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R3BRoot, simulation and analysis framework for the R3B experiment at FAIR

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Abstract. R3BRoot is the simulation and analysis framework for R3B experiment [4]. It is based on the FairRoot[5] base library which is common to many experiments at FAIR. It provides a common data structure for simulation and analysis based on Root trees [1] as well as a common detector geometry defintion based on the Root Geometry Modeller [1].

1. Introduction, the FAIR Project

FAIR, Facility for Antiproton and Ion Research, is a new international accelerator facility for the research with antiprotons and ions that will be located in north of Darmstadt in Germany. The heart of the new facility is a superconducting synchrotron double ring facility with a circumference of about 1,100 meters. A system of cooler-storage rings for effective beam cooling at high energies and various experimental halls will be connected to the facility. The accelerator will yield ion beams with highest beam intensity and also higher beam energies. Moreover, the facility offers the possibility to provide high quality beams of antiprotons and ions for the experimental program

2. The R3B experiment at FAIR

R3B [4], Reactions with Relativistic Radioactive Beams, is one amongst many experimental program at FAIR. The aim of the R3B international collaborationis to develop and construct a versatile reaction setup with high efficiency, acceptance, and resolution for kinematically complete measurements of reactions with high-energy radioactive beams. The setup will be located at the focal plane of the high-energy branch of the Super-FRS, the most powerful in flight separator for exotic nuclei up to relativistic energies

3. The FairRoot framework

R3BRoot is the simulation and analysis framework for R3B experiment. It is based on the FairRoot [5] base library which is common to many experiments at FAIR. The FairRoot base library provides:

- a common data structure for simulation and analysis based on Root Trees
- a common geometry description based on the Root Geometry Modeler
- an interface to different Monte Carlo engines using the Root Virtual Monte Carlo package [2]

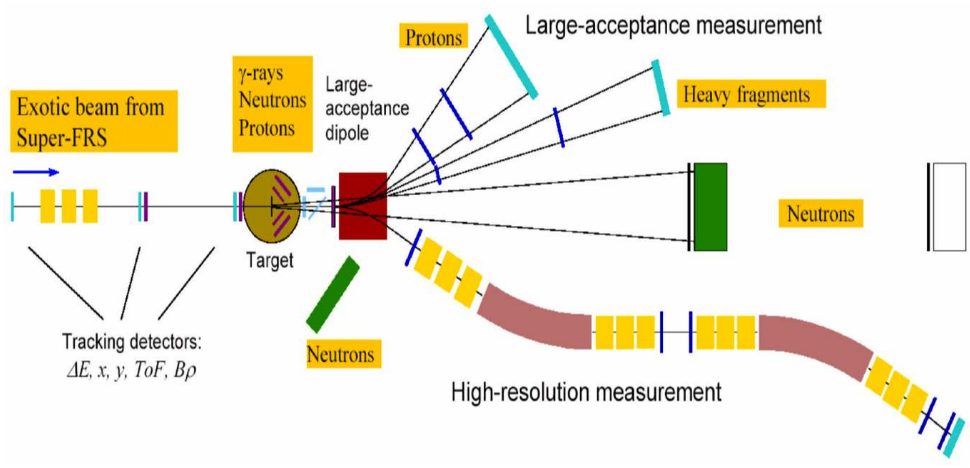

Figure 1. The R3B experimental setup

- Detectors base class hanling initialisation, geometry construction, hit processing (stepping action), etc ..
- geometry input readers supporting Ascii, Root and STEP (CAD) formats
- a generic track propagation based on Geane [3]
- a generic event dispay based on Eve and Geane
- a Runtime database for geometry and parameters handling
- a Fast simulation base services based on Virtual Monte Carlo [2] and the Root Tasks library
- Root macro commands for steering the simulation and the analysis
- Root macro commands for configuring the differents Monte Carlo engines
- a SVN repository is used for code development and managment
- CMake [6] is used as a build system
- CDash [6] and CTest[6] are used for Code Quality Assessement
- Grid computing using the Alien Grid Middleware from Alice Experiment

4. The R3BRoot Framework

R3BRoot is based on the FairRoot library [5] to implement the specific parts needed for the R3B experiment simulation:

- Detectors geometry and materials
- Magnetic field maps
- Detectors hit registration
- Dedicated physics list for low energy neutrons and gamma interations and nuclear fragment transport
- Dedicated event generators
- Database connectivity to handle multiple experimental setup

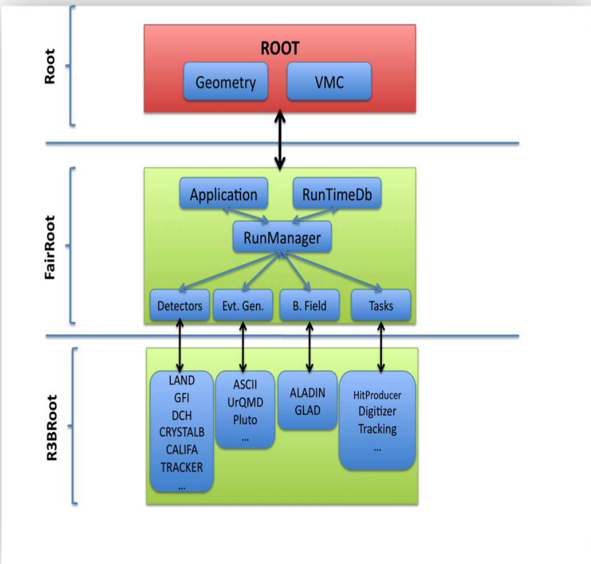

Figure 2. The R3BRoot design based on FairRoot and Root library

5. R3BRoot Databases Connectivity

Since the setup of a typical nuclear experiment varies depending on the physics case to study, the software for simulation and analysis should be able to handle a large amount of different parameters and their variation in time. For that purpose a database appears to be the proper choice. For accessing the data more than one database connection can be used according to the user-defined URLs list. At initialisation time, the list order reflects the access priority. The first database in the list is used for searching the data, if it fails the next database in the list is used until the complete set of data can be retrieved. This gives the user the flexibility to create its own database from a subset of the official one and to put it ahead in the list.

Ultimately, any of the data retrieved could depend on the run or the event being processed. Detector relevant parameters, such as calibration constants, will change with time and the interface has to retrieve the right ones for the current run or event. For this reason, all requests for data through the interface must supply information about:

- The type of data: real or Monte Carlo
- The type of Detector
- The date and time of the run or event (in UTC)

This information is called a Context.

In the database all information is tagged by a Context i.e by a validity range which identifies the type of data and detector and the ranges of date times for which it is valid. Another important point is to minimise IO. Some requests, particularly for detector relevant parameters, can pull in large amounts of data but users must not load it once at the start of the job and then use it repeatedly since it may not be valid for all the data they process. Also multiple users may want access to the same data and it would be inefficient for each to have their own copy. To deal with both of the above problems, the interface uses the concept of handle . When accessing a table, a table specific pointer. During construction of the pointer, a request for data is passed down through the interface and the results table, which could be large, is created on the heap. The interface places the table in its cache and the user's pointer is attached to the table, but the table is owned by the interface, not the user.

6. The R3B-GLAD Magnet

The large aperture superconducting magnet of the future R3B GLAD is being designed in order to reach four main goals:

- a bending power of 4.8 T.m which permits to bend to 18 deg fragments of $132S_n50^+$ whose kinetic energy is 1 GeV per nucleon
- a large angular aperture, both horizontal and vertical, for light charged particles, nuclear fragments as well as for neutrons whose trajectories are not modified by the magnetic field,
- a large momentum acceptance to allow for the simultaneous detection of protons and heavy beam residues of the same kinetic energy per nucleon produced at the target point in front of GLAD
- insure a low fringe field, with emphasis on the fringe field in the target region (entrance of the magnet) in order to make possible the use of detectors around the target which are sensitive to the presence of magnetic fields such as photomultipliers

The DAPNIA in CEA-Saclay are building now the GLAD from a complete mechanical drawing description based on CATIA [8].The original CATIA drawings have been first converted to STEP format [7]. Then a conversion to ROOT Geometry Modeller using dedicated VBA macro programs in CATIA, allows us to use the exact GLAD geometry for the R3B simulation. The GLAD magnetic field map have been calculated using TOSCA

