Dose and Radiation Damage in the PS Magnet Coils

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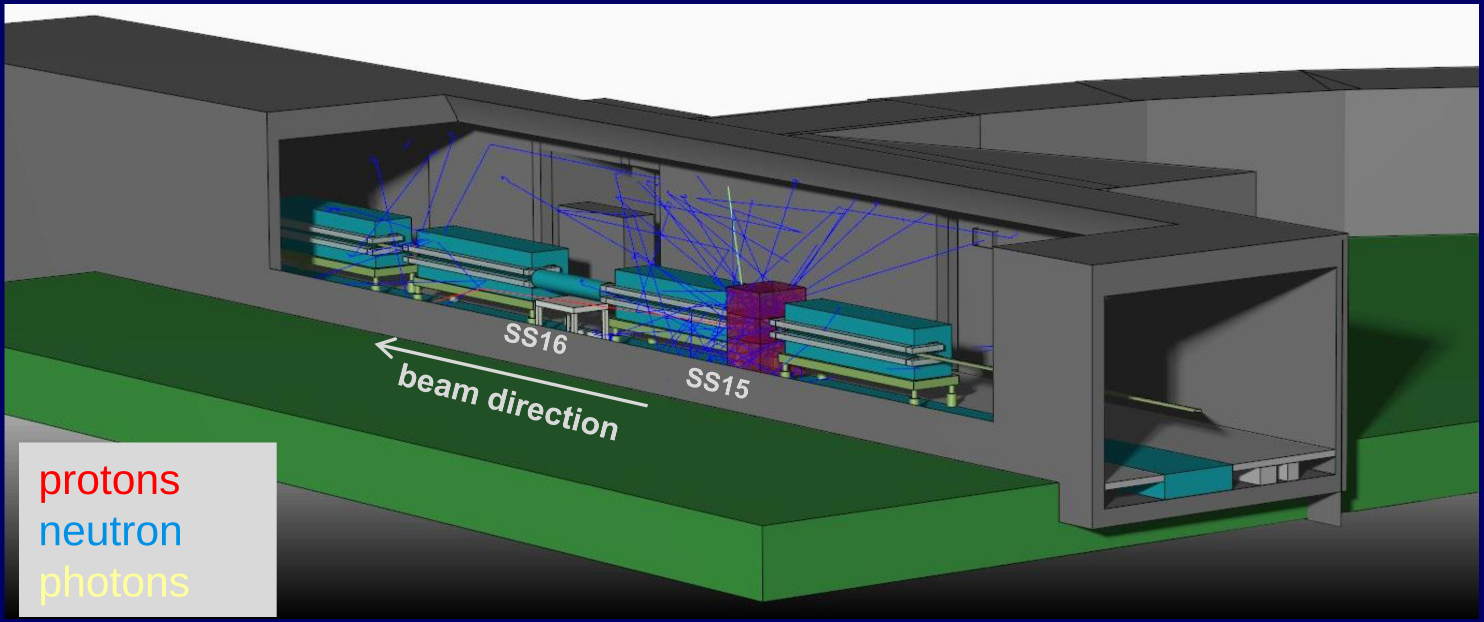
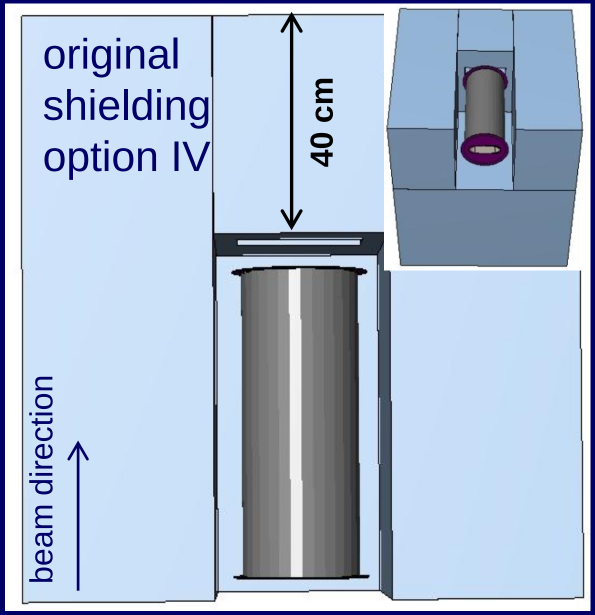
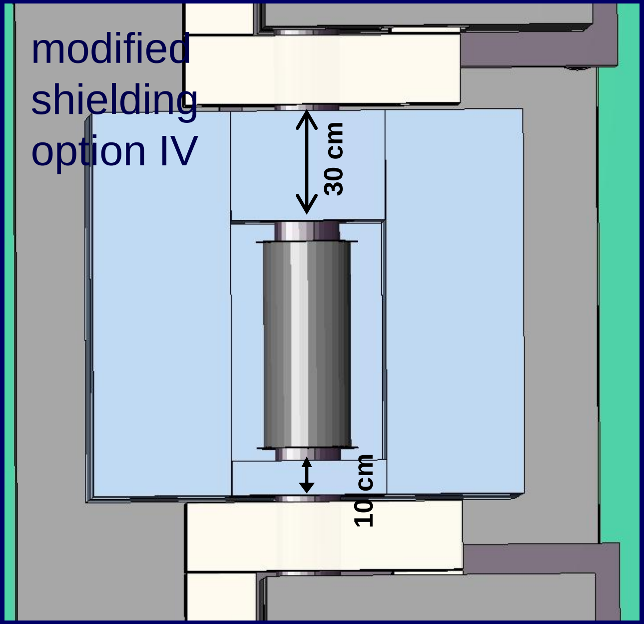
CERN, May 10, 2012

