

Prelude

During the past century particle physics has provided incredible insights into the nature of matter, and the origin and fate of the universe. Theories have been tested and, through an almost-Darwinian process, only those that are substantiated by experiment survive. Along the way, the technological advances we have made to facilitate our studies have found their way into everyday life, through communication techniques, medical imaging and disease treatment, to name but a few. The present experiments are able to measure phenomena to a precision that was not dreamt of when they began construction, and there are solid plans for continuing the exploration until the 22nd century, to help answer the many questions that remain and bring further insight into the Universe.

WE are all convinced of the overwhelming benefits our basic research has for humanity. But, as we face increasing challenges for resources, both financial and personnel, as well as environmental concerns for example, for the field to thrive for the next century it is vital to bring the rest of the world with us on our journey. And today we want to explore, with our distinguished panel, the role that communications, education and outreach need to play in achieving this, as well as your part in all of this!

Education & Outreach Summary, ICHEP 2024



10 Posters plus 29 talks in 3 parallel sessions: 35 - 60 attendees

With lots of discussion during and after the sessions

Educational Activities, Art & Science, E&O Strategy, Visits, Games, Social Media

+ Panel Discussion on importance of E&O

Dave Barney, Miroslav Myska & Connie Potter

With many thanks to the LOC:

Jiri Dolejsi, Barbara Trzeciak, Oldrich Kepka

The bottom lines

To help overcome the challenges faced by our field in the coming decades, communication from **everyone** involved in HEP, and at all levels, will be critical. This cannot be left to a handful of dedicated “outreach activists!”

The skills obtained from being involved in outreach are **valuable for our lives as physicists and engineers**

Education & outreach efforts by our physicists/engineers must be **encouraged, supported and acknowledged accordingly**



Highlights from the Parallel Sessions

Highlights: E&O Strategy

Physics Beyond Colliders Comms Strategy

Target audiences

Communication to physicists



Communication to general public

Communication to funding agencies



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Outreach can:

- build public appreciation
- aid financial support
- inspire young people

Social Media is important

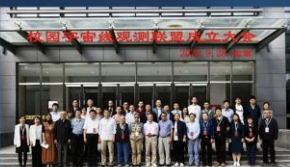
Printed Media is also important!

Campus Cosmic Comms Strategy

About CCOC

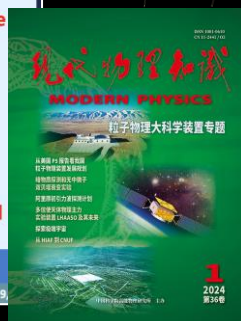
Campus Cosmic-ray Observation Collaboration

- Established on September 28, 2020
- Connected to the Institute of High Energy Physics (IHEP), Chinese Academy of Sciences (CAS)
- Relying on the LHAASO and Modern Physics
- Everyone is a volunteer



Purpose

- to set up campus observation stations and network
- to popularize cosmic-ray knowledge
- to encourage cosmic-ray study
- to strengthen collaboration on cosmic-ray observation
- to facilitate student and teacher training
- To strengthen relevant international exchanges



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Pierre Auger Communication Strategy

Local initiatives Science Fair

Exhibition in Malargüe

each year involves hundreds of students from primary and secondary schools in the Malargüe province and beyond

- close co-operation between Auger staff and teachers
 - Auger collaborators act as reviewers of the reports and judge the exhibition
 - best realizations rewarded with prizes
- stimulate students to pursue careers in science



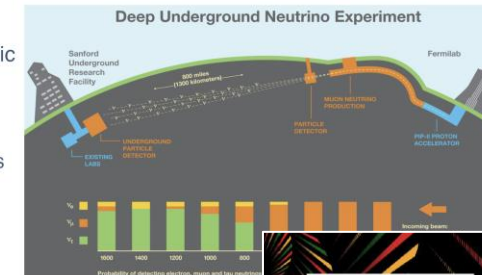
Emphasis on local-community engagement

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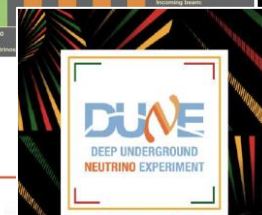
DUNE Communication Strategy

Outreach audiences

- Publicly funded experiments must communicate their science to the public
- Outreach can
 - Build appreciation among the public
 - Consolidate support from policy makers
 - Inspire young people to pursue STEM



