Slow Control for MPD TPC LV and HV systems based on CAEN Equipment

Full name

Youmna Ghoneim

Nuclear Engineer, 2nd Phd Student, Work for MPD Project at JINR

Former Chair of NAC division for INMM.

Fellow through Marie Curie IAEA Fellowship.

Objective

Iam really proud to conduct my Career in a team oriented environment like JINR.

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.

I'm a nuclear Engineer, a proud IAEA Marie-Sklodowska Curie fellow with Certified Level II Non-destructive Testing Examiner According to ASNT-TC-1A in the five methods of NDT (Non-Destructive Testing).

Work experience

- 06/2023 up till now as a research work at the Joint Institute for Nuclear Materials Research (JINR) at NICA (Nuclotron-based Ion Collider facility) project.
- 06/2023 up to now, Mentee remote position with administrative and research perspectives in more than Divisions, in Institute of Nuclear Materials Management INMM.
- 10/2022 up 06/2023 as a chair for the Non-proliferation and Arms Control (NAC) Division, Institute of Nuclear Materials Management (INMM).
- 12/2020 up 07/2023 Fellow through Marie curie fellowship from IAEA for Nuclear woman Master Studies.
- 11/2018 up till now, freelance work "technical writing, scientific research" with more than search engines.
- 4/2018-10/2018 work as NDT (Non-Destructive test) instructor at APEX-FI flawless industry company in Alexandria, Egypt.
- 1/2018-3/2018 work on Trainee Courses related to non-destructive test techniques to receive Certifications of Level II Non-destructive Testing Examiner According to ASNT- TC-1A in the five methods of NDT (Non-Destructive Testing).

Education

(2022-2026) PHD Student for a Nuclear engineering program at Tomsk polytechnic university, Russia.

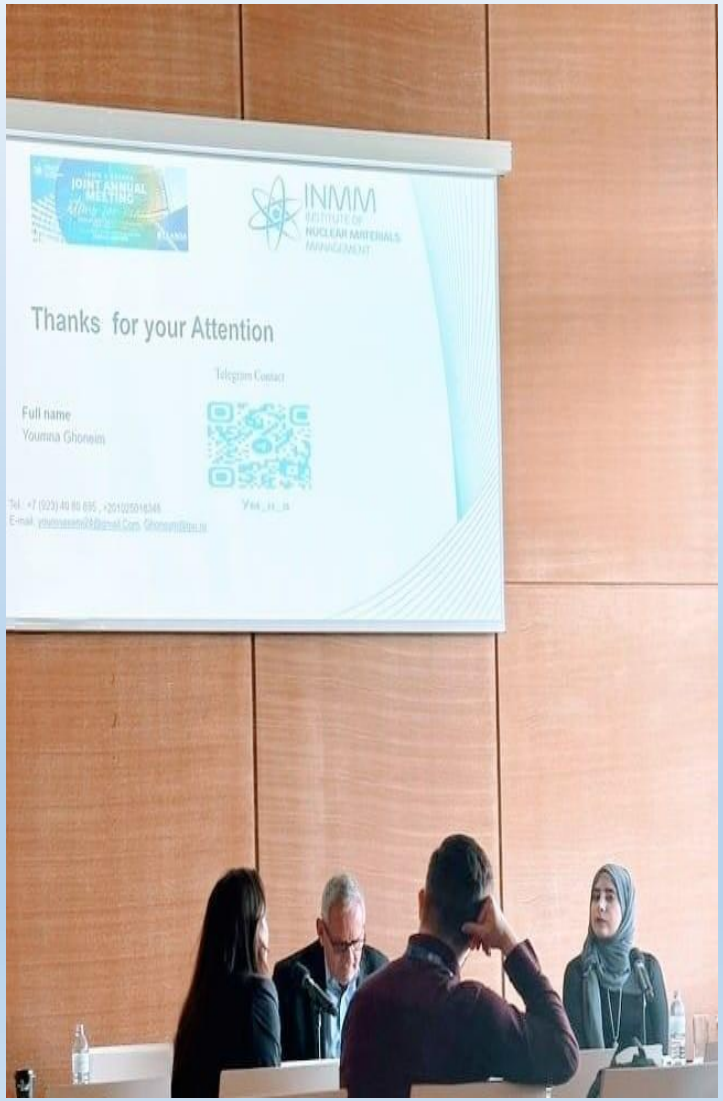
Research study: Plasma utilization of waste for spent nuclear fuel treatment.

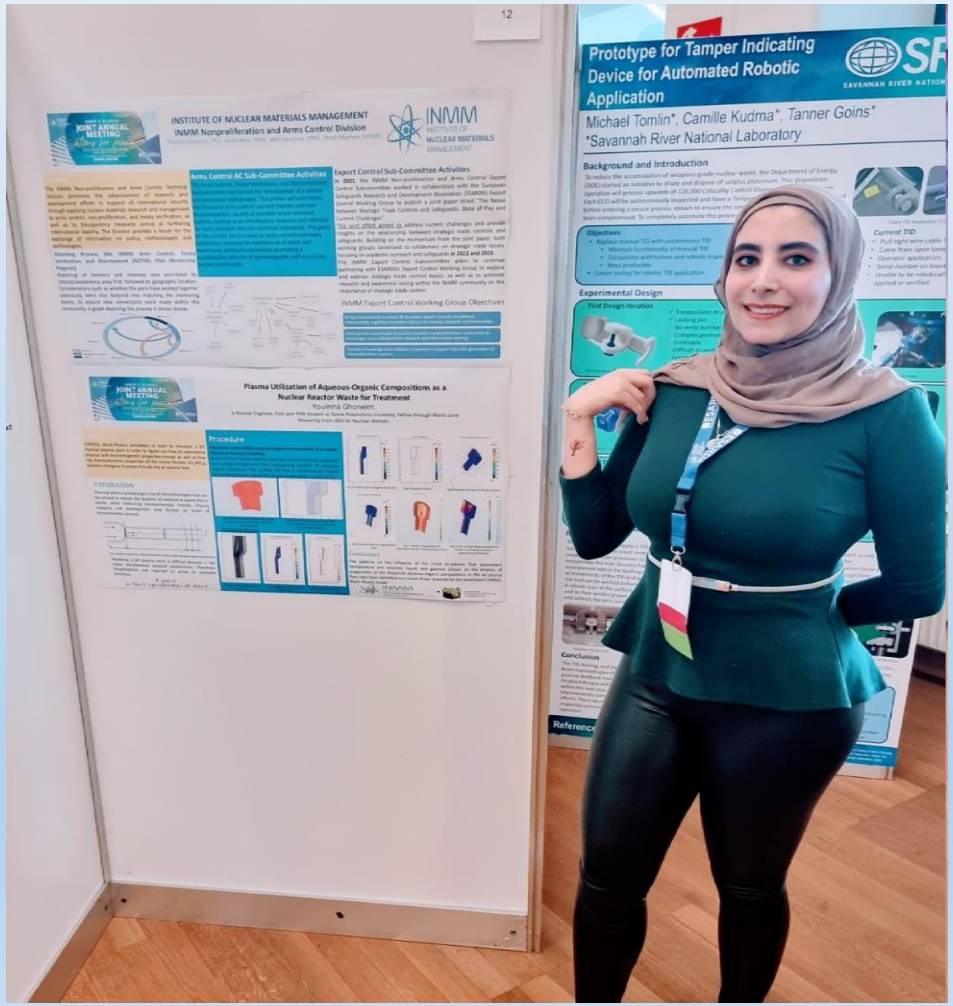
(2020-2022) A master Degree for a nuclear engineering program at Tomsk polytechnic university, Russia from 1/9/2020 up to 30/6/2022.

Research study for Plasma utilization of waste for spent nuclear fuel treatment, Grade: Distinction

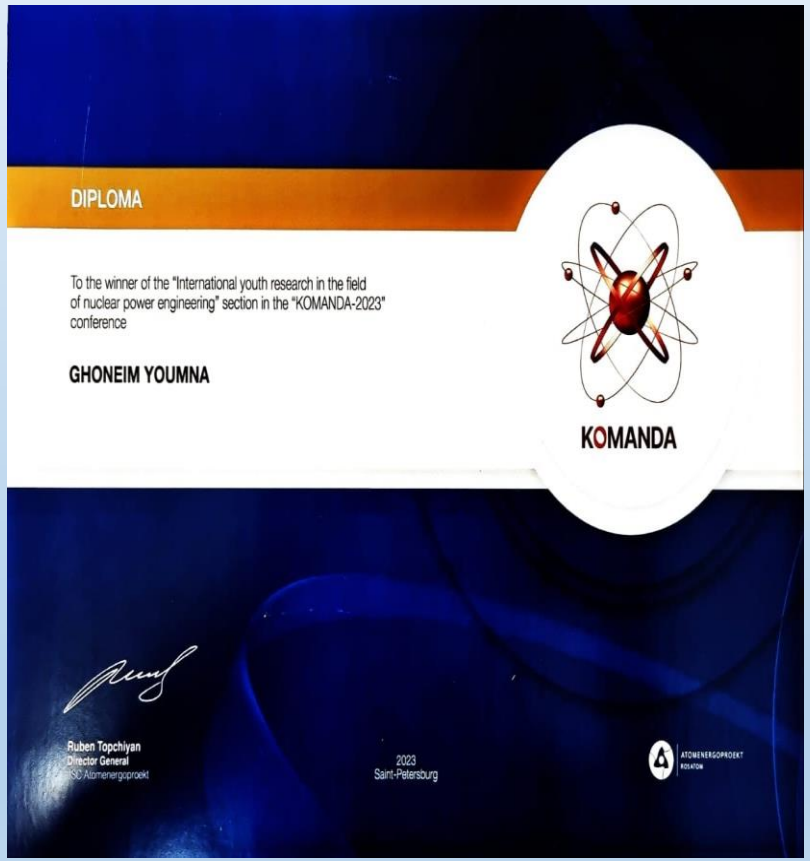
(2012 – 2017) B.Sc. degree in Nuclear Engineering, Alexandria University, Faculty of Engineering, Egypt.

