

(First estimates of)
Radiation levels and rates in the ePIC SVT

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Introduction

- Work has been done to start estimating the radiation levels and hit rates in the ePIC SVT
 - Based off the work of the [Background TF](#)
 - Presented by Stephen Maple at the [ePIC SVT meeting](#)
- The EIC running plan is not yet defined
 - The CDR gives five energy/luminosity combinations.

Beam energy [GeV]	5 x 41	5 x 100	10 x 100	10 x 275	18 x 275
L [$10^{33}\text{cm}^{-2}\text{s}^{-1}$]	0.44	3.68	4.48	10	1.54
DIS ep rate [kHz]	12.5	129	184	500	83

[EIC Conceptual Design Report, Table 3.3](#)

- For now we assume periods of running of 6 months per year

Summary of rates from background task force

- Rates for sources of **particle production** in central detector (+5m to -4.5m from IP)
 - Electron beam gas rates consider region of -5m to +15m from IP
 - Hadron beam gas rates consider region of -5.5m to 5m from IP

rates in kHz	5x41 GeV	5x100 GeV	10x100 GeV	10x275 GeV	18x275 GeV	Vacuum
DIS ep	12.5 kHz	129 kHz	184 kHz	500 kHz	83 kHz	
hadron beam gas	12.2kHz	22.0kHz	31.9kHz	32.6kHz	22.5kHz	10000Ahr
	131.1kHz	236.4kHz	342.8kHz	350.3kHz	241.8kHz	100Ahr
electron beam gas	2181.97 kHz	2826.38 kHz	3177.25 kHz	3177.25 kHz	316.94 kHz	10000Ahr

- Estimated with luminosity values from EIC CDR table 3.3 and cross section from Pythia

cross-section	5x41 GeV	5x100 GeV	10x100 GeV	10x275 GeV	18x275 GeV
DIS ep	28.5ub	35ub	41ub	50ub	54ub
hadron beam (p) gas	77.3mb	76.8mb	76.8mb	78.5mb	78.5mb
electron beam gas	622.158 +/- 0.036 mb	622.158 +/- 0.036 mb	699.393 +/- 0.041 mb	699.393 +/- 0.041 mb	768.343 +/- 0.049 mb
DIS eA	ub	ub	ub	/	/
hadron beam (Au) gas	3418mb	3440mb	3440mb	/	/

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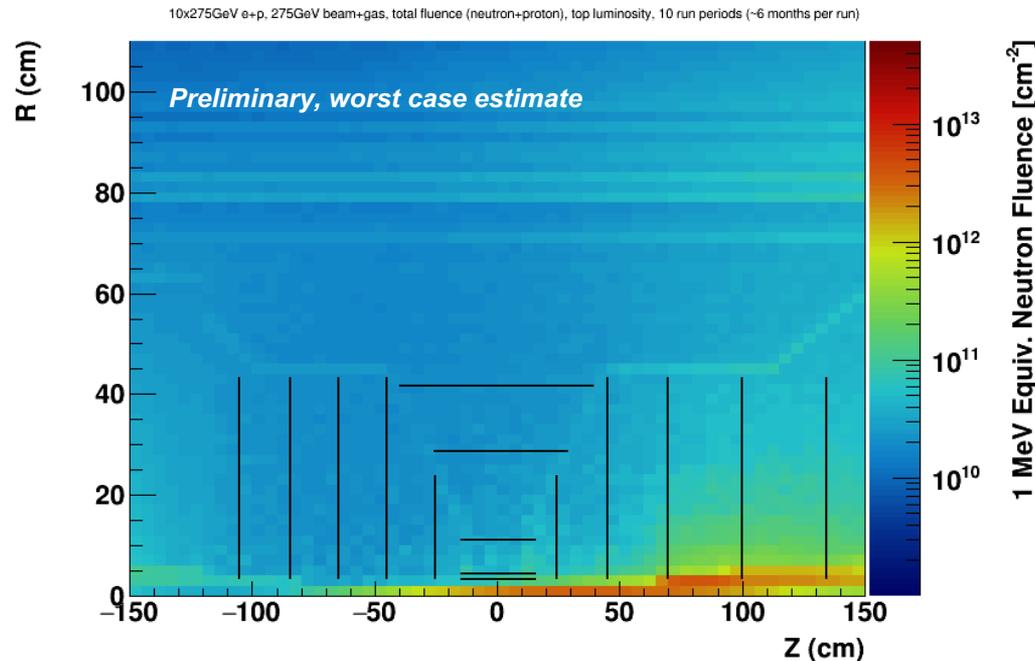
[EIC Conceptual Design Report, Table 3.3](#)

