LHeC IR status update

R. Martin

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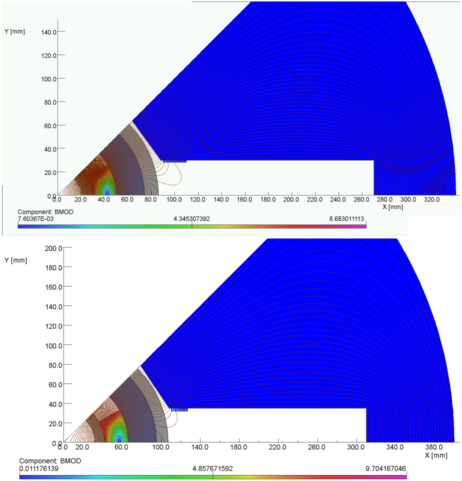
June 18, 2019

New Magnets (May 2018)

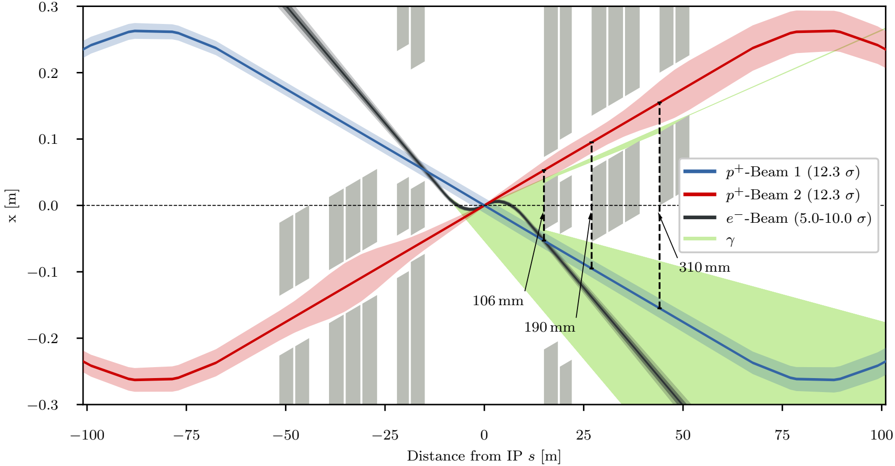
Magnet	Gradient [T/m]	Aperture radius [mm]
Q1a	252	20
Q1b	164	32
Q2	186	40
Q3	175	45

- Larger beam separation in Q1a ⇒ Synchrotron radiation increases
- Increase L^* to 15 m to keep Synchrotron radiation low



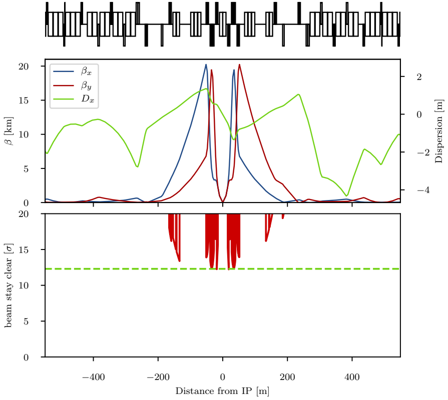
Magnet designs for Q1a and Q1b by B. Parker.

LHeC interaction region design: $\beta^* = 10$ cm



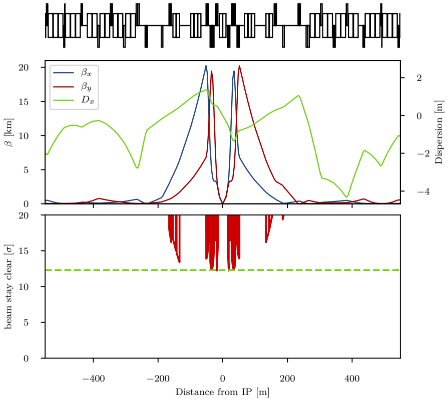
	50 GeV, 6.4 mA	50 GeV, 20 mA	60 GeV, 6.4 mA	60 GeV, 20 mA
P_{synch}	13 kW	40 kW	27 kW	83 kW
E_{crit}	296 keV		513 keV	

Beam optics: colliding beam with $\beta^* = 10\,\text{cm}$



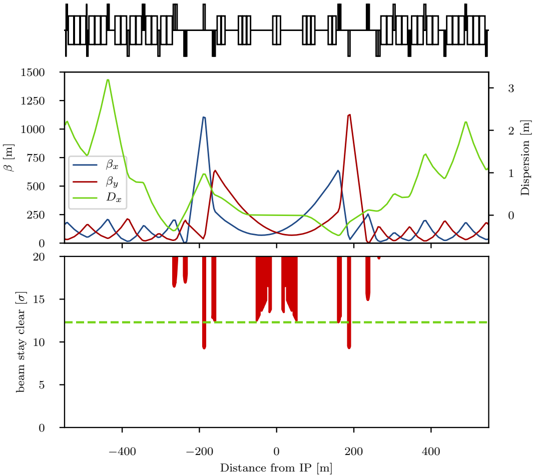
- June workshop: Assumed beam stay clear of 12.3 σ will require local protection and specific phase advances in the ring
- Specifically between extraction kicker and EVERY IP
- More difficult than expected since ATS locks phases between IP1 and LHeC
- $\Rightarrow$ Reintegrated in HL-LHC (V1.3) lattice, extending ATS to another arc
- **Chromaticity correction and dynamic aperture studies** presented by E. Cruz-Alaniz

