SLHC–IRP1: FLUKA STUDIES ON ENERGY DEPOSITION IN THE TAS–D1 REGION

Francesco CERUTTI

Marco MAURI

Alessio MEREGHETTI

Elena WILDNER

Overview

power deposition due to collision debris at $L = 2.5\,L_0$
with 220 μrad half crossing angle in the vertical plane (upwards)

no experimental vacuum chamber

back to the triplet (*symmetric* layout, 130mm coil aperture)

- last episode lesson
- total power in the quadrupoles and its distribution
- effect of the corrector magnetic field
- role of end plates in protecting the coils on the IP-side of Q2a
- increased Q1-corrector beam screen thickness for the same purpose
- update of the *symmetric* layout
- crossing angle effect
- magnetic TAS

the new D1

- implementation of the superconducting, superferric and resistive models
- peak power/dose and total power

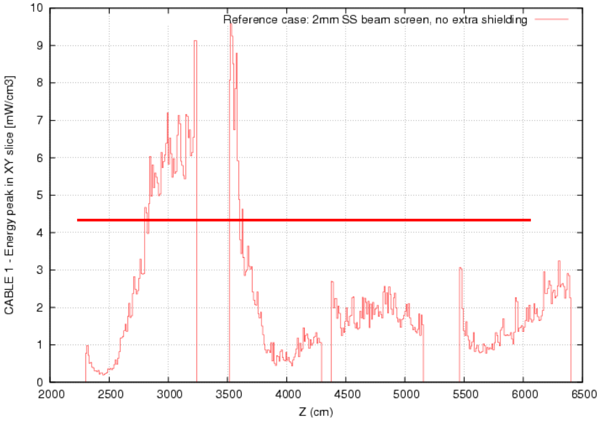
conclusions/perspectives

Peak power in the triplet coils

continuous *stainless steel* beam screen and cold bore tube

(*2 mm* and *3.44 mm* thick, respectively, according to mechanical needs)

no additional protection



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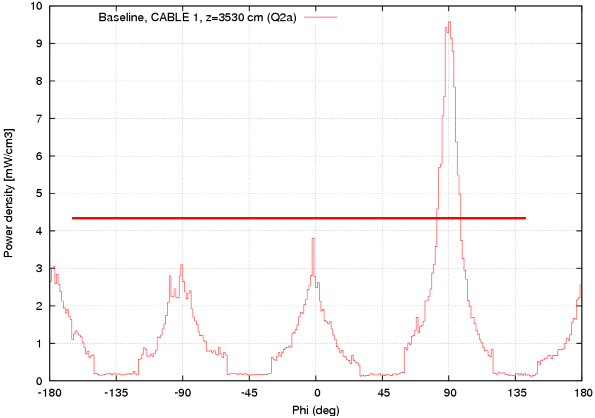
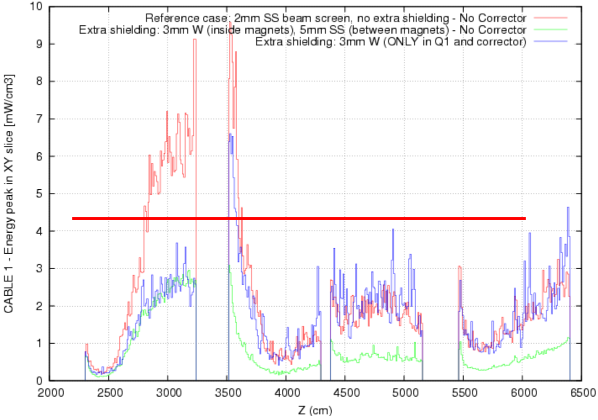


Peak power in the triplet coils

3 mm thick *tungsten* liner all along the triplet

for magnet protection



Total power in the quadrupoles [I]

no additional protection (*2 mm stainless steel* beam screen)

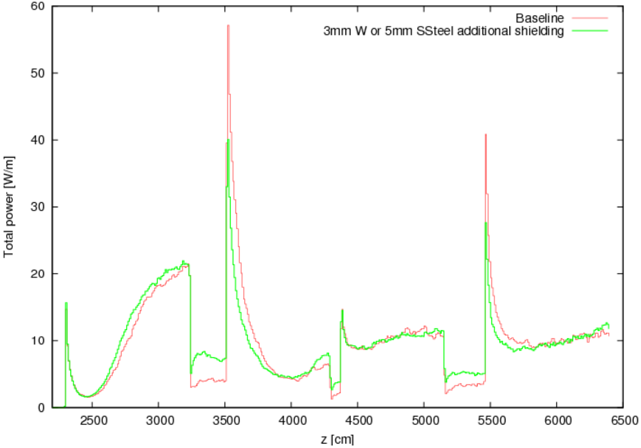
with additional protection (*3 mm tungsten* in the magnets, *5 mm SSteel* in the interconnections)

