Practical Statistics for Particle Physics Analyses: Introduction to Computing Examples

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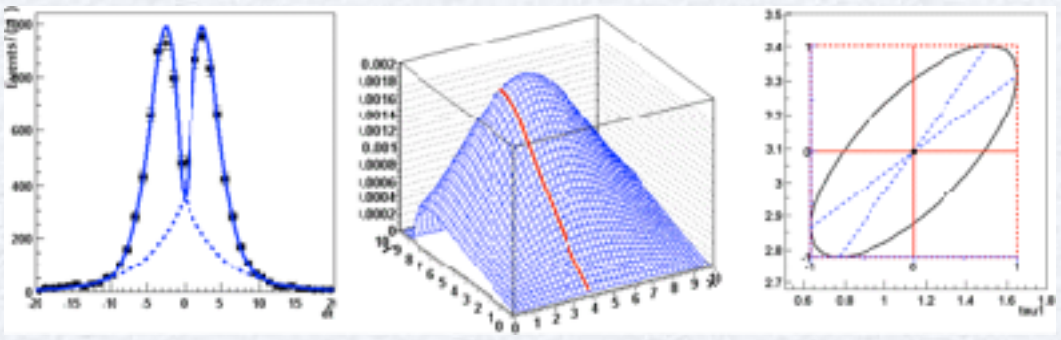


Introduction

- Hands-on session based on computing examples
- Examples uses **ROOT**
  - including its advanced statistical packages, RooFit and RooStats
- Examples are interactive demos made as **Jupyter** notebooks and written in C++
  - Jupyter supports also Python

