# The REINFORCE EU Science-for-Society (SwafS) project

*Stelios Angelidakis*

*Dimitris Fassouliotis*

*Christine Kourkoumelis*

*Stelios Vourakis*

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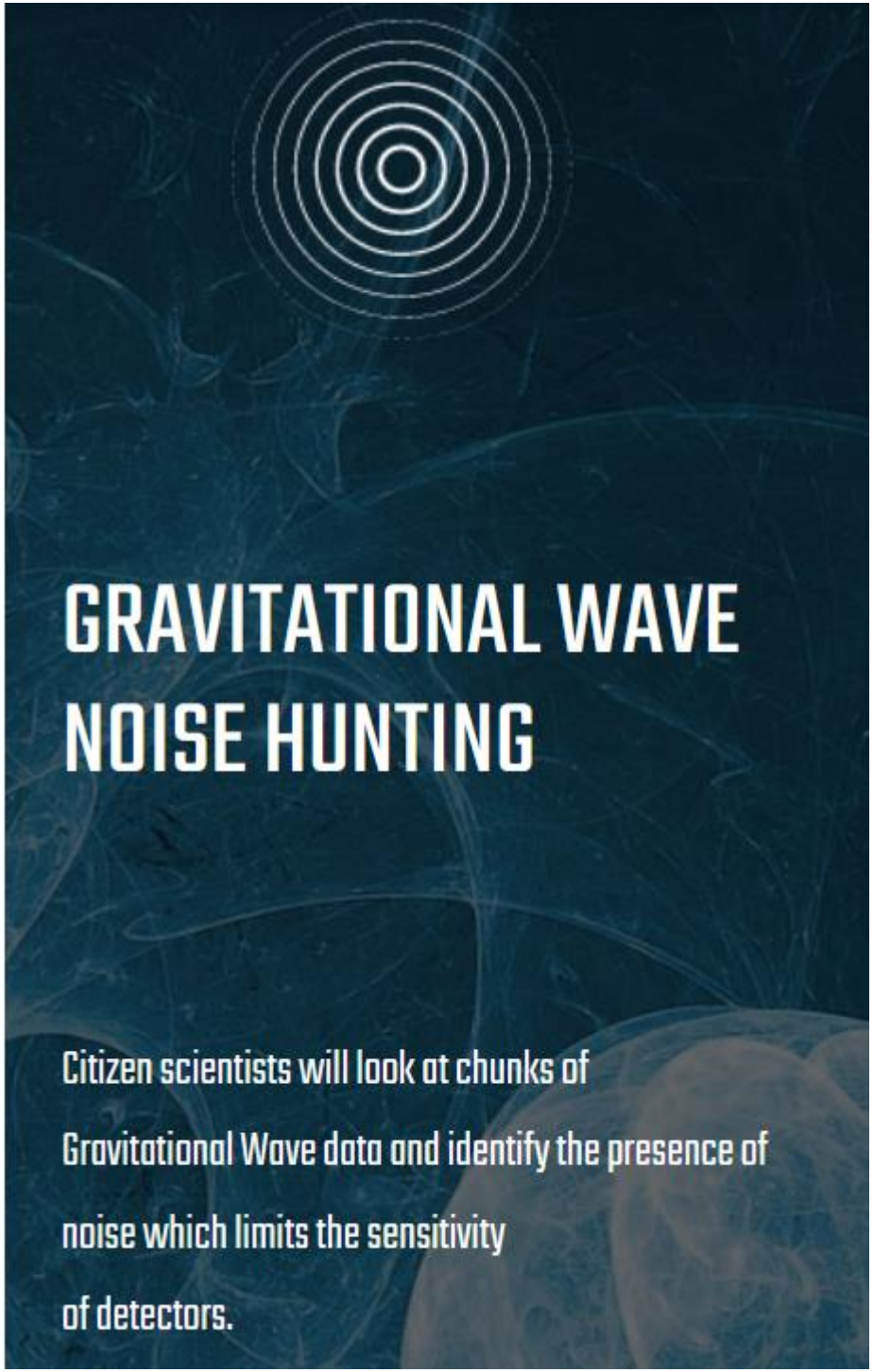
# The REINFORCE project

