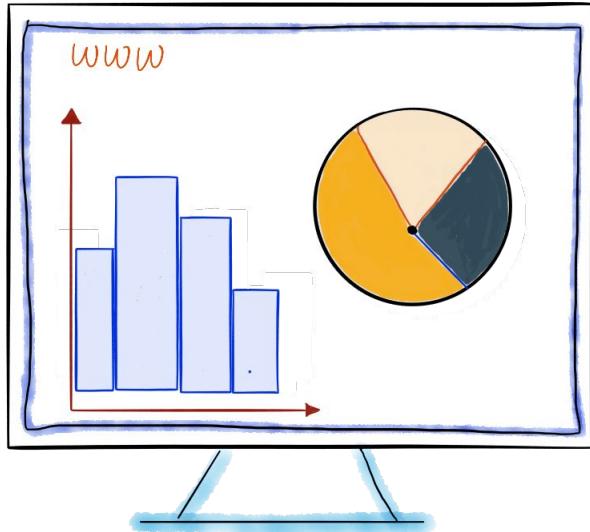


# ATLAS Key in Open Data



Arturo Sánchez

University of Udine, ICTP and INFN

CHEP 2018, Sofia - July 12<sup>th</sup>, 2018

## ATLAS OpenData and OpenKey: using low tech computational tools for students training in High Energy Physics

One of the significant challenges in High Energy Physics development is the fact that many potential -and precious- students and young researchers live in countries where internet access and computational infrastructure are poor compared to institutions already participating. To accelerate the process, the ATLAS Open Data project releases useful and meaningful data and tools using standard and easy-to-deploy computational means, such as custom and light Linux Virtual Machines, open source technologies, web and desktop applications. The ATLAS Open Key, a simple USB pen, allows transporting all those resources around the globe. As simple as it sounds, this approach is helping to train students that are now PhD candidates and to integrate HEP educational programs at Master level in universities where it did not exist before. The software tools and resources used will be presented, as well as results and stories, ideas and next steps of the ATLAS Open Data project.



# ATLAS Open Data+Key

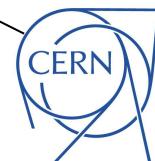
Why?... because it is part of our  
duties as collaboration, and to  
boost diversity in HEP

A Talent Training and Acquisition program

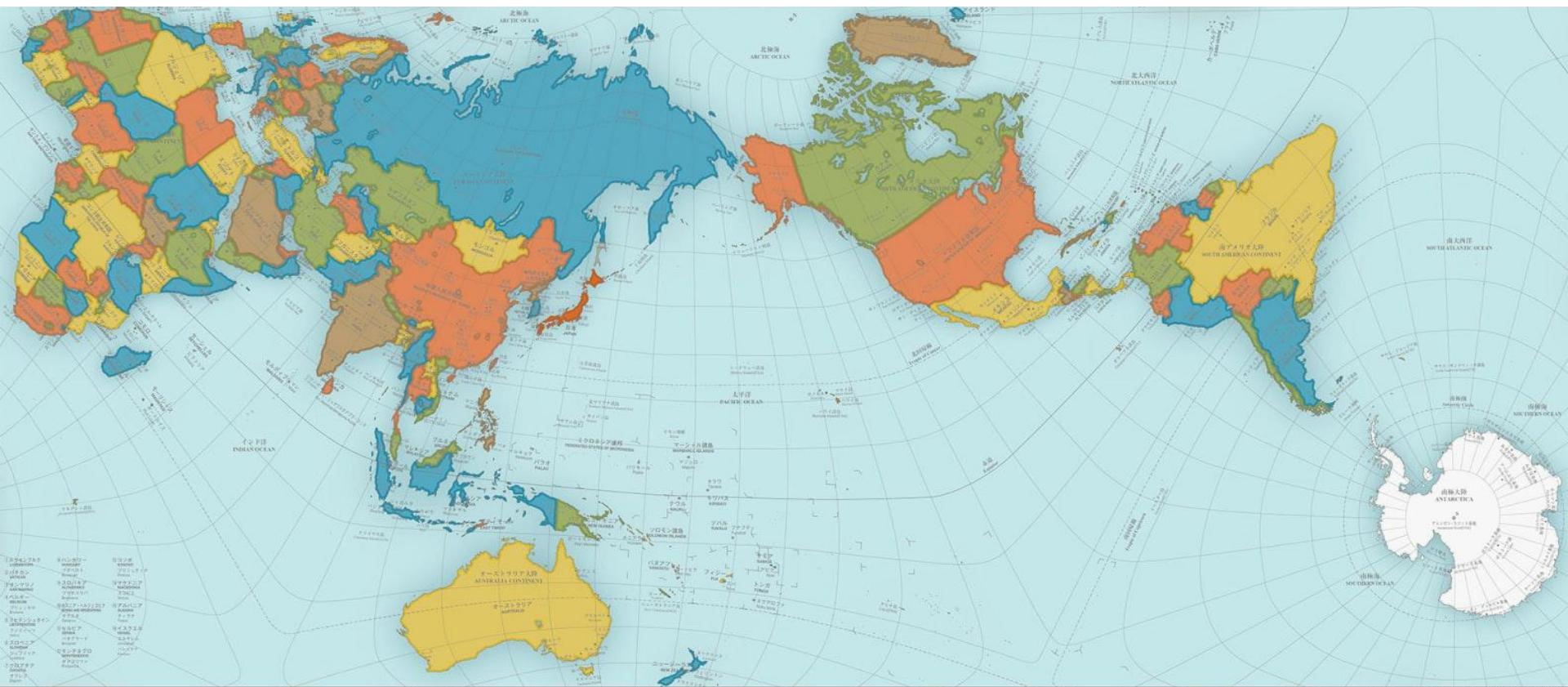
- Why do we need to reach them?



