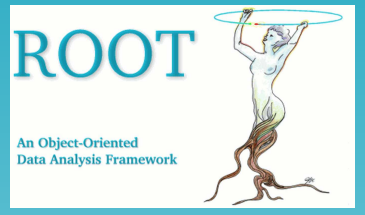


ROOT

An Object-Oriented Data Analysis Framework

KVI
RIJKSUNIVERSITEIT GRONINGEN

Overview

- ROOT Executive Summary
  - What ROOT can do for you: Examples
    - Getting ROOT
      - How to avoid this course
        - What to expect in this course

ROOT: Executive Summary — I

The ROOT system provides a set of OO frameworks with all the functionality needed to handle and analyse large amounts of data in a very efficient way. Having the data defined as a set of objects, specialised storage methods are used to get direct access to the separate attributes of the selected objects, without having to touch the bulk of the data. Included are histogramming methods in 1, 2 and 3 dimensions, curve fitting, function evaluation, minimization, graphics and visualization classes to allow the easy setup of an analysis system that can query and process the data interactively or in batch mode.

ROOT: Executive Summary — II

Thanks to the builtin CINT C++ interpreter the command language, the scripting, or macro, language and the programming language are all C++. The interpreter allows for fast prototyping of the macros since it removes the time consuming compile/link cycle. It also provides a good environment to learn C++. If more performance is needed the interactively developed macros can be compiled using a C++ compiler.

You'll be able to use ROOT without knowing C++, since many things are click-and-play ...

ROOT: Executive Summary — III

The system has been designed in such a way that it can query its databases in parallel on MPP machines or on clusters of workstations or high-end PC's. ROOT is an open system that can be dynamically extended by linking external libraries. This makes ROOT a premier platform on which to build data acquisition, simulation and data analysis systems.

Getting ROOT

ROOT can be freely downloaded from http://root.cern.ch

Binaries are available for many platforms:

- Intel x86 Linux for Redhat FedoraCore2 and gcc 3.3.3
- Intel x86 Linux for Redhat 9.0 and gcc 3.2.2
- Intel x86 Linux for Redhat RHEL 3 (SLC3) and gcc 3.2.3
- Intel x86 Linux for Redhat 7.3 and gcc 3.2.2
- Intel x86 Linux for Redhat 7.3 and gcc 2.96
- Intel x86 Linux for Redhat 7.3 and gcc 2.95.3
- Intel x86 Linux for Redhat 7.3 and gcc 2.95.2
- Intel x86 Linux for Redhat 9 and Intel's icc 8.0
- Intel x86 Linux for Redhat 6.1 (glibc 2.1) and gcc2.95.2
- AMD x86 64 (Athlon64 and Opteron) FC 2 and gcc 3.4
- Intel Itanium Linux for RHEL3 and gcc 3.2.3
- Intel Itanium Linux for RHEL3 and Intel's icc 8.0
- HP PA-RISC HP-UX 10.20 with aCC (v1.18)
- Compaq Alpha OSF1 with cxx 6.2
- Compaq Alpha OSF1 with cxx 6.2
- IBM AIX 4.5 with xlC version 5
- Sun SPARC Solaris 5.7 with CC5.2
- Sun SPARC Solaris 5.8 with CC5.2
- SGI IRIX 6.5 with CC
- SGI IRIX 6.5 with g++ 2.95.2
- SGI IRIX 6.5 with KCC
- MacOS X 10.3.6 and gcc 3.3
- WindowsXP/NT/w2000 with CYGWIN and gcc3.3 version 4.03/02
- WindowsXP/NT/w2000 with VC++ 7.1 (runs with VC++6)
- Windows/NT/w2000 with VC++ 7.0 (runs with VC++6)

For all others: source code

How to avoid this course

ROOT has excellent documentation available online:

Installation instructions	Very detailed
User's Guide	470 pages
Reference Guide	each class; also older versions
Tutorials	87 worked out examples
HOWTO's	34 chapters
RootTalk Forum	1123 members, 5787 articles
RootTalk Digest	all articles back to 1997; ROOT version 0.9
Example Applications	56 applications
BaBar Tutorials	not so clear
FNAL Tutorials	C++, presentations, exercises, examples
MINOS Tutorials	somewhat specific; excellent for new C++'ers

