Background from nuclear targets

Status update from the Task force:

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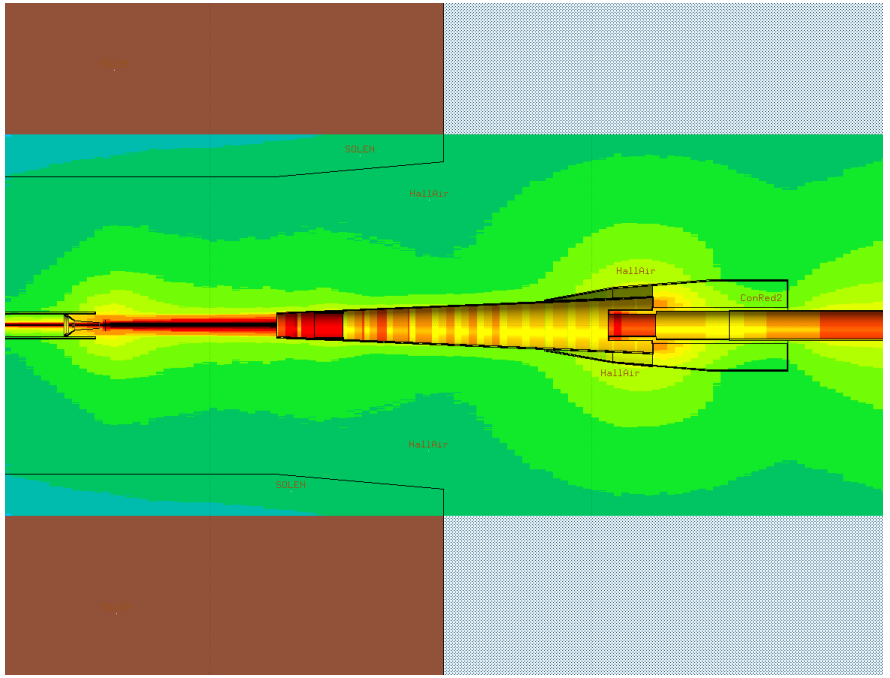
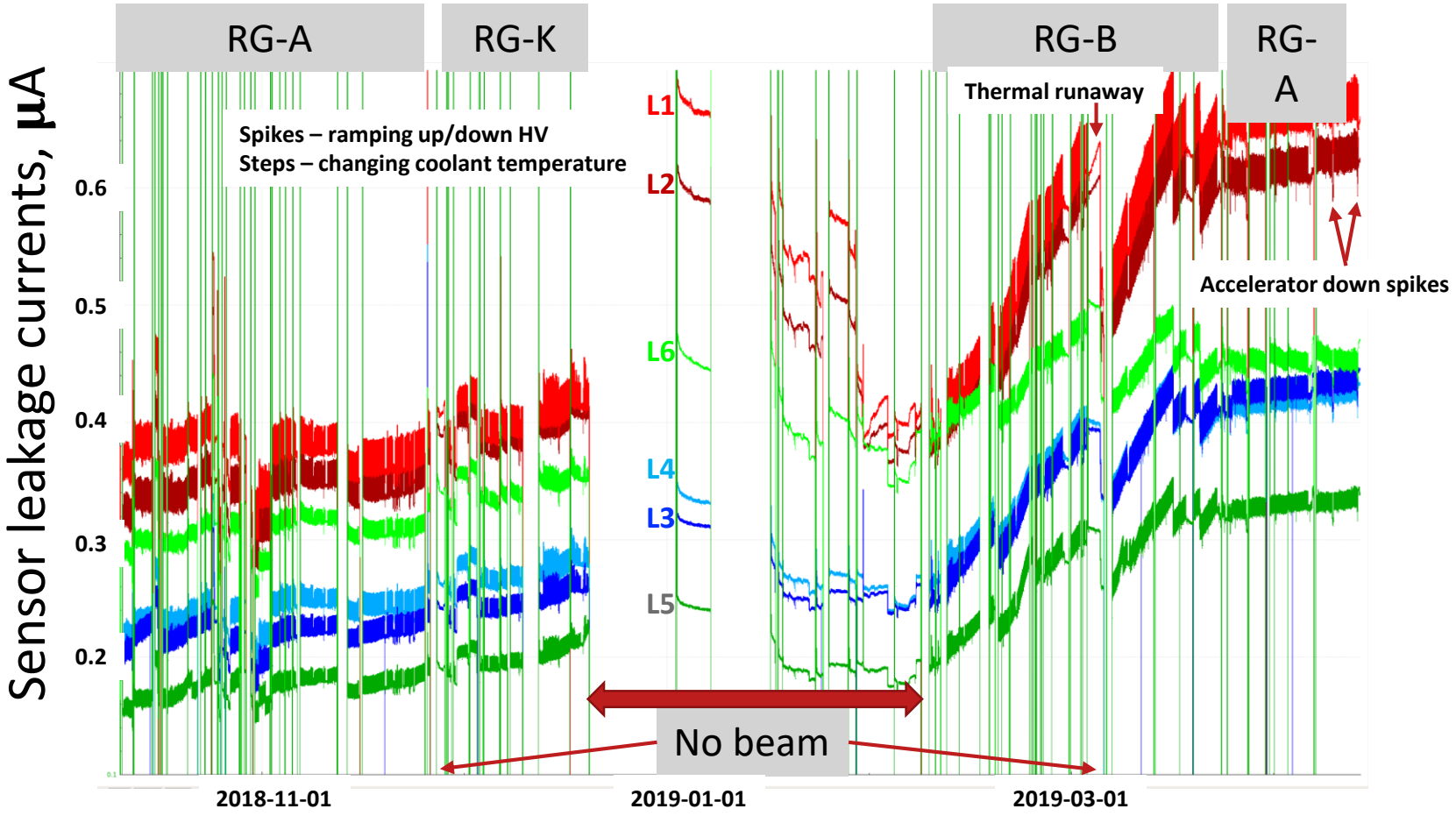


