Simulation and Data Analysis Software for Nuclear Physics Experiments

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DE COMPOSTELA

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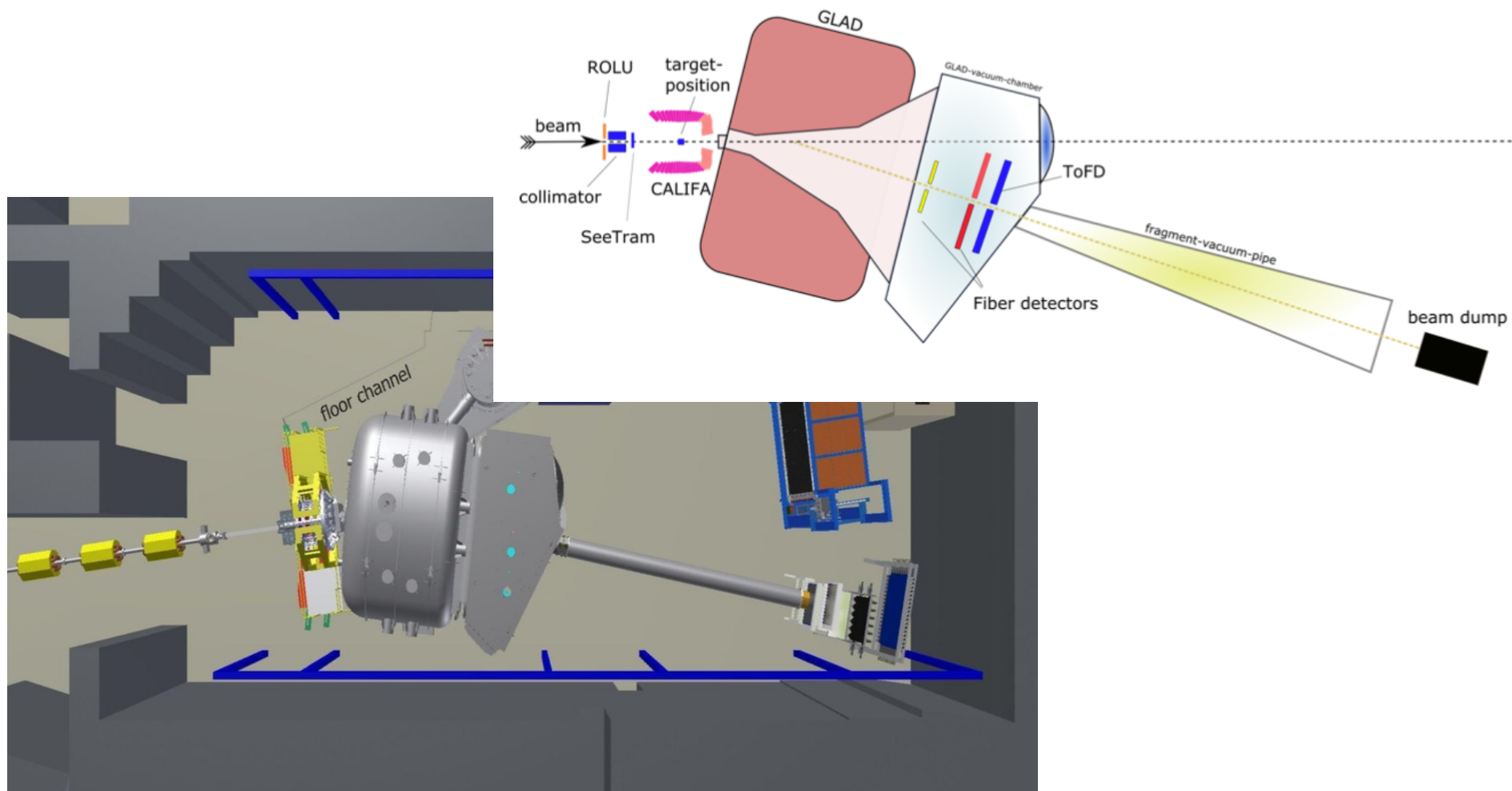
Contents: solutions for Sim&Ana in flexible setups

