

# Studies on Energy Deposition and Radiation for the 4horn system

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# Talk's Layout

## Energy Deposition on:

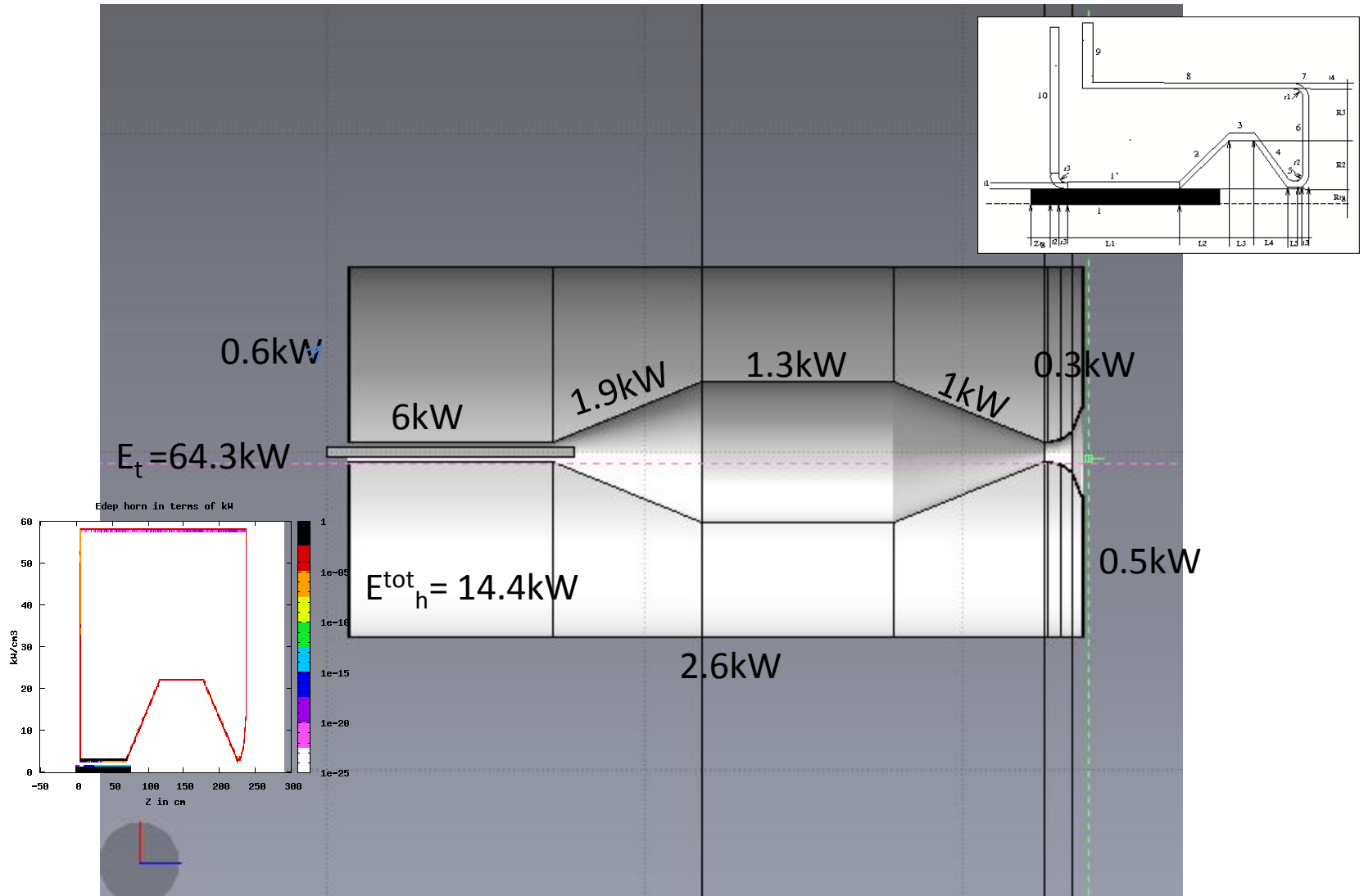
- Latest Horn Design
- 4horn system

## Radiation:

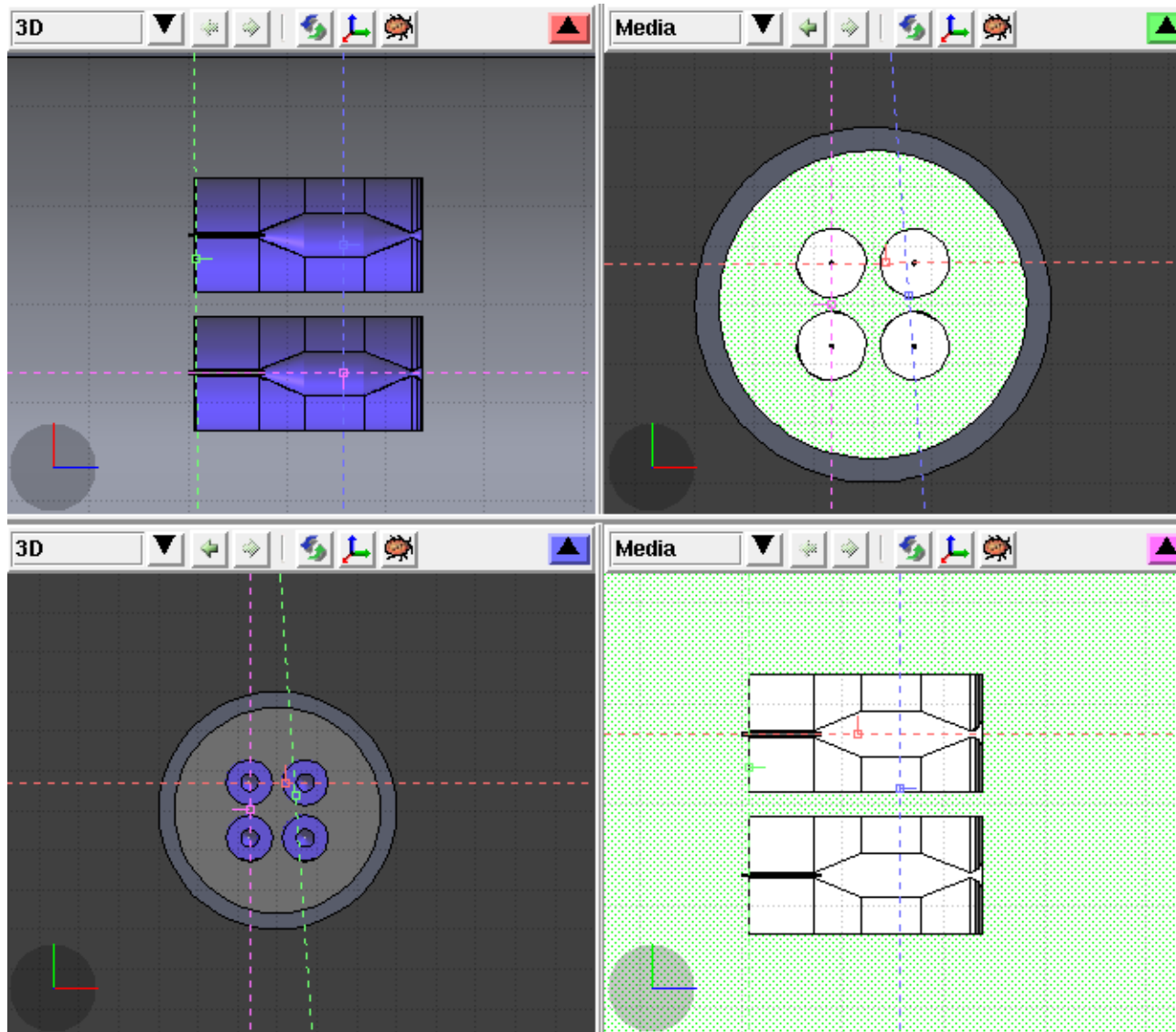
- plan for the study
- 1horn example (preliminaries):
