The Integrated Control System and Scientific IT of ELI-ALPS

Workshop on Large Scale Tomography

26th January, Szeged

Lajos Fülöp

SZÉCHENYI 2020

HUNGARIAN GOVERNMENT

European Union
European Regional Development Fund

INVESTING IN YOUR FUTURE

Agenda

- Control System: TANGO
  - prototypes and designs
- Scientific IT and ELITrans

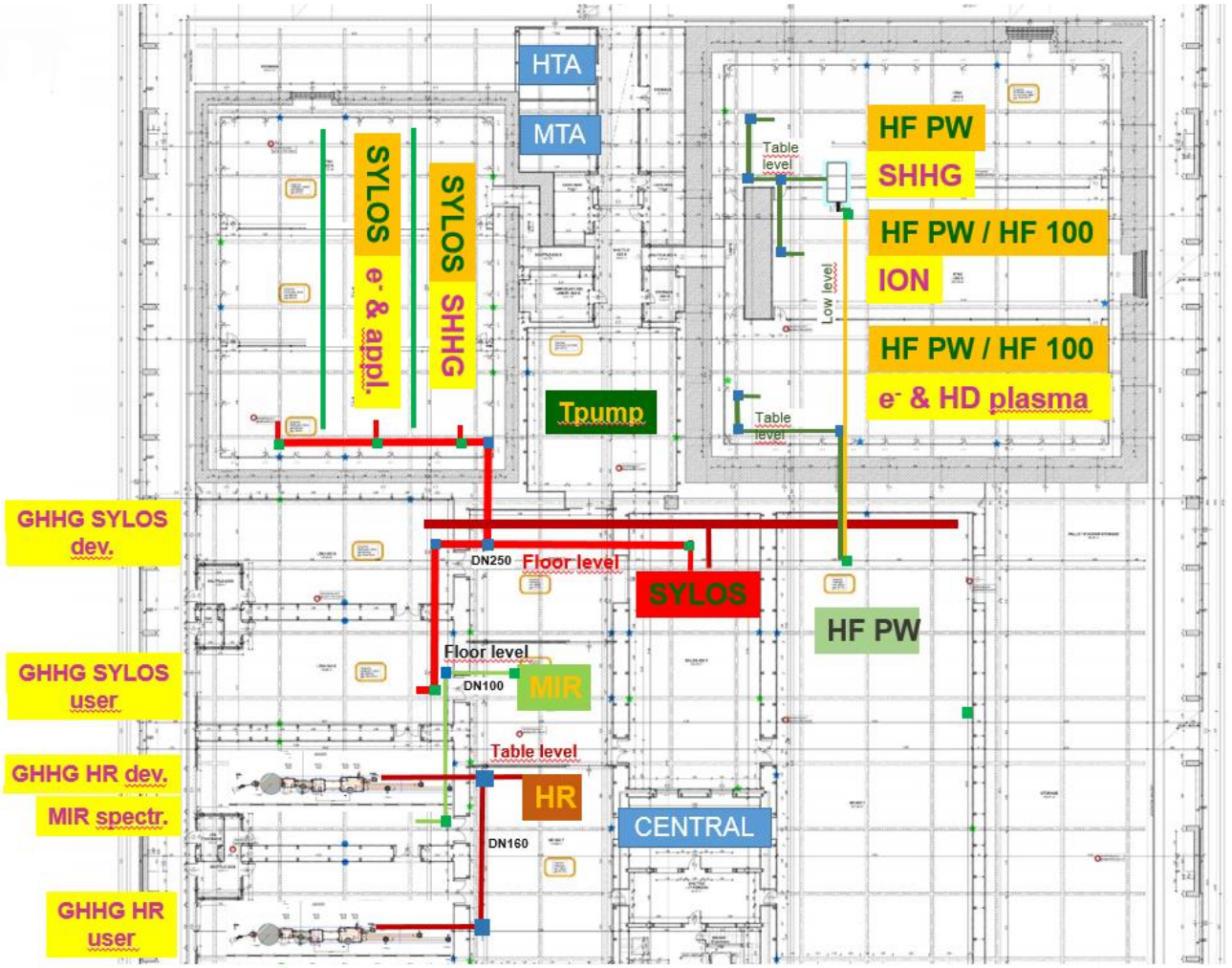
Control System:
TANGO, designs, prototypes

Buildings

Building A hosts lasers, secondary sources, experiments (data sources)

Building B hosts data centre, HPC cluster (among others, labs, offices, etc.)

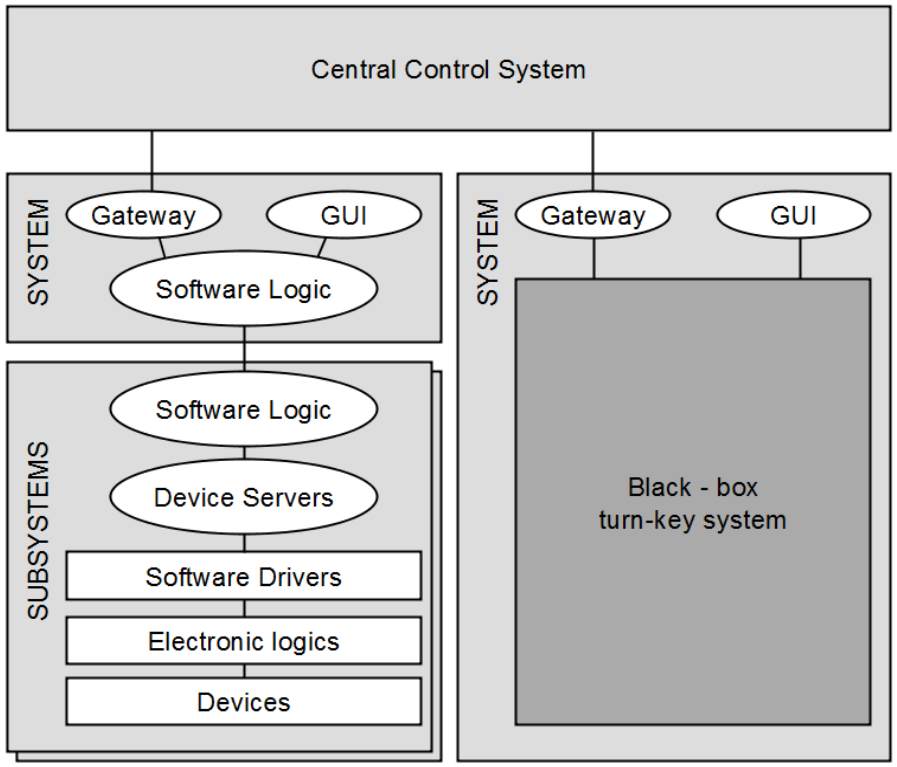
Building A – layout



Data Centre in Building B

Planned layout of laser sources (boxes in the middle), beam transport (lines connecting lasers to secondary sources), secondary sources (yellow boxes in the left and the top) and control rooms (blue boxes)

