FAIR Simulation & Analysis Framework
FairRoot

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Overview

- Motivation
- FairRoot Features
- CMake: Testing and building system
- Geometry Interface
- Fast simulation
- Integrated Track follower (Geane)
- Event display
- Summary

Motivation

- **2003 we start making simulations for CBM:**
  - **Which simulation engine to choose?**
    - One would like to use the modern and maintained GEANT4
    - But:
      1. We have to:
         - » Work fast ! (LOI, TDR deadlines …)
         - » Make reliable simulation

      1. In the CBM community and locally at the GSI :
         - » Better knowledge of “old” MC’s: GEANT3, FLUKA …
         - » lack of knowledge about GEANT4 (intrinsic cuts / physics list …)
         - » It was extremely difficult to get support for working with Geant4

CbmRoot

- In very close contact with CBM collaboration implementing a VMC based framework was started:
  - ROOT based.
  - Re-Use of Hades geometry interface
  - Re-Use of Hades Runtime database and Oracle interface
  - TGeoManger as a navigation from the beginning
  - Extended TTask for reconstruction
- 2006 the framework was also used for PANDA and became FairRoot

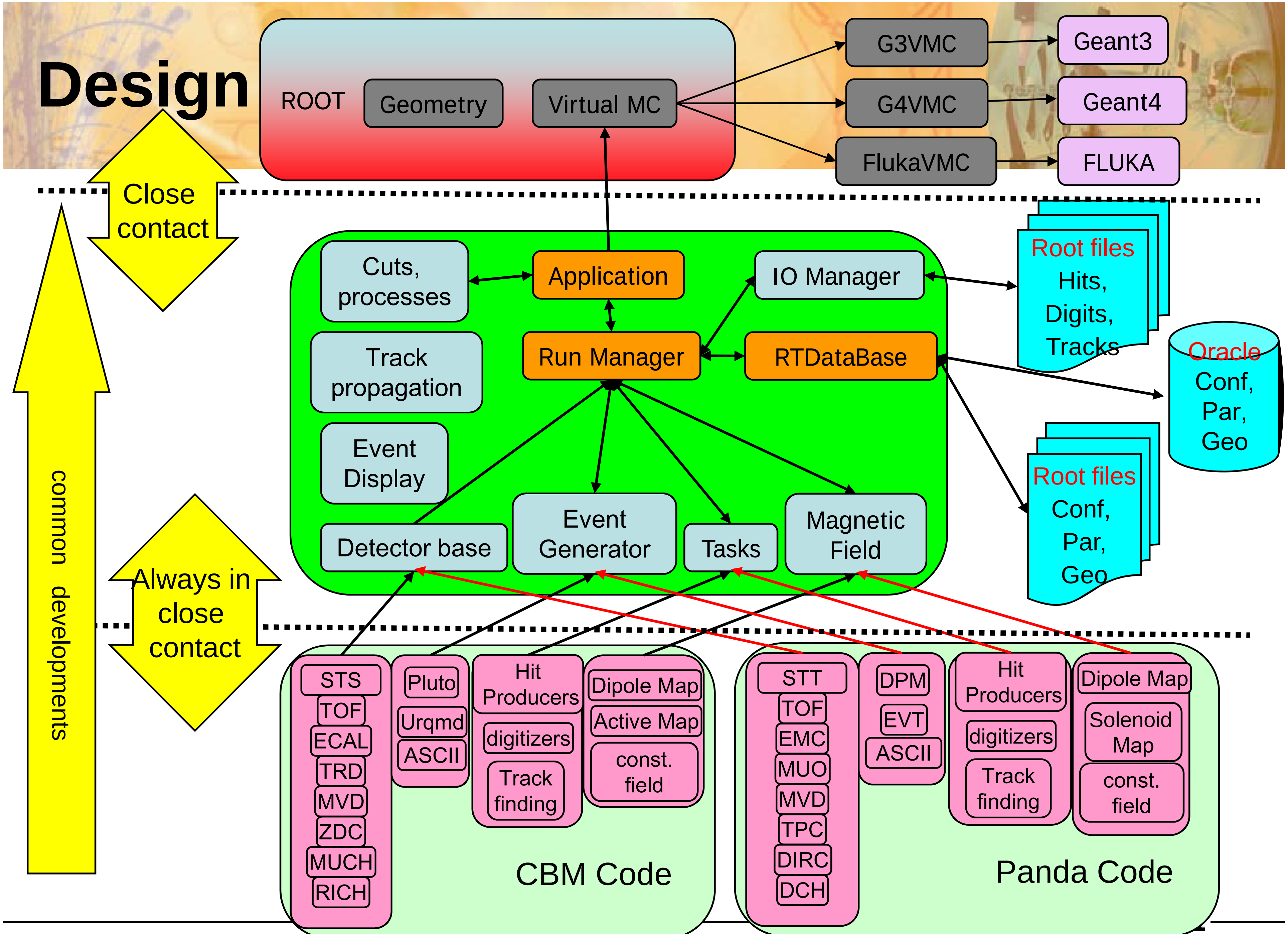
Features

- No Executable: (Only Rootcint)
  - Compiled Tasks for reconstruction, analysis, etc.
  - Root macros for steering simulation or reconstruction
  - Root macros for configurations (G3, G4, Fluka and Analysis)
- VMC and VGM for simulation
- Reconstruction can be done directly with simulation or as a separate step
- RHO Package for Analysis (optional: see talk by Klaus Götzen)
- TGeoManager for Simulation and Reconstruction
- Eve (Alice Event display) as base for a general event display
- Dynamic Event structure based on ROOT tree
- Hades oracle interface and run time data base

Features

- Hades Geometry Interface.
  - G3 Native geometry
  - Geometry Modeller (TGeoManager)
  - Different geometry input format
- Grid: we use AliEn!
- CMake: Makefiles, dependencies , QM (see talk by Florian)
- Doxygen for class documentation
- The same application for fast and full simulation

Design



ROOT
Geometry
Virtual MC
G3VMC
G4VMC
FlukaVMC
Geant3
Geant4
FLUKA
Close contact
common developments
Always in close contact
Cuts, processes
Application
IO Manager
Track propagation
Run Manager
RTDataBase
Event Display
Detector base
Event Generator
Tasks
Magnetic Field
Root files
Hits, Digits, Tracks
Oracle
Conf, Par, Geo
Root files
Conf, Par, Geo
STS
TOF
ECAL
TRD
MVD
ZDC
MUCH
RICH
Pluto
Urqmd
ASCII
Hit Producers
digitizers
Track finding
Dipole Map
Active Map
const. field
CBM Code
STT
TOF
EMC
MUO
MVD
TPC
DIRC
DCH
DPM
EVT
ASCII
Hit Producers
digitizers
Track finding
Dipole Map
Solenoid Map
const. field
Panda Code

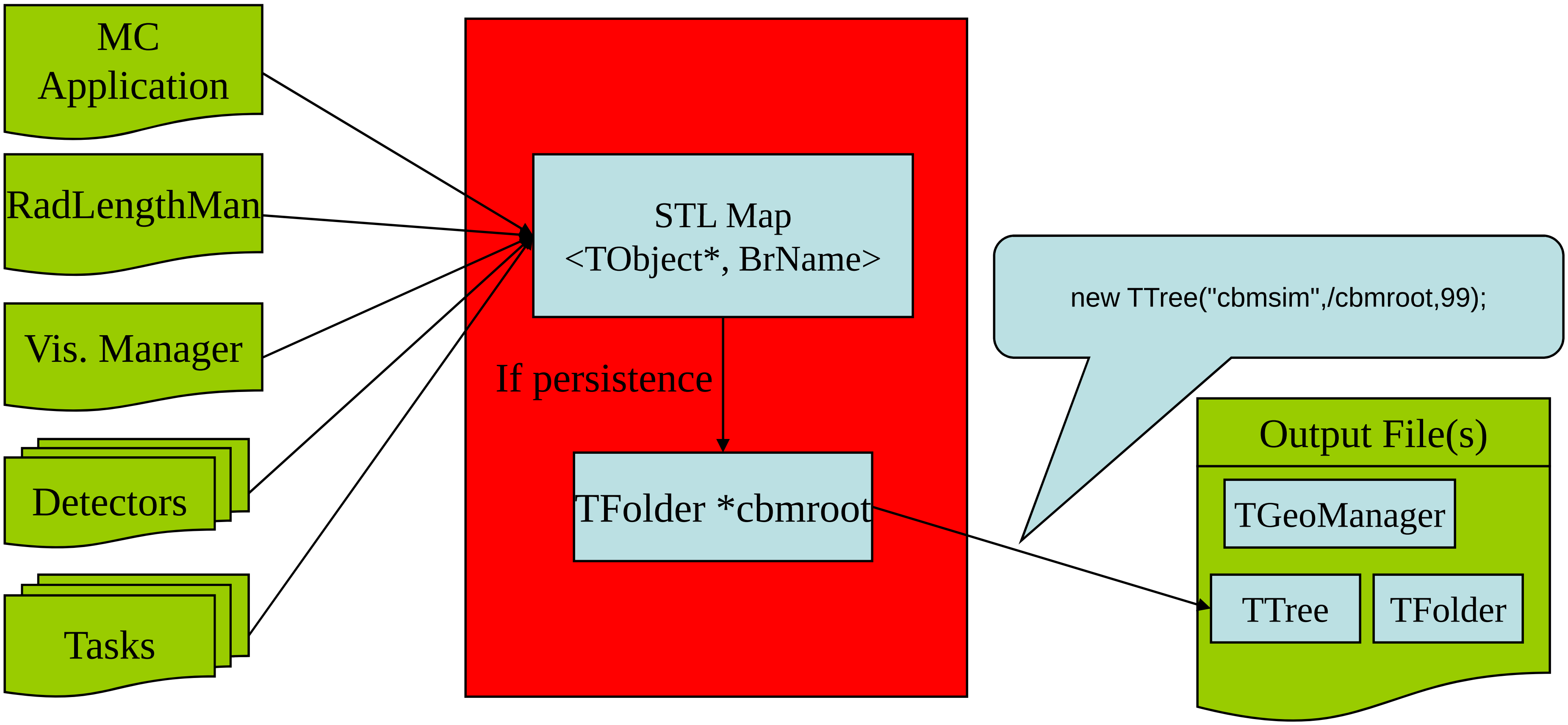
FairRoot IO

- Dynamic Tree creation at initialization time
  - TFolder to organize memory
  - Simulation: **CbmDetector::Init()**
  - Analysis: **CbmTask::Init()**
    - **(automatic partial IO)**
- Chaining Input data
  - **TChain** services
- Connection of Data levels
  - Use of **Root Friend mechanism**

