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Top-up operation plan in Canadian Light Source

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Contents

- Introduction
  - Objectives of the study
  - Importance of the study
  - Back ground information;- Canadian Light Source and Beam lines
- Materials and Methodology
  - Geometric Design of Hard X-Ray Beam line (HXMA)
  - Measurement Plan and Monte Carlo Model with MCNPX and FLUKA
  - Input card: Features and description
- Results and Discussion
  - Electrons and Photons distribution: McnpX
  - Electrons profile: Fluka
  - Comparison: Fluka and McnpX
- Future Plan

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Objective

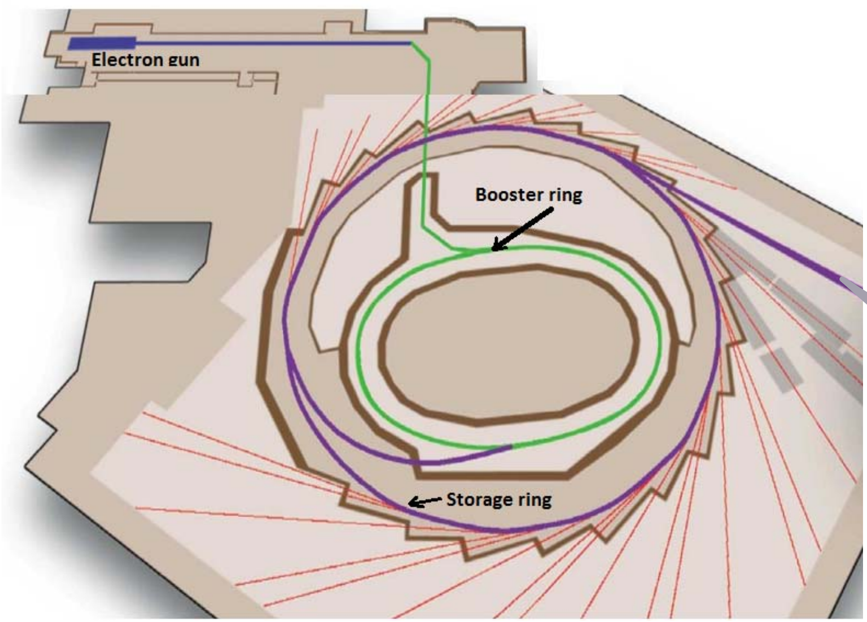
- Modelling a beam line of Canadian Synchrotron Research Facility
- Studying the impacts of beam loss scenarios in the storage rings during top-up and normal mode of operation, and to calculate the doses in the user's area
- Studying efficacy of existing shielding and to design new shielding.

Importance

- Beam-loss events may cause unwanted doses to the workers and damage equipment.
- The information achieved from this study will provide information regarding safe and controlled operation of the synchrotron
- CLS is planning to adopt a top-up operation mode in order to provide uninterrupted beam-light to the users, that can save both time and energy. This modeling study will directly facilitate the proposed top-up mode of operation at CLS.

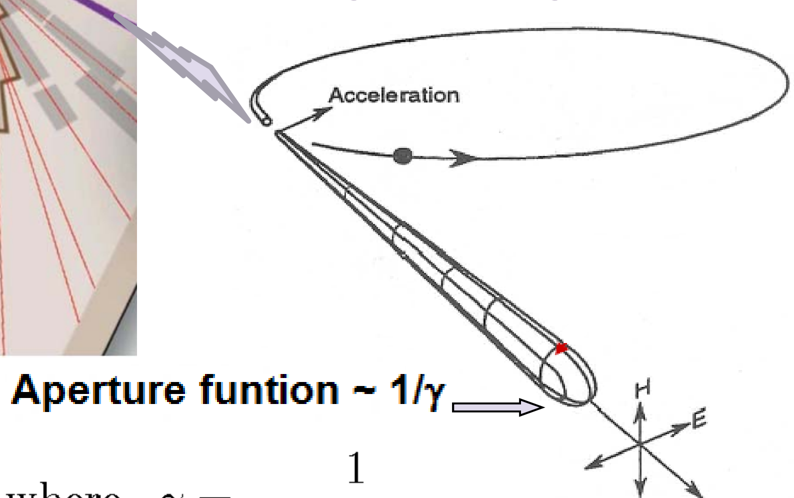
Introduction

Synchrotron Radiation



Relativistic electrons ($v/c \approx 1$) emit radiation that is sharply forwarded

Radiation becomes more focussed at higher energies



$$\text{where,} \quad \gamma = \frac{1}{\sqrt{1 - (\frac{v}{c})^2}}$$

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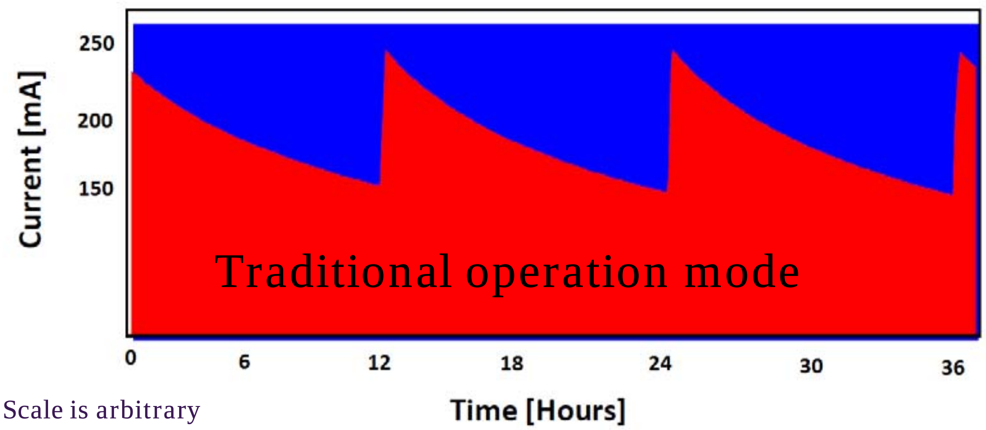
Introduction

Synchrotron operation: Decay Vs Top-up mode

Two modes in synchrotron operation: (*) Decay mode of operation



Scale is arbitrary

Limitations:

(*) No stability in storage-ring current
(*) No thermal stability in the beam line optics
(*) Users can not use beam line during the injection

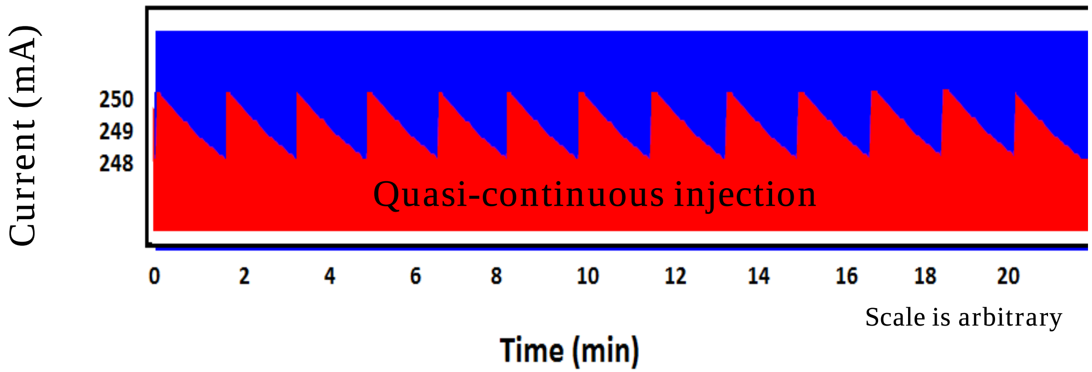
In decay mode of operation, the storage ring current slowly decay down with time, until next injection

No Safety Concern as the beam line safety shutter keeps closed

Introduction

- Synchrotron operation: Decay Vs Top-up mode

Top-up mode of operation



In top-up mode of operation, electron is injected to the storage ring in short time interval, yields almost steady state ring current.

