# 2023 NEA GLOBAL FORUM RISING STARS WORKSHOP

Time Projection Chamber "TPC" High-Voltage "HV" and Low-Voltage "LV" Systems: Control, Monitoring, and Plans.

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Abstract

The Multi-Purpose Detector (MPD) is one of two at Nuclotron-based Ion Collider facility "NICA" collider. For MPD detector control system the TANGO software was proposed. Time projection chamber (TPC) is the tracker of MPD. The TPC LV and HV systems concept is presented. It is based on CAEN equipment and OPC UA (OLE for Process Control) server protocol. The status of interface design for CAEN equipment based on OPC UA, TANGO server and GRAFANA is presented. GRAFANA will be used to present graphs of the variation in the parameters of HV and LV during the monitoring.

Objective

The main concept is to monitor and control high- and low-voltage systems using the software tools OPC UA, Tango and Grafana and the connections between software and hardware.

The MPD is a 4π spectrometer to detect charged hadrons, electrons and photons in heavy-ion collisions at high luminosity in the energy range of the NICA collider.

A general view of the MPD detector with end caps retracted for access to the inner detector components. The detector consist of three major parts: central barrel and two forward spectrometers. The following subsystems are drawn: superconductor solenoid (SC Coil) and magnet yoke (Yoke), inner tracker (IT), straw-tube tracker (ECT), time-projection chamber (TPC), time-of-flight system (TOF), electromagnetic calorimeter (ECAL), fast forward detectors (FFD), cathode pad chamber (CPC) tracker and zero degree calorimeter (ZDC).

Hardware of HV and LV Systems

(EASY (Embedded Assembly System)

The EASY3000 crate (for boards up to 40 cm long, A3XXX family) can house up to 10 boards (depending on board width). As illustrated in the figure on the right, the branch controller is the EASY interface between the mainframe unit (SY4527 or SY5527) and the remote boards in the EASY create.

The branch controller role is to configure the EASY channels as the belong to the supply unit slot in which the branch controller is placed.

EASY_XML EASY Rack Configuration Files

The .xml Configuration Files of all EASY Boards. These files contain the operating parameters of each EASY Board and are used to configure EASY Crates connected to the A1676A branch controller. The A1676A branch controller is a single width board and will be housed in one SYx527 system while the remote sections will operate in the "hostile area".

The User can build his crate configuration file using the CAEN EASY Rack Builder, a Java(TM) application which allows EASY Users to create their customised EASY Crate configurations.
- Board.xml configuration files for EASY Crate Configuration
- Contains operating parameters of All EASY boards
- CAEN EASY Rack Builder software required

TPC HV+LV System

CONTROL ROOM (no radiation and magnetic field):
- SY4527 — 2 pc
- controller A1676A — 4 pc
- HV modules –A72360P (+3.5kV/1.5mA) - 11 pc
- HV modules –A72360N (- 3.5kV/1.5mA) - 4 pc
- HV modules –A1542HDN (- 500V/1mA) - 3 pc
- Power converters A3486 AC/DC (380 V -> 48 V)– 15 pc

LV&HV system based on CAEN rad. hard design:
(up to 2000 Gauss and 15 kRad)
- EASY3000 crates - 14 pc
- LV module - A3100B (8V/100A) - 48 pc
- LV module - A3100HBP (14V/50A) - 6 pc
- HV modules –A3540P (+4kV/1mA) - 8 pc
- HV modules –A3540N (- 4kV/1mA) - 2 pc
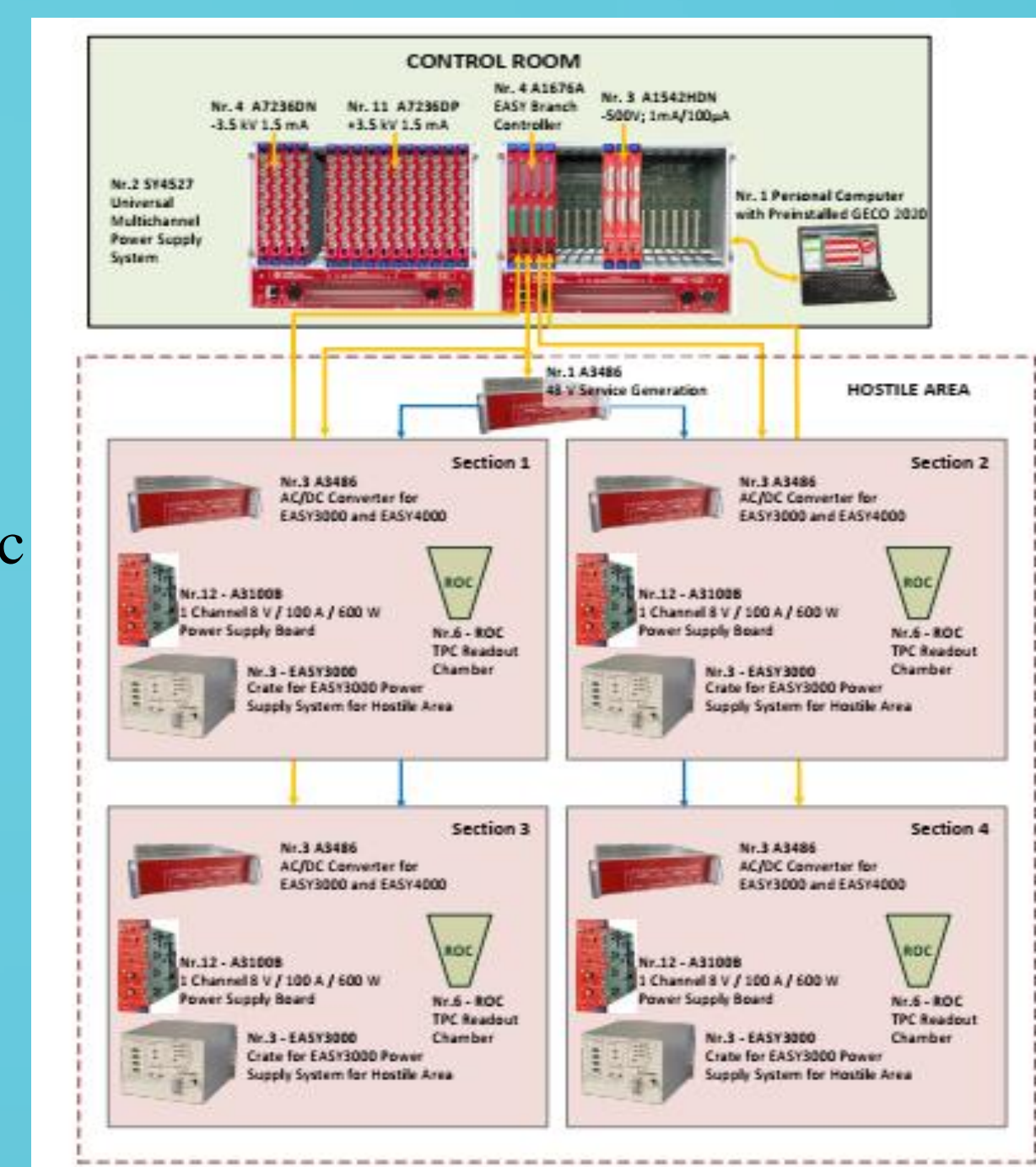
Crate SY4527 (Non Radiation Area)

The SY4527 system is the fully equipped experimental version of a new line of power supply systems which represent CAEN's latest proposal in the matter of High Voltage and Low Voltage Power Supplying. This system outlines a completely new approach to power generation and distribution by allowing the housing, in the same mainframe, of a wide range of boards with different functions, such as High/Low Voltage boards, generic I/O boards (temperature, pressure monitors, etc.) and branch controllers, where the latter are used to control other remote generators and distributors.

