Elettra Sincrotrone Trieste

EVOLUTION OF THE FERMI BEAM BASED FEEDBACKS* THPPC129

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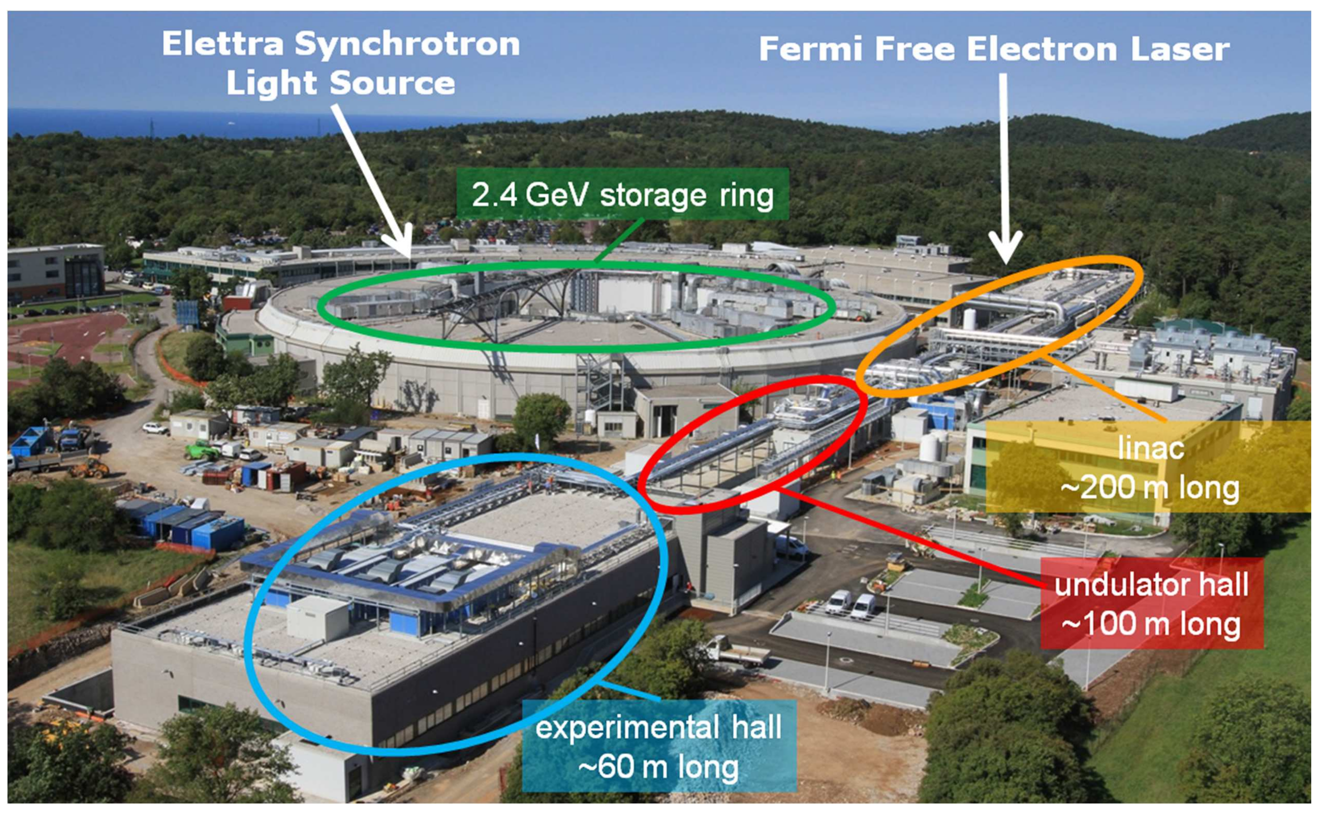
Abstract

FERMI is the first seeded Free Electron Laser (FEL) users facility. A number of shot-to-shot feedback loops running synchronously at the machine repetition rate (50Hz) stabilize the electron beam trajectory, energy and bunch length, as well as the trajectory of the laser beams used for the seeding and pump-probe experiments. They are based on a flexible real-time distributed framework integrated into the control system. The interdependence between feedback loops and the need to react coordinately to different operating conditions lead to the development of a real-time supervisor capable of controlling each loop depending on critical machine parameters not directly involved in the feedbacks. The overall system architecture, performance and user interfaces are presented.



