Update on optics in LEIR

LNO meeting 19/07/2024

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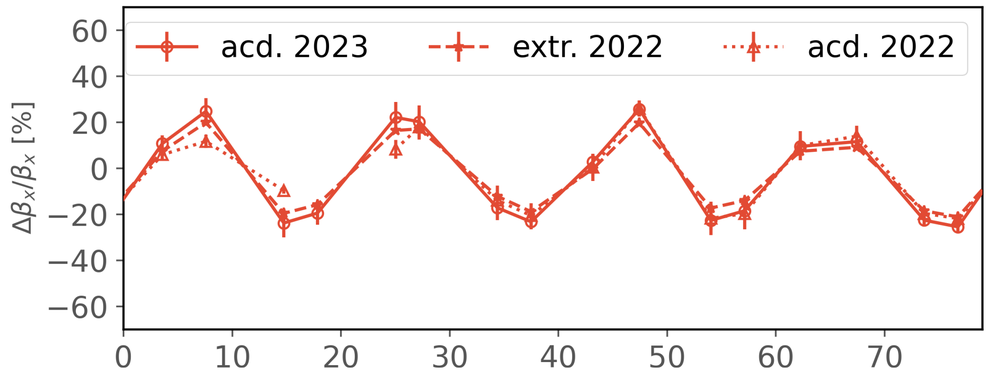
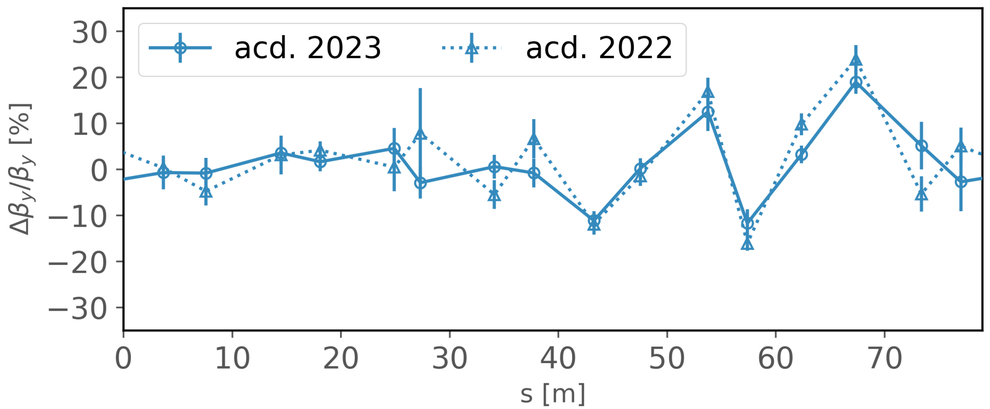
Recap of optics measurements in LEIR

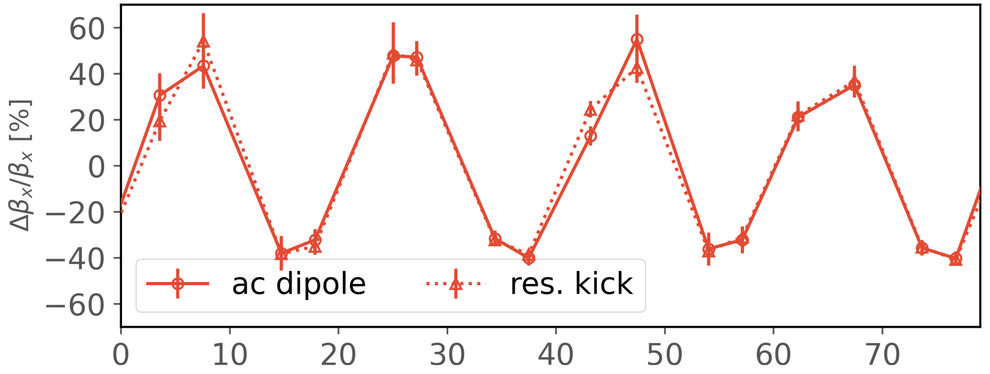
- Optics deviation increases from 25% at injection to 50% peak beta-beating at top energy in H plane
- Good agreement between 2022 & 2023 and methods at injection
- Good agreement between kick methods at top energy
- Clear 4-fold periodicity in horizontal beta-beating, while vertical plane remains lower.

