

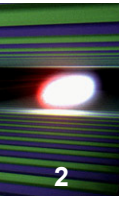
Experience Gained During the Commissioning of the Undulator Control System at the European XFEL

PCaPAC 2016, Campinas, Brazil, 28.10.2016

Suren Karabekyan

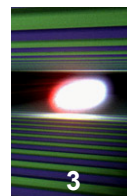
on behalf of the undulator control systems group

The European X-Ray Free Electron Laser

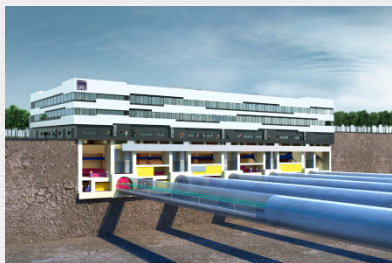


- European XFEL facility overview
 - Undulator system
- Commissioning of the hardware
 - Undulator system test setup
 - Control components for undulator cell
- Software for commissioning of the undulator systems
 - Image deployment automation
 - Undulator system tester

Facility overview



Schenefeld



- Experiment hall
- Laboratories
- Offices

Osdorfer Born

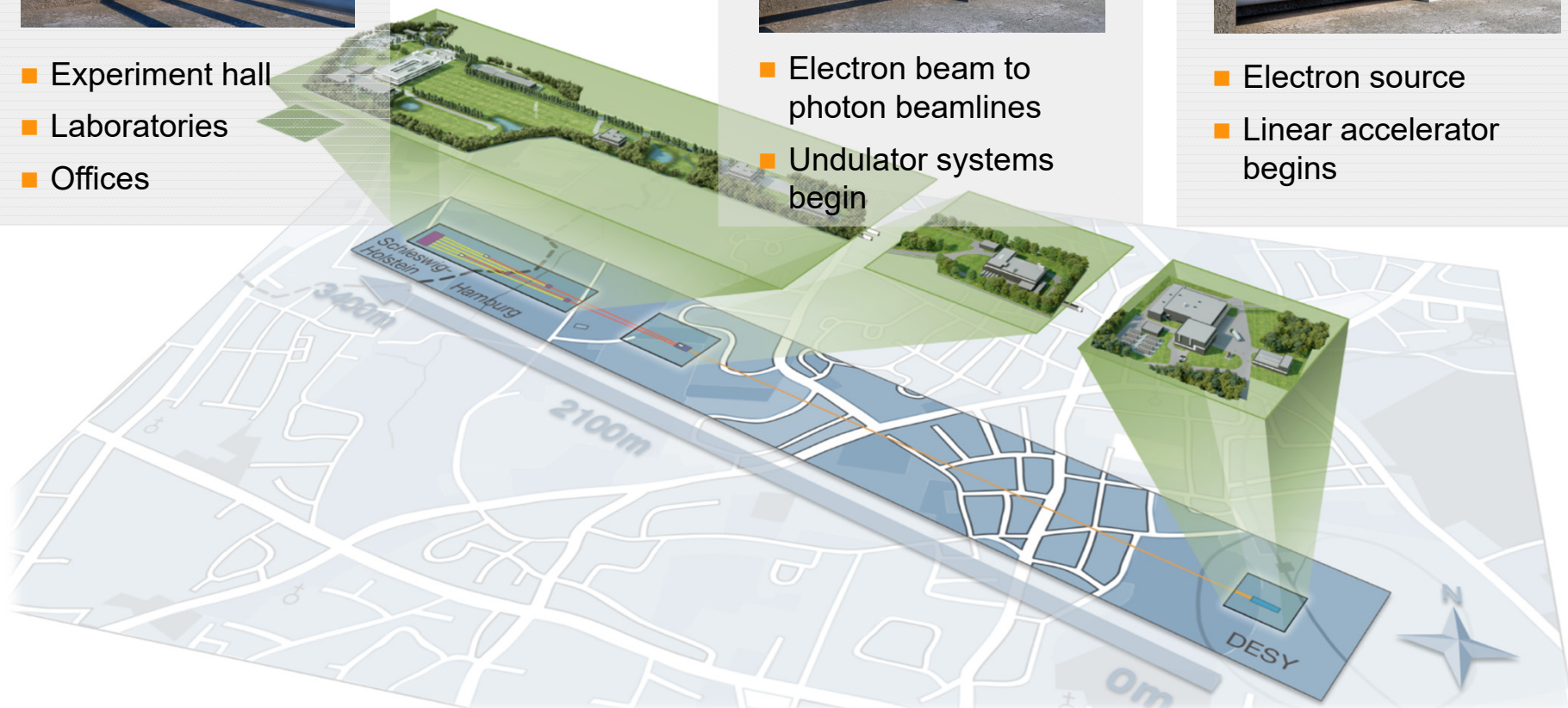


- Electron beam to photon beamlines
- Undulator systems begin

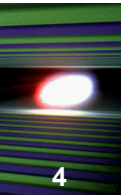
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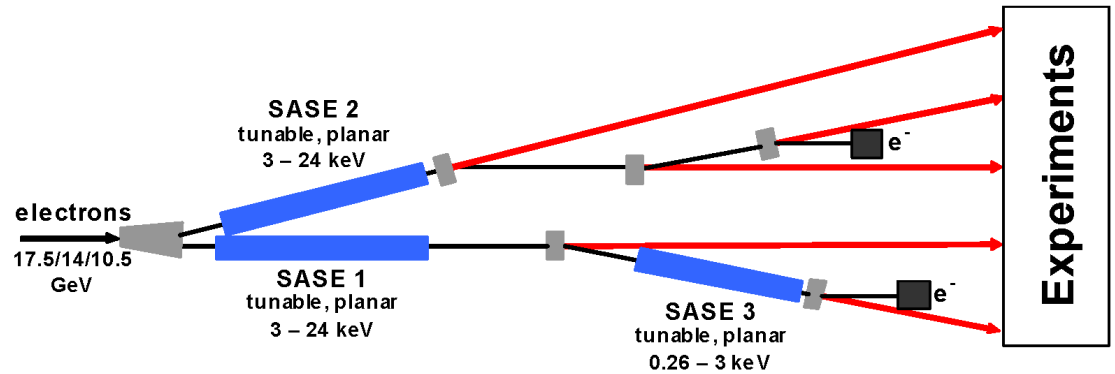
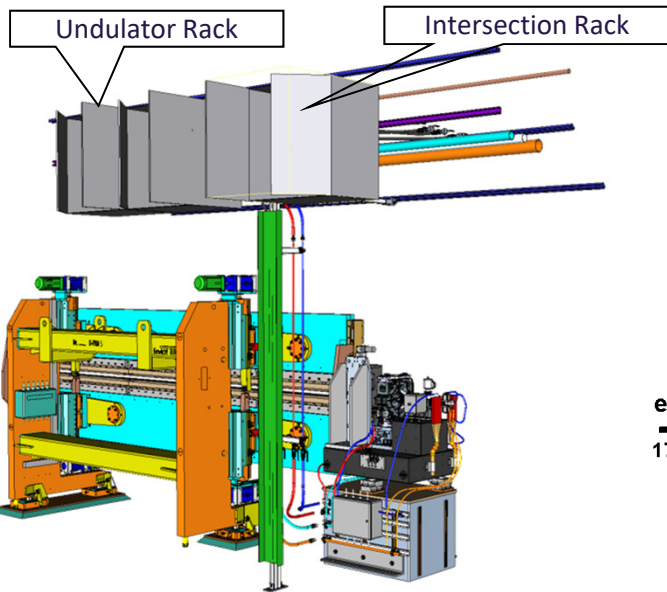
- Electron source
- Linear accelerator begins



Undulator Systems



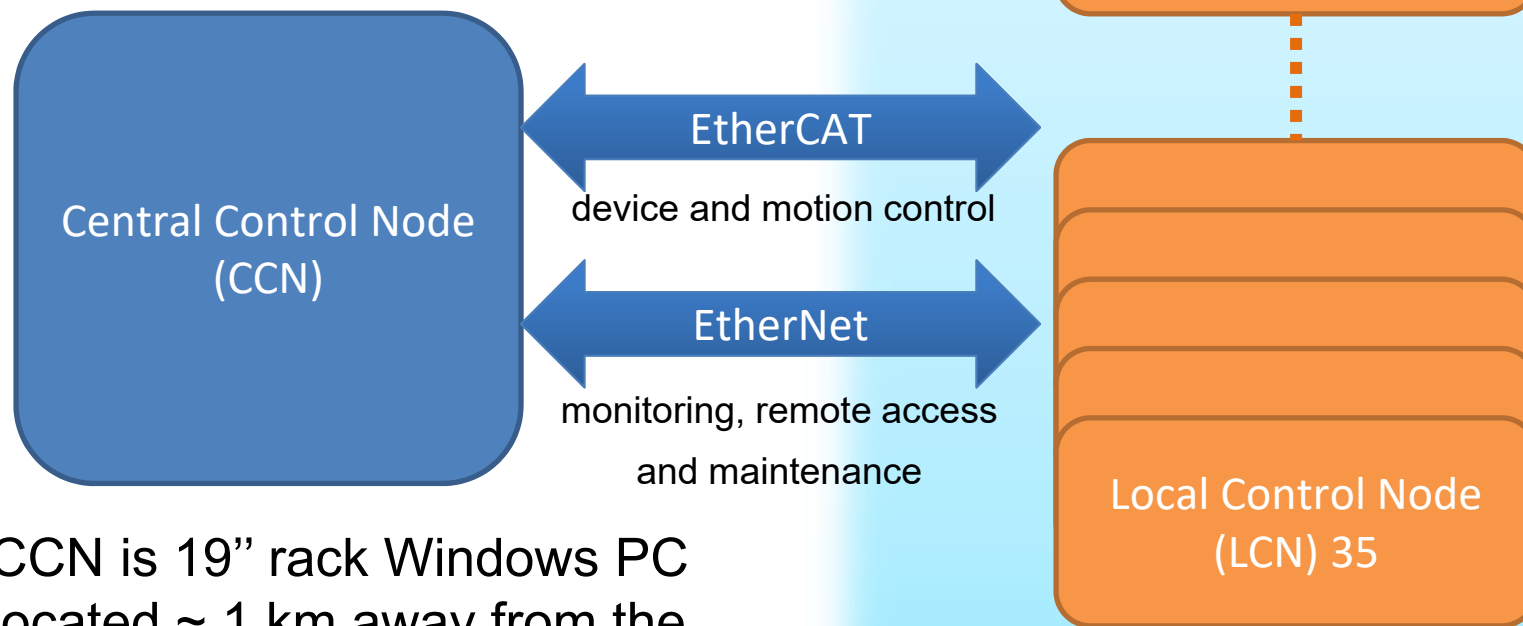
- Three undulator systems - SASE 1, SASE 2 and SASE 3 - will be used to produce photon beams.
- In total 91 undulators have been produced and commissioned.



