Compact Photon Source: Update

Baseline Radiation
Calculations with FLUKA

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Supervised by
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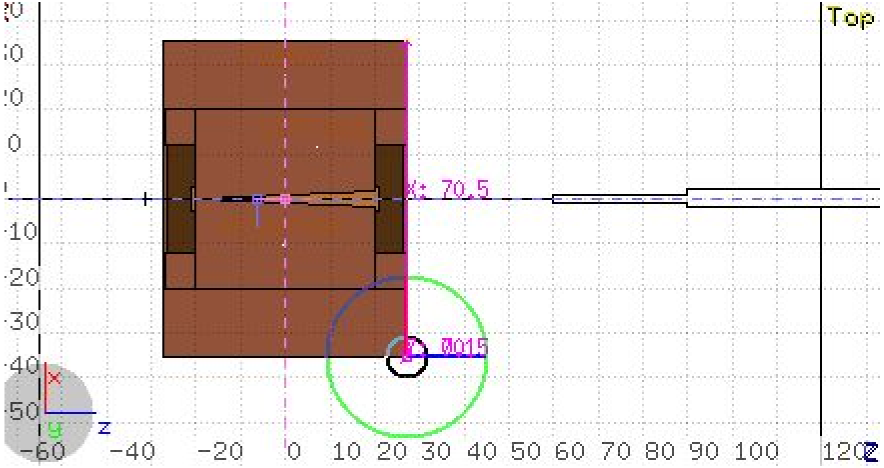
CPS Meeting February 13 2018

Summary of Updates from last Meeting



1. Beam direction and radiator thickness and location corrected
2. Fixed functionality of magnetic field
3. Addition of black hole beam dump
4. Two layers of detectors created
5. Baseline Neutron Flux and dosage calculations

Copper Proton Experiment (1/3)

FLUKA has a large set of libraries

- For most purposes, a black box

- Must ensure we know (I know) what we’re doing (I’m doing)

- Easiest way to confirm is to perform simple experiments, verifying measurements and units

Copper Proton Experiment (2/3)

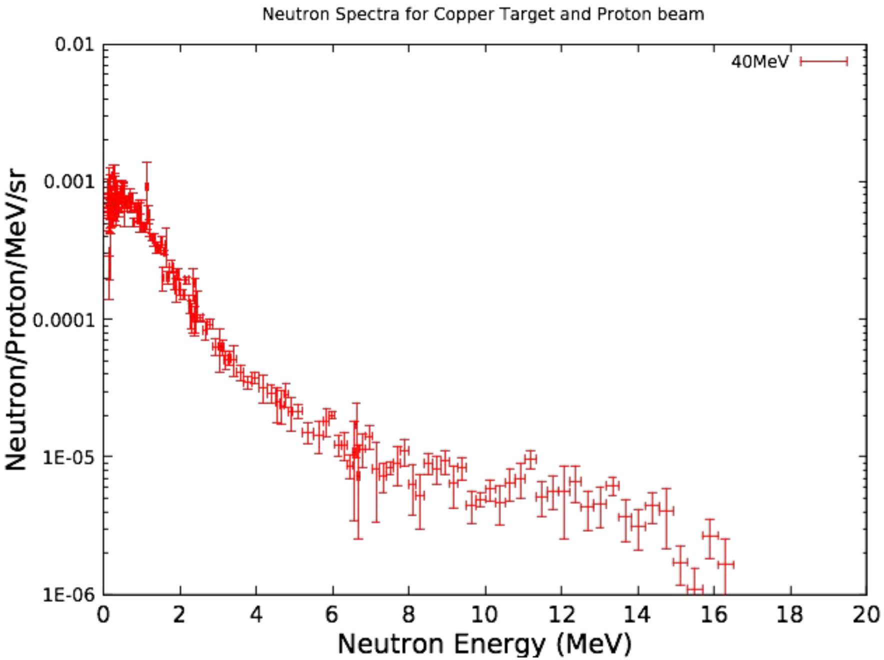
40MeV Proton beam directed at a copper cylinder,
Attempt to replicate published data

Basic Copper experiment Geometry with FLUKA

-Confirming similar results to the literature, neutron energy spectrum

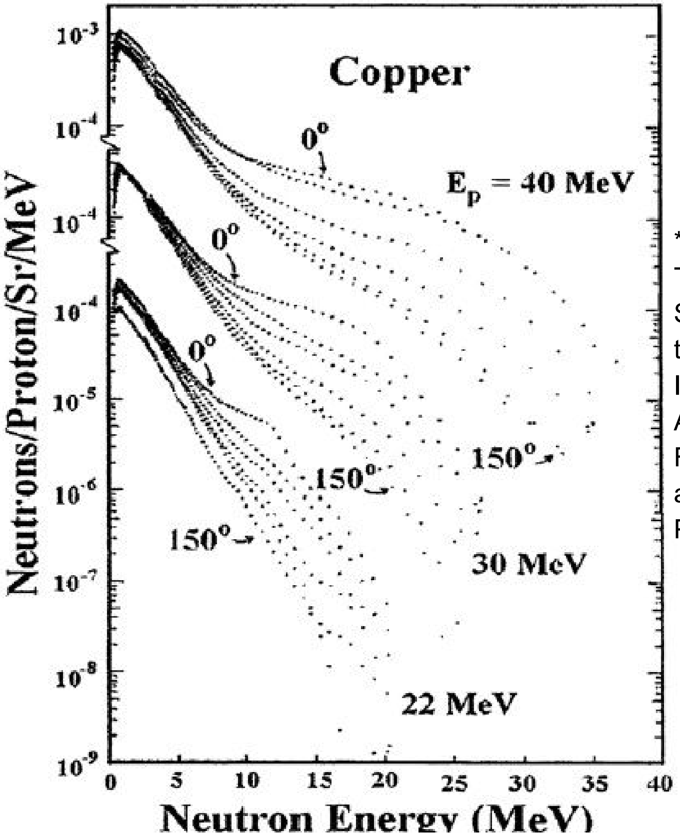
- Providing confidence in further results in CPS, continued understanding of model

Copper Proton Experiment (3/3)



Low Angle Neutron spectrum observed with FLUKA

Result: Reasonable degree of similarity achieved



Copper Target Neutron Spectrum taken from Indian Association For Radiation and Protection

Current CPS Model (1/3)

CPS Requirements:

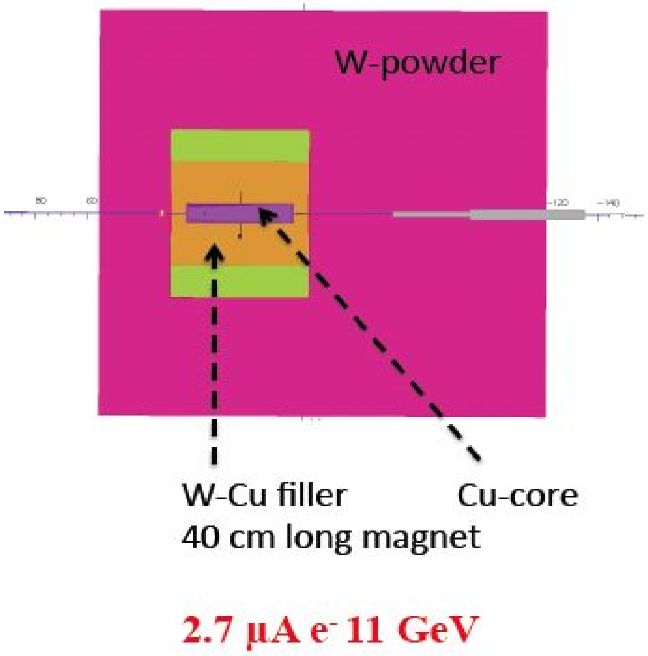
Magnet geometry fully described for 11 GeV e- beam at 2.7 μA

