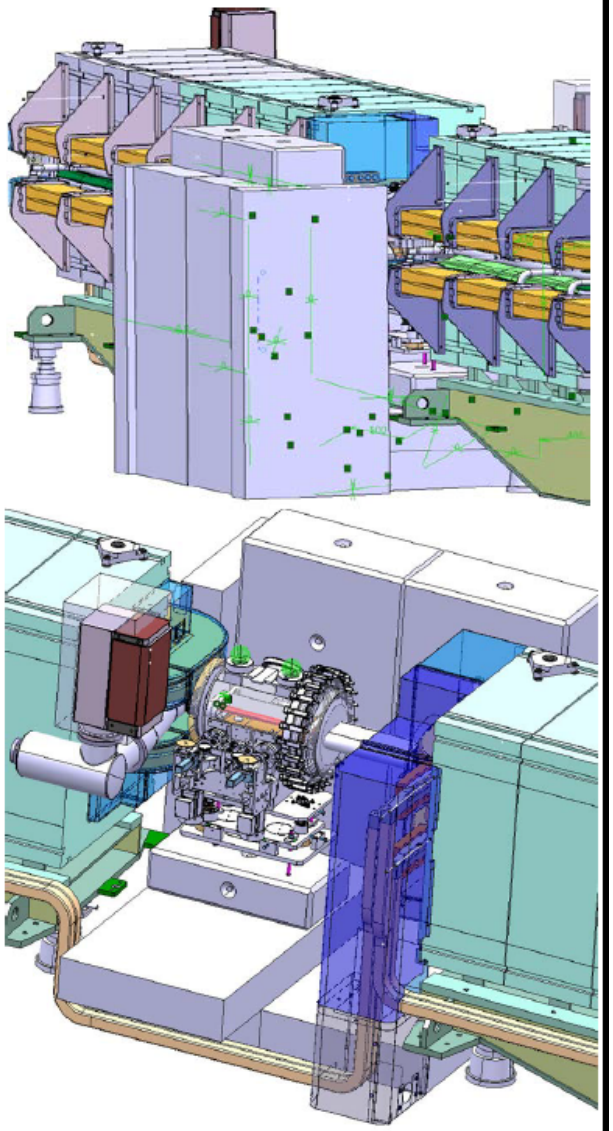
Individual and Collective Dose Estimates for Interventions at the PS SS15

Sanja Damjanovic, DGS-RP

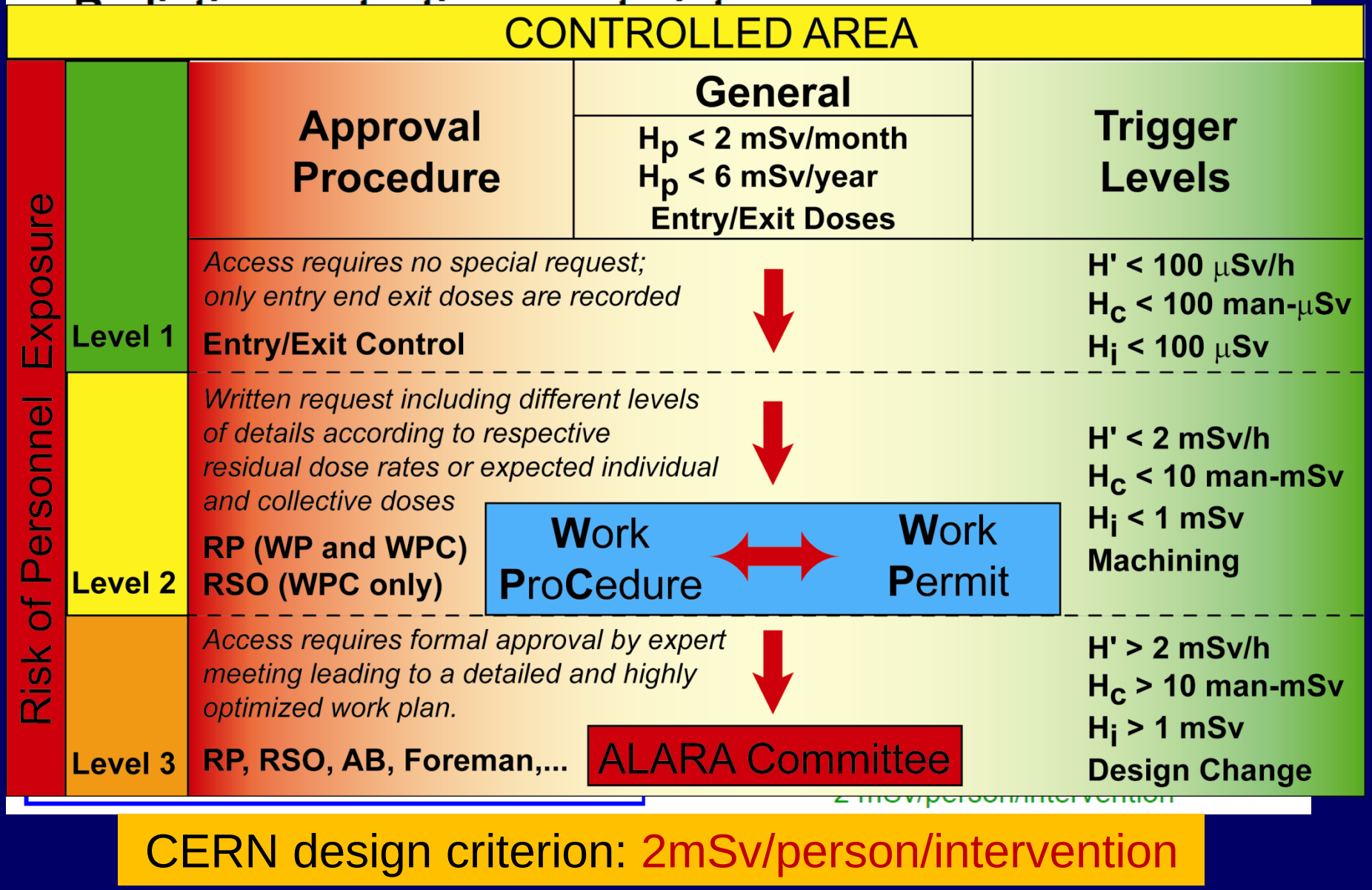
CERN, November 22, 2012

Intervention Scenarios TPS15

Failure	Classification	Operation
1. Blade damage	Catastrophic	Replacement of complete system
2. MU14 or 15 Failure	Catastrophic	Removal (?) and reinstallation of complete system
3. Vacuum leak	Catastrophic / local Intervention	Shielding dismantling + Diagnostics
4. Beam Instrumentation failure	Medium - Bad	Dismantle roof shielding or manual removal of blade (Manivelle)
5. Drive system	Medium - Bad	Manual removal of blade (Manivelle)
6. Water leak on cooling circuit	Medium	Replace joint or cooling hose, or isolate and run "hot"
7. Other failure modes??	??	??



Slide of Mike Hourican TE-ABT



CERN design criterion: 2mSv/person/intervention

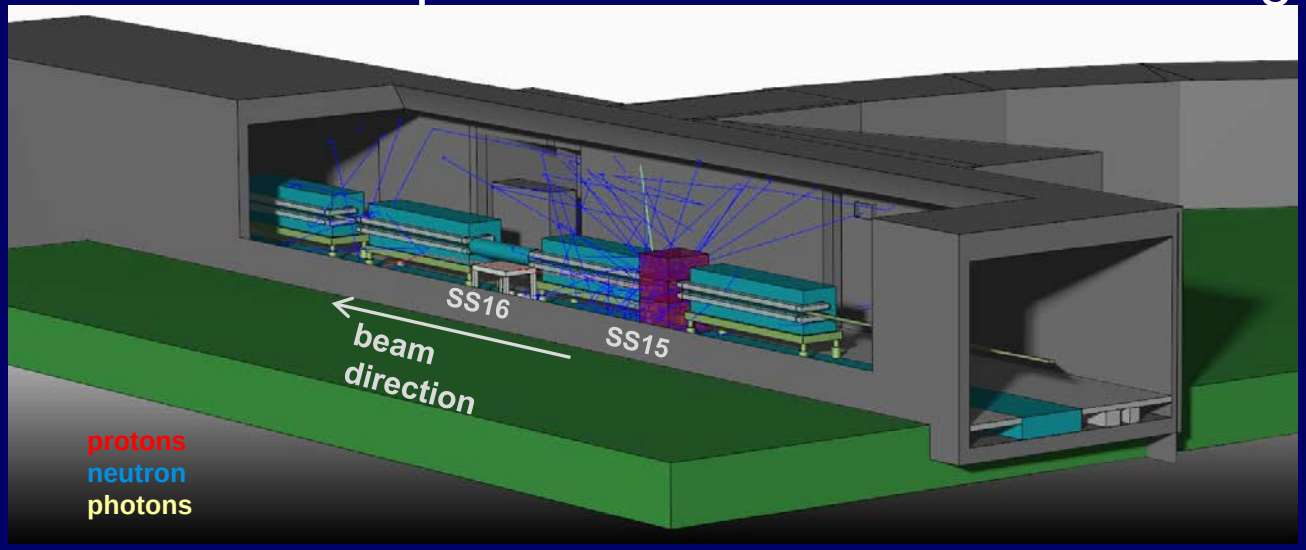
FLUKA simulations of 3-dim residual dose rate maps for different cooling times allow to estimate and optimize individual and collective doses for possible intervention processes

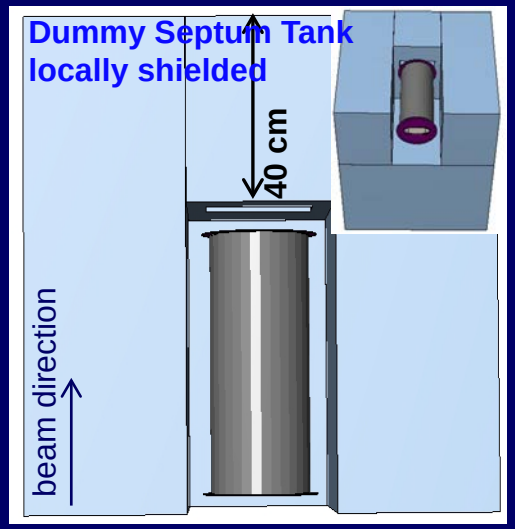
Detailed information on intervention processes and duration required

1 & 2, REPLACEMENT OF COMPLETE SYSTEM	Specialist	Time and distance	Comments
Venting of sector	TE-VSC	10 mins, remote intervention	
Dismantling of shielding	EN-HE-HH	1 hour, distance >1m	3 persons, 1h/person
Disconnection of upstream and downstream flanges	TE-VSC	5 mins, contact	2 persons, 2.5min/person
Disconnect cabling, compressed air, water cooling, etc	TE-ABT, BE-BI, TE-VSC	10 mins, distance -contact	2 persons, 2.5min/person 1 person (TE-VSC), 5min/person
Removal of tank assembly	TE-ABT, EN-HE-HH	10 mins, distance 1m 2 persons, 2min/person – contact, 8min/person - 1m	Includes removal of support locking mechanisms
Installation of spare	TE-ABT, EN-HE-HH	15 mins, contact	This spare is non radioactive 3 persons, 5min/person
Reconnection of flanges	TE-VSC	10-15 mins	2 persons, 7.5min/person
Reconnection of cables, air, and water cooling.	TE-ABT BE-BI TE-VSC	10 mins	3 persons, 10min/person
Leak test	TE-VSC	30 mins	1 person, 30min/person
Installation of shielding	EN-HE-HH	1 hour	3 persons, 1h/person
Testing			

