



The online laboratories for OCRA Outreach Cosmic Ray Activities INFN project

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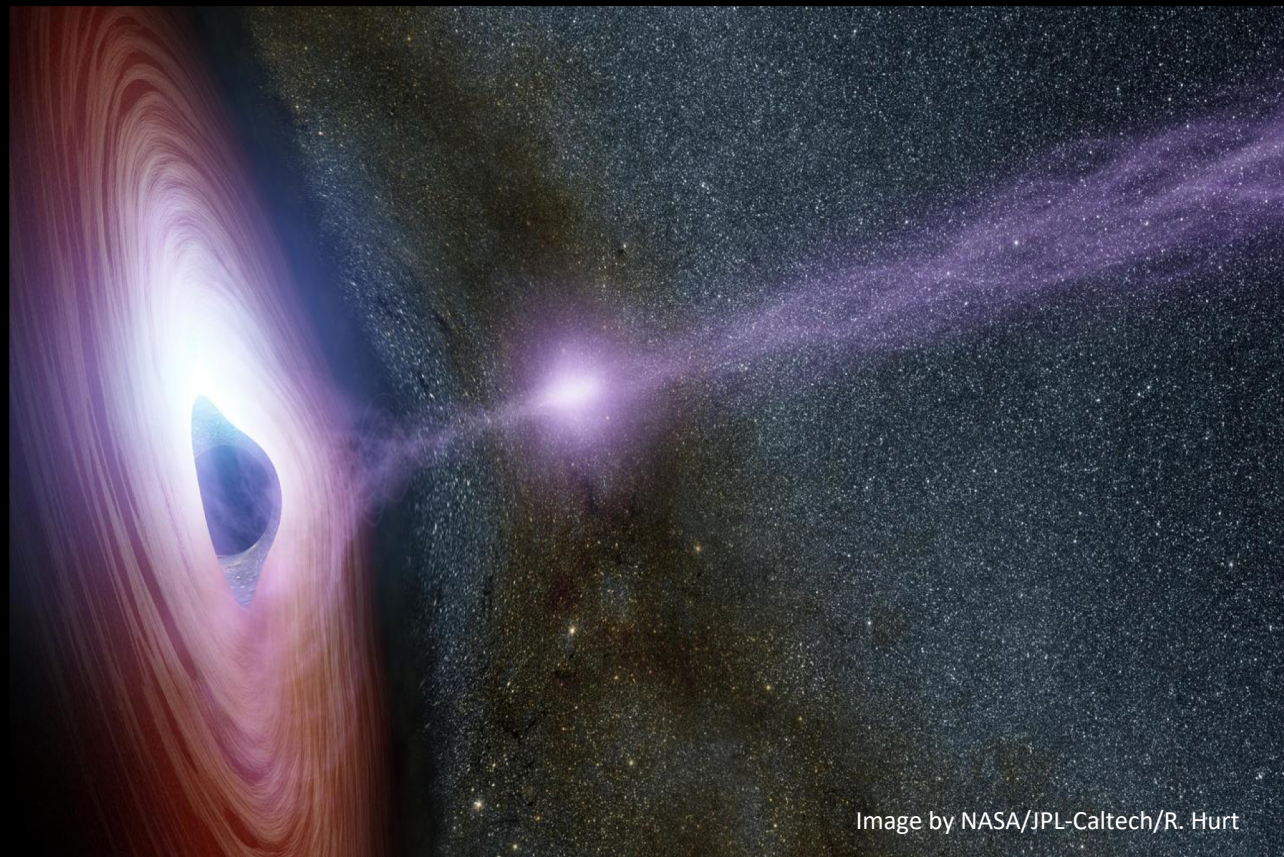
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<https://web.infn.it/OCRA/>