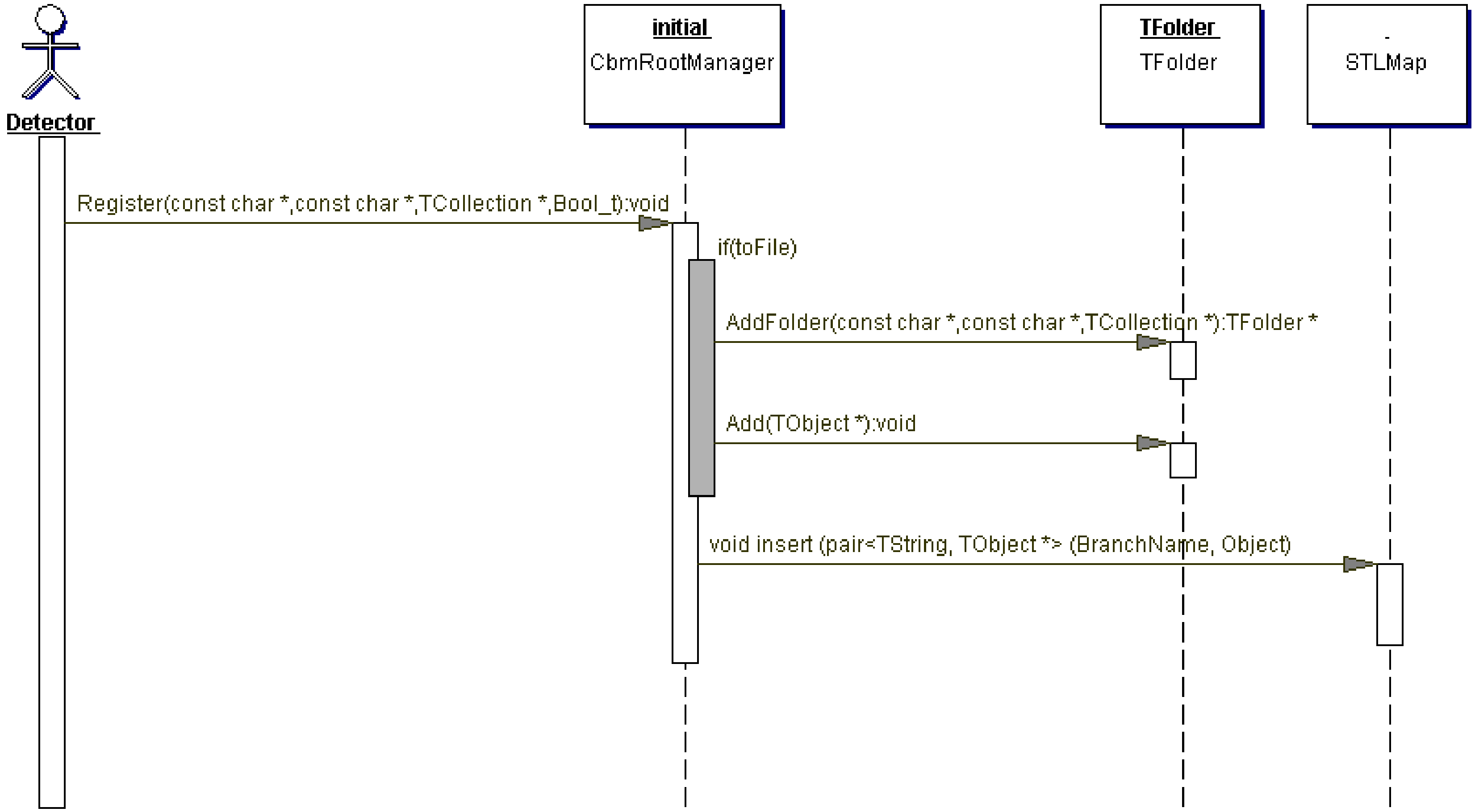
Why Dynamic structure:

- Detectors can be added or replaced on the fly without changing the compiled code
- For design studies it is easier to work with a subset of the detectors and then easily merge the rest
- Simple analysis on output files can be done in plain root without any extra libraries
- Connection of different files can be done via tree friends
- Transient and persistence objects are the same

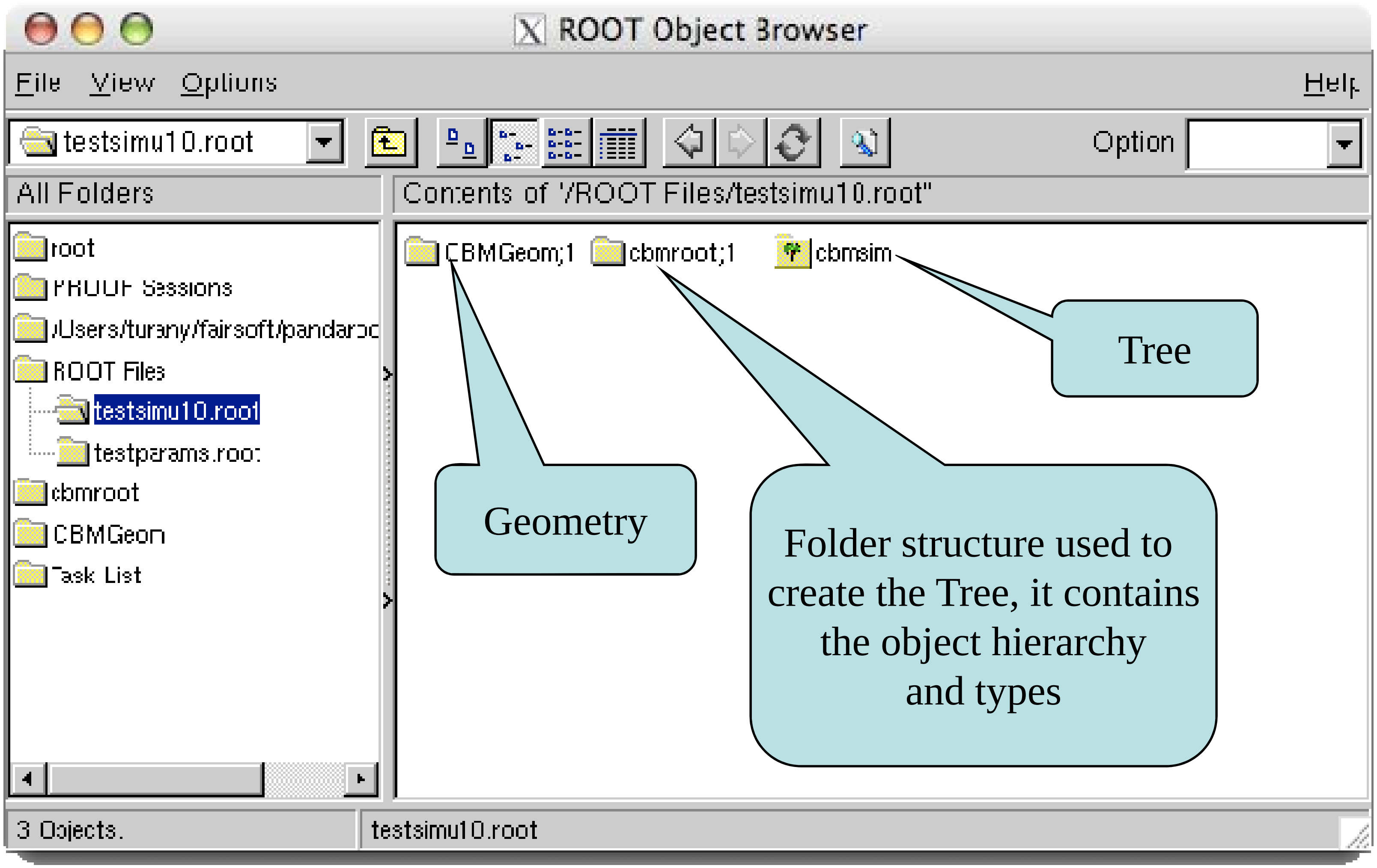
IO Manager (Simulation init)



