
WP2 Contribution to the
Safety Workshop

Safety Issues for WP2

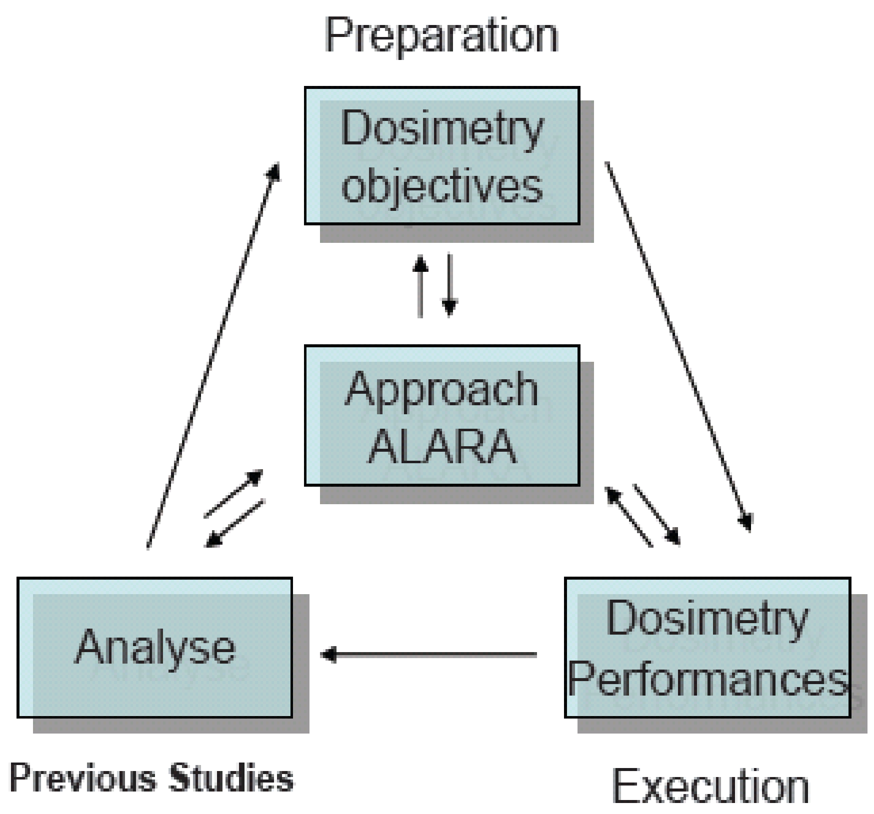
Outlines:

- ALARA Approach
- Simulation
- Conclusion

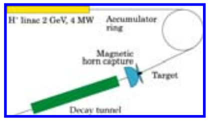
- **<u>ALARA approach :</u>**

⇒ **Anticipate and reduce individual and collective exposition to radiation**

- **<u>Iterative processes :</u>**
  - Préparation
    - Building Structure lists of materials
    - Dose Equivalent Rate Estimation
    - Optimize procedure during operation and maintenance phases
    - Evaluate residual activity of wastes ….
  - Execution
  - Safety Analyse from previous facilities (WANF, CNGS, NuMi, J-PARC…)

