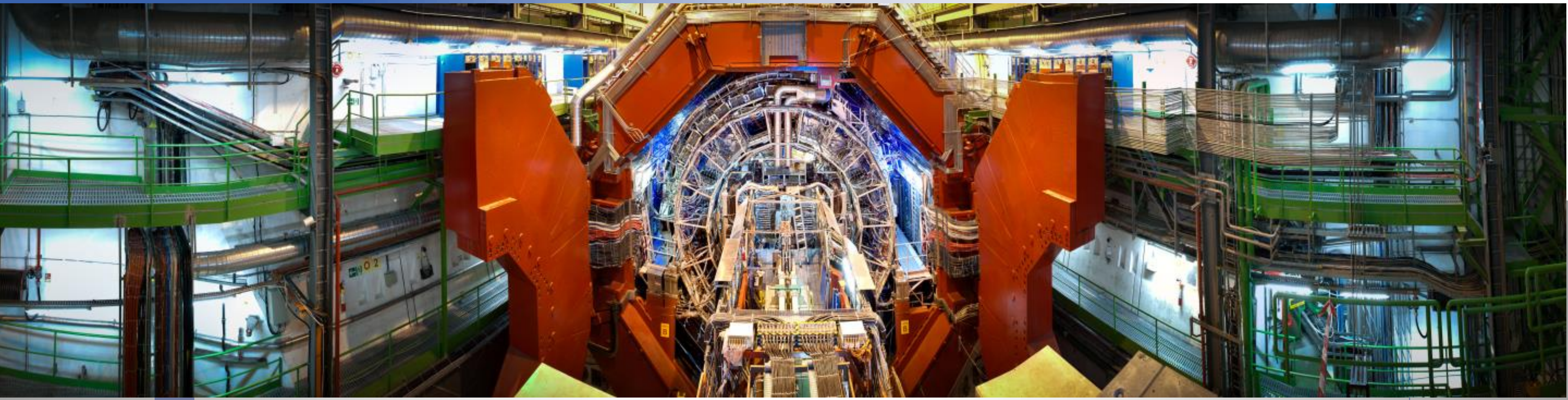


THE ALICE DETECTOR CONTROL SYSTEM

Peter Chochula - CERN

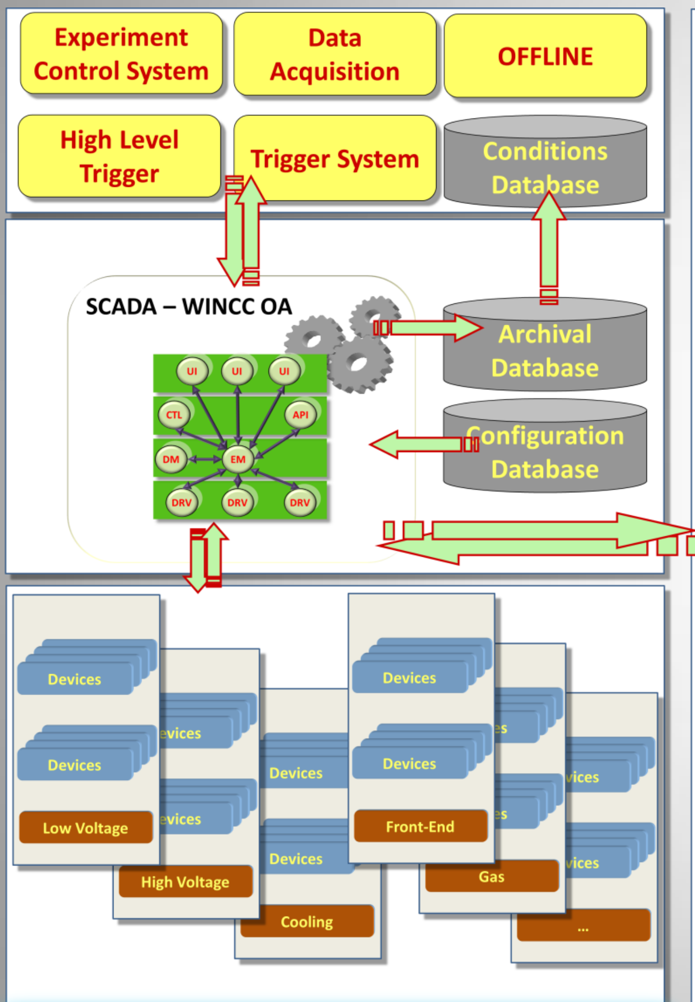
4th ALICE ITS, MFT and O2 Asian Workshop. Pusan, December 2014

The Detector Control System

- Responsible for safe and reliable operation of the experiment
  - Designed to operate autonomously
  - Wherever possible, based on industrial standards and components
  - Built in collaboration with ALICE institutes and CERN JCOP
  - Operated by a single operator

THE ALICE DCS ARCHITECTURE

The DCS context and scale



Devices with similar functionality are grouped into subsystems. About 100 different subsystems are implemented in ALICE. .

- Electricity
- Ventilation
- Cooling
- Magnets
- Gas
- Access Control
- LHC
- Safety
- B-field
- Space Frame
- Beam Pipe
- Environment
- Radiation

20 autonomous detector systems

1200 network attached devices

100 WINCC OA systems

>700 embedded computers

>100 subsystems

170 control computers

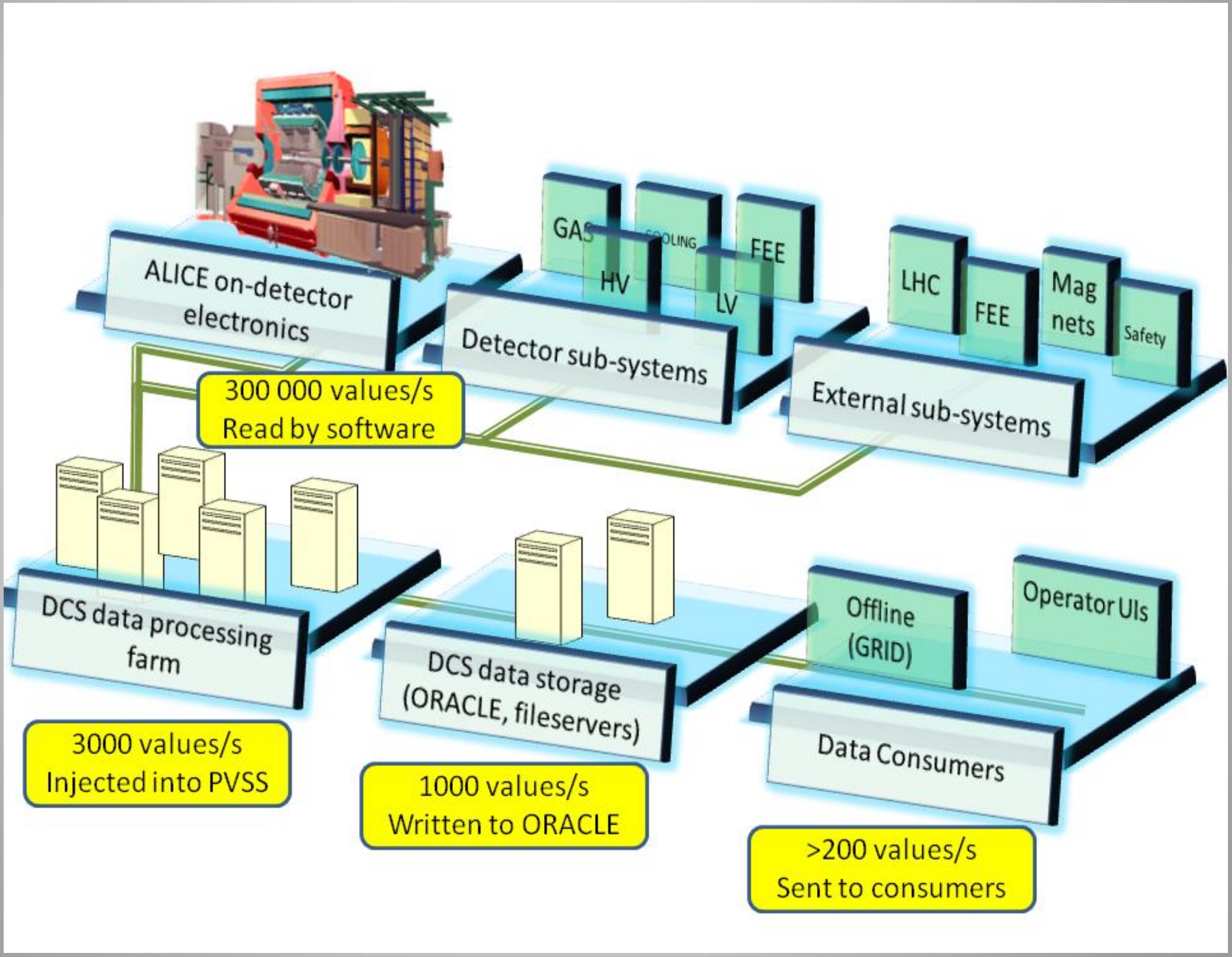
270 crates

200 000 OPC items

1 000 000 supervised parameters

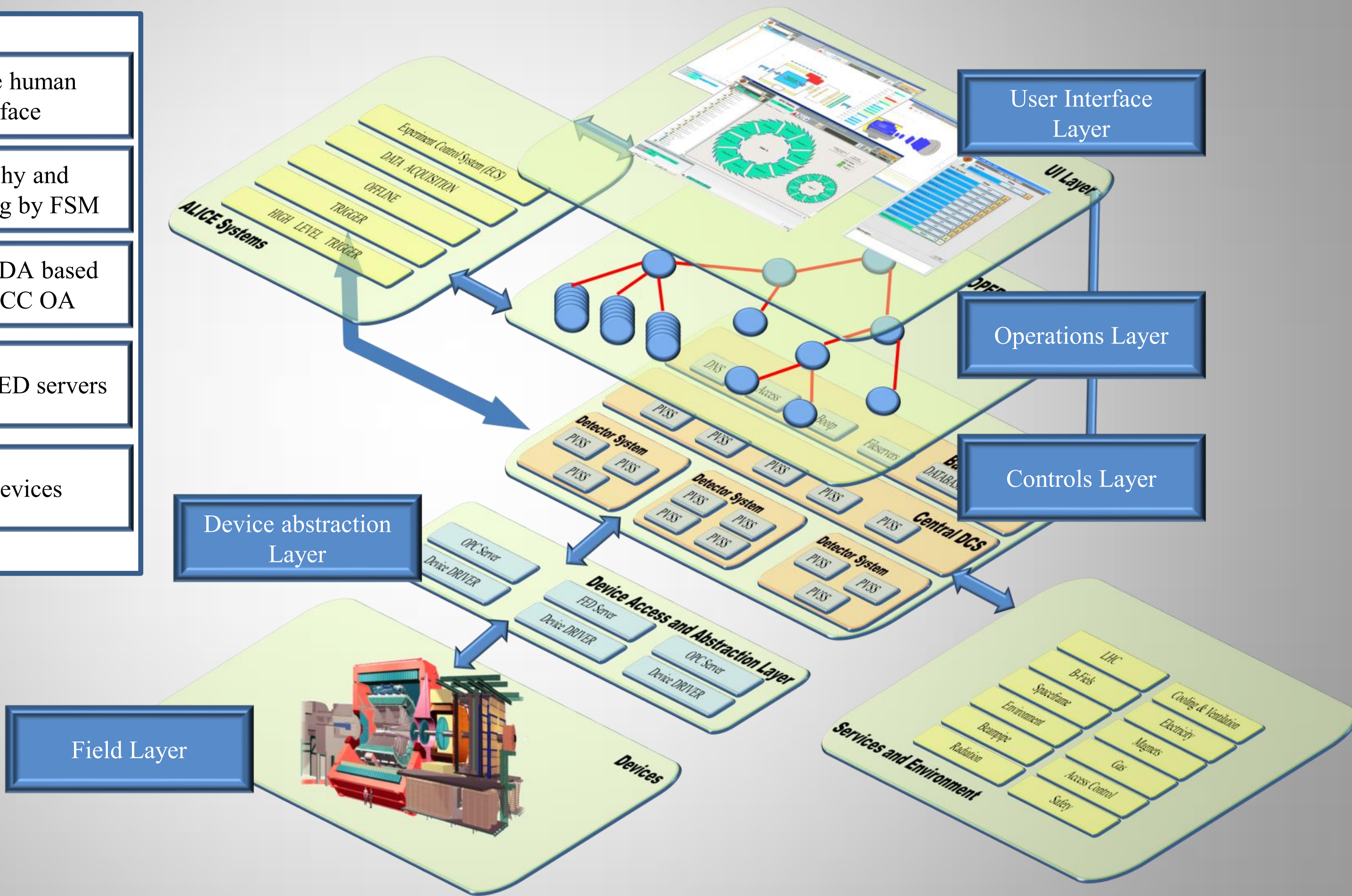
100 000 frontend services

The DCS data flow



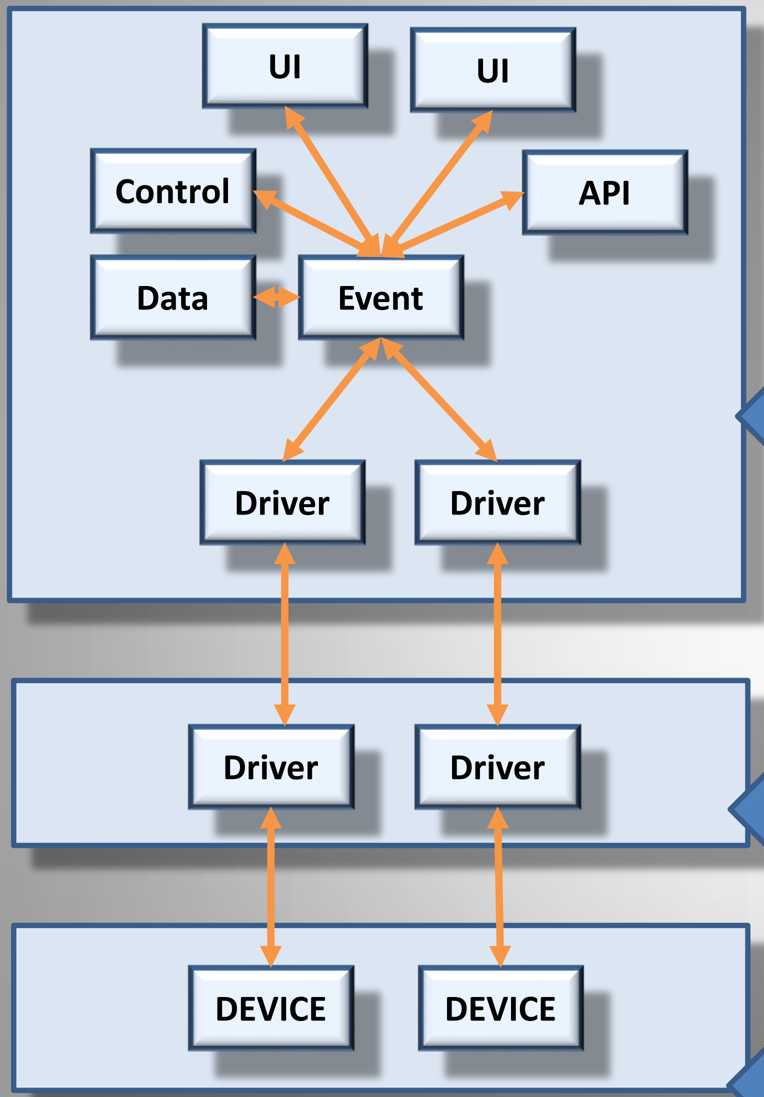
DCS Architecture

User Interface Layer	Intuitive human interface
Operations Layer	Hierarchy and partitioning by FSM
Controls Layer	Core SCADA based on WINCC OA
Device abstraction Layer	OPC and FED servers
Field Layer	DCS devices