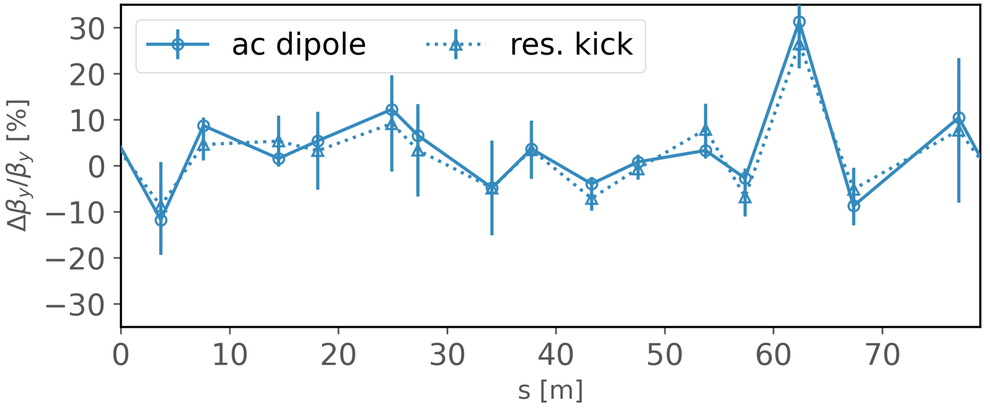
Injection





Extraction





Combined tbt and k-mod optics

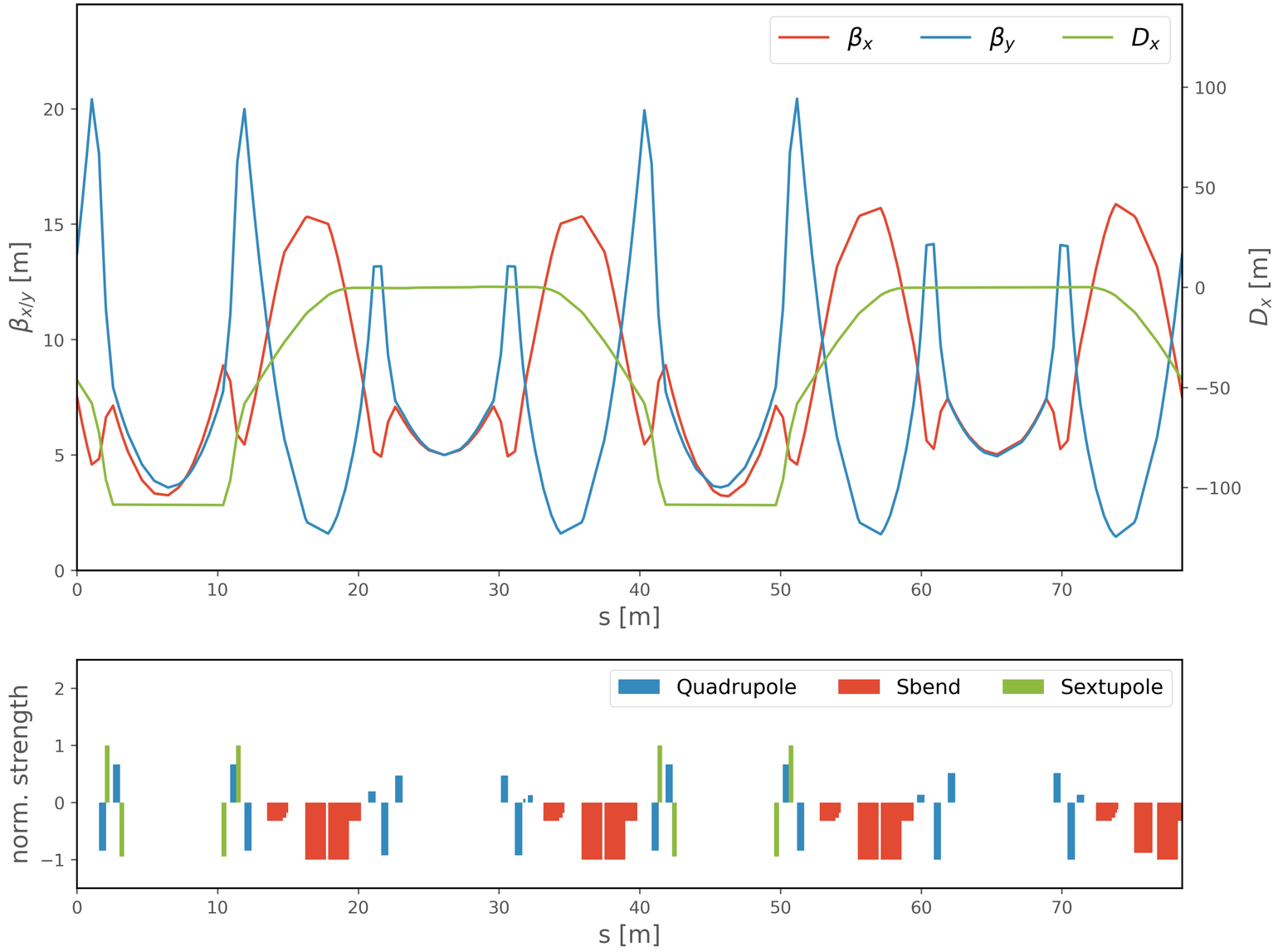
Square synchrotron with:

- two fold symmetry
- 4 arcs of 90 degrees.

