Status Report of the FERMI@Elettra Control System

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Sincrotrone Trieste, Trieste, Italy

Presented by Marco Lonza

Sincrotrone Trieste - Italy


Milano
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Napoli
Palermo

Sincrotrone Trieste Laboratory

ELETTRA Storage Ring Synchrotron: third generation light source

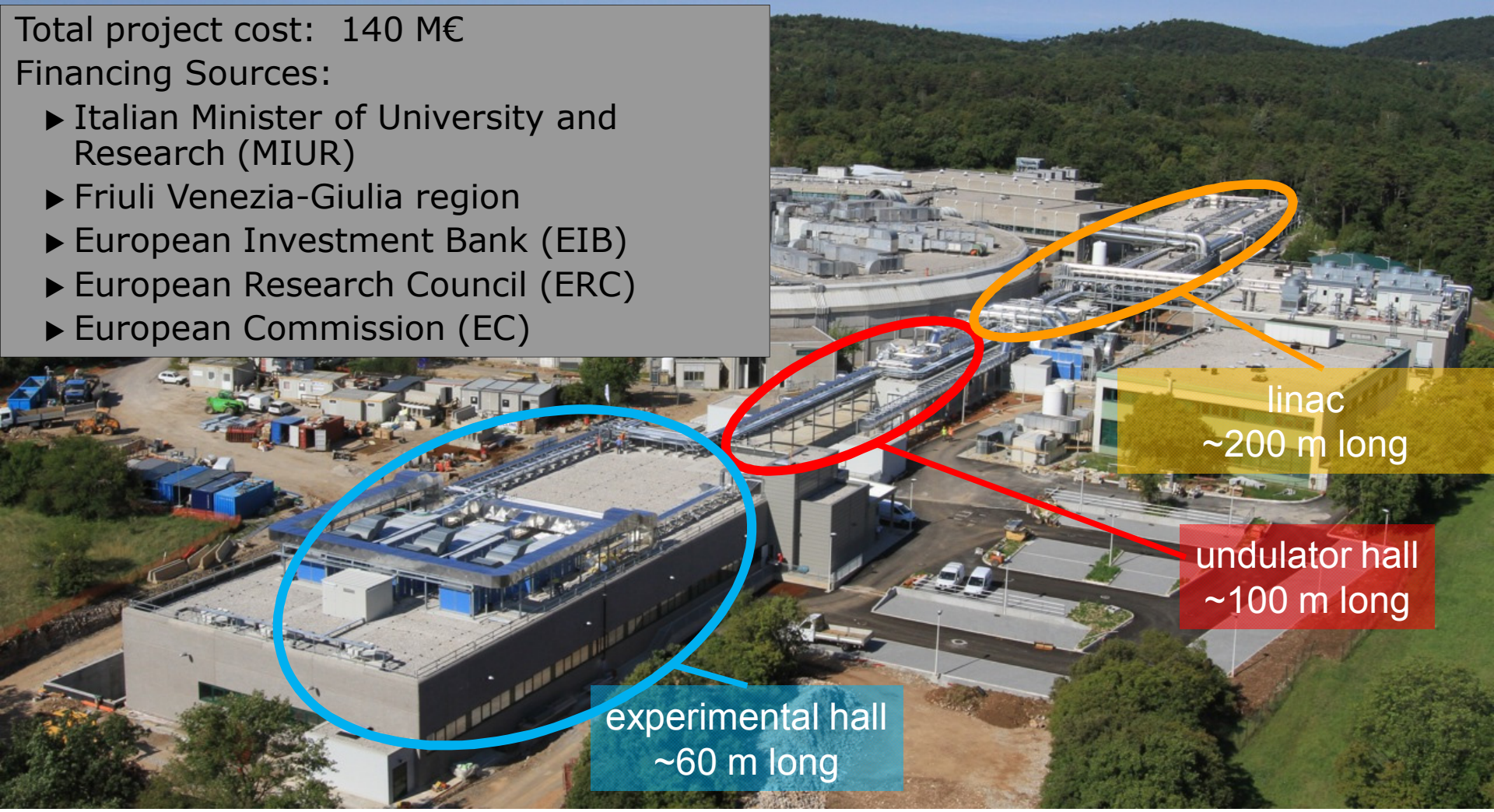
Sincrotrone Trieste Laboratory

FERMI@Elettra Free Electron Laser: fourth generation light source

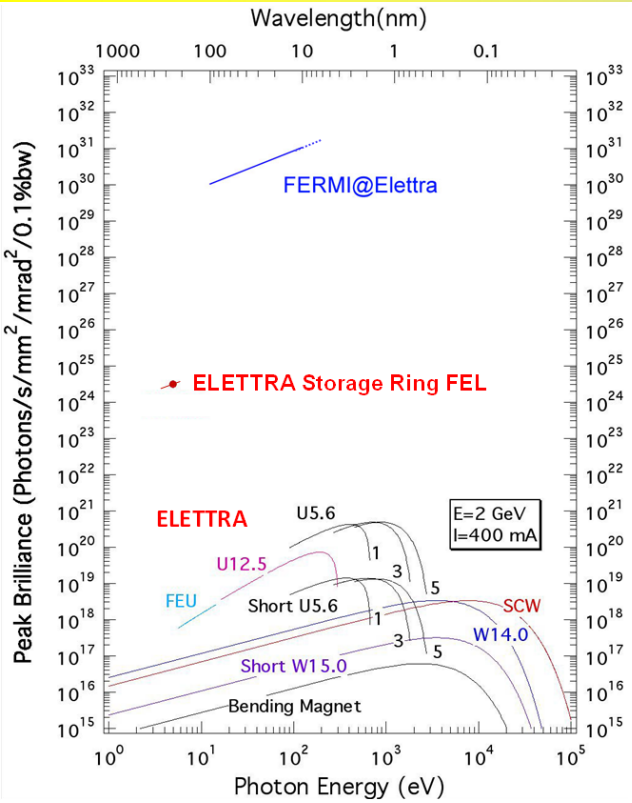
Total project cost: 140 M€

Financing Sources:

- Italian Minister of University and Research (MIUR)
- Friuli Venezia-Giulia region
- European Investment Bank (EIB)
- European Research Council (ERC)
- European Commission (EC)



