Model for determining energetic particle interactions with ESP

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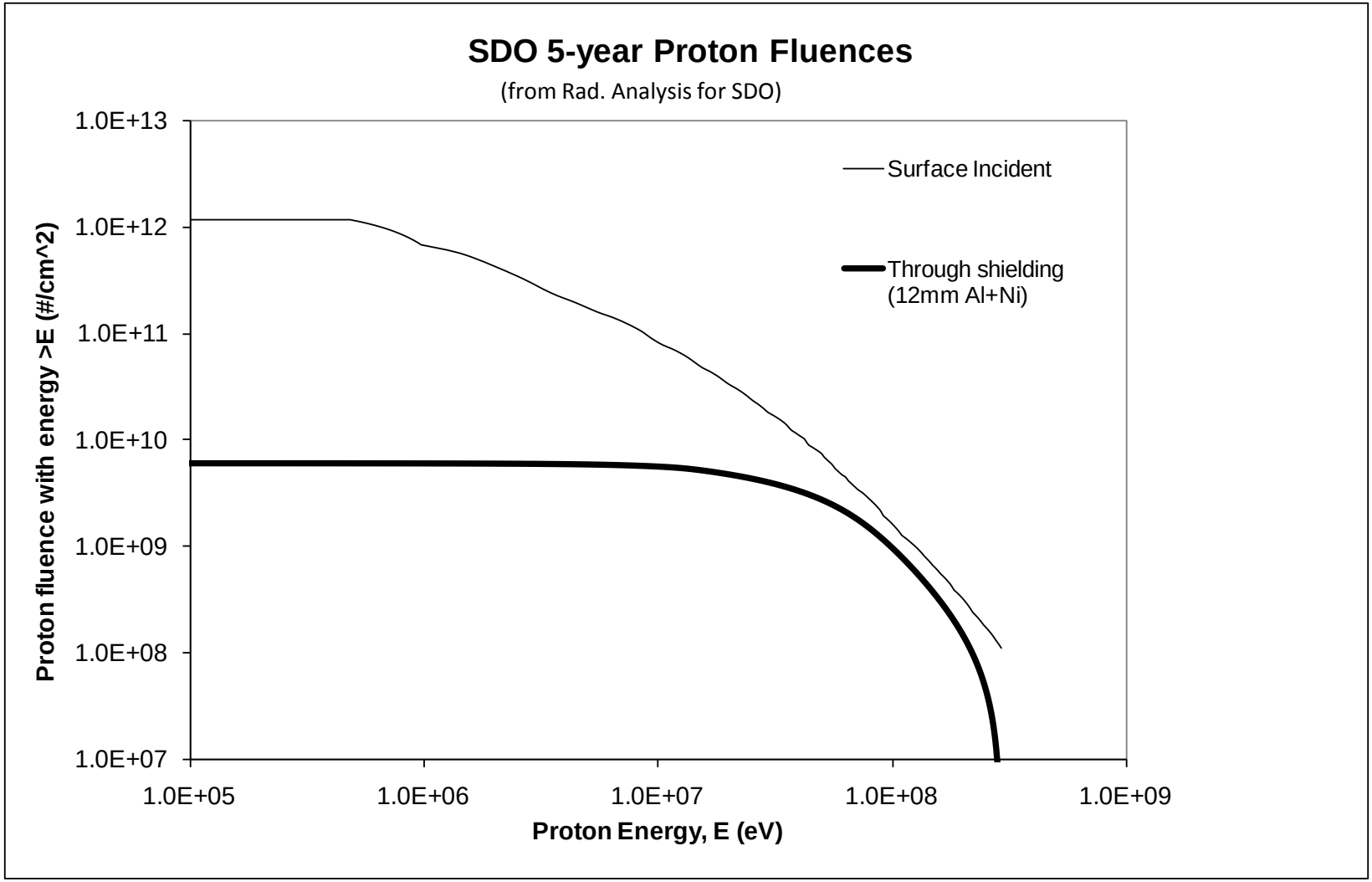
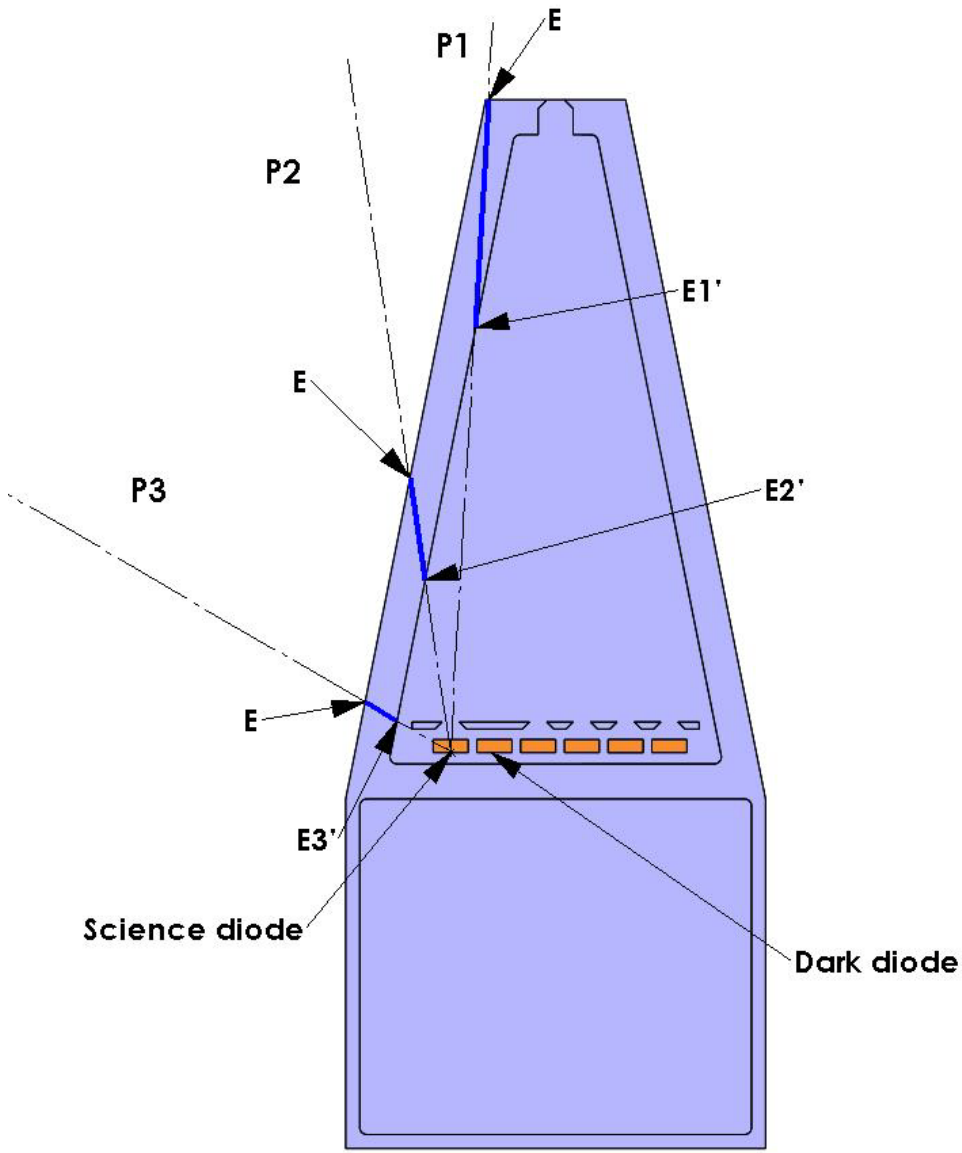
Proton effects analysis needed for

