

Astroparticle Outreach at DESY

Discover Cosmic Rays

Carolin Schwerdt
CCOC Seminar, online
March 15, 2022

About me

Where is my workplace?

DESY, GERMANY, ZEUTHEN

What is my task?

CONCEPTION OF
EDUCATION PROJECTS FOCUSED ON
ASTROPARTICLE PHYSICS

What I do when I'm not online?

WORK WITH STUDENTS AND TEACHERS
IN OUR COSMICLAB.
DEVELOPMENT OF EXPERIMENTS WITH
COSMIC RAYS FOR STUDENTS.



Astroparticle Outreach at DESY in Zeuthen

Contents of the talk

- DESY Overview
- Student Project: CosmicLab
- National Network: Netzwerk Teilchenwelt
- Experiments, Tools and Programs
- Event: International Cosmic Day



DESY – Overview

Deutsches Elektronen-Synchrotron

- national research centre
- member of the Helmholtz Association
- two sites: Hamburg and Zeuthen

<https://www.youtube.com/watch?v=LgmFr6b7WFY>

Research Topics

- Accelerators
- Photon Science
- Particle Physics
- Astroparticle Physics

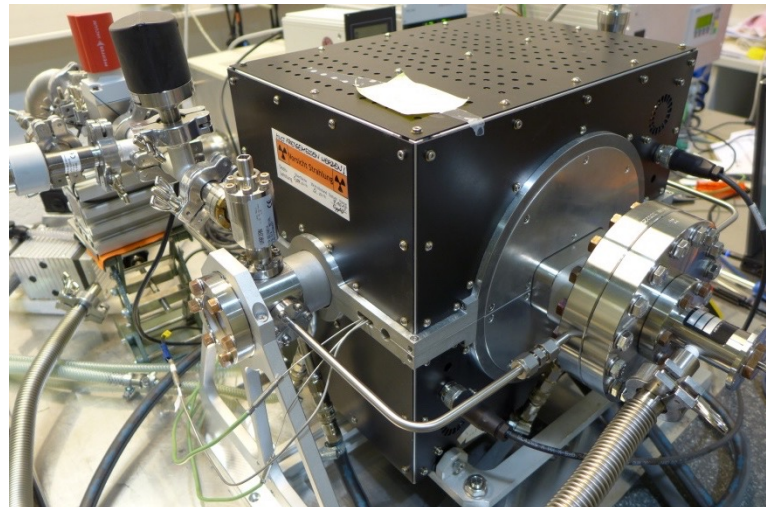
https://www.desy.de/about_desy/annual_reports/



DESY in Zeuthen

Modern research centre

- more than 280 employees
- international participation in science and research
- construction and development
- mechanical and electronic workshops
- computer centre
- detector development
- libraries, administration, communication
- school labs



Research in Zeuthen

Astroparticle Physics

- role of high-energy particles in the cosmic evolution
- neutrino and gamma astronomy, theoretical astroparticle physics, multimessenger astronomy

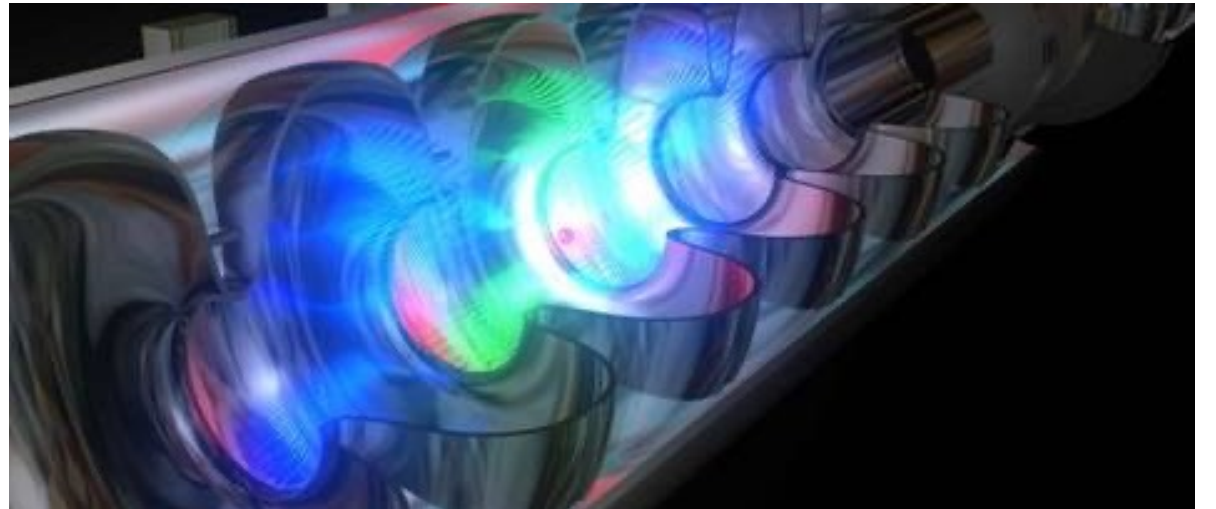
<https://www.youtube.com/watch?v=xpshIU-6n40>

Particle Physics

- search for the fundamental building blocks of nature and their interaction
- experimental and theoretical particle physics

Accelerators

- development of tomorrow's accelerators
- Photoinjector Test Facility in Zeuthen (PITZ)



DESY in Brandenburg close to Berlin



- students can benefit from regionally connections to universities and technical universities
- easier access to study

DESY School Lab ‘CosmicLab’

- education project: own research questions, conduct investigations, analyze data, report results
- for interested school students (age 15 to 19)
- PhDs supervise the young researchers
- standard: 2 weeks internship
- also mentoring of “Jugend forscht” - reports (contest for highly gifted young people)
- bachelor and master thesis



DESY School Lab 'CosmicLab'

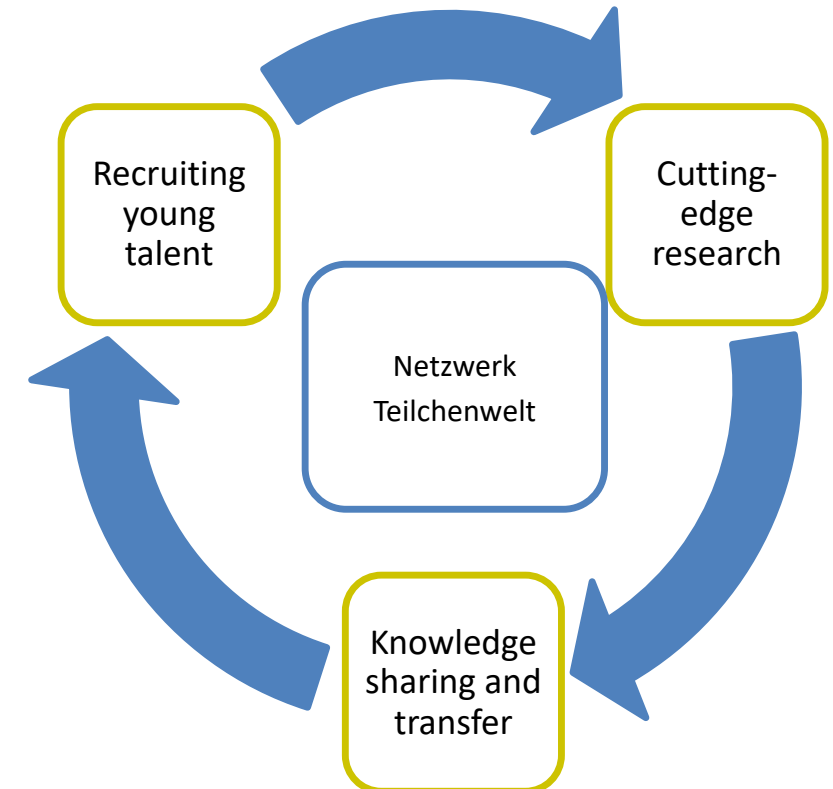
- enable students to:
 - explore scientific work of astroparticle physics
 - work with modern measurement and analysis methods
- support teachers to:
 - teach actual physics
 - have an hands-on experiment for own lessons or projects
 - have contact to scientists





NETZWERK
TEILCHENWELT

- German Education Network for Particle and Astroparticle Physics, Hadron & Nuclear Physics
- between scientists, school students (age 15-19) and teachers at schools, school labs, museums etc.



Nationwide Network

- 30 institutes at 26 cities in Germany
- in direct contact to CERN in Genf, Switzerland
- project team at TU Dresden, DESY in Zeuthen and CERN
- ~ 150 PhD and Master students (trainings) guide young people
- ~ 120 alumni (physics students)
- ~ 300 teachers (trainings, teaching material)

<http://www.teilchenwelt.de>



Goal of the project

Generate Fascination

- for basic questions about our universe

Enable authentic experiences

- with own measurements on original data
- by independent experimentation

Convey importance of basic research

In Addition:

- train PhD students in communication
- former alumni → physics students at the research labs



Step program for school students



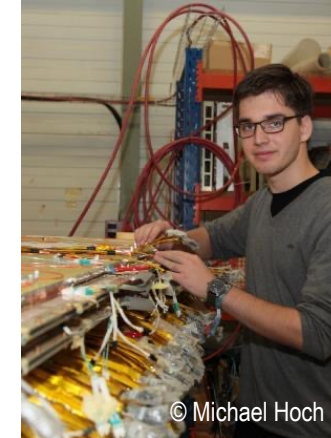
Masterclasses



Own commitment,
detector projects

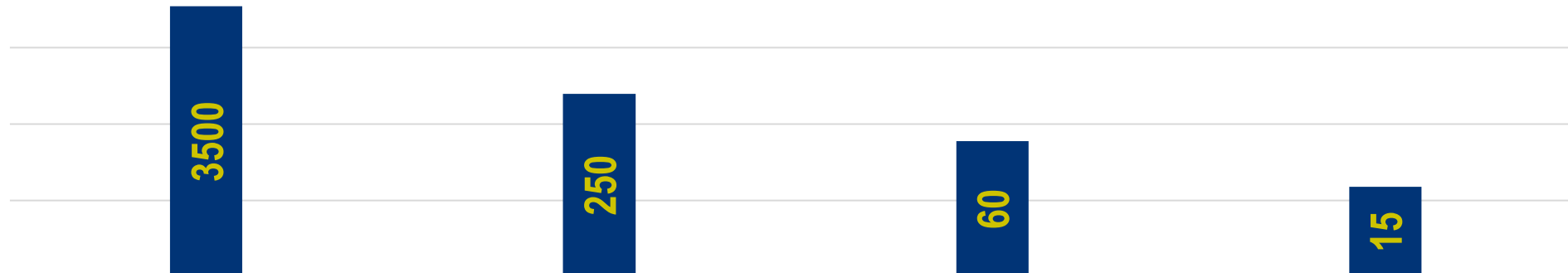


Workshops at
CERN and Mainz



own research
projects

Number of
teenagers/year



Win⁴ Situation for all involved

Young people...

