Spectrometer Simulation Studies

Understanding effects of irradiation

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  - Dose on insulation
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  - Dose on insulation
  - Power on coils and belly plates
- Conclusion and ongoing work:
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  - Implement detailed coil geometry with water channels into simulation

Introduction

Spectrometer Irradiation: Sources of concern and mitigating shielding

Spectrometer Region	Irradiation source	Shielded by
Upstream	Positrons passing through acceptance are bent radially inward and azimuthally defocused to hit the sides of the subcoils	Tungsten side plates
	Charged particles coming through bore of collimator 2 hit the bellies of the subcoils	Tungsten two bounce shield
Downstream	Charged particles coming through bore of collimator 4 hit the bellies of the subcoils after being pulled out by stray dipole field	Tungsten belly plates

Targets for Simulation Studies

1) Ensure that the dose on spectrometer insulation is low enough to mitigate degradation
2) Estimate power on shielding elements and coils to assess cooling needs

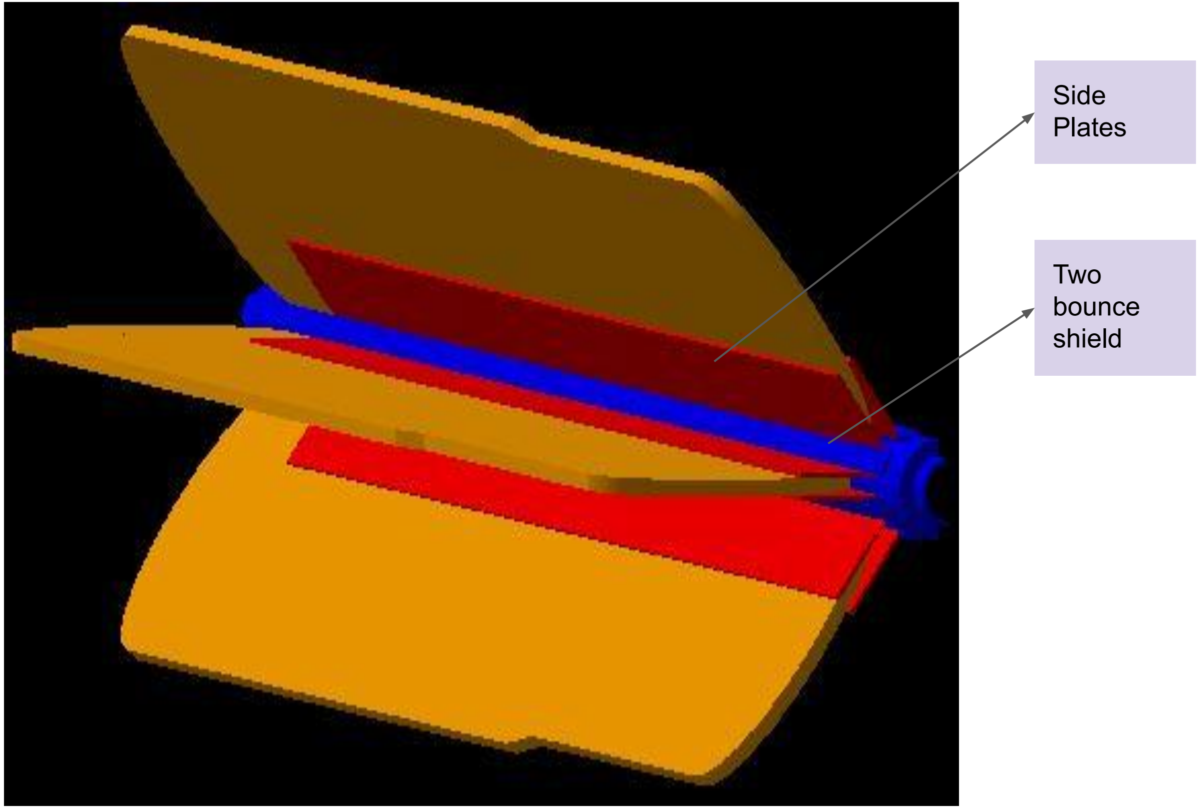
Simulation Configuration

1) Compute Canada: Geant4 10.06 and ROOT 6.20.04
2) JLAB: Geant4 10.07.p03 and ROOT 6.24.06
3) Generator: Beam
4) Number of events per run: ~100 million
5) Calculations assume 65 or 70 uA beam current
6) Symmetric and realistic asymmetric magnetic fields (unless noted otherwise)

