Tracer EVD for ATLAS Masterclasses

User Manual

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Introduction

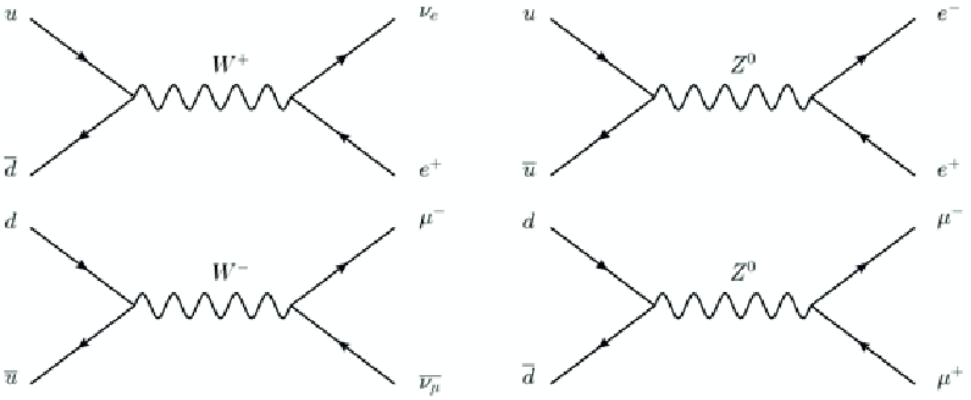
TracerEVD is web-based interactive application for the ATLAS experiment, the largest, general-purpose particle detector experiment at the Large Hadron Collider (LHC), a particle accelerator at CERN (the European Organization for Nuclear Research) in Switzerland. The application is used for performing ATLAS masterclasses and offers 3 dimensional workspace for event analysis. The aim of TracerEVD is to give students deeper understanding of how particle detectors work and the physics that they study. Currently, students are able to study W and Z boson events by observing their decay products and apply this knowledge to search for the Higgs boson. The application is built by the use of JavaScript and employs the Three.JS Web Graphics Library to create 3 dimensional view of ATLAS detector.

Proton-proton collisions, W and Z path

The W± and Z0 bosons may be produced in proton-proton collisions via hard scatterings between quarks and antiquarks.

The W± and Z0 bosons are short lived (with lifetimes of the order 10−25 s),and decay in practice immediately after their creation. They can therefore only be observed via their decay products, and decays into leptons are ideal for such detection.

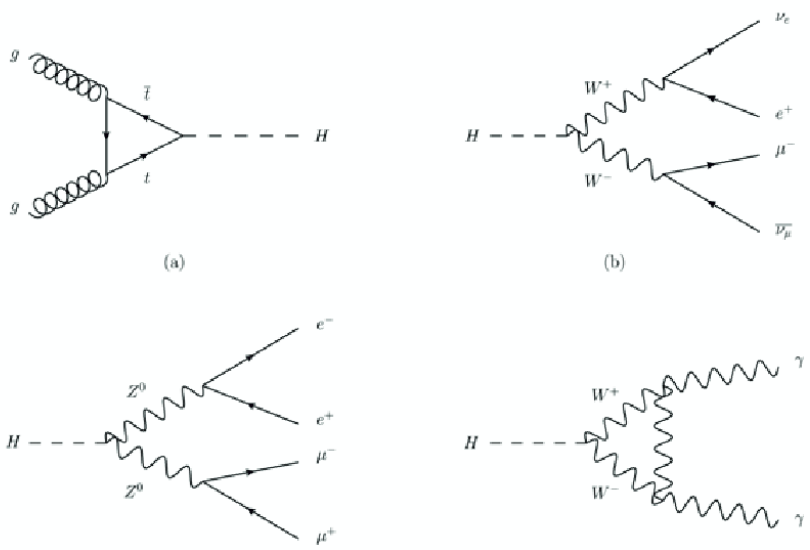
The decays of the W± and Z0 bosons into leptons provide characteristic experimental signatures. The decay of the Z0 boson into a pair of oppositely charged leptons gives such a pair among the particles emerging from the collision (among the final state particles), where each lepton will typically have a large momentum component perpendicular to the direction of motion of the colliding protons (perpendicular to the beam line).