Up to 3.2 T magnetic field

3x3 mm beamhole

~0.9 mm diameter photon beam 200 cm from radiator

2017 model



Source: B. Wojsekowski 9/26/17 Collaboration meeting

Current CPS Model (2/3)

Composition:

Updated Shielding methodology (Tungsten Powder outer shell) *REMOVED TEMPORARILY*

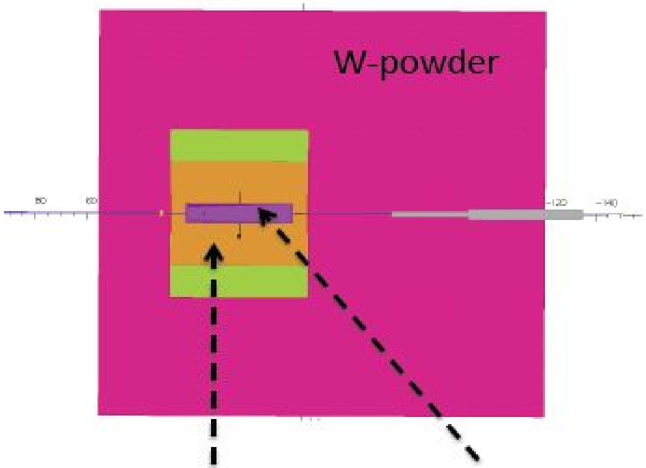
Inner shield of Tungsten Cu Alloy (20% Cu)

Fe Magnet components

Wedged inner Cu core

Thin 10% Cu radiator

2017 model



2.7 μA e⁻ 11 GeV

Source: B. Wojsekowski 9/26/17 Collaboration meeting

Current CPS Model (3/3)

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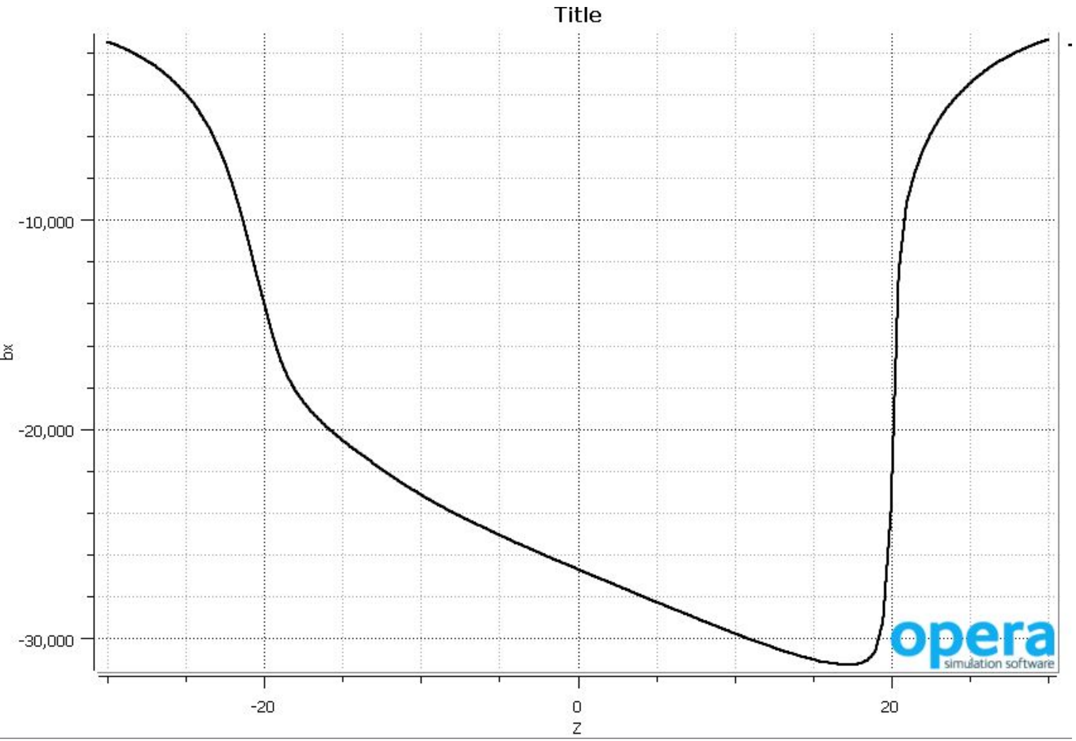
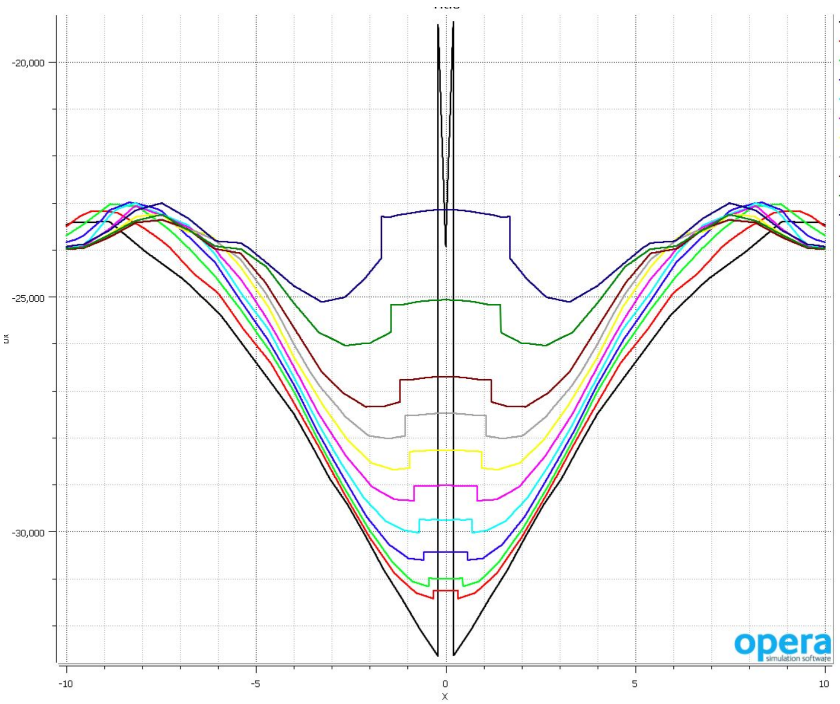