THE DCS CONTROLS LAYER

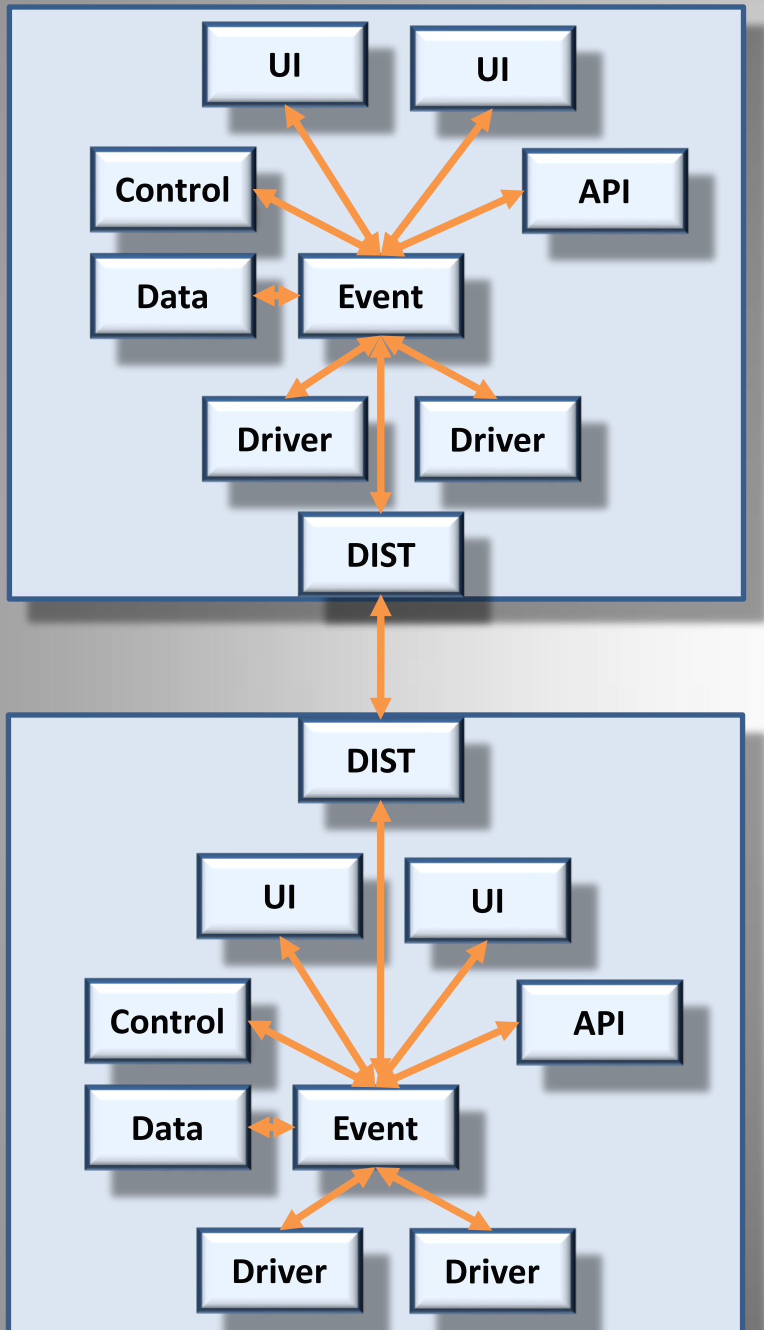
Vertical DCS slice



- Core of the Control Layer runs on WINCC OA SCADA system
- Single WINCC OA system is composed of managers

- Low level device drivers are interfaced to WINCC OA

- Physical devices

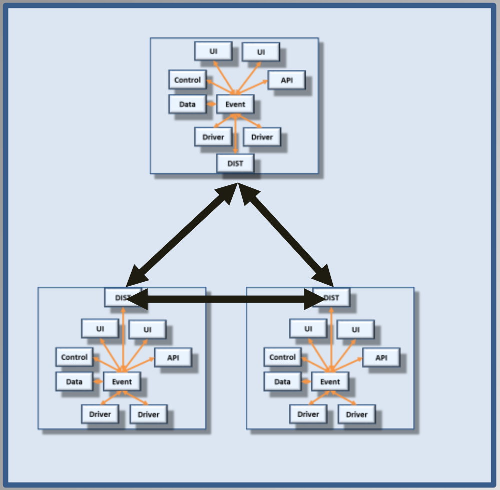


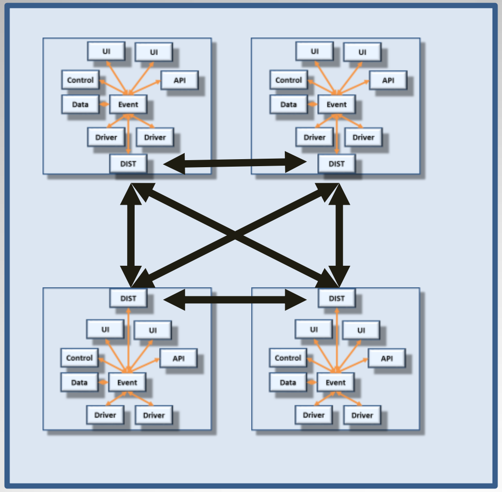
- Several WINCC OA systems can be connected into one distributed system

ALICE DCS:

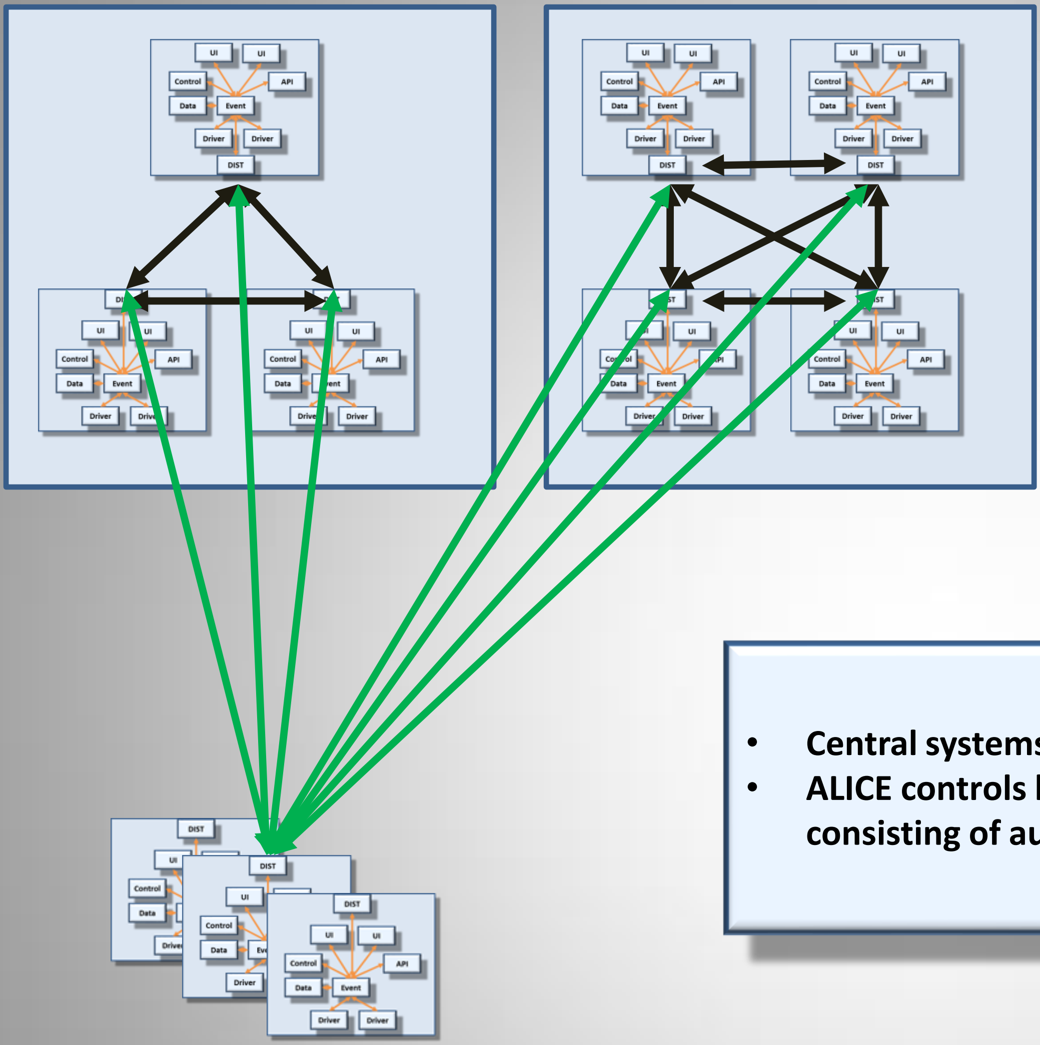
2700 managers

100 WINCC OA systems



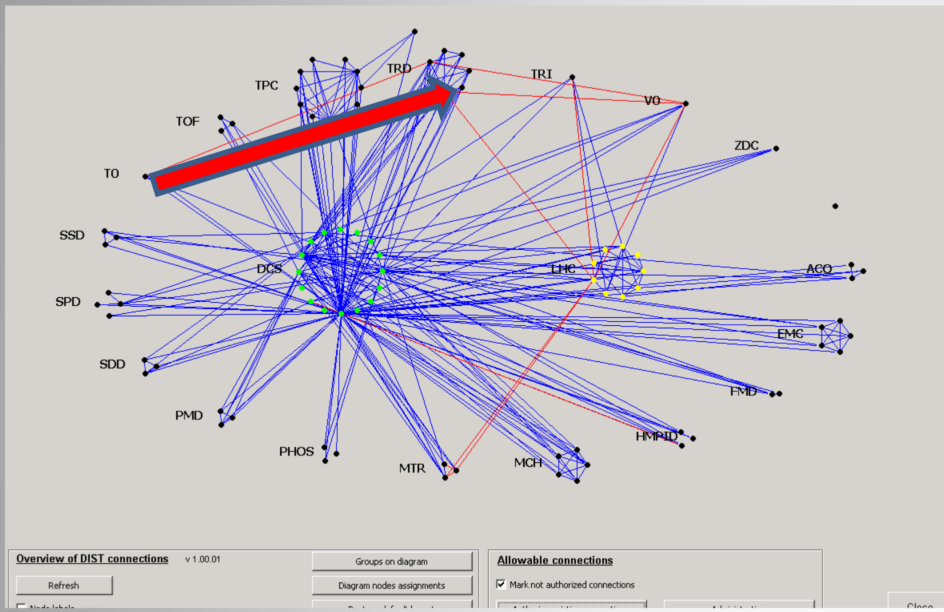


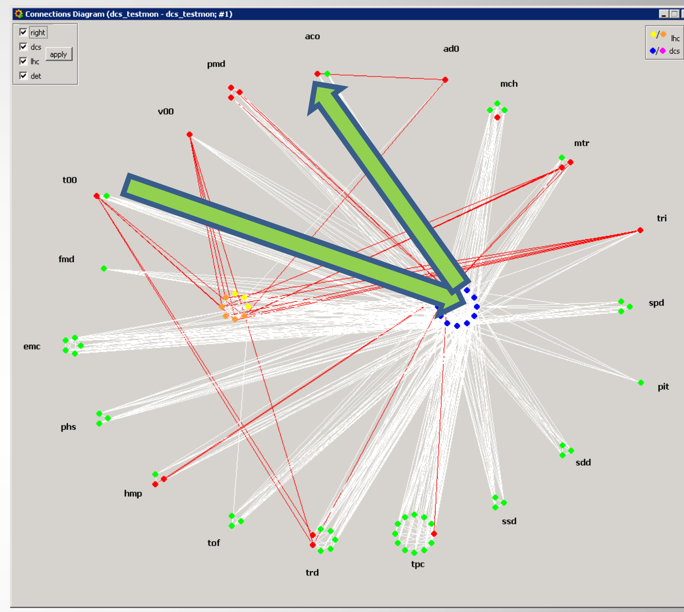
- **An autonomous distributed system is created for each detector**



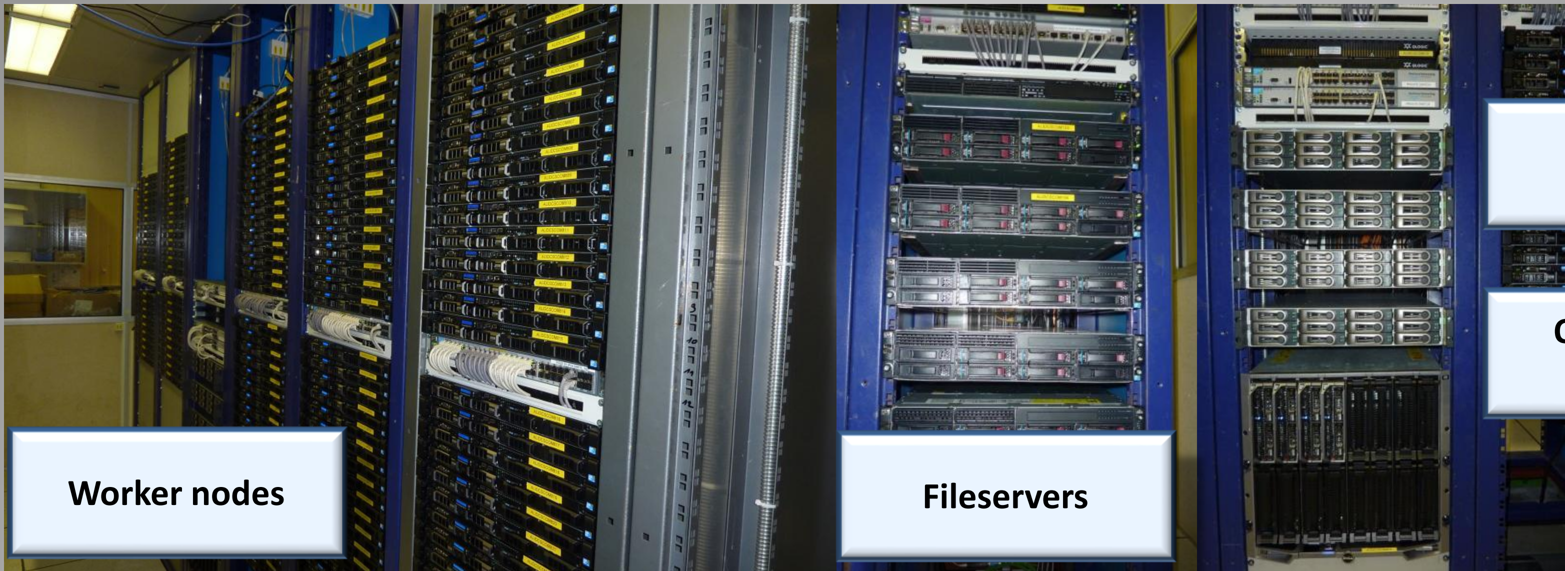
- Central systems connect to all detector systems
- ALICE controls layer is built as a distributed system consisting of autonomous distributed systems

‘illegal’ connection





- To avoid inter-system dependencies, connections between detectors are not permitted
- Central systems collect required information and re-distribute them to other systems
  - New parameters added on request
- System cross connections are monitored and anomalies are addressed

