



The protoDUNE Single Phase Detector Control System

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Outline

- The protoDUNE Single Phase (NP04) experiment
- Overall Detector Control System architecture
- Slow Control Software
- Hardware Layout
- Examples
- Conclusions

The protoDUNE Single Phase (NP04) experiment

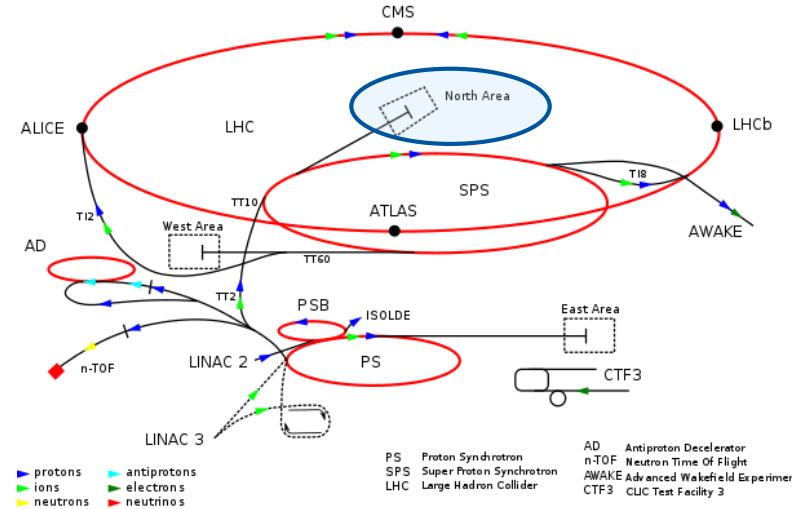
- Prototype of a Single-Phase Liquid Argon TPC for DUNE
- 0.77 kt LAr: largest monolithic single-phase LArTPC detector ^[1]
- Goals:
 - Prototype the **production and installation** procedures
 - **Validate the design** from the perspective of basic detector performance
 - **Calibrate the response** of the detector to different particle species
 - Demonstrate the **long-term operational** stability of the detector



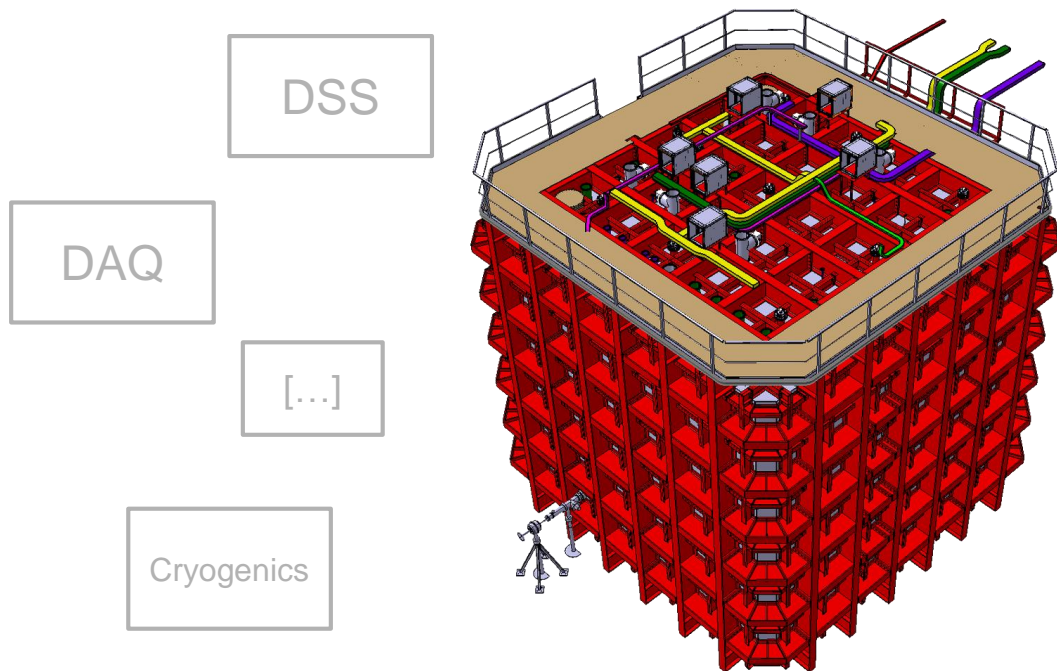
^[1] Cavanna, F., R. Rameika, and C. Touramanis. *Single-phase ProtoDUNE, the Prototype of a Single-Phase Liquid Argon TPC for DUNE at the CERN Neutrino Platform*. No. CERN-SPSC-2017-028. 2017.

