



# Initial Development of a Control System for the FDD Detector in the ALICE Experiment for Operation on LHC Run-3

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**XXXIV Annual Meeting of the Division of Particle and Fields of the Mexican Society of Physics**

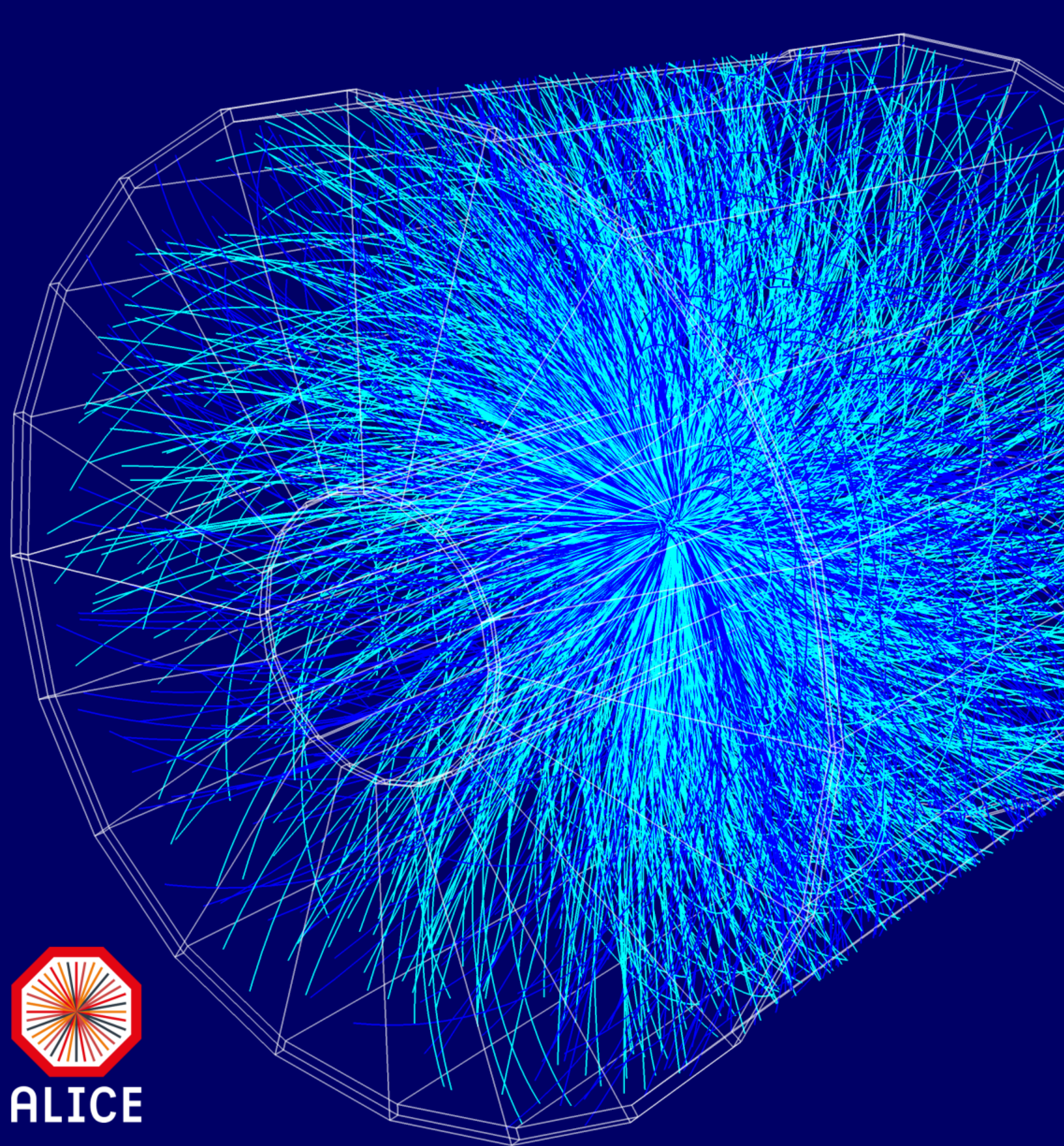
**M.E. Juan Manuel Mejía Camacho**  
**Dr. Juan Carlos Cabanillas Noris**

Dr. Ildelfonso León Monzón  
Dr. Mario Iván Martínez Hernández

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- \* Fast Interaction Trigger Diffractive Detector
- \* Hardware to be used with FDD
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ALICE

# Diffractive events in ALICE

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- \* The main characteristic of a diffractive process is the presence of a significant gap in the distribution of speed of the particles produced during collisions; that is, the absence of particles created in the collision whose direction is in a given interval.
- \* The study of diffractive events with boson production is important for the understanding of the Parton composition (quarks and gluons inside the protons) of the exchanged object called Pomeron. In most high energy experiments, the selection of diffractive events is made by using this characteristic in different ways [1-2].

# Diffraction events in ALICE

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- \* The study of diffractive production in Large Hadron Collider (LHC) at CERN is of great interest, both for theoretical and experimental reasons [3].
- \* The selection of diffractive events in ALICE is limited by the range over which speed gaps could be detected.
- \* The study of diffractive events with ALICE experiment of the LHC in proton-proton (pp), lead-lead (Pb-Pb), and proton-lead (p-Pb) collisions could improve its efficiency with the installation of the Fast Interaction Trigger Diffractive Detector (FDD) for Run-3 in 2021.

# Fast Interaction Trigger Diffractive Detector (FDD)

- \* The FDD detector consists of two sub-detectors called FDDA and FDDC.
- \* Each of them includes two detector layers, and each one of them consists of four scintillator modules arranged around the LHC beam pipe.
- \* The FDDA and FDDC designations refer to the installation positions at both ends of the ALICE site concerning the interaction point (IP).

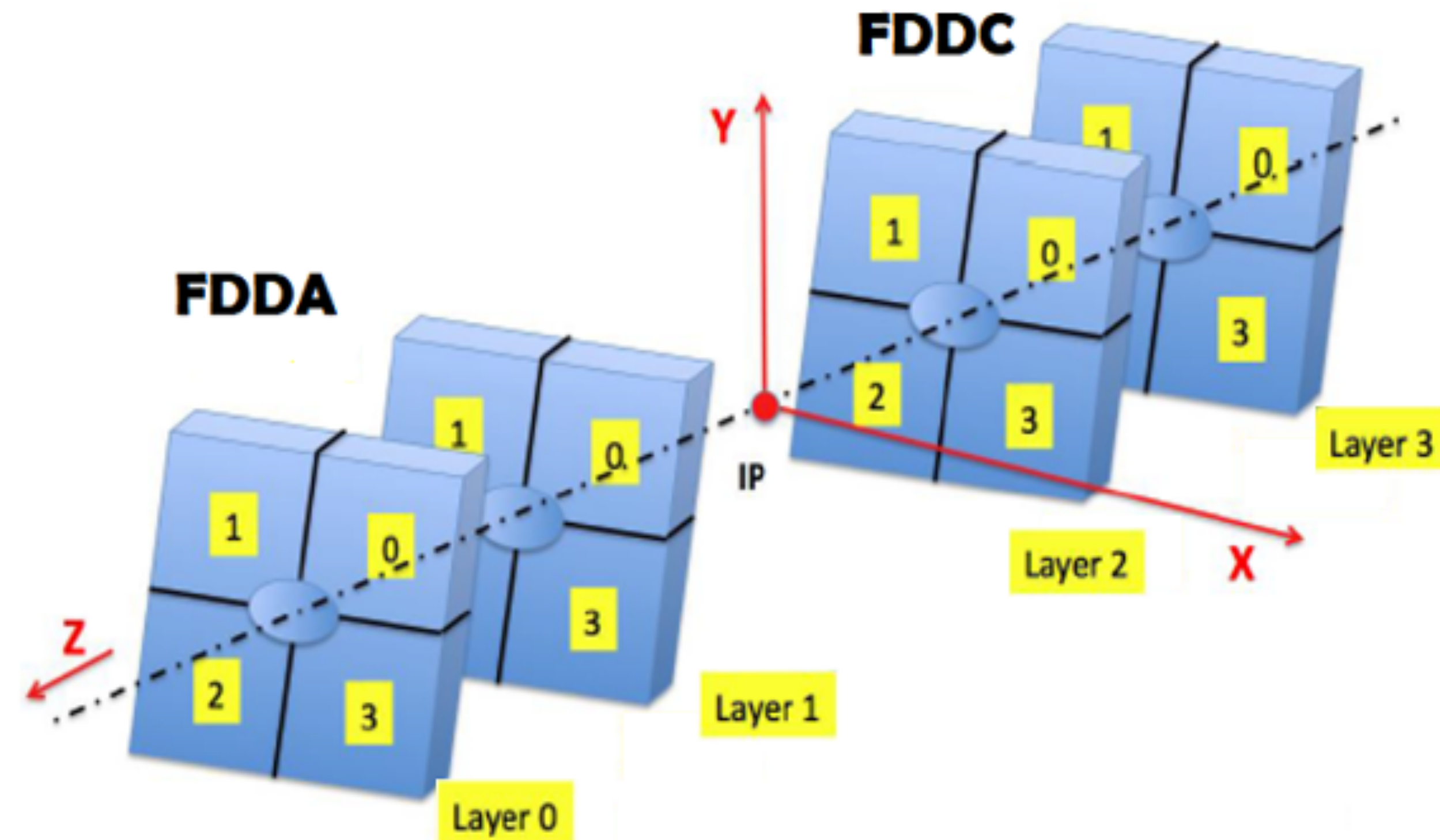


Figure 1. FDDA and FDDC sub-detectors nomenclature in the ALICE experiment cavern.