Ejection Region of the PS with the Dummy Septum in SS15







Original Shielding Proposal IV modified:

- downstream marble block shortened from 40 cm to 30 cm
- 10 cm long block added upstream (in between the vacuum chamber and the MMU14 coils)

Assumptions for the simulations

- proton beam of p=14 GeV/c
- beam loss intensity: 10^{11} p/s (~1% of the primary intensity 10^{13} p/s)
- Cu blade
- total operation time 2550 h/y

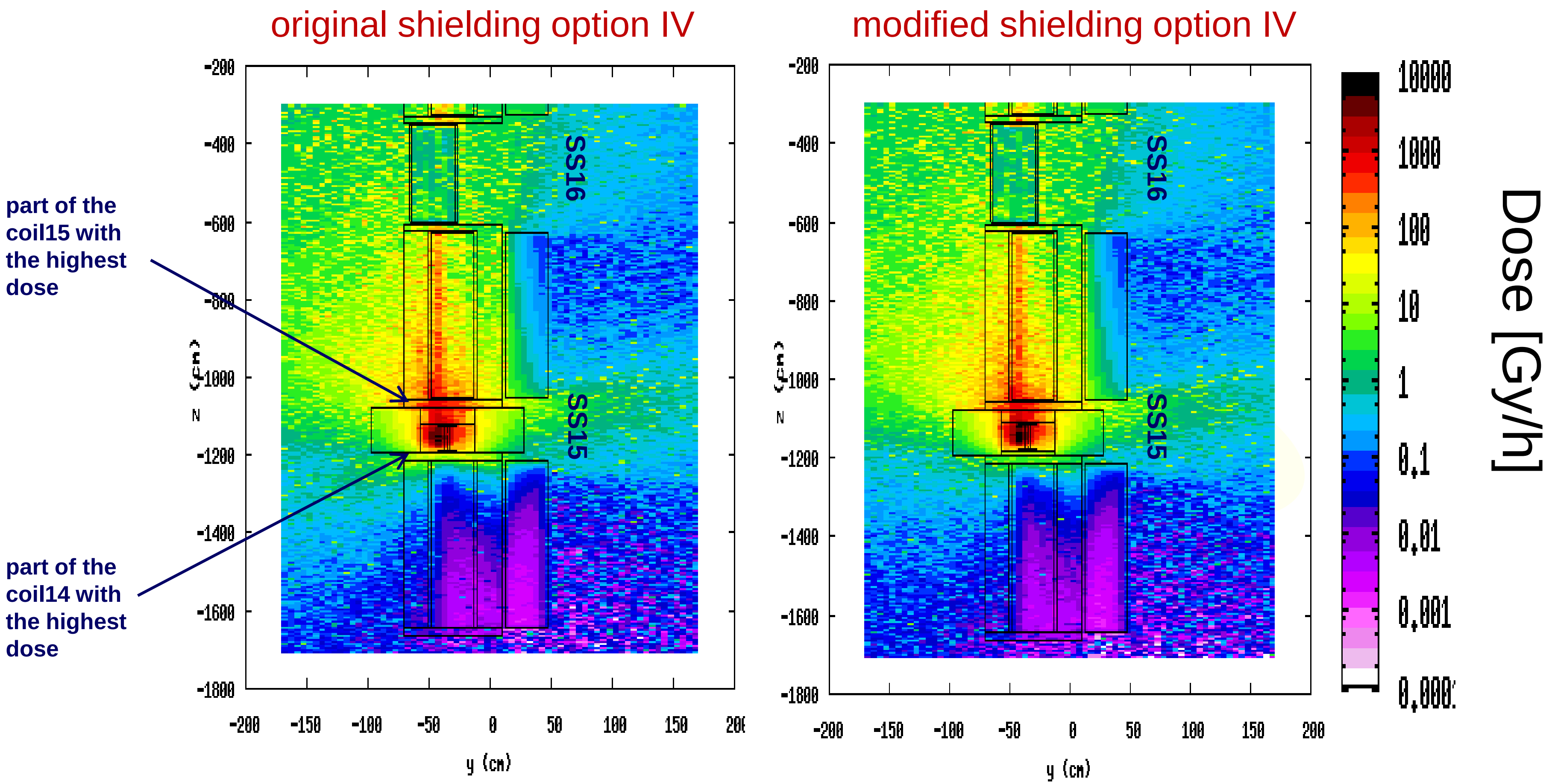
- source: dummy septum with distributed impact points

