

# FCC – 92B4 Optimizations

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| The European Synchrotron

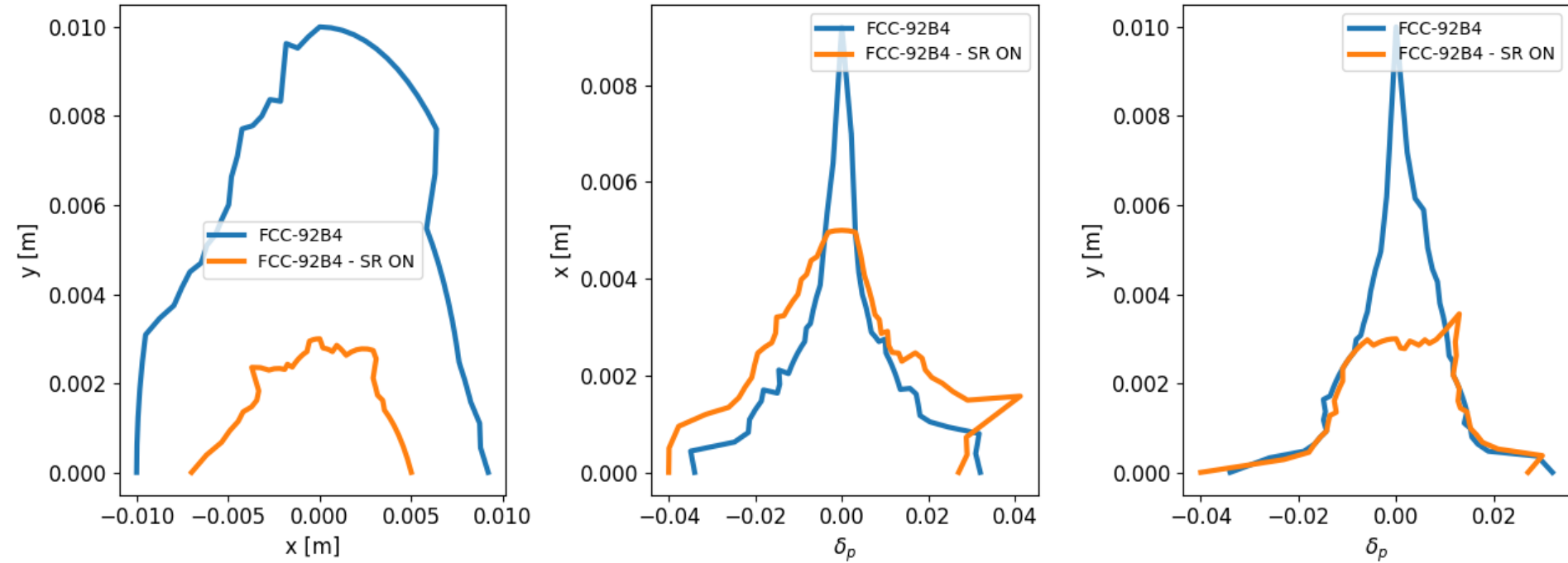
# SIMULATION PARAMETERS

- 16 GV RF voltage used
- Tapering calculated with radiation effects from dipoles only, applied to all magnets
- Only 32 turns needed to reach DA convergence
- $cs\_frac=0.3$ ,  $cs\_comp=0.1$
- Fixed tunes and chromaticity

```
Frac. tunes (6D motion): [0.20504858 0.30417061 0.12119645]
Energy: 1.825000e+11 eV
Energy loss / turn: 8.808215e+09 eV
Mode emittances: [ 2.10161873e-09 -7.92172220e-37 2.46045742e-06]
Damping partition numbers: [0.99994323 1.00000158 2.00005519]