Slide of Mike Hourican TE-ABT

Transport of a Realistic Beam through SS15

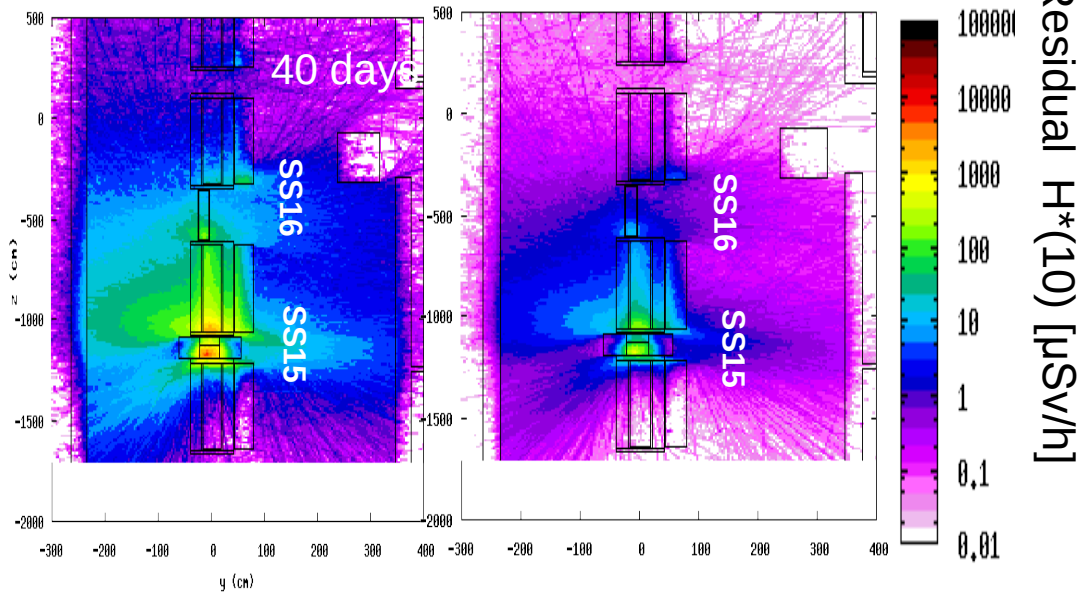




Dose Rates due to interactions within SS15

ISL beam: 0.47% loss

CORE beam: 0.06% loss



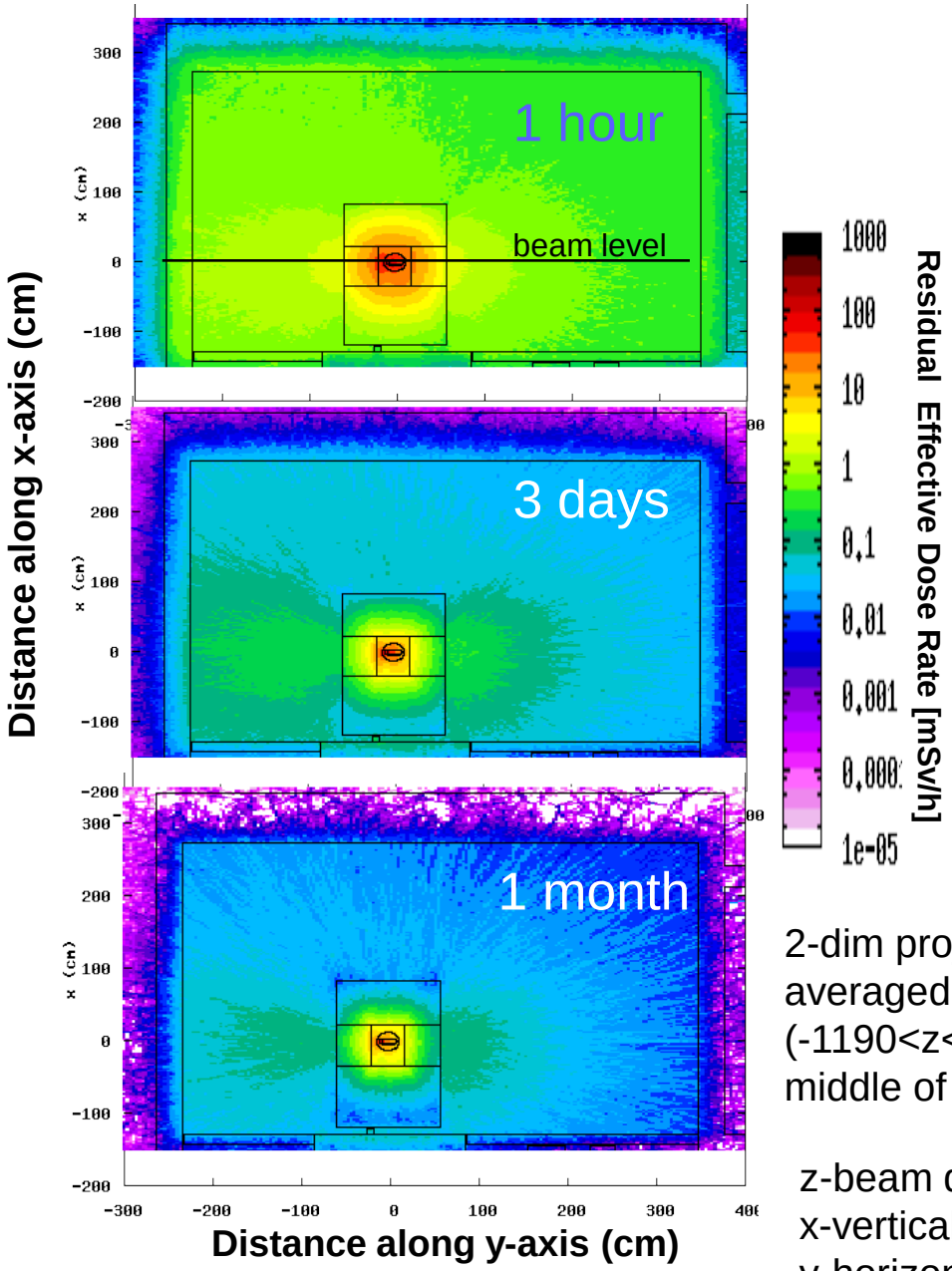
beam loss ~0.5% within SS15

for the same beam loss fractions within SS15 slightly higher dose for the ISL compared to CORE beam

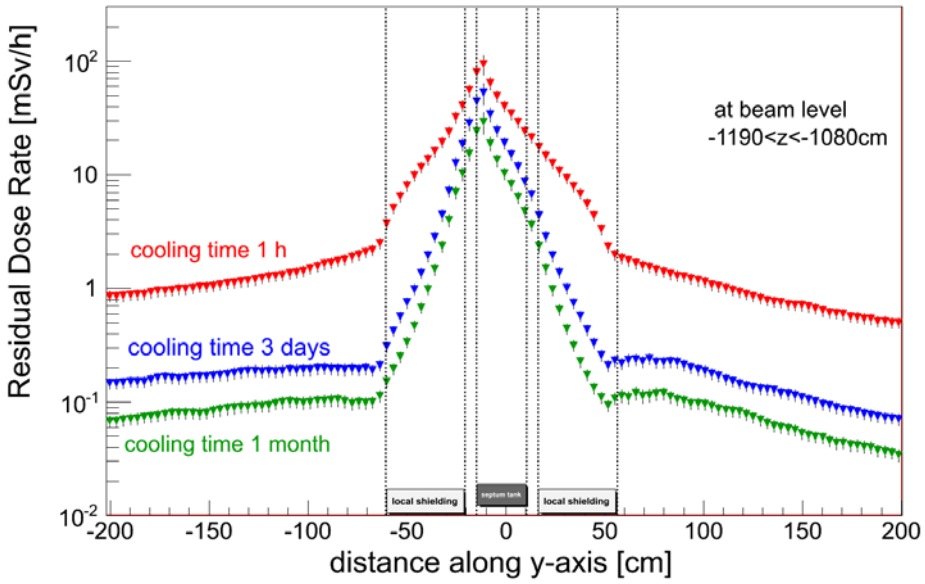
dose rate level in the region of SS15 due to additional beam losses within SS16 very small

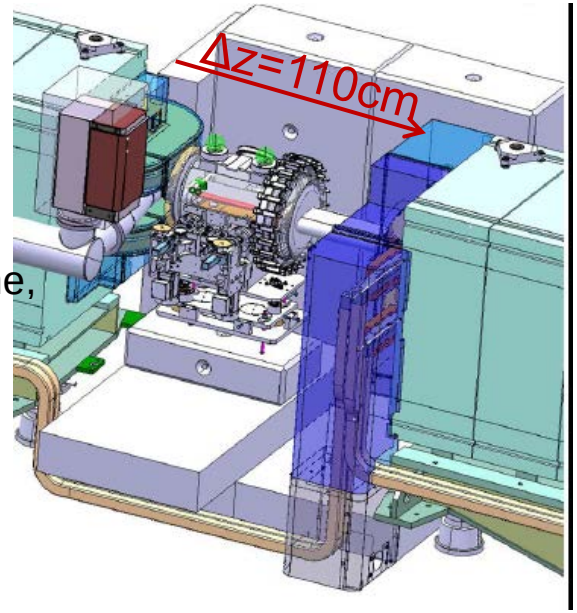
Conservative approach: consider 1% of ISL beam loss within SS15

Residual Effective Dose Rates [mSv/h]



projections along y (horizontal) at the beam level

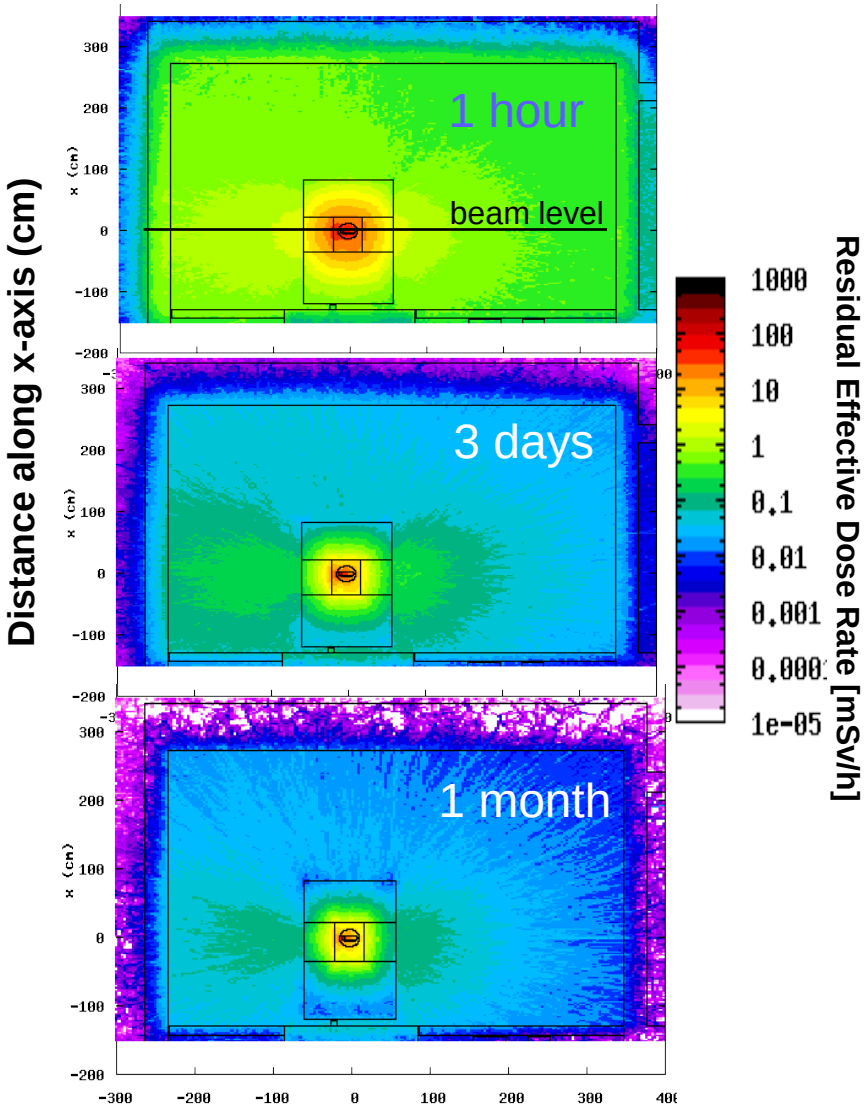




2-dim projections in x-y plane, averaged over Δz=110cm (-1190<z<-1080cm, middle of SS15)

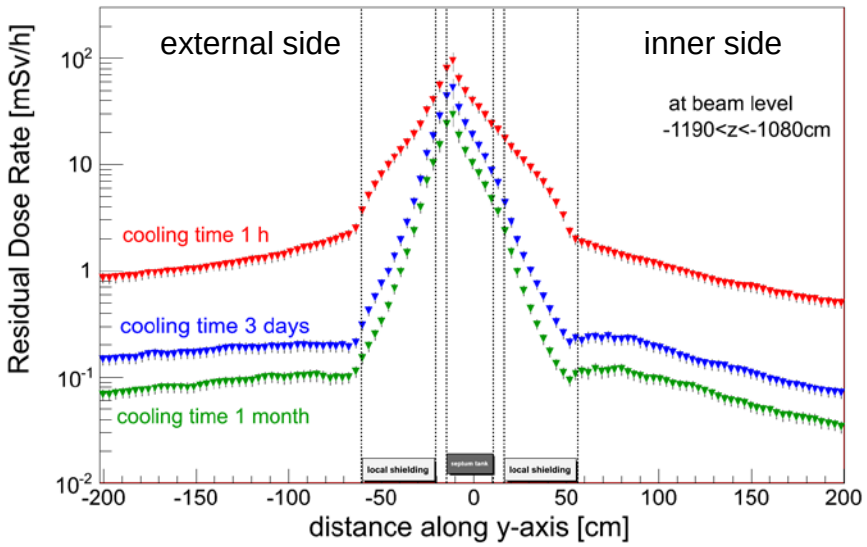
z-beam direction
x-vertical direction
y-horizontal direction

Residual Effective Dose Rates [mSv/h]



2-dim projections in x-y plane, averaged over Δz=110cm (-1190<z<-1080cm)

projections along y (horizontal) at the beam level



Dose Rate between septum tank and local shielding

1 hour: 22 – 70 mSv/h

3 days: 7 – 35 mSv/h

1 month: 3 – 15 mSv/h

(4-5 times higher rates in the gap towards external side of the machine)

