ROOT Tutorial

HASCO Summer School 2021
Antonio Sidoti
Antonio.sidoti@bo.infn.it

Istituto Nazionale Fisica Nucleare – Sezione di Bologna

Tutorial

For the hands on/tutorial we will use jupyter notebooks.
Two options to avoid overloading the cloud infrastructure:

- Those who **do not** have a CERN account: Use the Goettingen jupyter cloud https://jupyter-cloud.gwdg.de/
- Those who **have a CERN account**: the SWAN Service at CERN http://swan.cern.ch/

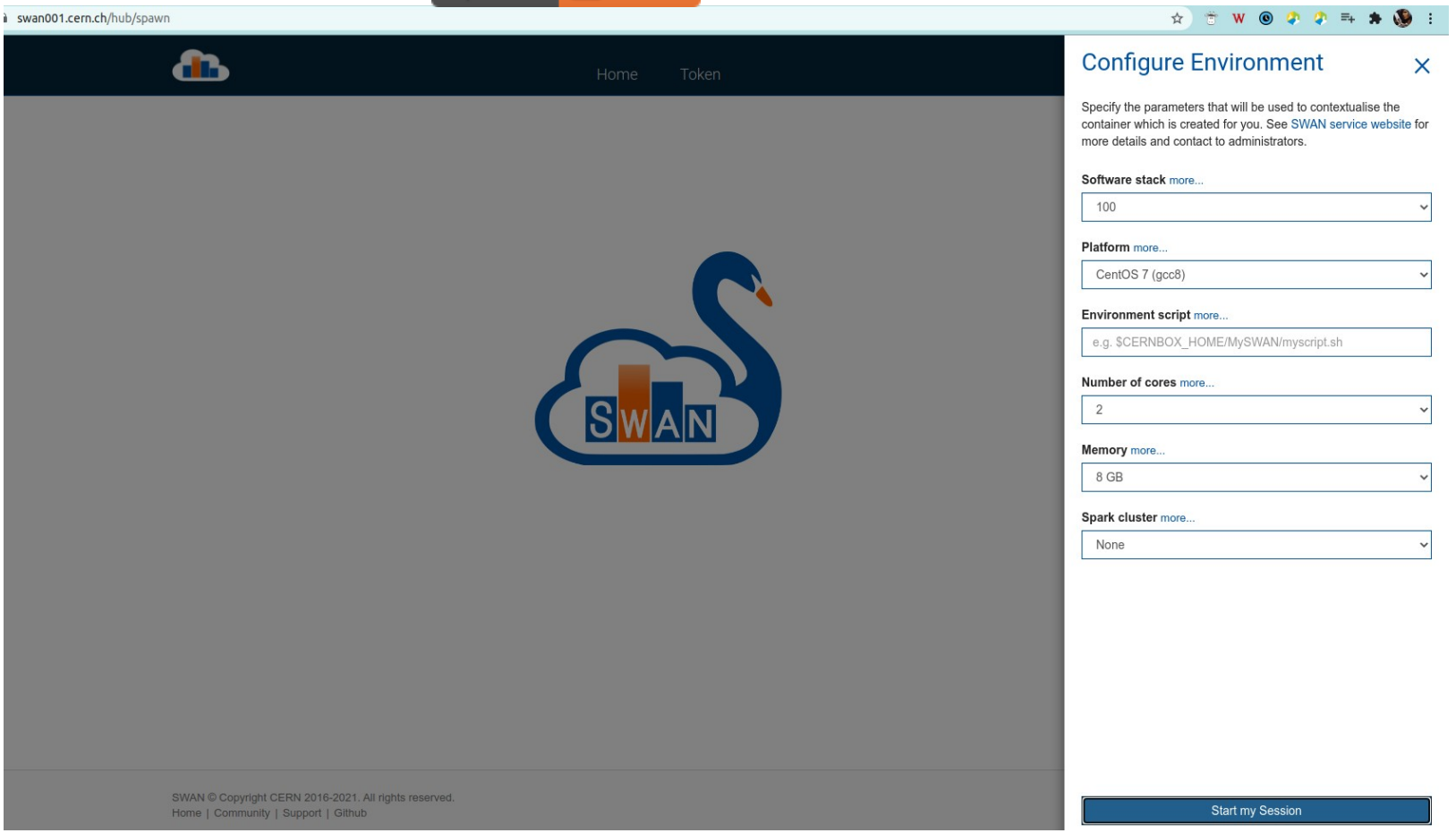
A web-based interactive computing platform that combines code, equations, text and visualisations.

Many supported languages: Python, Haskell, Julia… One generally speaks about a “kernel” for a specific language

In a nutshell: an “interactive shell opened within the browser”

Swan

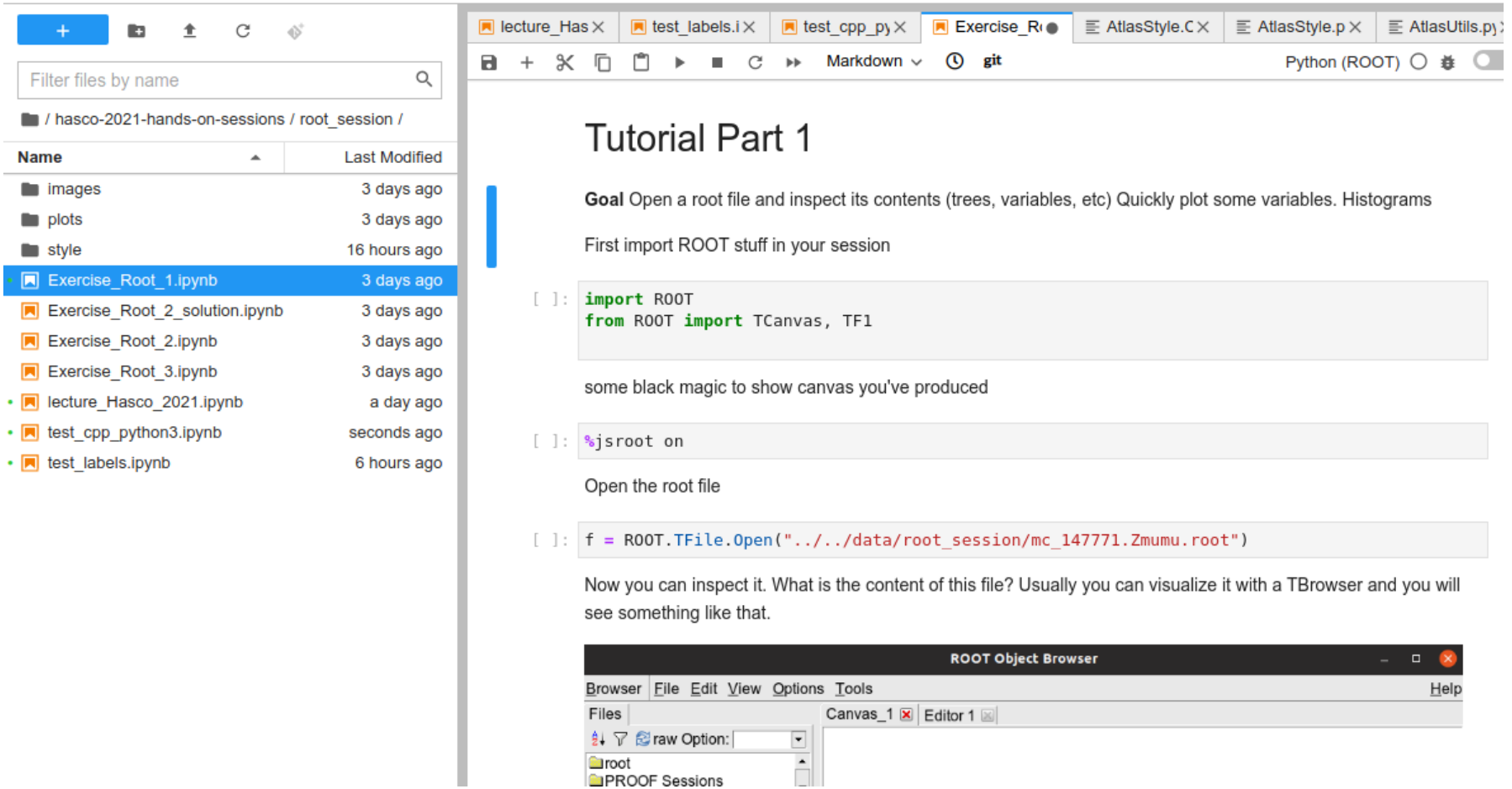
From gitlab: https://gitlab.cern.ch/chscheul/hasco-2021-root-update
Click on Swan button 