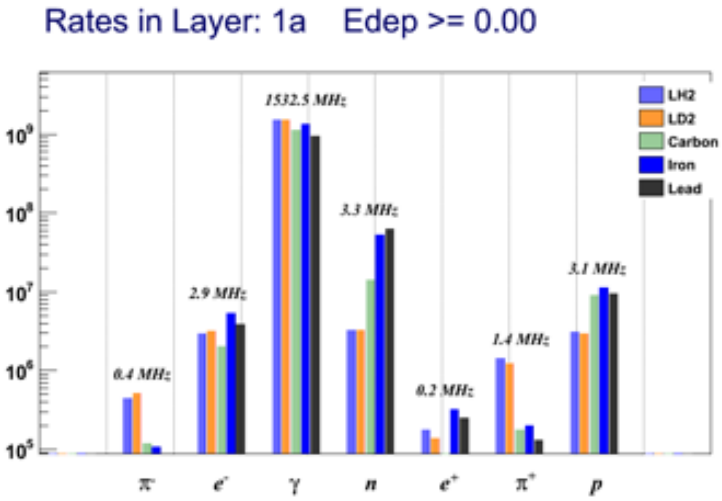
Eugene Pasyuk

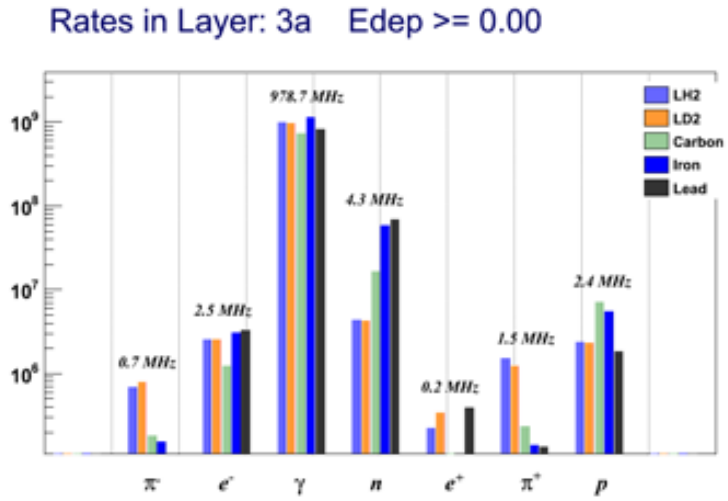
Unexpected increase of leakage current

SVT sensor leakage currents

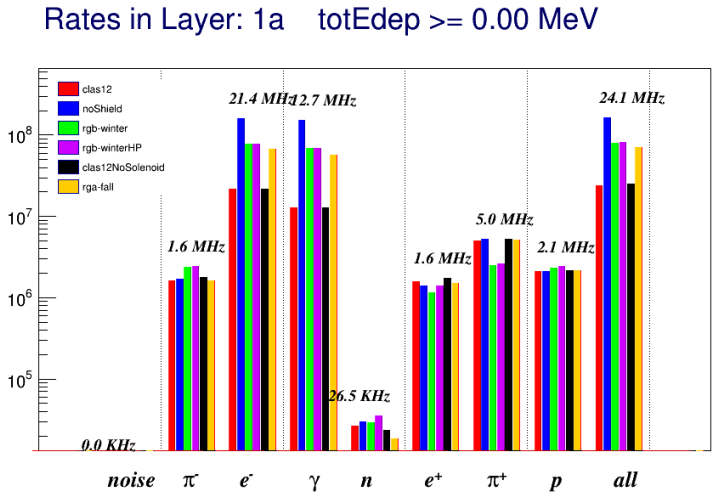


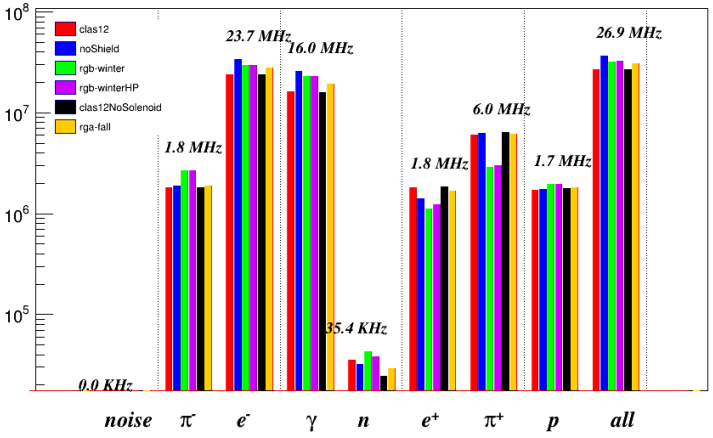
Now and then





10 years ago





1 month ago. Issue appeared sometimes after geant4 version 10.9.6

Questions

- Why current Geant4 neutron flux is a factor of ~100 less than the simulation in 2010?
- How accurate is geant4 compared to experimental cross sections, and to other models like FLUKA?