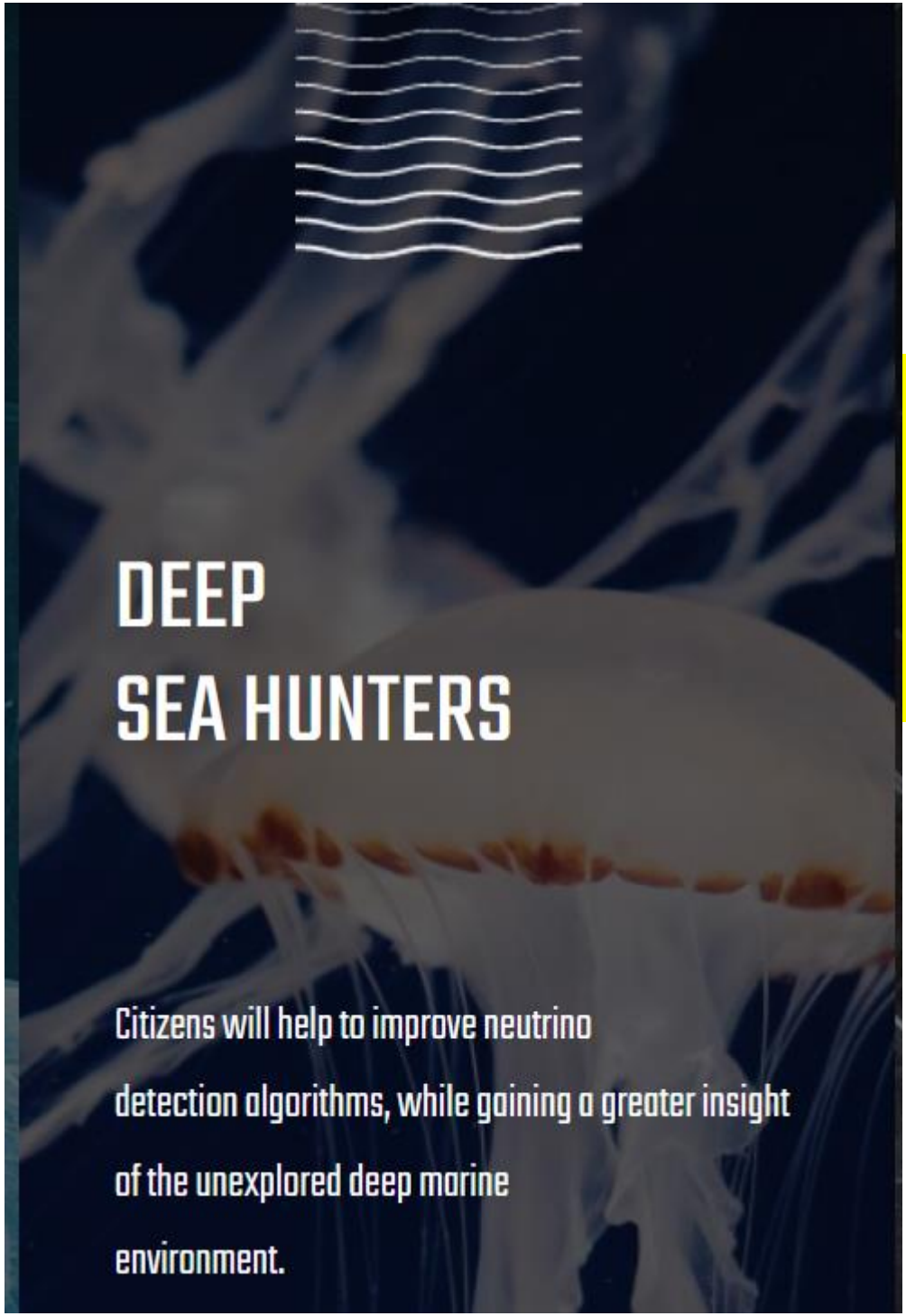
REINFORCE
REsearch INfrastructures FOR Citizens in Europe

- Since 1st December 2019 we started a Horizon 2020 "Science-for-Society" project called **REINFORCE RE**search **IN**frastructures **FOR C**itizens in **E**urope (**3 years long**, 11 partners, **four** WPs for "discoveries") coordinated by **EGO**. The site is [www.reinforceeu.eu](http://www.reinforceeu.eu)

- **REINFORCE is built on the Zooniverse platform**
- Zooniverse is known as the world's **largest platform for online citizen science,** allowing researchers across Europe and beyond to build and run their own projects
- Examples: HiggsHunters, GravitySpy, MuonHunters




Leader: EGO/ U. of Pisa
Data from Virgo and LIGO
Identify “glitches”



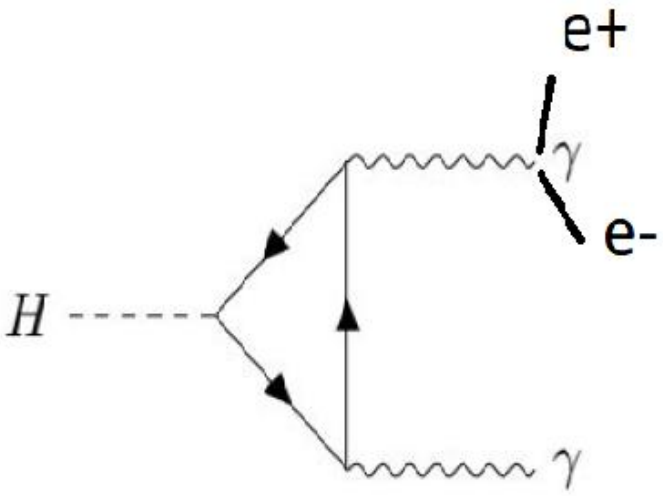

Leader: CNRS
Data from KM3NeT
Neutrino detection,
Noise sources from bioluminescence, dolphins, whales.

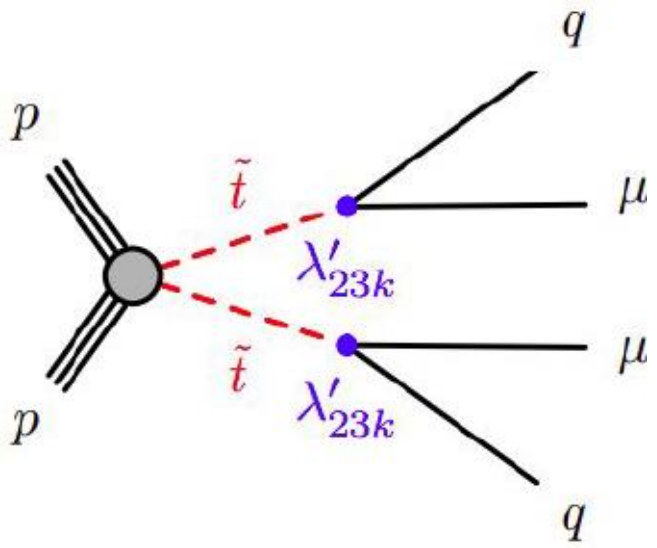

Leader: CNRS
Data from simple cosmic ray detectors
Muonography, volcanology, geosciences, archaeological surveys (Apollonia tumulus)

