Safety Meeting WP2

E. Baussan on behalf of WP2

Outlines:

- Status on WP2
- Safety
  - Alara Approach
  - Simulation

Target Technology

Summary of target options

Mercury jet
- high-Z (too many neutrons & heat load on horn)
- not chemically compatible with horn

Graphite rod
- thermal conductivity degrades with radiation damage
- mechanical stress depends on dT
- hence short life time

Beryllium rod
- thermal stress is significant
- alternative geometries could overcome the problem (still under investigation)

Integrated Be target and horn
- extra heat load makes it even more challenging
- combined failure modes could reduce the life time

Fluidised powder target
- potential solution for higher heat load

Static pebble bed
- reduced stresses. Favourable transversal cooling. Good yield

Science & Technology Facilities Council
Rutherford Appleton Laboratory

Ottone Caretta, RAL, January 2011

High Power Targets

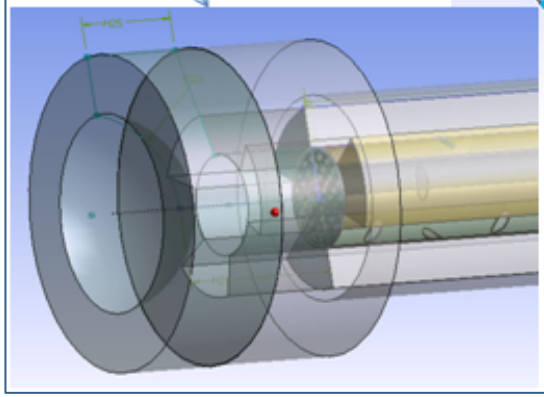
Target Technology

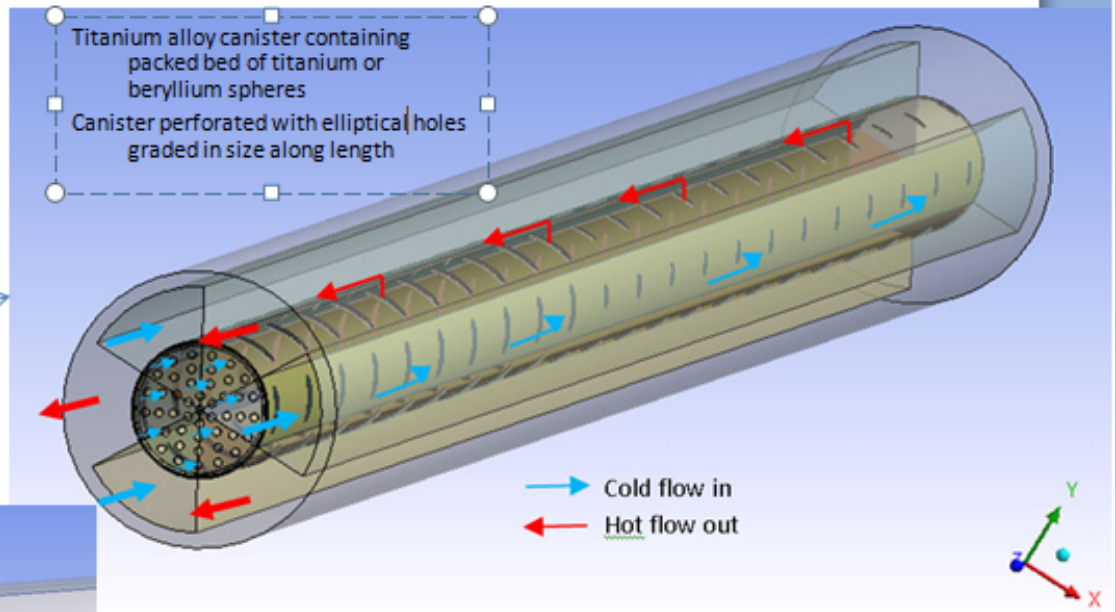
Science & Technology Facilities Council

Packed Bed Target Concept for Euronu (or other high power beams)

Packed bed canister in parallel flow configuration

Packed bed target front end





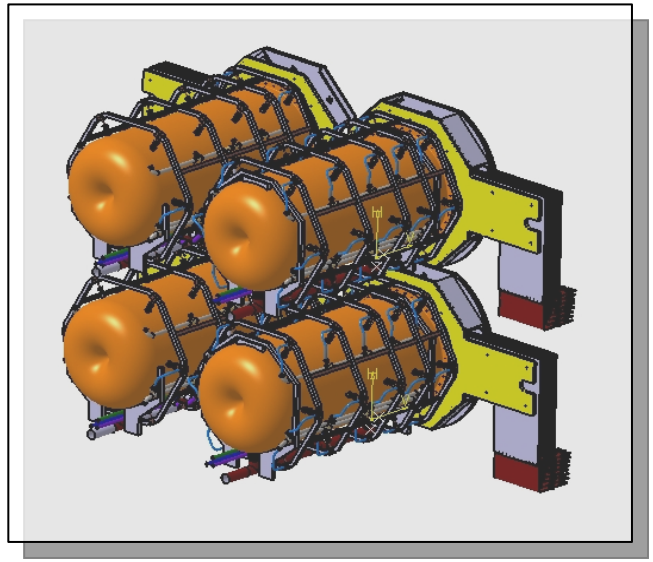
Model Parameters

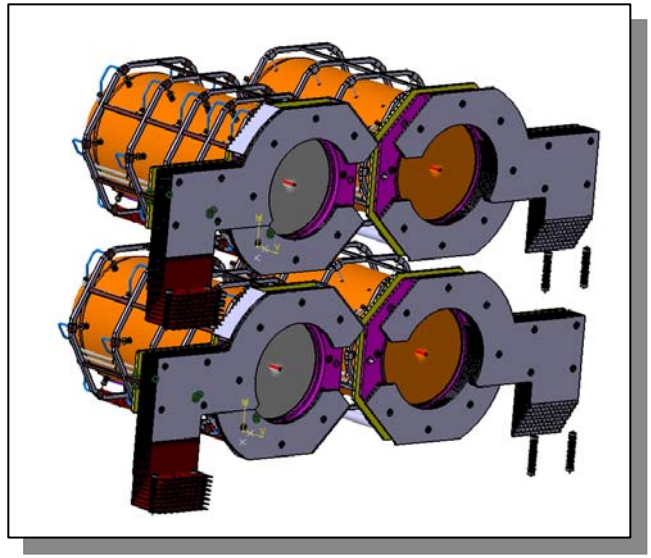
Proton Beam Energy = 4.5GeV
Beam sigma = 4mm
Packed Bed radius = 12mm
Packed Bed Length = 780mm
Packed Bed sphere diameter = 3mm
Packed Bed sphere material : Beryllium or Titanium
Coolant = Helium at 10 bar pressure