- Experience research
- Contacts to universities and researchers
- Study decision
- nationwide contacts among each other (alumnis)
- Support during studies



"The Netzwerk Teilchenwelt offers the opportunity to experience physics "for real". In school, mostly dry material is taught with little reference to current physics. Through my activities my thought to study physics was strengthened. This has also given me the will to overcome the difficult starting phase in my studies."

Win⁴ Situation for all involved

Teachers...

- Personal training
- Professional qualification
- Exchange with colleagues and researchers
- Suggestions and materials for teaching



Win⁴ Situation for all involved

PhD and Master students...

- Soft skills: science communication, didactics, presentation
- Advanced training - Workshop
- Looking beyond the horizon (particles - astro, theory - experiment)
- Fun and recognition



Win⁴ Situation for all involved

University and Research Institution...

- Carrying own research to schools and public
- Long-term contacts with future students
- Support: organization, material

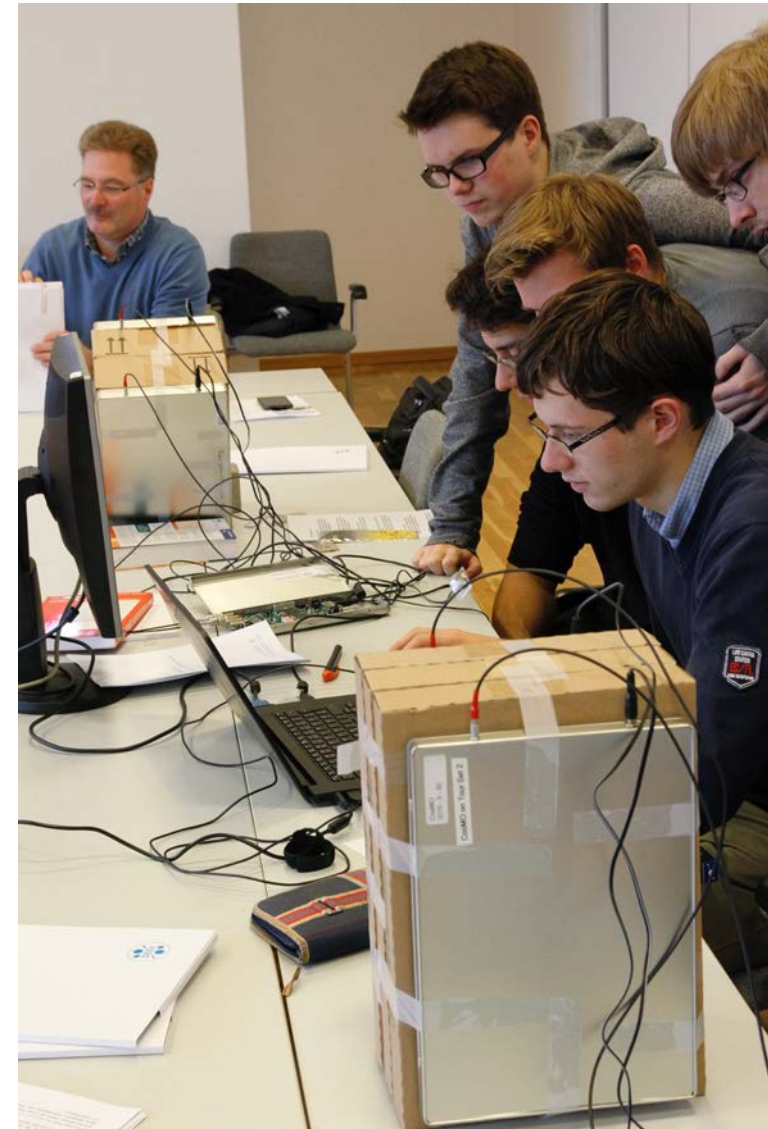


Astroparticle Project

Leaded by DESY in Zeuthen

Providing of...

- Concepts for Masterclasses
- Particle detectors for own measurements
- Cosmic@Web: online learning platform with online tools for data analysis
- Concepts for project days, project weeks, research weeks, teacher trainings
- Teaching materials



Astroparticle Masterclass

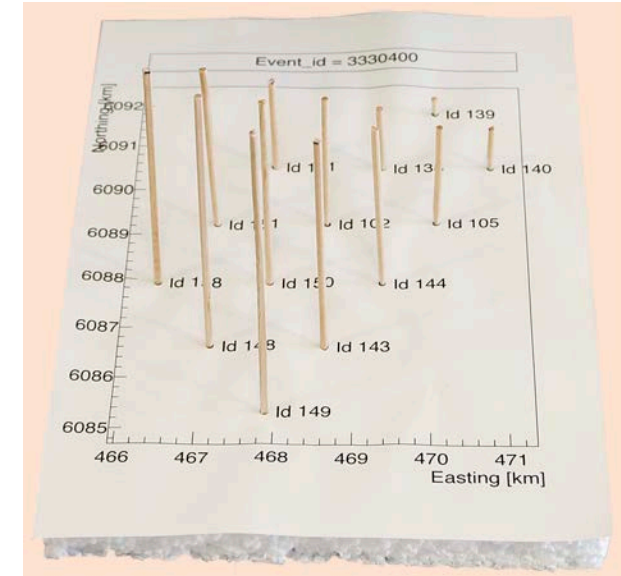
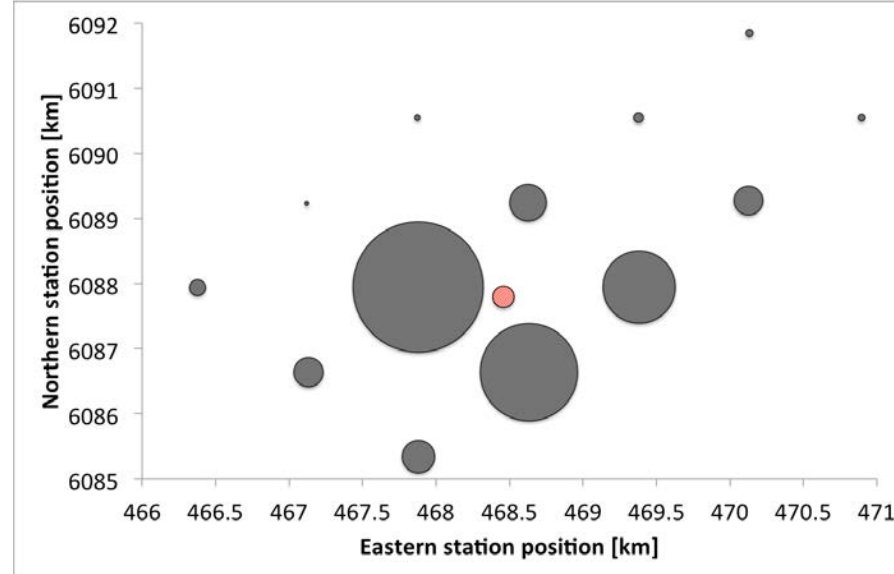
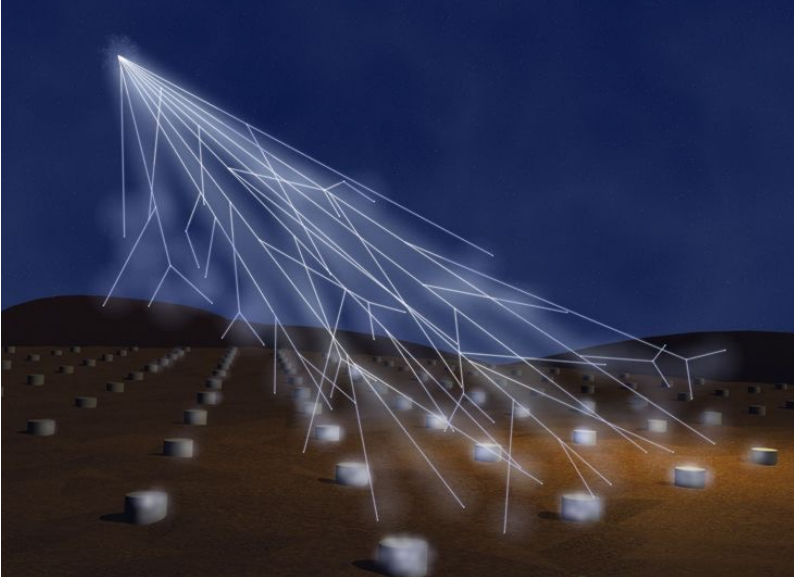
- One-day event in schools or scientific institution
- lead by PhD and Master students

Young people...

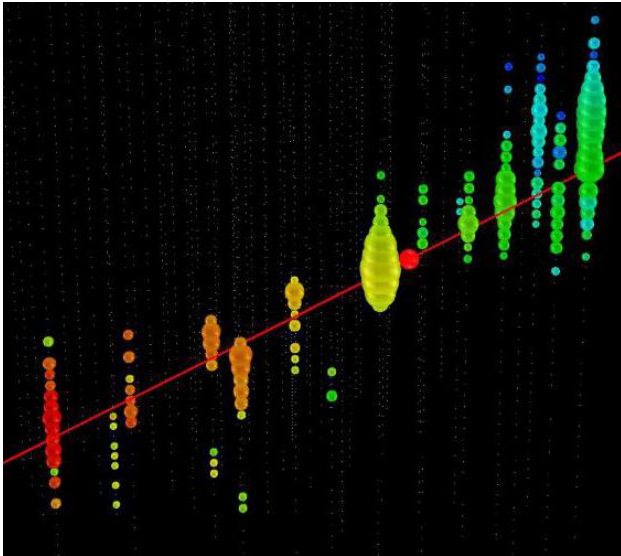
- understand how information about cosmic rays is obtained from an experiment and the measured data
- can experience part of the work on the experiment themselves
- understand the necessity of computer work and programming
- can better understand how to continue with the research work afterwards