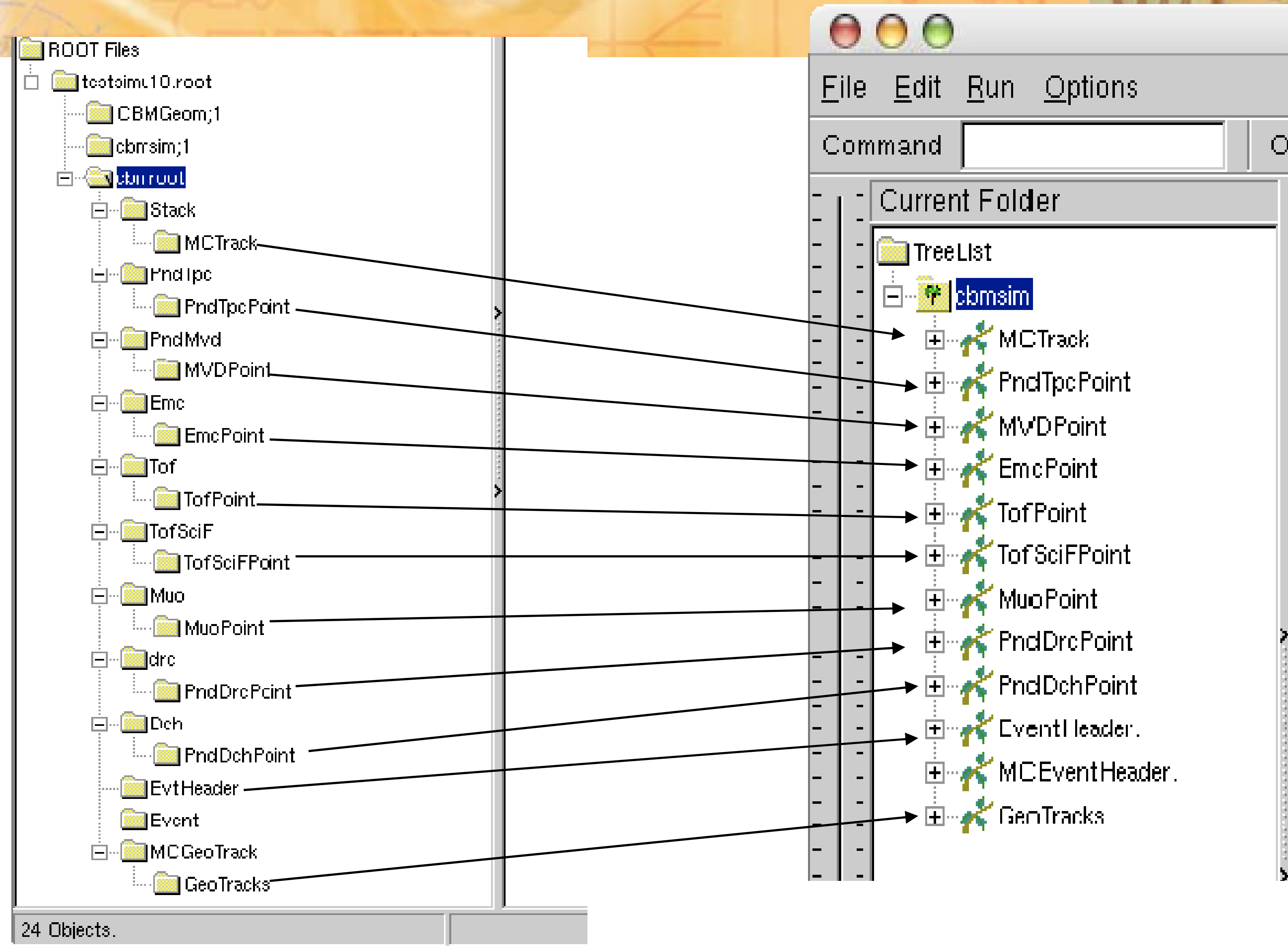
IO Manager: Register Object



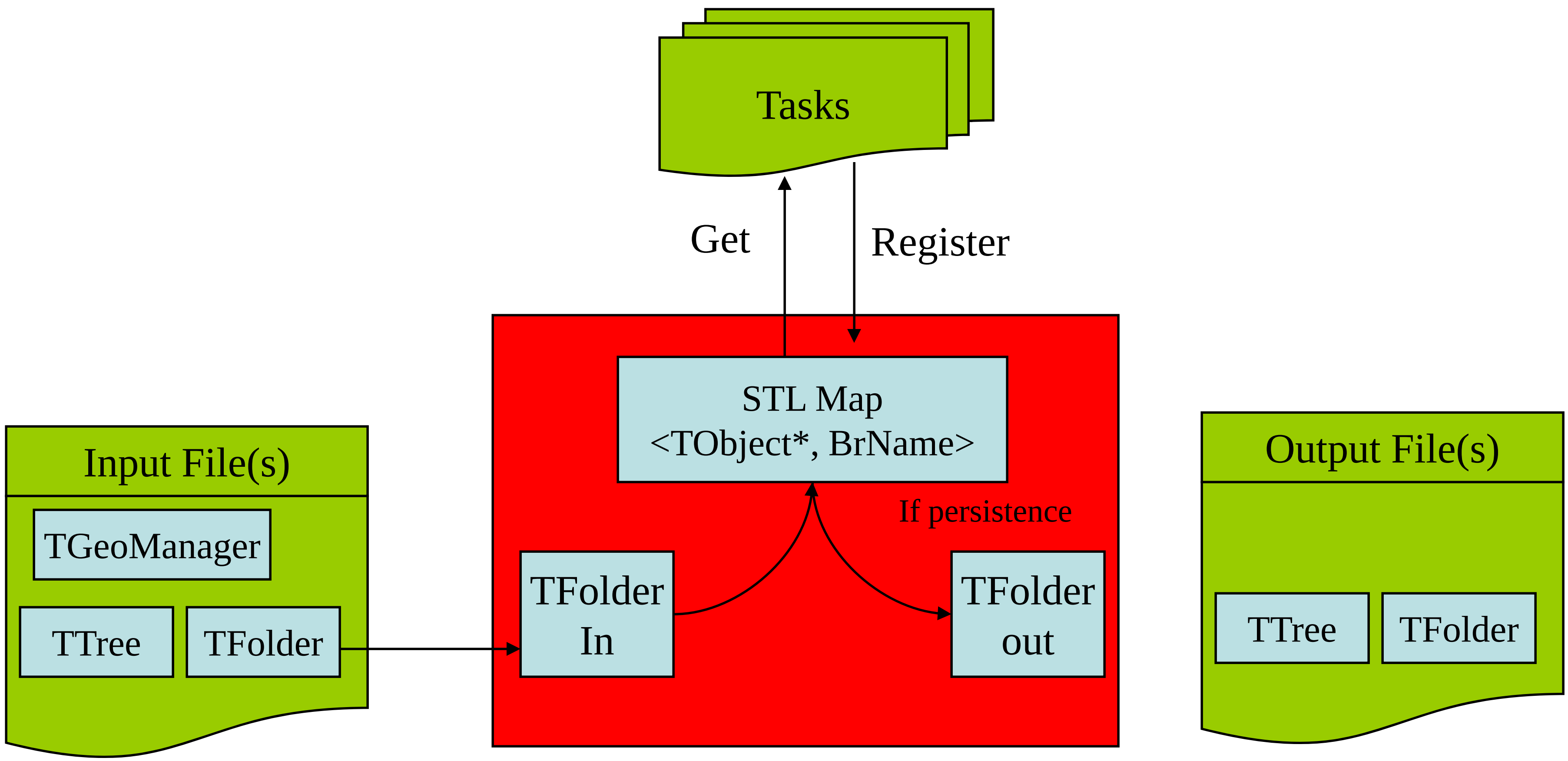
Output File


ROOT Object Browser
File View Options Help
testsimu10.root
Option
All Folders
Contents of "/ROOT Files/testsimu10.root"
root
PROOF Sessions
/Users/turany/fairsoft/pandarc
ROOT Files
testsimu10.root
testparams.root
cbmroot
CBMGeom
Task List
CBMGeom;1
cbmroot;1
cbmsim
3 Objects.
testsimu10.root
Tree
Geometry
Folder structure used to create the Tree, it contains the object hierarchy and types

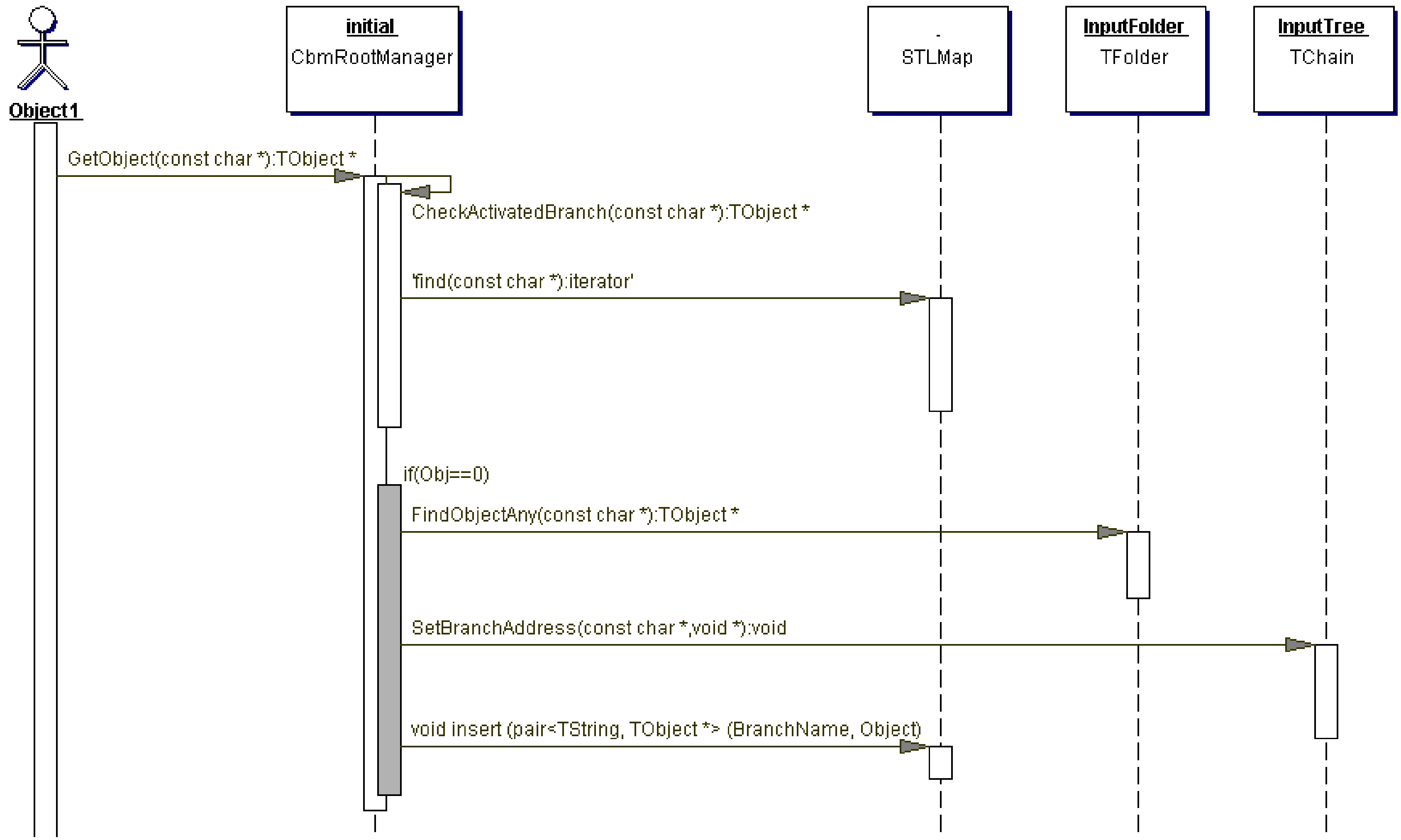
TFolder & Output Tree



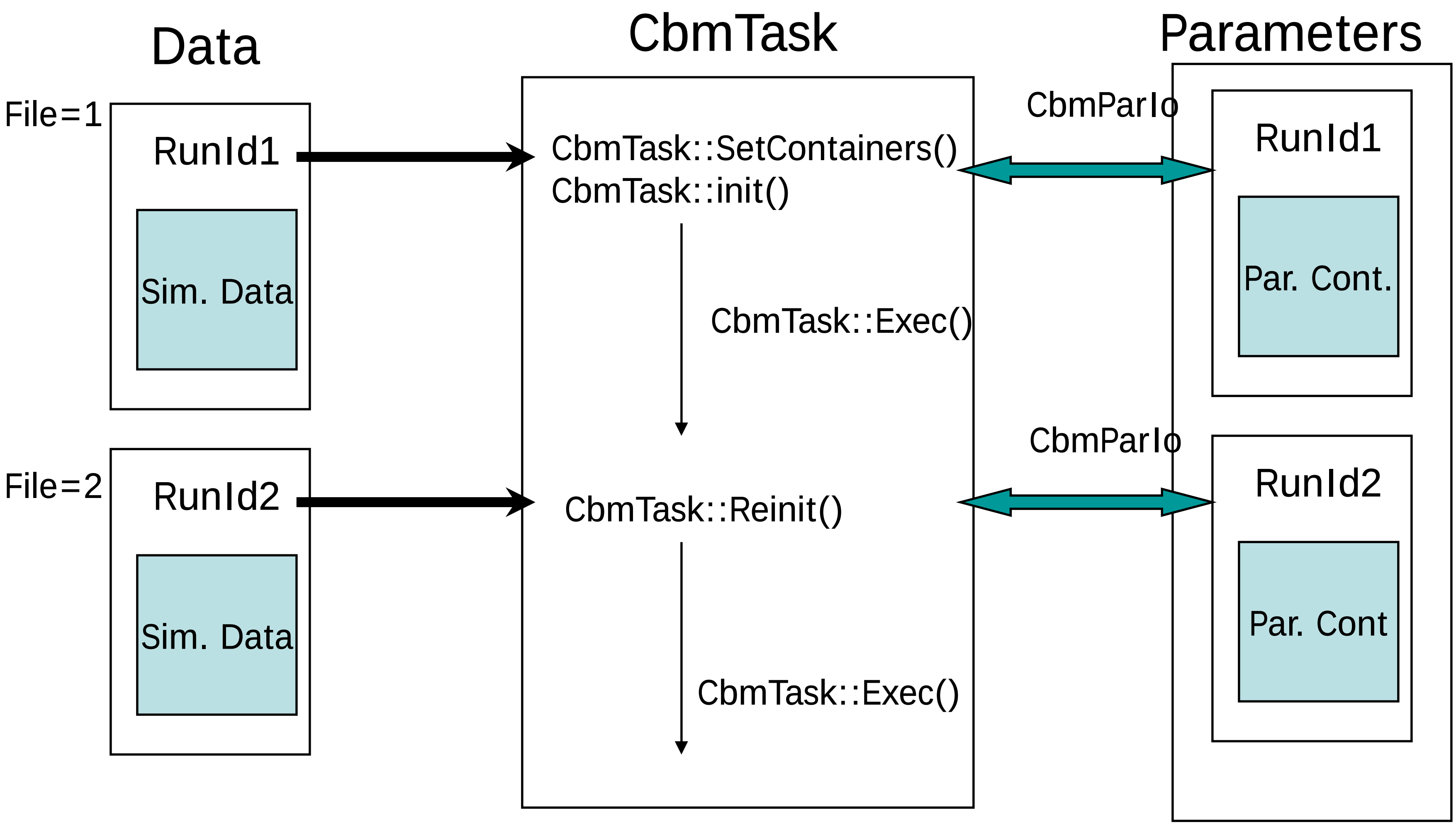
IO Manager (Analysis, Reconstruction init)



IO Manager:Get Object



Initialisation scheme (Analysis)