What to expect in this Course

We'll clearly not cover everything = 1058159 lines of code in 918 classes (a little under 47 MB)

LEARNING GOALS:

1. Knowledge and experience to do basic analysis from the command line
2. Ability to convert private data format to ROOT data structures
3. Skills to do more complex analysis
4. Make publication-worthy plots

REQUIREMENTS:

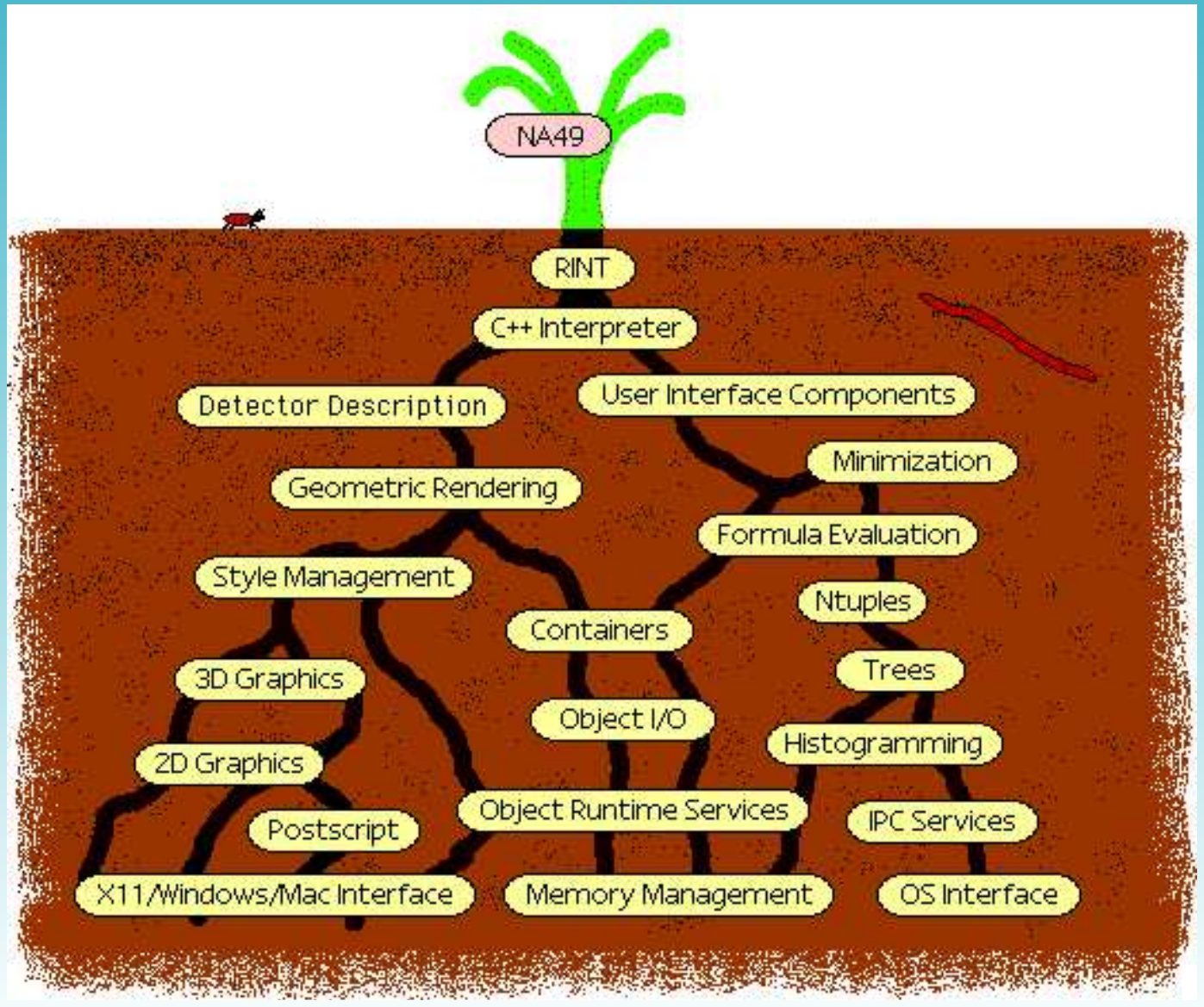
1. Access to computer with ROOT (version 4.03/02)
2. Some programming experience (in whatever language)
3. Data to play with

SCHEDULE: once a week for 1 hour till about June (tuesdays, 13:00–14:00)?