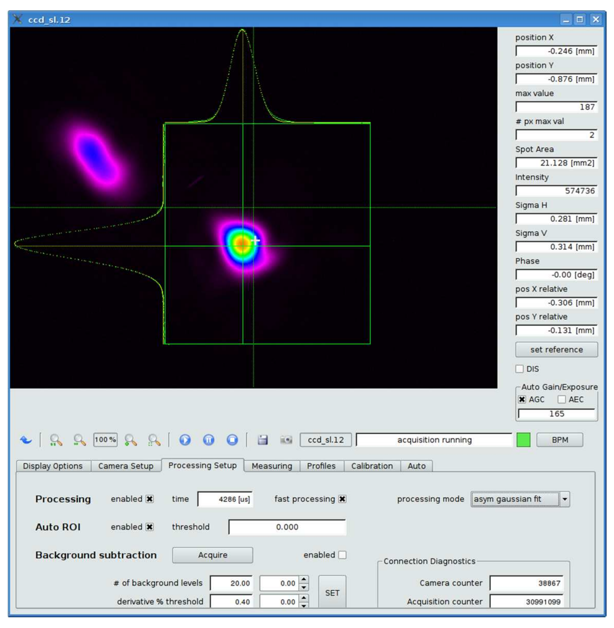
FERMI is a single-pass FEL user-facility covering the wavelength range from 100 nm to 4 nm, located next to the third-generation synchrotron radiation facility Elettra in Trieste, Italy. The advent of femtosecond lasers has revolutionized many areas of science from solid state physics to biology. This new research frontier of ultra-fast VUV and X-ray science drives the development of a novel source for the generation of femtosecond pulses.

The main machine characteristics are:

- High peak power (~ GW) short (100 fs.) optical pulses with synchronization to external laser sources.
- APPLE II type undulators to enable flexible tuning of both photon wavelength and polarization.
- Implementation of seeded harmonic cascade FEL schemes for tunable and controlled short-wavelength photon pulse production.
- Advanced feedback and feed-forward systems to improve output stability.