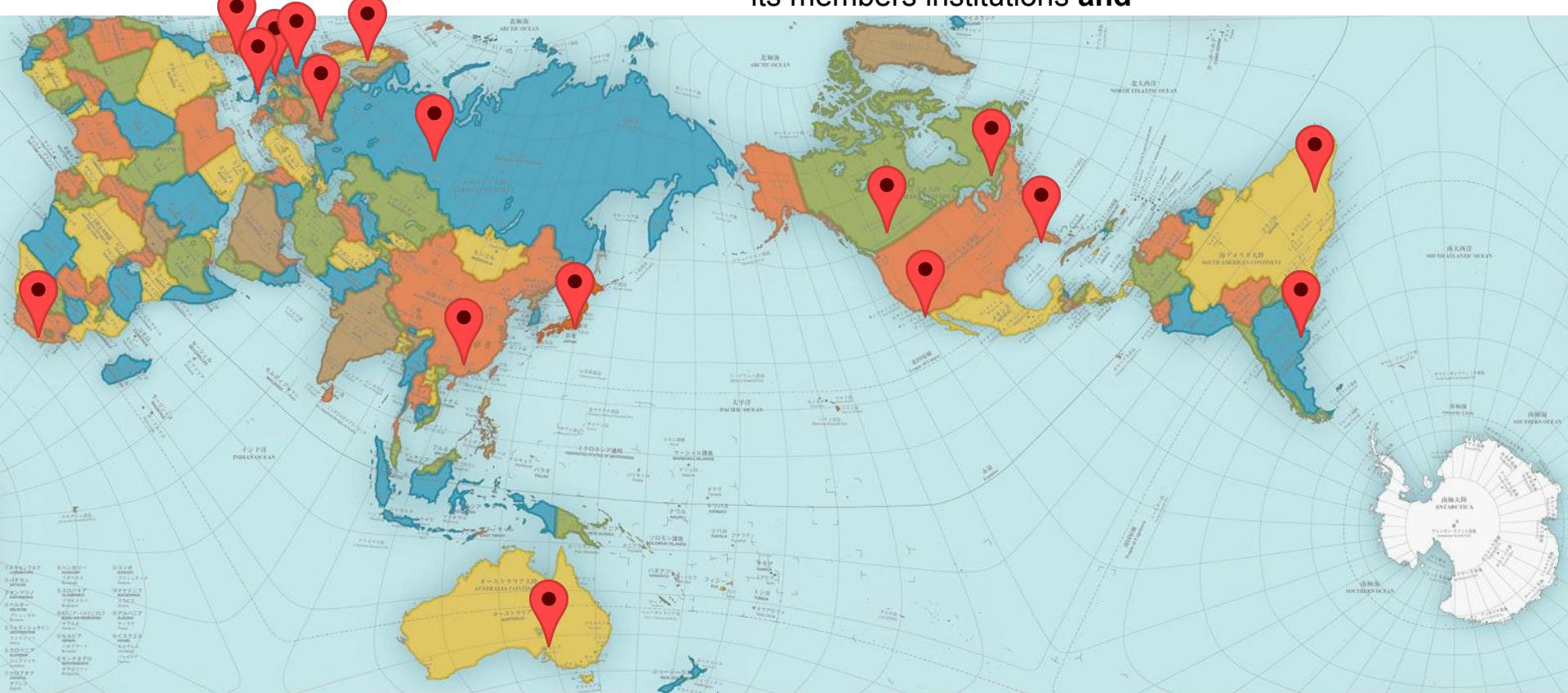
The **ATLAS** Collaboration, as part  
of the HEP community, has the  
responsibility and the need **to**



transfer knowledge and training to



its members institutions and



everybody else!



# <https://atlas.cern>

The ATLAS Experiment has a wide range of educational resources available for students and teachers. Explore the categories below to find out how you can engage with ATLAS.

## Primary School Students



Resources for students aged 5-12

## Secondary School Students



Educational initiatives for students aged 12-18

## University Students



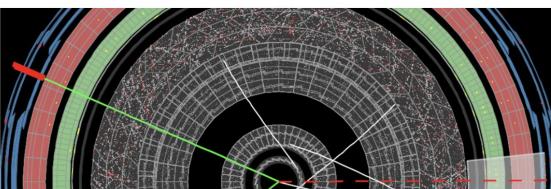
Opportunities for Undergraduate, Masters and PhD students

## Teachers



Ideas for physics and science educators

## Citizen Science



## Resources & Multimedia



**The ATLAS Collaboration** and the broad set of HEP experiments rely on public funding to support their programs.

Even more important, their **continuity depends on a constant integration and replacement of human power**.

Humans -**students, professionals**- that need to be trained by other senior members of those collaborations.

We can call it **Transfer of Knowledge**, and it goes in both ways: to retribute to society and to keep running the -even more- large scientific endeavours worldwide.

No single nation or entity can do this job alone, nor it should do so. **When knowledge is everybody's property, progress is possible and equally distributed.**

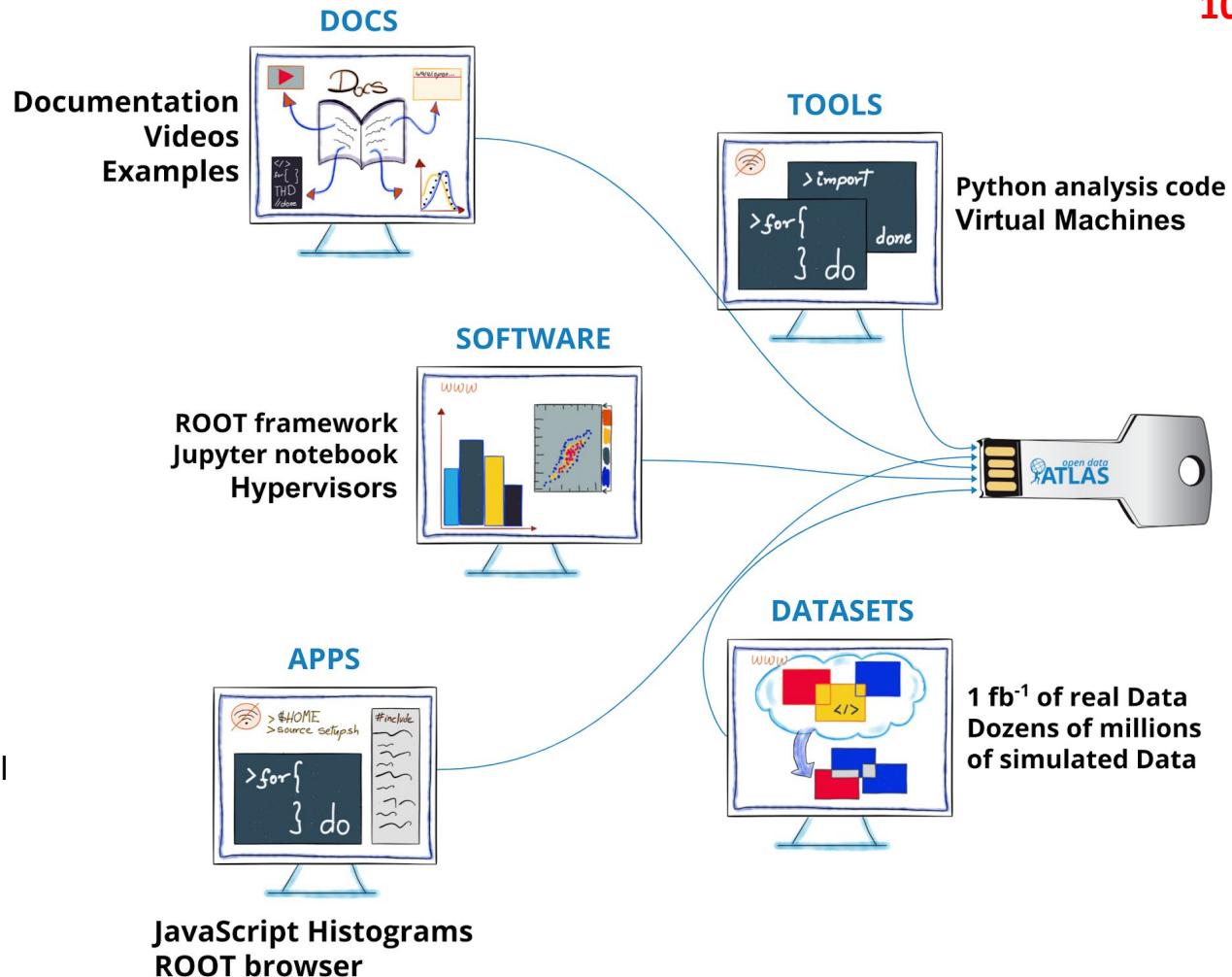
ATLAS Outreach Group  
tries to achieve that goal.