# The idea behind our WP (New Particles@LHC)


- To have citizens focus on visual inspection of events
- To train them to locate **displaced vertices** which they may do better than ATLAS (HiggsHunters example)
- To train them to recognize characteristic signatures of electrons, muons, photons and converted photons **using the online HYPATIA event display**
- Finally, by combining the above: to let them make **possible discoveries of "new physics"**

# Focusing on displaced vertices




Higgs →γγ with one converted photon

SUSY scenaria with long-lived particles (ex RPV)

The workflow is split in 3 stages

# REINFORCE & LHC

## 3-Stage Work Package

**Stage - 1**
Visual detection of
Displaced Vertices (DV)
**- SIMULATED DATA -**

**Stage - 2**
Particle Identification
**- SIMULATED DATA -**

**REAL DATA "DISCOVERY"STAGES**

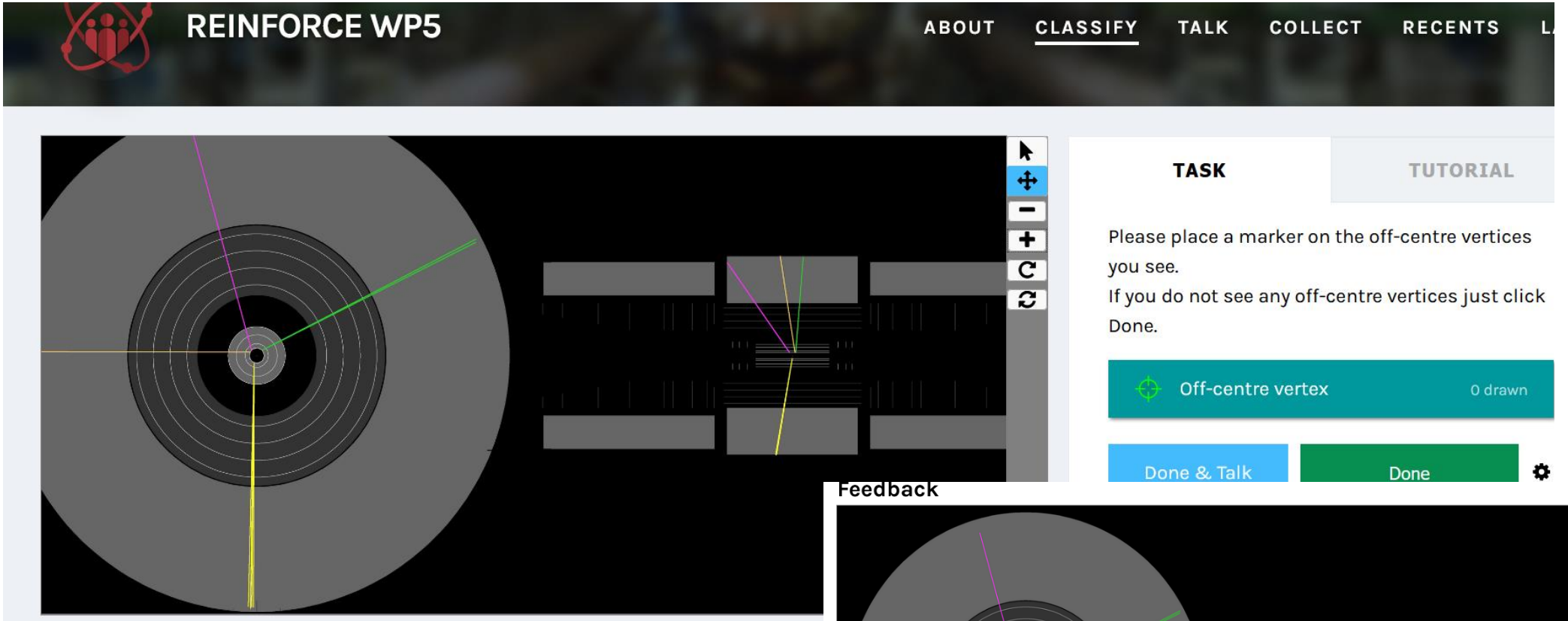
**Stage – 3a**
Higgs→γγ STUDY

**Stage – 3b**
LLP Hunting/Discovery

**Reminder:**

- **Stages 1 & 2:** will provide the main results (citizens' efficiency vs our custom algorithms).
- **Stage 3:** gives citizens the opportunity to apply what learned on samples of real data.

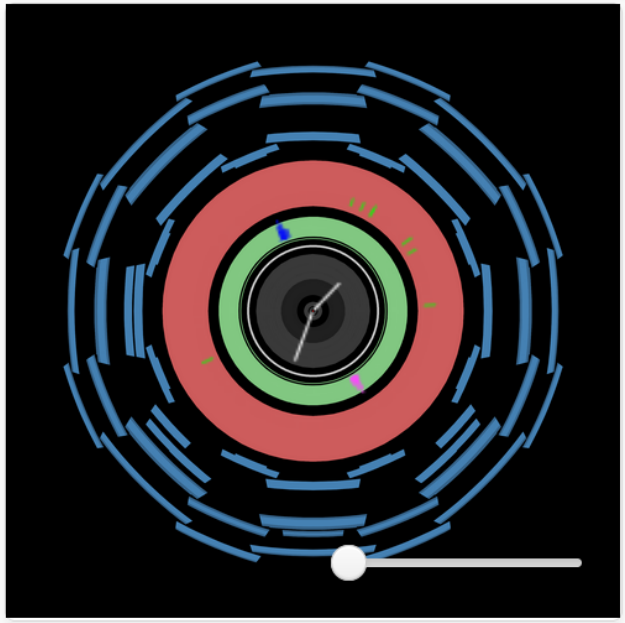
# Stage 1 (on Zooniverse –simulated data)

