ENERGY DEPOSITION STUDIES FOR THE NEW COMPACT FCC-hh FINAL-FOCUS SYSTEM

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An optimized design of a final-focus system for the main EIR of FCC-hh is presented here. The new design is more compact and enables unequal in both planes, whose choice is justified here. This is followed by energy deposition studies, where the total dose in the magnets as a consequence of the collision debris is evaluated.

The FCC Hadron Collider

The final-focus is based on a superconducting triplet and aims at a in the range 0.3 -1.1 m. The baseline design of the final-focus [5,6] allows for an instantaneous luminosity up to 20·10^{34} cm^{-2}s^{-1}. With regard to the integrated luminosity, a total of 20-30 ab^{-1} are envisaged.

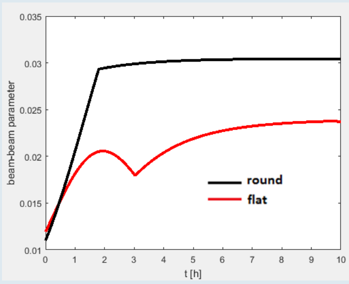
Alternative Flat Optics

The new design [7] is an alternative to the baseline design.

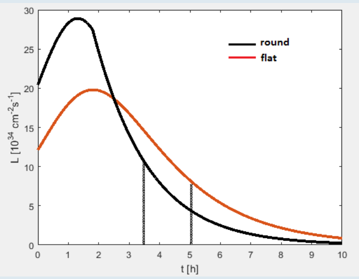
- The triplet is shorter [8]
- It provides the optics: 0.3/0.3, 1.0/0.2 and 1.2/0.15 by matching to the arc [7].
- No need for emittance blow up [10].
- Luminosity production is more stable with less peak.

Parameter Comparison:

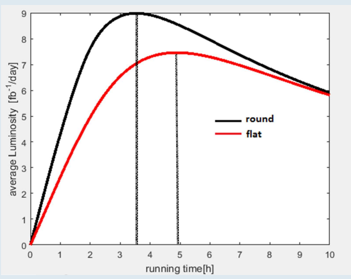
	Optics nominal (round)	Optics ultimate (round)	Optics alternative (flat)
$N[\cdot 10^{11}]$		1.0	
$\epsilon_N[\mu m]$		2.2	
n_b		10600	
σ_s [cm]		8	
β_x^* [m]	1.1	0.3	1.2
β_y^* [m]	1.1	0.3	0.15
θ [μrad]	92	176	114.4
ϕ	0.55	2.0	0.65
S	0.88	0.45	0.84
$\xi[\cdot 10^{-3}]$	10	11	12
$L[\cdot 10^{34}\text{cm}^{-2}\text{s}^{-1}]$	5	20	12
$L_{peak}[\cdot 10^{34}\text{cm}^{-2}\text{s}^{-1}]$	16	30	20
$L_{int}[\text{fb}^{-1}/\text{day}]$	6	9	7.5



Beam-beam parameter.



Luminosity evolution.



Average luminosity per day as a function of run time (4h turnaround).

Triplet and shielding

The final-focus triplet (Q1-Q2-Q3) has been optimized by

- Reducing its total length [7]
- Minimizing the total accumulated dose on the coils profiting from the flat-beam scenario.

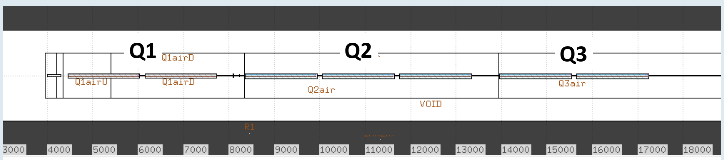


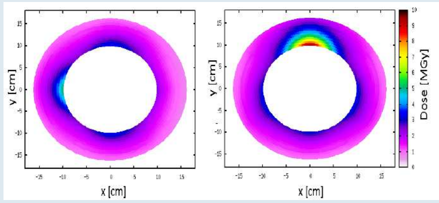
Table 2: Quadrupole Parameters of the Alternative Final Focus Triplet (each quad is 15 m)

quadrupole	Q1(×2)	Q2(×3)	Q3(×2)
g [T/m]	106	-111	97
r_i[mm]	46.7	57.7	66.7
Δ_{abs} [mm]	44.2	33.2	24.2
r_c [mm]	98.3	98.3	98.3

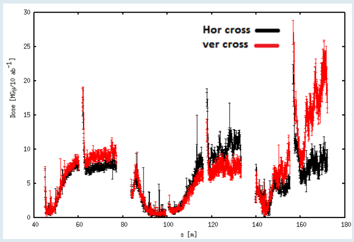
Transverse cross section of inner part of the Q1 in FLUKA model.

Energy Deposition Studies

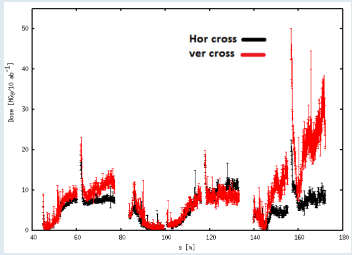
The debris coming from the pp collisions has been simulated with FLUKA [13, 14] in order to guarantee the triplet survival during the quadrupole life. This was done following the previous energy deposition studies on the baseline triplet [15, 16]. Figure 3 shows the results of the total dose received by Q3 for each crossing scheme. We can see that the transverse dose distribution is not symmetric.



Transverse cross section of the Q3 dose profile on the coils for the horizontal (left) and vertical crossing (right).



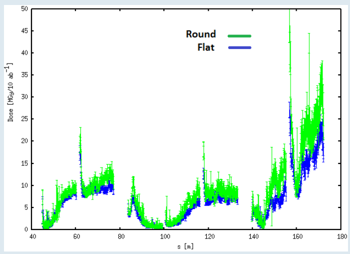
Peak dose profile in MGy per 10 inverse attobarn in the alternative flat optics.



Peak dose profile in MGy per 10 inverse attobarn in the alternative flat optics for the round configuration.

- For the flat configuration, the results are very similar for vertical and crossing angle, with the exception of Q3, where the vertical gets more dose.
- For the round optics, the maximum peak dose is higher due to the larger crossing angle, as this influences the spread of the collision debris.
- For Q1-Q2 and the flat-beam configuration, the maximum peak dose is below 15 MGy. For Q3 the dose is higher (~25 MGy). The reason is that the absorber is thinner as the beta is larger than for the other quadrupoles.

- The peak dose is found to be at different angular positions of the transverse plane (Fig. 3), and it can be reduced by alternating the crossing scheme [15].
- This can be done by establishing collisions in each plane 50% of the time. This is shown in for the flat and round simulations:



Peak dose profile in MGy per 10 inverse attobarn (50% collisions in each plane).

Conclusions

- A choice for an FCC flat optics parameters is made.
- It offers a significant reduction in L_{peak} with respect to the ultimate optics, with a minor loss in integrated luminosity, and without any need, in principle, for tune shift control.
- The new triplet can provide the required parameters for the flat optics, as well as those needed for the round optics.
- It was optimized for the flat-beam performance, and it offers the lowest dose for this scheme, which can be further improved by alternating crossing plane.
- This is a very promising option for the FCC-hh final-focus optimization.

References

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