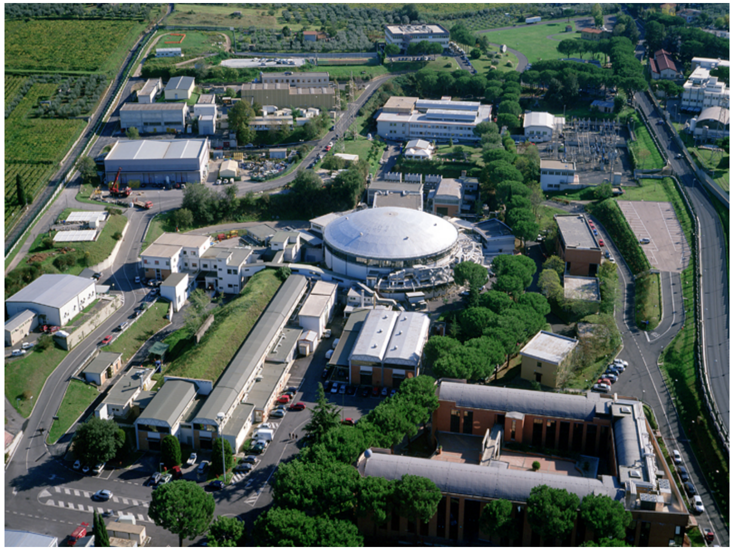


DAFNE-TF:
DAFNE as Test Facility

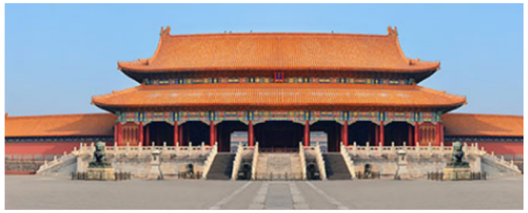
Manuela Boscolo (INFN-LNF)

for the DAFNE team

The 2019 International workshop on the high energy Circular Electron Positron Collider

INFN LNF Istituto Nazionale di Fisica Nucleare

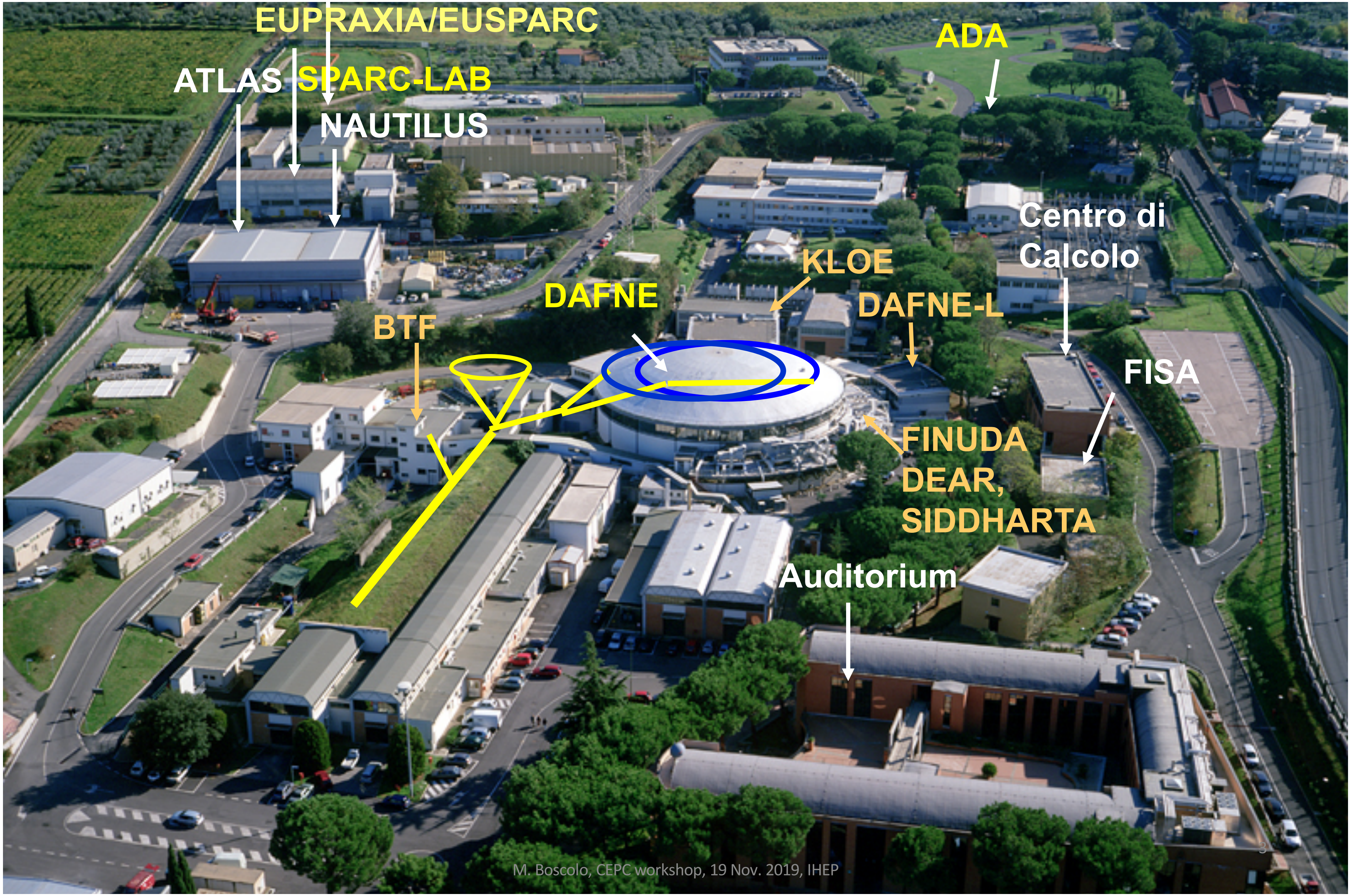
IHEP, Beijin, China, 18-20 November 2019



Outline

- Introduction: DAFNE
- The proposal of converting DAFNE into a Test Facility
- DAFNE-TF contributions: some proposals
- Conclusions

INFN-LNF Aerial View



DAΦNE History & Plans

- DAΦNE is an electron-positron collider designed in the mid `90s, it came into operation in 2000

- It has been providing data in consecutive data-taking periods to:
  - **KLOE**, **DEAR** and **FINUDA** experiments until 2007
  - **SIDDHARTA with the crab-waist test** in 2008 – 2009
  - again for the upgraded **KLOE2** between November 2014 and March 2018

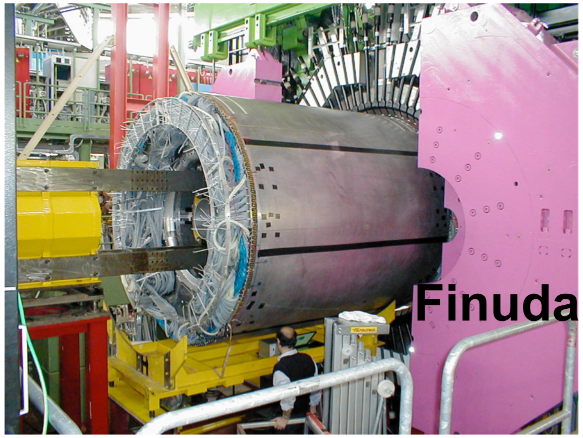
- Presently DAFNE is under commissioning for the **SIDDHARTA2** experiment and parasitically as Light Facility.

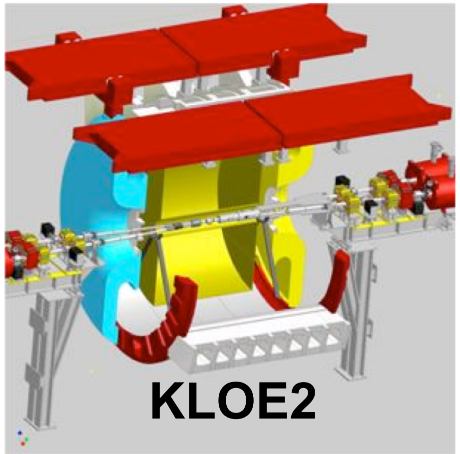
- DAFNE LINAC is securing data to the PADME experiment and to two BTF lines

- **By the end of 2020 DAFNE will stop running as a collider and hopefully will be transformed in an open accelerator test facility.**

DAΦNE

- Φ-Factory, E_{cm}=1.020 GeV at Φ resonance
- There have been different experiments in the Interaction Point: KLOE, FINUDA, KLOE2, and DEAR, SIDDHARTA





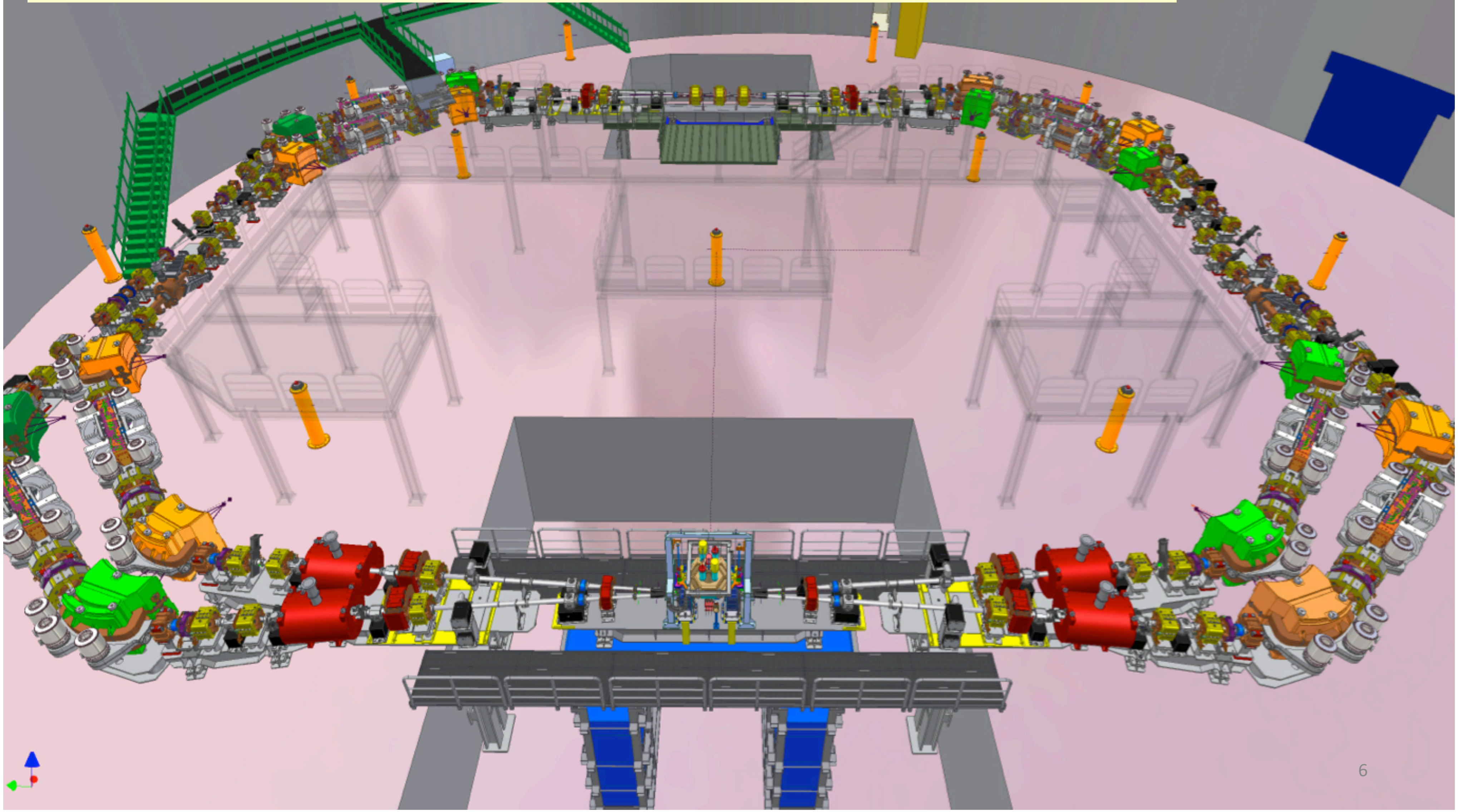
DEAR (DAFNE Exotic Atoms Research), **SIDDHARTA**: (Silicon Drift Detector for Hadronic Atom Research by Timing Applications): goal is to study the creation of exotic atoms, where the charged K mesons produced in the Φ resonance decays are captured in the electronic shells; **NO solenoidal detector**