See J. Mammei's talk

Upstream

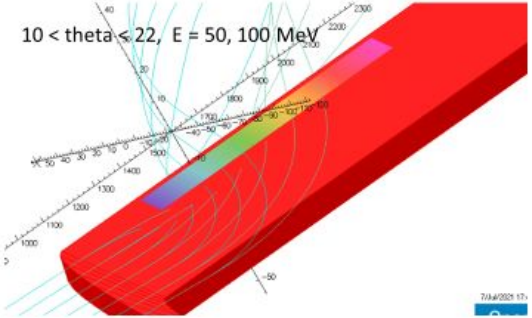
Upstream Spectrometer Region (TM0)



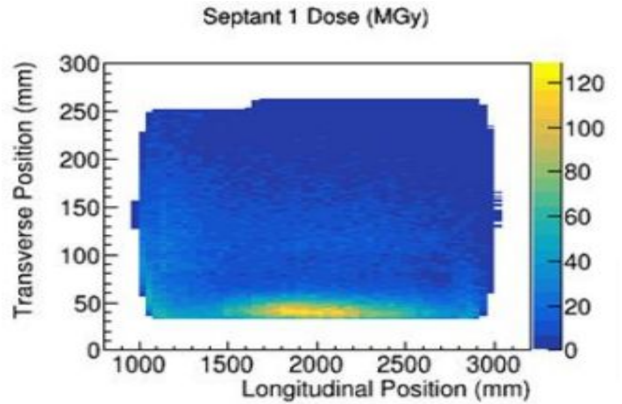
Geometry

- Two bounce shield
  - Starts at z = 936.5 mm with respect to hall pivot
  - 2152.65 mm long
  - Radially extends from 25-32 mm along closed sectors and 25-36 mm along open sectors. Coils and side plates are inserted into the slots along closed sectors. The slots are 23.43 degrees wide along azimuthal direction.
- Side plates (Dimensions tuned in recent months)
- 9 mm wide Cu Conductor
- Enclosed in 1 mm wide insulation on all sides
- Center of coil filled with insulation
- Insulation (SiO_2+Epoxy) effective density assumed to be 1.3 g/cm^3

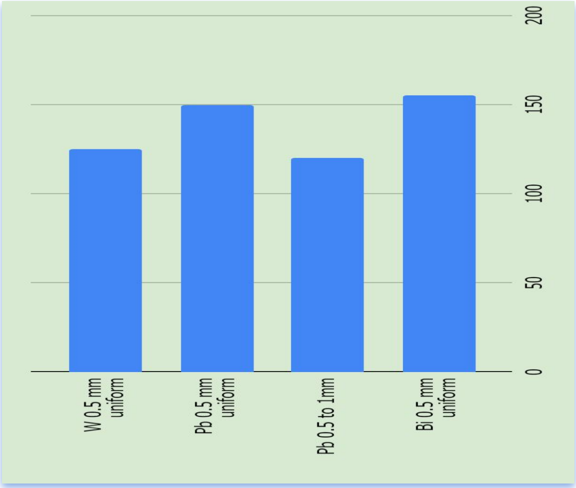
Dose on insulation

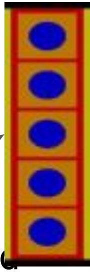


Positrons from target bending inward and azimuthally defocused

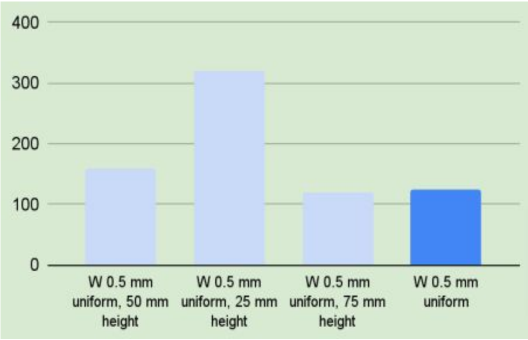


Focus on the peak value at the center (40x1x1 mm^3 bins)