Horn: Current status for WP2

Target Station Baseline :

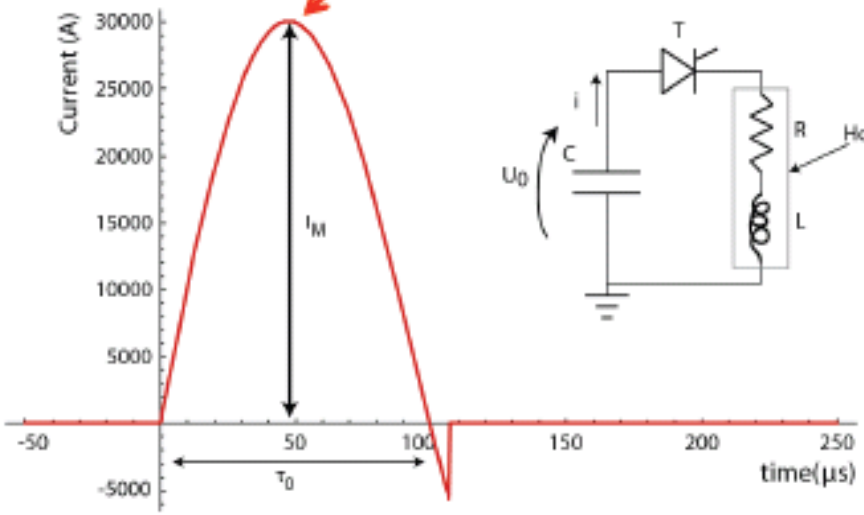
- Solid Static target
- Use multiple 4 targets+ horns
- Beam frequency 12.5 Hz
- Cooling (EUROnu WP2 Note 10-06)
- Power distribution due to Joule losses & secondary particles
- Energy balance, to maintain working temperature
- Flow rate
- Jet distribution along the outer conductor
- h correlation for jets' geometry

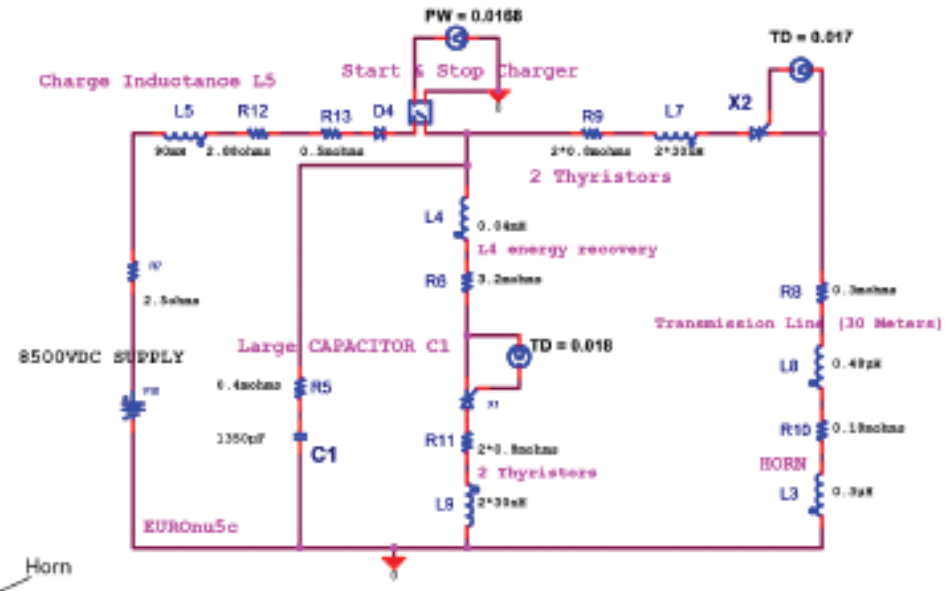




Horn: Current status for WP2

focusing done during this "plateau" proton pulse duration must be limited (<5 μs)





energy recuperation (>60%) and reinjection

U_0	7 kV
I_M	300 kA (14.5 rms)
τ_0	100 μs
L	0.6 (0.4 Horn) μH
R	500 (180 Horn) μΩ
C	1500 μF

