Status of new input definition of the beam-beam lens in SixTrack

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Introduction

- Action originated after debugging of the `lhc=2` for 6D beam-beam lens used in the case of flat beams.
- New input definition should provide full flexibility to the user wrt the full range of parameters used in the beam-beam interaction.
- New input definition should as well minimize the interaction with the SixTrack input files produced by MADX to avoid possible errors.
- However **NO** modifications on the *physics* of the beam-beam interaction both in 4D and 6D has been performed

New Input Format for BB elements

BEAM

This variable still to be kept because was used for other purposes. (lhc=9)

I[ppb] **$\varepsilon_{n,x}$** **$\varepsilon_{n,y}$** **σ_z[m]** **σ_e[m]** **ibeco** **ibtyp** **lhc** **ibbc**

"Exact" BB kicks (ibtyp=1) and linear coupling (ibbc=1) NOT TESTED with these new inputs!!!

Beam params

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name_4D **nsli** **$\sum_{xx}$[mm^2]** **$\sum_{yy}$[mm^2]** **Sep$_x$[mm]** **Sep$_y$[mm]** **strength-ratio**

4D

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name_6D **nsli** **θ/2 [rad]** **?[rad]** **Sep$_x$[mm]** **Sep$_y$[mm]**

$\sum_{xx}$ [mm^2] **$\sum_{xxp}$ [mm mrad]** **$\sum_{xpxp}$ [mrad^2]** **$\sum_{yy}$ [mm^2]** **$\sum_{yyp}$ [mm mrad]**

$\sum_{ypyp}$ [mrad^2] **$\sum_{xy}$ [mm^2]** **$\sum_{xpy}$ [mm mrad]** **$\sum_{xpyp}$ [mrad^2]** **strength-ratio**

6D

If a BB element is divided in several 4D or 6D different elements this variable sets the strength wrt to the total kick.

NEXT BEAM

Number of slices:
- 0 means 4D
- ≥ 1 means 6D

2.2000E+11 **2.5** **2.5** **7.5e-02** **1.10e-04** **1** **0** **0** **0**

Beam params

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bb_par.l5b1_18 **0** **5.92e-06** **2.45e-06** **2.43e+01** **3.83e-04** **1**

4D

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bb_ho1b1_0 **15** **0.0** **295e-03** **9.69123123e-07** **-1.37123123e-06**

5.021231233e-05 **-4.256123123e-09** **3.069123123e-07** **5.021231233e-05** **3.007123123e-08**

2.231123123e-03 **4.075123123e-08** **1.231123123e-07** **-4.264123123e-07** **2.236123123e-03** **1**

6D

NEXT

Status

- All modifications as discussed and agreed with all people involved merged with latest SixTrack versions.
- Realistic HiLumi examples were provided covering all posibilities (HO 4D, HO 6D, HO+LR).
- Small numerical differences due to expected floating point inaccuracy still under study. Afterwards full test suite (Javier with Kyrre,Eric?).
- Not yet officially released yet (available as a fork in git repo).
- Updated manual and wiki with new input variables. Sign convention for different variables to be explicitly specified in the different manuals. Physics manual to be proofread and eventually completed.
- All the additional features before hard coded in SixTrack (i.e. crab crossing, effect of CC rf curvature, etc.) will be now generated by MADX macros into the SixTrack input. However we should check that several 6D BB lens = 1 BB lens with several slices to validate this approach. (Javier will start looking at it).
- Request by MADX ticket of modifications in beambeam elements in MADX and conversion to SixTrack.

