STATUS OF THE MLS CONTROL SYSTEM*

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Abstract

The Physikalisch-Technische Bundesanstalt (PTB), the German national metrology institute, has set up in close cooperation with BESSY a low-energy electron storage ring next to the BESSY II site. The new storage ring, named "Metrology Light Source" (MLS), is mainly dedicated to metrology and technological developments in the UV and VUV spectral range. Its commissioning started in March 2007. The MLS control system is based on the Experimental Physics and Industrial Control System (EPICS) toolkit. Design and implementation choices guided by the experiences with the BESSY II control system have been flanked by other techniques and new approaches where needed and appropriate. The presentation introduces the MLS and discusses design and implementation of its control system.

INTRODUCTION

For more than 25 years, the Physikalisch-Technische-Bundesanstalt (PTB) uses synchrotron radiation at the storage rings BESSY I and II for photon metrology in the spectral range of UV to X-rays. Since decommissioning of BESSY I (1999), there is a shortcoming in the spectral range of UV and EUV wavelength due to the higher electron energy of BESSY II. Thus, in 2003, the Metrology Light Source (MLS), was approved, a low energy electron storage ring as central instrument in the future Willy-Wien-Laboratory [1,2,3].

THE METROLOGY LIGHT SOURCE

The Willy-Wien-Laboratory is being built adjacent to the BESSY II facility (Figure 1 and 2). Construction started in fall 2004, the building was completed in summer 2006, commissioning started in spring 2007, and regular user operation is scheduled to begin in January 2008. The MLS storage ring design, construction and operation are realized by BESSY [3,4], based on the PTB requirements for a permanent accessible radiometry source, optimized for the spectral range between UV and VUV.

Figure 1: The Metrology Light Source (MLS) in the close vicinity of BESSY II in Berlin-Adlershof.

The electron energy can be tuned in the range from 200 MeV to 600 MeV (equivalent to a characteristic photon energy from 11.6 eV to 314 eV). The MLS is designed for electron beam currents between a single electron (1 pA) up to 200 mA, a 100 MeV racetrack microtron is used as injector. The MLS has a circumference of 48 m and is designed as an asymmetric double-bend achromate with twofold symmetry. Figure 3 shows the storage ring layout, the main parameters of the MLS are listed in Table 1.

Table 1: Main Parameters of the Metrology Light Source

Lattice structure	Double-bend achromat
Circumference	48 m
Length of straight sections	2 x 6 m, 2 x 2.25 m
Injector	100 MeV racetrack microtron
Electron beam current	1 pA to 200 mA (1 to 2 x 10^{11} electrons)
Electron energy	200 MeV to 600 MeV
Injection energy	100 MeV
Max. field of bending magnet	1.3 T
Characteristic photon energy	12 eV to 314 eV
Natural emittance (600 MeV)	100 nm rad
Source size (1σ at 600 MeV)	250 µm (h) x 200 µm (v)
Budget	10 Mio. €

The radiation from four bending magnets, each of which can be equipped with two front-end systems, and from one undulator will be used. Seven stations will be

