Status of the HEPVis Class Library

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Abstract:

Since 1994 a group of High Energy Physicists and Computer Scientists have been collaborating on *HEPVis*, a library of 2-D and 3-D shapes for detector visualization and HEP analysis. Based on the *Open Inventor* (1) toolkit, HEPVis has grown into an international collaboration since its inception in 1994. This paper describes the library, its history, and its future. Images from HEP applications that use the library are also included.

1. Introduction

The HEPVis class library was created and is maintained with the following goals in mind:

- Identification of common elements of interactive detector and event visualization and analysis systems, to avoid duplication of effort
- Provision of an object-oriented class library with the following properties:
  - Generic graphics classes for detector and event objects.
  - Components for the construction of portable graphical user interfaces. This includes viewers with intuitive, HEP-specific controls and easily extensible menus.
  - Consistency with HEP software strategies. We intend the library to be used as part of the computing suite of LHC, FNAL Run II, GEANT4, and other near-term HEP projects.
  - Based on mainstream technologies. OpenGL 2 and OpenInventor are proven, widely used technologies that integrate easily into different applications.
- Participation in a forum, approximately every 18 months, for sharing progress. HEPVis workshops have been held at FNAL in 1995, CERN in 1996, and at SLAC in 1998.

2. History

- 1994 - The HEPVis library originated by Joe Boudreau. Concept for the entire project, and some basic shapes.
- 1996 – Collaborators were solicited at the HEPVis96 Workshop at CERN. Fermilab committed to writing an Open Inventor graphics subsystem for the Geant4 collaboration. As part of this effort, Open Inventor subclasses of the Geant4 shapes were developed, as well as complete viewers that make use of the library shapes.
- 1997 - Joe Boudreau and Matt Schell wrote the CDF Run II tracking program, which makes use of the library's Event Viewer. This application was used in the first Virtual Reality demonstration at FNAL. The L3, and CMS experiments began using the library. Guy Barrand contributed additional classes and optimization.
- 1998 – The library went into code management. CDF and D0 began experimenting

3. HEPVis Library Contents

3.1 Basic Shapes

The basic shape classes in the library are SoG4Box, SoG4Tubs, SoG4Cons, SoHelicalTrack, SoEllipsoid, SoEllipticalPrism, SoG4Trap, and SoG4Trd. These are subclasses of Open Inventor classes, with member data corresponding to various physical properties. In the case of SoG4*, they are also subclasses of the corresponding Geant4 shapes.

3.2 Complex Shapes/Node Kits

The next level of HEPVis shapes are the complex shapes and node kits. This group includes SoSiStrips, SoSiStripDetKit, SoDblStripDetKit, SoStereoStripDetKit, and SoDetectorTreeKit. They are subclasses of the Open Inventor nodes, and are used to construct the detector in a hierarchical form. The library provides the capability to edit the detector components interactively. By clicking with the mouse, the user can edit the material property or actually "move" the component out of the way to expose the underlying components.

