PROCEEDINGS OF SCIENCE
ONLINE ICRC 2021 THE ASTROPARTICLE PHYSICS CONFERENCE Berlin | Germany
37th International Cosmic Ray Conference 12–23 July 2021

The REINFORCE Project: Inviting Citizen Scientists to analyse KM3NeT data

R. Le Breton[a,*], V. Bertin[b], P. Coyle[b], G. de Wasseige[a], H. Glotin[d,e], C. Guidi[b], F. Huang[b], S. Martini[c], A. Kouchner[a,e], C. Tamburini[c] and V. van Elewyck[a,e]
on behalf the REINFORCE Consortium and KM3NeT Collaboration
(a complete list of authors can be found at the end of the proceedings)

[a] *Université de Paris, CNRS, Astroparticule et Cosmologie, F-75013 Paris, France*
[b] *Aix Marseille Univ, CNRS/IN2P3, CPPM, Marseille, France*
[c] *Aix Marseille Univ., Université de Toulon, CNRS, IRD, MIO UM 110, 13288 Marseille, France*
[d] *Université Toulon, Aix Marseille Univ., CNRS, LIS, DYNI, Marseille, France*
[e] *Institut Universitaire de France, 1 rue Descartes, Paris, 75005 France*
E-mail: remy.lebreton@apc.in2p3.fr

Large research infrastructures have opened new observational windows, allowing us to study the structure of matter up to the entire Universe. However, society hardly observes these developments through education and outreach activities. This induces a gap between frontier science and society that may create misconceptions about the content, context, and mission of public funded science. In this context, the main goal of the European Union's Horizon 2020 "Science with and for Society" REINFORCE project (REsearch INfrastructure FOR Citizens in Europe) is to minimize the knowledge gap between large research infrastructures and society through Citizen Science. A series of activities is being developed on the Zooniverse platform, in four main fields of frontier physics involving large research infrastructures: gravitational waves with the VIRGO interferometer, particle physics with the ATLAS detector at LHC, neutrinos with the KM3NeT telescope, and cosmic rays at the interface of geoscience and archeology. Using real and simulated data, Citizen Scientists will help building a better understanding of the impact of the environment on these very high precision detectors as well as creating new knowledge. This poster describes REINFORCE, with a special emphasis on the Deep Sea Hunter demonstrator involving the KM3NeT neutrino telescope, in order to show practical examples of Citizen Science activities that will be proposed through the project.

37th International Cosmic Ray Conference
Berlin, Germany
12-23 July 2021

*Presenter

PoS(ICRC2021)1392

1. REsearch INfrastructure FOR Citizen in Europe

The main goal of the REINFORCE project is to *minimise the knowledge gap between Large Research Infrastructures and Society through Citizen Science*. Through the development of Citizen Science activities, REINFORCE aims to engage citizens to interact directly with researchers in order to produce new knowledge. Large Research Infrastructures are often not entirely understood by society, and sometimes even misunderstood. REINFORCE believes that they can act as beacons of science if the awareness and attitude of citizens towards them are improved. Reducing this knowledge gap can contribute to reduce anti-intellectual beliefs in society and give the citizens the tools to make evidence-based decisions in their every day life.

The goals of REINFORCE will be achieved mainly by classification by citizen scientists of public data from gravitational waves with the VIRGO interferometer, particle physics with the ATLAS detector at LHC, neutrinos with the KM3NeT telescope, and cosmic rays at the interface of geoscience and archeology. However, to properly evaluate the impact of these activities, their societal, democratic and economic costs and benefits, REINFORCE also aims to develop statistical estimators thanks to regular surveys, communicated to citizen scientists, at different stages of the project. In this context, and in order to have robust estimators, REINFORCE aims to engage more than 100,000 citizens, mainly in Europe, but also from all over the world. To do that, the citizen science activities are developed on the Zooniverse platform that can give to REINFORCE the opportunity to get a lot of visibility in the citizen science world.

1.1 Citizen Science

Citizen Science is the cornerstone of REINFORCE. In relation to REINFORCE science cases, it can be defined as the engagement of citizens with frontier science through a participatory design. The interplay between all the actors of REINFORCE is summarised in Fig. 1.

