Beam-based alignment of CLIC Drive Beam decelerator using girders movers

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ALCPG11, Eugene, Oregon
22 March, 2011

Acknowledgments to D. Schulte,E. Adli, A. Latina and F. Stulle...

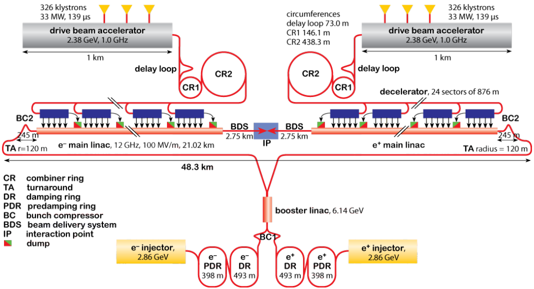
1. Introduction
   - The stability requirement on the CLIC DB current
   - The DB decelerator steering
2. Methods and results
   - Girders movers steering vs quadrupole steering
   - The performance of the girder mover
   - Ground motion studies
3. Conclusions

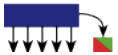
The CLIC DB is the RF source for the MB accelerating structures.

1. The I_{DB} pulse to pulse stability maximizes $\mathcal{L}$:

$$\left|\frac{\Delta I_{DB}}{I_{DB}}\right| \simeq 8\ 10^{-4} \longrightarrow \frac{\Delta L}{L} \simeq -0.01$$

2. An optimized I_{DB} transport maximizes the overall η.



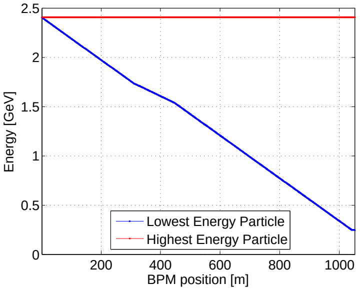
→ The 48 decelerators () contribute to maximize $\mathcal{L}$ and η by maximizing their energy acceptance.

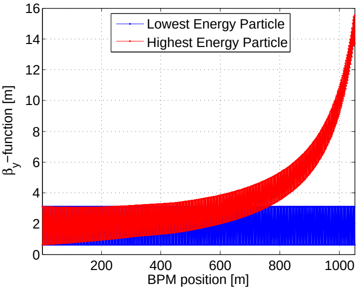
90% energy spread

The longest decelerator is ≈ 1050 m and has to transport a beam with a large energy spread trough a FODO lattice.

Weak focusing for high energy

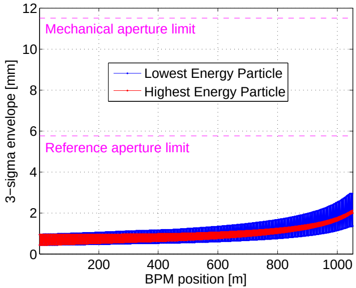
The FODO gradient is chosen wrt the lower energy particle therefore the higher energy particles are under-focused. The linear optics is dominated by the Q (negligible PETS effect).





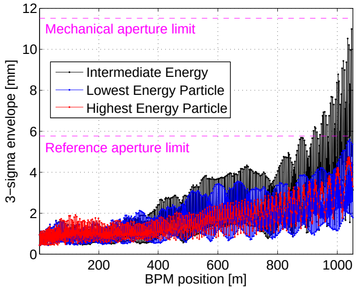
Beam envelope (ideal machine)

The ideal machine has an max envelope of ≈ 3 mm (radius) to compare with the aperture of 23 mm. It is driven by the lower energy particles.



Impact of misalignments

By displacing the quads by few μm in H or V, the beam envelope increases significantly. The envelope growth is non linear wrt the energy (resonances).



Beam envelope (ideal machine)

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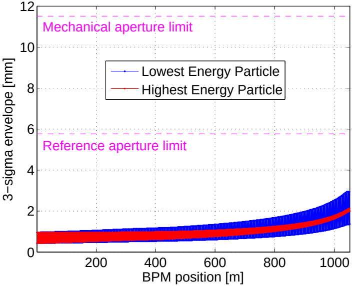

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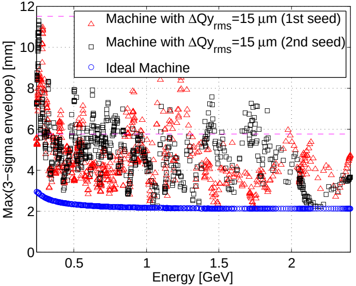
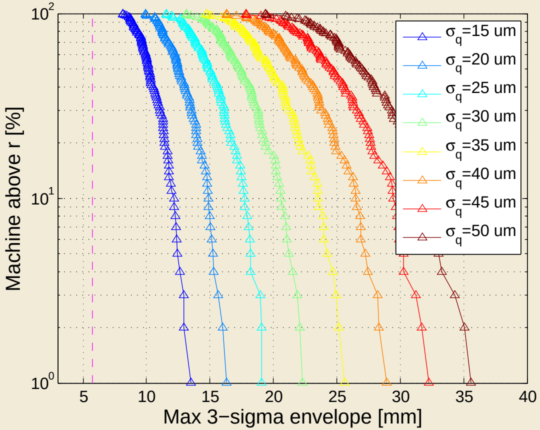


