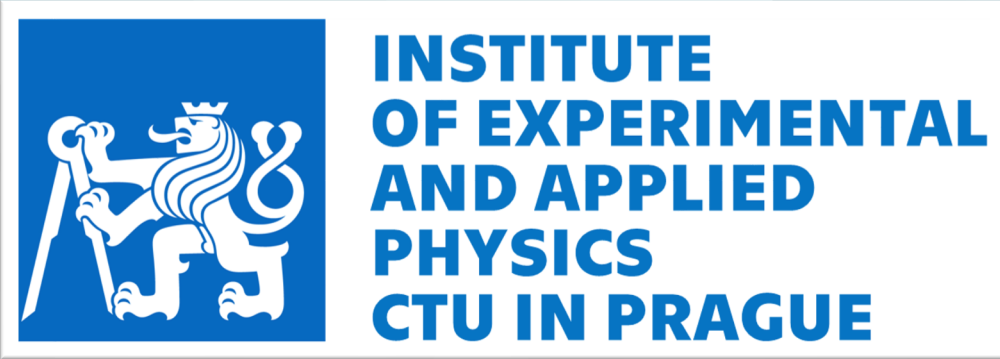


Outreach Modules for a New Particle Search Using the ATLAS Forward Proton Detector and Higgs Boson Physics



Czech Technical University in Prague, Institute of Experimental and Applied Physics

André Sopczak on behalf of the International Particle Physics Outreach Group (IPPOG)