MATERIAL: ROOT used guide, FNAL course and local development

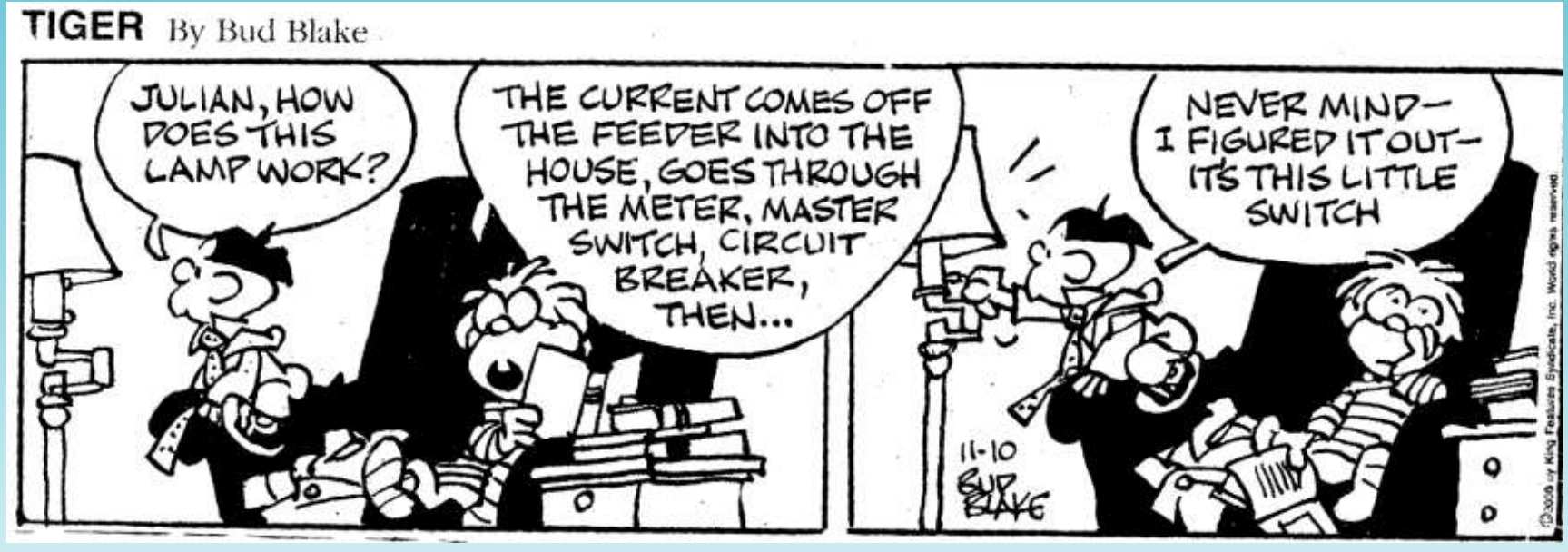
The END

Frameworks

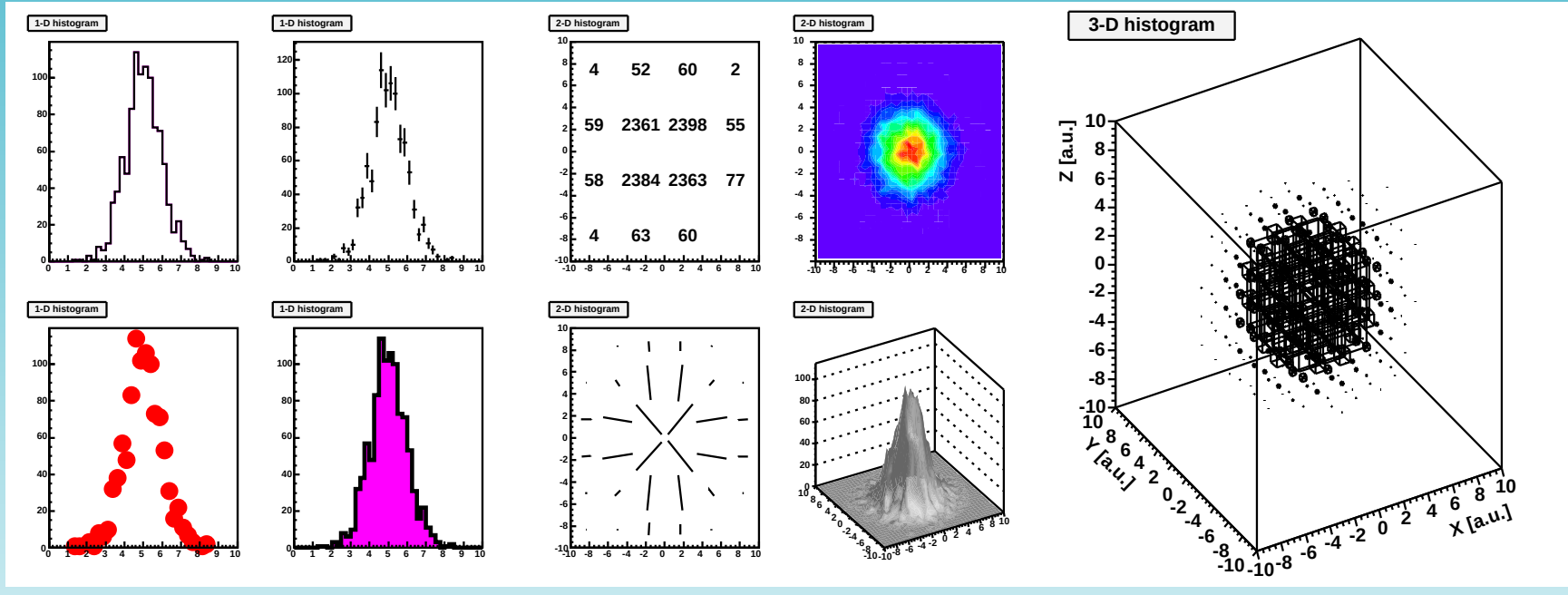

NA49
RINT
C++ Interpreter
Detector Description
User Interface Components
Minimization
Geometric Rendering
Formula Evaluation
Style Management
Ntuples
Containers
Trees
3D Graphics
Object I/O
Histogramming
2D Graphics
Object Runtime Services
IPC Services
Postscript
X11/Windows/Mac Interface
Memory Management
OS Interface

Some words on 'Object Oriented'