Controller A1676A (Non Radiation Area)

The Mod. A1676A EASY Branch Controller is implemented in a single width SYx527 board. Once plugged in, the Branch Controller must be linked to the EASY3000 and EASY4000 crates (which can work in the "hostile area"), via front panel connectors (Control and Power Supply).

The A1676A is the interface between the mainframe and the remote boards in the EASY3000/4000 crate. It configures the EASY3000/4000 channels as if they belong to the slot in which the branch controller is located: the channels of the EASY3000/4000 boards operate as channels of the A1676A. Up to six EASY3000/4000 crates can be controlled by one A1676A.
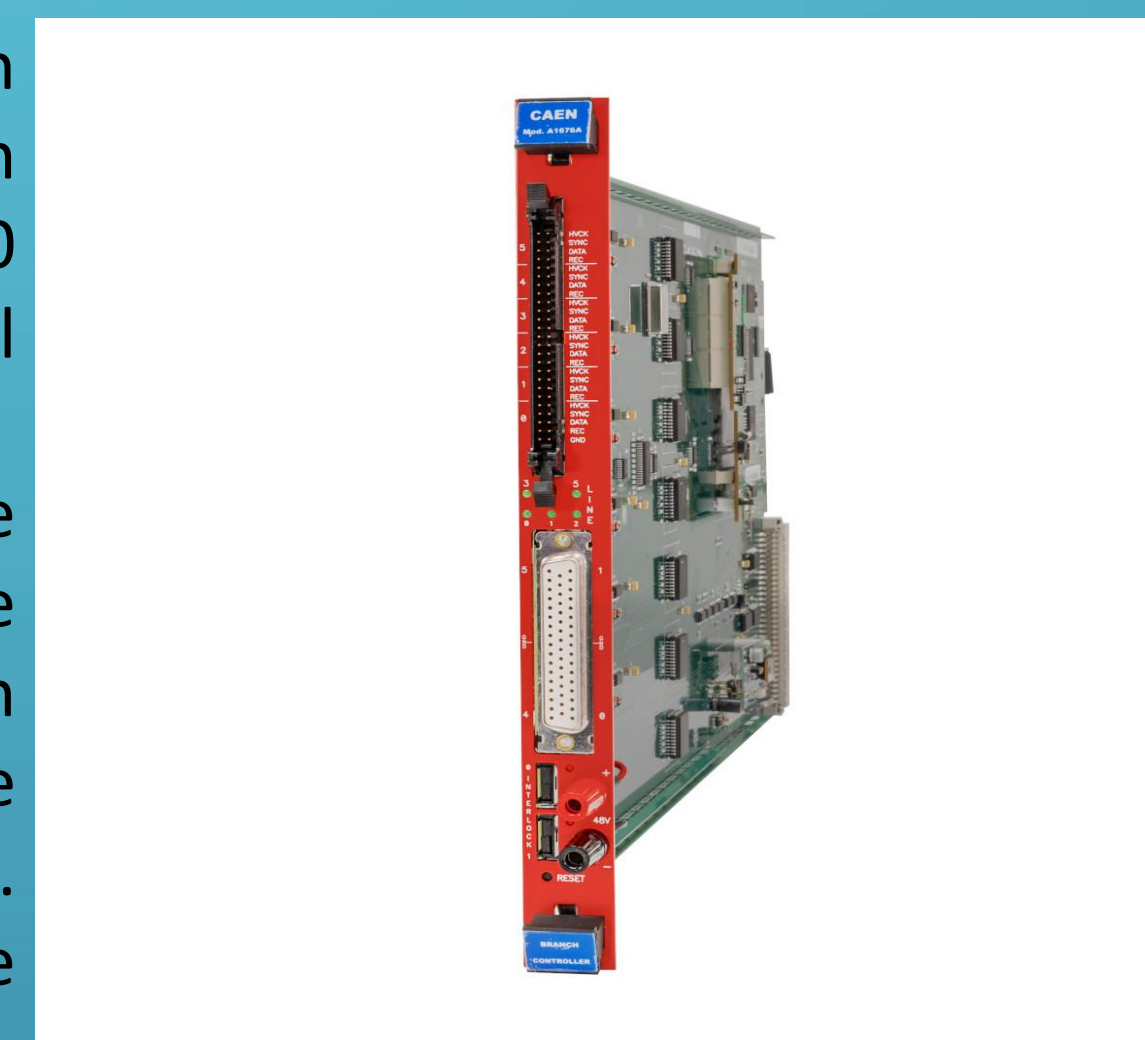
Software Tools to Monitor and control HV and LV Systems

OPC UA Server for CAEN Power Supplies

The OPC Unified Architecture (UA), is a platform independent service-oriented architecture that integrates all the functionality of the individual OPC Classic specifications into one extensible framework.

