Optimization of the Arc Compressor performance in the MariX free electron laser

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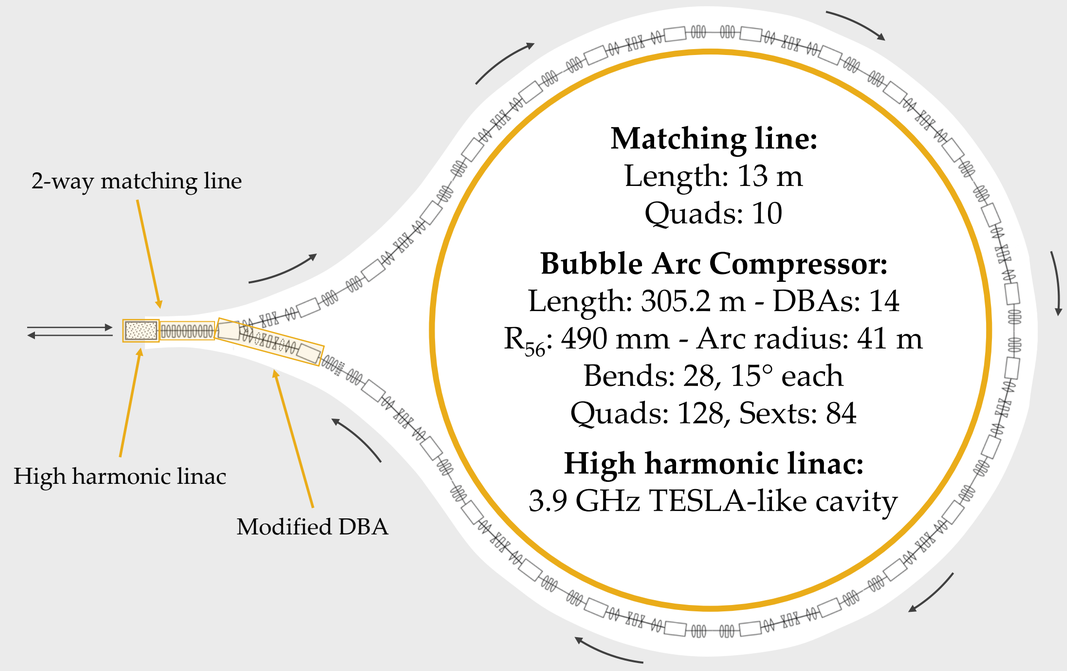
Introduction

The MariX Bubble Arc Compressor is a U-turn device able to multiply the beam peak current of a factor of 10^2.

The high performance of this device is hampered by the emission of CSR which can ruin the beam quality (well-known issue in magnetic compressors) and by the complicated dynamics in the 2-way matching line.

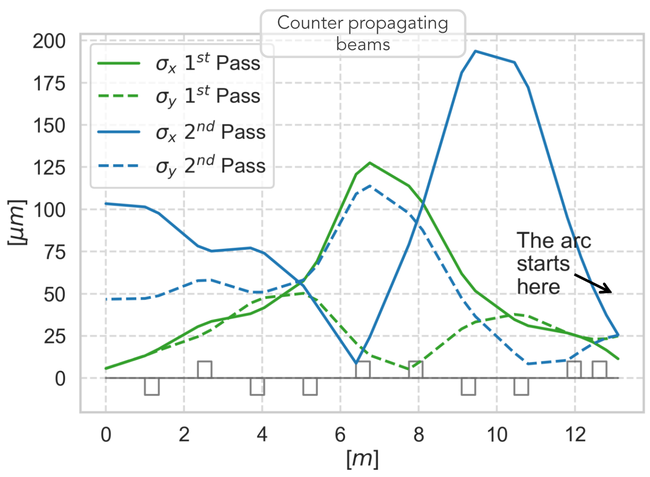
We addressed those issues with simulations performed with Elegant considering CSR and longitudinal space charge effects. The proposed solutions can be further explored in the MariX Conceptual Design Report.



Matching line

The magnetic effect of a quadupole is **opposite** for bunches traveling in opposite directions.

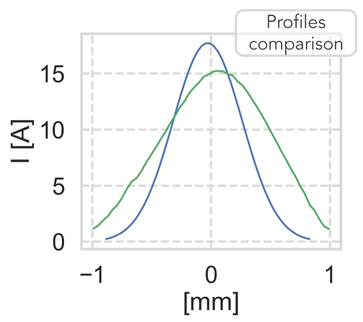
The line is set to match to the arc compressor the forward travelling beam **(green lines)** and to properly collimate the backward travelling beam **(blue lines)**.

