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Team Raindrops and Muons

Feeding your inner geek.

Guided by Oliver Keller and Mihaly Vadai

Summary

1. The CERN story behind this project.
2. Audio analysis as a model for data acquisition and raindrops as models for background muons.
3. Muon detection and experiments with an open source muon detector.
4. Expectations of your final project including creation of educational resources.
5. Learning opportunities in the field of real time digital signal processing, electronics, data analysis and programming.

As it happened… The story of the raindrops and muons project

Oliver hacked the ventilation system in the office. (51-R-023)

Mihaly listening to the rain hitting the cardboard and getting an email about 2 high school interns.

Homework

Record the rain under an umbrella with your phone / audio recorder for about 5 minutes and bring the recording to CERN.

Analysing rain audio samples

- Two year 9 interns at CERN during the Hungarian High-School Student Internship Programme.

- The kids' presentation is under Raindrops and Muons here (use the .pptx, since Dori wanted to include fancy effects in the presentation):

https://indico.cern.ch/event/630615/timetable/#day-2017-06-02

(You can also check what the older students did…)

Statistical distribution of raindrop arrival times

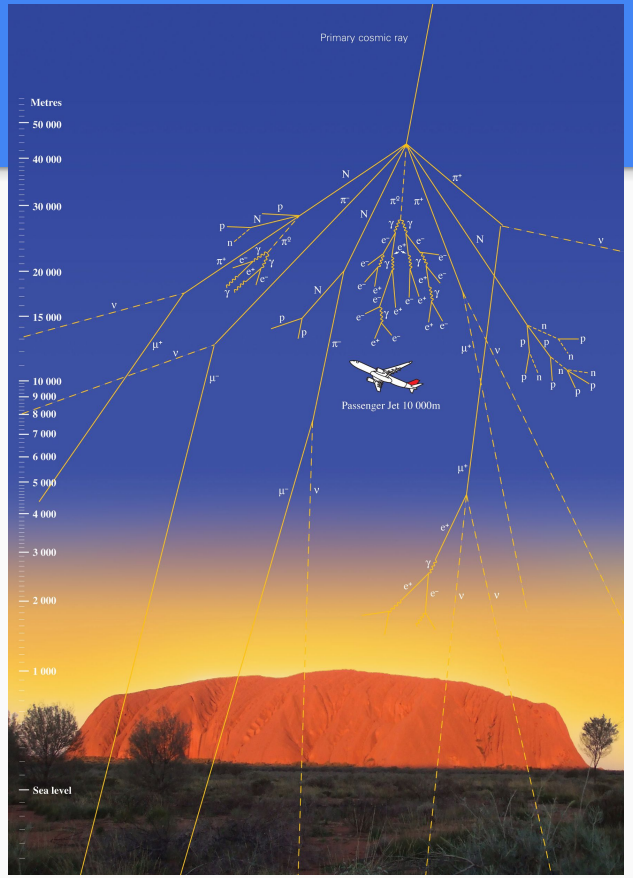
This part of your final presentation y*ou could use directly in your lessons when introducing background radiation*.

Including the muon component of the background.

Rain as a model of background radiation.

Rain as a model for atmospheric muons.

Image credit: redchairblogs.com



Audio filtering as a model for high speed, real time data processing / filtering

Motivation:

This is what the LHC experiments do: filter the data until the Higgs is found. This takes years of data logging at very high data acquisition rates.

Audio and LHC data rates

We will use a data rate of 44100 samples/second sampled at 16 bit stereo, which is about 176 kB/s data rate. This corresponds to CD quality. (MP3 DR is much less, about eg. 150 kb/s.)

The LHC data rates from all experiments: ~ 25 GB/s. Which has to be processed real time for most parts.

Interpreting this is equivalent to listening to *141 720 bands playing at lossless, CD quality at the same time.* Or about 1 133 800 teenagers listening to mp3.

Statistical distribution of muons.

Using the Muon Hunter open source detector to measure muons.

Opportunity to learn about analogue electronics and/or microcontrollers.

Experiments with muons.

- Electromagnetic cascades and the Rossi experiment.
- Elevation and muon rates.
- Angular distribution of muons.

Tasks - the topics are linked, the pairs are expected to communicate and share

Pair 1: Raindrops and muons. Creating radioactivity / background muon introductory resources / activities based on *the rain model* to be used in lessons. (incl. Graphs, statistics.)

Pair 2: Level 1 trigger and real time digital audio. Creating educational resources on real time data acquisition based on audio processing. (incl. audio files and optionally sampling GM events: can involve hardware tinkering)

Pair 3: Level 1 trigger and coincidence detection. Creating resources on muon experiments / electronics or programming. Muon Hunter open source detector. (Can include hardware tinkering, MCU programming.)

Advanced topics to study (voluntary)

Pseudo random and true random numbers - seminumerical algorithms (Knuth)

Geiger data unbiasing (von Neumann, Peres and perhaps more)

Random number tests

Level 1 trigger and programmable devices (how it’s actually done in the LHC)

Why choose this work group?
Learning opportunities:

- Enhance your CV and learn
  - Real time digital signal processing
  - Analogue electronics
  - Statistics
  - Programming for data analysis and plots
- Create resources for your lessons
  - Rain as the model of background muons and radioactivity in general
  - Audio as the model of real time data acquisition and processing
  - Muon detection and muon experiments - coincidence detection

Sessions for raindrops and muons

1. 05 July 2017 16:45-17:30
   Location: S'Cool LAB
2. 06 July 2017 16:00-17:30
   Location: S'Cool LAB
3. 10 July 2017 14:30-17:30
   Location: S'Cool LAB or 61-1-007 (B)
4. 12 July 2017 14:00-17:00
   Location: S'Cool LAB
5. 18 July 2017 14:00-17:00
   Location: S'Cool LAB or 61-1-007 (B)
6. 19 July 2017 14:00-17:00
   Location: S'Cool LAB or 61-1-017 (D)
7. 20 July 2017 14:00-16:00
   Location: S'Cool LAB

Final reports:

20 July 2017 16:00-17:30

21 July 2017 09:00-13:00

The students’ work as an example including .mp3 samples

We sent the original audio to the left channel and the filtered audio to the right.

Use headphones and start with a low volume. The recordings contain different digital filtering ideas. (All filters were common sense ones, so the students can understand, there was no fancy filter maths involved.)

https://cernbox.cern.ch/index.php/s/2ksrwjNLx9EMY6w/authenticate

Password: muonmuon

Equipment

1. 3 Muon Hunter kits (1 extra needed)
2. 6 pairs of headphones
3. Laptops for each pair of people. 3 basic laptops with jacks. To create curriculum resources and programming.
4. 2 Bela (we have it already - one has to be flashed)
5. Microphones (x 2)
6. Sprinkler, garden hose and umbrellas

First meeting

05 July 2017 16:45-17:30

Location: S'Cool LAB

Deciding on pairs.

Getting rain audio samples with a garden hose under an umbrella.

Bring an umbrella and earphones.

Communication

Work group email (live from 05/07): HST2017-WG2@cern.ch

Cloud file storage: http://cern.ch/go/gnd8 Password: raindrops

Download Mihaly's contact:  Or: http://cern.ch/go/N6zv

Link to this presentation: http://cern.ch/go/Kk6f