Collimation and Magnet Protection for beta-beams in the PS

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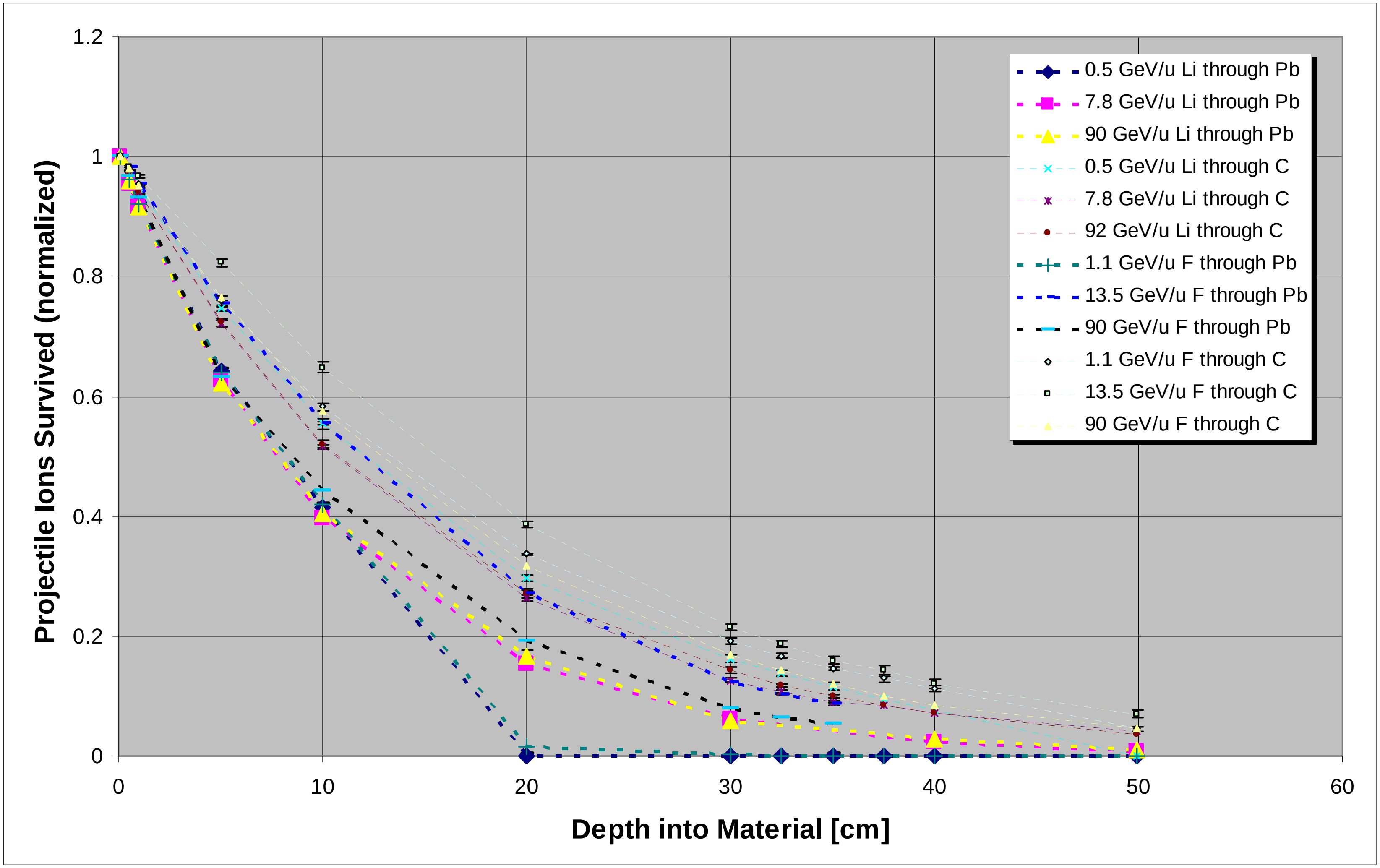
Overview

- Transmission of primary beam through a collimator
- Composition of the coil insulation
- Collimator thickness and dose rate in coil insulaton for a naïve beam-target geometry
- Realistic FLUKA target geometry
- Loss patterns with a single collimator
- Simplified beam distribution for FLUKA
- Fluence of all transportable products
- Dose rate spatial distribution over regions of the insulation
- Estimated lifetime of coil insulation
- Summary and outlook

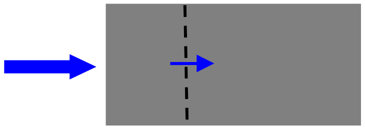
Projectile ranges in targets

Beta Beams in EURISOL

Transport with FLUKA code: Pencil beam along Z and orthogonal to block.



One way scoring: heavy ions across boundary



Composition of the coil insulation

Coil insulation: Epoxy fibre glass resin (4mm thick)

Mainly consists of glass type E (80%). 100% assumed in model.

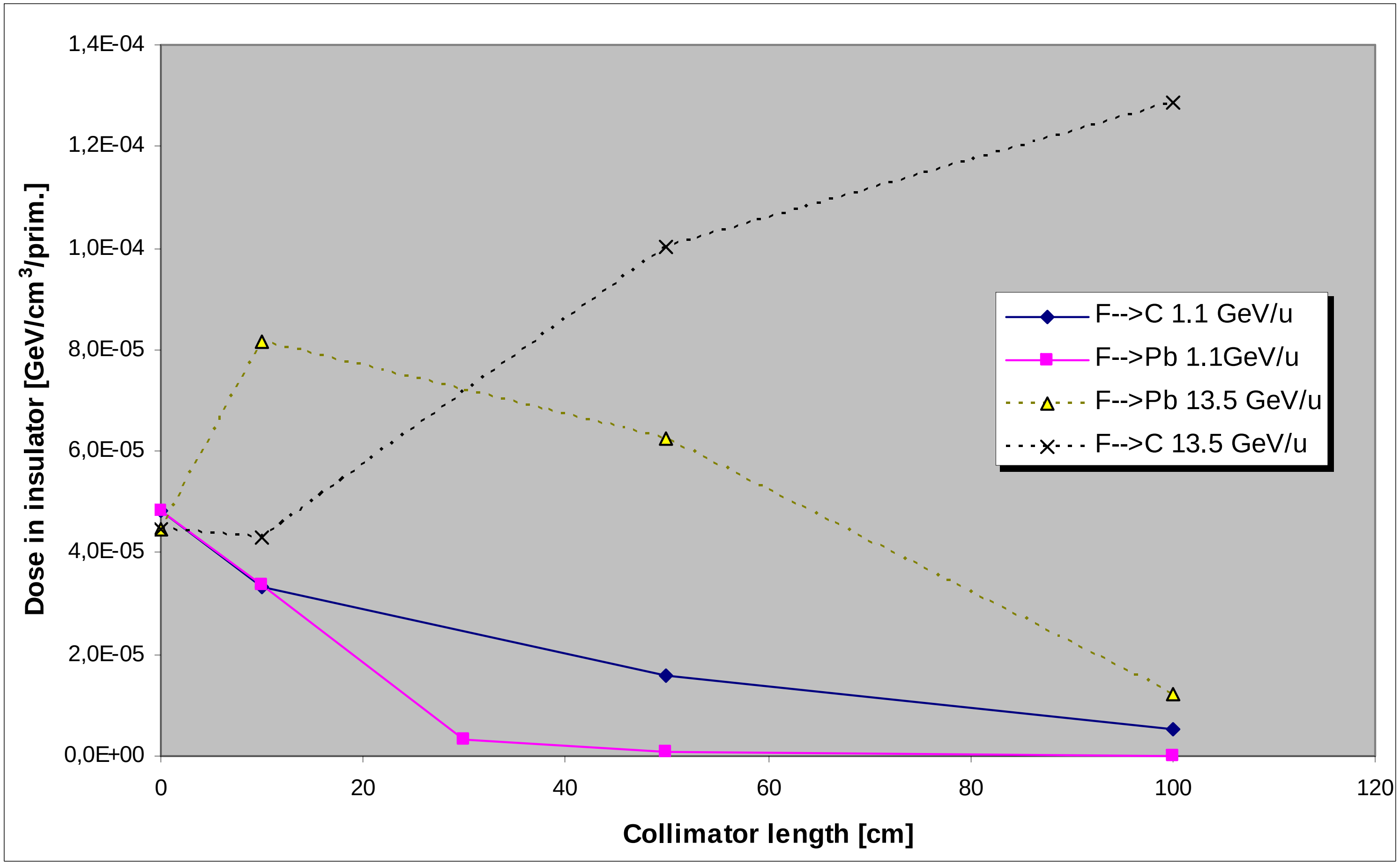
Chemical	Fraction of mass
SiO_2	**52-56 %**
Alkaline Oxides	0-2 %
CaO	**16-25 %**
MgO	**0-5%**
B_2O_3	**5-10%**
Al_2O3	**12-16%**
TiO_2	0-0.8%
Fe_2O_3	0.05-0.4%
F_2	0-1%

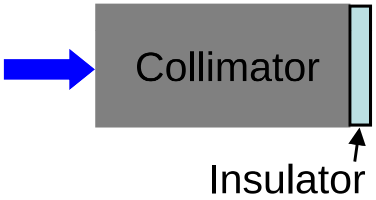
Collimator length and dose rate

Beta Beams in EURISOL

Rectangular uniform beam spot, beam perpendicular to target.

