

TECHNISCHE
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Possible Beam Studies at DAΦNE

JACQUELINE
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TU WIEN, VIENNA, AUSTRIA
CERN, GENEVA, SWITZERLAND

FCC November Week
10th November 2020

Acknowledgements:

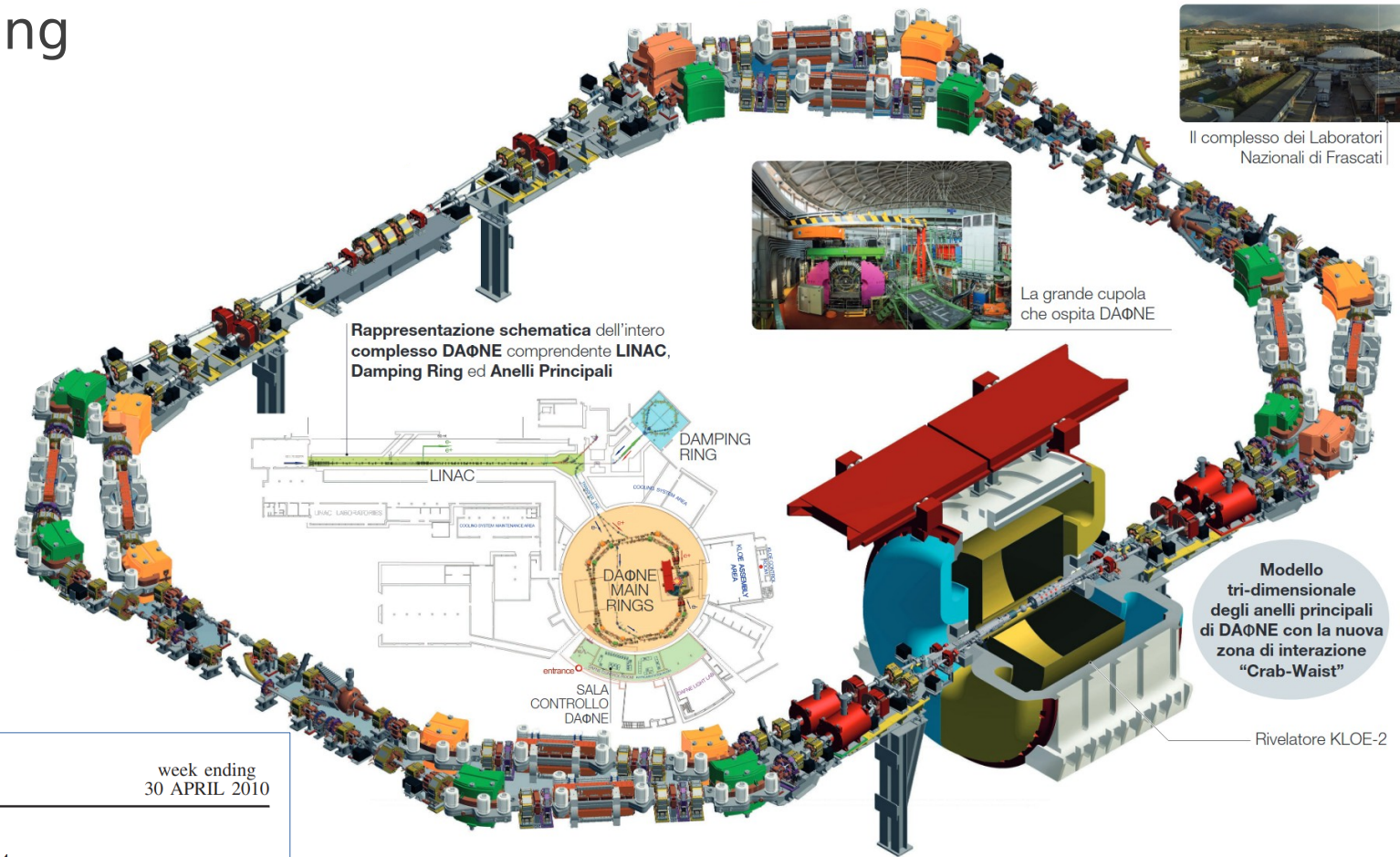
Michael Benedikt, Oscar Blanco, Alessandro Drago, Catia Milardi, Rogelio Tomás, Frank Zimmermann, Mikhail Zobov

The Future Circular Collider Innovation Study (FCCIS) project has received funding from the European Union's Horizon 2020 research and innovation programme under grant No 951754.