Auger Masterclass

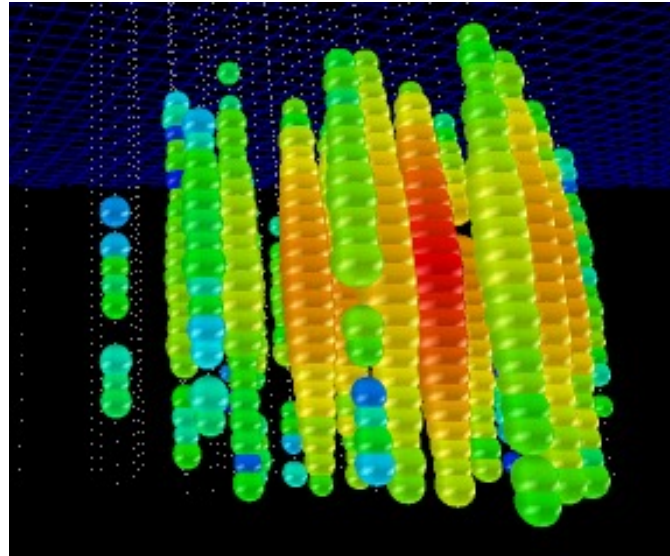
- reconstruction of cosmic air shower and arrival direction
- data analyses with Microsoft Excel or other spreadsheet programs
- developed by University Wuppertal, University Erlangen-Nürnberg and DESY <http://arxiv.org/abs/1508.03968>



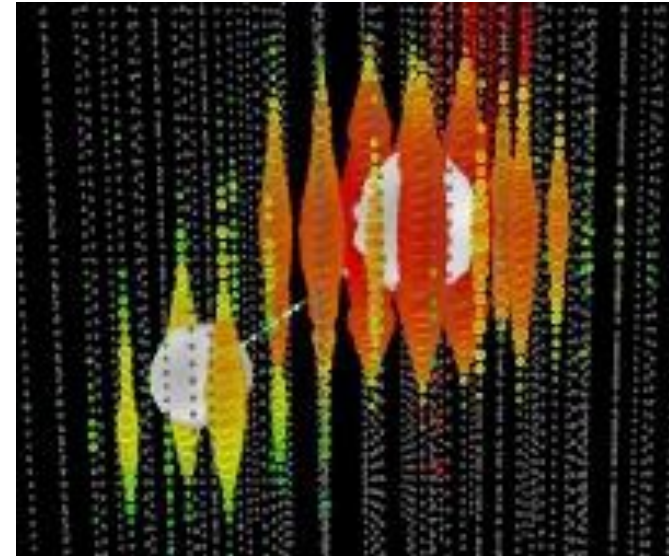
- distinguishing signatures and filtering neutrinos
- interface with already filtered data is provided
- <https://masterclass.icecube.wisc.edu/de>



Muon Neutrino
(data)



Elektronen
Neutrino (data)



Tau Neutrino
(simulation)

Particle detectors for own measurements

Developed for and distributed to 20 sites from the network Netzwerk Teilchenwelt:

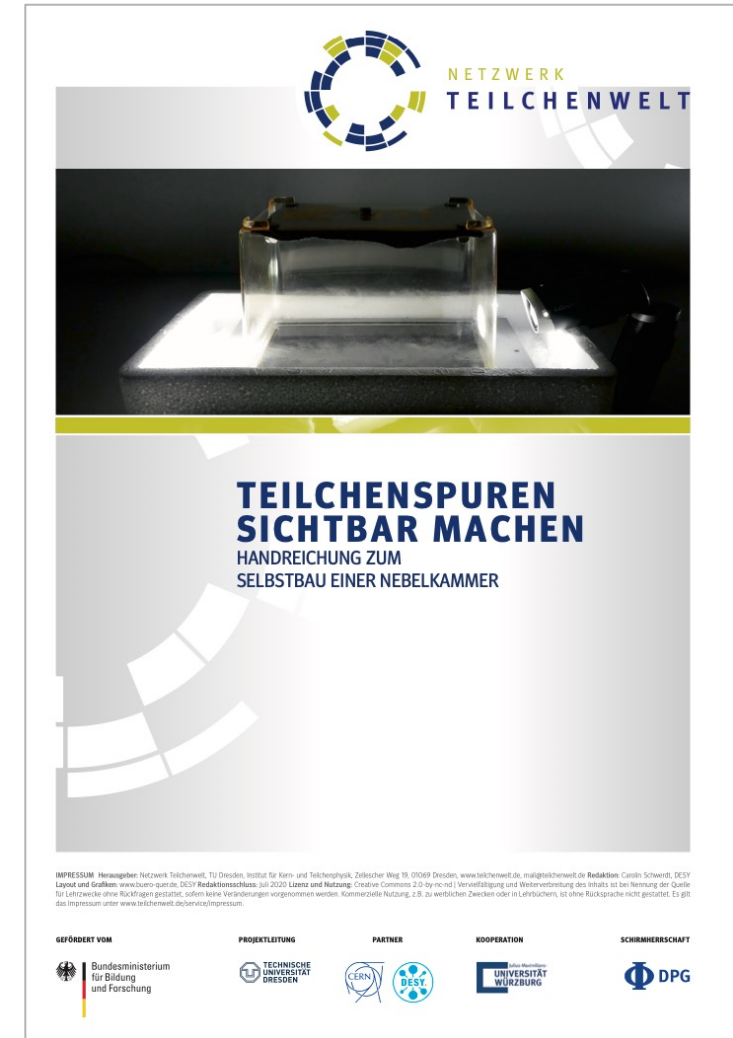
- 23 Kamiokannen-Experiments
- 73 CosMO-Experiments
- 22 Cloud Chamber DIY Sets



Cloud Chamber

Self assembly set

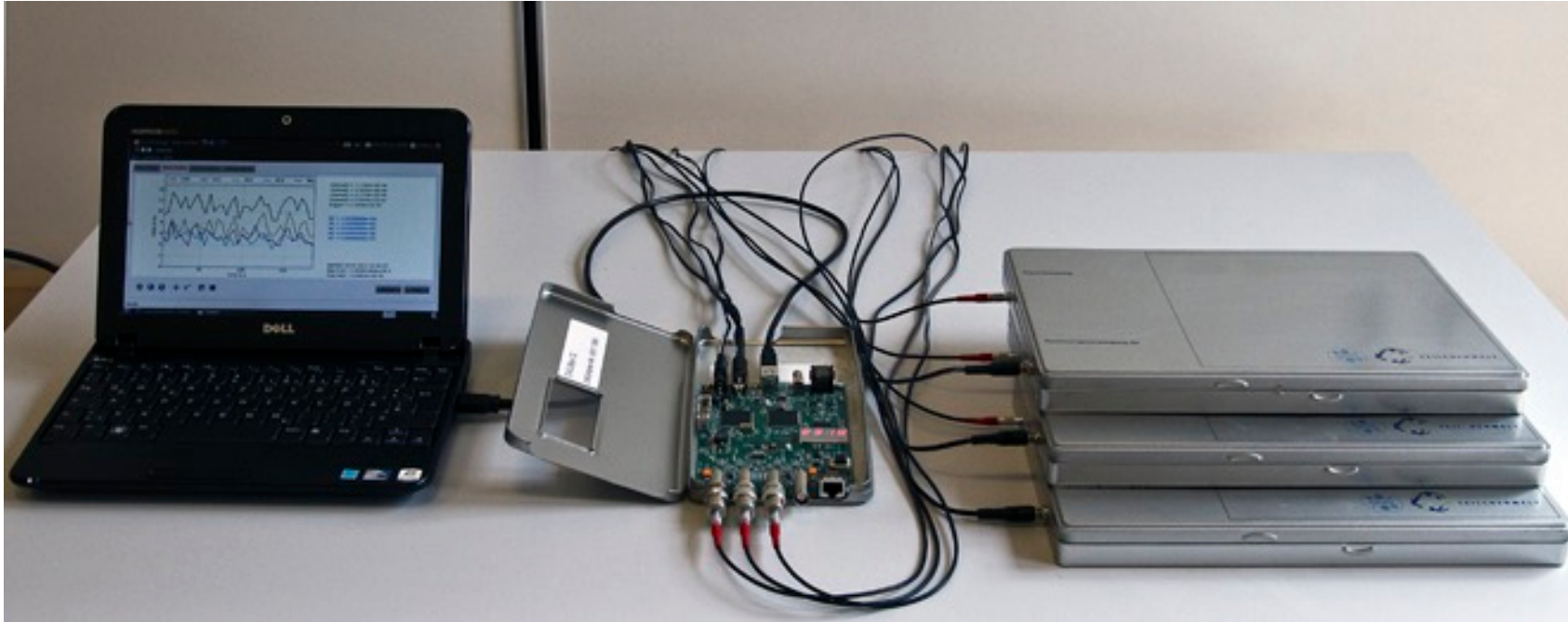
- Sets of components for 10 cloud chamber
- handout for teachers with notes and copy templates (in German)
- for workshop in institute or school, teachers can borrow set for free



https://www.teilchenwelt.de/Material_Lehrkraefte/Selbstbau_einer_Nebelkammer.pdf

CosMO

Cosmic Muon Observer

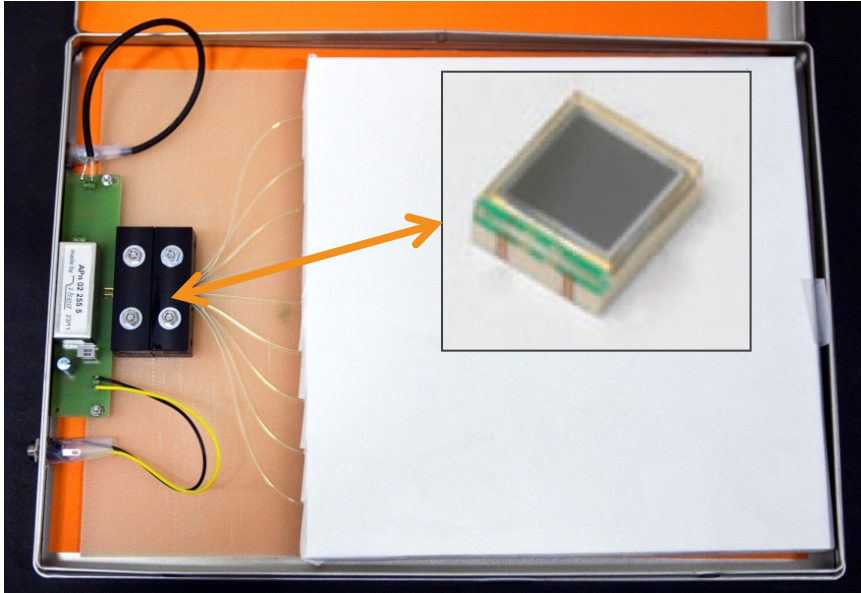


Components:

- 3 scintillation counters
 - DAQ from QuarkNet/Fermilab
 - computer with measuring program “Muonic”
- Developed and built at DESY
 - Presentation at ICRC 2013:
<http://arxiv.org/abs/1309.3391>

CosMO

A Look Inside



Counter:

- Scintillator with optical fiber
- photomultiplier (MPPC)
- integrated voltage supply



