Induced radioactivity and energy deposition studies for a H^0/H^- dump at 160 MeV

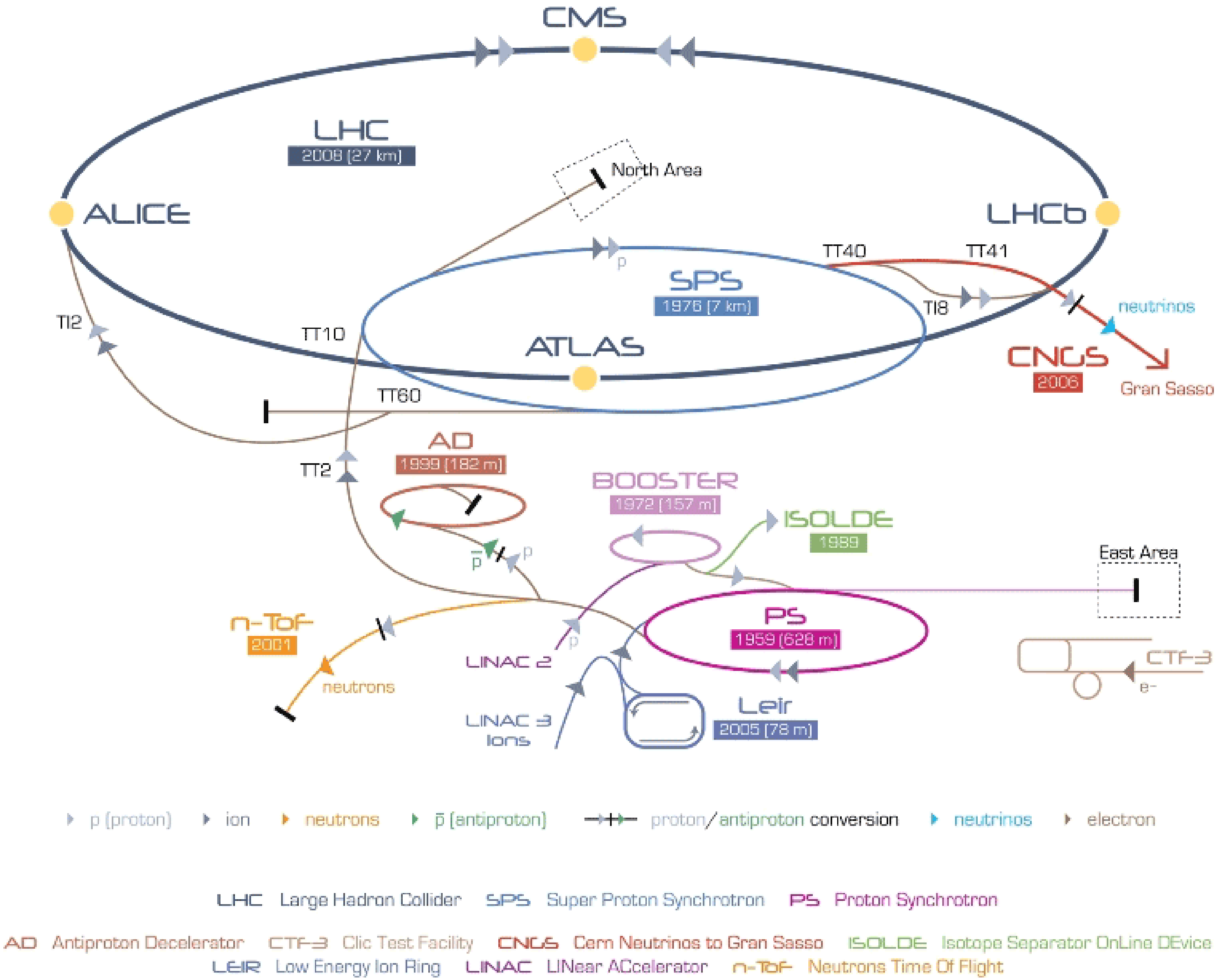
R. Versaci, A. Mereghetti, M. Silari, R. Chamizo