# Fast Interaction Trigger Diffractive Detector (FDD)

- \* The FDD detector is part of one of the three subdetectors that make up ALICE's Fast Interaction Trigger (FIT) project.
- \* The FDD detector will increase the time resolution compare with ALICE Diffractive Detector (AD) used in Run-2 (2015-2018), and it will provide triggers at level zero for ALICE [4].

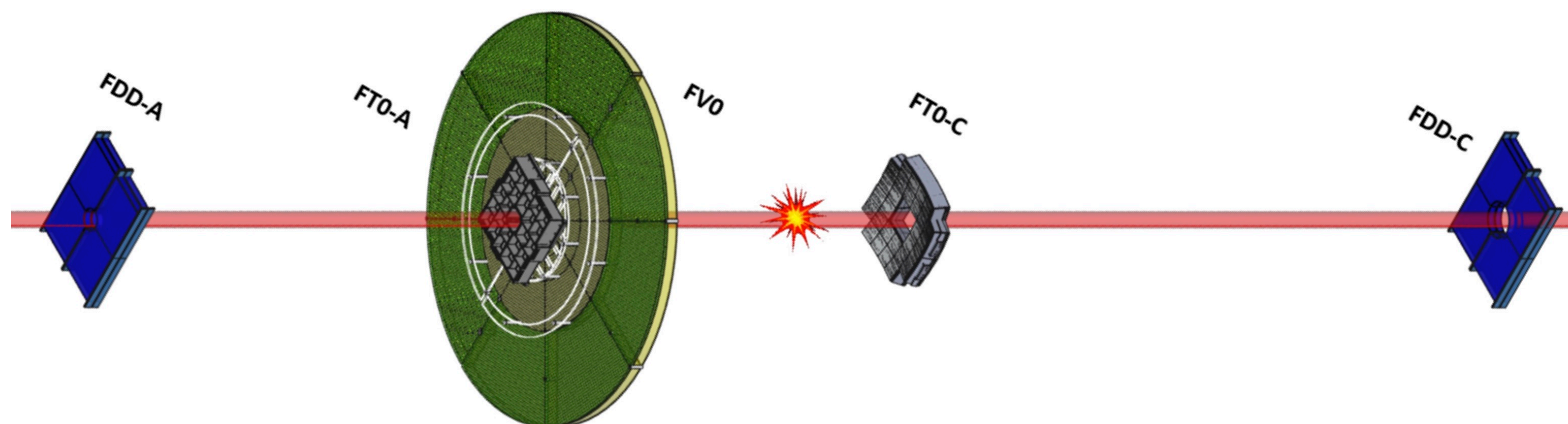
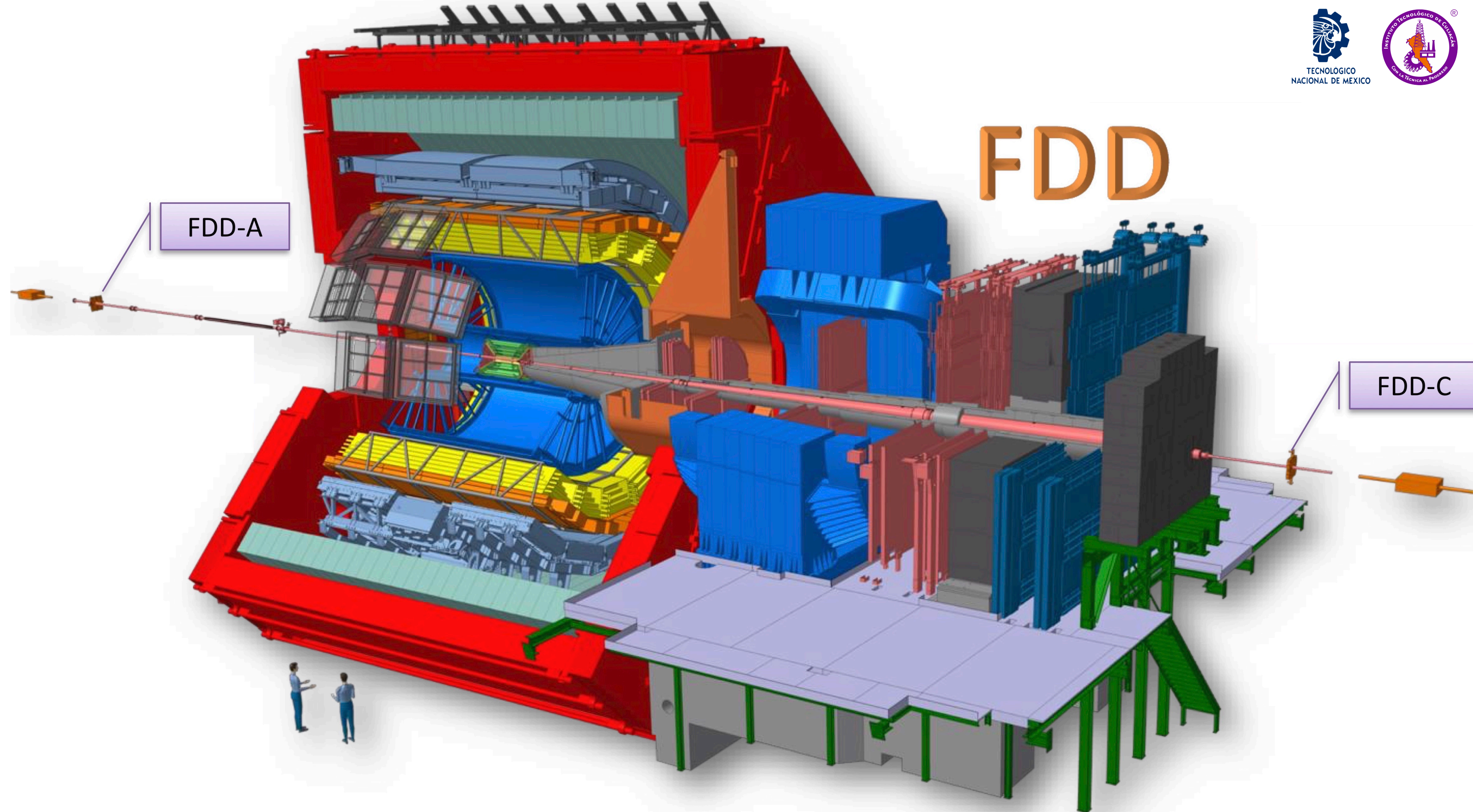


Figure 2. Detectors part of FIT project in ALICE for Run-3.



**The FDD detector will be installed at ends A and C of the ALICE cavern for operation during Run-3 of LHC**

Figure 3. FDDA and FDDC location at ALICE



Figure 4. Universal Multichannel Power Supply System



Figure 5. HV board A7236

- Two HV boards will be used to power 16 PMTs (8 for each FDD subdetector).



