Radiation studies on PS main magnets

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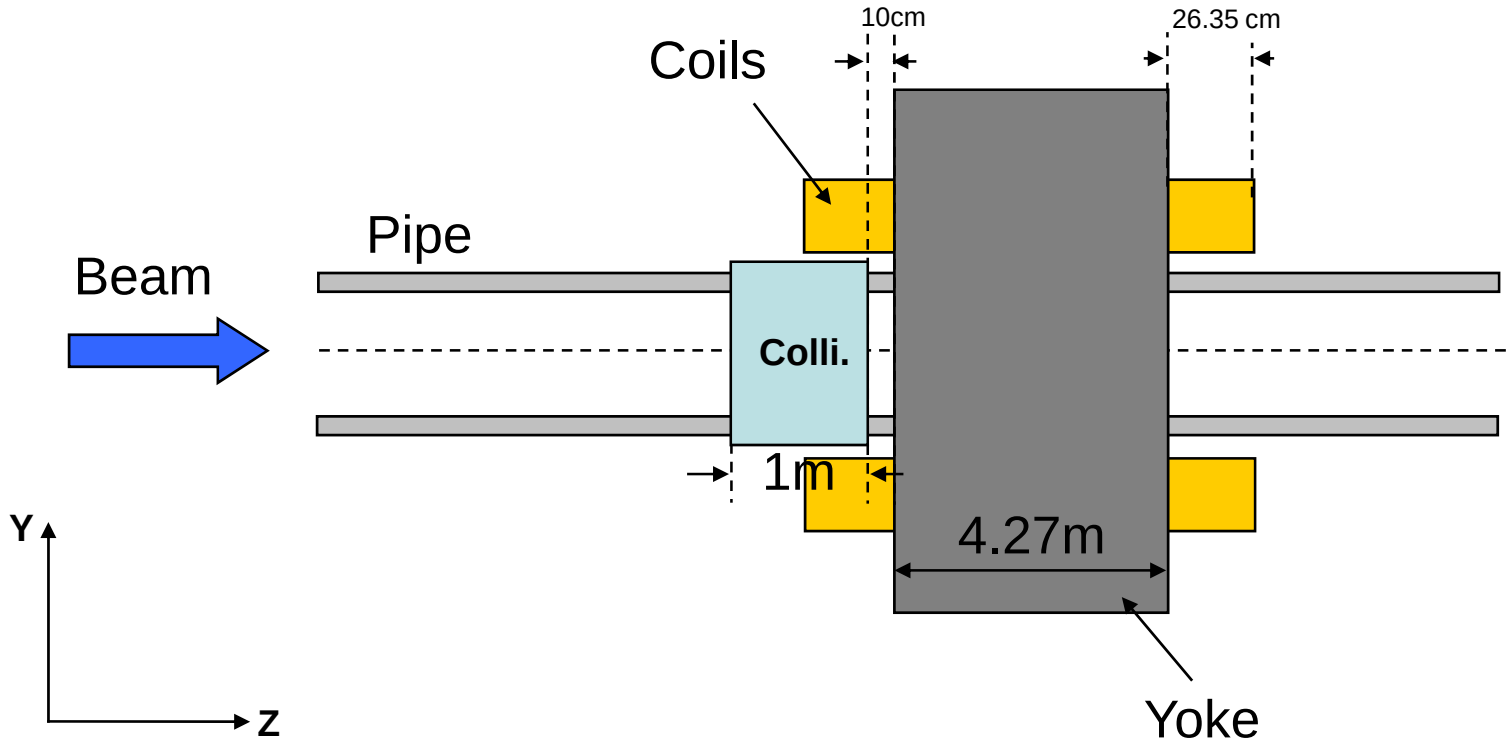
Contents

- Description of the FLUKA simulation model:
  - * Geometry,
  - * Transverse beam profile,
  - * Loss distributions: intensity, angles and energy,
  - * Materials of the important components.
- Review of the physical dose rates in the coil insulation.
- Reminant dose rates.

Schematic: Magnet Geometry

Beta Beams in EURISOL

Side view of beamline section including a combined function magnet.
(Not to scale.)

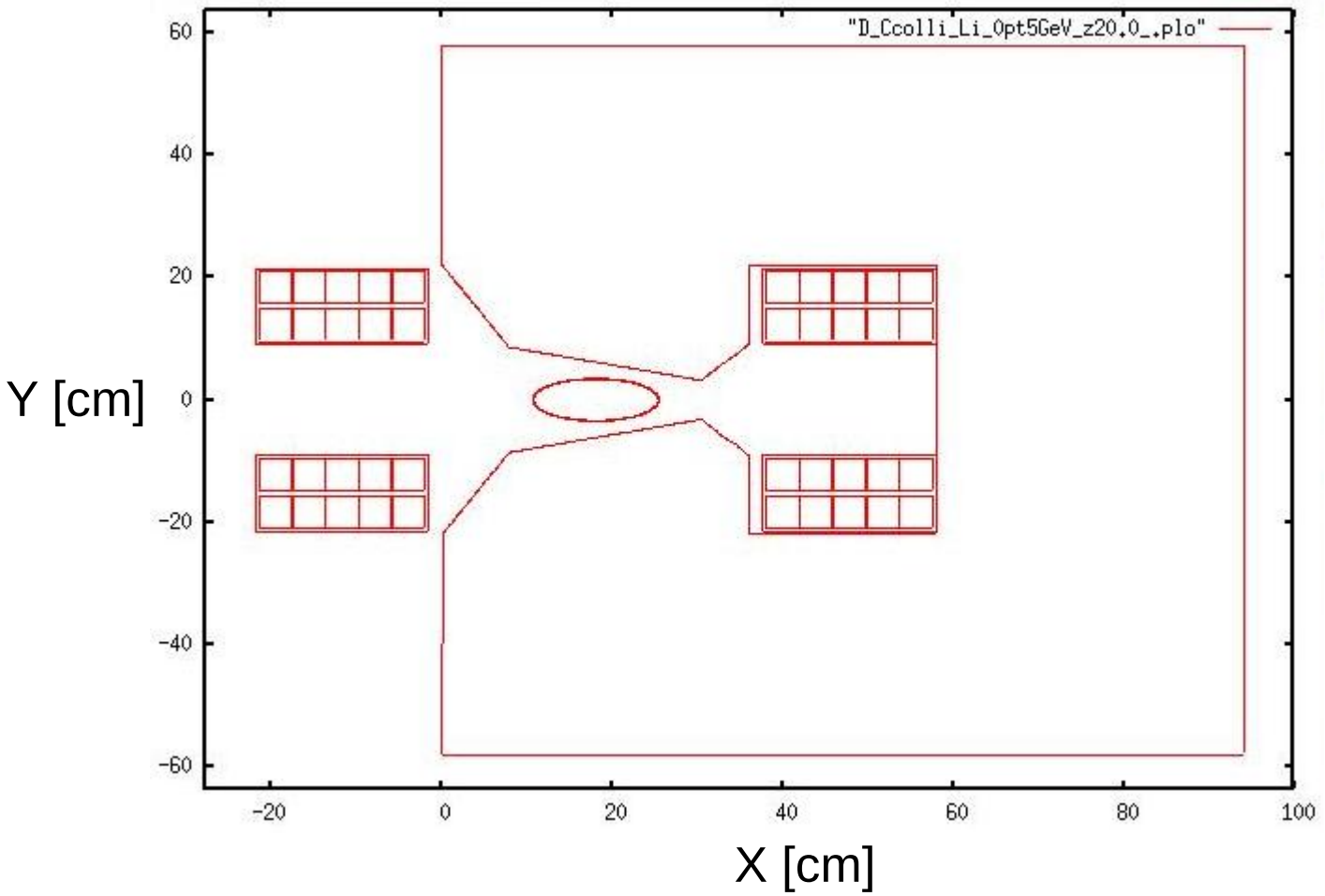


FLUKA: Magnet geometry

Beta Beams in EURISOL

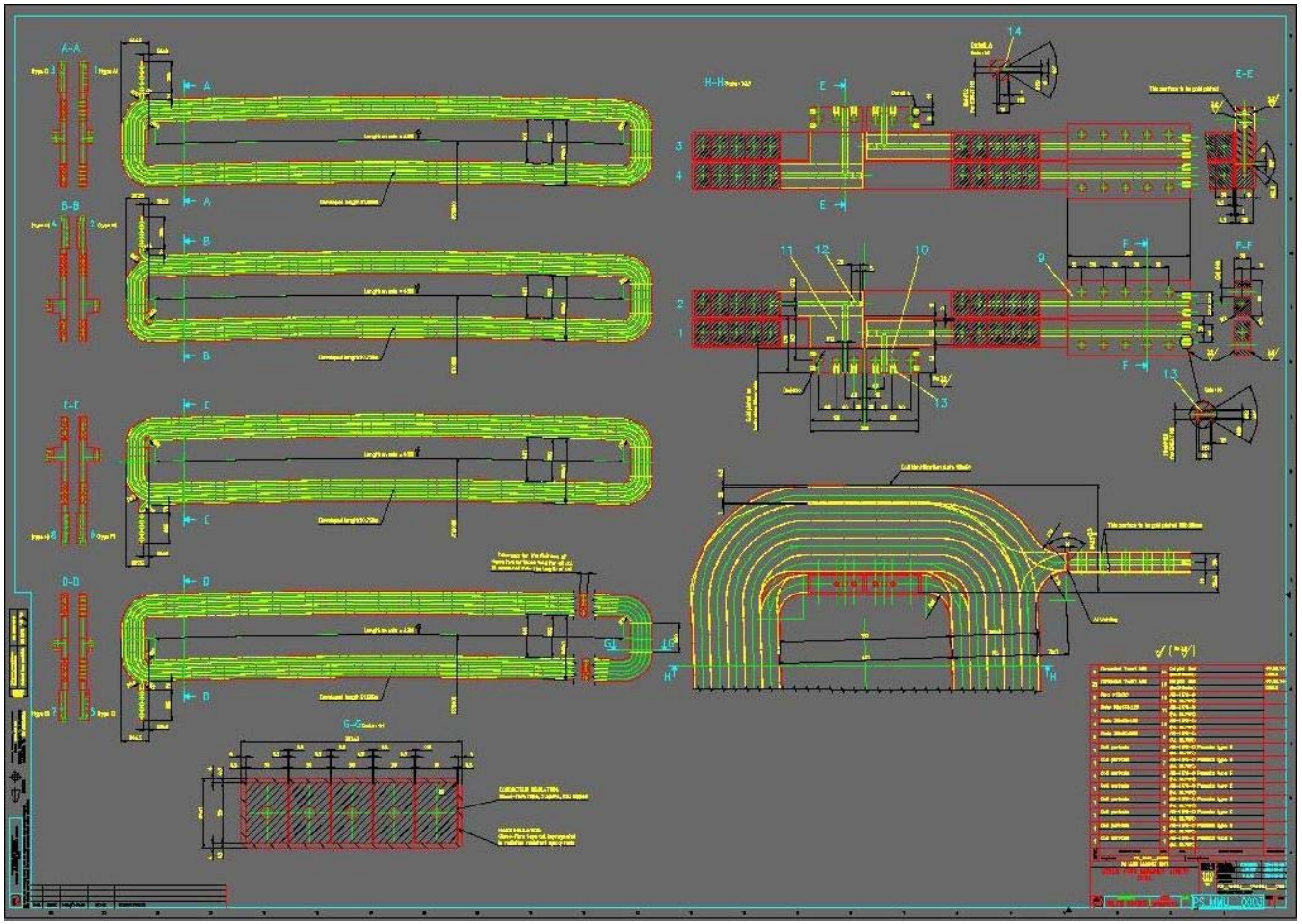
PS combined function D-magnet. Beam into page.

Vertical cross section through middle of magnet.



Coils of the CF magnet

Two „pancake coils“ per pole shoe. Approx.→ Straight.

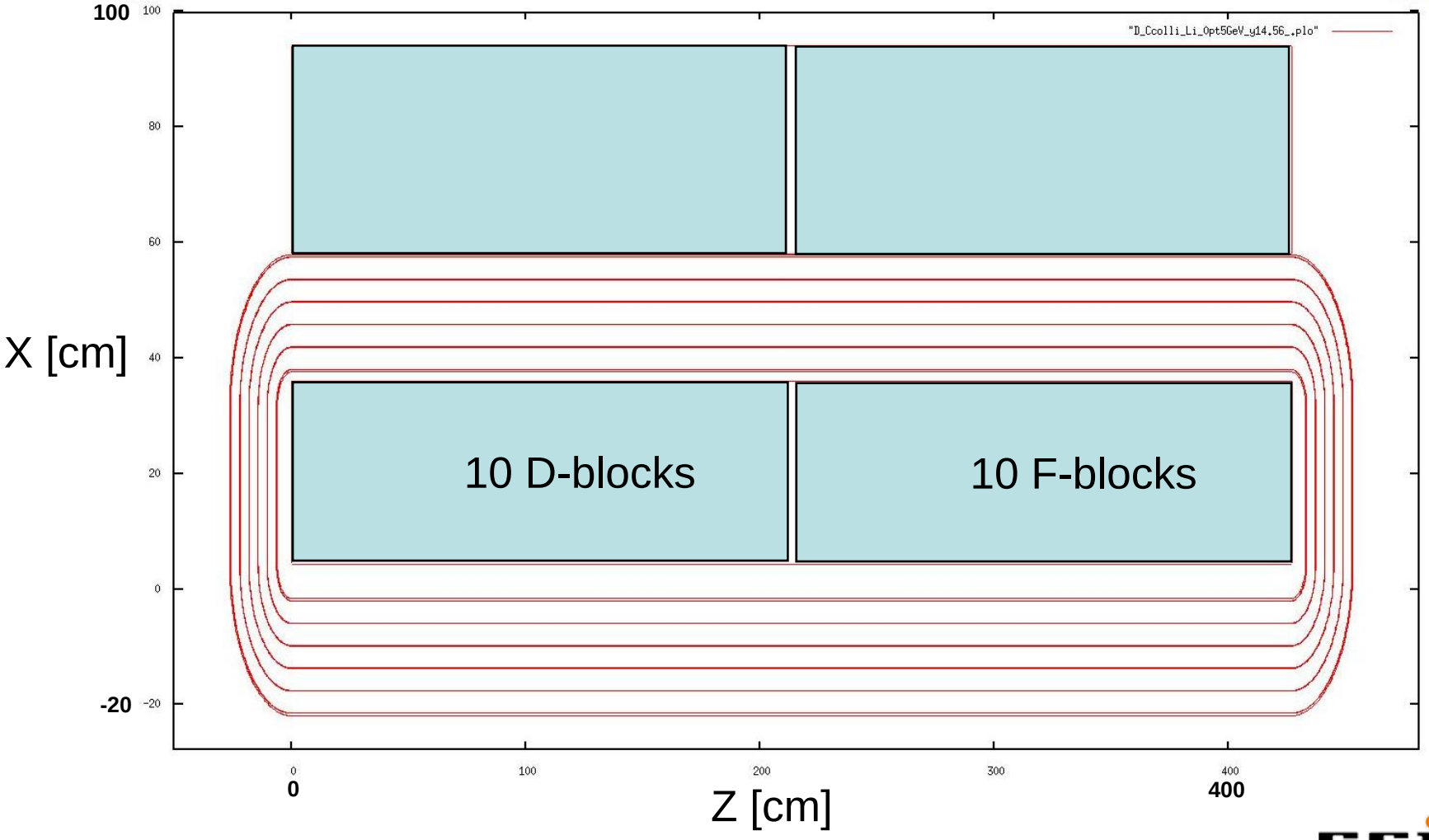


Magnet geometry

Beta Beams in EURISOL

PS combined function D-magnet. Beam from left to right.

