LASER MEGAJOULE TARGET DIAGNOSTIC CONTROL COMMAND SYSTEM

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What is LMJ, What are Target Diagnostics?
The LMJ Control Command architecture
Layer 0 for Target Diagnostics Control Command
Camera Drivers Modular Architecture and Vacuum System
Maintenance and Qualification Tools
Real and Virtual Modes
Layer 1 for Target Diagnostics Control Command
Managing Contractors
Conclusion
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Presentation Overview

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Overview

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- Managing Contractors
- Conclusion
The Laser Megajoule (LMJ)

LMJ is a large research instrument used to condition a very small quantity of matter at extrem temperature and pressure

Heavy and Hot Plasma studies and understanding
- Found in Thermonuclear Devices
- Found deep inside Stars

LMJ : A fundamental key in CEA’s Simulation Program
LMJ : An instrument for Astrophysics and Fundamental Research
LMJ : One step forward a new kind of energy source, Inertial Fusion
LMJ will concentrate $10^{25}$ atoms/cm$^3$ during 10 ps

ITER will heat a $10^{13}$ atoms/cm$^3$ gaz during 10 s

Same ratio than between 2 days and the age of the Universe
From the Target to the Facility

Target Ø 2 mm

Experiment Chamber Ø 10 m

Experiment Room
Ø 60 m / 50 m High

Laser Megajoule
150 m x 300 m
35 m High

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What are Target Diagnostics?

- **Hard and Soft X-ray imaging systems** (30 eV to 15 keV range) with a 15 to 150 µm spatial resolution and a 30 to 100 ps time resolution, providing 30 imaging channels,

- Diagnostic set for **Hohlraum temperature measurements** including an absolutely calibrated broadband X-ray Spectrometer, a Gating Spectrometer, a time resolved Imaging System of the emitting area,

- Optical diagnostic set dedicated to EOS measurements including 2 VISAR (Velocity Interferometer System for any reflector), 2 SBO (Shock Break Out), a Pyrometer and a Reflectivity Measurement,

- Full **Aperture Backscatter System**,

- **Near Backscatter Imager** to measure the power, spectrum, and angular distribution of backscatter light to determine the energy balance.

- **Neutron Detectors**

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**We will focus on a typical X-ray Imaging System**

Distribution of backscatter light to determine the energy balance.
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An X-ray Target Diagnostic is a Giant Microscope
## Overview

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Purdue Model of the LMJ CC

L3 Facility Planning and Operations
- ADM System Administration

L2 System Supervisory
- GTIR Shots & Results Admin
- GMAO CMMS
- GCI Facility Configuration
- PARC Automatic Prediction & Tuning System

L1 SubSystem Control
- SVP Sequence Administration System

L0 Equipment Control
- Laser Diag
- Target Diag
- Personal Safety
- PEPC
- Timing
- Vacuum
- Alignment

Communication Protocol

PARC: MOC3O06 / MOPGFO75, Sequence: TUB3O04, Status: FRA3O01
LMJ Control Command Development Constraints

For **LMJ**:
- Windows 7 64 bits,
- Panorama E$^2$ for the CCN1 SCADA,
- Equipments as LMJ Ressources.

For **Target Diagnostics**, be able to:
- Handle hundreds of various Equipments,
- Add (and develop) new Target Diagnostics during several years,
- Insure software Maintainability during dozen of years.

Leads to:
- A stable and open source language, easy to understand (Python for Scientists),
- An open source framework for drivers (Tango),
- Specific GUI for maintenance, developed in QT,
- As possible, the use of Ethernet TCP interface for Equipments.

Life expectancy: Open Source, Ethernet / Heterogeneity: TANGO
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The Old Stuff

Wasted time, but... meaningful Experience!
Abstraction Layer for Life Expectancy

Abstraction Layer: THE solution for Life Expectancy and Heterogeneity?
The TANGO Framework

TANGO : a nice Abstraction Layer Architecture
POGO : a code generator for Drivers
You can choose between 3 languages
The 14 TANGO States

- UNKNOWN
- INIT
- STANDBY
- ON
- OFF
- OPEN
- CLOSE
- RUNNING
- ALARM
- FAULT
- INSERT
- EXTRACT
- MOVING
- DISABLE

State Machine protection for all Devices Commands
Deadlock can occur with multiple clients and some hardwares.
Client 1:
Notifications on Change, Ranging... value of attributes

Client 2:
Using Methods/Attributes

Values are read inside the buffer
TANGO Polling

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Notifications on Change, Ranging… value of attributes

Client 2:
Using Methods/Attributes

Values are read inside the buffer

Polling can also be used for Computer Power Configuration or Full Driver testing
Jive: a low level TANGO Tool

All the drivers in a Class Window

Equipments in a Device Window

Jive is a usefull tool for the very low level debugging
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Optical Analyzers

1D Streak Camera:
- Electronic Board 1
- Agilent PS
- CCD Camera

2D Framing Camera:
- Electronic Board 2
- Agilent PS
- CCD Camera
- HV Pulse Generator

5 Device Servers for 2 Optical Analyzers
TANGO Device Servers Architecture for Optical Analyzers

- **TANGO Interface**
- **User Environments**: Python, LabView, Panorama, MatLab...
- **TANGO Software Bus**
- **Device Servers**:
  - High Level Streak Camera
  - High Level Framing Camera
  - Low Level Power Supply
  - Low Level Kentech Pulse Generator
  - Low Level Electronic

- **Components**:
  - Streak Camera Electronic Board (Ethernet)
  - Andor CCD Camera (USB)
  - Agilent PS (Ethernet)
  - GKD3 Kentech (Ethernet)
  - Electronic Framing Camera Board (Ethernet)
TANGO Device Servers Architecture for Optical Analyzers