Figure 6. Photomultiplier tube H8409-70

## Hardware to be used with FDD

# Hardware to be used with FDD



Figure 7. Taiko Laser Driver PDL M1 & Laser Diode Head LDH-IB-405-B

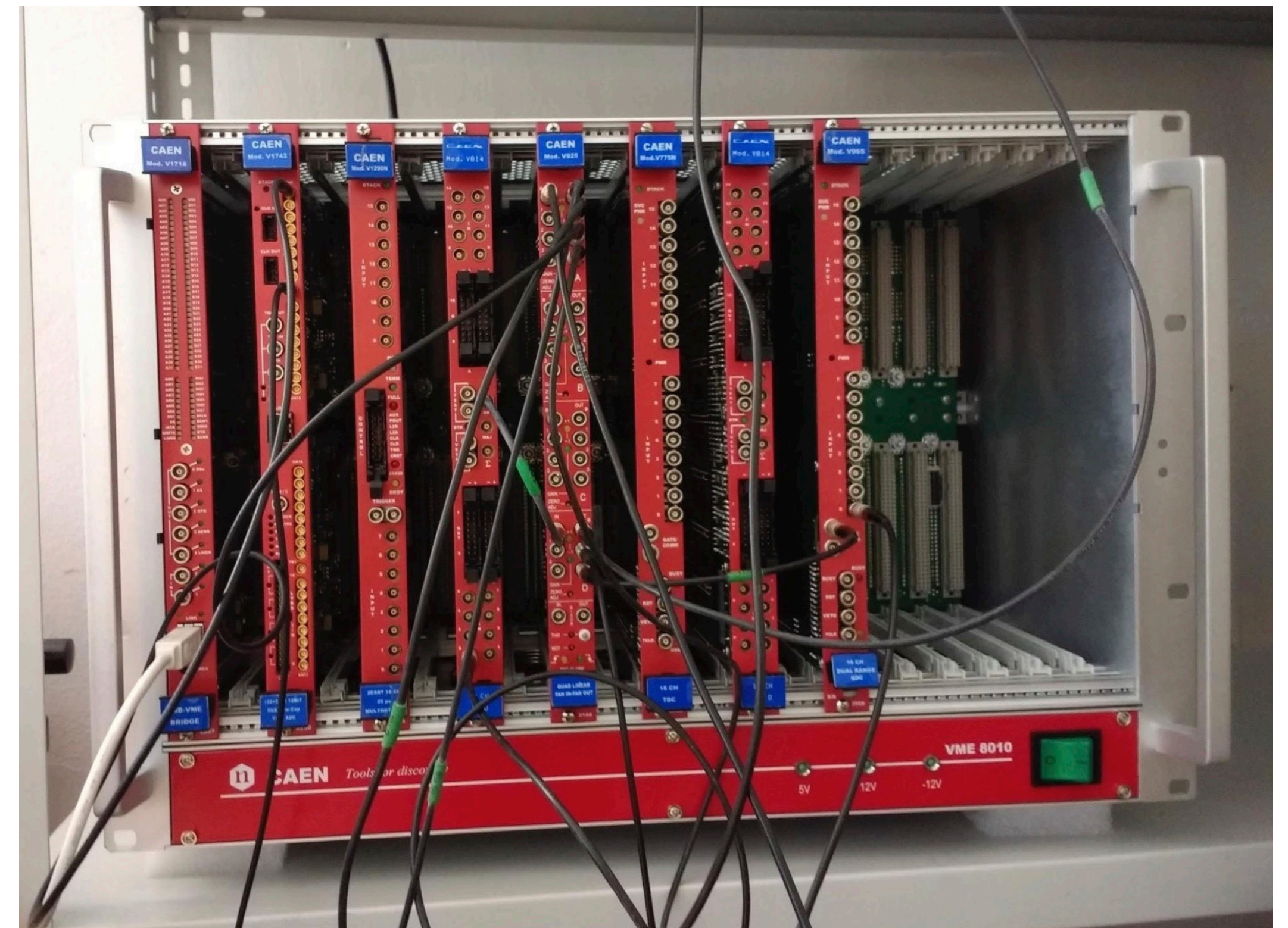


Figure 8. VME crate



# Detector Control System (DCS)

The main task of the ALICE control system is to ensure the safe and correct operation of the experiment.

# Detector Control System (DCS)

- \* The ALICE DCS is based on a commercial SCADA system named WinCC-OA®, running on a large Windows computer cluster [5].
- \* The DCS is responsible for performing control, configuration, reading and monitoring of hardware devices.
- \* It performs a hierarchical control of the subdetectors within ALICE experiment.
- \* The DCS also does monitoring of external systems such as: LHC, electrical system, gas system and more.

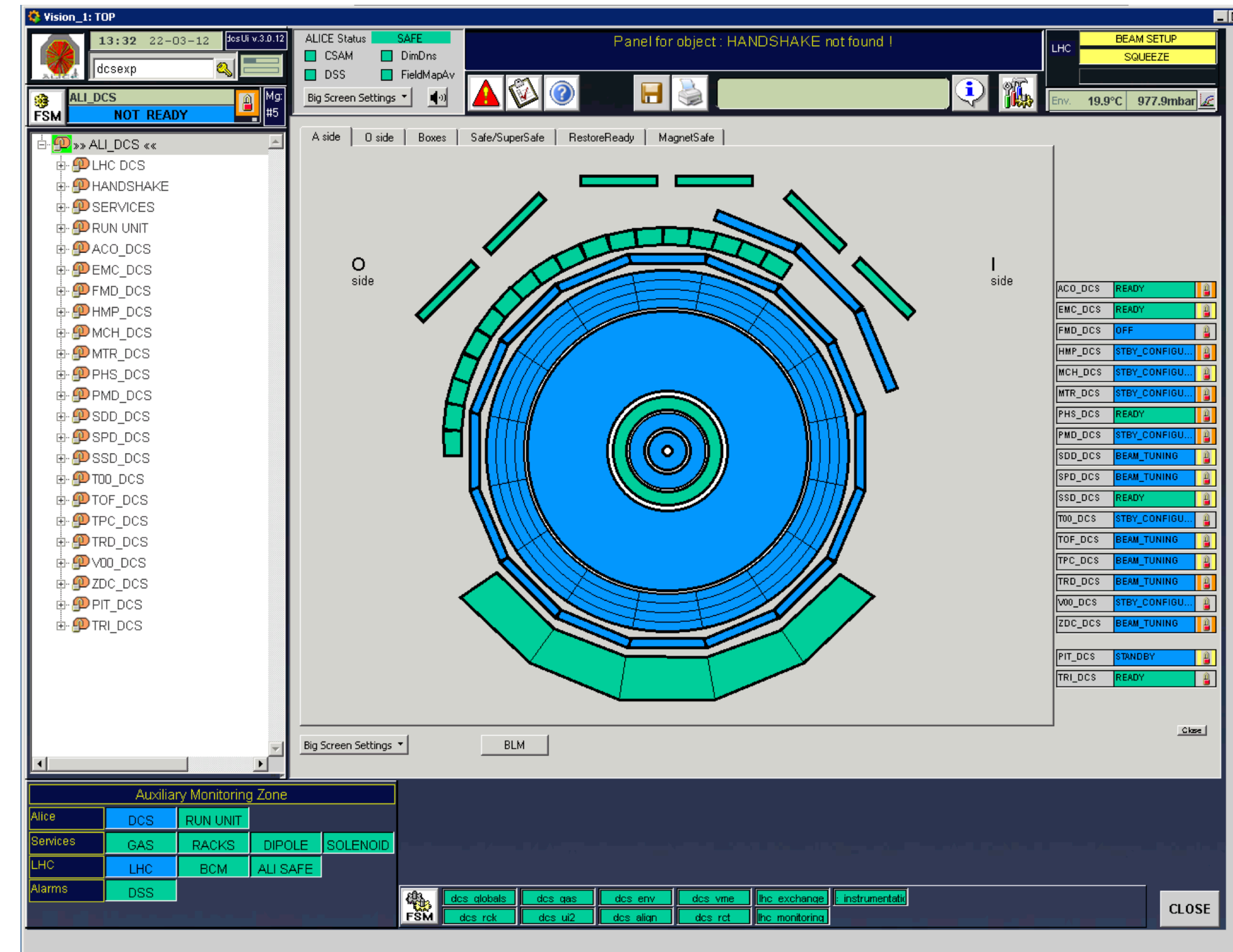
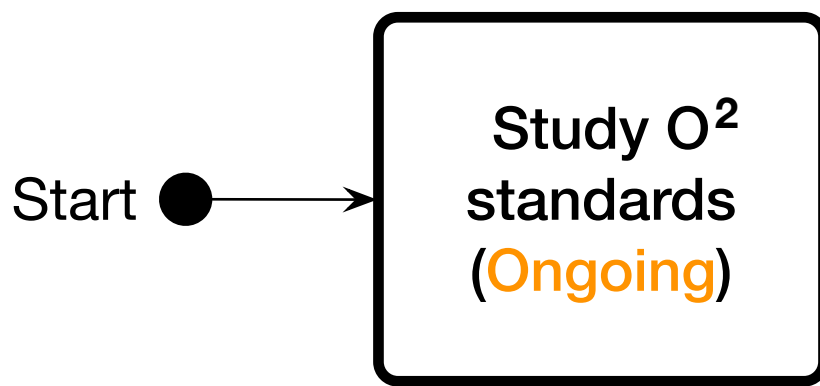


Figure 9. User interface of ALICE DCS [6]



# FDD-DCS development methodology

One of the main changes in Run-3 is to process online the data generated from the ALICE experiment during collisions [7].