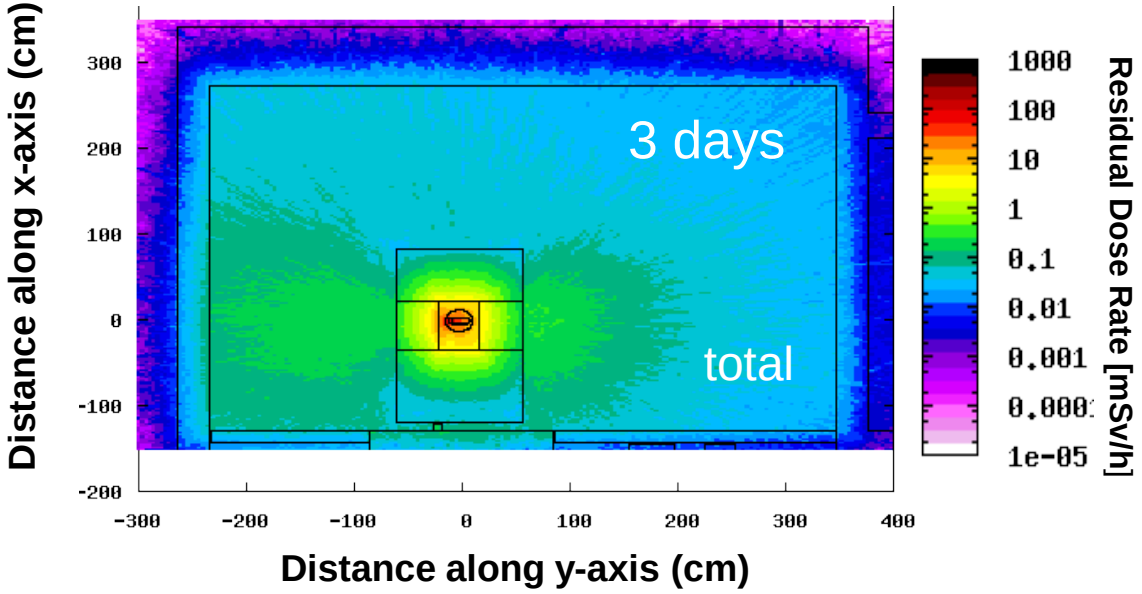
Dose Rate outside the local shielding

1 hour: 1.7 – 2 mSv/h

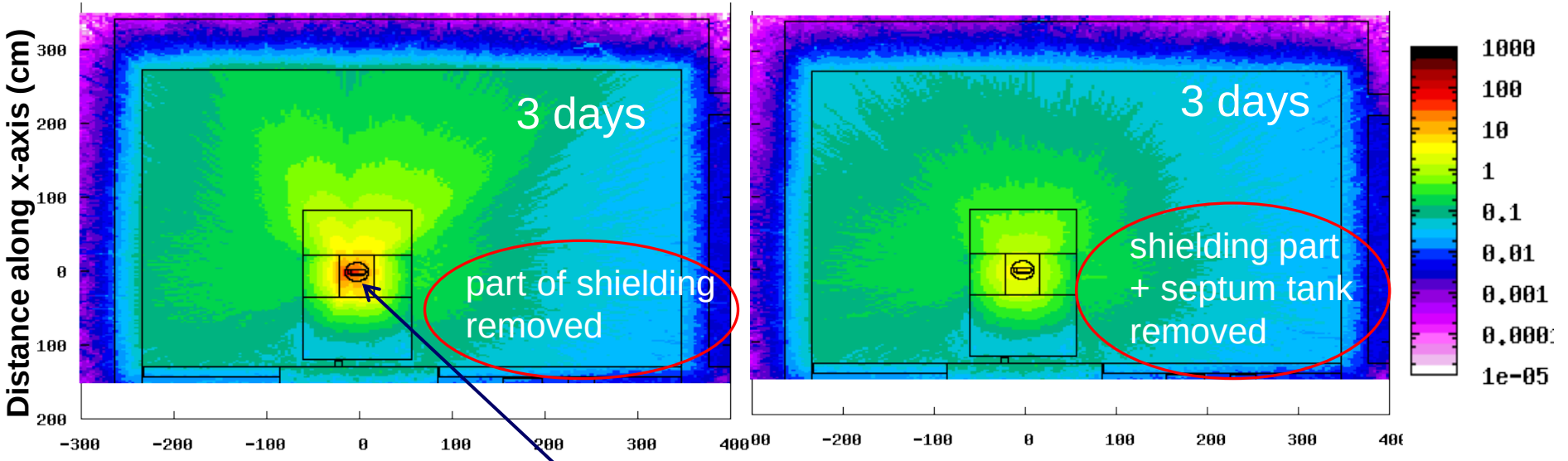
3 days: 0.2 – 0.25 mSv/h

1 month: 0.1 – 0.12 mSv/h

Residual Dose Rates [mSv/h] after a cooling time of 3 days

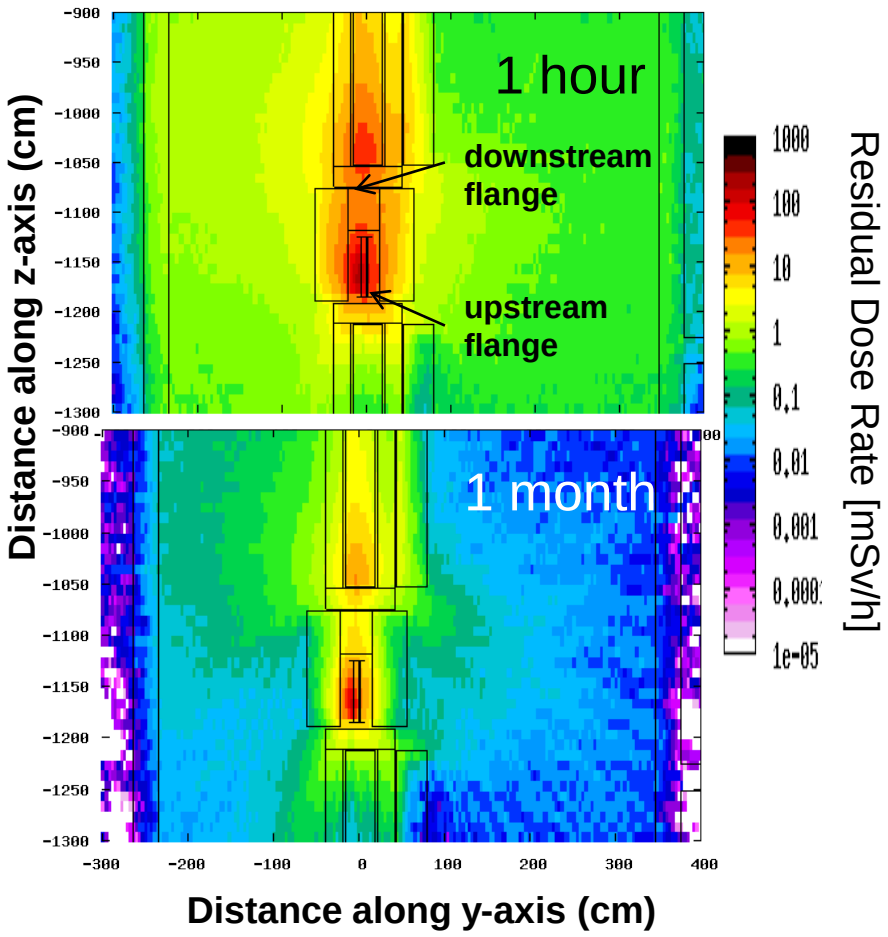


2-dim projections in x-y plane, averaged over Δz=110cm (-1190<z<-1080cm)



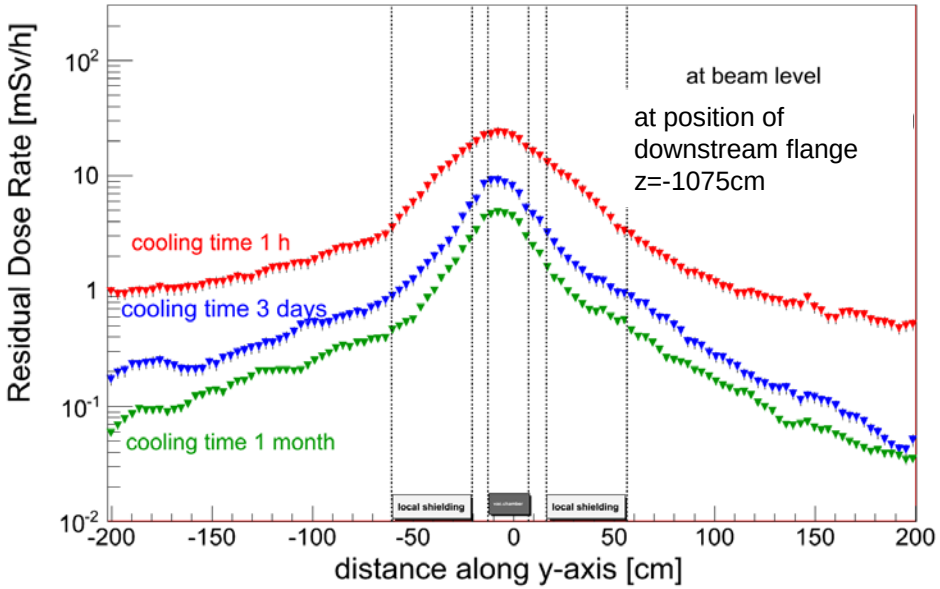
Removal: top and middle part of downstream shielding

Residual Dose Rate [mSv/h] – top and downstream part of the shielding dismantled



2-dim projections in y-z plane at the beam level (averaged over $-10<x_{beam}<10$ cm)

Projections along y at the beam level for the z position of the downstream flange



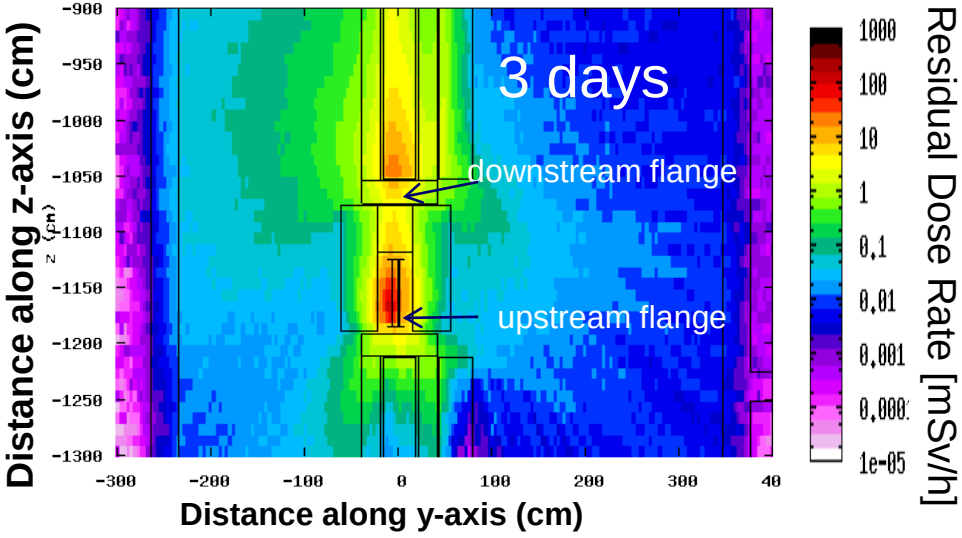
Dose Rate between septum tank and local shielding:

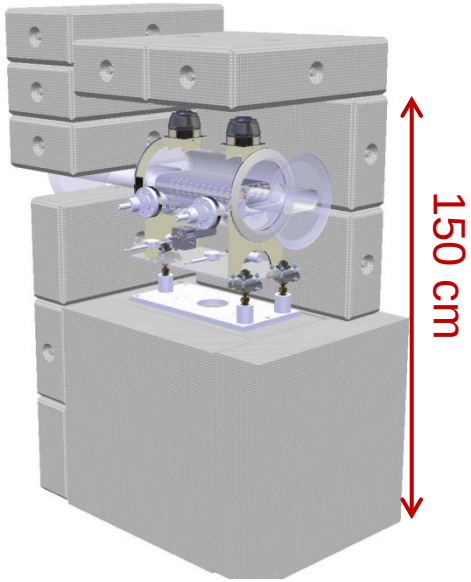
1 hour: 15 – 20 mSv/h

3 days: 4 – 6.5 mSv/h

1 month: 2.1 – 3.4 mSv/h

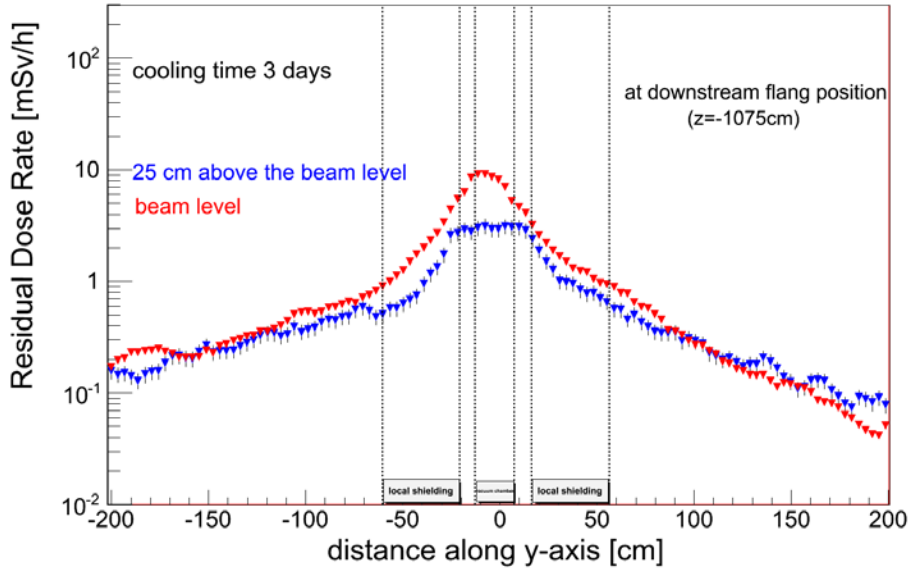
Residual Dose Rate after a cooling time of 3 days [mSv/h]

