MAX IV bulk shielding

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Outline

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- MAX IV
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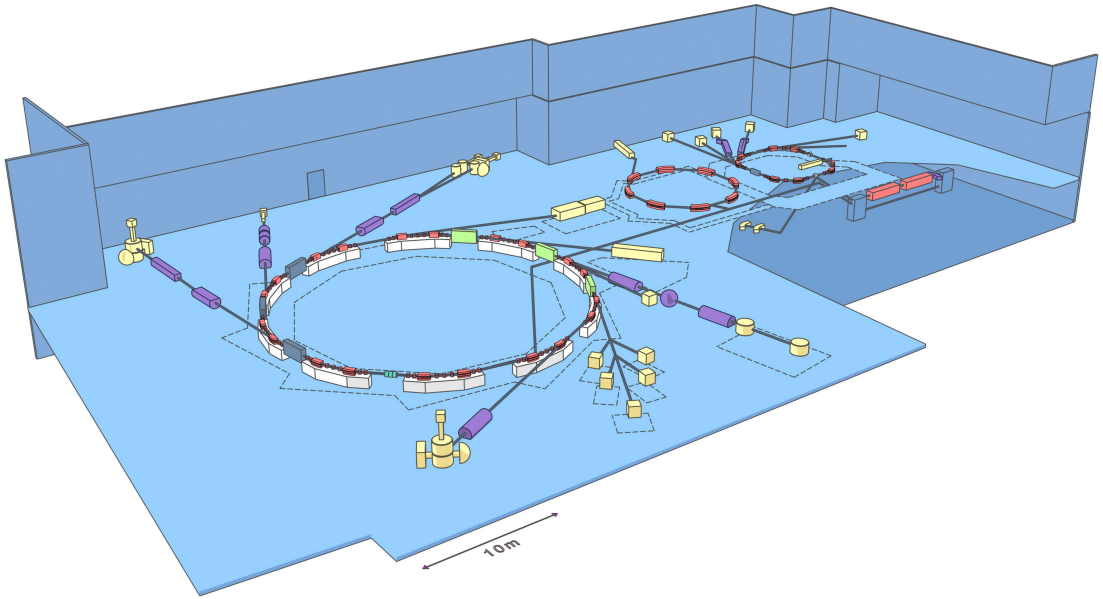
  - Empirical models
  - The ring (Bent Schröder)
  - The linac tunnel
  - The SPF
  - Activation (Lennart Isaksson)
  - Summary

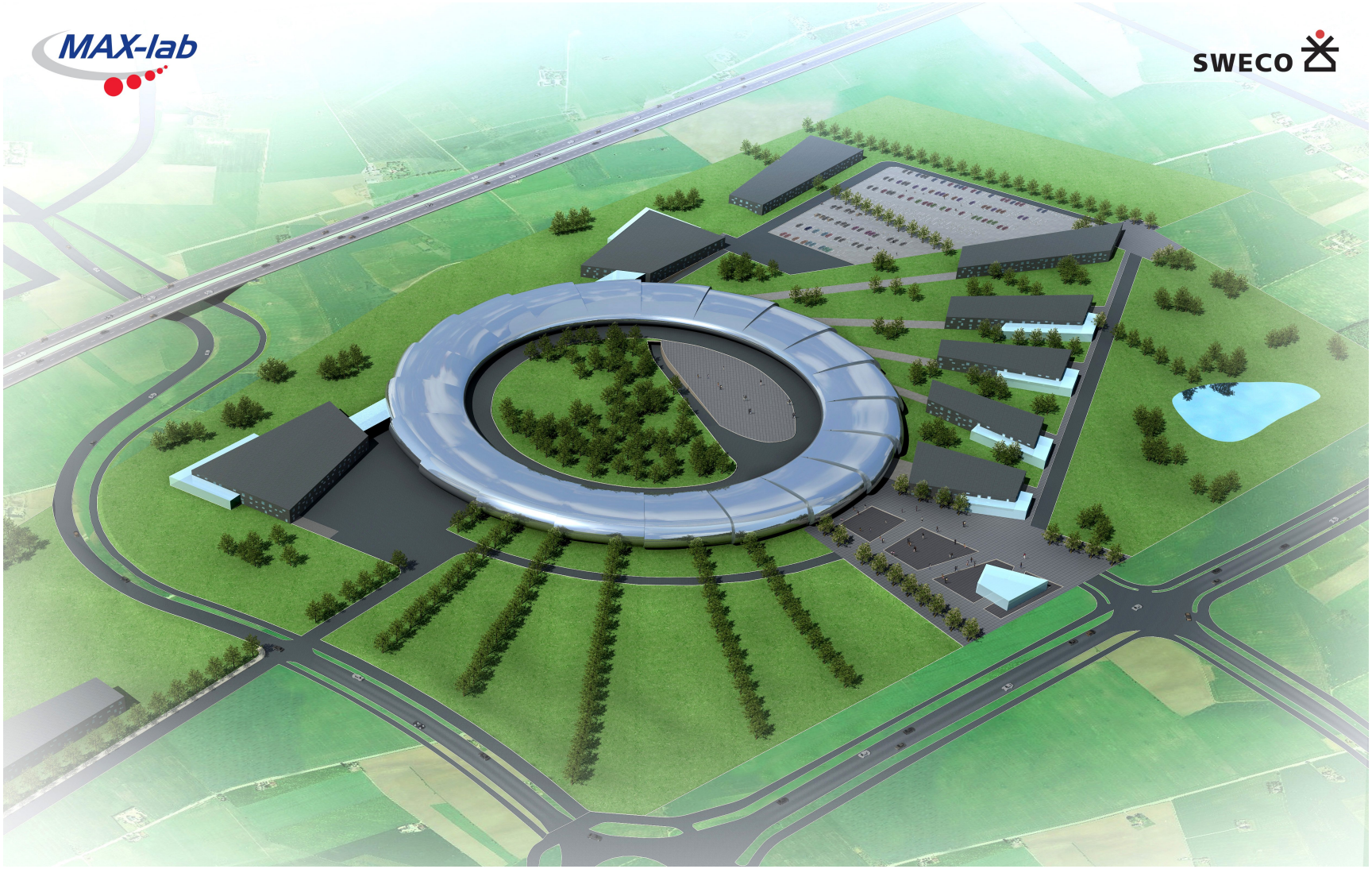
The existing MAX-lab



- 3 rings 500, 700, 1500 MeV
- 2 S.C wigglers
- 850 users/y

MAX IV key features

- 3 GeV linac
- 3 GeV, 500 mA, 530 m ring
- 20 5m straight sections
- A Short Pulse Facility (SPF)
- The upgraded MAX II and MAX III rings


MAX-lab
SWECO

Shielding objectives

The general public

- Sum < 1 mSv/y
- For MAX IV 100 μSv/y
- Estimate time spent on the linac tunnel

The MAX IV personnel

- < 1 mSv/y
- 2000 h/y
- 0.5 μSv/h

Linac modes

Mode	Rate (Hz)	Energy (GeV)	Charge (nC)	Power (W)	Duty
Filling/top-up	0.1	3.0	1	0.3	1.0
SPF	200	3.0	1	600	0.33

Source terms from NCRP144[1] normalized to Sullivan[2]

