Tracer 3D app: New version

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About

- Tracer-MC is a browser-based 3D application designed for the ATLAS exercises of the International Masterclasses.
- The application requires no installation and is compatible with a wide range of platforms, including portable and mobile devices.
- It can be accessed directly via any modern web browser using the link provided below.

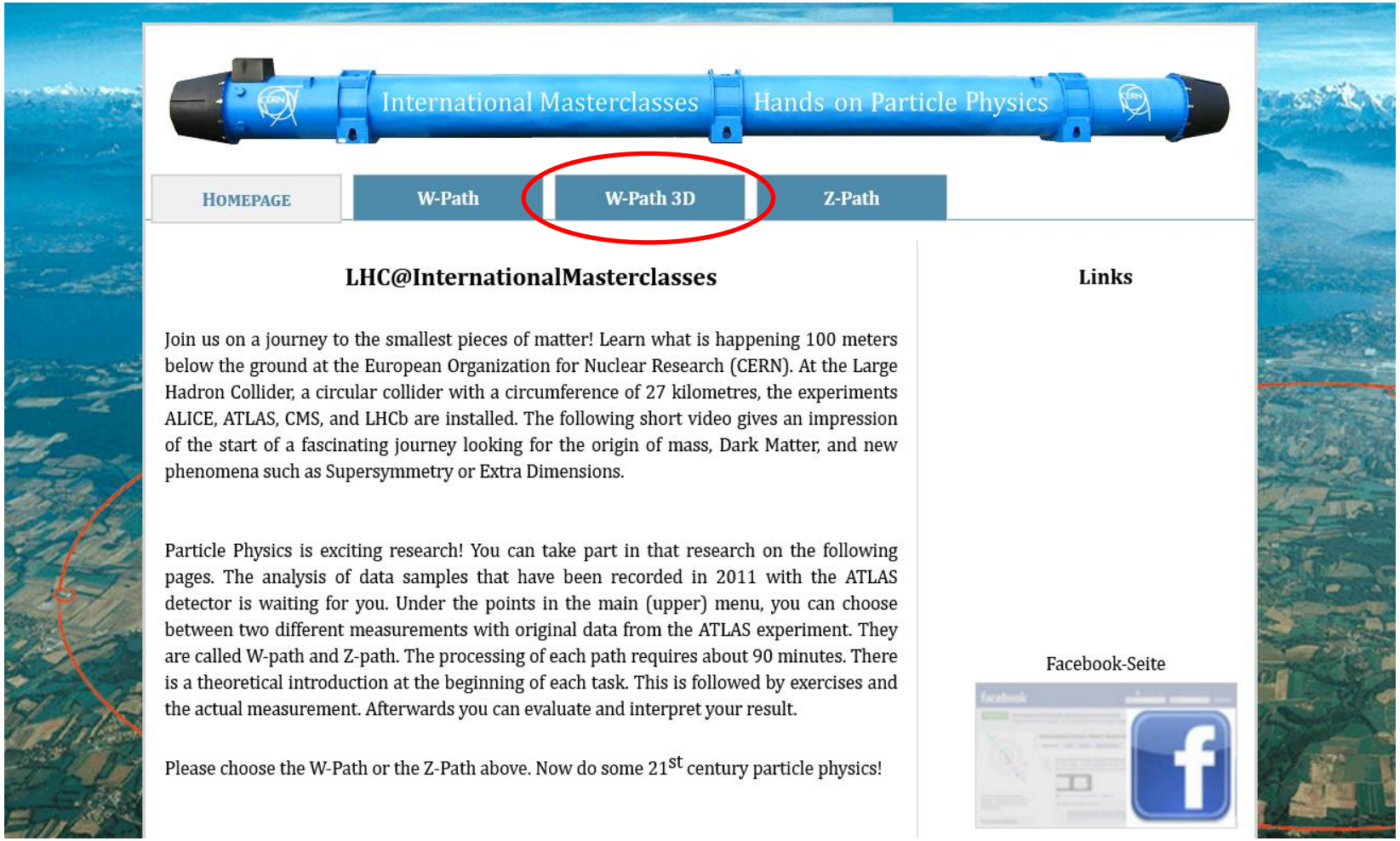
https://tracer-mc.web.cern.ch/

About

- Tracer-MC consists of two applications:
  I. 3D Event Display
  II. 3D Detector Display

Masterclasses Website

- Tracer-MC is available through the official IPPOG Masterclasses website standalone additional tab through the link is https://ippog-masterclasses-website.web.cern.ch



