General status of RP studies and investigations on the Decay Ring

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CERN

Summary

- Decay Ring:
  - Residual dose rates during maintenance
  - Airborne activity released in the environment
  - Produced radionuclides
- Status of RP studies:
  - Residual dose rates during maintenance
  - Airborne activity released in the environment

Decay Ring

- Only decay losses.
- Bumps and arcs.
- Total number of decays/s in the DR:

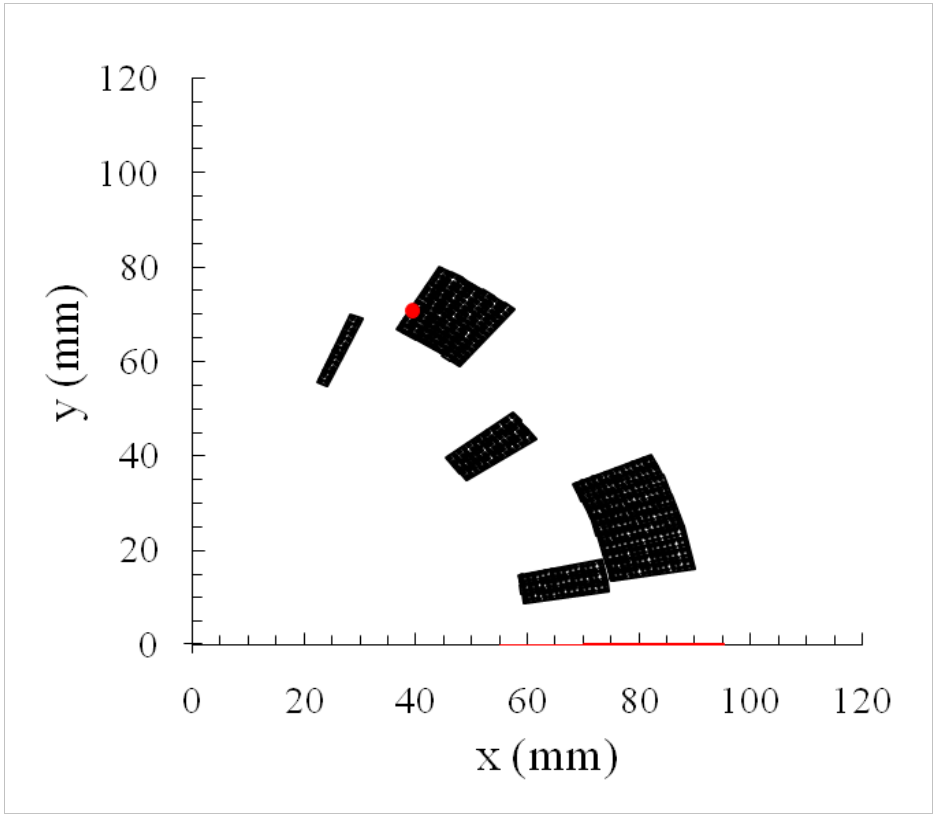
$$^{6}\mathrm{He}: \ 6.75\mathrm{E}11 \ (\frac{\text{total decays}}{\text{s}})$$

$$^{18}\mathrm{Ne}: \ 2.48\mathrm{E}11 \ (\frac{\text{total decays}}{\text{s}})$$

•Arc lattice cell: D-A-D-A-Q-A-D-A-D; (D=dipole, A=absorber, Q=quadrupole)

