Matching and error corrections for the Project X linac

PARTI meeting

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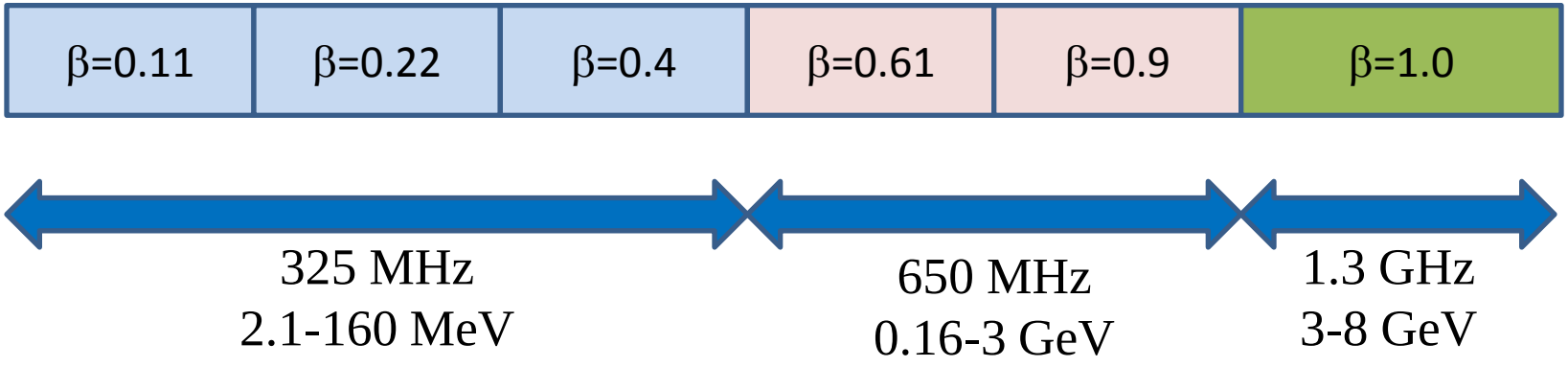
Project X linac layout



W_{in} = 2.1 MeV

Section	Freq	Energy (MeV)	Cav/mag/CM	Type
SSR0 (β_G=0.11)	325	2.1-10	18 /18/1	SSR, solenoid
SSR1 (β_G=0.22)	325	10-42	20/20/ 2	SSR, solenoid
SSR2 (β_G=0.4)	325	42-160	40/20/4	SSR, solenoid
LB 650 (β_G=0.61)	650	160-460	36 /24/6	5-cell elliptical, doublet
HB 650 (β_G=0.9)	650	460-3000	160/40/20	5-cell elliptical, doublet
ILC 1.3 (β_G=1.0)	1300	3000-8000	224 /28 /28	9-cell elliptical, quad (FODO)

Matching problem

The beam is matched when its envelope is periodic with the lattice period. Then the same phase-space distribution is reproduced period after period.

Beam is mismatched when it is not true.

$$\begin{pmatrix} x \\ x' \end{pmatrix}_{s_0+L_p} = \begin{pmatrix} cos\Delta\psi_{L_p} + \alpha\, sin\Delta\psi_{L_p} & \beta\, sin\Delta\psi_{L_p} \\ -\gamma\, sin\Delta\psi_{L_p} & cos\Delta\psi_{L_p} - \alpha\, sin\Delta\psi_{L_p} \end{pmatrix} \begin{pmatrix} x \\ x' \end{pmatrix}_{s_0}$$

The matrix equation describing the motion

$$\beta(s) = w^2(s) \qquad \alpha(s) = -\frac{1}{2}\frac{d\beta(s)}{ds} \qquad \gamma(s) = \frac{1+\alpha^2}{\beta}$$