Ne-beam

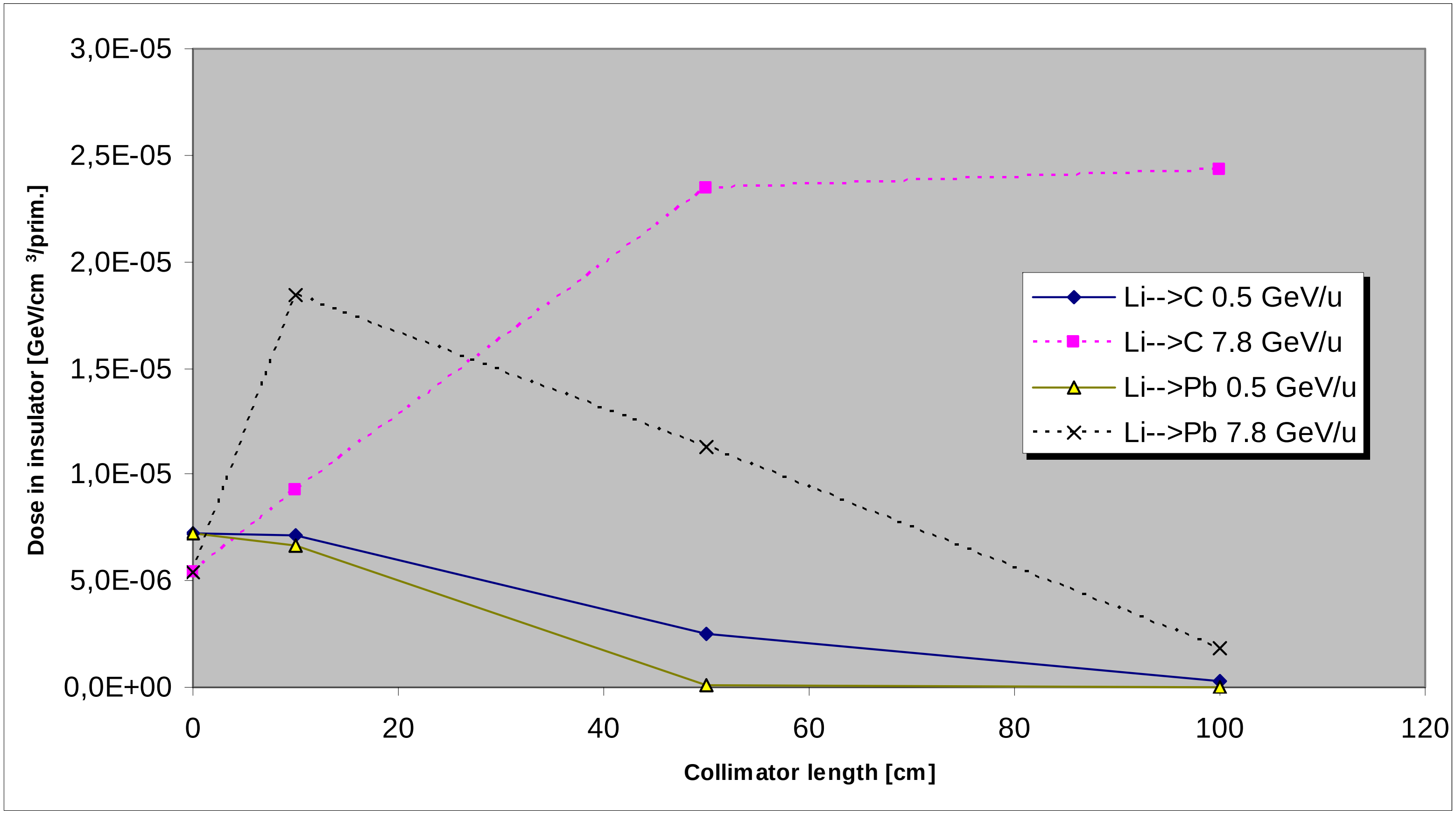




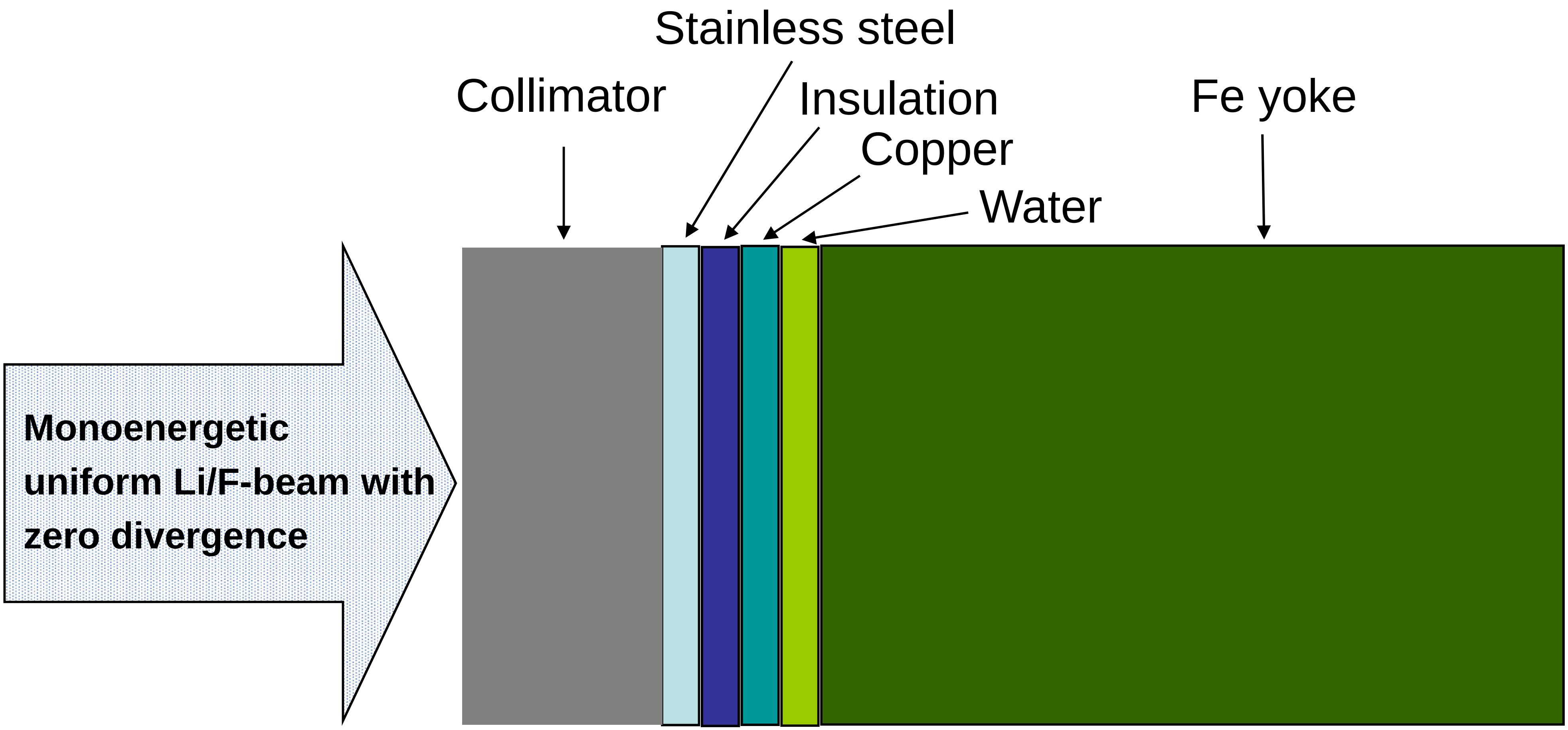
Collimator length and dose rate

Rectangular uniform beam spot, beam perpendicular to target.