Masterclasses Website

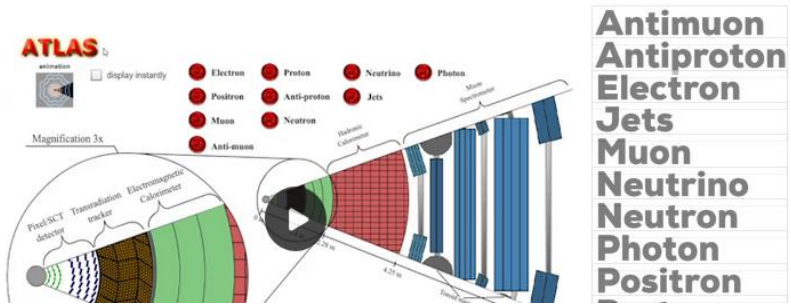
Identifying Particles

Here you can review how the detector is built. You will learn how elementary particles can be identified and how you can recognize them with our program. In a concluding exercise you may test your newly acquired knowledge.

Time for active playing! Discover the signals elementary particles leave in the detector with the help of the interactive animation of ATLAS below. Choose a specific particle from the upper menu and follow its way through the detector. Keep in mind that a dotted line represents the path of a neutral particle, which is not seen by the detector until it showers in a calorimeter, if at all.

The program that we will use is introduced on the next page. It illustrates events of proton-proton collisions in cross-sectional view similar to the picture you see at the bottom of the page.

If you do not yet understand the structure of the ATLAS detector, you can find more information under the menu item ATLAS detector.



Antimuon
Antiproton
Electron
Jets
Muon
Neutrino
Neutron
Photon
Positron

W-path 3D

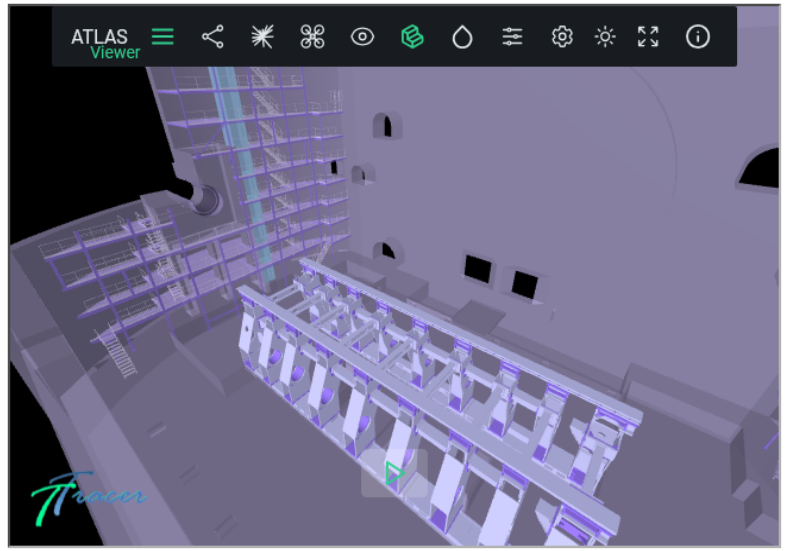
- Aims/Tasks
- Identifying Particles
  - ATLAS Detector
  - The Event Display Tracer
  - Identifying Particles
  - Exercise 1
- Identifying Events
- Measurement
- Analysis

https://ippog-masterclasses-website.web.cern.ch

Here, you'll learn about the structure of the ATLAS detector and how particles interact with the detector material. You can learn using videos, texts, and interactive resources, including the ATLAS Viewer tool developed by Tracer.

Products of proton-proton collisions are detected by the ATLAS detector (ATLAS stands for A Toroidal LHC ApparatuS). In the middle of ATLAS, two particle bunches (each with 100 billion protons) collide with each other after they have been accelerated in opposite directions in the LHC. It is therefore not possible to predict which parts of one proton will collide with which parts of another one nor can we tell which protons collide at all. When protons collide they may simple scatter off each other but stay whole or they will interact more violently and disintegrate. In the latter case, new particles are formed. From the data, physicists are able to say which physical processes may have taken place during the collisions. To do this, they need a good understanding of the detector and its function. So let's take a look at these points, below.