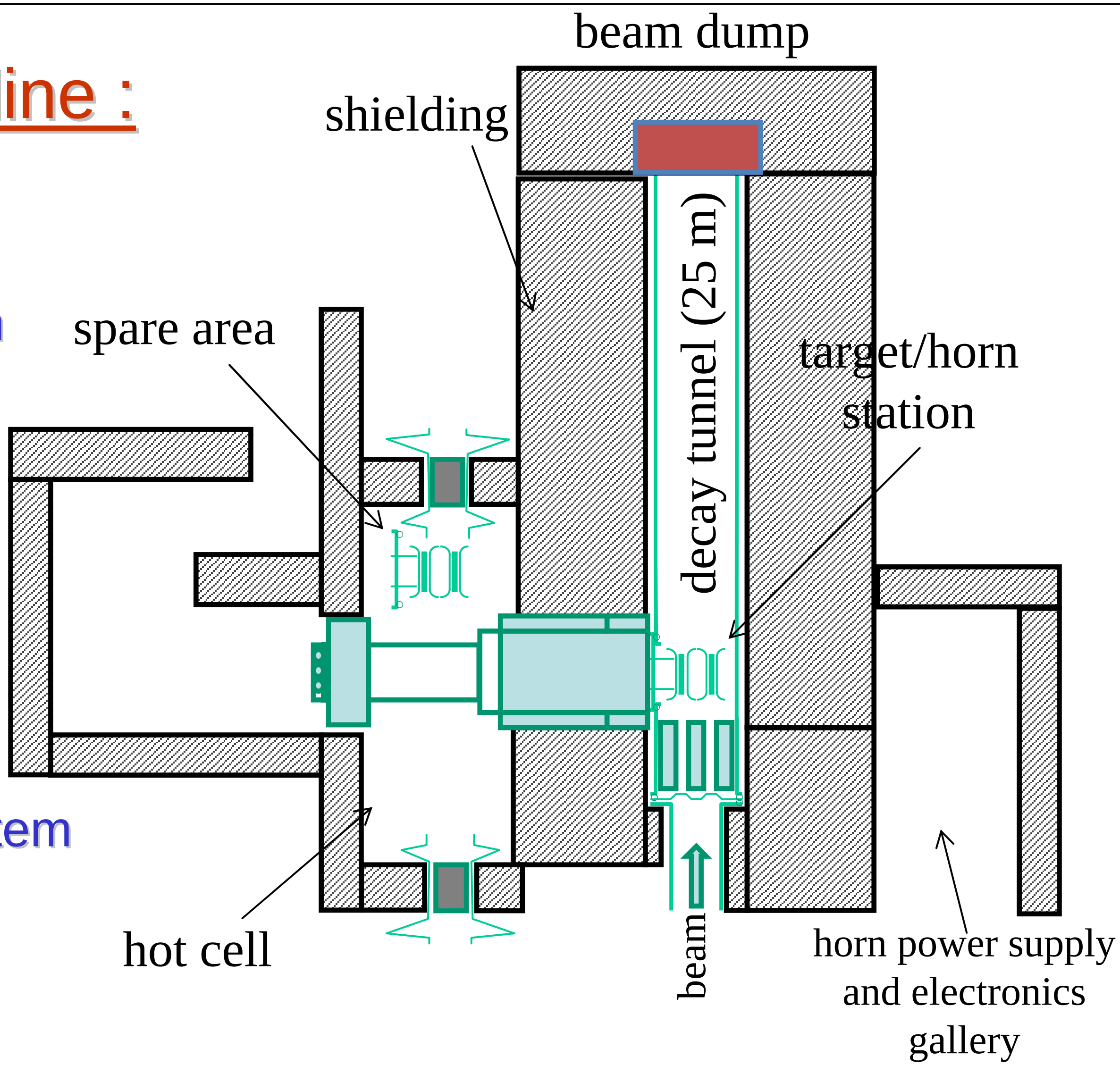


As Low As Reasonably Achievable

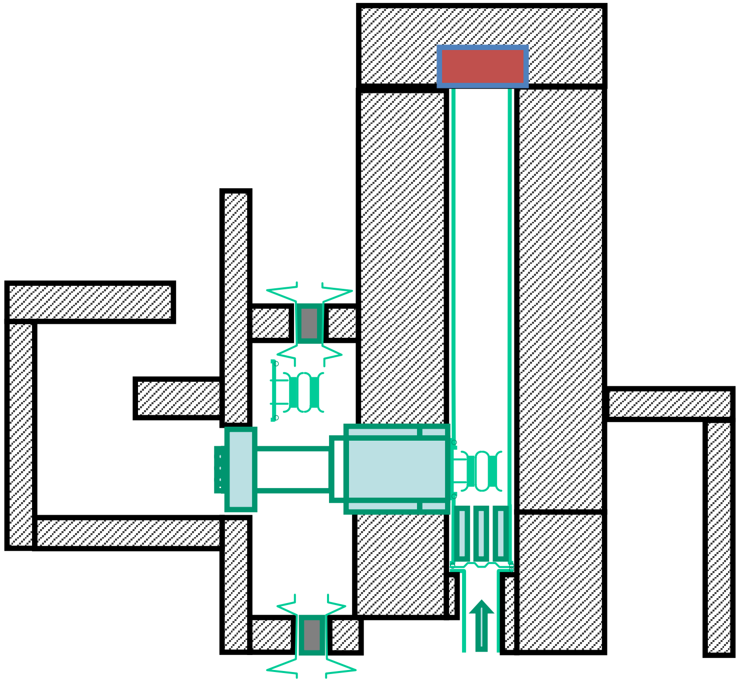


Design of the SB line :

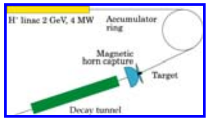
- **Proton Driver line**
- **Experimental Hall**
  - MW Target Station
  - Decay Tunnel
  - Beam Dump
- **Maintenance Room**
- **Service Gallery**
  - Power supply
  - Cooling system
  - Air-Ventilation system
- **Waste Area**



MW Target Station :

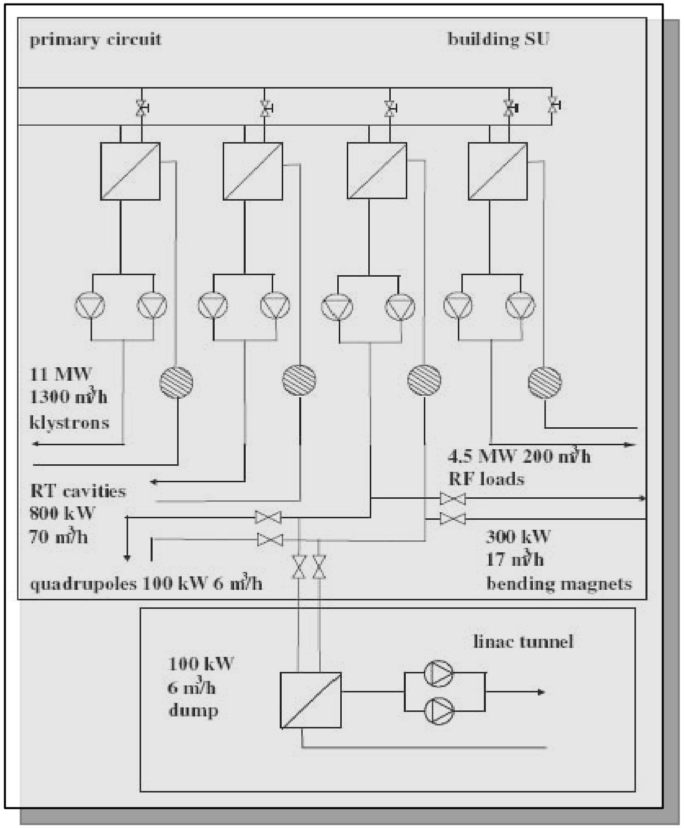


- Focusing System
- Crane System
- Automated robot
- Mechanical structure for the for horn
- Dose Rate Monitoring System
- Residual Dose Rate Plateform
- Operation under helium Atmosphere
  - flushing with air
  - filter to measure radioactive pollution (dust, tritium …)
- Investigation of other radionucleides transport (environmental constraint)
- …



SPL Cooling system :

Conceptual design of the SPL II, A high-power superconducting H- linac at CERN – CERN-2006-006 - 12 July 2006



*Schematic diagram of the main cooling plant

Table 5.5: Primary cooling needs and cooling-circuit parameters

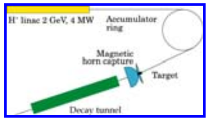
	ΔT [K]	Power [MW]	ΔP [bar]	Flow rate [m³/h]
Primary cooling SPL	9	16.8	5	1600
Cryo-compressors	5.7	4.0	5	600

Table 5.6: Secondary cooling circuits

Item	Fluid	Power [kW]	P_{max} [bar]	ΔT [K]	Flow rate [m³/h]
Klystron	Demineralized water	11000	8.5	7.5	1300
RF loads	Demineralized water	4500	8.5	20	200
RT cavities	Demineralized water	800	8.5	10	70
Magnets (quadrupole)	Demineralized water	100	12	15	6
Magnets (bending)	Demineralized water	300	12	15	17
Dump linac	Demineralized water	100	12	15	6

Complementary plants needed for
- cooling the 4 horns, decay tunnel and beam dump
- cooling and recirculating helium inside the vessel

Complementary infrastructures



Electrical infrastructure :

Conceptual design of the SPL II, A high-power superconducting H- linac at CERN – CERN-2006-006 - 12 July 2006