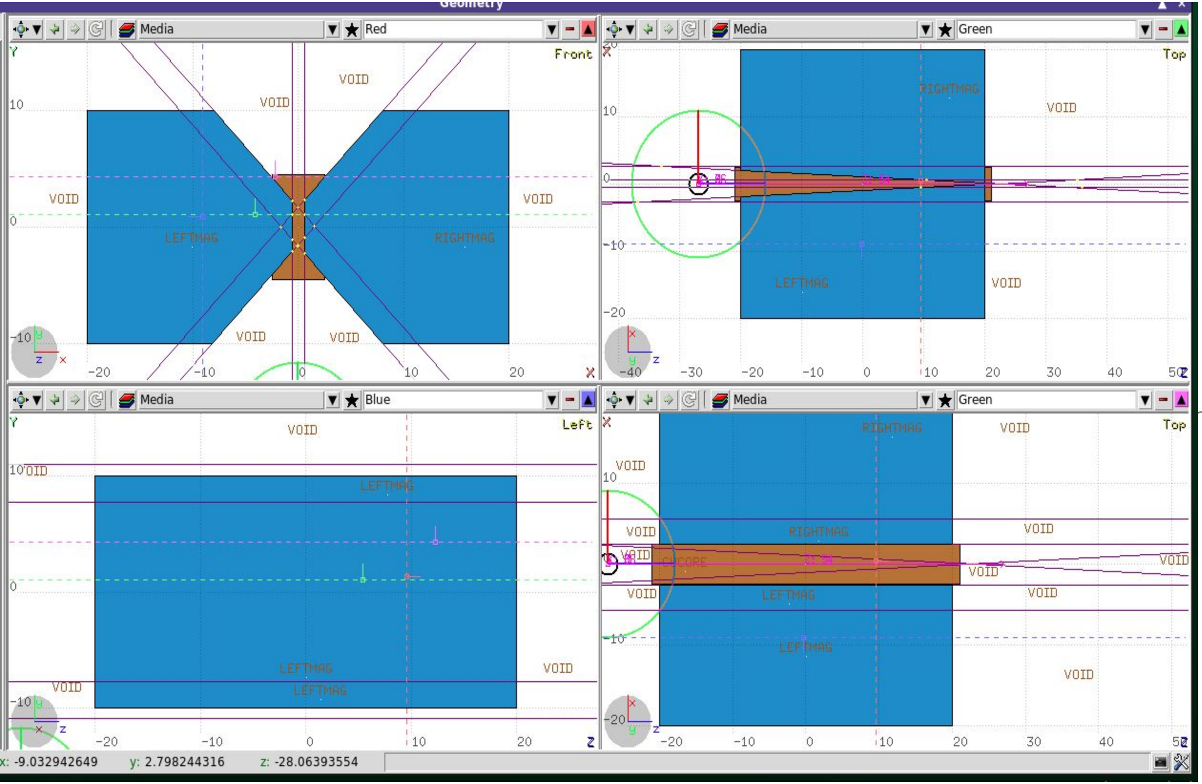
(0,0,Z) Magnetic Profile



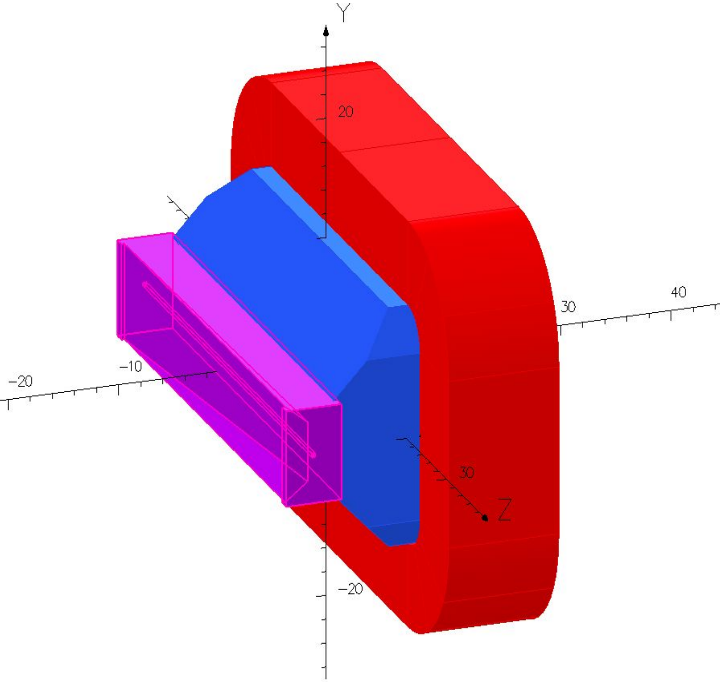
Along Z Different X (Gauss)

Source: B. Wojsekowski 9/26/17
Collaboration meeting

Geometry (1/4): Magnet + Cu Core



FLUKA Model



Source: B. Wojsekowski 9/26/17
Collaboration meeting

Current Model

Geometry (2/4): Coils + WCu

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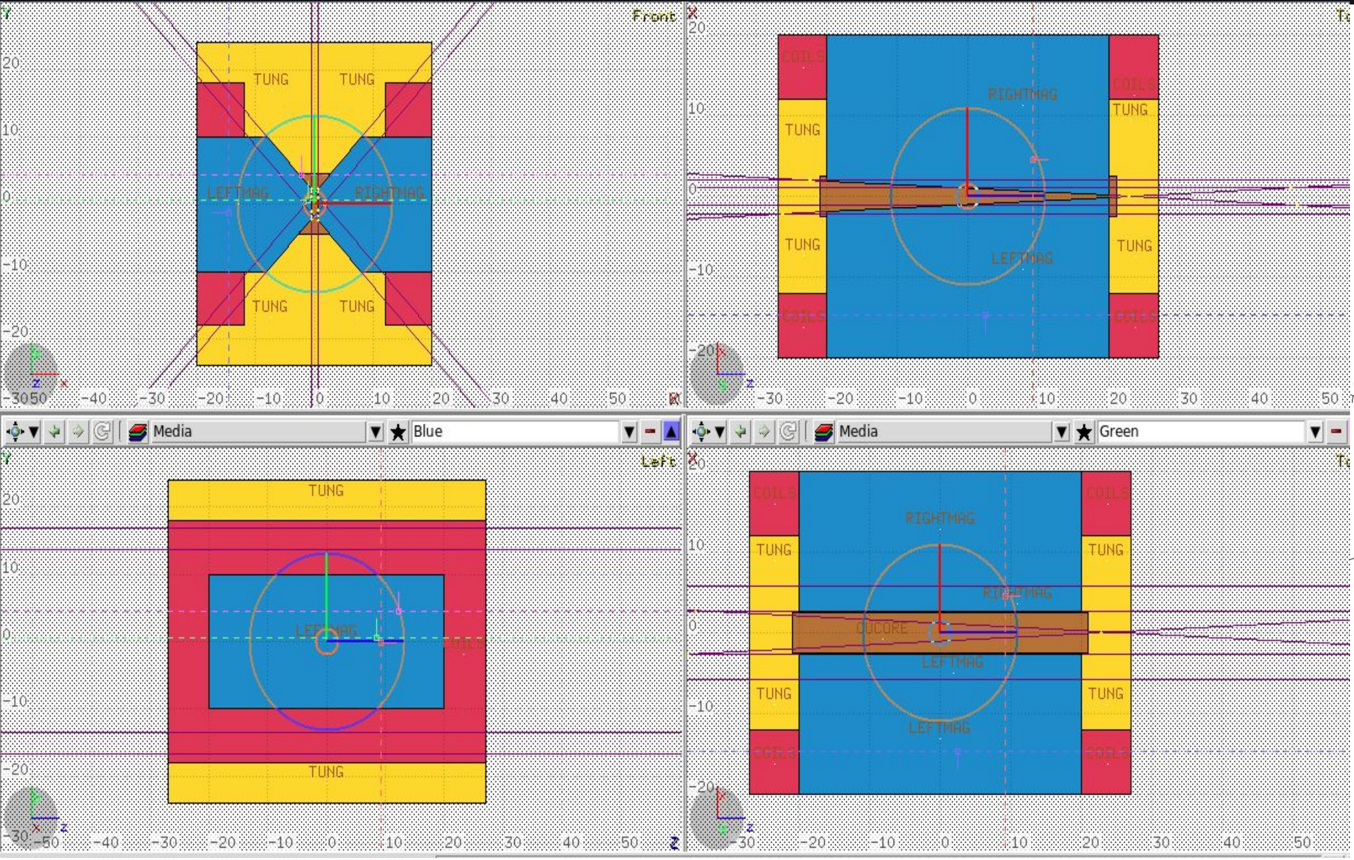
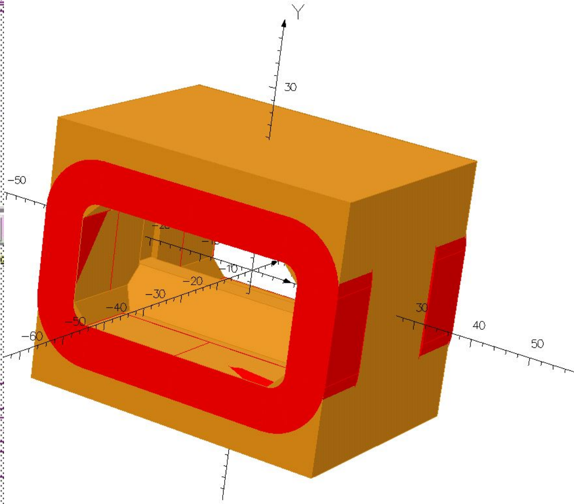


