ROOT Package in High Energy Physics tasks

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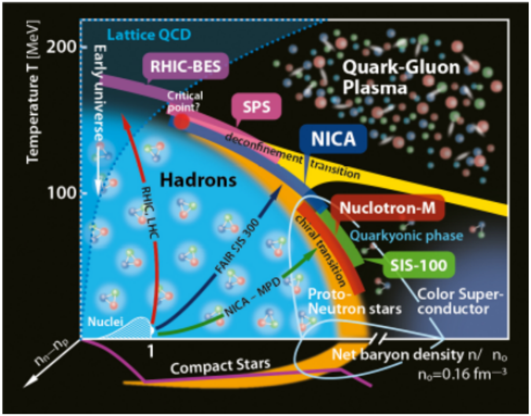
Outline

- Motivation
- Applications
- Results
- Conclusion

Motivation

We are interested in the study of the nuclear force, the law that governs how quarks are bind together is explained by QCD, and in order to get the information we have to analize data that is colected in heavy ion collisions.



RHIC - Relativistic Heavy Ion Collider (Brookhaven National Laboratory, New York, USA)

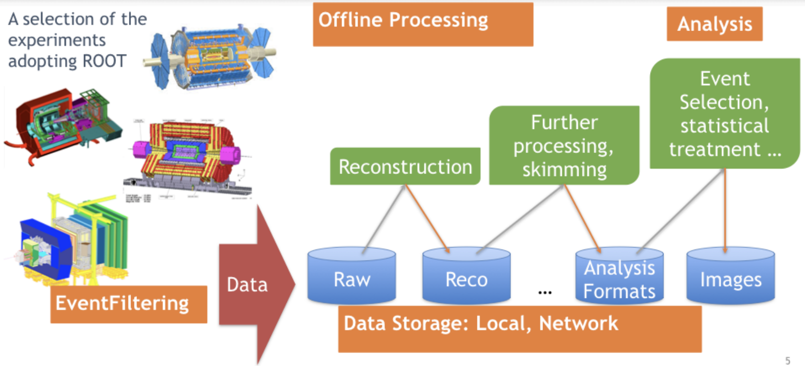
SPS - superproton synchrotron - ring particle accelerator (CERN, Geneva, Switzerland)

NICA - Nuclotron-based Ion Collider fAcility (JINR, Dubna, Russia)

Nuclotron - proton accelerator of the synchrophasatron type (JINR, Dubna, Russia)

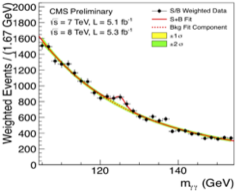
FAIR - facility for antiproton and ion research (GSI, Darmstadt, Germany)
SIS-100 - a synchrotron of the FAIR project

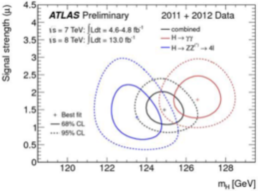
ROOT Application Domains



ROOT
Data Analysis Framework

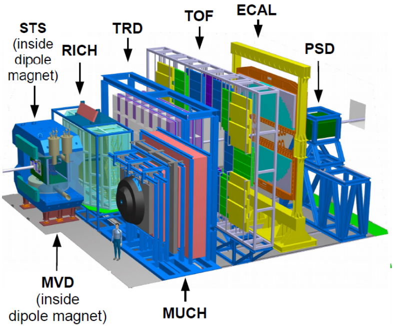
- ROOT is a software framework with building blocks for:
  - Data processing
  - Data analysis
  - Data visualisation
  - Data storage
- ROOT is written mainly in C++
  - Bindings for Python available as well
- Adopted in High Energy Physics and other sciences (but also industry)
  - 1 EB of data in ROOT format
  - Fits and parameters' estimations for discoveries (e.g. the Higgs)
  - Thousands of ROOT plots in scientific publications





Compressed Baryonic Matter

CBM experiment will be one of the four major scientific experiment that are planned to be performed at the FAIR. The goal of the CBM research program is to explore the QCD phase diagram of nuclear matter in the region of high baryon densities



Dipole Magnet
bends charged particle's trajectories

STS (Silicon Tracking System)
charged particle tracking

MVD (Micro-Vertex Detector)
secondary vertex reconstruction

RICH (Ring Imaging Cherenkov)

TRD (Transition Radiation Detector)
electron identification

TOF (Time of Flight detector)
hadron identification

MUCH (MUon CHambers)
muon tracking & identification

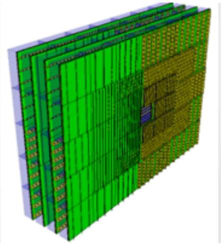
ECAL (Electromagnetic Calorimeter)
electron/photon identification