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Highlights: Educational Activities

Teaching astronomy through Sci-Fi

A New Kind of University Class

An introductory astronomy class that blends a science fiction world and story with learning astronomy

- Designed for intermediate university students who are comfortable with low-level math and science
- Aims to increase engagement through an immersive narrative
- Develops "soft" skills like problem solving, critical thinking, creativity, and collaboration
- Increases intrinsic motivation to learn
- Fosters a "Learner Mindset" over "Performer Mindset"
- Gives students agency in what and how they learn

Course Symbol
The World Tree
Yggdrasil



Course Website
Spring 2024 Version

slindsay@utk.edu

ICHEP 2024

Imaginative and peer-led teaching programs are beneficial to everyone

Engaging young minds (12-16) in Germany

Universität Münster

"Nobody likes physics"
Quote: Anonymous

The problem for young people is...

- Physics is rather unpopular
- The subjects for Senior High School and the Abitur are usually chosen at the age of 15/16
- A new choice is possible, but unusual/impractical

-> Physics is rarely chosen again and is therefore no longer a career prospect.

Choose courses Specialisation

Age → 14 15 16 17 18 Abitur

17

Young people teaching younger people!

SCIENCE OUTREACH – BENEFITS

- PRESENTING SKILLS
- PRACTICAL SKILLS
- OTHER TRANSFERRABLE SKILLS
- CONFIDENCE
- REMAINING ENGAGED WITH SCIENCE



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Peer Teachers (15+)

„In short, peer teaching occurs when students, by design, teach other students.“
(www.teachthought.com)

- Young people are experts regarding young people
- Young people are better role models within their peer group

Work together with peer group...

- Learners revise our presentations
- Parts of lectures taken over by them
- Joint representation of physics at public events
- Special support (e.g. workshops at CERN, Talks at conferences)



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Highlights: Educational Activities

ATLAS Open Data

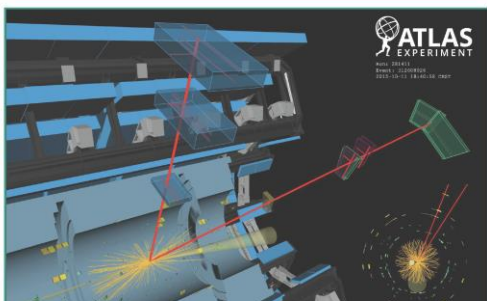
Released detector data and simulations

Detector data
Monte Carlo simulations

DAOD_PHYSLITE

Under the [CC0 waiver](#)

65 TB of data+MC.
Over 9 billion collisions !



Useful for new ATLAS physicists!

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Programs reaching
tens to thousands of
students!

Czech PP Outreach Project

The Czech Particle Physics Project

Andr  Sopczak (IEAP CTU in Prague), Peter  a ik (FIT CTU in Prague)

19 July 2024
ICHEP 2004 | Prague

www.cern.ch/cppp

Goals

- Easy access to publications
- Collection and categorization
- Visualisation of development precisions
- Bringing the research closer to the public

US-Ukraine Student Program

Example of Program Impact



11 Undergraduate Research at CERN - Programs for U.S. and Ukrainian Students

ICHEP, Prague, 19 July 2024



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Pierre Auger Open Data

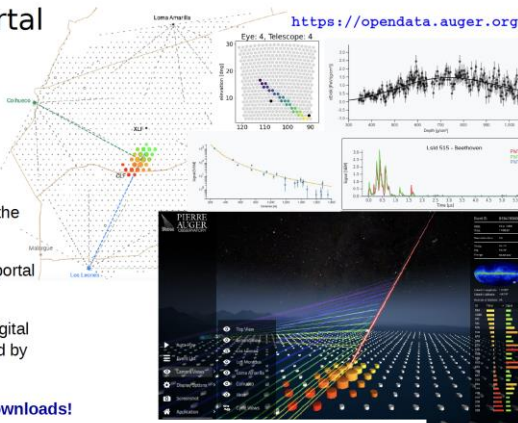
The Open Data Portal content

10% of cosmic-ray data
> 81000 events collected between
2004 and 2018

Dynamical content

- since the first release in 2021 the portal has been continuously extended
- task force responsible for the portal updates in synergy with the analysis tasks
- All datasets associated to a Digital Object Identifier (DOI) provided by Zenodo

> 40000 visits and > 3000 downloads!