FLUKA Model



Source: B. Wojsekowski 9/26/17
Collaboration meeting

Current Model

Geometry (3/4): Wpowder + Beam

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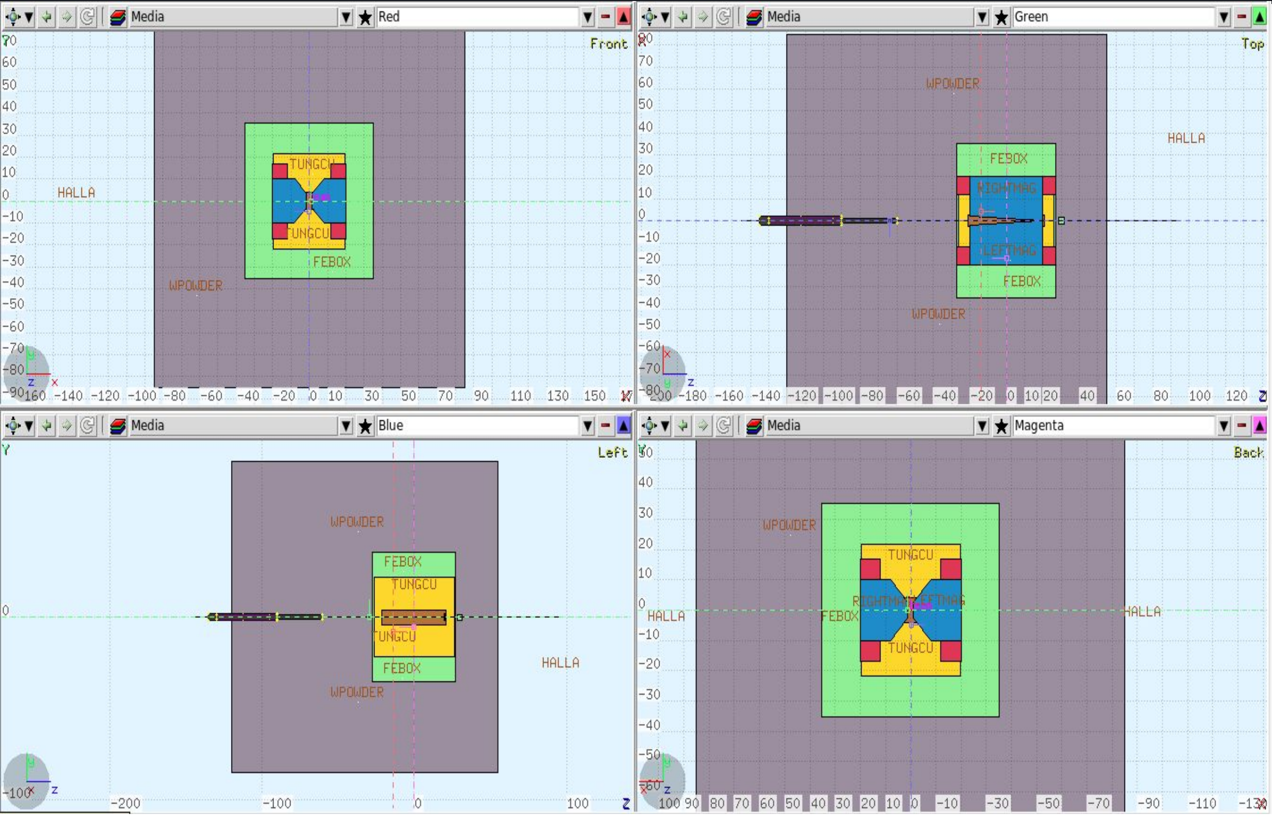
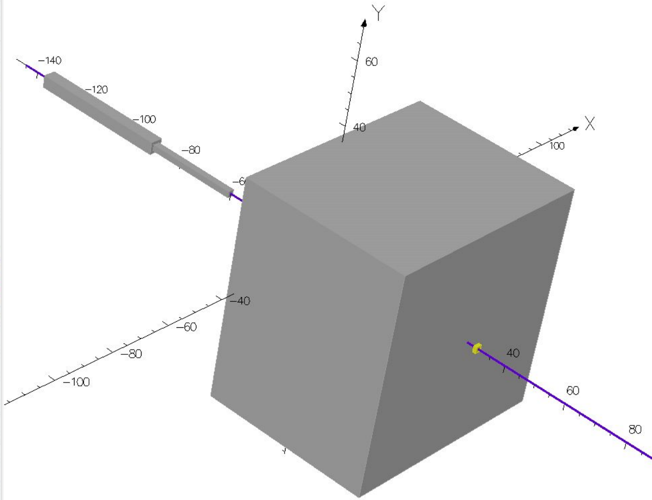


FLUKA Model



Source: B. Wojsekowski 9/26/17
Collaboration meeting

Current Model

Geometry (3/4): Beam Dump

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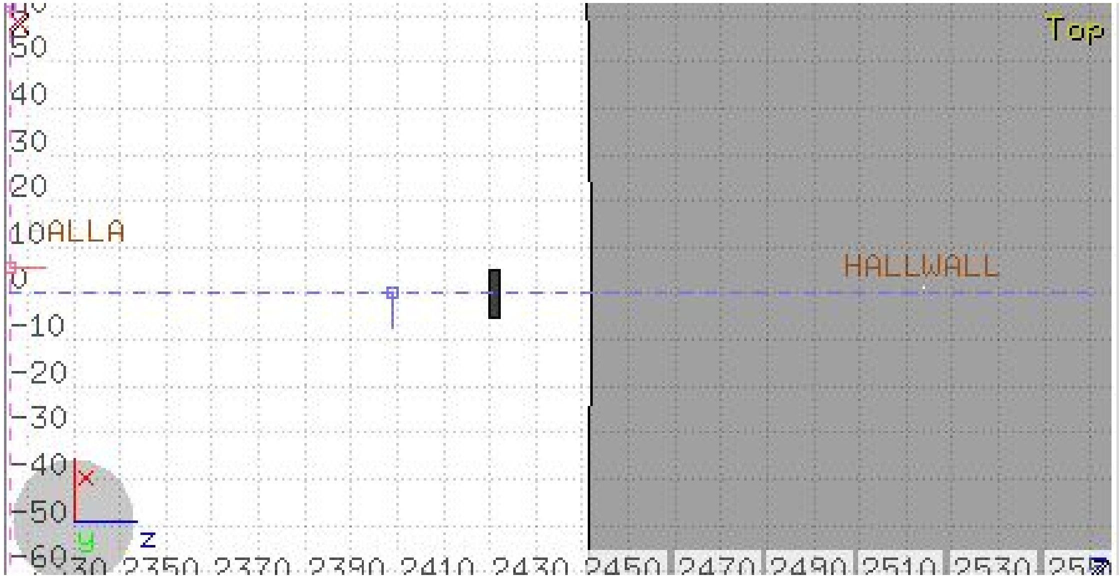
10x10x2 cm blackhole body located along beamline

