DEALING WITH BAD VIBES

keeping beams in collision at FCC-ee

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2nd FCC Early Career Forum: Deep dive across the FCC

Funding statement

EAJADE

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About me

Who Am I

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*Project within **FCCIS Task 2.3**: "Interaction region and machine detector interface design"*

Under **EAJADE Work package 3**: *"Special technologies, devices and systems performance"*

Thesis Goal

Develop a realistic, self-consistent, model of the FCC-ee IP collision feedback system

- Realistic modelling of the measurable signals (BPMs, luminometers and more)
- Realistic feedback hardware considerations (corrector magnets, processing time)
- Self-consistent 6D lattice tracking including modelling of beam-beam interaction

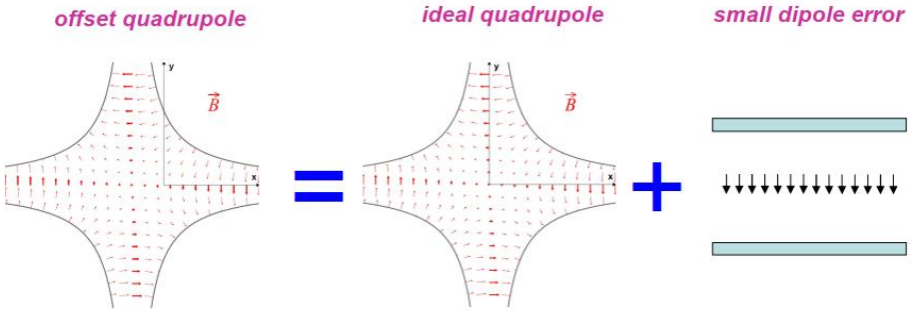
Using this model, study the luminosity performance in the presence of magnet vibrations

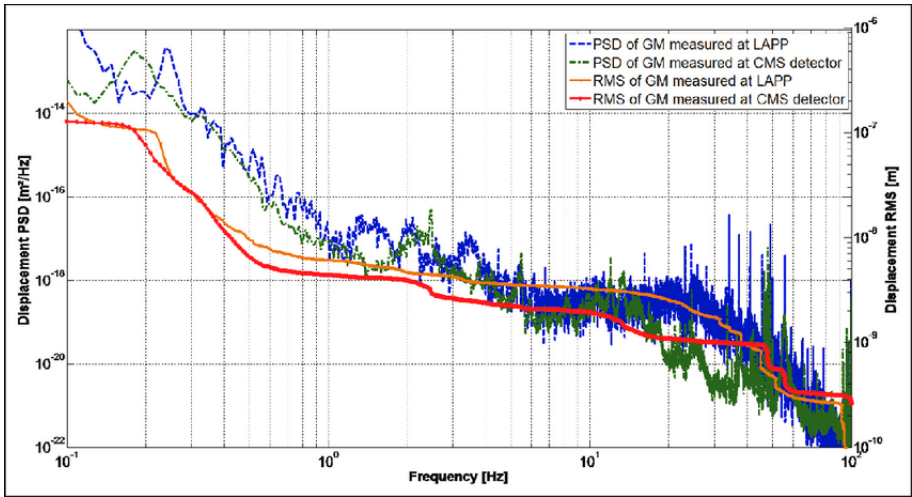
And first, can I demonstrate this for SuperKEKB?

Accelerator Orbit Errors

- Modern and future colliders have small beam sizes
- Accelerators are generally designed with all magnets on a plane
- Magnet offsets cause unwanted beam orbit (and other errors)
- Accelerator magnets are therefore sensitive to vibrations: ***bad vibes...***

So how do we correct this?





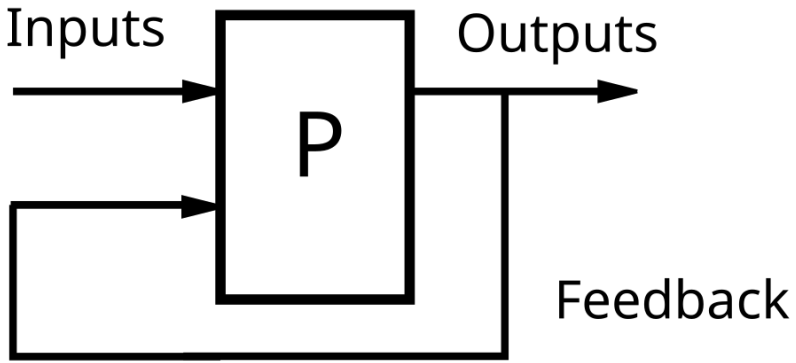
Accelerator Feedback and Performance

- Feedback systems exist to ensure that key performance metrics are achieved
- Some feedbacks are local and some are global

