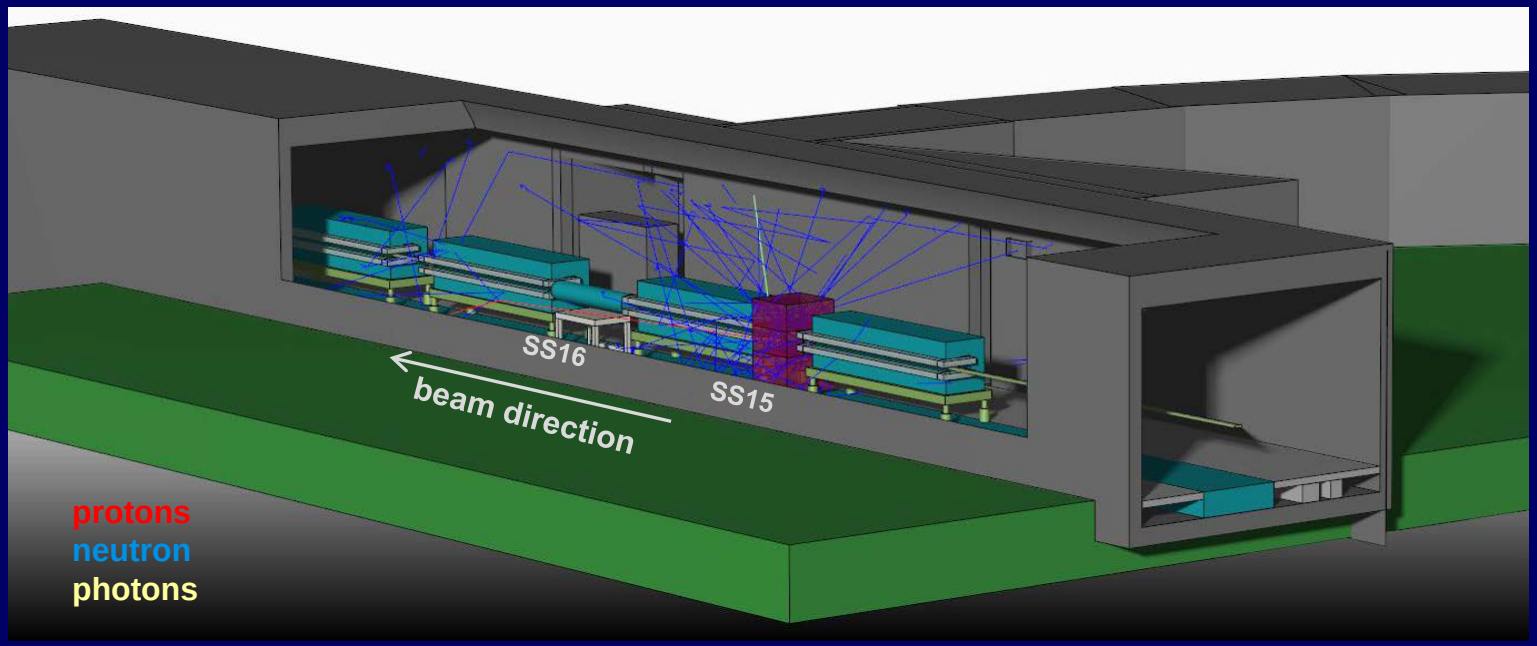
Shadowing of SMH16
Realistic beam tracking with FLUKA/PTC

Expected Radiation Level with Dummy Septum 15

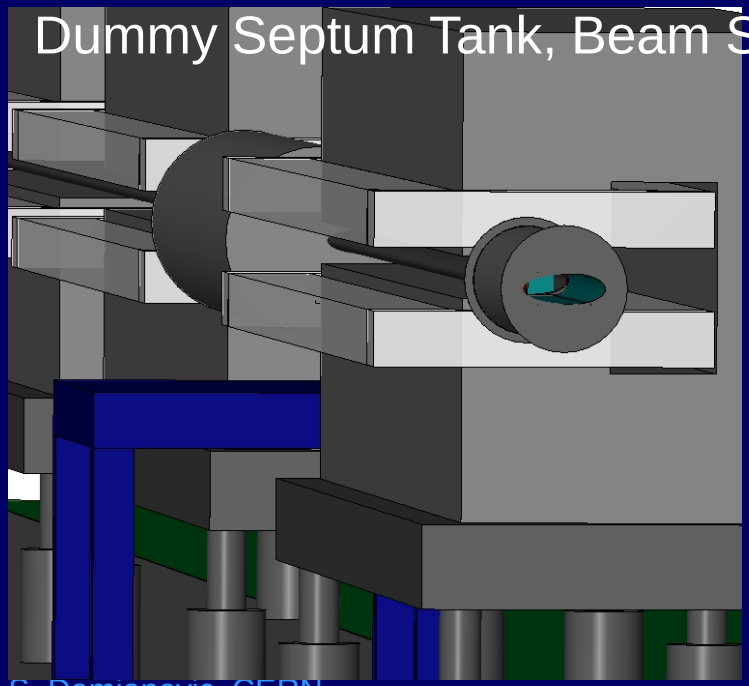
Sanja Damjanovic and Cedric Hernalsteens

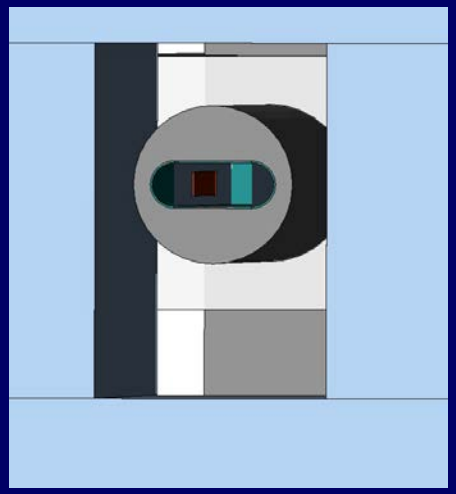
Dummy Septum Meeting, CERN, October 11, 2012

Ejection Region of the PS with the Dummy Septum in SS15

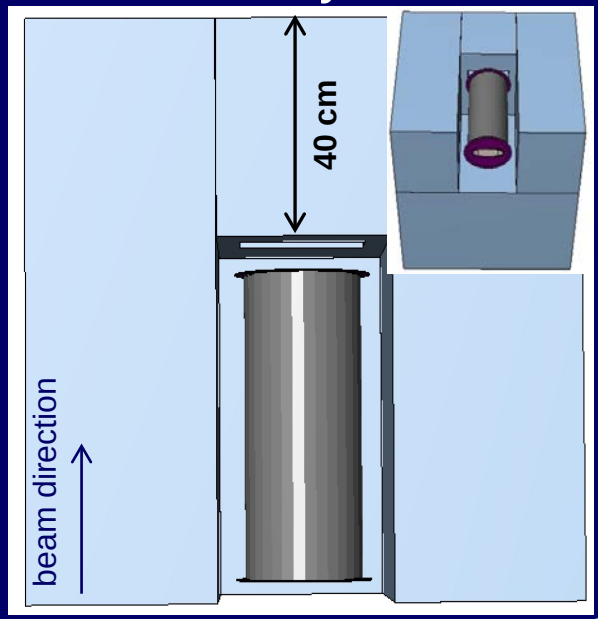


Dummy Septum Tank, Beam Screen Window and Blade – all locally shielded





copper stainless steel
concrete steel aluminum



Fluka/PTC simulations

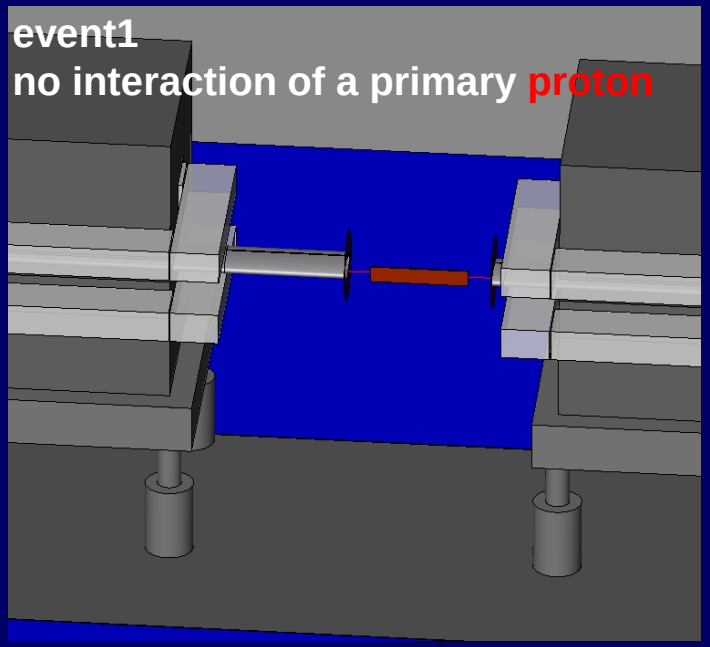
Simulation strategy

- Generate a realistic beam distribution at the start of SS15
- Transport it with Fluka through SS15 $\rightarrow$ realistic interaction with the dummy septum blade
- Evaluate the losses in SS15 $\rightarrow$ dose rate Map_{15}
- Track the remaining particles through MU15 $\rightarrow$ correct propagation in the magnet (Fluka geometry does not contain the curvature)
- Transport the distribution in SS16 $\rightarrow$ realistic effect of the complex interaction with the blades of SMH16
- Evaluate the losses in SS16 $\rightarrow$ dose rate Map_{16}
- The circulating beam at the end of SS16 can be tracked in the rest of the machine to check for hot spots along the ring
- Sum the dose rate maps $\rightarrow$ dose rate $\mathrm{Map}_{\mathrm{total}} = \mathrm{Map}_{15} + \mathrm{Map}_{16}$