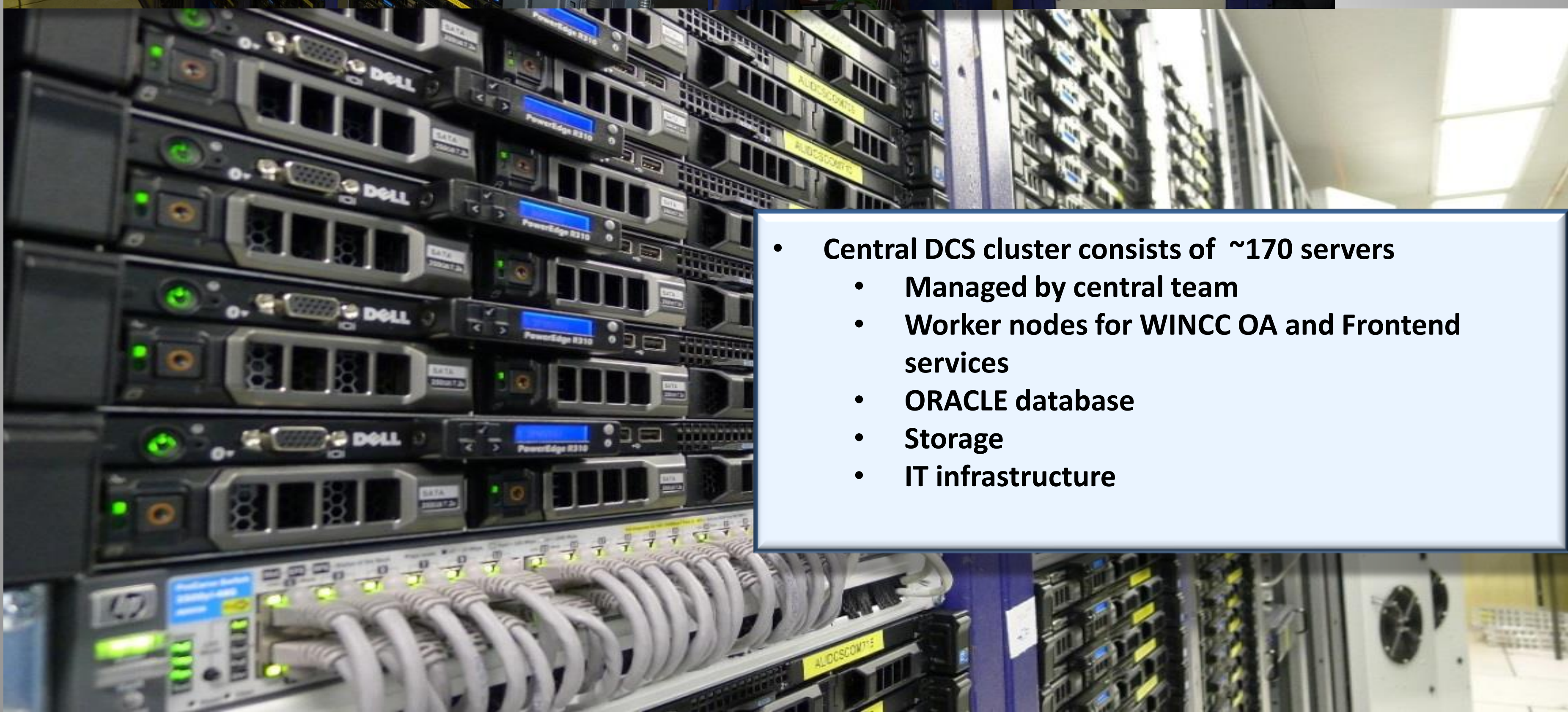


Worker nodes

Fileservers

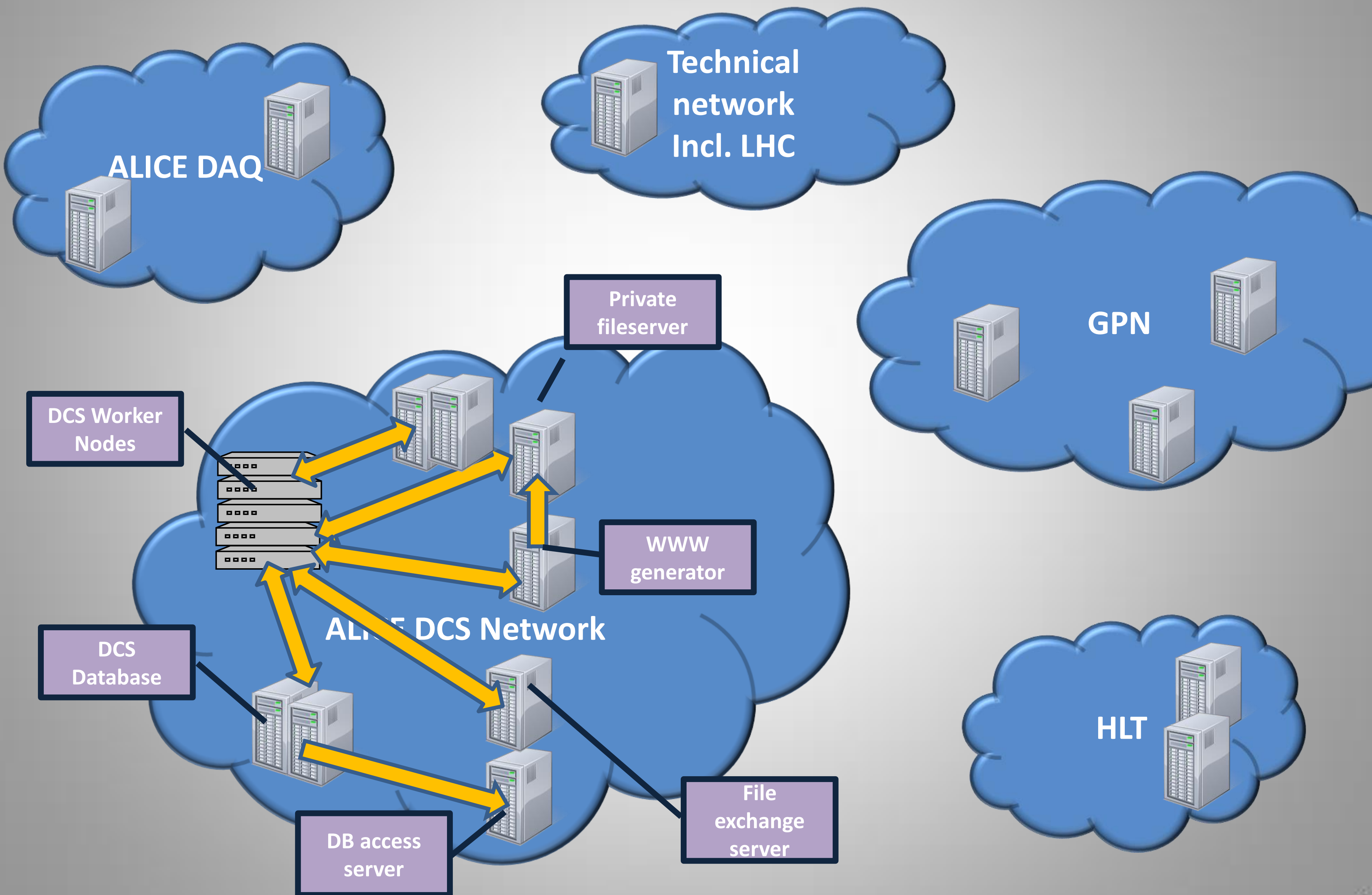
DB servers

ORACLE size:
5.4 TB

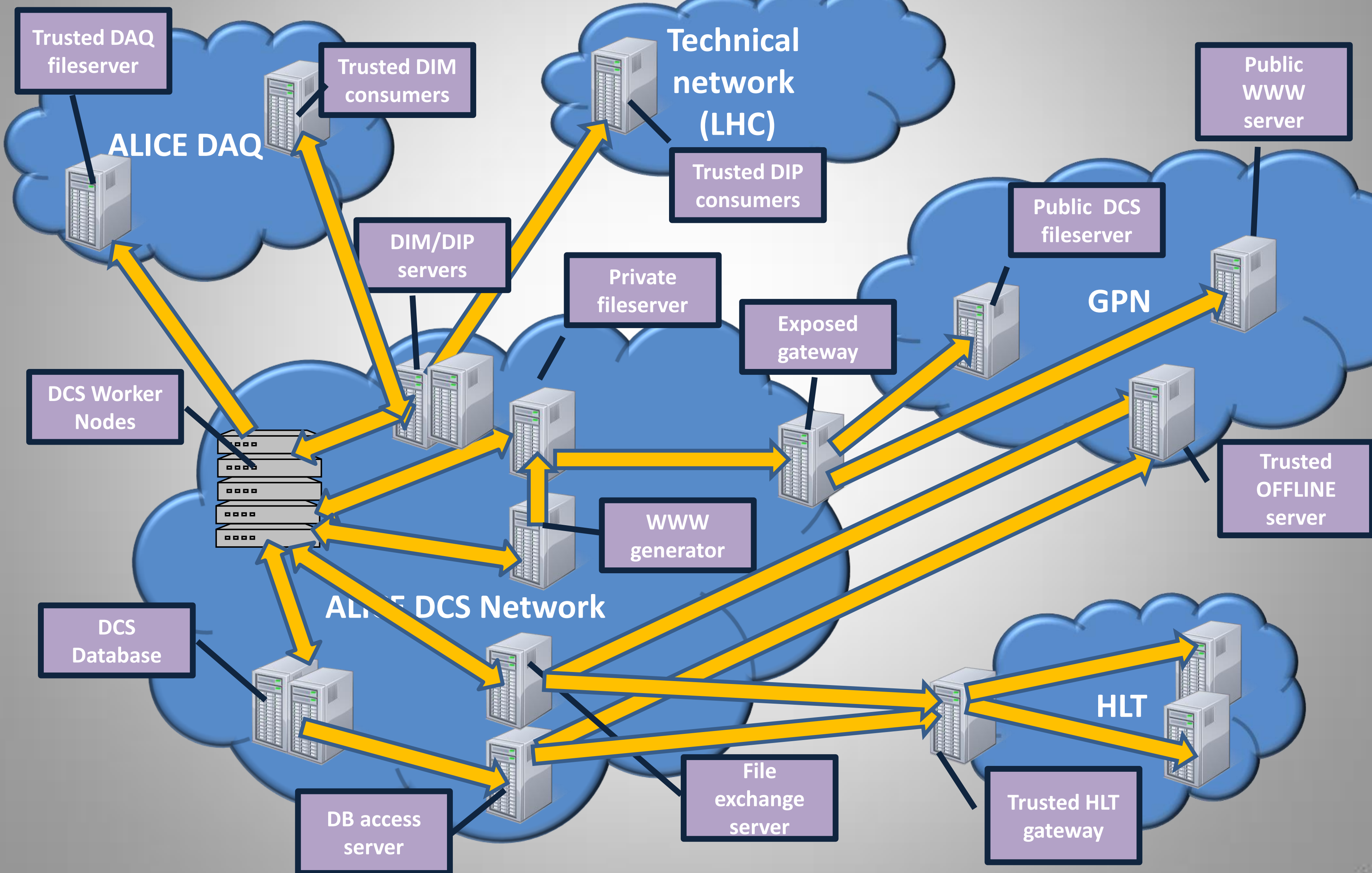


- Central DCS cluster consists of ~170 servers
  - Managed by central team
  - Worker nodes for WINCC OA and Frontend services
  - ORACLE database
  - Storage
  - IT infrastructure

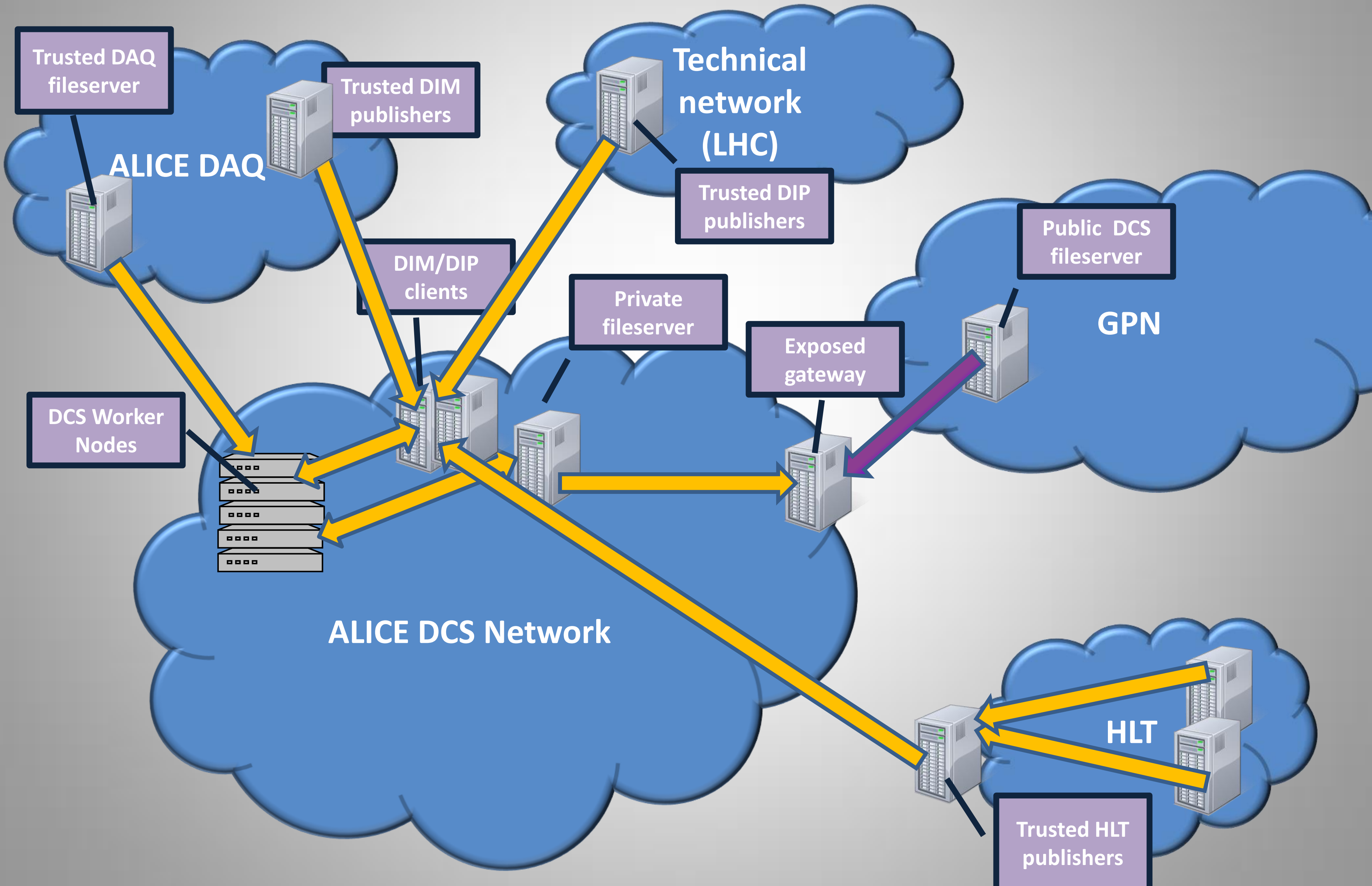
DCS can operated in isolated mode



DCS serves as a communication exchange point: Outbound.....



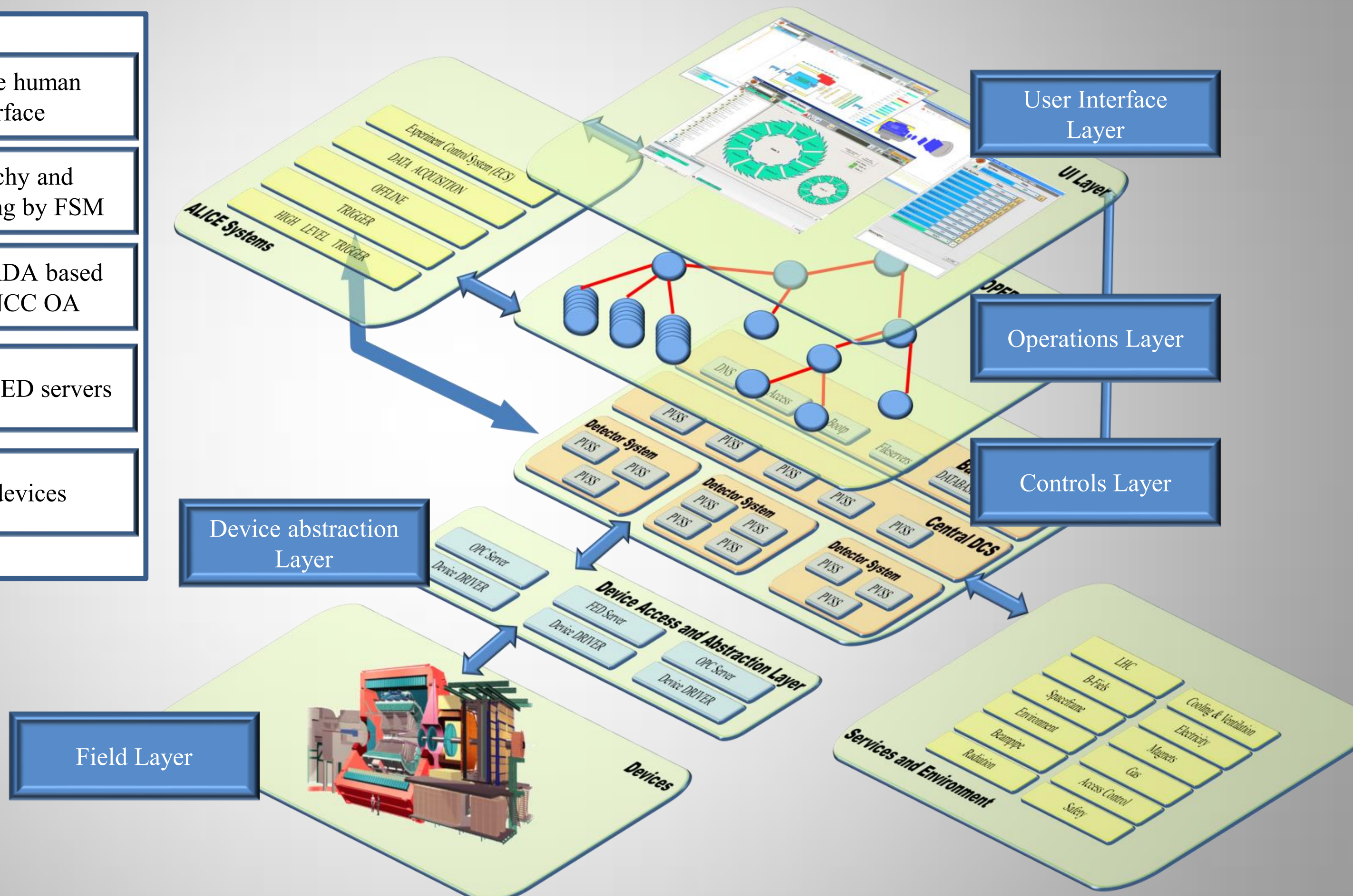
… and inbound

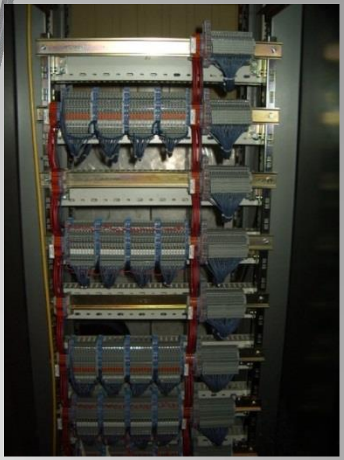

Trusted DAQ fileserver
Trusted DIM publishers
ALICE DAQ
Technical network (LHC)
Trusted DIP publishers
Public DCS fileserver
GPN
DIM/DIP clients
Private fileserver
Exposed gateway
DCS Worker Nodes
ALICE DCS Network
HLT
Trusted HLT publishers

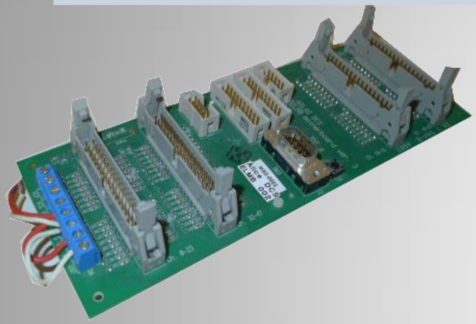
THE DCS FIELD LAYER
THE POWER OF STANDARDIZATION

DCS Architecture

User Interface Layer	Intuitive human interface
Operations Layer	Hierarchy and partitioning by FSM
Controls Layer	Core SCADA based on WINCC OA
Device abstraction Layer	OPC and FED servers
Field Layer	DCS devices