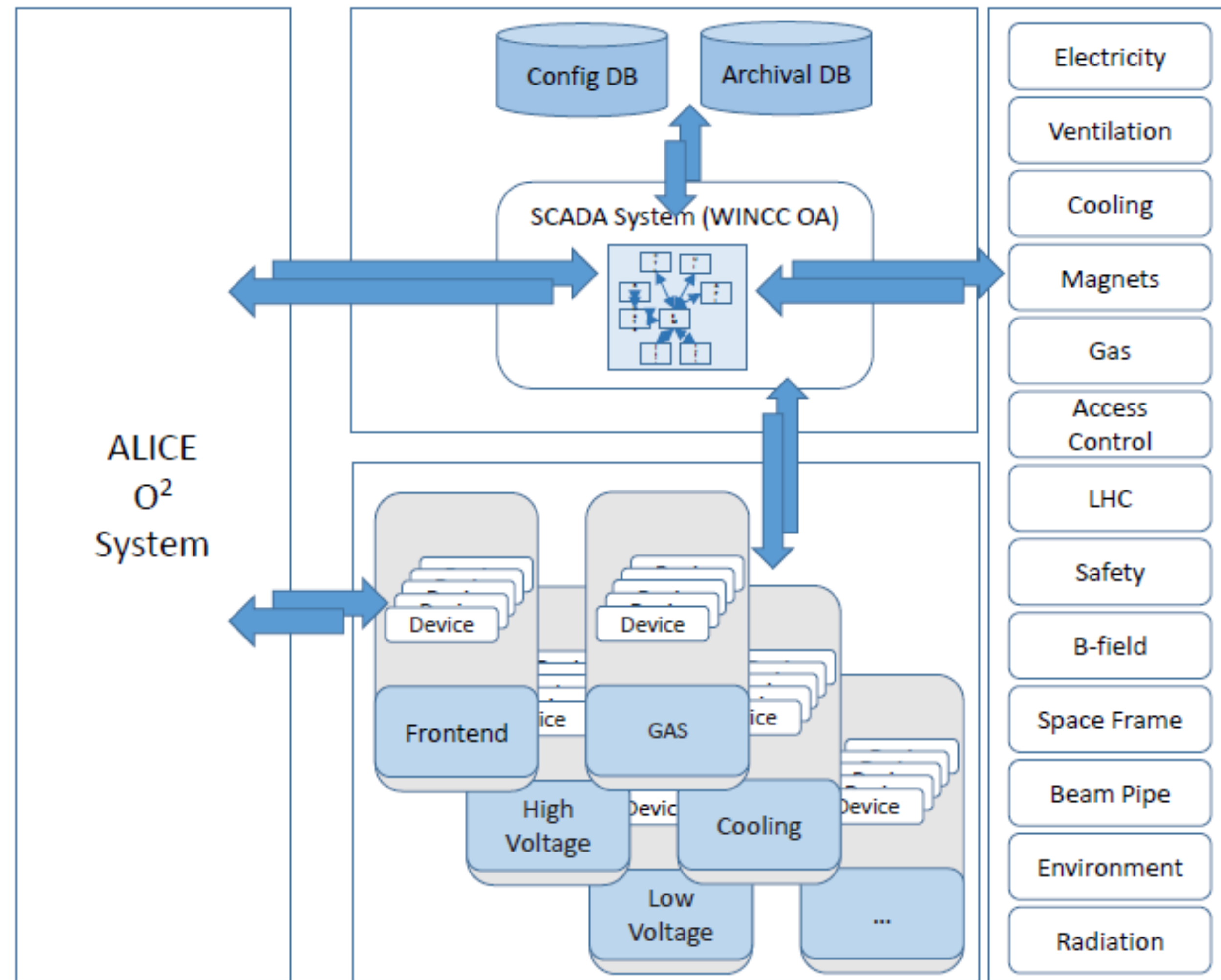
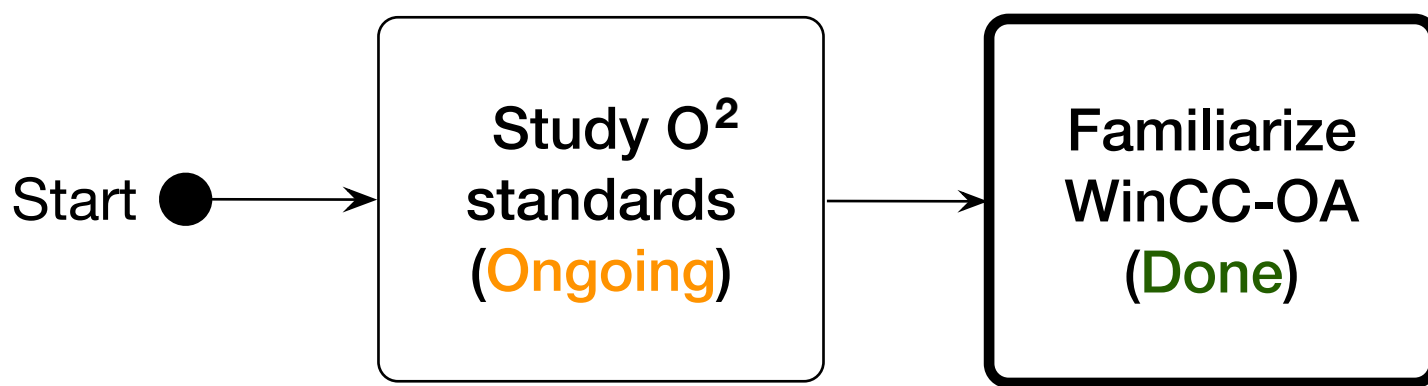


Figure 10. Overall block diagram of the ALICE DCS update for Run 3 [8].



# FDD-DCS development methodology

ALICE's DCS architecture is based on the standards adopted by the LHC experiments at CERN, such as the SCADA system named WinCC-OA® [9-12].

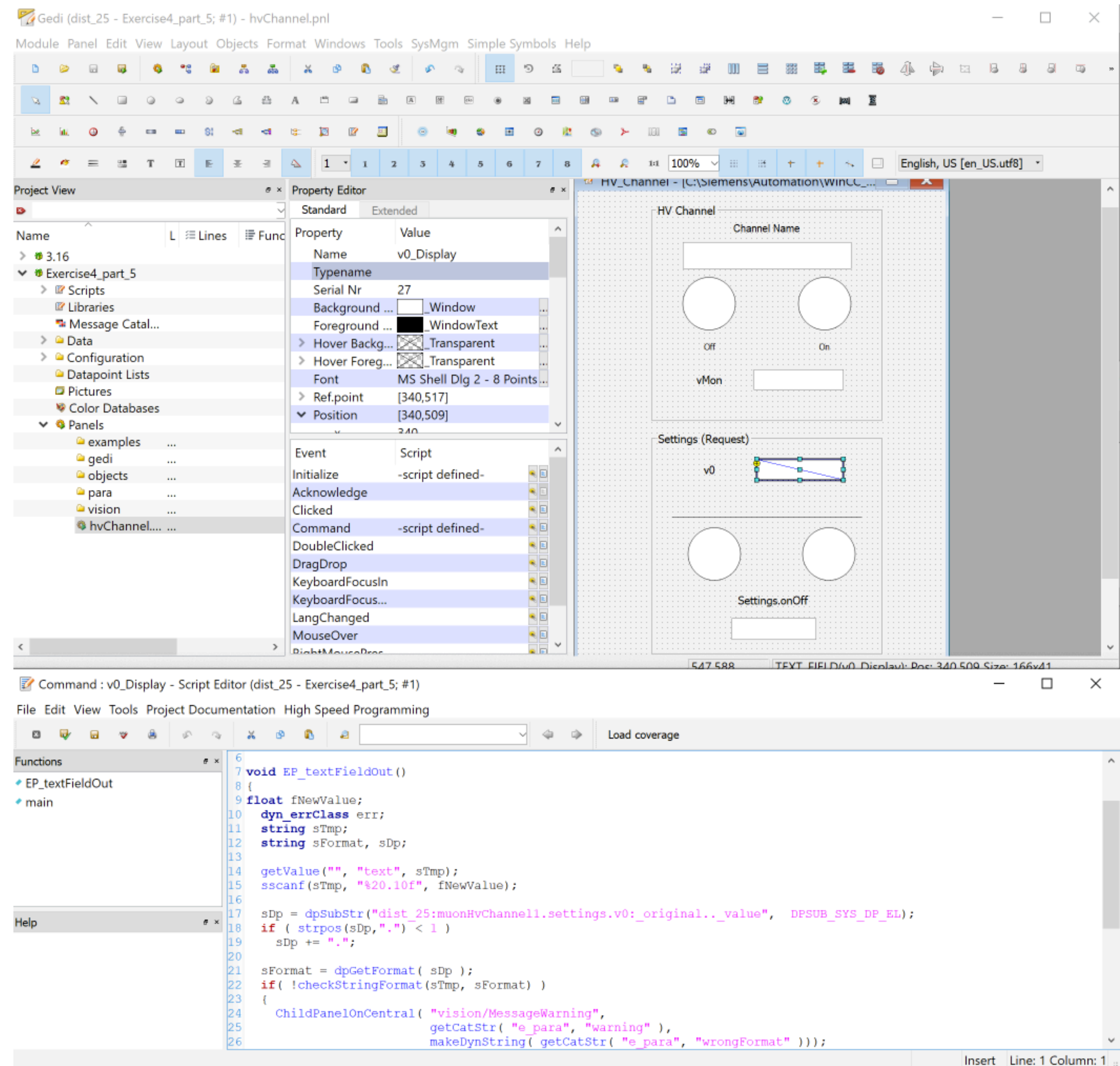
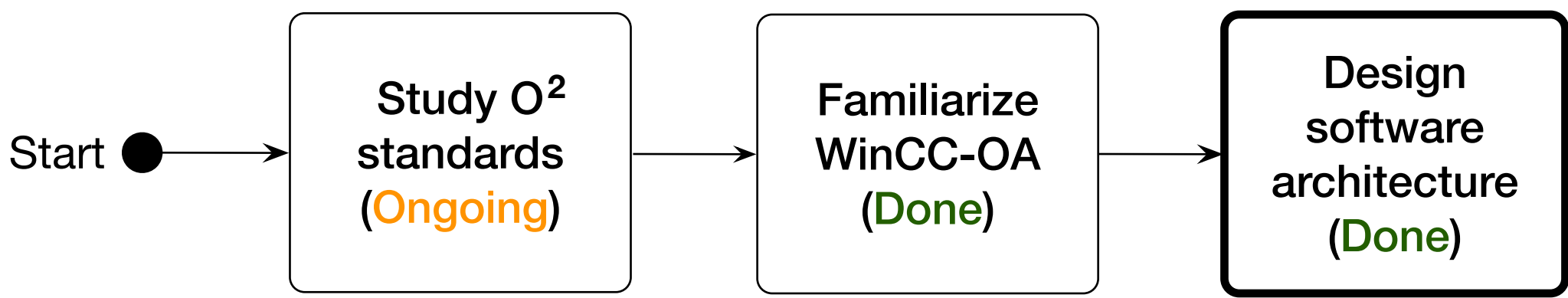


Figure 11. WinCC-OA® programming user interface.