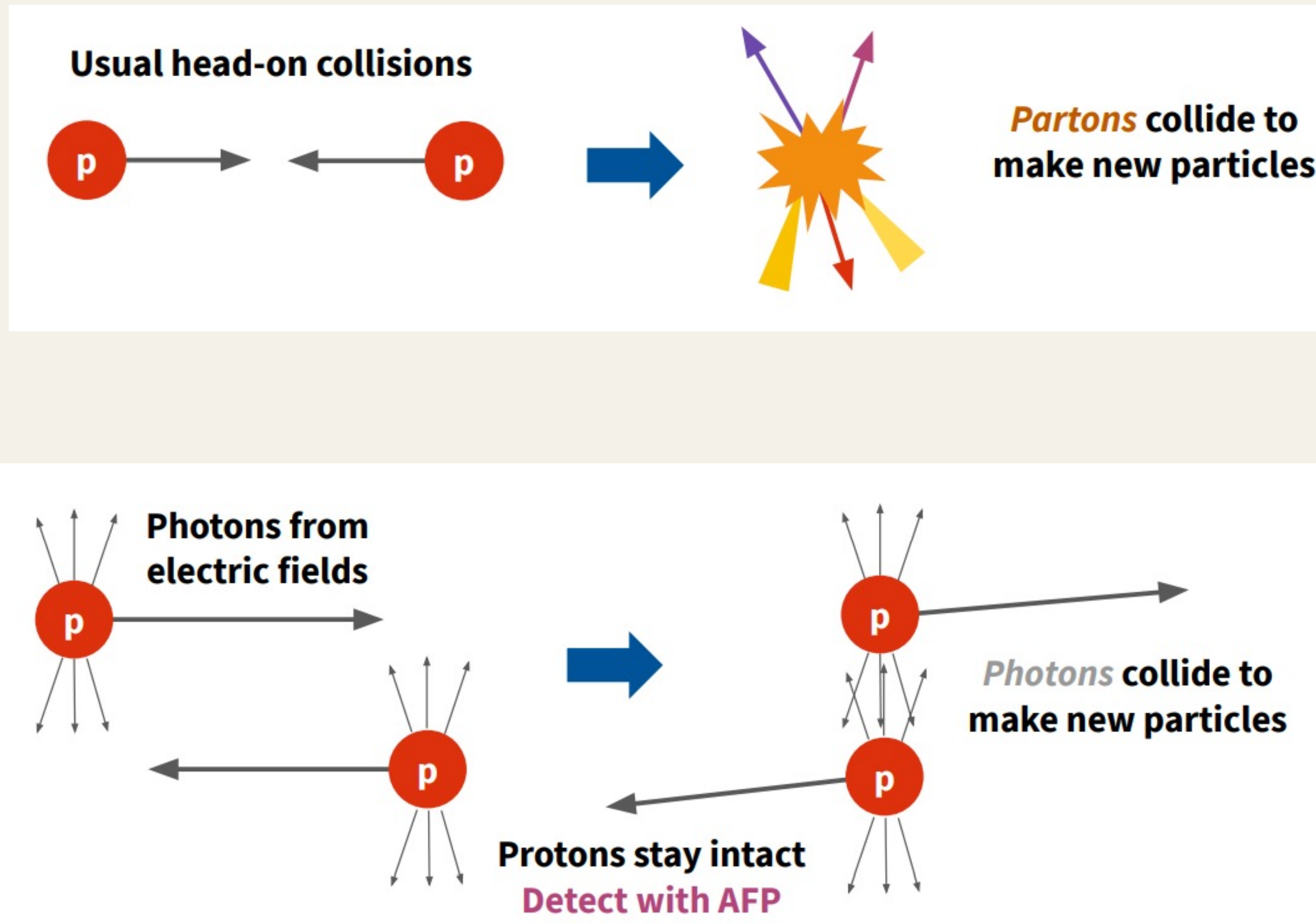
Introduction

- We present two modules as part of the Czech Particle Physics Project (CPPP).
- These are intended as learning tools in masterclasses aimed at high-school students (aged 15 to 18).
- The first module is dedicated to the detection of an Axion-Like-Particle (ALP) using the ATLAS Forward Proton (AFP) detector.
- The second module focuses on the reconstruction of the Higgs boson mass using the Higgs boson golden channel with four leptons in the final state.
- The modules can be accessed at the following link: <http://cern.ch/cppp>

Goal

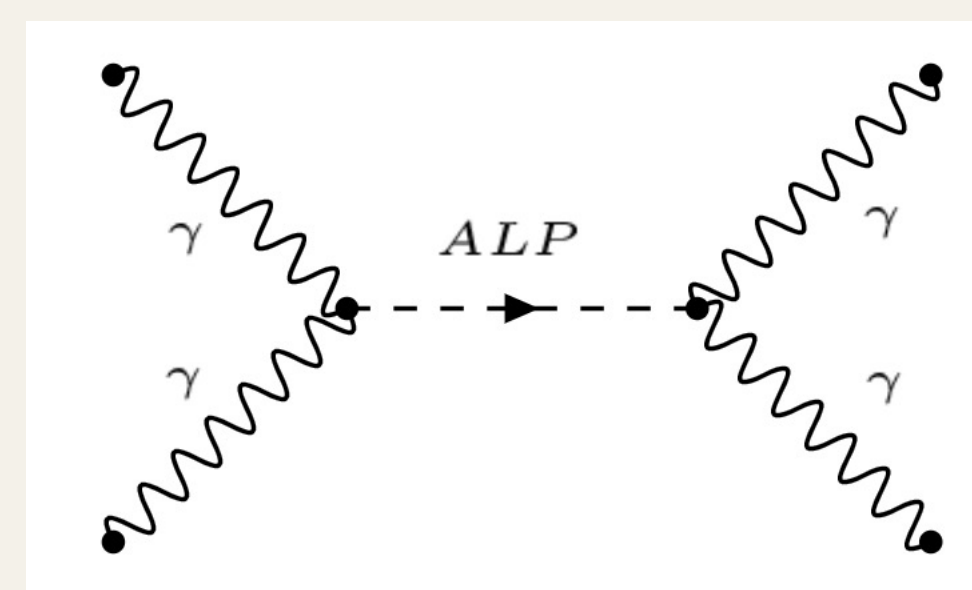
- Interactive web application for master classes.
- Aimed at high school students aged 15-18 years old.
- The aim is to walk students through the process of finding a 1 TeV Axion-Like Particle (ALP) using the ATLAS Forward Proton (AFP) detector.
- The simulation should be realistic but simplified.

