AliRoot for AFTER

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Physics at A Fixed Target Experiment using the LHC beam Workshop,
Trento, 04-13 February 2013

Outline

- ROOT as foundation
- AliRoot - ALICE software framework
- Virtual Monte Carlo
- Geometry tools
- Event display
- *Not covered*
  - Conditions data, Alignment, Analysis, AliEn (GRID deployment)

The ALICE offline framework

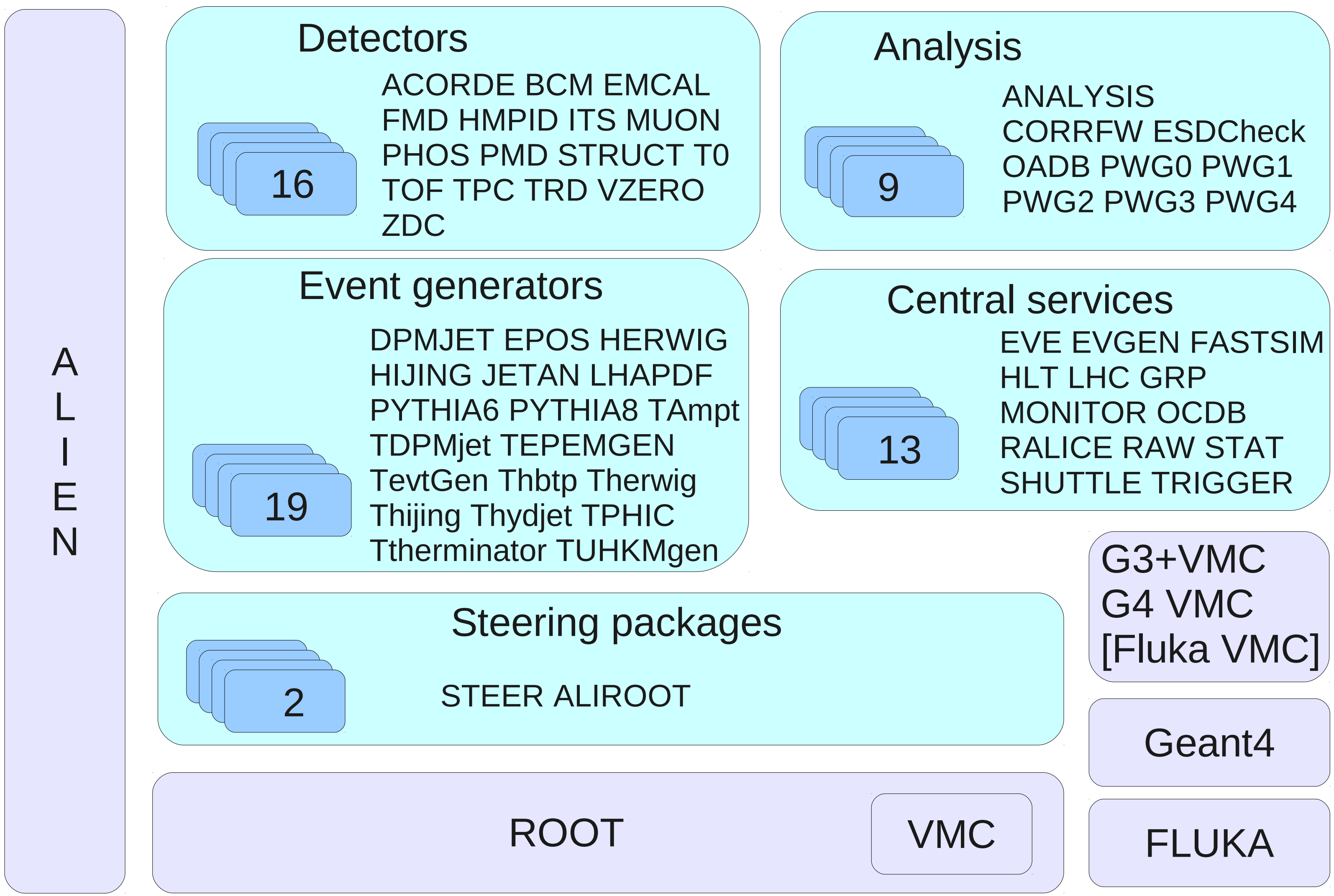
- AliRoot = the ALICE offline framework
  - The framework for simulation, reconstruction and analysis
  - Uses the ROOT system as a foundation
  - Based on the Object Oriented programming paradigm, and is written in C++ - except for large existing libraries, such as Pythia6, HIJING, and some remaining legacy code