This multi-layered approach accomplishes the original design specification goals of:
- Functional equivalence: all COM OPC Classic specifications are mapped to UA
- Platform independence: from an embedded micro-controller to cloud-based infrastructure
- Secure: encryption, authentication, and auditing
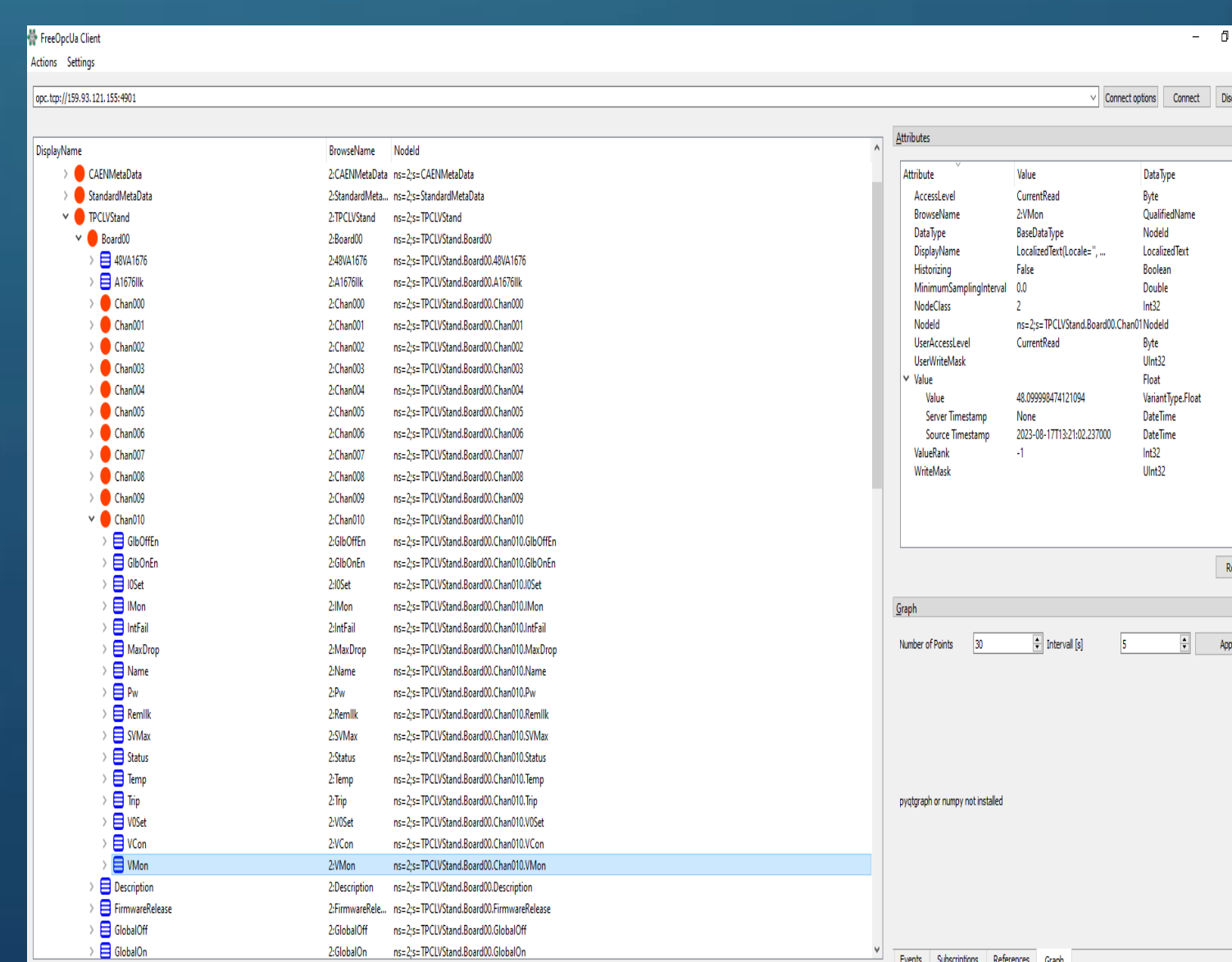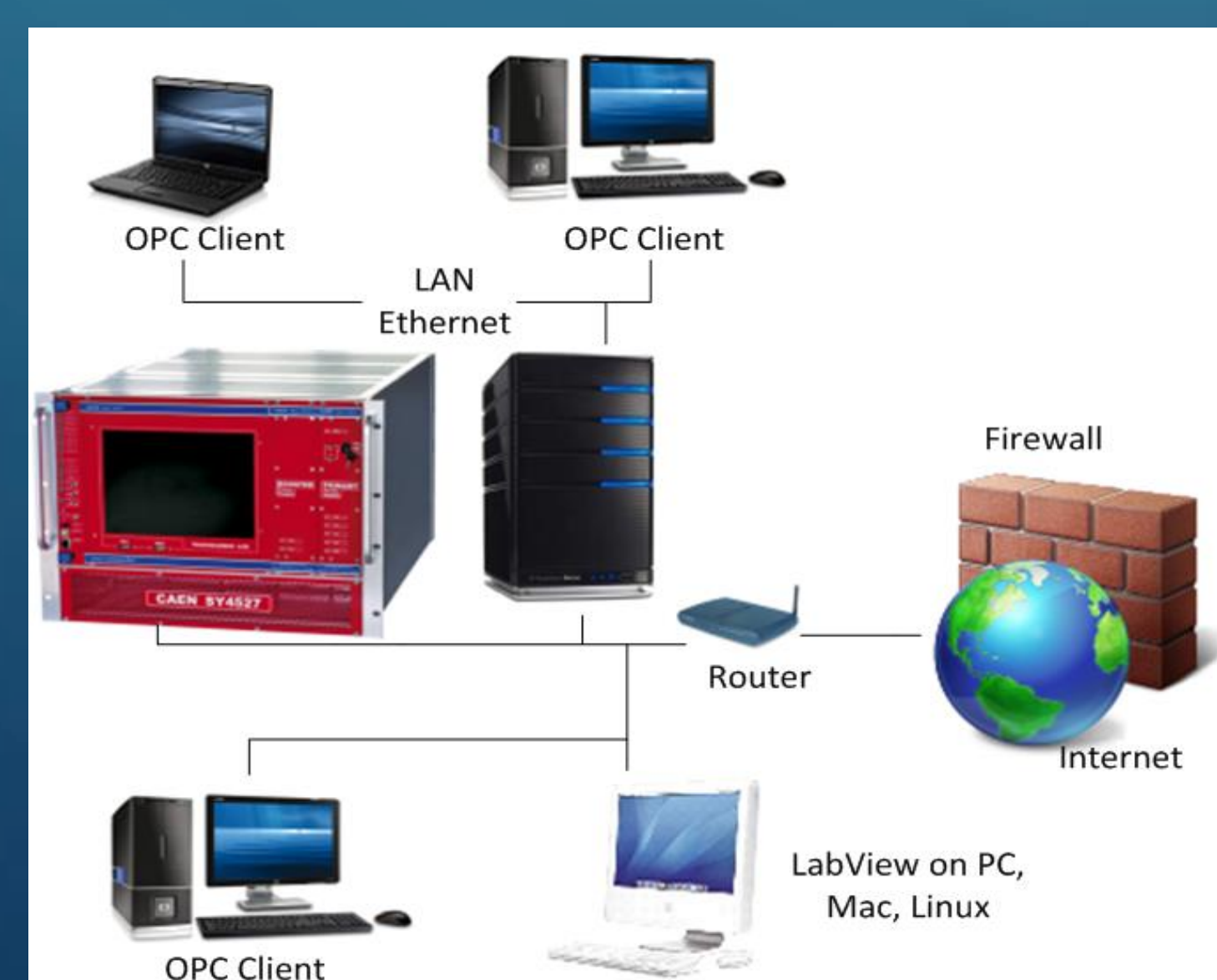
Tango Control Software Tool