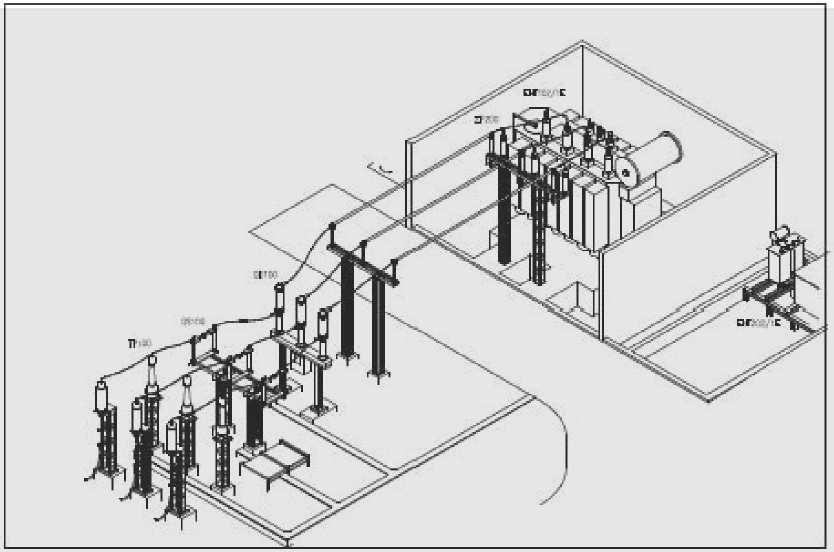


Fig. 5.9: Layout of CERN's standard 66/18 kV substation

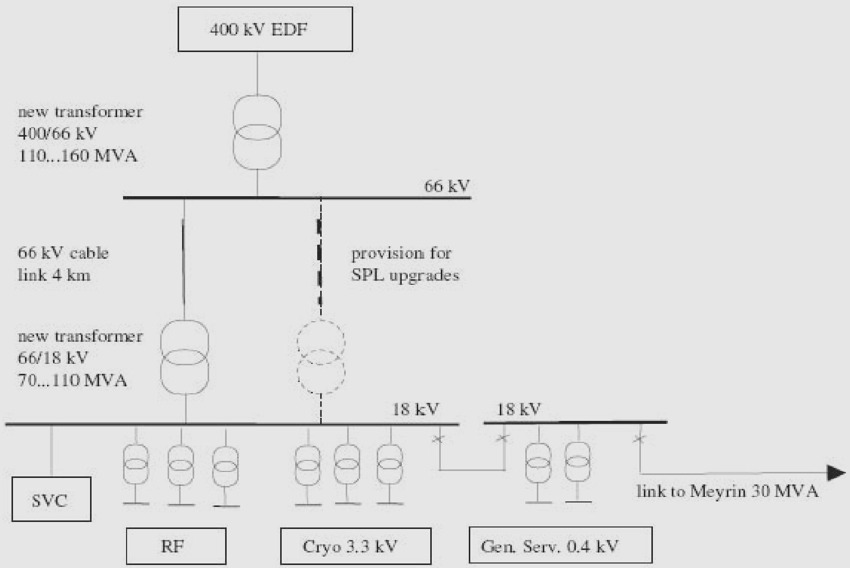


Fig. 5.10: Proposed electrical distribution system for the SPL

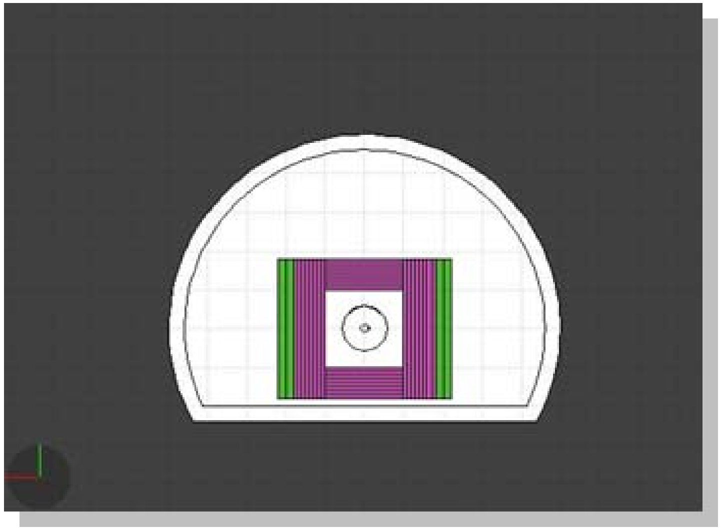
Table 5.9: Electrical power requirements (MW) of the SPL (r.m.s. values)

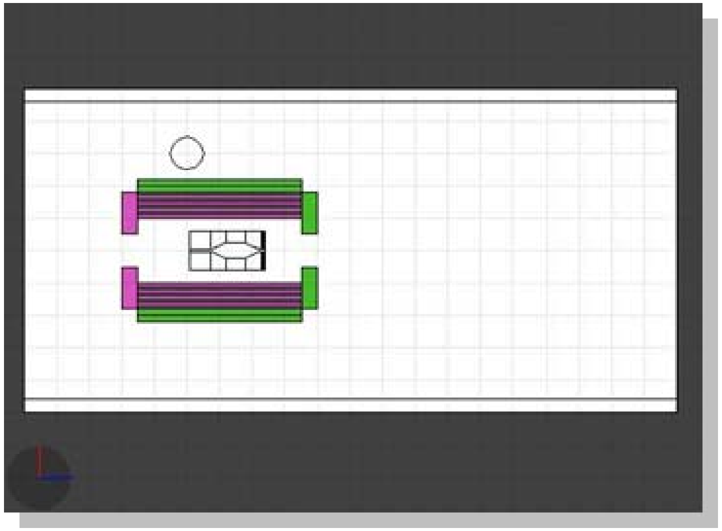
Load	4 MW neutrino baseline	5 MW EURISOL baseline
RF system[†]	20.2	24.4
Cryogenics	3.6	4.4
Cooling and ventilation	4	4
Other	1	1
General services (surface + tunnel), racks, computers, controls	3	3
Total	32	37

[†] Including 30% margin to compensate for Lorentz-force detuning in the SC cavities.

Complementary plants needed for the super beam infrastruture
- **alimentation station for the horns**
- **air conditioning installation**

Radiation simulation : shielding investigation





Beam Features (CNGS like):

- Proton Energy : 400 GeV/c
- Intensity : 8.0 10^{12} pps
- Irradiation time : 200 days

Target:

- Material : Graphite
- Cylinder : 130 cm x 4mm (Diameter)

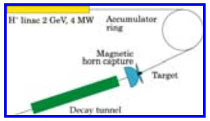
Horn:

- Material : Anticorodal 110

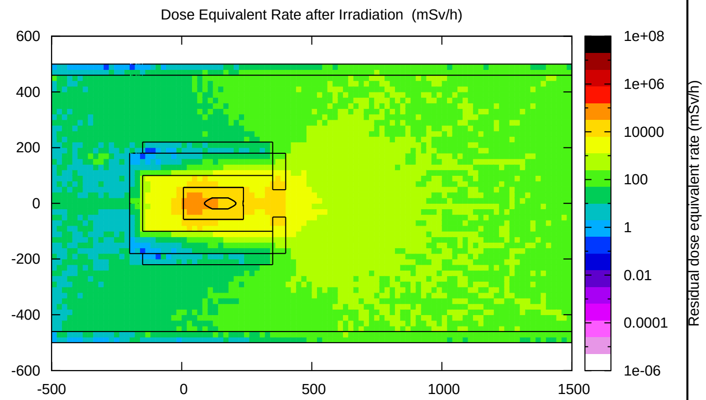
Shielding for the Target Station :

- Walls and roof : 80 cm of Iron,
  8 Slabs (2.5m x 2m x10cm)
- Lateral and Front Marble Slabs
- Front Iron Slab

