INTEGRATING THE FHI-FEL INTO THE FHI RESEARCH ENVIRONMENT – DESIGN AND IMPLEMENTATION ASPECTS

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Abstract

The new mid-infrared FEL at the Fritz-Haber-Institut (FHI) was presented at the FEL12 conference. [1] It will be used for spectroscopic investigations of molecules, clusters, nanoparticles and surfaces. This facility must be easy to use by the scientists at FHI, and should be seamlessly integrated into the existing research environment. The Experimental Physics and Industrial Control System (EPICS) software framework was chosen to build the FHI-FEL control system, and will also be used to interface the user systems. The graphical operator interface is based on the Control System Studio (CSS) package. It covers radiation safety monitoring as well as controlling the complete set of building automation and utility devices, regardless of their particular function. A user interface (subset of the operator interface) allows user-provided experiment-control software (KouDA, LabVIEW, Matlab) to connect with an EPICS Gateway providing secured access. The EPICS Channel Archiver continuously records selected process variable data and provides a web server offering archive and near real-time data. A sample experiment installation demonstrates how this user interface can be used efficiently.

User Experiment: Confirmed Resolved IR-Spectroscopy on Biomolecules

- The function on protein depends on its 3-dimensional structure and shape.
- The study of proteins in the gas phase yields information about isolated molecules and gives insight into intramolecular interactions that govern the protein's structure.
- The gas-phase techniques mass spectrometry (MS), ion mobility spectrometry (IMS), and IR-spectroscopy yield complementary information about the molecule.

The principle of Ion Mobility Spectrometry

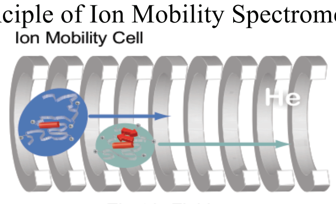

Figure 1: Ion mobility cell.

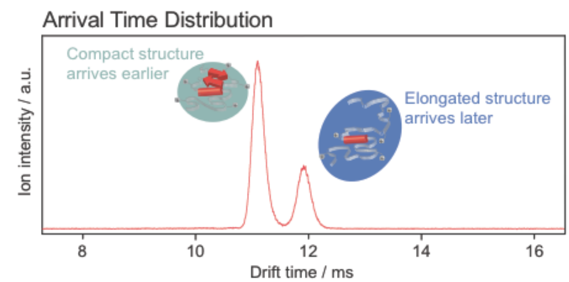

Figure 2: Arrival time distribution.

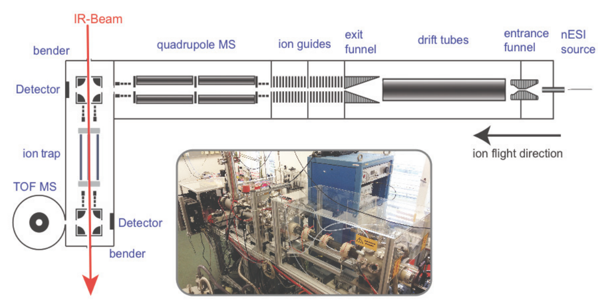

Figure 3: Experimental setup IMS.

- Combination of IMS, MS, and IR-Spectroscopy allows for spectroscopy on m/z- and shape-selected biomolecules.
- Shape- and m/z-selected ions will be stored in a cooled ion trap and irradiated with IR-light.
- The wavelength dependency of the ion-fragmentation will be monitored using LabVIEW programs and NI data acquisition cards. [2]

Operator Console

The operator interface is based on Control System Studio (CSS). This is an Eclipse RCP based development platform and the fundament for many applications like EPICS, TANGO, etc.. As most of these applications deal with process variables and connections to control systems, the CSS Core provides the necessary APIs for dealing with them. Taking advantage of modern graphical editor software technology, Operator Interface (OPI) editor and runtime - Best OPI, Yet (BOY) - has been developed by the CSS collaboration. [3] The Operator Interface is one of the basic components of the standard control system model. It provides not only operators but also scientists and engineers with rich graphical interfaces to view or operate the FEL locally or remotely [Fig. 4].