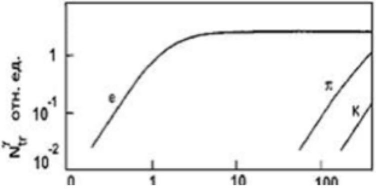
PSD (Projectile Spectator Detector)
collision centrality and
reaction plane determination

Measurements of charmonium (J/ψ, ψ) are among the key tasks of the CBM experiment. To register them via the dielectron decay channel, one need a reliable electron-positron identification in the consitions of a dominant hadronic, primarily from pions, background. The TRD is most suitable for solving the abovementiones task, which should yield reliable electron identification, a high pion suppression level, a reconstruction of trajectories of charged particles passing through the detector in conditions of intense fluxes (up to 10^7 collisions per second), and a high multiplicity of secondary particles (from 100 to 1000 particles per nucleus-nucleus collision.

Transition Radiation Detector

Multilayered TRD detects the charged high-energy particles using the transition radiation emitted by them when crossing the interface between media with different dielectric permeability.





Dependence of number of TR photons from the particle energy

In a wide range of energies from 1 GeV to 150 GeV only electrons (positrons) generate TR which is used to identify them.

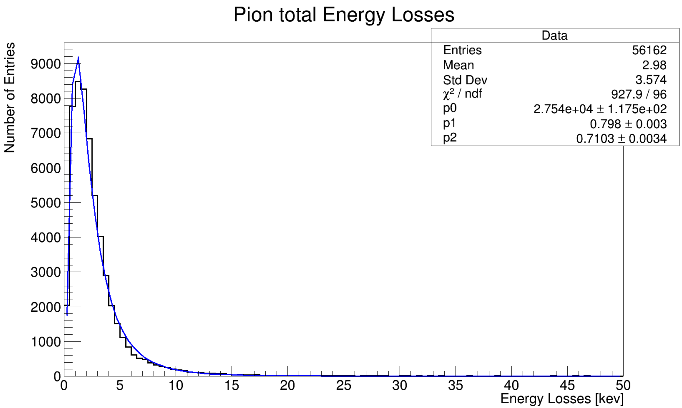
<u>The procedure of pion suppression and electron identification in the TRD includes several stages</u>:

(1) search and reconstruction of trajectories of the particles,

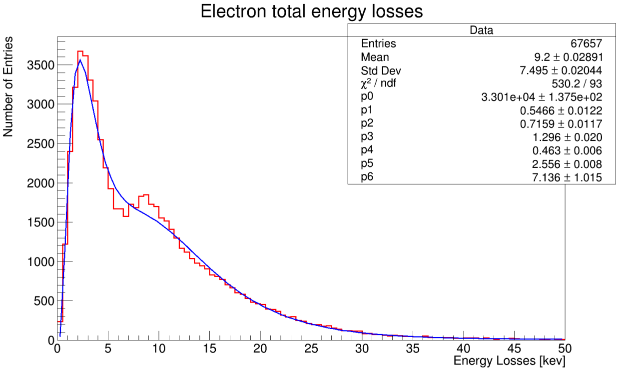
(2) particle identification taking into account energy losses.

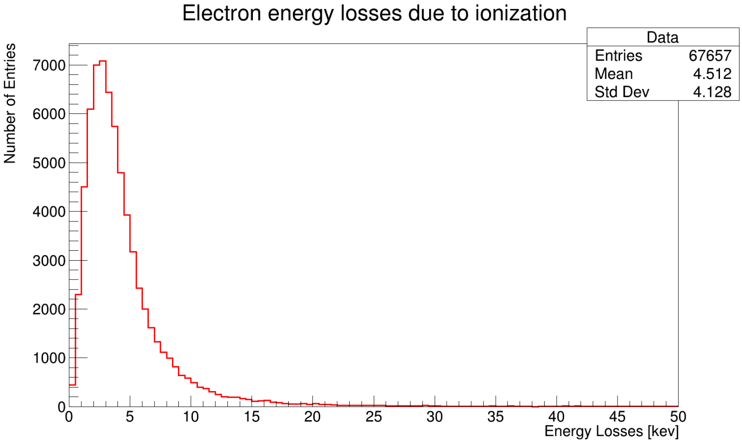
Fitting equation:

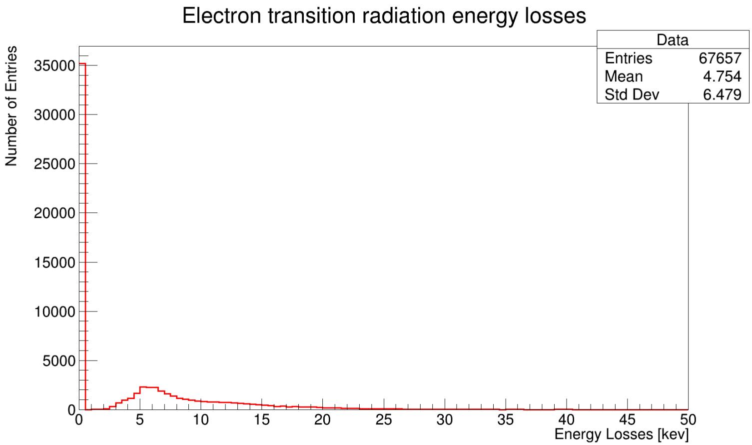
$$f_1(x) = \frac{A}{\sqrt{2\pi}\sigma x} \exp\left[-\frac{1}{2\sigma^2}(\ln x - \mu)^2\right]$$



$$f_2(x) = B\left(\frac{a}{\sqrt{2\pi}\sigma_1 x}\exp-\left[\frac{1}{2\sigma_1^2}\left(\ln x-\mu_1\right)^2\right]\right)+$$
$$\left(\frac{b}{\sqrt{2\pi}\sigma_2 x}\exp-\left[\frac{1}{2\sigma_2^2}\left(\ln x-\mu_2\right)^2\right]\right)+c$$

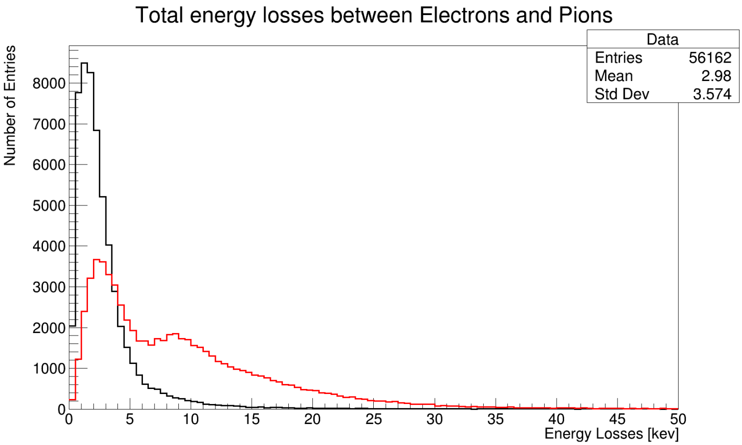



Electron energy losses due to ionization
Data
Entries 67657
Mean 4.512
Std Dev 4.128
Number of Entries
0
1000
2000
3000
4000
5000
6000
7000
0
5
10
15
20
25
30
35
40
45
50
Energy Losses [kev]

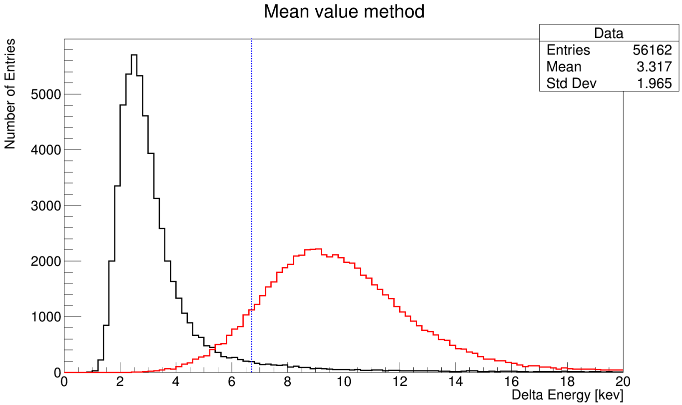

Electron transition radiation energy losses
Data
Entries 67657
Mean 4.754
Std Dev 6.479
Number of Entries
0
5000
10000
15000
20000
25000
30000
35000
0 5 10 15 20 25 30 35 40 45 50
Energy Losses [kev]

Methods:

- Artificial neural network.
- Goodness-of-fit criterion wkn.
- Mean value method.



