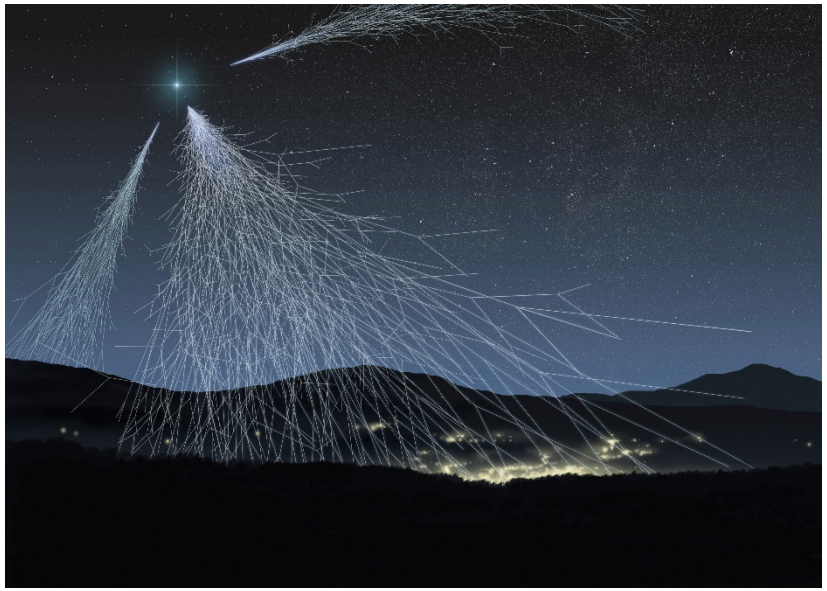
HST 2015



Work group 1 - ”Cosmic Rays”

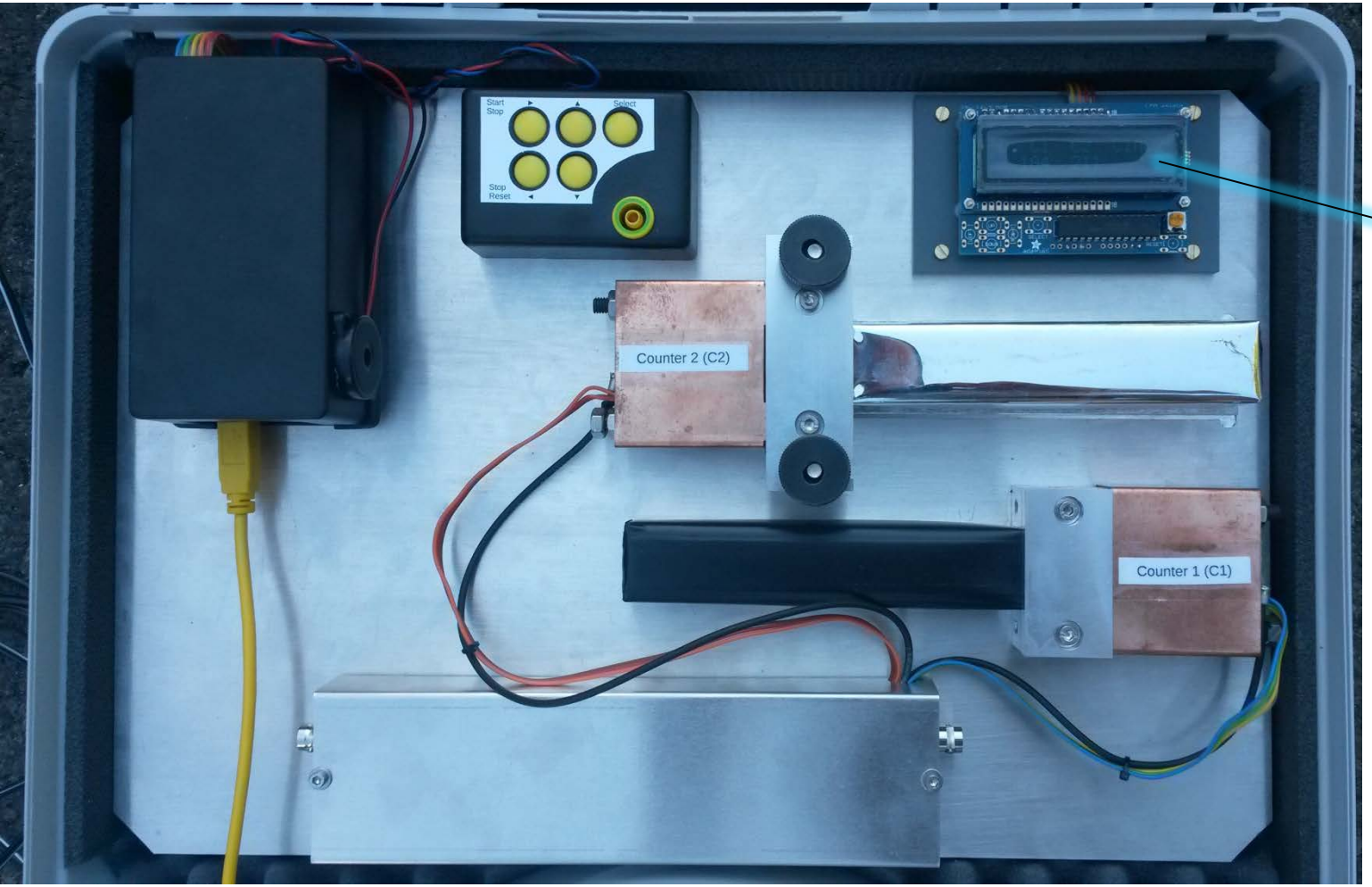
Work group 6 - ”Data Analysis”

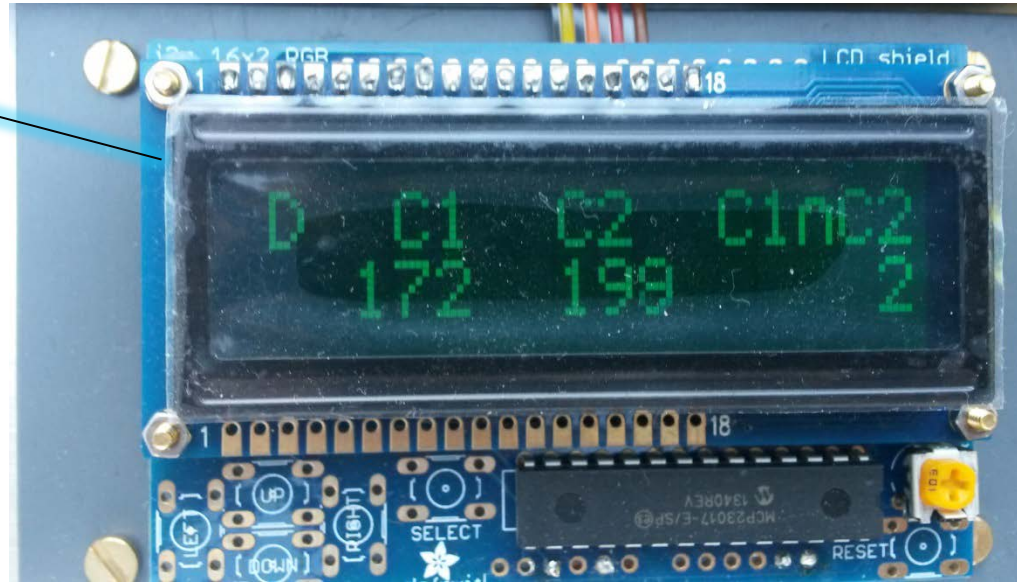

A mixed bunch
with two honorary members: Gurpreet and Patrick
Tero
Steffan
Morten
Mihály
Morgan
Edouard
Konrad
Paco
Maria
Sema
Takashi
Kamlesh
Natthorn
Sweden
Norway
Finland
Ireland
Poland
Belarus
Germany
Ukraine
Austria
France
Romania
Italy
Spain
Portugal
Greece
Turkey
Kazakhstan
Mongolia
Uzbekistan
Kyrgyzstan
Turkmenistan
China
Japan
Syria
Iraq
Iran
Afghanistan
Pakistan
India
Tunisia
Morocco
Algeria
Libya
Egypt
Western Sahara
Saudi Arabia
Oman
Yemen
Mauritania
Mali
Niger
Chad
Sudan
Burkina Faso
Guinea
Nigeria
Ghana
South Sudan
Ethiopia
Gulf of Aden
Arabian Sea
Bay of Bengal
Laccadive Sea
Thailand
Vietnam
Philippines
South China Sea
East China Sea
Gulf of Thailand

French detector : COSMIX

Like ASTERIX

HST CERN 2015





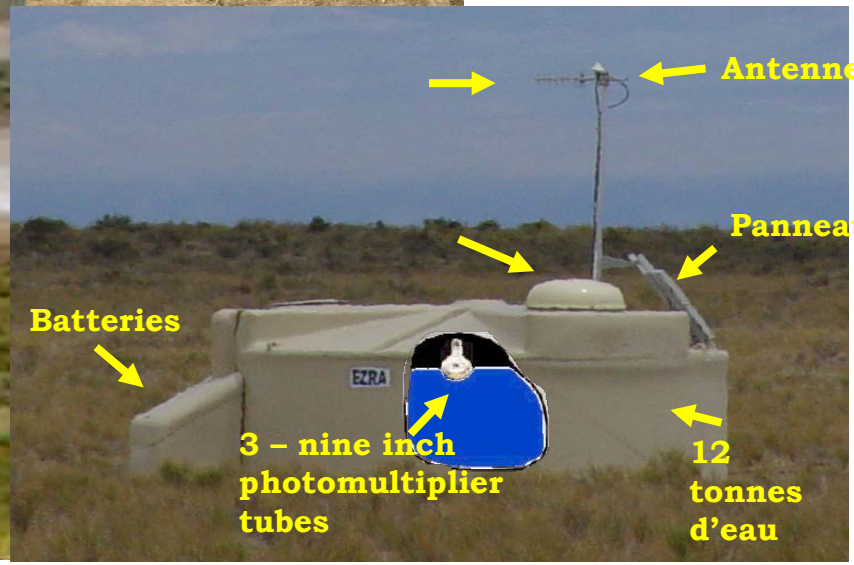
German detector :

COSMO Like … I don’t know

Measurements in CERN's Desert

HST CERN 2015

Like Argentina's desert
For the AUGER Experiment

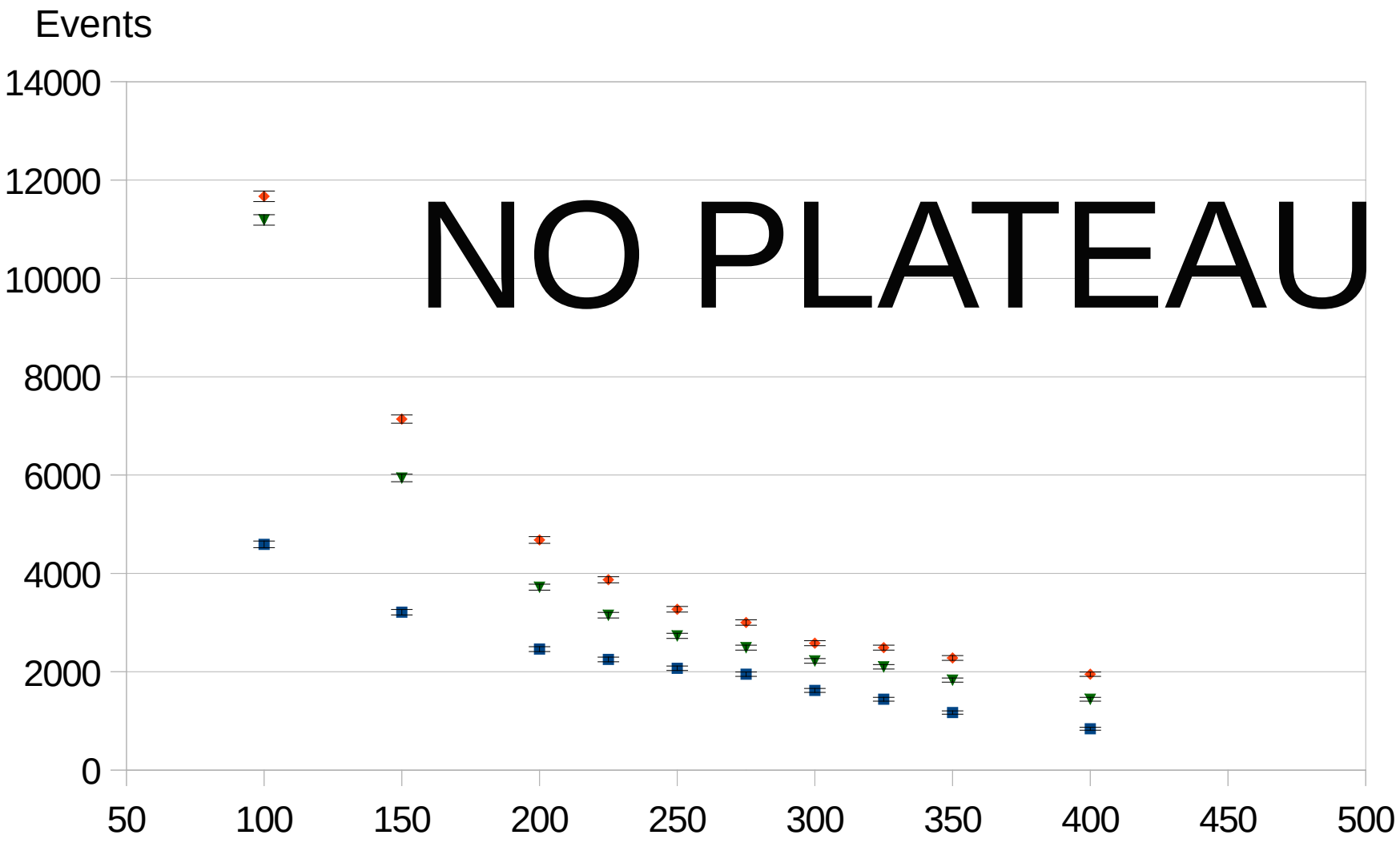


Moving the German detector

HST CERN 2015

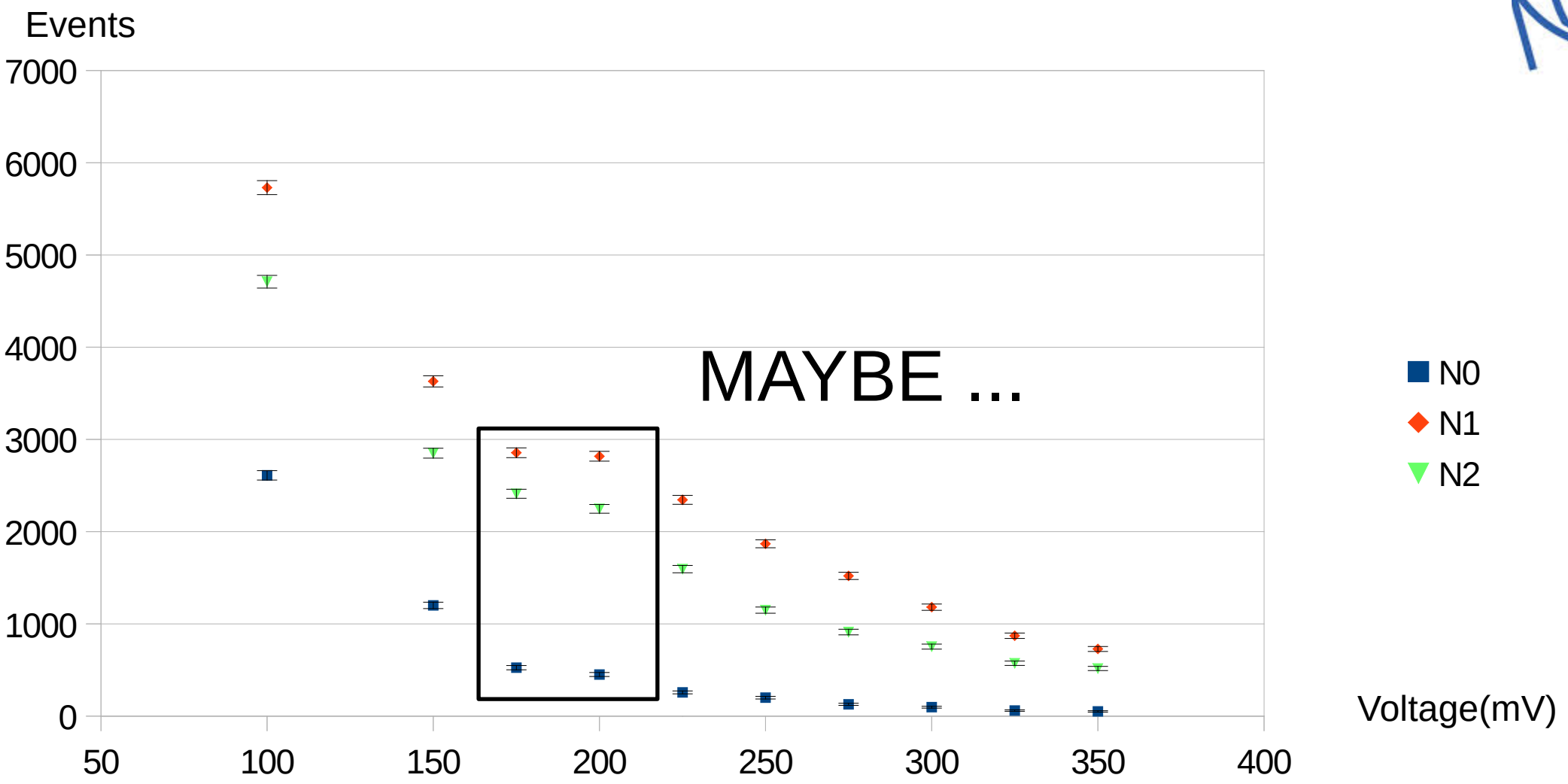
Like moving the AUGER Experiment???

Calibration RESULTS



NO PLATEAU !!!!

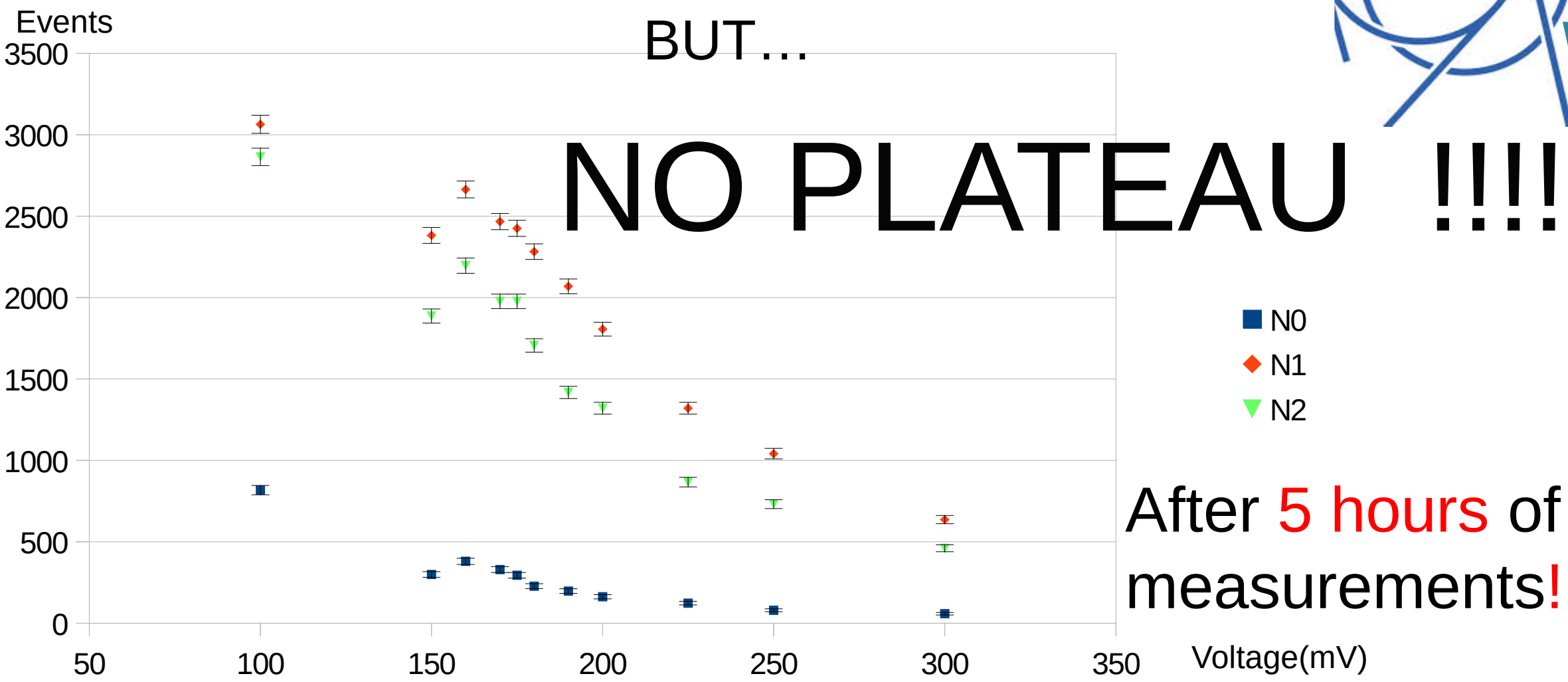
Calibration RESULTS



Calibration RESULTS

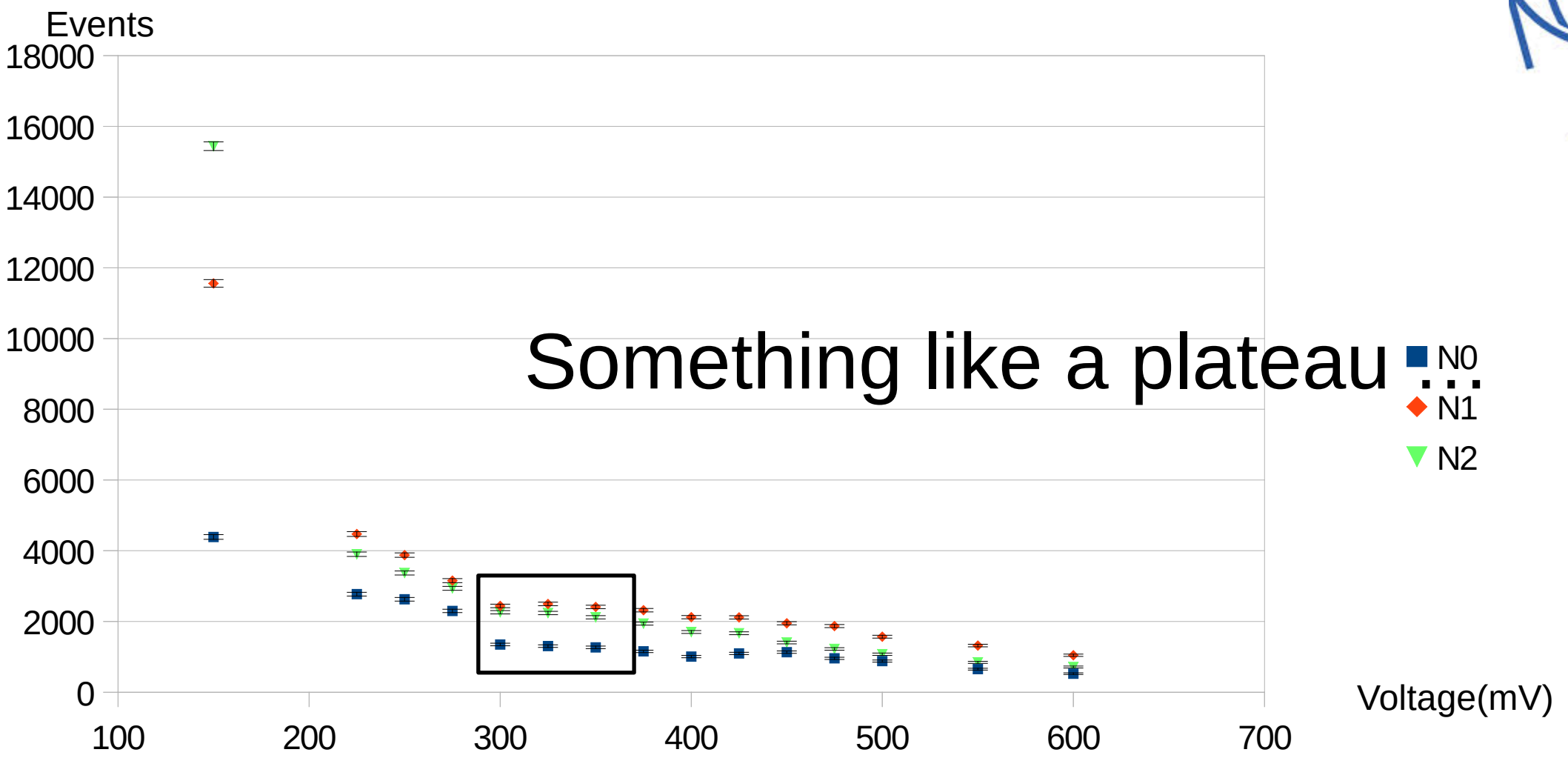
BUT…

NO PLATEAU !!!!