ROOT as a Foundation

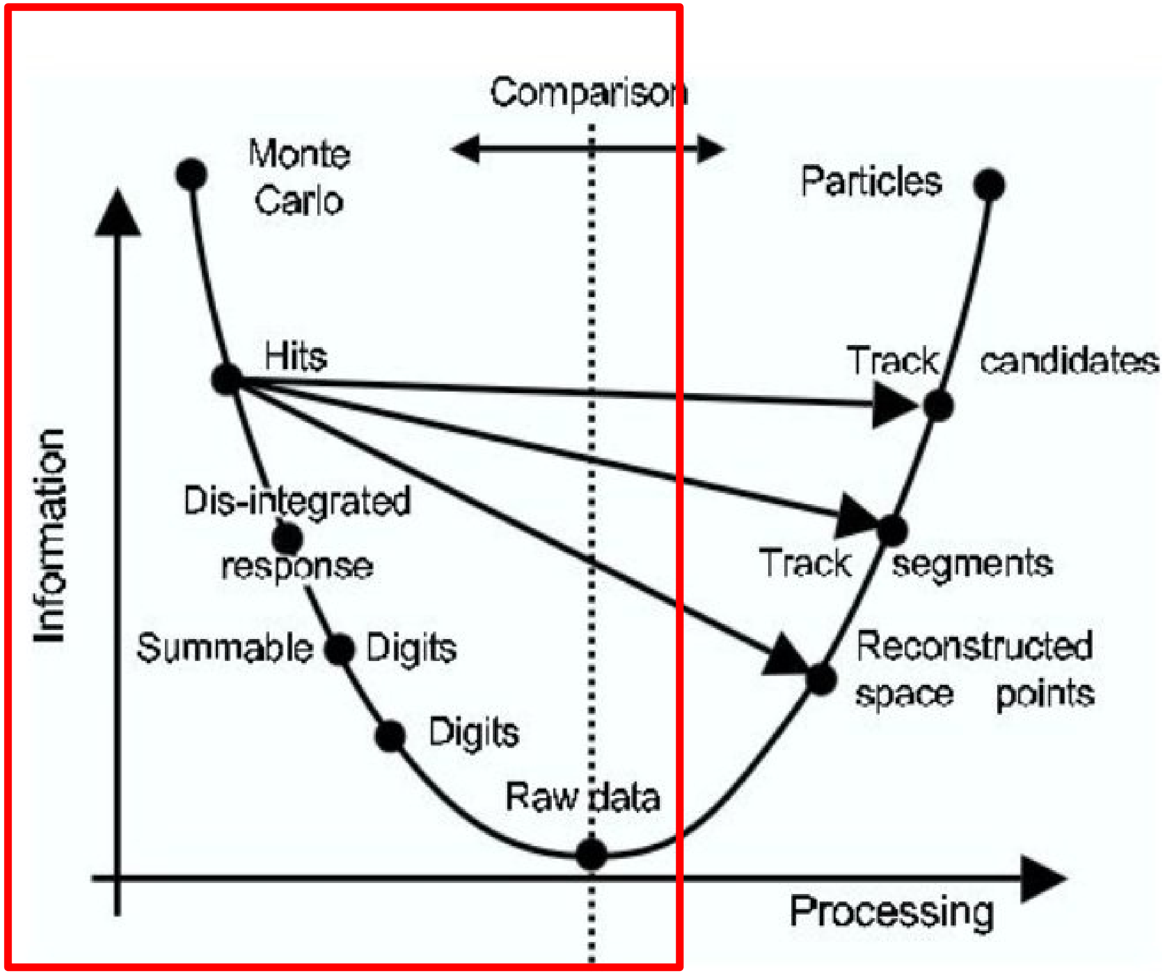
- AliRoot adopts from ROOT
  - ROOT collections
    - STL collections not allowed (though supported in ROOT)
  - ROOT IO
    - Using CINT for generation class dictionaries for IO
  - ROOT packages:
    - TGeo for geometry description
    - VirtualMC as a basis for simulation
    - EVE for event display

The AliRoot Layout

(Presented at LHC Detector Simulations Workshop, CERN, 06-07 October 2011)