The decay of a W+ or W− boson into a charged lepton and a neutrino gives one charged lepton with a large momentum component perpendicular to the beam line. In addition, there will be a momentum imbalance in the plane perpendicular to the beam line due to the neutrino, which experiences only the weak interaction, and is therefore not measured directly by the detector. This momentum imbalance motivates the calculation of an experimental quantity called the missing transverse energy, which can be thought of as an indirect measurement of the neutrino's momentum component in the plane perpendicular to the beam line.

The Higgs boson may also be produced in a proton-proton collision via a hard scattering of two gluons. This process is much more rare than the production of W± and Z0 bosons. Some Feynman diagrams for the production and decay of the Higgs boson in proton-proton collisions are shown in figure.

Note that both the production of the Higgs boson and its decays into photons and leptons happen via intermediate states of heavy particles. This is the top quark in the case of production, and the W± and Z0 bosons in the case of the decays. The reason for this is that the Higgs boson interacts primarily with heavy particles, and the W± and Z0 bosons and the top quark are the heaviest particles of the Standard Model.



This also explains why Higgs production at the LHC is much more rare than W± and Z0 boson production: the quarks inside the proton are very light, and their direct coupling to the Higgs boson is therefore very weak.

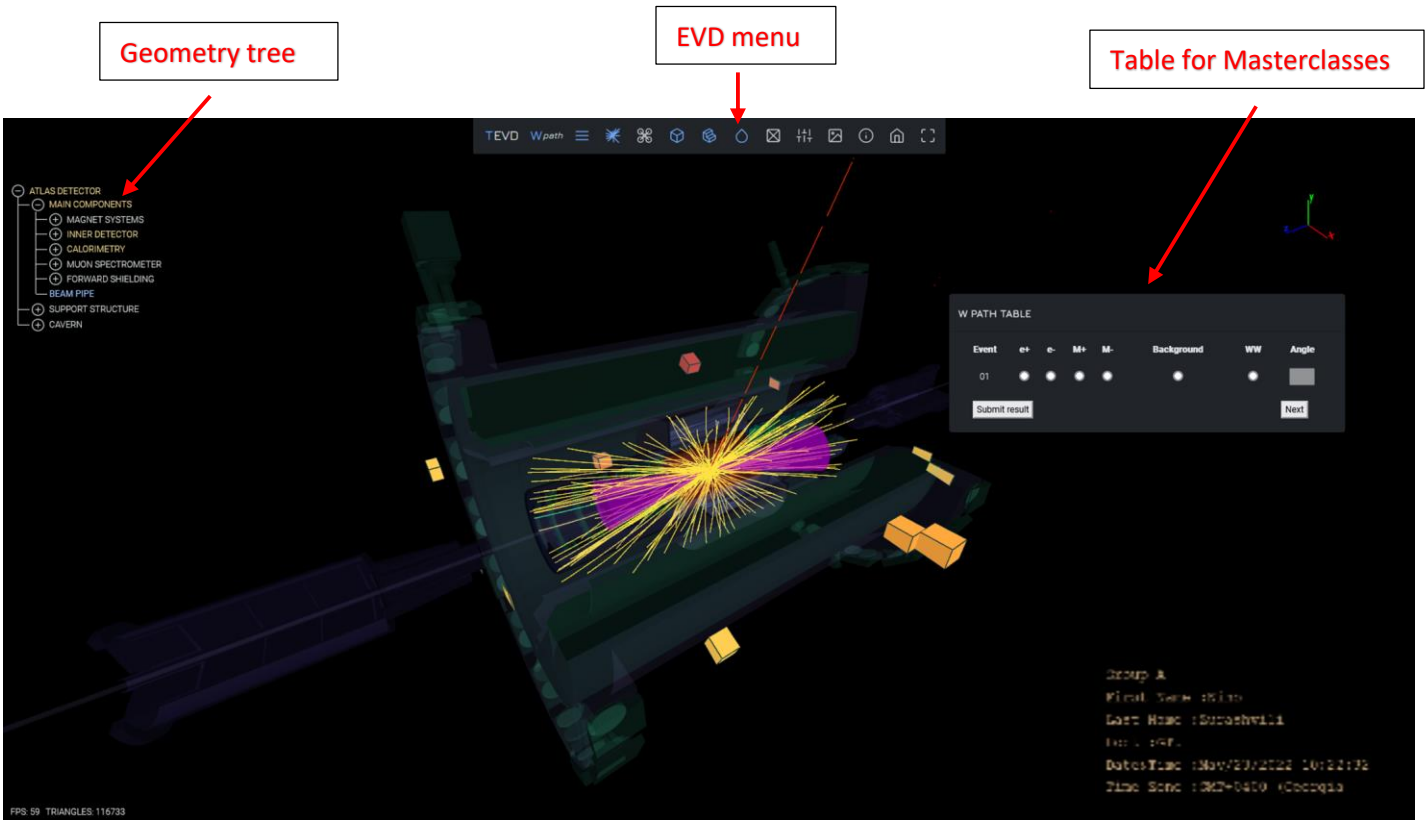
User Registration

Before performing ATLAS masterclasses user should fill out the registration form on starting page.

After filling out the form, the user can choose which path to perform (W or Z) and press Start button.

You are not able to participate in masterclasses if your host institution is not registered.

EVD tools



You can load or hide geometries from scene using geometry tree by clicking on the relevant geometry names. The blue colored parts indicate that all of its child geometries (is exists) are loaded. In case of yellow colored names, only a certain child parts are loaded.

The main tools of the application are located in the EVD menu.

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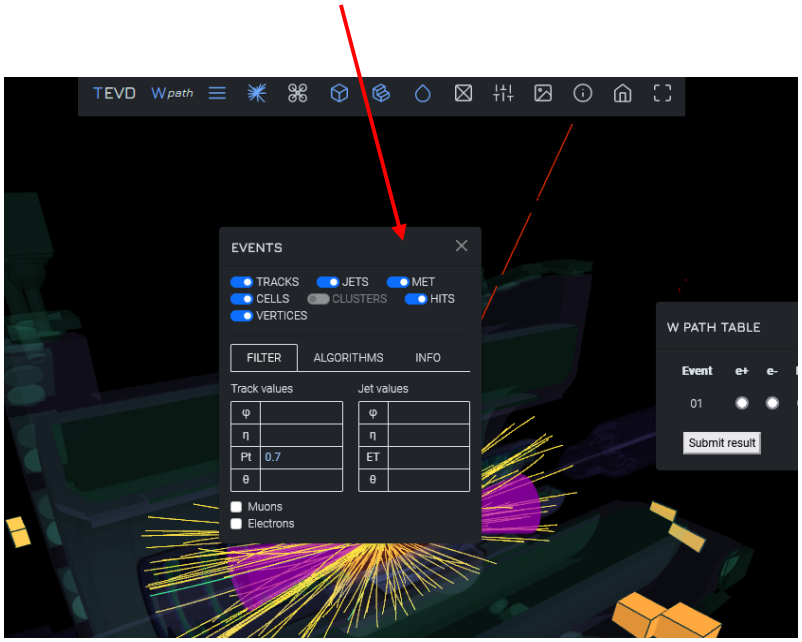
Indicates which masterclass problem is chosen by user.

-  hide/show geometry tree
-  show events menu:

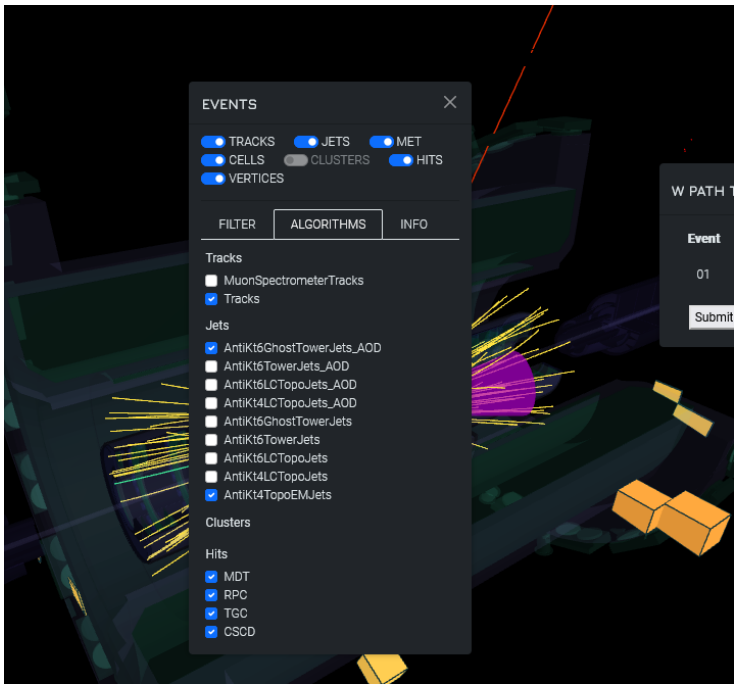


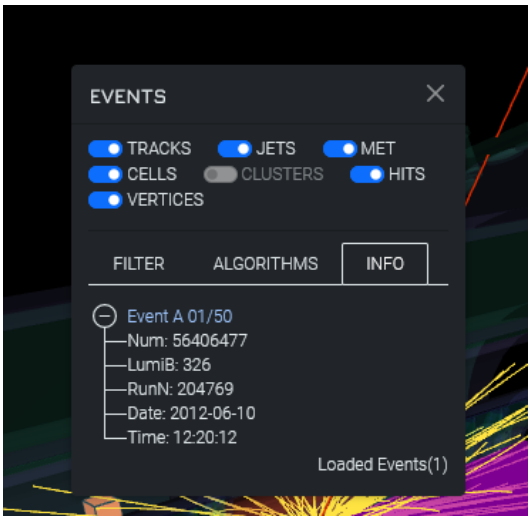
User can hide/show event objects by clicking on corresponding checkboxes.

Filtering tool helps user to filter event objects by parameters like angles: φ, η, ϑ; Pt, etc.

User can choose reconstruction algorithms for event objects in Algorithms window.

Additionally, you can load hits and cluster objects in scene, if corresponding xml contains such information.



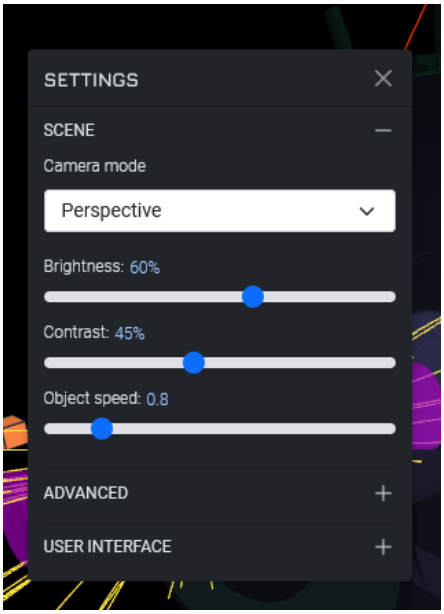


Info window shows loaded xml (event) parameters like group name, number, run number, event date, etc.

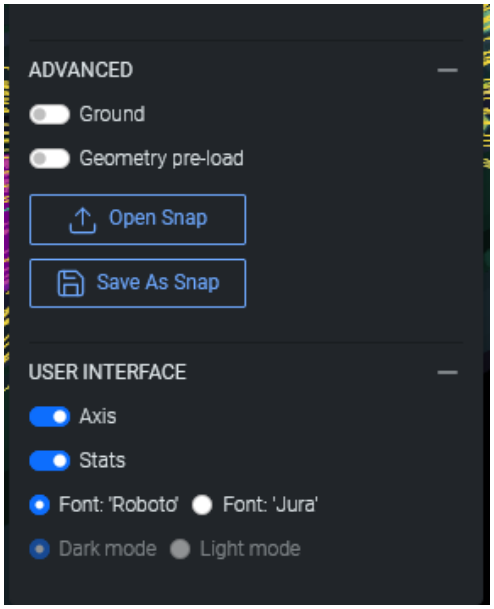
-  User can select drone animation modes which allows you to view the scene, geometries, event from different angles, record various processes, etc.