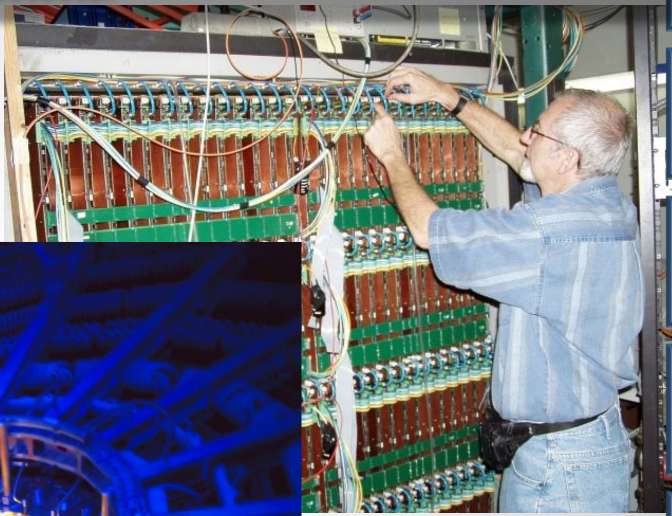






- Wherever possible, standardized components are used
  - Commercial products
  - CERN-made devices

- Frontend electronics
  - Unique for each detector
  - Large diversity, multiple buses and communication channels
    - Several technologies used within the same detector



CAN

ETHERNET

EASYNET

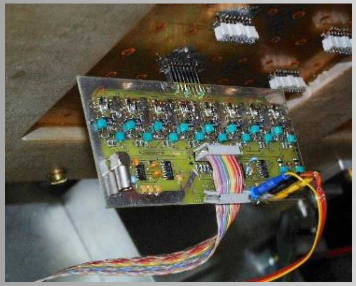
VME

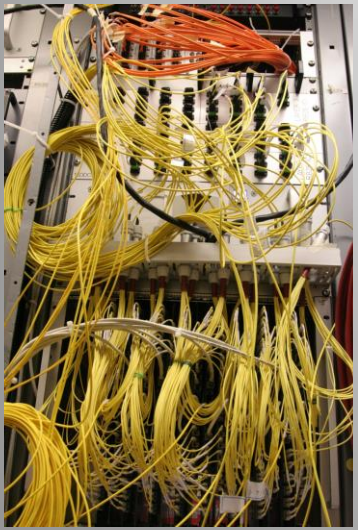
JTAG

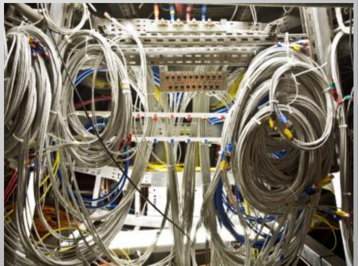
RS 232

PROFIBUS

Custom links…

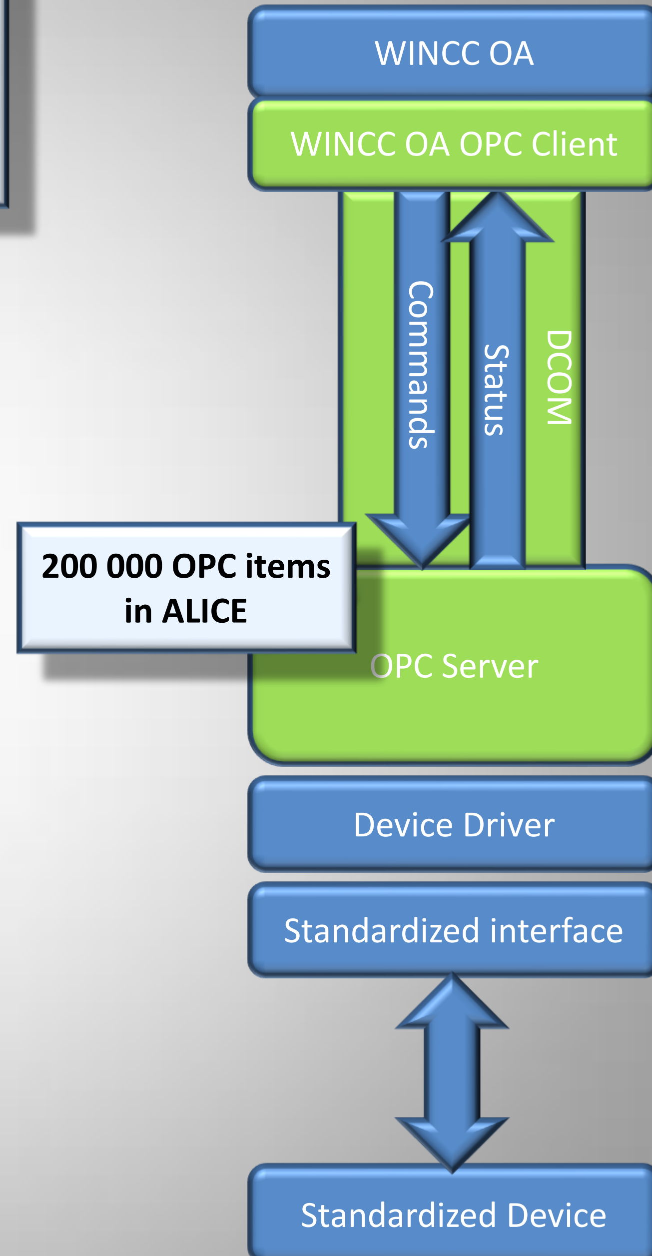




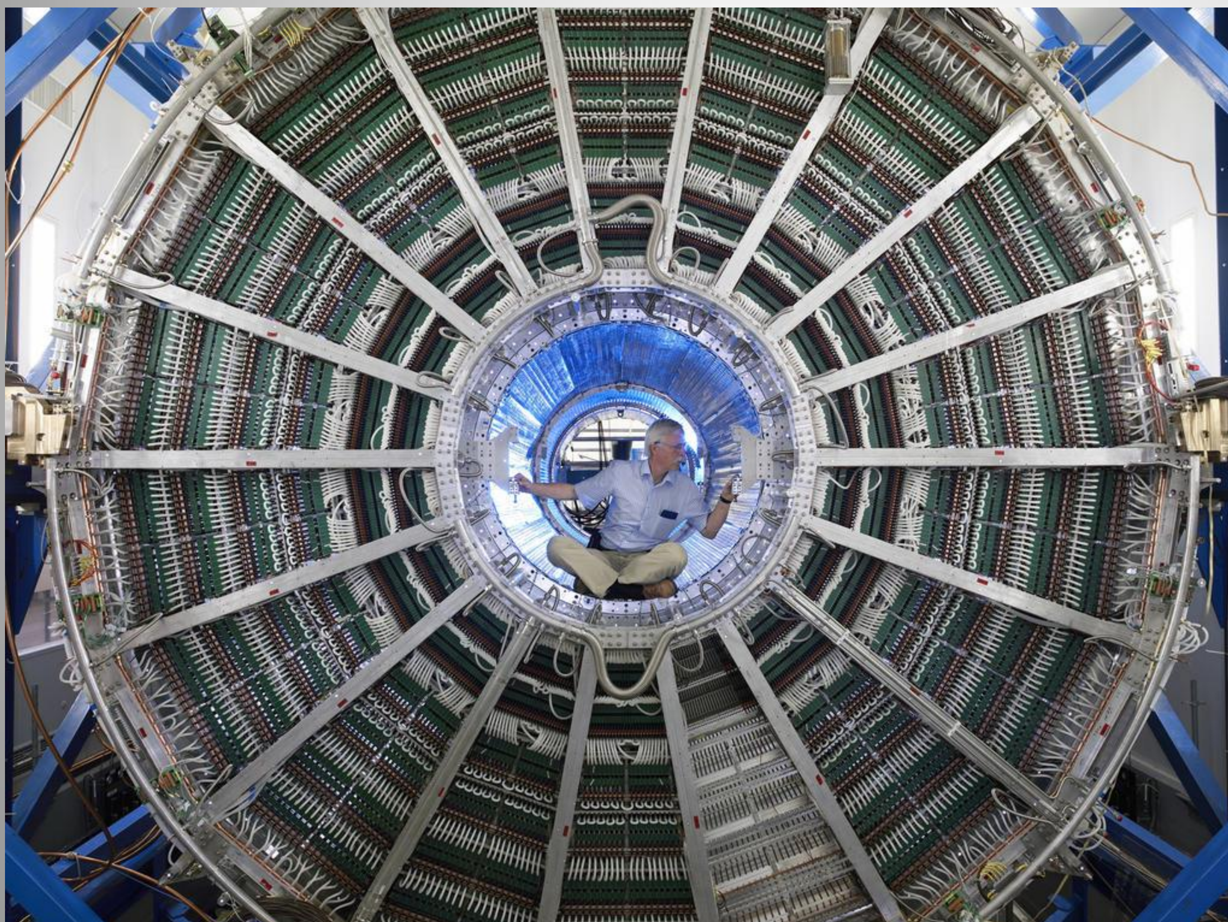


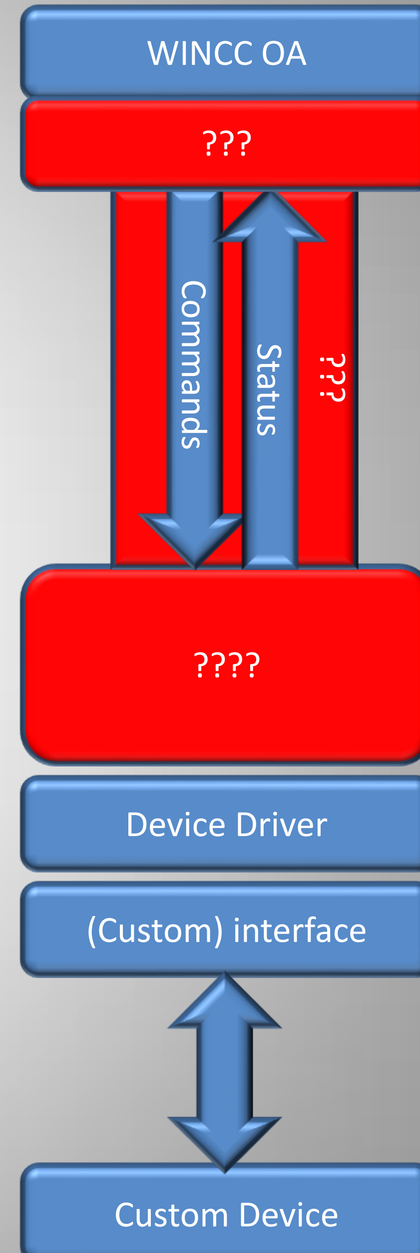
- **OPC used as a communication standard wherever possible**
  - **Native client embedded in WINCC OA**

Title	Version	Availability	Last Modified
FDI Usability Style Guide Draft	fd 04	Members	2013-09-10
OPC UA For Analyser Devices 1.1 Companion Specification	1.1	Members	2013-07-31
OPC UA For Devices 1.1 Companion Specification	1.1	Members	2013-07-29
OPC UA Part 7 - Profiles 1.02 Specification	1.02	Members	2013-04-18
OPC UA for ISA-95 Common Object Model	1.01.00	Members	2013-04-17
OPC UA Part 2 - Security Model 1.02 Specification	1.02	Members	2013-04-17
OPC Data Access 3.00 Errata	3.00	Members	2013-03-21
OPC Historical Data Access 1.20 Errata	1.20	Members	2013-03-21
OPC XML-DA 1.01 Errata	1.01	Members	2013-03-21
FDI Specifications, Release Candidate 0.9	0.9	Corporate Members	2013-02-12
OPC UA 1.02 Specifications Errata	1.00	Members	2012-10-23
OPC UA Part 1 - Overview and Concepts 1.02 Specification	1.02	NonMembers	2012-08-16
OPC UA Part 3 - Address Space Model 1.02 Specification	1.02	Members	2012-08-16

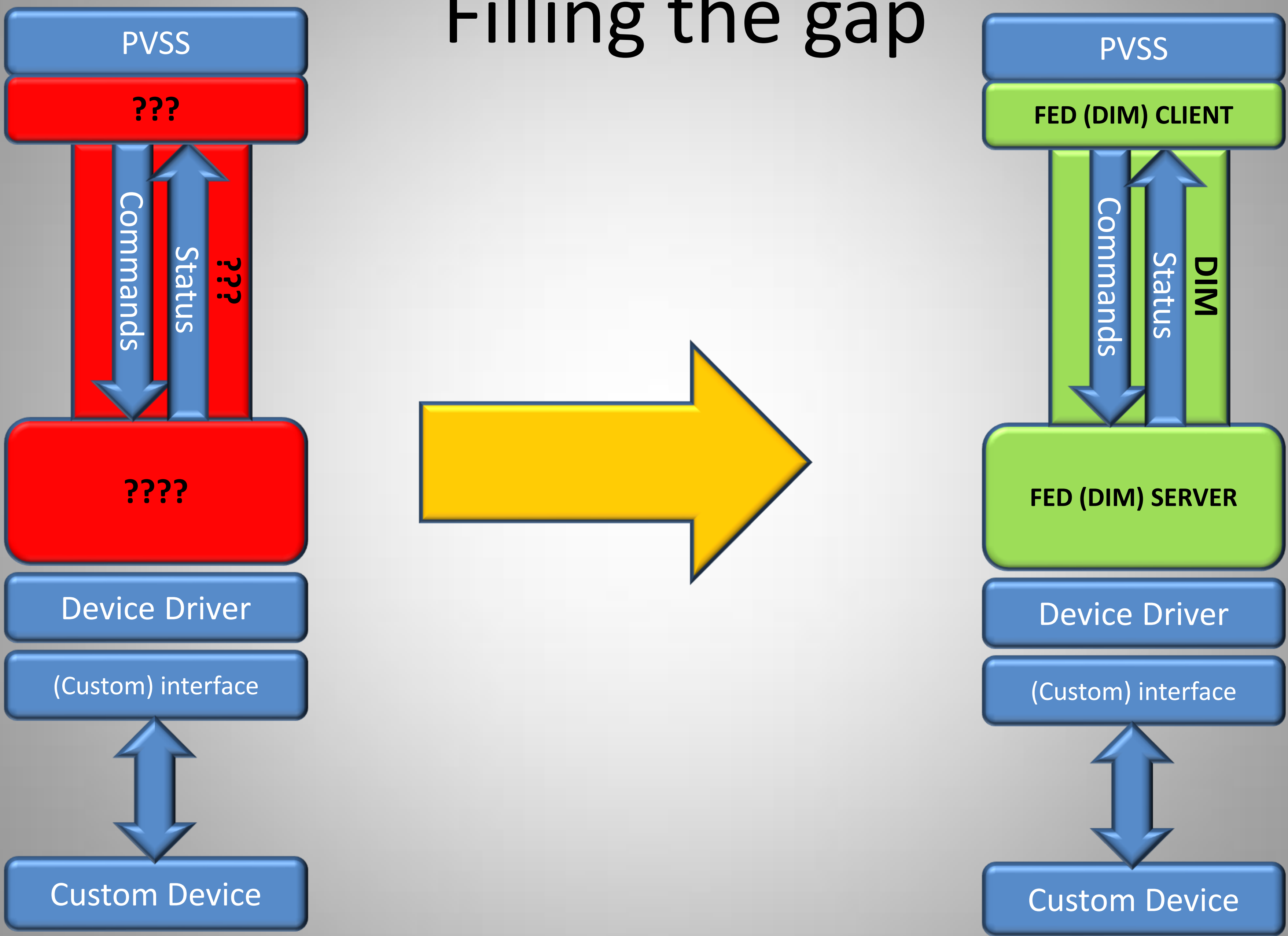


- Missing standard for custom devices
  - OPC to heavy to be developed and maintained by institutes
  - Frontend drivers often scattered across hundreds of embedded computers (Arm Linux)





Filling the gap



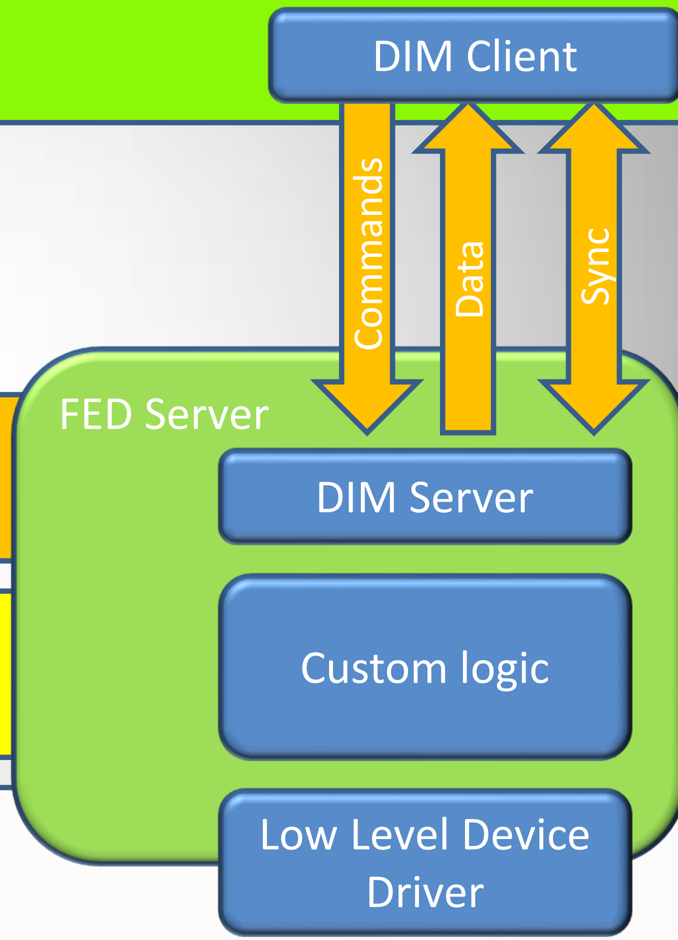
Generic FED architecture

Generic client implemented as PVSS manager

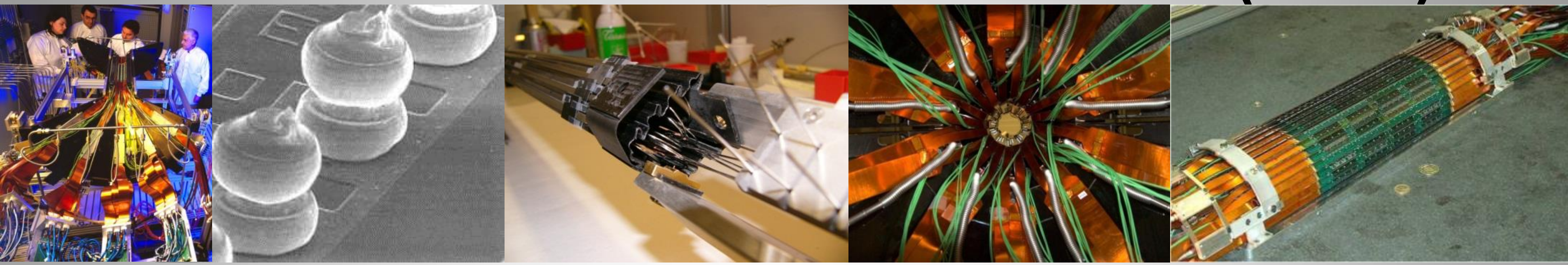
Communication interface with standardized commands and services

Device/specific layer providing high-level functionality (i.e. Configure, reset...)