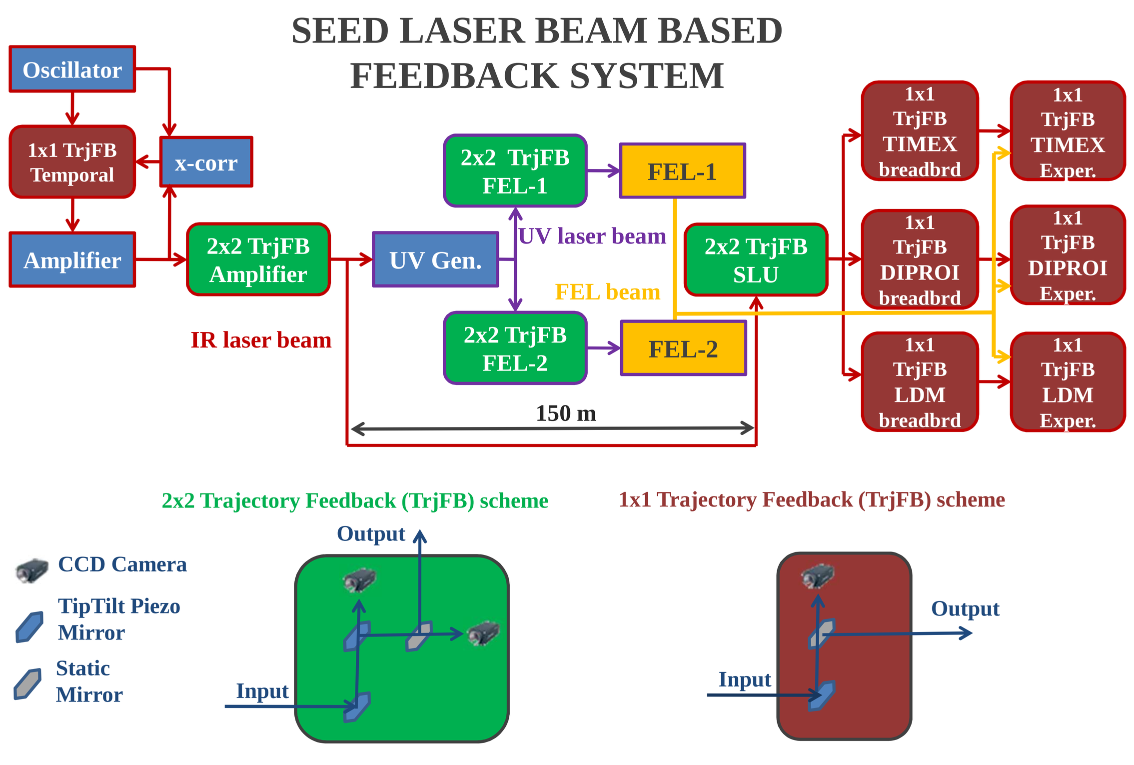
Laser Beam Feedbacks

Two pulsed laser systems are currently installed in FERMI: the **photo-injector laser** and the **seed laser**. The former is used to extract and shape the electron bunch from the cathode and also used for the Laser Heater. The latter is one of the most sensitive systems of FERMI: a variation of 0.01° C of the seed laser room temperature determines a time shift between the electron bunch and the seed laser pulse of 50 fs with a consequent drop of the FEL output intensity.
Two different types of **shot-to-shot feedbacks** guarantee temporal and trajectory stability of the seed laser. Both of them make use of **CCD camera**s and **mirrors** moved by **piezoelectric devices**.

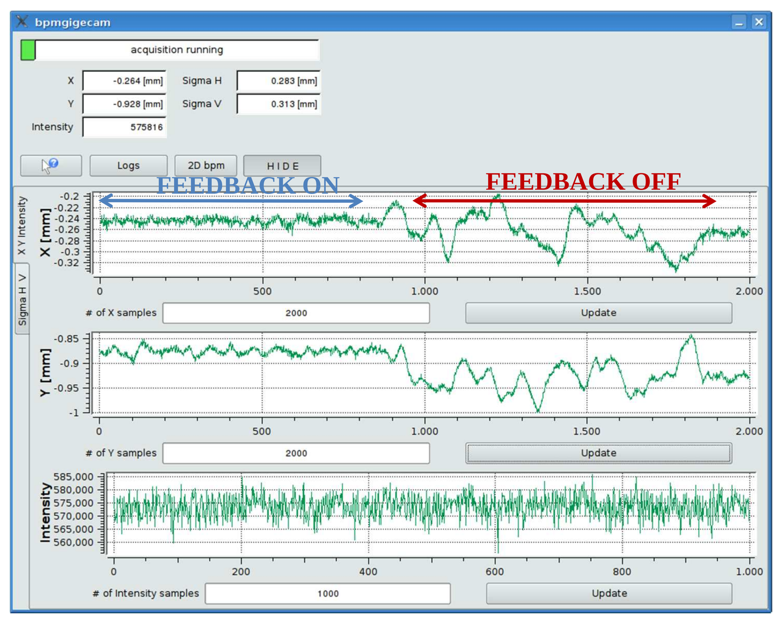


CCD control panel

The images are acquired by Intel based dual-CPU servers through Gigabit Ethernet links from **Basler CCD cameras**. The calculation of the beam position using one of the possible algorithms (**Raw RMS, Gaussian, Asymmetric Gaussian, etc.**) is performed by a Tango device server. An optimized code, which makes use of the GNU Scientific Library (GSL) for non-linear fitting and of the **OpenMP GCC** extension for parallel computing, allows calculating an Asymmetric Gaussian fitting of the laser spot on a 782x582 pixel image in less than **4 ms**, a time sufficient to perform a **50 Hz feedback loop**.