Advantages:

(*) Beam current stability within specified limit

(*) Avoid beamline shutter cycling during each injection

(*) Thermal stability of beamline optics, avoiding drifts

Safety Concern: Beam line safety shutter keeps open

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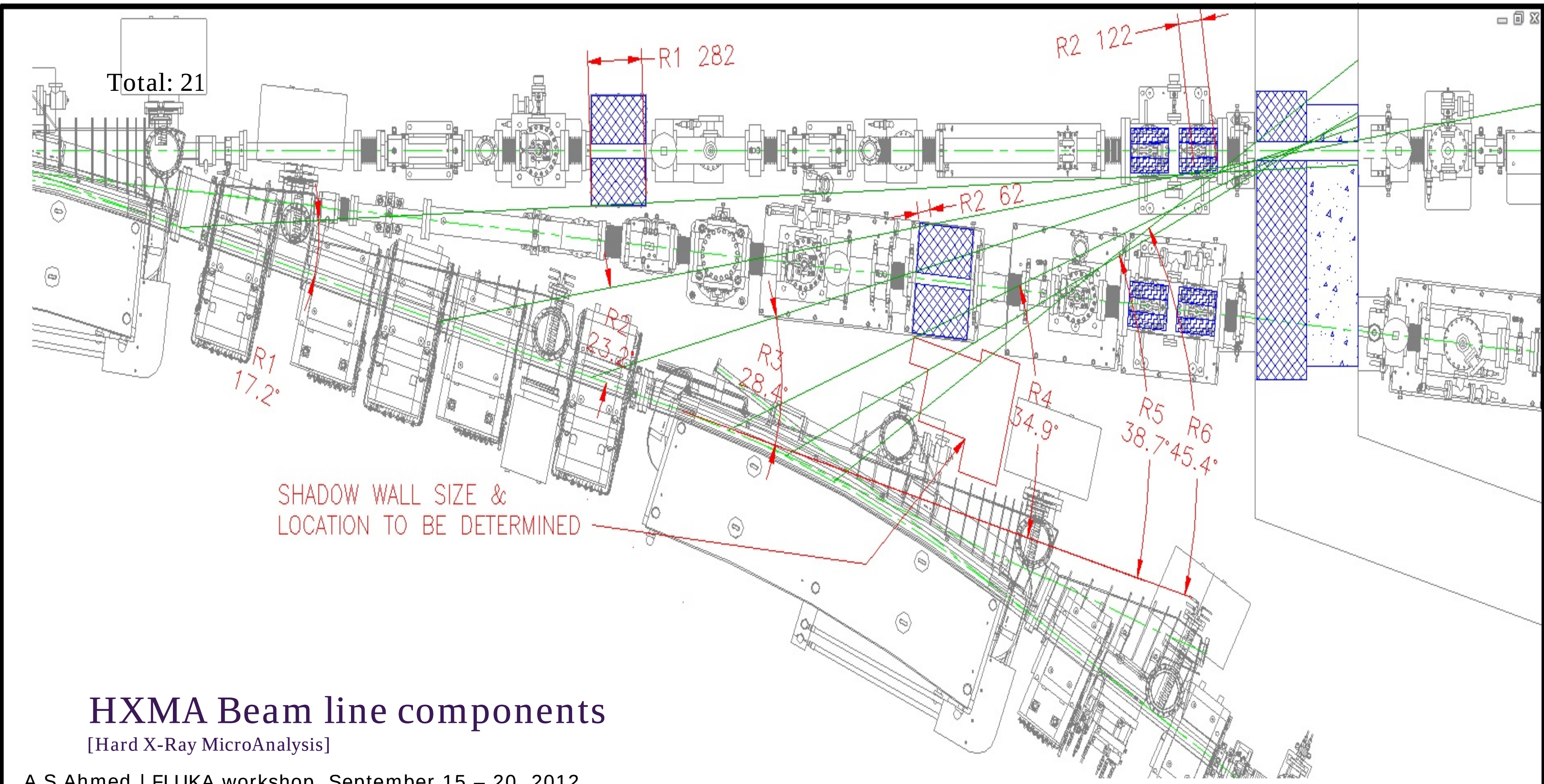
Introduction

Top up measurement plan



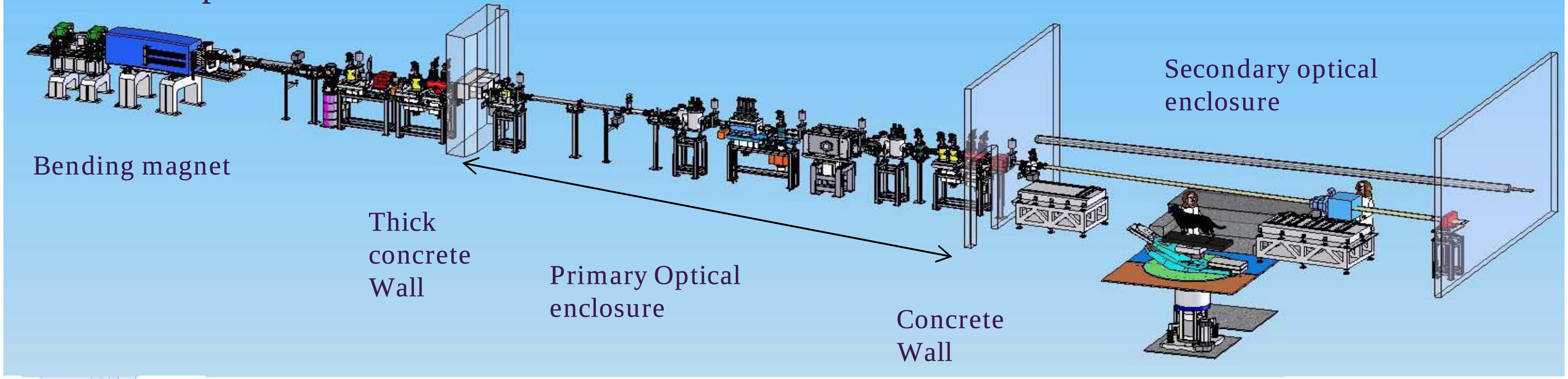
HXMA Beam line components

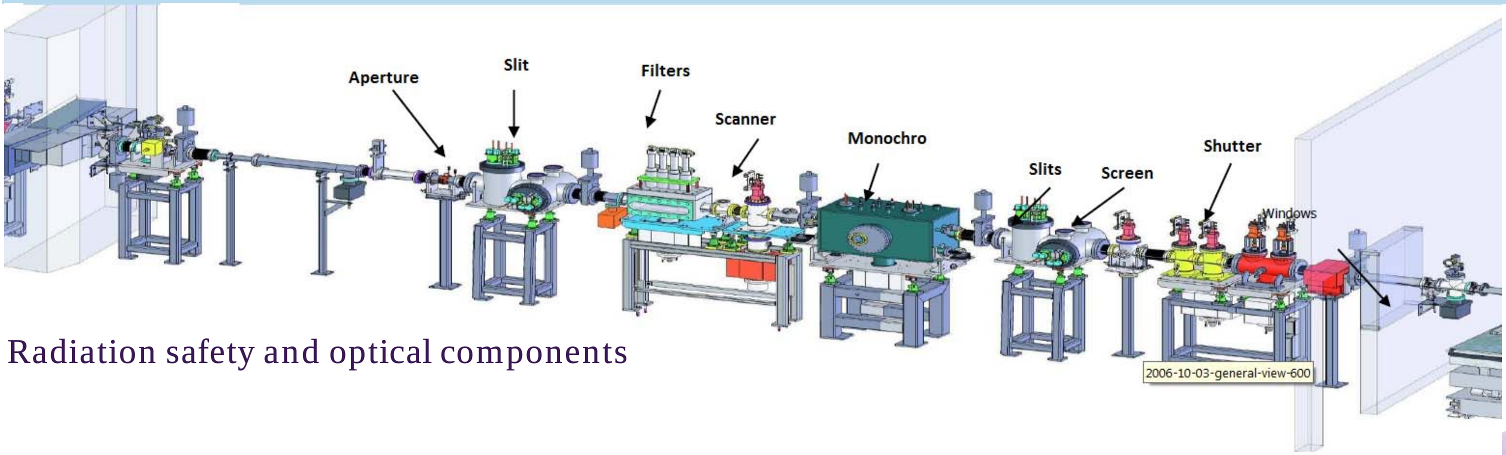
[Hard X-Ray MicroAnalysis]

