John Adams Institute for Accelerator Science

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UNIVERSITY OF OXFORD

Dynamic Aperture at Collision

Emilia Cruz Alaniz

Special thanks to: J. Abelleira, J. Barranco, A. Chance, B. Dalena, E. Maclean, R. Martin, R. Tomas, T. Persson, T. Pieloni, A. Seryi and L. van Riesen-Haupt.

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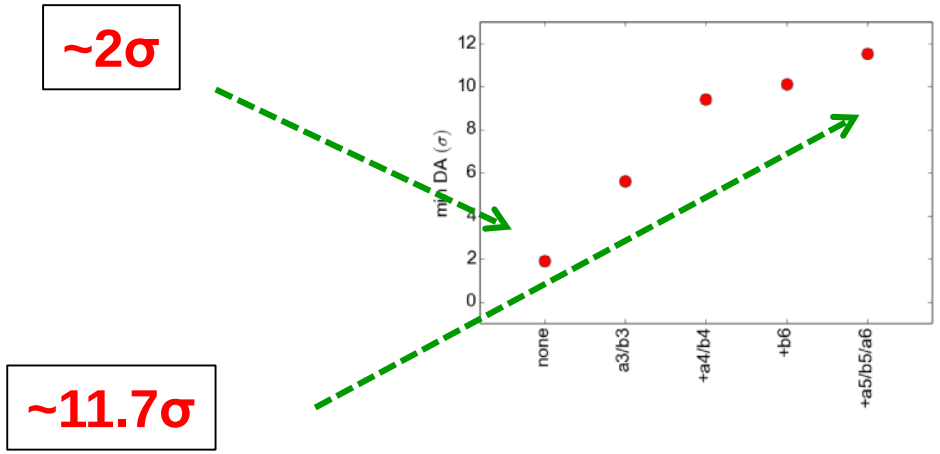
EuroCirCol
A key to New Physics

April 10th, 2018

Results FCC week @ Berlin

- DA at collision energy with errors on triplets no beam-beam and crossing angle on resulted in very low DA.

- Non-linear correctors:
  a3/b3/a4/b4/b6 + b5/a5/a6



- Acceptable DA with the use of non-linear correctors
  - Follow progress on its reliability (experiments LHC)
  - Find alternative corrections?

October update

CHANGES IN THE LATTICE

- New integrated lattice (97 km).
  - L* shortened to 40 m.

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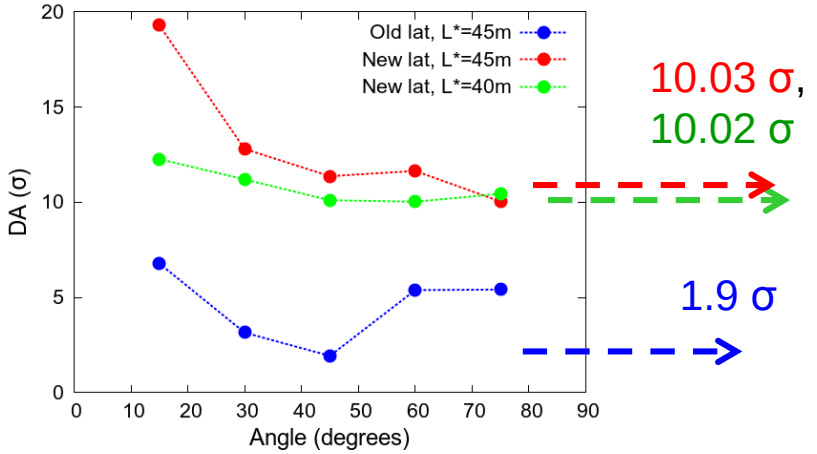

