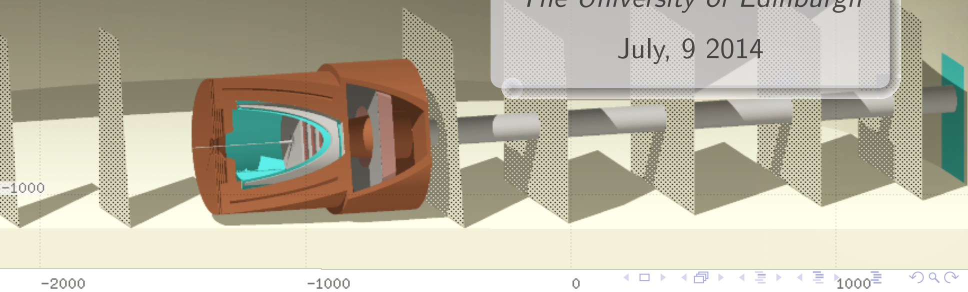
SoLID

Radiation and Activation with SoLID

Lorenzo Zana
The University of Edinburgh

July, 9 2014



Simulation: Two Simulation packages

Advantages

- Two simulation packages with independent code base.
- Independent cross checks both in geometry and in physics modeling.
- Unique capabilities expanding the overall reach.

Simulation: Two Simulation packages

FLUKA

- Easier tools to directly determine Full Radiation quantities.
- Established tool in determining activation estimates.

GEANT4

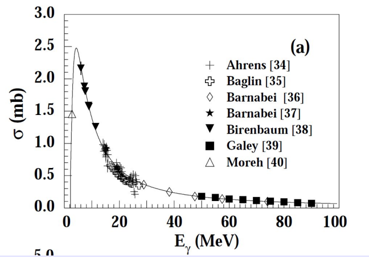
- Better for particular tasks in order to simplify the Shielding design (like vertex, energy reconstruction on particle fluxes over regions of interest).
- Established framework from other part of the simulation project of SoLID

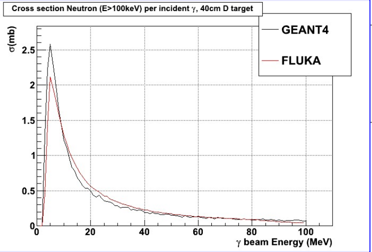
Neutron Photo-production on Deuterium

From all the different SoLID configurations, the Deuterium target is expected to have the highest radiation inpact

Neutron Photo-production on Deuterium

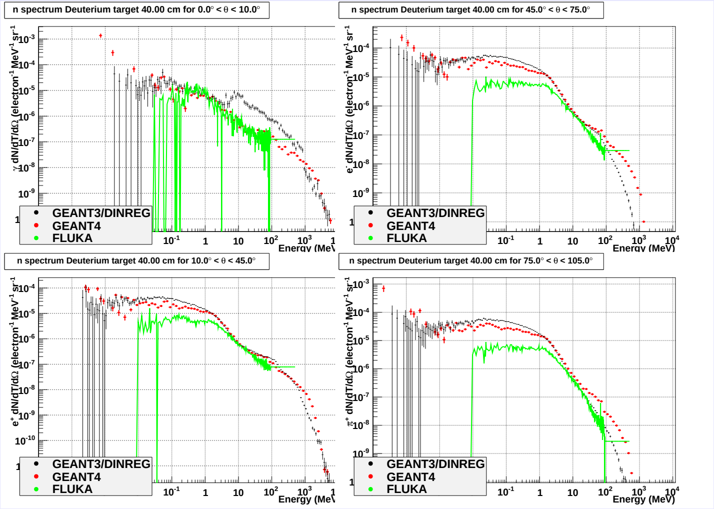
Comparison with real cross section for FLUKA and GEANT4 for Neutron Photo-production on Deuterium



