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LHC First Beam Event Display at CMS from online to the World Press - the first 3 minutes

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Abstract. Geneva, 10 September 2008. The first beam in the Large Hadron Collider at CERN was successfully steered around the full 27 kilometers of the world's most powerful particle accelerator at 10h 28 this morning. This historic event marks a key moment in the transition from over two decades of preparation to a new era of scientific discovery[2]. From 9:44 am CET attention of the CMS physicists in the control room is drawn to the CMS event display - the "eyes" of the detector. We observe the tell-tale splash events (see figure 1 and 2), the beam gas and beam halo muons. We see in real time how the beam events become more and more clean as the beam is corrected.

This paper describes the key component of the CMS event display: IGUANA - a well-established generic interactive visualisation framework based on a C++ component model and open-source graphics products. We describe developments since the last CHEP, including: online displays of the first real beam gas and beam halo data from the LHC first beam, flexible interactive configuration, integration with CMSSW framework, event navigation and filtering. We give an overview of the deployment and maintenance procedures in the commissioning and early detector operation and how the lessons learnt help us in getting ready for collisions.

1. Introduction

CMS detector and event display systems known collectively as "IGUANA - Interactive Graphics for User Analysis" are invaluable for debugging the detector performance and the simulation, reconstruction and analysis data and associated algorithms.

IGUANA has been deployed in the CMS control rooms in Cessy since 2006. It includes pre-configured set of windows at startup, automatic event processing, and various performance and robustness improvements. IGUANA has already been used to display cosmic rays in the Electromagnetic Calorimeter (ECAL), the Hadron Calorimeter (HCAL) and Muon Chambers providing invaluable early debugging feedback to the commissioning teams. The event display showed immediately cosmic muons bending as the magnet was ramped up to 2.6 tesla for the first time in May 2006.

IGUANA is routinely used for global cosmic runs as well as the CMS "Cosmic Run At Four Tesla" (CRAFT). The CRAFT is a crucial CMS-wide integration test which includes the detection of Cosmic

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Muons by multiple sub-detectors inside the CMS solenoid during 2008. A typical CRAFT event is shown on figure 3.

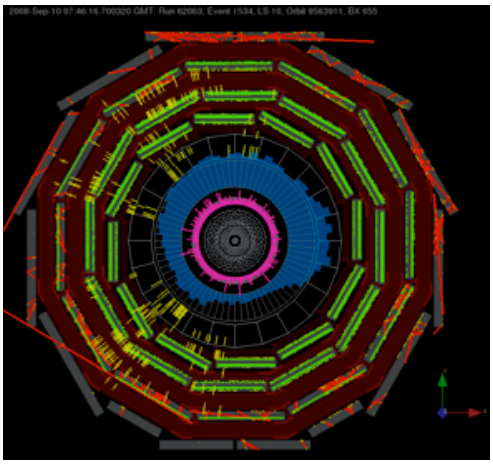

Figure 1. Picture on the top left shows RPhi projection of the first beam splash event from run in which the LHC beam was steered into the collimator at P5 at 9:46 AM, which led to lots of debris particles entering the detectors.

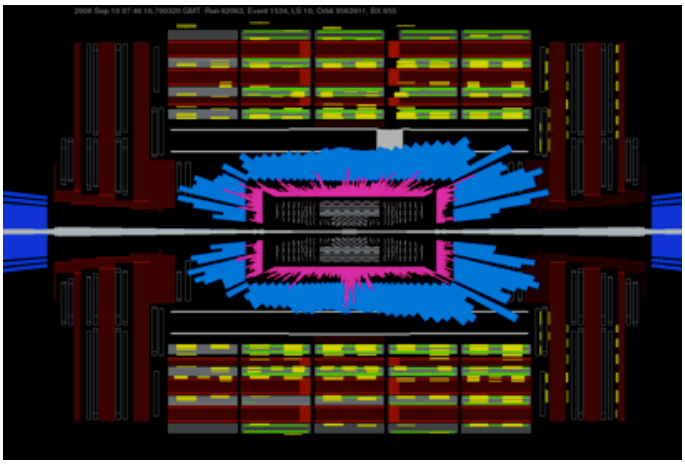

Figure 2. The RZ projection of the same event is shown on the top right. Pink are ECAL rechits, blue - HCAL and HF rechits, green - DT digis, yellow - RPC rechits, red - DT segments.