# FDD-DCS development methodology

- \* The software architecture currently proposed to ALICE group for the DCS of the FDD detector is compatible with the architecture required by the ALICE experiment.
- \* The DCS software architecture has a hierarchical tree structure representing the operation of the subsystems and hardware devices.

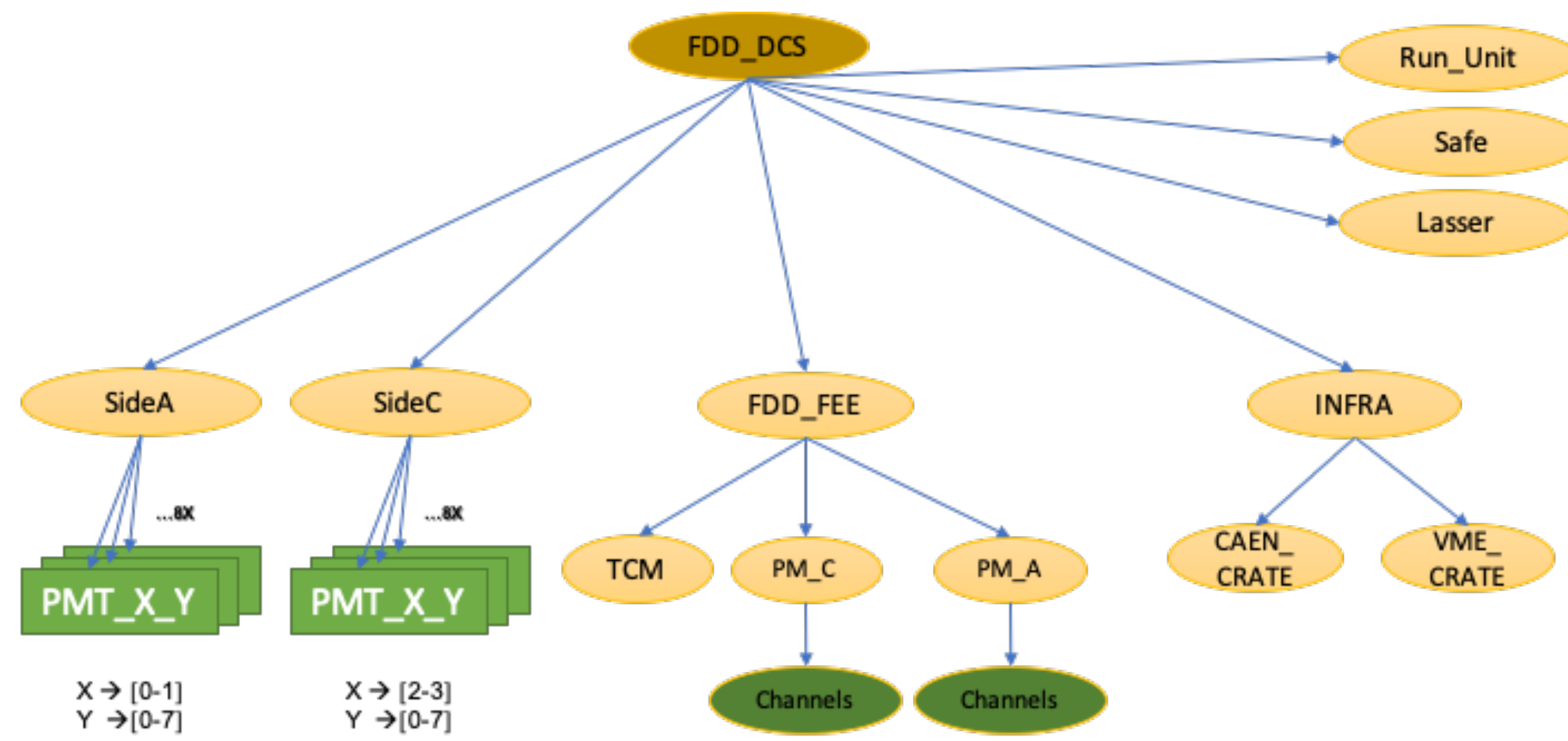
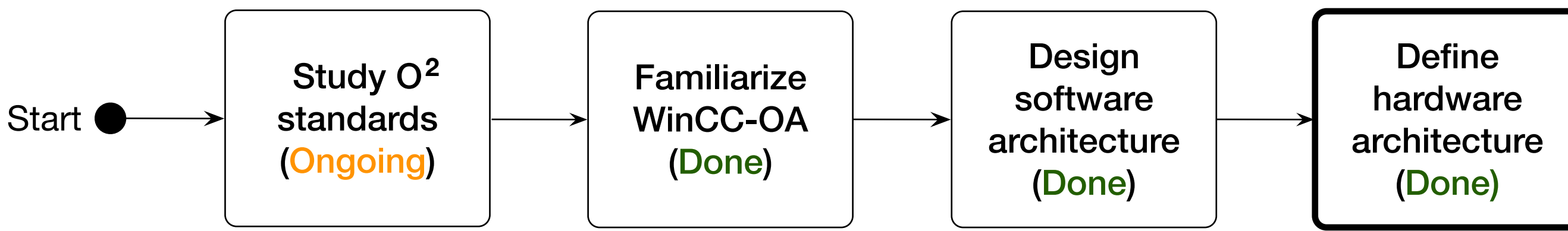


Figure 12. Proposed software architecture for DCS of the FDD.



# FDD-DCS development methodology

- \* The hardware architecture currently defined for the Control System (DCS) of the FDD detector is compatible with the architecture required by the ALICE experiment.
- \* The DCS of the FDD detector will interact with all the devices of the areas: Counting Room, Cavern and Inside Magnet.

