

Global Cosmics

Nicolas Arnaud (narnaud@lal.in2p3.fr)

Laboratoire de Physique des Deux Infinis Irène Joliot-Curie

(Université Paris-Saclay & CNRS/IN2P3)

European Gravitational Observatory (Consortium, CNRS & INFN)

On behalf of the **IPPOG Collaboration**

ICHEP – July 28, 2020

IPPOG-CONF-SLIDES-011



International Particle
Physics Outreach Group



Outline

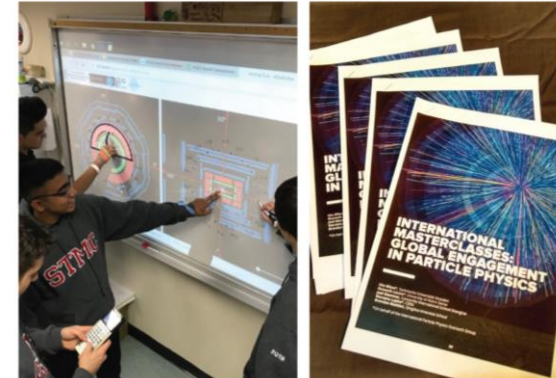
- The **IPPOG** Collaboration
- **Global Cosmics Group**
 - Why?
 - Who?
 - Student contests: **International Muon Week** and **International Cosmic Day**
- Some **special projects** involving **cosmic muons**
 - Polar Quest
 - Polar Stern
 - Balloon festival in Château d'Oex
 - High-school science club at Réunion
- Outlook

COSMIC SELFIE's 2019



The IPPOG Collaboration

- **Topics of interest**
 - Informal science education
 - Outreach for particle physics
- **Target audiences**
 - Teachers and students
 - Young people
 - The general public




→ **Statement from the 2020 Update of the European Particle Physics Strategy**
The International Particle Physics Outreach Group (IPPOG) has been established to streamline particle physics education at the high-school level and its mission could be expanded to provide public engagement material.

- **Flagship project:** the **International Masterclasses « Hands on Particle Physics »**
 - <http://www.physicsmasterclasses.org>
- A **wide multi-language resource database:** <http://ippog.org/resources>
 - **Curation in progress** to enhance its impact and make it easier to use
- More information: <http://ippog.org>
 - Website to be upgraded in the coming year

Global Cosmics Group

- Particle accelerators / large-scale experiments out of reach for most people
 - **Cosmic muons are not!**
 - They are everywhere: rate $\sim 1 / \text{cm}^2 / \text{minute}$ on the ground
- **Many diverse educational programs** based on cosmic muons worldwide
 - **A variety of detectors:** technology, size, accessibility, level of difficulty to use
 - **Applications and connections to curriculum for everybody!**
- **Global Cosmics initiative:** seeking for synergies among all these projects
 - **IPPOG** provides a forum where experts can meet, discuss, exchange ideas, etc.
- Not a new idea: in the air for at least two decades
 - **WALTA** (WA state) → **HISPARC** (NL) at the turn of the 21st century
 - **Eurocosmics** EU proposal in 2006-2007: not funded
- Starting point of the current effort: **2-day workshop** in **Rome** on **February 2017**
 - Indico: <https://indico.cern.ch/event/596002>

Workshop high school cosmic ray experiments

 15 Feb 2017, 09:30 → 16 Feb 2017, 17:00 Europe/Berlin

 CENTRO FERMI, ROME

Participating projects

Country	Name	Website
FINLAND	Callio Lab	https://calliolab.com
FRANCE	Cosmos à l'École	http://www.sciencesalecole.org
FRANCE	e-PÉRON	https://eperon.omp.eu
GERMANY	Netzwerk Teilchenwelt and Cosmic@Web	https://www.teilchenwelt.de https://cosmic.desy.de
ITALY	Extreme Energy Events EEE	http://eee.centrofermi.it
ITALY	OCRA	https://web.infn.it/OCRA
NETHERLANDS	HiSPARC	https://www.hisparc.nl/oud/en
POLAND	Cosmic-Ray Extremely Distributed Observatory (CREDO)	http://credo.science https://www.zooniverse.org/projects/credo/dark-universe-welcome
RUSSIA	Showers of Knowledge	http://livni.jinr.ru/index.php?lang=en
SPAIN	Cazadores de Rayos Gamma	http://www.cazadoresderayosgamma.com
SWEDEN	Cosmic ray outreach in Stockholm	http://vetenskapenshus.se.loopiadns.com/info-kosmisk-strålning
TAIWAN	QuarkNet-TW	http://hsiaoscu.pbworks.com/w/page/19665685/Quarknet-TW-page
UK	Detecting Cosmic Rays	http://www.ep.ph.bham.ac.uk/twiki/bin/view/General/QuarkNet
UK	High School Project on Astrophysics Research with Cosmics (HiSPARC)	http://www.hisparc.nl/en
UK	QuarkNet Cymru	http://blogs.cardiff.ac.uk/physicsoutreach/2016/11/03/quarknet-cymru
USA	Cosmic Ray e-Lab Studies	https://www.i2u2.org/elab/cosmic/home/project.jsp

→ Outreach, education and citizen science projects

- Don't see your favorite one listed above? Tell them to contact us!