-  Change camera position to 3 different default options
-  User can choose different cuts for geometries
-  Controls opacity of geometries
-  Switch to wireframe mode

-  Open settings window:



In scene settings user can change camera mode to perspective/orthographic, control brightness, contrast and object speed (In case using drone control)



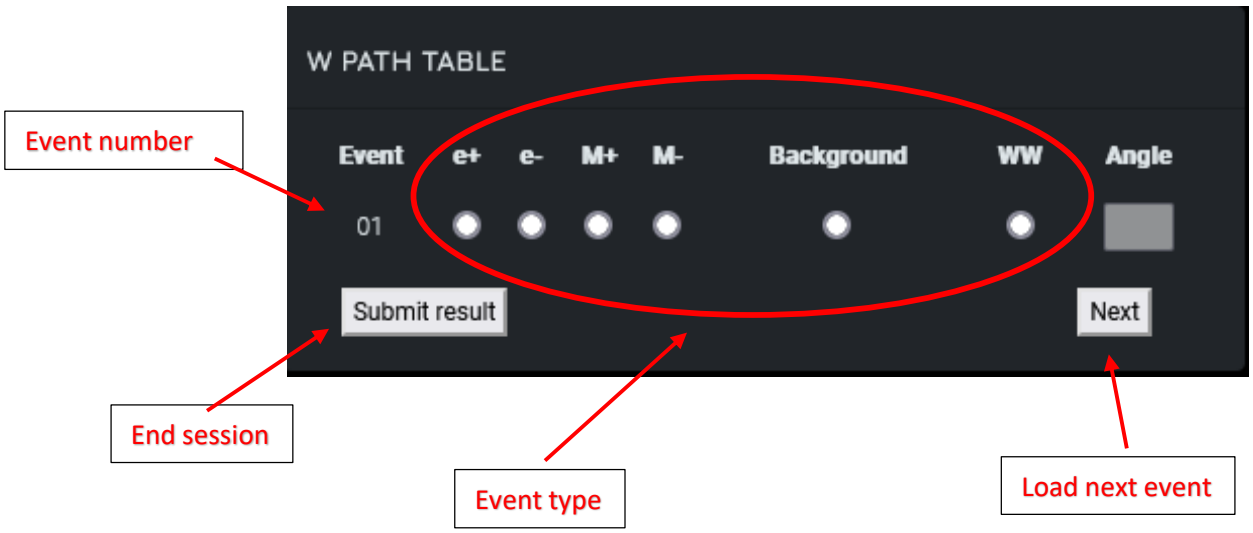
In advanced settings user can add ground grid in scene, use geometry pre-load (all geometries are loaded simultaneously, which increases the speed of adding/removing parts from geometry tree).

In user interface settings user can add axis, stats (FPS, triangles) in scene.

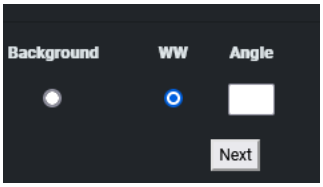
-  Screenshot tool
-  Information about tracer group
-  Fullscreen mode

Performing Masterclasses using EVD

At the beginning of the session first event of chosen problem is loaded. Student should analyze current event using EVD tools



After analyzing current event, user should check result and press “Next” button.



Angle input field is activated only in case of WW event

After pressing button “Next”, following event is loaded.

Student can return to the previous events and change results using “edit” tool.

Student can end current session by pressing “submit result”.

Displaying Masterclass results

After ending event analysis session, results received from all groups are displayed.

We use the database which is hosted by CERN to store this data.

Search:

Group Name	Positron	Electron	Muon	Antimuon	Background	WW	Angle
A	0	0	0	0	0	0	
B	0	0	1	2	1	1	90;
C	0	1	0	0	0	0	
D	0	0	0	0	0	0	
E	0	0	0	0	0	0	
F	0	0	0	0	0	0	

Students (group) can look over their results and explore others.