REINFORCE

REsearch INfrastructures FOR Citizens in Europe

The REINFORCE EU citizen science project

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on behalf of the REINFORCE consortium

1st CREDO Workshop
January 15th, 2024

HELLENIC REPUBLIC
National & Kapodistrian
University of Athens

IASA

This project has received funding from the European Union's Horizon 2020 research and innovation programme under `grant agreement No 872859.

THE REINFORCE PROJECT

- **RE**search **IN**frastructures **FOR C**itizens in **E**urope **r**esearch and Innovation Project
- Supported by EU's Horizon 2020 Swarfs "Science with and for Society"

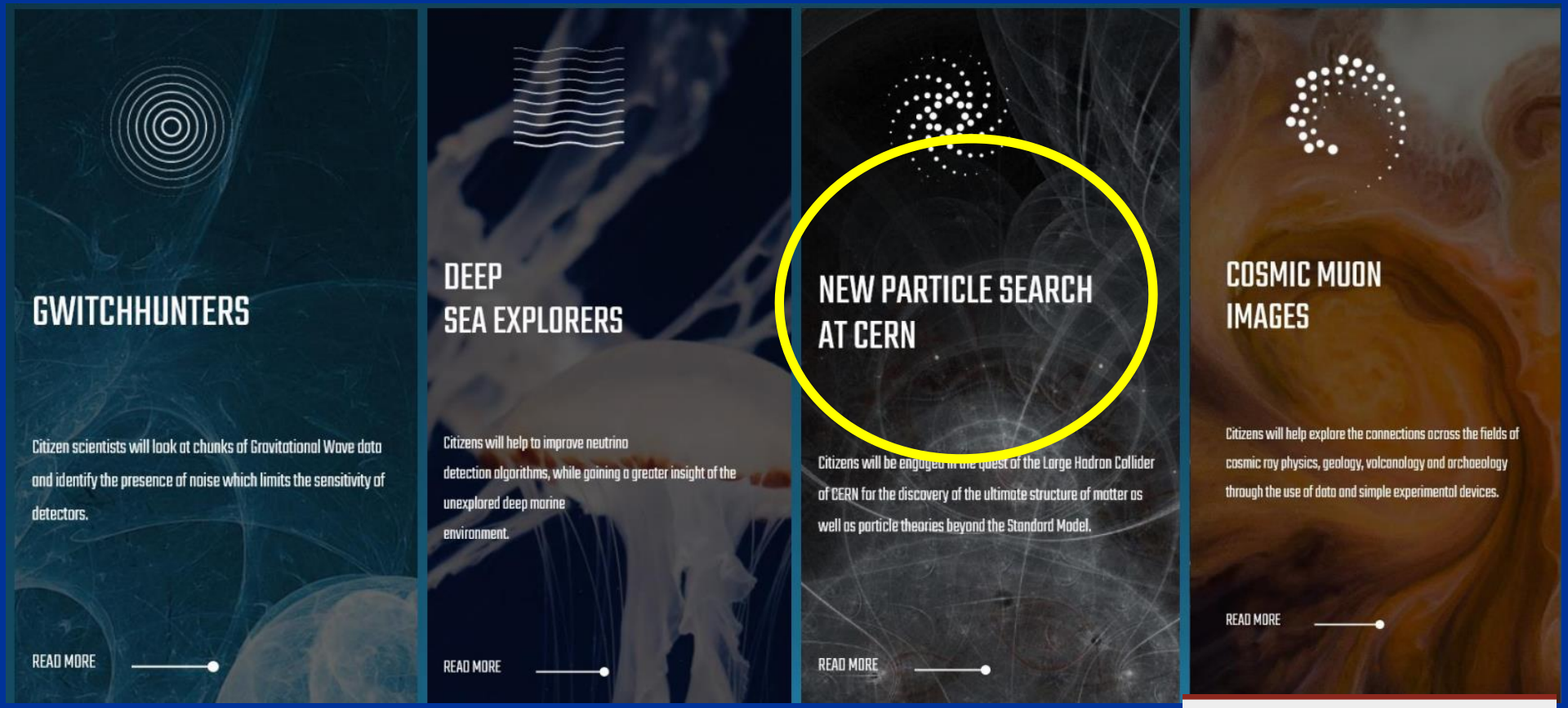
- **Mission : "Minimize the knowledge gap between Large Research Infrastructures and Society through Citizen Science"**
- **Goal :"E**stablish a community of citizens **actively** engaged in public-funded frontier research; encourage data accessibility **for everybody**"

- 3 years long (12/2019 – 11/2022)
- **11 partners** from Argentina, Austria, Belgium, France, Greece, Italy, UK

Four demonstrators for "discoveries"
(GW, KM3Net, CERN, Cosmic Rays)
Coordinated by S.Katsanevas/**EGO**
This talk is dedicated to his memory

- **REINFORCE is built on the Zooniverse platform**
- Zooniverse is known as the world's **largest platform for online citizen science,** with more than **2,5M registered volunteers**

THE DISCOVERY DEMONSTRATORS



A WP fully devoted to **inclusion+diversity**
(visually impaired, senior citizens, artistic intervensions)

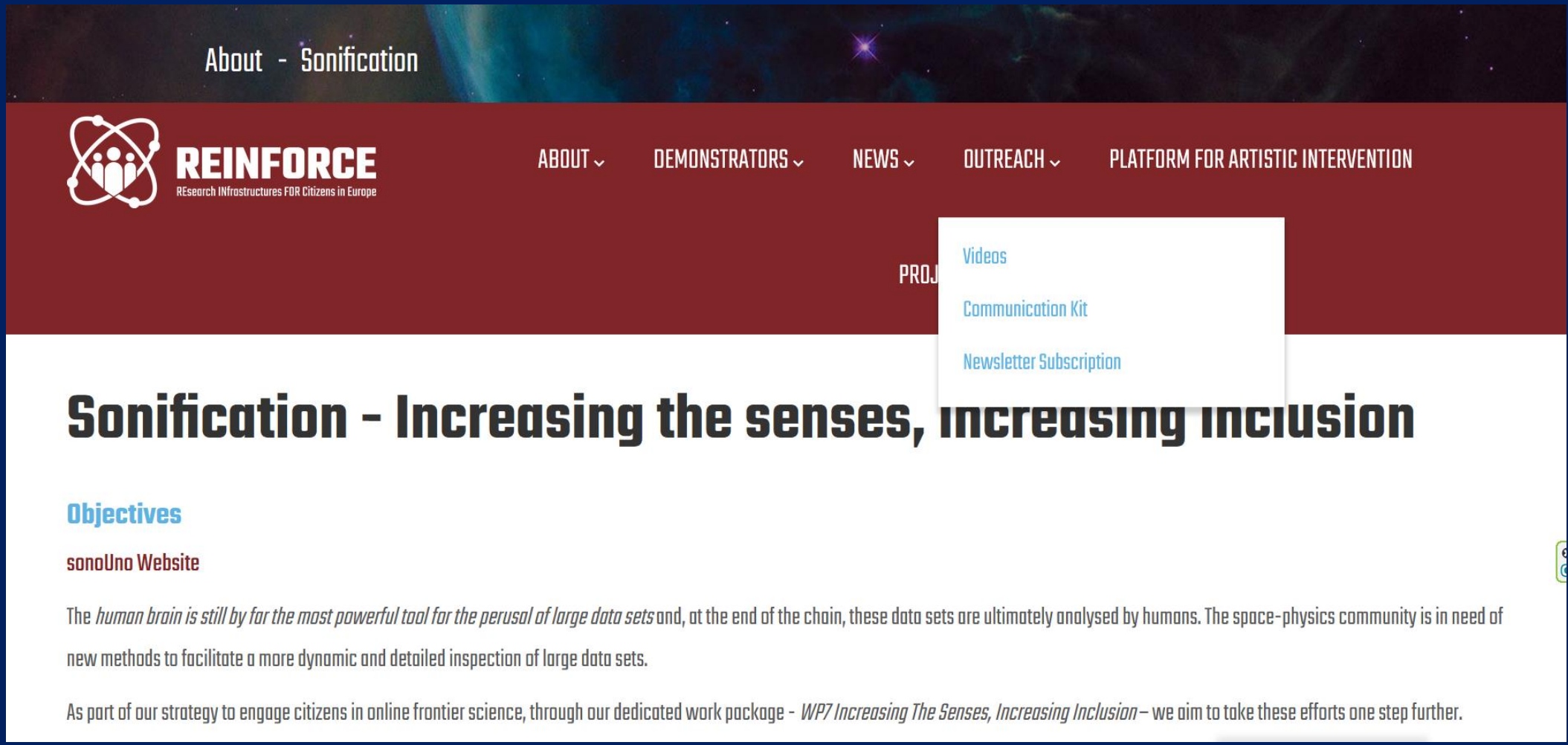
PLUS:

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

The site is **www.reinforceeu.eu**

SONIFICATION OF THE DATA

www.reinforceeu.eu



CONICET DEVELOPED THE **SONOUNO*** FOR SONIFICATION OF THE DEMONSTRATOR DATA

CONICET

sonoUno

Screen reader interpreter

https://www.sonouno.org.ar/

CLICK HERE →

Graphical interpreter

https://reinforce.sonouno.org.ar/

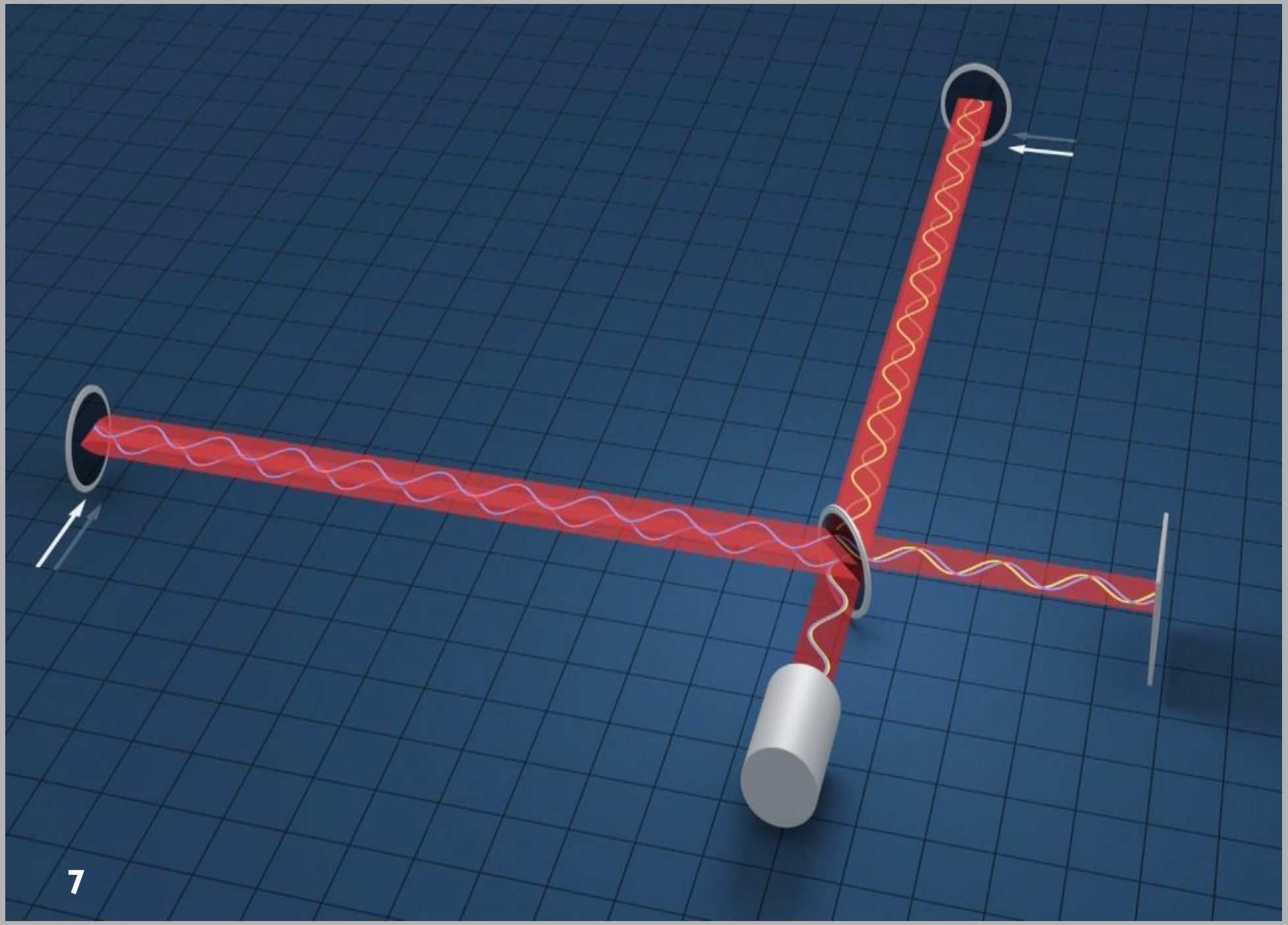
CLICK HERE →

https://www.sonouno.org.ar/

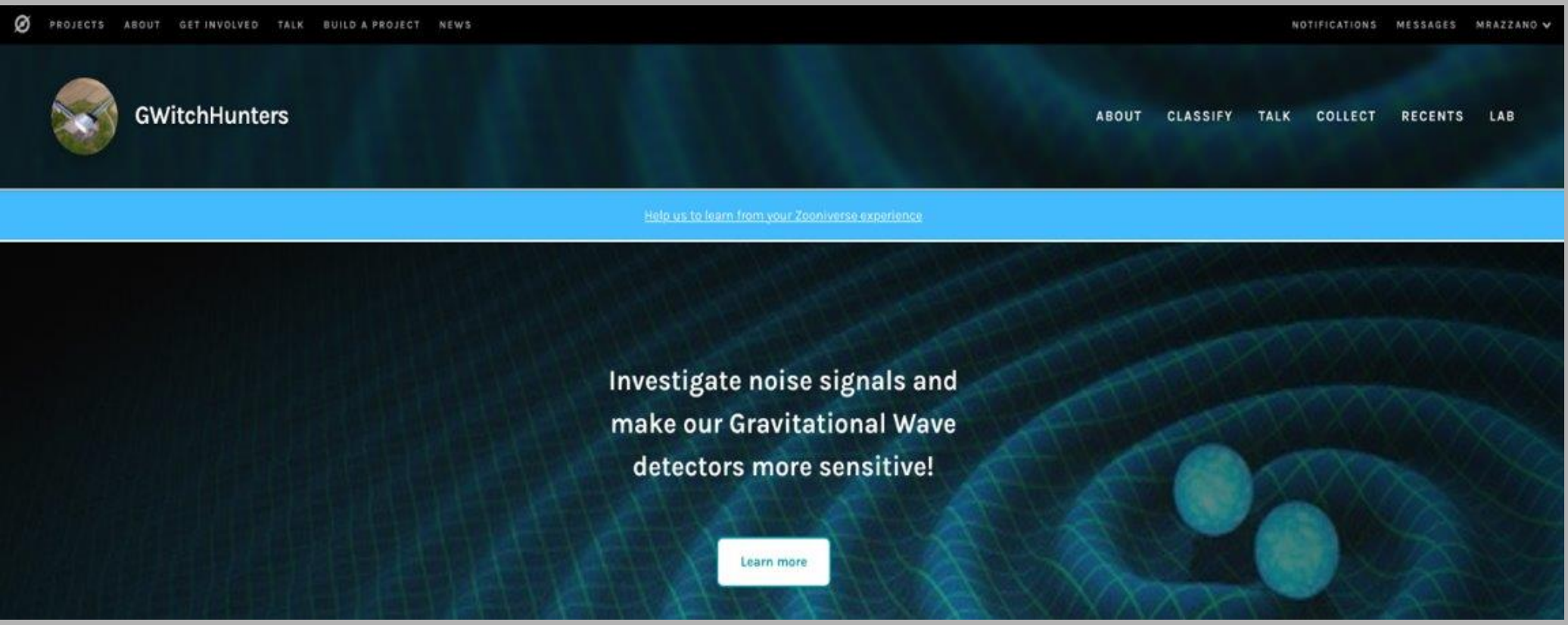
https://reinforce.sonouno.org.ar/

*The browser version was developed using HTML, CSS and JavaScript and uses the ARIA protocol to ensure communication with screen readers. For the sound synthesis itself, the tone.js library was selected.

GRAVITATIONAL WAVE NOISE HUNTING (VIRGO/LIGO)



GWitchHunters:
https://www.zooniverse.org/projects/reinforce/gwitchhunters

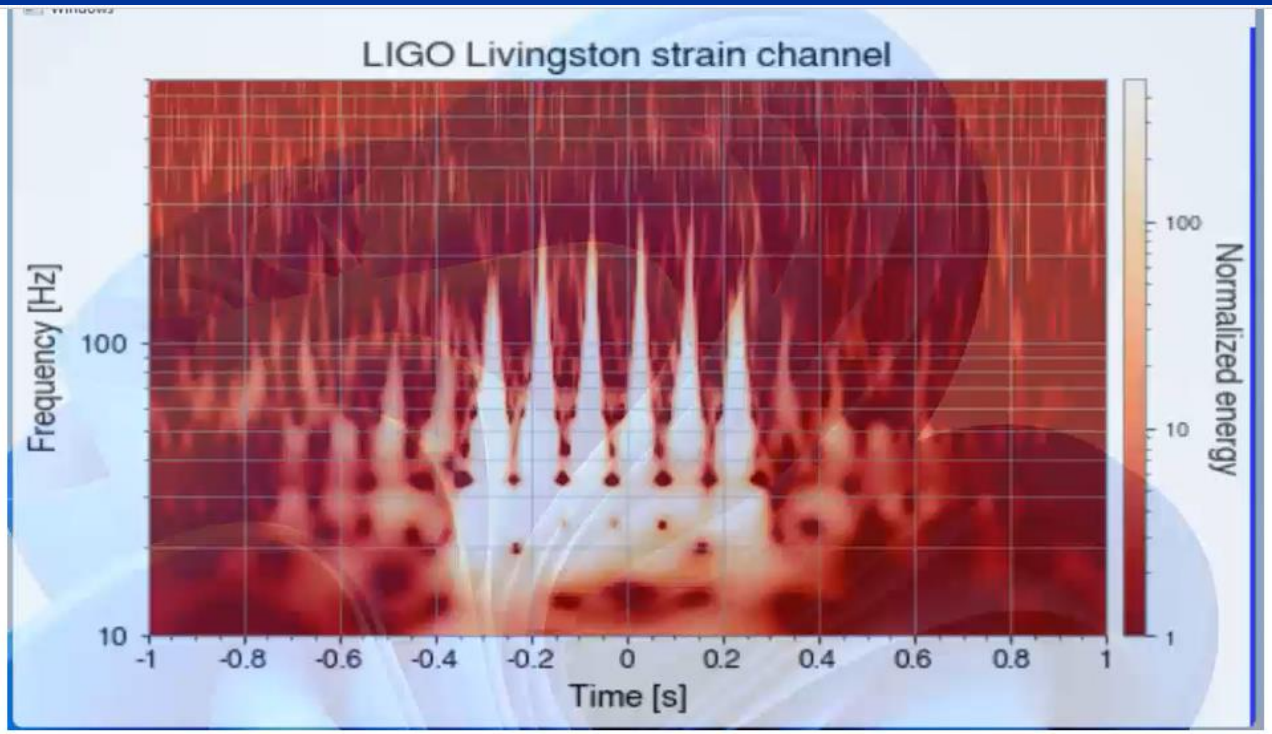


- Citizens recognize and classify different noise patterns

686,000 Classification

Different WorkFlows
Playground level for practicing:
Auxiliary channels (sensors)
Run on mobile devices

SONIFICATION OF GW GLITCHES



1126409678.84375_TS_ht_4096_raw data set:

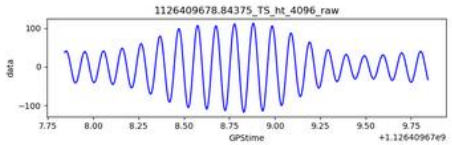
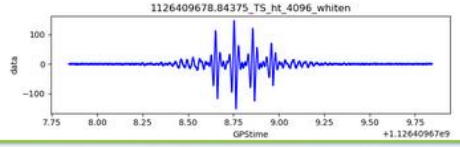


Figure 2 – Plot obtained from sonoUno with the raw data set of this glitch.

Sound 1 – Sound obtained from sonoUno with the raw data set of this glitch.

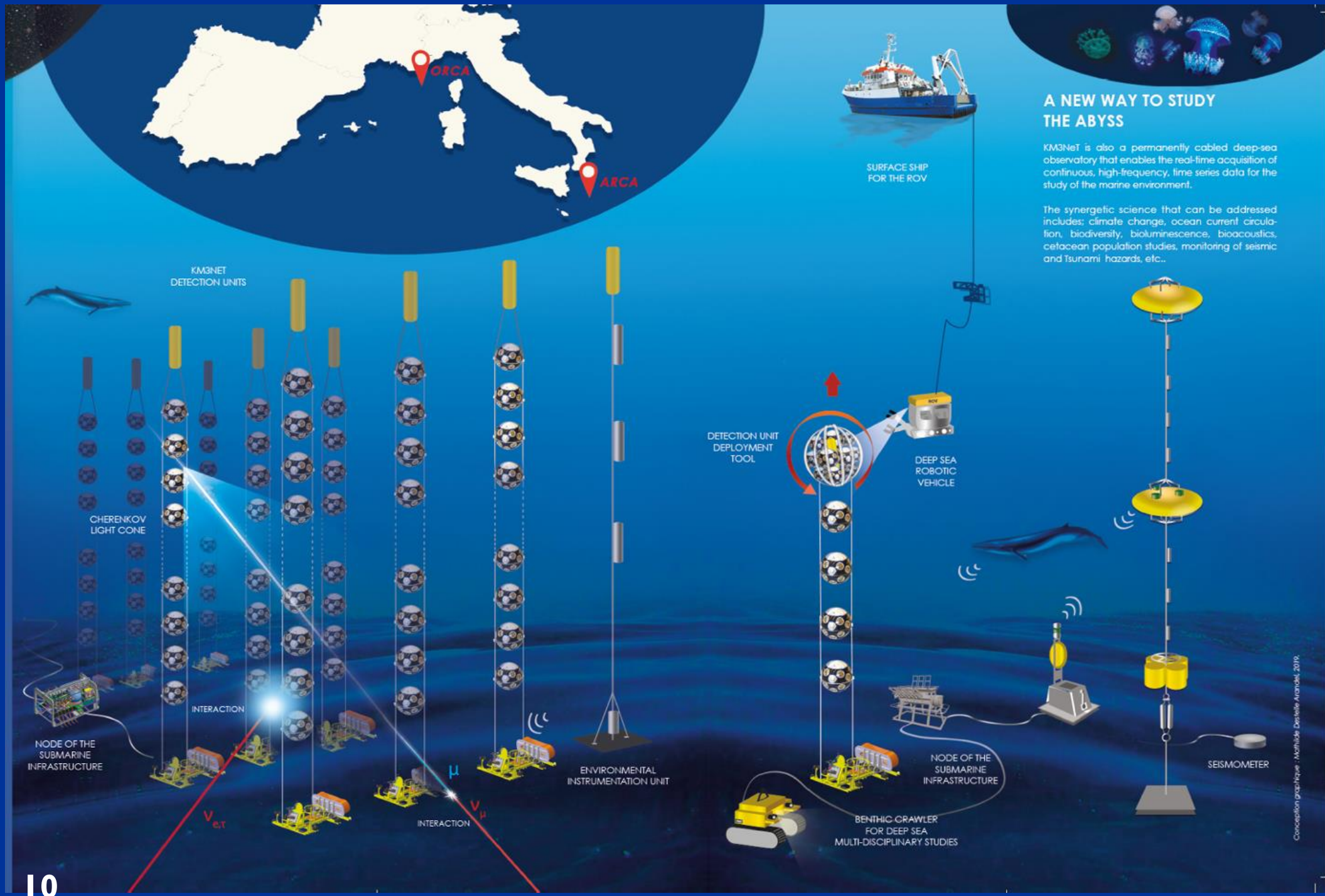
1126409678.84375_TS_ht_4096_whiten data set:



At the base of the sonification algorithm there is the association of frequencies with musical notes, and the signal energy with the notes intensities.