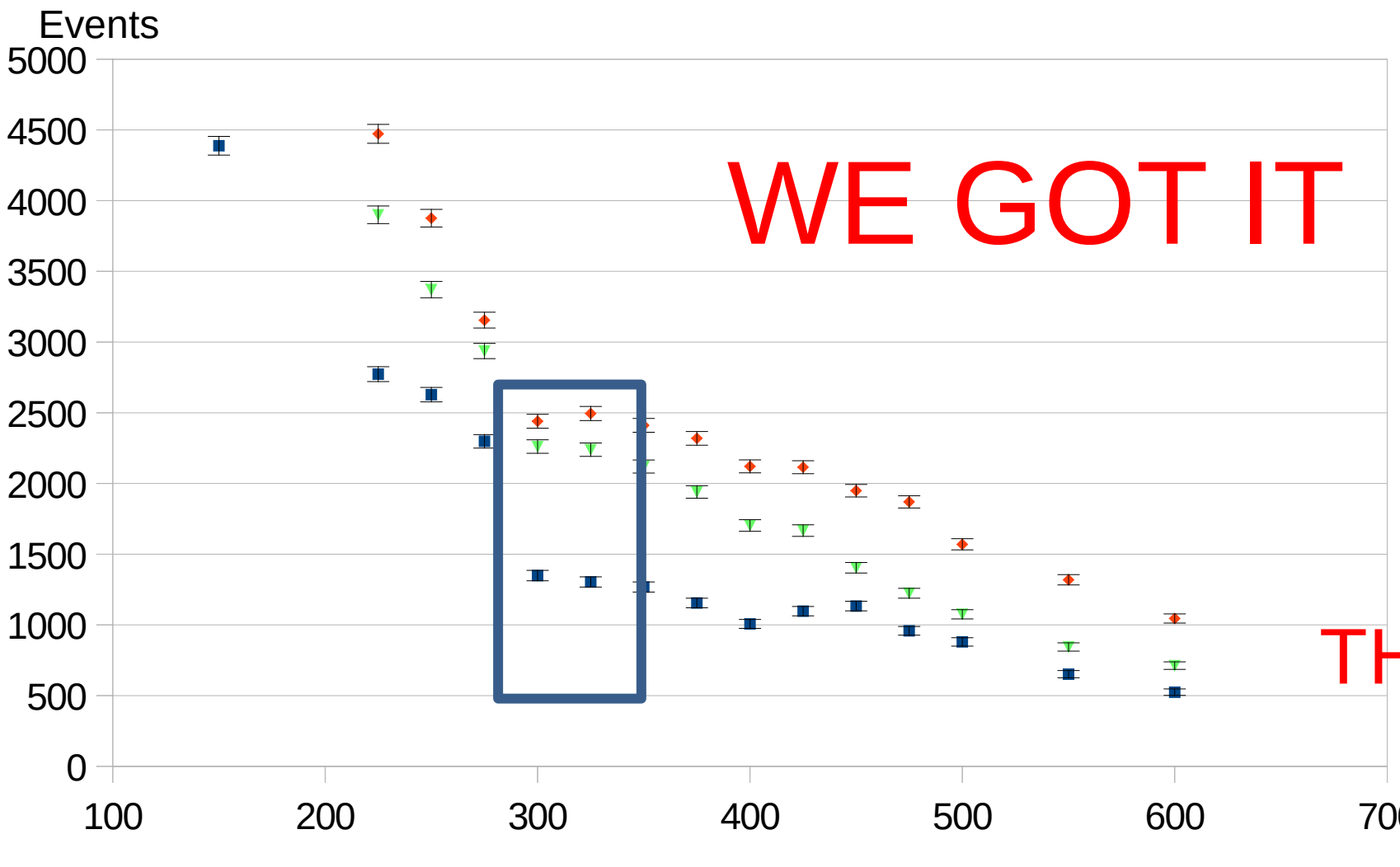
After 5 hours of measurements!!

Calibration FINAL RESULTS...



Something like a plateau ...

Calibration FINAL RESULTS...



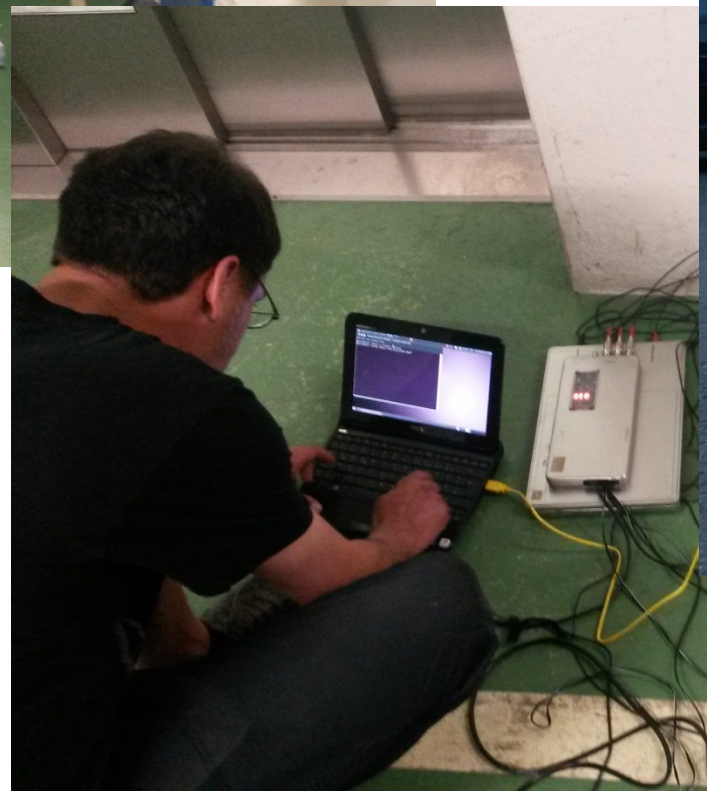
WE GOT IT !!!

THRESHOLD VOLTA

313 mV

MEASUREMENTS OF FLUXES OF MUONS

HST CERN 2015



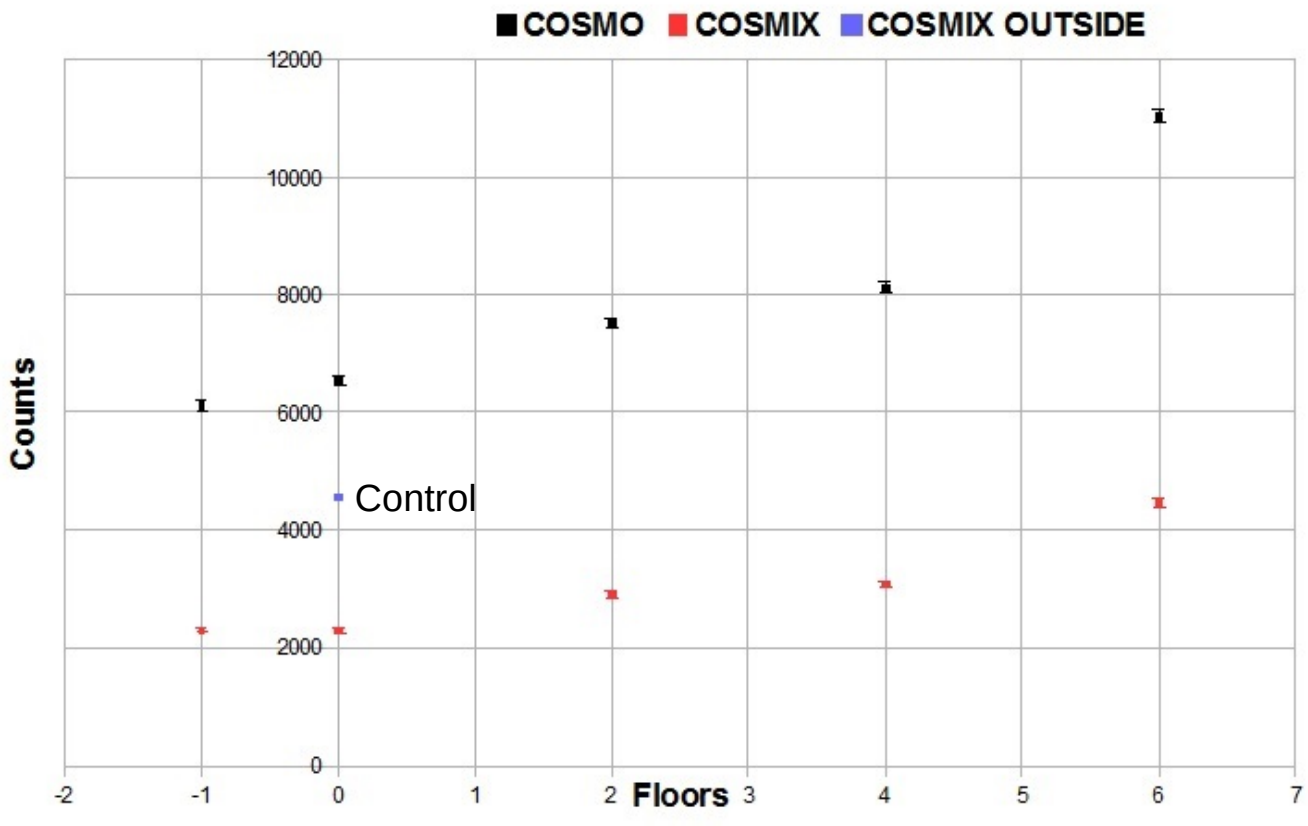
CosMo vs COSMIX

In the Building 60

German Muon Detector
2 scintillators in coincidence
20 cm x 20 cm x 1.8 cm

French Muon Detector
2 scintillators without coincidence
16 cm x 3 cm x 2 cm

From Basement to 6th Floor



"La fameuse boîte"
("The famous box")...
it looks like a car bomb!!!

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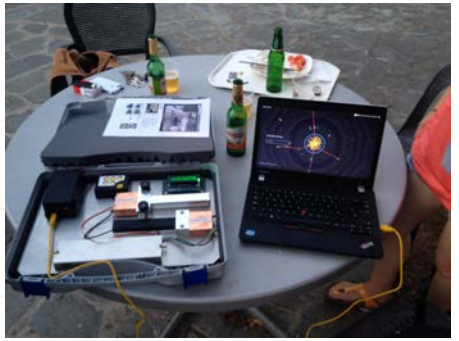
A trip to Col de la Faucille...

Altitude (m)

Col de la Faucille 1323 m
218 muons / minute

Le Pailly 1200 m
206 muons / minute

Le Florimont 990 m
200 muons / minute

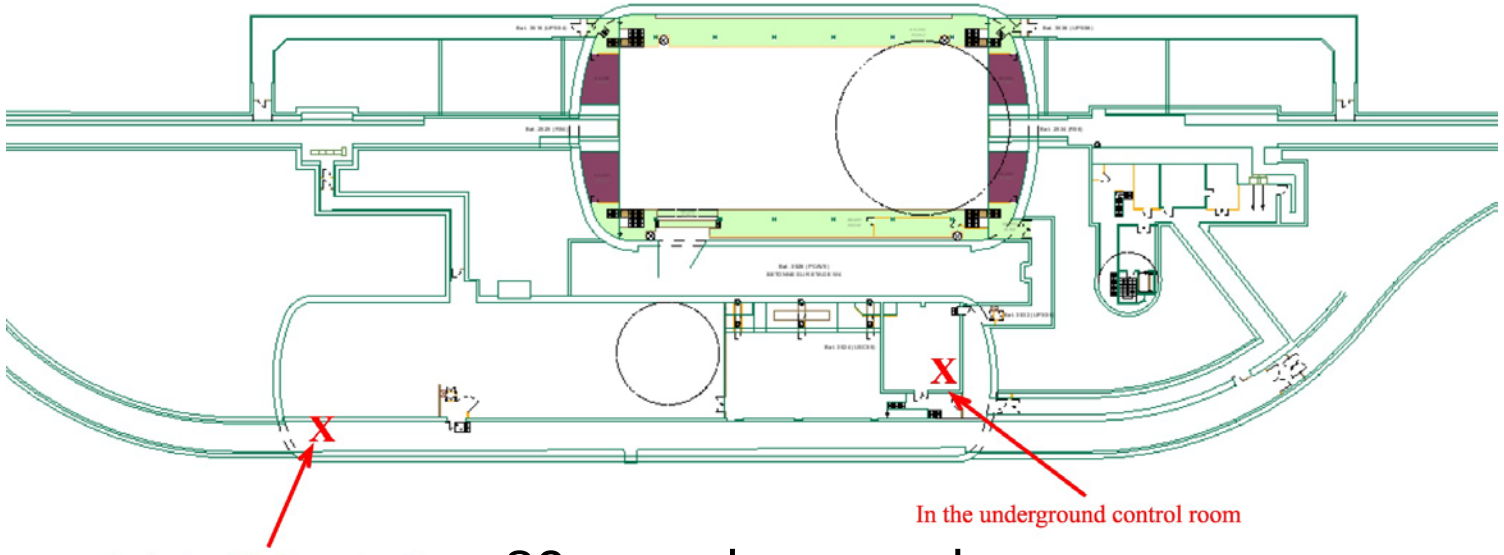


CERN 440 m
160 muons / minute

Departure

Return

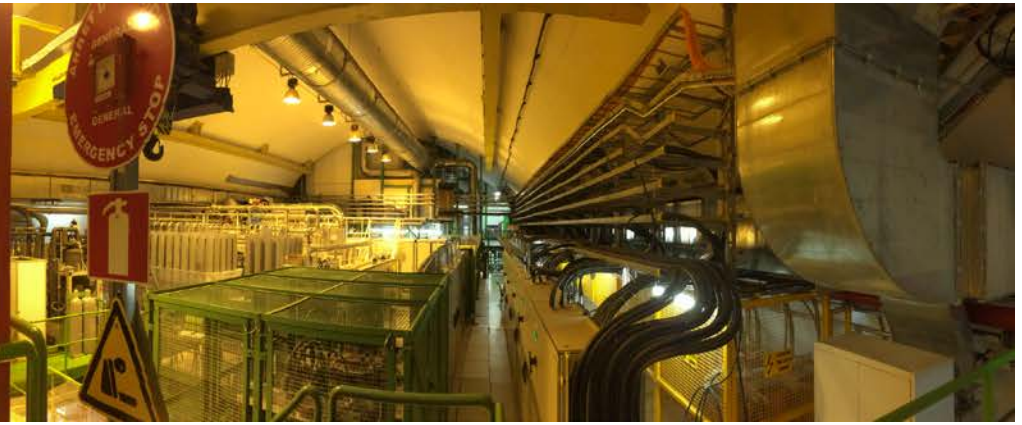
At CMS with COSMIX



80 m underground

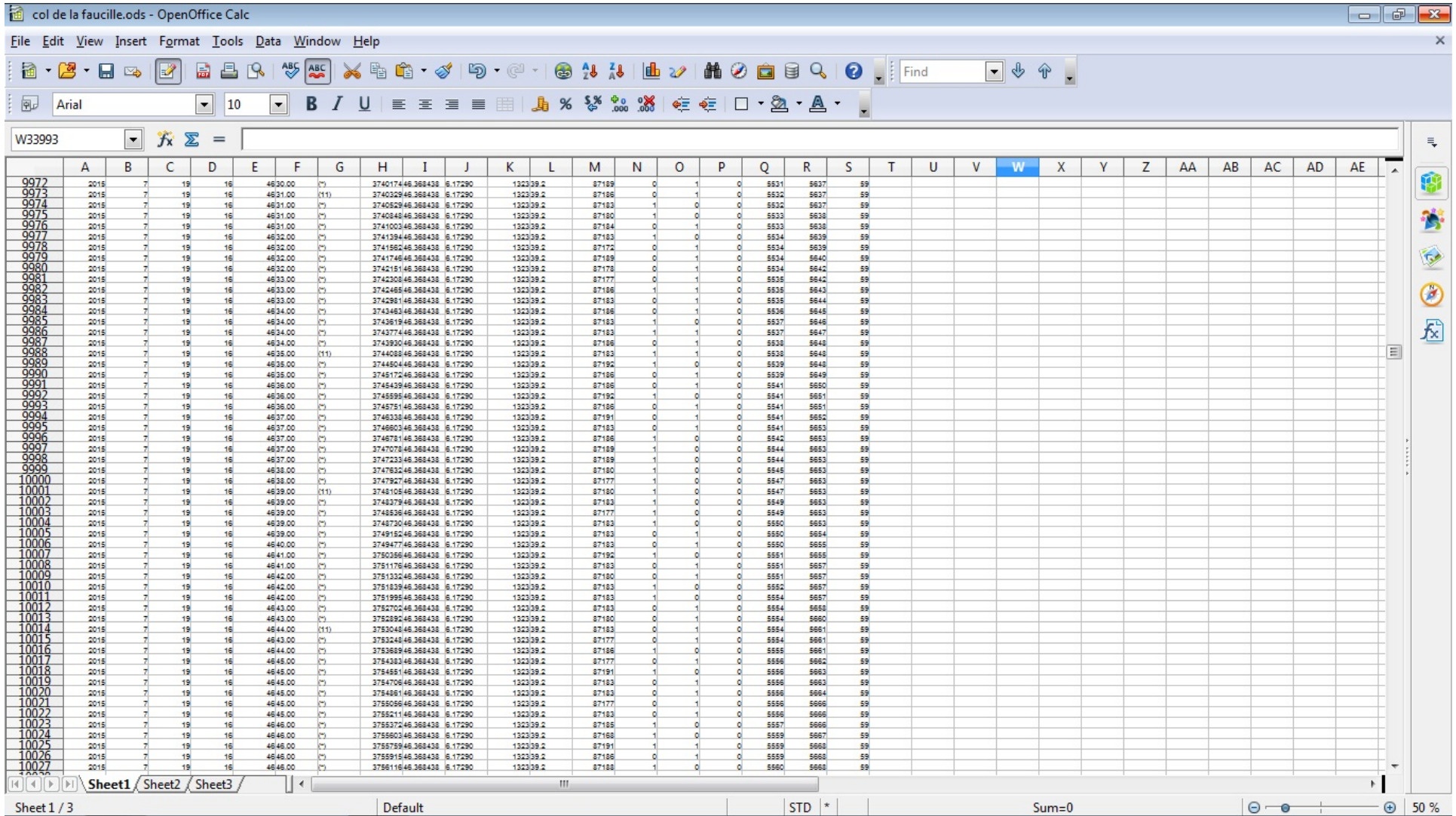
92 muons after 30 minutes
~ 3.1 muons / minute

83 muons after 30 minutes
~ 2.8 muons / minute



Compared with…
3162 muons after 30 minutes near the CMS control room!!!
~ 105 muons / minute

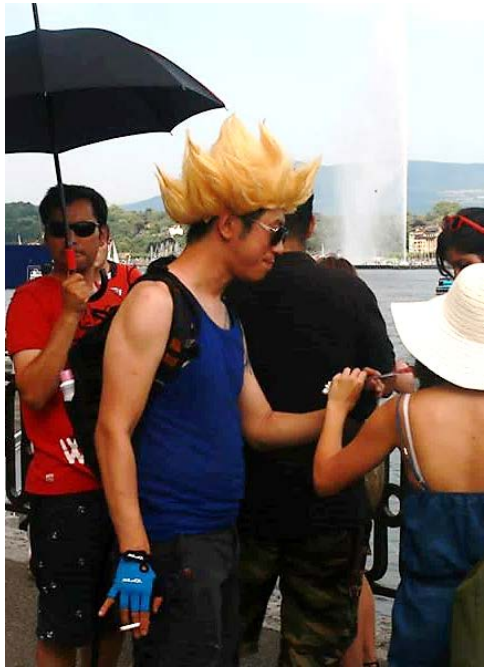
Not enough data...
only 34,023 lines
for that one!!!



