Accelerators Summary

Jacqueline Keintzel

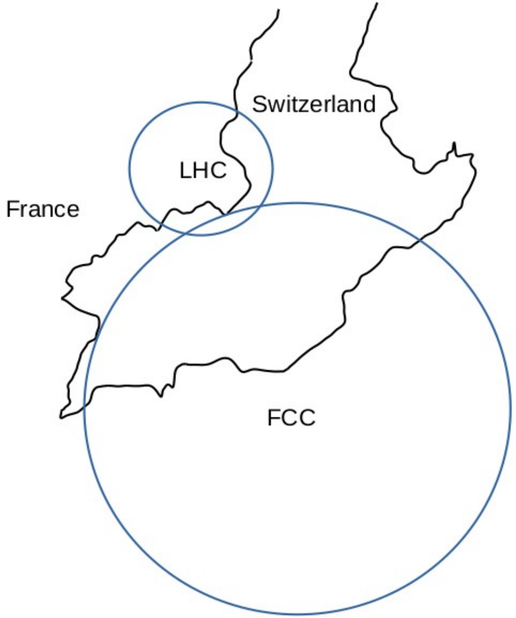
On behalf of the FCC-ee collaboration

Acknowledgements: Michael Benedikt, Tor Raubenheimer, Frank Zimmermann
All colleagues

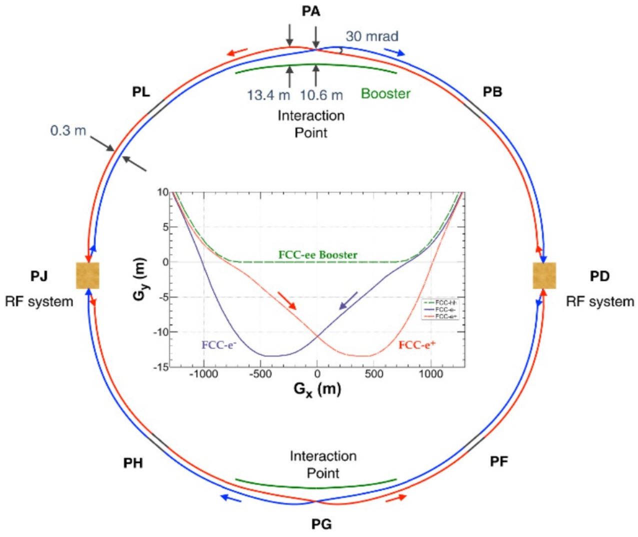
Future Circular Collider

Inspired by LEP-LHC programm

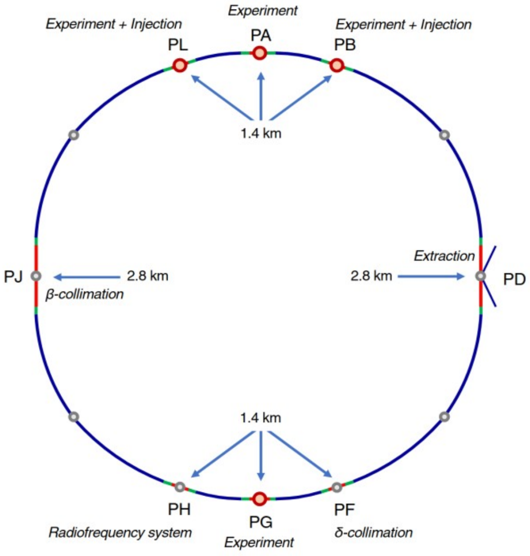
Re-using CERN infrastructure



FCC-ee
Electron-positron collider



FCC-hh
Proton-proton collider



Overview

- 11 sessions with 52 talks
- 21 posters total

Day	Monday	Tuesday				Wednesday			Thursday				Friday	Time
Room	Plenary	Parallel 1	Parallel 2	Parallel 3	Parralel 4	Parallel 1	Parallel 2	Parallel 3	Parallel 1	Parallel 2	Parallel 3	Parallel 4	Plenary	Room
	Campus Cordeliers	CICSU Jussieu				Campus Cordeliers		Réfectoire Cordeliers	Campus Cordeliers			Réfectoire Cordeliers	Campus Cordeliers	
Time	FARABOEUF	Room 105	Room 107	Room 109	Room 116	ROUSSY	PASQUIER		FARABOEUF	PASQUIER	ROUSSY		FARABOEUF	Time
09:00-09:30		FCCee accelerator FCCIS WP2	Phy Programme/ Performance	FCCIS WP4 Socio Econom		FCC hh accelerator	PED: EPOL	FCCIS WP3 Placement	PED/ACC: FCCee EPOL	RF Points for FCC-ee	Technology		Summaries	09:00-09:30
09:30-10:00	Plenary session													09:30-10:00
10:00-10:30		Chairperson	Chairperson	Chairperson		Chairperson	Chairperson	Chairperson	Chairperson	Chairperson	Chairperson		Chairperson	10:00-10:30
10:30-11:00	*Coffee break*	*Coffee break*				*Coffee break*			*Coffee break*				*Coffee break*	10:30-11:00
11:00-11:30	Plenary session	FCCee accelerator FCCIS WP2	Phy Programme/ Performance	SRF Directions for R&D		Technology	PED: Detector Concepts	Civil Engineering	PED/ACC: FCCee MDI	Electricity and Cooling	Technology		Summaries	11:00-11:30
11:30-12:00														11:30-12:00
12:00-12:30	Chairperson	Chairperson	Chairperson	Chairperson		Chairperson	Chairperson	Chairperson	Chairperson	Chairperson	Chairperson		Chairperson	12:00-12:30
12:30-14:00	*Lunch break*	*Lunch break*				*Lunch break*			*Lunch break*					12:30-13:00
14:00-14:30	Plenary session	FCCee injector FEB	Phy Programme/ Performance	Technology SRF	ISC meeting CLOSED	FCCee accelerator	PED: Detector Concepts	FCCIS WP5 Collaboration	PED/ACC: FCCee MDI	Transport & logistics, Safety				14:00-14:30
14:30-15:00														14:30-15:00
15:00-15:30		Chairperson	Chairperson	Chairperson	F. Gianotti	Chairperson	Chairperson	Chairperson	Chairperson	Chairperson				15:00-15:30
15:30-16:00	Chairperson	*Coffee break*				*Coffee break*			*Coffee break*					15:30-16:00
16:00-16:30	*Coffee break*	FCCee injector FEB	Phy Programme/ Performance	Technology SRF	ISC meeting CLOSED	FCCee accelerator	TI Geodesy and survey	FCCIS WP5 Communication				France, special session		16:00-16:30
16:30-17:00	Plenary session													16:30-17:00
17:00-17:30		Chairperson	Chairperson	Chairperson	F. Gianotti	Chairperson	Chairperson	Chairperson				Chairperson		17:00-17:30
17:30-18:00	Chairperson											Poster session & DRINK		17:30-18:00
18:00-18:30						Discussion with juniors	ICB meeting CLOSED							18:00-18:30

FCC-ee Accelerator I, Tuesday 31st June

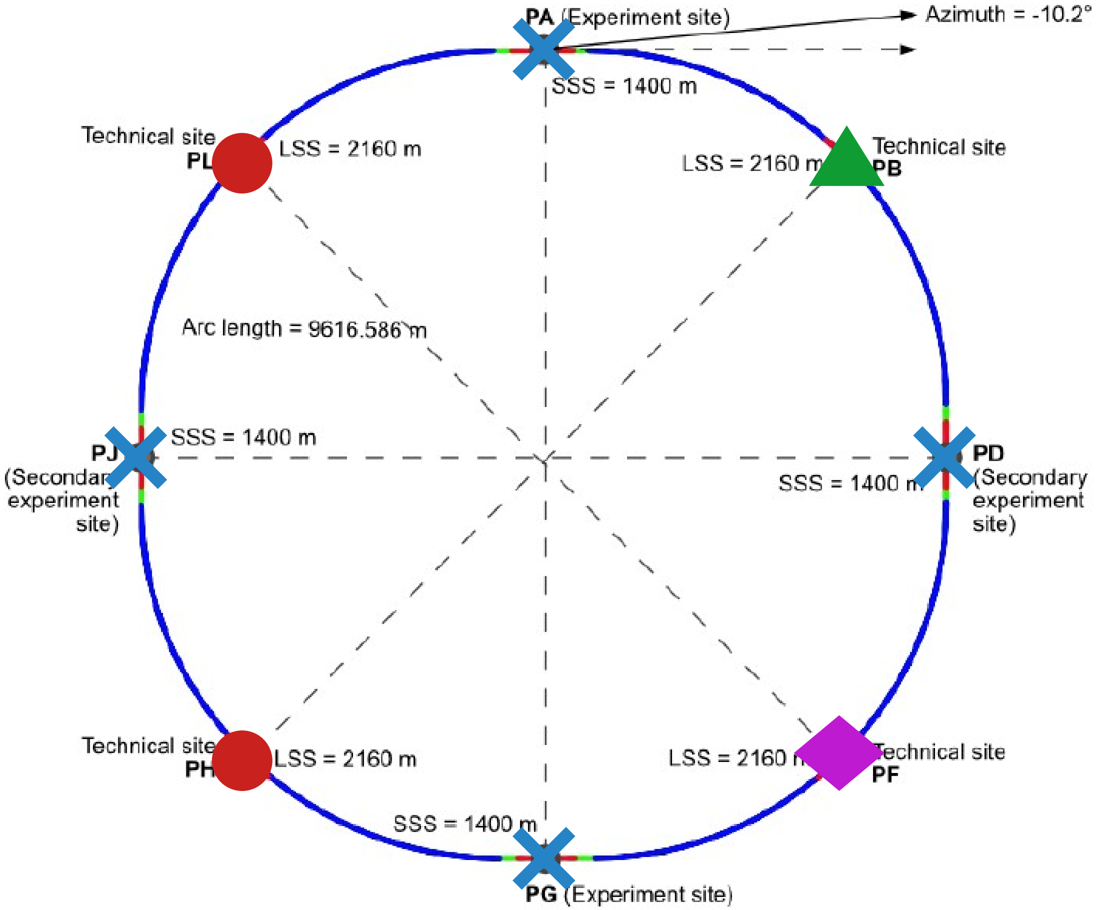
09:00	**FCC-ee parameter optimisation**	*Dmitry Shatilov*	*CICSU*	09:00 - 09:30
	Baseline optics and layout of the FCC-ee collider ring	*Michael Hofer*	*CICSU*	09:30 - 09:50
10:00	**Optics correction studies**	*Tessa Charles*	*CICSU*	09:50 - 10:10
	Top-up Injection into the FCC-ee Collider Ring	*Patrick James Hunchak*	*CICSU*	10:10 - 10:30


Top-up Injection Schemes


Yulei Zhang

FCC-ee Baseline

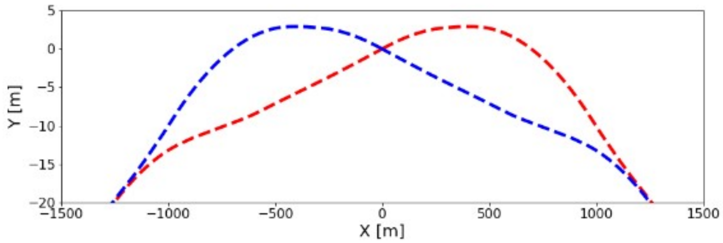
- 4 Interaction Points (IPs)
- 1-2 RF-sections
- Top-up injection and Beam extraction system
- Collimation system

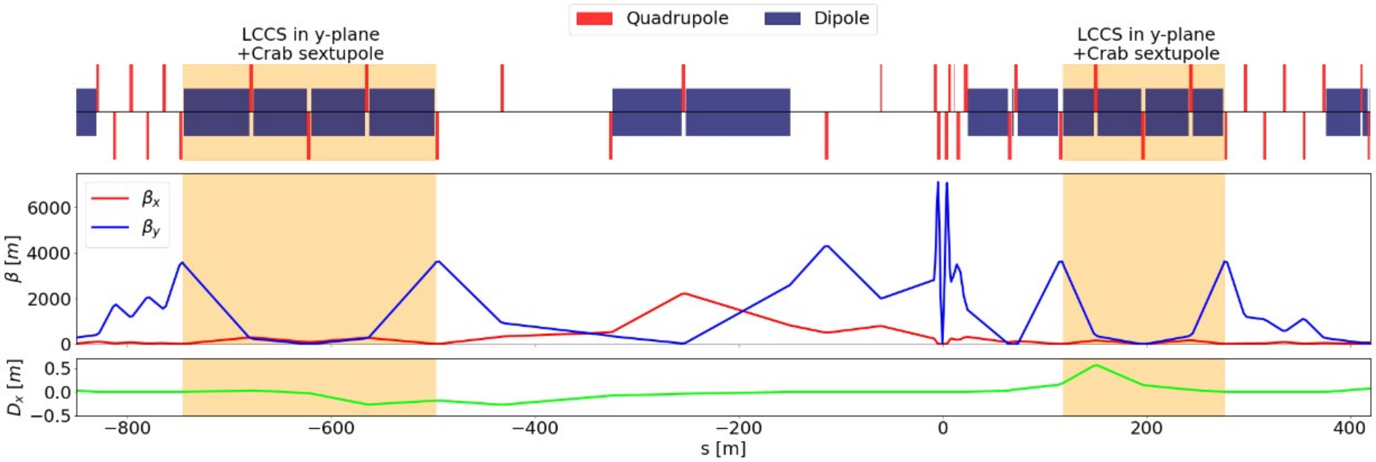


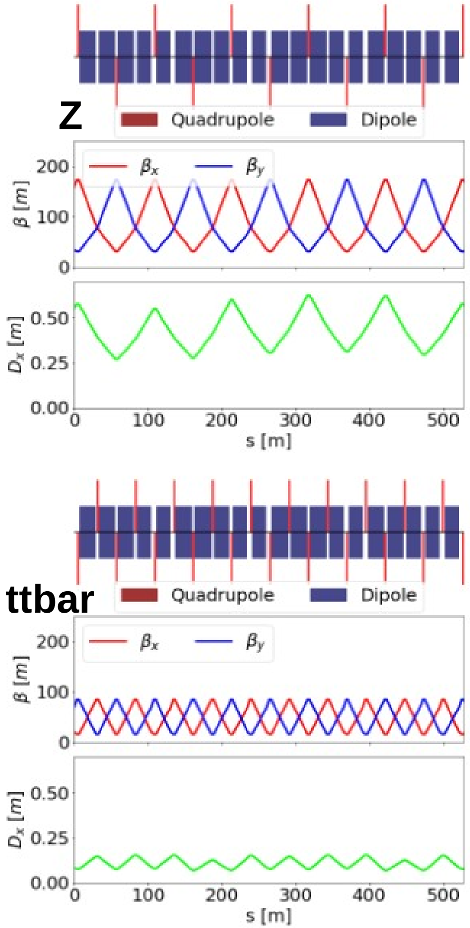
FCC-ee Baseline

M. Hofer, K. Oide

- 90°/90° arc cells for all energy stages, fewer quadrupoles at Z
- Crossing outwards the ring at all IPs to avoid impact of synchrotron radiation







FCC-ee Baseline

M. Hofer, K. Oide

- New Version V22
- Can be found on Gitlab:

  https://gitlab.cern.ch/acc-models/acc-models-fcc.git

- **Changes wrt CDR:**
- Lower circumference
- 4 IPs instead of 2 IPs
- Smaller β_x at Z-pole

Operation mode	Z (45.6 GeV)		$t\bar{t}$ (182.5 GeV)	
	V22.2	CDR	V22.2	CDR
Circumference [km]	91.17	97.75	91.17	97.75
Bending radius of main dipoles [km]	9.937	10.76	9.937	10.76
Energy loss/turn [GeV]	0.0391	0.036	10.0	9.2
Bunches/beam	10000	16640	40	48
Bunch population [10^{11}]	2.43	1.7	2.37	2.3
Hor. Emittance [nm]	0.71	0.27	1.49	1.46
Ver. Emittance [pm]	1.42	1.0	2.98	2.9
β_x^*/β_y^*[mm]	100/0.8	150/0.8	1000/1.6	1000/1.6
Luminosity/IP [$10^{34} cm^{-2} s^{-1}$]	182	230	1.24	1.5

D. Shatilov

FCC-ee Parameter Optimization

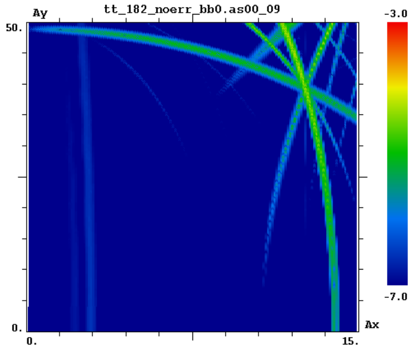
- Beam-beam parameter optimization ξy important
- Beamstrahlung leads to local bending radius at the IP
- At Z-, WW- and ZH-lattice :
  - 90°/90° optics for larger momentum compaction
  - Decrease of βy* to 10 cm from 15 cm
  - Larger RF-voltage to increase synchrotron tune to mitigate TMCI
- At ttbar-lattice: Luminosity limited by beamstrahlung photons → increase βx* to 1 m
- Lattice errors enhance resonances, e.g. footprint
- 2 IP simpler (commissioning, tolerances, etc.) compared to 4 IP lattice
- CDR Integrated luminosity perhaps not achievable with errors for 2 IPs, to be studied in detail for 4 IPs

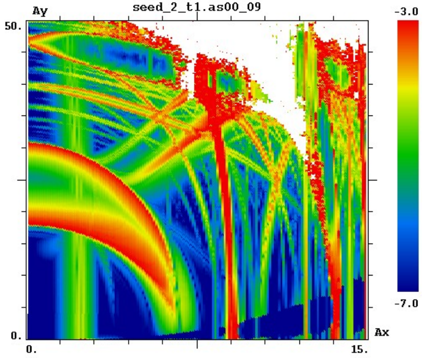
Bending radius in the field of the opposite bunch

surface density

$$\frac{1}{\rho_{\min}} \propto \frac{N_p}{\gamma \sigma_x \sigma_z} \propto \frac{\xi_y}{\sqrt{\beta_x^* \beta_y^*}} \sqrt{\frac{\varepsilon_y}{\varepsilon_x}}$$

0.002





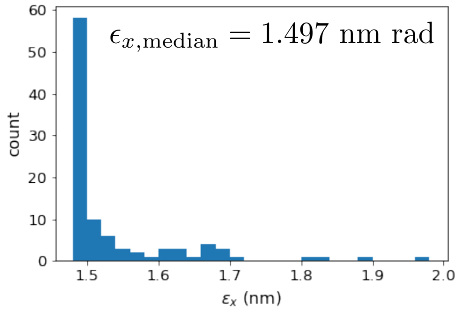
Optics Correction Studies

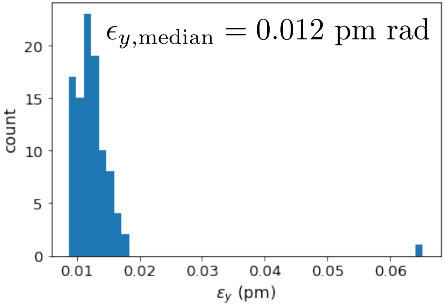
T. Charles

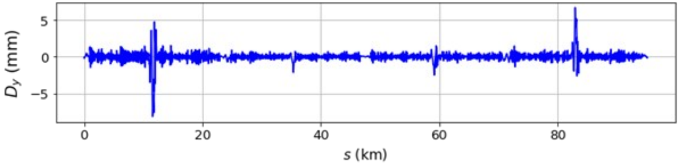
- Gaussian distribution misalignment and optics errors applied to elements
- Linear optics very well corrected, sextupole strengths increased slowly

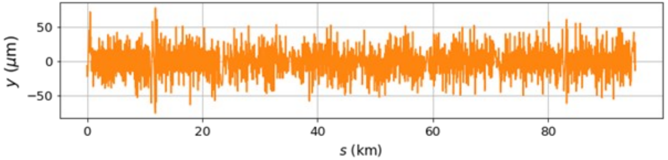
Values not final

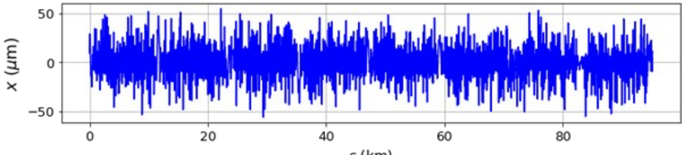
Type	ΔX (μm)	ΔY (μm)	ΔPSI (μrad)	ΔS (μm)	ΔDTHETA (μrad)	ΔDPHI (μrad)	Field Errors
Arc quadrupole*	50	50	300	150	100	100	$\Delta k/k = 2 \times 10^{-4}$
Arc sextupoles*	50	50	300	150	100	100	$\Delta k/k = 2 \times 10^{-4}$
Dipoles	1000	1000	300	1000	0	0	$\Delta B/B = 1 \times 10^{-4}$
Girders	150	150	-	1000	-	-	-
IR quadrupole	100	100	250	250	100	100	$\Delta k/k = 2 \times 10^{-4}$
IR sextupoles	100	100	250	250	100	100	$\Delta k/k = 2 \times 10^{-4}$

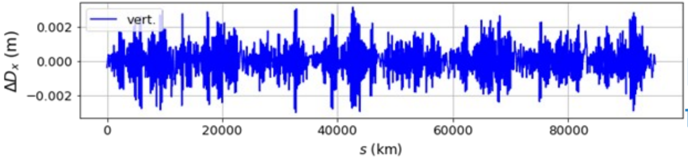










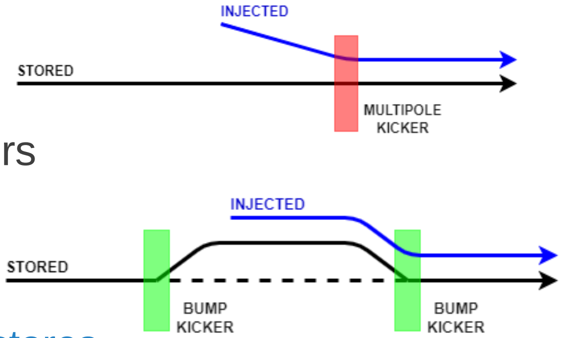


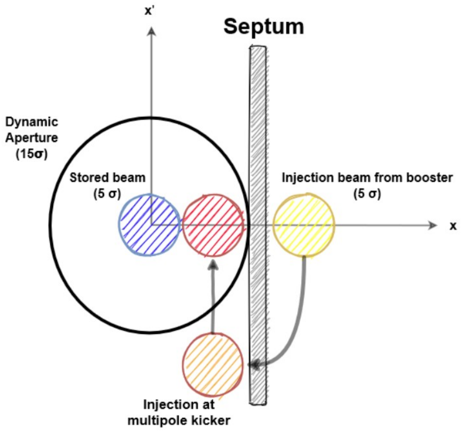
Final emittances after optics tuning at ttbar for 100 seeds

Top-Up Injection

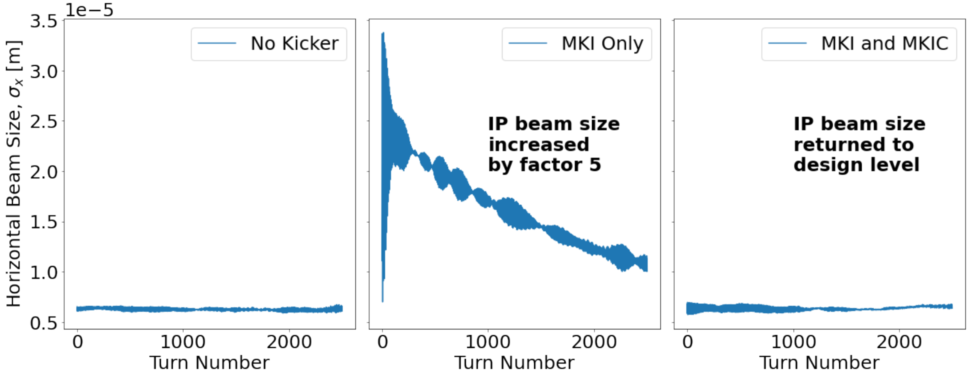
P. Hunchak

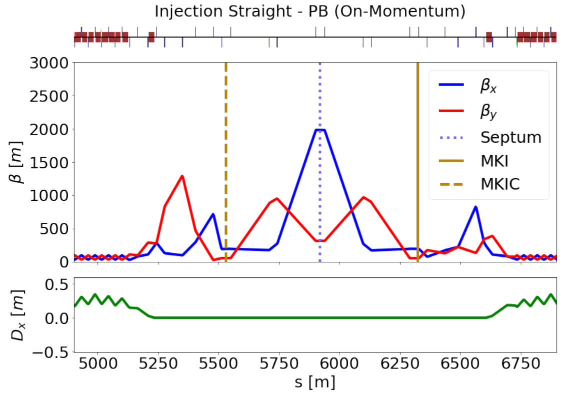
- Multipole Kicker Injection (MKI)
  - On- and off-momentum injection
  - 180° phase advance between kickers
  - Large optics at injection point
- Conventional orbit bump also studied