  - activity after initial irradiation time and different cooling times
  - synthesis of the radioactivity
- MicroShield program for dose rates
- comparison with older CERN's neutrino factory WG studies

# Energy deposition on 4horn System

studies done with flair 0.9.1 with geoviewer 0.9, fluka 2008.3d

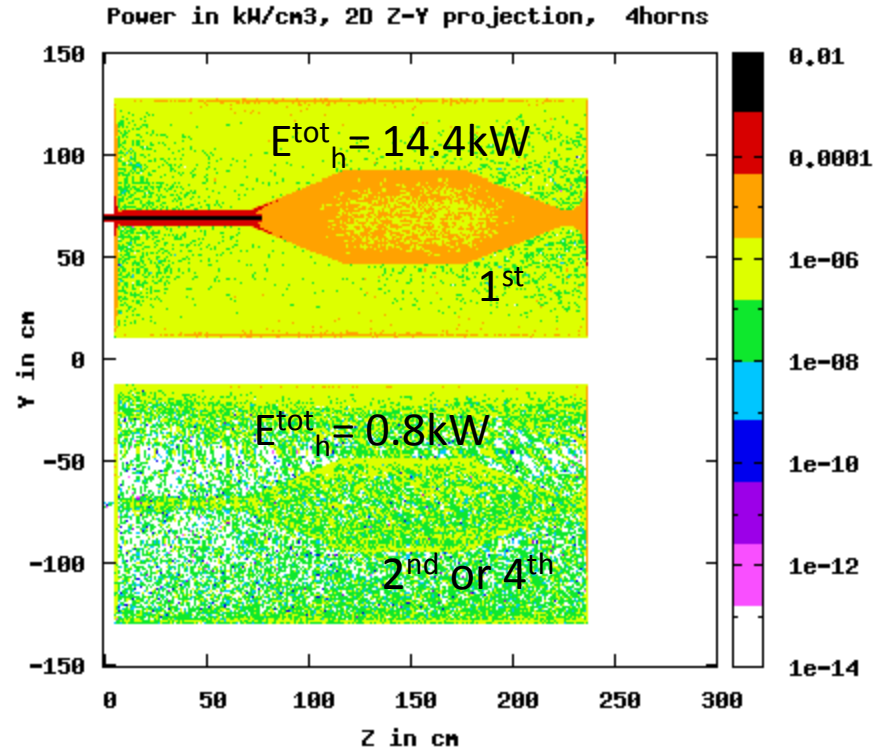
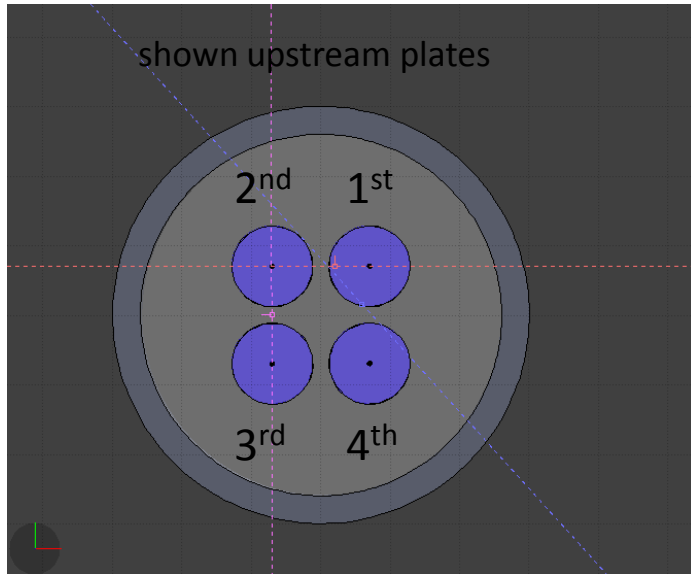