along the beam direction (z) at the start of the blade

Gaussian distribution in the vertical direction (x) with σ_x =2.5 mm centered in the middle plane

uniform distribution in the horizontal direction (y) over 3mm thickness of the blade

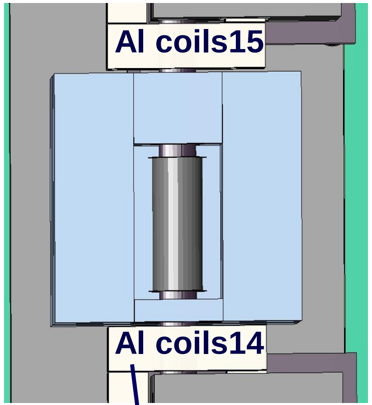
Dose distribution for beam losses in the dummy septum of SS15

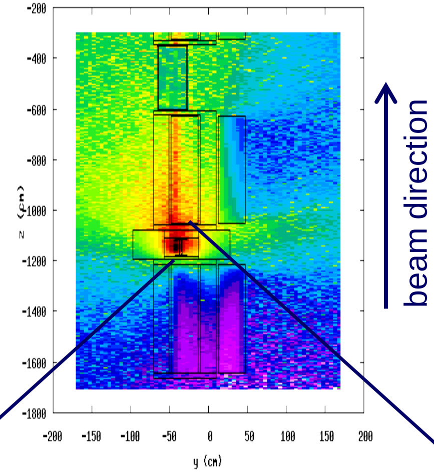


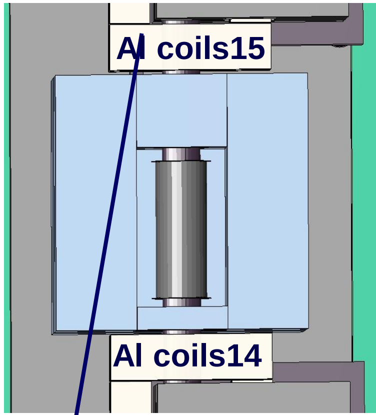
highest radiation dose in the part of the magnet coils closest to the dummy septum

similar dose distribution for the two shielding options

Dose Rate [Gy/h] in the Coils of the MMU14 and MMU15 for the two shielding options