Physics Motivation

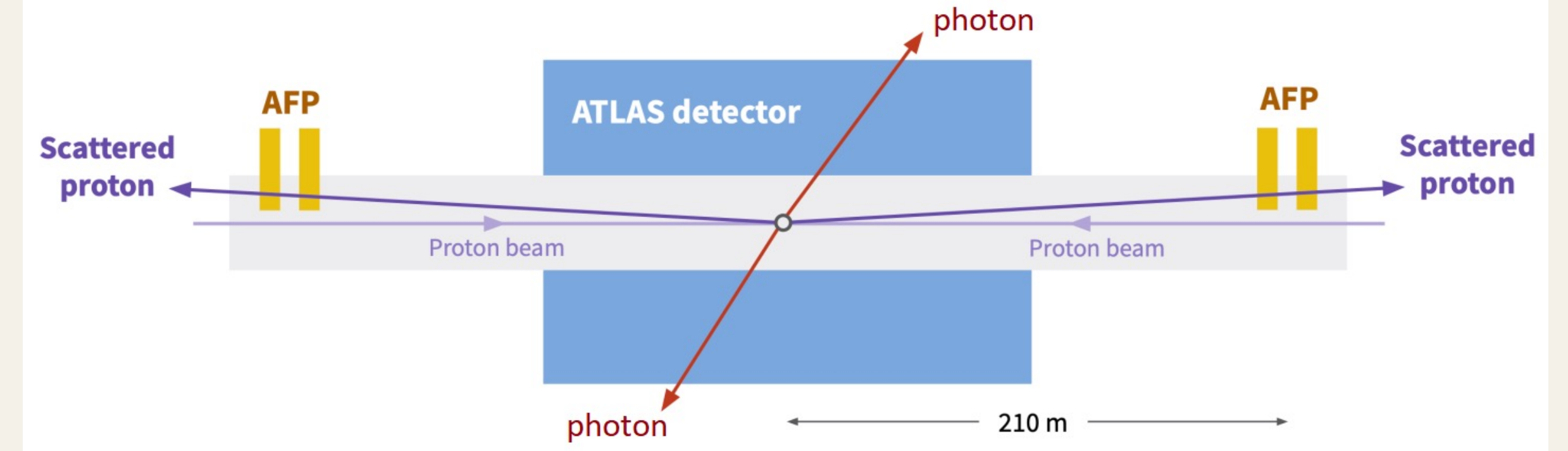


Axion-Like-Particle

- Axion-Like-Particle (ALP) Production
- Expected signature: two energetic photons in the ATLAS central detector