300 kA/50Hz it's a real challenge

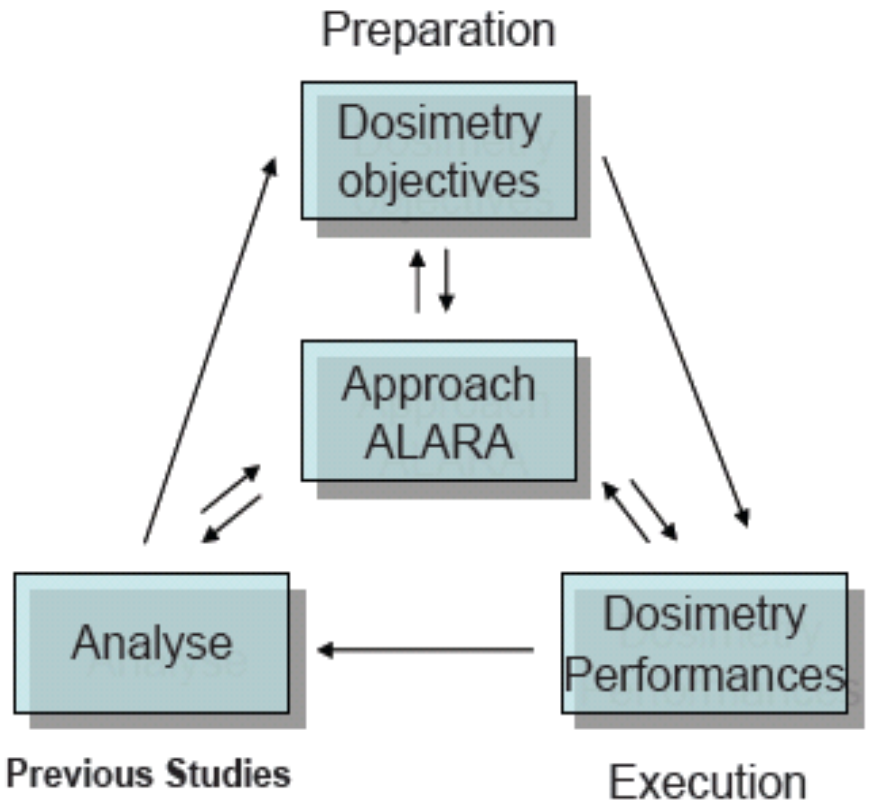
Safety Items in WP2

Toward a safety WP2 roadmap

- **ALARA approach :**

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

- **Iterative processes :**
  - 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…)

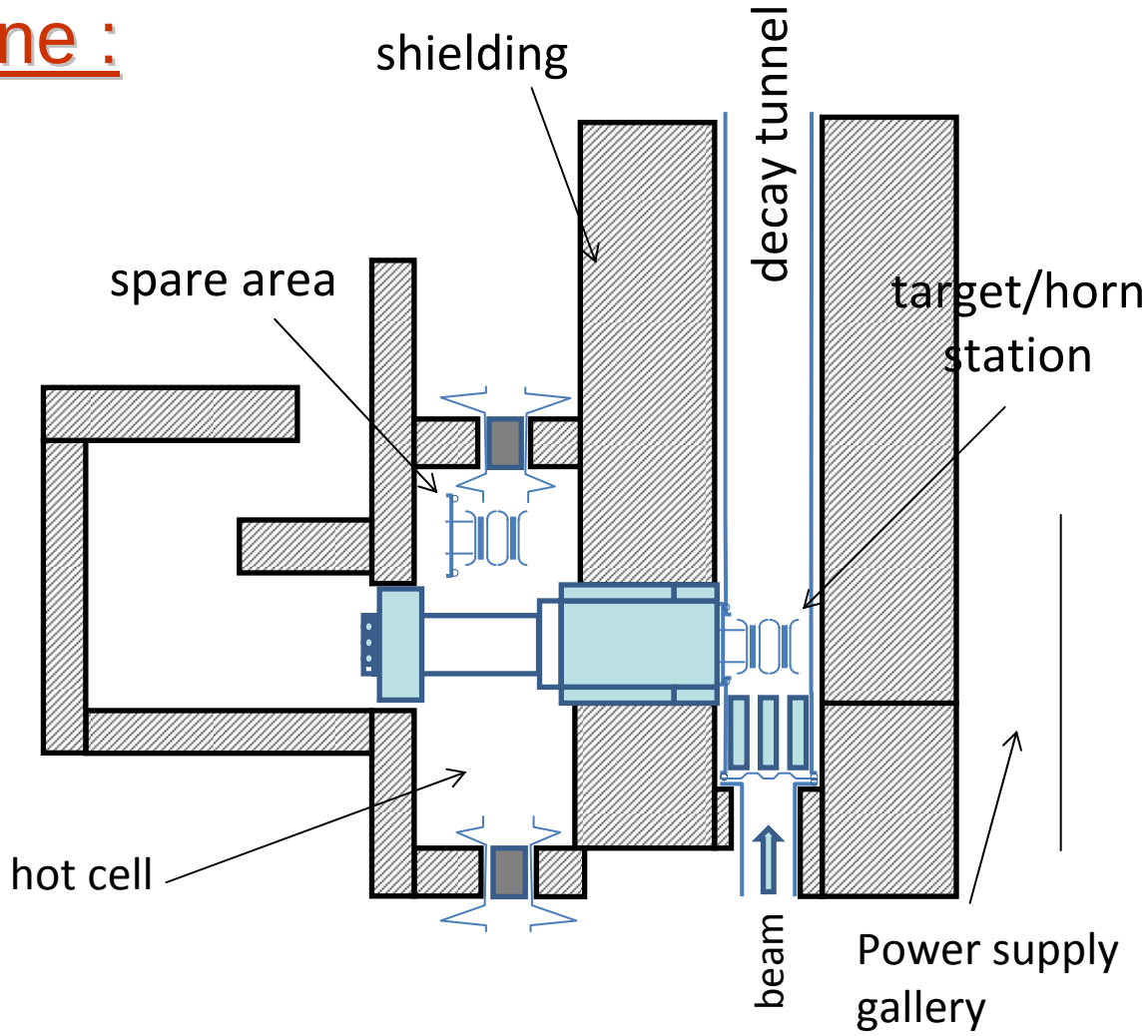


As Low As Reasonably Achievable

Design

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
  - …
- **Waste Area**



Safety : Elements

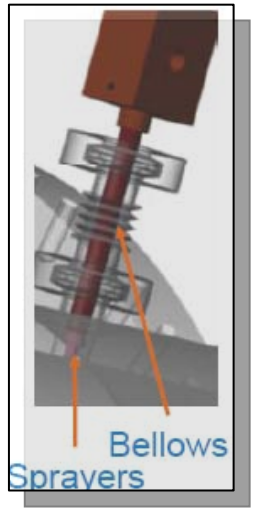
MW Target Station :

- 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 …)
- Residual Dose Rate Plateform
- Investigation of other radionucleides transport (environmental constraint)
- …

Feed back from other neutrino beam experiments

Recommandations from others facilities:

- Cracks in welds
- Use flexible pipes to reduce stress and fatigue
- Use semi flexible conductor because of important magnetic force between stripline => can break cable
- Heat dissipation of the stripline
- Water leaks due to galvanic corrosion => avoid trapped water and choose material carefully
- Remote design for repairing/exchange
- Need Spares
- …



Stripline plate with soft transition

Radiations simulations : CNGS Benchmark.