Layout of the seed laser feedback loops

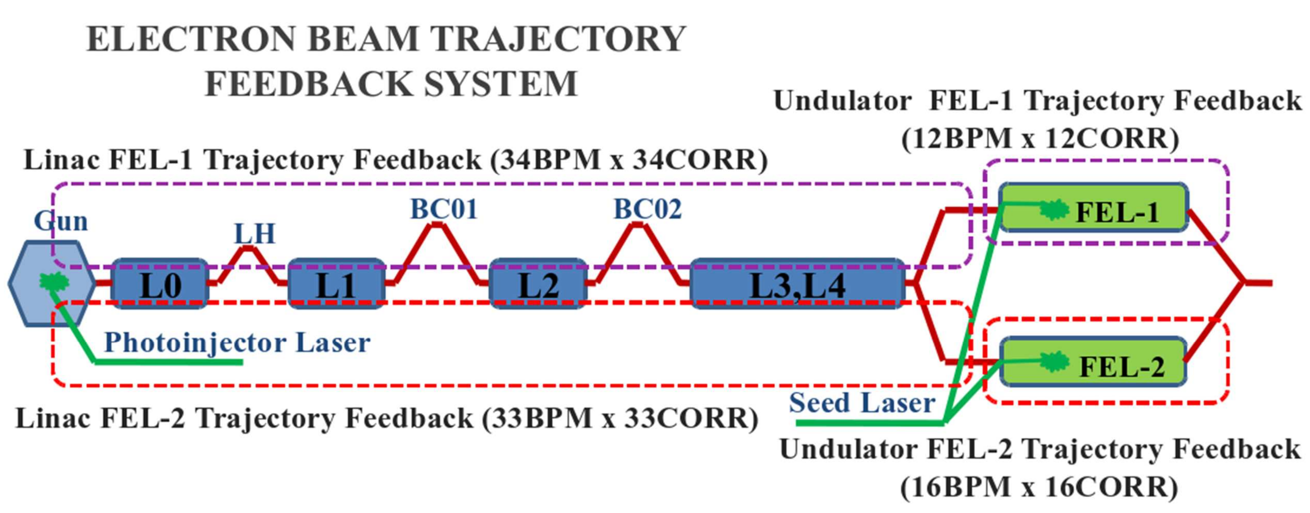


Position of the laser beam with loop ON/OFF

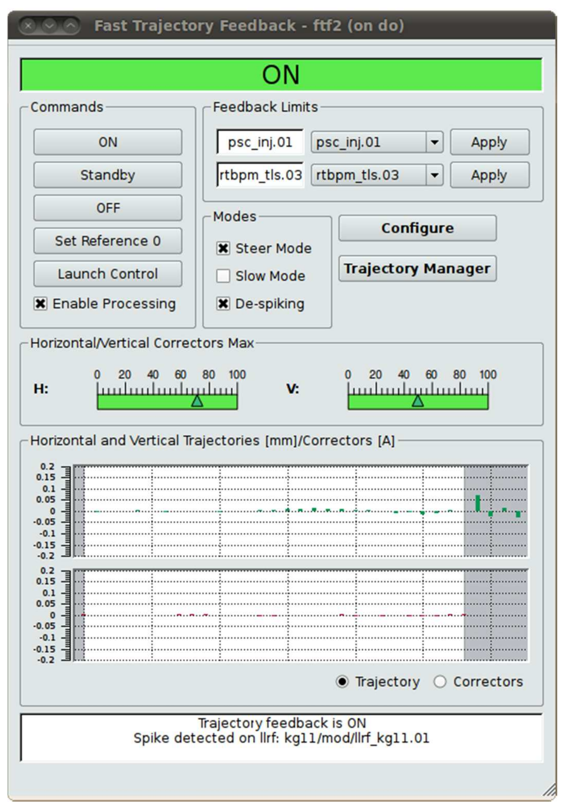
Electron Beam Feedbacks

Trajectory Feedbacks

The main goal of the **transverse feedbacks are** to stabilize the trajectory in the linac in order to control the wake-fields, and inside the undulators, to preserve the overlap with the seed laser. There are presently **four feedback loops**, two dedicated to FEL-1 operations, two to FEL-2 operations, controlling a total of **62 Beam Position Monitors (BPM)** and **62 correctors**.