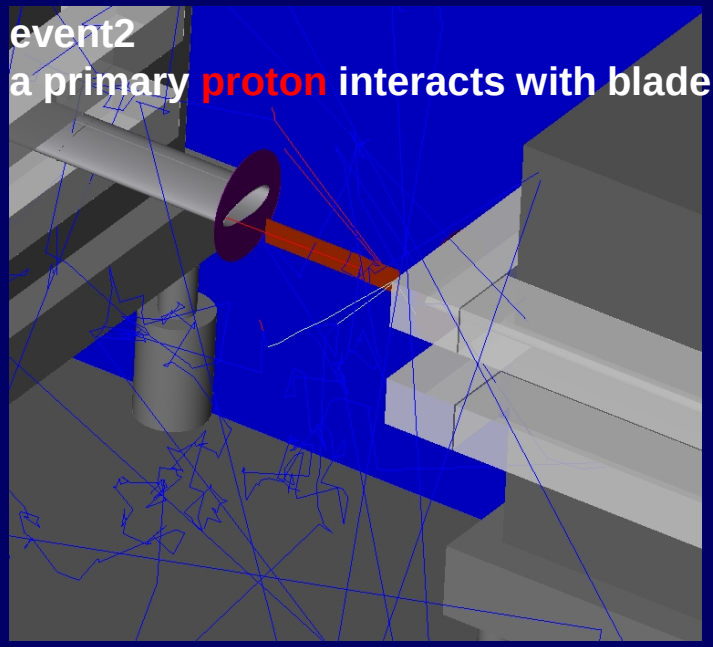
Nomenclature: start of SS(N) means end of the coils of MU(N-1)

FLUKA Transport through SS15 – Single event displays

a fraction of the primary beam interacts with the blade



protons
neutron
photons



relative beam loss extracted by counting the protons entering the vacuum chamber of MMU15

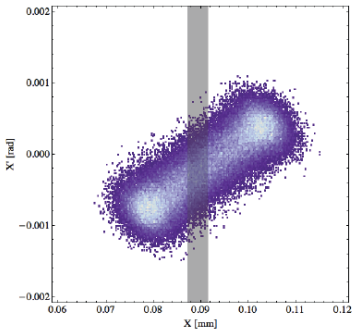


Figure 9: Start of SS15 and position of the blade

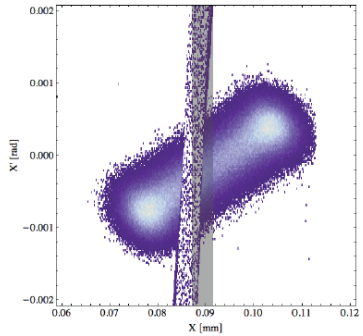
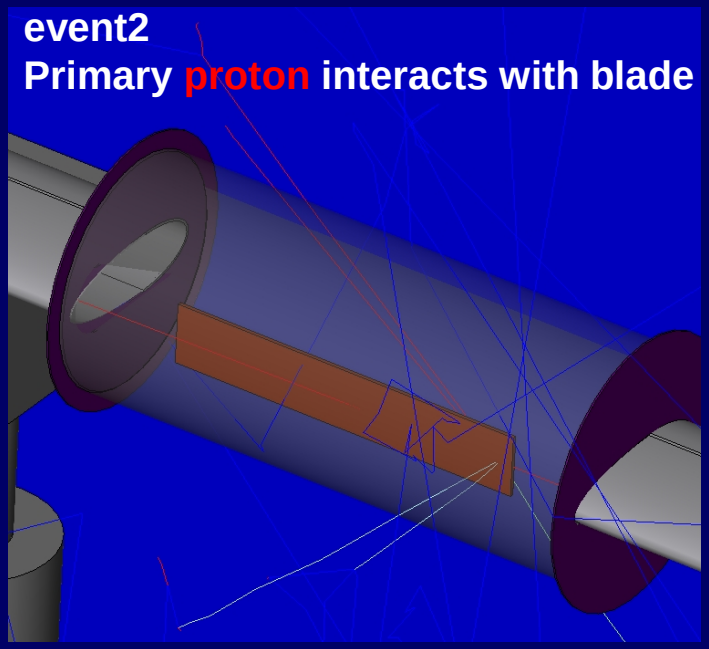
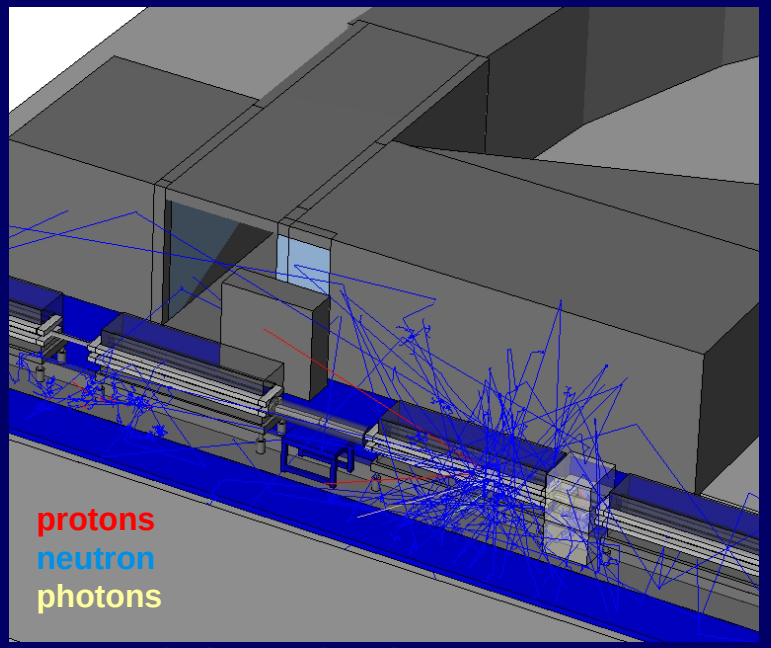


Figure 10: End of SS15, hole in the distribution

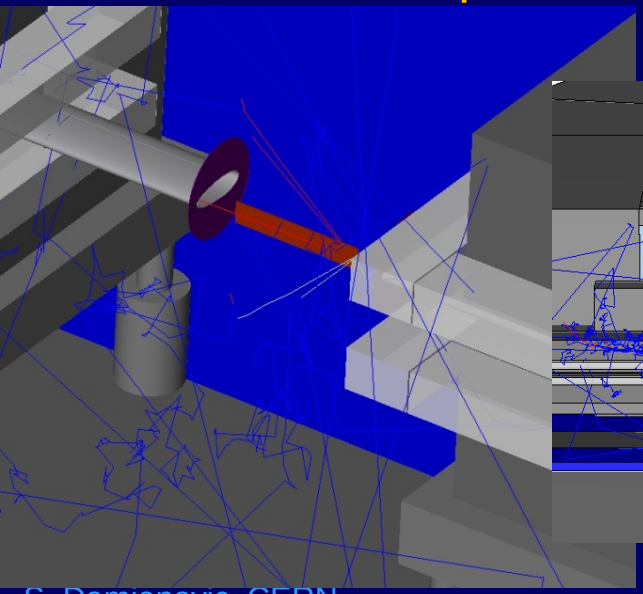
due to interaction of primary protons → secondaries produced - hadronic and EM showers producing other charged particles, neutrons, photons with a wide range of energies

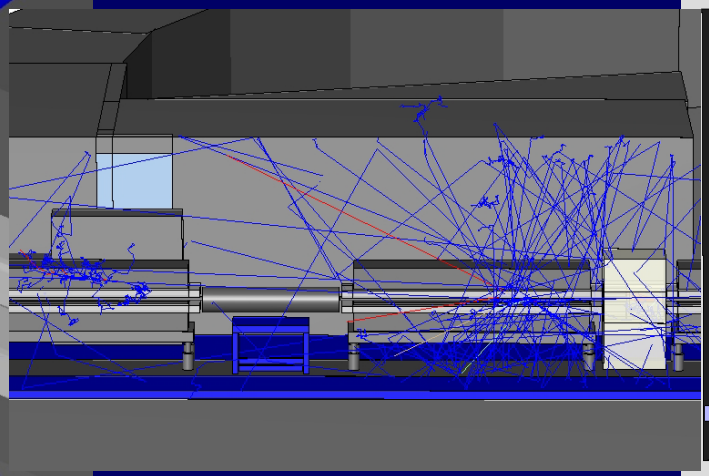
FLUKA Transport through SS15 – Single event display