Tune material and aimuthal thickness of the side plates (r=32-100 mm and z=1000-2750 mm)

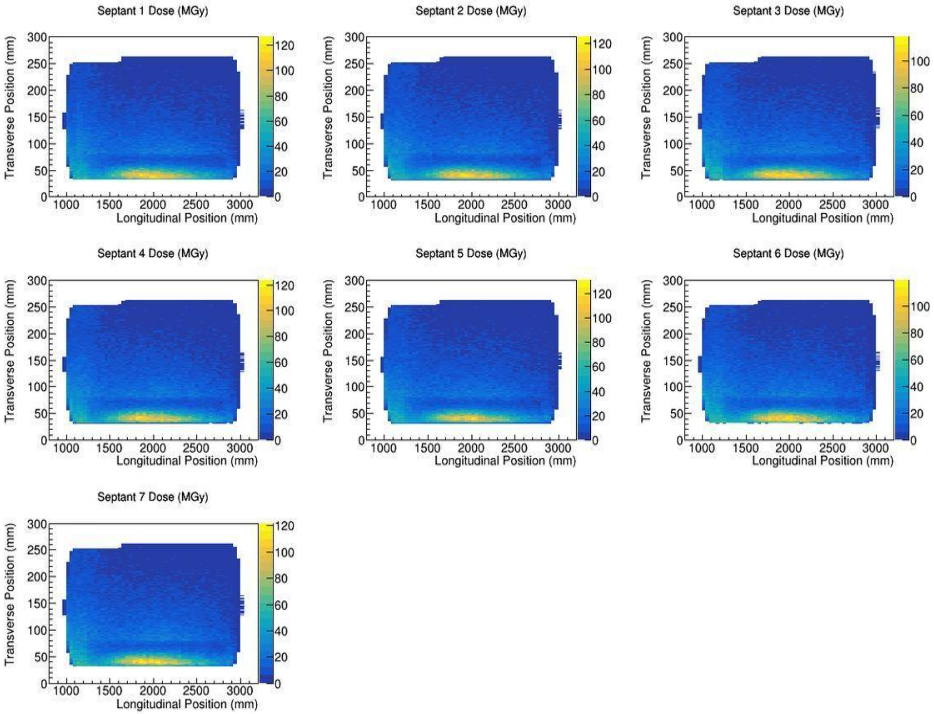


Tune radial extent. Anything with outer radius between 75 and 100 mm gives equivalent performance

N.B.: Results for symmetric fields. Upstream torus region is not affected by asymmetric fields drastically. See table 2 from DocDB#961

Dose on insulation

Tune z extent



Side plate z-extent = 1200-2800 mm

Moving the upstream end of the sideplate from 1000 mm to 1200 mm doesn’t effect peak value but spreads out the hot spot.

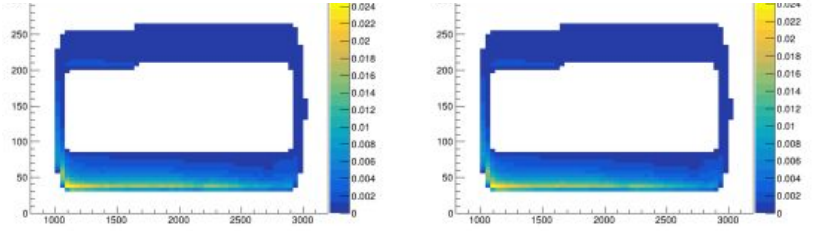
We similarly tuned the downstream end (See [doc db 1029](#)). Placing the downstream end somewhere between 2400 and 2600 mm shows similar effect.