What has changed?

Maybe due to physics list code implementation changes:

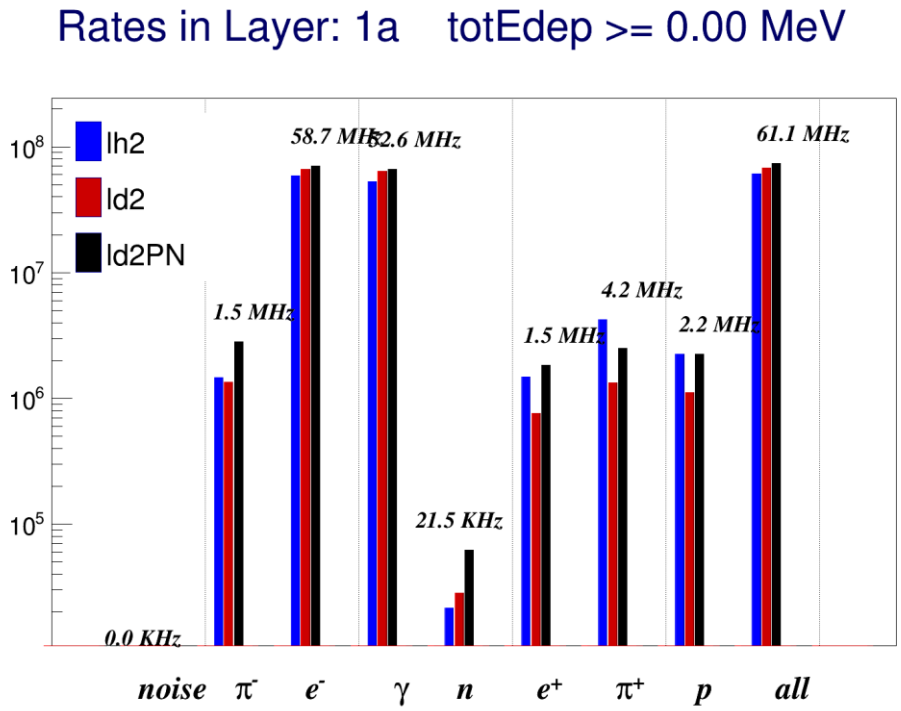
- modular physics list. Physics list packages now specialize in EM physics and Hadronic processes
- The photo-nuclear (PN) processes are not within a physics list package, and some models like CHIPS are not easily available as before.
- No documentation on how to use the PN models, except in some examples.
- Physics list changes even after introduction of physics list.