Goettingen cloud

https://jupyter-cloud.gwdg.de/

You should have already imported files and notebooks.
Otherwise open PYTHON(ROOT) launcher
And load gitlab repo: https://gitlab.cern.ch/chscheul/hasco-2021-root-update

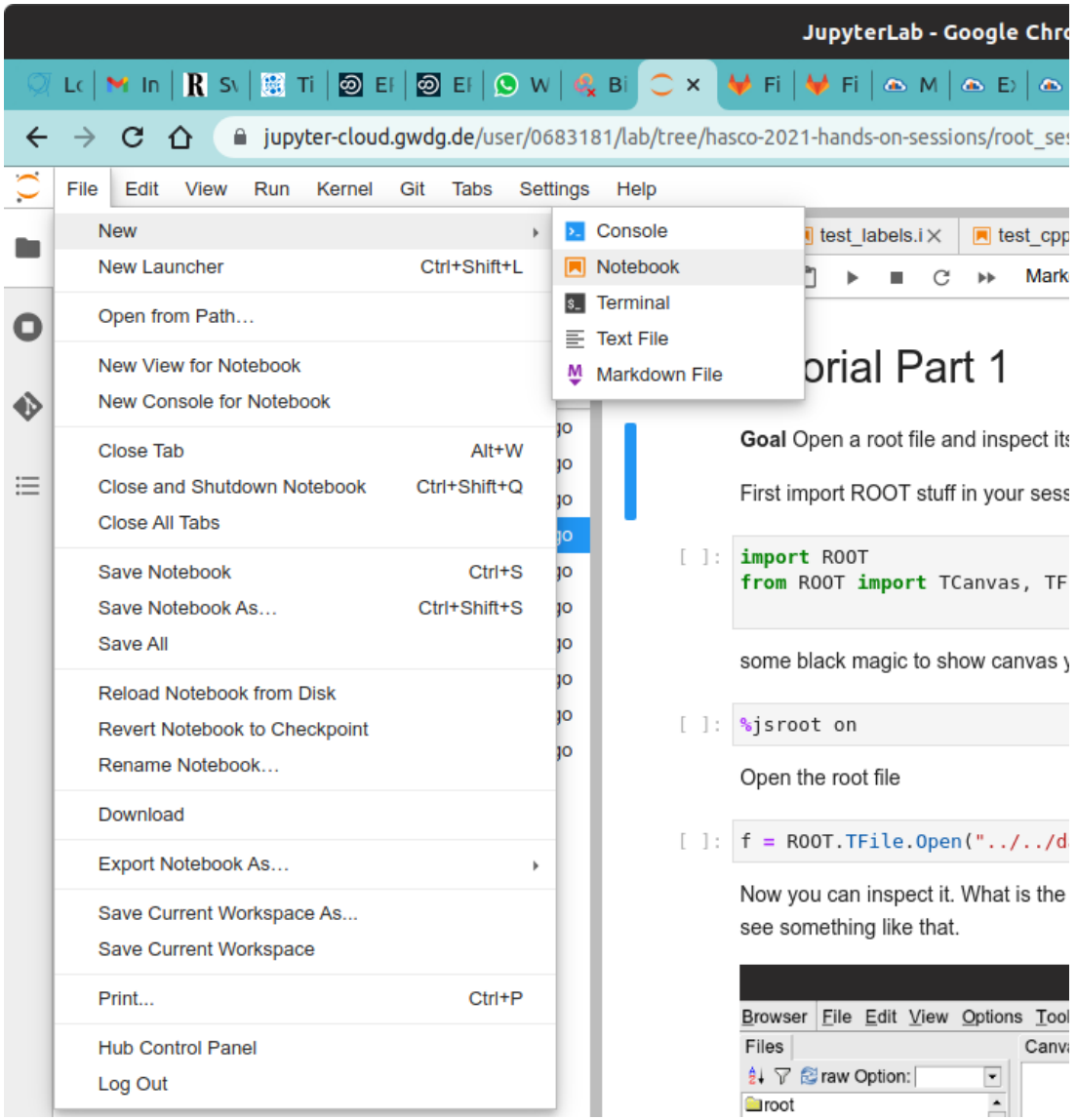


Before you start

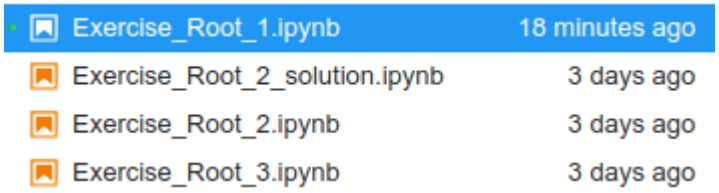
Make sure you've copied the data files in your home directory.
If not:
On swan run the script:
copy_swan.ipynb
On goetting cloud the script:
https://gitlab.cern.ch/chscheul/hasco-2021-hands-on-sessions/-/blob/master/setup/setup.sh

The best way to do the tutorial is to open a new notebook and proceed step by step

Important:
Set the boolean variable if you are working on swan



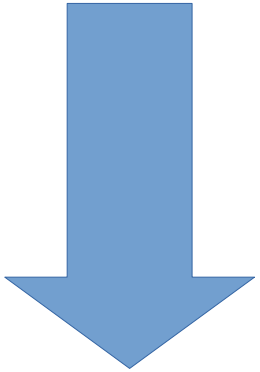

```
import ROOT
from ROOT import TCanvas, TF1

on_swan = True
```

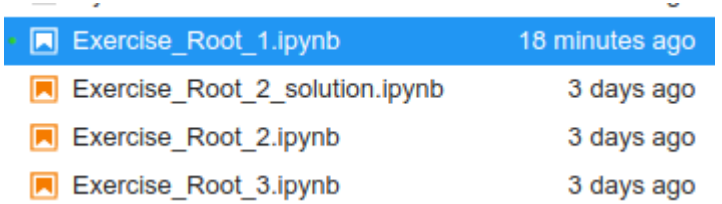


Tutorial Parts

Three different notebooks. 1 → 2 → 3
For testing purposes use as input the reduced file size