ATLAS Detector Viewer by Tracer



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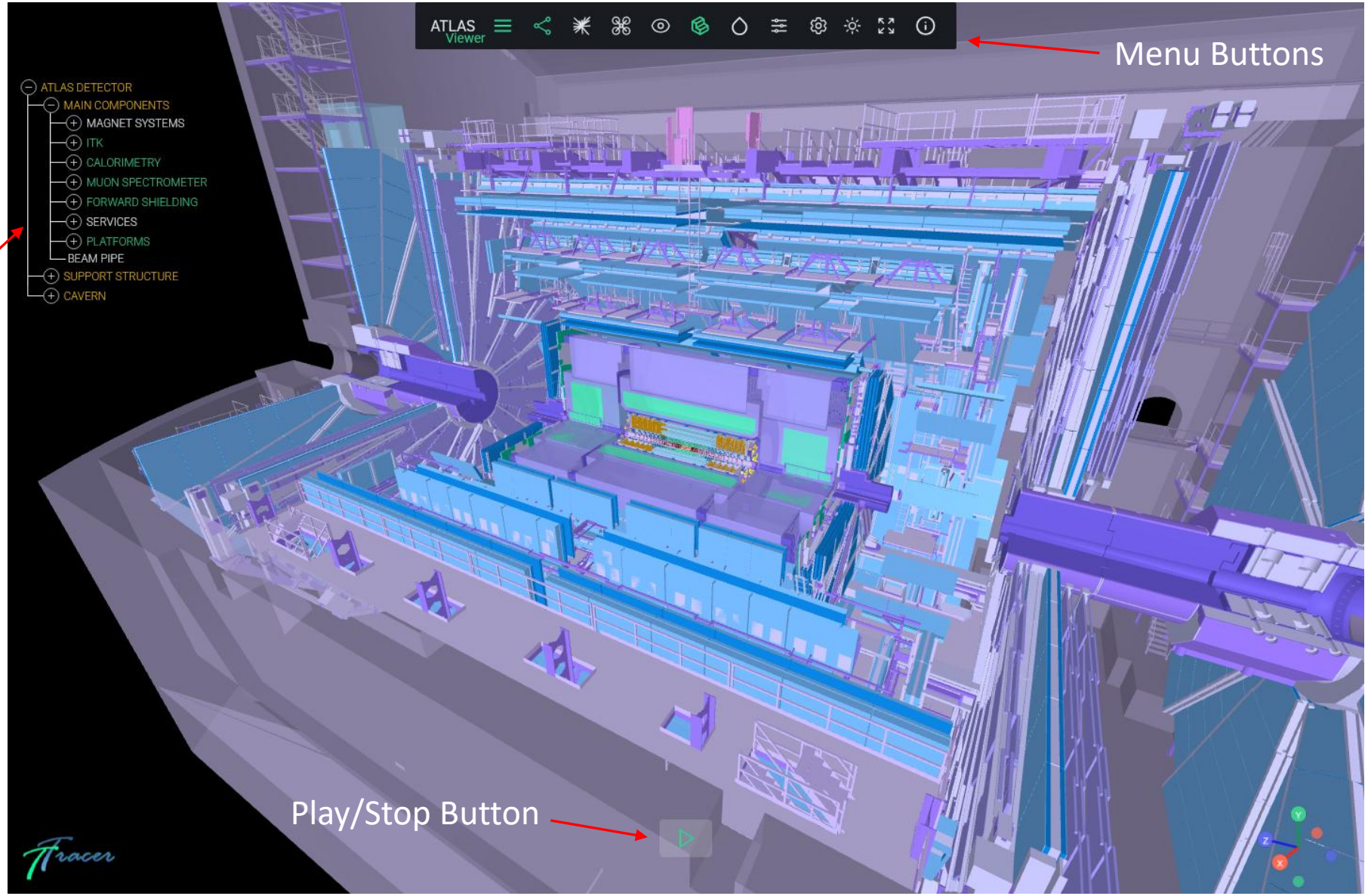
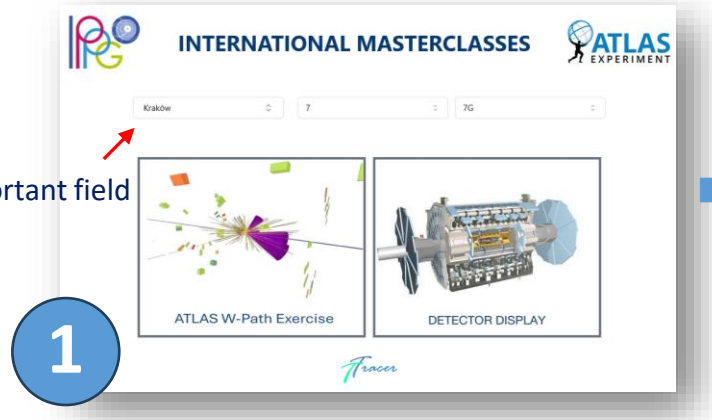
3D Detector Display

