

Enhancing ATLAS OpenData educational resource with the first ROOTbooks

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Structure

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- ▶ My task for the project weeks
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- ▶ Integration into the ATLAS OpenData Portal
- ▶ Pros and cons of ROOTbooks
- ▶ Further literature
- ▶ Little discussion



Background information

- ▶ High school student → work together with TU Dresden
- ▶ Currently writing a high school project (feb. 2017 - may 2018)
- ▶ Topic: „Optimization of the event selection in the search after semileptonic decaying Z prime bosons with data from the ATLAS experiment“
- ▶ April 2017: one week at TU Dresden for writing this analysis
- ▶ October 2017: CERN project weeks

**Optimierung der Eventselektion bei der
Suche nach semileptonisch zerfallenden
Z-prime-Bosonen mithilfe
von Daten des ATLAS-Experiments**

Besondere Lernleistung

Zur Einbringung als fünftes Prüfungsfach
in die Abiturprüfung 2018

vorgelegt von

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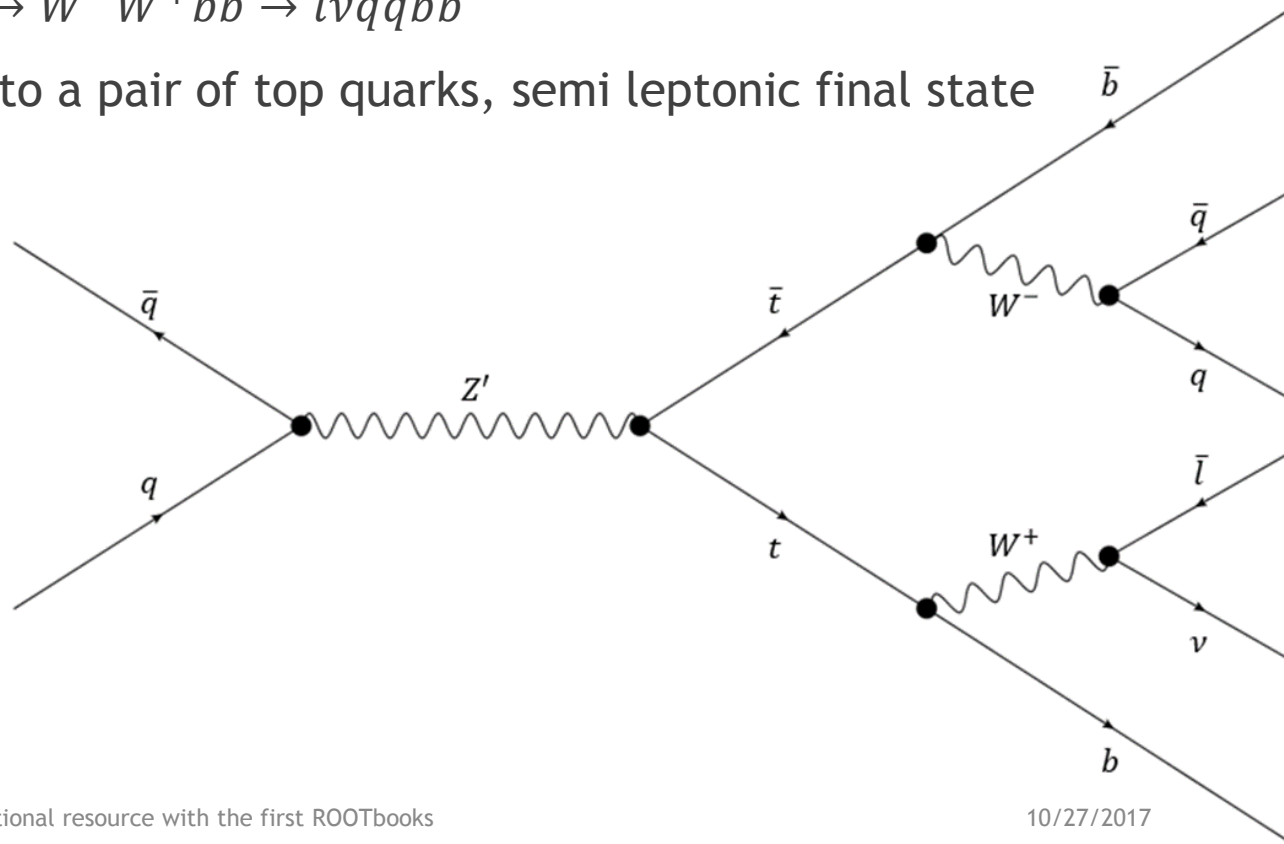
Fach: Physik

