R3BRoot

Simulations and Analysis of R^{3}B Experiment at FAIR
Presenter: D. Kresan

Facility for Antiproton and Ion Research GmbH

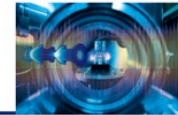**GSI Helmholtz Centre for Heavy Ion Research GmbH**
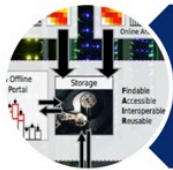
E-OSSR Onboarding Presentation

November 26^{-th} 2021

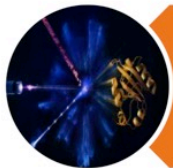# Data Management and Analysis

DMA ST 2 – The Digital Scientific Method

- Join the forces with the Open-source Scientific Software and Service Repository (ESCAPE-OSSR)

  - 23 March 2021: First Meeting with the Workpackage leaders and DMA-ST2
    https://indico.gsi.de/event/12261/

  - 07 May 2021: Mini workshop with OSSR
    https://indico.in2p3.fr/event/24239/

  - 27 May 2021: ESCAPE Executive Board gave the green light for starting the collaboration

ESFRI and Partner

- Super heavy elements
- Astro- and nuclear physics
- Biophysics
- Hadron physics
- Heavy ion collisions
- Plasma physics

GSI Helmholtzzentrum für Schwerionenforschung GmbH

Reactions with Relativistic Radioactive Beams – R^{3}B at FAIR

- Understand fundamental nuclear processes inside stars
- Study properties of short-lived exotic nuclei
- Understand nuclear reaction mechanism (GeV regime)
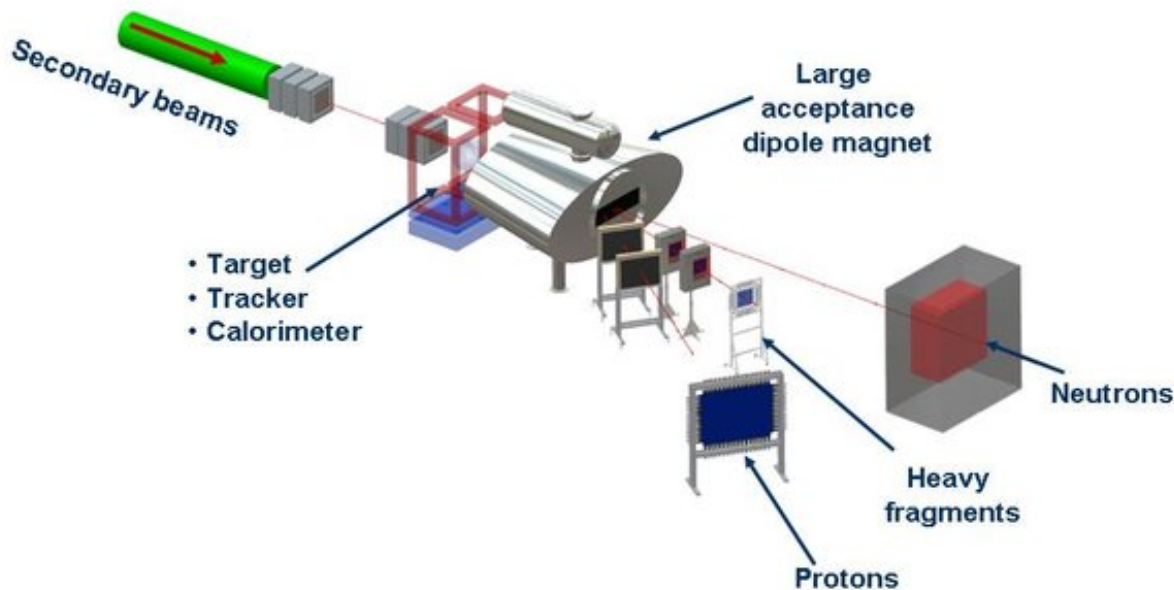
First experiments using SIS18 accelerator (FAIR-Phase0)

R³B at FAIR

- International collaboration: 250 scientists from 50 institutes involved (13 countries)

- Super conducting GLAD magnet

Part of NUSTAR collaboration

- 5 Tm field integral
- 55 t weight

R3BRoot

- R^{3}B-Detector specific software framework for MC simulations and data analysis

- Particle transport using Geant3 / Geant4 (VMC interface)

- Detector response simulations

- Feasibility studies of physics analysis

R3BRoot (2)