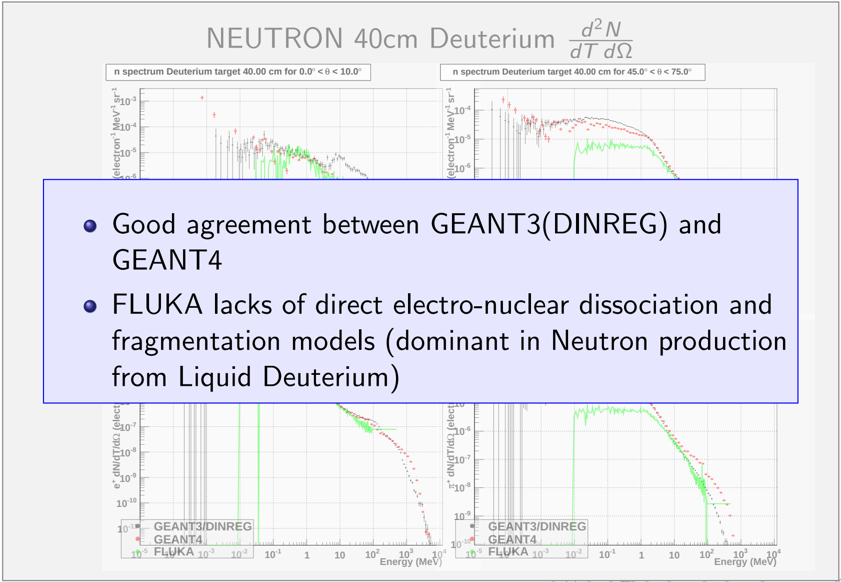


Neutron Full Production from electron beam

NEUTRON 40cm Deuterium $\frac{d^2N}{dT\,d\Omega}$

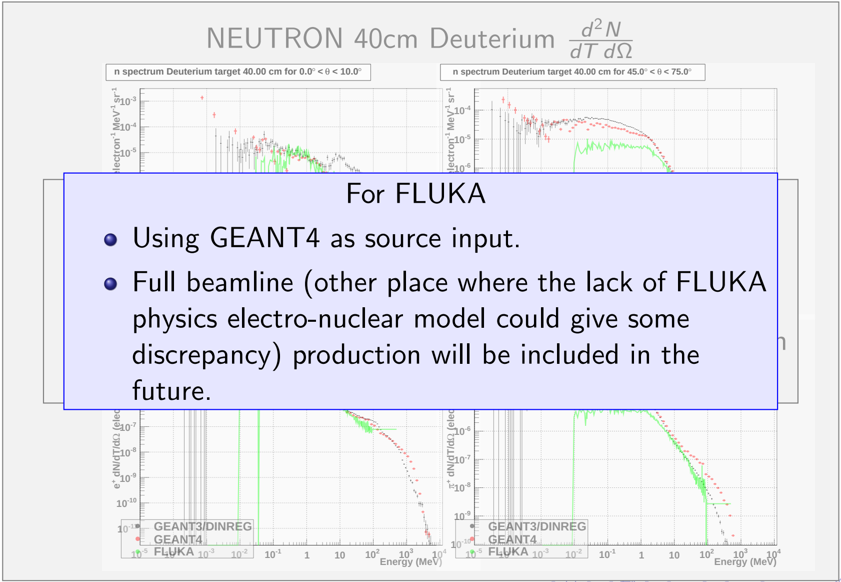


Neutron Full Production from electron beam



- Good agreement between GEANT3(DINREG) and GEANT4
- FLUKA lacks of direct electro-nuclear dissociation and fragmentation models (dominant in Neutron production from Liquid Deuterium)

Neutron Full Production from electron beam



For FLUKA

- Using GEANT4 as source input.
- Full beamline (other place where the lack of FLUKA physics electro-nuclear model could give some discrepancy) production will be included in the future.

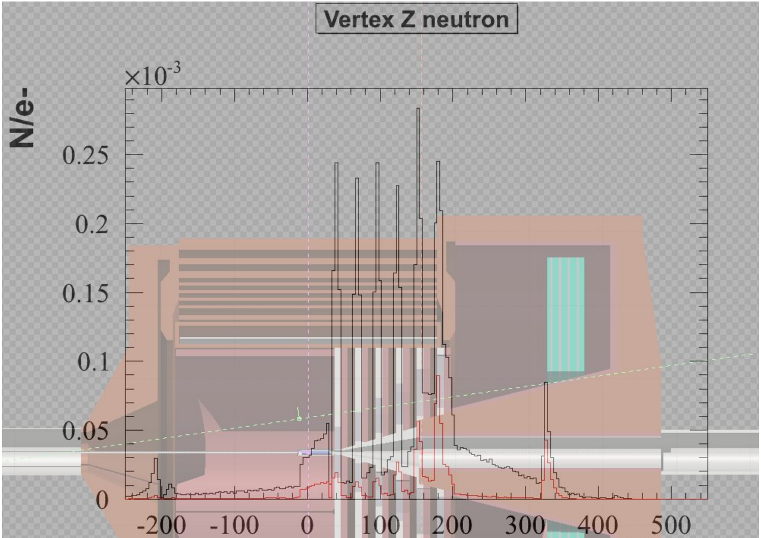
Radiation inside the Magnet

Shielding inside the Magnet: PVDIS configuration

- Shielding inside the Magnet will be based on Borated Polyethilene
- This Shielding is expected to give the best results in mitigating the expected background radiation spectrum.
- Shielding is placed Filling the space between the baffles, covering the coils on the section of the magnet outside the baffle region and in the downstream region in the available space.