	Q1	Q2a	Q2b	Q3
whole magnet	102.0 111.6	86.6 70.0	81.6 81.4	107.9 98.8
1st cable	28.6 17.4	17.1 7.9	20.7 10.2	23.8 11.0
2nd cable	15.0 10.2	11.3 5.4	10.4 5.9	13.0 6.7
beam pipe	10.6 7.2	8.0 4.1	10.3 5.4	13.6 6.0
beam screen	6.8 8.8	6.0 7.2	8.8 10.4	12.2 13.9
shielding	/ 32.2	/ 18.1	/ 26.4	/ 31.5

values in W

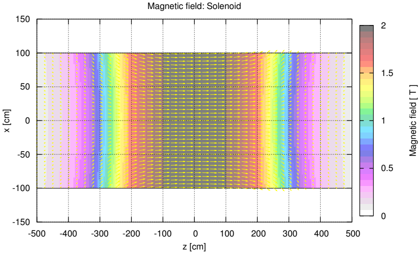
Total power in the quadrupoles [II]

longitudinal distribution

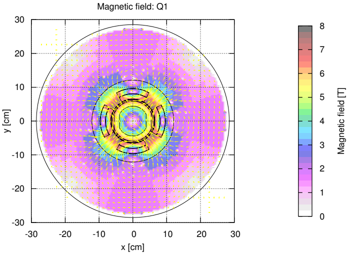


Magnetic field

solenoid field



Q1 & Q3 field



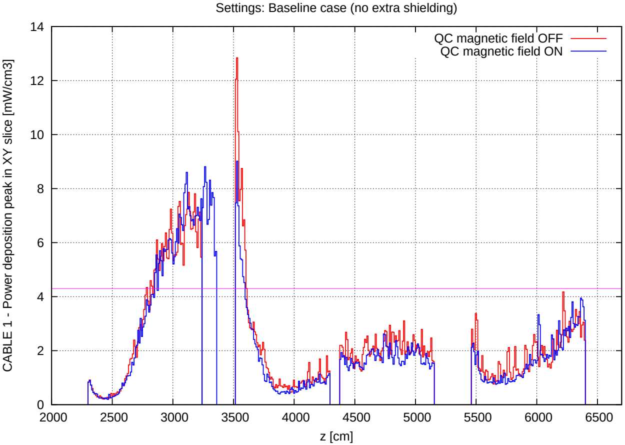
original implementation of the solenoid field
by F. Broggi (INFN)

thanks to F. Borgnolutti (AT-MCS)

→ from here on, no collision distribution (all assumed to take place at the IP with nominal momenta)

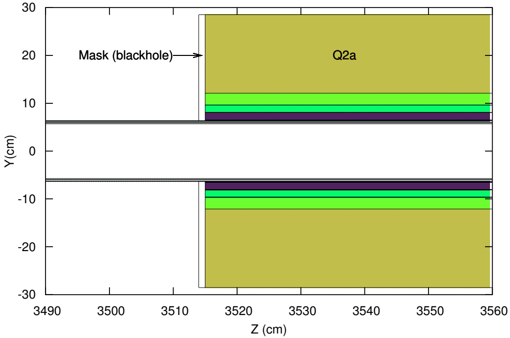
Switching on the corrector magnetic field