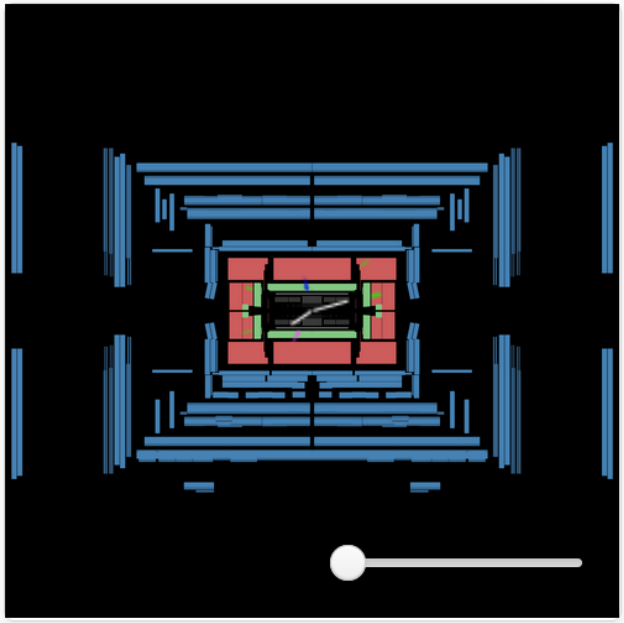



- Have provided selected events where the Primary Vertex (PV) is removed
- The user gets an immediate feedback of his/her success/failure
- An automatic algorithm will compare with the “truth” information

# Stage 2-particle identification (using HYPATIA)

A specially developed version of HYPATIA where users use simulated data and try to **identify muons, electrons, photons and converted photons**. Detailed tutorial for each kind of particle is given





Help

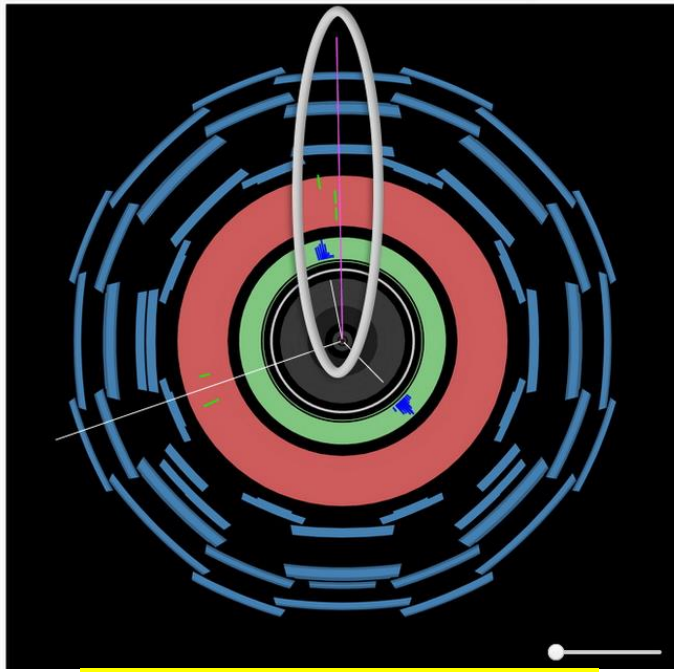
| Particle | +/- | $p_T$ [GeV] | e/μ/γ |
|---|---|---|---|
| cluster_1 | | 75.92 | γ |
| cluster_2 | | 50.81 | γ |

An automatic algorithm will compare users identification results with the “truth” information

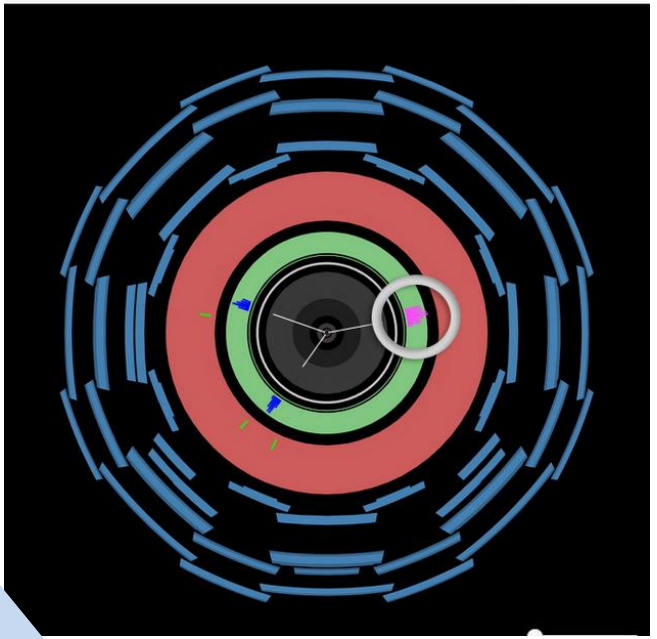
+ Electron | + Muon | + Photon | + Conv. P... | − Delete | → Next

| Particle | +/- | $p_T$ [GeV] | φ [rad] | θ [rad] |
|---|---|---|---|---|
| track_1 | + | 7.27 | 0.8 | 0.27 |
| track_2 | + | 5.14 | -1.92 | 2.57 |
| cluster_1 | | 75.92 | 1.95 | 1.8 |