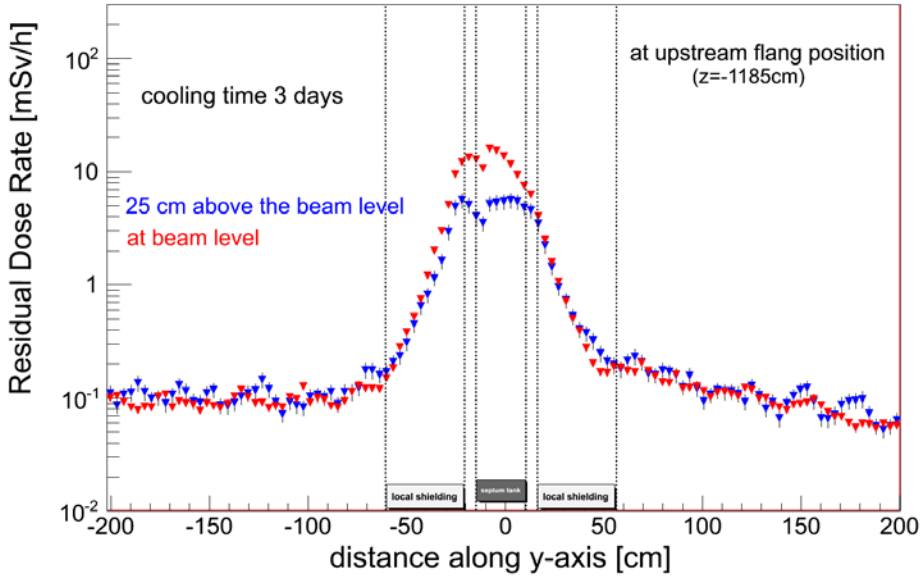




After removing the top part of the shielding, height of the remaining side shielding 150 cm (~23cm above the beam level)

Projections along y (horizontal) for the z positions of the downstream and the upstream flange for 2 different heights: beam level and +25 cm above the beam (~side shielding height)



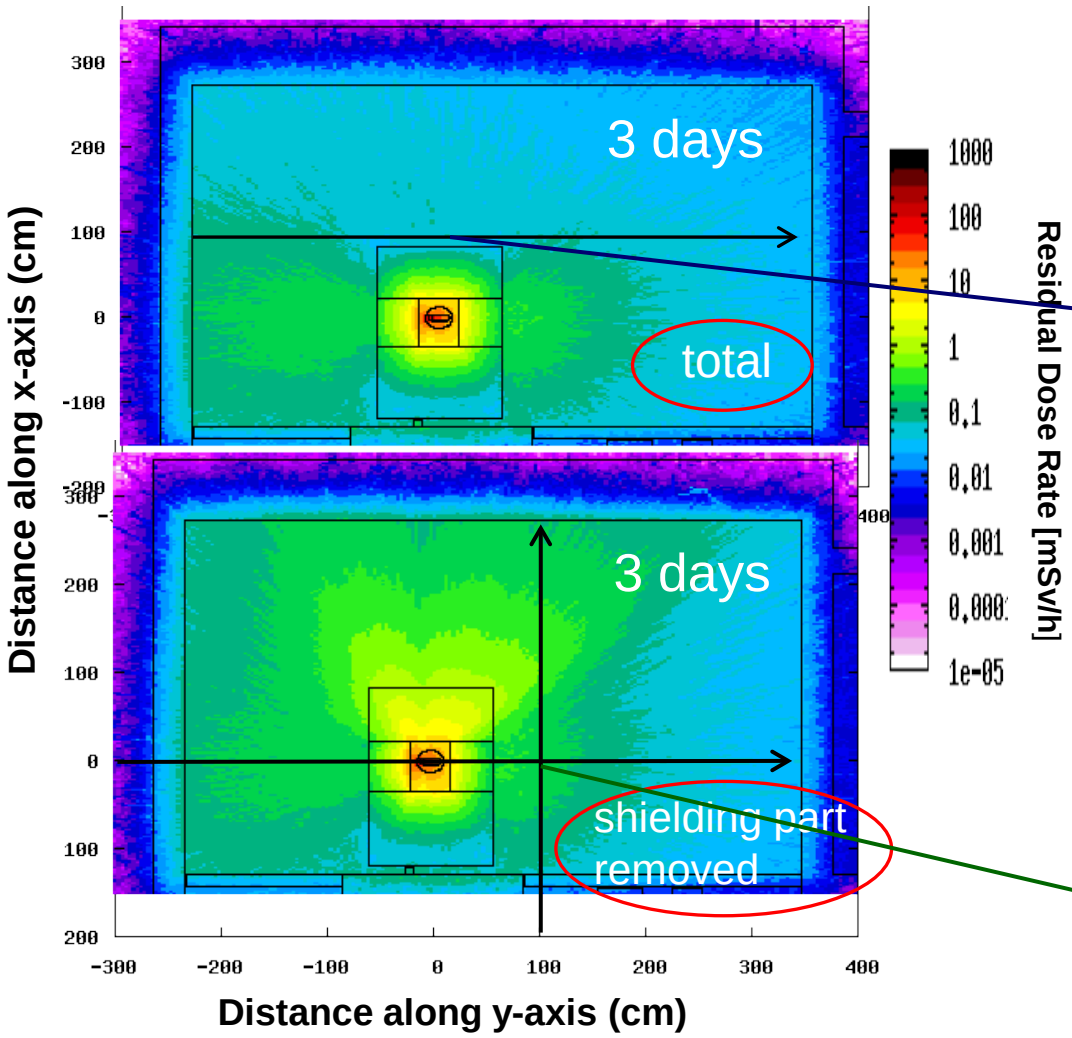


Estimation of Individual and Collective Doses for the Intervention Scenarios 1&2, i.e. Replacement of Complete System

1 & 2, REPLACEMENT OF COMPLETE SYSTEM	Specialist	Time and distance	Comments
Venting of sector	TE-VSC	10 mins, remote intervention	
Dismantling of shielding	EN-HE-HH	1 hour, distance >1m	
Disconnection of upstream and downstream flanges	TE-VSC	5 mins, contact	
Disconnect cabling, compressed air, water cooling, etc	TE-ABT, BE-BI, TE-VSC	10 mins, distance -contact	
Removal of tank assembly	TE-ABT, EN-HE-HH	10 mins, distance 1m	Includes removal of support locking mechanisms
Installation of spare	TE-ABT, EN-HE-HH	15 mins, contact	This spare is non radioactive
Reconnection of flanges	TE-VSC	10-15 mins	
Reconnection of cables, air, and water cooling.	TE-ABT BE-BI TE-VSC	10 mins	
Leak test	TE-VSC	30 mins	
Installation of shielding	EN-HE-HH	1 hour	
Testing			

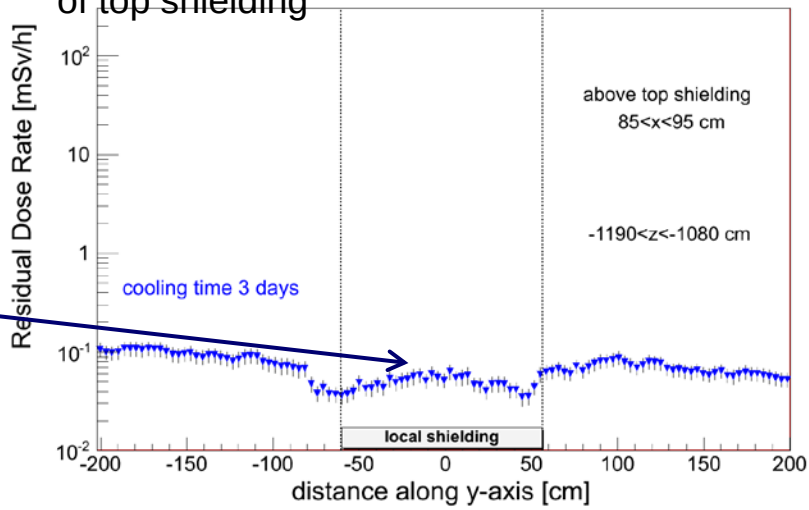
Intervention Scenario 1&2; Action - Dismantling of shielding

3 persons (EN-HE-HH specialists) involved: time/person = 1 h, distance >1m

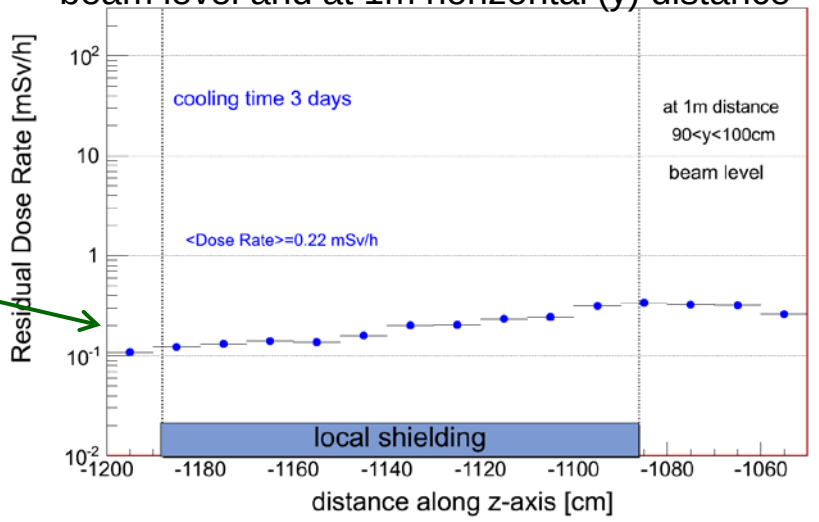


2-dim projections in x-y plane, averaged over Δz=110cm (-1190<z<-1080cm)

projections along y (horizontal) at the level of top shielding

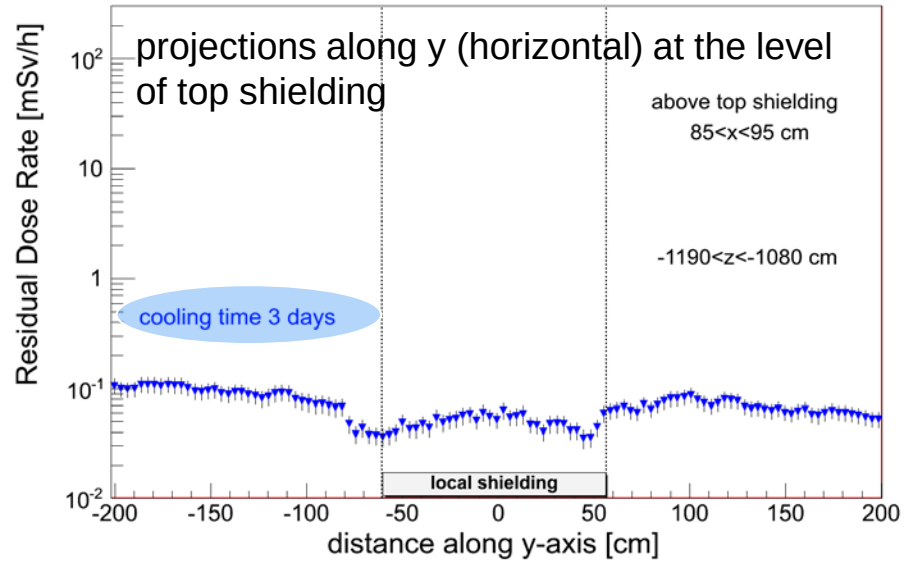


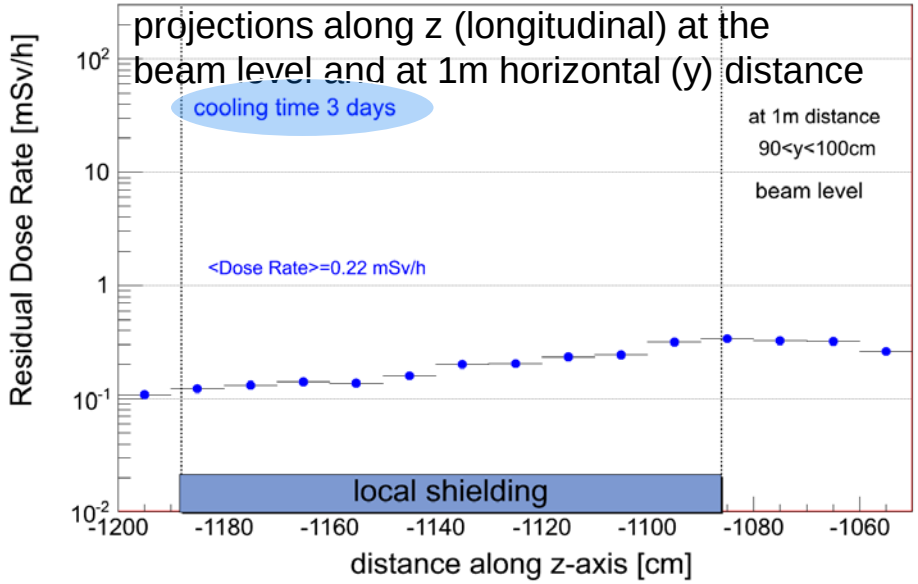
projections along z (longitudinal) at the beam level and at 1m horizontal (y) distance