Source term	Sv/kWh @ 1m and 90°
Bremsstrahlung	50
Neutrons $<$ 25 MeV	10
Neutrons 25-100 MeV	1.2
Neutrons $>$ 100 MeV	0.36

[1] NCRP Report No. 144, Radiation protection for particle accelerator facilities, National Council on Radiation Protection and Measurements, 2003

[2] A guide to radiation protection and radioactivity levels near high energy particle accelerators. A. H. Sullivan, Nuclear Technology Publishing, 1992

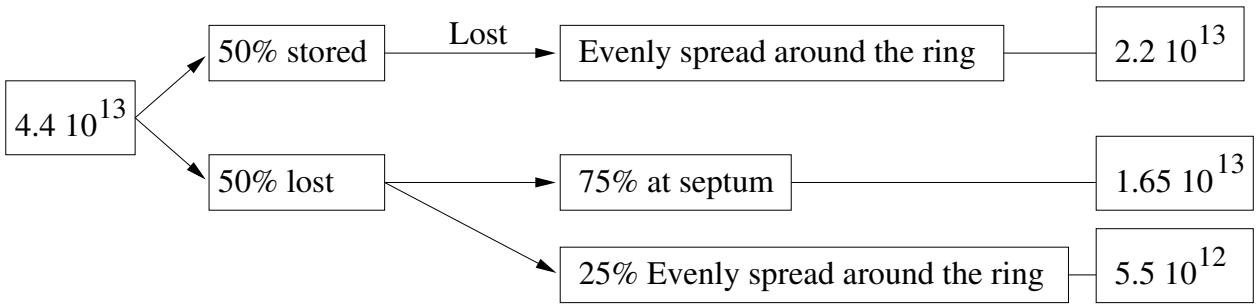
Material attenuation coefficients (in cm) same as NSLS-II[3]

Material	Brems	LEN	MEN	HEN
lead	2.2	14	17	17
iron	4.7	13	18	18
concrete	21	17	28	49
earth	44	21	56	56
polyethylene	69	6.2	61	61

[3] NSLS-II Preliminary Design Report (2007), Brookhaven National Laboratory

The MAX IV ring

Circumference 530 m, 500 mA, 4 injections/day



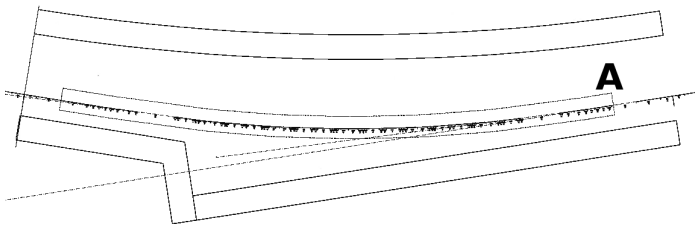
Per 2000 h

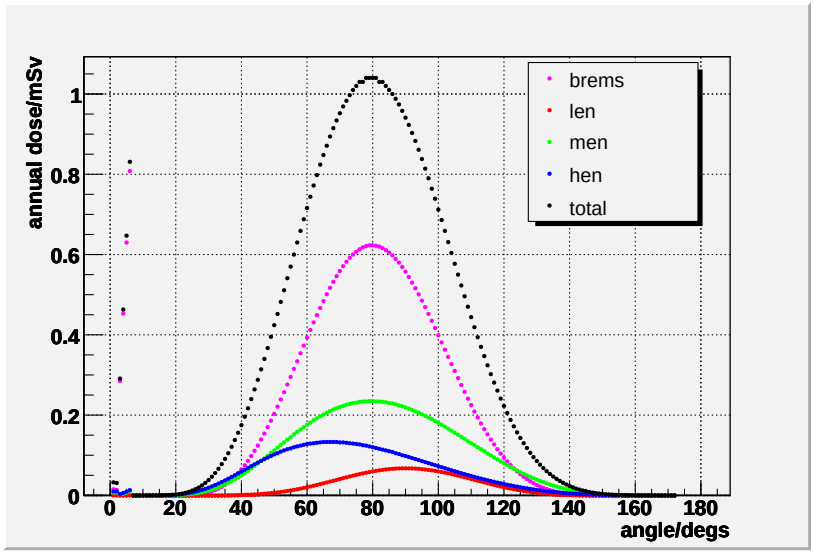
$5.53 \cdot 10^4$ J per straight section (20)

$7.17 \cdot 10^5$ J at septum

(The MAX IV ring)

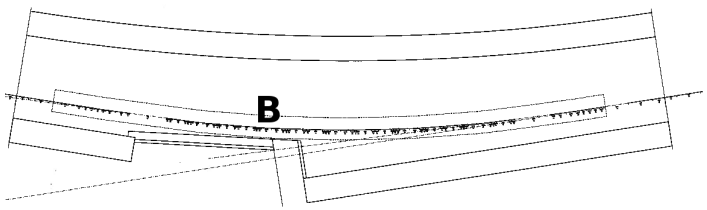
2000 h dose 50 cm off the 100 cm concrete wall (+ Pb around 0°)

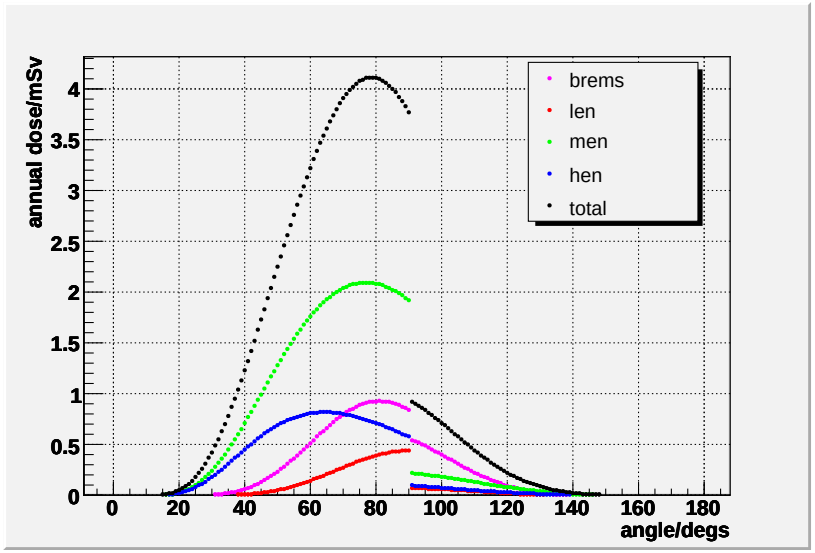




(The MAX IV ring)