Outline

- LINAC4 @ CERN
- Motivations
- Problem description
- Results

LINAC4

CERN Accelerator Complex



First step in the chain is LINAC2

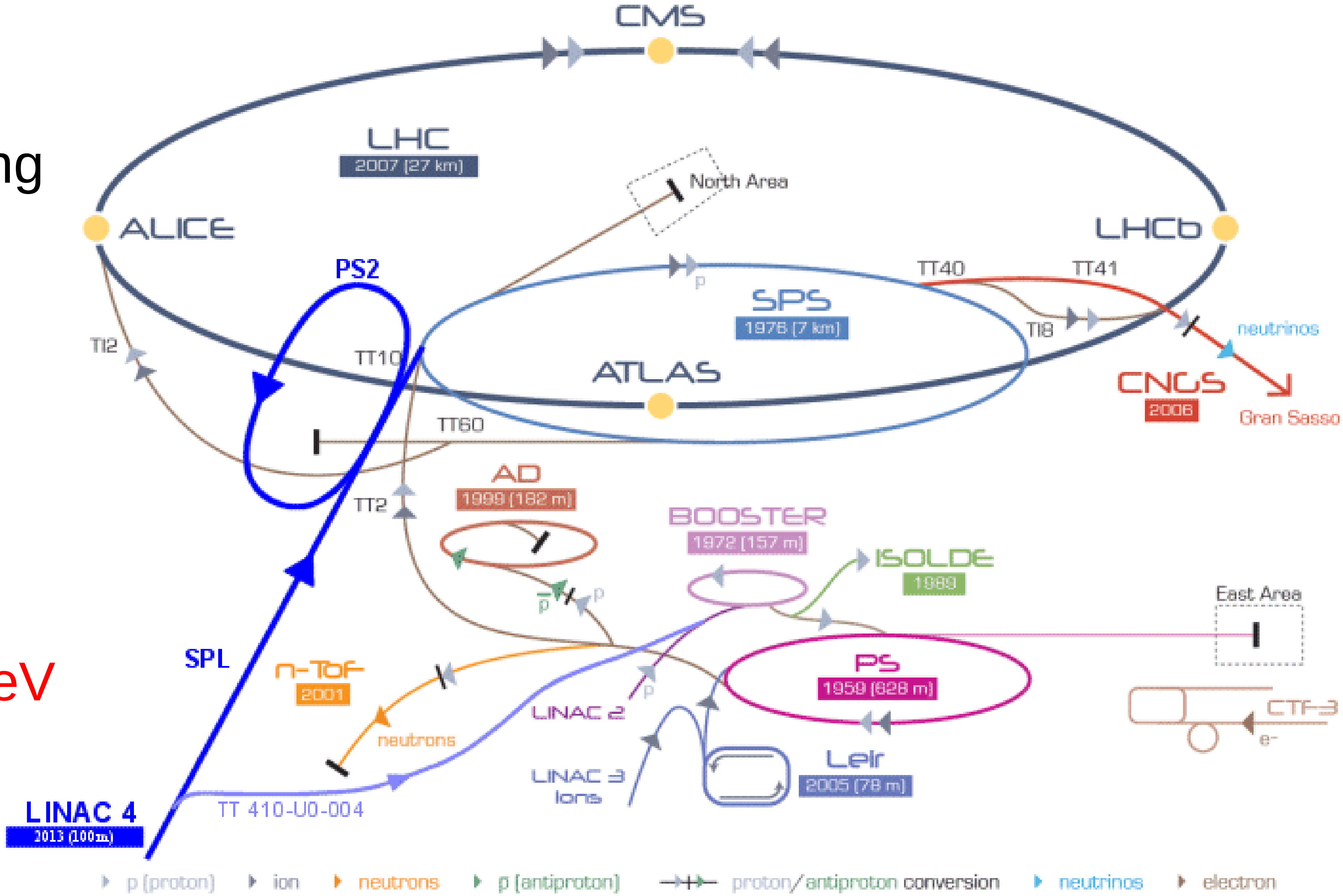
needs an upgrade because of the aging of the technologies (1978)

LINAC4

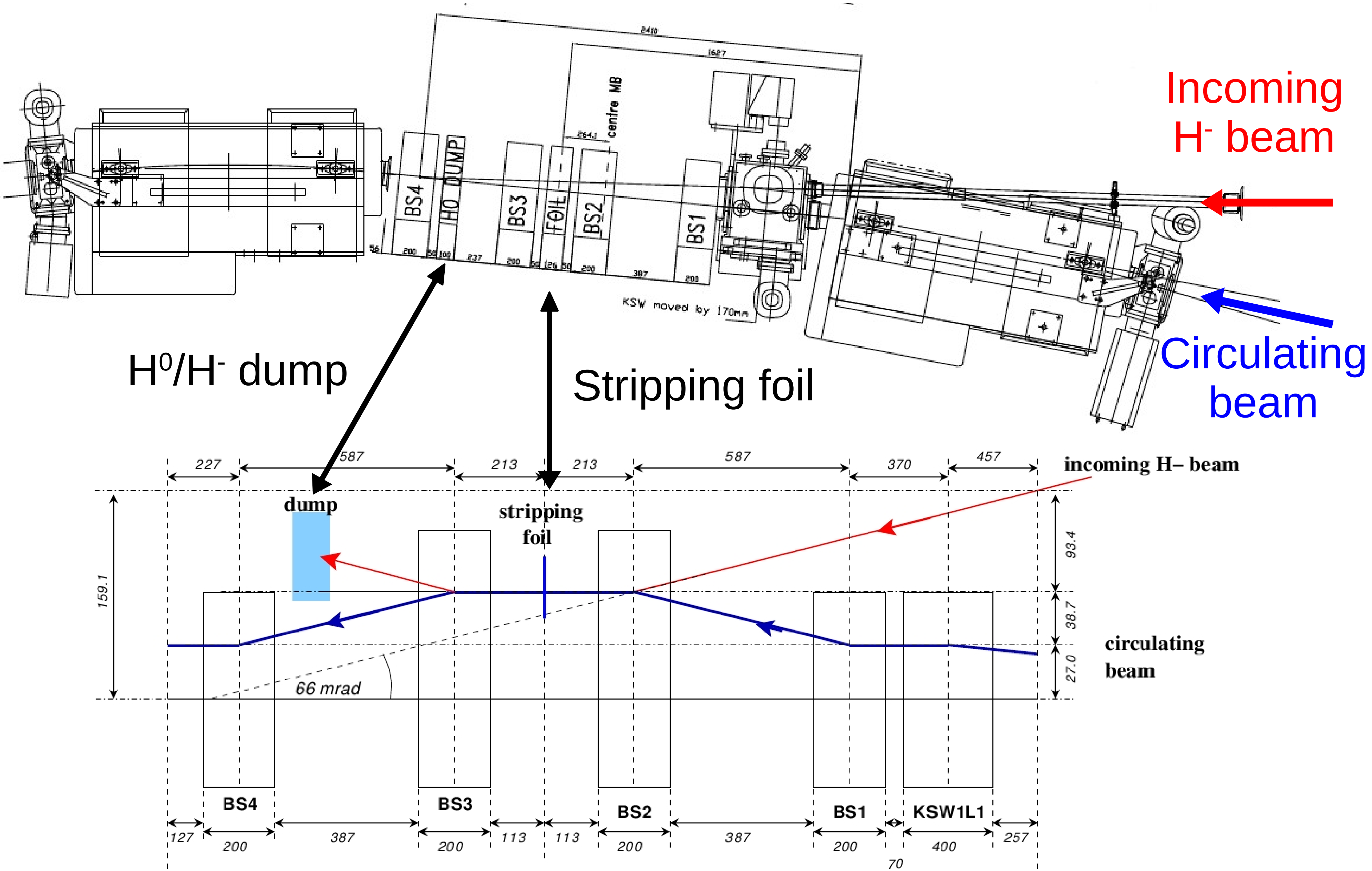
CERN Accelerator Complex

Proposal for a Superconducting Proton Linac (SPL)

The first part, called LINAC4, will be used to inject 160 MeV H^- into the PSB



PSB injection



Incoming H^- beam

Circulating beam

H^0/H^- dump

Stripping foil

PSB has four rings ⇒ four stripping foils and four dumps

Motivations

1-Choice of the dump material

Graphite, boron nitride or aluminum nitride?