Schema



TANGO-based (transparent)

Beam Transport
Secondary Sources

Other (black-box)

Secondary Sources
Laser Sources
Building

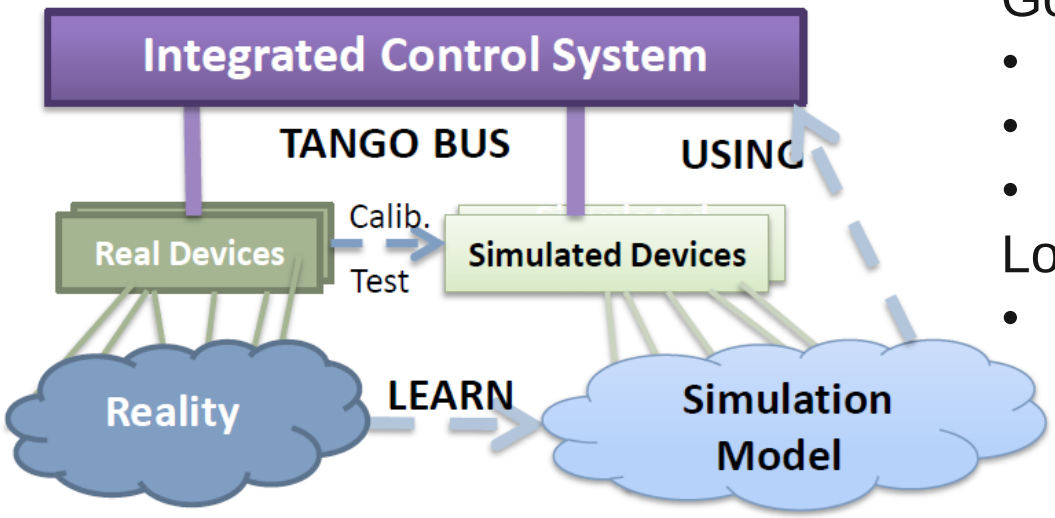
TANGO Community

- 15 (25) years old
- Synchrotrons
  - ESRF, ALBA, ELETTRA, DESY, MAX-IV, SOLEIL, SOLARIS, ANKA, …
- Laser sites
  - APOLLON, LMJ, ELI-Beamlines, ELI-NP, FERMI
- Companies
  - Thales: 10PW ELI-NP laser with TANGO
  - CosyLab, Nexeya, Observatory Sciences, …
- TANGO lectures at University of Szeged since 2014

Simulation

"The use of simulation systems to test configurations and applications early has enabled more mature applications to be available before first commissioning with real hardware. As a result the commissioning of the Diamond Control System went very smoothly with a high level of functionality available for day one commissioning with beam.„

Heron et al.: THE DIAMOND LIGHT SOURCE CONTROL SYSTEM 10th European Particle Accelerator Conference, 2006



Goals:

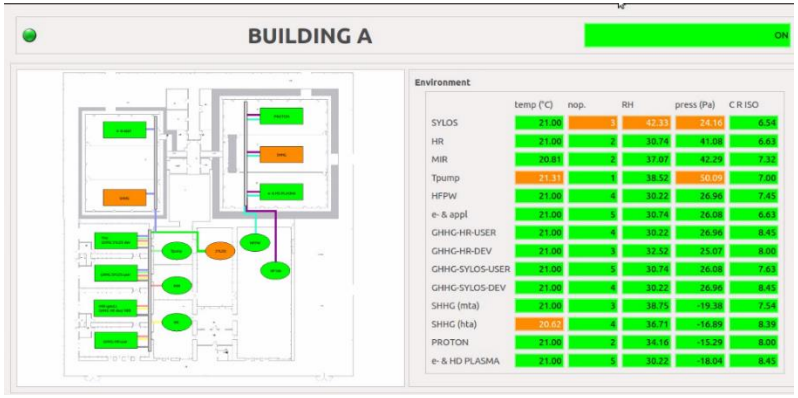
- Prototyping, proof of concept
- Device naming convention
- Gain experiences

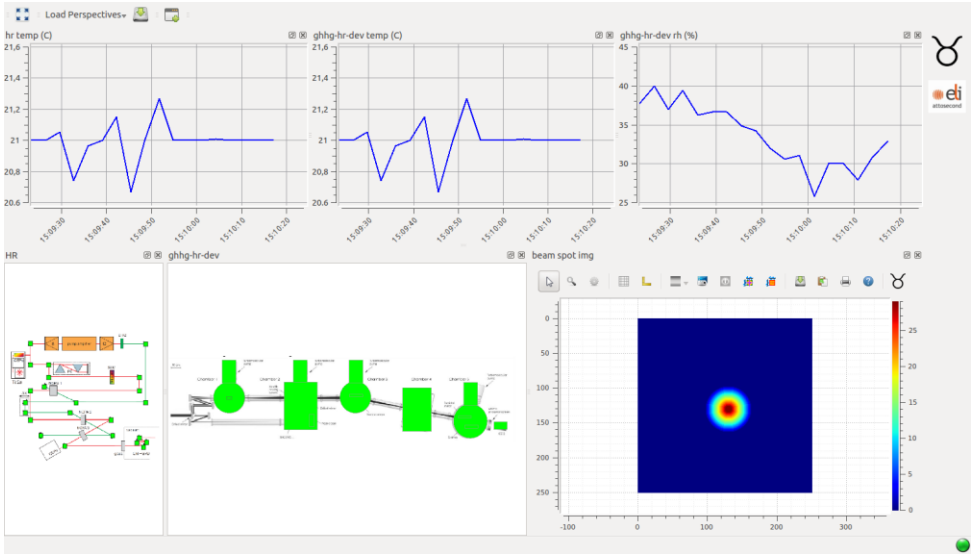
Long term:

- Prediction of events?