- Nuclear Physics experiments… Why are they a particular case?
- The VMC model and the **FAIRRoot** framework.
- Derived frameworks for specific problems:
  - **R3BRoot** for the R3B collaboration.
  - **ENSARRoot** for the ENSAR/ENSAR2 european programs.
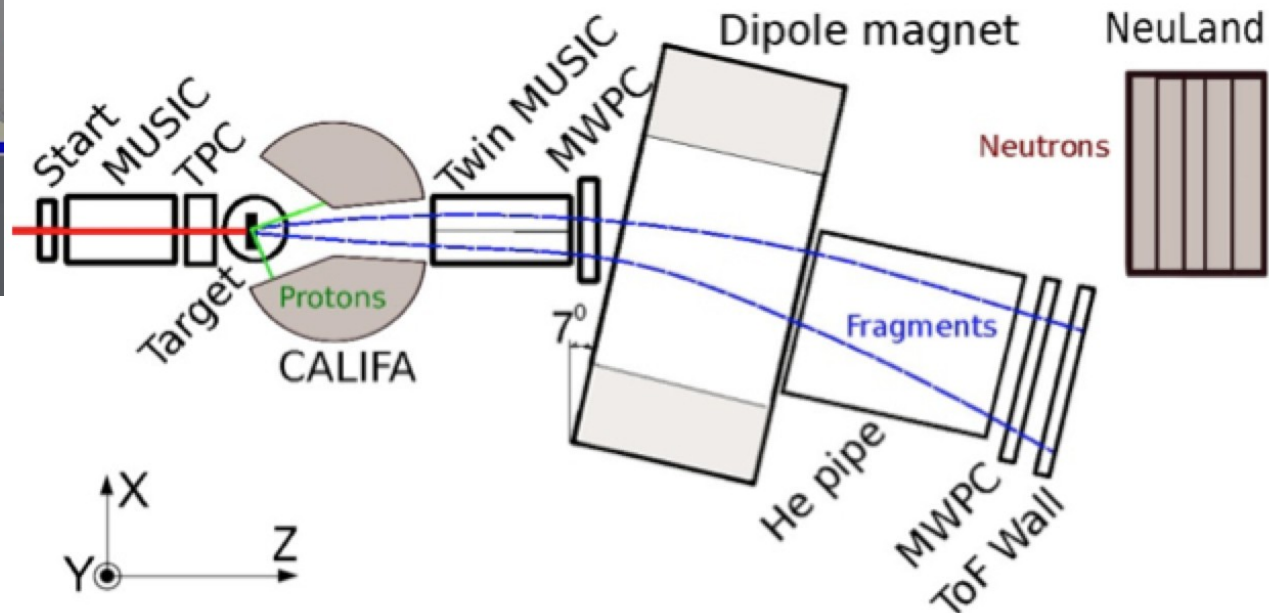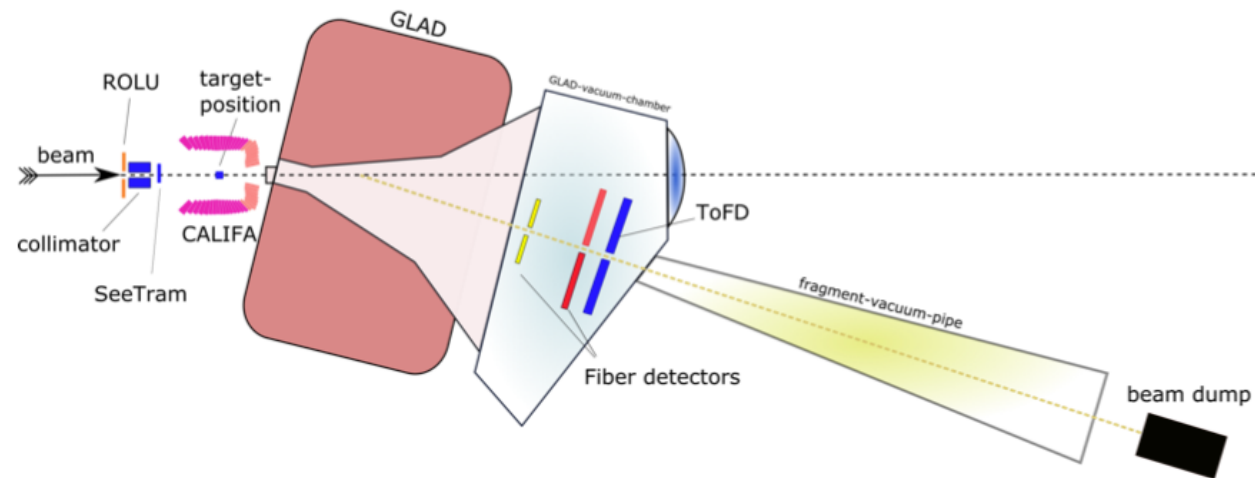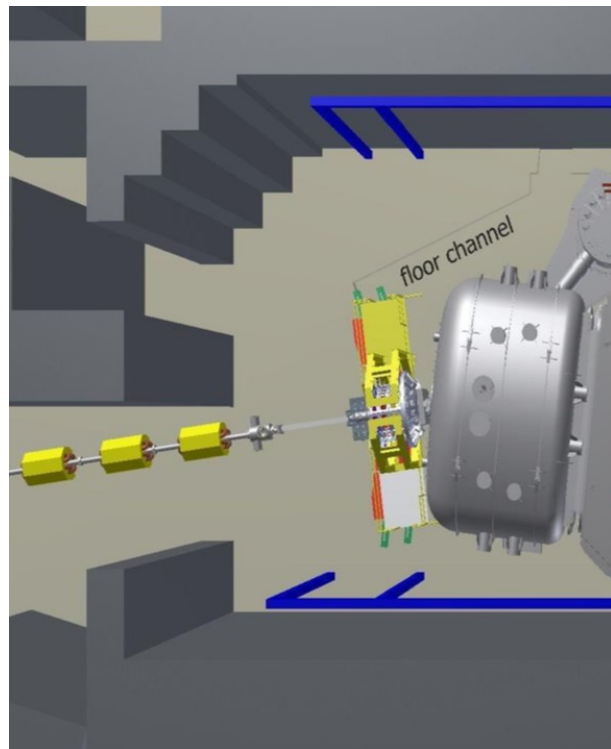
Solutions for Sim&Ana in flexible setups