Participating projects

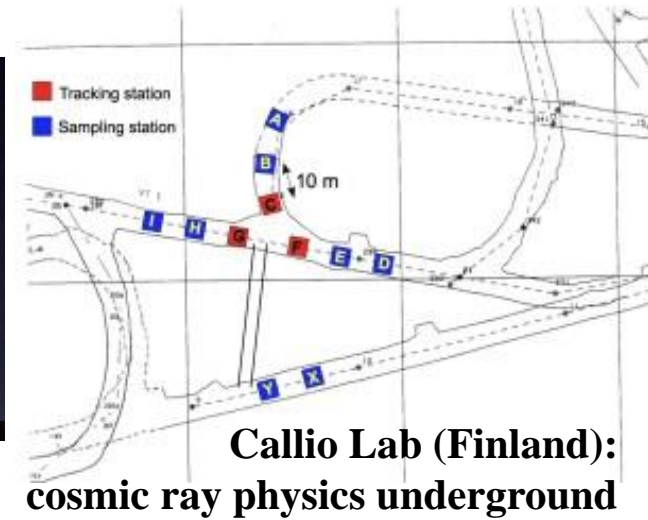
**Cosmodétecteurs
(France)**



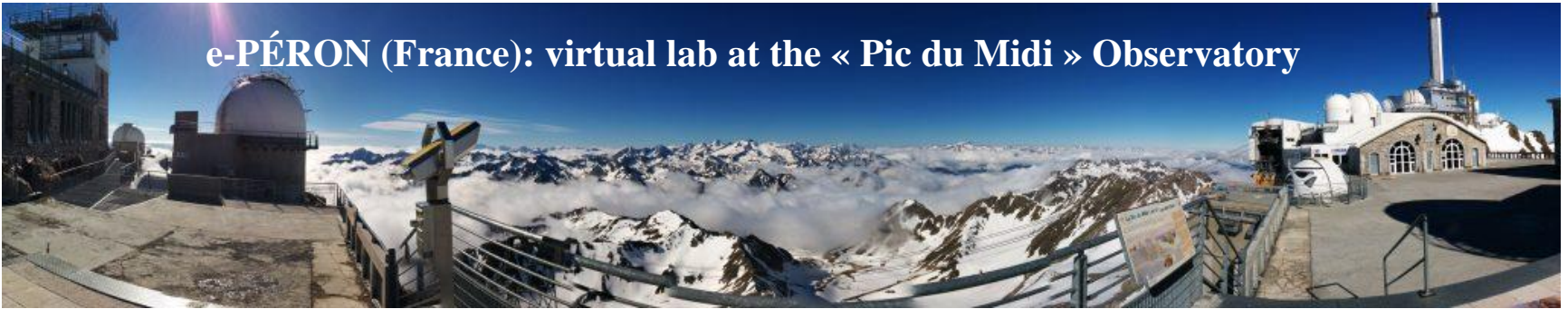
Spain

**Python-based
analysis of
MAGIC data**

Cazadores de Rayos Gamma



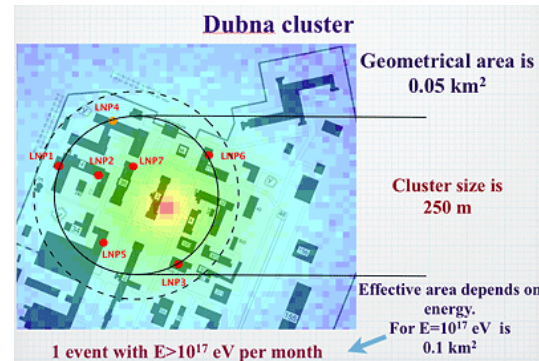
e-PÉRON (France): virtual lab at the « Pic du Midi » Observatory