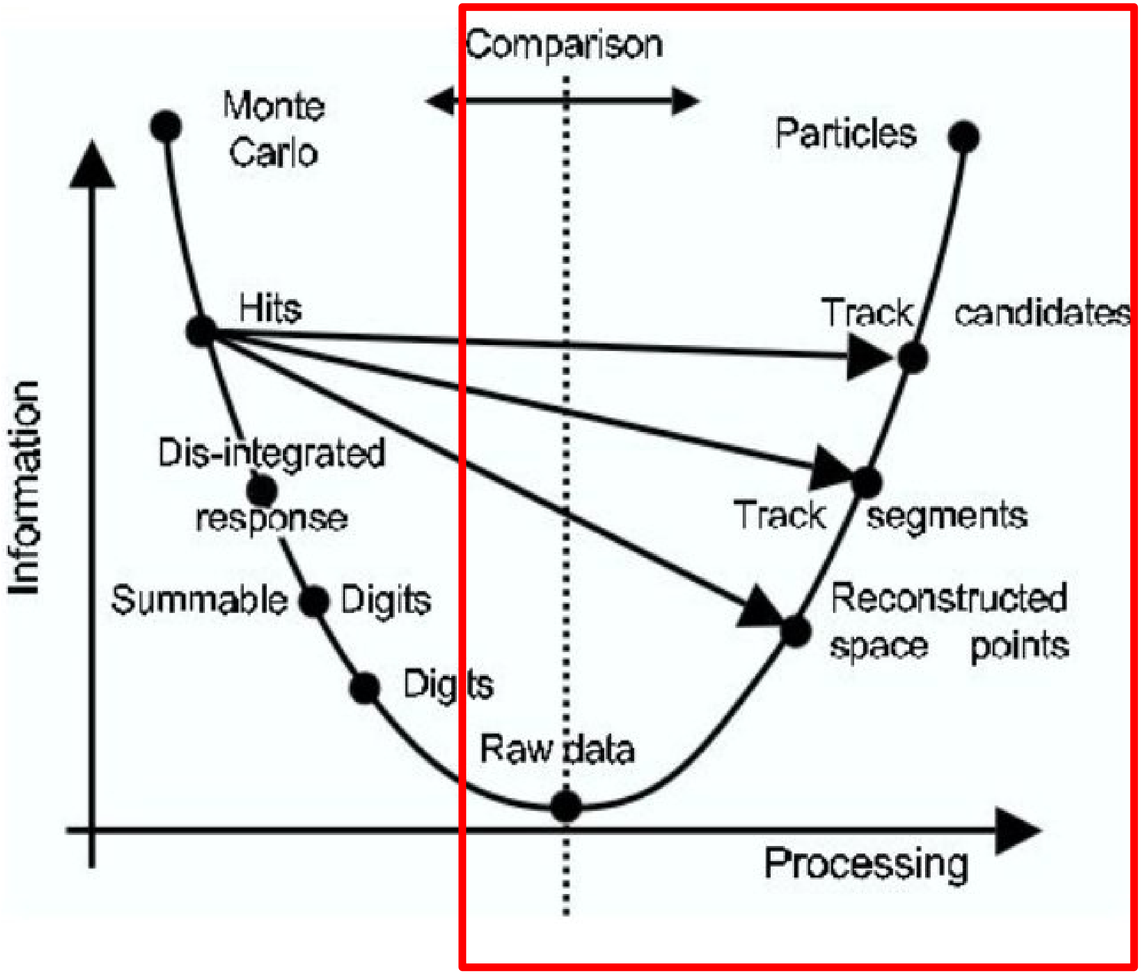
Data Processing



(From The ALICE Offline Bible)

- Simulation
- The primary interactions are simulated via event generators, and the resulting kinematic tree (Monte Carlo truth) is then used in the transport package.
- The transport package transports the particles through the set of detectors and produces Hits.
- Then the detector response is taken into account, and the hits are transformed into digits.
- Optionally, it is possible to perform the conversion from digits to raw data

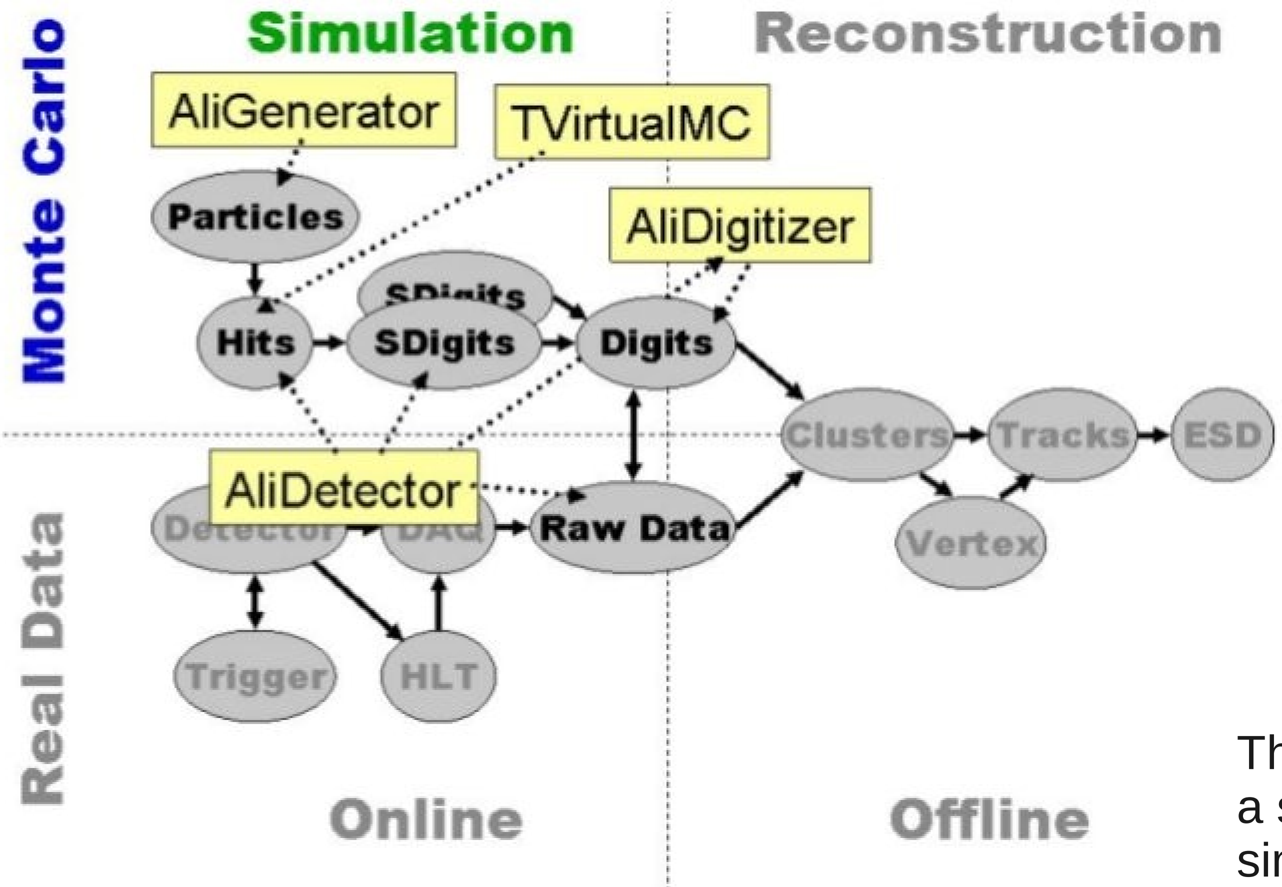
Data Flow (2)



(From The ALICE Offline Bible)

- Reconstruction
- After the creation of digits, the reconstruction and analysis chains can be activated to evaluate the software and the detector performance, and to study some particular signatures.
- The reconstruction takes as input digits or raw data, real or simulated.