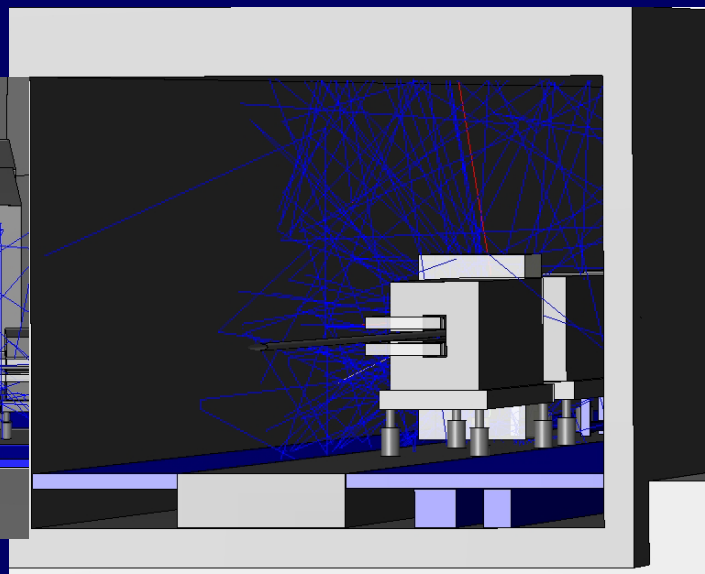




Secondaries produced lead to an elevated dose in the tunnel







Expected Residual Amb. Dose-eq Rates with Dummy Septum 15, due to primary beam interactions within SS15

example:
cooling time 40 days

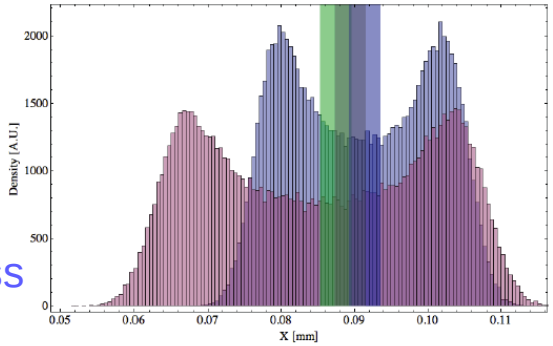
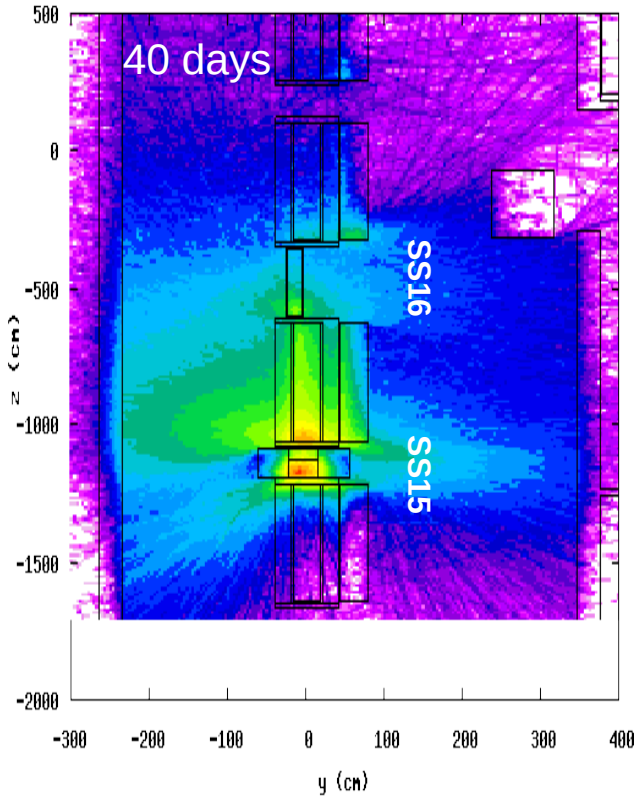
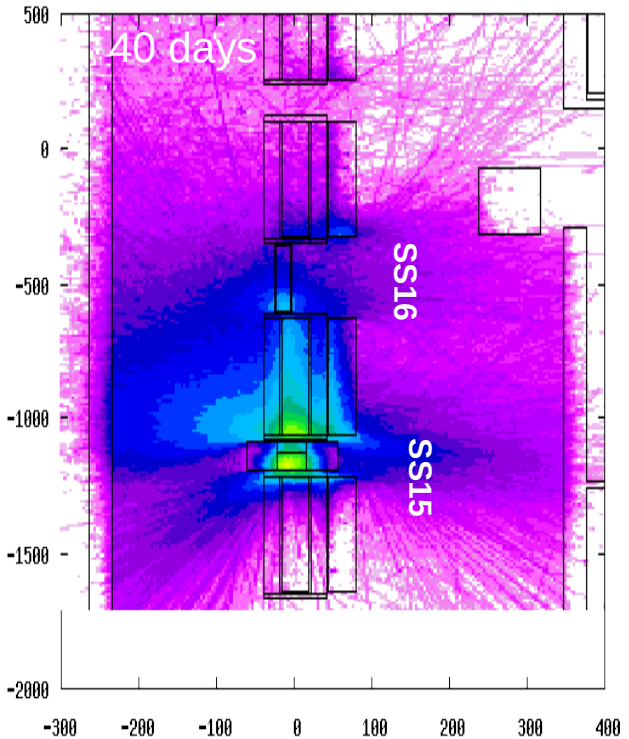


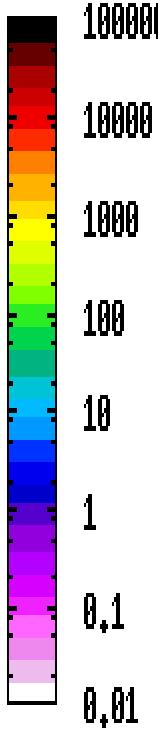
Figure 8: Aggregated distribution at the start of SS15 for the core (red) and for the outer island (blue)

ISL beam: 0.47% loss
(4.7×10^{10} lost p/s)

CORE beam: 0.06% loss
(6×10^{9} lost p/s)