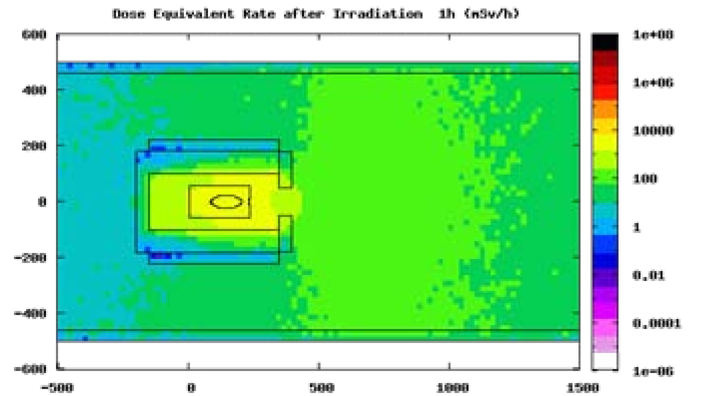
$\Rightarrow$ Evolution of the DER with time performed with FLUKA 2011.2.3



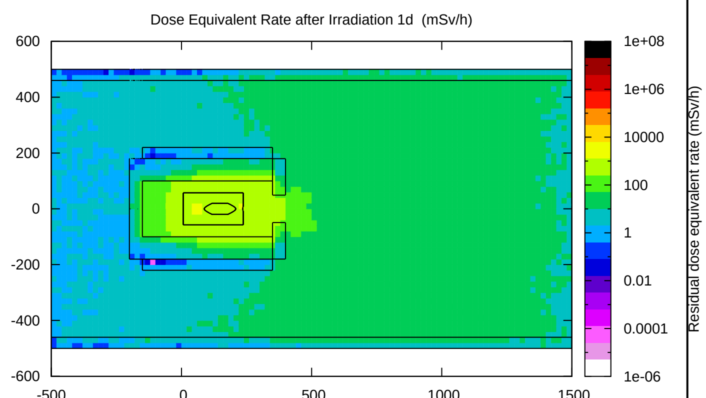
Radiation simulation : shielding investigation



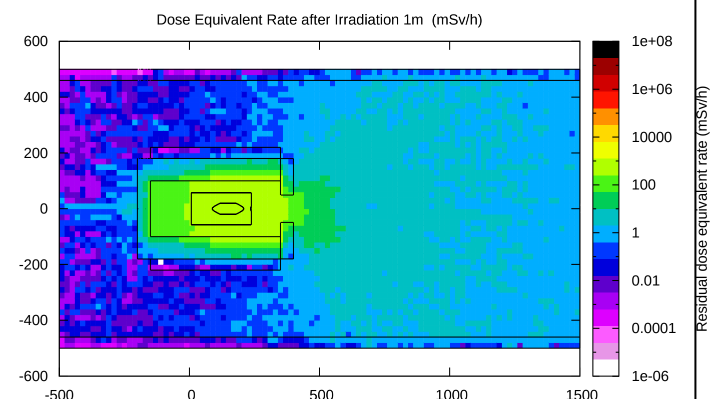
DER (mSv/h) after stopping irradiation



DER (mSv/h) after 1hour of cooling time



DER (mSv/h) after 1day of cooling time



DER (mSv/h) after 1month of cooling time

Radiation simulation : shielding investigation

Beam Features:

- Proton Energy : 4,5 GeV/c
- Intensity : 18. 10^{14} pps
- Irradiation time : 200 days

Target:

- Material : Titanium
- Cylinder : 78 cm x 1.5mm (Diameter)

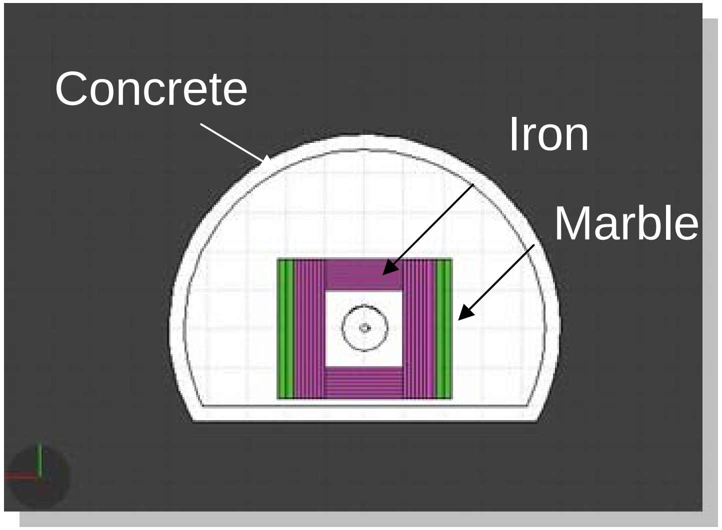
Horn:

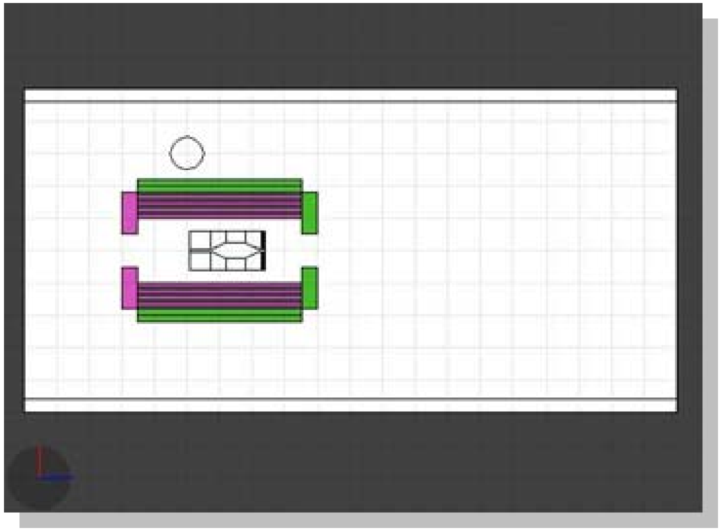
- Material : Anticorodal 110

Shielding for the Target Station :

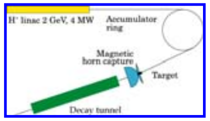
- Walls and roof: 80 cm of Iron, 8 Slabs (2.5m x 2m x10cm)
- Lateral and Front Marble Slabs
- Front Iron Slab

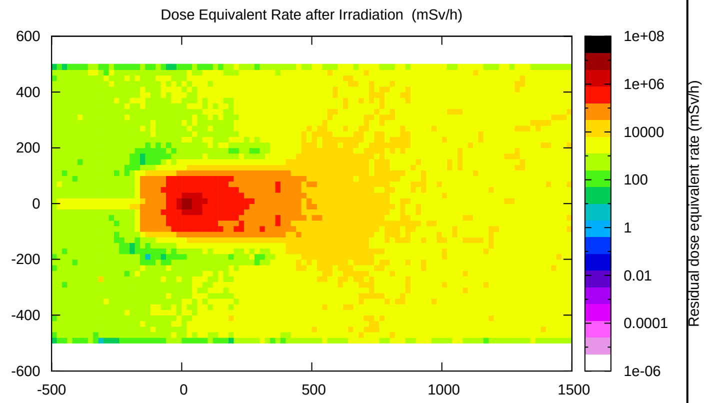
⇒ Evolution of the DER with time performed with FLUKA 2011.2.3