For FCC-ee, luminosity is a key focus

- *Luminosity: A measure of the rate of production of particles of interest*
- The luminosity comes from the collisions at the Interaction Points (IPs)

For high luminosity, stable collisions are required

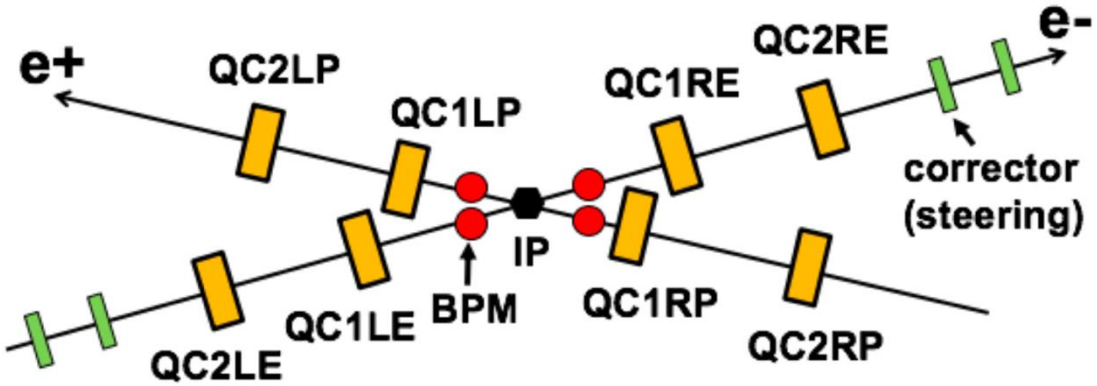


Maintaining Collisions: IP Feedback

- At the Interaction points (IPs), a local feedback system is required to correct the orbit

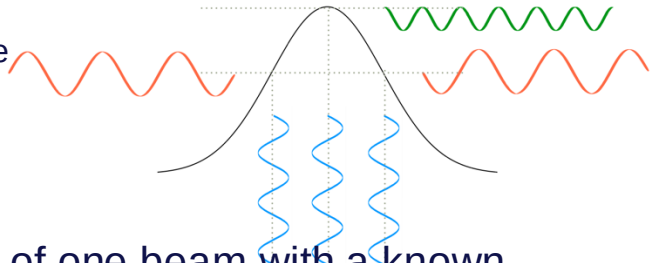
Required to maintain luminosity and beam lifetime

- Need to calculate the offsets from input signals
- Need to correct the beam orbits in a complicated region



IP Feedback Types

Image credit:
Katsunobu Oide



Beam-Beam Deflection

- When two beams collide, they exert a force on each other
- For small beam offsets, the kick is proportional to the offset
- From the angles in and out of the IP, the beam-beam kick can be calculated

Requires strong kicks and good detection hardware

Implemented at SLC and SKEKB

Dithering

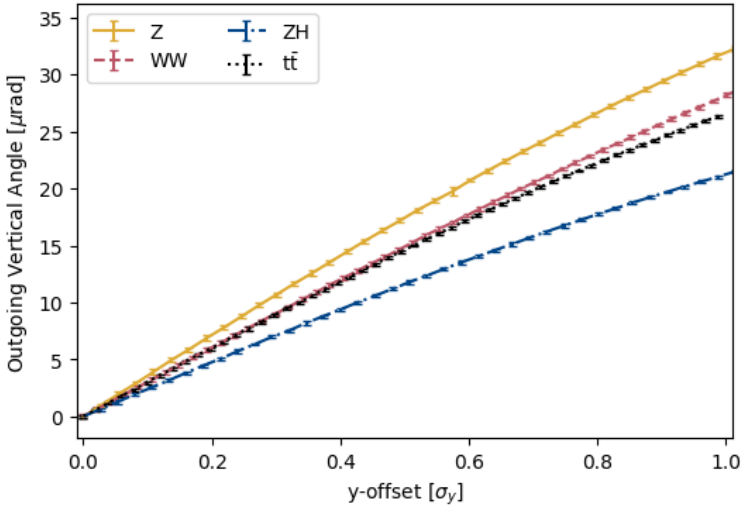
- Drive the orbit of one beam with a known frequency
- Detect how the luminosity changes
- Adjust the central position to where luminosity is maximum