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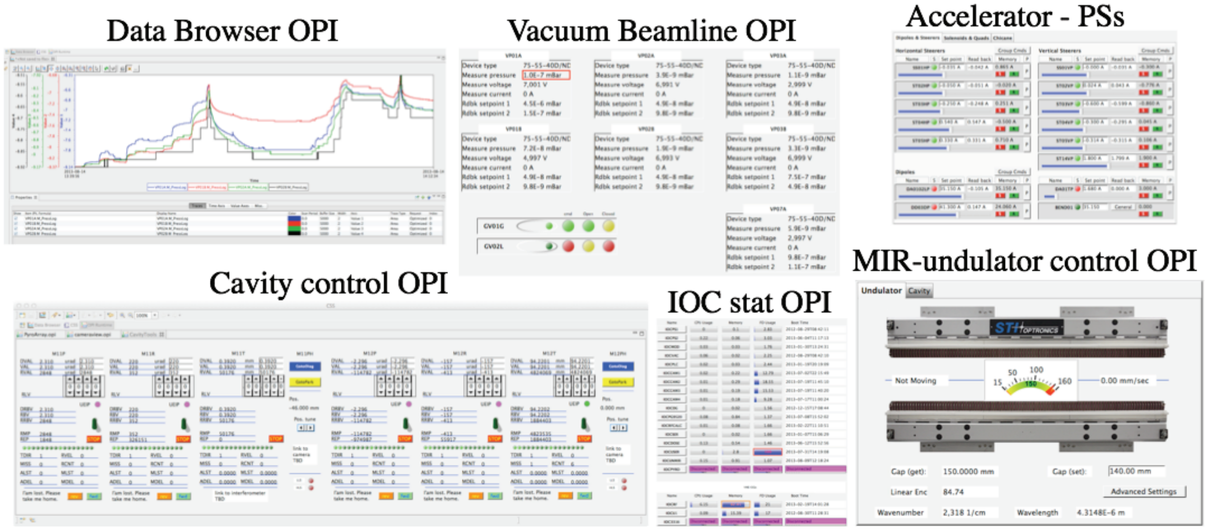

Figure 4: Operator console OPIs.

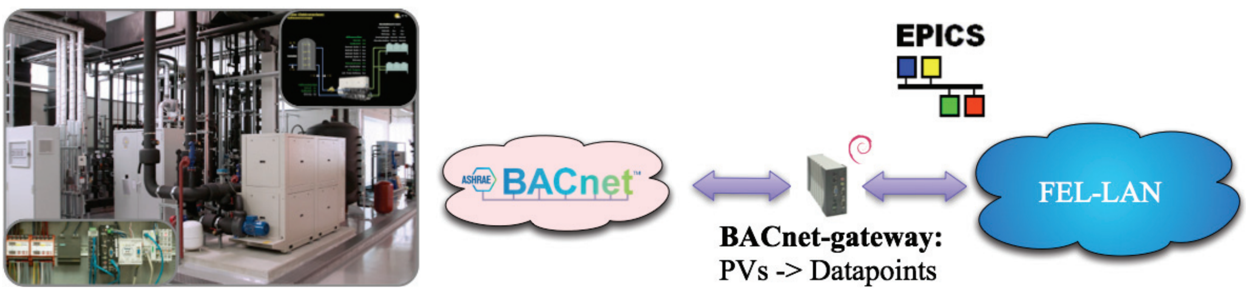

Figure 5: Integration into FM.