# flair's GUI geoviewer for 4horns



# Power on horn # 2,4 (next to the active one)

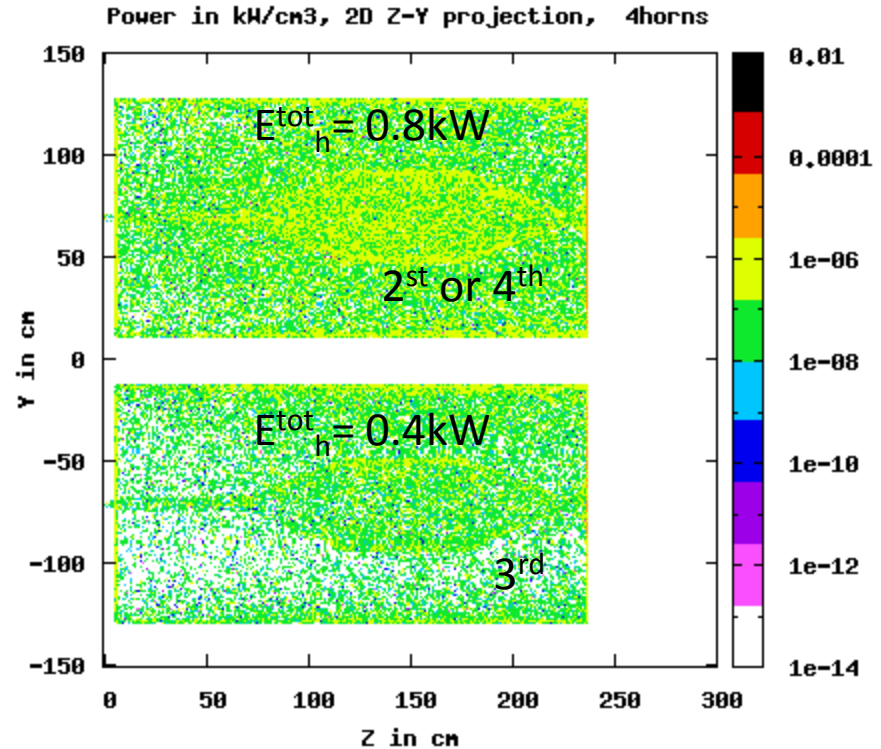
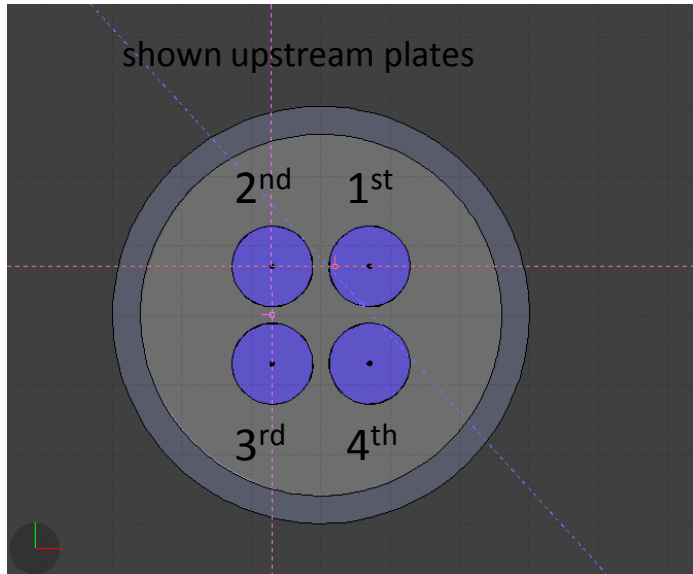
- active horn is # 1, 1.3MW beam, 350kA



Power in kW for the horn next to the active one			
total	inner	outer	plates
0.8	0.1	0.6 (50% next to 1 <sup>st</sup> )	0.1