**Cosmic@Web (Germany):
easy access to real
long-term measurements**

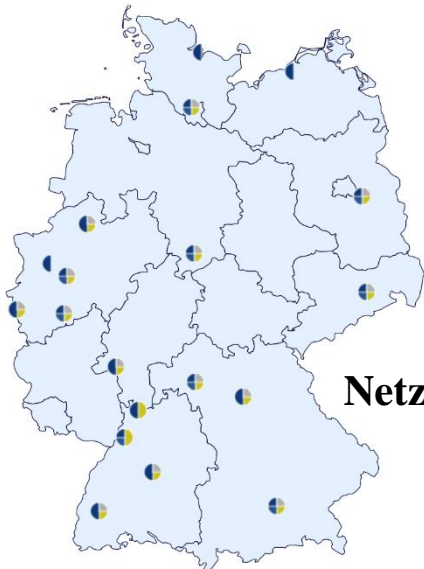
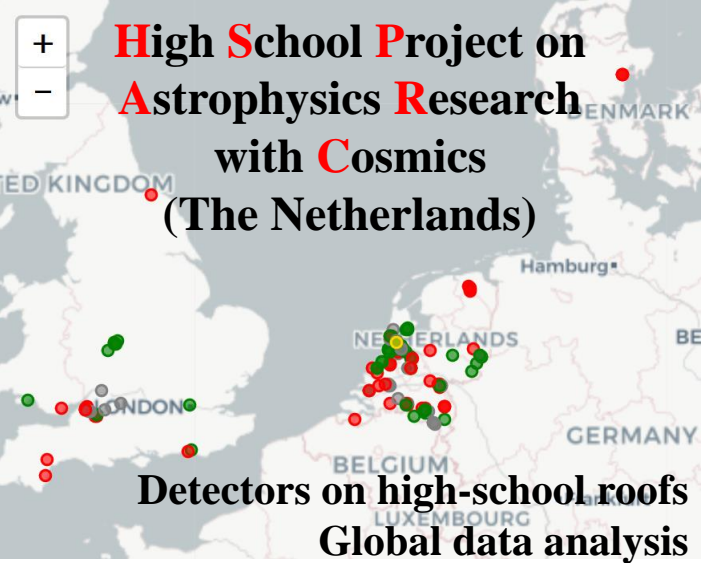
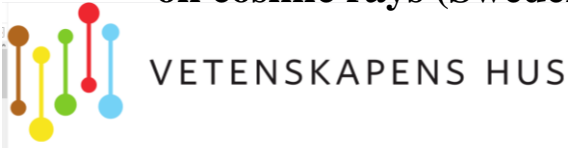


Dubna cluster



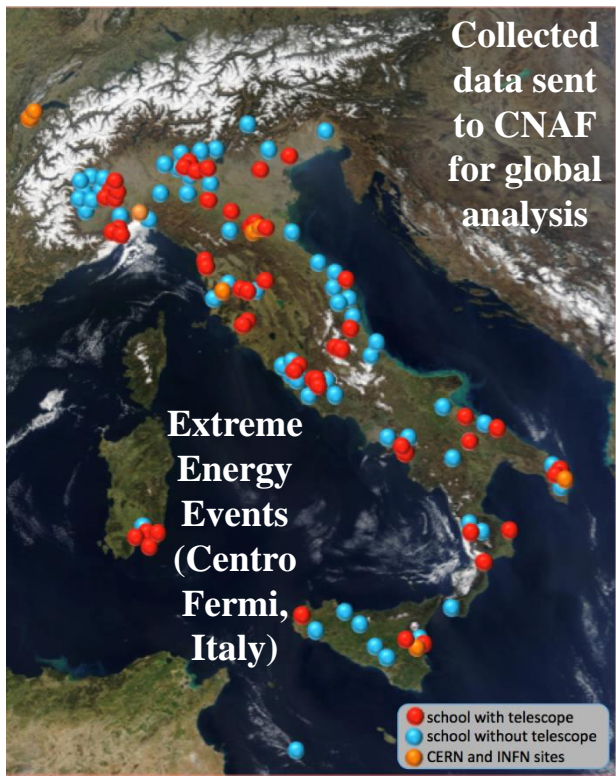
**Showers of Knowledge
(Russia):
Distributed Detector
for Studying Broad
Atmospheric Showers**

High-school projects on cosmic rays (Sweden)



**Netzwerk Teilchenwelt (Germany):
19 Astroparticle Institutes**

Participating projects



Particles detected by smartphone cameras

Cosmic-Ray Extremely Distributed Observatory (Poland)

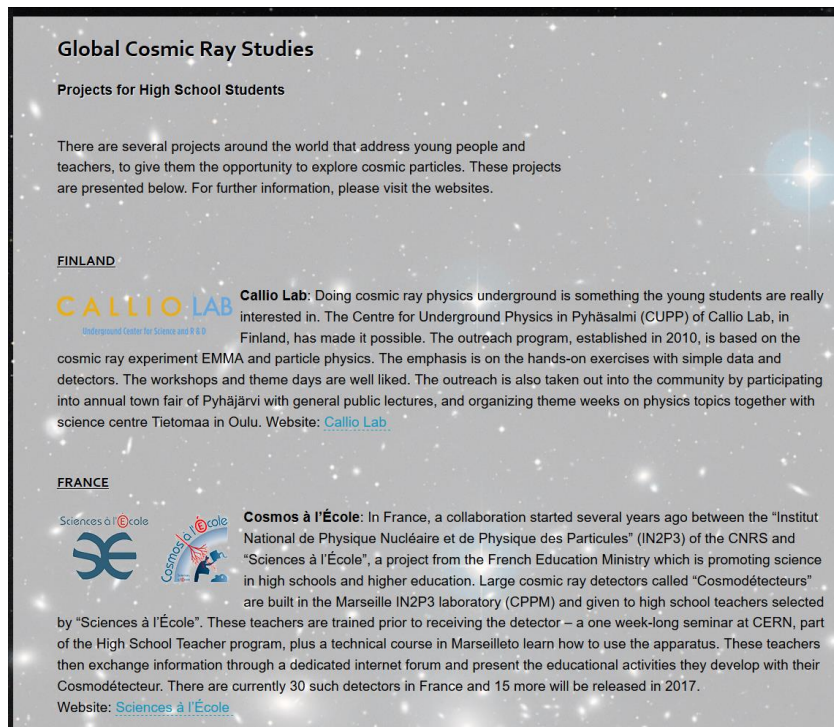
24 (1539758314040)
2018-10-17 06:38:34.040
Hit position XY: [1216, 568]
Rozmiar wycinka obrazu: 60x60
Brightest: 255
Average: 17.6
Blacks: 999.8% (37)
Gravity: X:-0.0 Y:-0.1 Z:9.7
Azimuth: 359.0°