Horizontal cross section through magnet and top/bottom pancake coil.

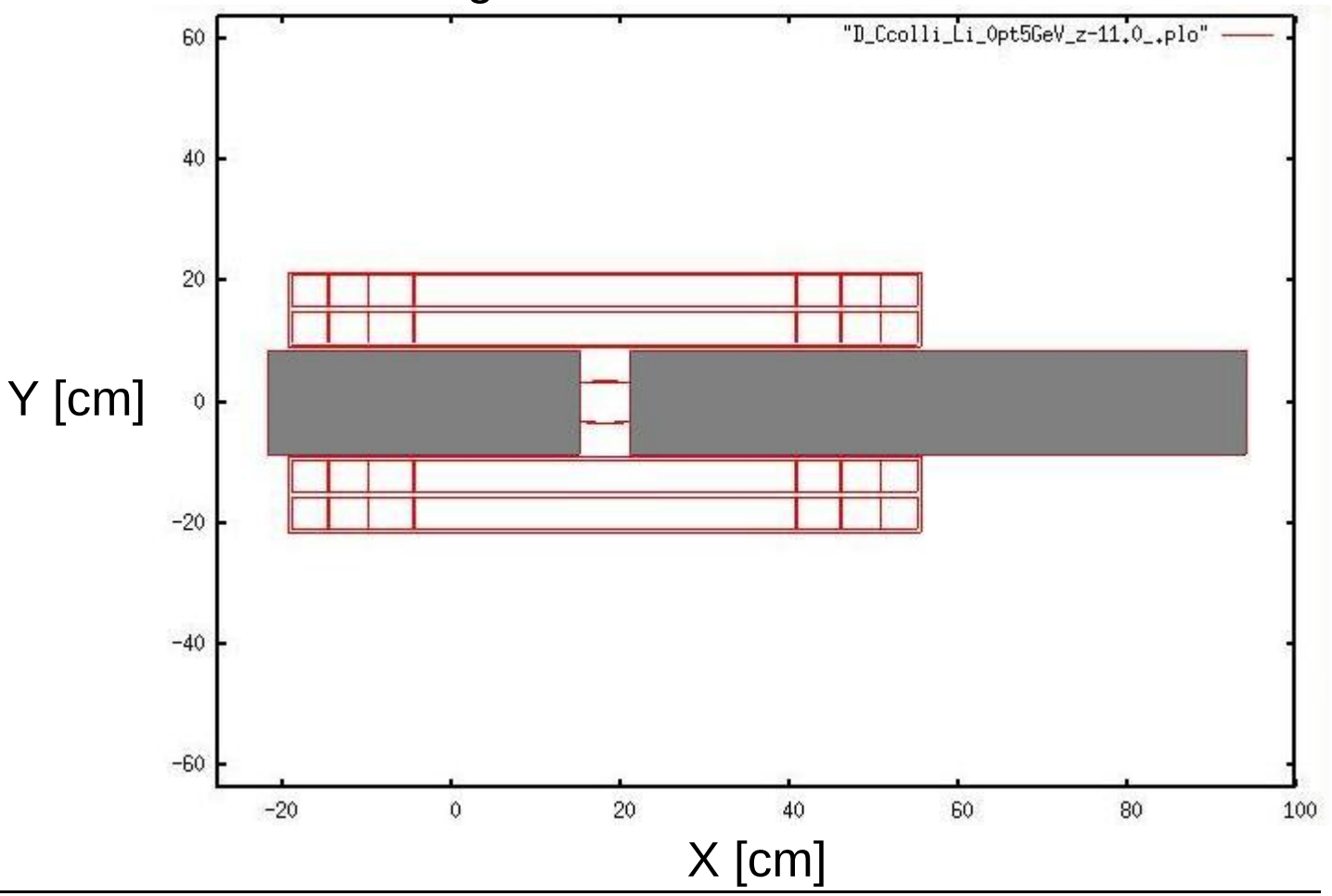


Magnet geometry

Beta Beams in EURISOL

PS combined function D-magnet. Beam into page.

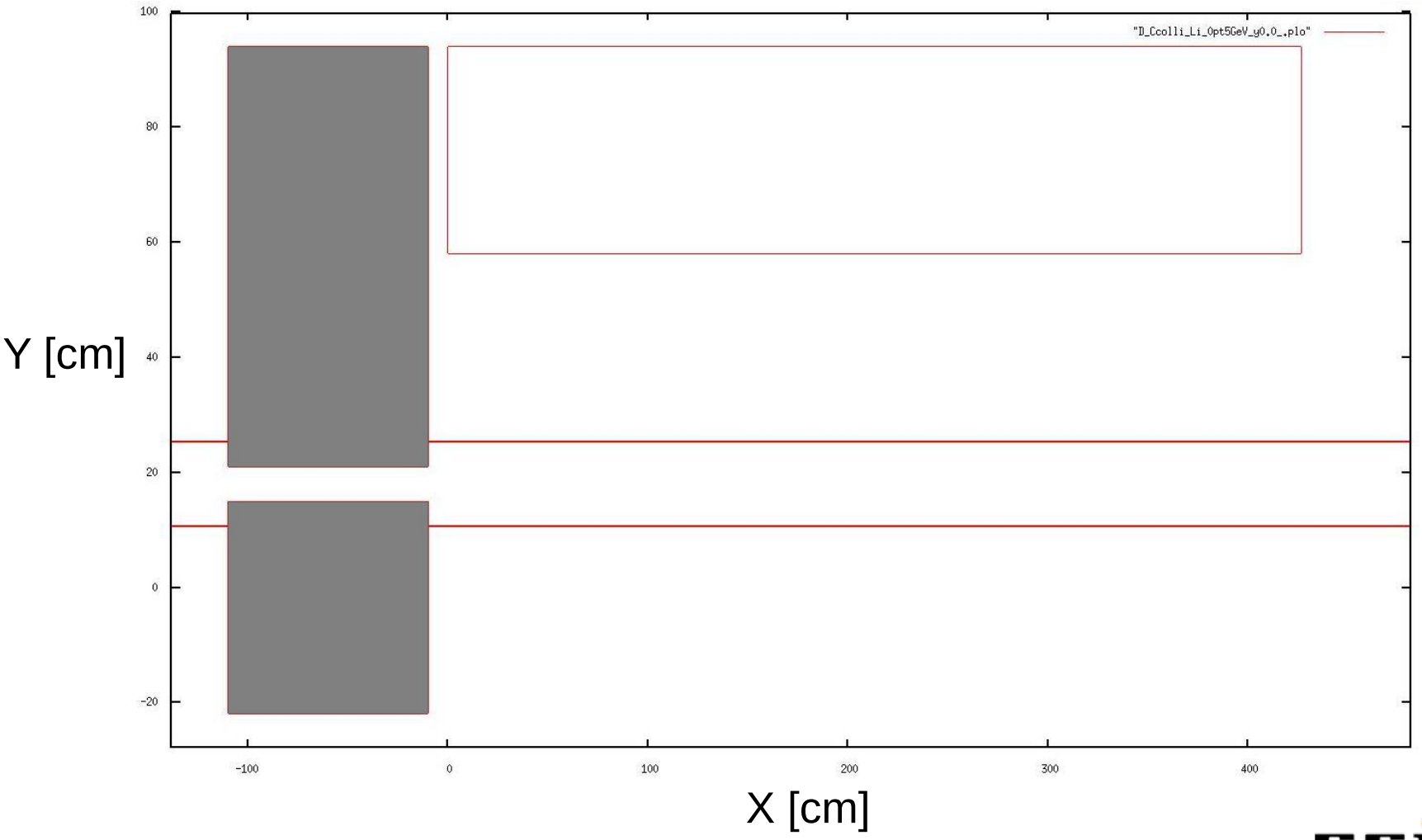
Vertical cross section through collimators and coils at the front of the magnet.



Magnet geometry

Beta Beams in EURISOL

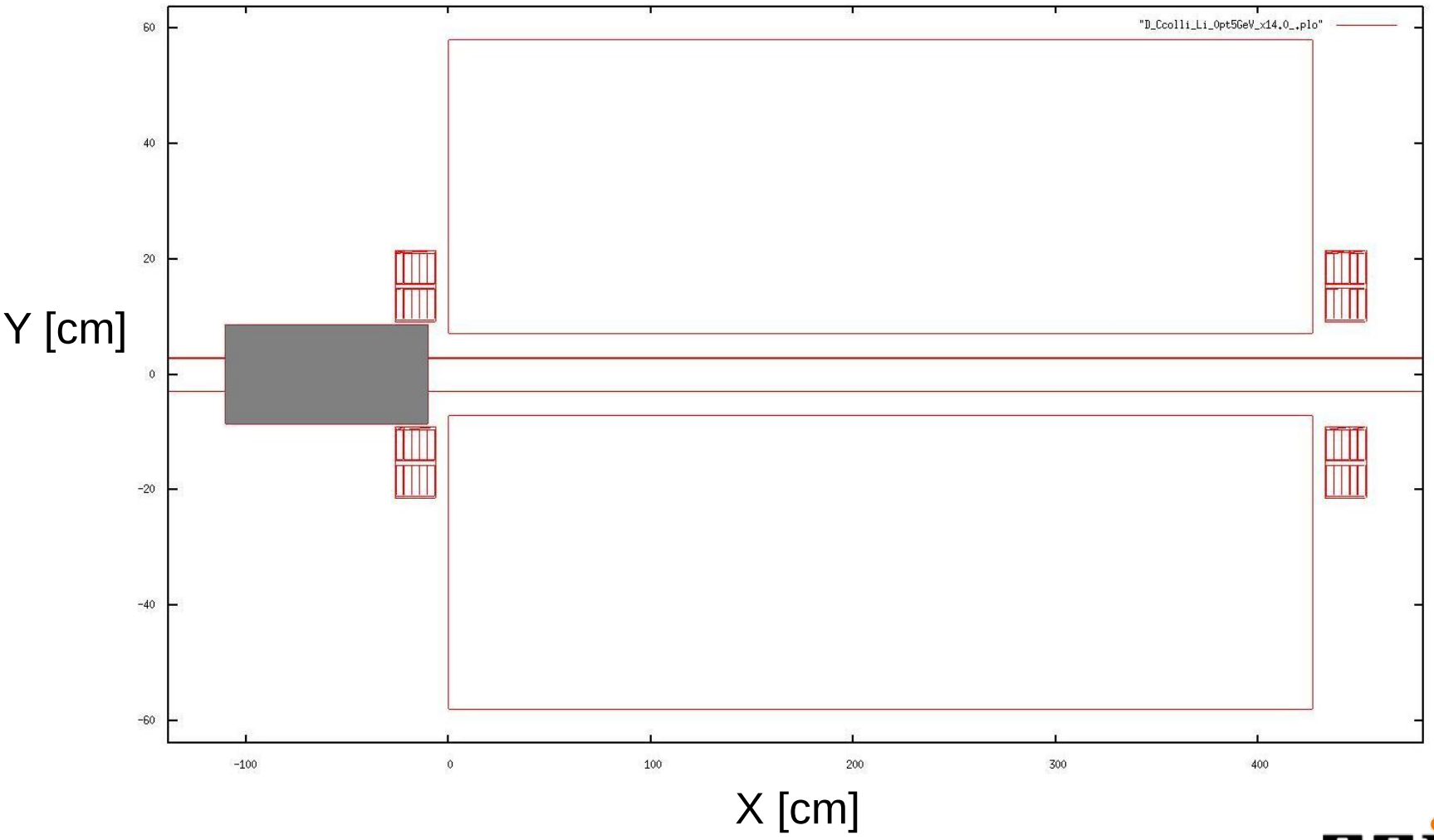
PS combined function D-magnet. Beam from left to right.



Magnet geometry

Beta Beams in EURISOL

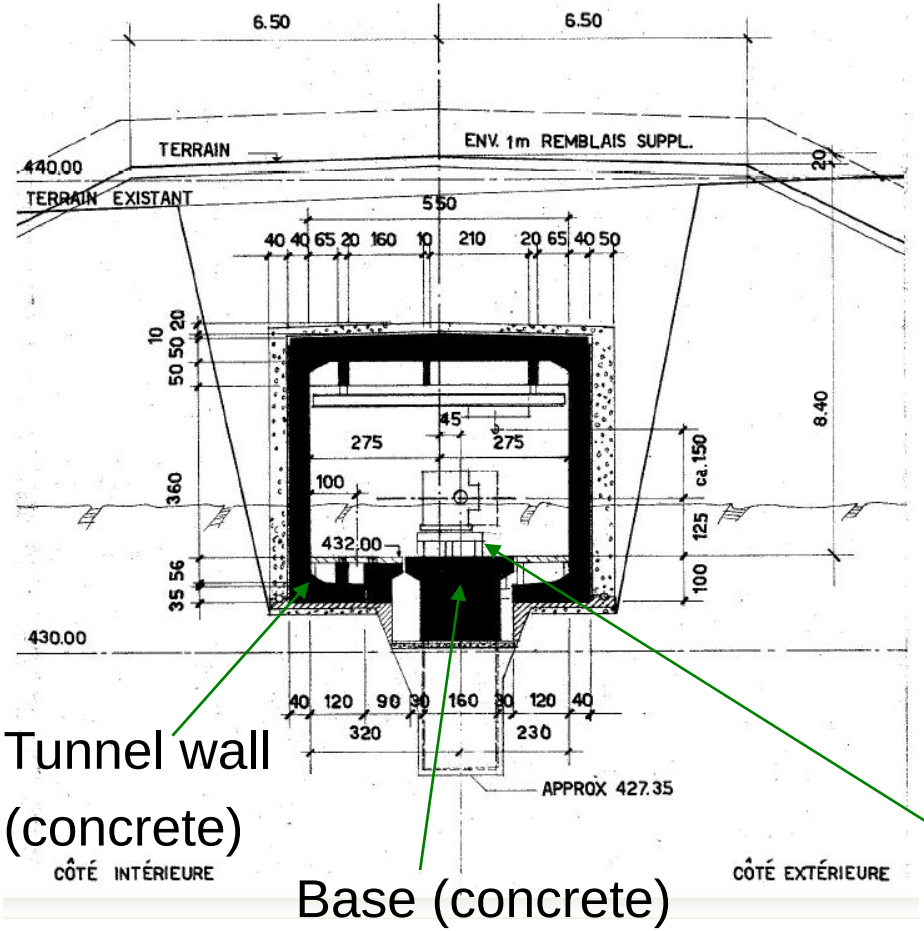
PS combined function D-magnet. Beam from left to right.