Beam Features:

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

Target (CNGS like):

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

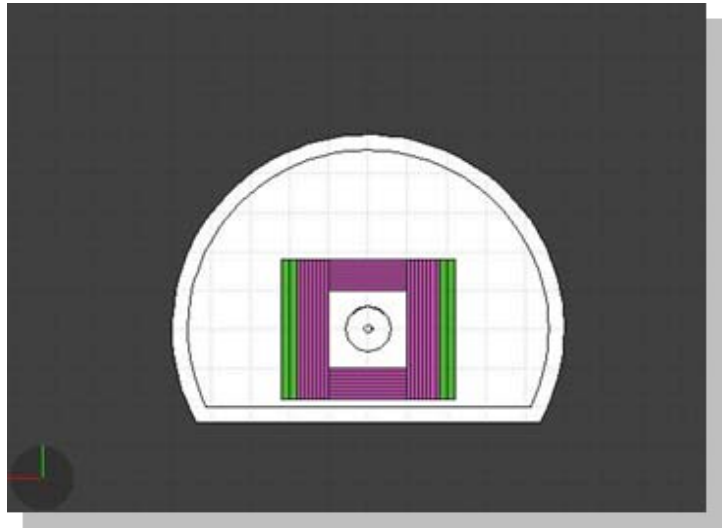
Horn:

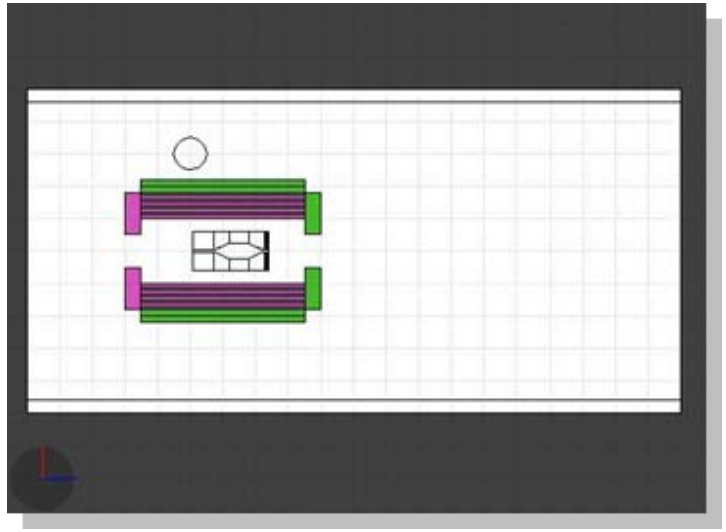
- Material : Anticorodal 110

Shielding for the Target Station :

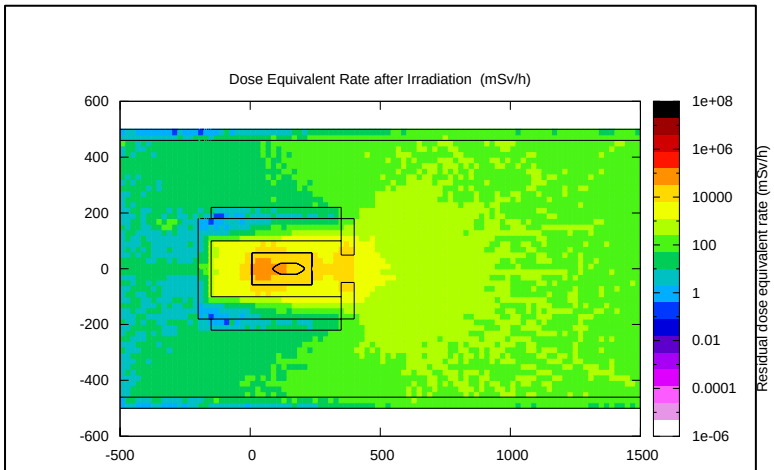
- Walls and roof: 80 cm of Iron, 8 Slabs (2.5m x 2m x10cm)
- Lateral and Front Marble Slabs
- Front Iron Slab

⇒ Evolution of the DER with time performed with FLUKA 2011.2.3

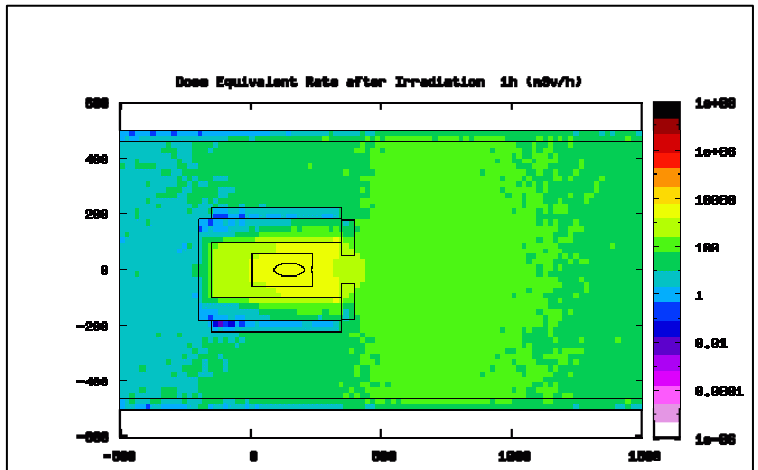




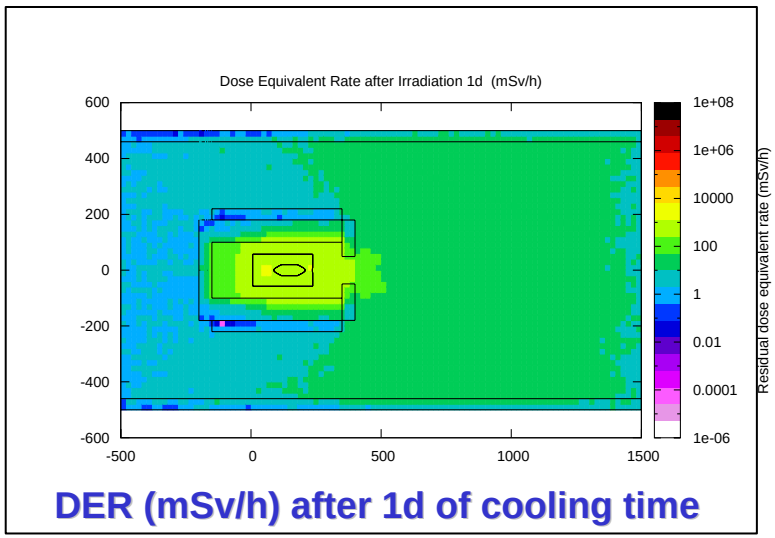
Radiations simulations : CNGS Benchmark.



