PROCEEDINGS OF SCIENCE

Integration of ROOT notebook as an ATLAS analysis web-based tool in outreach and public data release projects

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Integration of the ROOT data analysis framework with the Jupyter Notebook technology presents the potential of enhancement and expansion of educational and training programs. It can be beneficial for university students in their early years, new PhD students and post-doctoral researchers, as well as for senior researchers and teachers who want to refresh their data analysis skills or to introduce a more friendly and yet very powerful open source tool in the classroom. Such tools have been already tested in several environments. A fully web-based integration of the tools and the Open Access Data repositories bring the possibility to go a step forward in the ATLAS quest of making use of several CERN projects in the field of the education and training, developing new computing solutions on the way.

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1. Introduction and Vision

The ATLAS Collaboration[1][2], through its outreach group, is developing methods and educational resources to share together with real and simulated data. The recent created ATLAS Open Data project[3] implements the ATLAS policy[4] of releasing datasets to the public together with tools that allow their inspection and analysis, mainly for educational purposes. One of the tools -or frameworks- that is used to do such analyses is ROOT[5].
In order to do that, we are dedicated to finding resources that allow the use of ROOT in the most accesible way for university students, professors and the general public, removing as much as possible any previous computational enviroment's setup.
Jupyter[6] Notebook technology allows to perform data analysis directly on a web browser and the ROOT group at CERN[7] developed the necessary kernels[8] to execute ROOT commands on a Jupyter Notebook. We called that combination a ROOTbook (Figures 1 and 2).

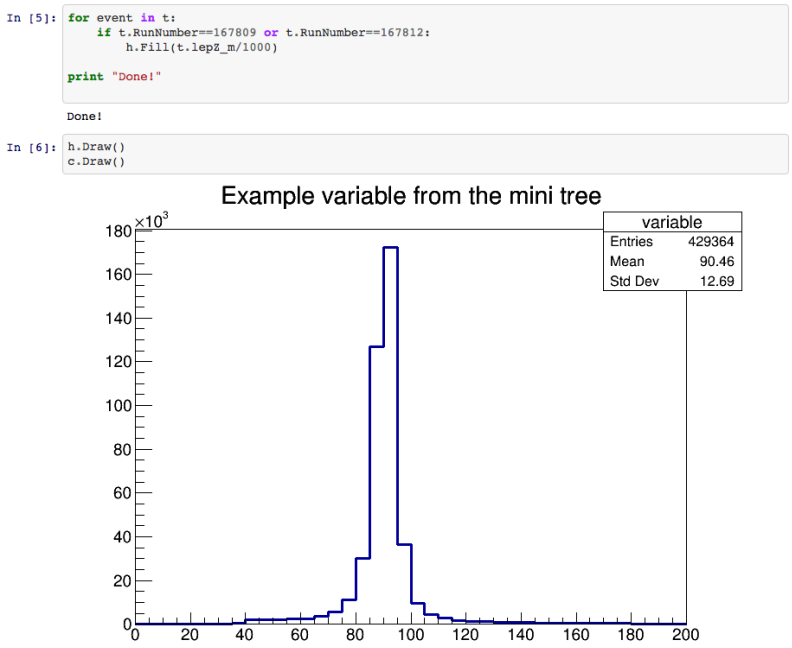

Figure 1: An extract of a Jupyter notebook under PyROOT kernel[8] to exemplify their look. Note the small set of instructions that are needed in order to loop, select and create a histogram using as input an ATLAS simulated dataset file containing the reconstructed invariant mass of a Z boson[9].

2. Objective, concepts and status

We want to take advantage of the integration of the ROOT framework with the Jupyter Notebook to create educational and training material that can be easy to use and share. The material under creation is a set of ROOTbooks and complementary documentation, that using ATLAS public data -but not only- allows the teaching of concepts about HEP, data analysis, computing and statistics between others, where the main target audience are students at the high school level and beyond.