Tunnel cross section

Beta Beams in EURISOL

Dashed line to right of beampipe indicates the yoke is closed on the „inside“. (Beam into page.)



Tunnel wall (concrete)

Base (concrete)

Supports for main dipole (steel)

Transverse beam profiles

Beta Beams in EURISOL

He- and Ne beams in the FLUKA model.

Approximation 1. effect of adiabatic damping represented as a time-average:

$$\langle \beta\gamma \rangle_t = \frac{\beta\gamma_{inj}(t_1 + t_2) + \frac{1}{2} t_2 \left(\beta\gamma_{ext} - \beta\gamma_{inj}\right)}{t_1 + t_2} \qquad \langle \varepsilon_y \rangle_t = \varepsilon_{inj,y} \frac{\beta\gamma_{inj}}{\langle \beta\gamma \rangle_t}$$

Linear dipole field ramp: Flat bottom time t_1, acceleration time t_2.

Approximation 2. Transverse vertical primary beam profile is

static and Gaussian with the width given by

$$\Delta Y_{FWHM} = 2\sqrt{\ln(4)\langle \varepsilon_{rms,y} \rangle_t \langle \beta_y \rangle}$$

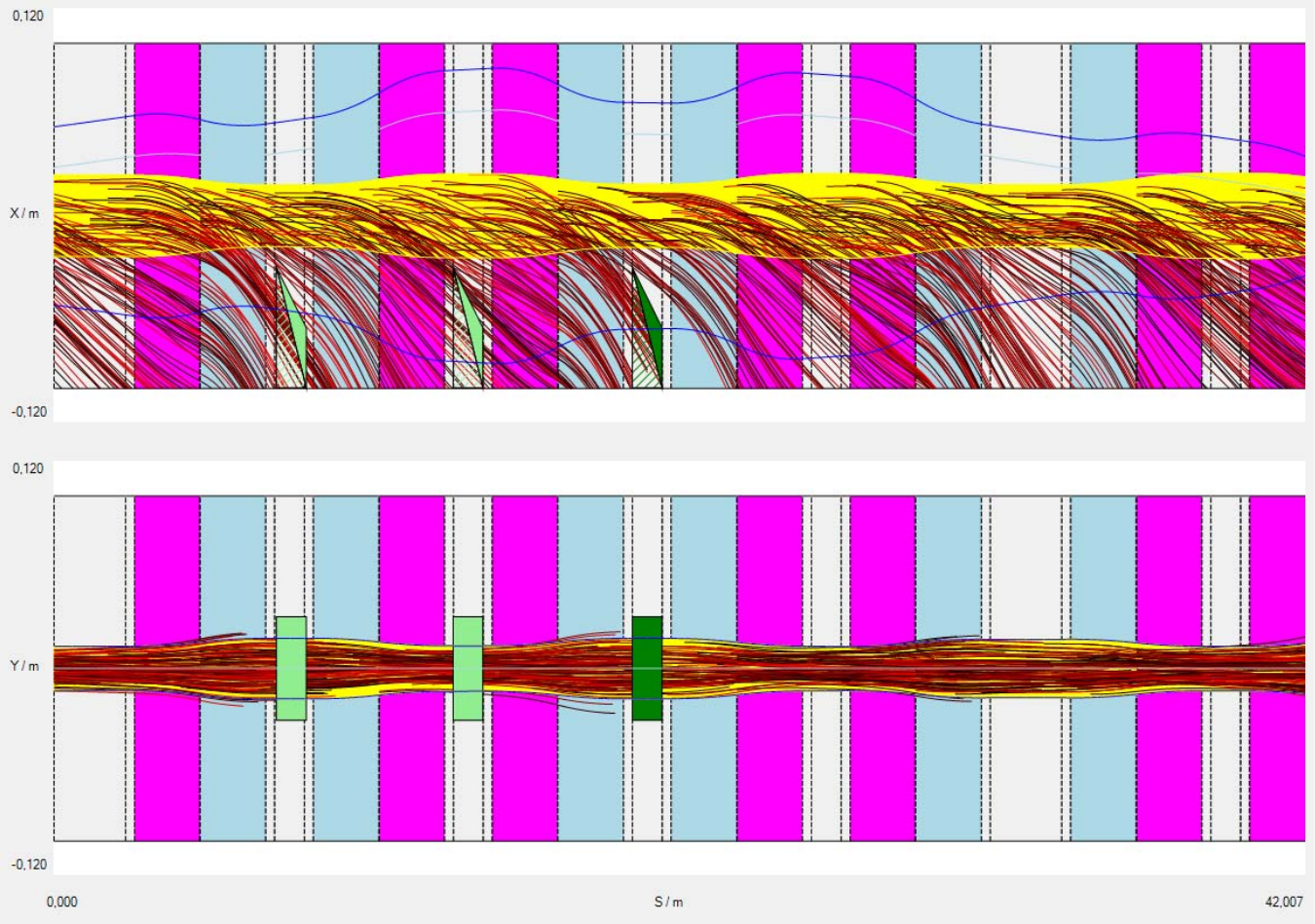
StrahlSim: Losses

Beta Beams in EURISOL

He-beam. Decay products tracked to the collimator and beampipe.

Horizontal

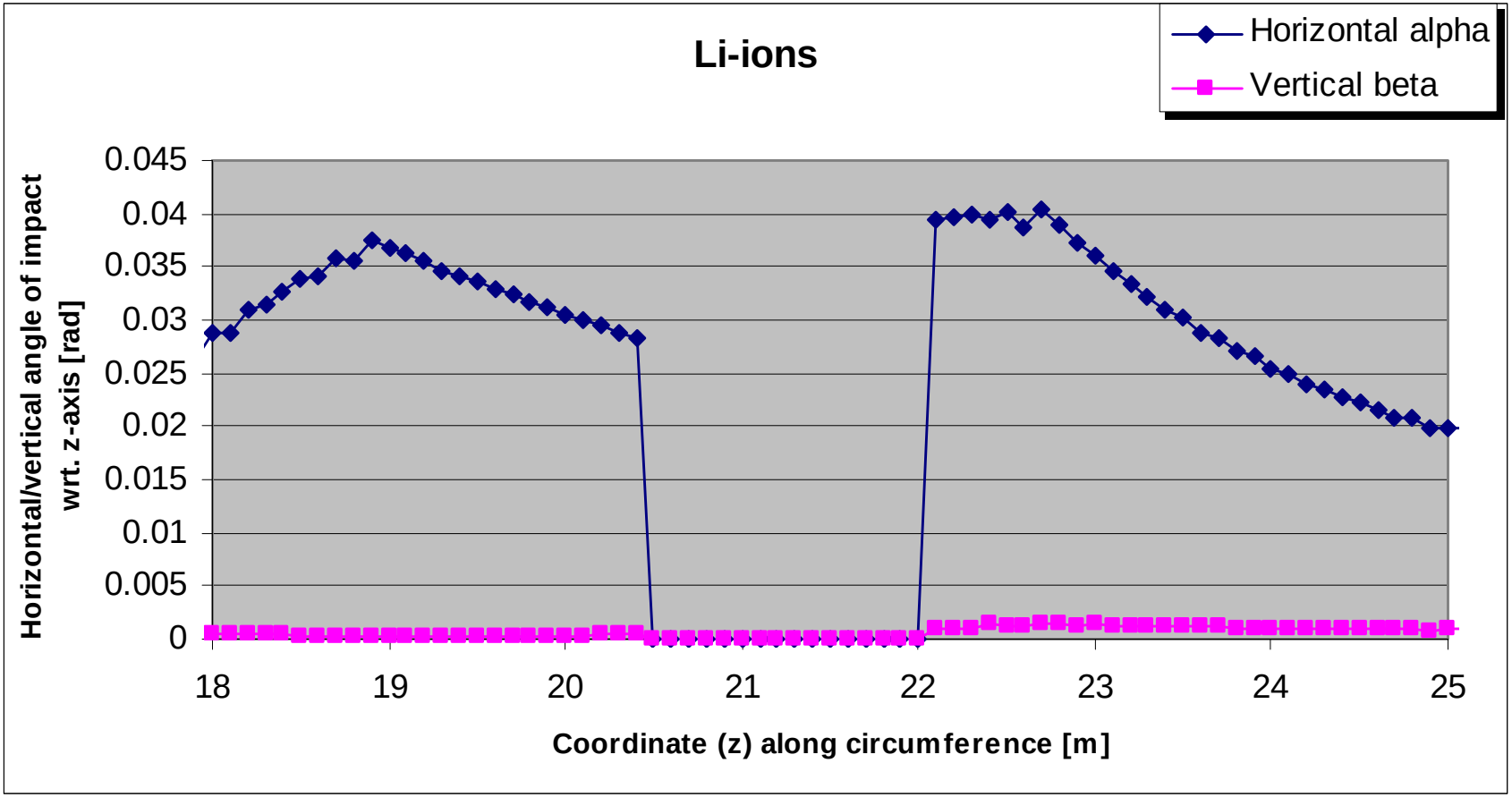
Vertical



StrahlSim: Loss map with collimator

Beta Beams in EURISOL

He-beam. Angles of incidence (wrt. z axis) on the beampipe.



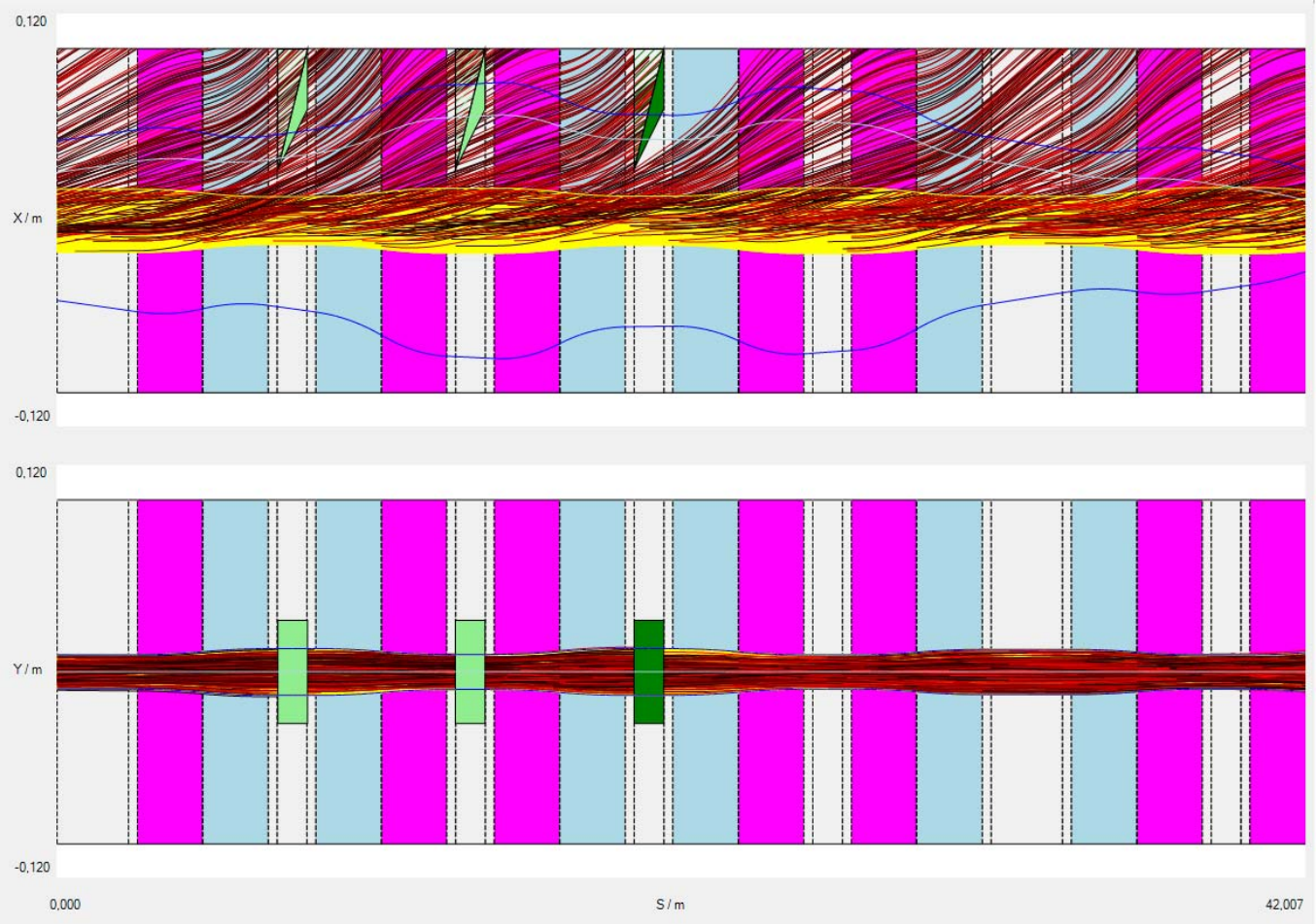
StrahlSim: Losses

Beta Beams in EURISOL

Ne-beam. Decay products tracked to the collimator and beampipe (red curves).