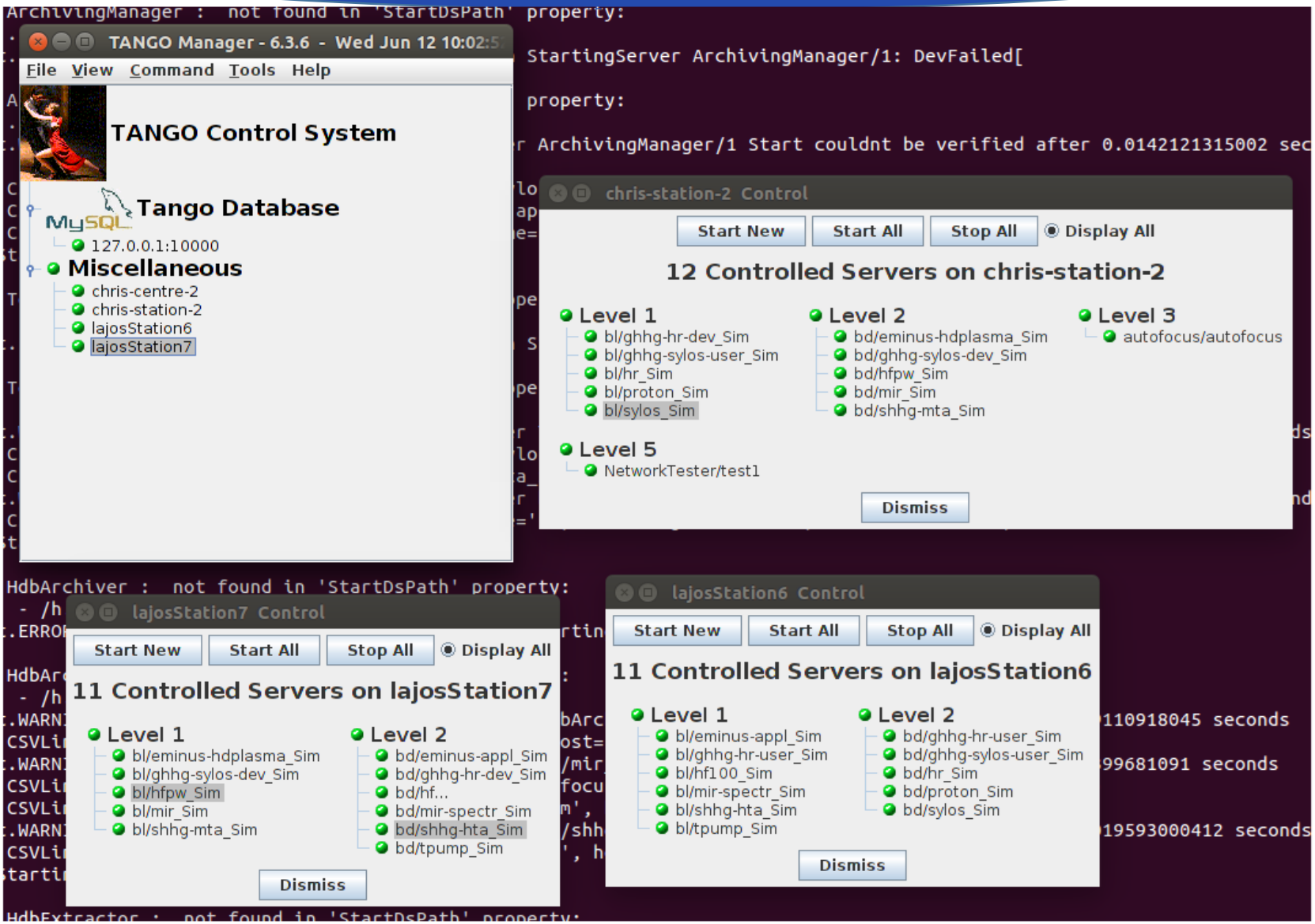
Prototype based on CDRs:

5 lasers, 10 secondaries, 700 sim. devices

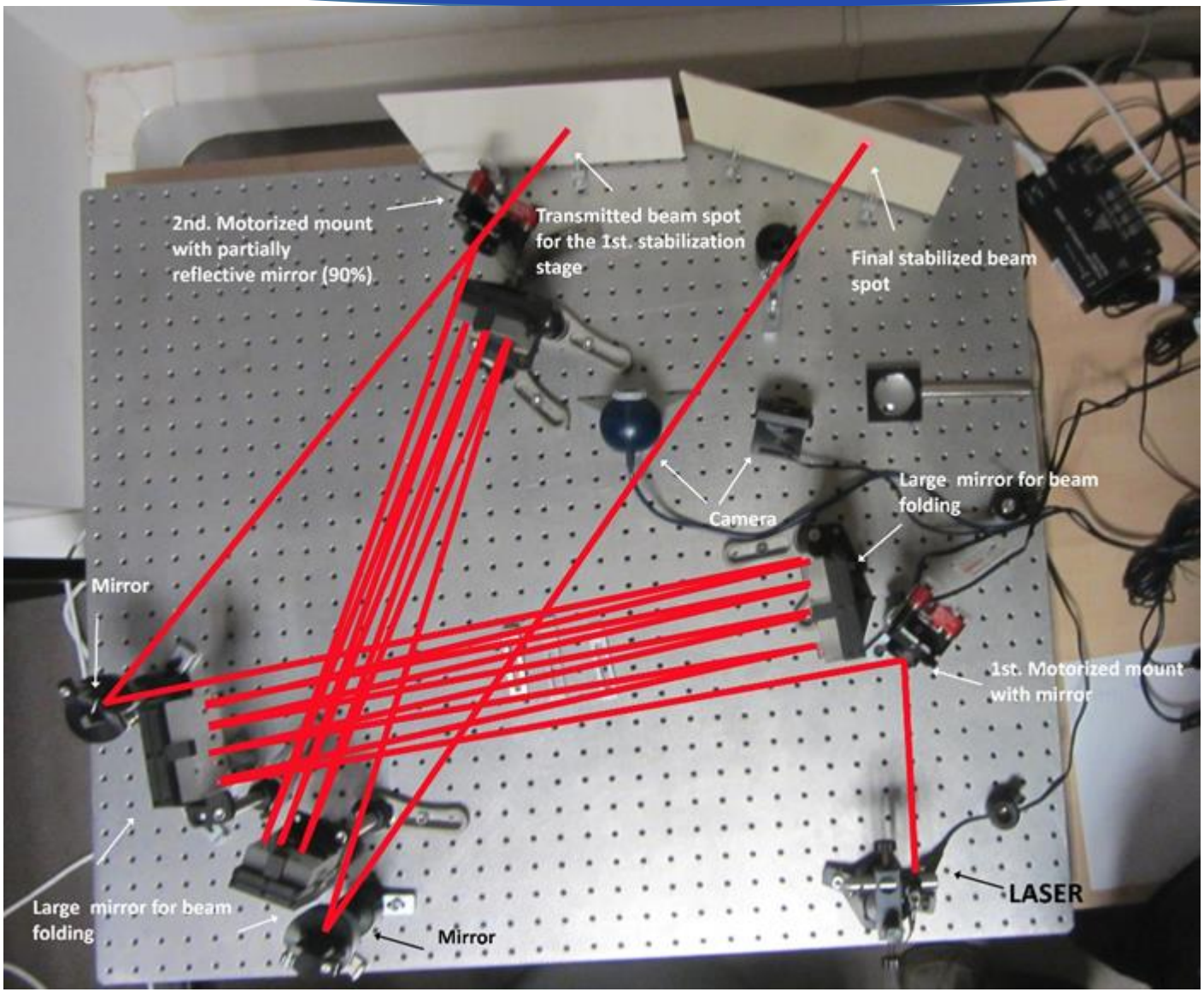




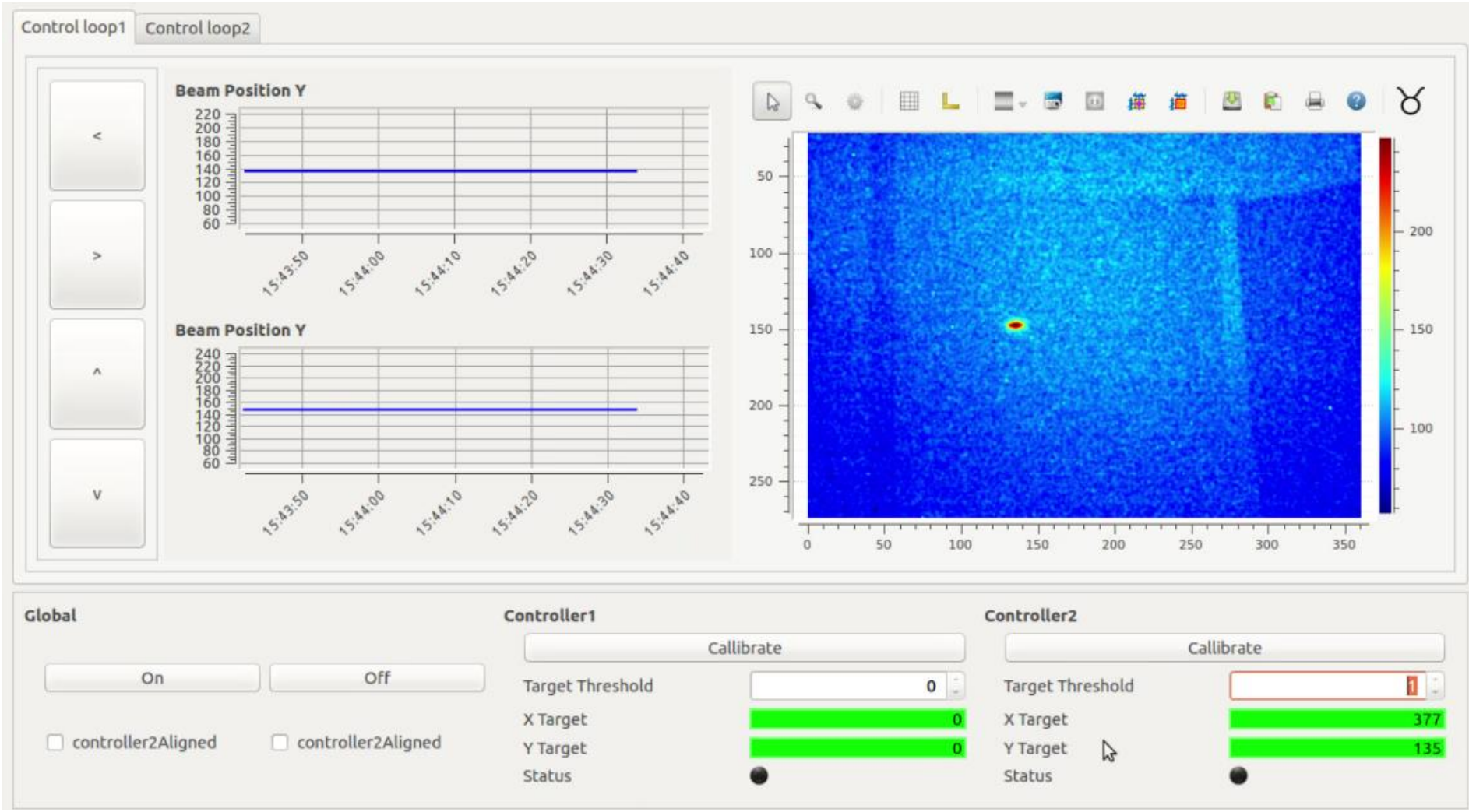
TANGO – Astor
Control system management



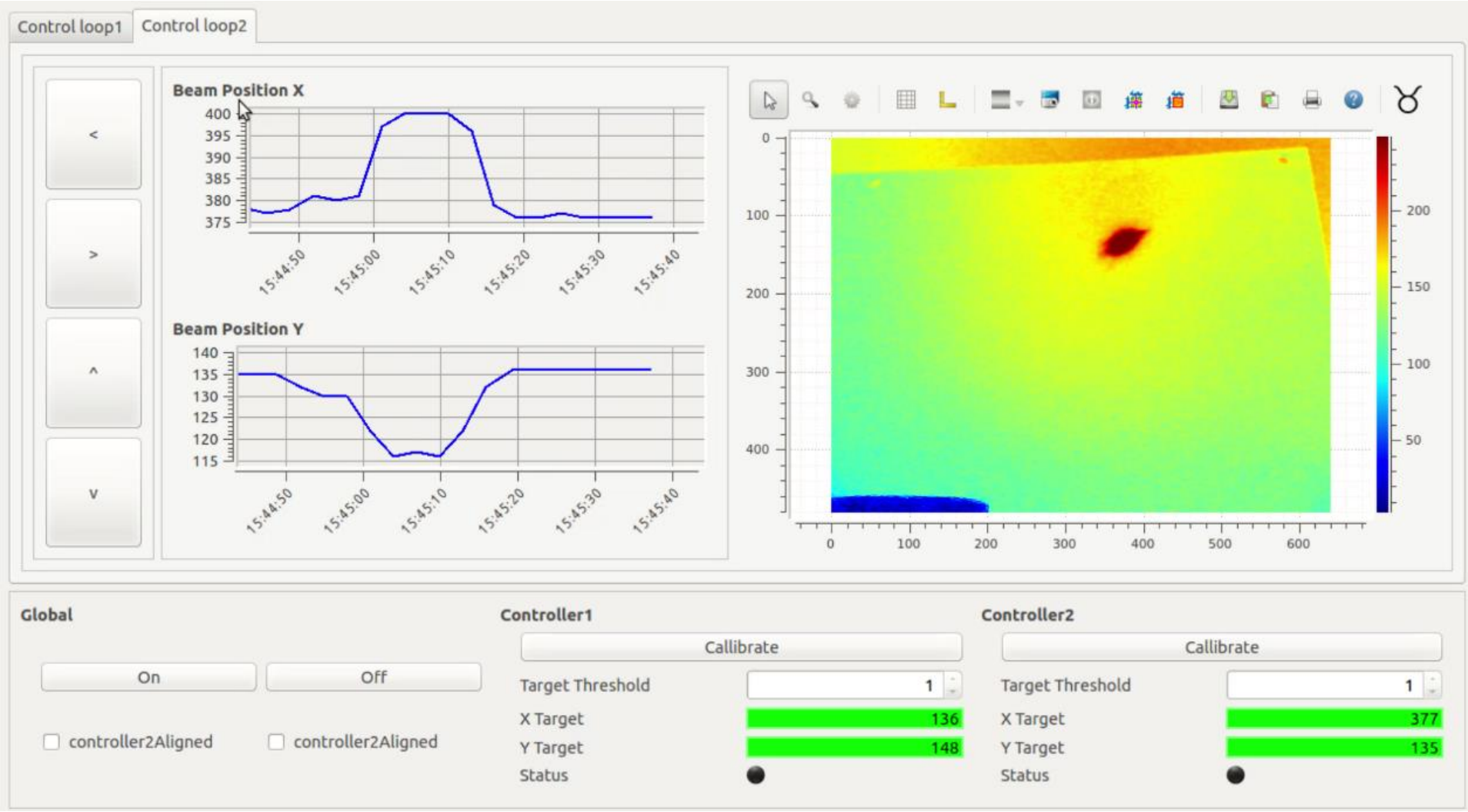
Prototype:
Beam alignment with Tango



Prototype:
First stabilization beam spot

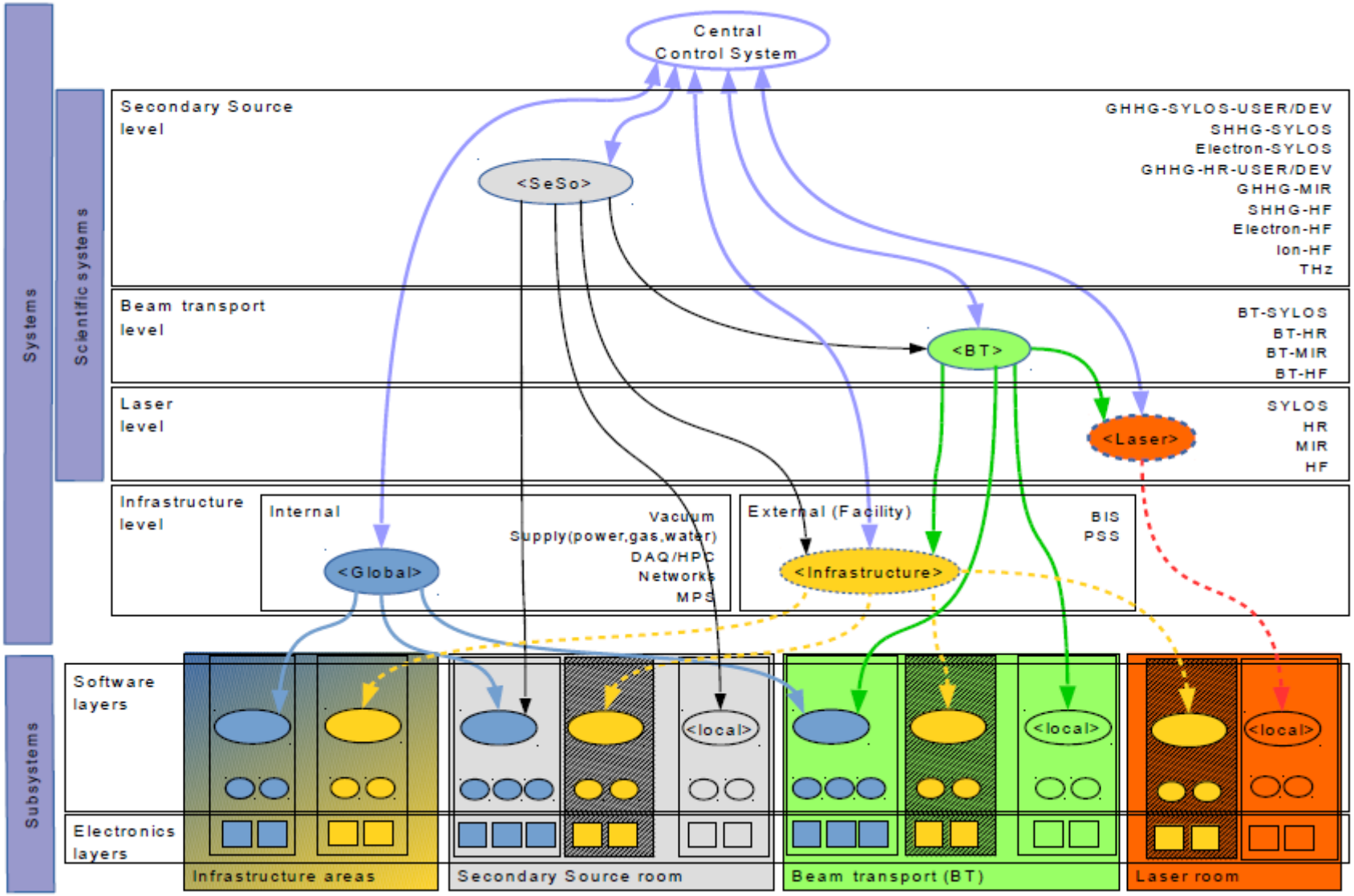


Prototype:
Final stabilized beam spot



Systems and subsystems

Systems and Subsystems



Publications, posters: ICALEPCS

ELI-ALPS Control System Status Report

L.J. Fülöp, S. Brockhauser, S. Farkas, V. Hanyecz, M. Kiss, M.T. Koncz, Á. Mohácsi, K. Nelissen, L. Schrettner, B. Szalai, P. Sász, C. Turner
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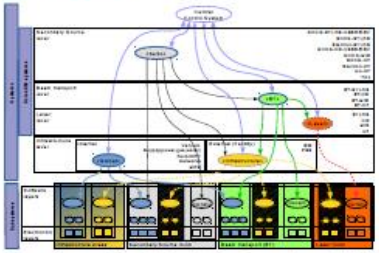
Motivation

ELI-ALPS is one of the three pillars of the European Extreme Light Infrastructure project. As a research facility, the infrastructure will contain a large number of experimental devices and equipment which have to be managed and controlled by a robust and flexible system. The Control System of ELI-ALPS will be based on TANGO.

