

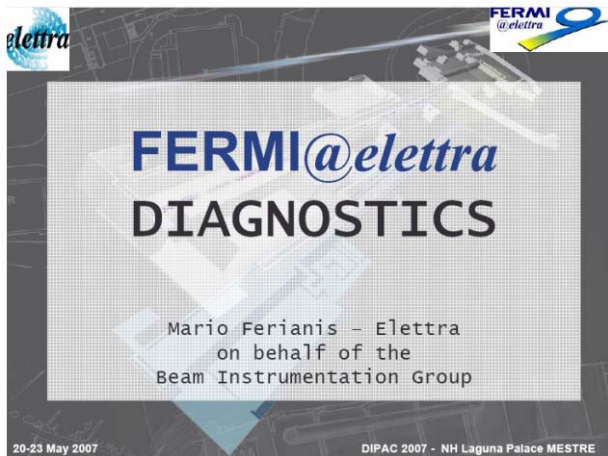
FERMI@elettra Diagnostics

Mario Ferianis (ELETTRA, Basovizza, Trieste)

Abstract

FERMI@elettra is the fourth generation light source currently under construction at the Sincrotrone Trieste Laboratory. It is a seeded FEL based on the existing 1.0GeV Linac which will be fitted with FEL specific sub-systems like a new photoinjector and two bunch compressors to obtain in front of the undulator chain a stable and high quality beam. Due to the challenging beam parameters, the diagnostics play a key role for the successful commissioning first, and then for a reliable operation of the new facility. In this paper we give an overview on the FERMI diagnostics operating in the 6-D phase space along with some keynotes on the timing system which is an integral part of the longitudinal diagnostics.

**Paper not received
(See slides of talk on
following pages)**



FERMI@elettra DIAGNOSTICS

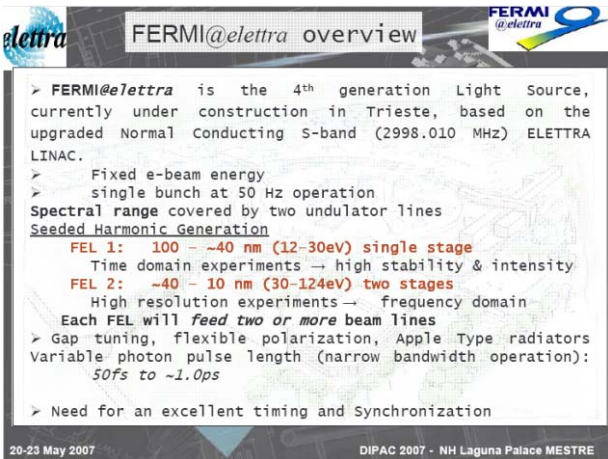
Mario Ferianis - Elettra
on behalf of the
Beam Instrumentation Group

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- FERMI@elettra overview
- Diagnostics
- Current activities and achievements

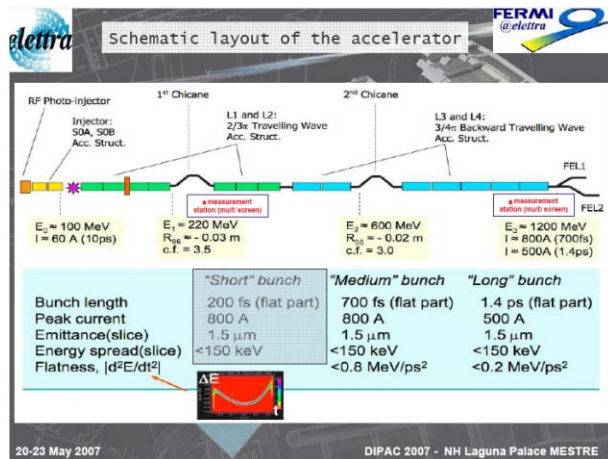
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FERMI@elettra overview

- FERMI@elettra is the 4th generation Light Source, currently under construction in Trieste, based on the upgraded Normal Conducting S-band (2998.010 MHz) ELETTRA LINAC.
- Fixed e-beam energy
- single bunch at 50 Hz operation
- Spectral range covered by two undulator lines
- Seeded Harmonic Generation
- FEL 1: 100 – ~40 nm (12-30eV) single stage
- Time domain experiments → high stability & intensity
- FEL 2: ~40 – 10 nm (30-124eV) two stages
- High resolution experiments → frequency domain
- Each FEL will feed two or more beam lines
- Gap tuning, flexible polarization, Apple Type radiators
- Variable photon pulse length (narrow bandwidth operation): 50fs to ~1.0ps
- Need for an excellent timing and Synchronization

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Schematic layout of the accelerator

RF Photo-injector

Injector: 30A, SSB Acc. Struct.