Speaker as a Chair for Non Proliferation and Arms Control Division for INMM 64rd annual meeting May, 2023.





First winner for research work on plasma utilization for reactor waste treatment, in the KOMANDA event June 2023.



Publications

1 Research paper about Plasma utilization of waste after spent nuclear fuel processing through russian competition

scientific research works of pre graduate and graduate students "application of modern physical and technical knowledge".

2Research paper & Abstract for poster submission about end-of-life management of discussed radioactive sources topic for INMM 63rd annual virtual meeting July 24-28, 2022.

3Essay about Innovations related to fast reactors nuclear technology and related fuel cycles through International Conference on Fast Reactors and Related Fuel Cycles (FR22) IAEA Headquarters, Vienna, Austria 19 to 22 April 2022.

4Article about Spent Nuclear Fuel effect related to nuclear technology through the II International Science and Practical Conference “171; Scientific Initiative of Foreign Students and Graduate Students (Tomsk, April 26-28, 2022).

5 Research work, Radiation technologies in science, industry and medicine, Topic: Plasma disposal of spent nuclear

fuel reprocessing waste, in VI all-Russian Competition of Scientific Research Works Students and Post Graduates of Russian Higher Education Institutions for Natural, Technical and Humanities "Step into Science".

6 Research work, radiation technologies in science, industry and medicine, topic: plasma disposal of spent nuclear

fuel reprocessing waste, in vi all-Russian competition of scientific research works students and post graduates of Russian higher education institutions for natural, technical and humanities "step into science.

7 Article about boron filled polyethylene shielding ceramic-metal applied for composite shielding to nuclear radiation the 3rd international conference "scientific initiative of international students and postgraduates “April, 25-27 2023.

Publications Followed

8 Research paper about nuclear reactor modeling using ‘COMSOL multi-physics’ for nuclear fuel element xx international

conference of students, postgraduates and young scientists “prospects for the development of fundamental sciences “Russia, Tomsk, April 25–28, 2023.

9 Research paper about air-plasma disposal of spent nuclear fuel reprocessing waste through xxiii international scientific

and practical conference of students and Young scientist’s chemistry and chemical technology in the xxi century xxt-2022 may 16 - 19, 2023, Tomsk.

10 Research paper about principles of pet imaging tools and pet protocols using COMSOL simulation through xxiii

international scientific and practical conference of students and young scientist’s chemistry and chemical technology in the xxi century xxt-2022 may 16 - 19, 2023, Tomsk.

11 Research paper about neutron distribution during the operation of VVER reactor 1000-mw through xxiii international

scientific and practical conference of students and young scientist’s chemistry and chemical technology in the xxi century xxt-2022 may 16 - 19, 2023, Tomsk.

12Research paper & poster submission about Plasma Utilization of Aqueous-Organic Compositions as a Nuclear Reactor Waste for Treatment topic for INMM 64rd annual meeting May 22-26, 2023.

13Position Paper for NAC division about Iran's Uranium Enrichment reaches a new Peak, placing diplomacy in a Conflict for INMM 64rd annual meeting May 22-26, 2023.

14 Poster for NAC division of the INMM for INMM 64rd annual meeting May 22-26, 2023.

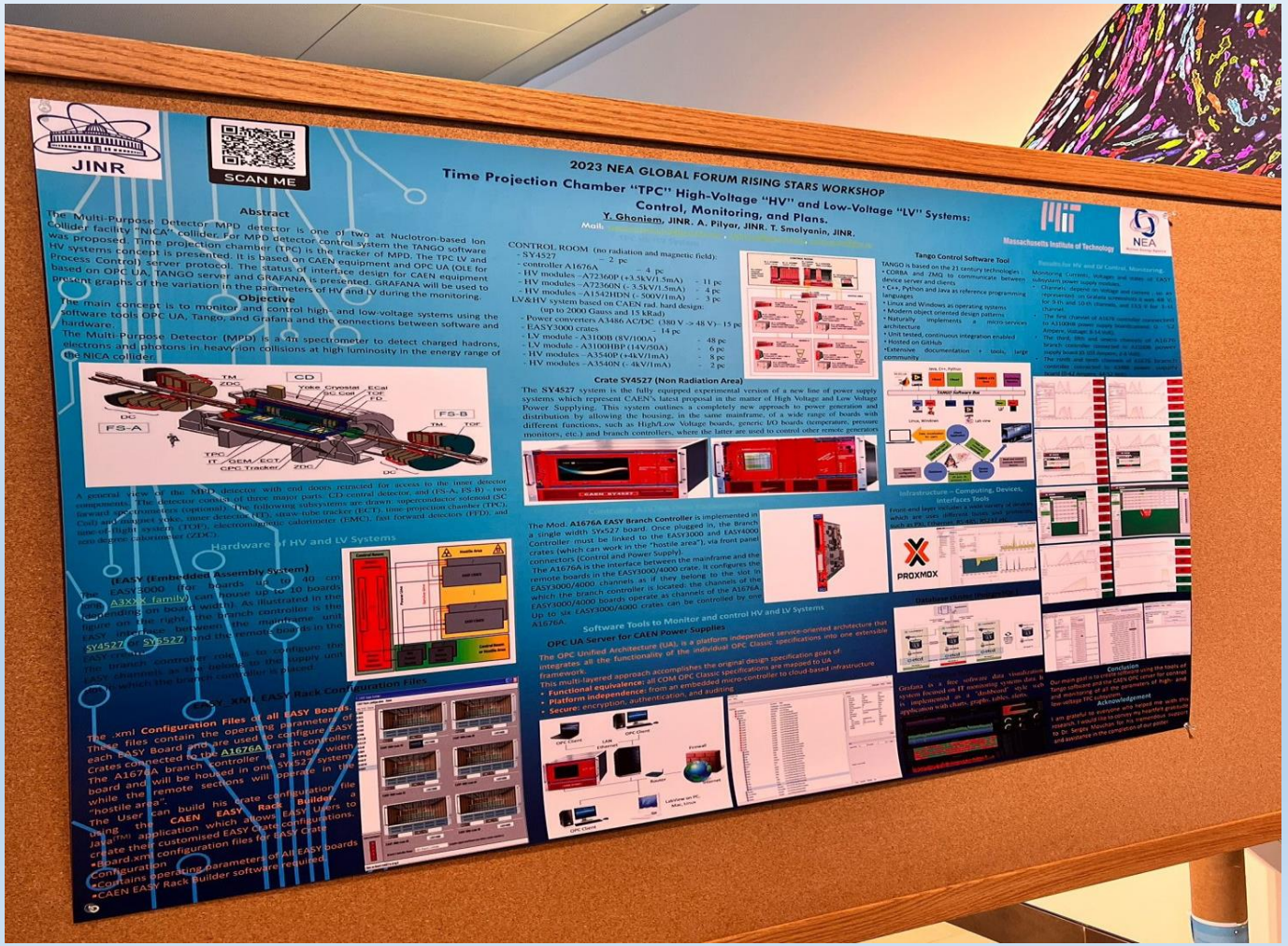
15Research paper about plasma utilization for nuclear reactor waste treatment in the event (x international scientific and practical conference of young scientists and specialists of the nuclear industry "team, June 28 to July 01 2023.

My Awards

1. I have been chosen as a rising star for my research work in the NEA Global Forum Rising Stars Program, which is organized under the guidance of the Massachusetts Institute of Technology and the Nuclear Energy Agency for a workshop in September 2023.
2. Diploma of the 1st degree for the First winner for research work on plasma utilization for reactor waste treatment, in the KOMANDA event (x international scientific and practical conference of young scientists and specialists of the nuclear industry "team, June 28 to July 01 2023.
3. Diploma of the 1st degree for the First winner for research work on plasma disposal of SNF processing waste based on the results of the all-Russian competition for Tomsk polytechnic university student and Postgraduate Students "Application of Modern Physical and Technical Knowledge", April2022.
4. Marie Curie fellowship for nuclear woman master student December 2021-July 2023. 5. The best graduation project on Nuclear and Radiation Engineering Department, 2017.
5. The best graduation project on Nuclear and Radiation Engineering Department, 2017.