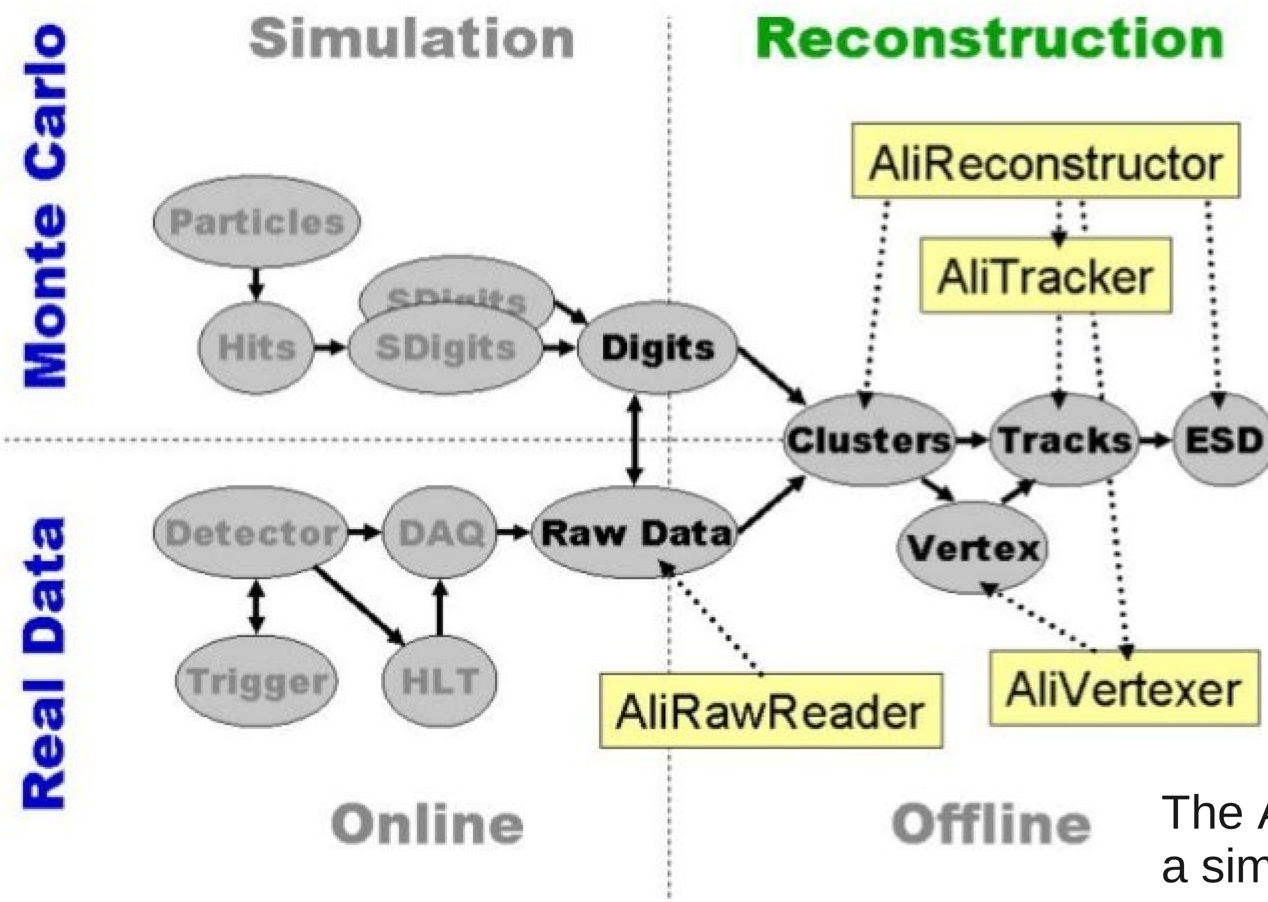
The ALICE Simulation Framework



The AliRoot classes provide a simple user interface to the simulation framework

(From The ALICE Offline Bible)

The ALICE Reconstruction Framework



The AliRoot classes provide a simple user interface to the reconstruction framework

