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

**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 engage thousands of citizens to bring science and society together.

**Stage 1: Identification of Displaced Vertices**

- 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.

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<tr>
<th>October 19 – June 07</th>
<th>#Users</th>
<th>#Classified Events</th>
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</thead>
<tbody>
<tr>
<td>All users</td>
<td>2447</td>
<td>72042</td>
</tr>
<tr>
<td>Registered Users</td>
<td>1422</td>
<td>60710</td>
</tr>
<tr>
<td>Not Registered Users</td>
<td>1025</td>
<td>5332</td>
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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.
- Using simulated events in order to know the true identity 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.

**Stage 3: Discovery Challenge**

- Handled by Zooniverse and HYPATIA interactive framework.
- 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.

**Preliminary Results:**

Distribution of the users' efficiency in each view of the ATLAS inner detector.

The blue dotted line shows the average efficiency whereas the green dotted line shows the consensus efficiency.

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80.4% identification success rate (preliminary results)

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