Side Plate Recommended Specification:

Material: Tungsten
Thickness: 0.5 mm
Radial extent: Cover coil cross-section
Z-extent: 1200-2500 mm
Peak dose on insulation: 120 MGy assuming 70 uA beam current (within safety limits suggested by irradiation beam tests)

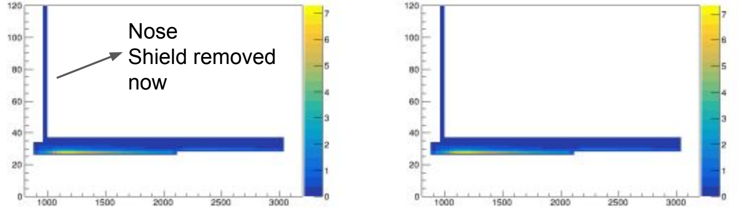
Power on coils, side plates and twobounce shield

Coil Power



(a) D1 (b) D2

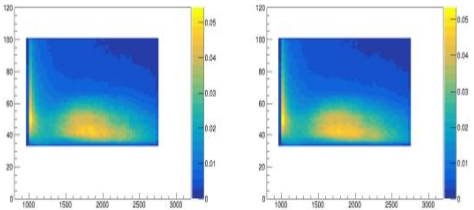
Twobounce power



(a) D1 (b) D2

Figure 28: Power Deposited (W)

Sideplate power



(a) D1 (b) D2

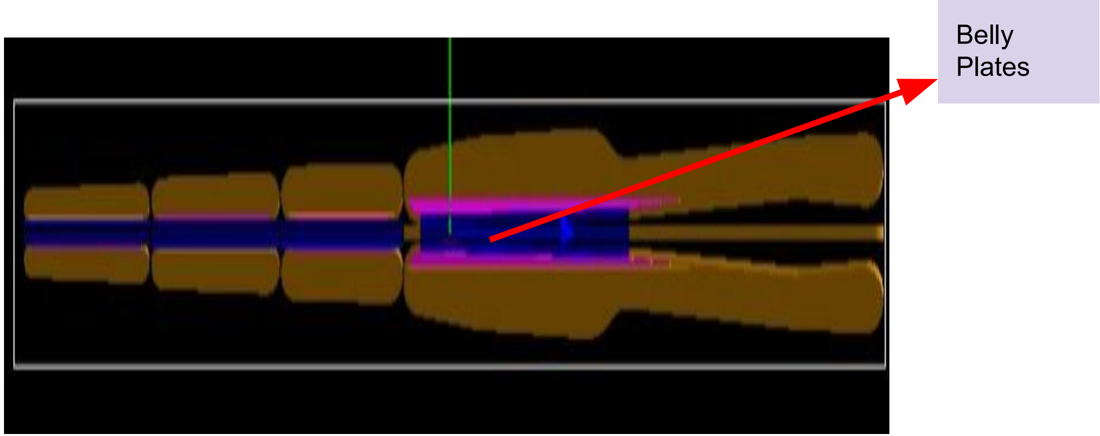
Configuration	Power in conductor [Per Coil]	2-bounce power [Total]	Side Plate Power [Total]
A.1	18,18,18,18,18,18,18	N/A	N/A
A.2	16,16,17,16,16,16,16	N/A	N/A
D.1	3,3,3,3,3,3,3	322	42
D.2	3,3,3,3,3,3,3	323	42

Doc db 961: Slightly older design of shieldings but don’t expect significant changes to these numbers. .1: Symmetric map .2: Real asymmetric maps. Results show integrated power in watts for 65 uA.

Downstream

Downstream Spectrometer Region (TM1/2/3/4)

Geometry



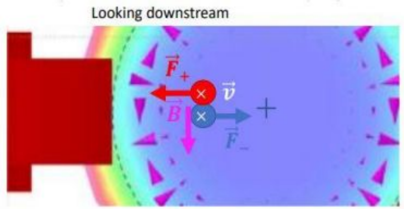
Belly plates cover the azimuthal extent of the coils. Current default parameters in simulation are shown below (small differences with CAD drawings)

	Begin Coil Straight	B-D	Begin Belly Plate		End Coil Straight	H-F	End Belly Plate		Belly Plate Min Rad	Belly Plate Max Rad
TM1	5001.227	67.292	4933.935		5857.536	78.6405	5936.1765		38	41
TM2	6038.541	87.935	5950.606		6874.961	98.241	6973.202		43.5	46.5
TM3	7097	110.27	6986.73		7844.81	115.605	7960.415		46	49
TM4	8096.987		8096.987				9763.02		52.808 (begin) 74.652(end)	55.808 (begin) 77.652 (end)