Using MKI with correction magent restores beam at IP to desired size





FCC-ee Accelerator II, Tuesday 31st June

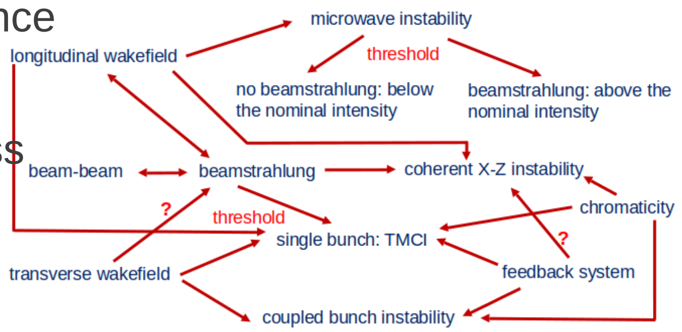
11:00	**Single-beam collective effects** *Room 105, CICSU*	*Mauro Migliorati* 11:00 - 11:20
	Single-bunch instabilities *Room 105, CICSU*	*Emanuela Carideo* 11:20 - 11:35
	Resistive-wall impedance *Room 105, CICSU*	*Ali Rajabi* 11:35 - 11:55
12:00	**Combined effect beam-beam & impedance** *Room 105, CICSU*	*Yuan Zhang* 11:55 - 12:15
	Recent Advances on the FCC-ee Electron Cloud Build-up Studies *Room 105, CICSU*	*Dr Fatih Yaman* 12:15 - 12:30

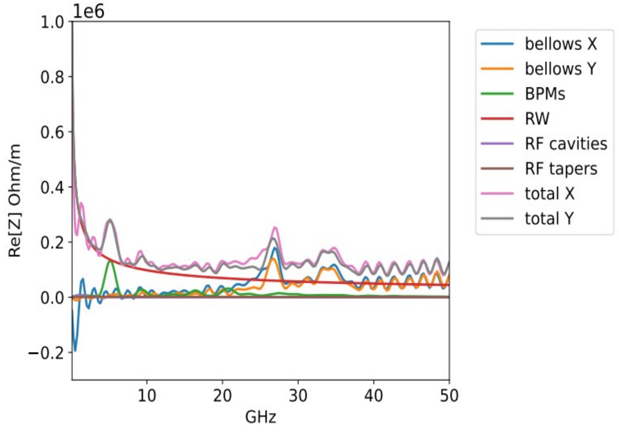
Single Beam Collective Effects

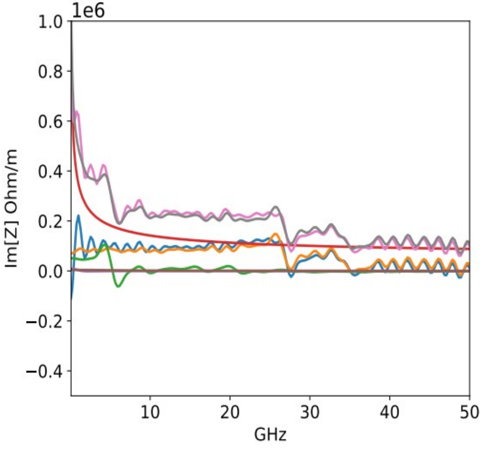
M. Migliorati

- Z-lattice most critical in terms of impedance
- **Resistive wall and bellows main contributors** to impedance
- Resistive wall impedance
  - Neg and copper coating, Im increases with Neg thickness
- Detailed impedance model for Bellows (~20 000)

Interplay between different collective effects for FCC-ee (mainly single bunch) that we have analysed so far







Complex interplay of collective effects with optics (tune, chromaticity,…) etc. and must be studied for the FCC-ee

Impedance model constantly updated
Not yet all contributors included (collimation, vacuum flanges, …)

Need to find mitigation strategies

Single Beam Collective Effects

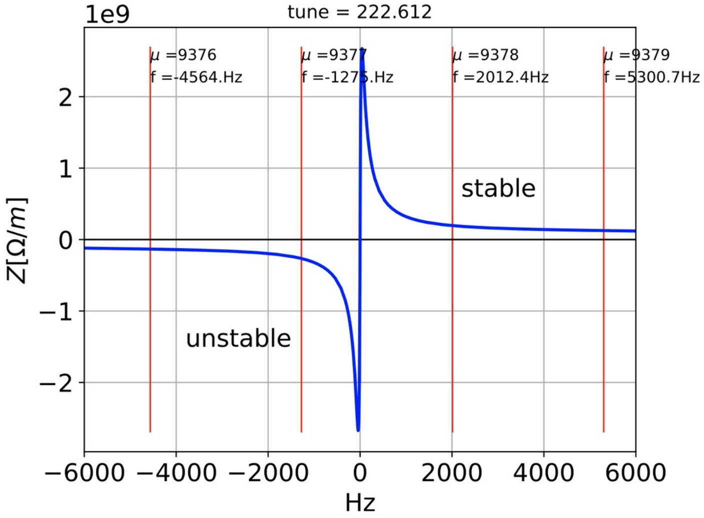
M. Migliorati

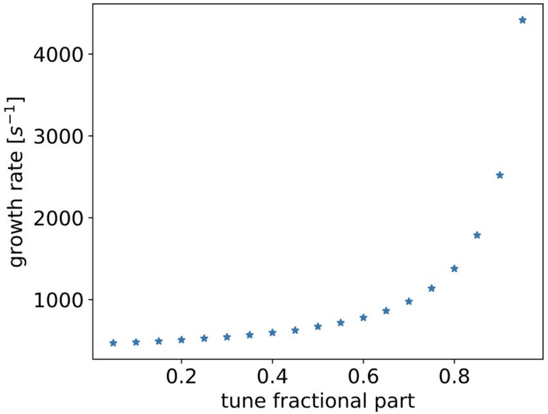
- Growth times about 6 turns → maybe one feedback system not sufficient, or to be optimized
- Impact of feedback system on instabilities to be studied

PHYSICAL REVIEW ACCELERATORS AND BEAMS **24**, 041003 (2021)

Imaginary tune split and repulsion single-bunch instability mechanism in the presence of a resistive transverse damper and its mitigation

E. Métral





[…] However, a resistive transverse damper also destabilizes the single-bunch motion below the transverse mode coupling instability intensity threshold (for zero chromaticity), introducing a new kind of instability, which has been called ITSR instability (for imaginary tune split and repulsion). […]

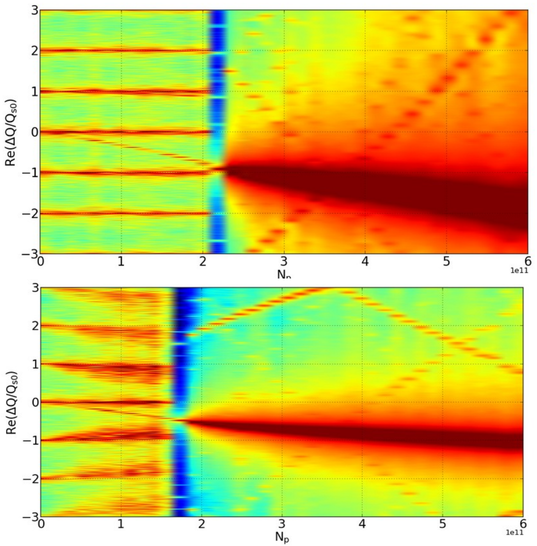
Impedance changes with tune

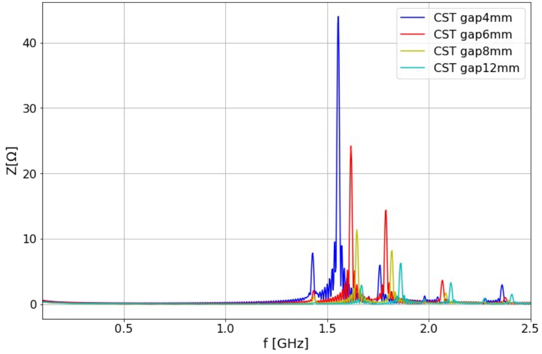
Single Bunch Instabilities

E. Carideo

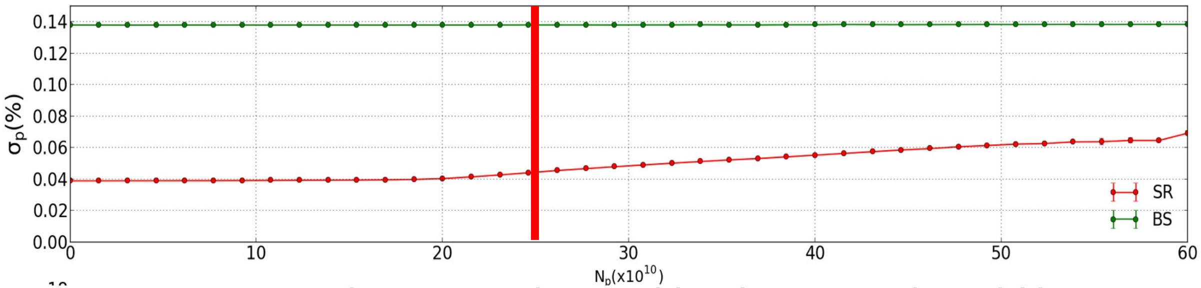
- Wake potentials used to define Green-functions of various impedance sources
- Gitlab repository available: https://gitlab.cern.ch/ecarideo/FCCee_IW_Model

Transverse (top) + longitudinal (bottom) TMCI, with both acceptance reduced
Bunch length 4.37 mm





Impedance model for collimators in progress based on knowledge for HL-LHC, constant at low frequency, non-linear fit for higher frequencies

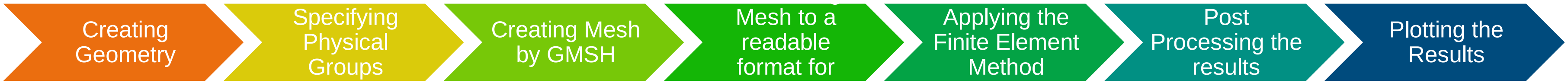


Beamstrahlung can help mitigating TMCI instabiliy

Resistive Wall Impedance

A. Rajabi

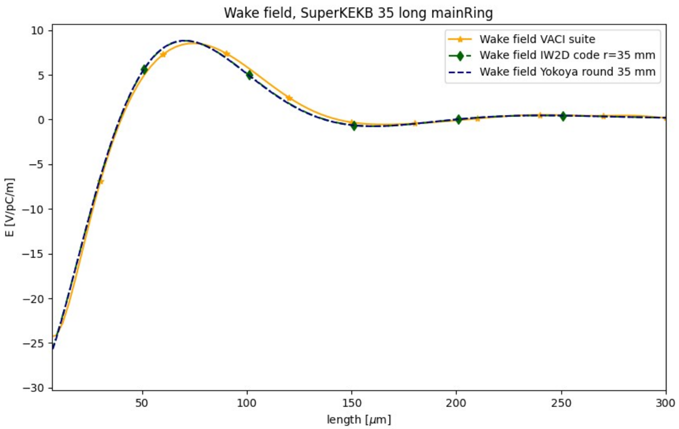
- Code developed: VACI (Vacuum Chamber Impedance suite), solves Maxwell's Equations

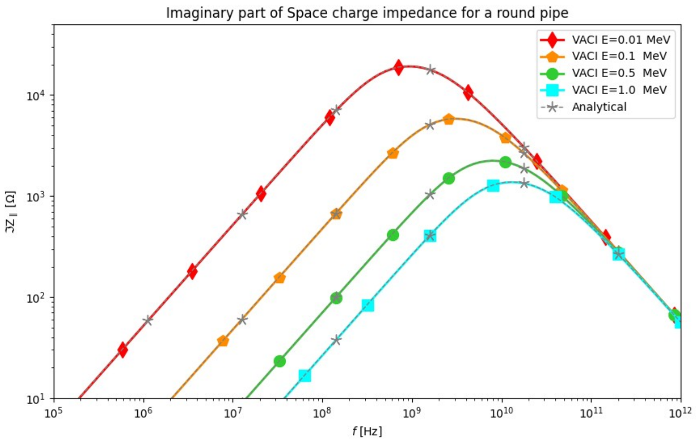


- Wake fields calculated
- Resistive wall impedance calculated

Very good agreement between analytical model and VACI

Copper pipe without NEG coating calculated and in good agreement with other codes

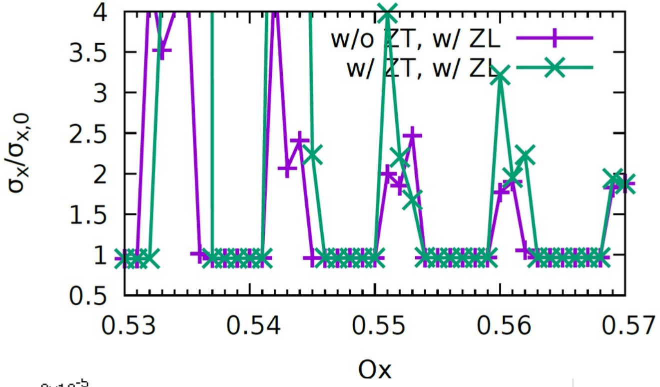




Beam-beam and Impedance

Y. Zhang

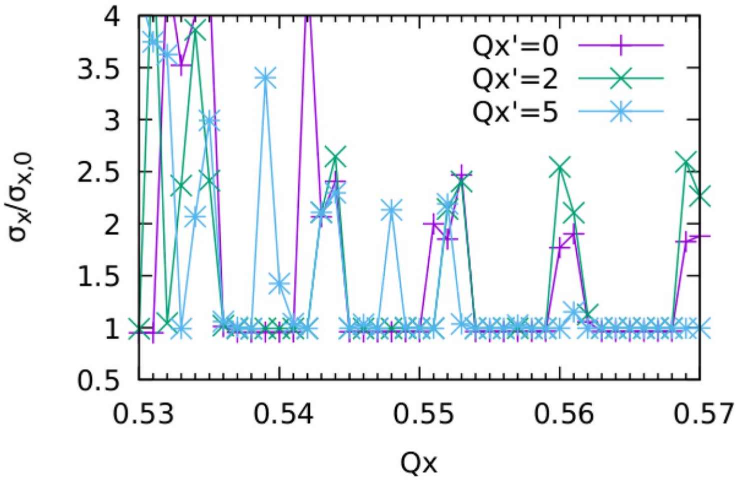
- Instabilities strongly depend on optics parameters

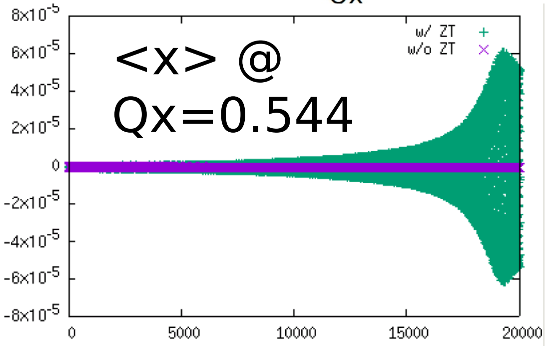


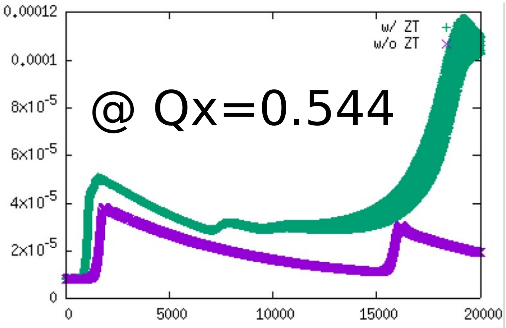
Combined X-Z instability and TMCI

Stability regions equal

Beam size growth





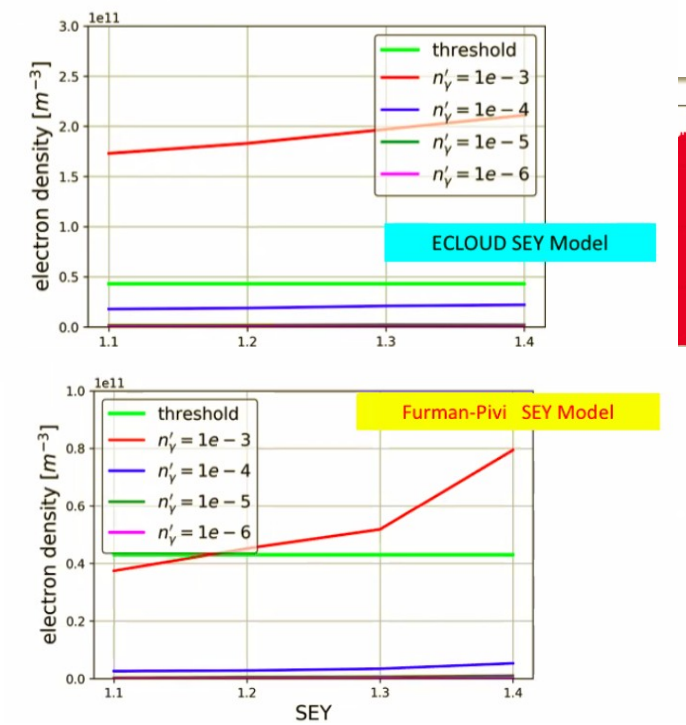


Beam-beam and non-zero chromaticity found to introduce new X-Z instabilites

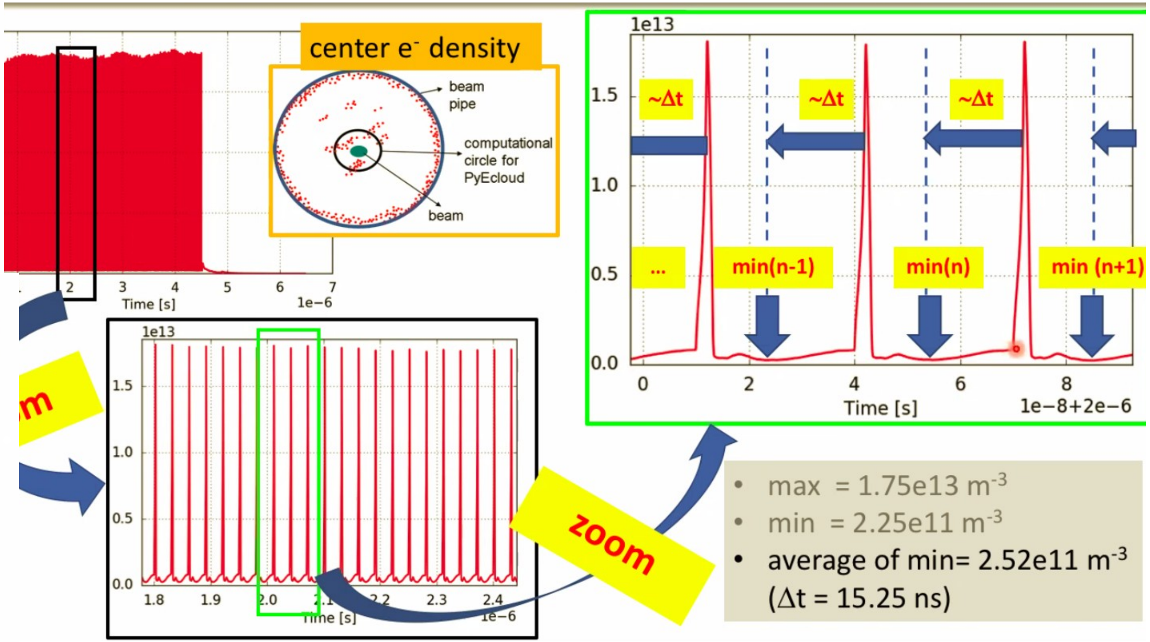
Electron Cloud Build up

F. Yaman

- Simulations performed with PyECLOUD and Furman-Pivi Model



≤ 1.4 SEY and n_γ' = 1x10^{-4} e-/m/e+



FCC-ee Accelerator IV, Wednesday 1st June

14:00	**Correction and tuning** *ROUSSY, Campus des Cordeliers*	*Rogelio Tomas Garcia* 14:00 - 14:20
	Studies of the ground motion induced vibrations in FCC-ee Z mode *ROUSSY, Campus des Cordeliers*	*Eva Montbarbon* 14:20 - 14:40
	Alignment network error propagation and alignment examples *ROUSSY, Campus des Cordeliers*	*Georg Gassner* 14:40 - 15:05
15:00	**ESRF optics correction tools** *ROUSSY, Campus des Cordeliers*	*Simone Liuzzo* 15:05 - 15:30

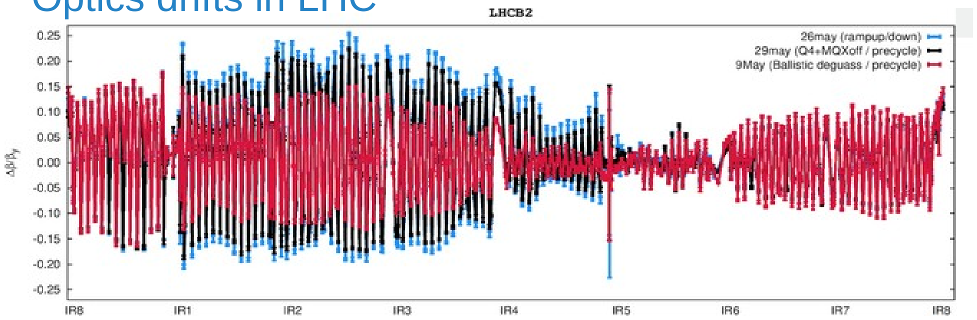
Correction and Tuning

R. Tomas

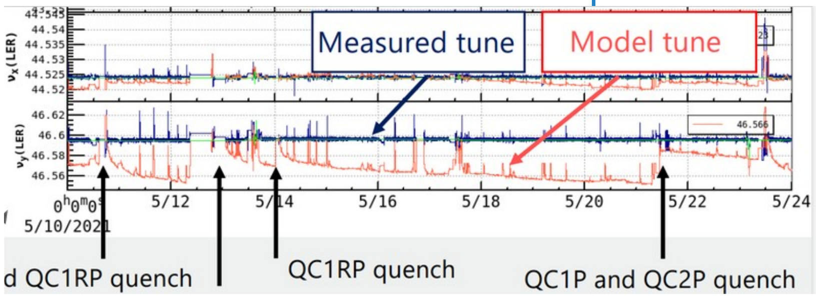
- Optics drifts also in LHC and SuperKEKB → fast and efficient tuning required for FCC-ee

Understanding and optimizing SuperKEKB is inevitable for FCC-ee

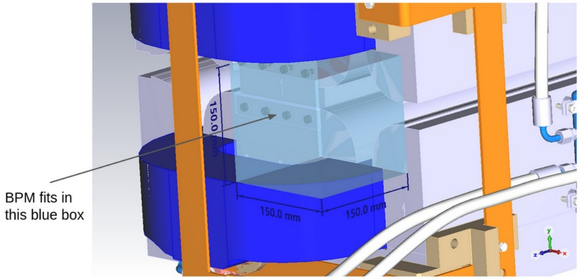
Optics drifts in LHC



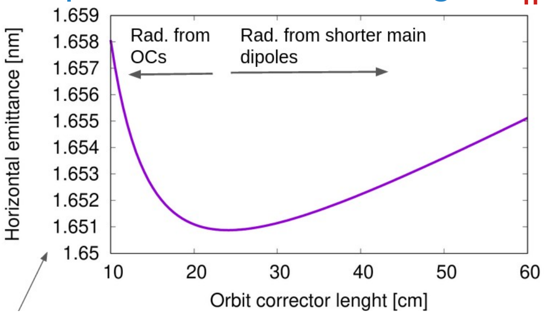
Tune drifts in SuperKEKB



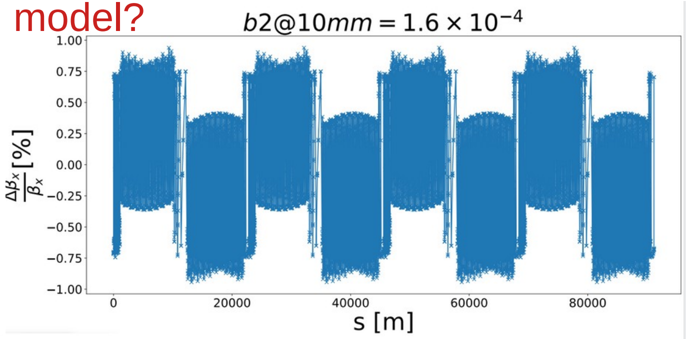
No extra space for BPMs



25cm optimum corrector length



Should systematic b2-errors be included in model?



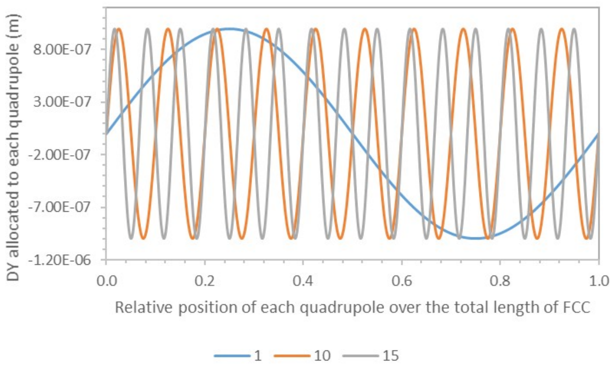
Ground Motion Induced Vibration

E. Montbarbon

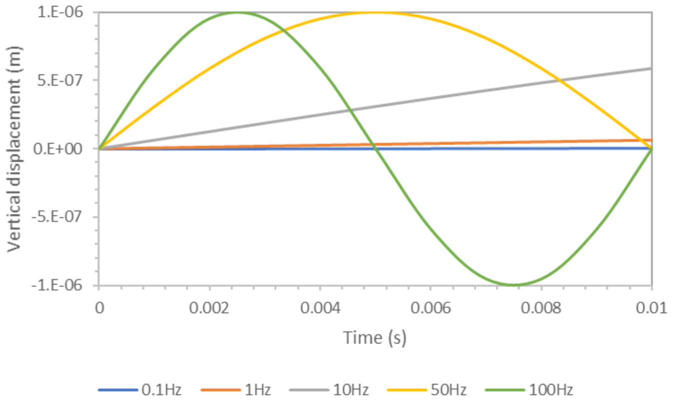
- Aim to link beam optics to mechanical design
- Aim to quantify impact of vibrating MDI quadrupoles on beam characteristics
- Additional error to optics tuning studies

How to other contributions (ocean, tides, etc.) impact the optics?