eingereicht am: 22.12.2017



The analyzed decay

- ▶ $pp \rightarrow Z' \rightarrow \bar{t}t \rightarrow W^-W^+\bar{b}b \rightarrow \bar{l}\nu\bar{q}q\bar{b}b$
- ▶ Z' decaying into a pair of top quarks, semi leptonic final state



My task for the CERN project weeks

- ▶ Creation of ROOTbooks of different degrees of difficulty
- ▶ Goal: explain beginners the main analysis techniques of HEP
- ▶ After creation: run notebook with SWAN

A screenshot of a web-based C++ notebook interface. The title bar reads "1. C++ notebook" and includes "Control Panel" and "Logout" buttons. The menu bar contains "File", "Edit", "View", "Insert", "Cell", "Kernel", and "Help". A "Not Trusted" warning is visible. The toolbar includes icons for file operations and a "Markdown" dropdown. The main content area contains text and code blocks:

At first we have to include several helpers that will support our analysis.

```
In [1]: #include <iostream>
#include <string>
#include <stdio.h>
```

In order to activate the interactive visualisation of the histogram that is later created we can use the JSROOT magic:

```
In [2]: %jsroot on
```

Next we have to open the data that we want to analyse. It is stored in a `.root` file. By creating a `TChain` it is possible to add more datasets and accordingly analyze more data.



The ATLAS OpenData Portal

- ▶ access to a range of data produced at CERN (especially ATLAS) → software and documentation to understand and analyze the data being shared
- ▶ for students and general public to learn sth. about the research at CERN



What is a ROOTbook?

- ▶ Jupyter notebook: document containing computer code and text elements
- ▶ <https://jupyter.readthedocs.io/en/latest/>
- ▶ ROOTbook: jupyter notebook with included ROOT library for python/C++ to analyze data, especially if it comes as ROOT files



Integration into the ATLAS OpenData Portal

- ▶ Let's look at the ROOTbooks:

<http://nbviewer.jupyter.org/github/timhebe/ROOTbooks/tree/master/>

open data ATLAS

Get Started
Documentation, Histogram
Analyser, Analysis Browser

Web Analysis
Documentation, Analysis
ROOTBooks

Data & Tools
Documentation, Datasets,
Software, Virtual Machines

ATLAS ROOTbooks Gallery

ready to test our examples?

Example of the reconstruction of the invariant Mass of the Z boson in C++

Title for ROOTbook Three

Description of the notebook: The ATLAS data from 100 trillion proton collisions is now public! This marks the world's first open release of 8 TeV data, gathered from the Large Hadron Collider in 2012.

Creation: ~1920 - [check the notebook in our repo](#)

Execute this ROOTbook using one of the methods below

- Run using [Tool X](#)
- Run using [Tool X](#)
- Run using [Tool X](#)



Pros and cons of ROOTbooks

Pros

- ▶ Useful for education and training
- ▶ Easy to document code (via Markdown)
- ▶ Clear structure and clear pointers on what to execute
- ▶ Implementation in websites is easy (e.g. via GitHub)

Cons

- ▶ Lack of performance if large amount of data
- ▶ No good options to visualize large amount of plots
- ▶ Loops only executable in one box



Further literature

- ▶ <http://opendata.atlas.cern/>
- ▶ <http://jupyter.org/>



Little discussion

- ▶ What do you think about the notebooks?
- ▶ What should be improved?