Energy deposition and activation to be considered

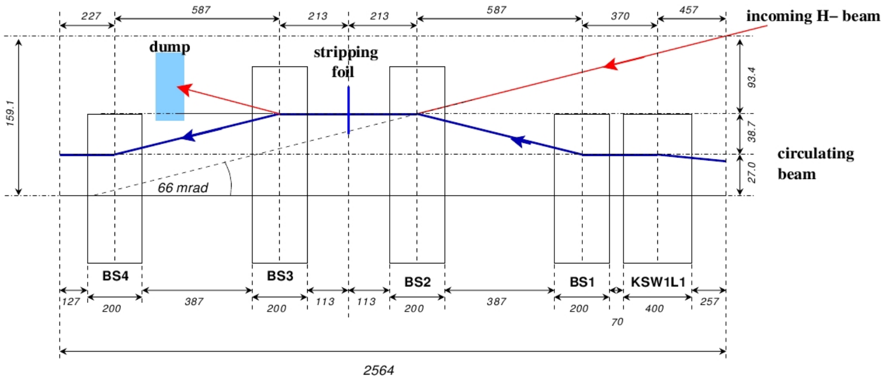
2-Possibility of the insertion of BLM

to control the status of the stripping foils

Signal above threshold and below saturation

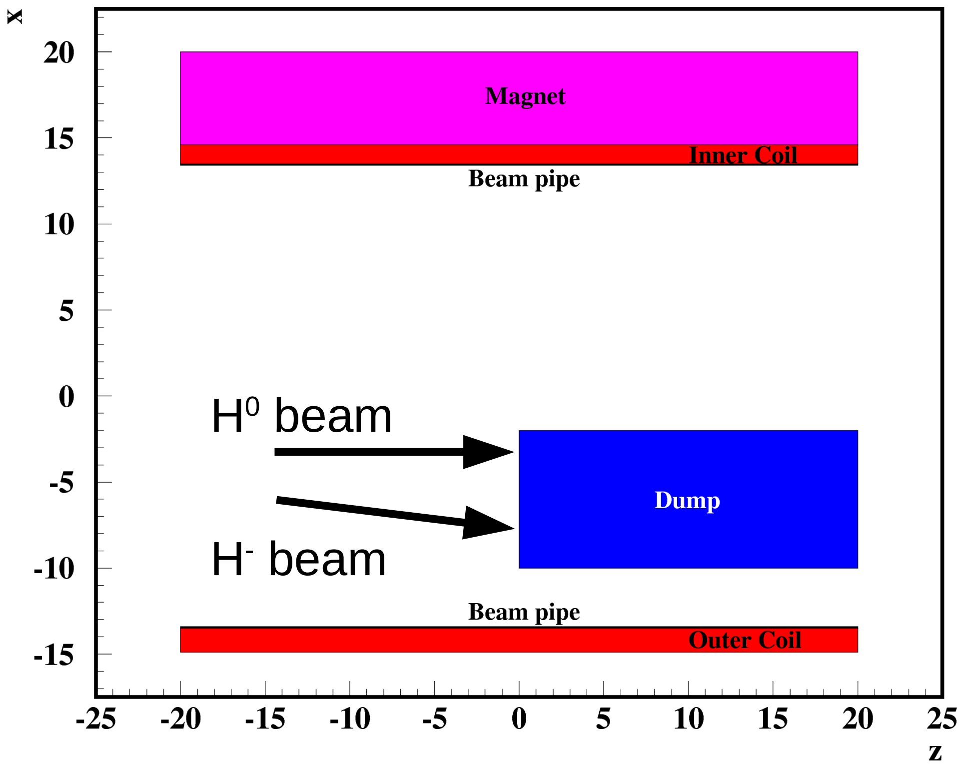
The four PSB rings have to be taken into account