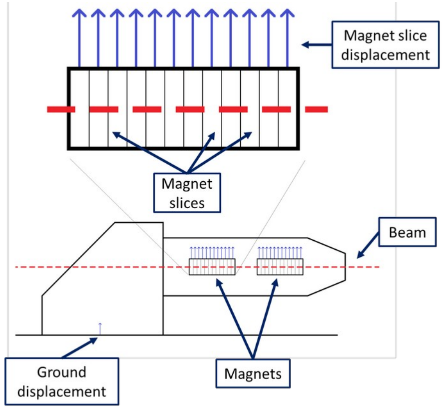
Effect of plane ground waves on the closed orbit



Impact of time dependent vibrations in single MDI magnet



For the Z-lattice with smallest β*



Magnets — From only one quadrupole to all quadrupoles of the MDI region

Vertical vibration — From a vertical static alignment to mechanical related vibrations

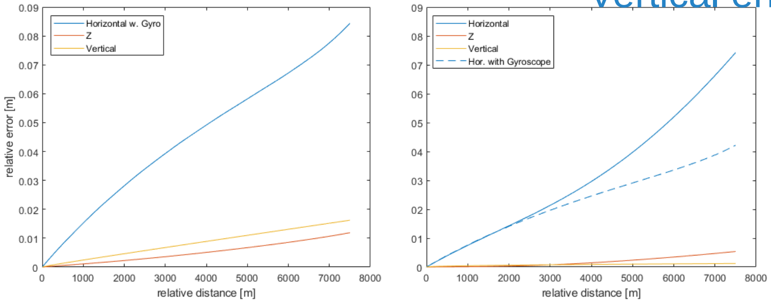
Spatial coherence — From no coherence to coherence between quadrupoles

Alignment

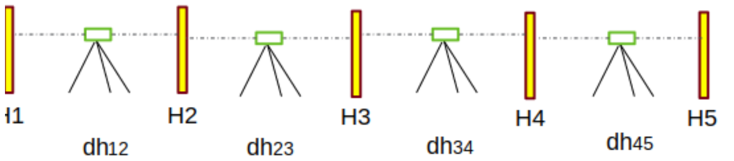
G. Gassner

- Typically randomly distributed alignment errors presumed, however:
- A lot of errors are not random (environment, refraction, instrument errors, etc.)

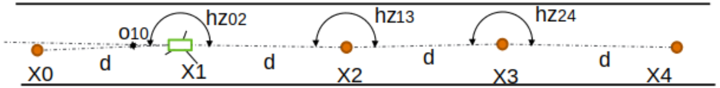
Left: only random errors
Right: part of errors not random



Vertical errors add up linearly, measurement no issue



Horizontal errors add up quadratically, challenging, needs additional system



FCC tunnel will have unique alignment challenges

311 Laser Tracker (Leica AT401/402) setups with 5082 measurements

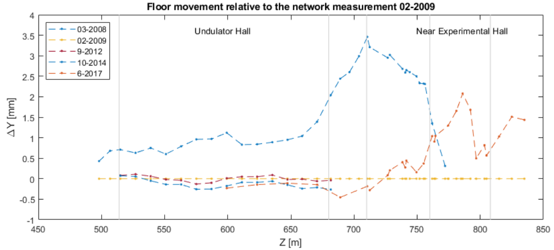
577 Height differences (Leica DNA03)

200 Linac Light Pipe readings

(3km - 6 weeks with 1 crew (2-person)

->100km –> 200 weeks 1 crew + above ground network)

Tunnel moves, especially after construction



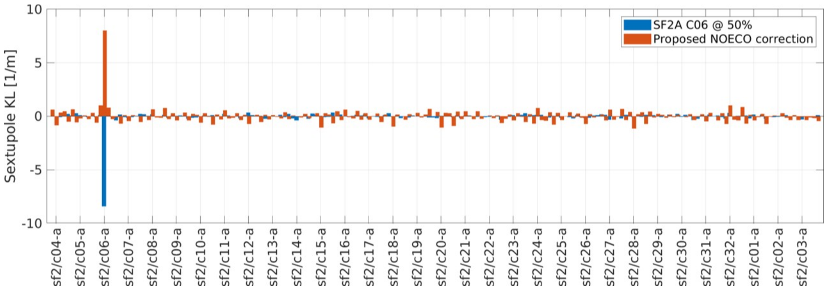
How can beam based alignment help?

ESRF Optics Correction Tools

S. Liuzzo

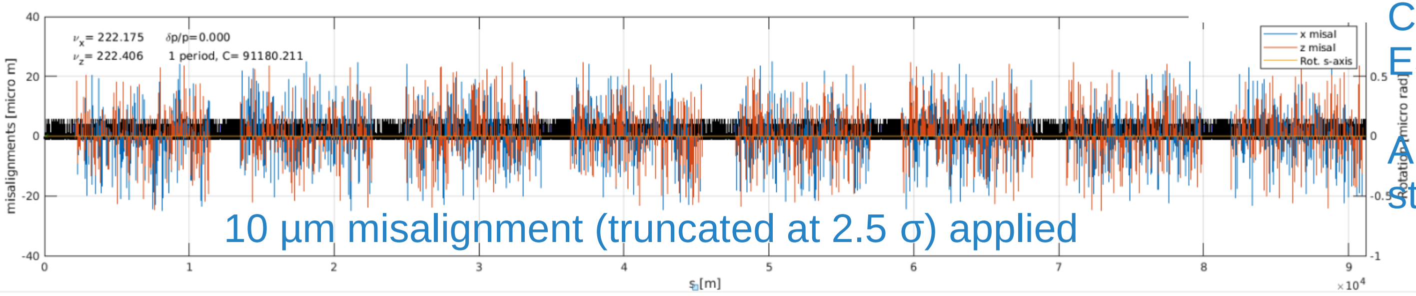
- ESRF tooles used to start simulating FCC-ee commissioning

PHYSICAL REVIEW ACCELERATORS AND BEAMS 23, 102803 (2020)



Compute sextupole correction strengths based on off-energy Fast-RM and dispersion measurement in ESRF

```
open trajectory (steerers) Tikhonov
tune (quadrupoles, 2 families)
RF cavity
orbit (steerers) Tikhonov
tune (quadrupoles, 2 families)
chromaticity (sextupoles, 2 families)
orbit (steerers) Tikhonov
tune (quadrupoles, 2 families)
chromaticity (sextupoles, 2 families)
Fit Quad+Dip Errors
Correct RDT and Dispersion of fitted model
orbit (steerers) Tikhonov
tune (quadrupoles, 2 families)
chromaticity (sextupoles, 2 families)
Fit Quad+Dip Errors
Correct RDT and Dispersion of fitted model
RF cavity
tune (quadrupoles, 2 families)
```



10 µm misalignment (truncated at 2.5 σ) applied

Correction strategy for ESRF applied to FCC-ee

Allows to correct optics and study DA, MA, etc…

FCC-ee Accelerator V, Wednesday 1st June

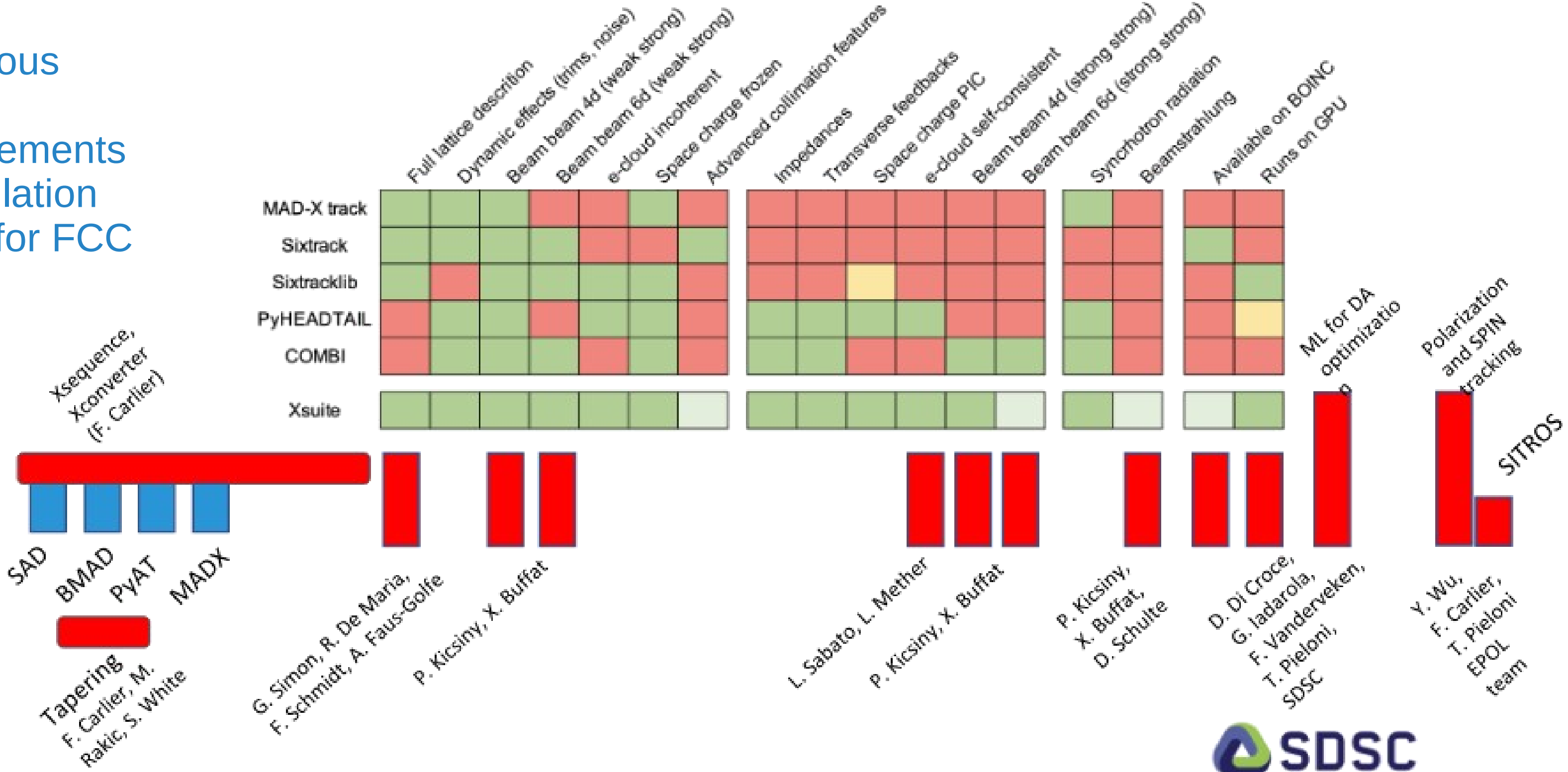
16:00	**Overview of the Software framework and developments for the FCC-ee** *ROUSSY, Campus des Cordeliers*	*Felix Simon Carlier et al.* 16:00 - 16:15
	Simulations of FCC-ee beam-beam effects with xsuite *ROUSSY, Campus des Cordeliers*	*Peter Kicsiny* 16:15 - 16:30
	MAD-X progress *ROUSSY, Campus des Cordeliers*	*Riccardo De Maria* 16:30 - 16:45
	FCC-ee Collimation Studies *ROUSSY, Campus des Cordeliers*	*Andrey Abramov* 16:45 - 17:00
17:00	**MAD-X benchmarking and solenoid models** *ROUSSY, Campus des Cordeliers*	*Leon Van Riesen-Haupt* 17:00 - 17:15
	IR solenoid modelling *ROUSSY, Campus des Cordeliers*	*Helmut Burkhardt* 17:15 - 17:30

Software Framework for the FCC-ee

T. Pieloni

- Reliable software required for FCC design; XSUITE: New python framework

Numerous recent improvements in simulation codes for FCC

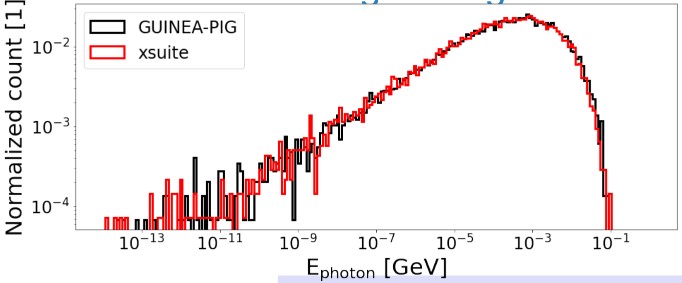


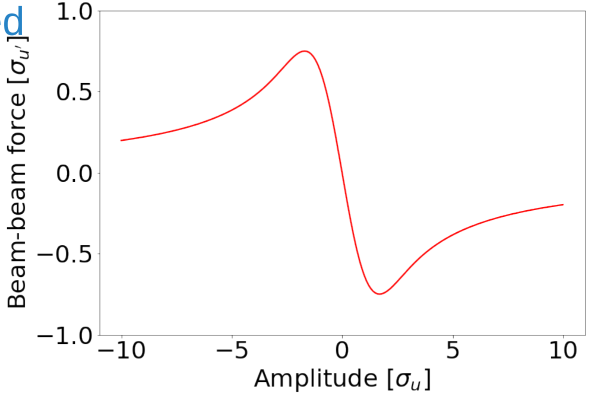
FCC-ee Beam-Beam Effects

P. Kicsiny

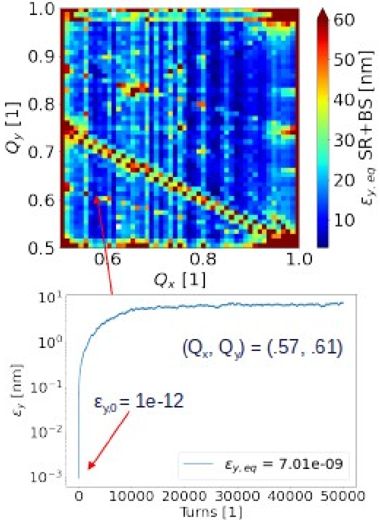
- Beam-beam effects highly non-linear, studied using XSUITE

Beamstrahlung sprectrum benchmarked
Xsuite: weak-strong
GUINEA-PIG: strong-strong





Tune scan and emittance blow-up



Beamstrahlung one of the most limiting factors for the FCC-ee

multi-turn effects	low disruption parameter	high disruption parameter
single particle effects	slow instabilities	fast instabilities, wakefield & lattice interplay

fastest & least accurate ⟷ **slowest & most accurate**

never	**periodically**	**after each slice-slice interaction**
weak-strong [**WS**]	quasi strong-strong [**QSS**]	strong-strong [**SS**]

Frequency of recomputing slice moments

MAD-X Progress

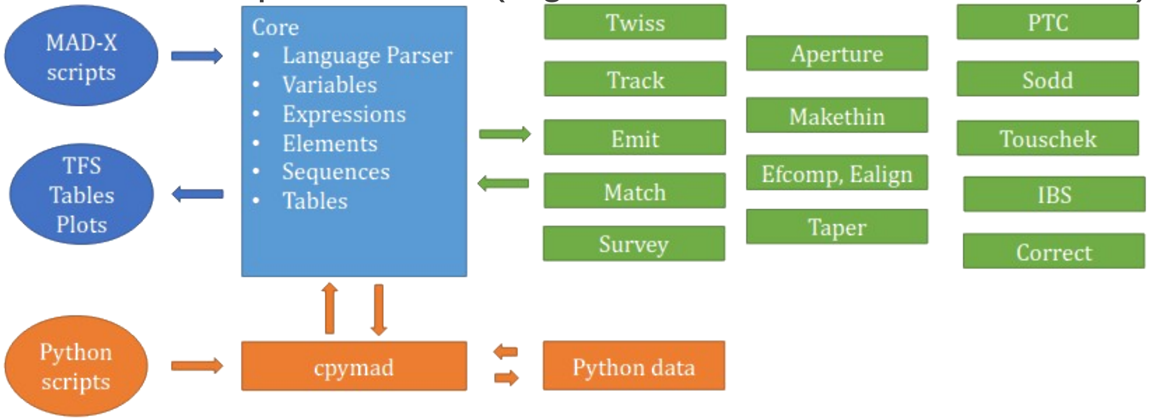
R. de Maria

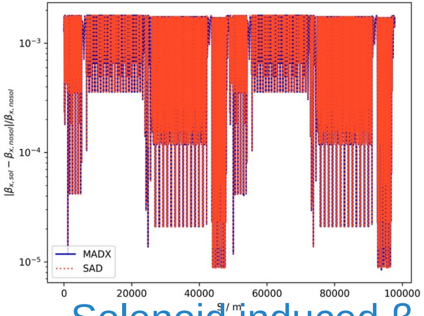
- Code framework since 2002 with continous improvements (e.g. radiation effect benchmarked)

MAD-X is used for all circular accelerators in the CERN complex as well as for linacs.

For FCC, MAD-X should be able to calculated:

- Closed orbit with energy loss with/without tapering (see TWISS, TAPER, CORRECT)
- Undamped lattice functions (TWISS)
- Damping times, equilibrium emittance (EMIT)
- Tracking with energy (without damping, with damping, with quantum excitation
- Build PTC universe and run PTC physics: normal forms, spin (PTC)





Solenoid induced β-beating

MAD-X language
+ fast element manipulation
+ re-use vast existing scripts
+ concise language
- parser is brittle
- often silent errors, crashes
- limited control flow and data structures

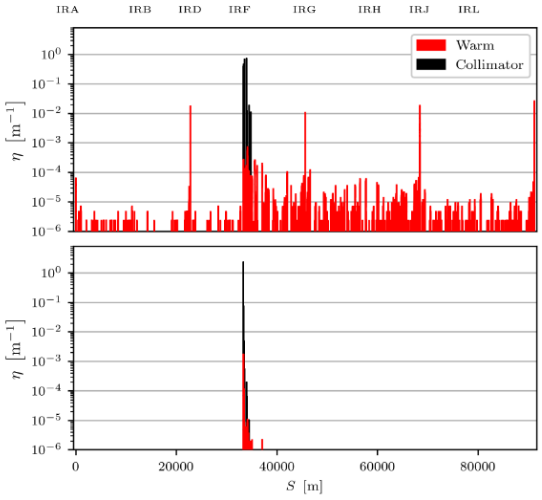
Python
+ well known, flexible and robust
+ easy to run multiple instance of MAD-X
+ seamless integration with the vast Python scientific ecosystem
- slow element manipulation for large machines
- little more verbose

FCC-ee Collimation Studies

A. Abramov

- Stored beam energy in the FCC-ee reaches 20.7 MJ
- Halo (downstream) and betatron (upstream) collimation foreseen in PF

Betatron collimation
182.5 GeV, no radiation or tapering, 5x10^6 primary positrons, 700 turns

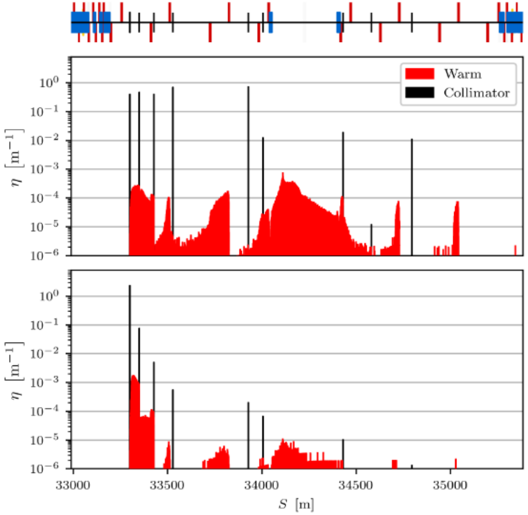


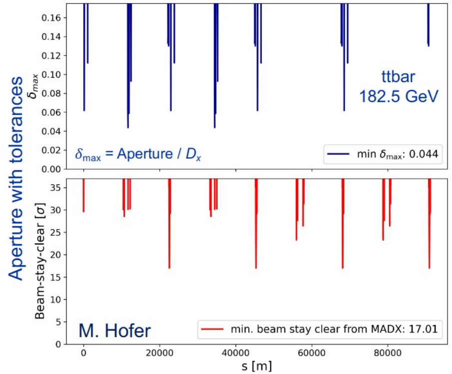
PRELIMINARY

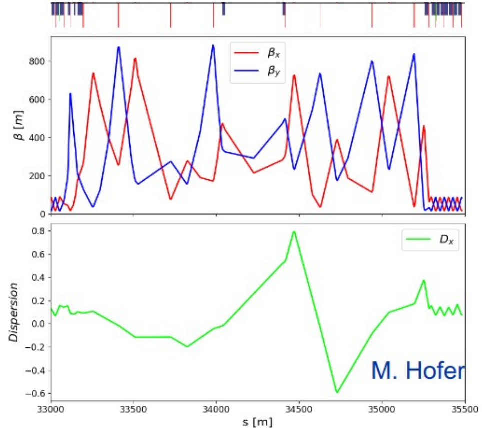
Molybdenum-Graphite primary collimator

Tungsten primary collimator

for comparison only, likely not feasible with with multi-MJ beams







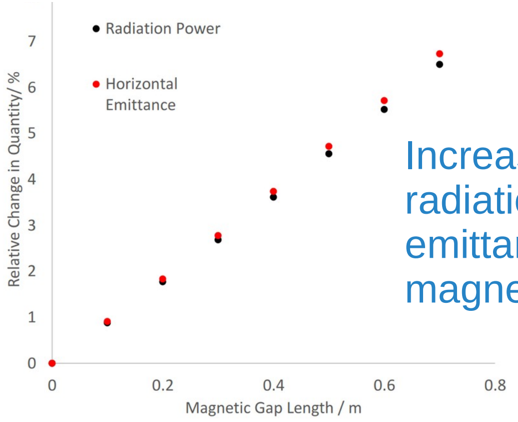
Collimation optics in PF

MAD-X Benchmarking and Solenoid

L. van Riesen-Haupt

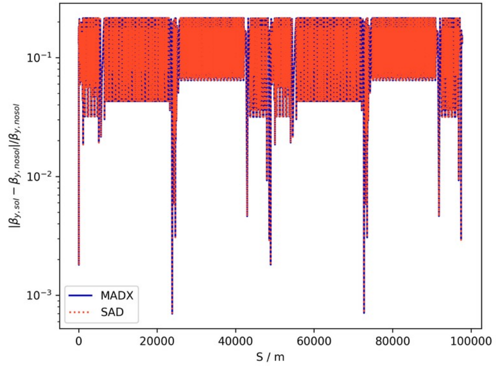
- Aim to implement tilted solenoid in MAD-X
- Making the current lattice more realtistic ongoing
  - Split large dipoles into smaller ones
  - No significant orbit or optics change
  - About 3% increase of radiation and emittance

Method	Benefits	Drawbacks
Misalignment of Solenoid Implemented like alignment errors	• Very simple • No need to change lattice file	• Not SAD layout • Radiation in solenoid currently not correct
Sliced Solenoid interleaved with thin vertical bends angle = vertical dipole field $\theta = k_0 L_{slice} = k_{sol} L_{slice} \sin(\phi/2)$	• Gives correct radiation and emittance calculations	• Lattice has to be heavily modified • Not SAD layout
Tilt through change of coordinate system Rotations and translations at solenoid entrance/exit	• Exact replication of SAD layout • Exact agreement with SAD β, α, μ and horizontal dispersion	• Completely new lattice file from new translator • Rotation (currently) causes strange vertical dispersion • EMIT does not currently work



Increase of radiation and emittance over magnet gap length

SAD tilted solenoid implementation in MAD-X

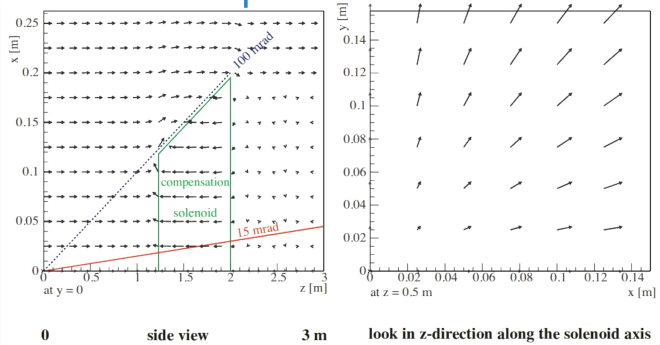


IR Solenoid Modeling

H. Burkhardt

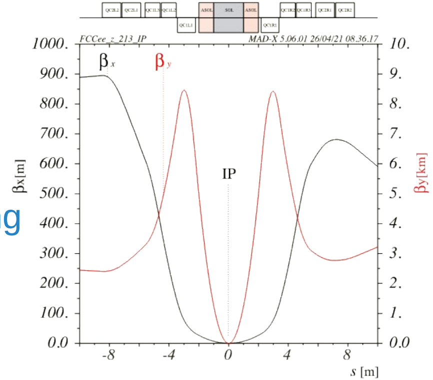
- Highly complex interaction region design for the FCC
- Overlap of solenoid and final focus quadrupoles