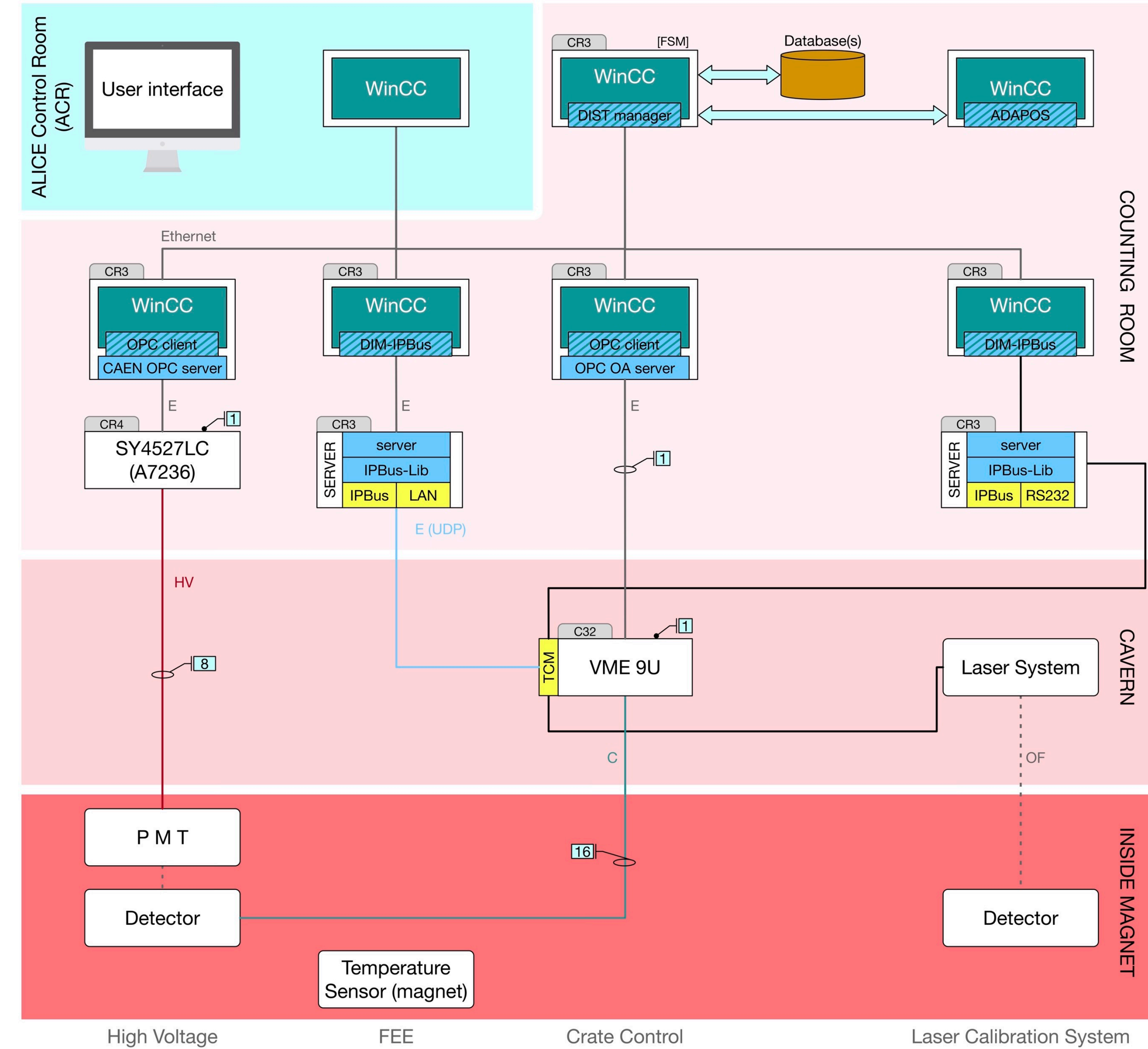
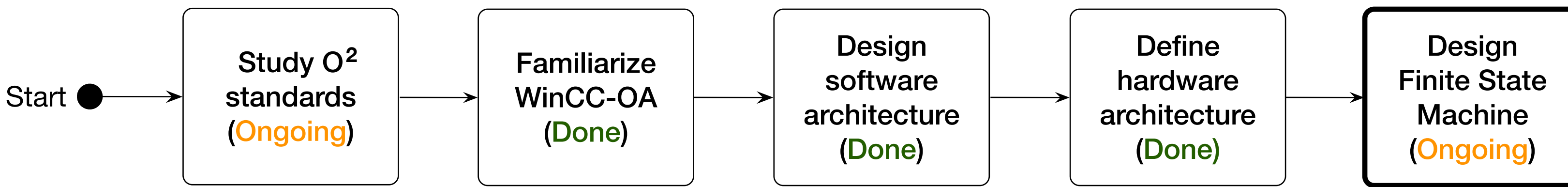
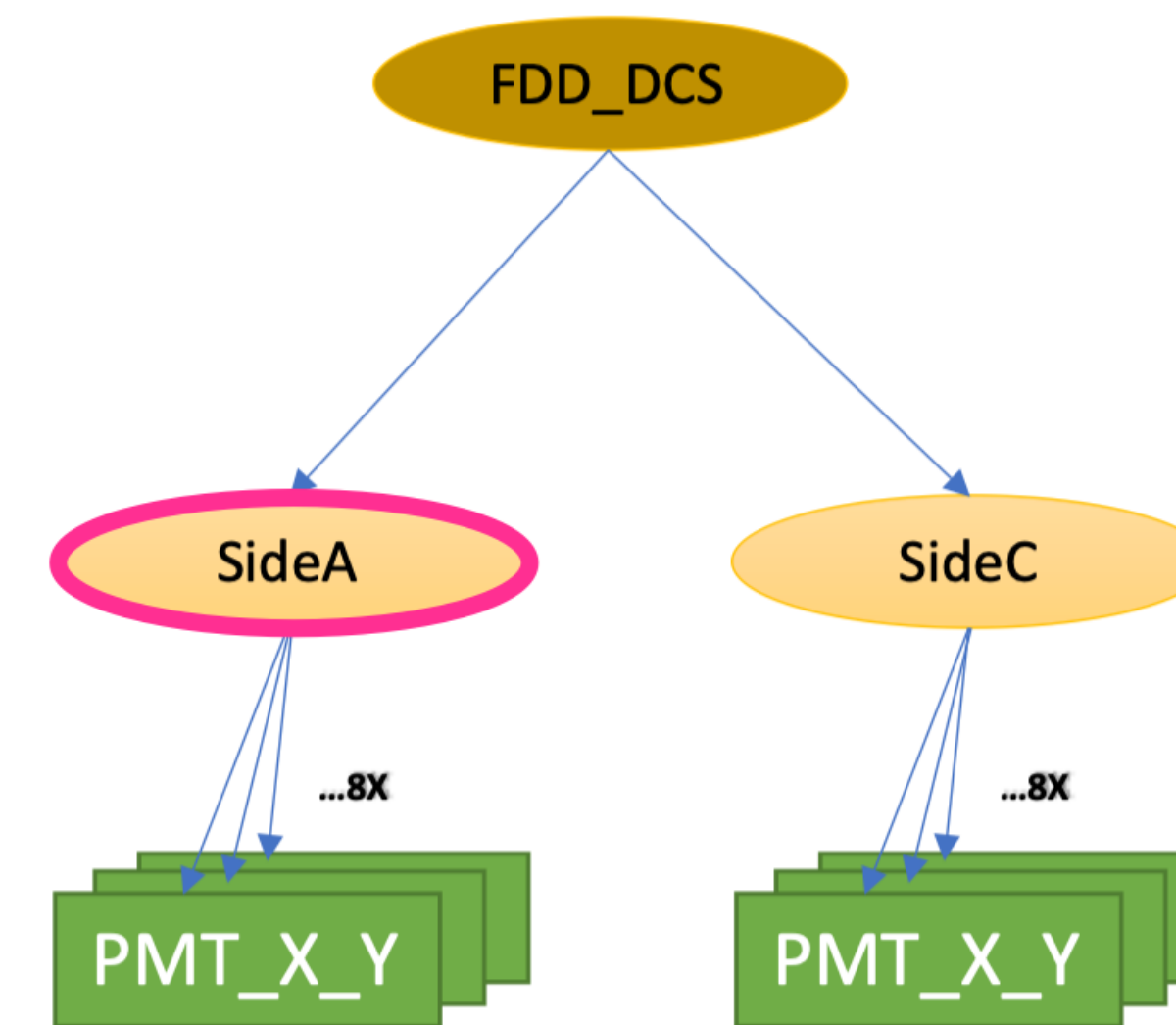


Figure 13. Hardware architecture defined for DCS of the FDD.



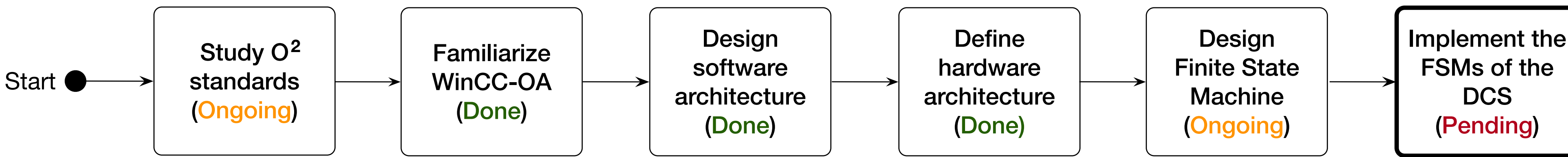
# FDD-DCS development methodology

- \* The FSM concept is a generic and intuitive mechanism to model the functionality of an equipment or an entire system.
- \* A hierarchical architecture was defined to represent FDD-A and FDD-C subdetectors through the FSMs using SCADA system WinCC-OA®.



Sub-System	State	
PMT_0_0	ON	✓
PMT_0_1	ON	✓
PMT_0_2	ON	✓
PMT_0_3	ON	✓
PMT_1_0	ON	✓
PMT_1_1	ON	✓
PMT_1_2	ON	✓
PMT_1_3	ON	✓

Figure 14. Finite State Machine for FDD Side A node.



## FDD-DCS development methodology

- \* Once the FSMs for the Control System (DCS) of the FDD detector are defined, the next step is to represent such FSMs for each node using programming code. For this, we will first make use of UML diagrams.
- \* The resulting UML diagrams will be considered for the modeling of the nodes in the software architecture of the DCS.