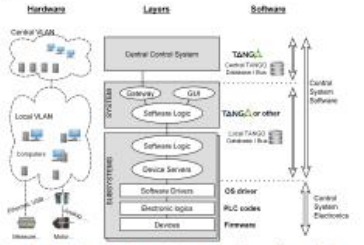
System Design

Systems and Subsystems



Systems are composed of combining subsystems. These can be organized into different levels, represented by boxes in the Figure: the group name (e.g. Beam Transport Level) is indicated in the top-left corner, while the instances (the corresponding systems) are indicated on the right side of the box (e.g. BT-SYLOS).

Layers



Each system (and subsystems) has some layers and each layer addresses hardware and software aspects. The layers can be grouped into Control System Electronics and Control System Software.

Layer	Role	Hardware	Software
Devices	Elementary building blocks	electronically controllable device, e.g. a motor	Firmware
Electronic Logics	Controlling the device and providing fast logics	An electronic controller, a relay, a PLC, etc.	PLC codes, interlocks, etc.
Software Drivers	Connecting the electronic and software worlds	A device/controller can be connected to computer(s)	OS drivers and/or dedicated ones, e.g. UMA
Device Servers	Making the devices available on the TANGO network and hiding all details about layers below	One computer can host several device servers on the local network	One device server can provide access to several devices
Software Logic (subsystem)	Providing subsystem level functionalities on sets of related device servers	Computer(s) host all the software logics	Software logics are implemented also as TANGO device servers
Software Logic (system)	System level functionalities on sets of subsystems	Computer(s) host all the software logics	Also implemented as TANGO device servers
Graphical User Interface (GUI)	Giving access to the software logics and to the devices for the operators and users.	Clients can be executed on dedicated computers of the local network	TANGO provides generic clients and a toolkit to create custom ones.
Gateway	System provides this as an access point (monitor/ control) for other subsystems and to the central control system	One or several computers can provide the gateway. It should be accessible on the local LAN.	TANGO device server(s) can represent the Gateway. It should accessible in the local TANGO Bus.

Requirements

Scientific Systems

- Laser Sources will be delivered as black-box turn-key systems with the Gateway
- Secondary Sources: The requirements, the technical design, the hardware shopping list are provided by expert institutes
- Beam Transport: The requirements, the technical design, the hardware shopping list are provided by in-house experts
- The control systems and the integration of these will be delivered by dedicated project(s)

Central Control System

- Basic central services: archiving, alarms, logging, overview GUIs
- Integration platform orchestrates the collaboration of the systems through the gateways. The gateways are accessible only from the central system; the systems can communicate through a proxy. Systems can be pre-allocated.

Data Acquisition

- Software framework acquiring, data processing, and augmenting experimental data with metadata from all of the experiments and secondary sources
- use the common facility level timing for both triggering and timestamping
- An experiment consist a series of batches, each batch will have a unique ID

Prototypes

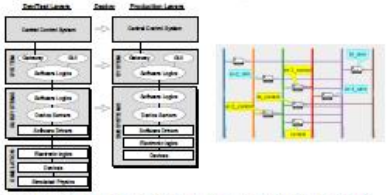
Two types of PoC prototypes were developed: vertical prototype works with real-hardware on a small setup, while horizontal prototype works with simplified hardware simulation of all laser and secondary sources (~700 simulated devices).

Vertical prototype

A really simplified optical system has been assembled (on the left). In the software logic layer there were two loops for stabilizing the manually pre-aligned beam. The GUI (on the right) displays these loops and also gives action buttons to the users.

Simulation framework

The horizontal prototype was not enough generic and reusable directly for development and testing, therefore a simulation framework PoC prototype is elaborated. The framework is demonstrated with a simplified scenario.



Layers of simulation and deployment to the production (on the left); hardware and network is virtualized with Openstack (on the right); the software differs only in configuration.

Acknowledgement

The ELI-ALPS project (GOP-1.1.1-12/B-2012-000, GINOP-2.3.6-15-2015-00001) is supported by the European Union and co-financed by the European Regional Development Fund.

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Kepler-TANGO Integration at ELI-ALPS

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Motivation

ELI-ALPS is one of the three pillars of the European Extreme Light Infrastructure project. As a research facility, the infrastructure will contain a large number of experimental devices and equipment which have to be managed and controlled by a robust and flexible system. We found that the TANGO Control system is able to address this complexity. But using TANGO by researchers for experiment design is not obvious, because it requires programming knowledge. Scientific workflow systems provide easy-to use graphical interface to create applications, therefore we decided to integrate TANGO with the Kepler workflow system to facilitate the flexibility of the control system.

Main concept

- One TANGO actor represents one TANGO Device
- The user is able to select a TANGO actor from the list of available ones (i.e. the TANGO devices in the TANGO database)
- An input/output port of a TANGO actor represents an attribute or a command of the corresponding TANGO Device
- The user is able to filter which TANGO attributes and/or commands appear as ports of the corresponding TANGO actor.

TANGO Controls architecture with Kepler and scientific workflows.

Steps of the development

1) Hard-coded integration

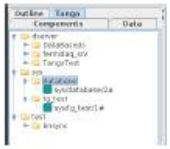
Goal: whether the workflow system capable of adopt TANGO's unique functionalities.

Result: It is able to
- ✓ handle the connection of a device
- ✓ manage the execution of a command
- ✓ read/write some attributes

2) Database level integration

Goal: facilitate deploying the TANGO actors on the workflow canvas by choosing from the list of available TANGO actors.

Result: The extension appearing on a separate tab is able to query the available devices from the TANGO Database and to integrate it in a way that the user can conveniently deploy TANGO actors.



3) Complete type conversion

Goal: solve the type conversion, which experienced as one of the most challenging task.

Result: for basic datatypes the conversion is obvious. In case of exotic types, the developers have to agree on a general integration.