CMake

- Why CMake:
  - It supports great variety of platforms
    - (basically every *ix, Mac OS, Windows)
    - (Win: Borland, MS Visual C++, cygwin, mingw)
  - CMake generates out of simple rules native Makefiles for all supported platforms
  - produce project files for IDE's (KDevelop, XCode, VStudio)
  - Input files (rules) are the same on all platforms
  - Big community behind it, CMake is the build tool for KDE 4
  - CMake has a testing framework

See talk by Florian Uhlig

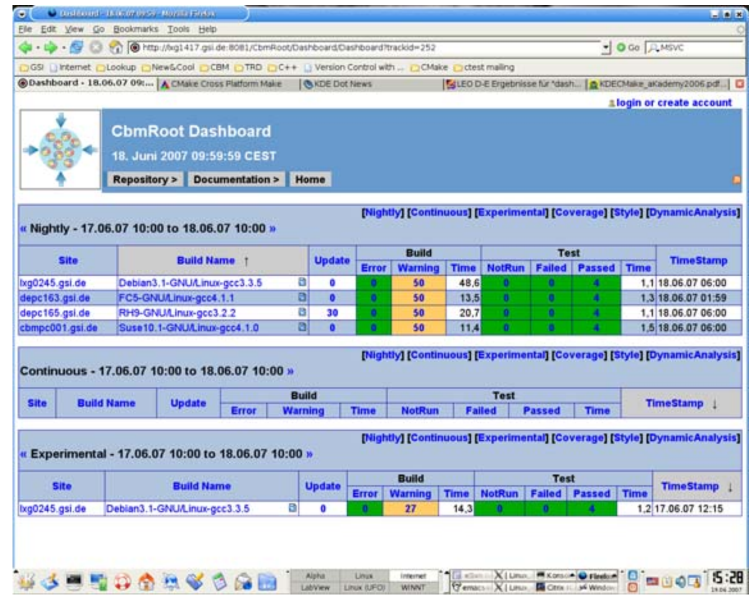
Why test daily

- Large code base is too large/complicated for a single developer to understand/maintain
- Identify problems when they occur
- Project depends on external packages which can cause problems
- Provide direct feedback to the developers as they experiment with new features

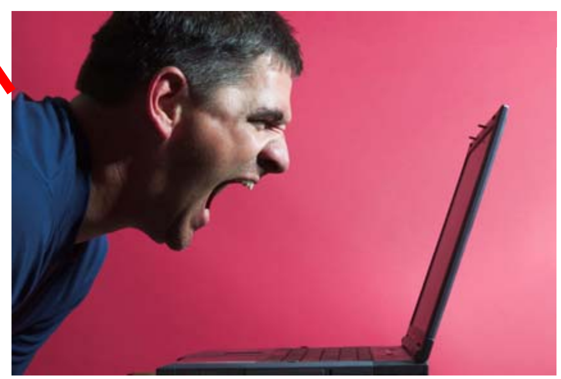
Software Process Dashboards

SVN maintains source code revision

CTest/CMake compiles and test the newly commited source code on distributed clients



Typical developer checks in code



Developer reviews the results

Dashboards

- Client/Server architecture
- Cross platform testing
- Memory testing (purify, valgrind)
- Coverage testing
- Create documentation on a nightly basis (Doxygen)
- Check coding conventions (Rule Checker)

If it's not tested it's not working

Detector geometry in FairRoot

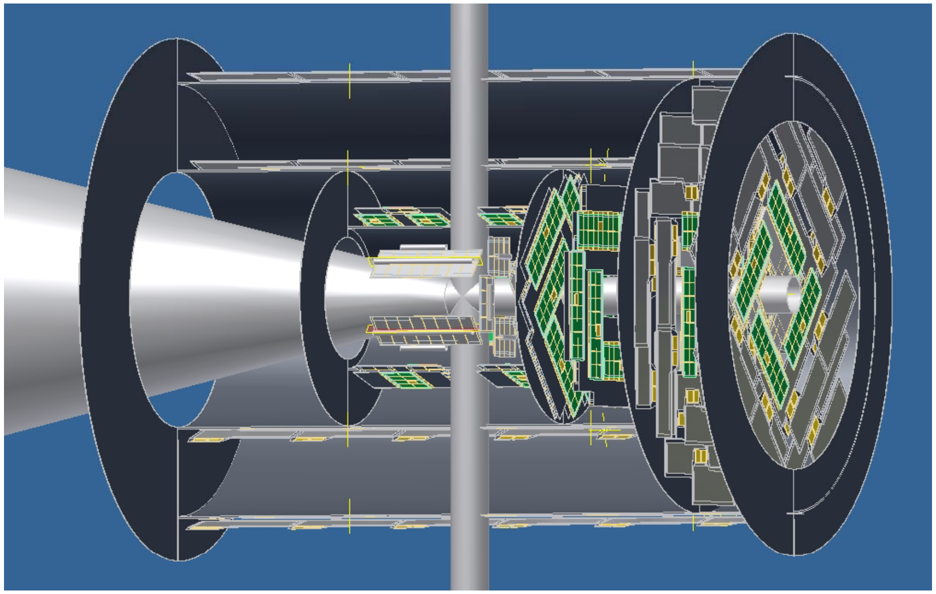
- Hades Geometry interface
  - Advantage:
    - more flexibility : different inputs can be used.
    - closer to technical drawings and analysis coordinate systems
  - Oracle interface
    - Hades geometry table design reusable
- Step converter (Tobias Stockmann)
  - Step To Root
  - Step To Hades ASCII
  - Step To DDL (Not used in FairRoot)
- Defined directly (TGeo) in the detector code
  - (make sense for certain geometries CbmEcal, PandaEMC)

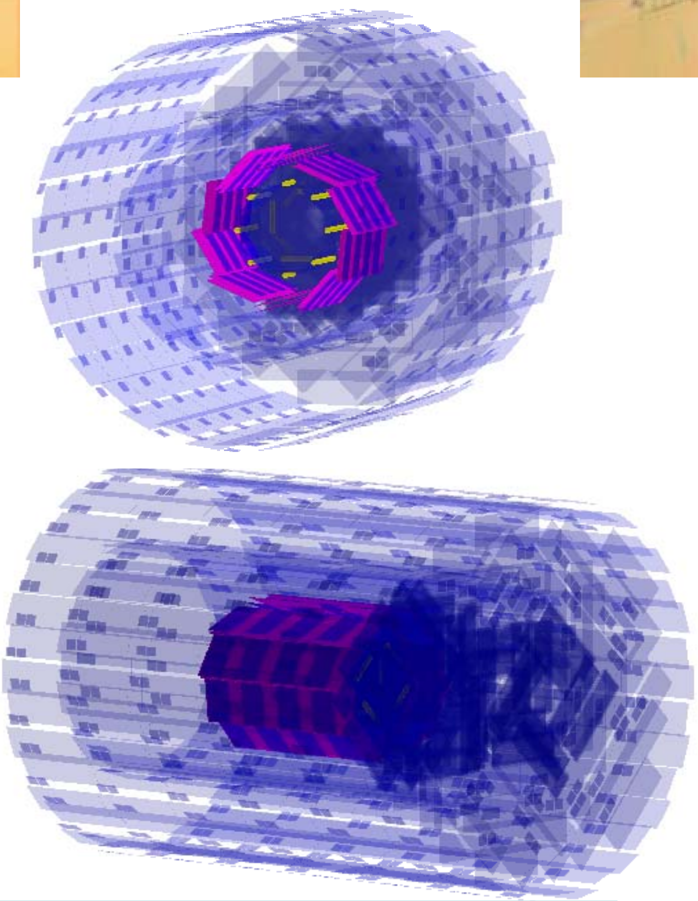
Geometry construction:

Detector can implements:

- ConstructGeometry:
  - One can implement his own reader, or TGeo directly
- ConstructASCIIGeometry
  - To use the Hades geometry format
- ConstructRootGeometry
  - Geometry can be read from a root file containing:
    - TGeoManager or TGeoVolume
    - Special TGeoVolume coming from StepToRoot converter

CAD converter, updates and improvements





Usage of CAD converter tool was already successful for MVD

Tobias Stockmanns

CAD converter, updates and improvements

Solenoid, Barrel Yoke

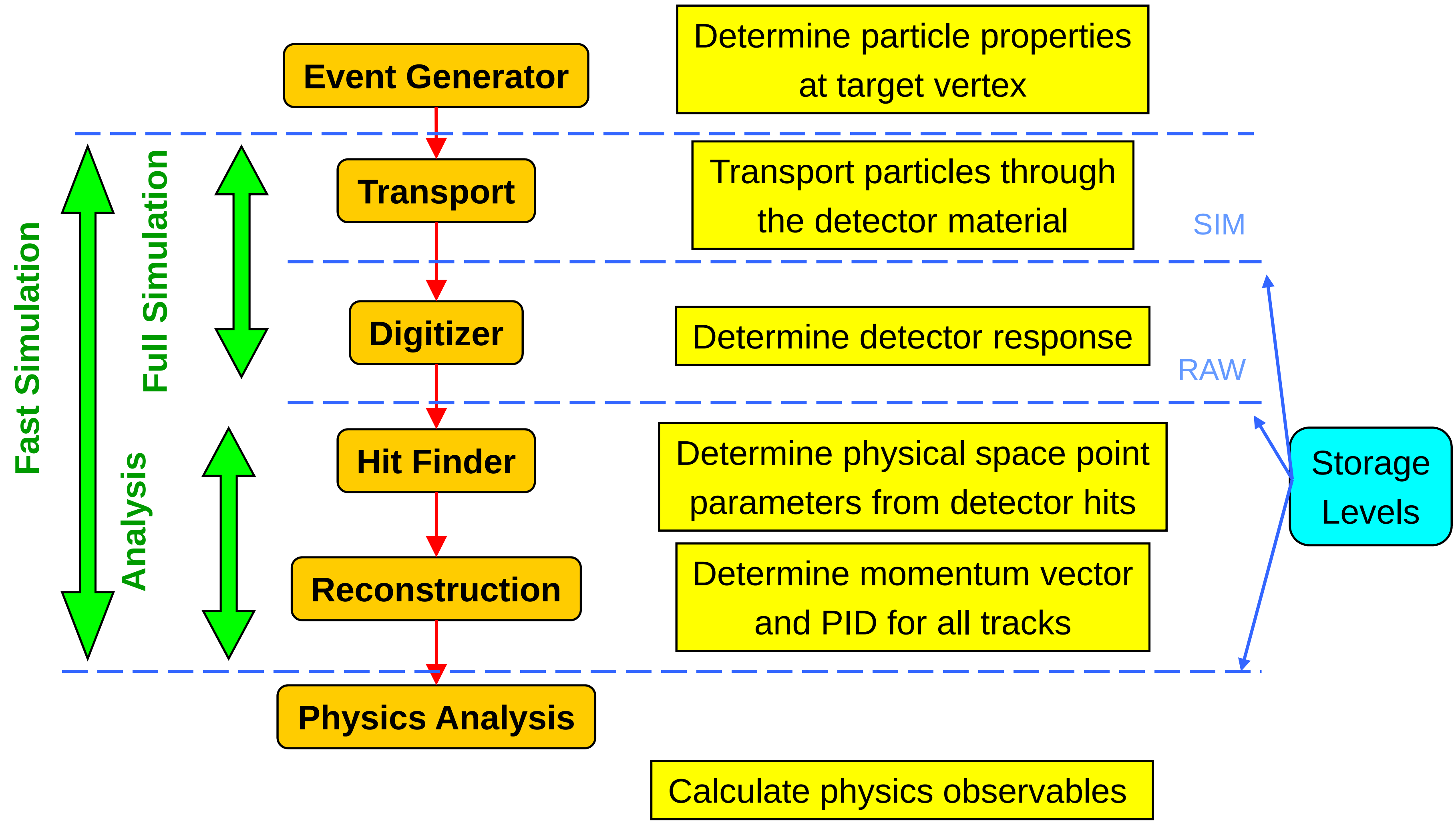
See talk by Tobias Stockmanns

Some geometries are too complex to convert "blindly"