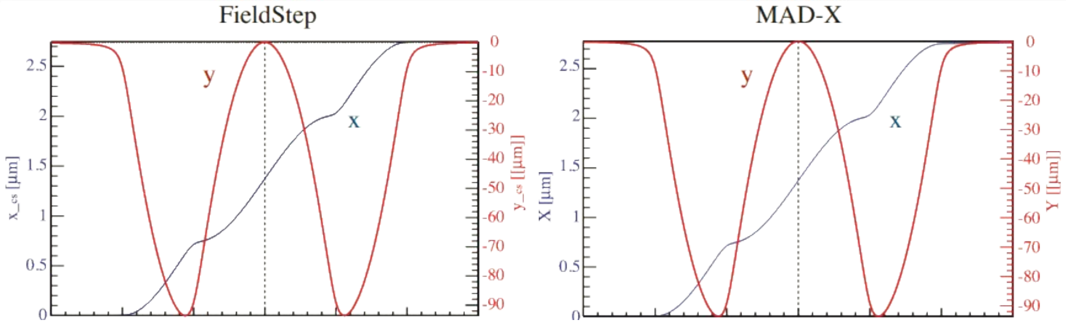
Field map of solenoid



Given B(x, y, z) **the passage through the interaction region can be well modelled on the MAD-X level with orbit correctors** (kicker elements, describing the bump generated by the tilted solenoid detailed fringe fields) **and thin solenoid slices** (coupling + overall focusing)

β-function variation over 7 orders of magnitudes





Thin multipole in MAD-X

$$
\begin{bmatrix}
\cos(\psi) & 0 & \sin(\psi) & 0 & 0 & 0 \\
0 & \cos(\psi) & 0 & \sin(\psi) & 0 & 0 \\
-\sin(\psi) & 0 & \cos(\psi) & 0 & 0 & 0 \\
0 & -\sin(\psi) & 0 & \cos(\psi) & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}
\quad
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 \\
-\frac{1}{f} & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & -\frac{1}{f} & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}
$$

FCC-ee Injectors I, Tuesday 31st June

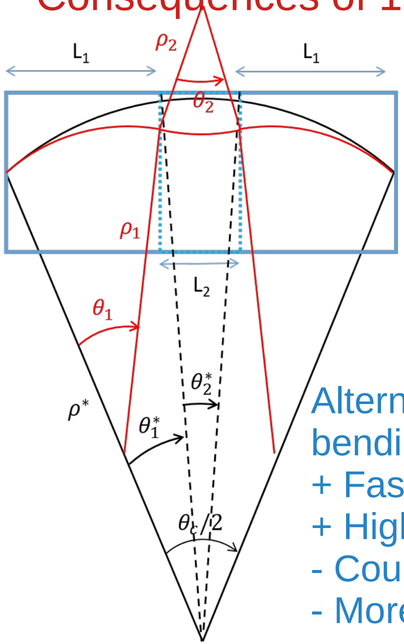
14:00	**Status of the high-energy booster** *Room 105, CICSU*	*Antoine Chance* 14:00 - 14:25
	General pre-injector layout and parameter summary *Room 105, CICSU*	*Paolo Craievich* 14:25 - 14:45
	FCC-ee Linacs design from 200 MeV up to 6 GeV beam energy *Room 105, CICSU*	*Simona Bettoni* 14:45 - 15:00
15:00	**positron Beam dynamics in linac 1** *Room 105, CICSU*	*Mattia Schaer* 15:00 - 15:15
	RF design of traveling-wave structures for the FCCee injector *Room 105, CICSU*	*Hermann Winrich Pommerenke* 15:15 - 15:30

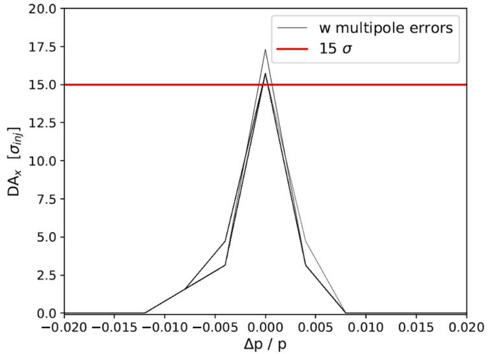
Status of the High-Energy Booster

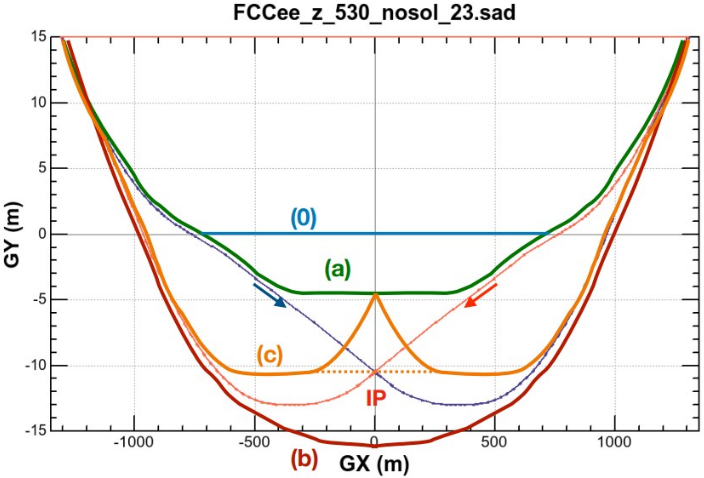
A. Chance

- 60°/60° (Z-, WW-) and 90°/90° (ttbar) optics available
- Dynamic aperture improvements for 90° optics ongoing
- Consequences of 10x smaller inj. emittance to be studied

Various layouts could be considered for the booster bypassing the detectors at the IPs, implications on booster optics and main rings to be studied carefully





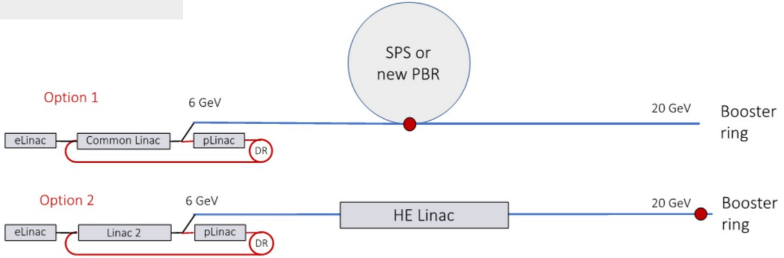


Alternative booster dipoles with two different bending radii; implications on RF to be studied
+ Faster damping without wigglers
+ Higher field at injection
- Could reduce beam stay clear
- More SR in opposite direction

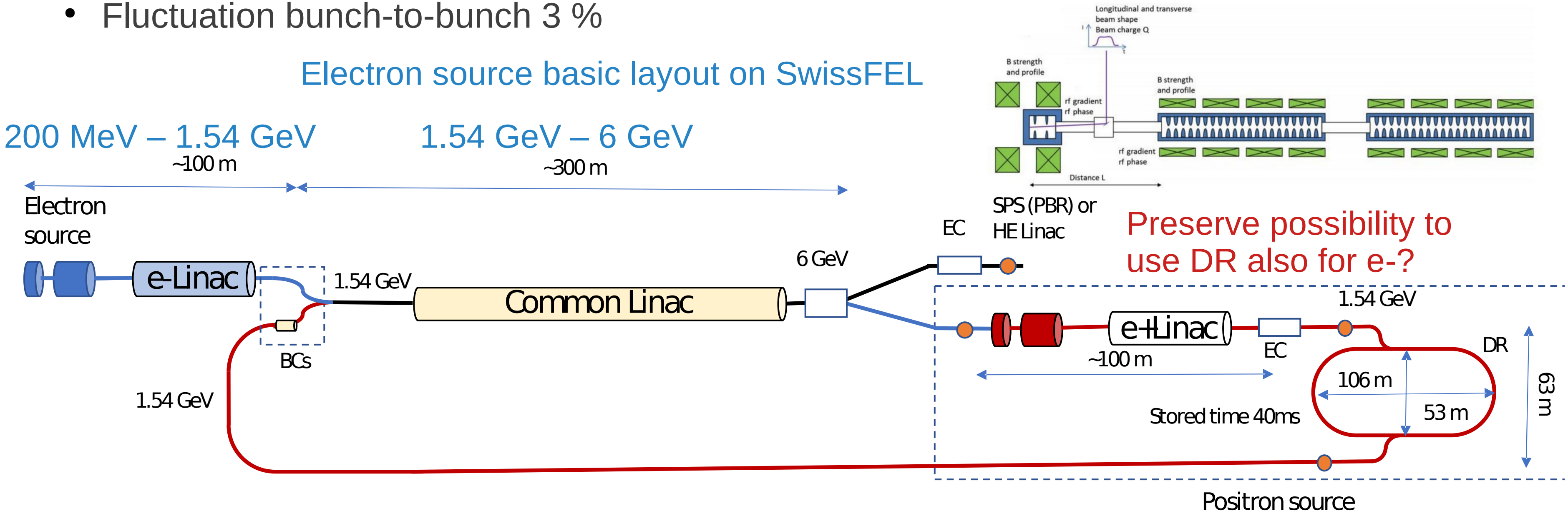
Pre-Injector Layout

P. Craievich

- Two different injector layouts studied
- Important requests:
  - Bunch-by-bunch intensity from 0 – 100 %,
  - Fluctuation bunch-to-bunch 3 %



Electron source basic layout on SwissFEL

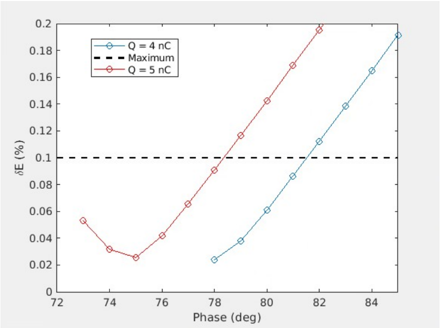


Linac from 200 MeV to 6 GeV

S. Bettoni

- FODO lattice with 90° phase advance
- Studies for determination of working point
- Jitter amplification due to multi-bunch effect
- Aim to decrease energy spread below 0.1%
  - Optimize phase extend
  - Shorter bunch from the gun
  - Bunch compression

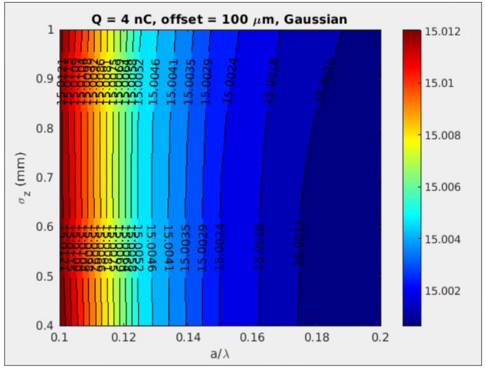
What happens if bunch intensity changes between 0.-100 %?

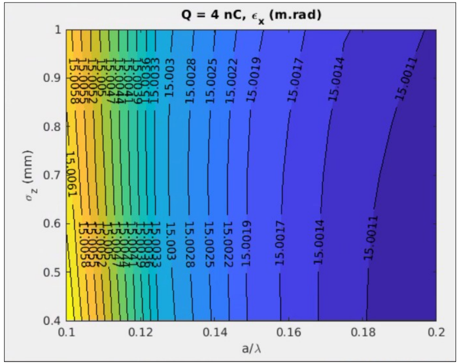


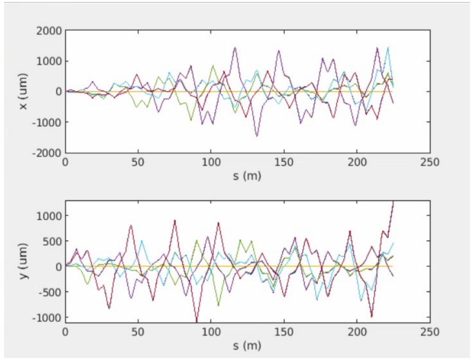
Change of 1 nm will require a phase change of 3°

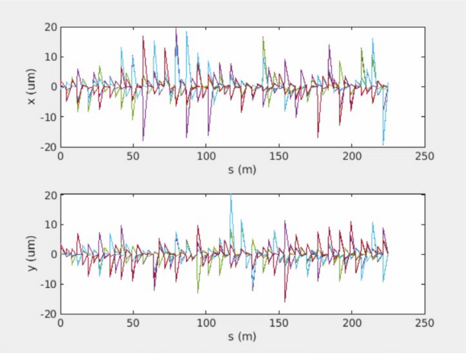
~6 µm rad emittance after linac

Applied errors lead to emittance blow-up and recovered with dedicated corrections





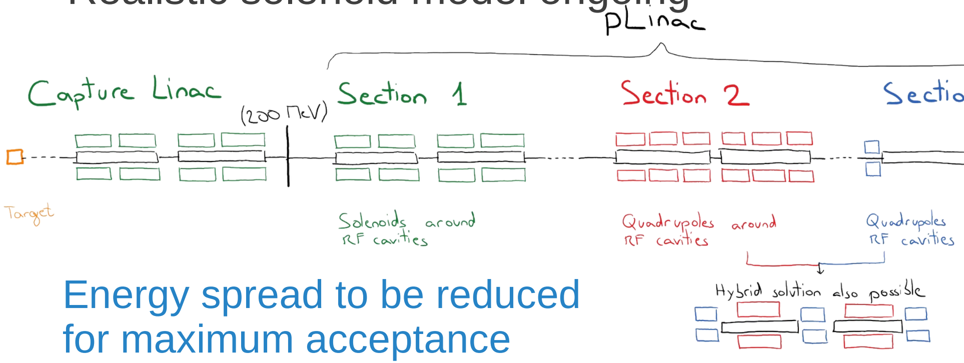




Positron Beam Dynamics in Linac 1

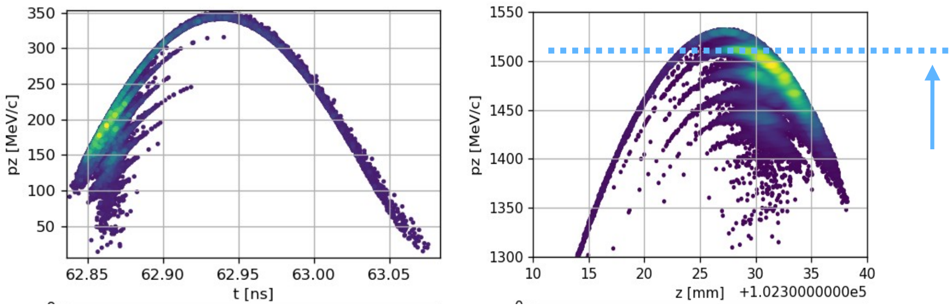
M. Schaer,
A. Latina

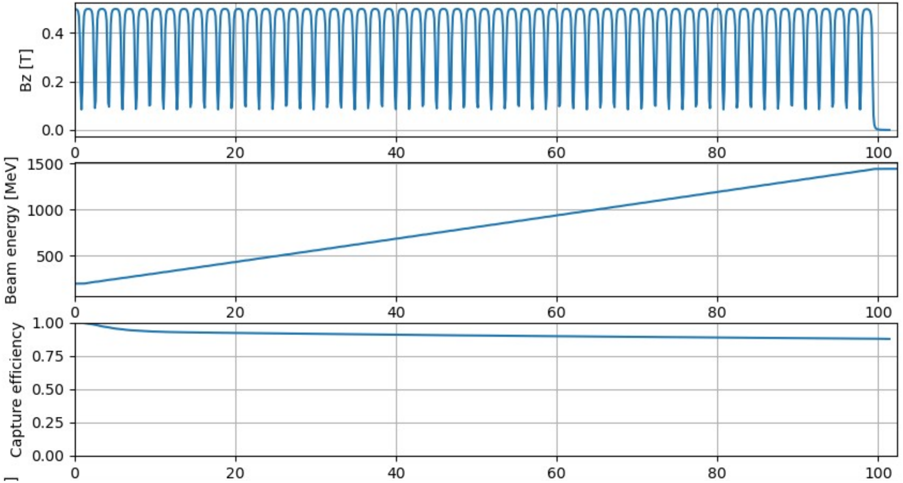
- One of the key challenge huge transverse emittance (10 000 mm mrad)
- Realistic solenoid model ongoing



Solenoids can transport up to 1.54 GeV
Small particle loss during acceleration

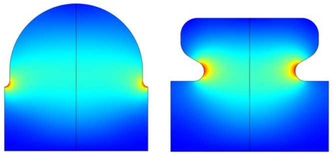
Energy spread to be reduced for maximum acceptance





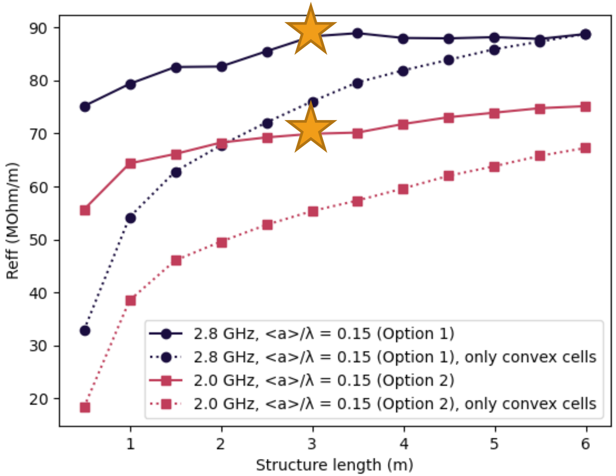
RF Design Traveling Wave Structure

H. Pommerenke

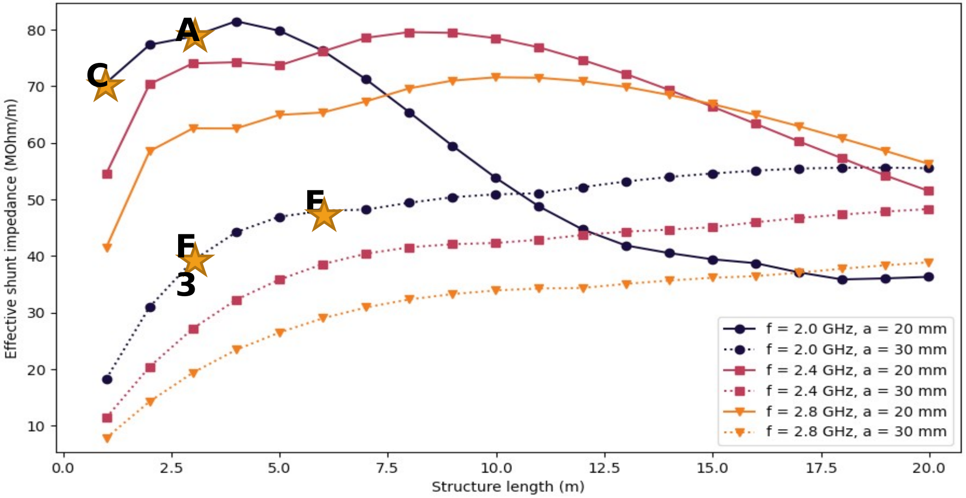


- Convex and reentrant geometries considered, very large parameters phase
- Operated with pulse compressor, e.g. 5 ms puls shortened to 1 ms with larger amplitude

Electron linac, black option (higher frequency, smaller aperture) preferred



Positron linac, L-band linac, 162° phase advance
Optimum structures with low frequencies and large apertures would need to be very long



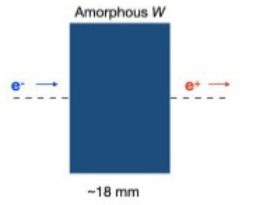
FCC-ee Injectors II, Tuesday 31st June

16:00	**Positron capture simulations of the FCC-ee positron source**	*Mr Yongke Zhao*	
	Room 105, CICSU	16:00 - 16:15	
	Radiation load studies for the FCC-ee positron source with a superconducting matching device	*Barbara Humann*	
	Room 105, CICSU	16:15 - 16:30	
	DR Design	*Antonio De Santis*	
	Room 105, CICSU	16:30 - 16:45	
	HTS solenoids for the PSI Positron production project in the context of the CHART FCCee injector study	*Michal Duda*	
	Room 105, CICSU	16:45 - 17:00	
17:00	**Transfer lines for the FCC-ee injector complex**	*Rebecca Louise Ramjiawan*	
	Room 105, CICSU	17:00 - 17:15	
	The PSI Positron Production Project	*Nicolas Vallis*	
	Room 105, CICSU	17:15 - 17:30	

Y. Zhao

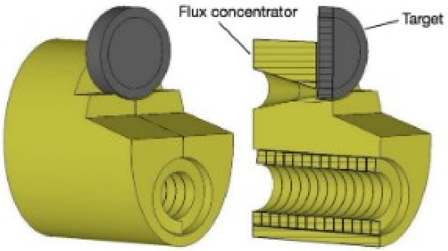
Positron Capture Simulations

- Two possible target schemes
- Afterwards either FC or HTS

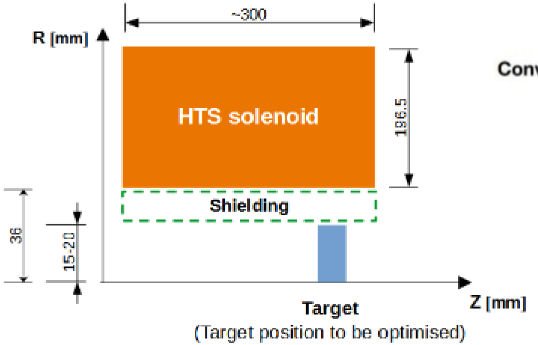


Conventional target scheme

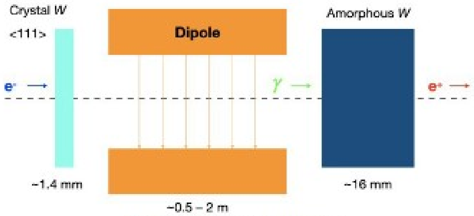
- **Baseline option**
- **High e+ yield**
- PEDD is no more a problem
- **Adopted in this study**



Flux Concentrator (FC)
designed by P. Martyshkin (BINP)



High-Temperature Superconducting (HTS) solenoid
designed by J. Kosse et al. (PSI)



Hybrid target scheme

Compared with HTS solenoid:

- Low peak field (5–7 T, ~1.5–3 T at target exit)
- Small entrance aperture (Φ = 8–16 mm)
- Fixed target position (2–5 mm upstream)
- Therefore, **low e+ yield**

Yield

Compared with FC:

- High peak field (~15 T, ~12 T at target exit)
- Large aperture (Φ = 40 mm)
- Flexible target position (can be placed inside the bore)
- Therefore, **high e+ yield**

Yield

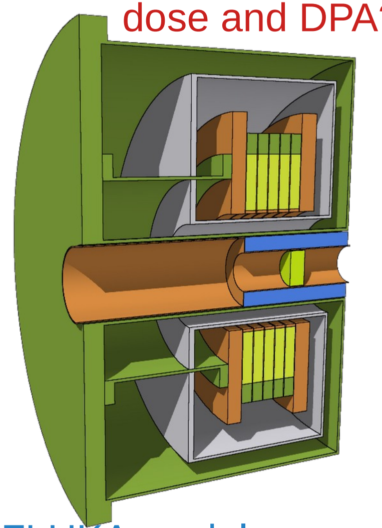
- **Alternative option**, with **potential smaller PEDD and safer radiation and thermal load**, for which the **study is still in progress**
- **Low e+ yield** due to large beam size arriving at the amorphous target
- Therefore, **not adopted in this study**

B. Humann

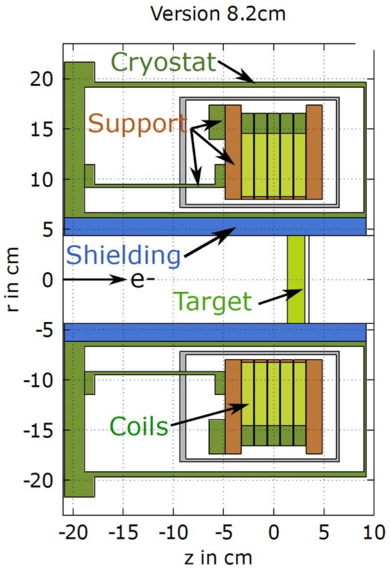
Radiation Load Studies for Positron Source

- Superconducting matching device design based on design in P3

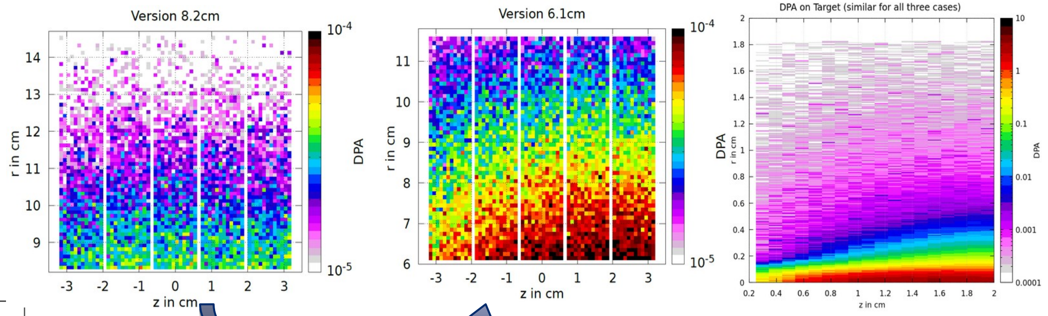
What are the limits on dose and DPA?