The protoDUNE Single Phase (NP04) experiment

- Located in CERN Test Beam area EHN1
- Tertiary beam of the CERN SPS accelerator



Detector Control System



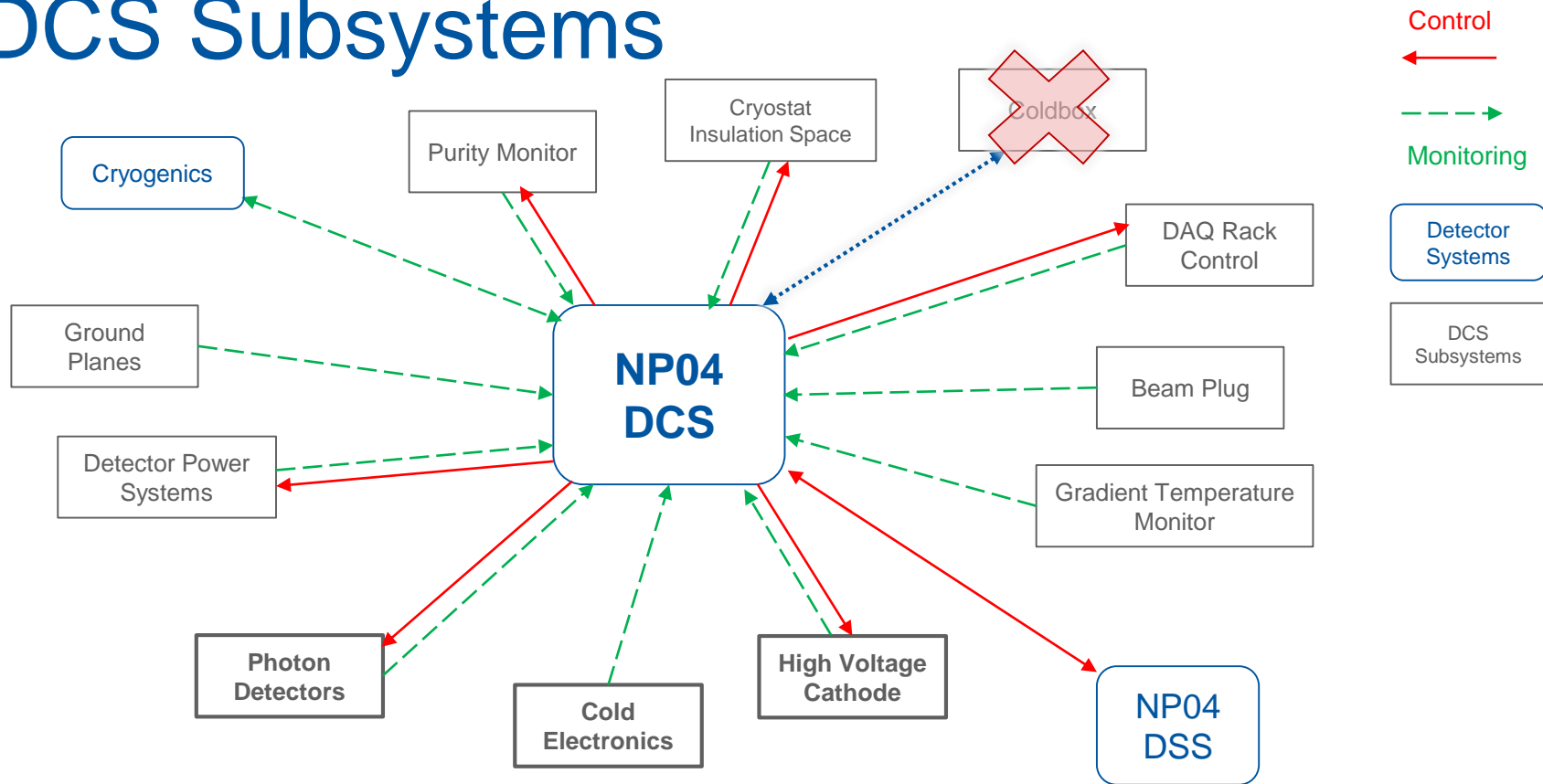
DCS

The DCS contains all the elements (hardware and software) which allow for proper **detector operation**

It is in charge:

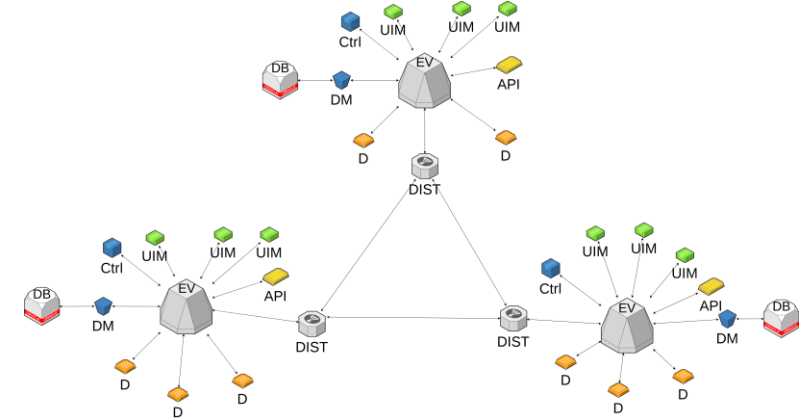
- **Monitoring** and **controlling** the detector
- Observing the **state**
 - Temperature, voltages, currents, etc.
- **Powering** different parts by sending specific commands
- Enabling/disabling **interlocks**.