Integration into the Facility Management

To operate large-scale facilities for scientific research, integration of technical facility management data into their control systems has become mandatory. The use of detectors with highest sensitivity and resolution levels introduce a high influence of environmental factors. Room temperatures have to be held constant, and are continuously measured to allow reproducible experiment conditions. 24/7 operation of the facilities requires archiving technical infrastructure data – together with machine parameters and experimental data – for a scientifically correct off-line analysis and interpretation. Quality, temperature, and flow of cooling water have to be monitored permanently to guarantee a safe shutdown of sensitive equipment in case of problems. [4] [Fig. 5]

Cavity Stabilization

A feedback system was developed to stabilize the FEL cavity. A HeNe-laser interferometer (Agilent 10895A) is used for monitoring and stabilizing the resonator length. The interferometer beam is split in two beams (70 % and 30 %). The high-intensity beam passes through the FEL's 5.4-m-long cavity chamber, slightly angled with respect to the cavity axis, from one side of the cavity end mirror to the other side of the out-coupling mirror where it is reflected by a retroreflector. The low intensity beam is directed to another retroreflector located on the other side of the cavity end mirror. [5] Furthermore, five out-coupling mirrors with different out-coupling hole sizes from 0.75 to 3.5 mm are mounted on a precision in-vacuum translation stage allowing to choose the hole-size that is best suited for a given IR wavelength. The control runs on a VMEbus-based RTEMS-IOC with MVME3100. A MAXv motion system based software controls and stabilizes the relative distance between the two cavity mirrors using motorized micrometer drives on the translation. The roll and pitch of the mirrors can also be controlled by using in-vacuum pico motors [Fig. 6].

Figure 6: Cavity and undulator.

Isolated Networks

In order not to interfere with other (lightweight) network devices two isolated (by a router) networks are installed.

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One for the used GigE cameras ProSilica GC650 with jumbo frames enabled to support large image block transfers. Another one for the undulator control [Fig. 7].

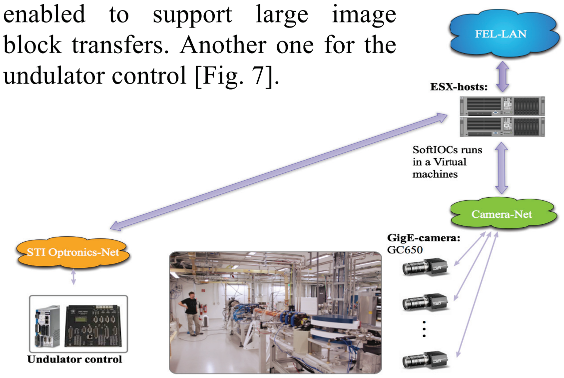

Figure 7: Isolated networks.

Safety-system

The correct steering of the electron beam all the way to the beam dump is continuously monitored. A Struck 3316 IP-connected 16 channel VME-bus digitizer is used to compare the signals from BPMs, current-transformer toroids, and the Faraday cup of the beam dump with expectation values. If the comparison fails, RF will be switched off. This interlock will prevent accidental electron loss anywhere between gun and dump.

IR-beam-diagnostic

The use of an Acton vacuum monochromator (VM-504, EPICS-control via SD3 SpectraDrive Controller) in conjunction with a Pyroelectric Linear Array (DIAS 128LT [6] [Fig. 8], connected to a PC104 based IOC) allows monitoring the wavelength.

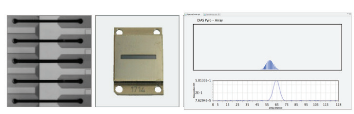

Figure 8: DIAS 128LT.

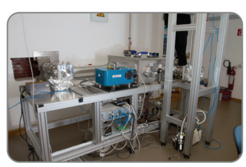

Figure 9: Setup.