Radiation levels in the ePIC SVT

- This work estimates fluence and dose over the SVT region in the following conditions:
 - 10 x 275 GeV ep minimum bias events, top luminosity $10^{34} \text{ cm}^{-2}\text{s}^{-1}$, 500kHz DIS event rate
 - 10 GeV electron beam+gas events at 10000 Ahr
 - 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 during data taking periods
 - The SVT will work at room temperature and a certain level of annealing will take place during irradiation

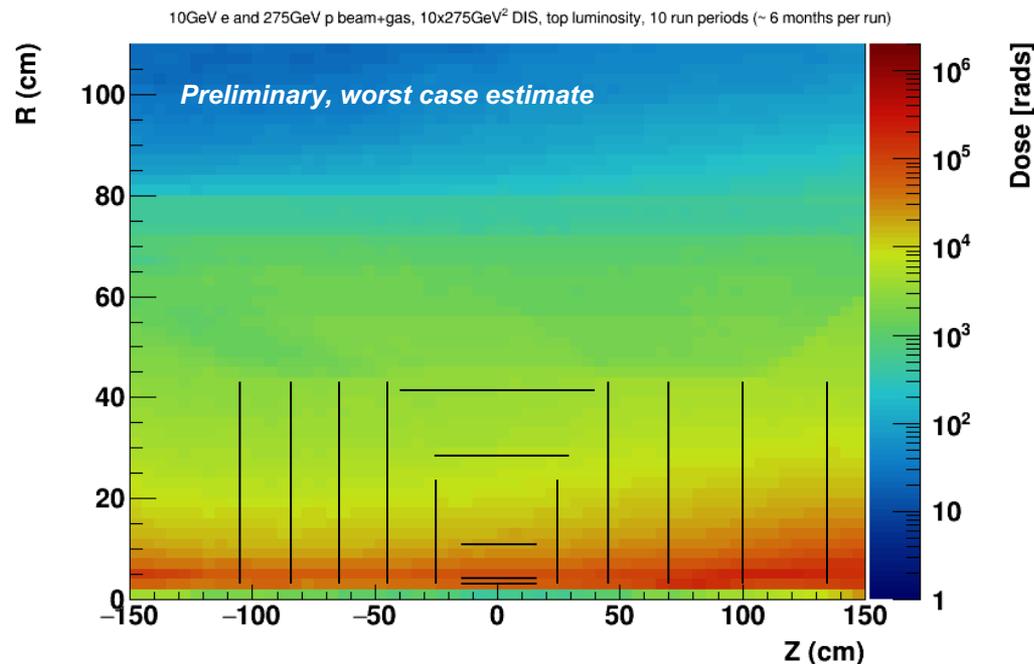
Fluence

- 1 MeV neutron equivalent fluence in the ePIC SVT region
 - Black lines show the **approximate position** of the SVT layers and disks
 - Note in particular that the inner radius of the disks will be larger for
- The majority of the SVT will see fluence levels **below 10^{11} n_{eq}/cm^2**
- **HD**: fluence between **10^{11} and 10^{12} n_{eq}/cm^2** ; in the innermost part of HD2-4 fluence of a **few 10^{12} n_{eq}/cm^2**
- **L0, L1**: fluence between **10^{11} and 10^{12} n_{eq}/cm^2**