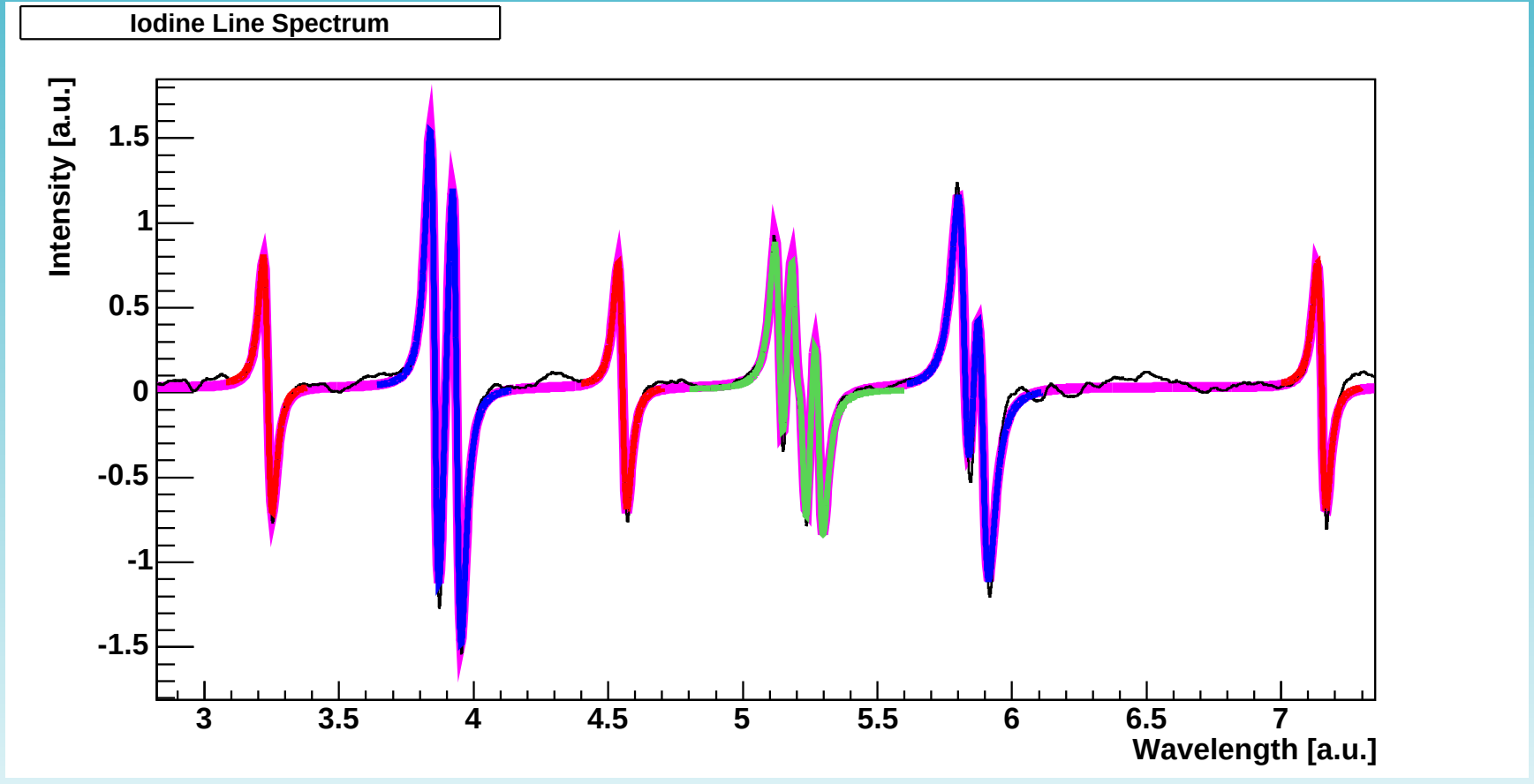
Hiding complex things behind something simple ....



Histogramming



Fitting



data courtesy Umakanth Dammalapati

Functions

Abs ACos ACosH ASin ASinH ATan ATan2 ATanH BesselI BesselI0 BesselI1 BesselJ0 BesselJ1 BesselK BesselK0 BesselK1 BesselY0 BesselY1 Beta BetaCf BetaDist BetaDistI BetaIncomplete BinarySearch Binomial BreitWigner BubbleHigh BubbleLow C CauchyDist Ccgs Ceil Cos CosH Cross CUncertainty DegToRad DiLog E Erf Erfc ErfcInverse ErfInverse Even Exp Factorial FDist FDistI Finite Floor Freq G Gamma GammaDist Gaus Gcgs GeomMean GhbarC GhbarCUncertainty Gn GnUncertainty GUncertainty H Hash Hash Hbar Hbarcgs HbarUncertainty HC HCcgs Hcgs HUncertainty Hypot InvPi IsInside IsNaN K Kcgs KolmogorovProb KOrdStat KUncertainty Landau LaplaceDist LaplaceDistI Ldexp Ln10 LnGamma LocMax LocMin Log Log10 Log2 LogE LogNormal Max MaxElement Mean Median Min MinElement MWair Na NaUncertainty NextPrime Nint Nint Normal2Plane Normalize NormCross NormQuantile Odd Permute Pi PiOver2 PiOver4 Poisson Power Prob Qe QeUncertainty R RadToDeg Range Rgair RMS RootsCubic RUncertainty Sigma SigmaUncertainty Sign Sin SinH Sort Sqrt StruveH0 StruveH1 StruveL0 StruveL1 Student StudentI StudentQuantile Tan TanH TwoPi Voigt

and of course any other function that you might want to program yourself (code or symbolically)