The Geiger-Müller co measurement

HST CERN 2015

Geneva

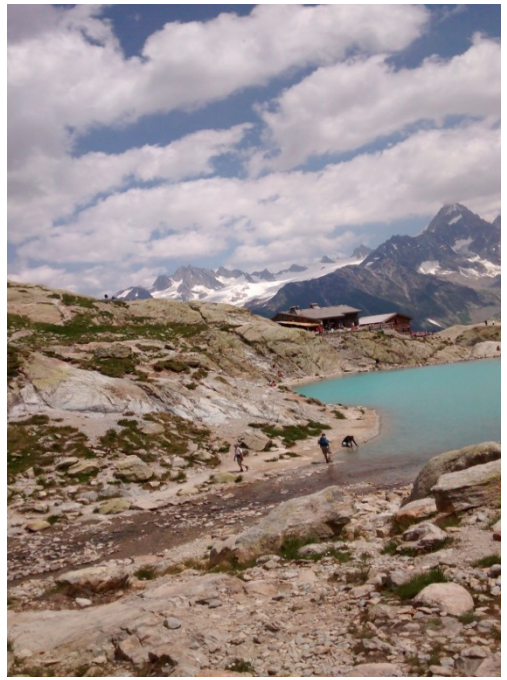


441m high

Chamonix

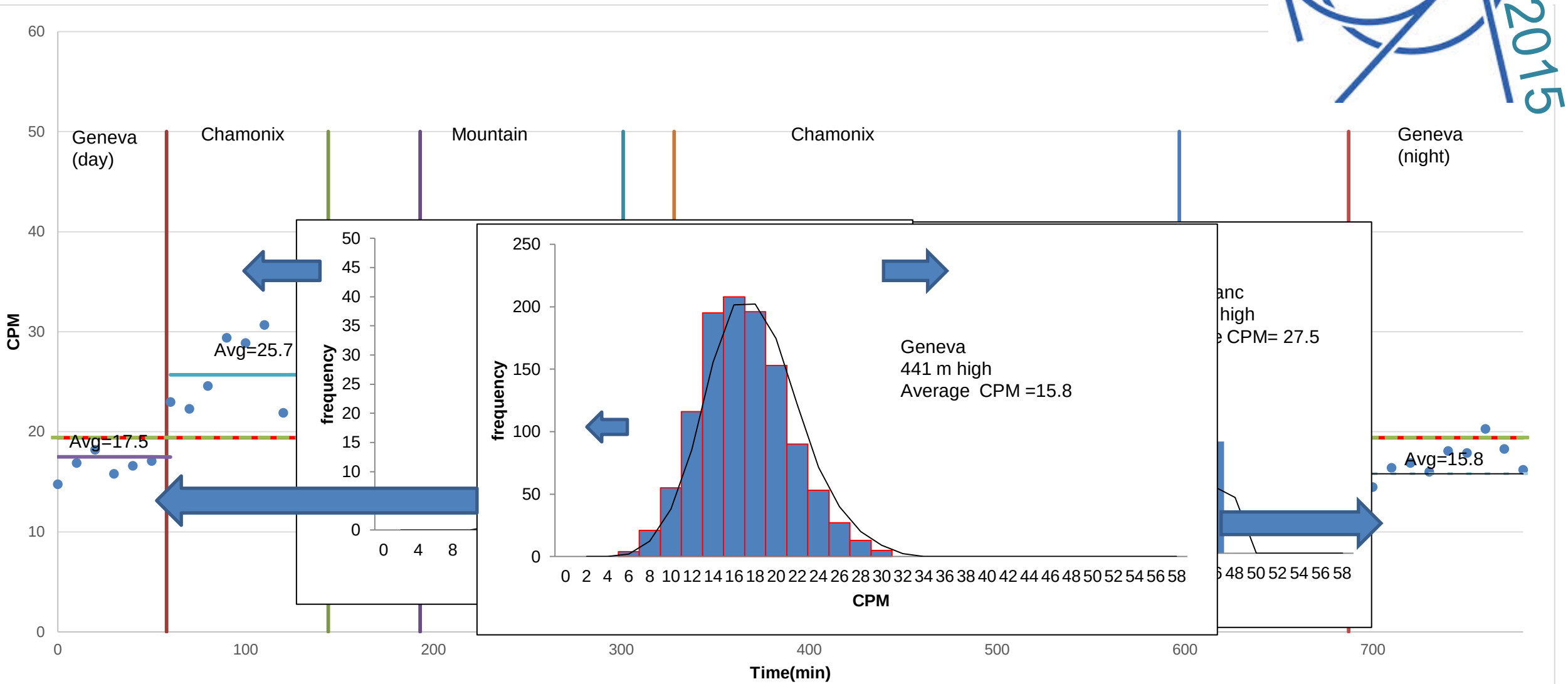
1000m high

Mountain

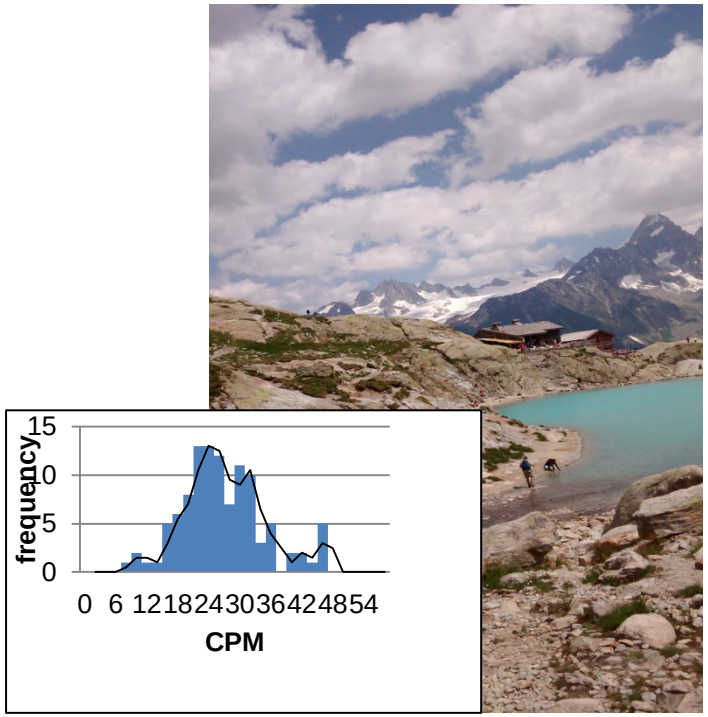


3600m high

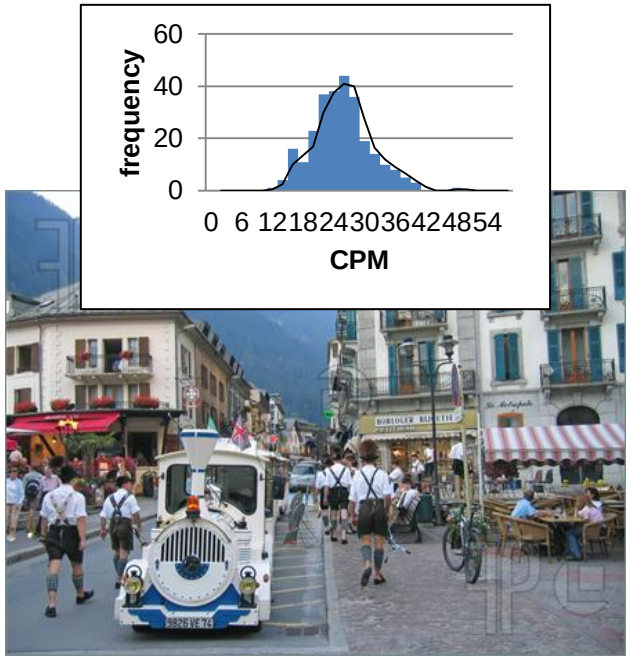
An Analysis of Number of Events in Different Level by Geiger counter.



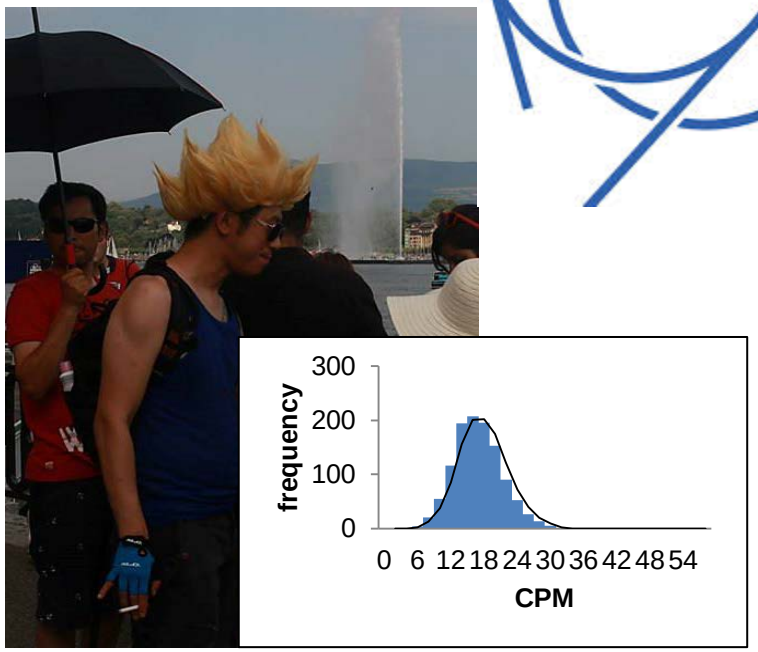
HST CERN 2015



441m high



1000m high



3600m high

Mountain>Chamonix>Geneva
(27.5) (25.7) (17.5)

Exploring the correlation between Pressure, Altitude and Intensity of the radiation

HST CERN 2015

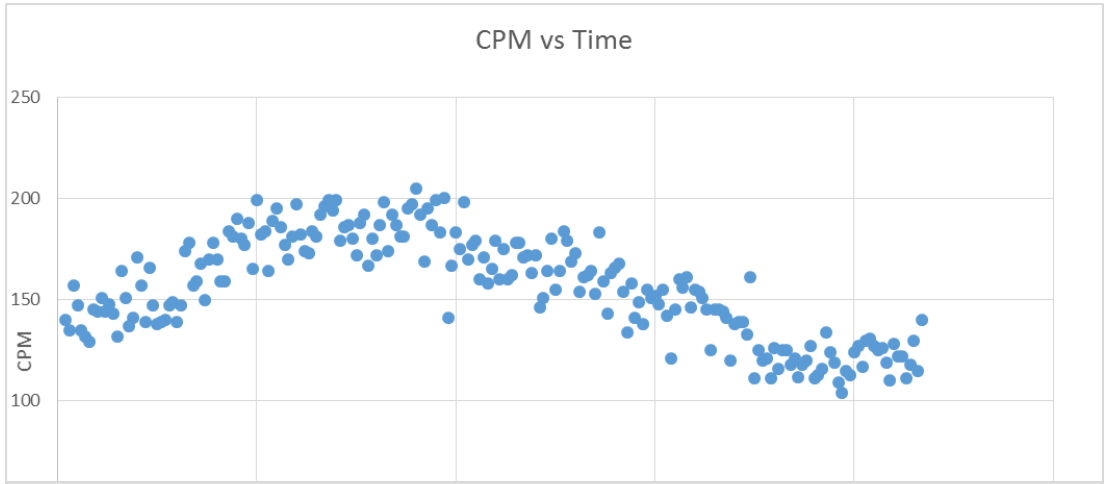
In a trip from Geneva (415 m) to La Faucille (1320 m) our colleagues (Sema, Edouard & Paco) took the COSMIX detector with them.

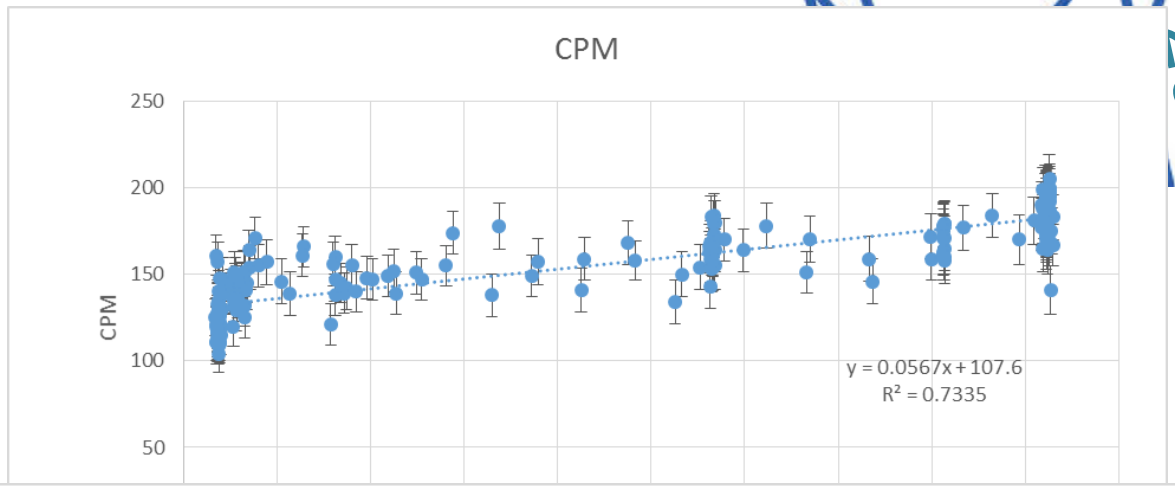
It collects data of CPM, altitude, pressure, latitide.

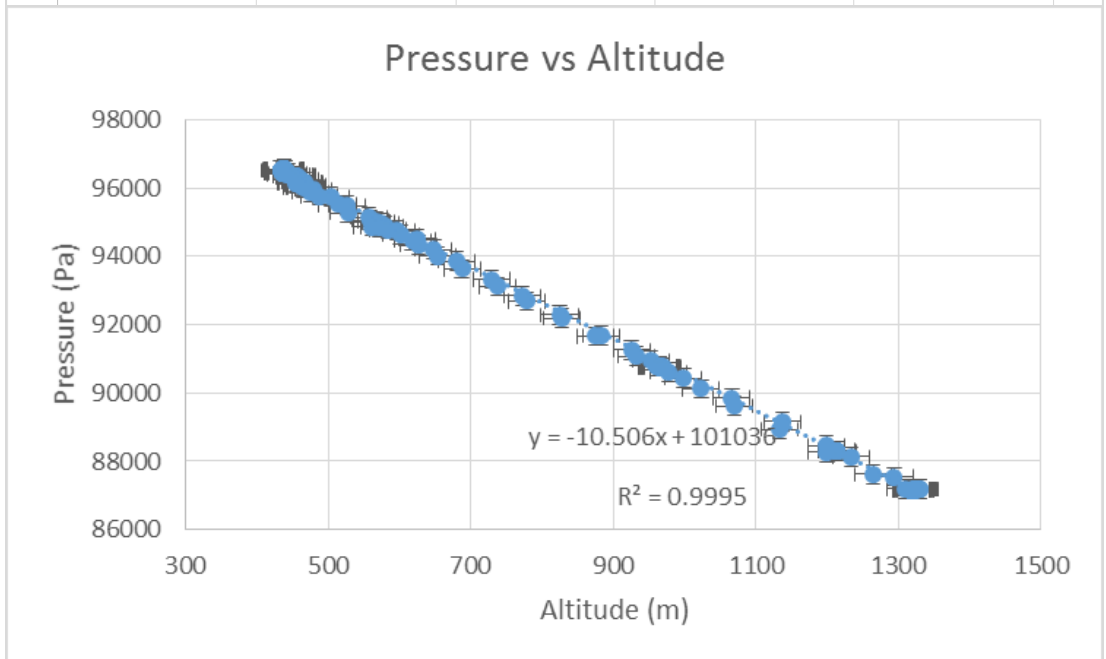
- ✓ CPMs increase linearly with altitude
- ✓ CPMs decreases linearly with pressure

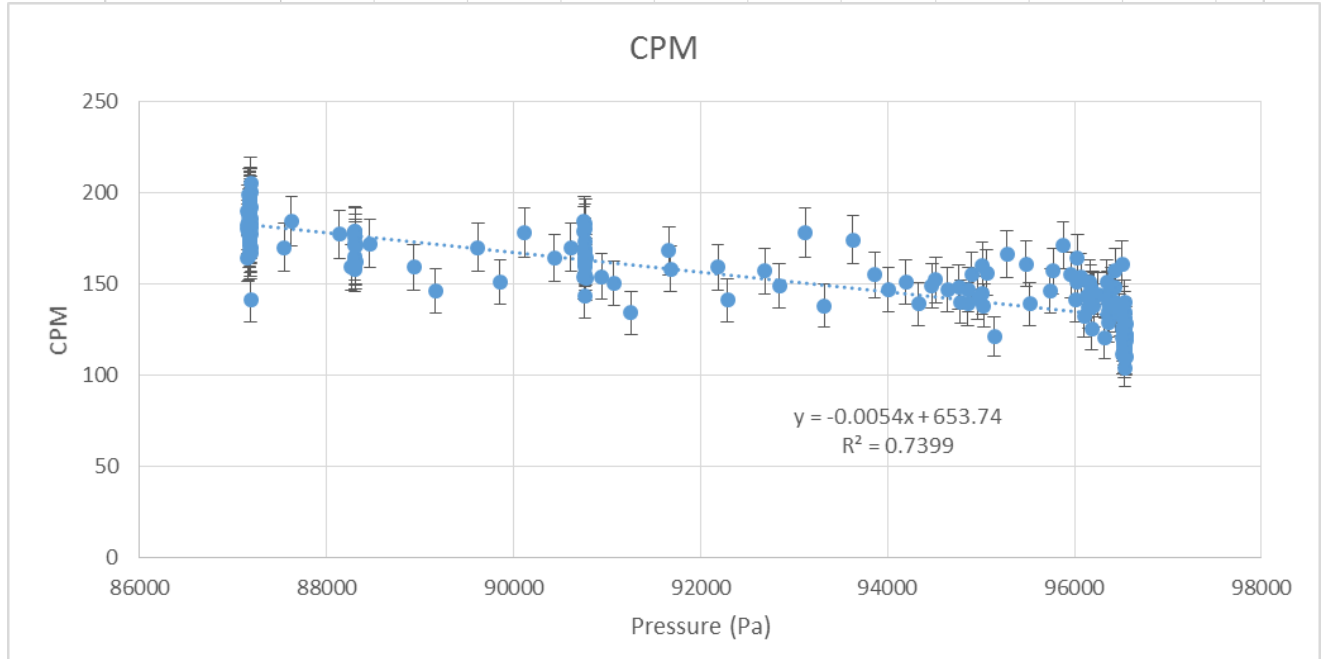
Exploring the correlation between Pressure, Altitude and Intensity of the radiation

HST CERN 2015









Didactical aspects

- ✓ Cosmic Rays as introduction to particle Physics
- ✓ Cheap instruments, easy to use
- ✓ Possibility to collect data at school
- ✓ Properties of Cosmic Rays (relations among intensity, altitude, pressure,...)
- ✓ Work on data analysis (statistics: mean, standard error, linear regression, histograms, poissonian distribution..., use of statistical software: excel, R, plotly....)

RADOS RDS-30 Survey Meter

Low cost survey meter

- Count rate
- Dose rate
- Dose rate mrem/h
- Accumulated dose
- Data logging
- IR link to computer

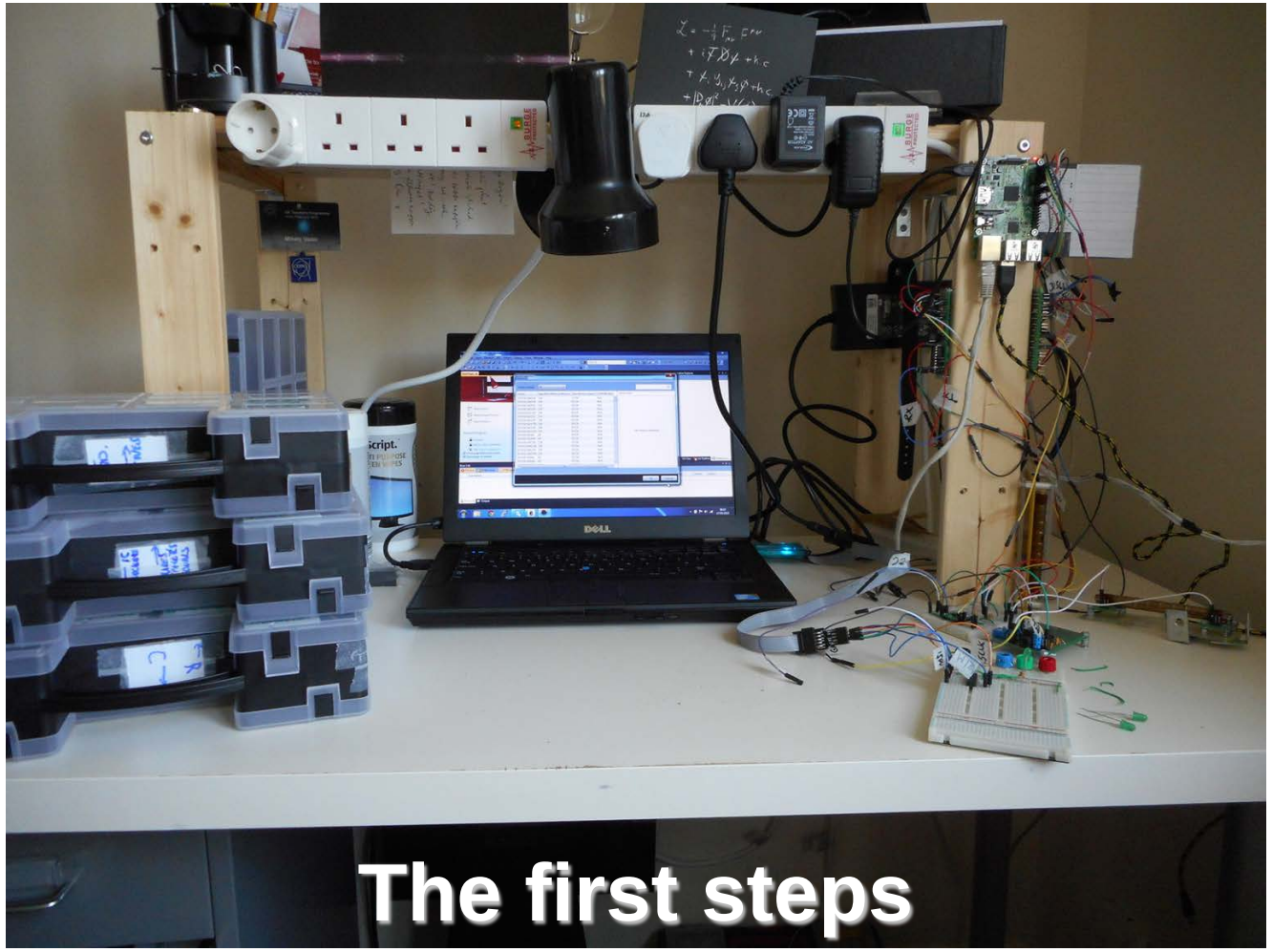
References

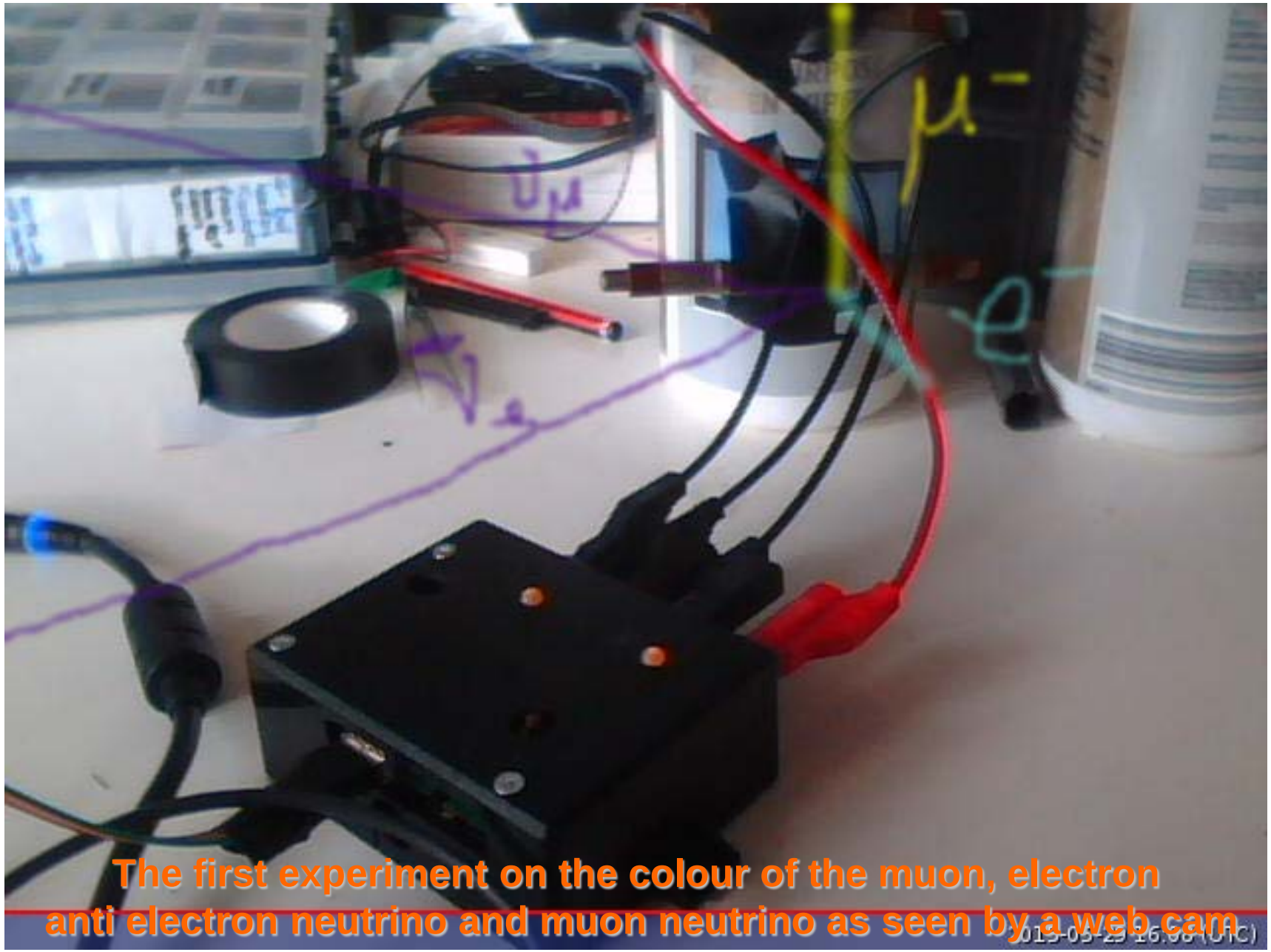
- ✓ Famoso B., La Rocca P., Riggi F., (2005), An educational study of the barometric effect of cosmic rays with Geiger counter, Physics Education 40 (5), 461-467.
- ✓Wibig T., Kolodziejczac K., Pierzynski R., Sobczak R., (2006) Educational studies of cosmic rays with a telescope of Geiger-Muller counters, Physics Education 41 (6), 542-545.
- ✓Blanco F., La Rocca P., Riggi F., Cosmic rays with portable Geiger counters: from sea level to airplane cruise altitute, (2009), European Journal of Physics, 30, 685-695.
- ✓GMC-320 Plus Geiger Counter User Guide.
- ✓COSMIX detector User Guide.