Introduction

- Radiation Safety in Top-up operation

Front components in a beam line





Radiation safety and optical components

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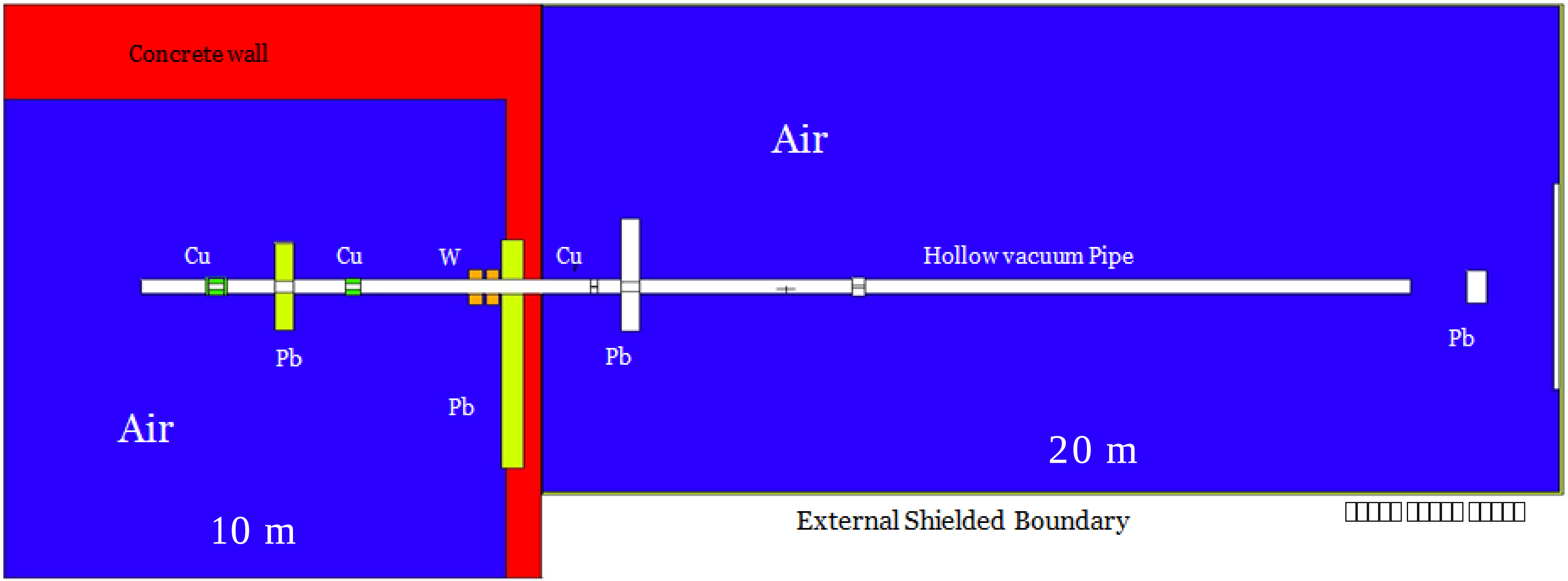
Materials and Methods