Minimization

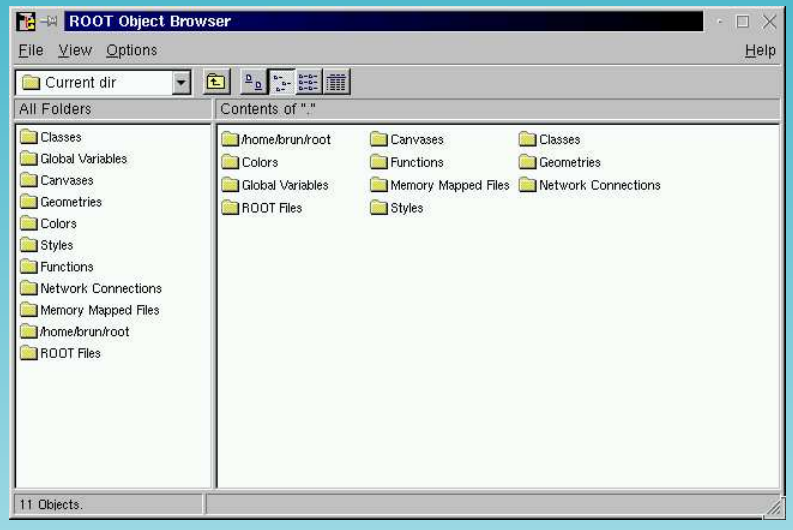
Full implementation of MINUIT:

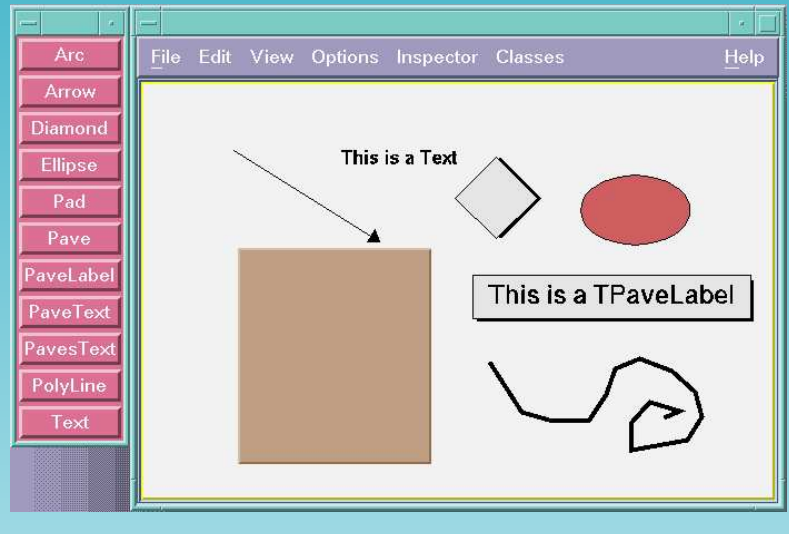
- squared differences, χ^2, and $\log \mathcal{L}$ standard
- something else also possible
- fitting with bounded parameters
- fitting over sub-range of data
- full evaluation of errors and correlations
- and much more ...