Intervention Scenario 1&2; Action – Dismantling of shielding

3 persons (EN-HE-HH specialists) involved: time/person = 1 h, distance >1m





position of 1st person:
10 min: x=85 cm, <z>=-1140cm, <y>=0
50 min: x=0, <z>-1140 cm, y=100cm

accumulated dose by 1st person:

0.1mSv/h×10min = 0.02 mSv
0.22mSv/h×50min = 0.18 mSv
Total 0.2 mSv

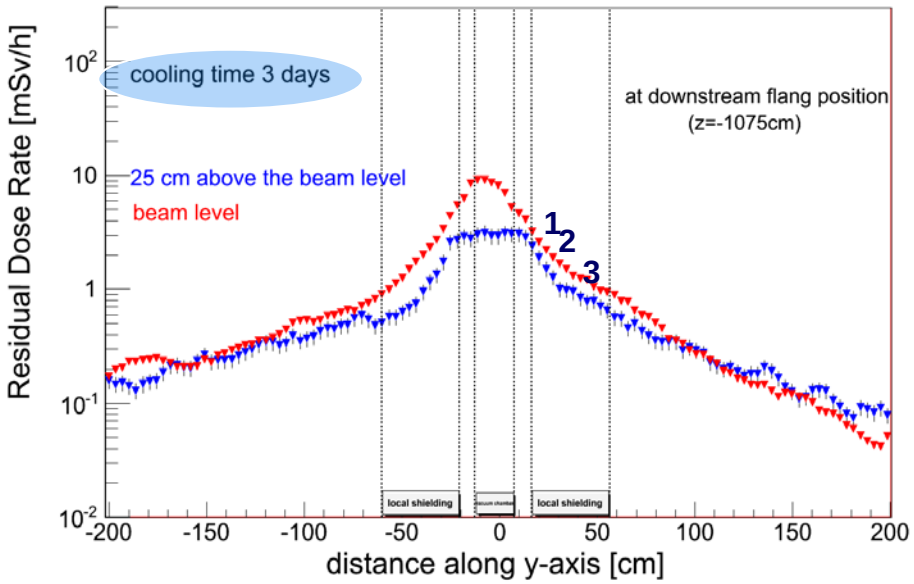
positions of 2nd and 3rd persons:
x=0 cm, <z>=-1140cm , y=100cm

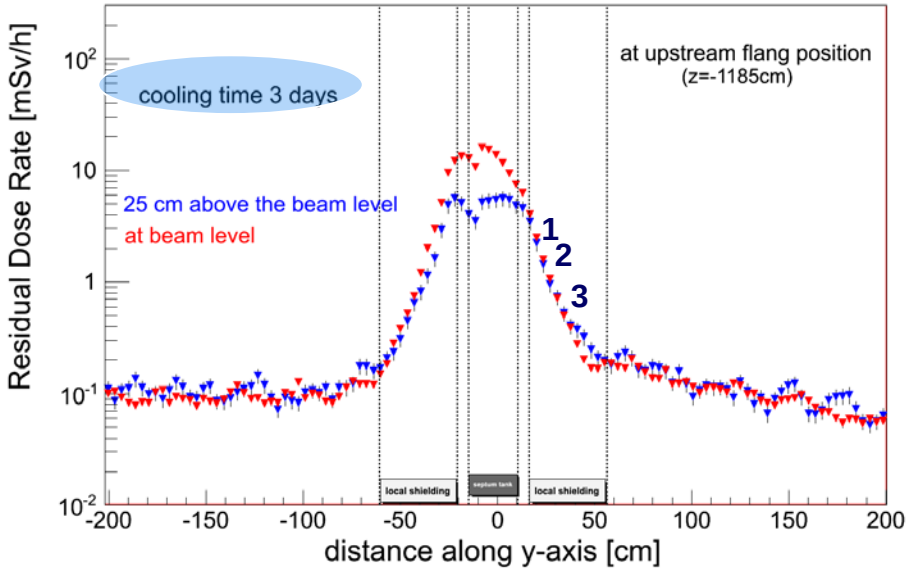
accumulated dose by 2nd person:
0.22 mSv/h×60min = 0.22 mSv

accumulated dose by 3rd person:
0.22 mSv/h×60min = 0.22 mSv

Total collective dose: 0.64 mSv

Intervention Scenario 1&2; Action - Disconnection of upstream and downstream flanges





projections along y for the z positions
of the downstream and upstream flanges

2 persons (TE-VSC specialists) involved, time/person = 2.5 min, contact

example - cooling time 3 days

position of 1st person: x=25 cm, z=-1075cm
3 different y-options considered:
1) y=20 cm; 2) y=30cm; y=40cm

accumulated dose by 1st person:

1) 1.9mSv/h×2.5min = 0.08 mSv
2) 1.0mSv/h×2.5min = 0.042 mSv
3) 0.86mSv/h×2.5min = 0.036 mSv

position of 2nd person: x=25 cm, z=-1185cm
1) y=20 cm; 2) y=30cm; y=40cm

accumulated dose by 2nd person:

1) 2.3mSv/h×2.5min = 0.1 mSv
2) 0.8mSv/h×2.5min = 0.033 mSv
3) 0.3mSv/h×2.5min = 0.013 mSv

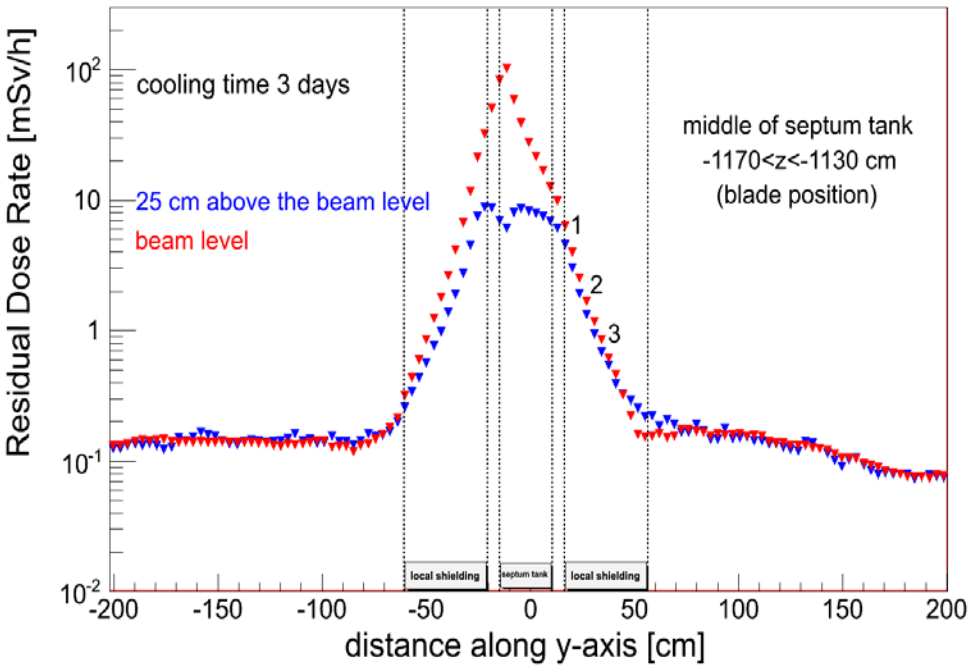
1) Total collective dose: 0.18 mSv

Intervention Scenario 1&2

Action – Disconnect cabling, compressed air, water cooling, etc.

3 persons involved, total time 10 min, contact
1st TE-ABT specialist: time/person = 2.5 min, contact
2nd BE-BI specialist: time/person = 2.5 min, contact
3rd TE-VSC specialist: time/person = 5 min, contact

example - cooling time 3 days



projections along y (horizontal) for z averaged over the blade length (-1170cm<z<-1130 cm), and for 2 different heights: beam level and +25 cm above the beam (~side shielding height)

persons positions: x=25 cm, <z>=-1150cm
3 different y-options considered:
1) y=20 cm; 2) y=30cm; y=40cm

accumulated dose by 1st and 2nd person:

1) 3.0mSv/h ×2.5min = 0.125 mSv
2) 0.95mSv/h×2.5min = 0.04 mSv
3) 0.4mSv/h ×2.5min = 0.017 mSv

accumulated dose by 3rd person:

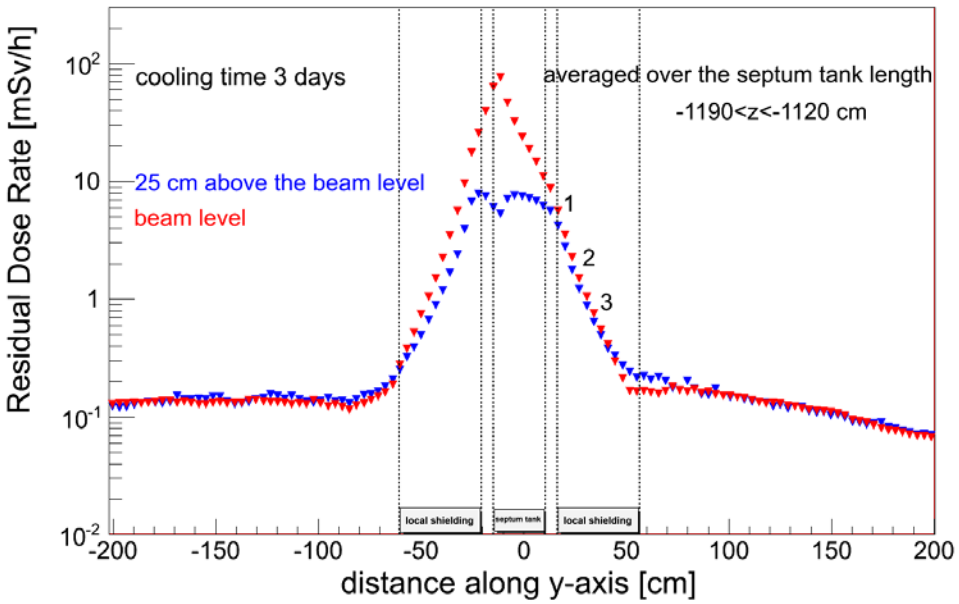
1) 3.0mSv/h ×5.0min = 0.25 mSv
2) 0.95mSv/h×5.0min = 0.08 mSv
3) 0.4mSv/h ×5.0min = 0.033mSv

1) Total collective dose= 0.5 mSv

Intervention Scenario 1&2
Action – Removal of tank assembly

2 persons involved, total time 10 min
1st TE-ABT specialist: time/person = 2 min-contact, 8min-distance 1m
2nd EN-HE-HH specialist: time/person = 2 min-contact, 8min-distance 1m

example - cooling time 3 days



projections along y (horizontal) for z averaged over the septum tank length (-1190cm<z<-1120 cm), and for 2 different heights: beam level and +25 cm above the beam (~side shielding height)

persons positions: x=25 cm, <z>=-1155cm
contact - 3 different y-options considered:
1) y=20 cm; 2) y=30cm; y=40cm

accumulated dose by 1st and 2nd person:

contact:

1) 3.0mSv/h×2min = 0.1 mSv
2) 0.9mSv/h×2min = 0.03 mSv
3) 0.4mSv/h×2min = 0.013 mSv

distance 1m:

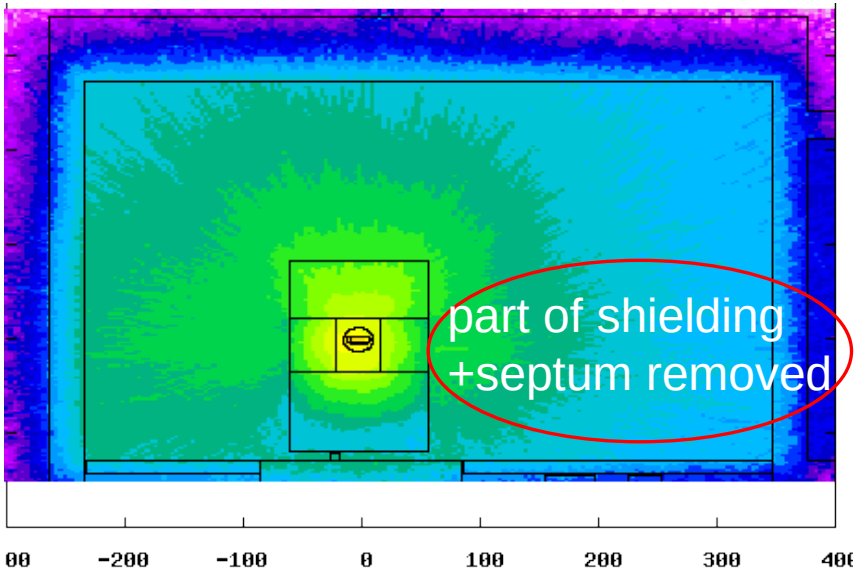
0.15×8 min = 0.02 mSv

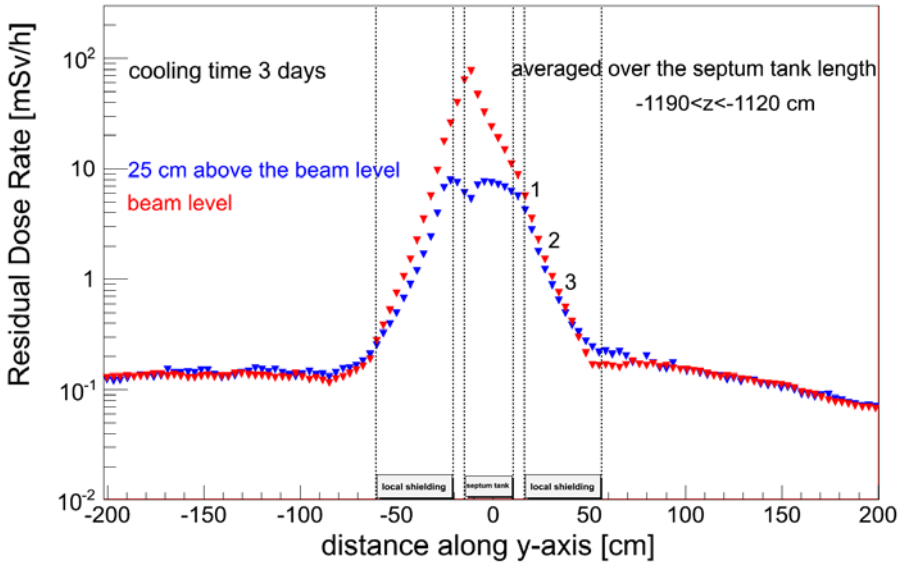
1) Total collective dose= 0.24 mSv

Intervention Scenario 1&2
Action – Installation of spare tank

3 persons involved, total time 15 min
1st and 2nd TE-ABT specialist: time/person = 5 min-contact
3rd EN-HE-HH specialist: time/person = 5 min-contact

example - cooling time 3 days





2-dim projections in x-y plane, averaged over Δz=110cm (-1190<z<-1080cm) with the septum tank and the top part of the shielding removed