FERMI@Elettra Free Electron Laser

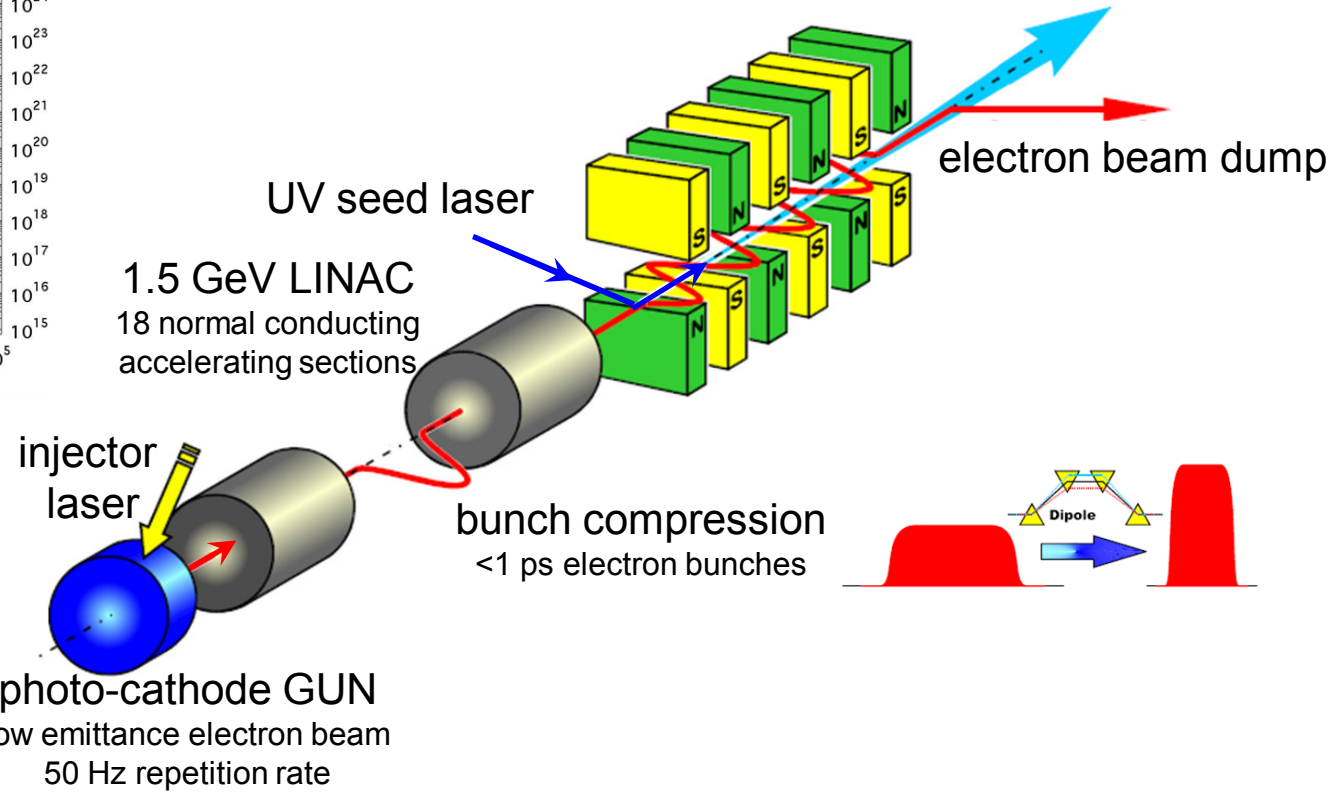


First seeded FEL designed to produce fundamental output wavelength of 4 nm with **High Gain Harmonic Generation**

FEL photon beam

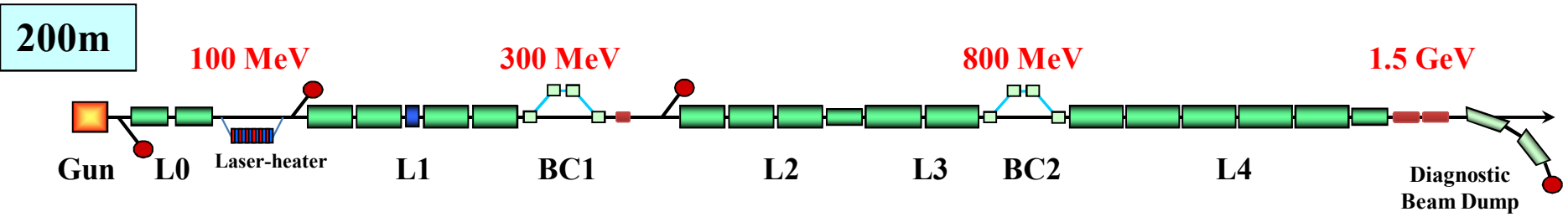
high peak power (>GWs), short pulse length (<100 fs)
full spatial and temporal coherence