The NEA Global Forum Rising Stars Programme

which is organized under the guidance of the Massachusetts Institute of Technology and the Nuclear Energy Agency for a workshop in September 2023 in Cambridge USA.

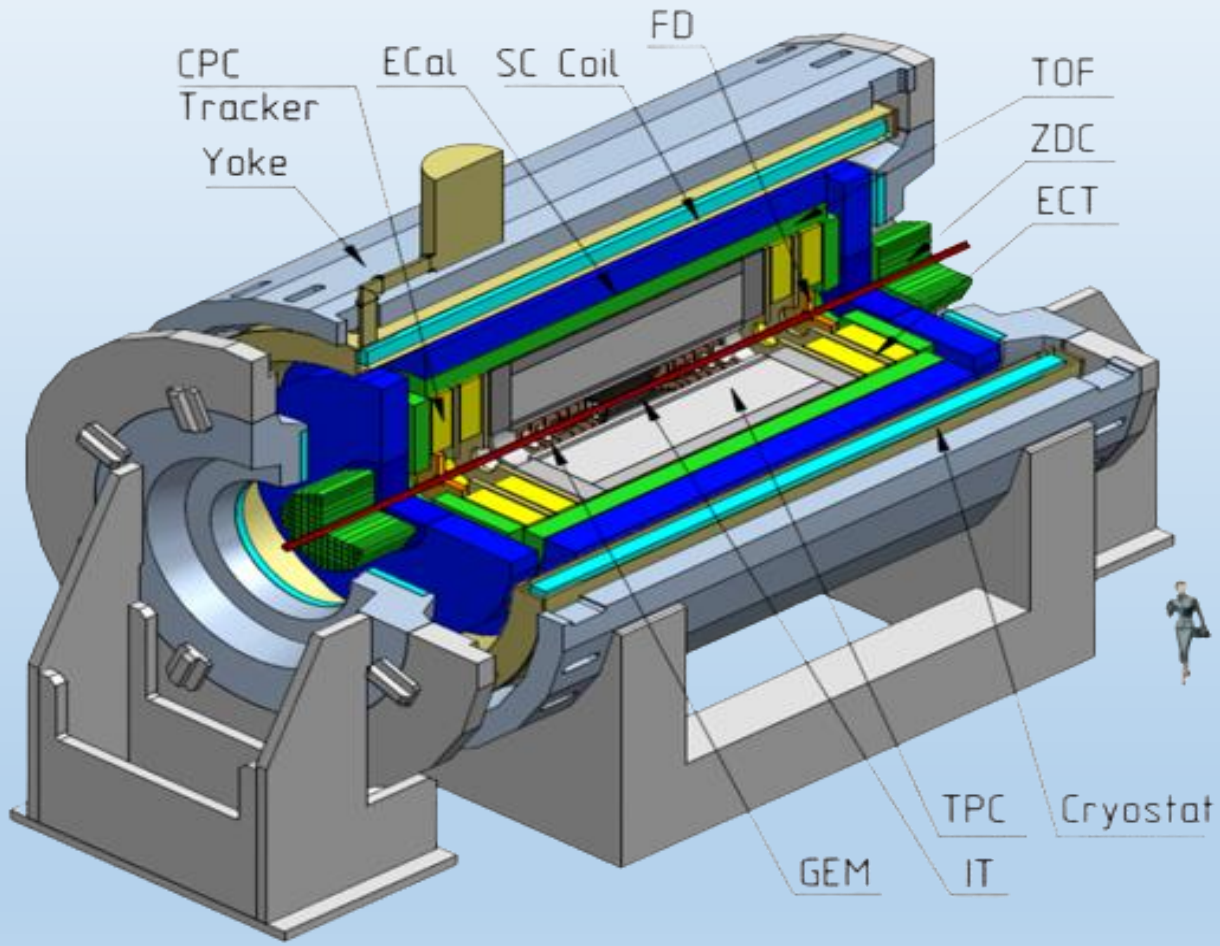


Let's move on to an abstract of Slow control for MPD TPC LV and HV systems based on CAEN Equipment

Y.Ghoniem, A.Pilyar, T.Smolyanin

MPD at NICA collider

The Multi-Purpose Detector (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 doors retracted for access to the inner detector components. The detector consist of three major parts: CD-central detector, and (FS-A, FS-B) - two forward spectrometers (optional). The following subsystems are drawn: superconductor solenoid (SC Coil) and magnet yoke, inner detector (IT), straw-tube tracker (ECT), time-projection chamber (TPC), time-of-flight system (TOF), electromagnetic calorimeter (EMC), fast forward detectors (FFD), and zero degree calorimeter (ZDC).

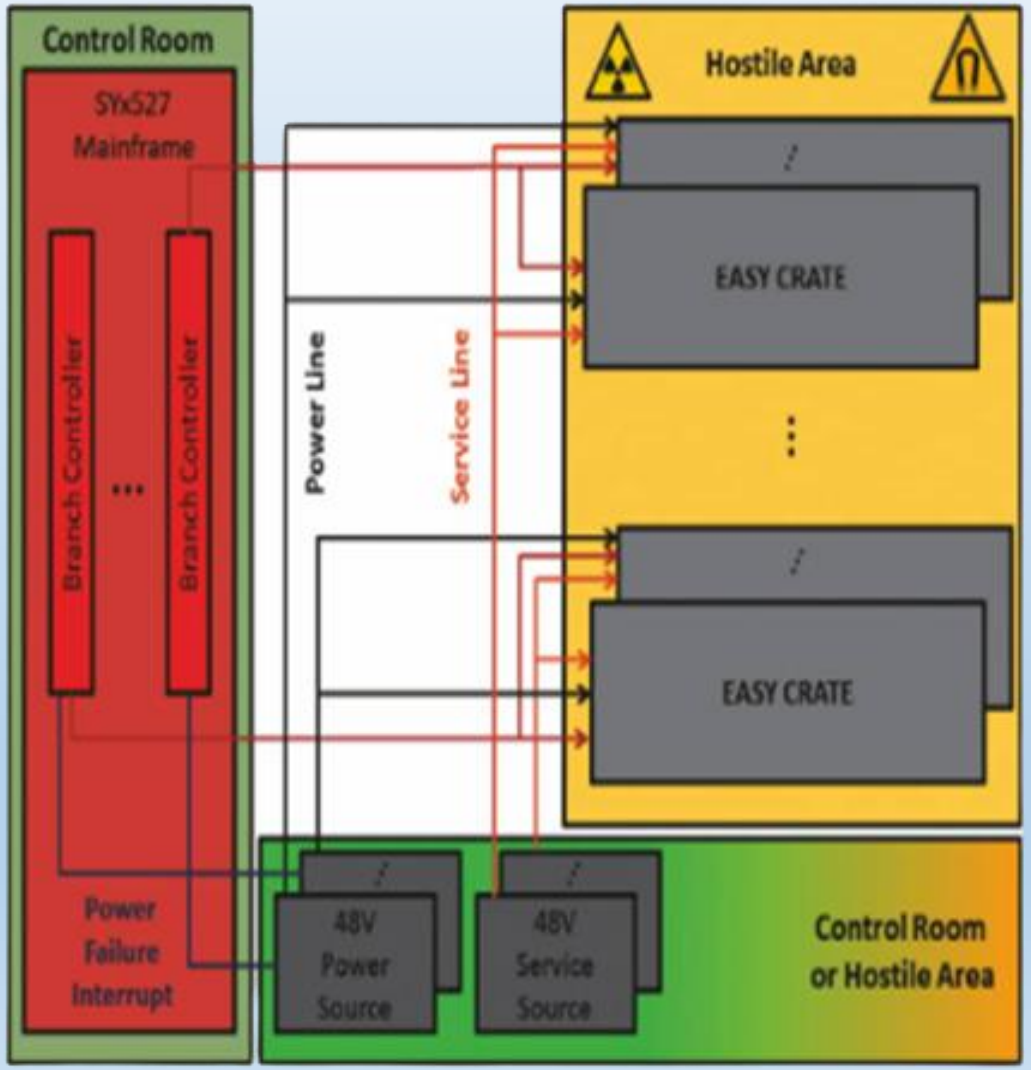
EASY (Embedded Assembly System)

Architecture

- The EASY3000 (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.

- In this way, all channels of the EASY boards will be considered as channels of the branch controller board, increasing the number of channels the system can handle.

