Feedback systems for FCC-ee

Alessandro Drago
(formerly INFN-LNF, now Senior Associate)

INFN
LNF
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali del Frascati

This project has received funding from the European Union's Horizon 202
Research and Innovation programme under Grant Agreement No 730871

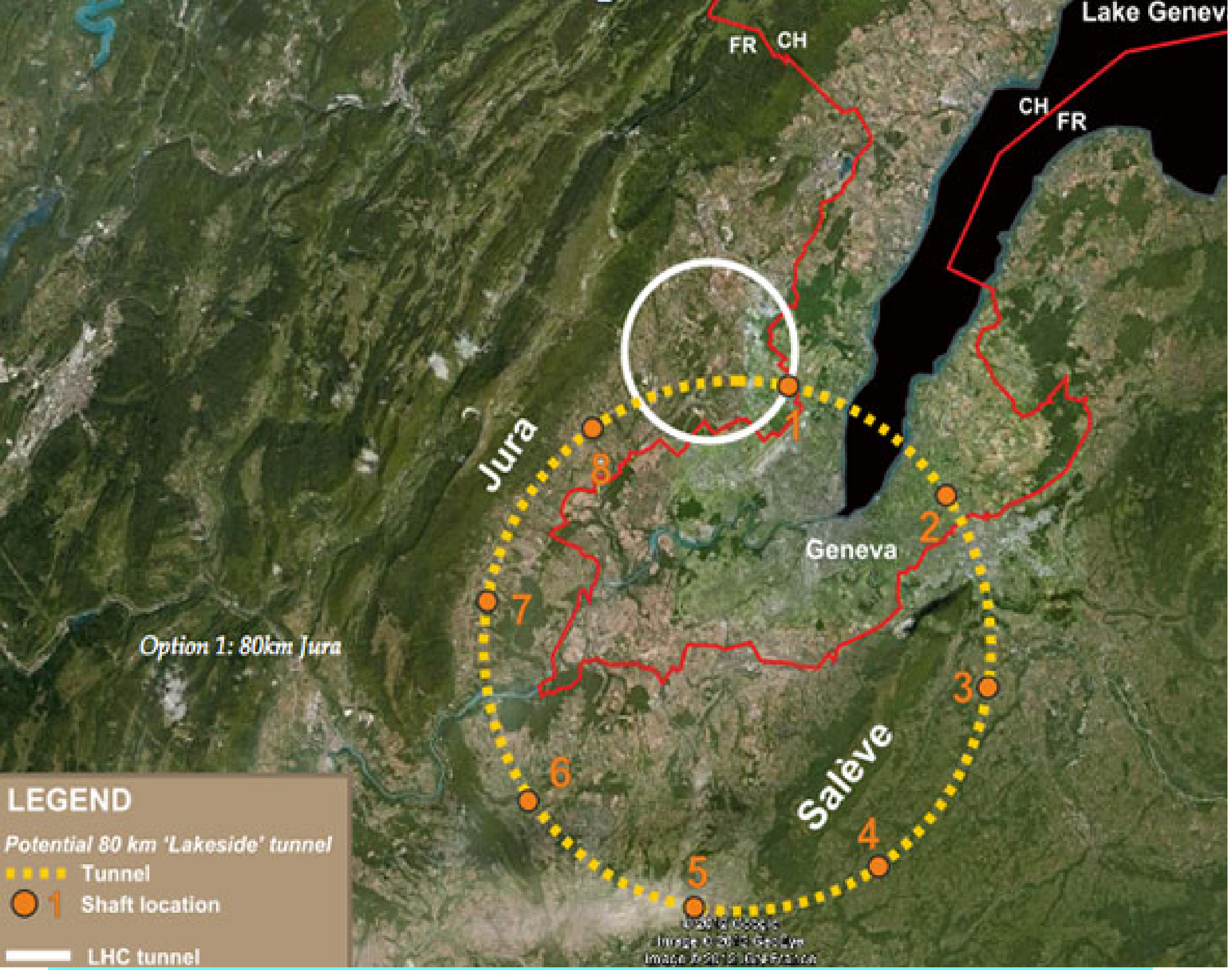
ARIES

TOPICS

- Introduction
- Future Circular Collider e+/e-   (FCC-ee)
- The ARIES Project
- Collective effects in FCC-ee
- Considerations on the bunch-by-bunch feedback limits
- Some ideas to overcome the feedback limits in FCC-ee
- After 2020
- Conclusion

Introduction

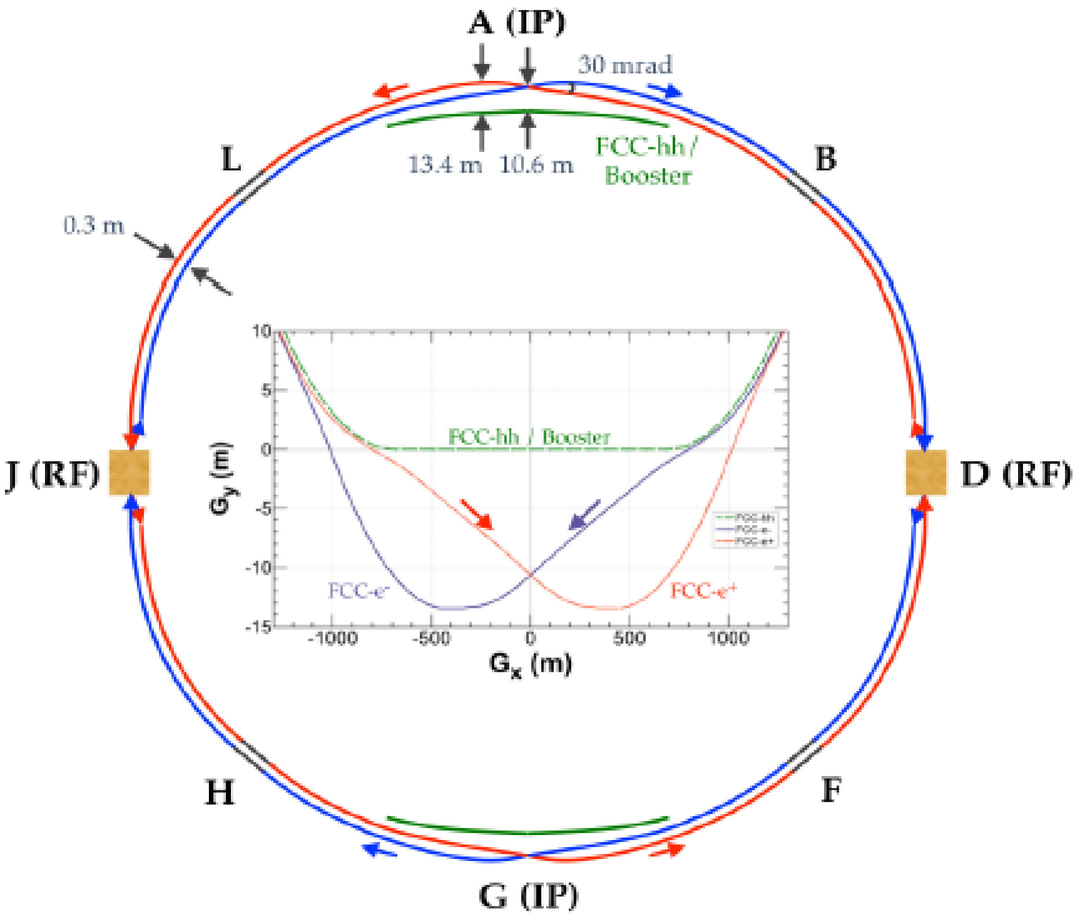
- The motivations to develop a preliminary research about how to design the feedback systems for FCC-ee were triggered by two large collaborations:
  - the **FCC Weeks** held in the years 2016-18 to prepare the CDR for the 2019
  - the **ARIES** project, funded in the frame of Horizon 2020 by EU Commission
- Presentations and discussions were held at:
  - FCC Week 2016 – Rome, 11-15 April 2016
  - eeFACT2016, 58th ICFA Advanced Beam Dynamics workshop On High Luminosity Circular e+e- Colliders – Cockcroft Institute at Daresbury Laboratory, UK, 24-27 October 2016,
  - FCC Week 2018 – Amsterdam, 9-13 April 2018
  - ARIES (& EUCARD-2) meetings and workshops in the years 2016-2019.
  - [Note: EUCARD-2 was a 4-year project started on 1st May 2013. EuCARD-2 project was part of FP7 and ended in 30/4/2017]



FCC tunnel map with 8 shaft locations

FCC-ee

The lepton version of the collider



97.75 km double ring, full-energy $e^{\pm}$ injection

Table 1. Machine parameters of the FCC-ee for different beam energies.