tunable wavelength (100-4 nm), variable polarization

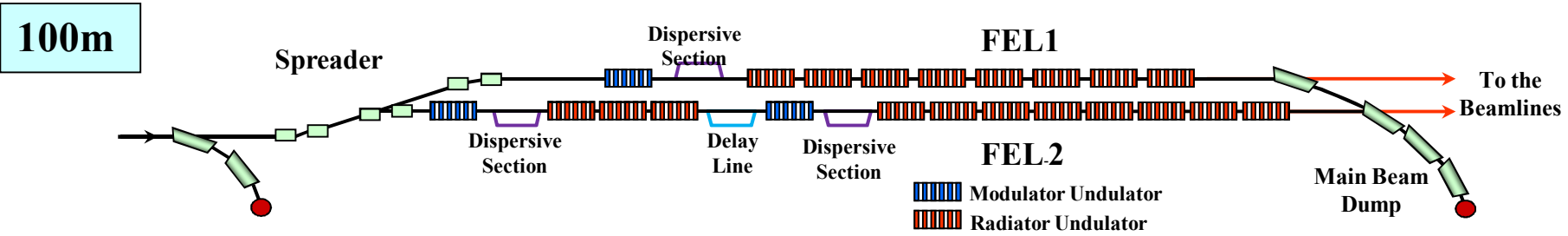


Machine Layout

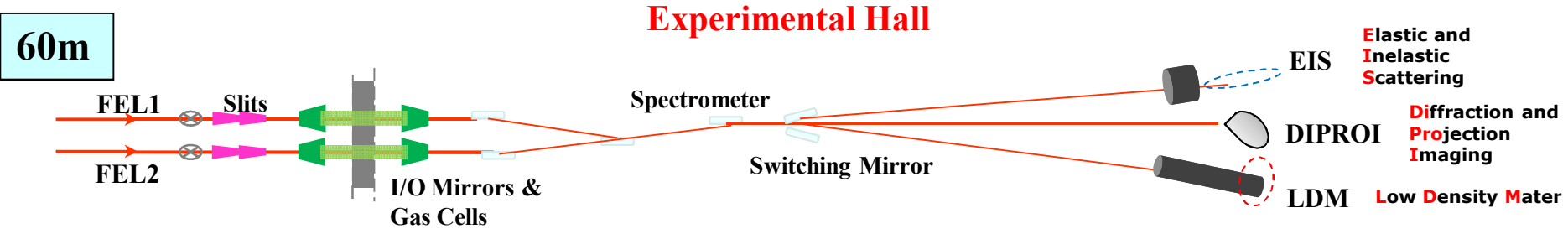
Linac



Undulator Hall

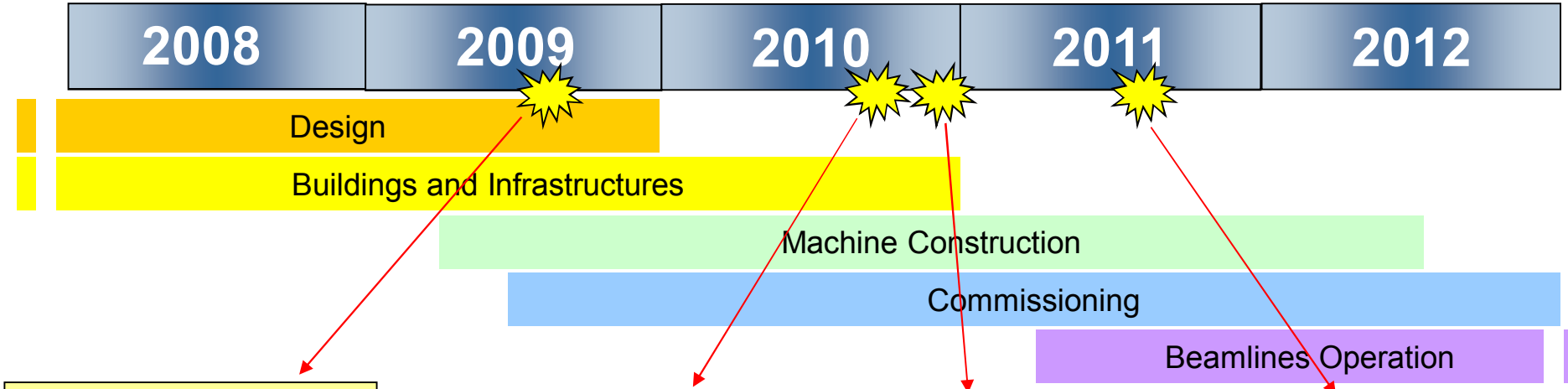


Experimental Hall

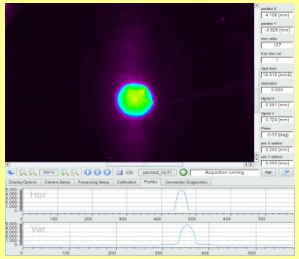


The particular characteristics of the FEL photon beam enable time resolved experiments to study ultrafast dynamics and transient phenomena of matter under extreme irradiation conditions