Today's presentation is  
about one of those  
**efforts that strongly  
depends on the  
computer tools  
developed for the Open  
Source and HEP  
worldwide**



We **fill USB keys with all the educational resources and give them away to instructors & professors to**

- Perform workshops -enhanced “masterclasses”- for advanced students
- Create and run laboratory’s courses and e-courses in HEP
- Promote HEP into their institutions and with policymakers
- To dedicated students and small libraries who share/copy the resources between them, as we are used to do with books.



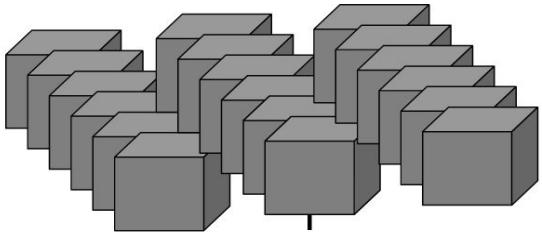
# ATLAS Open Data

How?...

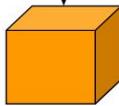
the ATLAS members, try to “be”  
there

**How are we trying to get more people involved?**

- The Data and the Tools
- Keep data useful and not *just big*
- The Virtual Machine’ approach
- Going for the Apps’ development



datasets



The ATLAS Open Data project ([more here](#)) aims to release real and simulated **Data**, together with Open Source **software resources** to analyse those samples. As well as **documentation** in several useful formats!



<http://opendata.atlas.cern>

**Access Open Data from the ATLAS Experiment at CERN**

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.

ATLAS Open Data guides you through how to visualise the data, how to download and use the data, and even provides open-source software for you to make your own discoveries. Check the introductory video and get started now!

Note! ATLAS Open Data is primarily aimed at University students, postgraduate and external researchers. Please read more in [Target section](#)

Many resources are in constant integration and updates

**Video introductions and Tutorials**

We deploy the resources on the Internet.

In a nutshell, they are a series of

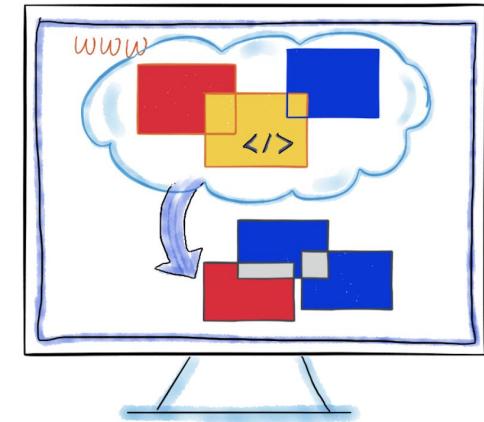
- Data samples in ROOT n-tuple format
- Software and Jupyter [Notebooks](#) in Python and C++ to analyse the samples and produce physics analysis
- JavaScript (JS) applications to produce cut-and-count analysis
- Virtual Machines with several Linux-based OS and ROOT CERN analysis framework
- [GitHub](#) & [GitLab](#) repositories
- GitBooks to document the several possible activities that can be performed

## Data & Tools Repository

Here you have in a single place all the necessary pieces in order to start you physics analysis in a more complete way. Look into the data like an ATLAS particle physicist!

In this section, you can find where to download:

- The complete collection of available datasets
- The different analysis software
- The virtual machines to perform physics searches



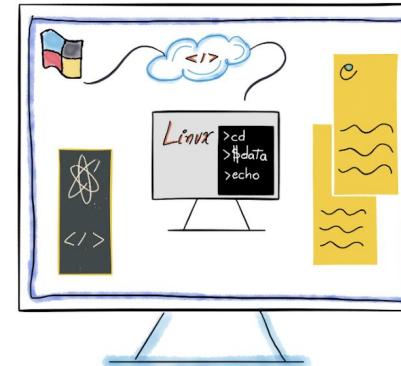
## Downloads

Datasets	Software	Virtual Machines

# Data & Tools - Virtual Machines

Download a Virtual Machine, which includes useful software, samples and tools for your analysis. Follow the instructions to run a Virtual Machine (**VM**) on any operating system.

**We design and develop VM images that can be run in any OS via a hypervisor like VirtualBox**



- Documentation
- Datasets
- Software
- Virtual Machines ✓

VM Version S    VM Version S+    VM Version M    VM Version L    VM Version N    VM Version μ

## VM Version S+

<http://opendata.atlas.cern/extendedanalysis/vm-toolbox.php>

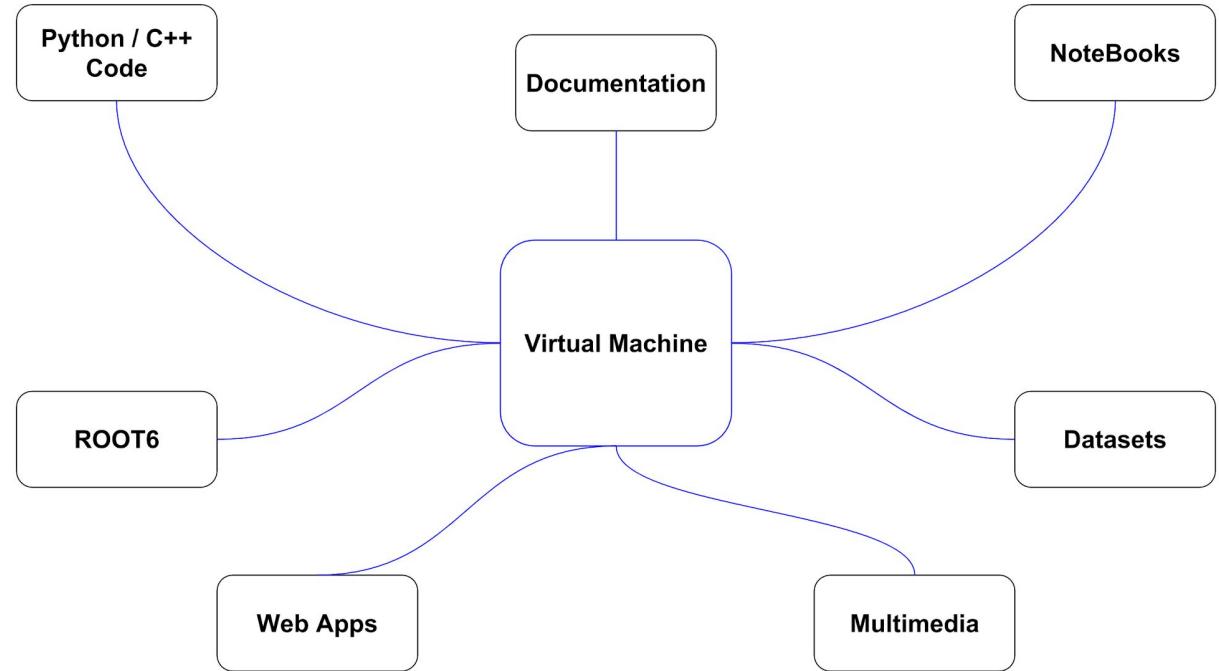
File type	Name	Last modified	Size
	VM_ATLAS-OpenData-ROOT6-Xubuntu-15.04_May_2017-size_S.ova	28-May-2017 03:30	3,1Gb

