Towards a Low Alpha Lattice for the ALBA Storage Ring

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Low alpha optics

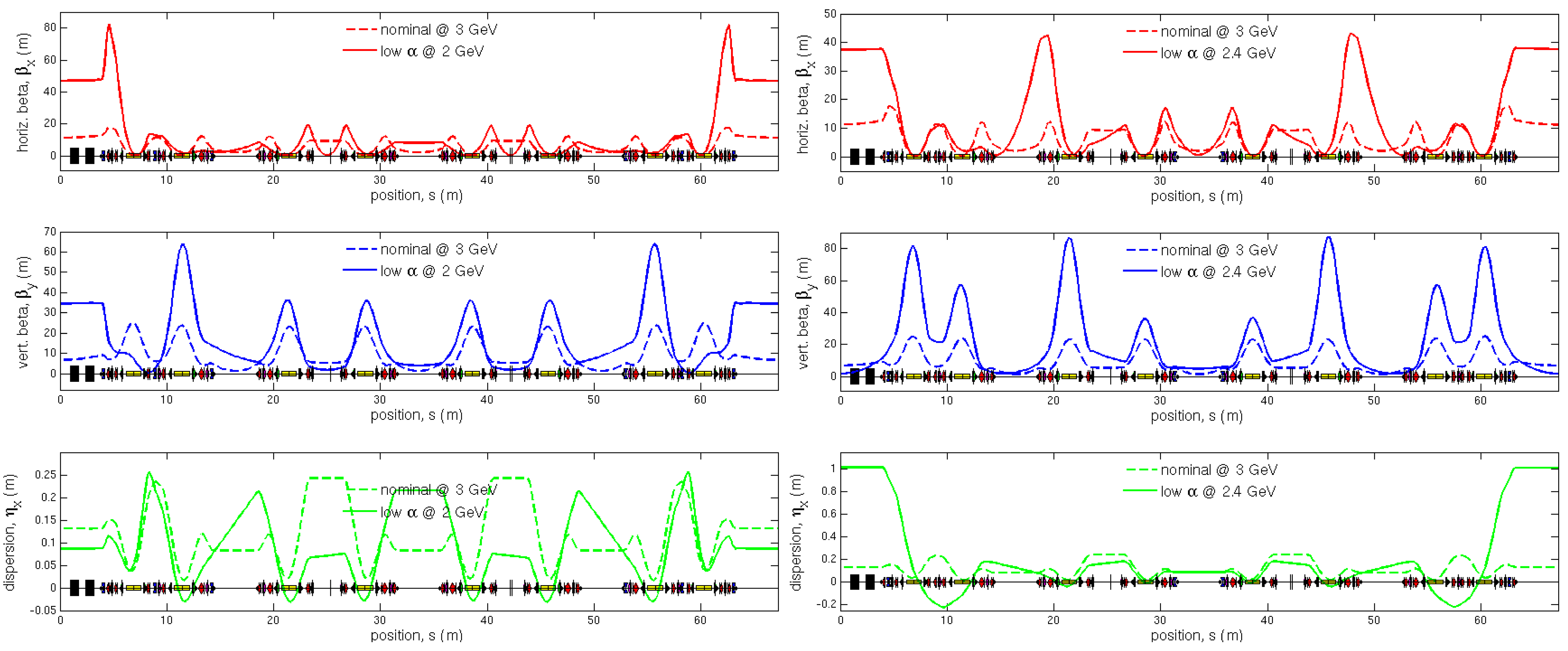
Low momentum compaction factor (alpha) optics are employed in synchrotron light source in order to provide users with pulses of x-ray shorter than one ps and coherent THz radiation. Such operation mode can be obtained by carefully tuning the lattice function in order to produce an almost isochronous ring. The first order contribution to the alpha factor is given by:

$$\alpha_0 = \frac{1}{L}\int \frac{\eta_1(s)}{\rho(s)}ds$$

Where η_1 is the first linear dispersion, ρ is the radius of curvature and L the length of the ring. To achieve low alpha a negative dispersion has to be generated inside the bending magnets such that the negative and positive contributions cancel out each other. Different schemes to achieve such condition have been already proposed and successfully employed in other machines. Unluckily the lack of degrees of freedom in the ALBA lattice prevents to apply directly such solutions and a different strategy is needed:

- **Lack of quadrupole strength $\Rightarrow$ Compensated by lowering beam energy (From 3 GeV nominal energy to 2/2.4 GeV).**
- **Lack of flexibility in quadrupole scheme $\Rightarrow$ Partially recovered by breaking internal lattice symmetry. (Possible with current hardware)**
- **Lack of flexibility in sextupole scheme $\Rightarrow$ Also recovered by breaking internal lattice symmetry. (Not possible with current hardware)**

Linear Lattice



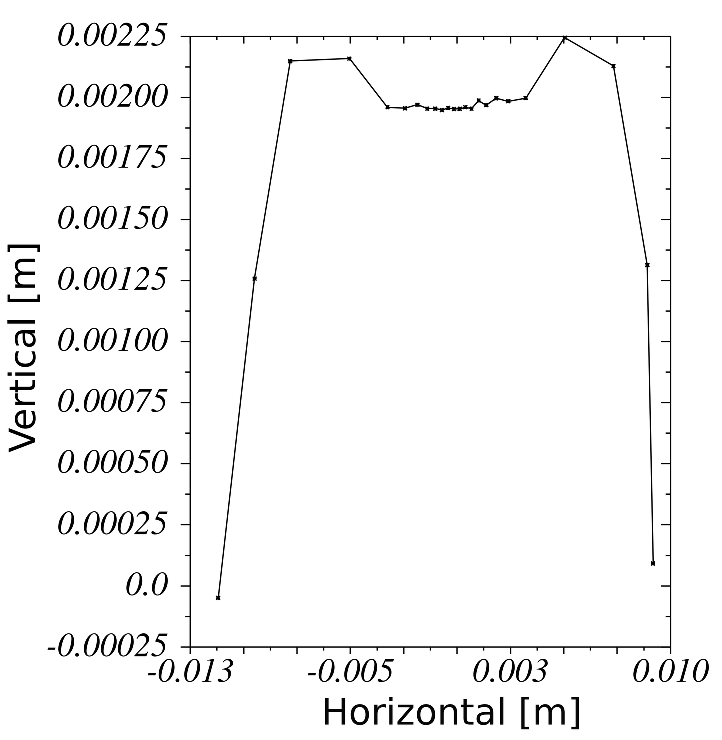
Design Results

Lattice	Q_x	Q_y	α_1	Q'_x	Q'_y	ϵ	ϵ at 3 GeV
ALBA Nominal	18.155	8.363	8.8×10^{-4}	-40.0	-27.7	4.3 nm	4.3 nm
2.0 GeV Low α	18.360	8.192	$<10^{-6}$	-69.4	-54.1	13 nm	31 nm
2.4 GeV Low α	18.106	6.092	$<10^{-6}$	-50.0	-71.2	20 nm	30 nm

- Two solutions for the linear lattice at 2.0 GeV (left) and 2.4 GeV (right).
- Exploiting the independent quadrupole power supplies the internal symmetry of the DBA cells is broken allowing to match a closed solution while keeping low alpha.

Dynamic Aperture Optimization for the 2.4 GeV Low α Lattice

- The break of symmetry in the linear lattice is cause of a major lattice function rearrangement requiring a reorganization of sextupoles. The initial 9 families are splitted into 15.