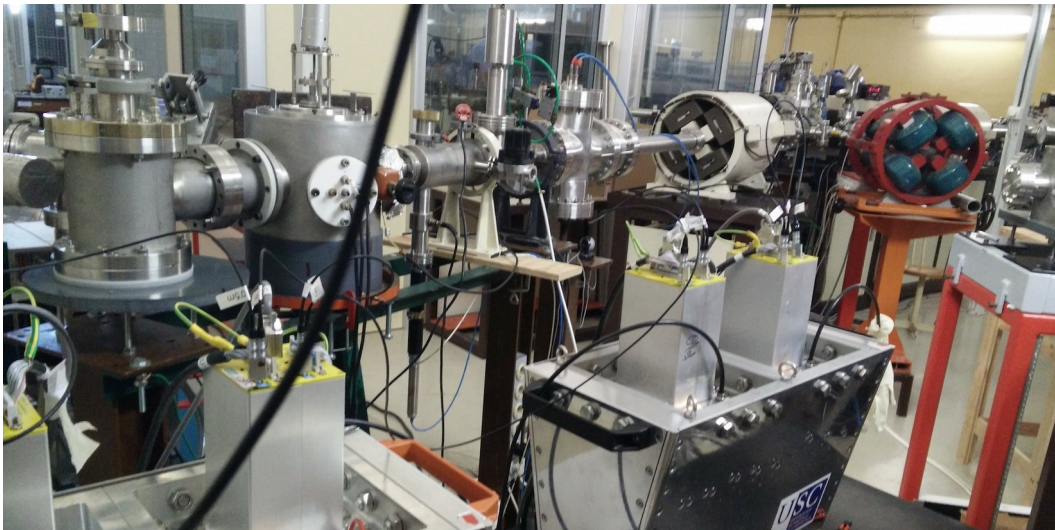R3B: a versatile setup for the study of reactions with radioactive, relativistic beams in inverse kinematics.
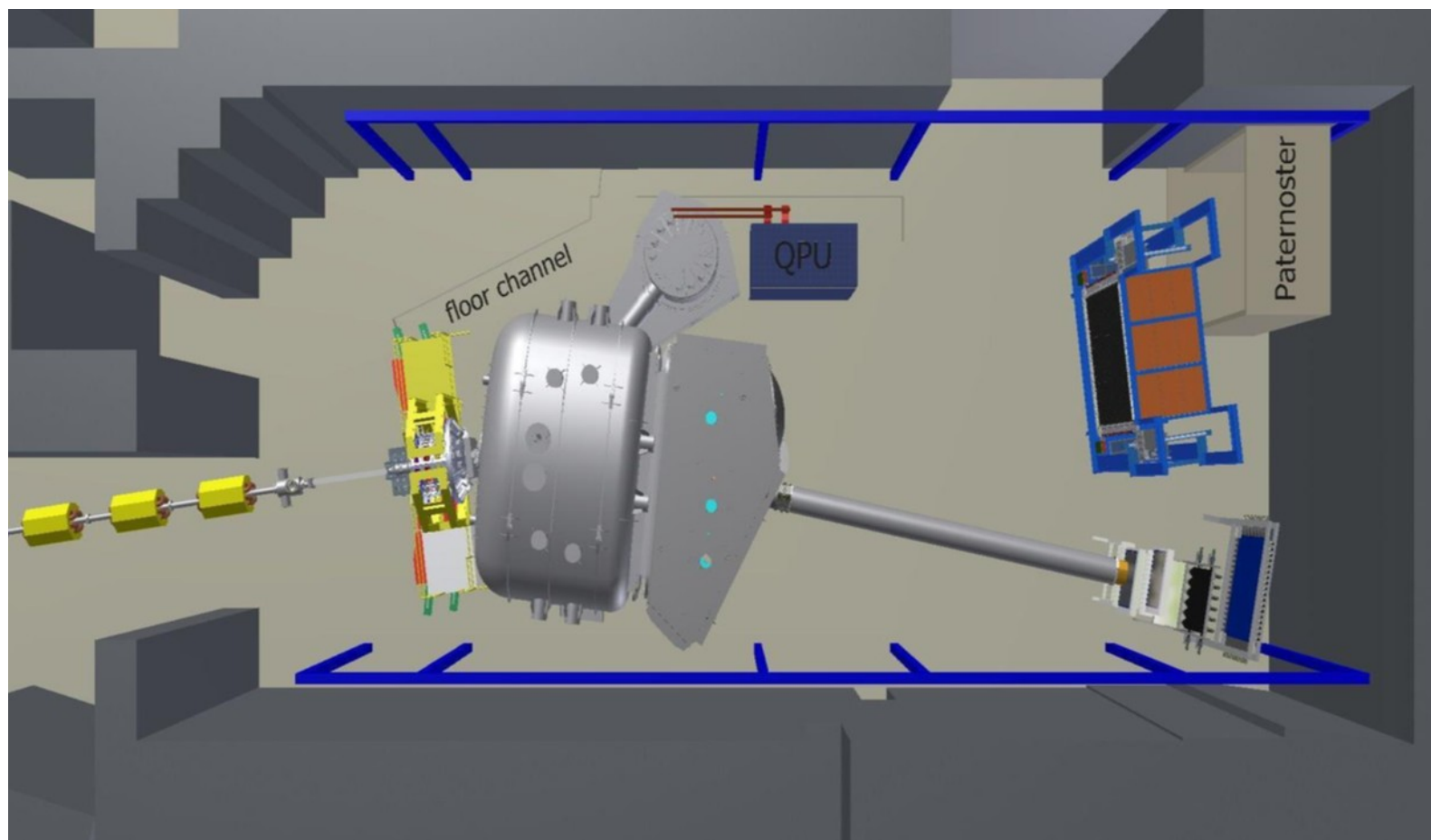
Solutions for Sim&Ana in flexible setups

