ALICE MONITORING IN 3-D

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Abstract

The ALICE experiment is a complex hardware and software device, monitored and operated with a control system based on WinCC OA. ALICE is composed of 19 detectors and installed in a cavern along the LHC at CERN; each detector is a logical set of modular elements, assembled in a hierarchical model called Finite State Machine. A 3-D model of the ALICE detector has been realized, where all elements of the FSM are represented in their relative location, giving an immediate overview of the status of the detector. For its simplicity, it can be a useful tool for the training of operators. The development is done using WinCC OA integrated with the JCOP fw3DViewer, based on the AliRoot geometry settings. Extraction and conversion of geometry data from AliRoot requires the usage of conversion libraries, which are currently being implemented. A preliminary version of ALICE 3-D is now deployed on the operator panel in the ALICE Run Control Centre. In the next future, the 3-D panel will be available on a big touch screen in the ALICE Visits Centre, providing visitors with the unique experience of navigating the experiment from both inside and out.

INTRODUCTION

With a length of about 26 m, width and height of 16 m, ALICE [1] is one of the biggest and most complex experimental apparatus in the world. It's installed at CERN in Geneva, at access Point2 of the Large Hadron Collider, in an underground hall at a depth of 52 m.

The experimental apparatus is extremely complex, being composed of 19 sub-detectors, each with its own specific technology choices. Monitoring, operating and managing ALICE is accomplished in collaboration by more than 1000 physicists and engineers, from 105 Institutes in 30 different countries.

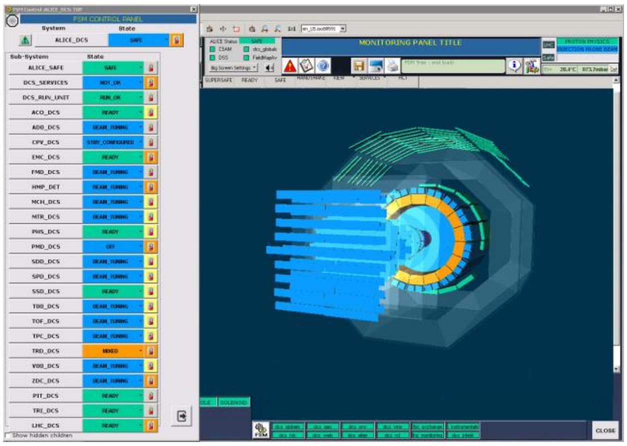
The ALICE Detector Control System (DCS) [2] is a composite hardware and software structure, connecting and coordinating controls and operations on the sub-detectors and the infrastructure. All software controls are developed and integrated through the SCADA software framework WinCC OA [3], selected by CERN as a standard for all experiment control systems.

Monitoring and controlling ALICE through the DCS is performed by an on-site shifter on a 24/7 basis, whose main duties are to guarantee the safety and the integrity of the detectors and the infrastructure, and smooth running of the experiment. Several on-call experts collaborate with the shifter for the most delicate operations.

The interfaces available for the operators are mainly table based, and all states and actions are encoded using a Finite State Machine (FSM) concept [4]. In this way, complexity is hidden and operators are able to evaluate the status in real time, based on simple colours and keywords.

3-D GRAPHICS FOR WINCC-OA BASED CONTROL SYSTEMS

In spite of the evident simplicity of the tabular panels, a more realistic view of the system with its geometrical characteristics would allow a better understanding and a more faithful evaluation of the overall status of the experiment. For this reason, we decided to develop a new panel and display the sub-detectors and their actual FSM state in an intuitive way (see Figure 1).



System	State
ALICE_DCS	SAFE

Sub-System	State
ALICE_SAFE	SAFE
DCS_SERVICES	NOT_OK
DCS_RUN_UNIT	RUN_OK
ACO_DCS	READY
AD0_DCS	BEAM_TUNING
CPV_DCS	STBY_CONFIGURED
EMC_DCS	READY
FMD_DCS	BEAM_TUNING
HMP_DET	BEAM_TUNING
MCH_DCS	BEAM_TUNING
MTR_DCS	BEAM_TUNING
PHS_DCS	READY
PMD_DCS	OFF
SDD_DCS	BEAM_TUNING
SPD_DCS	BEAM_TUNING
SSD_DCS	READY
T00_DCS	BEAM_TUNING
TOF_DCS	BEAM_TUNING
TPC_DCS	BEAM_TUNING
TRD_DCS	MIXED
V00_DCS	BEAM_TUNING
ZDC_DCS	BEAM_TUNING
PIT_DCS	READY
TRI_DCS	READY
LHC_DCS	READY

Figure 1: Tabular and 3-D representation of ALICE in one of the operator panels.

All DCS operator panels are integrated in WinCC OA. On top of WinCC, CERN has delivered a set of software tools called JCOP Framework, where common solutions and developments typical to HEP needs are made available. Among these tools, a 3-D viewer widget is available as an extension of the WinCC OA User Interface.