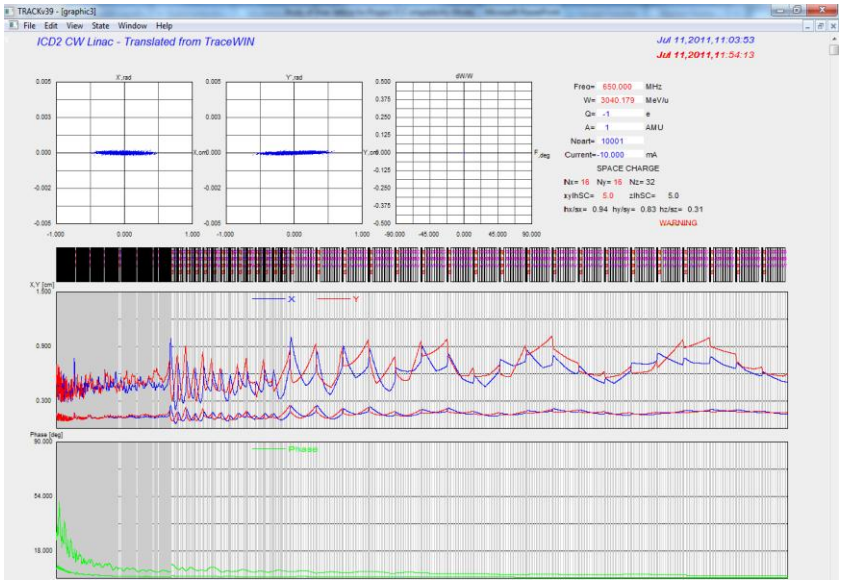
Courant-Snyder parameters

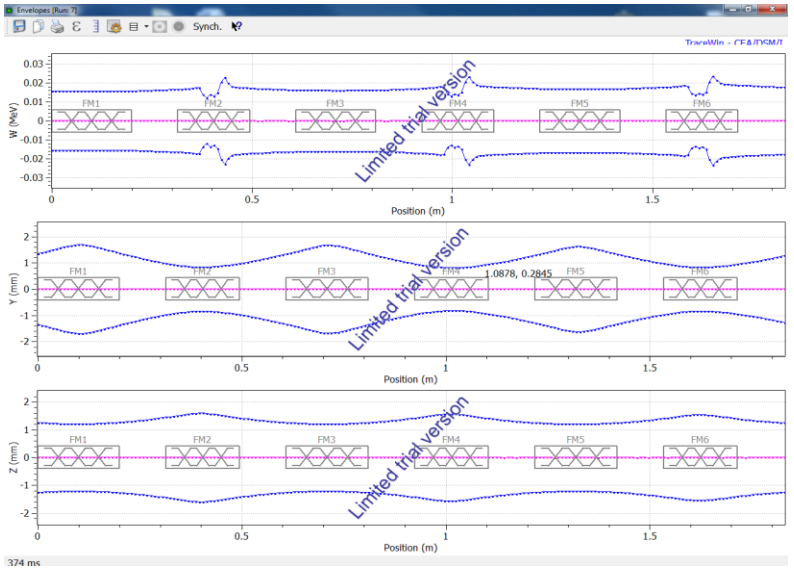
$$\beta_w = \frac{w^2}{\varepsilon_w} \qquad \gamma_w = \frac{w'^2}{\varepsilon_w} \qquad \widetilde{\alpha_w} = -\frac{\langle (w - \langle w \rangle)(w' - \langle w' \rangle) \rangle}{\varepsilon_w}$$

Twiss parameters

For the ideal periodic lattice the beam is matched when its Twiss parameters correspond to the lattice Courant-Snyder parameters

Software





TRACK (P. Ostroumov, ANL) - matching is very slow and limited, because it requires tracking the whole beam, “black box” (no source code)

TraceWin (commercial CEA/Saclay), good matching routines, well-documented, “black box” (no source code)

- For design purposes we often need to match lattice functions between different sections of linac

Goals

- Taking advantages of the existing facilities provided by TRACK write stand-alone procedures to perform the matching and error correction.
- Study sensitivity to the initial conditions (Twiss parameters centroid mismatch)
- Establish misalignment tolerances
- Optimize the number of correctors needed
- Investigate optics reconfiguration that would allow operation following cavity/solenoid/magnet fail