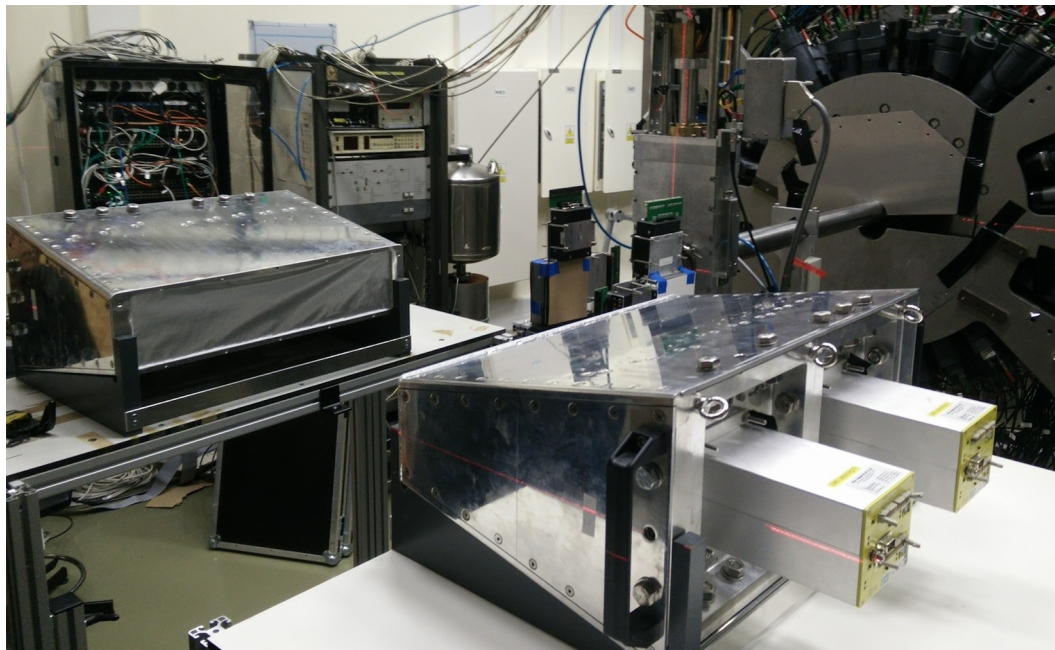# Solutions for Sim&Ana in flexible setups

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Solutions for Sim&Ana in flexible setups

^{27}Al(p,γ)^{28}Si analysis at ITN Lisbon, 2016.

(p,2p) q-elastic reactions at IJP Krakow, 2017.

TRAGALDABAS setup at USC, cosmic run campaign since 2016.

FAIRRoot: a VMC framework based on ROOT

- **The FairRoot framework is an object oriented simulation, reconstruction and data analysis framework.**