Teaching Material

- instructions for operating the experiment (for students)
- teaching material with copy templates and task sheets
- only in German

Kamiokannen



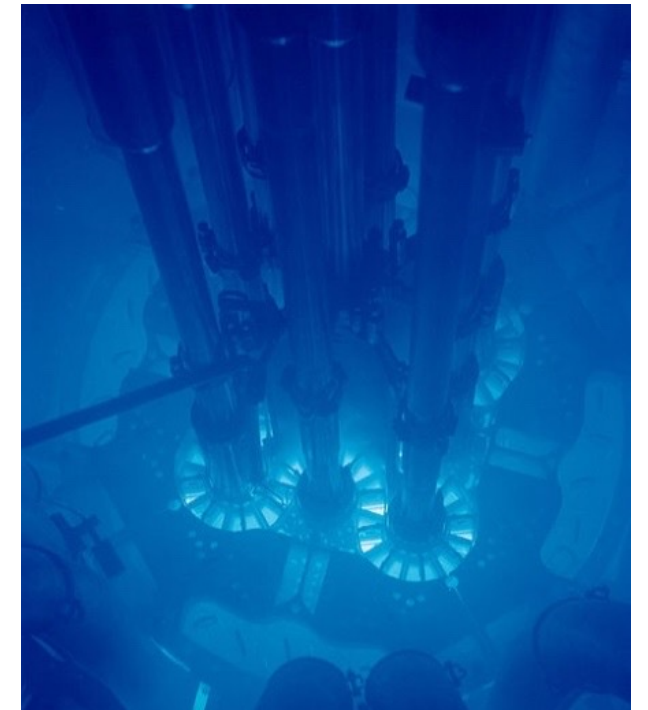
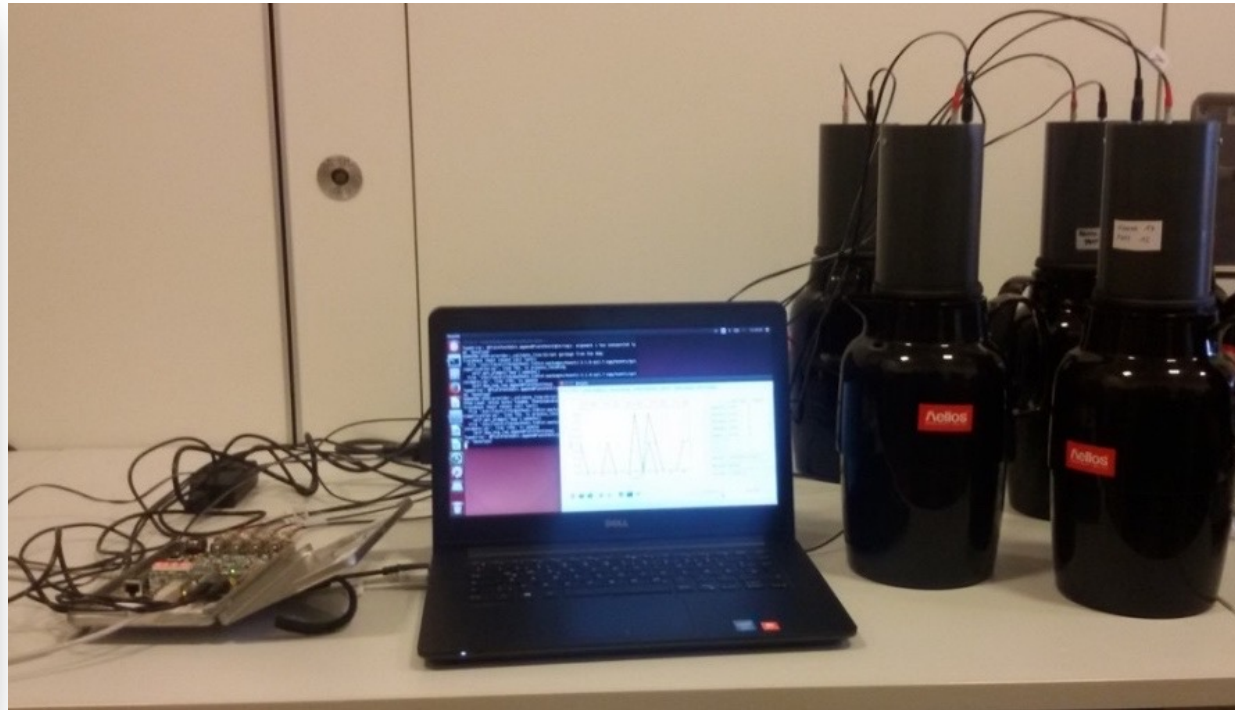
Components:

- 2 Cherenkov water counters
- measuring electronic from University Göttingen or DAQ from QuarkNet and Computer with “Muonic”

Kamiokannen

Counter:

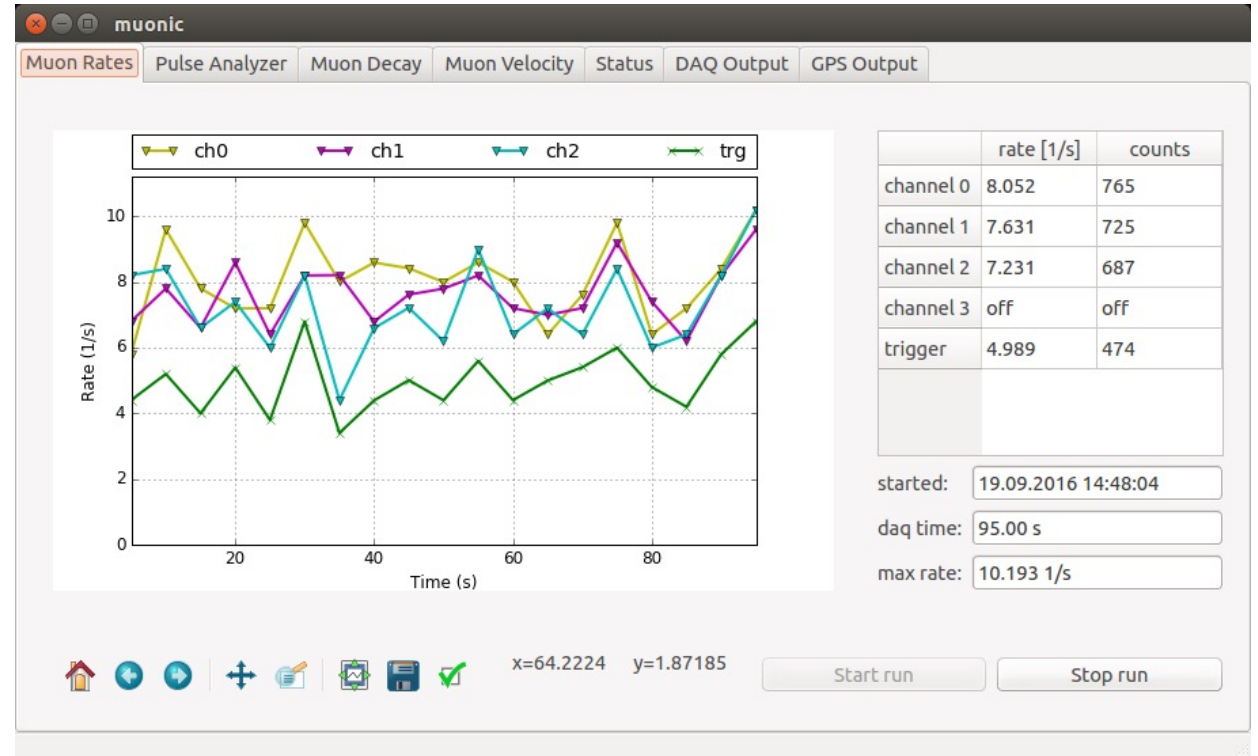
- water filled thermos flask with photomultiplier, detect Cherenkov light
- new: integrated power supply
- idea developed by University Mainz and University Göttingen



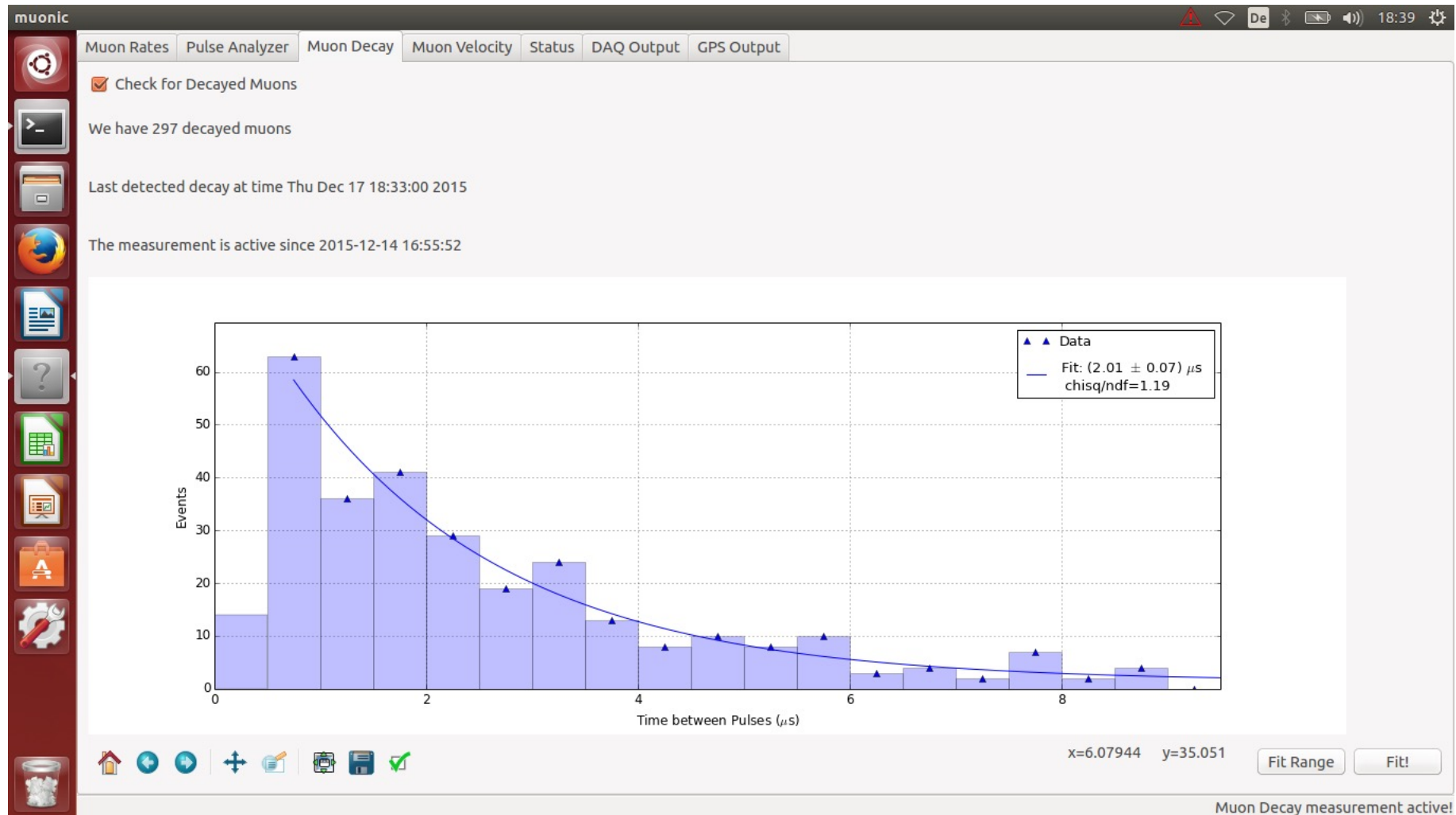


Analysis software for measurement and investigation of cosmic particles

- python software developed by DESY
- interface to communicate with QuarkNet DAQ cards
- to perform simple analysis of the measured data
- python graphical user interface (in English)
- German documentation for teachers and students