The fw3DViewer Framework tool [5] is based on the GEANT logic [6], and permits building several different shapes using the standard scripting language available in WinCC. The shapes can be simple "Boxes", "Spheres", "Cylinders", "Tubes", "Cones", up to more general "Trapezoids" and "Polyhedra". Each shape is represented by a typical set of geometrical data: a sphere is defined by the position of its centre and the radius; drawing a box

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requires position, half-lengths in x,y,z, and a 3x3 rotation matrix; a generic trapezoid is represented by at least 13 parameters. Describing the ALICE geometry with this logic requires a combination of several different shapes, and a good knowledge of different detectors' details.

ALICE GEOMETRY AND DATA AVAILABILITY

The ALICE offline group maintains a highly detailed representation of all parts of the ALICE detectors. The parameters are stored in ALICE OCDB; geometry encoding was done by the various experts of all detector groups, and is available in raw code or through the analysis tools based on Root/AliRoot [7].

Since it's maintained centrally, always up-to-date, and is going to include information about detectors upgrade foreseen during LS2, this set of data is of course the official reference for all geometrical based applications. Among these, the ALICE Event Visualisation Environment (AliEve), is a Root based software, able to superimpose the online reconstructed tracks to the geometrical schema (see Figure 2.).

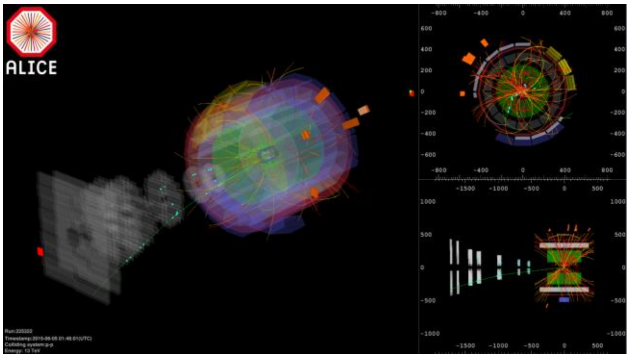

Figure 2: AliEve, the ALICE Event viewer based on ROOT, showing a semi-transparent ALICE frame as the spatial reference for online reconstructed tracks.

Experts and developers from offline, DAQ and DCS would benefit of a joint effort in extracting geometry data from OCDB into flat text files. Using standard Root tools, the conversion of Root objects consists of dumping all fields from the geometry class into an XML file. From here, different applications need suitable libraries to convert XML into their specific formats and standards.

The exported geometry is actually an XML file, describing all shapes and parameters available in the .root file, from the biggest containers (the "BoundingBoxes") down to the smallest internal components, including the description of materials.

During the export phase from Root, the GDML format can be specified. GDML (Geometry Description Markup Language) is an application-independent geometry description format based on XML, and is mainly used to interchange geometry between Root and GEANT4. Since the WinCC 3-D library used by DCS applications is derived from the same GEANT4 geometry description, GDML is the preferred format for the Root geometry extraction. Nonetheless, a conversion library is necessary whose development is currently ongoing.

Other formats were tested, like Collada, which is an open standard XML schema with extension *dae* (Digital Asset Exchange), widely used to interchange data between 3-D applications. Being based on meshes, triangles and vertices, Collada appeared versatile and easy to understand from within WinCC. Unfortunately, every attempt to load Collada geometry in fw3DViewer provoked the crash of the panel, and we focused then back to the XML/GDML format.

FULL AND SIMPLIFIED GEOMETRY

The ALICE detector geometry encoded in the offline OCDB is highly detailed, both in the geometrical description but also in the materials composition. This level of detail is too high for the DCS aim, and for the logical monitoring performed through the FSM. In ALICE case the first level of the FSM hierarchy is normally a geometrical representation of the detector, so that a part (a supermodule, a chamber, a sector, …) can be easily included or excluded from data taking. Operational experience confirms that simple and lightweight panels, showing only the first level of the FSM hierarchy with its included/excluded parts, can guarantee efficient operations, provided that the FSM logics is taking care of masking or propagating relevant events on the children units.

Where available in OCDB, a simplified representation is then extracted (see Figure 3.), as made available directly from detector experts for the sole scope of a geometrical representation, which is called "gentle geometry". In all other cases, the conversion of Root objects is limited to the first level Bounding Boxes, introduced as simple-shaped virtual containers for the real hardware parts.

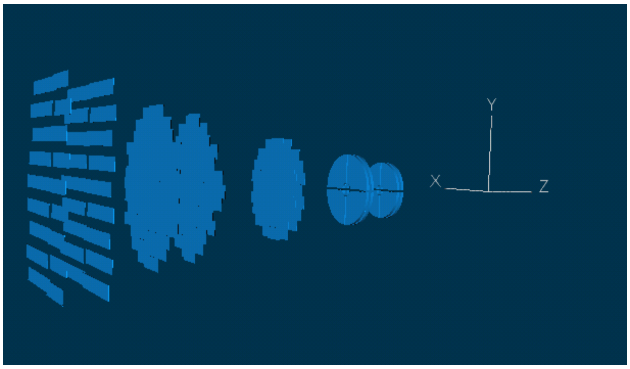

Figure 3: Detail of the ALICE muon arm, using a simplified description of the MCH and MTR detectors' geometry.