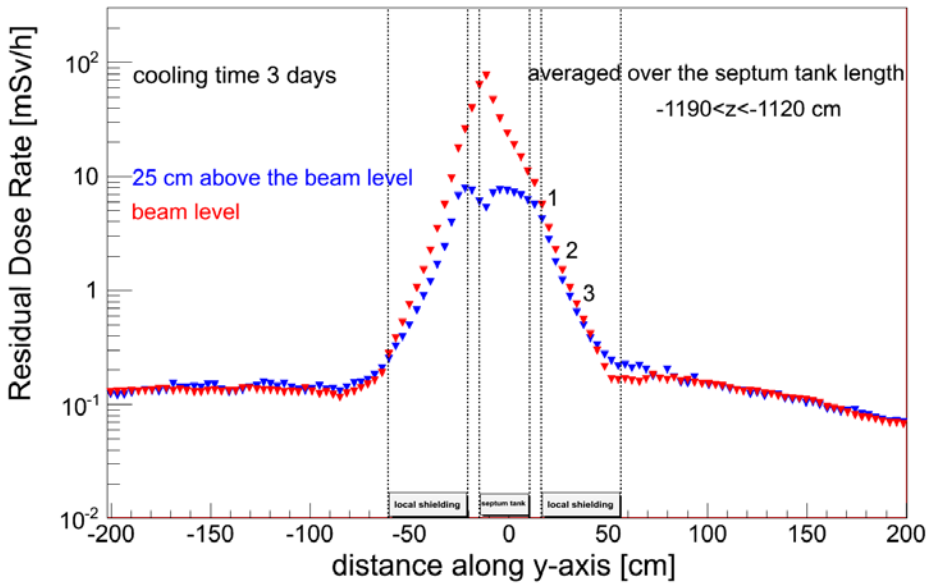
Removal: dummy septum tank and top and middle part of downstream shielding

projections along y (horizontal) for z averaged over the septum tank length (-1190cm<z<-1120 cm), and for 2 different heights: beam level and +25 cm above the beam (~side shielding height)

Intervention Scenario 1&2
Action – Installation of spare tank

3 persons involved, total time 15 min
1st and 2nd TE-ABT specialist: time/person = 5 min-contact
3rd EN-HE-HH specialist: time/person = 5 min-contact

example - cooling time 3 days



projections along y (horizontal) for z averaged over the septum tank length (-1190cm<z<-1120 cm), and for 2 different heights: beam level and +25 cm above the beam (~side shielding height)

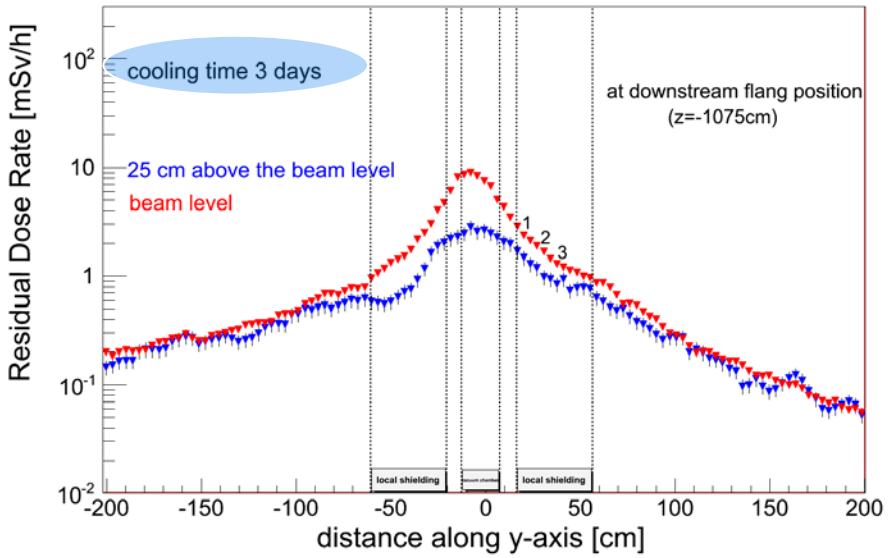
persons positions: x=25 cm, <z>=-1155cm
3 different y-options considered:
1) y=20 cm; 2) y=30cm; y=40cm

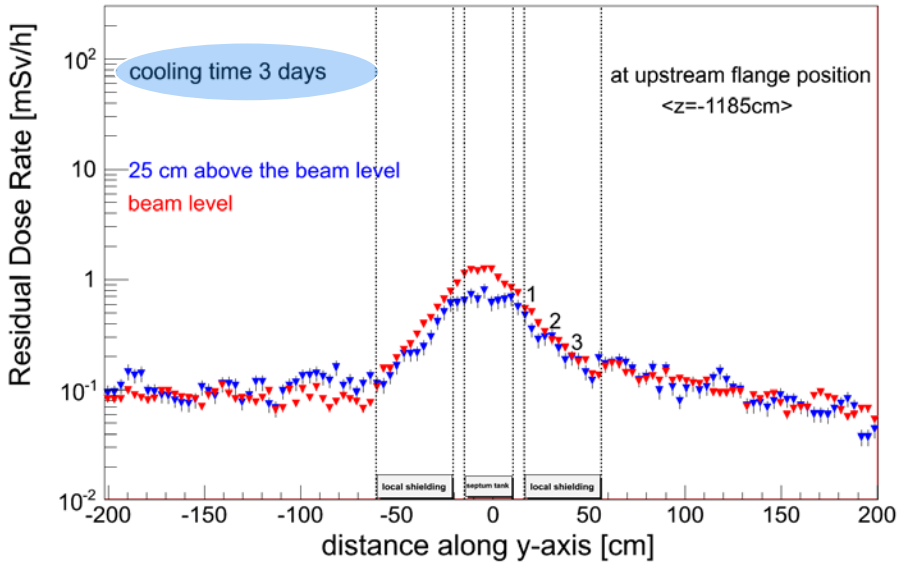
accumulated dose by 1st,2nd and 3rd person:

1) 0.6mSv/h ×5min = 0.05 mSv
2) 0.4mSv/h ×5min = 0.03 mSv
3) 0.26mSv/h×5min = 0.02 mSv

1) Total collective dose= 0.15 mSv

Intervention Scenario 1&2; Action – Reconnection of flanges





projections along y for the z positions
of the downstream and upstream flanges

2 persons (TE-VSC specialists) involved, time/person = 7.5 min, contact

example - cooling time 3 days

position of 1st person: x=25 cm, z=-1075cm
3 different y-options considered:
1) y=20 cm; 2) y=30cm; y=40cm

accumulated dose by 1st person:

1) 1.5mSv/h×7.5min = 0.19 mSv
2) 1.0mSv/h×7.5min = 0.13 mSv
3) 0.8mSv/h×7.5min = 0.1 mSv

position of 2nd person: x=25 cm, z=-1185cm
1) y=20 cm; 2) y=30cm; y=40cm

accumulated dose by 2nd person:

1) 0.4mSv/h×7.5min = 0.05 mSv
2) 0.25mSv/h×7.5min = 0.03 mSv
3) 0.2mSv/h×7.5min = 0.025 mSv

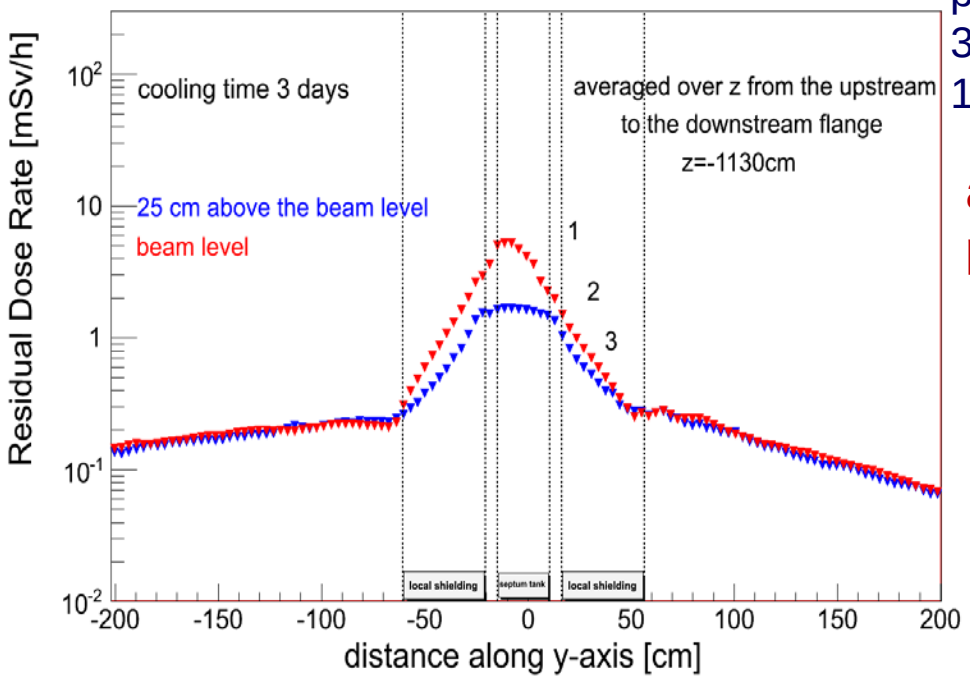
1) Total collective dose: 0.24 mSv

Intervention Scenario 1&2

Action – Reconnection of cables, compressed air, water cooling, etc.

3 persons involved, total time 30 min, contact
1st TE-ABT specialist: time/person = 10 min, contact
2nd BE-BI specialist: time/person = 10 min, contact
3rd TE-VSC specialist: time/person = 10 min, contact

example - cooling time 3 days



persons positions: x=25 cm, <z>=-1130cm
3 different y-options considered:
1) y=20 cm; 2) y=30cm; y=40cm

accumulated dose by 1st, 2nd and 3rd persons:

1) 0.9mSv/h×10min = 0.15 mSv
2) 0.5mSv/h×10min = 0.08 mSv
3) 0.4mSv/h×10min = 0.07 mSv

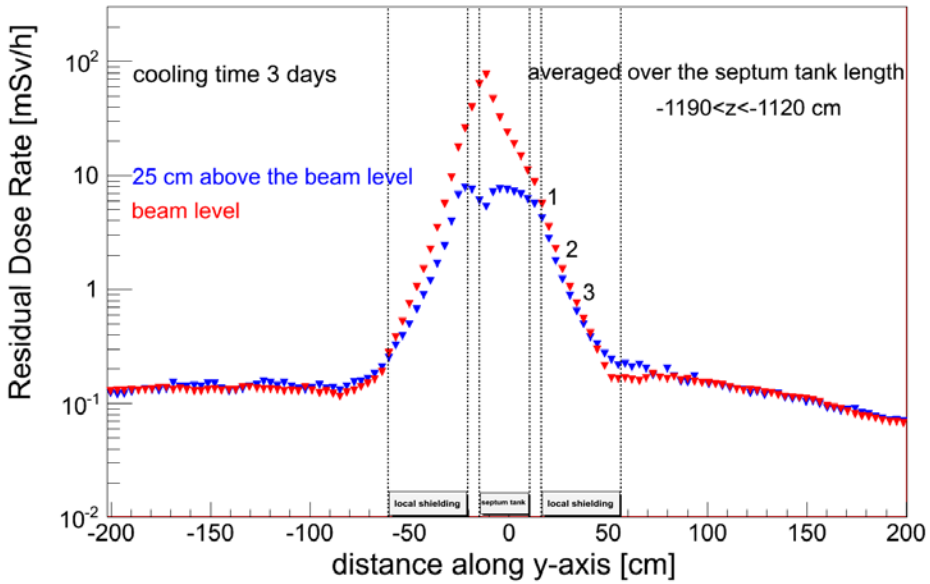
projections along y (horizontal) for z averaged from the upstream to the downstream flange, and for 2 different heights: beam level and +25 cm above the beam (~side shielding height)