TANGO is based on the 21 century technologies :
- CORBA and ZMQ to communicate between device server and clients
- C++, Python and Java as reference programming languages
- Linux and Windows as operating systems
- Modern object oriented design patterns
- Naturally implements a micro-services architecture
- Unit tested, continuous integration enabled
- Hosted on GitHub
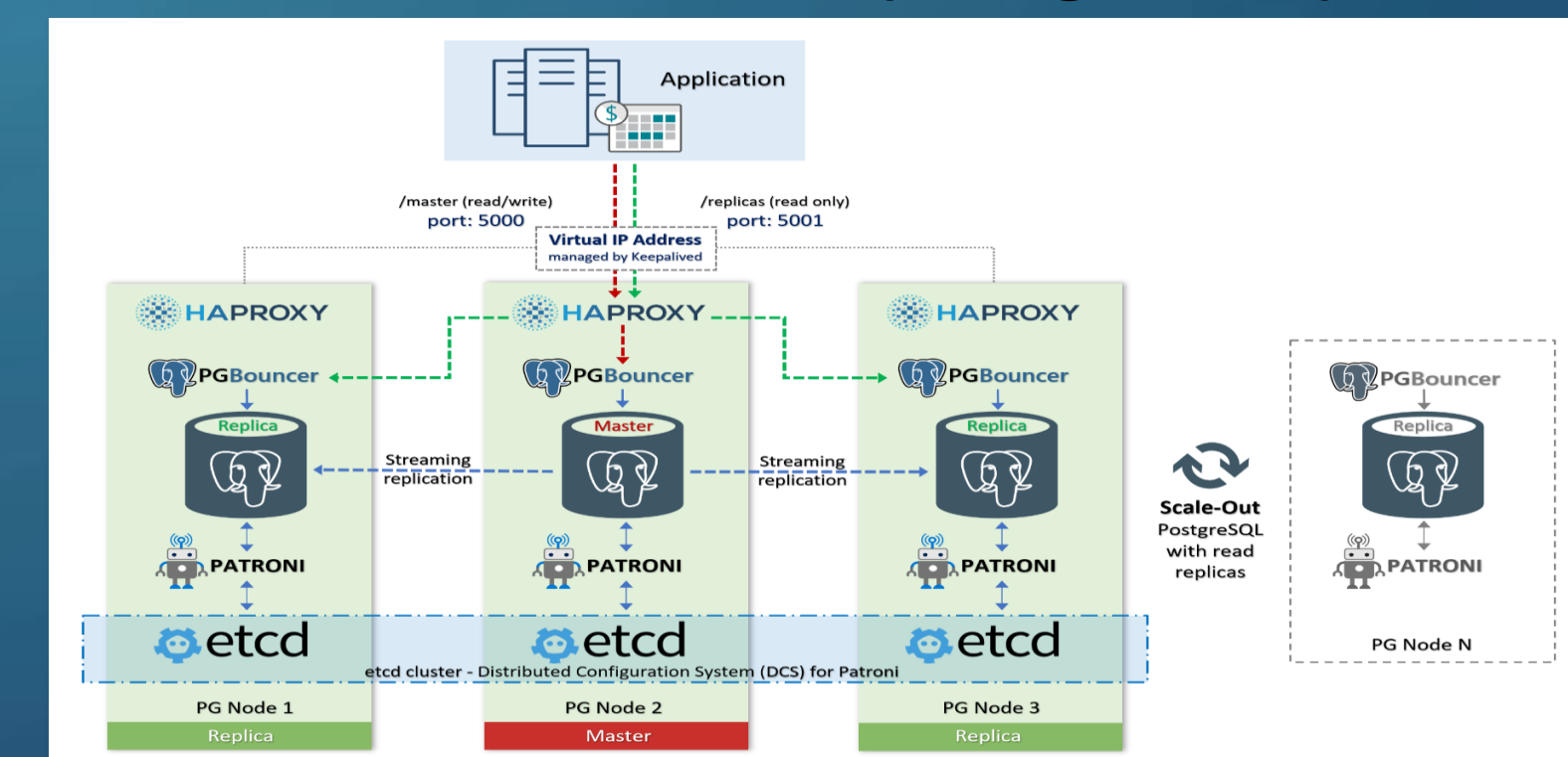- Extensive documentation + tools, large community
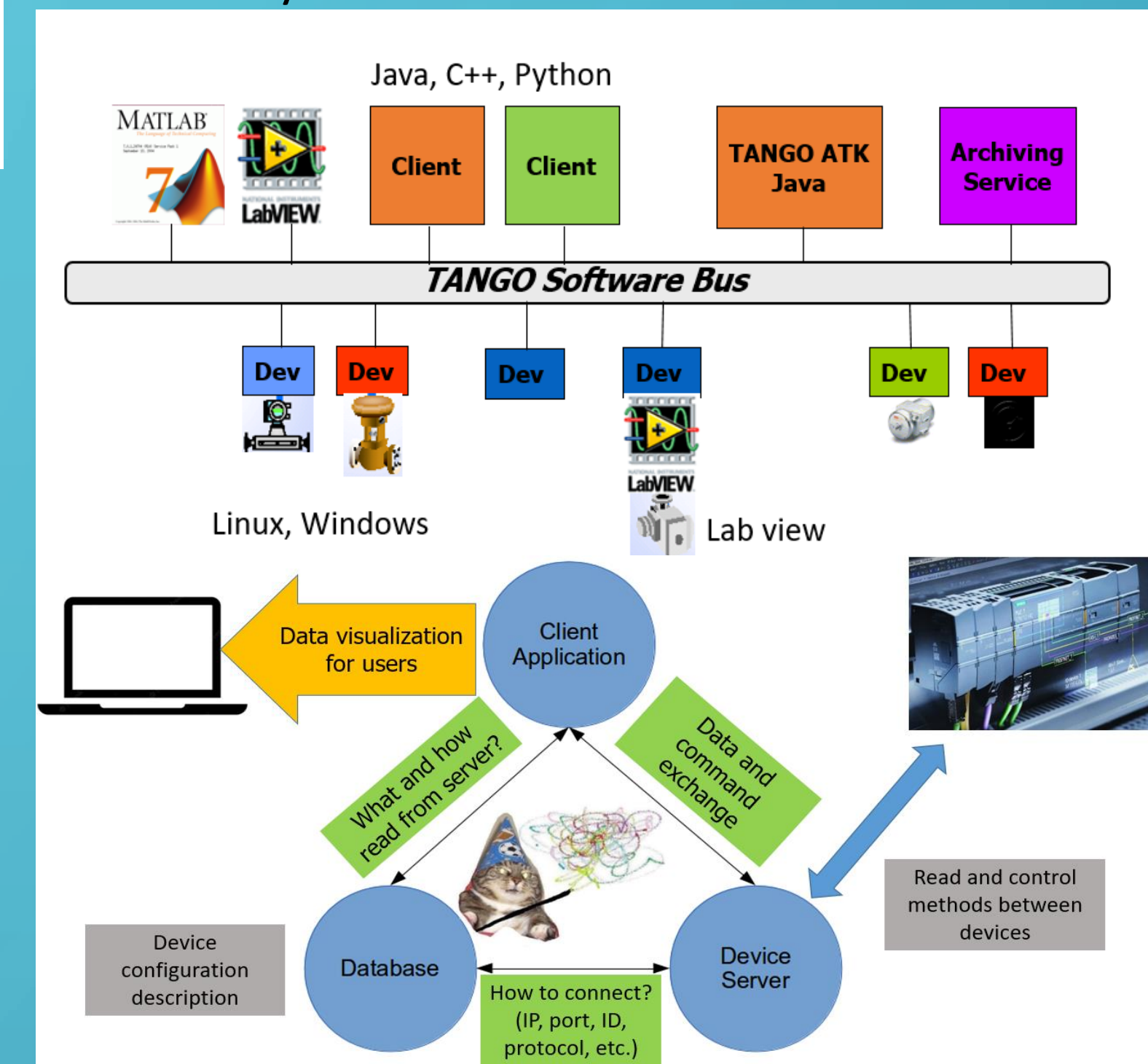
Infrastructure – Computing, Devices, Interfaces Tools