	Z	WW	ZH	$t\bar{t}$	
Circumference (km)	97.756				
Bending radius (km)	10.760				
Free length to IP l^* (m)	2.2				
Solenoid field at IP (T)	2.0				
Full crossing angle at IP θ (mrad)	30				
SR power/beam (MW)	50				
Beam energy (GeV)	45.6	80	120	175	182.5
Beam current (mA)	1390	147	29	6.4	5.4
Bunches/beam	16 640	2000	328	59	48
Average bunch spacing (ns)	19.6	163	994	2763	3396
Bunch population (10^{11})	1.7	1.5	1.8	2.2	2.3
Horizontal emittance ε_x (nm)	0.27	0.84	0.63	1.34	1.46
Vertical emittance ε_y (pm)	1.0	1.7	1.3	2.7	2.9
Horizontal β^*_x (m)	0.15	0.2	0.3	1.0	
Vertical β^*_y (mm)	0.8	1.0	1.0	1.6	
Energy spread (SR/BS) σ_δ (%)	0.038/0.132	0.066/0.131	0.099/0.165	0.144/0.186	0.150/0.192
Bunch length (SR/BS) σ_z (mm)	3.5/12.1	3.0/6.0	3.15/5.3	2.01/2.62	1.97/2.54
Piwinski angle (SR/BS) ϕ	8.2/28.5	3.5/7.0	3.4/5.8	0.8/1.1	0.8/1.0
Energy loss/turn (GeV)	0.036	0.34	1.72	7.8	9.2
RF frequency (MHz)	400			400/800	
RF voltage (GV)	0.1	0.75	2.0	4.0/5.4	4.0/6.9
Longitudinal damping time (turns)	1273	236	70.3	23.1	20.4
Energy acceptance (DA) (%)	±1.3	±1.3	±1.7	-2.8 +2.4	
Polarisation time t_p (min)	15000	900	120	18.0	14.6
Luminosity/IP (10^{34}/cm^{2}s)	230	28	8.5	1.8	1.55
Beam-beam ξ_x/ξ_y	0.004/0.133	0.010/0.113	0.016/0.118	0.097/0.128	0.099/0.126
Beam lifetime by rad. Bhabha scattering (min)	68	59	38	40	39
Actual lifetime incl. beam-strahlung (min)	>200	>200	18	24	18

The lowest beam energy collider (Z layout) is much more critical from feedback performance point of view.

Indeed it asks for
high current (1390mA),
and
high number of bunches (16640).

These parameters are usually correlated to fast grow rate instabilities

Vacuum Considerations for FCC-ee

R. Kersevan, CERN-TE-VSC-VSM

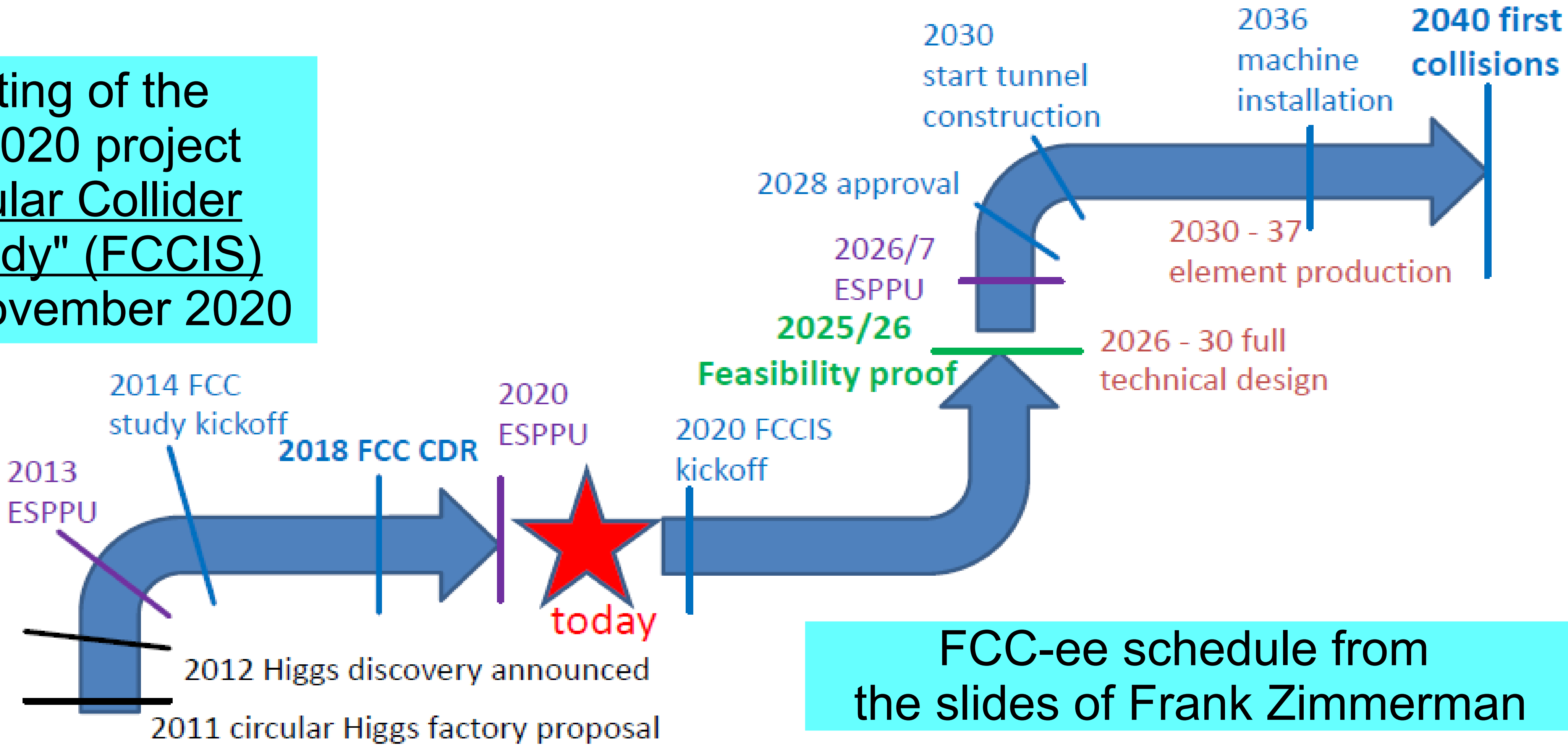
1. Introduction

- The FCC-ee is a very challenging machine, since it aims at accommodating 4 different energies, the Z-, W-, H- and T-pole, running at 45.6, 80, 120, and 175/182.5 GeV, respectively, with rather stringent time schedule driven by integrated luminosity at each energy;
- It has become immediately evident that, vacuum-wise, **the Z-pole is the most challenging one**, with its B-factory-like currents of almost 1.4 A, compared to the 10 mA or so that LEP stored at the time at the same energy;
- FCC-ee is conceived as a **very low-emittance, high-luminosity machine**, and therefore **all impedance issues and related beam instabilities must be avoided**: this requirement calls for a very careful design of its vacuum system, with very low-loss components, such as flanges, synchrotron radiation (SR) absorbers, tapers, resistive wall (NEG-coating);
- We have tried our best to take advantage of the lessons learned in the last 2 decades on B-factories (SLAC, KEK, Cornell) and the legacy studies on LEP, trying to combine different features, design, and material choices into a reasonable solution applicable to **a twin ~100 km ring (plus ~100 km booster!)**;

I agree completely with Kersevan's considerations presented yesterday

FCC Roadmap

Kickoff meeting of the
EU Horizon 2020 project
"Future Circular Collider
Innovation Study" (FCCIS)
from 9 to 13 November 2020