Introduction DAΦNE

Ref: [1,2]

- Injection linac and damping ring
- 510 MeV beam energy
- 2 beam crossings
- 1 interaction point
 - Now: Siddharta-2, no solenoid
 - Before: Kloe-2, solenoid
- First collider with crab waist collision scheme



PRL 104, 174801 (2010)

PHYSICAL REVIEW LETTERS

week ending
30 APRIL 2010

Test of "Crab-Waist" Collisions at the DAΦNE Φ Factory

Introduction DAΦNE

Ref: [3-5]

- Electrodes for e-cloud mitigation
- No periodicity → each ring is one cell
- Independently powered quadrupoles and sextupoles
- Very flexible optics e.g. collisions with negative momentum compaction factor

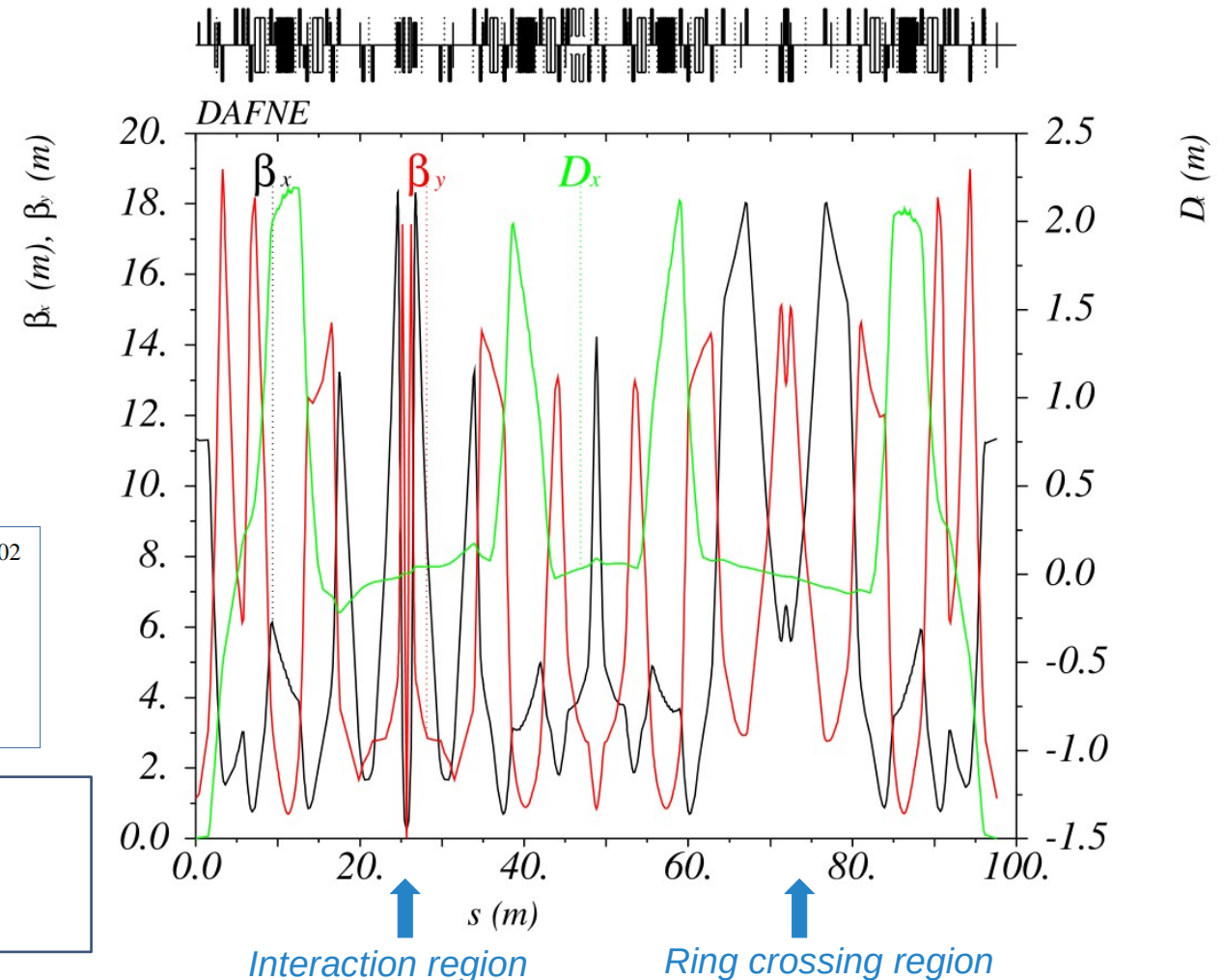
Proceedings of EPAC 2006, Edinburgh, Scotland