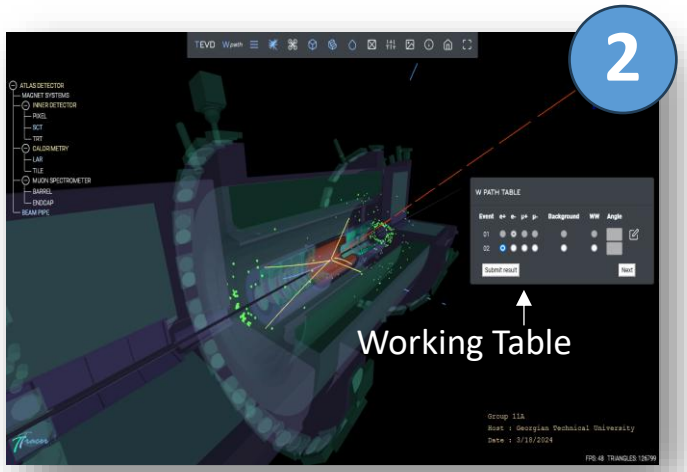
Geometry Tree

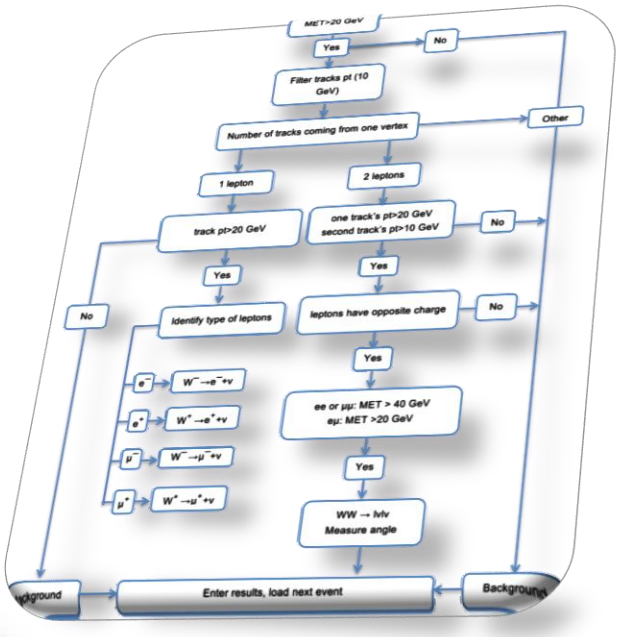


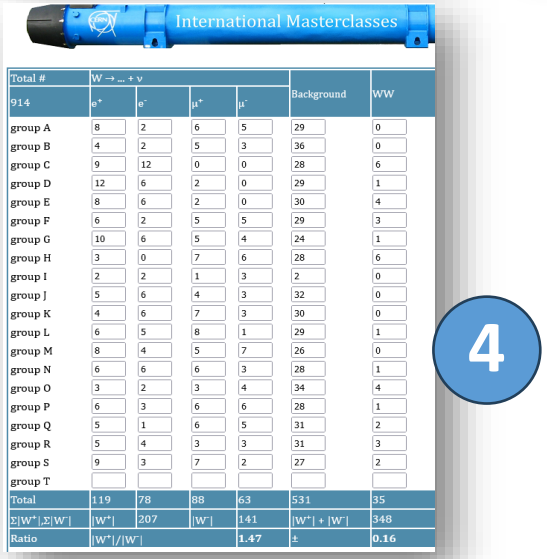
3D Event Display for the W Exercise

- Simple steps allow students to pass through the exercise





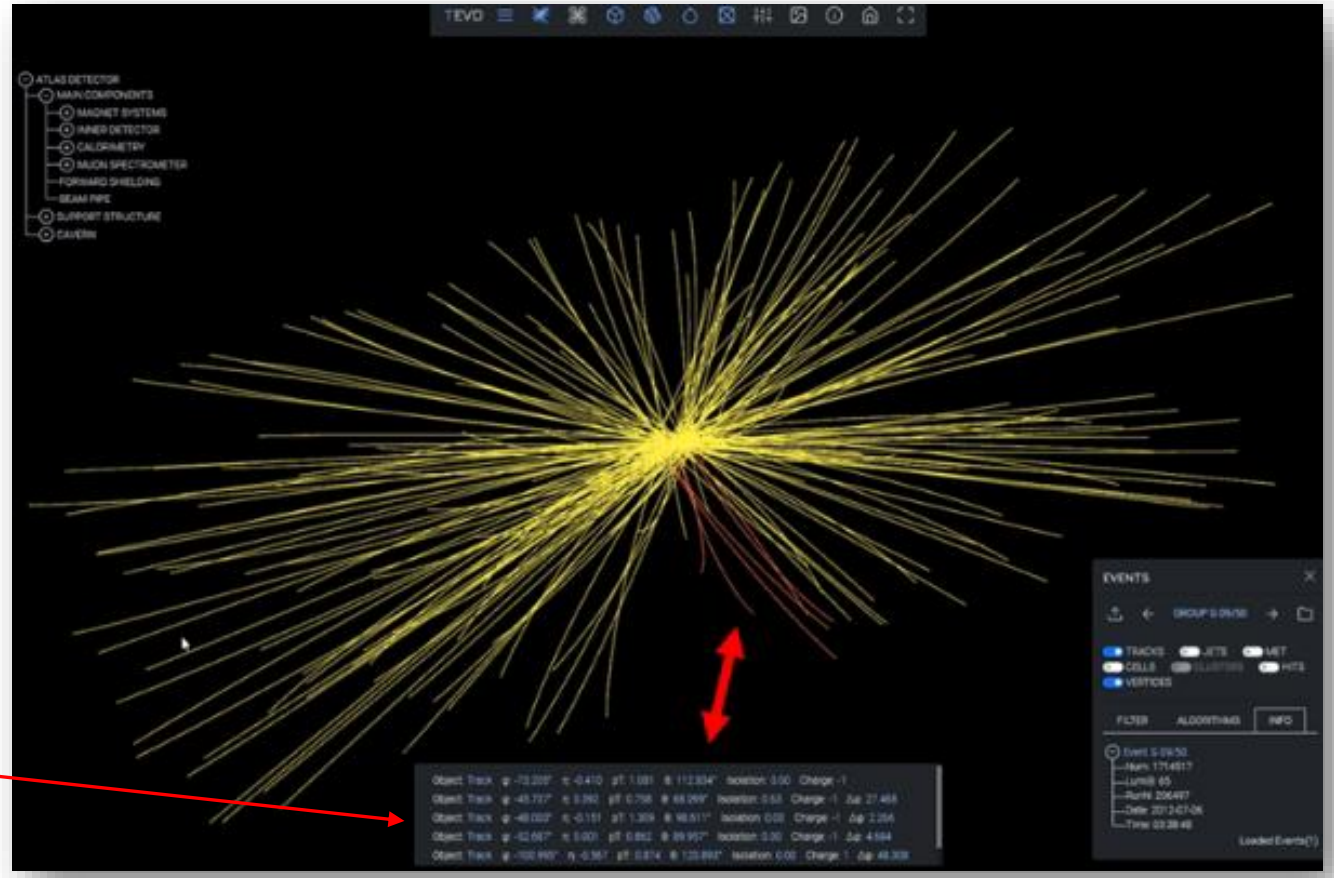




Total #	W → … + ν				Background	WW
914	e^+	e^-	μ^+	μ^-		
group A	8	2	6	5	29	0
group B	4	2	5	3	36	0
group C	9	12	0	0	28	6
group D	12	6	2	0	29	1
group E	8	6	2	0	30	4
group F	6	2	5	5	29	3
group G	10	6	5	4	24	1
group H	3	0	7	6	28	6
group I	2	2	1	3	2	0
group J	5	6	4	3	32	0
group K	4	6	7	3	30	0
group L	6	5	8	1	29	1
group M	8	4	5	7	26	0
group N	6	6	6	3	28	1
group O	3	2	3	4	34	4
group P	6	3	6	6	28	1
group Q	5	1	6	5	31	2
group R	5	4	3	3	31	3
group S	9	3	7	2	27	2
group T						
Total	119	78	88	63	531	35
$\Sigma\lvert W^+\rvert,\Sigma\lvert W^-\rvert$	$\lvert W^+\rvert$	207	$\lvert W^-\rvert$	141	$\lvert W^+\rvert + \lvert W^-\rvert$	348
Ratio	$\lvert W^+\rvert/\lvert W^-\rvert$			1.47	±	0.16