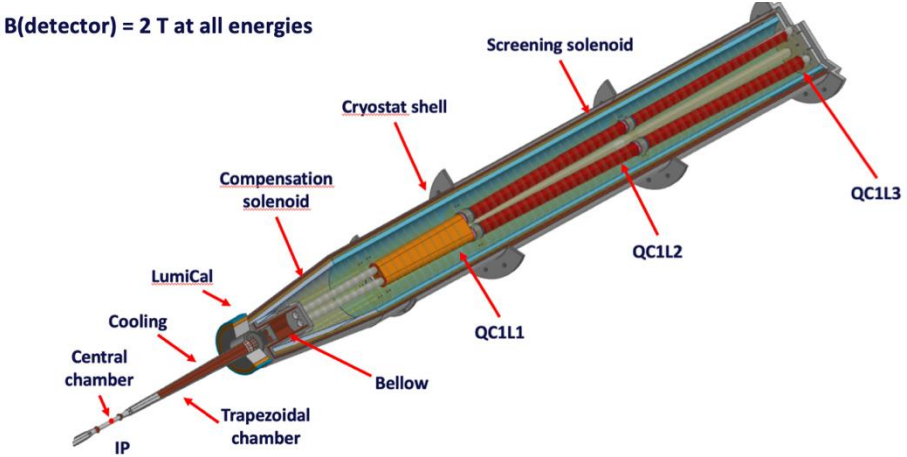
Intrinsically degrades luminosity

Implemented at PEP II and SKEKB

Challenges

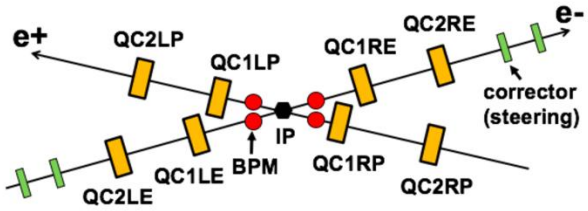
- Challenging region:
  - Complicated Machine Detector Interface: solenoids, cryocooling
  - High radiation: luminosity, synchrotron radiation, beamstrahlung radiation
- **Challenging measurements:**
  - Small offsets to measure
  - High radiation power on detectors (~>300kW!) beamstrahlung
- **Very strict performance requirements**
  - *Only order nm offsets tolerable!*

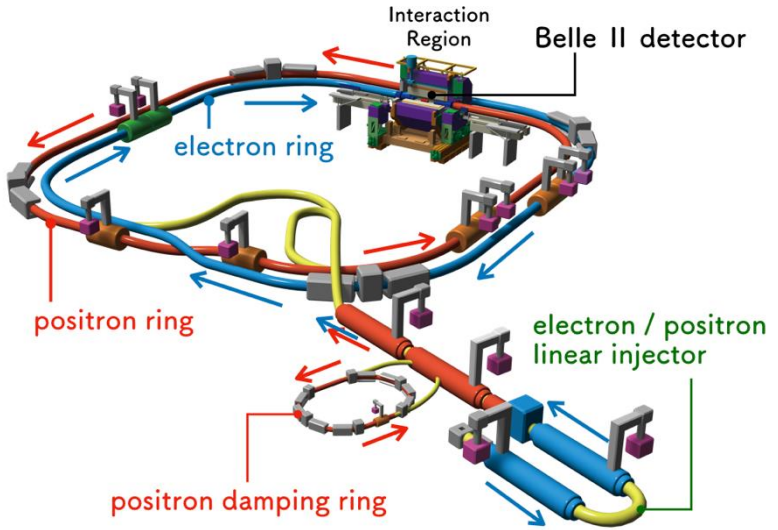




Testing our plans: SuperKEKB

- SuperKEKB background:
  - 3km e+e- collider at KEK, Tsukuba, Japan
  - B factory at the Y(4s) resonance (10.58 GeV)
  - Current world record luminosity of $5.1 \times 10^{34} cm^{-2} s^{-1}$
- Synergistic with FCC-ee
  - High current, nano beam scheme, crab waist scheme
- ***Features both types of IP Feedback!***
  - "iBump" beam-beam deflection feedback
  - SLAC Dither feedback





Outlook

- Many ongoing simulation studies for FCC-ee
  - Setting performance requirements
  - Modelling output signals (across a range of tools)
  - Considering correction strategy
- Ongoing studies with SuperKEKB
  - Supported by international exchanges (with thanks to EAJADE)
  - Studying the operational experience of their systems

FUTURE CIRCULAR COLLIDER

Much work to do, but fortunately, *No Showstoppers*!

Thank you for your attention.