TUODFI02

DAΦNE EXPERIENCE WITH NEGATIVE MOMENTUM COMPACTION

M. Zobov, D. Alesini, M.E. Biagini, A. Drago, A. Gallo, C. Milardi, P. Raimondi,
B. Spataro, A. Stella, LNF-INFN, Frascati, Italy

➔ *DAΦNE can test innovative and novel concepts !*

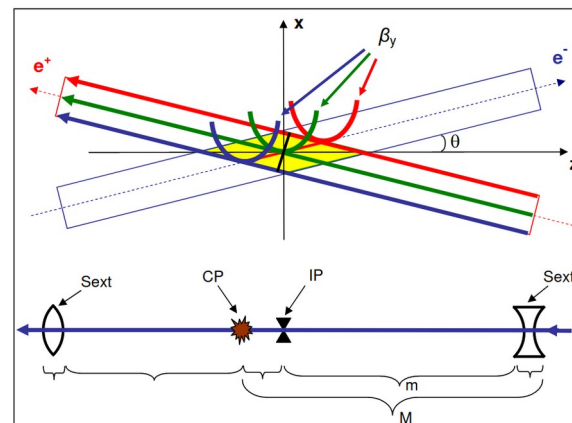


DAΦNE and FCC-ee

Ref: [3,6-8]

Parameter	FCC-ee				DAFNE
	Z	WW	ZH	tt	
Circumference [km]	97.756				0.098
Beam Energy [GeV]	45.6	80	120	182.5	0.510
Hor. Emittance [nm]	0.27	0.84	0.63	1.46	260
βx^* [cm]	15	20	30	100	26
βy^* [mm]	0.8	1.0	1.0	1.6	9
Bunch Length with SR/BS [mm]	3.5/12.1	3.0/6.0	3.3/5.3	2.0/2.5	1.4
Beam Current [A]	1.390	0.147	0.029	0.0054	2.45 (-) / 1.4 (+)

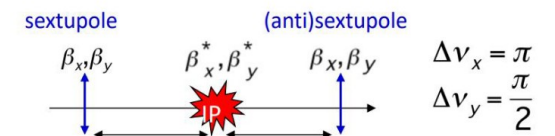
- Electron-positron circular collider
- Comparable beam currents
- Crab-waist collision scheme



3 Steps:

- 1) Large Piwinski angle
- 2) βy comparable to overlap area size
- 3) Crab-waist transformation

Special crab sextupoles



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- Electron-positron circular collider
- Comparable beam currents
- Crab-waist collision scheme

➔ *DAΦNE can test FCC-ee challenges!*

Possible Studies at DAΦNE

- High current operation
 - Impedance, wake field effects, ..
- E-cloud suppression studies
- Test FCC-ee feedback system
- Impact of experiments with and without solenoid
 - Benchmark codes, monitor luminosity
- Studies of the crab-waist collision scheme
 - Operation with crab-waist collisions
 - Lattice and optics tolerances
 - Measuring and correction and (crab-waist) optics
 - Luminosity increase thanks to crab-waist
- Possibility to connect BPMs to Libera Modules to record turn-by-turn data

