Optical corrections in ATF2 and its long-term behavior

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Guidelines

1. Effect of Ground Motion on the beam at IP
2. Steering correction
3. Optical corrections

Beam displaced in a sextupole

mainly due to :

- sextupole displacement
- quadrupoles displacements

main effect of x displacement :

- quadrupole term added

main effects of y displacement :

- x'y coupling
- y dispersion introduced by coupling if in dispertive region
- geometrical aberations (x'x'y coupling)

Other effects

- There is several relations (symetries) set up in design between strength of magnets and transfert matrix to minimize non-linear optics effects (eg. geometrical aberations).
- α_x et α_y y errors change phase and so change transfert matrix
- This can break the symetries and so high order terms become hudge and so does the beam size at IP.

How correct it ?

- Each correlation or displacement due to a misalignement of a magnet is at the magnet phase.
- Opposite correlation or displacement at the same phase correct it.
- Nearest the correction is, lowest will be non-linear contribution of the effect.
- As the correction can not always be introduce at the same phase, one can use two correctors at differents phases.
- Some correlations needs several pertubations to be introduced. This linear combinaison is a knob for this correlation.

Principle of steering correction

Misalignement in a quadrupoles (or a sextupoles) will produce betatron oscillation in all the line. BPMs measurments caracterize this oscillation (amplitude and phase) so we can correct it.

Main correction algorithms :

- 1 to 1 : one corrector is modified at once to put the beam in the center of a corresponding BPM.
- 1 to all : one corrector is modified at once to minimize the offset in all following BPMs.
- all to all : all correctors are modified at once to minimize the offset in all BPMs.

Comparison of algorithms

Correction	Advantages	Inconvenients
1 to 1	Simple correction	Need $\frac{\pi}{2}$ phase advance between correctors and bpms.
		If big focusing : small errors at start become huge at the end.
		Long : One correction for each corrector.
1 to all	Very robust	Long : One correction for each corrector.
all to all	Quick	Very sensitive to errors on knowledge of the line and bpm readings.

Implementation of "1 to all" algorithm

1. Get BPMs readings of the perfect line B_0 ($\simeq$ get transfert matrix).
2. For each corrector i, apply an unitary correction.B are values of BPMs readings.
   $B_i - B_0$is a vector proportional to the correction (linear aproximation).
3. Get $B_i^{-1} = (B_i - B_0)^{-1}$ pseudo-invert of this vector. It allows to have the measure of what should have the value of the corrector to have such displacement of the beam.
4. For a corrector i, apply the correction C_i given by $C_i = -\alpha(B_{exp} - B_0) \times B_i^{-1}$ where B_{exp} is the "experimental" BPMs measurement.

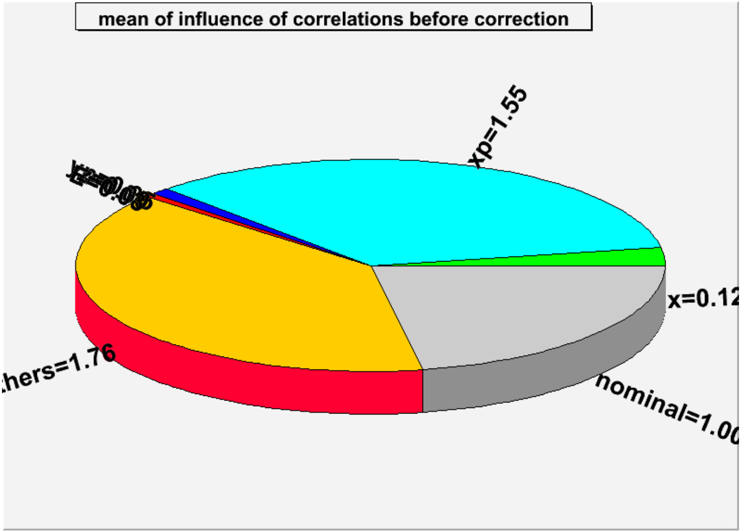
Oservations

- Main influence from Final Focus section where all sextupoles are at $\frac{\pi}{2}$ from IP.
  $\Rightarrow$ Need just 1 corrector !
- Correlation of the beam is not directly measurable.
  $\Rightarrow$ Make scan and fit the parabola of size function of the correction.

Implementation of optical corrections

1. Get the main correlations D_0 introduced by the perfect line at the IP. ($\simeq$ get transfert matrix).
2. Look for ways to introduce it (sextupole displacement, variation of strength of quadrupole or sextupole)
3. For most efficient way found, get the values D_i of the correlations of the beam at IP introduced by an unitary pertubation of the magnet.
4. Get D^{-1},invert of matrix made by $D_i - D_0$.
5. Vector of D^{-1} are knobs that change an unique correlation. Make a scan of each knob, fit the parabola of size function of the knob amplitude. Mininum size is obtained for uncorelated beam, apply the corresponding correction.