HST CERN 2015

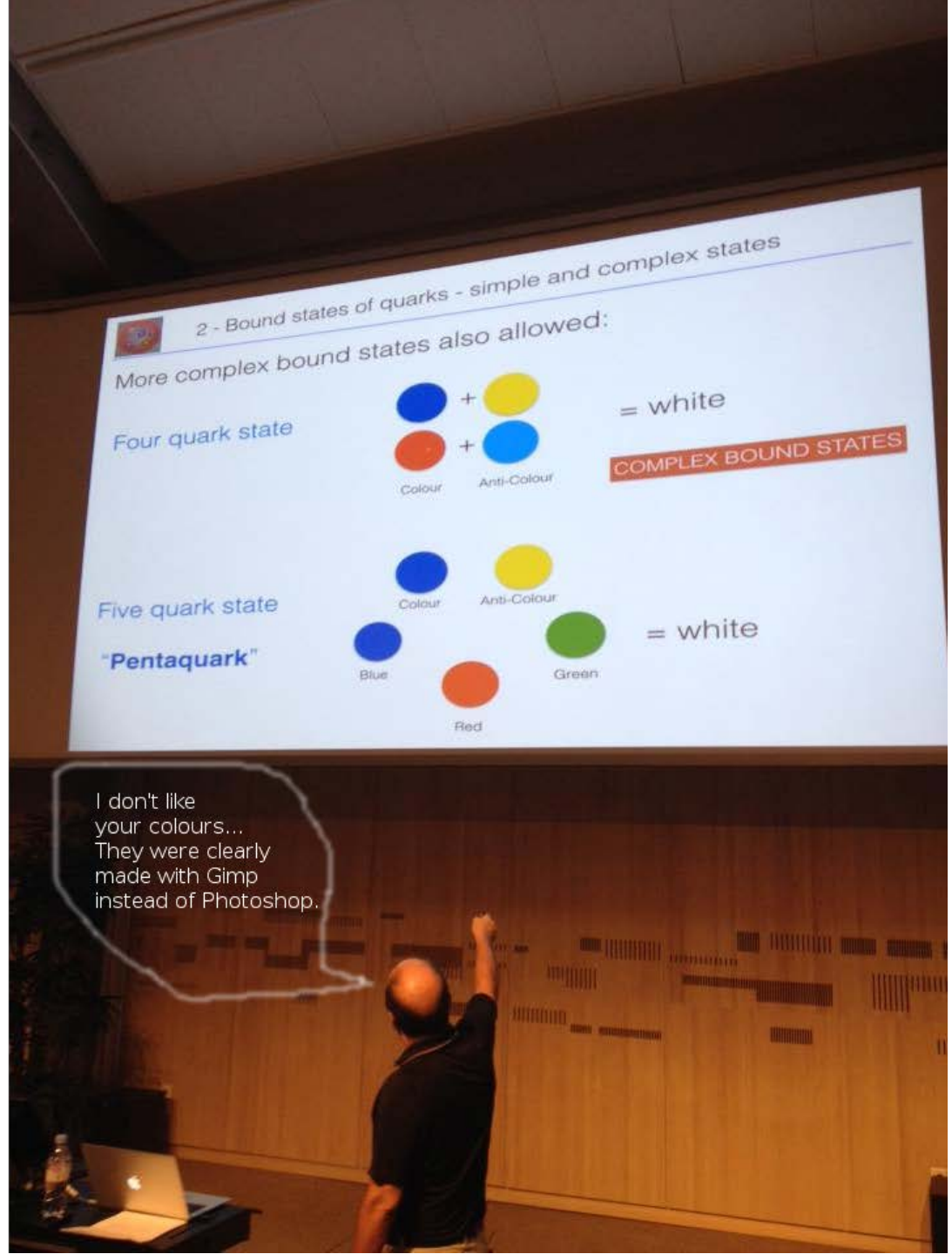
- Coincidence detector using GM tubes
- Nobel prize in physics 1954 for Walter Bothe ”for his discovery of the method of coincidence and the discoveries subsequently made by it”
- Experiments and electronic devices made by Bruno Rossi

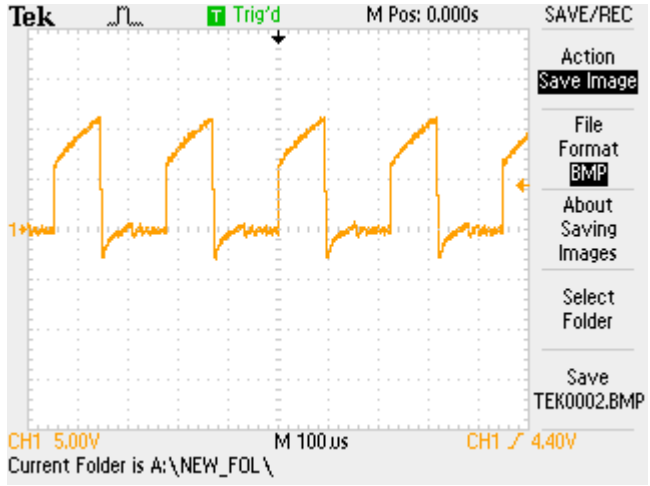

CMS muon system

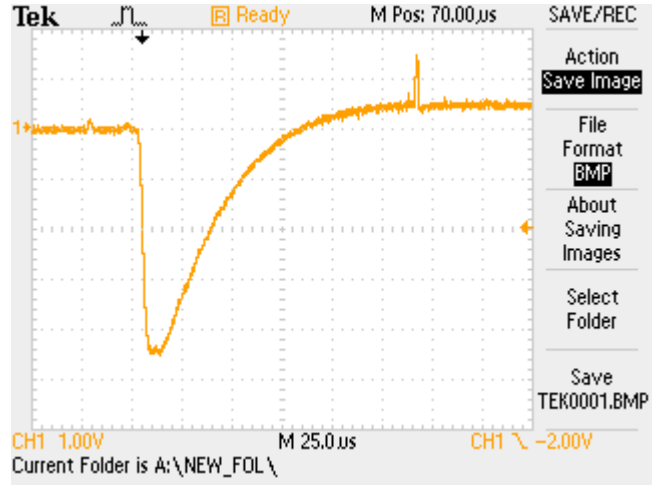

The first steps

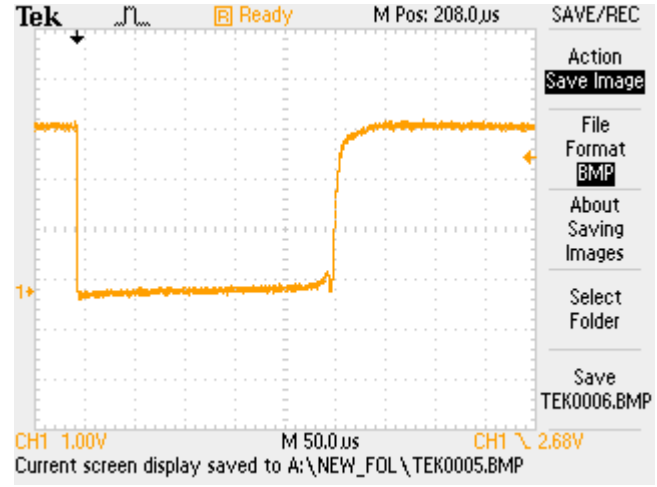


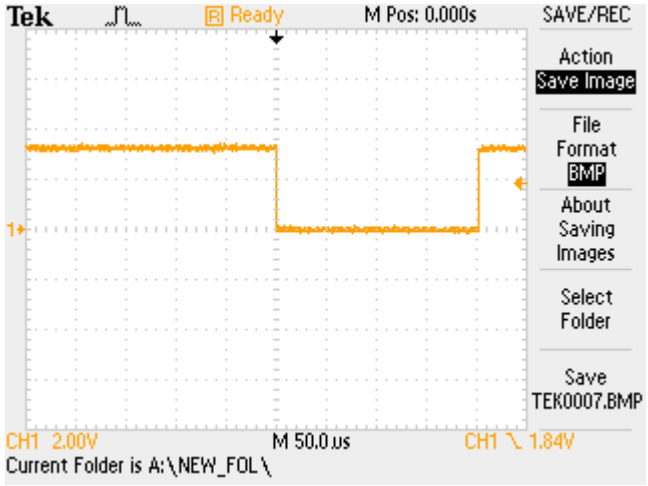
The first experiment on the colour of the muon, electron anti electron neutrino and muon neutrino as seen by a web cam

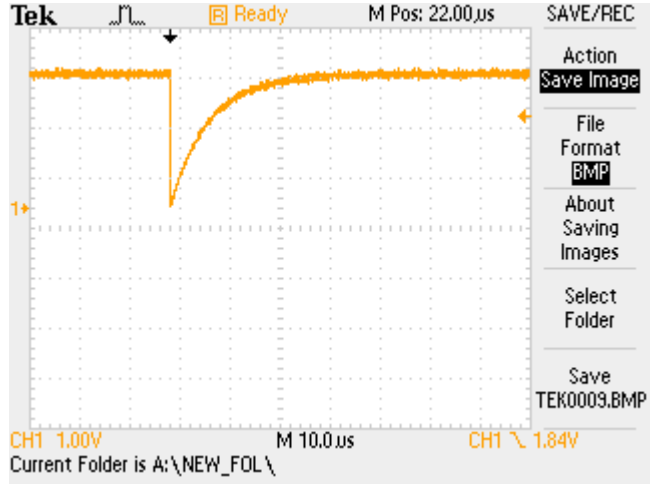

2 - Bound states of quarks - simple and complex states
More complex bound states also allowed:
Four quark state
+
+
Colour
Anti-Colour
= white
COMPLEX BOUND STATES
Five quark state
"Pentaquark"
Colour
Anti-Colour
Blue
Green
Red
= white
I don't like
your colours...
They were clearly
made with Gimp
instead of Photoshop.

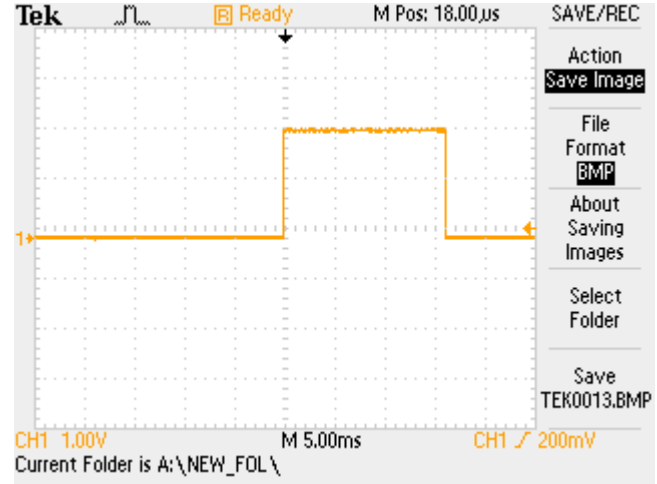

Tek
Trig'd
M Pos: 0.000s
SAVE/REC
Action
Save Image
File Format
BMP
About Saving Images
Select Folder
Save TEK0002.BMP
CH1 5.00V
M 100 µs
CH1 ⁄ 4.40V
Current Folder is A:\NEW_FOL\

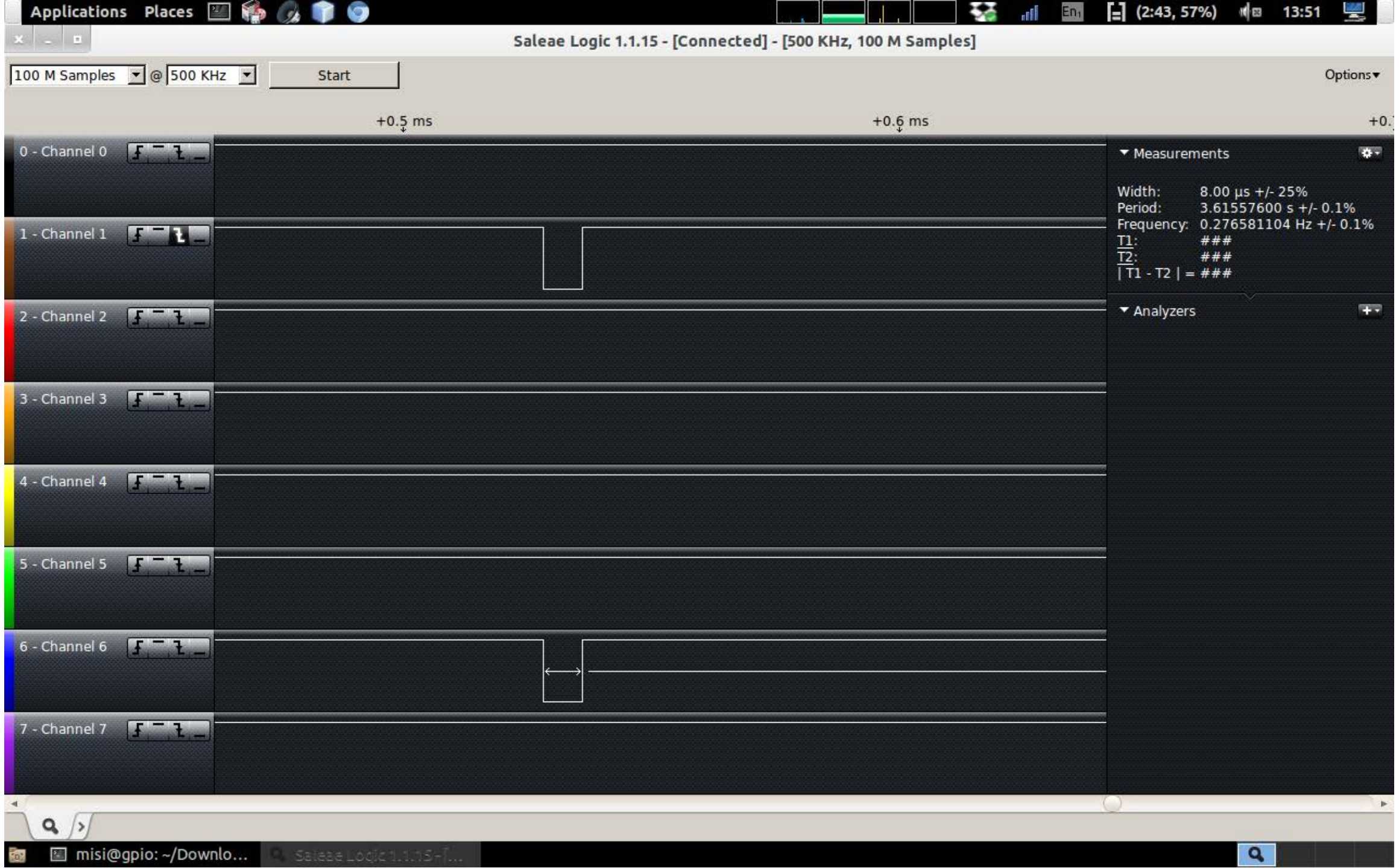

Tek
Ready
M Pos: 70.00 µs
SAVE/REC
Action
Save Image
File Format
BMP
About Saving Images
Select Folder
Save TEK0001.BMP
CH1 1.00V
M 25.0 µs
CH1 \ −2.00V
Current Folder is A:\NEW_FOL\

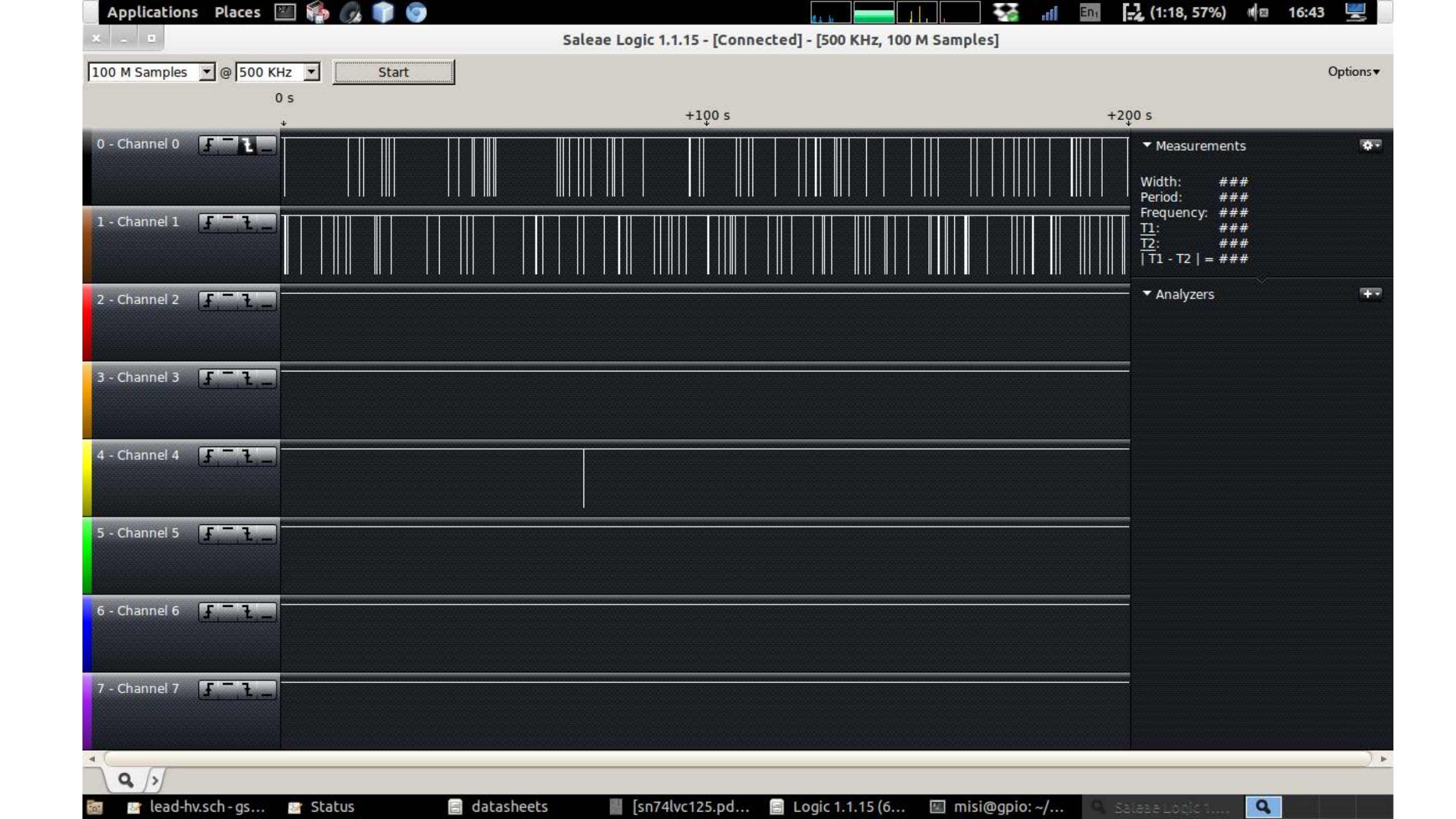

Tek
Ready
M Pos: 208.0 µs
SAVE/REC
Action
Save Image
File Format
BMP
About Saving Images
Select Folder
Save TEK0006.BMP
CH1 1.00V
M 50.0 µs
CH1 \ 2.68V
Current screen display saved to A:\NEW_FOL\TEK0005.BMP


Tek
Ready
M Pos: 0.000s
SAVE/REC
Action
Save Image
File Format
BMP
About Saving Images
Select Folder
Save TEK0007.BMP
CH1 2.00V
M 50.0 µs
CH1 \ 1.84V
Current Folder is A:\NEW_FOL\


Tek
Ready
M Pos: 22.00 µs
SAVE/REC
Action
Save Image
File Format
BMP
About Saving Images
Select Folder
Save TEK0009.BMP
CH1 1.00V
M 10.0 µs
CH1 \ 1.84V
Current Folder is A:\NEW_FOL\


Tek
Ready
M Pos: 18.00 µs
SAVE/REC
Action
Save Image
File Format
BMP
About Saving Images
Select Folder
Save TEK0013.BMP
CH1 1.00V
M 5.00ms
CH1 ⁄ 200mV
Current Folder is A:\NEW_FOL\


Applications
Places
(2:43, 57%)
13:51
Saleae Logic 1.1.15 - [Connected] - [500 KHz, 100 M Samples]
100 M Samples
@
500 KHz
Start
Options
+0.5 ms
+0.6 ms
0 - Channel 0
1 - Channel 1
2 - Channel 2
3 - Channel 3
4 - Channel 4
5 - Channel 5
6 - Channel 6
7 - Channel 7
Measurements
Width: 8.00 µs +/- 25%
Period: 3.61557600 s +/- 0.1%
Frequency: 0.276581104 Hz +/- 0.1%
T1: ###
T2: ###
| T1 - T2 | = ###
Analyzers
misi@gpio: ~/Downlo...

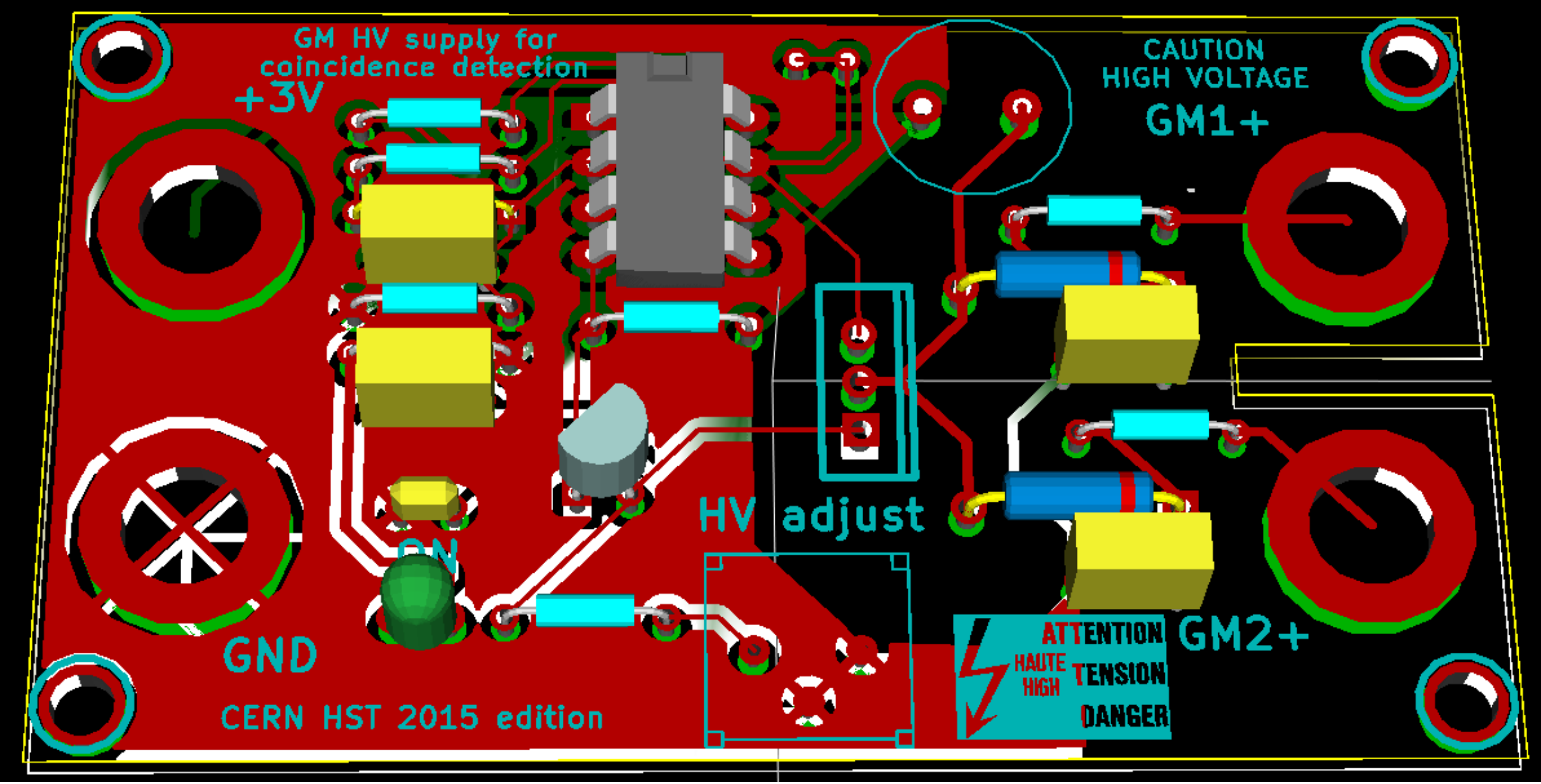

Applications
Places
(1:18, 57%)
16:43
Saleae Logic 1.1.15 - [Connected] - [500 KHz, 100 M Samples]
100 M Samples
@
500 KHz
Start
Options
0 s
+100 s
+200 s
0 - Channel 0
1 - Channel 1
2 - Channel 2
3 - Channel 3
4 - Channel 4
5 - Channel 5
6 - Channel 6
7 - Channel 7
Measurements
Width: ###
Period: ###
Frequency: ###
T1: ###
T2: ###
| T1 - T2 | = ###
Analyzers
lead-hv.sch - gs...
Status
datasheets
[sn74lvc125.pd...
Logic 1.1.15 (6...
misi@gpio: ~/...