Integration into the FHI Environment

Every user at the FHI should have the possibility to monitor the machine state of the FEL independent of the computer system and operating system used. To control the FEL an IP-network was implemented. This FEL-LAN is isolated from the standard FHI-LAN by a gateway system. Through the use of EPICS which is based on the channel-access protocol (CA) for communication all machine states (represented by so-called Process Variables (PVs)) can be monitored and controlled within the FEL-LAN by every connected system. The access from the FHI-LAN to the PVs is realized by a Channel-Access-Proxy running on the gateway system. The PVs can be accessed from almost any software (CSS, Matlab, LabVIEW, Perl-API, C-API, KouDA, Web-Browser,…). For easy use to the users predefined monitoring views are prepared. Some PVs must be writable for the FEL assigned experiment (e.g. SetWavelength, TuneCavity). This is achieved by adding a release tag (special PV) for each registered experiment. After setting up the FEL one of such a PV will be assigned by the operator. If the PV associated with the experiment is released the user can then direct the beam out of the diagnostic to his lab space with the help of motor-driven mirrors [Fig. 10].

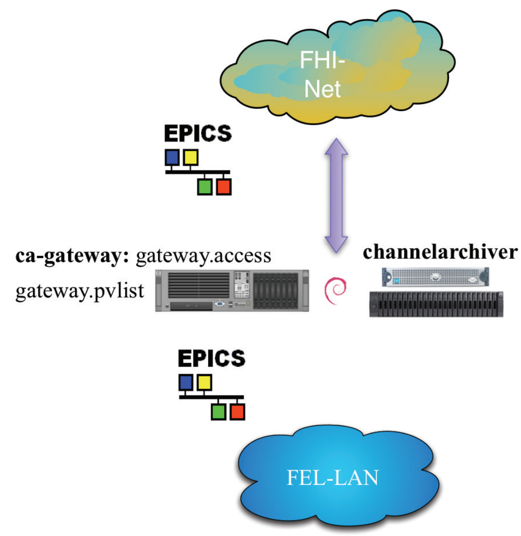

Figure 10: EPICS gateway.

Documentation

The Web application ELOG (written by Stefan Ritt at PSI) is used as electronic logbook at the FHI by different groups (mostly as group-shared logbooks). The ELOG has been extended by a low level postscript service to offer a platform independent input interface (we have learned from DESY E-logbook). [7][8] [Fig. 11]

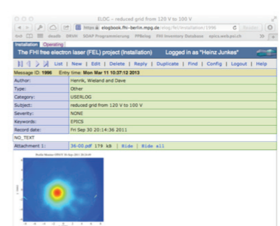

Figure 11: ELOG entry.

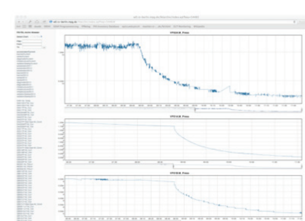

Figure 12: CGI example.

Channel Archiver

The EPICS channel archiver is a channel access client that automatically records PVs as a function of time and then stores them to disk. It can be configured to sample at a periodic rate or it can post channel access monitors onto PVs. The data can be viewed at a later date using several tools. In particular, a CGI web interface allows users from off-site to retrieve configuration and telemetry data from the time of their run. [Fig. 12]

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Future Experiment: Action Spectroscopy

The chemical physics department plans to set up a machine for vibrational spectroscopy of deposited metal clusters on flat ordered substrates, so-called model catalysts. Such deposited metal aggregates cannot be studied directly with IR absorption spectroscopy and therefore a method belonging to the class of action spectroscopies is employed. Here the clusters are decorated with weakly bound rare gas atoms and the system is irradiated with tunable IR-FEL light. Rare gas atoms desorb when the IR energy is in resonance with a vibrational state of the deposited aggregates. Thus, rare gas pressure maxima as measured with a QMS are indicative of vibrational. [9] [Fig. 13]

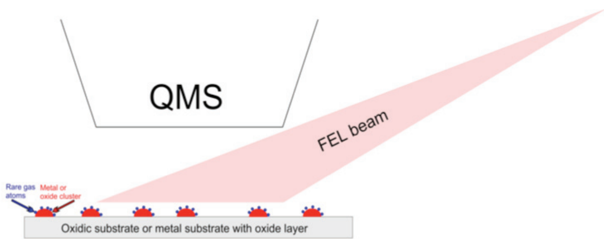

Figure 13: Action spectroscopy.

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