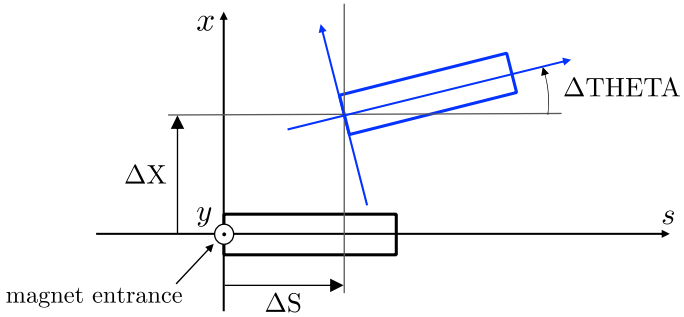
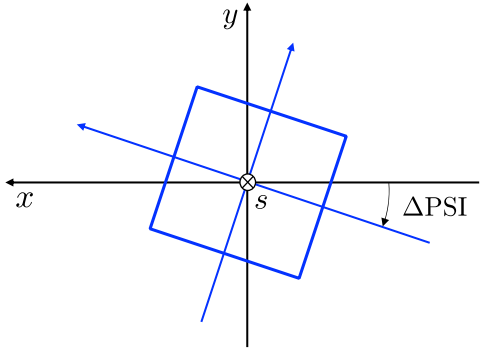
FCC-EE
TUNING SIMULATIONS

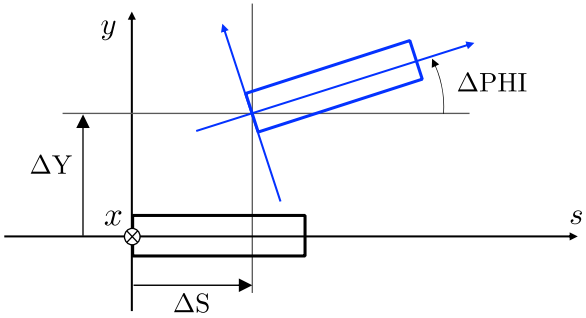
Tessa Charles [1,2], Bernhard Holzer [3], Katsunobu Oide [3], Dmirty Shatilov, Frank Zimermann [3]
Rogelio Garcia [3], Leon Van Riesen-Haupt [3] and the FCC-ee optics team