Swan

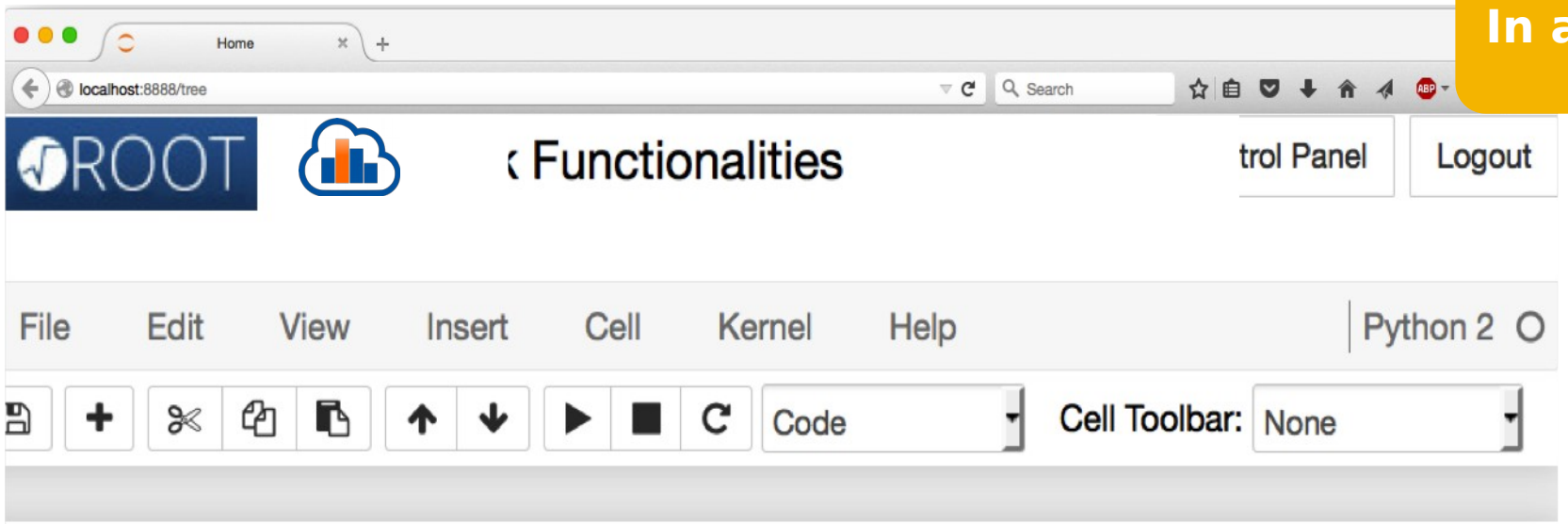




Goettingen cloud

Reference

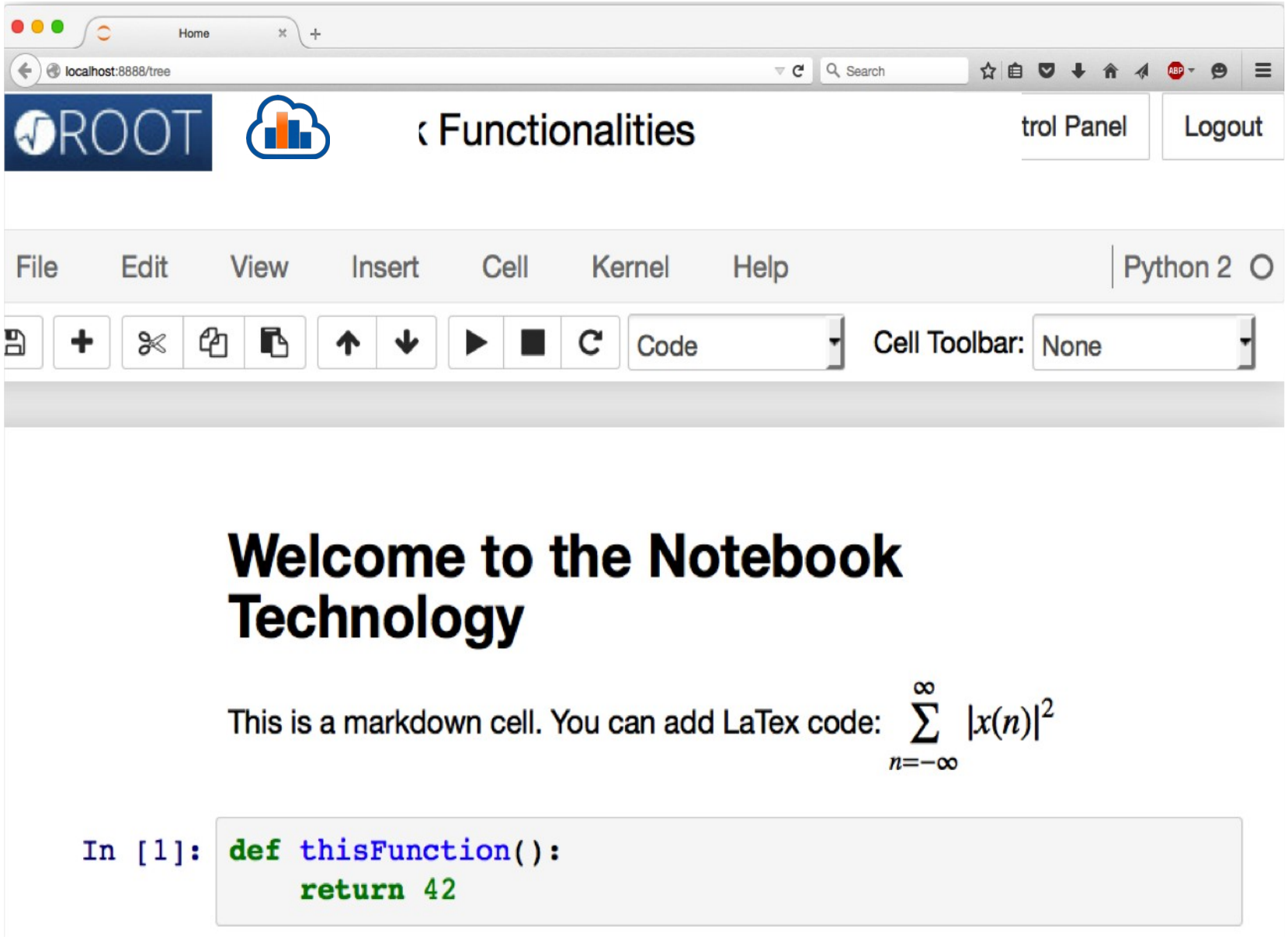
In a browser

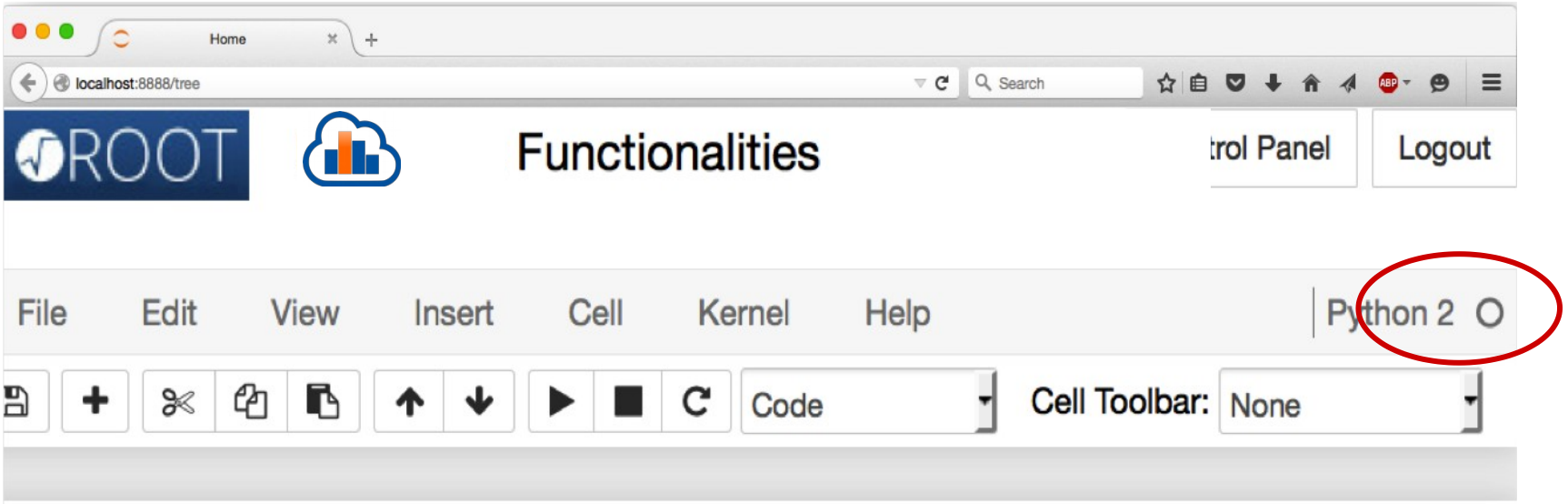


Welcome to the Notebook Technology

This is a markdown cell. You can add LaTex code: $\sum_{n=-\infty}^{\infty} |x(n)|^2$

Text & Formulas


Home
localhost:8888/tree
Search
ROOT
Functionalities
trol Panel
Logout
File
Edit
View
Insert
Cell
Kernel
Help
Python 2
Code
Cell Toolbar:
None
Welcome to the Notebook Technology
This is a markdown cell. You can add LaTex code: $\sum_{n=-\infty}^{\infty} |x(n)|^2$
In [1]:
def thisFunction():
return 42