Damping times: [0.01253191 0.01253118 0.00626543] s
Energy spread: 0.00148887
Bunch length: 0.00165673 m
Cavities voltage: 16000000000.0 V
Synchrotron phase: 2.55861 rd
Synchrotron frequency: 400.776 Hz
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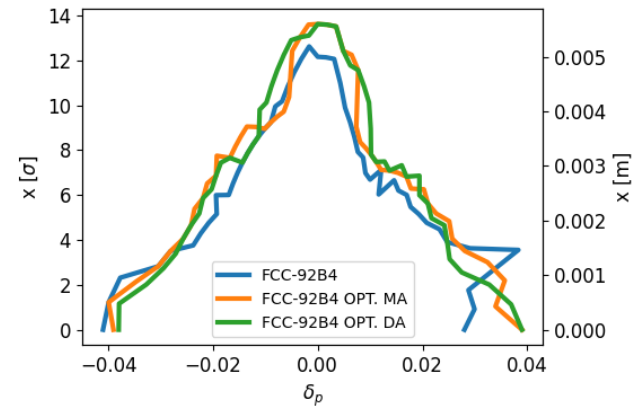
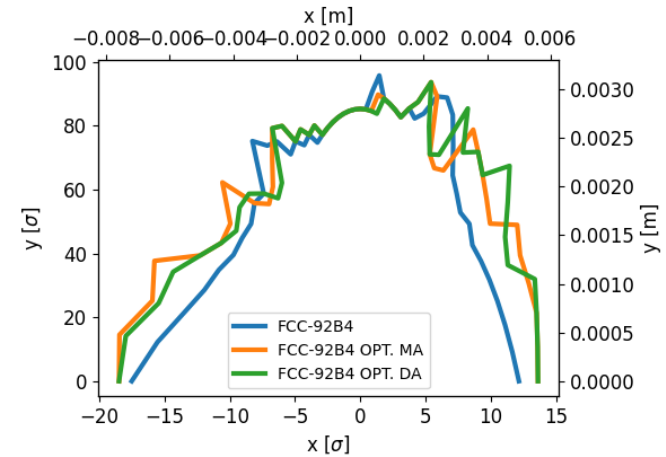
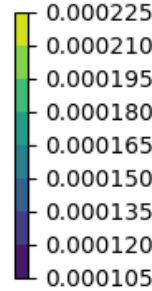
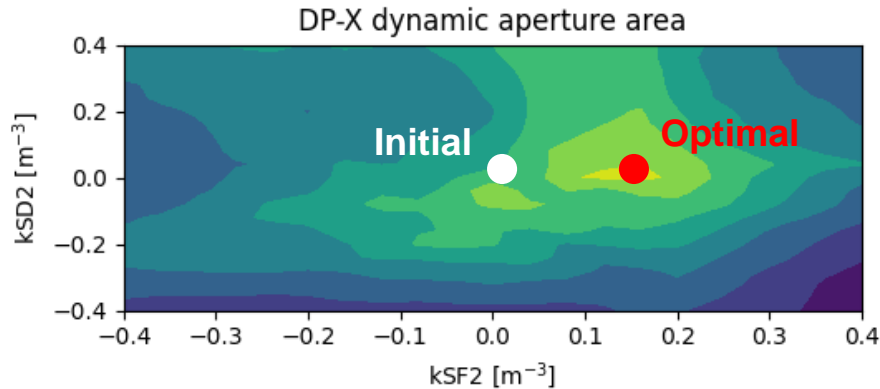
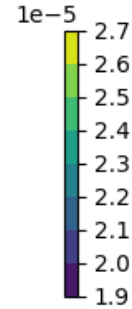
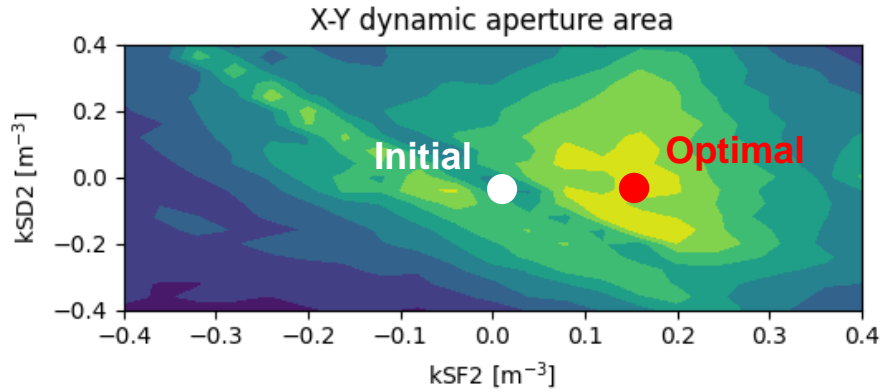
Emittance of the LCCO optics is 2.1 nm.rad vs 0.68 nm.rad for the Z lattice:

- Expect shrinkage of DA expressed in sigma
- Not an issue for injection



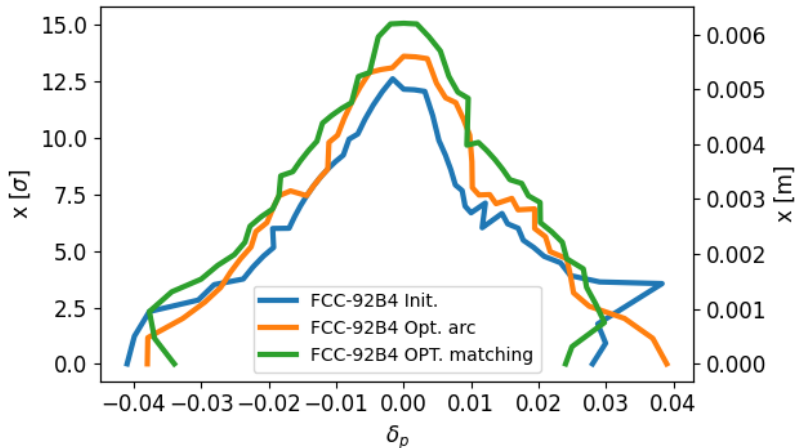