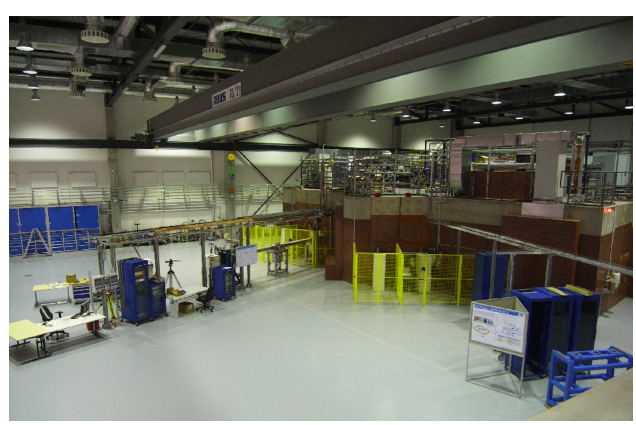

Figure 2: Experimental Hall with the Synchrotron Bunker in the Background

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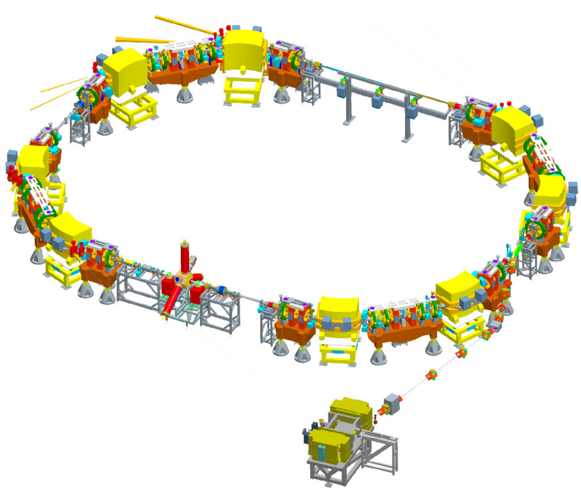

Figure 3: Layout of the MLS

set up on the experimental floor for the coverage of the UV up to the EUV spectral range, and on the top of the storage ring bunker roof, an FIR/THz and two IR stations are planned.

CONCEPT AND SYSTEM DESIGN

A tight budget and the use of synergetic effects based on a shared use of hard- and software between the MLS and the BESSY II control systems were part of the MLS design from the very beginning. This created a number of requirements for the control system design, including:

- One main control room
- Reuse of BESSY II hard- and software solutions wherever possible
- Common spare parts and maintenance equipment

There was only a minimal amount of additional manpower provided as part of the contract between BESSY and PTB – the MLS control system had to be mostly developed and implemented "on the side" by the BESSY controls group. The resulting concept is very similar to the BESSY II control system, with a small number of improvements in different parts. The system is based on the Experimental Physics and Industrial Control System (EPICS) toolkit and architecture.

SUPPORTING EXTERNAL VENDORS

The 100 MeV racetrack microtron has been developed, constructed, and commissioned off-site as a turn-key solution by an external vendor, Danfysik.

To facilitate the use of BESSY power supplies for the microtron magnets, and to allow for an efficient, smooth commissioning phase, BESSY was providing all power supplies and the complete control system for the microtron, which were shipped to Denmark and set up at the Danfysik site.

To allow remote help and maintenance, a complete EPICS control system development and operation environment was installed in a virtual machine (virtualization software by VMware) running Linux. During the microtron's construction and commissioning, remote access was used to extend and maintain its control system as needed. Using this approach, the microtron was commissioned and tested with the original MLS control system and power supply hard- and software. Setting up the microtron and its controls after shipping everything to the MLS site went smooth, easy and fast, even though the MLS controls infrastructure was not even present, when the microtron arrived.

HARDWARE

High Level

Operator consoles and servers are running under Linux (Debian GNU/Linux distribution) on mostly rack-mounted PC-hardware, Motorola VME computers based on Power-PC processors running under VxWorks in Wiener full-size VME crates with 3x7 slot backplanes are used as front-end Input/Output Controllers (IOCs). The connecting network is based on TCP/IP on 100 MBit/s ethernet using twisted pair cabling, with the exceptions of 1 GBit/s being used within switches and for central servers, and fibre-optics cable connecting the MLS system to the BESSY II network infrastructure.

Low Level

Front-end controls are similar to the BESSY II system: power supplies are interfaced through 24bit-resolution highly stabilized converter cards, which are connected to the IOCs using a subset of the CANopen protocol on CAN field bus lines. PLCs are also connected using the same CAN field bus connection, intelligent scopes are interfaced through VXI-11, signal generators and similar equipment use a GPIB connection to an Agilent Ethernet-GPIB-converter, which is also accessed through VXI-11.

The beam position monitor system is a full copy of the existing BESSY II system [5,6]: in-house developed pick-ups and front-end signal processing units are connected to A/D-converter boards placed in VME crates, where VME computers provide the interface to the EPICS control system.