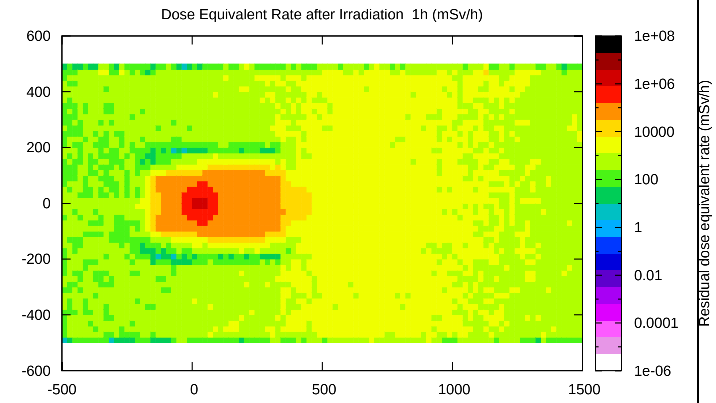


Radiation simulation : shielding investigation

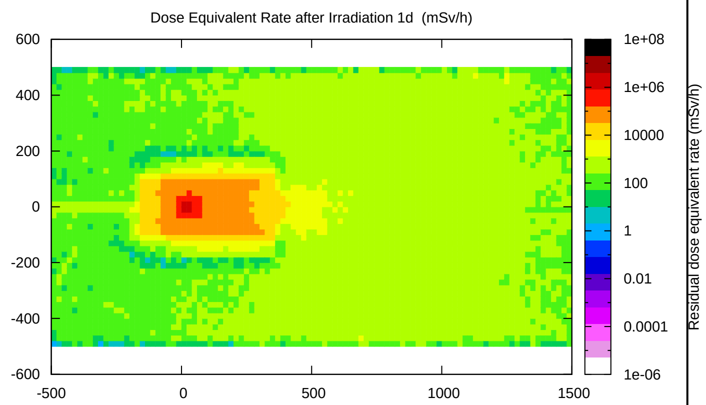




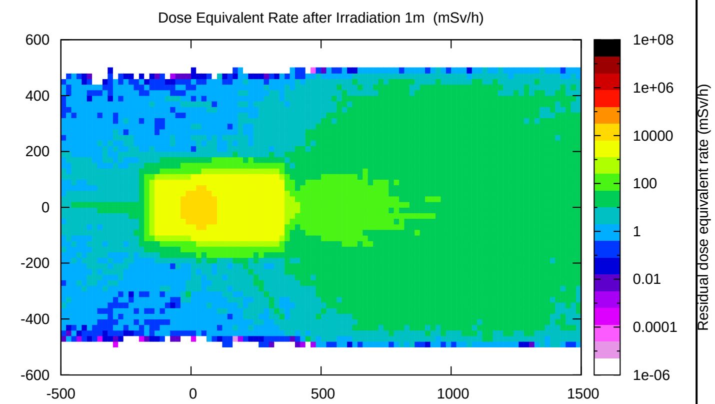
DER (mSv/h) after stopping irradiation



DER (mSv/h) after 1 hour of cooling time

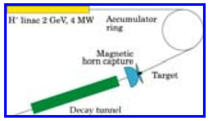


DER (mSv/h) after 1 day of cooling time



DER (mSv/h) after 1month of cooling time

Radiation simulations : Four Horn Station



Chemical composition of Material:

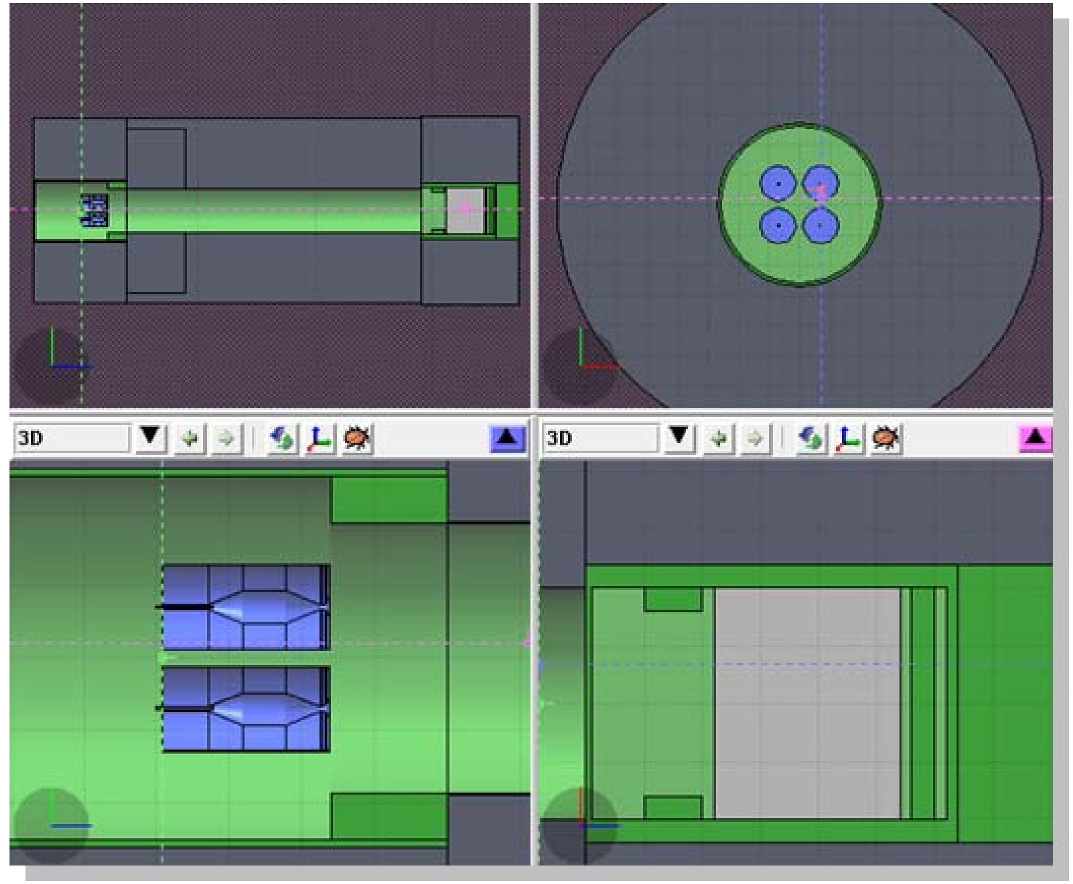
Target => Ti(100%)

Horn => Anticorodal 110 alloy
Al (95.5%), Si(1,3%), Mg(1,2%), Cr(0.2%), Mn(1%), Fe (0.5%), Zn(0.2%), Cu(0.1%)

Decay Pipe => Steel P355NH
Fe(96.8%), Mn(1.65%), Si(0.5%), Cr(0.3%), Ni(0.3%), C(0.2%)

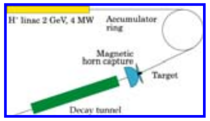
Tunnel => Concrete
O(52.9%), Si(33.7%), Ca(4.4%), Al(3,49%), Na(1,6%), Fe(1.4%), K(1,3%), H(1%), Mn(0.2%), C(0.01%)