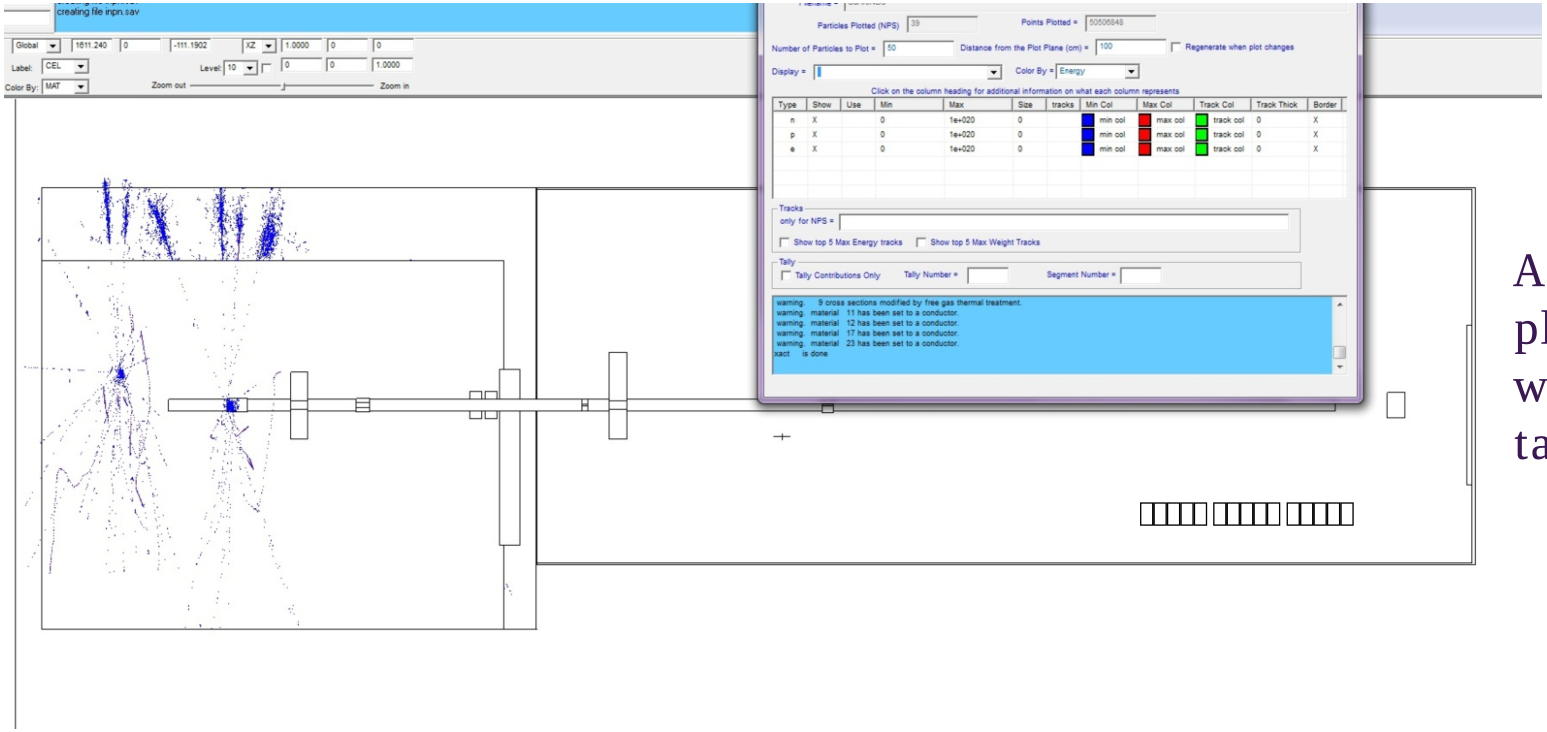
Monte Carlo Design Features: MCNPX



Basic radiation Safety components in the HXMA beam line

Materials and Methods

HXMA initial model: MCNPX

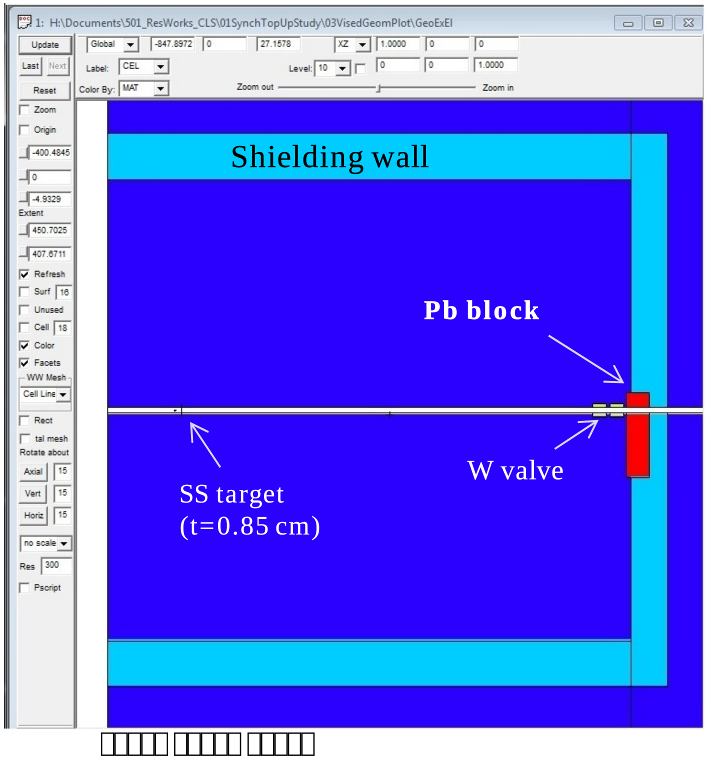


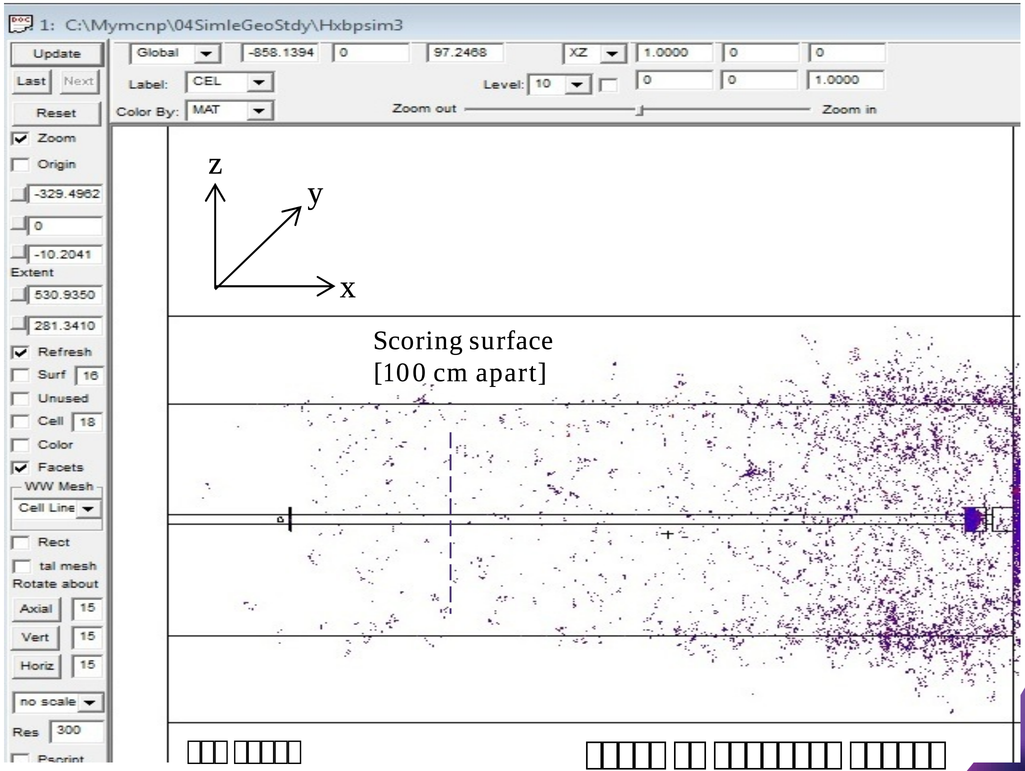
A thick Cu plate (t=3 cm) was used as target

- Statistics was poor
- After conversion from SimGeo to MCNPX, the input card was manually restructured

Materials and Methods

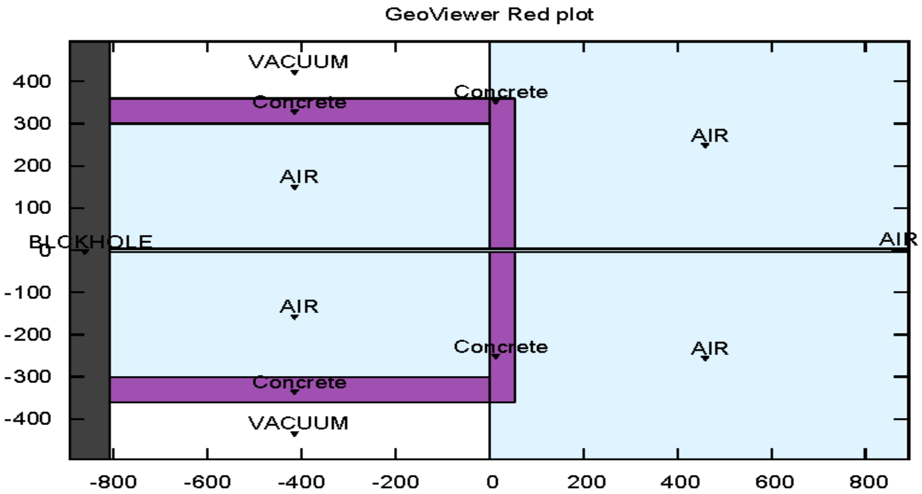
Study of Electron Distribution: MCNPX

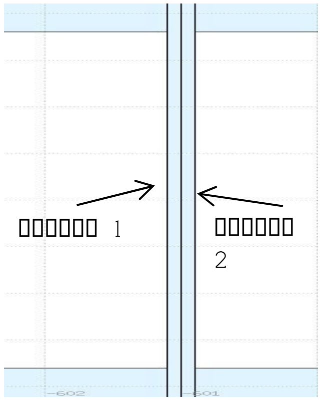




Materials and Methods

Study of Electron Distribution: Fluka





----------- TITLE ... DEFAULTS : 2 cards hidden -----------

The beam is gaussian shaped; FWHM (0.3, 0.3) along X-Y

BEAM	Beam: Energy ▼	E: 2.9	Part: ELECTRON ▼
Δp: Gauss ▼	Δp(FWHM): 0.029	Δϕ: Flat ▼	Δϕ:
Shape(X): Gauss ▼	x(FWHM): 0.3	Shape(Y): Gauss ▼	y(FWHM): 0.3
BEAMPOS	x: -710.	y: 0.0	z: 0.0
	cosx: 1.	cosy: 0.0	Type: POSITIVE ▼