0.47 T m i.e. ∼20 μrad negative vertical kick



Possible role of end plates

black hole shielding the Q2a IP-side outside the beam pipe



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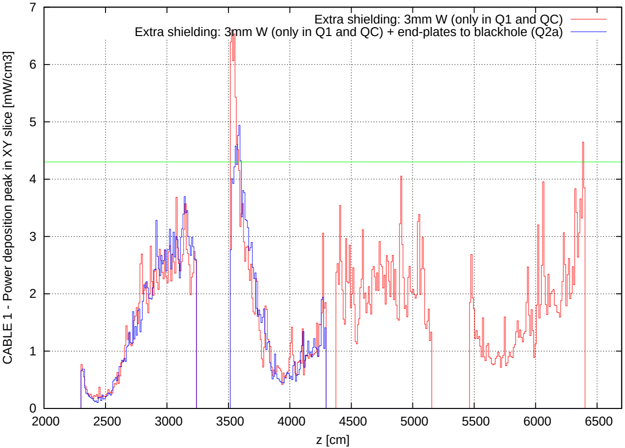
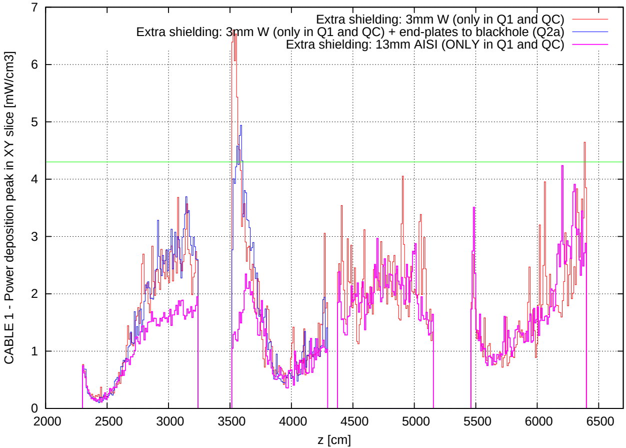


“Maximum thickness” liner in Q1 and corrector

additional shielding of *13 mm stainless steel* casting a shadow over Q2a



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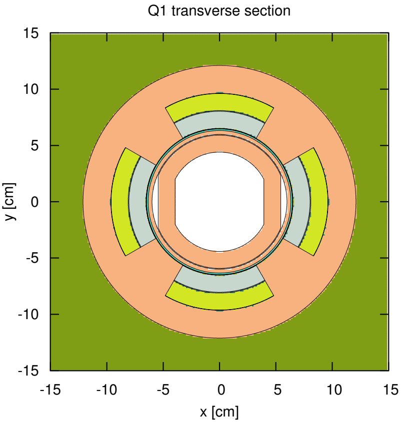
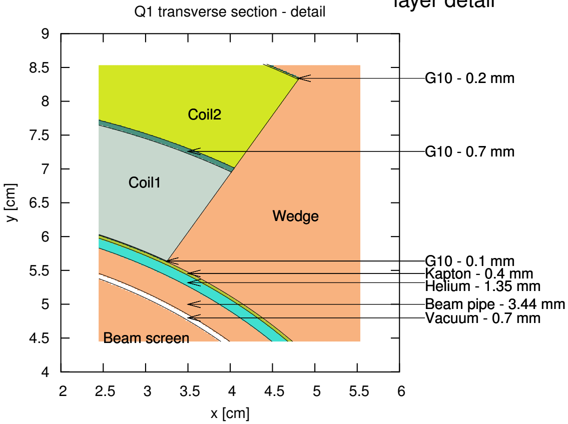


“Maximum thickness” liner in Q1 and corrector

layer detail



inner cable 8.128 g/cm^3

63.6% Cu 19.3% Nb 17.1% Ti

outer cable 8.291 g/cm^3

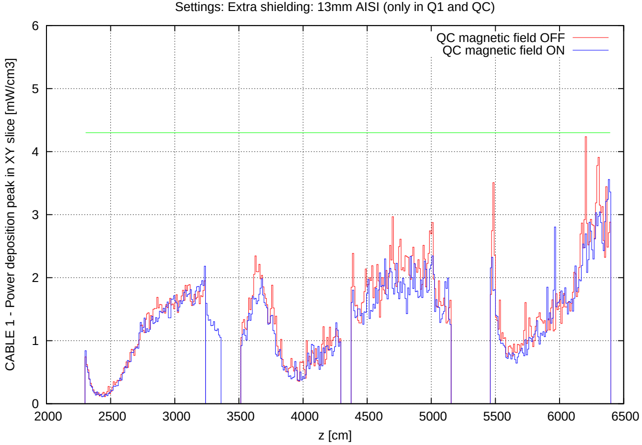
70.7% Cu 15.5% Nb 13.8% Ti

(mass fraction)

“Maximum thickness” liner in Q1 and corrector

back to the *corrector dipole field effect*

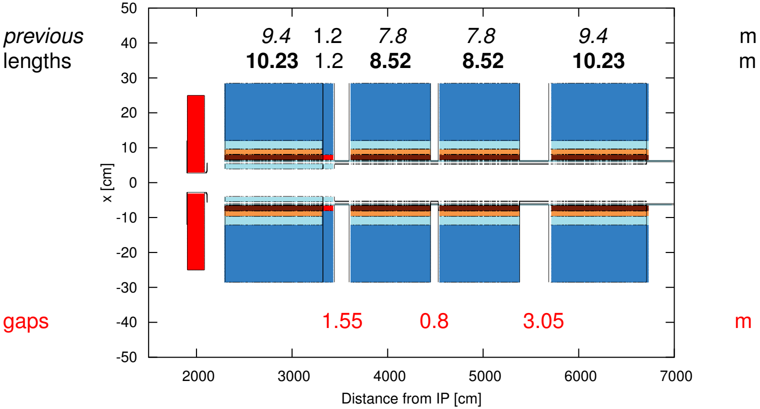
additional shielding of *13 mm stainless steel* casting a shadow over Q2a