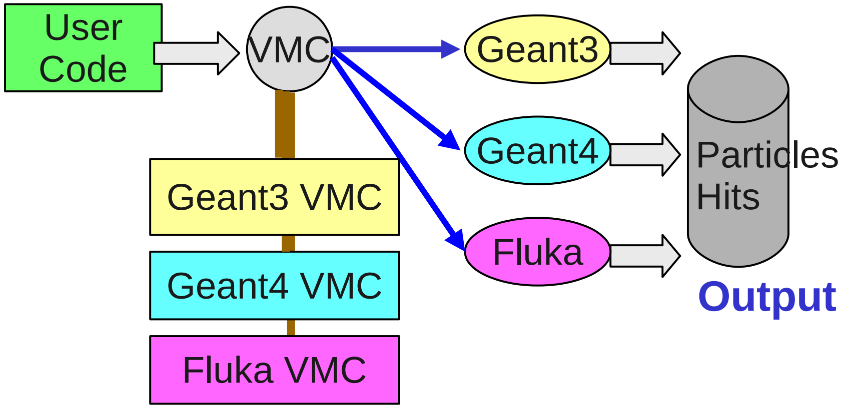
(From The ALICE Offline Bible)

Data Representation

- Particles (the Monte Carlo truth) are represented via ROOT TParticle class
- Hits, Digits, SDigits, Clusters, Vertexes, Tracks – usually defined in detector specific classes derived from ROOT TObject
  - Often also as a specification of the ALICE generic base classes (AliHit, AliDigit)
- The collections of data objects are then saved in ROOT file(s) using TTree technology
- Raw data can be saved either in binary format (*.raw) or in ROOT format

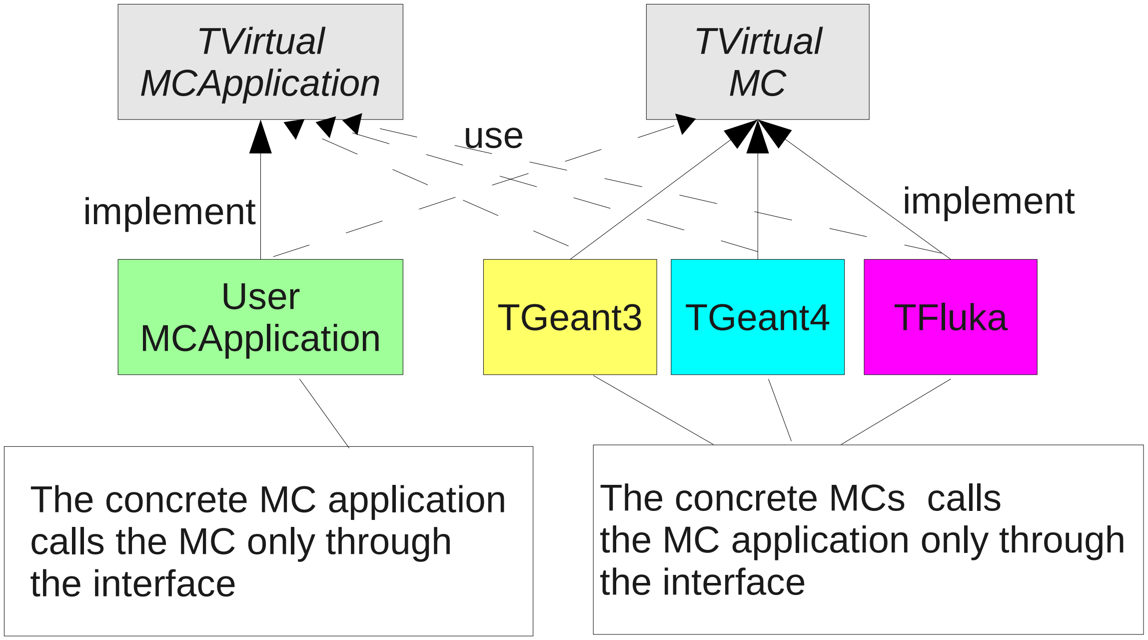
Virtual Monte Carlo

- ALICE has developed in the close collaboration with the ROOT team the Virtual Monte Carlo interface:
  - First, it allowed a smooth transition from GEANT3 based FORTRAN code to C++ and then it made possible to run the same code with three transport codes: GEANT3, Geant4 and FLUKA
- The VMC is distributed with ROOT since 2002 and now it is used in more experimental frameworks
  - http://root.cern.ch/drupal/content/vmc



The VMC Design

- In VMC, we introduce the abstract interface both for the MC simulation program and for the user application
- In this way we decouple the dependence between the user code and the concrete MC



Available VMCs

- Geant3 VMC (C++) is provided within a single package together with GEANT3 (Fortran) – geant3
  - It includes both Geant3 source code with modifications for VMC and TGeant3 directory with classes implementing VMC interface
  - ALICE is using this Monte Carlo in production
- Geant4 VMC implements:
  - It implements TVirtualMC interface (via calls to the Geant4 objects) and Geant4 user classes (via calls to the VMC application interface
  - ALICE performed several test production (on the GRID) with Geant4 in 2011, 2012 for the validation of the interface
- Geant3 and Geant4 VMC are distributed via the ROOT site
  - http://root.cern.ch/drupal/content/geant4-vmc
- The implementation for FLUKA, FLUKA VMC, has been discontinued by the FLUKA team in 2010,
  - Only ALICE has a permission to use it for its studies

VMC for AFTER?

