Experience of studying Z bosons with ATLAS open data for high school diploma project (gymnasiearbete)

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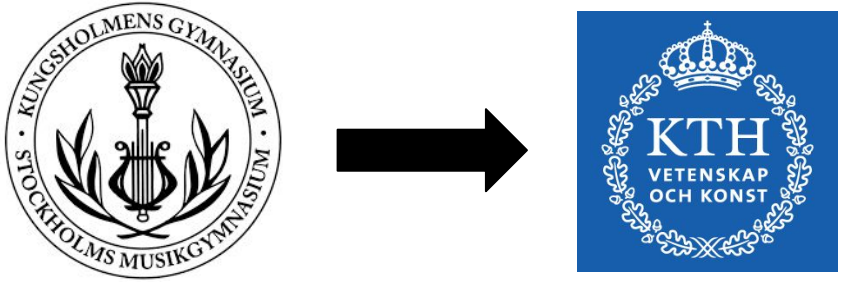
Supervisors: Christian Ohm & Giulia Ripellino

2019



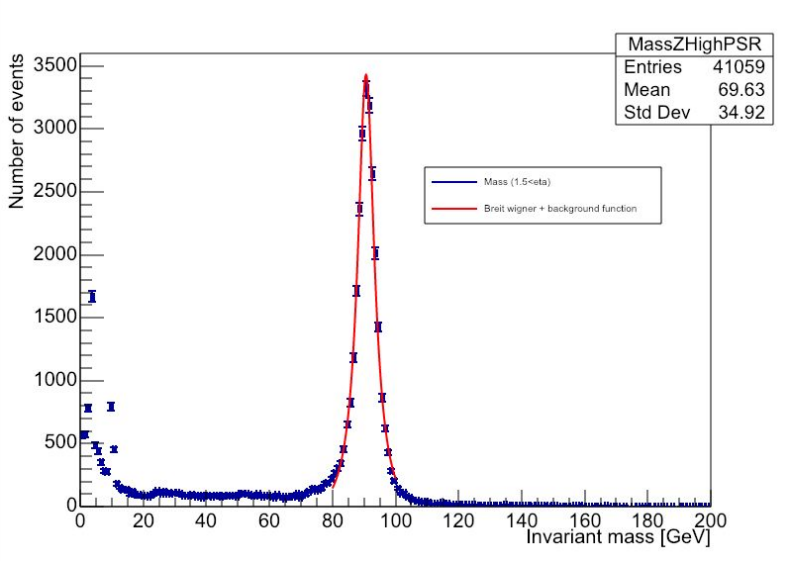
What I did

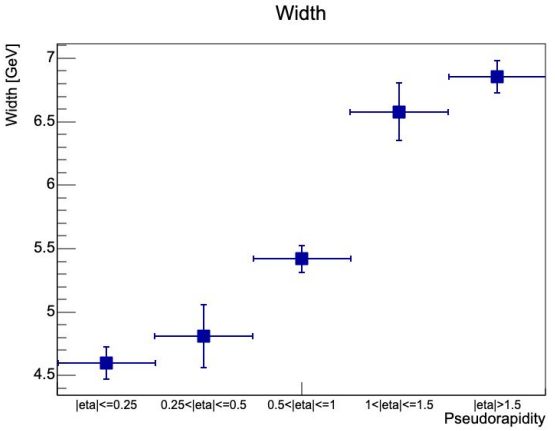
- Diploma project (Gymnasiearbete) → mandatory project last year of high school
- Studied the performance of the ATLAS detector for measuring the mass of the Z boson using the ATLAS open data collection
- Calculated the invariant mass of the Z boson
  - Muon decay channel
  - Electron decay channel
  - $m = \sqrt{(2p_{T1}p_{T2}((cosh(\eta_1 - \eta_2) - cos(\phi_1 - \phi_2)))}$ where η is the pseudorapidity, p_T is the transverse momentum and ϕ is the angle from the x-axis in the xy-plane.

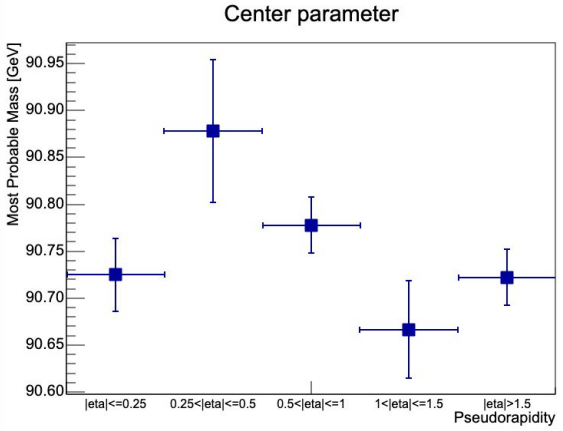
Subsamples of the data & fitting the invariant mass