- Shielding vs. mass optimization/PDR request for action
- Comparing proton noise in “dark” channel to other channels

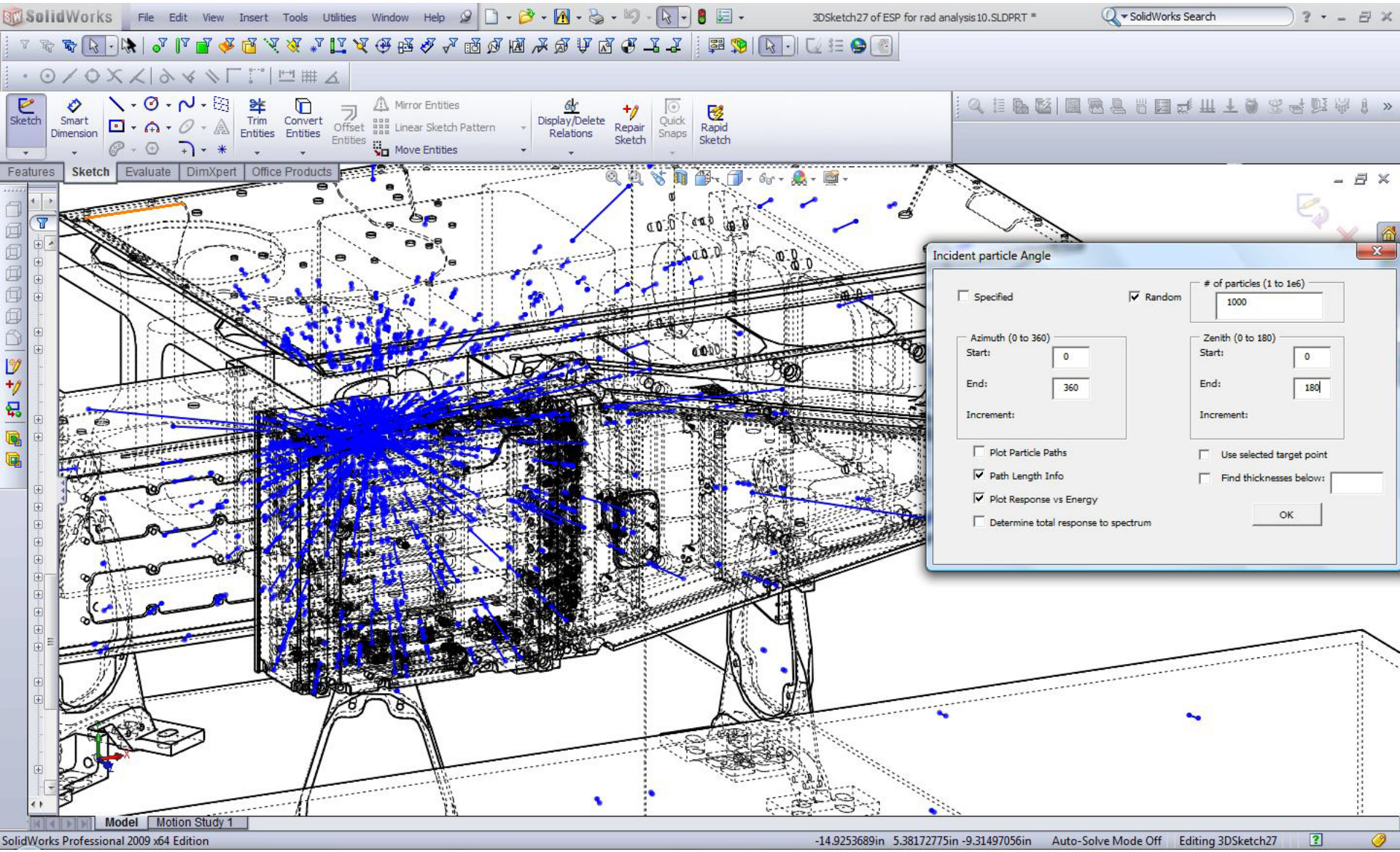


Geometry issues



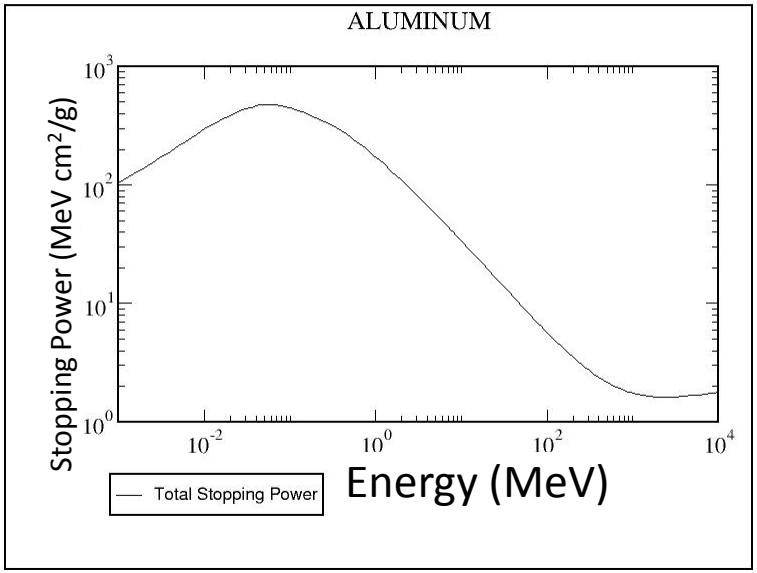
3 particles with the same initial energy follow different paths to a target point on the detector. Each traverse a different amount of material in traversing the shielding and thus reach the detector with different reduced energies.

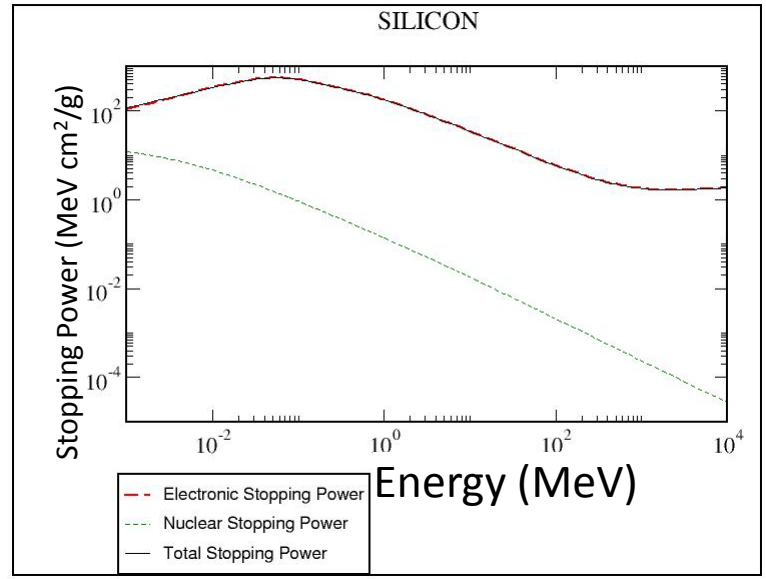
SolidWorks based analysis



Energy deposition

PSTAR : Stopping Power and Range Tables for Protons





From N.I.S.T. PSTAR (http://physics.nist.gov)

For each incident energy, E_i, mean per particle displacement damage, ionizing dose or signal contamination may be calculated from:

$$E_r = E_i - \int_0^{t1} \sigma_T(E,Z)dx$$

$$E_D = \int_0^{t2} \sigma_n(E)dx \approx \sigma_n(E_r)\cdot t2\,*$$

$$E_I = \int_0^{t2} \sigma_e(E)dx \approx \sigma_e(E_r)\cdot t2\,*$$

$$\overline{E}_{I,D}(E_i) \approx \frac{\sum_{j=1}^{N} \sigma_{e,n}(E_{r_j})\cdot t2_j}{N}$$

where: E_r = *Proton reduced energy (after slowing in shielding)*

E_i = *proton incident energy*

E_I = *Energy deposited in electronic interactions*

E_D = *Energy deposited in displacement interactions*

$\sigma_T, \sigma_n, \sigma_e$ = *Total, nuclear, electronic stopping power, respectively*

t1, t2 = thickness of shielding layers, target, respectively

** - approximation holds for small t2*

. . . or expressed as expected detector count rates:

$$C_p = \frac{\overline{E}_I}{3.63 \frac{eV}{e^-}} \cdot \phi_p(E_i) \cdot G_e$$

Where:

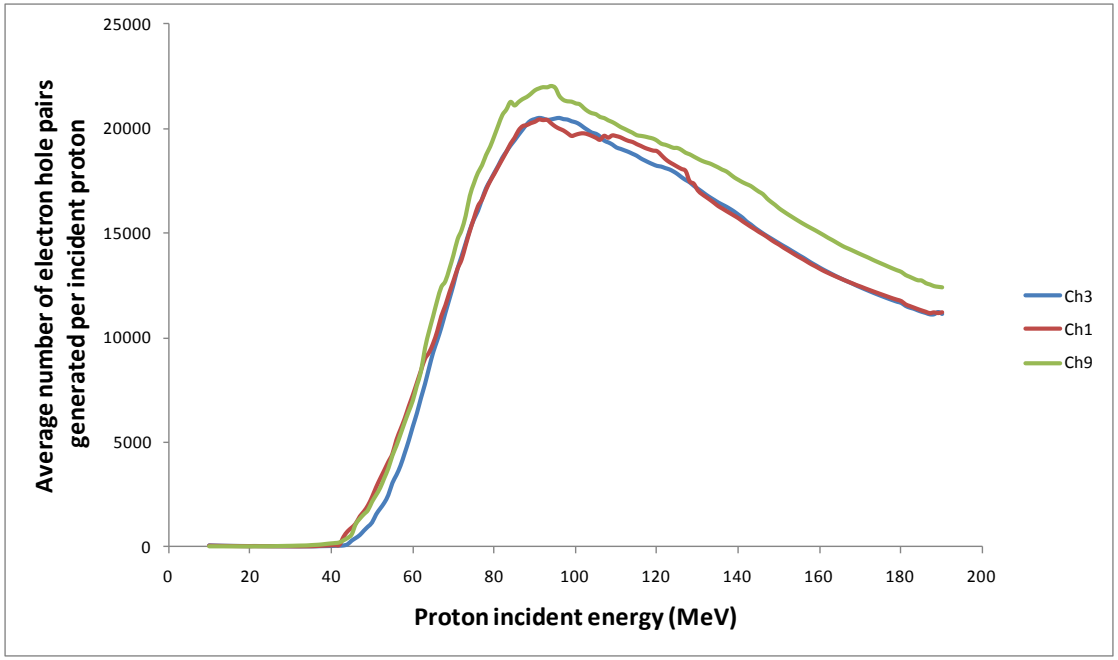
C_p *= DN counts per 0.25 sec*

3.63 eV/e- = average energy per electron-hole pair, Si

$\phi_p(E_i)$ *= input proton spectrum (adjusted for input solid angle)*

G_e *= electrometer gain (0.25 sec count = 40 fA)*

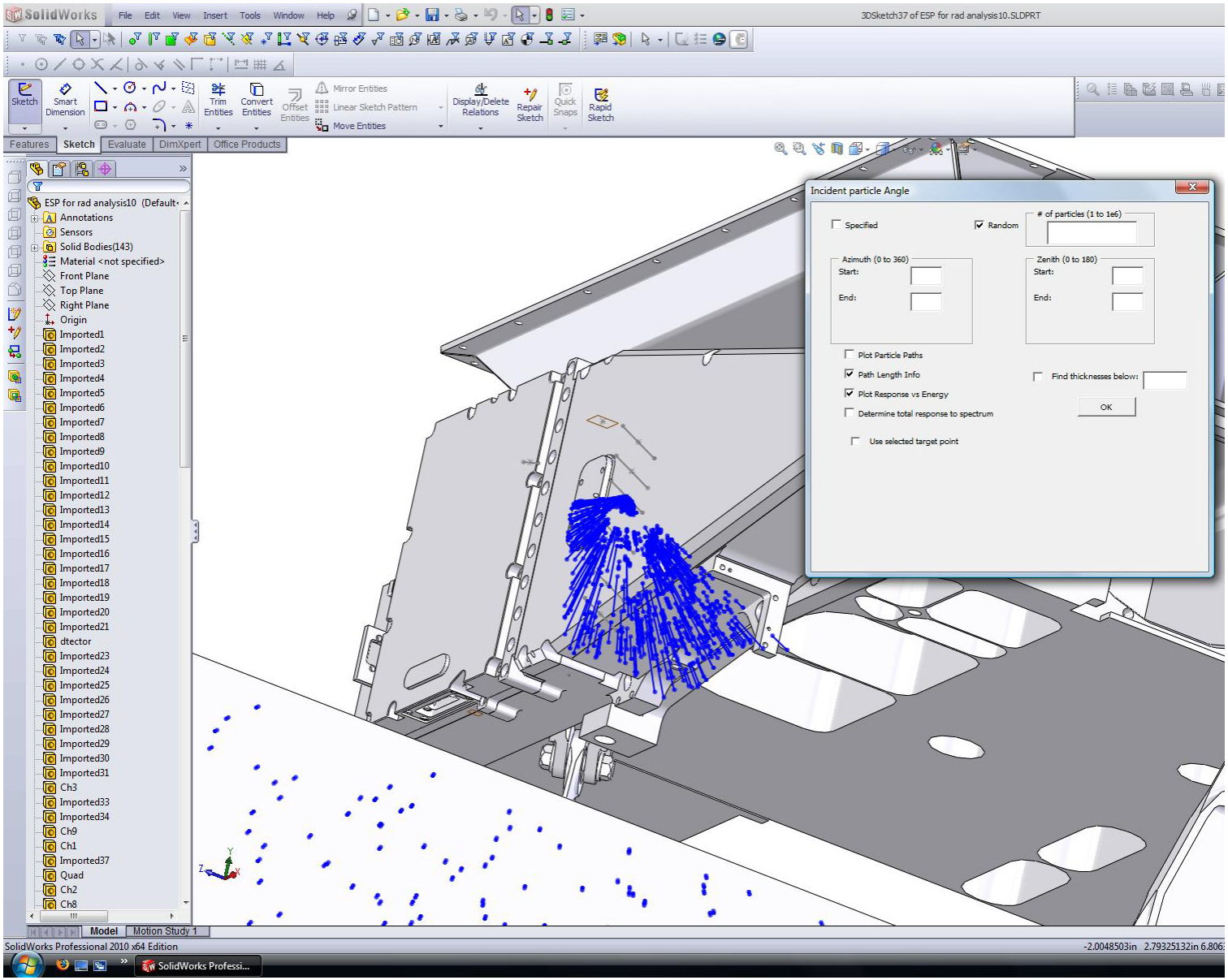