FCC-ee schedule from
the slides of Frank Zimmerman

ARIES

- PROJECT ACRONYM: Accelerator Research and Innovation for European Science and Society
- PROGRAMME: Horizon 2020 (Integrating Activity)
- DURATION: from May 2017 to April 2021 (4 years)
- TOTAL BUDGET: 24.8 M€ (mainly for travels, conference management and fellowships)
- TOTAL EC CONTRIBUTION:10 M€
- CONSORTIUM: 41 participants from 18 countries

- ARIES is structured in to 18 separate Work Packages (WPs) over several Joint Research Activities (JRAs), Networking Activities (NAs), and Transnational Access Activities (TNAs). Every WP is divided in Tasks.
- FB studies are in **WP6** → Accelerator Performance and Concepts (APEC)
  - WP Leader: Frank Zimmerman
- Some of the WP6 goals:
  - Review of existing strategies & methods for beam-impedance assessments and impedance models;
  - proposing and evaluating novel methods to reduce accelerator impedance;
  - identification or development of strategies for electron cloud mitigation at future accelerators;
  - conceptual design of advanced beam feedback systems for future machines
- Task 6.4 Improved Beam Stabilization
  - Task Leaders: M. Migliorati (Sapienza & INFN) & A. Drago (INFN-LNF)

Study results from the collective effect study group in FCC-ee

(presented by Eleonora Belli in the FCC week 2017)

On the side the Instability growth rates as foreseen by the impedance model (without considering e-cloud effects):

6 revolution turns

Courtesy of E.Belli, FCC week 2017

E. Belli - Impedance model and collective effects for FCC-ee

Transverse coupled bunch instability

- Growth rate for the μ-th mode

$$\boxed{\frac{1}{\tau_{\mu,\perp}} = -\frac{ecI}{4\pi E Q_\beta}\sum_q Re\left[Z_\perp(\omega_q)\right]\cancel{G_\perp\left(\frac{\sigma_z}{c}\omega'_q\right)}}=1$$

with

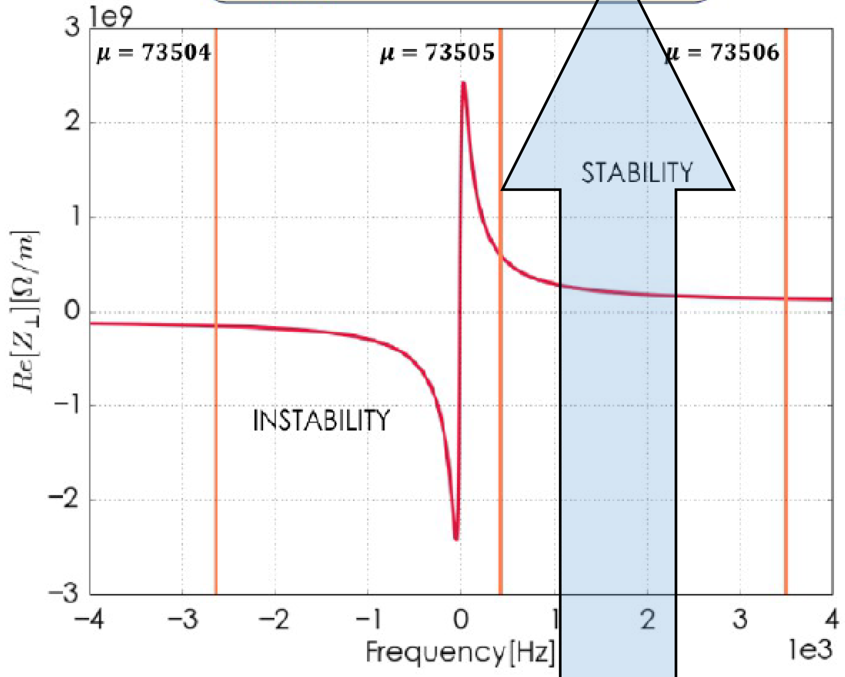
$$\omega_q = (qM + \mu + Q_\beta)\omega_0$$

$$\omega'_q = \omega_q + \xi\frac{\omega_\beta}{\eta}$$

$$\boxed{Re\left[Z_\perp(\omega)\right] = sgn(\omega)\frac{C}{2\pi b^3}\sqrt{\frac{2Z_0 c}{\sigma_c|\omega|}}}$$

- Negative ω → **unstable** mode with exponential growth
- Positive ω → **stable** mode with damped oscillations
- The most dangerous coupled mode when $\omega_q \approx 0$
  - $\mu = -qM - Q_0 - 1 = 73504$

$$\frac{1}{\tau_{73504}} = 494.8\ s^{-1} \simeq 6\ turns$$



Robust feedback for instability suppression

11

The question is:

what are the performance limits of the currently implemented bunch-by-bunch feedback systems?

Feedback performance limits at SuperKEKB

- In the year 2016, Makoto Tobiyama, John Flanagan † (passed away last March), both from KEK, and myself studied the feedback performance in SuperKEKB.
- The performance of the transverse BxB feedback systems are reported in
- https://www.pasj.jp/web_publish/pasj2016/proceedings/PDF/TUOM/TUOM06.pdf
- The fastest observed damping rate in the SuperKEKB configuration was around 0.1 ms, **about 10 turns of revolution**
- Comment from Tobiyama-san : “For the real operation of the SuperKEKB collider, I've reduced the feedback gain as small as possible (to keep the beam) not to inject the unnecessary noise to avoid the **beam size blowup** so the damping rate, especially in the vertical plane, is around the order of 1 ms.”

Proceedings of the 13th Annual Meeting of Particle Accelerator Society of Japan
August 8-10, 2016, Chiba, Japan
PASJ2016 TUOM06

BUNCH BY BUNCH FEEDBACK SYSTEMS FOR SUPERKEKB RINGS

Makoto Tobiyama[†], John W. Flanagan,
KEK Accelerator Laboratory, 1-1 Oho, Tsukuba 305-0801, Japan,
and Graduate University for Advanced Studies (SOKENDAI), 1-1, Oho, Tsukuba 305-0801, Japan
Alessandro Drago, INFN-LNF, Via Enrico Fermi 40-00044, Frascati(Roma), Italy

Abstract

Bunch by bunch feedback systems for the SuperKEKB rings have been developed. Transverse and longitudinal bunch feedback systems brought up in very early stages of beam commissioning have shown excellent performance, and helped realize smooth beam storage and very quick vacuum scrubbing. Also, via grow-damp experiments and unstable mode analysis, they contributed to finding the possible source of an instability. The measured performance of the bunch feedback systems, together with the performance of the bunch feedback related systems such as the bunch current monitor and betatron tune monitor are reported.

analysed by the unstable mode analysis with the grow-damp experiments. Also the related beam diagnostic tools such as the bunch current monitor, large scale memory board, will be shown.

Table1: Main Parameters of SuperKEKB HER/LER in Phase 1 Operation.

	HER	LER
Energy (GeV)	7	4
Circumference(m)	3016	
Max. Beam current (mA)	1010	870
Max. Number of bunches	2455	2363

It is important to conclude that:

achievement of the performance limits of the bunch-by-bunch feedback systems may <u>not</u> be the best solution from the point of view of beam emittance

==>

"<u>not to inject the unnecessary noise to avoid the beam size blowup</u>"

A new idea was implented at DAFNE in 2008 that gives advantages in terms of better damping rate but also in terms of less noise on the beam that means less beam enlargement.

It consists in a technique to have a better signal-to-noise ratio in the correction signal output.

At DAFNE in the year 2008 a new double feedback tecnique was implemented successfully

Proceedings of PAC09, Vancouver, BC, Canada THREP072

DAFNE HORIZONTAL FEEDBACK UPGRADE

Alessandro Drago, INFN - LNF
Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati, 00044 Frascati, Italy

Abstract

In this paper the horizontal feedback upgrade for the positron DAFNE ring is presented. After having completed the analysis of the e+ current limit behavior, a feedback upgrade turned out to be necessary. A fast implementation was required for the success of the crab waist experiment in 2008. It was considered if a simple power increase would have been the best solution. The lack of power combiners and space for other two power amplifiers has brought to a different approach, doubling the entire feedback system. The advantages of this implementation with respect to a more traditional power amplifier doubling are evident: two feedback kicks for every revolution turn, more efficient use of the power amplifiers, greater reliability, and less coherent noise in the system. Measurements of the performance for each of the two feedbacks have shown a perfect equivalence between the new and the old system. In fact the resulting damping rate is exactly twice the rate of each system taken individually. A description of the implementation is presented together with the performance of the system.