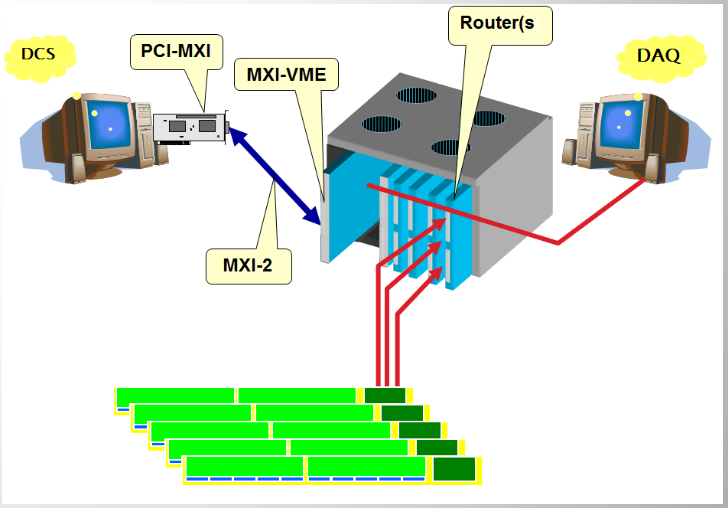
Low-level device interface (i.e. JTAG driver and commands)

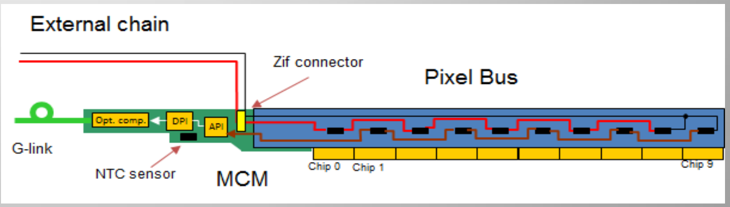


ALICE Silicon Pixel Detector (SPD)

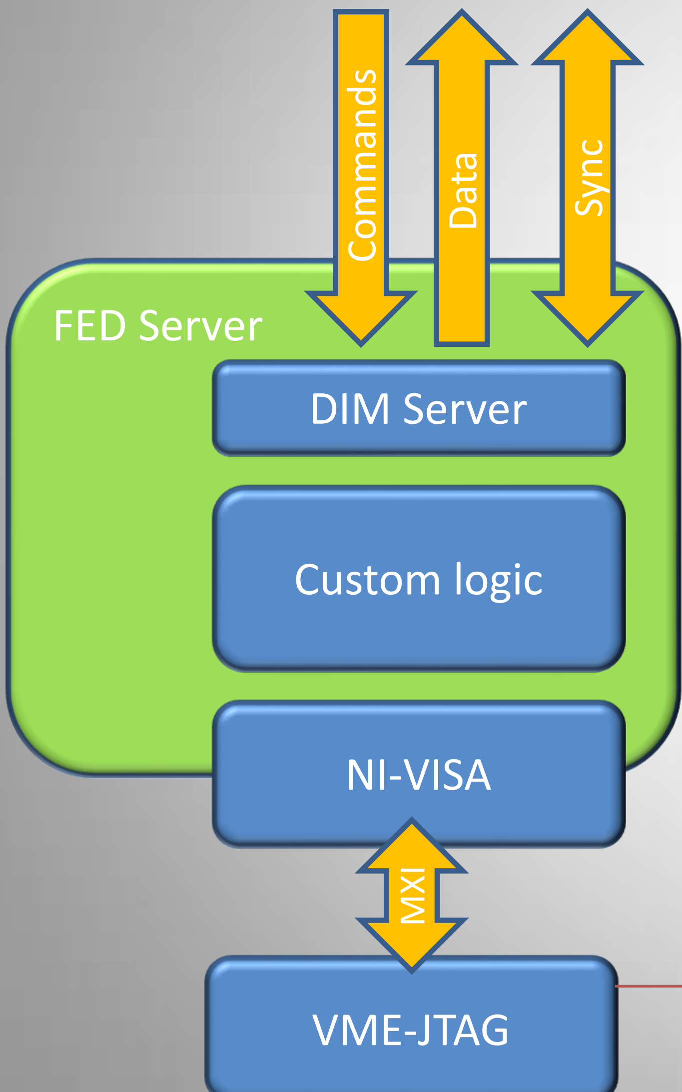


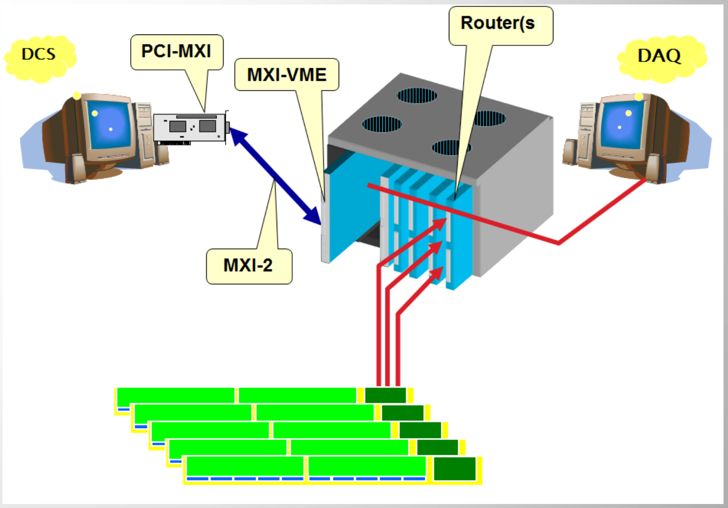
- 2 layers
  - 2.5 and 7 cm away from beam
- 10 000 000 pixels bump-bonded to 1200 readout chips
- Power dissipation 1.3kW
  - Total thickness of pixel assembly (200+150)µm
  - 1^0C/s increase in case of cooling failure
    - Less than 1min contingency!
- Reliable frontend control is essential!

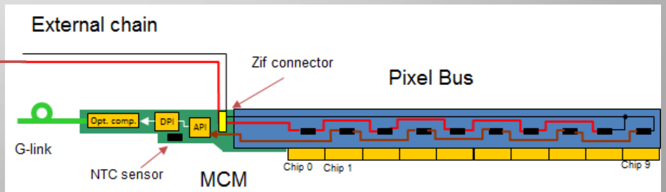




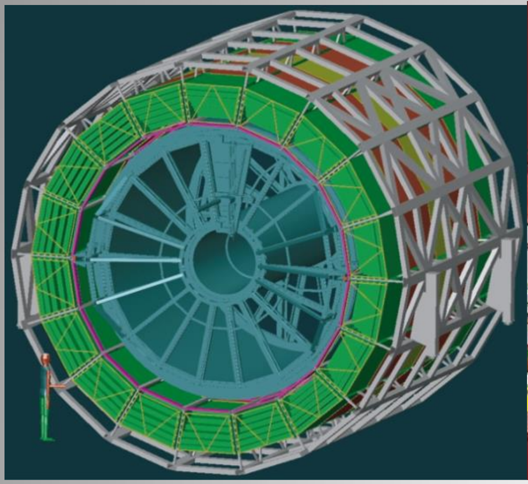
SPD FED Implementation

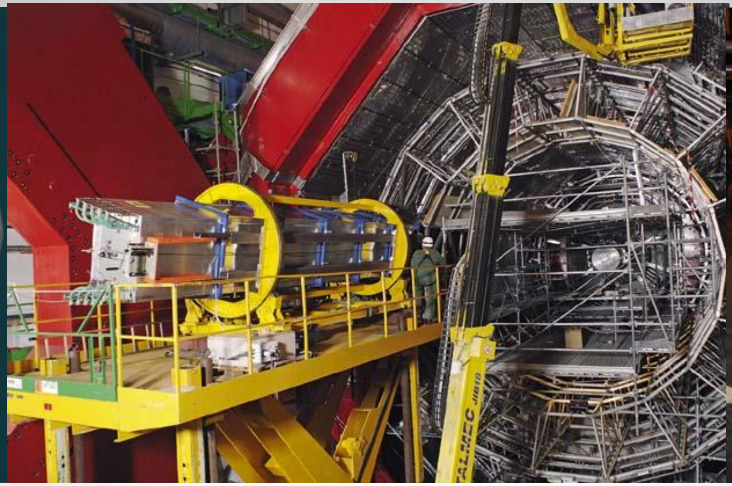


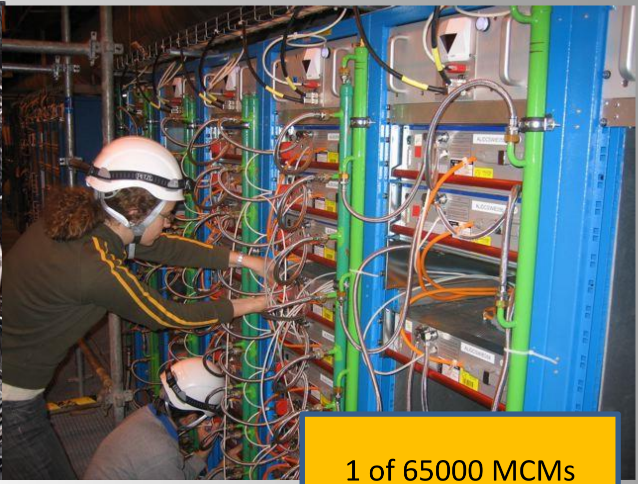




ALICE Transition Radiation Detector (TRD)





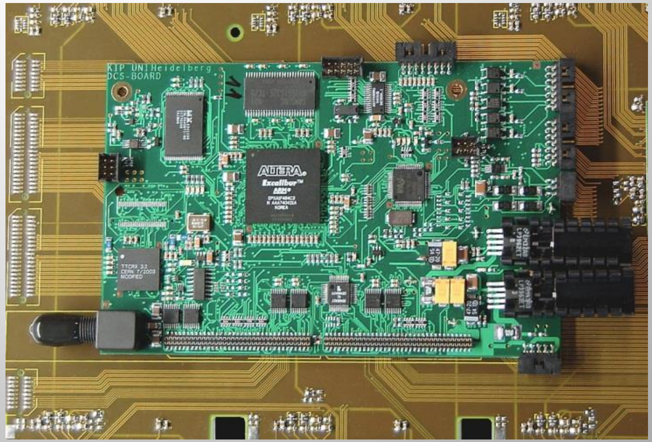


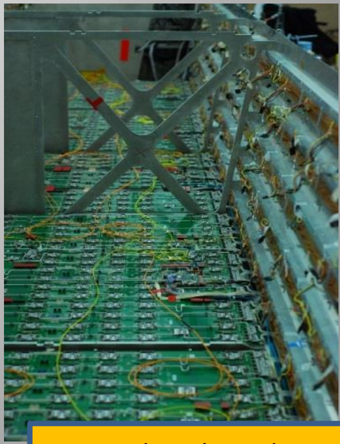
- > 500 drift chambers, 760 m^2
- 28 m^3 Xe based gas mixture
- 1.2M electronics channels
  - 65000 MCM
  - 250 000 tracklet processors
  - 17TB/s raw data

- 89 LV Power supplies
  - ~65 kW heat

1 of 65000 MCMs

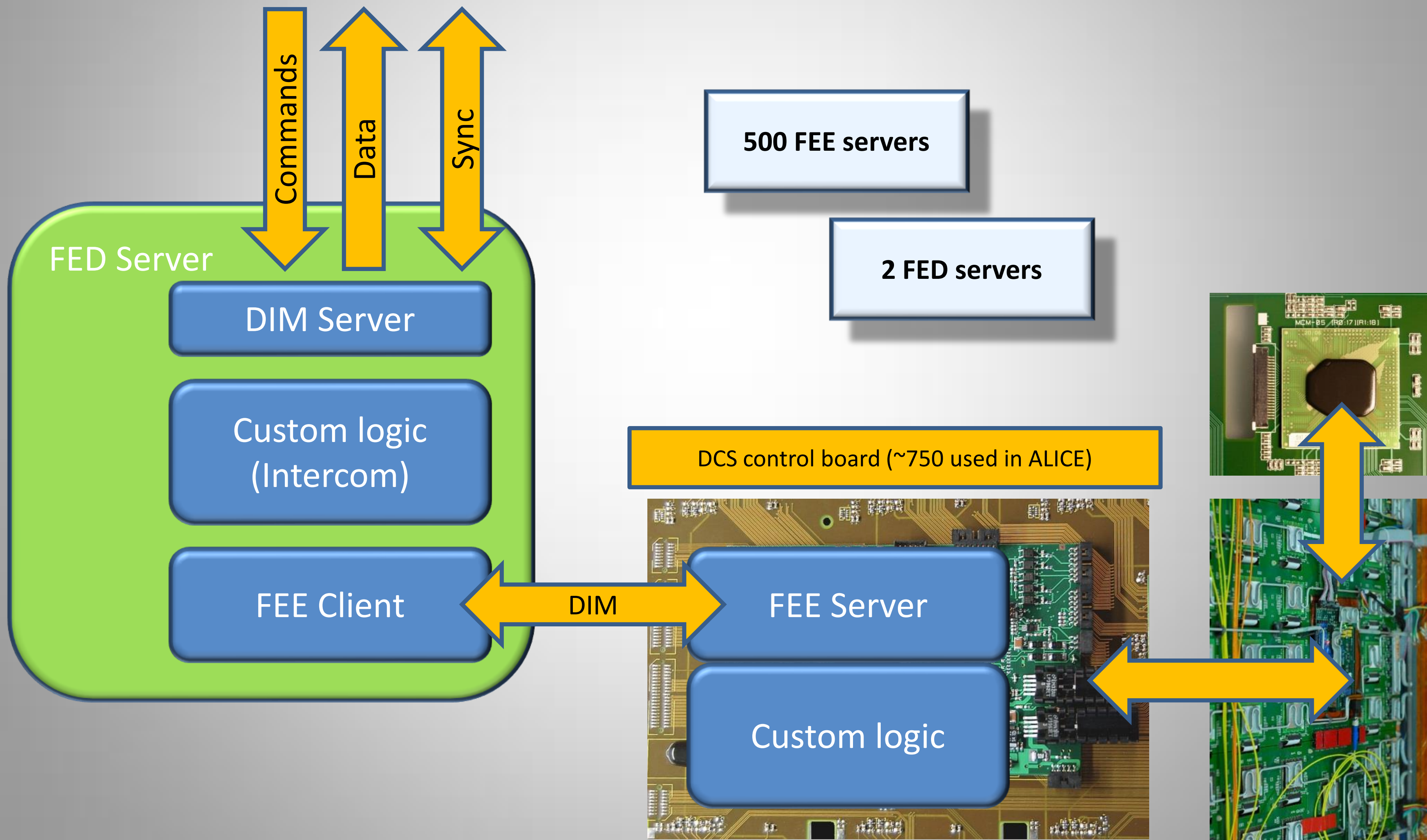
DCS control board (~750 used in ALICE)





Readout boards

TRD FED Implementation



THE DCS OPERATION LAYER

Hierarchical approach

Based on CERN toolkit (SMI++)