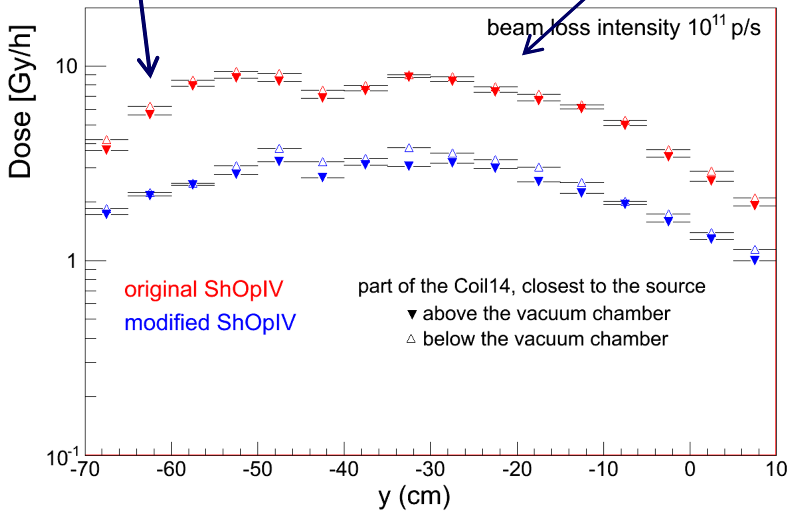


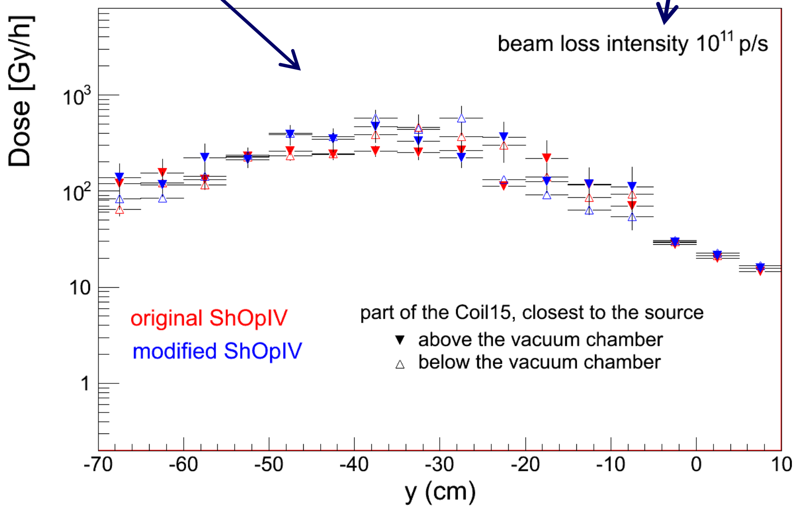




part of the coil14 with the largest accumulated dose

part of the coil15 with the largest accumulated dose



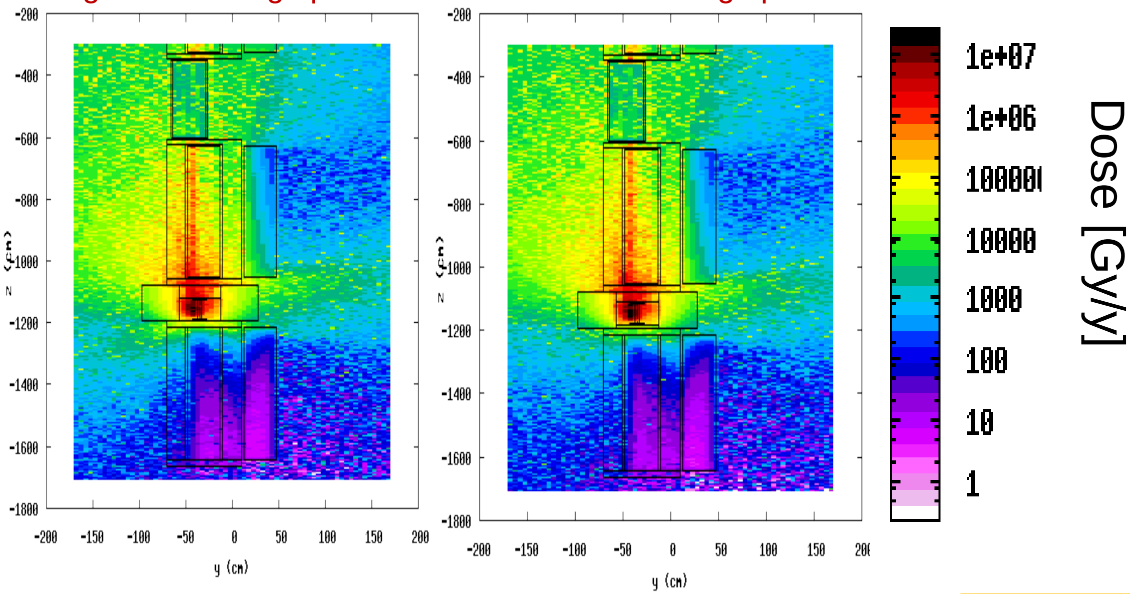


addition of 10 cm shielding further upstream, in between the vacuum chamber and the coils of MMU14, reduces the dose inside the coils14 by a factor of 2.5

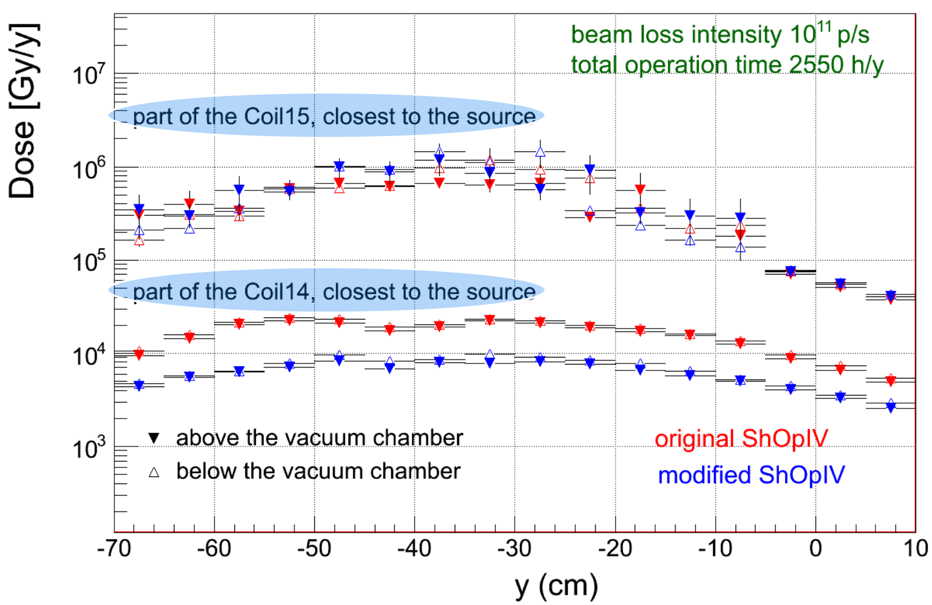
reduction by 10 cm of the shielding further downstream, in between the vacuum chamber and the coils of MMU15, increases the dose inside the coils15 by a factor of 1.2