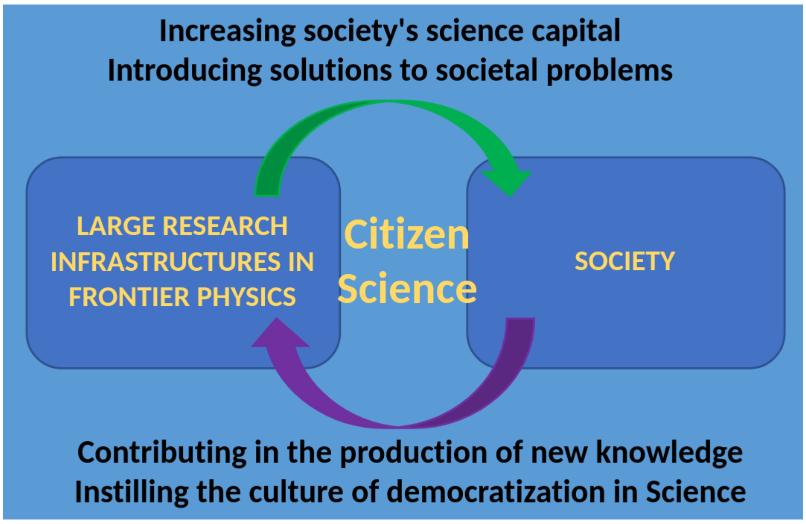


Figure 1: The interplay between Large Research Infrastructures, Society and Citizen Science in the framework of REINFORCE. Citizen Science acts like a bridge between society and large research infrastructure in frontier physics.

Why do we need citizen science? While computers might outshine humans in analysing very large data-sets, human eyes and ears are still better than a computer at noticing subtleties. Furthermore, for the analysis tasks that need to be done, there are not enough people available in the research world. Involving citizens in the analysis pipeline of all the REINFORCE large research infrastructures will allow to meet REINFORCE main goal while producing scientific results that are valuable for the society and the scientific community.

1.2 Zooniverse

Since its launch in 2010, Zooniverse [1] has gathered more than 2,300,000 users who produced almost 600,000,000 classifications[1]. Subjects are ranging from the arts and literature, to physics and astronomy. Zooniverse staff members take part in the REINFORCE project. Their expertise in citizen science provided from the very beginning of the project helped the REINFORCE Consortium to develop four attractive, accessible, and useful citizen science projects.

1.3 Workpackages

The REINFORCE project is composed of 11 workpackages (WP), including 5 WPs focusing on science. This section presents a short description of each of them.

1.3.1 Management and organisation

- WP1: Management
- WP2: Citizen engagement strategy
- WP8: Participatory engagement activities
- WP9: Impact assessment
- WP10: Raising awareness and sustainability
- WP11: Ethics requirement

1.3.2 Science and sonification

- WP3: *Gravitational waves*
  This WP will provide a better understanding of noises in VIRGO data.
- WP4: *Deep Sea Hunters*
  The goal of this project is to perform novel studies of bioluminescence and bioacoustics signals at the bottom of the sea and build a better understanding of sources of background noise in KM3NeT data. The work performed in this WP is presented in details in Section 2.
- WP5: *Search for new particles at the LHC*
  The objective of WP5 is to search for new particles in ATLAS data at LHC/CERN.
- WP6: *Interdisciplinary studies with archeology and geoscience*
  In this WP, muon tomography is used, a non-invasive, and non-destructive process, to conduct geoscience (e.g., to monitor volcanoes) and archeology (e.g. to find hidden chambers in ancient structures).
- WP7: *Increasing the senses*
  SonoUno [2] is a User Centered software that allows people with different sensory styles to explore scientific data, visually and by sonorization.

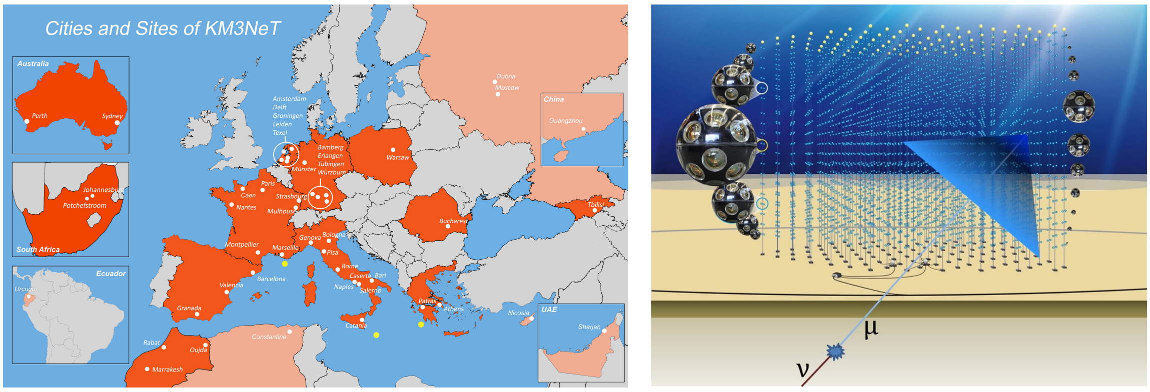
[1]Zooniverse numbers in 06/2021

2. WP4: Deep Sea Hunters

The Deep Sea Hunters project takes place in the context of KM3NeT [3], the Kilometer Cube Neutrino Telescope, which is currently being deployed in the Mediterranean Sea. In order to detect neutrinos, which are really difficult to catch, one needs a a very large detector volume with optical and acoustic sensors, operating in a transparent medium. Sea water, the environment of the KM3NeT detector, is full of living organisms that create background noise: bioluminescent species produce light detectable by KM3NeT photomultipliers, and marine mammals produce sound that can be recorded by KM3NeT hydrophones.