Front-end layer includes a wide variety of devices which are uses different buses and protocols, such as PXI, Ethernet, RS-485, RS232 etc.
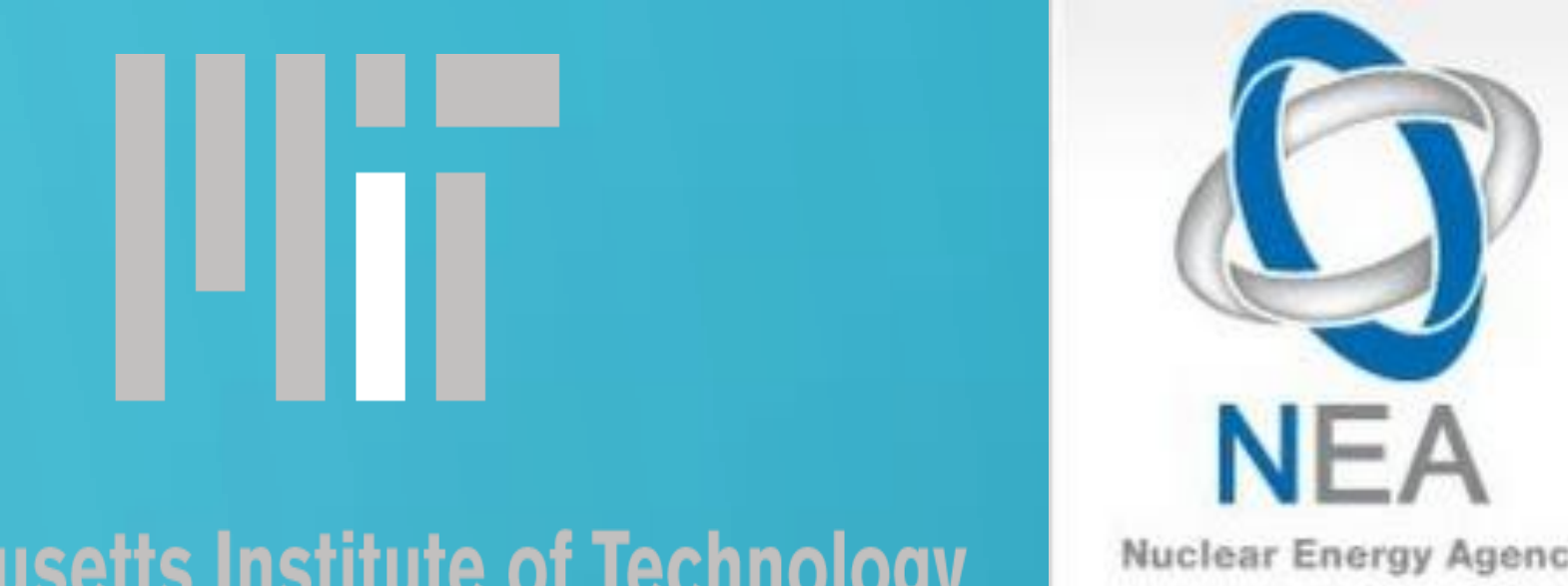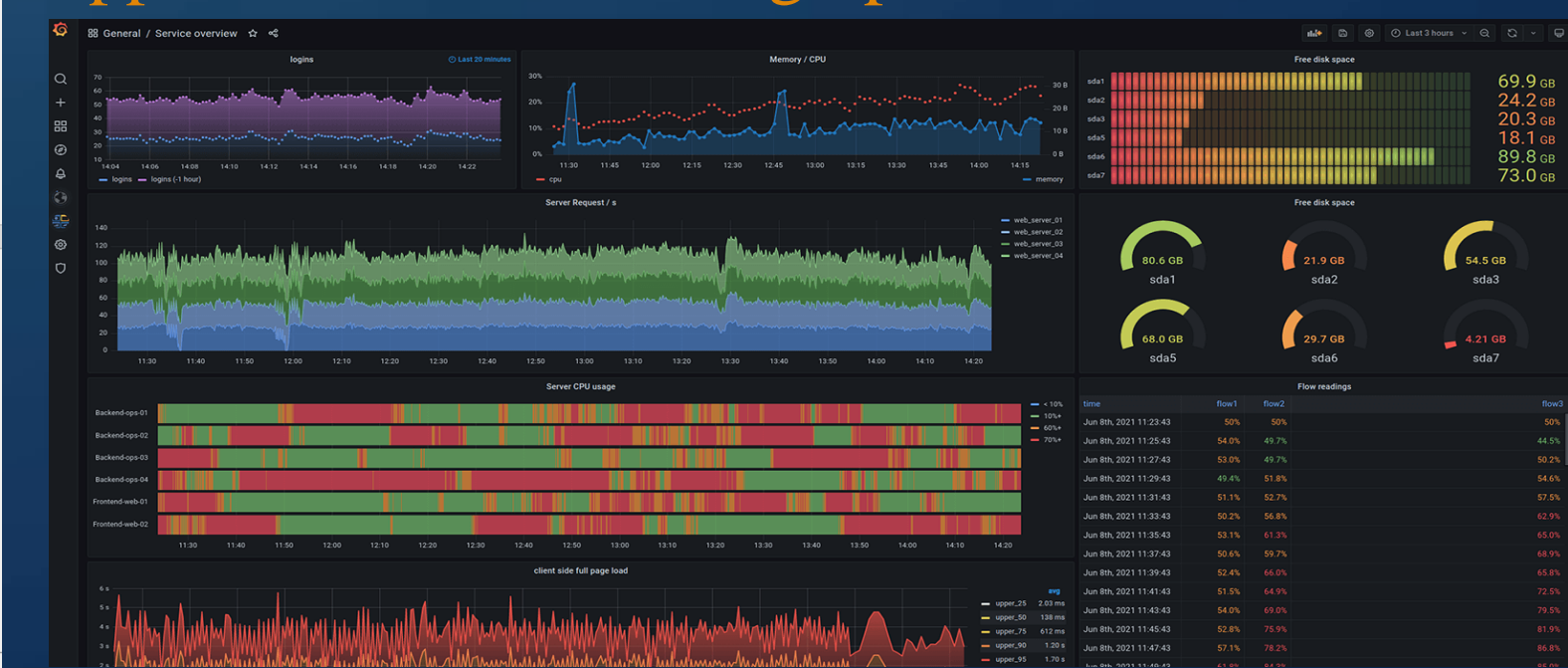
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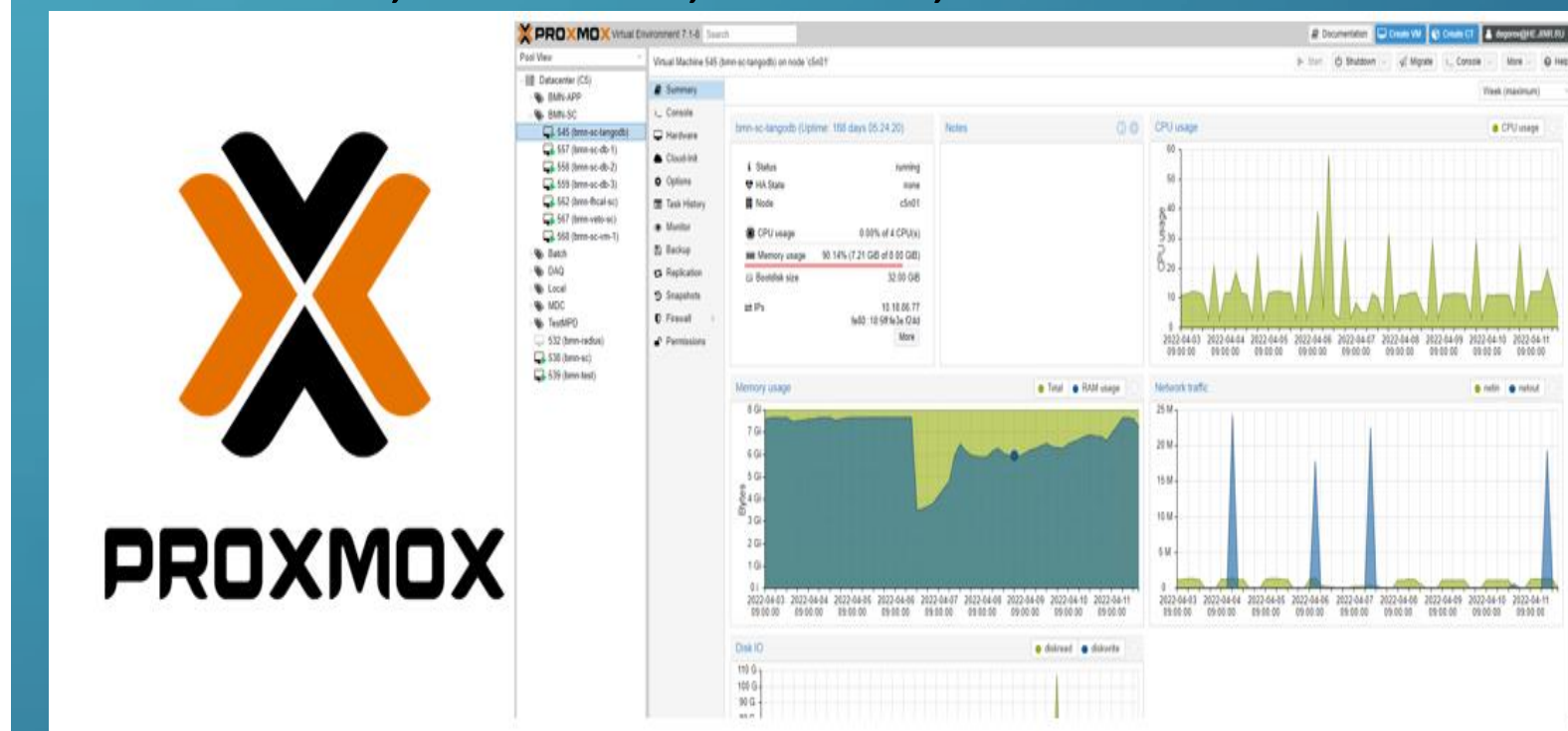
Database cluster (PostgreSQL)