ICRC2021 | 12 – 23 July 2021

Cosmic radiation: a key to our knowledge of the Universe

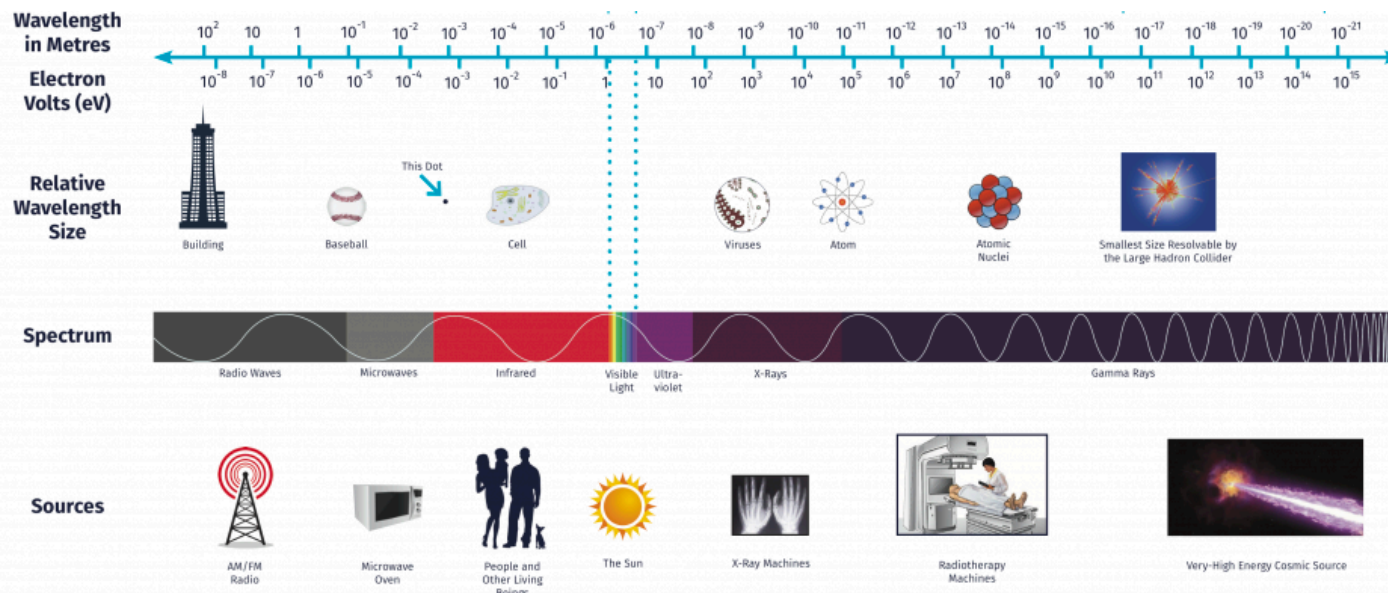




INFN
OCRA

Cosmic radiation: an excellent educational laboratory

The Electromagnetic Spectrum





OCRA - Outreach Cosmic Ray Activities

OCRA - Outreach Cosmic Ray Activities founded in 2018 within the National Institute of Nuclear Physics (INFN), aims to collect the many public engagement activities in the field of cosmic ray physics already present locally and to disseminate them nationally.

see the contribution by S. Hemmer in this conference

Percorso Raggi Cosmici



1. Particelle dallo spazio
2. La conferma di Hess
3. Cosa sono i raggi cosmici
4. Dove si studiano i raggi cosmici
5. I Muoni
6. L'astronomia multi-messaggera
7. Ricadute tecnologiche
8. In laboratorio con noi

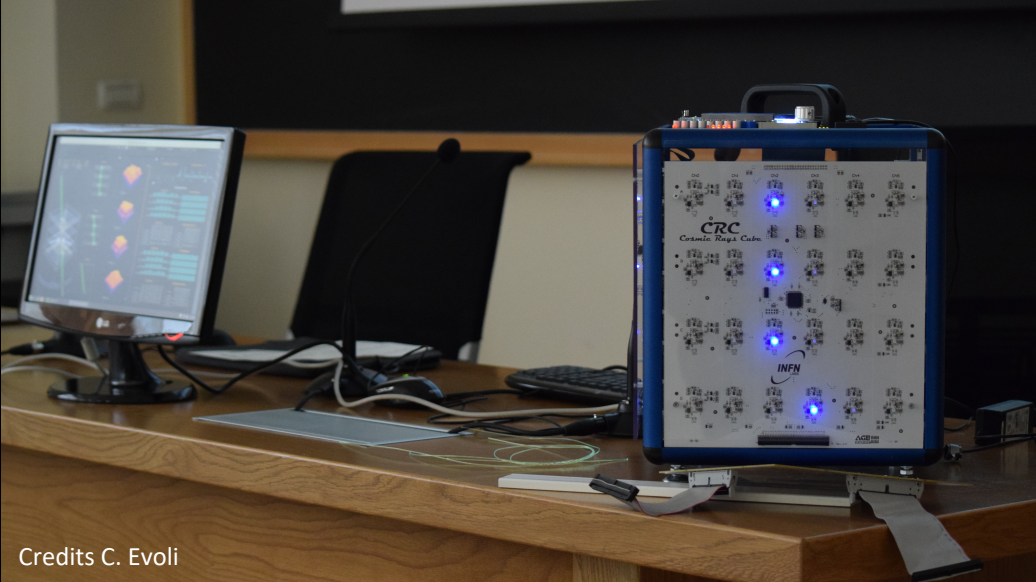
Il percorso presenta una breve introduzione alla fisica dei raggi cosmici, particelle provenienti da tutte le possibili direzioni dello spazio, da sorgenti che ancora oggi in molti casi sono sconosciute, come sconosciuti sono alcuni fenomeni ad essi associati. Lo studio dei raggi cosmici, cominciato nei primi anni del '900, ha dato inizio alla fisica delle particelle elementari e continua a dare importanti contributi per la comprensione dell'Universo.

Completano il percorso esperimenti didattici e per la ricerca inseriti nella sezione "In laboratorio con noi", buon divertimento!