- Muon and electron decay channels
- Pseudorapidity for the muon decay channel
  - $|\eta| \leq 0.25$, $0.25 < |\eta| \leq 0.5$, $0.5 < |\eta| \leq 1$, $1 < |\eta| \leq 1.5$ and $|\eta| > 1$
- Transverse momentum of the muons
  - $p_T \leq 30$ GeV, 30 GeV $< p_T \leq 40$ GeV, 40 GeV $< p_T \leq 45$ GeV, 45 GeV $< p_T \leq 50$ GeV and $p_T > 50$ GeV
- Transverse momentum of the Z boson
  - $p_T(Z) \leq 20$ GeV and $p_T(Z) > 20$ GeV
- Breit-Wigner function
  - Center parameter
  - Width parameter

Histograms

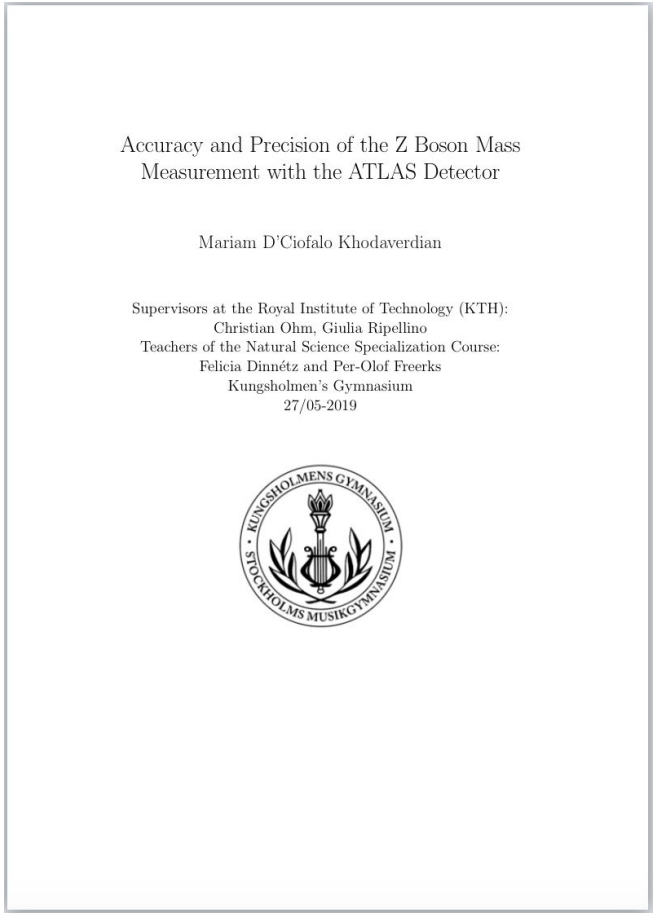

MassZHighPSR
Entries 41059
Mean 69.63
Std Dev 34.92
Mass (1.5<eta)
Breit wigner + background function
Number of events
Invariant mass [GeV]


Width
Width [GeV]
|eta|<=0.25
0.25<|eta|<=0.5
0.5<|eta|<=1
1<|eta|<=1.5
|eta|>1.5
Pseudorapidity


Center parameter
Most Probable Mass [GeV]
|eta|<=0.25
0.25<|eta|<=0.5
0.5<|eta|<=1
1<|eta|<=1.5
|eta|>1.5
Pseudorapidity

Results

- More accurate and precise for the muon decay channel
- Precision decreased as pseudorapidity increased
- Precision and accuracy decreased as the transverse momenta of the muon increased
- For increasing Z boson momenta:
  - Accuracy increased for the electron decay channel
  - Accuracy increased but precision decreased for the muon decay channel



Accuracy and Precision of the Z Boson Mass Measurement with the ATLAS Detector

Mariam D'Ciofalo Khodaverdian

Supervisors at the Royal Institute of Technology (KTH):
Christian Ohm, Giulia Ripellino
Teachers of the Natural Science Specialization Course:
Felicia Dinnétz and Per-Olof Freerks
Kungsholmen's Gymnasium
27/05-2019

KUNGSHOLMENS GYMNASIUM · STOCKHOLMS MUSIKGYMNASIUM ·

My experience

- Fun and interesting
- New concepts
- Challenging
- Most difficult: ROOT and programming
- Most interesting: The theory