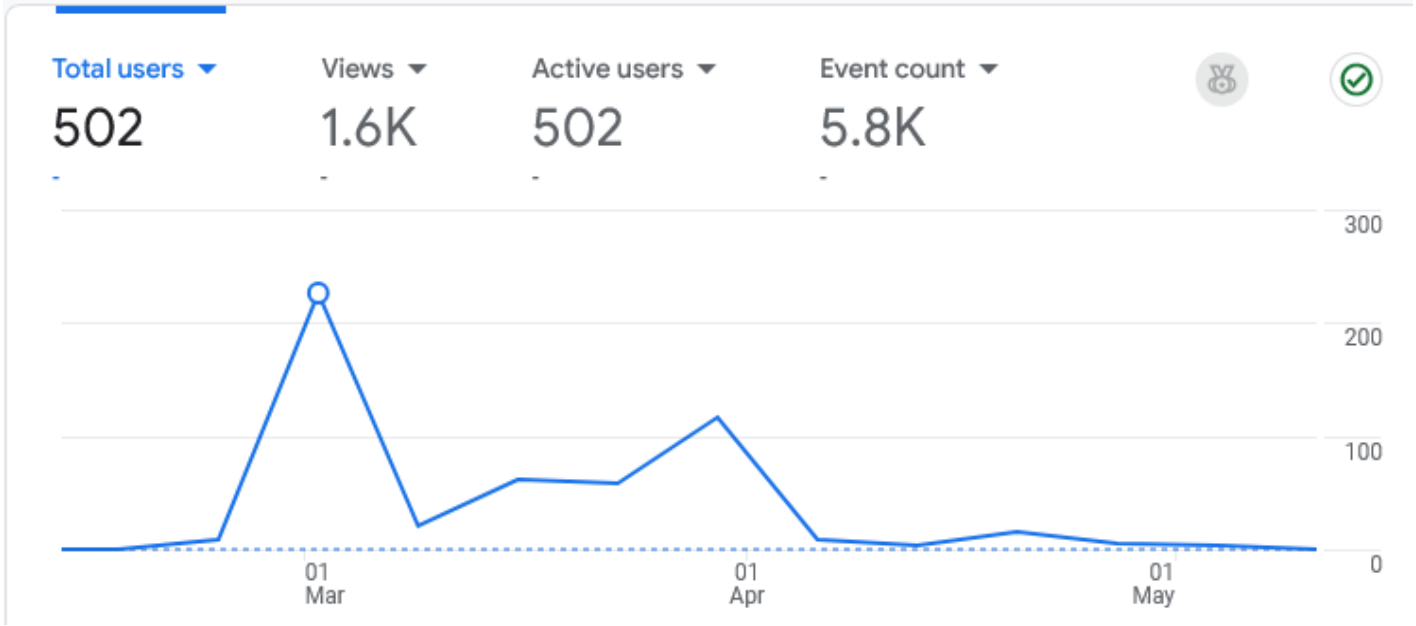
3D Event Display for the W Exercise

- Tracks-Jets-MET are selectable
- Detailed parameters are available in the status bar
- Cuts and event-sensitive parameters are available in the Events window



Tracer-MC Implementation in the 2025 IMC

- Tracer had 465 users during the masterclasses in 2025
- We have observed 4 days of W masterclasses on the 7th of March, 17th of March, 25th of March, and 3rd of April
- 227 users on the 7th of March
- 62 users on the 17th of March
- 59 users on the 25th of March
- 117 users on the 3rd of April



Tracer-MC Implementation in the 2025 IMC

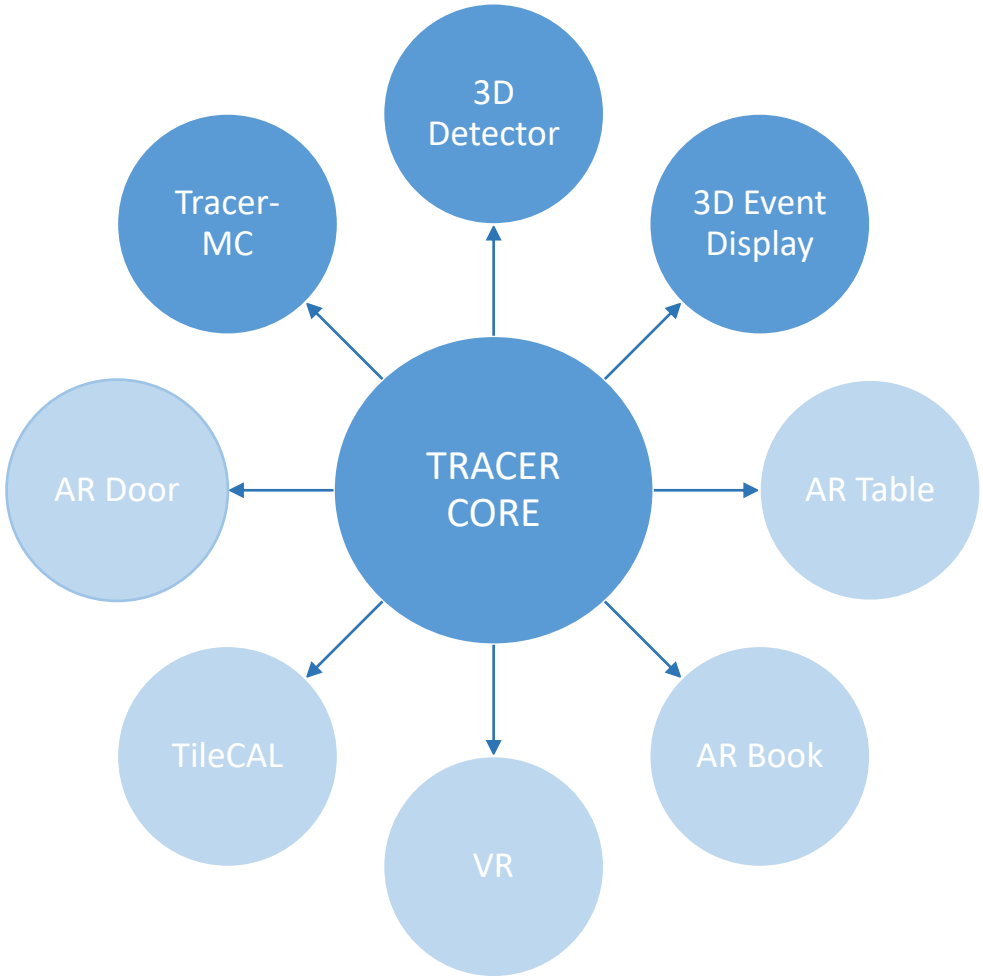
- Participants:
  - 7th of March:
    - Strasburg – 922 data
    - Kraków – 739 data
    - Tbilisi – 836 data
  - 17th of March:
    - Telavi – 1’918 data
  - 25th of March:
    - Bern – 254 data
    - Bonn – 1’304 data
    - Kutaisi – 1’156 data
  - 3rd of April:
    - Parma – 656 data
    - Batumi – 1’100 data