$E_e = 100$ MeV
 $I = 60$ A (10ps)

1st Chicane

L1 and L2: 2/3 λ Travelling Wave Acc. Struct.

$E_e = 220$ MeV
 $R_{56} = -0.03$ m
c.f. = 3.5

2nd Chicane

L3 and L4: 3/4 λ Backward Travelling Wave Acc. Struct.

$E_e = 600$ MeV
 $R_{56} = -0.02$ m
c.f. = 3.0

FEL1

FEL2

$E_e = 1200$ MeV
 $I = 800$ A (700fs)
 $I = 500$ A (1.4ps)

	"Short" bunch	"Medium" bunch	"Long" bunch
Bunch length	200 fs (flat part)	700 fs (flat part)	1.4 ps (flat part)
Peak current	800 A	800 A	500 A
Emitance(slice)	1.5 μ m	1.5 μ m	1.5 μ m
Energy spread(slice)	<150 keV	<150 keV	<150 keV
Flatness, d ² E/dt ²	<0.8 MeV/ps ²	<0.8 MeV/ps ²	<0.2 MeV/ps ²

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Financed by:

- Italian Research & Univ. Ministry
- Friuli Venezia G. Region
- European Investment Bank
- EUROFEL FP6 Design Study

FERMI@elettra









Conceptual Design Report 2006

Conceptual Design Report 2006

European Investment Bank

Stanford Linear Accelerator Center

MIT

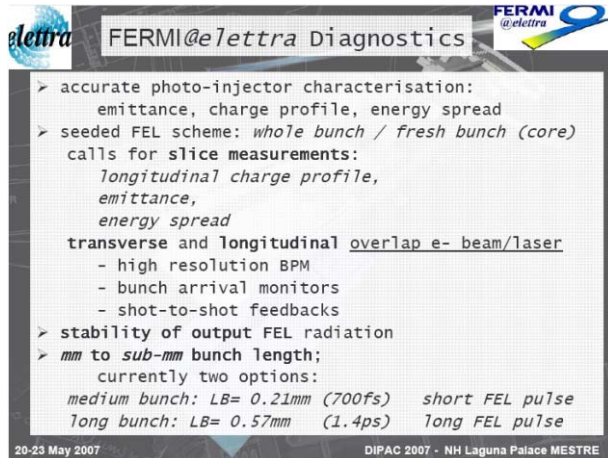
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DESY

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FERMI@elettra Diagnostics

- accurate photo-injector characterisation:
 - emittance, charge profile, energy spread
- seeded FEL scheme: *whole bunch / fresh bunch (core)* calls for slice measurements:
 - longitudinal charge profile,
 - emittance,
 - energy spread
- transverse and longitudinal overlap e- beam/laser
 - high resolution BPM
 - bunch arrival monitors
 - shot-to-shot feedbacks
- stability of output FEL radiation
- mm to sub-mm bunch length; currently two options:
 - medium bunch: LB= 0.21mm (700fs) short FEL pulse
 - long bunch: LB= 0.57mm (1.4ps) long FEL pulse

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Photo injector Diagnostics line

ELETTRA- UCLA agreement for a 10 Hz Gun development

beam parameter	beam monitor	type	resolution
charge	current transformer	on-line	1pC
	Faraday cups	interceptive	10 pC
transverse position	stripline BPM	on-line	20 μ m
	screens	interceptive	15 - 50 μ m
transverse profile	screens	interceptive	15 - 50 μ m
longitudinal profile	Cherenkov radiator + streak camera	interceptive	< 300 fs @ 800 nm

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Bunch Compressor Diagnostics