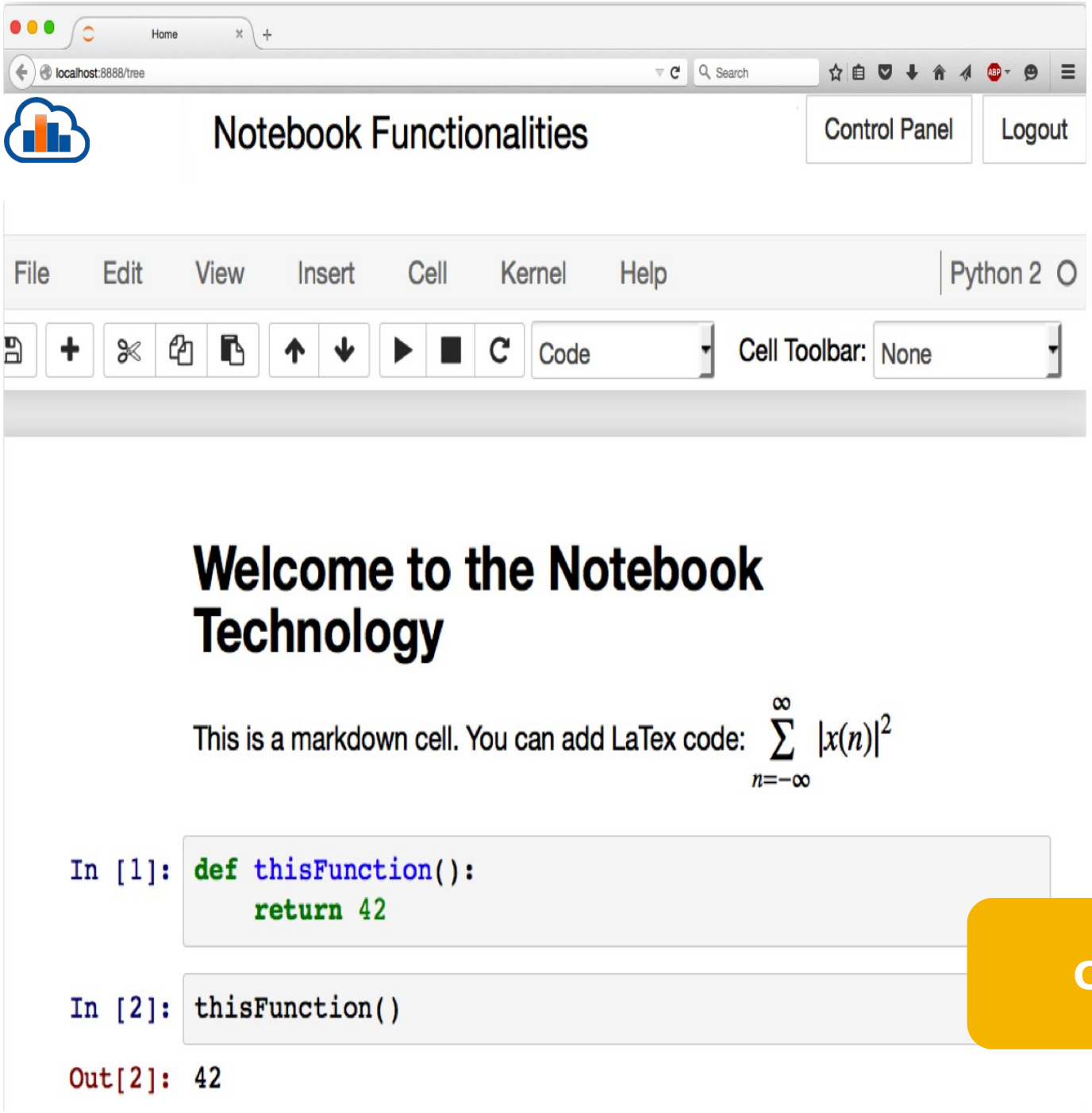
Welcome to the Notebook Technology

This is a markdown cell. You can add LaTex code: $\sum_{n=-\infty}^{\infty} |x(n)|^2$

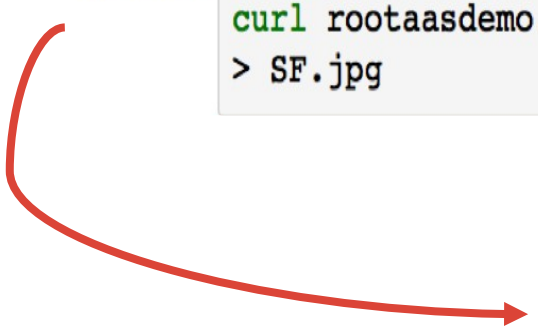
```
In [1]: def thisFunction():
            return 42
```

Code

A *Python* notebook


Home
localhost:8888/tree
Search
Notebook Functionalities
Control Panel
Logout
File
Edit
View
Insert
Cell
Kernel
Help
Python 2
Code
Cell Toolbar:
None
Welcome to the Notebook Technology
This is a markdown cell. You can add LaTex code: $\sum_{n=-\infty}^{\infty} |x(n)|^2$
In [1]:
def thisFunction():
return 42
In [2]:
thisFunction()
Out[2]:
42
Code

```
In [1]: def thisFunction():
            return 42

In [2]: thisFunction()

Out[2]: 42

In [3]: %%bash
        curl rootaasdemo.web.cern.ch/rootaasdemo/SaasFee.jpg \
        > SF.jpg
```

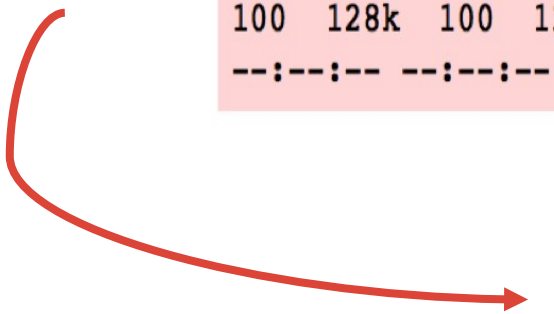


Invoke shell commands ...

Shell commands

```
In [1]: def thisFunction():
            return 42

In [2]: thisFunction()

Out[2]: 42

In [3]: %%bash
        curl rootaasdemo.web.cern.ch/rootaasdemo/SaasFee.jpg \
        > SF.jpg
```

```
  % Total    % Received % Xferd  Average Speed   Time
  Time     Time  Current
                                 Dload  Upload   Total
  Spent    Left  Speed
100  128k  100  128k    0     0  2731k      0 --:--:--
--:--:-- --:--:-- 2787k
```



… and get their output

Shell commands

In [1]:
```
def thisFunction():
    return 42
```

In [2]:
```
thisFunction()
```

Out[2]: 42

In [3]:
```
%%bash
curl rootaasdemo.web.cern.ch/rootaasdemo/SaasFee.jpg \
> SF.jpg
```

```
  % Total    % Received % Xferd  Average Speed   Time
  Time     Time  Current
                                 Dload  Upload   Total
  Spent    Left  Speed
100  128k  100  128k    0     0  2731k      0 --:--:--
--:--:-- --:--:-- 2787k
```

In [4]:
```
from IPython.display import Image
Image(filename="./SF.jpg",width=225)
```

In [1]:
```
def thisFunction():
    return 42
```

In [2]:
```
thisFunction()
```

Out[2]:
```
42
```

In [3]:
```
%%bash
curl rootaasdemo.web.cern.ch/rootaasdemo/SaasFee.jpg \
> SF.jpg
```

```
  % Total    % Received % Xferd  Average Speed   Time
  Time     Time  Current
                                 Dload  Upload   Total
  Spent    Left  Speed
100  128k  100  128k    0     0  2731k      0 --:--:--
--:--:-- --:--:-- 2787k
```

In [4]:
```
from IPython.display import Image
Image(filename="./SF.jpg",width=225)
```

Out[4]:

Figures

In a browser

Text & Formulas

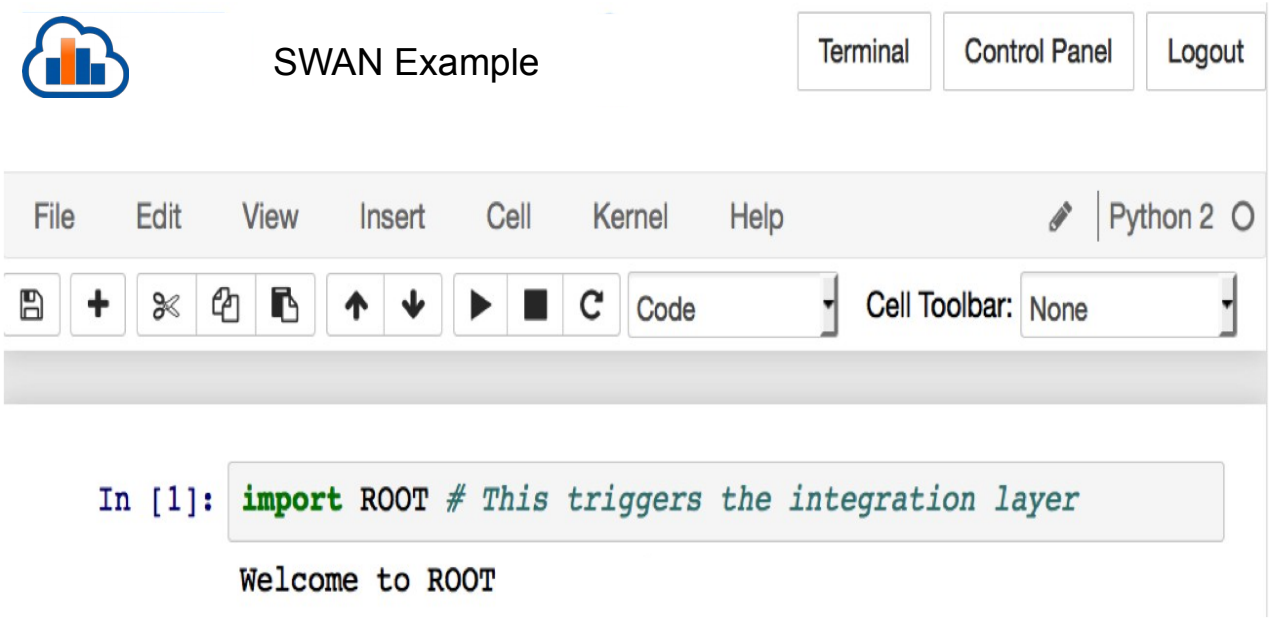
No excuse not to document your analysis !!

Code

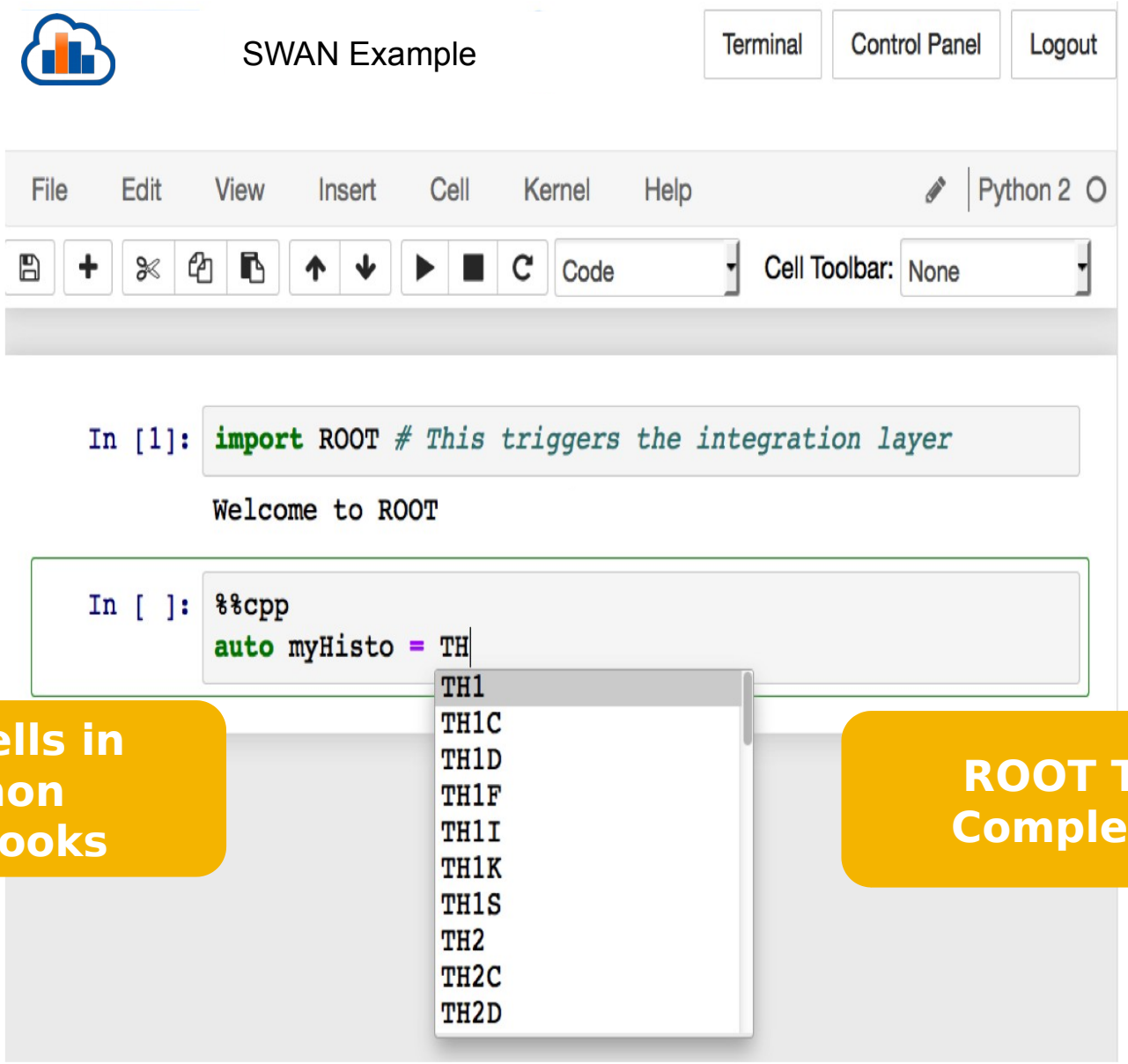
Shell commands

Figures

Some Goodies



Some Goodies



C++ Cells in Python Notebooks

ROOT Tab-Completion

Some Goodies

SWAN Example

Terminal | Control Panel | L

Edit View Insert Cell Kernel Help Pytho

Code | Cell Toolbar: None

In [1]:
```
import ROOT # This triggers the integration layer
```

```
Welcome to ROOT
```

In [2]:
```
%%cpp
auto myHisto = TH1F("h","MyData;X;Y",64,-4,4); // C++11
```

I really wanted to show modern C++...