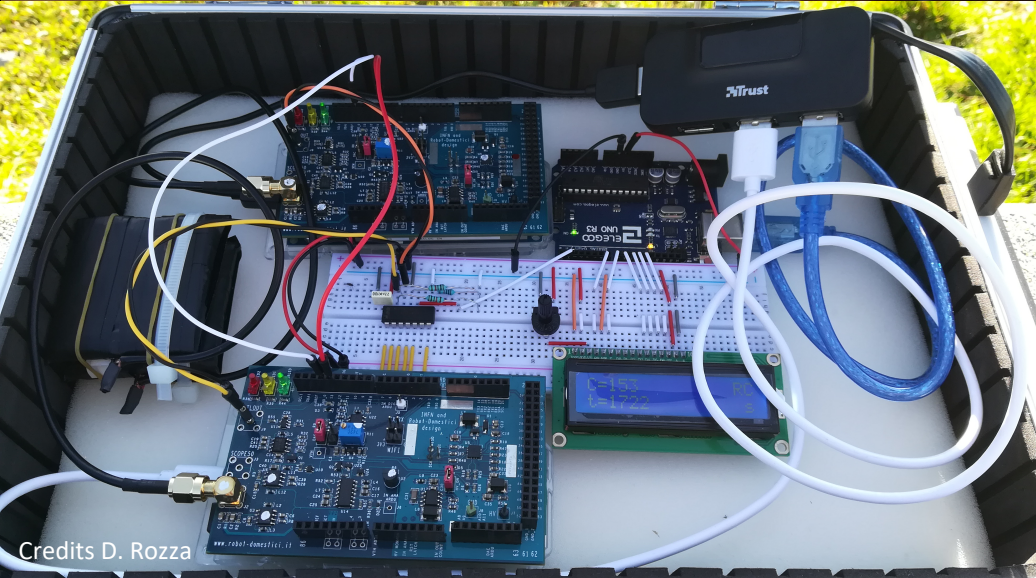
The cosmic ray pathway

- Use of instrumentation and of experimental data to create an online pathway to allow **students** to acquire the notions useful to understand what cosmic rays, extensive air shower, muons and other quantities useful to understand cosmic radiation are.
- Introduction also to the **instruments for cosmic ray detections**, especially to perform measurements of atmospheric muons under different conditions.

In the lab with us: the laboratories are set up with simple devices for the detection of cosmic muons and describe their behaviour. Each one is dedicated to the description of an **experimental measurement** and with the data students are guided through the analysis that allows the measurement of a physical quantity of **muons**.



Credits C. Evoli



Credits D. Rozza

Laboratories from didactics ... to research

C. Aramo | ICRC2021



Credits NASA



Credits L. Caccianiga

OUTLINE



The screenshot shows the INFN OCRA website with a dark blue header containing navigation links: HOME, INTERNATIONAL COSMIC DAY, STAGE, PERCORSO RAGGI COSMICI, LABORATORIO, and GLOSSARIO. The main content area is titled "Laboratori" and is divided into two sections: "Esperimenti didattici" and "Esperimenti per la ricerca".

Esperimenti didattici

Gli esperimenti descritti di seguito sono realizzati con semplici dispositivi con i quali è possibile rivelare il loro comportamento. In ogni esperimento è dedicato alla descrizione di una misura sperimentale e come sarete guidati nell'analisi che porterà alla misura di una grandezza fisica dei muoni:

- Misura della rate di muoni cosmici e ricostruzione della traccia
- Misura della distribuzione angolare dei muoni
- Misura dell'intensità dei muoni in funzione dell'angolo di Zenith
- Misura dei muoni in funzione dell'altezza in atmosfera
- Misura dei muoni in funzione della profondità in acqua

Esperimenti per la ricerca

Alcuni esperimenti hanno reso pubblici parte dei loro dati che è possibile scaricare direttamente dalla questa sezione verrete guidati nell'esplorazione di tali dati e nella loro analisi e potrete confrontare i vostri risultati con quelli pubblicati.

- L'osservatorio Pierre Auger

A sidebar menu on the right lists the following items:

- MISURA DELLA RATE DI MUONI COSMICI
- MISURA DELLA DISTRIBUZIONE ANGOLARE DEI MUONI
- MISURA DEI MUONI IN FUNZIONE DELL'ANGOLO DI ZENITH
- MISURA DEI MUONI IN FUNZIONE DELL'ALTEZZA IN ATMOSFERA
- MISURA DEI MUONI IN FUNZIONE DELLA PROFONDITÀ IN ACQUA
- L'OSSERVATORIO PIERRE AUGER
- RACCOLTA DI MATERIALE PER DOCENTI

- Measurement of the cosmic muon rate and track reconstruction
- Measurement of muon angular distribution
- Measurement of muon intensity as a function of Zenith angle
- Measurement of muons as a function of height in the atmosphere
- Measurement of muons as a function of depth in water
- Pierre Auger Observatory
- Teachers' area