Citizen science



Global Cosmics Group

- **Open group**
 - **Mailing list:** contact us to become member
- **Meeting (in person) once a year at the IPPOG spring meeting**
 - **Telecons** organized in between annual meetings, when there is a need
- **Dedicated website:** <https://icd.desy.de/e49245>
 - **With more information on all participating projects**




Global Cosmic Ray Studies



Projects for High School Students

There are several projects around the world that address young people and teachers, to give them the opportunity to explore cosmic particles. These projects are presented below. For further information, please visit the websites.

FINLAND

CALLIO LAB  **Callio Lab:** Doing cosmic ray physics underground is something the young students are really interested in. The Centre for Underground Physics in Pyhäsalmi (CUPP) of Callio Lab, in Finland, has made it possible. The outreach program, established in 2010, is based on the cosmic ray experiment EMMA and particle physics. The emphasis is on the hands-on exercises with simple data and detectors. The workshops and theme days are well liked. The outreach is also taken out into the community by participating into annual town fair of Pyhäjärvi with general public lectures, and organizing theme weeks on physics topics together with science centre Tietomaa in Oulu. Website: Callio Lab

FRANCE

  **Cosmos à l'École:** In France, a collaboration started several years ago between the "Institut National de Physique Nucléaire et de Physique des Particules" (IN2P3) of the CNRS and "Sciences à l'École", a project from the French Education Ministry which is promoting science in high schools and higher education. Large cosmic ray detectors called "Cosmodétecteurs" are built in the Marseille IN2P3 laboratory (CPPM) and given to high school teachers selected by "Sciences à l'École". These teachers are trained prior to receiving the detector – a one week-long seminar at CERN, part of the High School Teacher program, plus a technical course in Marseille to learn how to use the apparatus. These teachers then exchange information through a dedicated internet forum and present the educational activities they develop with their Cosmodétecteur. There are currently 30 such detectors in France and 15 more will be released in 2017. Website: Sciences à l'École


International Muon Week



- <https://quarknet.org/content/international-muon-week>
 - Organized by [QuarkNet](#)
- Participating teams should let their detectors run 24/7
 - Data and measurements shared on a common website
- Last edition: April 1-5, 2019
 - 54 participating groups
 - ◆ Many from Italy (EEE project)

International Muon Week

Worldwide Cosmic Ray Flux and Time-of-Flight Study



International Muon Week

Join us!

Measure the speed of cosmic ray muons!

Check here early in the year for the next International Muon Week (IMW) details.

Participants share data worldwide. By sharing data, we are developing a detector research community and connecting students around the world.

Participants collect and analyze data and share results on an interactive Google map. We pair schools to facilitate student discussion.

We encourage students to ask questions about shared data and how other schools participate in our cosmic ray studies community.



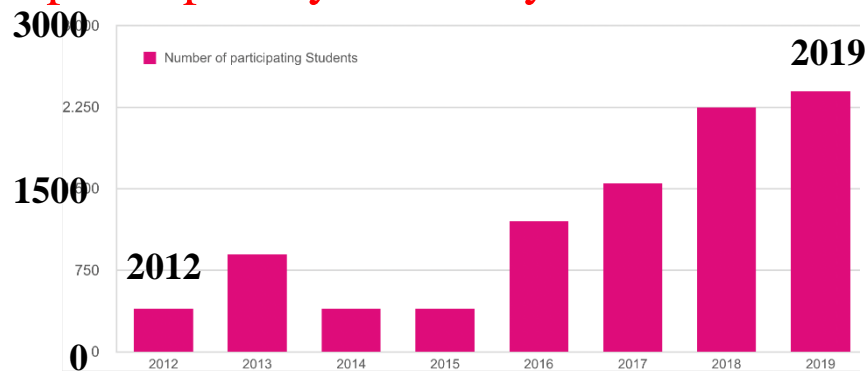


International Cosmic Day

- <https://icd.desy.de>
 - Organized by DESY
- All participating groups work on same topic
 - Like an international collaboration
 - Results discussed in videoconferences and documented in proceedings
 - Booklet
 - Quiz on kahoot + Instagram/FB contest
- Last edition: November 6, 2019
 - Strong participation from Italy as well: EEE and OCRA