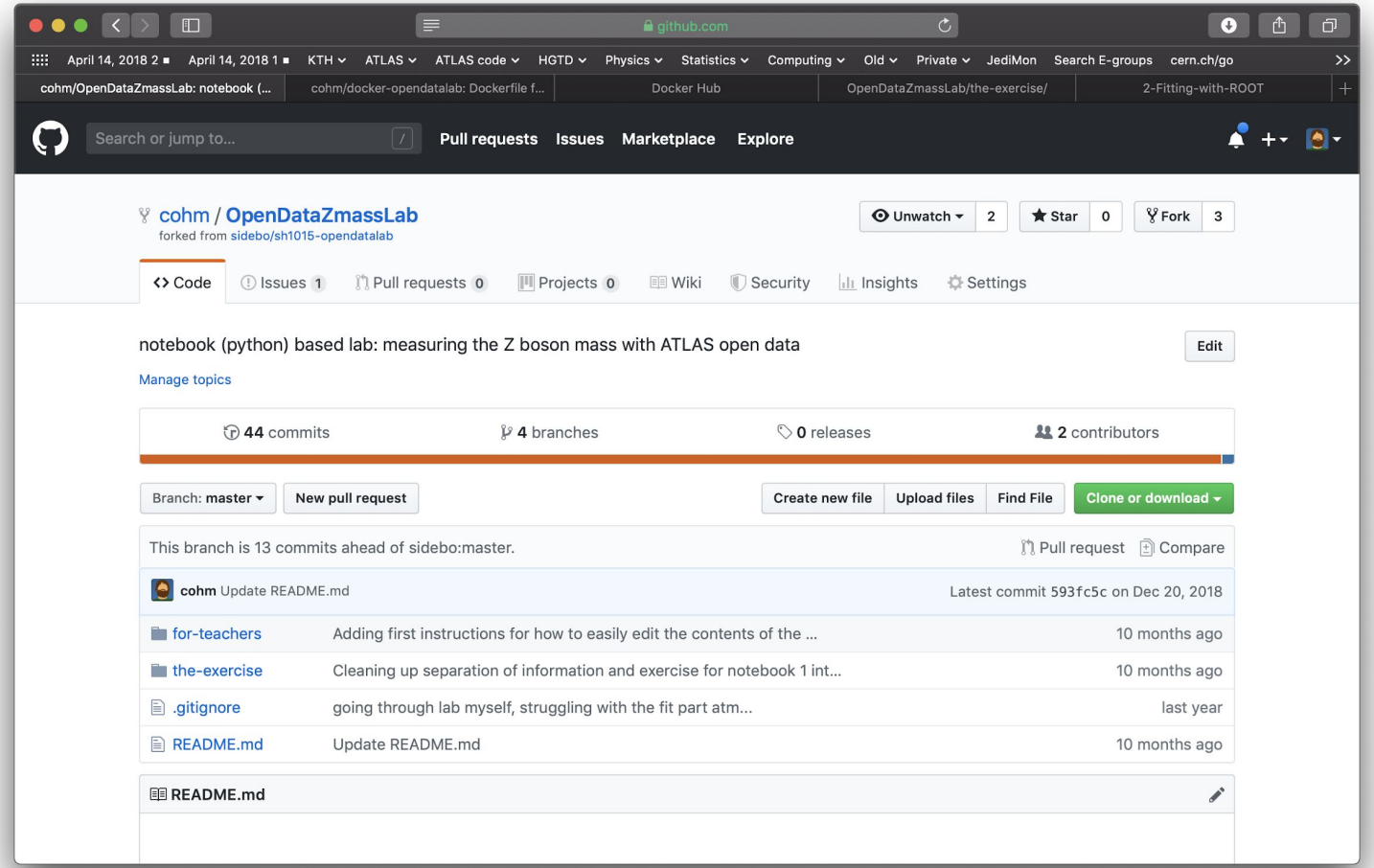
Back-up material

The KTH open-data analysis framework

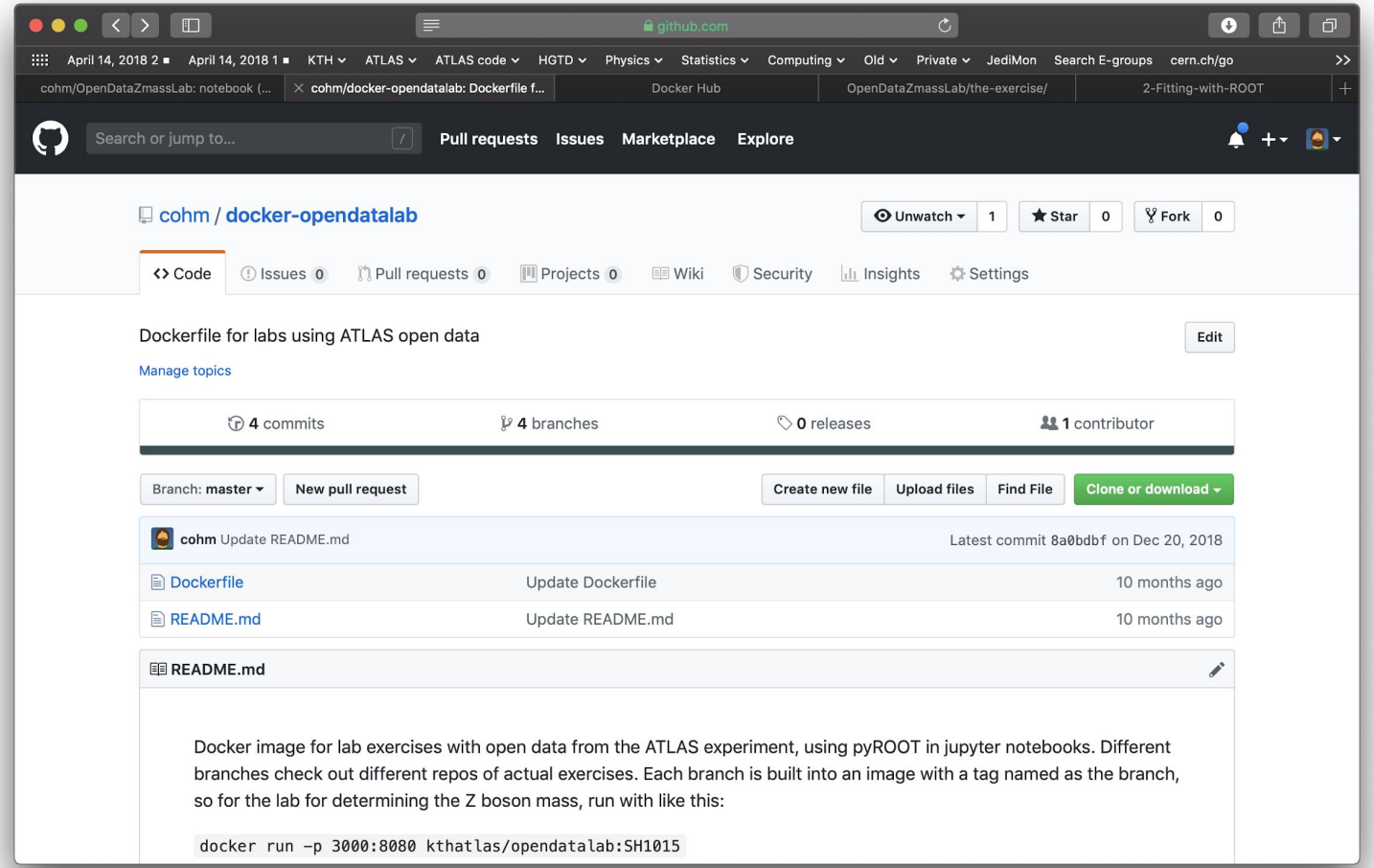
- Purpose:
  - Developed as a platform for computer labs (Edvin Sidebo, Christian Ohm)
  - Includes mini tutorial on python, ROOT and fitting distributions
- Technical details:
  - Based on Jupyter notebook running ROOT in python
  - Packed up in a docker image - up and running within minutes!
  - Try it yourself:

```
docker run -p 3000:8080 kthatlas/opendatalab:SH1015
```