Horizontal

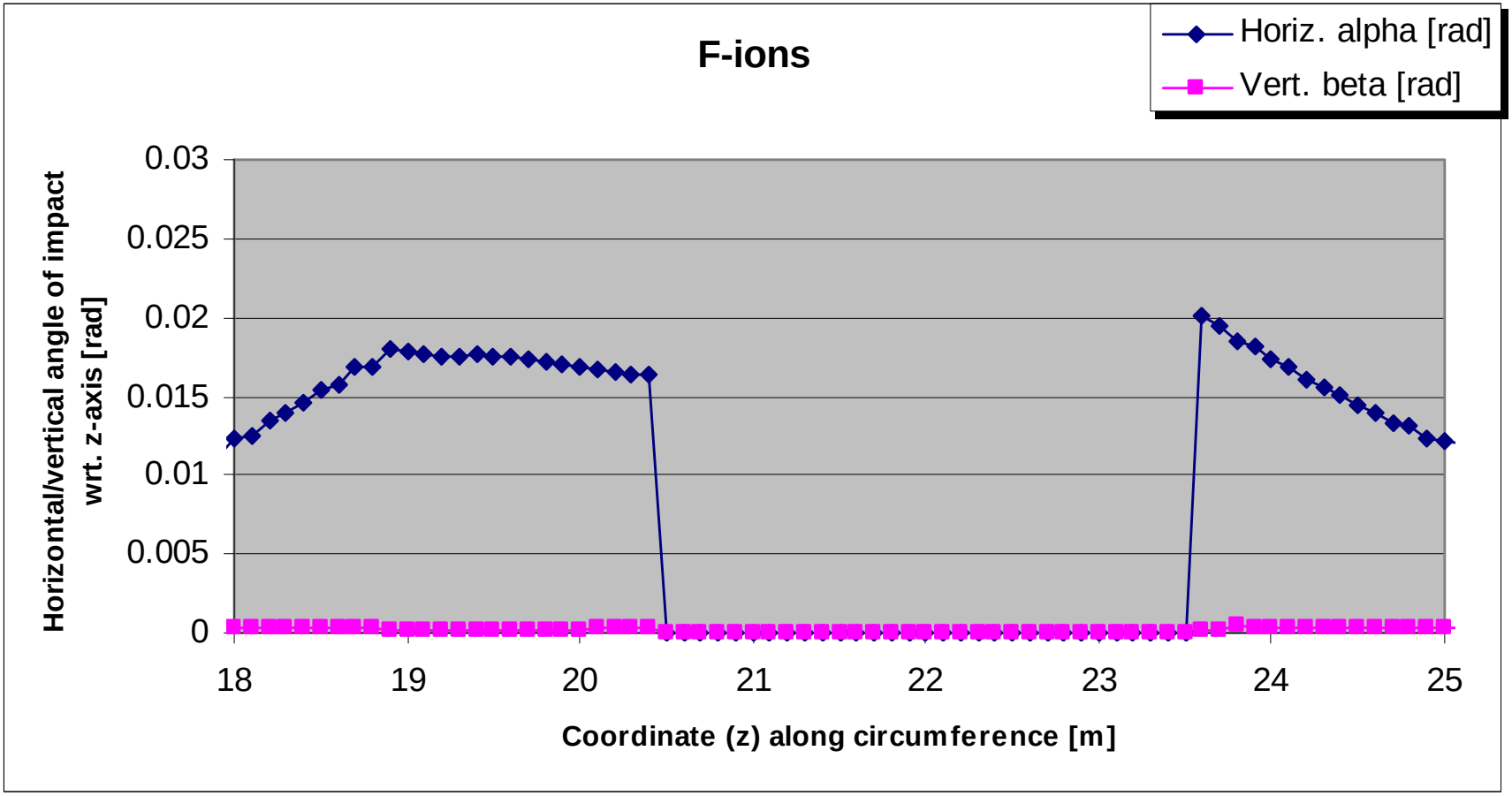
Vertical



StrahlSim: Loss map

Beta Beams in EURISOL

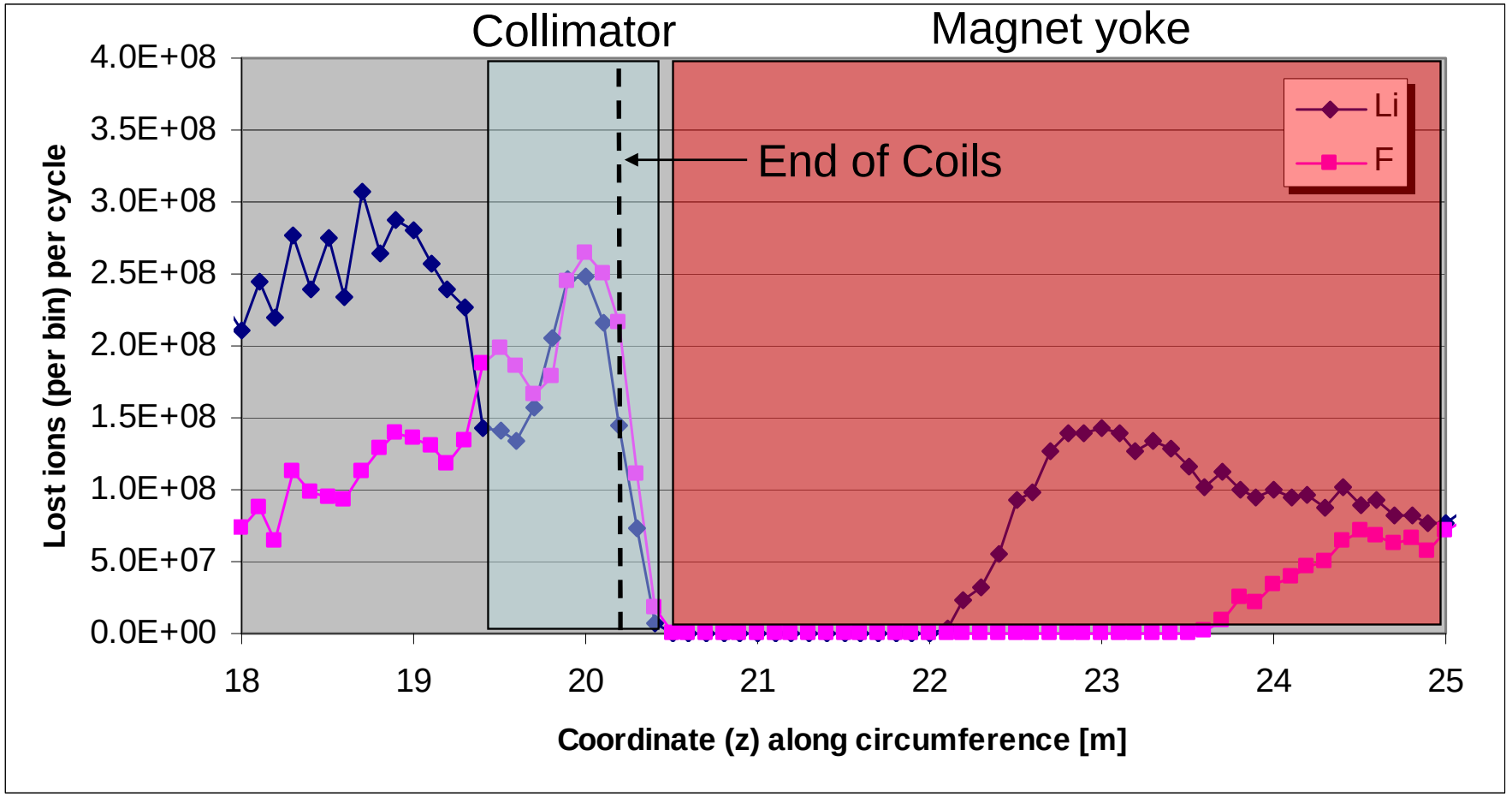
Ne-beam. Angles of incidence on the beampipe (wrt. longitudinal axis)



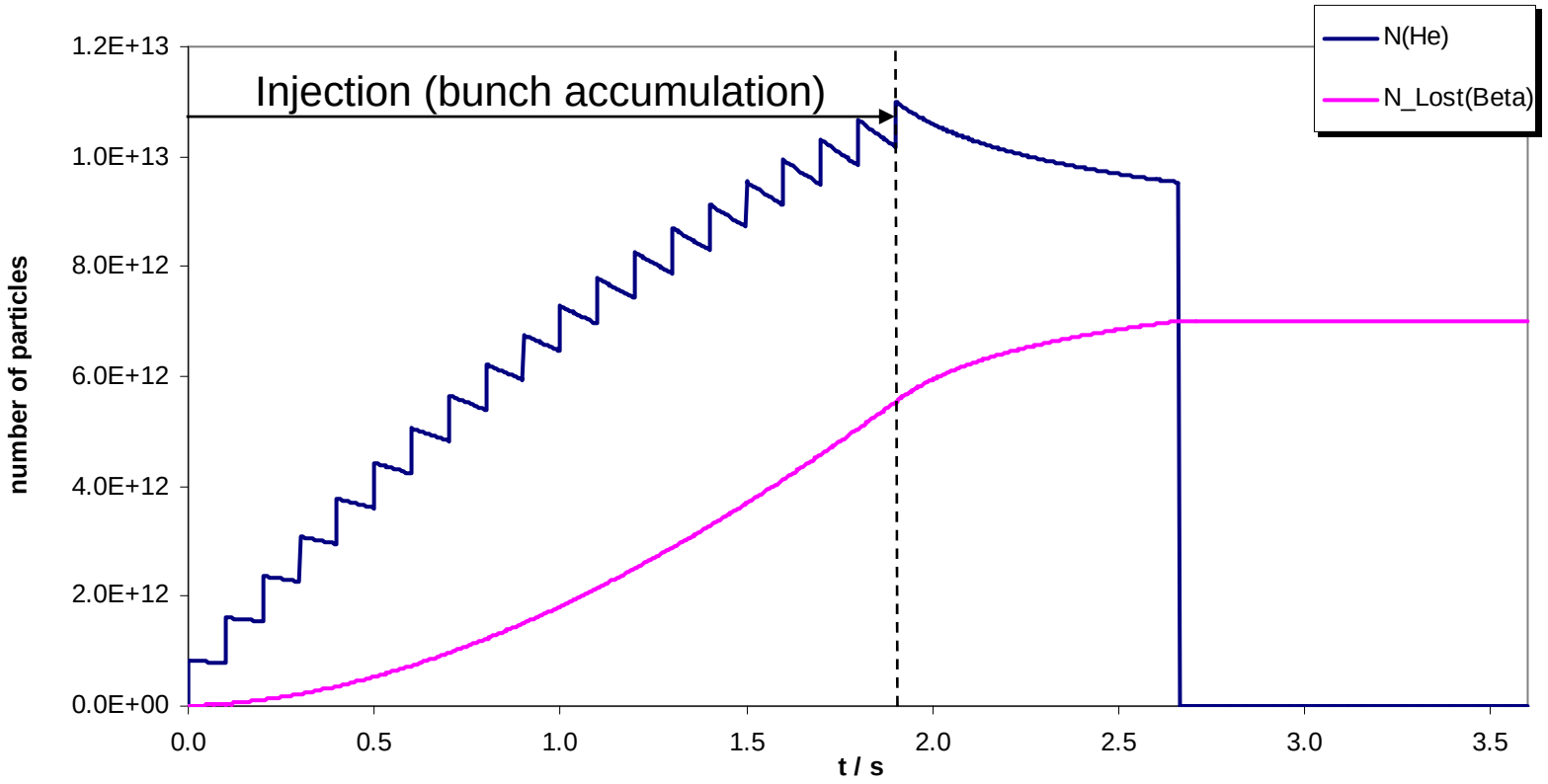
StrahlSim: Loss maps

Beta Beams in EURISOL

He- and Ne beams. Loss distribution along the machine.



StrahlSim: Losses (1 of 2)

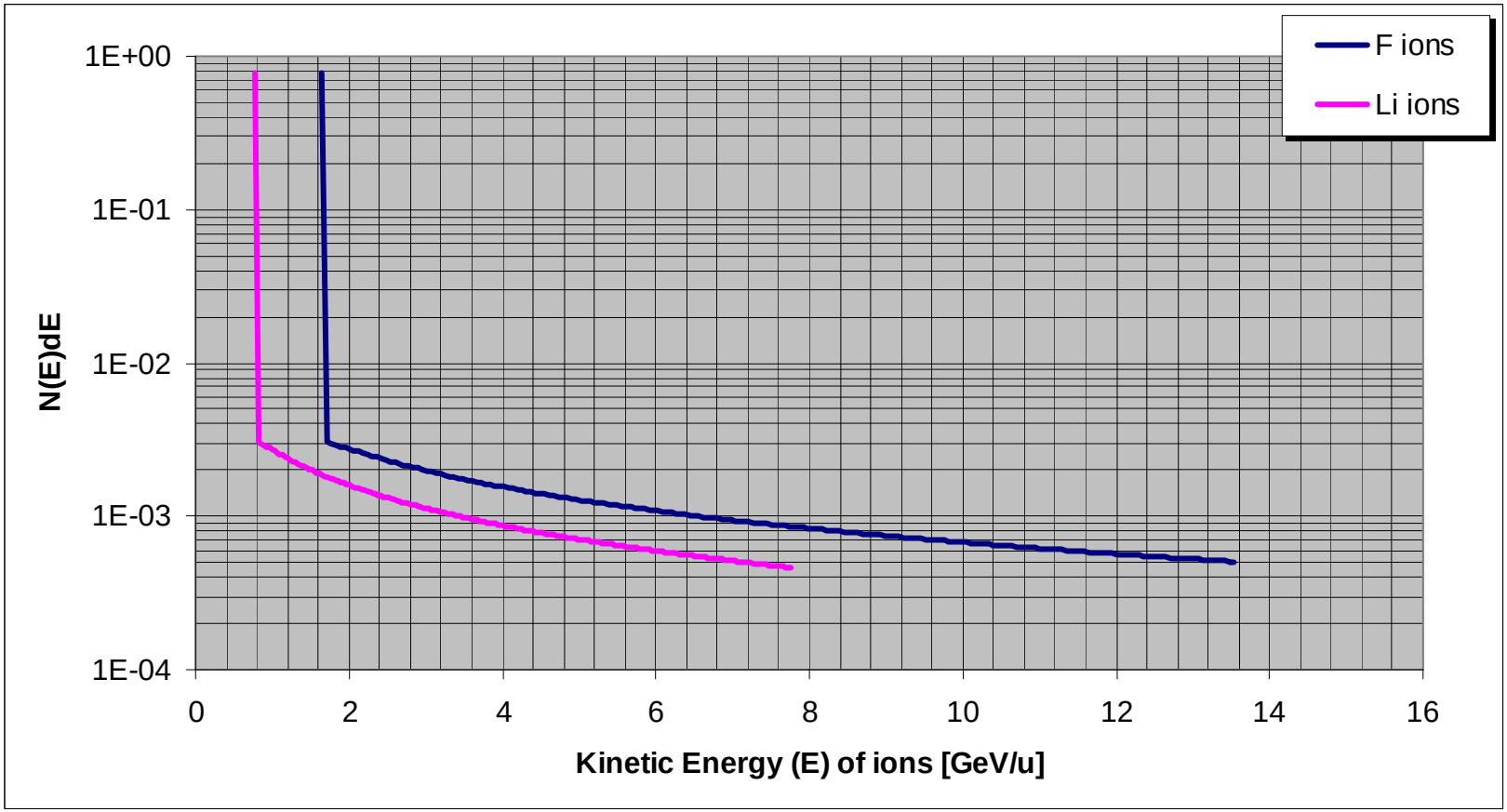


See next slide! …

StrahlSim: Losses (2 of 2)

Beta Beams in EURISOL

He- and Ne beams. Energy distributions of the daughter nuclei over the complete cycle.