- It includes core services for **detector simulation** and **offline analysis** of particle and nuclear physics data.

- The framework enable the users to design and/or construct their detectors and/or analysis tasks in a simple way, it also delivers some general functionality like track visualization.
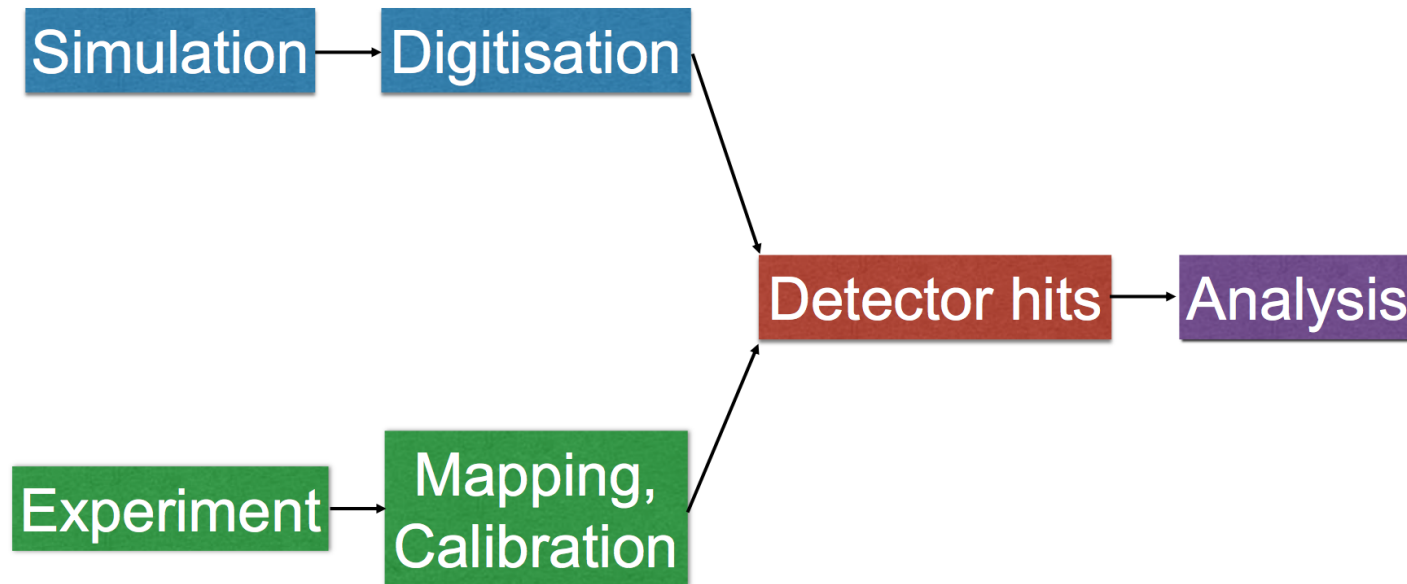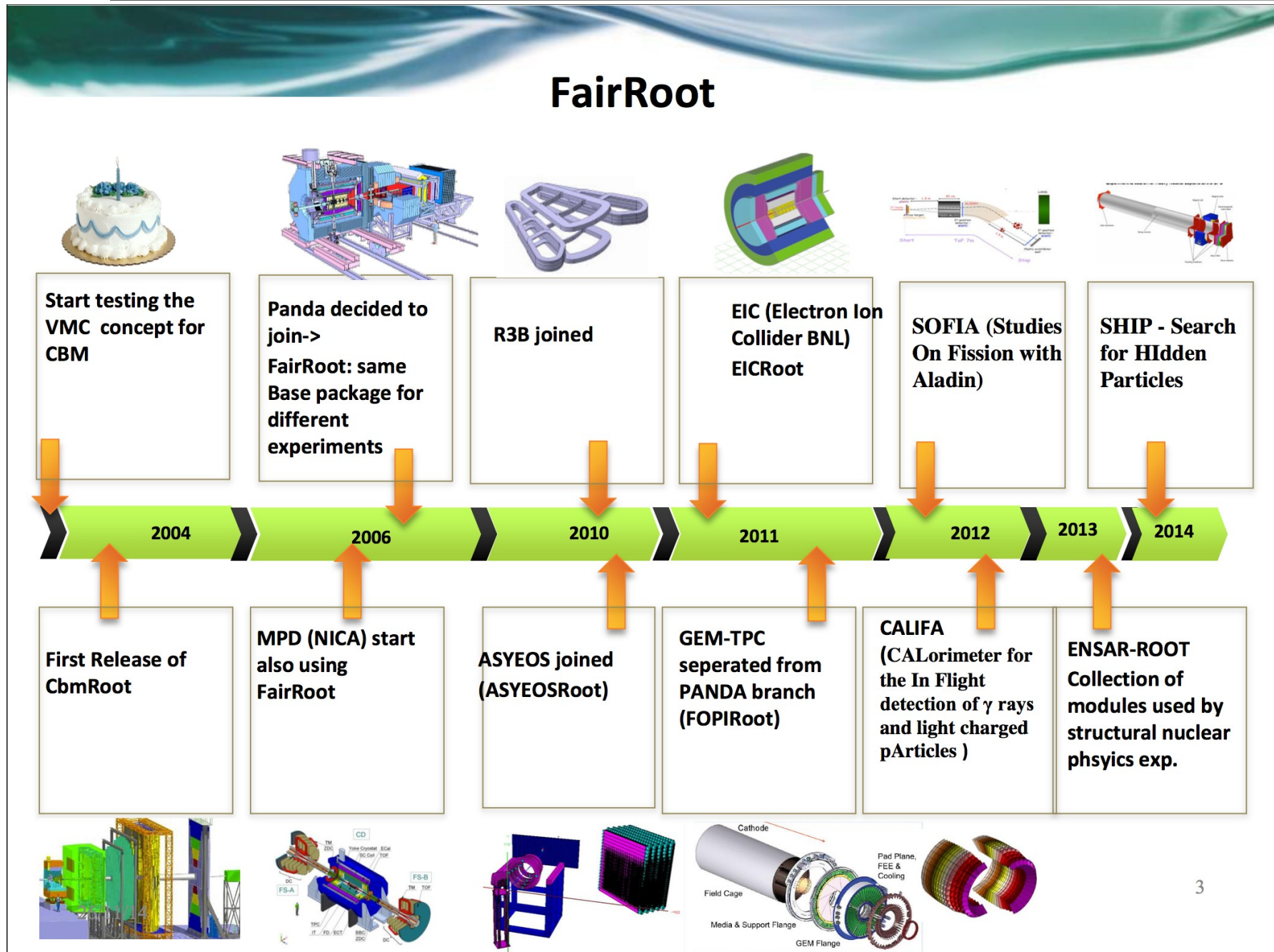
What is a Sim&Ana framework?