Digging into GEANT4

- GEMC updated to use the very latest geant4 version. No effects on the result, still factor of 100 discrepancy
- Revamp of Physics list mechanism to match the latest examples. Also, Adding PN processes in gemc: physics list option "PhotoNuclear" added

Effects:

- difference between LH2 and LD2 (previously, no difference).
- With "PhotoNuclear" processes: 2x pions, 2x protons, 3x neutrons.



Ongoing work: step in right direction (factor of 30 instead of 100)

particle	rate (MHz)	1 MeV Neutron Damage Rate (MHz)
e-	67.2124	0.329577
pions	1.21853	0.809765
neutrons	0.0374612	0.0204375
protons	1.1229	8.50723
Total:	69.5913	9.667

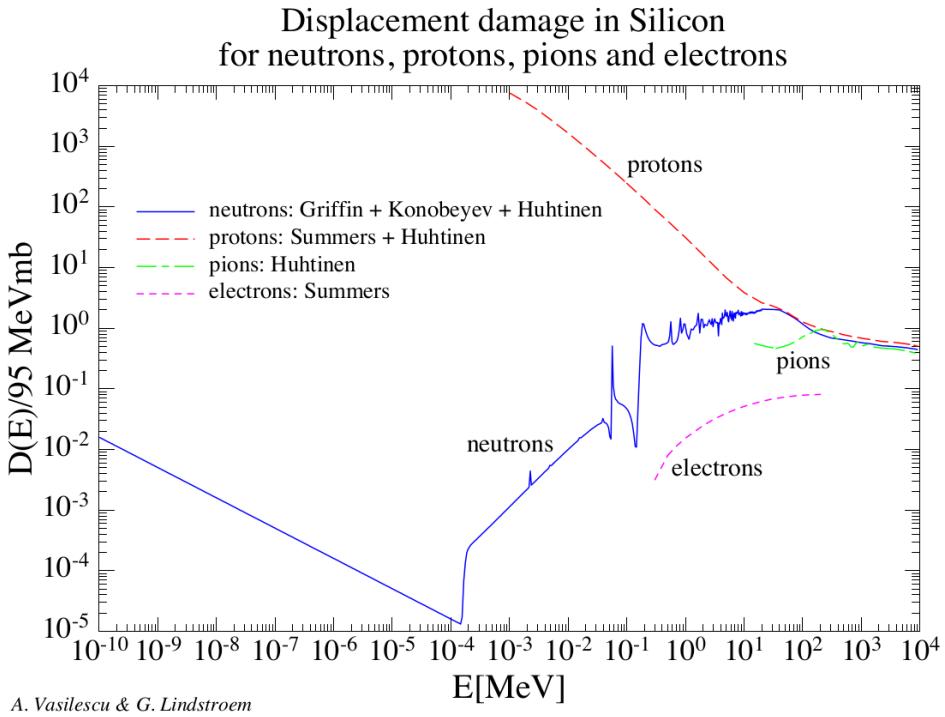
No PN (old)

particle	rate (MHz)	1 MeV Neutron Damage Rate (MHz)
e-	69.0779	0.431341
pions	2.51686	1.66231
neutrons	0.104969	0.0362654
protons	2.25628	17.257
Total:	73.956	19.3869