The vacuum system is controlled using an EPICS enabled ion pump power distribution and vacuum measurement logarithmic converter device (microIOC LOCO by cosylab).

SOFTWARE

Similar to the control system hardware, the software and user interfaces have been implemented based on copying the existing BESSY II system, while trying to fix shortcomings that have been realized, but cannot easily be fixed for a large existing system.

Signal and Device Names

The device naming convention scheme used for BESSY II has been extended by a signal naming convention. These rules enforce – in a similar fashion – the creation of obvious and browsable signal names.

High Level Applications

The MLS control system interface uses the BESSY II TCL/TK based program and panel launcher.

Standard device control is implemented using the edm display manager. Most of the operator panels are based on generic device-dependent panels, some panels are entirely software generated, and some are manually edited.

Orbit feedback and control as well as other high level physics applications use the BESSY II approach and software, some of which has been adapted to the Linux OS.

Archiving, snapshot save and restore, alarm handling and event logging are implemented using standard tools widely spread in the EPICS community: the Channel Access Archiver, the backup and restore tool BURT (with a TCL/TK-based graphical user interface developed for BESSY II), the ALH alarm handler and the CMLOG logging system.

Low Level Applications

All VME-based IOCs are running a recent EPICS 3.14 release under VxWorks. The necessary subset of the locally developed device and driver supports has been converted to EPICS 3.14, necessary changes for the PPC processor architecture had already been applied when these processors were introduced at BESSY II.

Soft IOCs (EPICS 3.14 front-end controllers running as a single process on a Linux server) have been introduced and immediately evolved into an important part of the MLS control system. All VXI-11 based databases, as well as the major part of high level device control (e.g. power supply groups, virtual devices that map onto a set of real devices) have been moved to soft IOCs, which outnumbered their VME counterparts only weeks after commissioning began.

Application Development Environment

The IOC application development environment has been modified from the version used at BESSY II to adapt to EPICS 3.14 and changes in development tools: vdct has been established for graphical database creation and configuration, configuration management with a generic RDB data-model has been introduced [7].

Revision Control

CVS, the revision control system of BESSY II, has been replaced by darcs. Darcs is a distributed, interactive revision control and code management system by David Roundy. It is based on a formalism for manipulating changes, which makes it change-based rather than history-based – the most important difference from traditional systems, such as CVS. After an initial orientation phase, darcs has been proven to be a reliable and convenient tool, which is very well suited for development in parallel branches – something that is gaining importance at BESSY, with the parallel developments of the BESSY II and MLS control systems.

Application and Configuration Deployment

A new approach has been taken for the deployment of control system applications and configurations from the development area to the production system. The existing deployment system at BESSY II supports versioning in a simple way: A new version is tagged and installed (using the rdist tool) into a separate directory named after the tag. All subsequent push operations using the same version tag overwrite the target files. For the MLS system, a new mechanism has been developed, based on the rsync tool: Each push operation creates its own unique tag (based on date and time) and installs into a separate target directory, but only files that differ are physically copied to the target – unchanged files (the vast majority in a usual push operation) are hard linked to the previous version on the target system. That way, the target contains a full copy of the installation area for every push operation, while each of the versions only uses disk space for the changed files. By setting a single soft link, any single IOC can be rolled back to any version that was ever installed on the production system.

CONCLUSIONS

Setting up a control system for a small, but nevertheless complete new storage ring facility is a task that needs an ever underestimated amount of effort and time.

Starting with the experiences gained by running a large similar system for several years, and re-using many parts and concepts of that system create an interesting and fascinating situation. All the parts are known, all the shortcomings and deficiencies are known, and finally there is a chance to "do it right this time": straighten out the flaws, replace some less optimal parts, fix things that are too late to fix for the old system, keep all the good stuff, and try a few, selected new tools and concepts.

Some of the successful new developments and ideas for the MLS control system have already been applied to the BESSY II system (revision control, deployment, soft IOCs) – the new project was a perfect test environment.

The MLS control system was successfully built using a slim, efficient, straightforward, and functional design and implementation. Not only MLS, but also BESSY II will greatly benefit from these developments.

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