Tracer-MC Updates

- We did updates and generated a new version - Tracer-mc v2.0
- Modifications done in two directions:
    I. New user interface development
    II. New engine development

New Engine Development

- Tracer-MC build based on the *Parent-Child* architecture
- The parent module is Tracer-Core.
- This architecture enables automatic updates of all child applications once the Core is updated with the new functionalities and WebGL versions.
- Previous Tracer-MC was built on core version 2.1 and WebGL version r127
- New version built based on the Core version 7.0 and WebGL version r177



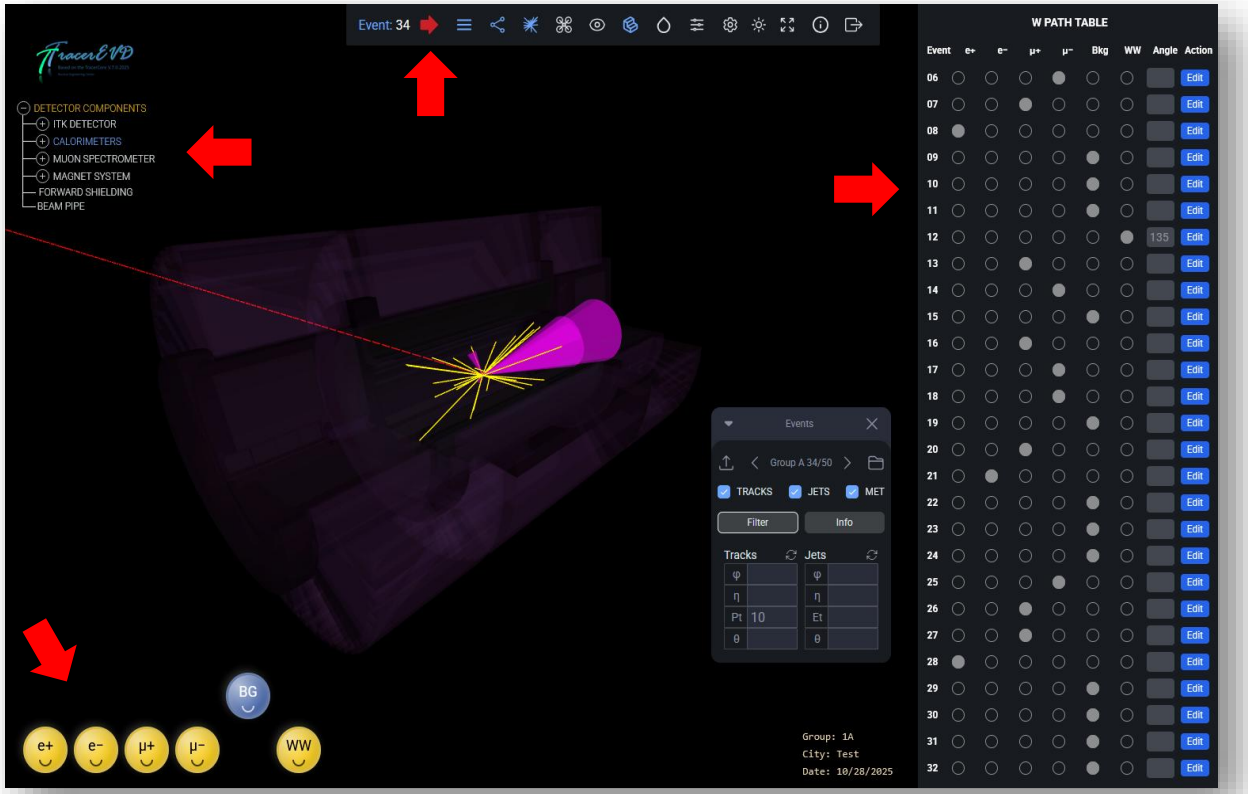
New Engine Development

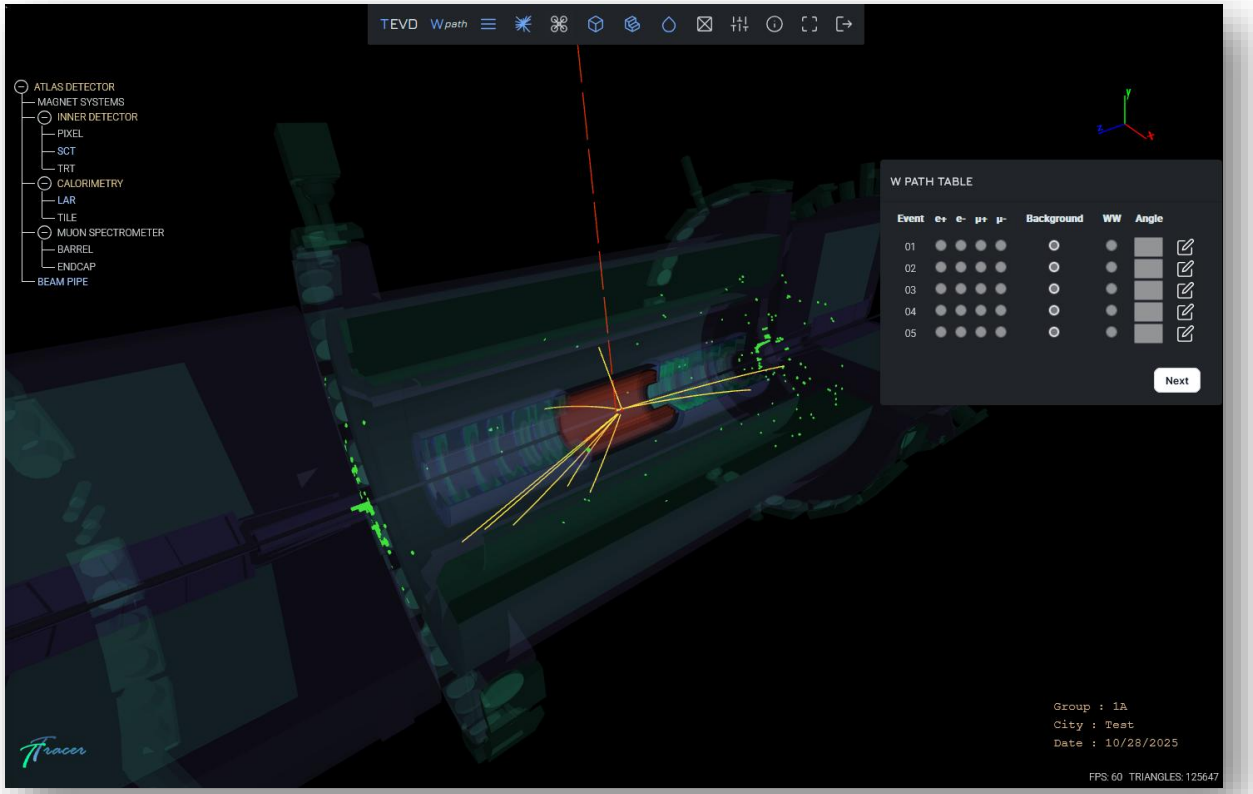
- As a result, the application now runs twice as fast.
- The geometry loading time has been significantly reduced.
- By default, the full geometry is now loaded into the cache when the application starts.
- While this increases memory usage on users' portable devices and may lead to unnecessary loading of unused geometry during a session, it also offers a key advantage: geometry is now loaded directly from the cache rather than from the server, resulting in reduced latency.

Tracer-MC Updates

New UI Development

https://tracer-mc.web.cern.ch/ **vs** https://tracer-mc-dev.web.cern.ch/





Future Ideas

- We currently rely on standard platforms for our backend and hosting. For the backend, we are using Supabase rather than CERN servers.
- However, we are not satisfied with either the Supabase database service or the CERN hosting. Therefore, we plan to migrate to more stable platforms that can ensure the long-term sustainability and reliability of Tracer-MC.
- We are still exploring how to link the Tracer-MC output table with the Physics Masterclasses input table. This connection will enable the automatic transfer of masterclass data at the end of each session.

Comments are welcome

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Thanks!