- The purpose of a framework is to improve the efficiency of creating new software.

- All of the tedious, low-level details of creating experiment software are already addressed in a reusable package.

- Reuse code that has been pre-built and pre-tested.

- Increase the reliability of the new application and reduce the programming and testing effort.

FAIRRoot: a VMC framework based on ROOT

Common analysis algorithms for simulation
and experimental data

FAIRRoot roadmap

FairRoot

Start testing the VMC concept for CBM	Panda decided to join-> FairRoot: same Base package for different experiments	R3B joined	EIC (Electron Ion Collider BNL) EICRoot	SOFIA (Studies On Fission with Aladin)	SHIP - Search for HIdden Particles

2004	2006	2010	2011	2012	2013	2014

| First Release of CbmRoot	MPD (NICA) start also using FairRoot	ASYEOS joined (ASYEOSRoot)	GEM-TPC seperated from PANDA branch (FOPIRoot)	CALIFA (CALorimeter for the In Flight detection of γ rays and light charged pArticles)	ENSAR-ROOT Collection of modules used by structural nuclear phsyics exp.

R3BRoot: the R3B Analysis and Simulation code

R3BRoot is the analysis and simulation code for the R3B collaboration:

Main management classes derive from **FAIRRoot,** a general object oriented framework for **simulation, reconstruction and data analysis**. It includes core services for detector simulation and offline analysis of particle physics data.
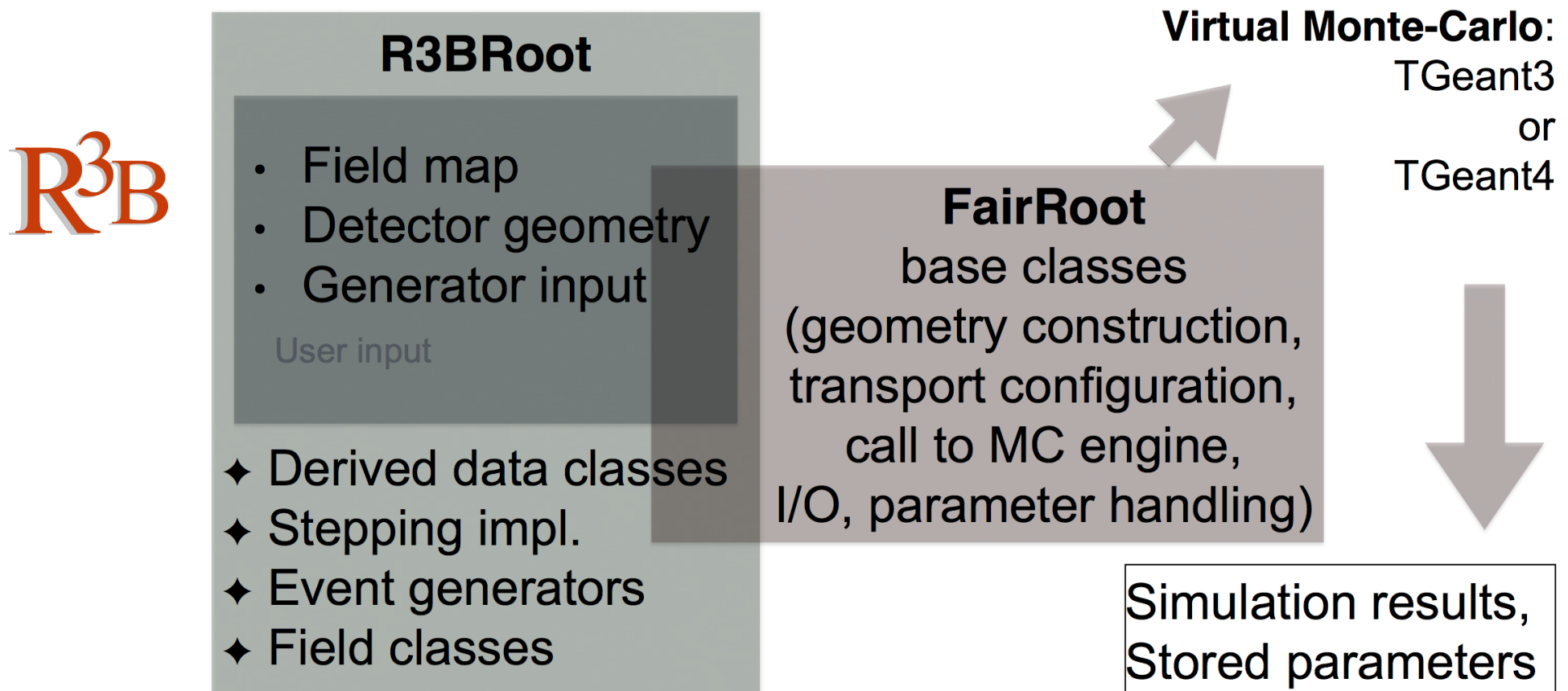
R3BRoot: the R3B Analysis and Simulation code
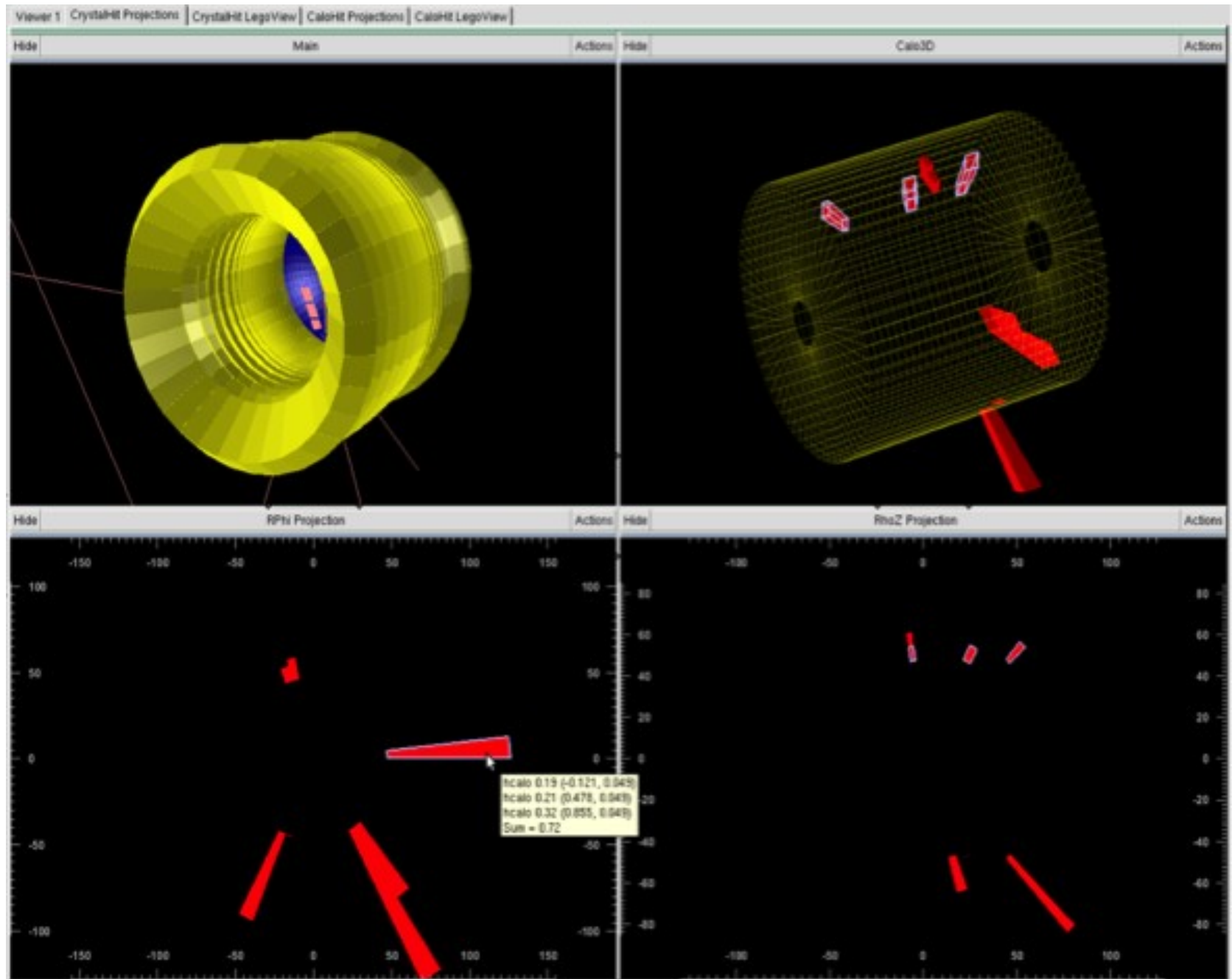
ENSARRoot: a code for the ENSAR European Program