But also, in a parasitic mode:

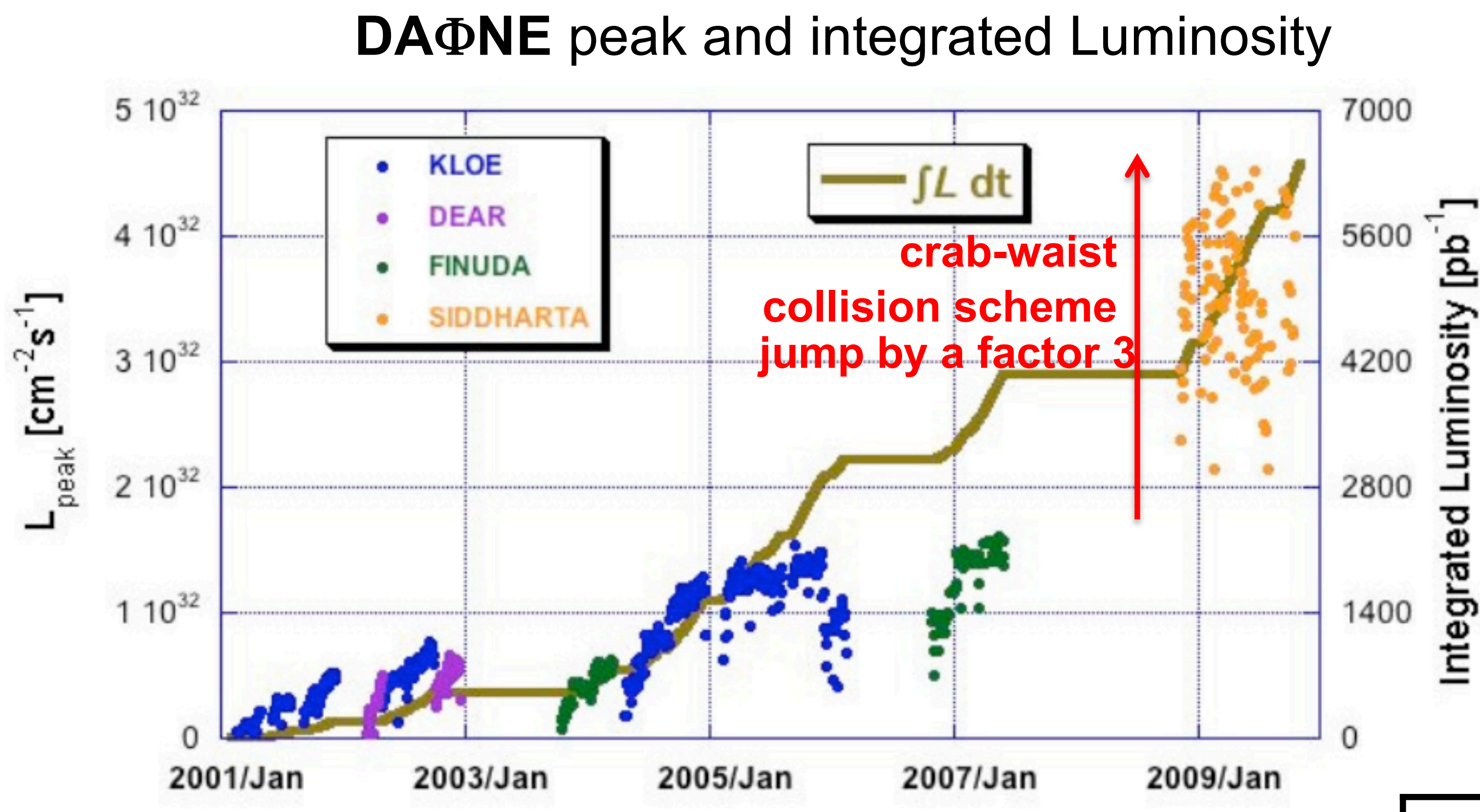
- two beamlines for the **synchrotron light** produced by a dipole and a wiggler of the e- main ring: **UV** 2-10 eV, **X-rays** 900-3000 eV, **IR** 1.24 meV-1.24 eV
- Beam Test Facility (BTF) in the LINAC

DAFNE is a very complex and compact machine, at low energy: challenging to provide high L

- beam-beam and non-linear resonances damped after many machine turns
- experiment high solenoidal field -high beam coupling
- very strong Touschek effect -low beam lifetime, continuous injection
- electron cloud instability in the e+ ring



Luminosity Achievements



L_{logged} (fb^{-1})
2001/2007

KLOE	3.0
FINUDA	1.2
DEAR	0.2

- First collider where the crab waist collision scheme was tested
- Since this plot : KLOE2 run done, now commissioning for SIDDHARTA2

DAΦNE Luminosity Achievements

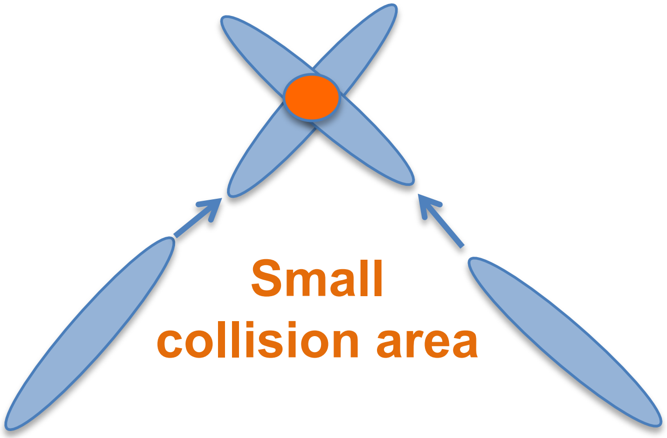
	KLOE run (2005)	CRAB WAIST SIDDHARTA run (2009)	CRAB WAIST KLOE2 run (2014)
L_{peak} [$cm^{-2}s^{-1}$]	**1.50×10^{32}**	**4.53×10^{32}**	**2.38×10^{32}**
I^- [A]	1.4	1.52	1.18
I^+ [A]	1.2	1.0	0.87
ε_x [mm mrad]	0.34	0.28	0.28
$N_{bunches}$	111	105	106
$\int_{1h} L$ [pb^{-1}]	0.4	0.79	0.67
$\int_{day} L$ [pb^{-1}]	9.8	15	14.3
ξ_y	0.0245	0.0443 - 0.074	--

Crab-Waist Collision Scheme

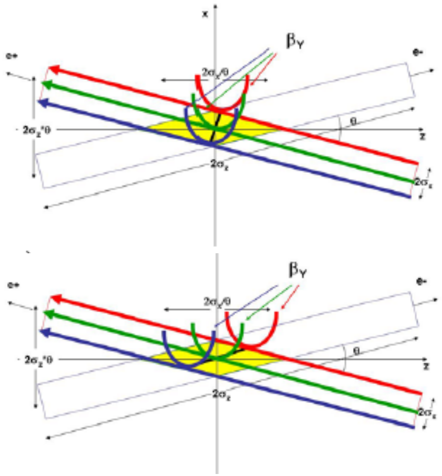
P. Raimondi, 2° SuperB Workshop, March 2006
M. Zobov et al., PRL 104 174801 (2010)

nano-beam

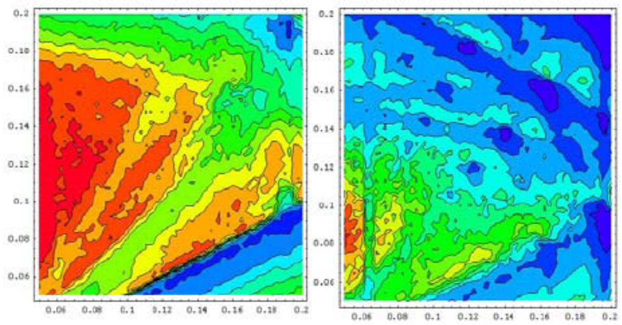
- Currents comparable to present Factories
- Ultra low emittances
- Large Piwinsky angle
  - small collision area
  - very small β^* (stronger focusing at IP)



- A couple of sextupoles/ring to twist the beam waist at the IP (crab-waist transformation), no parasitic crossings



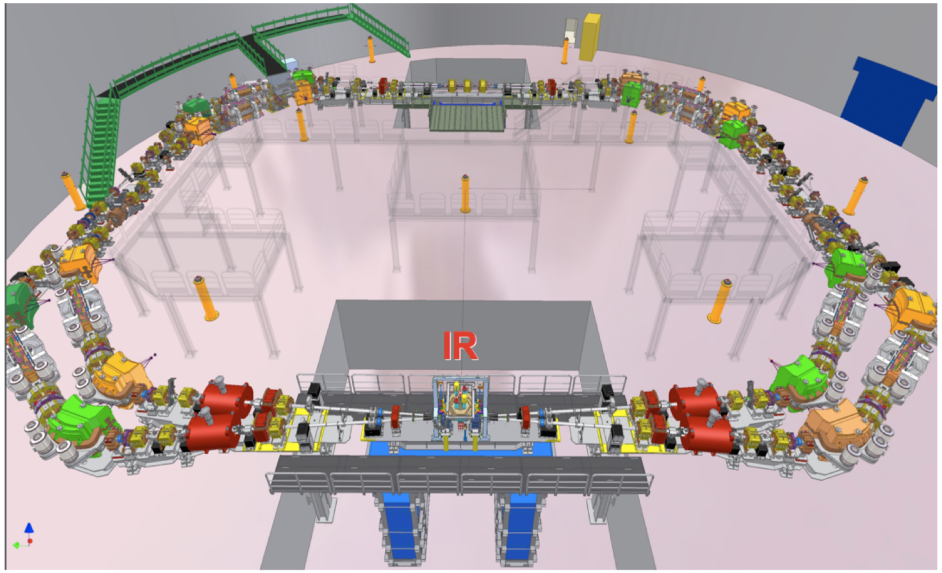
Placed at a proper phase advance they produce a constant β_y along the longer axis of the overlap area, thus suppressing the hourglass effect, enhancing luminosity.