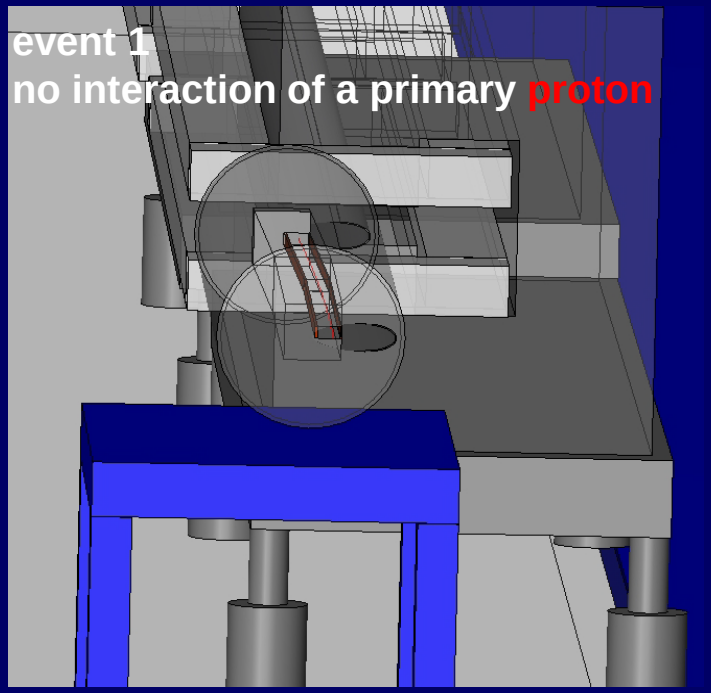


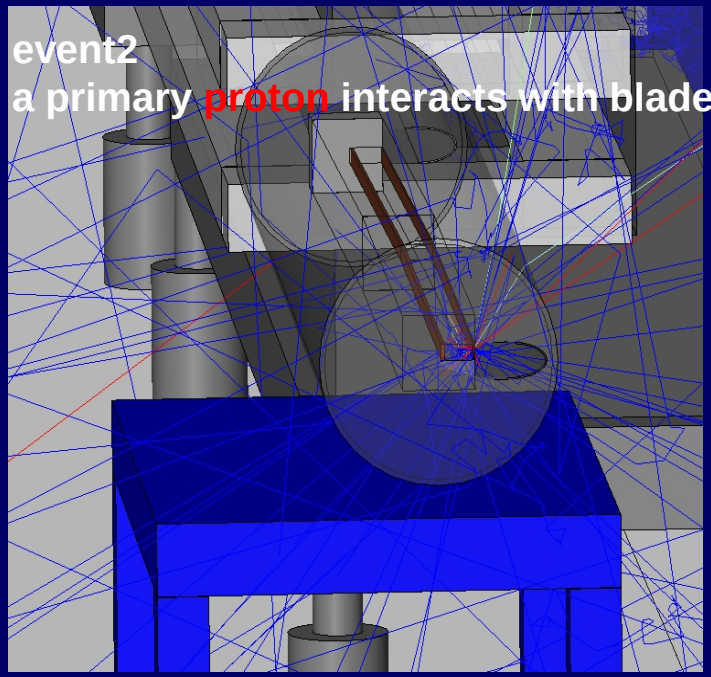


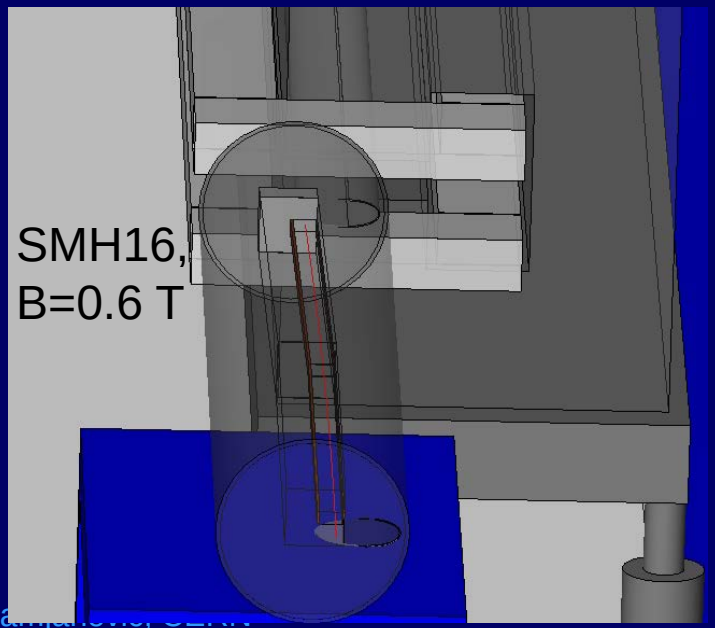


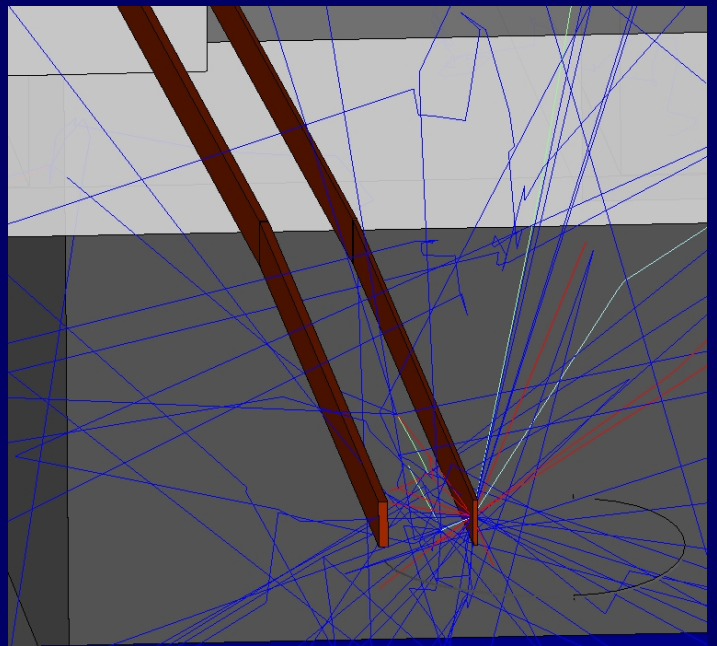
2dim projections of H*(10) in y-z plane at the beam level

FLUKA Transport through SS16 – Single event displays



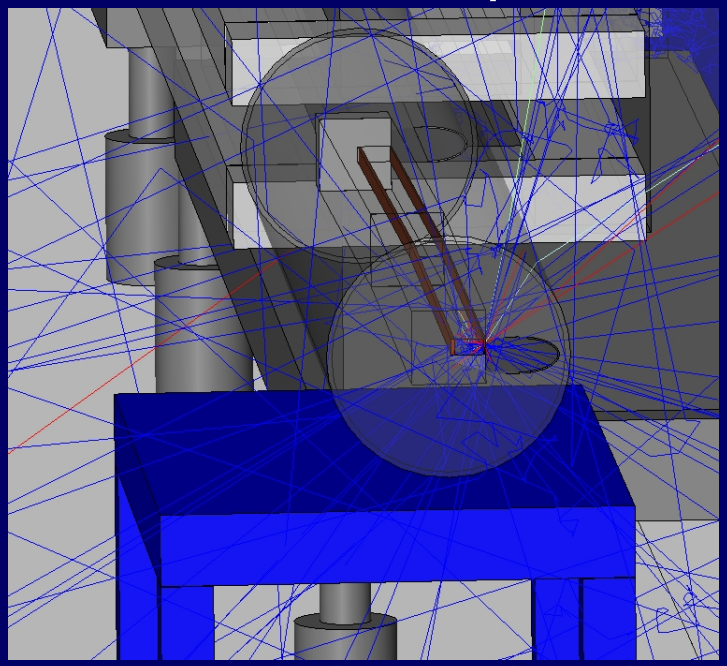


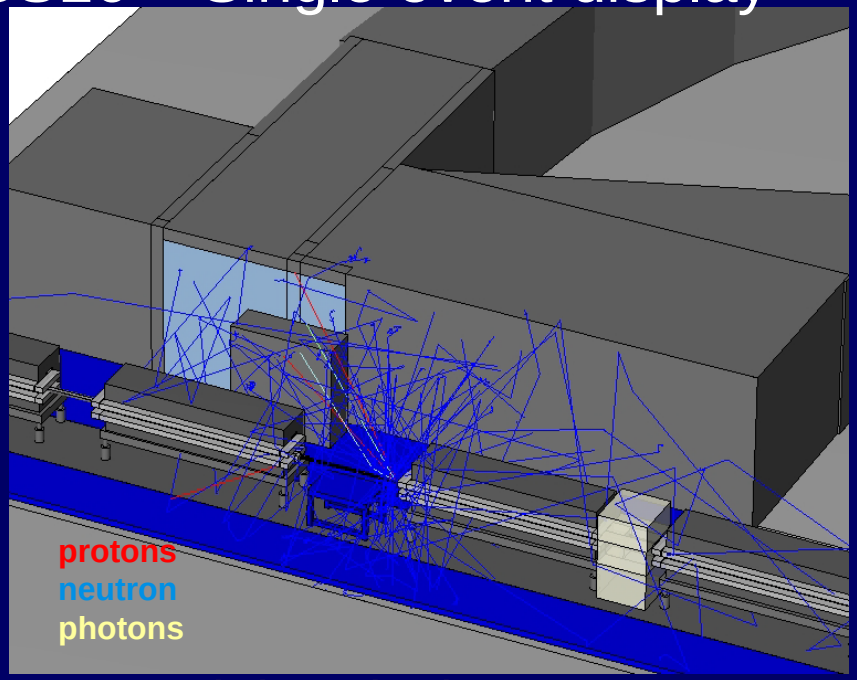




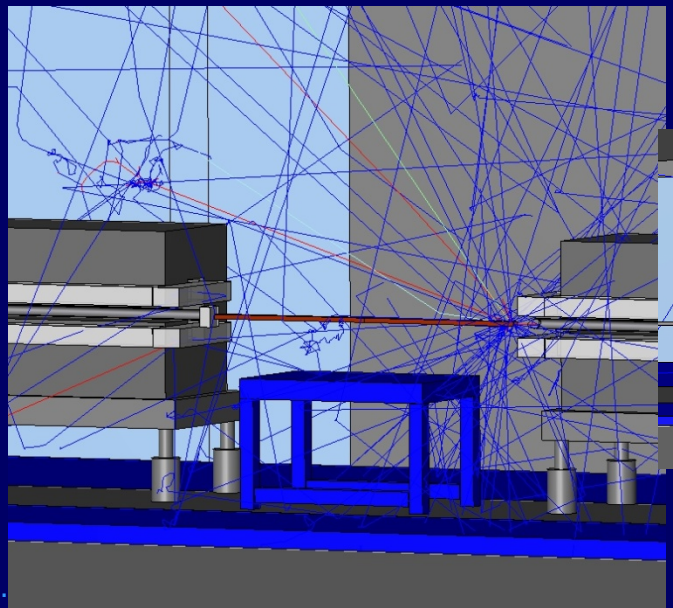
protons
neutron
photons

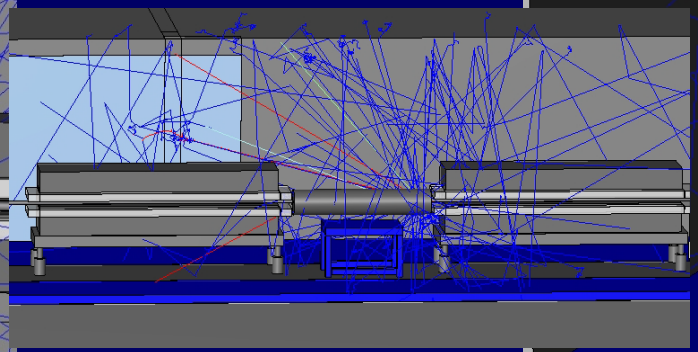
FLUKA Transport through SS16 – Single event display