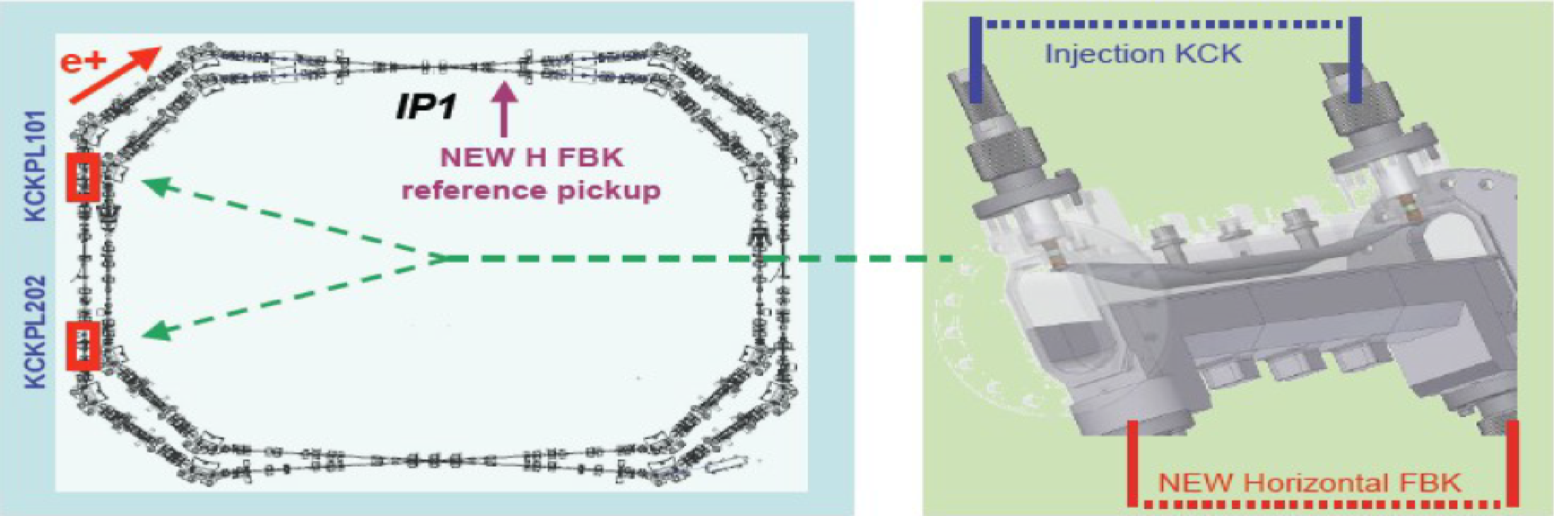
- **DAFNE, year 2008**
- **New e+ Transverse Horizontal Feedback**
- The damping times of the two feedback's add up linearly
- Damping time measured:
- ~100 ms-1 (1 FBKs) → fb damps in 30 revolution periods (~10 us)
- ~200 ms-1 (2 FBKs) → fb damps in 15 revolution periods (~ 5 us)
- The power of the H FBK has been doubled

Fast feedbacks for diagnostics and mitigation of e-cloud instability

Alessandro Drago
INFN-LNF

International Linear Collider Workshop 2008
LCWS08 & ILC08
ILC08 Damping Ring session

November 16-20, 2008
University of Illinois at Chicago



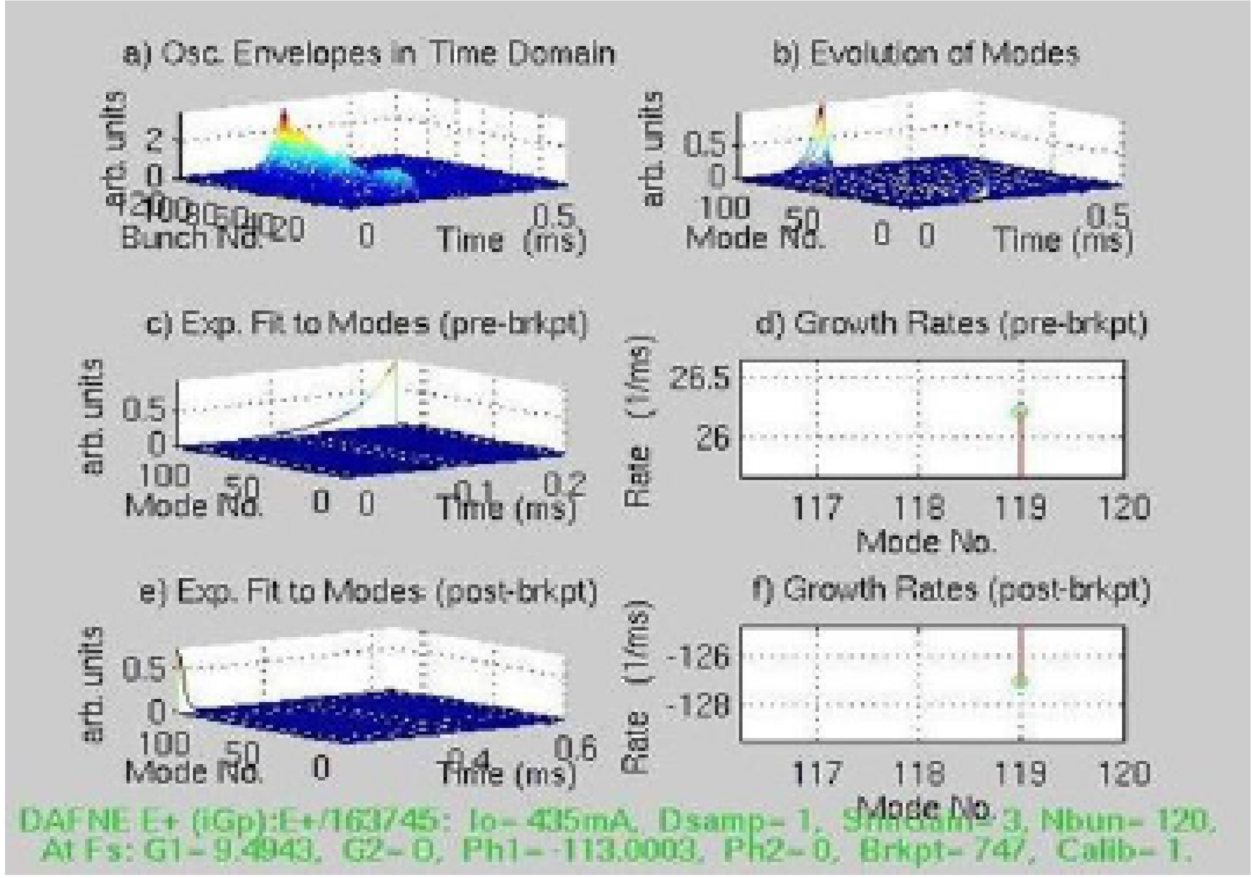


Figure 3: Single feedback damping rate [128 ms^{-1}].