He-beam

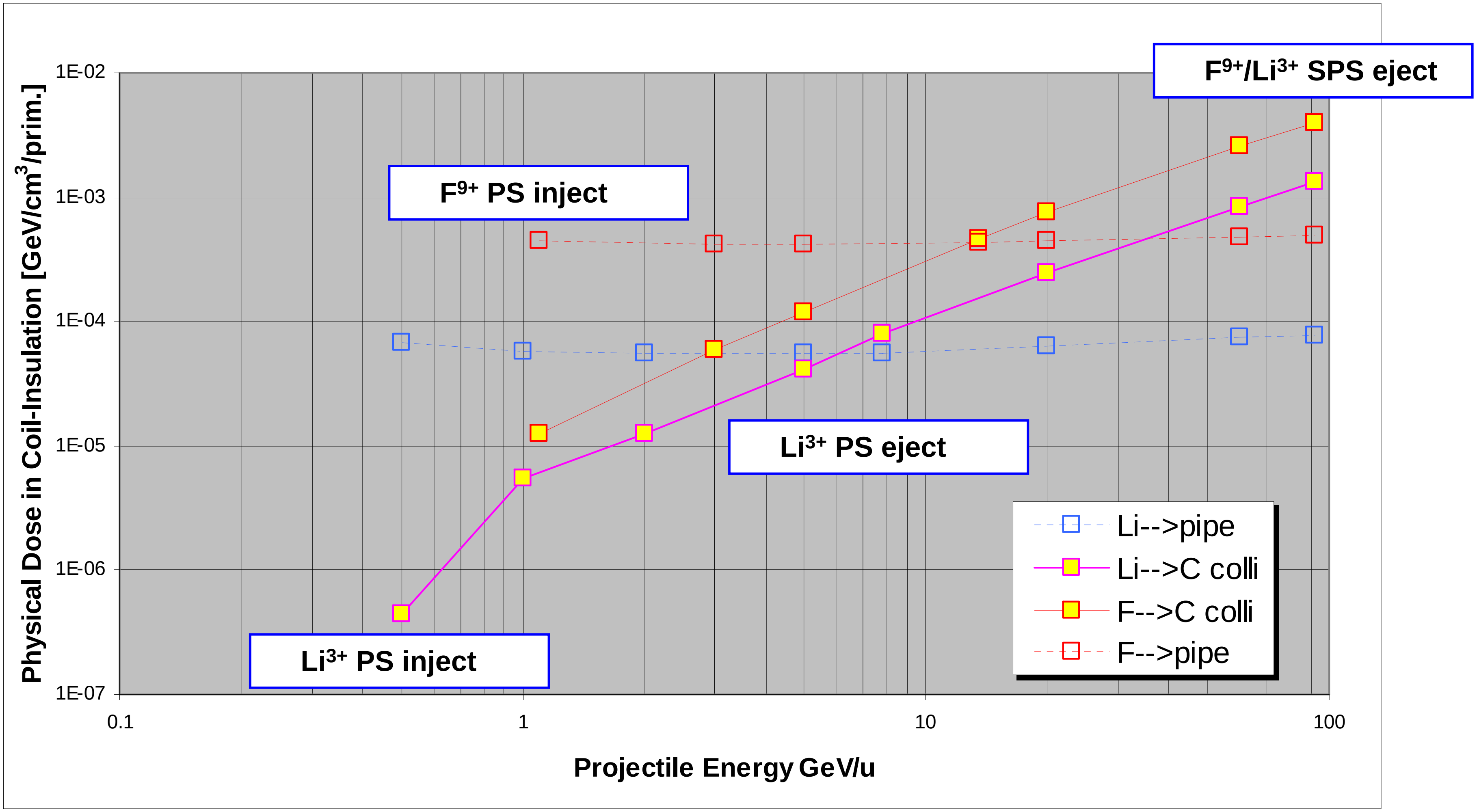


Initial test geometry



Dose in the coil insulation

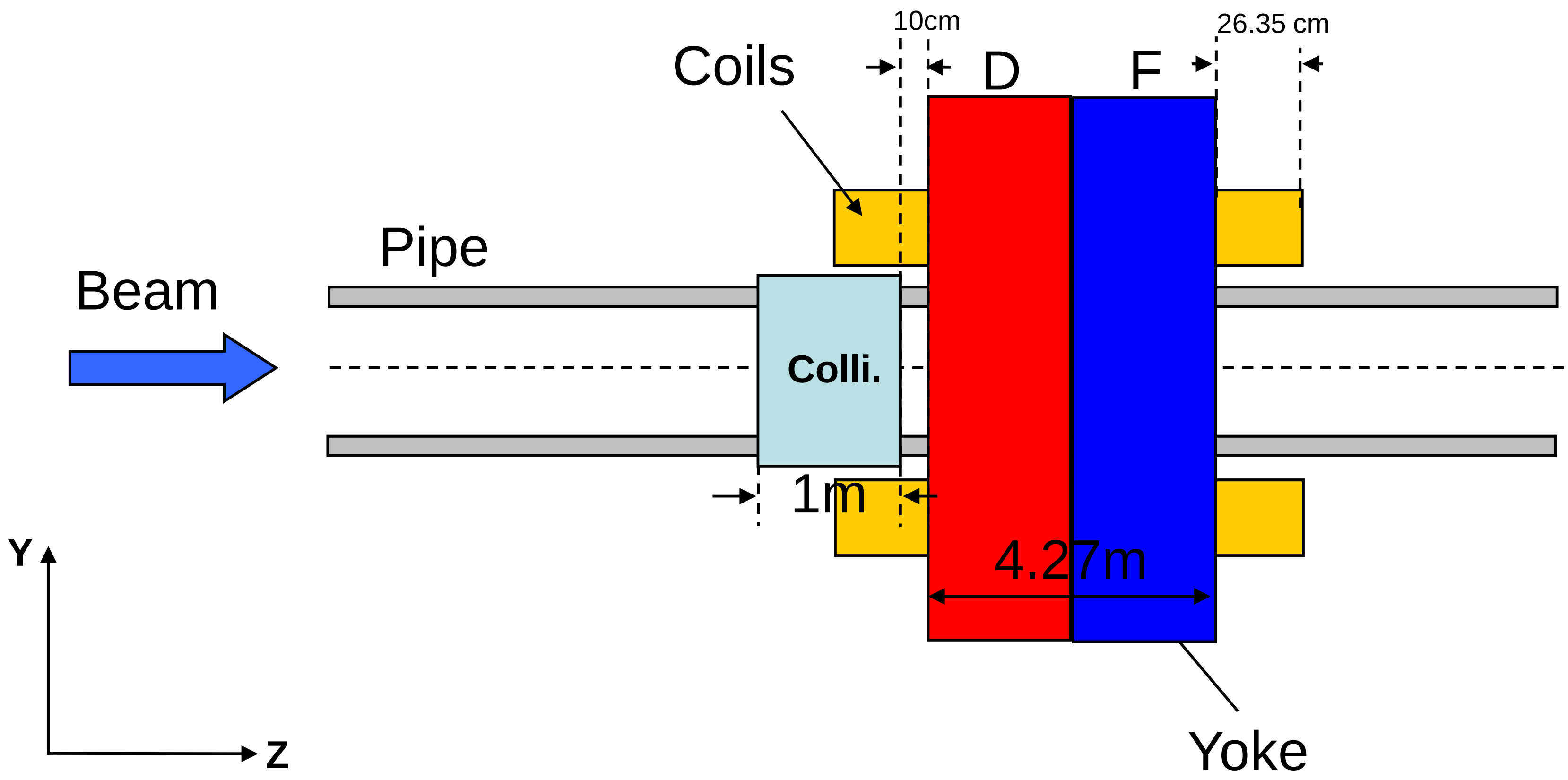
For a carbon collimator with 1m length



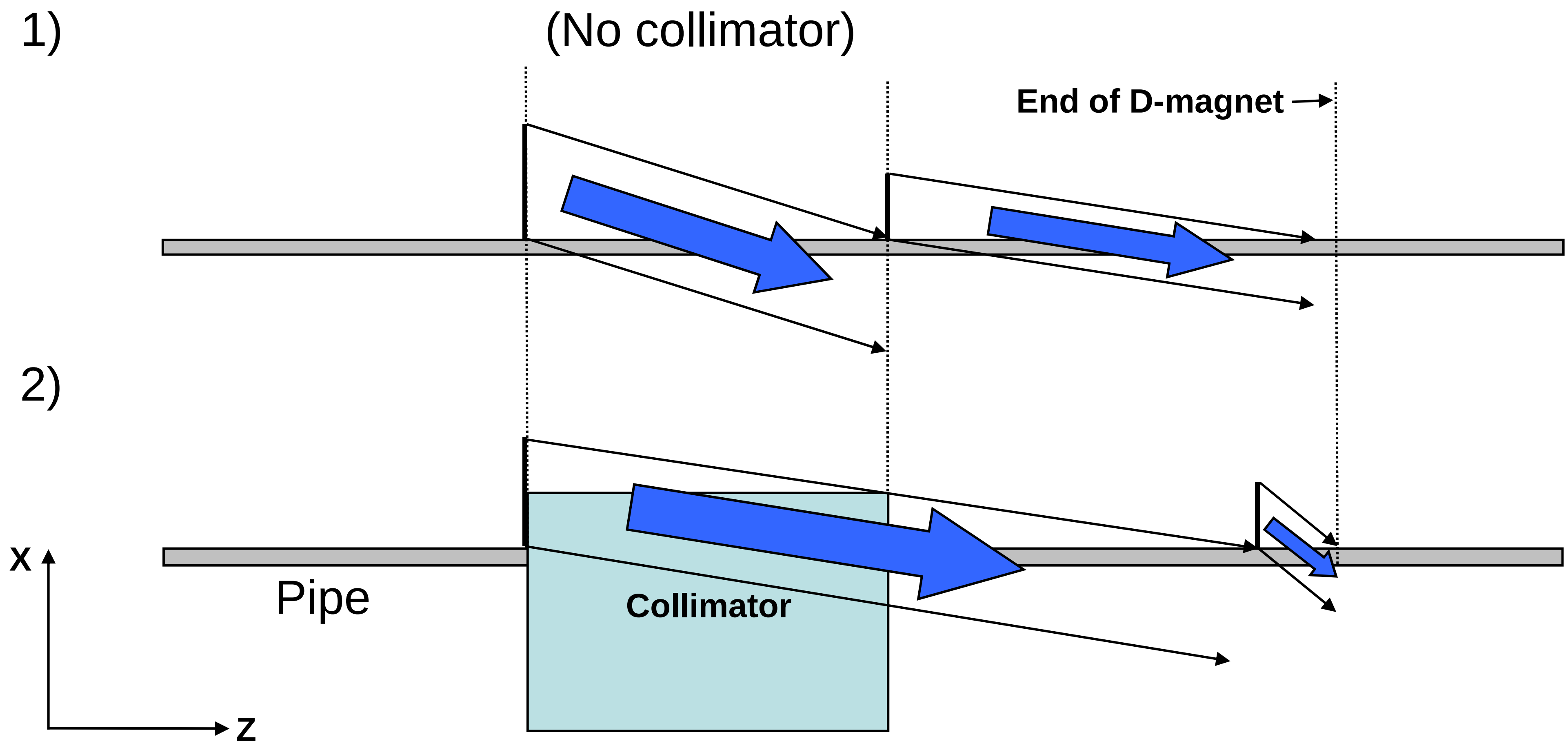
Sketch - magnet geometry

FLUKA geometry: vertical cross-section of beamline section around magnet

Initial beam distribution generated by StrahlSim (C. Omet)



