

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

Ivan Demchenko, Martin Kupka, André Sopczak (IEAP CTU in Prague), **Antoine Vauterin** (CERN Summer Student 2021) and Peter Zacik

AFP

Goal of the project

Introduction page

Simulation

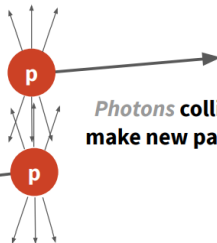
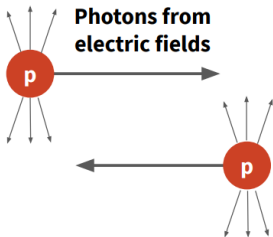
Admin and back-end

Higgs Golden Channel

Usual head-on collisions



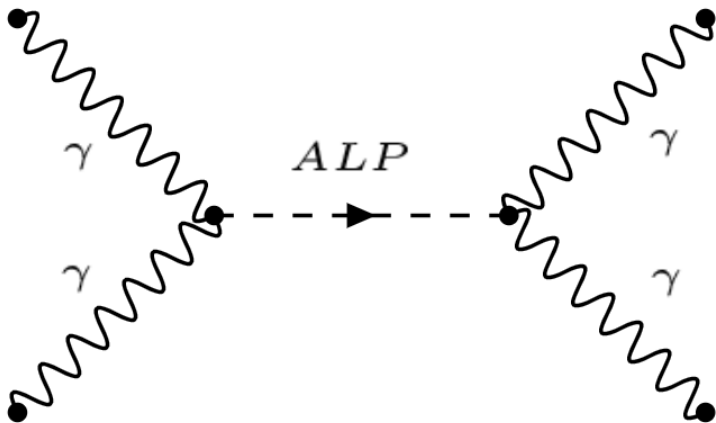
Partons collide to make new particles



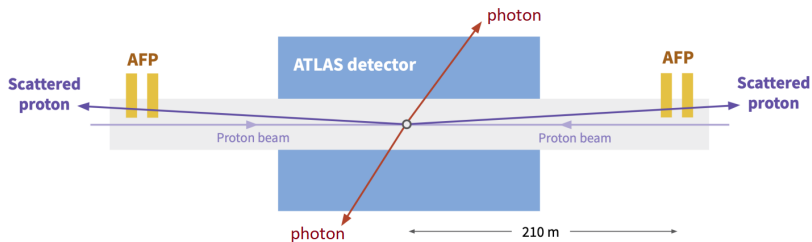
Photons collide to make new particles

Protons stay intact
Detect with AFP

Axion-Like Particle (ALP)



ATLAS Forward Proton (AFP) detectors



Two ways of calculating energy loss: photons in central detector and deflected protons in AFP detectors. They should match if there was an ALP.

Goal of the project

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.

Introduction page

First page is an introduction on the LHC, AFP and the physics involved. The content is aimed at high school students.

Simulation

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

Find match

1

Measure photon energies

Energy of photon 1: 147.33 GeV
Energy of photon 2: 245.15 GeV

Measure angle

Angle photon 1, photon 2: 131.8230°

Calculate photon pair invariant mass

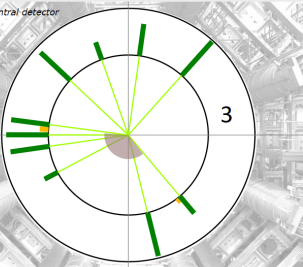
Invariant mass: 346.99 GeV

Calculate photon pair energy loss

Energy loss Side-A: 11.104 %
Energy loss Side-C: 10.164 %

Match energy losses in the top right plot

ATLAS central detector



Total events: 200

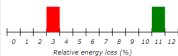
2

Events in current autofire: 0

Side-A

Matching?

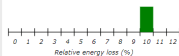
5



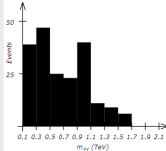
Side-C

Matching?

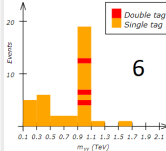
6



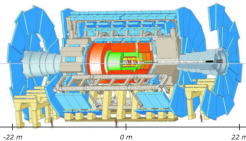
ATLAS central detector only



AFP detector information

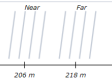


ATLAS central detector



4

AFP Side-C



Admin password:

7

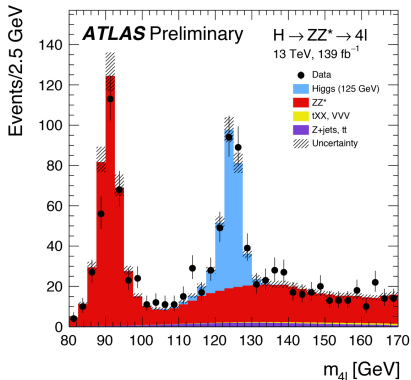


Admin and back-end

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 Golden Channel



$$H \rightarrow ZZ \rightarrow 4\mu$$

Goal: get the student to reproduce this figure

¹ Measurements of the Higgs boson inclusive, differential and production cross sections in the 4ℓ decay channel at $\sqrt{s} = 13$ TeV with the ATLAS detector, ATLAS-CONF-2019-025

The events are generated using MadGraph but the invariant mass is picked from the distribution shown on the previous slide.

We add some low transverse momentum particles. The student should choose a momentum cut-off such as to keep only 4 muons.

Auto-fire

Fire Reset Auto fire Stop

Events in next autofire: 100

23 GeV

Apply cut-off

Confirm cut-off

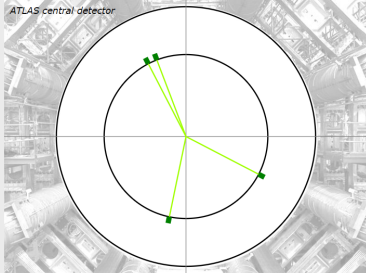
Measure lepton energies

Energy of lepton 1:
Energy of lepton 2:
Energy of lepton 3:
Energy of lepton 4:

Calculate invariant mass from the 4 leptons

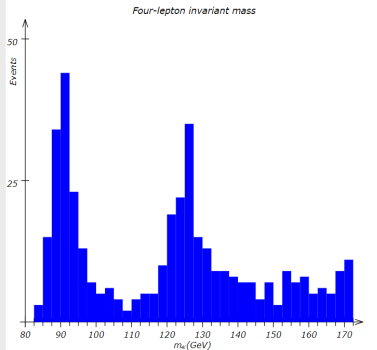
Invariant mass: 123 GeV

Add invariant mass to histogram



Total events: 398

Events in current autofire: 100



Admin password: Submit

CPFF

Summary

- Module ALP with AFP completed and online
- Module Higgs (golden channel) completed and online
- External summer student report:
<https://cds.cern.ch/record/2789040>
- These are new modules for the Czech Particle Physics Project (CPPP): <https://cern.ch/cppp>
- Previous module: Higgs boson publication data base (BA thesis Peter Zacik)
- Modules presented to IPPOG