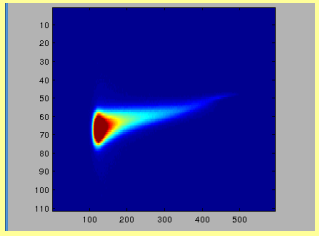
Project Schedule and Achievements

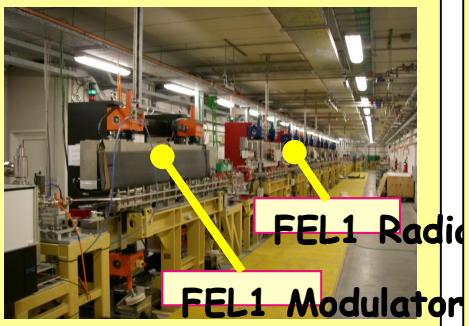


August 2009
First electron beam by the photo-cathode gun

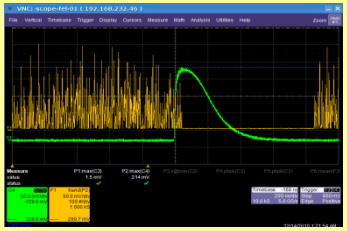


September 2010
Linac energy 1.212 GeV

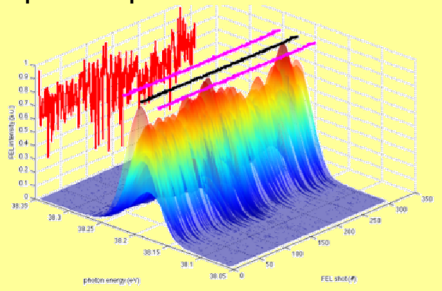




December 2010
First FEL coherent photon beam generated



July 2011
FEL-1 photon beam achieved expected parameters



FERMI@Elettra Controls

Scope of the FERMI@Elettra Controls Area:

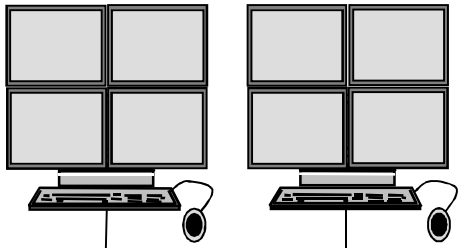
- Control system
- Personnel Safety System
- Interlock System (Equipment and Machine Protection) **Poster: WEPMU025**
- Fast Feedback Systems **G. Gaio: FRBHAULT04**
- Experimental Data Acquisition, Storage and Processing **Poster: MOPMU015**

- Budget and manpower:
  - Total cost: ~2 M€
  - Total effort: 50 person-years in four years (2008-2011)

Control System Architecture and Technologies

Control Room

Control system consoles: low consumption PCs with 4 monitors

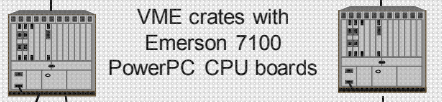


Control system servers: hot-backup configuration, 11 XEN virtual machines

Controls Network: Gigabit Ethernet, HA configuration, 17 VLANs, Wi-Fi

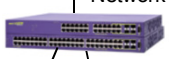
Field computers

VME crates with Emerson 7100 PowerPC CPU boards



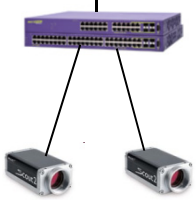
Direct I/O

Network switch



Field Ethernet network

Intel-based rack-mount acquisition servers



Serial device servers

RS-232/485

Siemens S7 PLCs

Profibus

Profibus peripherals

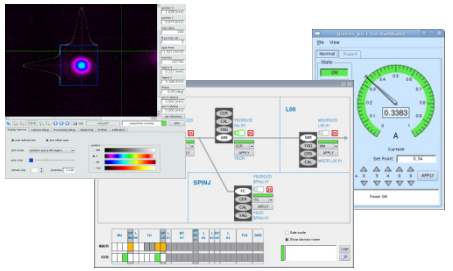
Operator Panels

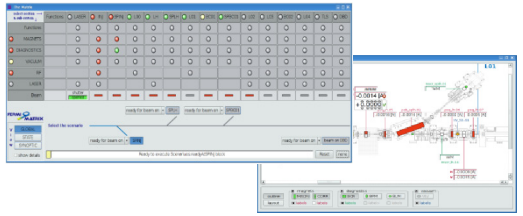
Equipment and machine protection systems, PSS, undulator controls