Alt. B (0° exit 21m → 16m)
2000 h dose 50 cm off the 30 cm Fe + 10 cm PE wall



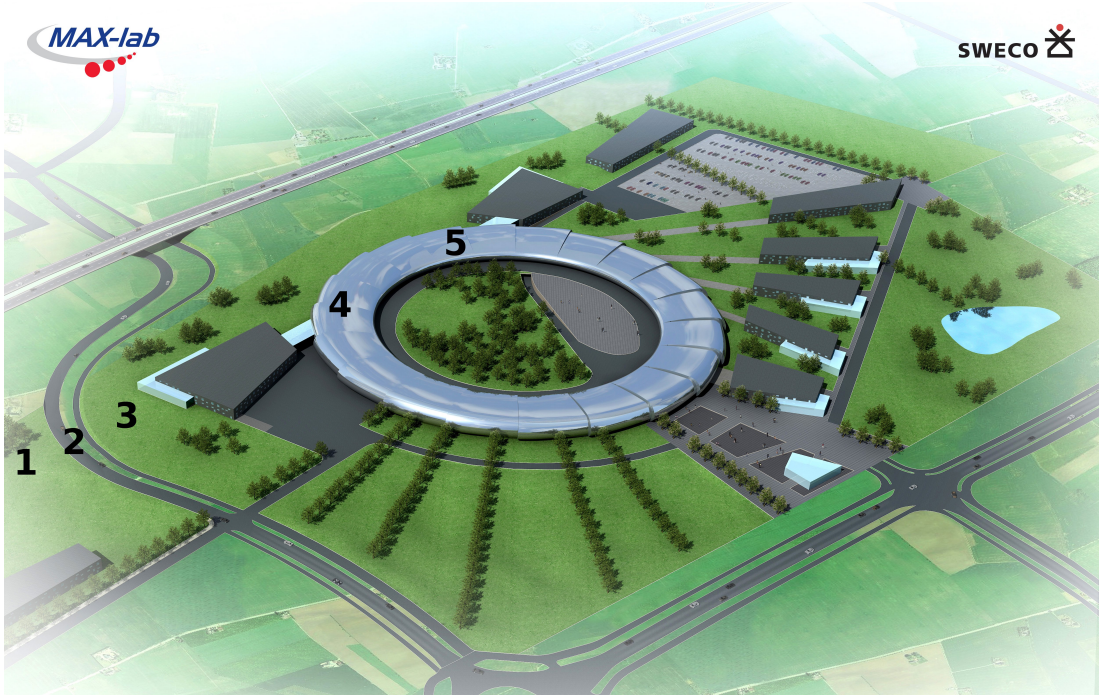


(The MAX IV ring)

Summary

Item	Shield	Comment
lateral wall	100 cm concrete	
	170 cm concrete	septum
	30 cm Fe + 10 cm PE	alt B
ratchet wall	100 cm concrete + 10 cm Pb	
	200 cm concrete + Pb	septum

The linac tunnel

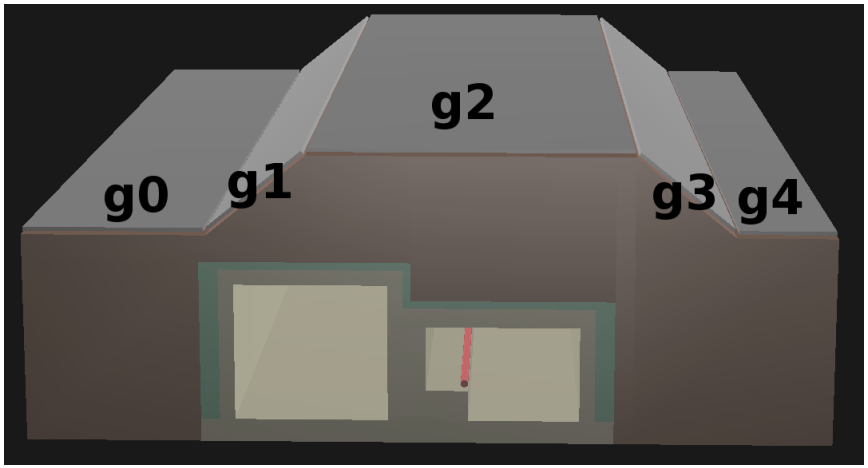


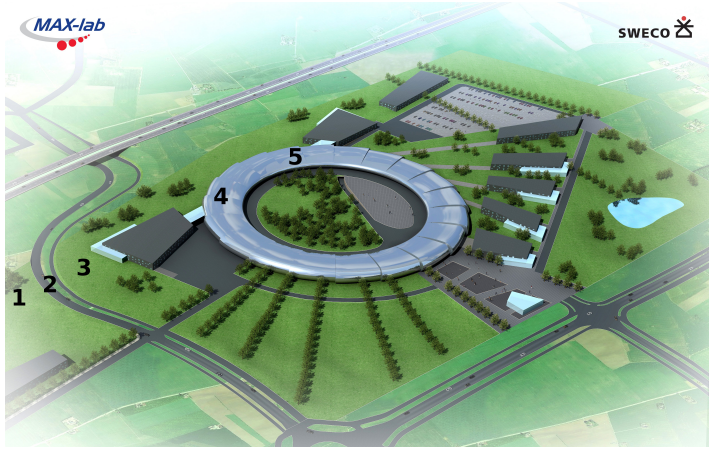
4 locations

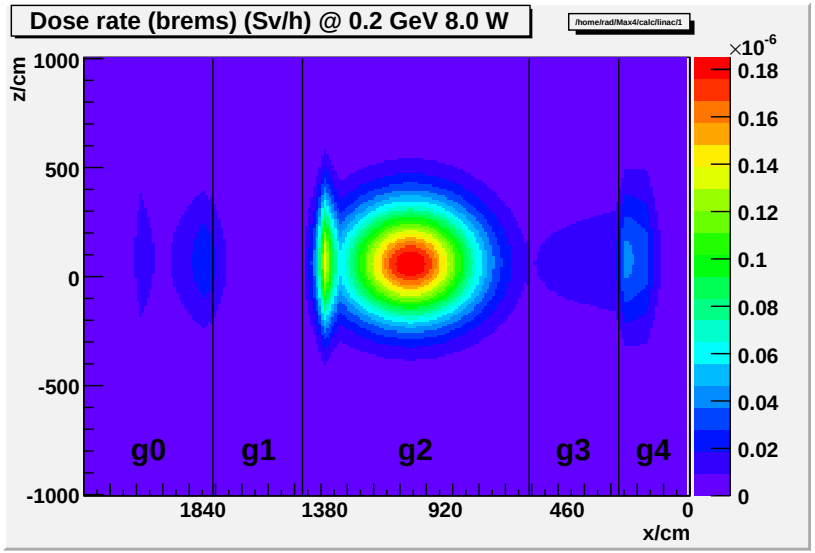
Location	Energy (GeV)	Loss (%)	Loss @ 200 Hz (W)
1	0.2	20	8
2	1.0	1	2
3	1.5	1	3
4	3.0	1	6

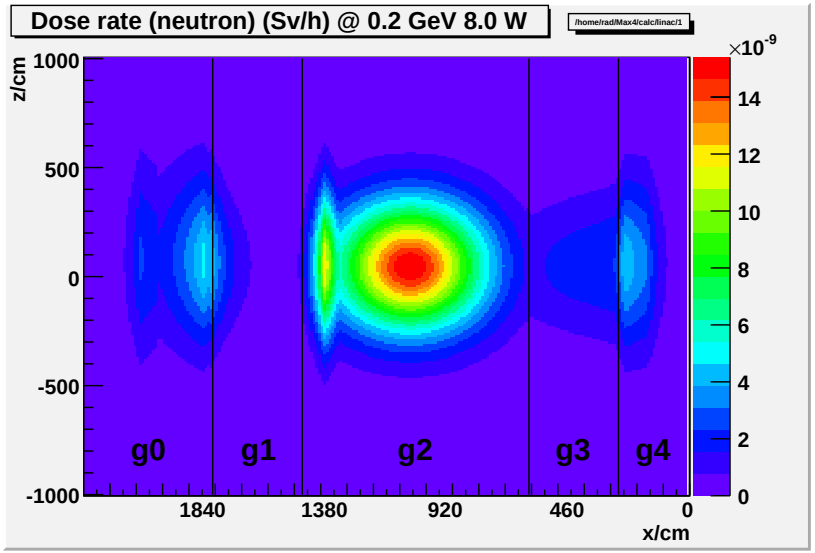
Linac 1, 0.2 GeV, 8 W loss (20%)