Update of the symmetric layout

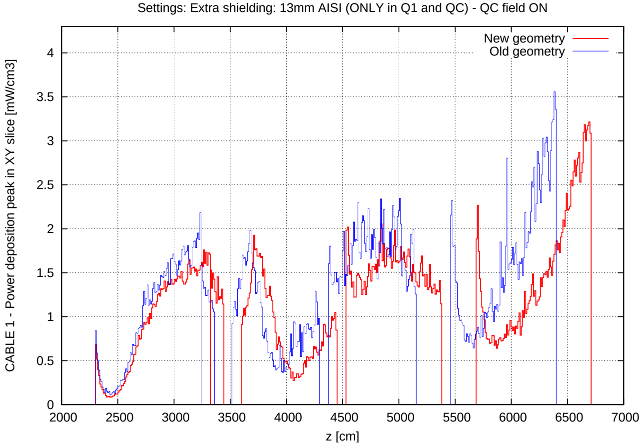
thanks to E. Todesco (AT-MCS)

112 T/m *(vs. 122 T/m)* quadrupole gradient



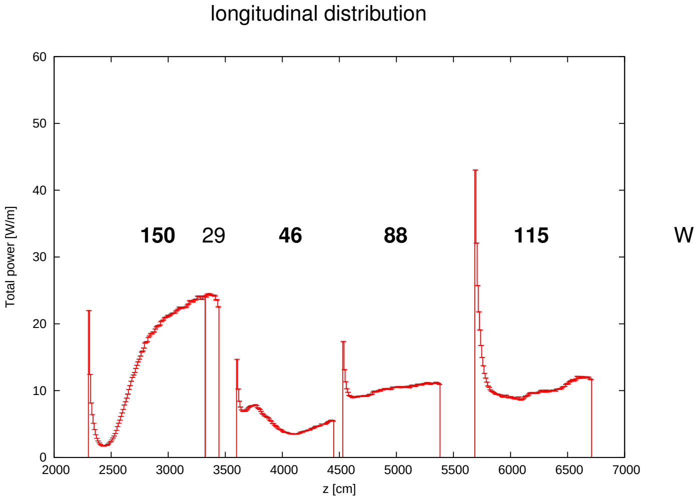
additional shielding of *13 mm stainless steel*

Update of the symmetric layout



additional shielding of *13 mm stainless steel*

Total power for the shielded configuration of the updated layout [I]



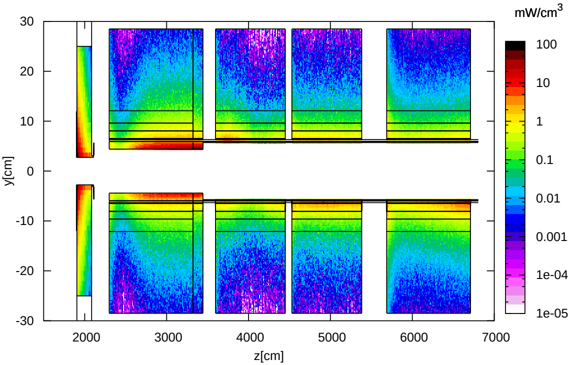
Total power for the shielded configuration of the updated layout [II]

	Q1	Q2a	Q2b	Q3
beam screen	14	5	10	14
shielding	56	/	/	/
beam pipe	7	6	12	16
1st cable	17	11	23	25
2nd cable	10	5	10	12
SSteel collar	21	10	18	25
iron yoke	24	10	15	22

values in W

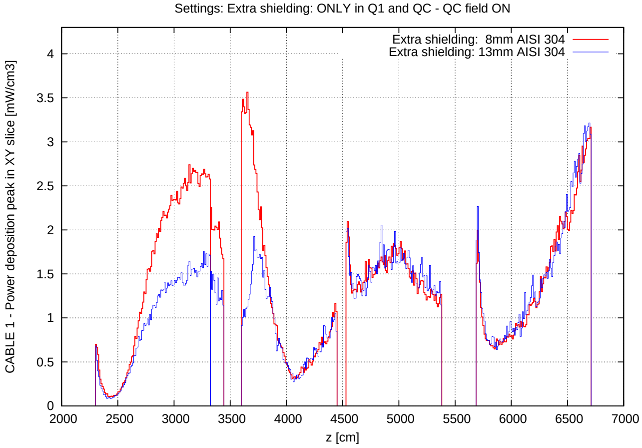
Power density for the shielded configuration of the updated layout