Simulations with FLUKA Monte Carlo

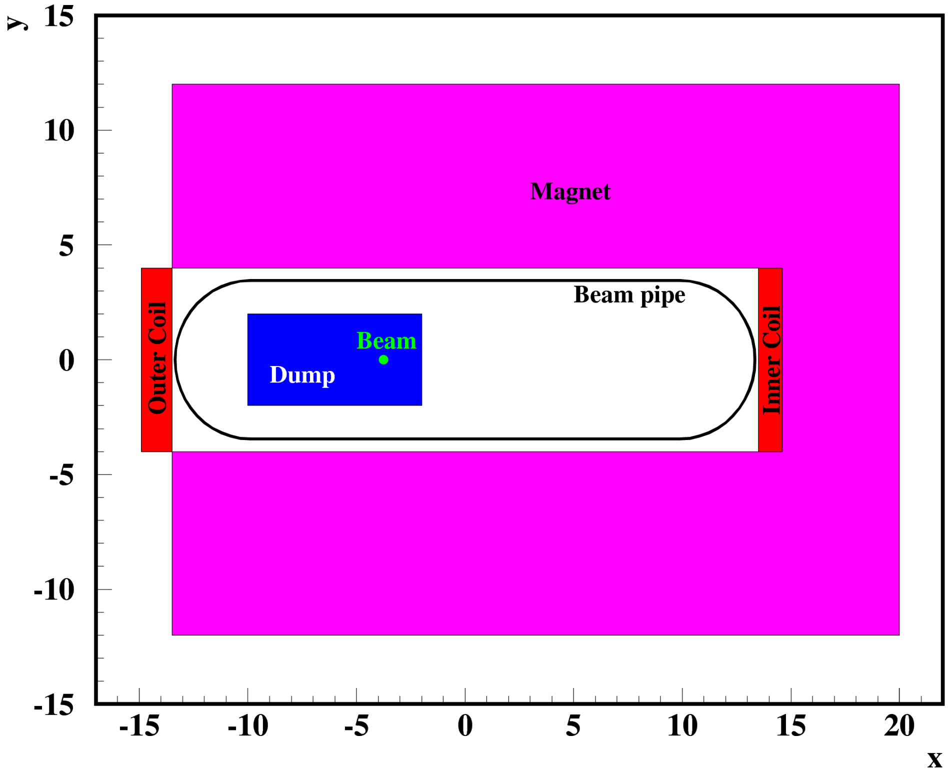


Geometry

Top view



Front view



Beam is outgoing

Very simple, accounts also for tunnel walls

Beam description

Nominal operation

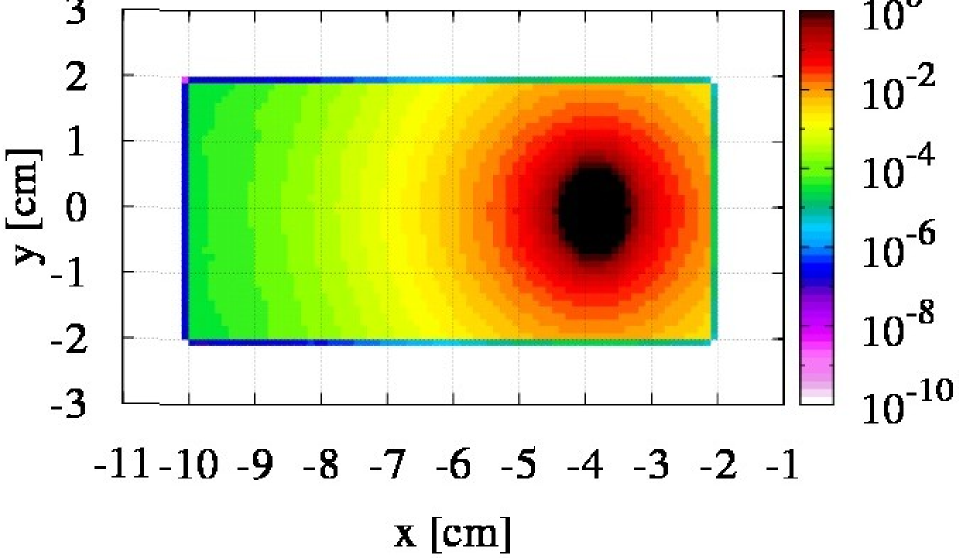
# particles per beam pulse	10^{14}
Beam pulse frequency	1.11 Hz
Pulse length	$4 \cdot 10^{-4}$ s
Peak current	0.04 A
Average current	$0.018 \cdot 10^{-3}$ A
Stripping efficiency	0.98
# impinging particles per dump	$5.55 \cdot 10^{11}$ s^{-1}
σ_v	3 mm
σ_h	2 mm
Days of operation	200