Vertical shield: 50 cm concrete, 380 cm earth



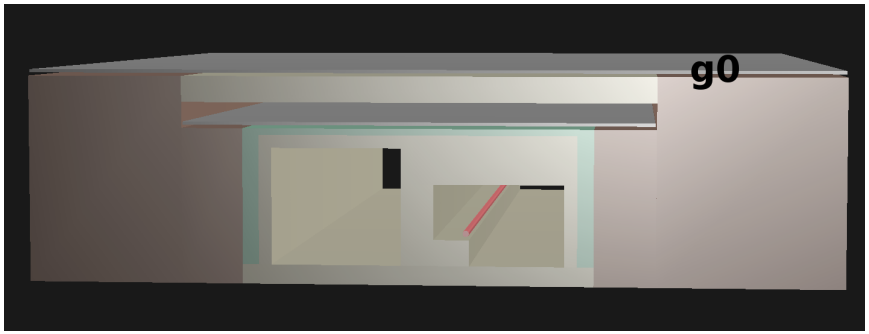


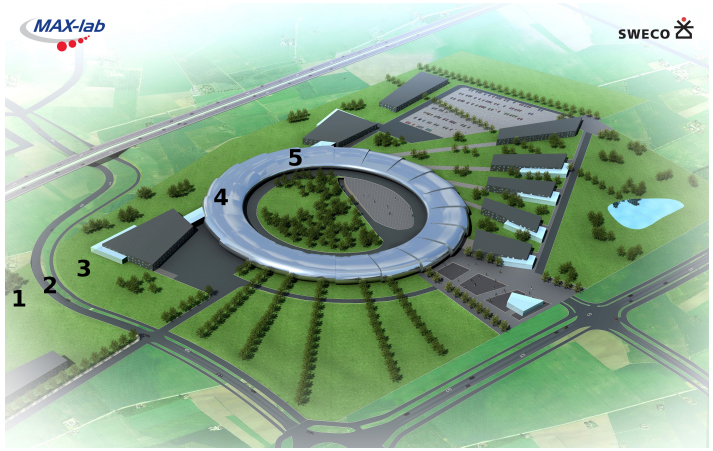


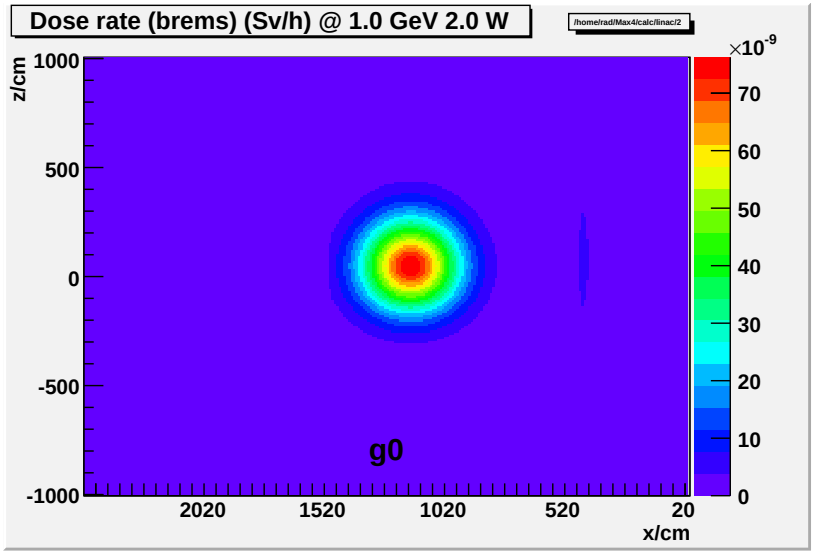


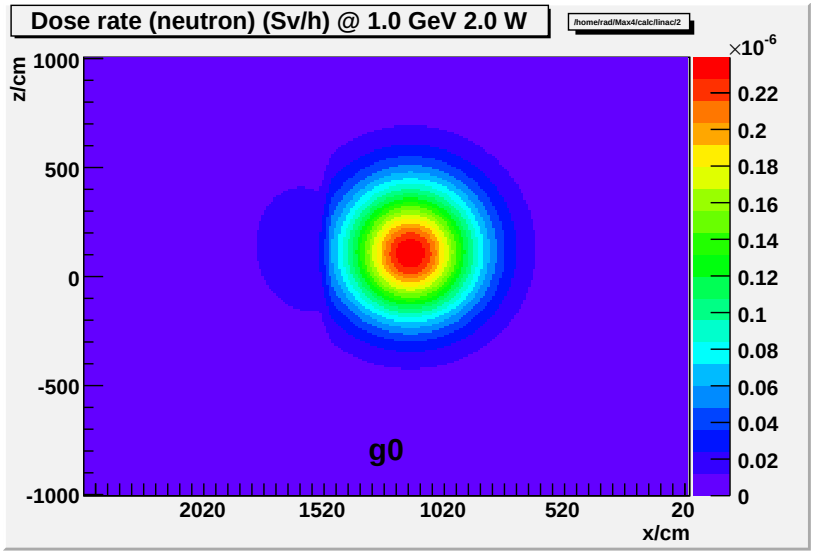
Linac 2, 1.0 GeV, 2 W loss (1%)