Beam-beam simulations showing that syncro-betatron resonances are suppressed

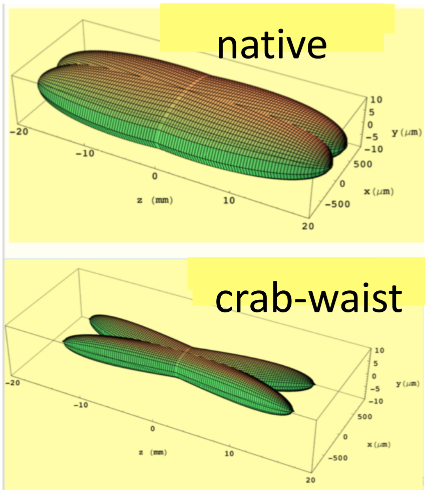
Crab-Waist Collision Test

with the SIDDHARTA experiment (no solenoid) in 2008-2009



	DAΦNE native	DAΦNE Crab-Waist
Energy (MeV)	510	510
$\theta_{cross}/2$ (mrad)	12.5	25
ε_x (mm•mrad)	0.34	0.28
β_x^* (cm)	160	23
σ_x^* (mm)	0.70	0.25
$\Phi_{Piwinski}$	0.6	1.5
β_y^* (cm)	**1.80**	**0.85**
σ_y^* (μm) low I	5.4	3.1
Coupling, %	0.5	0.5
Bunch spacing (ns)	2.7	2.7
I_{bunch} (mA)	13	13
σ_z (mm)	25	15
N_h	120	120

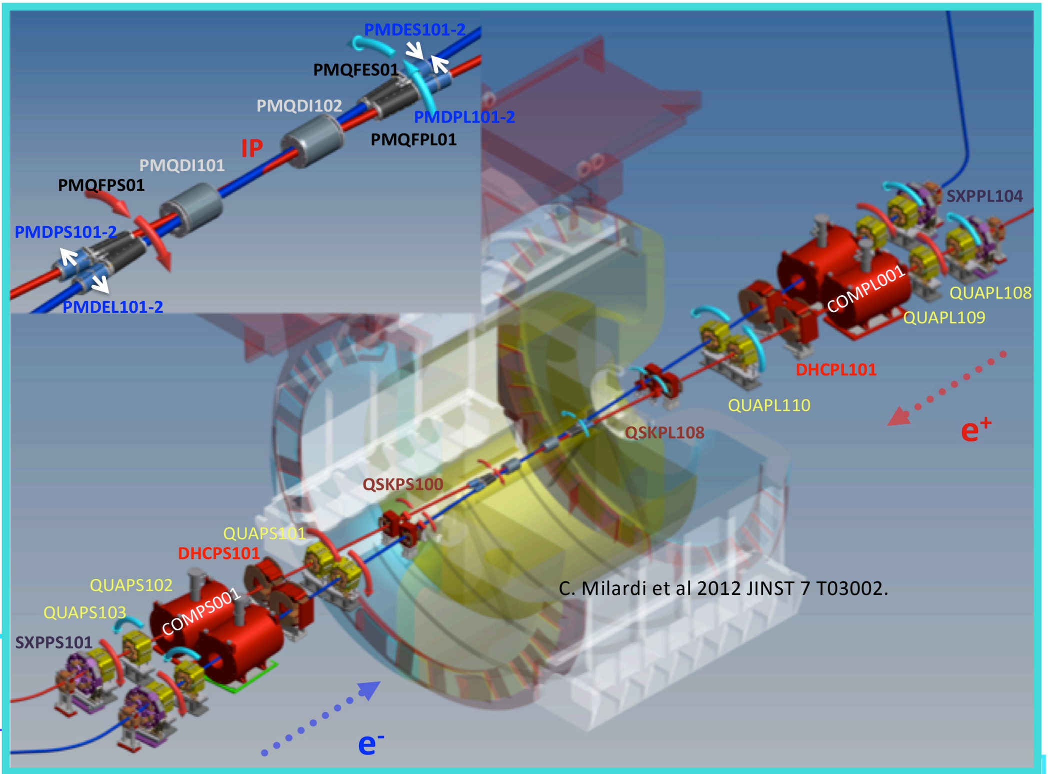
- optimal control of the beam-beam interaction
- a factor 3 higher L_{peak}

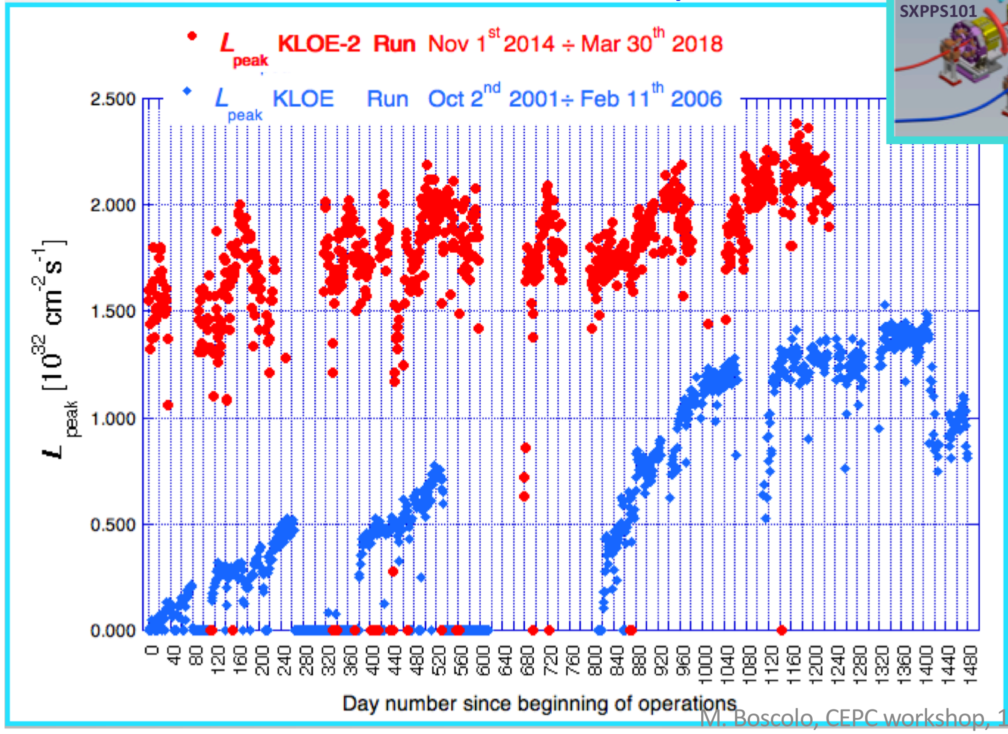


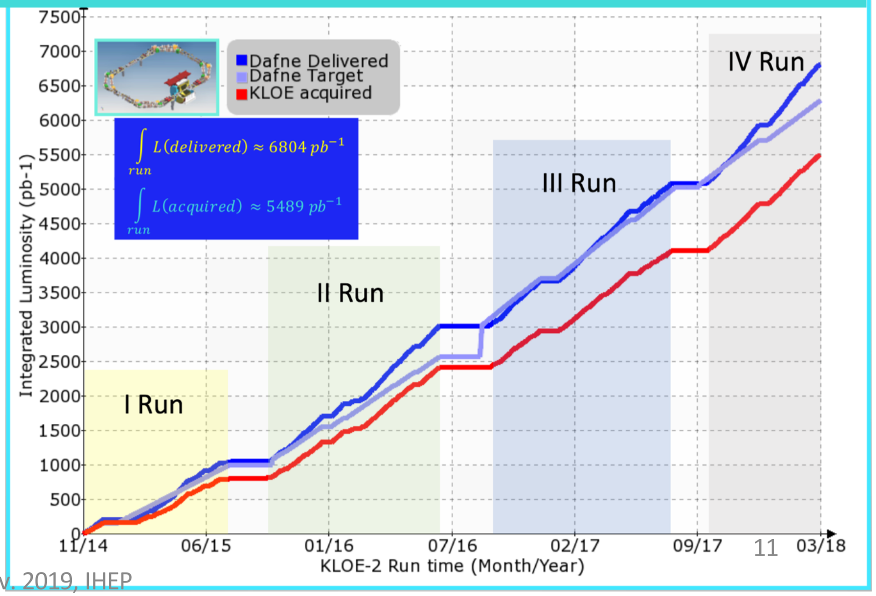
Crab-Waist Collision with KLOE2

Crab-Waist collision scheme implemented for the first time with a large detector including a high intensity axial field

The new approach to collision provided a **~60% improvement in terms of L_{peak}**







Crab-Waist Colliders

All new e+e- collider projects around the world have adopted the Crab-Waist collision scheme as their main design concept

Colliders	Location	Status
DAΦNE	Φ-Factory Frascati, Italy	In operation (SIDDHARTA, KLOE-2)
SuperKEKB	B-Factory Tsukuba, Japan	Phase III commissioning in 2019
SuperC-Tau	C-Tau-Factory Novosibirsk, Russia	Russian mega-science project
FCC-ee	Z,W,H,tt-Factory CERN,Switzerland	100 km, CDR at the end of 2018
CEPC	Higgs-Factory China	100 km, CDR released in September 2018
HIEPA	2-7 GeV China	Considered option

About the DAΦNE Infrastructure

- Much of the **hardware** installed in DAΦNE, although constantly maintained and improved, dates from the mid '90s.
- A major **refurbishment** for an amount of about 1 M€ was realized in 2013, and continued in the following years.
- A significant upgrade of the **LINAC** was recently done, including the split of the Beam Test Facility (**BTF**) in order to increase the number of future users.
- The power supplies of the steering magnets, short and long type, both in the positrons and in the electrons rings have been substituted by new equipment. The new power supplies better have accuracy and resolution by more than a factor 10 with respect to the old devices.

- Despite the relatively obsolete nature of part of its components, DAΦNE and BTF are able to regularly provide beams for more than 6,000 hours per year, keeping their **operational efficiency** at levels of the orders of 80% for long periods.

- In the same years, the **synchrotron-light laboratory** has profited from the e^- beam radiation in parasitic mode, hosting external users for about 800 hours per year, and getting the CALYPSO program of Horizon 2020. The synchrotron-light activity allowed the Laboratory to be included into LEAPS, *League of European Accelerator-based Photon Sources*

- The DAΦNE complex also hosts a **cryogenic plant**, recently refurbished, which can be efficiently used to operate superconducting magnets, experimental setups, and superconducting radiofrequency systems (although the latter ones have never been used at DAFNE).

LNF Proposal for DAFNE-TF

DAFNE is a unique facility, now almost at the end of its life as collider.

The run with SIDDHARTA will end at the end of next year 2020.

DAFNE-TF could operate starting from 2021.

DAFNE-TF would be the only facility in Europe to provide a positron beam.

It is an excellent opportunity to:

- **test innovative concepts**
- **perform accelerator physics studies**
- **test innovative technologies of interest for our community**
- **implement short term experiments on fundamental and applied physics**
- **train young accelerator physicists**

DAFNE-TF workshop with proposals

https://agenda.infn.it/event/16334/Summary_workshop

17 December 2018 *INFN - Laboratori Nazionali di Frascati*

HOME PROGRAM REGISTRATION SUBMIT A CONTRIBUTION ACCOMMODATION HOW TO REACH US CONTACT

ICFA Mini-Workshop on

DAFNE as Open Accelerator Test Facility in year 2020

The workshop will take place on **December 17th, 2018** at the Touschek Aud[…] Frascati Laboratory of INFN, Italy.
The workshop is intended to discuss the interest from scientists to access […]plex, which will conclude its physics program as collider in 2020. An infrastructure almost unique, that could open as T[…] international community for studies of accelerator technologies and beam physics, for small experiments, and […] active in the sector of components for accelerators.

Invitation Letter of Prof. Lenny Rivkin, Chair of the International Scientific […]
INFN-18-10-LNF - "Proposal for a possible use of DAFNE as an open infrastruc[…]

Call for Contributions:
Registrants are invited to submit ideas and contributions for scientific activ[…]
filling the online form (**Deadline: November 10, 2018**).

Scientific Committee
L. Rivkin (EPFL and PSI, chair), C. Bloise (INFN-LNF), Y. Cai (SLAC), A. Ghigo (INFN-LNF), M. Giovannozzi […]
N. Pastrone (INFN-Torino), A. Variola (INFN-LNF)

Organizing Committee
O. R. Blanco Garcia (INFN-LNF), A. De Santis (INFN-LNF), A. Drago (INFN-LNF, chair)

Secretariat
D. Ferrucci (INFN-LNF), M. Luciani (INFN-LNF)

26 contribution received
17 oral presentations
96 participants from: CERN, Switzerland, Italy, Germany, Austria, Japan, China, USA

DAΦNE-TF Workshop
(December 17th 2018 in Frascati)

Organized under the auspices of the LNF Director Dr. Pierluigi Campana

Scientific Committee:

- ***L. Rivkin*** *(EPFL and PSI, chair)*
- *C. Bloise (INFN-LNF)*
- *A. Ghigo (INFN-LNF)*
- *M. Giovannozzi (CERN)*
- *C. Milardi (INFN-LNF),*
- *N. Pastrone (INFN-Torino)*
- *A. Variola (INFN-LNF)*

Local Organizing Committee

- ***A. Drago*** *(INFN-LNF, chair)*
- *S. Caschera (INFN-LNF)*
- *A. De Santis (INFN-LNF)*
- *O. R. Blanco Garcia (INFN-LNF)*

DAFNE-TF proposals guidelines

The lines of scientific and technological research identified so far should be compliant with the following items:

- Machine operating parameters
- Minimal machine layout modification
- Maturity level of the proposal

The guidelines have been settled in order to limit budget and personnel efforts needed to implement the proposal.
The aim is to profit of the existing infrastructure beyond the collider usage.