Selection of a muon

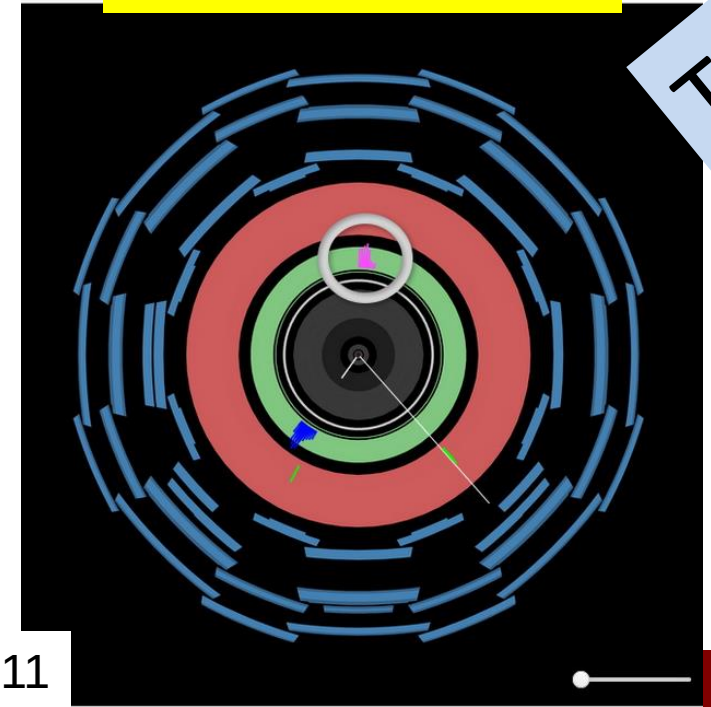


Selection of an electron

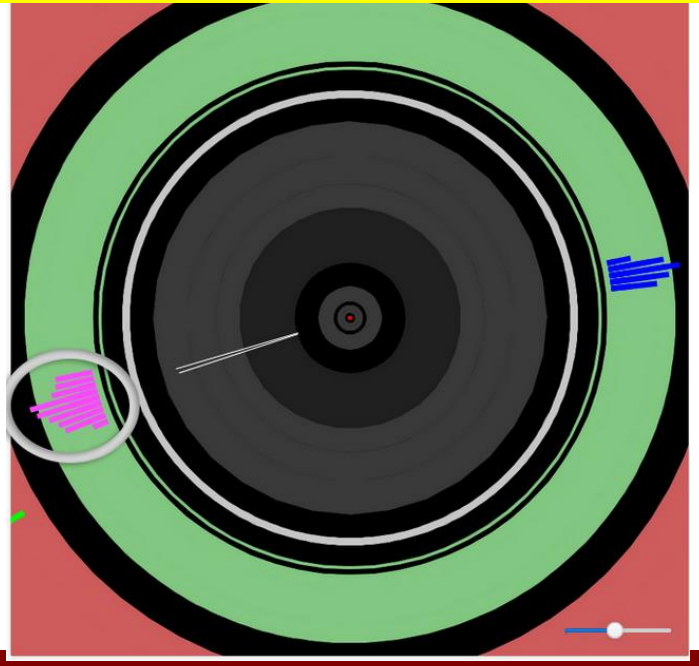


Tutorials

Selection of a photon

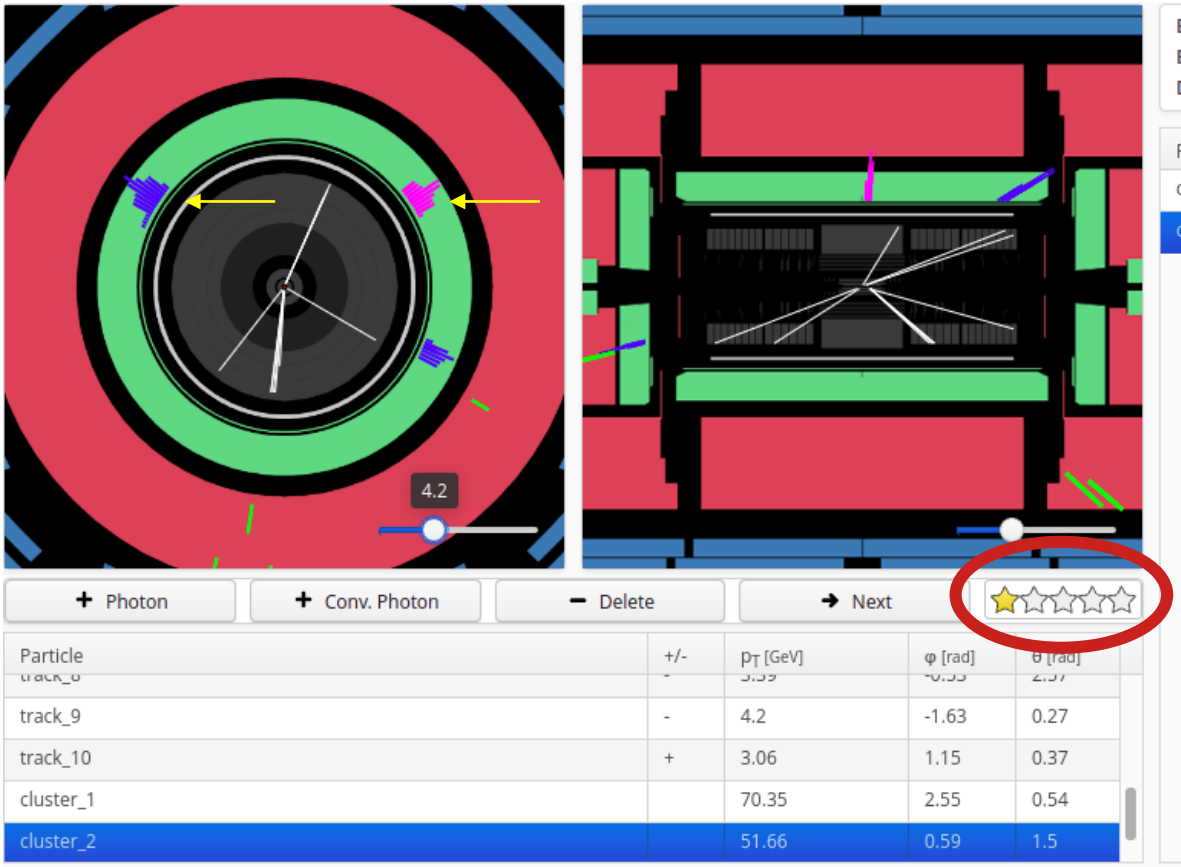


Selection of a converted photon



# Stage 3a - H→γγ STUDY (using HYPATIA)

## Event Handling




| Particle | +/- | $p_T$ [GeV] | φ [rad] | θ [rad] |
|---|---|---|---|---|
| track_9 | - | 4.2 | -1.63 | 0.27 |
| track_10 | + | 3.06 | 1.15 | 0.37 |
| cluster_1 | | 70.35 | 2.55 | 0.54 |
| cluster_2 | | 51.66 | 0.59 | 1.5 |