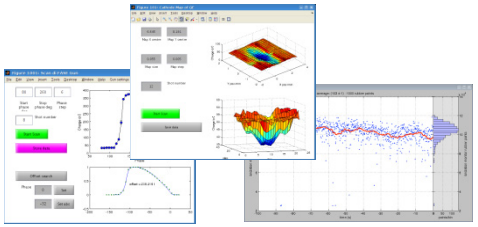
Software

- System software:
  - Ubuntu/Linux operating system on all computers (with a few Windows exceptions)
  - Adeos/Xenomai real-time extension on PPC boards and Intel acquisition servers
  - Tango everywhere, also in some embedded devices (ex. Libera BPM detector): ~4000 Tango Device Servers written in C/C++ and Python

- GUIs development:
  - *QTango:* C/C++ library developed in house based on *Qt* (Nokia-Trolltech)
    - *Matrix and Sequencer: automation and "intelligent" display of the machine state* **(Poster: MOPMN013)**
    - Mango: online GUI development tool based on *QTango* for online development of graphical panels **(Poster: WEPKS022)**
  - Matlab: machine physics applications and GUIs for the commissioning are mostly developed in Matlab by physicists







Synchronized Operation

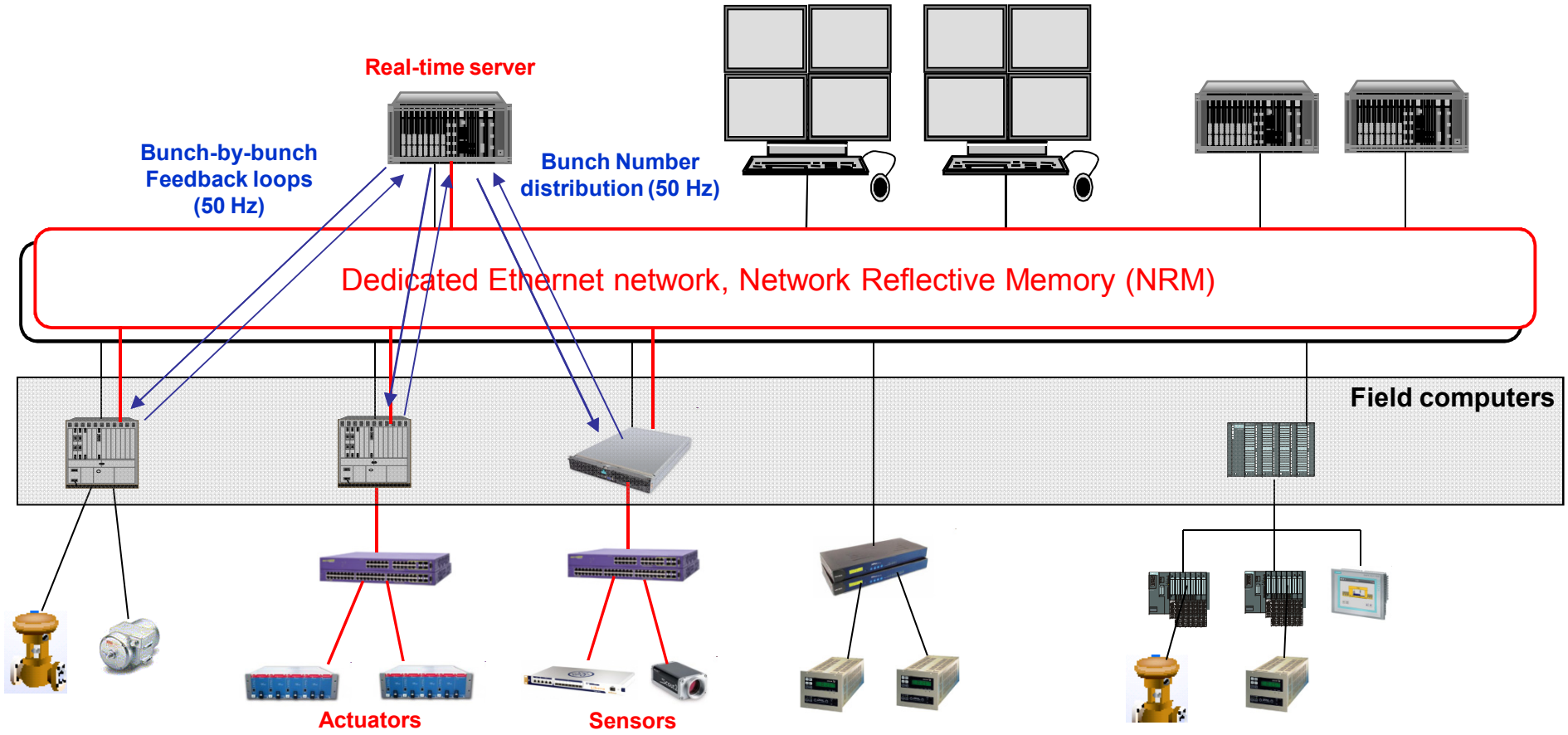
- FERMI@Elettra is a pulsed machine with repetition rate of 10-50 Hz