DAΦNE-TF Workshop Program

Program Timetable

Book of Abstracts

MONDAY DECEMBER 17th, 2018 - AUDITORIUM B. TOUSCHEK		
8:00 - 8:30	Registration	
8:30 - 8:40	**LNF Director Welcome**	P. Campana *(INFN-LNF)*
Present and Future Test Facilities - Chair A. Ghigo (INFN-LNF)		
8:40 - 9:00	**ATF2 International Test Facility @ KEK for Nano-Scale Beam Generation and Measurements (Slides)**	G. White *(SLAC)*
9:00 - 9:20	**The KIT accelerator test facilities: Karlsruhe Research Accelerator KARA, short-pulse linac FLUTE, and Magnet Characterization Facilities (Slides)**	A. Mochihashi *(KIT)*
9:20 - 9:40	**DAFNE as Open Accelerator Test Facility: DAFNE-TF (Slides)**	C. Milardi *(INFN-LNF)*
Positron Beam Lines and Crystal Technologies - Chair N. Pastrone (INFN-TO)		
9:40 - 9:55	**Proposal for Using DAFNE as Pulse Stretcher for the Linac Positron Beam (Slides)**	S. Guiducci *(INFN-LNF)*
9:55 - 10:15	**Intense crystal-based hard-X and gamma sources with the DAFNE beam (Slides)**	L. Bandiera *(INFN-Ferrara)*
10:15 -10:35	**Crystal high quality positrons extraction from the DAFNE accelerator ring (Slides)**	M. Garattini *(CERN)*
10:35 - 10:45	***Discussion***	
10:45 - 11:05	***Coffee Break (Foto)***	
11:05 - 11:25	**Dark sector experiments and test-beam facility based on the slow extraction of a positron beam from the DAFNE ring (Slides)**	P. Valente *(INFN-Roma)*
Collider issues: technology - Chair A. Drago (INFN-LNF)		
11:25 - 11:45	**DAFNE as a test bench for innovative vacuum equipment and surface treatments (Slides)**	P. Chiggiato *(CERN)*
11:45 - 12:05	**Vacuum and e-cloud studies at DAFNE-TF (Slides)**	O. Malyshev *(STFC Daresbury Laboratory)*
12:05 - 12:35	**DAFNE-TF as a Beam Diagnostic and Instability Control Test Facility (Slides)**	J. Fox *(Stanford University)*
12:35 - 12:50	**Using DAFNE to study the physics of the e+/e- beam interaction with vacuum devices (Slides)**	S. Casalbuoni *(KIT)*
12:50 - 13:00	***Discussion***	
13:00 - 14:00	***Lunch***	

https://agenda.infn.it/event/16334/

sitron, photon and kaon facilities - Chair C. Bloise (INFN-LNF)		
:00 - 14:20	**Proposal of an experimental test at DAFNE for LEMMA (Slides)**	M. Boscolo *(INFN-LNF)*
:20 - 14:35	**DAFNE-Light synchrotron radiation facility: status and perspectives (Slides)**	M. Cestelli Guidi *(INFN-LNF)*
:35 - 14:55	**Strangeness precision frontier: a unique opportunity from kaonic atoms to kaon-nuclei interaction measurements (Slides)**	J. Zmeskal *(Stefan Meyer Institute for Subatomic Physics)*
:55 - 15:10	**A tagged polarized gamma-ray facility in the medium- to high- energy range as calibration tool for detectors in gamma-ray astrophysics (Slides)**	P. W. Cattaneo *(INFN-Pavia)*
:10 - 15:25	**DAFNE Compton ring for ultra high flux photons in the 100 KeV-1 MeV range (Slides)**	D. Alesini *(INFN-LNF)*
:25 - 15:35	***Discussion***	
:35 - 15:55	***Coffee Break***	
llider issues: beam dynamics & beam-beam - Chair M. Giovannozzi (CERN)		
:55 - 16:25	**DAFNE-TF as FCC-ee Demonstrator (Slides)**	K.Oide - F. Zimmermann *(CERN)*
:25 - 16:45	**DAFNE-TF to benchmark models and probe Future Circular Colliders (HE-LHC and FCC-hh) Challenges: Optics, Beam-beam effects and beam stability. (Slides)**	T. Pieloni *(EPFL)*
:45 - 17:05	***Discussion***	
:05 - 17:30	***Concluding discussion and remarks - chair: L. Rivkin (EPFL and PSI)***	

I will present few selected topics, which I think are more interesting for this community

DAFNE-TF: possible fields of interest

- Study of **low Secondary Electron Yield** (SEY) **elements and impedances**; Graphitization of chambers and other technologies
- Study of **collective effects**
- Test **new components for accelerators**, i.e. vacuum chambers, collimators, masks, kickers and **innovative beam diagnostic techniques**
- **Beams** interacting **with** amorphous **materials, crystals**, lasers, plasma
- High-power **positron source R&D**: peak Energy Deposition Density in the targets, wide aperture capture, accelerating sections in S Band
- Emittance manipulation
- Wide-excursion adjustable permanent magnets
- High power solid state RF amplifiers
- Components for future SLED and pulse flatness compensation
- Accelerator components realized with 3D printers
- Nuclear or particle physics experiment with short baseline
- Outreach & High level (Master degree and Post-Doc) **educational programs**

Test bed for LEMMA

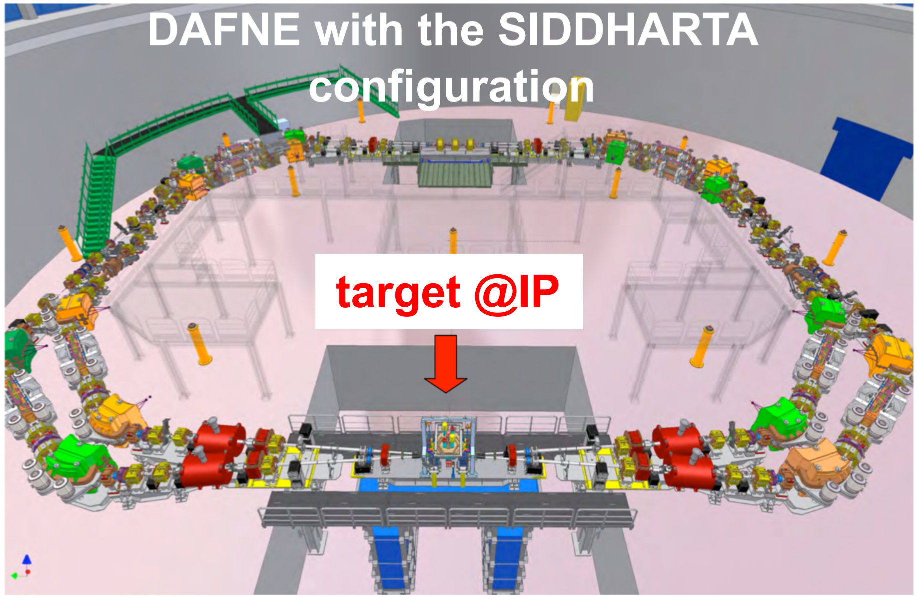
link to talk

[M.B. *et al.*, "*Proposal of an experimental test at DAΦNE for the low emittance muon beam production from positrons on target*", 2018 J. Phys.Conf.Ser.1067 022013(IPAC18)]

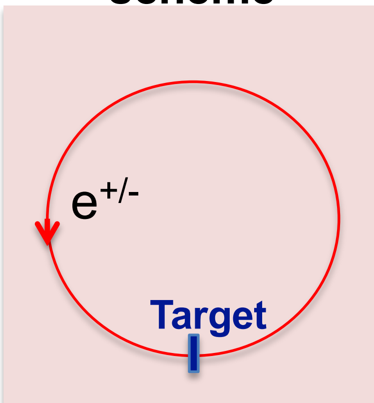
Low EMittance Muon Accelerator: positron-driven muon source

$e^+e^- \rightarrow \mu^+\mu^-$ at $\sqrt{s}$ around the $\mu^+\mu^-$ threshold

- **Measure thermo-mechanical stress of different targets**
  PEDD for different materials and thickness vs expectation
- **Beam degradations study vs targets**



multi-pass scheme



Add a single target in a low-β and dispersion-free location (Interaction Point)
(PR-AB 21, 061005 (2018))

Goals of the test: two-fold Experiment

1. **Test thermo-mechanical stress of different targets, benchmark PEDD estimates**, and measure:
   - ✓ temperature
   - ✓ surface deformation
2. **Validation beam degradation simulations,** benchmark beam dynamics simulations, measuring:
   - transverse beam size
   - beam current
   - beam lifetime

Light targets (Be, C) with thickness in the range ≈ **100 μm**

Liquid Lithium and H_2 targets foreseen as second step

R&D different targets and benchmark with simulations is mandatory,
so even with a LEMMA single-pass scheme, where the muon production target is outside the positron ring (as described in par. 5.1 of NIMA 807 (2016)) this test would be very valuable for the possibility of benchmarking data with expectations.

Converting DAFNE to European/Int'l high-current beam & cw SRF Test Facility

F. Zimmermann: link to talk

some ideas:

- **test & demonstration of other concepts for future circular colliders**
  - **crab-waist collision scheme**
  - **SR effects on vacuum for ee and hh colliders**
- qualifying multi-cell SC cavities for high current CW operation
- demonstrating target SRF efficiency
- impedance & HOM effects for RF cavity and other accelerator components
- energy calibration methods
- e+ source studies
- Several schemes for top-up injection
- 4-beam collisions? Plasma b-b compensation? crystals?

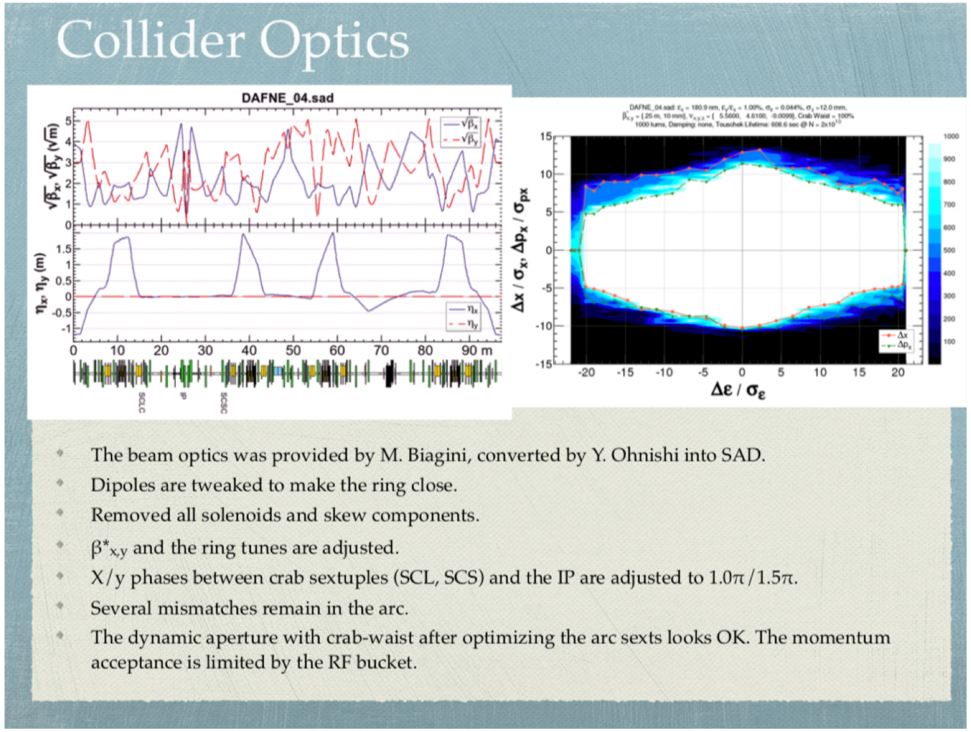
Converting DAFNE to European/Int'l high-current beam & cw SRF Test Facility