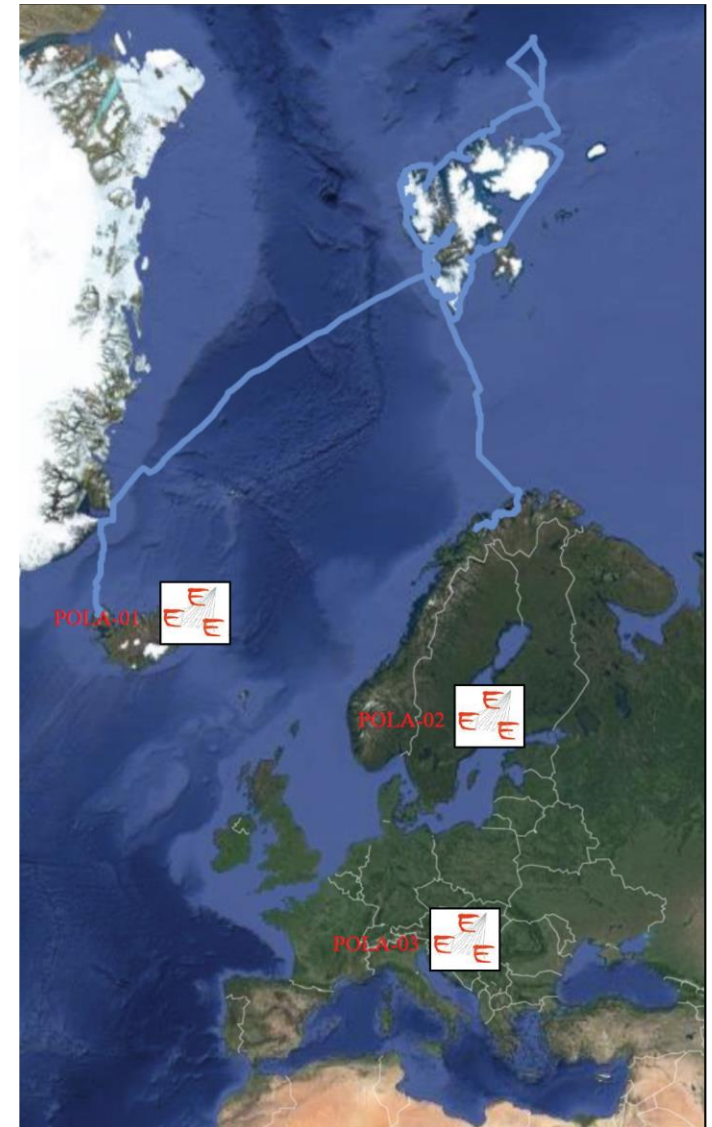


→ Growing number of participants year after year



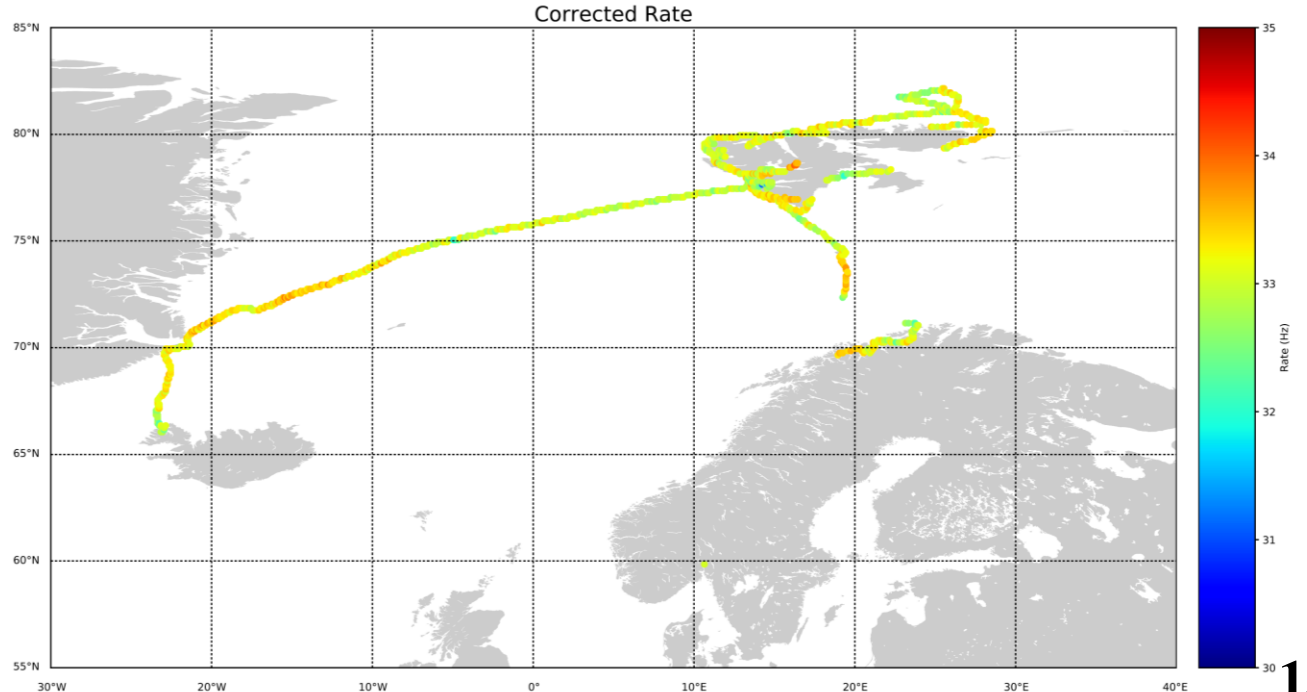
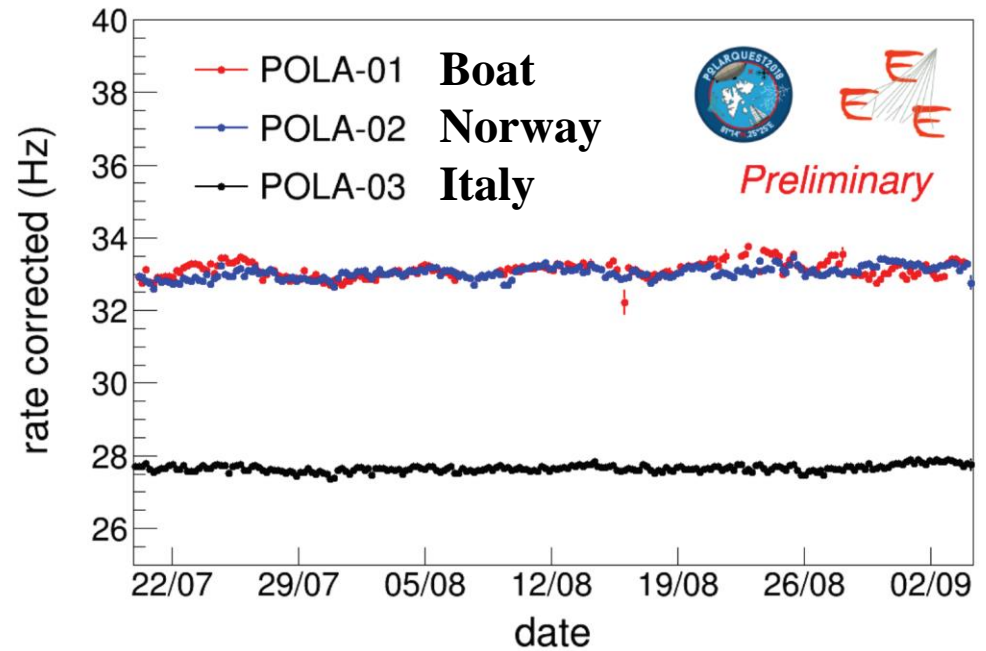
Polar Quest