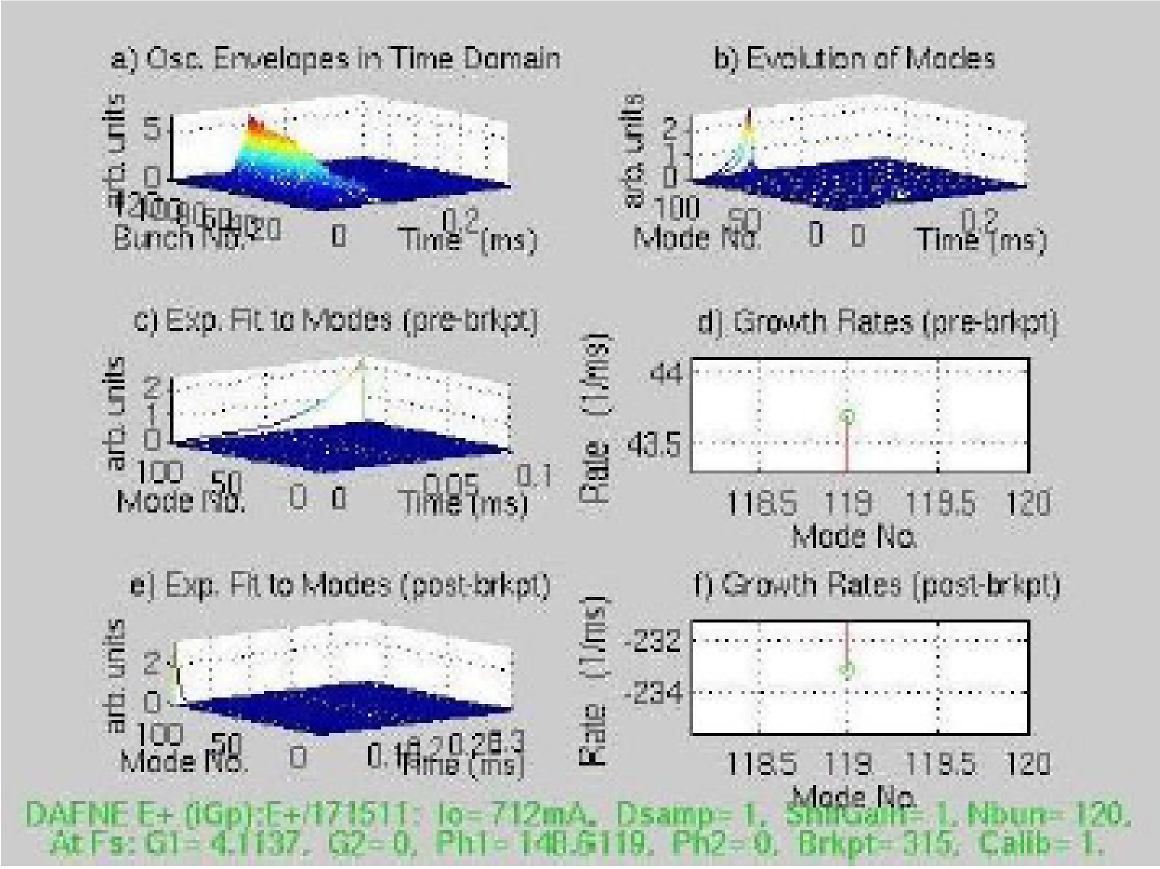


Figure 4: Two feedbacks damping rate [234 ms^{-1}].

After DAFNE test the double feedback technique was implemented successfully also at SuperKEKB and BEPCII

第 42 卷 第 3 期 核 技 术 Vol.42, No.3
2019 年 3 月 NUCLEAR TECHNIQUES March 2019

BEPCII 逐束团双反馈系统运行试验研究

蓝清宏[1,2] 尹 頔[1] 岳军会[1,2] 麻惠洲[1] 何 俊[1] 赵敬霞[1]
曹建社[1,2] 随艳峰[1,2]
1（中国科学院高能物理研究所 北京 100049）
2（中国科学院大学 北京 100049）

核 技 术 2019, 42: 030401

DOI: 10.11889/j.0253-3219.2019.hjs.42.030401

Research of the double feedback system operating in BEPCII

LAN Qinghong[1,2] YIN Di[1] YUE Junhui[1,2] MA Huizhou[1] HE Jun[1] ZHAO Jingxia[1]
CAO Jianshe[1,2] SUI Yanfeng[1,2]
1(*Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China*)
2(*University of Chinese Academy of Sciences, Beijing 100049, China*)

Abstract **[Background]** Digital bunch-by-bunch feedback control is the best way to control bunch instability. It will be applied to the super collider to suppress the beam oscillation within a dozen or even several cycles. The damping time of circular electron positron collider (CEPC) and FCC-ee (Future Circle Collider e^-e^+) is very short, but it is impossible to realize through using traditional digital feedback system. **[Purpose]** This study aims to cure the coupled-bunch instability by using a dual-feedback control system to reduce the damping time for BEPCII (Beijing Electron Positron Collider II). **[Methods]** Several feedback systems operate simultaneously and act on the same time beam in storage ring can superimpose the damping effect and then reduce the damping time of the system. With the favorable condition of two stripline kicker located on the outer ring, we make a experimental research about double feedback system in BEPCII synchrotron mode. Among the double feedback system, one system is the self-make

digital bunch-by-bunch transverse feedback system based commercial card, the other system is
feedback system produced by the Dimtel company. **[Results]** The damping time of commercial fee
measured as 0.93 ms, the damping time of self-make digital bunch-by-bunch transverse feedbac
commercial card is measured as 2.98 ms, and the damping time of double feedback system is measu
[Conclusions] Several feedback systems work simultaneously can effectively reduce the damping tim

Key words Double feedback system, Damping time, Beam oscillation, Linear fitting

国家自然科学基金(No.11475204)资助
第一作者：蓝清宏，女，1992年出生，2015年毕业于武汉大学，现为硕士研究生，电子与通信工程专业，研究领域为加速器束流测量
通信作者：岳军会，E-mail：yuejh@ihep.ac.cn
收稿日期：2018-12-03，修回日期：2019-02-19
Supported by National Natural Science Foundation of China (No.11475204)
First author: LAN Qinghong, female, born in 1992, graduated from Wuhan University in 2015, master student, major in electronics and communication engineering, focusing on accelerator beam measurement technology research

About the feedback damping limits there is also another measurement done at DAFNE in 2005 and presented in a talk given at the 2008 Siberian ICFA workshop

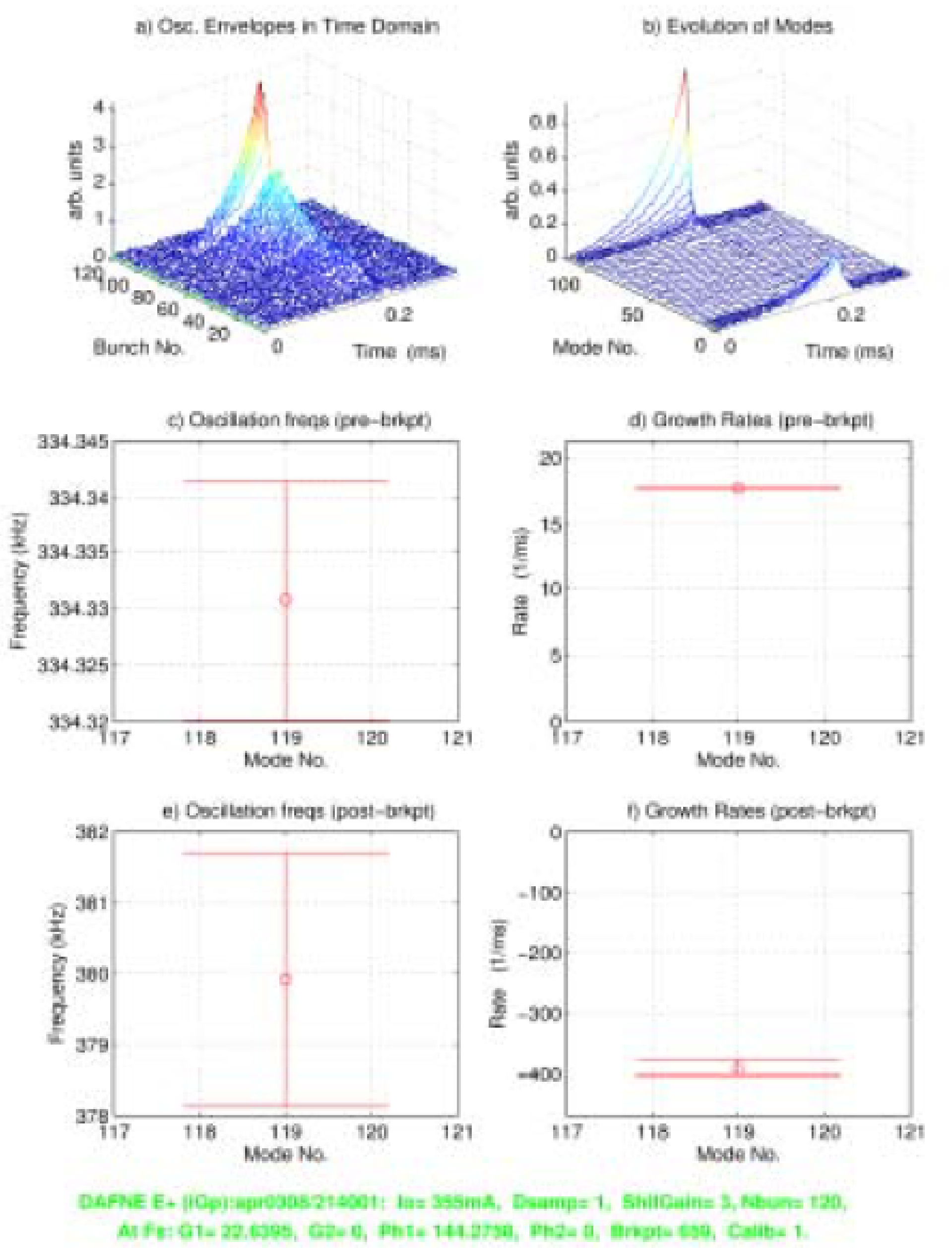
Trends in fast feedback R&D

Alessandro Drago
INFN-LNF

The 40th ICFA Advanced Beam Dynamics Workshop on High Luminosity e+e– Factories

Budker Institute of Nuclear Physics, Novosibirsk
14/16 April 2008

https://accelconf.web.cern.ch/fac08/TALKS/TUACH12_TALK.PDF



Horizontal grow/damp at 355 mA;