1. University of Liverpool,
2. Cockcroft Institute
3. CERN

Assigning misalignments

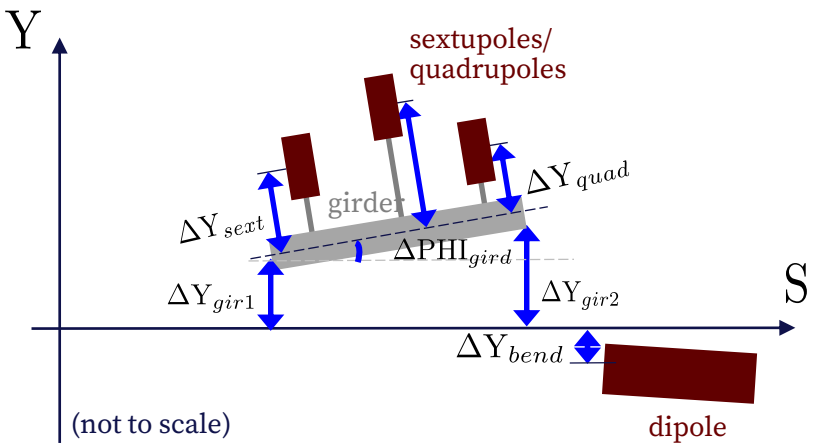


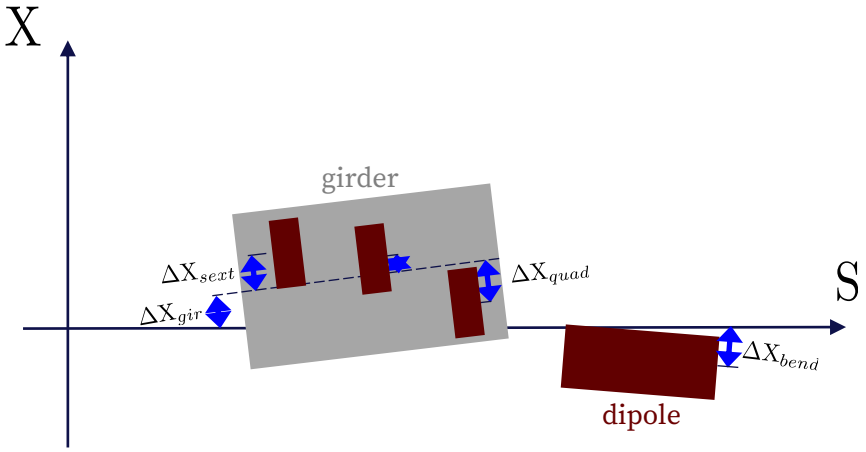




- Misalignments are randomly distributed via a Gaussian distribution, truncated at 2.5 sigma.

Assigning girder misalignments





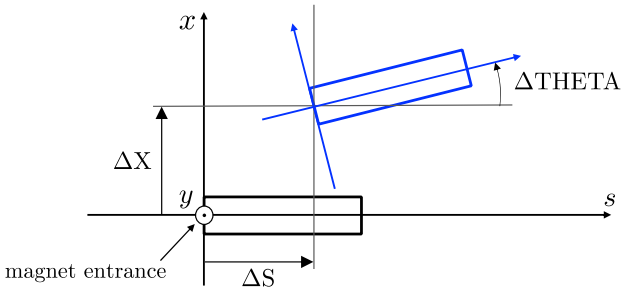
- 2 independent DX and DY misalignments for each end of the girder, and which can be used to calculate DTHETA and DPHI.

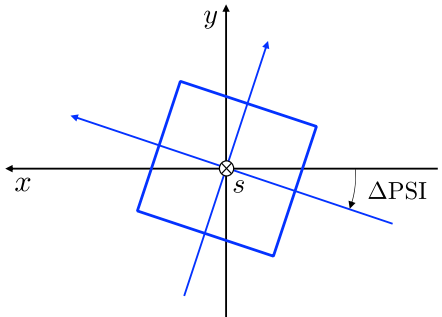
Misalignments and field errors

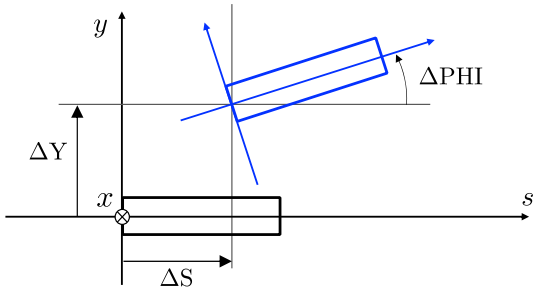
Type	ΔX (μm)	ΔY (μm)	ΔPSI (μrad)	ΔS (μm)	ΔTHETA (μrad)	ΔPHI (μrad)	Field Errors
Arc quadrupole*	50	50	300	150	100	100	$\Delta k/k = 2 \times 10^{-4}$
Arc sextupoles*	50	50	300	150	100	100	$\Delta k/k = 2 \times 10^{-4}$
Dipoles	1000	1000	300	1000	-	-	$\Delta B/B = 1 \times 10^{-4}$
Girders	150	150	-	1000	-	-	
IR quadrupole	100	100	250	50	100	100	$\Delta k/k = 2 \times 10^{-4}$
IR sextupoles	100	100	250	50	100	100	$\Delta k/k = 2 \times 10^{-4}$
BPM**	40	40	100	-	-	-	-

* misalignments relative to girder placement
** misalignments relative to quadruple placement

Misalignments are randomly distributed via a Gaussian distribution, truncated at 2.5 sigma.