Undulator cell

Undulator Control System

- The undulator control system is based on industrial components produced by Beckhoff company and a PLC implemented in the TwinCAT system.

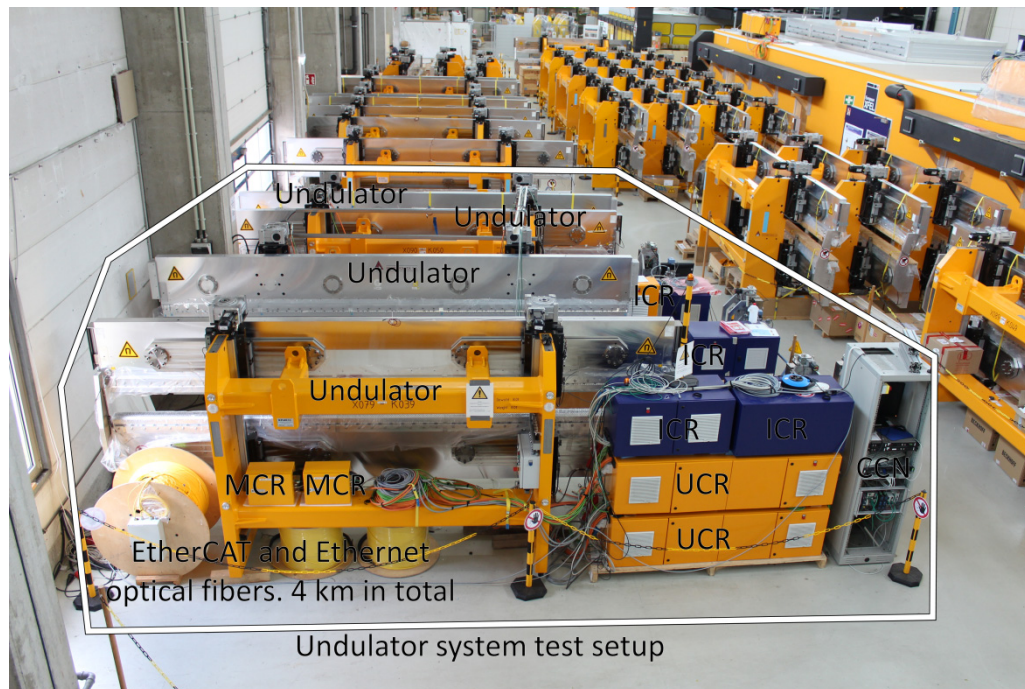


- CCN is 19" rack Windows PC located ~ 1 km away from the undulator system

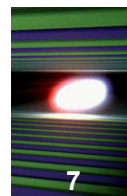
- LCN is Beckhoff industrial Windows PC

Undulator system test setup

- The system is controlled by a central control node (CCN), which is located about 1 km away from the undulator system
- CCN communicates with the undulator cells over optical fibers
- Media converter racks are used to convert signals from copper carriers to optical fiber carriers and vice versa
- It was obvious that all the envisaged components were to be tested before installation in the tunnel.
- An undulator system test setup with 4 cells was built in the undulator hall
- It was used for developing the global control system software three years ahead of the installation of the system in the tunnel.



Control components for undulator cell

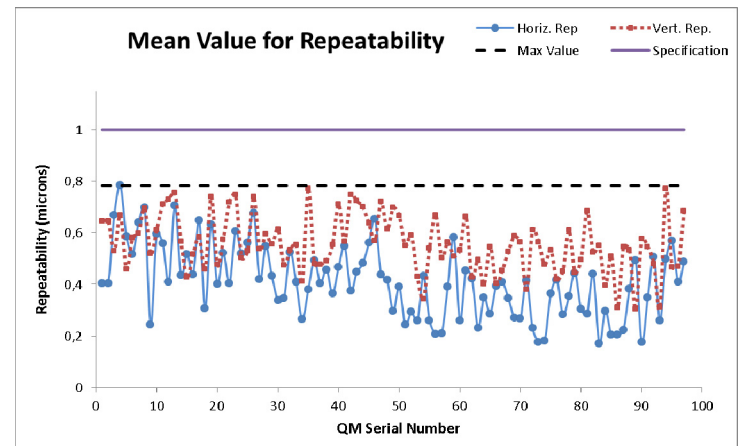


- For the magnetic commissioning of the undulator it was necessary to bring it into the magnetic measurement hutch.
- Control of all undulators introduced to the hutch can be carried out using the same rack
- It was decided to commission the undulator with the assigned control rack.
- During this commissioning, a complete set of tests was carried out.
- The hardware related errors was about 5% of the system