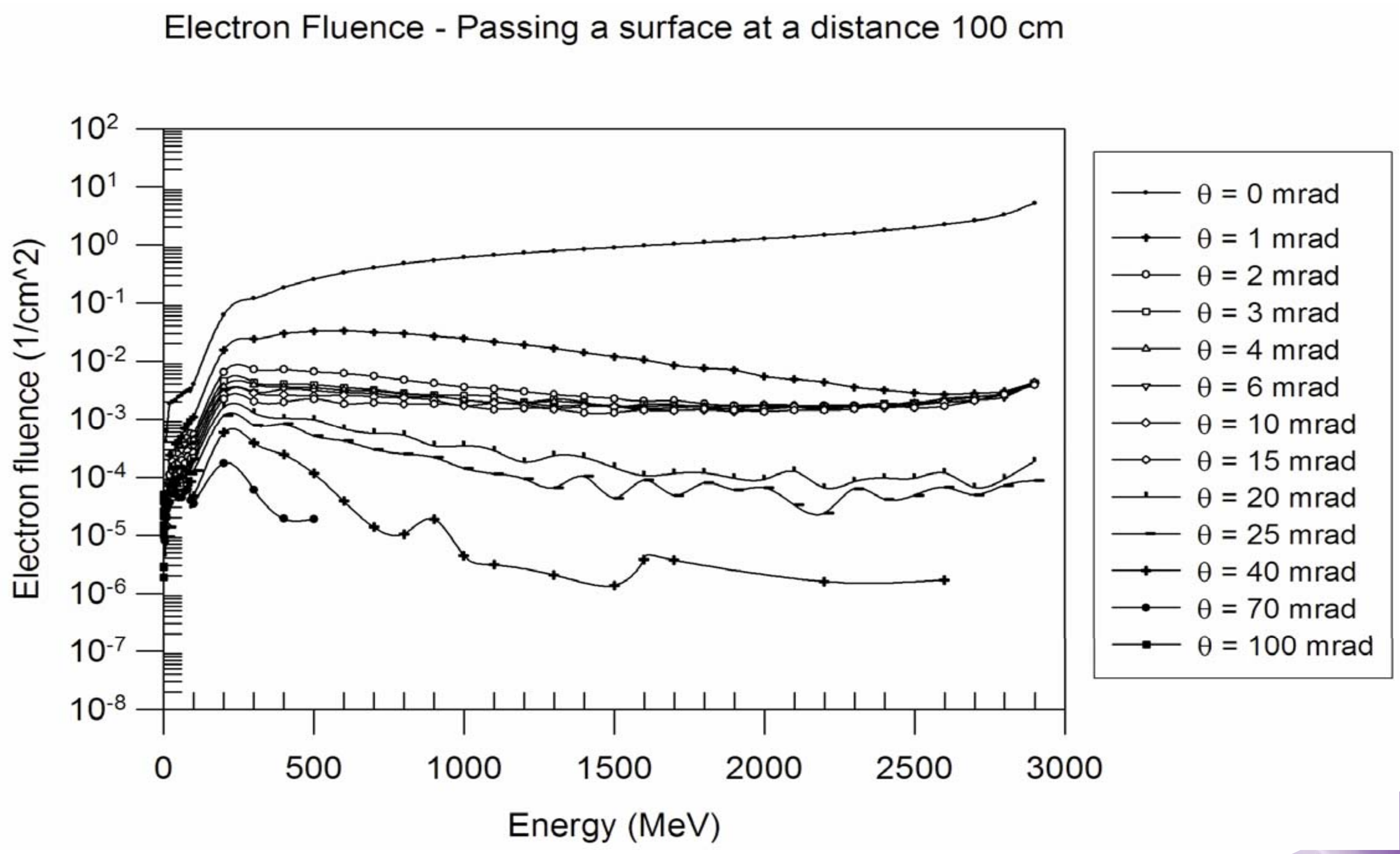
--------- USRBIN ... MAT-PROP : 51 cards hidden ----------

START	No.: 5000000.	Core: On ▼	
	Time:	Report: default ▼	

----------- STOP : 1 card hidden-----------

Results

Study of Electron Distribution: MCNPX



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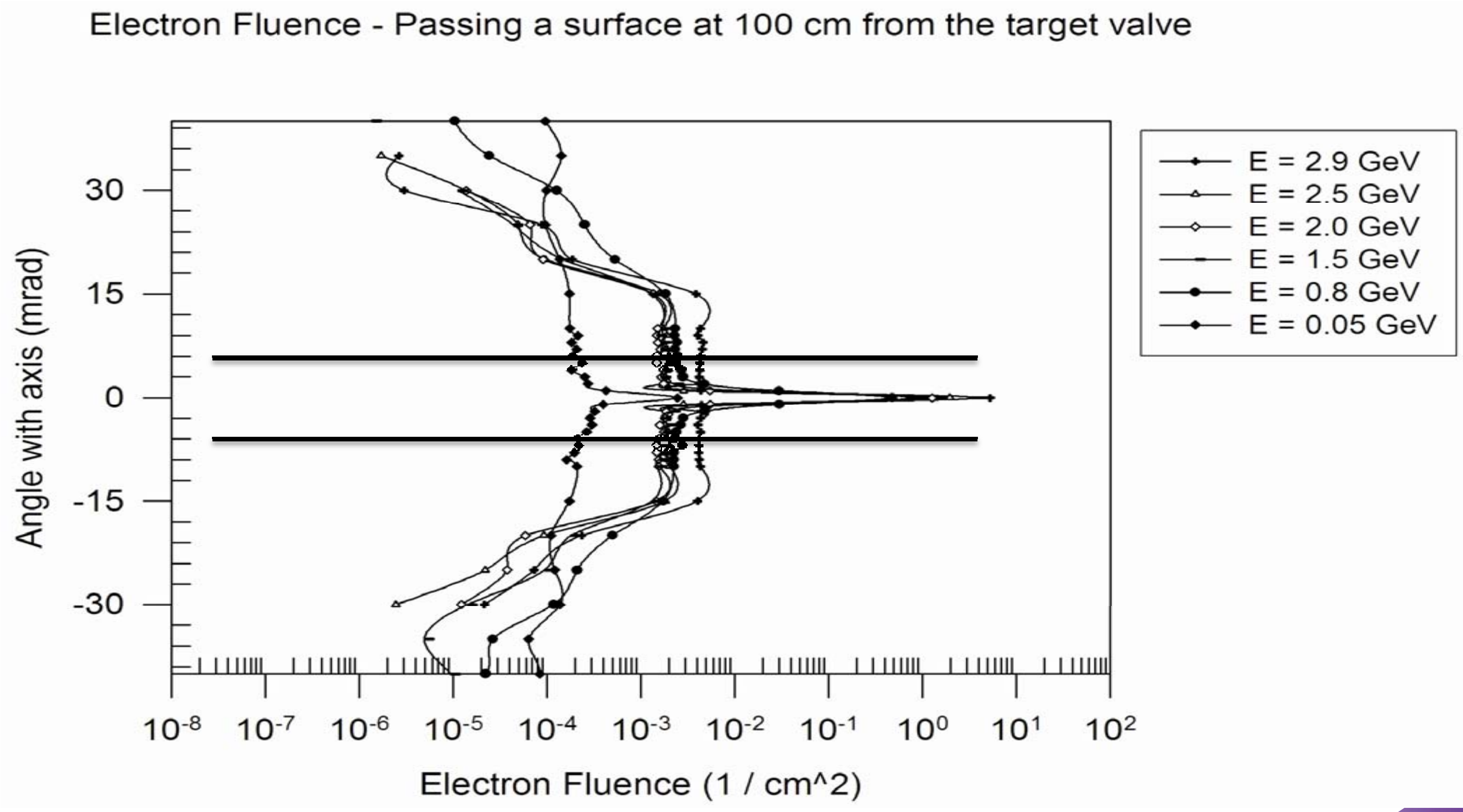
Results