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Italian Inspyre Student Program



- One-week school organized by INFN and held at INFN Frascati National Laboratory
- Addressed to 30/40 students from all over the world attending the last two years of high school
- Our aim is to bring participants closer to STEM careers by introducing them to INFN and other research institutions and universities

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Highlights: Spinoffs from HEP Research

IPPOG Particle Therapy Masterclass



What are the benefits for society?

The developed accelerator technology is used for cancer research and therapy

Innovative technologies developed for future CERN projects find already applications in medicine



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Direct and indirect applications of HEP research are powerful persuaders for some audiences

IPPOG witness stories



International Particle Physics Outreach Group

About Resources Activities News Calendar



IPPOG witness stories

Concrete examples of successful applications for the benefit of society from (particle) physics and related sciences

Compiled and presented by the : IPPOG Working Group on Outreach of Application for Society

https://ippog.org/ippog_witness_stories



01 July, 2024

Accelerators to reduce pollution of maritime traffic

The accelerator community has a lot of examples of applications of accelerators used for the benefit of the society. One of the most unexpected applications is the pioneering use of compact modular linear accelerators for treating the exhaust gas of ships.



International Particle Physics Outreach Group

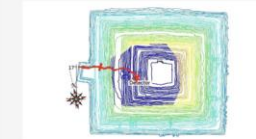
IPPOG witness stories

[cross-references: general principles and witness cases](#)



International Particle Physics Outreach Group

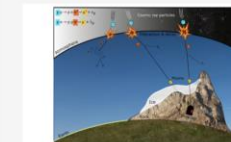
About Resources Activities News Calendar



01 July, 2024

Searching for hidden cavities inside the Sun pyramid in Mexico

A first-hand witness of the experience of the main author searching for hidden cavities inside the Sun pyramid in Mexico, in a collaboration of Mexican physics groups and archeologists. This is explained as an example of the many applications of muon tomography.



01 July, 2024

Muon Tomography - Invisible particles help to reveal invisible structures

Among the IPPOG Forum members, many experimentalists work with (or even developed) specialized muon detectors for the purposes of fundamental research. However, such devices find many direct applications for society spanning from scanning lorries and controlling the nuclear fuel that was spent in power plants to exploring underground cavities.