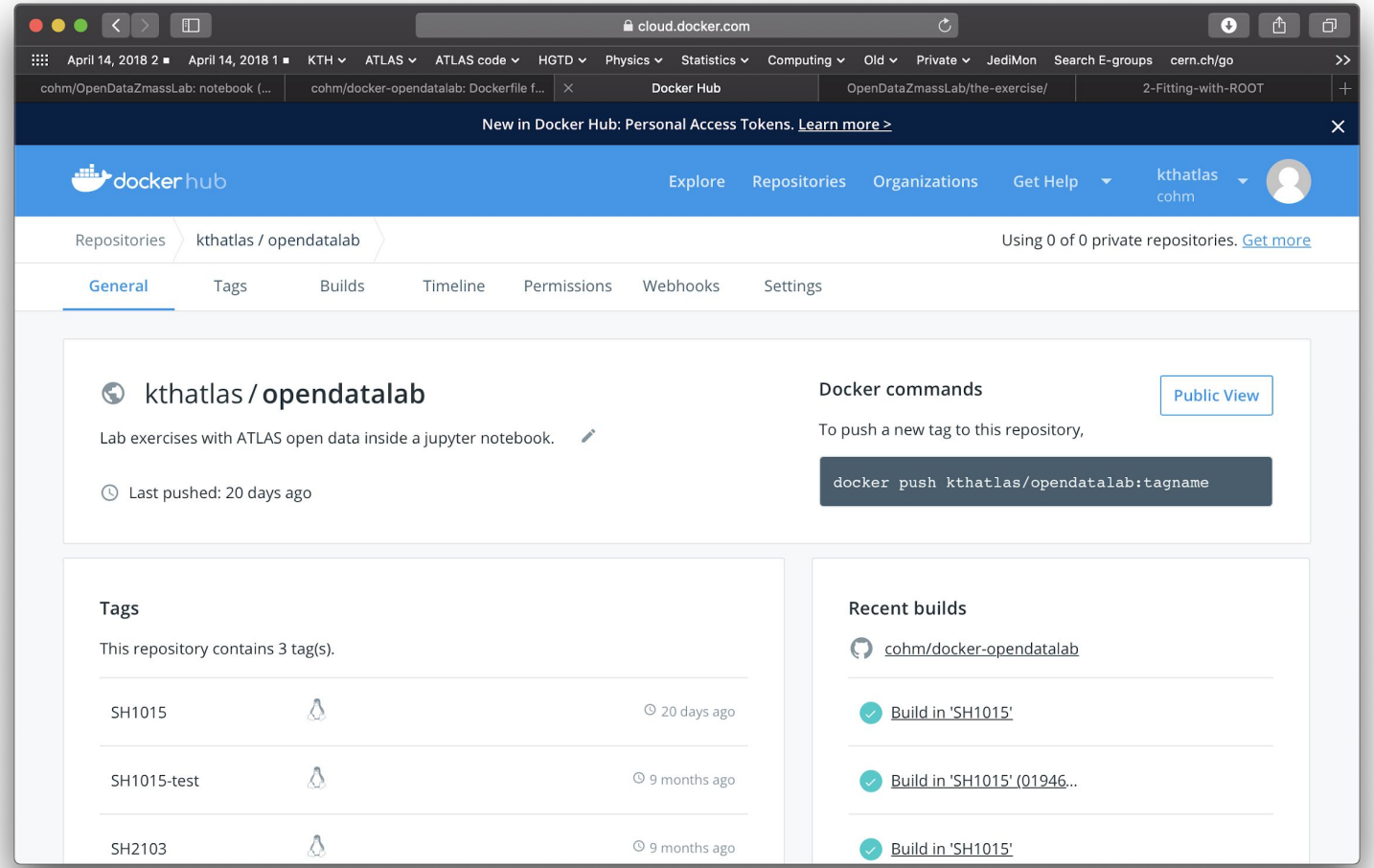
Point your browser to 127.0.0.1:3000 and put in the token printed in the terminal



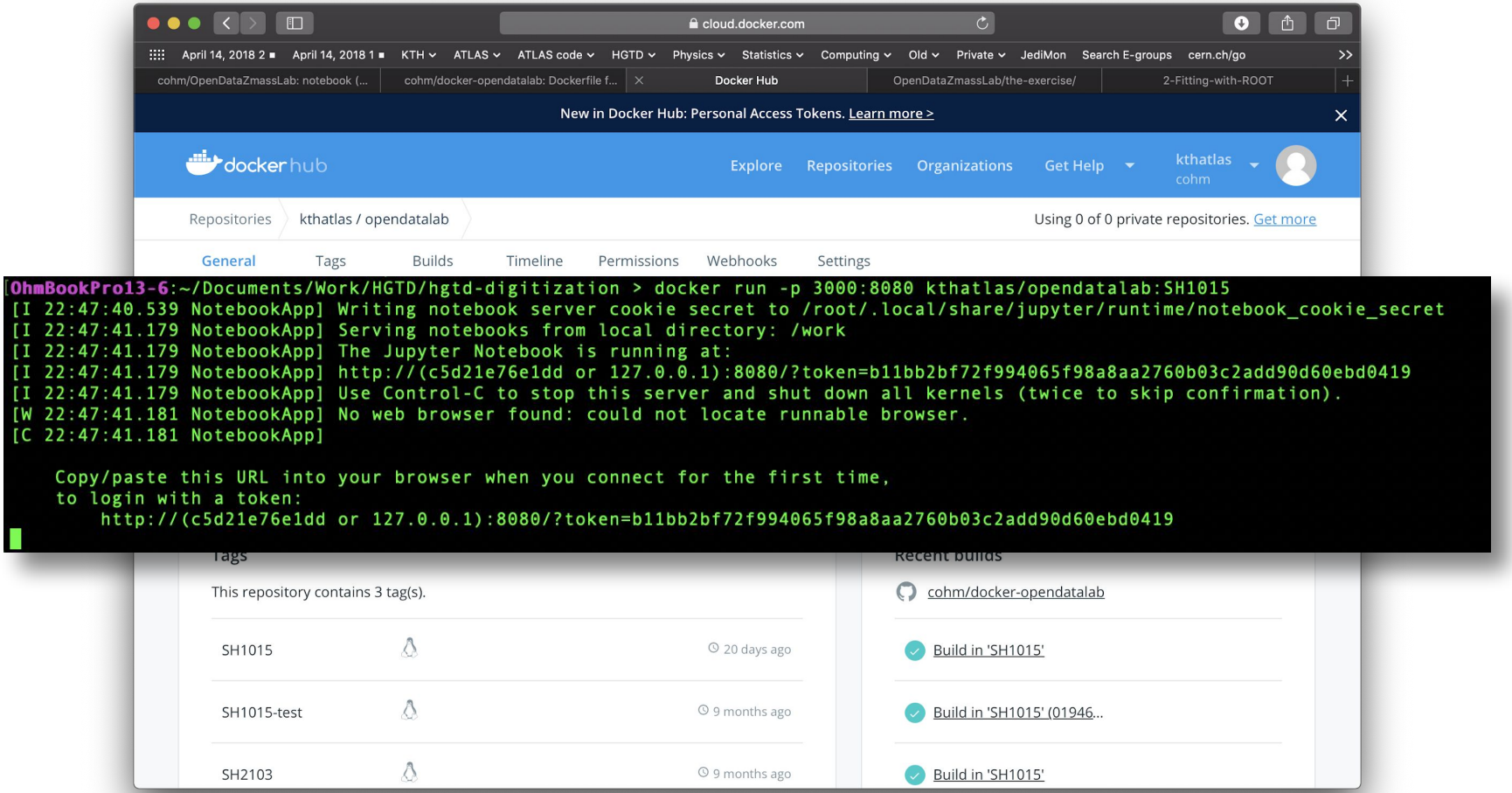
Repository containing the exercises and code templates in the Jupyter notebook