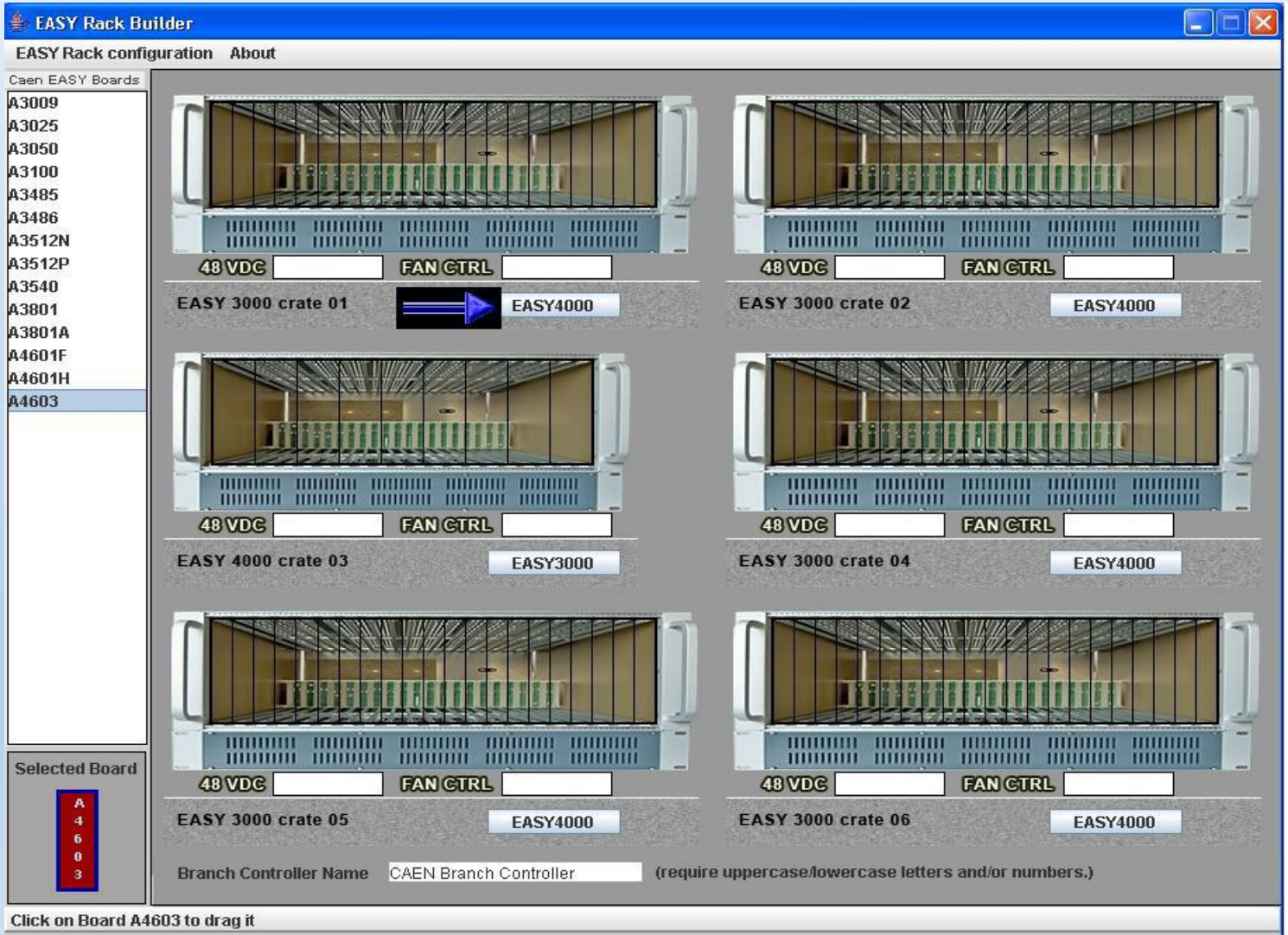


EASY_XML
EASY Rack Configuration Files

- 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 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



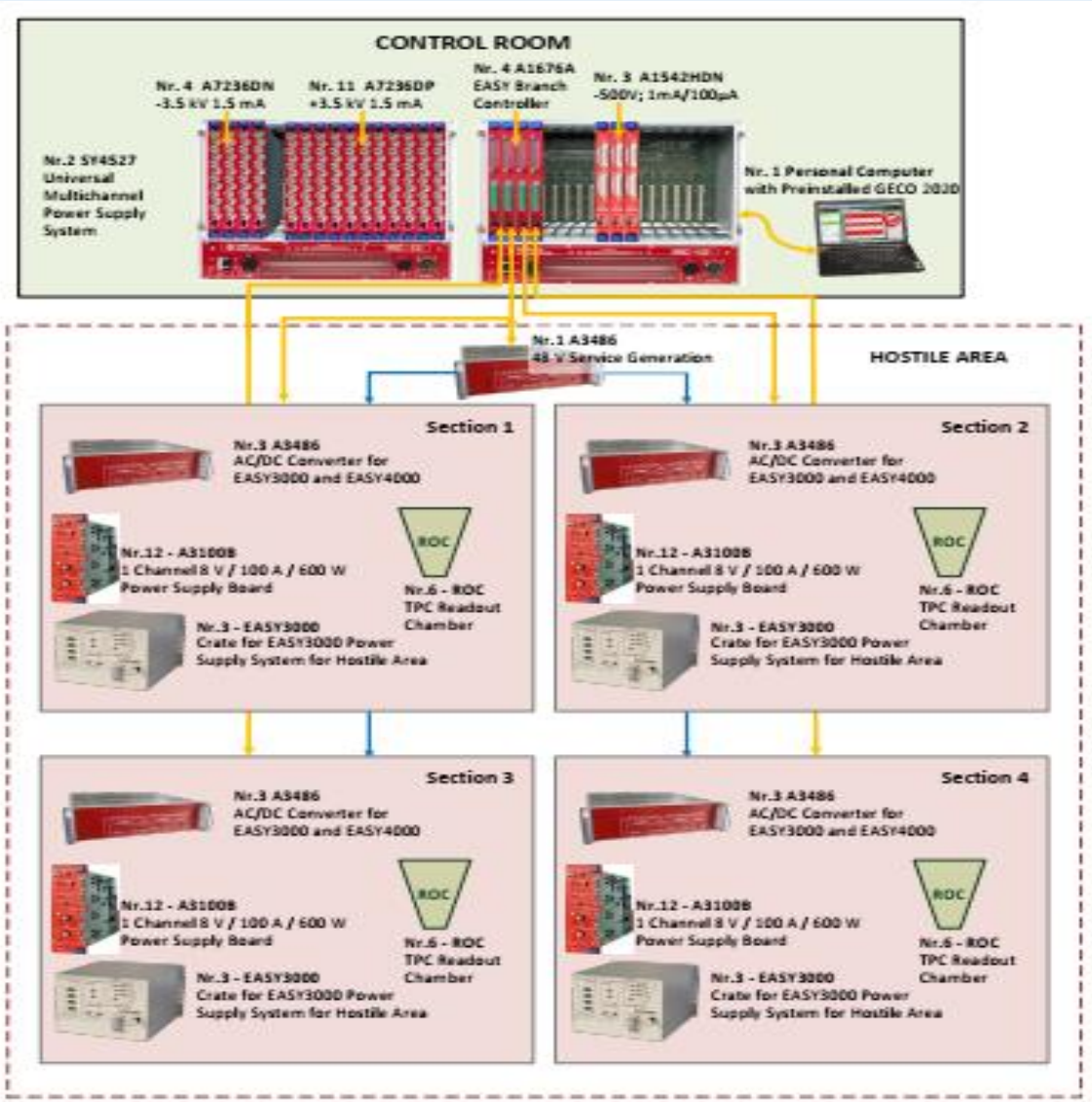
TPC HV+LV System

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

LV&HV system based on CAEN rad. hard design:
(up to 2000 Gauss and 15 kRad)

- Power converters A3486 AC/DC (380 V -> 48 V) – 15 pc
- 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)

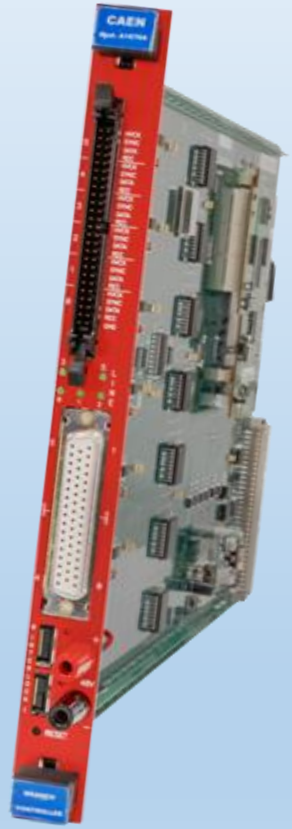
The **SY4527** system is the fully equipped experimental version of a new line of power supply systems which represent CAEN's latest proposal in the matter of High Voltage and Low Voltage Power Supplying.

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.