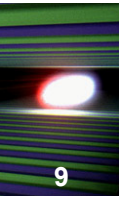


Intersection Control Components

- The intersection control components are the hardware installed on the Quadrupole Mover, Phase Shifter and Intersection Control Rack
- 6 companies were producing the intersection components
- All necessary hardware for the factory acceptance tests (FAT) have been provided by European XFEL
- After delivery of all components to European XFEL, site acceptance tests were arranged.
- If any of the components didn't match the specifications, this component was sent back to the manufacturer
- Our experience has demonstrated that after the SAT only 1% of the delivered QMs and PSs needed to be returned.
- Approximately the same failure rate has been observed for ICRs

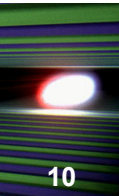


Software for commissioning of an undulator system



- A specific feature of undulator systems for free-electron lasers is the large number of recurring elements.
- The software running on each LCN must be identical, although each cell component has its individual settings
- The other aspect is the need to have possibilities to update the version of the TwinCAT software as well as specific firmware.
- These arguments lead to the decision to develop software which will automate this process

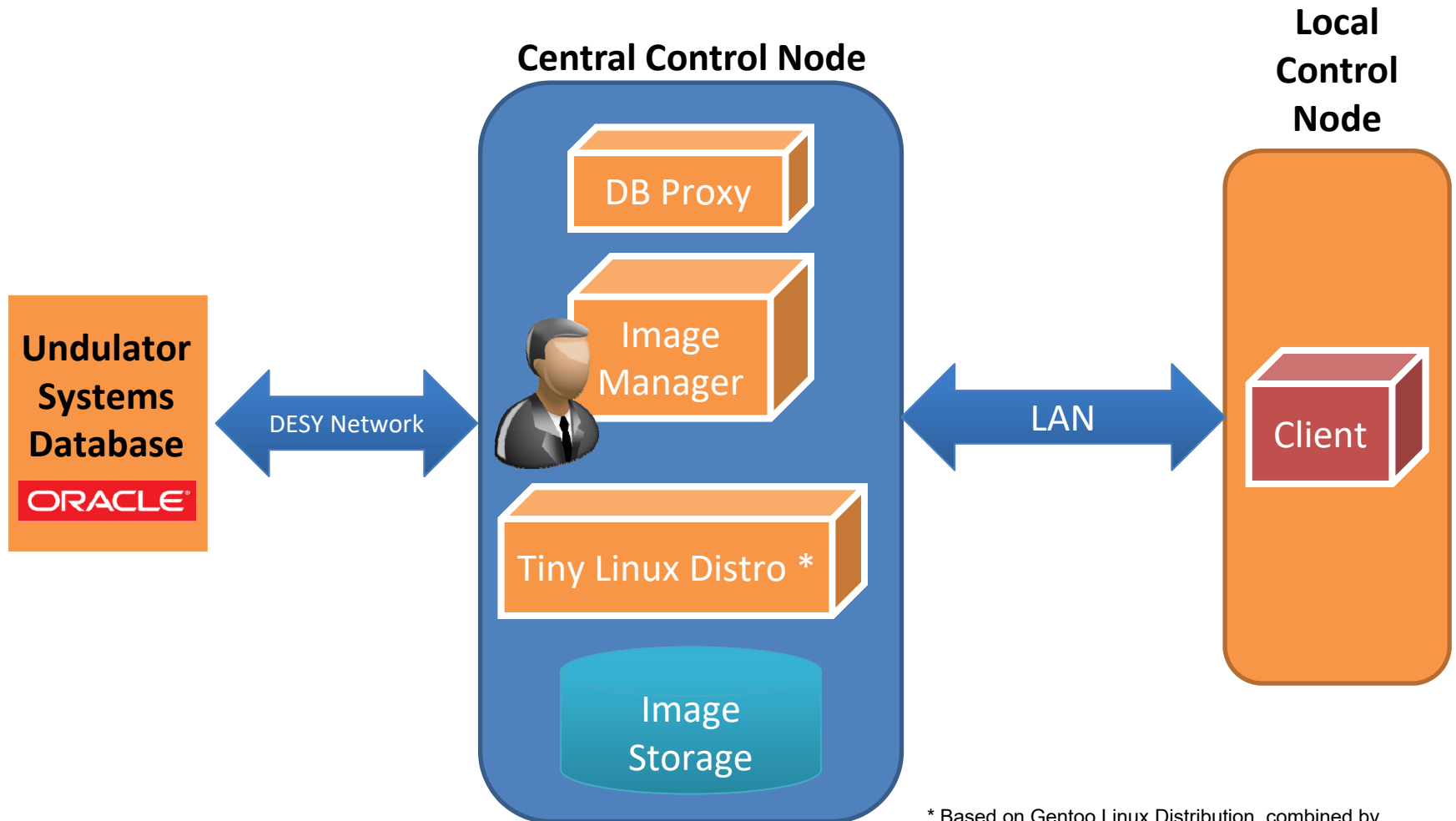
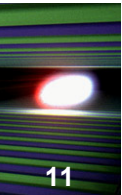
Software for setting up, configuration, and maintenance of an undulator system