Sketch - beam geometry

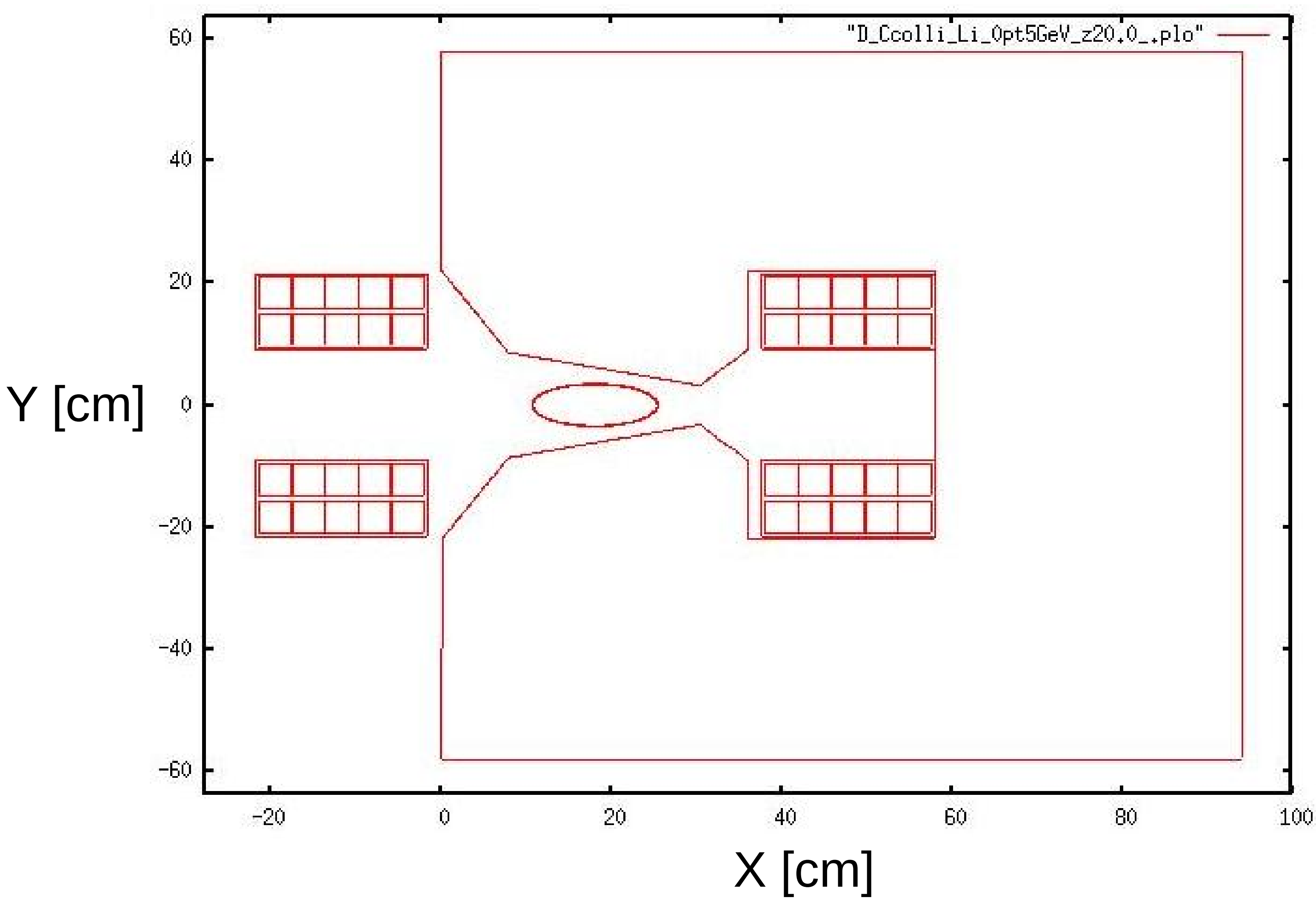


Beam profile along X approximated to random uniform

Beam profile along Y is Gaussian with FWHM specified as input in FLUKA

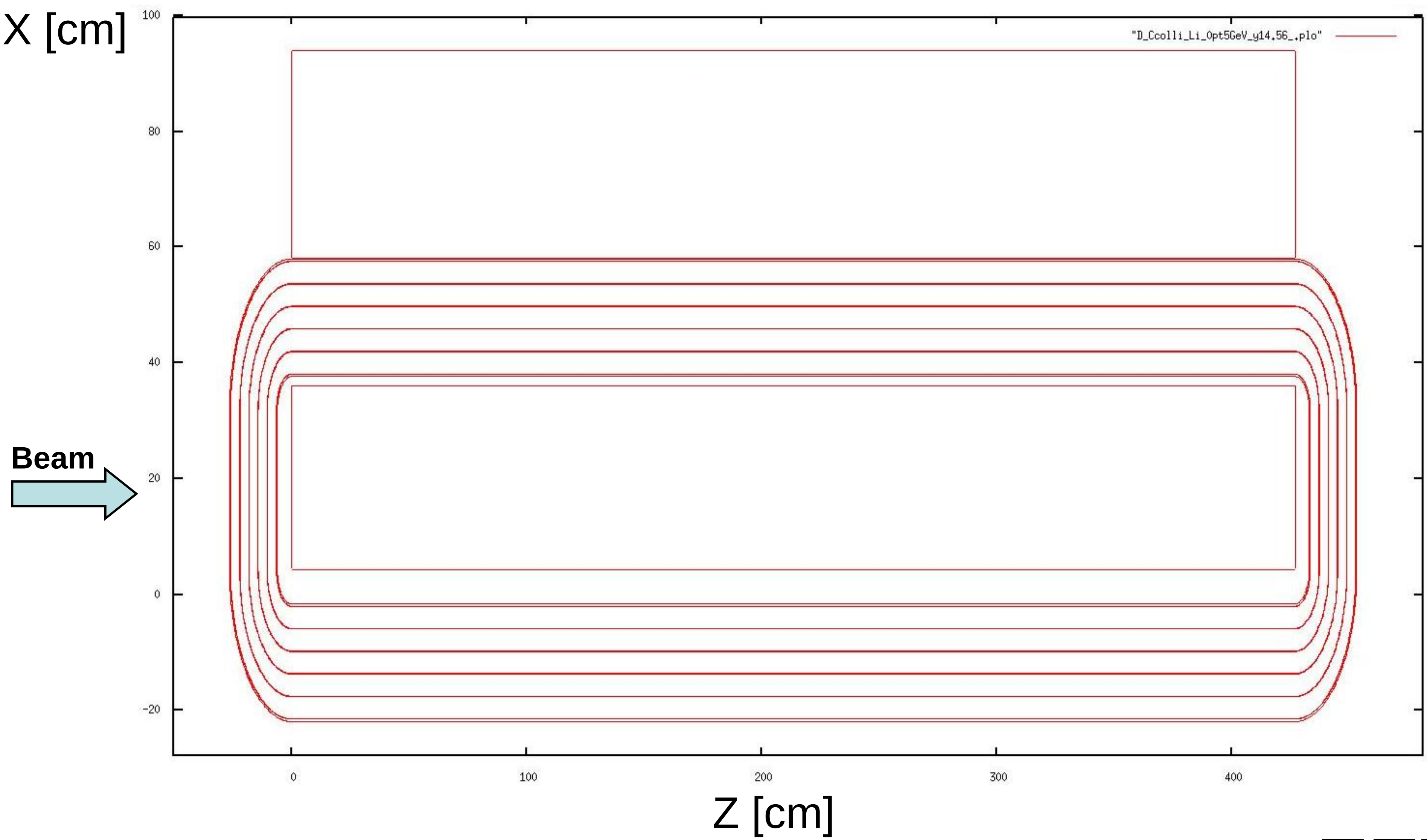
Magnet geometry

FLUKA geometry: PS combined function D-magnet (beam into page)



Magnet geometry

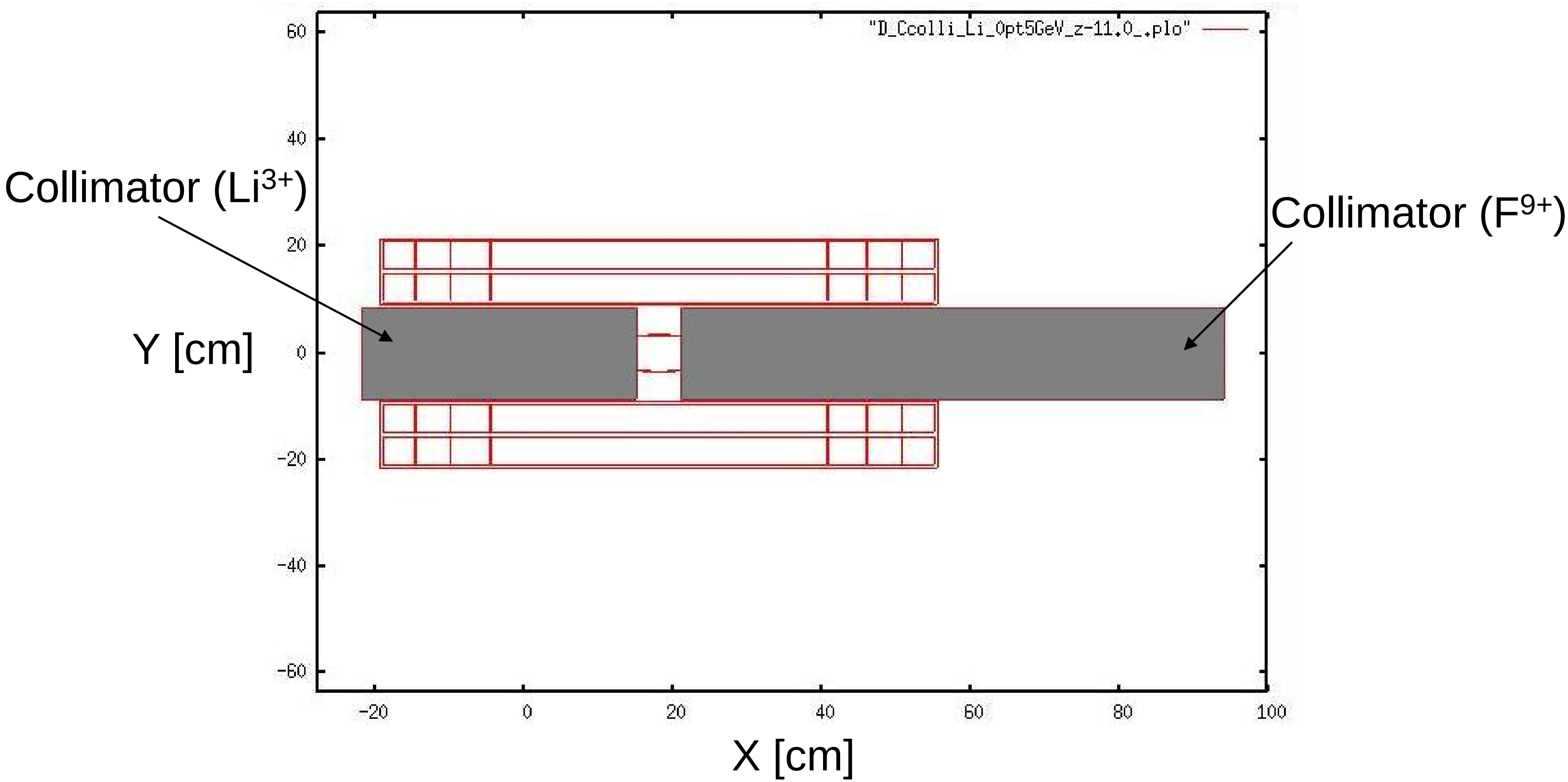
FLUKA geometry: PS combined function D-magnet