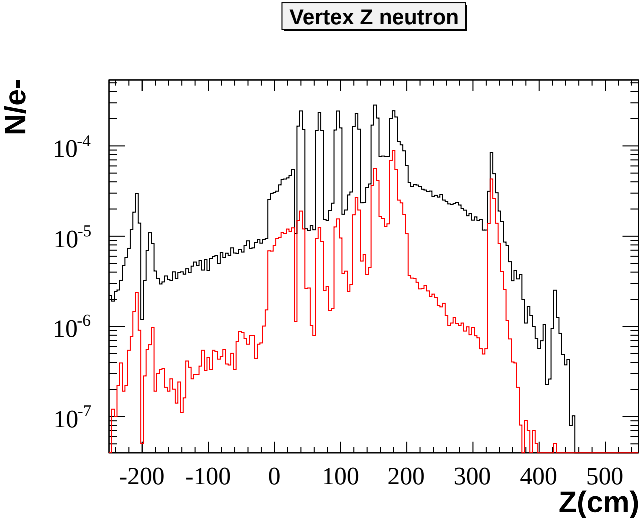
Radiation inside the Magnet

Neutron Origin Vertex on gems (Z) Position location.



Radiation inside the Magnet

Possible strategy of shielding Z vertex results (Red: with SHIELD)



Displacement damage in Si, NIEL

A. Vasilescu (INPE Bucharest) and G. Lindstroem (University of Hamburg), Displacement damage in silicon, on-line compilation

see http://sesam.desy.de/members/gunnar/Si-dfuncs.html

for actual use of this tabulation, please refer to:
A. Vasilescu and G. Lindstroem
Displacement damage in Silicon
on-line compilation: http://sesam.desy.de/~gunnar/Si-dfuncs

neutron induced displacement damage in silicon
-most reliable data, listed for kinetic energies between 0.1meV and 10 GeV-
P.J. Griffin et al., SAND92-0094 (Sandia Natl. Lab. 93), priv. comm. 1996
A. Konobeyev, J.Nucl.Mater. 186 (1992) 117
M. Huhtinen and P.A. Aarnio, NIM A 335 (1993) 580 and private comm.*)
*) tabulation see also A. Ferrari (ATLAS TDR '97), priv. comm. 1997

Griffin

Ekin [MeV]	D/(95MeVmb)
1,025E-10	1,575E-02
1,075E-10	1,537E-02
1,125E-10	1,503E-02
1,175E-10	1,470E-02

Huhtinen

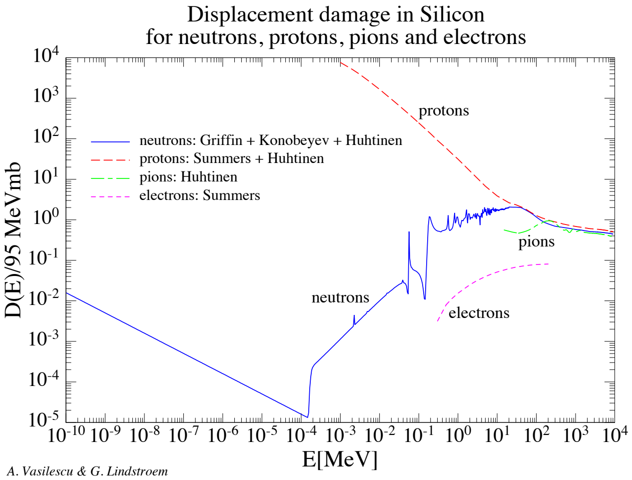
Ekin [MeV]	D/(95MeVmb)
8,050E+02	6,004E-01
8,150E+02	5,980E-01
8,250E+02	5,959E-01
8,350E+02	5,942E-01

Konobeyev

Ekin [MeV]	D/(95MeVmb)
2,000E+01	2,071E+00
2,500E+01	2,049E+00
3,000E+01	2,041E+00
4,000E+01	2,012E+00