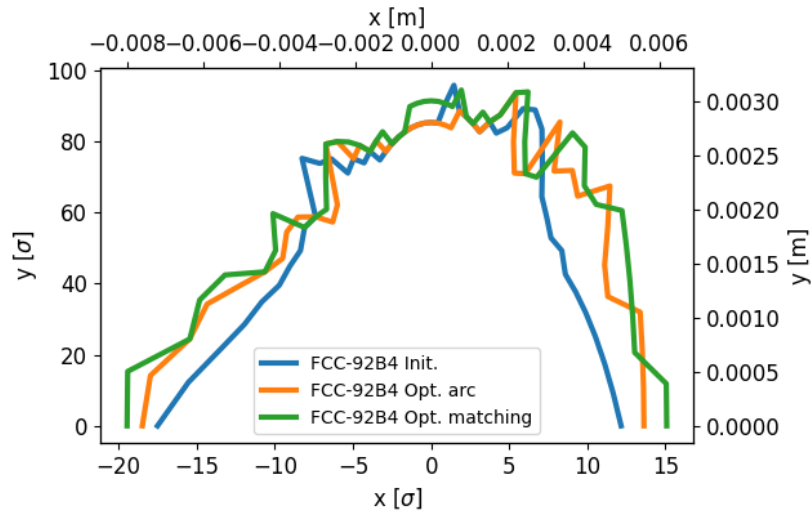
Synchrotron radiations have a **major** impact on DA  
Key ingredient in any characterization / optimization work

# ARC SEXTUPOLES



Slight adjustments of arc sextupoles: **SF2 increased by ~16%, optimal DA ~ optimal MA**

# MATCHING SECTIONS



Now look at arc and matching section: many variable, genetic algorithm used

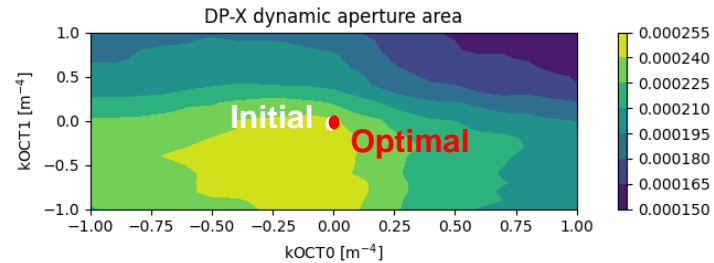
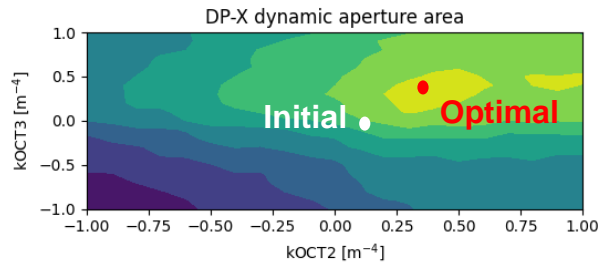
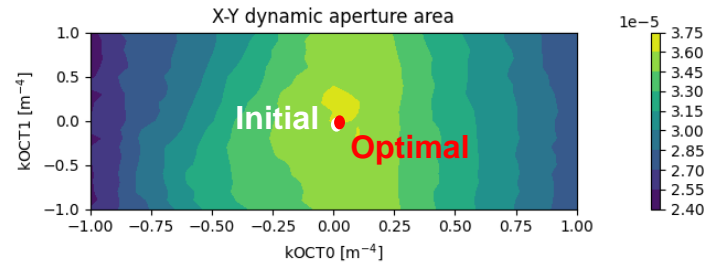
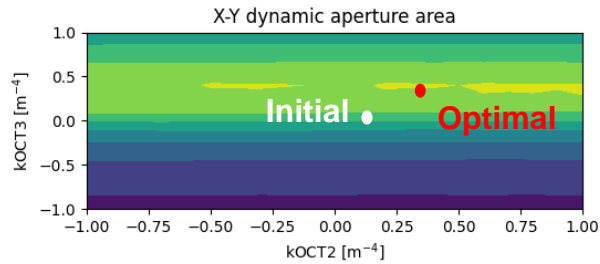
Modest gain in horizontal dynamic aperture

Degradation of off-momentum aperture: still large  $> \pm 2\%$

Similar results were obtained using the final focus sextupoles