- Part of the EEE project
 - **Detectors sailing to North Pole**
 - Built at CERN by high-school students
 - ◆ 1 on the boat
 - ◆ 1 in Norway
 - ◆ 1 in Italy
- **Historical background:**
Airship Italia – 1928, Umberto Nobile



Polar Quest

- Corrected rates
 - Barometric effect
 - Boat rolling



Polar Stern


- **Scintillation counters** on board
 - **Data since 2012**, including **weather**
- **One of the nine experiments** whose data are available online
 - <http://cosmicatweb.desy.de>
 - Reference: <https://pos.sissa.it/358/419>



Credit: Levy Hoffman, AWI

COSMIC@WEB

Online Analyse Tools for Cosmic Particle Data



Language: English / German

With Cosmic@Web's online analysis tools, you can easily analyse real experimental data from a global network of cosmic particle detectors. Read more about the tools of Cosmic@Web in the [documentation](#). The tutorial (only in German until now) explains how to start with an analysis. Introductory materials to the topic of [cosmic particles](#) and description of the [experiments](#) can be found on the websites. [Work like a real scientist](#) and do your own astroparticle research!

1. Data Array

Choose Dataset

Experiment: Polarstern

Dataset: 2020-PS-nm-mt-01-04 - Po

Plot Type: 1D-Histogram

Choose Variables

x-Variable:

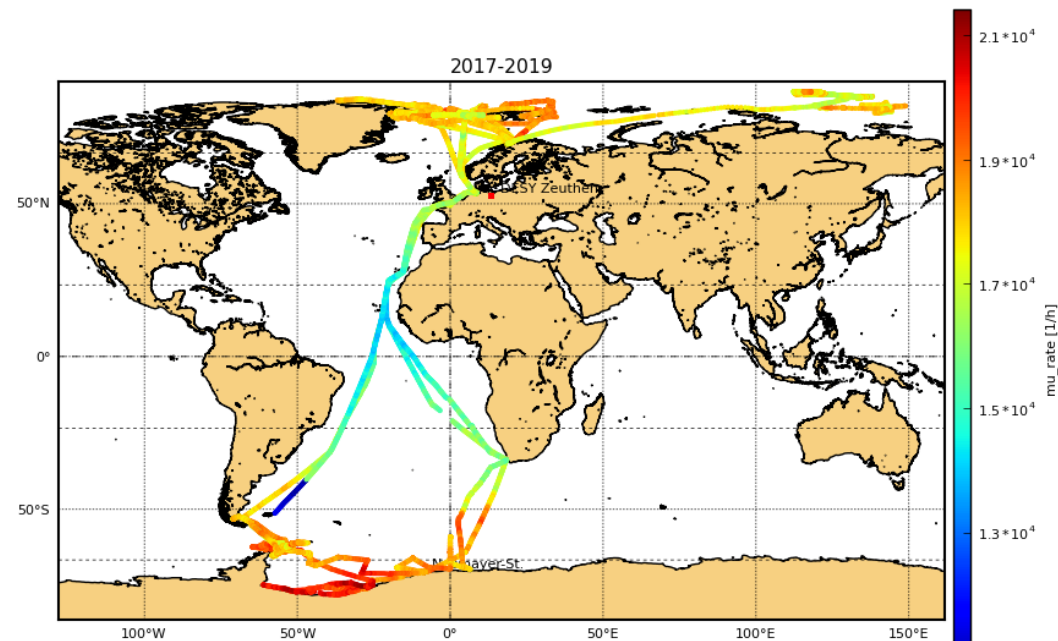
Plot Option

Title:

Legend

Position: automatically

Reset Plot Creation



Physics at an international hot-air balloon festival

- **Château d'Oex**
 - Rural village in Switzerland
 - Yearly international hot-air balloon festival since 1979
 - Balloon museum
- **Obvious connection with cosmic muons**
 - Balloon flights to see how ionization evolves with altitude
 - ◆ 'Local' pioneer: **Albert Gockel** (1909)
 - ◆ 1912: 10 flights from **Viktor Hess** up to 5,350 m
 - ◆ 1913-1914: **Werner Kolhörster** flies up to 9,000 m



Physics at an international hot-air balloon festival

- Cosmic rays → Particles → Universe

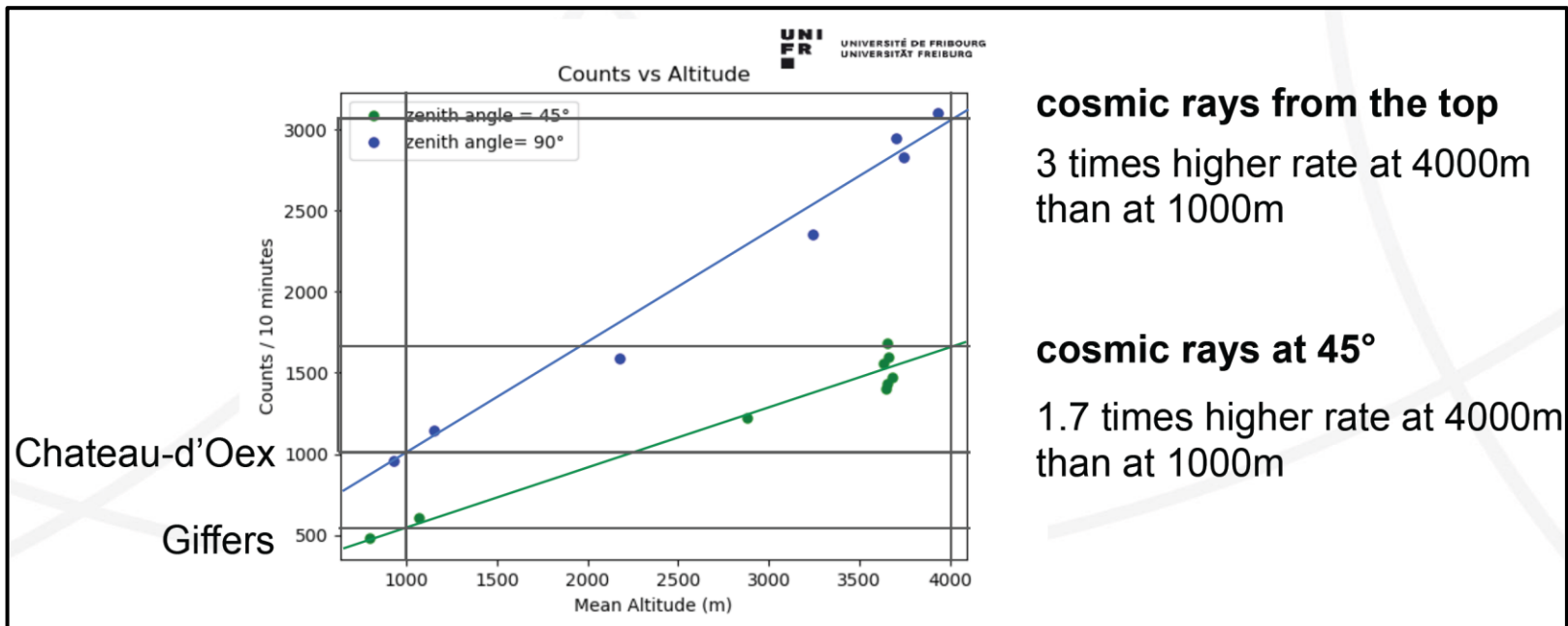
- Original items on display

- Interleaving with art

→ Win-win operation

- Museum: significant increase of the number of visitors

- And a balloon flight (January 25, 2020) with modern cosmic muon detectors on board