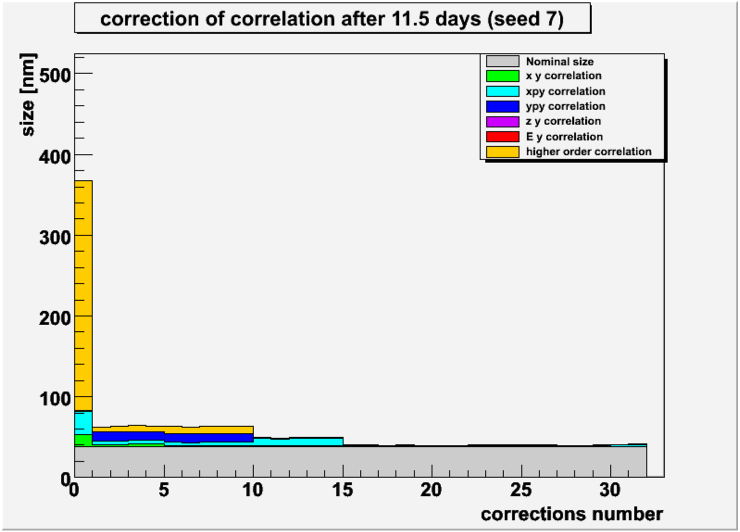
Main correlation at IP before correction



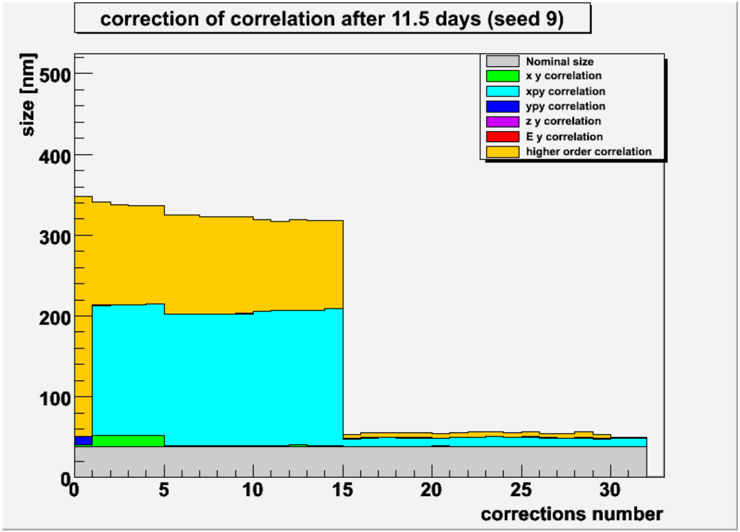
Simulation in PLACET

- Initial displacement generated by 11.5*days* ($10^6 s$) of ground motion.
- Steering correction each second.
- Size measurement are 90*s* long (Shintake monitor).
- 20 seeds for the ground motion generator fitted on measurement at KEK.
- 100*nm* of resolution on BPMs (7*nm* on IPBPMs)

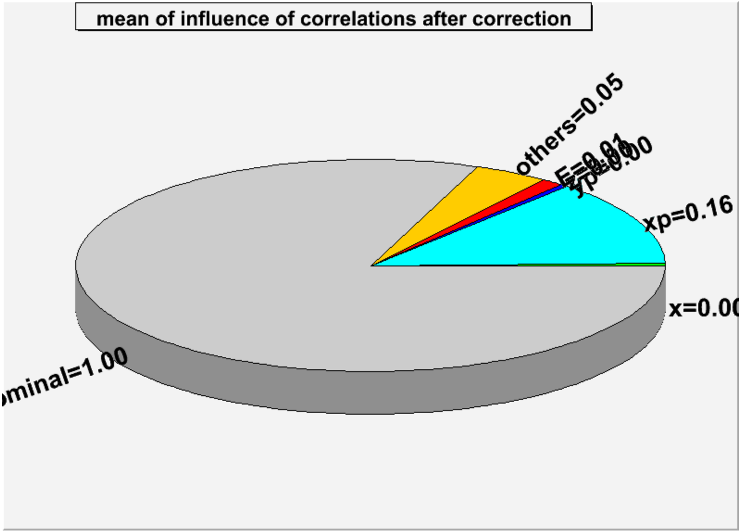
Results for a seed



Results for an other seed



Correlation at IP after correction



Size at IP before and after correction