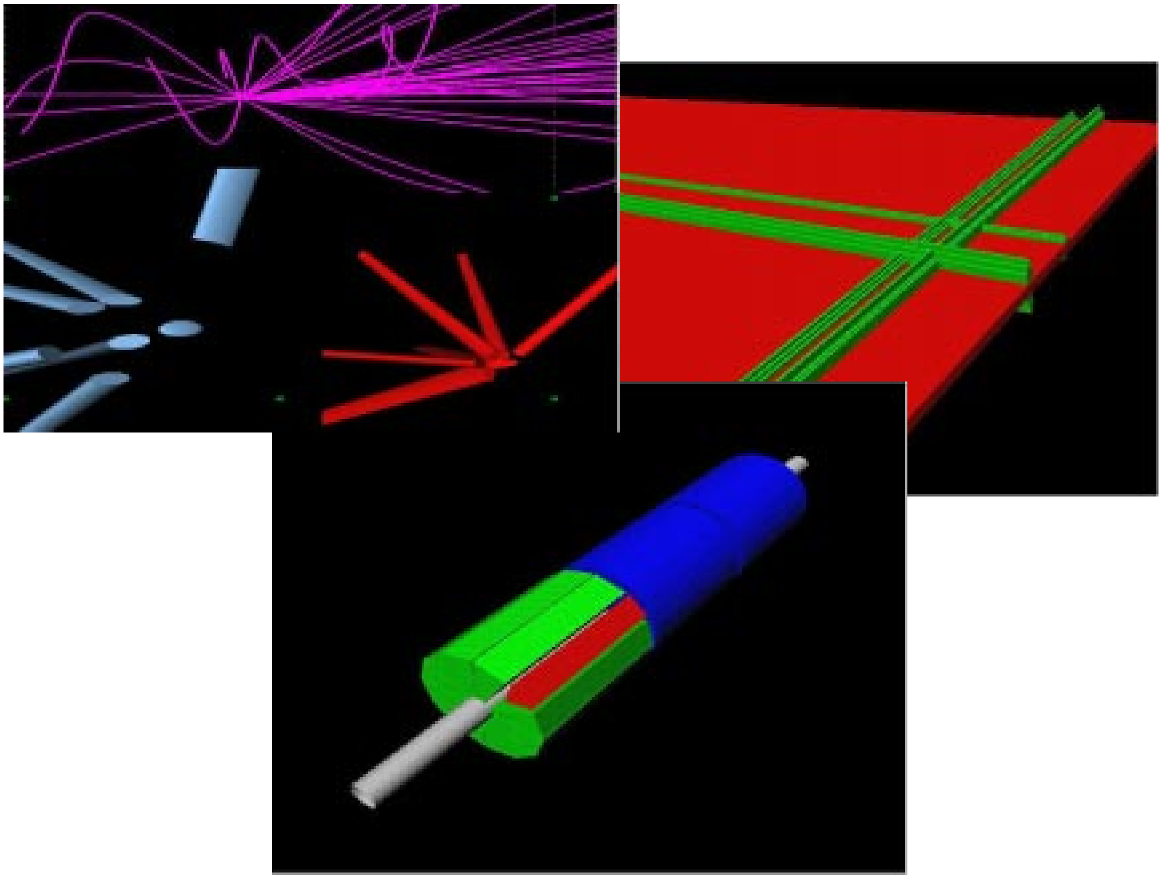


Figure 1 – HEPVis primitives – basic shapes, SoSiStrips, SoDetectorTreeKit

Figure 1 shows a number of the basic shapes and features of the HEPVis library. In the upper left, SoHelicalTrack and SpVtxReconTrack are used to represent tracks in two different ways. SoEllipsoid is used to display a computed vertex. In the upper right, SoSiStripDetKit and SoStereoStripDetKit are used to show silicon strips on a wafer. Note the stereo strips, and how the pulse height is shown using the height of the strip. In the bottom view, SoDetectorTreeKit is used to show the layers of a silicon detector. Using mouse clicks, the user of the program can "peel off" layers of the detector to view, at different points, the barrel exteriors, the wedges, or the individual silicon wafers. Note how in all views color is used to differentiate between the various components.

3.3 Widgets & Add-ons

In addition to basic shapes and primitives, HEPVis also contains X widgets and annotators. SoArrow and SbAxis can be used to add 3D arrows and axes to the Open Inventor scene, respectively. The SmPushButton class adds an X pushbutton and the corresponding callback. SoPlotter is a new class that provides the capability to add an histogram to the Open Inventor scene. The key here is the fact that the new nodes and their corresponding data are actually part of the entire scene being visualized.