Description of 28-May-2017 VM: VM-S+ for "small + ROOTbooks", it has a total size of ~3.1GB. This contains a complete Xubuntu OS 15.04, important software dependencies, the version of ROOT6 v6-07-06. It does not contain datasets inside.

**Simple specifications aim to guide the user to select the right VM for her/his task(s)**

## Quick view of the anatomy of the ATLAS Open Data VM

- Based in a Linux-kind OS with standard graphical UI
- The OS is enhanced with *all* ROOT's needed libraries and dependencies
- ROOT5 or ROOT6 analysis framework and IPython
- The **Open Datasets and Software** analysis frameworks
- Jupyter-notebook technology and Examples Notebooks
- Documentation in form of PDFs and Video tutorials.



## The software provided in the **ATLAS Open Data** is

- The preparation of the enhanced OS with ***all*** ROOT's needed libraries and dependencies
- The **analysis frameworks written in Python and C++** for Particle Physics educational analysis
- **Jupyter Notebooks using the ROOT kernel** with concrete analysis examples
- The **JS web-based applications** to run out of the box.

[open data](#)

**ATLAS**

Get Started  
Documentation, Histogram  
Analyser, Analysis Browser

Web Analysis  
Documentation, Analysis  
ROOTbooks

Data & Tools  
Documentation, Datasets,  
Software, Virtual Machines

take our 15 seconds survey!... ...or do you have 60 seconds?!

DOWNLOAD COMMUNITY

[Facebook](#) 283  
[Twitter](#)  
[Email](#)  
[LinkedIn](#)  
[Google+](#)

**Access Open Data from the ATLAS Experiment at CERN**

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.

**ATLAS Open Data** guides you through how to visualise the data, how to download and use the data, and even provides open-source software for you to make your own discoveries. Check the introductory video and get started now!

[Provide feedback](#)

**open data**  
**ATLAS**

Note! ATLAS Open Data is primarily aimed at University students, postgraduate and external researchers. Please read more in Target section

<https://github.com/atlas-outreach-data-tools>

Github, Inc. (US) | https://github.com/atlas-outreach-data-tools/

Search or jump to... Pull requests Issues Marketplace Explore

**ATLAS EXPERIMENT**

Overview Repositories 4 Stars 2 Followers 7 Following 1

Popular repositories

**atlas-outreach-data-tools-framework**  
Python software framework for the ATLAS OpenData project  
● Python ★ 6 ⚡ 7

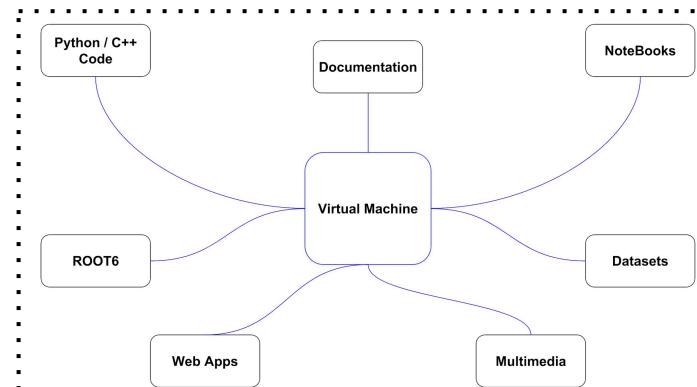
**notebooks**  
This is the ATLAS outreach data and tools official repository for notebooks under ROOT  
● Jupyter Notebook ★ 2 ⚡ 2

**atlasoutreach-webpage**  
Forked from artifice/atlasoutreach-webpage  
ATLAS collaboration outreach DataTools webpage  
● JavaScript ★ 1 ⚡ 1

**histogram-analysers**  
This is the JavaScript code for the Histogram Analyser Apps in the ATLAS Open Data Website  
● JavaScript ★ 1 ⚡ 1

Unfollow Block or report user

**software**

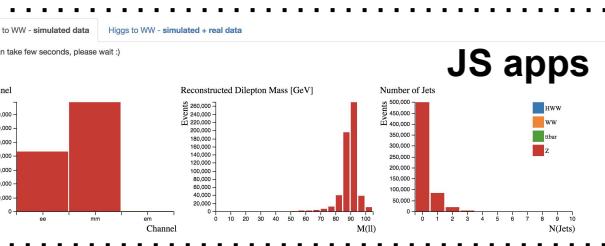


Documentation      Histograms Analyser      Analysis Browser      Live Events

The ATLAS detector      Top Pair physics analysis      ROOTbrowser

Note: take into account that the ATLAS visualization can take several seconds to load (~15 to ~30 sec) please, be patient! (updated on July 2017)

**ROOT apps**



External Examples & Viewers

Documentation      ATLAS Official nbviewer      ROOT Official Gallery

**notebooks**

Execute ROOTbooks

Run, edit and save ROOTbooks. Use our examples to explore the public datasets. You can create your own ROOTbooks as well!

We are working hard to provide the Binder service soon!