2. IGUANA Event Display

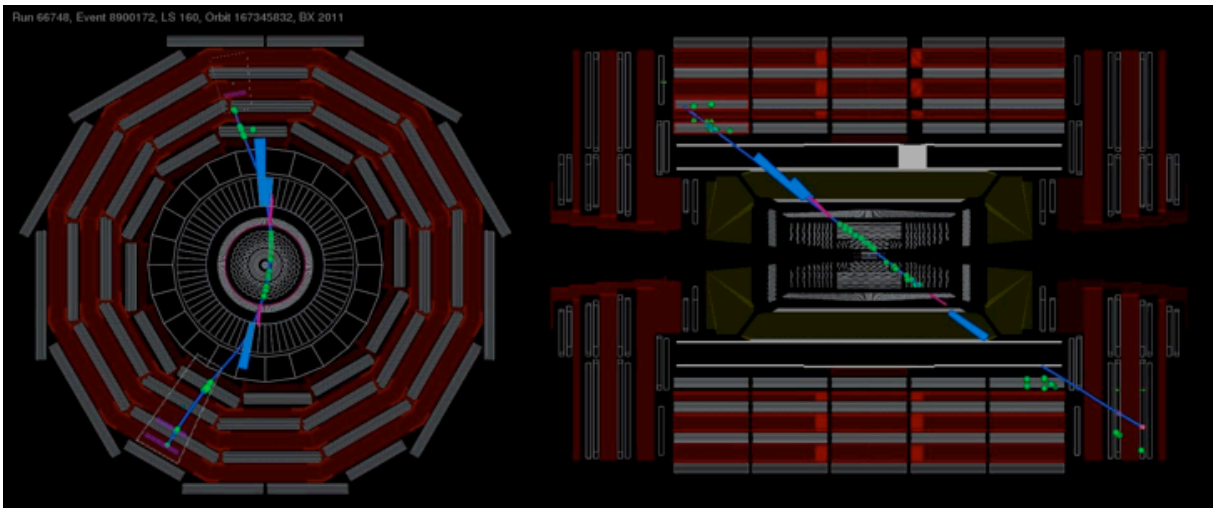

Figure 3. Picture on the top left shows RPhi projection of the cosmic muon from the CRAFT run in which the magnet was ramped up to 3.8 T. The muon left a clear signal in the CSC, DT, HCAL, ECAL, Tracker and Pixel detectors. The RZ projection of the same event is shown on the right. Pink are ECAL rechits, blue - HCAL rechits, green - tracking rechits, yellow - RPC rechits, red - DT and CSC segments.
The RPhi projection shows CSC chambers with wire digis - magenta.

IGUANA event display features and its framework architecture have been previously described in detail (see references 1-4). Among features recently developed and deployed for the online and offline event display the most valuable for commissioning are:

- Various 2D/3D specialized views of the data (such as "lego plot" histograms of calorimetric energies, RZ and RPhi views, etc.)

- Vector printing
- Management of multiple views
- Magnetic field displays
- Full simulation and reconstruction geometry display and inspection
- Magnetic field map display with level of details
- Dynamic and static content of the event inspection
- Display of effects of calibration and alignment

Care is taken to ensure documentation and tutorials are kept up-to-date for the steady flow of newcomers to the software, as we are steadily approaching LHC startup.

3. Online Solution

There are two aspects to the usage: the event display itself, and the seamless integration of it to the online environment (online vs. offline mode, choice of streams, etc.). Both require some maintenance.

Our strategy has been to separate out what are limitations of the CMS experiment software framework (CMSSW) and associated code itself (long start-up times, and possibly some crashes) vs. the display itself. On the other hand we focus on building in some tolerance of problems with the other code.