Through the project, citizen scientists will classify various signatures of light and acoustic noise produced by the environment. These classifications have a two-sided aspect. On one hand, it will help us to better understand the response of the KM3NeT instruments and so the data they are recording; on the other hand, it will help KM3NeT researchers to better understand life in the deep sea, near the KM3NeT sensors. The Deep Sea Hunters work package is hence an opportunity for astroparticle and neutrino physicists, but also for experts in bioluminescence and bioinformaticians. To this date (06/2021), the Deep Sea Hunters project is already carried out by an interdisciplinary team.

2.1 Kilometer Cube Neutrino Telescope



(a) **(b)**

Figure 2: (a) : Cities and Sites of KM3NeT. (b) : Illustration of a neutrino event in KM3NeT.

The light produced by charged particles going faster than the speed light in a transparent medium is called the Čerenkov radiation. This radiation can be the signature of a neutrino interaction, as shown in Fig. 2b. One key concept of KM3NeT is that the same technology can be used to study neutrinos over a wide energy range: KM3NeT/ORCA[2], being deployed near Toulon in France, studies neutrinos at the GeV range, and KM3NeT/ARCA[3], being deployed near Sicily in Italy, searches for neutrinos in the TeV range and above. Because of its deep-sea environment, KM3NeT also provides Earth and Sea science measurements. More details can be found in [3].

[2]Oscillation Research with Cosmics in the Abyss
[3]Astronomy Research with Cosmics in the Abyss

KM3NeT is based on a flexible design, which is referred to as a *building block*. The full KM3NeT research infrastructure will consist of three building blocks, each composed of 115 *Detection Units* (DUs). Along these lines, 18 Digital Optical Modules (DOMs) are equally distributed, each composed of 31 Photo-Multiplier Tubes (PMTs). A building block is thus a 3D array of photo sensors.

In the international KM3NeT Collaboration, many institutes and groups from around the world (see 2a) participate with about 250 researchers. Because of its great potential in fundamental physics, the astroparticle and astrophysics communities have included KM3NeT as a high priority project in their European road maps (APPEC/ASPERA, AstroNet) and the European Strategy Forum on Research Infrastructures (ESFRI) in their priority project list.

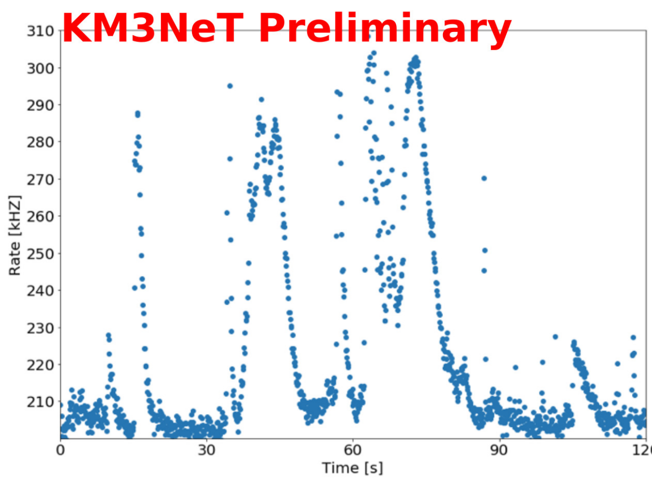
2.2 Workflows on Zooniverse

A citizen science activity is called a workflow in Zooniverse. In the Deep Sea Hunters workpackage, we have two workflows for the time being (06/2021), but more will be developed depending on the first results and feedback from the citizen scientists taking part in the project. One workflow is related to bioluminescence, while the other one focuses on bioacoustics. When visiting the corresponding workflow for the first time, a tutorial is automatically presented to the citizen scientists. This tutorial explains the essence of the task the visitor is asked to perform as well as some concrete examples. The tutorial is then accessible whenever the citizen scientist wants to read it.

2.2.1 Bioluminescence

One of the main optical noise in KM3NeT is bioluminescence, a very common phenomenon in open water, as around 70% of the marine species emit light [4].