Near the edge of the hall



FLUKA Model

Geometry (4/4): Hall Geometry

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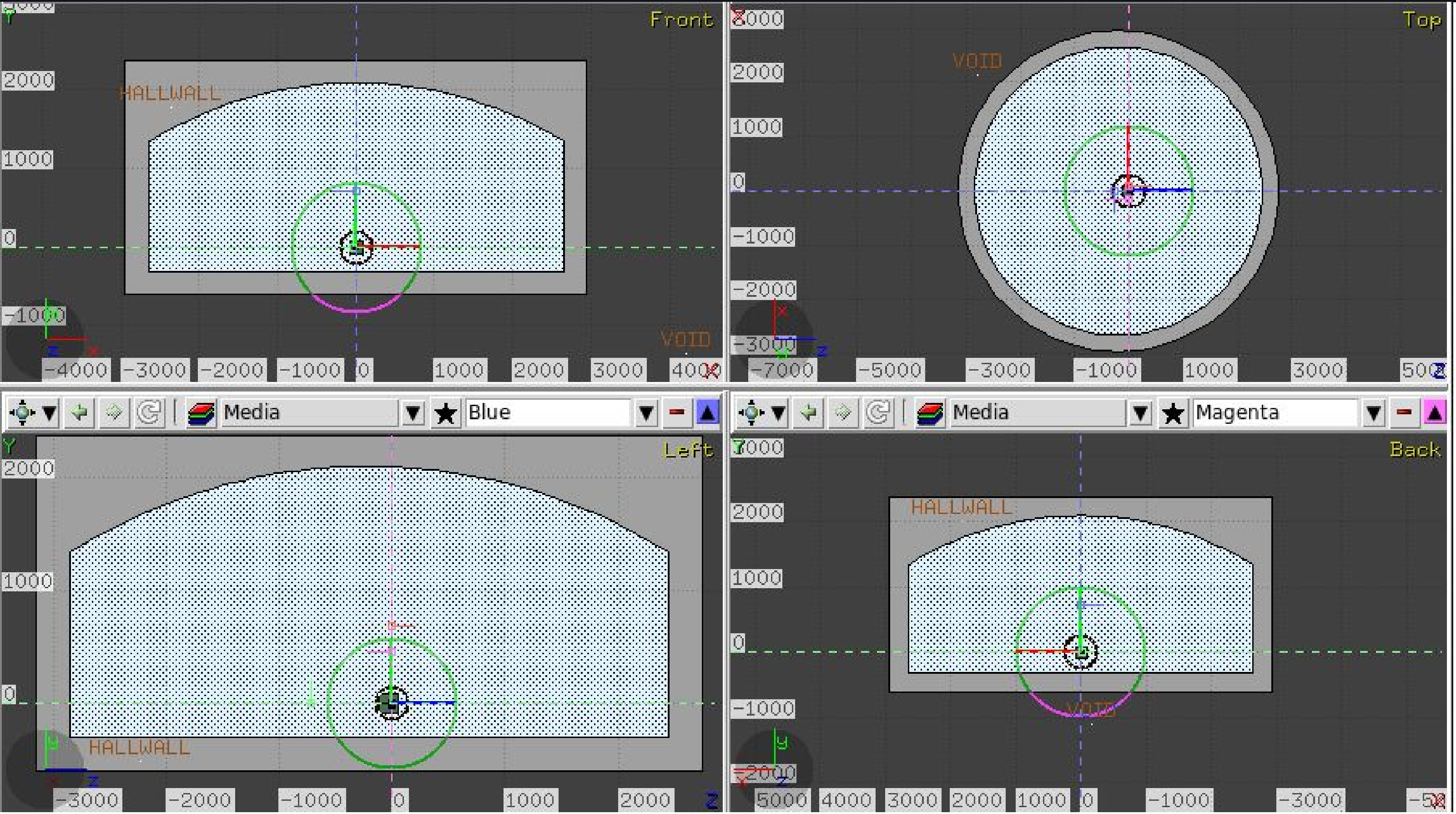

Baseline
Radiation Runs

Tungsten Powder Absent

2.7μA beam running for 40 days.

Dosage as function of Radius from Beamline(cm)

Dosage recorded as rem/hr

USRBIN recorded dosages at 5m from beamline

Recorded Activity:
Prompt Radiation
Activated material at 40 days

Supplementary FLUKA Information

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Define the beam characteristics

BEAM	Beam: Energy ▾	E: 11.0	Part: ELECTRON ▾
Δp: Flat ▾	Δp:	Δϕ: Flat ▾	Δϕ:
Shape(X): Annular ▾	Rmin: 0	Rmax: 0.1	

Define the beam position

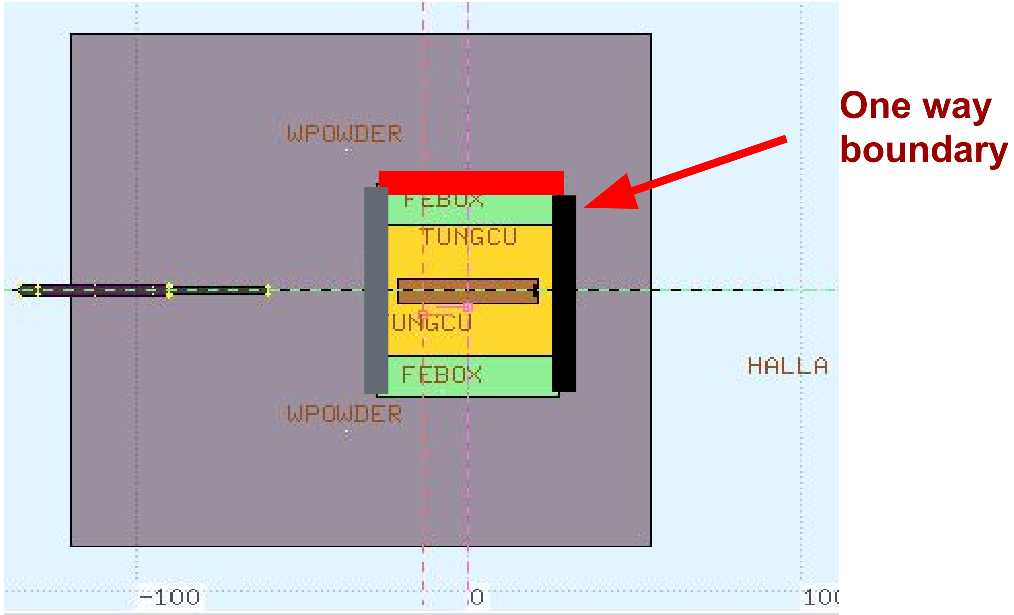
BEAMPOS	x:	y:	z: -300
	cosx:	cosy:	Type: POSITIVE ▾
PHOTONUC	Type: ▾		All E: On ▾
E>0.7GeV off ▾	Δ resonance off ▾	Quasi D off ▾	Giant Dipole off ▾
	Mat: BLCKHOLE ▾	to Mat: @LASTMAT ▾	Step:
PHYSICS	Type: EVAPORAT ▾	Model: New Evap with heavy frag ▾	
	Zmax: 0	Amax: 0	
PHYSICS	Type: COALESCE ▾	Activate: On ▾	

LAM-BIAS	Type: ▾	× mean life:	× λ inelastic: 0.001
Mat: ▾	Part: PHOTON ▾	to Part: PHOTON ▾	Step:
EMFCUT	Type: transport ▾		
	e-e+ Threshold: Kinetic ▾	e-e+ Ekin: 0.0007	γ: 0.00007
	Reg: VOID ▾	to Reg: @LASTREG ▾	Step:
EMFCUT	Type: PROD-CUT ▾		
	e-e+ Threshold: Kinetic ▾	e-e+ Ekin: 0.0007	γ: 0.00007
Fudgem:	Mat: BLCKHOLE ▾	to Mat: @LASTMAT ▾	Step:
RADDECAY	Decays: Active ▾	Patch Isom: On ▾	Replicas: 3
h/μ Int: ignore ▾	h/μ LPB: ignore ▾	h/μ WW: ignore ▾	e-e+ Int: ignore ▾
e-e+ LPB: ignore ▾	e-e+ WW: ignore ▾	Low-n Bias: ignore ▾	Low-n WW: ignore ▾
	decay cut: 0.0	prompt cut: 0.0	Coulomb corr: ▾