Thank you for your attention 😊

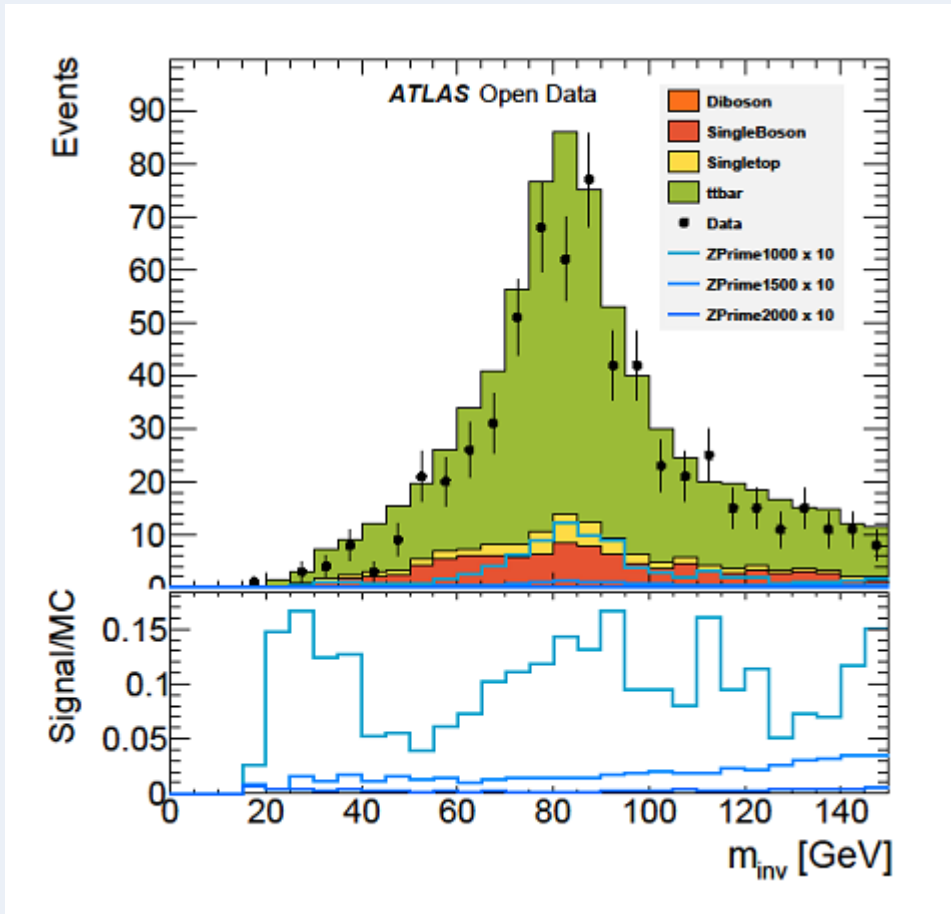


Backup

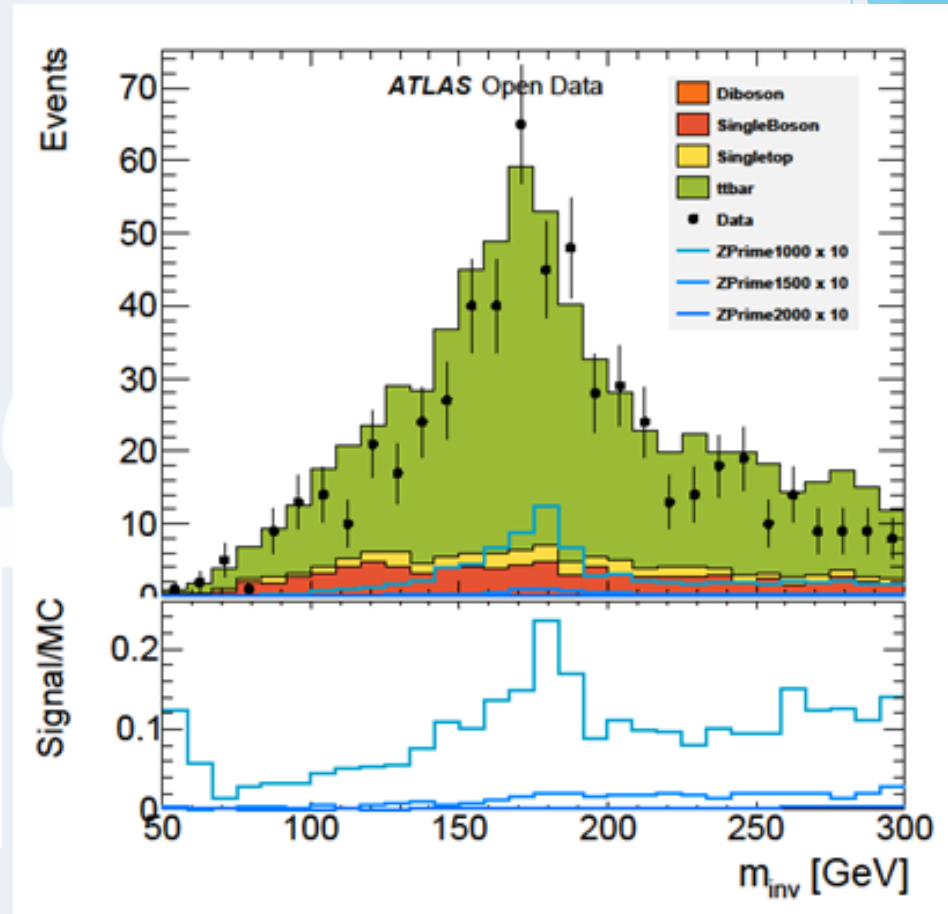
Conclusion of the results for a mass hypothesis of the Z prime Boson of 1000GeV