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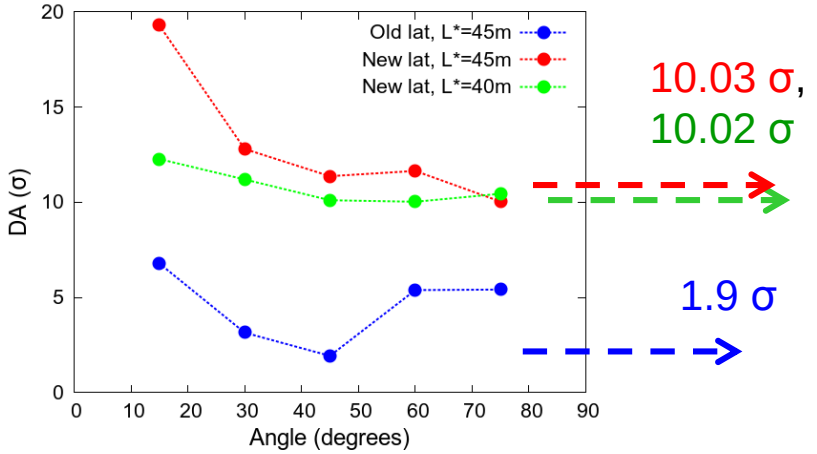

WORK TO DO

- check what is causing the difference on DA between the old and new lattice.

  - Will give us an indication of problem with last lattice and what to avoid
  - Will give us more flexibility to include more errors in the DA studies.

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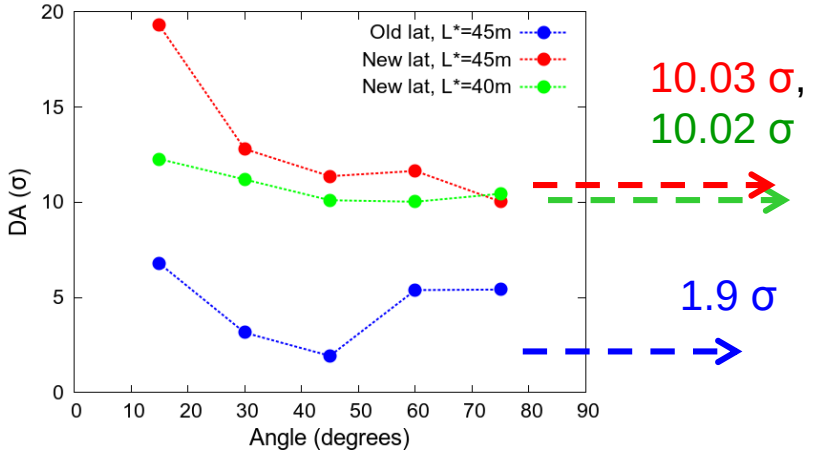

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  Phase between main IR ✔

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DA Studies

- 60 seeds/10^5 turns/5 angles no beam-beam (Talk: Beam-Beam studies T. Peloni)
- Triplet errors IRA/IRG
- Corrections

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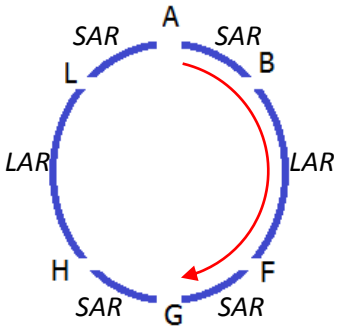

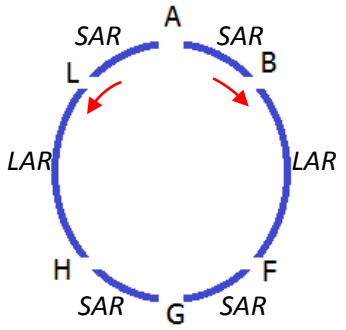

Method 1: Double-tuning

1. Change horizontal and vertical phase from IPA to IPG with trim quads on the right.
2. Adjust tune with trim quads on the left.

