(Not a summary)

A few comments on beam-beam based on my limited experience on colliders

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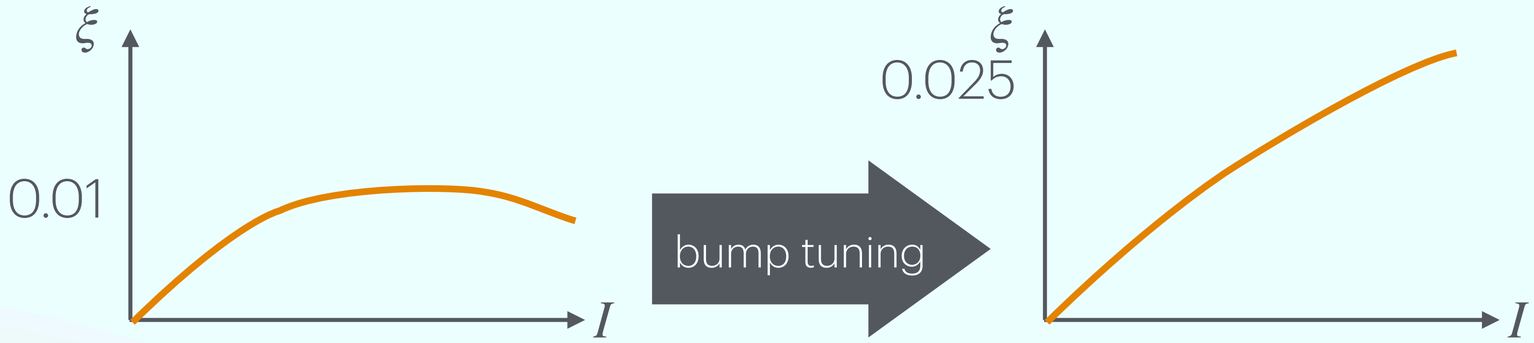
Sep. 5, 2024 @ BB24 Workshop @ EPFL

“Beam-beam limit” — TRISTAN

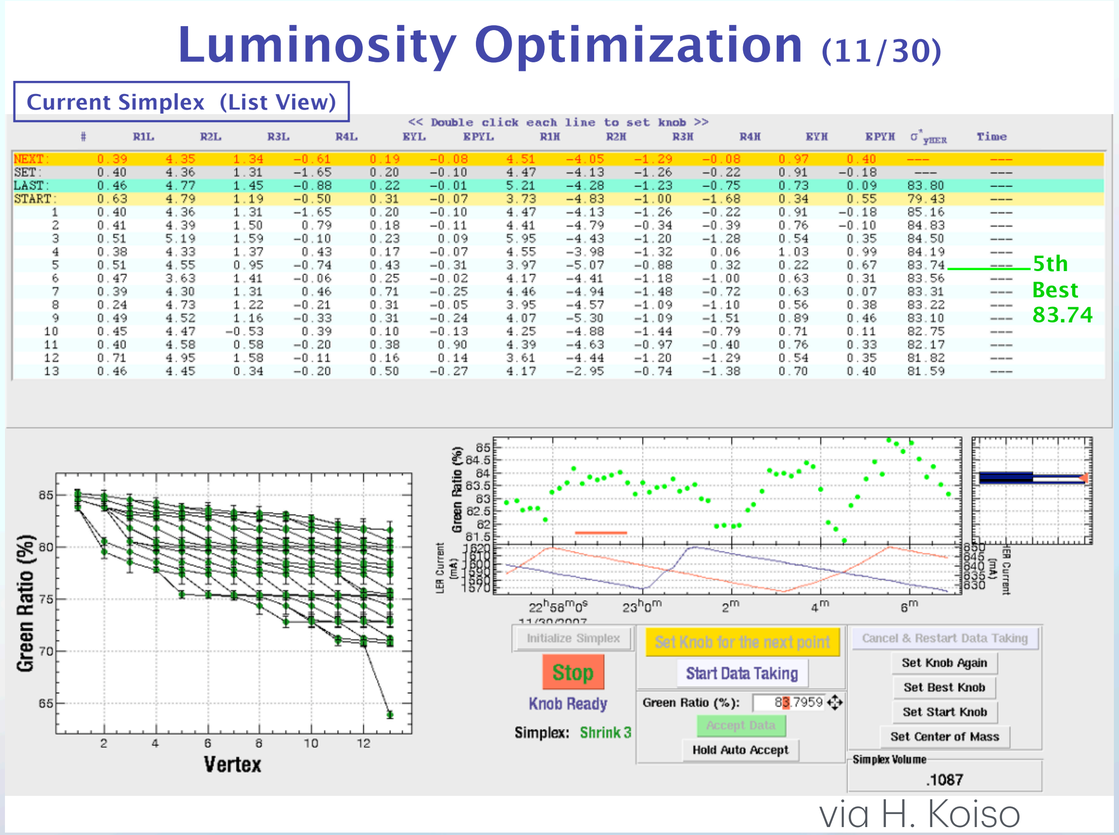
- A the time of TRISTAN, it had been said that there exists a mysterious number for a collider “beam-beam limit” to limit the beam-beam parameter.