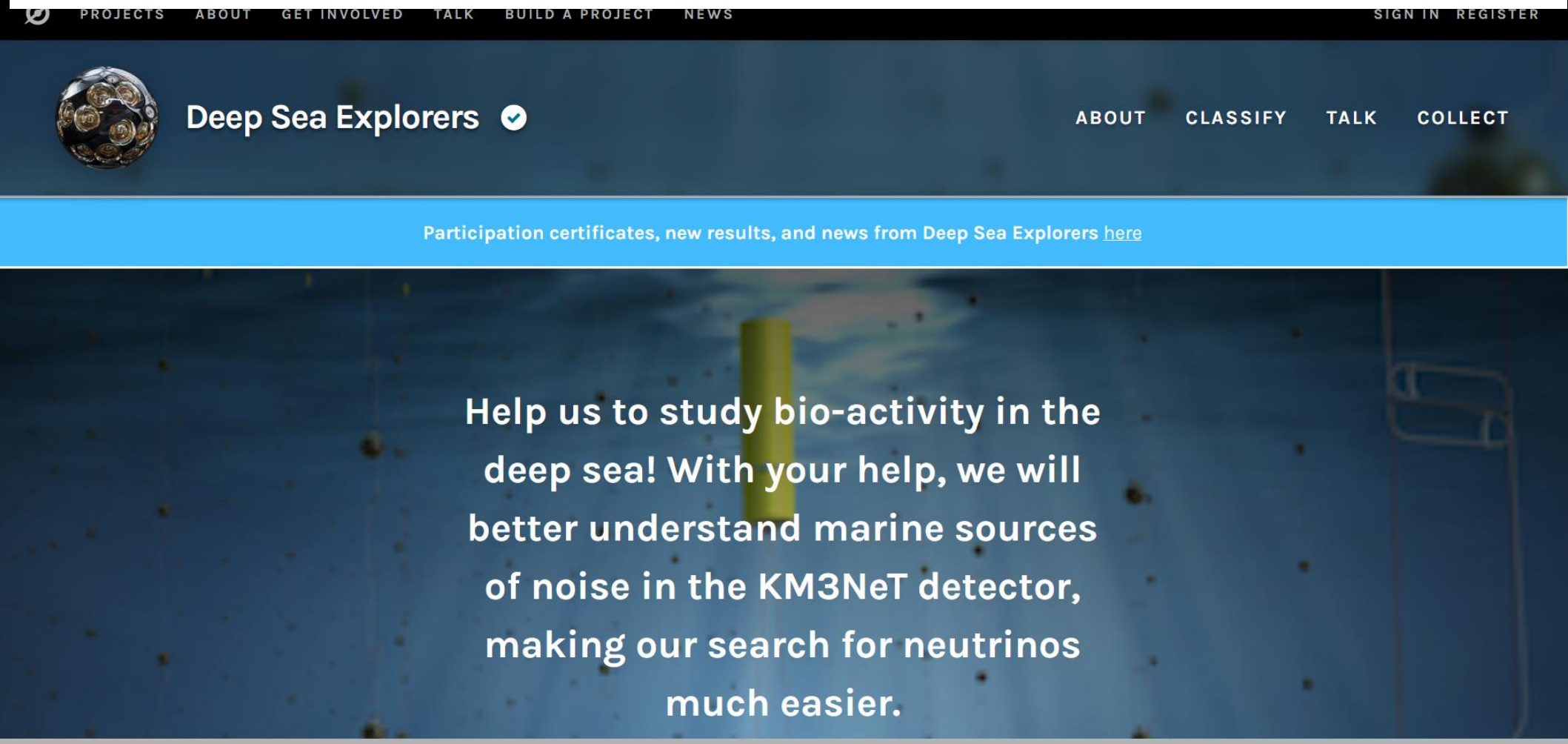
https://www.sonouno.org.ar/glitch-1126409678-84375/

KM3NeT (ORCA+ARCA) NEUTRINO TELESCOPE



Deep Sea Explorers

https://www.zooniverse.org/projects/reinforce/deep-sea-explorers

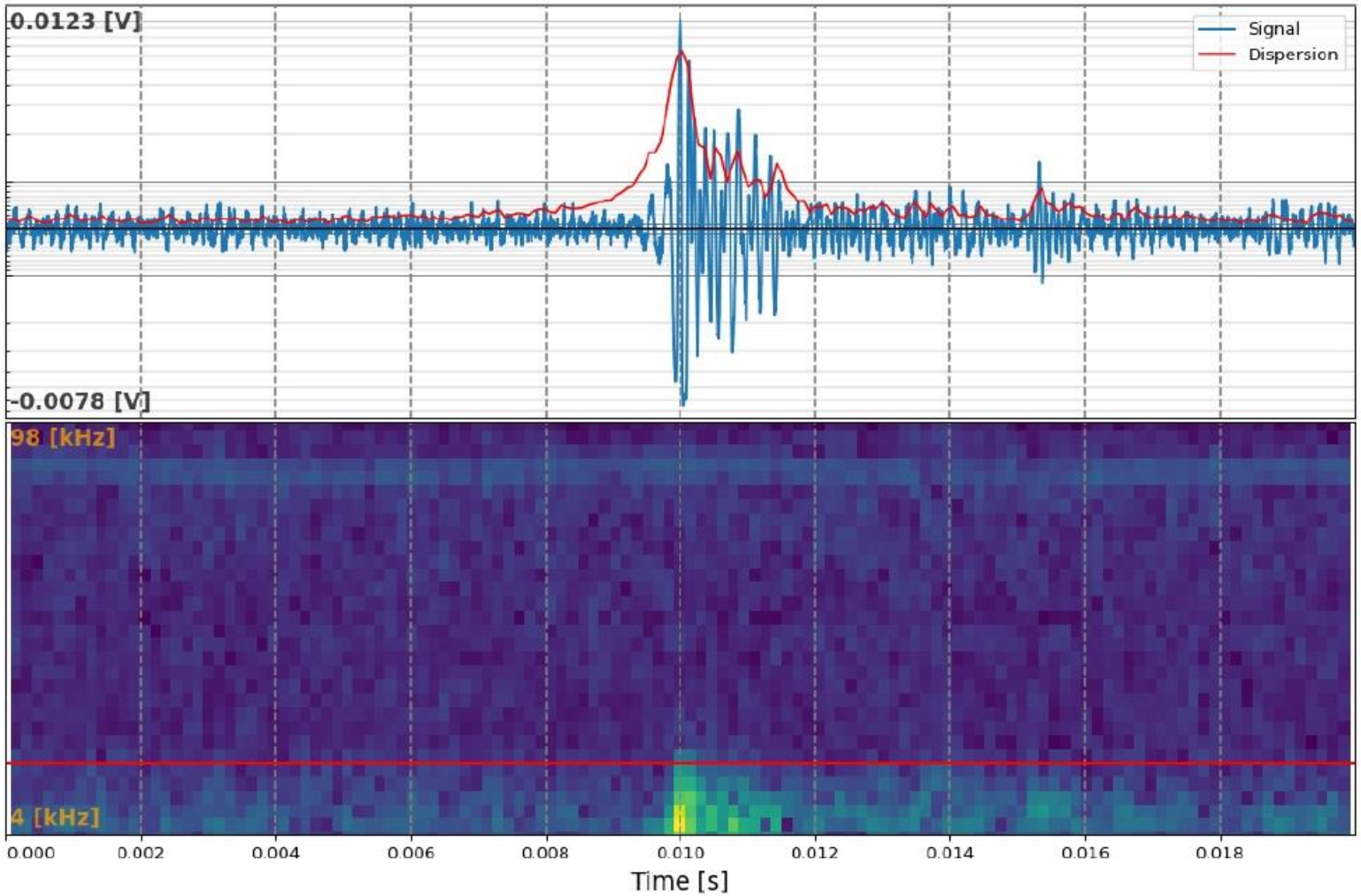


- Hunt what is not a neutrino

170,000 Classification

2 WorkFlows:
Bioluminesce
Bioacoustics

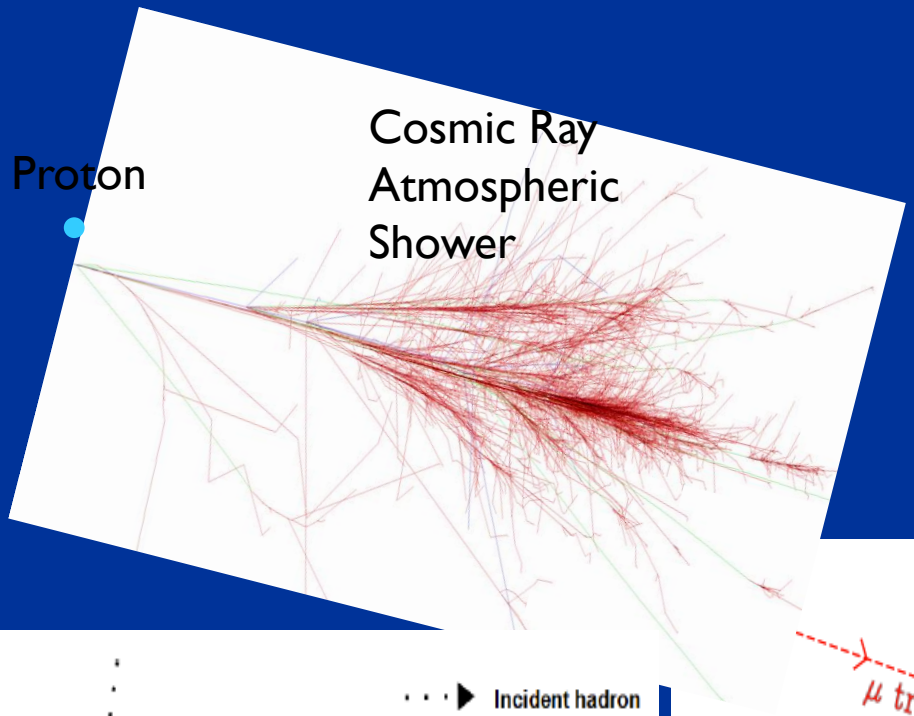
SONIFICATION OF DEEP SEA NOISE



A click (millisecond-range soundwave) from a sperm whale

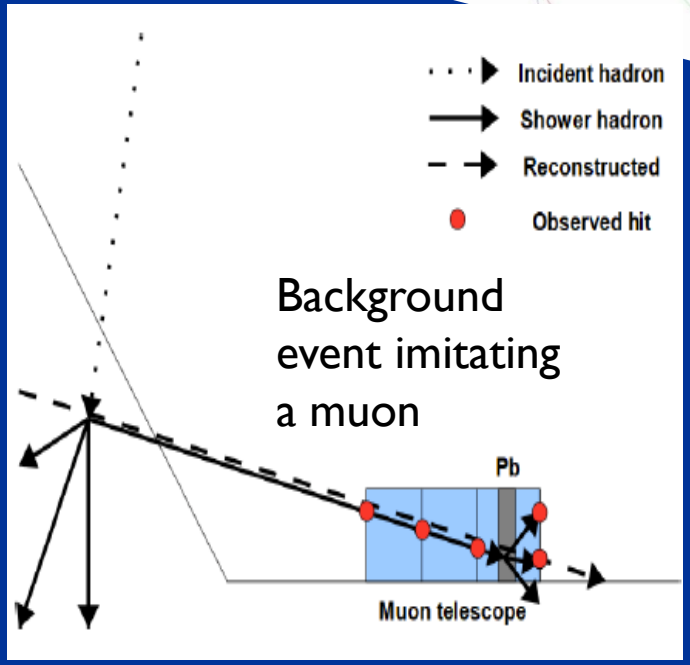
https://www.youtube.com/watch?v=pkiGdZu5gEo

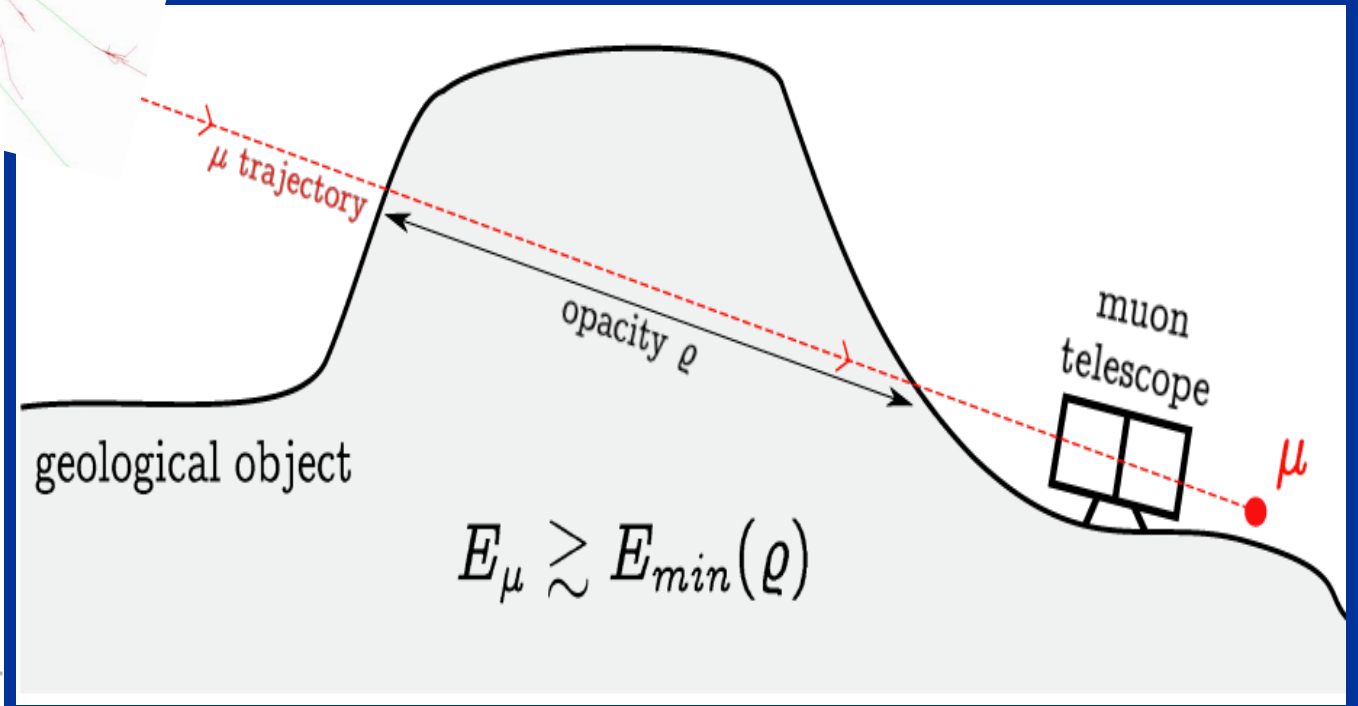
MUOGRAPHY (COSMIC RAYS) OVERVIEW



Use muons to reveil internal structure of :