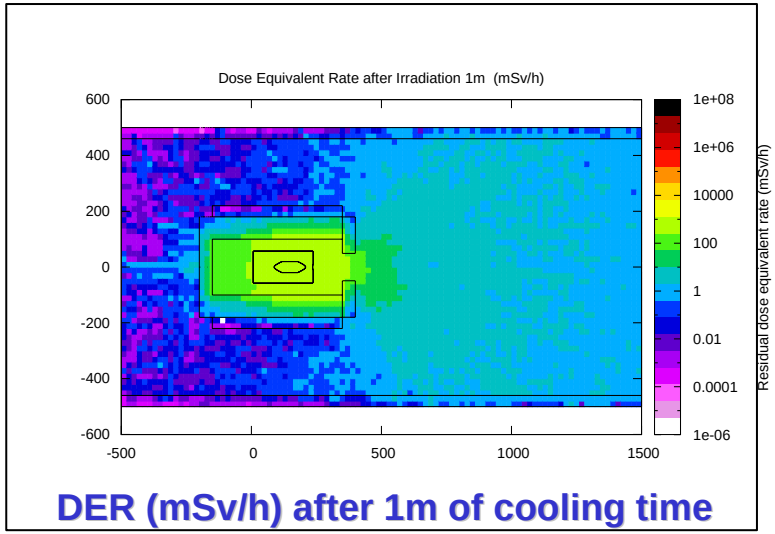
DER (mSv/h) after stopping irradiation



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



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



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

Radiations simulations : Titanium Target.

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)

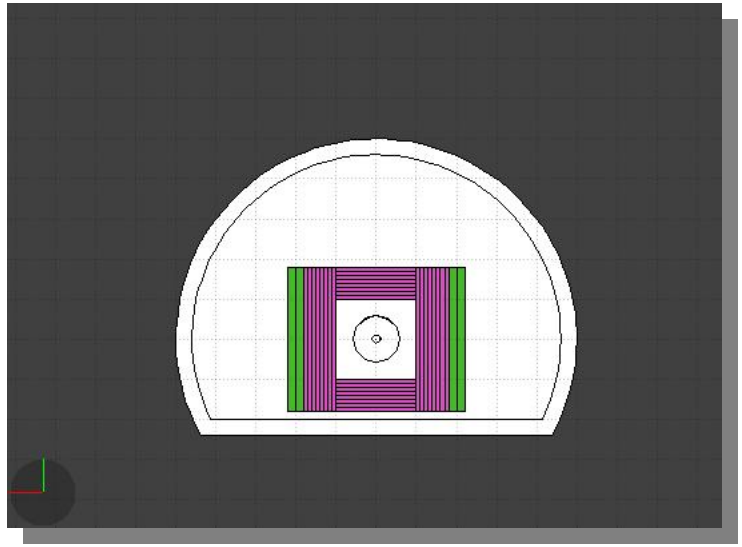
Horn:

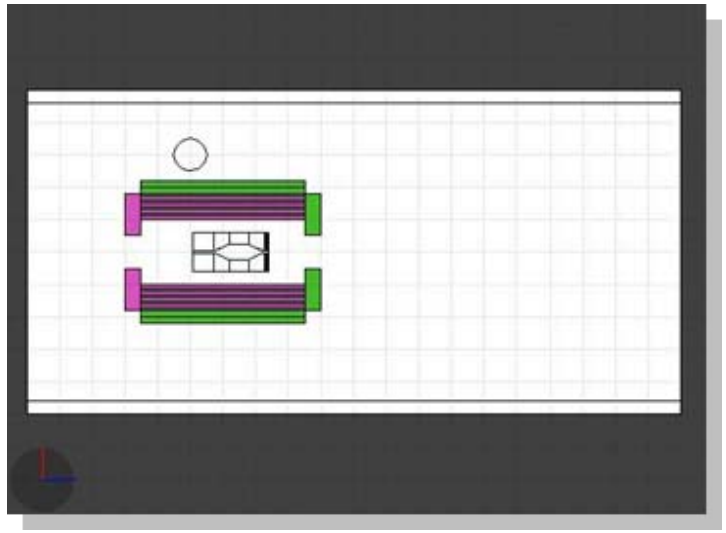
- Material : Anticorodal 110

Shielding for the Target Station :

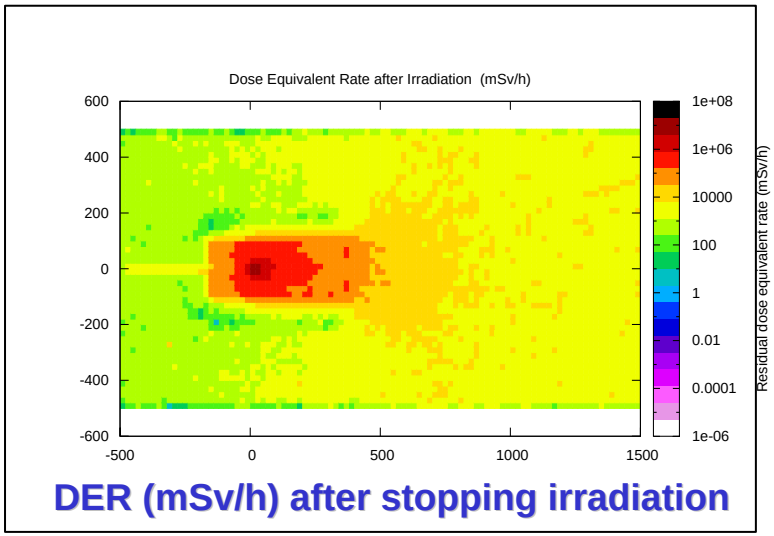
- Walls and roof: 80 cm of Iron, 8 Slabs (2.5m x 2m x10cm)
- Lateral and Front Marble Slabs
- Front Iron Slab