Background Reduction



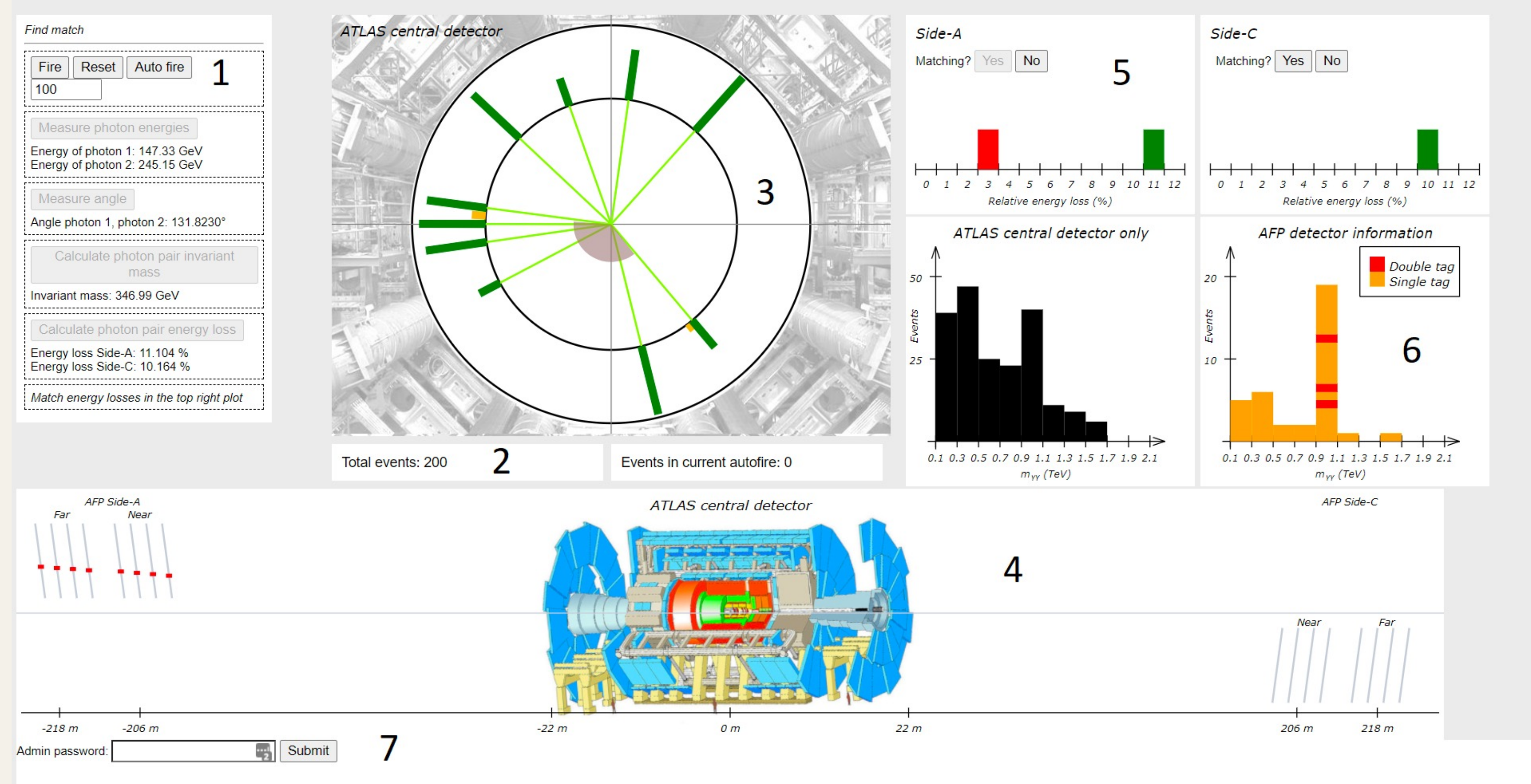
In order to reduce the background of the AFP signal:

- Two ways of calculating energy loss: photons in central detector and deflected protons in AFP detectors.
- Di-photon events, where the energy loss does not match, are considered background events and are removed.
- In this way the AFP detector contributes to separate signal from background events.

Interactive Application

The visualisation page contains:

1. Control panel
2. Event counter
3. ATLAS central detector
4. ATLAS central detector side view with AFP on either side
5. Energy loss matching histograms
6. Invariant mass histograms
7. Access to admin page