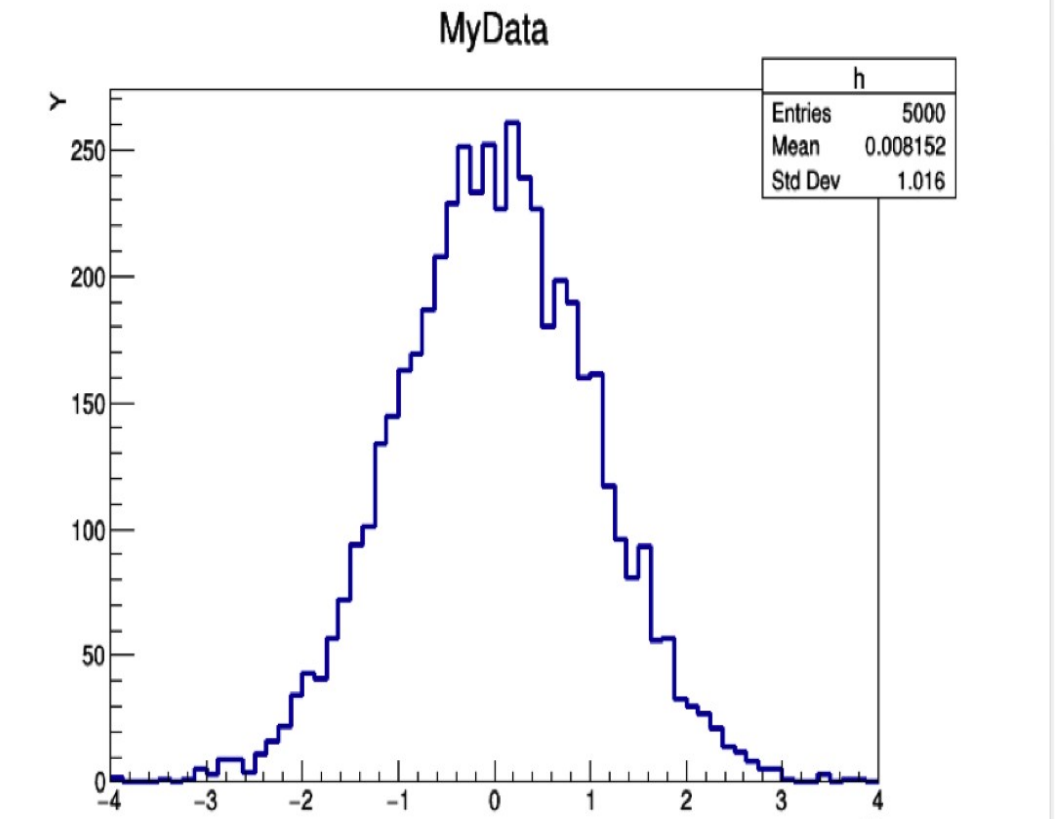
Some Goodies

SWAN Example

Full Python-C++ interoperability

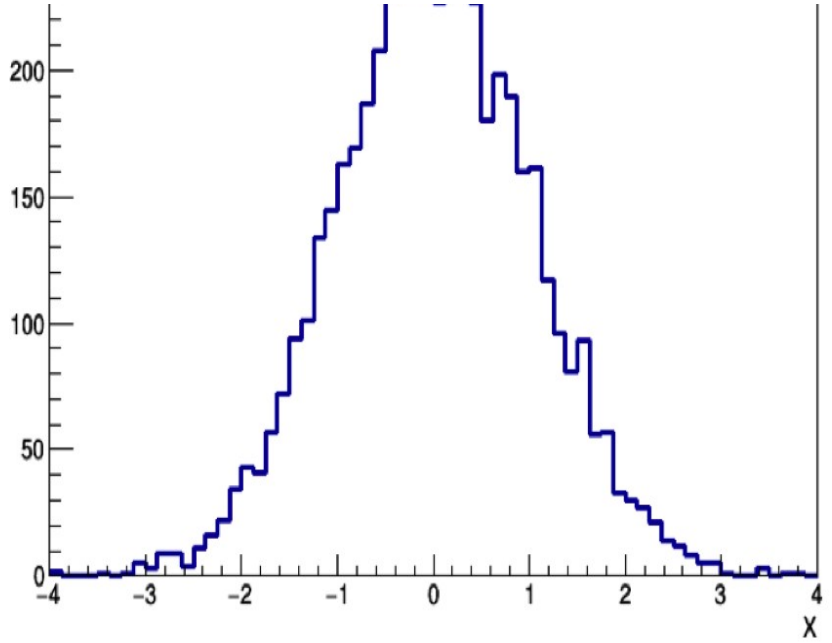
Some Goodies

```
c.Draw()
```



Seamless display of graphics

Some Goodies



In [4]:
```
%%cpp -d
double myG(double* x, double* par){
  auto res = (x[0]-par[1])/par[2];
  auto e = -.5 * res * res;
  return par[0] * exp(e); // declare function
}
```

Syntax highlighting

Some Goodies

In [4]:
```
%%cpp -d
double myG(double* x, double* par){
  auto res = (x[0]-par[1])/par[2];
  auto e = -.5 * res * res;
  return par[0] * exp(e); // declare function
}
```

In [5]:
```
f = ROOT.TF1("myGf",ROOT.myG,-5,5,3)
f.SetParameters(200,0,1);f.SetParNames("N","mu","sigma")
fr = ROOT.h.Fit(f,"S") # Capture printouts
```

Some Goodies

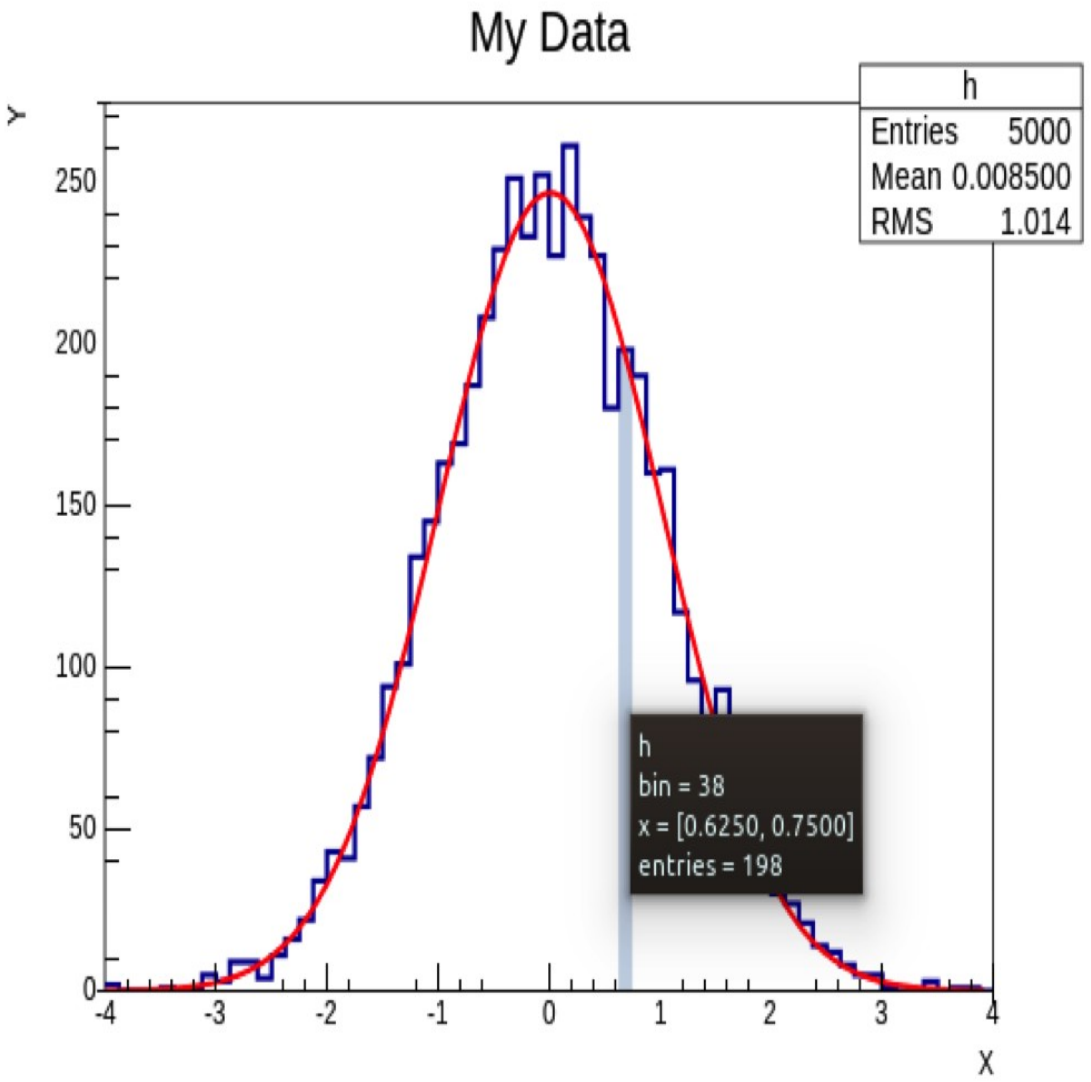
In [4]:
```
%%cpp -d
double myG(double* x, double* par){
  auto res = (x[0]-par[1])/par[2];
  auto e = -.5 * res * res;
  return par[0] * exp(e); // declare function
}
```

In [5]:
```
f = ROOT.TF1("myGf",ROOT.myG,-5,5,3)
f.SetParameters(200,0,1);f.SetParNames("N","mu","sigma")
fr = ROOT.h.Fit(f,"S") # Capture printouts
```

```
 FCN=47.4997 FROM MIGRAD    STATUS=CONVERGED      69 CALLS          70 TO
TAL
                     EDM=2.04372e-09    STRATEGY= 1      ERROR MATRIX ACC
URATE
  EXT PARAMETER                                   STEP         FIRST
  NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
   1  N           2.46469e+02   4.31493e+00   1.19092e-02  -5.38026e-06
   2  mu          1.04793e-02   1.43576e-02   4.87640e-05   4.15093e-03
   3  sigma       1.00316e+00   1.03818e-02   2.86307e-05  -2.55310e-04
```