Magnet geometry

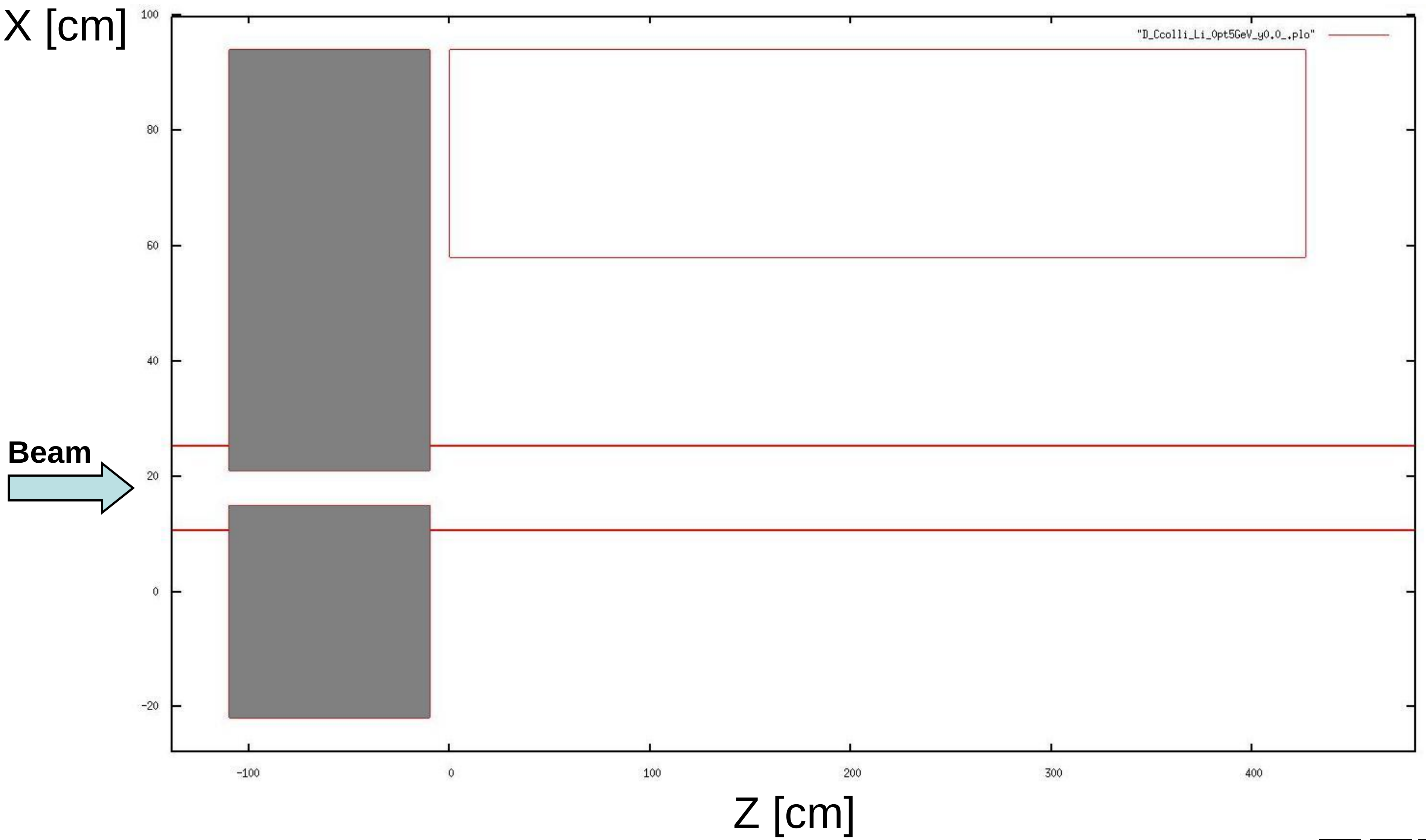
Beta Beams in EURISOL

FLUKA geometry: PS combined function D-magnet. Beam into page.



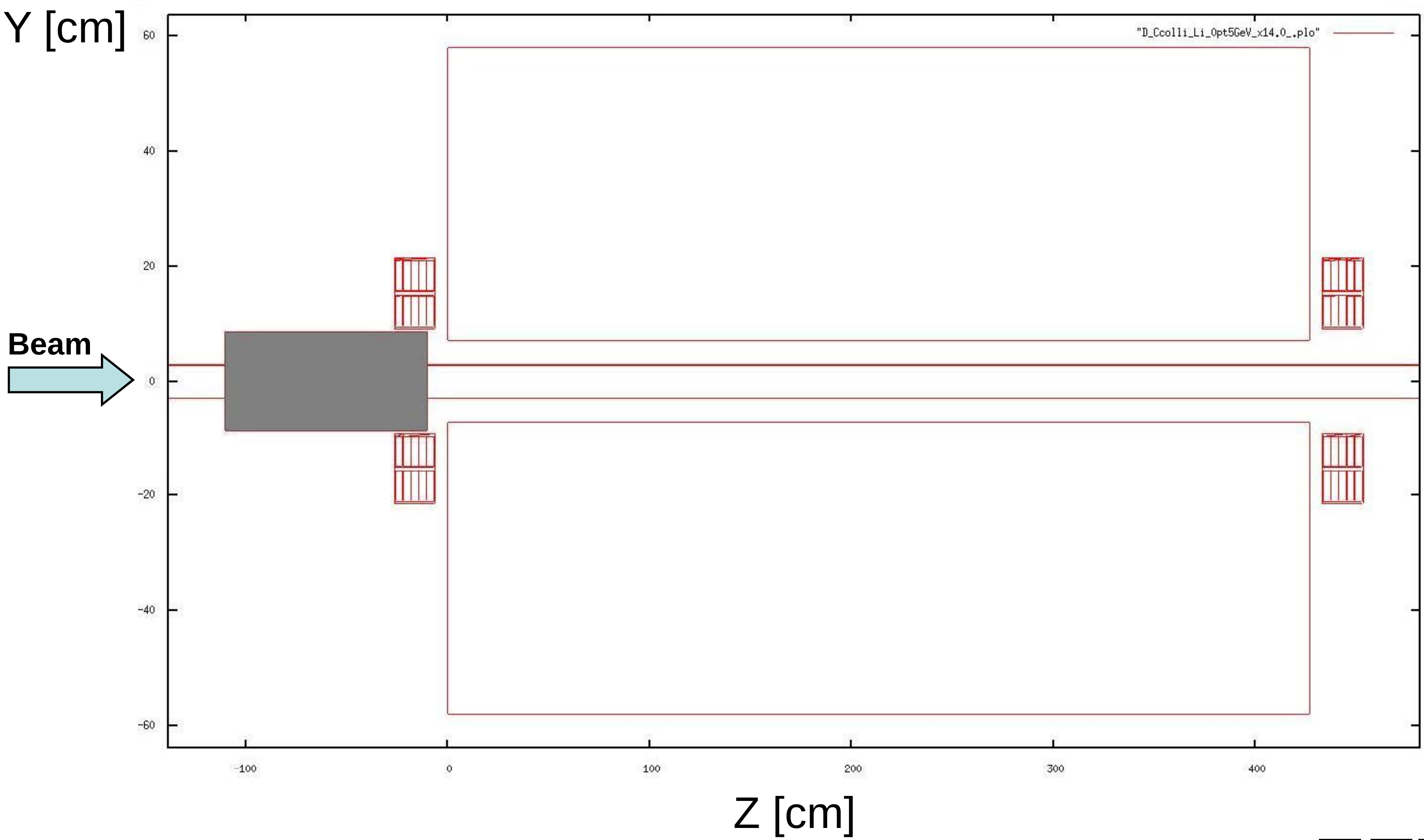
Magnet geometry

FLUKA geometry: PS combined function D-magnet



Magnet geometry

FLUKA geometry: PS combined function D-magnet (beam from left to right)



Components

FLUKA geometry: main components

Coils:

- 2 pancakes coils per pole (copper)
- Holes in copper through which water flows
- Insulation: Epoxy Fibreglass (100% glass assumed)

Yoke:

- Iron
- Length 427 cm = (41.7+1)x10 such blocks (curvature neglected)
- Shape of poles approximated with flat surfaces

Beampipe:

- Stainless Steel
- Elliptical
- Outer dimensions: horiz. Rx=7.4cm, vert. Ry=3.5cm
- Inner dimensions: Rx=7.3cm, Ry=3.4cm

Dose distributions

* He and Ne losses negligible. Li and F losses dominant.

* Collimator edge 3cm from beam axis.

* StrahlSim provides the mean angle of incidence and Li/F loss rates along the collimator and beampipe surfaces upto end of D-magnet

* Full width in horizontal (randon uniform) and Gaussian in Y

Beam distribution averaged

Beam pattern: average angle of incidence and loss rates impinging the collimator and section of pipe upto end of D-magnet – calculated from StrahlSim output files

Primary ions	Collimator?	Loss rate [prim./sec]		PS repitition time [s]	Mean angle of incidence [rad]	
		In straight before D-magnet	After D-magnet		In straight	In D-magnet
18F9+	No	5.83E8	2.15E9	3.6	0.017	0.022
	Yes	3.35E9	1.02E-3	3.6	0.017	0.022
6Li3+	No	2.40E9	6.51E9	6	0.031	0.035
	Yes	8.21E9	7.07E8	6	0.031	0.035

Beam widths

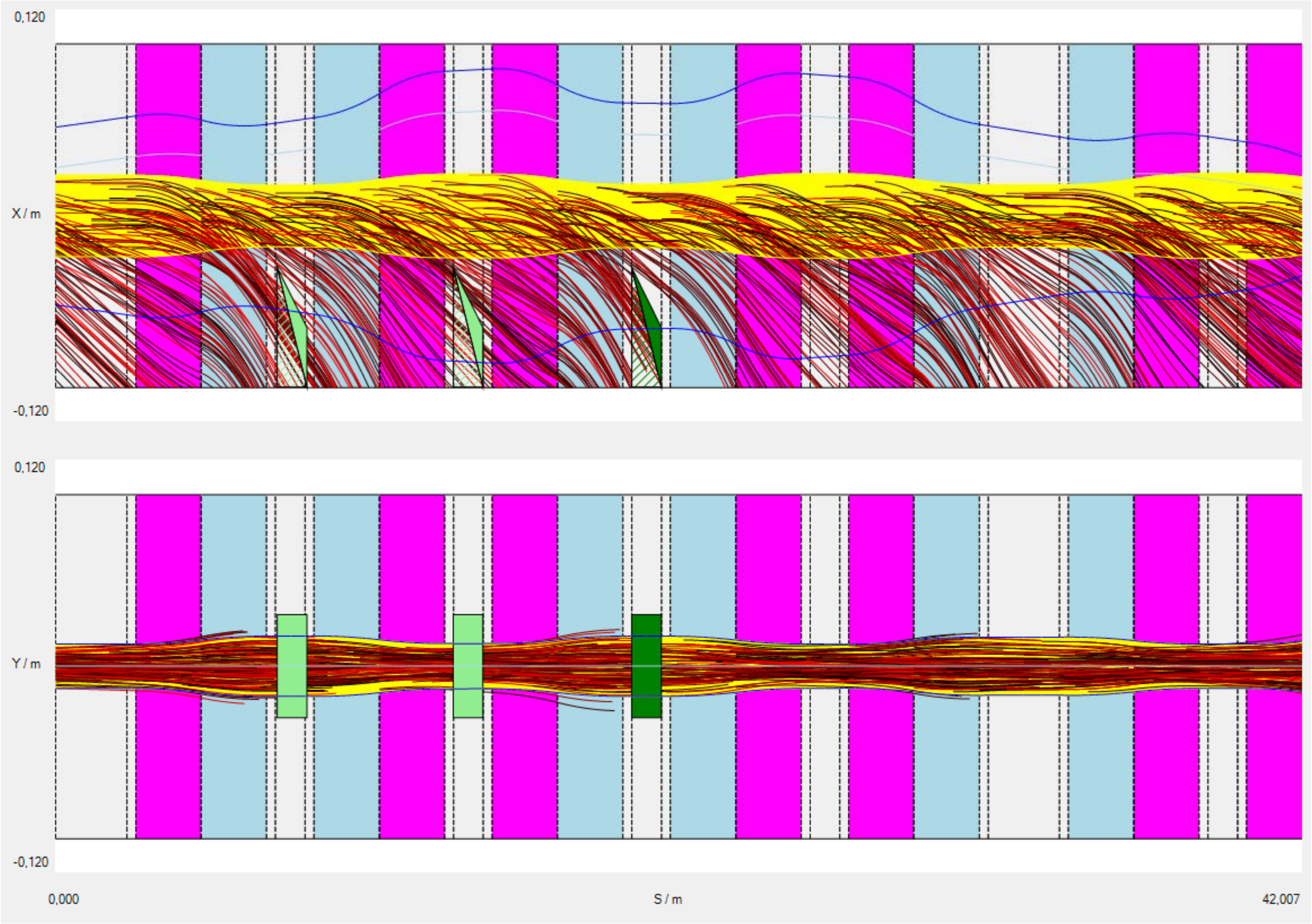
Beam pattern: average angle of incidence and loss rates impinging the collimator and section of pipe upto end of D-magnet – calculated from StrahlSim output files