- Mapping and calibration of experimental data
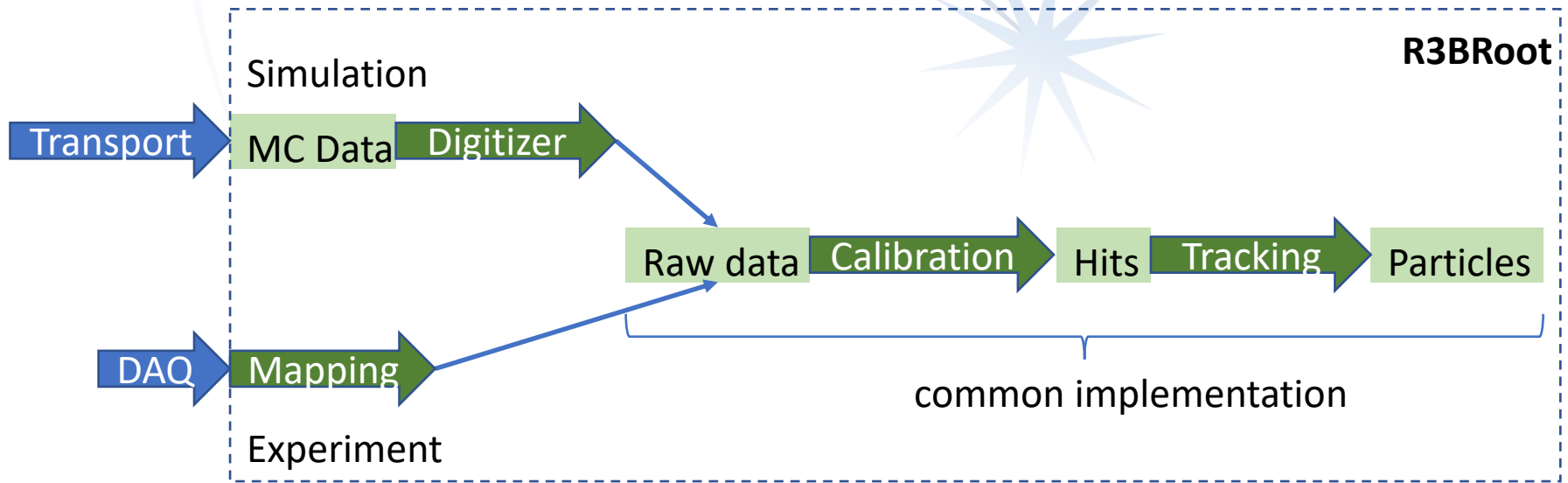- Track reconstruction in non-homogeneous field
- Neutron tracking
- Online monitoring

- Synergy of efforts: many parts of code are re-used in derived projects
  - SofiaRoot - fission experiments
  - GladTpc – TPC detector inside GLAD vacuum chamber

Workflow

- Common implementation of reconstruction and analysis is essential in simulation vs. experiment comparison

Software Development

- https://github.com/R3BRootGroup/R3BRoot.git

- Pull requests, issues

- Well defined workflow: https://github.com/AnarManafov/GitWorkflow/blob/master/GitWorkflow.markdown

- Development:
  - Clang-format integrated in CI
  - Documentation in GitHub Wiki
  - Release ~1 per year: month+year (e.g. "oct21")

Software Development (2)

- License: GPL 3.0

- Testing:
    - CI based on GitHub actions
    - Self-maintained runners
    - Test compilation and execution (functional tests)

Requirements

- Linux / macOS

- gcc / clang

- No special hardware requirements

- Size of container ~ 3 – 5 GB (depending on build configuration)

- Requires:
  - FairSoft - software stack
  - FairRoot - base framework, part of OSSR

OSSR Integration

- What is available: source code, steering macros

- What will be onboarded:
  - source code ("oct21" release)
  - sample data (with next release)

- Workflow for container deployment in OSSR?

OSSR Integration (2)

- User story using current "oct21" release
  - Particle transport through one of R3B setups
  - Reconstruction of simulated data (including tracking)

- Plans for future release:
  - Near-line analysis of small sample of real data

Demo

Starting simulation run

```
kresan@kresan-VirtualBox:~$ cd R3BRoot/github/build/
kresan@kresan-VirtualBox:~/R3BRoot/github/build$ . ../config.sh
System during compilation: Ubuntu 18.04.6 LTS
                           x86_64
System now               : Ubuntu 18.04.6 LTS
                           x86_64
kresan@kresan-VirtualBox:~/R3BRoot/github/build$ cd ../R3BRoot/macros/r3b/
kresan@kresan-VirtualBox:~/R3BRoot/github/R3BRoot/macros/r3b$ root -l run_sim.C 
```

Steering macro example

```cpp
void run_sim()
{
    TString transport = "TGeant3";

    TString outFile = "sim.root";
    TString parFile = "par.root";

    Bool_t magnet = kTRUE;
    Float_t fieldScale = -0.6;

    TString generator1 = "box";
    TString generator2 = "ascii";
    TString generator3 = "r3b";
    TString generator = generator1;
    TString inputFile = "";

    Int_t nEvents = 1;
    Bool_t storeTrajectories = kTRUE;
    Int_t randomSeed = 335566; // 0 for time-dependent random numbers

    // Target type
    TString target1 = "LeadTarget";
    TString target2 = "Para";
    TString target3 = "Para45";
    TString target4 = "LiH";
    TString targetType = target4;

    // -----------------------------------------------------------------------
```