Annual Dose for a nominal MTE operation year with 9.2×10^{17} lost p in the dummy septum of SS15

original shielding option IV modified shielding option IV



assumption:
operation time 2550 h/y



Radiation dose in the coils of MMU15 higher by factors of 25-60 compared to coils of MMU14

Maximum expected annual dose:
~ 1MGy/y in the coils of MMU15
~10-20 kGy/y in the coils of MMU14

Dose & Displacement Damage

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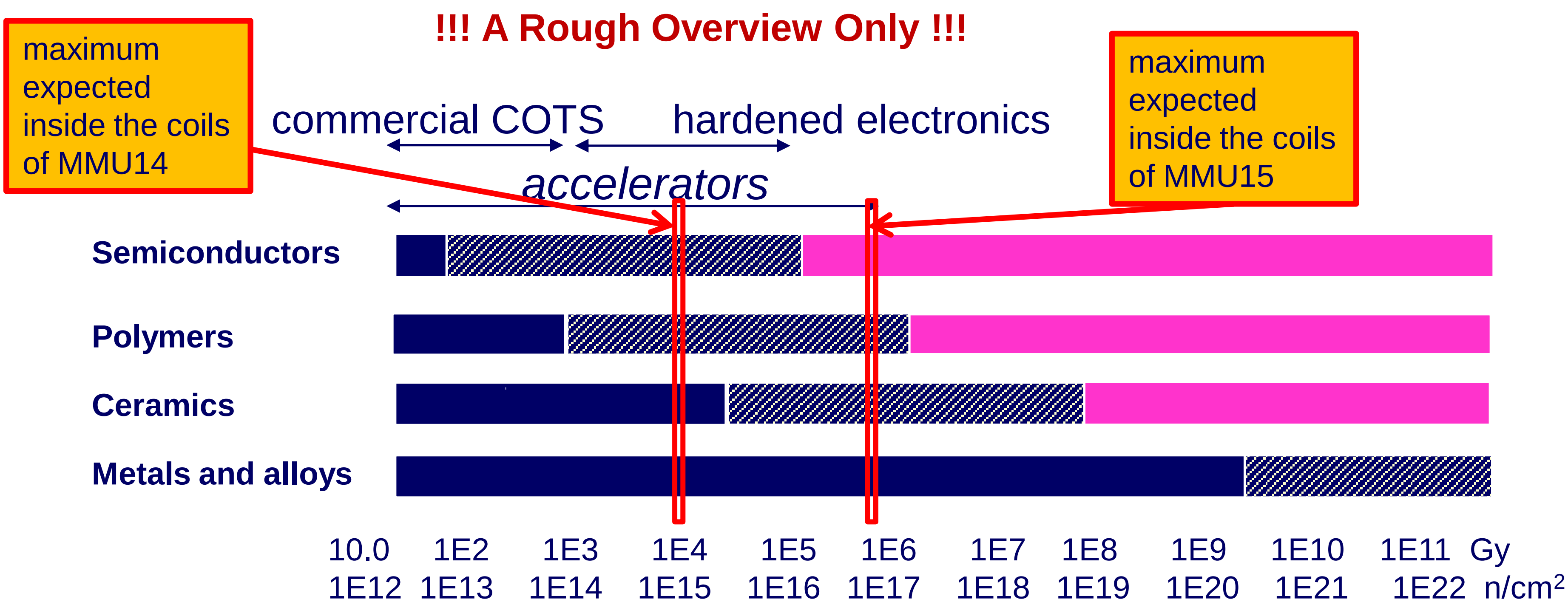
Radiation Damage to Materials/Electronics



