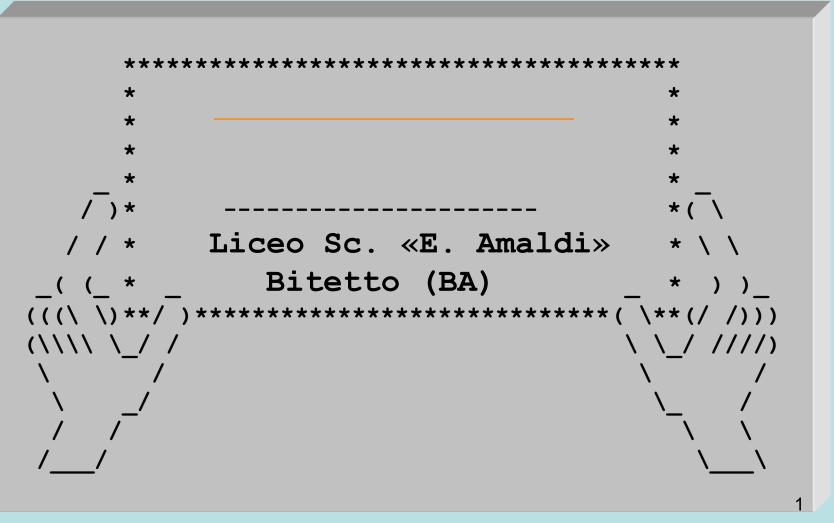
RUN MEETING

Extreme

Energy Events

Science inside Schools

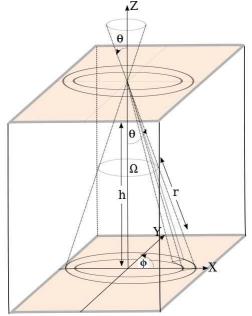
MAY 2, 2018





The Aim

 To measure the speed of cosmic ray muons analysing data collected by the Telescopes.





Data Download

We downloaded data collected by two Telescopes: CERN-02 and ALTA-01

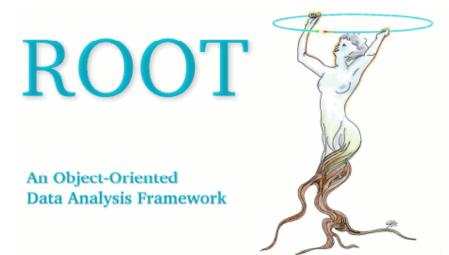
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C++ Programming with Root

We started C++ programming using Root.

- 1) ROOT is a Framework developed at CERN (see the web site http://root.cern.ch)
- 2) It's completely developed in $\underline{C++}$
- 3) It supports a collection of classes useful for data analysis
- 4) The IDE is based on the C++ interpreter, CINT





Root for Windows

• Which Release we used? root_v5.34.36.win32.vc12





C++: an introduction

- Our Teacher Mr. Ricchiuti explained, during our lessons, the basics of C++ programming:
- Data types;
- Declaring variables;
- Decision Making
- Loop Types
- Arrays
- Functions
- Classes and Objects



Notepad ++

The Fields TimeOfFlight and TrackLength are separated in CSV files using ",", we have substituted each comma with \tab using the freeware software Notepad ++. In this way the file has a record layout ready to be read by root



Notepad:

importing data from a CSV file

G:\root\dati_telescopi\cern_chi_min_3\CERN-02from2018-04-01to2018-04-01.csv\tmp\CERN-02from2018-04-01to2018-04-01.csv - Notepad
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3.700012,125.765083
2.750031,88.971748
2.850037,110.429657
3.049988,92.550102
3.650024,91.803947
4.149963,98.153633
3.649994,89.622383
3.299988,97.750191
4.049988,110.724167
3.950012,90.302910
4.449982,105.231491
3.350037,101.575829
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2.700012,96.191063
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3.350037,92.701431
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2.850006,96.170441
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Notepad: replacement

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Histogram of the speed

 We calculated the speed of muons as the ratio TrackOfLength / TimeOfFlight, creating a frequency histogram about the distribution of the speeds