Displacement damage in Si, NIEL

(Non Ionizing E-Loss) for e^-, p, π, n

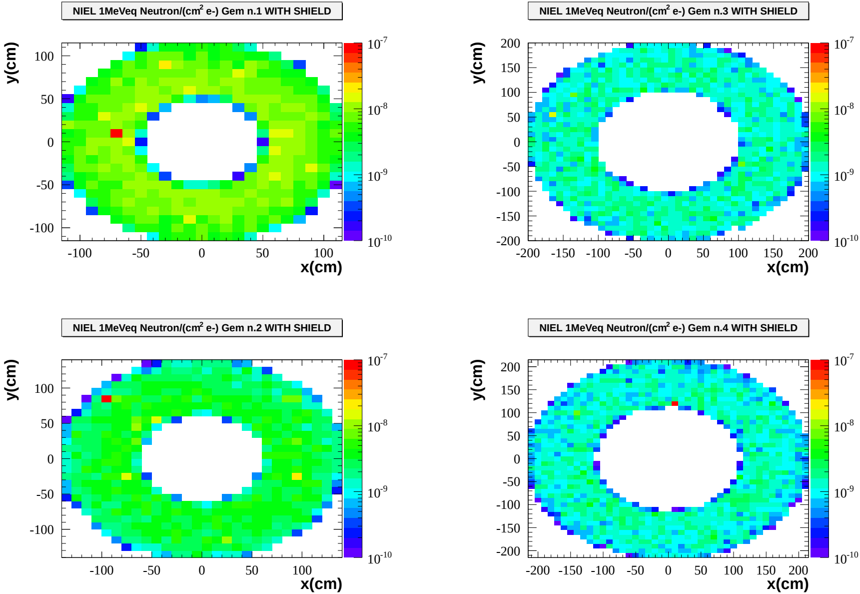


Displacement damage in Si, NIEL

What is a tolerable level for APV25 (GEM) ?

- CMS experiment total dose expected be around $5x10^{13}\frac{N}{cm^2}$
- CMS experiment Neutron flux peaks at 1MeV (curves norm to 1MeV Neutron)
- Our flux is ($2000h$ at $100\mu A$) $5x10^{13}\frac{N}{cm^2} \Rightarrow 1.1x10^{-8}\frac{N}{e^- cm^2}$

PVDIS 1MeV eq $\frac{N}{e^- cm^2}$ WITH SHIELDING



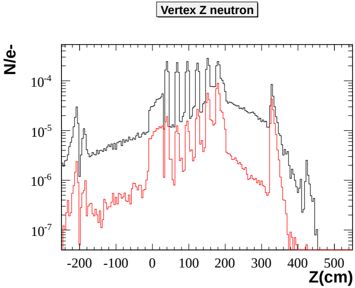
Radiation on SIDIS

Neutron radiation dominates the PVDIS configuration.
What is the comparison with SIDIS?

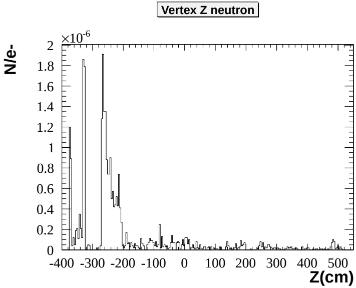
Radiation on SIDIS

Neutron radiation dominates the PVDIS configuration.
What is the comparison with SIDIS?

