Radiation hardness studies for the ePIC SVT

L. Gonella, E. Sichtermann
TIC meeting
11 December 2023

Radiation levels in the ePIC SVT

- Work has been done to understand the radiation levels in the SVT
  - Based off the work of the Background TF
  - Presented by Stephen Maple at the ePIC SVT meeting

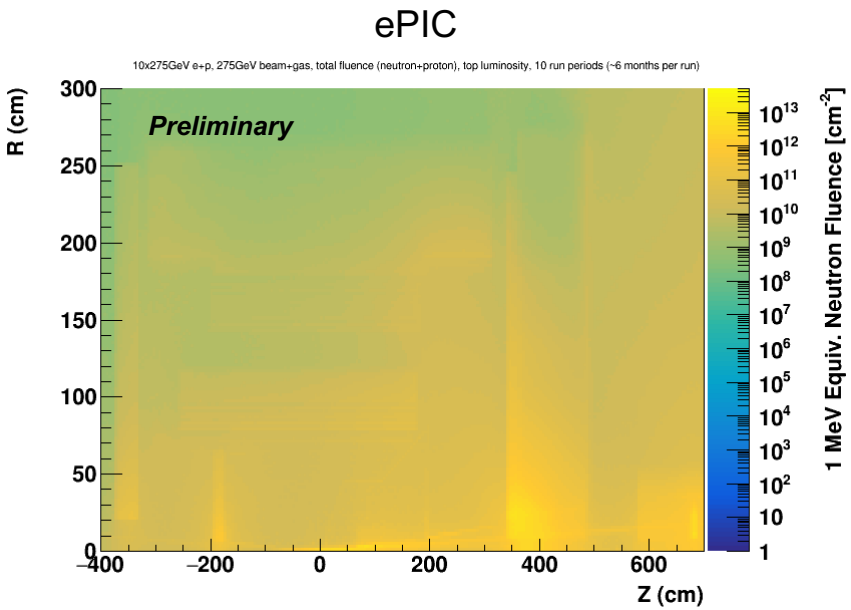
- This work estimated fluence and dose over the SVT region in the following conditions:
  - 10 x 275 GeV ep minimum bias events, top luminosity 10^{34} $cm^{-2}s^{-1}$, 500kHz DIS event rate
  - 10 GeV electron beam+gas events
  - 275 GeV proton beam+gas events at 10000 Ahr
  - Ten run periods, ~6 months each, with 100% machine and detector efficiency

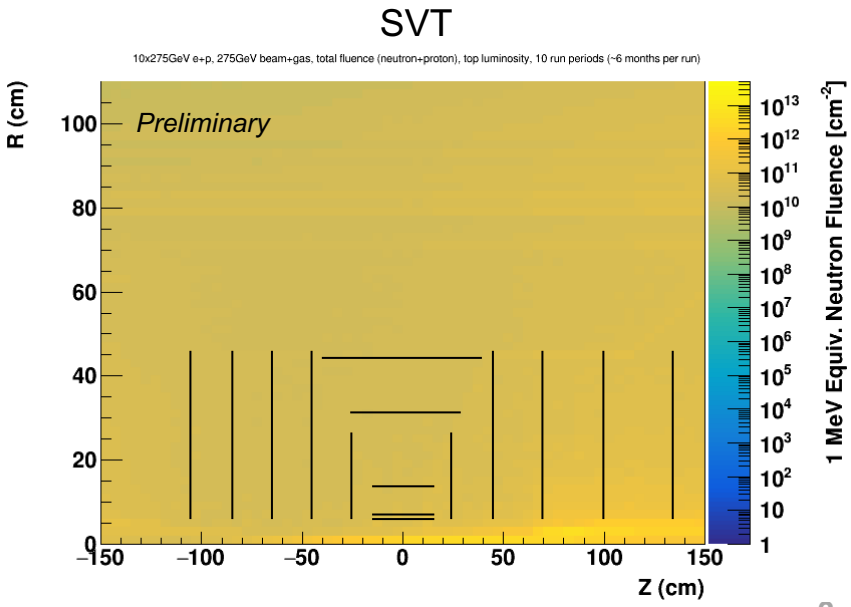
- **THIS IS A WORST-CASE ESTIMATE**
  - The EIC will not run at top luminosity for ten years
  - The EIC and ePIC will not run at 100% efficiency
  - The SVT will work at room temperature and a certain level of annealing will take place during irradiation

Fluence

- These plots show the 1 MeV neutron equivalent fluence in the ePIC detector and zoomed-in in the SVT region
  - Black lines show the approximate position of the SVT layers and disks
  - The colour scale needs improving

- Higher fluence close to beam pipe and in the hadron direction
  - L2 + OB + EDO-4 ~ 10^{11} n_{eq}/cm^2
  - L0, L1, HD0-4 ~ $10^{11\text{-}12}$ n_{eq}/cm^2