•Arc entrance cell: D-drift(~ 20 m)-Q

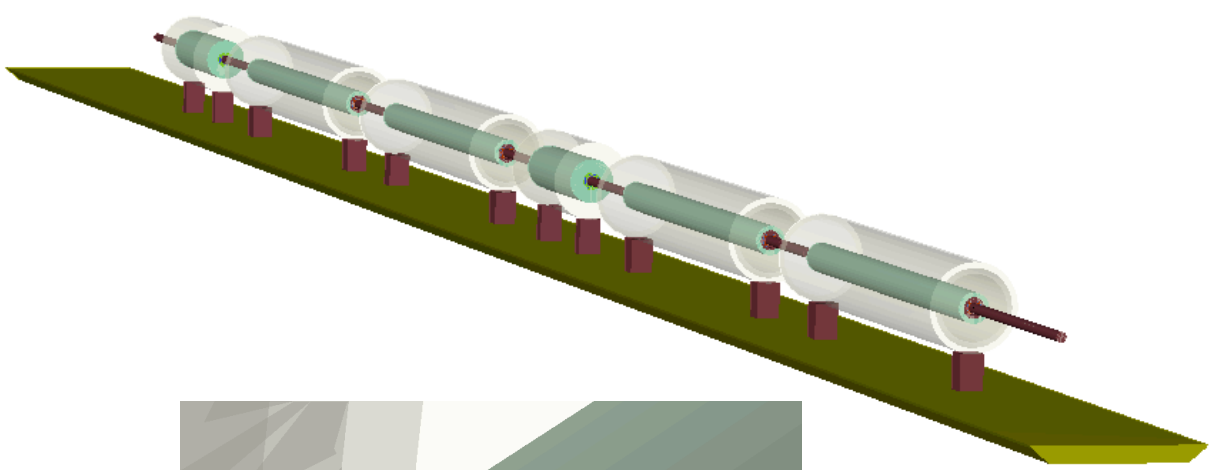
Layout for FP7

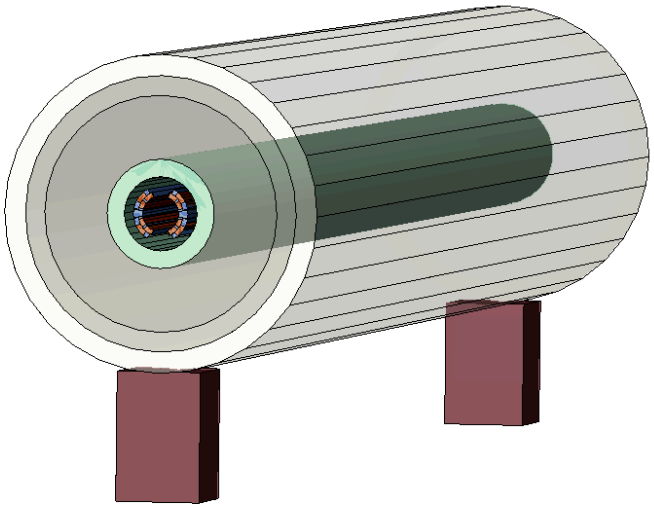


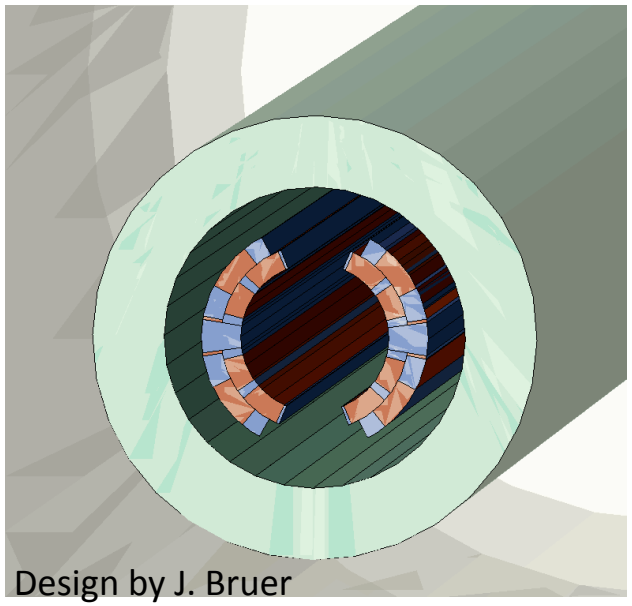
NO OPEN MID-PLANE: CABLES INSTEAD!

Design	1
r (aperture)	60
b_3	-0.90
b_5	-0.73
b_7	0.67
b_9	-0.25
b_{11}	0.38
Bss (T)	5.95
Gap in midplane (mm)	8.9
φ_1	8.500
φ_2	35.4
φ_3	66.3
φ_4	10.2
φ_5	51.00
r1,r2 (mm)	60,76
Ncon	3,3,1,11,7
Tot Ncon	25
Collars (mm)	30
Copper wedge #1 (degrees)	0-8.5
Copper wedge #2	14.2-35.4
Copper wedge #3	41.1-66.3
Copper wedge #4	0-10.2
Copper wedge #5	26.6-51.0
Yoke (mm)	180
Sector 1 (degrees)	8.5-14.2
Sector 2	35.4-41.1
Sector 3	66.3-68.2
Sector 4	10.2-26.6
Sector 5	51-61.4