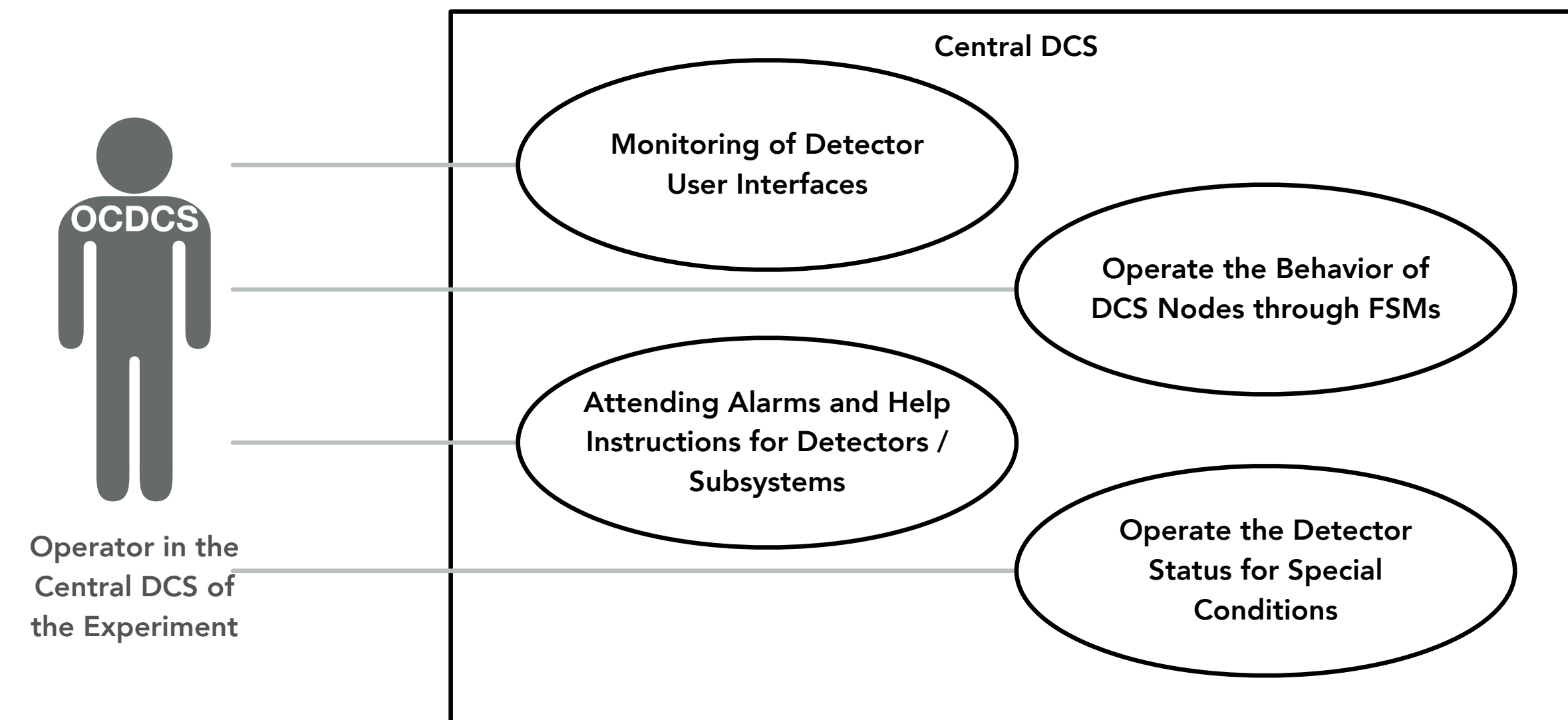
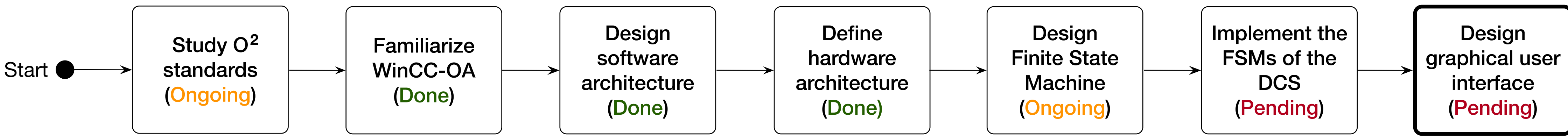


Figure 15. Elements that form the diagram of the Operator in the Central DCS / DCS Shifter of the Experiment (OCDACS).



# FDD-DCS development methodology

- \* The next step is to design the UI, that will allow the Control System (DCS) operators of the FDD detector to interact with the devices and equipment of the ALICE experiment.
- \* It must be use the tools and guidelines available [6], since it is important to maintain the uniformity between the operation panels used by the operators of the Central DCS and keep the interface user friendly.

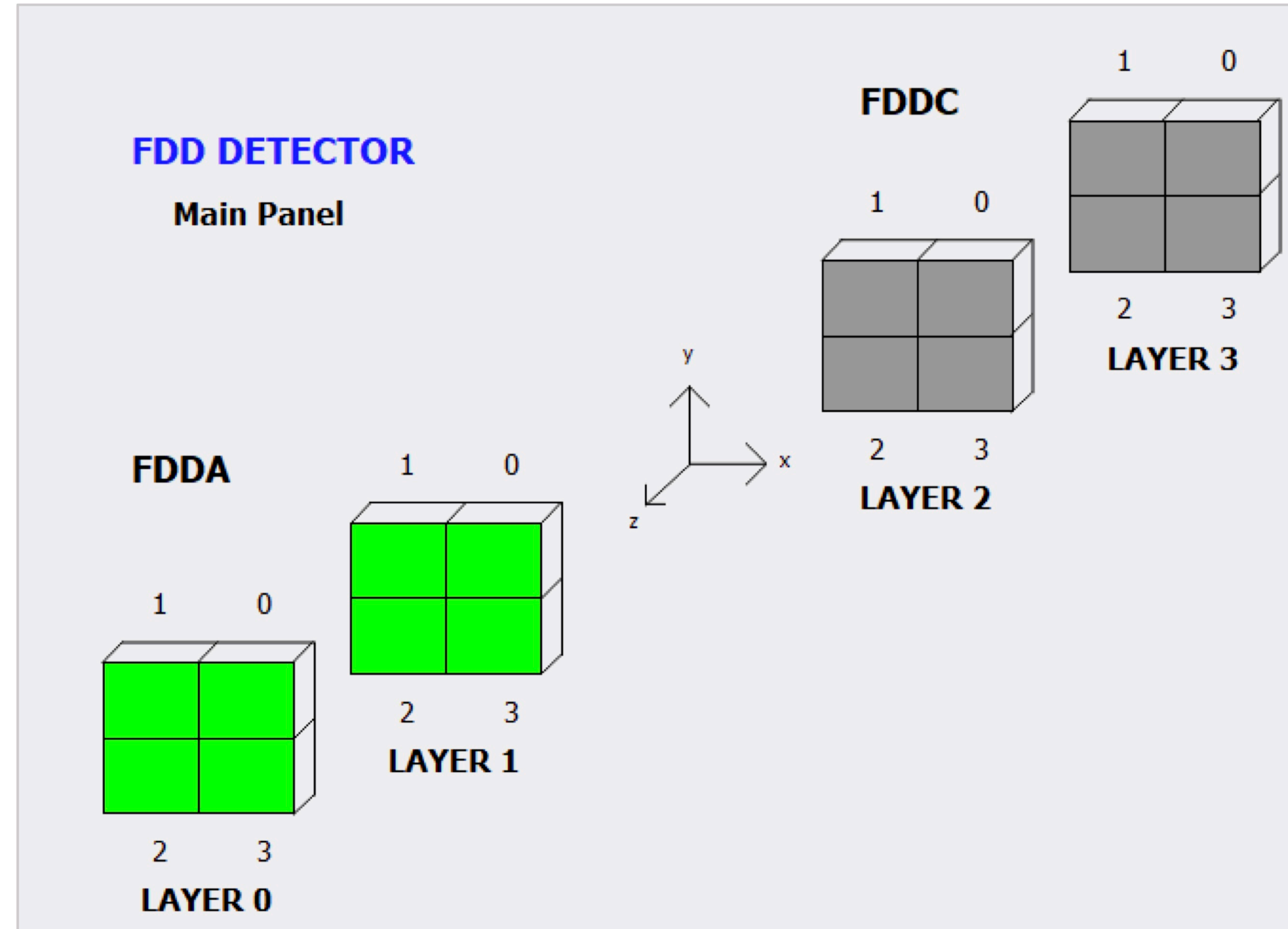
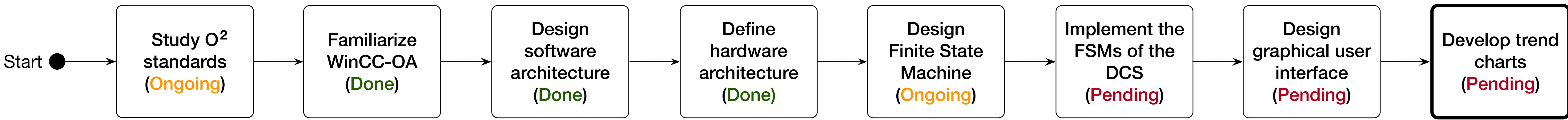


Figure 16. Draft of main panel user interface for FDD detector.



# FDD-DCS development methodology

The DCS of the FDD detector will implement charts to visualize the temperature behavior, power supplies, and electronics; as well as the voltage and current values for HV (High Voltage) system.