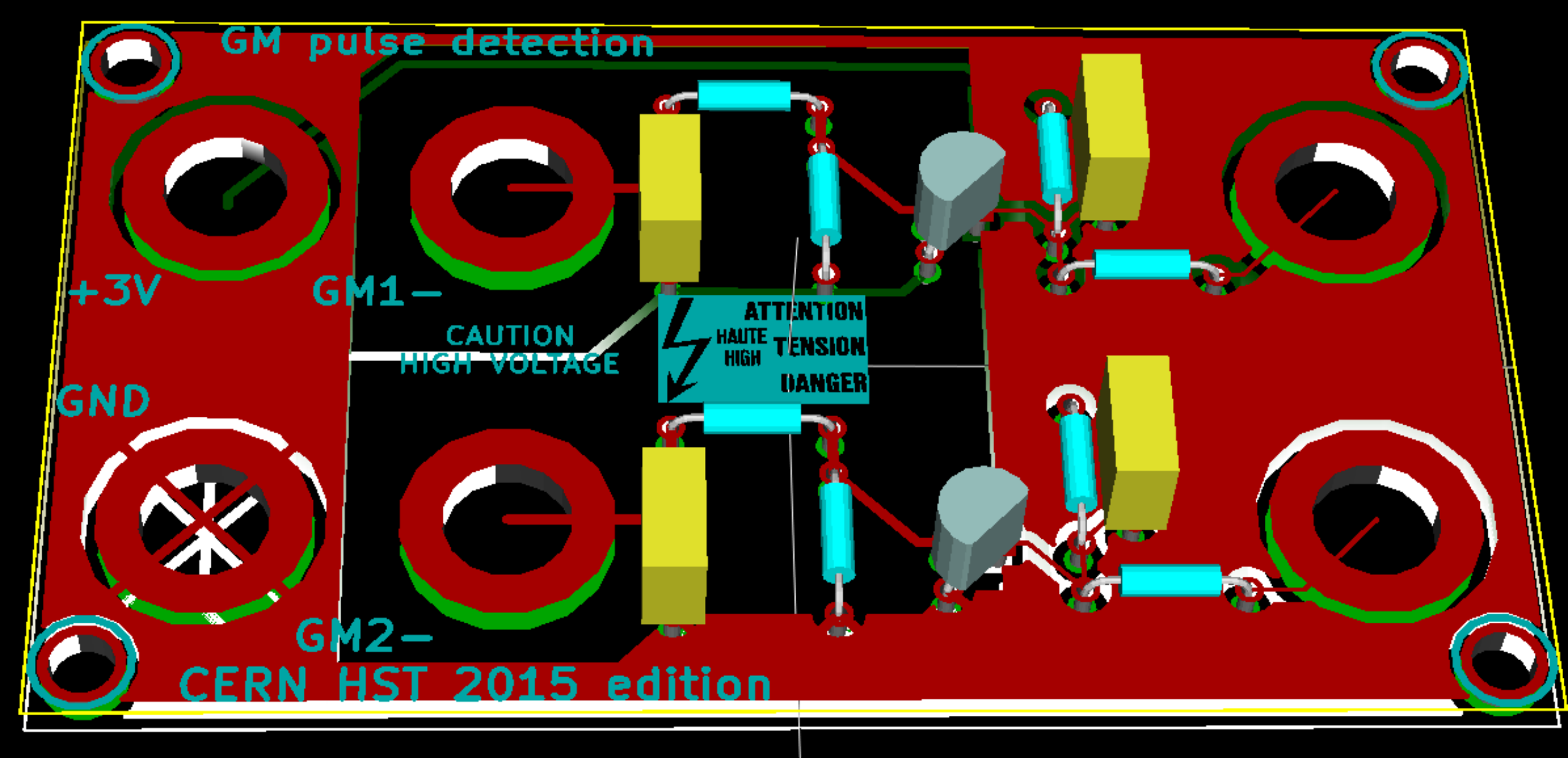
How good is the kit?
How many accidental coincidences do we get?

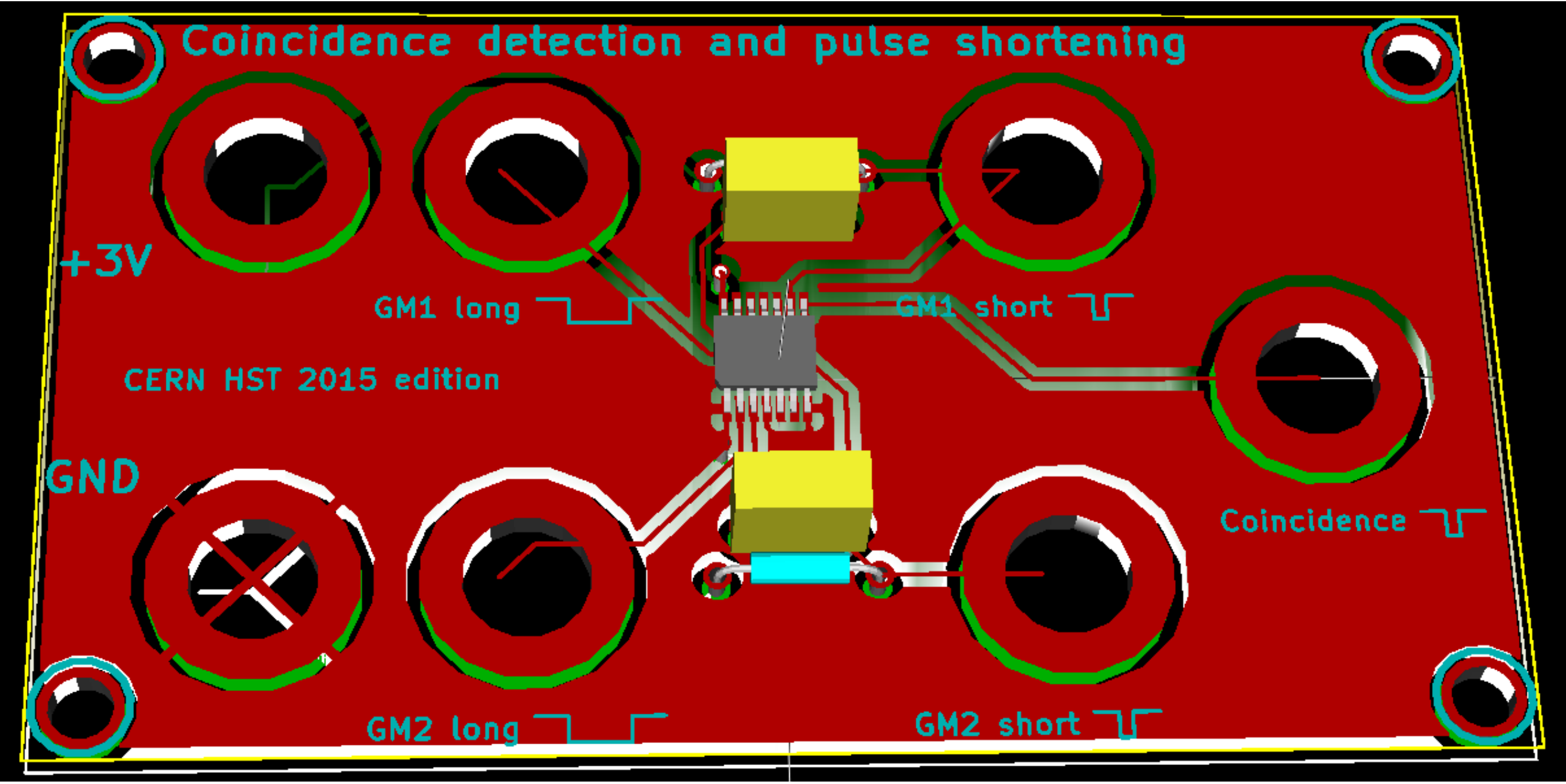
2*n1*n2*pulse width
n1 number of hits per second on gm1
n2 number of hits per second on gm2

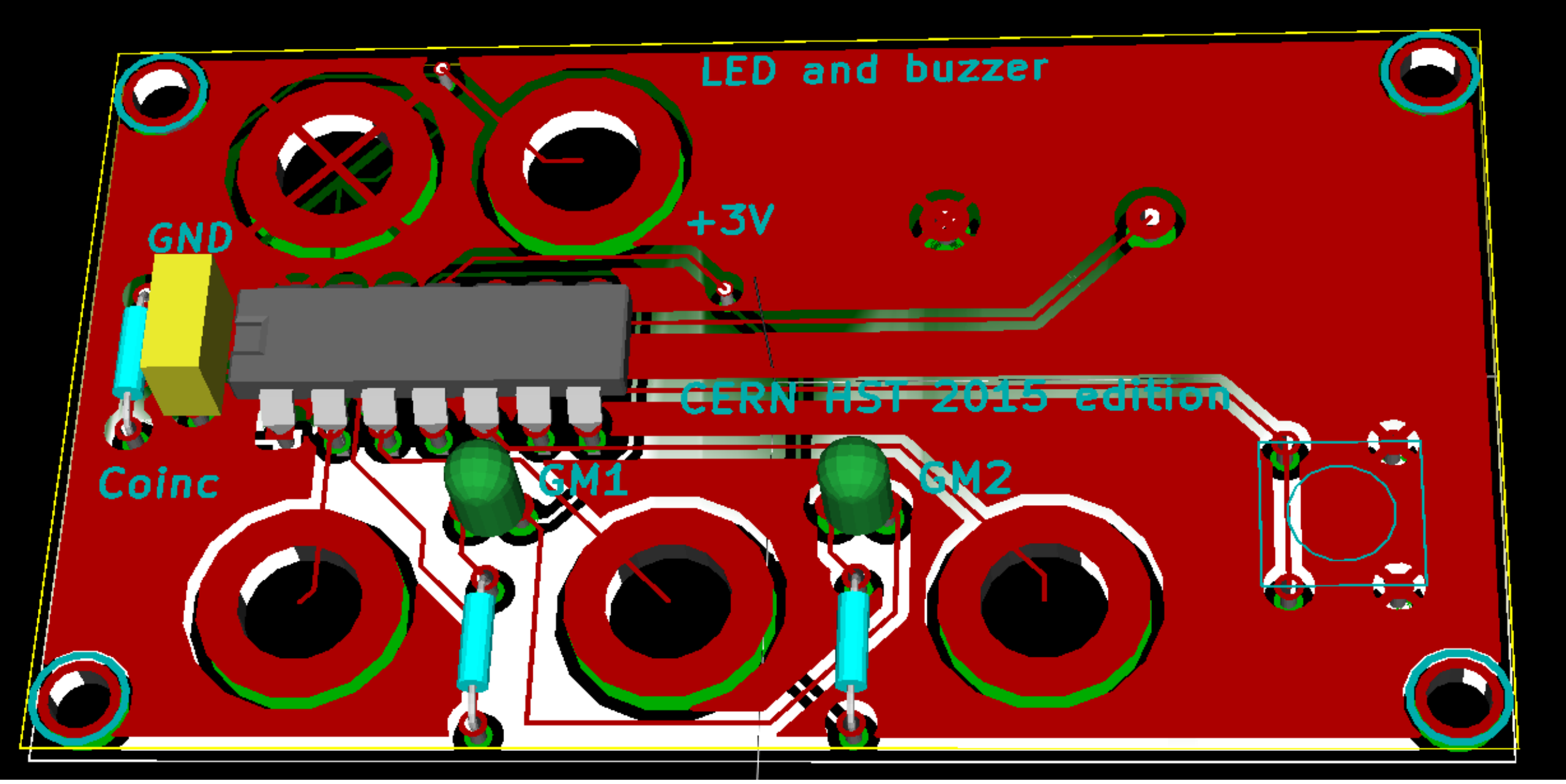
The muon hunter:
$2*(30/60)^2*5*10^{-6}=2.5*10^{-6}$ accidentals per second assuming normal background.
1 false detection happens in 4.3 days (103 h)

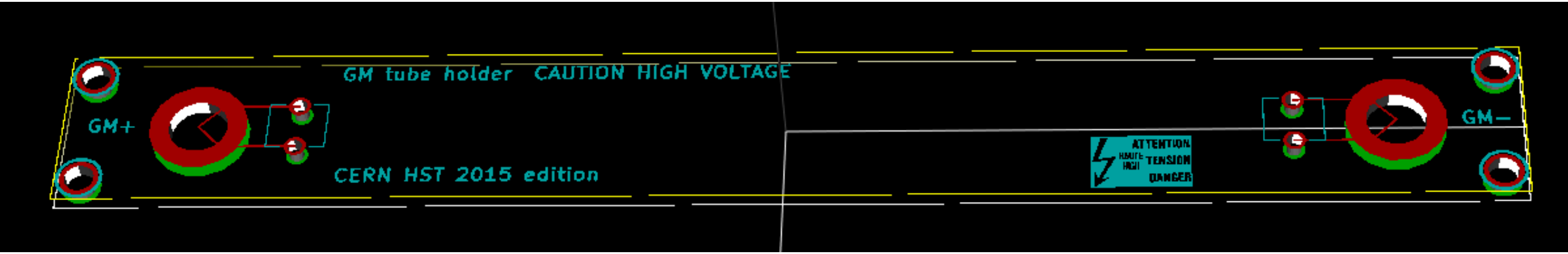
Without shortening this would be 1 false detection in 2.8 hours
with the same equipment. (see the HST2000 publication)

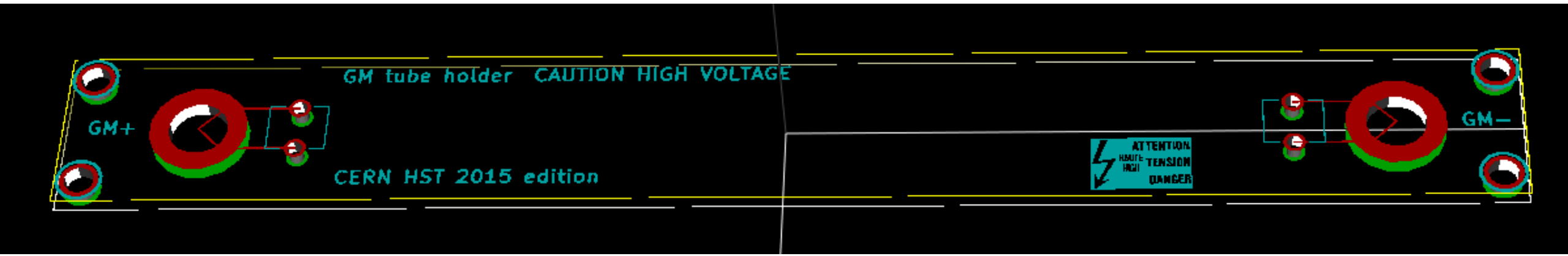

GM HV supply for
coincidence detection
+3V
CAUTION
HIGH VOLTAGE
GM1+
HV adjust
ON
GND
GM2+
ATTENTION
HAUTE TENSION
HIGH
DANGER
CERN HST 2015 edition

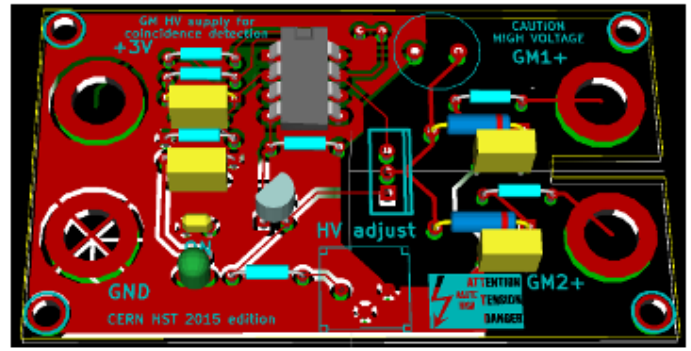

GM pulse detection
+3V
GM1−
CAUTION
HIGH VOLTAGE
ATTENTION
HAUTE TENSION
HIGH
DANGER
GND
GM2−
CERN HST 2015 edition

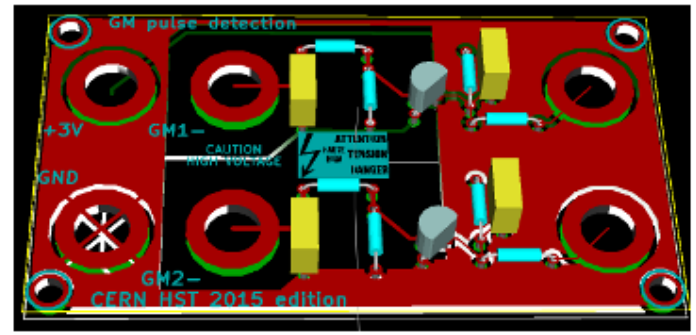

Coincidence detection and pulse shortening
+3V
GM1 long
GM1 short
CERN HST 2015 edition
GND
Coincidence
GM2 long
GM2 short

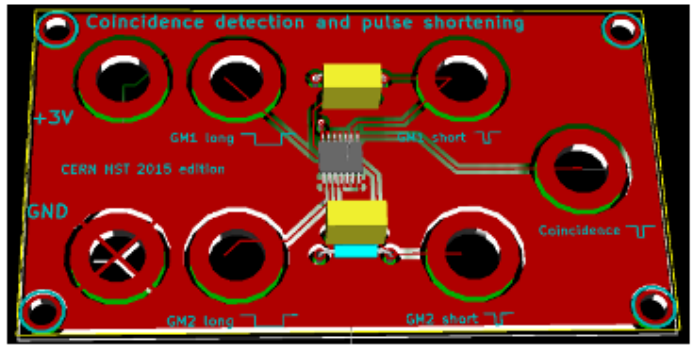

LED and buzzer
GND
+3V
CERN HST 2015 edition
Coinc
GM1
GM2

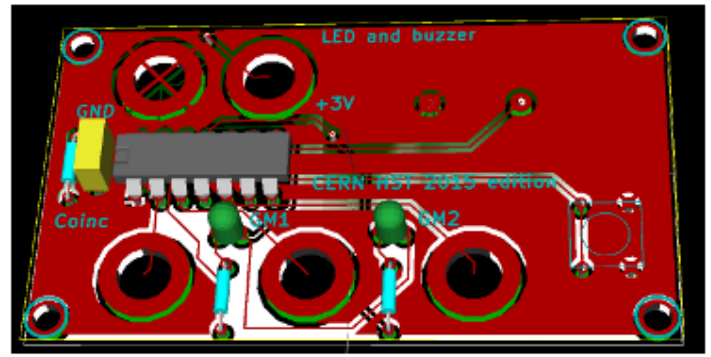

GM tube holder CAUTION HIGH VOLTAGE
GM+
CERN HST 2015 edition
ATTENTION
HAUTE TENSION
HIGH
DANGER
GM–


GM tube holder CAUTION HIGH VOLTAGE
GM+
CERN HST 2015 edition
ATTENTION
HAUTE TENSION
HIGH
DANGER
GM–