Vertical shield: 150 cm concrete, 80 cm concrete



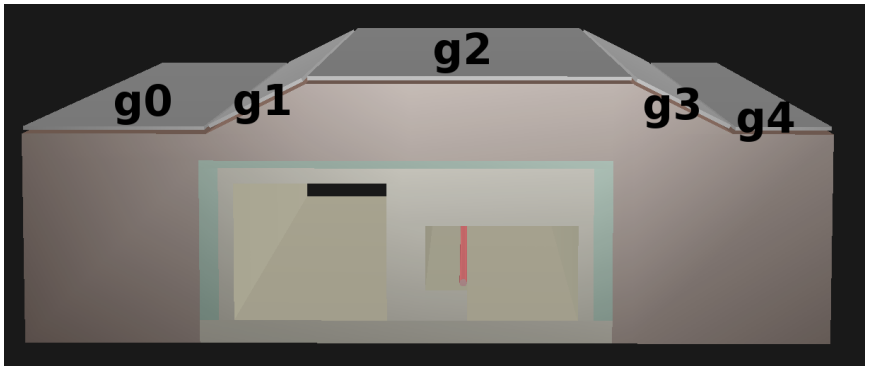


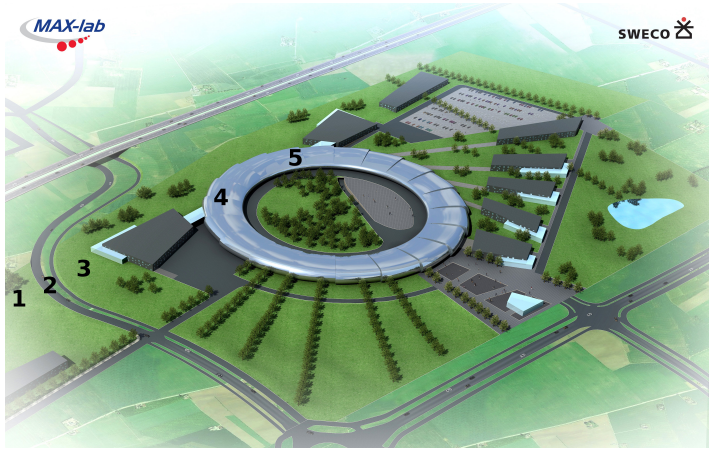


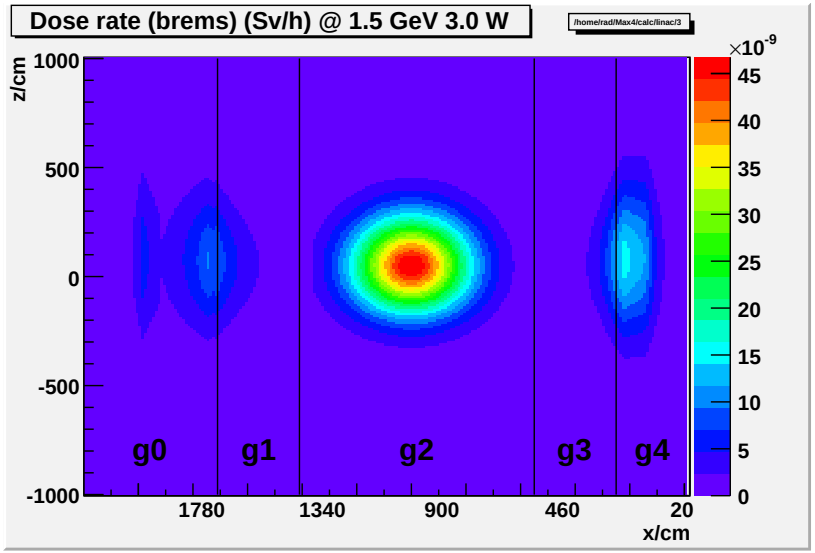


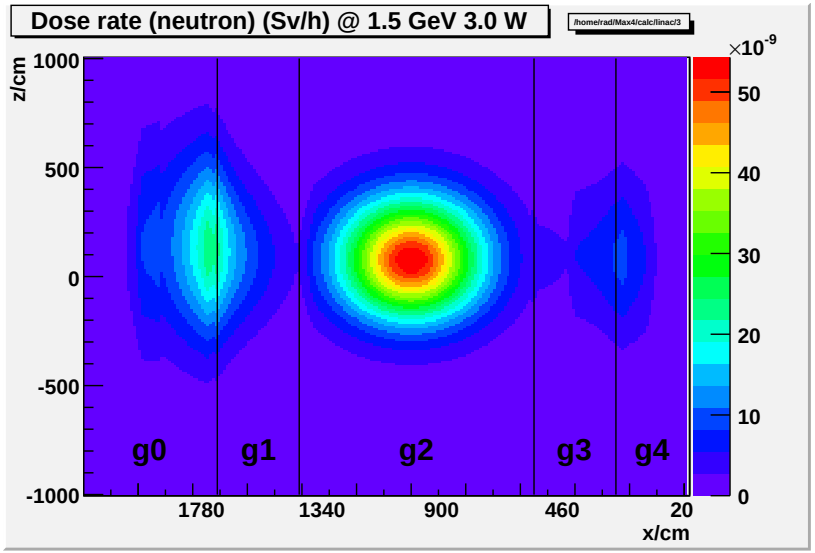
Linac 3, 1.5 GeV, 3 W loss (1%)