Streak Camera OIO (Maintenance GUI Interface)
Other Low Level OIO and TANGO Tools
User Environments: Python, LabView, Panorama, MatLab...
TANGO Interface

TANGO Software Bus

Device Server
Low Level Electronic
Streak Camera Electronic Board

Device Server
Low Level Andor CCD
Andor CCD Camera

Device Server
Low Level Power Supply
Agilent PS

Device Server
Low Level Kentech Pulse Generator
GXD3 Kentech

Device Server
High Level Framing Camera
Electronic Framing Camera Board

Device Server
High Level Streak Camera

[Diagram of TANGO device servers architecture]

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High and Low Level Device Servers for PLCS

TANGO Software Bus

Device Server: S7 Table
Device Server: S7 Manager
Device Server: S7 S7 Subset
Device Server: S7/Ctrl
Device Server: Vac Valve
Device Server: Pressure Gauge
Device Server: Pumps

S7/300 PLC
COM RS232C
I/O

RS232C
Pressure Gauge Controller
Vac Valves

PLC DS: Access to all low level Equipments (Gauges, Valves, Pump...
Architecture and Sequence

N2/N3 Supervisory

Facility Network

Other SubSys

N1 Target Diagnostic

CCNo Computing

TANGO DB

Shot Sequence

Shot Sequence Initialization

TD Configuration

TD Alignment

TD Parametting

Validation Shot

Last Configuration

Power Shot

Data Transfer

No Real Time ➞ Configuration, Arming, Waiting, Getting results
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Main GUI for Maintenance

OIQ GUI gives access to « Mid Level » TD commands
Motor Expert Mode gives access to a specific Motor Controler Interface
The BMAC Specific Expert Mode Interface
The Back Alignment Interface

...and many others Maintenance Interfaces...
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The Integration Platform (PFI)

3 steps for the integration of the control system

• Step 1: Contractor acceptance tests
  – Acceptance tests for equipment
  – Acceptance tests for control system
    • With real equipment (Representativeness)
    • With simulators (CS Robustness)

• Step 2: Integration Platform tests (PFI)
  – Global tests for N3-N2 supervisory
  – Global tests for all subsystems control systems: between each other and with N3-N2 supervisory

• Step 3: Functional integration (Integration Room)
  – Contractor tests for each subsystem
  – Global tests with the N2-N3 supervisory
Real Mode
- **Directly** drive the equipment
- Gets datas from the **Physical** equipment,
- The **Main** using mode inside the Facility.

Virtual Mode
- Gets Equipment Datas throu an **External File**
- Can be used to **test** the high level Device Server **without the need of the real equipment**
- Can be used to make a full « **Virtual** » **Target Diagnostic**

Implémentation :
- By using a **boolean** inside a kind of metadriver
- First idea, mode selection for each function, now, mode selection for the full equipment
- Simulated datas in HDF5 format, configuration file in XML format,
Real and Virtual Mode Management

TANGO Software Bus

- Streak Camera OIQ (Maintenance GUI Interface)
- Other Low Level OIQ and Tango Tools
- Supervisory Simulation Tool
- Supervisory Configuration Tool

Specific Property Pointing either the Real or the Virtual Low Level Device Server Name

Device Server
- High Level Driver
- XML Parameters
- HDF5 Datas

Low Level Real Mode

Low Level Virtual Mode
High and Low Level for the Telescopic Arm

A Versatile configuration: The High Level DS can be set to a different Driver.
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L0/L1 interface: TANGO/PANORAMA Binding

Bidirectional Integration of Tango components inside PANORAMA E² IDE

ISO image available @ www.tango-controls.org
Layer 1 Architecture

- GTIR: Shots and Results Management
- ADM: System Administration
- SVP: Main Supervisor

**Layer 1 Common Framework**

- TDi L1 Supervisor Interface
- TDi+1 L1 Supervisor Interface

**Layer 1**

- CMMS: Maintenance Management
- GCI: Facility Configuration

**Layer 0**

- ECI: Alignment Camera
- Synchro: Synchronization Signals

A Open System with TD Interfaces as Level 1 Plugins
Layer 1 Common Interface

The Panorama Interface with 4 TD
The X Ray TD Layer 1 Interface

Access to Sequence, other SubSystems, Equipments and High Level States
X-ray Imaging Target Diagnostics Contractors for Device Servers

- Oscilloscopes drivers (NEXEYA)
- CID Camera (GFTy)
- Alignment Pointing Devices (IDIL)
- Integration (THALES)

X-ray Cameras (BERTIN)
Managing Industrial Contractors

Many Contractors
- Command Control,
- Cameras,
- Target Diagnostics Mechanics,
- Integration.

Majors Challenges
- Full Outsourcing,
- First Tango Industrial Development (after the European Synchroton Team),
- We were using Windows (Tango initial development and LIMA for Linux OS),
- Project Development Timing not easy to handle with so many interfaces.

Experience Feedback
- Who’s in charge: Mechanics, Electronics, Optronics, Software Contractor?
- Who is making the Glue between Subcontractors?
- DS Design Guide Rules specification was written during developments…
  → It took some time to be stabilized

Is Full Outsourcing good?
→ Better understanding of contractors development by internalising DS prototypes.
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### Life Expectancy:
- Tango Open Source Architecture,
- Open Source Python language, with DS code quite easy to maintain for scientists,
- Keeping (almost !) the software DS core, even if the OS changes,
- Using the same architecture running on future computers.

### Modularity:
- Mixing DS instantiations for several equipment (i.e. CCD, Power Supplies…),
- Dispatching DS, Tango Database in different computers.

### Heterogeneity:
- Capability of making DS for any kind of equipment,
- Using already developed DS for future diagnostics

### Independancy:
- Using any new contractor for DS developing!
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Thank you for your attention...