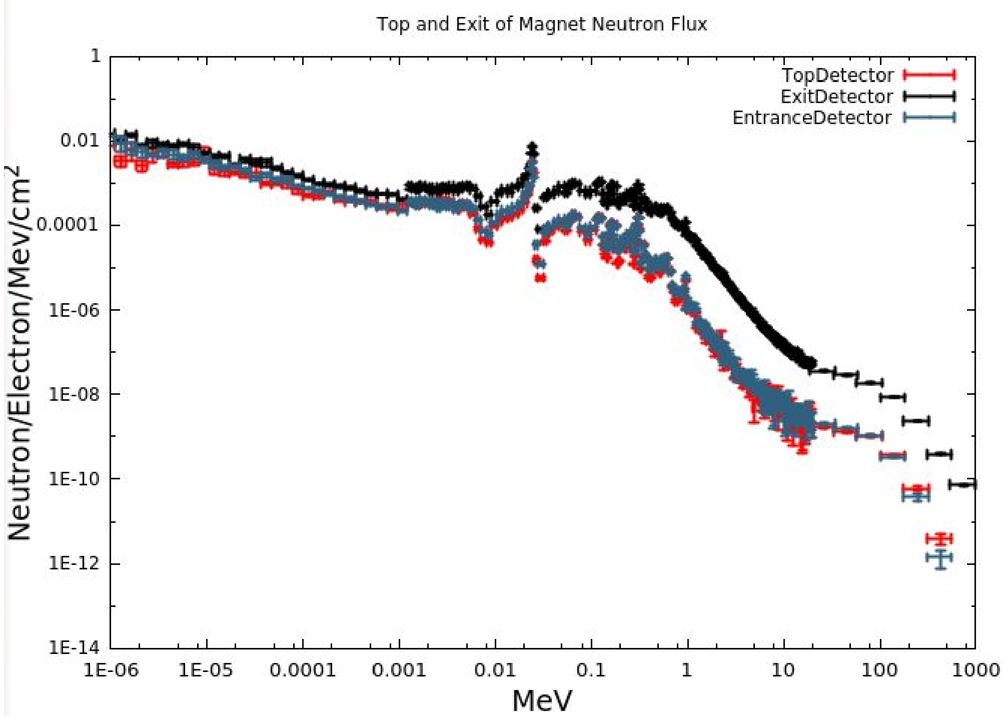
Baseline Results (1/3)

Implemented square "slab" detectors on all sides of the magnet, useful in determining neutron flux (USRBDX Detector)

2cm Radius hole in entrance and exit slab detectors to avoid beamline in calculation



Baseline Results (2/3)



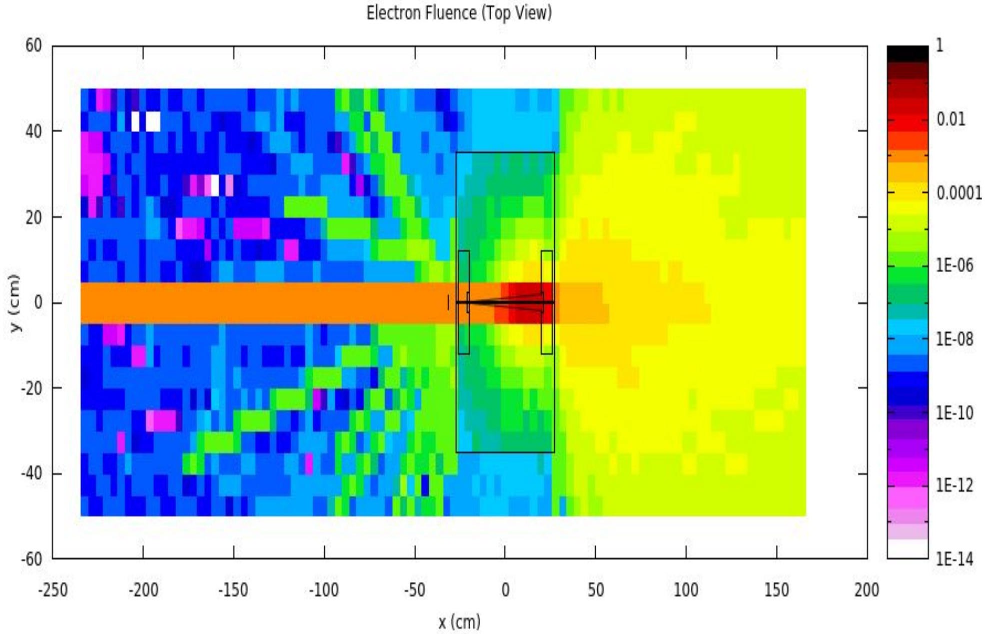
Indicates that neutron flux shape remains the same (As one might expect)

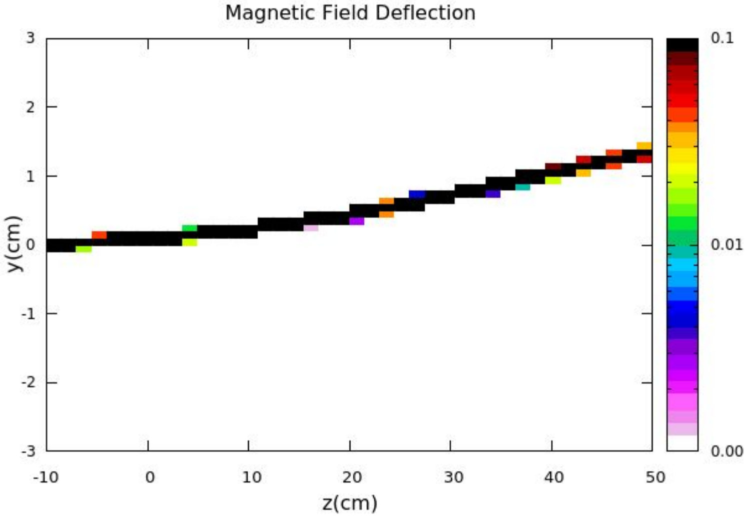
Neutron Flux calculated at various boundaries.

Taken from sides of the magnet, with no W shield

Baseline Results (3/3)

Tracking Electron Flow with Cartesian USRBIN





Note This serves to test the functionality of the magnetic field. Ensuring nothing passes the copper

2,500 Primaries

5M Results (1/4) No W shield

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Detector information:

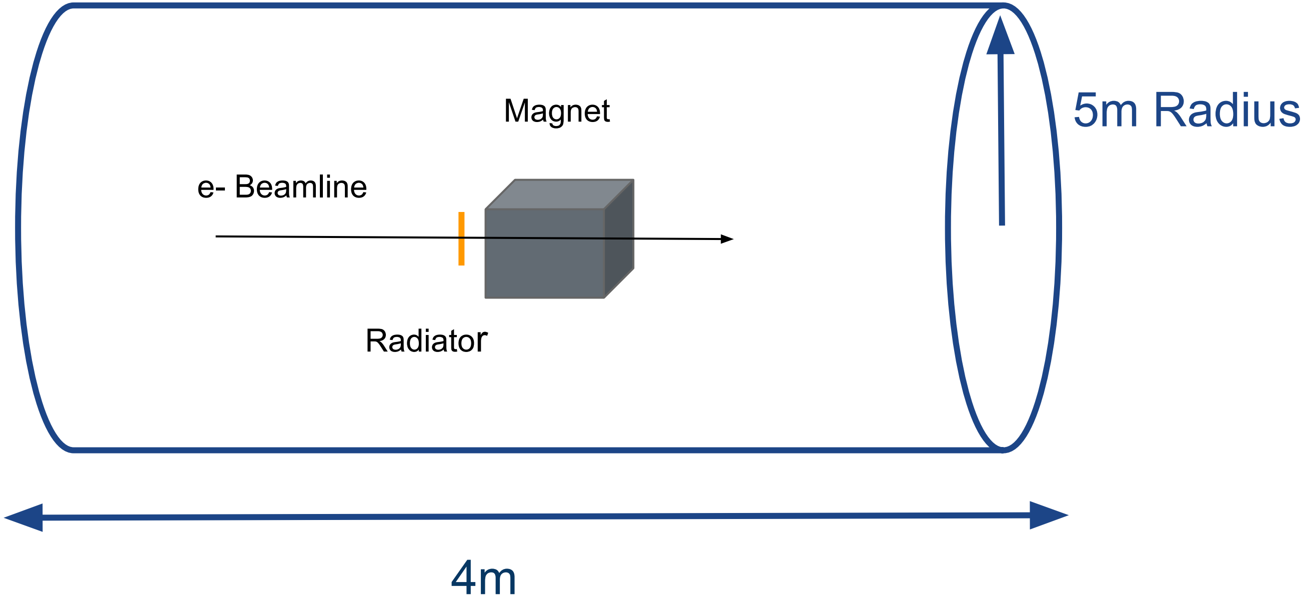
Clylindrical Dose detector

USRBIN

Type: R-Φ-Z		Unit: 22 BIN	Name: D1H2
	Rmin: 0	Rmax: 500	NR: 100
Part: DOSE-EQ	X: 0	Y: 0	NΦ: 1
	Zmin: -234	Zmax: 166	NZ: 100

USRBIN Dose equivalence option, AMB74 Default coefficients

Cylinder Centered about radiator



5M Results (2/4) No W shield

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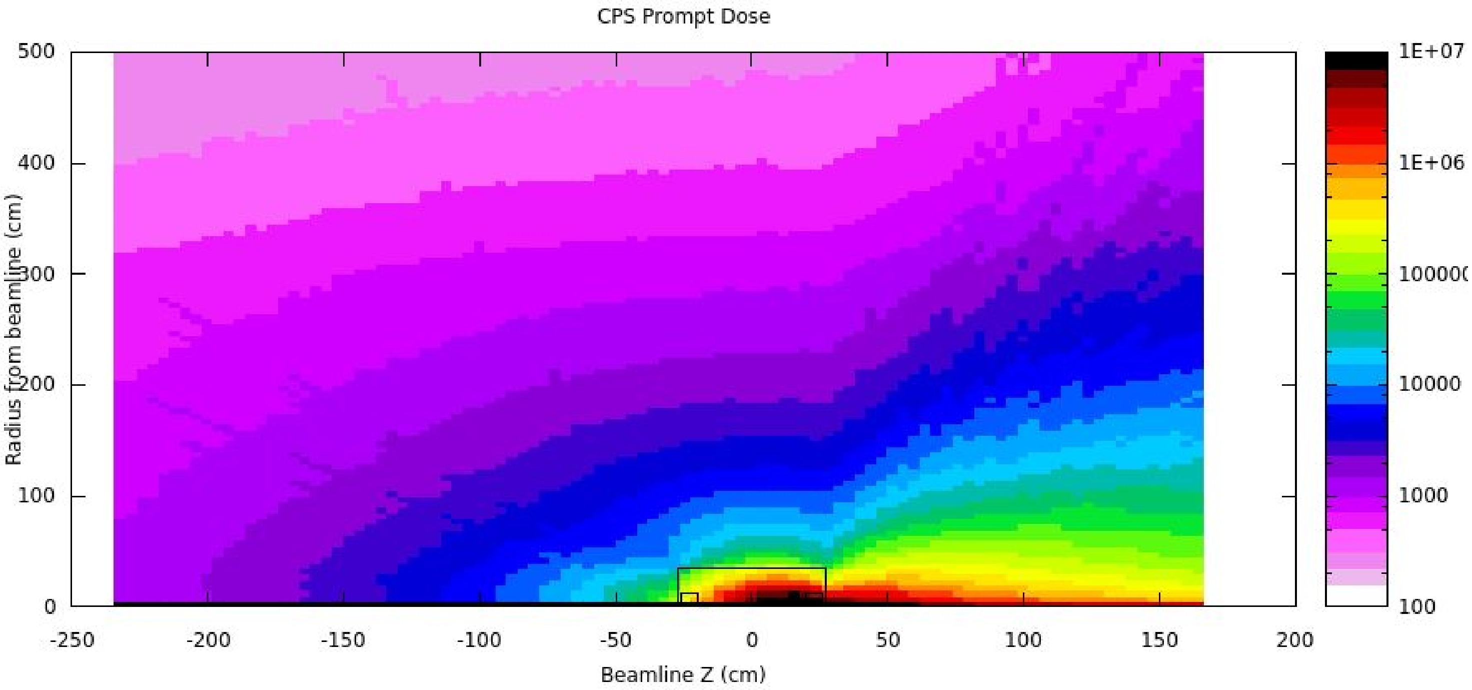

~Dose in rem/hr

Dosage Calculation:

Doseeq -> psv/primary

Convert psv to rem (1e-10)

Multiply by current (2.7ua =0.027*6.624E14 prim/sec)

Multiply by 3600(sec->hours)

Dosage is Very High without a shield

2,500 Primaries

5M Results (3/4) No W shield

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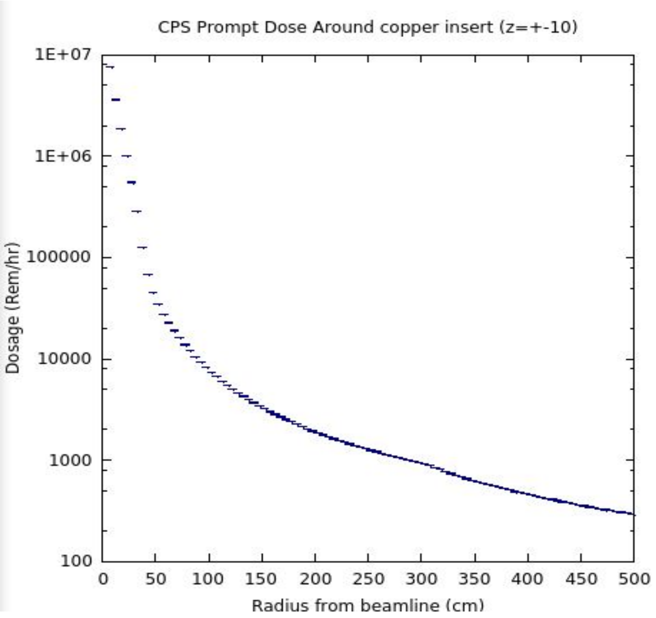
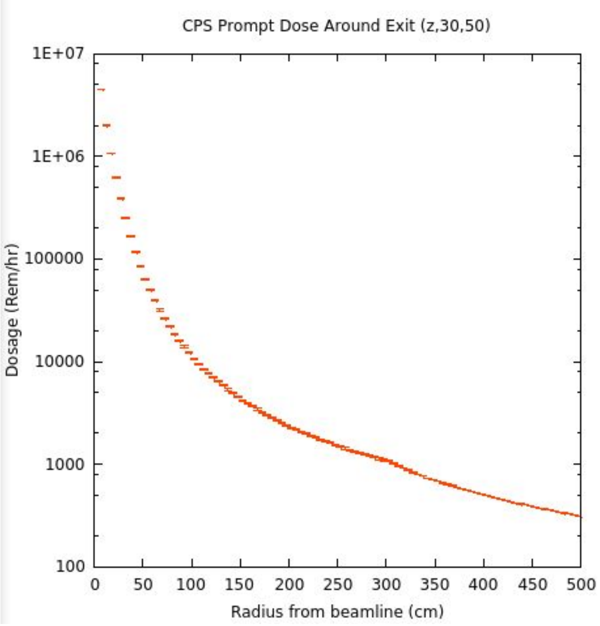
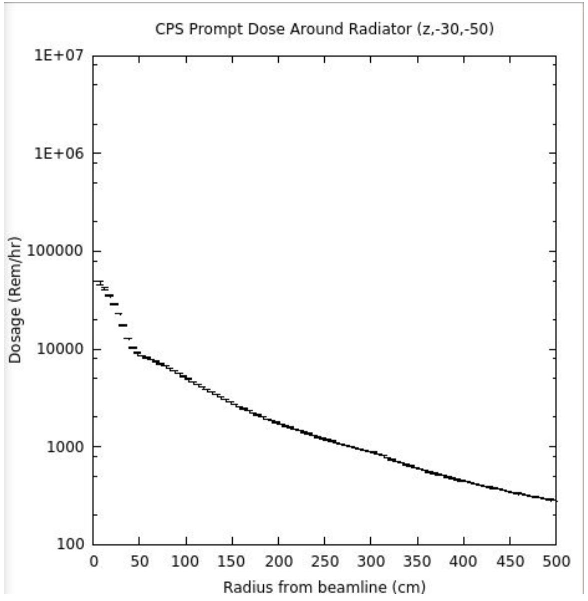