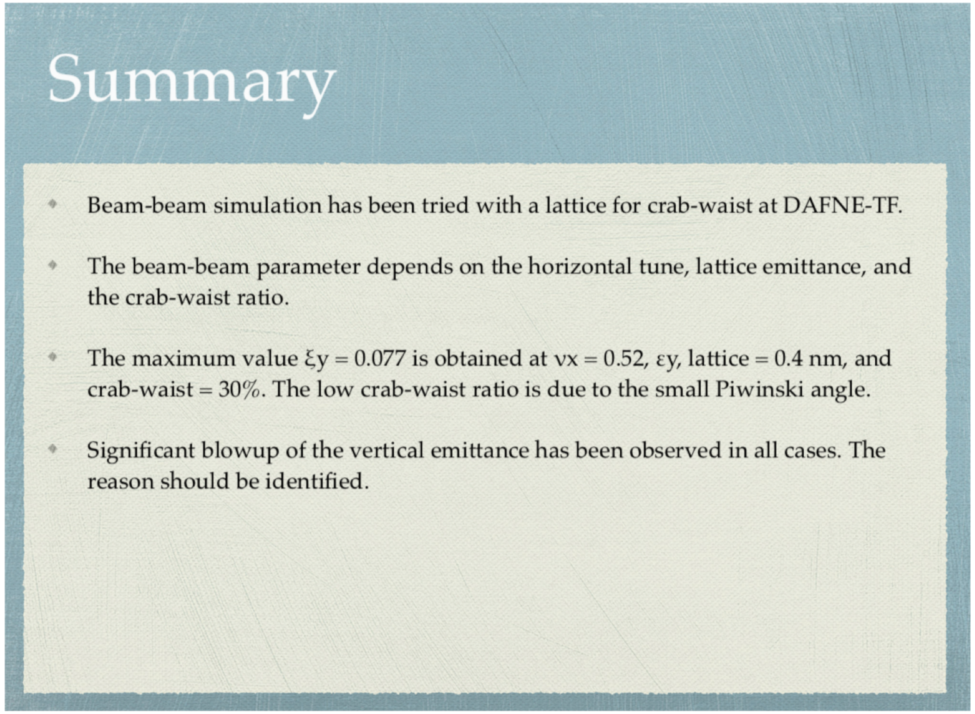
- **test & demonstration of other concepts for future circular colliders**
  - **crab-waist collision scheme**

The beam-beam behaviour for the novel crab waist collision scheme and possibly, its sensitivity to various optics aberrations at the collision point, can be examined at the DAΦNE collider.

This is envisaged in the recently submitted proposal to the EU-H2020 program, the FCC-ee design study, named **FCC IS (Frontier Circular Collider Innovation Study).**

An exercise for Crab-waist at DAFNE-TF [K. Oide: link]





The possibility of deep experimental investigations on the crab-waist scheme at DAFNE is very interesting, considering that all present and frontier e+e- colliders foresee the use of this collision scheme.

DAΦNE-TF as test bench for vacuum equipment and surface treatments (CERN proposal)

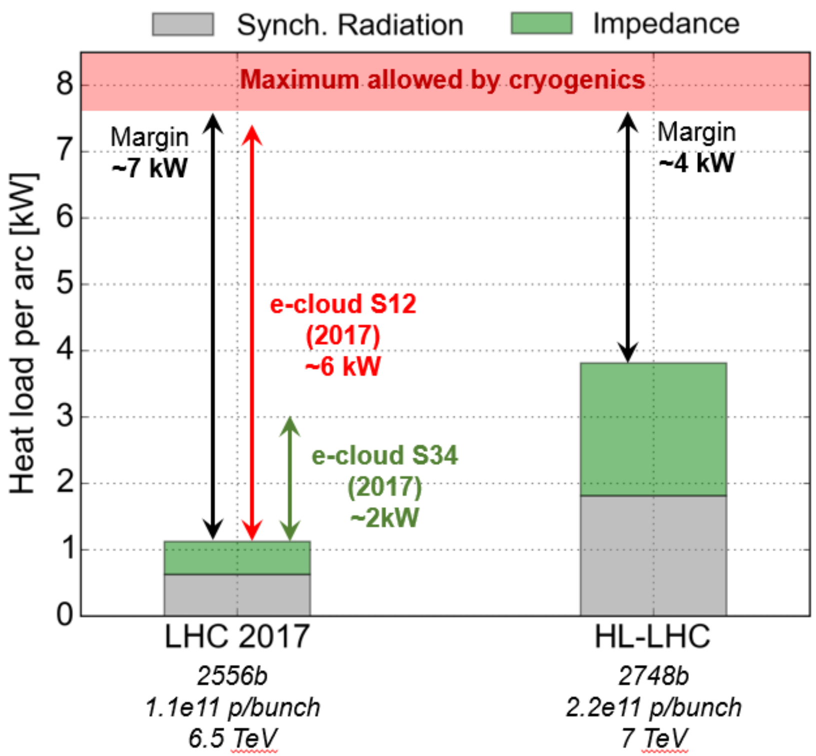
P. Chiggiato: link to talk

DAΦNE contribution on the short term:

- dedicated e-cloud studies to clarify the origin of the high heat load observed in few arcs at LHC
- systematic studies on carbon coating, which is the main technique foreseen to keep under control the excessive heat load on the HL-LHC triplet magnets

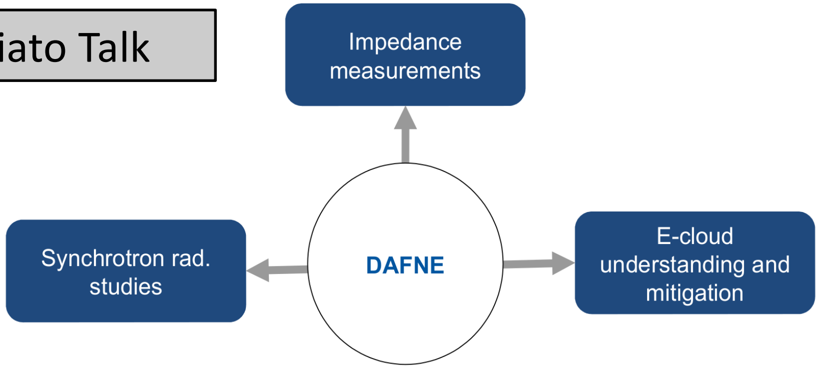
Concern for LS2 and LS3 until the cause for the higher heat load is not fully understood.

And the situation is not going to be better with HL-LHC beams…



DAFNE-TF: vacuum equipment & surface treatment

P. Chiggiato Talk



DAFNE-TF contribution on the long term:

• characterize new components in terms of impedance

• Systematic measurements on LASER treated surface as a function of the laser parameter in order to achieve an optimal trade-off between e-cloud mitigation and impedance

• measure synchrotron radiation impact on vacuum systems

• test NEG coating in order to optimize film thickness without compromising the NEG coating activation efficiency

• provide reliable experimental data to be used for validating simulation code

• characterize coating with high temperature superconductor

- Operating colliders can dedicate very limited time to equipment test and measurements
- **DAFNE can become the reference Lab for synchrotron radiation studies in vacuum technology.**

DAFNE-TF: benchmark models and probe for future colliders in optics and collective effects

T. Pieloni link to talk

- Impact of **radiation damping** on beam dynamics and on collisions
- Collective effects
- **Beam-Beam** behaviour and limits: explore possible B-B limitation in the case of large B-B parameter (0.03 – 0.06)
  - in presence of external noise
  - for different damping time
  - with and without LRBB
  - as a function of the colliding angle
  - with and without Crab-Waist
- Coherent effects (beam-beam, impedance and e-cloud) and their mutual interplay
- Beam stability measurements to study Landau damping trends in presence of (beam-beam, impedance and e-cloud)
- **Optics issues**
  - Beta beating and emittance growth due to head on collisions and their impact on the collimation system design
  - Local chromaticity compensation in low beta sections

DAFNE-TF: Feedbacks R&D

J. Fox: link to talk

4 Ideas for Activities at DAFNE-TF

Ideas and Motivations for Discussion

A. Drago, J. Fox, S. Gallo, W. Hofle, D. Teytelman, M. Tobiyama

4 Theme Areas

- High-gain Transverse Instability Feedback Control Methods
  - Motivated by FCC, overcome limits of existing architectures
- Novel Tune and Beam Diagnostics
  - characterize, quantify several methods
  - Passive (closed loop spectra), active (chirps, phase locked excitations)
- Next-generation Wideband Kicker structures
  - Motivated by HL-LHC and FCC
  - expand SPS 1 GHz intra-bunch kicker -> 4+ GHz
  - lab tests and beam evaluations
- hands-on Beam Instrumentation and Feedback School
  - train the next generation of Accelerator Scientists and Engineers
  - In-residence school, expands role of USPAS, CAS, JUAS, AAS, etc.

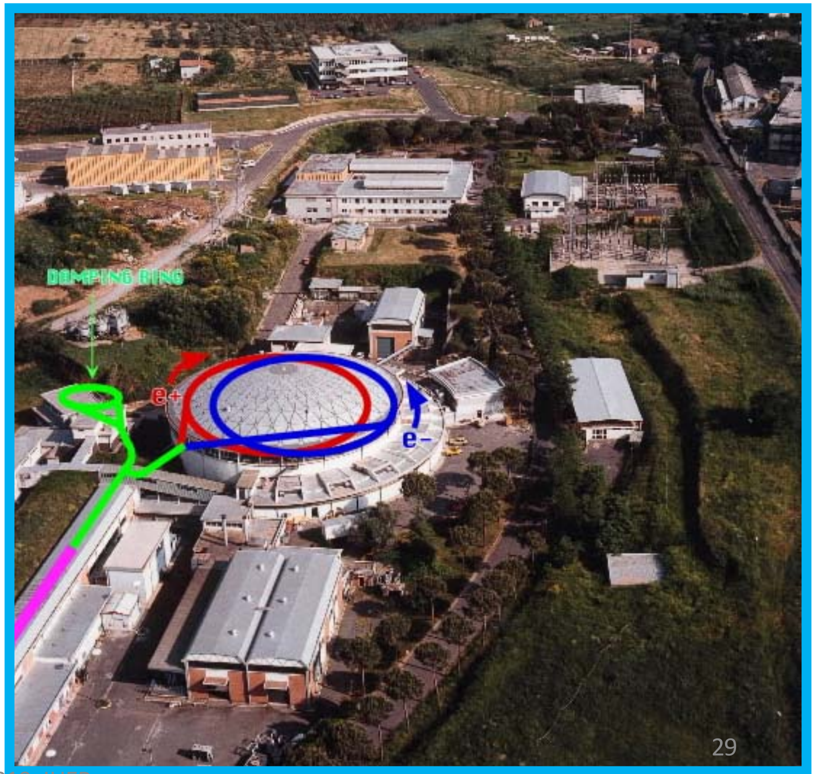
Conclusion

DAΦNE is a valuable and unique infrastructure that we hope will have the chance to still play a role in the particle accelerator community.

It could be:

- test bed for new ideas
- excellent training facility for accelerator physics

This proposal has been submitted to our INFN management and is under review.