FLUKA model
Shielding (blue) varied

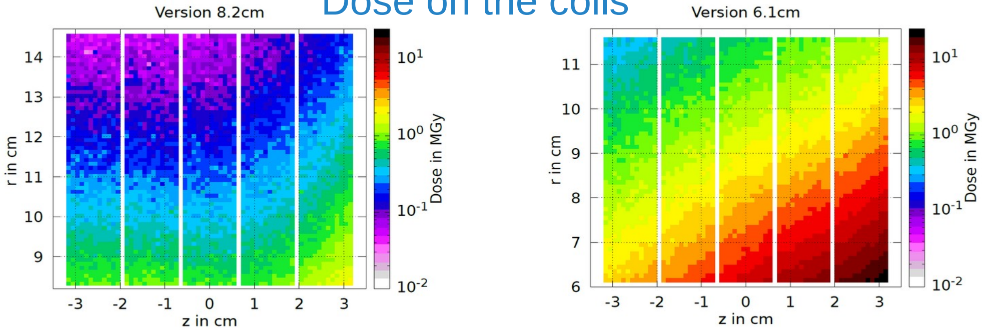


Displacement per Atom



~5x higher

Dose on the coils

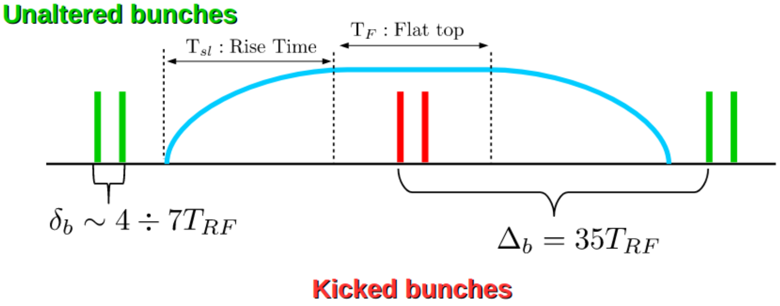


~10x higher

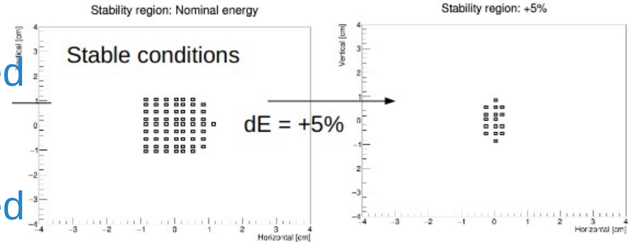
Damping Ring Design

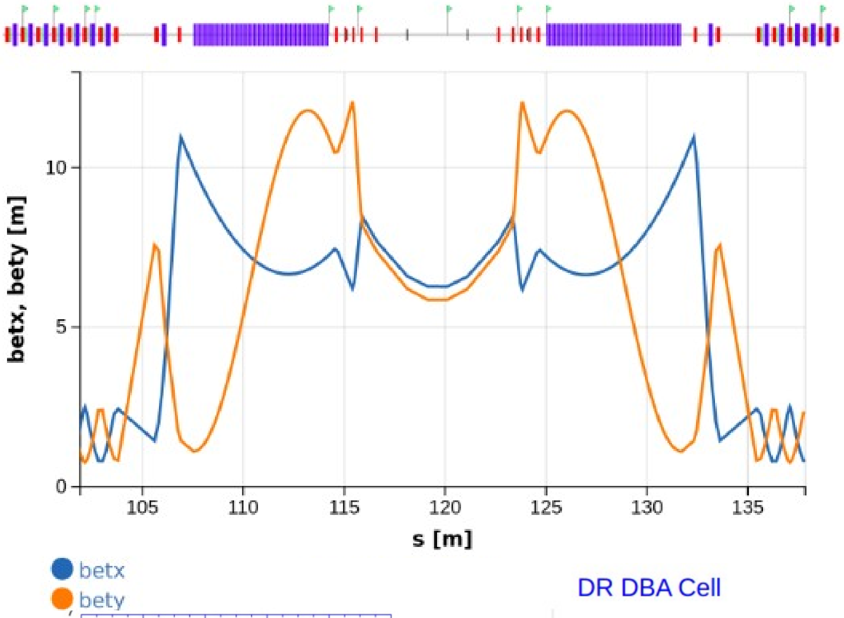
A. de Santis

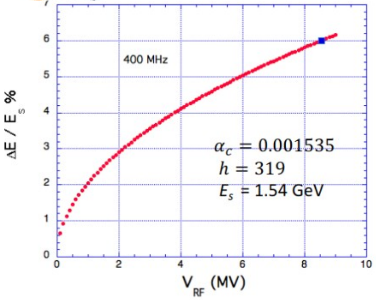
- About 5% energy acceptance required
- At least 9 bunch pairs injected in damping ring
- Maximum 35 bucket separation between train



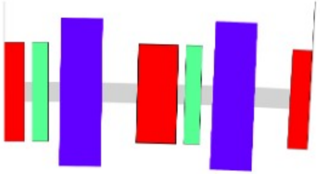
About 5% energy acceptance required
However, at +/-5 % dynamic aperture significantly reduced







DR DBA Cell

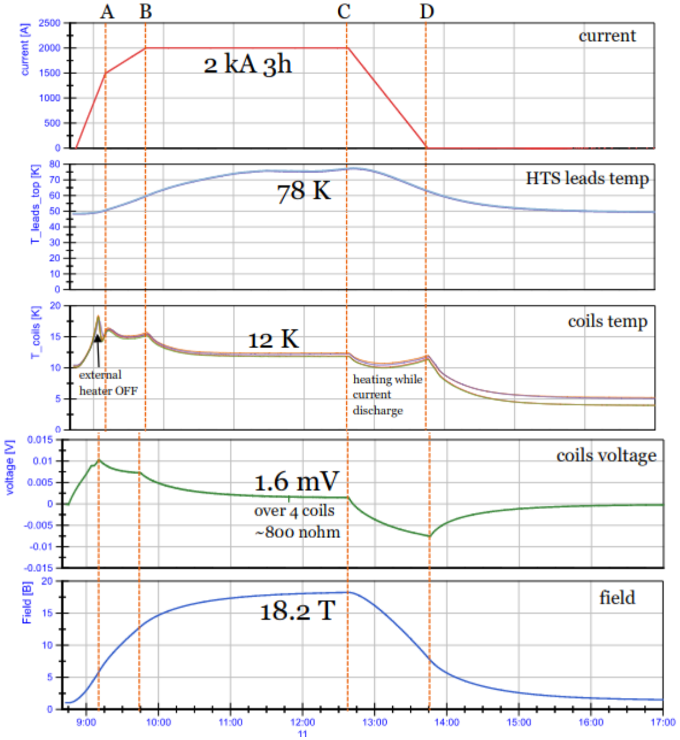


RF-voltage of 8.5 MV for 6% energy acceptance

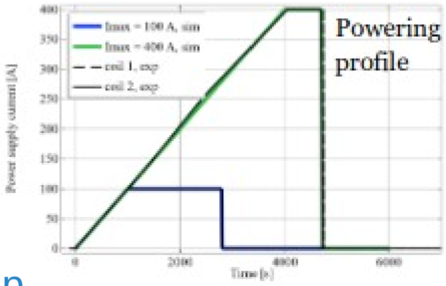
HTS Solenoids for P3

M. Duda

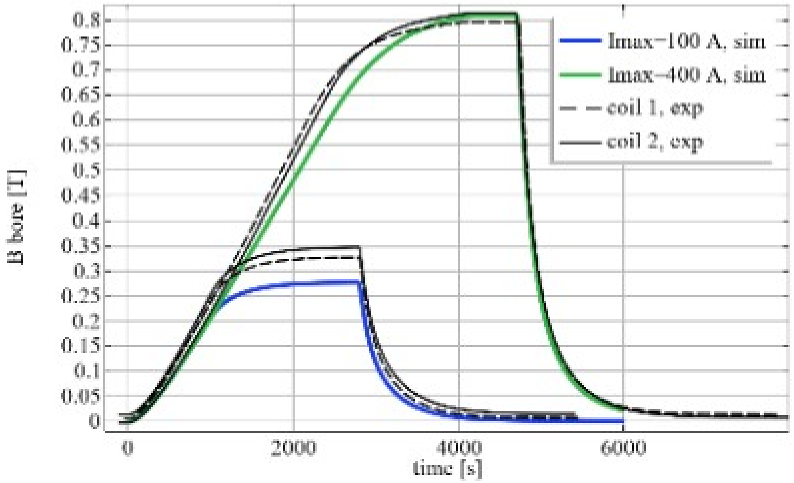
- Build in-house at PSI, and validated model



Very slow ramp down → still suitable for matching device since positron production time planned



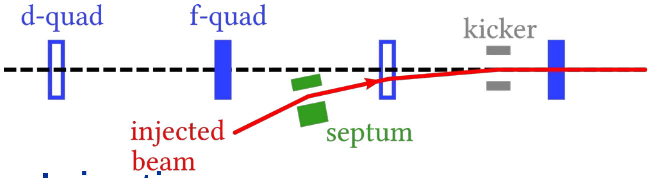
Field still rising at plateau due to non-isolating HTS

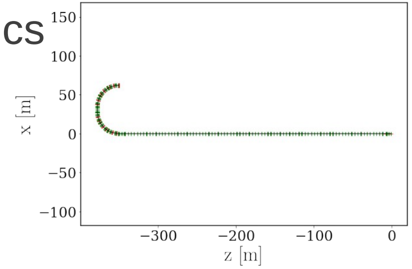


Transfer Lines for FCC-ee Injectors

R. Ramjiawan

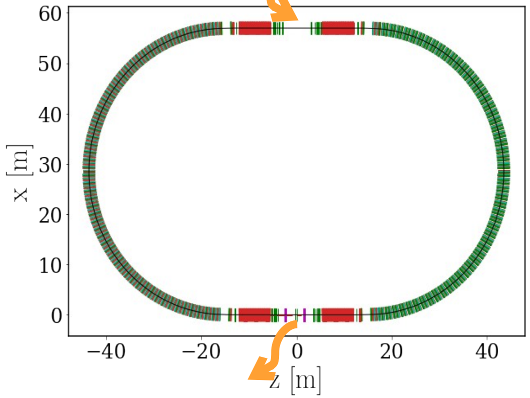
- Transfer line optics between positron damping ring and common linac optics
- Septum foreseen for injection into damping ring, extraction to be studied



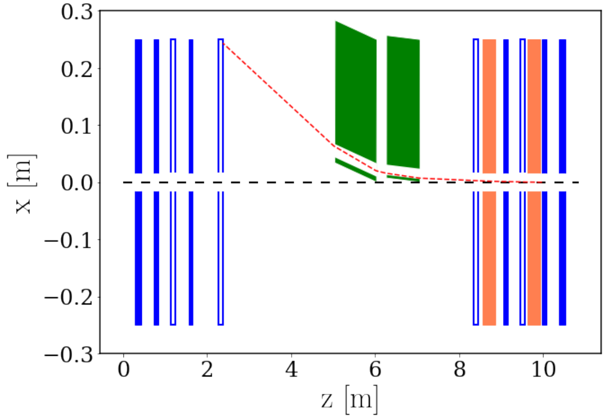


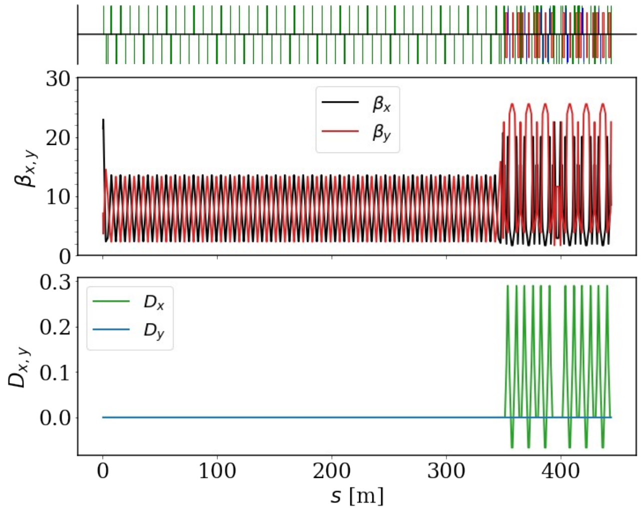
47.5 kV voltage for septum required → ideally should be halved

Injection



Extraction



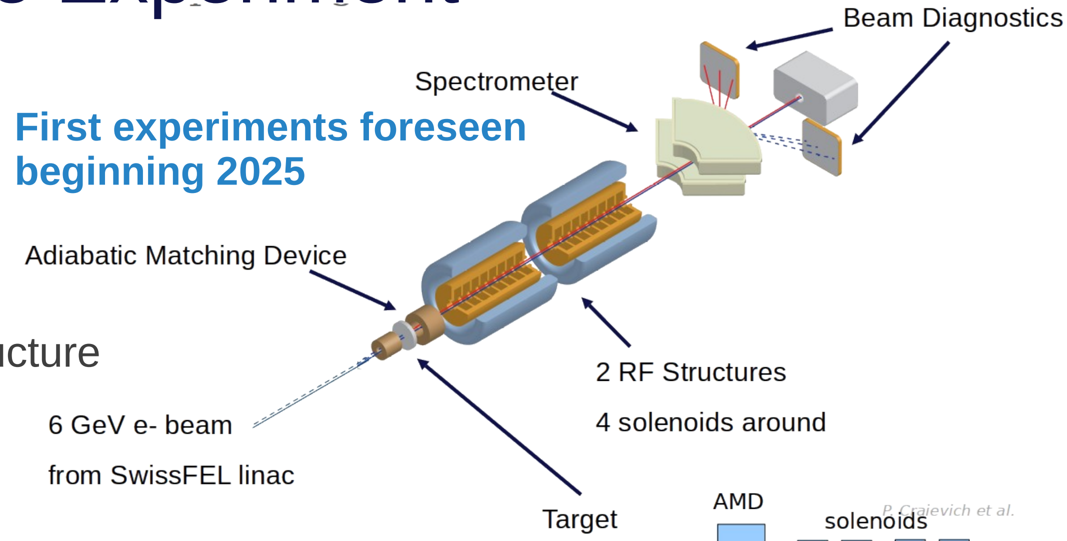


PSI Positron Source Experiment

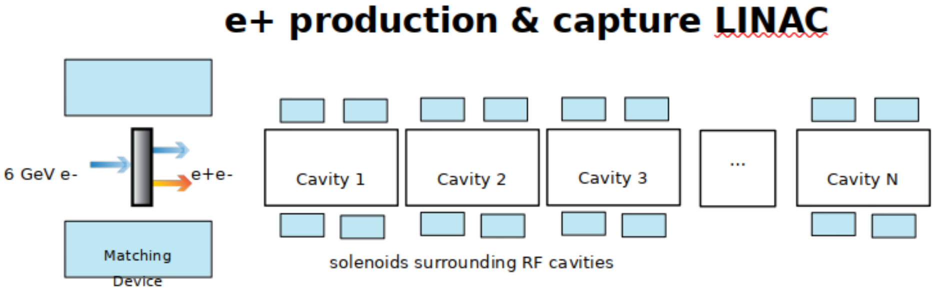
N. Vallis

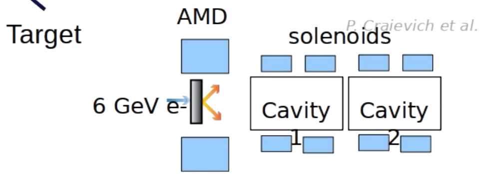
- Want to validate:
  - Positron Yield > 3
  - SC solenoid with HTS technology
  - RF structure: large iris aperture
  - NC vs SR solenoid around RF structure

First experiments foreseen beginning 2025

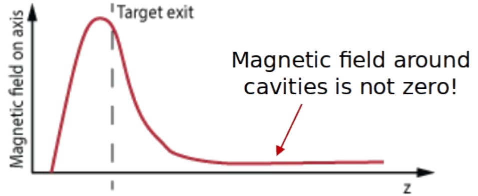


Repetition rate only 200 pC at 1 Hz
Dissipated power on the target only few kW, whereby will be W for the FCC-ee





Captured e+ beam divergent → solenoids required

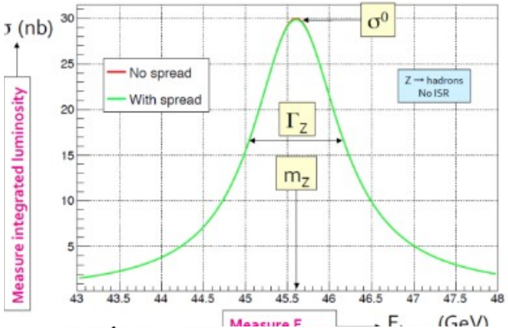


FCC-ee Accelerator III, Wednesday 1st June

09:00	**FCC-ee EPOL The center-of-mass energy calibration and polarization working group** *Bilsky PASQUIER, Campus des Cordeliers*	*Alain Blondel* 09:00 - 09:20
	Center-of-mass energy and boosts for various RF-configurations *Bilsky PASQUIER, Campus des Cordeliers*	*Jacqueline Keintzel* 09:20 - 09:40
	Polarimeter and wigglers integration status *Bilsky PASQUIER, Campus des Cordeliers*	*Katsunobu Oide* 09:40 - 10:00
10:00	**Laser system for Compton polarimeter** *Bilsky PASQUIER, Campus des Cordeliers*	*Aurelien Martens* 10:00 - 10:20

The EPOL Working Group

A. Blondel



- Energy Polarization, Calibration and Monochromatization
- FCC-ee aims to decrease present statistical errors drastically

Table for 2 IPs: √1.7 smaller for 4 IPs

Quantity	statistics	ΔE_{CMabs} 100 keV	$\Delta E_{CMSyst-ptp}$ **40 keV**	calib. stats. $200\ keV/\sqrt{(N^i)}$	σE_{CM} (84) ± **0.05** MeV	stat/present
m_Z (keV)	**4**	100	**28**	1	–	500
Γ_Z (keV)	**4**	2.5	**22**	1	**10**	400
$sin^2\theta_W^{eff} \times 10^6$ from $A_{FB}^{\mu\mu}$	**2**	–	**2.4**	0.1	–	75
$\frac{\Delta\alpha_{QED}(M_Z)}{\alpha_{QED}(M_Z)} \times 10^5$	**3**	0.1	**0.9**	–	**0.05**	15 (qualitiative!)
m_W(MeV)	**0.250**	-- **0.300** --				40

Resonant depolarization is a cornerstone of the precision programme of FCC-ee

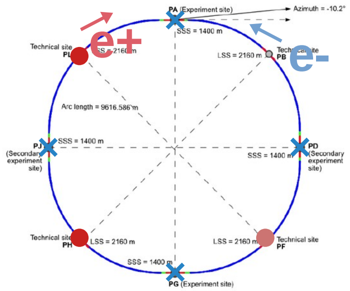
factor 500-75 more precise than LEP

~40 times more precise than CDF

➔ Improvement by factor 10-1000 on a long list of EW precision measurements.
e.g. W mass down to ±250 keV, Z mass and width ±4 keV, $sin^2\theta_W$ eff ± 2.10^{-6} etc..
➔ explore new physics at 10-100 TeV scale, or 10^{-5} mixing with known particles.

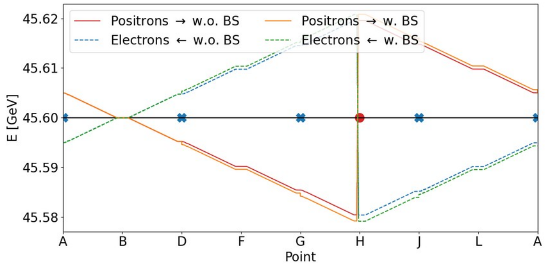
ECM and Boosts for FCC-ee

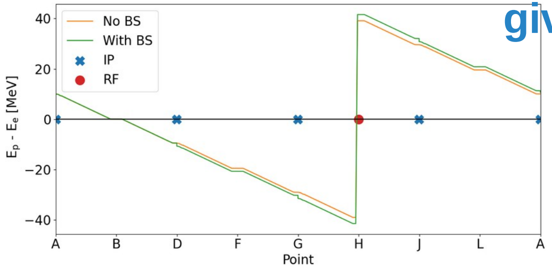
J. Keintzel, D. Shatilov



- ECM and boosts depend on RF sections, beamstrahlung, etc.

Z-lattice: 1 RF section, almost constant ECM



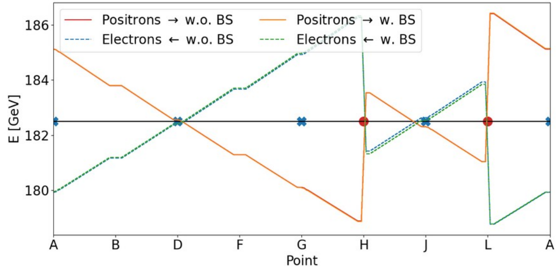


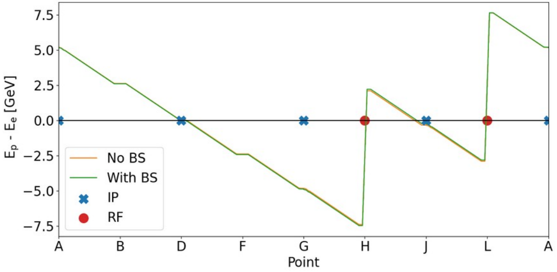
One 8 h shift will give 5 keV precision

IP	ΔECM [keV]	Boost [MeV]
PA	- 379.203	96.402
PD	- 384.749	- 91.447
PG	40.753	- 279.299
PJ	57.530	284.254

Beam energy spectrum with and without beamstrahlung

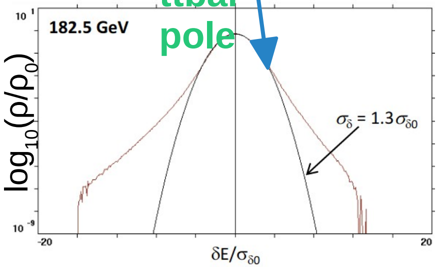
ttbar-lattice: 2 RF sections, almost constant ECM





IP	ΔECM [MeV]	Boost [GeV]
PA	42.813	5.187
PD	- 30.176	0.157
PG	34.236	- 4.873
PJ	-152.467	- 0.233

ttbar-pole



Polarimeter and Wigglers Status

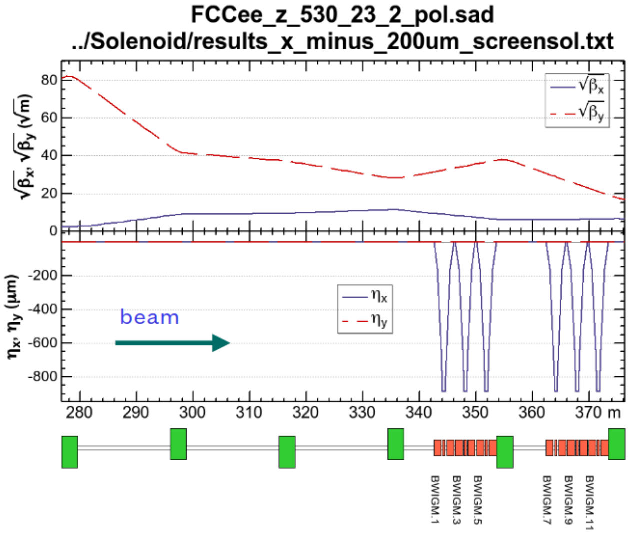
K. Oide, M. Hofer

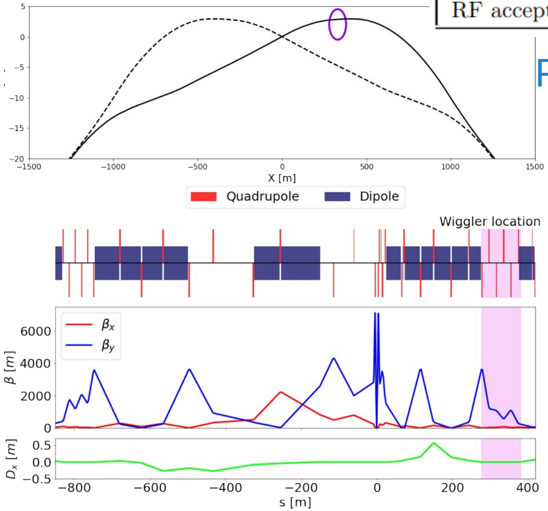
- Wigglers integrated in layout to decrease damping time

Energy spread (SR/BS) σ_δ	[%]	0.038 / 0.132	
Bunch length (SR/BS) σ_z	[mm]	4.38 / 15.4	