Vertical shield: 150 cm concrete, 200 cm earth



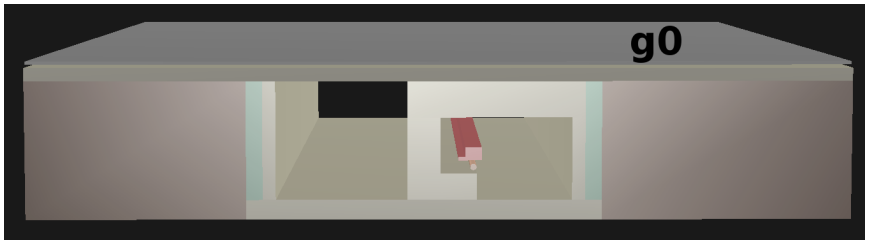


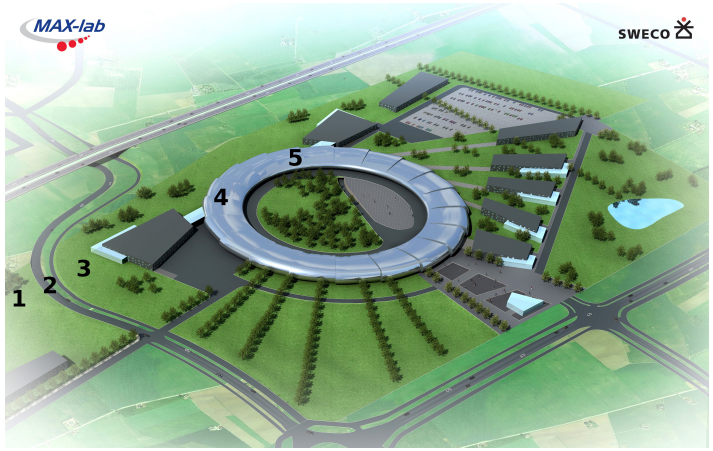


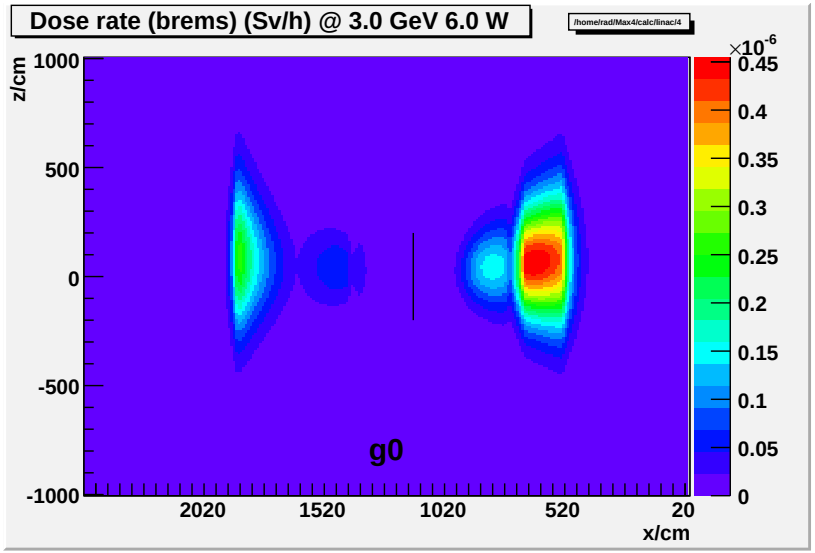


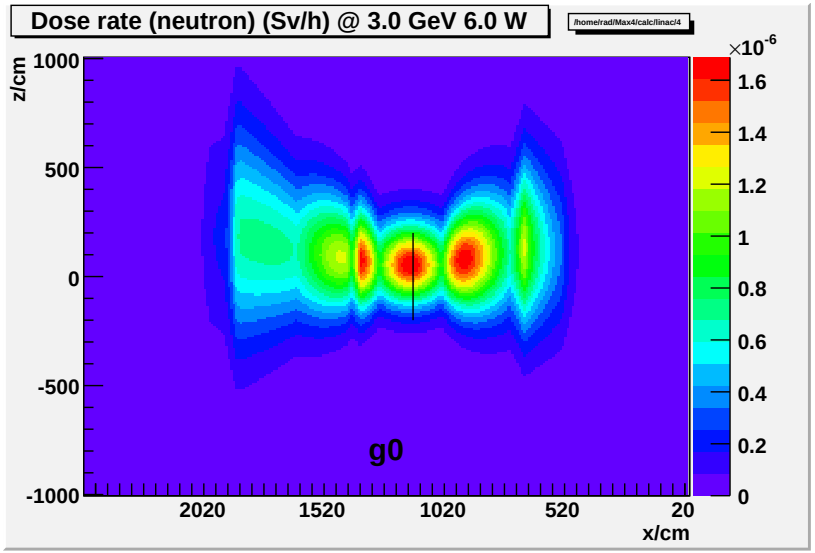
Linac 4, 3.0 GeV, 6 W loss (1%)

Vertical shield: 40 cm Fe, 110 cm concrete, 40 cm concrete

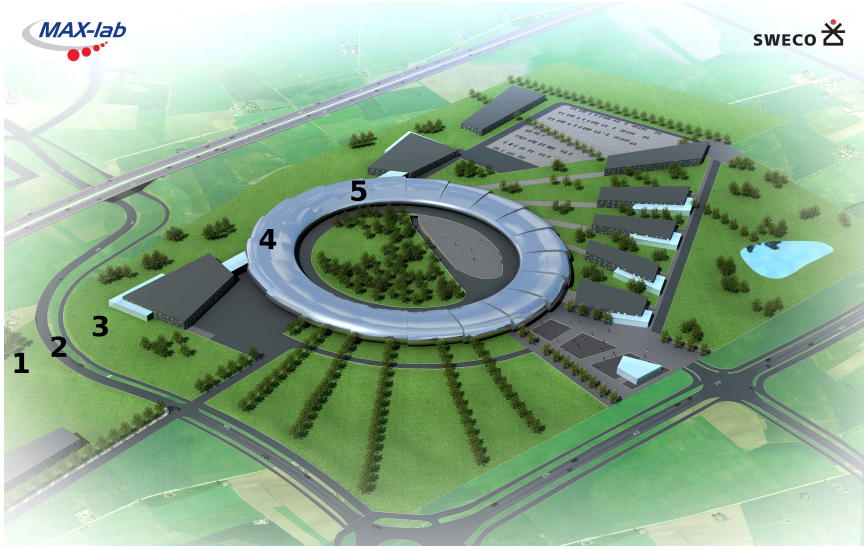








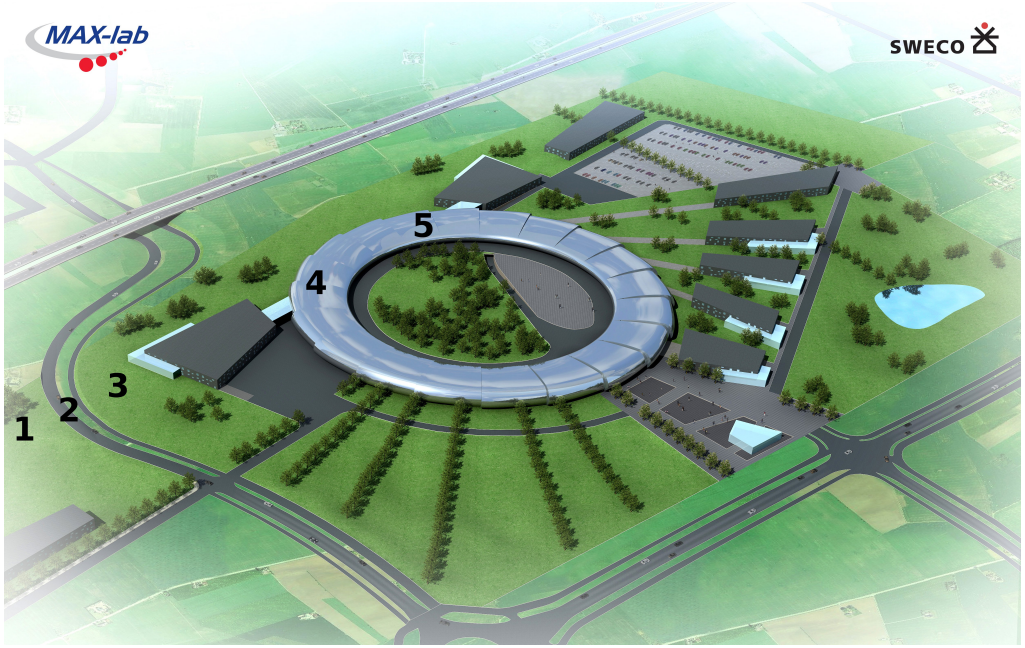
Summary linac

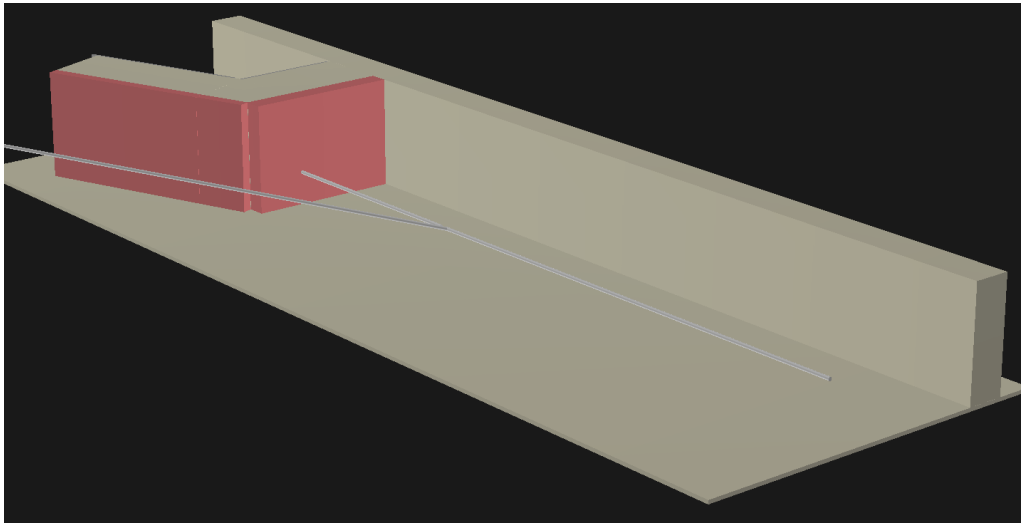


Location	Dose rate (μSv/h)	Dose limit (mSv)	Hours [4]
1	0.20	0.1	1500
2	0.31	0.1	968
3	0.10	0.1	3000
4	1.65	1.0	1818