Tango type	Kepler Token
Boolean scalar	BooleanToken
Boolean Spectrum and Image	BooleanMatrixToken
Byte, short and int Scalars	IntToken
Byte, short and int Spectrums and Images	IntMatrixToken
Long Scalar	LongToken
Long Spectrum and Image	LongMatrixToken
Double Scalar	DoubleToken
Double Spectrum and Image	DoubleMatrixToken
Float Scalar	FloatToken
Float Spectrum and Image	FloatMatrixToken
String Scalar	StringToken
String Spectrum	ArrayToken(string)
String Image	ArrayToken(ArrayToken(string))
DevState Scalar	StringToken
DevState Spectrum	ArrayToken(string)
DevState Image	ArrayToken(ArrayToken(string))
DevEncoded	unsupported
DoubleString(array and Long)StringArray	RecordToken

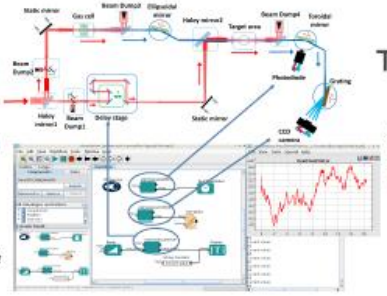
4) Configuring ports (attributes, command)

Goal: reduce the graphical elements as much as possible. One TANGO Device may have large number of attributes and commands, which means hundreds of input and output ports in a TANGO actor.

Result: The users should choose the attributes and the command in advance.

Beamline Simulation

For a proof of concept, a simple control system was created on top of a simulated beamline to demonstrate the usability of the prototype. From control side the following parts are static: holey mirrors, gas cell, beam dump 3 and 4 and target area while beam dump 1 and 2, ellipsoidal mirror, spherical mirror, photodiode and CCD camera can be controlled. In this Kepler demonstration only the delay stage was moved. The diagram shows the measured voltage (by photodiode) as the function of the delay.



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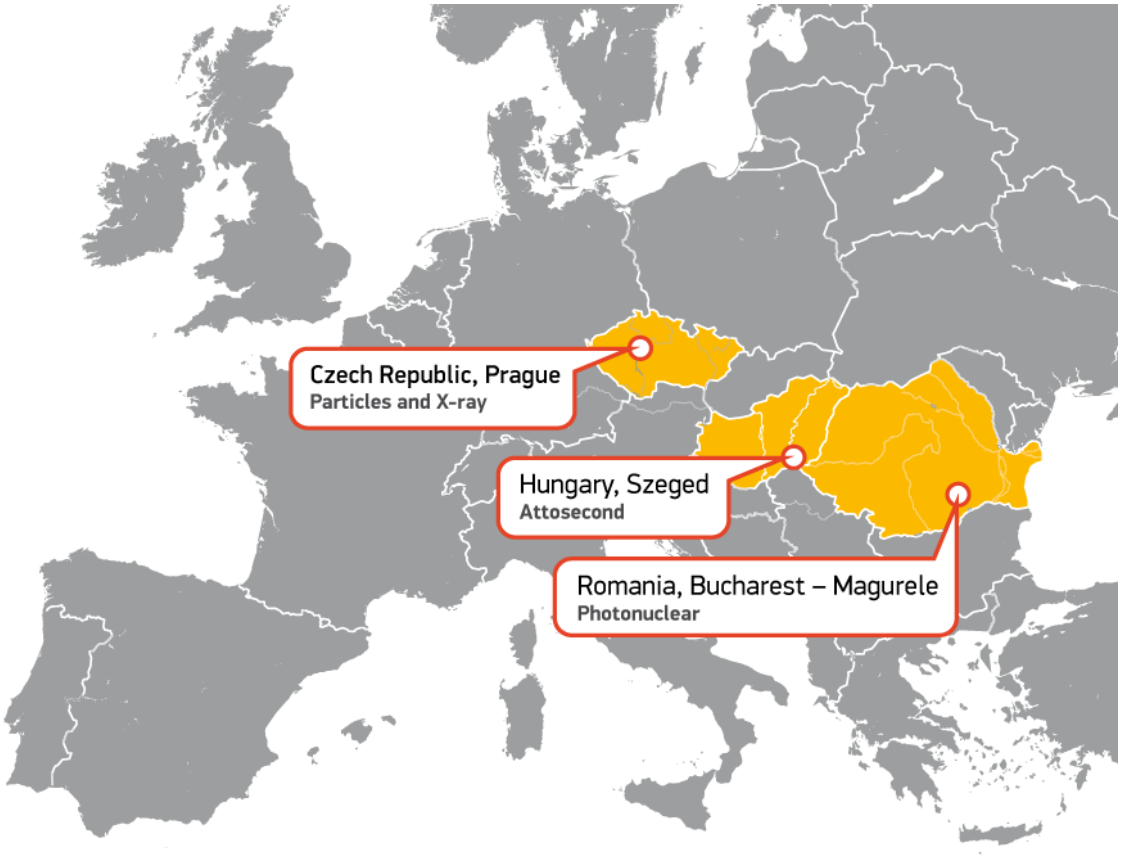
Agenda

