GENERAL INFORMATION

Frank Zimmermann

FCC-ee Optics Design Meeting #192 & 63rd FCCIS WP2.2 meeting, 26 September 2024

Upcoming

- Xsuite beam lifetime
- Dynamic aperture with Q'~5, 10, 20
- Beam-beam at Z with larger RF voltage
- 400 MHz 2-cell scenario, same RF system for Z, WW, and ZH
  - all relevant aspects clarified for CGM 11 October, voltage, beam-beam, HOM (?), ….
- SuperKEKB model in xsuite
- Impedance update
- Xsuite-BDSIM developments
- Specification, requirements & tolerances

Feasibility Study Report for March 2025

Structure:Three Volumes

- ***Vol. 1:*** *Physics, Experiments and Detectors (~200 pages)*
- ***Vol. 2:*** *Accelerators, Technical Infrastructures, Safety Concepts (~400 pages)*
- ***Vol. 3:*** *Civil Engineering, Implementation & Sustainability (~200 pages)*
- - **Executive Summary of the FCC Feasibility Study: ~40 pages**

Input for Update of European Strategy for Particle Physics

to be prepared with Overleaf & published by EPJ (Springer-Nature) – FCCIS members

Overleaf

FUTURE CIRCULAR COLLIDER Innovation Study

EPJ.org your physics journal

SPRINGER NATURE

In addition:

a. Documentation on Cost Estimate – Funding Models

FSR draft table of contents (1)

P. Charitos, M. Benedikt, C. Carli, J.-P. Burnet et al.

INTRODUCTION (~10 pages)

FCC-ee & hh Requirements & Design considerations (approaches & general brief introduction/principles)
FCC-ee & hh Layout and Key Parameters

1 **FCC-ee Collider**

1.1 Design & Performance (40 pages)

1.1.1 Beam-beam and luminosity

1.1.2 Optics design including synchrotron radiation and tapering

1.1.4 Impact of misalignments and field errors, optics corrections ,
1.1.3 Single beam collective effects (impedance., electron cloud ,ions)
1.1.4 Collimation
1.1.5 Machine - Detector Interface (MDI)
1.1.6 Energy Calibration and polarisation
1.1.7 Injection and Extraction (top up injection)
1.1.8 Radiation Environment
1.1.9 Ongoing studies and possible upgrades

1.1.10 Preliminary requirements on technical systems

1.2 Operation concept (20 pages)

1.2.1 Operation and performance
1.2.2+xx requirements (filling schemes, efficiency, physics goals, RF staging?, energy switching. beam-based alignment, luminosity tuning, injection requirements, beam diagnostics requirements)

1.2.3 Preliminary requirements on technical systems

split into pieces?

1.3 Technical Systems (40 pages)

1.3.1 Main magnets
1.3.2 Vacuum system, electron-cloud mitigation, and radiation shielding
1.3.3 Radiofrequency systems layout, configurations, and parameters
1.3.4 Survey and alignment concepts and system
1.3.5 Beam Intercepting Devices (halo collimators, beam dump)
1.3.6 Beam Transfer Systems & Separator
1.3.7 Powering Systems
1.3.8 Beam diagnostics instruments (beam position, beam size/length, beam loss, beam current, polarization & spectrometry)
1.3.9 Control systems
1.3.10 Integration
1.3.11 Machine Protection

1.3.13 Dismantling

1.3.14 Preliminary requirements on technical infrastructure systems

FSR draft table of contents (2)

items from last tuning meeting, 13 September

10:00 → 10:10 **News**
Speakers: Jacqueline Keintzel (CERN), Rogelio Tomas Garcia (CERN)

10:10 → 10:30 **Tuning studies with girders**
Speaker: Elaf Musa (DESY)
Elaf_Musa_TuningM... | Elaf_Musa_TuningM...

10:30 → 10:50 **Progress with tuning simulations and with IP tuning knobs**
Speaker: Satya Sai Jagabathuni (Universite de Geneve (CH))
FCCee tuning simul...

10:50 → 11:10 **Ballistic FCC optics**
Speaker: Cristobal Garcia (EPFL - Ecole Polytechnique Federale Lausanne (CH))
Ballistic Optics tuni... | Ballistic Optics tuni... | Ballistic Optics tuni...