LEIR **bends** are almost ‘strong’ focussing

- Area where **betax >> betay**

=> proper modelling in simulation is crucial

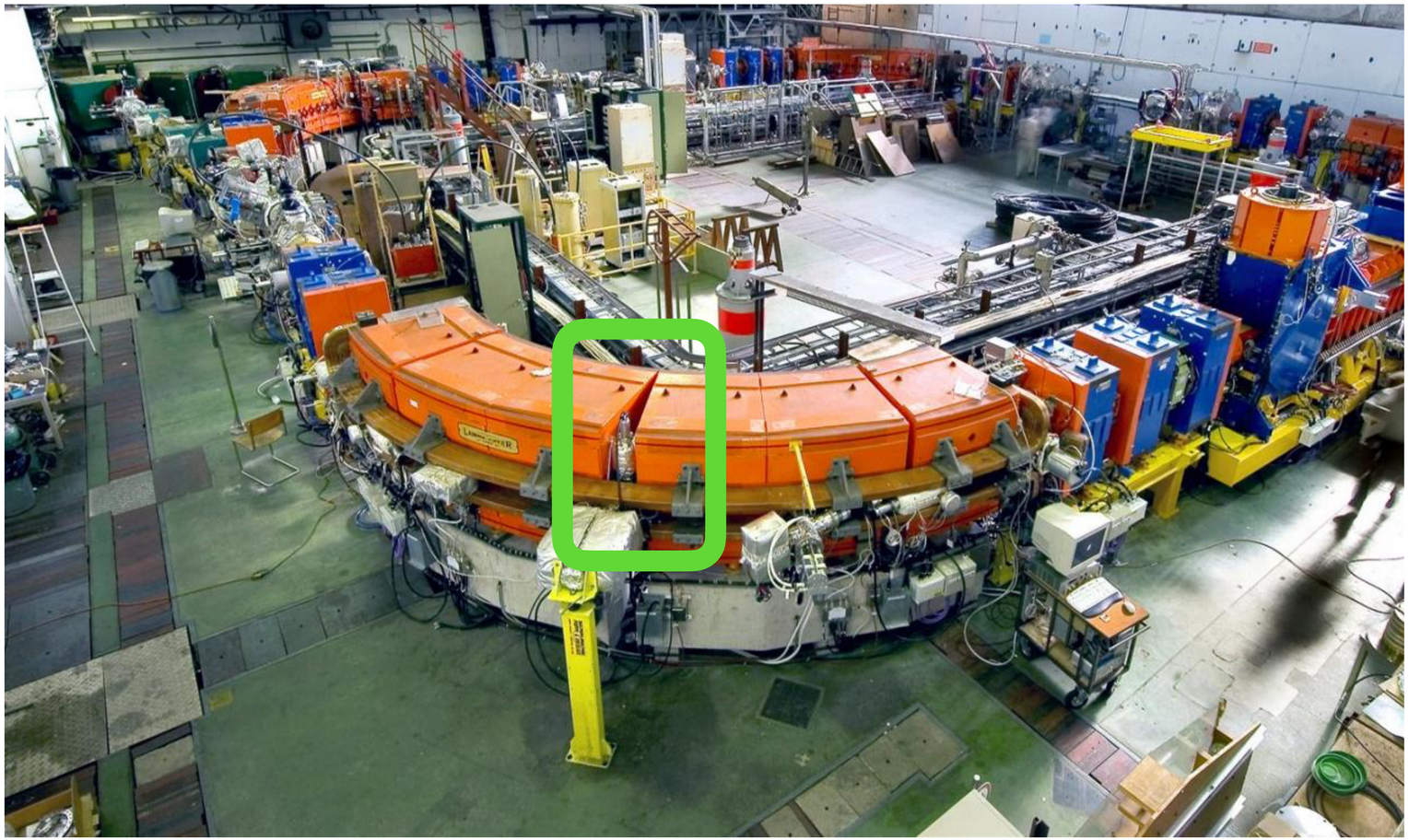


The 90 degree bends are not continuous

LEIR bends first used in 1982 in LEAR

- A wedge has been cut out to install instrumentation devices.
- Fringe fields in this region are currently not modelled

