

DE LA RECHERCHE À L'INDUSTRIE



Lattice integration

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CEA/DRF/IRFU/DACM

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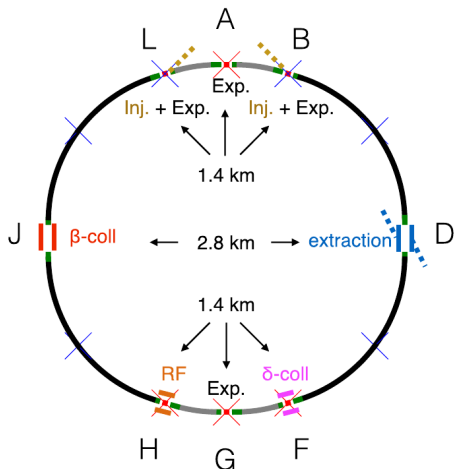
▶ **Current status:**

- ▶ **The ring lattice has been updated** to fit with the new layout.
- ▶ The lattice is available on the git repository
<https://gitlab.cern.ch/fcc-optics/FCC-hh-lattice.git>.
- ▶ The dispersion suppressor has been modified to insert collimators.
- ▶ The aperture model is being updated to take into account the last beam screen geometry.
- ▶ A new spurious dispersion scheme has been integrated.
- ▶ The coupling and tune correction is under integration.
- ▶ Alternatives for the arc FODO cell have been provided (60 degrees and longer cell).

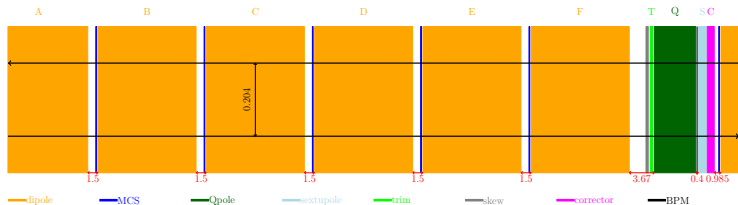
▶ **Perspectives:**

- ▶ Inserting octupoles (with optimized location) for Landau damping.
- ▶ To refine tune and chromaticity corrections (by freezing phase advances between IPs).
- ▶ To refine alternatives for the arc cells.
- ▶ To integrate other correction schemes (skew sextupoles,...).
- ▶ Options of combined multipole lenses.

- ▶ New Experimental Insertion Region (EIR).
 - see R. Martin's and Van Riesen-Haupt's talks.
 - ▶ New triplet configuration.
 - ▶ $L^* = 45 \text{ m} \rightarrow L^* = 40 \text{ m}$.
 - ▶ Total length $L = 1.5 \text{ km} \rightarrow L = 1.4 \text{ km}$.
 - ▶ More working points $\beta^* = 0.15, 0.2, 0.3, 1.1 \text{ m}$ (collision) and $\beta^* = 4.6, 6.0 \text{ m}$ (injection).
- ▶ Updated low-luminosity + injection insertions.
 - see M. Hofer's talk.
 - ▶ Changes on the magnet families.
 - ▶ $\beta^* = 8 \text{ m} \rightarrow \beta^* = 27 \text{ m}$ at injection.
- ▶ New arc FODO cells:
 - ▶ FODO cells a bit longer (because of shorter EIR).
 - ▶ Longer inter-dipole distance ($1.36 \text{ m} \rightarrow 1.5 \text{ m}$).
 - ▶ The dipole length is now optimized to fit the arc FODO cell.
- ▶ Crossing scheme: crossing angle in one plane and separation in the other plane at injection.



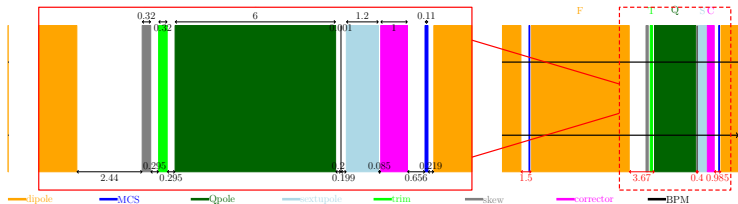
- ▶ Short arc length: 3.4 km.
- ▶ New EIR:
 - see R. Martin's and Van Riesen-Haupt's talks.
 - ▶ $L = 1.5 \text{ km} \rightarrow L = 1.4 \text{ km}$.
 - ▶ LAR a bit longer.
 - ⇒ $B_{MB} \downarrow$
- ▶ New arc FODO cells:
 - ▶ FODO cells a bit longer.
 - ▶ Longer inter-dipole distance (1.36 m \rightarrow 1.5 m).
 - ⇒ $B_{MB} \uparrow$
- ▶ $B_{MB} = 15.71 \text{ T} \rightarrow B_{MB} = 15.78 \text{ T}$