Highlights: Arts & Science

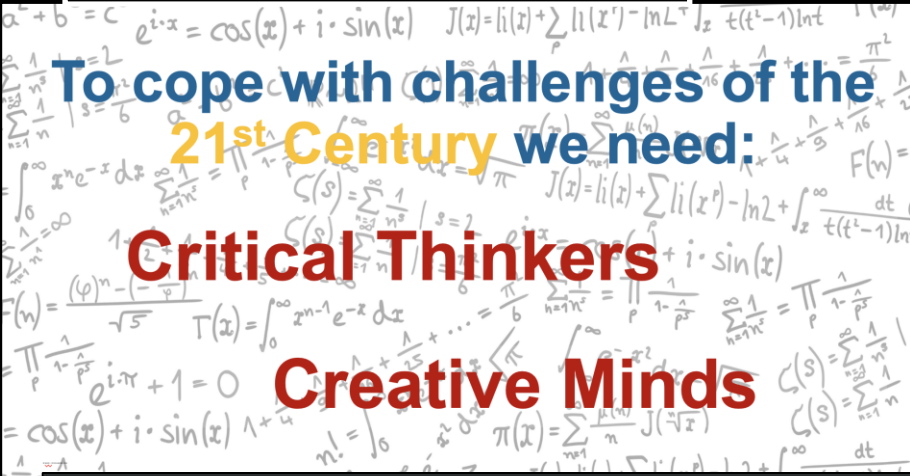
Arts & Science in Italy

Beinspired student artworks

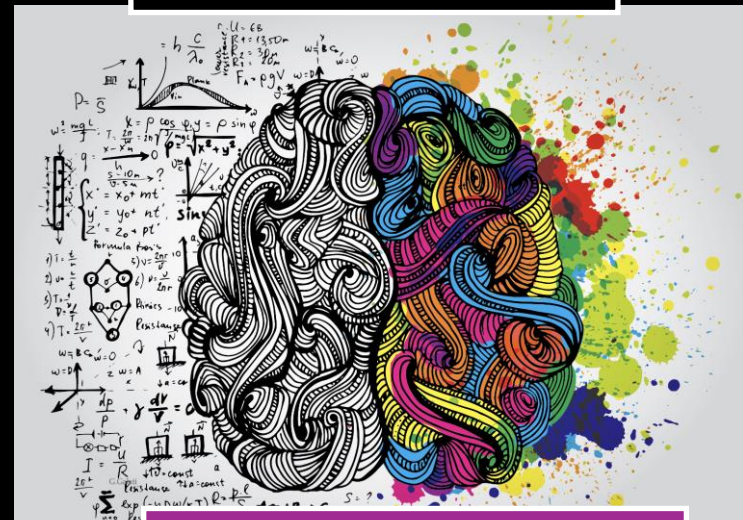
To cope with challenges of the 21st Century we need:

Critical Thinkers

Creative Minds



Being active in Outreach improves creative thinking, crucial for our field!



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Proton cookies



Katharine.Leney@cern.ch



~8000 high-school students creating science-inspired artworks



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Image: Matt Le Blanc

Highlights: Arts & Science

Cosmic Piano...

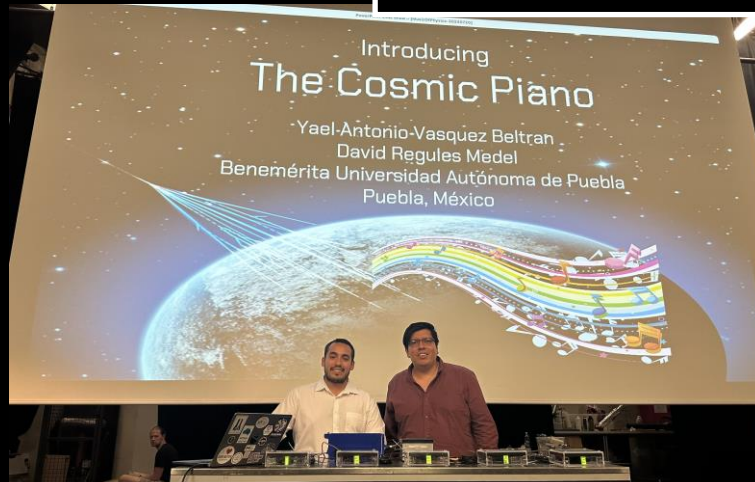


“Don’t be afraid to try something new”

“Collisions” – Science & Literature



...at “Colours of Ostrava” festival 20/7/24



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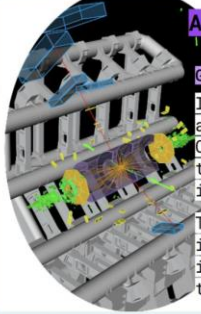
regules.medel.hector.david@cern.ch



~300 people attended talks by Fabiola and Charlotte
Many great & intelligent questions!

Highlights: Games

ATLAS Game Workshops



ATLAS Game Jam

Group Activity:

Imagine you are a videogame developer and have been asked by scientists at CERN to create a new videogame using the LHC and the Atlas Detector as inspiration.

They would also like you to incorporate physics (real or imagined) in an interesting way... the rest is up to you!

Genre

1. Racing
2. Sandbox
3. Puzzle
4. Multiplayer
5. Battle Royale
6. Platformer

Goal

1. Escape
2. Survive
3. Reach Destination
4. Remove all Enemies
5. Rescue or Capture
6. Highest Score

Feedback



Workshop tested with over 50 participants so far

Feedback received from 25

Workshop rated as outstanding: 4.4 ★★★★★

Rated difficulty as 2.8 - right in between too hard (5) and too easy (1)

50% feel more likely to consider studying science for A Level or at university

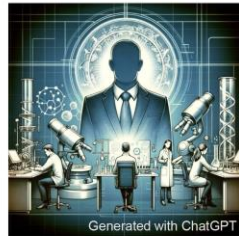
50% feel they are more likely to consider a career in science



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Sci-Me Board Game

You are a researcher starting your research group/lab



Generated with ChatGPT

Build your own lab and publish!