DCS Subsystems



DCS Supervisory control and data acquisition

- SIEMENS Simatic WinCC Open Architecture®
- Extensively used at CERN, why?
 - Scalability
 - Multiplatform
 - Open Architecture
 - Long-term partnership with the company
- CERN Frameworks
 - Joint **C**ontrols **P**rojects (JCOP)
 - **U**nified Industrial **C**ontrol **S**ystem
 - Developed for the LHC accelerator and experiments, with **official CERN support**

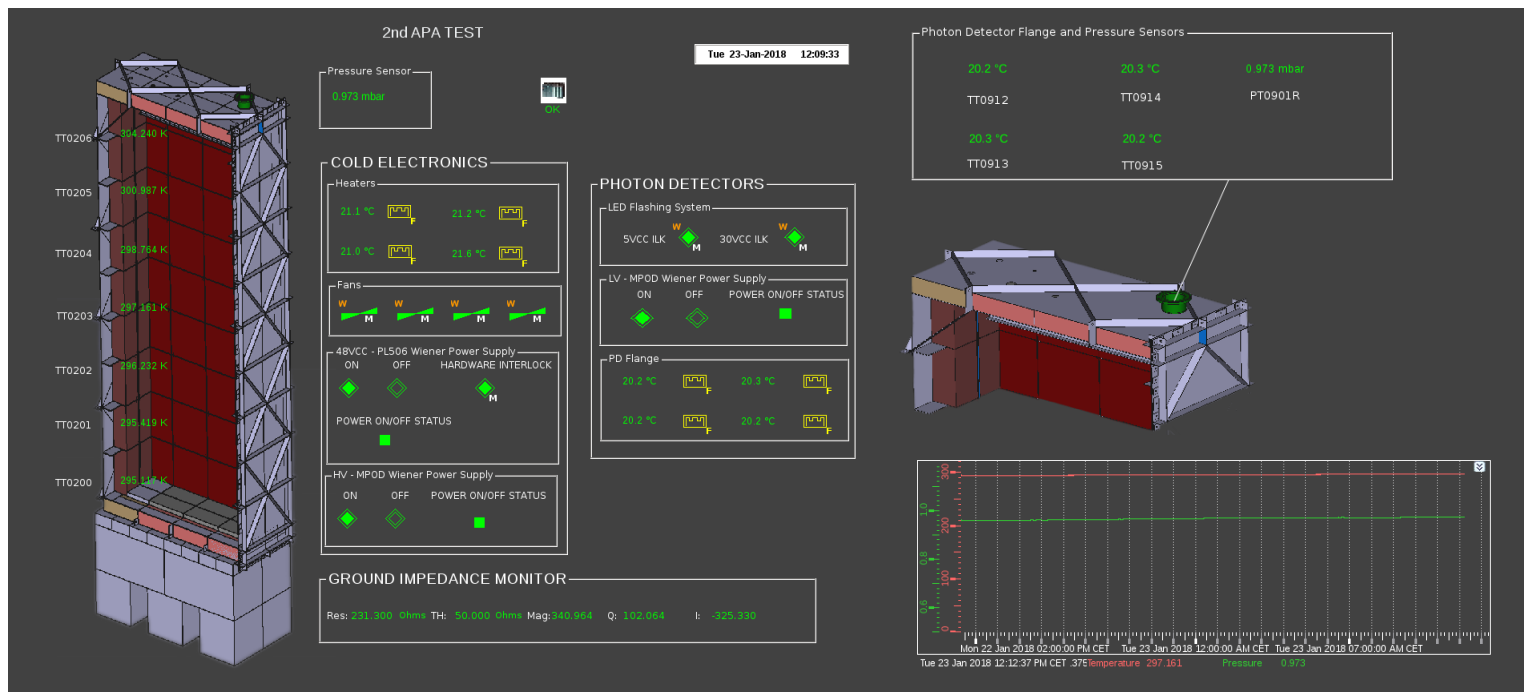


JCOP + UNICOS

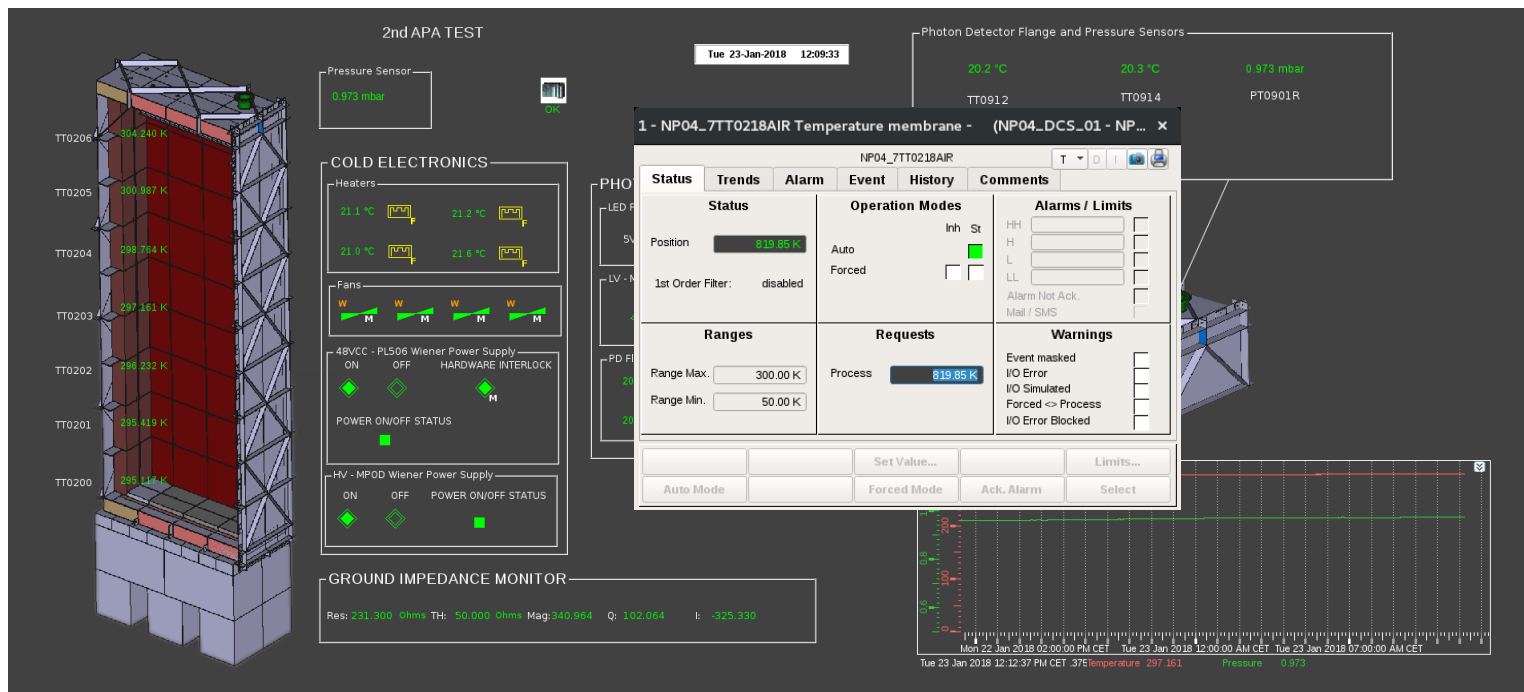


- Tools & Libraries:
 - I/O widgets, trending tools, Access Control, HMI, DB Archiver, FSM, PS Components...
- Integration of standardized hardware types into WinCC OA SCADA
 - ELMB, Wiener, CAEN, ISeg, MPOD, S7 PLCs, Schneider PLCs...
- Communications & middleware
 - DIP, DIM, OPC-UA...