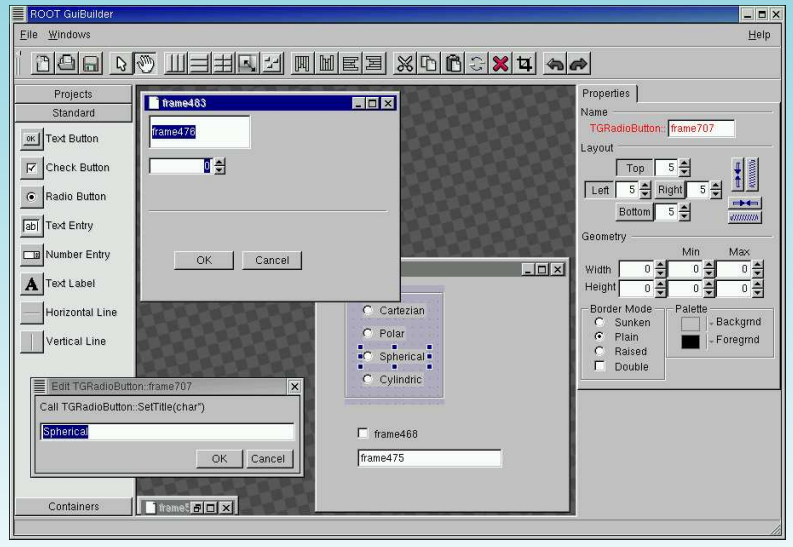
Alternative:

Neural networks

Graphics

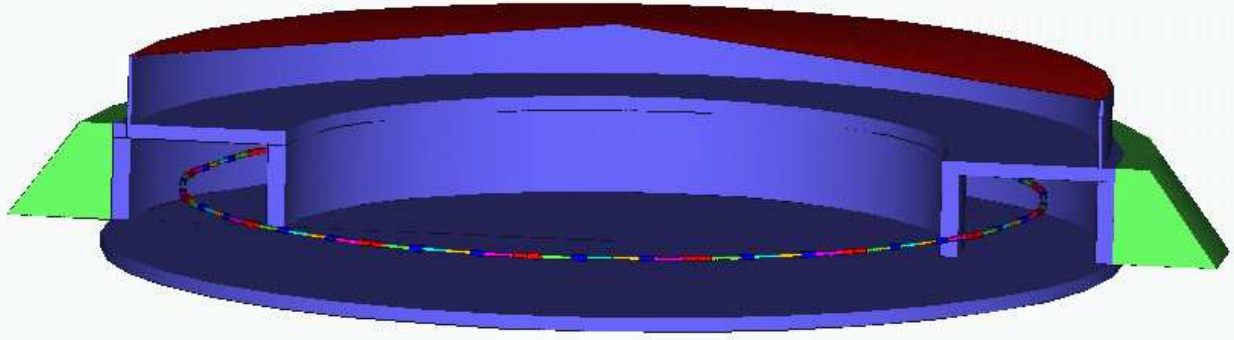

ROOT Object Browser
File View Options Help
Current dir
All Folders
Contents of "."
Classes
Global Variables
Canvases
Geometries
Colors
Styles
Functions
Network Connections
Memory Mapped Files
/home/brun/root
ROOT Files
Canvases
Functions
Memory Mapped Files
Styles
Classes
Geometries
Network Connections
11 Objects.


Arc
Arrow
Diamond
Ellipse
Pad
Pave
PaveLabel
PaveText
PavesText
PolyLine
Text
File Edit View Options Inspector Classes Help
This is a Text
This is a TPaveLabel


ROOT GuiBuilder
File Windows Help
Projects
Standard
Text Button
Check Button
Radio Button
Text Entry
Number Entry
Text Label
Horizontal Line
Vertical Line
Containers
frame483
frame476
OK
Cancel
Properties
Name
TGRadioButton::
frame707
Layout
Top
Left
Right
Bottom
Geometry
Min
Max
Width
Height
Border Mode
Sunken
Plain
Raised
Double
Palette
Backgrnd
Foregrnd
Cartezian
Polar
Spherical
Cylindric
frame468
frame475
Edit TGRadioButton::frame707
Call TGRadioButton::SetTitle(char*)
Spherical
OK
Cancel