Fast Simulation

- The same application, just different configuration:
  - Event generators just push the event into the stack, no transport is taking place
  - Detector response is presented as TTask
  - The output has the same form as full simulation

Simulation-Reconstruction Chain



PANDA: Fast Simulations

Full Simulation	Fast Simulation

Event Generation

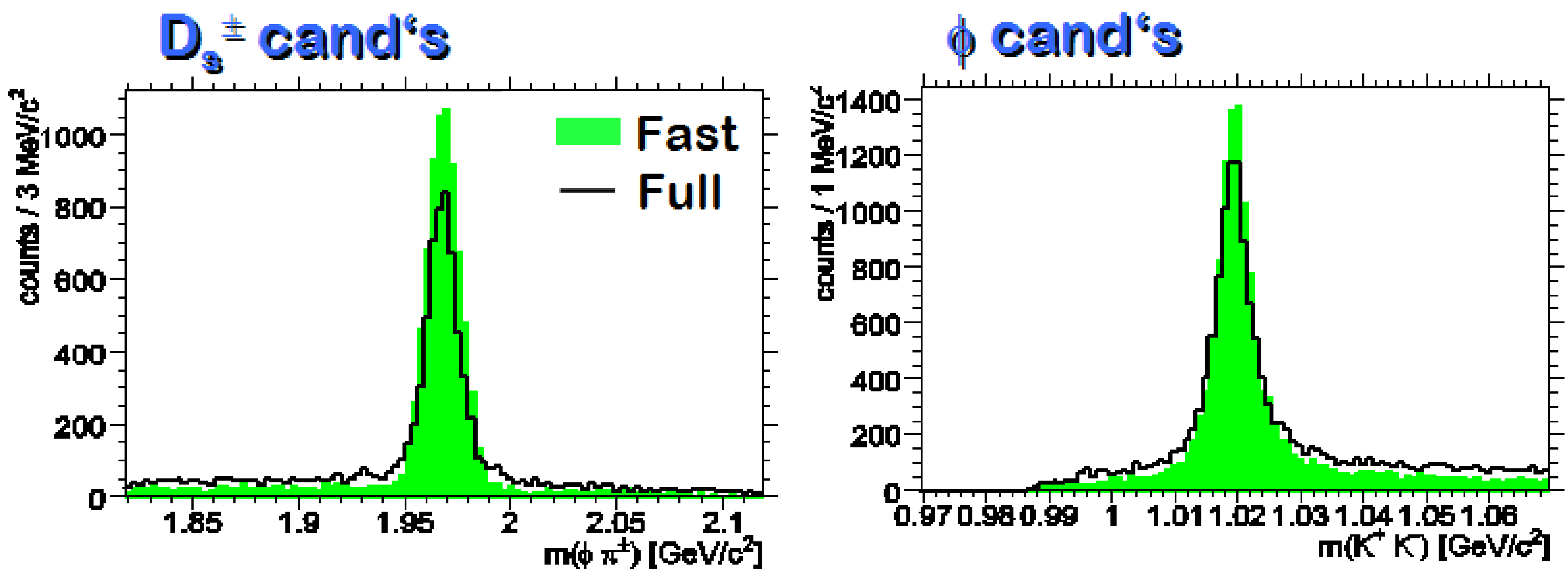
Particle Transport Digitization Calibration Reconstruction	Effective parametrization - acceptance cuts - resolution smearing - PID info

Physics Analysis

Klaus Goetzen

Compared to Full Sim

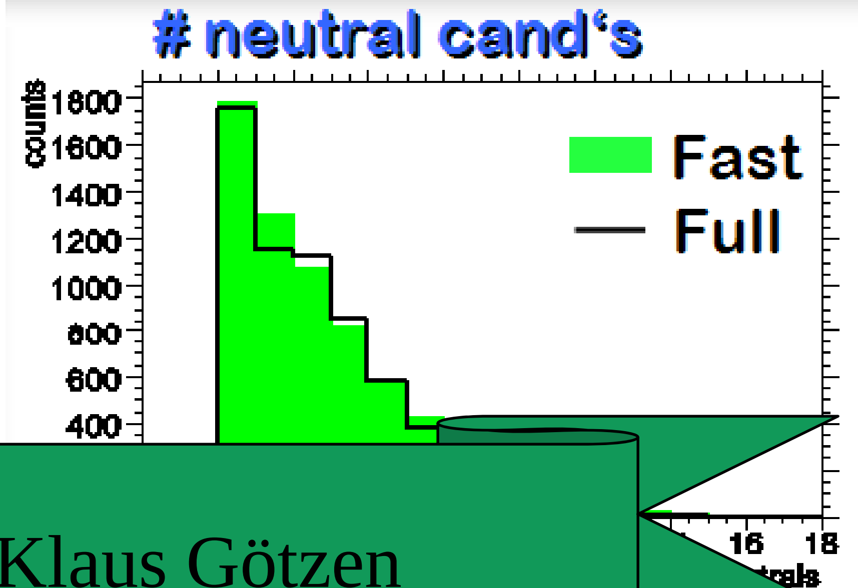
Comparison to Full Sim are reasonable
(channel: $\bar{p}p \rightarrow D_s D_{s0}$)

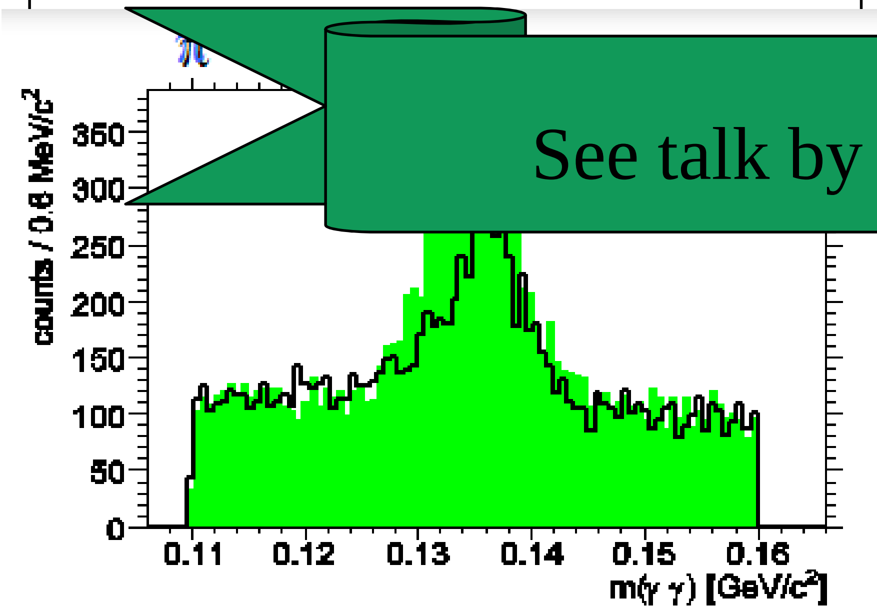


(10 k Signal events; absolute numbers)

Split offs – Compared to Full Sim

Overall multiplicity per $p\bar{p}$ candidate are quite reasonable (channel: $p\bar{p} \rightarrow D_s D_{s0}$)





See talk by Klaus Götzen

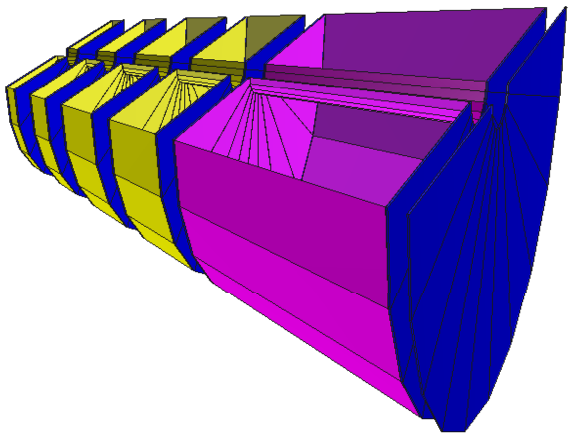
π^0 mass shape and background also looks quite ok

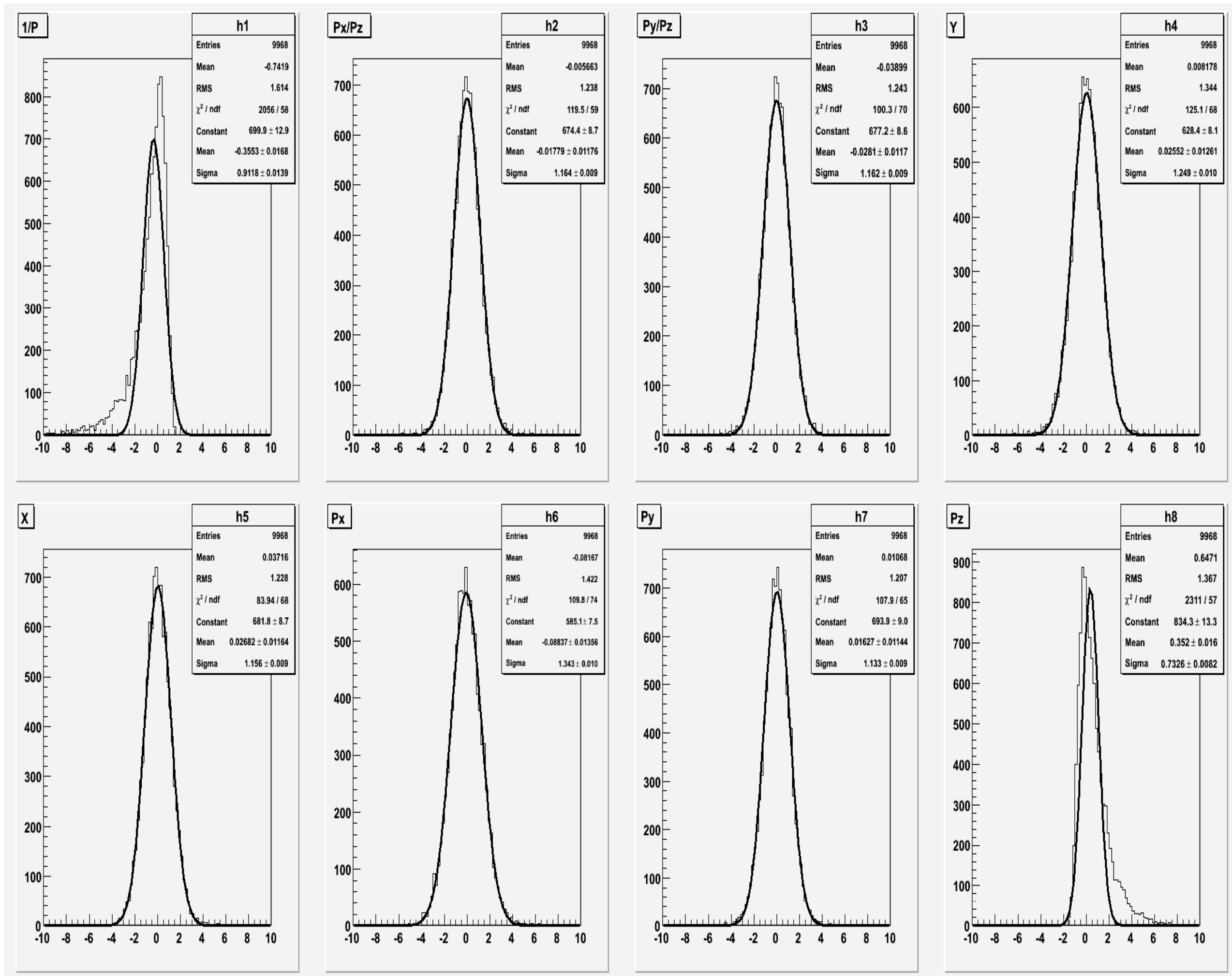
Geane Integration in FairRoot

- The integration into the VMC (TGeant3) is done
- In FairRoot:
  - Geane can be used in the analysis or from macro
  - Propagation to
    - Length
    - Plane
    - Volume (Enter or Exit point)
    - To Line
    - To Point
    - Point of closest approach on a wire