(a)



(b)

Figure 3: (a) : A Digital Optical Module used in KM3NeT. (b) : Exemple of bioluminescence signature in KM3NeT data.

In this workflow, the citizen scientist are asked to classify the rate recorded by one of the optical sensors of KM3NeT in a time window of 120 s, as illustrated in Fig. 3b. The displayed data contain a snapshot of the environmental conditions at the moment they were recorded. Classifying them allows us to study the signature of bioluminescent species in the deep sea, over a very large volume of study, in order to have a better understanding of some bioluminescent phenomena and even discover new bioluminescent species. Moreover, it will also help us to improve neutrino detection through more efficient background rejection. The citizen scientists therefore directly contribute to improving the KM3NeT discovery potential both in neutrino physics and astrophysics.

Each image of the bioluminescence workflow comes with an audio file, which contains the corresponding data points sonified with the sonoUno software. Thanks to the combination of the visual data and the audio file, every citizen scientist, including visually or hearing impaired people, will be able to have an idea of what the data are. More information about bioluminescence can be found in [4] and references within.

2.2.2 Bioacoustics

KM3NeT hydrophones are primarily used in the acoustic positioning system illustraed in Fig. 4).

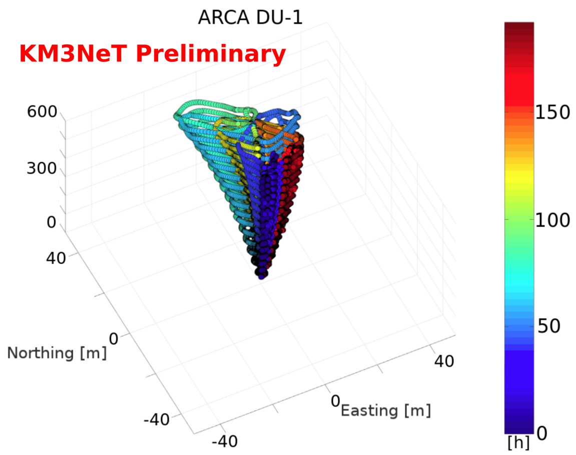
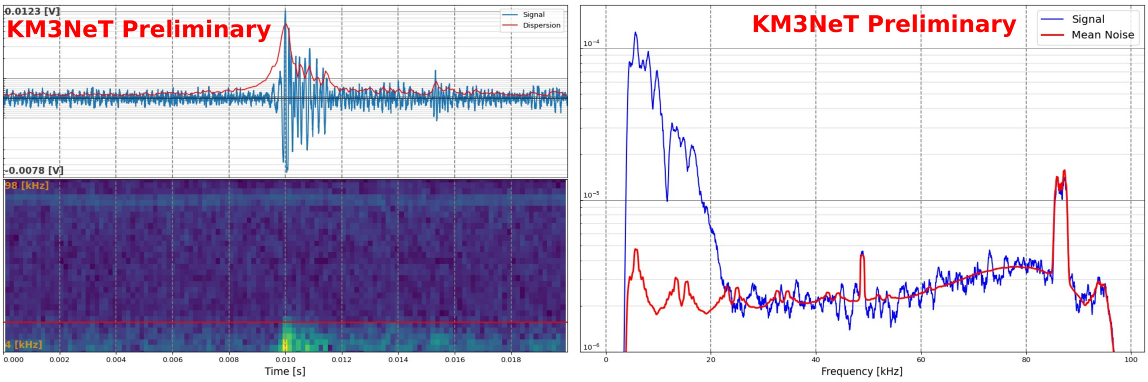


Figure 4: Exemple of positioning monitoring in KM3NeT, for one DU of ARCA.

In this workflow, the citizen scientists are asked to classify cetacean clicks detected by KM3NeT hydrophones. The aim of this acoustic workflow is to understand what happened on May 11^{th}, 2020. From preliminary analysis, it has been shown that several individuals from at least two species seemed to be hunting at the same time in the close neighbourhood of KM3NeT. This period being very active, our machine learning algorithm sometimes has difficulties to clearly identify species. The classification made by citizen scientists will help us to improve our identification model, which was not specifically designed for the environment around KM3NeT. In the end, we will be able to identify more accurately cetacean species over greater distances and perform more relevant bioacoustics studies. For example, KM3NeT will help to track and count cetaceans in the Mediterranean Sea, as function of the species and period of the year, to have a better understanding of cetaceans lives (hunting, migration, etc.) and also to improve existing real-time anti-collision systems to avoid accidents between boats and animals in KM3NeT vicinity.