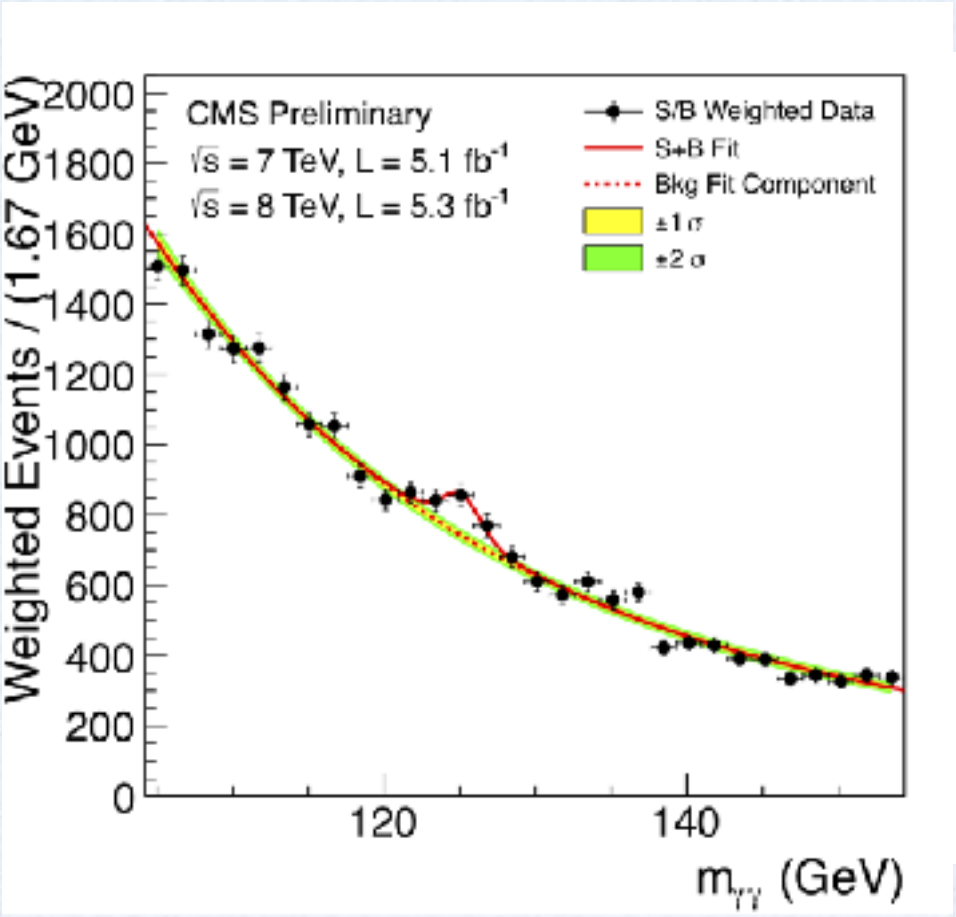
Computing Examples

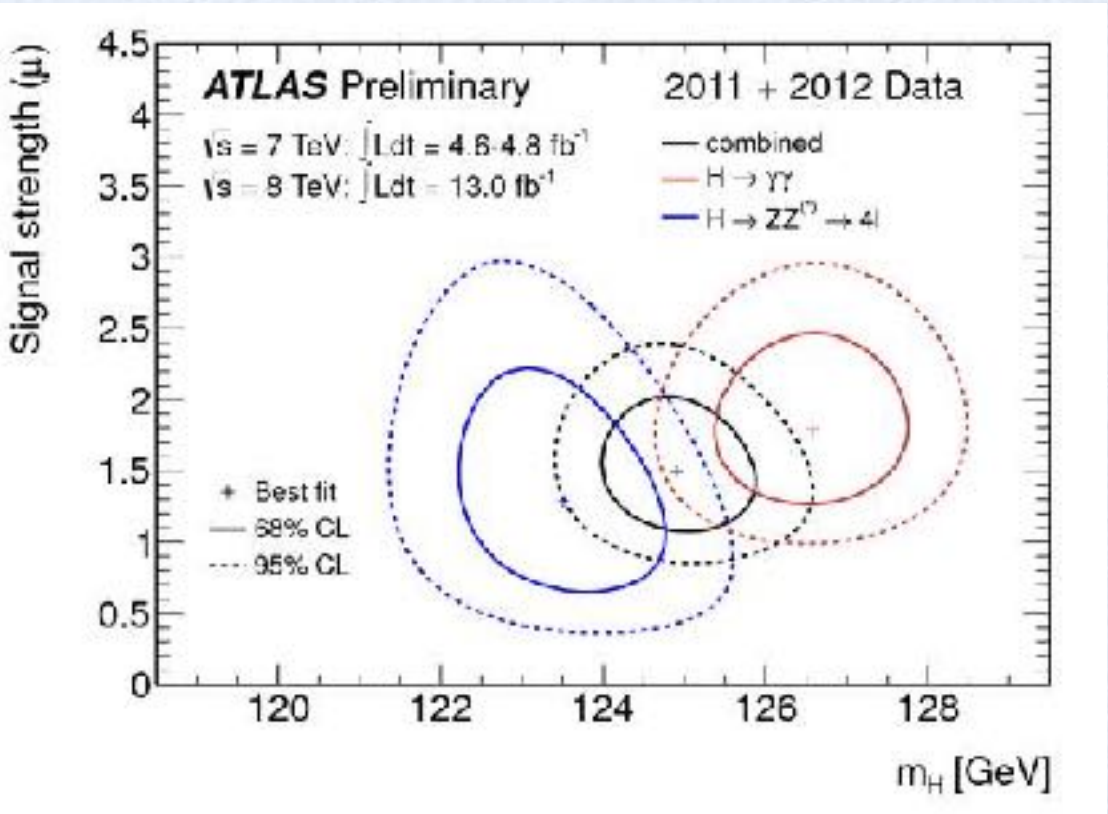
- Interactive demos made of Jupyter notebooks
- **How to run them ?**
- We have 3 possible options:
  1. **Running in the CERN notebook service**
     - SWAN **(swan.cern.ch)**
     - no installation required but needs a CERN account
  2. Install ROOT in your computer and run a local notebook
     - root —notebook
  3. Use a Virtual Machine containing the installed software
     - https://cernbox.cern.ch/index.php/s/oKBM14VDqGFT7Wl

Computing Examples

- We recommend running the notebooks at CERN in
  - **SWAN** (swan.cern.ch)
    - files will be stored in **CERNBOX** (shared file system at CERN)
- If you have a CERN account you can log-in in SWAN using your CERN credential
- Don't worry if you don't have a CERN computing account, some special accounts are provided for the course
  - Please fill in this case the form:
    https://goo.gl/forms/ZhoVzBjiQVEiTjsn2
- If you have not used before **CERNBOX** you need to login first there:
  - cernbox.cern.ch

What can you do with ROOT?