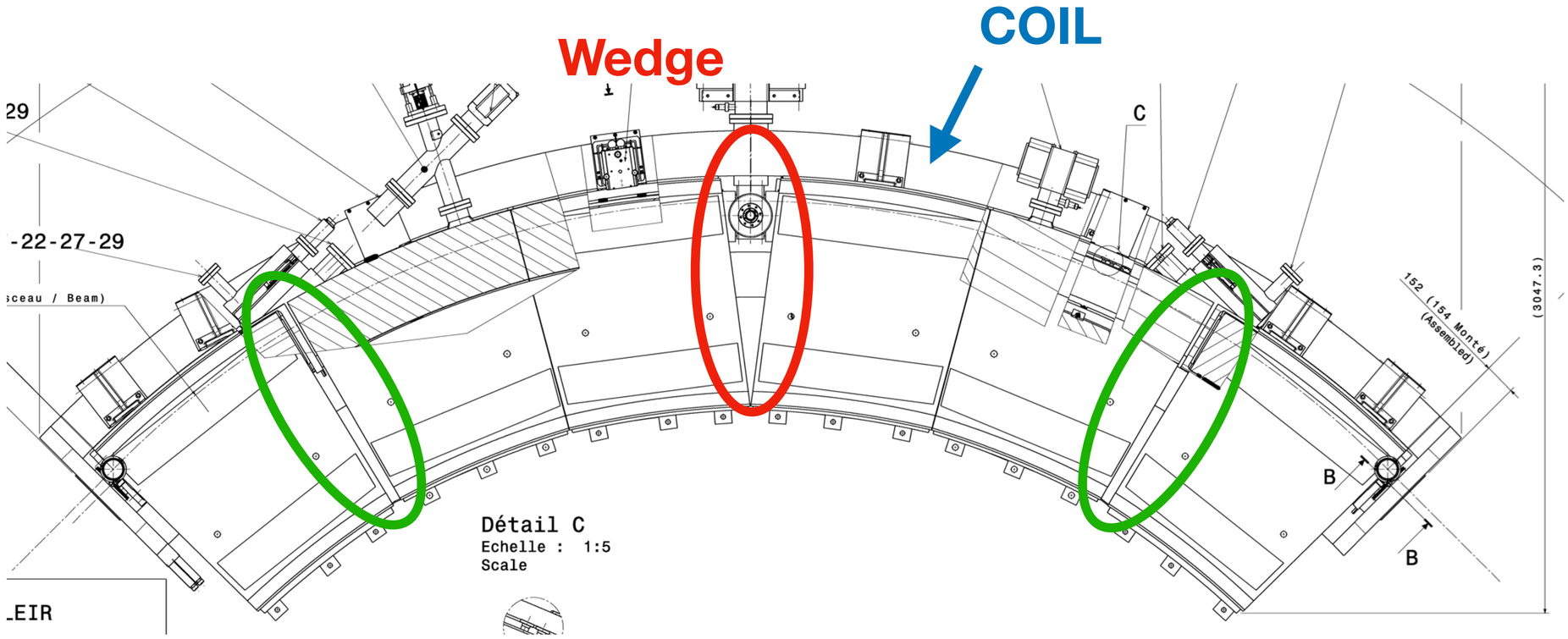
=> Can cause large discrepancies between model and measurement.



Design of LEIR dipoles

LEIR dipoles consist of 6 separate blocks of iron with:

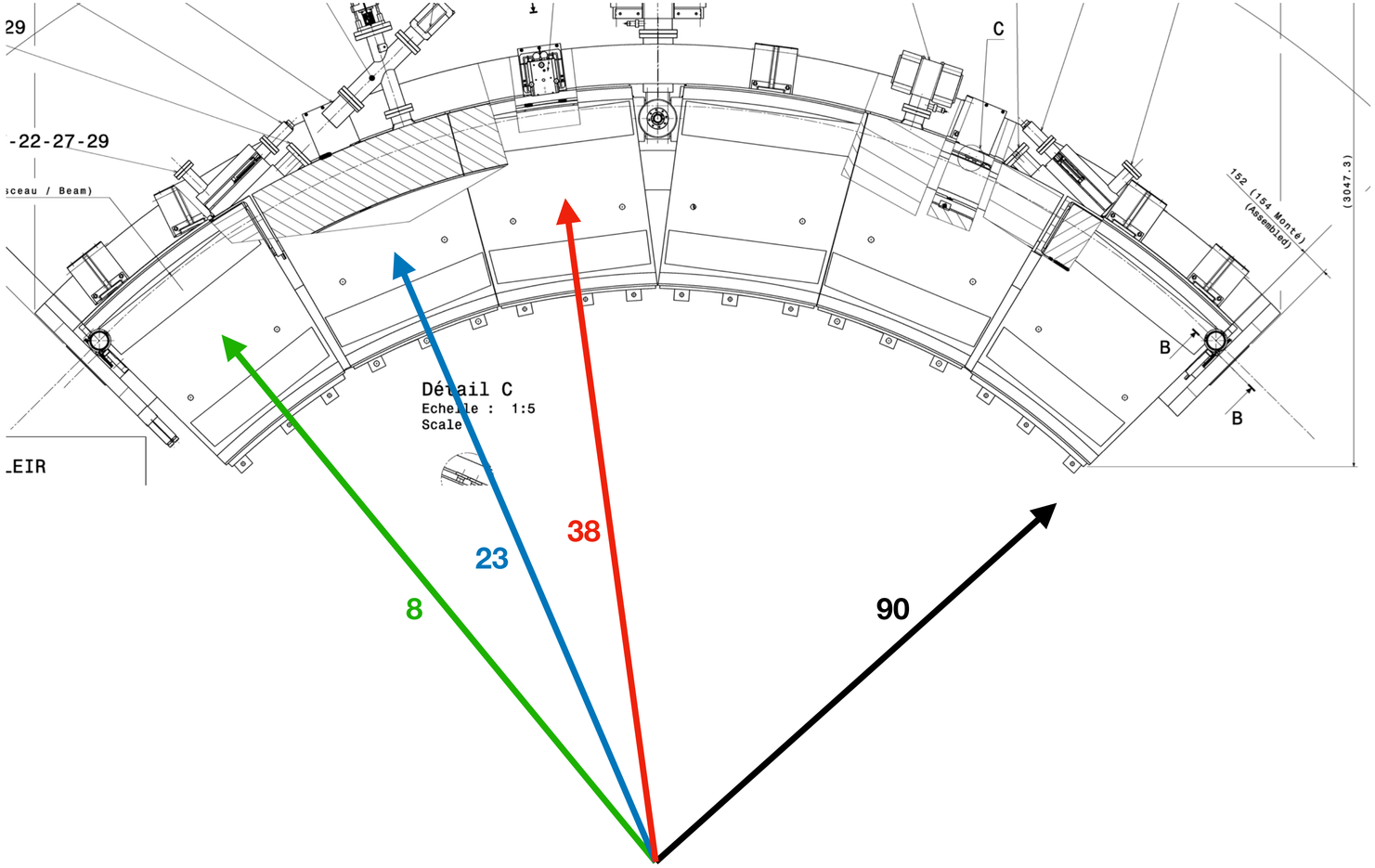
- single continuous coil.
- small gap between block 1 & 2 (5&6) -> probably insignificant
- Large wedge -> probably significant