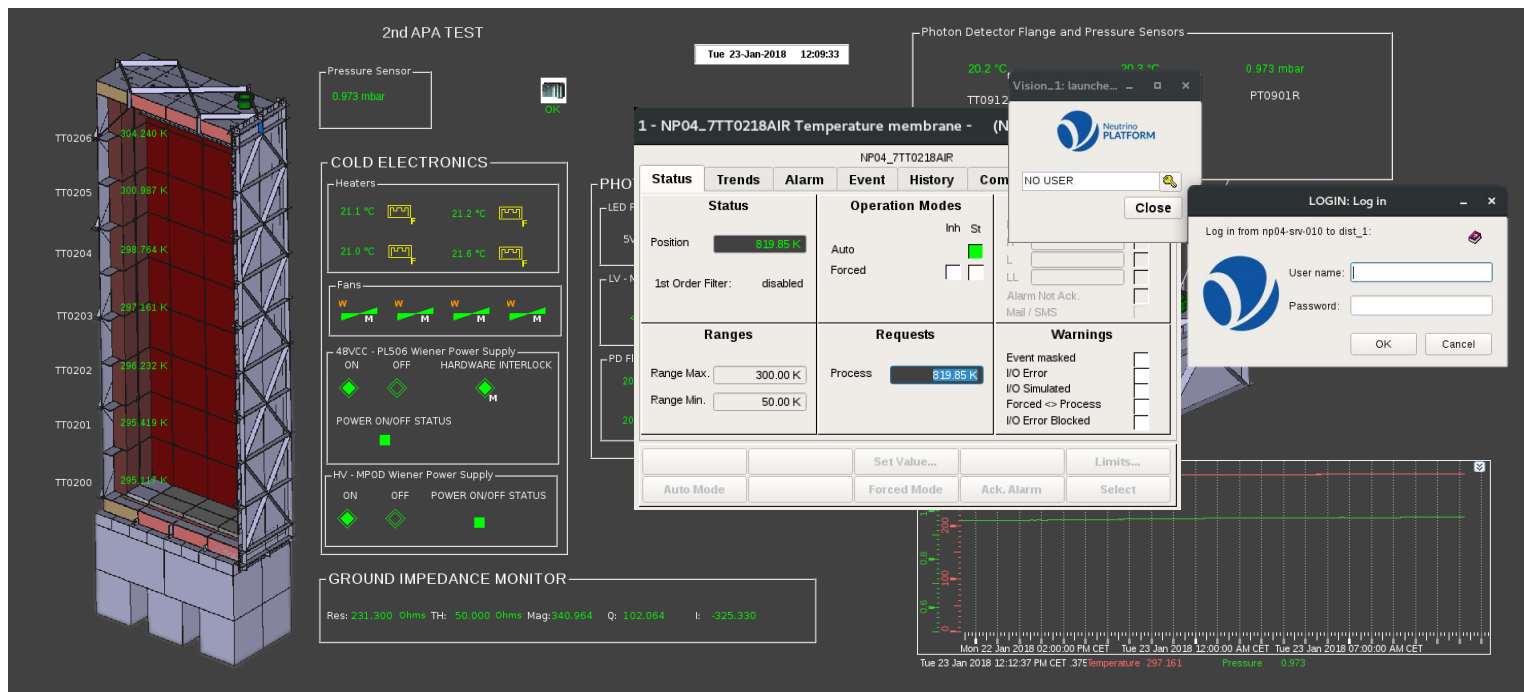
JCOP + UNICOS



JCOP + UNICOS



JCOP + UNICOS



Hardware Layout

- Hardware Components:
 - Power Supplies:
 - WIENER PL506 for Cold Electronics Low Voltage (6 Channels)
 - WIENER MPOD
 - Photon Detector Low Voltage (96 Channels)
 - Cold Electronics HV (64 Channels)
 - **Heinzinger 300 kV High Voltage**
 - Siemens S7-1500 PLC (~500 Channels)
 - National Instruments cRIO FPGA
 - High accuracy mass temperature acquisition
 - Fast data acquisition
 - **Custom Hardware** (Impedance Monitor, Photon Detectors, Front-End Electronics)



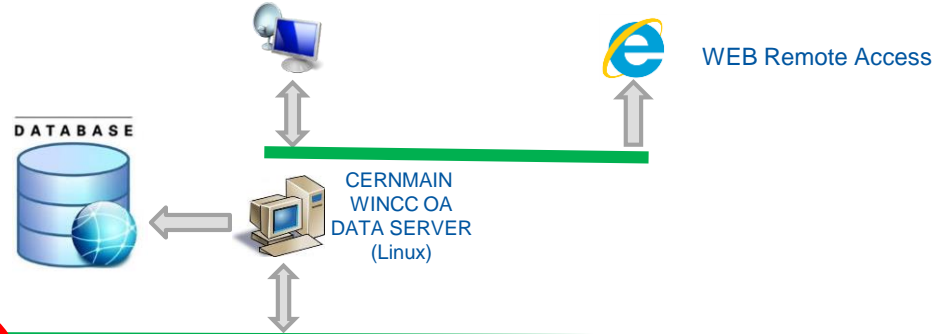
Hardware Layout

- Control Interfaces:
 - Power Supplies → OPC DA
 - cRIOs & LabView → OPC UA
 - PLCs → S7 Driver
 - Custom Hardware → DIM
 - Cryogenics → DIP