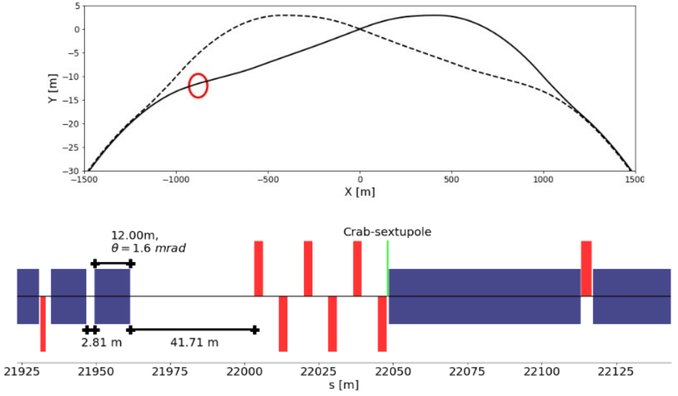
Beam energy	[GeV]	45.6	
Wiggler poles/ring (long/short)		-	48 / 24
Wiggler field	[T]	-	-0.1167 / 0.6
Wiggler length	[m]	-	1.29 / 0.43
Energy loss / turn	[MeV]	39.3	54.8
Horizontal emittance ε_x	[nm]	0.702	0.563
Vertical emittance ε_y	[pm]	0.426	0.305
Energy spread (SR) σ_δ	[%]	0.040	0.137
Bunch length (SR) σ_z	[mm]	4.5	15.7
Synchrotron tune $4Q_s$		0.0370	0.0359
Long. damping time	[turns]	1160	830
Polarization time	[min]	11887	730
RF acceptance	[%]	1.61	1.37

Wiggler location downstream of the IP, 5min lifetime



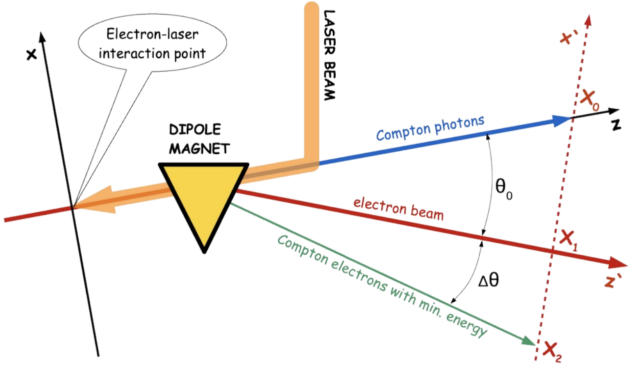


Polarimeter location upstream of the IP



Laser System for Compton Polarimeter

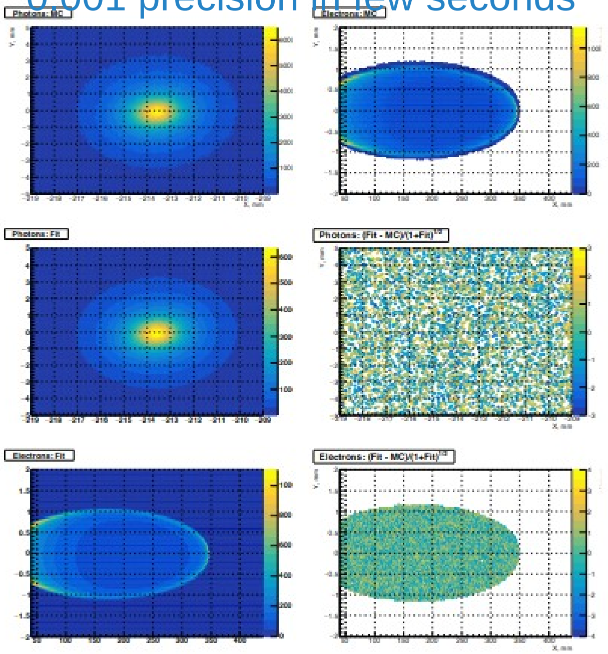
A. Martens,
N. Muchnoi



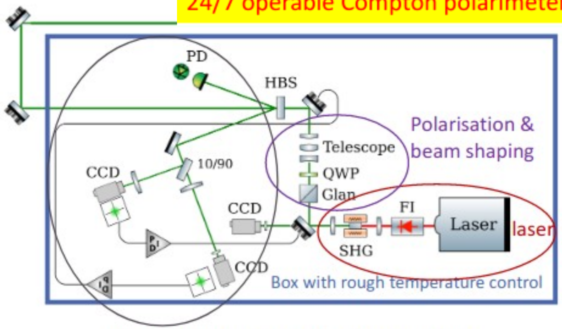
- Measurement of electrons and photons allows to reconstruct 3D polarization vector

Parameters extracted within 0.001 precision in few seconds

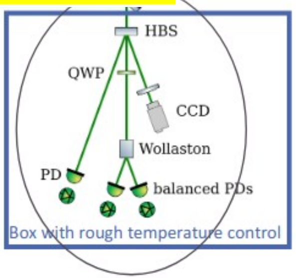
Photon rate $n = \sigma_C \frac{\mathcal{E}}{E_\lambda} \frac{Q}{q} \frac{\mathcal{F}}{4\pi\sigma_y\sigma_x}$



24/7 operable Compton polarimeter for pilot and colliding bunches



Position, pointing control and monitoring
Polarisation independent intensity monitoring
Optical spectrum monitoring possible



Polarisation monitoring
Duplicated at injection
Add Position and pointing monitoring

24/7 operable laser system, with full monitoring, remote control

FCC-ee Accelerator VI, Thursday 2nd June

09:00	**Simulations of the Spin Polarization for the Future Circular Collider e+e- using Bmad** *FARABOEUF, Campus des Cordeliers*	*Yi Wu* 09:00 - 09:20
	Study of the depolarization process, possible biases *FARABOEUF, Campus des Cordeliers*	*Ivan Koop* 09:20 - 09:40
	Effect of misalignments, collision offsets, beamstrahlung *FARABOEUF, Campus des Cordeliers*	*Alain Blondel et al.* 09:40 - 10:00
10:00	**Progress on monochromatization** *FARABOEUF, Campus des Cordeliers*	*Angeles Faus-Golfe et al.* 10:00 - 10:25

Spin Polarization Using Bmad

Y. Wu

- Transversely polarized pilot bunches foreseen in FCC-ee for energy calibration
- Lepton beams polarize naturally over time
- Depolarization with errors

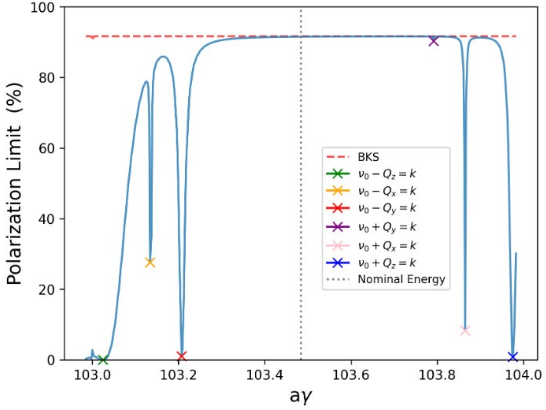
$$P_{ST} = \frac{W_{\uparrow\downarrow} - W_{\downarrow\uparrow}}{W_{\uparrow\downarrow} + W_{\downarrow\uparrow}} \simeq 92.38\% \quad \text{and} \quad \tau_{ST}^{-1} = \frac{5\sqrt{3}}{8}\frac{r_e\gamma^5\hbar}{m_e|\rho|^3}$$

$$\tau_{dep}^{-1} = \frac{5\sqrt{3}}{8}\frac{r_e\gamma^5\hbar}{m_e}\frac{1}{C}\oint \mathrm{d}s \left\langle \frac{\frac{11}{18}\left(\frac{\partial\hat{n}}{\partial\delta}\right)^2}{|\rho(s)|^3} \right\rangle_s$$

Resonances between betatron tunes, synchrotron tune and spin tune

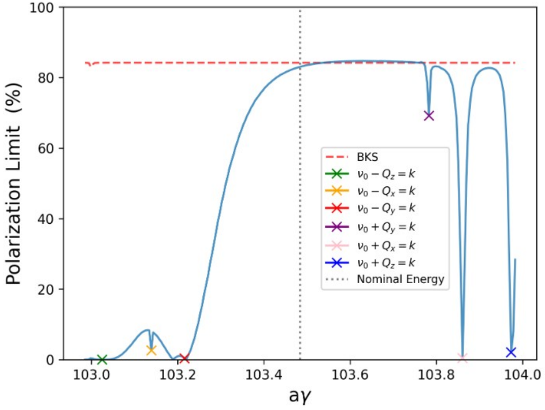
$$\nu_0 = m + m_x Q_x + m_y Q_y + m_z Q_z$$

$(\Delta y)_{\rm rms} = 43.7\ \mu\text{m}$



91.6% near nominal energy

$(\Delta y)_{\rm rms} = 148\ \mu\text{m}$

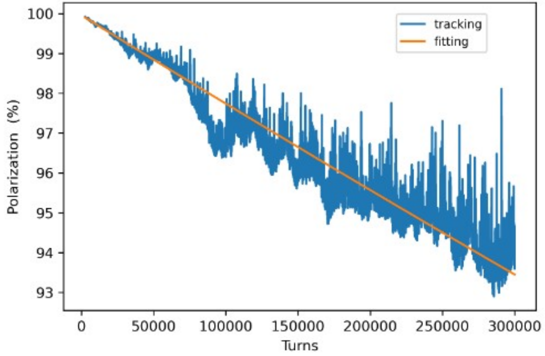


84.6% near nominal energy

Spin tracking of 10 particles

$$\nu_0 = m + Q_y - Q_s$$

$$P_{eq} = 0.15\%$$



Larger vertical orbits reduce polarization

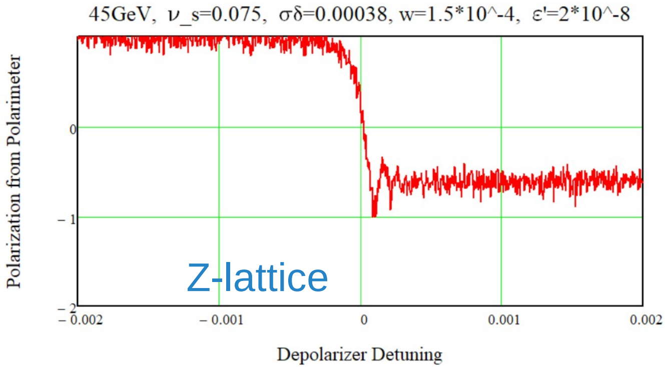
Resonances with Qs strong

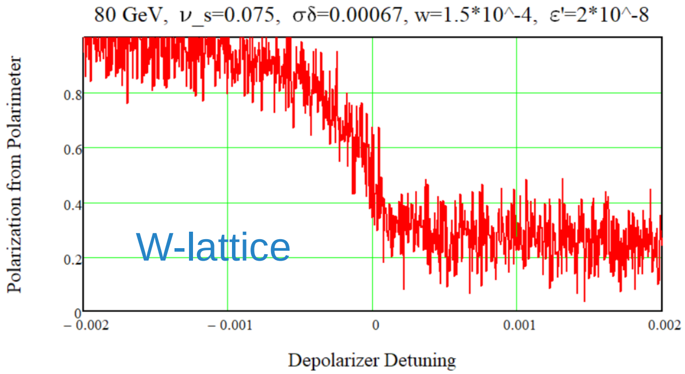
Depolarization Process

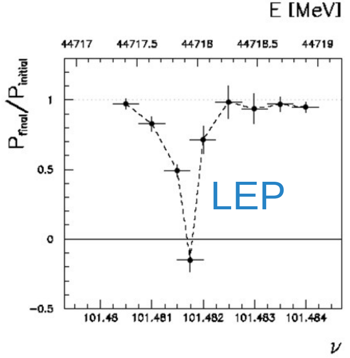
I. Koop

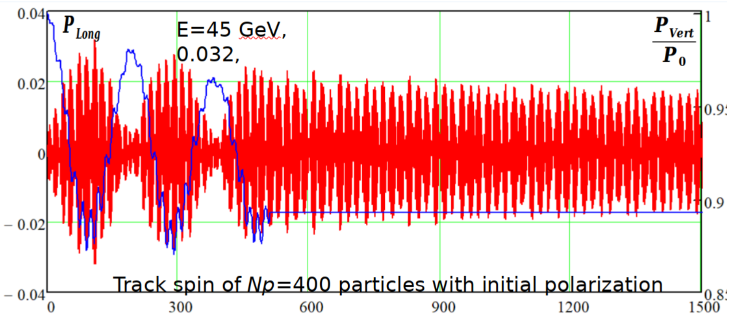
- Resonant depolarization allows to determine spin tune and thus energy

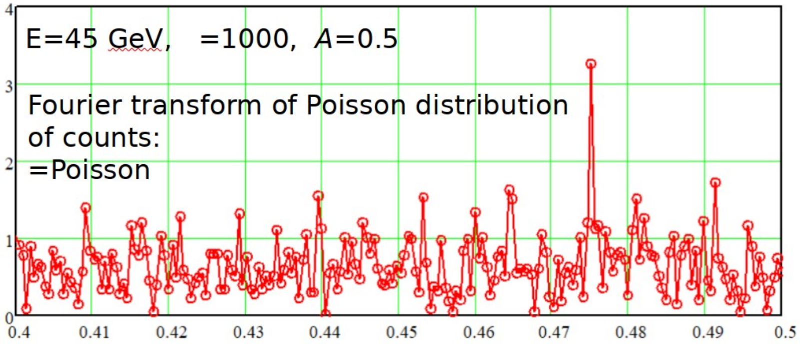
At W Qs too large, step-wise depolariozation required









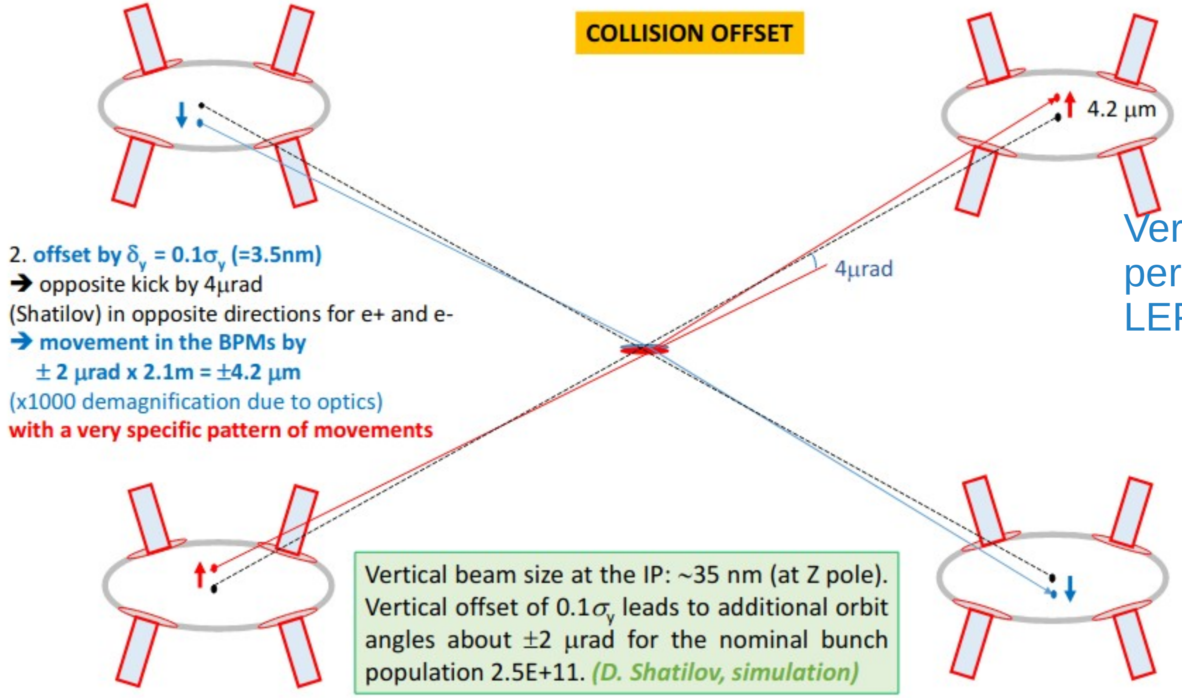


FT of spin coherent spin motion gives spin tune

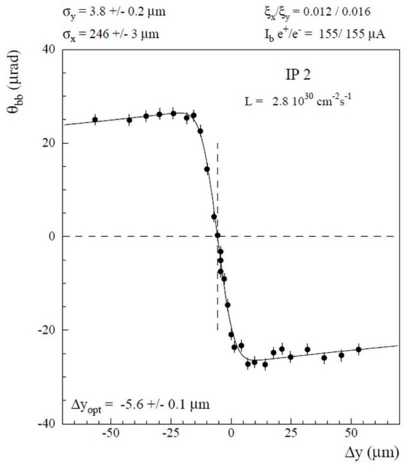
Effect of Misalignments

A. Blondel

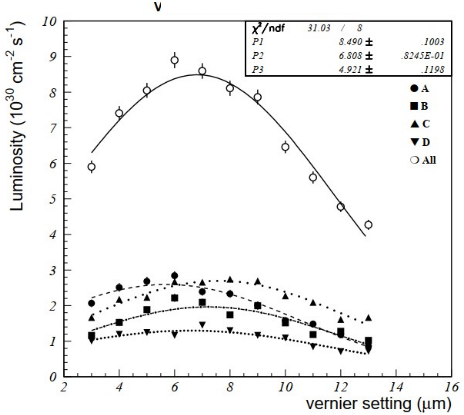
- Collision offsets need to be understood and controlled



Beam-beam deflection at LEP



Vernier-scans performed at LEP

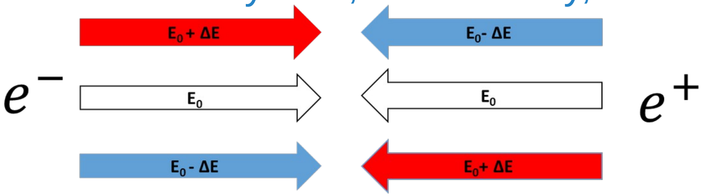


Monochromatization

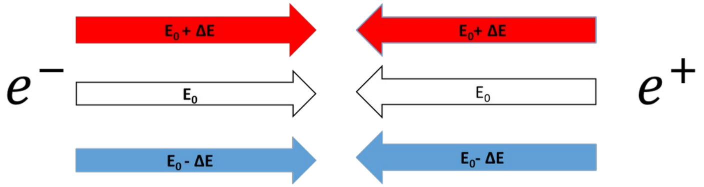
H. Jiang

- Helps reducing the ECM spread from 50 to 5 keV

  Transverse monochromatization scheme most promising → introduce dispersion → luminosity loss, chromaticity, etc.



Same dispersion at the IP



The monochromatization factor

$$\lambda = \left(1 + \sigma_\varepsilon^2 \left(\frac{D_x^{*2}}{\sigma_{x\beta}^{*2}} + \frac{D_y^{*2}}{\sigma_{y\beta}^{*2}}\right)\right)^{1/2}$$

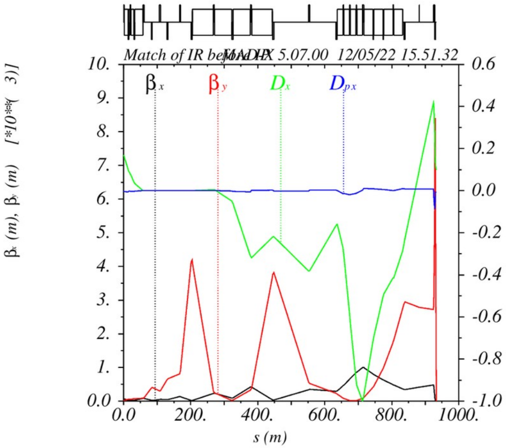
The monochromatization factor for FCC-ee($D_y^* = 0$)

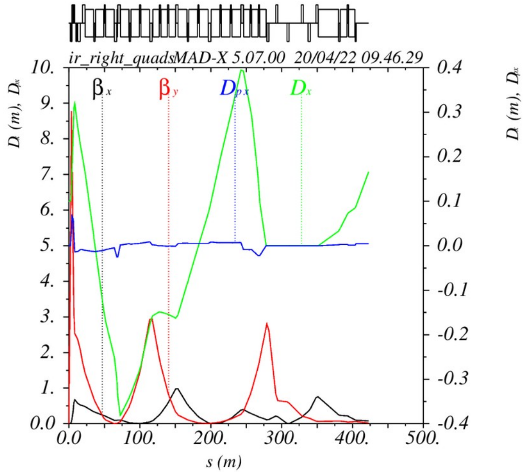
$$\lambda = \sqrt{1 + \frac{D_x^{*2}\sigma_\varepsilon^2}{\epsilon_x \beta_x^*}}$$

The needed dispersion value at IP estimated from [5

$$D_x^*(e^+) = -D_x^*(e^-) = -0.105m$$

IR optics with monochromatization scheme





FCC-ee Accelerator VII, Thursday 2nd June

11:00	**MDI overview** *FARABOEUF, Campus des Cordeliers*	*Manuela Boscolo* 11:00 - 11:20
	Luminosity calorimeter *FARABOEUF, Campus des Cordeliers*	*Mogens Dam* 11:20 - 11:40
	IR chamber & Calculations *FARABOEUF, Campus des Cordeliers*	*Francesco Fransesini* 11:40 - 12:00
12:00	**Modelling process for vibrations estimations** *FARABOEUF, Campus des Cordeliers*	*Stanislas Grabon* 12:00 - 12:15
	Machine Detector Interface Alignment System Update and challenges *FARABOEUF, Campus des Cordeliers*	*Leonard Watrelot* 12:15 - 12:30

MDI Overview

M. Boscolo

- Numerous requirements
  - Common IR for all energies
  - 2 T detector solenoid field
  - Solenoid compensation scheme
  - SR control
  - Lumimeter
  - 100 mrad physics cone
  - Background suppression
  - Radiation shielding
  - …

Proposal for mock-up of the IR

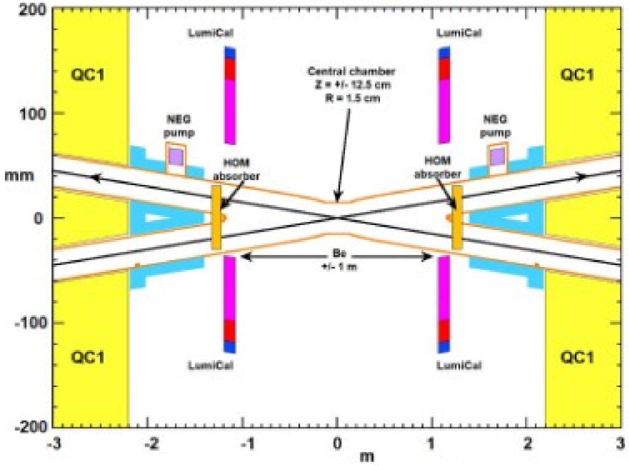
step1

- Central IP vacuum chamber
  - test the cooling system and the vacuum system
- AlBeMet162 – steel transition
  - study the shape of the transition, EBW process
- Bellow
  - vacuum and thermal tests
- Welding
  - EBW for elliptical geometry

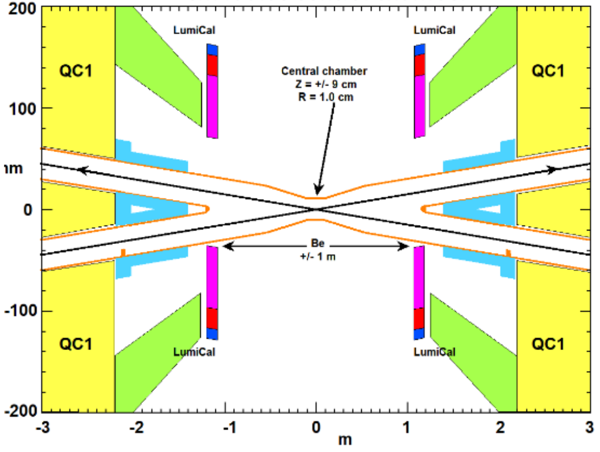
step2

- Trapezoidal vacuum chamber with remote vacuum connection
- QC1
- cryostat
- beam pipe and quadrupole and cryostat support
- vibration and alignment sensors

CDR
1.5 cm radius central chamber



present low impedance beam pipe
1 cm radius central chamber



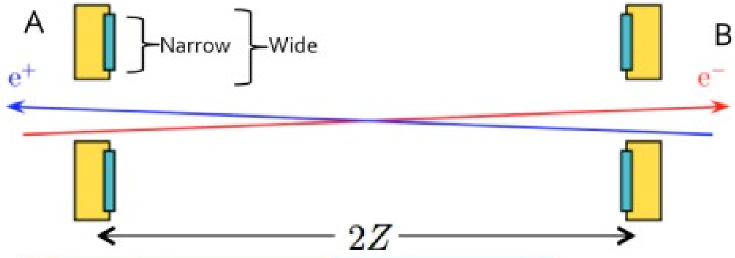
MDI design; Blue: shielding

Luminosity Calorimeter

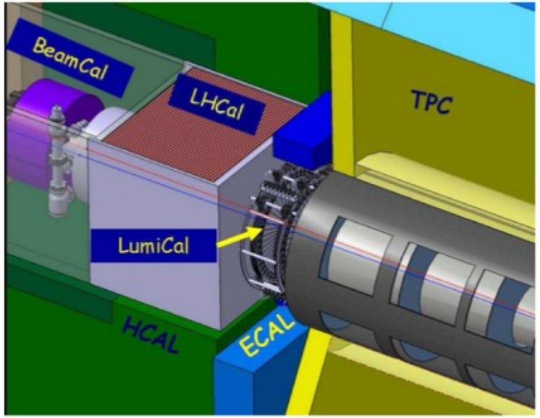
M. Dam

- Standard lumi process is small angle elastic e + e - (Bhabha) scattering

Goal: absolute normalization 10^{-4} (Best OPAL at LEP 3.4×10^{-4})

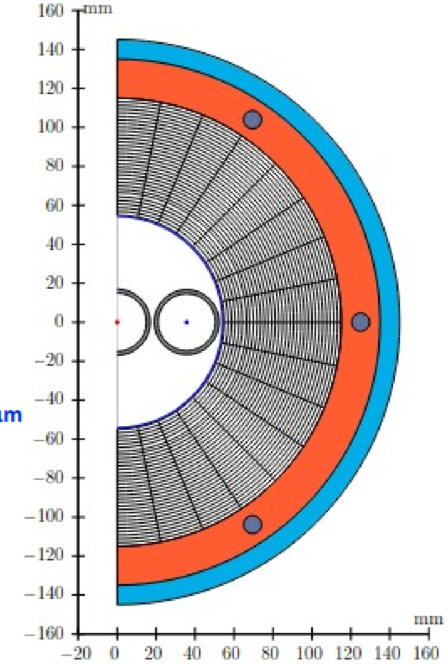


Could or should some detectors be built asymmetrically to follow the physics?