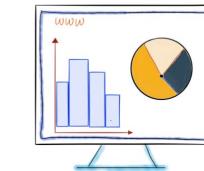
## Simple and useful Web-based Apps that

- Allow to explore the ATLAS detector, thanks to ROOT.JS
- Allow to “touch” the histograms and perform simple analysis
- Interact with **Jupyter Notebooks** using the **ROOT kernel** with concrete analysis examples



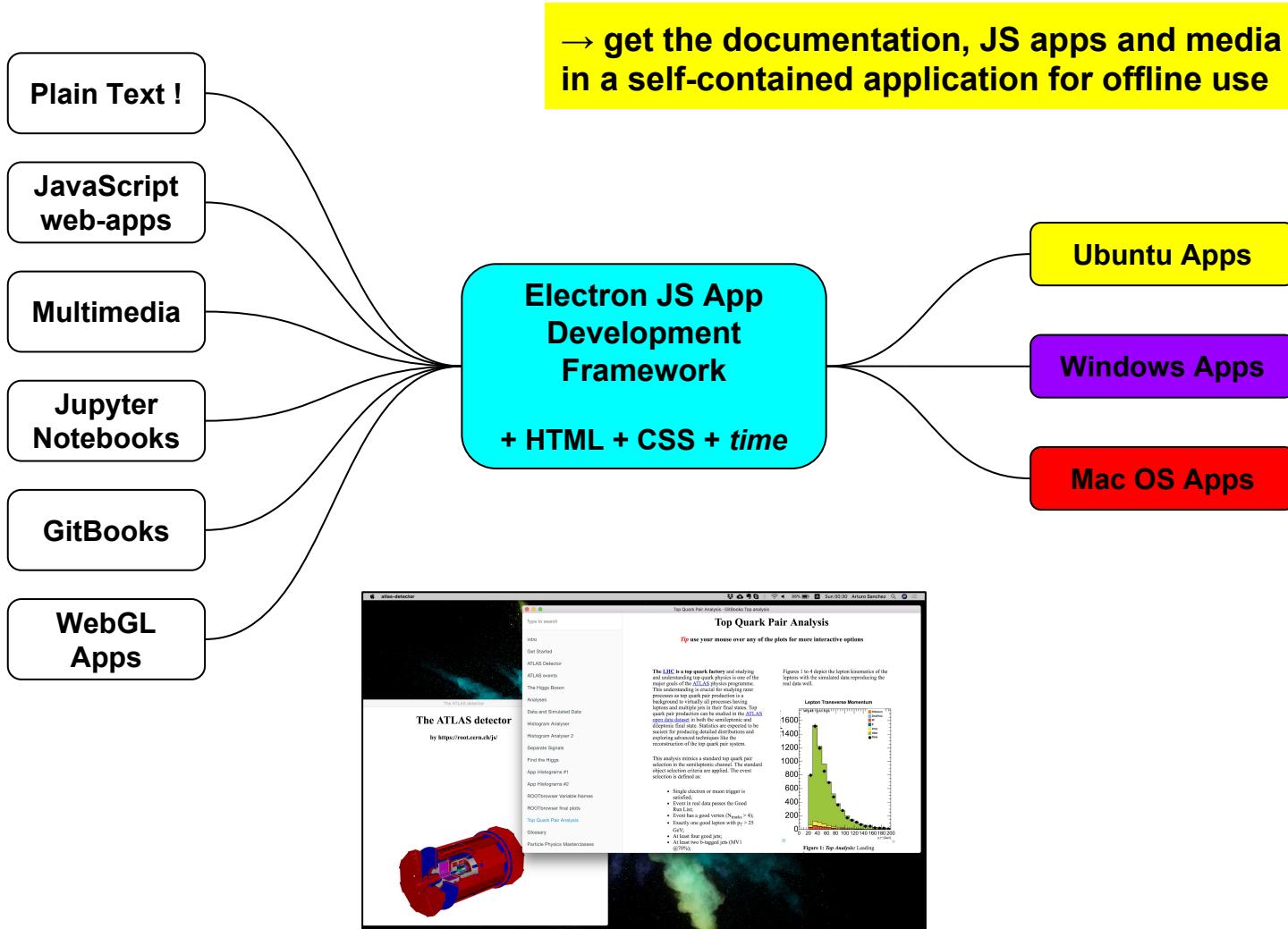
Build cross platform desktop apps with JavaScript, HTML, and CSS  
[http://universidad.ch/ATLAS/outreach/presentations/March\\_28\\_2018/\\_book](http://universidad.ch/ATLAS/outreach/presentations/March_28_2018/_book)

**ATLAS Open Data apps**  
*looking into* the interactivity of the website to the desktop

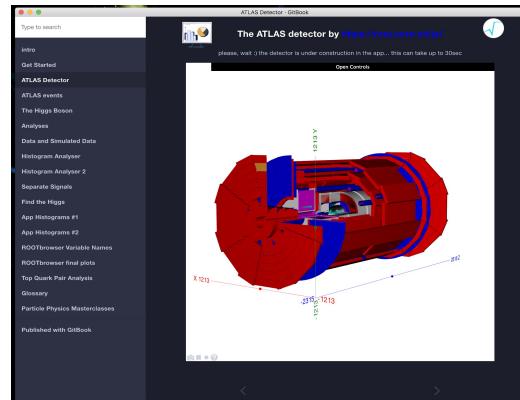
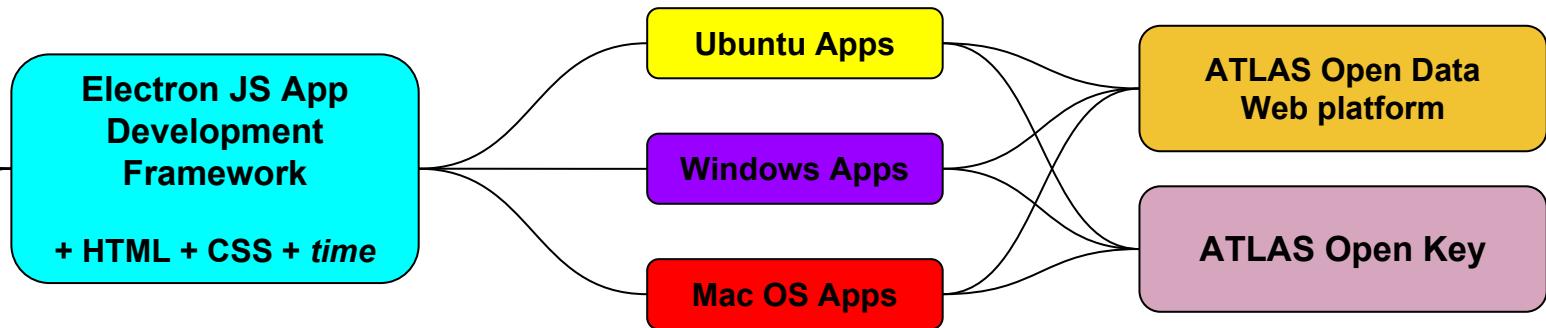


Arturo Sánchez, ATLAS Open Data Project University of Udine, ICTP and INFN  
 WLCG & HSF workshop, Naples, Italy | March 28<sup>th</sup> 2018

**Other ideas like the use of the Electron.JS apps' developing framework to →**



Apps that can be distributed on the web portal and with the use of the Key !



## The software provided in the **ATLAS Open Key** is

- The preparation of the enhanced OS with ***all* ROOT's** needed libraries and dependencies
- The **analysis frameworks written in Python and C++** for Particle Physics educational analysis
- **Jupyter Notebooks using the ROOT kernel** with concrete analysis examples
- The **JS web-based applications** to run out of the box.