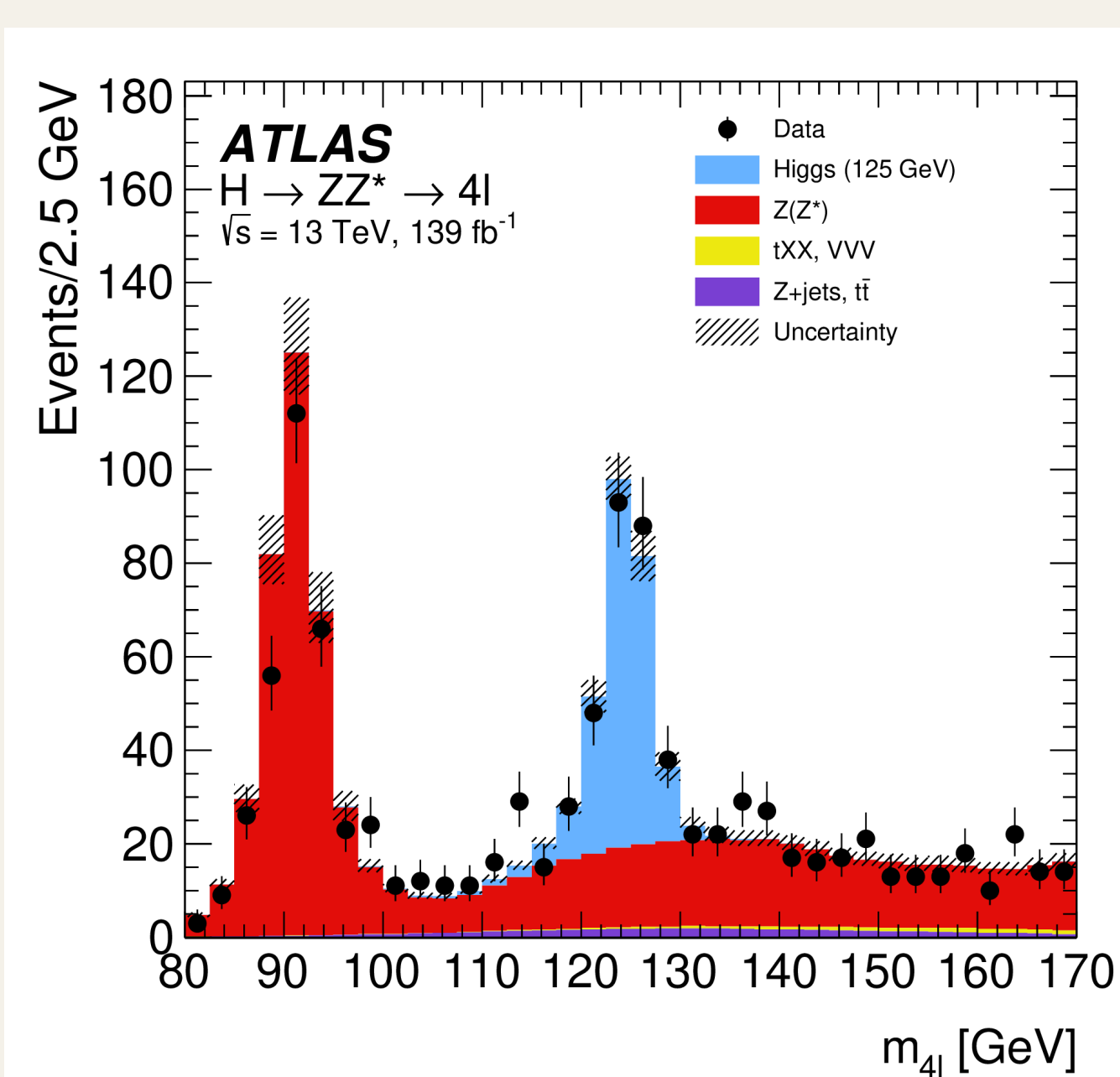


Admin and Back-end

- A password protected page enables an admin to change the parameters of the simulation (eg. making signal more visible, accelerating the animations).
- Any changes made on this page are sent to the server and are applied globally.
- Website hosted using CERN webservices and deployed with OpenShift connected to a GitLab.