Some Goodies

```
%jsroot on
```



JSROOT Visualisation

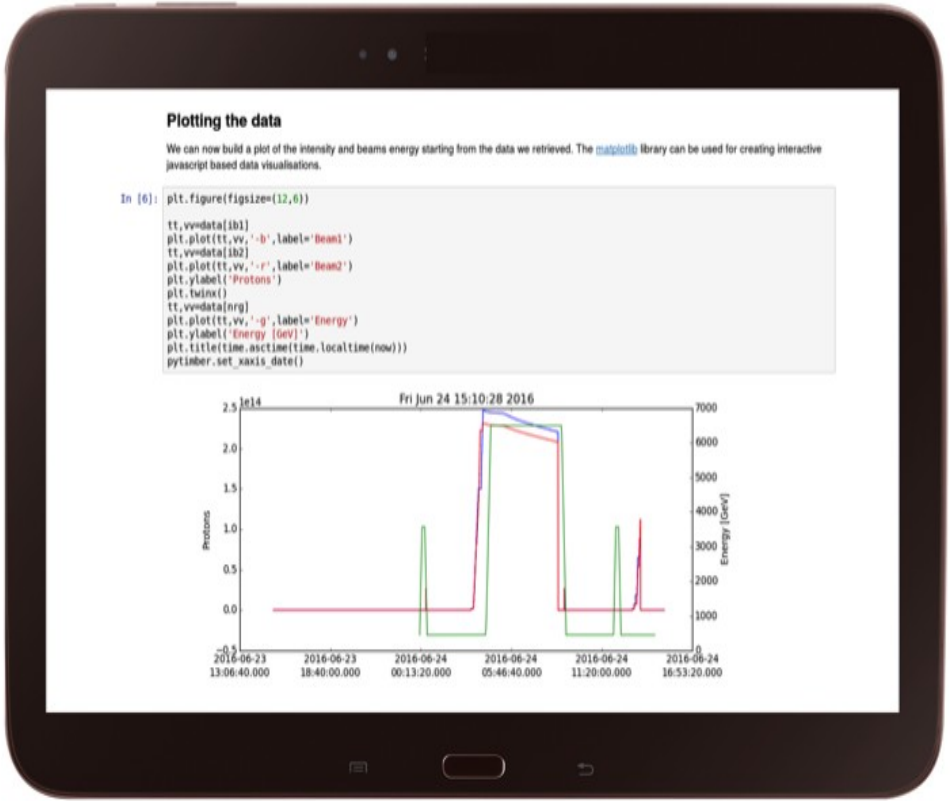
Use Notebooks at CERN

- **SWAN**: **S**ervice for **W**eb based **AN**alysis
- Get a CERNBox (if you don’t have one)
  - Visit https://cernbox.cern.ch