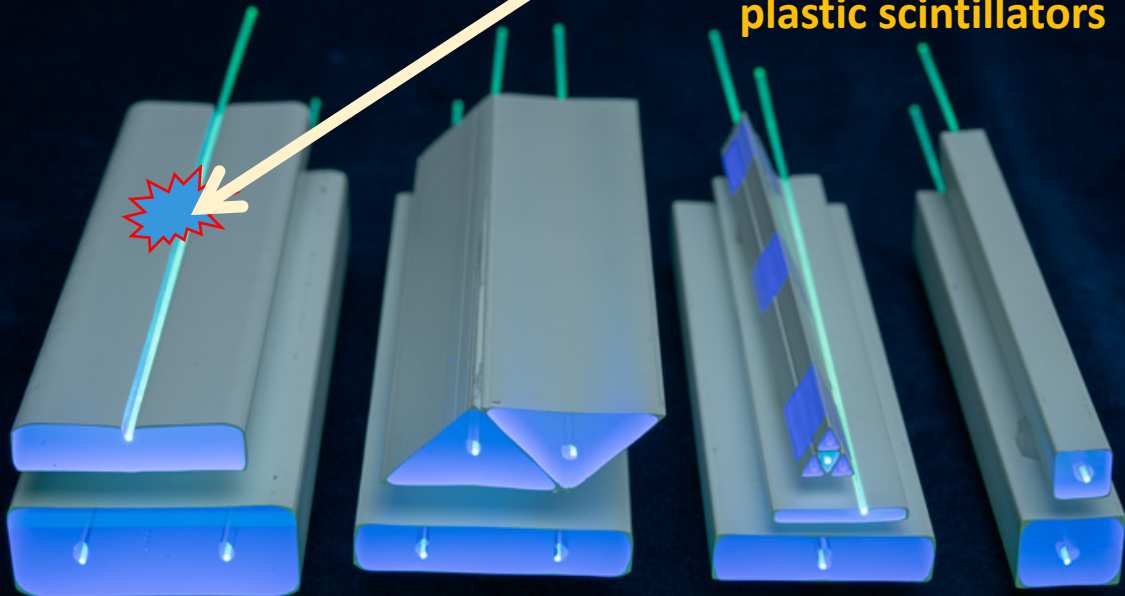


Measurement of the cosmic muon rate and track reconstruction with Cosmic Ray Cube

4 double-plane horizontal scintillation levels orthogonal to each other

The data can then be analyzed to reconstruct the tracks left by muons in the telescope

plastic scintillators

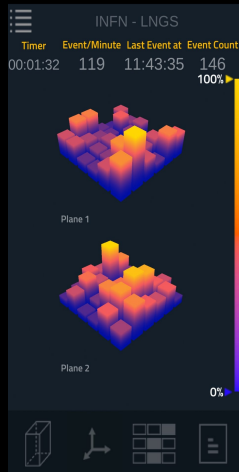
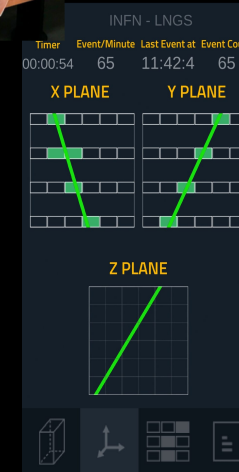
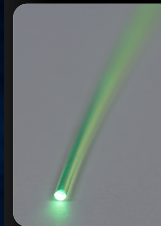


COSMIC RAYS LIVE

Timer	Event/Minute	Last Event	Event Count
00:01:36	70	09:19:36	110

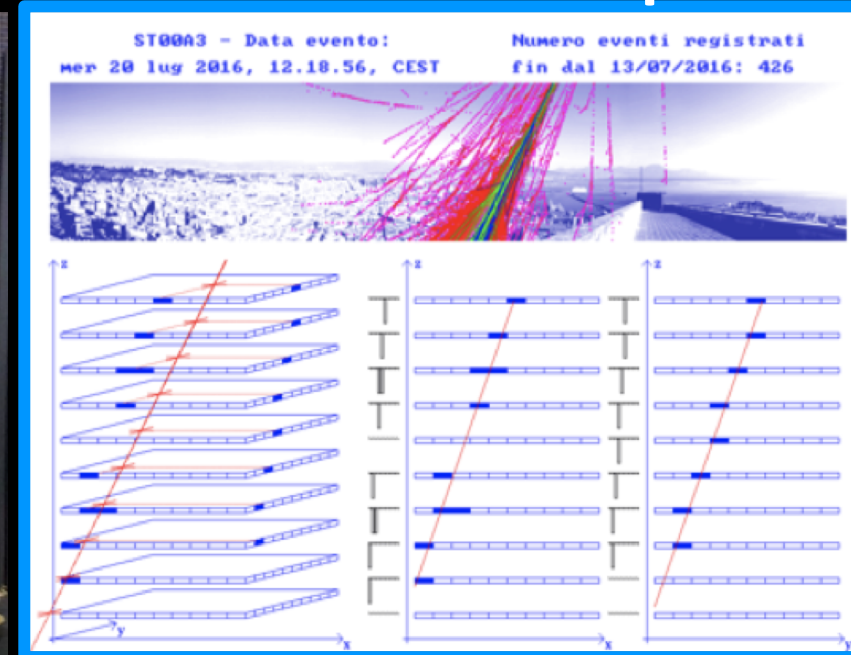
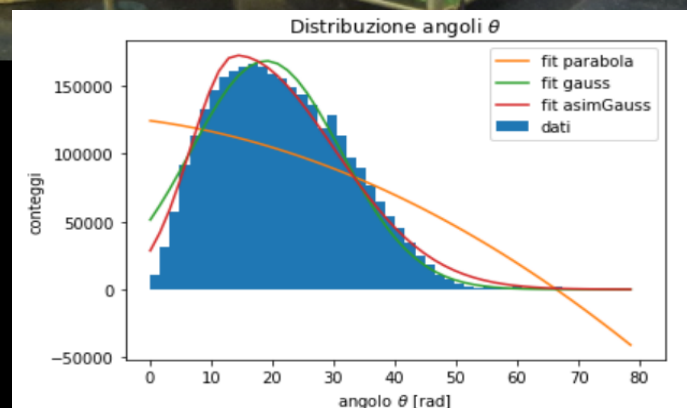
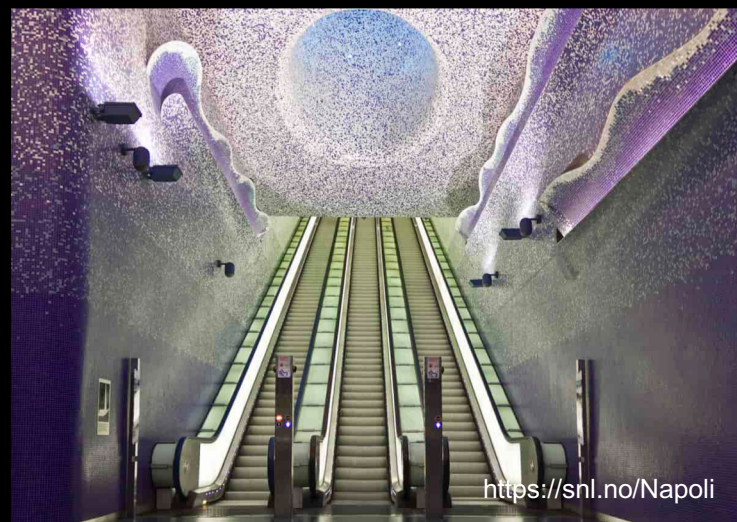
PLAY STORE
APPLE STORE