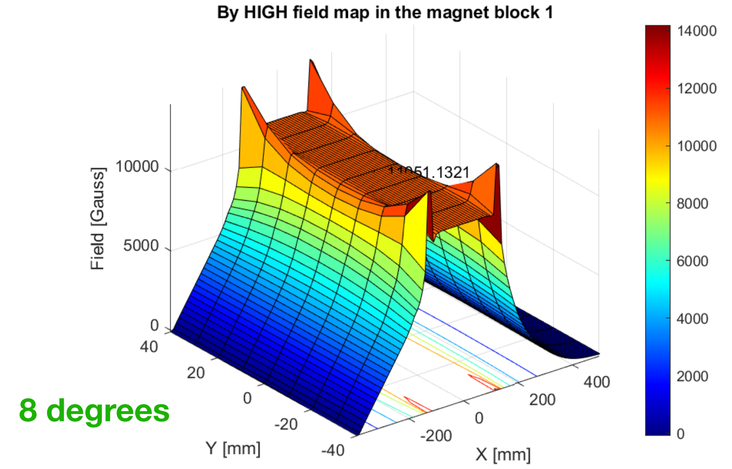


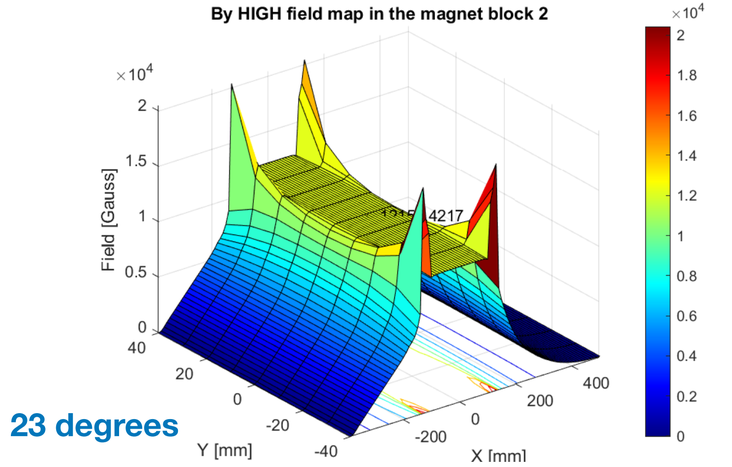
OPERA simulations of single blocks

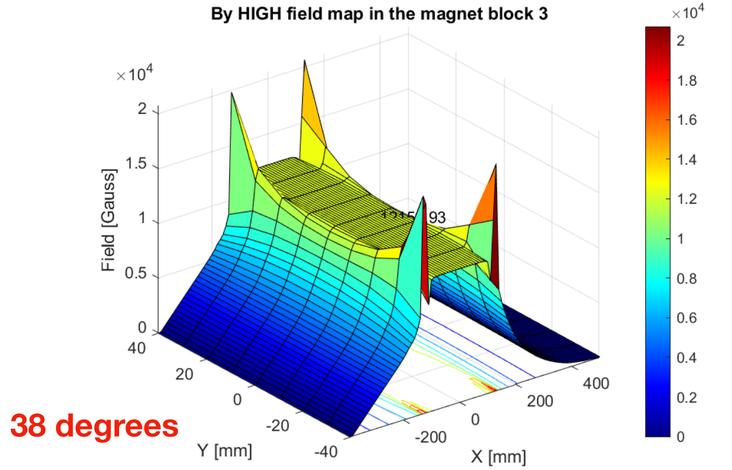
Vincenzo Di Capua found an analysis of OPERA simulations done years ago by A. Aloev.

- Results only available at the centers of the individual magnet yoke blocks.