1) Total collective dose= 0.45 mSv

Intervention Scenario 1&2
Action – Leek Test

1 person involved, total time 30 min
TE-VSC specialist: time/person = 30 min-contact

example - cooling time 3 days



projections along y (horizontal) for z averaged from the upstream to the downstream flange, and for 2 different heights: beam level and +25 cm above the beam (~side shielding height)

person position: x=25 cm, <z>=-1130cm
3 different y-options considered:
1) y=20 cm; 2) y=30cm; y=40cm

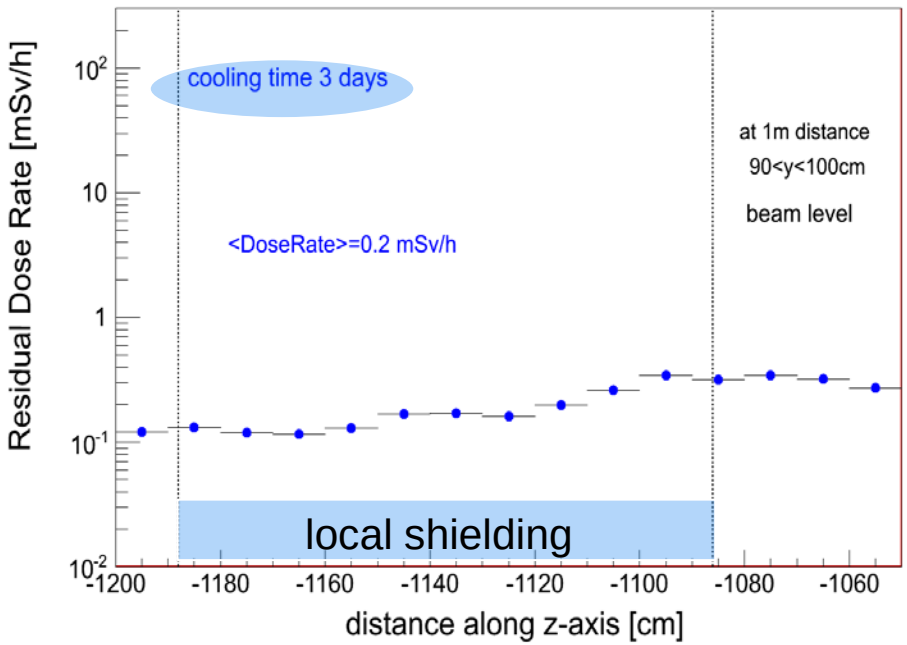
accumulated dose by the person:

1) 0.9mSv/h×30min = 0.45 mSv
2) 0.5mSv/h×30min = 0.25 mSv
3) 0.4mSv/h×30min = 0.2 mSv

1) Total collective dose= 0.45 mSv

Intervention Scenario 1&2; Action – Installation of shielding

3 persons (EN-HE-HH specialists) involved:
time/person = 1 h, distance >1m



projections along z (longitudinal) at the beam level and at 1m horizontal (y) distance

positions of 1st, 2nd and 3rd persons:
60 min: x=0, <z>-1140 cm, y=100cm

accumulated dose by 1st person:
0.22 mSv/h×60min = 0.22 mSv

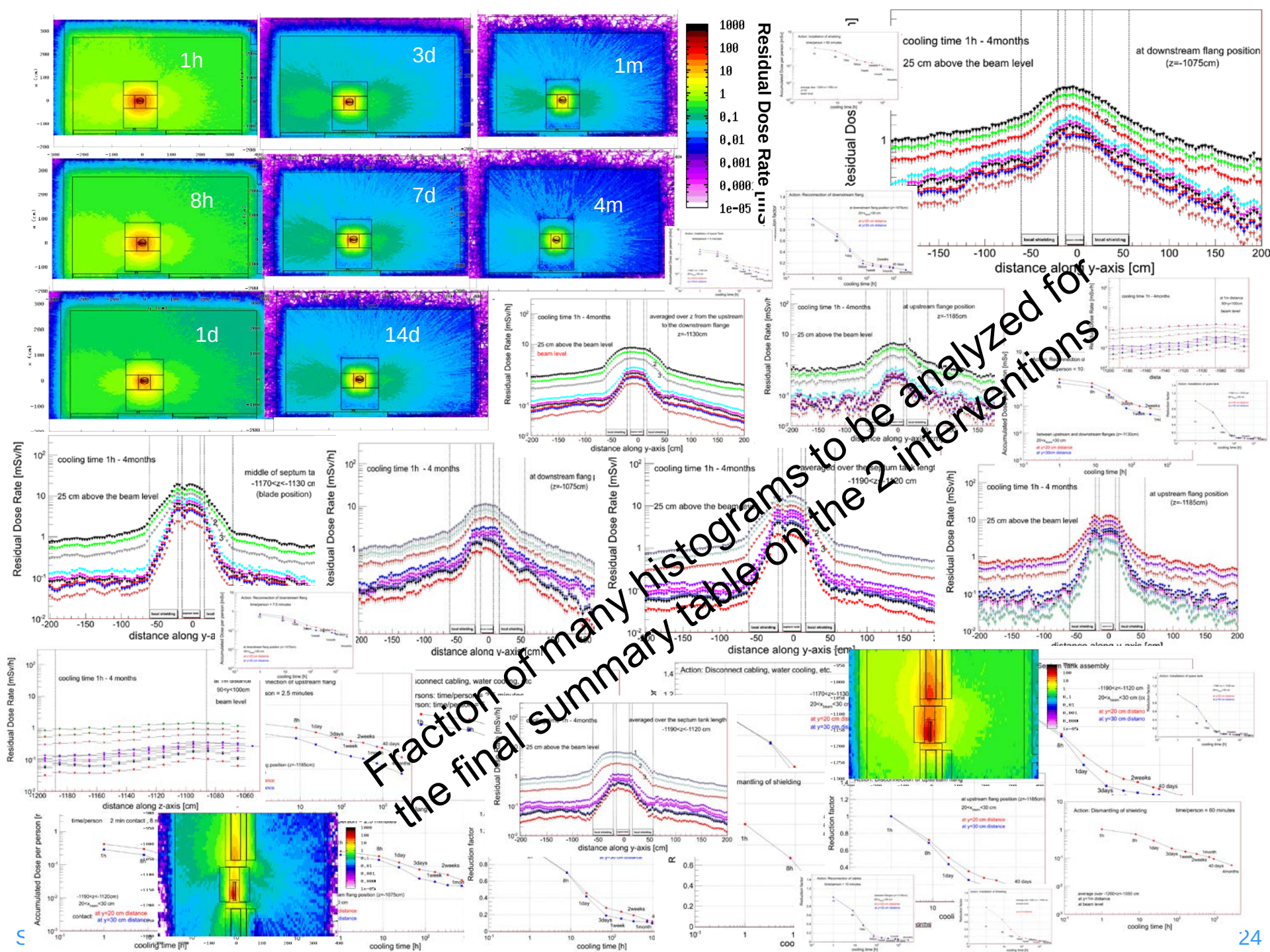
accumulated dose by 2nd person:
0.22 mSv/h×60min = 0.22 mSv

accumulated dose by 3rd person:
0.22 mSv/h×60min = 0.22 mSv

Total collective dose: 0.64 mSv

Dose per person and intervention accumulated during the 'Replacement of the complete system' at PS SS15 after cooling time of 3 days

Work description (Task)	Dep/Grp (executing)	Dose/person (EN-HE-HH_1st/2nd/3rd) [mSv]	Dose/person (TE-VSC_1st) [mSv]	Dose/person (TE-VSC_2nd) [mSv]	Dose/person (TE-ABT-1st/2nd) [mSv]	Dose/person (BE-BI) [mSv]	Total collective Dose [mSv]
Actions							**3.51**
Venting of sector	TE-VSC	remote					
Dismantling of shielding	EN-HE-HH	0.2/0.22/0.22					0.64
Disconnection of downstream and upstream flanges	TE/VSC		0.08	0.1			+0.18
Disconnect cabling, compressed air, water cooling, etc.	TE-ABT, BE-BI, TE-VSC		0.25		0.125/0	0.125	+0.5
Removal of tank assembly	TE-ABT, EN-HE-HH	0.12/0/0			0.12/0		+0.24
Installation of spare	TE-ABT, EN-HE-HH	0.05/0/0			0.05/0.05		+0.15
Reconnection of downstream and upstream flanges	TE/VSC		0.19	0.05			+0.24
Reconnection of cables, air, and water cooling	TE-ABT/BE-BI/TE-VSC		0.15		0.15/0	0.15	+0.45
Leak test	TE-VSC		0.45				+0.45
Installation of shielding	EN-HE-HH	0.22/0.22/0.22					+0.66
		0.59/0.44/0.44	1.12	0.15	0.45/0.05	0.275	**3.51**



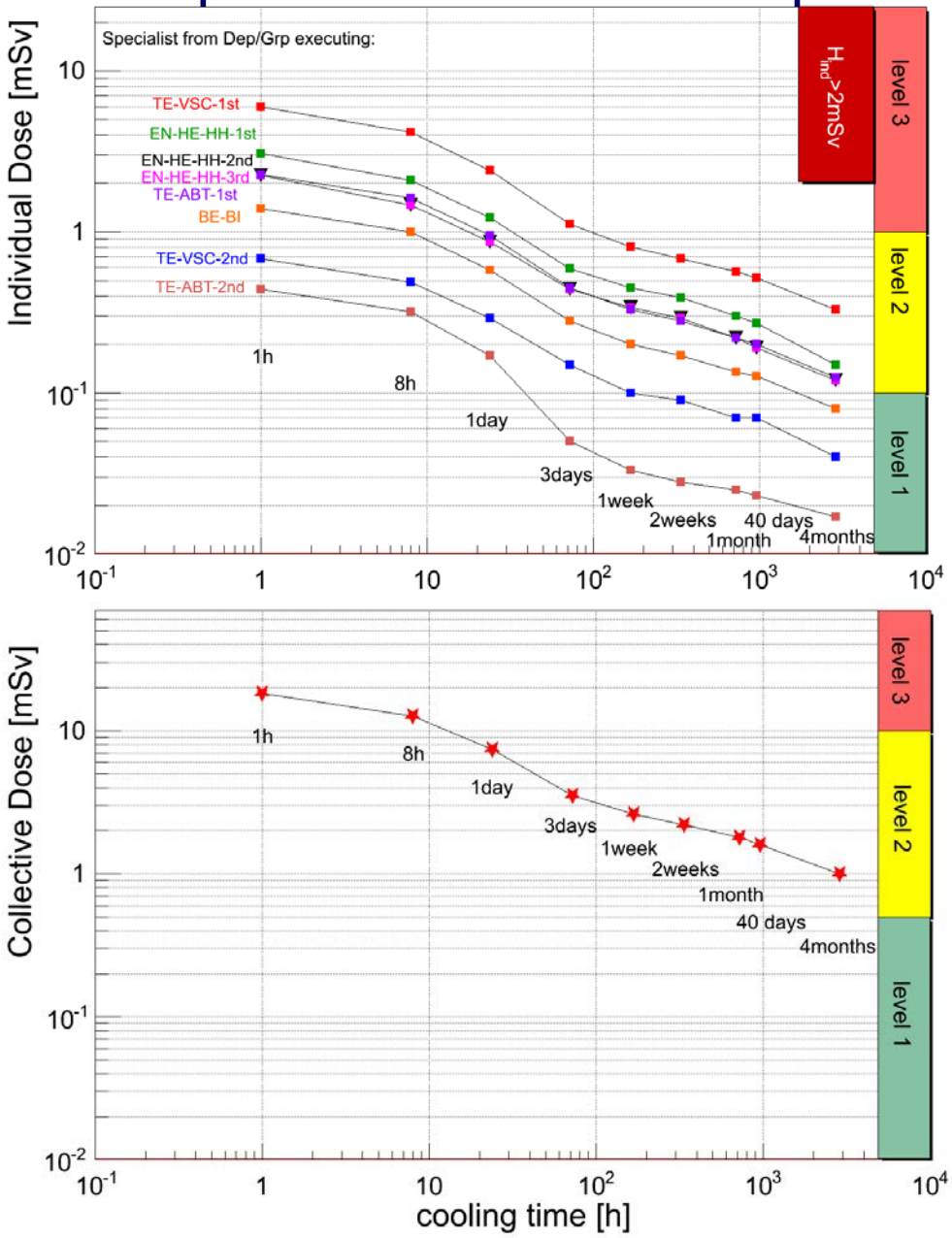
Fraction of many histograms to be analyzed for the final summary table on the 2 interventions

Individual and Collective Doses Estimated for the Intervention -Replacement of the complete system- at PS SS15

Specialist from Dep/Grp executing	cooling time								
	Accumulated Dose / Person [mSv/person]								
	1h	8h	1 day	3 days	1 week	2 weeks	1 month	40 days	4 months
TE-VSC-1st	5.86	4.16	2.41	1.12	0.81	0.68	0.57	0.52	0.33
TE-VSC-2nd	0.68	0.49	0.29	0.15	0.1	0.09	0.07	0.07	0.04
EN-HE-HH-1st	3.06	2.08	1.22	0.59	0.45	0.39	0.3	0.27	0.15
EN-HE-HH-2nd	2.24	1.47	0.87	0.44	0.34	0.29	0.22	0.19	0.12
EN-HE-HH-3rd	2.24	1.47	0.87	0.44	0.34	0.29	0.22	0.19	0.12
TE-ABT-1st	2.26	1.62	0.95	0.45	0.33	0.28	0.22	0.2	0.125
TE-ABT-2nd	0.44	0.32	0.17	0.05	0.033	0.028	0.025	0.023	0.017
BE-BI	1.4	1.0	0.58	0.28	0.2	0.17	0.13	0.13	0.08
Collective Dose [mSv] – '8 persons'	**18.2**	**12.6**	**7.4**	**3.5**	**2.6**	**2.2**	**1.8**	**1.6**	**1.0**