Method 2: Phasors

1. Install phasors (elements that only change the phase) in IPL and IPB
2. Change phase with phasor on the right (IPB)
3. Recuperate with phasor on left (IPL)

Phase Study

- Study to analyse impact of phase between main IR on DA

- 10 seeds/10^5 turns/5 angles
- Triplet errors, no beam-beam
- Normal corrections
- w/o non-linear correctors
- Double-tuning method
  (Phasors show similar results)

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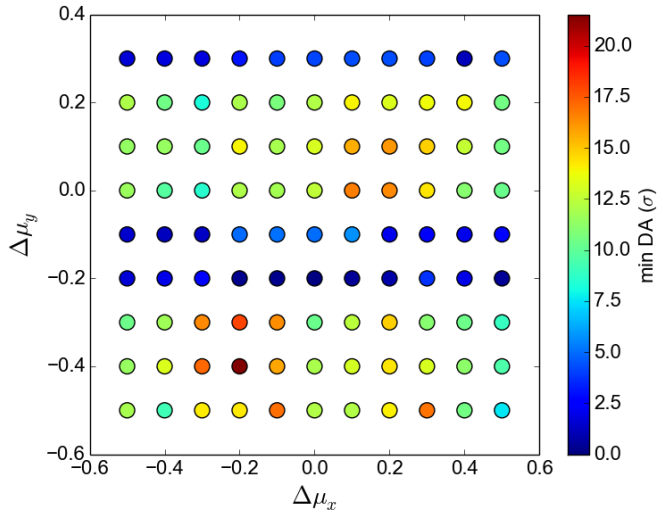

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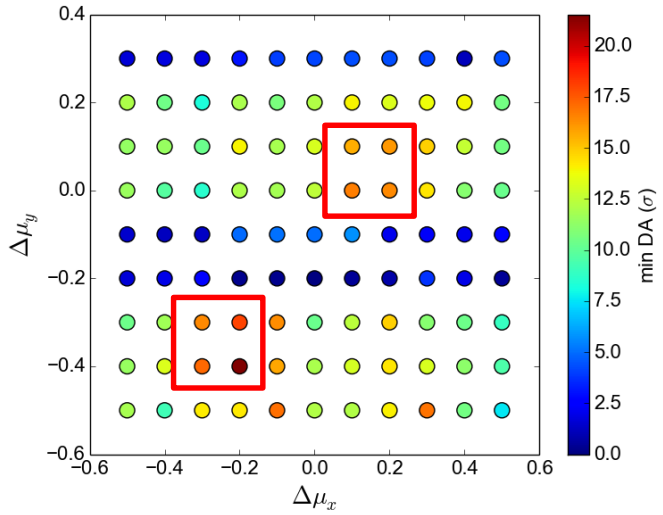

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- Bigger dependency with change in μ_y. Bigger refinement changing μ_x.
- Found two good zones:

  1. $\Delta\mu$=[0.2, 0.05]
  2. $\Delta\mu$=[-0.2, -0.4]

- Run best case for 60 seeds: 16.5 sigma (6.5 σ more than original!)

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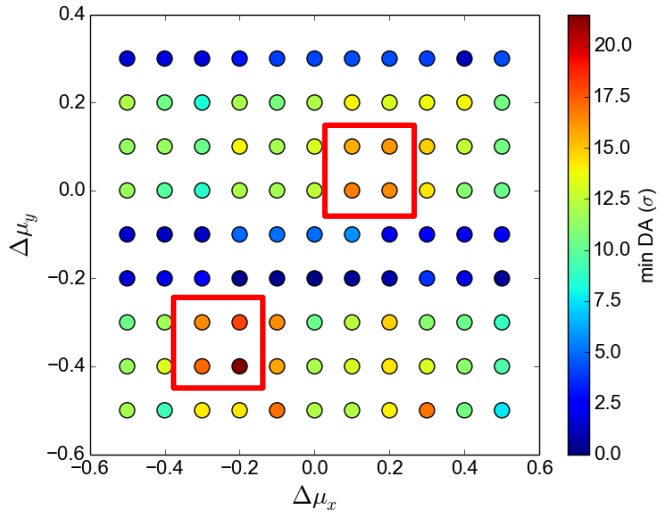