CAEN Control Software Models

OPC Server for CAEN Power Supplies

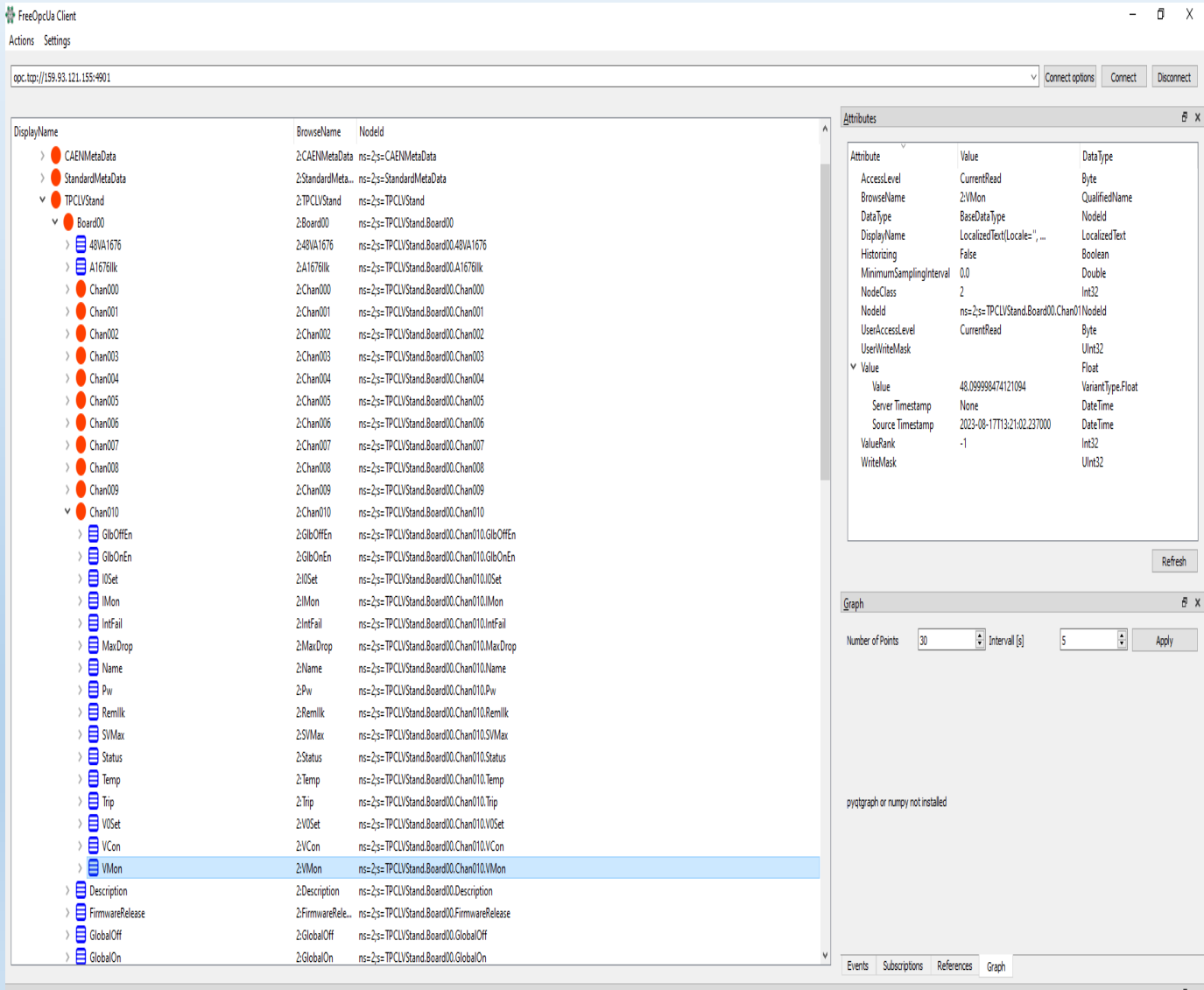
- CAEN, in close collaboration with CERN, has developed an **OPC Server** which allows powerful, flexible and yet simple control of its power supply systems by any OPC compliant client application.

- OPC (OLE for Process Control) is an open interface based on the OLE/COM and DCOM technology; OPC offers “Plug & Play” connectivity between disparate hardware devices.

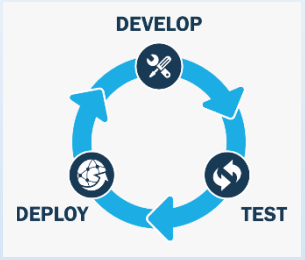
OPC Server for CAEN Power Supplies

- 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



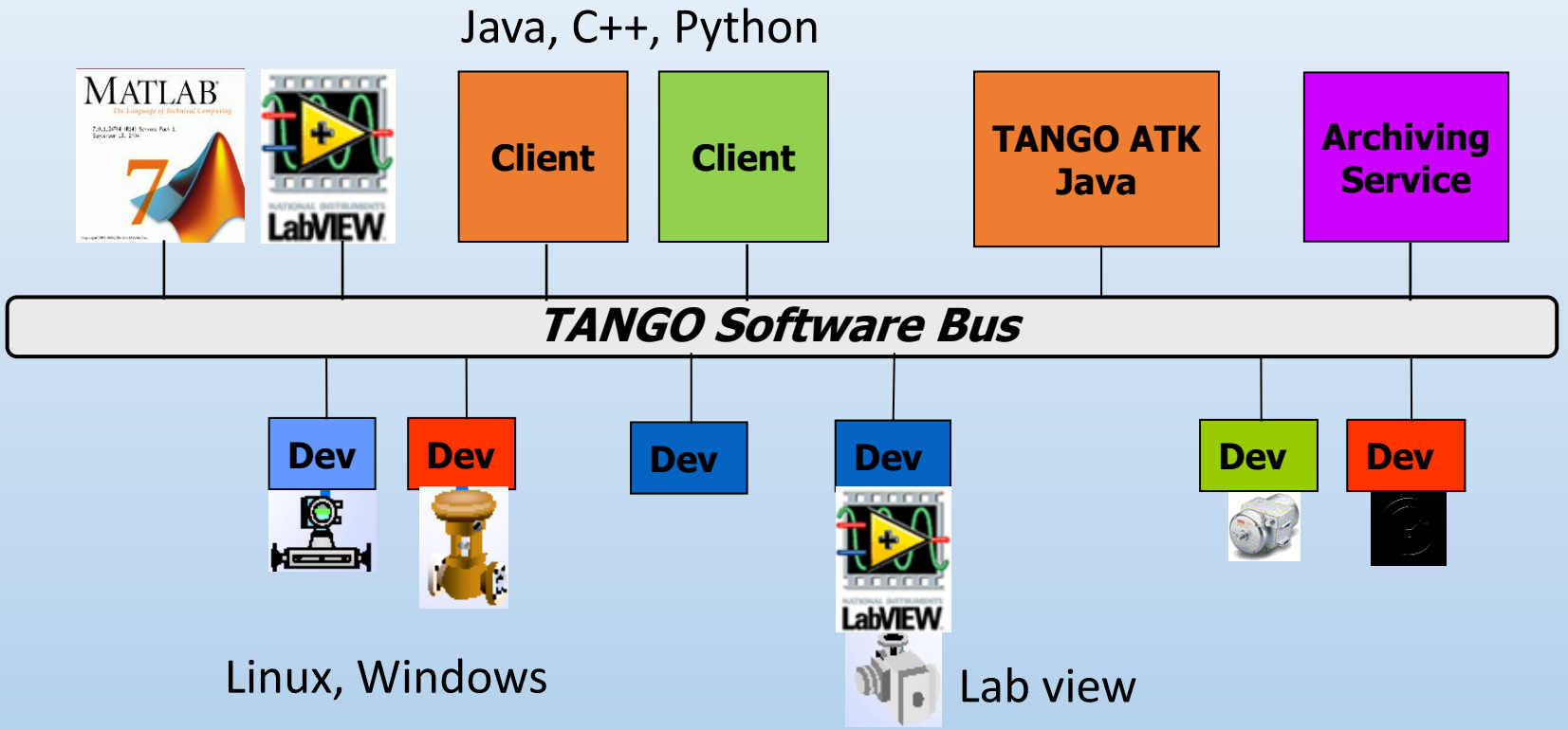
What is Tango Controls



TANGO is based on the 21 century technologies :