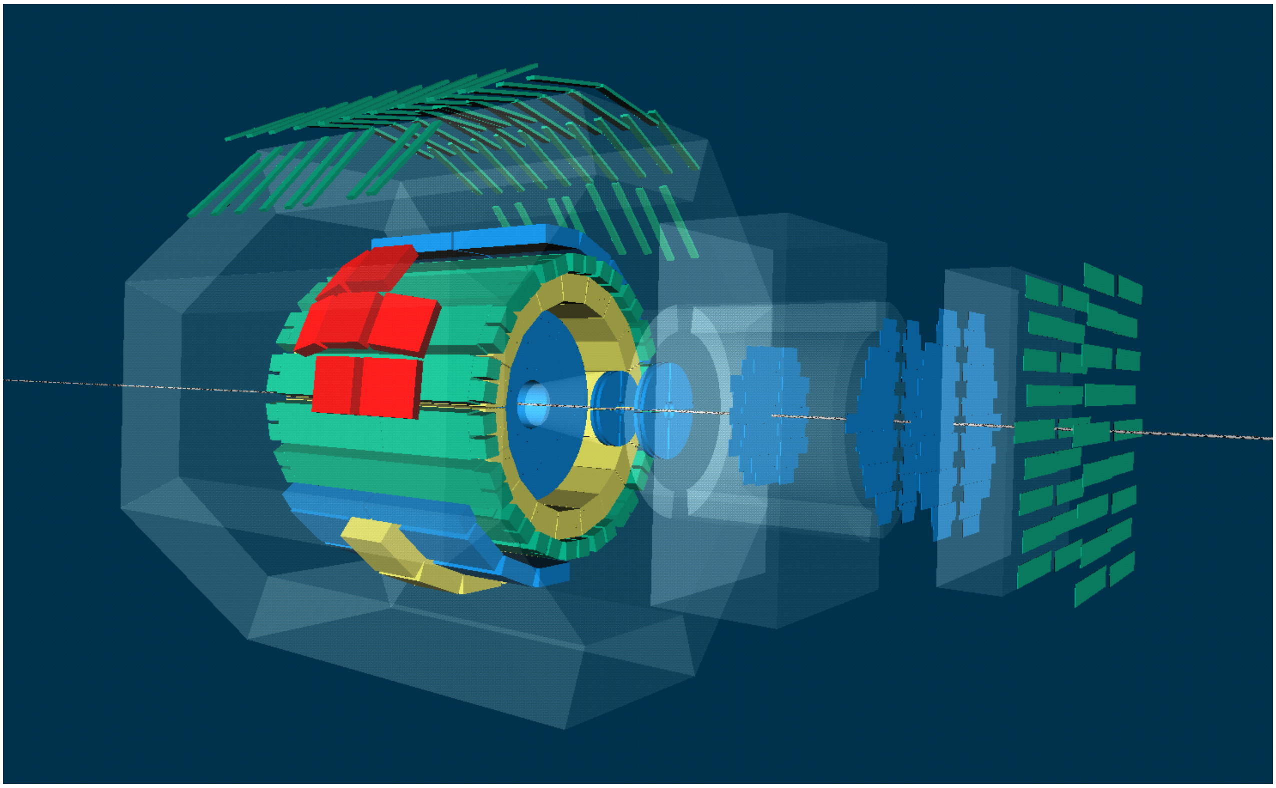

Figure 4: ALICE and its magnets, represented as semi-transparent shapes to allow a better view of the internal detectors. The colours represent the actual FSM state of the detectors.

CONCLUSIONS, THE EXPERIENCE OF MONITORING ALICE IN 3-D

One of the purposes of this work is to develop a general library to convert data extracted from Root objects in simple logical shapes, recognized by WinCC+fw3DViewer.

While proceeding with the realization of the conversion libraries, the ALICE DCS group has realized a first working version of the 3-D DCS panel in native WinCC+fw3DViewer format, in collaboration with detector experts. Even if Root extracted data was not ready to be used, the resulting panel is very accurate in the general shapes. At present, the panel is part of the principal User Interface for DCS shifters, in the ALICE Run Control Centre (see Figure 4).

It is interactive, in the sense that single parts of ALICE (detectors and magnets) can be removed or added, transparency can be set and the full shape can be moved and rotated using the computer mouse. FSM actions are available but not yet activated for the operators.

The panel shall be integrated into the ALICE simulator available in the ALICE DCS lab and used for the training of operators. The aim is to provide a realistic operational view to junior scientists and technologists who haven't had the opportunity for a closer experience with the hardware and the infrastructure.

A preliminary instance of the 3-D model was installed on a large touch screen, that was made available for the public during the OpenDays at CERN in September 2013. We plan to deploy an up-to-date and highly detailed copy on the active multimedia "Magic Windows" which will be installed at P2, in the area devoted to visitors.

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