- Geometric tolerance on (system of two) LumiCals:
  - Inner radius: $\delta R_{min} = \pm 1.5\ \mu m$
  - Outer radius: $\delta R_{min} = \pm 3.3\ \mu m$
  - Longitudinal distance between each LumiCal and nominal IP: $\delta Z = \pm 55\ \mu m$

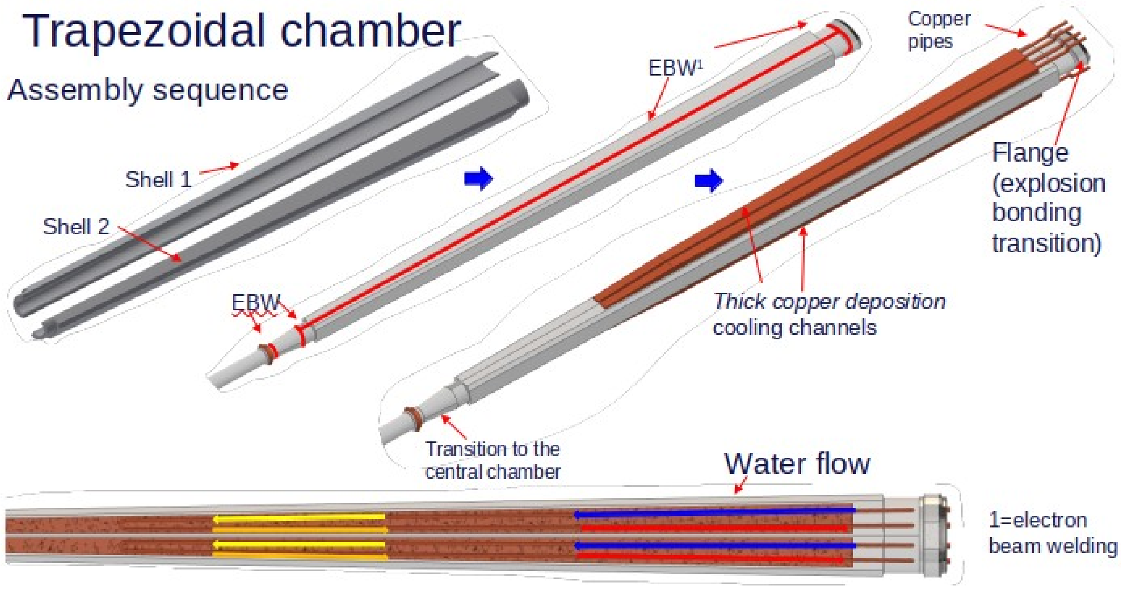
- Geometric tolerance of IP position w.r.t. LumiCal system:
  - Transverse: few tenths of a mm
  - Longitudinal: few mm



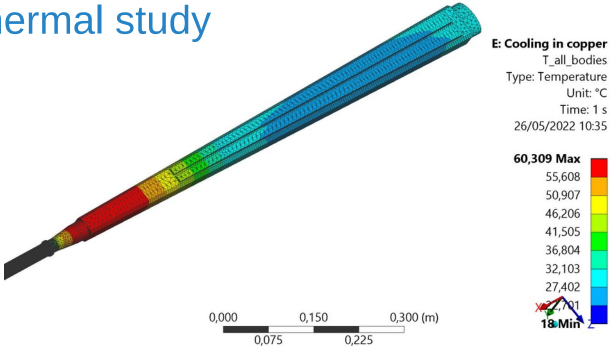
IR Chamber and Calculations

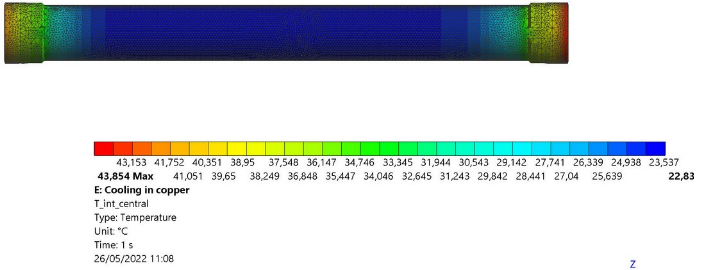
F. Fransesini

- Main assembly updated and thermal study performed



First results on thermal study

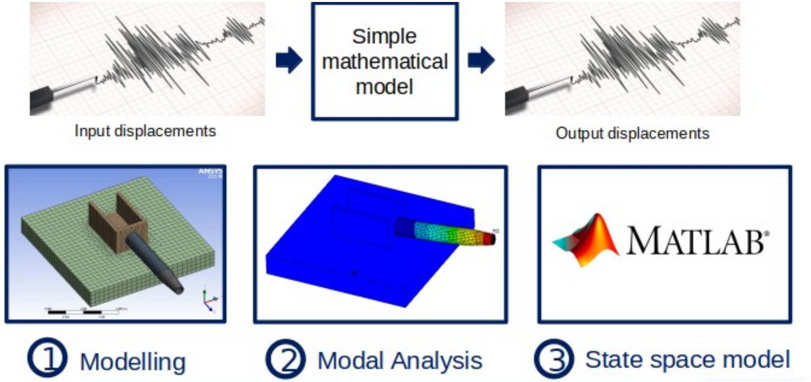




Modeling for Vibration Estimates

S. Grabon

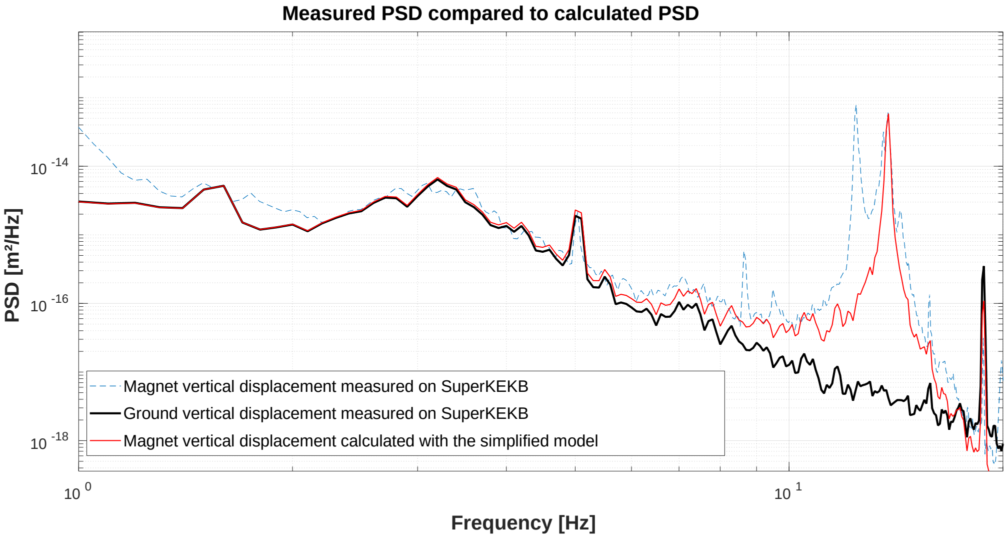
- Goal is to understand, model and predict dymanic behaviour of magnets



Define input and output point, where motion will be measured

Obtain natural frequencies and mode shapes

Magnet vertical displacement modeled and measured for SuperKEKB
Shows good agreement



MDI Alignment System

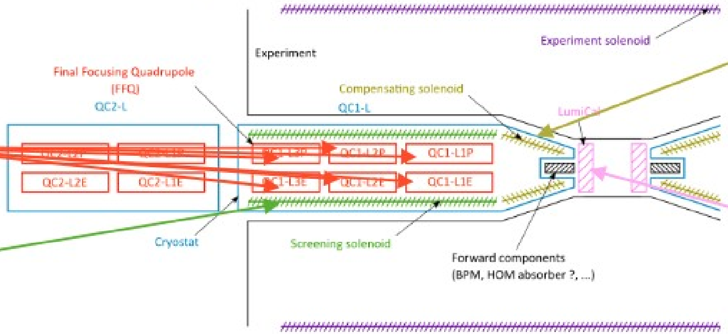
L. Watrelot

Alignment monitoring system required

- Tighter alignment constraints compared to the rest of the lattice

FFQ : Alignment tolerance at 30 µm + Monitoring

Screening solenoid : Alignment tolerance at ~100 µm + Monitoring

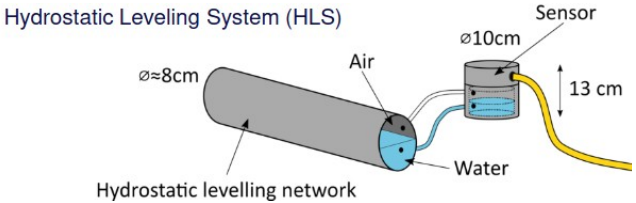


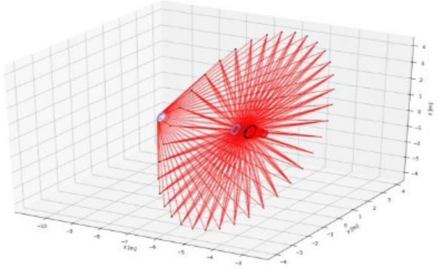
Compensation solenoid : Alignment tolerance at ~100 µm + Monitoring

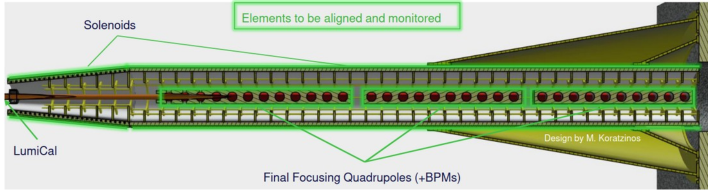
LumiCal
Alignment tolerance at 50 µm w.r.t. the IP (longitudinal) + Monitoring

Present sensors (hydraulic, wire, optical) not precise enough; e.g. HL-LHC not directly applicable (?)

Internal alignment system ongoing work
Plan for external alignment system:







Sensors and alignment strategies presently developed for the FCC-ee

FCC-ee Accelerator VIII, Thursday 2nd June

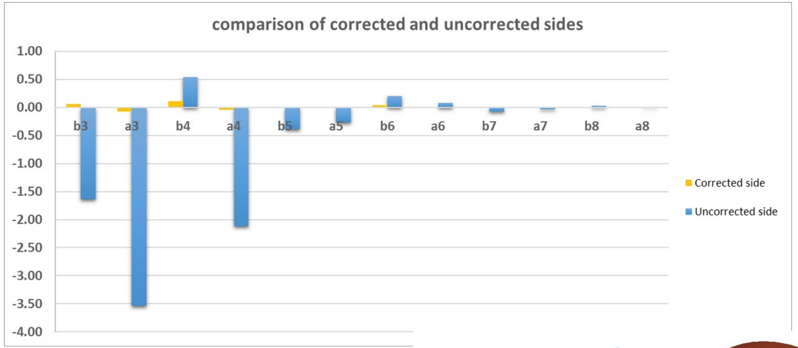
14:00	**IR Magnet concepts** *FARABOEUF, Campus des Cordeliers*	*m Koratzinos* 14:00 - 14:20
	IR Magnet review *FARABOEUF, Campus des Cordeliers*	*John Seeman* 14:20 - 14:35
	Machine induced backgrounds in the FCC-ee MDI region and Beamstrahlung radiation *FARABOEUF, Campus des Cordeliers*	*Andrea Ciarma* 14:35 - 14:55
15:00	**Synchrotron radiation background studies** *FARABOEUF, Campus des Cordeliers*	*Kevin Daniel Joel Andre* 14:55 - 15:10
	Challenges for instrumented beamstrahlung *FARABOEUF, Campus des Cordeliers*	*Marco Calviani* 15:10 - 15:30

IR Magnet Concepts

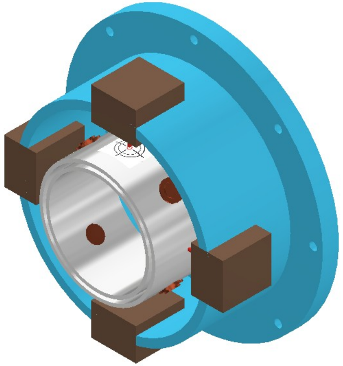
M. Koratzinos

- Detailed studies on final focus quadrupoles performed

Multipole components with and without correction

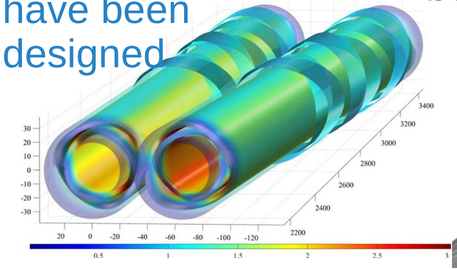


New BPM design

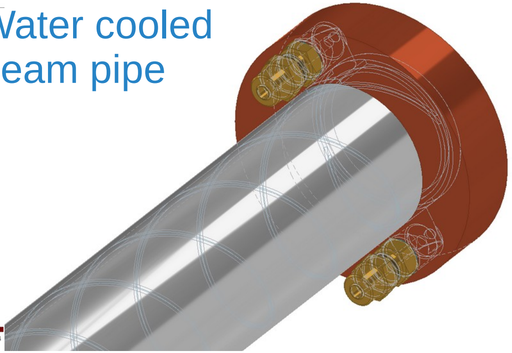


One of the most crucial parts of FCC-ee

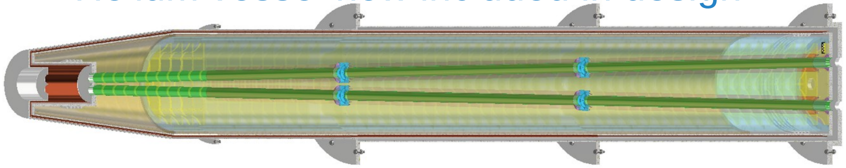
Correctors have been designed



Water cooled beam pipe



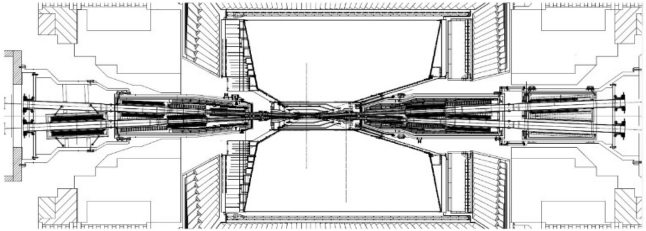
Helium vessel now included in design



IR Magnet Review

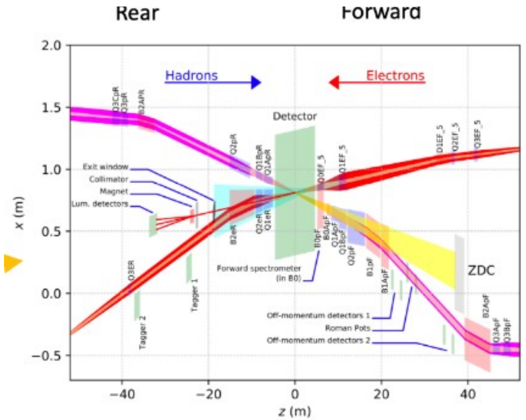
J. Seeman

- IR review took place on 6th April 2022



- Review general overall highlights:
- The cone angle between accelerator and detector of 100 mrad should be optimized given all the constraints on both sides.
- All the mechanical, electrical, and field tolerances should be studied as an integrated group and loosened as much as is possible.
- All the various magnetic fields and SC correctors in the cryostat need to be studied together along with the main coils for field quality, compatibility, and constructability.
- The mechanical and heat designs of the cryostats should be taken to the next level.

Use experience from e.g. EIC and SuperKEKB

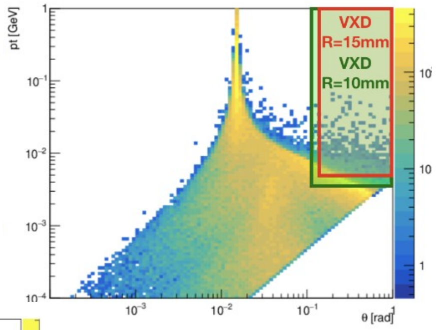


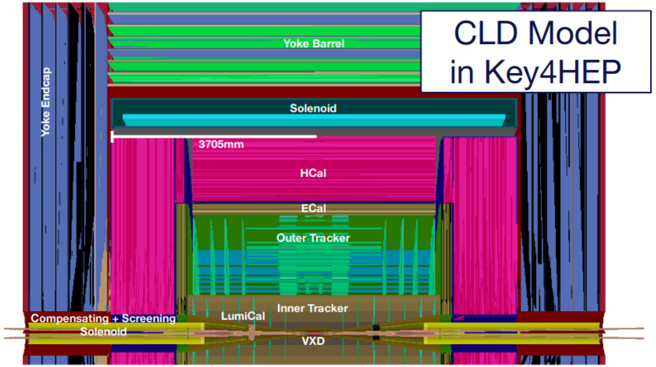
Backgrounds and Beamstrahlung

A. Ciarma

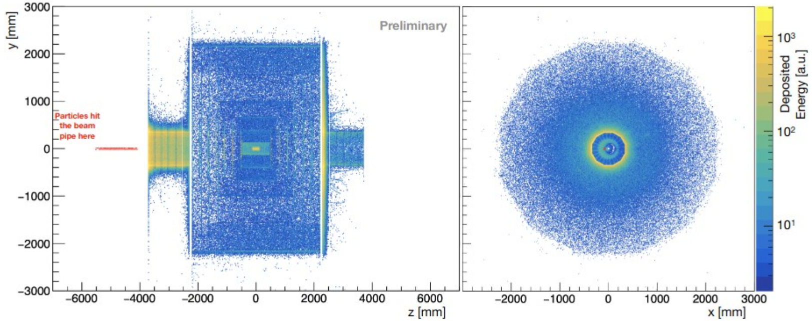
- Focused on vertex detector and inner tracker

Generated photons increase for higher energy

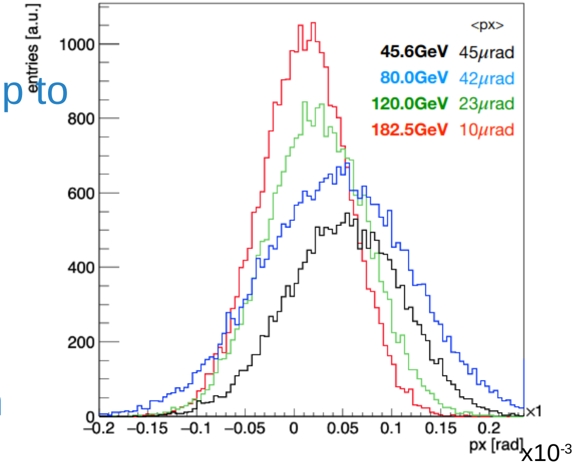




About 60 particles lost per beam crossing per beam
Detailed studies ongoing to dertermine impact on QC1



Beamstrahlung photons (up to 300 kW with 10-100µm divergence) → dump
less energetic particles receive stronger kick
→ Photons hit beam pipe in different locations
Power peak shifted by mm



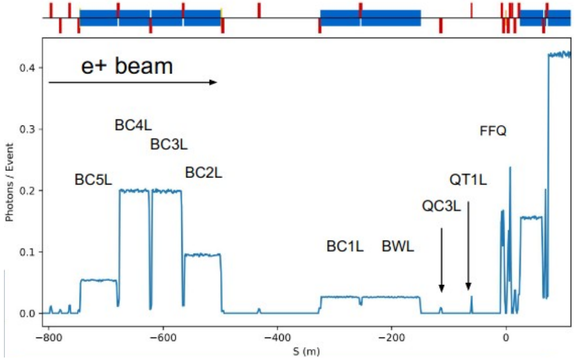
How much shielding do we need and where?
How are the losses for a new injected beam?

Synchrotron Radiation Background

K. Andre

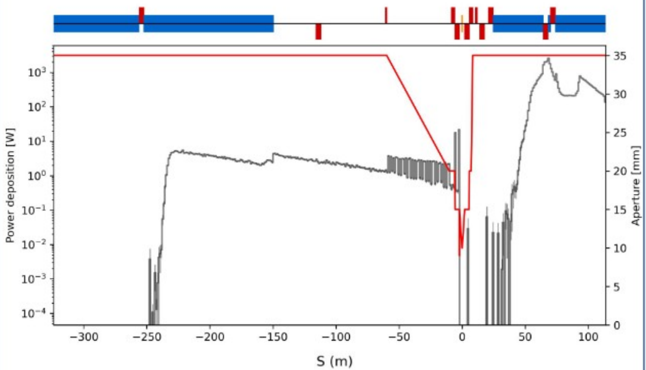
- Synchrotron radiation photons generated simulated using BDSim and compared with previous results from MDISim

Power of emitted photons around the IP

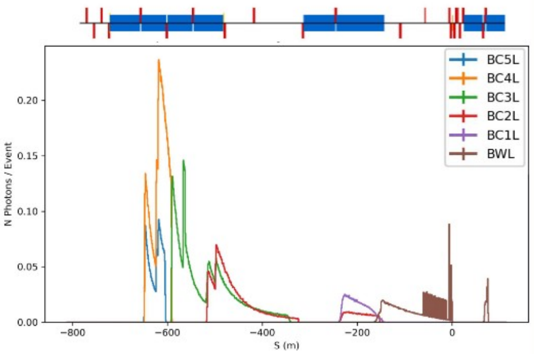


SR masks for shielding required, photons generated from different dipoles hit at different location

Where do we need the masks and collimators?
Which dimensions should they have?



SR photons hits and beam pipe aperture including masks but no collimator.



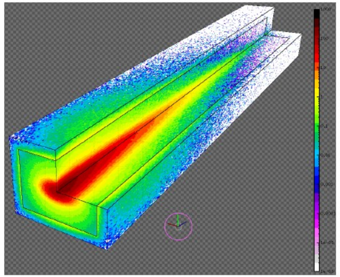
SR photon hits from the dipoles

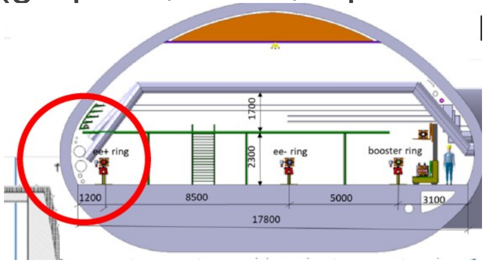
Beam Dumps for Beamstrahlung

M. Calviani

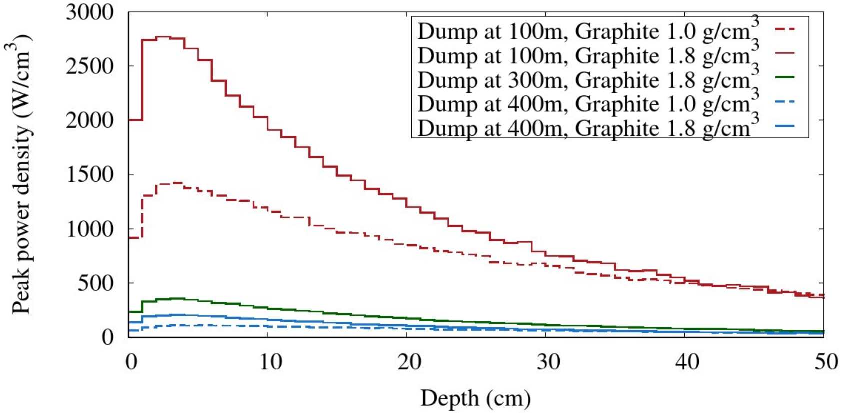
- Various absorbers could be considered (graphite, water, liquid metal) and integration studied

Power Density in graphite core for Z-lattice
Typical HD and LD graphite densities for different distances from IP

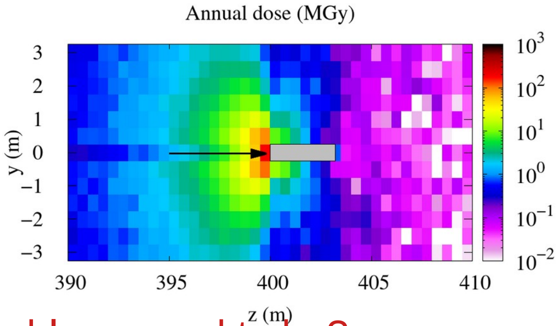




kW/cm^3	Graphite	
	1.0 g/cm^3	1.8 g/cm^3
100 m	1.4	2.8
300 m		0.4
400 m	0.1	0.2



Deposited dose around around the beam dump must also be considered



How far away does the beam dump for beamstrahlung need to be?
Do we need a window and what is its impact on the vacuum design?