Grafana Data Visualization

Grafana is a free software data visualization system focused on IT monitoring systems data. It is implemented as a "dashboard" style web application with charts, graphs, tables, alerts.
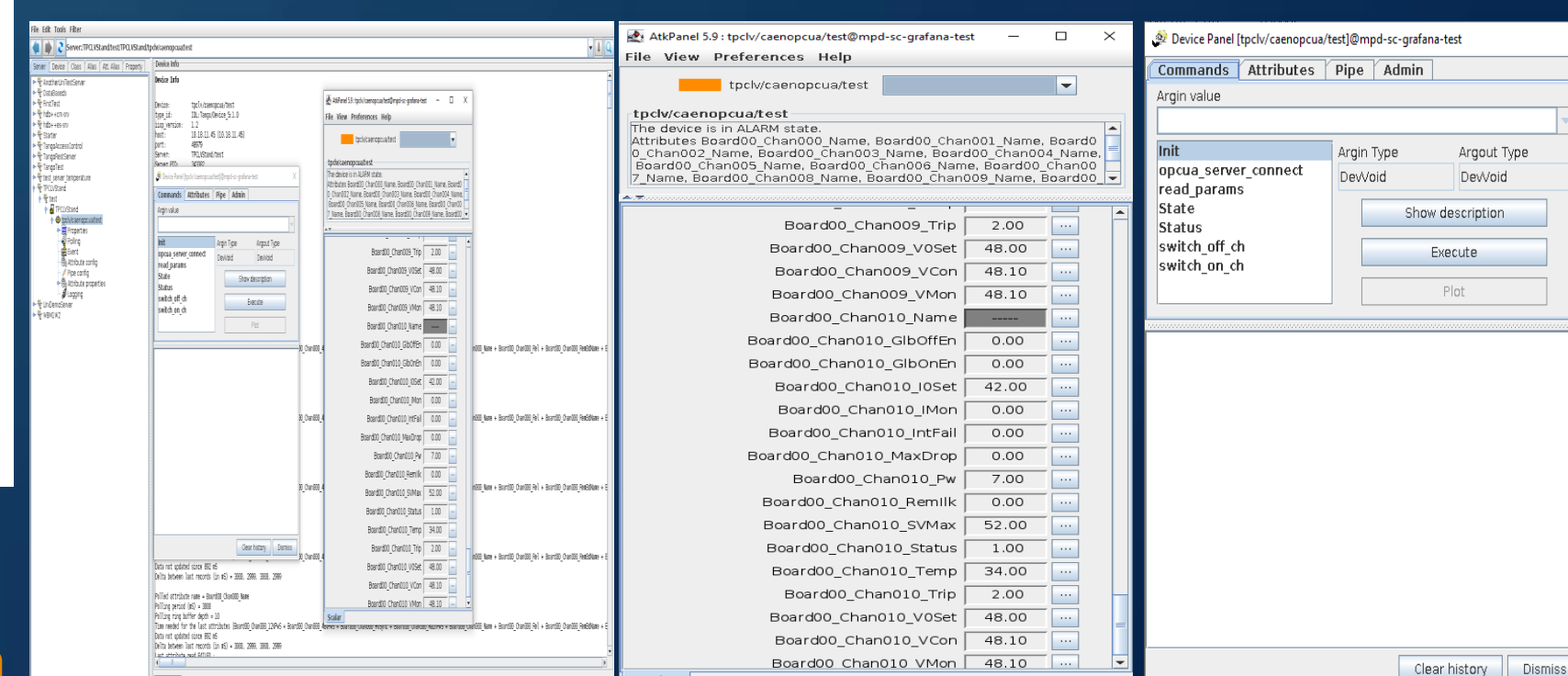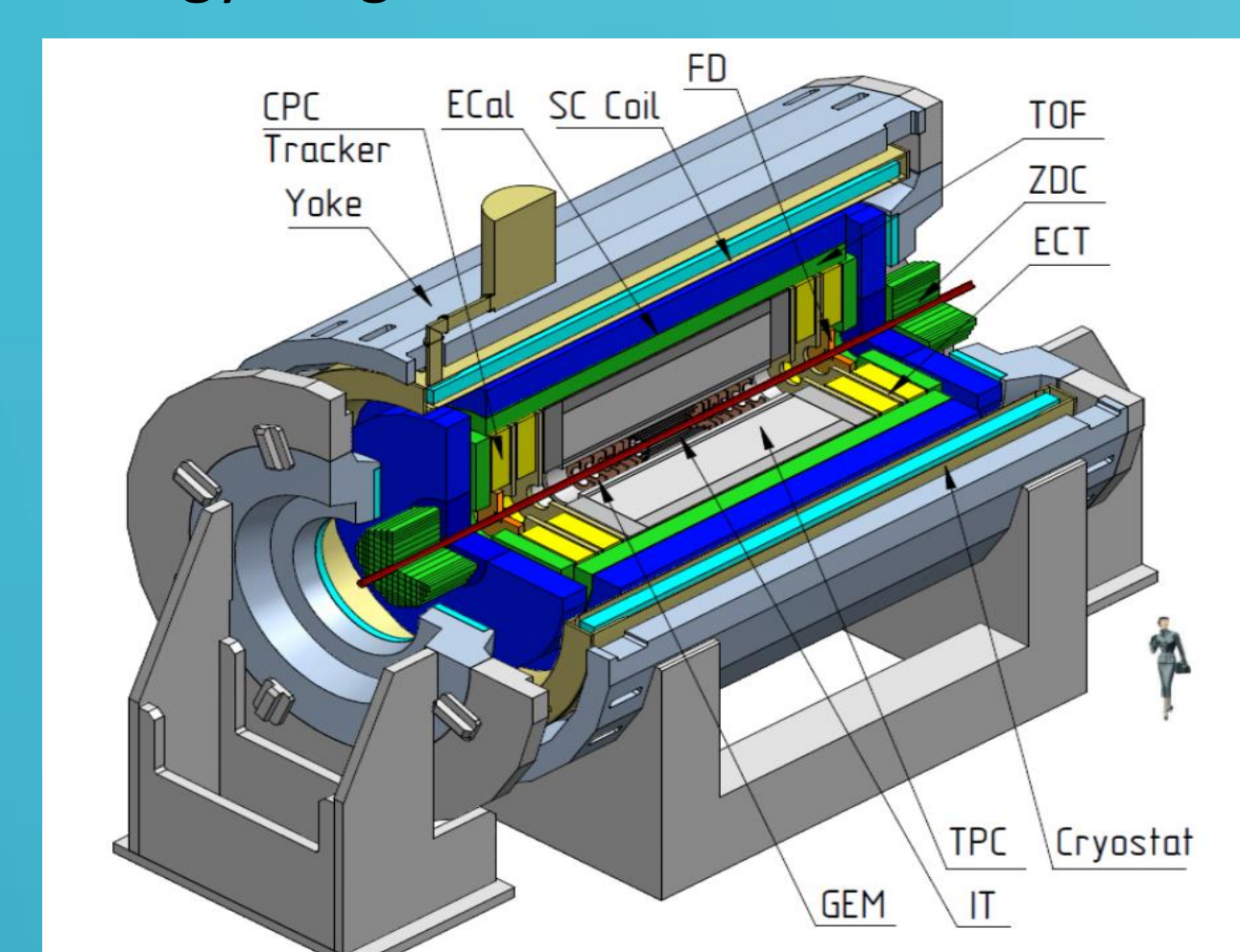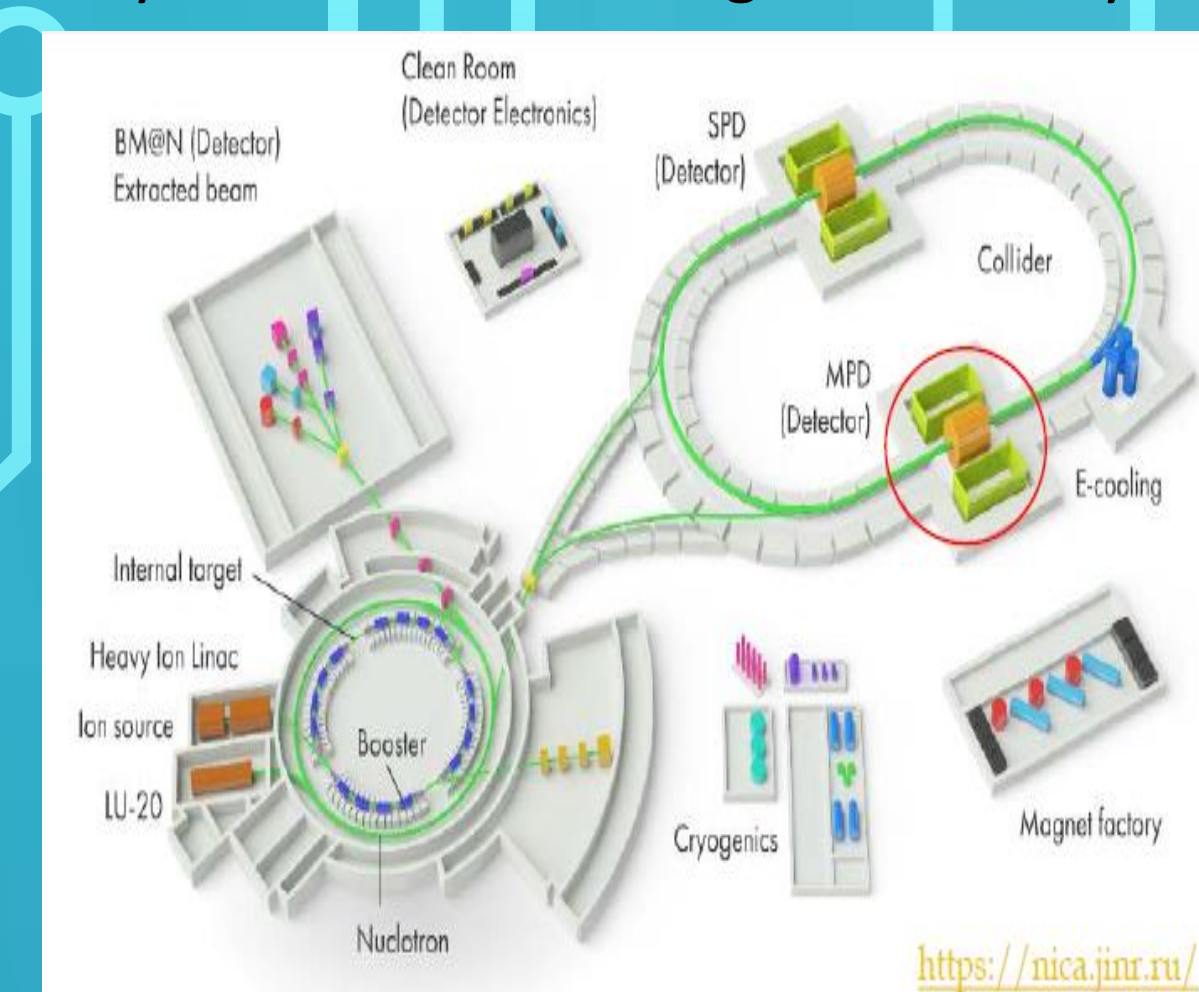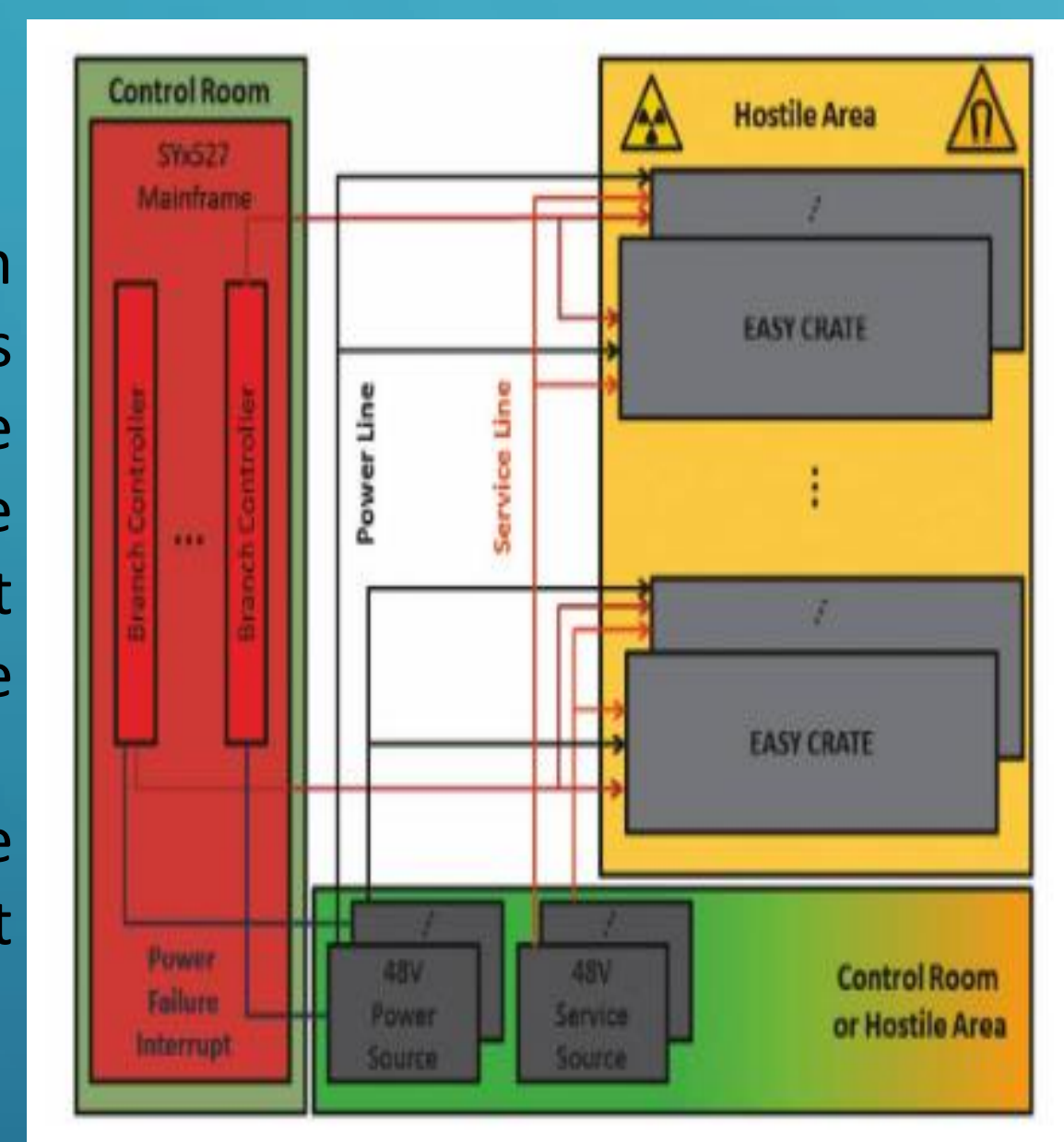
Results for HV and LV Control, Monitoring.