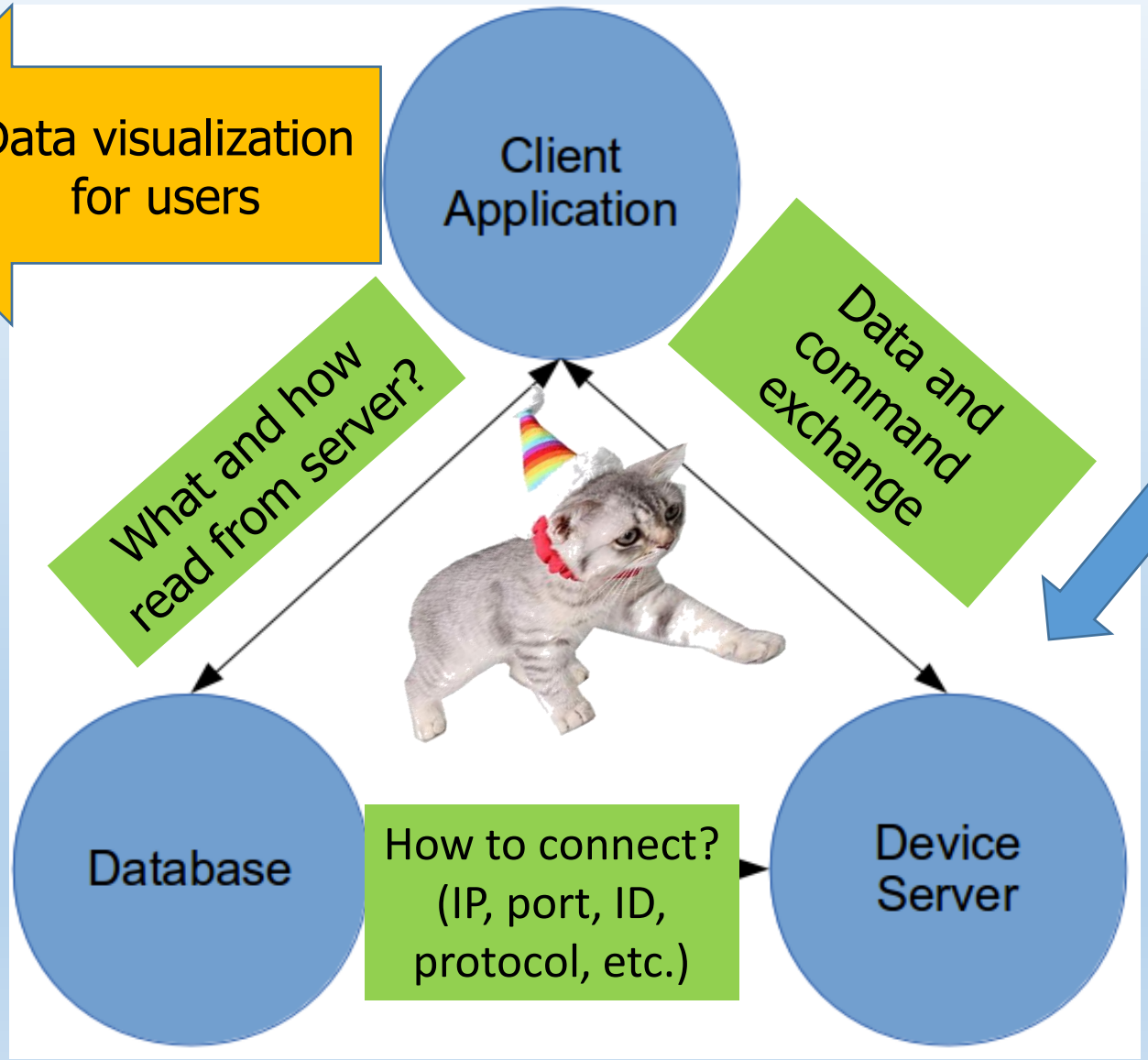
- CORBA and ZMQ to communicate between device server and clients
- C++, Python and Java as reference programming languages
- Linux and Windows as operating systems
- Modern object oriented design patterns
- Naturally implements a microservices architecture
- Unit tested, continuous integration enabled
- Hosted on Github (https://github.com/tango-controls)
- Extensive documentation + tools, large community

What is Tango Controls Followed



What is Tango Controls

Data visualization for users



Device configuration description

Read and control methods between devices

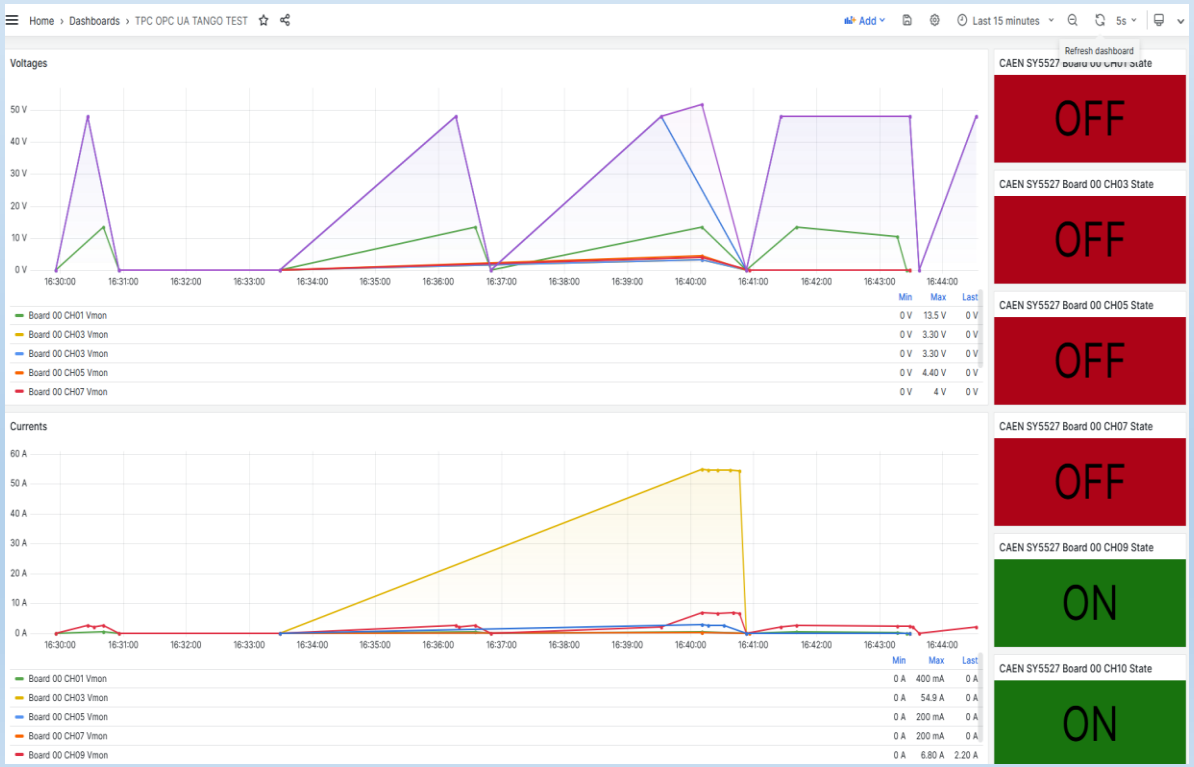
Infrastructure – computing, devices, interfaces…
Grafana Data Visualization

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.

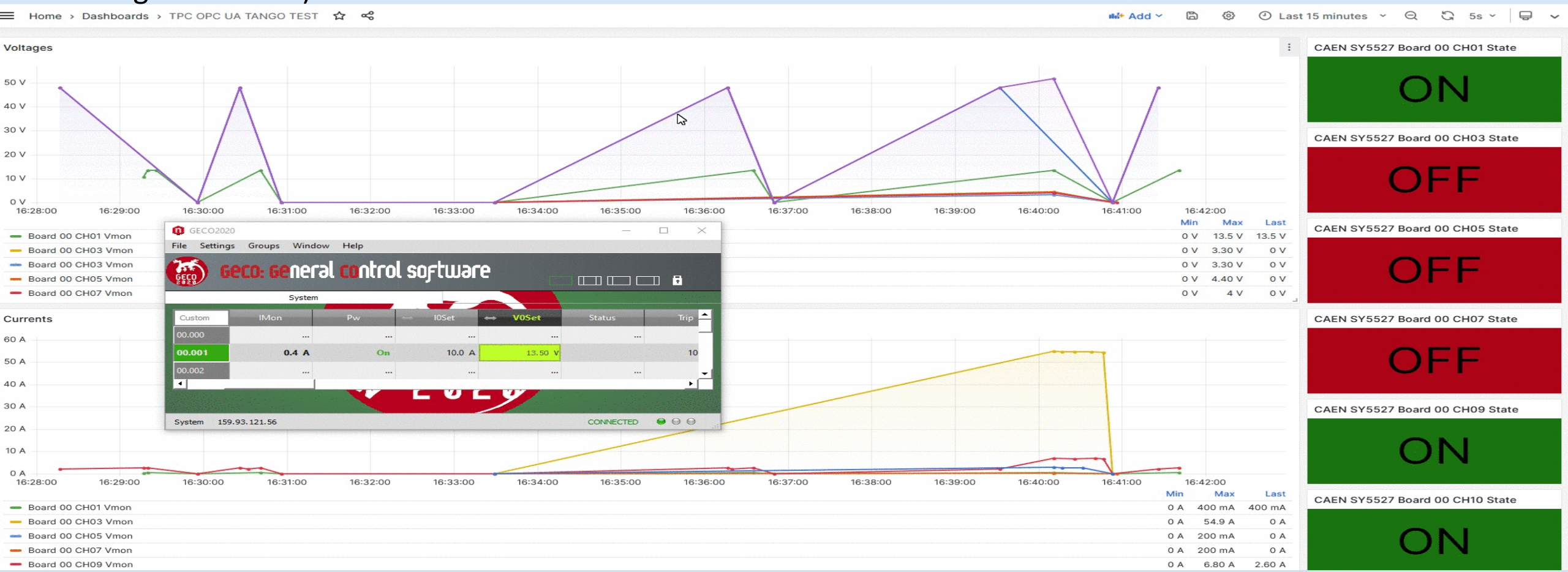
- Channels depend on Voltage and current , so as represented on Grafana screenshots it was 48 V, for 9-th and 10-th channels, and 13.5 V for 1-st channel.