→ Look first at octupoles

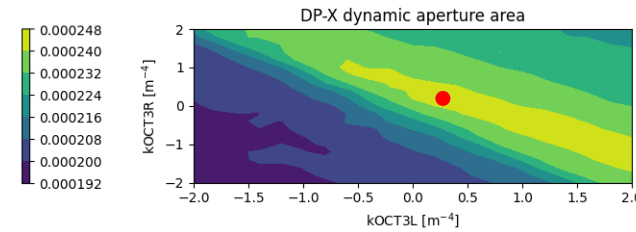
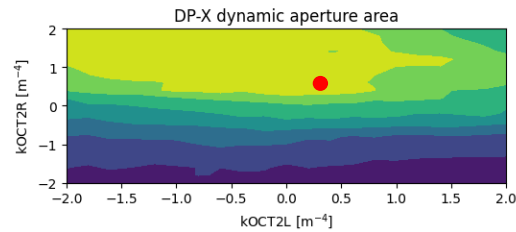
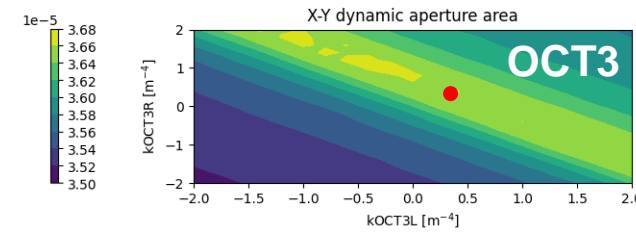
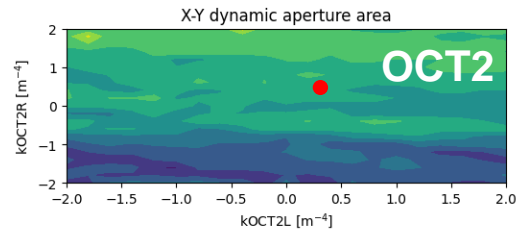
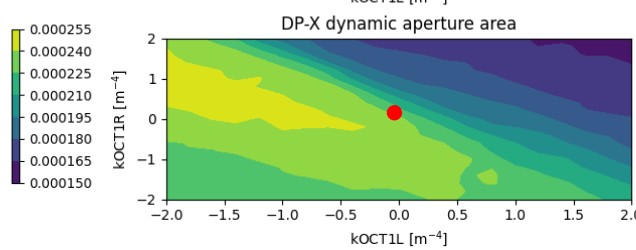
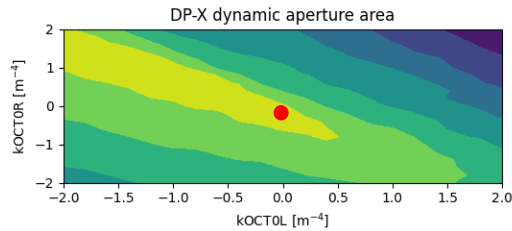
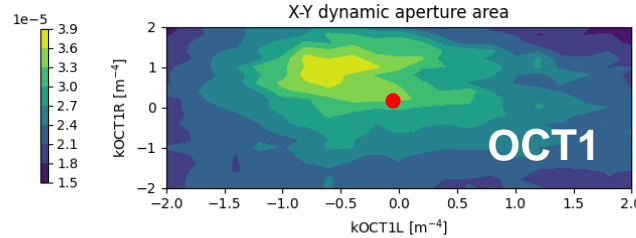
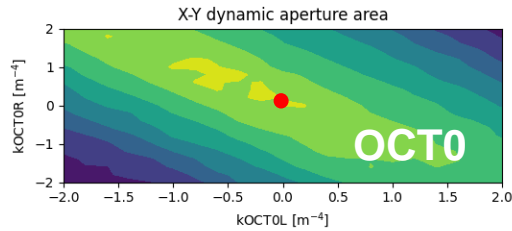
# SYMMETRIC OCTUPOLES



LR Octupole families moved together  
Pairing arbitrary: OCT0 and OCT1 were initially zero  
Significant gain obtained with OCT2 and OCT3 scan

Use optimum for OCT2 and OCT3, leave OCT0 and OCT1 at zero

# ASYMMETRIC OCTUPOLES



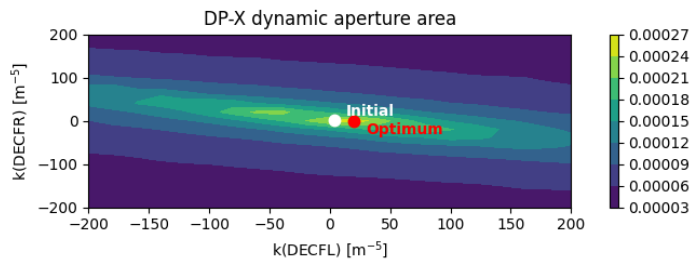