<https://github.com/NetzwerkTeilchenwelt/muonic4>



Measurements

with CosMO and Kamiokanne

- calibration of the detectors
- rate measurement (statistical analysis)
- examination of various conditions such as temperature and air pressure
- angle dependence of the cosmic radiation

- influence of absorber materials
- velocity and decay time of muons



Cosmic@Web

Analysis of Data from Cosmic Particles

- online learning platform
- evaluation of data from experiments that measure cosmic particles 24/7
- students can work like scientists and do their own astroparticle physics research without programming skills
- offered in German and English

<http://cosmicatweb.desy.de>

PHYSIK.BEGREIFEN

School lab in Zeuthen

HOME / Offers / Cosmic Particles / Cosmic@Web

OFFERS

- Vacuum Lab
- Cosmic Particles
 - Basics
 - Student Experiments
- Cosmic@Web
 - Trigger Hodoscope
 - CosMO Mill
 - CosMO-muv
 - LIDO
 - Polarstern Project
 - Neumayer Station III
 - SEVAN
 - Weather Data Zeuthen
 - How To
 - Glossary
 - Links

PHOTOS

CONTACT

MORE SCHOOL LABS

LINKS

PARTNER

SCHOOL LAB HAMBURG

Cosmic@Web

- » plotting tool
- » manual
- contact

Further Offers

- » visit DESY



COSMIC@WEB

Das Webinterface von physik.begreifen in Zeuthen

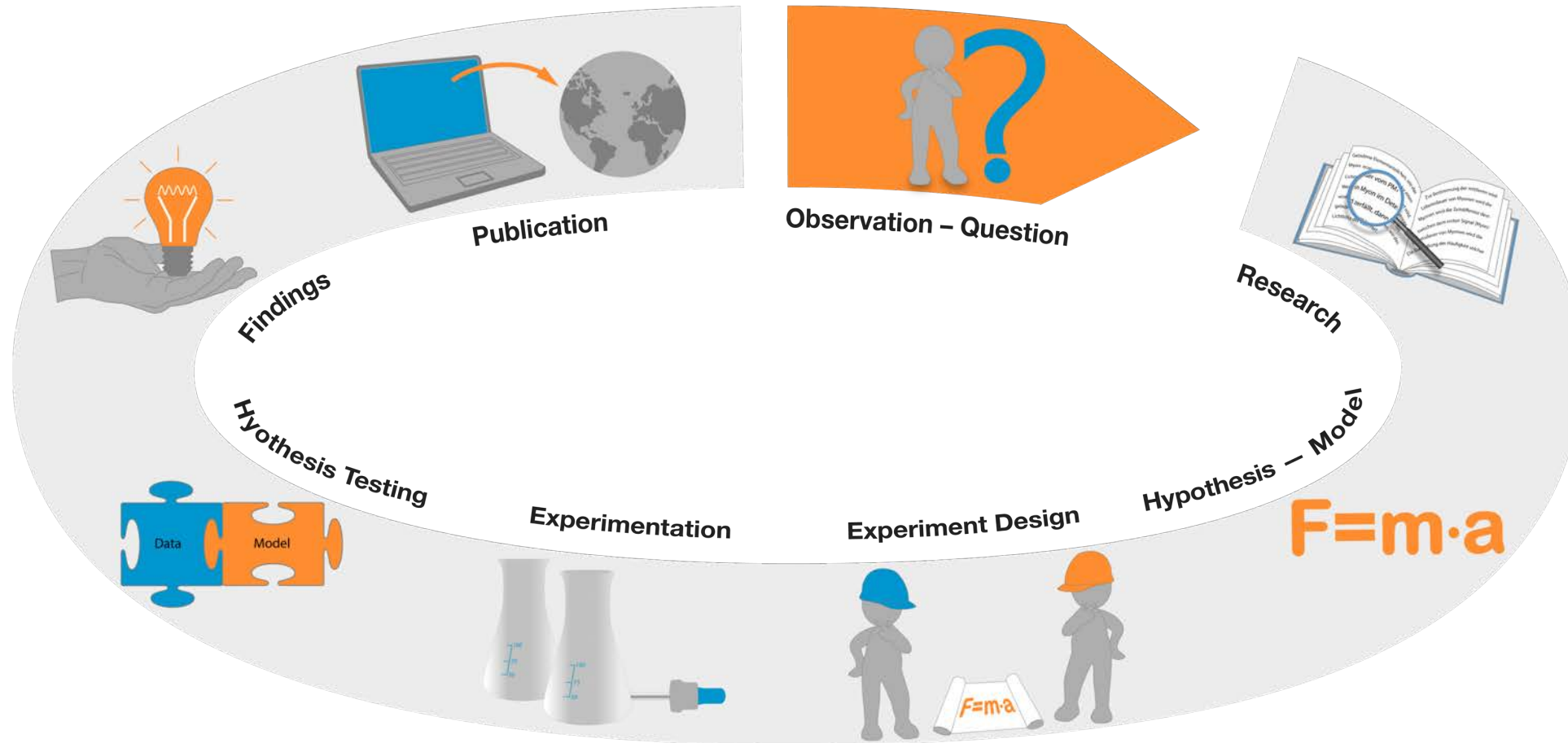
When working in scientific research it is not always possible to have the experiment on-site. Especially the large-scale experiments researching particle and astroparticle physics are so complex and expensive, they are made only once in coordination of all involved science facilities. Examples of DESY's participations in such projects are the IceCube experiment in the Antarctica, the experiments at the Large Hadron Collider (LHC) at CERN and the planned Cherenkov Telescope Array (CTA). For astroparticle experiments additional aspects infringe the ability to build an experiment as the location and available infrastructure play a significant role. Since scientific data from these experiments is available via internet it can be analysed from home. The scientists and technicians that travel to the locations of the experiment, mainly do so for maintenance and upgrade of the experimental facilities.

It is almost impossible for schools and teachers to arrange lessons about particle and astroparticle physics with the appropriate experiments. As can be seen in [Student Experiments](#), DESY has developed and produced a large number of CosMO and Kamiokannnen experiments which were made available by DESY and other astroparticle physics institutes in Germany for student and school projects with cosmic particles.

To expand the possibility of investigations with cosmic particles in the classroom and to reach a broader audience, the use of experimental data by students via the internet was introduced. DESY provides the internet portal [Cosmic@Web](#) which allows to analyse a large amount of data taken by different cosmic particle experiments running continuously at DESY, on the research

Work like a Scientist

From the Question to the Publication



https://www.desy.de/school/school_lab/zeuthen_site/cosmic_particles/scientific_work

Provides:

- introduction pages
- experiment descriptions
- data descriptions
- selection of interesting problems to solve
- How to and glossary
- plotting tool

PHYSIK.BEGREIFEN

School lab in Zeuthen

Home / Offers / Cosmic Particles / Cosmic@Web / CosMO Mill

CosMO Mill

As seen on the photo, the CosMO Mill consists of two [CosMO detectors](#) mounted on a wing arm. The particle rate is measured with a coincidence requirement; a signal must appear in both detectors. Starting at the 90 degree position, data is taken for one hour. Then, a step motor moves the arm by 15 degrees into the new position. This allows the continuous measurement of the dependence of cosmic particle rate on the Zenith angle at an interval of 90 to -90 degrees. [Zenith angle](#) dependence of the cosmic particle rate in the angle interval of 90 to -90 degrees.

Setup

The CosMO Mill consists of:

- > two CosMO detectors
- > a [DAQ card](#),
- > a wing arm with the two detectors mounted at 97 cm distance,
- > a step motor and the electronic components to steer the arm,
- > a notebook to control the angle position and for the accumulation of data with the program [muonic](#).



Data Structure

The datasets available via Cosmic@Web contain: time, air pressure, temperature, angle position, particle rate. More detailed information can be found in the description of the [Dataset](#).

Possible Student Exercises

- > Investigate the particle rate in dependence of the zenith angle.
- > Investigate the influence of weather conditions on the rates.
- > Compare the measurements from different years.
- > Compare the mill's rates with those of the Trigger Hodoscope.
- > Compare with own measurements performed with the CosMO or Kamiokannen experiments.