Results for HV and LV Control, Monitoring, Followed

Monitoring Currents, Voltages and states of EASY subsystem power supply modules.

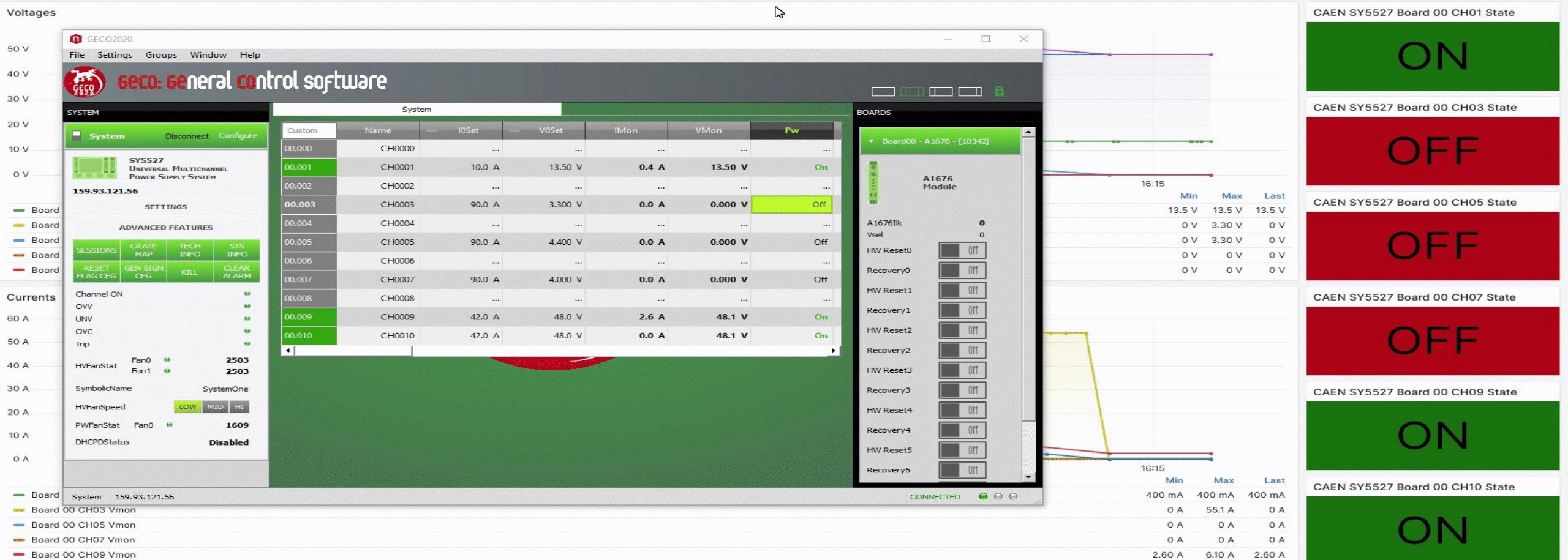
- The first channel of A1676 controller connected to A3100HB power supply board(current: 0 - 52 Ampere, Voltage: 8-14 Volt).



Results for HV and LV Control, Monitoring Followed

Monitoring Currents, Voltages and states of EASY subsystem power supply modules.

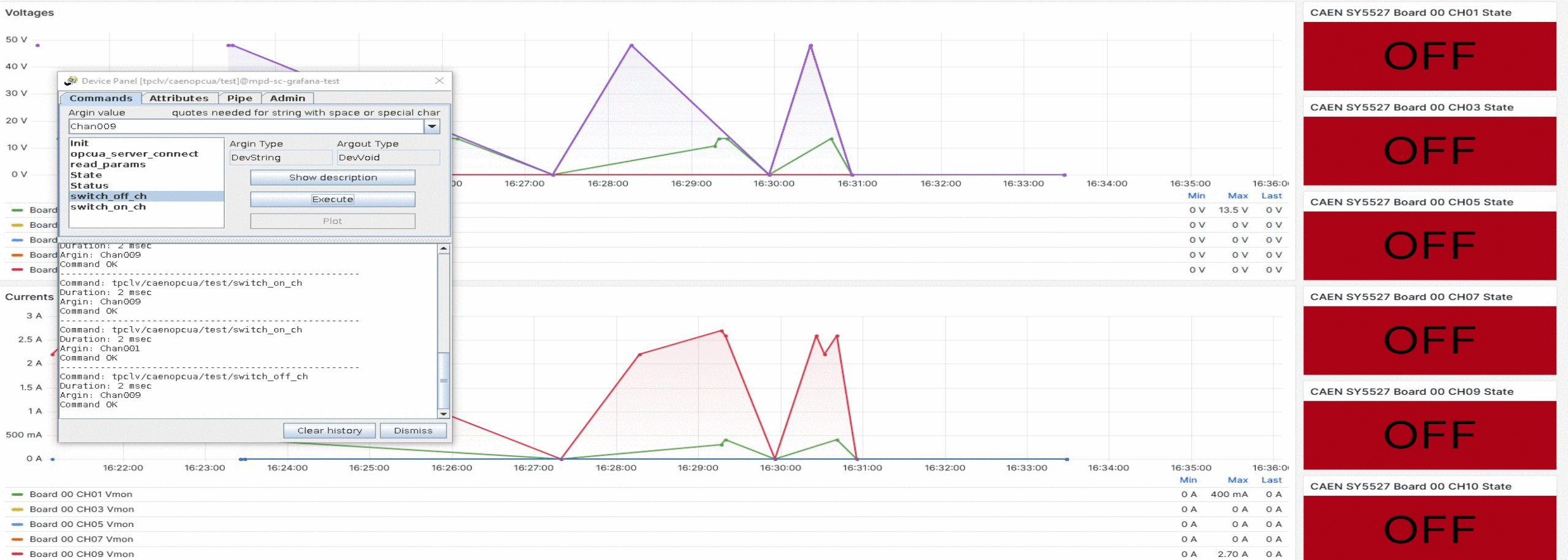
- The third, fifth and sevens channels of A1676 branch controller connected to A3100B power supply board (0-103 Ampere, 2-8 Volt).



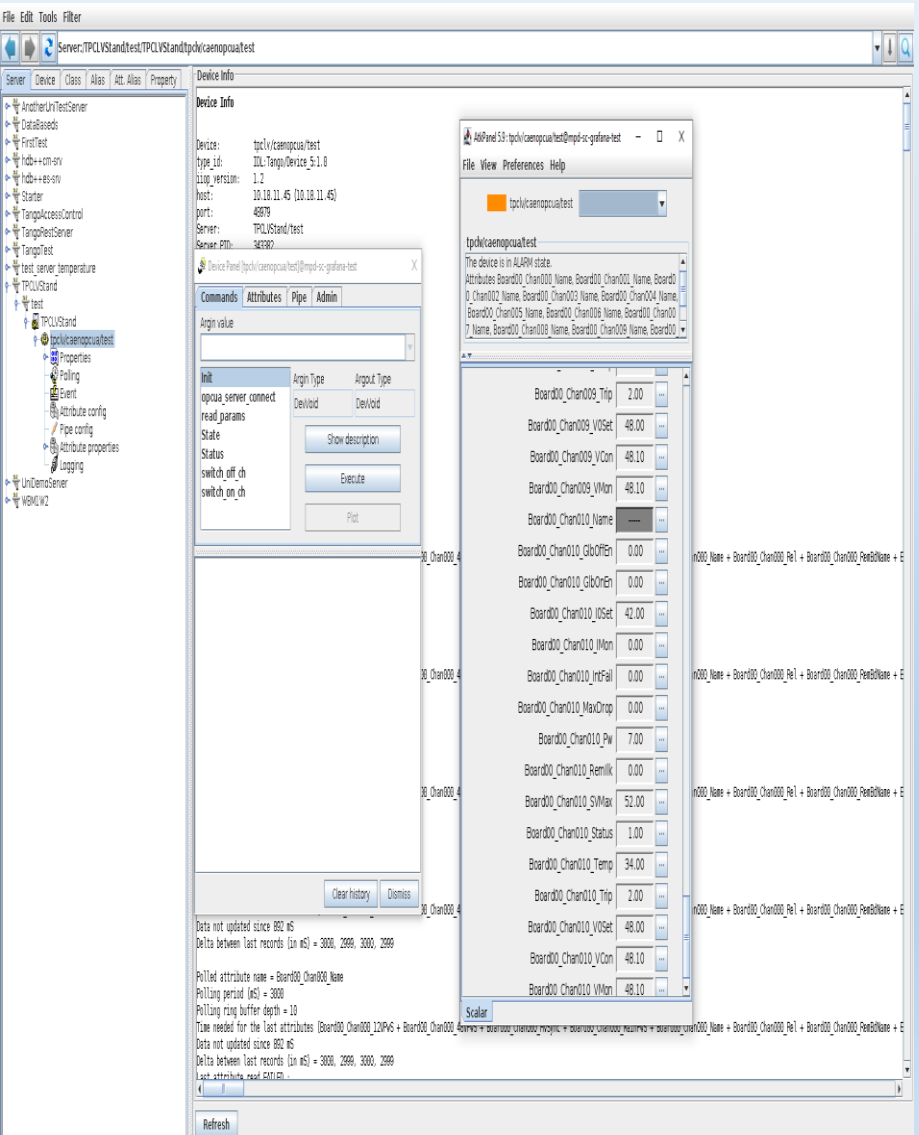
Results for HV and LV Control, Monitoring Followed