**Event: 1/170** (39081409/297730) 2016-04-28
**ETMiss: 9.08 GeV** φ: -2.53 rad
**DV Mass:** -

| Particle | $p_T$ [GeV] | $m_{\gamma\gamma}$[GeV] | $\gamma/\gamma \rightarrow e^+e^-$ |
|---|---|---|---|
| cluster_1 | 70.35 | 126.30 | γ |
| cluster_2 | 51.66 | | γ |

**Citizens will search for H → γγ candidates*:**

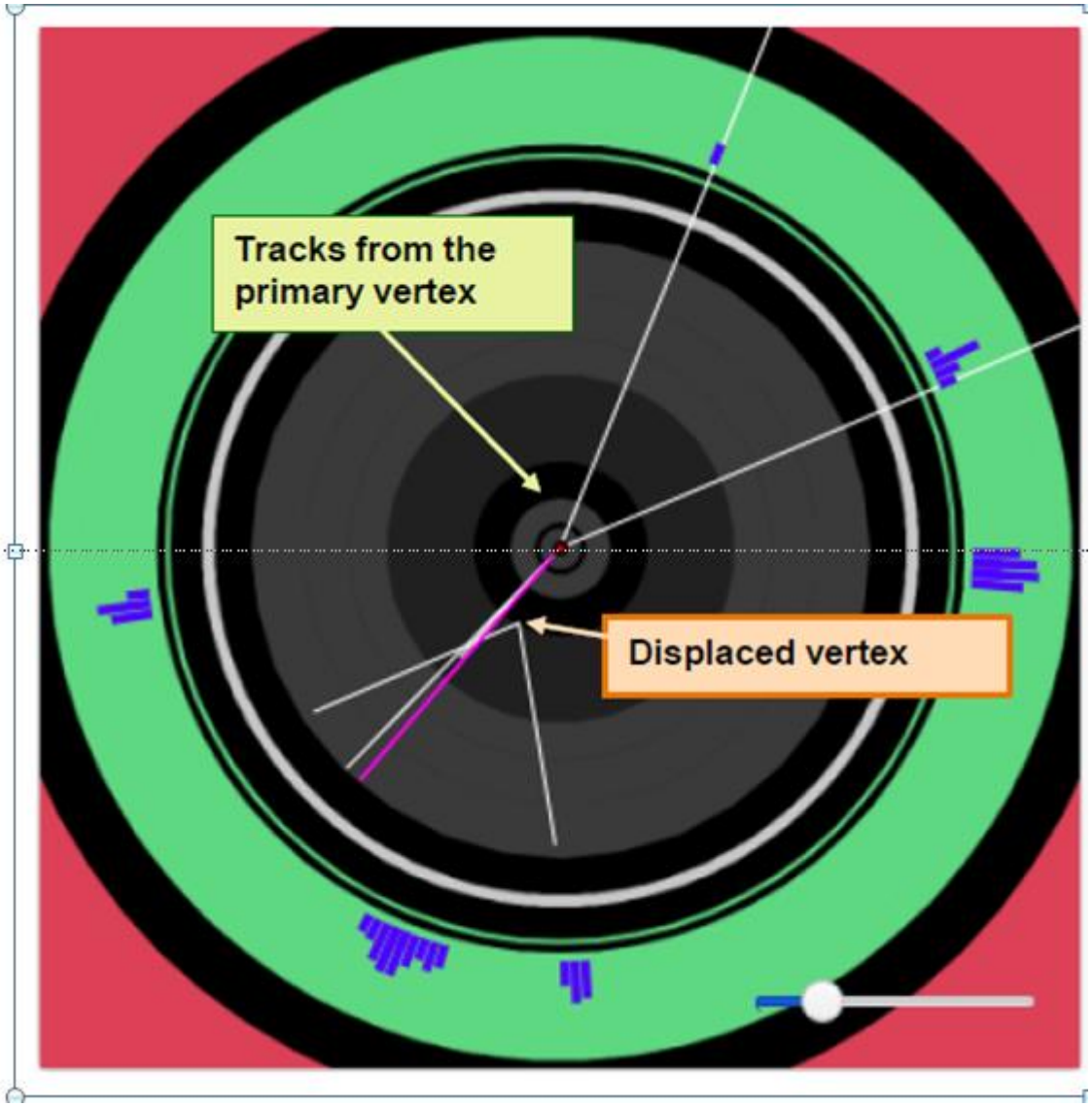
- **select** the candidate photon pair,
- **rate** the event (low → high interest).

**Highly rated events** can be discussed on the project's discussion boards.

Potential statistical processing of user outputs may be carried out by us alone.