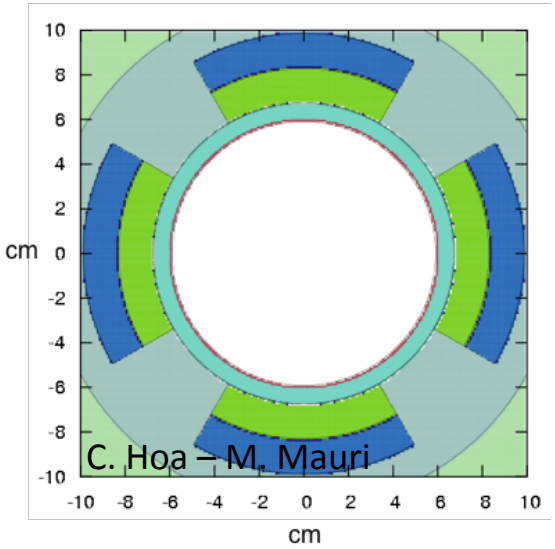
ARC DIPOLES & QUADRUPOLES







Design by J. Bruer



C. Hoa – M. Mauri

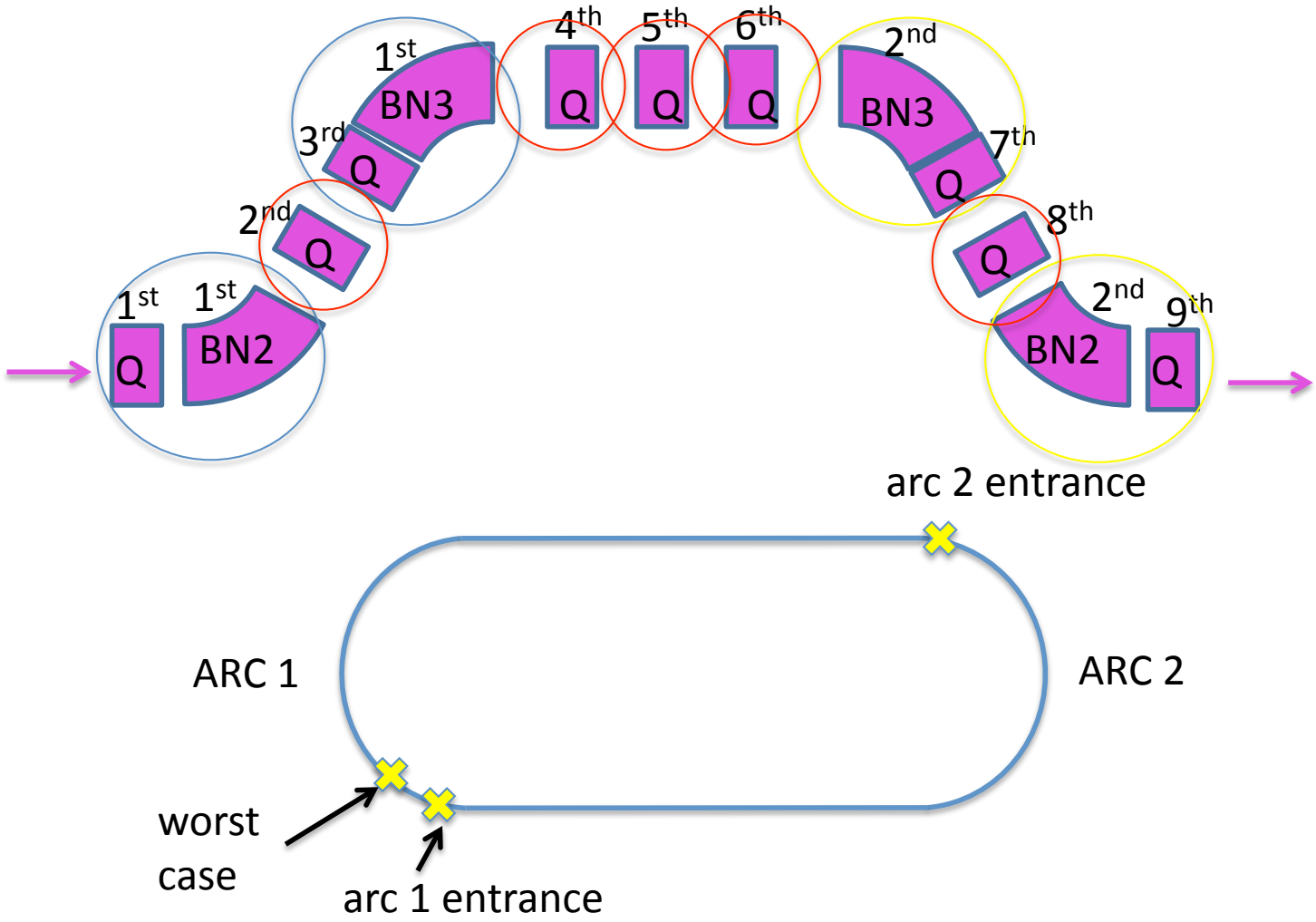
Material compositions*

		P ($g\ cm^{-3}$)	Cu Volume Fraction %	Nb Volume Fraction %	Liq. He Volume Fraction %	Kapton Volume Fraction %	Ti Volume Fraction %
Dipole	NbTi(in)	6.1	48	10	12	13	17
	NbTi(out)	7.6	47	9	11	17	16
Quadrupole	NbTi(in)	7.0	63	7	10	9	11
	NbTi(out)	6.3	53	8	10	15	14

- For dipoles: copper wedges implemented separately from cables.
- For quadrupoles: compound material that includes copper wedges into cables.
- Yoke material composition: 98% iron, 1% nichel, 0.4% manganese, 0.1 % silicon, 0.1% carbonium,).2 % copper.
- Dipole length: 5.687 m
- Quadrupole length: 2 m
- Absorber length: 1 m

*Courtesy of F. Cerutti (specifications by J. Miles - N. Mokhov)

DR losses


1st
BN3
3rd
Q
2nd
Q
1st
Q
1st
BN2
4th
Q
5th
Q
6th
Q
2nd
BN3
7th
Q
8th
Q
2nd
BN2
9th
Q
arc 2 entrance
ARC 1
ARC 2
worst
case
arc 1 entrance