The proposed data contain clicks[4], buzzes, whistles, and also noise from the detector itself. For the purpose of the classification, four different images are shown. Figure 5 presents an example that shows two separate representations of the data: in the top, the waveform (figure 5a), which is the amplitude as a function of time, and in the bottom, the spectrum (figure 5b), which is the frequency as a function of time. The second image shows a power spectrum of the full considered time-window. The *events* to be classified being centered on the first image, the third and fourth images correspond to a zoom in the middle of the time-window. Citizen scientists are asked to classify what they see on the image into one of the following categories, which should correspond to the emitter of the recorded data: Sperm Whale, Short-finned pilot whale, Pure noise, Another Species or human-made noise.



(a) **(b)**

Figure 5: (a) : Waveform and spectrum as function of time. (b) : Spectrum of the whole time window.

Each classification of the bioacoustic workflow comes with three audio files:

- the sonification of the data points with the sonoUno software, similarly to what is done in the bioluminescence workflow
- an audio file corresponding to the true recorded sound, without any modification so that citizen scientists can compare it to what they see on the spectrum (frequencies above ~20 kHz are not in the human audible range)
- an audio file corresponding to the true recorded sound, but slowed down, so that citizen scientists can more easily identify features of the clicks (which are intrinsically very short), and also hear frequencies that are above the human audible range.

[4]Short (ms scale) sound wave emitted by cetaceans.

2.3 Status and Conclusion

The Deep Sea Hunters project has been reviewed by the REINFORCE Consortium and has been submitted for review to the Zooniverse team (06/2021). Once the demonstrator is confirmed as an official Zooniverse project, the first citizen scientists will be able to join the project.

The next steps will be to optimise the existing workflows and develop new ones based on feedback from the first citizen scientists involved and the first classification results on Zooniverse. On a longer time scale, the goal of the Deep Sea Hunter project is to compare the results from the classification made by citizen scientists with that of the machine learning tools of KM3NeT in order to increase KM3NeT potential in neutrino physcics and astronomy, but also to produce long term results both in bioluminescence and bioacoustic studies.

3. Acknowledgements

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

4. Get involved!

- REINFORCE website: https://reinforceeu.eu/
- LinkedIn: https://www.linkedin.com/company/reinforceeu/
- Twitter: https://twitter.com/reinforceeu
- Facebook: https://www.facebook.com/ReinforceEU/

www.reinforceeu.eu /company/reinforceeu @ReinforceEU @ReinforceEU

References

[1] Zooniverse: https://www.zooniverse.org/

[2] SonoUno: http://sion.frm.utn.edu.ar/sonoUno/

[3] S. Adrián-Martínez *et al.*, Letter of intent for KM3NeT 2.0, JoP G, 2016 https://iopscience.iop.org/article/10.1088/0954-3899/43/8/084001

[4] The Dark Ocean Is Full of Lights: https://kids.frontiersin.org/articles/10.3389/frym.2020.00069