WLS SiPM



<https://web.infn.it/OCRA/misura-della-rate-di-muoni-cosmici/>

Measurement of muon angular distribution with Toledo Telescope



The reconstruction of the muon trajectory is described step by step, and two exercises are developed with Python Google Colab scripts to draw histograms of the distributions of the muon arrival directions, as well as to find which of the proposed curves best fits the distributions found by the fit procedure.

<https://web.infn.it/OCRA/misura-della-distribuzione-angolare-dei-muoni/>

Measurement of muon intensity as a function of Zenith angle

International Cosmic Day



Muoni

Misura del flusso di raggi cosmici in funzione dell'angolo di zenit

Il flusso di muoni a terra non è uniformemente distribuito. ... Come è spiegato in Review of Particle Data (1), la distribuzione dei valori misurati può essere descritta usando una funzione \cos^2 .

...

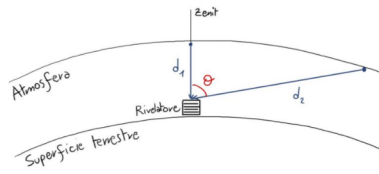


Fig.1: Rappresentazione dei cammini (d_1 e d_2) effettuati da due muoni prodotti in atmosfera e diretti verso il rivelatore posto sulla superficie terrestre.

LA TECNICA SPERIMENTALE

Il numero di muoni (conteggi, C) incidenti nel rivelatore in un intervallo di tempo (T) prende il nome di rate ($R=C/T$) espresso in particelle al secondo. La presa dati risulta quindi sintetizzata in questo modo:

...

a) $\theta_{\text{zen}} = 0^\circ$ b) $\theta_{\text{zen}} = 30^\circ$ c) $\theta_{\text{zen}} = 60^\circ$

...

Raccolta dati

Per questa parte dell'esperienza è conveniente utilizzare un foglio di calcolo, puoi usare quello che preferisci, o che usi già, per esempio Excel, Calc o un foglio di lavoro google.

Noi li abbiamo inseriti in un foglio di lavoro google che trovi a: shorturl.at/kvEOo

...

ANALISI DEI DATI

1. Calcolare il rate dei muoni: $R = C / T$ (part/sec) per ciascun angolo e associare il relativo errore statistico

...