FCC-ee emittance tuning results

RMS misalignment and field errors tolerances:

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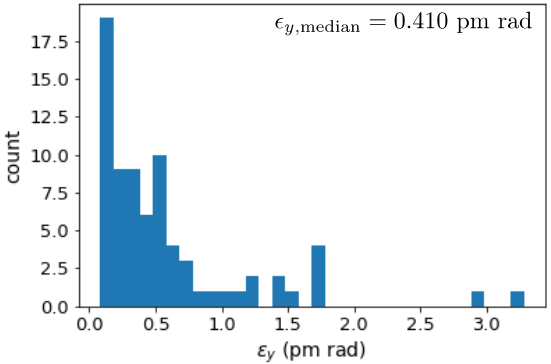
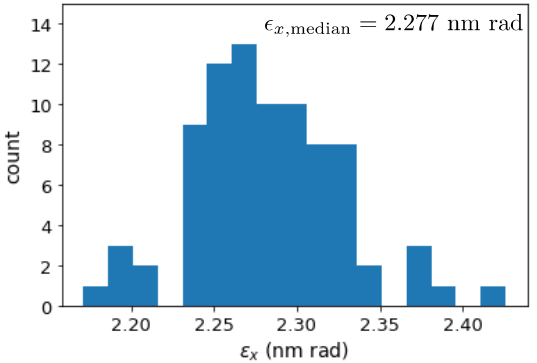
ttbar (182.5 GeV) 4IP lattice, after correction strategy:





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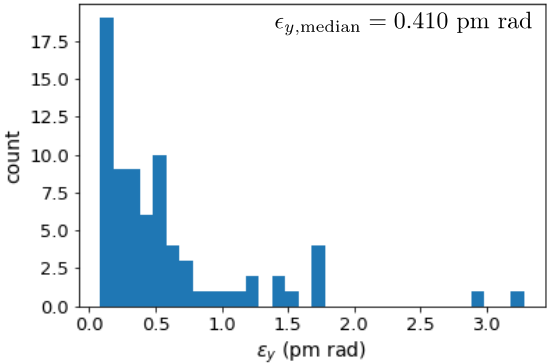