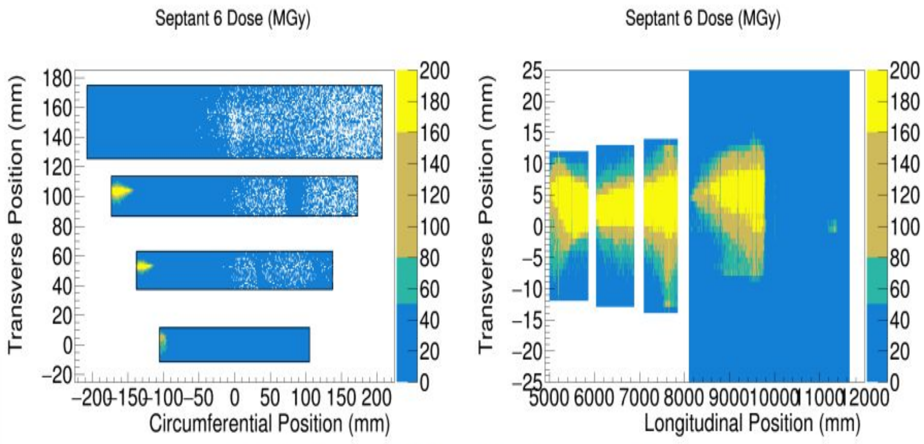
Dose in insulation

Doc db 1020 by Damon Spayde

Beamline charged particles deflected by stray field

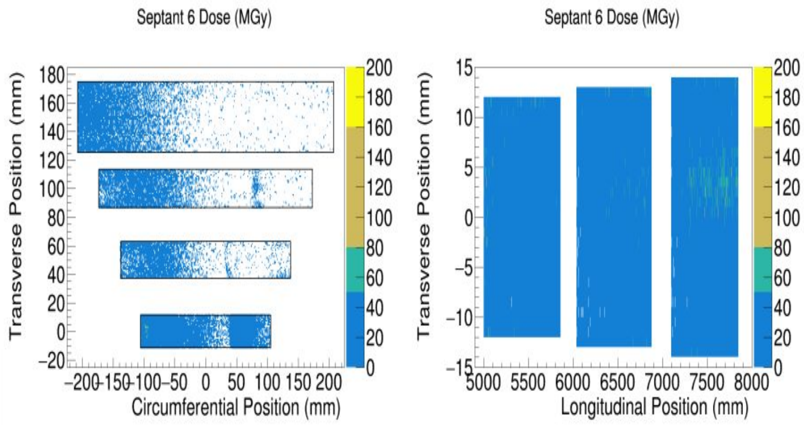


ds000 (Unshielded) Configuration (High Statistics)



Need to shield underbellies of SC 1-4 and nose of SC 1-3

ds022 Configuration

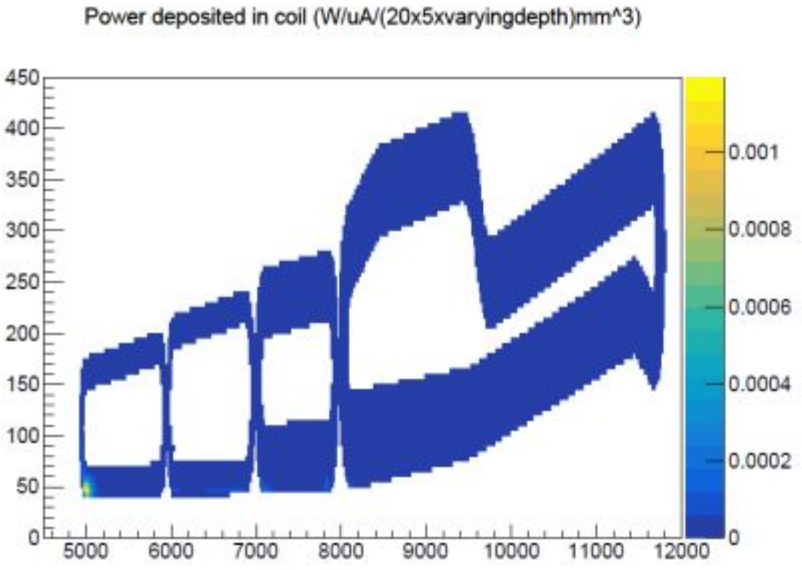


3 mm W does the trick everywhere.