Higgs analyses plots done with ROOT!

ROOT in a Nutshell

- ROOT is a software toolkit which provides building blocks for:
  - Data processing
  - Data analysis
  - Data visualisation
  - Data storage

An Open Source Project

All contributions are warmly welcome!

- ROOT is written mainly in C++ (C++11 standard)
  - Bindings for Python are provided.

- Adopted in High Energy Physics and other sciences (but also industry)
- ~250 PetaBytes of data in ROOT format on the LHC Computing Grid
- Fits and parameters' estimations for discoveries (e.g. the Higgs)
- Thousands of ROOT plots in scientific publications

ROOT in a Nutshell

ROOT can be seen as a collection of building blocks for various activities, like:

- Data analysis: histograms, graphs, trees
- I/O: row-wise, column-wise storage of **any** C++ object
- Statistical tools (RooFit/RooStats): rich modeling and statistical inference
- Math: non trivial functions (e.g. Erf, Bessel), optimised math functions (VDT)
- C++ interpretation: fully C++11 compliant
- Multivariate Analysis (TMVA): e.g. Boosted decision trees, neural networks
- Advanced graphics (2D, 3D, event display).
- And more: HTTP servering, JavaScript visualisation.

Jupyter Notebooks

- A web-based interactive computing interface and platform that combines code, equations, text and visualisations.
  - Many supported languages: Python, Haskell, Julia, R … One generally speaks about a "kernel" for a specific language
- No need to download any software
  - can execute code step by step
  - can display text and formulae
- In a nutshell: an "interactive shell opened within the browser"