Visualization

EDM ring @ KVI

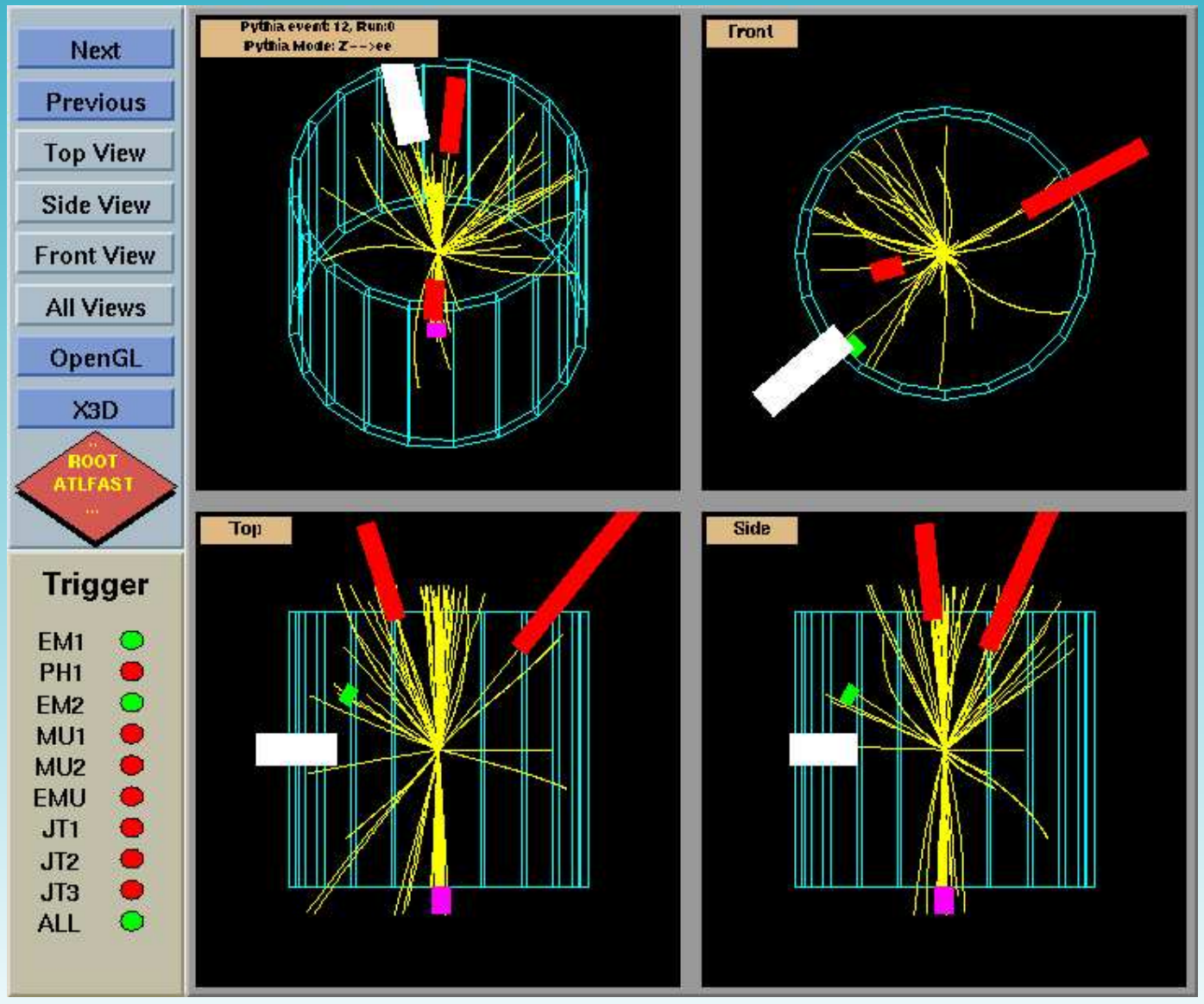


E = 100 MeV
p = 625 MeV/c

E = 6 MV/m
B = 0.44 T
R = 12 m

Lq = 40 cm
Ld = 150 cm

Analysis System



Differences from PAW

- Regular grammar (C++) on command line
- Single language (compiled and interpreted)
- Object Oriented (use your class in the interpreter)
- Advanced Interactive User Interface
- Well Documented code. HTML class descriptions for every class.
- Object I/O including Schema Evolution
- 3-d interfaces with OpenGL and X3D.