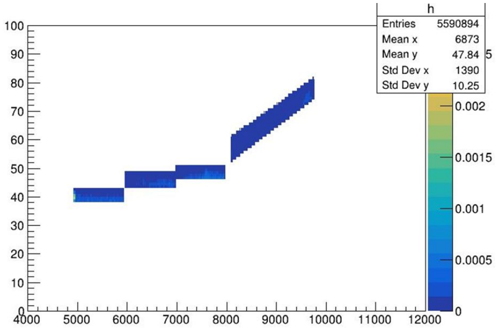
Assumes 65 uA

This study was done with the most asymmetric field config we had (dipole exaggerated far beyond real asymmetric)

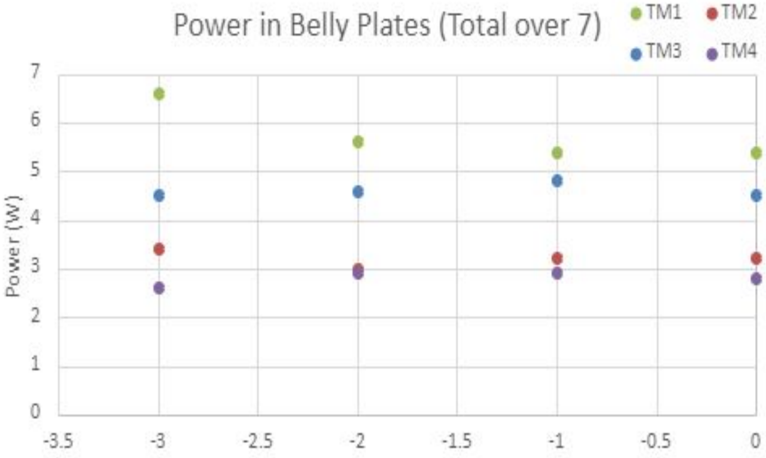
Coil and Belly plate power



Old result with most asymmetric field config: ~60 W (summed over the entire region for 65 uA)
[Doc db 758](#)



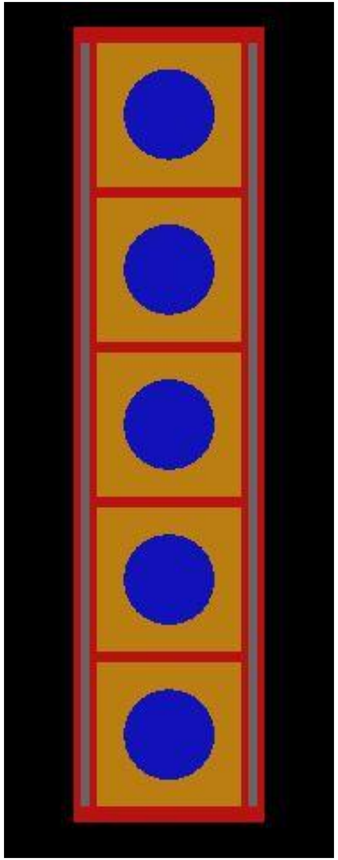
Tested sensitivity of power in Tungsten belly plates to inward radial offsets ([Doc db 1084](#)) for 70 uA