Materials

Coil insulation: Epoxy fibre glass resin (80% glass E)

Coil conductor: copper

Cooling of coils: water

Tunnel wall: concrete

Magnet supports: steel 1

Beampipe: steel 2

Insulation: Mainly consists of glass type E.

	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%

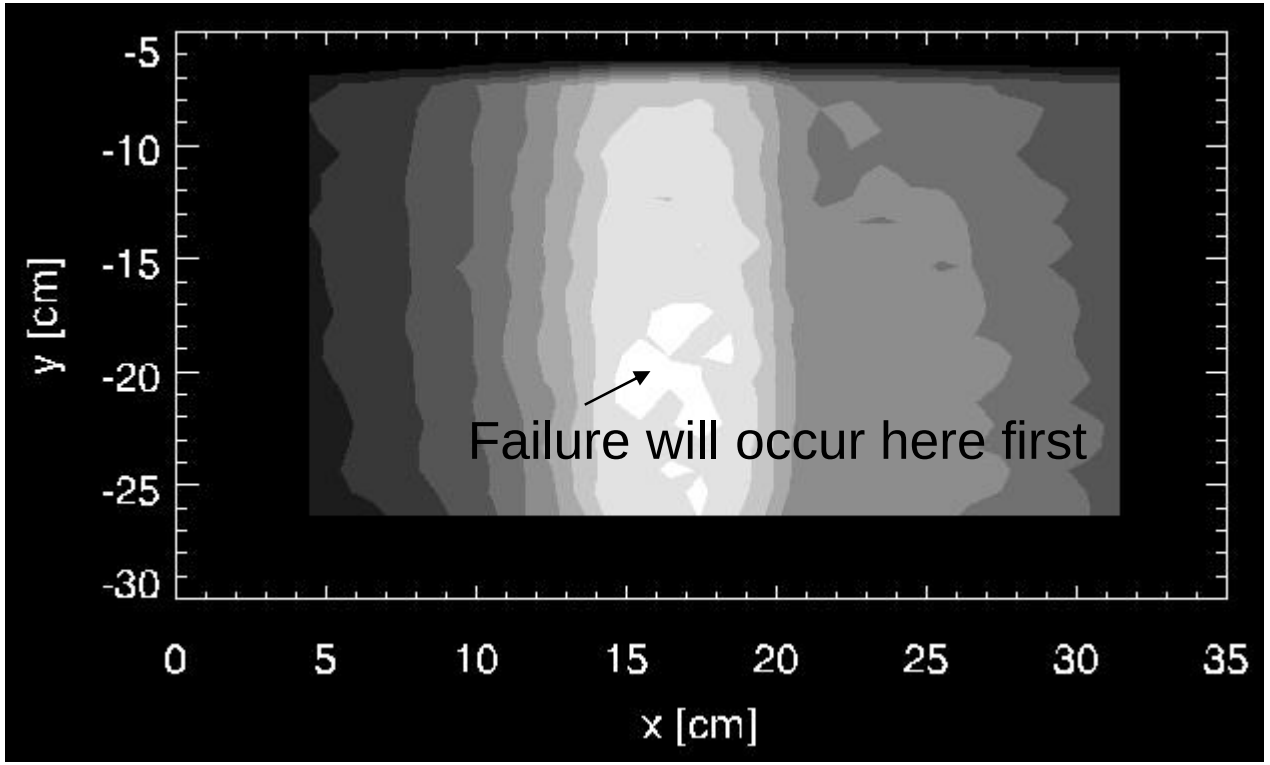
Dose rate distribution in the coils

Beta Beams in EURISOL

Insulation: bottom horizontal sheet of the top front straight.

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

Illustration only!



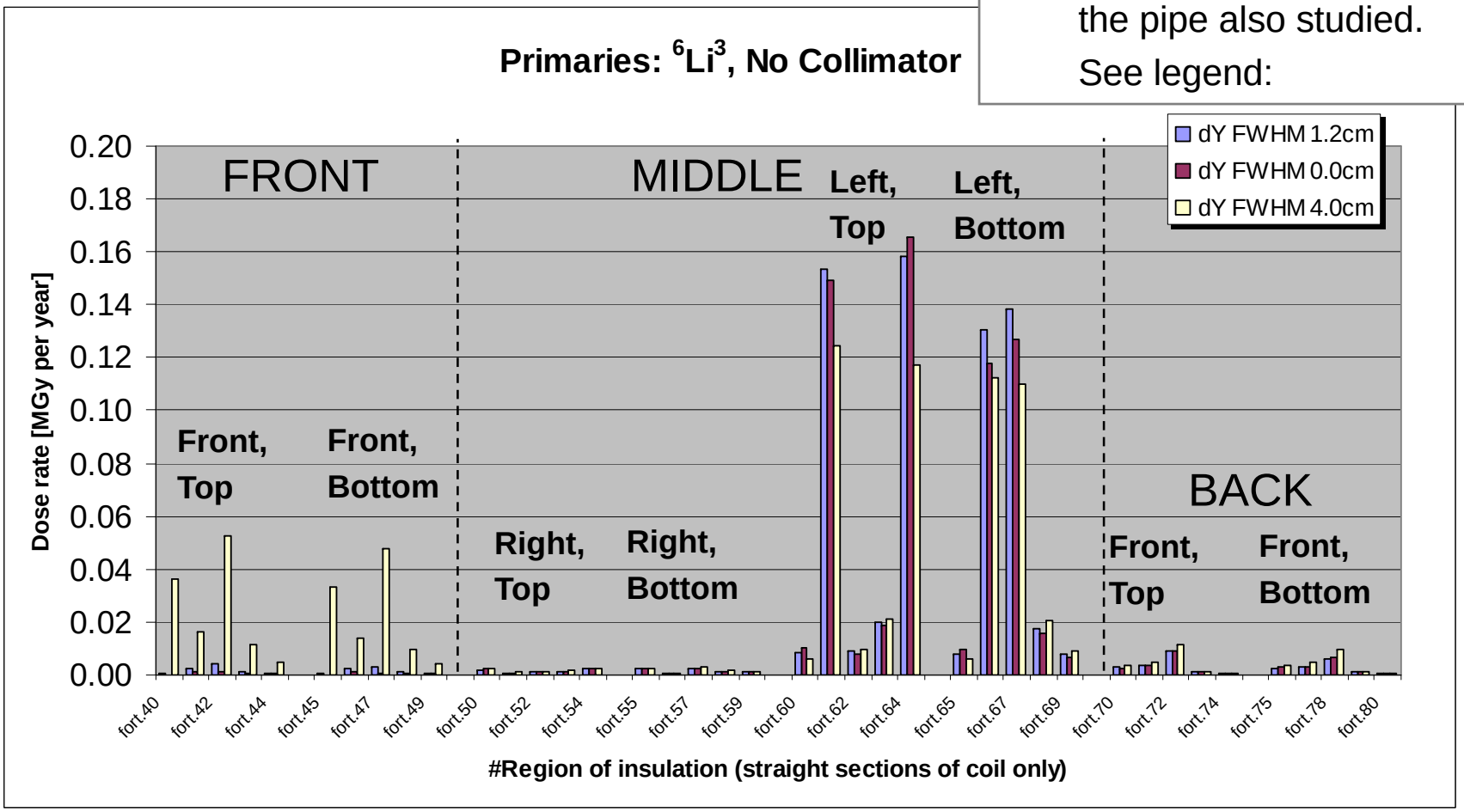
Dose rates and lifetimes (1)

Beta Beams in EURISOL

He-beam pattern: Angular and energy distributions given by StrahlSim.

Preferred dose rate <0.2 MGy/year

Pencil beam and 2σ filling the pipe also studied. See legend:



Bends in the coils and straights at the back not included.

GSI

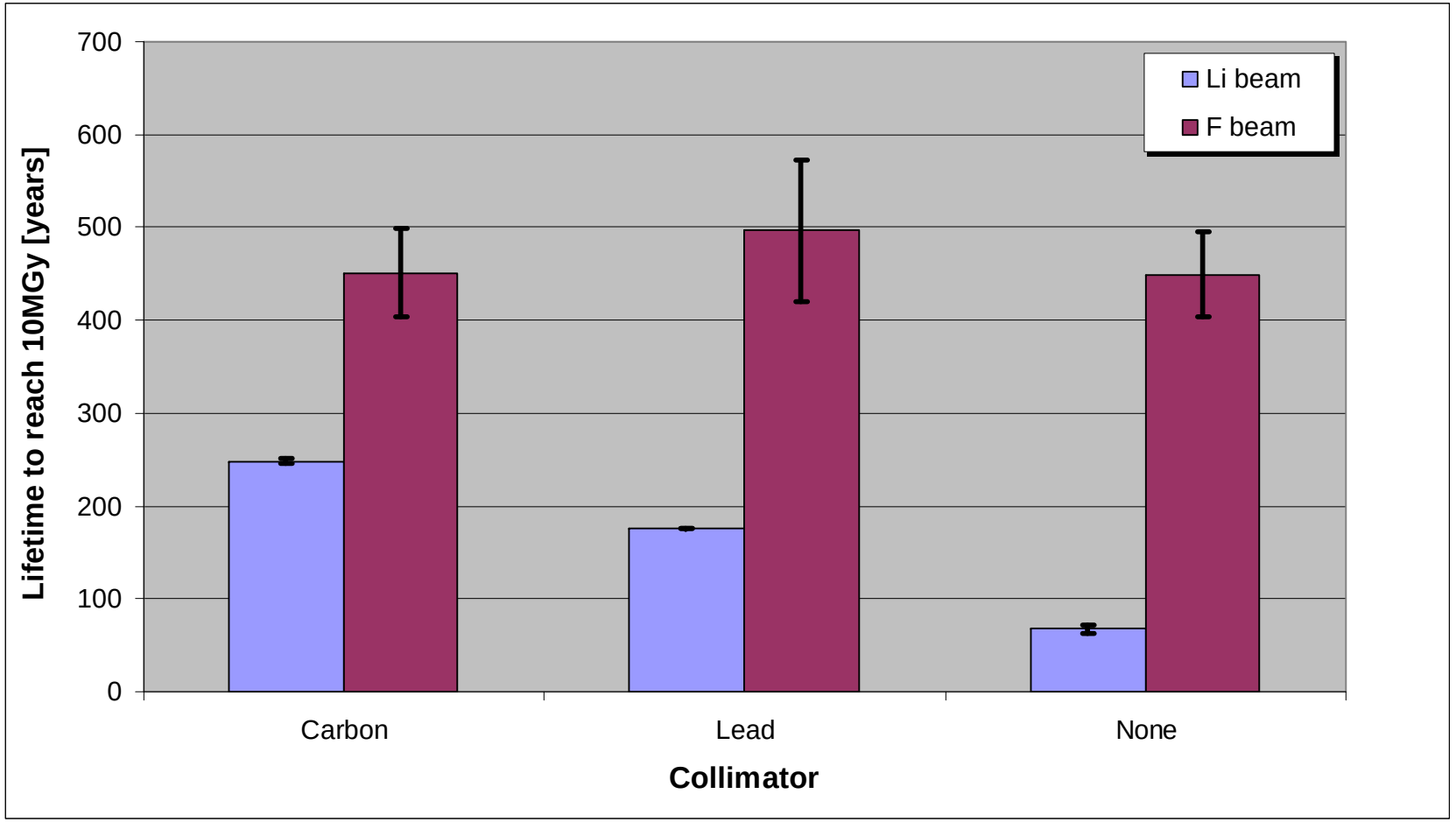
Lifetimes

Beta Beams in EURISOL

Losses on target geometry (z=18-25m):