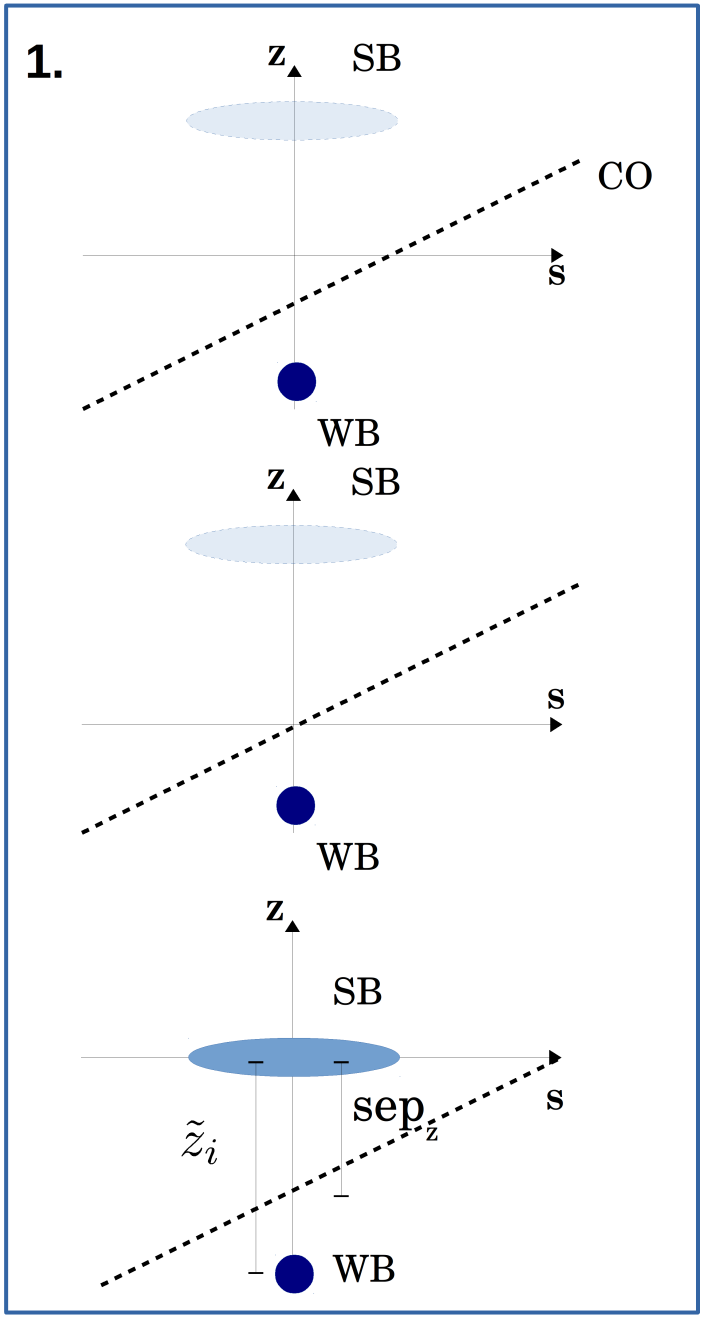
Sign convention: Separation

1. The separation is added to the transverse coordinates of each particles just before the beam-beam subroutines.

$$\tilde{x}_i = x_i + sep_x - CO_x$$
$$\tilde{y}_i = y_i + sep_y - CO_y$$

2. Boost applied to those updated coordinates.
3. Then the separation used for the actual kick ($sep_{x,y,kick}$) is the difference between the centroid of the strong slice ($X^{\dagger}$,$Y^{\dagger}$) and the each particle (x_i,y_i).
4. Antiboost to return to accelerator frame.
5. Remove separation and add back the closed orbit and keep tracking.