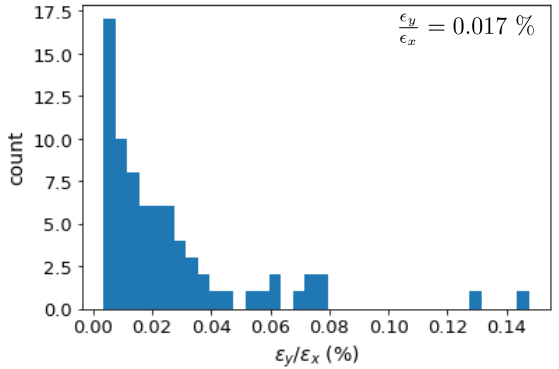

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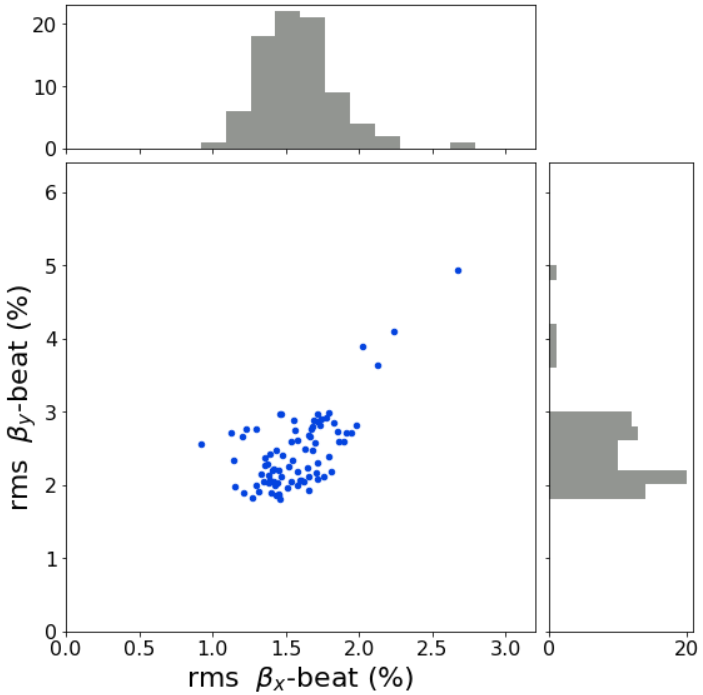
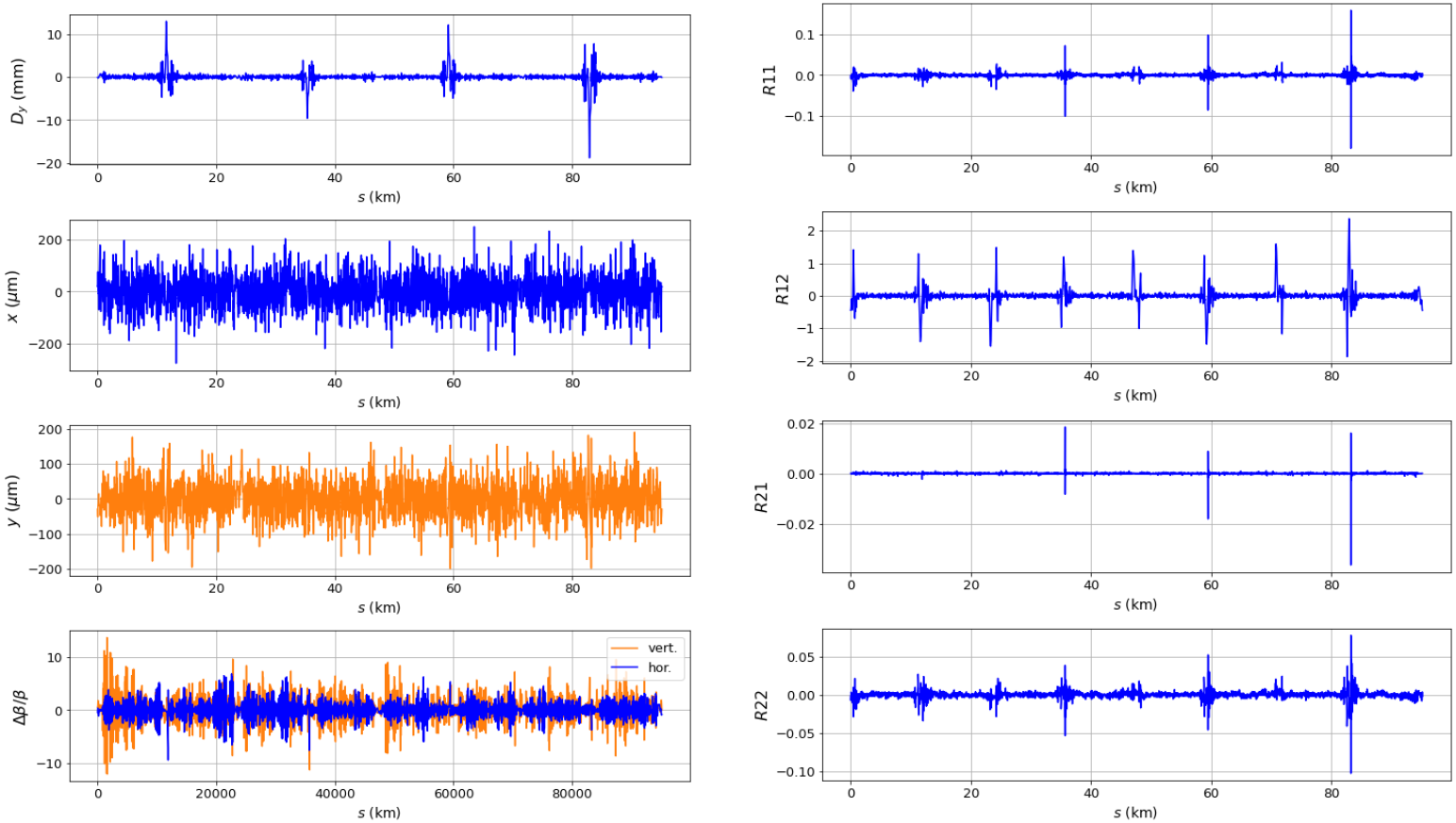


After corrections, ttbar 4 IP lattice:



What's been adjusted (since last time I presented)?

- Inclusion of BPM roll angles as additive to Quad roll angle.
- Fixed error in BPM misalignment (MREX, MREY)
- Chromaticity correction added
  - Need to calculate DA with these results
  - Didn't include SY* sextupoles
- Correcting the phase advance between IPs

What I’ve made available (or will do in the coming days)

- Latest results (including changed from the previous slide)
- Results for half misalignment values (for certain studies, e,g, beam-beam simulations.)

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In progress

- Relaxed optics
- Weighted coupling and dispersion correction
- Applying to new FCC-ee ttbar 4 IP lattice.