Spare slides

The DAΦNE Parameter List

Physics start date	1999
Physics end date	---
Maximum beam energy (GeV)	0.510
Luminosity (10^{30} cm^{-2} s^{-1})	453
Time between collisions (μs)	0.0027
Full crossing angle (μ rad)	5.*10^4
Energy spread (units 10^{-3})	0.40
Bunch length (cm)	1.4 (at 10 mA)
Beam radius (μ)	H: 260 (at IP) V: 4.8
Free space at interaction point (m)	±0.295
Luminosity lifetime (h)	0.2
Maximum achieved current e^-/e^+ (A)	2.45 / 1.4
Turn-around time (min)	2 (topping up)
Injection energy (GeV)	on energy
Transverse emittance (10^{-9} π rad-m)	H: 260 V: 2.6
β* amplitude function at interaction point (m)	H: 0.26 V: 0.009
Beam-beam tune shift per crossing (units 10^{-4})	440 (at L_{MAX} SIDDHARTA run)
RF frequency (MHz)	368.667
Particles per bunch (units 10^{10})	e^-: 3.2 / e^+: 2.1
Bunches per ring per species	100 ÷ 105 (120 buckets)
Average beam current per species (mA)	e^-: 1500 e^+: 1000
Circumference (km)	0.098
Interaction regions	1 (a second one can be restored)
Magnetic length of dipole (m)	Outer ring: 1.2 Inner ring: 1
Length of standard cell (m)	No standard cell
Phase advance per cell (deg)	---
Dipoles in each ring	8
Quadrupoles in each ring	48
Peak magnetic field in dipoles (T)	1.2
Wigglers in each ring	4
Damping Times (t_E/t_x), ms	17.8 / 36.0

Stored Beam Currents at DAΦNE

Beam Currents achieved so far

	beam current I [A]	bunch population N_b [10^{11}]	rms bunch length [mm]	bunch spacing [ns]	comment
PEP-II	2.1 (e^-), 3.2 (e^+)	0.5, 0.9	12	4.2	e+e-
SuperKEKB	2.62 (e^-), 3.6 (e^+)	0.7, 0.5	7	6	e+e
DAFNE	**2.4 (e^-), 1.4 (e^+)**	**0.4, 0.3**	**16**	**2.7**	**e+e-**
BEPC-II	0.8	0.4	<15?	8	e+e-
CesrTA	0.2	0.2	6.8	4	e+ / e-
VEPP-2000	0.2	1	33	80 (1 b)	e+e-
LHC (des)	0.58	1.15	75.5	25	proton-proton
ESRF	0.2	0.04	6.0	2.8	e-
APS	0.1	0.02	6.0	2.8	e-
Spring8	0.1	0.01	4.0	2.0	e-
SLS	0.4	0.05	9.0	2.0	e-

DAΦNE LINAC

Diagnostics	
Fluorescent screens	5
BPMs	14
Current monitors	4
Spectrometer	1

Based on S-band technology

LINAC Parameters

- Pulse width: 1ns $\leq$ lp $<$ 350 ns
- f = 2.865 GHz
- 15 accelerating sections
- 4 klystron 45 MW, each one followed by a SLED
- repetition rate 50 Hz

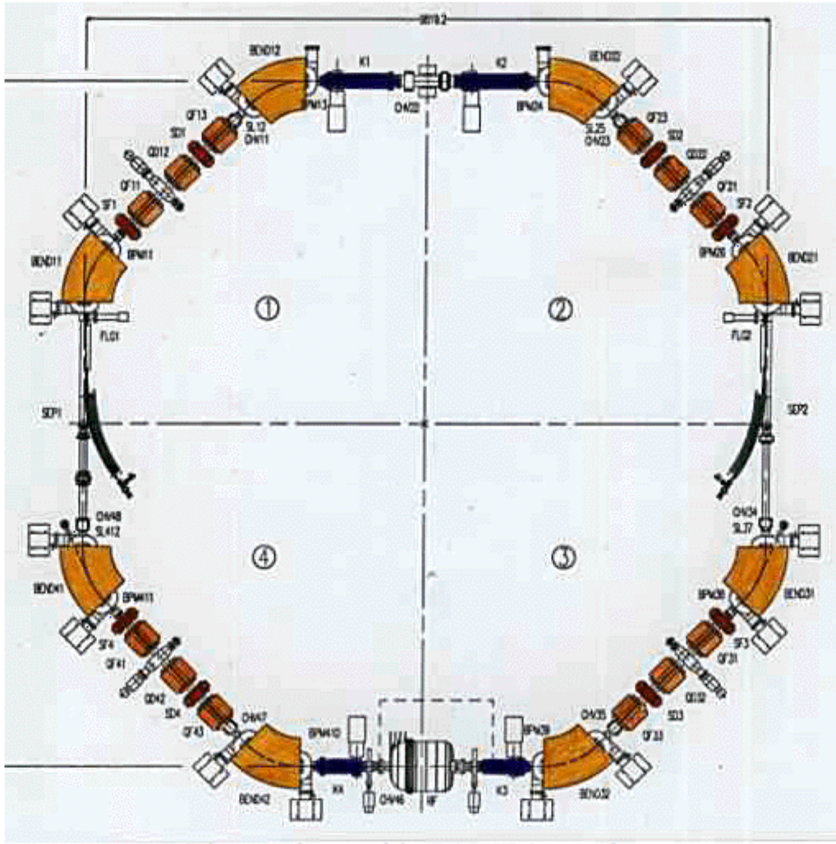
LINAC Beam Parameters

- $E_{e+} \leq 550$ MeV $I^{+}_{(pulse)} \sim 100$ mA
- $E_{e-} \leq 780$ MeV $I^{-}_{(pulse)} \sim 250$ mA
- $\varepsilon^{-} \sim 1$ mm•mrad, $\Delta p/p \sim 1\%$
- $\varepsilon^{+} \sim 5$ mm•mrad, $\Delta p/p \sim 5\%$

A possible LINAC upgrade aims at reaching $E_{e-} \sim 1.$ [GeV] by installing additional accelerating sessions

DAΦNE Accumulator

Energy [MeV]	**510**
Circumference **[m]**	**32.56**
ε_x [mm•mrad]	**0.26**
RF f [MHz]	**73.65**
RF V [KV]	**200.**
σ_z [cm]	**3.8**
SR loss [KeV]/turn	**5.2**
Damping time τ_E/τ_x [ms]	**10.7/21.4**



Schematic layout of the DAFNE Accumulator.

All Dipoles and Quadrupoles are based on laminated yoke technology

Energy operation range up to E = 560 [MeV]

8 45^0 sector dipole n = 0.5

3 independent QUAD families

2 independent SXT families

Transfer Lines

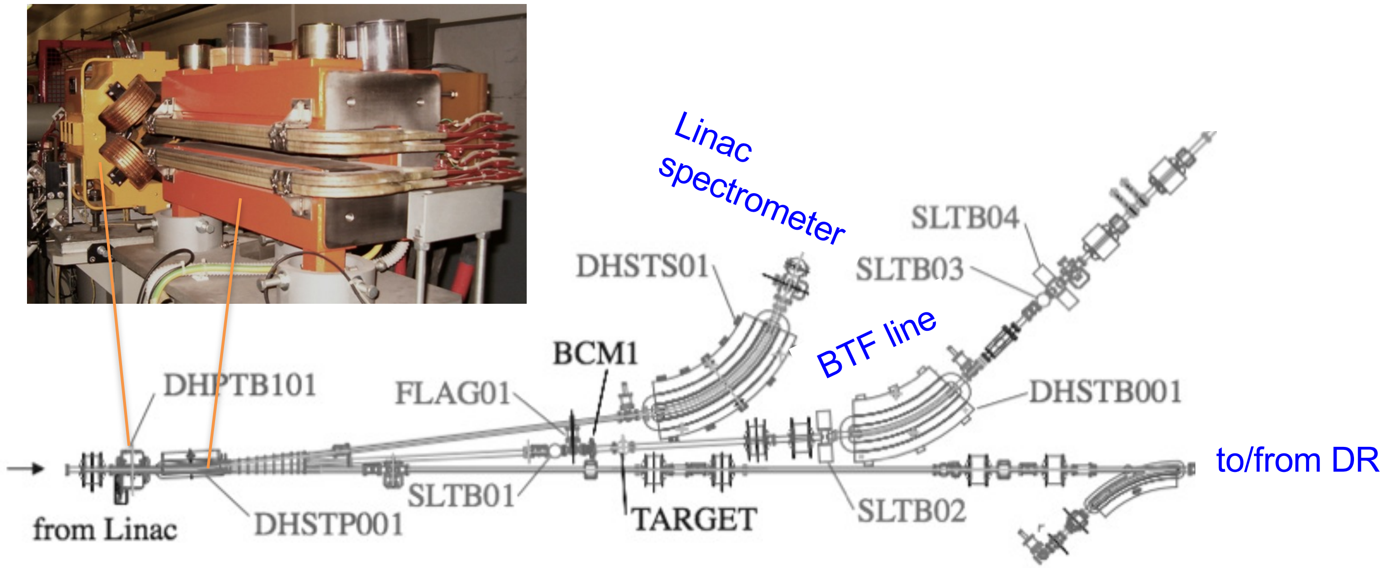
All Dipoles are based on laminated yoke technology

Dipoles can work up to E ~ 800 [MeV]

Diagnostics	Tle Acc inj	Tle Acc ext	Tlp Acc inj	Tlp Acc ext
Fluorescent screens	7	12	5	12
Striplines	9	16	9	10
Current monitors	3	5	3	5

Beam Test Facility Beamline

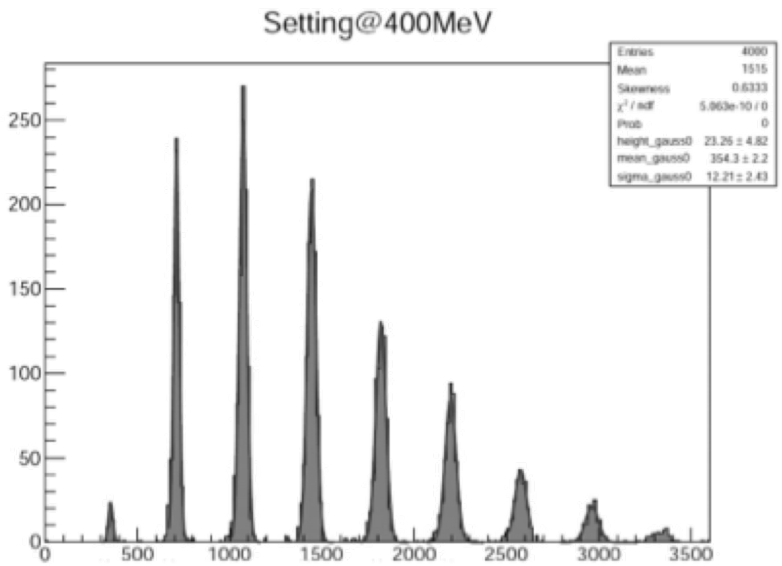
It works parasitically to the DAΦNE runs



Fast-dipole 3° + Pulsed dipole 3° can drive bunches at

- 0° to damping ring
- 3° to BTF line
- 6° to Linac spectrometer

Beam Test Facility @DAΦNE concept



[Mambo BGO]

From 10^7-10^9 positrons or electrons at 510 MeV from the linac…

…To a finely tuned “single-particle” beam:

- 50-500 MeV electrons or positrons
  - Independent from linac primaries
- Poisson statistics at low intensity
- Few % intensity fluctuations at intermediate intensity (thousands of particles)
  - Limited by Linac energy uncertainty
- <1% momentum spread
  - Limited by selection/collimation configuration
- Few mm beam spot
  - Limited by emittance and optics

BTF Users

More infos: http://www.lnf.infn.it/acceleratori/btf/

Mainly, two kinds of users:

- Test of detectors or beam diagnostics
  - Any kind of detector: calorimeter's scintillators, fibers, drift chambers, micro-pattern gas detectors (GEM, MSGC), RPC, diamond, silicon pixels, silicon micro-strips, fluorescence detectors, Cerenkov, RICH, …
- Real experiments using the electron or positron beam
  - Thermo-acoustic expansion of materials due to ionizing particles (RAP)
  - Absolute air and Nitrogen fluorescence yield (AIRFLY)
  - Microwave emission from e.m. showers (AMY)
  - Electron and positron channeling, parametric radiation

Main Rings

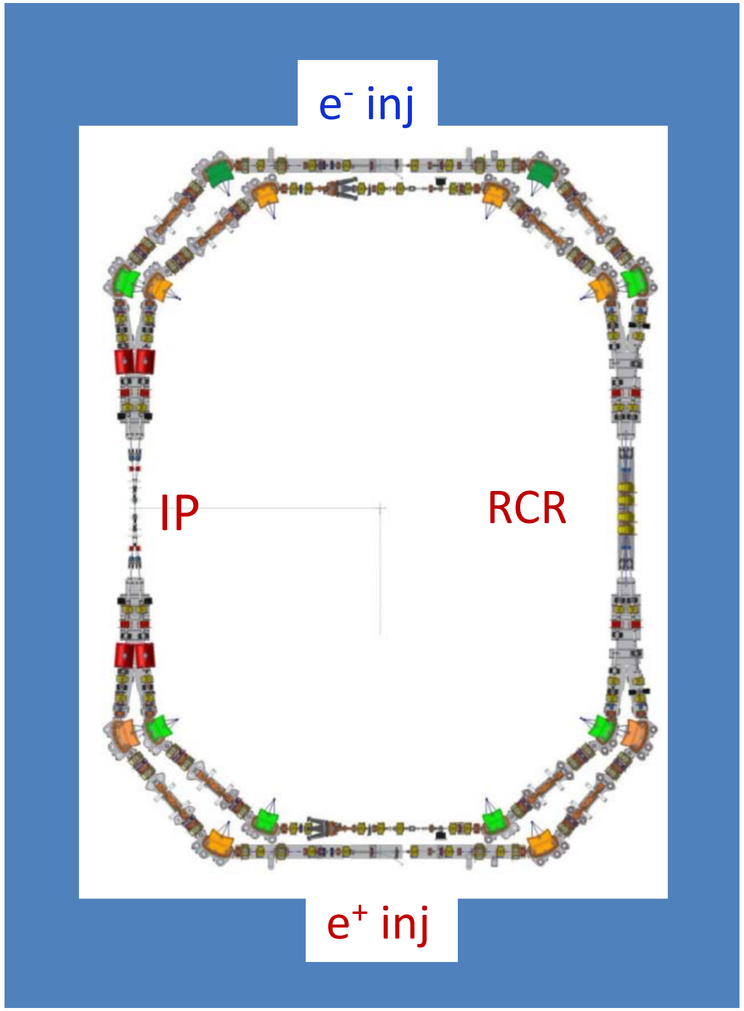
DAΦNE ring optics does not have any periodicity, each ring is a cell

Ring optics is based on a modified Chasman-Green lattice

It consists of 4 achromats, each one including a 2 m long normal conducting wiggler allowing to tune over a wide range:

- beam emittance
- radiation damping
- momentum compaction

Ring optics is very flexible since all *Quadrupole* and Sextupole magnets are independently powered



Main Rings

All magnets are based on laminated yoke technology.