Residual Ambient Dose Equivalent Rate at 1 m from the beamline (mSv h^{-1})

BUMP 1	1h		1d		1w	
	^{6}He	^{18}Ne	^{6}He	^{18}Ne	^{6}He	^{18}Ne
1st Q- 1st BN2	12	0.72	6	0.36	3.6	0.18
2nd Q	1.5	21.6	0.6	9	0.45	5.4
3rd Q - 1st BN3	3	1.08	1.5	0.36	0.75	0.27
4th Q	1.5	3.6	0.6	1.62	0.45	1.08
2nd BN3 - 7th Q	90	1.8	60	1.08	30	0.54
8th Q	1.5	9	0.6	3.6	0.45	0.162
5th Q	0.3	0.072	0.15	0.027	0.09	0.0162
6th Q	0.12	0.054	0.06	0.018	0.03	0.0126
2nd BN2 - 9th Q	60	1.8	30	1.08	21	0.54

Area classification (CERN Safety Code F)*

BUMP 1	1 hour	1 day	1 week
1st Q- 1st BN2	high-radiation area	high-radiation area	high-radiation area
2nd Q	high-radiation area	high-radiation area	high-radiation area
3rd Q - 1st BN3	high-radiation area	limited-stay controlled area	limited-stay controlled area
4th Q	high-radiation area	limited-stay controlled area	limited-stay controlled area
2nd BN3 - 7th Q	high-radiation area	high-radiation area	high-radiation area
8th Q	high-radiation area	high-radiation area	limited-stay controlled area
5th Q	limited-stay controlled area	limited-stay controlled area	limited-stay controlled area
6th Q	limited-stay controlled area	limited-stay controlled area	simple controlled radiation area (NO p.w.)
2nd BN2 - 9th Q	high-radiation area	high-radiation area	high-radiation area

*worst case between the 2 ions

Residual Ambient Dose Equivalent Rate at 1 m from the beamline (mSv h^{-1})

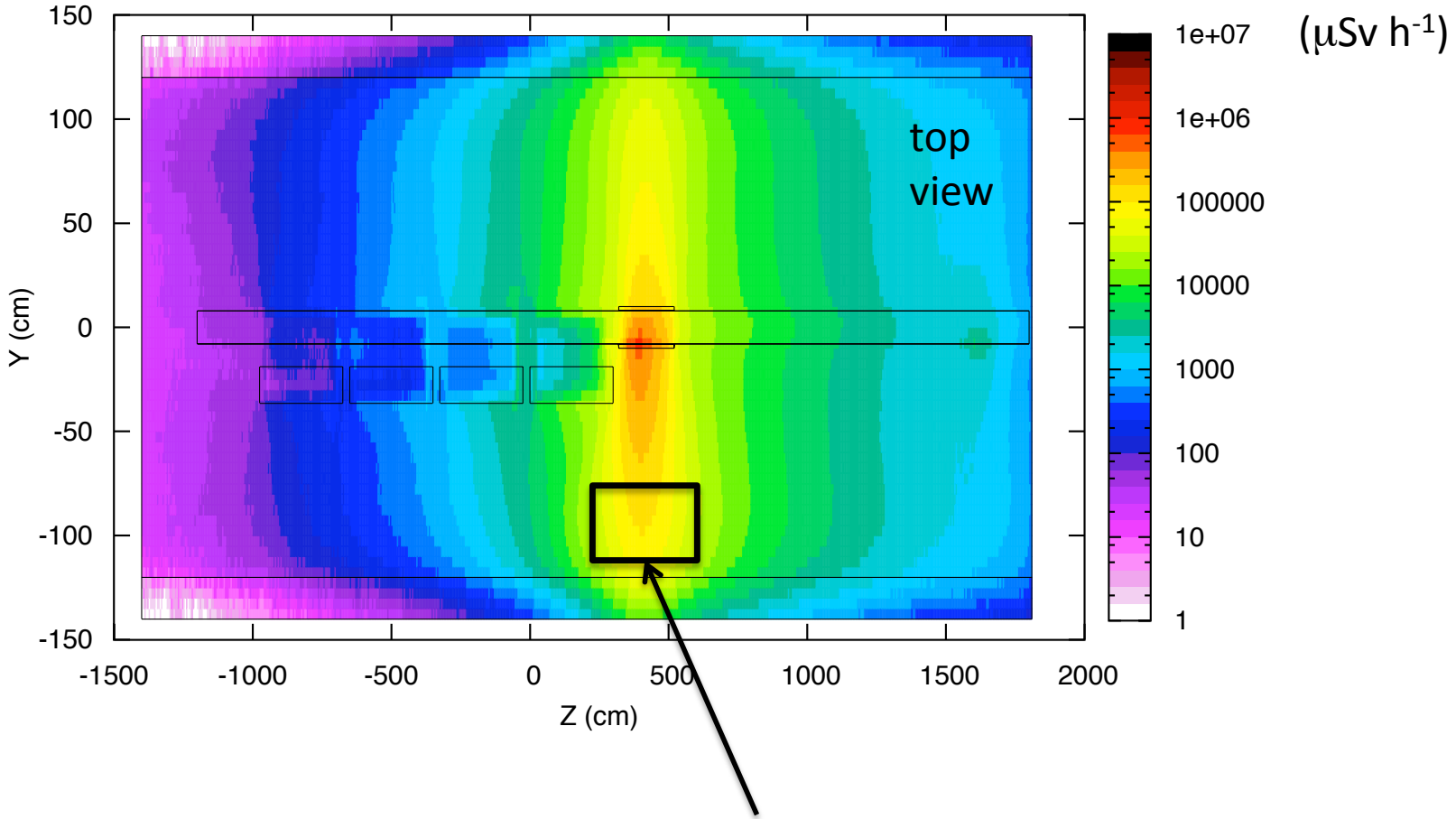
BUMP 2	1h		1d		1w	
	^{6}He	^{18}Ne	^{6}He	^{18}Ne	^{6}He	^{18}Ne
1st Q- 1st BN2	15	1.8	12	0.72	7.5	0.54
2nd Q	1.2	27	0.6	10.8	0.3	5.4
3rd Q - 1st BN3	2.7	3.6	1.2	1.44	0.6	1.08
4th Q	1.2	3.6	0.6	1.62	0.3	0.72
2nd BN3 - 7th Q	90	0.9	60	0.54	33	0.27
8th Q	1.5	5.4	0.9	3.6	0.45	1.44
5th Q	0.45	0.126	0.3	0.054	0.18	0.027
6th Q	0.06	0.027	0.03	0.0162	0.024	0.0054
2nd BN2 - 9th Q	60	3.6	30	1.62	18	0.9