Summary of simulation run
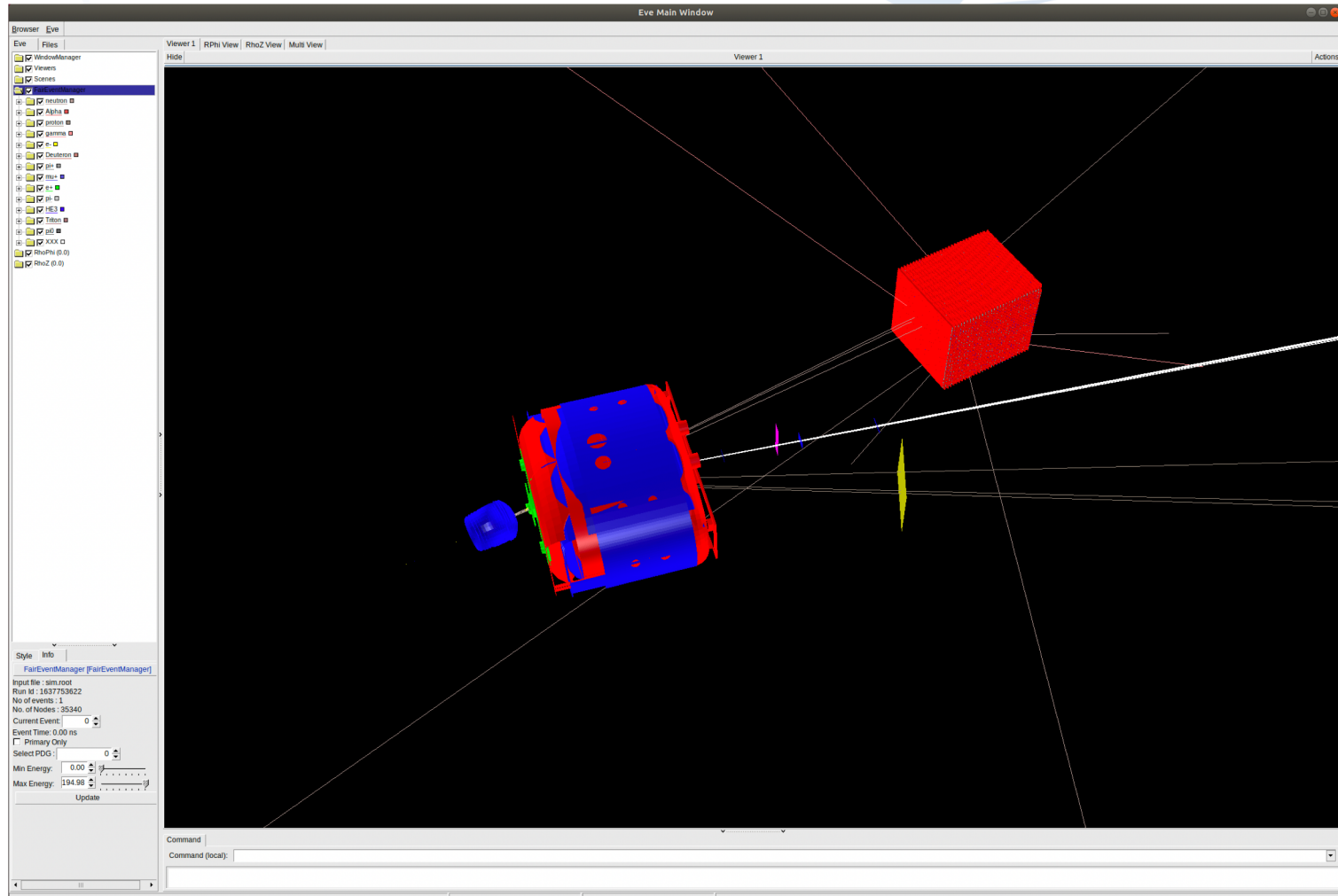
```
 GTREVE_ROOT : Transporting primary track No          10
[INFO] R3BStack: Number of primaries = 16
[INFO]            Total number of particles = 862
[INFO]            Number of tracks in output = 794
[INFO] R3BPsp: 26 points registered in this event
[INFO] R3BStartrack: 0 points registered in this event
[INFO] R3BCalifa: 0 points registered in this event
[INFO] R3BFi4: 19 points registered in this event
[INFO] R3BFi6: 20 points registered in this event
[INFO] R3BFi5: 10 points registered in this event
[INFO] R3Bsfi: 0 points registered in this event
[INFO] R3BTof: 3 points registered in this event
[INFO] R3BTofd: 0 points registered in this event
[INFO] R3BNeuland: 556 Neuland Points registered in this event


Macro finished succesfully.
Output file is sim.root
Parameter file is par.root
Real time 6.72604 s, CPU time 6.72s


 Test passed
 All ok
root [1]
```

Event display with geometry and trajectories

Looking at simulated data