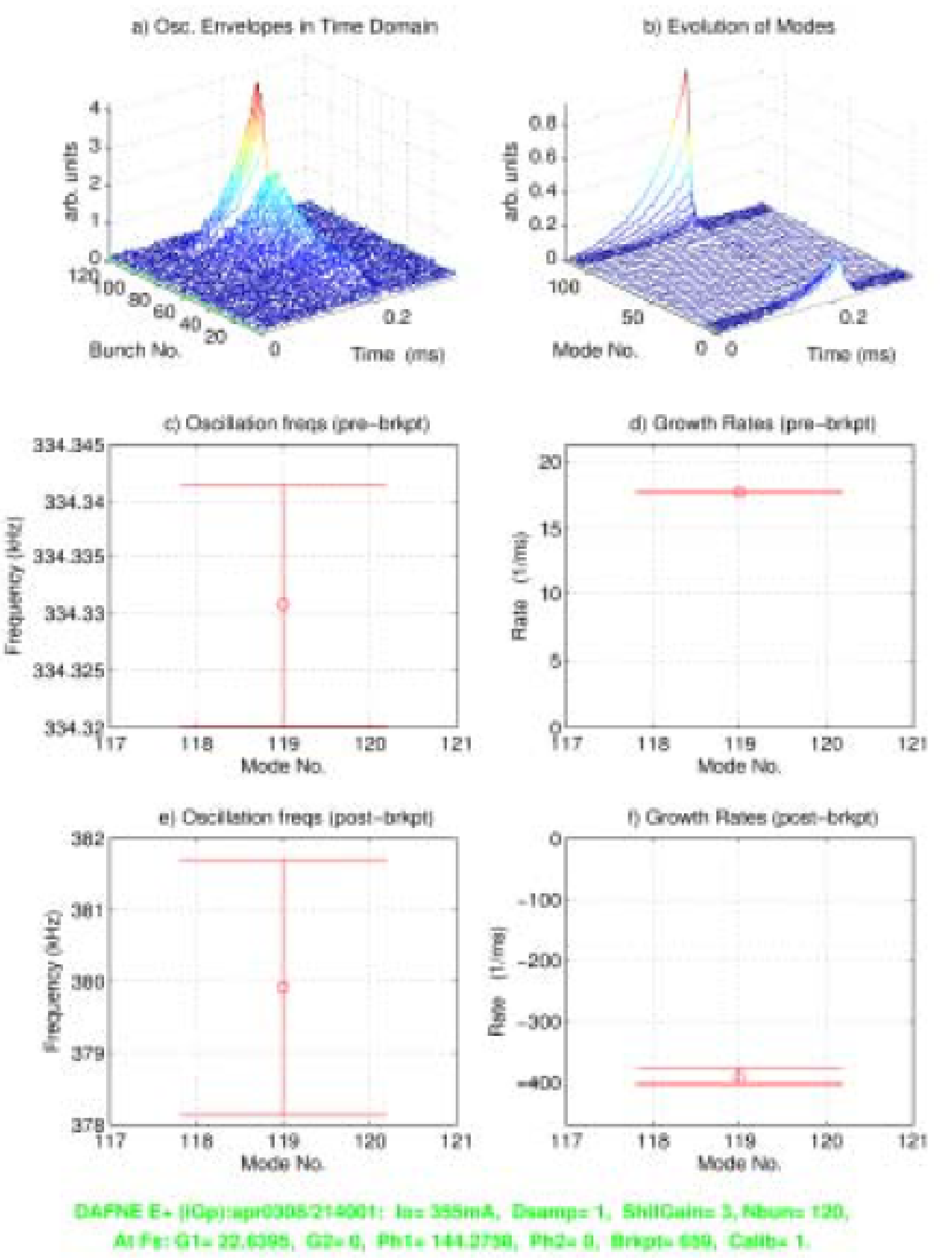
Mode -1

Extremely fast damping of 2.5 microseconds rate

This is the slide n.ro 31 of the talk

Considering that the DAFNE revolution period=324 ns
The fb damping rate is 2500 ns / 324 ns = **7.16 turns**

This measurements was done on April,03rd, 2005 by using the positron horizontal feedback.
Note that 355ma is less than 1/3 of usual top beam current in positron ring.



Horizontal grow/damp at 355 mA;

Mode -1

Extremely fast damping of 2.5 microseconds rate

This is the slide n.ro 31 of the talk

Considering that the DAFNE revolution period=324 ns
The fb damping rate is 2500 ns / 324 ns = <u>**7.16 turns**</u>
<u>A very important comment: given that 355 mA is less than 1/3 of top beam current stored in the DAFNE positron ring (1.2A), it is compatible with the “usual” 10 turns value that has to be considered as an *ideal perfomance limit*</u>

Some ideas to overcome the feedback limits in FCC-ee

FCC-ee: 3 design cases

- Going to FCC-ee design and looking to what we foresee about the beam dynamics, three possible scenarios can be considered:

- Case A → slow or fast instabilities (growth rates slower than 10 revolution turns)
- Case B → very fast instabilities (growth rates up to 3 revolution turns)
- Case C → extremely fast instabilities (growth rates around 1-2 turns o even less than one turn).