Monitoring Currents, Voltages and states of EASY subsystem power supply modules.
- Channels depend on Voltage and current , so as represented on Grafana screenshots it was 48 V, for 9-th and 10-th channels, and 13.5 V for 1-st channel.
- The first channel of A1676 controller connected to A3100HB power supply board(current: 0 - 52 Ampere, Voltage: 8-14 Volt).
- The third, fifth and sevens channels of A1676 branch controller connected to A3100B power supply board (0-103 Ampere, 2-8 Volt).
- The ninth and tenth channels of A1676 branch controller connected to A3486 power supply board (0-42 Ampere, 44-52 Volt).
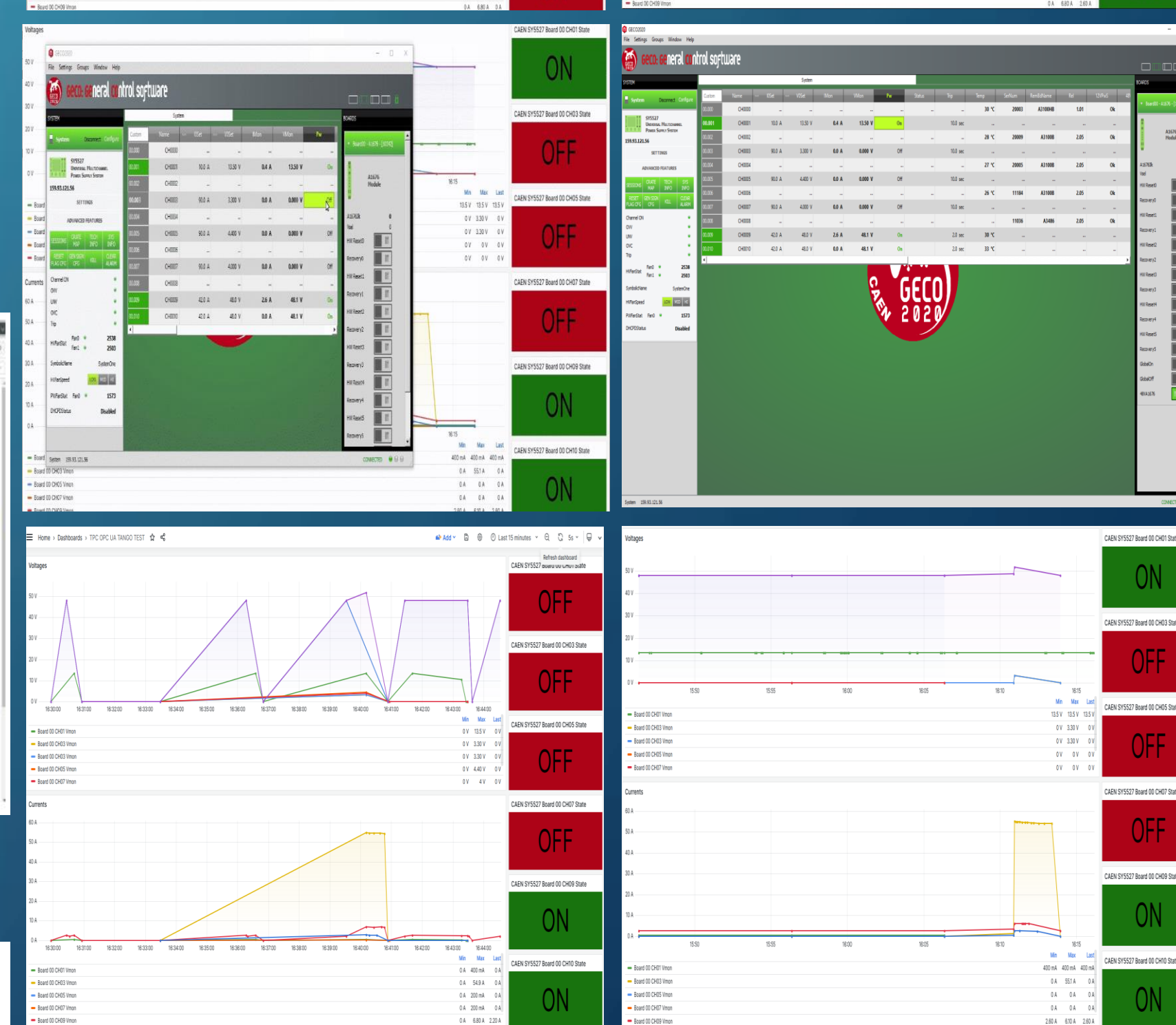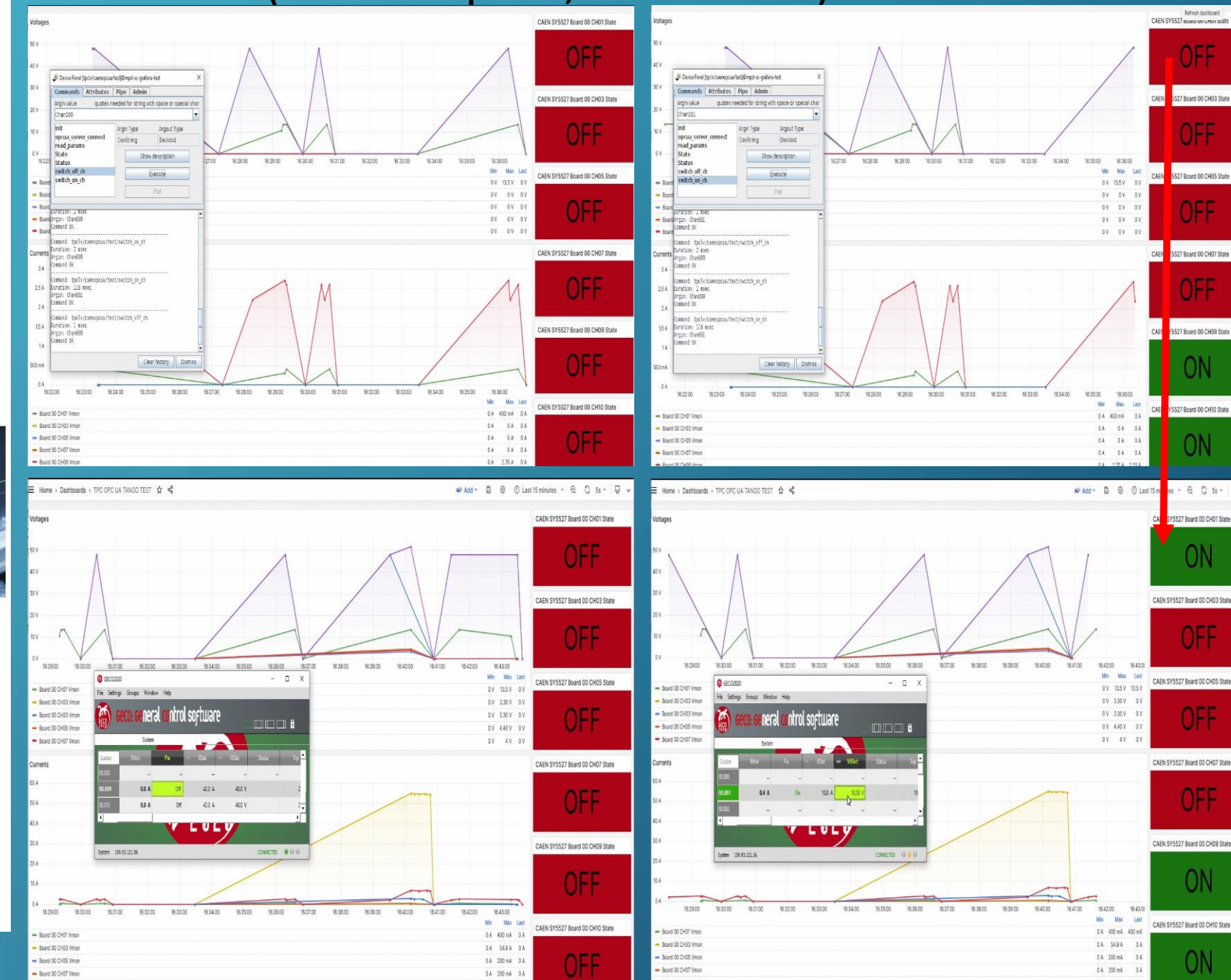
JIVA Control Panel Results

Conclusion

Our main goal is to create software using the tools of Tango software and the CAEN OPC server for control and monitoring of all the parameters of high- and low-voltage TPC subsystem.

Acknowledgement