Motivation

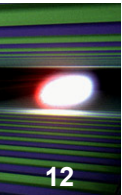
- Minimize the time used to set up, configure and maintain undulator systems;
- Interlink the configuration to the Undulator Systems Database (USD);
- Provide possibility to create a master image and follow the version numbering of the images;
- Distribute the master image to the LCNs;
- Provide capability to quickly update Beckhoff TwinCAT, whenever an update is released
- Eliminate errors arising from manual work.

Image Deployment Automation (IDA) Operation Principals

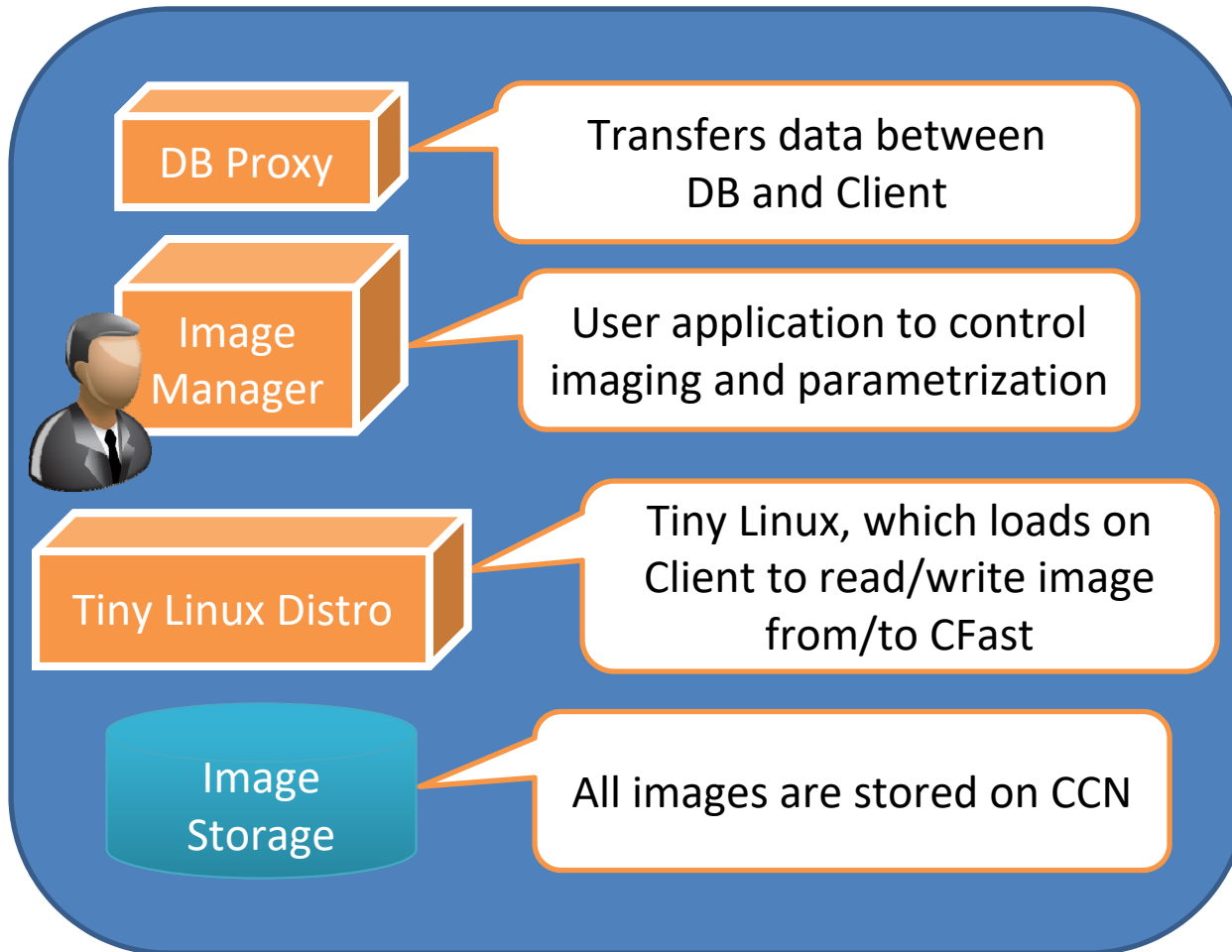


* Based on Gentoo Linux Distribution, combined by Martin L. Porschke, Brookhaven National Laboratory