[4] Taking the dutyfactor of 0.33 into account

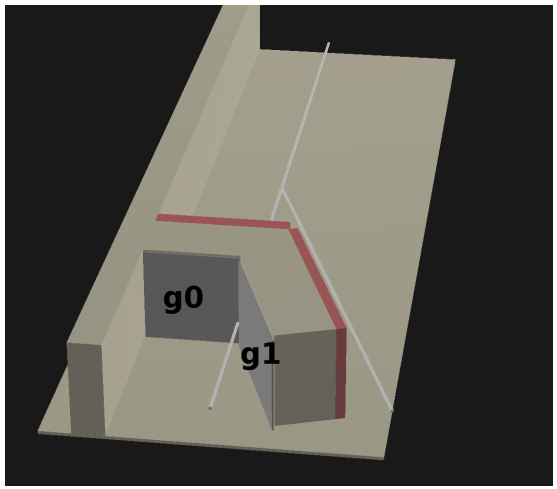
SPF 5, 3.0 GeV, 12 W loss at 0° (2%) and 6 W loss at 90° (1%)

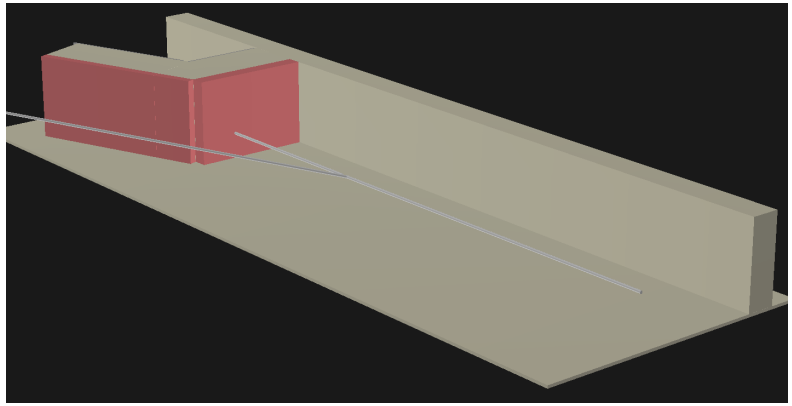


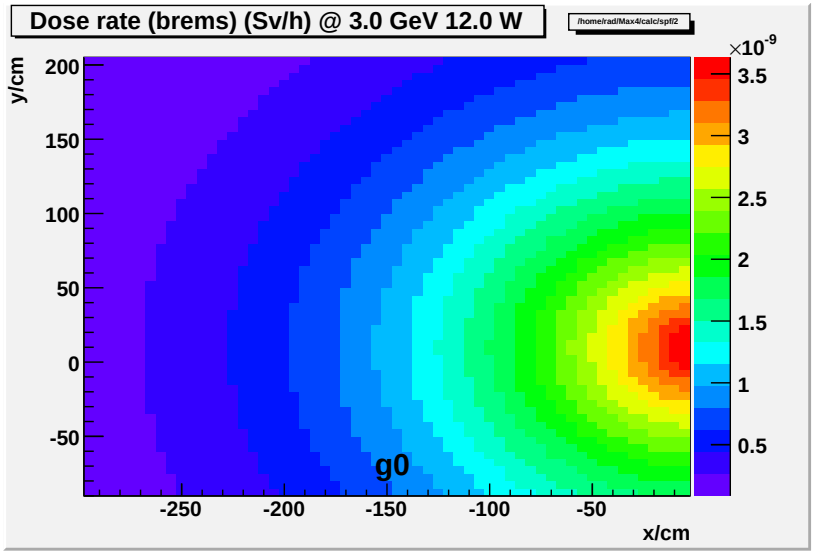


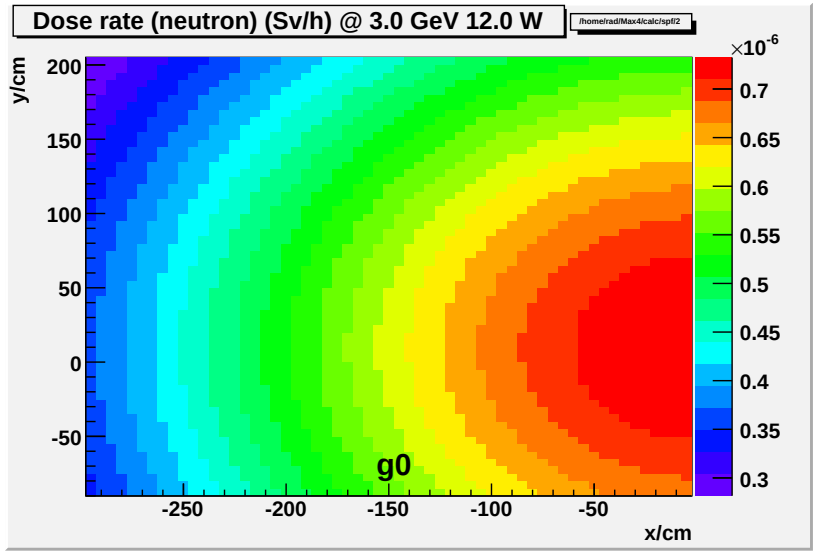
SPF 5 (g0), 3.0 GeV, 12 W loss at 0° (2%)