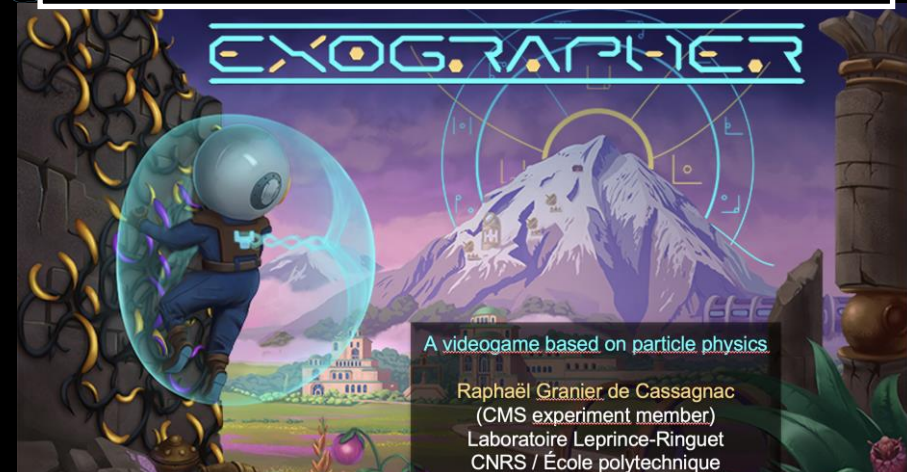
michal.jex@fjfi.cvut.cz



Board game includes the funding process for scientific research, publications etc.

Initiatives target audiences who may not normally look at HEP/science
→ Creates support and interest

Exographer – Ubisoft/LLR Development



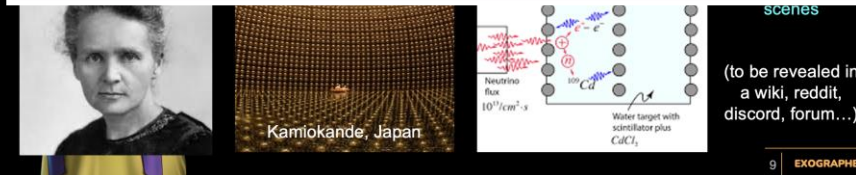
A videogame based on particle physics

Raphaël Granier de Cassagnac
(CMS experiment member)
Laboratoire Leprince-Ringuet
CNRS / École polytechnique

A SCIENCE-INSPIRED WORLD BUILDING



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“Platform” game in style of “Super Mario” with Feynman diagrams, forces, Higgs... 5000 people already added this to their “wishlist” on the Steam platform – 20 €

Highlights: Exhibitions

Quantum Mechanics exhibition in Trento



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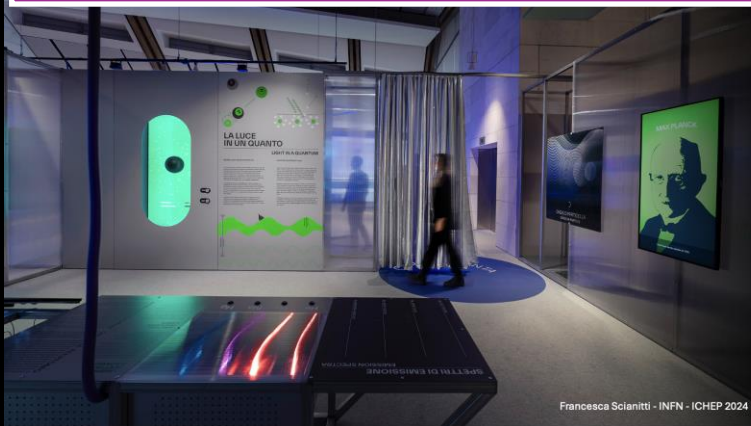
Excellent involvement from PhD students & post-docs who learned how to explain their own topics more clearly

European Researchers Night across Italy



Guided tours of labs were by far the most impactful activity

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Public's response

- 100,000 visitors in 6 months
- 5,000 visitors guided tours
- 5,700 students attended guided tours

TAKE HOME MESSAGE FOR PHYSICISTS

- Eliminate stereotypes about the role of researchers in the society and about the role of women in STEM
- Promote scientific careers in young people
- Learn how to communicate and share the scientific knowledge to the "outside world"
- Increase awareness of the importance of research within the community
- Increase trust in research by bringing researchers among the people.