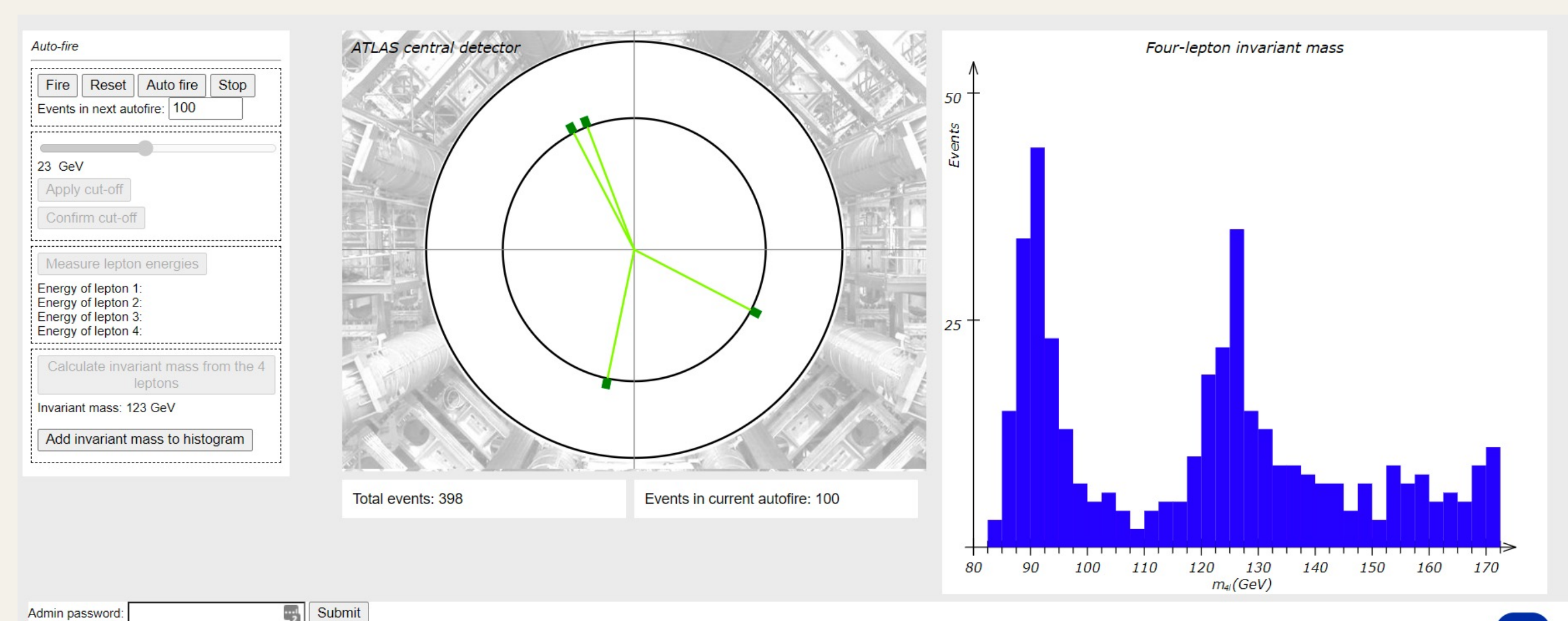
Higgs Boson Golden Channel

Measurements of the Higgs boson inclusive and differential fiducial cross sections in the 4ℓ decay channel at $\sqrt{s} = 13$ TeV
Eur. Phys. J. C 80 (2020) 942



Specific case: $H \rightarrow ZZ \rightarrow 4\mu$

- Goal: the student/user shall reproduce this mass spectrum and learn how to perform a simple analysis and reconstruct the Higgs boson mass peak with sufficient statistics
- For the outreach project, the events are generated using MadGraph but the invariant mass is picked from the ATLAS mass spectrum. Some low transverse momentum particles are added to illustrate the analysis in a simple form.
- The student/user should choose a momentum cut-off such as to keep only 4 muons, and reconstruct the invariant mass.



References/Acknowledgements

- Antoine Vauterin, [CERN-STUDENTS-Note-2021-227](https://indico.cern.ch/event/1084892), Outreach Modules for a New Particle Search Using the ATLAS Forward Proton Detector and Higgs Boson Physics
- Antoine Vauterin, André Sopczak, 22nd IPPOG meeting, 17-19 Nov. 2021, <https://indico.cern.ch/event/1084892>, New Web-based Educational Tool for ATLAS
- 18th International Masterclasses 2022, <https://physicsmasterclasses.org>

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