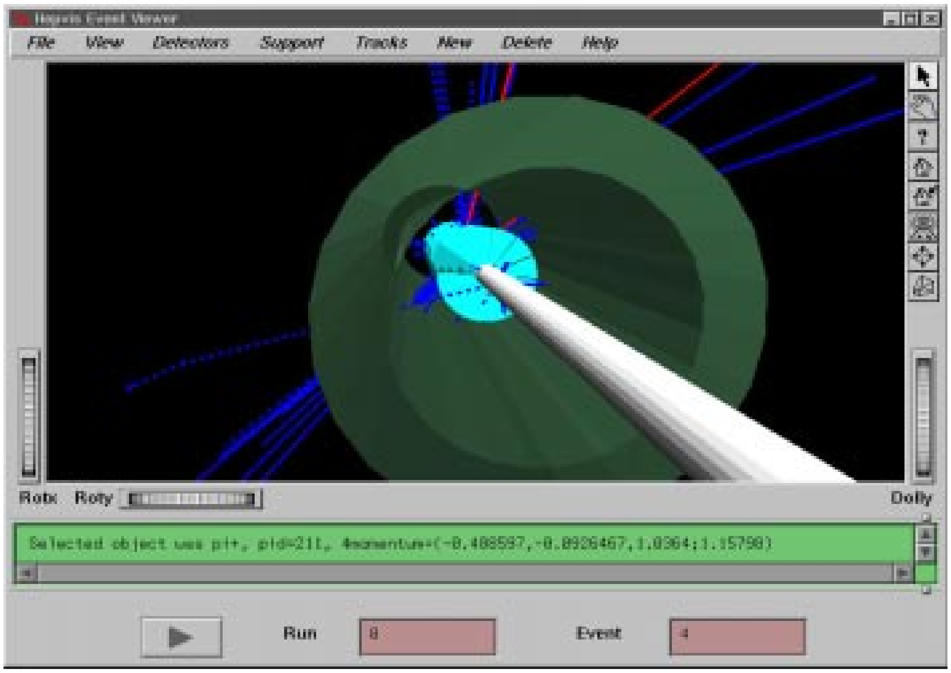
3.4 Viewers

HEPVis also comes with two viewer classes, SoXtHepViewer and SoXtHepEventViewer. These viewers are extensions of the Open Inventor class SoXtFullViewer, and as such provide full 3D control, material editors, and other value-added features. In addition, the HEPVis viewers provide the following features:

- Intuitive control of scene & data. Conventional mouse clicks are used for selection, rotation, etc.
- C++ provides extensibility. For example, the CDF tracking program is a subclass of SoXtHepEventViewer, which in turn is a subclass of SoXtHepViewer.
- The GUI can be extended by adding to the default menu bar or by creating new panels.
- Complete management of selection lists
- Node Kits provide scene reduction & geometry hierarchy

4.0 HEPVis in use

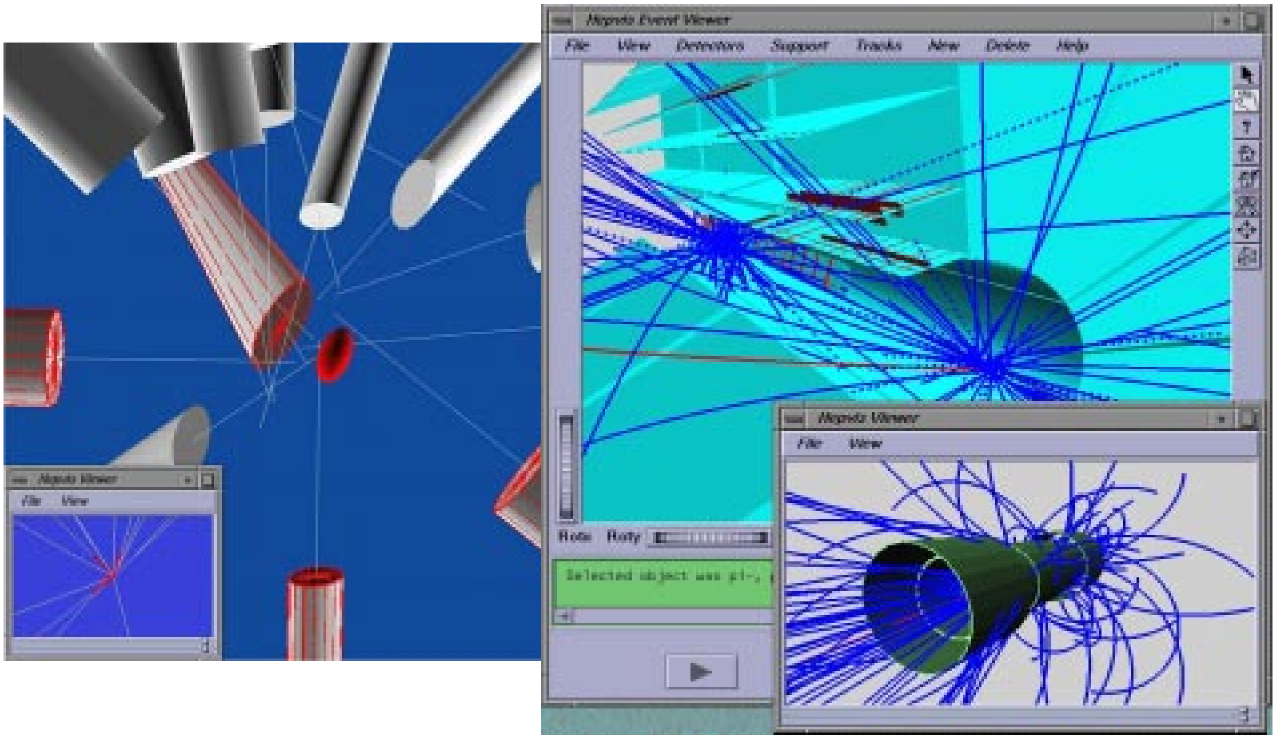
4.1 CDF RunII Tracking



Selected object was pi+, pid=211, 4momentum=(-0.488597,-0.0926467,1.0364;1.15798)

Figure 2 – CDF RunII Tracking using SoXtHepEventViewer

Figure 2 shows features of SoXtHepEventViewer as used in the CDF RunII tracking. The intuitive menu bar appears, and properties of the selected particle appear in the message box. Color and linestyle are used to distinguish different particles. The ISL is transparent to expose the SVX. One SVX wedge has been removed to expose individual wafers.