HOME

OFFERS

- Vacuum Lab
- Cosmic Particles
- Basics
- Student Experiments
- Cosmic@Web
- Trigger Hodoscope
- CosMO Mill
- CosMO-muv
- LIDO
- Polarstern Project
- Neumayer Station III
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- Weather Data Zeuthen
- How To
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- Links

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MORE SCHOOL LABS

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PARTNER

SCHOOL LAB HAMBURG

Cosmic@Web

- » plotting tool
- » manual
- contact

Further Offers

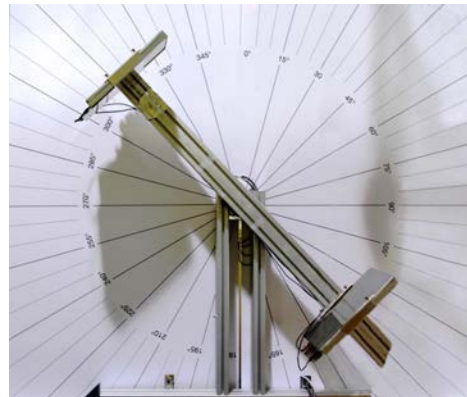
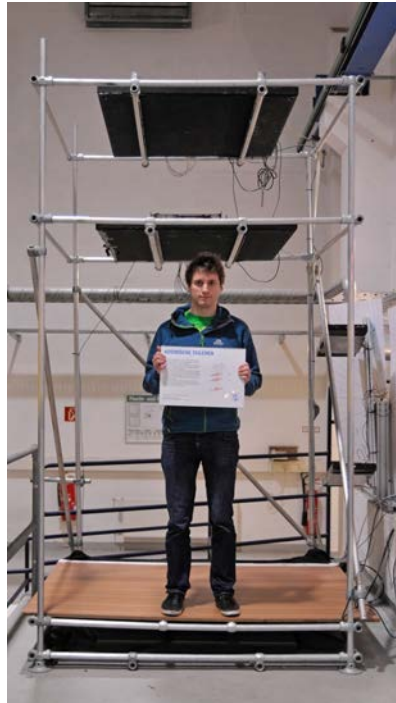
- » LIDO

Cosmic@Web

Investigate Atmospheric Muons

9 experiments:

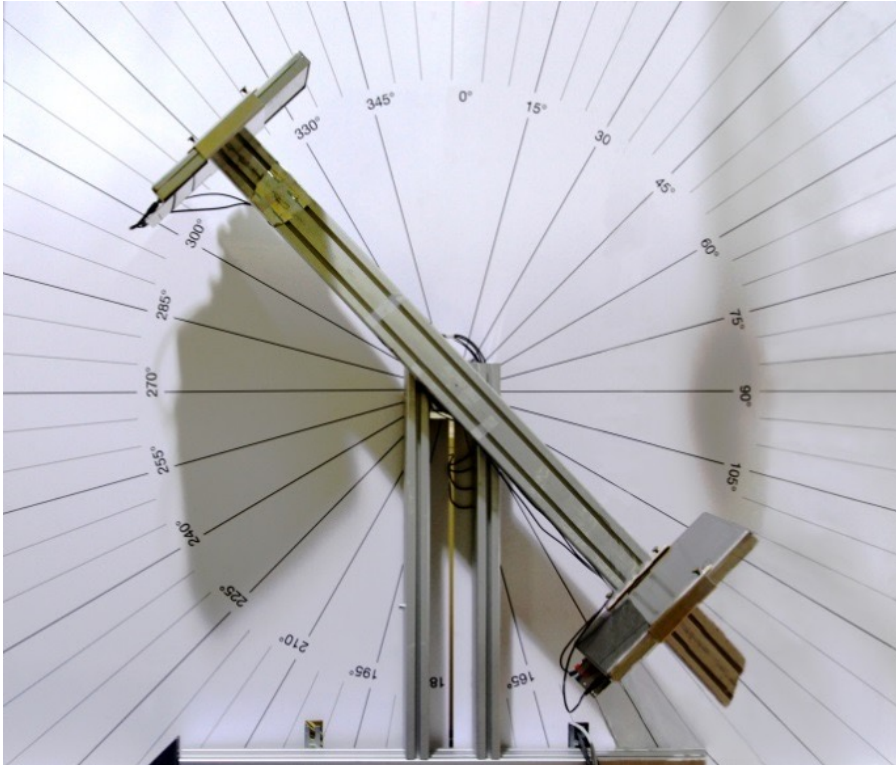
- lifetime of muons
- geomagnetic effect
- zenith angle dependence
- rate in Germany, Armenia and Antarktis
- rate depending on weather conditions



CosMO-Mill

Investigation of zenith angle dependence

- possibility to participate in ICD without own experiment on site
- instruction: <https://icd.desy.de/e35439/>



Zenith Angle Dependence of the Cosmic Muon Rate



Measurement and Analysis with Cosmic@Web

Status: October 2020

Contact: cosmicatweb@desy.de

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carolin.schwerdt@desy.de
Platanenallee 6 | 15738 Zeuthen | Germany

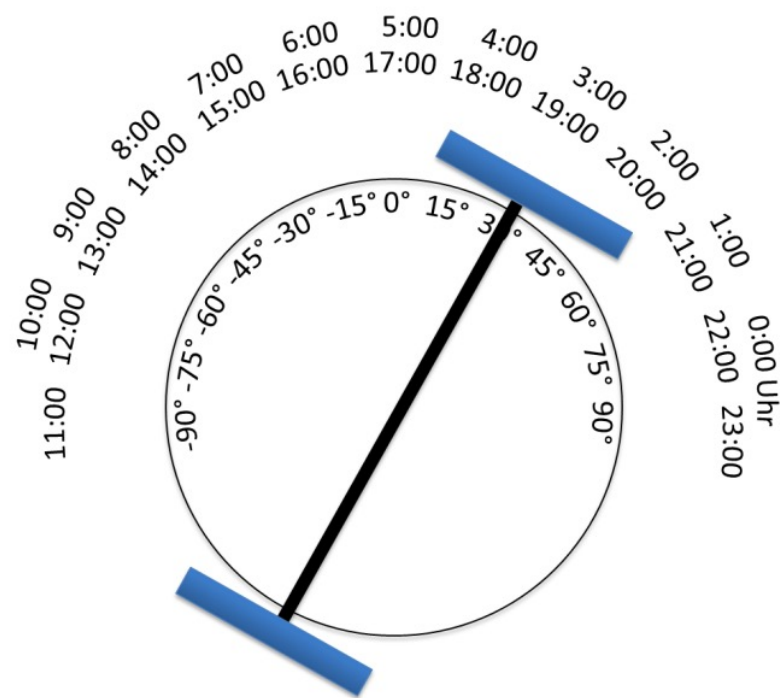


CosMO-Mill

Investigation of zenith angle dependence

Location: Zeuthen

Mill changes its position
every hour by 15°



SETTINGS

DIAGRAMS

SAVED DIAGRAMS

Language: **English** / German

» More information about Cosmic@Web

» Cosmic@Web manual (still in German)

» Start Tutorial, (still in German)

Diagram Creation

Setting of detail level

Standard

1. Data Array

✖

Add Data Array

Choose Data Set

Experiment

CosMO-Muehle

Data Set

2017_M - rate per angle

Diagram Type

xy-Diagram

Choose Variables

x-Variable

time [s]

y-Variable

mu_rate [1/h]