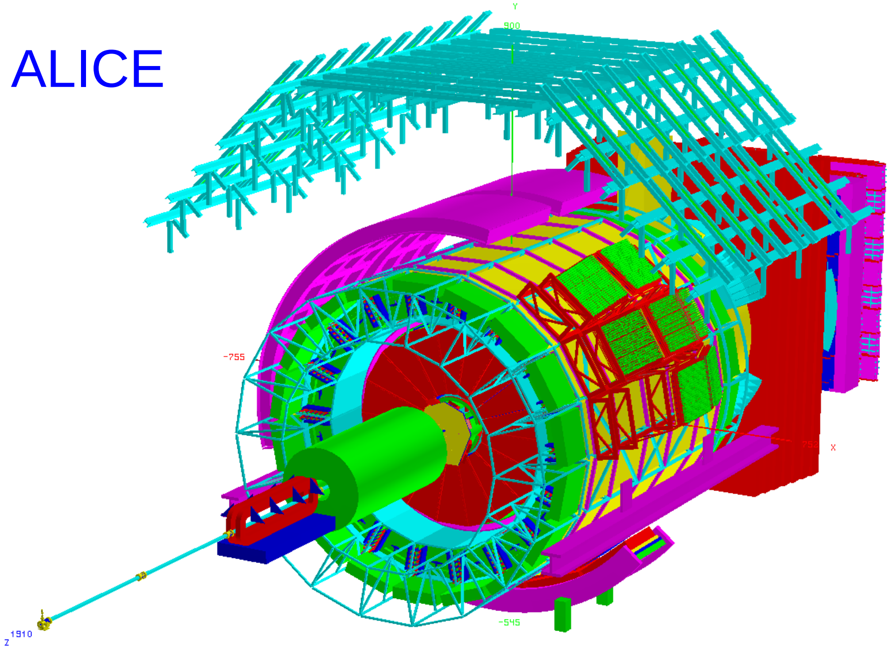
- The + of VMC:
  - Simulation with 2 different Monte Carlos
  - VMC application fully in the ROOT framework
  - Simple configuration with macros
- The – of VMC:
  - Disconnecting FLUKA makes VMC less interesting
  - The VMC layer brings a performance penalty in Geant4 simulation
    - 15% for an evaluated simple application

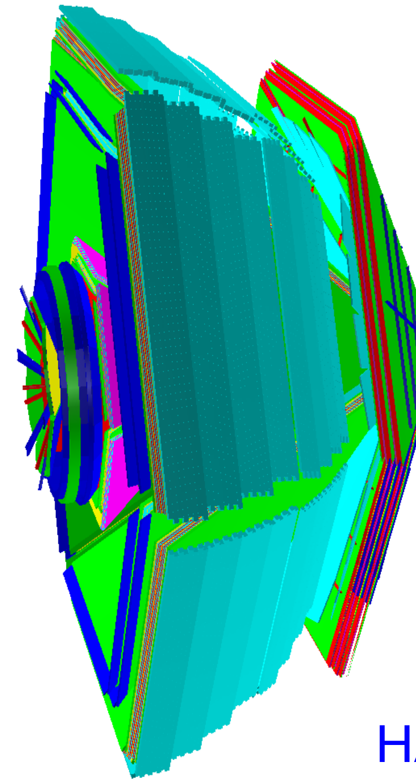
Geometry in ALICE: TGeo

From Andrei Gheata (for LHC Detector Simulations Workshop, CERN, 06-07 October 2011)

- ALICE geometry is defined via TGeo, the geometry toolkit inside ROOT
  - TGeo was developed following closely the needs of ALICE
  - Besides simulation, it is used also in reconstruction and event display
  - Performance was a design goal
  - It is used also by other experiments: PANDA, CBM, OPERA, STAR, ...
- It provides the full geometry description of the ALICE detector and:
  - Navigation functionality used in simulation.
  - Ability to store and directly use misalignment within the geometry itself
  - Built-in checking tools, geometry builder, visualization