Dose

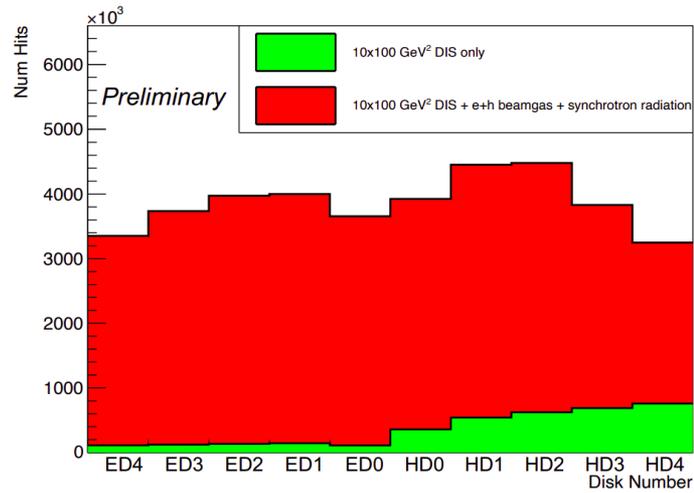
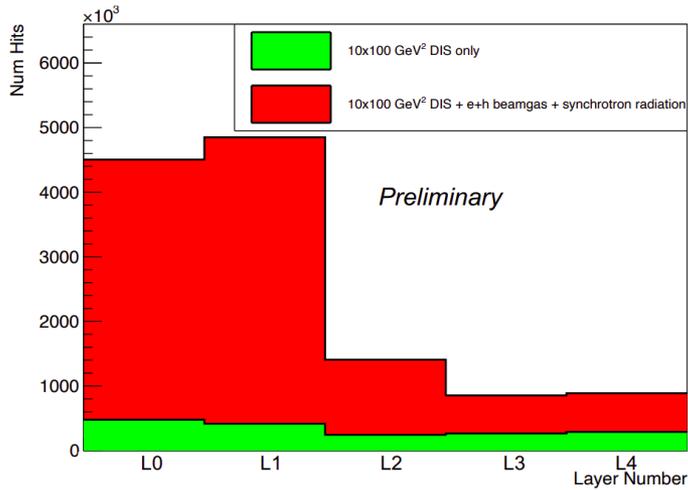
- Dose in rad in the ePIC SVT region
 - Black lines show the **approximate position** of the SVT layers and disks
- Area close to the beam pipe will experience a total ionising dose **between 10 krad and a few hundred krad**
- The rest of the SVT remains **below 10 krad**



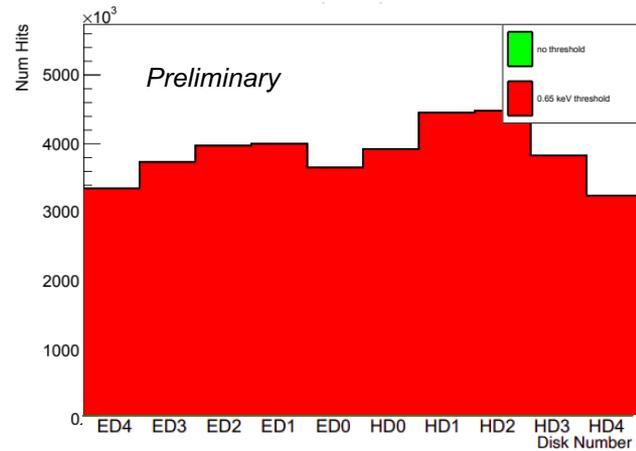
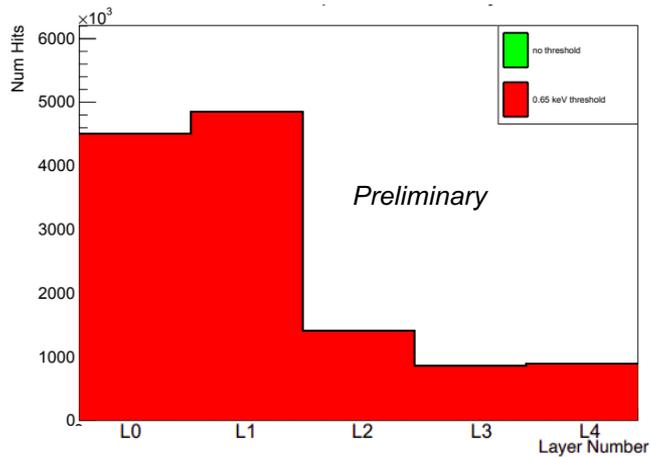
Hit Rates in the ePIC SVT