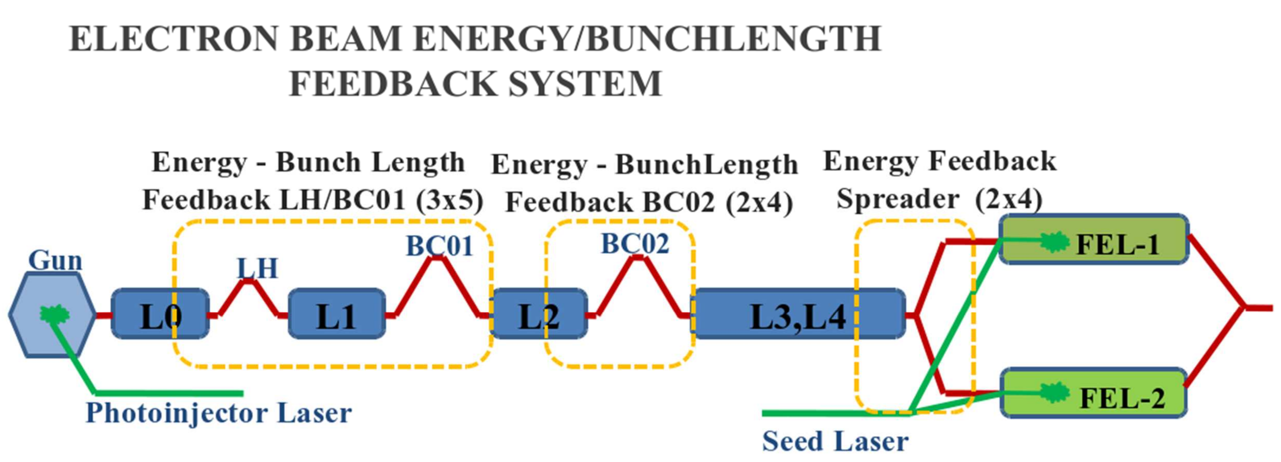
Layout of the trajectory feedback loops



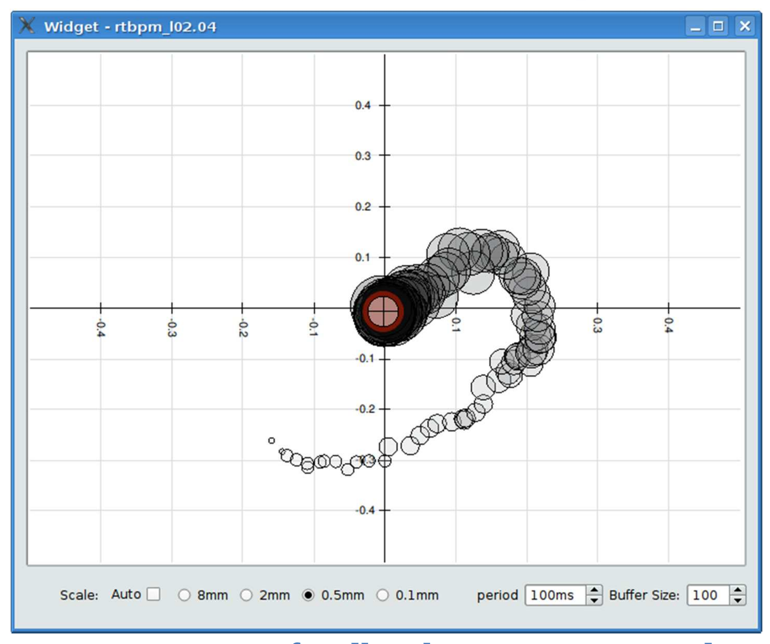
Trajectory feedback control panel

Energy / BunchLength Feedbacks

At present we operate **three separate longitudinal feedback loops**. The first controls the energy in the Laser Heater (**LH**) and energy and bunch length in the first Bunch Compressor (**BC01**). A second loop controls energy and bunch length in the second Bunch Compressor (**BC02**). At the end of the linac a third loop stabilizes the final beam energy. Energy and bunch length are measured by **BPMs** in dispersive regions and **pyro detectors** respectively. The actuators are **amplitudes and phases** of the RF plants.



Layout of the energy/bunchlength feedback loops



Trajectory feedback set-point panel

*Work supported in part by the Italian Ministry of University and Research under grantsFIRB-RBAP045JF2 and FIRB-RBAP06AWK3

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