Each node modelled as FSM

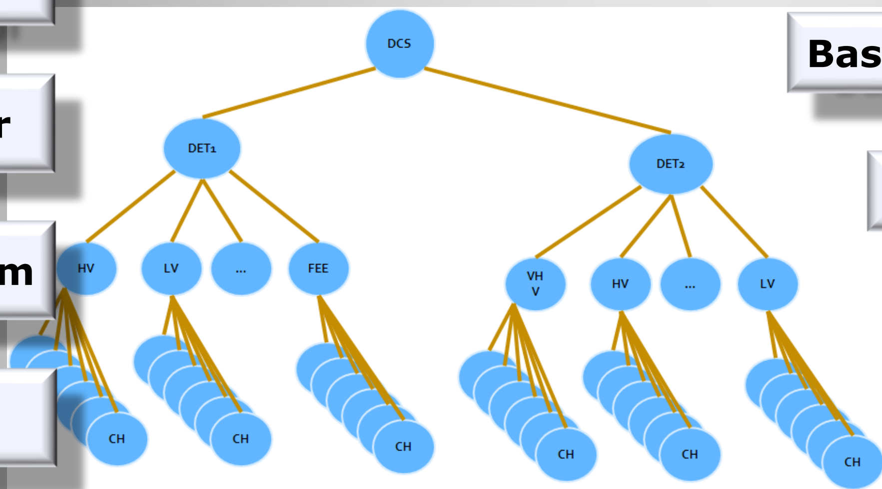
Integrated with WINCC OA

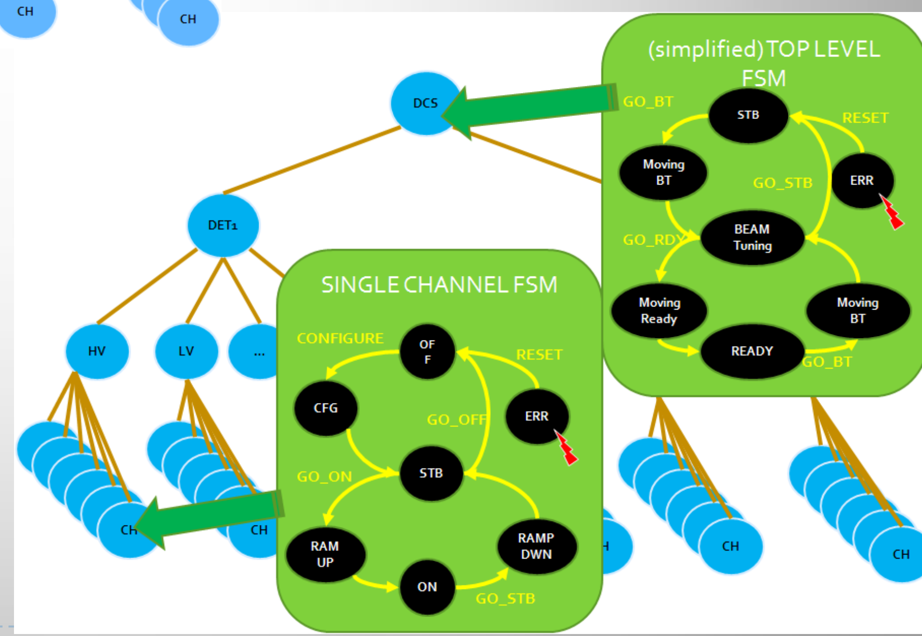
Central control

Detector

Subsystem

Device





ALICE central FSM hierarchy

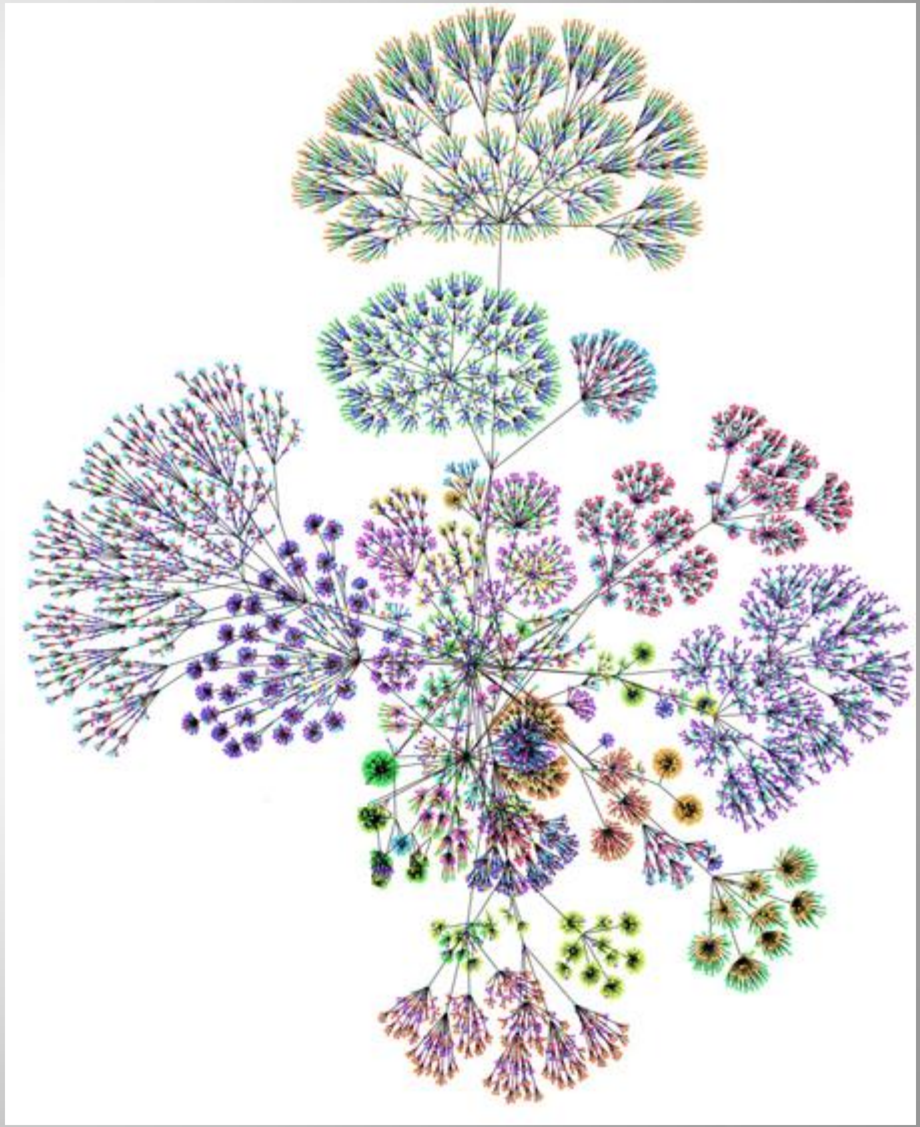
1 top DCS node

18 detector nodes

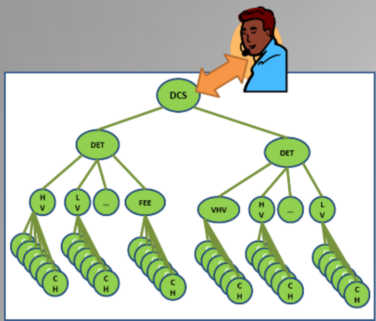
100 subsystems

5000 logical devices

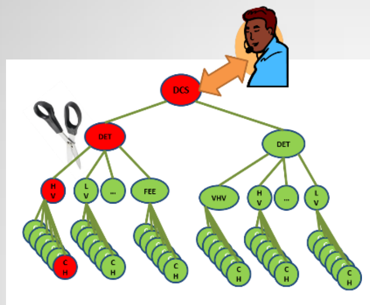
10000 leaves



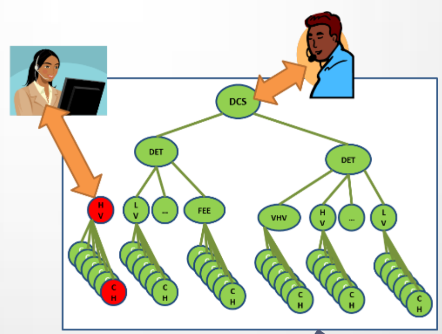
Partitioning



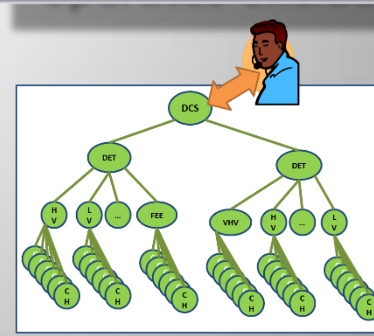
Single operator controls ALICE



Failing part is removed from hierarchy



Remote expert operates excluded part

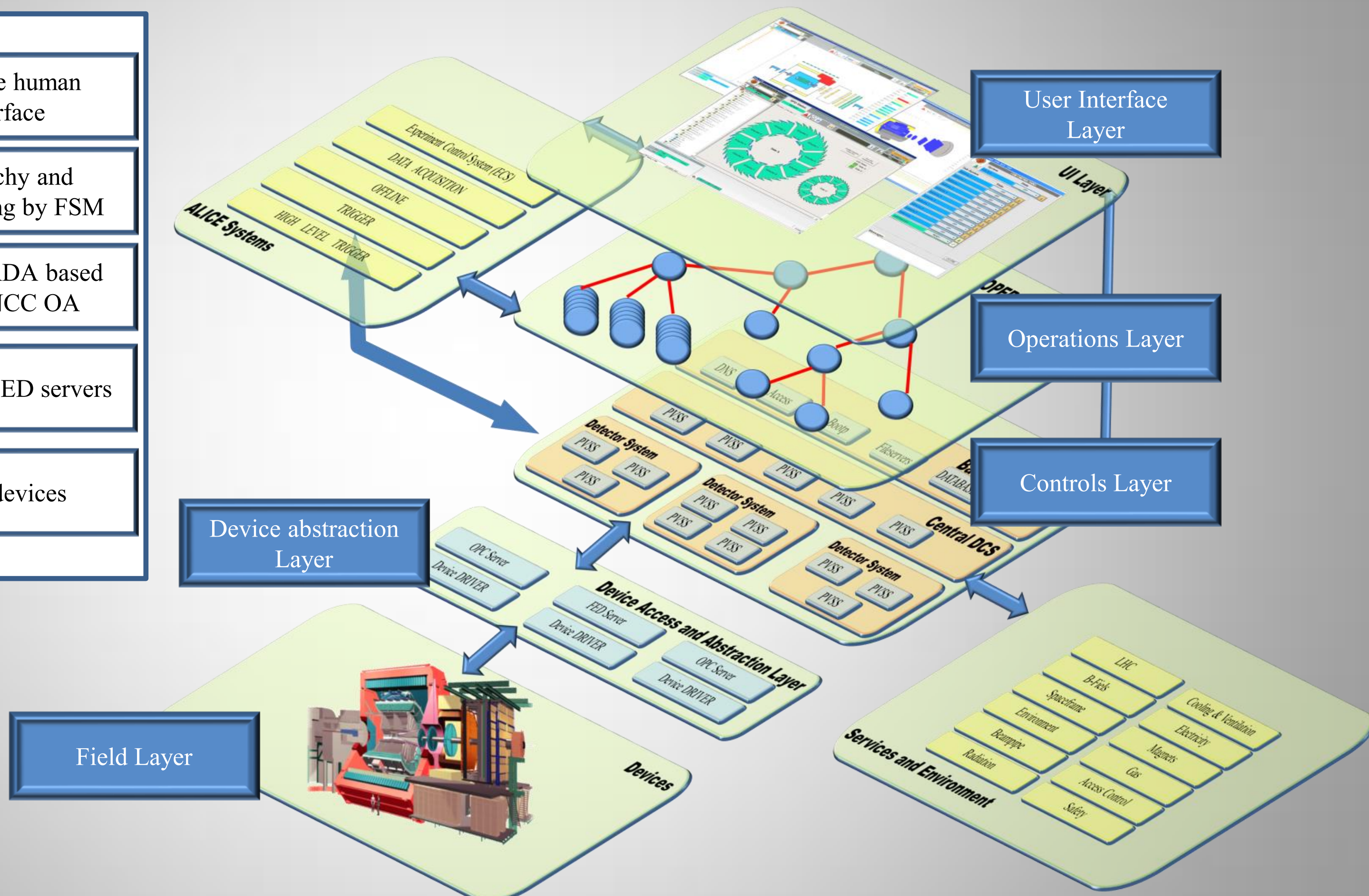


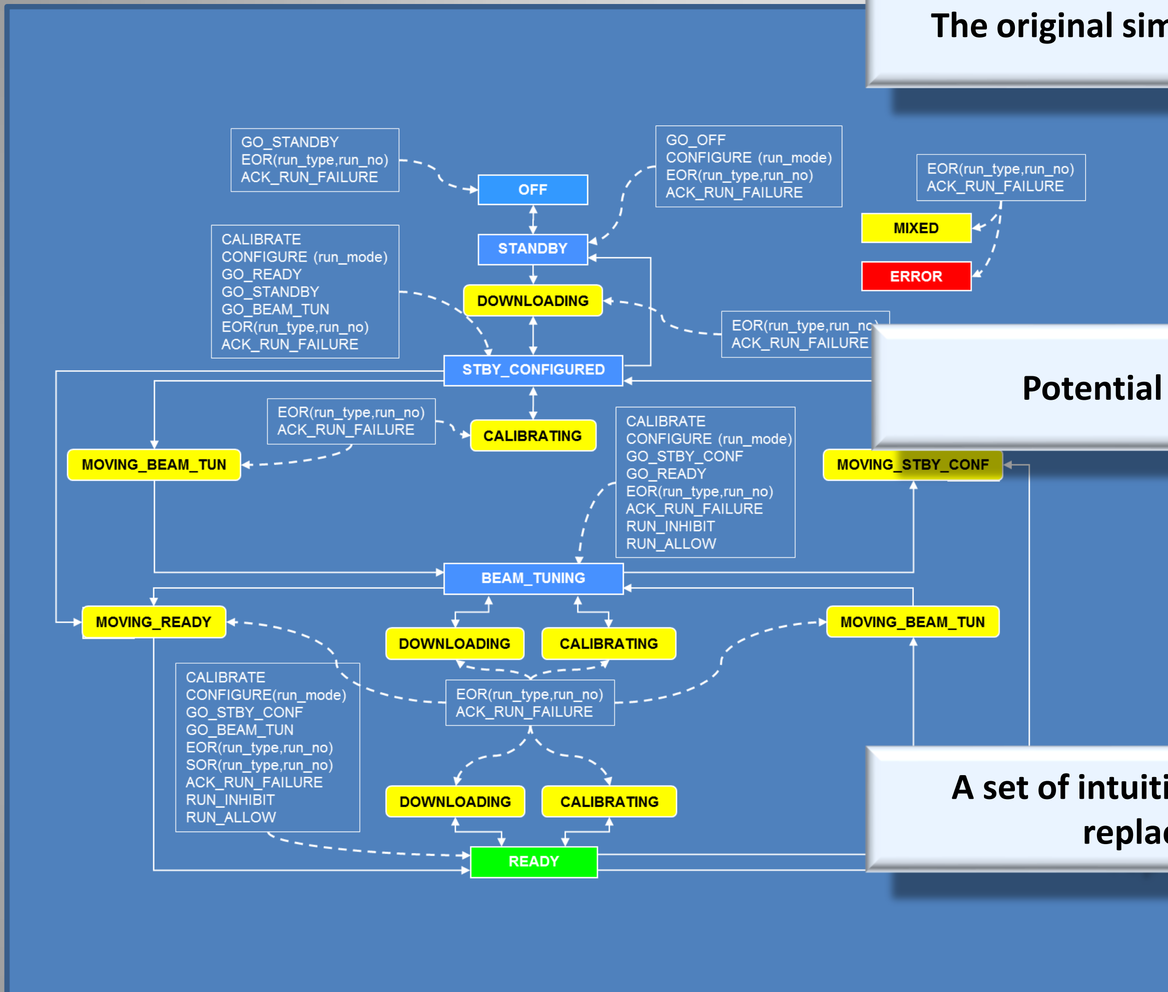
- **ALICE is primary interested in ion physics**
- **During the LHC operation with protons, there is small room for developments and improvements**
- **Partitioning is used by experts to allow for parallel operation**

THE DCS USER INTERFACE LAYER

DCS Architecture

User Interface Layer	Intuitive human interface
Operations Layer	Hierarchy and partitioning by FSM
Controls Layer	Core SCADA based on WINCC OA
Device abstraction Layer	OPC and FED servers
Field Layer	DCS devices