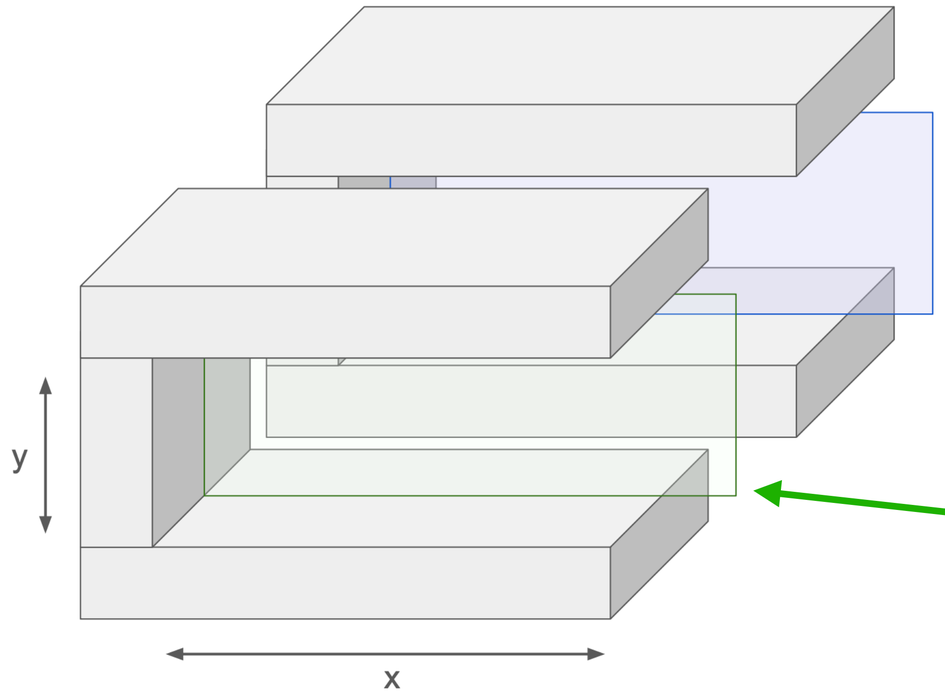


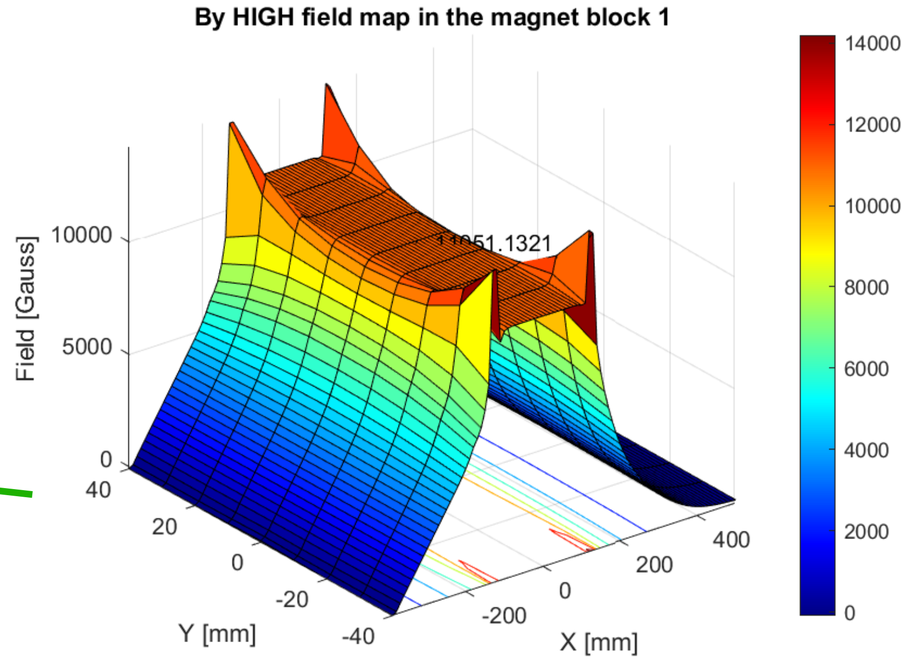




Field map only available at centers of blocks

As a future reference to clarify axes in field map plots.





There is no full OPERA model for the moment

Currently we only have:

- Analysis of models that represent independent magnet yoke blocs

  *(*Still not clear to me if these models have been found or not..)*

Missing for full Opera model:

- Full model of the 6 blocks
- Pole Face Windings
- Corrector coils

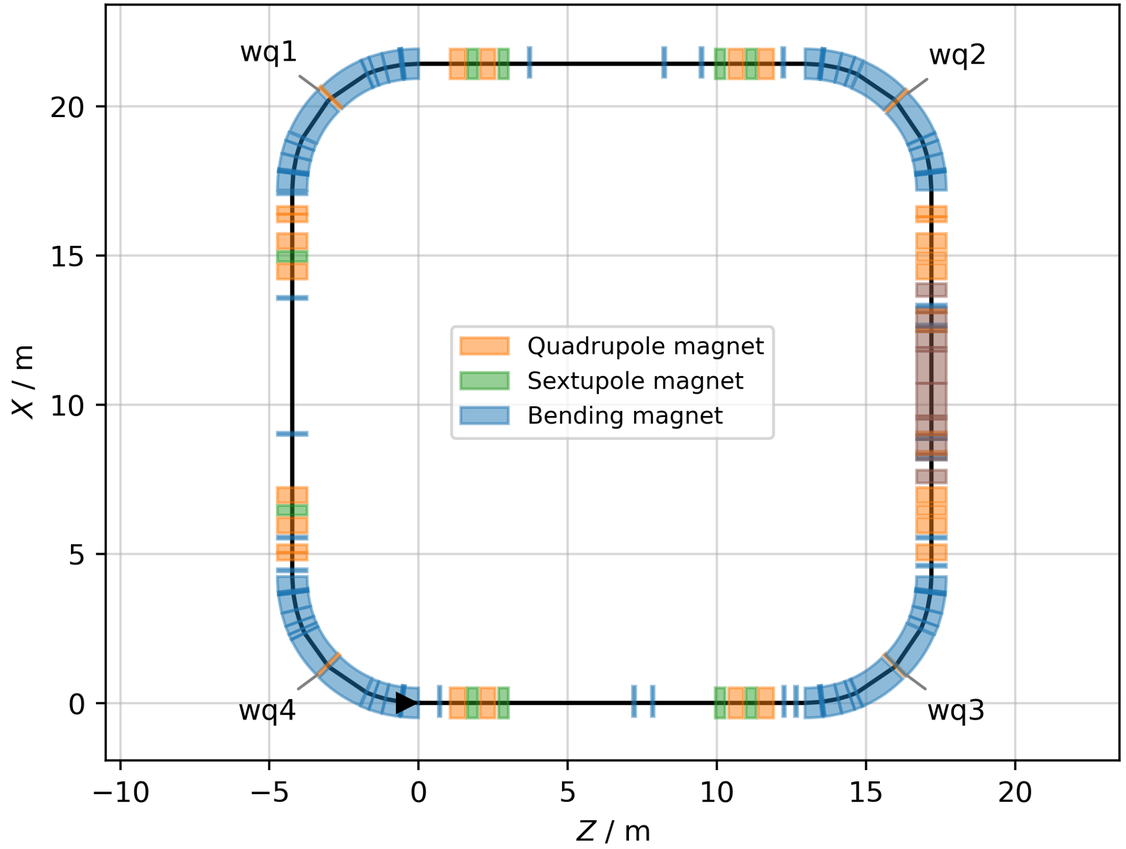
=> So edge effects & wedge harmonics are currently not available from Opera model

Other possible approach is to use the analytical fringe field models of Silke & Riccardo, but not yet ready.

Approximate wedge contribution as thin quadrupole

A naive study was done to see what would be required to reproduce the measured optics deviation

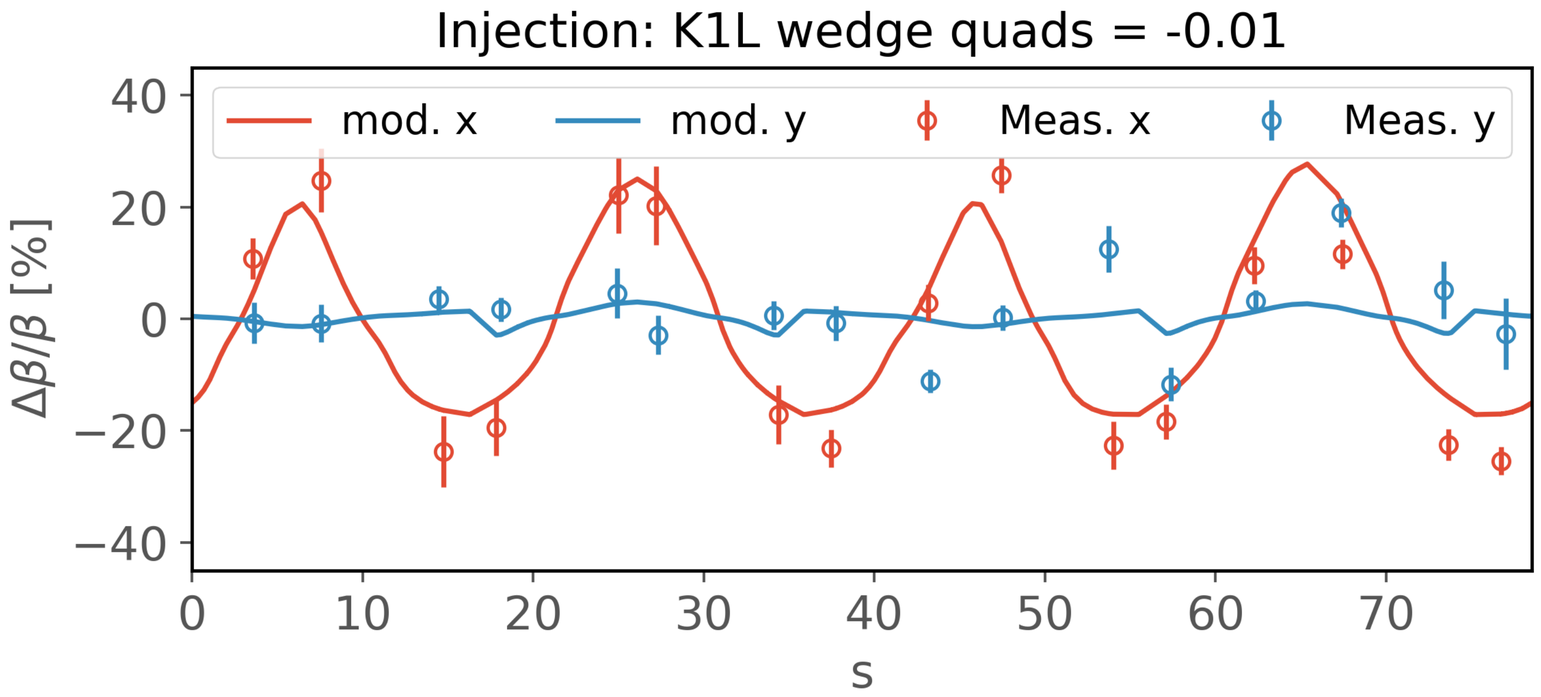
- Installed 4 thin quadrupoles at the centers of each wedge



Approximation gives comparable results

Quadrupoles at the location of the wedges give significant horizontal beta-beating, while minimally affecting the vertical plane.