# Power on horn # 3 (diagonal to the active one)


- active horn is # 1, 1.3MW beam, 350kA



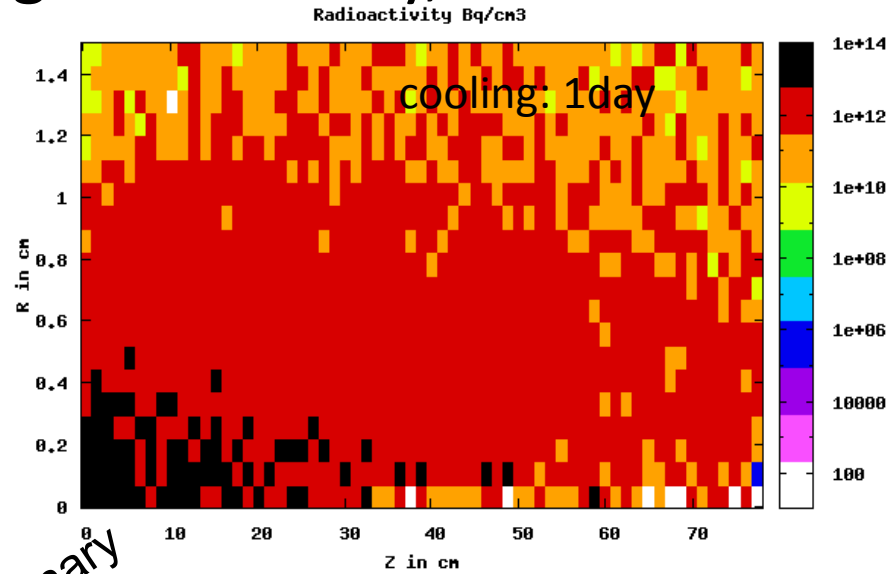
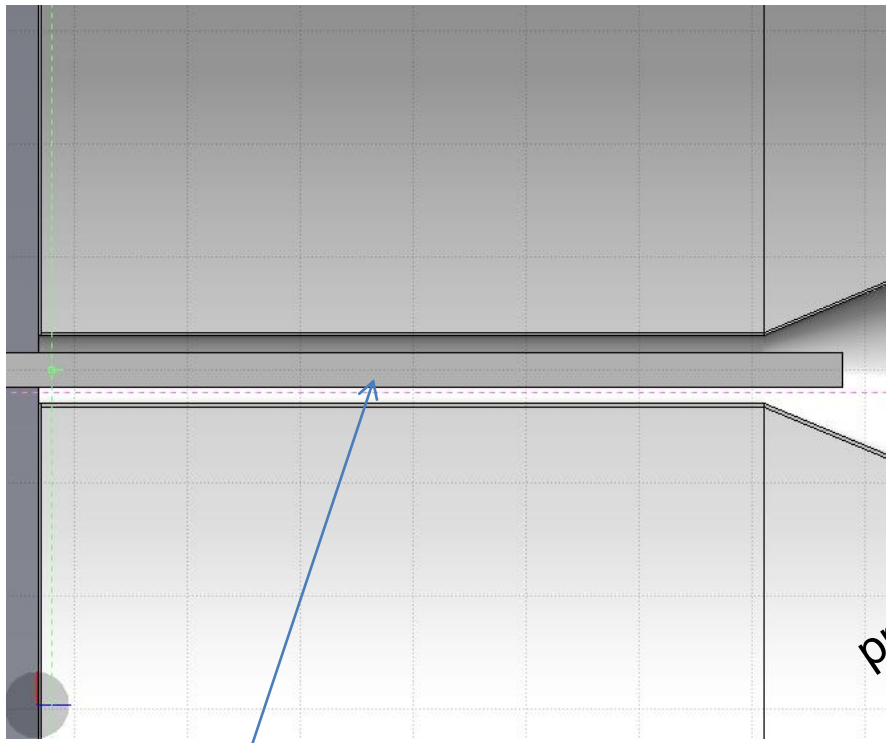
Power in kW for the horn diagonal to the active one			
total	inner	outer	plates
0.4	0.06	0.28 (50% next to 1 <sup>st</sup> )	0.06

# Layout of Radiation Studies

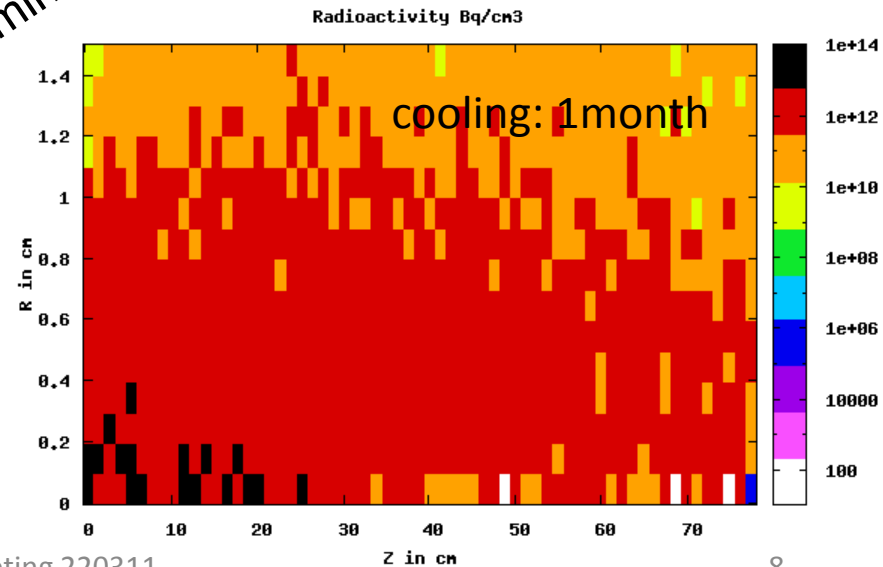
for a given part of the SB layout e.g. target, horn, cable, tunnel ...