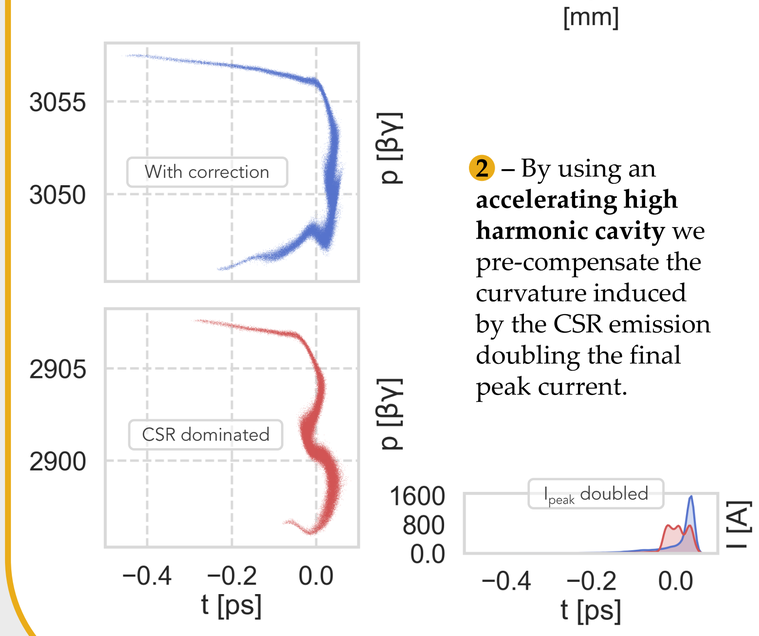


CSR compensation

Two important strategies allowed to **reduce** the deteriorating **effects** of the **CSR** on the beam.

1 – We performed a **Current profile shaping** in the injector to obtain a triangular-like current profile **(green line)** that shows much better performance than Gaussian profiles **(blue line)**.





2 – By using an **accelerating high harmonic cavity** we pre-compensate the curvature induced by the CSR emission doubling the final peak current.

Dispersion damping

Particles in the main spike inevitably undergo a **betatron kick** induced by the **CSR** that unbalances the bunch.

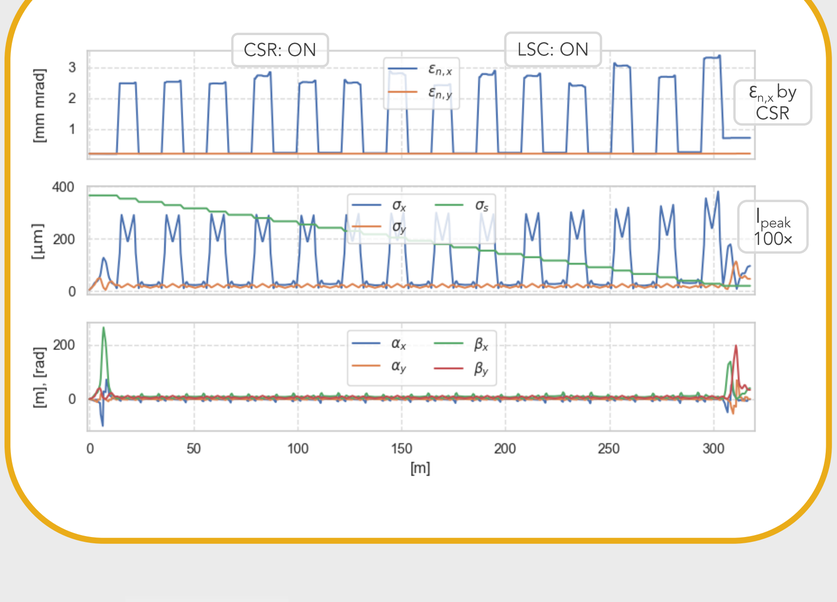
We modified the last DBA to compensate the retained **dispersion residue** and the **horizontal centroids drift** effects.

The line is tuned to set to zero:

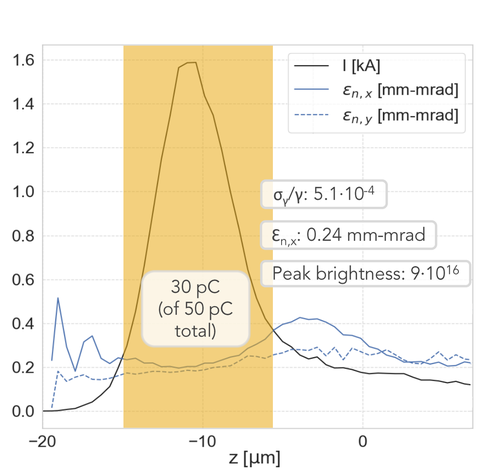
$$\eta_x = \frac{\langle x\, p_r \rangle}{\sigma_{p_r}^2} \qquad \eta'_x = \frac{\langle x'\, p_r \rangle}{\sigma_{p_r}^2}$$
$$with: \ \ p_r = \frac{p - \langle p \rangle}{\langle p \rangle}.$$

As result we **decreased** the projected horizontal **emittance** by 30% and **re-centered** the beam **on axis**.

Tracking



Spike @ exit



Conclusion & perspectives

- A new **U-turn** device "bubble arc compressor" reinjects & ultra-compress e-bunches, with **negligible ε_n degradation**.
- A 10 quads **matching line** satisfies **two** BD **tasks**:
  1. **match** the beam to the arc,
  2. **focus** and **collimate** coming back bunches.

Coming soon: analysis of **jitters** and a deep study of the **μBunching instability**; considering that:

1. The MariX layout can host a laser heater.
2. Preliminary evaluations with **CSR** and **LSC** give indication of moderate μBI gain (not a show-stopper).

Thanks!

Visit the **MariX** initiative **website** for more material **https://www.marix.eu** (or scan the **QR code**):

- Conceptual Design Report.
- Executive Summary (published on *NIM-A*).
- Foreward & theses on the topic.

COMING SOON (submitted to *PRAB*):

- A. Bacci et al., "Two-pass two-way acceleration in a Super-Conducting CW linac to drive low jitters X-ray FELs".

Visit us

Main actors

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Fun fact

The **golden** color used in this poster is identified by the **Hex code**:

#EAAC19