- Volcanoes
- Civil Infrastructures
- Archaeological sites





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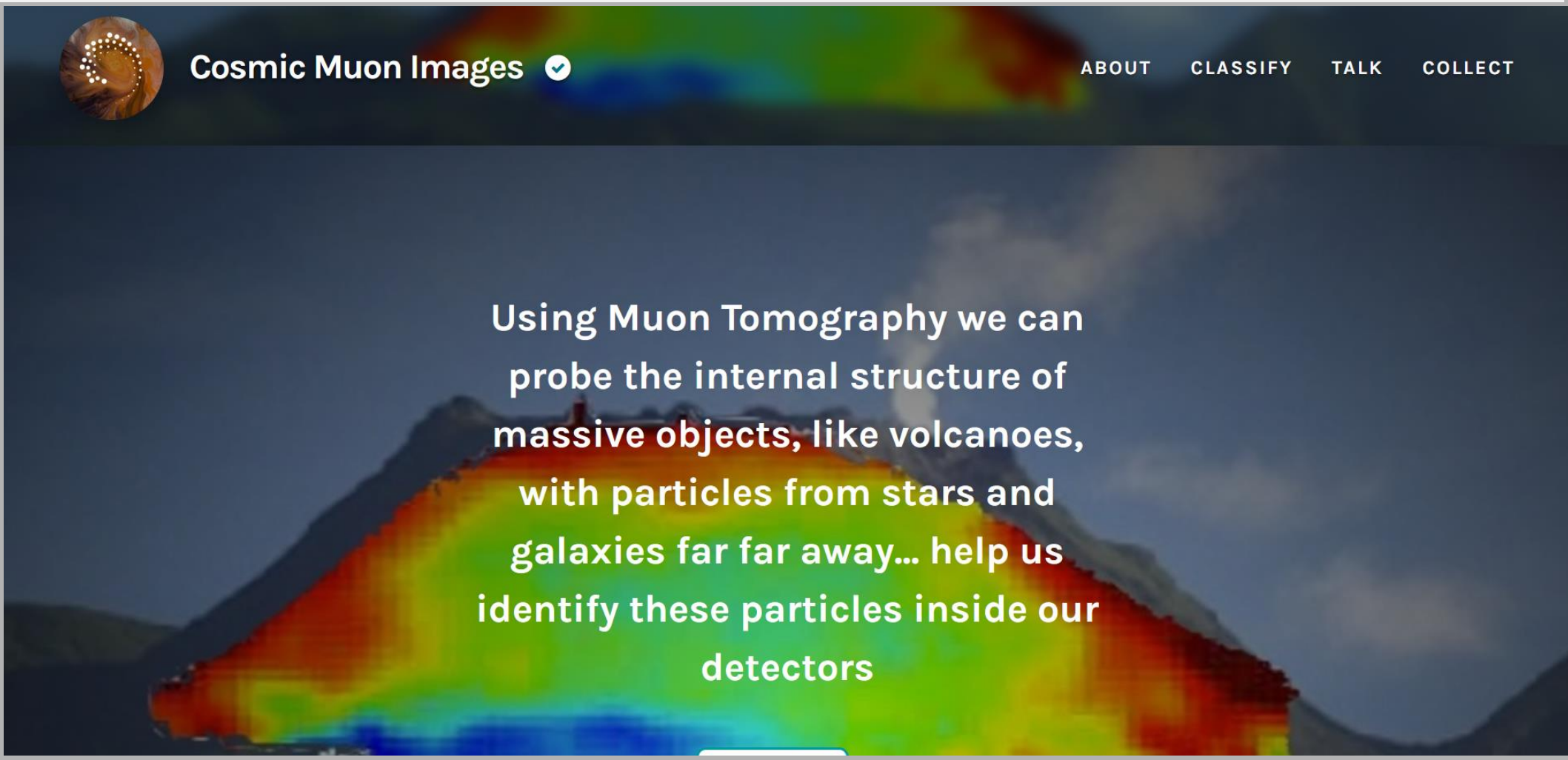
Cosmic Muon Images

https://www.zooniverse.org/projects/reinforce/cosmic-muon-images



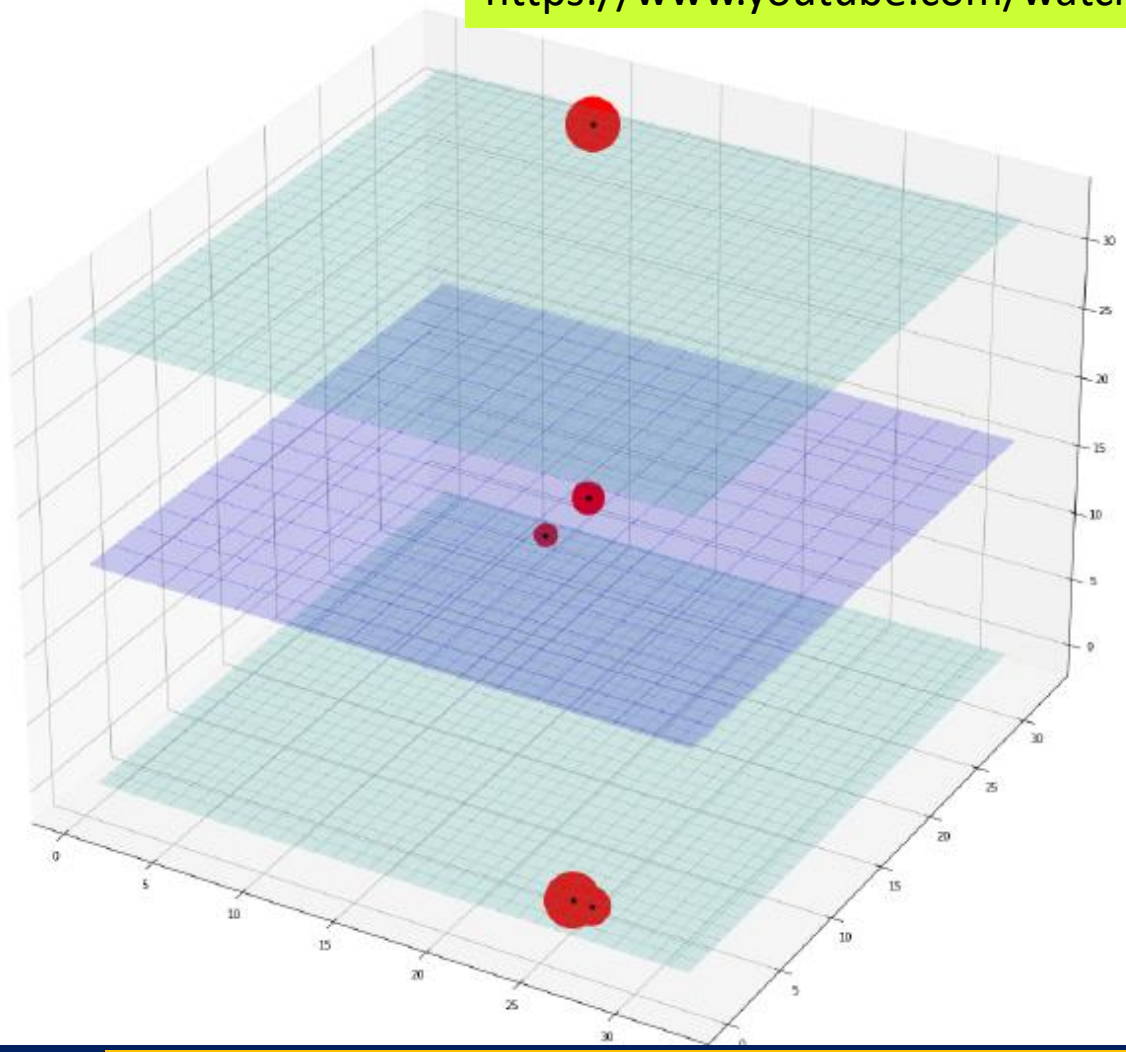
- Citzens perform the difficult task of track finding even in ambigous cases

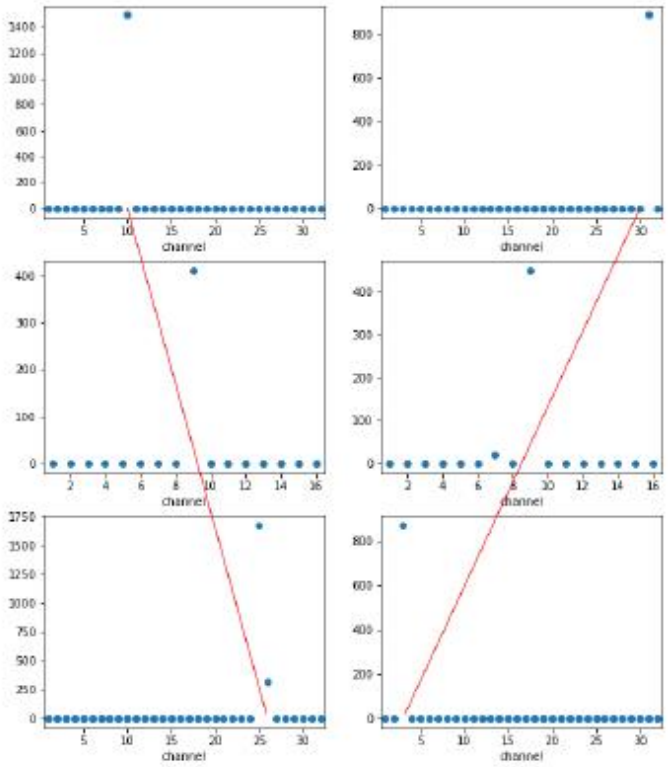
202,000 Classification

2 WorkFlows:
Introductory – Simple events
Advanced – Complicated Events

SONIFICATION OF COSMIC RAYS

https://www.youtube.com/watch?v=EYhcdyO2w2I





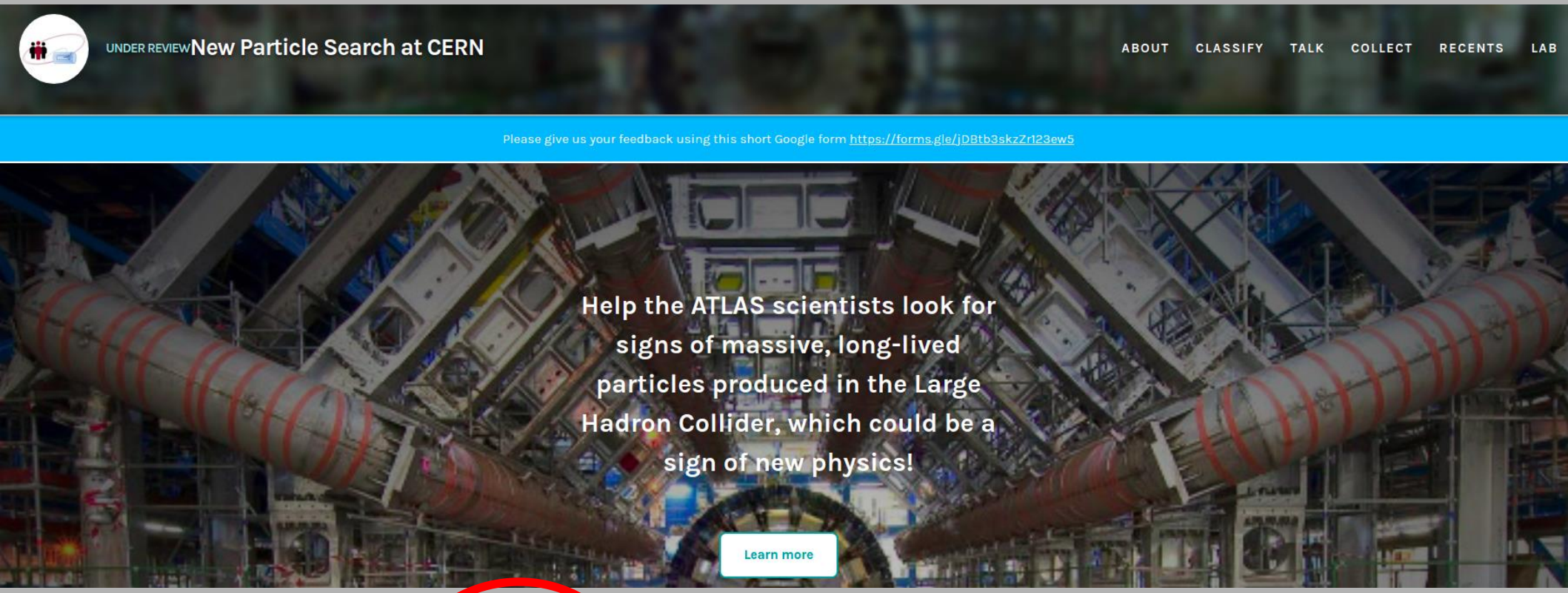
The note heard correspond to deposit of energy in the channel