Selected object was pi-,

Figure 3 – Multiple views in the SoXtHepEventViewer

Figure 3 shows different features of SoXtHepEventViewer. The left side shows a computed vertex along with the tracks from which it was computed. The multiple views remain in synch. On the right side is a shot of the full viewer. The intuitive menu bar and message box appear. Color and linestyle are used to distinguish different particles, and zoomed and panned views orient the user.

4.2 L3/CMS [3]

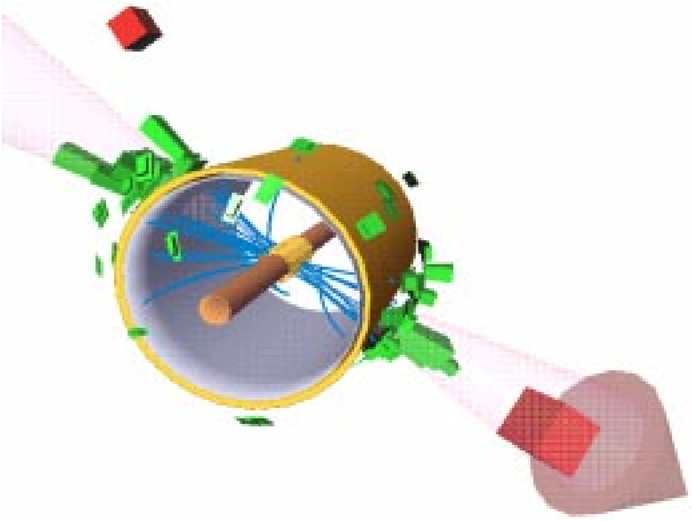


Figure 4 – An event in the L3 detector displayed using a prototype OO event display program based on HEPVis.

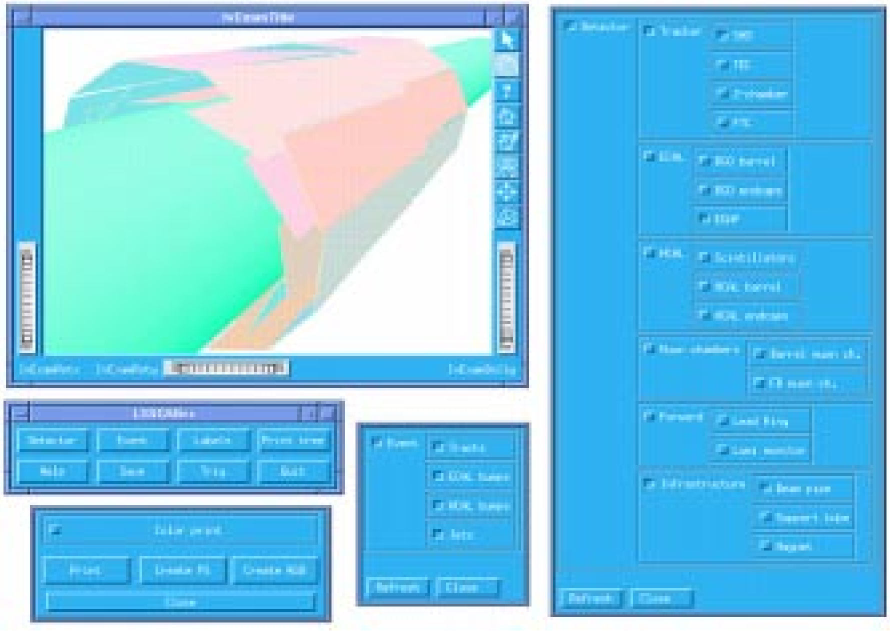


Figure 5 – L3/CMS extensions to the standard GUI for controlling visibility. Now this functionality can be invoked from the main menu bar in the standard HEPVis fashion.