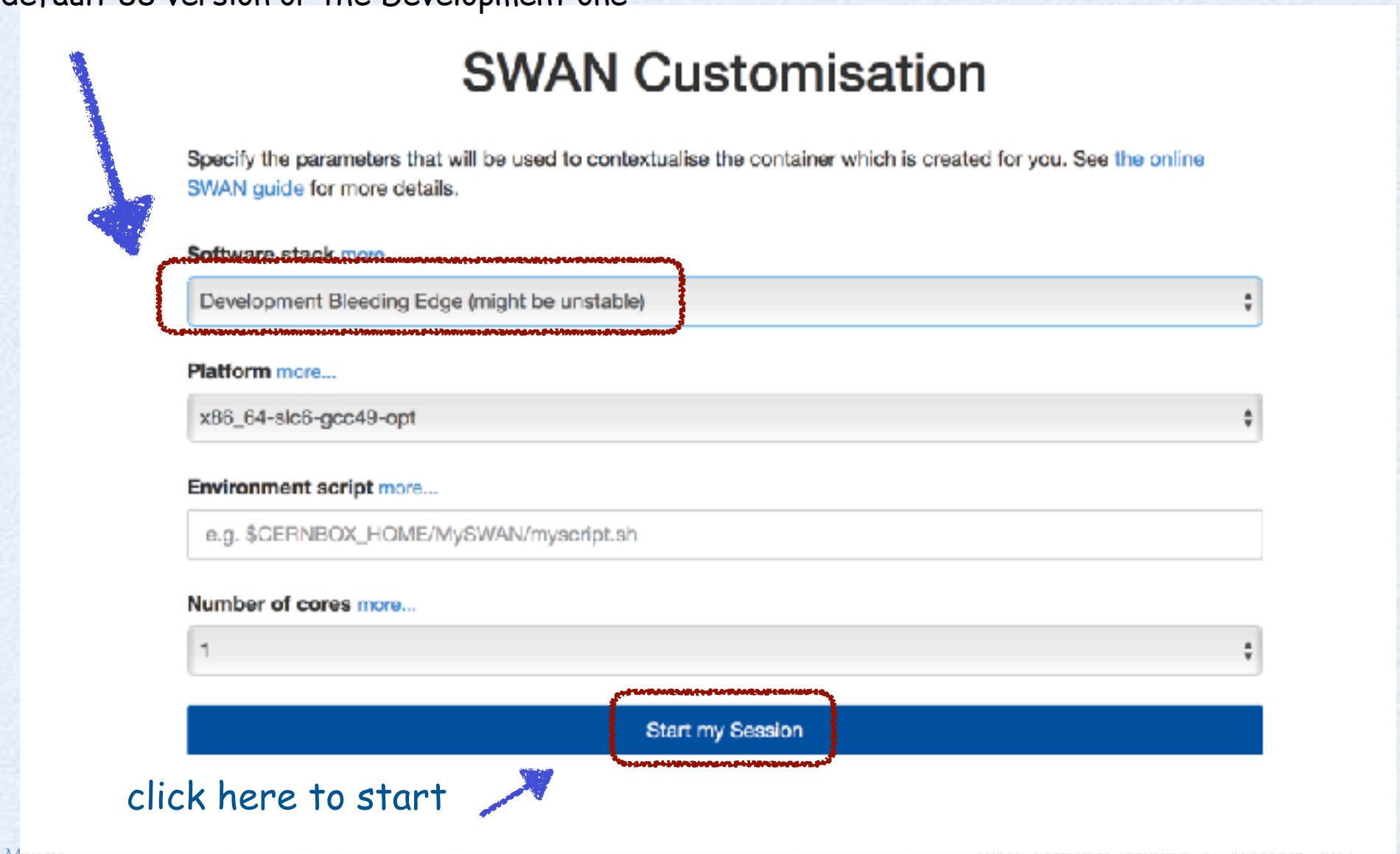
http://www.jupyter.org

SWAN

- go to swan.cern.ch

Starting SWAN

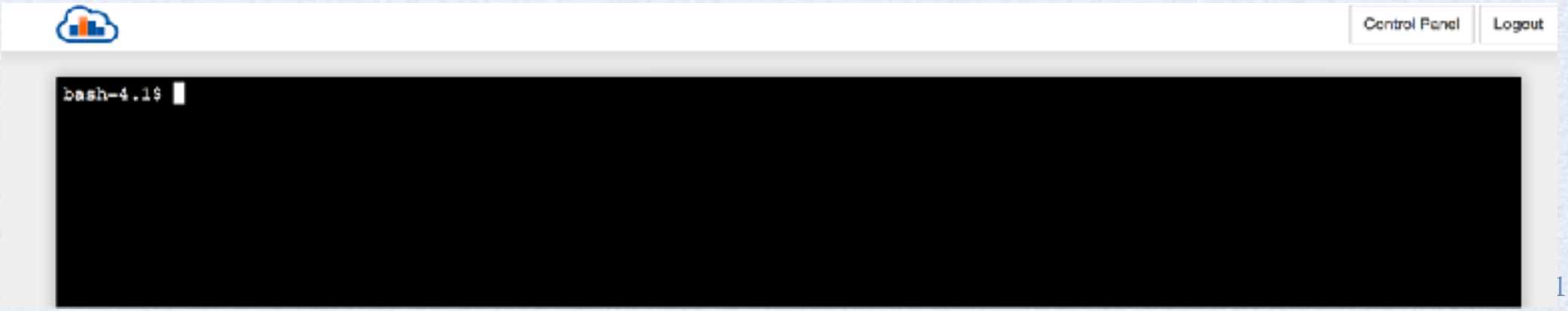
make sure to have selected
the default 88 version or the Development one