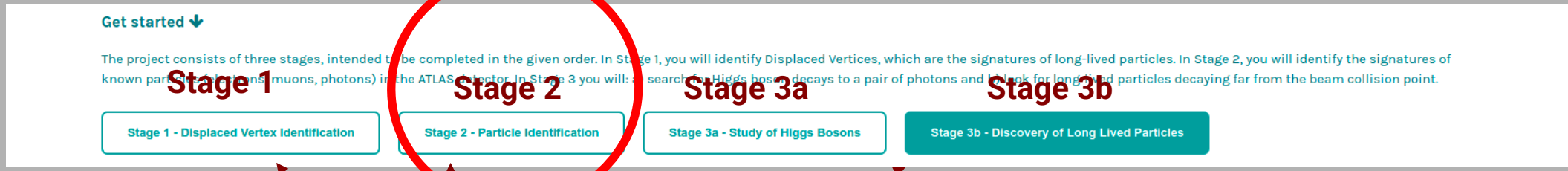
Top and bottom -> 32 channels->one note fot two close-by channels

Middle 16 channels-> 16 piano notes

New Particle Search at CERN

https://www.zooniverse.org/projects/reinforce/new-particle-search-at-cern





Each button loads the respective stage.

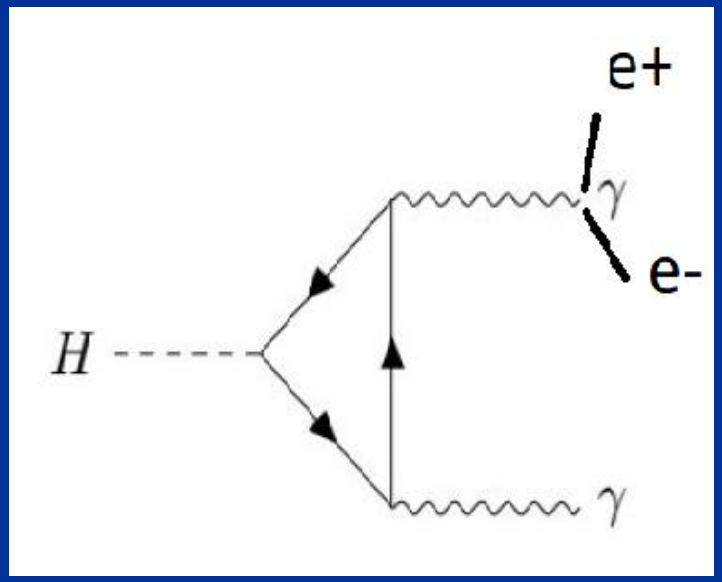
365,000 Classifications since Oct 21

Four different workflows
simulation
Real data from ATLAS Open Data Set

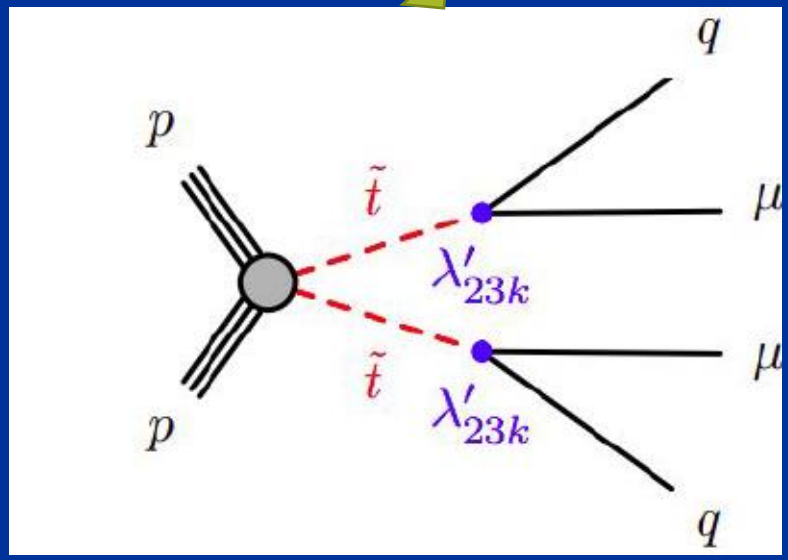
VISUAL INSPECTION OF DISPLACED VERTICES

The workflow is split in 3 stages

simulated data human Vs machine-based algorithms	Stage 1 Displaced Vertex Identification	Stage 2 Particle Identification
ATLAS open data identification of interesting events	Stage 3a Study of Higgs Bosons	Stage 3b Discovery of Long Lived Particles

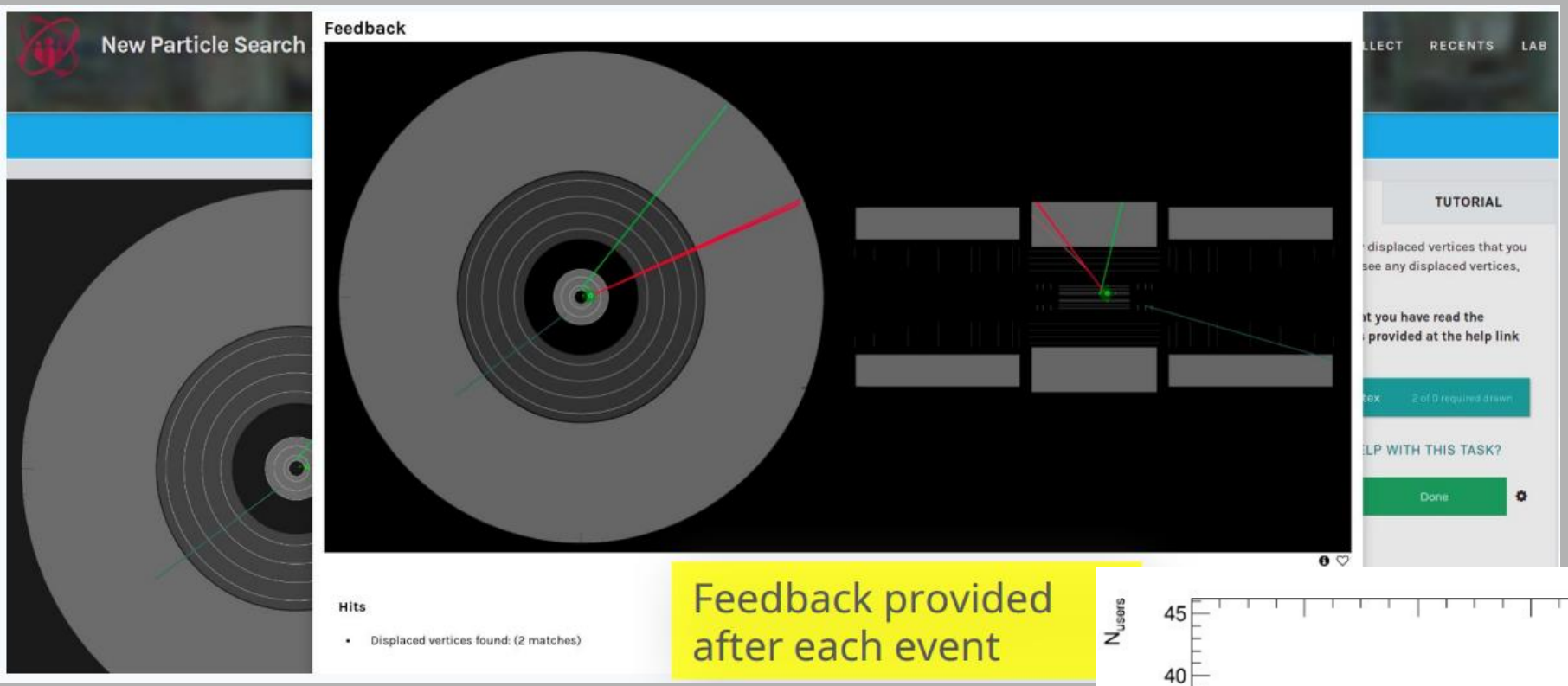


Higgs →γγ with one converted photon



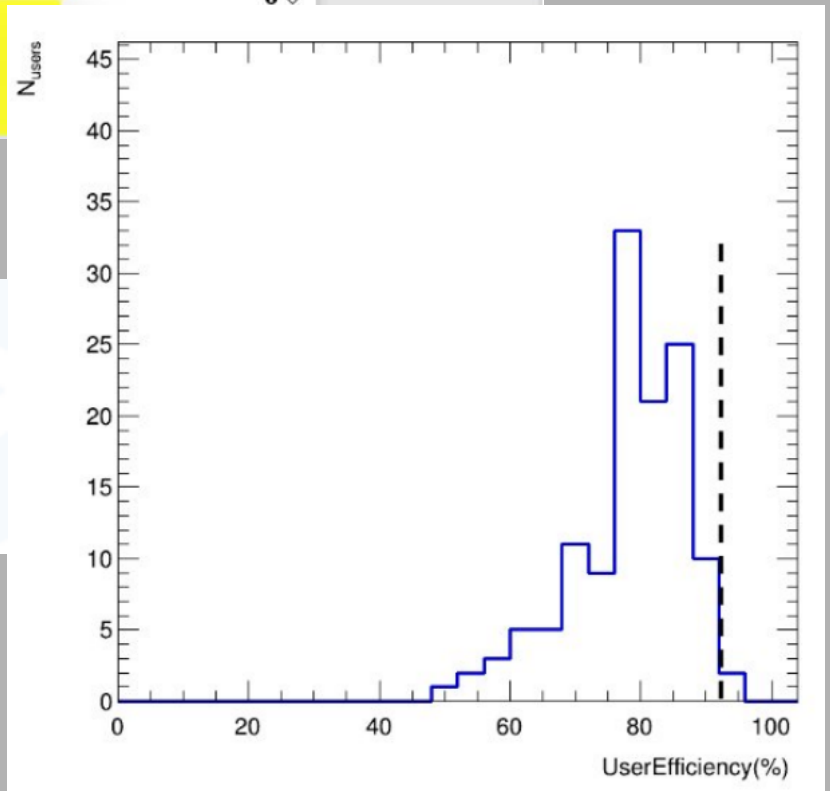
SUSY scenaria with long-lived particles (ex RPV)