z-Variable

optional

Diagram Option

Title

International Cosmic Day

Legend

Position

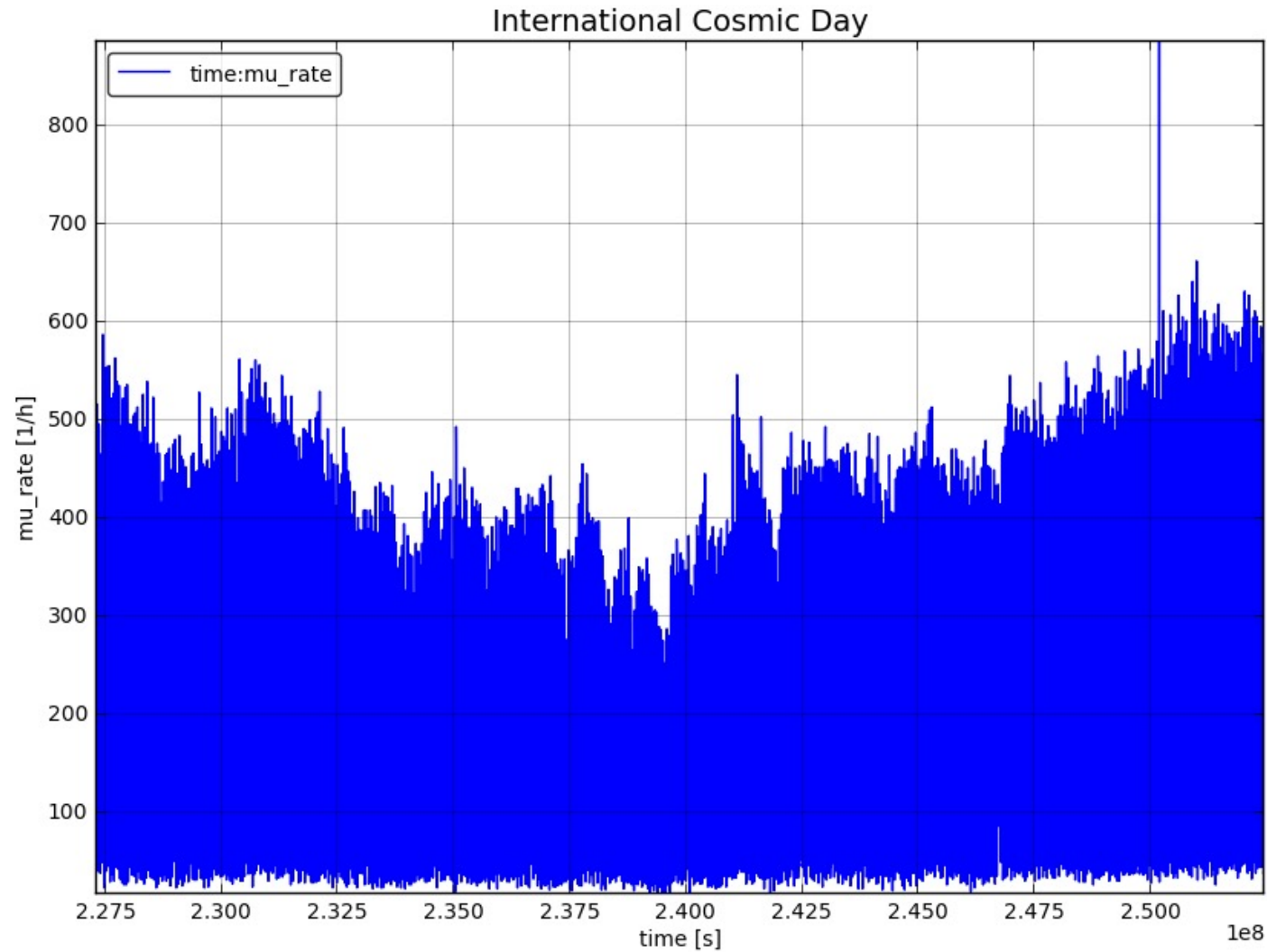
automatically

Reset

Diagram Creation

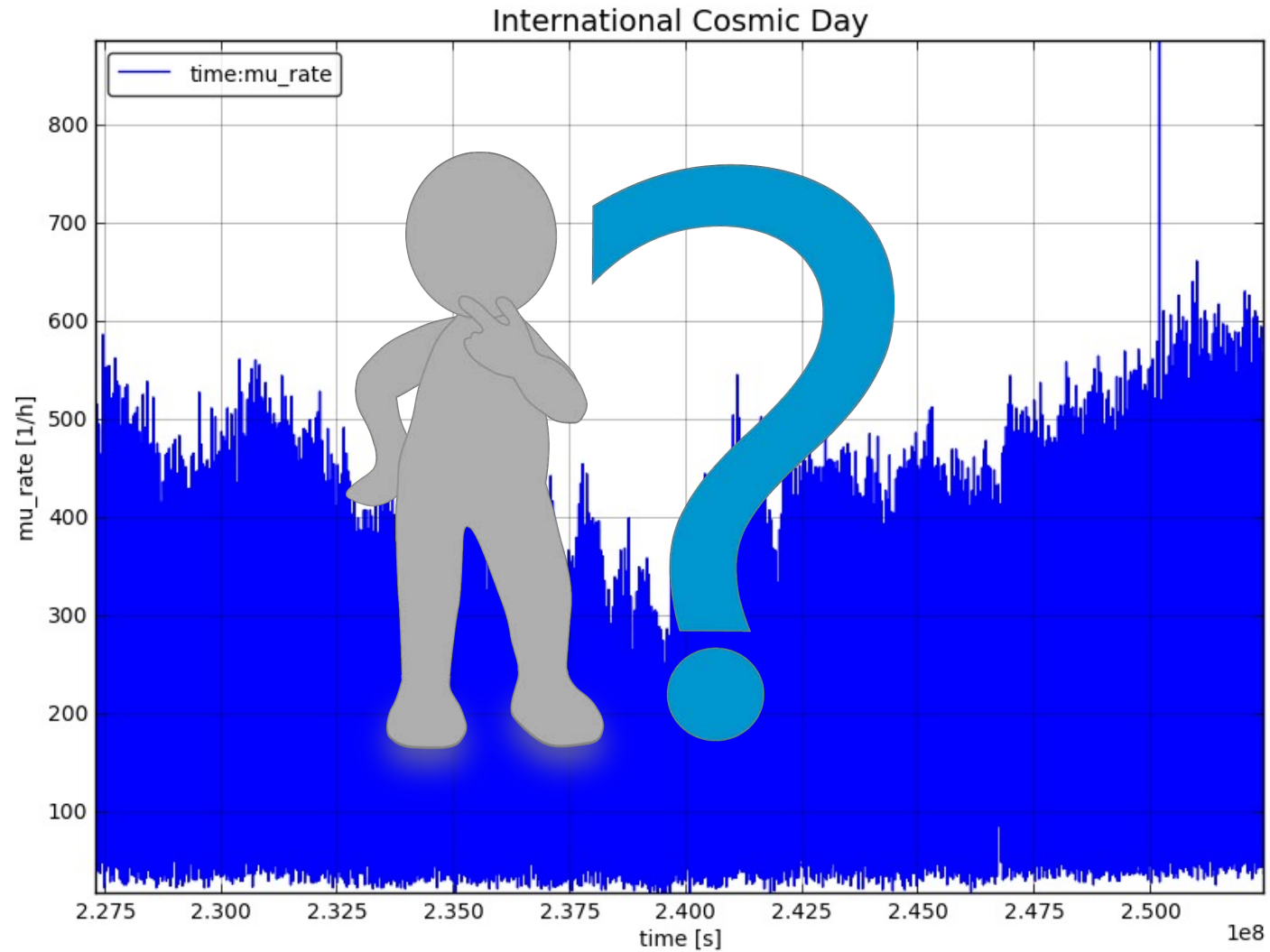
CosMO-Mill

Investigation of zenith angle dependence



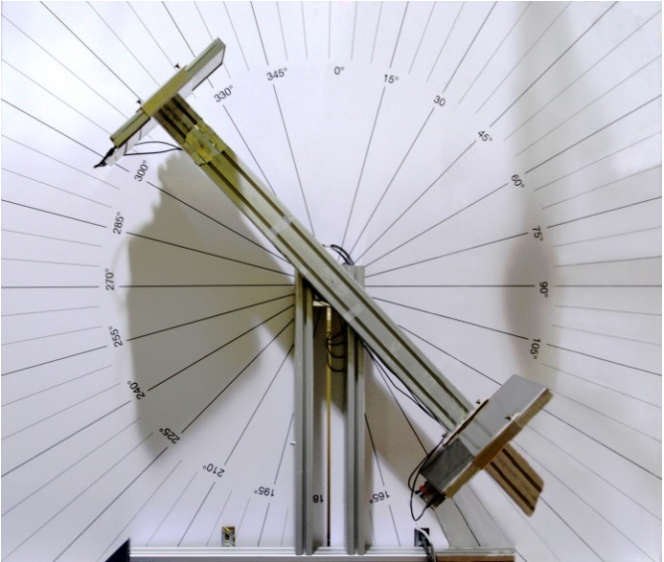
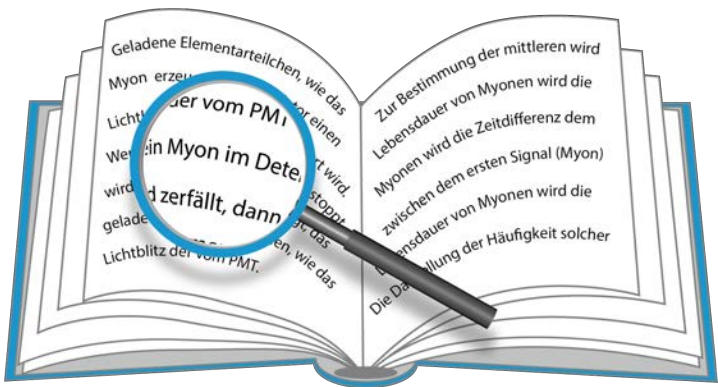
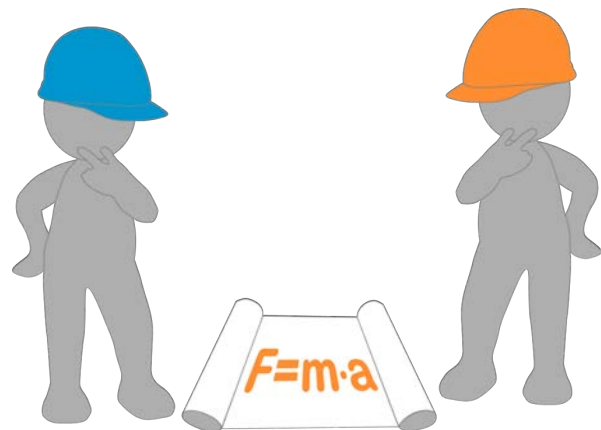
CosMO-Mill

Investigation of zenith angle dependence



CosMO-Mill

Investigation of zenith angle dependence



Dataset CosMO Mill

Parameter Webinterface	Definition	SI-Unit	Example
time	UTC time since 1.1.2010 00:00:00	seconds	165500000
p	Air Pressure	hPa	1013.7
T	Temperature	Grad Celsius	17.0
angle	Zenith Angle	Grad	0.0
mu-rate	Muon Rate, number of muons per hour	1/h	9331

CosMO-Mill

Investigation of zenith angle dependence

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Choose Data Set

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CosMO-Muehle

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2017_M - rate per angle

Diagram Type

xy-Diagram

Choose Variables

x-Variable

angle [deg]

y-Variable

mu_rate [1/h]