Area classification (CERN Safety Code F)*

BUMP 2	1 hour	1 day	1 week
1st Q- 1st BN2	high-radiation area	high-radiation area	high-radiation area
2nd Q	high-radiation area	high-radiation area	high-radiation area
3rd Q - 1st BN3	high-radiation area	limited-stay controlled area	limited-stay controlled area
4th Q	high-radiation area	limited-stay controlled area	limited-stay controlled area
2nd BN3 - 7th Q	high-radiation area	high-radiation area	high-radiation area
8th Q	high-radiation area	high-radiation area	limited-stay controlled area
5th Q	limited-stay controlled area	limited-stay controlled area	limited-stay controlled area
6th Q	limited-stay controlled area	limited-stay simple controlled area	limited-stay simple controlled area
2nd BN2 - 9th Q	high-radiation area	high-radiation area	high-radiation area

*worst case between the 2 ions

^{6}He, Bump 2, 3rd arc (worst case): residual dose rate after 1 h



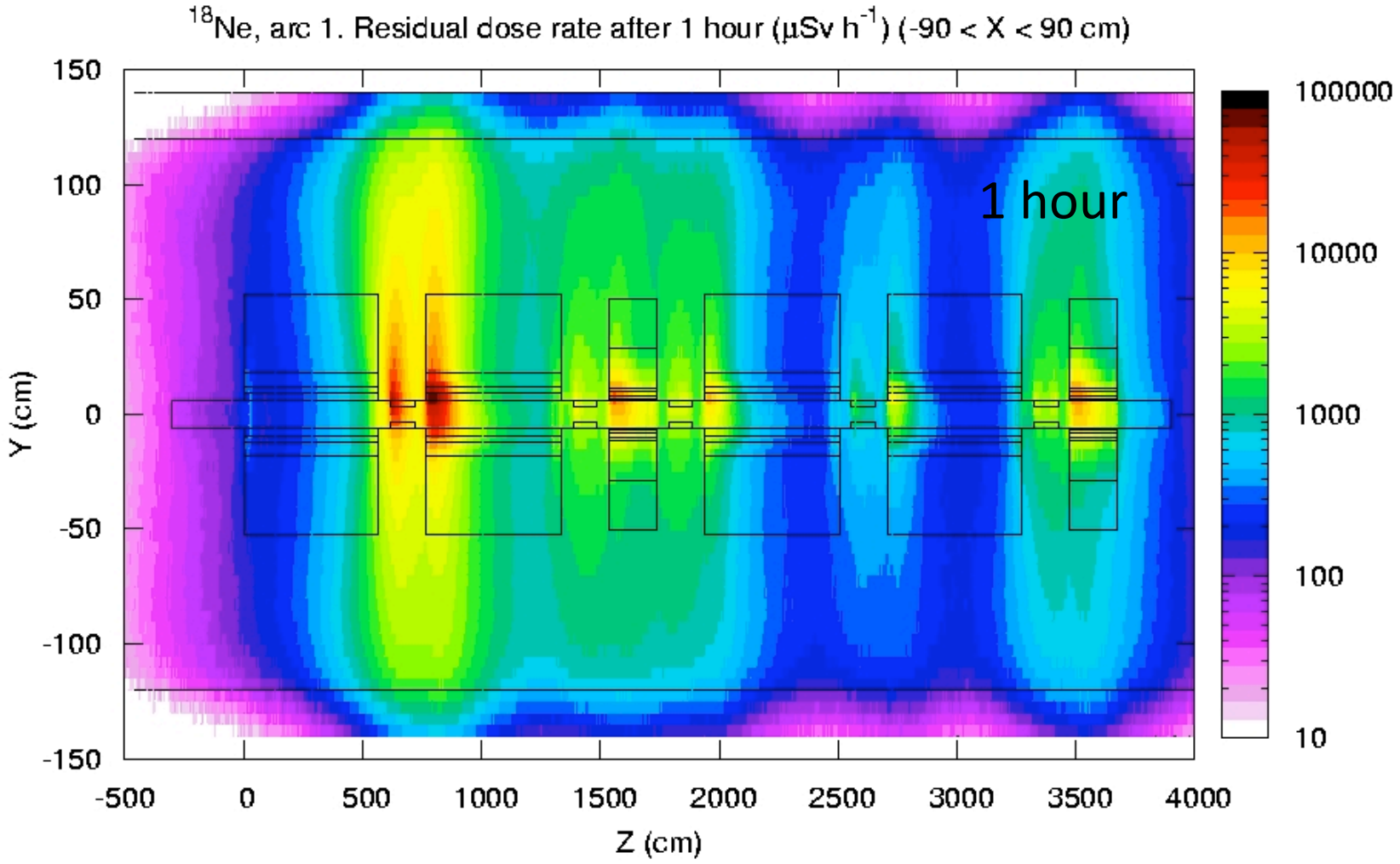
Residual Ambient Dose Equivalent Rate at 1 m from the beamline (mSv h^{-1})