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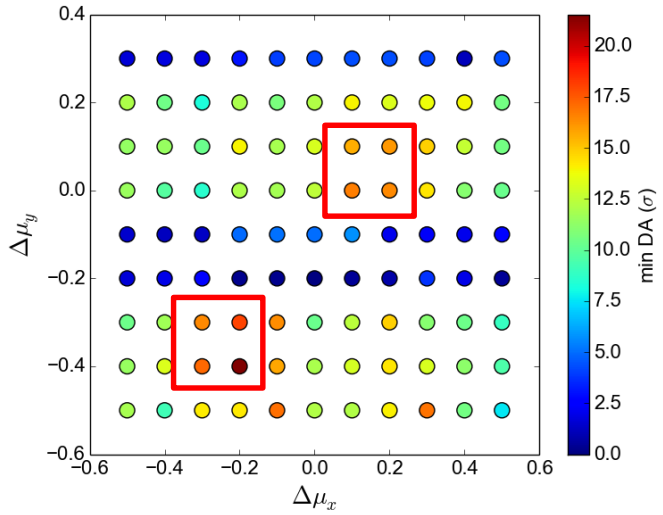

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- Not necessarily the same ones. Objective: Find the best compromise at different stages of the operation cycle.
- Higher DA gives flexibility to amplify study: include **arc** and **dipole** errors.

Expanded Study

- Add Errors:
  - **Triplet** Errors
  - **Arc Errors** + correction (B. Dalena, Talk: Dynamic Aperture at injection and 3.3 TeV energy choice)
  - Separation/Recombination **dipoles** errors (R. Martin)
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Original case: ----> **5.8 σ**

+ Non-linear corr: ----> **7.5 σ**

+Optimize phase: ----> **9.55 σ**

+non-linear+opt phase: ----> **15.9 σ**

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- Check other lattice options?

(Even more) expanded Study

Expand study to include:

1. Other lattice options (β*=0.15, 0.2, 1.1 m in IPA and IPG)

   Draw line when non-linear correctors are needed?

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3. Alternative IR design round and flat

   Phase Dependency? Same pattern?

   Good DA?

Talk: Flat beam alternative
J. Abelleira

Poster: An optimised Alternative Triplet for the final Focus of the FCC-hh.
L. Van Riesen-Haupt

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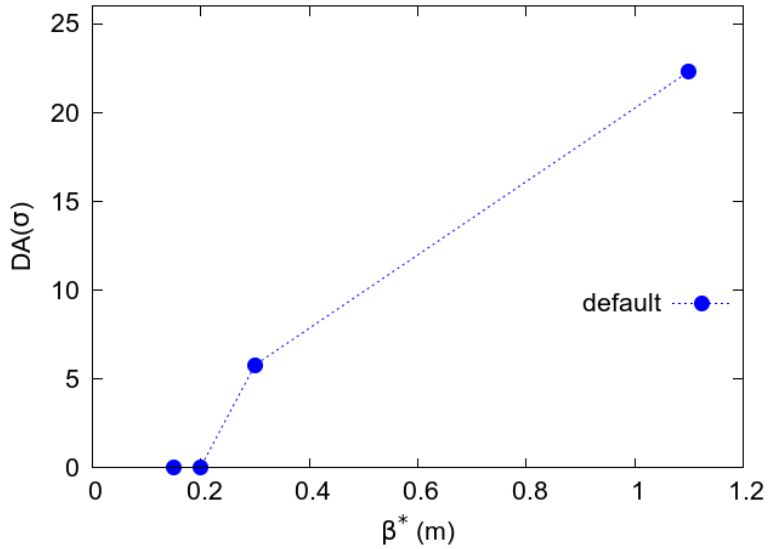