- ▶ The EIR is a bit shorter (1.4 km against 1.5 km).
- ⇒ The FODO cell is a bit longer: **212.579 m** against 211.986 m before.
- ▶ The **distance inter-dipole** has been lengthened from 1.36 m to **1.5 m** (source: FCC week 2017 and confirmation by D. Schoerling).
- ▶ The main dipole MD is a bit shorter: **14.242 m** against 14.3 m before.
- ▶ The maximum dipole field is **15.78 T** against 15.71 T before with an aperture of 50 mm.
- ▶ MCS has the same length as in LHC: **0.11 m**.
- ▶ The maximum quadrupole gradient is **380 T/m**.

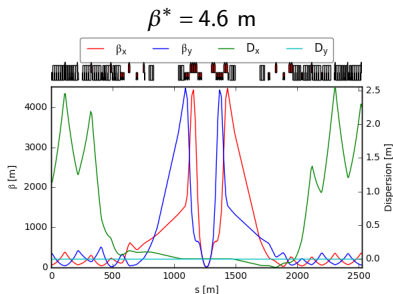
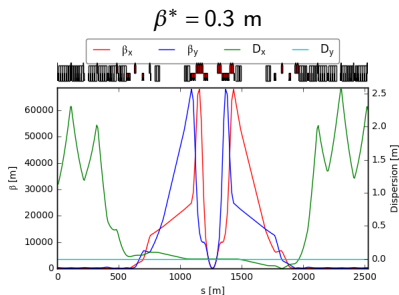


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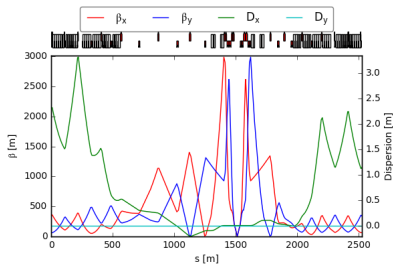
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- ▶ Version 7 of the EIR.
- See R. Martin's and Van Riesen-Haupt's presentations.
- ▶ $L^* = 40$ m.
- ▶ $L_{EIR} = 1.4$ km.
- ▶ β^* considered:
 - ▶ 6.0 m (injection)
 - ▶ 4.6 m (injection)
 - ▶ 1.1 m (baseline)
 - ▶ 0.3 m (ultimate)
 - ▶ 0.2 m (more ultimate)
 - ▶ 0.15 m (even more ultimate)
- ▶ Note: the sextupole gradient inversely scales with β^*
 - ▶ $\beta^* = 0.3$ m \Rightarrow 6821 T/m²
 - ▶ $\beta^* = 0.15$ m \Rightarrow 11158 T/m²

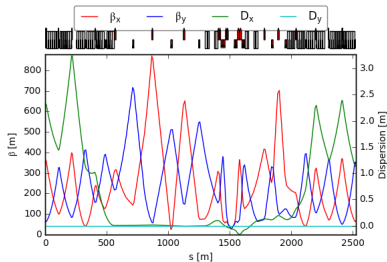


- see M. Hofer's presentation.
- ▶ New version of the insertion with changes on the magnet lengths.
- ▶ Larger β^* at injection.
- ▶ β^* considered:
 - ▶ 27 m (injection)
 - ▶ 3 m (collision)
- ▶ Note: the element class MBRD is different compared to EIR (length of 12.5 m against 15 m).
- ▶ Both families should be harmonized or changes on the naming convention.