11:10 → 11:30 **DA in relaxed optics**
Speaker: Kyriacos Skoufaris (CERN)
DA_in_relaxed_optic...

11:30 → 11:50 **BBA updates**
Speaker: Christian Goffing (CERN and KIT)
Measurement Prop...

11:50 → 12:10 **BPM resolution tolerances**
Speaker: Jacqueline Keintzel (CERN)
20240913_Keintzel_...

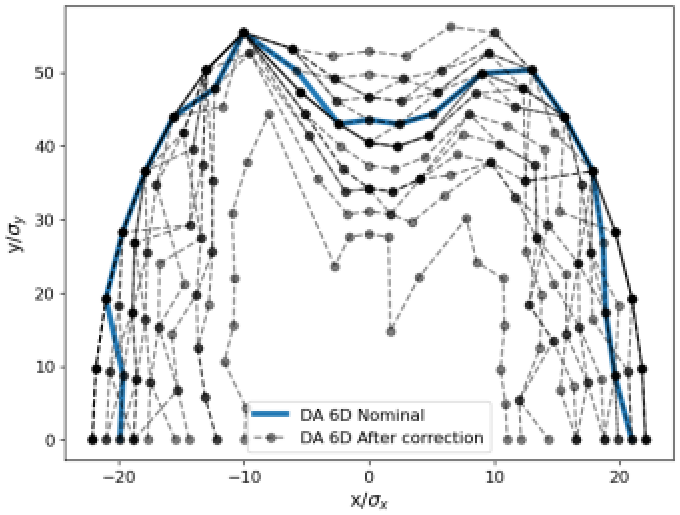
coordinated by J. Keintzel & R. Tomas

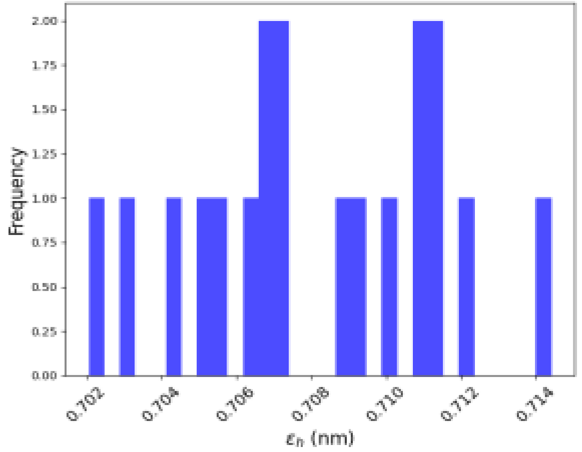
tuning studies with girders

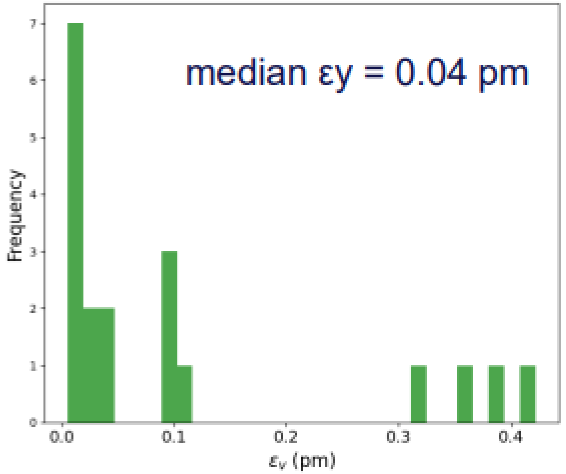
E. Musa

Elements	Hor. & Ver. displaceme nt	Tilt θ
Arc quads and sext.	50 µm	50 µrad
All dipoles	150 µm	150 µrad
BPMs	same as quads/sext.	-
Girders	150 µm	-

- **After correction of alignment errors**
  - **Case 1**
    BPMs aligned to quadrupoles
    20 seeds







BPMs must be attached to quadrupoles

Results are unchanged with dipole alignment error or 1 mm

Progress with tuning simulations (Z mode)