Réunion: journey of a portable cosmic muon detector

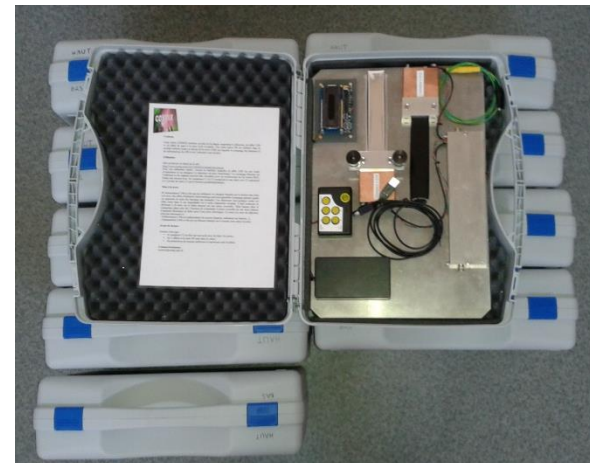
- **Réunion**

- French island in the Indian Ocean, east of Madagascar: **sea**
- Born from a volcano hot spot: **mountains**
- Southern hemisphere:
base for French missions to southernmost territories

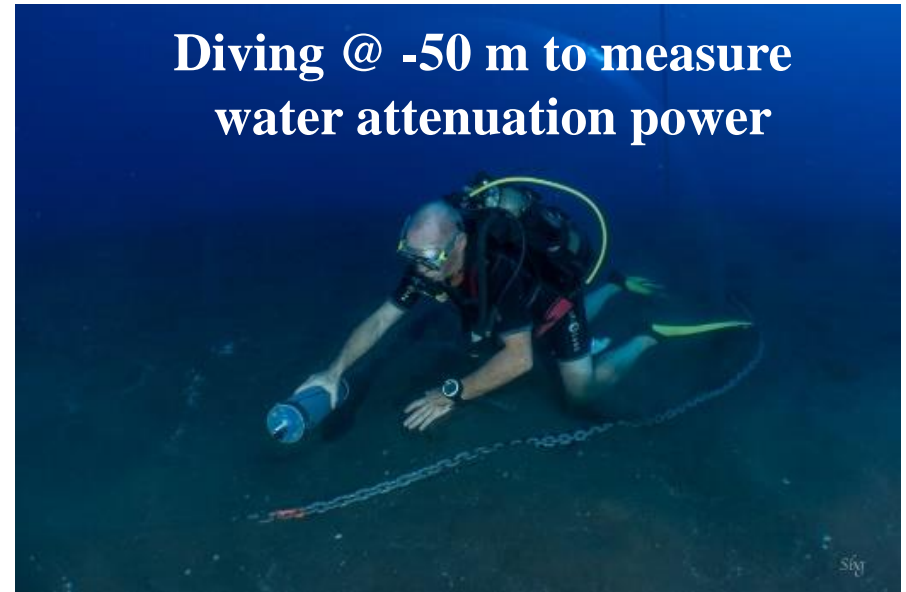
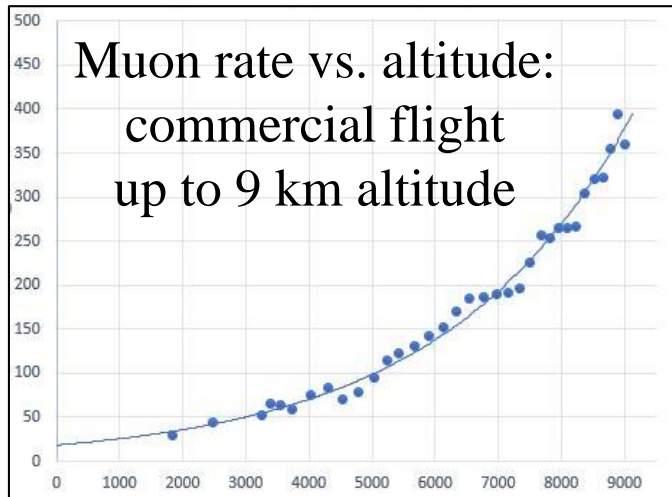
- **Initial trigger: teacher participating to the 2013 French Teachers Programme (FTP) @ CERN**

→ « **Atelier des deux Infinis** » in local high-schools

- 1+ teacher sent yearly to FTP
- A core team of a handful of teachers
- ~30 students a year
- Scientific trips to mainland France
- HSSIP, S'Cool LAB, science contests
- Only « **cosmodétecteur** » overseas
- **COSMIX: a portable cosmic muon detector** (CENBG: IN2P3 lab)



Réunion: journey of a portable cosmic muon detector



**Study of the latitude effect: trip by boat
to the French Southern and Antarctic Lands**



The same
COSMIX
detector
in all cases!

Next step: Antarctica!
→ Agreement with
the French Navy,
based on the success
of the first trip

Outlook

- IPPOG's **Global Cosmics Group** (created in 2017) reaching cruising speed
 - A forum allowing all existing projects to get in touch and exchange
 - ◆ Educational and scientific (publication) endeavors
 - Growing collaboration with worldwide events like **IMW** and **ICD**
 - Some activities delayed or slowed down due to the covid-19 pandemic
- Regular reports of ongoing / past actions
 - Give ideas to others
 - ◆ Creativity, adaptation to local environment and resources
 - Foster projects in preparation
 - Events that cannot be easily redone boost motivation and energy anyway
- Cosmic muons are really the front door for global, multidisciplinary projects targeting a wide range of audiences and allowing direct involvement from the public
 - A 'concrete' entry point leading to current, state-of-the-art science
 - Links with art can help attracting people's interest