Starting a Terminal in SWAN

After login cernbox home directory will be visible

Start a terminal window



Downloading the Notebooks

- After starting the terminal, get the notebooks for today's session.
- Download them from github

git clone https://github.com/lmoneta/stat-course-ipmu.git

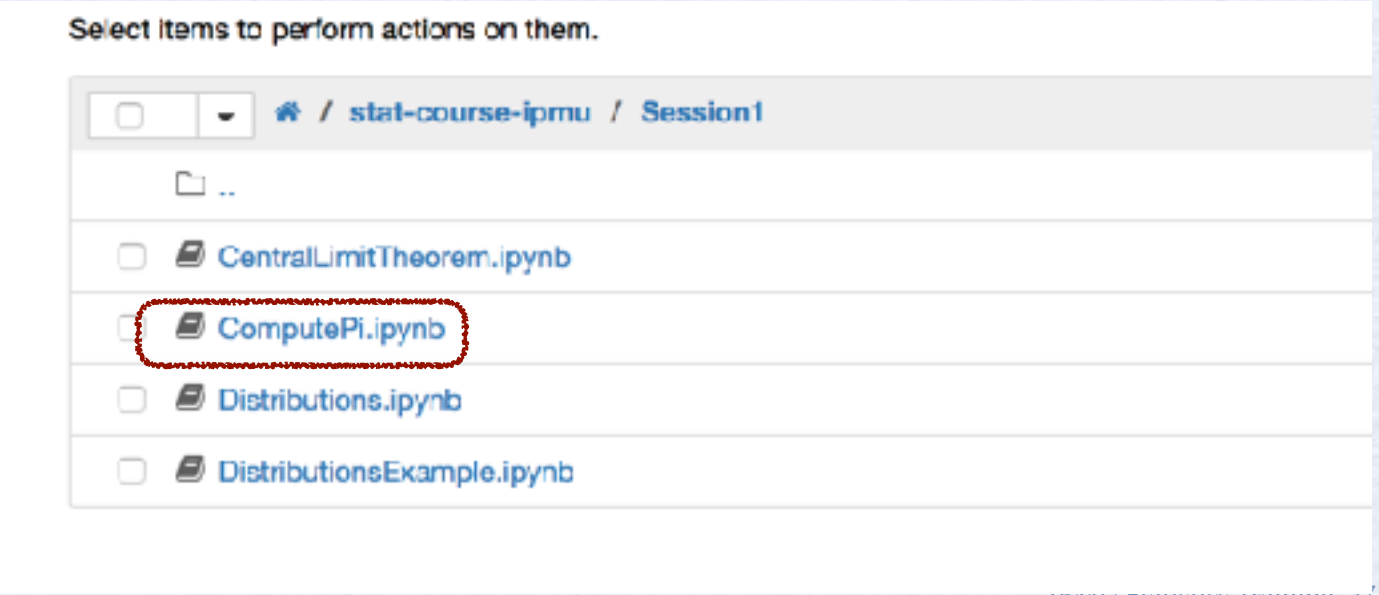
```
bash-3.2$ git clone https://github.com/lmoneta/stat-course-ipmu.git
Cloning into 'stat-course-ipmu'...
remote: Counting objects: 53, done.
remote: Compressing objects: 100% (30/30), done.
remote: Total 53 (delta 23), reused 52 (delta 22), pack-reused 0
Unpacking objects: 100% (53/53), done.
bash-3.2$ cd stat-course-ipmu/Session1
bash-3.2$
```