New Methods introduced by Pavia group in PANDA

Muon Absorber in CBM

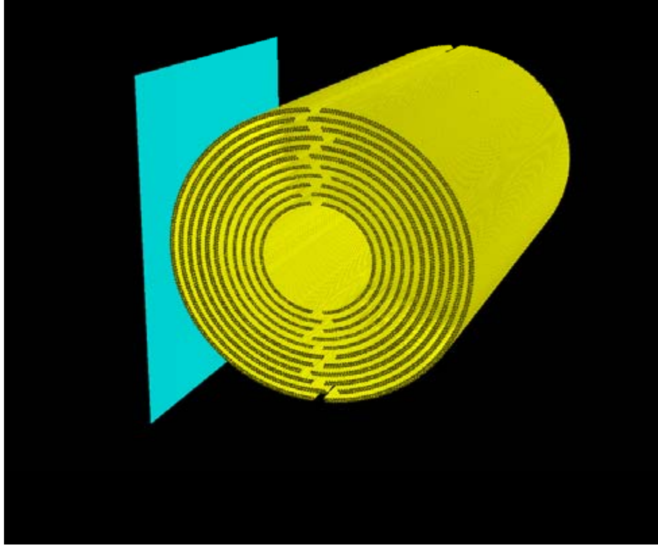


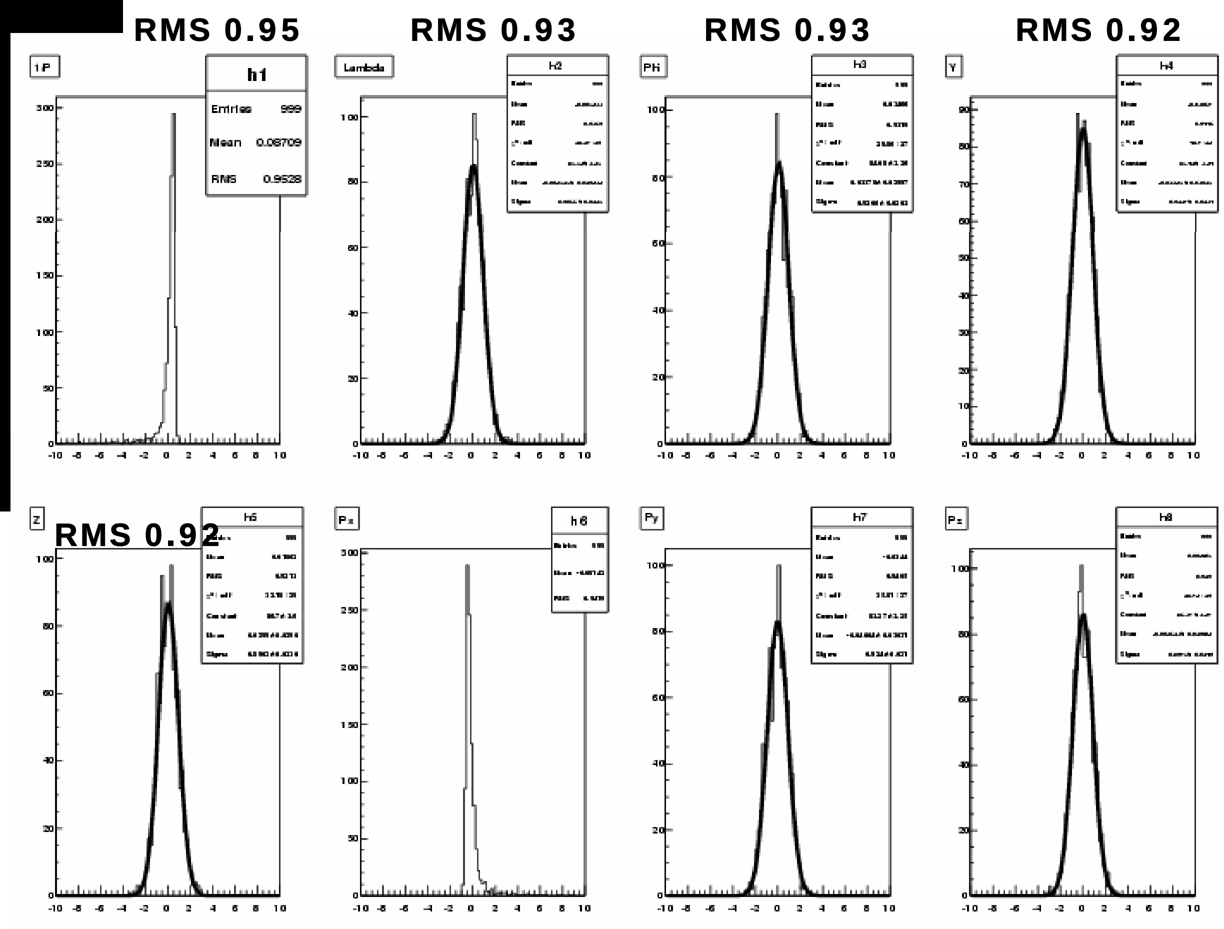


Pulls for the Panda STT

We have defined a plane to which we extrapolate the track parameters.

