

A browser-based event display for the CMS experiment at the LHC

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Abstract. The line between native and web applications is becoming increasingly blurred as modern web browsers are becoming powerful platforms on which applications can be run. Such applications are trivial to install and are readily extensible and easy to use. In an educational setting, web applications permit a way to deploy tools in a highly-restrictive computing environment.

The I2U2 collaboration has developed a browser-based event display for viewing events in data collected and released to the public by the CMS experiment at the LHC. The application itself reads a JSON event format and uses the JavaScript 3D rendering engine pre3d. The only requirement is a modern browser using HTML5 canvas. The event display has been used by thousands of high school students in the context of programs organized by I2U2, QuarkNet, and IPPOG. This browser-based approach to display of events can have broader usage and impact for experts and public alike.

1. Introduction

The I2U2 (Interactions in Understanding the Universe) [1] collaboration aims to bring cutting-edge, hands-on physics to high school students via eLabs: web-based, student-led, and teacher-guided explorations of datasets from a number of experiments, including LIGO [2] and CMS [3]. The CMS collaboration has agreed to release a small fraction of its collected data to the public for the purposes of education and outreach. This release includes over 300,000 events. I2U2 has created an eLab based around these datasets. A key component of this eLab is a browser-based 3D event display [4] written using JavaScript, HTML, and CSS.

The event display has also been used in masterclasses organized and run by QuarkNet [5] and the International Particle Physics Outreach Group (IPPOG) [6]. In the current exercise students are assigned up to 100 events ($Z \rightarrow e^+e^-$, $\mu^+\mu^-$ and $W \rightarrow e\nu, \mu\nu$, with dimuon events having an invariant mass from 2-110 GeV) to visually scan and to determine whether or not the event is a W or Z. If the former, the identity and charge of the lepton is determined. If the latter, an invariant mass is calculated. Students then make a determination of the $W^+:W^-$ charge ratio as well as construct an invariant mass spectrum.

eLabs and masterclasses have been conducted in a variety of computing environments. Some facilities, such as universities and laboratories, have modern computing resources and pose few challenges. Other facilities, such as school classrooms, often use older computers, run older browsers and/or maintain restrictive environments. In addition, some places have poor or no connection to the Internet.

An event display used in such varied and potentially restrictive environments with non-expert users (or at least users who are not physicists) must have minimal and intuitive controls. Having a web-based display allows for one to circumvent potential computing environmental restrictions as well as satisfy the broadest possible user base.

We next describe the features and architecture of the display that fulfill these requirements.

2. Display features

The event display has many of the standard features one finds in standard event displays in high-energy physics: These include button controls that switch to standard views along each of the XYZ axes and between projected and orthographic views. The view can be saved as a png file and background color can be switched between black and white.

The contents of the geometry and events are displayed in a standard tree view, with two possible controls. The first is a selector which turns on or off the event content. A second control opens a sub-window which displays a histogram of a value (such as energy) in the collection. An example can be seen in Figure 1. A selection of "Barrel Rec. Hits" under "ECAL" shows a histogram of the energy of the hits. A slide selector selects the range of energy of hits that are visible in the display. In the example, only deposits in the electromagnetic calorimeter with an energy range in the highest 25% are displayed. In addition, each category of content (*e.g.* ECAL, HCAL, Muon) has a popup help window which contains descriptions of the individual objects. An example can be seen in Figure 1.

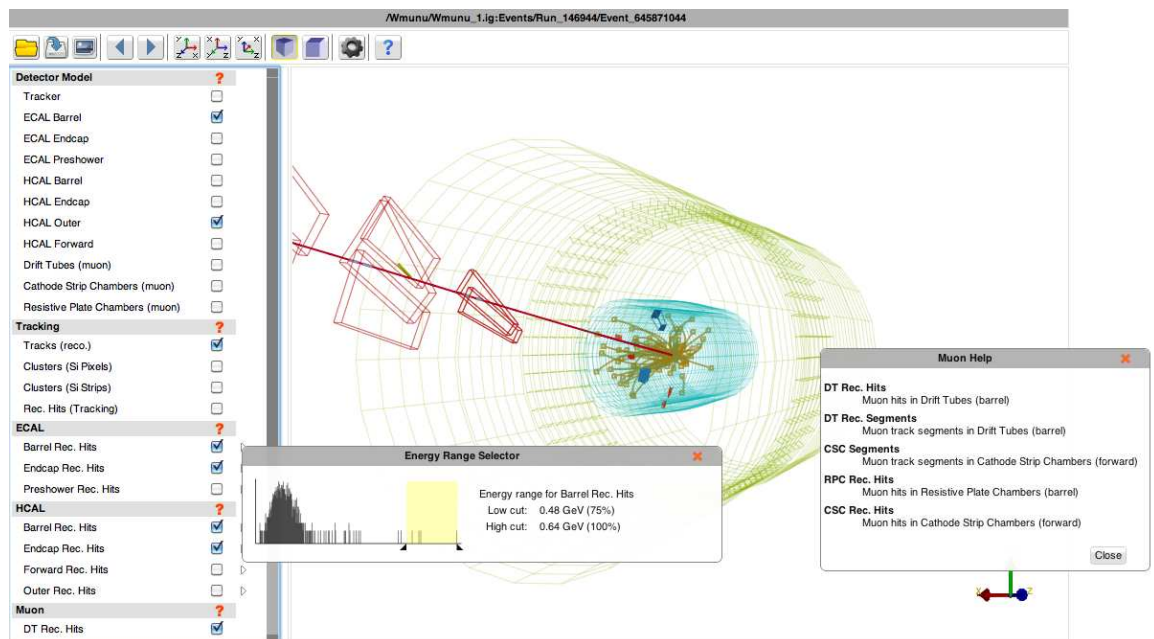


Figure 1. Screenshot of event display showing 3D view, menu items, collection view, collection histogram, and help window.

The display has currently only a 3D view, which is rendered in an HTML5 `<canvas>` element. The rendering is done with the pre3d[7] JavaScript rendering engine. Event display controls are implemented using jQuery [8]. A prototype table view has been implemented using DataTables [9], a jQuery plugin.

3. Input

The display runs in two modes, online and offline. In online mode the display runs from the standard location on i2u2.org loading data via AJAX calls to the i2u2.org server. It then loads and parses list of events for the user to choose. The display then loads the requested event. In stand-alone, offline mode, data is loaded locally either from the local disk or other external storage like a memory stick or DVD. The display uses the HTML5 File API to access local files. The user opens a file on local media like in any other application.

The input for the event display is the ig format: a zip-archived JSON [10] file originally developed for the iSpy event display developed for the CMS experiment [11, 12]. The event content of these files are valid JSON or python dictionaries. Data read from the i2u2.org server are in unzipped form and read directly. The offline stand-alone version can either read JSON directly or ig files zipped using base64 encoding [13] and unzipped using js-inflate [14].

4. Future plans and features

The online version of the event display is part of the CMS eLab developed by I2U2. Another feature of the eLab is a histogram tool with which users can explore the publicly-released data (in a summary JSON format). We plan to provide interaction between the display and the histogram tool. Example interactions would be selection of events (and event objects and their associated variables) in the display for insertion into the histograms as well as the opposite process: display of representative events selected from the histograms. Event object selection in the display requires picking capabilities, which we plan to implement.

We also plan to add dedicated RPhi and RZ views. The former will be especially useful in the masterclass context where students attempt to determine the charge of particles from their curvature in the magnetic field. It will be worth exploring other 3D technologies as well, including WebGL [15] and adding touch events for use in tablets.

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