- no damage

- mild to severe damage

- destruction

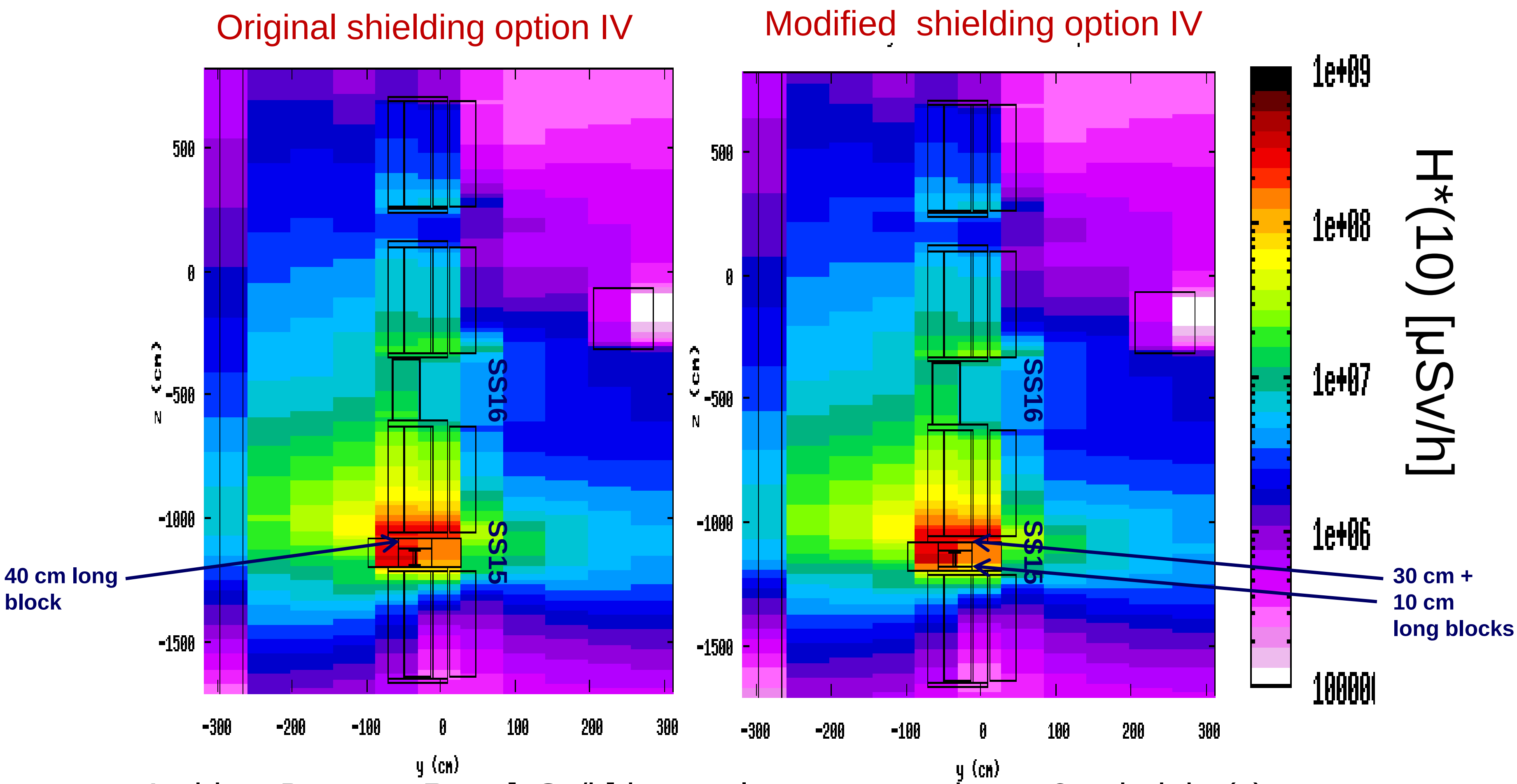
!!! Assumption !!!

(depends on particle energy spectra)

1 neutron (1MeV) /cm^2 ~ 3.3E-11 Gy

Since the maximum radiation level expected inside the coils of MMU15 is very high, there is not much sense in reducing the downstream part of the shielding