Misure Flusso vs Angolo

File Modifica Visualizza Inserisci Formato Da

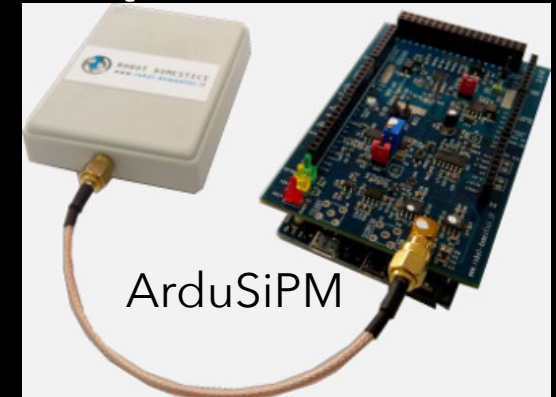
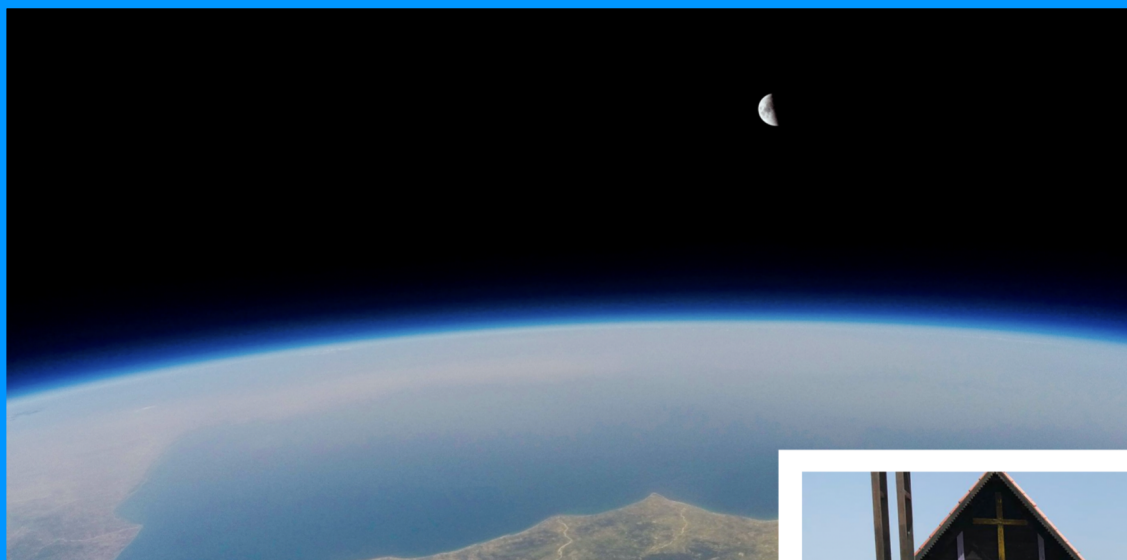
100% Solo visualizzazione

SxT ScienzaPerTutti

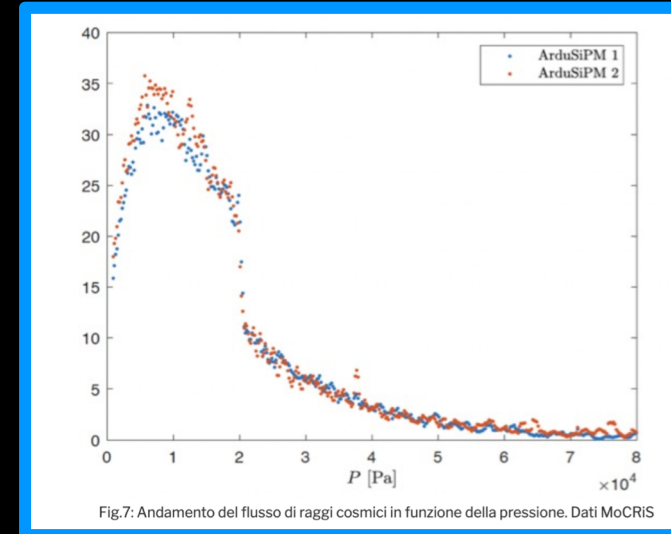
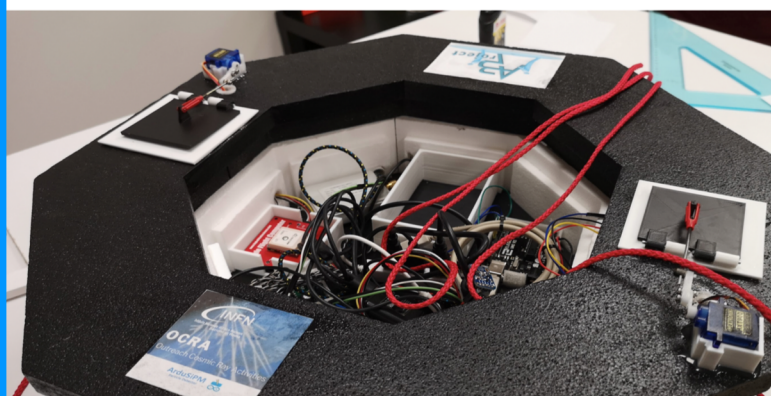
angle* [deg]	counts [in 100 s]	counts [in 100 s]	counts [in 100 s]
0	64	71	66
15	59	73	55
30	52	56	60
45	36	44	34
60	30	28	24
75	24	20	15
90	7	8	7
-15	74	65	72
-30	65	55	43
-45	34	42	42
-60	38	30	22
-75	16	15	13
-90	9	14	15

*) l'angolo in tabella è l'angolo formato tra lo Zenit e l'asse dello strumento, con segno positivo se l'inclinazione è verso EST