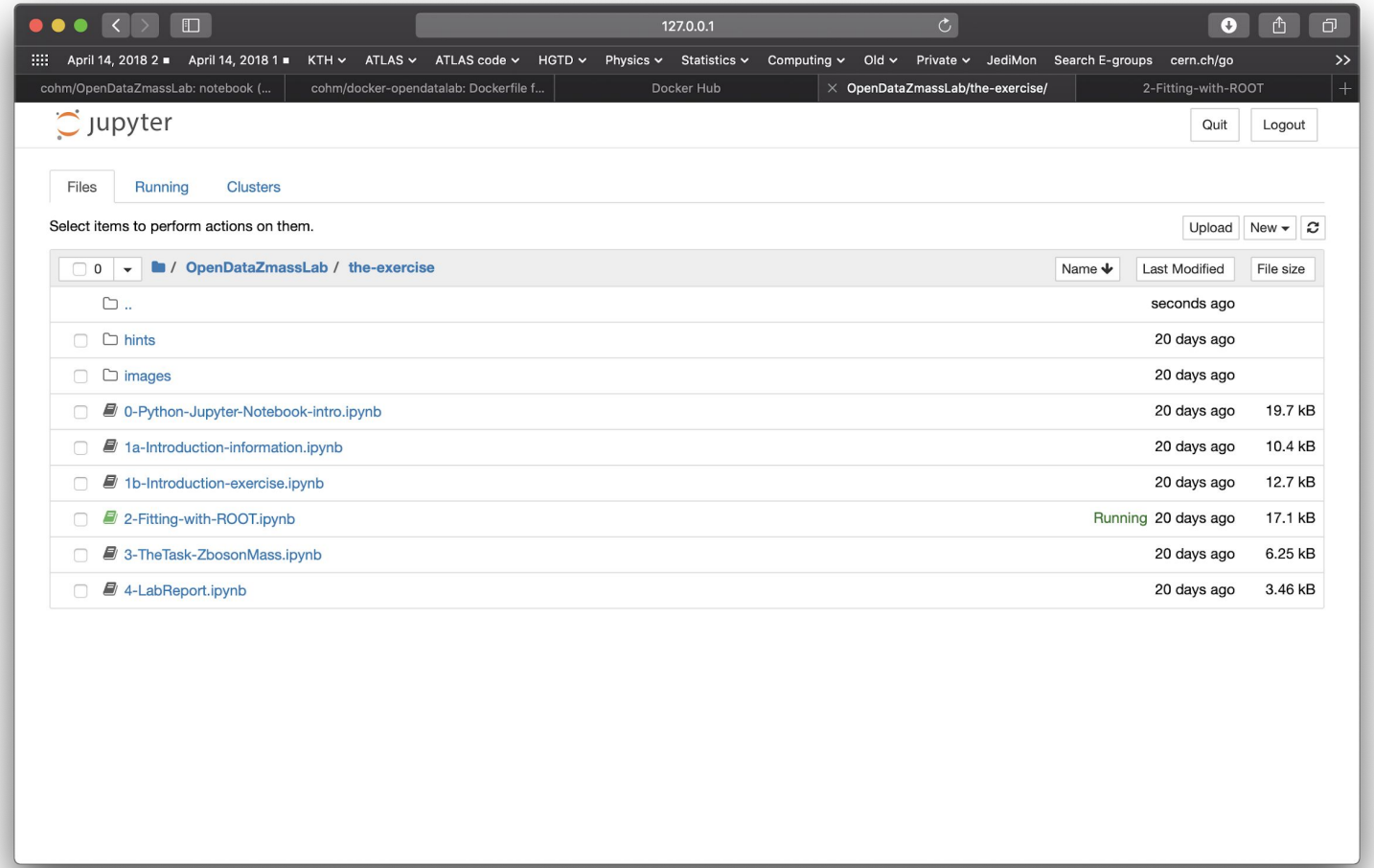
Repository containing the definition of the docker image containing the full setup