- specify the level radioactivity and its synthesis after irradiation of 200days and different cooling times ...
- use MicroShield program to calculate effective doses at the different distances from the radiated material  define shielding
- make comparisons with results from older CERN's Neutrino Factory Group studies based on notes from
  - CNGS <http://proj-cngs.web.cern.ch/proj-cngs/>
  - old CERN's Neutrino Factory studies <http://slap.web.cern.ch/slap/NuFact/NuFact/NFNotes.html>
  - FLUKA courses [http://fluka-course.web.cern.ch/fluka-course/index.php?id=c\\_program](http://fluka-course.web.cern.ch/fluka-course/index.php?id=c_program)

target's radioactivity, 4MW :  
 irradiation=200days cooling times= 1day, 1month



preliminary

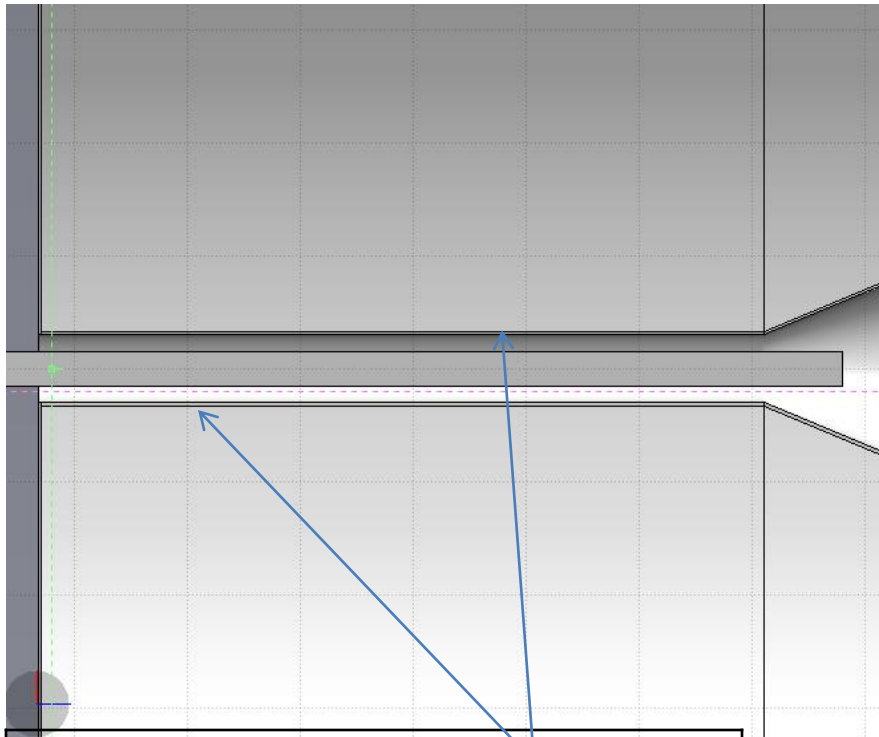


target activity in Bq (decays/sec)	
1day	1month
3.8E14	2.7E14

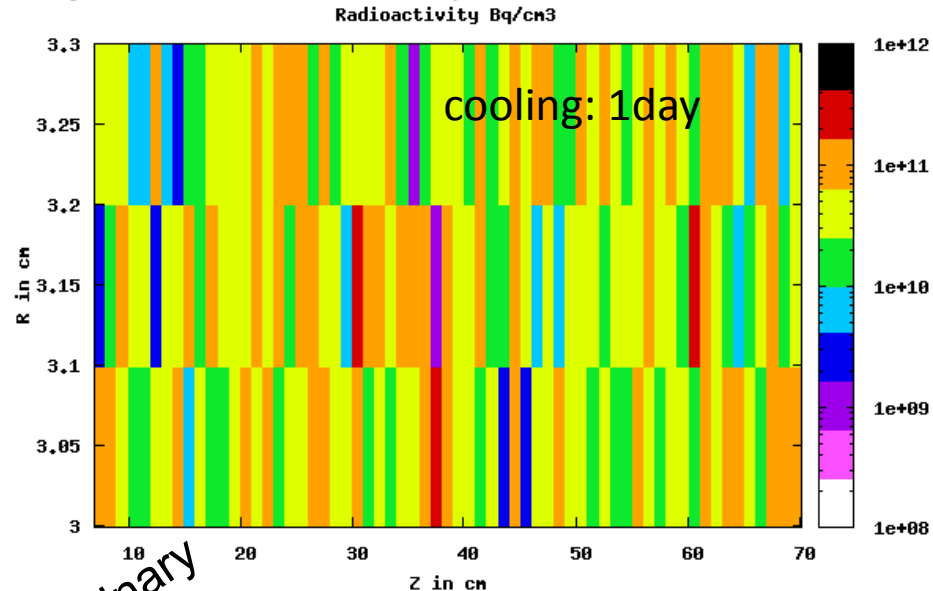


# Horn's radioactivity, 4MW :

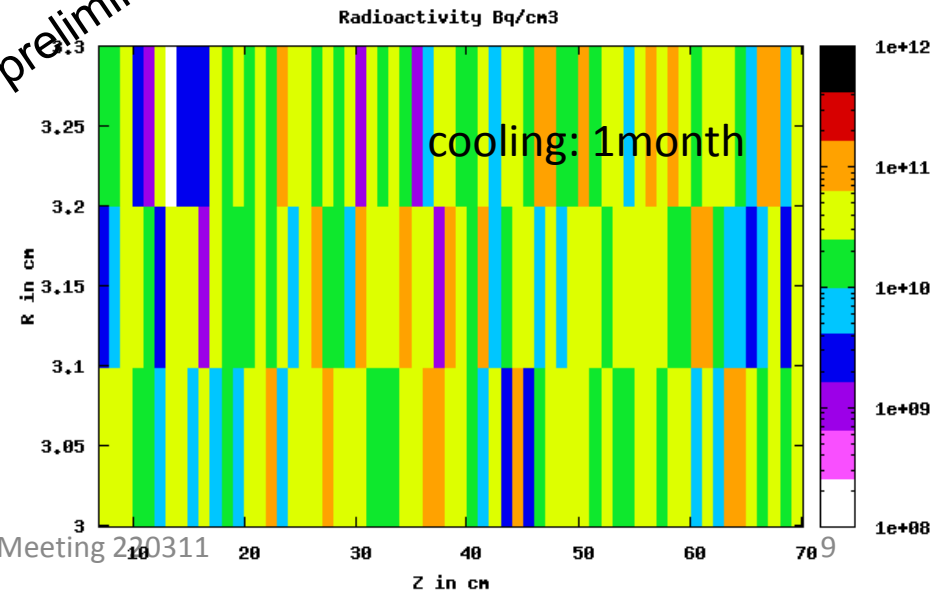
irradiation=200days cooling times= 1day, 1month