500 MeV/c

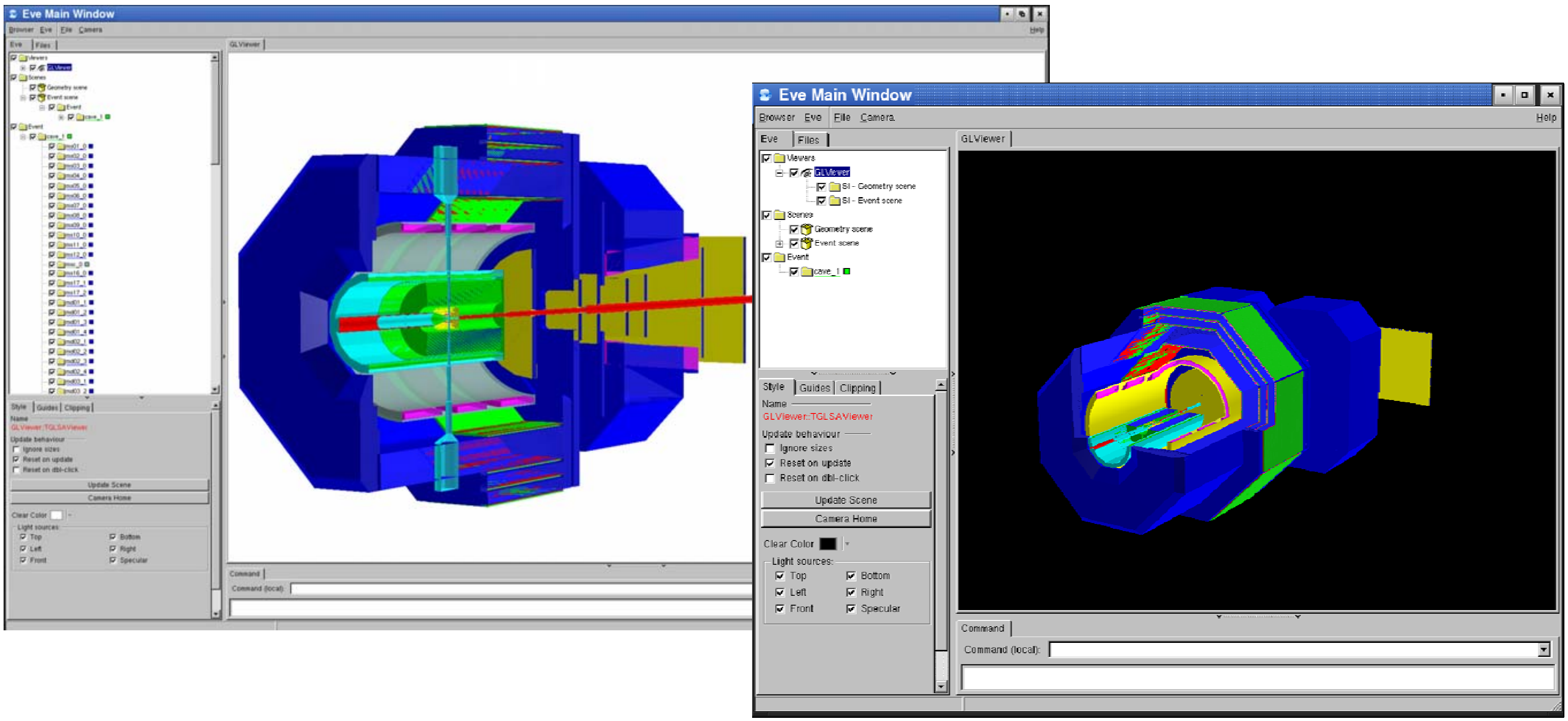




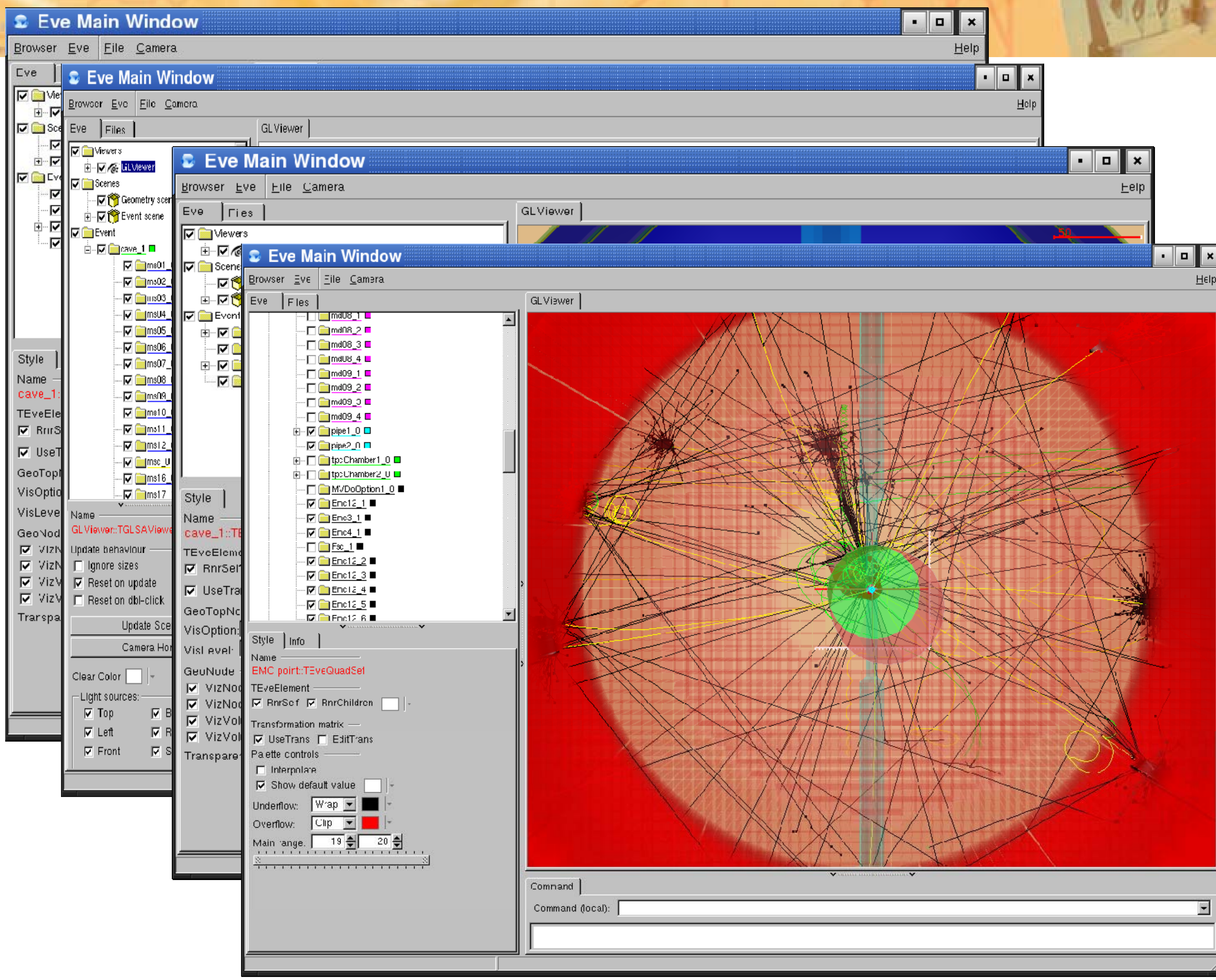
Kapton	1.42	g/cm3
Isobutan	2.7e-3	g/cm3

Eve in FairRoot

- Integration is straight forward (already done)
- Some features can be used directly (even from macro)



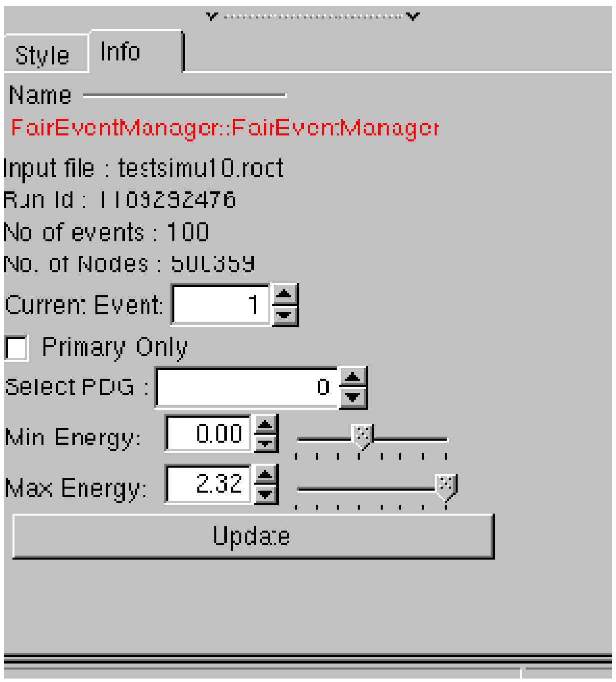
Examples: Panda Detector

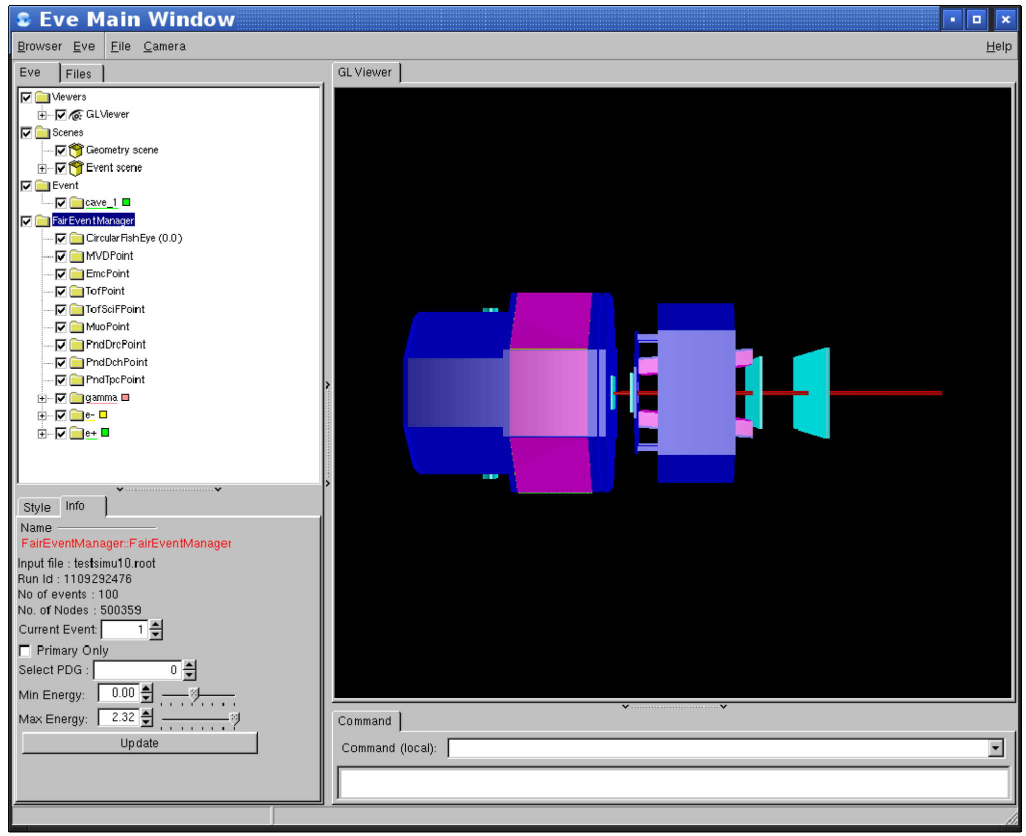


FairEventManager

- FairEventManager: (Sub-class of TEveEventManager)
  - Read Events directly from FairRoot Tree
  - Select Events for Display
  - Apply cuts to whole event
  - Navigation (Next Event, Previous Event and Event No)
  - Read and display the geometry