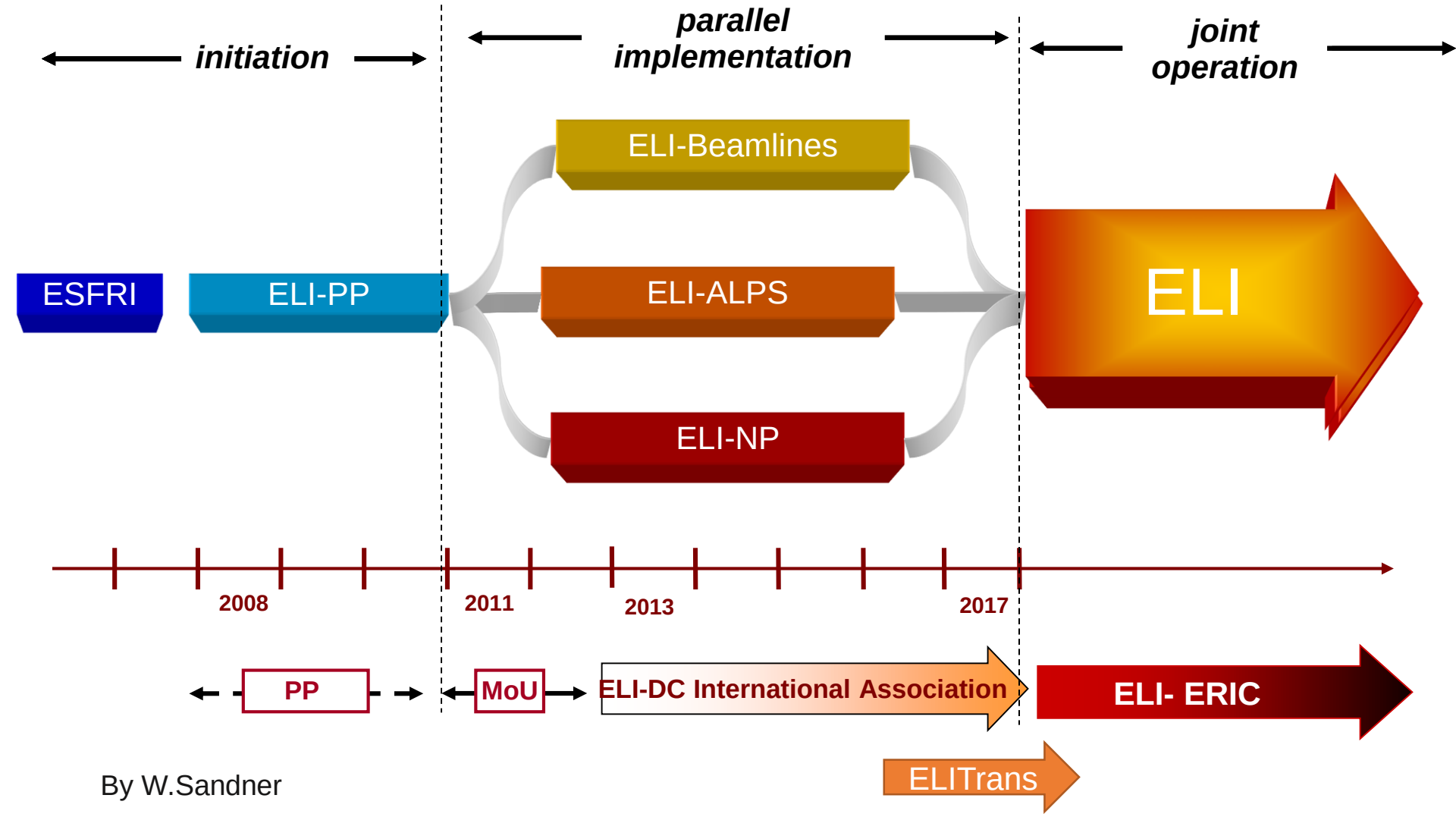
Scientific IT and ELITrans

ELI pillars

- ELI-Beamlines
- ELI-ALPS
- ELI-NP

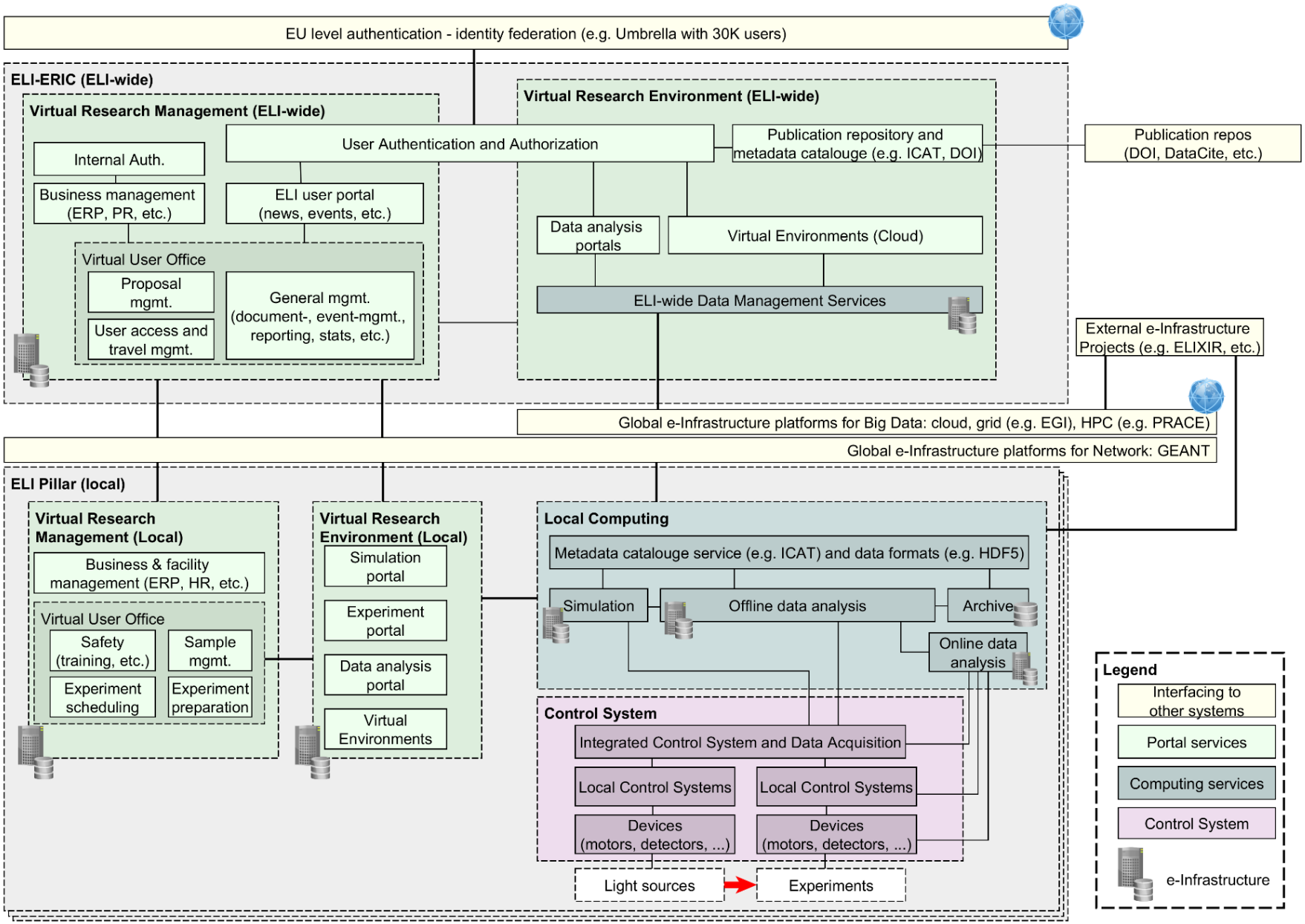


What is ELITrans?



By W.Sandner

ELITrans: Data, Computing, Management



THANK YOU FOR YOUR ATTENTION!

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