ENSAR2: European Nuclear Science and Applications Research 2, funded by the **EU Horizon 2020**, is the integrating activity for nuclear scientists who are performing research in: **Nuclear Structure, Nuclear Astrophysics and Applications of Nuclear Science.**

Within ENSAR2 there is a program (SATNuRSE) to **improve our simulation and data analysis codes** and also to **come up with new tools**:

• Profit of the community to construct new event generators and improved physics models relevant in the energy domain of ENSAR2 facilities.

• Within ENSAR, **ENSARRoot**, a platform for simulations and data analysis based on ROOT and the GEANT4 simulation toolkit has been developed and can now be used for experiments foreseen at the ENSAR2 facilities.

• Investigate and propose open access procedures for experimental data in the ENSAR facilities.

• Disseminate the technical procedures and knowledge to the community by the organization of workshops and meetings of advanced users and code developers.

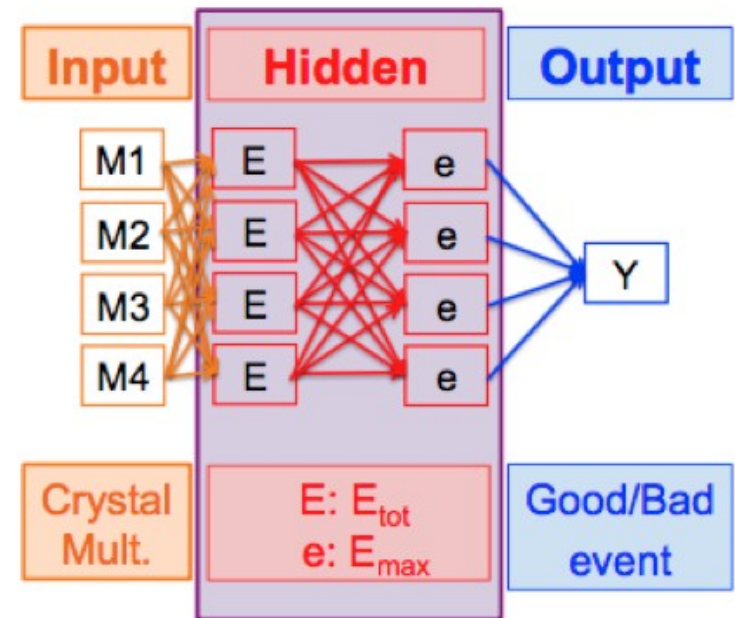# ENSARRoot: a code for the ENSAR European Program

4. Track reconstruction routines and pattern recognition (Task 2.3).

1. Implementation of the TimTrack Tracking Method:
The TimTrack [1] method (short name of Timing Tracking) is able to determine the kinematical parameters in one step taking as input time and position information from the detectors. TimTrack is based on the Least Squares Method (LSM) and therefore it is possible to make a full matrix description.
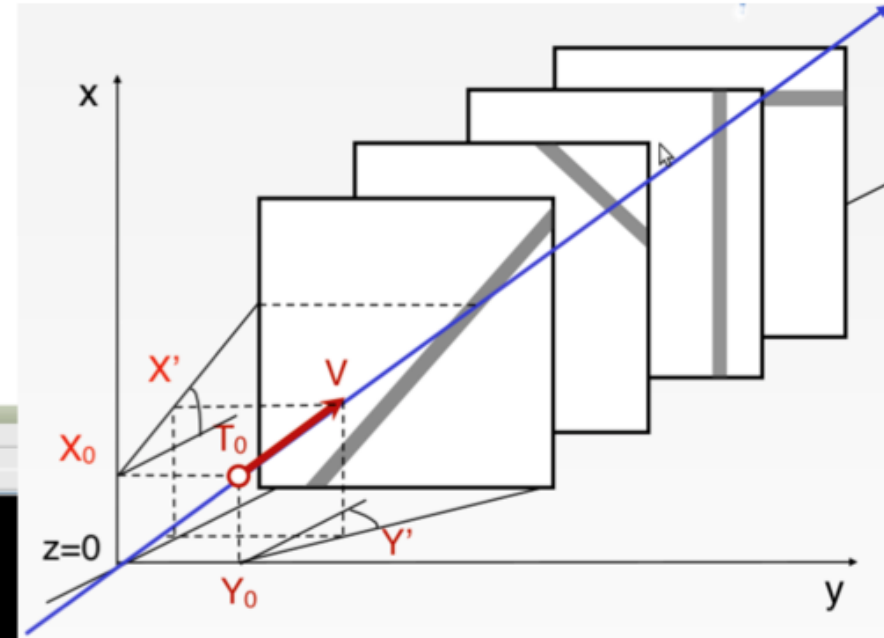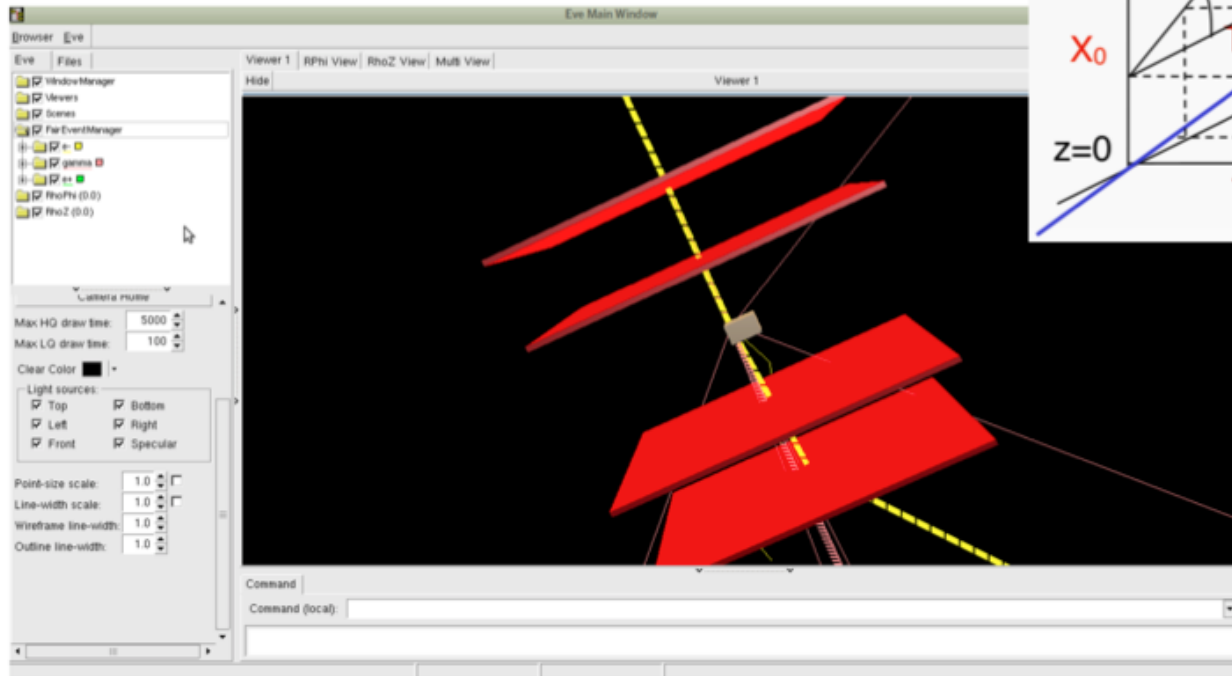
TimTrack has been implemented in ENSARRoot and an example of track reconstruction is included with the TRAGALDABAS detector. Users can decide the number of planes