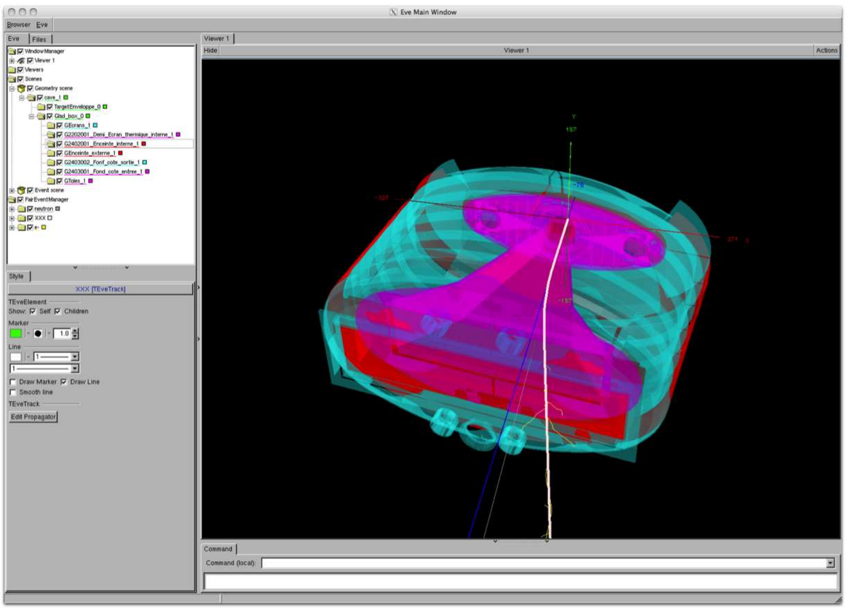

Figure 3. Geometry Modeler conversion of the R3B-GLAD Magnet used in R3B simulation

7. The New Large Acceptance Neutron Detector: LAND

Two alternatives for the new Large Acceptance Neutron Detector (LAND) are currently under investigations:

- a purely plastic scintillator design
- a RPC based design

From the consideration of the physics cases to be studied at R3B, the following objectives have been set for the development:

- efficiency for one neutron detection > 90%
- geometrical acceptance +/- 80 mrad
- invariant mass resolution of 20 keV at an excitation energy og 100 keV abave threshold
- multi-hi capability up to 5 neutrons detection

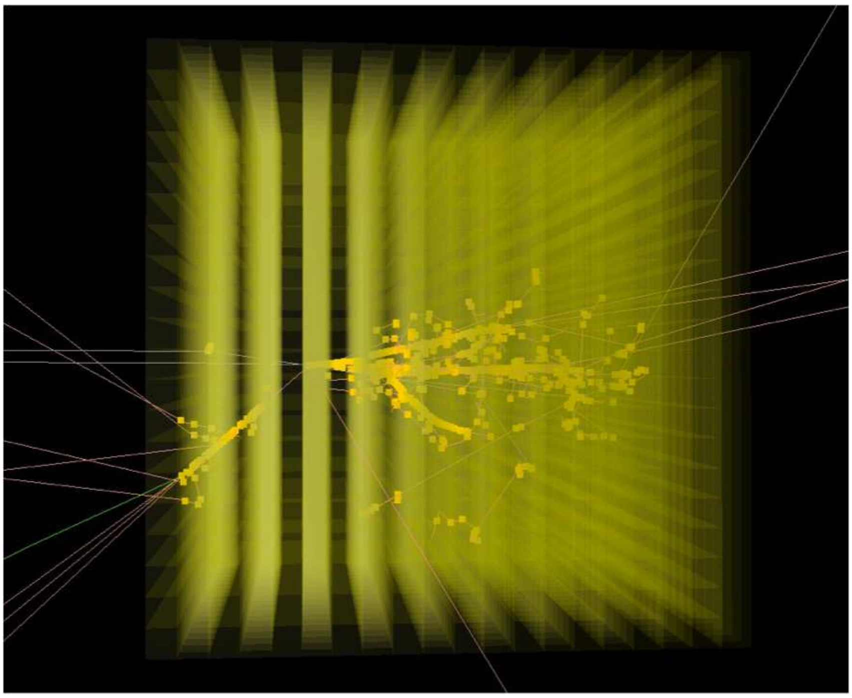

Figure 4. LAND geometry used in R3B simulation

8. References

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