Parameter	BC1	BC2
Energy Range	220 : 260 MeV	880 : 615 MeV
Rel. En. Spread	2.3 : 2.7 %	0.97 : 1.05 %
Beta (β_x)	16 m ($\alpha=31$ m)	23 m ($\alpha=98$ m)
Dispersion (D_x)	0.165 : 0.255 m	0.155 : 0.24 m
En. Spread Beam size Δx	28 : 44 mm	10 : 15 mm
Betatron Beam size Δx	1.4 mm	2.0 mm
Bunch Length	2.8 psec Medium 5.4 psec Long	0.7 psec Medium 1.4 psec Long

Intensity $\propto N$ particles Int $\propto N^2$ particles

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RF deflectors

"Banana shape" induced by the Linac horizontal transverse wake field (unsuppressed instability). Bunch head is on the left in "t" coordinate (particle tracking result) and on the top in "y" coordinate (simulation of bunch deflection).

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Cavity BPM

Two locations: LINAC & FEL

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and much more...

- Longitudinal diagnostics: collaboration with DESY on Bunch Arrival Monitor (BAM) **WEPC02 / ref. L.Pavlovic, F.Rossi**
- Electro optical sampling (EOS) station **ref. M. Veronese**
- Optical Timing developments: collaborations with MIT / DESY, LBNL, CNIT (Pisa) **WEPC22 / ref. Mario Ferianis**
WEPC11 / ref. L. Banchi

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Current Activities and achievements

Storage Ring FEL seeding

Parameters:
 fundamental wavelength of Ti:Sa ~780 nm
 (the modulator is tuned at 780nm)
 the radiator is tuned at 260nm (3rd harmonic)
 spontaneous emission (of second undulator)=260 nm
 coherent radiation=260 nm
 E. Allaria, M. Coreno, F. Curbis, M. B. Danailov, G. De Ninno, B. Diviacco, E. Karantzoulis, L. Romanzin, C. Spezzani, S. Tileva, M. Trovo'

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Storage Ring FEL seeding experiment

During successive shifts the ratio between seeded and spontaneous peaks has been significantly improved: the seeded signal is about a factor 50 above spontaneous emission. The factor becomes about $1.5 \cdot 10^4$ taking into account the difference between spontaneous (i.e., 30ps_{RMS}) and seed (i.e., 100fs_{RMS}) pulse durations.

19.04.07 h.7:20 a.m.
Seeding works!

The graph plots Intensity (arb. units) on the y-axis (ranging from 0.00 to -0.30) against time (s) on the x-axis (ranging from 0.0 to 5.0 x 10⁻⁹). Two data series are shown: 'spontaneous radiation' (blue line) and 'coherent harmonic radiation' (red line). The coherent radiation shows a much higher peak intensity compared to the spontaneous radiation.

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Current Activities and achievements

100MeV & 1.0GeV LINAC test bed for FERMI diagnostics

TUPC11 / ref. L. Badano M. Veronese

bunch profile and position
transverse emittance (Q- scan)
current/charge
bunch longitudinal profile
bunch length variations (CTR)
energy / energy spread

The top photograph shows a metallic component with a '182 mm' label. The bottom photograph shows a person in a lab coat working on a piece of equipment.

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Current Activities and achievements

optical clock test bed

WEP C22 / ref. M. Ferianis

Jitter on the optical Reference: <math><135\text{fs}_{\text{RMS}}</math>
(after 300m SMF FO)
Locking of a remote laser oscillator: $\approx 400\text{fs}_{\text{RMS}}$
(to an optical Clock)

The diagram illustrates the optical clock test bed. It includes a 'Low phase noise RF generator 2.997GHz', a 'PICO-SOURCE FIBER LASER', and a 'Stabilized Single Mode Fiber link'. The signal path involves 'RF OUT 2.997GHz', 'Gate @ f_{LASE} (=100MHz)', 'Laser F1 Synchron.', 'Timing stabilizer', 'Laser F2 Synchron.', and 'Storage Ring'. A legend indicates red for electrical signals and green for optical signals.

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Thank you for your attention and visit our posters:

TUPC11 / ref. L. Badano

TUPC06 / ref. M. Veronese

TUPC10 / ref. P. Craievich

TUPC09 / ref. P. Craievich, G. Trovato

WEP C02 / ref. L. Pavlovic, F. Rossi

WEP C11 / ref. L. Banchi

WEP C22 / ref. Mario Ferianis

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