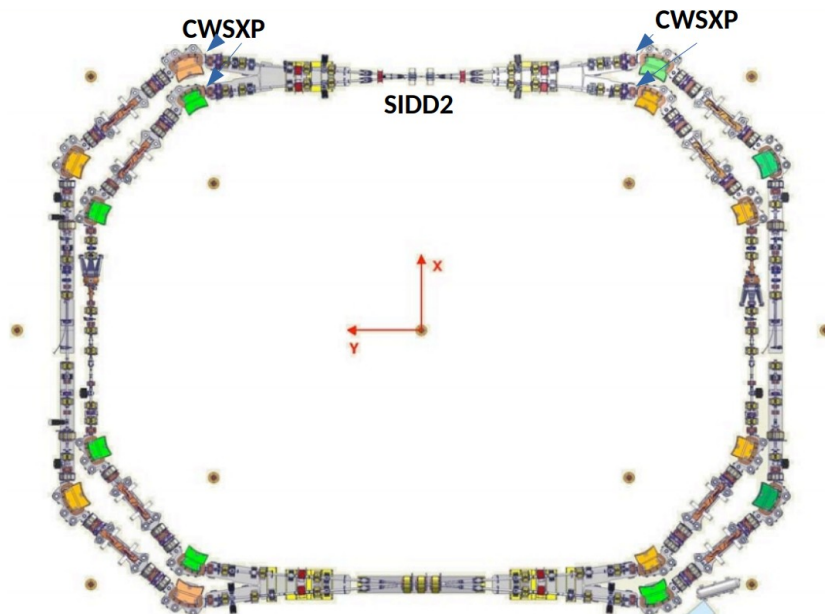
Already successfully performed or presently ongoing also in the framework of the FCC-ee study

Alignment Sensitivity

Ref: [5]

- Final focus quadrupole location essential for crab-waist
 - Huge impact on phase advance between crab sextupoles
 - Moving final focus quadrupoles by 2 cm this spring improved optics

Sextupoles for crab-waist collision scheme



- Off-center orbit through (crab-) sextupoles (CS) lead to tune shift
 - CS off and generate knobs for 1 mm orbit
 - CS on and measure tune shift
 - Increase knob strength until initial tune reached to determine CS transverse offset

FCC-ee:

- ✓ *Sensitivity of misalignments on crab-waist*
- ✓ *Techniques to identify and correct misalignments*

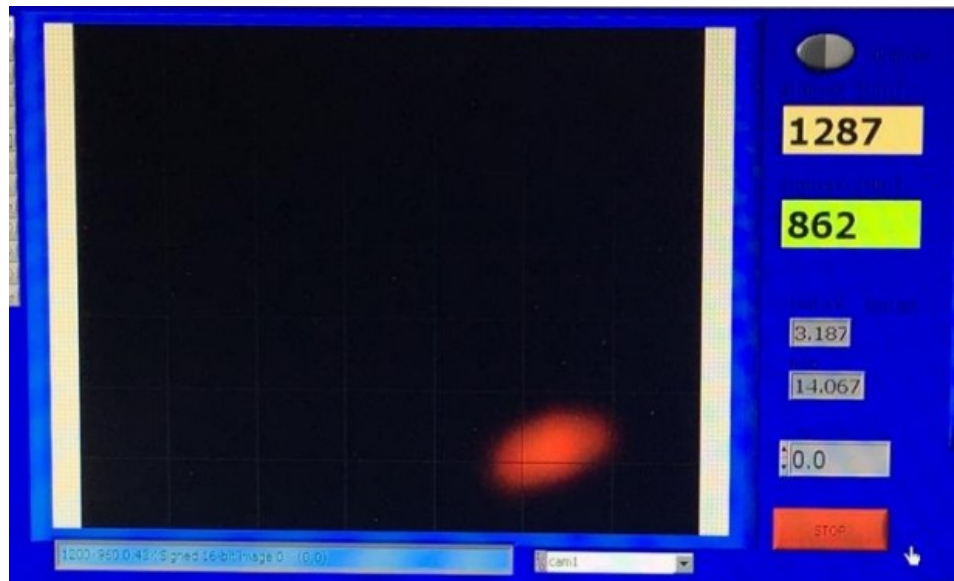
Coupling Correction

Ref: [5]