FairRootManagerEditor

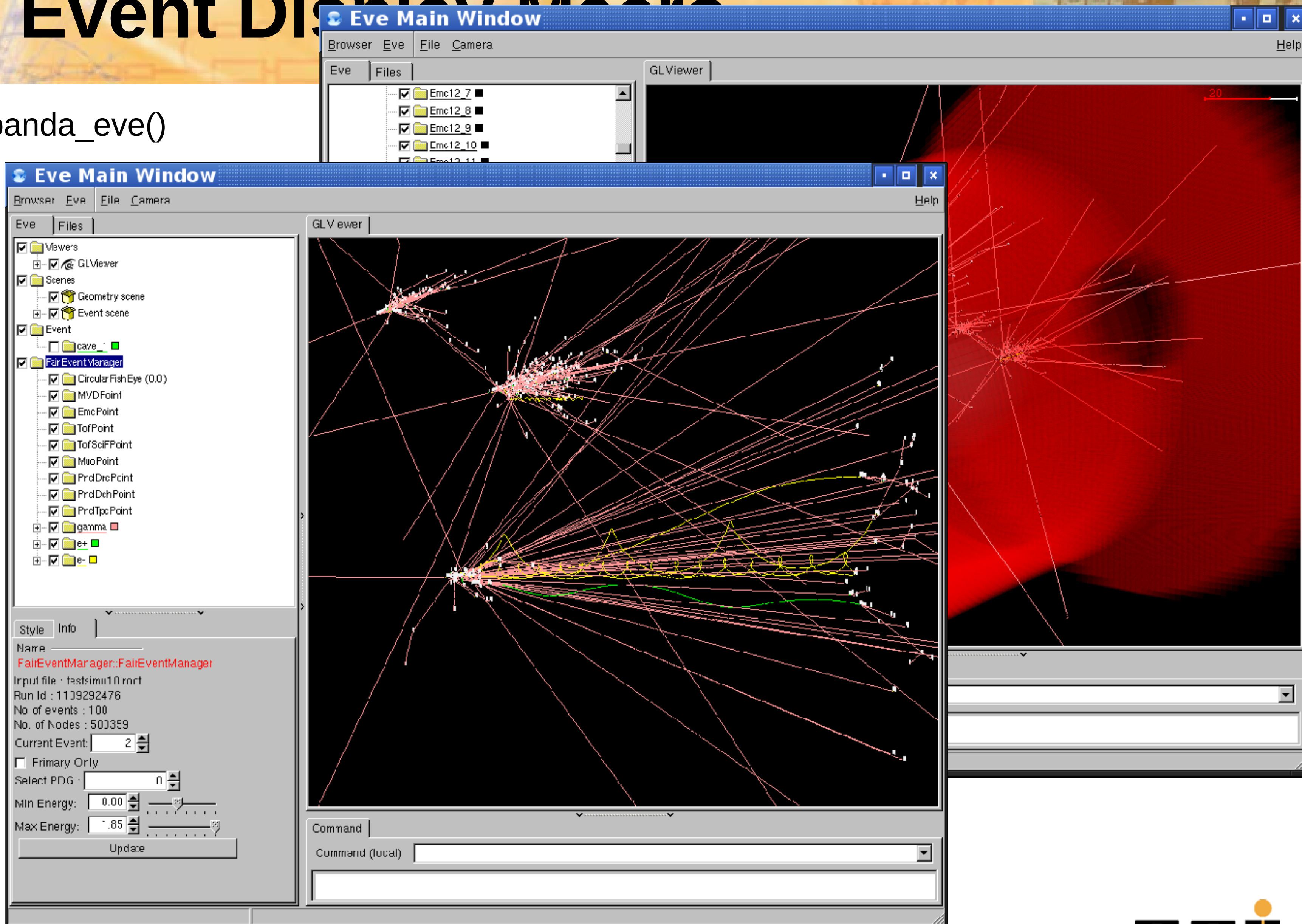




Event Display Macro

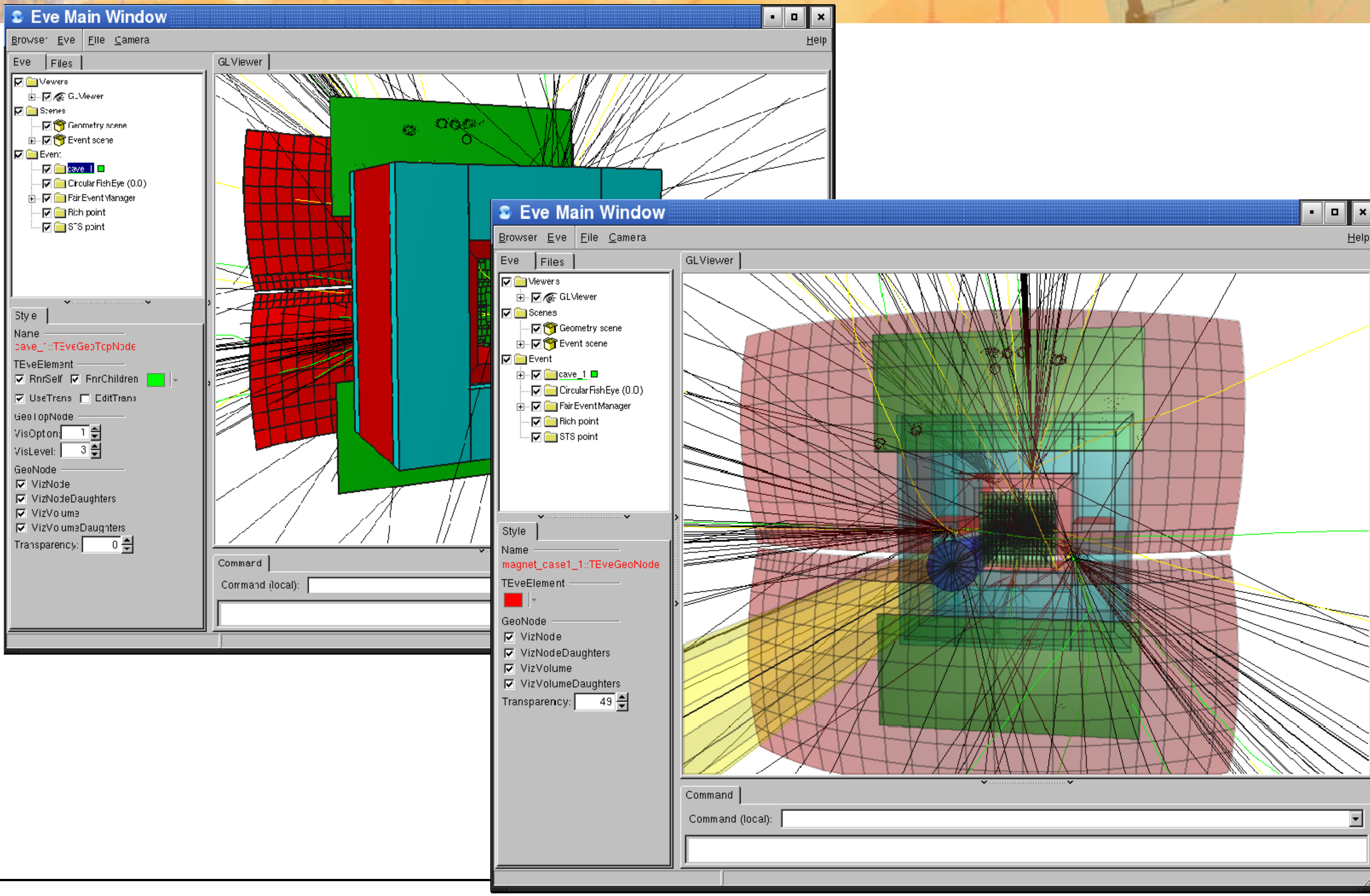
panda_eve()

{

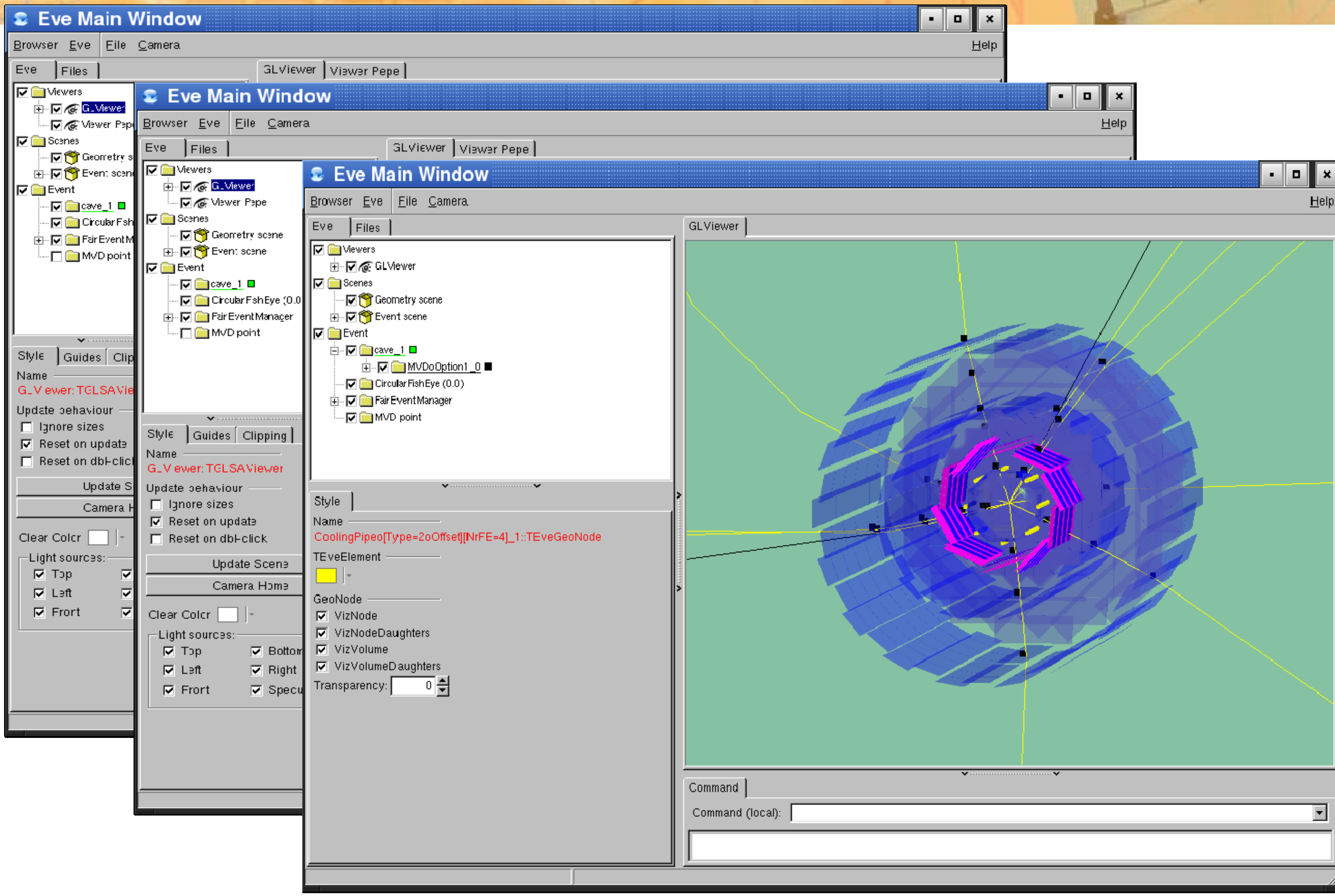


}

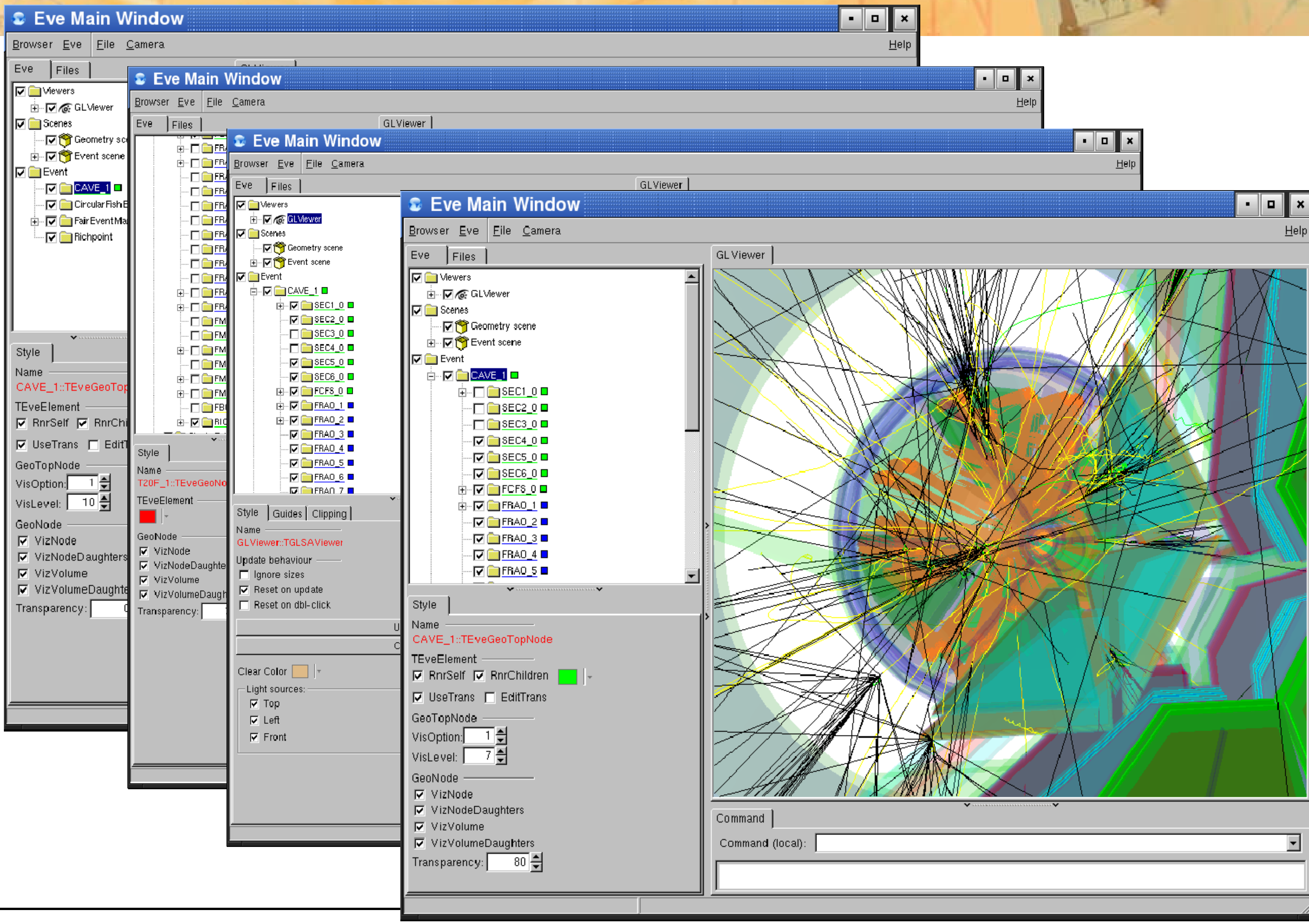
CBM: Points and Tracks



Examples: Panda Detector (MVD)



Examples: HADES Detector



Status Event Diplay

- Any TGeoManager based geometry can be used directly
- Combined with trajectory visualization in FairRoot, it can be used directly from macro to display TGeoTracks (MC Tracks) and all sub-classes of CbmPoint
- A task which should handle CbmHit subclasses is in preparation.
- Digits has to be implemented by detectors

Status Event Diplay: Tracks

- TEveTrack and TEveTrackPropagator:
  - Can be used directly with Track visualization option in FairRoot
- MCTracks and Reconstructed Tracks
  - Need A realistic track propagator
  - Field maps has to be taken into account

Possible solution would be Geane Propagator!!

Availability

- Tested on Linux and Mac OS
- Some documentation: fairroot.gsi.de
- subversion.gsi.de/fairroot/cbmroot
- subversion.gsi.de/fairroot/pandaroot

FairRoot Status!

- CBM:
  - Mainly using Geant3 for simulation
  - We have our own work around to use native FLUKA and put the output in FairRoot format (Dosimetry studies) (See talk by Denis)
  - Comparisons with TFluka are ongoing
- PANDA:
  - Mainly using Geant4 and compare to Geant3
  - Some prototypes for EMC, TPC are build, test beams data is available and will be compared to Geant3, Geant4 and Fluka
- HADES:
  - Mainly used by us to compare to the data and existing native Geant3 simulation (e.g. Cerenkov production etc.)
- NUSTAR:
  - Still evaluating if FairRoot will be suitable for them.

Thanks ...