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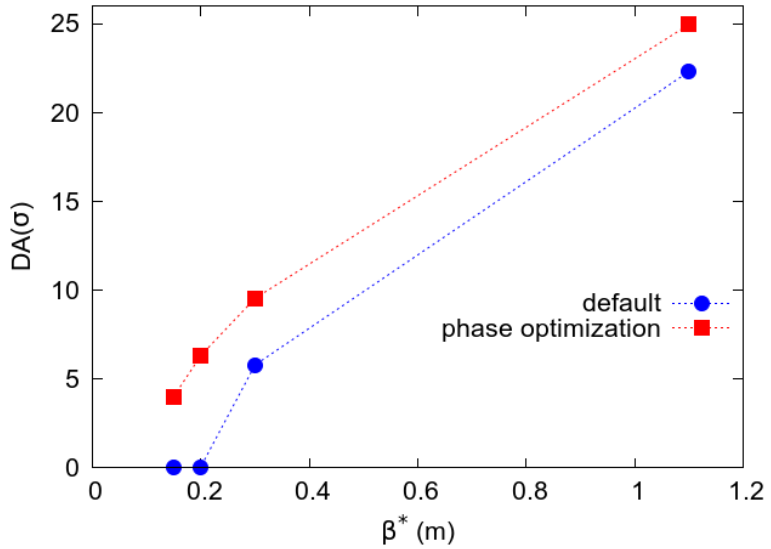

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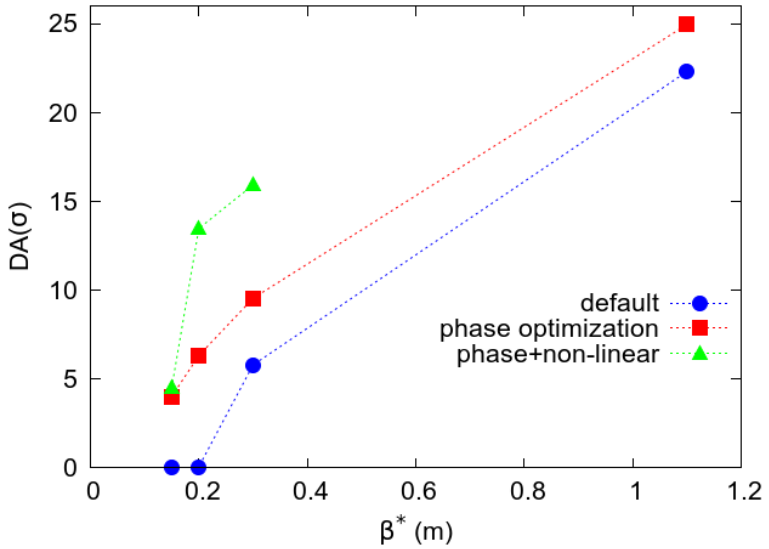

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- β*=0.15 m still challenging but likely to improve with improved phase.

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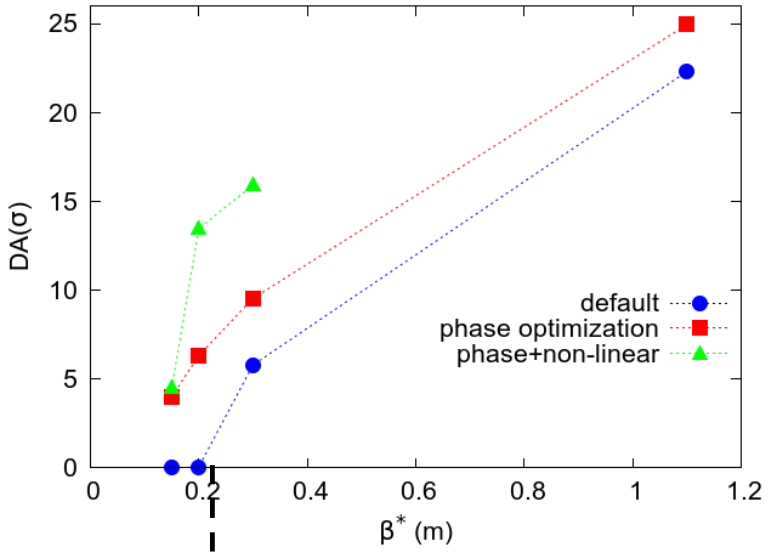

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- Using non-linear correctors becomes more crucial for cases β*=0.15 and 0.2 m

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   Same errors than before, no errors on FCC-eh IR yet.