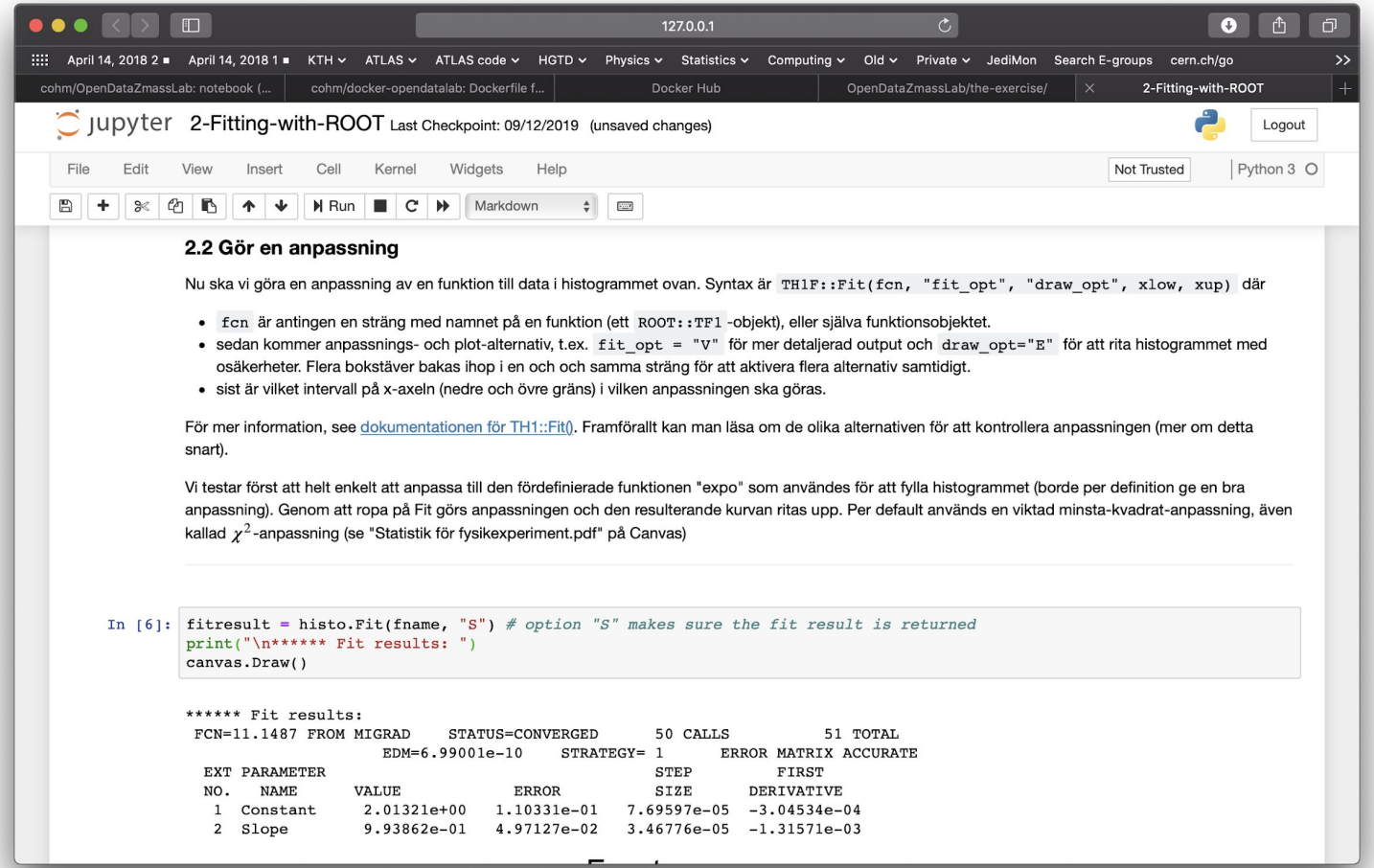
At dockerhub.com the image is automatically built when the code repo is updated