- ▶ $n_{\text{leptons}} = 1$
- ▶ $MET > 150\text{GeV}$
- ▶ $n_{\text{jets}} \geq 4$
- ▶ $1 \leq n_{b\text{-jets}} \leq 2$
- ▶ $m_{W\text{-Boson}}^T \geq 30\text{GeV}$
- ▶ $m_{W\text{-Boson}}^T + MET \geq 60\text{GeV}$



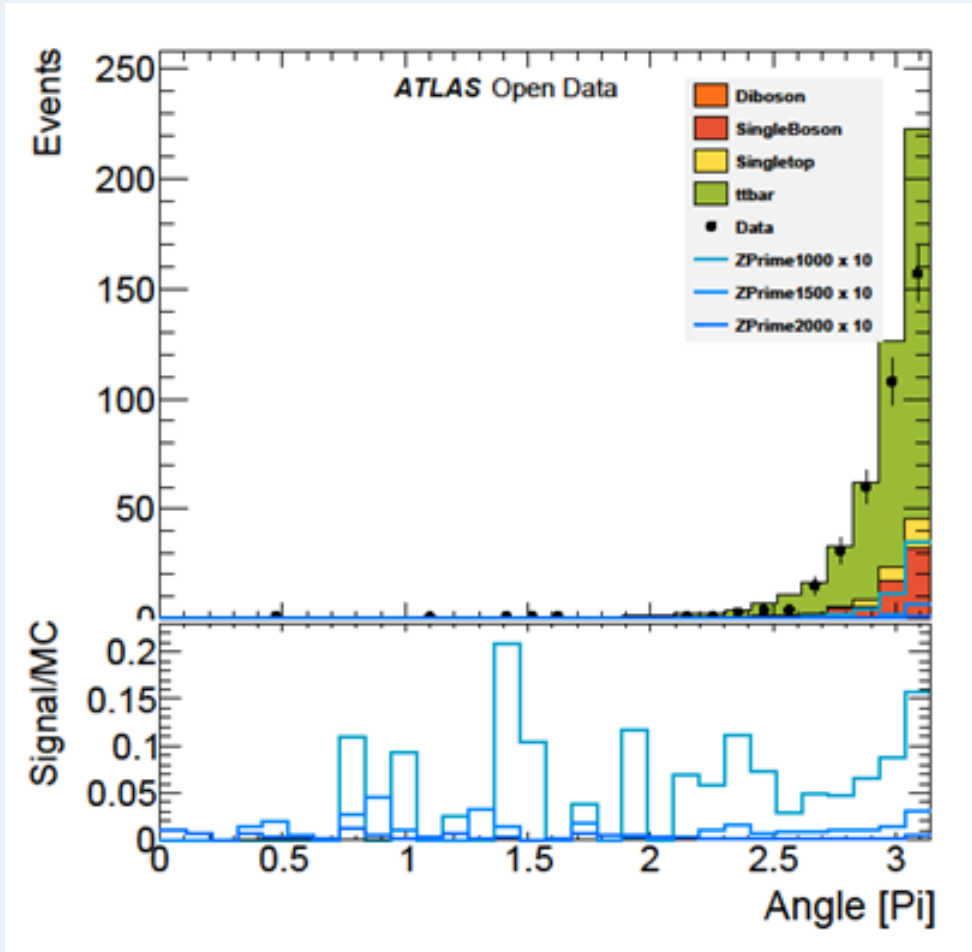