Starting a Notebook

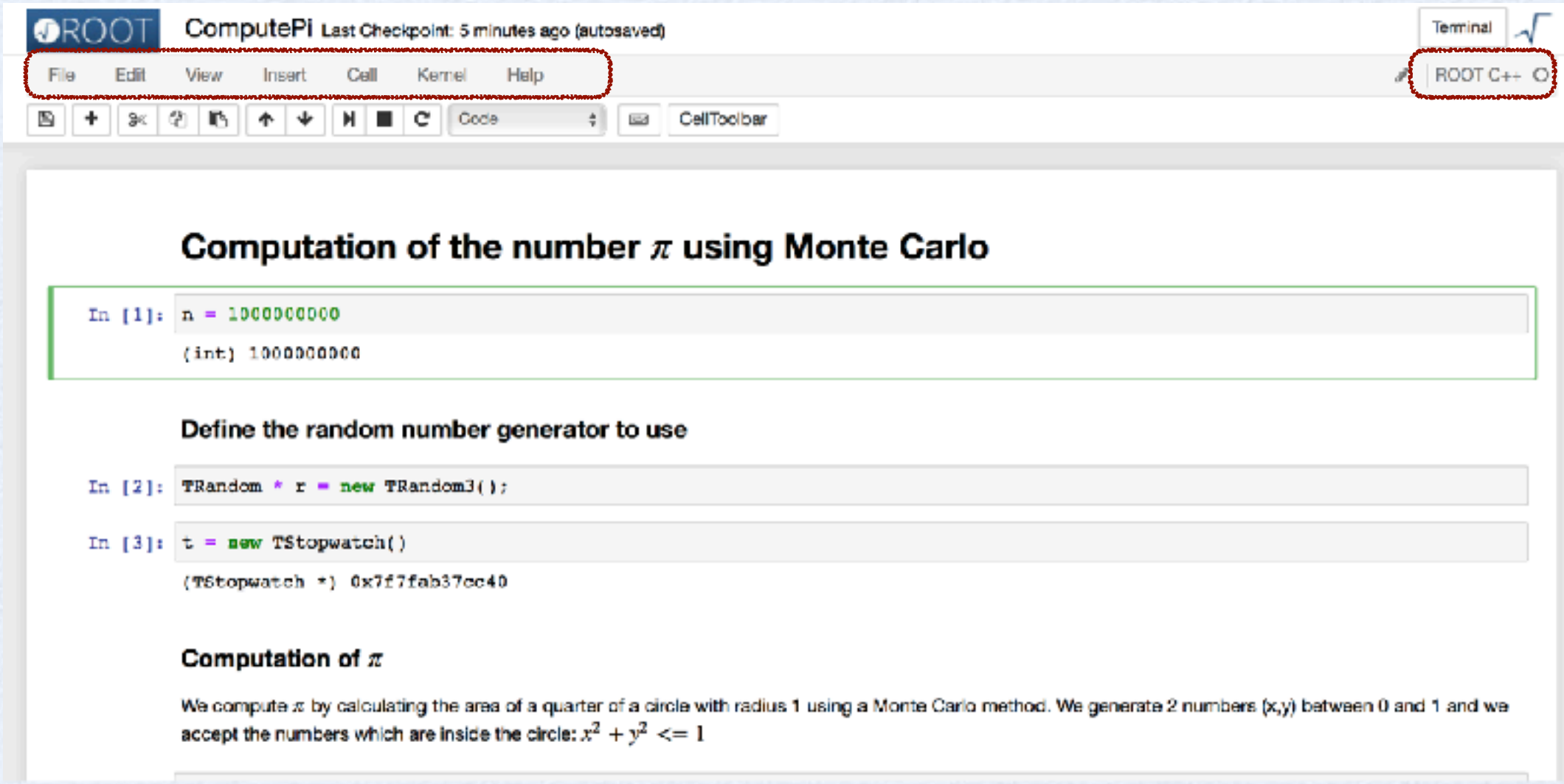
- After having downloaded the repository, go back to SWAN home page and go to the notebook folder

```
bash-3.2$ cd stat-course-ipmu/Session1
bash-3.2$
```

- select on of the notebook or create a new one



Starting a Notebook



References

- Presentation about Jupiter notebooks and SWAN
  - https://cernbox.cern.ch/index.php/s/cpqdIOaNIwrlzJu
- Basics of ROOT for fitting
  - https://cernbox.cern.ch/index.php/s/SjJnYSkJrY9Kv8y
- RooFit tutorial slides
  - https://cernbox.cern.ch/index.php/s/kzGv4406IrpFpVM
- RooStats tutorial slides
  - https://cernbox.cern.ch/index.php/s/9DWJCObingTWB3r