$$\overline{\Delta E} = \frac{1}{n}\sum_{i=1}^{n} \Delta E_i$$

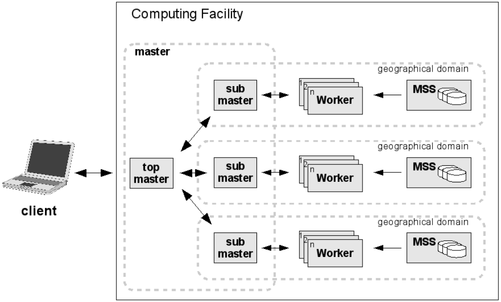


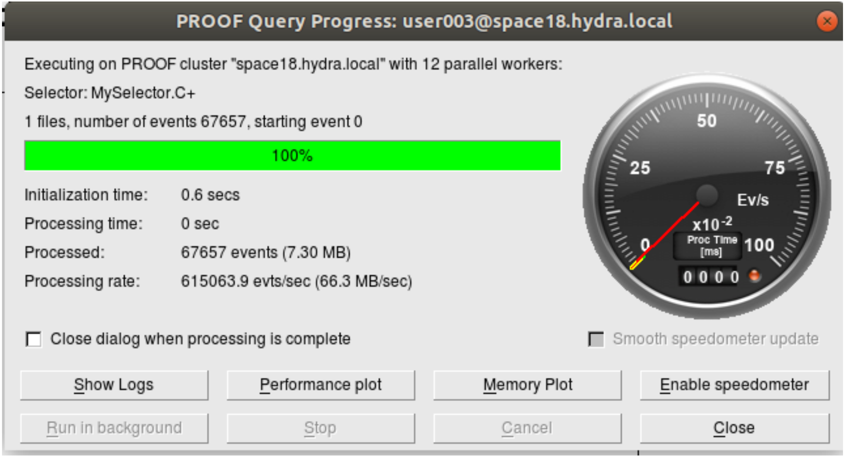
Pions supression factor = 16.34

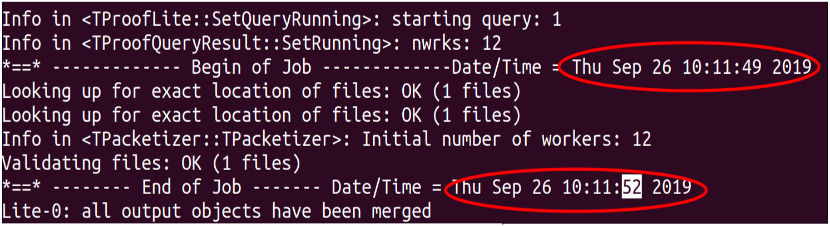
Percentage of electrons = 90.03

PROOF

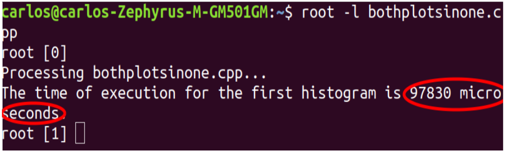
The Parallel ROOT Facility, PROOF, is an extension of ROOT enabling interactive analysis of large sets of ROOT files in parallel on clusters of computers or many-core machines. More generally PROOF can parallelize tasks that can be formulated as a set of independent sub-tasks




PROOF Query Progress: user003@space18.hydra.local
Executing on PROOF cluster "space18.hydra.local" with 12 parallel workers:
Selector: MySelector.C+
1 files, number of events 67657, starting event 0
100%
Initialization time: 0.6 secs
Processing time: 0 sec
Processed: 67657 events (7.30 MB)
Processing rate: 615063.9 evts/sec (66.3 MB/sec)
50
25
75
Ev/s
x10 -2
0
Proc Time [ms]
100
0 0 0 0
Close dialog when processing is complete
Smooth speedometer update
Show Logs
Performance plot
Memory Plot
Enable speedometer
Run in background
Stop
Cancel
Close



```
Info in <TProofLite::SetQueryRunning>: starting query: 1
Info in <TProofQueryResult::SetRunning>: nwrks: 12
*==* ------------- Begin of Job -------------Date/Time = Thu Sep 26 10:11:49 2019
Looking up for exact location of files: OK (1 files)
Looking up for exact location of files: OK (1 files)
Info in <TPacketizer::TPacketizer>: Initial number of workers: 12
Validating files: OK (1 files)
*==* -------- End of Job ------- Date/Time = Thu Sep 26 10:11:52 2019
Lite-0: all output objects have been merged
```



```
carlos@carlos-Zephyrus-M-GM501GM:~$ root -l bothplotsinone.c
pp
root [0]
Processing bothplotsinone.cpp...
The time of execution for the first histogram is 97830 micro
seconds
root [1]
```

Conclusions

- ROOT is very versitile for processing raw data and organizing it.
- PROOF can be used to improve our calculation time.
- We have learned to analyze raw data from (CBM) experiment, to get useful information about $\pi^{\pm}$ and $e^{\pm}$ particles.


obrigado
Dank U
Merci
mahalo
Köszi
спасибо
Grazie
Thank you
mauruuru
Takk
Gracias
Dziękuję
Děkuju
danke
Kiitos