Minimum waiting time of at least 3 days required

Individual and Collective Doses Estimated for the Intervention -Replacement of the complete system- at PS SS15



Minimum waiting time of at least 3 days required

For waiting times between 3 days and 1 week no need for ALARA committee

Annex

Accumulated Dose per Person and Intervention during the ‘Replacement of the complete system’ at PS SS15 for different cooling times

Accumulated Dose per person and intervention during the 'Replacement of the complete system' at PS SS15 after cooling time of 1 hour

Work description (Task)	Dep/Grp (executing)	Dose/person (EN-HE-HH_1st/2nd/3rd) [mSv]	Dose/person (TE-VSC_1st) [mSv]	Dose/person (TE-VSC_2nd) [mSv]	Dose/person (TE-ABT-1st/2nd) [mSv]	Dose/person (BE-BI) [mSv]	Total collective dose [mSv]
Actions							**18.2**
Venting of sector	TE-VSC	remote					
Dismantling of shielding	EN-HE-HH	1.06/1.1/1.1					3.26
Disconnection of downstream and upstream flanges	TE/VSC		0.28	0.27			+0.55
Disconnect cabling, compressed air, water cooling, etc.	TE-ABT, BE-BI, TE-VSC		0.8		0.4/0	0.4	+1.6
Removal of tank assembly	TE-ABT, EN-HE-HH	0.42/0/0			0.42/0		+0.84
Installation of spare	TE-ABT, EN-HE-HH	0.44/0/0			0.44/0.44		+1.32
Reconnection of downstream and upstream flanges	TE/VSC		0.78	0.41			+1.19
Reconnection of cables, air, and water cooling	TE-ABT/BE-BI/TE-VSC		1.0		1.0/0	1.0	+3.0
Leak test	TE-VSC		3.0				+3.0
Installation of shielding	EN-HE-HH	1.14/1.14/1.14					+3.42
		3.06/2.24/2.24	5.86	0.68	2.26/0.44	1.4	**18.2**

Accumulated Dose per Person and Intervention during the 'Replacement of the complete system' at PS SS15 after cooling time of 8 hour

Work description (Task)	Dep/Grp (executing)	Dose/person (EN-HE-HH_1st/2nd/3rd) [mSv]	Dose/person (TE-VSC_1st) [mSv]	Dose/person (TE-VSC_2nd) [mSv]	Dose/person (TE-ABT-1st/2nd) [mSv]	Dose/person (BE-BI) [mSv]	Total collective dose [mSv]
Actions							**12.6**
Venting of sector	TE-VSC	remote					
Dismantling of shielding	EN-HE-HH	0.7/0.71/0.71					2.12
Disconnection of downstream and upstream flanges	TE/VSC		0.2	0.2			+0.4
Disconnect cabling, compressed air, water cooling, etc.	TE-ABT, BE-BI, TE-VSC		0.6		0.3/0	0.3	+1.2
Removal of tank assembly	TE-ABT, EN-HE-HH	0.3/0/0			0.3/0		+0.6
Installation of spare	TE-ABT, EN-HE-HH	0.32/0/0			0.32/0.32		+0.96
Reconnection of downstream and upstream	TE/VSC		0.56	0.29			+0.85
Reconnection of cables, air, and water cooling	TE-ABT/BE-BI/TE-VSC		0.7		0.7/0	0.7	+2.1
Leak test	TE-VSC		2.1				+2.1
Installation of shielding	EN-HE-HH	0.76/0.76/0.76					+2.28
		2.08/1.47/1.47	4.16	0.49	1.62/0.32	1.0	**12.6**

Accumulated Dose per Person and Intervention during the 'Replacement of the complete system' at PS SS15 after cooling time of 1 day

Work description (Task)	Dep/Grp (executing)	Dose/person (EN-HE-HH_1st/2nd/3rd) [mSv]	Dose/person (TE-VSC_1st) [mSv]	Dose/person (TE-VSC_2nd) [mSv]	Dose/person (TE-ABT-1st/2nd) [mSv]	Dose/person (BE-BI) [mSv]	Total collective dose [mSv]
Actions							**7.36**
Venting of sector	TE-VSC	remote					
Dismantling of shielding	EN-HE-HH	0.4/0.42/0.42					1.24
Disconnection of downstream and upstream flanges	TE/VSC		0.13	0.14			+0.27
Disconnect cabling, compressed air, water cooling, etc.	TE-ABT, BE-BI, TE-VSC		0.4		0.2/0	0.2	+0.8
Removal of tank assembly	TE-ABT, EN-HE-HH	0.2/0/0			0.2/0		+0.4
Installation of spare	TE-ABT, EN-HE-HH	0.17/0/0			0.17/0.17		+0.51
Reconnection of downstream and upstream flanges	TE/VSC		0.35	0.15			+0.5
Reconnection of cables, air, and water cooling	TE-ABT/BE-BI/TE-VSC		0.38		0.38/0	0.38	+1.14
Leak test	TE-VSC		1.15				+1.15
Installation of shielding	EN-HE-HH	0.45/0.45/0.45					+1.35
		1.22/0.87/0.87	2.41	0.29	0.95/0.17	0.58	**7.36**

Accumulated Dose per Person and Intervention during the 'Replacement of the complete system' at PS SS15 after cooling time of 1 week

Work description (Task)	Dep/Grp (executing)	Dose/person (EN-HE-HH_1st/2nd/3rd) [mSv]	Dose/person (TE-VSC_1st) [mSv]	Dose/person (TE-VSC_2nd) [mSv]	Dose/person (TE-ABT-1st/2nd) [mSv]	Dose/person (BE-BI) [mSv]	Total collective dose [mSv]
Actions							**2.6**
Venting of sector	TE-VSC	remote					
Dismantling of shielding	EN-HE-HH	0.15/0.17/0.17					0.49
Disconnection of downstream and upstream flanges	TE/VSC		0.07	0.07			+0.14
Disconnect cabling, compressed air, water cooling, etc.	TE-ABT, BE-BI, TE-VSC		0.2		0.1/0	0.1	+0.4
Removal of tank assembly	TE-ABT, EN-HE-HH	0.095/0/0			0.095/0		+0.19
Installation of spare	TE-ABT, EN-HE-HH	0.033/0/0			0.033/0.033		+0.1
Reconnection of downstream and upstream flanges	TE/VSC		0.14	0.03			+0.17
Reconnection of cables, air, and water cooling	TE-ABT/BE-BI/TE-VSC		0.1		0.1/0	0.1	+0.3
Leak test	TE-VSC		0.3				+0.3
Installation of shielding	EN-HE-HH	0.17/0.17/0.17					+0.51
		0.45/0.34/0.34	0.81	0.10	0.33/0.033	0.2	**2.6**

Accumulated Dose per Person and Intervention during the 'Replacement of the complete system' at PS SS15 after cooling time of 2 weeks

Work description (Task)	Dep/Grp (executing)	Dose/person (EN-HE-HH_1st/2nd/3rd) [mSv]	Dose/person (TE-VSC_1st) [mSv]	Dose/person (TE-VSC_2nd) [mSv]	Dose/person (TE-ABT-1st/2nd) [mSv]	Dose/person (BE-BI) [mSv]	Total collective dose [mSv]
Actions							**2.2**
Venting of sector	TE-VSC	remote					
Dismantling of shielding	EN-HE-HH	0.13/0.14/0.14					0.41
Disconnection of downstream and upstream flanges	TE/VSC		0.054	0.067			+0.12
Disconnect cabling, compressed air, water cooling, etc.	TE-ABT, BE-BI, TE-VSC		0.18		0.09/0	0.09	+0.36
Removal of tank assembly	TE-ABT, EN-HE-HH	0.08/0/0			0.08/0		+0.16
Installation of spare	TE-ABT, EN-HE-HH	0.028/0/0			0.028/0.028		+0.084
Reconnection of downstream and upstream flanges	TE/VSC		0.12	0.025			+0.145
Reconnection of cables, air, and water cooling	TE-ABT/BE-BI/TE-VSC		0.08		0.08/0	0.08	+0.24
Leak test	TE-VSC		0.25				+0.25
Installation of shielding	EN-HE-HH	0.15/0.15/0.15					+0.45
		0.39/0.29/0.29	0.68	0.09	0.28/0.028	0.17	**2.2**

Accumulated Dose per Person and Intervention during the 'Replacement of the complete system' at PS SS15 after cooling time of 1 month

Work description (Task)	Dep/Grp (executing)	Dose/person (EN-HE-HH_1st/2nd/3rd) [mSv]	Dose/person (TE-VSC_1st) [mSv]	Dose/person (TE-VSC_2nd) [mSv]	Dose/person (TE-ABT-1st/2nd) [mSv]	Dose/person (BE-BI) [mSv]	Total collective dose [mSv]
Actions							**1.76**
Venting of sector	TE-VSC	remote					
Dismantling of shielding	EN-HE-HH	0.1/0.11/0.11					0.32
Disconnection of downstream and upstream flanges	TE/VSC		0.038	0.05			+0.088
Disconnect cabling, compressed air, water cooling, etc.	TE-ABT, BE-BI, TE-VSC		0.13		0.065/0	0.065	+0.26
Removal of tank assembly	TE-ABT, EN-HE-HH	0.06/0/0			0.06/0		+0.12
Installation of spare	TE-ABT, EN-HE-HH	0.025/0/0			0.025/0.025		+0.075
Reconnection of downstream and upstream flanges	TE/VSC		0.11	0.022			+0.132
Reconnection of cables, air, and water cooling	TE-ABT/BE-BI/TE-VSC		0.07		0.07/0	0.07	+0.21
Leak test	TE-VSC		0.22				+0.22
Installation of shielding	EN-HE-HH	0.11/0.11/0.11					+0.33
		0.3/0.22/0.22	0.57	0.072	0.22/0.025	0.135	**1.76**

Accumulated Dose per Person and Intervention during the 'Replacement of the complete system' at PS SS15 after cooling time of 40 days

Work description (Task)	Dep/Grp (executing)	Dose/person (EN-HE-HH_1st/2nd/3rd) [mSv]	Dose/person (TE-VSC_1st) [mSv]	Dose/person (TE-VSC_2nd) [mSv]	Dose/person (TE-ABT-1st/2nd) [mSv]	Dose/person (BE-BI) [mSv]	Total collective dose [mSv]
Actions							**1.6**
Venting of sector	TE-VSC	remote					
Dismantling of shielding	EN-HE-HH	0.09/0.095/0.095					0.28
Disconnection of downstream and upstream flanges	TE/VSC		0.033	0.046			+0.079
Disconnect cabling, compressed air, water cooling, etc.	TE-ABT, BE-BI, TE-VSC		0.12		0.06/0	0.06	+0.24
Removal of tank assembly	TE-ABT, EN-HE-HH	0.055/0/0			0.055/0		+0.11
Installation of spare	TE-ABT, EN-HE-HH	0.023/0/0			0.023/0.023		+0.069
Reconnection of downstream and upstream flanges	TE/VSC		0.1	0.021			+0.121
Reconnection of cables, air, and water cooling	TE-ABT/BE-BI/TE-VSC		0.067		0.067/0	0.067	+0.2
Leak test	TE-VSC		0.2				+0.2
Installation of shielding	EN-HE-HH	0.1/0.1/0.1					+0.3
		0.27/0.195/0.195	0.52	0.067	0.2/0.023	0.127	**1.6**

Accumulated Dose per Person and Intervention during the 'Replacement of the complete system' at PS SS15 after cooling time of 4 months

Work description (Task)	Dep/Grp (executing)	Dose/person (EN-HE-HH_1st/2nd/3rd) [mSv]	Dose/person (TE-VSC_1st) [mSv]	Dose/person (TE-VSC_2nd) [mSv]	Dose/person (TE-ABT-1st/2nd) [mSv]	Dose/person (BE-BI) [mSv]	Total collective dose [mSv]
Actions							**1.0**
Venting of sector	TE-VSC	remote					
Dismantling of shielding	EN-HE-HH	0.05/0.056/0.056					0.162
Disconnection of downstream and upstream flanges	TE/VSC		0.02	0.023			+0.043
Disconnect cabling, compressed air, water cooling, etc.	TE-ABT, BE-BI, TE-VSC		0.07		0.035/0	0.035	+0.14
Removal of tank assembly	TE-ABT, EN-HE-HH	0.028/0/0			0.028/0		+0.056
Installation of spare tank	TE-ABT, EN-HE-HH	0.017/0/0			0.017/0.017		+0.051
Reconnection of downstream and upstream flanges	TE/VSC		0.06	0.015			+0.075
Reconnection of cables, air, and water cooling	TE-ABT/BE-BI/TE-VSC		0.045		0.045/0	0.045	+0.135
Leak test	TE-VSC		0.135				+0.135
Installation of shielding	EN-HE-HH	0.06/0.06/0.06					+0.18
		0.15/0.12/0.12	0.33	0.038	0.125/0.017	0.08	**1.0**

Real Action – exchange of PE.SMH16 in 2009

Description: Preventive removal of SMH16.1 and reinstallation of spare SMH16.2 in PS SS16
PE.SMH16_exchange.xlsx