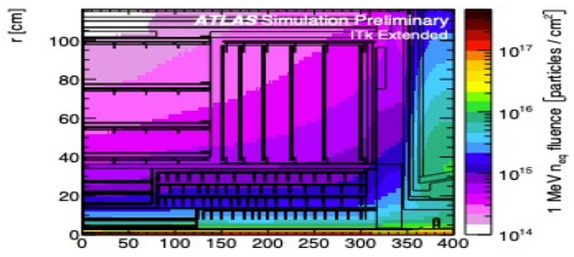




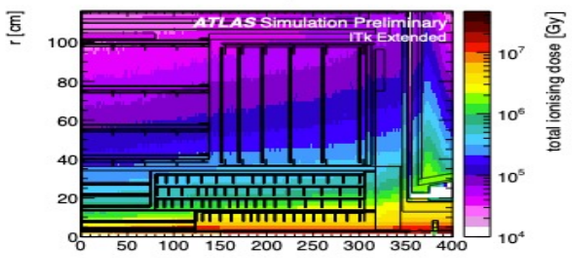
ATLAS Inner Tracker

- Inner layer of high granularity **Pixel** detectors.
- Inner layer of lower granularity **Strips** detectors.
- On of major challenges of upgrade is radiation damage, radiation dose becomes critical closer to the beam
  - Total Ionizing Dose (TID) up to ~50MRad in the strip region
  - Particle fluence up to 1.2 x 10^{15} 1MeV n_{eq}/cm^2 in the strip region

Max fluence [1MeV n_{eq}/cm^2]
Barrel: 8.1×10^{14}
End-cap: 1.2×10^{15}

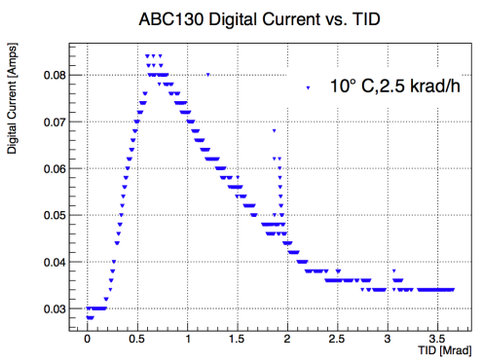


Max dose [Mrad]
Barrel: 35.7
End-cap: 50.4



Background of TID Bump

- Increase in the ABC130 digital current with Total Ionizing Dose (TID) has been observed, reaching a maximum up to ~600 krad, followed by a current decrease. This is known as TID bump.
- The bump brings up issues on power consumption reducing the reliability of the detector.

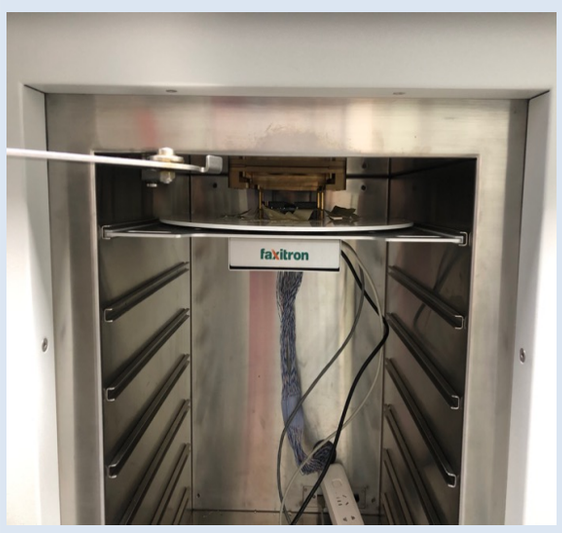


TID study at IHEP

Restricted to the number of chip, experiment was developed in which leakage current could be studied under the same room temperature and dose rate condition

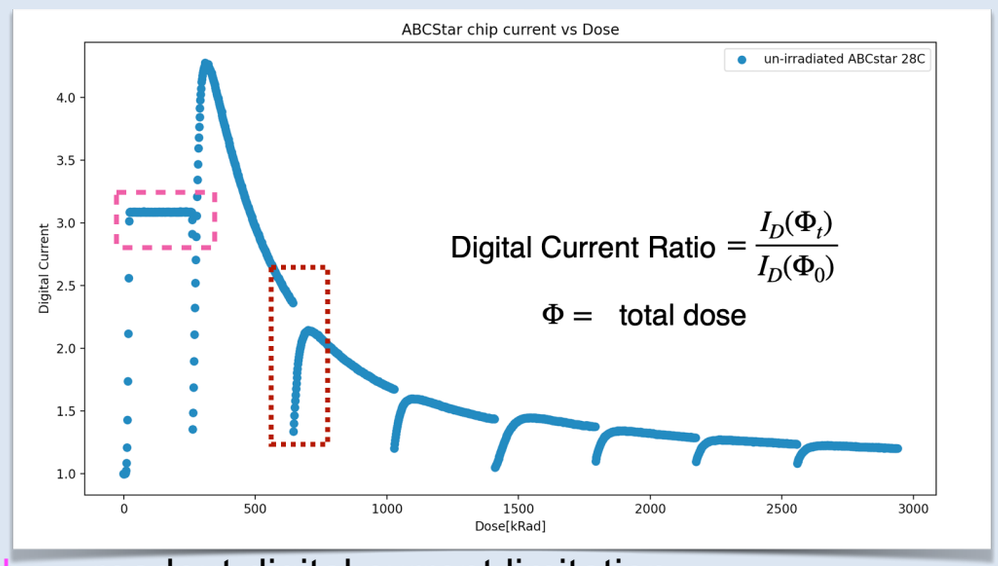
Experiment Setup

- Experimental apparatus comprises:
  - ABCstar readout chip (unirradiated)
  - Faxitron MultiRad X-ray
  - ITSDAQ system
    - PC running software
    - FPGA Board and Interface Board
  - Single-chip test Board
- Experimental conditions:
  - Room temperature: 28C
  - X-ray : 60kV, 20mA 0.36MRad/h



Results

- Study of the radiation-induced digital current of the ABCStar chip



- Pink box: readout digital current limitation
- red box: source OFF to run electrical functionality tests
- TID bump peak position: 400k~500kRad (less than results in RAL and BNL), maybe due to the limitation
- TID bump is presented and Annealing effect is shown apparently

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