Exhibition focussed on storytelling: macrocosm, microcosm, quanta, paradoxes

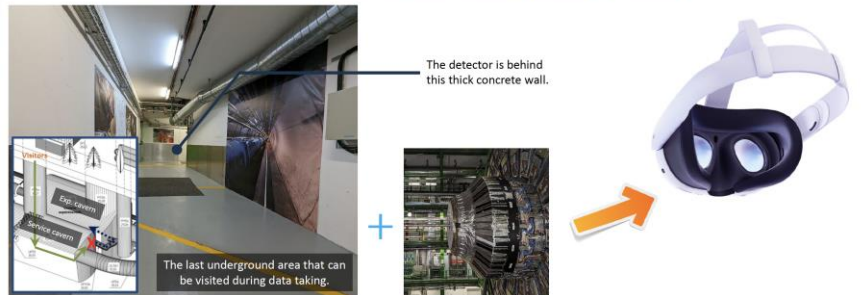
Highlights: Visits – improving inclusivity

CMS Virtual Reality

CMS VR: The concept

- Go around the aforementioned limitation by utilising the transformative technology of virtual reality (VR).
- Create a virtual 3D environment of the underground spaces leading to the detector cavern, integrate 3D models of the detector, and deploy on VR headsets.

⇒ An immersive and interactive framework for visits, usable even during data taking and remotely!



Visits to major facilities can be done cheaply and effectively without traveling

ATLAS Virtual Reality

Google cardboard...

Move your head around → look up and down, you can look all around in the scene

Press to change scene *

Look through here

Here the ph



To get started put the headset on and look around to discover the space.

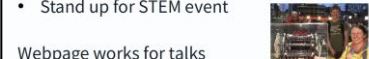
- Cardboard: 5 – 10 GBP (plastic ones also available, but more expensive)
- Phone 49.00 – 65 GBP (Motorola Moto G5 16GB 2GB Unlocked XT1675 SINGLE SIM, Can be cheap specs, but needs gyroscope!)
- Implemented using Unity game engine
- Standalone .apk application for Android → phone can run without mobile, Works ~4 hours without charging



Lightweight and cheap VR head set works well for exhibitions:

- STFC Daresbury lab open days
- Museum exhibition (+ATLAScraft, exhibition on physics in videogames and project on rigid body avatars)
- Stand up for STEM event

- Webpage works for talks
- School visits, Pint of Science



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r 3000 people reached

CMS Virtual Visits

Visiting CMS from your living room (virtually!)

Noemi Beni, Zoltan Szillasi
on behalf of CMS Collaboration

ICHEP2024, Prague, Czech Republic

Our aim became:

- Accessible
- Interactive
- Flexible
- Multilingual
- Talk to a real scientist
- Inspirational & relatable guide
- Inclusive



University of Sheffield <https://atlas.cern/Resources/Atlascraft>

Also used for engineering!

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Highlights: Social Media

CERN Social Media

CMS@DESY Instagram Stories

CROWD-SOURCED PARTICLE PHYSICS STORIES

Instagram account with all our stories, told by each of us



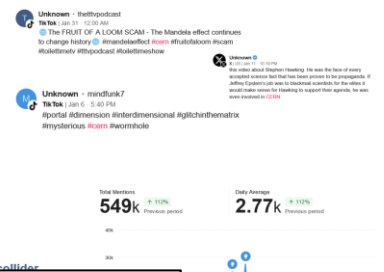
lucia.ximena.coll.saravia@desy.de

“The power of a smartphone”

Advice given to people hosting Social-Media accounts

What words come to mind about CERN?

Word cloud containing terms like: solar eclipse, higgs boson, world, israel, earth, peter higgs, european organization for nuclear research, aleister crowley, cia, cern, switzerland, shiva, us, nasa, #cern, god higgs, rockets, the vatican, large hadron collider, satan, large hadron collider.



A few simple tricks to 'please' the algorithms (1/3)

Instagram

- Success is high engagement (likes, views to the end) in a short period after a post is made.
- *What works:* high-quality vintage and unusual pictures, galleries, explainers, leveraging UGC.
- *What doesn't work:* posters, event pictures, typical institutional communication.

LinkedIn

- Success is engagement, but over time. The algorithm monitors engagement signals.
- *What works:* carousels (save your pictures as PDF), physics news, high-quality images, mentions.
- *What doesn't work:* links, short posts, content meant for the internal community.