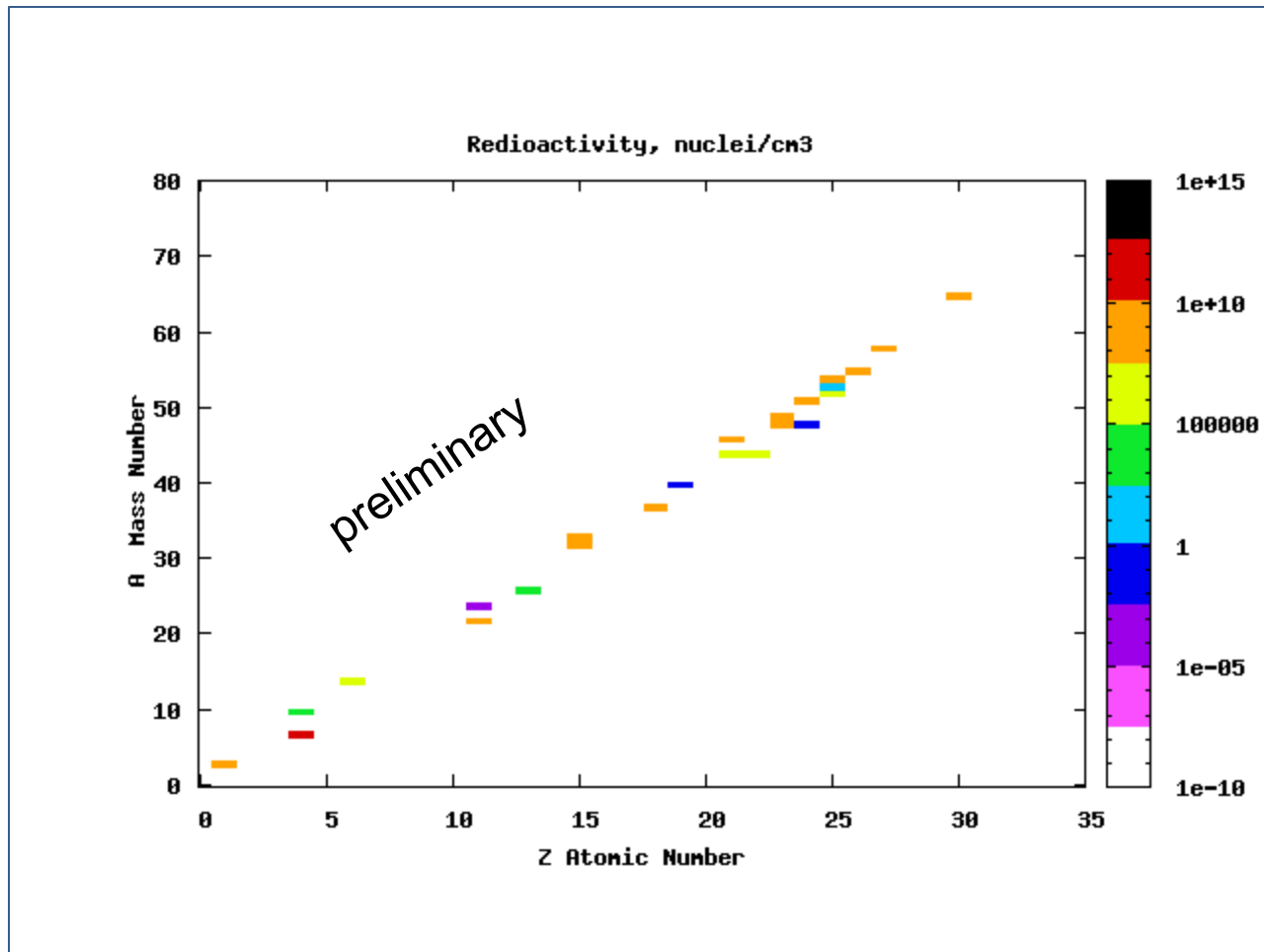
inner conductor (around target) activity in Bq	
1day	1month
2.E13	1.2E13



preliminary



# map of radio nuclei, cooling= 1month



*analyses will be done with MicroShield program*



# Operational Quantity Estimation

## Operational Quantities:

Equivalent Dose (Sv) :

$$H_T = \sum_R w_R \cdot D_{T,R}$$

Effective Dose (Sv):

$$E = \sum_T w_T \cdot H_T$$

## Microshield v8.03 :

- Evaluate **gamma** dose from library/user-defined source with simple geometry,
- Include the conversion coefficients defined by ICRP 74 for operational quantities,
- Possibility to investigate the protection of workers with simple shielding and different materials