The Northeastern University group (G. Alverson, T. Paul, L. Taylor, and S. Villa) are using and extending the HEPVis library to create new event display programs for the L3 and CMS experiments. Figure 4 shows an example of the L3 prototype showing the L3 detector, based on new classes for GEANT3 detector volumes for tracks, energy towers in the crystal calorimeter, clusters in the HCAL, and reconstructed jets. Figure 5 shows extensions to the user interface for controlling the visibility using a tree-like visibility widget constructed automatically from the tree-like organization of the Inventor scene. Recently Northeastern (G. Alverson) has become active in the D0 effort to produce a new event display for Run II based on HEPVis.

5. HEPVis Recent Activity

Other current activity using HEPVis includes:

- MCFast (A. Boehnlein)[4]
- Geant4 (G. Barrand, J. Boudreau, J. Kallenbach)[5]
- Prototyping at D0 (various), Muon Collider (P. Lebrun), Minos (J. Kallenbach)
- Virtual reality demonstration at FNAL (J. Kallenbach, A. Kubarovsky)[6]
- SND (I. Gaponenko)[7]

Recent improvements to the library include:

- SbAxis – Axis base class
- SbGraphicContext – Graphics context including font, linestyle, fill style, etc.
- SmPushButton – Complete pushbutton class, derived from trd
- SoPlotter – Histogram class
- SoGrid – Grid class derived from SoShape
- SoTextHershey – Provides the capability to mix English and Greek text
- Win32 Port
- Lots of Optimization of picking and rendering
- Collaboration and source code control

Figure 6 shows a demonstration of the use SoPlotter, SmPushButton, SoGrid, and SbAxis classes to construct and plot a histogram in an Open Inventor window.

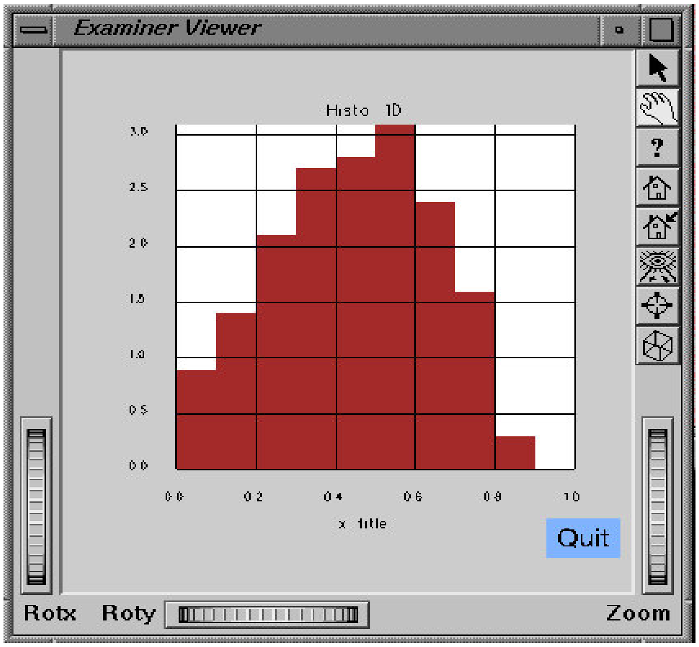


Figure 6 – Histogram in OpenInventor using SoPlotter, SbAxis, SmPushButton

6. Hepvis Future

We expect the near future to be busy. At FNAL, we will be finishing the port to Linux KCC, and hoping to make the product an integral part of CDF and D0 as well as other experiments such as Minos and Btev. We hope to complete the Geant4 shape list as well. Of major importance will be the merging of the efforts of our users/collaborators. We plan to help those who are using the library to get their fixes/extensions into the future releases. The code is now under cvs control, and anyone who has something to contribute should make contact and we'll grant them access to the repository.

7. HEPVis Availability

- Platforms
  - IRIX 5, 6 - CC, KCC, NT - VC++, Linux (g++), Digital Unix (cxx)
- To get the library:
  - Users - http://www-pat.fnal.gov/graphics/hepvislib.html
  - Collaborator information, picture gallery, etc.: http://cactus.phyast.pitt.edu/~joe/hepvis/hepvis.html

8. References

1. Open Inventor is a trademark of Silicon Graphics, Inc. and Template Graphics Software, Inc.
2. Open GL is a trademark of Silicon Graphics, Inc.
3. See http://l3www.cern.ch/~taylorl/l3scan/
4. See http://fnpspa.fnal.gov/mcfast.html
5. See http://asdwww.cern.ch/asd/geant/geant4.html
6. See http://fnpspa.fnal.gov/virt/
7. See http://www.inp.nsk.su/snd