S. Sai Jagabathuni

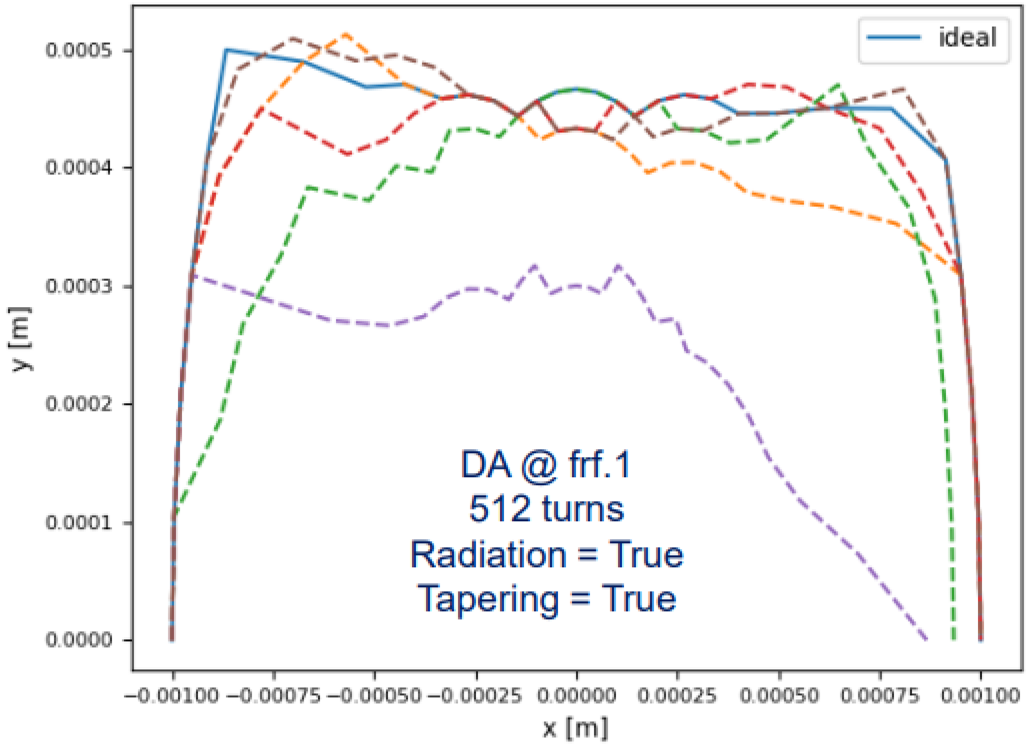
Type	Δx (µm)	Δy (µm)	Rotation (µrad)
Arc quadrupoles incl. quads in RF section	130	130	100
Arc sextupoles	130	130	100
IR quadrupoles incl. FF quads	40	40	40
IR sextupoles incl. crab sextupoles	40	40	40
All Dipoles	1000	1000	[illegible]

Linear Optics	Seed 0 (std)	Seed 1 (std)	Seed 2 (std)	Seed 3 (std)	Seed 4 (std)
ΔX [um]	12.053		4.574	4.658	
ΔY [um]	2.539		11.759	2.904	
ΔDx [mm]	4.399	Failed	3.885	4.309	Failed
ΔDy [mm]	2.622		2.445	2.675	
beta-beating H [%]	1.486		1.839	2.148	
beta-beating V [%]	2.005		3.442	2.299	