[1] A. J. Garzón, and P. Cabanelas. TimTrack: A matrix formalism for a fast time and track reconstruction with timing detectors. Nucl. Inst. and Meth. A (661) 2012.
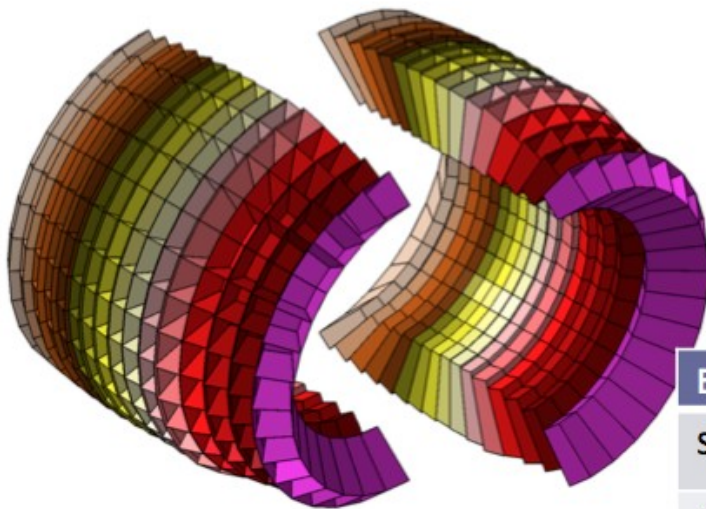
ENSARRoot: a code for the ENSAR European Program

4. Track reconstruction routines and pattern recognition (Task 2.3).

2. Gamma reconstruction using an Artificial Neural Network:
ANNs are computer models that attempt to mimic the processing capability of the nervous system.

The network considered to model the response of the highly segmented CALIFA Barrel to the interaction with photons, is based on three parameters: the crystal multiplicity (M), the Total Energy (Etot) and the Maximum Energy (Emax).

Efficiency	Photopeak	Background	Ratio Ph/Bg	Energy
Std. algorithm	83,3%	16,6%	5	Fixed 1MeV
ANN	77,5%	6%	12,9	
Std. algorithm	74.9%	25,1%	3	0,1 – 2,5 MeV
ANN	60,4	4,3%	14,0	

ENSARRoot: a code for the ENSAR European Program

Ongoing implementation in ENSARRoot:
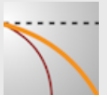
a) **PIGE: Proton-Induced Gamma-ray Emission**, based on the detection of the prompt gamma rays emitted from nuclei in an excited state, following a proton-induced nuclear reaction.

Simulation and data-analysis application in ENSARRoot, together with the Tandem accelerator of the CTN/IST (Lisbon).

b) **(p,gamma) reactions**: Simulation and analysis code for a set of reactions for the detailed analysis of the gamma cascades from the decay of unbound systems.

As example: ^{56}Fe and ^{60}Ni, near or at the shell closer Z=28, providing very valuable insights in the understanding of the nuclear continuum just above the particle threshold.

Outlook and reference

FAIRRoot: https://fairroot.gsi.de/

R3BRoot: https://www.r3broot.gsi.de/

R3BRoot GitHub: https://github.com/R3BRootGroup/R3BRoot

ENSARRoot: https://github.com/EnsarRootGroup/EnsarRoot