*All ATLAS open data pre-selection cuts have been applied to the sample

# Stage 3b - Neutral long-lived particle-hunting (using HYPATIA)




Citizens will search for muon-jet DV*s:

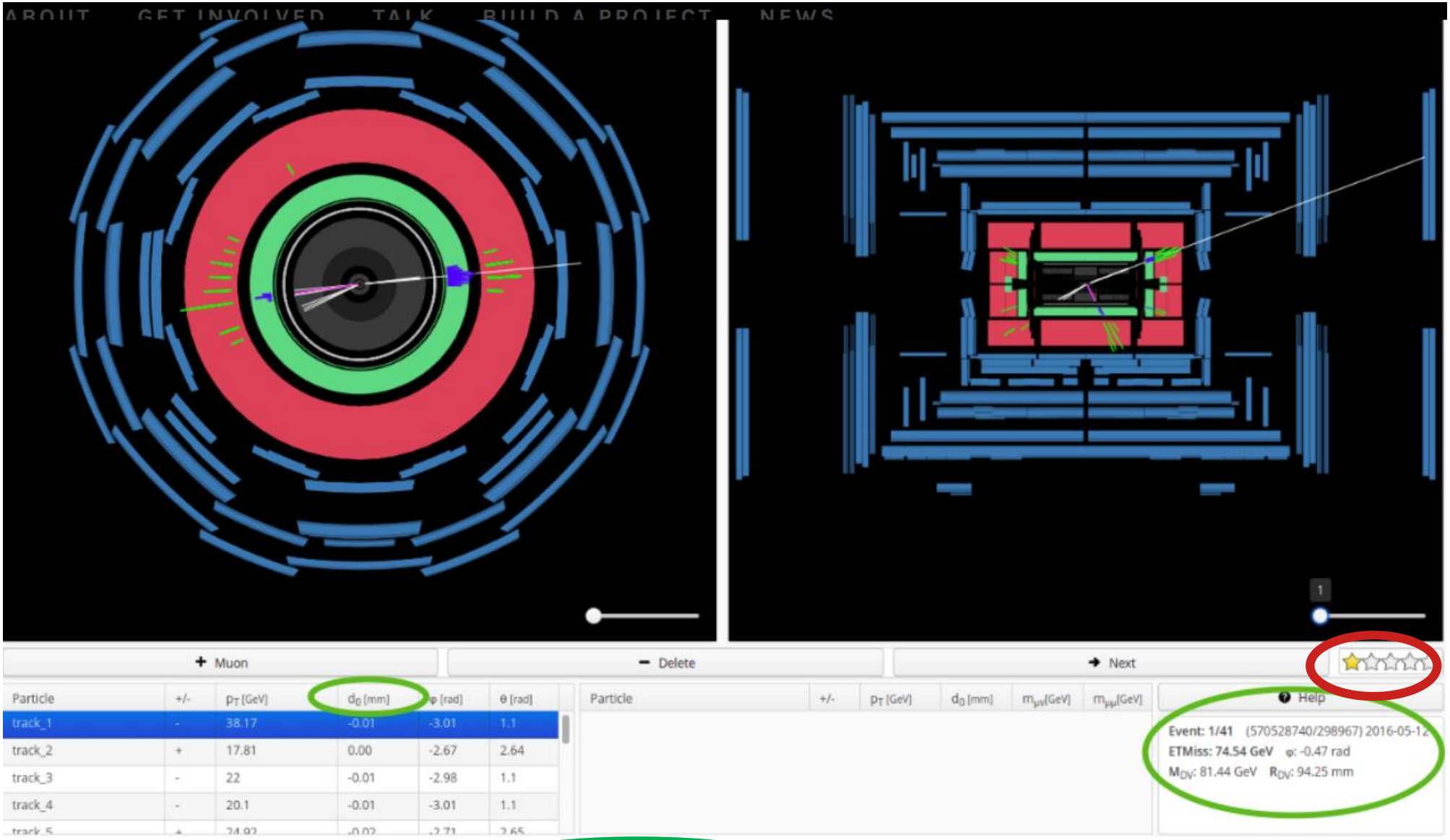
- **mark the muon** associated with the DV,
- **rate** the event (low → high interest).

**Highly rated** events can be discussed on the project's discussion boards.

Potential statistical processing of user outputs may be carried out by us alone.

*preselection of events where distance between PV and DV is >5cm has been applied