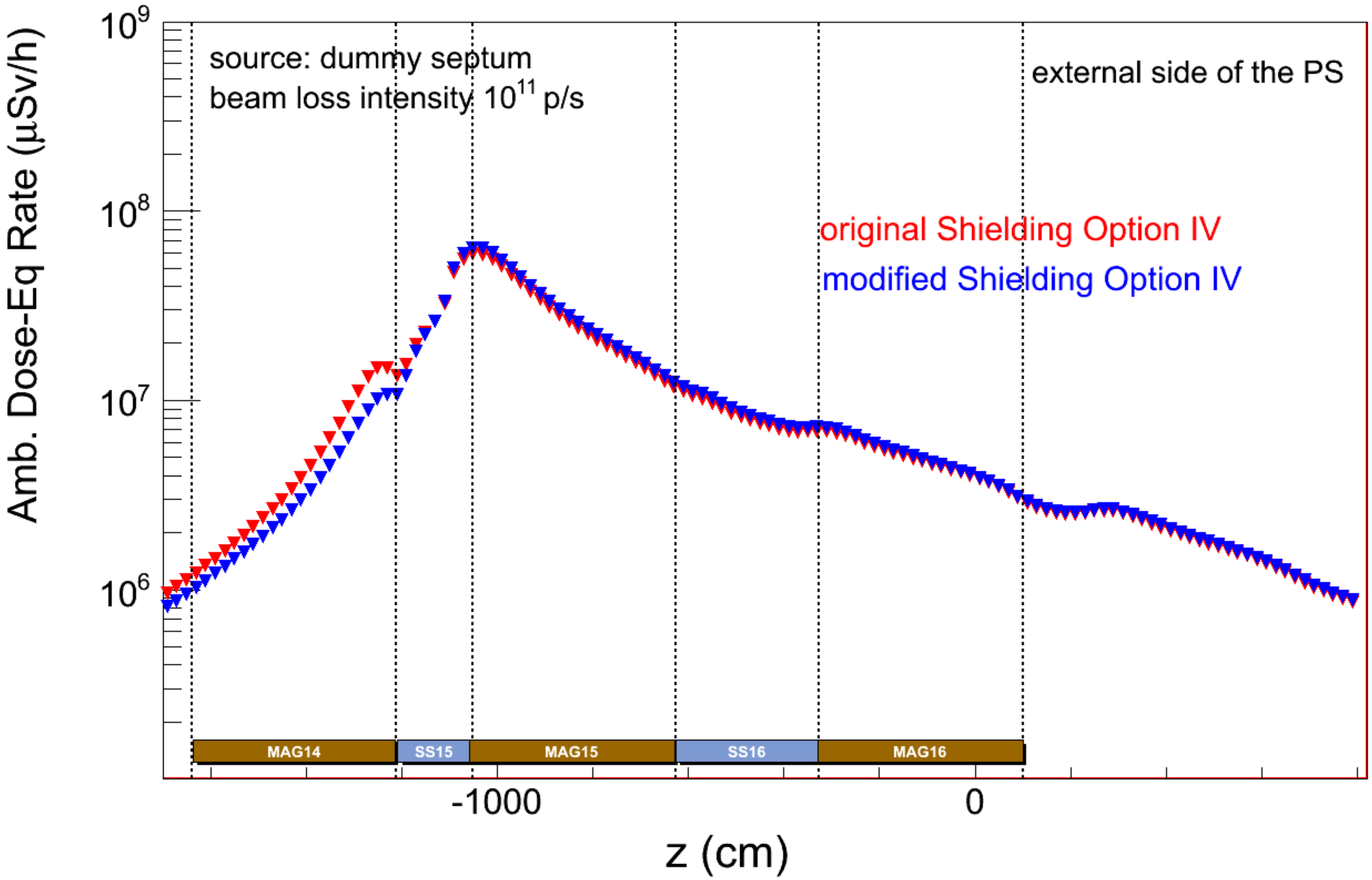
Stray Radiation – Ambient Dose-Eq Rates



Ambient Dose-eq Rate [μSv/h] in z-y plane averaged over 2 m height (x)

hardly any differences in ambient dose-eq rate distribution for the two different shielding options

Stray Radiation along external side of the machine



1-dim Projections of Ambient Dose-eq Rate [µSv/h] along z

hardly any differences in ambient dose-eq rate distribution
for the two different shielding options

BKP

Proceedings of EPAC 2004, Lucerne, Switzerland

RADIATION DAMAGE OF MAGNET COILS DUE TO SYNCHROTRON RADIATION

K. Tsumaki, S. Matsui, M. Ohishi, T.Yorita, JASRI/SPring-8, Hyogo, Japan
T. Shibata, T. Tateishi, KOBELCO RESEARCH INSTITUTE, INC., Hyogo, Japan

Test piece – magnet coil made of hollow conductor (Cu)