PVDIS

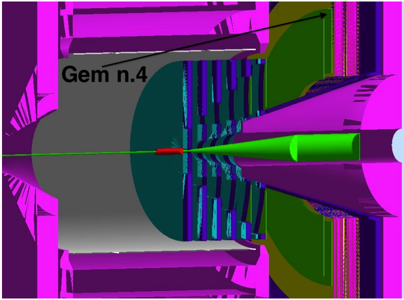


SIDIS

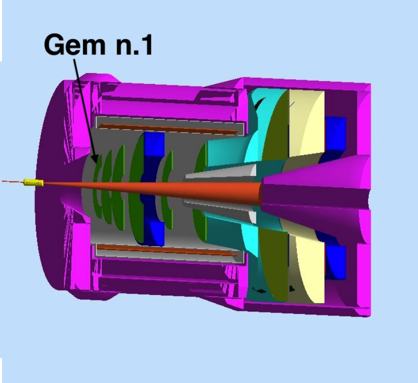


Radiation on SIDIS

PVDIS



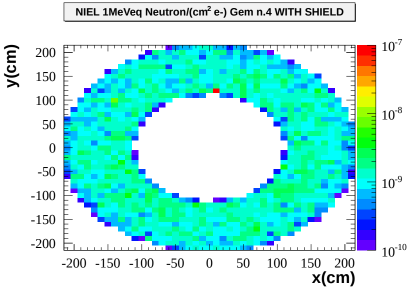
SIDIS



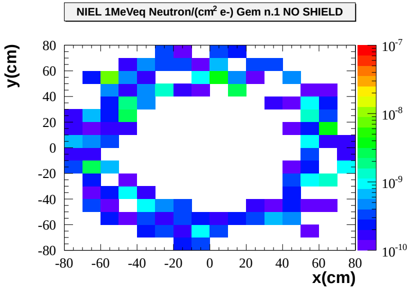
Radiation on SIDIS

What is the comparison for 1MeV eq radiation in the gems?

PVDIS Gem n.4



SIDIS Gem n.1



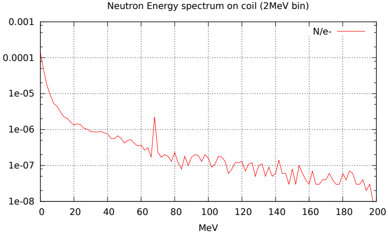
Radiation on Coils

Radiation limit $\frac{Neutron_{(E_N>0.1MeV)}}{cm^2} = 10^{19}\frac{N}{cm^2}$ for NbTi

see
http://supercon.lbl.gov/WAAM/WAAM_Talks/Al%20Zeller%0WAAM.pdf

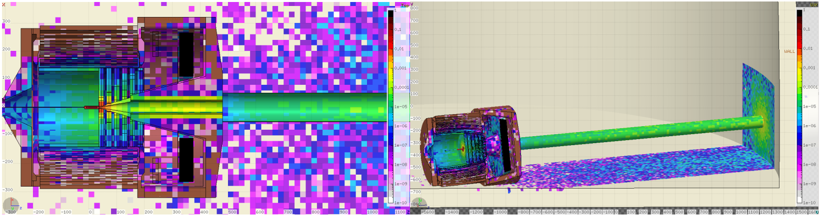
FLUKA Simulation full FLUX on the Coil (not per cm^2)

Considering also that FLUKA is off of an order of magnitude in this angle range, we are expecting a flux of $Neutron_{(E_N>0.1MeV)} = 10^{18}N$, well in the limit for NbTi

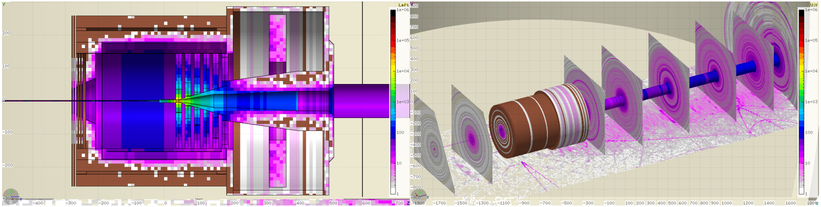


SoLID PVDIS: Power and Activation

$E_{dep}(W)/cm^3$ PVDIS, Liquid D target ($100\mu A$)

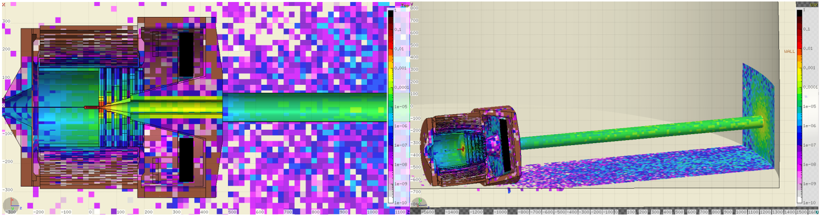


$Dose_{eq}(mrem)/h$ after $1hour$ from beam exposure (1 Month running time)

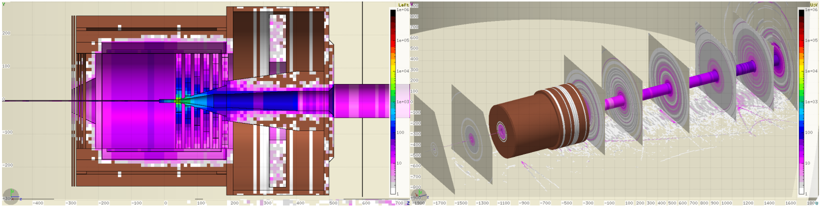


SoLID PVDIS: Power and Activation

$E_{dep}(W)/cm^3$ PVDIS, Liquid D target ($100\mu A$)