Colliding beam: Issues



- Q6 needs more strength AND aperture
- Some tuning quadrupoles in dispersion suppressor too strong
- Polarity of left Q4-Q5 $\Rightarrow$ compatible with injection optics?
- 15 mm residual dispersion at IP $\Rightarrow$ can maybe be reduced with better correction macros

Beam optics: non-colliding beam



- Unchanged since June workshop
- Optics for injection and collision energy exist
- Aperture bottleneck in Q6 (reminder: Q6 on colliding beam is also too strong)
- Reintegration in new lattice neccessary
- To be adressed: Arc 2-3 optics at collision ⇒ ATS? Chromaticity correction?

Next steps (beyond CDR?)

- $\beta^* = 7\,\text{cm}$? $\Rightarrow$ new triplet, larger apertures, larger separation $\Rightarrow$ **more synchrotron radiation**
- **Recombination dipole design** $\Rightarrow$ escape line for neutral particles?
- Rematch and reintegrate **non-colliding beam**
- **Injection and collision optics** (very different because of ATS)
- Solution for aperture/strength/polarity **issue** of quadrupoles
- Address **unbalanced chromaticity** in both beams $\Rightarrow$ ATS in both cases? Asymmetric sextupoles?
- **Electron IR**
- **Shift IP** by 12.5 ns downstream or upstream to avoid parasitic *pp* collisions
- **Lattice repository**

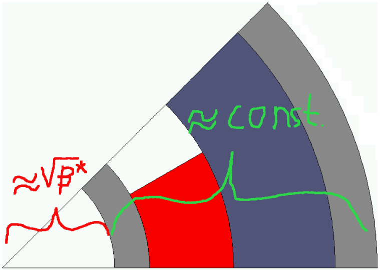
Thoughts on Lumi vs SR power

$$\text{Luminosity: } \mathcal{L} \propto \frac{1}{\beta^*} \cdot I \quad (1)$$

$$\text{Separation: } d \propto \sqrt{\beta^*} + \text{const.} \quad (2)$$

$$P_{\text{SR}} \propto d^2 = \left(\sqrt{\beta^*} + \text{const.}\right)^2 \quad (3)$$

$$P_{\text{SR}} \propto \beta^* + \sqrt{\beta^*}\text{const.} + \text{const.}^2 \quad (4)$$



Coil image by B. Parker, Professional annotations by me.

$\Rightarrow$ Doubled β^*: Half Luminosity but **less than half** SR Power
Instead: half beam current I: Half Luminosity, **half** SR Power

$\Rightarrow$ When trading luminosity for lower SR power, **beam current** seems to have **better leverage** (also easier for ERL)

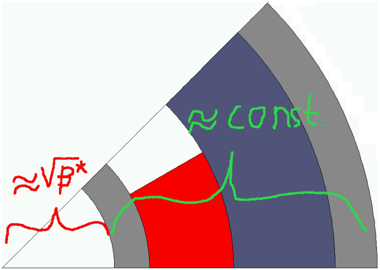
Luminosity: $\mathcal{L} \propto \frac{1}{\beta^*} \cdot I$ (1)

Separation: $d \propto \sqrt{\beta^*} + \text{const.}$ (2)

$P_{SR} \propto d^2 = \left(\sqrt{\beta^*} + \text{const.}\right)^2$ (3)

$P_{SR} \propto \boxed{\beta^*} + \sqrt{\beta^*}\text{const.} + \boxed{\text{const.}^2}$ (4)

small HUGE



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Alternative approach to Final Focus System

- Currently the final focus system is an antisymmetric triplet
- inherited from ALICE IR
- good for shared aperture as both beams can have same optics, same chromaticity in both planes/beams
- Not necessary for LHeC as no shared (magnet) apertures exist
- Alternative: **symmetric doublets**
- peak β function in horizotal plane $\Rightarrow$ chromaticity correction is easier
- less integrated quadrupole strength is required $\Rightarrow$ shorter final focus system
- Short final focus: Recombination dipoles closer to IP $\Rightarrow$ less bending required
- Shorter final focus: **Longer** L^*? $\Rightarrow$ lower SR load
- **Flat beams**?
- Disadvantages: higher peak β function, need to break symmetry elsewhere to match to arcs