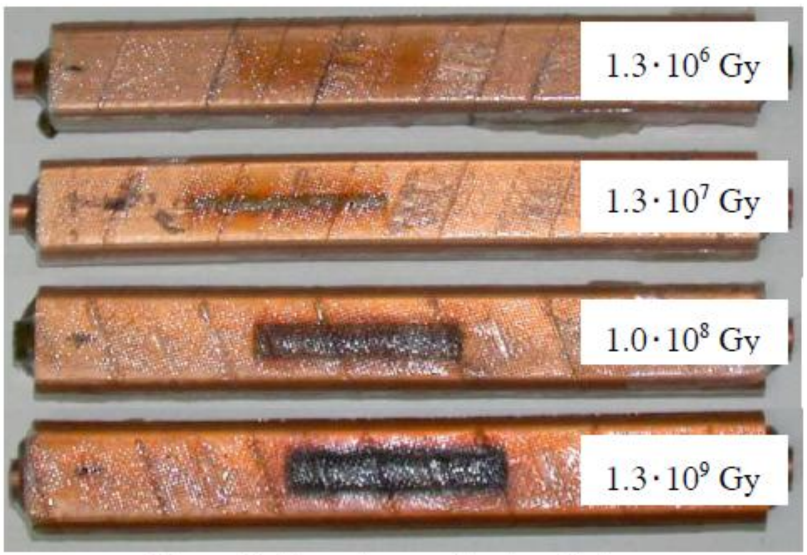
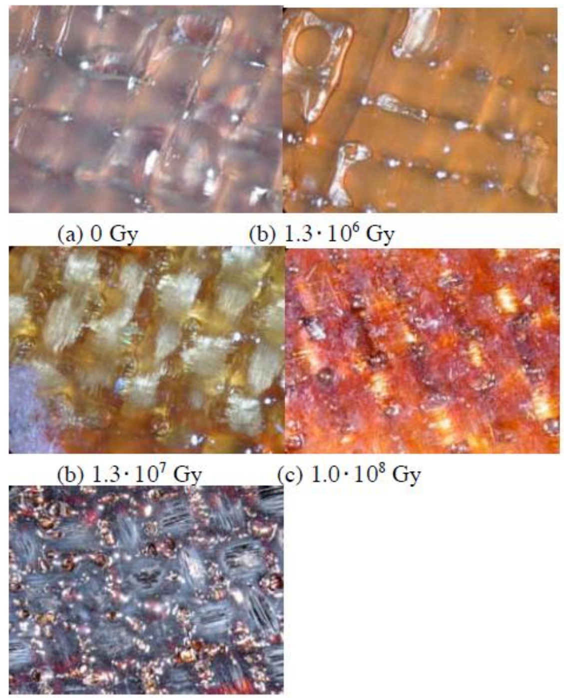


Figure 3: Test pieces after irradiation.



(a) 0 Gy (b) $1.3 \cdot 10^6$ Gy

(b) $1.3 \cdot 10^7$ Gy (c) $1.0 \cdot 10^8$ Gy

(d) $1.3 \cdot 10^9$ Gy

Figure 4: Test piece photographs magnified by a microscope.

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- External view of the removed magnet coil suggests irradiation of 10^6-10^7 Gy.
- However, the resistance between the conductors remained high such that the coils continued to function well

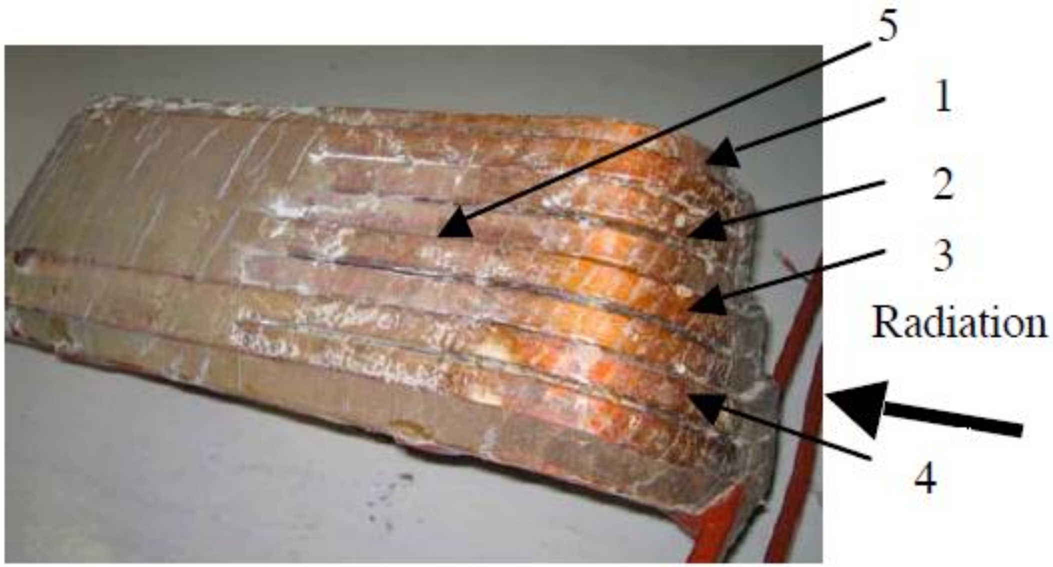

Figure 8: External view of the removed magnet coil.