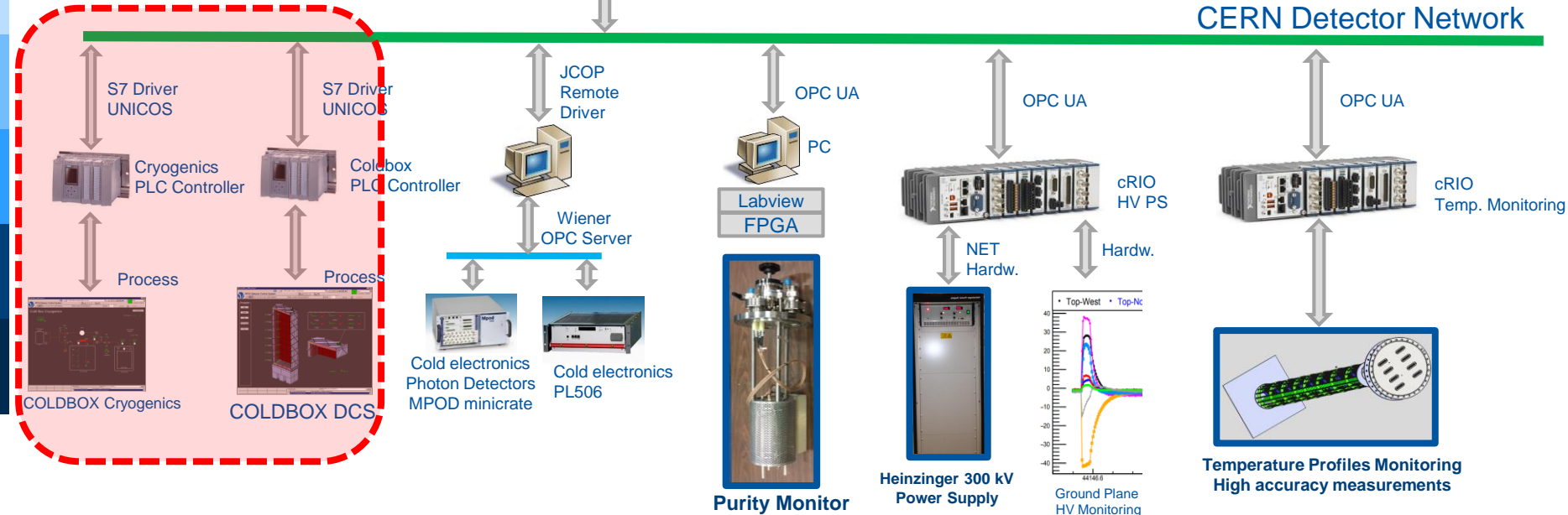


protoDUNE Single Phase Slow control Architecture On 05/2018

Remote Access-Multiple session

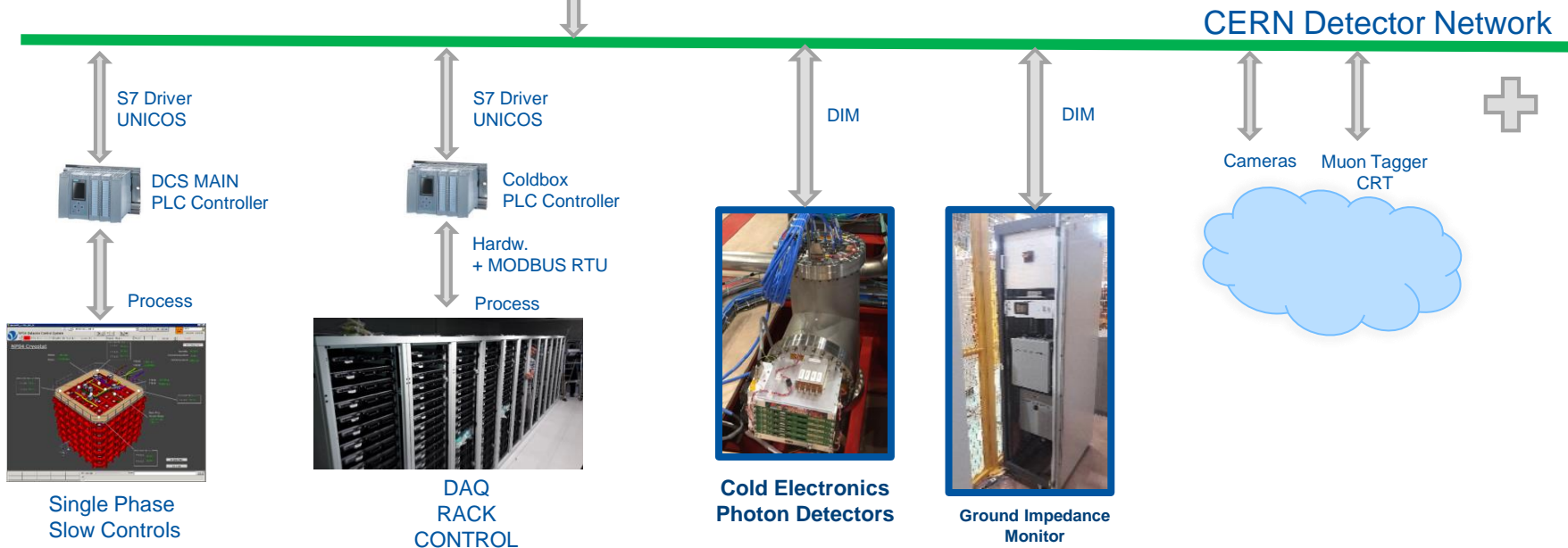
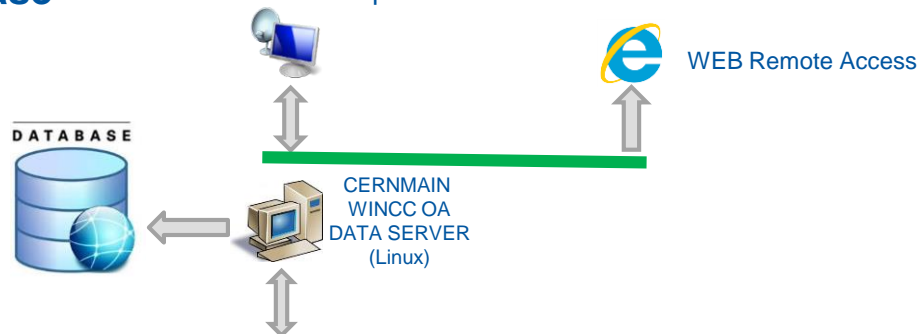


CERN Detector Network



protoDUNE Single Phase Slow control Architecture On 05/2018

Remote Access-Multiple session



Examples

- Photon Detectors
 - Using **DIM** protocol to communicate with the hardware
 - Receive status and send commands

ssp101
ssp102
ssp103
ssp104
ssp201
ssp202
ssp203
ssp204
ssp301
ssp302
ssp303
ssp304
ssp401
ssp402
ssp403
ssp404
ssp501
ssp502
ssp503
ssp504
ssp601
ssp602
ssp603
ssp604

Double click to open in a new window

SET VOLTAGE

SSP 204

Voltage supply and Temperature

Bias Supply Rail Voltage: V

Voltage of chage injection: V

Voltage at Voltage Monitor: V

Voltage at Current Monitor: V

Temp. at Voltage Monitor: °C

Temp. at Current Monitor: °C

Clock and memory

Data processor clock status register:

PDTS status register: ✓

Free Event Memory: M

Total number of commands received:

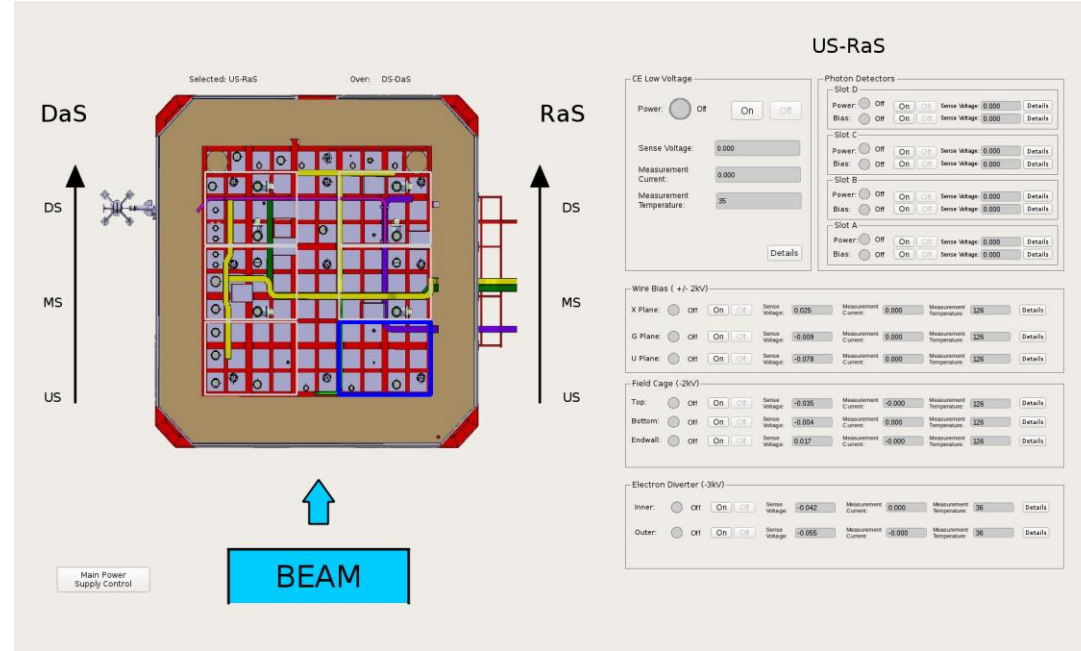
5352	0	0	0
6	15	0	0
140810	0	0	0
0	0	0	0

Channel	Bias			Rate monitoring			
	Target (mV)	Bias Voltage (V)	Bias Current (A)	Disc Rate	Ahit Rate	Accepted Event	Dropped Event
Channel 0	0	-0.032	-2.351e-07	0	0	0	0
Channel 1	0	-0.033	-2.301e-07	0	0	0	0
Channel 2	0	-0.034	-2.351e-07	0	0	0	0
Channel 3	0	-0.032	-2.251e-07	0	0	0	0
Channel 4	0	-0.032	-2.201e-07	0	0	0	0
Channel 5	0	-0.032	-2.251e-07	0	0	0	0
Channel 6	0	-0.032	-2.251e-07	0	0	0	0
Channel 7	0	-0.032	-2.201e-07	0	0	0	0
Channel 8	0	-0.032	-2.251e-07	0	0	0	0
Channel 9	0	-0.032	-2.251e-07	0	0	0	0
Channel 10	0	-0.032	-2.301e-07	0	0	0	0
Channel 11	0	-0.031	-2.151e-07	0	0	0	0