Study of Electron Distribution: MCNPX



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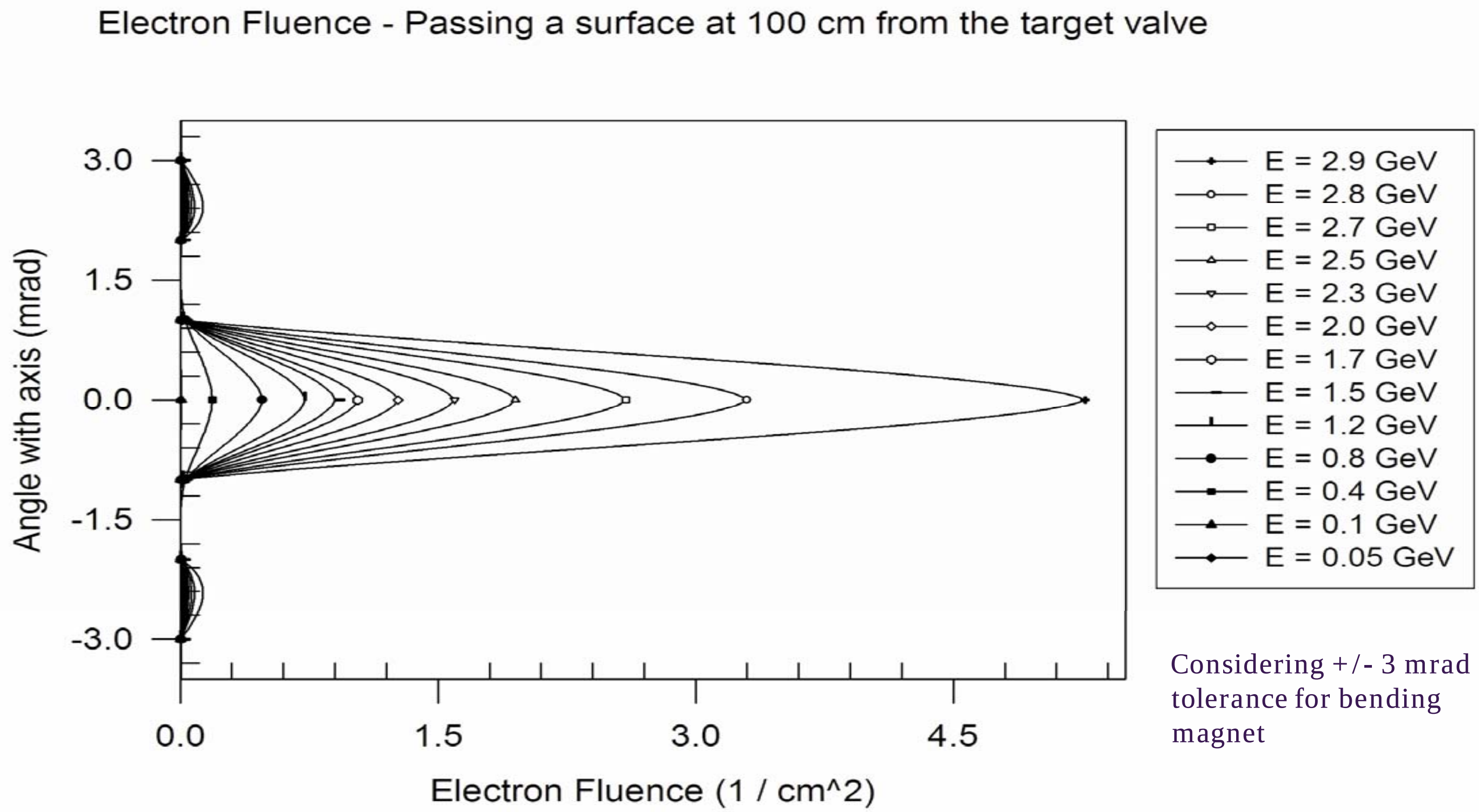
Results

Study of Electron Distribution: MCNPX



Considering +/- 3 mrad tolerance for bending magnet

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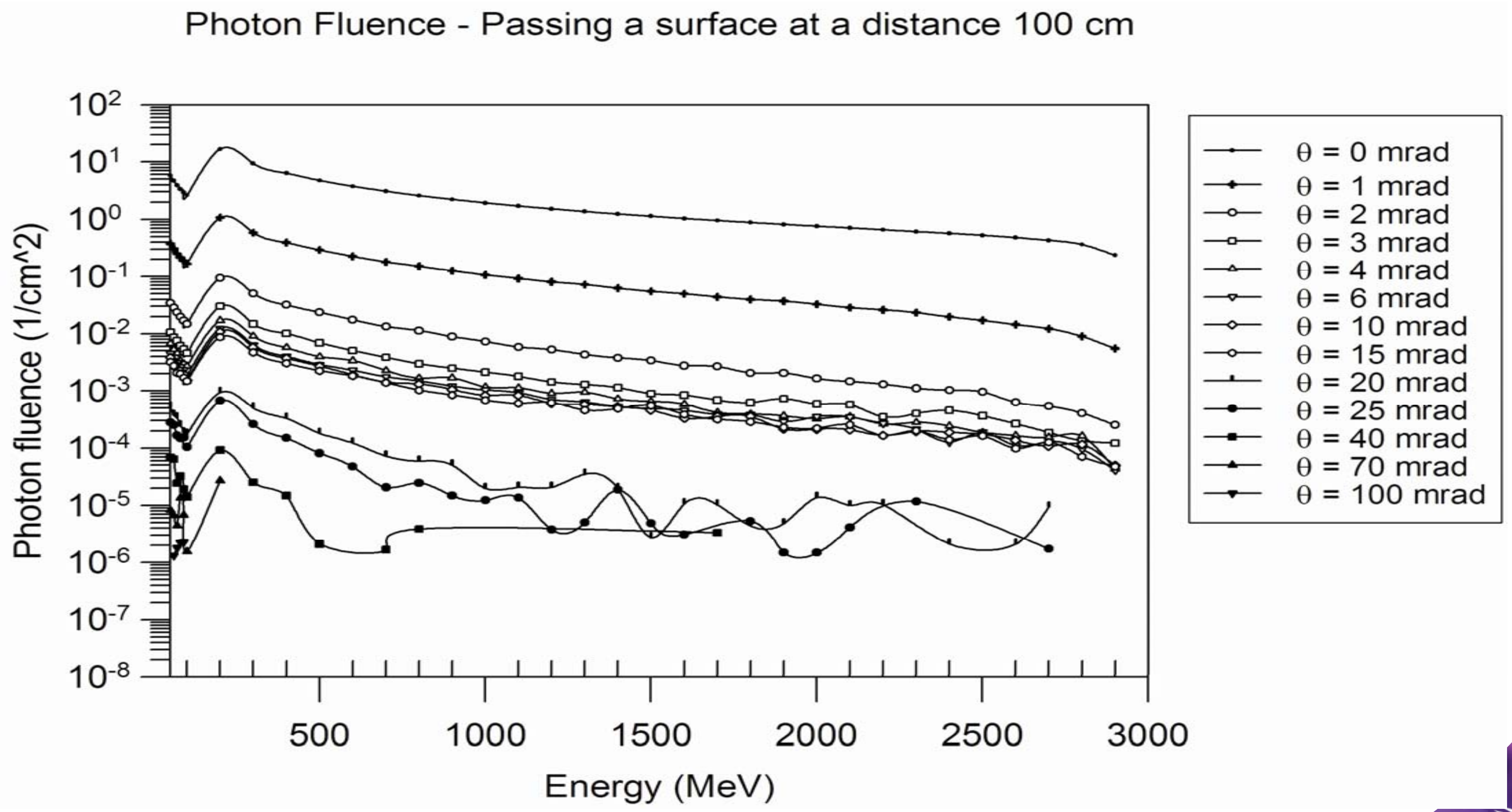
Results