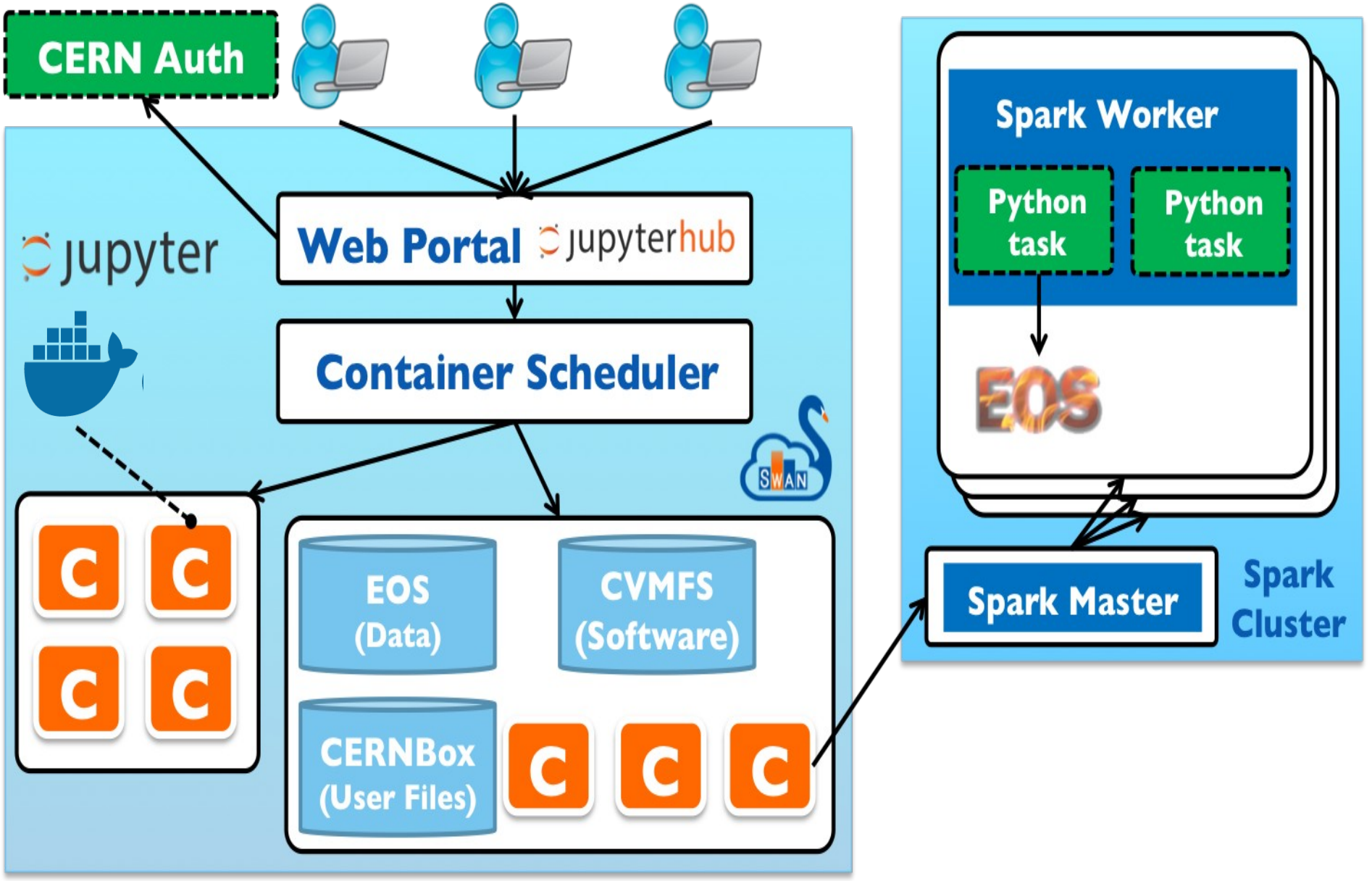
https://swan.cern.ch

The Original Idea: A Turn-Key System

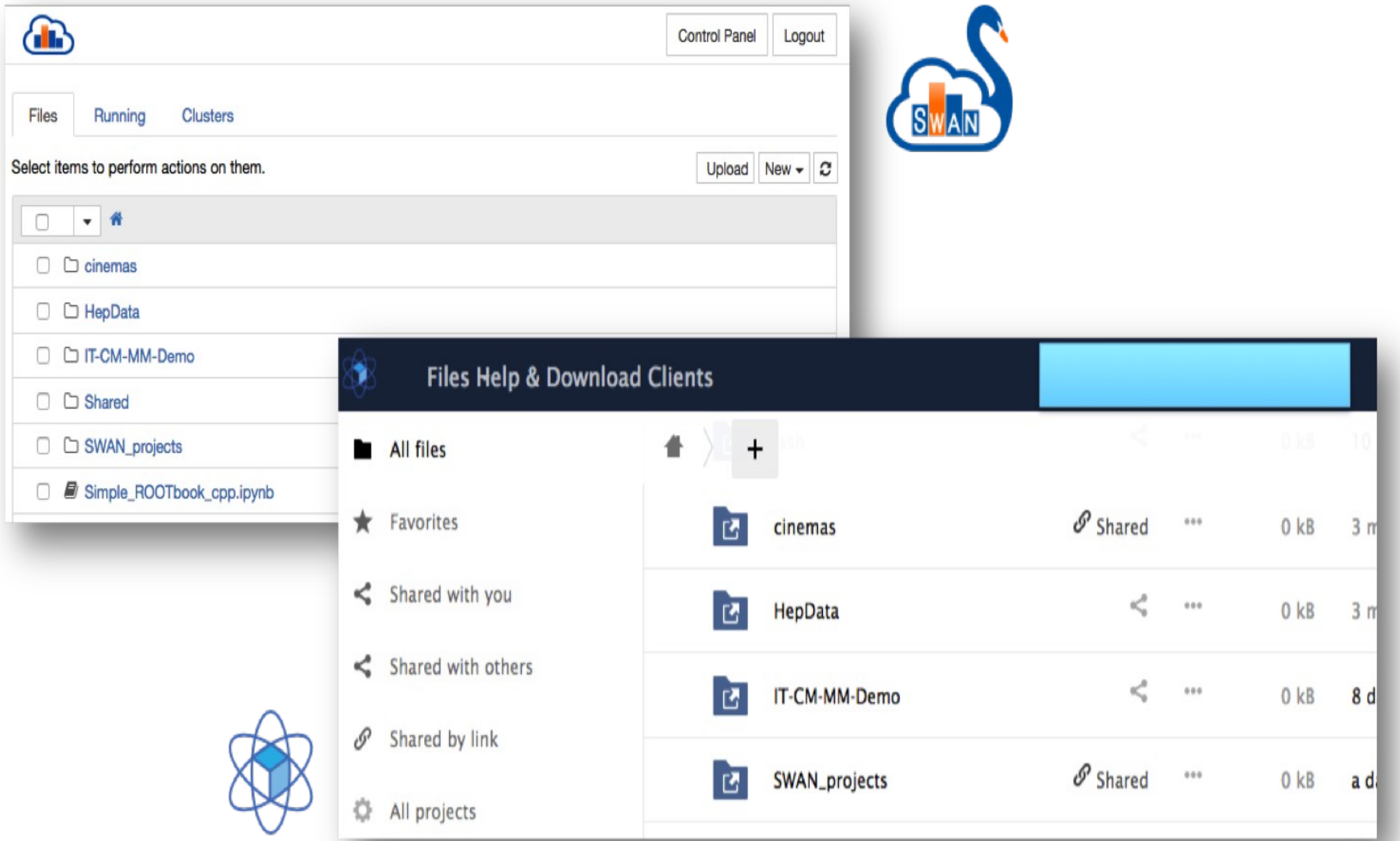
- A ready-to-use system for performing data analysis with **all the software on all the data we need**. **Only requirement: a web browser.**



The Service in a Nutshell



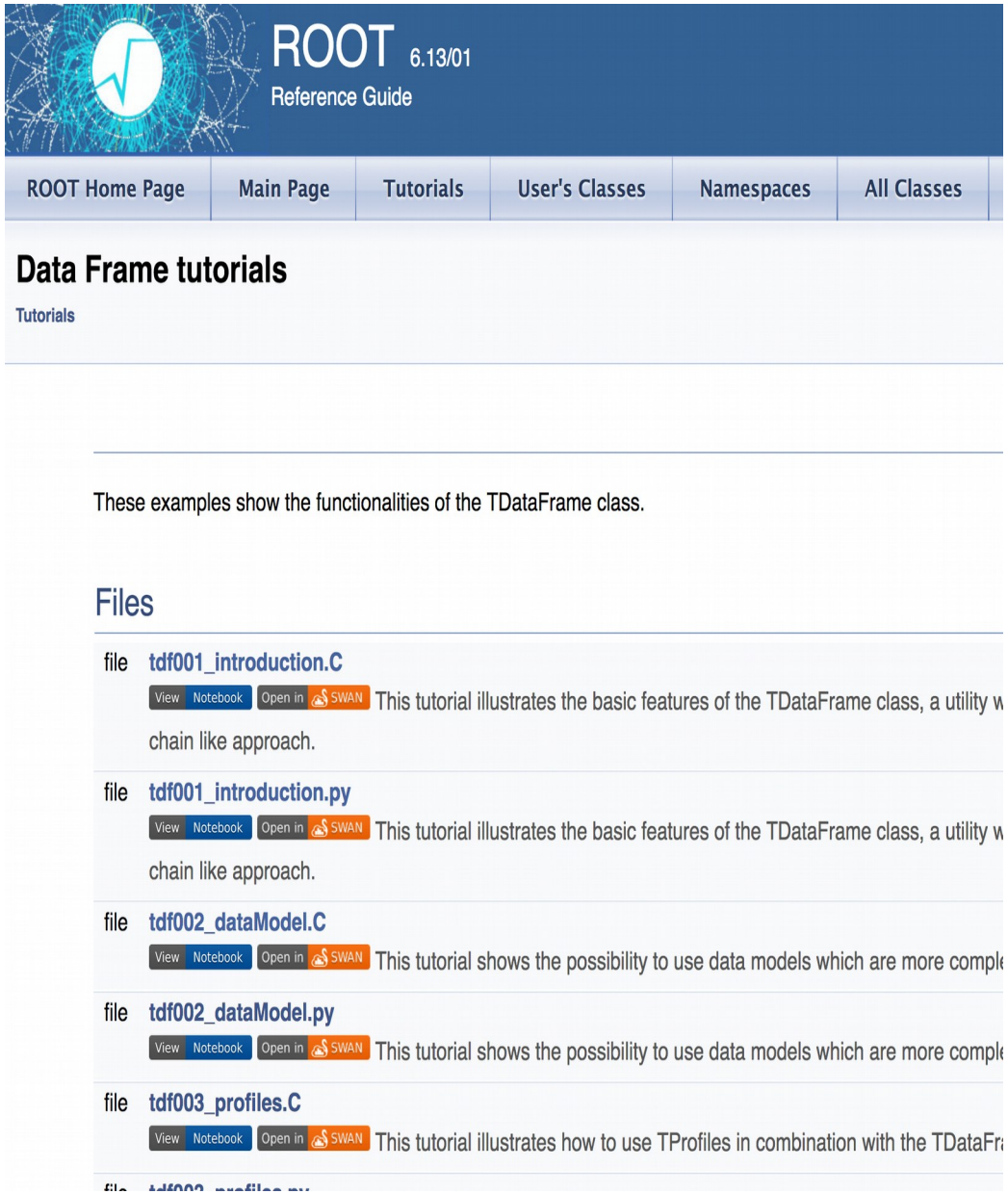
CERNBox is Your HOME



Interactive Tour of ROOTBooks

Image taken from https://pixabay.com/

More Examples



https://root.cern/doc/master/group__Tutorials.html

More Examples

SWAN

Interactive Data Analysis, in the Cloud.

Home | Galleries | FAQ | Talks and Publications

Basic | ROOT Primer | Accelerator Complex | Beam Dynamics | Machine Learning | Apache Spark | Outreach

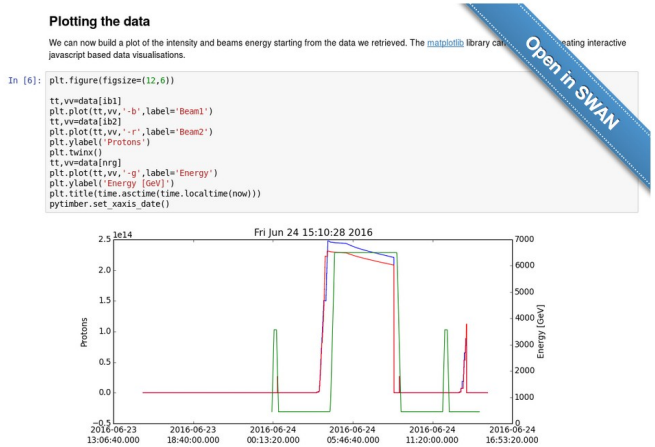
https://swan.web.cern.ch

Accelerator Complex

This gallery shows examples of machine studies relative to the CERN accelerators' complex.

Open in SWAN

LHC Page1



Experiments' Luminosities