- Indeed, at the beginning of TRISTAN, something like the left plot was observed.
- Then we have noticed that this “limit” depends on vertical orbit bumps in the arcs.
  - They should affect the x-y coupling, vertical dispersion, and vertical emittance through the vertical offset in sextupoles.
- Then by tuning up to about 20 sets of such bumps, luminosity and beam-beam parameter were improved step by step, like as the right plot above.
  - As the bema current was limited by TMCI, it was no longer possible to look at where is the “beam-beam limit” after the bump tuning.

Multiple knobs tuning — KEKB

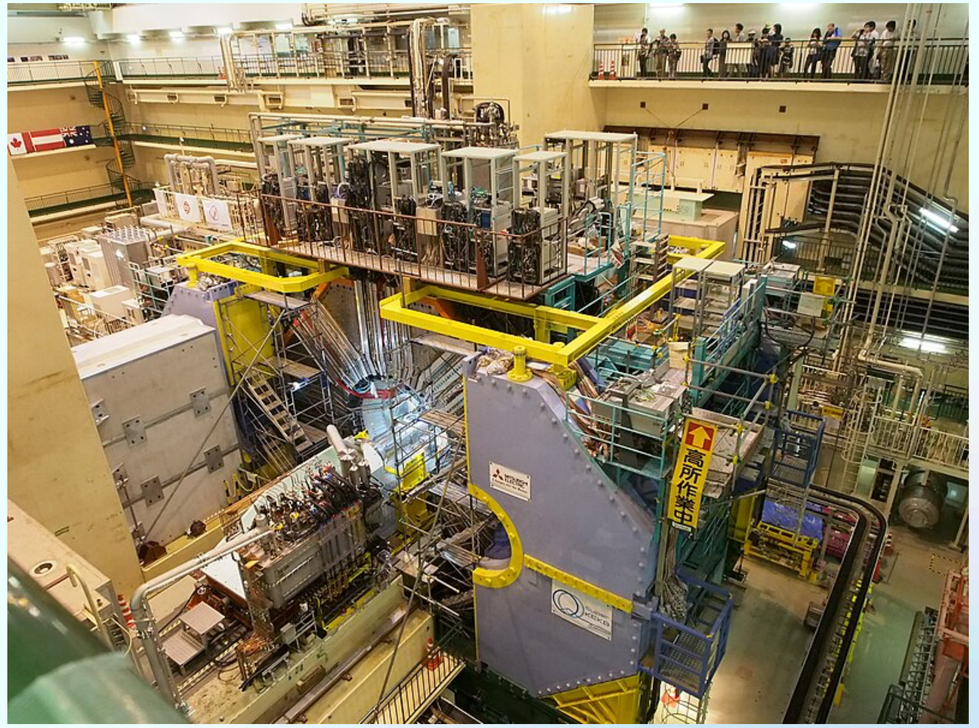
- At KEKB, such a bump knob tuning started at TRISTAN became more systematic and orthogonal.
  - Symmetric & asymmetric vertical bumps at a -I sextupole pair produce x-y coupling & vertical dispersion, respectively.
  - IP knobs: $(\eta_y, \eta_{py}, R_{1,2,3,4}, \Delta s_y) \times 2\,\mathrm{rings}$.
  - Chromatic coupling knobs joined later at crab crossing.
  - Tuning each knob one by one takes time, esp. under disturbance by other things: such as temperature change.
- Then a multi-dimension tuning has been tried in 2007 using downhill simplex (right figure).
  - It was working well, but not sufficient to reach the beam-beam parameter expected by simulations (0.15, achieved 0.09).
- For FCC-ee with 4 IPs, the number of knobs will be at least $14 \times 4 = 56$.
  - Tuning at one IP interferes the luminosity at the other IPs via emittance change, optics disturbance.
  - More advanced tuning methods are required.



via H. Koiso

Alignment of the detector (a speculation) — SuperKEKB

- All accelerator components of SuperKEKB have been well aligned with accuracy better than $\sigma \lesssim 100\,\mu\mathrm{m}$.
- However, the orbit around the interaction region looks strange:
  - Unexpected shining of the inner detector by SR observed.
  - Strange steering of the orbit is required to ensure the collision and avoid the SR shining.
- A speculation is that the alignment of the Belle-II detector might have large errors, in positions and angles, relative to nearby accelerator components.
  - It may explain the low beam-beam parameter (0.03) achieved so far.
- If it is true, re-alignment of accelerator components is necessary, by smoothly redefine the ring layout in this straight from the IP to the arc.
  - It is very difficult to move the detector itself (1400 tons) with a good accuracy.



https://en.wikipedia.org/wiki/Belle_II_experiment