Verifying dark channel correction



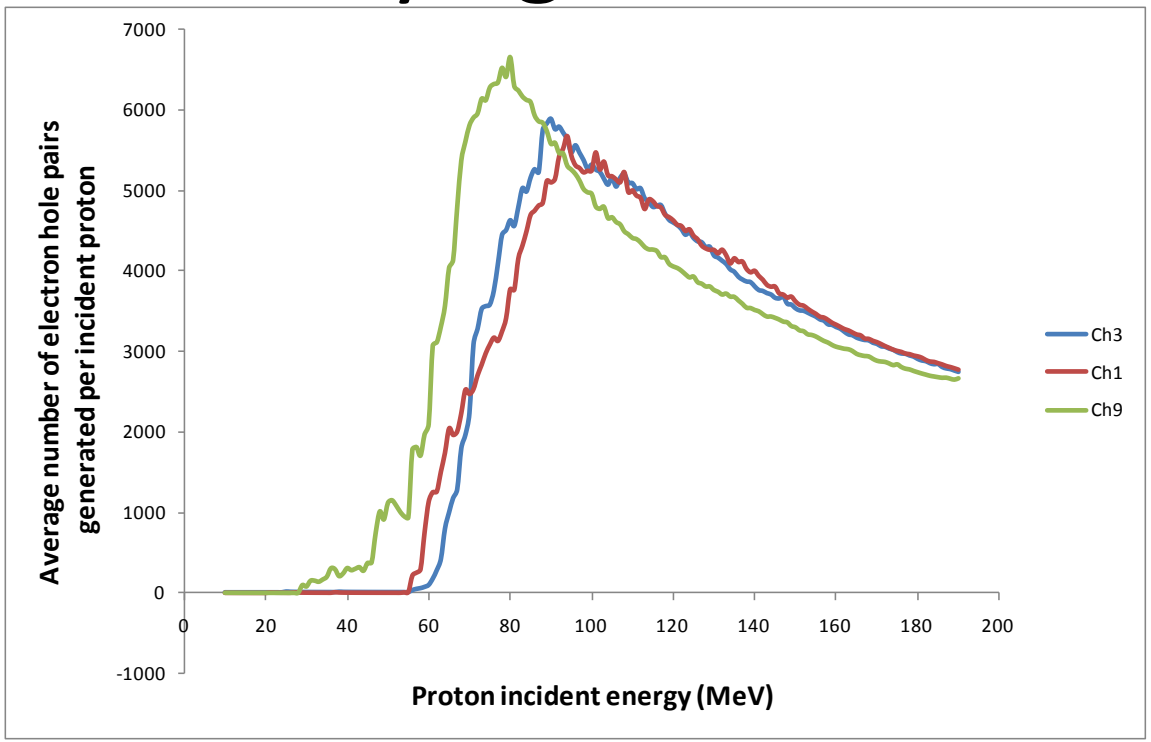
Oct. 29, 2003 and Nov. 2, 2003 1 AU proton fluxes are from GOES EPEAD from the Space Weather Prediction Center, Boulder, CO, National Oceanic and Atmospheric Administration (NOAA), US Dept. of Commerce