Image Deployment Automation Components



Central Control Node



Local Control Node

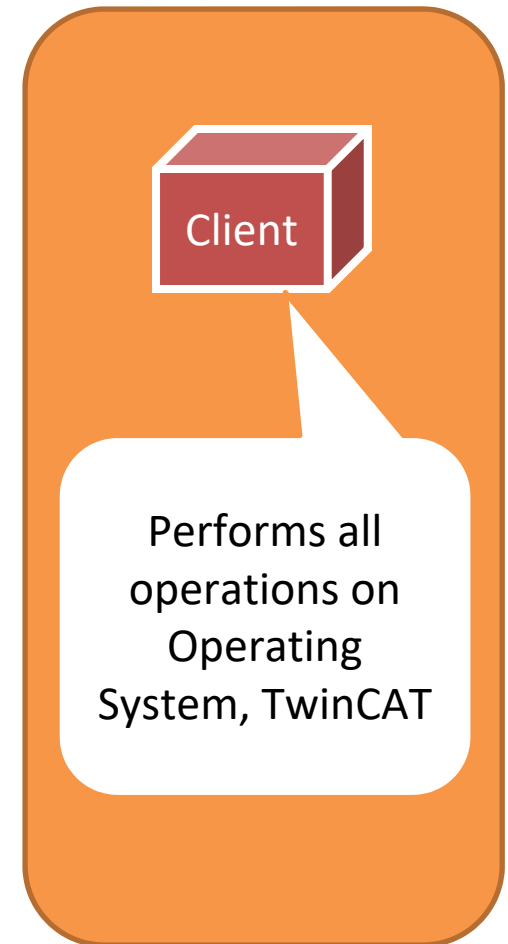


Image Deployment Automation Update Image

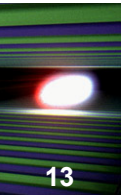


Image Manager --- version: 2.0.2.175

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<input type="checkbox"/> 5	10.10.1.5	000105116466		✓	✗		07-Oct-15 10:25:30 AM
<input checked="" type="checkbox"/> 6	10.10.1.6	0001050DEC44		✓	✗		07-Oct-15 10:27:16 AM
<input type="checkbox"/> 7	10.10.1.7	N/A		✓	✗		23-Sep-15 5:09:26 PM
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Operations

Update Params | Update Image | Refresh Versions | Refresh Status | Refresh Ping | Make Master | Filter

Image Deployment Automation

Update Image

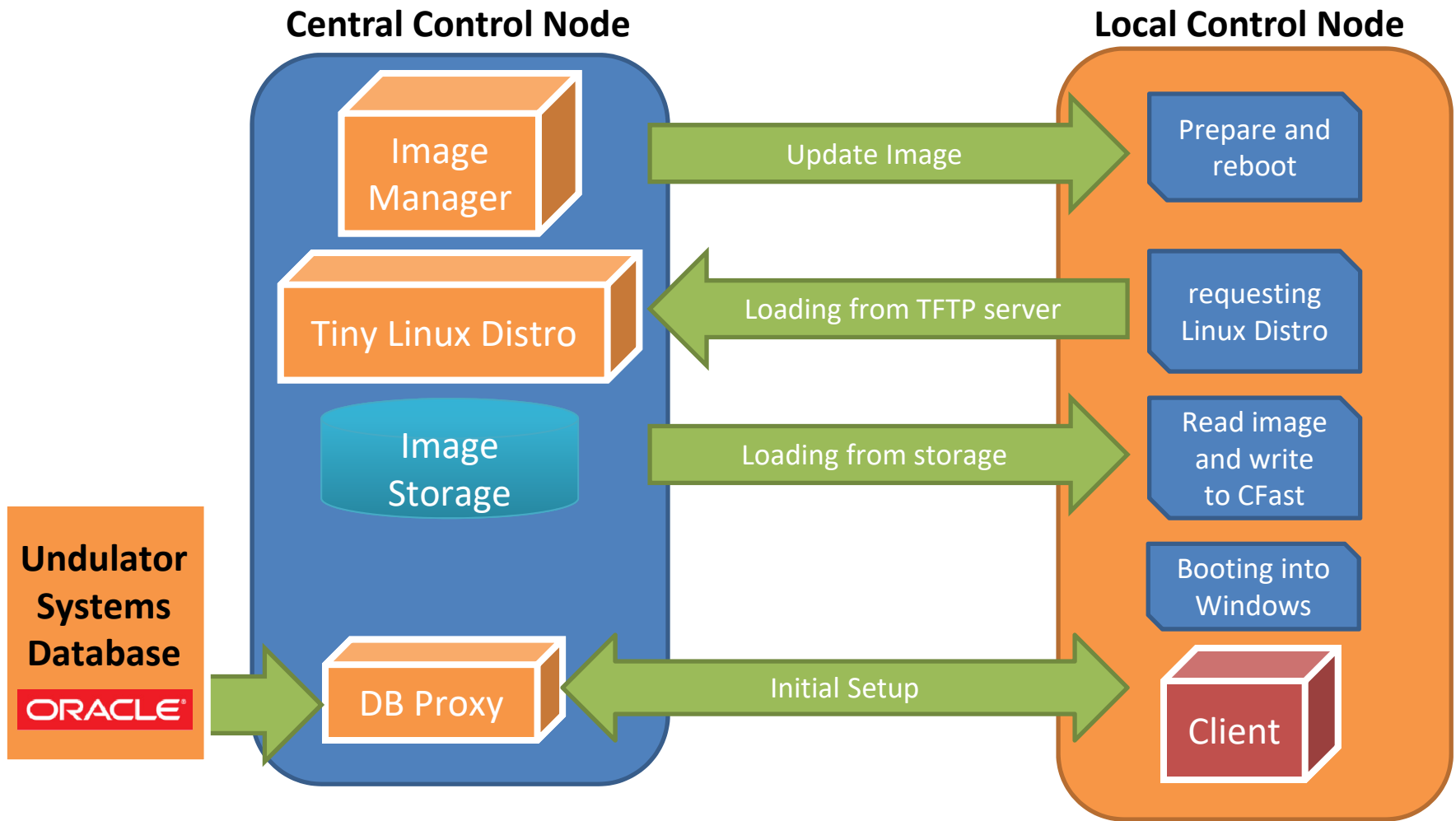
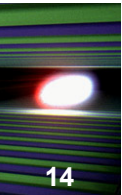