The visualisation, execution, edition, storage and distribution of those ROOTbooks to members of the collaboration and general public is done through the ATLAS[3] and CERN[10] Open Data web platforms and other services like NBviewer[11] and myBinder[12]. A ROOT-CERN cloud computing service called SWAN[13] in combination with CERNbox[14] have been setup as well. All of them are open source and/or rely on open source projects.

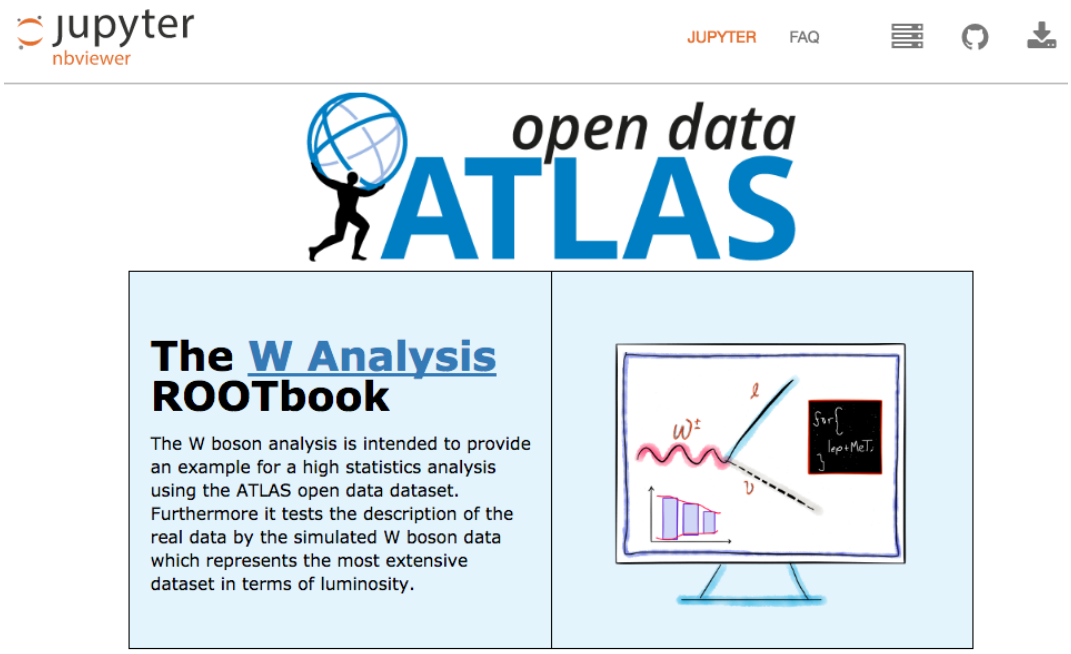

Figure 2: The initial part of a Jupyter notebook under C++ ROOT kernel[8]. Note the HTML capabilities that allows to create very rich *in situ* documentation. This example is an analysis that looks for a W boson[9].

Right now we are developing and documenting services that provide the possibility to interact with the notebooks as well. Under the above mentioned computing solutions we can execute notebooks in a complete cloud computing environment using a public service like myBinder, the SWAN+CERNbox (under production tests inside CERN) or in local installations of ROOT: this can be done installing one of the latest versions of ROOT or using one of the Virtual Machines (VM) provided into the ATLAS/CERN Open Data platforms. In this last case, we provide a free installation and software licenses service that teachers, students and general public can use under any operative system (Figure 3). The aim is to inspire others to create new notebooks too: ATLAS and not-ATLAS members can consider to use notebooks as a complementary way to create educational resources (like tutorials) and share those with us for distribution into the ATLAS Open Data website. We want to encourage developers and students to share their notebooks and ideas under the ATLAS Open Data platform. In this way other groups, institutions or individuals eager to create a local project can fork a complete project or example already in the platform. Or to start from one of them, instead of doing it from scratch. Finally, the combination of notebooks with other online and offline resources looks like a promising channel to do outreach within and outside ATLAS and any other scientific community.