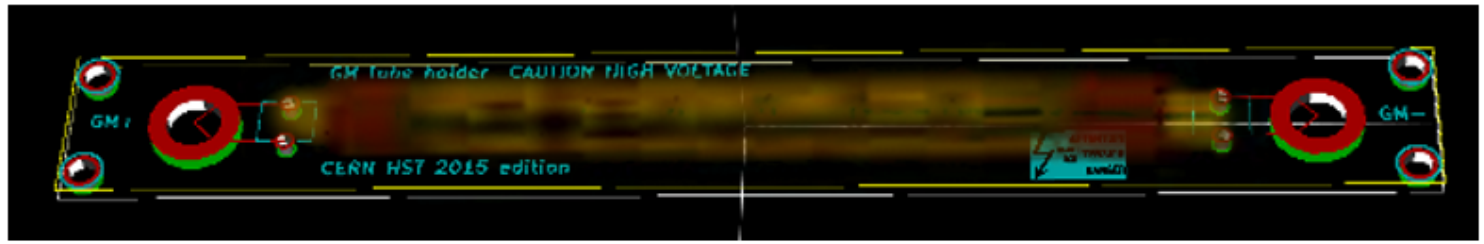


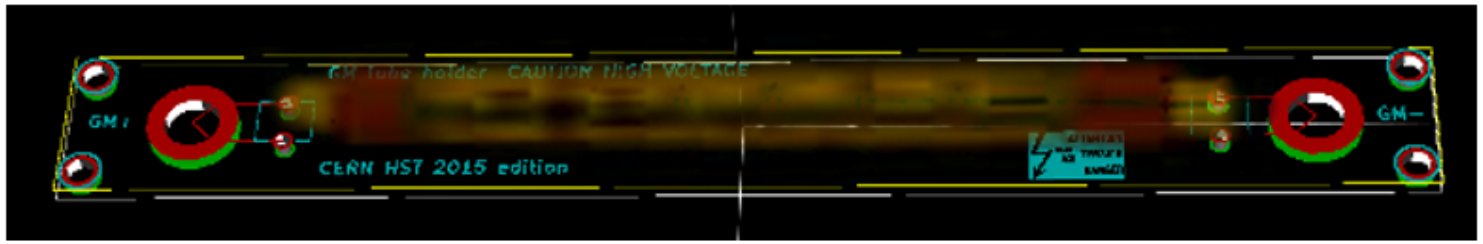






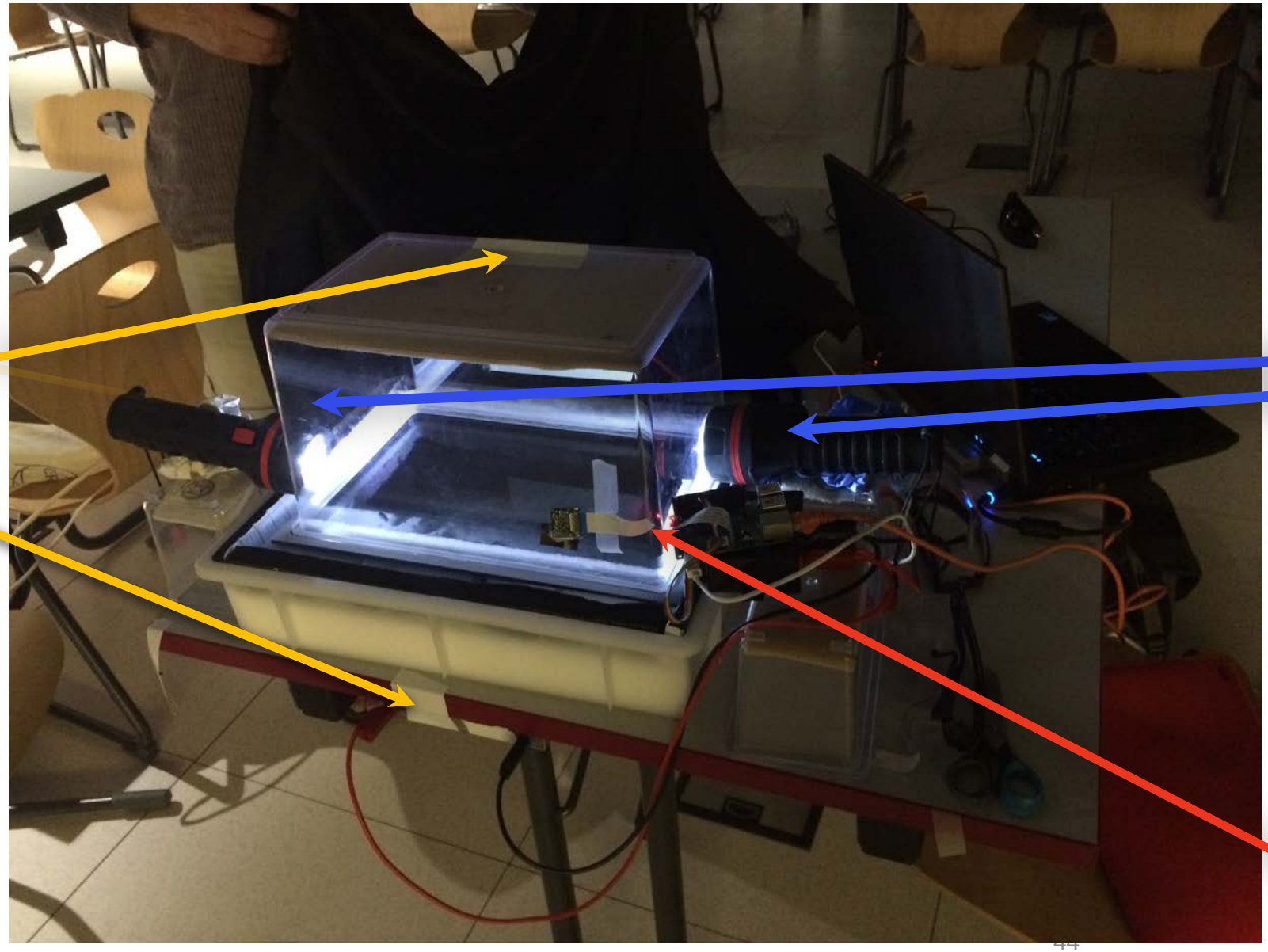
The muon hunter minimum kit



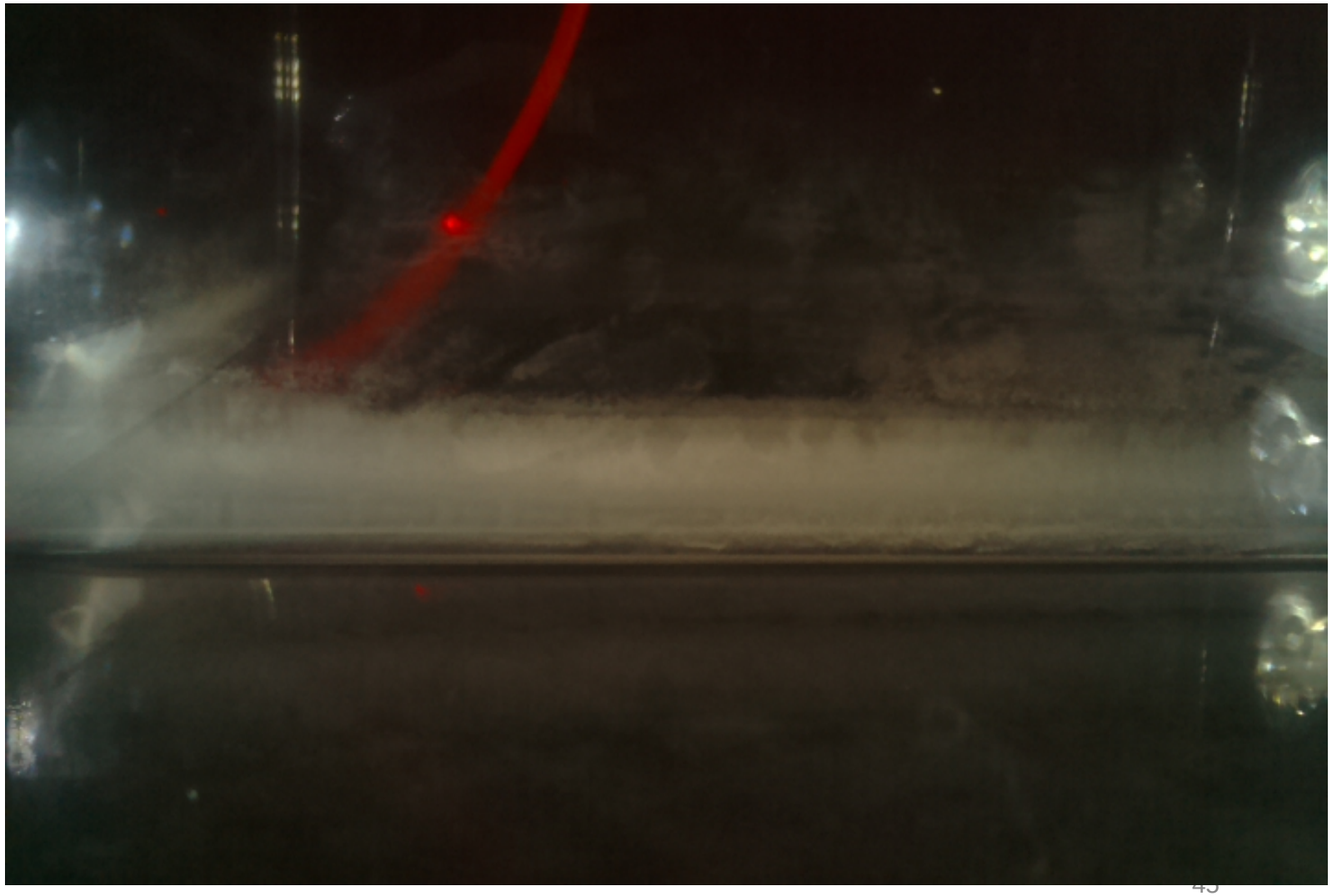


SEASON 1

HST CERN 2015

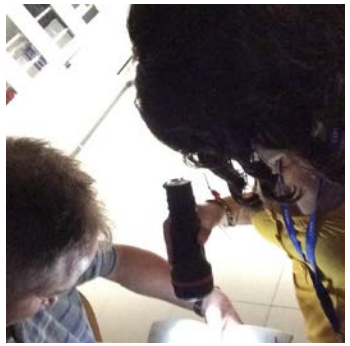


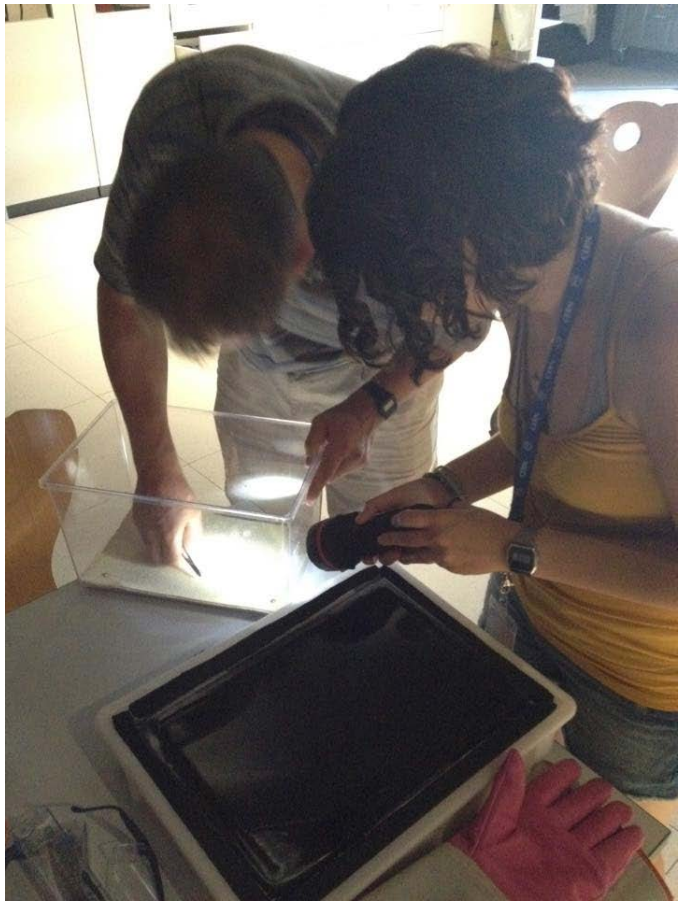
SEASON 1

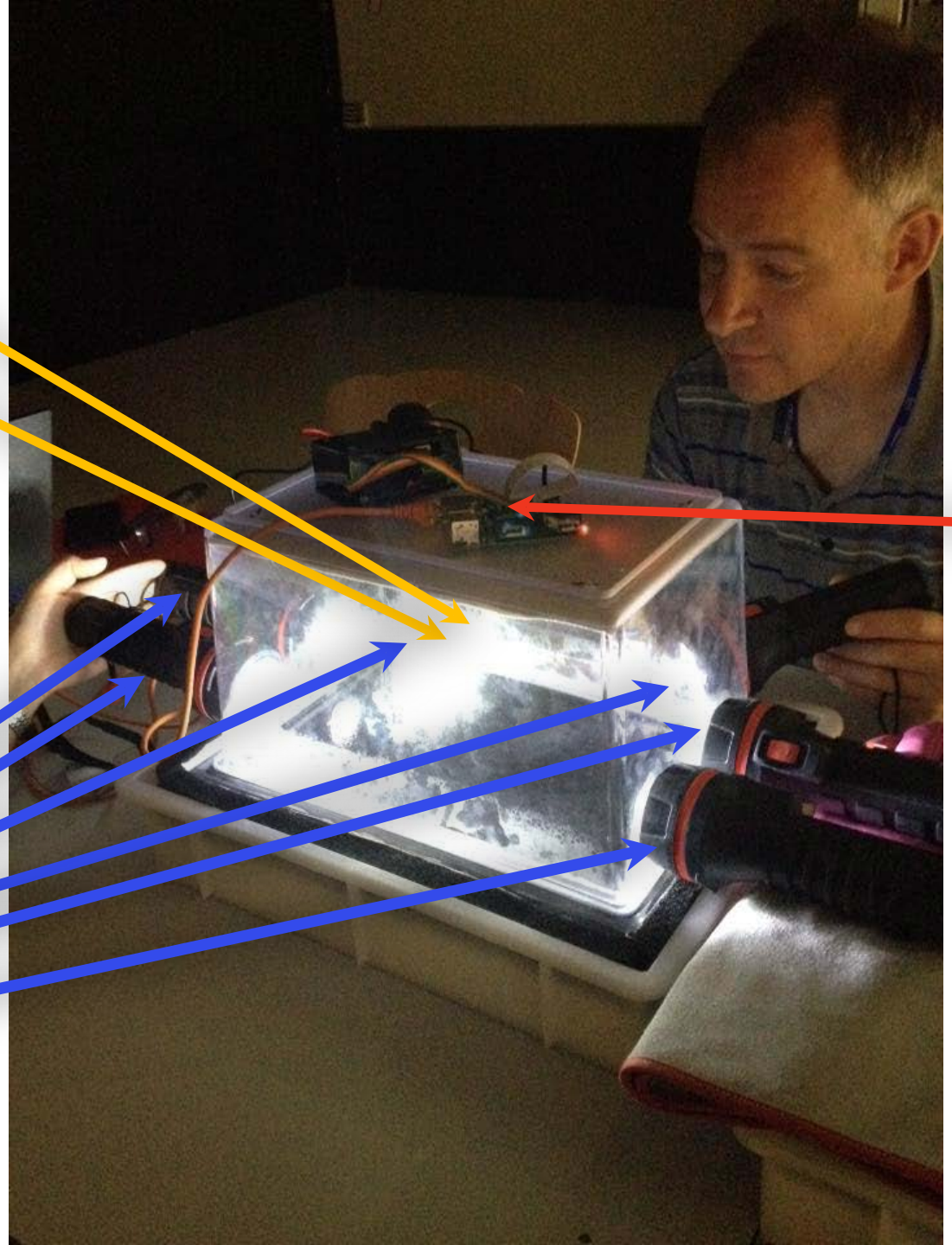


SEASON 2

HST CERN 2015

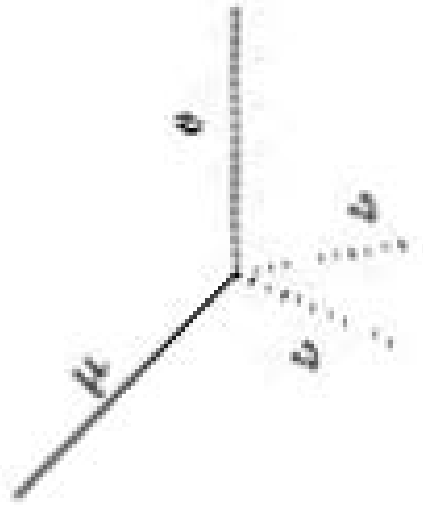






HST CERN 2015

HST CERN 2015



What is the offer?
An opportunity to build this detector with your students.

HST

How much does it cost?
Minimum kit 1-4: £80, $127, €115, CHF120 + shipping

1. Electronic parts only: **£25 per kit ($39, €36, CHF37)**
(you'll need breadboards, wires to make this work, so these are the components only)

2. 6 Printed circuit boards (CERN HST 2015 edition) **£20 per kit. ($32, €29, CHF30)**
(you'll need a 3V power supply / batteries and 4mm lab test connectors / banana plugs, soldering irons to make this work)

3. logic analyzer to look at the signals in a cheap way: **£10** (Chinese) **($17, €14, CHF15)**

4. GM tubes: **£25 per pair**. **($39, €36, CHF37)** (old Soviet/Warsaw pact)

5. **The camera & datalogging module £70 ($110, €100, CHF105)**:
- Raspberry Pi 2 board (quad core linux computer) + Rpi camera + open source datalogging and trigger programs I wrote (Python) + USB power supply + Ethernet cable + connectors + 8GB memory card Class10 (~ 5 GB usable for data & pictures)

References & Credits

BOTHE Walter: Zur Vereinfachung von
Koinzidenzzählungen, Zeitschrift für Physik,
Band 59, 1929

ROSSI Bruno: Method of Registering
Multiple Simultaneous Impulses of
Several Geiger's Counters
(Nature 125, 636-636 (26 April 1930)
doi:10.1038/125636a0

DUNNE Peter: Demonstrating cosmic ray induced electromagnetic cascades
http://teachers.web.cern.ch/teachers/archiv/HST2000/teaching/expt/muons/cascades.htm

The muon hunter kit (coincidence detection)

Link to my blog: http://mihalysprojects.weebly.com/blog/category/cosmic-ray

Video on the prototype detector: https://www.youtube.com/watch?v=HbSULMrOnOs

Credits:
The HV supply is based on John Giametti's circuit:
https://sites.google.com/site/diygeigercounter/circuit-description
The original HV circuit appears in
“Biasing G-M Tubes Isn’t So Hard” by Tom Napier in the January 2004 issue of
Nuts & Volts.

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Manufacturers:
Alps (JP)
Atmel (US)
AVX (US)
Bourns (US)
Fairchild (US)
Kingbright (TW)
Murata (JP)
Nippon Chemi-Con (JP)
NXP (NL)
ON semi (US)
Panasonic (JP)
Rapsberry Pi Foundation (UK)
RS (UK)
Taiwan Semiconductor (TW)
TE connectivity (SWI)
Texas Instruments (US)
Vishay (US)
Wurth Elektronik (DE)

Suppliers:
Conrad, DE
RS Components Ltd., UK

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Putting it all to use in class

Limitations and possibilities in Denmark

Competences, learning objectives

- Learning objectives "physics level A":
  - Know, use and analyze physical quantity, dimensions and units
  - Know the main aspects of the subject verbally and in writing
  - Planning physical phenomena
  - Analyze problems, find solutions, plan and carry through experiments
  - Show ability to familiarize themselves with new areas
- Competences, learning objectives "physics level A":
  - Methods: document knowledge of cooperation and use that
  - Through the course, there will be considerable training in the
  - Methods: Set personal goals and evaluate own work
  - Knowledge and forms of knowledge: know how knowledge is produced and absorbed inside of different subjects
- Competences, learning objectives "physics level A":
  - Quote from https://www.retsinformation.dk/Forms/R0710.aspx?id=152550#Bil13 § 2.1)

So, catch their interest..

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- Connections: Supernovae – High Voltage - Avalanches



- Build a detector somewhere between…

AND

Cosmic detector – a good idea

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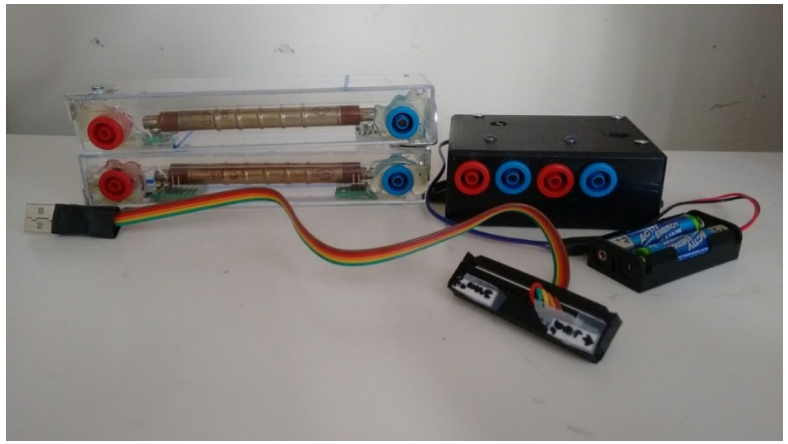
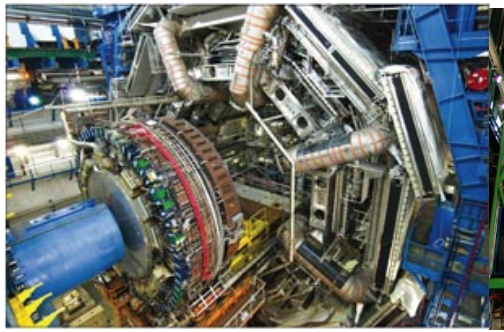
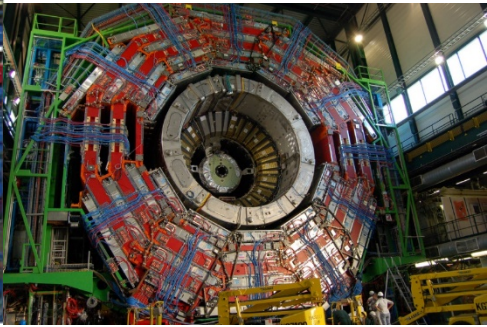
- Build your own Geiger-Müller based cosmic ray detector.



- Start with building and understanding individual parts in groups.
- Then cooperate in assembly and measuring.
- Basicly a project like CMS and ATLAS
  – only smaller





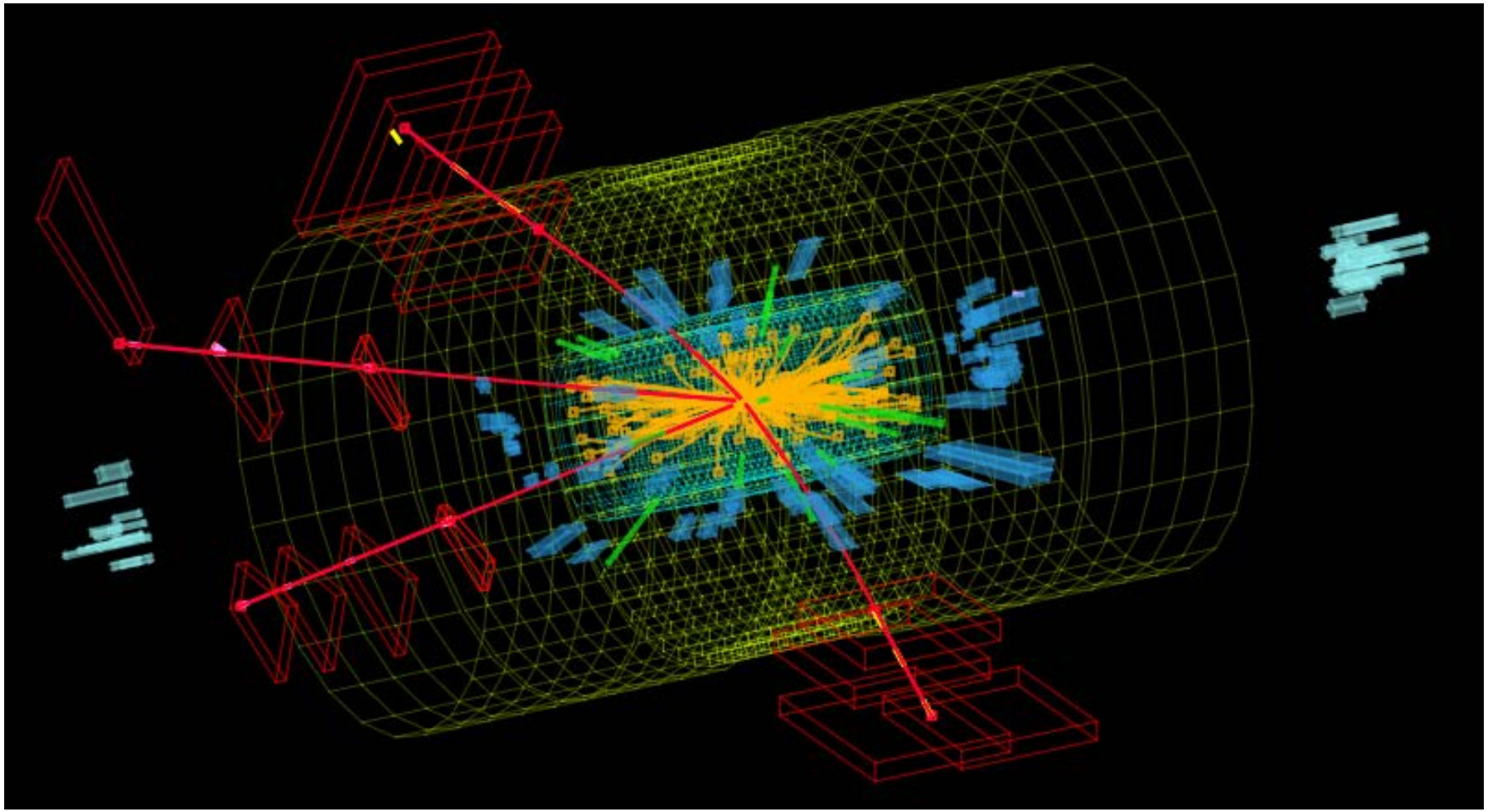
Plan

- Phase 1 – Introduction to the subject – Cosmic Rays
- Phase 2 – groupwork on construction of the detector incl. tests.
- Phase 3 – measurements with single GM-tubes
- Phase 4 – measurement with coincident circuit
- Phase 5 – Group work – structure measuring data and background research
- Phase 6 – Presentation of data and theory

If you want to build a ship,
don't drum up people to collect wood
and don't assign them tasks and work,
but rather teach them to long for the
endless immensity of the
sea