Image Deployment Automation Update Parameters

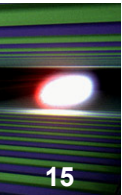


Image Manager --- version: 2.0.2.175

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Operations

Update Params Update Image Refresh Versions Refresh Status Refresh Ping Make Master Filter

Image Deployment Automation Update Parameters

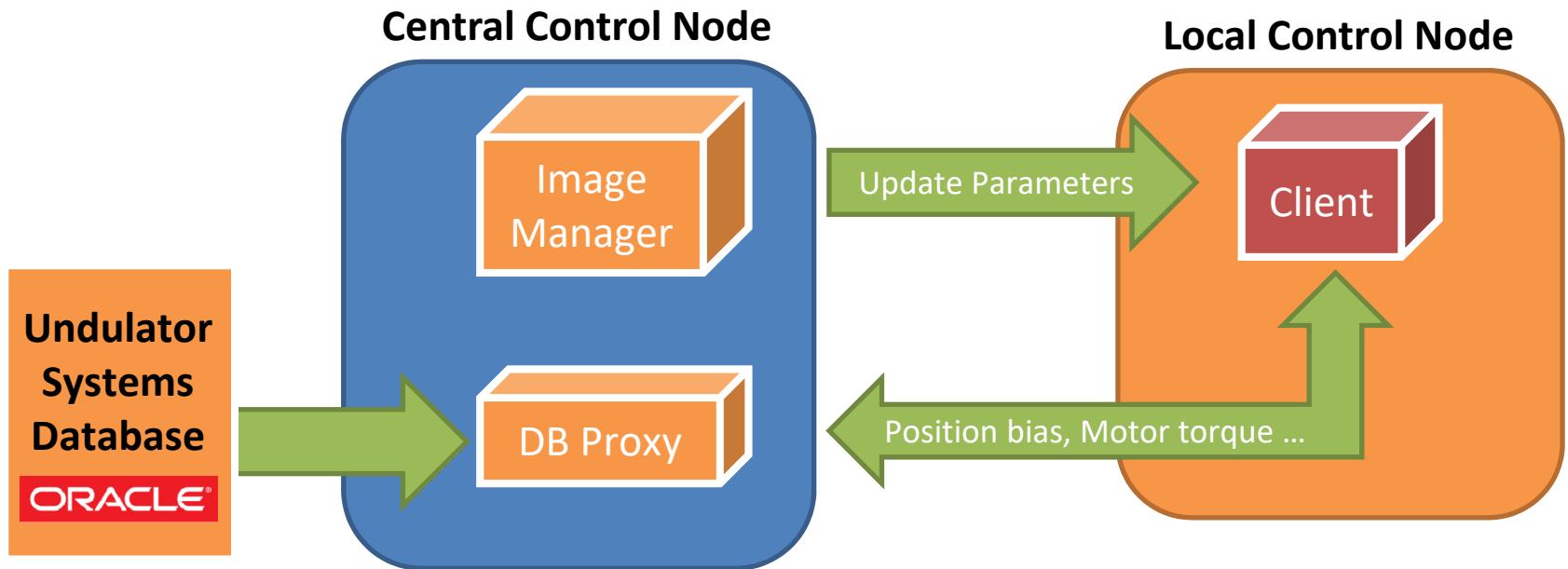
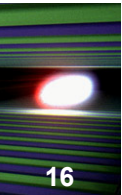