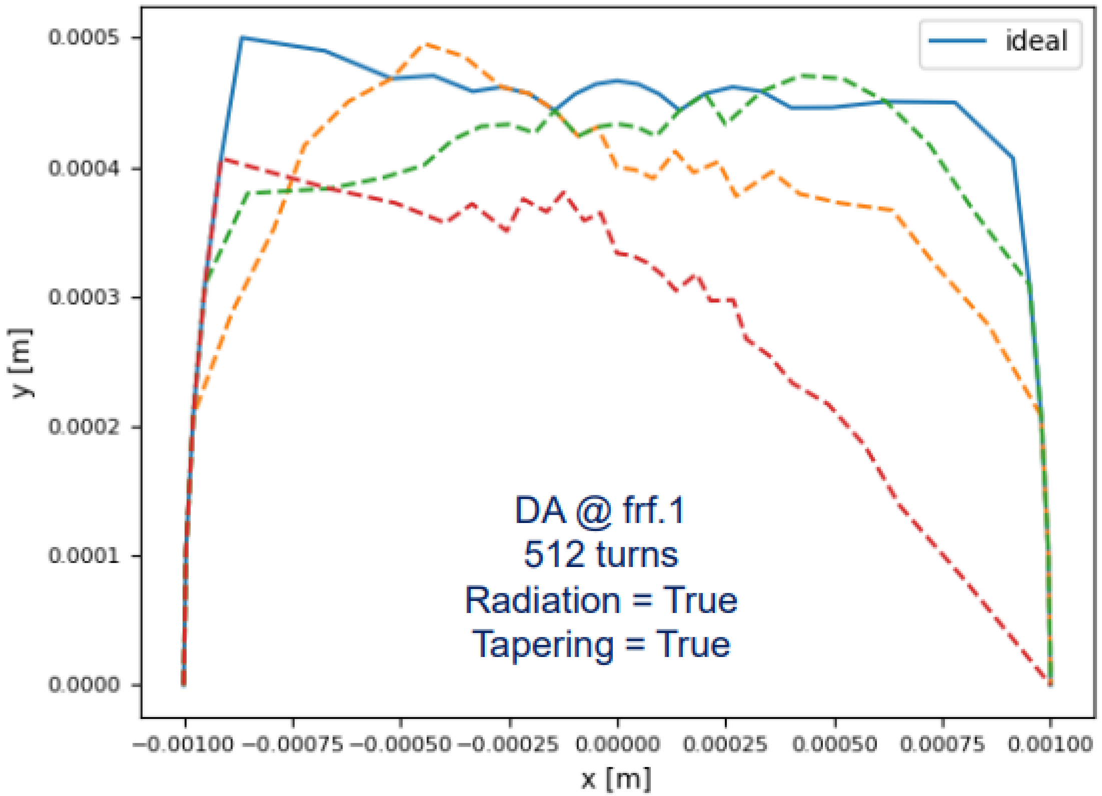
Progress with tuning simulations (Z mode)

S. Sai Jagabathuni

For the case of 100um