ALICE

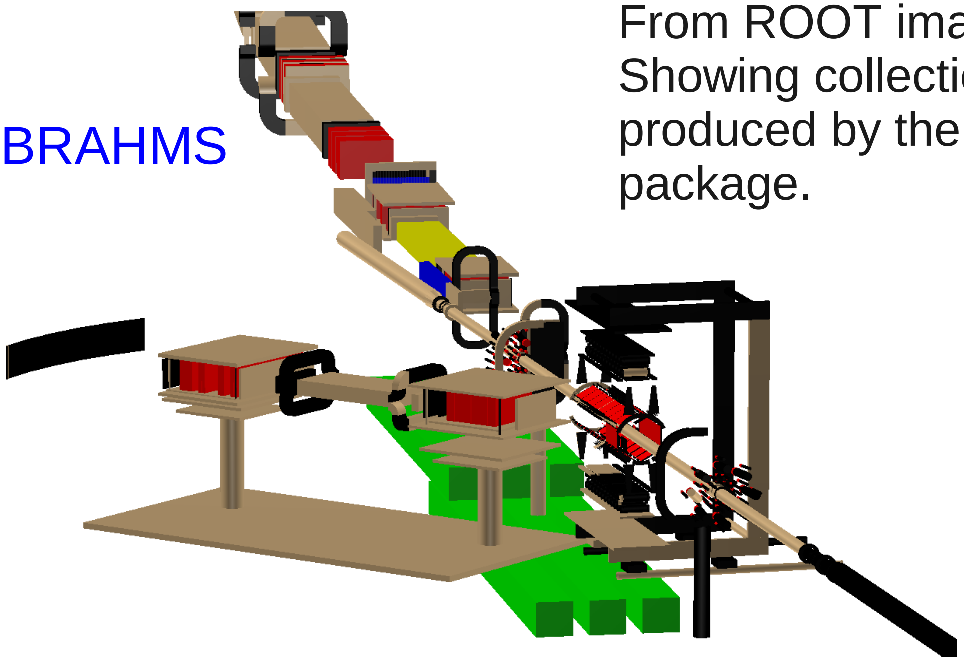


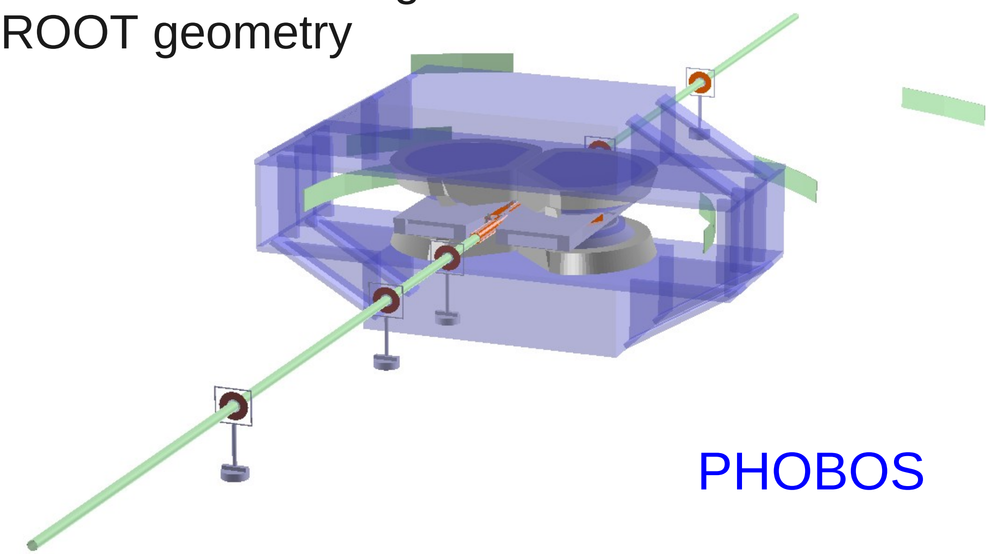


HADES

From ROOT image galleries:
Showing collection of detectors images produced by the ROOT geometry package.

BRAHMS

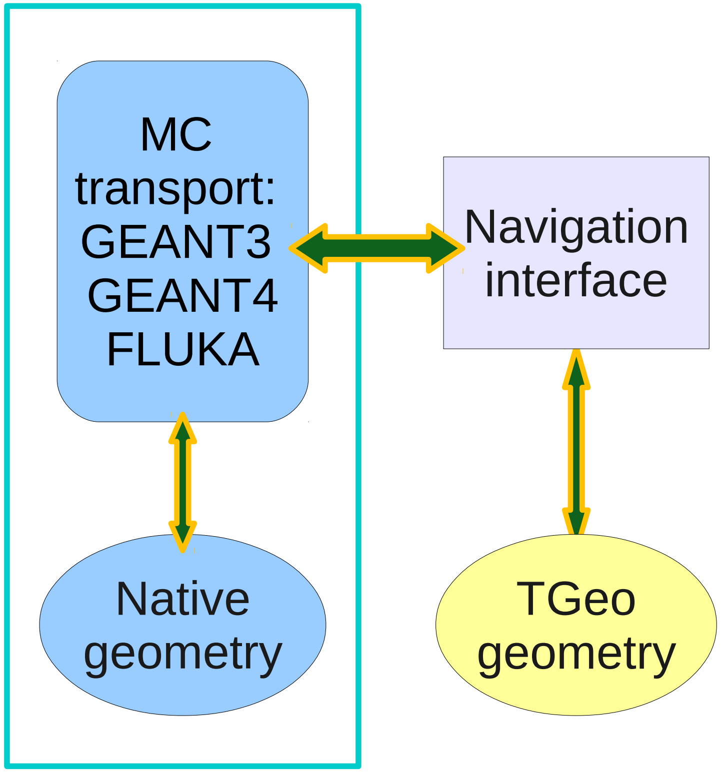




PHOBOS

Navigation Interfaces

- Particle transport MC's are using their own geometry
  - Transportation procedures are using own geometry navigation as ingredient
- The navigation interfaces had to be implemented to allow navigation using TGeo geometry modeller
  - Not only to test the principle, but actually to make the ROOT geometry work for simulation purposes
  - Several tests done in the development process to compare with results of native geometries (produced via conversion)



Navigation Interfaces (2)