Energy deposition

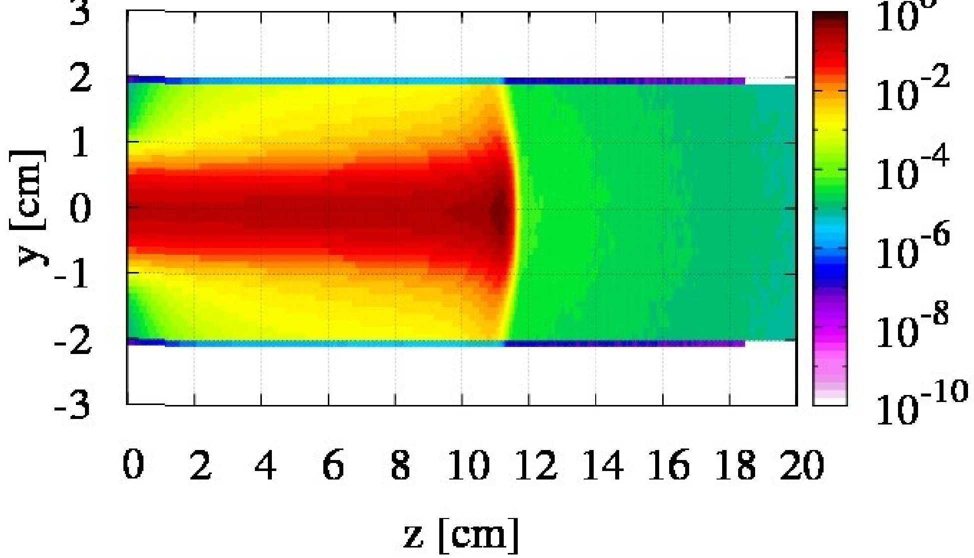
H^0 beam impinging on the graphite dump

Unit: J cm^{-3} per pulse

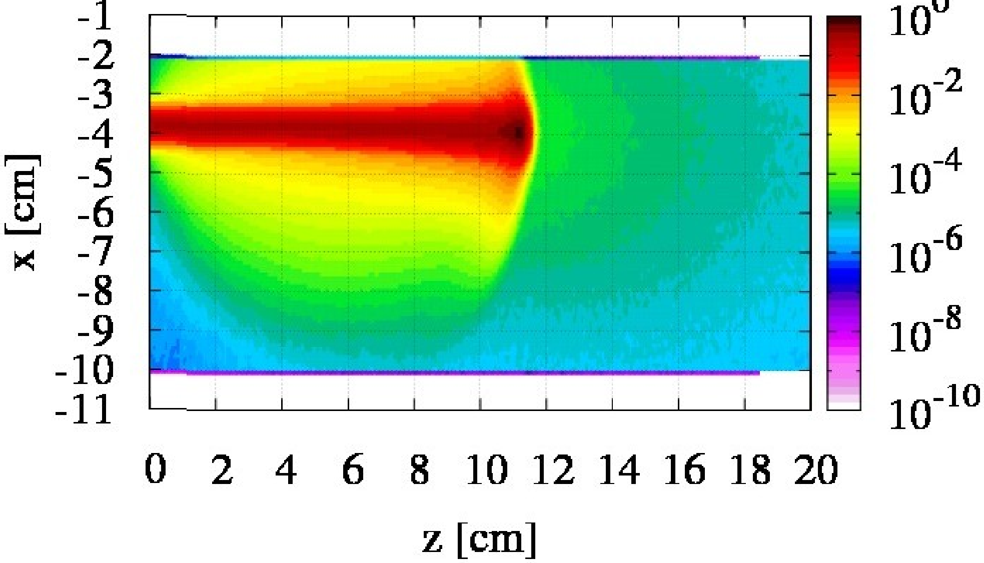
front view



lateral view



top view



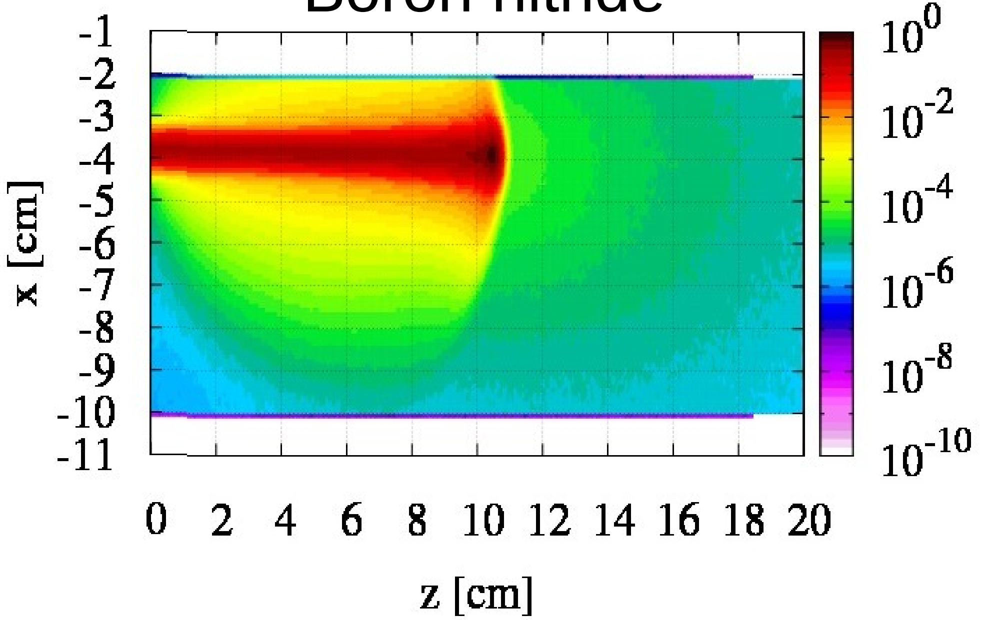
Energy deposition

Top view of the