Stage 1 : Displaced Vertex Identification

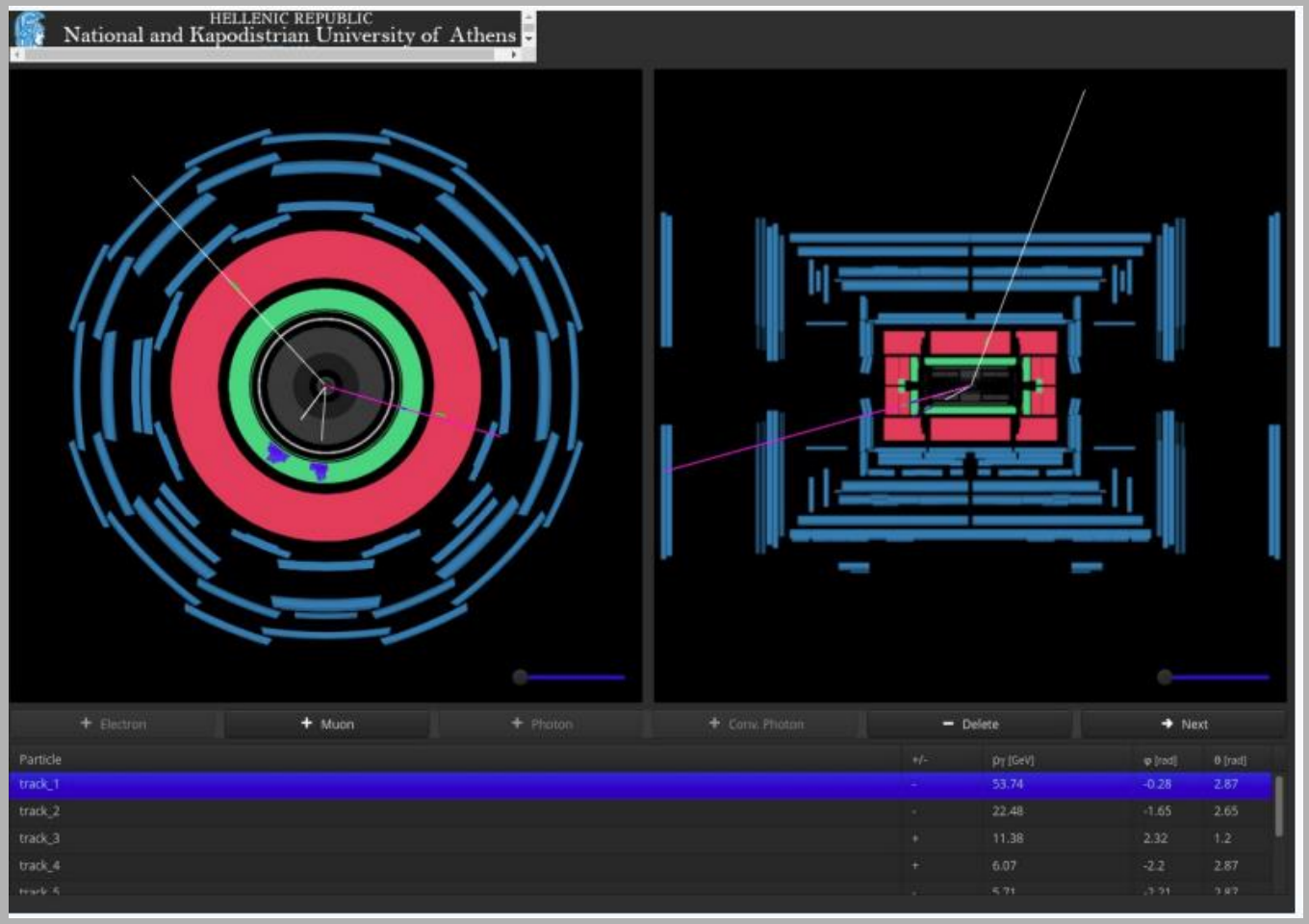


Feedback provided after each event

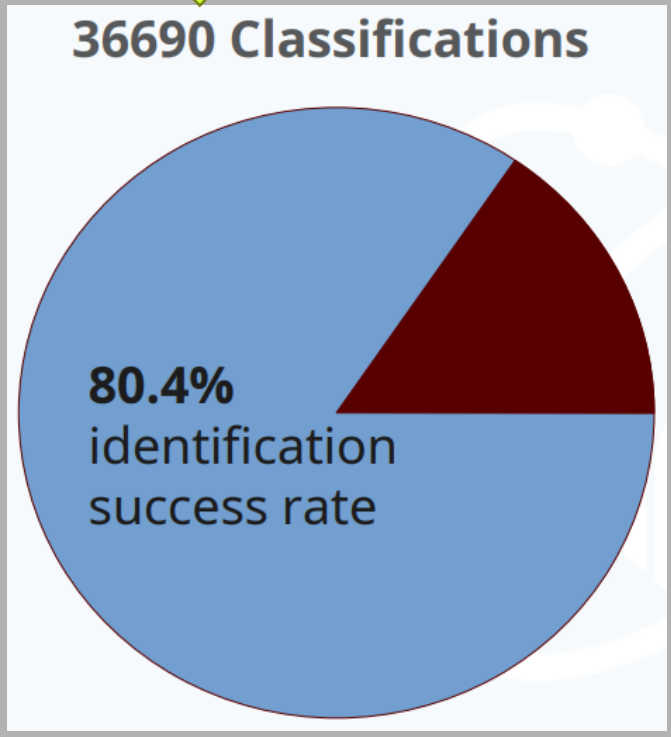
- **User consensus efficiency: 93% (combined user response per event)**
- **Efficiency of automated algorithm: 94%**



Stage 2: Particle Identification
Users have to learn how to identify
e, μ, γ, γ->e^+e^- conversions

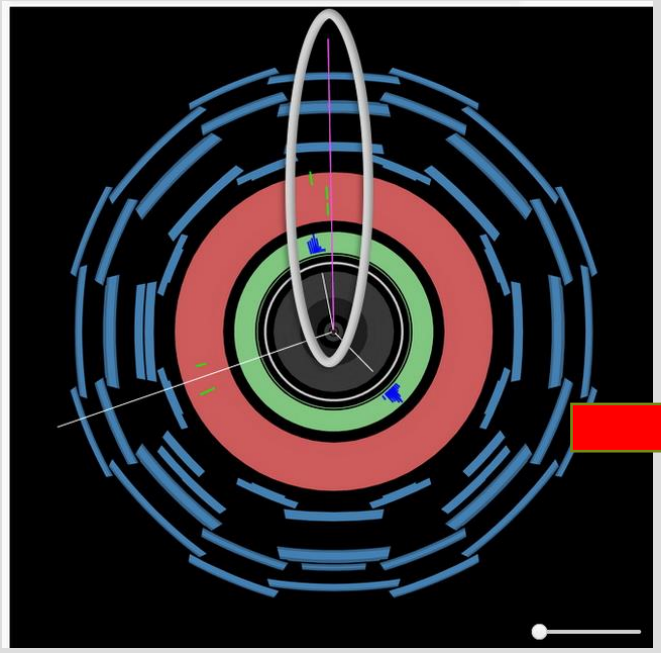


An ML algorithm compares users identification results with the "truth" information



Data=Products of pp collisions sonified by CONICET

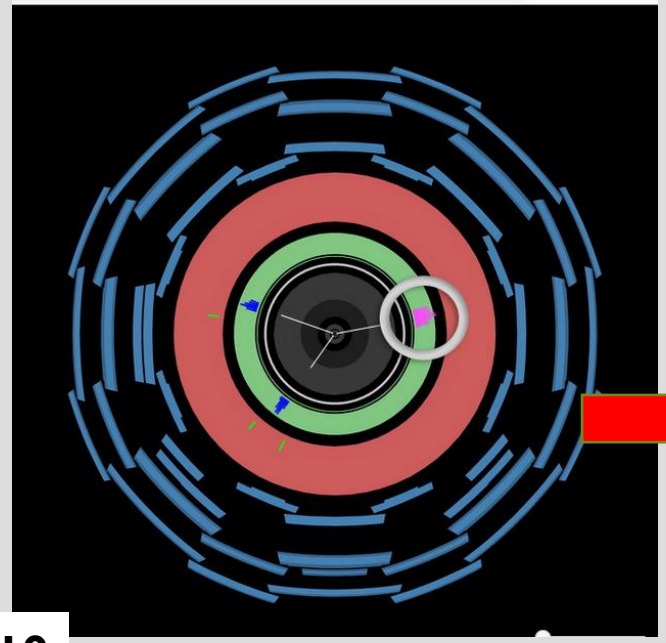
HOW TO IDENTIFY PARTICLE TYPE BY SOUND(1/2)



Selection of a muon

A muon is a long track which reaches the outer layers of the detector

- ✓ Tracks :continuous sound (D6, 2sec)
- ✓ Long tracks (muons) :continuous sound 4 sec,

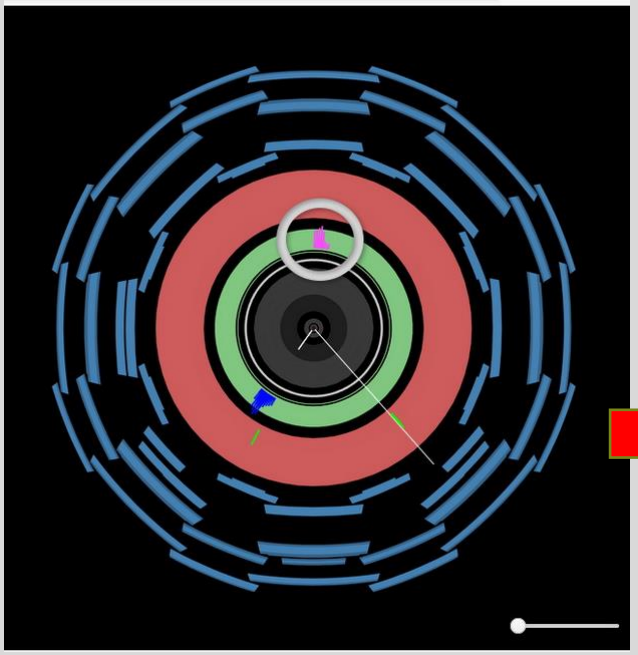


Selection of an electron

An electron leaves a track+a cluster of energy

- ✓ Tracks :continuous sound (D6, 2sec)
- ✓ Clusters: short sounds volume related to energy

HOW TO IDENTIFY PARTICLE TYPE BY SOUND (2/2)

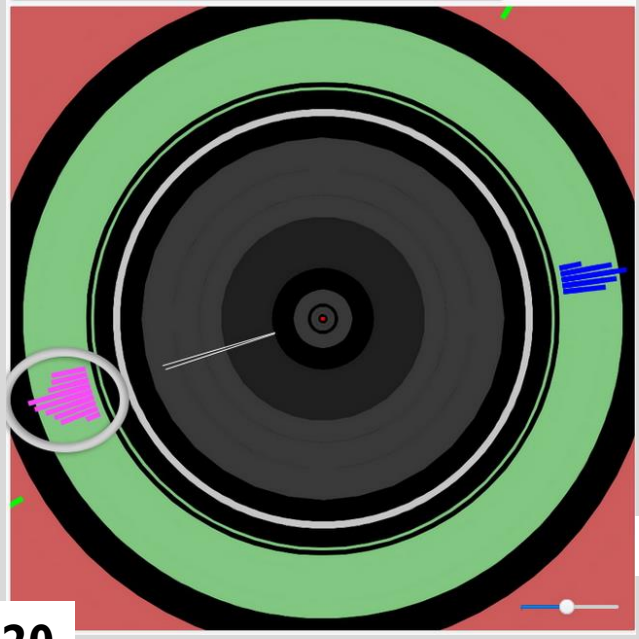


Selection of a photon

A photon gives a cluster of energy and
NO tack associated with it

✓ No track: silence 2 sec

✓ Clusters: short sounds volume related to energy



Selection of a converted photon ($\gamma \rightarrow e^+e^-$)

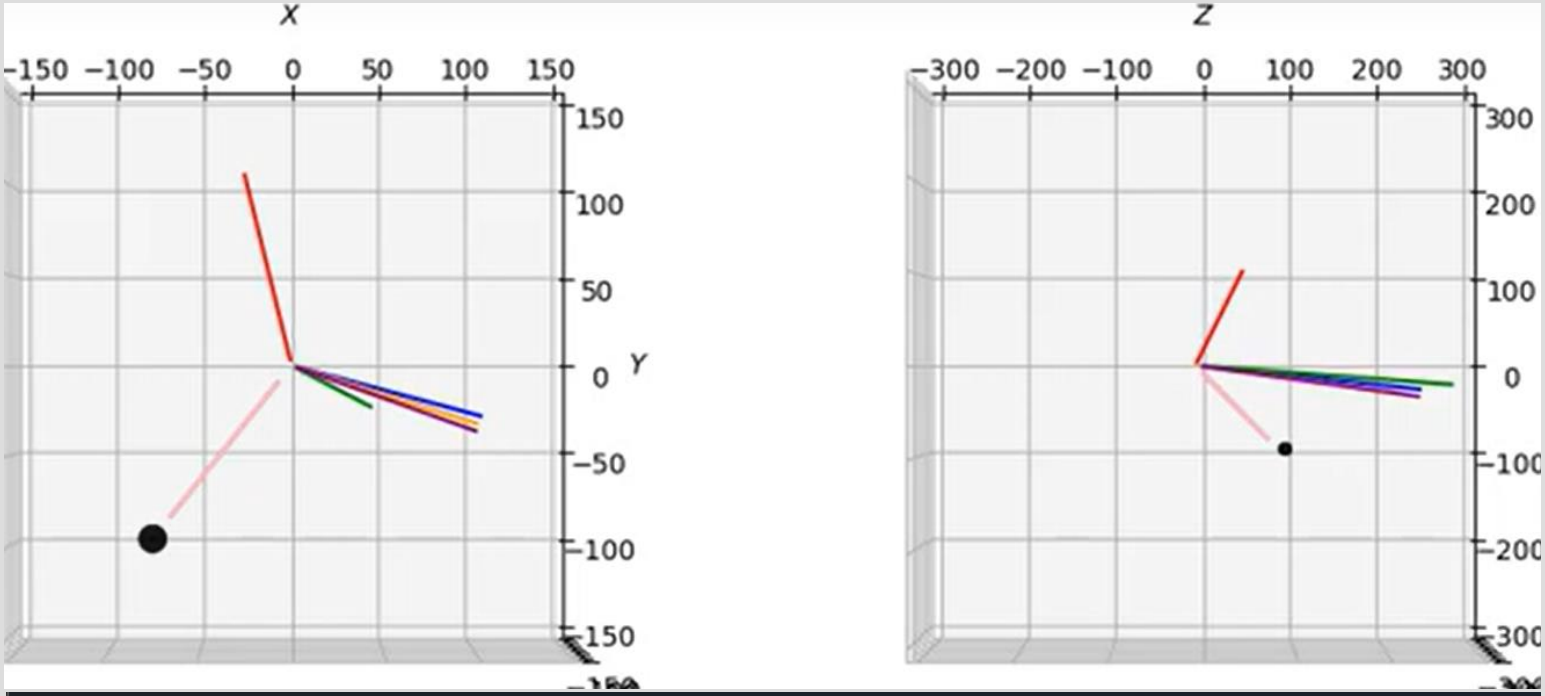
A converted photon converted photon
(the most difficult case) gives two CLOSE-BY tracks
and a (double) cluster of energy