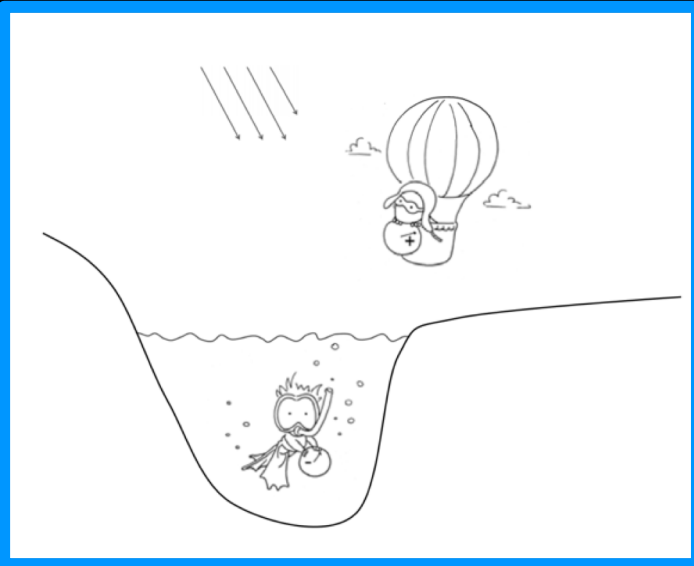
Measurement of muons as a function of height in the atmosphere



see the contribution by V. Bocci
in this conference



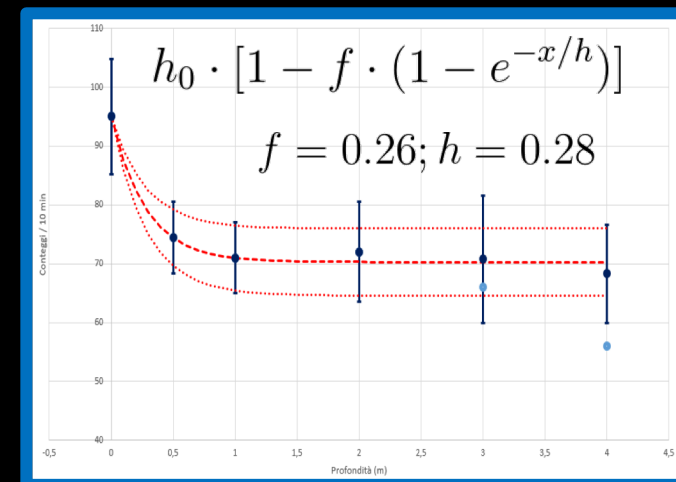
Measurement of muons as a function of depth in water



- Geiger counters equipped with a high-precision counter tube to detect alpha, beta and gamma rays
- The data are stored in an internal memory, and can be read via a USB interface.
- Using an Excel spreadsheet, the decrease of events as a function of depth is verified



Pacini @ Accademia Navale - Livorno



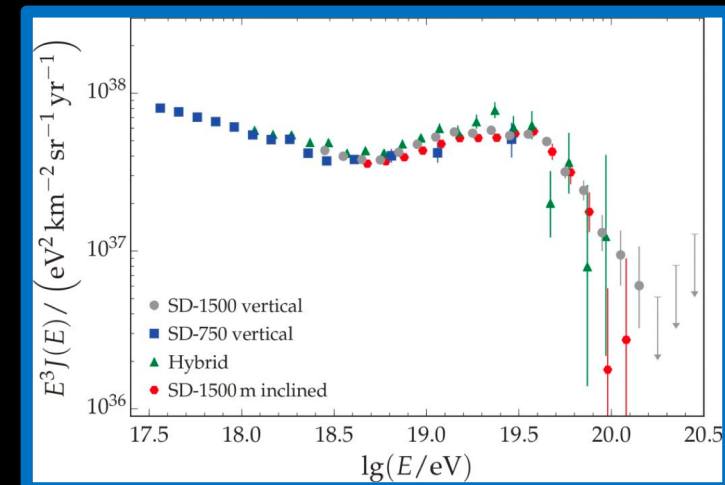
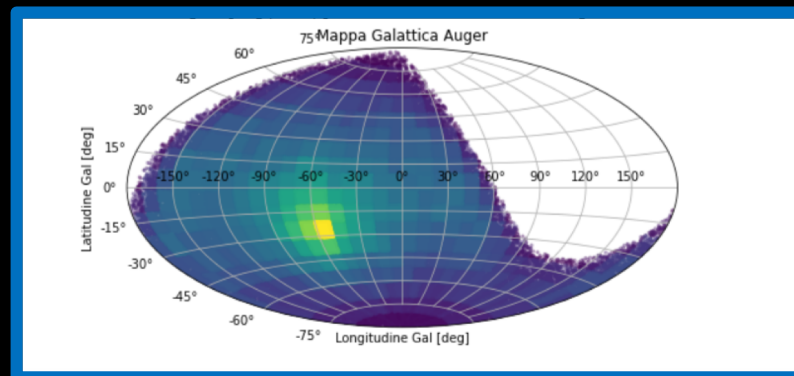
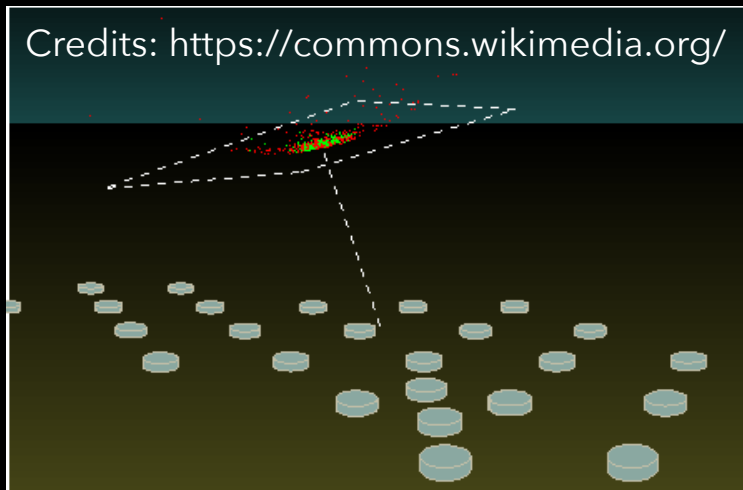


Pierre Auger observatory

The Observatory has made public 10% of the data acquired so far (see the contribution by V. Scherini in this conference), which can be used to carry out simple data analysis exercises reported in the online pathway

Three interactive exercises:

- spectrum of primary cosmic rays
- galaxy map
- search for excesses of very high energy cosmic rays



Each exercise is carried out step-by-step using a notebook provided by Google Colab and the Python programming language.