in the vertical plane all along the triplet



Searching for minimum thickness liner in Q1 and corrector

additional shielding of *8 mm stainless steel*



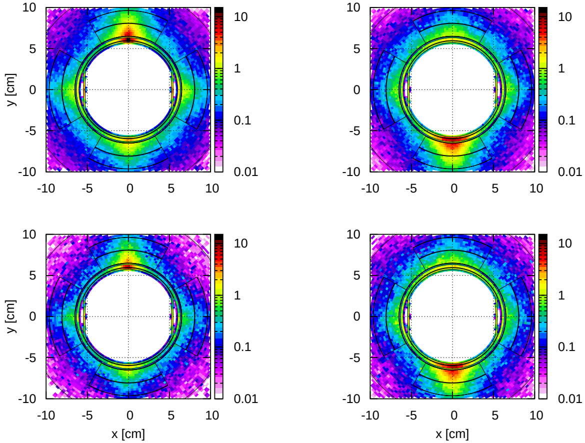
Azimuthal distribution at the inner cable peak

SSteel additional shielding

Q2a | Q3

8 mm

13 mm

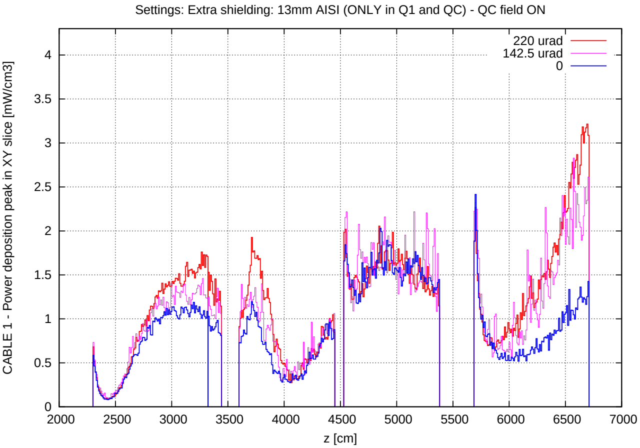


values in mW/cm^3

Influence of the crossing angle

checking for nominal optics and head-on collisions

$L = 2.5\,L_0$ **for all cases**

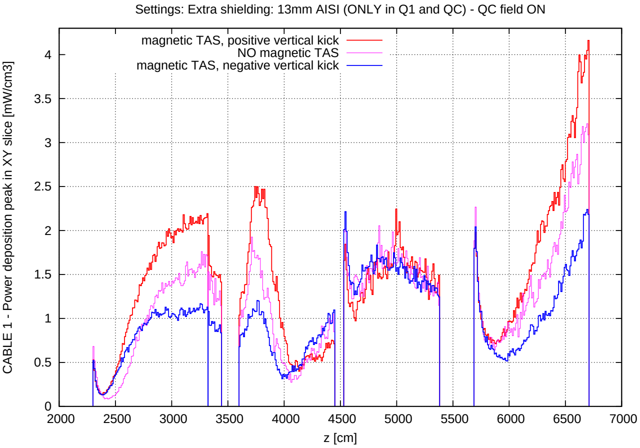


vertical crossing plane (transverse component of beam momentum upwards directed)

A magnetic TAS ?

1 T dipole field in the 1.8 m long TAS vacuum chamber

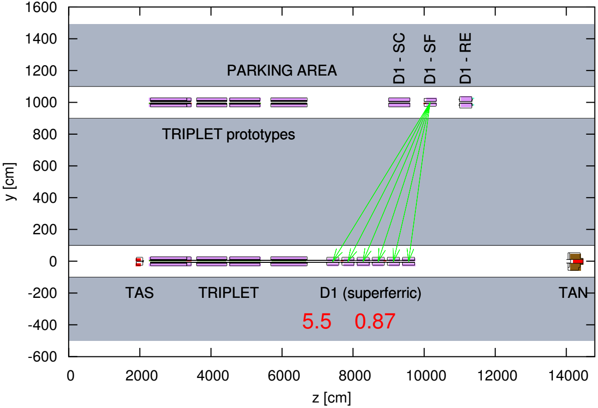
$\sim$80 μrad positive/negative vertical kick