⇒ Evolution of the DER with time performed with FLUKA 2011.2.3

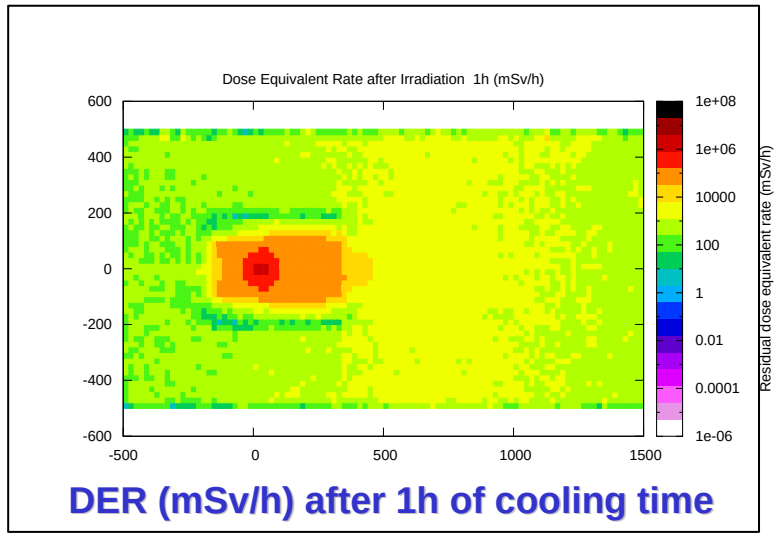




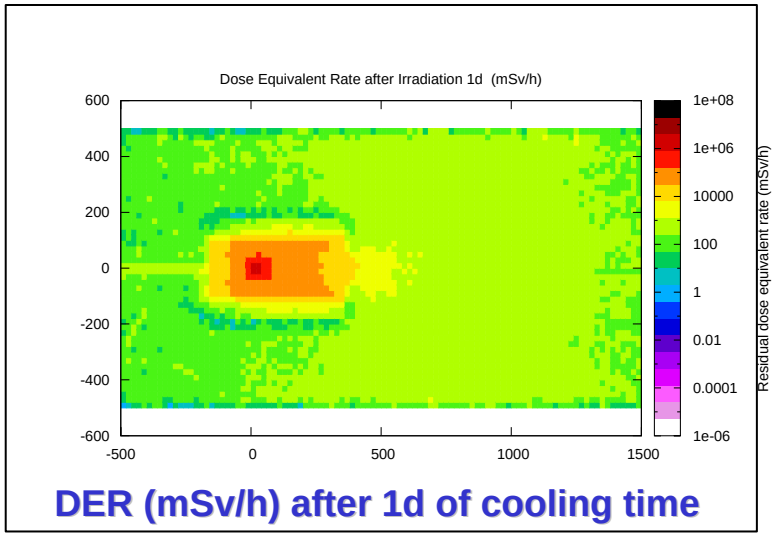
Radiations simulations : Titanium Target.



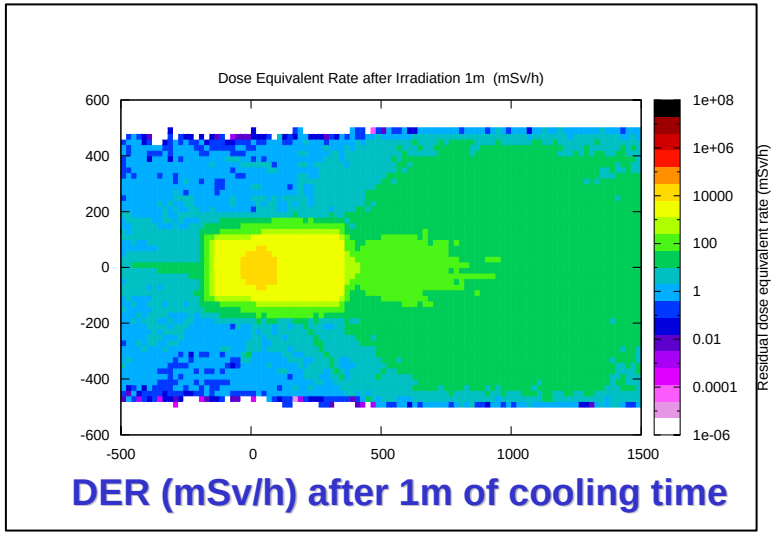
DER (mSv/h) after stopping irradiation



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



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



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

Radiations simulations : Four Horn Station

Chemical composition of Material:

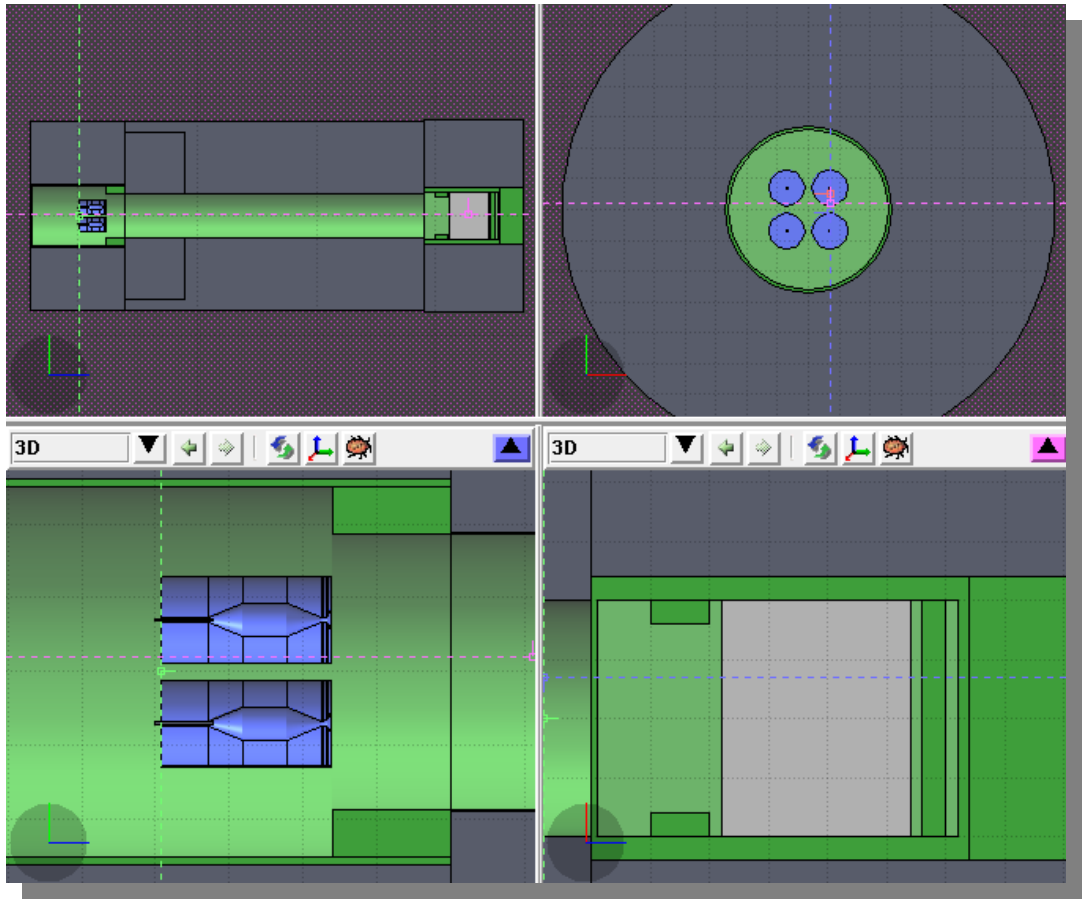
Target => Ti(100%)

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%)

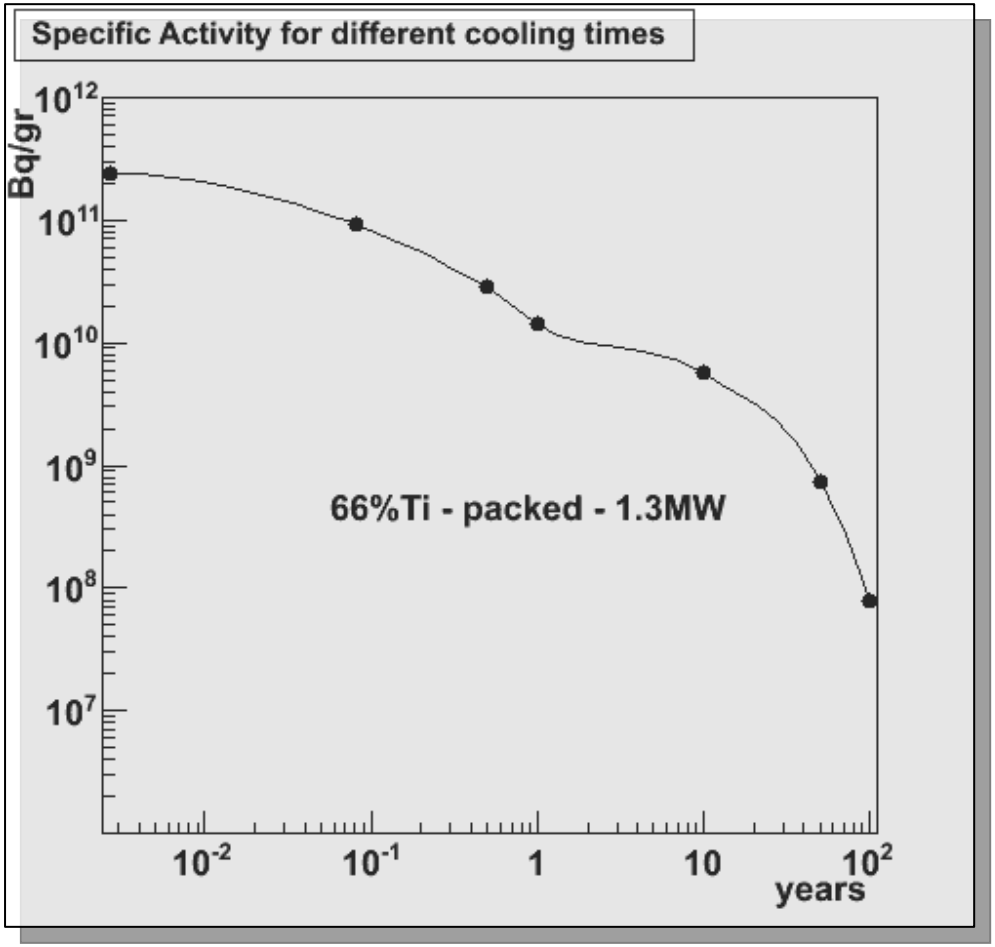
Surrounding Environment => Molasse
O(49%), Si(20%), Ca,(9.7%), Al(6.4%), C(5%), Fe(3.9%), Mg(3.2%), K(1%), Na(0.5%), Mn(0.1%)