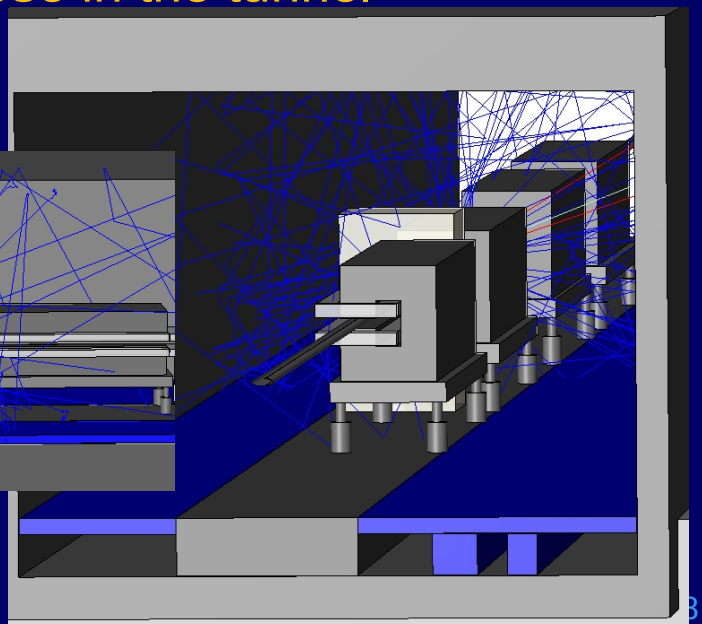




Secondaries produced lead to an elevated dose in the tunnel







Expected Residual Amb. Dose-eq Rates with Dummy Septum 15, due to primary beam interactions within SS16

example:
cooling time 40 days

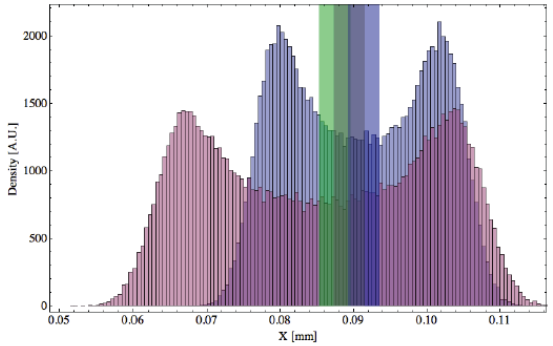
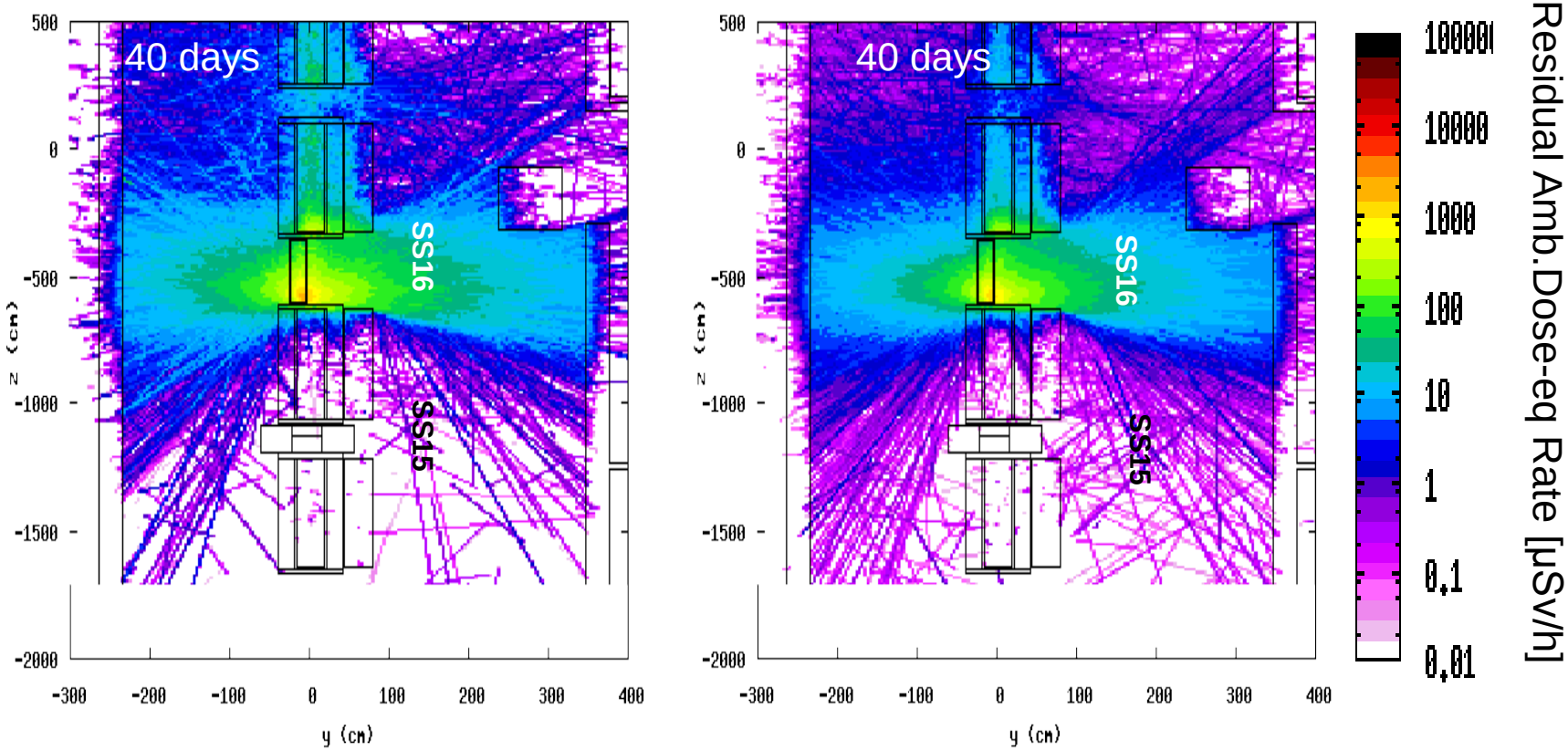


Figure 8: Aggregated distribution at the start of SS15 for the core (red) and for the outer island (blue)

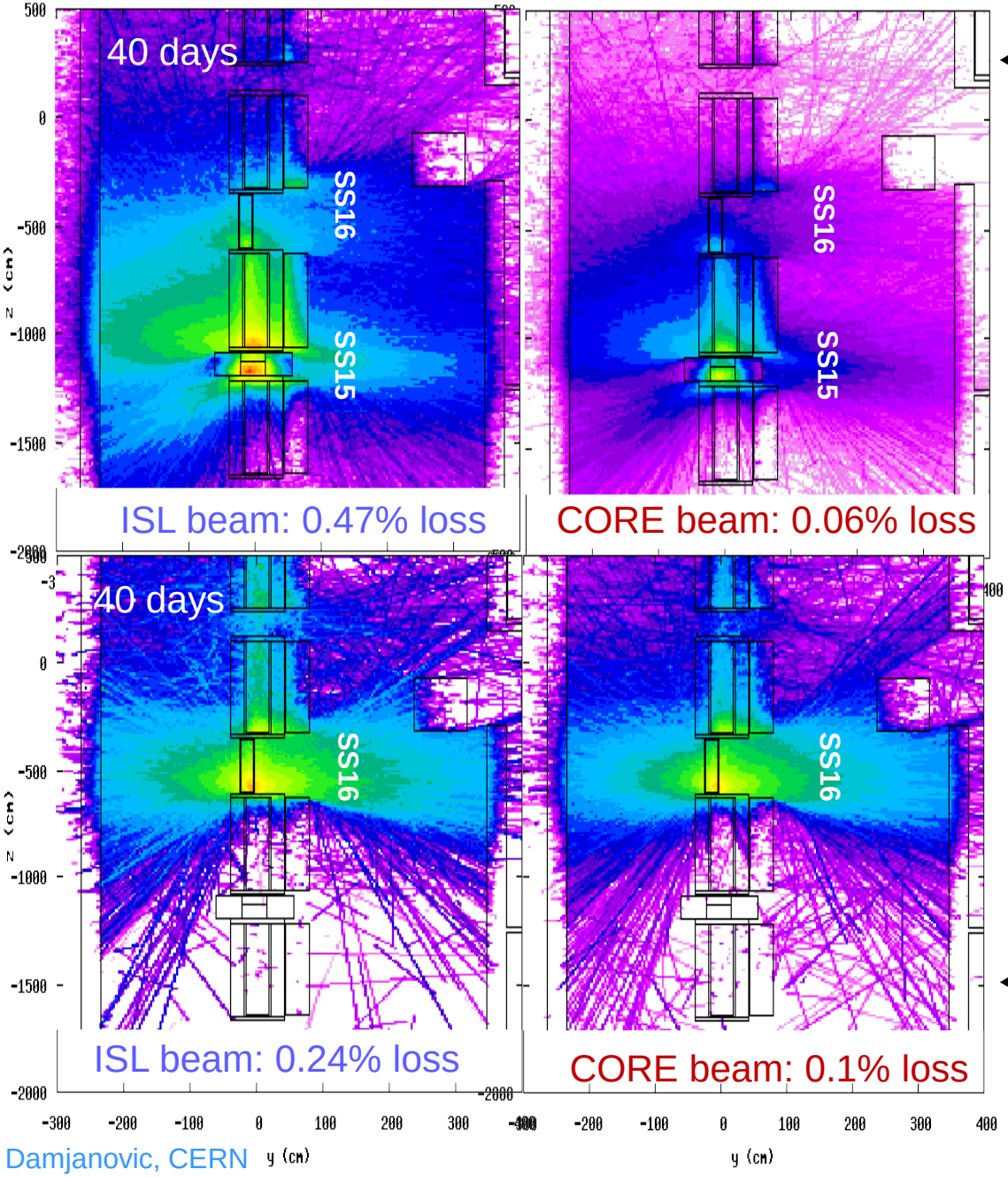
ISL beam: 0.24% loss
(2.4×10^{10} lost p/s)

