The search for New Particles at CERN on the Zooniverse citizen-science platform



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The REINFORCE Project

Research & Innovation Project, supported by the European Union's Horizon 2020 SWAFS "Science with and for Society" work programme. **Duration:** December 2019 – November 2022

Coordinating Partner: European Gravitational Observatory (EGO)

Four demonstrators developed in four respective Work Packages



WP5: New Particle Search at CERN

The demonstrator is based on the **Zooniverse citizen-science** platform and adopts a three-stage process to engage non-expert citizens in searches of new elementary particles produced in high energy proton-proton collisions recorded by the **ATLAS experiment at the LHC of CERN**.





engage thousands of citizens to bring science and society together.





Fully embedded into Zooniverse.

- A sample of simulated events based on Long-Lived Particle hypotheses is used to derive images displaying reconstructed tracks on the ATLAS inner detector.
- Using the mouse pointer, citizens click on each image to report the coordinates of any displaced vertex in the event, in both views of the ATLAS inner detector.
- Zooniverse records and assesses user selections after each event, based on generation-level truth information, and provides feedback to the user.
- The efficiency of citizens' selections is analysed in terms of efficiency and purity and compared to the performance of a machine-based algorithm.
- For events classified by more than 10 users, user responses are statistically combined to derive a *user consensus* also to be compared with the algorithm.

October 19 – June 07	#Users	#Classified Events	2 40		2 50		Preliminary Results: Distribution of the users' efficiency in
All users	2447	72042	$\begin{array}{c} 30 \\ 2 \\ 25 \\ 20 \\ 20 \\ 15 \\ 10 \\ 10 \\ 10 \\ 10 \\ 10 \\ 10 \\ 1$		ן ר <u>ן</u>	each view of the ATLAS inner detector.	
Registered Users	1422	66710			30		The blue dotted line shows the average efficiency whereas the green dotted line shows the consensus efficiency.
Not Registered Users	1025	5332					

Citizen contribution to Stage 1 since the launch of the project on October 2021.



Stage 2: Particle Identification



• Handled by Zooniverse and HYPATIA interactive framework.

Stage 3: Discovery Challenge

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Handled by Zooniverse and HYPATIA interactive framework.

- Using simulated events in order to know the true identify of each displayed particle.
- Citizens select reconstructed tracks and energy deposits in the ATLAS electromagnetic calorimeter to classify particles as electrons, photons, converted photons or muons.
- Citizen classifications are analysed in terms of efficiency and purity based on generation-level truth information.
- Citizens' performance will be compared to the performance achieved with a machine-learning algorithm, which has been developed and trained to perform the same identification task.

identification success rate (preliminary results)

80.4%

- Real data from the sample of ATLAS Open Data are used.
- In Stage 3A, citizens search for Higgs boson decays to photons/converted photons, and select the respective energy deposits in the electromagnetic calorimeter.
- In Stage 3B, citizens search for the displaced vertices of Long-Lived particles decays to a muon and a hadronic jet.
- In both sub-stages citizens are asked to study kinematic properties and classify each event from 0 to 5, according to how interesting it is.
- Events that are found interesting by many users are closer inspected and discussed with them.



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REINFORCE: https://reinforce.eu

ATLAS Open Data: https://atlas.cern/Resources/Opendata

HYPATIA Project: https://hypatia.iasa.gr/