Surrounding Environment => Molasse
O(49%), Si(20%), Ca,(9.7%), Al(6.4%), C(5%), Fe(3.9%), Mg(3.2%), K(1%), Na(0.5%), Mn(0.1%)

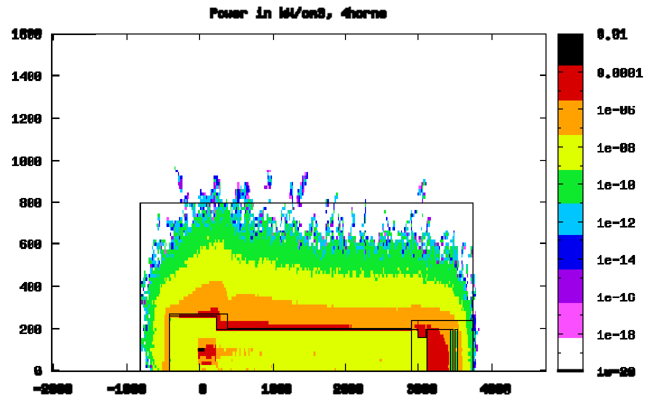


Four horn station layout

Simulations : Energy deposition for the Four Horn Station

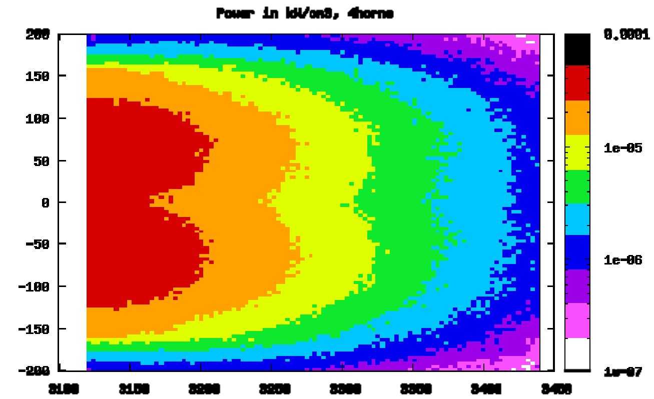


Transverse view



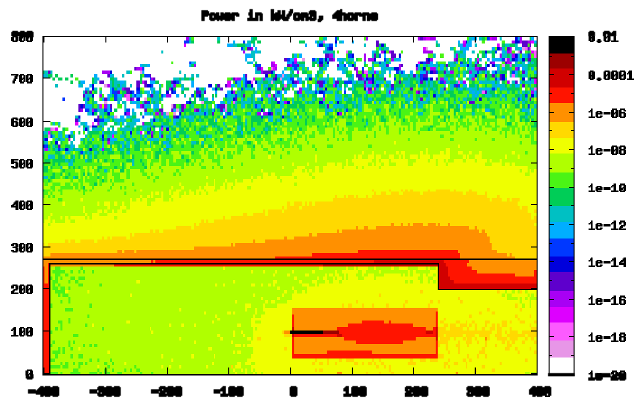
Energy deposition (kW/cm^3) in the all layout

Transverse view



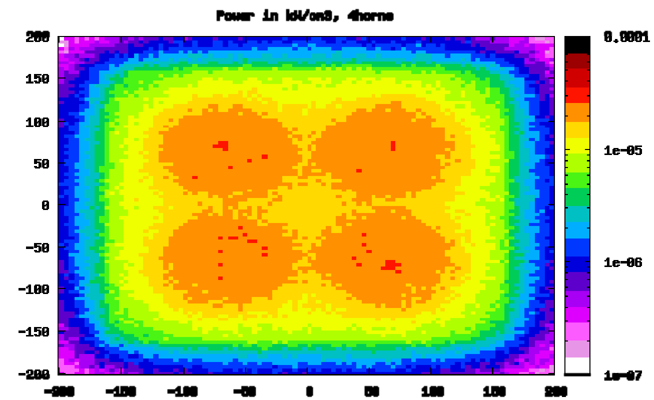
Beam dump energy deposition (kW/cm3)

Transverse view



Target station energy deposition (kW/cm3)

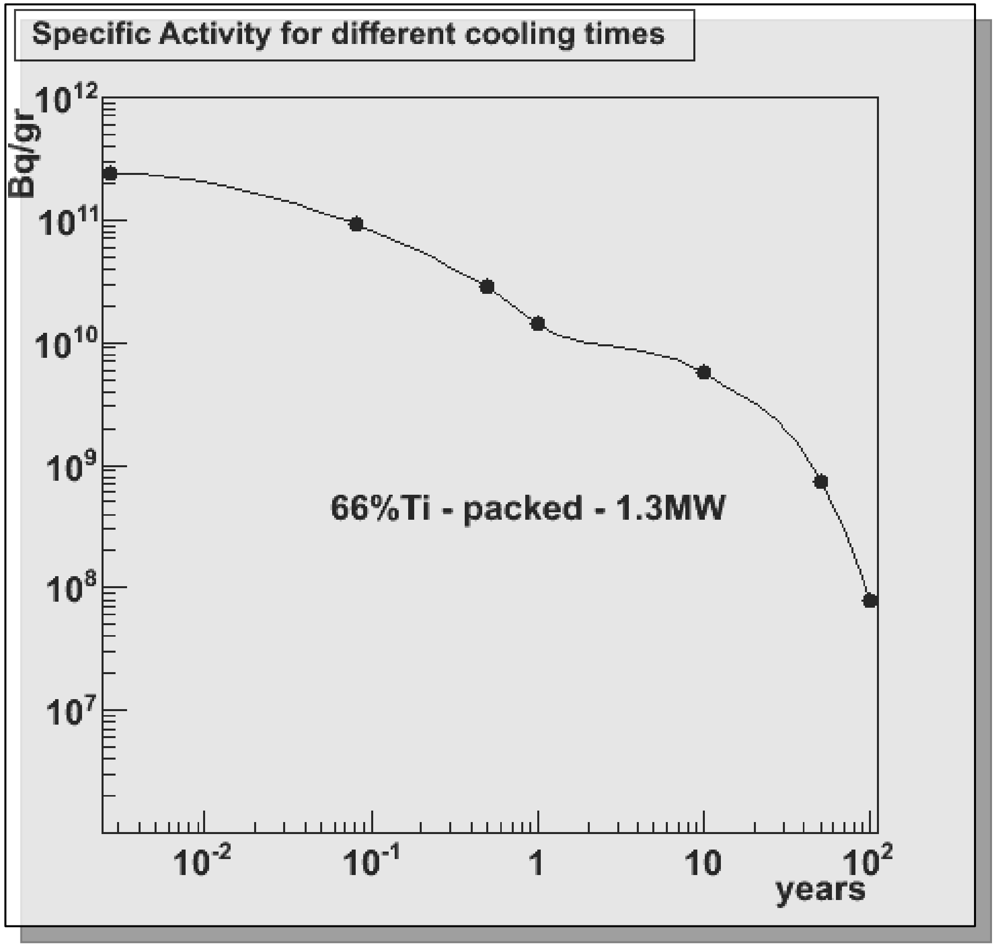
Front view

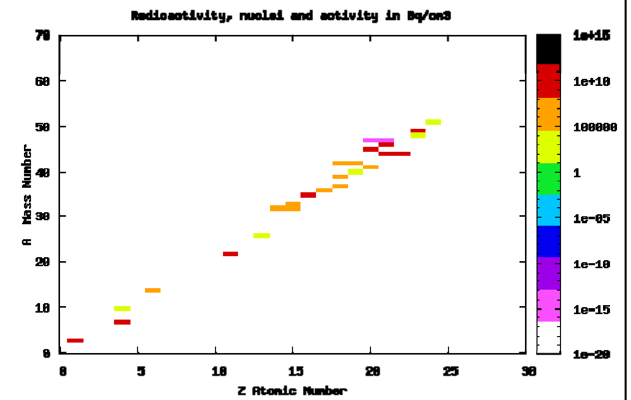


Beam dump energy deposition (kW/cm3)