► Mass of the hadronic decaying W boson

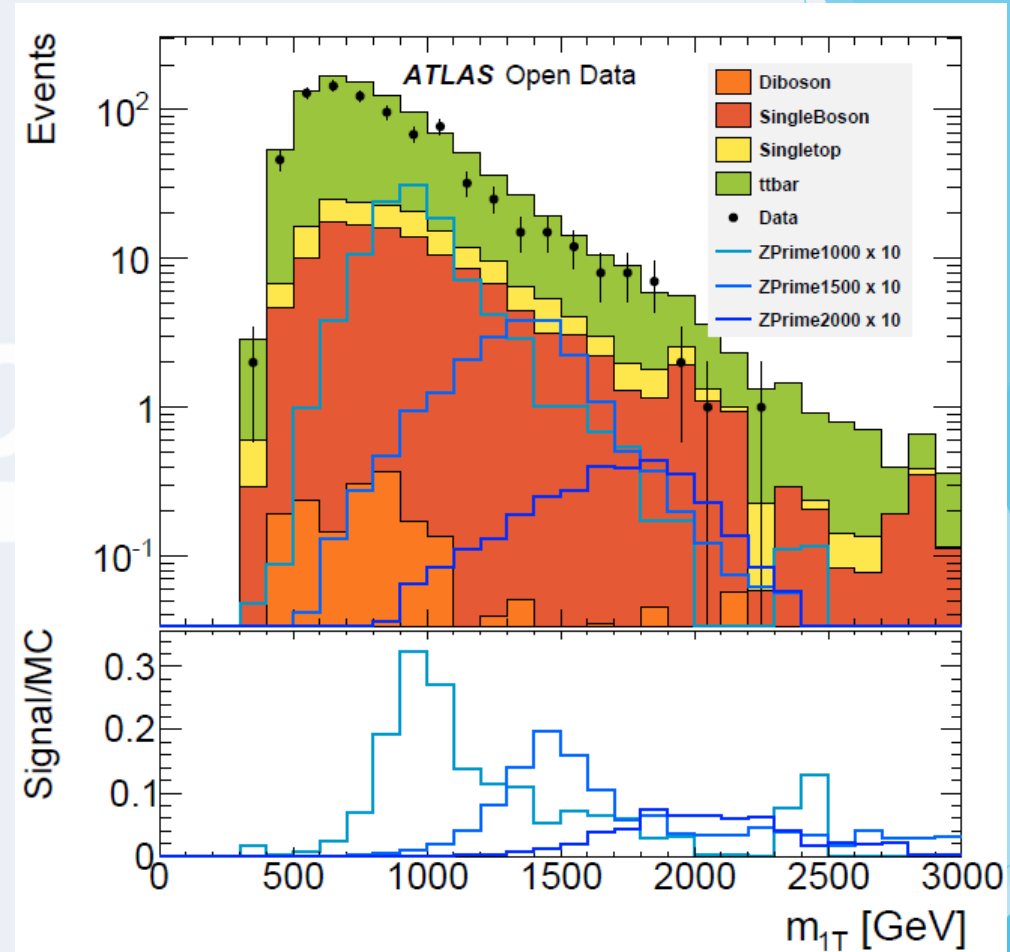


► Mass of the hadronic decaying top quark





- ▶ Angle between the decaying top quarks



- ▶ The late-projected invariant mass m_{1T} of the Z prime boson