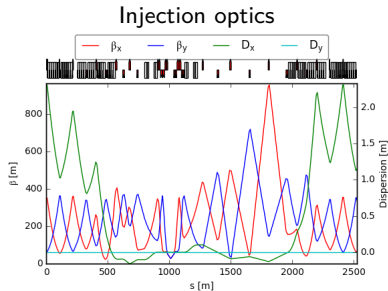
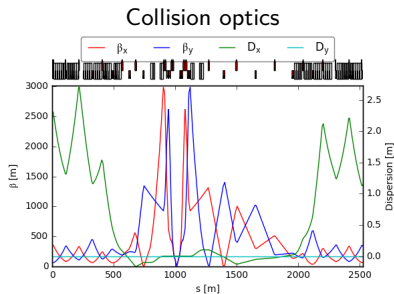
Collision optics



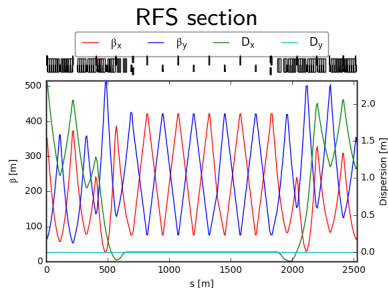
Injection optics

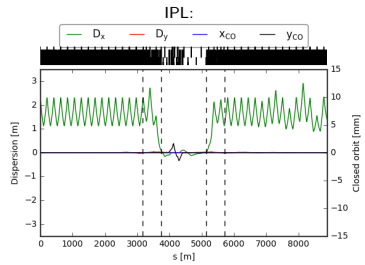
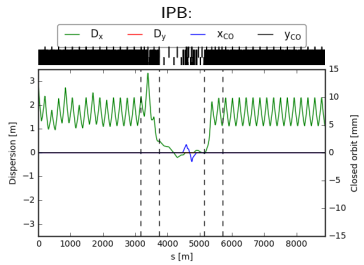
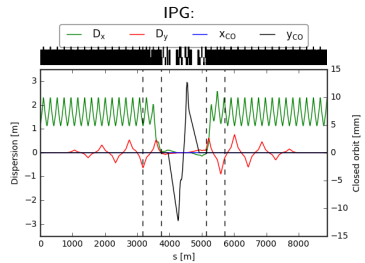
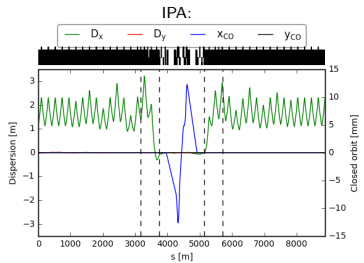


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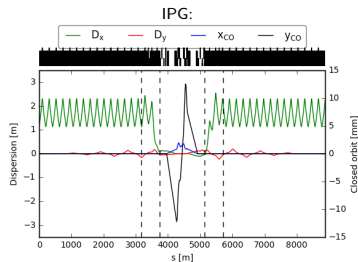
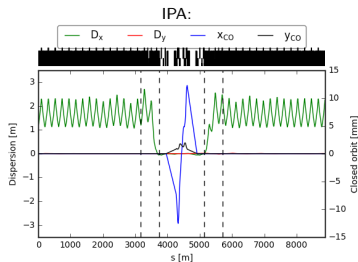


- ▶ The collimator length in the DIS was corrected: 1 m against 5 m before.
- ▶ A total distance of 5 meters is still allocated in the DIS.
- ▶ The FODO cell length in the RFS has been decreased (230 m against 300 m) to be nearer from the arc FODO cell.
- ▶ Cleaning insertions (β and δ) and extraction section stay unchanged.





- ▶ In previous versions, when the separation scheme was switched on, there was no crossing angle in the other plane.
- ▶ It is corrected.
- ▶ Some signs of the crossing angle were wrong (Courtesy: M. Hofer and R. Martin).



- ▶ The new version of the EIR and low-luminosity insertions are integrated.
- ▶ The FODO arc cell has changed a bit to take into account the new interconnection distances and the reduction of the EIR length.
- ▶ The needed maximum field is increased from 15.71 T to 15.78 T.
- ▶ The crossing angle can now be switched on with separation.
- ▶ A new version of the lattice has been released on gitlab:
 - ▶ the master branch is now for the new layout.
 - ▶ any bug reporting is more than welcome!

- ▶ More and more people are using masks or need to retune the machine (beam-beam, dynamic aperture studies, triplet errors, ...).
 - ▶ That would be useful to define what the needs are (macro interfaces, masks, ...) to make sure that everything is fine when the lattice version is updated.
 - ▶ To update the masks on the repository accordingly.
 - ▶ The phase advance between the IPs has a big impact on the dynamic aperture.
- see E. Cruz' talk
- ▶ When the needs in phase advances are frozen, a refined tuning procedure should be discussed and implemented.
 - ▶ Adding multipole lenses for Landau damping correction or beam-beam mitigation.
 - ▶ To release alternative versions with the alternative triplet (see Van Riesen-Haupt's talk) or 60 degrees in the arc cells.
 - ▶ Any other requirements?