Full Author List: KM3NeT Collaboration

M. Ageron[1], S. Aiello[2], A. Albert[3,55], M. Alshamsi[4], S. Alves Garre[5], Z. Aly[1], A. Ambrosone[6,7], F. Ameli[8], M. Andre[9], G. Androulakis[10], M. Anghinolfi[11], M. Anguita[12], G. Anton[13], M. Ardid[14], S. Ardid[14], W. Assal[1], J. Aublin[4], C. Bagatelas[10], B. Baret[4], S. Basegmez du Pree[15], M. Bendahman[4,16], F. Benfenati[17,18], E. Berbee[15], A. M. van den Berg[19], V. Bertin[1], S. Beurthey[1], V. van Beveren[15], S. Biagi[20], M. Billault[1], M. Bissinger[13], M. Boettcher[21], M. Bou Cabo[22], J. Boumaaza[16], M. Bouta[23], C. Boutonnet[4], G. Bouvet[24], M. Bouwhuis[15], C. Bozza[25], H.Brânzaş[26], R. Bruijn[15,27], J. Brunner[1], R. Bruno[2], E. Buis[28], R. Buompane[6,29], J. Busto[1], B. Caiffi[11], L. Caillat[1], D. Calvo[5], S. Campion[30,8], A. Capone[30,8], H. Carduner[24], V. Carretero[5], P. Castaldi[17,31], S. Celli[30,8], R. Cereseto[11], M. Chabab[32], C. Champion[4], N. Chau[4], A. Chen[33], S. Cherubini[20,34], V. Chiarella[35], T. Chiarusi[17], M. Circella[36], R. Cocimano[20], J. A. B. Coelho[4], A. Coleiro[4], M. Colomer Molla[4,5], S. Colonges[4], R. Coniglione[20], A. Cosquer[1], P. Coyle[1], M. Cresta[11], A. Creusot[4], A. Cruz[37], G. Cuttone[20], A. D'Amico[15], R. Dallier[24], B. De Martino[1], M. De Palma[36,38], I. Di Palma[30,8], A. F. Díaz[12], D. Diego-Tortosa[14], C. Distefano[20], A. Domi[15,27], C. Donzaud[4], D. Dornic[1], M. Dörr[39], D. Drouhin[3,55], T. Eberl[13], A. Eddyamoui[16], T. van Eeden[15], D. van Eijk[15], I. El Bojaddaini[23], H. Eljarrari[16], D. Elsaesser[39], A. Enzenhöfer[1], V. Espinosa[14], P. Fermani[30,8], G. Ferrara[20,34], M. D. Filipović[40], F. Filippini[17,18], J. Fransen[15], L. A. Fusco[1], D. Gajanana[15], T. Gal[13], J. García Méndez[14], A. Garcia Soto[5], E. Garçon[1], F. Garufi[6,7], C. Gatius[15], N. Geißelbrecht[13], L. Gialanella[6,29], E. Giorgio[20], S.R. Gozzini[5], R. Gracia[15], K. Graf[13], G. Grella[41], D. Guderian[56], C. Guidi[11,42], B. Guillon[43], M. Gutiérrez[44], J. Haefner[13], S. Hallmann[13], H. Hamdaoui[16], H. van Haren[45], A. Heijboer[15], A. Hekalo[39], L. Hennig[13], S. Henry[1], J. J. Hernández-Rey[5], J. Hofestädt[13], F. Huang[1], W. Idrissi Ibnsalih[6,29], A. Ilioni[4], G. Illuminati[17,18,4], C.W. James[37], D. Janezashvili[46], P. Jansweijer[15], M. de Jong[15,47], P. de Jong[15,27], B.J. Jung[15], M. Kadler[39], P. Kalaczyński[48], O. Kalekin[13], U. F. Katz[13], F. Kayzel[15], P. Keller[1], N. R. Khan Chowdhury[5], G. Kistauri[46], F. van der Knaap[28], P. Kooijman[27,57], A. Kouchner[4,49], M. Kreter[21], V. Kulikovskiy[11], M. Labalme[43], P. Lagier[1], R. Lahmann[13], P. Lamare[1], M. Lamoureux[5][4], G. Larosa[20], C. Lastoria[1], J. Laurence[1], A. Lazo[5], R. Le Breton[4], E. Le Guirriec[1], S. Le Stum[1], G. Lehaut[43], O. Leonardi[20], F. Leone[20,34], E. Leonora[2], C. Lerouvillois[1], J. Lesrel[4], N. Lessing[13], G. Levi[17,18], M. Lincetto[1], M. Lindsey Clark[4], T. Lipreau[24], C. LLorens Alvarez[14], A. Lonardo[8], F. Longhitano[2], D. Lopez-Coto[44], N. Lumb[1], L. Maderer[4], J. Majumdar[15], J. Mańczak[5], A. Margiotta[17,18], A. Marinelli[6], A. Marini[1], C. Markou[10], L. Martin[24], J.A. Martínez-Mora[14], A. Martini[35], F. Marzaioli[6,29], S. Mastroianni[6], K. W. Melis[15], G. Miele[6,7], P. Migliozzi[6], E. Migneco[20], P. Mijakowski[48], L. S. Miranda[50], C. M. Mollo[6], M. Mongelli[36], A. Moussa[23], R. Muller[15], P. Musico[11], M. Musumeci[20], L. Nauta[15], S. Navas[44], C. A. Nicolau[8], B. Nkosi[33], B. Ó Fearraigh[15,27], M. O'Sullivan[37], A. Orlando[20], G. Ottonello[11], S. Ottonello[11], J. Palacios González[5], G. Papalashvili[46], R. Papaleo[20], C. Pastore[36], A. M. Păun[26], G.E. Păvălaş[26], G. Pellegrini[17], C. Pellegrino[18,58], M. Perrin-Terrin[1], V. Pestel[15], P. Piattelli[20], C. Pieterse[5], O. Pisanti[6,7], C. Poirè[14], V. Popa[26], T. Pradier[3], F. Pratolongo[11], I. Probst[13], G. Pühlhofer[51], S. Pulvirenti[20], G. Quéméner[43], N. Randazzo[2], A. Rapicavoli[34], S. Razzaque[50], D. Real[5], S. Reck[13], G. Riccobene[20], L. Rigalleau[24], A. Romanov[11,42], A. Rovelli[20], J. Royon[1], F. Salesa Greus[5], D.F.E. Samtleben[15,47], A. Sánchez Losa[36,5], M. Sanguineti[11,42], A. Santangelo[51], D. Santonocito[20], P. Sapienza[20], J. Schmelling[15], J. Schnabel[13], M. F. Schneider[13], J. Schumann[13], H. M. Schutte[21], J. Seneca[15], I. Sgura[36], R. Shanidze[46], A. Sharma[52], A. Sinopoulou[10], B. Spisso[41,6], M. Spurio[17,18], D. Stavropoulos[10], J. Steijger[15], S.M. Stellacci[41,6], M. Taiuti[11,42], F. Tatone[36], Y. Tayalati[16], E. Tenllado[44], D. Tézier[1], T. Thakore[5], S. Theraube[1], H. Thiersen[21], P. Timmer[15], S. Tingay[37], S. Tsagkli[10], V. Tsourapis[10], E. Tzamariudaki[10], D. Tzanetatos[10], C. Valieri[17], V. Van Elewyck[4,49], G. Vasileiadis[53], F. Versari[17,18], S. Viola[20], D. Vivolo[6,29], G. de Wasseige[4], J. Wilms[54], R. Wojaczyński[48], E. de Wolf[15,27], T. Yousfi[23], S. Zavatarelli[11], A. Zegarelli[30,8], D. Zito[20], J. D. Zornoza[5], J. Zúñiga[5], N. Zywucka[21].