Forward shield: 50 cm Fe, 200 cm concrete



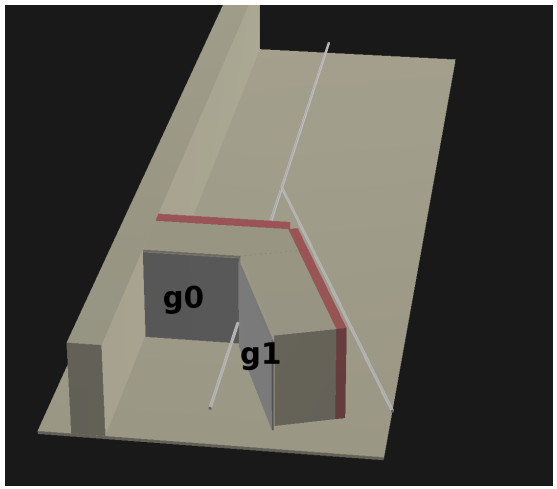


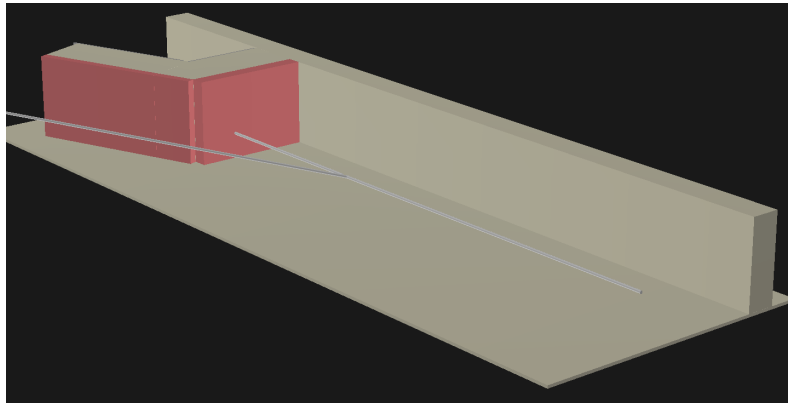


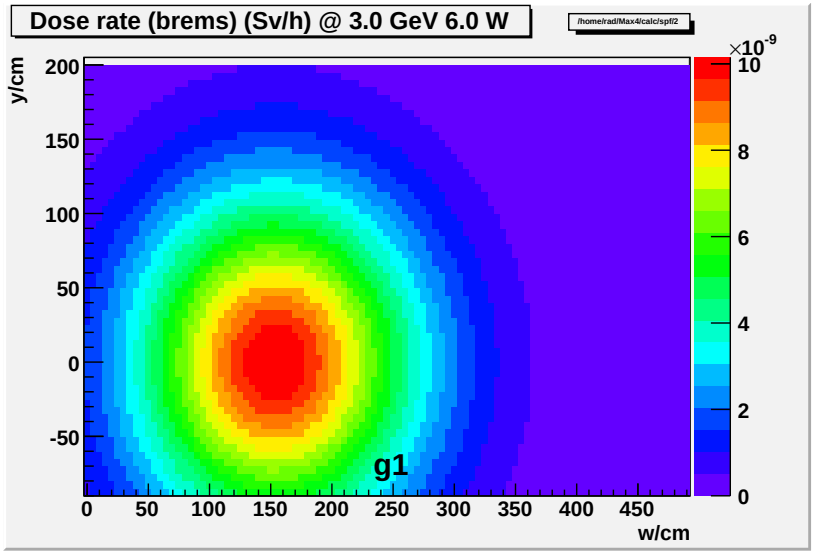


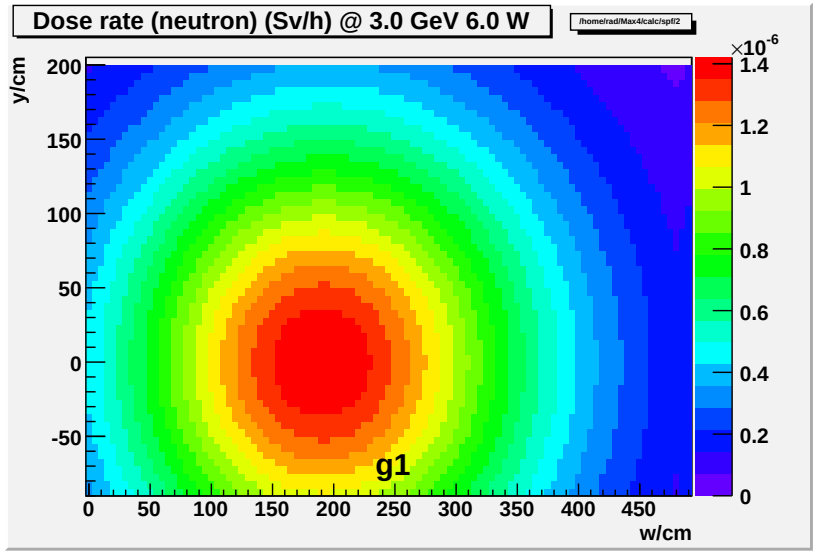
SPF 5 (g1), 3.0 GeV, 6 W loss at 90° (1%)

Side shield: 30 cm Fe, 180 cm concrete

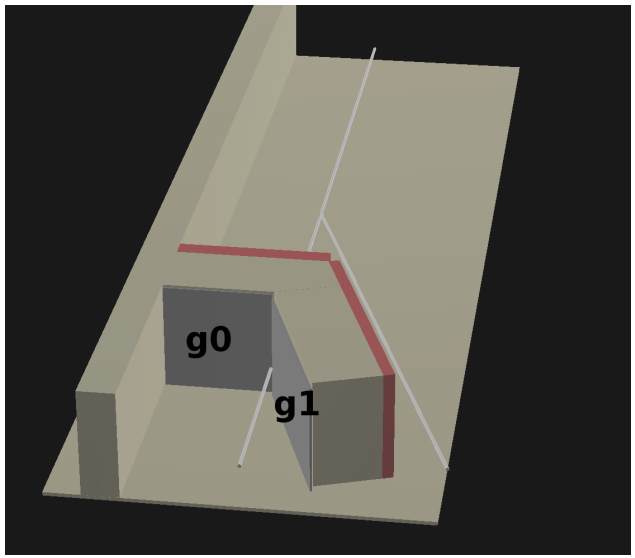








Summary SPF



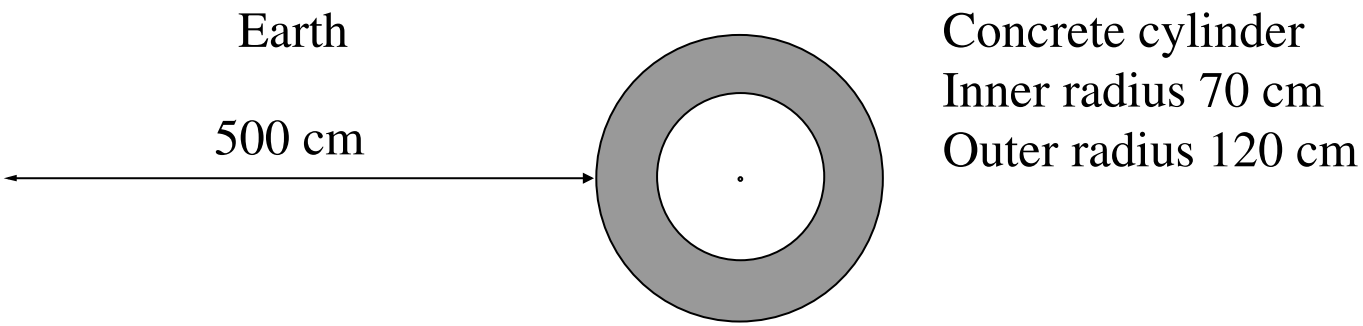
Location	Dose rate (μSv/h)	Dose limit (mSv)	Hours [5]
g0	0.70	1.0	4286
g1	1.40	1.0	2142

Distance dipole bend to experimental area: 910 cm

[5] Taking the dutyfactor of 0.33 into account

Activation of the earth surrounding the linac tunnel

- Geant4
- Simple cylindrical geometry
- 3 GeV, 200 W
- Fe target r=4 mm



Longlived (>1 day) results after running 1 year

Isotope	Bq/g
^{7}Be	0.0012
^{22}Na	0.0004
^{33}P	0.0004
^{37}Ar	0.35
^{45}Ca	0.0006
^{49}V	0.0002
^{51}Cr	0.0004
^{54}Mn	0.0002
^{55}Fe	0.0024

(Major) Uncertainties

- The estimated electron losses
- The shielding properties of “earth”