- This work estimates hit rate in the SVT region in the following conditions:
 - 10 GeV x 100 GeV DIS ep events, 184 kHz DIS event rate (not worst case physics rate)
 - 10 GeV electron beam gas, 3177.25 kHz (10000 Ahr)
 - 10 GeV electron beam SR
 - 100 GeV hadron beam gas, 342.8 kHz (100 Ahr)
 - $20.8 \times 22.8 \mu\text{m}^2$ pixel, 2 μs frame rate
- Cluster size and fake hit rate in the sensor not accounted for (yet)

Hit Rates in the ePIC SVT



No threshold applied
 Green: DIS only
 Red: DIS + backgrounds



Green: no threshold
 Red: 0.65 keV threshold

Hit occupancy in the ePIC SVT

- $20.8 \times 22.8 \mu\text{m}^2$ pixel, $2\mu\text{s}$ frame rate

	Hz	r (cm)	l (cm)	Area cm ²	Hits/s/cm ²	Hits/pixel/frame
L0	4.50E+06	3.6	27	610.73	7.38E+03	7.00E-08
L1	4.85E+06	4.8	27	814.30	5.96E+03	5.65E-08
L2	1.41E+06	12	27	2035.75	6.91E+02	6.56E-09
L3	8.55E+05	27	54	9160.88	9.33E+01	8.85E-10
L4	8.89E+05	42	84	22167.08	4.01E+01	3.80E-10
	Hz	r_in (cm)	r_out (cm)	Area cm ²	Hits/s/cm ²	Hits/pixel/frame
ED0	3.66E+06	3.676	24	1767.11	2.07E+03	1.96E-08
ED1	4.00E+06	3.676	41.5	5368.16	7.45E+02	7.07E-09
ED2	3.97E+06	3.676	42.14	5536.32	7.18E+02	6.81E-09
ED3	3.74E+06	3.848	42.14	5532.26	6.75E+02	6.40E-09
ED4	3.35E+06	4.152	42.14	5524.62	6.07E+02	5.76E-09
	Hz	r_in (cm)	r_out (cm)		Hits/s/cm ²	Hits/pixel/frame
HD0	3.92E+06	3.676	24	1767.11	2.22E+03	2.11E-08
HD1	4.45E+06	3.676	41.5	5368.16	8.30E+02	7.87E-09
HD2	4.48E+06	3.786	42.14	5533.75	8.10E+02	7.68E-09
HD3	3.83E+06	4.558	42.14	5513.51	6.95E+02	6.59E-09
HD4	3.25E+06	5.412	42.14	5486.76	5.92E+02	5.62E-09

Summary

- Fluence and dose
 - Estimated for **worst case scenario** of running 10 years at top luminosity
 - Including electron and hadron beam gas; SR contribution not included
 - **Low to moderate levels**
- Hit rate and hit occupancy in the SVT
 - Estimated for 10 GeV x 100 GeV DIS ep events plus beam gas backgrounds and SR
 - Cluster size and fake hit rate not included
 - Hit rate in the SVT dominated by background hits
 - 3-5 MHz in IB and endcaps, ≤ 1 MHz in OB
 - **Low hit occupancy per pixel per 2 μ s frame rate**

Next steps

- Work needs to continue to get to realistic estimates
- Hit rate and hit occupancy
 - Estimate for highest rate and luminosity (10×275 GeV), worst case
 - Add cluster size and fake hit rate (needs estimating/knowing)
- Repeat radiation and hit rate studies for eA collisions
 - When minimum bias DIS and ion beam+gas events available
- Once EIC running plan is finalised, get more realistic estimates