Antoine de Saint-Exupery

WG6 - Making use of the Open data portal

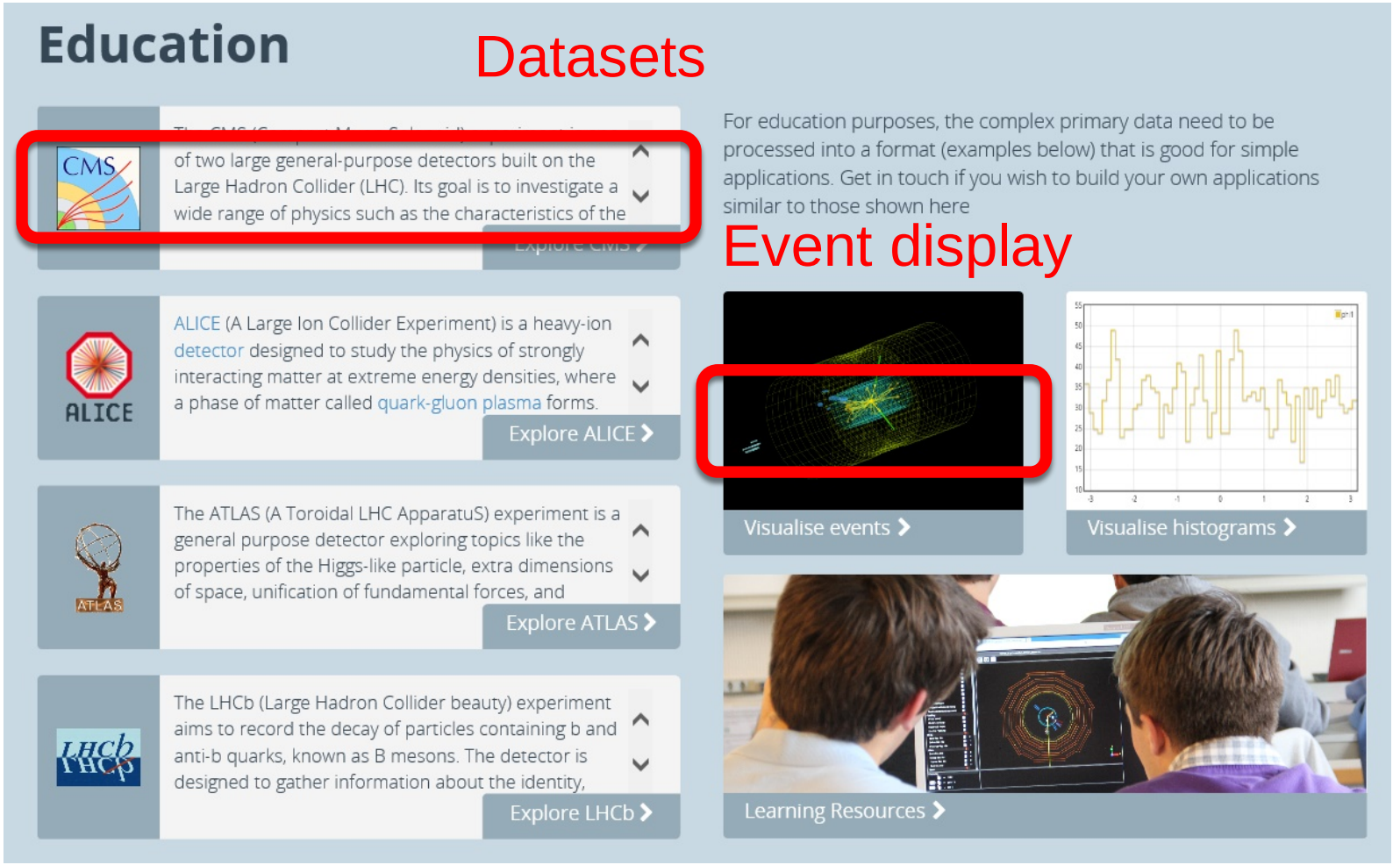


Takashi Horikoshi

from Japan

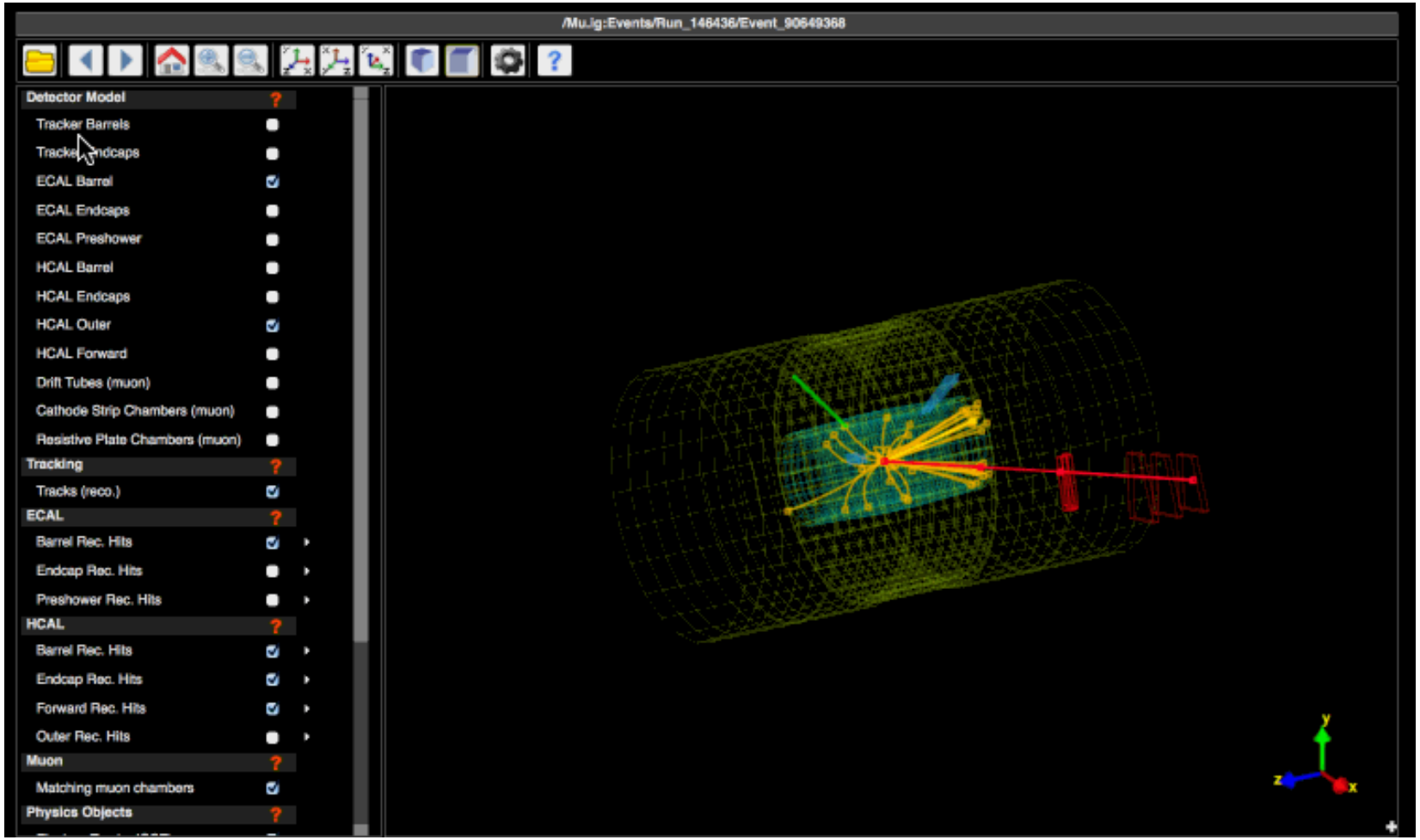
Where to find the Public data

opendata (http://opendata.cern.ch/) > Education



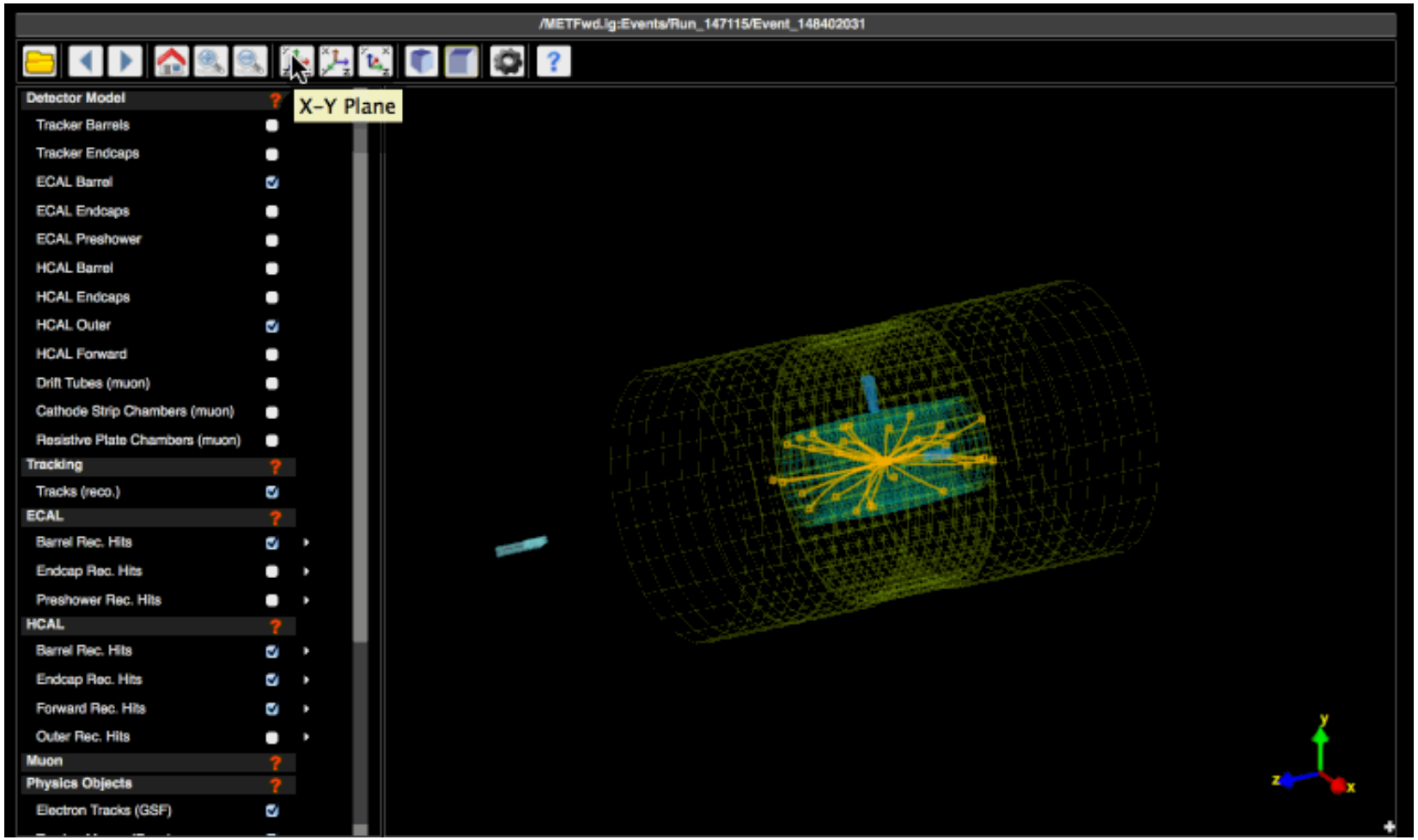
Event display

Open the event files



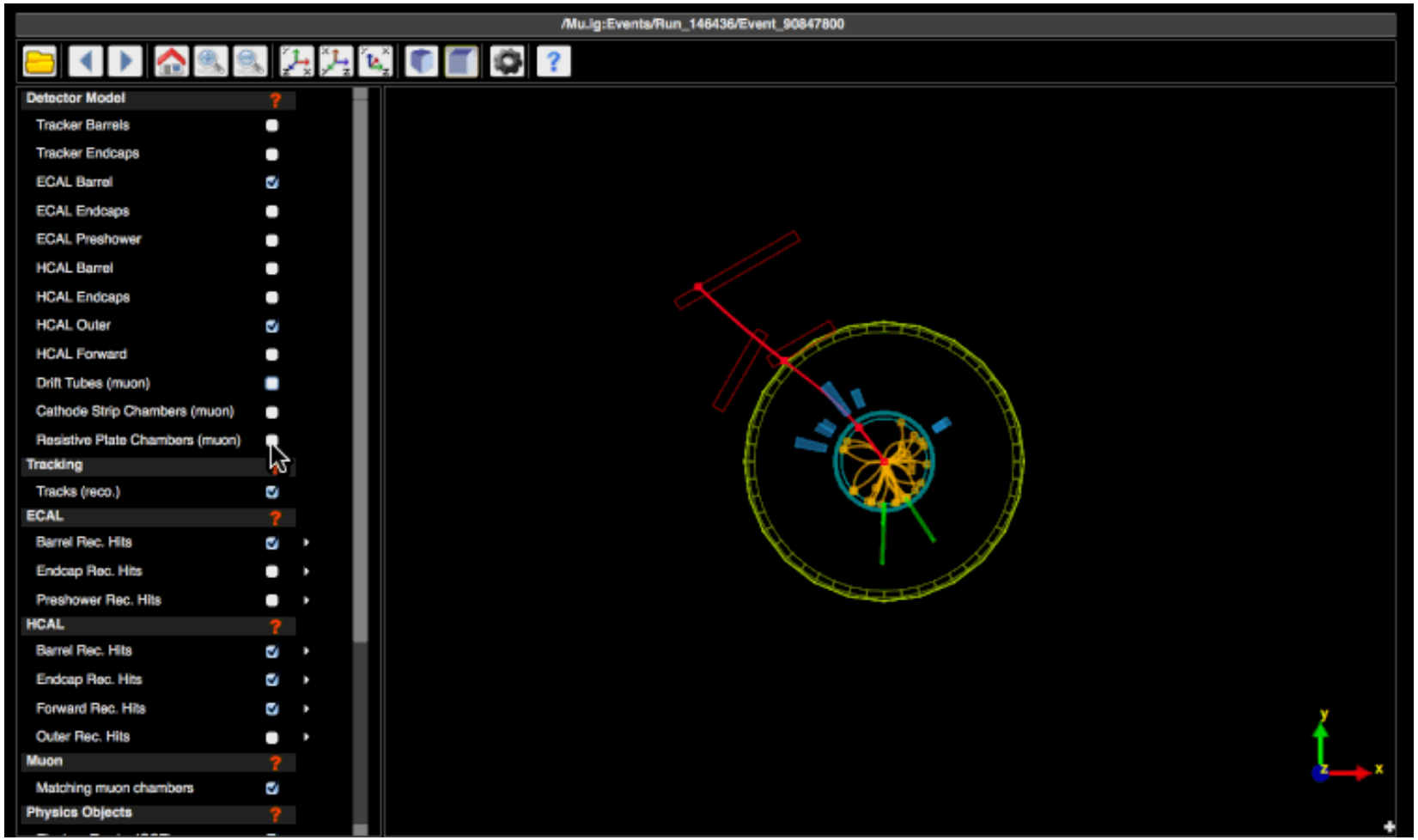
Event display

View the collision event from all angles



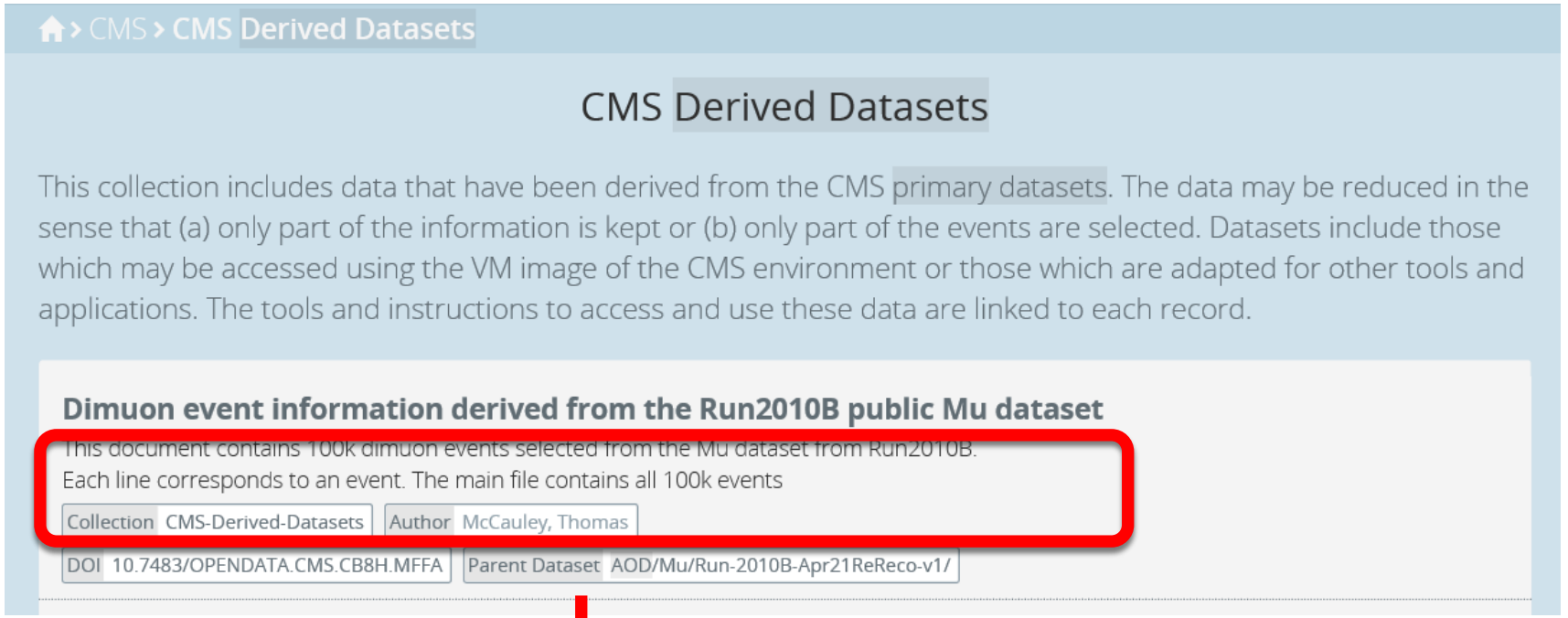
Event display

Show or hide the CMS sub-detectors , tracks , and more



Where to download clean data

opendata > Education > CMS > CMS Derived Datasets

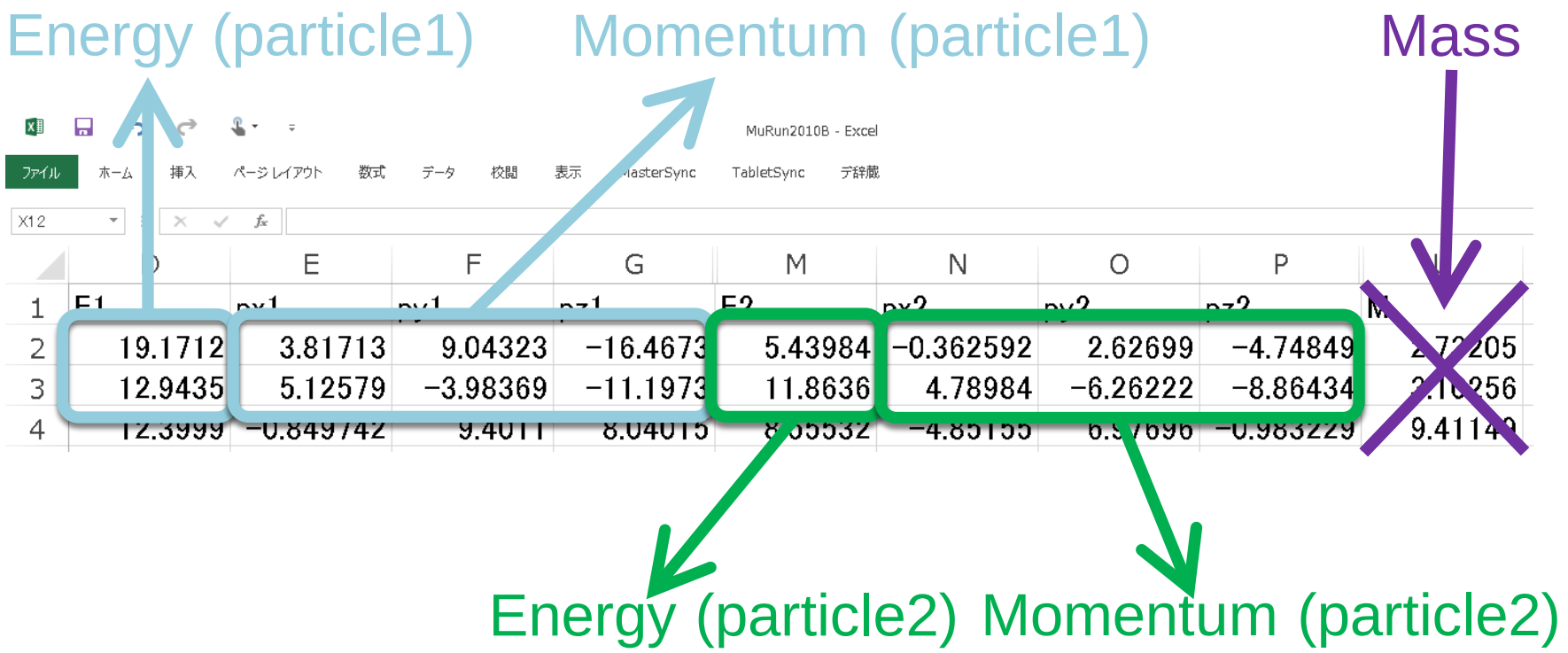


download “MuRun2010B.csv” !!

File format

MuRun2010B.csv

- This document contain the 100,000 dimuon event data !
- Dimuon is a one of a high-quality “global” muon.