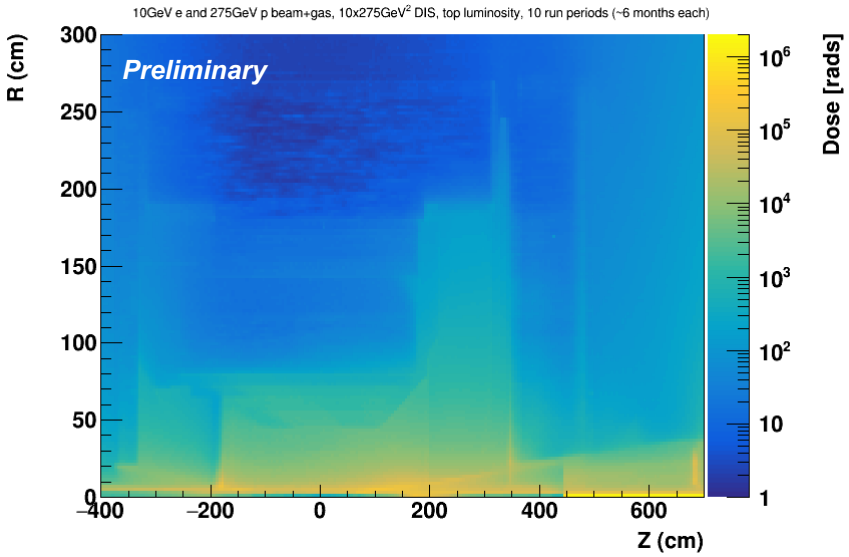


Dose

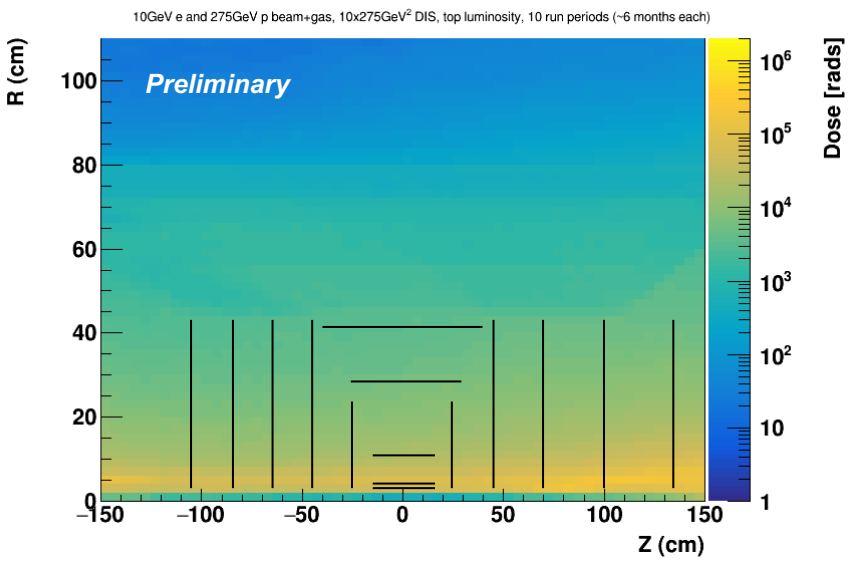
- These plots show the dose in rad in the ePIC detector and zoomed-in in the SVT region
  - Black lines show the approximate position of the SVT layers and disks
  - The colour scale needs improving

- Higher dose close to beam pipe
  - L0, L1 and inner part of the disks ~ 0.1 – 1 Mrad
  - L2, OB and outer part of disks ~ 10 krad

ePIC



SVT



SVT parts to be irradiated

(Preliminary list, work in progress by WP coordinators, to define all components)

- Sensor
  - ITS3 ER2, ER3
  - LAS
  - LAS support chip(s)

- Readout circuitry
  - COTS alternatives to lpGBT, VTRX+
  - COTS alternative to LAS support chip(s), i.e. FPGA
  - Power converters for lpGBT, VTRX+

- Mechanics and electrical services
  - Fibre optics cables
  - FPC
  - Foams, 3D printed materials (if any)

Irradiation details

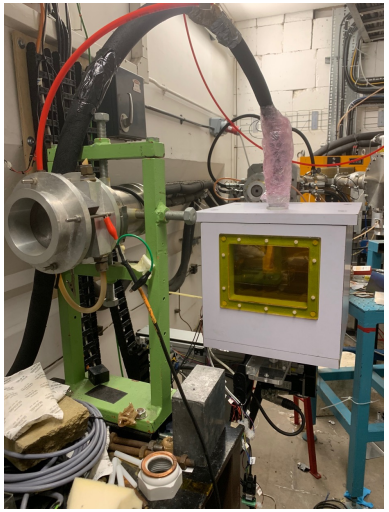
- Bulk damage: protons, neutrons
  - Sensors
- TID: gamma
  - Sensors, readout electronics
- SEE
  - Sensors, readout electronics

- Irradiations with conditions as representative as possible of the operational environment, or multiple irradiations with different parameters to allow extrapolation of the damage in the detector
  - E.g. Temperature, bias condition, dose rate influence the magnitude of TID effects
  - Facility specific irradiation conditions might require use of multiple sites (typ. biasing not possible in neutron reactors, typ. low temperature needed for high current proton beams, etc.)

- Detailed plan to be developed

Irradiation facilities within the SVT

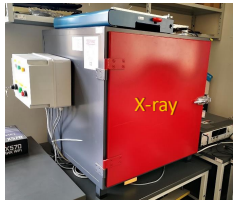
- High Intensity Irradiation Line at the Birmingham MC40 cyclotron
  - 27 MeV protons
  - EURO-LABS TA facility



- Irradiation facilities accessible via the Czech Technical University in Prague

What can we offer to ePIC SVT?

- Irradiation tests of detectors – available resources in collaboration with our partners:
  - **"In house"**: X-ray source 120kV, 36W, various table radioactive sources (Fe55, Am etc.), slow and fast neutrons (AmBe, 14 MeV DT generator, small nuclear reactor),
  - **UJP Prague** (ujp.cz): Cobalt-60 gamma ray, measured dose rate up to 400 Gy/min in area 5x5 cm^2,
  - **Nuclear Physics Institute CAS Rez** (ujf.cas.cz): reactor neutrons, ~30 MeV proton and heavy ion beam, electrons up to 25 MeV.



9.6.2023 ePIC SVT DSC kickoff meeting 7

- Berkely 88" cyclotron, BASE facility
  - Heavy ions, protons, neutrons
  - SEE testing facility