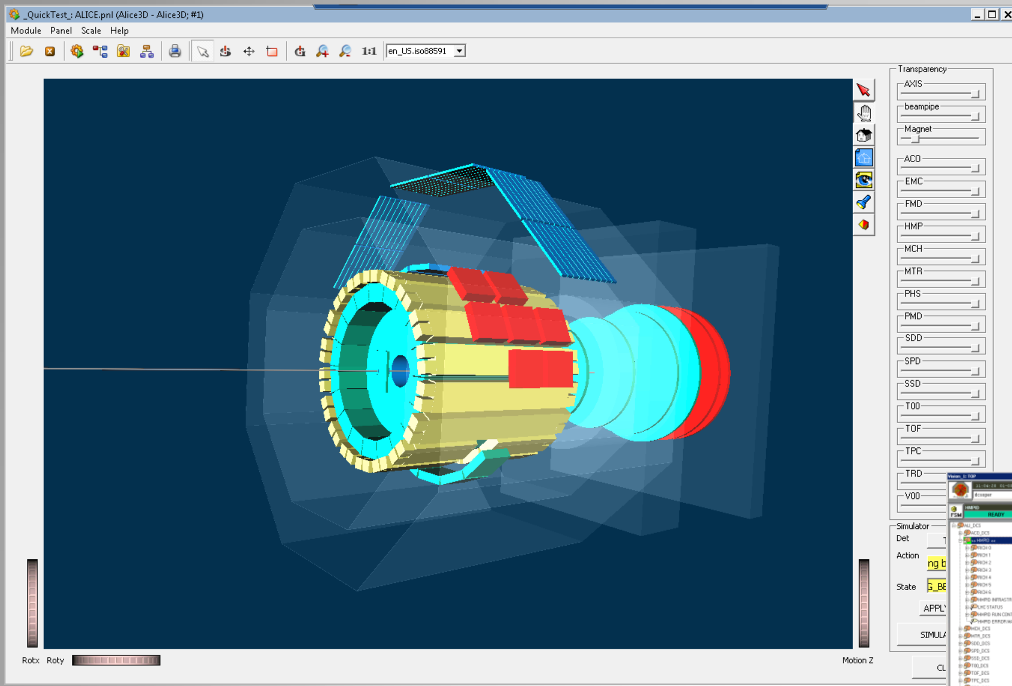


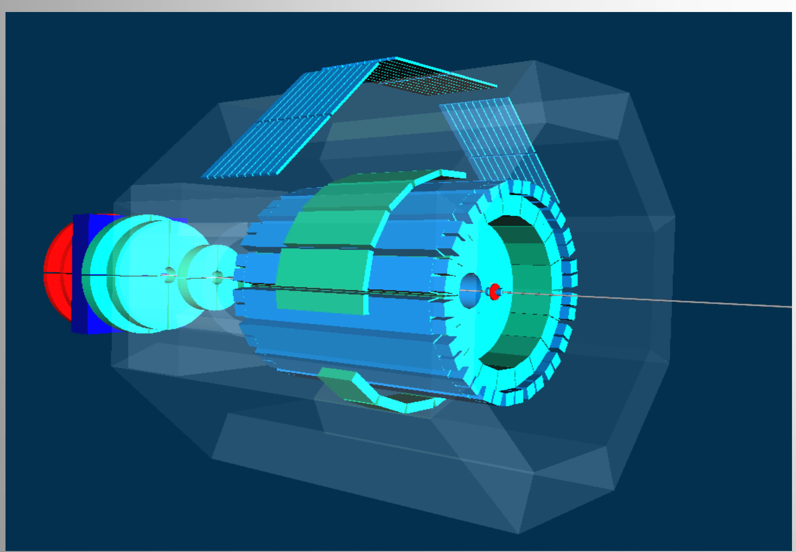


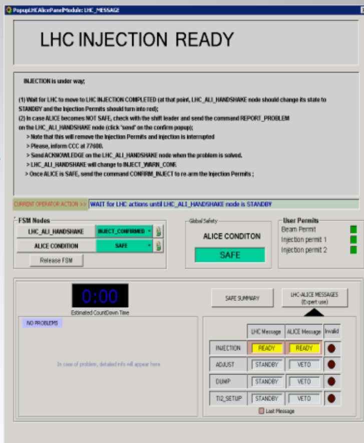
The original simple FSM layout got complex with time

Potential risk of human errors in operation

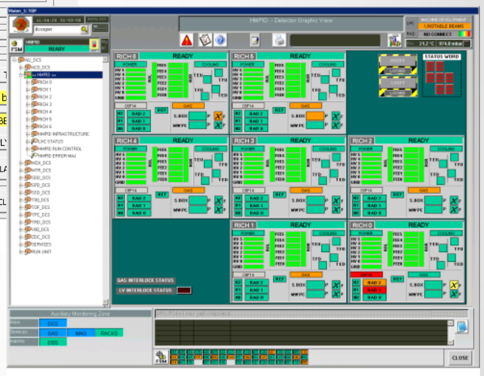
A set of intuitive panels and embedded procedures replaced the direct FSM operation

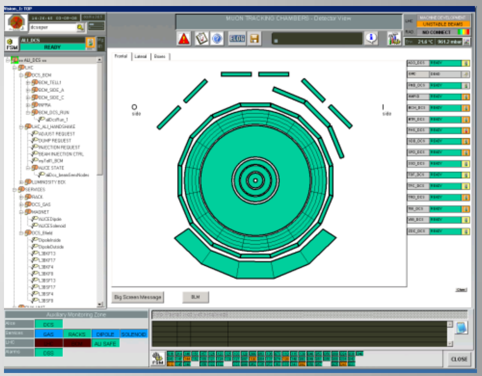

QuickTest: ALICE.pnl (Alice3D - Alice3D; #1)
Module Panel Scale Help
Transparency
AXIS
beampipe
Magnet
ACO
EMC
FMD
HMP
MCH
MTR
PHS
PMD
SDD
SPD
SSD
T00
TOF
TPC
TRD
V00
Simulator
Det
Action
State
Rotx Roty
Motion Z

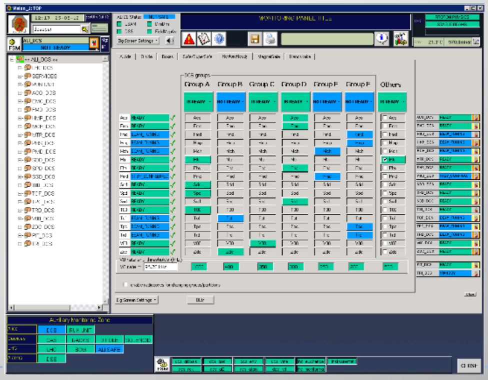


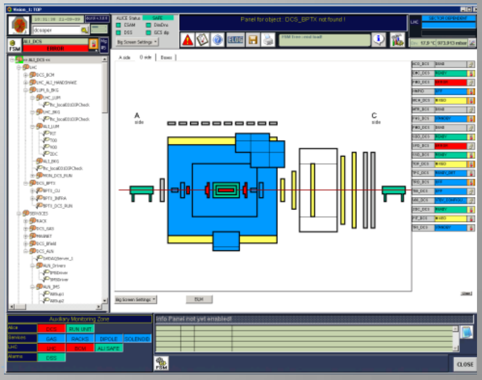

LHC INJECTION READY
ALICE CONDITION
SAFE
0:00


LHC INJECTION WARNING
ALICE CONDITION
NOT SAFE
6:22







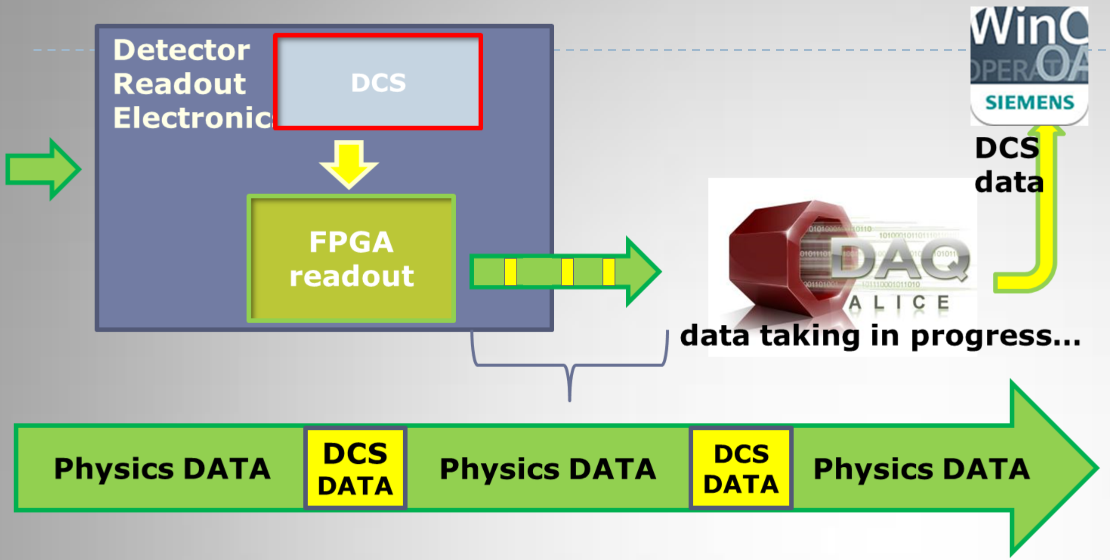


The ALICE Run Control Center (ARC)

DCS and O2 project

- The overall DCS architecture will not significantly change for RUN3
  - Flexible design allows for implementation of new requirements
  - Distributed system provides enough flexibility and is scalable
- Major modifications:
  - DDL3 will be used to carry DCS data between the DCS and detector readout electronics
  - DCS conditions need to be published to O2 continuously (present shuttle mechanism cannot be used)

DAQ+DCS proposal of sharing DDL3

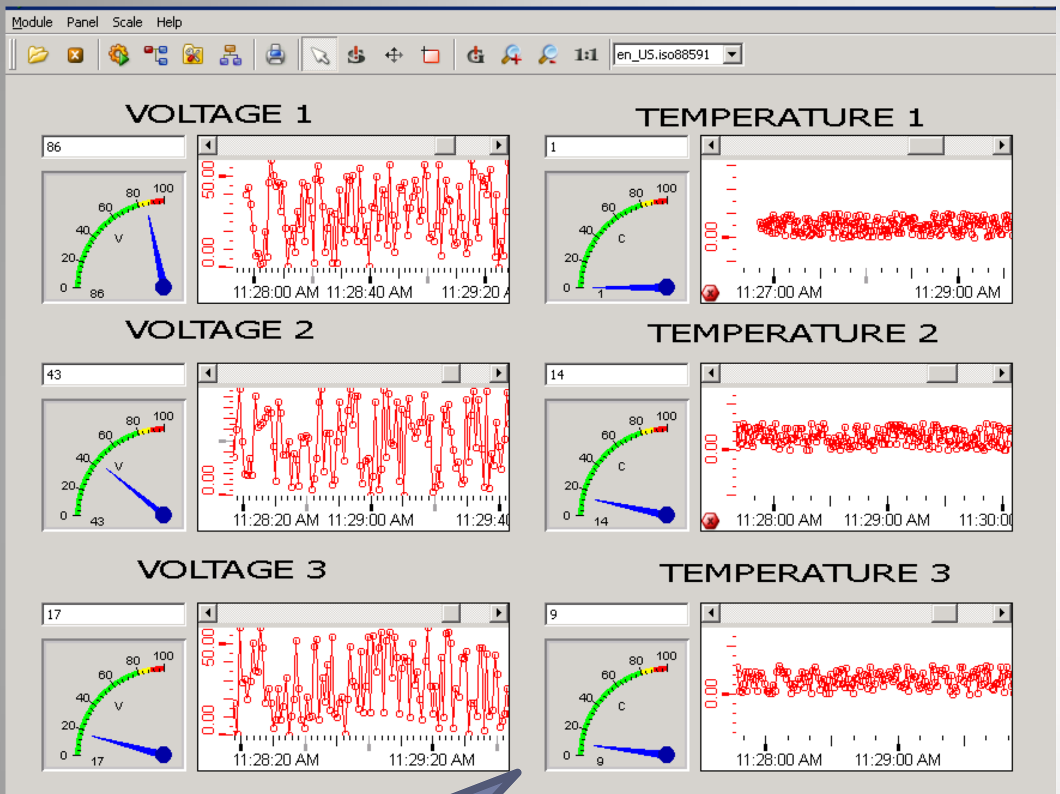


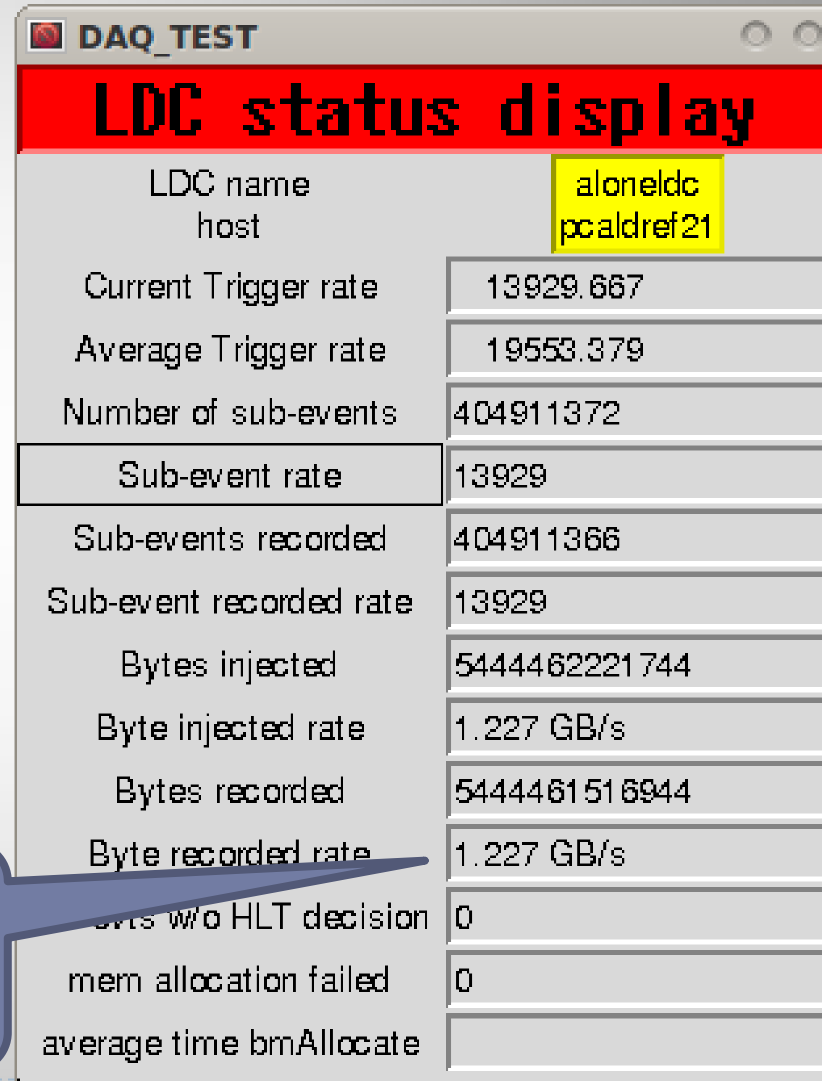
The same physical link will be shared between the 2 data traffics:

- **99% PHYSICS data**
- **1% or less, DCS monitoring data**

The same infrastructure can be used to send configuration data from DCS to readout electronics

DAQ+DCS DDL3 sharing proof of concept. Example stripped DCS data from DAQ stream and injected it into WINCC OA system





~10 MB/s

~1000 MB/s

How to get the DCS Data to O2?

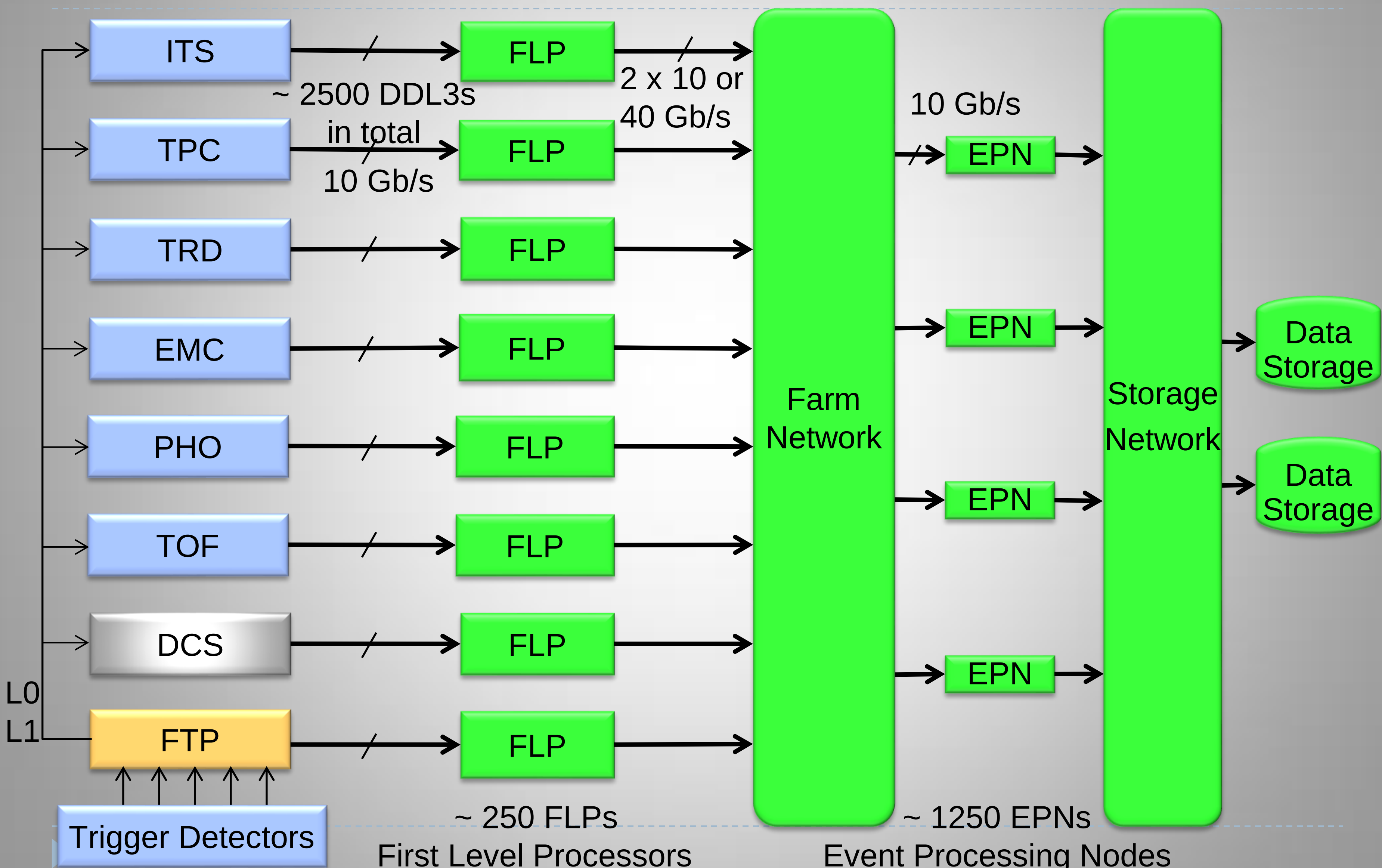
- O2 requires a block of DCS conditions to be updated every 100ms
  - DCS readout is in average much slower
  - Most condition parameters change at much slower rates