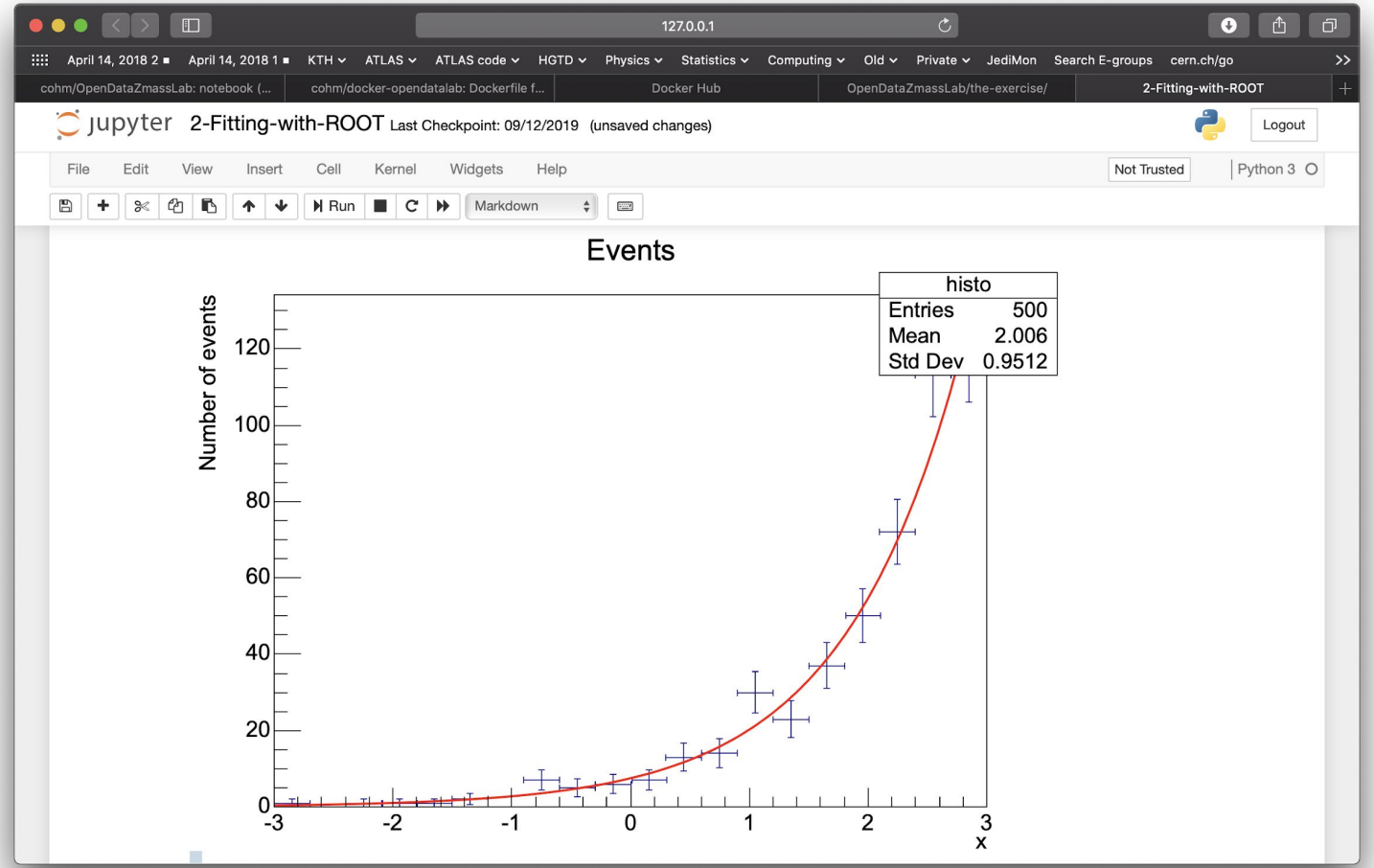
You start the docker image on any laptop (windows, linux, mac) in a matter of seconds



Docker container runs a local web server, you code through the web interface



The notebook contains exercises to learn how to make fits with PyROOT


127.0.0.1
April 14, 2018 2
April 14, 2018 1
KTH
ATLAS
ATLAS code
HGTD
Physics
Statistics
Computing
Old
Private
JediMon
Search E-groups
cern.ch/go
cohm/OpenDataZmassLab: notebook (...
cohm/docker-opendatalab: Dockerfile f...
Docker Hub
OpenDataZmassLab/the-exercise/
2-Fitting-with-ROOT
jupyter
2-Fitting-with-ROOT
Last Checkpoint: 09/12/2019
(unsaved changes)
Logout
File
Edit
View
Insert
Cell
Kernel
Widgets
Help
Not Trusted
Python 3
Run
Markdown
Events
histo
Entries 500
Mean 2.006
Std Dev 0.9512
Number of events
0
20
40
60
80
100
120
-3
-2
-1
0
1
2
3
x

Voilà!


A5:1011