ARCS	1h		1d		1w	
	^{6}He	^{18}Ne	^{6}He	^{18}Ne	^{6}He	^{18}Ne
Arc 1 (entrance)	9	21.6	7.5	14.4	3	5.4
Arc 2 (entrance)	24	54	15	21.6	7.5	10.8
Arc (worst cell)	1.2	5.4	0.45	3.6	0.3	1.44

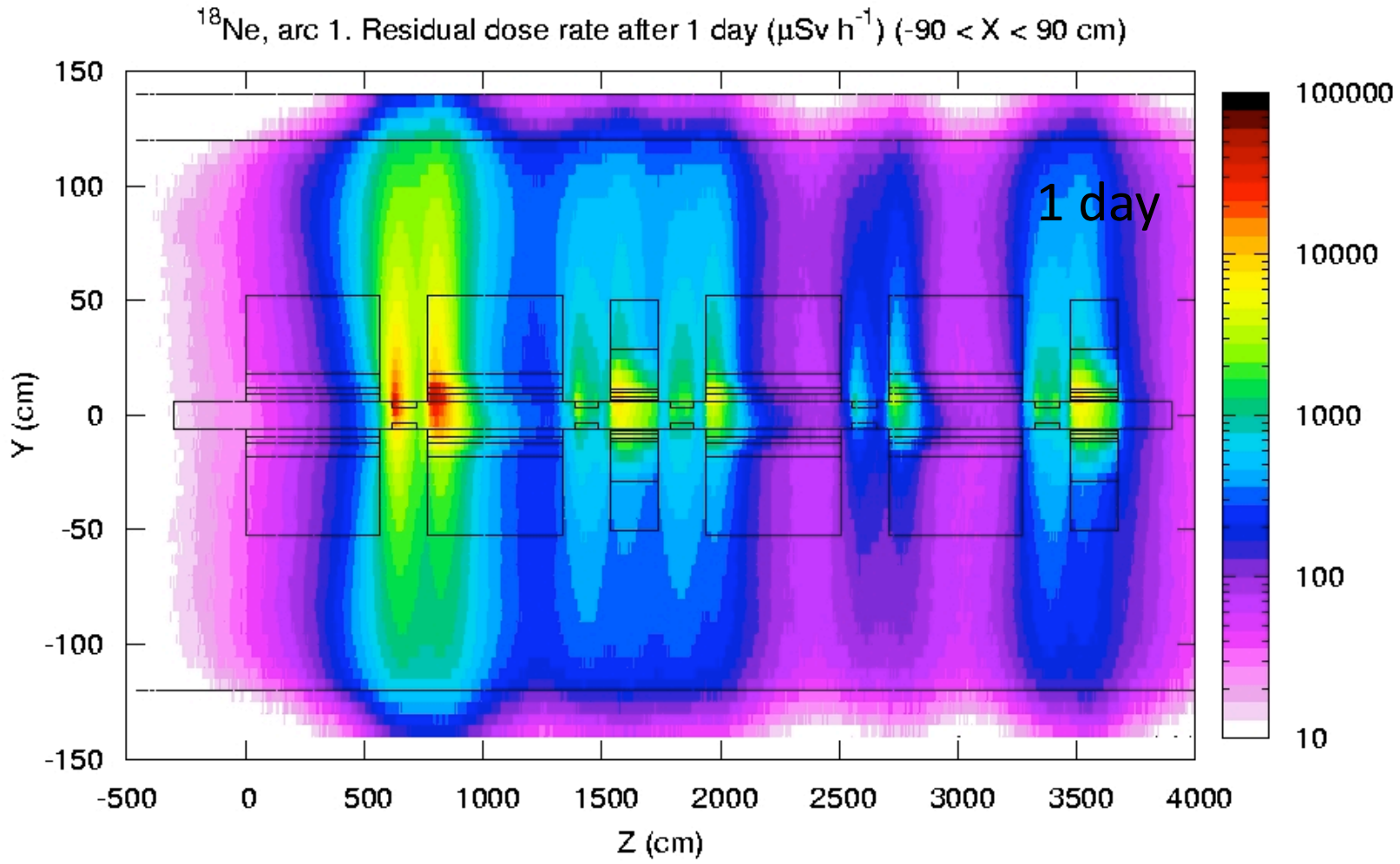
Area classification (CERN Safety Code F)