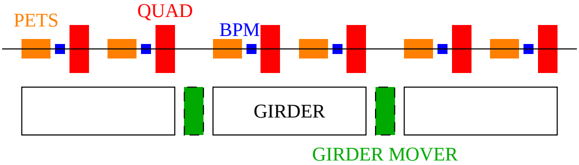
Errors in Quad position are the driving term of envelope growth.



GOAL$\rightarrow$ max(envelope) $>$ 5.75 mm (R/2) for $< 0.1 \div 1\%$ of cases.

Beam-based alignment is required: three HW options.

- Moving the quads (BASELINE),
- Using dipole corrector integrated in the quads,
- Moving the girders to adjust the quads positions:
  - PRO: reduction of system complexity.
  - CON: we cannot adjust the single quadrupole position (expected loss in efficiency).



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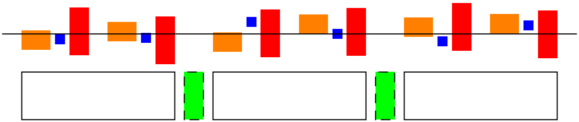

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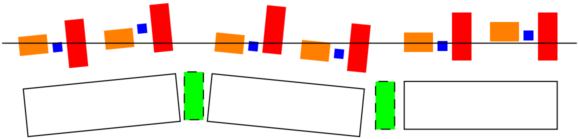

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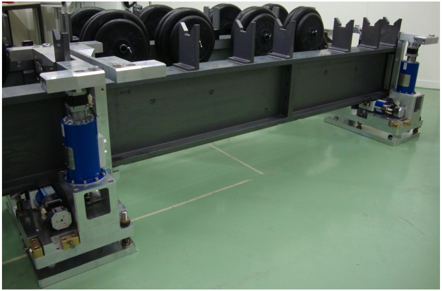
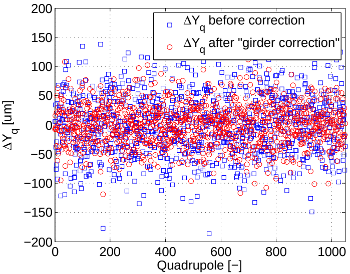


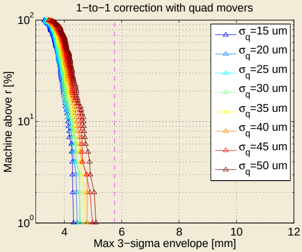


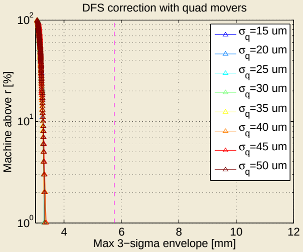
Working hypotheses

Parameters	Units	Value
RMS QUADS misalignment	μm	15-50
RMS PETS misalignment	μm	100
RMS BPM misalignment	μm	20
RMS QUADS tilt	mrad	1
RMS PETS tilt	mrad	1
RMS BPM tilt	mrad	1
BPM resolution	μm	2
Movers resolution	μm	2
ϵ_n (H and V)	mm mrad	150

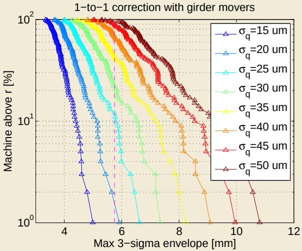
- We consider mainly 1-to-1 and DFS algorithms.
- Simulations are done for the vertical plane and for the longest decelerator.

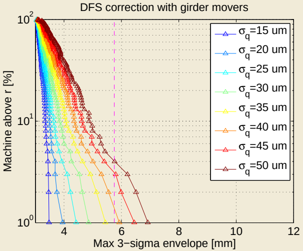
Using quadrupole movers → excellent performance