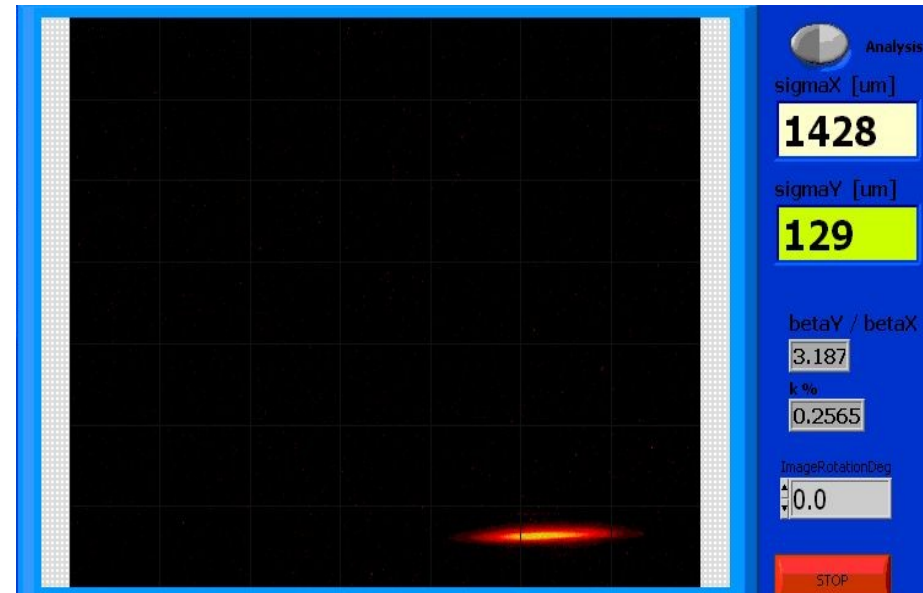
- Coupling correction for high intensity beams
 - Rotate quadrupoles to reduce tilt and coupling
 - Switch on skew quadrupoles

After corrections:

*0.3 % transverse coupling for electron ring
and beam is no longer tilted*



*Starting point with new optics:
14 % transverse coupling for electron ring,
together with beam tilt*



FCC-ee:

- ✓ *Operation and hands-on experience with optics corrections*
- ✓ *Study high current beams*

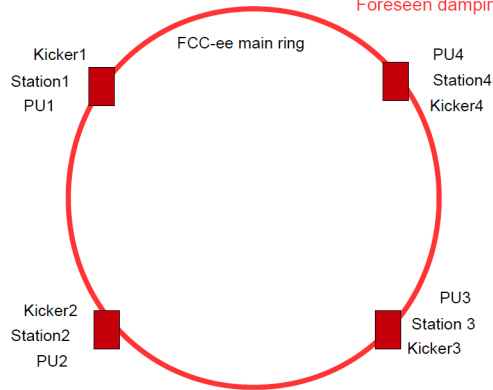
Possible FCC-ee Feedback Test

Ref: [9-11]

Very fast instabilities (growth rates up to 3 revolution turns)

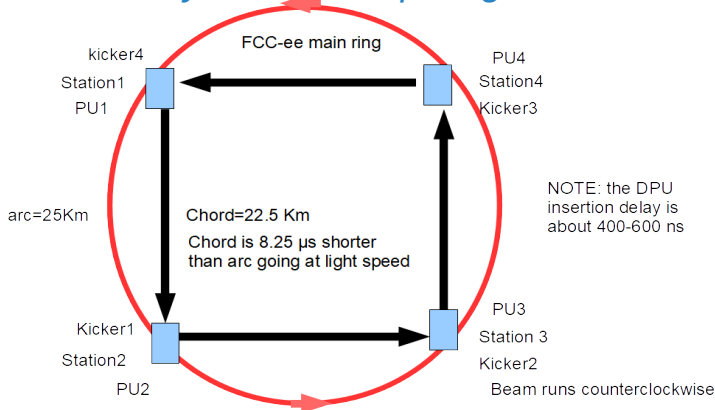
4 feedback systems (4 stations)