8.2×10^9 Li-ions/s 1.2×10^9 F-ions/s

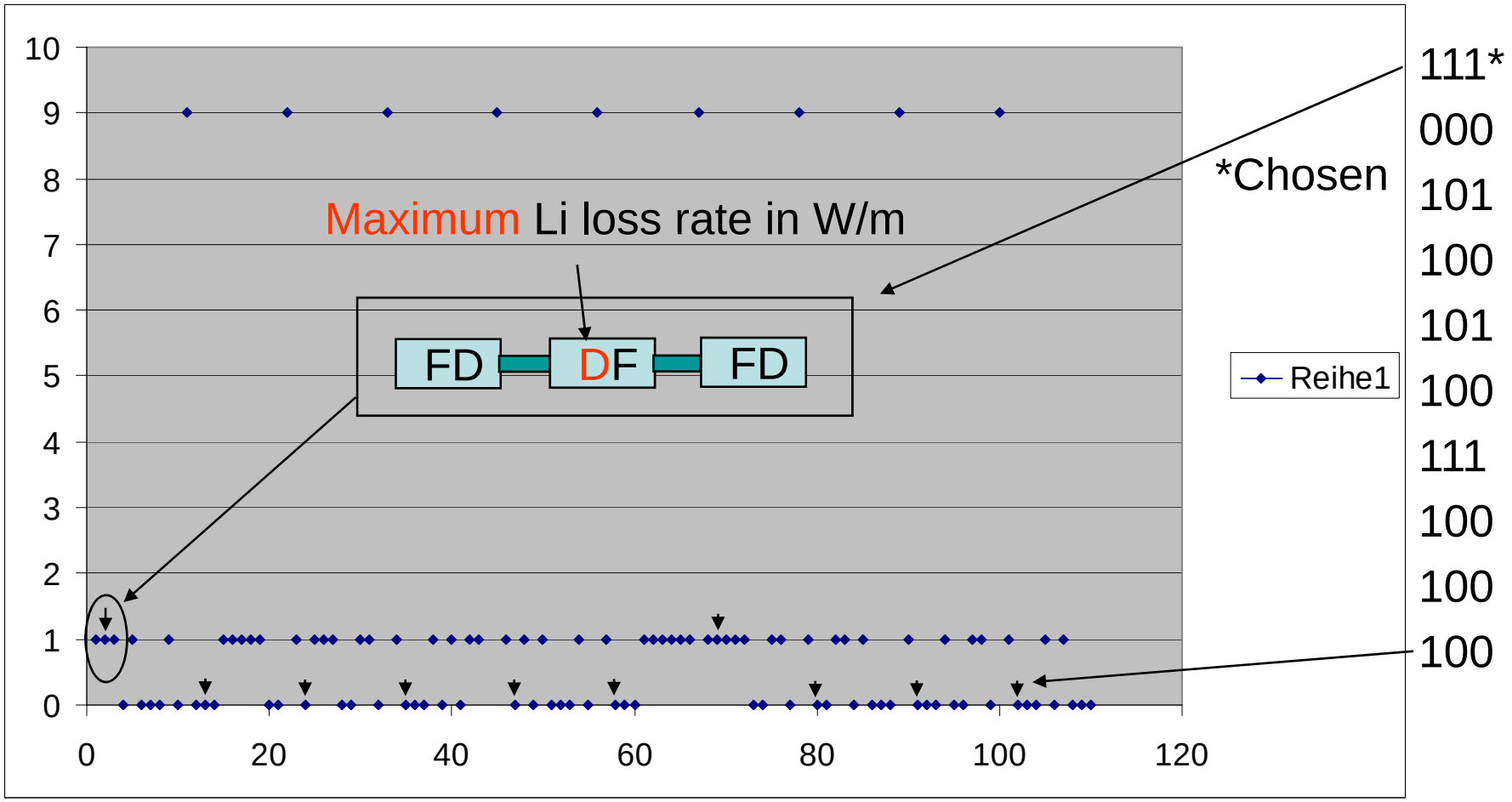
Error bars due to statistical error; differences taken in reflection asymmetry.



Orientation of yokes along the PS

Beta Beams in EURISOL

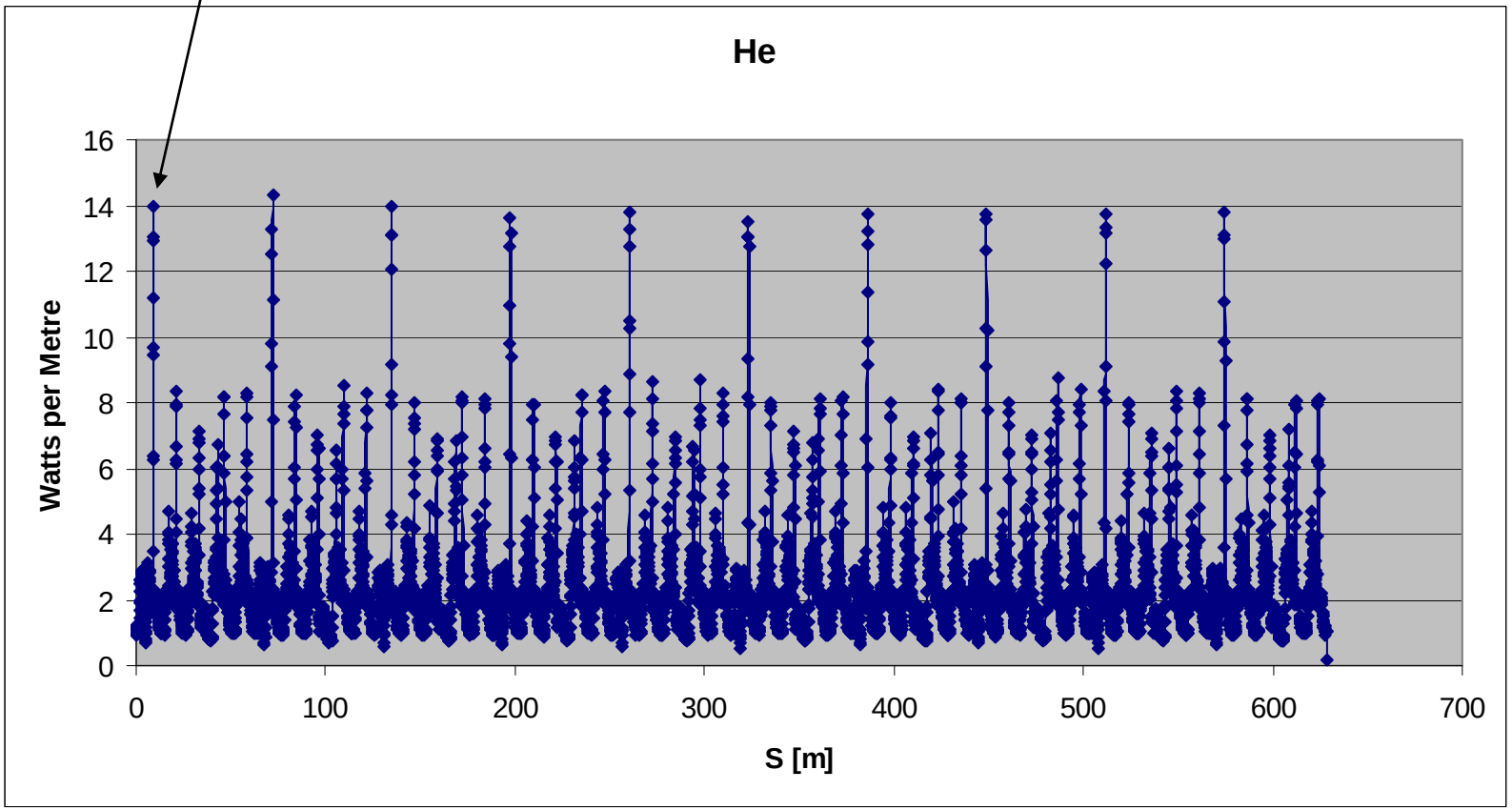
1=Inside 0=outside 9=end of section (period) first 9=end of sec01.



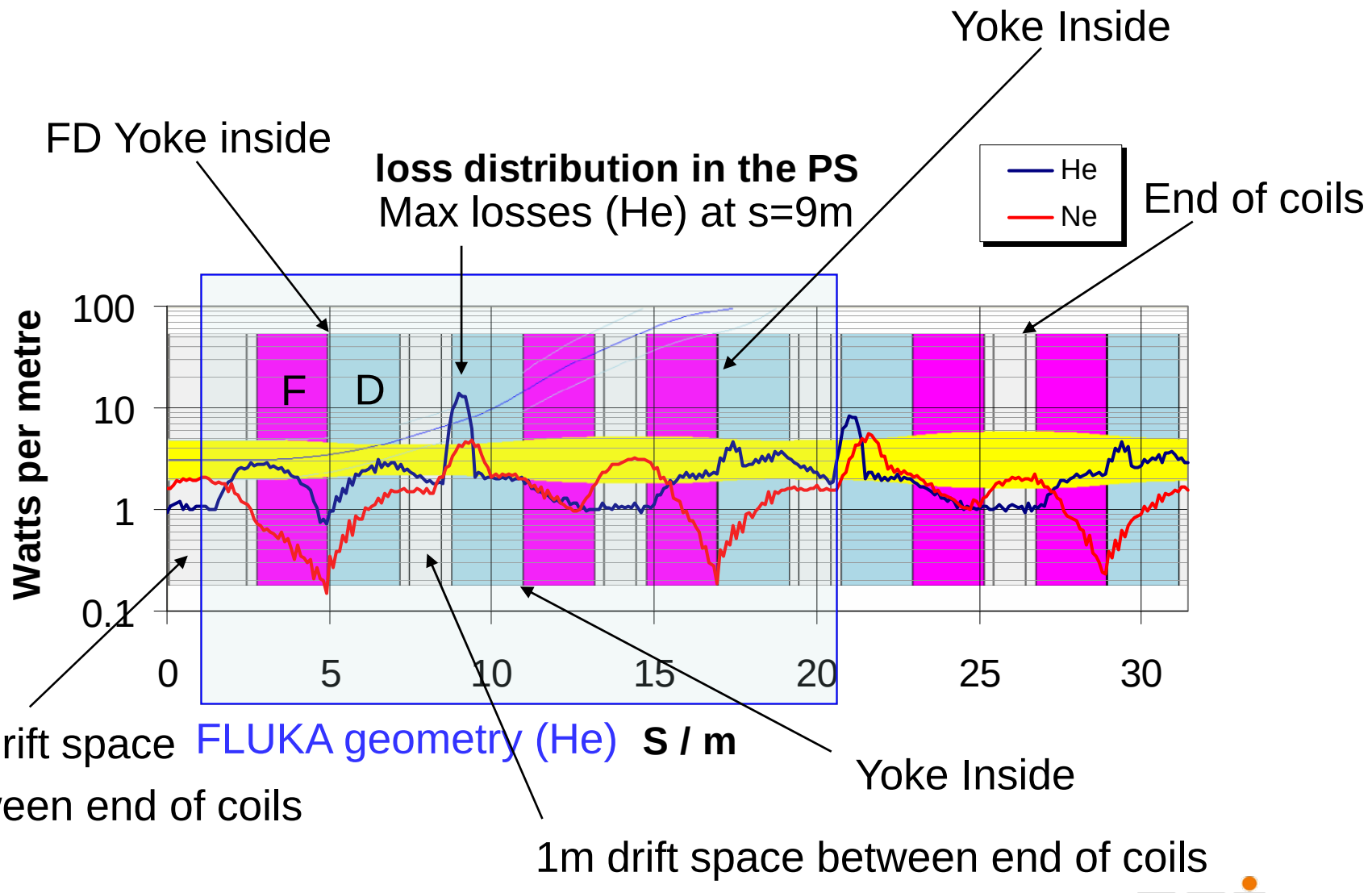
Loss map of Helium …

Beta Beams in EURISOL

S=9m (zoom is on the next slide)

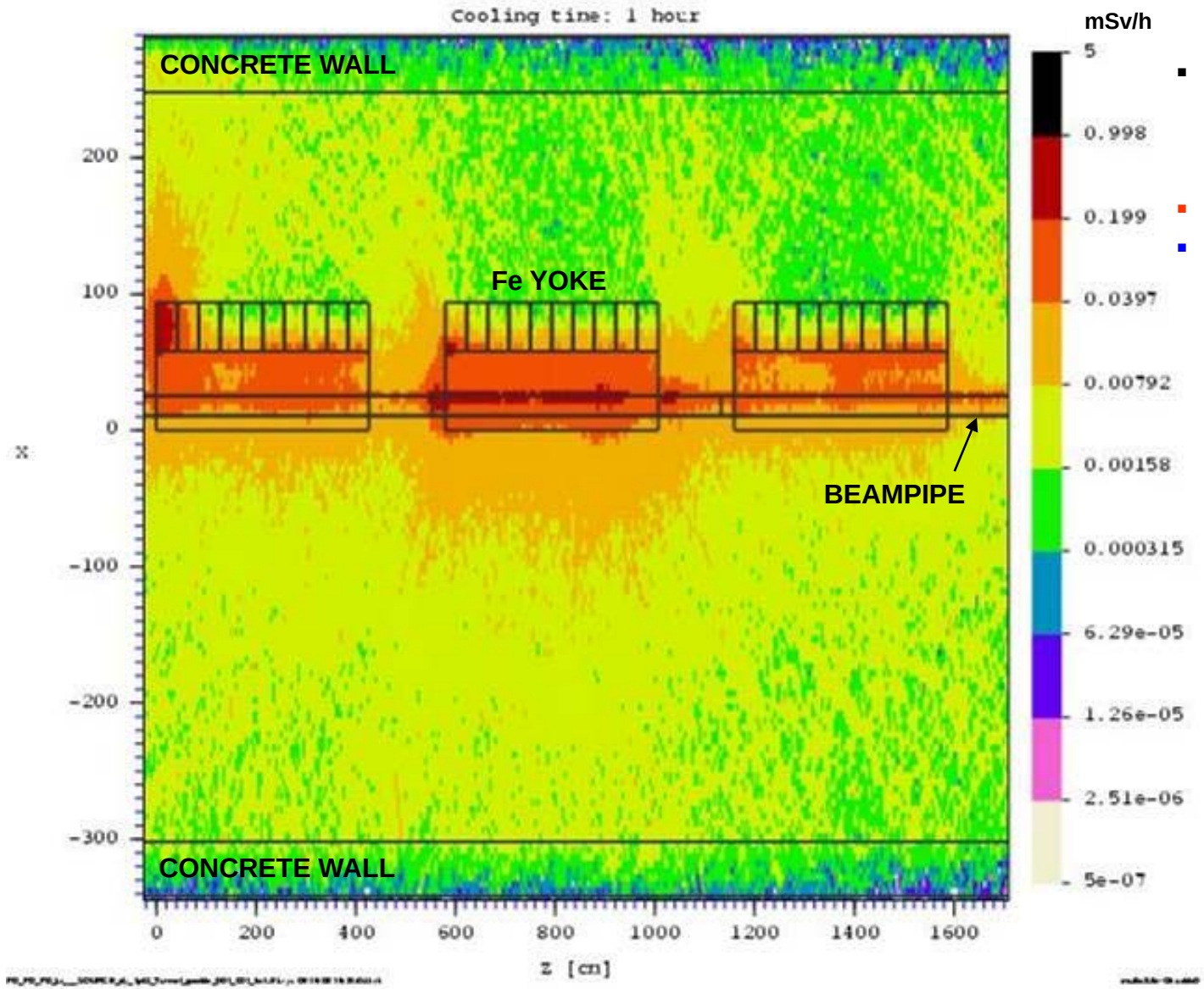


… Loss maps: zoom without collimator



Reminant Dose maps (1 of 8)