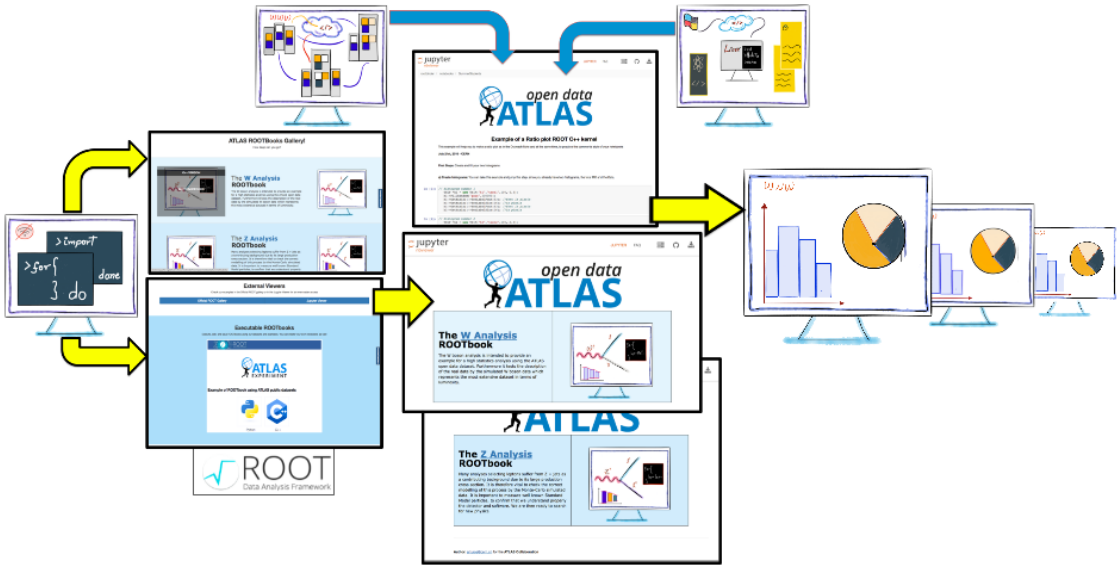

Figure 3: Schematic view of the resources access: The Jupyter Notebook under ROOT kernels[8] are accessible though the ATLAS Open Data portal[3] (left), and using NBviewer[11], myBinder[12], SWAN[13] and/or a VM (top and middle), they can be visualised, executed and modified by interested users.

References

[1] ATLAS Collaboration 2012 *Phys. Lett. B* **716** pp 1-29.

[2] G. Aad *et al.* **The ATLAS Experiment at the CERN LHC** - ATLAS Collaboration, JINST **3** (2008).

[3] The **ATLAS Open Data** portal - http://opendata.atlas.cern

[4] The ATLAS Data Policy - http://opendata.cern.ch/record/413/files/ATLAS-Data-Policy.pdf

[5] Brun R and Rademakers F 1996 ROOT - An Object Oriented Data Analysis Framework *Nucl. Inst. & Meth. in Phys. Res. A* **389** pp 81-86.

[6] The Jupyter Notebook web application - http://jupyter.org.

[7] European Organization for the Nuclear Research (CERN) - http://home.cern

[8] ROOT has its Jupyter Kernel - https://root.cern.ch/root-has-its-jupyter-kernel

[9] Particle Data Group Online references for *Z* and *W* bosons, *PR* **D86**, 010001 (2012) - http://pdg.lbl.gov/2012/listings/rpp2012-list-z-boson.pdf, http://pdg.lbl.gov/2012/listings/rpp2012-list-w-boson.pdf

[10] The **CERN Open Data** portal - http://opendata.cern.ch

[11] A web-based viewer for Jupyter notebooks - http://nbviewer.jupyter.org.

[12] Web-based Jupyter notebook execution service- http://mybinder.org

[13] Data analysis web-based and cloud computing service for CERN users: **SWAN** Software as a Services (SaaS) - https://swan.web.cern.ch.

[14] A cloud storage service for CERN users - CERNBOX, https://cernbox.cern.ch.