in the arcs and 40um in IR's



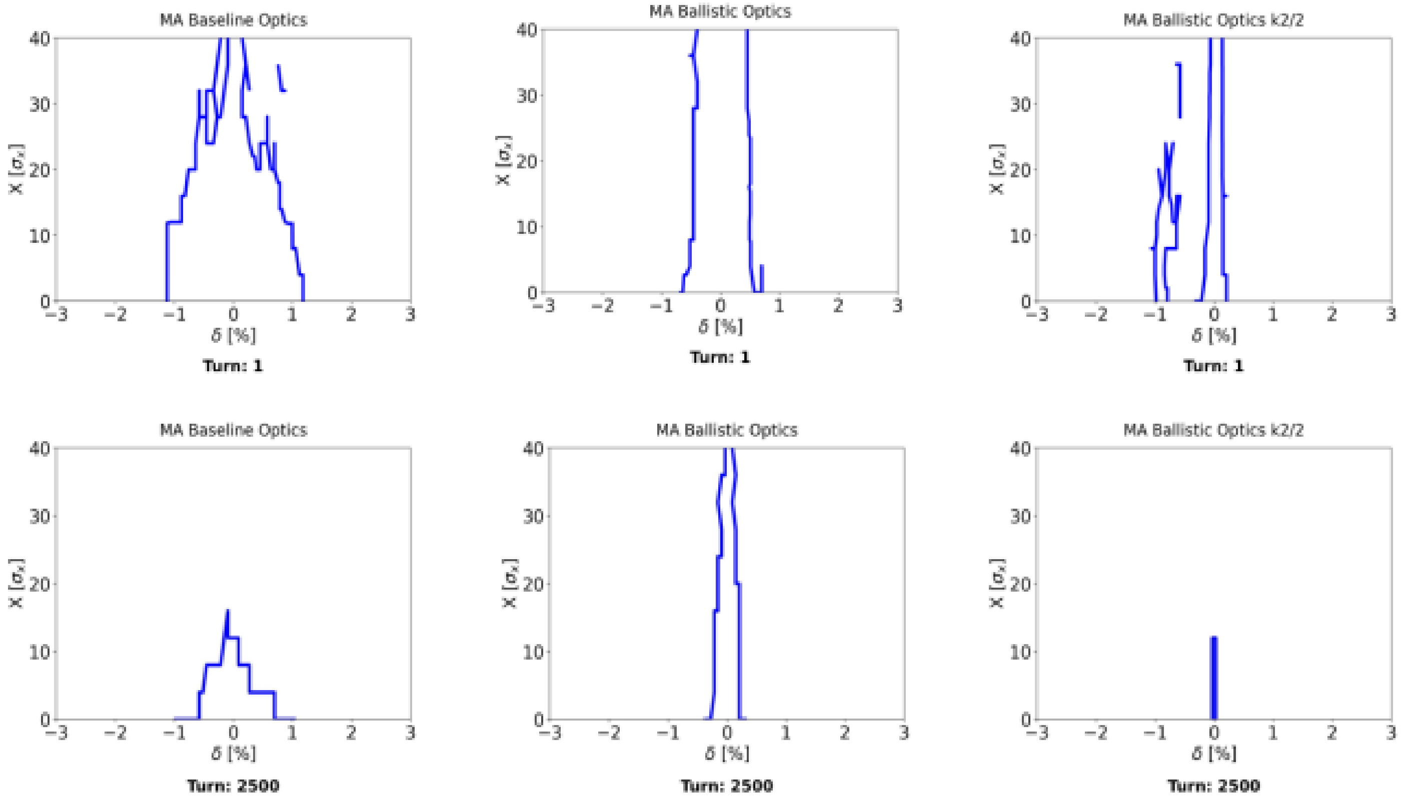
For the case of 130um in the arcs and 40um in IR's



