### (Not a summary)

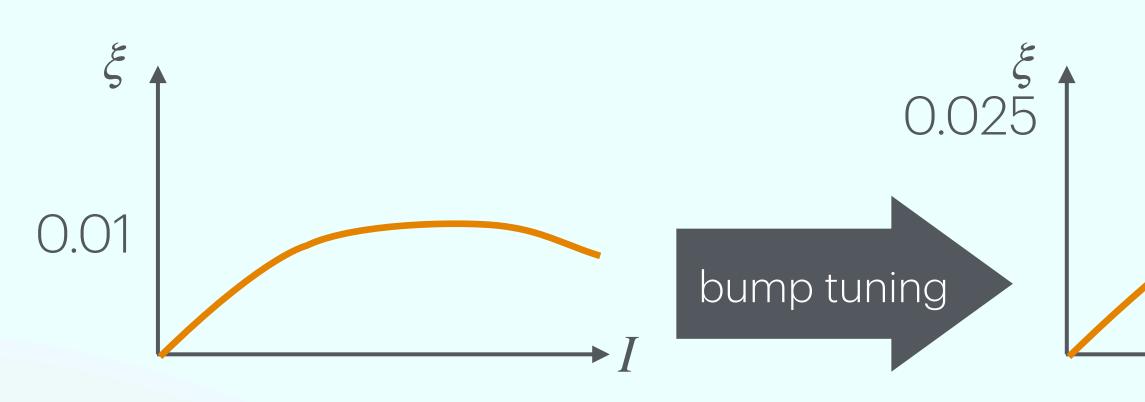
# A few comments on beam-beam based on my limited experience on colliders

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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.
  - offset in sextupoles.
- improved step by step, like as the right plot above.
  - beam limit" after the bump tuning.

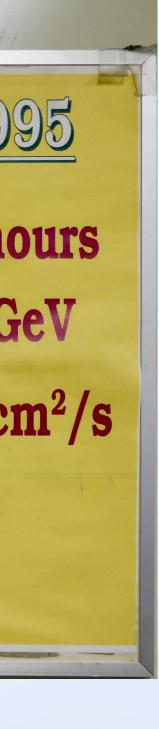
TRISTAN Records 1986~1995 **Total Running Hours : 21,000 hours** : 32 + 32 GeV Max. Energy  $: 4 \times 10^{31} / \text{cm}^2 / \text{s}$ Max. Luminosity Max. Integrated Luminosity / Day : 1.2 / pb

• They should affect the x-y coupling, vertical dispersion, and vertical emittance through the vertical

• Then by tuning up to about 20 sets of such bumps, luminosity and beam-beam parameter were

• As the bema current was limited by TMCI, it was no longer possible to look at where is the "beam-

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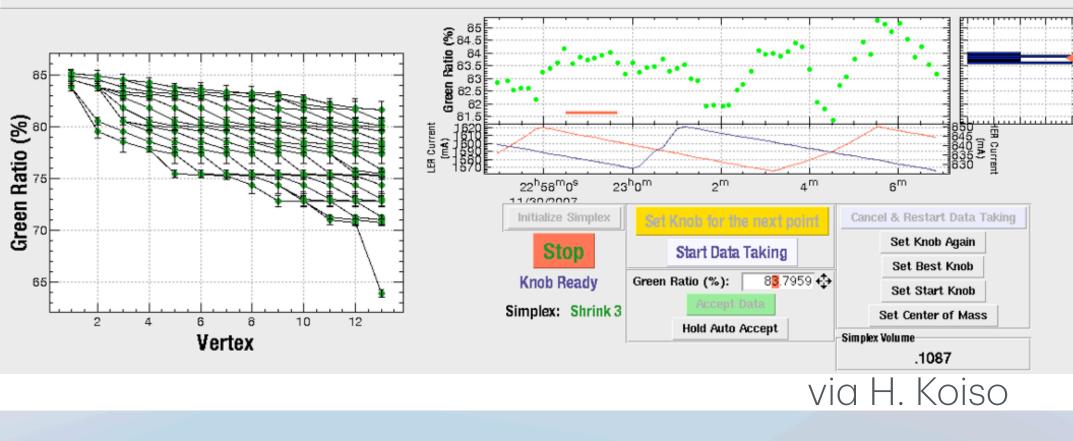


# Multiple knobs tuning – KEKB

- 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:  $(\eta_v, \eta_{pv}, R_{1,2,3,4}, \Delta s_v) \times 2$  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 beambeam 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.