GitHub, Inc. [US] | <https://github.com/atlas-outreach-data-tools/>

Search or jump to... Pull requests Issues Marketplace Explore

Overview Repositories 4 Stars 2 Followers 7 Following 1

**Popular repositories**

**ATLAS EXPERIMENT**

**ATLAS Outreach data and tools**  
atlas-outreach-data-tools

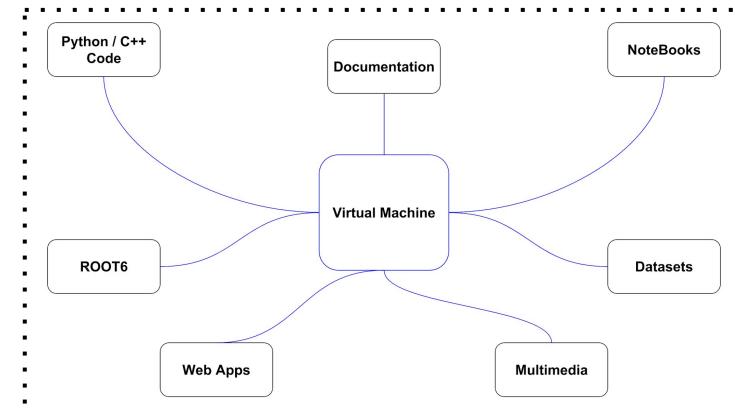
Unfollow Block or report user

**atlas-outreach-data-tools-framework**  
Python software framework for the ATLAS OpenData project  
Python ★ 6 72

**atlasoutreach-webpage**  
Forked from artificia/atlasoutreach-webpage  
ATLAS collaboration outreach Data&Tools webpage  
JavaScript ★ 1 71

**notebooks**  
This is the ATLAS outreach data and tools official repository for notebooks under ROOT  
Jupyter Notebook ★ 2 72

**histogram-analysers**  
This is the JavaScript code for the Histogram Analyser Apps in the ATLAS Open Data Website  
JavaScript ★ 1 71



# ATLAS Open Key

And...  
...now?

## The Open Key project

- How does it works?
  - Results and cases
  - Plans
-

CERN Open Data portal

Explore more than 1 petabyte of open data from particle physics!

Explore

Focus on

ATLAS  
ALICE  
CMS  
LHCb

About

open data ATLAS

Get Started Documentation, Helpdesk Analyzer, Analysis Browser

Web Analysis Tools Documentation, Analysis ROOTools

Data & Tools Documentation, Datasets, Software, Virtual Machines

Community

take our 15 seconds survey... or do you have 60 seconds?

DOWNLOAD

Access Open Data from the ATLAS Experiment at CERN

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.

ATLAS Open Data guides you through how to visualize the data, how to download and use the data, and even provides open-source software for you to make your own discoveries. Check the introductory video and get started now!

Note: ATLAS Open Data is primarily aimed at University students, postgraduate and external researchers. Please read more in Target section.



On top of the core teams platforms, extra means and projects were developed by the ATLAS and HEP community to reach and hub Groups and Resources

### Awesome Projects using ATLAS Open Data

Main Area	Category	Text search
1 - 9 / 9		
	Interactive Event Analysis with the HYPATIA Online Tool	Make a particle physics discovery by interactively optimizing a set of event selection criteria
	HYPATIA Event Visualization and Analysis Tool	Learn how a modern particle physics detector works by visualizing event signatures
	CEVALE2VE	Latin-American education group for the dissemination and outreach in Particle Physics. CEVALE2VE carries on Educational, Outreach and Diplomatic activities. And its main project, a complete Online HEP course takes place once a year.
	ATLAS Tracer	A web based interactive learning tool of ATLAS facilities and physical processes carrying out on it. Running inside users browser and suitable for all type of hardware and OS (More on <a href="https://atlas-tracer.web.cern.ch">https://atlas-tracer.web.cern.ch</a> )
	TU Dortmund Particle Physics Lab Course	In this lab course, real data taken with the ATLAS experiment are analyzed. Students search for resonances decaying to a pair of top quarks. Such new massive particles are predicted in many theories that extend the Standard Model
	The ZPATH project	It started as educational material for high school students to work with data collected by the ATLAS detector. The Z-path and some of the accompanying tools have been developed at the University of Oslo. Advanced university projects complement this educational and outreach project.
	TU Dresden: Exploring Particle Physics Hands-on methods using LHC data	The lecture covers the latest results and techniques from the LHC. The tutorial lets you play with real ATLAS data, design your own analysis and search for the Higgs boson or New Physics yourself.
	Göttingen University: Laboratory course on cross-section of top-quark pairs production	The ATLAS group of the IfI Institutes has set up a lab course where students can experience working with ATLAS data. Given an authentic framework for an analysis of the production cross-section of top-quark pairs at the centre-of-mass energy of 8 TeV with the ATLAS experiment

**Multiple Workshops  
and hands-on sessions  
help us to get feedback  
and learn how to (and  
how not to) produce  
and use the resources**



<https://indico.cern.ch/event/647642>

And some attention from local media

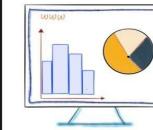


PWF



Tutorial  
@CERN

Learn about the ATLAS  
OpenData project



<http://opendata.atlas.cern>

and how it's used by the Outreach  
community all over the World

Get and Use  
Public Data & Tools

- Datasets
- Web Apps
- Analysis Code
- Virtual Machines
- Docs & Multimedia
- and...



Agenda?

<https://indico.cern.ch/e/atlasopendata>

To whom?

Everybody @CERN

When?

Friday June 23rd. 14h-15h

Where?

40-R-C10

Questions?  
[atlas-outreach-data-and-tools@cern.ch](mailto:atlas-outreach-data-and-tools@cern.ch)



...the Key

**Multiple collaborations (ICTP, PWF, CEVALE2VE...), workshops and hands-on sessions help us to get feedback and learn how to (and how not to) produce and use the resources**



The Abdus Salam International Centre for Theoretical Physics

UNESCO  
Educational, Scientific and Cultural Organization

IAEA  
International Atomic Energy Agency

Research ▾ Scientific Calendar Programmes ▾

Home > Physics Without Frontiers > Get Involved and Apply

## Physics Without Frontiers

Worldwide physics outreach

<https://www.ictp.it/physics-without-frontiers/current-country-projects.aspx>



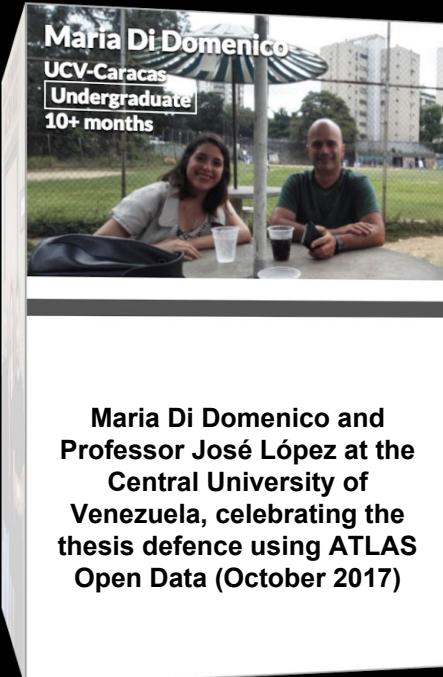
<https://www.instagram.com/p/BW3a9PtAoP0>

The VMs & the Jupyter Notebook -or ROOTbooks- have been valuable resources to train, teach and explore particle physics...