Study of Photon Distribution: MCNPX



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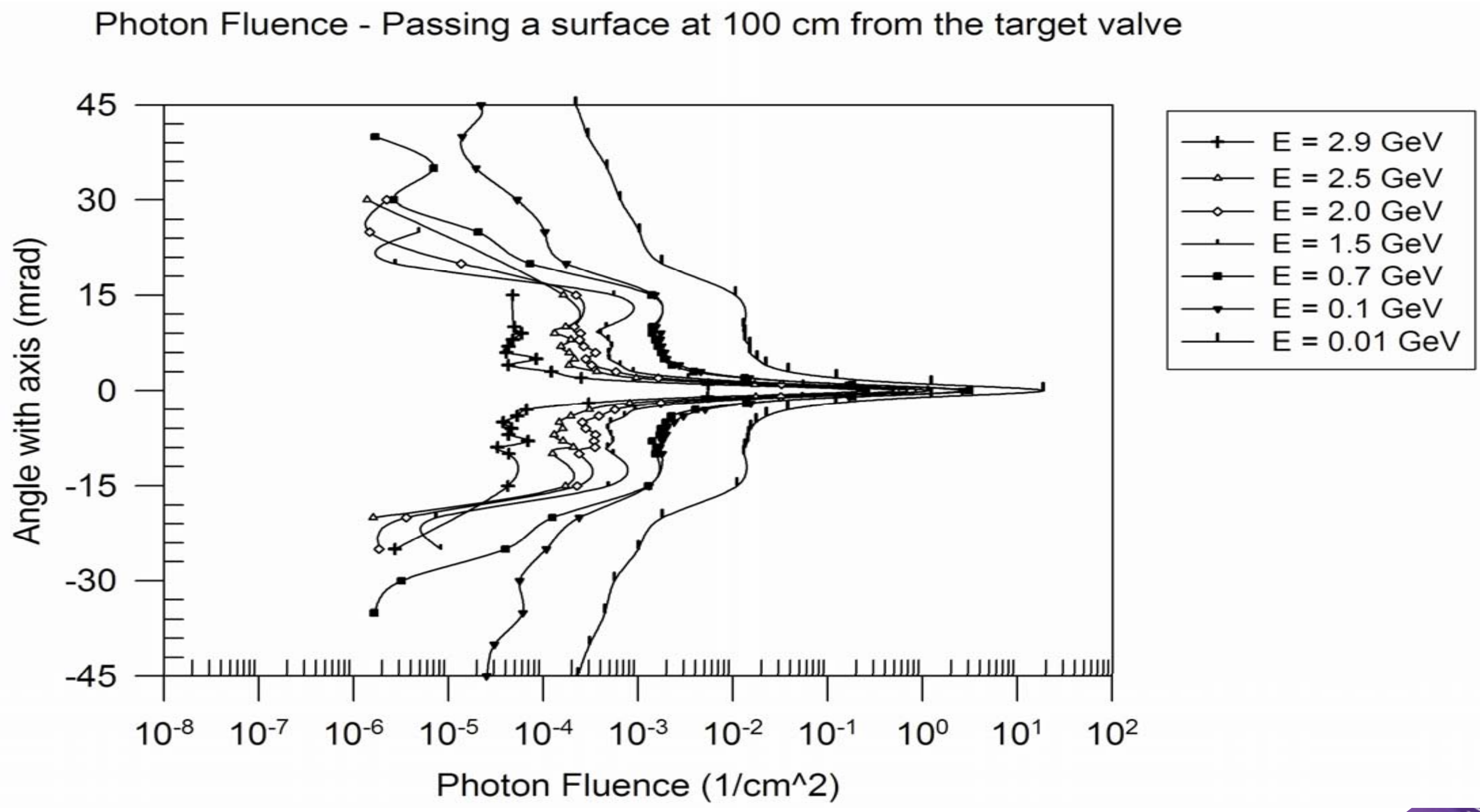
Results

Study of Photon Distribution: MCNPX



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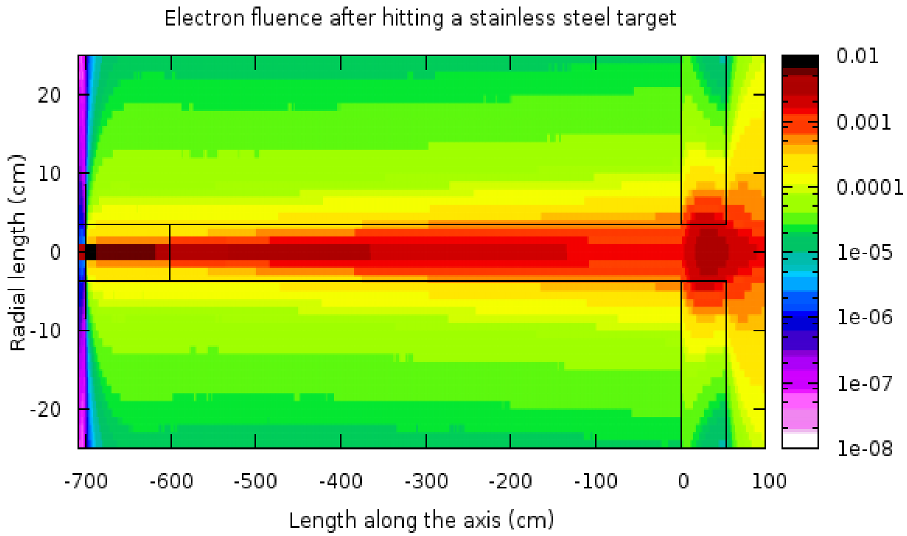
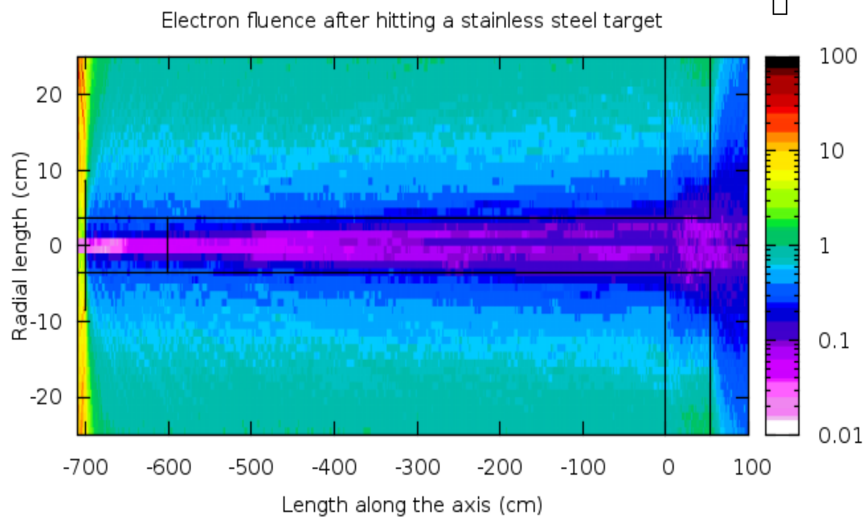
Results

Study of Electron Distribution: Fluka_UsrBin





----------- TITLE ... BEAMPOS : 4 cards hidden -----------

USRBIN Unit: 40 BIN ▼ Name: XYZflu

Type: X-Y-Z ▼ Xmin: -750. Xmax: 100. NX: 1000.

Part: ELECTRON ▼ Ymin: -50. Ymax: 50. NY: 100.

Zmin: -50. Zmax: 50. NZ: 100.

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Results

Study of Electron Distribution: Fluka_UsrBdx

The image cannot be displayed. Your computer may not have enough memory to open the image, or the image may have been corrupted. Restart your computer, and then open the file again. If the red x still appears, you may have to delete the image and then insert it again.

□□□□□□ Φ□Ω

USRBDX			Unit: 40 BIN ▼	Name: q=1.6E-06
	Type: Φ1,LinE,LinΩ ▼	Reg: C205 ▼	to Reg: C206 ▼	Area:
	Part: ELECTRON ▼	Emin: 0.0	Emax: 3.0	Ebins: 100.
		Ωmin: 0.0	Ωmax: 6.28E-06	Ωbins: 10.
USRBDX			Unit: 41 BIN ▼	Name: q=1.4E-05
	Type: Φ1,LinE,LinΩ ▼	Reg: C205 ▼	to Reg: C206 ▼	Area:
	Part: ELECTRON ▼	Emin: 0.0	Emax: 3.0	Ebins: 100.
		Ωmin: 6.28E-06	Ωmax: 2.51E-05	Ωbins: 10.

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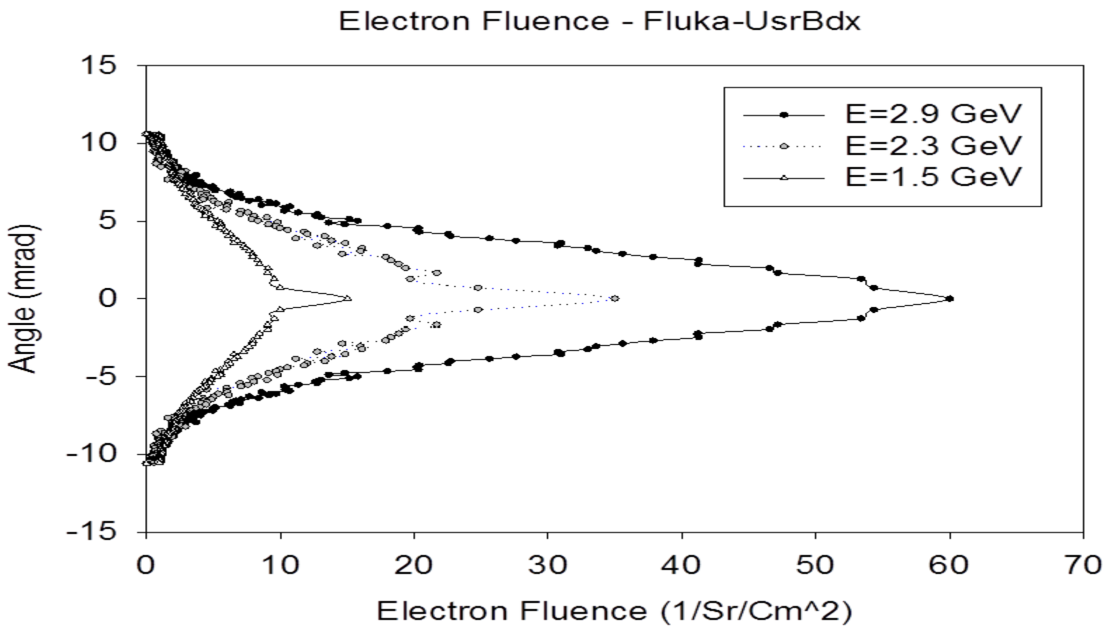
Results