Extension of the insertion model

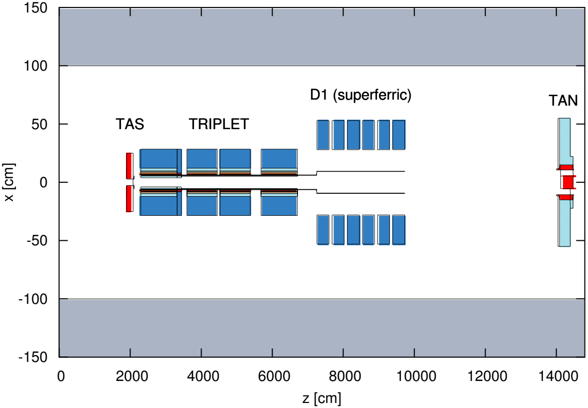
lattice capability implemented

D1 module length **6** **3.4** m



gaps 5.5 0.87 m

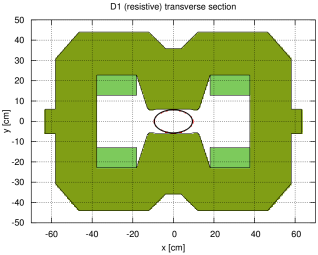
Extension of the insertion model

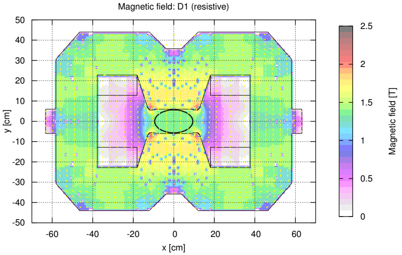


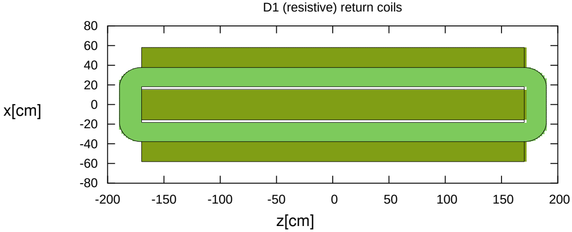
original version of the TAN geometry from M. Fuerstner (SC-RP)

Resistive D1

1.4 T



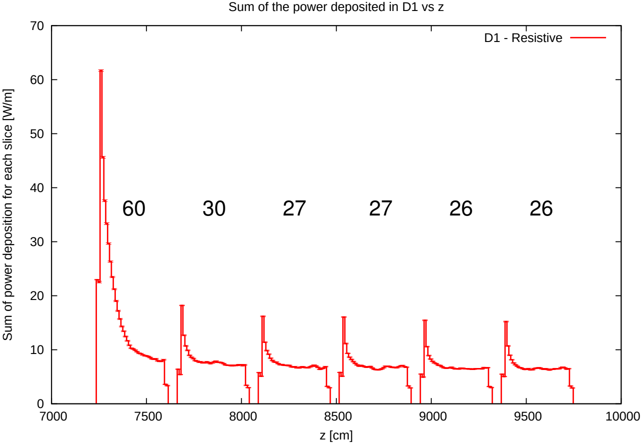




thanks to M. Karppinen (AT-MCS)

Total power for the resistive D1

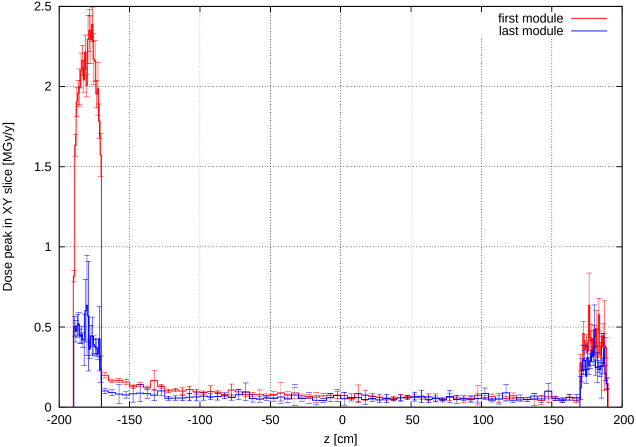
longitudinal distribution



total	60	30	27	27	26	26	W
upper coil	3.0	1.7	1.5	1.5	1.45	1.4	W
lower coil	3.7	1.3	1.2	1.2	1.2	1.2	W