CORE beam: 0.1% loss
(1×10^{10} lost p/s)



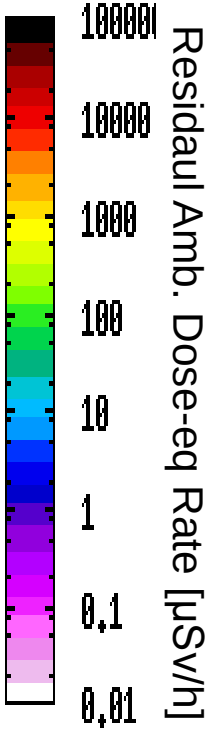
2dim projections of H*(10) in y-z plane at the beam level

Expected Residual Amb. Dose-eq Rates with Dummy Septum 15



← H*(10) due to interactions within SS15

beam loss ~0.53%



example:
cooling time
40 days

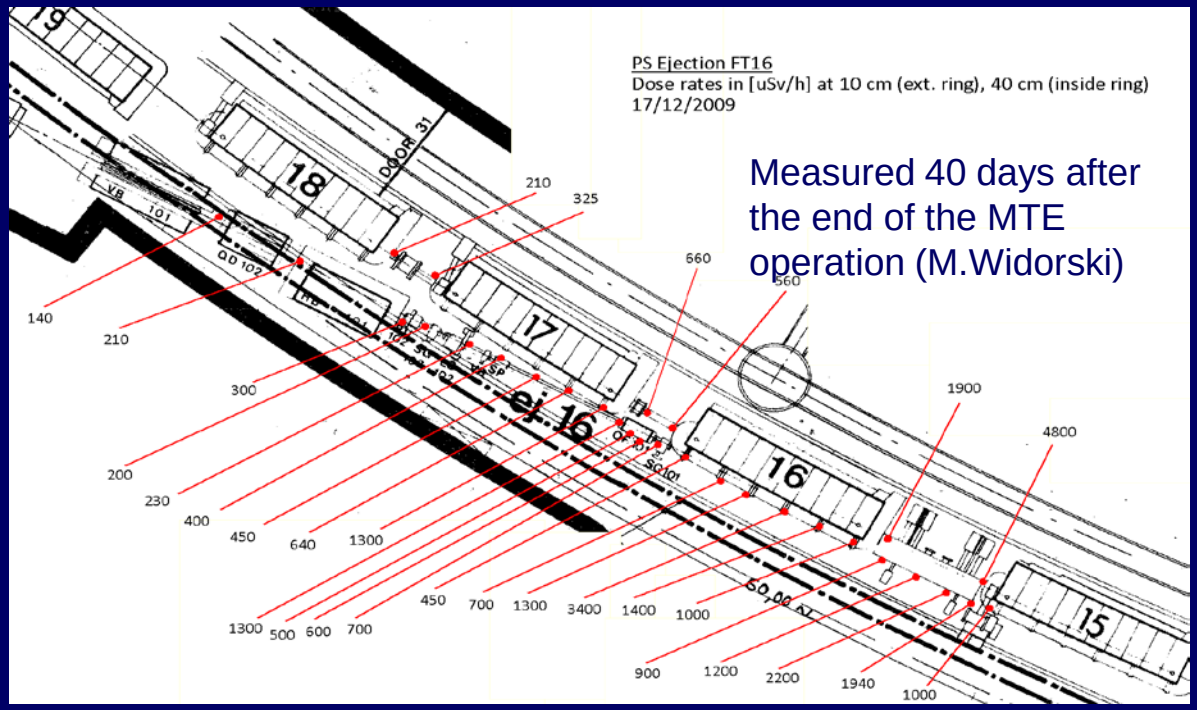
beam interactions in blades of SMH16 reduced by 60%

total absolute beam loss 0.9%; same as today

← H*(10) due to interactions within SS16

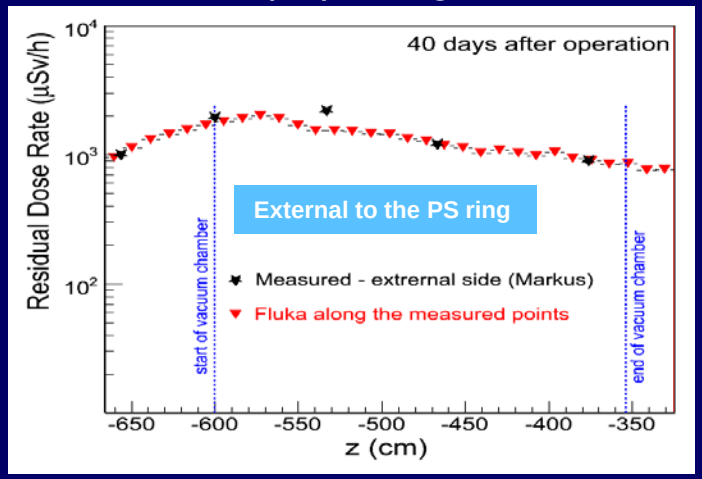
beam loss ~0.34%

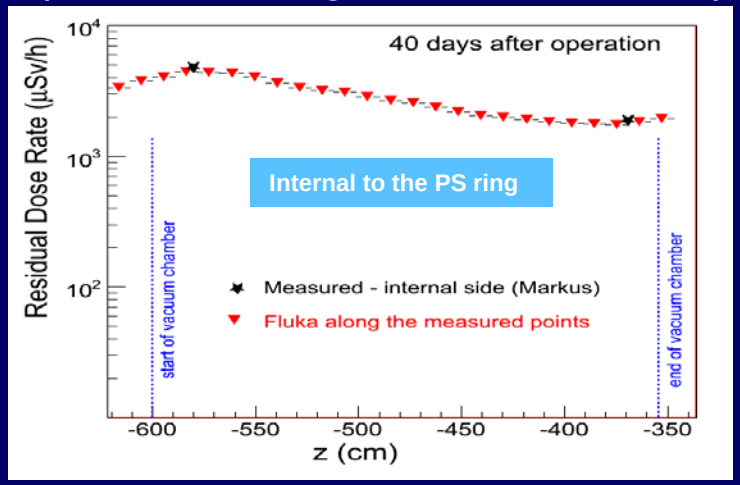
Present Situation: SMH16 too radioactive with MTE



Residual Amb. Dose-eq Rates after cooling time of 40 days 1-5 mSv/h in the region of SMH16

Simulated H*(10) along the measured points in the region of SS16 for the present situation