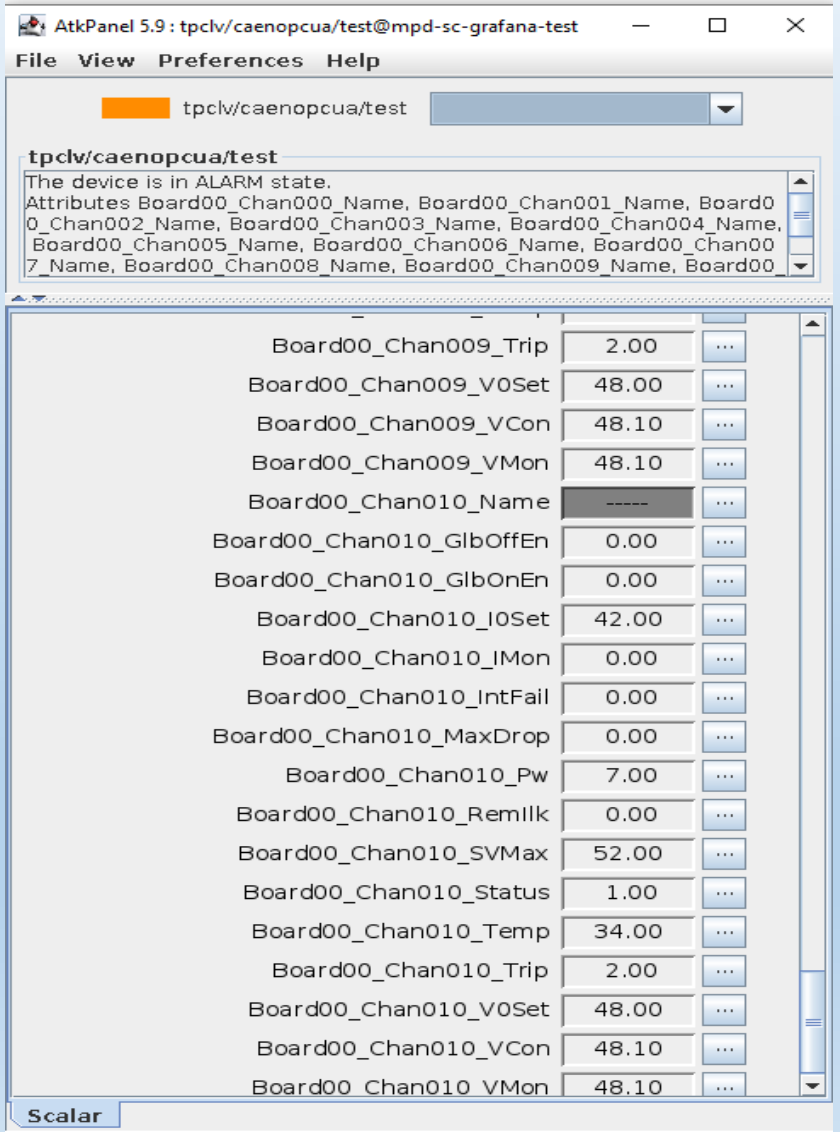
Monitoring Currents, Voltages and states of EASY subsystem power supply modules.

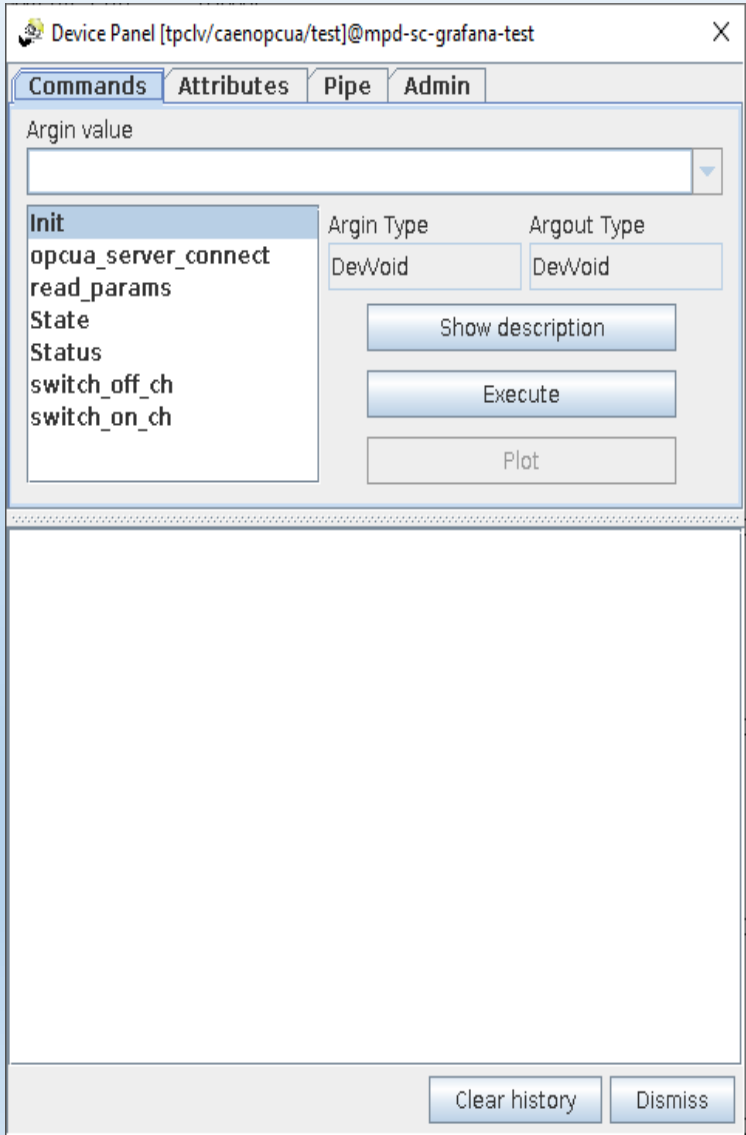
- The ninth and tenth channels of A1676 branch controller connected to A3486 power supply board (0-42 Ampere, 44-52 Volt).



JAVA Control Panel Results.





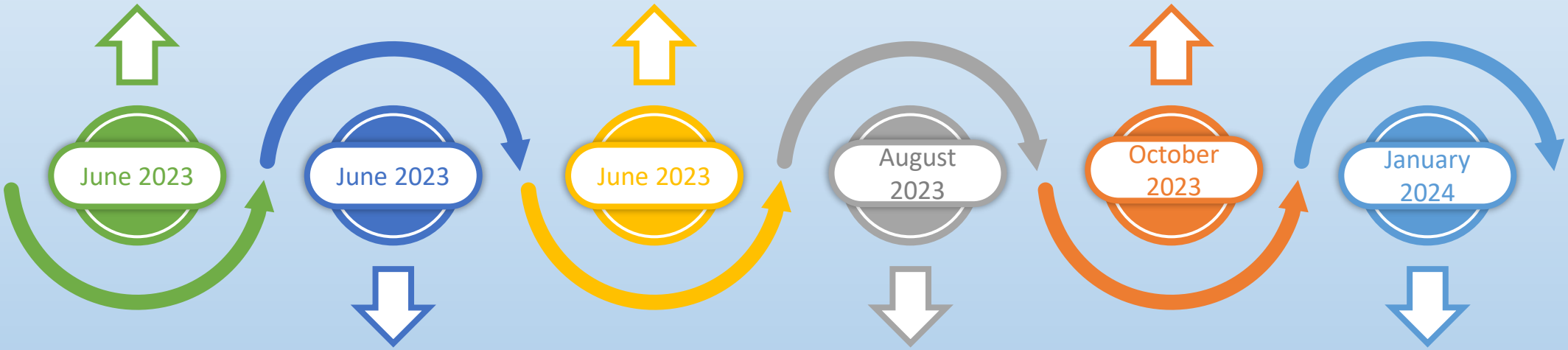


Time Frame

1.Connect between Server, Client to our Mainframe.

3.Read Data from modules through the Mainframe.

5. Create a graphic user interface (GUI) for TPC LV+HV subsystem



2.Install software tools used for control and monitoring variety of parameters.

4.Control and read data using Tango and OPC Server Tools.

6. Test and improve GUI

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.
- Create, test and optimize a graphic user interface (GUI) for TPC LV+HV subsystem. To do GUI for each TPC subsystem. combine the GUIs for each TPC subsystem to control and monitoring TPC detector (TPC DCS).

Acknowledgement

I am grateful to everyone who helped me with this research.
I would like to convey my heartfelt gratitude to Dr. Sergey Movchan for his tremendous support and assistance in the completion of our Research work ad Poster.

Thanks for your Attention

Scan here for PPT

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12.10.2023