$$\tilde{x}_i = x_i - sep_x + CO_x$$
$$\tilde{y}_i = y_i - sep_y + CO_y$$



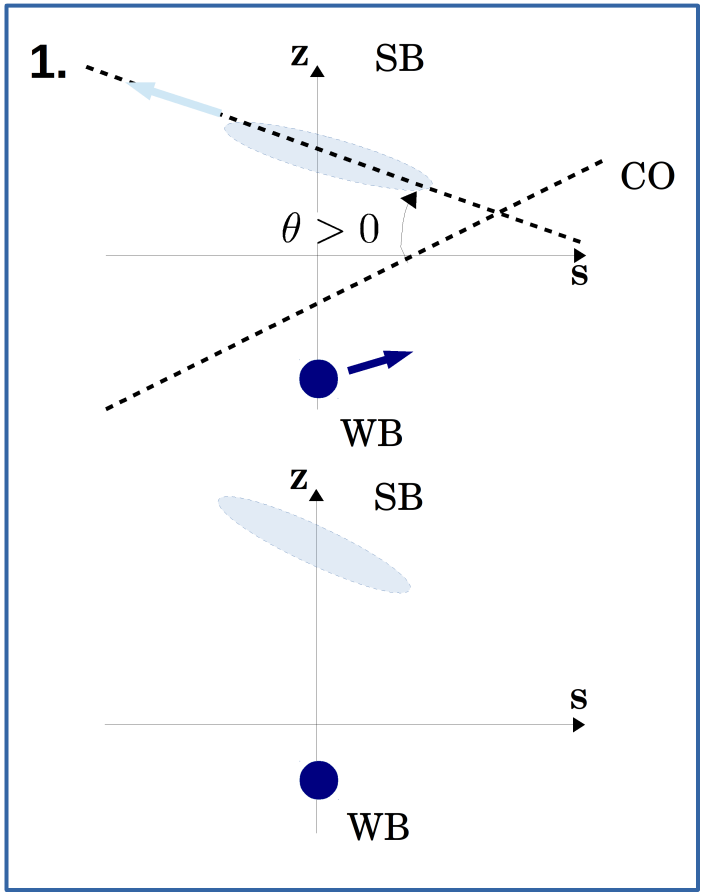
Sign convention: Crossing angle

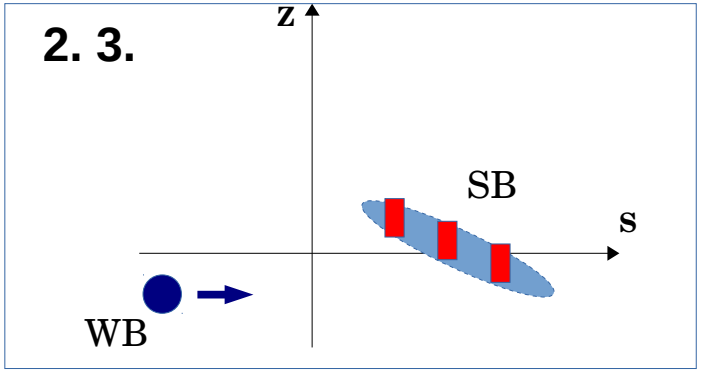
1. Remove the closed orbit just before the beam-beam subroutines.

$$\tilde{x}'_i = x'_i - CO_{x'}$$
$$\tilde{y}'_i = y'_i - CO_{y'}$$

2. Boost applied to those updated coordinates.
3. Apply the SBM.
4. Antiboost to return to accelerator frame.
5. Add back the closed orbit and keep tracking.

$$\tilde{x}'_i = x'_i + CO_{x'}$$
$$\tilde{y}'_i = y'_i + CO_{y'}$$



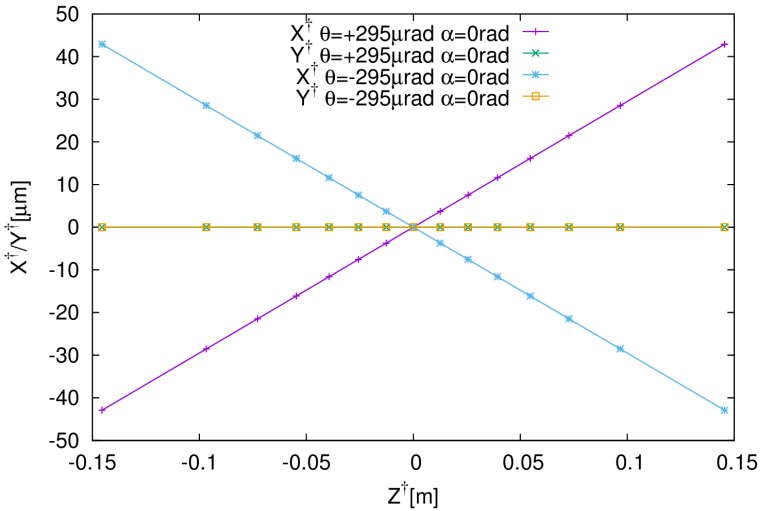


Sign convention: Crossing angle

$$X^\dagger = Z^\dagger \sin(\theta/2)\cos\alpha$$
$$Y^\dagger = Z^\dagger \sin(\theta/2)\sin\alpha$$