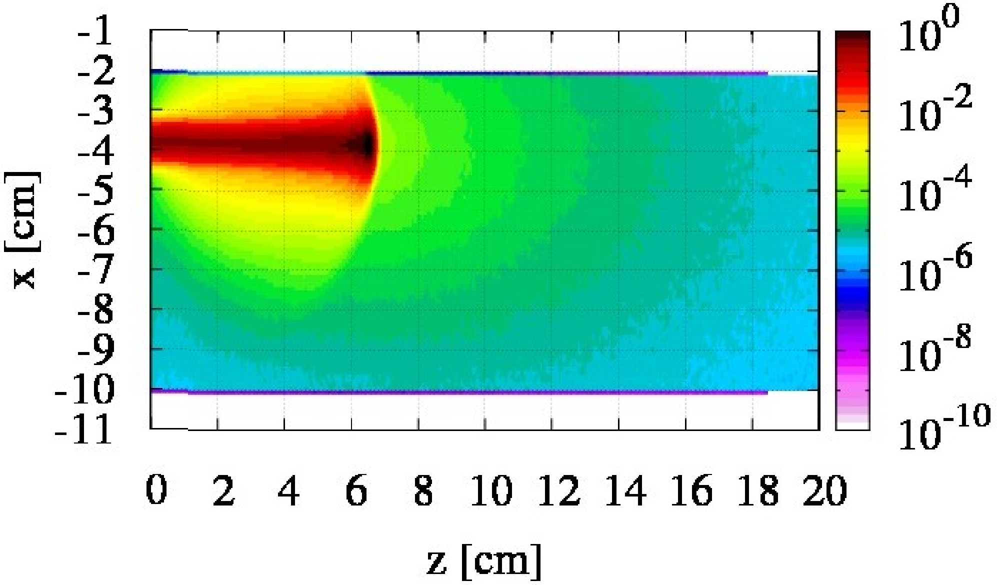
H^0 beam impinging on

the three dumps

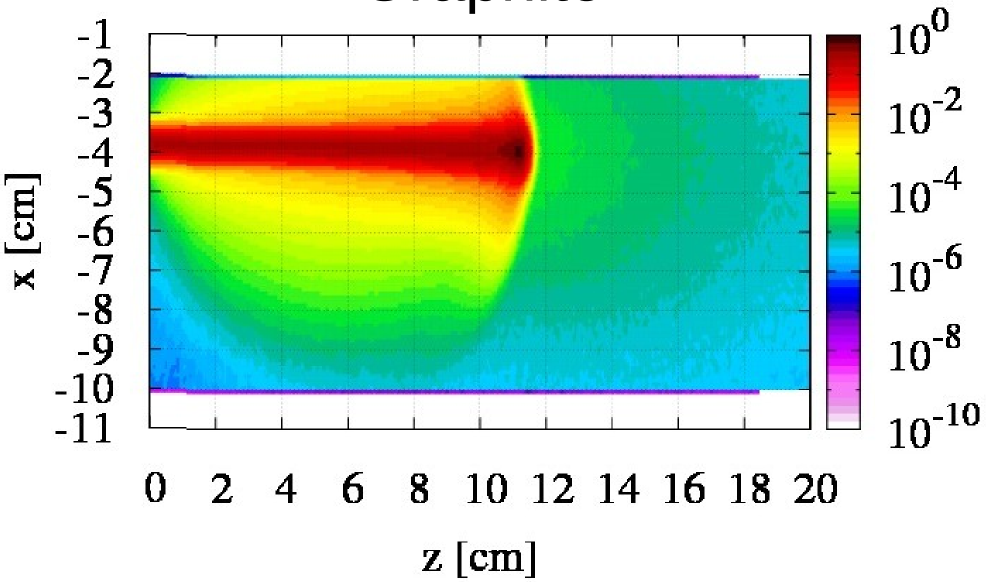
Unit: J cm^{-3} per pulse



Boron nitride

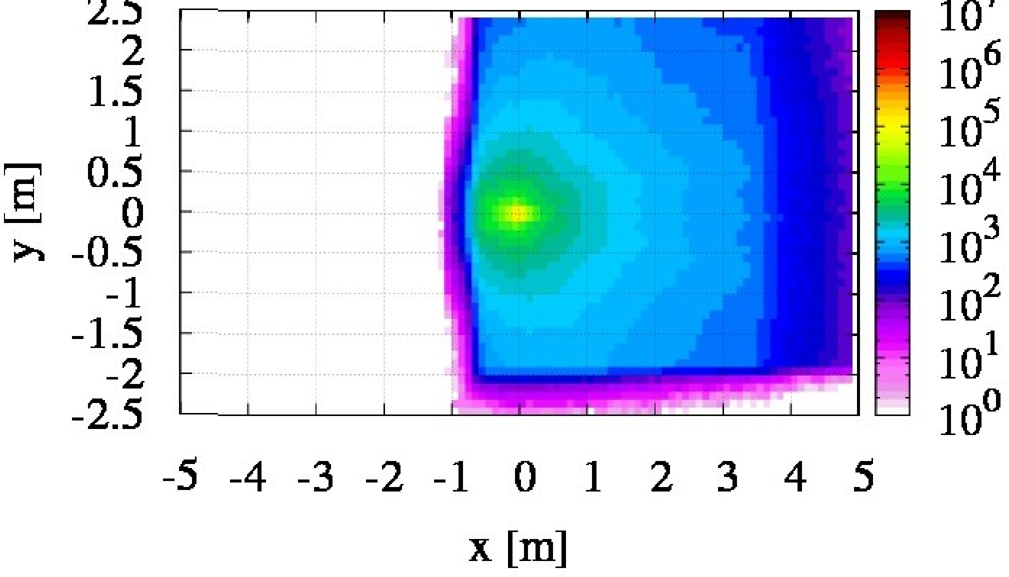


Aluminum nitride



Graphite

Ambient dose equivalent rate H*(10)