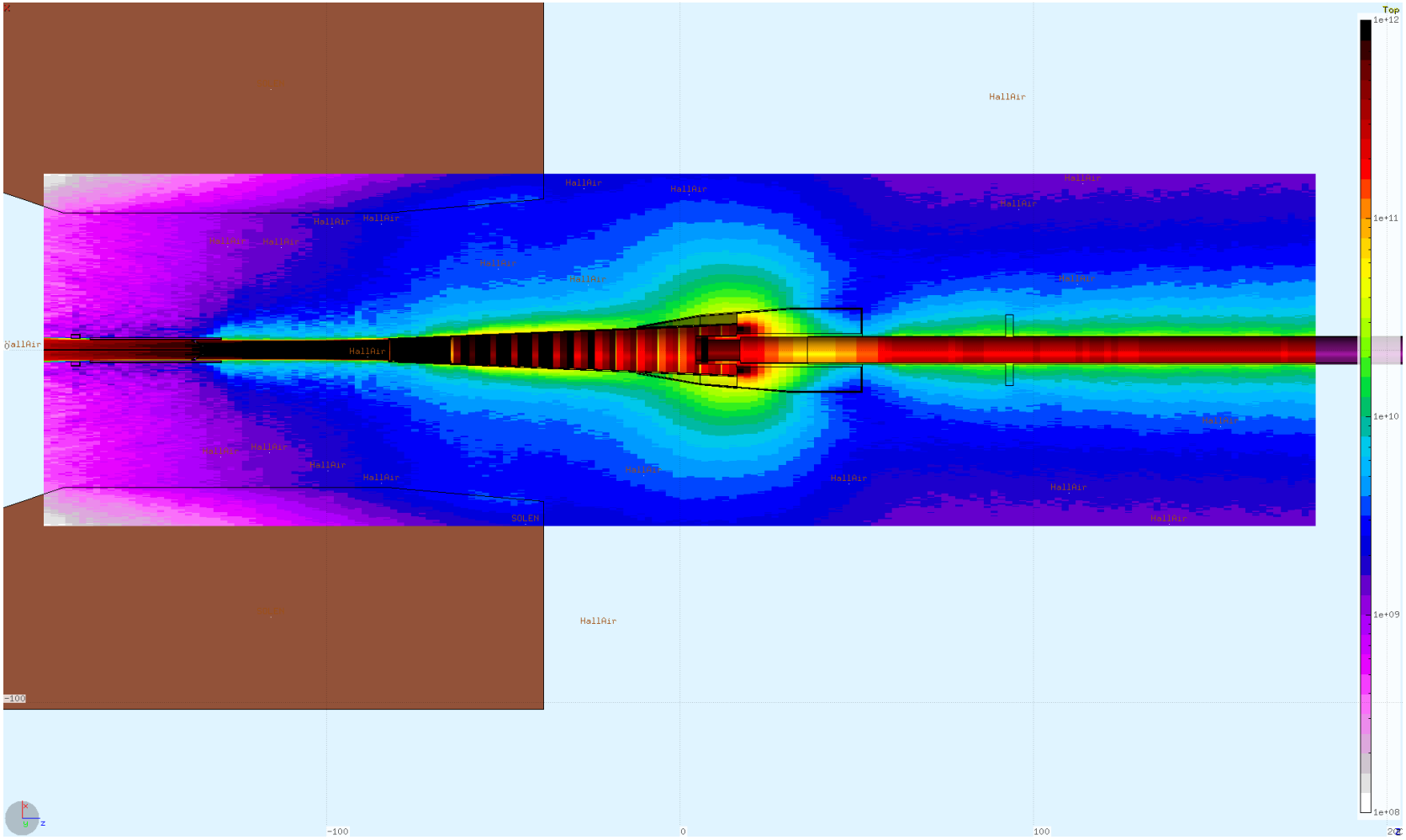
New: PN

Simulation with FLUKA

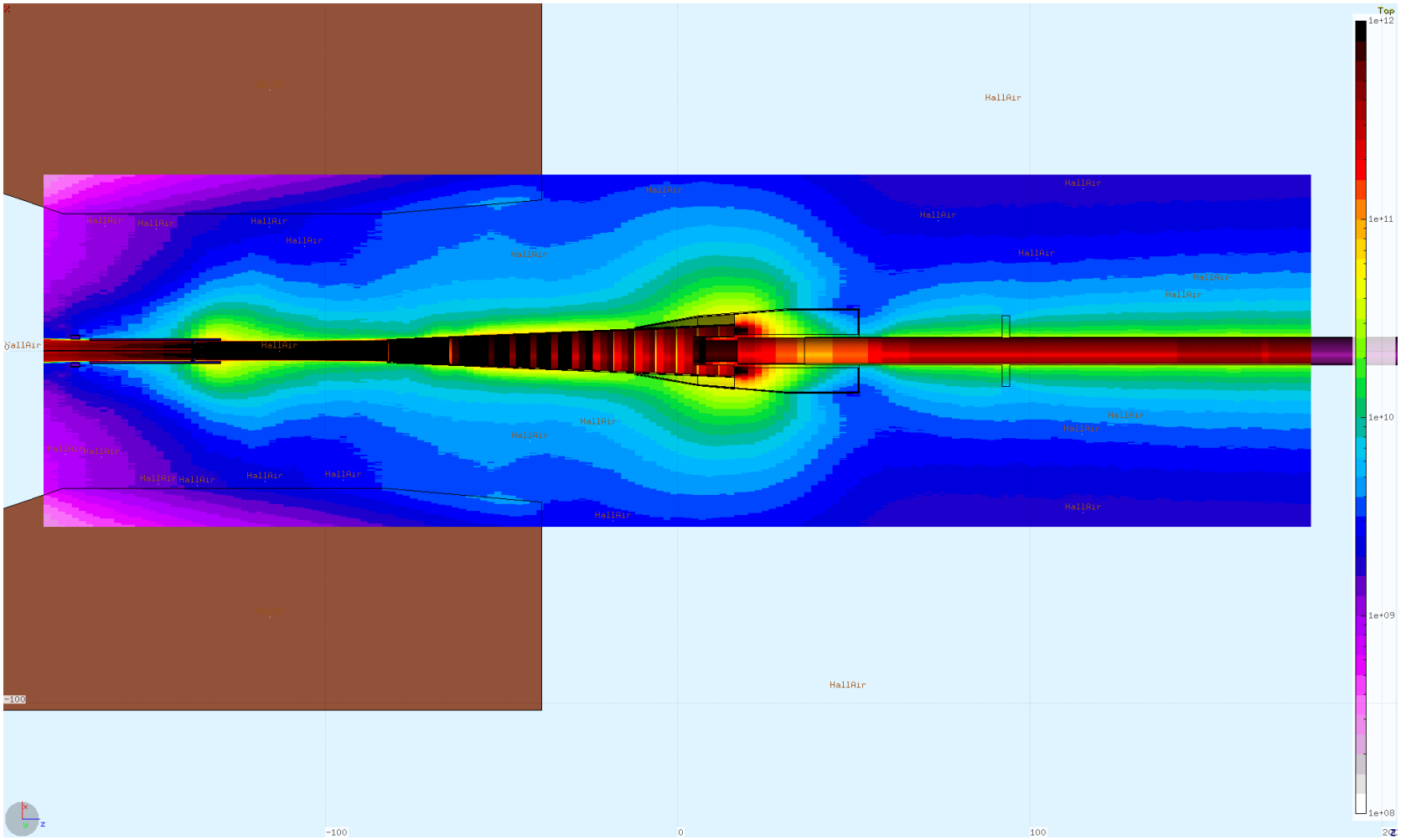
- Radiation is calculated for experiment, convoluting exposure with different targets
- Dose is expressed in rad
- Activation is expressed in mrem/h
- For damage on Silicon, 1MeV-eq neutron fluence



Spring Run with Hydrogen (1MeV-eq) 108mC



Spring Run with Deuterium (1MeV-eq) 108mC



Comparison

- Increase fluence ~10 times in the proximity of the target
- Still, levels below 3 order of magnitude respect to the expected lifetime of the detector

Radiation levels for different planned experiment

- Hall-B Run Group M: Run group M presentation
- Hall-B Run Group C: Run Group C presentation

Future work

- More Revamp of Physics list mechanism. Need to also check energy limits of applicability.
- CHIPS model found on examples. Need to try it.
- If geant4 CANNOT reproduce the PN data, we need to communicate this to the geant4 collaboration.

An alternative model is the CHIPS-based G4ElectroNuclearReaction [DKW00]. This model also uses the equivalent photon approximation in which the incoming electron or positron generates a virtual photon at the electromagnetic vertex, and the virtual photon is converted to a real photon before it interacts with the nucleus. The real photon interacts with the hadrons in the target using the CHIPS model in which quasmons (generalized excited hadrons) are produced and then decay into final state hadrons. Electrons and positrons of all energies can be handled by this single model.

Future work

- Build systematic way of comparing geant4 processes with known experimental data and FLUKA
- Small framework to measure fluxes and distribution for a very simple target
- Experimental data to compare
- Extract inclusive yields of various particles from random trigger data
- Dedicated background measurements with beam

Beam test

Schedule	Experiment	Energy (GeV)	Polarization	Days	Total days
CY 2020					
01/22 – 01/23	BONUS12	2.2	-	2	
01/24 – 04/10	BONUS12	10.6	-	78	80
04/11 – 05/05	Contingency		-	24	
Likely no beam in remainder of 2020					

Test setup:

- Solid target
- One or two silicon sensors
- Dosimeters
- Low energy neutron detectors
- …