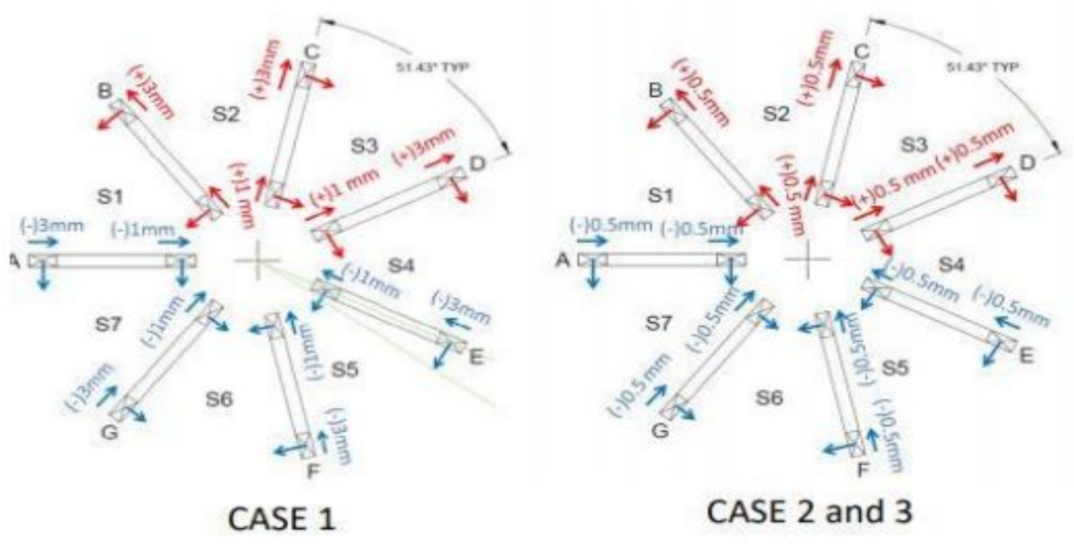
See [Doc db 1020](#) for Damon's old results with most asymmetric field config for 65 uA

Conclusion and Ongoing Work

1) Completed:
   a) Dose estimated with current simulation approximation is ~100 MGy for insulation in upstream and downstream torus magnet subcoils. Consistent with safety limits imposed by irradiation beam tests.
   b) Power on coils and shielding elements were estimated to assess needs for cooling mechanism
2) Ongoing work and crosschecks:
   a) Implement detailed coil cross-section with water channels in straight sections of coils in remoll.
   b) Implement more realistic description of space between two arms of each subcoil - spacers in the right location instead of filling out entire inner region.



Backup



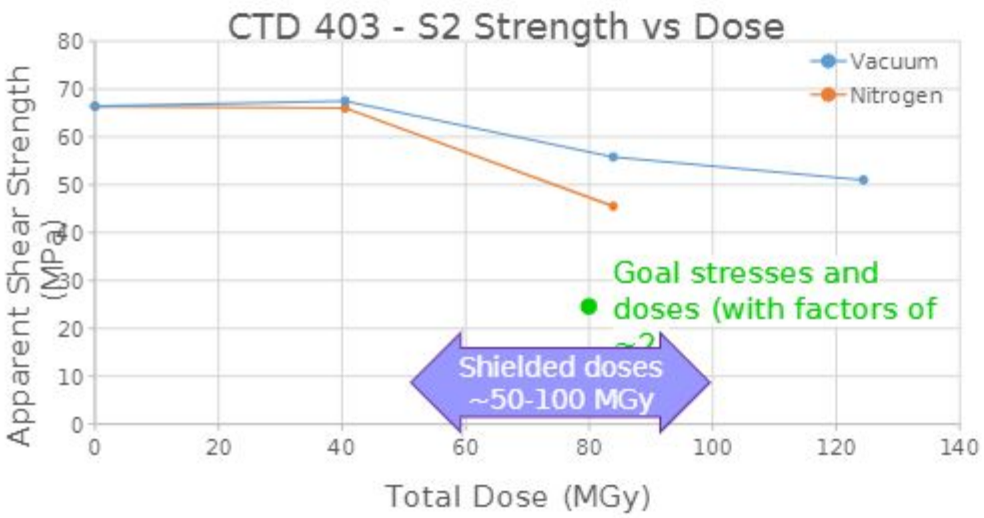
Case 1 is the worst case within optical tolerance. Coil arrangement conspiratorial to maximize dipole field.

Case 2 is lesser magnitude offset but arrangement still conspiratorial.

Case 3 is the most realistic worst case scenario. Randomized arrangement.

Backup

CTD Epoxy radiation tests



Unsheilded doses > 300 MGy

*See Dave's talk for details