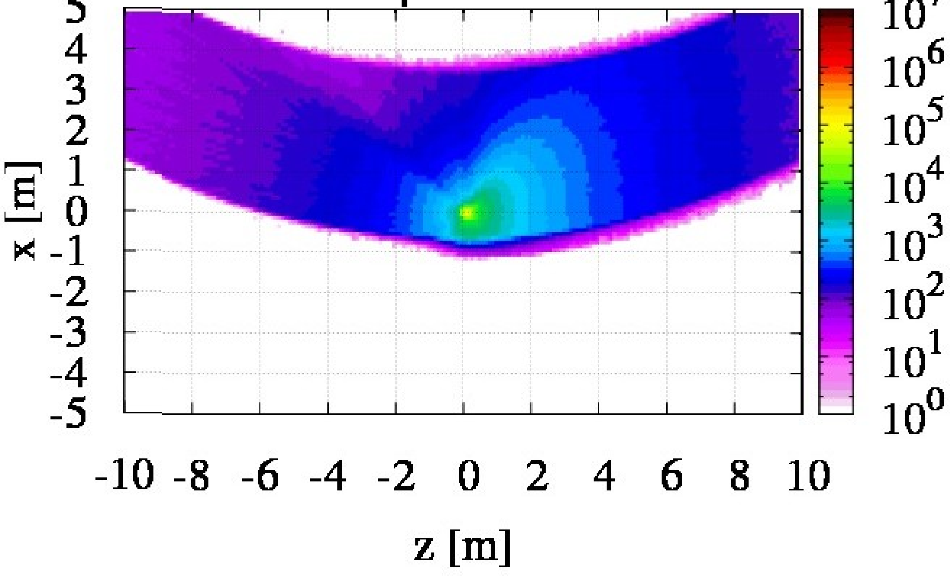


front view

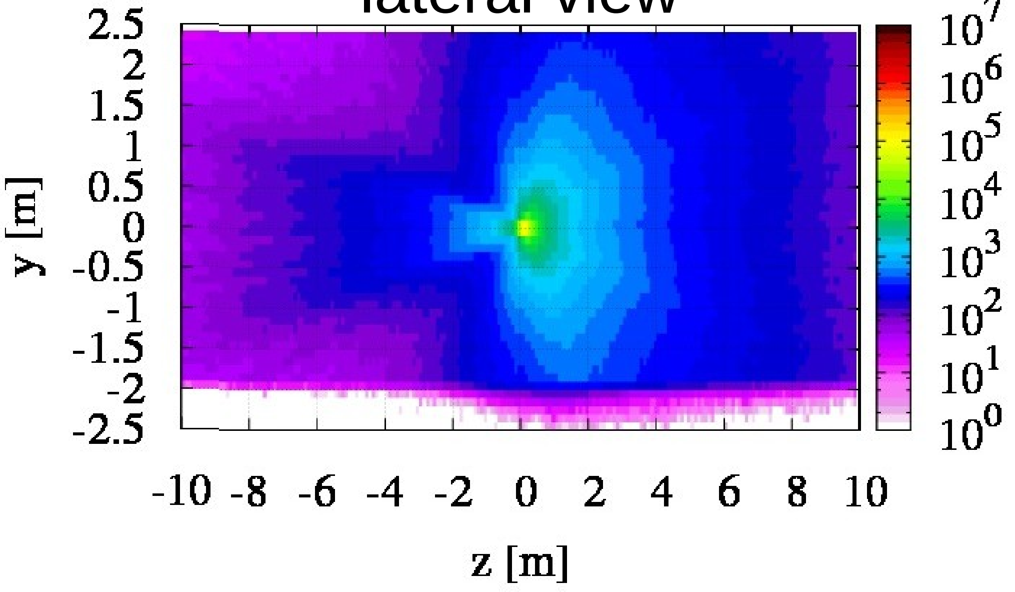
Dump material: graphite

Cooling time: 1 week

Unit: μSv/h



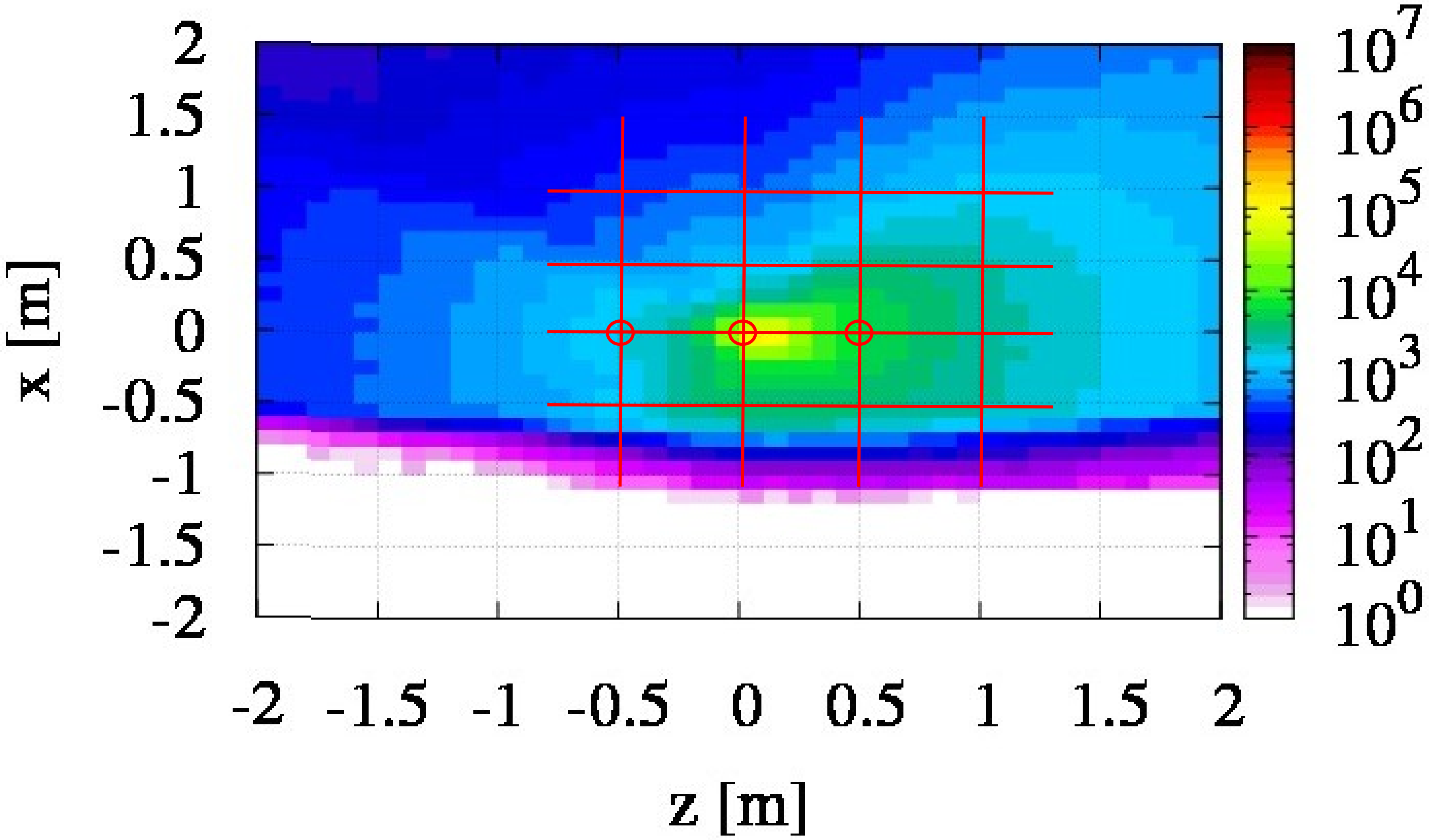
top view



lateral view

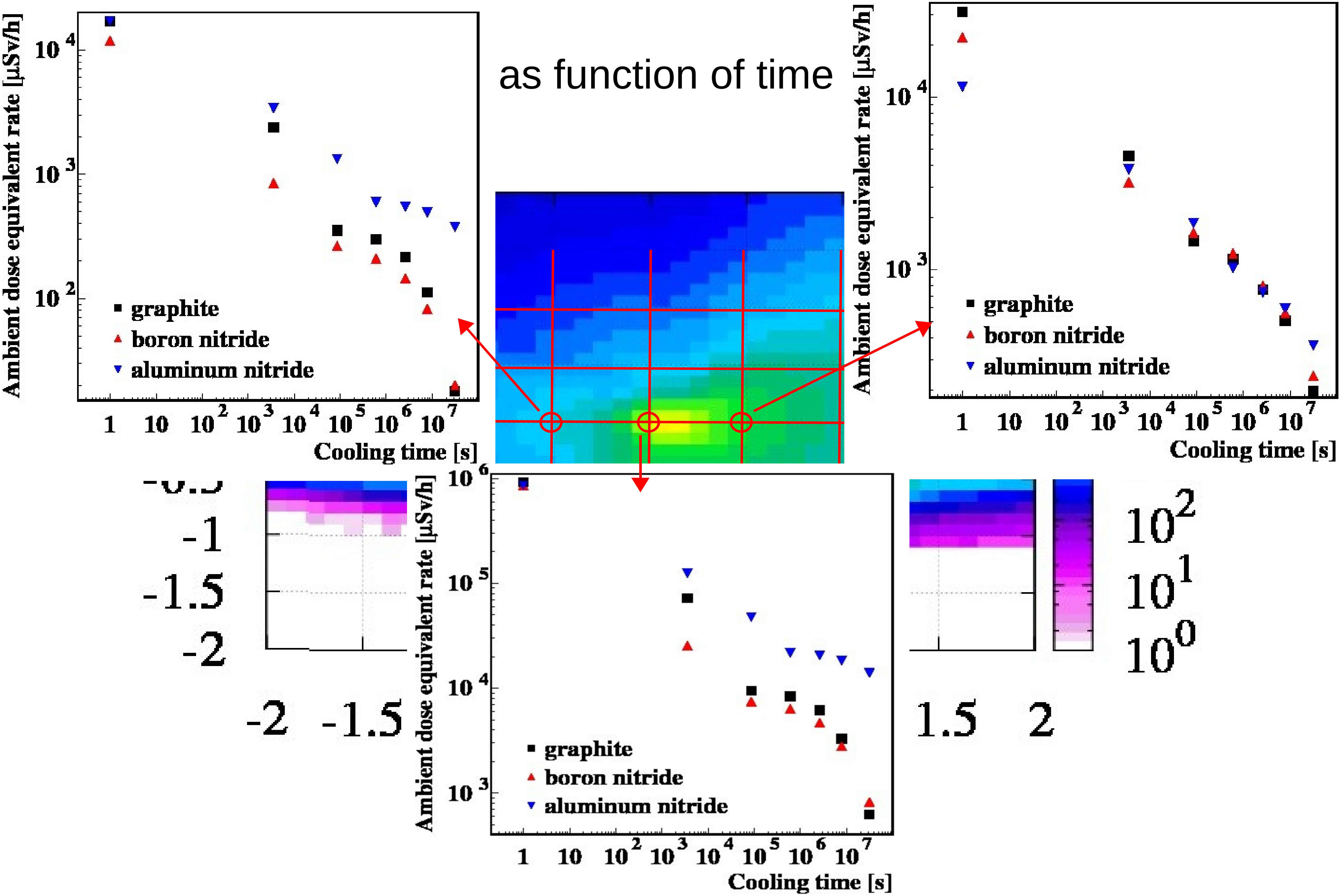
Ambient dose equivalent rate H*(10)

as function of time



Ambient dose equivalent rate H*(10)

as function of time



BLM study

Function to simulate 3D grid of BLMs (cell: 5 cm × 5 cm × 5 cm)

without need to implement BLMs in the FLUKA geometry

Uncertainty on energy deposited expected at most 5-10%

Results compared with four BLMs actually implemented

in the FLUKA geometry as cross-check:

less than 1% discrepancy observed

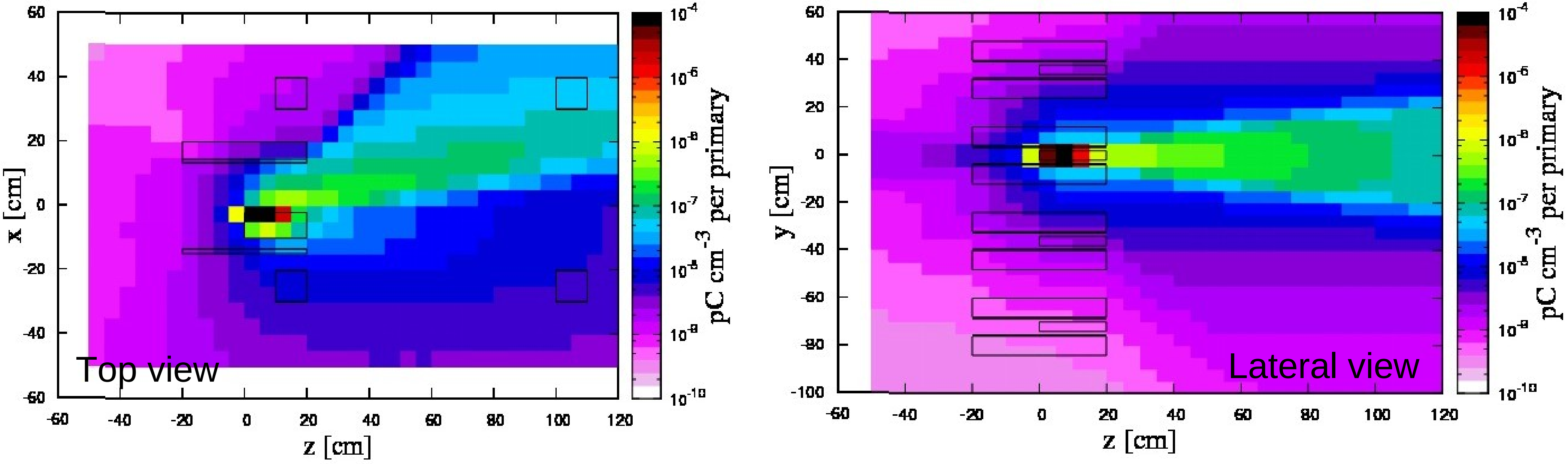
BLM study

In our case, 8 separated simulations performed:

2 beams (H^0 and H^-) × 4 dumps (one per each PSB ring)

Linear combination of the 8 output matrices allows to study the aging of the stripping foils and the event of failure

H^0 beam impinging on the dump of the 3rd PSB ring



Conclusions

Aluminum nitride favored by energy deposition
because of higher density
but suffers of higher ambient dose equivalent rate

Graphite and boron nitride are similar

A shield surrounding the dump could be considered
to reduce the fraction of energy escaping vertically

Also interesting to evaluate the possibility
to increase the dump width with z

Conclusions

Expected ~10^{-8} pC cm^{-3} per primary in a BLM

Corresponding to O(10^{-6}) C s^{-1}

In the middle of the BLMs operating range
(saturation at O(10^{-6}) C s^{-1})

Use of BLMs seems possible

Very interesting function “to insert” BLMs in FLUKA