All Quadrupoles and Sextupoles in the Main Rings are independently powered

Wiggler are series powered in each Main Ring

Magnets:

Dipoles can work and have been characterized up to E ≤ 530 [MeV]

Large quadrupoles |Kq|E ≤ 2224 [MeV m^{-2}]

Small quadrupoles |Kq|E ≤ 3200 [MeV m^{-2}]

Large Sextupoles |Ks| Ls E ≤ 7500 [MeV m^{-2}]

Small Sextupoles |Ks| Ls E ≤ 6666 [MeV m^{-2}]

RF systems:

f_{RF} = 368.667 [MHz]

V_{RF} = 250 ÷ 300 KV

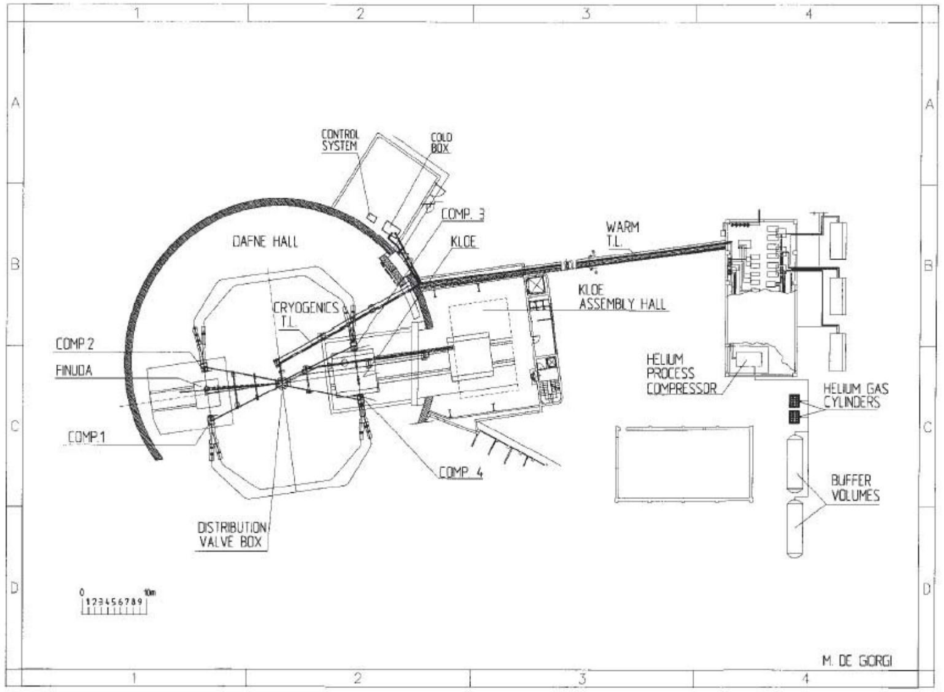
120 harmonic number

Diagnostics in each ring	Number	Details
BPMs	46	4 buttons, Bergoz acq. 6 Hz, res_{rms} = 5÷10 μ
BPMs	6	8 buttons for diag. and FBKs
Libera modules	4	res ~ μ
DCCT	1	
SRM	1	
Streak Camera	1	res ~ 10 ps
Gated Camera	1	gate time ~ 20 ms, res ~ 20 μ
FFT spectrum analyser + white noise generator	1	Tune measurements
Scope	2	
FBK systems	3	

DAΦNE Cryogenic System

LINDE TCF 50 liquid He refrigeration plant

- Users: KLOE/FINUDA/4 Antisolenoids
- Operated at DAΦNE 1998-2018
- Refrigeration capacity:
  - 100 W @ 4.4K/1.2 bar
  - 1.14 g/s LHe
  - 900 W @77 K/10 bar
- Distribution valve box for 6 users
- Control system updated on 2014
- Plant compressor replaced on 2016



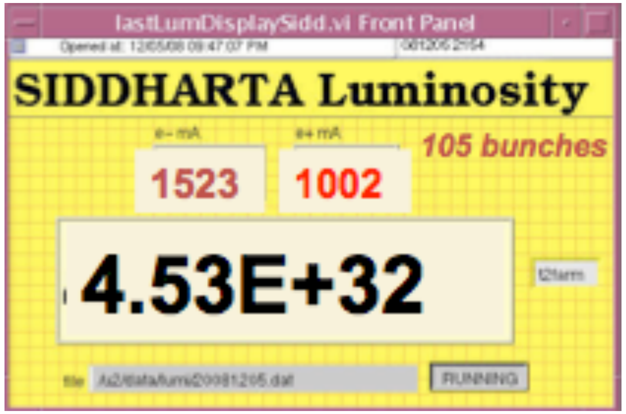
G. Delle Monache, C. Ligi

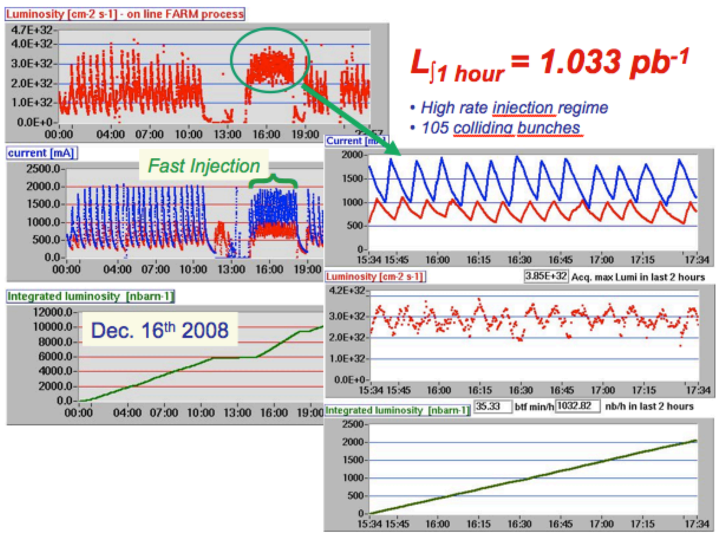
Crab-Waist collision scheme and SIDDHARTA

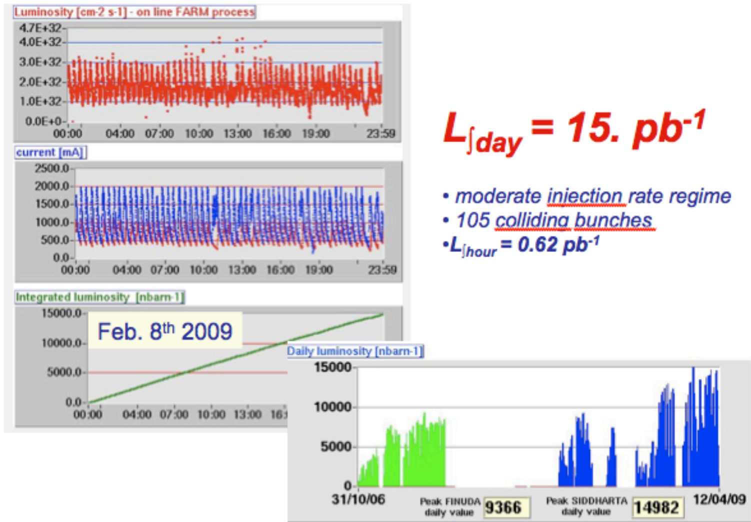
- Large Piwinski angle and Crab-Waist scheme proved to be effective in increasing luminosity, a factor 3 higher than in the past

- The new approach to collision provided

L_{peak}= 4.5*10^{32} cm^{-2} s^{-1}
$L_{\int 1\ day}$= 15.0 pb^{-1}
$L_{\int 1\ hour}$ = 1.033 pb^{-1}
$L_{\int run}$~ 2.8 fb^{-1} (SIDDHARTA detector)



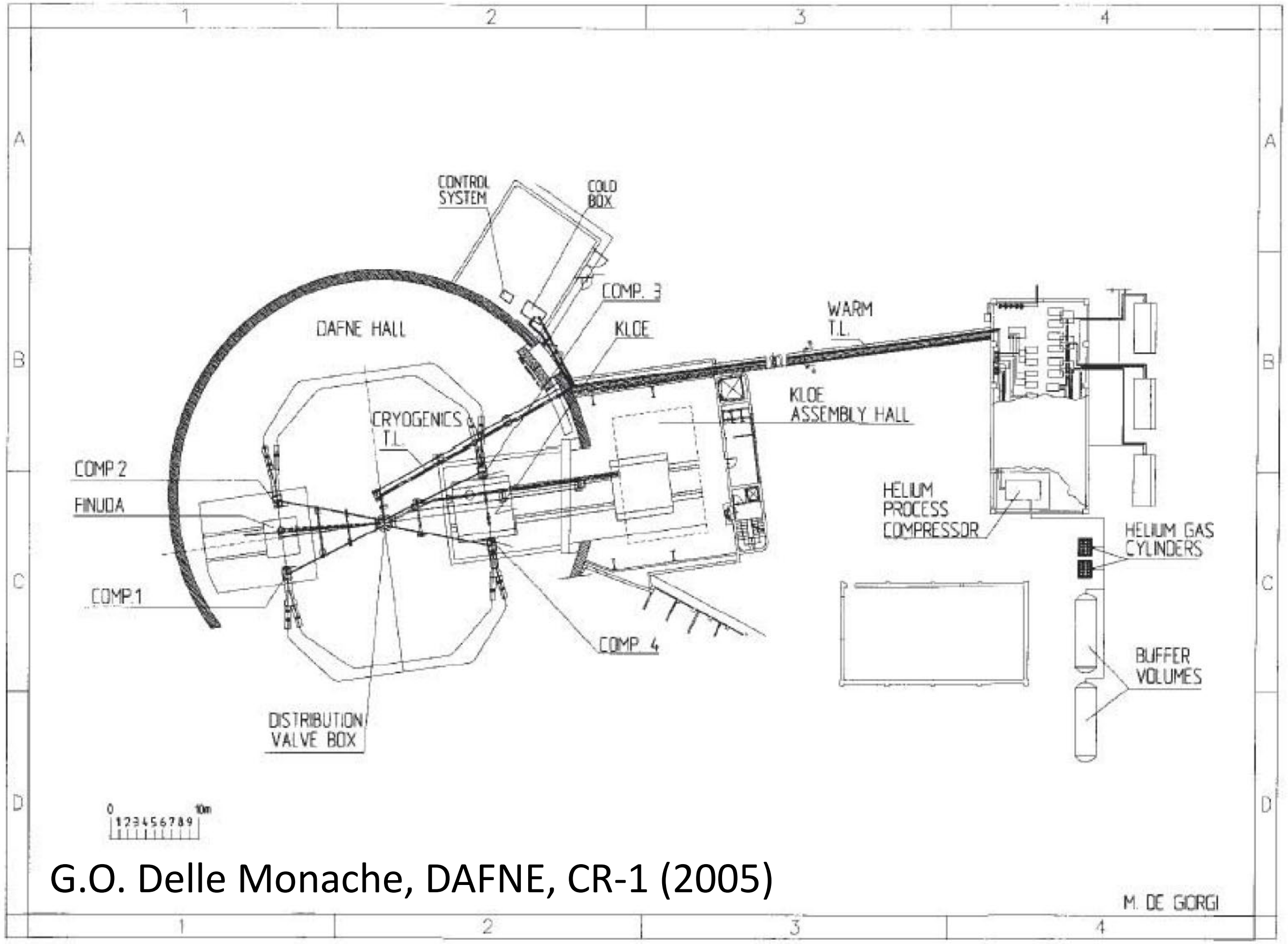




existing DAΦNE cryogenic system

layout of DAFNE cryo
system for 6 SC magnets

marginal for 4.4 K operation
of 1 cavity ?