### Luminosity Optimization (11/30)

Curi	rent Sim	plex	(List )	View)									
	# R1L	. R2	L R	SL R4L		< Double c (L EPYL			set knob H R3		RYH	RPYH	σ <sup>*</sup> yHER
NEXT:	0.39	4.35	1.34	-0.61	0.19	-0.08	4.51	-4.05	-1.29	-0.08	0.97	0.40	
SET :	0.40	4.36	1.31	-1.65	0.20	-0.10	4.47	-4.13	-1.26	-0.22	0.91	-0.18	
LAST:	0.46	4.77	1.45	-0.88	0.22	-0.01	5.21	-4.28	-1.23	-0.75	0.73	0.09	83.80
START :	0.63	4.79	1.19	-0.50	0.31	-0.07	3.73	-4.83	-1.00	-1.68	0.34	0.55	79.43
1	0.40	4.36	1.31	-1.65	0.20	-0.10	4.47	-4.13	-1.26	-0.22	0.91	-0.18	85.16
2	0.41	4.39	1.50	0.79	0.18	-0.11	4.41	-4.79	-0.34	-0.39	0.76	-0.10	84.83
3	0.51	5.19	1.59	-0.10	0.23	0.09	5.95	-4.43	-1.20	-1.28	0.54	0.35	84.50
4	0.38	4.33	1.37	0.43	0.17	-0.07	4.55	-3.98	-1.32	0.06	1.03	0.99	84.19
5	0.51	4.55	0.95	-0.74	0.43	-0.31	3.97	-5.07	-0.88	0.32	0.22	0.67	83.74
6	0.47	3.63	1.41	-0.06	0.25	-0.02	4.17	-4.41	-1.18	-1.00	0.63	0.31	83.56
7	0.39	4.30	1.31	0.46	0.71	-0.25	4.46	-4.94	-1.48	-0.72	0.63	0.07	83.31
8	0.24	4.73	1.22	-0.21	0.31	-0.05	3.95	-4.57	-1.09	-1.10	0.56	0.38	83.22
9	0.49	4.52	1.16	-0.33	0.31	-0.24	4.07	-5.30	-1.09	-1.51	0.89	0.46	83.10
10	0.45	4.47	-0.53	0.39	0.10	-0.13	4.25	-4.88	-1.44	-0.79	0.71	0.11	82.75
11	0.40	4.58	0.58	-0.20	0.38	0.90	4.39	-4.63	-0.97	-0.40	0.76	0.33	82.17
12	0.71	4.95	1.58	-0.11	0.16	0.14	3.61	-4.44	-1.20	-1.29	0.54	0.35	81.82
13	0.46	4.45	0.34	-0.20	0.50	-0.27	4.17	-2.95	-0.74	-1.38	0.70	0.40	81.59

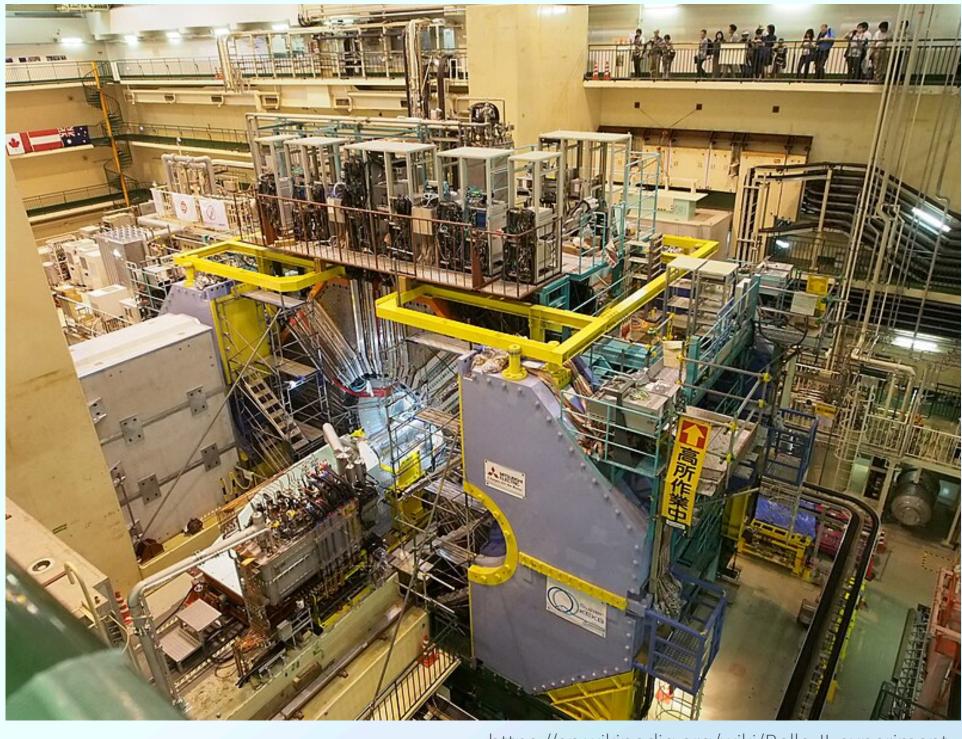


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# Alignment of the detector (a speculation) — SuperKEKB

- All accelerator components of SuperKEKB have been well aligned with accuracy better than  $\sigma \leq 100 \,\mu m$ .
- 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. 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
- If it is true, re-alignment of accelerator components is necessary, by
  - accuracy.



https://en.wikipedia.org/wiki/Belle\_II\_experiment