ROOT VR: A Realtime VR Implementation and Extension of the Data Structures in the ROOT Analysis Framework

(UCLA VR for Science, 2026)

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October 25, 2026

Discussion Points

1. Data Analysis Software
   - Goals of Data Analysis Software
   - VR Data Analysis
2. Introduction to ROOT VR
   - What is ROOT?
   - What is ROOT VR?
   - ROOT::VR Objects
3. Future Research
   - Options
   - New Plots

Goals of Data Analysis Software

- Play a role in the understanding of relationships between variables

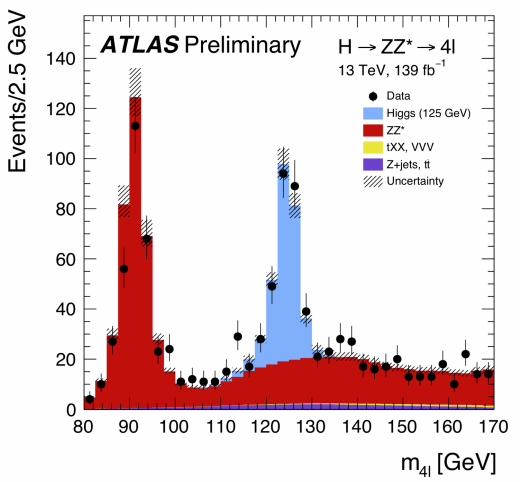


Figure: Example relationship – 4 lepton mass vs event frequency

Goals of Data Analysis Software

- Play a role in the understanding of relationships between variables
- Fit data to make predictions

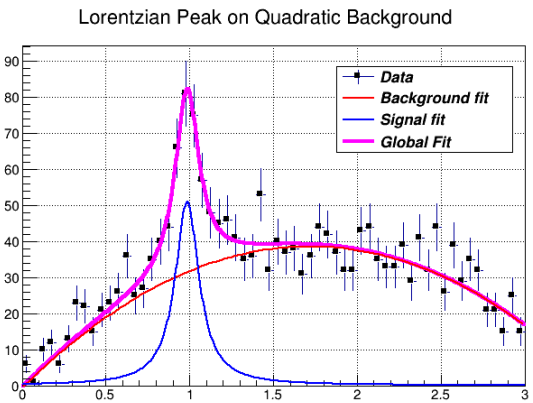


Figure: Example fit

Goals of Data Analysis Software

- Play a role in the understanding of relationships between variables
- Fit data to make predictions
- Interact with data from command line: add data, remove bins, etc.

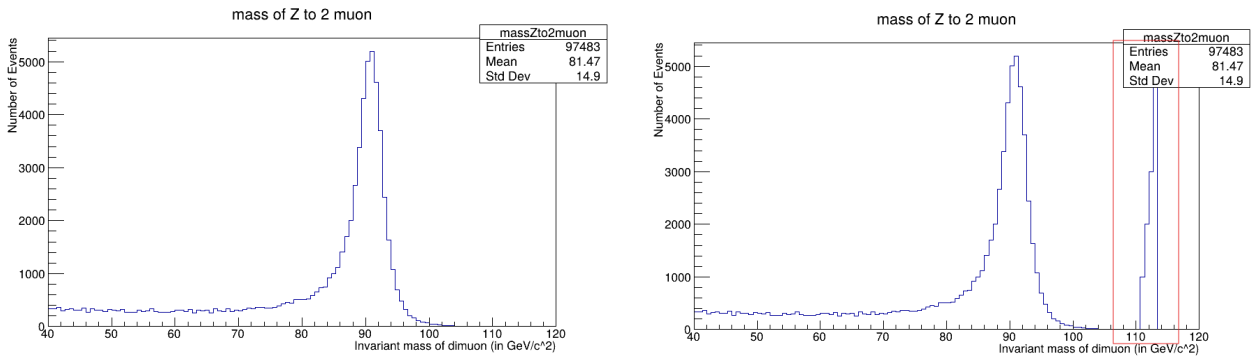


Figure: Adding (arbitrary) data entries

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- Real-time data interaction
  - No CLI
  - Previews available
- Higher-dimensional plots
  - Few suitable implementations outside of VR
- Dynamic data
  - Few suitable implementations outside of VR

What is ROOT?

- One of the most advanced data analysis packages, trusted by particle physicists worldwide
- Ongoing project at CERN; started development in 1995
- MASSIVE collection of data structures with vast hierarchy webs

What is ROOT VR?