*SSP = Silicon photomultiplier Signal Processor

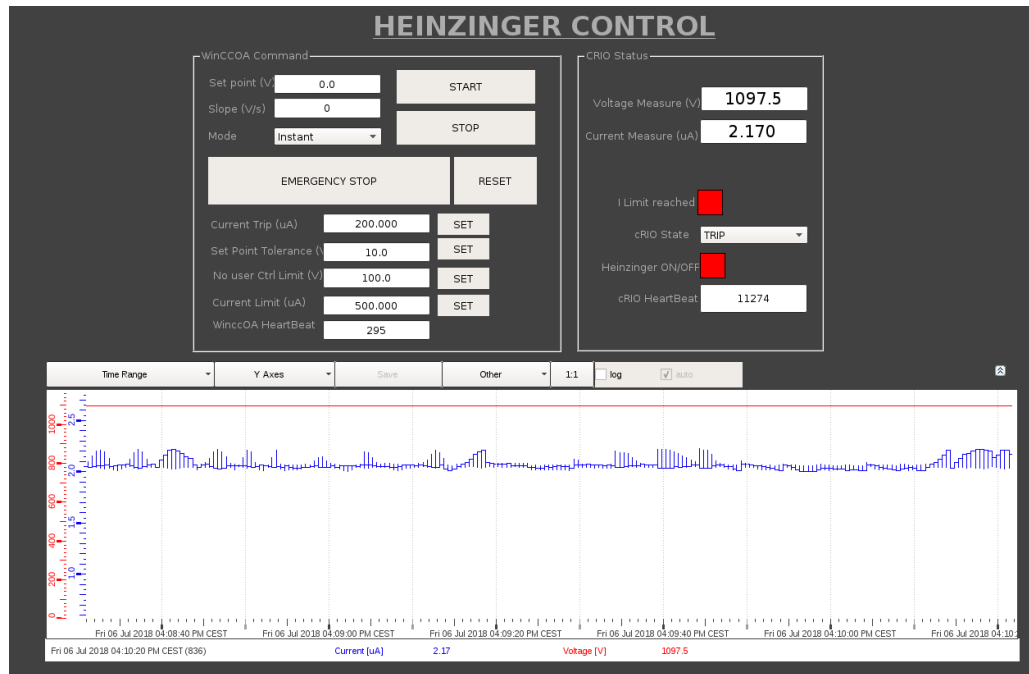
Examples

- **Cold Electronics PS Control**
 - Using **OPC-DA** protocol to communicate with the hardware
 - High Voltage and Low Voltage
 - Set voltage or current
 - Monitor status per channel



Examples

- **Heinzinger power supply**
 - Using **OPC-UA** protocol to communicate with the cRIO
 - The cRIO processes user input and sends commands to the power supply for execution
 - All the data is archived in an **Oracle DB**

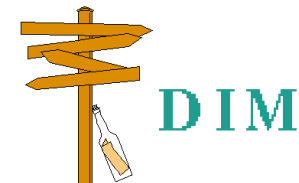


Summary

- ProtoDUNE SP is the prototype of a Single-Phase Liquid Argon TPC for DUNE
- The DCS is the orchestrator of the detector components
- UNICOS + JCOP on top of WinCC-OA[®] as SCADA system
- Hardware architecture and implementation on the DCS
- The DCS is being integrated with the last NP04 components
- It is already in use for experiment commissioning
- It will continue evolving to enhance operability by non experts, ready for 24/7 shifts in August.

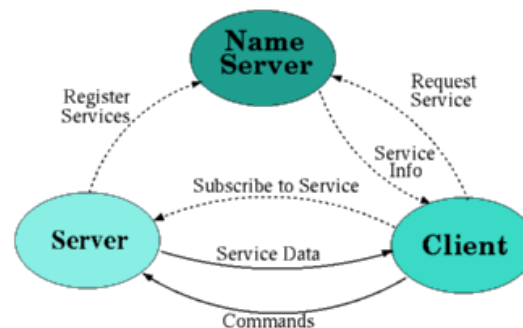
Backups

DIM



Distributed Information Management System

- DIM is a **communication system** for distributed / mixed environments, it provides a network transparent **inter-process communication** layer.
- Servers "**publish**" their services by registering them with the name server (normally once, at start-up).
- Clients "**subscribe**" to services by asking the name server which server provides the service and then contacting the server directly, providing the type of service and the type of update as parameters.
- The name server keeps an up-to-date directory of all the servers and services available in the system.^[1]



[1] <http://dim.web.cern.ch/dim/>

DIP

What is DIP?^[1]

- DIP is a communication system which allows relatively small amounts of soft real-time data to be exchanged between very loosely coupled heterogeneous systems.
- These systems do not need very low latency. The data is assumed to be mostly summarised data rather than low-level parameters from the individual systems, i.e. cooling plant status rather than the opening level of a particular valve.
- DIP is currently only supported on Windows 64-bits and Linux 64-bits.
- The DIP service is composed of :
 - A **Central Name Server** that provides the list of available publications
 - An **API** (Application Programming Interface) that allows to publish and receive information.
 - A **PVSS** extension (PVSS API Manager) that allows to publish and receive DIP data in PVSS.
 - A **LabVIEW** extension that allows to publish and receive DIP data in NI LabVIEW.



[1] <https://readthedocs.web.cern.ch/x/BCdDAQ>

OPC (Open Platform Communications)

OPC Data Access

- OPC Data Access is a group of client-server **standards** that provides specifications for communicating **real-time** data.
- Is based on **Microsoft Windows** technology using the COM/DCOM (Distributed Component Object Model) for the exchange of data between software components.

OPC Unified Architecture

- OPC UA was designed to enhance and surpass the capabilities of the OPC Classic specifications
 - **Functional Equivalence**
 - **Platform Independence**
 - **Security**
 - **Extensible**

See more on: <https://opcfoundation.org/>



DCS in numbers

- Power Supply:
 - 2x PL506
 - 4x MPOD MiniCrate (4 board each)
 - 1x Heinzinger Power Supply
 - Total 141 Channels configured (140 + Heinzinger)
- PLC:
 - 2x SIEMENS S7-1500 (~500 Channels)
- Detector Interface
 - 137 panels
 - 44 trends predefined
- DIM clients:
 - Service: 3.248 services subscribed
 - Commands: 329 commands subscribed
- Data points:
 - DP: 3.202 data points
 - DPE: 117.094 elements
 - RDB: 22.342 elements archived