Still to do (there are many things)

- BPM orthogonality errors are not included
- DA calculation
- Solenoid imperfections to be considered
- Tapering imperfections
- Local corrections need to be implemented to target spikes in Dy and coupling matrix elements.
- Non-linear corrections (with impact on DA)
- Profiling simulation and look towards speeding up algorithm
- Simulate optics measurements
- Apply correction technique to low energy, Z lattice
- Determine how to apply measure optics quickly
  - LOCO is too slow on such a large machine
  - AC dipole method may run into problems due to strong damping
- Simulation of commissioning process

FCC

Thank you
for your attention.

Correction Strategy (1/2)

- **Sextupoles strengths set to zero.**
  - Gradient errors applied
    - Weighted beta-beat correction was performed and tune re-matched
    - Sextupole and dipole field errors introduced
    - Weighted beta-beat correction was performed and tune re-matched
  - Misalignments applied to arc magnets and girders
    - Tune re-matched to the nominal tune, and orbit correction performed
    - Initial beta-beat correction and coupling correction
  - Misalignments applied to IR magnets
    - Tune re-matched to the nominal tune, and orbit correction performed
    - Beta-beat correction applied, and if needed orbit corrected and tune rematched
    - Coupling correction, followed by beta-beat correction and coupling correction

- **Sextupoles set to 10% of their design strength**

  (details on next slide)

- **Final correction** (at 100% sextupole strength)

  (details on next slide)

Correction Strategy (2/2)

- **Sextupoles strengths set to zero.**
  (details on previous slide)

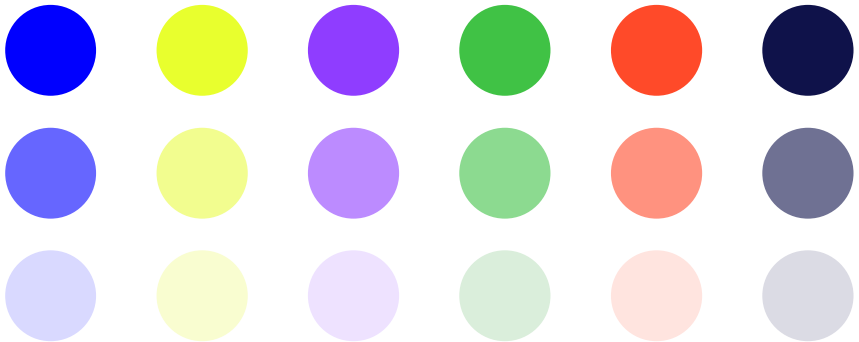
- **Sextupoles set to 10% of their design strength**
  - Orbit correction
  - Combined coupling and dispersion correction
  - Beta-beating correction applied.
  - Sextupole strengths increased by 10%

These two steps repeated ~12 times.

Constant checking of the tunes and orbit avoids running into resonances, or failure to find the closed orbit.

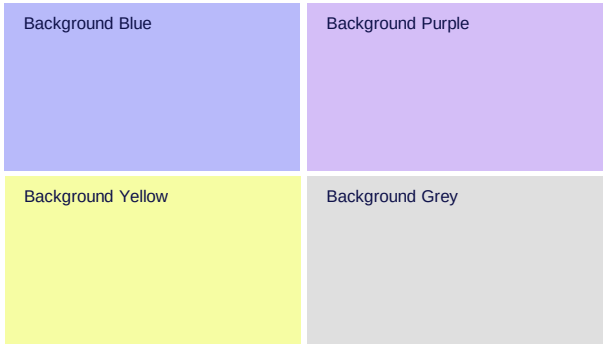
- **Final correction** (at 100% sextupole strength)
  - Additional coupling, dispersion and beta-beating correction was applied.
  - Step through corrections until beta beating threshold is reached (trade-off between beta beating and vertical emittance can be varied).
  - Vary SV cut off values

COLORS



Radiant Blue | Flash | Energy | Green | Red | Deep Blue

BACKGROUNDS



Use for Layout

GRAPHICAL ELEMENTS

Separation lines 1.5 pt

Arrows

BADGES

This information is a badge because it is important!

This information is a badge because it is important!

Use blue badges on light backgrounds

This information is a badge because it is important!

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Use light badges on dark backgrounds

INFOGRAPHICS