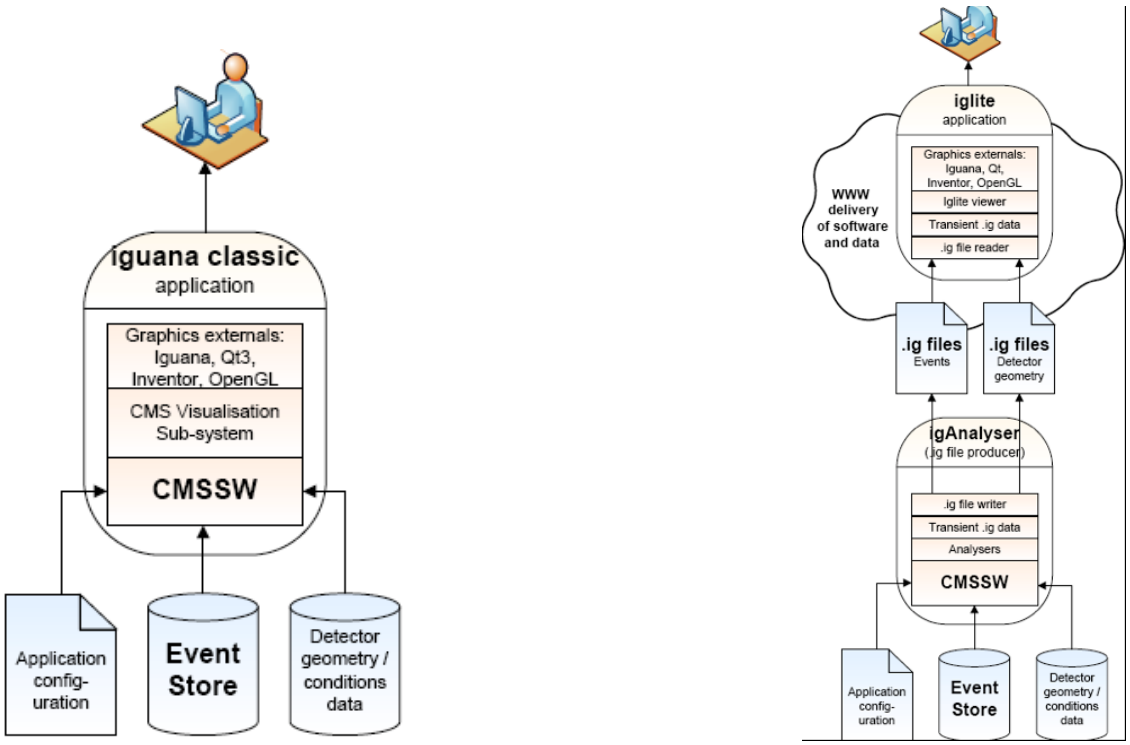

Figure 4. Picture on the left shows "classic" IGUANA architecture. The graphics client application is fully integrated with CMS software framework (CMSSW). On the right new IGUANA client decoupled from the CMSSW. Communication between CMSSW (a producer) and IGUANA application (a client) is done via files or shared memory.

An online client has been implemented as a continuously running IGUANA session, completely de-coupled from CMSSW framework interactively switching to a different source. There are two separate parts: cmsRun and IGUANA session. The client connects to cmsRun online and / or reads files off-line (see figure 4).

The strategy is to leverage on existing development and deployment effort for CMS Data Quality Monitoring (DQM) (see reference 5). The online communication between the client and the producer

is based on DQM software development for sharing event(s) in memory. The producer deployment to run analyzers is done along with DQM deployment.

4. Full Framework Integration Benefits

Integration of IGUANA graphics application with CMSSW framework brings certain advantages:

- Input source – can be raw data format, on the fly reconstruction, etc.
- Complete and precise geometry with access on demand to sensitive volumes, cabling, etc.
- Integration with CMSSW == flexibility for experts

On the other hand there is a price to pay:

- Long start-up time due to the framework initialization such as an event setup, conditions, etc.
- Re-start is needed for changing conditions (magnetic field, different source, etc.)
- Manual release integration, long release cycle

Careful balance between pro and cons must be maintained.

5. Online vs Offline

The conditions of running an online event display are much stricter then when running offline. The online event display must not interfere with data taking while giving the most valuable feedback to the shift crew in real time. The number of human interactions with starting and running the event display should be minimal while full interactivity should be available at any time.

The event display starts with several predefined views of the detector and event (RPhi, RZ, 3D, Lego) that give complete information about detector operation at a glance.

The trigger menu information displayed on the screen adds to a better understanding of a very complex event selection. This also allows an interactive navigation to an event triggered by specific triggers. For easier event identification both HLT and raw data information are displayed.

Running the online event display and accessing detector conditions data and MSS from control room computers that are behind the firewall protection differs from running the same event display offsite. However, in the CMSSW framework it is defined in a configuration script. The event display uses the same script.

While non-invasive running online is a must, the offline experts can also benefit from the division described in section 3, e.g. to look at recent online events without actually being in the control room.

6. Filtering, Selection and Skimming

While the IGUANA event display allows event filtering, selection and skimming via CMSSW framework the question remains whether it is the job for a graphics client or for a batch analysis job?

Iguana event display systems are used to navigate and filter the immense amounts of complex event data from the CMS detector and prepare clear and flexible views of the salient features to the shift crews and offline users. These allow shift staff and experts to navigate from a top-level general view to very specific monitoring elements in real time to help validate data quality and ascertain causes of problems.

7. Algorithm Tuning and Debugging

Interactive tuning of reconstruction algorithms gives a better insight and understanding of the detector performance. The IGUANA event display allows interactive tuning of reconstruction algorithms by:

- Interactive tuning of certain parameters of the algorithm
- On demand inspection of more detailed properties

This feature has been proved very useful in debugging and fixing numerous problems.

8. Configuring Event Display

Configuration of the event display can be done either at its startup as described above or interactively. The following is saved and restored as the application state:

- Interactively tuned parameters

- Full screen mode
- Auto event fetching
- Material map
- Multiple views, background, lights
- Auto printing
- Animation
- Annotations

9. Summary and Conclusions

The IGUANA event display complements data quality monitoring systems and is especially crucial for commissioning CMS in the imminent CMS physics run at the LHC. It has already proved invaluable for the CMS cosmic runs and the LHC first beam.

Full integration with CMSSW framework has certain advantages while clean separation helps to speed the event display up. Preference of using batch jobs whenever and wherever possible gives an additional flexibility for a fast and slim event display client.

Release integration time for online event display is vital. We observe, that the bigger the code base and the number of developers the list time left for integration of the event display systems which depend on multiple packages. This may slow down deployment of bug fixes and newly implemented features.

Implementation of an independent client without dependency on full CMSSW framework is proven to be a scalable solution.

10. References

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