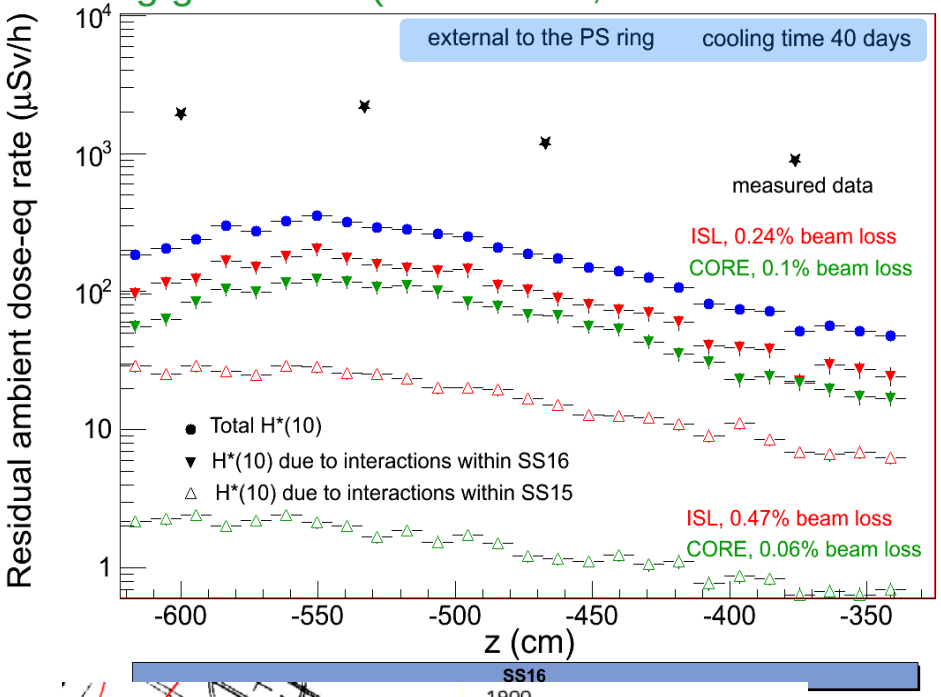




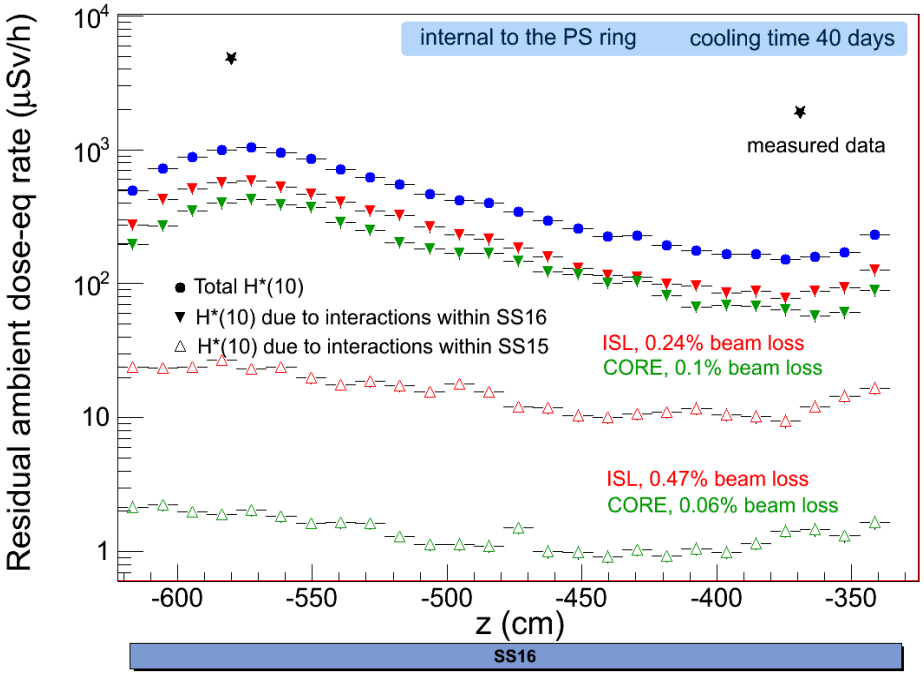
assumption:
pencil beam,
1% beam loss
(10^{11} p/s)
in SMH16

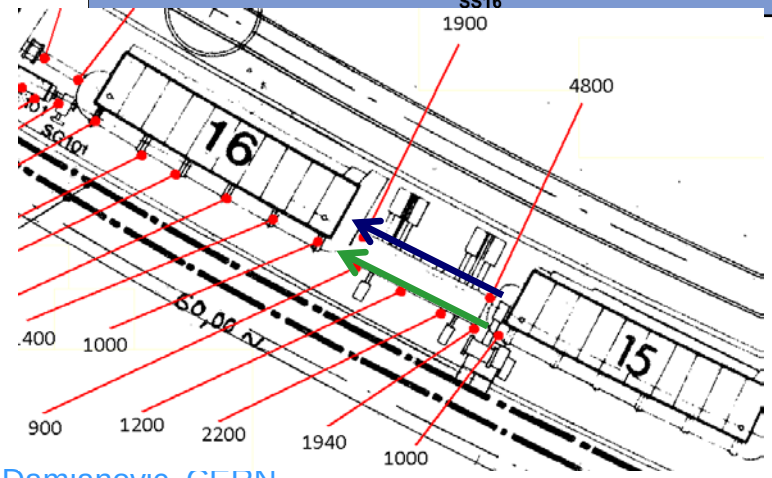
Expected Total Radiation Field and Residual Activation along SMH16 with Dummy Septum 15

along green line (beam level, at 10 cm distance)



along blue line (beam level, at 10 cm distance)





Installation of Dummy Septum 15

→ Reduction of radiation field and the resulting activation associated with MTE operation by a factor of 5 -10 in the whole environment of SMH16

How does this compare to the radiation level due to CT operations?

Radiation Survey along the PS ring after the end CT operation

PS Ring Radiation Survey 2011

Débits de dose en µSv/h à 40 cm de la ligne de faisceau côté intérieur (08/12/2011)

Dose rates in µSv/h at 40 cm of the beam line inside of the ring (08/12/2011)

Section droite Straight section	Amont Upstream	Aval Downstream
1	101	48
2	32	38
3	44	43
4	8	25
5	15	28
6	10	9
7	18	13
8	9	23
9	163	95
10	9	7
11	17	13
12	19	47
13	55	56
14	20	28
15	36	67
16	2590	942
17	283	307
18	107	94
19	54	44
20	30	21
21	52	30
22	19	73
23	68	138
24	26	27
25	52	42
26	77	66
27	30	22
28	39	43
29	76	57
30	423	430
31	870	1786
32	480	432
33	375	435
34	609	508
35	609	662
36	115	118
37	1336	1051
38	202	170
39	1699	890
40	97	182
41	343	286
42	427	839
43	845	465
44	188	160
45	201	27
46	41	72
47	76	48
48	51	66
49	66	53
50	34	25

Section droite Straight section	Amont Upstream	Aval Downstream
51	44	31
52	37	38
53	46	43
54	15	27
55	35	28
56	11	12
57	377	1030
58	137	90
59	67	48
60	69	124
61	87	84
62	28	30
63	107	122
64	25	24
65	40	56
66	7	10
67	34	21
68	13	15
69	36	40
70	29	16
71	26	18
72	26	18
73	26	53
74	29	32
75	1411	800
76	162	62
77	50	46
78	10	11
79	18	21
80	5	4
81	4	4
82	9	37
83	21	21
84	19	17
85	50	68
86	14	17
87	66	37
88	19	36
89	38	30
90	17	19
91	40	28
92	3	19
93	14	43
94	7	9
95	20	21
96	3	3
97	21	33
98	15	18
99	42	41
100	13	43

Color Code:

> 100 µSv/h
> 200 µSv/h
> 500 µSv/h
> 2000 µSv/h

If you have any questions concerning radiation protection, please call:
Pour tout renseignement concernant la radioprotection, veuillez contacter: **Phone: 72504**

Measured Amb.Residual Dose-eq Rates after cooling time of 2 weeks (08/12/2011; G. Dumont) 1-2.6 mSv/h downstream and upstream of the SMH16

(inner side of machine, beam level at 40 cm distance)

Section droite Straight section	Amont Upstream	Aval Downstream
1	101	48
2	32	38
3	44	43
4	8	25
5	15	28
6	10	9
7	18	13
8	9	23
9	163	95
10	9	7
11	17	13
12	19	47
13	55	56
14	20	28
15	36	67
16	2590	942
17	283	307
18	107	94
19	54	44
20	30	21

Radiation Survey along the PS ring after the end of CT operation

PS Ring Radiation Survey 2011

Débits de dose en µSv/h à 40 cm de la ligne de faisceau (17/11/2011)

Dose rates in µSv/h at 40 cm of the beam line (17/11/2011)

Section droite Straight section	Amont Upstream	Aval Downstream
1	170	70
2	48	50
3	78	75
4	15	38
5	30	30
6	12	15
7	20	20
8	12	30
9	200	130
10	8	13
11	15	19
12	25	80
13	80	85
14	27	45
15	40	100
16	4000	1450
17	380	450
18	150	150
19	55	55
20	45	40
21	75	40
22	25	100
23	105	280
24	30	35
25	60	70
26	130	100
27	45	36
28	60	65
29	75	75
30	550	920
31	1700	3200
32	715	870
33	600	800
34	800	1000
35	1150	1000
36	175	280
37	2400	1800
38	350	330
39	3300	1500
40	160	290
41	475	450
42	800	1450
43	900	700
44	300	290
45	400	60
46	80	170
47	140	100
48	60	100
49	110	105
50	40	60