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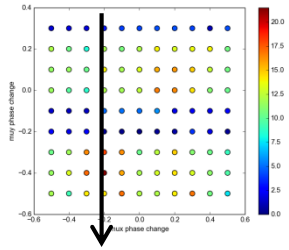

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Increase DA to similar values

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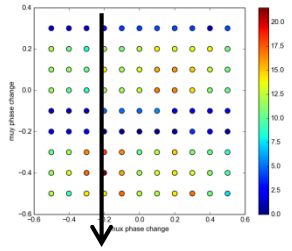

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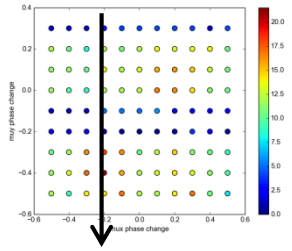

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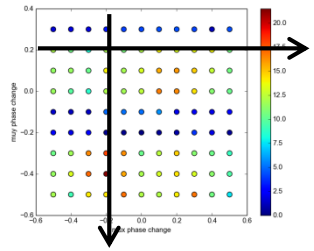

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Not strong dependency in 'y'

DA looks good!

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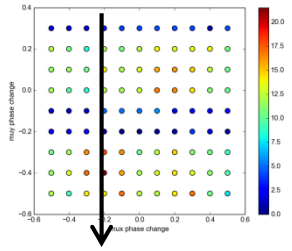

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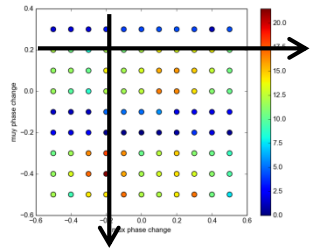

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3b. Alternative IR design (Leon/Jose) Flat optics β*=1.2/0.15 (IPA/IPG) 10.6 σ

Conclusions

- Study at collision without beam-beam has been expanded to include further errors: triplet errors, dipole arc errors, separation and recombination dipoles

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- Flat beams
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4-6 σ
- β*=0.15, 0.2 m *w/o non-linear correctors*

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25 σ	-	β*=1.1 m	*w/o non-linear correctors*
14-16 σ	-	β*=0.2 and 0.3 m	*with non-linear correctors*
	-	Expected the same for alternative design, flat beams and FCC-eh	
10-13 σ	-	β*=0.3 normal and alternative design	
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	- Flat beams	*w/o non-linear correctors*
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4-6 σ	- β*=0.15, 0.2 m	*w/o non-linear correctors*

- In conclusion with the phase scan optimization almost all studies (except for β*=0.15, 0.2 m) show good results, even without non-linear correctors.
- Check compatibility with beam-beam studies. Find best phase optimization for different stages of operation cycle.

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10-13 σ	- β*=0.3 normal and alternative design - Flat beams - FCC-eh IR	*w/o non-linear correctors*
4-6 σ	- β*=0.15, 0.2 m	*w/o non-linear correctors*

- In conclusion with the phase scan optimization almost all studies (except for β*=0.15, 0.2 m) show good results, even without non-linear correctors.
- Check compatibility with beam-beam studies. Find best phase optimization for different stages of operation cycle.
- Non-linear correctors improved results for all cases, useful to give safety margin but particularly important for the β*=0.2 m.
- More extensive study to be done for the challenging case β*=0.15 and for the FCC-eh in case new errors affect DA.

Thanks!