[1]Aix Marseille Univ, CNRS/IN2P3, CPPM, Marseille, France.
[2]INFN, Sezione di Catania, Via Santa Sofia 64, Catania, 95123 Italy.
[3]Université de Strasbourg, CNRS, IPHC UMR 7178, F-67000 Strasbourg, France.
[4]Université de Paris, CNRS, Astroparticule et Cosmologie, F-75013 Paris, France.
[5]IFIC - Instituto de Física Corpuscular (CSIC - Universitat de València), c/Catedrático José Beltrán, 2, 46980 Paterna, Valencia, Spain.
[6]INFN, Sezione di Napoli, Complesso Universitario di Monte S. Angelo, Via Cintia ed. G, Napoli, 80126 Italy.
[7]Università di Napoli "Federico II", Dip. Scienze Fisiche "E. Pancini", Complesso Universitario di Monte S. Angelo, Via Cintia ed. G, Napoli, 80126 Italy.
[8]INFN, Sezione di Roma, Piazzale Aldo Moro 2, Roma, 00185 Italy.
[9]Universitat Politècnica de Catalunya, Laboratori d'Aplicacions Bioacústiques, Centre Tecnològic de Vilanova i la Geltrú, Avda. Rambla Exposició, s/n, Vilanova i la Geltrú, 08800 Spain.
[10]NCSR Demokritos, Institute of Nuclear and Particle Physics, Ag. Paraskevi Attikis, Athens, 15310 Greece.
[11]INFN, Sezione di Genova, Via Dodecaneso 33, Genova, 16146 Italy.
[12]University of Granada, Dept. of Computer Architecture and Technology/CITIC, 18071 Granada, Spain.
[13]Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen Centre for Astroparticle Physics, Erwin-Rommel-Straße 1, 91058 Erlangen, Germany.
[14]Universitat Politècnica de València, Instituto de Investigación para la Gestión Integrada de las Zonas Costeras, C/ Paranimf, 1, Gandia, 46730 Spain.
[15]Nikhef, National Institute for Subatomic Physics, PO Box 41882, Amsterdam, 1009 DB Netherlands.
[16]University Mohammed V in Rabat, Faculty of Sciences, 4 av. Ibn Battouta, B.P. 1014, R.P. 10000 Rabat, Morocco.
[17]INFN, Sezione di Bologna, v.le C. Berti-Pichat, 6/2, Bologna, 40127 Italy.

[5]also at Dipartimento di Fisica, INFN Sezione di Padova and Università di Padova, I-35131, Padova, Italy