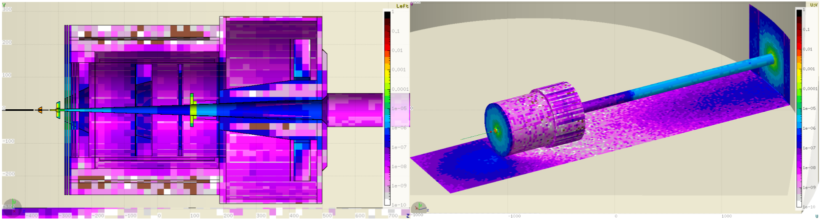


$Dose_{eq}(mrem)/h$ after $1day$ from beam exposure (1 Month running time)

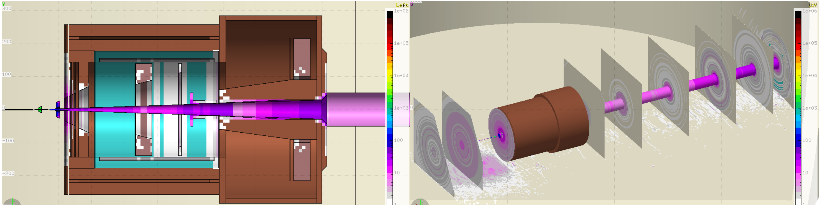


SoLID SIDIS: Power and Activation

$E_{dep}(W)/cm^3$ SIDIS, Liquid ^3He target ($15\mu A$)

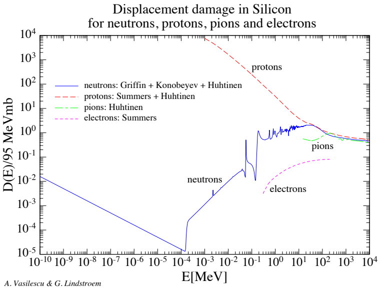


$Dose_{eq}(mrem)/h$ after $1hour$ from beam exposure (1 Month running time)

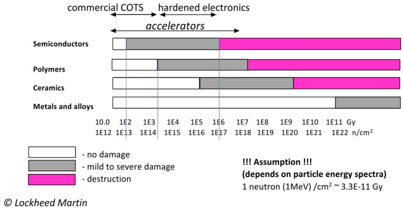


Radiation Estimates and Tolerance

Radiation Estimates

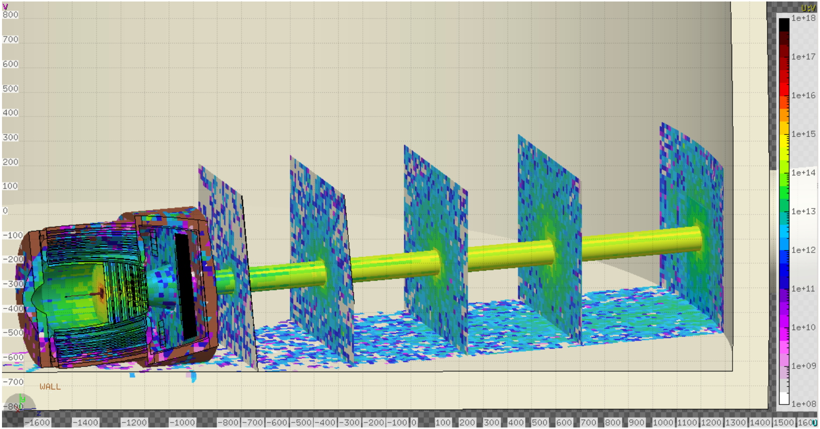


Tolerance (guideline)



SoLID PVDIS: 1MeVeq Neutrons

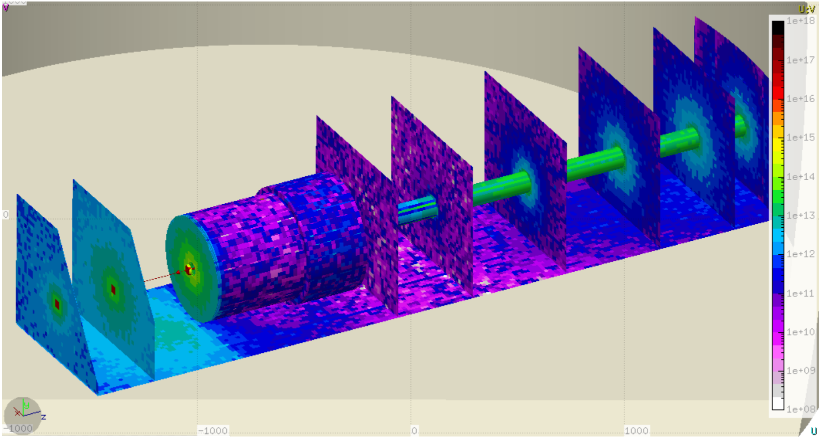
$Neutrons(1MeV - eq)/cm^2$ PVDIS, Liquid D target
$(100\mu A$ for $2000 hours)$