Case A: design option A

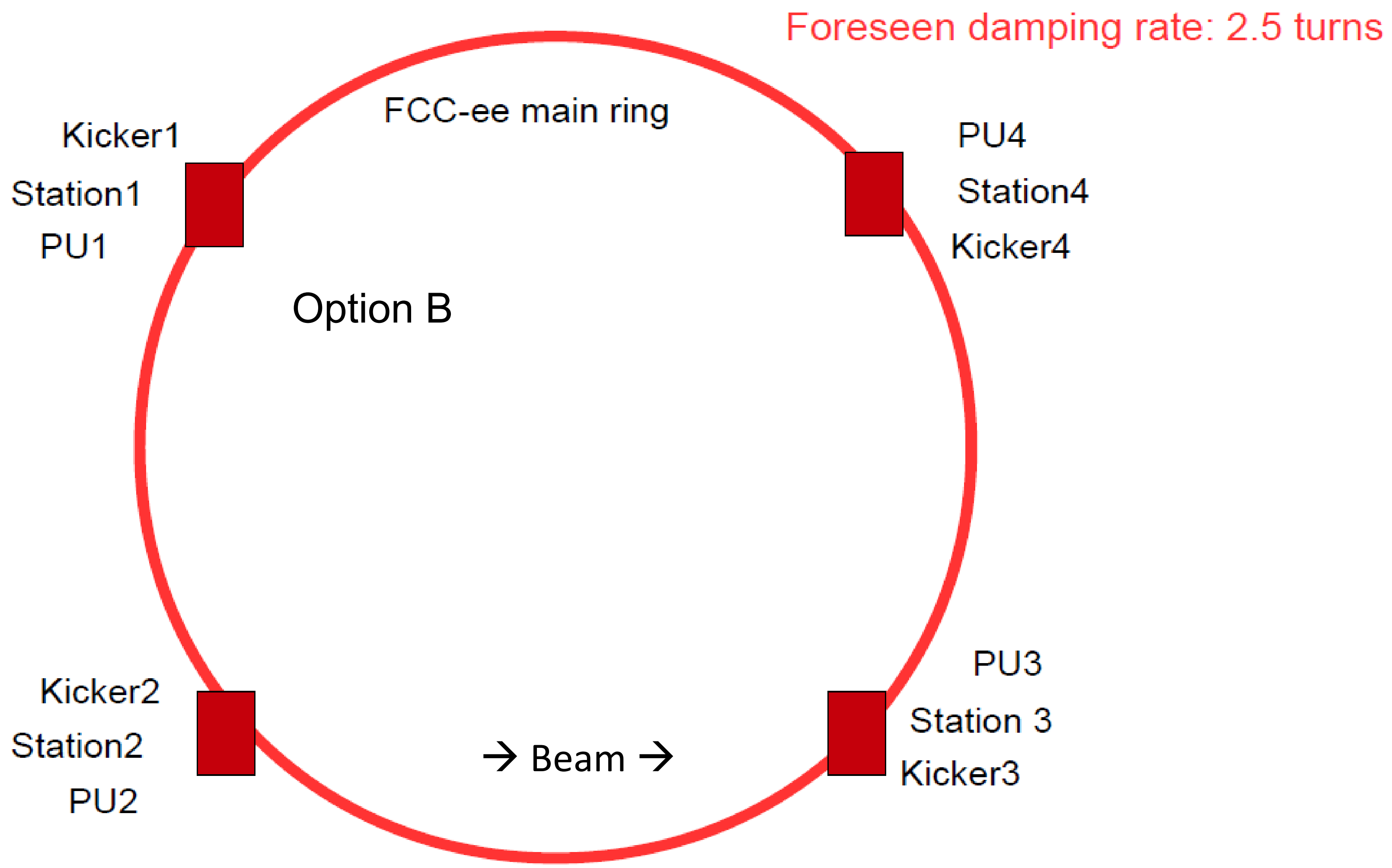
- Going to discuss the three cases described, and wishing to maintain the <u>standard</u> mixed analog and digital technologies developed for the feedback in the past, only the case A could be based on the usual well known approach, used in the previous lepton colliders, in which many parts are commercially available.
- <u>Nevertheless</u> the present systems are able to process up to few thousands of buckets. Note that usually all the bucket signals are acquired and handled even if they are empty. This is to make simpler and faster the real time computation.
- As a consequence new and more powerful processing units have to be built even in the case A to cope with a very high harmonic number (of the order of 100k).
- Another possible issue can rise due to the possible very low frequency of the modes that have to be damped. Of course kickers and power amplifiers feeding the correction signal must have the appropriate bandwidth.
- Even if power amplifiers are commercial devices, they have to be checked carefully for working at the requested very low frequencies and same check has to be done for the kicker bandwidth.
- This “standard” feedback design is foreseen to have a damping rate as the experience done in the other colliders has shown in the prevous slides.

Case B: design option B

- Analyzing the case B, that considers instability growth rates up to 3 revolution turns, a different scheme must be implemented.
- Indeed only one feedback system does not guarantee to manage enough power to damp.
- The experience done at DAFNE in 2007 by implementing two complete feedbacks in the same horizontal plane as reported in the next slide, clearly highlights that the feedback damping rate is limited mainly by the noise entering in the loop from the pickup.
- High beam current makes worse the signal-to-noise ratio leading to the feedback saturation.
- Moreover saturation or excess of feedback gain can induce enlargement of the bunch dimension.
- This effect is more dangerous in the vertical plane and it can be also amplified by the kick given by beam-beam collisions. Implementing four systems spaced by a distance of a quarter of main ring can bypass the gain saturation limit with the goal to achieve a feedback damping rate of the order of 10/4=2.5 revolut. turns
- Note that the number (4) of systems is a modifiable choice can be changed (other options 2 or 8, see shaft locations)

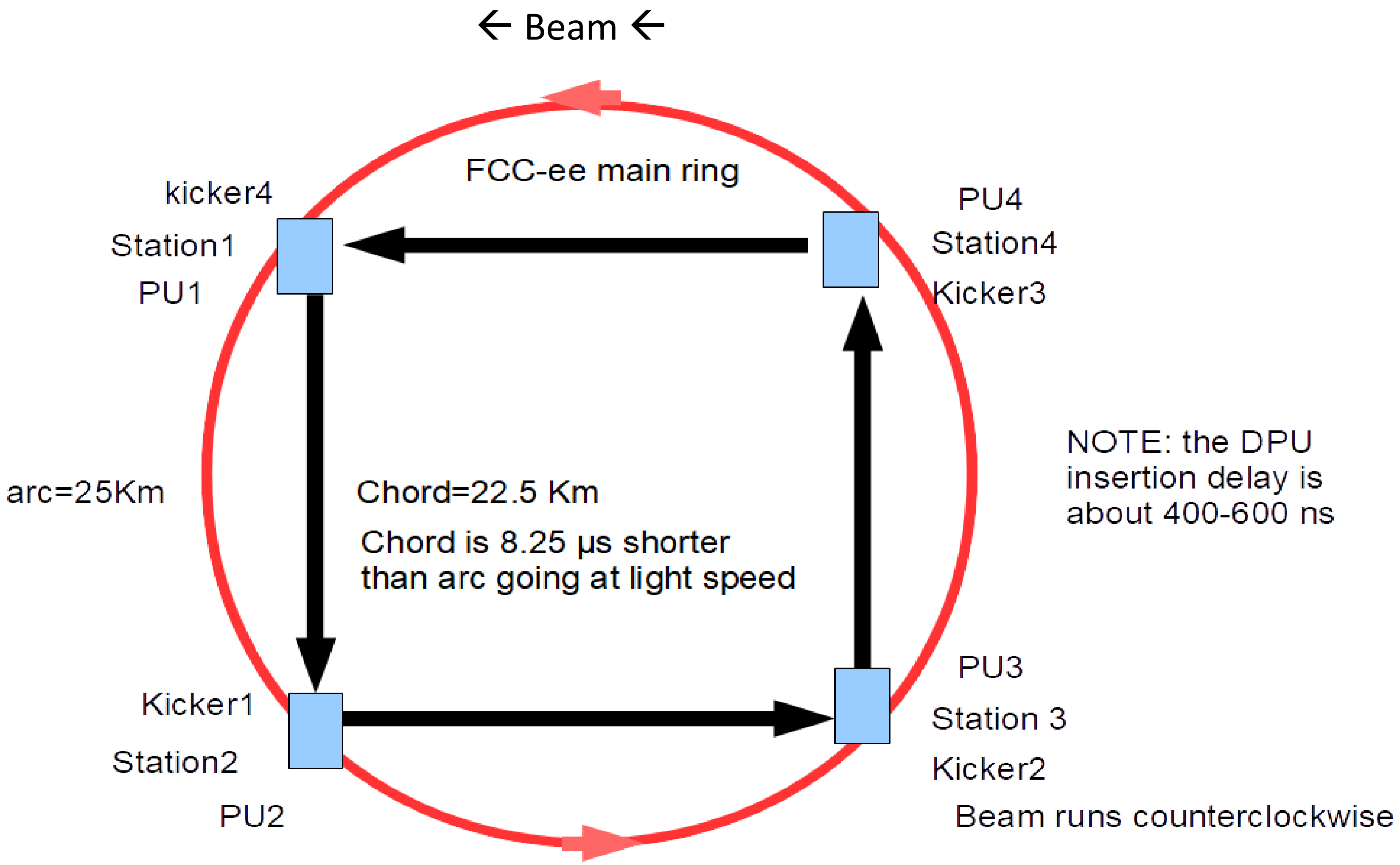
4 Feedback systems (4 stations)

Option B



Case C: design option C

- Finally considering a possible case C with instability growth rate of the order of 1-2 turns or even less, a very different design scheme is necessary.
- Indeed the solution found for the case B is not sufficient.
- To achieve a faster damping rate it is necessary to apply the correction signal earlier than by implementing the previous scheme (that kicks in one revolution period).
- Again four systems are proposed but they are not enough.
- The way to implement the Option C scheme consists in putting the kicker with a distance of a quarter of the ring downstream the feedback pickup.
- To be effective the correction signal has to arrive to the kicker BEFORE the bunch.
- This is possible because the path along the chord (for the signal) is shorter than the path along the arc (for the beam).



proposed feedback scheme for Option C

Option C

- In order to implement the option C design, a signal transmission system with a speed close to the light speed is necessary.
- Radio (or optical fibers/lasers) communication systems have to be considered to transmit the correction signal.
- Actually commercial optical fibers have a signal propagation speed of about 0.7 c that is 31% slower speed in silica glass than in vacuum. A new technology, the hollow optical fiber transmission, seems in this moment the state-of art solution to achieve the speed goal.
- Radio transmission offers the advantage of not having to occupy land (and light speed)
- By implementing this technique, the feedback damping rate should be able to up to be effective in **0.625 revolution turns (10/4/4=0.625).**

Option C

- A signal transmission system with a speed close to the light speed is necessary but not sufficient condition.
- Indeed the correction signal has to be transmitted in digital format (and not in the analog one) that means 32 bits (bunch label + datum) every 2.5 ns.
- This requirement asks to a modification of the usual feedback architecture that has to be split in two parts.
- The first block before the transmission (composed by pick-up, analog front end, ADC, FIR, timing, bunch labelling, transmitter).
- The second block after the transmission (composed by receiver, timing, decoder, DAC, analog back end, power amplifiers and kicker).