Dose Around Copper insert
-10<z<-10



Dose Around Magnet Exit
30<z<50



Dose Around Radiator
-50<z<-30

Dose in rem/hr

2,500 Primaries

5M Results (4/4) No W shield

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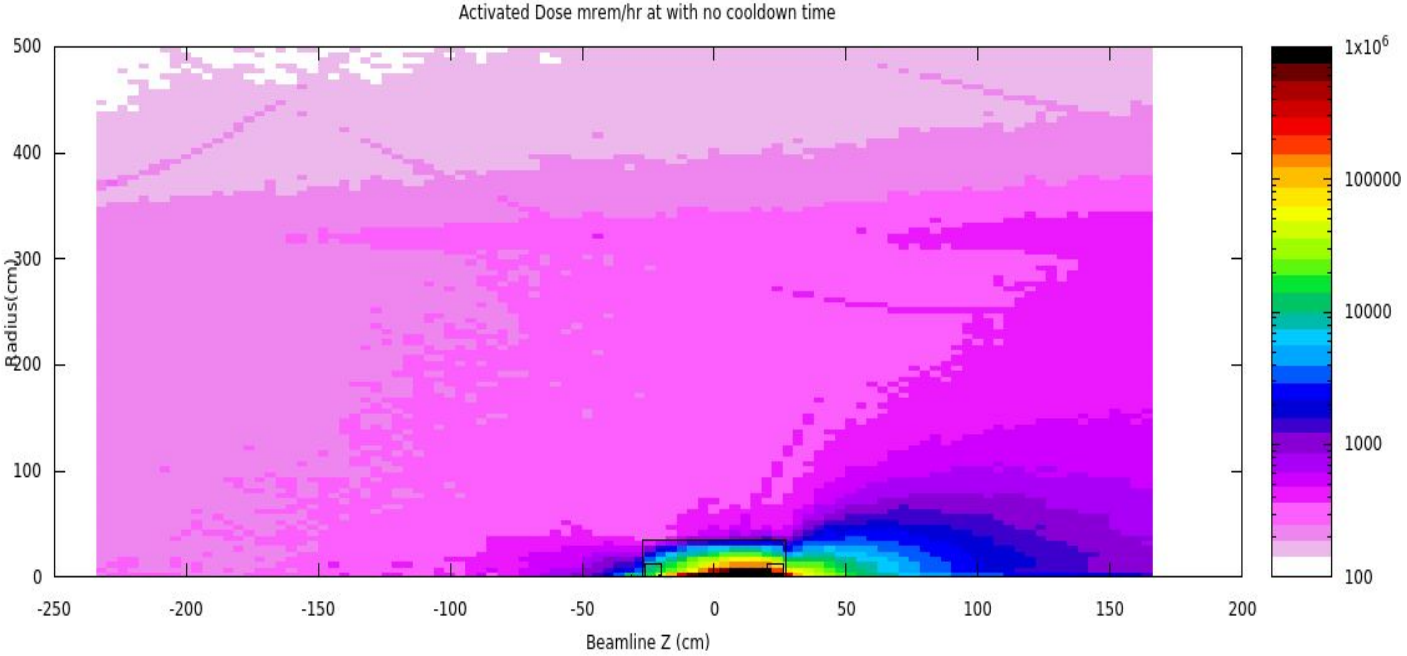

Dosage Calculation:

Doseeq -> psv/sec

Convert psv to mrem (1e-7)

Multiply by 3600(sec->hours)

Activated dose with no cooldown time

Dose in mrem/hr

2,500 Primaries

Completed Goals of Project

1. Describe required CPS geometry and Fields within FLUKA environment.

2. Create a robust basic geometry to continue testing

3. Create an absolute baseline radiation level with no shielding

4. Methodology for direction dependant boundary flux

Moving Forward....

1. Add Shielding! Along the lines of Jixie's efforts, confirm results if possible
2. Additional cooling time detectors
3. More primaries (Magnetic field correction adds significant simulation time)
4. Evaluate Photon intensity

Questions/Comments/Concerns?

As always, FLUKA insight is greatly appreciated!

Thank you

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Neutron Effect expectation

1 rem = 27,000,000 n/cm^2

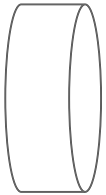
Output ~30kW

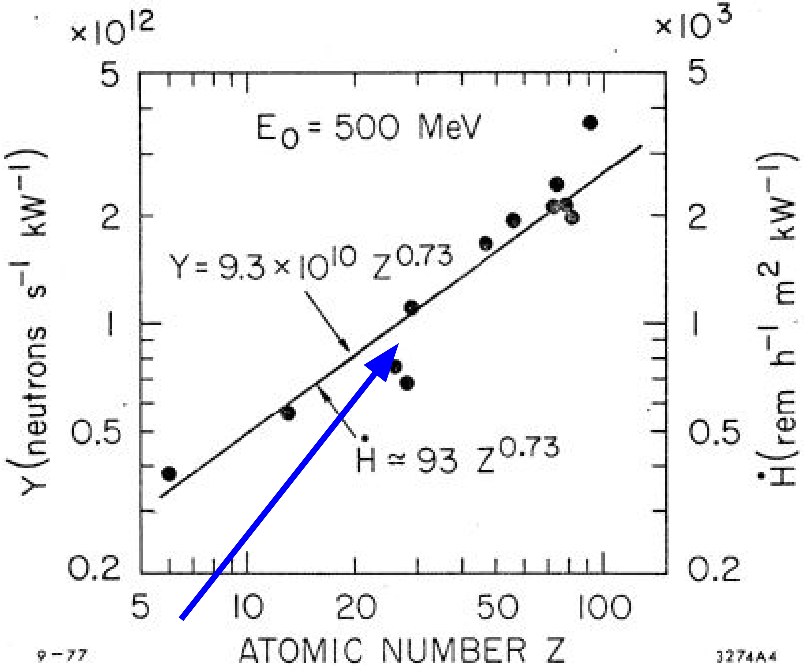
10^{12}neutron/kw/s x 30kW = $3*10^{13}$neutron/s

$1.08*10^{17}$neutron/hr produced from target

$4x10^9$ rem/hr/cm^2

In cylindrical detector at 1m we expect factor
4π(100cm^2) Dispersion =~$3x10^5$rem/hr





Copper/Iron range =~ 1neutron/kW/s