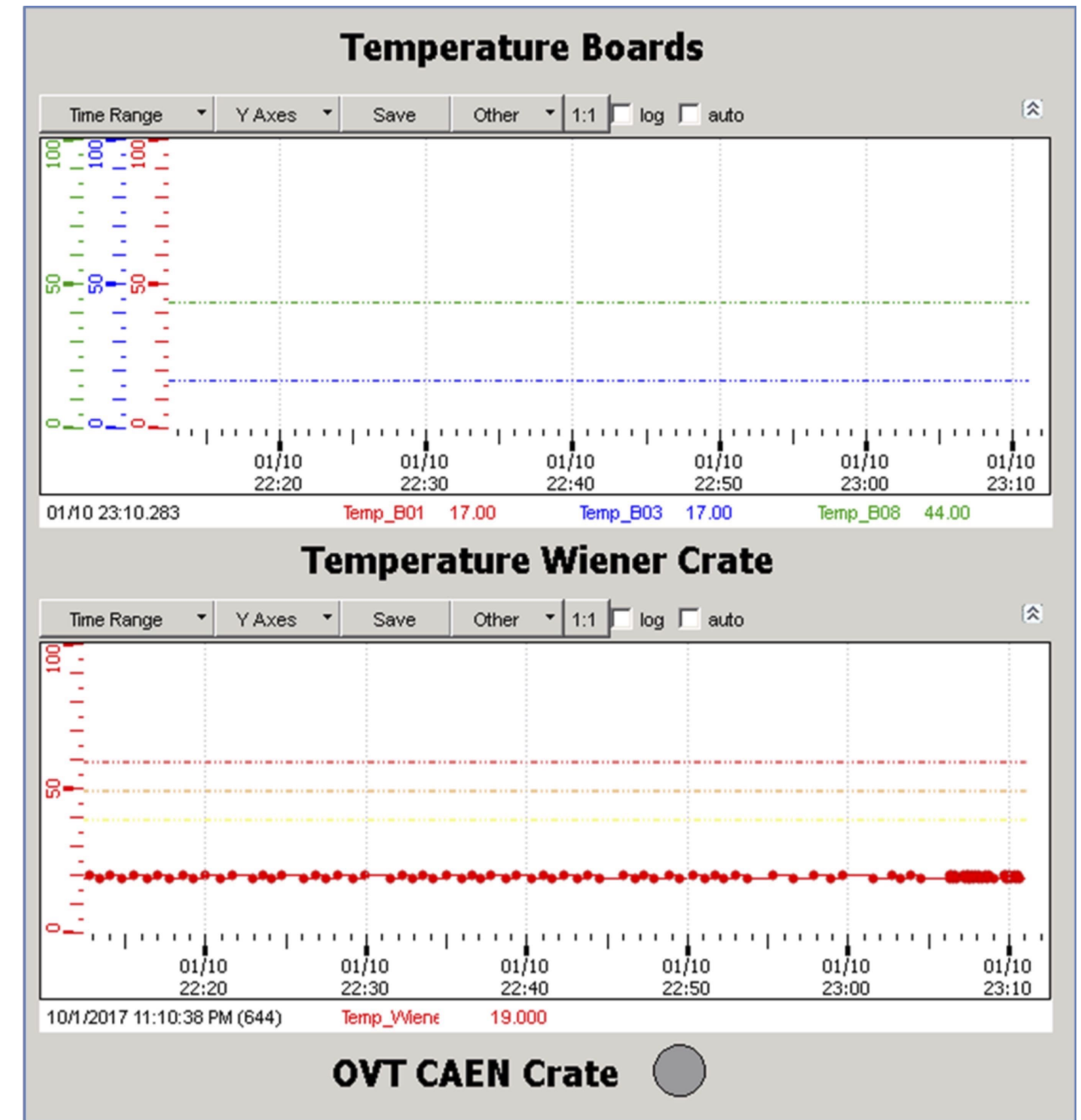
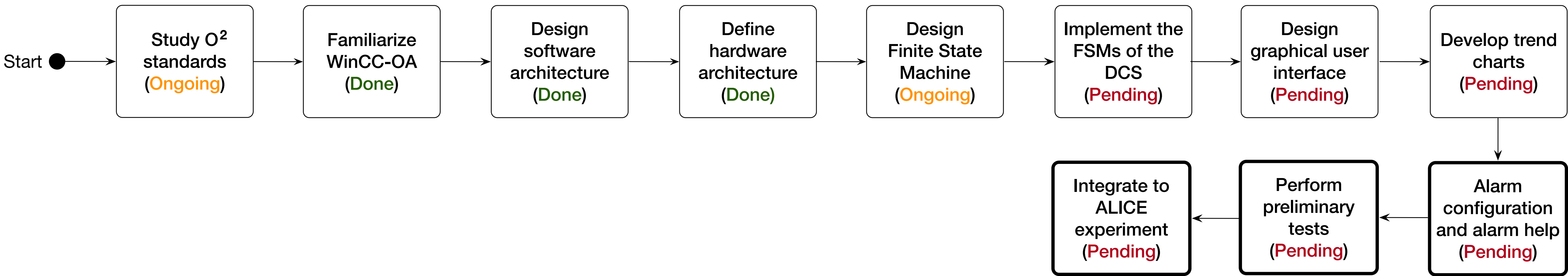
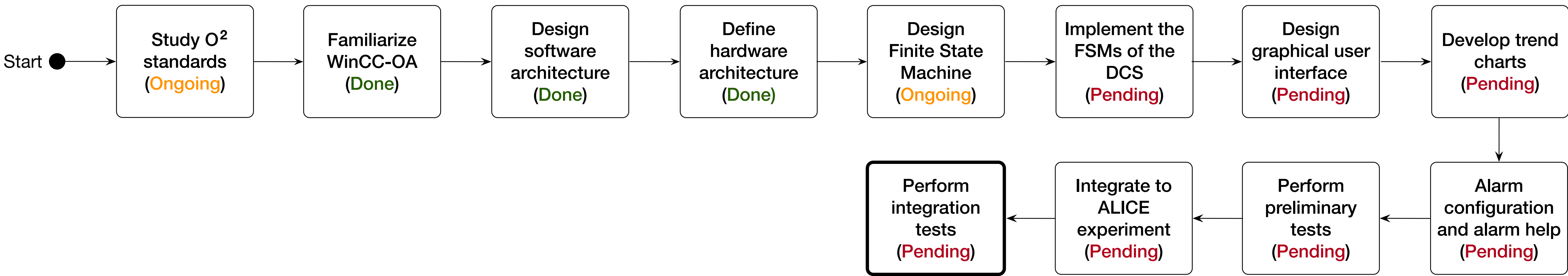


Figure 17. Temperature charts of the Wiener crate and the electronic boards in the ALICE experiment during Run-2 [4].



## FDD-DCS development methodology

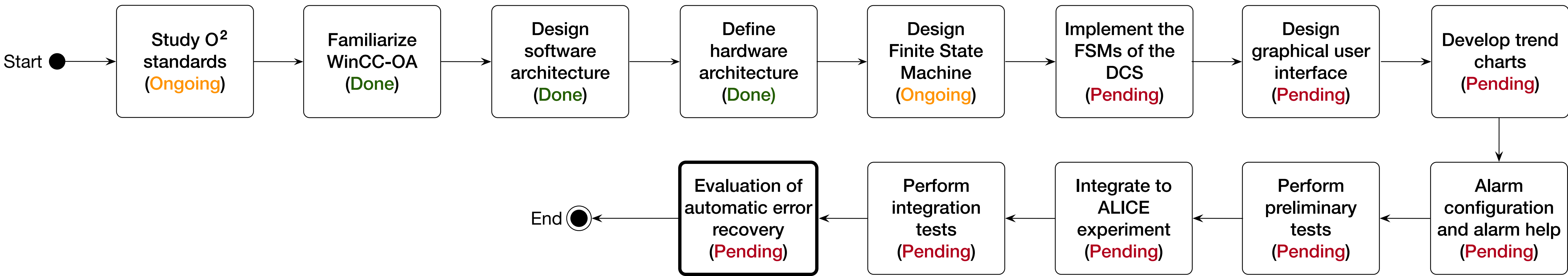
- \* Configuration and alarms help will be specified for the FDD detector, which will consist of a set of procedures that the central DCS operator in the ALICE Experiment must follow to resolve the issue that triggered the alarm.
- \* Once the development of the DCS software is complete, the testing stage will begin directly on the new FDD detector.
- \* The requirements for the integration of the FDD DCS in the central DCS of ALICE will be met during Run 3 of the LHC. For this it is necessary to comply with the various requirements established by the ACC group of ALICE [15].



## FDD-DCS development methodology

The parameters to measure the DSC performance of the FDD detector in physics Runs and its comparison with the other ALICE detectors during Run 3 will be the following:

1. Number of runs in which participated.
2. Total duration of physics data collection.
3. Data Taking Efficiency (DTE) of the experiment and the detectors [16].
4. End of Run (EOR) of detectors and systems [17].
5. Pause and Reconfigure (PAR) procedure executed, successful and failed [16],[18].



## FDD-DCS development methodology

- \* Evaluation of Artificial Intelligence (AI) algorithms will be carried out in the (DCS) to achieve automatic error recovery and more stable performance of the experiment.
- \* The potential source of errors may be related to the variation of voltage and current levels in low voltage (LV) and high voltage (HV) power supplies, as well as changes in temperature.

# Conclusions

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- \* The main physics task of FDD detector will be to efficiently tag the presence/absence of photon-induced and/or diffractive process by monitoring the (lack of) activity in the forward direction during Run-3.
- \* The software and hardware architecture already proposed will allow to release a fully operative DCS for the FDD detector to comply with the new Online-Offline ( $O^2$ ) infrastructure requirements of ALICE experiment.
- \* The design of the DCS for the FDD detector is a challenging task due to the upgrade in ALICE's hardware and change of the data processing strategy. The data will be provided to the  $O^2$  processing facilities in streamed mode for which the DCS data stream has to be diverted from its standard path.
- \* The commissioning for the DCS of the FDD detector is expected for March 2021.

“Thanks for your attention”

**Juan Manuel Mejía Camacho**  
**Juan Carlos Cabanillas Noris**



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