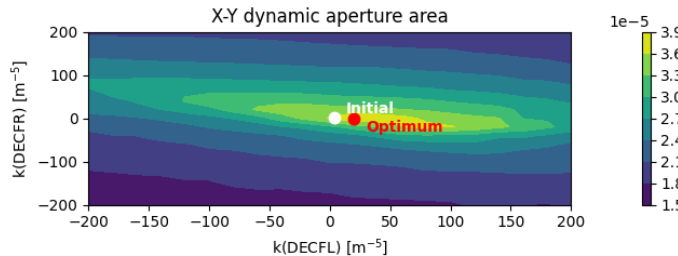
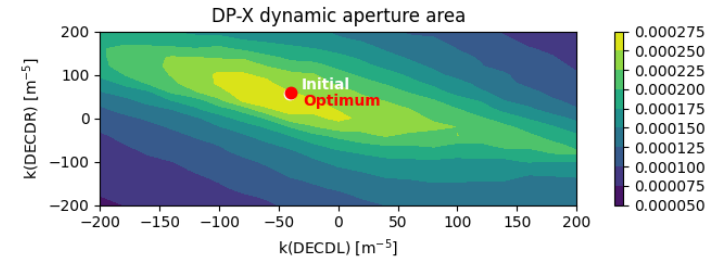
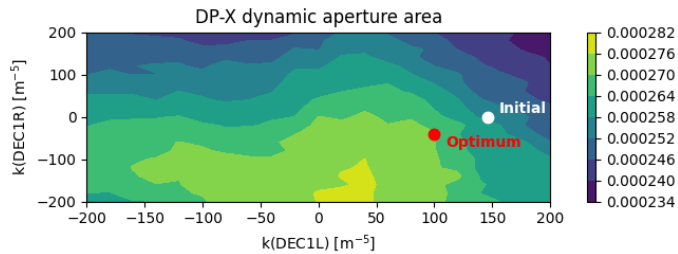
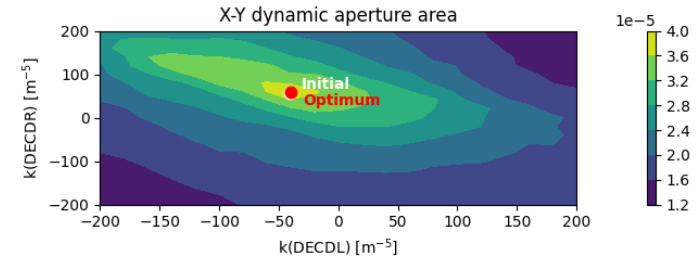
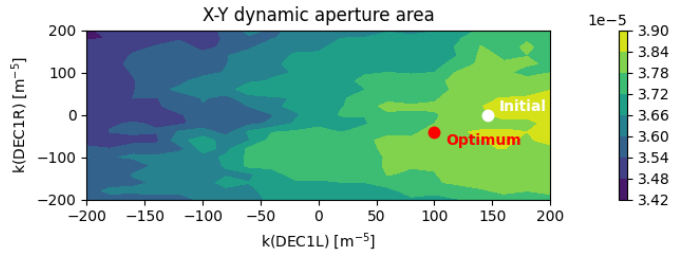
Red dots mark the results of previous slide with symmetric settings

Asymmetric settings: no significant gain

For the future: some correlation observed, could be used to build some knobs

For now: keep symmetric settings

# DECAPOLES

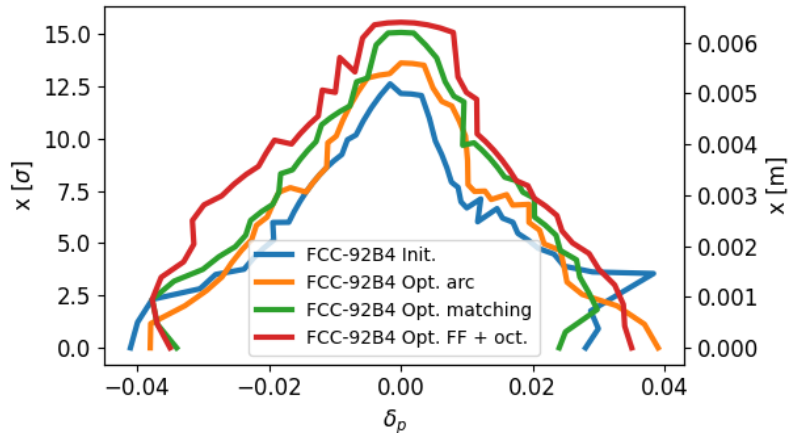
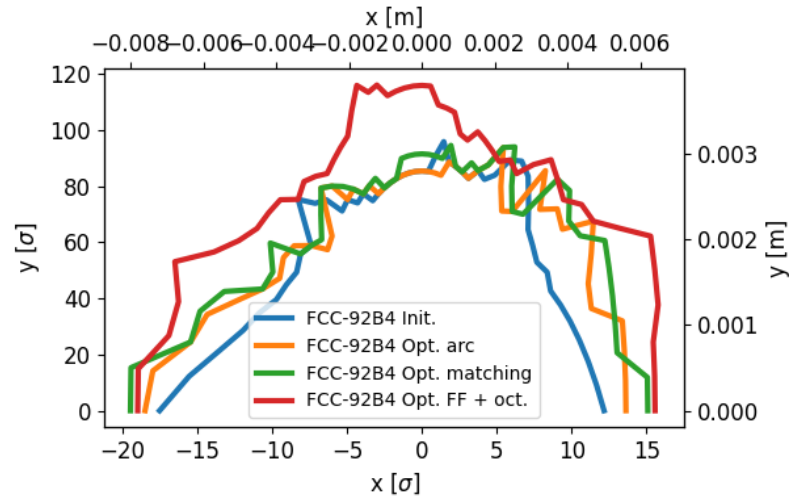


Decapoles already well optimized

Leave at initial values



# FINAL OPTIMIZATION



A final optimization is done including FF sextupoles and octupoles (OCT2 and OCT3 symmetric)

Significant gain in DA, mostly due to octupoles: approx. +20/-16 sigmas

Momentum aperture preserved: > +/- 2%

FCC requirement (MA>2%, DA > 15sigmas) met for **lattice without errors**

## Robust optimization procedure established:

- can now be done easily for any LCCO providing magnet definition remain the same
- strongly profits from “built-in” knobs of the LCCO lattice
- **Further improvements:** combined knobs, reduce number of variables

## Substantial gain of DA/MA demonstrated with this procedure:

- May help to recover performance for lattices with errors

**A similar procedure could be used for online optimization of the real machine**