Strategy:

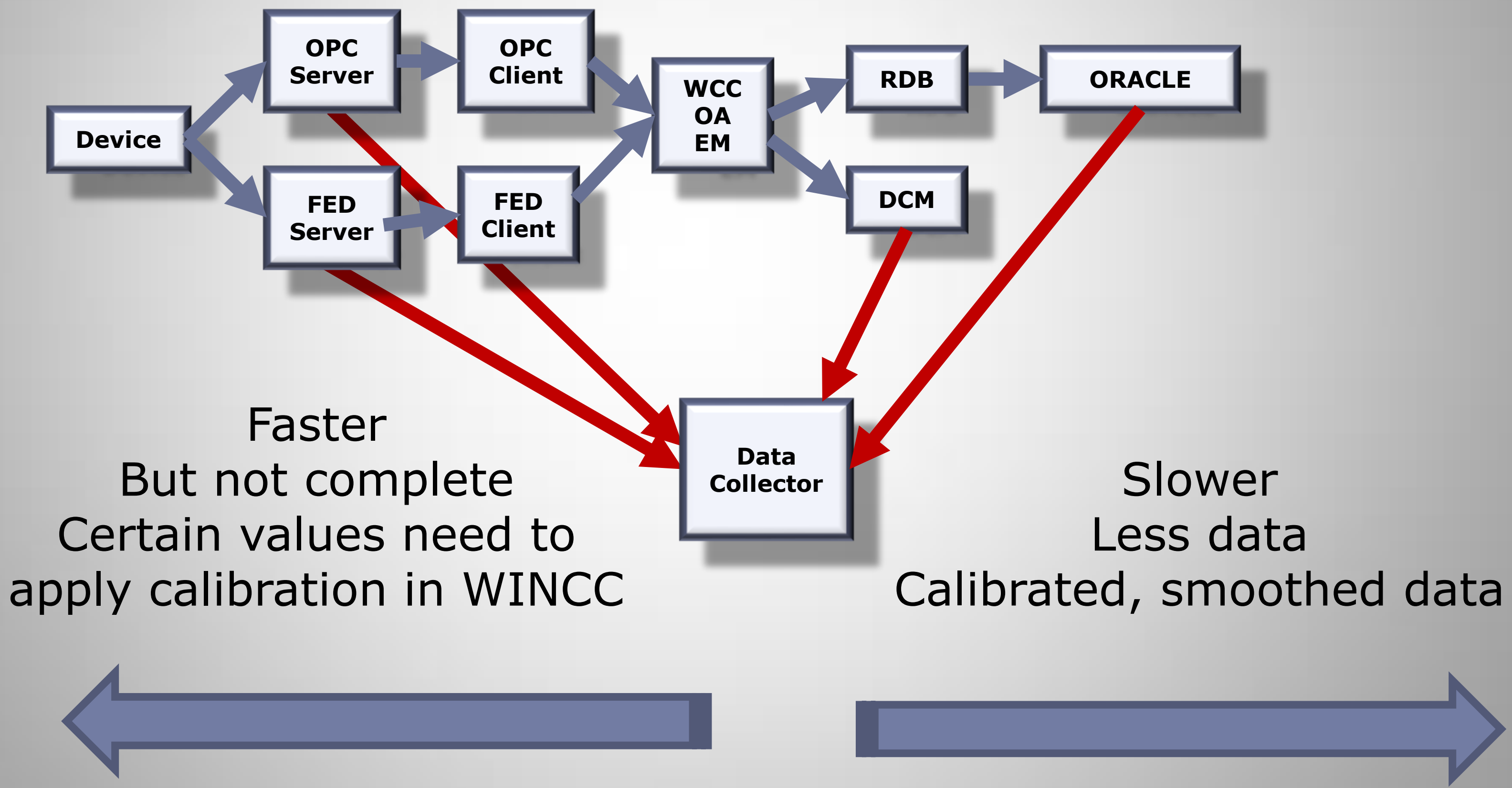
  - read all conditions and store them in a memory block
  - Update only values which changed

- DCS Data Collector will find data in the distributed system and keep updating the process image

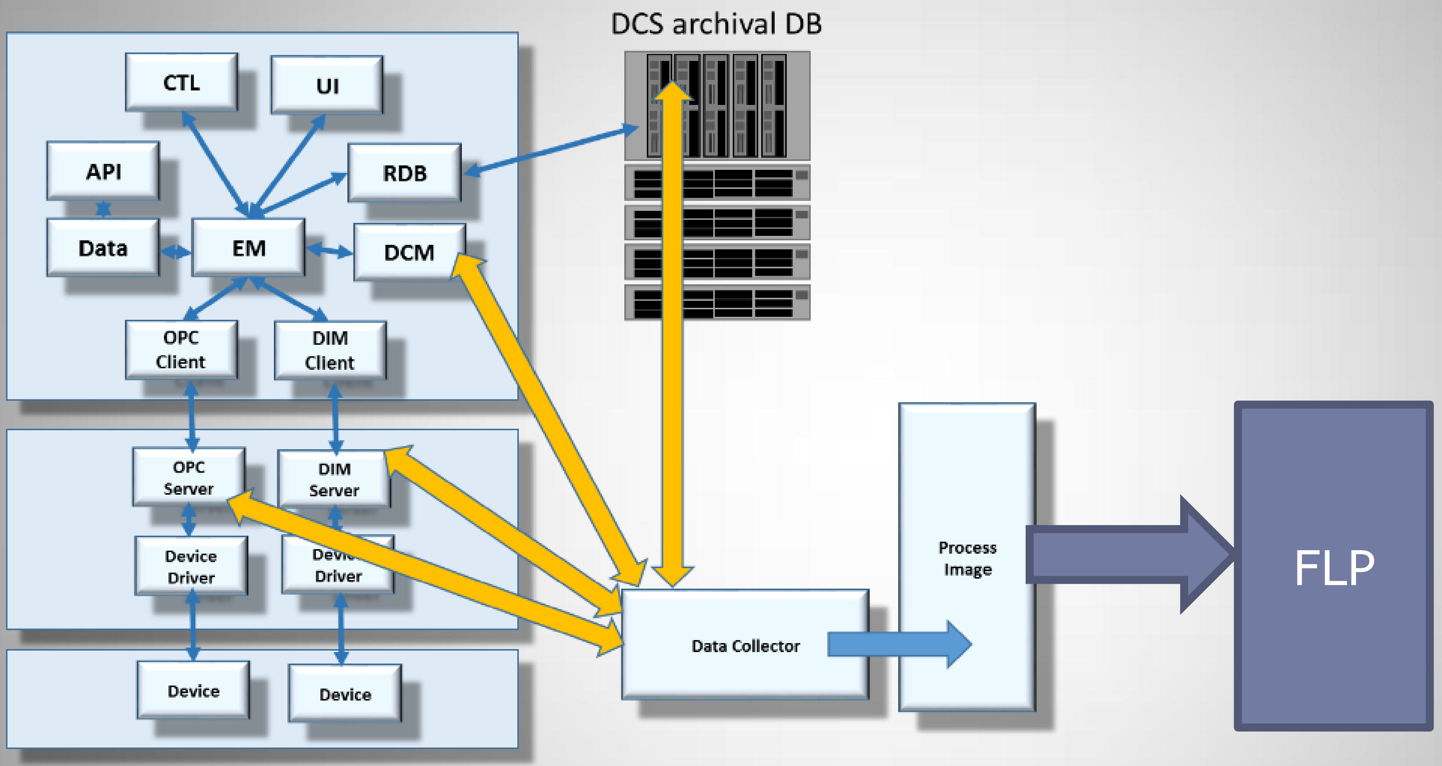
Hardware Architecture – DCS will interface to O2 in standard way



Depending on requirements, DCS data can be collected at various stages of processing



The DCS data collector



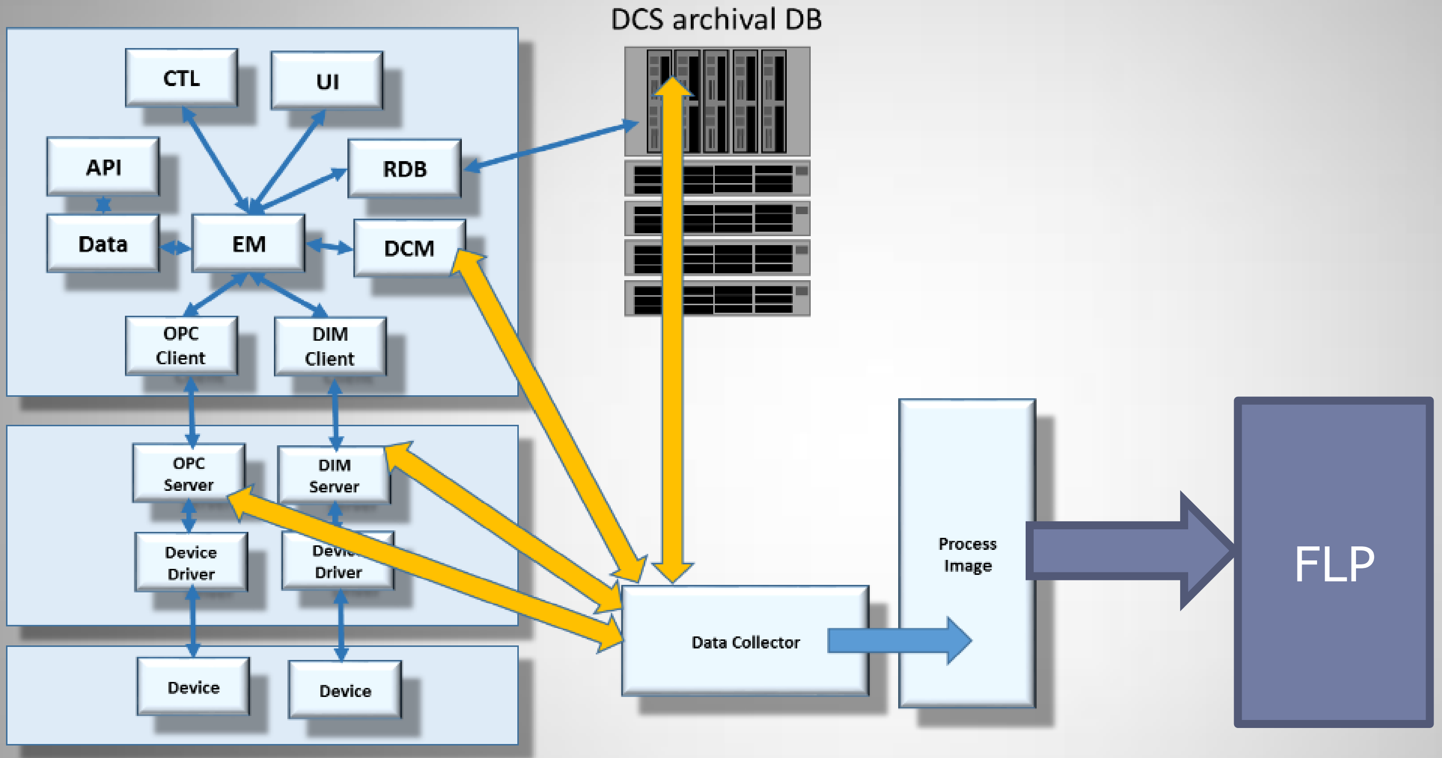
Data Collector performance

- O2 expects about 100 000 conditions parameters to be handled by the data collector
  - The parameters are distributed across ~100 systems
- Present tests suggest, that a manager hooked on the EM will handle the data with sufficient margin
  - DIM seems to be a good choice for the transfer protocol

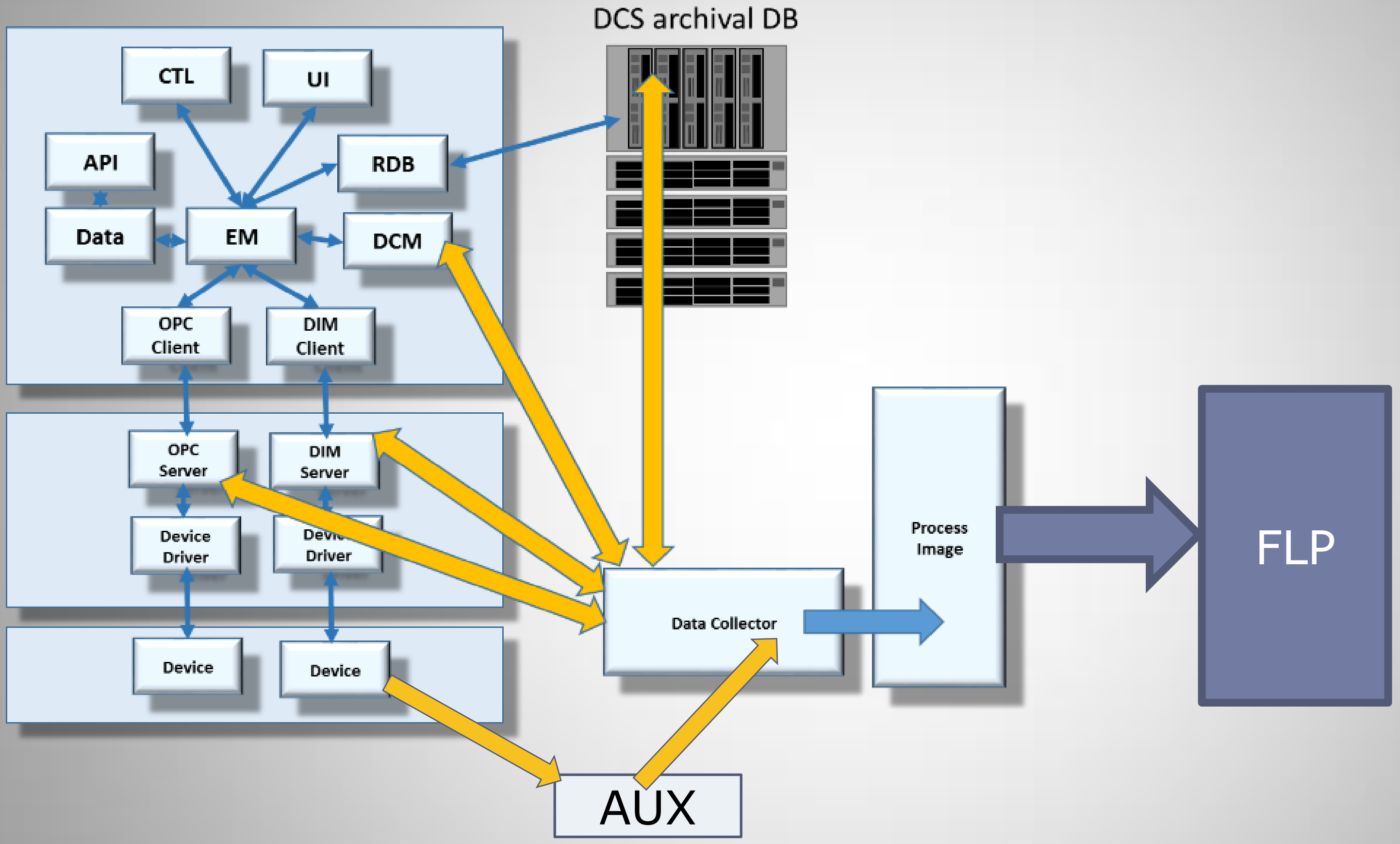
Fast-changing parameters

- Most of conditions change slowly during the run
- Certain values (like current spikes) could be too fast for standard processing
  - These are not even spotted by the power supplies due to internal readout latency
- Fast changes with importance for reconstruction will be detected by auxiliary devices and transmitted directly to the data collector
  - Current example: fast TPC chamber currents monitoring based on PLC

The DCS data collector



The DCS data collector



DCS-O2 interface status

- Realistic data simulator contains now ~75 000 values
  - Real replica of RUN2 conditions data
    - For each parameter a realistic value with typical update frequency and fluctuation is simulated
- First prototype of data collector plugin is being developed and evaluated
- Fast values readout based on PLC being installed for ALICE TPC

DCS-ITS Workshop Kosice (Slovakia)

Workshop organized by ALICE DCS team in Kosice 25-26 November 2014

Participation:

- 12 colleagues from Technical University of Kosice and Slovak Academy of Sciences (Institute of Experimental Physics)
- 4 colleagues from CERN

Topics covered:

- General DCS overview
- Computing organization and rules
- WINCC OA and JCOP framework (presentation and hands-on sessions)
- DCS architecture for ALICE SSD, SDD and SPD
- DCS requirements for new ITS
- DCS and the O2 project
- DCS – OFFLINE interfaces (review of tools developed at the Technical University)

Workshop outcome

- As a result of the workshop, the joint team of the Technical University and Academy of Sciences expressed its interest in participation in the DCS project for the new ALICE ITS
- The Slovak team is proposing to take the responsibility for all software components of the new ITS controls system
- The Central DCS team of ALICE welcomes this initiative and is happy to provide guidance and support for the new developments
  - Short term plan – setup a DCS for the tests of new modules
  - Developed components will be used as prototypes for the new DCS and will be released as an ALICE framework to other detectors

Conclusions

- None. Work is in progress