Option A,B,C comparison

- In conclusion instability growth rates of the order of one revolution turn require strong R&D efforts to implement the above proposed innovative design.
- Less critical instability growth rates can be coped by a more moderate R&D program.
- From the ring impedance point of view, it is important to underline that the three feedback design options have different impact.
- The option A requires only one cavity kicker for the longitudinal case and two stripline kickers for the transverse planes (1 H + 1 V).
- On the contrary, both options B and C need four cavity kickers and eight stripline kickers increasing consequently the ring impedance.
- However every feedback (H,V,L) system can be implemented independently by the design option that is more adapt to cope with the related instability grow rate.

After the year 2020

- ARIES will be finished in a few months and should be followed by "ARIES-2". The new project takes the name of I-FAST (Innovation Fostering in Accelerator Science and Technology)
- The INFN coordinator for I-FAST is Lucio Rossi (UNI-MI).
- I-FAST is a CERN coordinated H2020 project in the submission stage. This new project should have a different approach, more technological, more dedicated to the industrial world.
- Project starts on 1st May 2021 (at end of ARIES). Duration 4 years (2021 – 2025), until 30 April 2025.
- The FCC CDR has been published in January 2019 and now a new phase of studies begins with the label “FCCIS”. Kickoff meeting from 9 to 13 November
- This collaboration should be the way to prepare a TDR for the year 2026
- FCCIS contact persons for INFN are: M.Boscolo (LNF) and M.Migliorati (UNI-ROMA1)

FIAST becomes I-Fast

Historical background

FP6

CARE 01/2004 – 12/2008
5 years, 15.2 M€ EC contribution

FP7

EuCARD 04/2009 – 03/2013
4 years, 10.0 M€ EC contribution

EuCARD-2 05/2013 – 04/2017
4 years, 8.0 M€ EC contribution

H2020

ARIES 05/2017 – 04/2021
4 years, 10.0 M€ EC contribution

Integrating Activities

New Innovation Pilot (FIAST)
05/2021 – 04/2025
4 years, 10.0 M€ EU contribution

Innovation Pilot

Requirements for the new project – I-FAST (=FIAST)

Scope: Funding will be provided to research infrastructure networks to kick-start the implementation of a common strategy/roadmap for technological developments required for improving their services through partnership with industry. Proposals should then involve research infrastructures, industry and SMEs to promote innovation and knowledge sharing through co-creation of needed technical solutions and make use, when appropriate, of large-scale platforms combining R&D (Research and Development), integration and validation for the technological developments.

- RI Networks
- Technological developments in partnership with industry
- Use of large scale platforms

3 components:
1. Technological roadmaps in partnership with industry
2. «Development» of technologies.
3. «Prototyping» of technologies.

- if not already done,the identification of key techniques and trends which are crucial for future construction and upgrade of the involved Research Infrastructures and the definition of roadmaps and/or strategic agendas for their development, in close partnership with the industrial partners, especially with innovative SMEs;
- the development of the identified fundamental technologies or techniques underpinning and arising from the efficient and joint use of the involved research infrastructures, taking into due account resource efficiency and environmental (including climate-related) impacts.
- the prototyping of higher performance methodologies, protocols, and instrumentation including the testing of components, subsystems, materials, and dedicated software, needed to upgrade the involved research infrastructures, construct their next generation, or develop new advanced applications.

General goal:
Boost innovation in the accelerator community via a reinforced partnership with industry

(*) an innovation is the implementation of a new or significantly improved product or process (OECD, The Oslo Manual)

ARIES

11

Project structure – Work Packages

WP	WP Name	WP Coordinator	Coord. Lab.
1	Coordination, dissemination	M. Vretenar	CERN
2	Training, communication, outreach	P. Burrows	UOXF
3	Industry engagement	M. Morandin	INFN
4	Managing Innovation, new Materials	M. Losasso	CERN
5	New concepts, performance improvements	F. Zimmermann	CERN
6	Novel particle accelerators concepts and technologies	R. Assmann	DESY
7	High brightness synchrotron light sources	*R. Bartolini*	UOXF
8	Innovative superconducting magnets	L. Rossi	INFN
9	Innovative superconducting cavities	*C. Antoine, O. Malyshev*	CEA/STFC
10	Advanced accelerator technologies	T. Torims	RTU
11	Sustainable concepts and technologies	M. Seidel	PSI
12	Societal applications	R. Edgecock	HUD
13	Technology Infrastructure	S. Leray	CEA

FCC November workshop 2020 (FCC NoW)

- The 2020 FCC November meeting will take place from Monday, 9 to Friday, 13 November. It will review the most recent developments of the concepts for the next generation of colliders that were laid out in the 2019 Conceptual Design Report. The event combines the 4th FCC Physics Week with the kick-off meeting of the new EU-funded Horizon 2020 FCC Innovation Study (FCCIS), which is the continuation of EuroCirCol.
- Crucially, this is the first meeting of the FCC collaboration after the recent update of the European Strategy for Particle Physics (ESPP), which identified the need for more in-depth study of the Higgs boson and exploration of the high-energy frontier. The updated Strategy emphasises the importance of international investigation into the technical and financial feasibility of an electron–positron Higgs and electroweak factory as a possible first stage, while at the same time guaranteeing a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV in the most affordable and efficient way.
- The FCCIS design study will support the development of a roadmap for the design and the implementation plan of a new research infrastructure that will assist in the exploration of both fronts. The proposed infrastructure, a 100-km-long tunnel with a dozen surface sites, would initially host an electron–positron collider (FCC-ee) that would allow for precise measurement of the properties of the Higgs boson and other Standard Model particles. This would be followed by an energy frontier proton collider (FCC-hh), reaching collision energies of 100 TeV or higher following developments in the superconducting and magnet technology. This project will validate the key performance enablers at particle accelerators in a sustainable way while offering opportunities for co-development of needed technologies with industry.
- In parallel, the 4th FCC Physics and Experiments Workshop will take place from 10 to 13 November and will also address the outcome of the ESPP update. Subsequently, the workshop will engage with the most recent literature on the study of the physics prospects of the FCC study. It will also propose new activities aimed at developing the FCC-ee detector designs and technologies and collaborations to tackle the challenges of this machine.

Conclusion

- FCCIS and I-FAST projects have both a different approach from the past collaborations [and I will not be in the business].
- If the coupled bunch instabilities in FCC-ee will be slower than 10 turns, in my opinion it will be possible to use the systems similar to the current feedback implemented in other lepton colliders, as SuperKEKB and DAFNE (even if many modifications are necessary)
- Otherwise, without any new mitigation techniques, the feedback systems need to be implemented in more powerful way
- Three compatible but with different complexity level designs are presented in this proposal in order to be able to damp instability grow rates slower than 10 revolution turns (by option A), or up to 3 revolution turns (by option B) or even slightly faster than 1 revolution turn (0.625 turns by implementing the option C).
- However an R&D phase is necessary for preparing the TDR.
- ***Pumping all the necessary damping power can increase the beam emittance !***

Thank you for the attention

For any questions mail to: alessandro.drago2@gmail.com

INFN
LNF
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali del Frascati

This project has received funding from the European Union's Horizon 202
Research and Innovation programme under Grant Agreement No 730871

ARIES