Foreseen damping rate: 2.5 turns

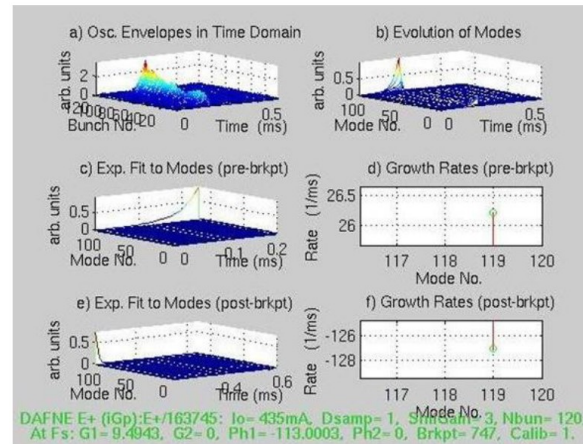


Extremely fast instabilities (growth rates up to 1-2 revolution turns)

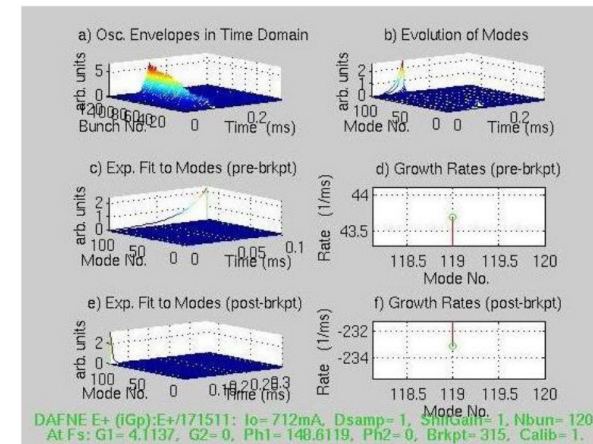
4 feedback systems anticipating correction kicks



- Dynamic beam simulations for FCC-ee main rings and booster exhibit extremely fast coupled bunch instabilities of the order of few revolution turns → Powerful new feedback design required
- In DAFNE positron ring very rapid horizontal instability → multiple cooperative feedback scheme has been installed



Single feedback dumping rate 128 ms^{-1}



Double feedback dumping rate 234 ms^{-1}

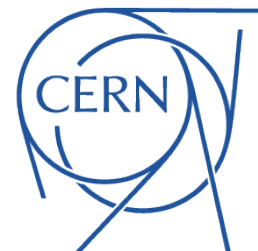
Since 2008 a new double feedback technique is implemented successfully

FCC-ee:

- ✓ Test possible FCC-ee feedback at DAFNE
- ✓ Measure damping performance with different beam and layout conditions

Summary

- DAΦNE is demonstrating high current operation and crab-waist collisions for FCC-ee
 - First collider with crab waist collision scheme → two runs with two different detectors
 - High current operation with crab-waist
- Presently ongoing studies useful for FCC-ee
 - Lattice misalignments and impact on crab-waist optics
 - Optics measurements and correction which allow high current operation
- Possible studies in the framework of the FCC Innovation Study
 - Analyse new crab-waist optics and implications on performance
 - Quantify crab-waist and lattice tolerances
 - High current operation
 - E-cloud mitigation
 - Test possible FCC-ee feedback system
 - ...



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References

- [1] <http://edu.lnf.infn.it/wp-content/uploads/2016/06/01-Poster-DAFNE.pdf>
- [2] M. Zobov et al., Test of crab-waist collisions at the DAΦNE Φ factory, Phys. Rev. Letters 104, 174801, 2010.
- [3] C. Milardi, DAFNE as Open Accelerator Test Facility: DAFNE-TF, presented at the DAFNE TF Workshop, 17th December 2018.
- [4] M. Zobov, et al. DAFNE experience with negative momentum compaction, presented at the European Particle Accelerator Conference (EPAC06), Edinburgh, Scotland, 2006.
- [5] J. Keintzel et al., Brief report from DAFNE Commissioning, 113th FCC-ee Optics Design Meeting, 6th March 2020.
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- [7] P. Raimondi, D. Shatilov, M. Zobov, Beam-beam issues for colliding schemes with large piwinski angle and crabbed waist, arXiv:physics/0702033, 2007.
- [8] M. Zobov et al., Crab-waist collision scheme: a novel approach for particle colliders, arXiv:1608.06150 (2016).
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- [11] A. Drago, DAFNE horizontal feedback upgrade, presented at the Particle Accelerator Conference 2009 (PAC09), Vancouver, Canada, 2009.