✓ Double tracks: (conversions) two continuous sounds of dif. freq. D6+C6

HOW IT IS DONE (DETAILS)

The various ATLAS subdetectors are used.
The HYPATIA image is transformed to an acoustical/visual representation is based on the existence (a continuous sound of two seconds) or not (a silence of two seconds) of the track in the inner detector, the existence (a characteristic sound of one second) or not (a silence of one second) of the cluster in the calorimeter (the volume of the sound represents the energy), and the existence of a track beyond the inner detector (in this case the initial continuous sound length changed from two seconds to four seconds)

https://www.youtube.com/embed/Foa_8fT2NYY?start=1&end=57


X
Y
Z
−150 −100 −50 0 50 100 150
150
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50
0
−50
−100
−150
−300 −200 −100 0 100 200 300
300
200
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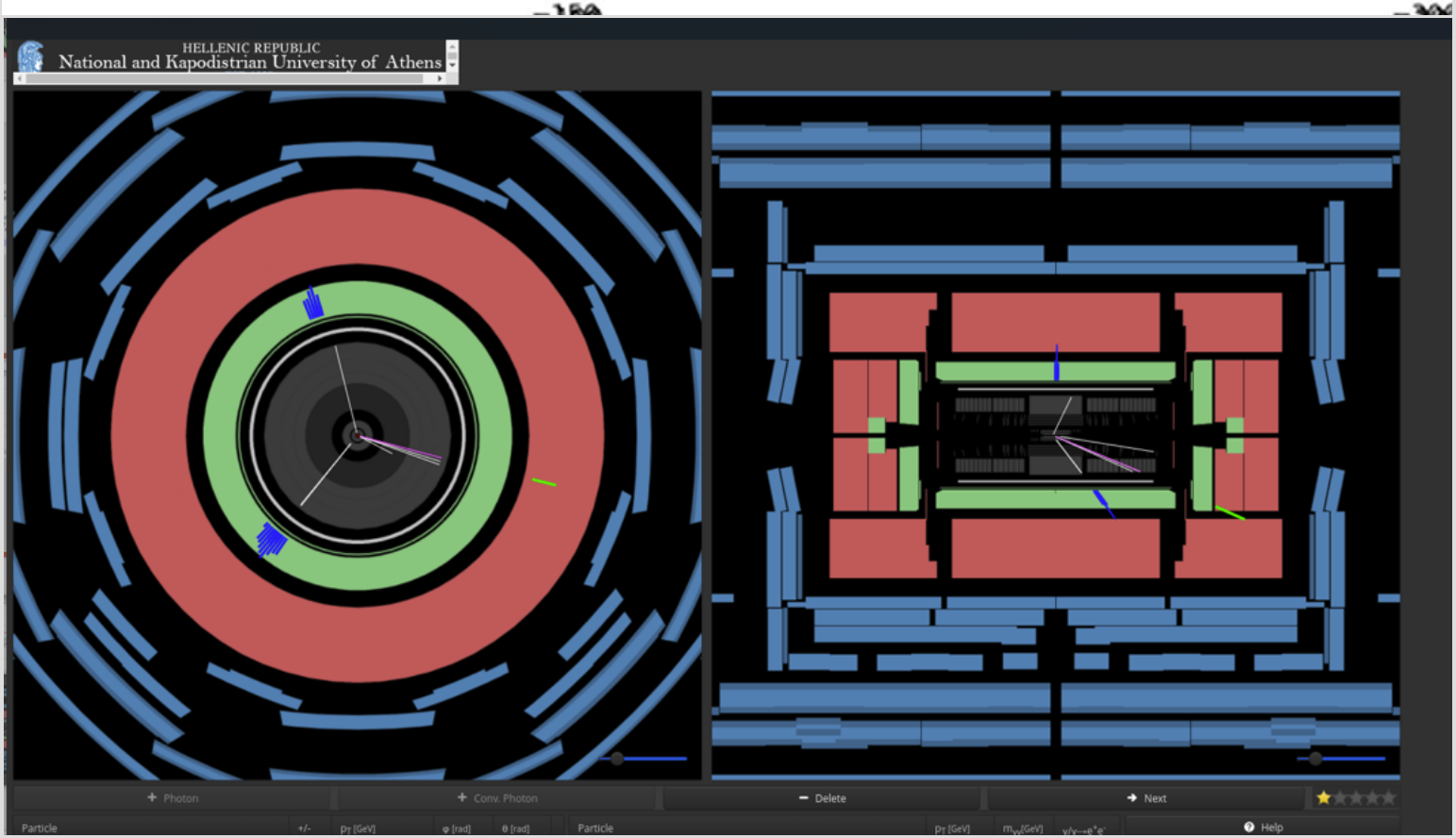
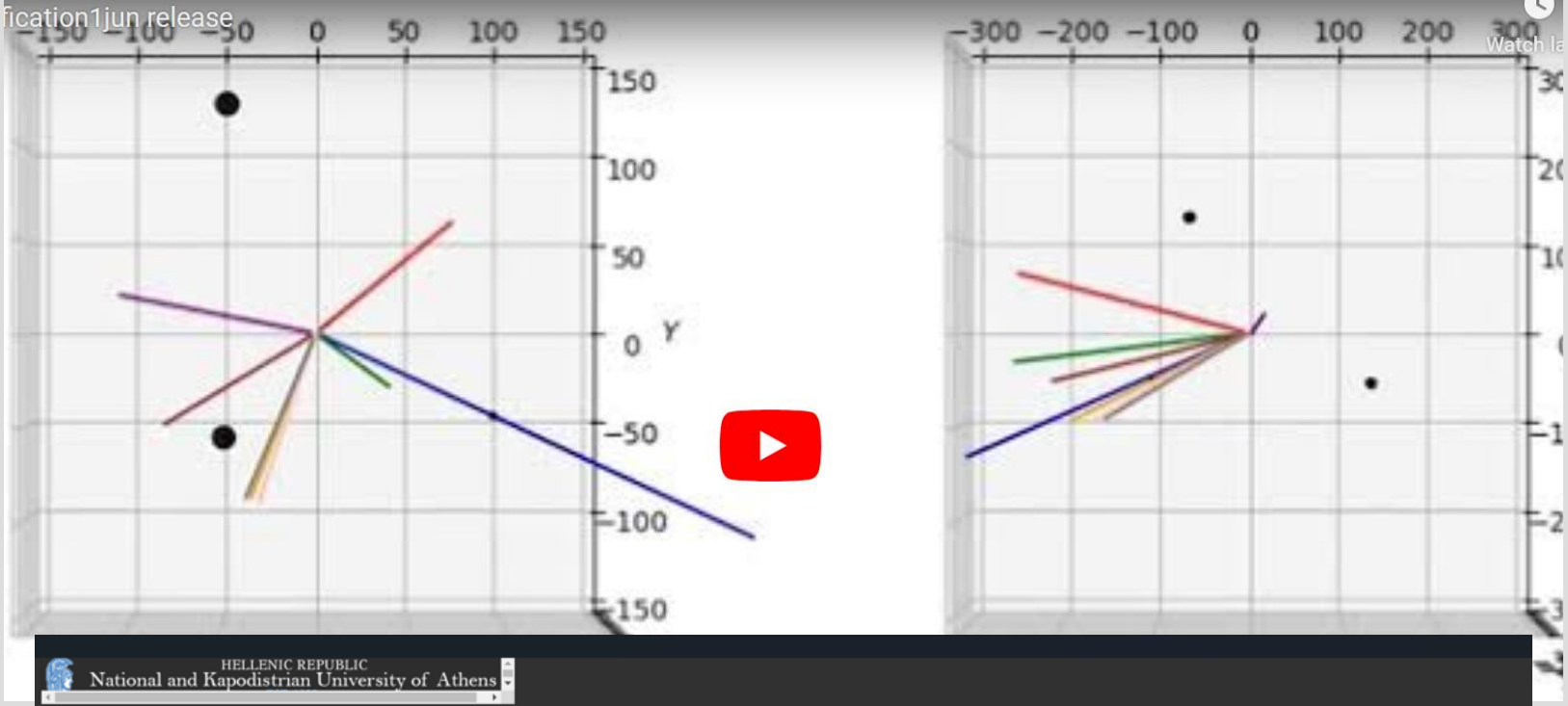
−300


HELLENIC REPUBLIC
National and Kapodistrian University of Athens
+ Photon
+ Conv. Photon
− Delete
→ Next
Particle
Particle
Help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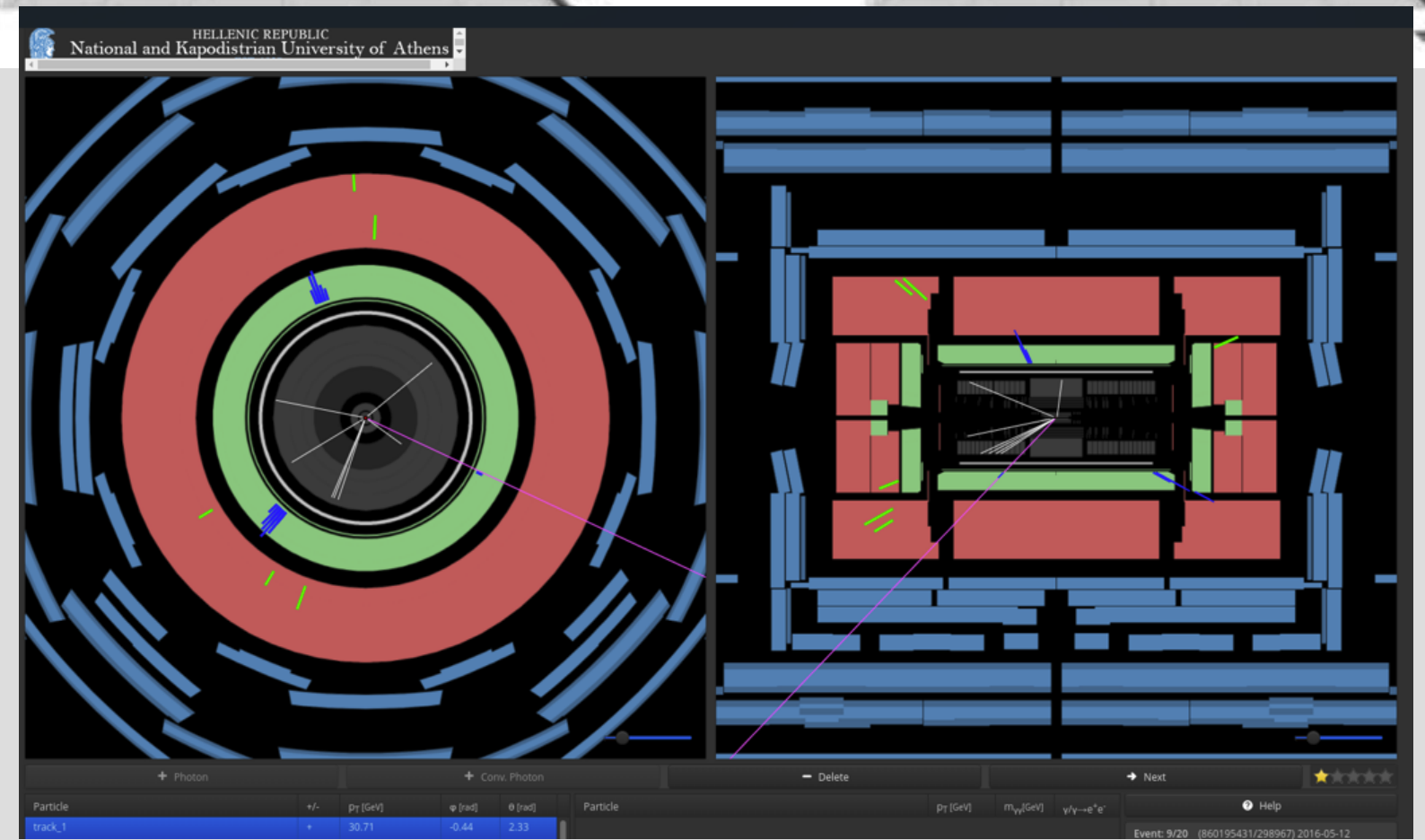
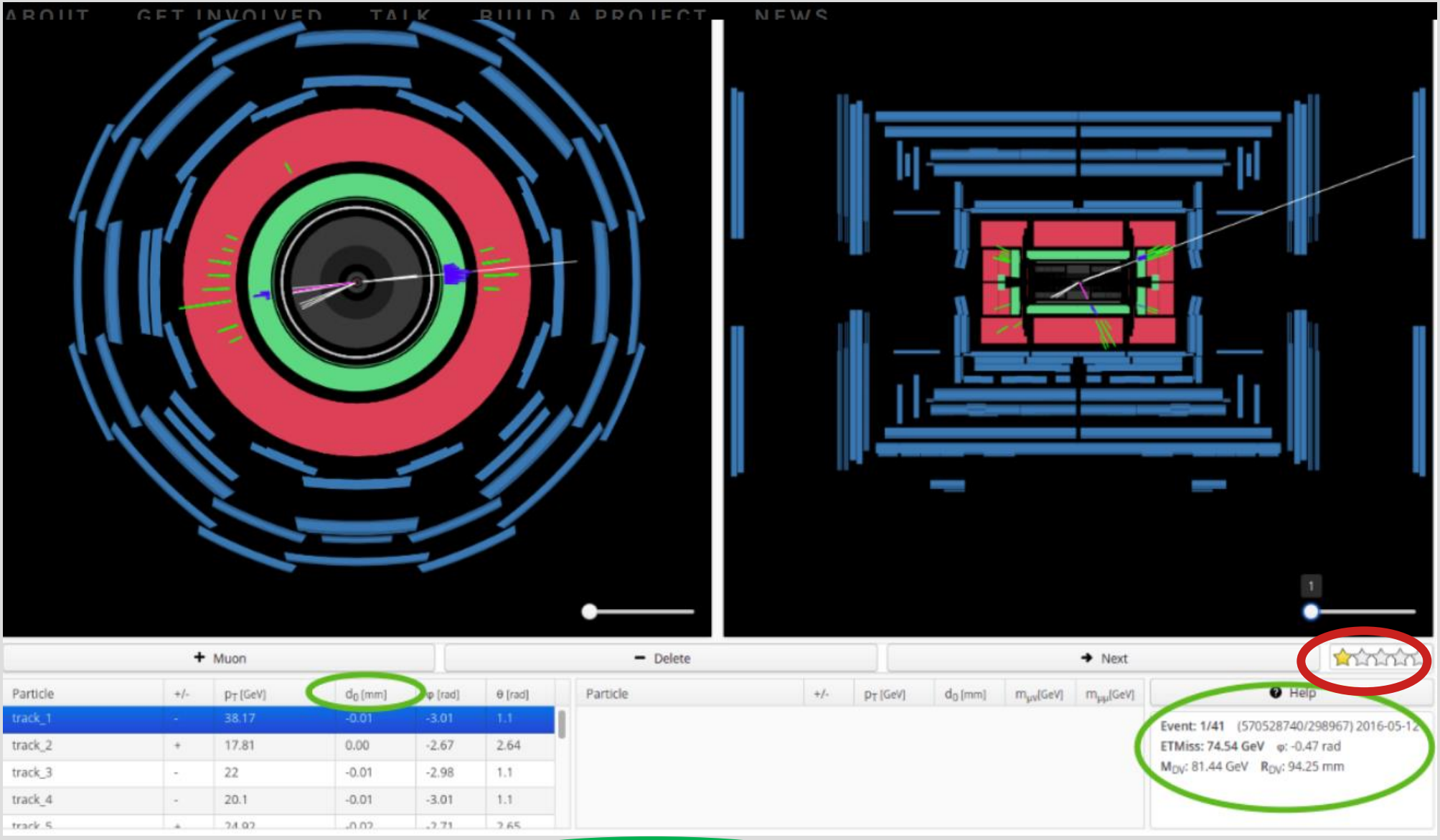