	Difference in proton related counts (.25 sec counts)	
	Moderate fluxes (11/2/2003)	High fluxes (10/29/2003)
Ch1-Ch3	2.1	24.3
Ch9-Ch3	1.9	31.6

Non-isotropic Example



Verifying dark channel correction



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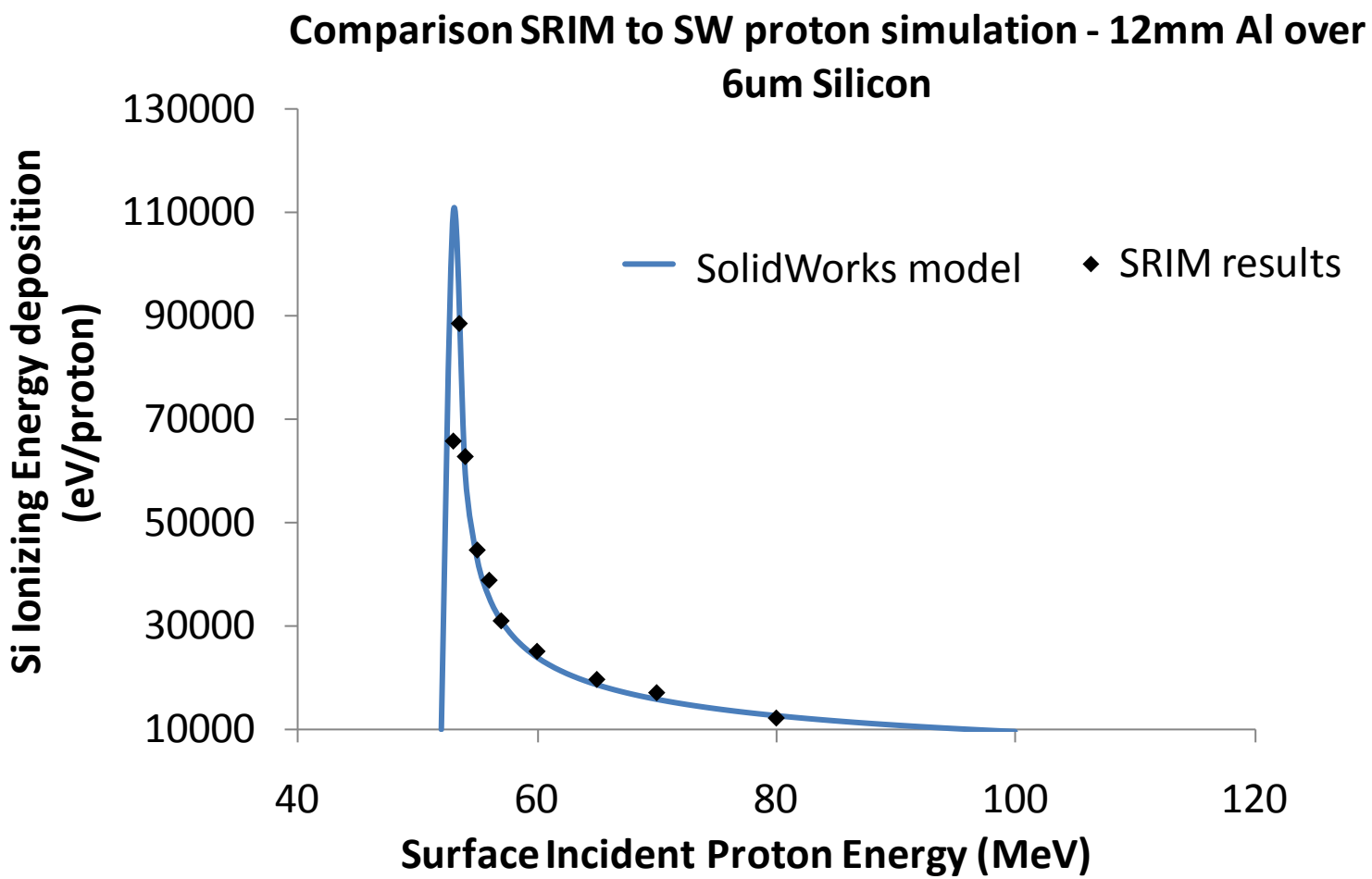
	Difference in proton related counts (.25 sec counts)	
	Moderate fluxes (11/2/2003)	High fluxes (10/29/2003)
Ch1-Ch3	0.0	5.4
Ch9-Ch3	2.0	38.5