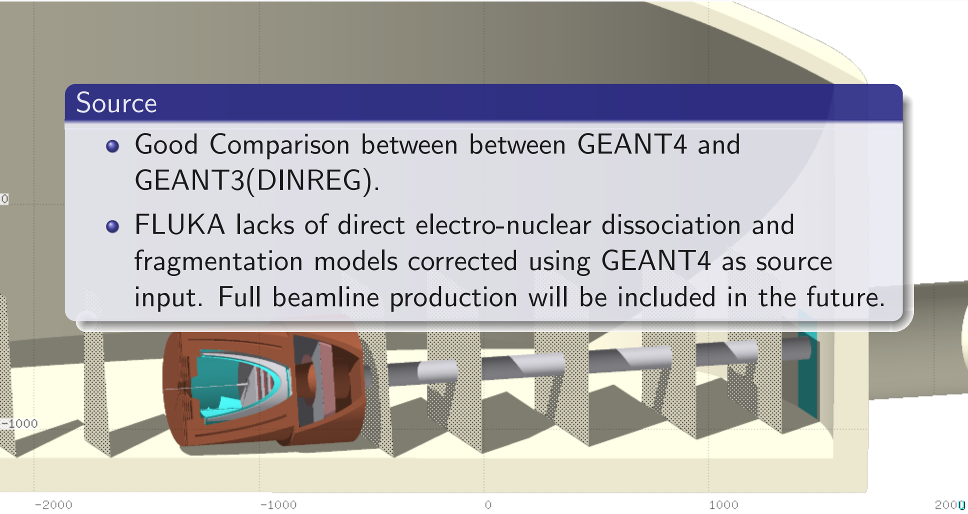
SoLID SIDIS: 1MeVeq Neutrons

$Neutrons(1MeV - eq)/cm^2$ SIDIS, Liquid ^3He target

$(15\mu A$ for $3000hours)$



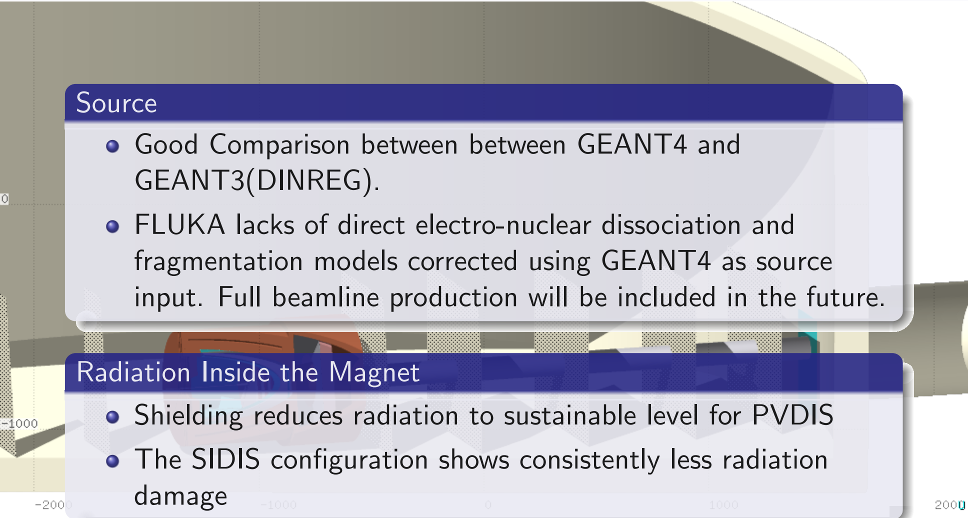
Conclusions



Source

- Good Comparison between between GEANT4 and GEANT3(DINREG).
- FLUKA lacks of direct electro-nuclear dissociation and fragmentation models corrected using GEANT4 as source input. Full beamline production will be included in the future.