Reconstruct Particle

Energy-Momentum conservation (X → A + B)

$$E_X = E_A + E_B \qquad \boldsymbol{p}_X = \boldsymbol{p}_A + \boldsymbol{p}_B$$

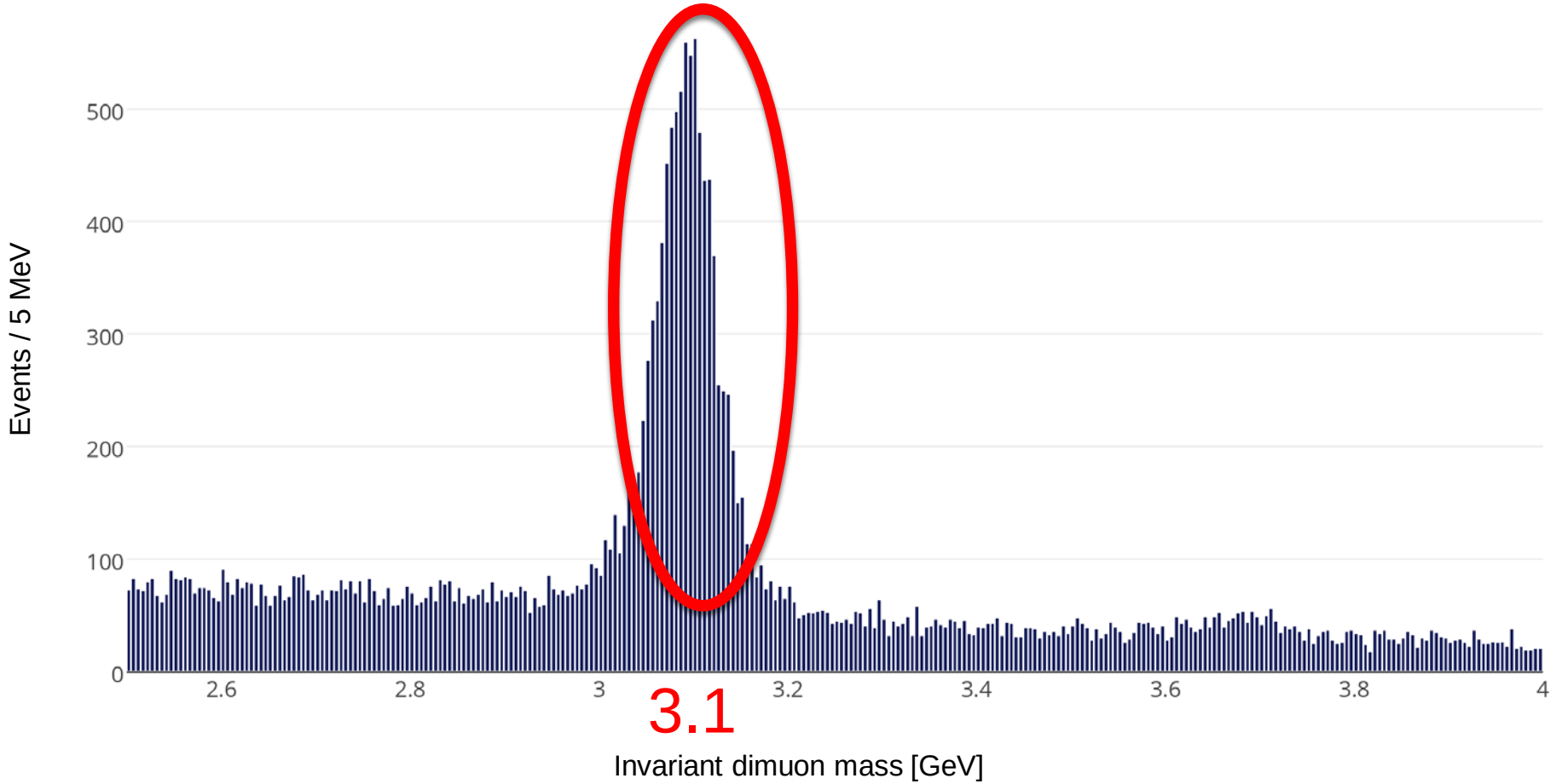
Theory of relativity

$$E^2 = p^2c^2 + m^2c^4$$

Mass from

$$m_X = \frac{1}{c^2}\sqrt{(E_A + E_B)^2 - (\boldsymbol{p}_A + \boldsymbol{p}_B)^2c^2}$$

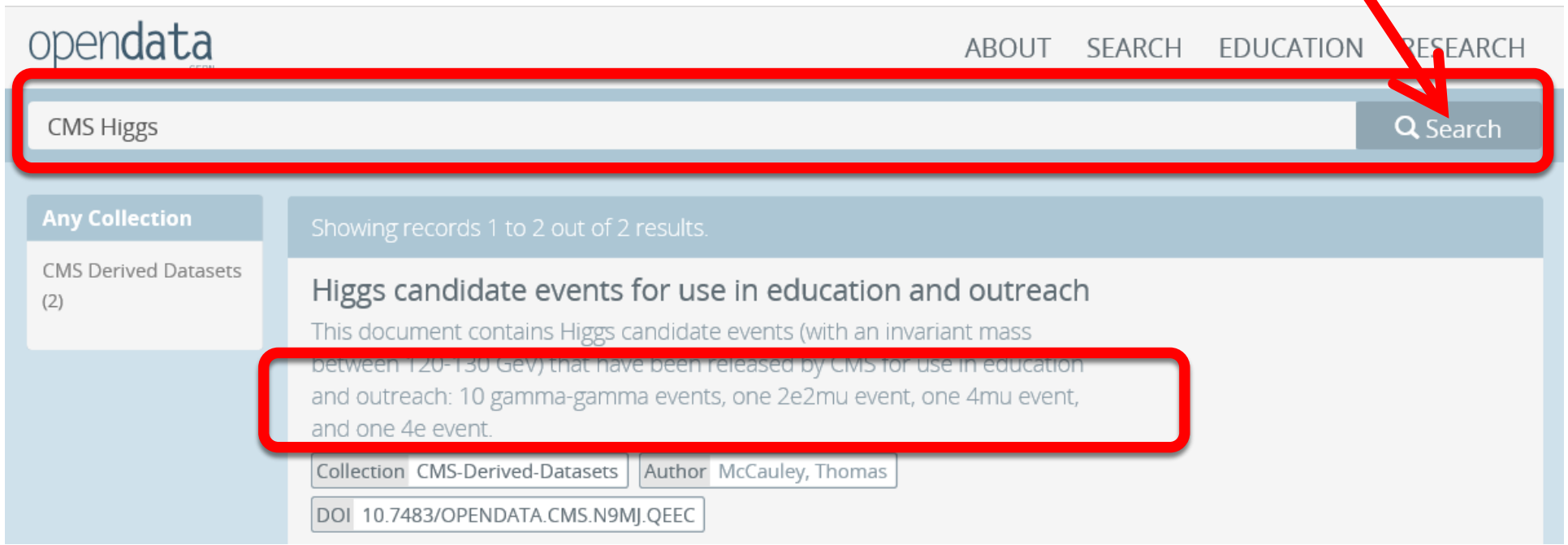
Results for **J / Ψ**



Higgs candidate events

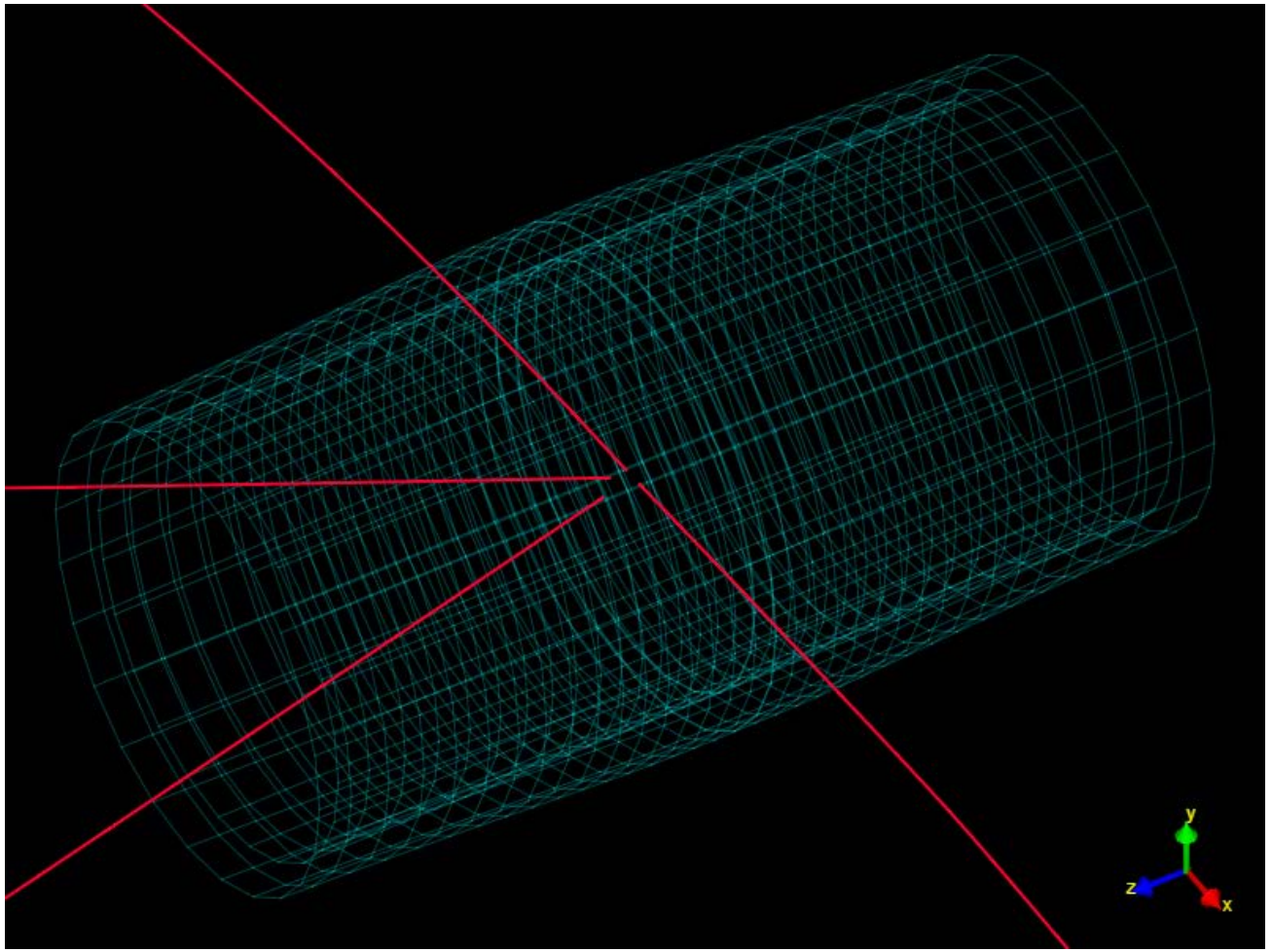
Higgs candidate events for use in education and outreach

Search “CMS Higgs” !



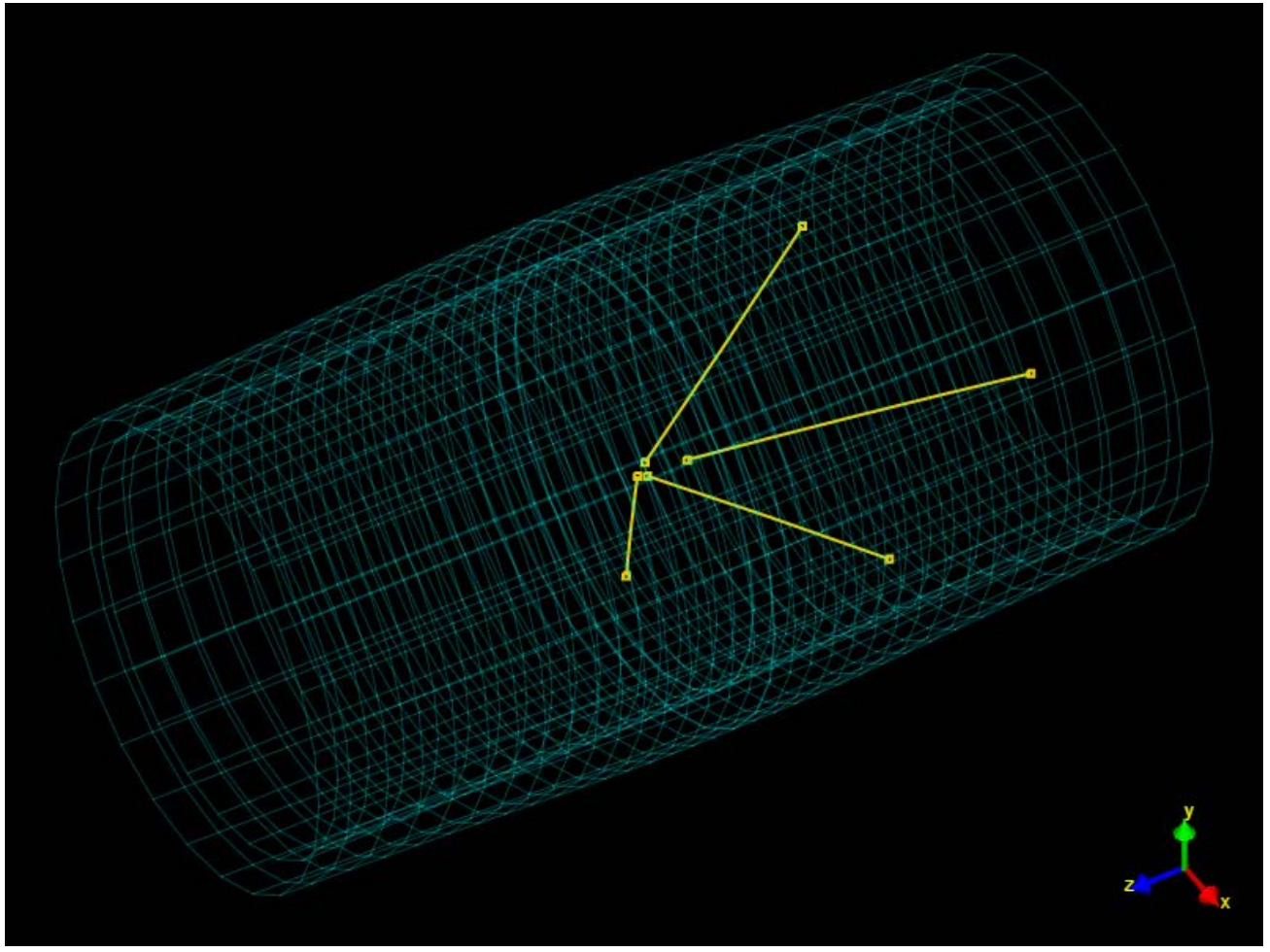
Higgs candidate events

$H \rightarrow \mu^+ \mu^- \mu^+ \mu^-$



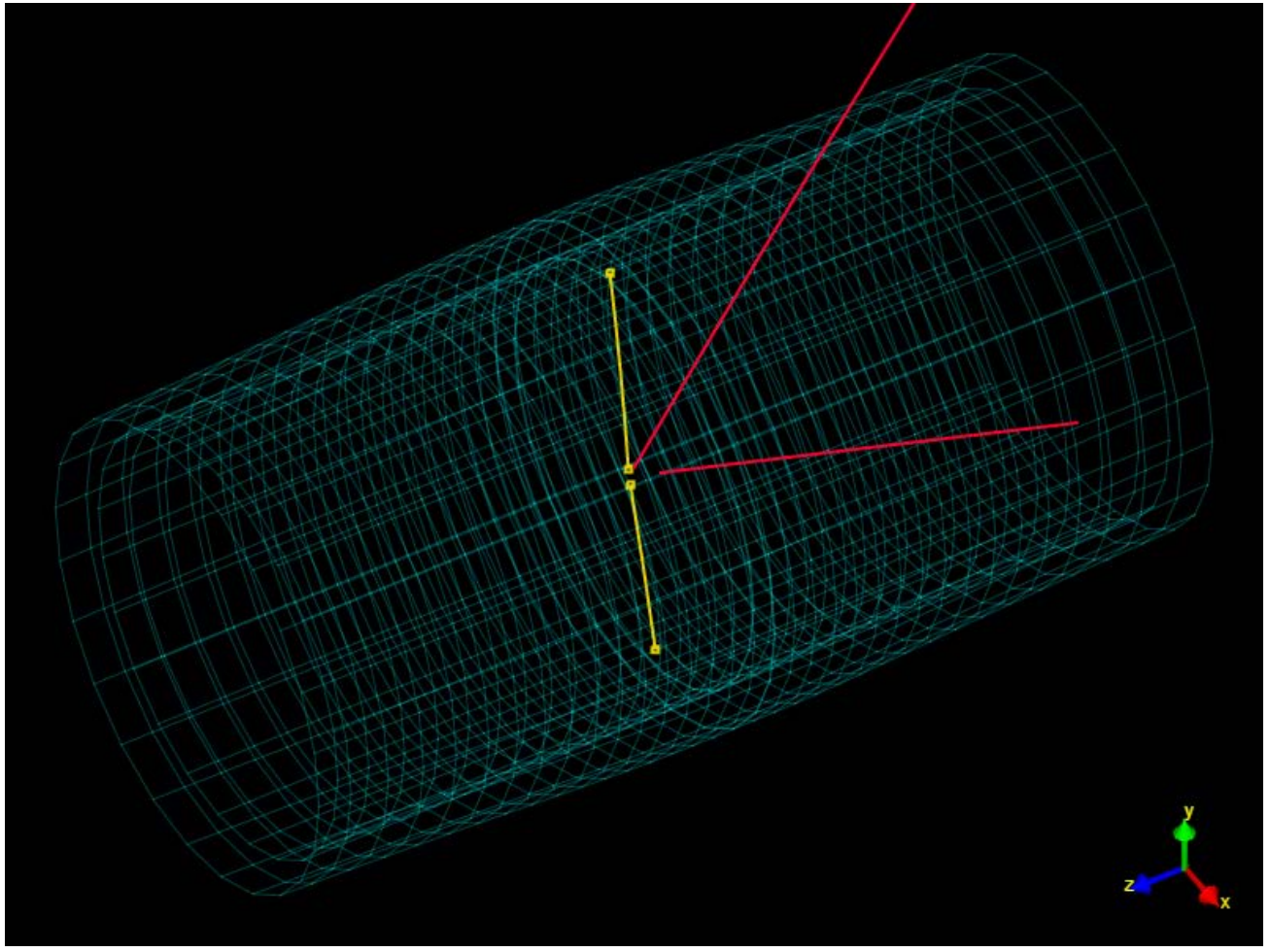
Higgs candidate events

$H \rightarrow e^+ e^- e^+ e^-$



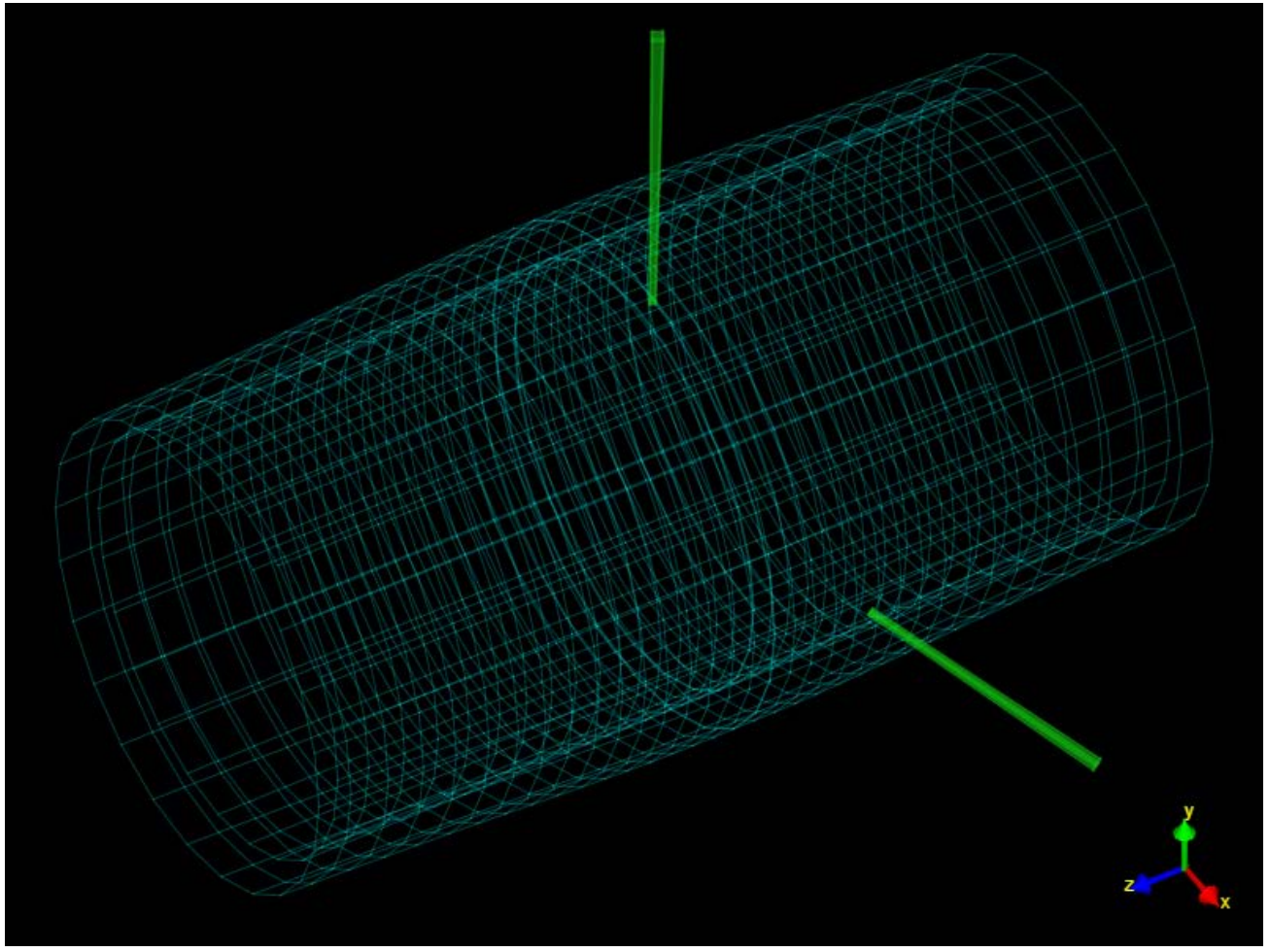
Higgs candidate events

$H \rightarrow e^+ e^- \mu^+ \mu^-$

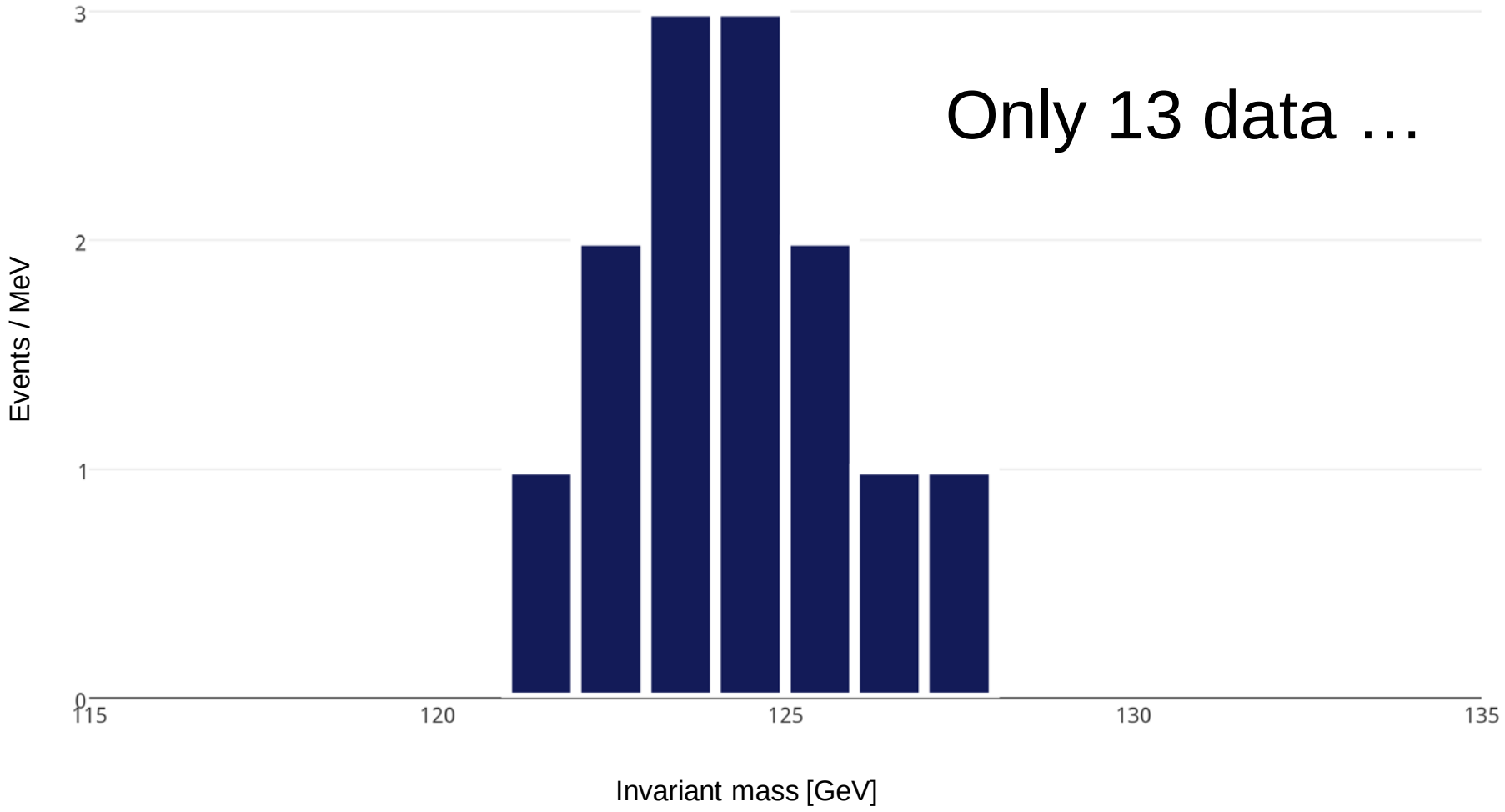


Higgs candidate events

$H \rightarrow \gamma\ \gamma$



Results for Higgs



Thank you for attention !