Radiation Weighting factors

Radiation Type and Energy Range	Radiation Weighting Factor, $w_R$
X and $\gamma$ rays, all energies	1
Electrons positrons and muons, all energies	1
Neutrons:	
< 10 keV	5
10 keV to 100 keV	10
> 100 keV to 2 MeV	20
> 2 MeV to 20 MeV	10
> 20 MeV	5
Protons, (other than recoil protons) and energy > 2 MeV,	2-5
$\alpha$ particles, fission fragments, heavy nuclei	20

## Tissue weighting factors

Tissue	Tissue Weighting Factor, $w_T$
Gonads	0.20
Red bone marrow	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Bladder	0.05
Breast	0.05
Liver	0.05
Esophagus	0.05
Thyroid	0.05
Skin	0.01
Bone surfaces	0.01
Remainder	0.05

# MicroShield : Example dose calculation for 1Ci $^{24}\text{Na}$ .

MS Cylinder Volume - Side Shields - Case1 - Example Case

Dimension	Materials	Source	Buildup	Integration	Title	Sensitivity
Height	48					
Radius	24					
Wall Clad	0.5					
Top Clad	0					

Dose	X	Y	Z	Air Gap
1	120	36	0	59.5
2	108	24	0	47.5
3				NA
4				NA

X: 20 Y: 340 Z: 0 Zoom In Out

T  
 Sh 1  0 Cy  
 Sh 2  12 Tr  
 Sh 3  24 SI  
 Sh 4  0 SI  
 Sh 5  0 SI  
 Sh 6  0 SI  
 Sh 7  0 SI  
 Sh 8  0 SI  
 Sh 9  0 SI  
 Sh 10  0 SI

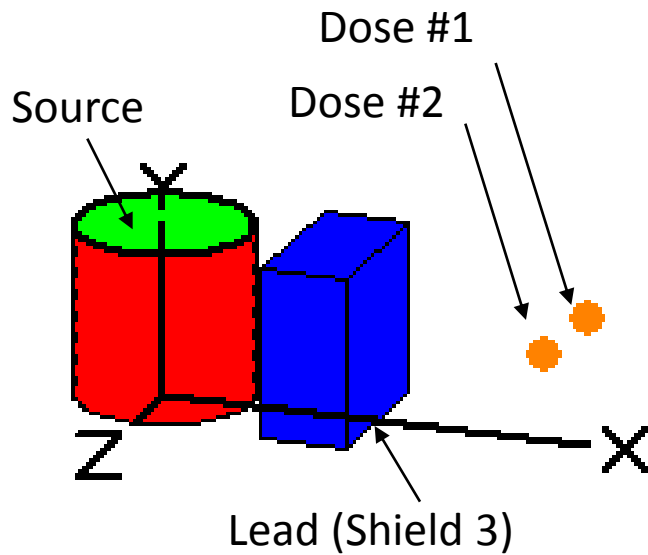
Units: Inches

Run Status

Run Case Save Save As Results Report With Buildup Without Buildup Lin. Atten. Coeff. Dose Equivalent Graph Sensitivity Cancel Close

# MicroShield : Example dose calculation for $1\text{Ci }^{24}\text{Na}$ .

**Summary** : the  $^{24}\text{Na}$  source is uniformly distributed in an iron cylinder.



Geometry with Lead Shielding

Source Dimensions			
Height	121,92 cm (4 ft)		
Radius	60,96 cm (2 ft)		
Dose Points			
A	X	Y	Z
#1	304,8 cm (10 ft)	91,44 cm (3 ft)	0,0 cm (0,0 in)
#2	274,32 cm (9 ft)	60,96 cm (2 ft)	0,0 cm (0,0 in)
Shields			
Shield N	Dimension	Material	Density
Source	8,69e+04 in <sup>3</sup>	Iron	7,86
Transition	12,0 in	Air	0,00122
Shield 3	24,0 in	Lead	11,34
Air Gap		Air	0,00122
Wall Clad	0,5 in	Iron	7,86

# MicroShield : Example dose calculation for 1Ci <sup>24</sup>Na.

## Results no shielding :

Results - Dose Point # 1 - (120,36,0) in					
Energy (MeV)	Activity (Photons/s)	Fluence Rate MeV/cm <sup>2</sup> /s No Buildup	Fluence Rate MeV/cm <sup>2</sup> /s With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
1,3685	3,700e+10	6,422e+02	1,848e+03	1,107e+00	3,185e+00
2,7541	3,695e+10	2,123e+03	4,554e+03	2,960e+00	6,351e+00
3,8236	2,371e+07	2,221e+00	4,284e+00	2,789e-03	5,380e-03
<b>Totals</b>	<b>7,397e+10</b>	<b>2,767e+03</b>	<b>6,407e+03</b>	<b>4,070e+00</b>	<b>9,541e+00</b>
Results - Dose Point # 2 - (108,24,0) in					
Energy (MeV)	Activity (Photons/s)	Fluence Rate MeV/cm <sup>2</sup> /s No Buildup	Fluence Rate MeV/cm <sup>2</sup> /s With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
1,3685	3,700e+10	8,224e+02	2,361e+03	1,417e+00	4,069e+00
2,7541	3,695e+10	2,715e+03	5,816e+03	3,786e+00	8,111e+00
3,8236	2,371e+07	2,839e+00	5,471e+00	3,565e-03	6,871e-03
<b>Totals</b>	<b>7,397e+10</b>	<b>3,540e+03</b>	<b>8,183e+03</b>	<b>5,207e+00</b>	<b>1,219e+01</b>

# Previous studies from CERN Neutrino Factory.

## Beam Parameters :

- Energy : 2.2 GeV
- Beam Power : 4 MW
- Target Material : Mercury

## Magnetic Horn Parameters :

- Current 300kA and 600kA
- Horn Material ANTICORODAL 110 Alloy

## Framework :

- Particle Transp. Code : FLUKA
- Equiv. Dose Rate Estimation : MicroShield

Radionuclide map obtained with FLUKA after 6 weeks of irradiation.