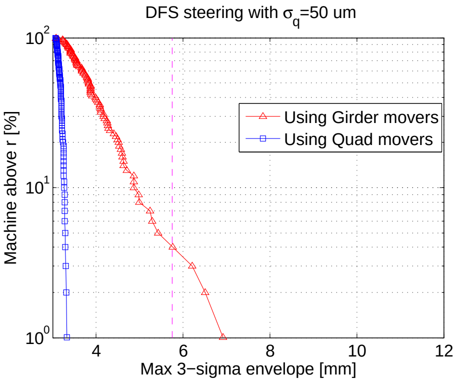




Using girders movers → problems, strong dependence on σ_q

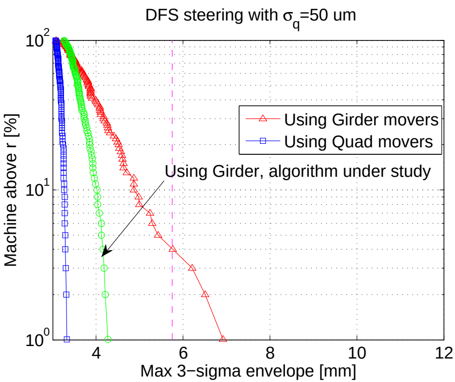






Q: The 'bad' performance of the girder movers is due to an intrinsic limit of the method or of the chosen algorithm?

A: We think it is an algorithm limit, in fact we know that there are better solutions for correction (algorithm needs further studies).



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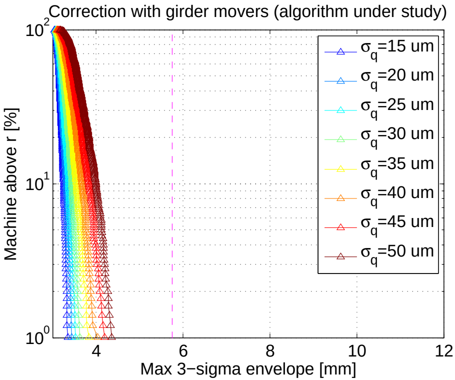

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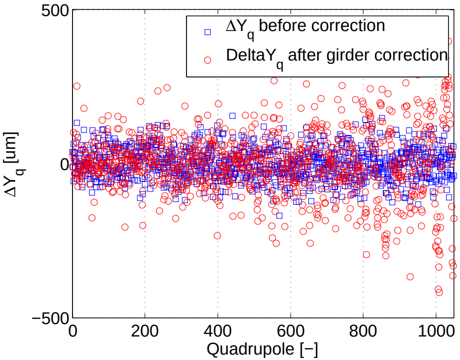

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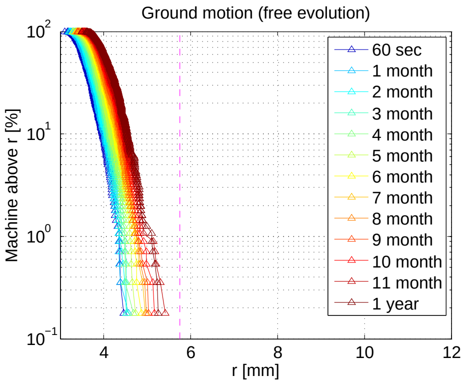
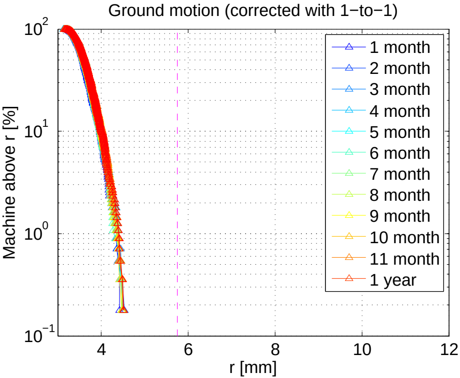


How often do we need to realign the decelerator?

Assuming ATL ground motion with A=0.5 10^{-6} $\mu m^2/$ (s m) after 1-2 months we observe in simulations 100÷200 μm of envelope growth: we can correct it by 1-to-1 correction on the golden orbit.



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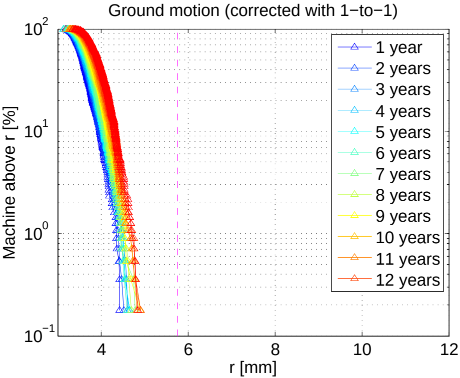

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Summary

- From the HW perspective, the steering with girders reduces the system complexity.
- Compared to the quadrupole steering there is a reduction of performance: in particular the performance depends on the alignment of the quadrupoles on the girder.
- For $\sigma_q < 20$ μm the performance of DFS with girders seems acceptable.
- For $\sigma_q \approx 50$ μm:
  - DFS algorithm: $\leq$1% of the decel's with r>7 mm,
  - algorithm under study: $\leq$1% of the decel's with r>4.5 mm.
- The decelerator is robust wrt the ground motion: a 1-to-1 correction each months and a DFS each year seems enough, assuming ATL model with A=0.5 10^{-6} $\mu m^2/$ (s m).

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Thank you!