	1 hour	1 day	1 week
Arc 1 (entrance)	high-radiation area	high-radiation area	high-radiation area
Arc 2 (entrance)	high-radiation area	high-radiation area	high-radiation area
Arc (worst case)	high-radiation area	high-radiation area	limited-stay controlled area

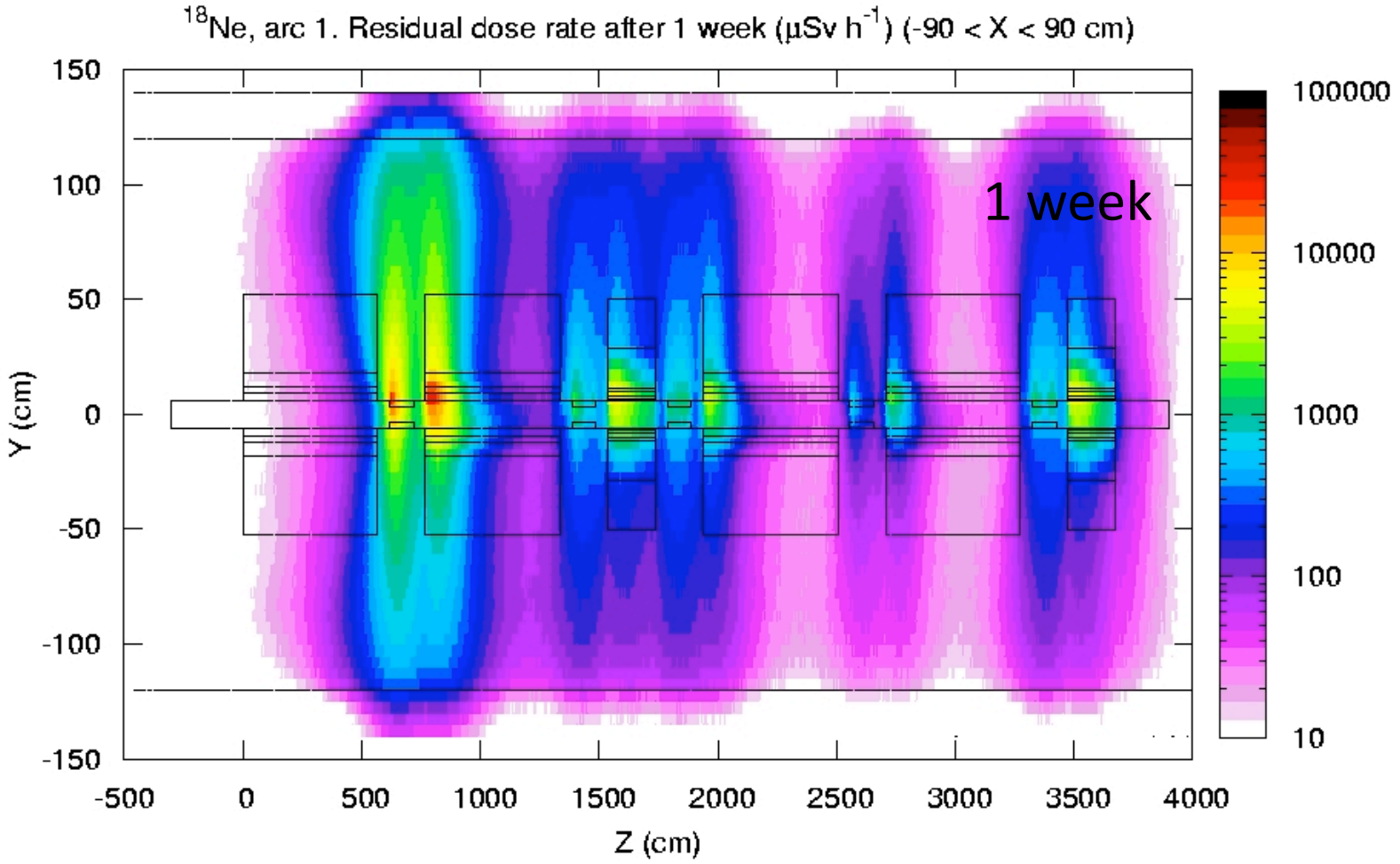
^{18}Ne, arc 1. Residual dose rates (μSv h^{-1})