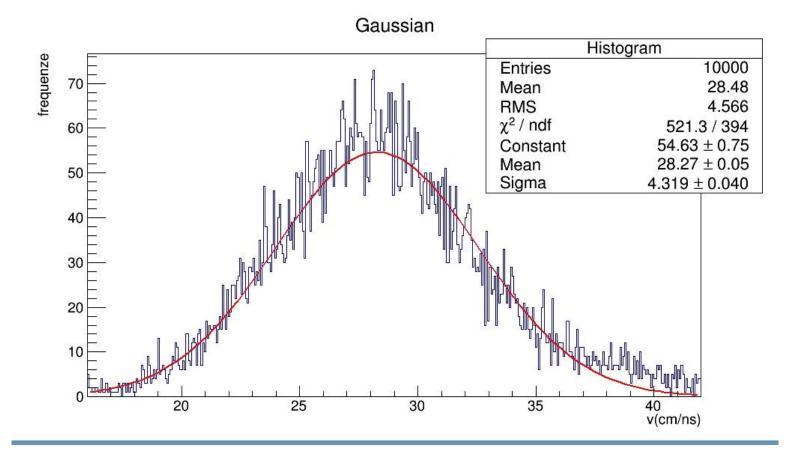
Gaussian Fitting: 10.000 events (1)

We obtained the gaussian fitting writing the line of code: hist -> Fit("gaus");

The centroid of the curve is the average speed of cosmic rays muons. We found a value very close to the speed of light, about 28,5 cm/ns. But the distribution is not perfectly a Gaussian function.

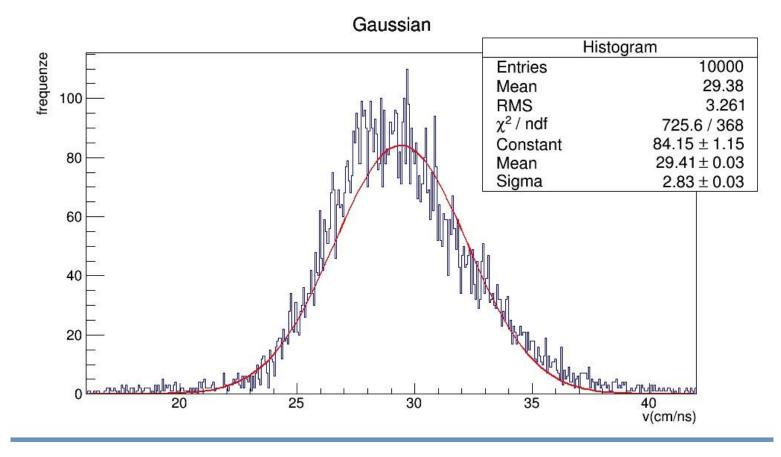


Gaussian Fitting:





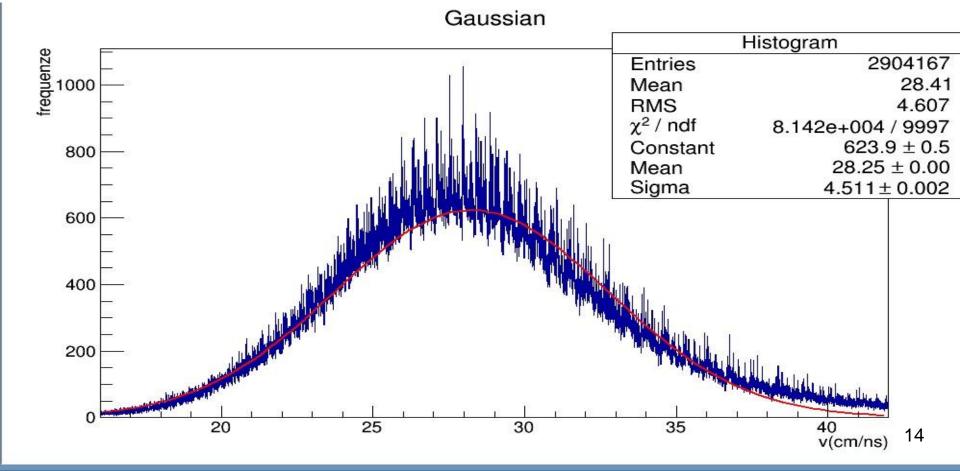
Changing Telescope: Altamura





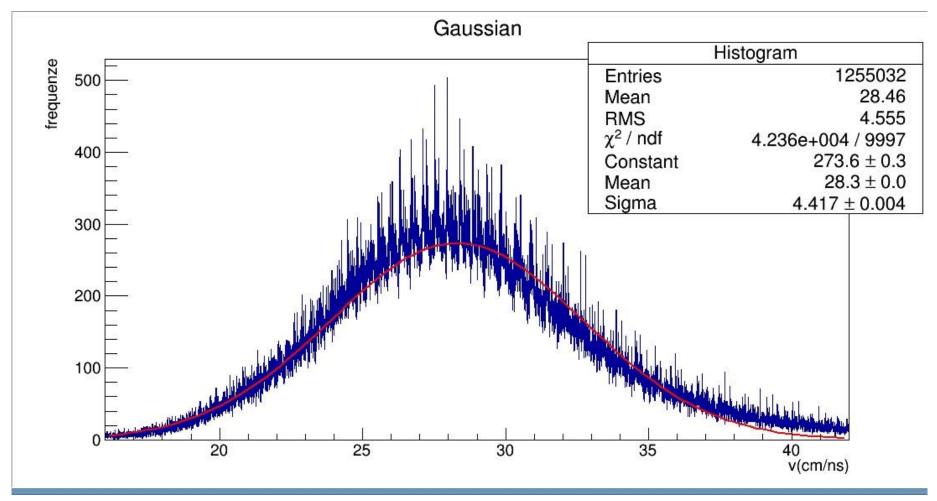
3 millions events – CERN 02

What happens? We have to increase the number of bins to reduce the ratio ChiSquare/ndf.





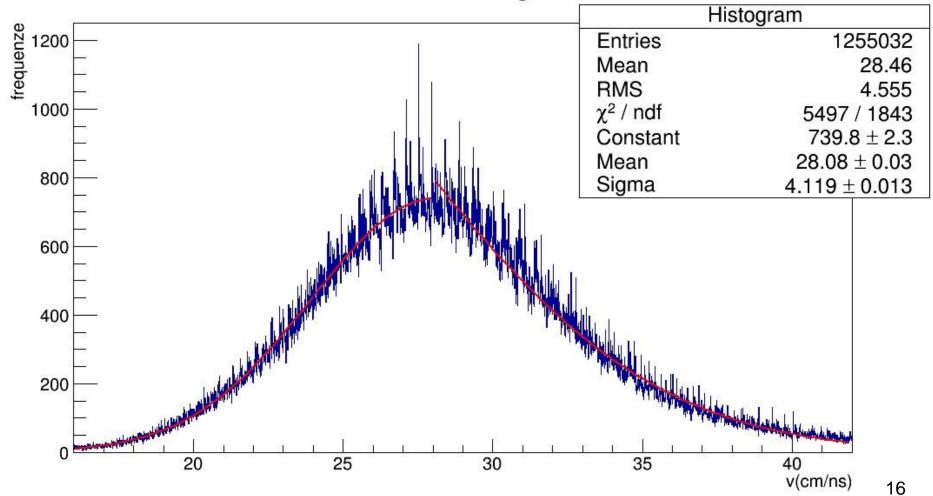
CUT ChiSquare <3





Multi-fitting

Multi-Fitting





Data Analysis in Excel: CERN-02

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Counting Negative values of the speed: CERN02

		ROOT sessio	n		- 🗆 🗙
103.259 3.90002 26.4764 91.8858 3.70004 24.8337 FCN=4033.6 FROM	MIGRAD STATUS=	CONVERGED	113 CALLS	114 T	
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EXT PARAMETER NO. NAME 1 Constant 2 Mean 3 Sigma I have read 29041 Negative values:3 root [9]	VALUE 1.08245e+003 2. 1.94881e+001 2. 8.08924e+000 7. 67 events	ERROR 85972e+001 62468e-001	STEP SIZE 6.11507e-002 2.87941e-004	FIRST DERIVATIVE -9.51654e-000 -1.39105e-003	5



CONCLUSIONS

- The position of the centre of the peak in the distribution in velocity of muons is a value very close to the speed of light (we found about 29 cm/ns);
- Choosing a cut with ChiSquare <3, the fitting with a gaussian function slightly improves;</p>
- Inside the data we found negative values of the velocity due to electrons produced as decay products of cosmic muons stopped in the ground;
- Probably the best fit for the distribution of the speeds is a double fitting with two gaussian functions.



Extreme Energy Events Science inside Schools

THANK YOU FOR YOUR ATTENTION!

Teachers involved in EEE Project: Antonella Azzone Francesco Cirrottola Domenico Ricchiuti Student Speakers Maria Nicassio Domenico Rinaldi Classes III A III B III C IIIASA IV A IV B IV C IV ASA IV BSA VB VC VD VE