Peak dose in the coils of the resistive D1

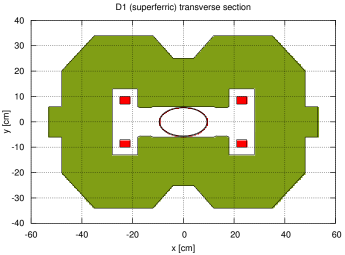
for a total luminosity of $\mathbf{2.5} \cdot 120\ 10^{15}\ b^{-1} y^{-1}$

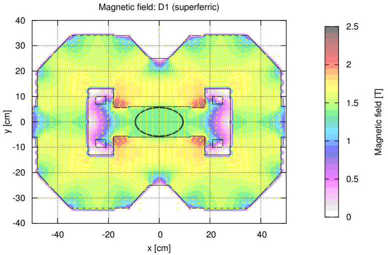


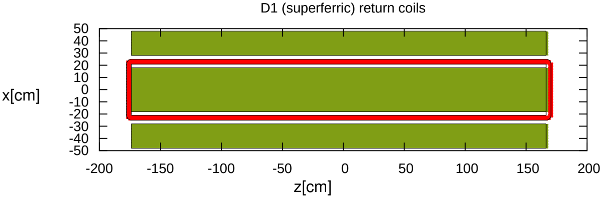
1 x 1 x 1 (5) cm^3 scoring grid

Superferric D1

1.4 T



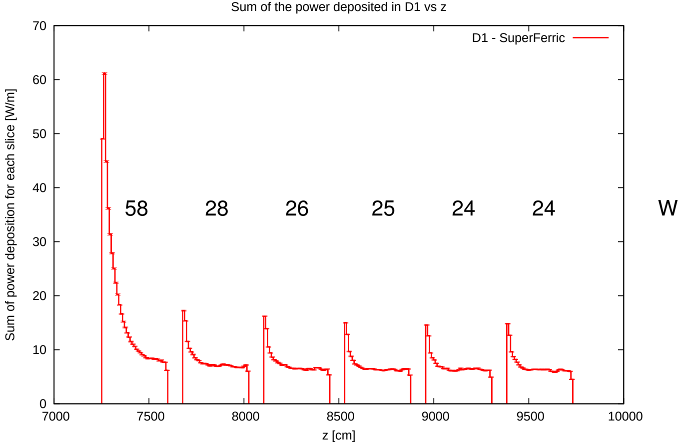




thanks to D. Tommasini (AT-MCS)

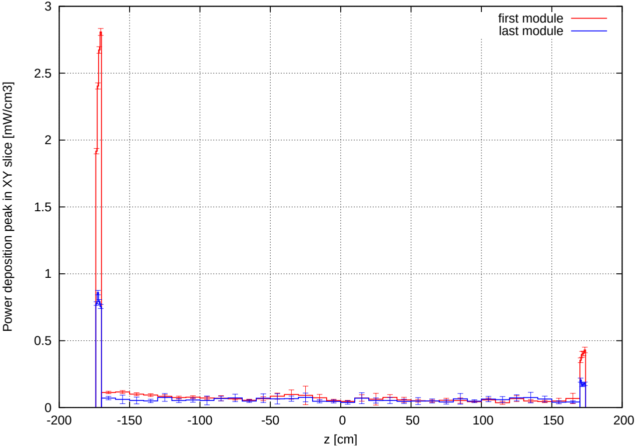
Total power for the superferric D1

longitudinal distribution



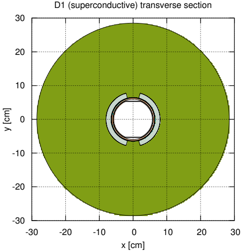
upper coil	0.56	0.38	0.37	0.36	0.34	0.35	W
lower coil	0.67	0.36	0.34	0.33	0.32	0.33	W

Peak power in the (Cu) coils of the superferric D1

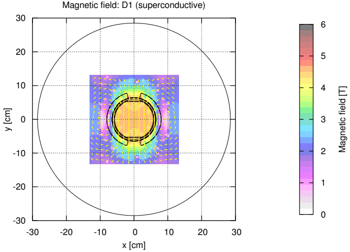


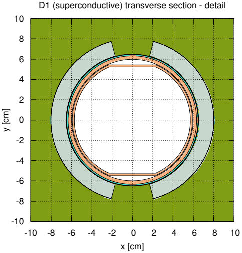
no protection implemented!