...and to create a *small* community of developers and instructors around them!

## ATLAS Open Data ROOTbooks are a reality thanks to the effort of many people like you

step over the picture to know more about some of them!





Our first “version” of the ATLAS Open Key helped to the development of two theses in HEP.

Since 2016 we have been testing and learning how this simple idea can be improved

<http://cds.cern.ch/record/2293251>

Thesis	
Report number	CERN-THESIS-2017-239
Title	Reconstrucción de masas invariantes de bosones del Modelo Estándar usando datos públicos de ATLAS Open Data
Translation of title	Reconstruction of the invariant masses of bosons of the Standard Model using public data from ATLAS Open Data
Author(s)	Di Domenico Franco, María Rosaria (Caracas, U. Central) ; López Rodríguez, José Antonio (dir.) (Caracas, U. Central) ; Sánchez Pineda, Arturo (dir.) (Caracas, U. Central)
Publication	Caracas, Venezuela : Universidad Central de Venezuela, 2017-10-04. - 207 p.
Thesis note	Licenciate : Caracas, U. Central : 2017-09-01
Note	Presented 04 Oct 2017
Subject category	Particle Physics - Experiment ; Education and Outreach
Accelerator/Facility, Experiment	CERN LHC ; ATLAS
Abstract	In this thesis were studied and produced a set of analysis with the end of reconstructing the invariant masses of the $W$ , $Z$ and Higgs bosons. Together with other physical variables, following the rules of the Standard Model. These analyses are produced using proton-proton collision data collected by ATLAS Experiment in 2012, at a centre of mass energy of 8 TeV corresponding to an integrated luminosity of $1\text{ fb}^{-1}$ . This data is available in the <a href="http://OpenData.ATLAS.cern">http://OpenData.ATLAS.cern</a> portal. All this was made using a cloud computing platform called SWAN, also developed and localized at CERN. SWAN is based on Jupyter notebooks and ROOT. With the use of SWAN, several physical analysis were made, from the initial production to the final product: a set of self-explained notebooks showing the physics and the programming elements that are needed to do such reconstructions on analysis of cut-and-count type. Finally, these notebooks will be used as educative resources for teaching and outreach of HEP at the university level.

<http://cds.cern.ch/record/2291838>

Thesis	
Report number	CERN-THESIS-2017-217
Title	Perspectivas y Evaluación de producción de Materia Oscura en asociación con un quark liviano, un quark pesado (quark b) o un bosón electro débil en colisiones de particular a energías de colisión de $\sqrt{s} = 8 \text{ TeV}$
Translation of title	Perspectives and Evaluation of Dark Matter production in association with a light quark, a heavy quark (b-quark) or an electroweak boson in particle colliders at a centre-of-mass energy of $\sqrt{s} = 8 \text{ TeV}$
Author(s)	García, Iskya (Caracas, U. Central) ; Sanchez Pineda, Arturo (dir.) (ICTP, Trieste)
Publication	2017. - 130 p.
Thesis note	Master : Caracas, U. Central : 2017-11-07
Note	Presented 14 Jul 2017
Subject category	Particle Physics - Experiment ; Education and Outreach
Accelerator/Facility, Experiment	CERN LHC ; ATLAS
Abstract	The Weakly Interacting Massive Particles, or WIMPs, are the only major Dark Matter (DM) candidate particles currently accessible at the LHC. It is expected that the production of a pair of these particles in association with particles belonging to the Standard Model (SM) will be evidenced in final states with the presence of large quantities of Missing Transverse Moment ( $E_T^{\text{miss}}$ ). This thesis summarises a model independent search for DM, in several final states that contain $E_T^{\text{miss}}$ , called: Mono-jet, Mono-b and Mono-Z. Where the designation "Mono" refers to the presence of a single jet or boson which is used as a guide to discern between DM production and other final states with $E_T^{\text{miss}}$ but corresponding to only SM particle decays. The analysis were performed using open data published by ATLAS in 2016, collected during 2012, and that corresponds to an integrated total luminosity of $1 \text{ fb}^{-1}$ . Where a pair of protons were collided with center-of-mass energy of $\sqrt{s} = 8 \text{ TeV}$ . No excess events were observed over predictions of the SM in any of the final states studied, as is evidenced by $p$ -values calculations. Discarding the presence of events coming from new physics, coinciding with official results of the ATLAS Collaboration for such DM searches at $\sqrt{s} = 8 \text{ TeV}$ . All this using tools and techniques of high energy physics that is currently in used at the LHC collaborations.

# Summary

**ATLAS Open Data and its Key help to perform Knowledge Transfer:**  
to retribute to society and to keep running the -even more- large scientific  
endeavours worldwide.

<http://opendata.atlas.cern/community/contact.php>

# Thanks!



# backup

# ATLAS Open Key

Why? How? Who? Where? And...  
...now?

## A Talent Training & Acquisition program

- Why we need to reach them?

## Where are our target audiences?

- Worldwide

## How are we trying to get more people involved?

- The Data and the Tools
- Keep data useful and not *just big*
- The Virtual Machine' approach
- Going for the Apps' development

## The Open Key project

- How it works?
- Results and cases
- Plans

**ATLAS Note**

Report number	ATL-OREACH-PUB-2018-001
Title	<b>Review of ATLAS Open Data 8 TeV datasets, tools and activities</b>
Corporate Author(s)	The ATLAS collaboration
Collaboration	ATLAS Collaboration
Imprint	18 Jun 2018. - mult. p.
Subject category	Particle Physics - Experiment
Accelerator/Facility, Experiment	CERN LHC ; ATLAS
Free keywords	ATLAS ; OUTREACH ; Open Data ; 8 TeV ; CERN open data portal
Abstract	<p>The ATLAS Collaboration has released two 8 TeV datasets and relevant simulated samples to the public for educational use. A number of groups within ATLAS have used these ATLAS Open Data 8 TeV datasets, developing tools and educational material to promote particle physics. The general aim of these activities is to provide simple and user-friendly interactive interfaces to simulate the procedures used by high-energy physics researchers. International Masterclasses introduce particle physics to high school students and have been studying 8 TeV ATLAS Open Data since 2015. Inspired by this success, a new ATLAS Open Data initiative was launched in 2016 for university students. A comprehensive educational platform was thus developed featuring a second 8 TeV dataset and a new set of educational tools. The 8 TeV datasets and associated tools are presented and discussed here, as well as a selection of activities studying the ATLAS Open Data 8 TeV datasets.</p>