Conclusions



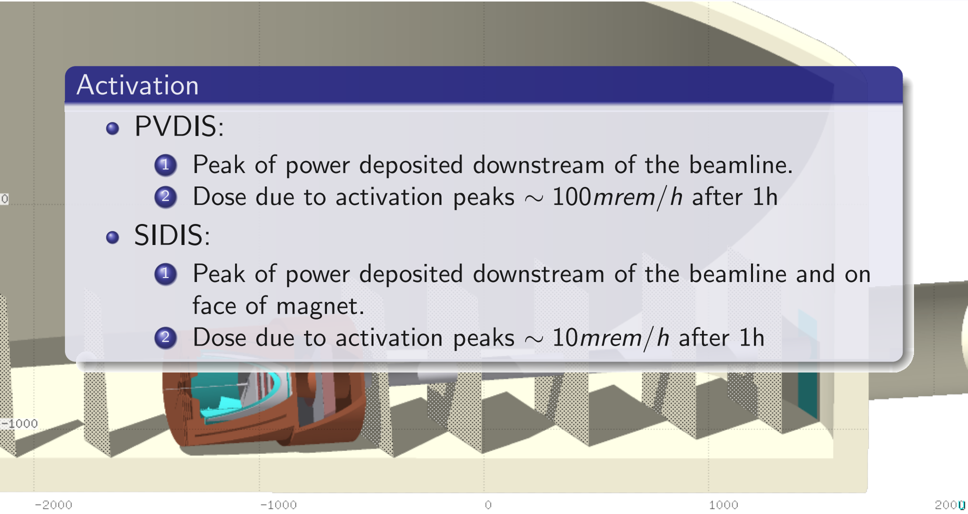
Source

- Good Comparison between between GEANT4 and GEANT3(DINREG).
- FLUKA lacks of direct electro-nuclear dissociation and fragmentation models corrected using GEANT4 as source input. Full beamline production will be included in the future.

Radiation Inside the Magnet

- Shielding reduces radiation to sustainable level for PVDIS
- The SIDIS configuration shows consistently less radiation damage

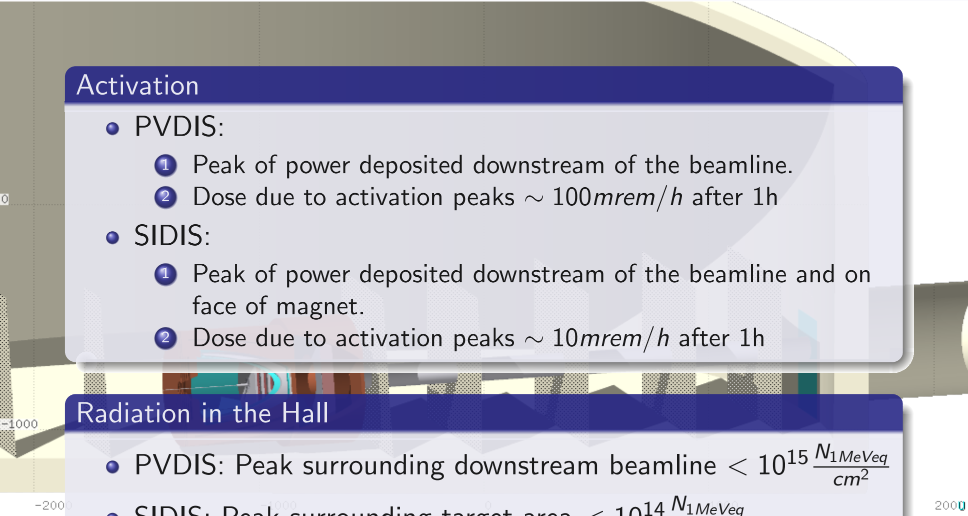
Conclusions



Activation

- PVDIS:
  1. Peak of power deposited downstream of the beamline.
  2. Dose due to activation peaks $\sim 100 mrem/h$ after 1h
- SIDIS:
  1. Peak of power deposited downstream of the beamline and on face of magnet.
  2. Dose due to activation peaks $\sim 10 mrem/h$ after 1h

Conclusions



Activation

- PVDIS:
  1. Peak of power deposited downstream of the beamline.
  2. Dose due to activation peaks $\sim 100 mrem/h$ after 1h
- SIDIS:
  1. Peak of power deposited downstream of the beamline and on face of magnet.
  2. Dose due to activation peaks $\sim 10 mrem/h$ after 1h

Radiation in the Hall

- PVDIS: Peak surrounding downstream beamline $< 10^{15} \frac{N_{1MeVeq}}{cm^2}$
- SIDIS: Peak surrounding target area $< 10^{14} \frac{N_{1MeVeq}}{cm^2}$