G.O. Delle Monache, DAFNE, CR-1 (2005)

refrigerator plant LINDE TCF 50
nominal compressor power of 250 kW, delivering two cold He lines:

- 4.4 K @ 3.0 bar (100 W nominal power + 1.14 g/s LHe);
- 77 K @ 10 bar (900 W nominal power).

DAFNE R&D: Feedbacks

DAFNE performances are assured by the 3 feedbacks installed in each ring in order to dump coupled-bunch instabilities both in the longitudinal and transverse plane

DAFNE FBKs are based on iGp (Integrated Gigasample Processor) digital BBB hardware developed by a KEK / SLAC / INFN-LNF joint collaboration and engineered by DIMTEL, Inc. The total power available for each apparatus is of the order of 500 W and 750 W for transverse and longitudinal feedbacks respectively.

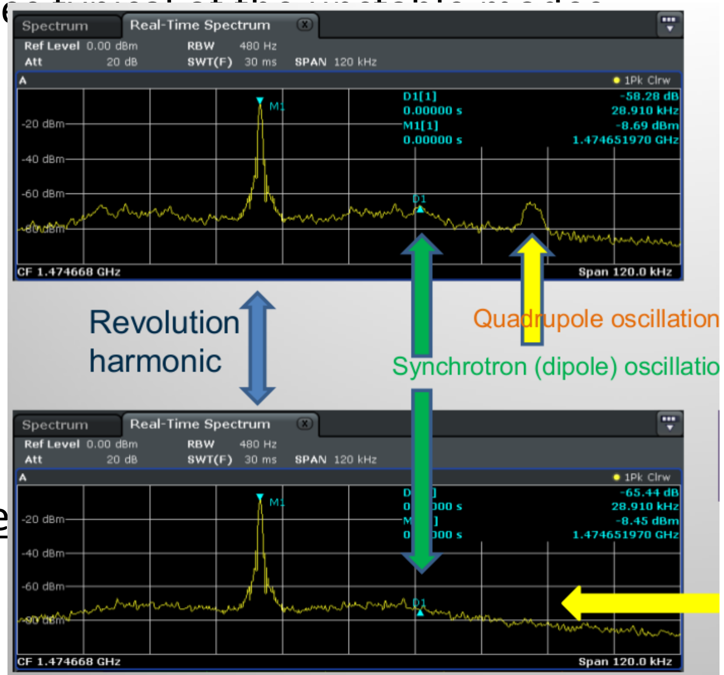
Transverse FBKs have been equipped with in house developed new kickers having doubled strip-line length and providing larger shunt impedance at the low frequenci

Beam current limits observed

- longitudinal mode-0 & quadrupole oscillations
- noise coming from pickups (harmful for beam vertical size)
- e-cloud effects (in the e+ ring)

Solutions:

- <u>Longitudinal quadrupole control by a special technique impleme</u>
<u>feedback system</u>
- Transverse low noise front end (in collaboration with KEK)



(A.Drago, et al., PRST-AB, 6, 052801-1-11, 2003)

Summary: Impact of ecloud mitigation on other systems

	LASE	NEG coating
E-cloud	• SPS and LHC machine tests • More data are required for different LASE and different conditions	• LHC operation • No systematic data for different types of NEG coating
SEY	$\delta_{max} < 0.6$	$\delta_{max} < 1$
PEY	• PEY? (scaled with SEY?) • Data are required	• PEY scaled with SEY (KEK data) • No data for different types of NEG coating
Vacuum		
Thermal outgassing	Low	Negligible
Photon stimulated desorption (PSD)	• To be studied (KARA experiment) • More data are required for different LASE and different conditions (cleaning, storage, bakeout, etc.)	Lower than for 316LN • BINP and ESRF data, • experience from many machines • No data for different types of NEG coating
Electron stimulated desorption (ESD)	Much lower than for Cu	Much lower than for 316LN
Bakeout/activation temperature	• Bakeable to 150 – 300 °C	• Can be activated to 140 – 250 °C • SR induced activation study needed
Beam wakefield impedance	• Low R_s LASE surface development • Machine tests are essential	• Low R_s NEG coating development • Machine tests are essential

O.B. Malyshev ICFA mini-Workshop on DAFNE-TF, INFN/LNF, 17th Dec 2018 24

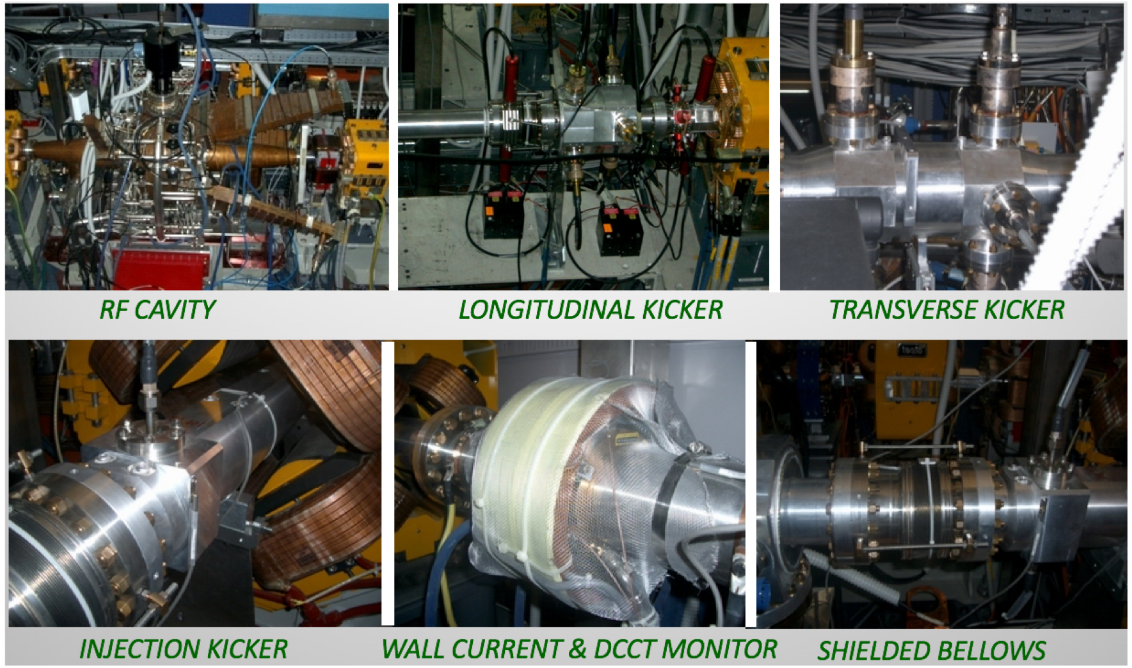
DAΦNE Vacuum Chamber Elements

Optimized to: avoid heating, reduce impedance, and damp HOM

Impedance budget is a factor of 80 lower than in similar storage ring (EPA)

Longitudinal feedback kicker designed for DAFNE have been adopted at: KEKB, BESSYII, PLS, SLS, HLS, ELETTRA, KEK Photon Factory, PEP II

This R&D effort largely contributed to improve beam dynamics and beam-beam performances



D. Alesini, Boni, A. Drago, A. Gallo, A. Ghigo, M. Serio, A Stella, M. Zobov, F. Marcellini, P. Raimondi

R&D: e-cloud mitigation

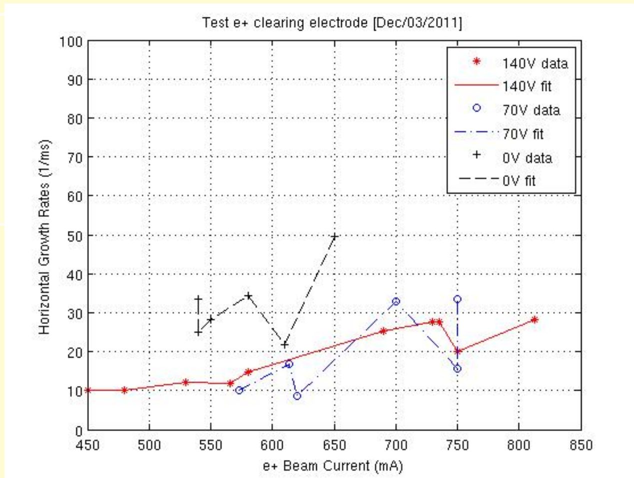
DAΦNE is the first collider operating routinely with electrodes, for e-cloud mitigation, ECE.
ECE provided stable operation with the e^+ beam, and allowed unique measurements such as:

- e-cloud instabilities growth rate
- transverse beam size variation
- tune shifts along the bunch train

demonstrating their effectiveness in restraining e-cloud induced effects.

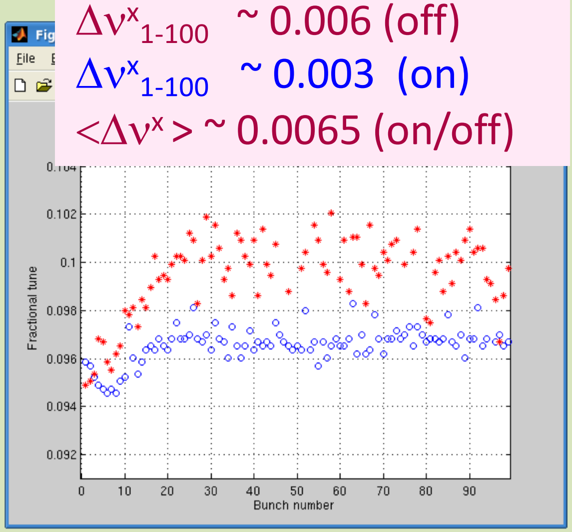
(D. Alesini et al, Phys. Rev. Lett. 110, 124801 (2013)

Horizontal Instability Growth Rate as a function of the ECE voltage measured by using bunch-by-bunch FBK frontend

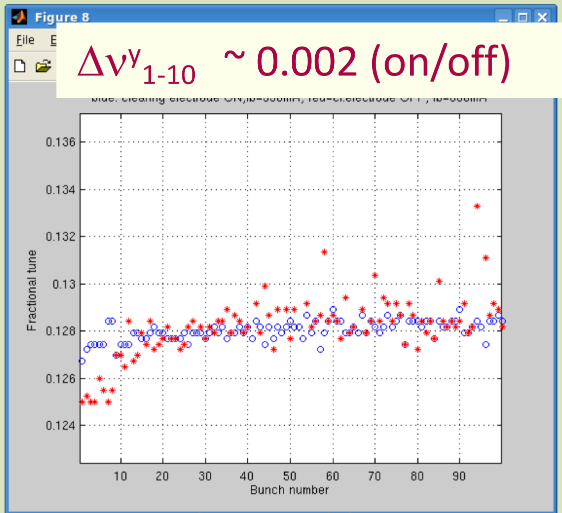


Tune Spread measurements

$\Delta\nu^x_{1-100}$ ~ 0.006 (off)
$\Delta\nu^x_{1-100}$ ~ 0.003 (on)
$<\Delta\nu^x>$ ~ 0.0065 (on/off)



$\Delta\nu^y_{1-10}$ ~ 0.002 (on/off)



Vertical Beam Size