- Synchronization and timing signals at different level of precision:
  - tens of *ps*: Event System by Microresearch
  - tens of *fs*: optical synchronization system

- The control system has special capabilities to measure and manipulate the beam pulse-by-pulse:
  - All the relevant monitor and control points are synchronized with the bunch trigger: beam diagnostics and power supplies feature real-time interfaces to the control system
  - A real-time time stamp called "bunch number" is distributed to the control system computers
  - A number of pulse-to-pulse feedback loops stabilize the crucial parameters of the beam

A real-time framework integrated into the control system provides these capabilities: based on the Network Reflective Memory (NRM)

Network Reflective Memory



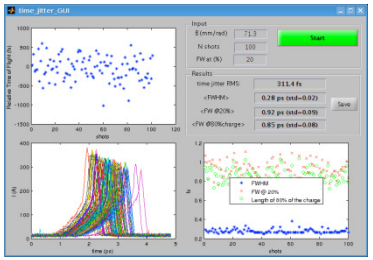
- The Network Reflective Memory (NRM) is an in house developed software communication protocol based on broadcast packets in a dedicated Ethernet network **Lorenzo Pivetta: THDAUST03**
- Implements a real-time shared memory with ~1 ms latency: data can be shared between computers in real-time
- Used for Bunch Number distribution, centralized acquisition of bunch-by-bunch data and implementation of bunch-by-bunch feedback loops

Keys to Success

- Standardization of hardware and software:
  - Same architecture and technologies on the whole machine, hw interfaces (mostly Ethernet and serial), low level computers (VME, Intel based, PLC), software (Linux and Tango on all the computers), GUIs (QTango and Matlab), stepper motor controllers (YAMS an in-house project using Galil controller, more than 400 axes controlled) **Poster: WEPMN034**

- Tango:
  - good performance, reliable, stable
  - the real "glue" of the control system: effective integration of the technical systems
  - Object Oriented approach, Device Model: easier software design development and maintenance
  - coordination, processing and automation functionalities implemented in the Tango device servers

- Real-time framework:
  - bunch-by-bunch observation and manipulation of laser, electron and FEL beams
  - simple APIs to client applications: many machine physics applications exploiting these capabilities (jitter studies with correlation, real-time emittance measurements, …)



- Matlab:
  - widely used by physicists for commissioning and machine physics applications
  - the "specify-implement-modify" never-ending cycle between physicists and software developers have been almost eliminated
  - Matlab application are eventually translated to QTango/C++ only when they become stable

FERMI@Elettra

The FERMI@Elettra team thanks you all for your interest in this project and invites you to visit our facility