Primary ions	Collimator?	In straight before D-magnet		After D-magnet	
		Width in x [cm]	FWHM in y [cm]	Width in x [cm]	FWHM in y [cm]
18F9+	No	1.6732	0.93	4.859	0.93
	Yes	5.9732	0.93	-	-
6Li3+	No	3.063	1.2	7.889	1.2
	Yes	7.3625	1.2	3.17669	1.2

Beam losses on collimator

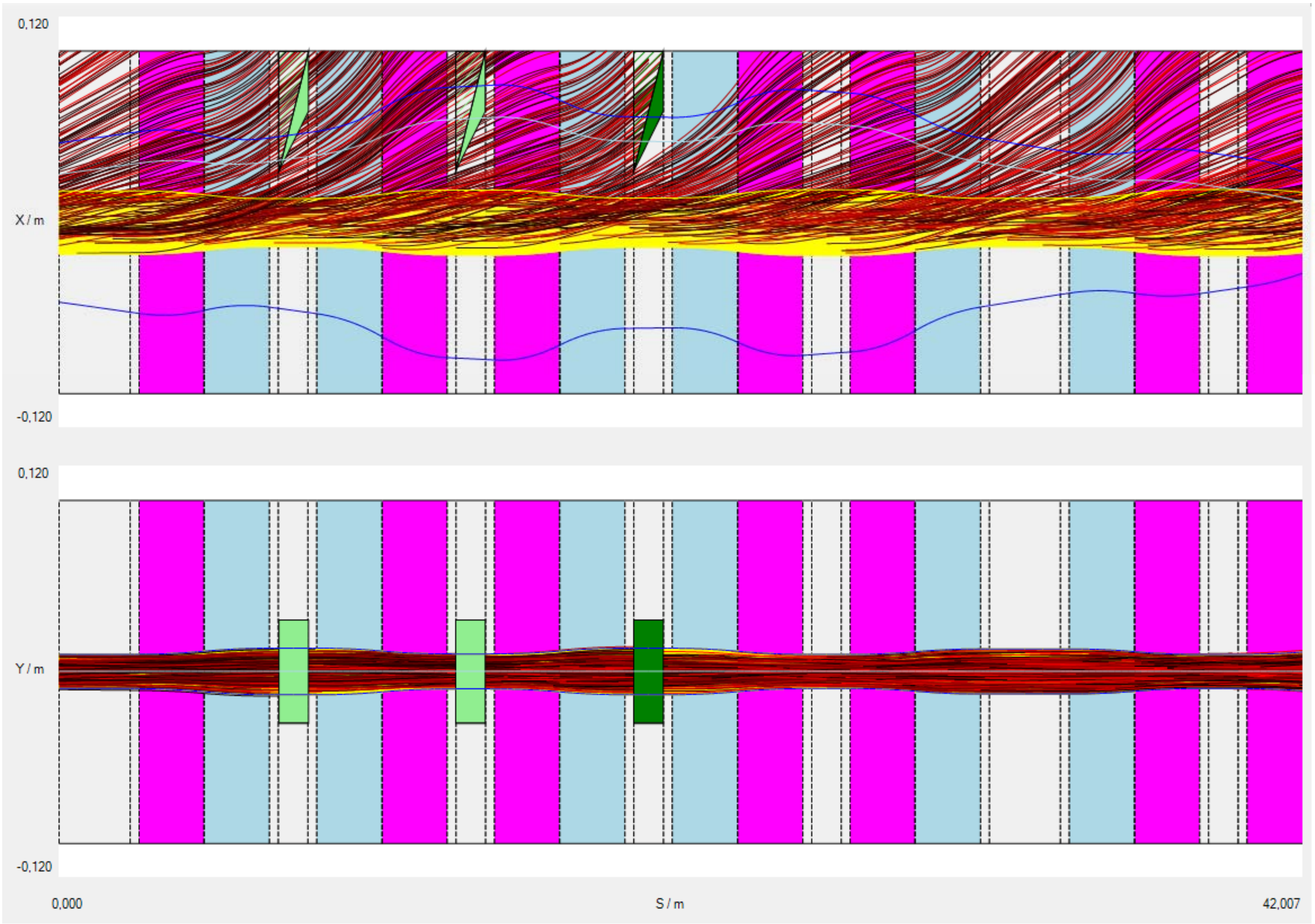
Beta Beams in EURISOL

He-beam.   Generated by StrahlSim.