C. Garcia Jaimes

Momentum Acceptance for Ballistic Optics

➔ The MA decreased compared to the baseline, which needs to be improved through an optimization of the sextupoles. There are 75 families of them.



DA in relaxed optics

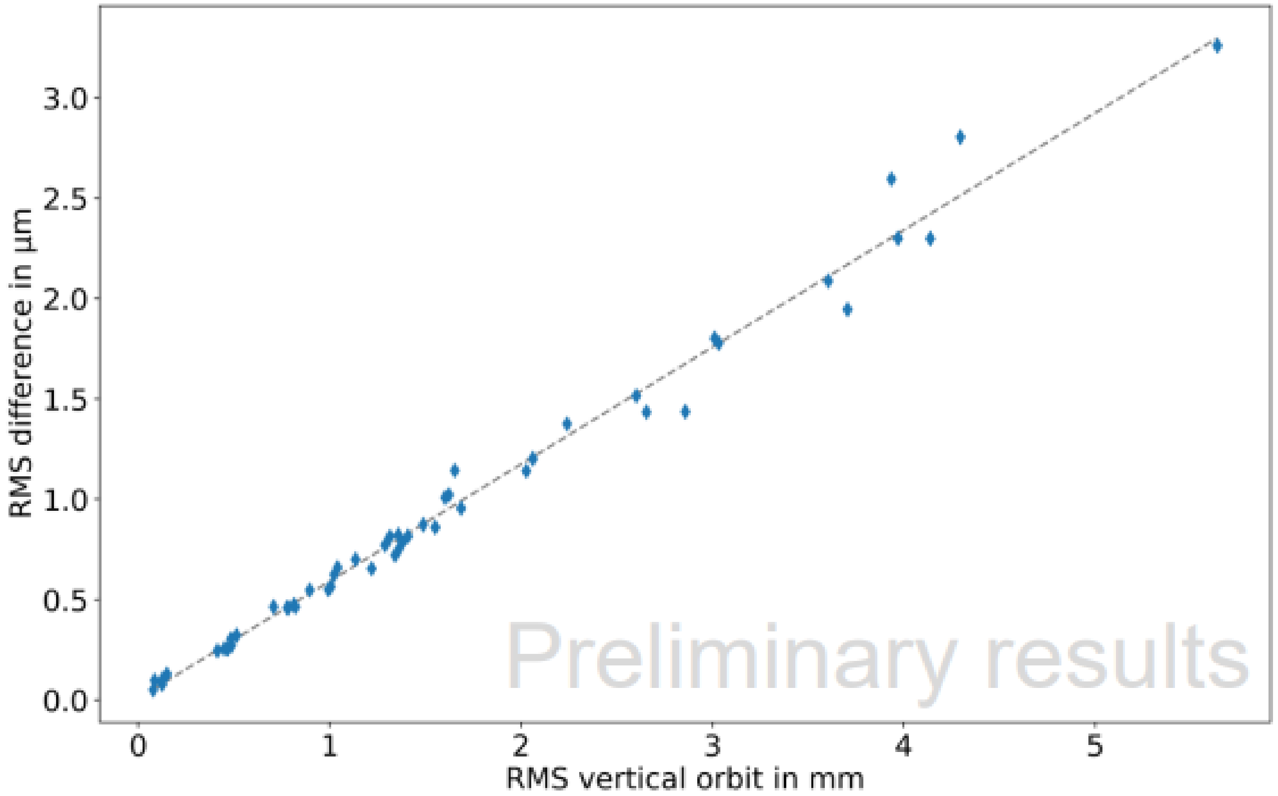
K. Skoufaris

- With half sextupole strength
  - the v24.3-GHC lattice with **high betas shows good lifetime** (~350 turns)
  - the **ballistic optics** of v23-GHC **significantly improve the lifetime** (~650 turns) **with smaller emittances.**
- **Ballistic optics still has significant margin for optimization promising even larger lifetime with smaller sextuple strength** (less nonlinearities).