=> Dose Rate at 1 m : 10.Sv/h

S. Agosteo, M. Magistris, T. Otto, M. Silari, « Induced radioactivity in the target Station and the decay tunnel from 4MW Proton beam », CERN –TIS – 2002 – 018 – RP – CF

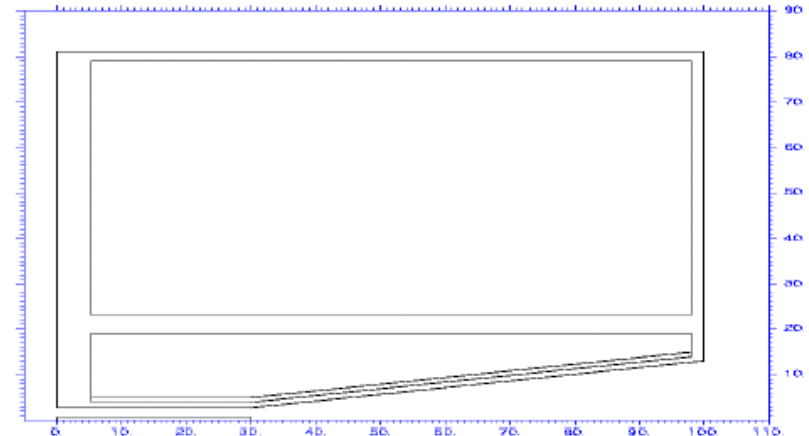


Figure 2: Cross sectional view of the magnetic horns

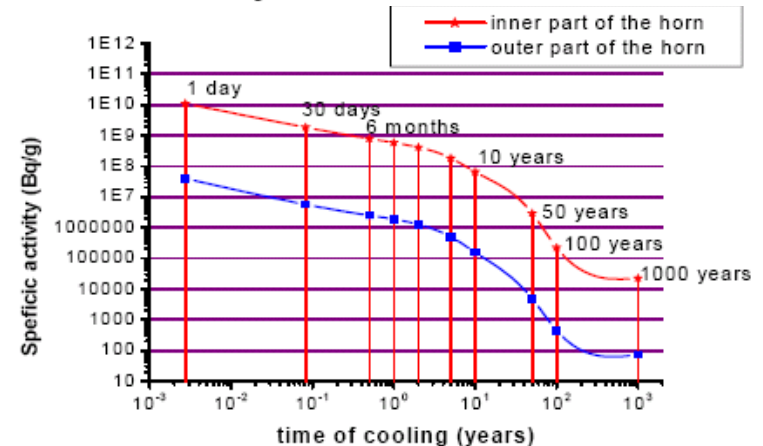
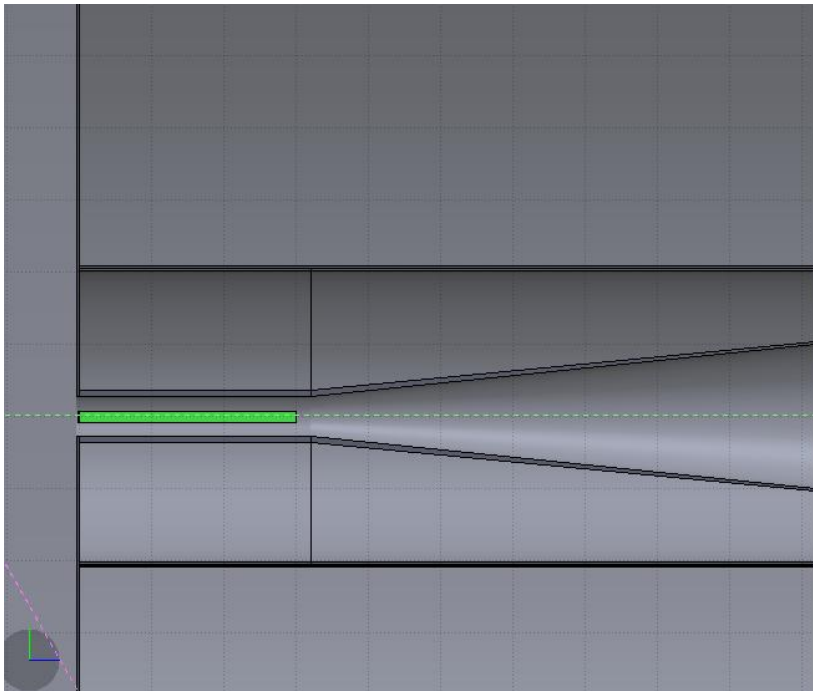


Figure 3: Specific activity of the magnetic horns after 6 weeks of irradiation.

# simulation of the old CERN's NF Group horn

- reference CERN-NUFACT-Note-134



in progress, have to make sure similar parameters are used

- target, inner energy deposition at 15% agreement
- radiation studies shows similar specific activity degradation from 1day to 10years



# future work, plans for next month

further studies on Energy deposition

- calculate the energy deposition of the secondary particles at the target/horn's area and at the decay tunnel/beam dump

Continuation of radiation studies

- first calculate the dose rates for target and horn then for the 4horn system
- also, comparisons with the work from older CERN's Neutrino Factory Group

*THANKS*