[18]Università di Bologna, Dipartimento di Fisica e Astronomia, v.le C. Berti-Pichat, 6/2, Bologna, 40127 Italy.
[19]KVI-CART University of Groningen, Groningen, the Netherlands.
[20]INFN, Laboratori Nazionali del Sud, Via S. Sofia 62, Catania, 95123 Italy.
[21]North-West University, Centre for Space Research, Private Bag X6001, Potchefstroom, 2520 South Africa.
[22]Instituto Español de Oceanografía, Unidad Mixta IEO-UPV, C/ Paranimf, 1, Gandia, 46730 Spain.
[23]University Mohammed I, Faculty of Sciences, BV Mohammed VI, B.P. 717, R.P. 60000 Oujda, Morocco.
[24]Subatech, IMT Atlantique, IN2P3-CNRS, Université de Nantes, 4 rue Alfred Kastler - La Chantrerie, Nantes, BP 20722 44307 France.
[25]Università di Salerno e INFN Gruppo Collegato di Salerno, Dipartimento di Matematica, Via Giovanni Paolo II 132, Fisciano, 84084 Italy.
[26]ISS, Atomistilor 409, Măgurele, RO-077125 Romania.
[27]University of Amsterdam, Institute of Physics/IHEF, PO Box 94216, Amsterdam, 1090 GE Netherlands.
[28]TNO, Technical Sciences, PO Box 155, Delft, 2600 AD Netherlands.
[29]Università degli Studi della Campania "Luigi Vanvitelli", Dipartimento di Matematica e Fisica, viale Lincoln 5, Caserta, 81100 Italy.
[30]Università La Sapienza, Dipartimento di Fisica, Piazzale Aldo Moro 2, Roma, 00185 Italy.
[31]Università di Bologna, Dipartimento di Ingegneria dell'Energia Elettrica e dell'Informazione "Guglielmo Marconi", Via dell'Università 50, Cesena, 47521 Italia.
[32]Cadi Ayyad University, Physics Department, Faculty of Science Semlalia, Av. My Abdellah, P.O.B. 2390, Marrakech, 40000 Morocco.
[33]University of the Witwatersrand, School of Physics, Private Bag 3, Johannesburg, Wits 2050 South Africa.
[34]Università di Catania, Dipartimento di Fisica e Astronomia "Ettore Majorana", Via Santa Sofia 64, Catania, 95123 Italy.
[35]INFN, LNF, Via Enrico Fermi, 40, Frascati, 00044 Italy.
[36]INFN, Sezione di Bari, via Orabona, 4, Bari, 70125 Italy.
[37]International Centre for Radio Astronomy Research, Curtin University, Bentley, WA 6102, Australia.
[38]University of Bari, Via Amendola 173, Bari, 70126 Italy.
[39]University Würzburg, Emil-Fischer-Straße 31, Würzburg, 97074 Germany.
[40]Western Sydney University, School of Computing, Engineering and Mathematics, Locked Bag 1797, Penrith, NSW 2751 Australia.
[41]Università di Salerno e INFN Gruppo Collegato di Salerno, Dipartimento di Fisica, Via Giovanni Paolo II 132, Fisciano, 84084 Italy.
[42]Università di Genova, Via Dodecaneso 33, Genova, 16146 Italy.
[43]Normandie Univ, ENSICAEN, UNICAEN, CNRS/IN2P3, LPC Caen, LPCCAEN, 6 boulevard Maréchal Juin, Caen, 14050 France.
[44]University of Granada, Dpto. de Física Teórica y del Cosmos & C.A.F.P.E., 18071 Granada, Spain.
[45]NIOZ (Royal Netherlands Institute for Sea Research), PO Box 59, Den Burg, Texel, 1790 AB, the Netherlands.
[46]Tbilisi State University, Department of Physics, 3, Chavchavadze Ave., Tbilisi, 0179 Georgia.
[47]Leiden University, Leiden Institute of Physics, PO Box 9504, Leiden, 2300 RA Netherlands.
[48]National Centre for Nuclear Research, 02-093 Warsaw, Poland.
[49]Institut Universitaire de France, 1 rue Descartes, Paris, 75005 France.
[50]University of Johannesburg, Department Physics, PO Box 524, Auckland Park, 2006 South Africa.
[51]Eberhard Karls Universität Tübingen, Institut für Astronomie und Astrophysik, Sand 1, Tübingen, 72076 Germany.
[52]Università di Pisa, Dipartimento di Fisica, Largo Bruno Pontecorvo 3, Pisa, 56127 Italy.
[53]Laboratoire Univers et Particules de Montpellier, Place Eugène Bataillon - CC 72, Montpellier Cédex 05, 34095 France.
[54]Friedrich-Alexander-Universität Erlangen-Nürnberg, Remeis Sternwarte, Sternwartstraße 7, 96049 Bamberg, Germany.
[55]Université de Haute Alsace, 68100 Mulhouse Cedex, France.
[56]University of Münster, Institut für Kernphysik, Wilhelm-Klemm-Str. 9, Münster, 48149 Germany.
[57]Utrecht University, Department of Physics and Astronomy, PO Box 80000, Utrecht, 3508 TA Netherlands.
[58]INFN, CNAF, v.le C. Berti-Pichat, 6/2, Bologna, 40127 Italy.

PoS(ICRC2021)1392