# FLUKA Update

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# Electronics Hardness

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

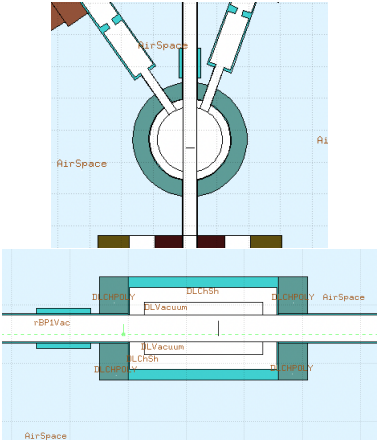
- Cumulative damage
  - Energy deposition (ionizing)
  - Lattice displacement (1-MeV *n* equivalent fluxes, non-ionizing)
- Single event upsets
  - "High" energy hadrons ($>$ 20 MeV), not significant with 30 MeV beam energy

# 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 Results

- 1 MeV *n* equiv. NIEL
  - With shielding we see $\mathcal{O}(10^{10})/\text{cm}^{-2}/\text{hour}$
  - Indicates we can run for $10^4$ hours before we begin to see any impact on scintillator resolution and dark current
- $\gamma$-related IEL
  - With shielding we see $10^4$ Gy
  - Indicates we can run for 10 hours before dark current begins to increase
  - Can run for $10^4$ hours before damage to plastic becomes serious

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

# Next Steps

- Implement detectors in FLUKA
- Understand dark current limits
- Implement slanted lead shielding