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Highlights individuals and groups

Show the “real life” of physicists, engineers, technicians...

Help in recruitment

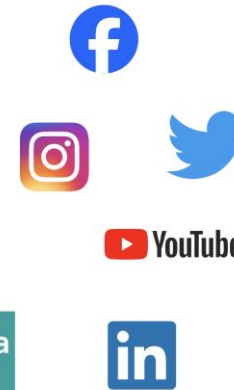
RECRUITMENT

4

- Life at the lab videos
- Reach young scientists that are interested in joining us
- in Germany and around the world

ALICE Social Media

Facebook
X
Youtube
LinkedIn
Instagram



Why

- The power of a smartphone
- Almost everyone is connected to social media
- Engaging content, immediate exposure to physics content
- Possibility of going “viral” reaching millions of people

Social media presence

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Benefits of involvement in E&O

Several talks emphasized the benefit to physicists/engineers from participating to E&O, including:

- Improving creative thinking
- Better understanding of the “big pictures” of HEP (physics, detectors, past & future)
- Better appreciation of the whole HEP landscape
- Helps physicists/engineers explain more clearly their own research

Young people teaching younger people!

SCIENCE OUTREACH – BENEFITS

- PRESENTING SKILLS
- PRACTICAL SKILLS
- OTHER TRANSFERRABLE SKILLS
- CONFIDENCE
- REMAINING ENGAGED WITH SCIENCE



Presenting HEP to non-HEP audiences

Another good way to end a talk is with a summary of the main messages!

- Know your audience and target them!
- Select a few main messages that you want to get across and focus the talk around these messages
- Anecdotes – especially triumph over adversity – are really powerful
- Be of local interest if you can
- Add some personal history if you can
- Be interactive (if appropriate)
- Simplify plots to focus on the main message
- Don't be afraid to think differently for the content ordering

ICHEP 19.07.24

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35

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Highlights from the Panel Discussion

Panel Discussion#1 – Participants & Reason



Paris Sphicas
ECFA Chair



Spencer Kelly
BBC Journalist



Sarah Demers
Yale Physicist



Matt Chalmers
CERN Comms



Daniel Stach
Czech Journalist

HEP faces enormous challenges that put its future at risk, including:

- Limited likelihood of major **discoveries** in the coming years
 - But huge progress in **precision physics**, that may point to deeper understanding
- “**Competition**” from other “big science” fields, such as astrophysics, AI, environment science etc.
 - So **can we still attract the best scientists/engineers** into our field?
- **Cost** of major new collider facility is large in absolute terms
 - Although cost per TeV will be **lower than any present accelerator**
- **Environmental impact** of any new collider facility
 - Electricity, construction etc. – but **advances driven by HEP will limit this**

Communication from **everyone** involved in HEP is necessary!

Brief summary of the panel discussion



~150 people for 1.5 hours!



Very lively discussion, inc. audience. Video available

Suggestions for E&O participation included:

Storytelling – everyone has a story to tell

Don't promise things - focus on always exploring further (like in astrophysics)

Adapt to your audience

Practice practice practice

Everyone can – and should - play a role – many different ways to communicate

Education & Outreach activities must be recognized by our hierarchies as important

Some quotes from the Panel Discussion

“Make people want to talk about particle physics to their friends”

Daniel Stach

“The story of particle physics is the ultimate narrative and lifts people outside of their everyday lives”

Matt Chalmers

“Start with a headline that grabs their attention and then slip in something new that excites them”

Spencer Kelly

“We’re getting paid to create knowledge. And if you are going to create knowledge you need to share it as well”

Paris Sphicas

“Do at least one thing per year to engage non-HEP audiences, that takes you out of your comfort zone. You will be a better scientist”

Sarah Demers

Some comments from Future Facilities Panel Discussion



“Share our stories with passion.
We owe it to the taxpayers who
fund our science”

Shoji Asai (KEK)

“The Public are fascinated by our
research. Particle physics is the modern
equivalent of “where are we going?”