Beam losses on collimator

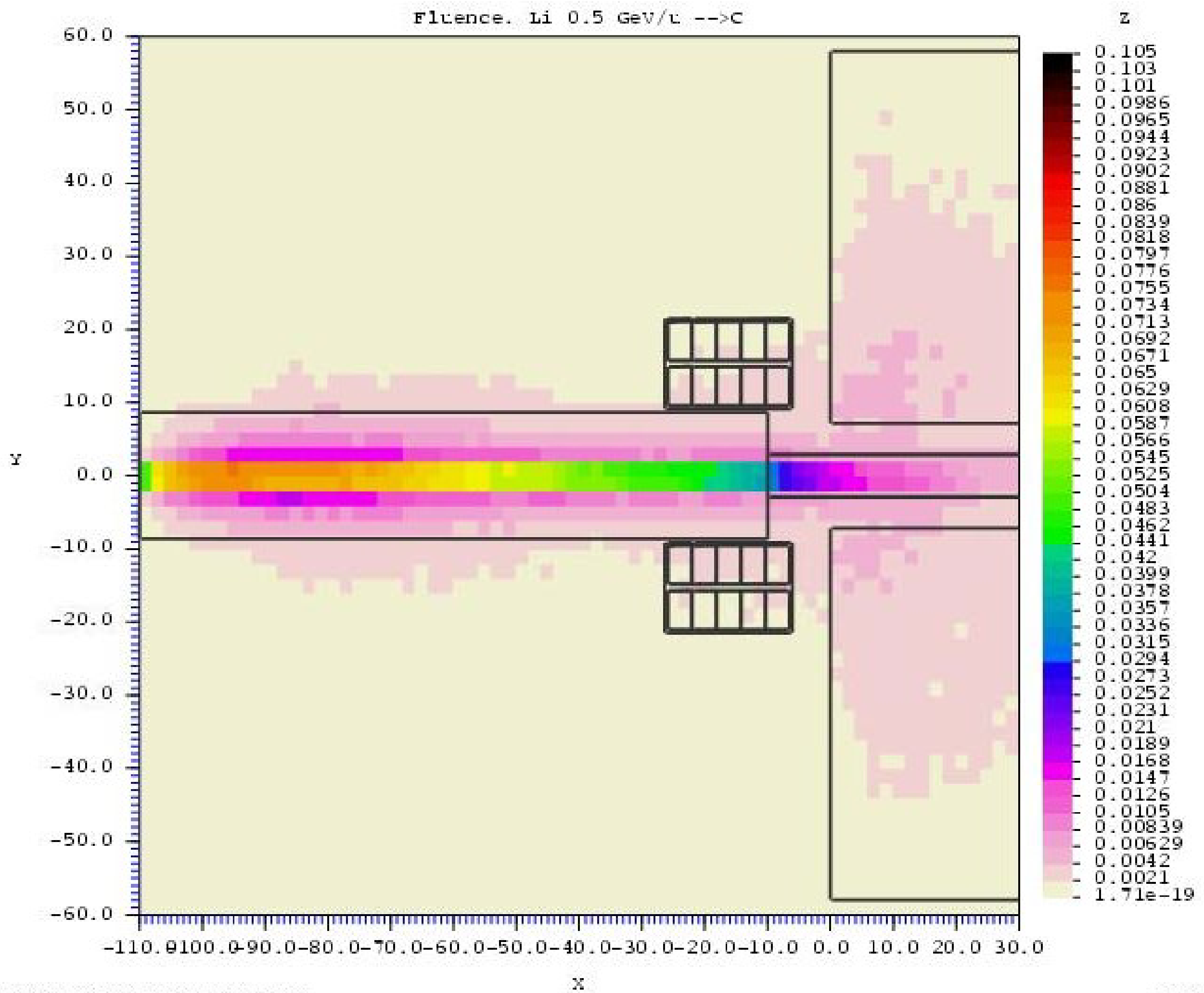
Ne-beam



Fluence distribution

All transportable particles

$^{6}Li^{3+}$ 0.5 GeV/u → C collimator

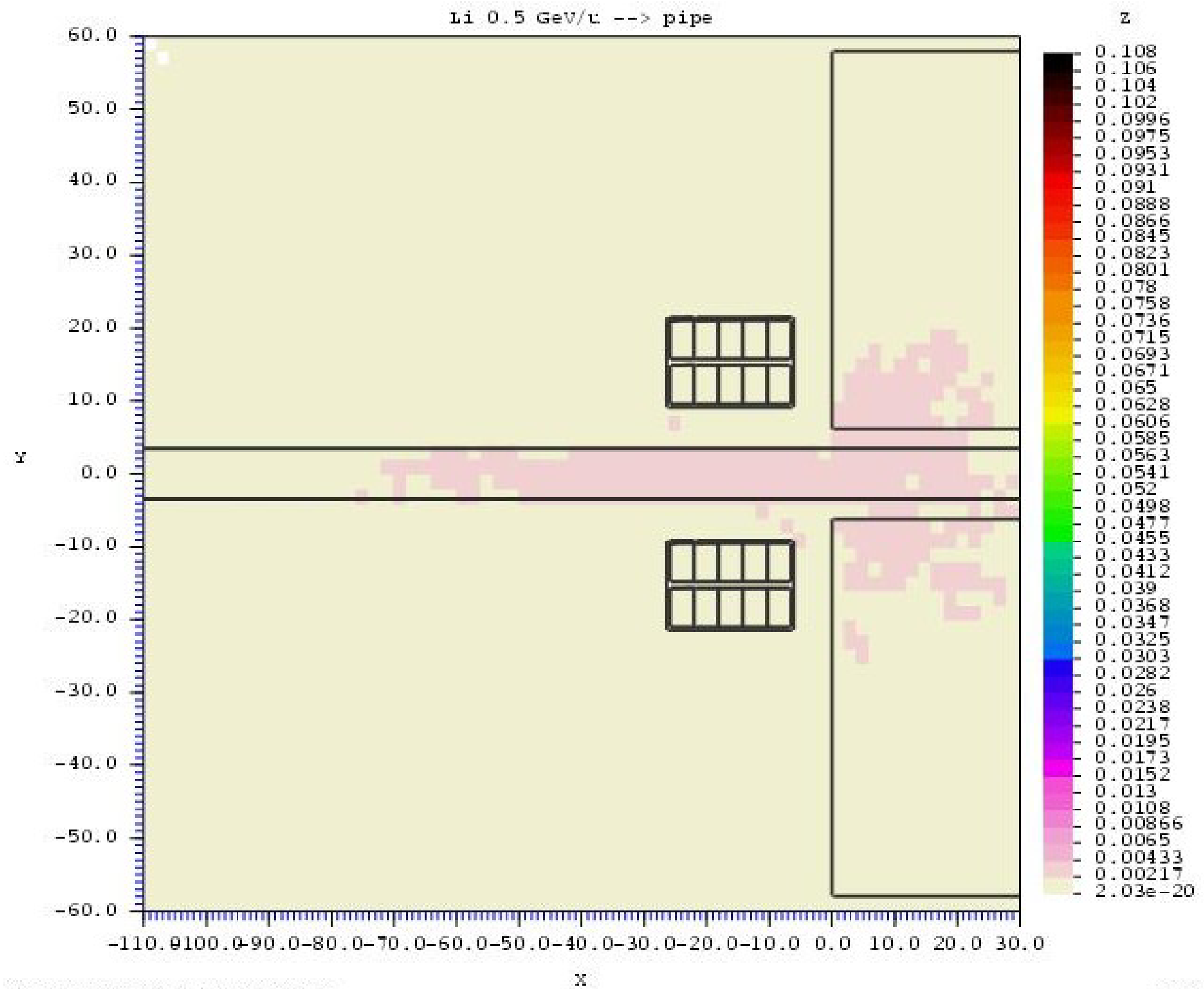


Z=14cm

Fluence distribution

All transportable particles

$^{6}Li^{3+}$ 0.5 GeV/u → pipe (no collimator)



Z=18cm

Dose rate distribution of the coils

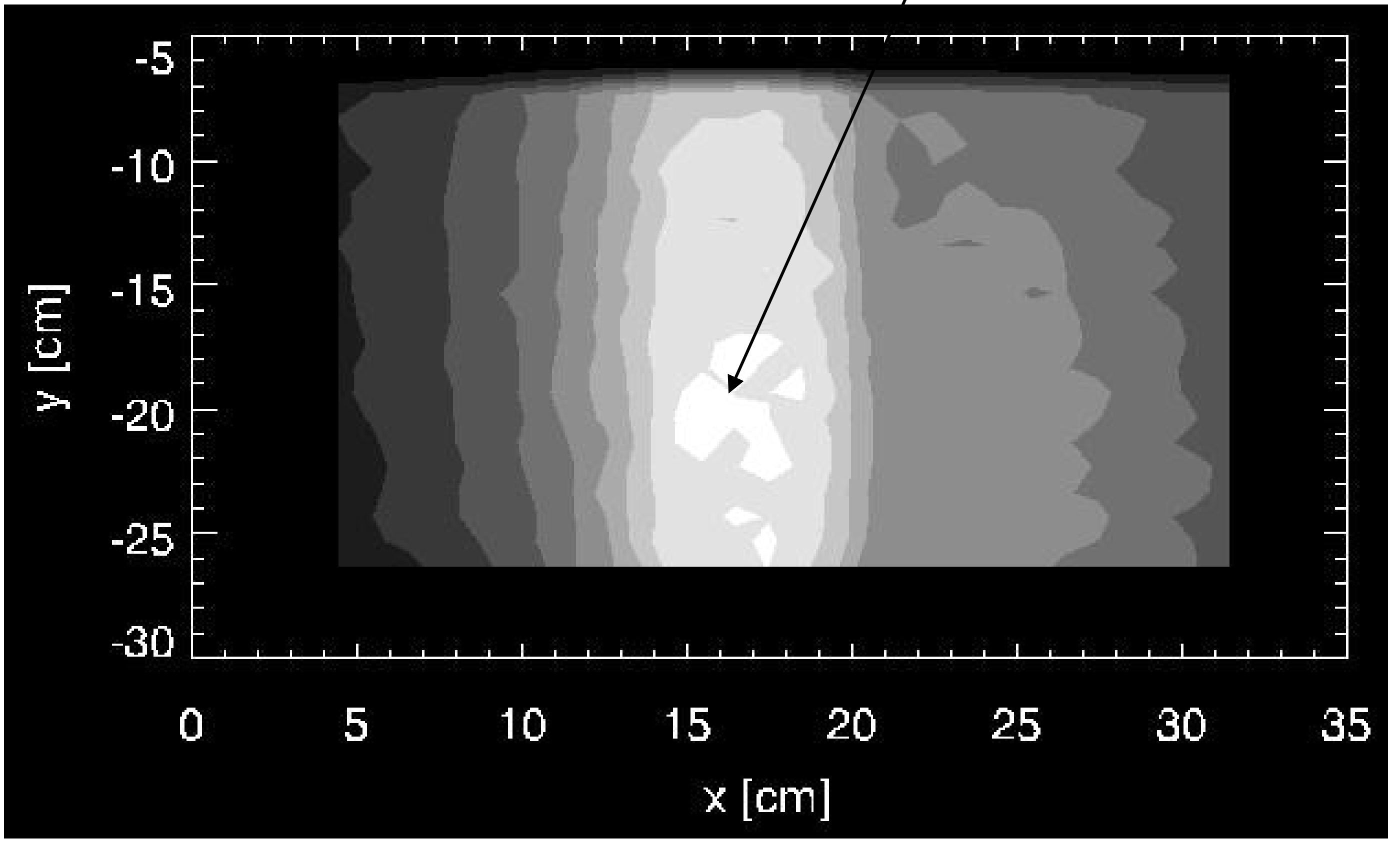
Example: Insulation: top front straight: bottom horizontal sheet

$^{18}F^{9+}$ 1.1 GeV/u → C collimator

Maximum dose rate:

Coil will fail here first!