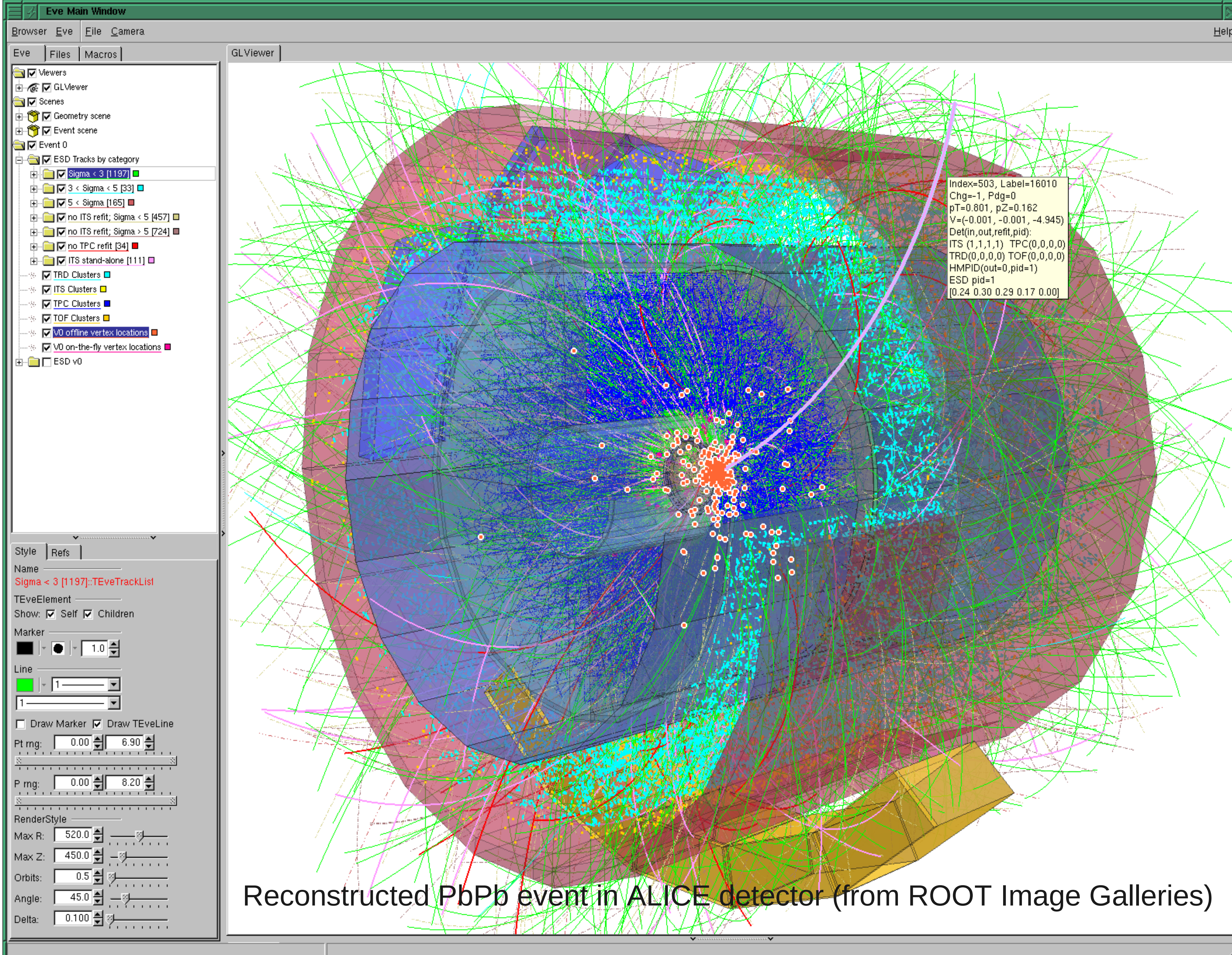
- G4Root = the Root geometry navigation interface for Geant4
  - Besides its use in the VMC context, it can be also used in a standalone Geant4 application using TGeo as geometry
  - A test case based on Geant4 novice example N06 demonstrates using the native TGeo features in GEANT4 simulations
  - Initially in ROOT, it is now part of Geant4 VMC
    - http://root.cern.ch/drupal/content/g4root
- The navigation interfaces for Geant3 and FLUKA are integrated in Geant3 VMC and FLUKA VMC

Virtual Geometry Model (VGM)

- Integrated in Geant4 VMC as an optional package
  - Performs a conversion from Root geometry in Geant4 geometry and so allows to run Geant4 simulation with Geant4 native navigation
- Provides conversion between Root and Geant4 geometry, as well as an export in XML (GDML)
  - Conversion does not support all geometry features (“exotic solids”, overlapping volumes), but its coverage is quite large
- Available from:
  - http://ivana.home.cern.ch/ivana/VGM.html
- Not in use in ALICE, but used in FAIR and other experiments frameworks
- VGM for AFTER?
  - Can be used for Geant4 -> ROOT geometry conversion

Event Display

- ROOT EVE package – base for ALICE event display
- Supports elements suitable for visualization of both tracker and calorimeter detectors
  - 3D view, 2D projections, fish-eye transformations, detector pre-scaling, lego view 2D & 3D
  - Supported elements: geometry, tracks, lines, points
- Use of ROOT components:
  - GL – interface to OpenGL; GUI – OS independent widget library; TGeo – interface to geometry and alignment data
- ALICE specific software in AliRoot EVE package



Reconstructed PbPb event in ALICE detector (from ROOT Image Galleries)

Conclusions

- AliRoot is a mature offline framework
- Strong coupling to ROOT brought the advantage of the availability of ROOT tools:
  - IO, Geometry, Virtual Monte Carlo, Visualization
- Fully operational software for LHC data taking
- The framework has its followers in other experiments, eg. the experiments for the FAIR facility at GSI