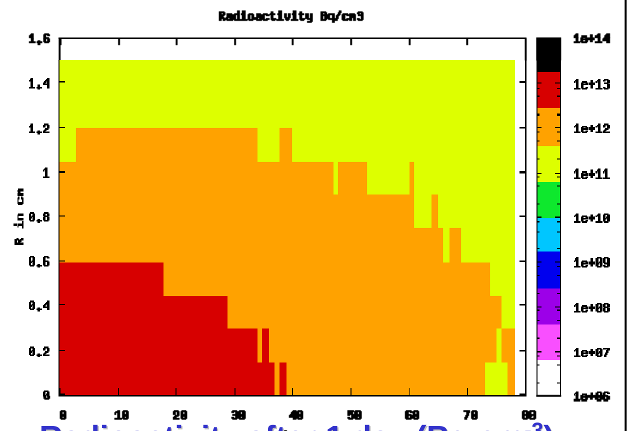
Radiation simulations : Four Horn Station

Evolution of the target activity with cooling time:



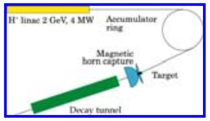


Radionucleides after 1 day (Z,A)

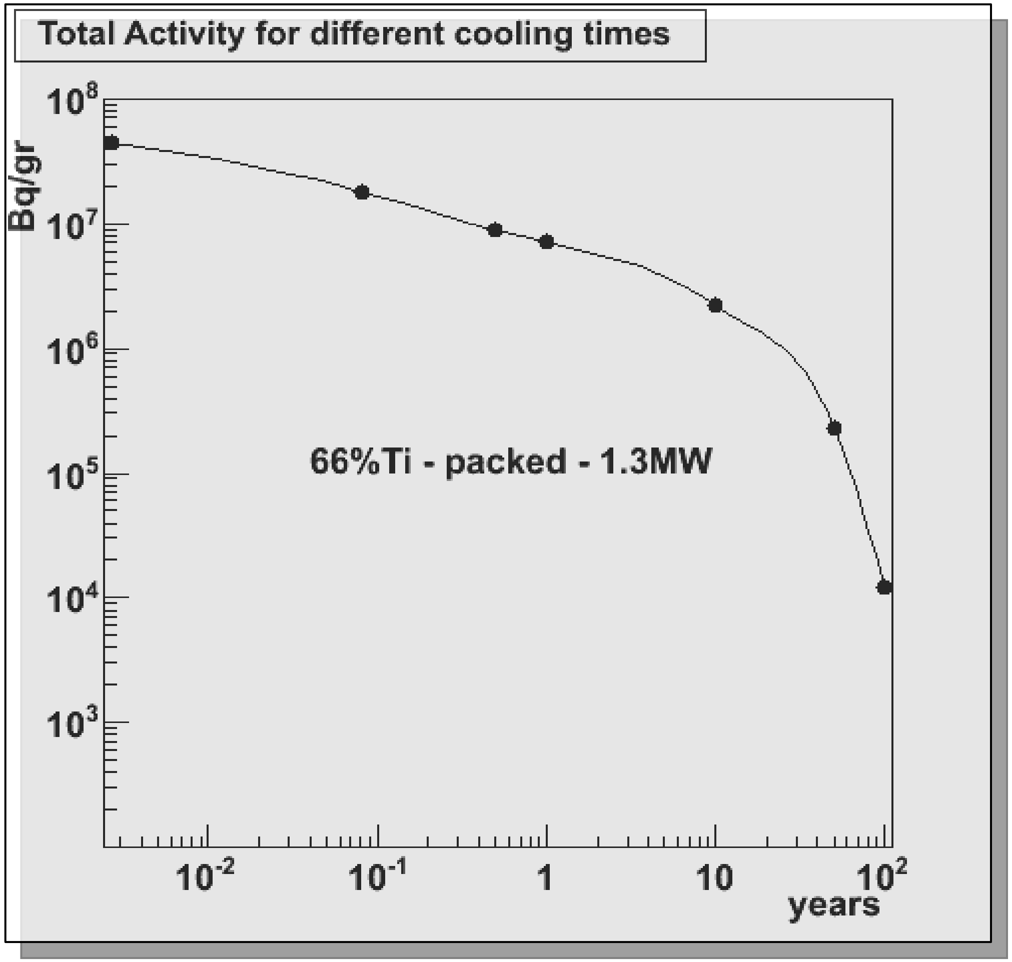


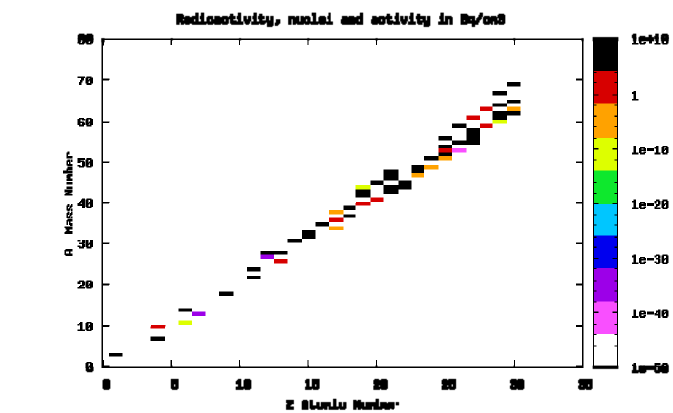
Radioactivity after 1 day ($Bq.cm^{-3}$)

Radiation simulations : Four Horn Station



Evolution of the horn activity with cooling time:





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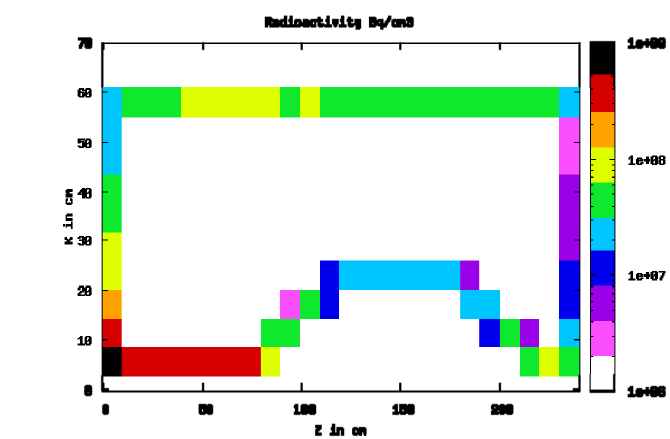
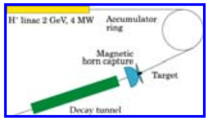


Radioactivity after 1 day ($Bq.cm^{-3}$)



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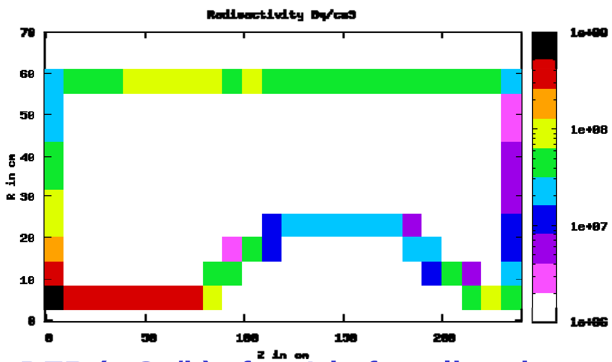
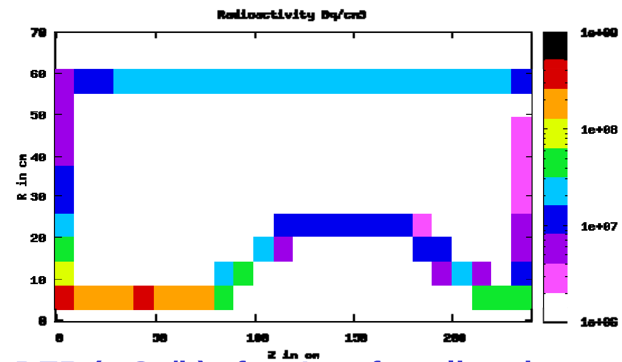
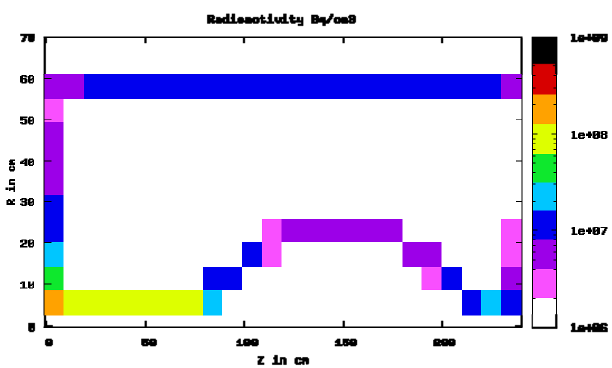


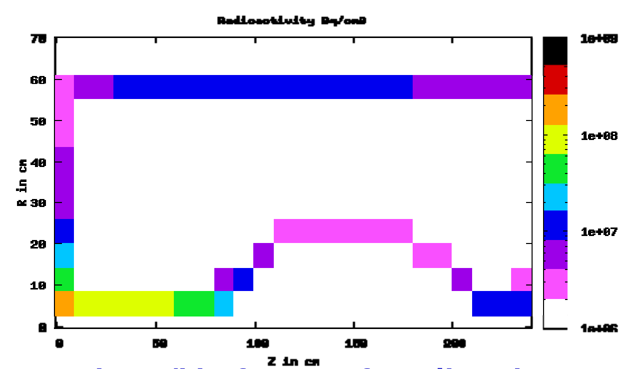
DER (mSv/h) after 1d of cooling time



DER (mSv/h) after 1m of cooling time

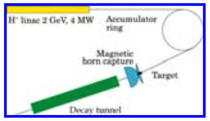


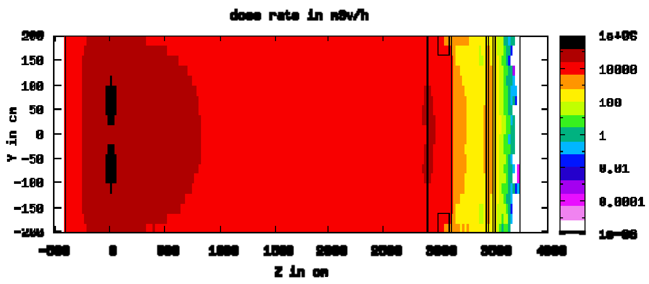
DER (mSv/h) after 6m of cooling time



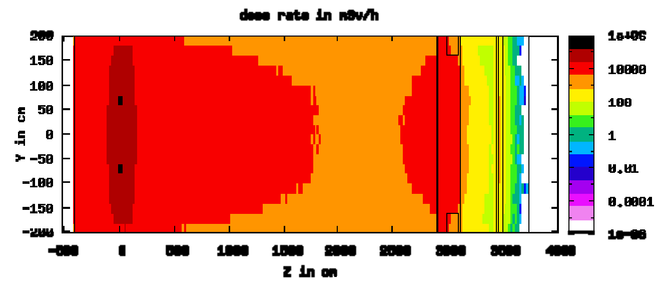
DER (mSv/h) after 1y of cooling time

Radiation simulations : All Layout





DER (mSv/h) after 1d of cooling time



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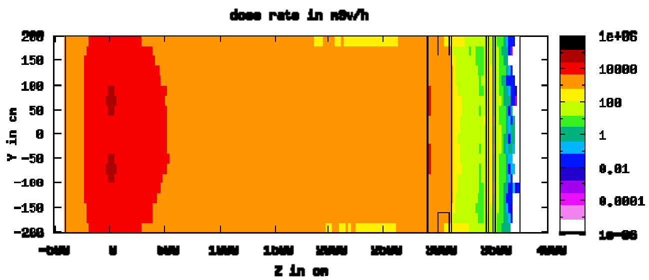
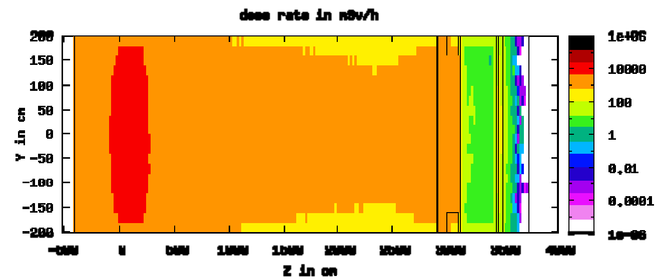
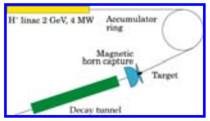


DER (mSv/h) after 6m of cooling time



DER (mSv/h) after 1y of cooling time

Radiation simulations : Four Horn Station



Next Steps :

- Full Design simulation of the installation
- Contribution of each element to the dose rate
- Individual and collective dose rate calculation with cooling times
- Intervention Scenarios (normal operation, maintenance, emergency….)
- Costing