Superconducting D1



4.5 T



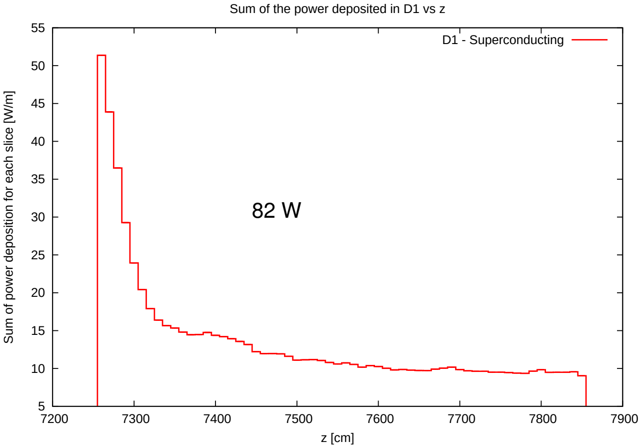


130 mm aperture

horizontal beam screen

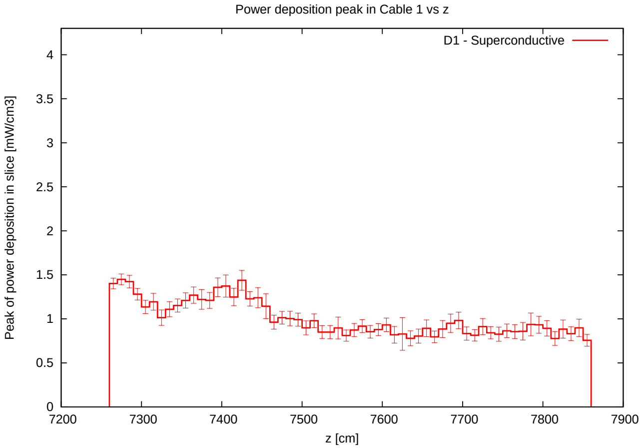
thanks to J. Bruer (AT-MCS)

Total power for the superconducting D1



16 W in the coils

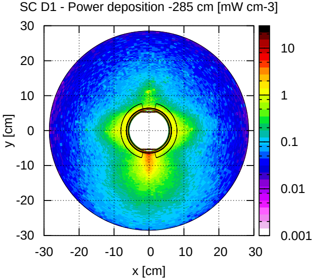
Peak power in the coils of the superconducting D1 [I]

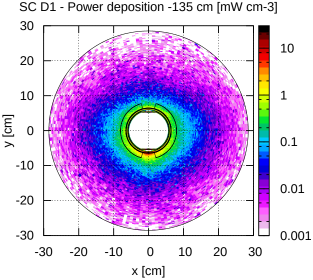


no protection implemented!

Azimuthal distribution at the cable peak

10–20 cm 160–170 cm from its IP-side

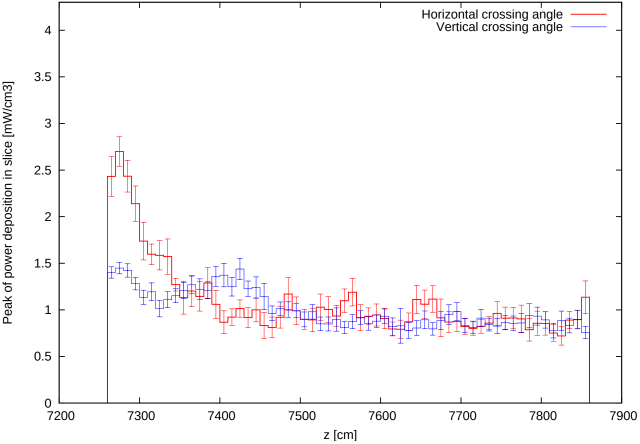




no protection implemented!

Peak power in the coils of the superconducting D1 [II]

increase for horizontal crossing angle



no protection implemented!

Conclusions

vertical crossing plane, horizontally FDDF triplet ⇒ peaks in the vertical plane
(initially at 90^o and then at -90^o for positive crossing angle)

Q1 non-IP side and **Q2a IP-side** are the critical point: liner in Q1 (and corrector)
either extended *along the interconnection too* or of *increased thickness to cast a shadow*

with this protection option highest peak at the Q3 non-IP side

$\sim$400 W the triplet total load

larger the crossing angle, higher the peak power density
a magnetic TAS can play a role "closing" the crossing angle

a 130mm aperture superconducting D1 is not expected to quench (minimal protection needed)

the same for a superferric D1

for the first module of a resistive D1 the damage to the insulator in the return coils (on the IP-side) can have an impact on the magnet lifetime (protection can be envisaged)

Perspectives

- horizontal crossing plane
- experimental vacuum chamber
- energy deposition in the TAN
- contribution of beam losses in the TCT
- triplet misalignment
- looking at the matching section