Study of Electron Distribution: Fluka_UsrBdx



ΦΩ

USRBDX
Type: Φ1,LinE,LinΩ ▼
Part: ELECTRON ▼
Reg: C205 ▼
Emin: 2.89
Ωmin: 1.57E-06
Unit: 40 BIN ▼
to Reg: C206 ▼
Emax: 2.9
Ωmax: 3.53E-04
Name: E=2.9GeV
Area:
Ebins: 1.
Ωbins: 100.

USRBDX
Type: Φ1,LinE,LinΩ ▼
Part: ELECTRON ▼
Reg: C205 ▼
Emin: 2.79
Ωmin: 1.57E-06
Unit: 40 BIN ▼
to Reg: C206 ▼
Emax: 2.8
Ωmax: 3.53E-04
Name: E=2.8GeV
Area:
Ebins: 1.
Ωbins: 100.

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Discussion

Study of Electron Distribution: Fluka_McnpX

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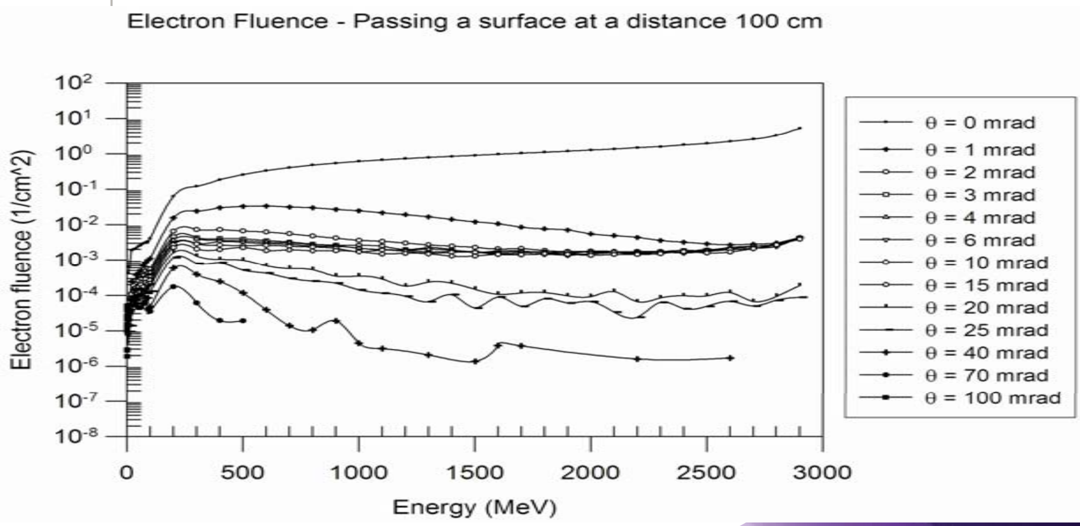
- E < 0.5 Gev, electron fluence increases with increase angle

Electron fluence decreases when angle increases, over full energy range



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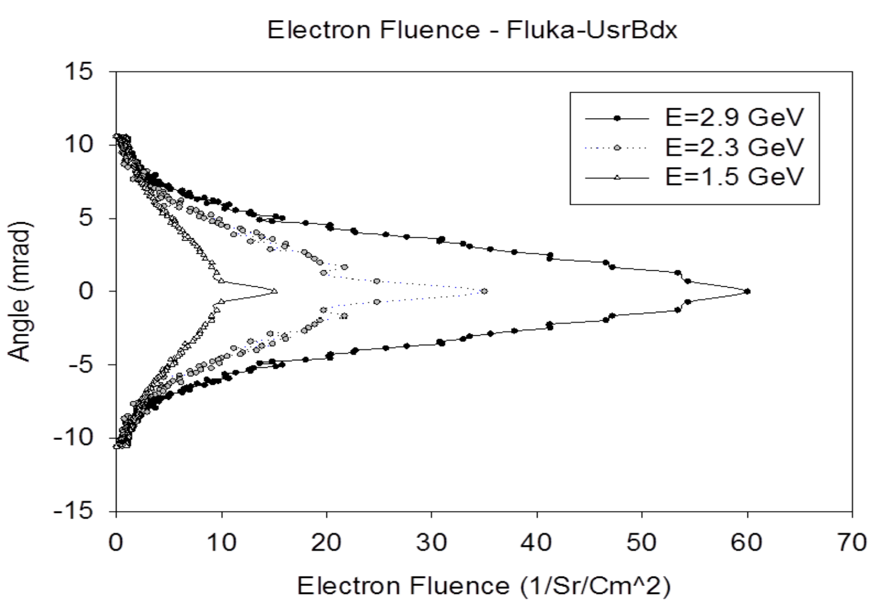
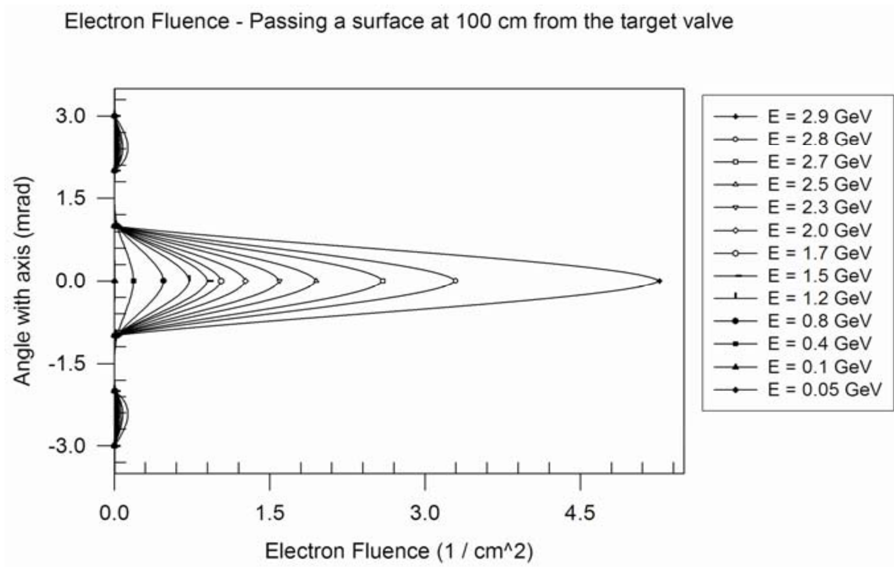
Discussion

Study of Electron Distribution: Fluka_McnpX





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Evaluation

Comparison: MCNPX vs FLUKA [My experience]

Parameter	MCNPX	Fluka
Building Input card	• Geometry convention: Same • Source definition: Hard • Material and cross section data: Hard • Advanced feature: Magnetic field, electric field etc. not available	• Geometry convention: Same • Source definition: Simpler • Material and cross section data: Simpler • Advanced features are available
Scoring option	• Limited	• Wider
Visual Editor	• I have limited knowledge to plot with Vised	• Flair is user friendly
Application in high energy physics	• New version of MCNPX is capable to work at high energy	• FLUKA is SPECIFICALLY designed for high energy
Time	Simple geometry: 0.48 msec/par	Simple geometry: 0.642 msec/par
Version and update	• Strictly controlled and strongly monitored	• FLUKA is free and update not controlled

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