^{18}Ne, arc 1. Residual dose rates (μSv h^{-1})



^{18}Ne, arc 1. Residual dose rates (μSv h^{-1})



Dominant residual radionuclides in the bump magnets (worst case) after 1 hour (^{6}He)

Pipe	
Radionuclide	A (Bq g^{-1})
Cr-51	2.15E+05
Mn-56	1.16E+05
V-48	9.17E+04
Mn-52	4.91E+04
Sc-44	4.62E+04
Mn-54	4.05E+04
Sc-44m	2.50E+04
Ti-45	2.50E+04
Ni-57	1.32E+04
Co-56	1.25E+04
Na-24	8.13E+03

Yoke	
Radionuclide	A (Bq g^{-1})
Cr-51	7.50E+05
V-48	3.11E+05
Mn-52	2.68E+05
Mn-54	2.36E+05
Mn-56	2.24E+05
Fe-55	1.54E+05
Sc-44	1.29E+05
Ti-45	7.32E+04
Co-56	2.87E+04

Coils	
Radionuclide	A (Bq g^{-1})
Cu-61	2.71E+05
Co-58	2.05E+05
Cr-51	8.81E+04
Co-57	5.88E+04
Co-61	4.92E+04
Co-56	4.89E+04
V-48	3.68E+04
Mn-52	2.81E+04
Mn-54	2.53E+04
Mn-56	2.19E+04
Ni-65	2.00E+04
Sc-44	1.93E+04
Ni-57	1.78E+04

Airborne activity in DR

^{6}He case.
F = 10000 m^3 h^{-1}
Tunnel volume = 86852 m^3
Exit duct volume = 300 m^3

Radionuclide	Half-life	Annual dose (μSv)
Ar-41	hours	6.94E-03
N-13	minutes	1.26E-03
C-11	minutes	1.60E+00
Be-7	months	3.88E-01
O-15	minutes	9.27E-01
Cl-39	minutes	3.54E-03
Cl-38	minutes	6.16E-02
P-32	days	1.38E-01
Na-24	hours	3.47E-03
O-14	seconds	9.29E-03

ISOLDE conversion coefficients

The total annual dose is of 4.5 μSv

Airborne activity in DR

^{18}Ne case.
F = 10000 m^3 h^{-1}
Tunnel volume = 86852 m^3
Exit duct volume = 300 m^3

Radionuclide	Half-life	Annual dose (mSv)
Ar-41	hours	1.50E+00
N-13	minutes	1.43E+00
C-11	minutes	1.36E+00
Be-7	months	5.89E-01
O-15	minutes	2.52E-01
Cl-39	minutes	1.86E-01
Cl-38	minutes	8.12E-02
P-32	days	7.71E-02
Na-24	hours	5.63E-02
O-14	seconds	2.07E-02

ISOLDE conversion coefficients

The total annual dose is of 5.6 μSv

Some considerations

- 100 mSv h^{-1} is the maximum limit for access to areas.
- In the calculations safety margins are not included (usually a factor of 3 for doses).
- For the airborne activity released in the environment only decay losses have been considered. The total annual dose exceeds the "limit-per-machine" of 1 μSv.

STATUS OF THE RP STUDIES

Residual dose rates during maintenance (WORST CASES)

Residual Ambient Dose Equivalent Rate at 1 m distance from the beam line (mSv h^{-1})				
	RCS (quad - ^{18}Ne)	PS (dip - ^{6}He)	SPS	DR (2^{nd} BN3 - 7^{th} Q, bump 1,2)
1 hour	15	1	-	90
1 day	3	0.5	-	60
1 week	2	0.25	-	30

Airborne activity released in the environment: dose to the reference population

Annual Effective Dose to the Reference Population (μSv)			
RCS	PS	SPS	DR
0.67	0.64	-	5.6 (only decay losses)

PARAMETERS	RCS	PS	DR
F	10000 $m^3 h^{-1}$	40000 $m^3 h^{-1}$	10000 $m^3 h^{-1}$
Exit Duct Volume	20 m^3	0 m^3	300 m^3

Summary

DONE

- RCS: all studies completed
- PS: ^{6}He case (residual doses and airborne activity)
- DR: decay loss studies completed

TO DO

- PS: ^{18}Ne case (residual doses and airborne activity)
- PS: residual radionuclides for ^{6}He and ^{18}Ne cases.
- SPS: all studies
- DR: injection and collimation loss studies

thanks for your attention!