Fabiola Gianotti (CERN)

“It might be time to add science
communication courses to
undergraduate science courses”

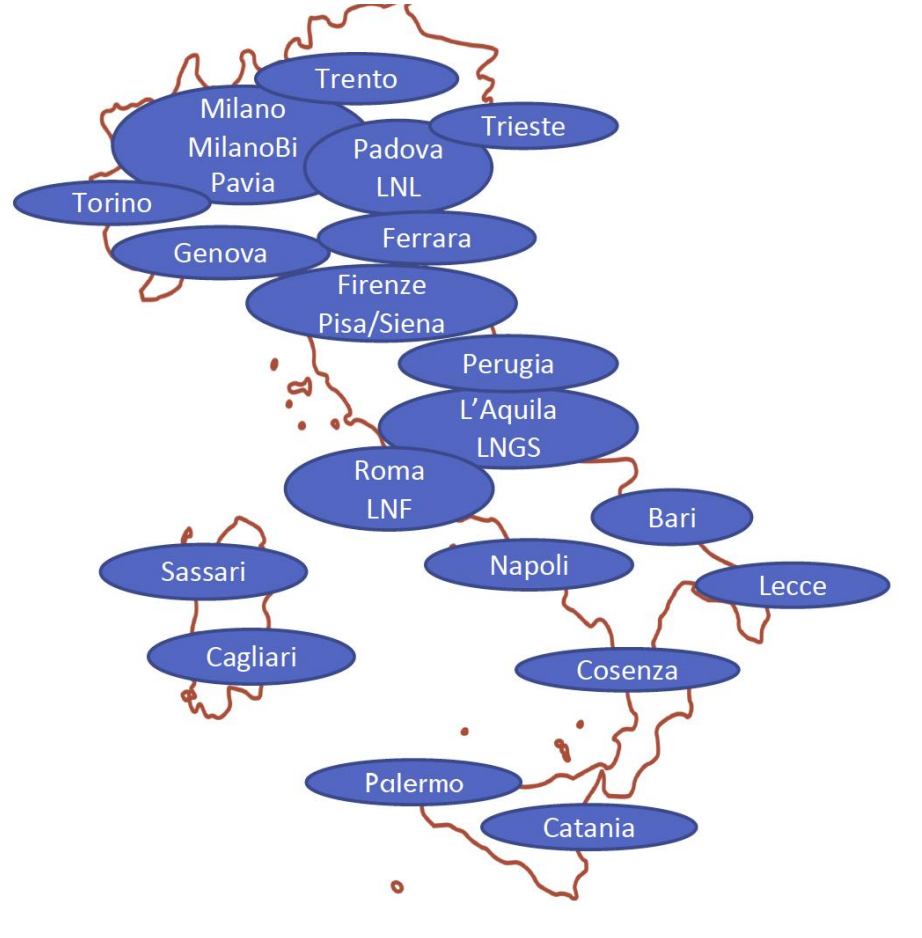
Lia Merminga (FNAL)

“We need to educate the public on
the importance of science”

Yifang Wang (IHEP)

Acknowledgment & support of E&O is crucial

Outreach Cosmic Ray Activities throughout Italy



Italian example: many activities ongoing!

- “Mission 3” in INFN is to pursue E&O activities
 - Directive from the top!
- Several hundred k Euros/year for E&O
- Percentage of “score” for jobs and promotions comes from E&O

Some other countries include the need for E&O explicitly in grant applications

Education & outreach efforts by our physicists/engineers must be encouraged, supported and acknowledged accordingly

The bottom lines

To help overcome the challenges faced by our field in the coming decades, communication from **everyone** involved in HEP, and at all levels, will be critical. This cannot be left to a handful of dedicated “outreach activists!”

The skills obtained from being involved in outreach are **valuable for our lives as physicists and engineers**

Education & outreach efforts by our physicists/engineers must be **encouraged, supported and acknowledged accordingly**

HEP needs YOU to communicate & educate!



Response to first audience comment

The first audience comment basically said “it takes weeks to plan an event like a Masterclass...it is a waste of our valuable time”.

My response was along the lines of “actually there are many types of activity that don’t take so much time” and another audience member added “and there are people to help you”.

What I should have added was “doing the type of research we do, that is funded by the public, without telling anyone about what we do: that would be a waste of time. Several funding agencies have acknowledged the need to recognize E&O work explicitly, in grants and in job applications/promotions – as it is vital for our field to proceed. The lab directors also emphasized the need to communicate our work and future plans as being imperative. In the words of Paris Sphicas: “we just have to do it!””