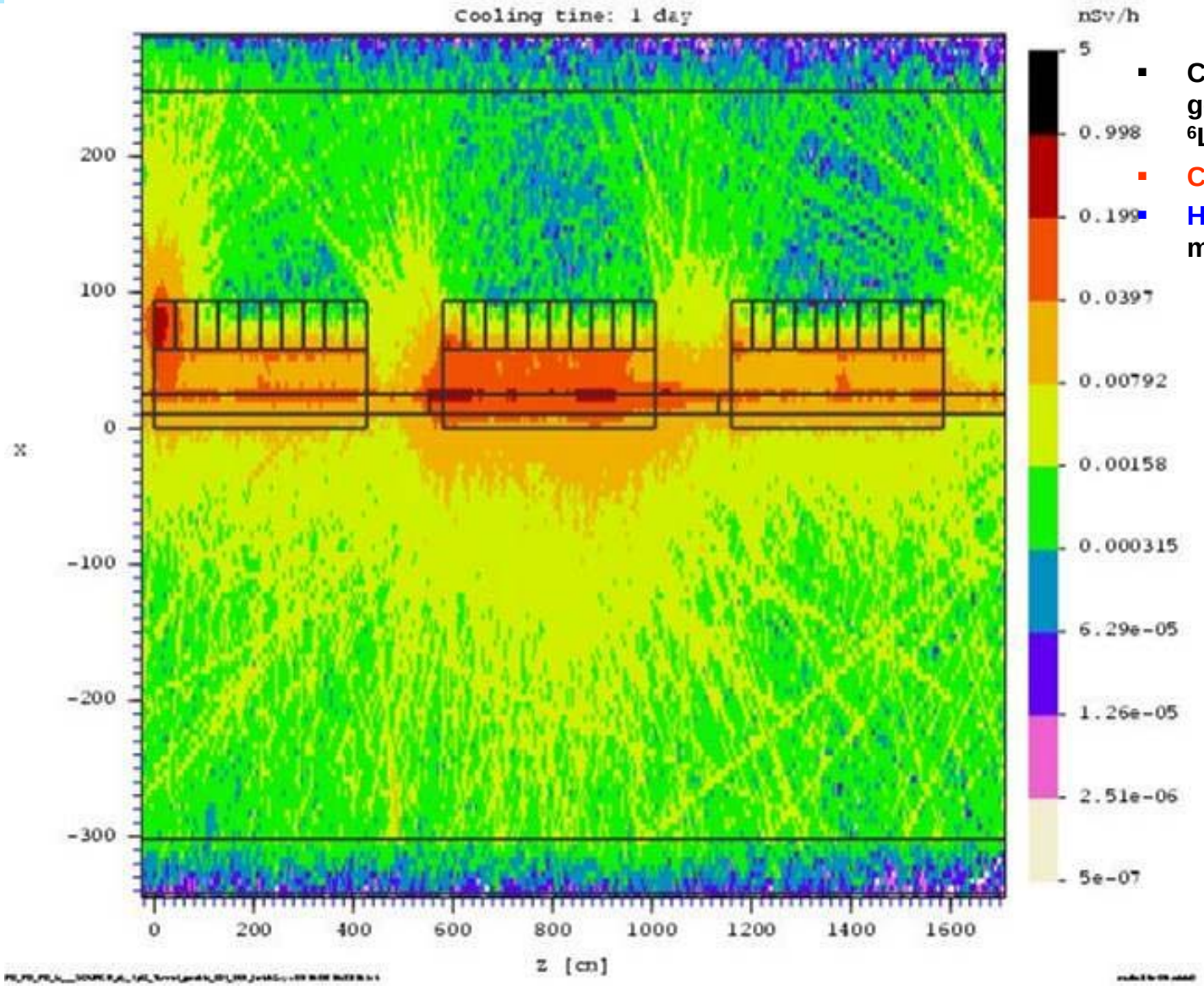
Beta Beams in EURISOL



- Continuous irradiation over geometry shown with 7.1×10^9 ^{6}Li ions per second for 3 months
- Cooling time: 1 hour
- Horizontal slice through middle of beampipe

Reminant Dose maps (2 of 8)

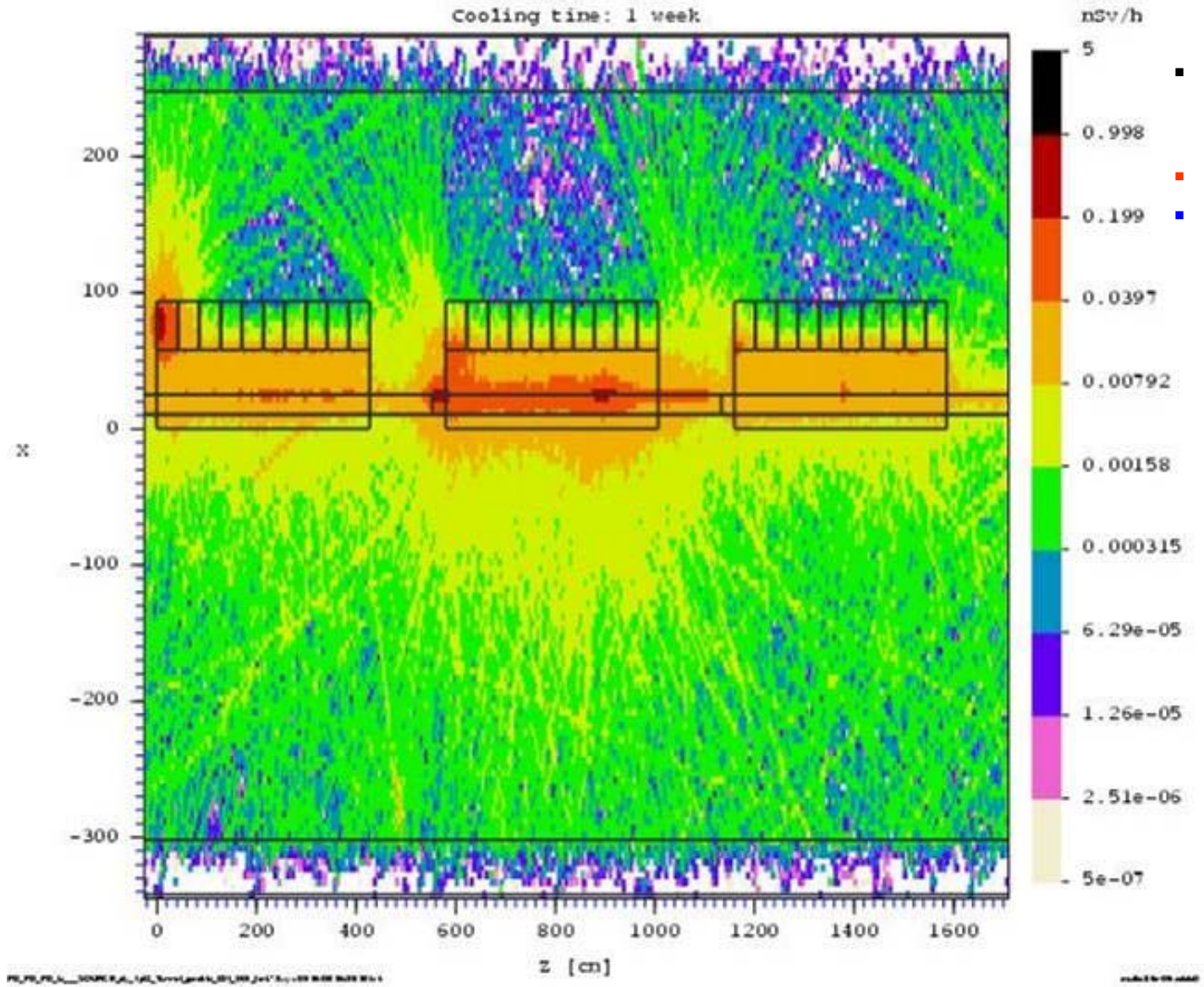
Beta Beams in EURISOL



- Continuous irradiation over geometry shown with 7.1×10^9 ^{6}Li ions per second
- Cooling time: 1 day
- Horizontal slice through middle of beampipe

Reminant Dose maps (3 of 8)

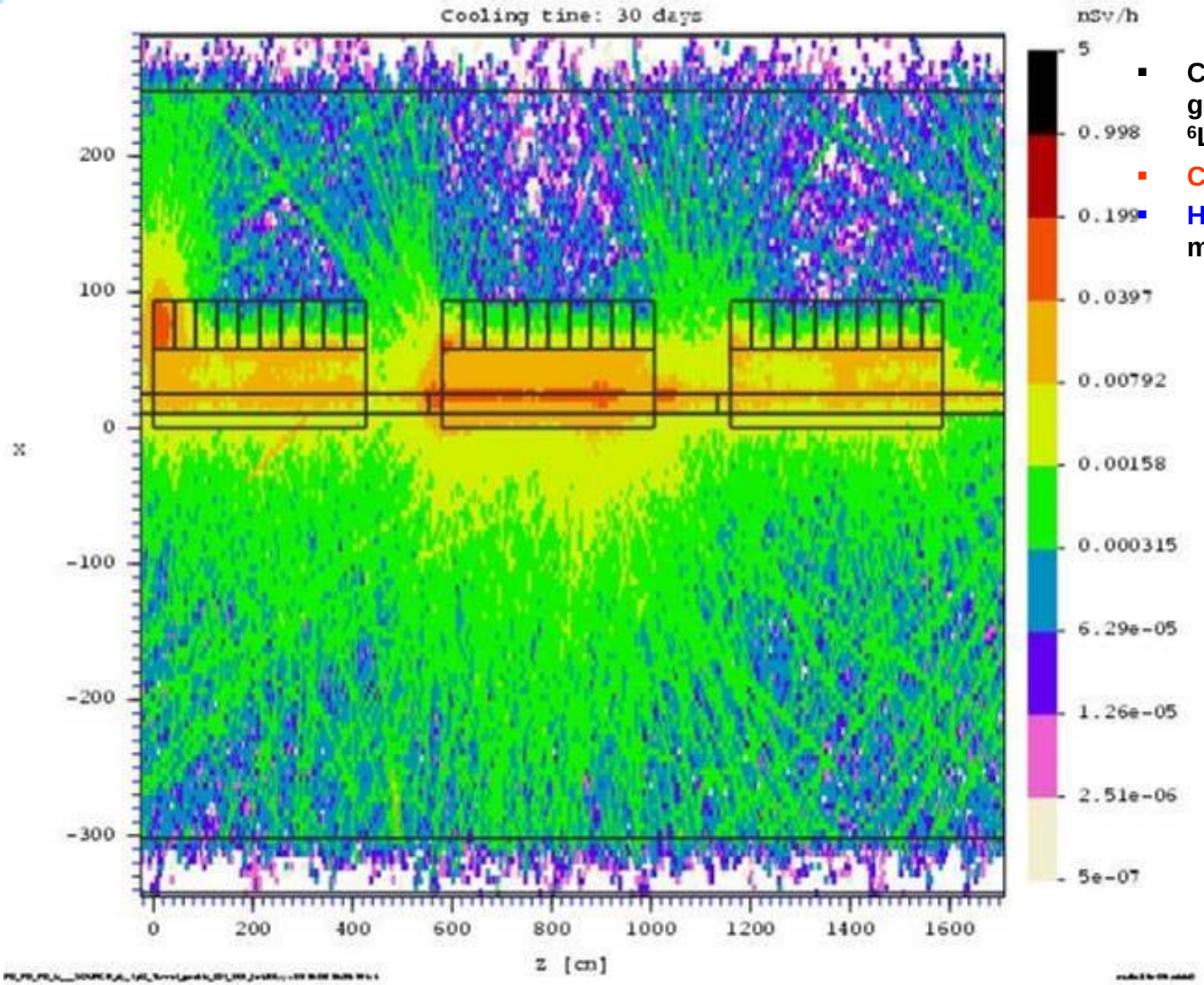
Beta Beams in EURISOL



- Continuous irradiation over geometry shown with 7.1×10^9 ^{6}Li ions per second
- Cooling time: 1 week
- Horizontal slice through middle of beampipe

Reminant Dose maps (4 of 8)

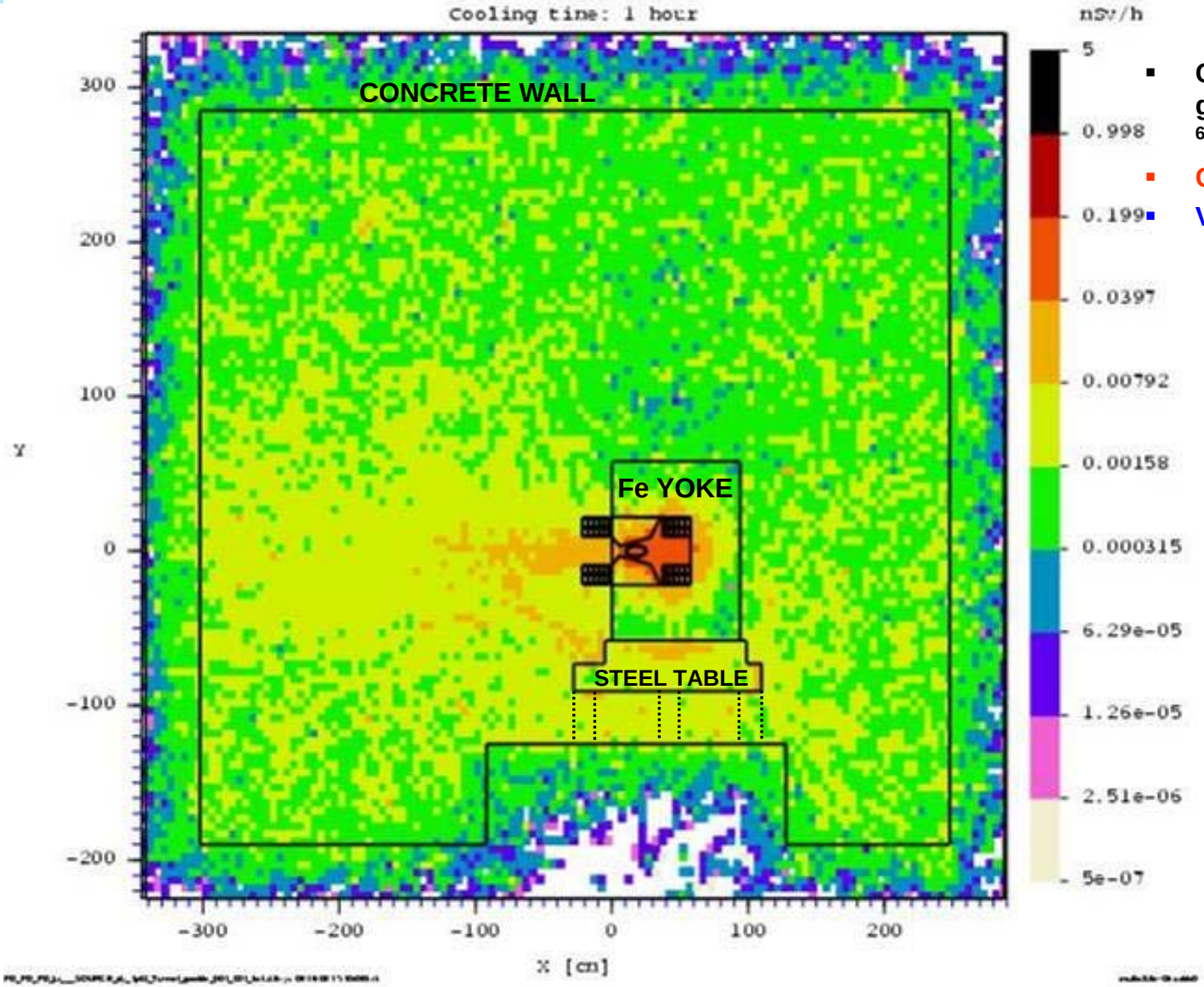
Beta Beams in EURISOL



- Continuous irradiation over geometry shown with 7.1×10^9 ^{6}Li ions per second
- Cooling time: 30 days
- Horizontal slice through middle of beampipe