C. Goffing

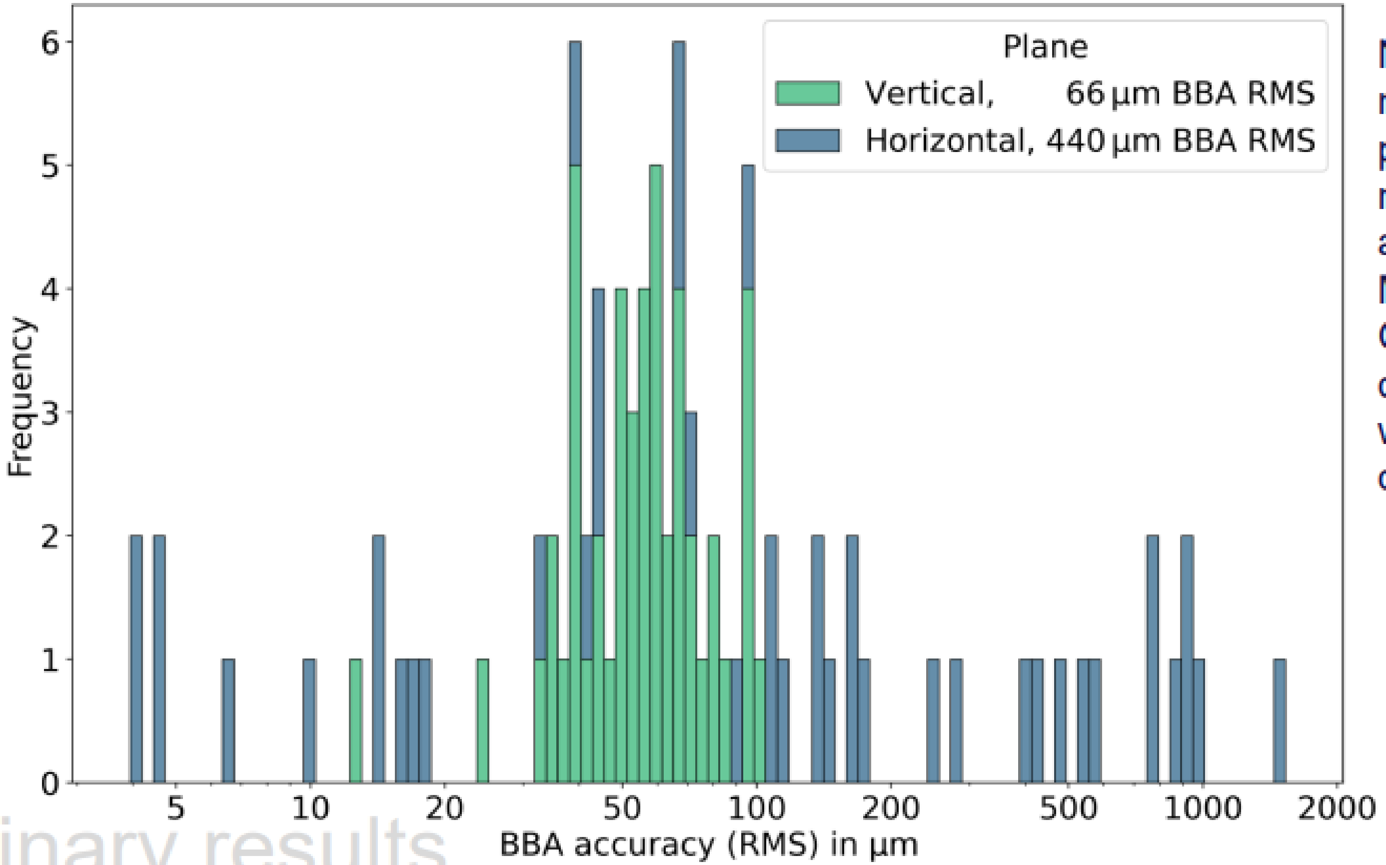
Quadrupole BBA

- Simulations with optimized position measurement (at end of each quadrupole)
- Linear dependence of BBA accuracy on orbit deviations after orbit correction in vertical plane
- At KARA 100 – 200 μm RMS vertical orbit achievable



C. Goffing

Sextupole BBA



No BPM noise, position measurement at sextupole, Magnet shift Gaussian distribution with σ = 100 µm

Preliminary results

BPM resolution studies

J. Keintzel

- Many turns required to achieve phase advance tolerance → AC-dipole essential
- Arcs: Rather relaxed BPM resolution tolerances of up to few µm
- IRs: 10-4 goal very challenging, achieved with < 1µm BPM resolution

S. Lund

USPAS Web Site: https://uspas.fnal.gov/index.shtml , USPAs Overview: https://uspas.fnal.gov/about/about-uspas.shtml

USPAS Winter 2025 session: Knoxville, TN (proximity to Oak Ridge National Lab). January 27 - February 7, 2025

Session Web Page (including linked application page): https://uspas.fnal.gov/programs/2025/knoxville/index.shtml
There will be two paired half-courses of interest to the USA collider physics community:

1) "**Colliders for High Energy and Nuclear Physics**," Jan 27-31, 2025, Instructors: **Vladimir Shiltsev**, Northern Illinois University; **Vadim Ptitsyn** (BNL); + TBA
   https://uspas.fnal.gov/programs/2025/knoxville/courses/colliders-henp.shtml
1) "**Collider Interaction Regions for High Energy and Nuclear Physics Applications**, " Feb 3 -7, 2025, Instructors: **Michael Sullivan (SLAC), Yulia Furletova (JLab), Dali Georgobiani (Fermilab), and Nikolai Mokhov (Fermilab, retired)**
   https://uspas.fnal.gov/programs/2025/knoxville/courses/collider-interaction.shtml

Academic credit will be served by Michigan State University (MSU). **Scholarship support is available** (details on application page) for qualifying students enrolled for credit.

USPAS sessions cover the full scope of accelerator science and engineering. Classes change session-by-session to represent the full field over time. Specialty courses such as these collider classes likely repeat, at most, only every few years. So interested students are encouraged to enroll. Classes are demanding yet rewarding, and the school is an excellent opportunity to make lasting professional connections with people who work, or will work in the field.

Today's agenda

15:00 → 15:20	**General Information, Plan for FSR, etc.**	20m	
	Speaker: Frank Zimmermann (CERN)		
15:20 → 15:35	**Transient beam loading for reverse phase operation mode**	15m	
	Speaker: Ivan Karpov (CERN)		
15:40 → 16:00	**Non-local solenoid compensation and associated effects on beam-beam & polarization**	20m	
	Speaker: Dr Katsunobu Oide (Universite de Geneve (CH))		