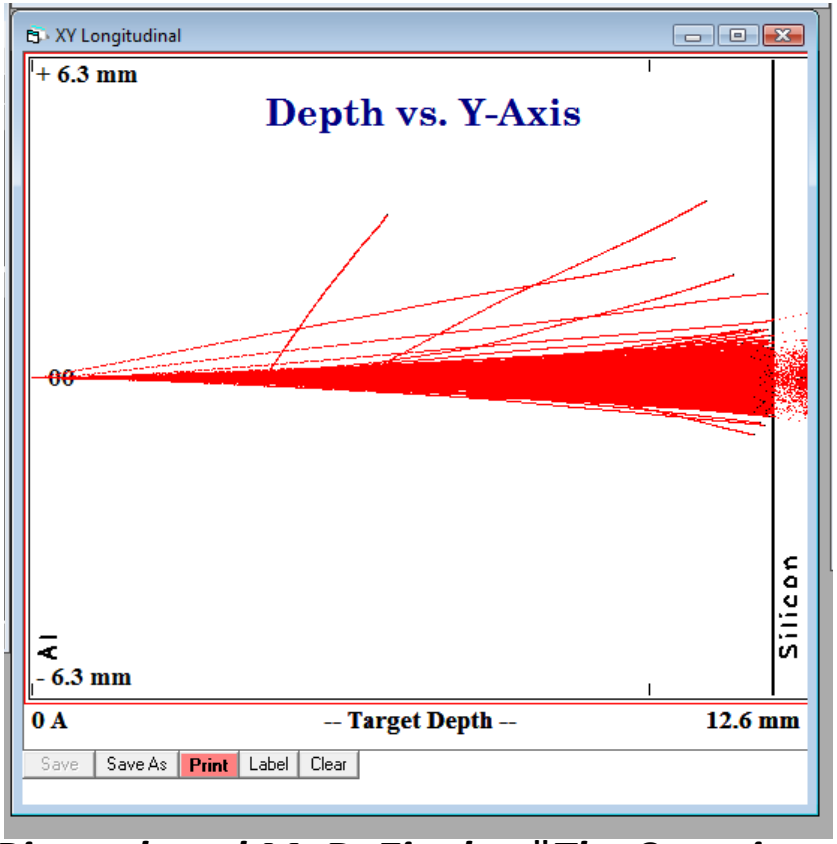
Model Verification

Model is “spot checked” for discrete Incident Energies, shielding and target thicknesses using Stopping and Ranges of Ions in Matter (SRIM) transport code (www.srim.org)



Planned Improvements

Use compiled monte carlo simulation data rather than CSDA tables to represent energy transfer and particle scattering more accurately (e.g. database assembled of SRIM data)



J. F. Ziegler, J. P. Biersack and M. D. Ziegler, "The Stopping and Range of Ions in Solids", by available from www.SRIM.org (2008)