Reminant Dose maps (5 of 8)

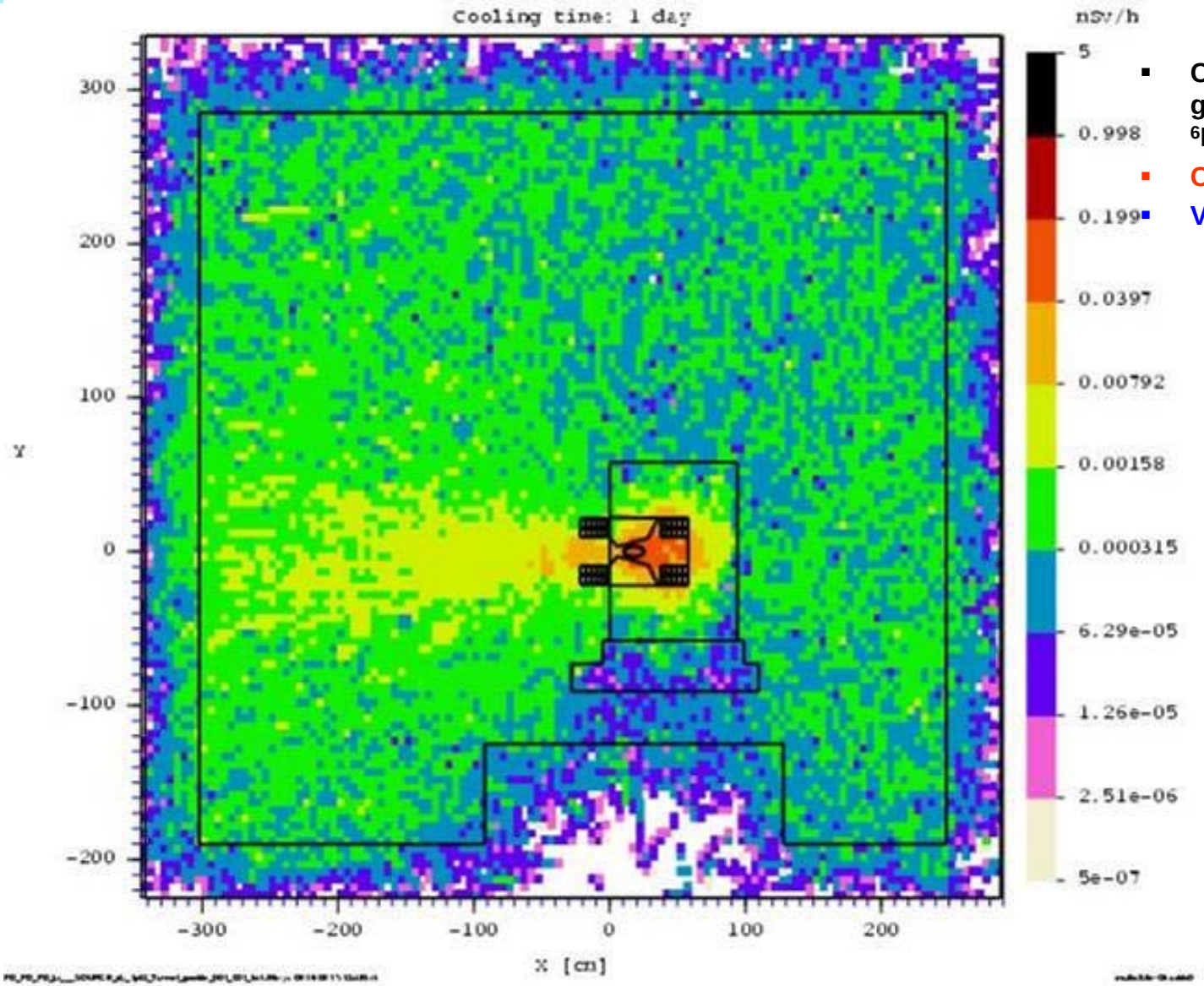
Beta Beams in EURISOL



- Continuous irradiation over geometry shown with 7.1×10^9 ^{6}Li ions per second
- Cooling time: 1 hour
- Vertical slice: z=747.25cm

Reminant Dose maps (6 of 8)

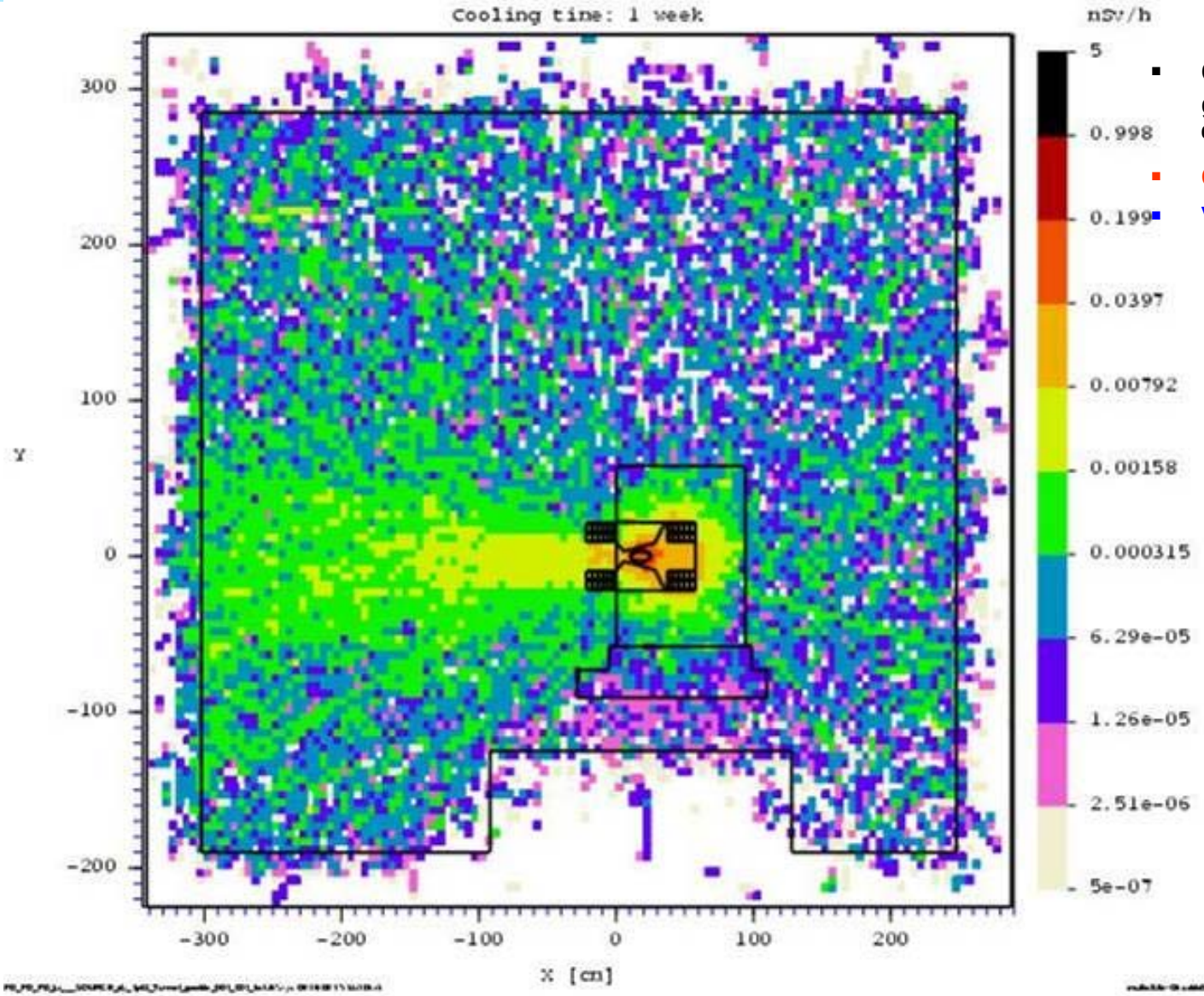
Beta Beams in EURISOL



- Continuous irradiation over geometry shown with 7.1×10^9 ^{6}Li ions per second
- Cooling time: 1 day
- Vertical slice: z=747.25cm

Reminant Dose maps (7 of 8)

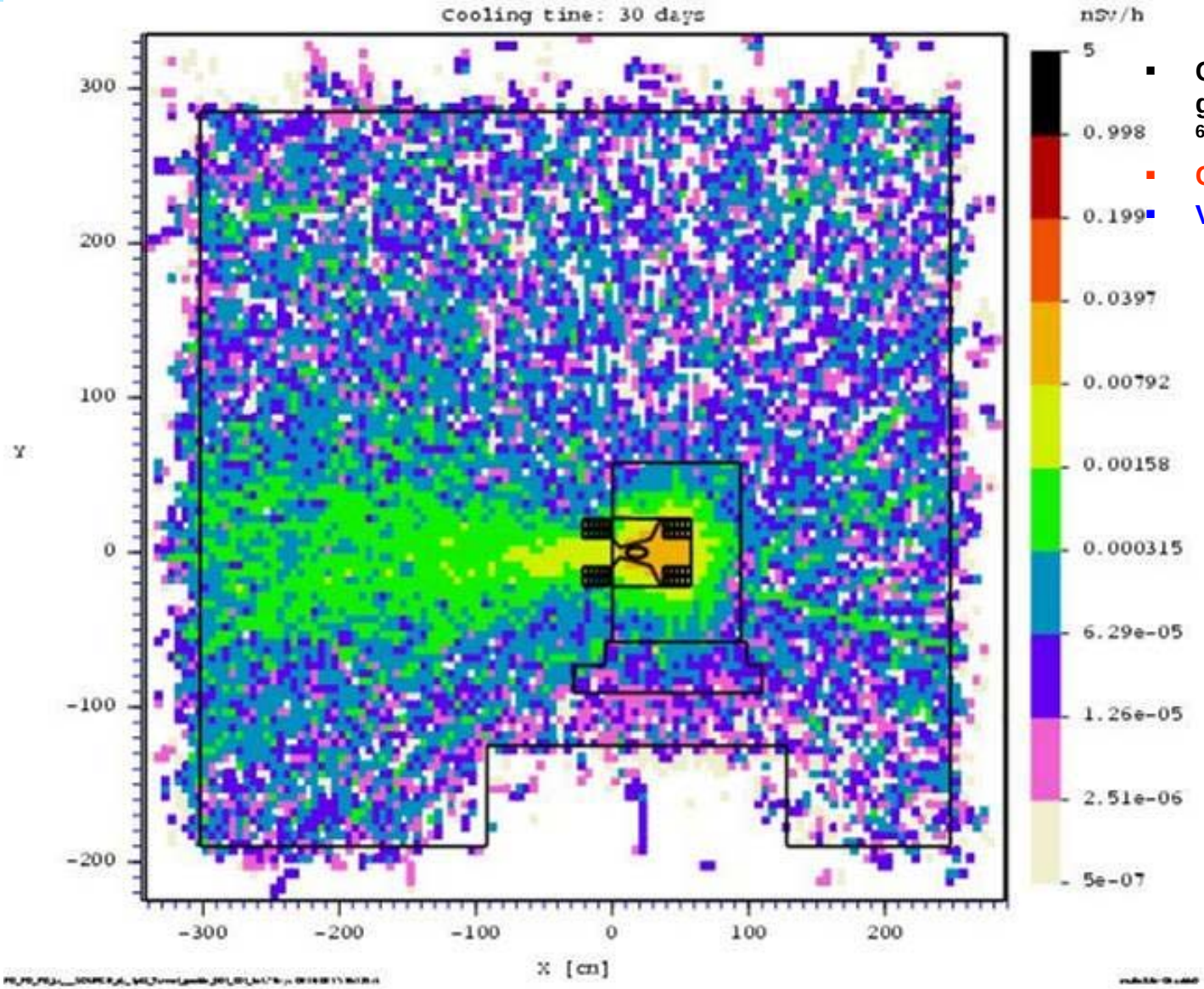
Beta Beams in EURISOL



- Continuous irradiation over geometry shown with 7.1×10^9 ^{6}Li ions per second
- Cooling time: 1 week
- Vertical slice: z=747.25cm

Reminant Dose maps (8 of 8)

Beta Beams in EURISOL



- Continuous irradiation over geometry shown with 7.1×10^9 ^{6}Li ions per second
- Cooling time: 30 days
- Vertical slice: z=747.25cm

Summary

- **Physical prompt dose rates in the coil insulation look tolerable as concerns their functional lifetime.**
- **Maintenance of the PS appears to be realistic as concerns the reminant dose rates in within the tunnel.**

Outlook

- **He operation: The dose rates in the lamination in the Fe should be investigated since heavy losses occur on the closed side of the yoke.**
- **Activation: Ne operation has yet to be looked at.**
- **Activation of air in the tunnel.**
- **Activation in the surrounding soil.**