

Open Data in Teaching and Education

International Teacher Weeks

12 Aug 2019

Linda Hemmann, linda.isabella.hemmann@cern.ch
Juha Teuvo, juha-matti.teuvo@cern.ch

Open Data

- Anyone can access, free to use and share
- Why should we use it in education?
- How can we use it?



High-school students analysing CMS open data. Photo credit: Marzena Lapka

Benefits of using open data

- Open data is everywhere
- Bring real scientific data to schools
- Link between classrooms and recent research
- Make students enthusiastic about science
- It is easy to use!



How can we use open data in education?

- Data-analysis
 - **Programming**, spreadsheet, other software
- Jupyter Notebooks and programming
- Tools are scientifically valid and widely used

The screenshot shows a Jupyter Notebook interface with the following content:

Calculating the invariant mass

We can calculate the invariant mass of two particles by using the following equation:

$$M = \sqrt{(E_1 + E_2)^2 - \|\mathbf{p}_1 + \mathbf{p}_2\|^2}$$

where $\|\mathbf{p}_1 + \mathbf{p}_2\|^2$ is the square of the vector norm, which can be calculated by

$$\|\mathbf{p}_1 + \mathbf{p}_2\|^2 = (p_{x1} + p_{x2})^2 + (p_{y1} + p_{y2})^2 + (p_{z1} + p_{z2})^2$$

If these two particles were initially from the same parent particle, the invariant mass corresponds to the mass of the parent particle.

Let's calculate the **invariant mass!**

```
In [1]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

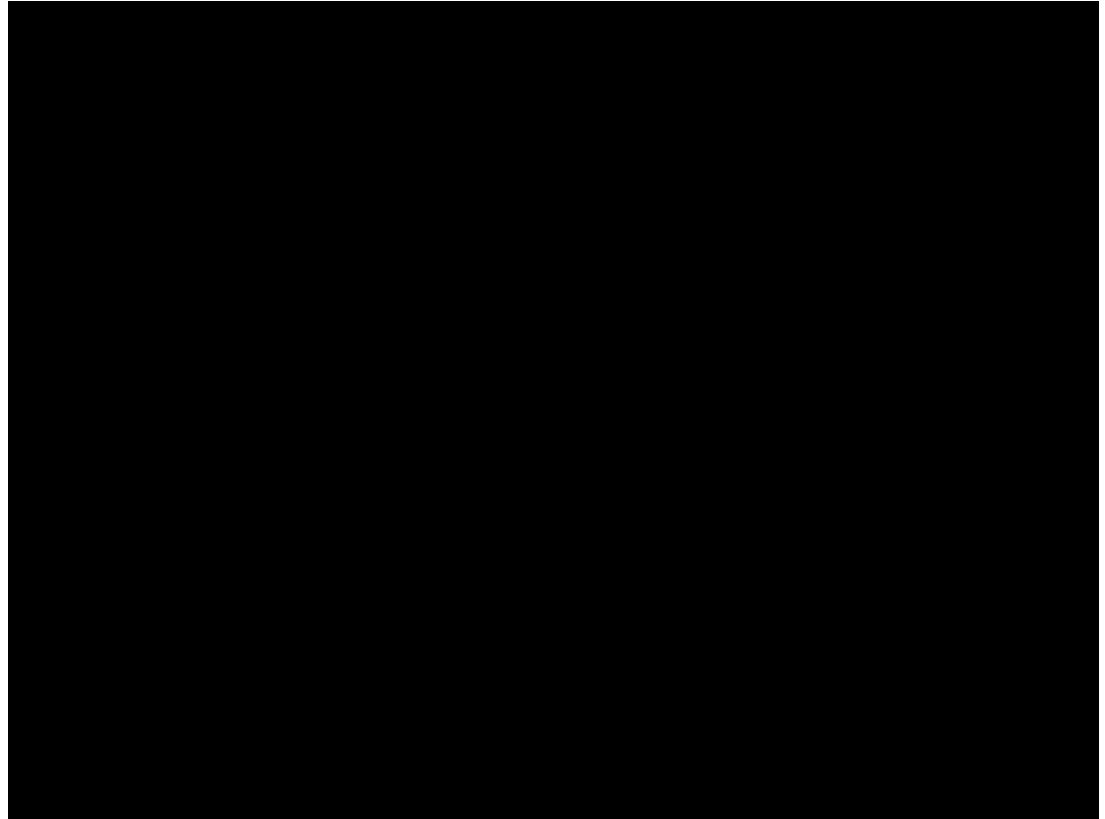
data = pd.read_csv('https://raw.githubusercontent.com/cms-opendata-education/cms-jupyter-materials-english/master/Da

In [ ]:

In [ ]: plt.hist('invariant_mass', bins=200)
plt.xlabel('Invariant mass (GeV)')
plt.ylabel('Number of events')
plt.title('Invariant mass histogram of two muons')
plt.show()
```

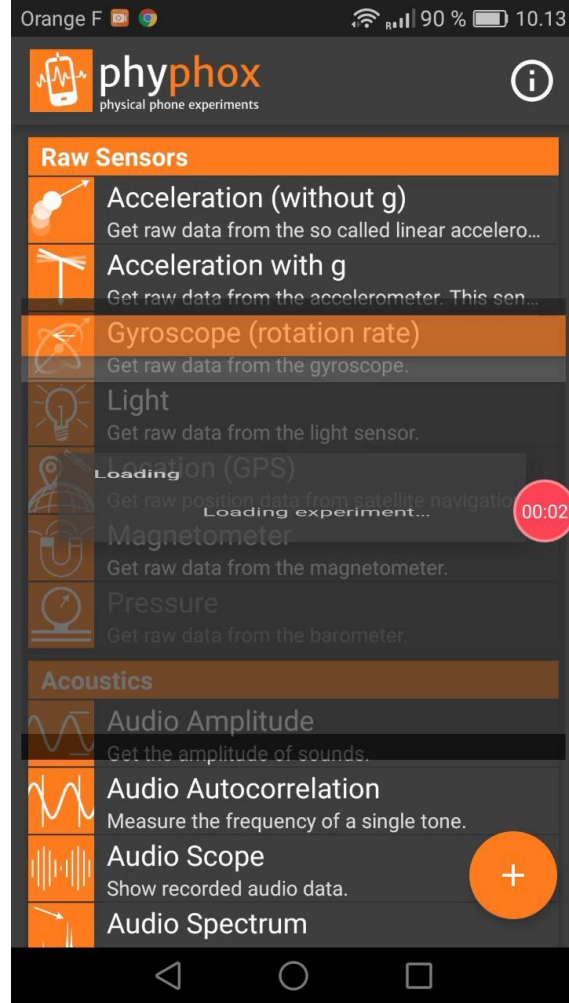
Other possibilities

- Visualize collisions using CMS event display



Other possibilities

- Visualize collisions using CMS event display
- Collect your own data (e.g. Phyphox)



Workshop

- Today we use MyBinder because
 - no software installation needed
 - no need to create an account
 - handy tool in classroom
 - easy to share and open for everyone
- Let's try out one of our exercises!
- Open the demo exercise on MyBinder [here](#) and follow the instructions on the notebook

Got interested?

- Have these tools been tested in classroom?
- Where and how can you use them
- How to create your own materials
- Instructions and teaching material
 - <https://github.com/cms-opendata-education>

Questions?