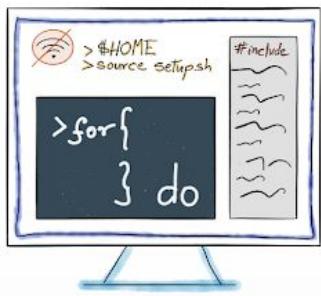
# Review of ATLAS Open Data 8 TeV datasets, tools and activities

**ATL-OREACH-PUB-2018-001**  
<https://cds.cern.ch/record/2624572>

# Projects Ongoing



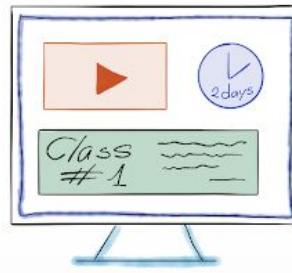
The ATLAS Open Data C++ Analysis Framework's project



[Internship Proposal #1 \(2018\)](#)



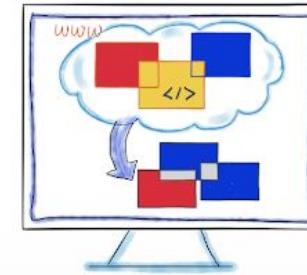
The ATLAS Open Data WorkshopS' project



[Internship Proposal #2 \(2018\)](#)



The ATLAS Open Data 13 TeV Data&MC project



[Internship Proposal #3 \(2018\)](#)

# ATLAS Open Data is Updated in CERN Open Data

<http://opendata.atlas.cern> (ATLAS Open Data platform) , <http://opendata.cern.ch> (CERN Open Data)

The screenshot shows a web browser window with the URL [opendata.cern.ch/docs/about-atlas](http://opendata.cern.ch/docs/about-atlas) in the address bar. The page title is "About ATLAS". Below the title, there are two buttons: "Documentation" and "About". The main content area starts with a paragraph about the ATLAS experiment, followed by a section on its scientific goals, another on the Standard Model, and a link to the official site. Below this, there is a section titled "About ATLAS Open Data" with a paragraph about the project's purpose and its connection to International Masterclasses. At the bottom, there is a section about the new 8 TeV dataset and its objectives, accompanied by a bulleted list.

**About ATLAS**

[Documentation](#) [About](#)

**ATLAS** (A Toroidal LHC ApparatuS) is one of the four major experiments at the [Large Hadron Collider](#) (LHC) at [CERN](#). It is a general-purpose particle physics experiment run by an international collaboration and, together with [CMS](#), is designed to exploit the full discovery potential and the vast range of physics opportunities that the LHC provides.

ATLAS's scientific exploration uses precision measurement to push the frontiers of knowledge by seeking answers to fundamental questions such as: What are the basic building blocks of matter? What are the fundamental forces of nature? Could there be a greater underlying symmetry to our universe?

ATLAS physicists test the predictions of the [Standard Model](#), which encapsulates our current understanding of what the building blocks of matter are and how they interact. These studies can lead to ground-breaking discoveries, such as that of the Higgs boson, physics beyond the Standard Model and the development of new theories to better describe our universe.

For more about the ATLAS Collaboration, the experiment, the physics and its members, please visit our [Official Site](#).

**About ATLAS Open Data**

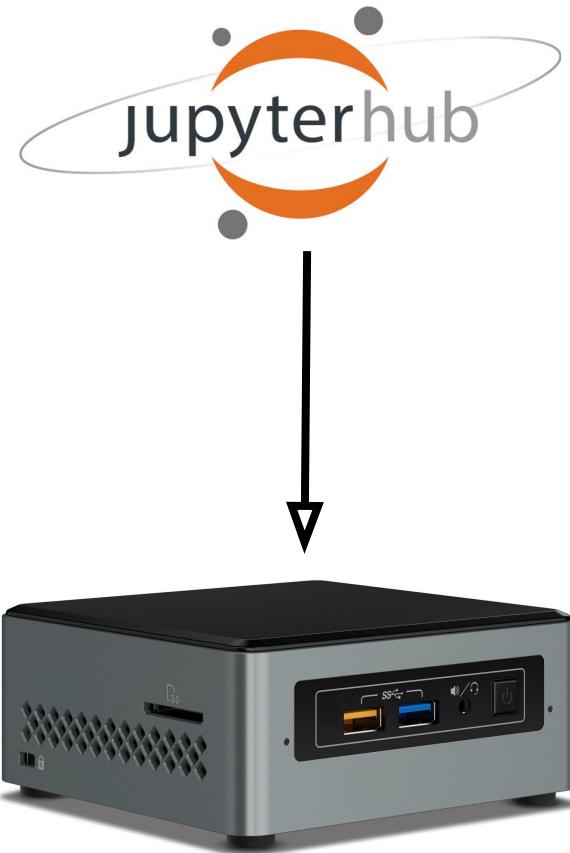
The ATLAS Collaboration's current approach on the release of datasets is intended for Education, Training and Outreach activities around the World. In order to fulfil that objective, the [ATLAS Open Data project was created](#).

ATLAS Open Data project aims to provide data and tools to high-school, masters and undergraduate students, to help educate them in physics analysis techniques used in experimental particle physics. Sharing data collected by the [ATLAS](#) experiment aims to generate excitement and enthusiasm for fundamental research, inspiring physicists of the future.

[International Masterclasses](#) introduce particle physics to high-school students and have been running very successfully for the last 20 years. ATLAS data [were first used in 2011](#), and 8 TeV ATLAS Open Data in 2015. Inspired by the success of International Masterclasses, a new [ATLAS Open Data initiative was launched in 2016](#).

The target audience is physics undergraduate and masters students, but may also include advanced high-school students or indeed anyone with some basic understanding of particle physics and coding experience. A comprehensive [educational platform was developed featuring a new 8 TeV dataset and a set of educational tools at a more advanced level](#). The objectives of this initiative are to provide:

- 8 TeV proton-proton data collected by ATLAS plus associated simulated data.
- 13 TeV proton-proton data collected by ATLAS plus associated simulated data.



JupyterHub, a multi-user **Hub**, spawns, manages, and proxies multiple instances of the single-user Jupyter notebook server. JupyterHub can be used to serve notebooks to a class of students, a corporate data science group, or a scientific research group.

Three subsystems make up JupyterHub:

- a multi-user **Hub** (tornado process)
- a **configurable http proxy** (node-http-proxy)
- multiple **single-user Jupyter notebook servers** (Python/IPython/tornado)

JupyterHub performs the following functions:

- The Hub launches a proxy
- The proxy forwards all requests to the Hub by default
- The Hub handles user login and spawns single-user servers on demand
- The Hub configures the proxy to forward URL prefixes to the single-user notebook servers