# Stage 3b - Neutral long-lived particle-hunting

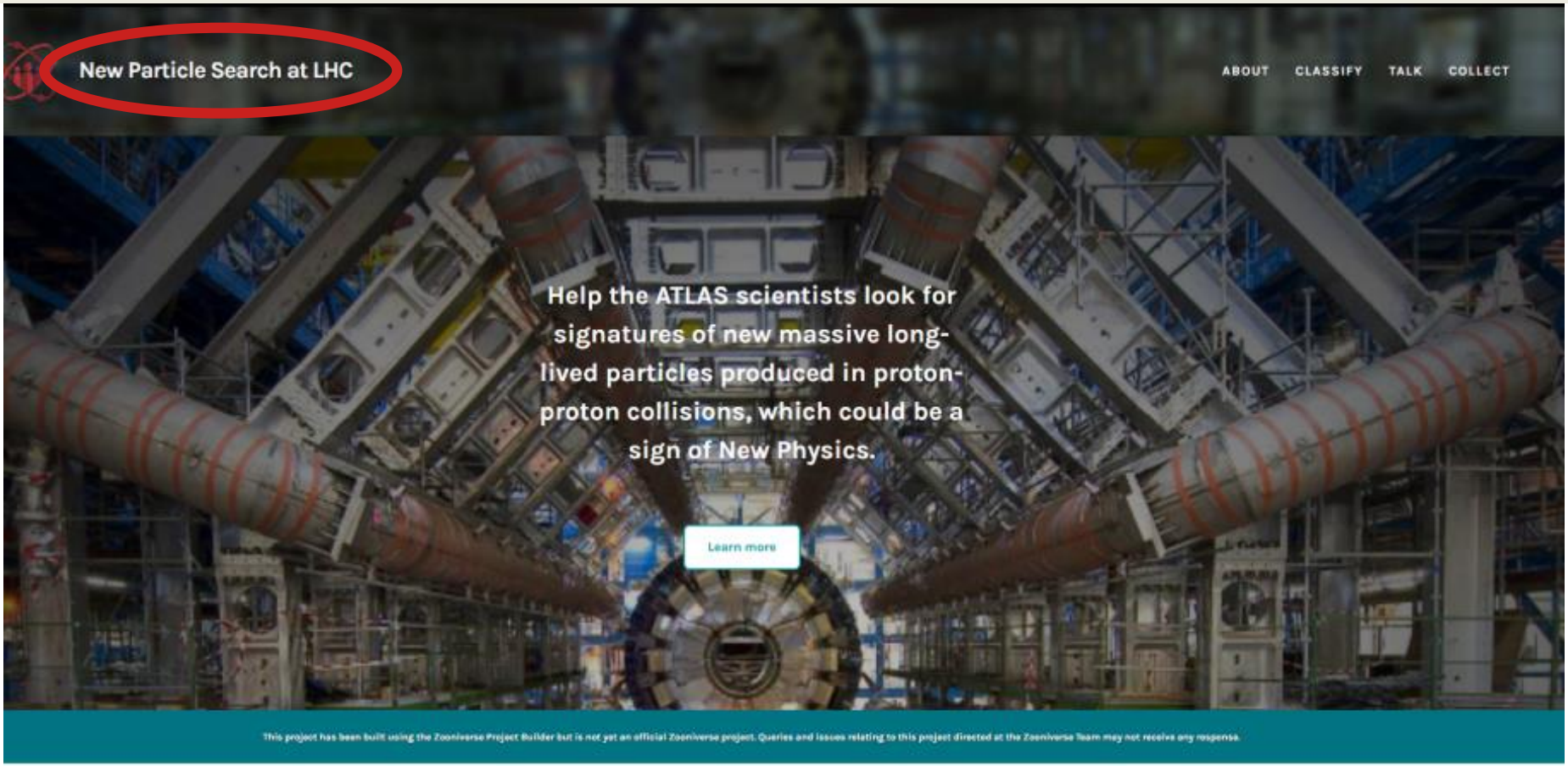



- Citizens are advised to look at $M_{DV}$, $R_{DV}$, $p_T$ and $d_0$ of the event and rate it accordingly with stars
- Every time they select a muon: the $M_T$ of muon $p_T$ and the $E^T_{miss}$ is calculated ($m_{\mu\nu}$)

# Home page @Zooniverse

## All stages uploaded and available

### Waiting for approval by Zooniverse team to become official




Get started

This project consists of three stages - Stages 1, 2 and 3 - which are intended to be completed in the given order. In STAGE 1, you are presented with high-purity simulated samples of events. These will help to train you how to identify Displaced Vertices, which are among the products of proton-proton collisions and are the signatures of long-lived particles. Results from this stage will also allow researchers to determine whether the human eye is better at this task than automated algorithms. In STAGE 2, you are presented with simulated samples of events in order to train how to identify known particles (electrons, muons, photons, converted photons) in the ATLAS detector. This is necessary because the above listed particles can be the decay products of the sought after particles of Stage 3. Your identification results will also allow researchers to determine whether the human eye is better at identifying them than automated algorithms. In STAGE 3, you will use the knowledge acquired in the previous stages to browse a large sample of real ATLAS data, searching for new physics signatures. Your search will be twofold: a) you will look for decays of the Higgs boson to two photons, one of which could be converted in the material in front of the calorimeters to an electron-positron pair; and b) look for long-lived hypothetical particles (predicted by certain theories Beyond-the-Standard-Model) which decay further away from the primary vertex (at a Displaced Vertex) to a lepton and a jet of other particles. We look forward to receiving your "discovery" events and discussing them with you! We strongly recommend reading the given instructions carefully. If, having read them, you feel that you already have the knowledge to move straight to a specific certain stage, please proceed to the stage that seems appropriate to you. However, it is HIGHLY ADVISABLE to go through as many events as possible in Stages 1 and 2, in order to become familiar with both the detector and the traces the particles leave in its separate parts. This will enhance your ability to spot the sought after events from real events collected by ATLAS

Stage 1 - Displaced Vertex Identification | Stage 2 - Particle Identification | Stage 3a - Study of Higgs bosons | Stage 3b - Discovery of Long Lived Particles

# Last but not least: WP on inclusion and diversity

PLUS:

Explore the potential of frontier citizen science for inclusion and diversity.

Leader: EGO/ CONICET Argentina

- The aim is to include sense-impaired people ( especially visual-impaired) and senior citizens
- **We are already discussing with Wanda how to make accessible the particle identification part (Stage 2)**
- The data will be sonified
- *Sonification software(SonoUno)*

*https://pypi.org/project/sonoUno/*

- We also aim to cross-connect artists with scientists


Wanda Diaz Merced

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# CONCLUSIONS

- All four platforms will be ready sometime in **June 2021** and data for citizens will be collected for a year
- Through the **four** demonstrators of REINFORCE we hope to reach thousands of citizens of all ages and backgrounds
- The exploration of cutting-edge research subjects as well as the interdisciplinary interconnection between them will be available to the citizens. Additionally they may contribute to the improvement of research algorithms and patterns
- The project emphasizes the inclusion and diversity and art/sciences activities

# PARTNERS

COORDINATOR

EGO European Gravitational Observatory










# Primary Goal:

Establish a community of citizens actively engaged in public-funded frontier research

Assess the benefit in science

Assess the benefit in society


Visual info->Sound