Image Deployment Automation

Make Master Image

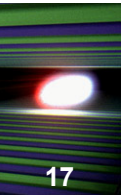


Image Manager --- version: 2.0.2.175

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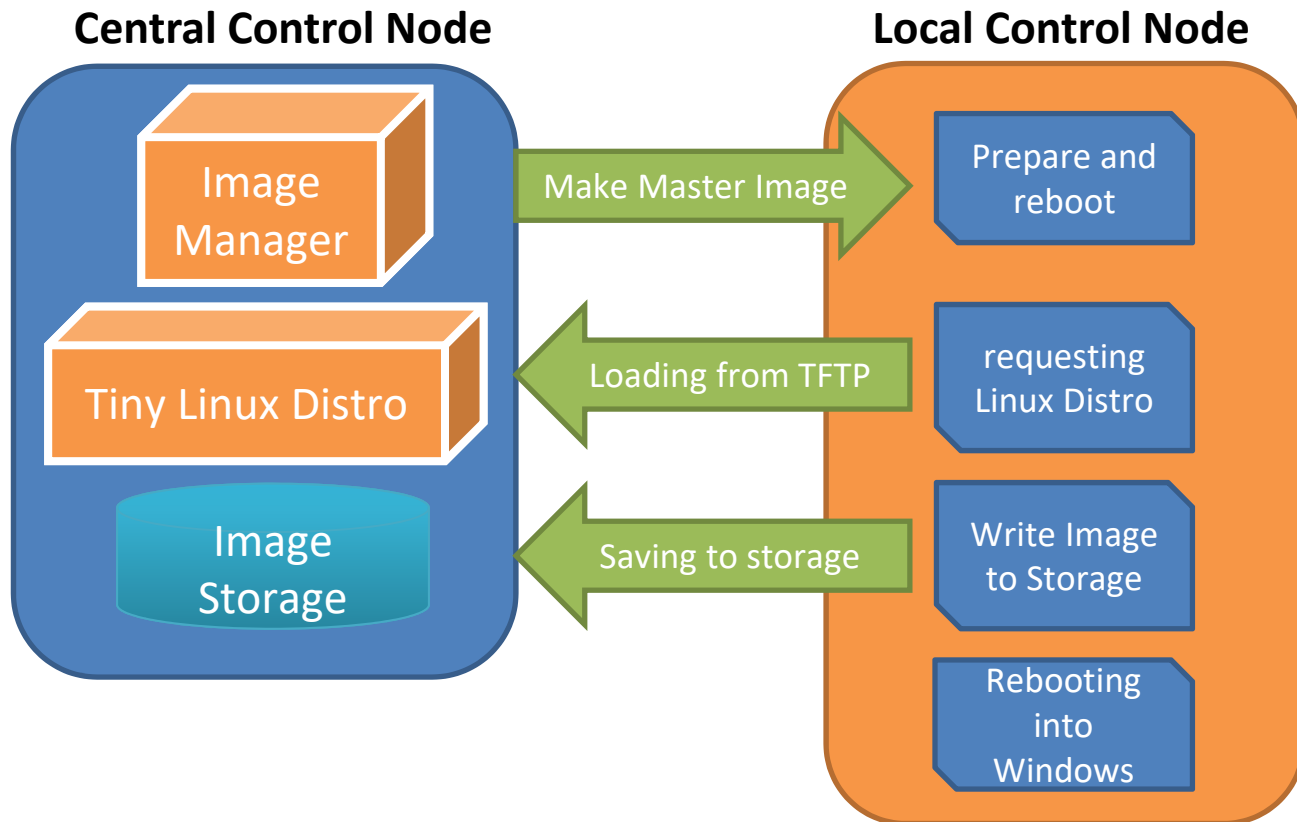
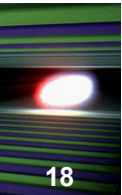
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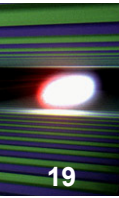
Operations

Update Params Update Image Refresh Versions Refresh Status Refresh Ping Make Master Filter

Image Deployment Automation

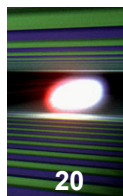
Make Master Image





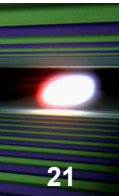
- The next step after putting the undulator system into operation is the commissioning of all control components that belong to it
- This task could be time consuming because several hundred values per system must be examined.
- This was a motivation to create a supervisory control and data acquisition (SCADA) program.
- This program is running on the CCN and is sending commands to the LCNs.
- After the execution of the commands, the program receives a feedback value.
- If the value is inside of an expected range, then the test is accepted; otherwise the test is marked as not successful.

Undulator System Tester

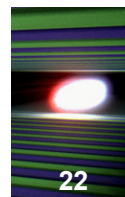


20

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- The selected strategy - to test each piece of hardware before installation in the tunnel - fully justified itself
- The hardware related problems, 5% of the undulator components and 1% of the intersection components, have been found and fixed in ~ 3 years during the magnetic adjustment of the undulators.
- Thank to the developed software, after the assembly of SASE 1 and SASE 3 - in the tunnel, the full process of commissioning takes approximately one week per system.
- The time mainly was spend to fix the problems with the newly installed hardware.



Thank you for your
attention!