HELLENIC REPUBLIC
National and Kapodistrian University of Athens
+ Photon
+ Conv. Photon
− Delete
→ Next
Particle
track_1
Help

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 ($m_{\mu\nu}$)

CONCLUSIONS

- REINFORCE made available Open Data from Large Research Infrastructures for education and citizen research, extended inclusion through sonification of data samples.

- About 12,000 citizens are involved, with 1,600,000 classifications in all four demonstrators

- Comparative studies show that the power of citizen's performance (often similar to ML algorithms).
- The demonstrators will remain open on zooniverse platform

PARTENERS

Thank you

Back-up

The idea behind our WP (New Particles@CERN)

https://www.zooniverse.org/projects/reinforce/new-particle-search-at-cern*

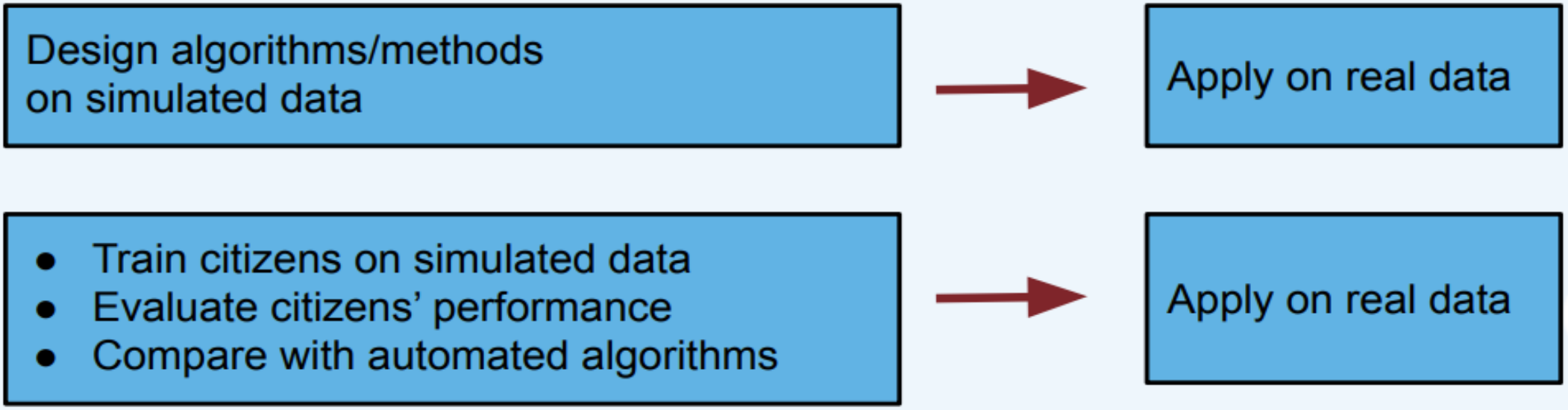
WP5 on Zooniverse

- 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"**

*Translations: English, Greek, Spanish

REINFORCE
REsearch INFrastructures FOR Citizens in Europe

THE SCIENTIFIC METHODOLOGY/EVENT DISPLAYS



Stage 1: Fully hosted by Zooniverse

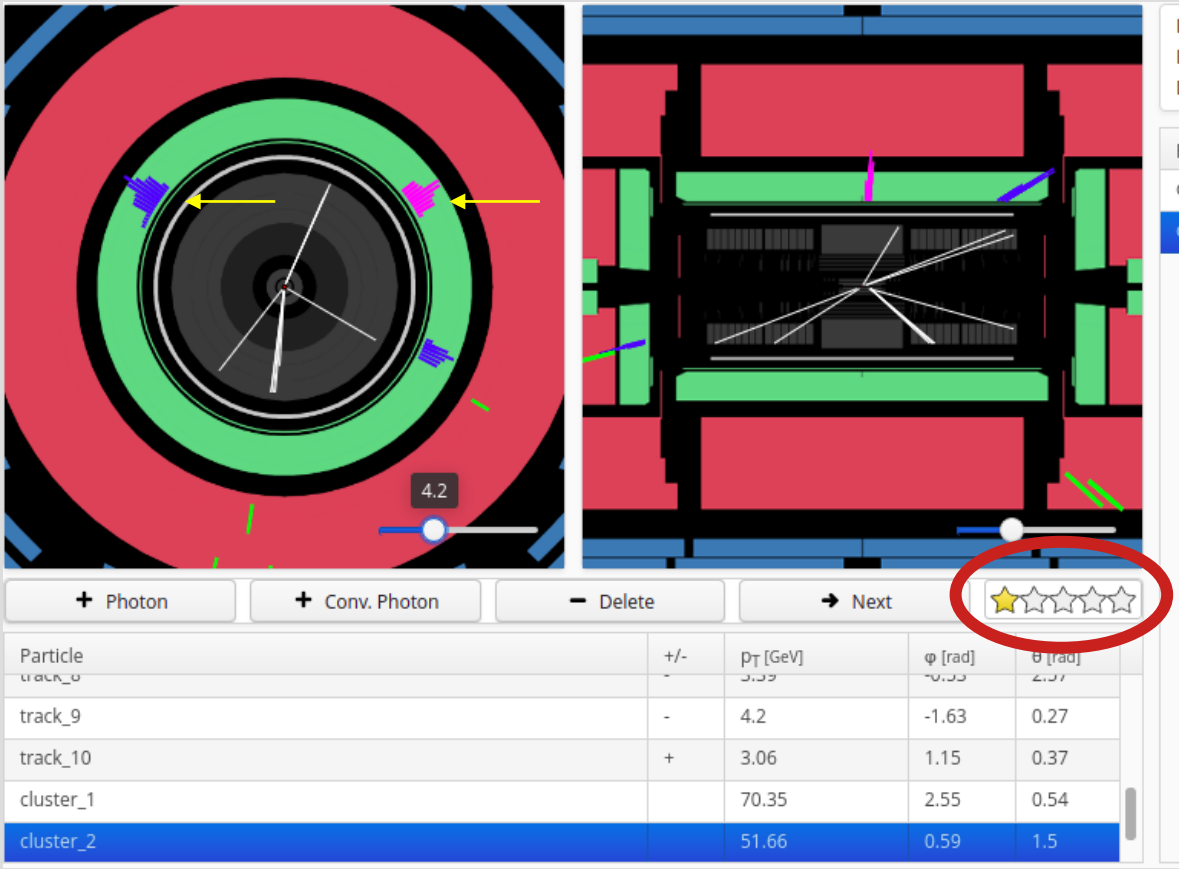
Stages 2, 3a,b: Co-hosted by Zooniverse and online HYPATIA

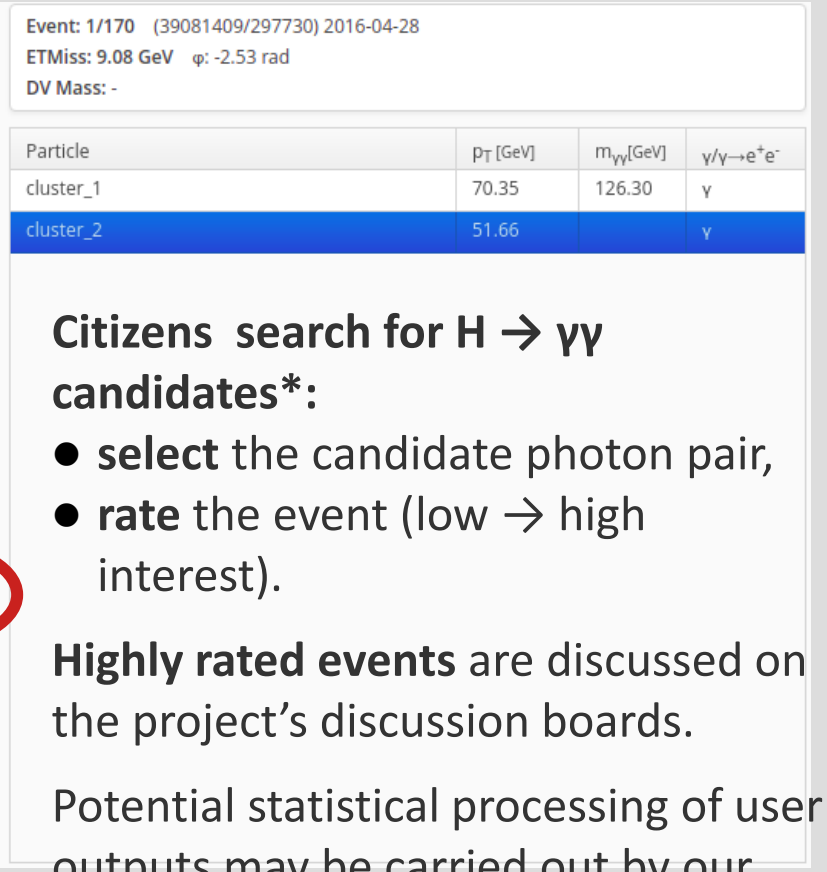
Stage 2: **Sonified** by CONICET

All tasks carried out by using only mouse clicks

Stage 3a - H→γγ STUDY (using HYPATIA)

Event Handling





Citizens search for H → γγ candidates*:

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

Highly rated events are discussed on the project's discussion boards.

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

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