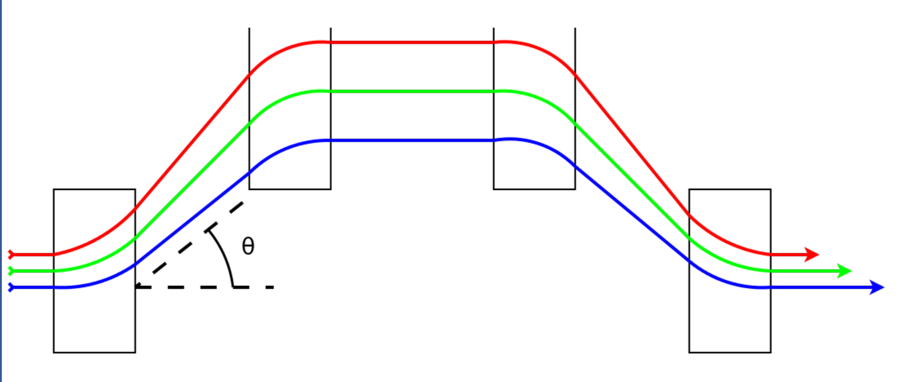


Elegant and OPA have been used for sextupoles optimization. A linear combination of:

- sextupolar driving term
- chromaticities
- second order α

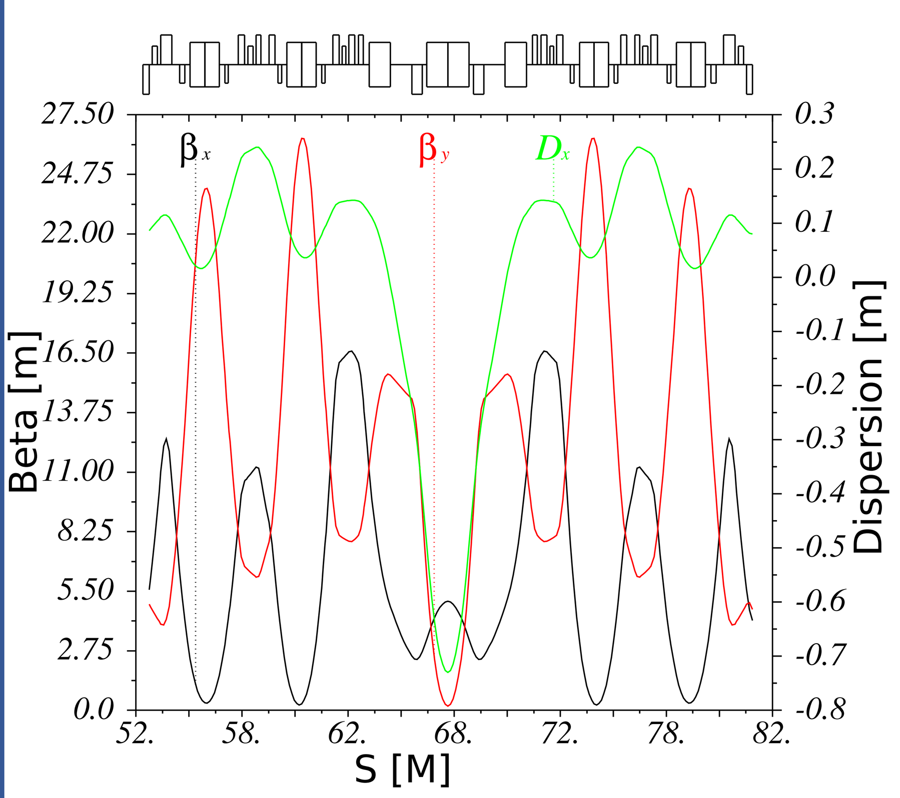
has been used as target function for a random-walk optimization algorithm. Even if the dynamic aperture would be **enough to inject** and store a beam it is **far from being satisfactory** for normal operation.

An Alternative Approach With A Magnetic Chicane



4 dipoles arranged in a chicane. Electrons with higher energy travel through longer paths than electrons with lower energy, resulting in a negative momentum compaction factor.

A Chicane for ALBA



A chicane placed in one long straight section zero the α:

- Only local modification $\Rightarrow$ **Transparent to the rest of the ring.**
- Emittance rise up to 27 nm $\Rightarrow$ **Still competitive for ALBA.**

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