<https://web.infn.it/OCRA/losservatorio-pierre-auger/>

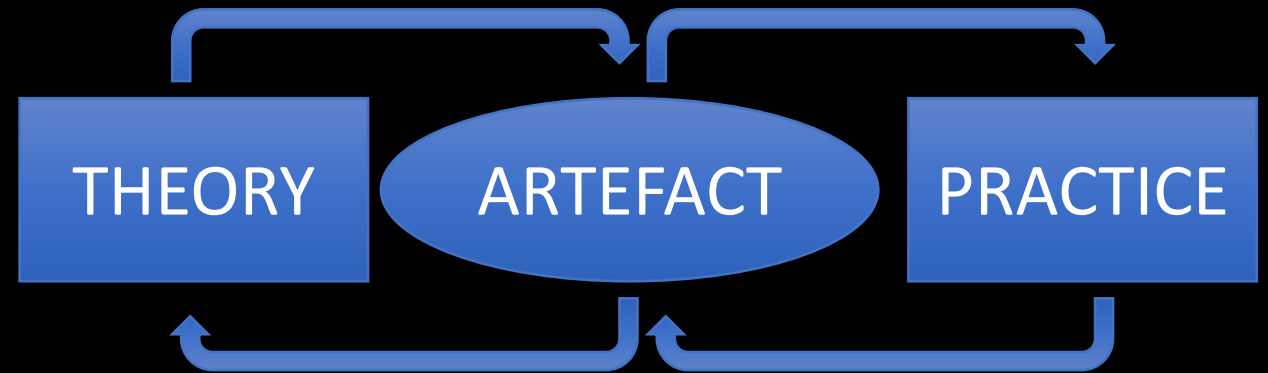
Teachers' Area

Space dedicated to the teachers with:

- a brief introduction to the most common teaching methodologies
- provides an overview of materials to support for the development of teaching projects in the classroom,
- a broad overview of current legislation
- indications of international platforms that deal with identifying the objectives in various school contexts
- indications on teaching activities in CLIL (Content and Language Integrated Learning) mode
- handbook on teaching design

<https://web.infn.it/OCRA/raccolta-di-materiale-per-docenti/>

Teaching methods: having available teaching models with descriptions can stimulate experimentation with new approaches in one's own teaching styles



Laboratory activities in education: description of the constructivist theoretical framework to provide pedagogical and didactical tools to make the most of the variety of scientific pathways

Teachers Forum to exchange experiences and activities

<https://web.infn.it/OCRA/forums/forum/forum-di-ocra/>

The OCRA online course for teachers

The online laboratories were presented in an online meeting dedicated to high school teachers on the INFN Edu Physics YouTube channel <https://youtu.be/ZNoG2etdJ7s> and on the OCRA Facebook page <https://www.facebook.com/ocra.infn.1/posts/442461246949492>

More than 200 teachers took part in the online meeting in January and 70 of them enrolled in the 9-meeting course in spring 2021

A promotional poster for the OCRA online course. It features a cosmic background with a purple streak representing a cosmic ray. The text is arranged in a circular layout. The main title is "IN LABORATORIO CON NOI percorsi didattici di INFN OCRA". Below it, it says "Outreach Cosmic Ray Activities - OCRA vi invita alla scoperta della sua proposta online: un percorso in diretta sui raggi cosmici e l'analisi di veri esperimenti scientifici per voi e i vostri studenti, con la moderazione di Davide Coero Borga". To the right, it specifies the target audience: "RIVOLTO A TUTTI I DOCENTI DI SCIENZE, MATEMATICA E FISICA DELLE SCUOLE SUPERIORI DI SECONDO GRADO". At the bottom right, it gives the date and time: "20 GENNAIO ORE 17.00 - 18.30", and provides social media links for "canale INFN Edu Physics" and "OCRA INFN". It also includes the contact email "PER INFORMAZIONI: OCRA.INFN@GMAIL.COM". Logos for INFN and OCRA are at the bottom.

Conclusions

Since its foundation, OCRA has made a substantial and effective contribution to the implementation of the INFN's cosmic ray outreach activities, adding other activities in the meantime, also in response to specific needs, such as the online laboratories developed during the first spring lockdown.

The fact that the initiative is heading in the right direction is demonstrated by the enthusiastic and interested participation of the teachers and students in the activities being carried out.



In the future, the standard initiatives, such as the ICD and the science camp for the students, will continue to be implemented, but others will be developed, in particular teacher courses, both face-to-face and online, as well as masterclasses in high schools.