=> K1L = -0.01 corresponds to ~1.7% of main defocussing quadrupole K1L



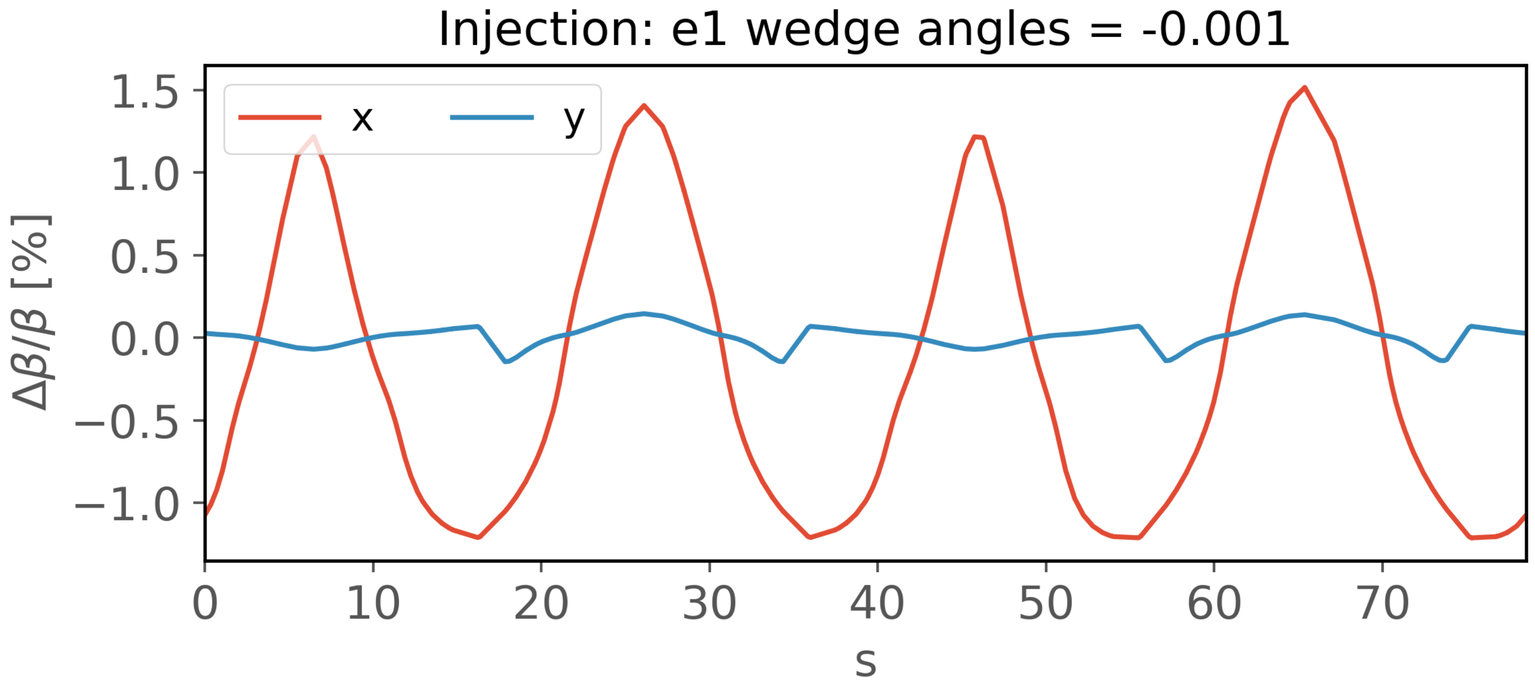
Also looked at the effect of edge angle deviation

The effect of edge angles is much weaker than the thin quadrupoles.

- e1 of 0.001 corresponds to about 1% of main e1

  => so 1% change in angle gives ~1% change in beta_x

In the right direction, but insignificant compared to measurements.



Conclusions

- Recap:
    - Good reproducibility of optics measurements between 2022 and 2023, and across kick methods
    - Optics increases in H-plane from injection to top-energy

- A big wedge in the LEIR bends are suspected to create significant focussing errors. There are currently:
    - no accurate models of wedge
    - no OPERA models of wedge
    - no magnetic measurements

  => Discussions ongoing to conjure funding for modelling

- Approximating wedge contribution with thin quadrupole with ~1.7% of main quad K1L yields comparable beta-beating in horizontal plane at injection energy.

- Further measurements in 2024 with better control of orbit, sextupoles, chroma, etc.. could help further constrain the localisation of error sources.