FLUKA Update

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Simulation Meeting

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Electronics Hardness

All important risks of damage to electronics can be scored in FLUKA

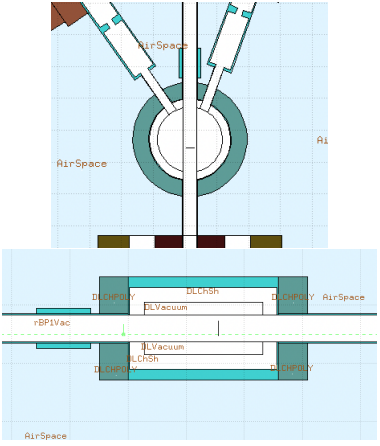
- Cumulative damage
  - Energy deposition (ionizing)
  - Lattice displacement (1-MeV *n* equivalent fluxes, non-ionizing)
- Single event upsets
  - "High" energy hadrons ($>$ 20 MeV), not significant with 30 MeV beam energy

Simulated Shielding

As a starting point:

- 1 cm thick lead sheet around GEMs, 10 cm high, no roof, for gammas
- 5 cm thick borated polyethylene around chamber, for neutrons

Unfortunately, exact placement of permanent magnets is still up in the air, can impact shielding



Acceptable Levels

- Non-ionizing energy loss (NIEL)
  - A quick literature search indicates a total 1 MeV n equiv. flux $\mathcal{O}(10^{14})/\text{cm}^{-2}$ has a noticeable impact on SiPM breakdown voltage
  - Dark current begins to increase $\mathcal{O}(10^{10})/\text{cm}^{-2}$, and we lose single photon resolution
- Ionizing energy loss (IEL)
  - Surface current density roughly doubles around 10^5 Gy
  - Plastic damage at 10^8 Gy

NIEL reference
https://www.sciencedirect.com/science/article/pii/S0168900218315055
IEL reference
https://www.sciencedirect.com/science/article/pii/S0168900213007420?via%3Dihub

FLUKA Shielding Comparisons

1 MeV *n* equiv. fluence and Dose estimate from FLUKA in the SpecL *far* SiPMs.

Pb (cm)	0	1	5
B-PE (cm)	0	5	5
n_{fl} (cm^{-2} hr^{-1})	40×10^{10}	1×10^{10}	10×10^{10}
Dose (kGy/h)	$\approx$10	$\approx$6	$\approx$4

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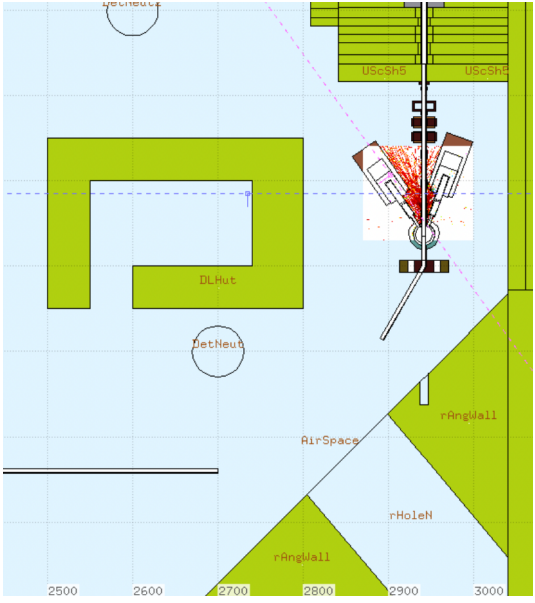
Dose (kGy/h)	$\approx$6	$\approx$3	$\approx$7

Near and *far* refer to proximity to target.

FLUKA Shielding Conclusions

- ???
- Statistics limited
- Shielding clearly needed for neutrons
- Shielding not making a huge difference for γ
- Need to run for additional thickness, 10 cm (?), and for 10 times more events

Additional Work - Electronics Hut



Need dimensions, location, etc. NB. Don't put it directly in the path of the proton shine.

Additional Work

Bonus: Presented on minor hot spots near experiment hall roof from γ at collab meeting. Those spots disappear completely with additional experiment shielding.

- Implement detectors in FLUKA
- Understand dark current limits
- Implement slanted lead shielding
- Talk with TRIUMF about proton beamline shine