Beam-beam Meeting 7th November 2013

1. A. Valishev (Lifetrac Introduction)
   A. Valishev from FNAL explained the origin of the Lifetrac code written by D. Shatilov (BINP). The code was mainly used for e+e- machines. At DAFNE it was used to define the crab waist, and for simulations of crab cavities in KEKB. For e_e- machines the code determines the equilibrium distribution with radiation damping.
   From 2003 it has been applied to the Tevatron collider to try to improve/solve the big problems with beam-beam effects. The Tevatron collider had 70 long-range interactions with a separation in the range [6,8] sigma.
   The code was modified and a lot of emphasis was put on the use of simulations for the real machine tuning and performance improvement. The code also features very advanced GUIs to be on-line with the collider performances.
   The code can simulate real measurable parameters: intensity lifetimes, emittance blow-up, lumi degradation.
   It is a single particle tracking code but the normally used mode is to simulate macro-particle bunch (10,000 particles in 6D phase space with weighted charge with larger number of particle in tails but not in core) for 10^6-10^7 turns. It allows also for Frequency Map Analysis since 2007.
   Initially the code had a linear transfer map between the beam-beam interactions, which was adequate for the Tevatron because the nonlinearities from beam-beam effects were much stronger than the machine nonlinearities.
   Since 2012 the element-by-element thin lens tracking was implemented as in Sixtrack. Many other special elements have been added (e-lenses, crab cavities, wire compensators, collimators, special magnets). More recently, the calculation of Dynamic Aperture as been added (for direct comparisons with SixTrack) and a MADX to LIFETRAC lattice conversion implemented.
   Sasha showed some benchmark with MADX:
   - Closed orbit calculation of strong and weak beam at the long range encounters
   - Transverse beams sizes at the interaction points
   - Footprints in tune diagram from MADX and from FMA for LHC nominal 2 IPs. Differences are small and maybe understood.

   Sasha then went through some known differences between the codes:
   - The beam-beam macros in Sixtrack do not take into account dispersion but it is a negligible effect while Lifetrac does take this effect into account.
   - Beam-beam transverse size for strong beam doesn't take into account for dynamic beta
   - Different definition of dynamic aperture: Sixtrack uses averaging while in Lifetrac it's the initial value

   Compare footprints and single particle motion in physical coordinates.
   To avoid this problem/difference one could look at many particles and track particles at the DA limit in physical coordinates.

Sasha showed also the GUI that follows Liftrac to show its functionality i.e. show results in amplitude space or by using different phases, one can see variation of the FMA in amplitude space.
Tatiana asked how is the 6D FMA defined, how does Lifetrac calculate the frequencies over 8000 turns used? Sasha mentioned that a fft with sliding window is performed and each point corresponds to the rms value over 400 points plus a normalization factor. **Action: concerning the 6D FMA Sasha will let us know the normalization factor for the diffusion index and the details of the fft calculations for the 6D FMA.**
Riccardo asked if also misalignments are included, Sasha said they are not.
Gianluigi asked if the phase is in betatron or physical space: Sasha answered its in betatron space, adding that in Sixtrack this is avoided by averaging the motion.
Gianluigi asked if crab cavities were tested with KEK simulations (Ohmi simulations). Sasha mentioned yes, the code confirmed the simulations but did not test the data.
Sasha mentioned that noise is an important effect with beam-beam, introducing some smearing on higher order resonances, which might be not important affecting the results. A noise source could be useful.

2. J. Barranco (Lifetrac versus Sixtrack: what is missing?)

Javier has shown some tests performed on Sixtrack to verify the beam-beam lens. First test we normally perform is to cross check the footprints produced by Sixtrack versus MADX. The 6D Hirata lens has been checked in the code and seems consistent with Hirata original treatment (more in BB Meeting 22nd August2013). We started then to cross-check tune shifts per single particle at 0-amplitude versus crossing angle for the different optics and also in the presence of crab crossing. Tracking results are now compared to analytical formulas. The plots are preliminary and the formulas approximations have to be defined. Formulas do not take into account for the hourglass effect. Examples of the tune shift versus crossing angle show larger discrepancies for reduced beta*. More studies needed to identify the source of the difference. **Action Javier/Tatiana: Verify the formulas approximations for different cases.**
Javier has also shown the suppression of synchrotron sidebands when the crab crossing is on suppressing the crossing angle as should be expected. The differences between the 4D beam-beam lens with 5 slices and the 6D beam-beam lens with 5 slices (the differences between the two models come from the longitudinal Lorentz boost of Hirata modelling) has been shown to come when the second Long-range set of encounters of IP5. Seems that particles motion become chaotic earlier (at smaller amplitudes) when the 6D lens is used. Needs studies to identify/exclude other sources i.e. numerical bugs.
Javier also showed a list of future checks to be performed to identify possible sources of errors in Sixtrack. A close cross-check with Lifetrac is

fundamental. **Action for all: verify tune shifts versus crossing angles in Sixtrack and Lifetrac.**

3. D. Banfi (DA studies)
   Due to the very late time we decided the presentation of Danilo has been post-poned.

   Reported by T. Pieloni 25th November 2013

Presence:
D. Banfi, J. Barranco, D. Schulte, G. Arduini, E. Metral, R. De Maria, T. Pieloni