- A VR dictionary (add-on; plugin) for ROOT
- Runs alongside ROOT; not as a replacement to it
- Implements VR analogues of ROOT data structures AND introduces VR-exclusive structures (recall some of the goals of VR data analysis)

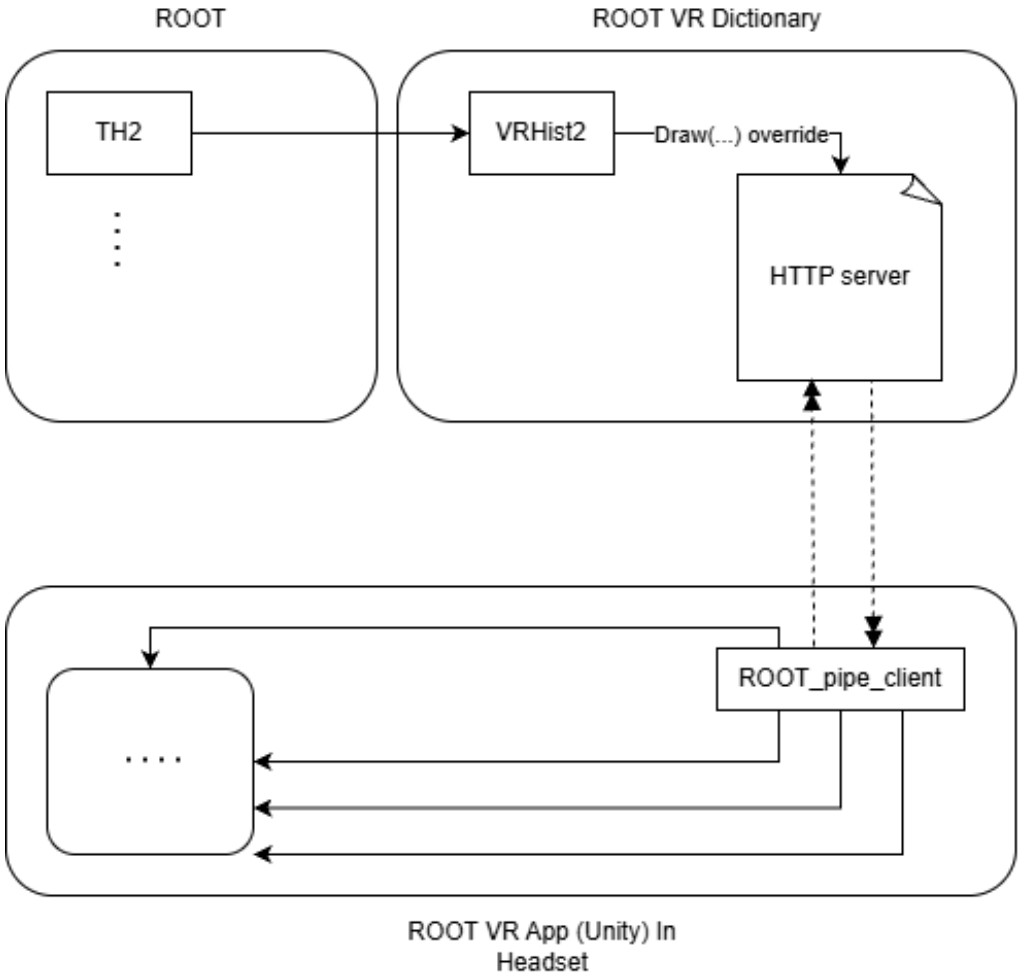
ROOT VR Implementation

- Two sides:
  1. ROOT side: requires making additions to ROOT codebase using C++
     - Data analysis functionality handled here
     - Upon loading dictionary, ROOT VR additions act as direct additions to ROOT source code
     - Runs on user's computer, via ROOT
  2. VR application: requires designing VR visuals with Unity (C#)
     - VR visualization handled here
     - Runs completely independently of ROOT
     - Runs natively on the headset
- BOTH are needed to perform effective VR data analysis!

Key ROOT VR Data Structures

ROOT	ROOT VR
TH2< X >	VRHist2< X >
TGraph2D	VRGraph2D
∼	VRGraph3D

ROOT VR Data Flow



ROOT VR Data Flow

- VR app and ROOT session run asynchronously; VR app is launched by user whenever convenient for them
- Data exchanged via HTTP server, which the computer hosts and the headset connects to in order to retrieve data
- Public builds for both Windows and Ubuntu

Special Data Structure: VRGraph3D

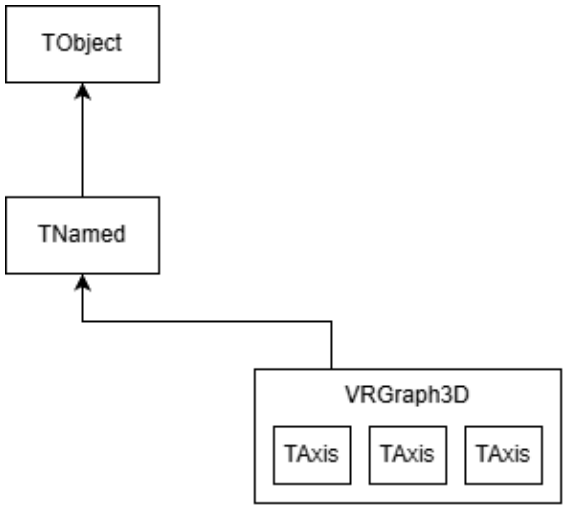


Figure: Inheritance diagram for ROOT::VR::VRGraph3D

- Is a 3-dimensional analogue of the 2D object TGraph2D
- First implementation of multidimensional data and "dynamic data" to ROOT VR

(Documentation.)

Future Directions

- Options for ROOT::VR objects (IMPORTANT)
  - Fit analysis options (lots of linear algebra to be used!)
  - Aesthetic options
- New plots (e.g. contour plots, smooth functions, complex plane, etc.)