Section droite Straight section	Amont Upstream	Aval Downstream
51	70	50
52	45	65
53	90	75
54	30	50
55	70	40
56	20	13
57	900	2300
58	230	180
59	110	90
60	140	210
61	150	230
62	60	60
63	200	220
64	30	55
65	80	165
66	30	40
67	90	41
68	17	40
69	90	80
70	35	40
71	60	30
72	65	45
73	45	105
74	45	50
75	2400	1400
76	230	105
77	90	75
78	17	20
79	25	45
80	7	8
81	7	8
82	20	90
83	35	40
84	30	30
85	105	110
86	15	30
87	140	80
88	40	110
89	60	60
90	20	20
91	70	50
92	15	60
93	30	95
94	15	20
95	40	40
96	5	7
97	40	60
98	20	35
99	60	85
100	20	90

Color Code:

> 100 µSv/h
> 200 µSv/h
> 500 µSv/h
> 2000 µSv/h

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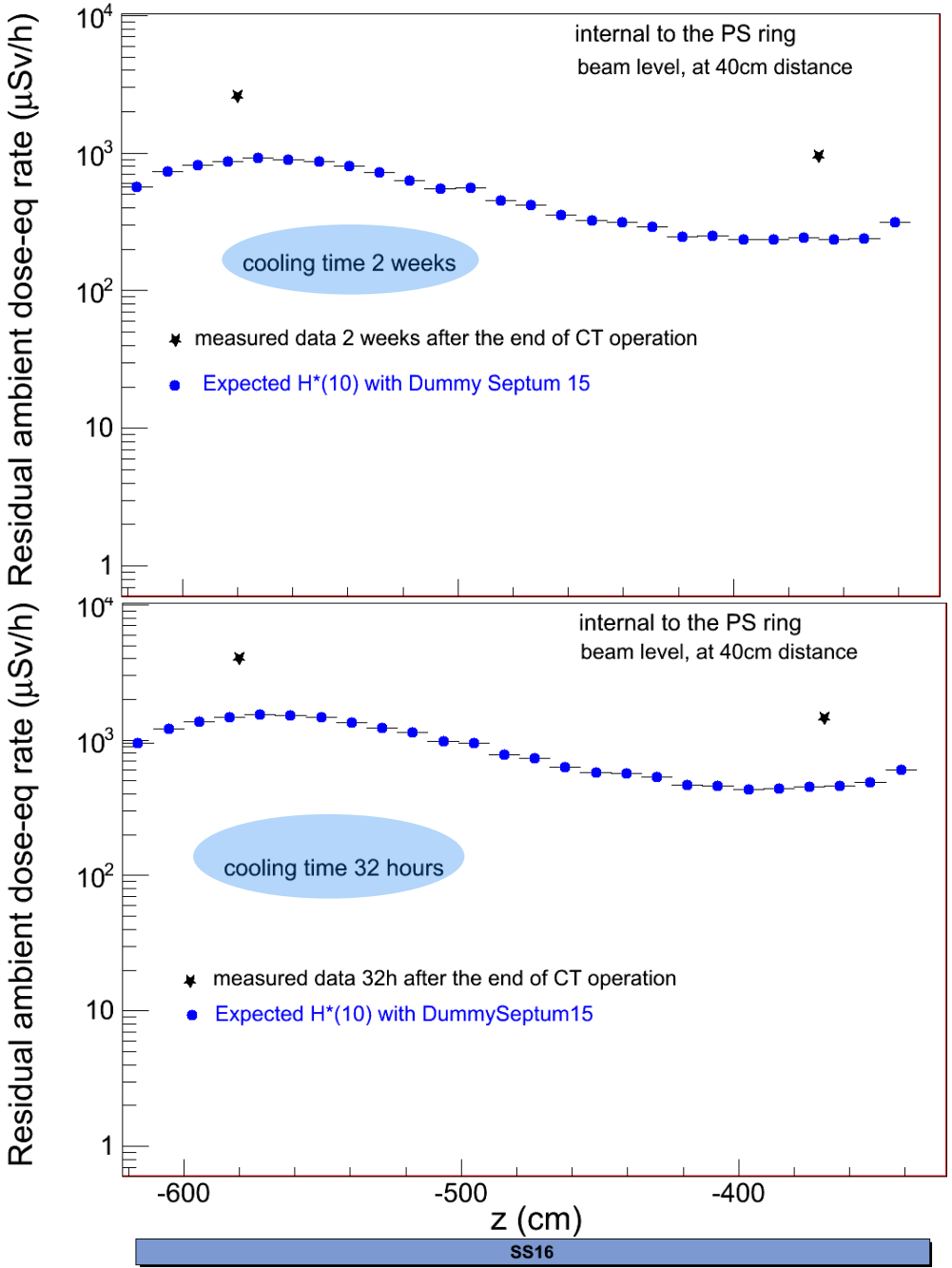
Measured Residual Dose-eq Rates after cooling time of 32 hours (17/11/2011; G. Dumont) 1.5-4 mSv/h downstream and upstream of the SMH16

(inner side of machine, beam level at 40 cm distance)

Section droite Straight section	Amont Upstream	Aval Downstream
1	170	70
2	48	50
3	78	75
4	15	38
5	30	30
6	12	15
7	20	20
8	12	30
9	200	130
10	8	13
11	15	19
12	25	80
13	80	85
14	27	45
15	40	100
16	4000	1450
17	380	450
18	150	150
19	55	55
20	45	40

Expected Total H*(10) along SMH16 with Dummy Septum 15

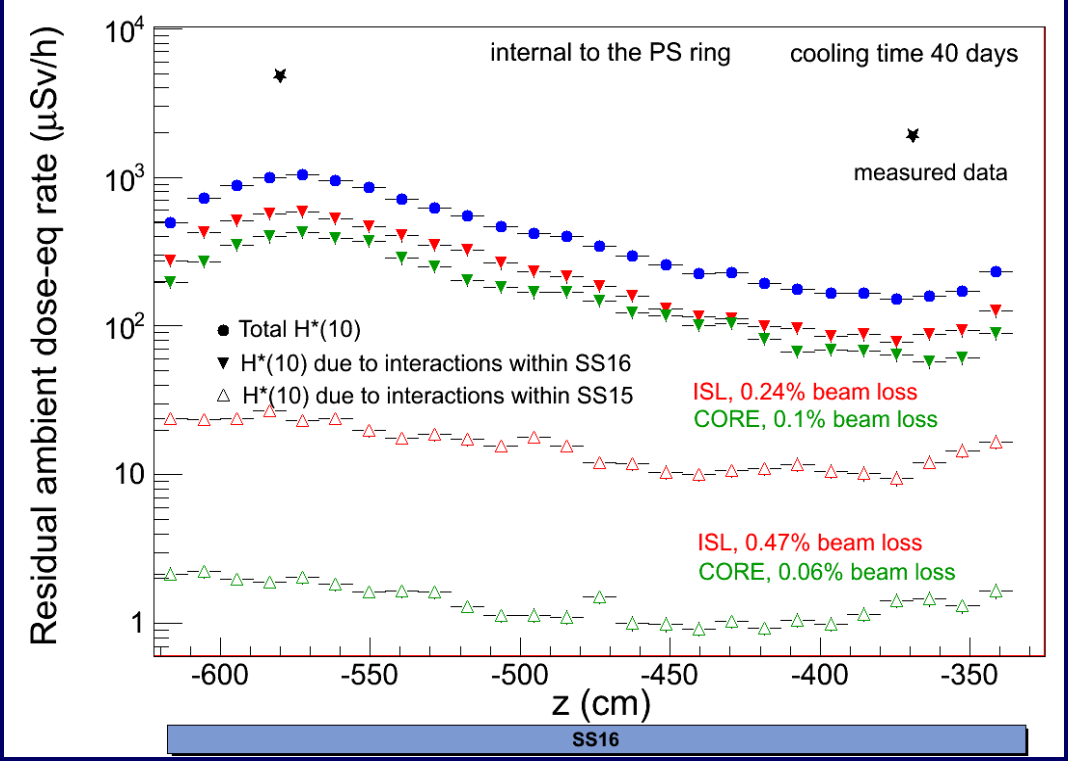


Comparison to measured data after the end of CT operations

Installation of Dummy Septum 15

→Radiation field and resulting activation associated with future MTE operation lower by a factor of 3 than present CT operation in the whole environment of SMH16

Open questions



(I) for the present scenario of 1% beam loss in the region of SS16:

simulated dose with realistic beam (w_1*ISL+w_2*CORE) lower by a factor of 1.6 than the data.

→ Dose reduction for future MTE operation relative to CT operation still factor of 2

(II) Further improvements of the shadowing efficiency possible?