FCC-hh, Wednesday 1st June

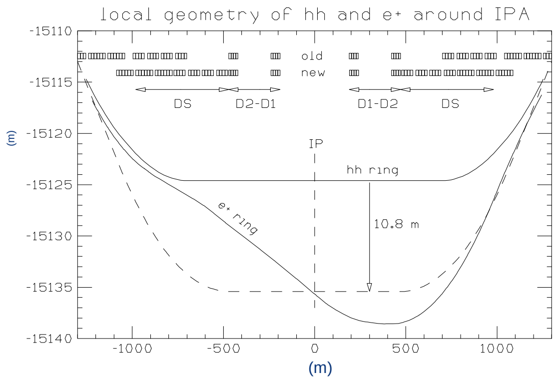
09:00	**FCC-hh layout and optics studies** *ROUSSY, Campus des Cordeliers*	*Massimo Giovannozzi* 09:00 - 09:25
	FCC-hh collimation *ROUSSY, Campus des Cordeliers*	*Dr Roderik Bruce* 09:25 - 09:45
	A Hybrid REBaCuO-Cu Coating for the FCC-hh Beam Screen *ROUSSY, Campus des Cordeliers*	*Guilherme Telles* 09:45 - 10:05
10:00	**Injectors, injection, extraction, transfer lines** *ROUSSY, Campus des Cordeliers*	*Wolfgang Bartmann* 10:05 - 10:25


FCC-hh (pp) collider parameters
FCC-hh
HL-LHC
LHC

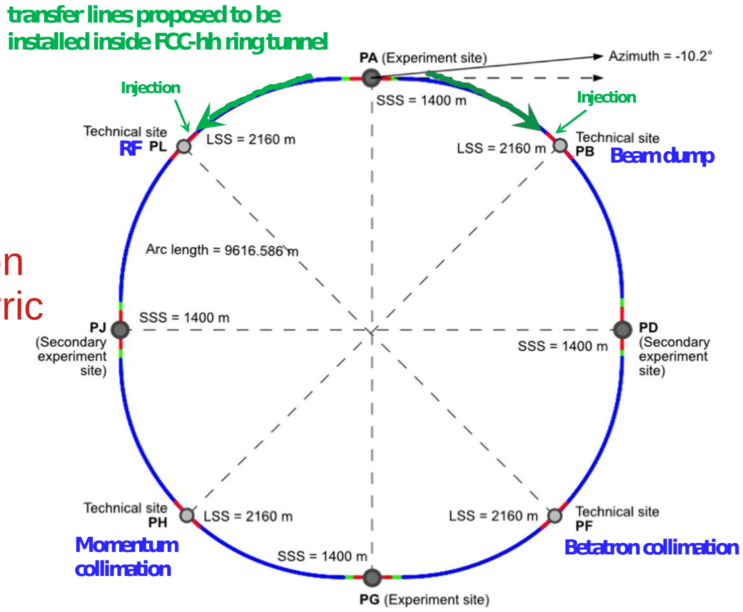
FCC-hh Layout and Optics Studies

M. Giovannozzi

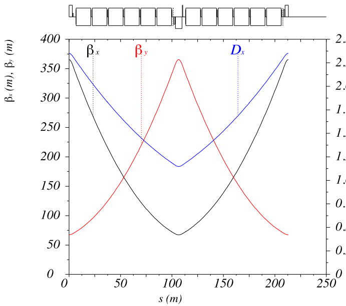
- Exact four-fold symmetry



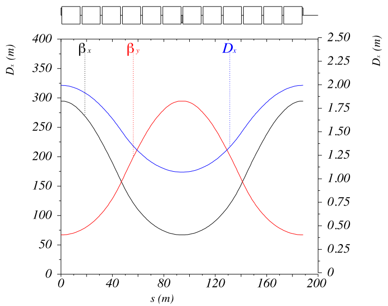
What is the best injection option (scSPS, superferric LHC)?



FODO cell



Combined function FODO



Circumference: 91.9 km
Number of cells: 42
Cell length: 215.3 m
Experimental straight section: 1400 m
Technical straight section: 2160 m

FCC-hh Collimation

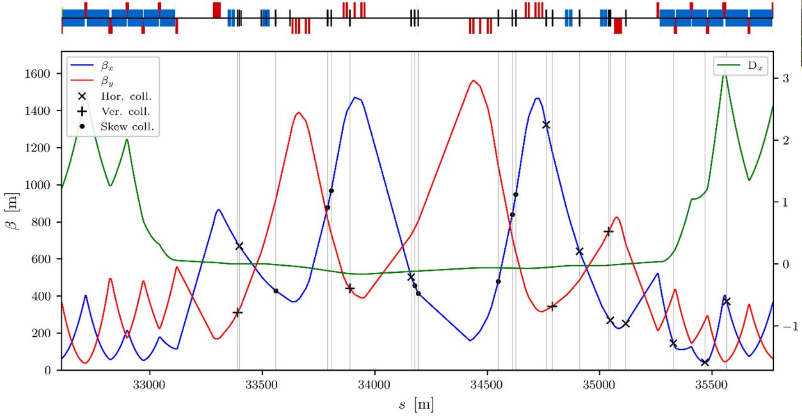
R. Bruce

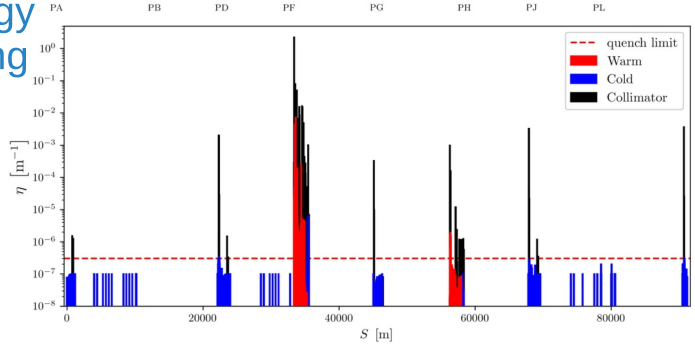
Horizontal halo collimation
Beam 1
50 TeV

- New halo collimation optics and lattice, foreseen in PF

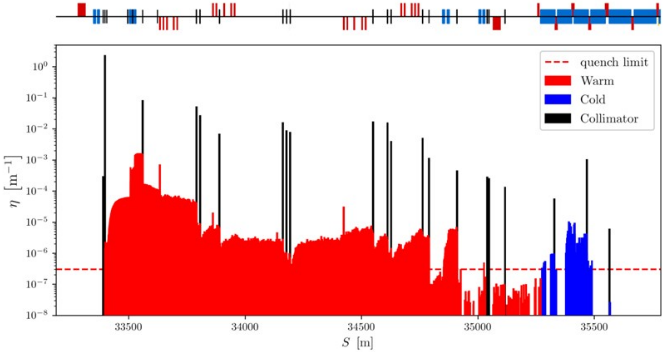
LHC: 362 MJ - kinetic energy of TGV train cruising at 155 km/h

FCC-hh: 8.3 GJ – kinetic energy of Airbus A380 (empty) cruising at 880 km/h:





Smallest collimator half gap (vertical primary) around 0.8 mm (cf ~1mm in LHC)

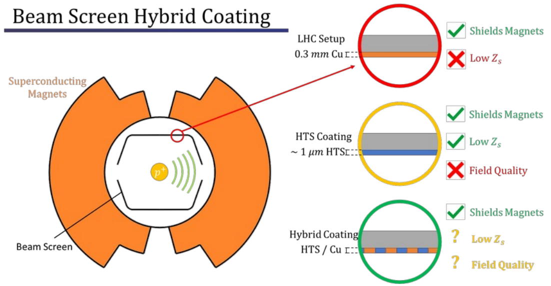


Hybrid HTS-Cu Coating for Beam Screen

G. Telles

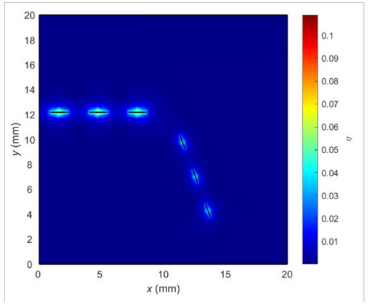
- New studies for FCC-hh beam screen presented

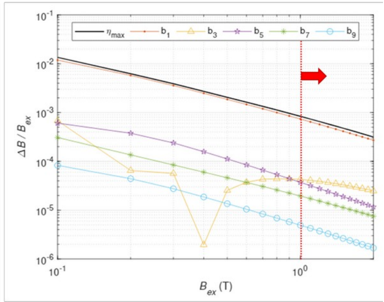
Beam Screen Hybrid Coating



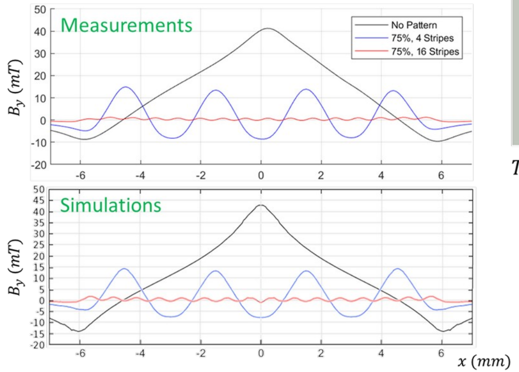
HTS tapes inside beamscreen → lower impedance and acceptable field quality

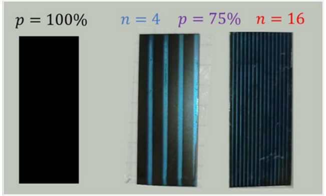
One simulation: $n = 6;\ p = 50\%$



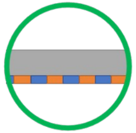


Hall Microscopy: low trapped field





$T = 77\ K,\quad h = 400 \pm 100\ \mu m$



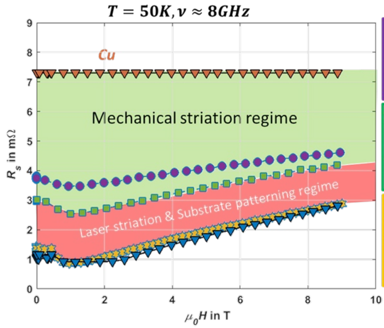
✓ Shields Magnets

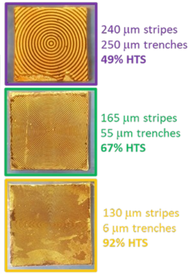
Low Z_s

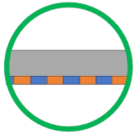
✓ **Field Quality**

Surface Resistance: almost no change

✓ Surface resistance very close to full REBCO







✓ Shields Magnets

✓ Low Z_s

✓ **Field Quality**

Injectors, Injection, Extraction and Transfer Lines

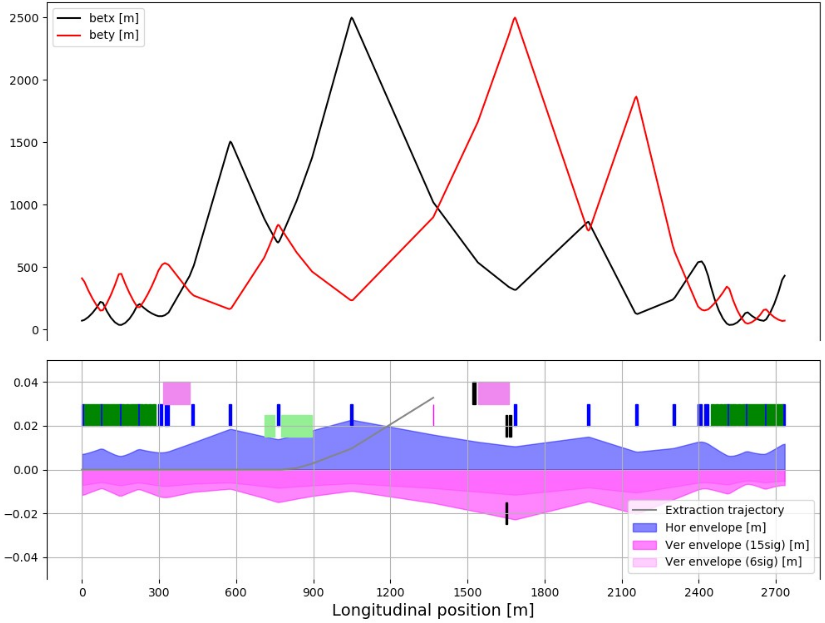
W. Bartmann

- For FCC-hh injection and extraction combined in the same straight section
- Injector options:
  - scSPS: 1.3 TeV
  - (Superferric) LHC: 1.3 - 3.3 TeV
- Synergy between hadron and lepton transfer line

Main optics constraint of kicker-absorber = 90° phase

Most critical is injection failure impacting all extraction elements

Optics and beam enveloped for injection and extraction for FCC-hh



If SPS serves as hadron injector – more obvious synergy between hadron and lepton lines

For the LHC option should study possibility of extracting both beams in either P1 or P8 & envisage re-use of TI8

With updated 8IP layout need to direct injection lines into the arc tunnel to avoid excessive tunnel lengths

Poster Session, Thursday 2nd June

Measuring Z boson couplings to bottom quarks at FCCee — *Giovanni Guerrieri*
Réfectoire des Cordeliers — 17:50 - 17:51

Strange jet tagging at the FCC-ee using a transformer NN architecture and K short reconstruction — *Eduardo Ploerer*
Réfectoire des Cordeliers — 17:51 - 17:52

Incorporation of LCFIPlus vertexing module in FCCAnalyses — *Kunal Gautam*
Réfectoire des Cordeliers — 17:53 - 17:54

Presentation of the Grainite calorimeter project — *Jacques Lefrancois*
Réfectoire des Cordeliers — 17:54 - 17:55

Higgs Self Couplings Measurements at Future proton-proton Colliders — *Claudio Caputo*
Réfectoire des Cordeliers — 17:55 - 17:56

Performance of different FCC-ee vertex detector geometries and benefit of extended forward coverage — *Armin Ilg*
Réfectoire des Cordeliers — 17:56 - 17:57

Monte Carlo KKMCee 5.00 for lepton and quark pair production in lepton colliders — *Prof. Stanislaw Jadach*
Réfectoire des Cordeliers — 17:57 - 17:58

The high-energy QCD dynamics from Higgs-plus-jet correlations at FCC collision energies
Dr Francesco Giovanni Celiberto

Constraining 3-3-1 Models at the LHC and Future Hadron Colliders — *Ms Yoxara Sánchez Villamizar*
Réfectoire des Cordeliers — 17:59 - 18:00

Technological and operational challenges of FCC cryogenic distribution system. — *Prof. Maciej Chorowski*
Réfectoire des Cordeliers — 18:00 - 18:02

Studies towards an electro-optical longitudinal bunch profile monitor for FCC-ee based on the setup at KARA
Micha Reißig

Enhanced electromagnetic processes in oriented crystalline tungsten for high-performance positron production
Mattia Soldani

Frequency and Temperature Dependence of High-Temperature Coated-Conductors Surface Resistance
Nikki Tagdulang et al.

Optics measurement prospects for the FCC-ee — *Jacqueline Keintzel*
Réfectoire des Cordeliers — 18:08 - 18:10

Spin precession as a method for beam energy measurment — *Victor Caudan*
Réfectoire des Cordeliers — 18:10 - 18:12

Development and Optimization of Plasma Cleaning Process for QWR type Cavities — *Oleksandr HRYHORENKO et al.*
Réfectoire des Cordeliers — 18:12 - 18:14

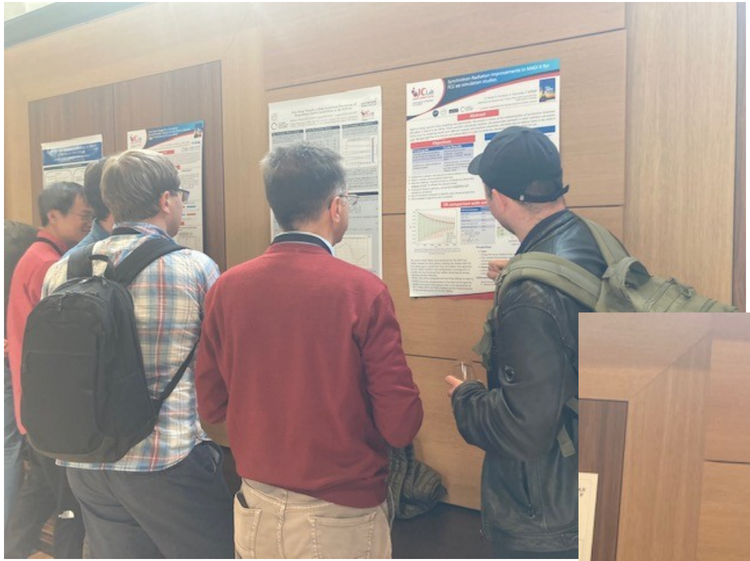
SR radiation issues in FCC-ee — *Guillaume Simon*
Réfectoire des Cordeliers — 18:14 - 18:16

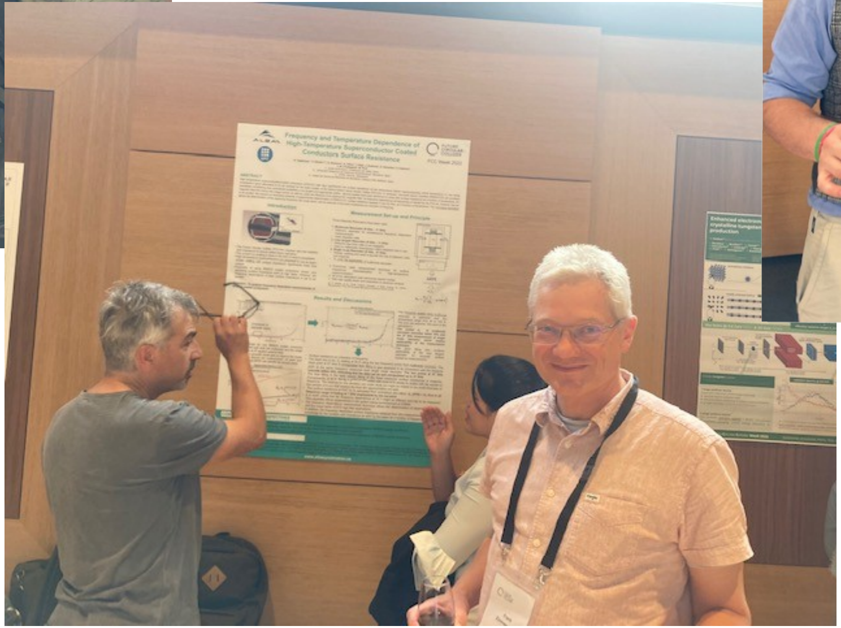
Beam-Beam effects at FCC-ee — *Nikos Nikolopoulos*
Réfectoire des Cordeliers — 18:16 - 18:18

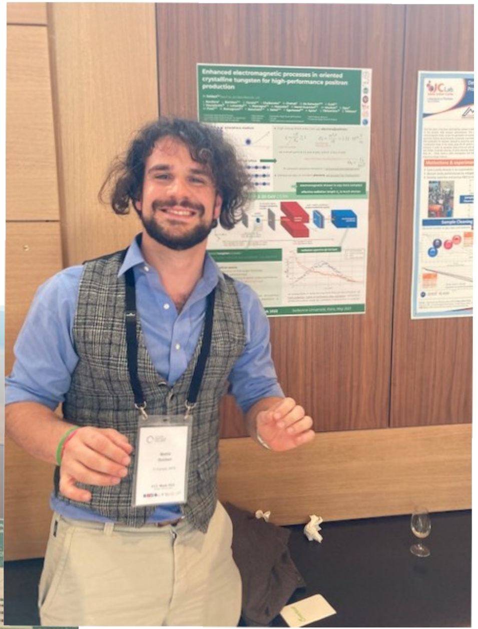
First optics design for a transverse monochromatic scheme for the direct s-channel Higgs production at FCC-ee collide
Angeles Faus-Golfe

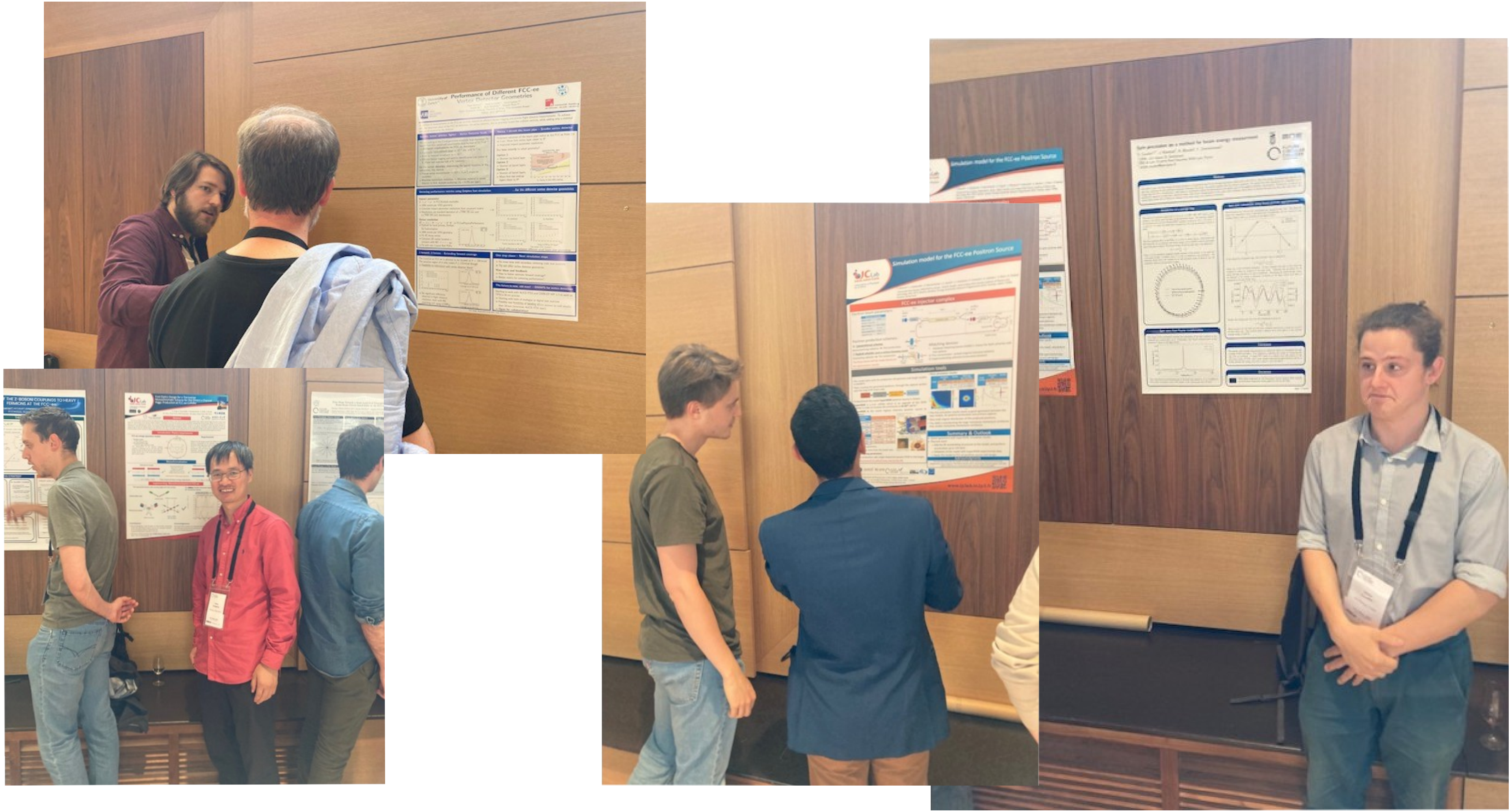
Development and Optimization of Plasma Cleaning Process for QWR type Cavities — *Oleksandr HRYHORENKO*
Réfectoire des Cordeliers — 18:20 - 18:22

Simulation model for the FCC-ee Positron Source — *Fahad ALHARTHI*
Réfectoire des Cordeliers — 18:22 - 18:24




Frequency and Temperature Dependence of High-Temperature Superconductor Coated Conductors Surface Resistance


Enhanced electromagnetic processes in oriented crystalline tungsten for high-performance positron production


Performance of Different FCC-ee
Vertex Detector Geometries
Simulation model for the FCC-ee Positron Source
FCC-ee injector complex
Simulation tools
Summary & Outlook

Thank you
for your attention.