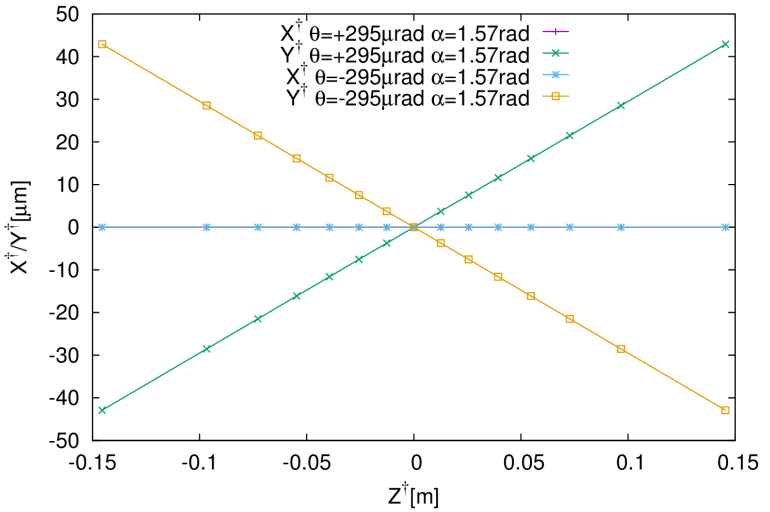
Nsli,1,-1

Horizontal crossing



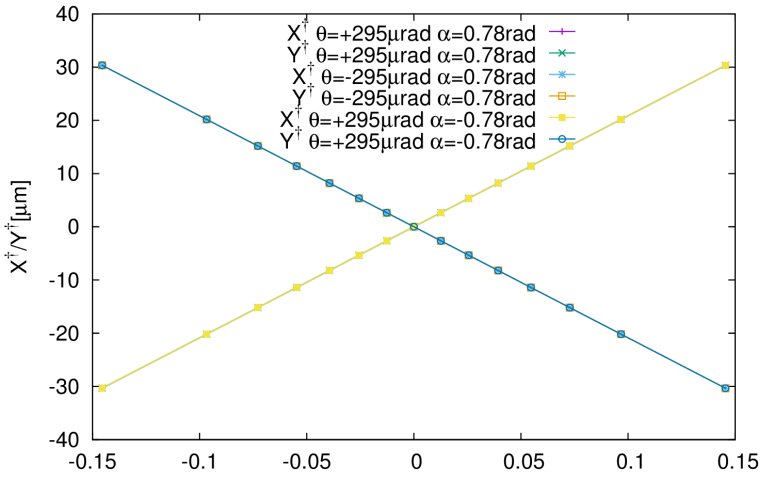
Weak beam

Vertical crossing

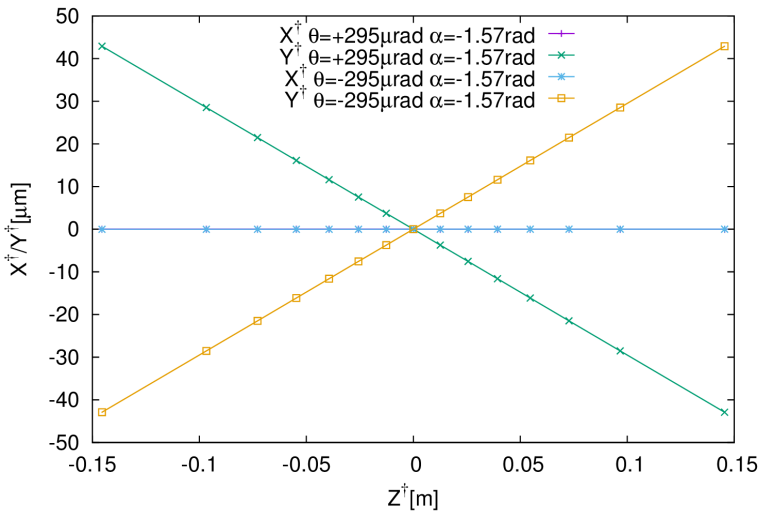


Weak beam

Mixed crossing



Weak beam



Weak beam

The minus sign for the strong beam crossing angle is faked by SixTrack by changing the order of the strong beam slices!