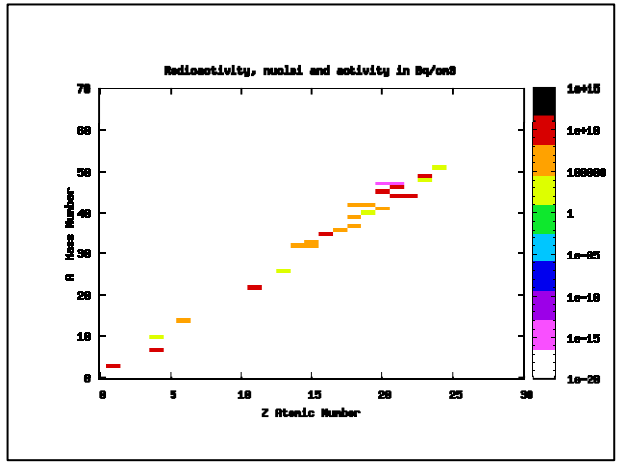


Four horn station layout

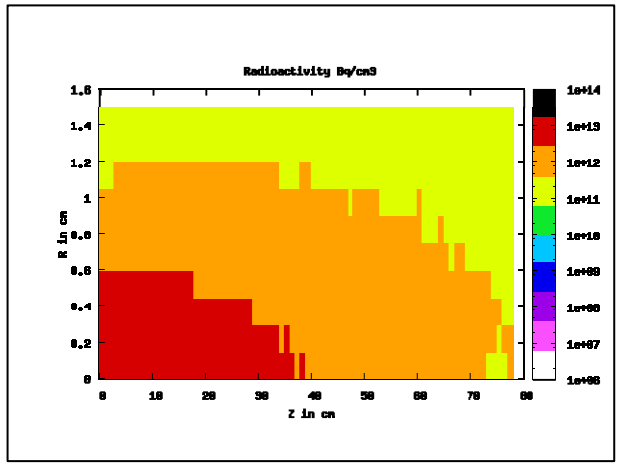
Radiations simulations : Four Horn Station

Evolution of the target activity with cooling time:





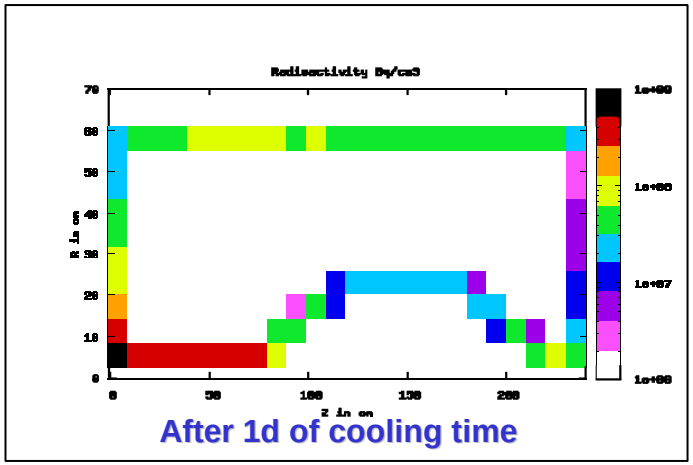
Residual nuclei



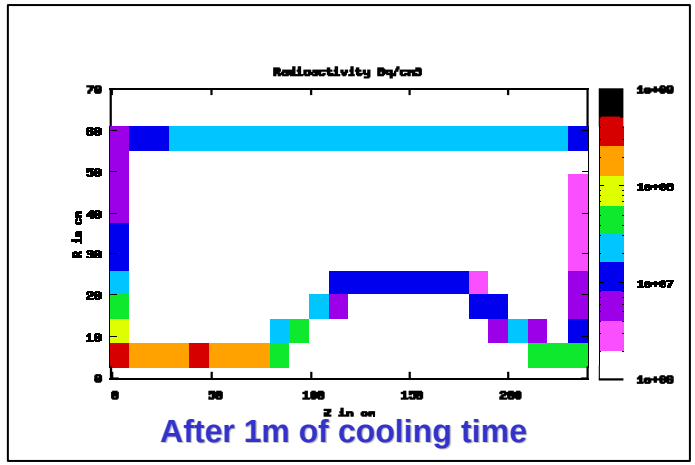
After 1 day

Radiations simulations : Four Horn Station

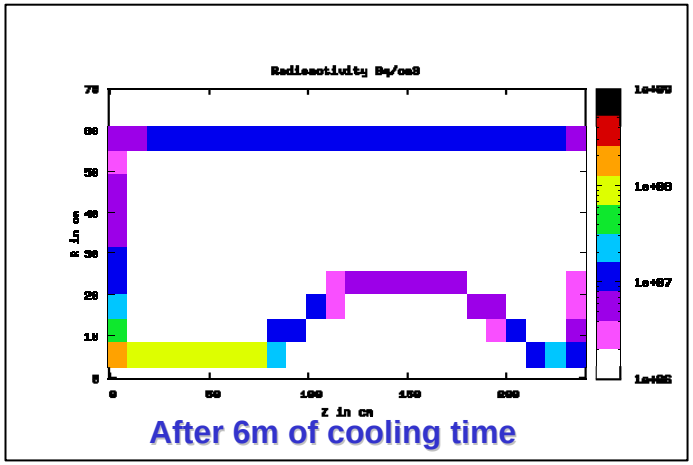
Evolution of the horn specific activity (Bq.cm^{-3}) with cooling time:



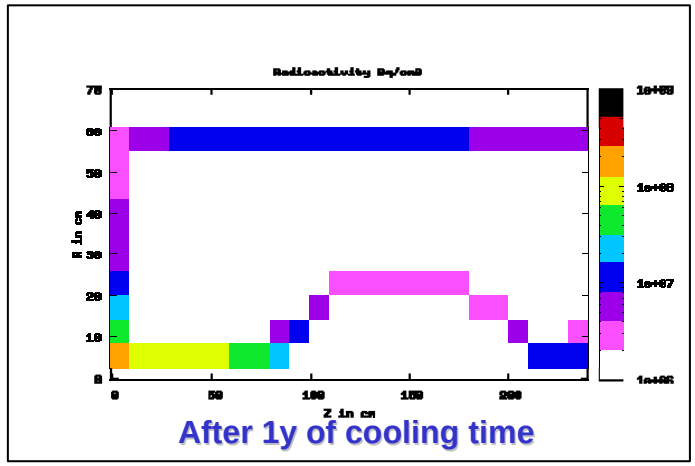
After 1d of cooling time



After 1m of cooling time



After 6m of cooling time



After 1y of cooling time

Radiations simulations : Four Horn Station

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