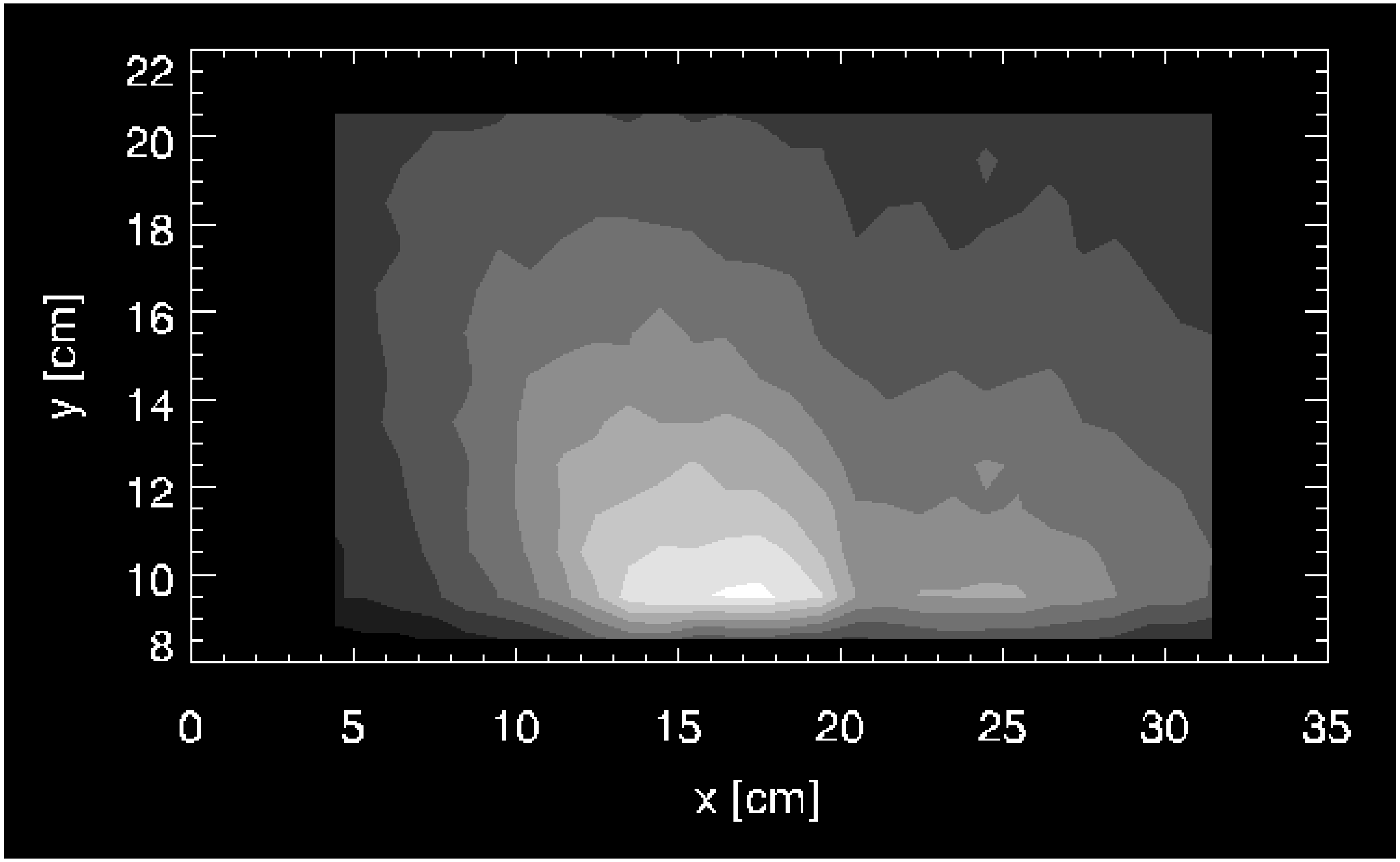
Towards yoke



Dose rate distribution of the coils

Example: Insulation: top front straight: front vertical sheet

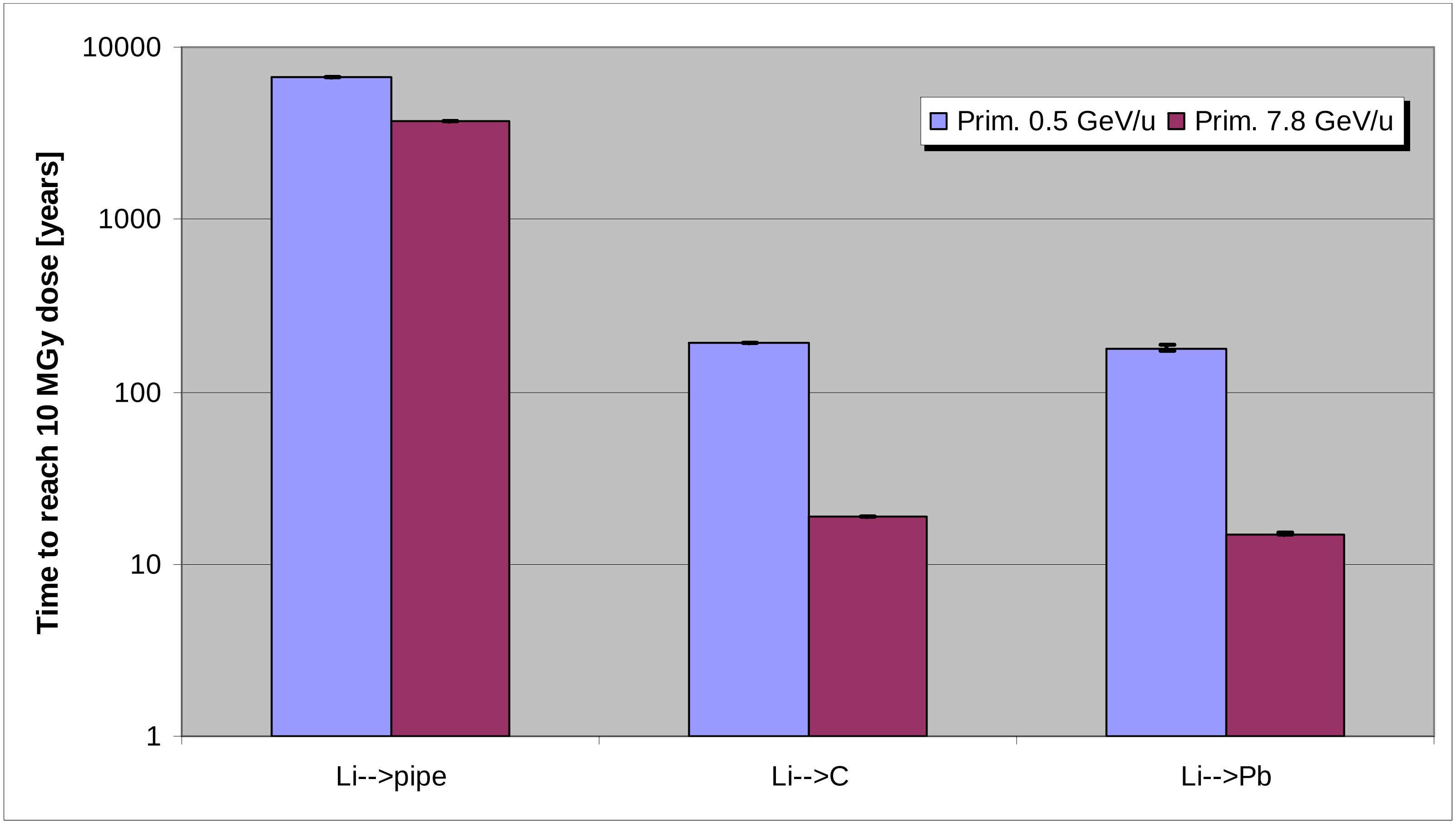
$^{18}F^{9+}$ 1.1 GeV/u → C collimator



Dose rates and lifetimes

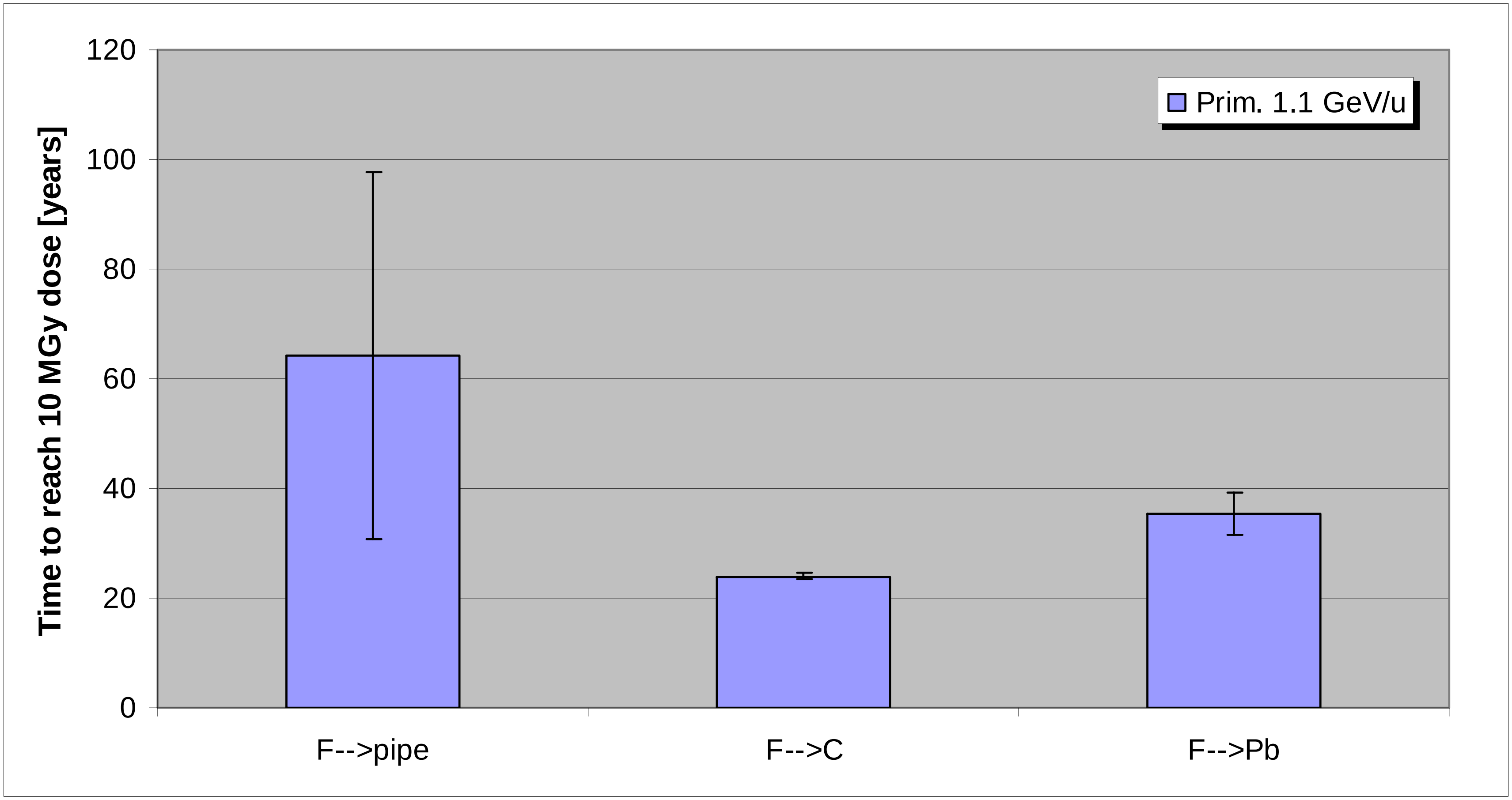
Beta Beams in EURISOL

He-beam pattern: average angle of incidence and loss rates impinging the collimator and section of pipe upto end of D-magnet – calculated by StrahlSim



Dose rates and lifetimes

Ne-beam pattern: average angle of incidence and loss rates impinging the collimator and section of pipe upto end of D-magnet – calculated by StrahlSim



Summary

- Dose rates and therefore estimated operation lifetimes of the coils in the PS (D-dipole) have been estimated using the FLUKA transport code.
- The variation in the dose fluence spatial distributions seems to agree qualitatively with what would be expected.
- For a maximum possible operational life expectancy, it is better not to use collimation before the magnet, since –for this BEAM and GEOMetry- the fragmentation products from the collimator deposit their energy in the upper and lower straight sections at the front of the magnet.

Outlook

- The lamination in the magnet -particularly for F9+ hitting the right side of the D-magnet (likewise Li3+ hitting left side of F-magnet)- needs to be looked at.
- What is the activation in the magnet and the collimator after a long exposure?
- Dose rates in the coil insulation at the back of the D-F pair.
- The error bars in the case without collimation (Ne-beam) are rather large. Must simulate with a realistic beam across the whole straight-D-F section.
- Energy spread (PS ramping) in primaries should be introduced; more realistic BEAM distribution.