z-Variable

optional

Add Data Array

Diagram Option

Title

International Cosmic Day

Legend

Position

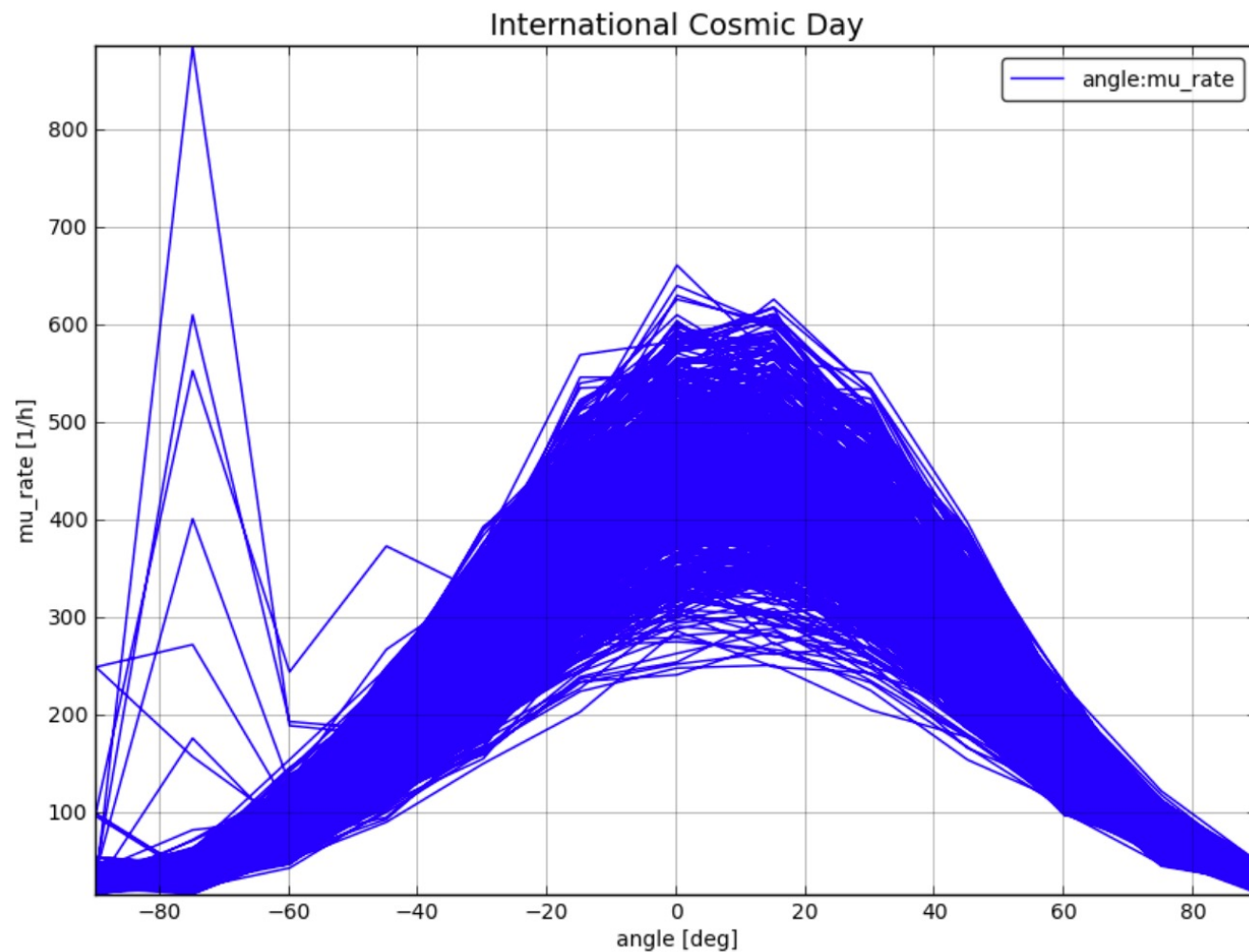
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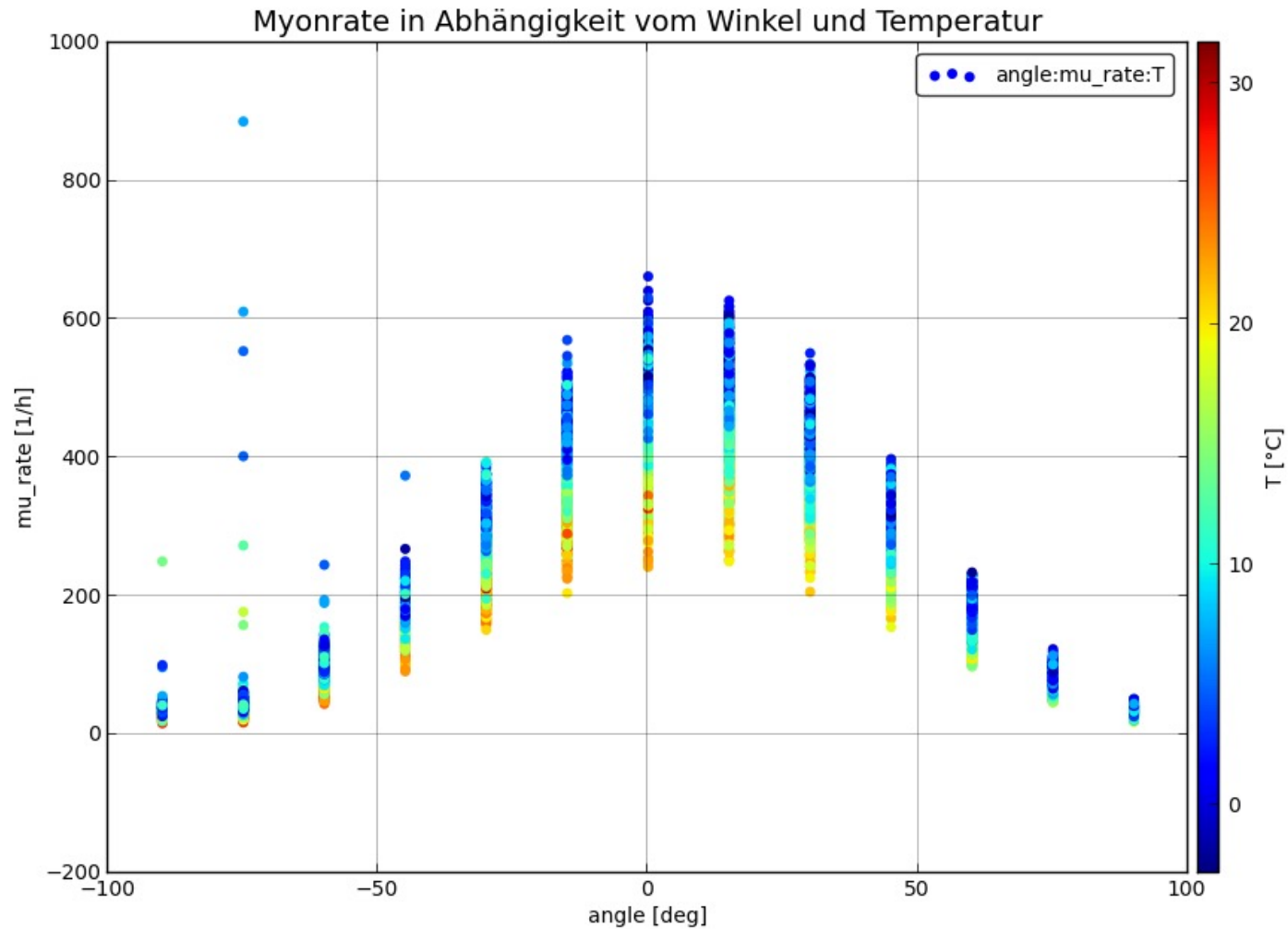
CosMO-Mill

Investigation of zenith angle dependence



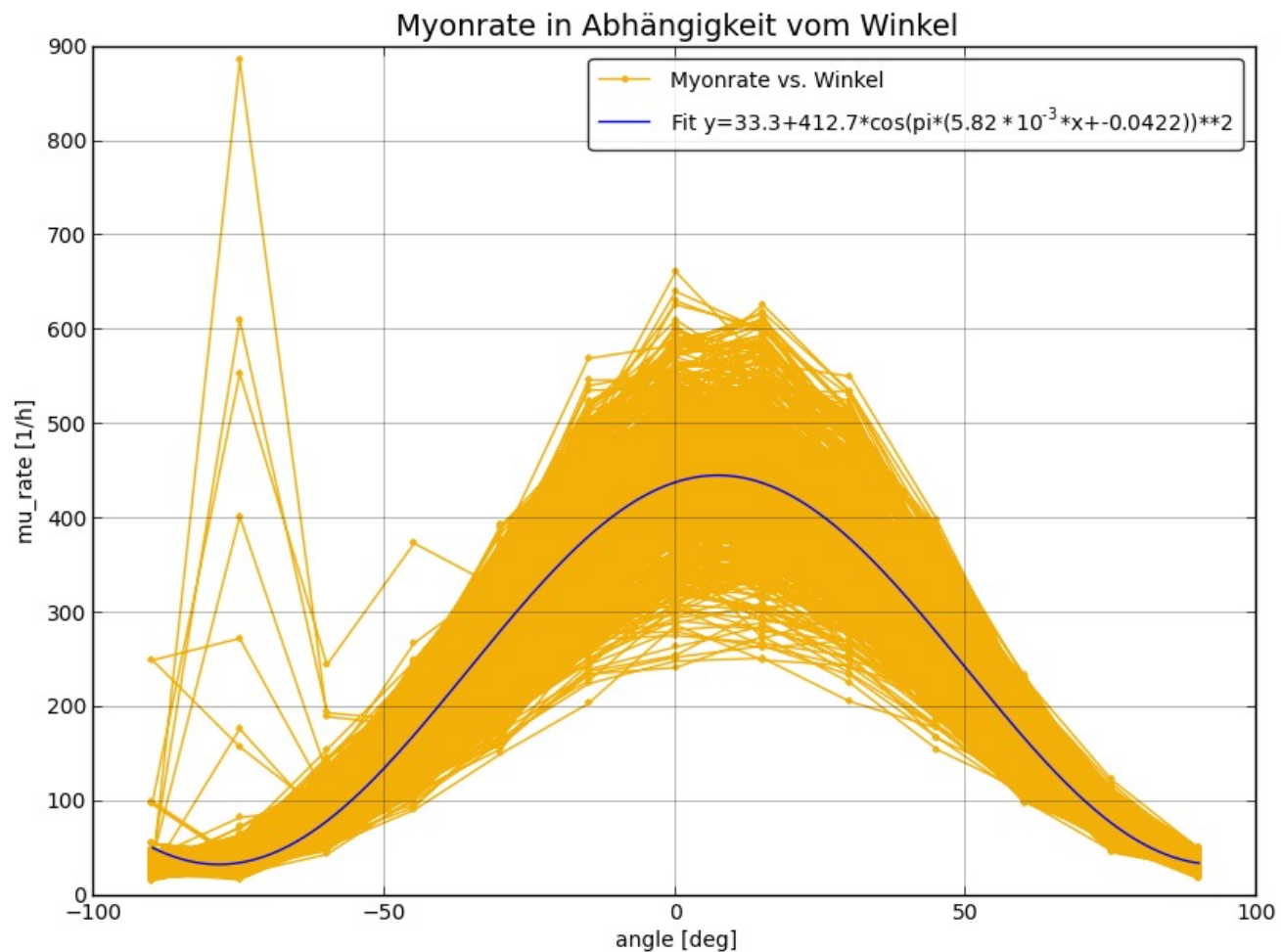
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Investigation of zenith angle dependence



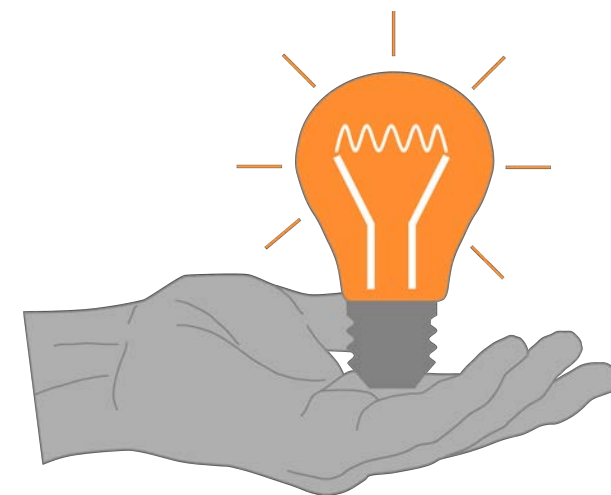
CosMO-Mill

Investigation of zenith angle dependence

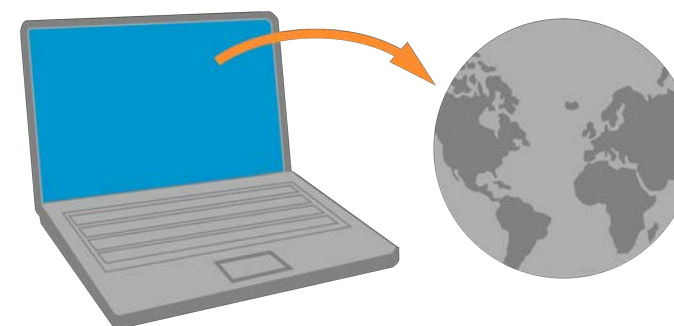


$$y=p[0]+p[1]*\cos(\pi*(p[2]*x+p[3]))^{**2}$$

$N/N = 1.713*10^7/6991$
 $p[0] = 33.31\%1.315$
 $p[1] = 412.7\%1.697$
 $p[2] = 5.824*10^{-3}\%2.174*10^{-5}$
 $p[3] = -0.04221\%6.668*10^{-4}$



Rate of measured muons depends on temperature and zenith angle



International Cosmic Day

About

- one day event, once a year (usually in November)
- focuses on cosmic rays
- students, teachers and scientists come together to talk and learn about cosmic rays
- <https://icd.desy.de>
- Facebook and Instagram:
[#InternationalCosmicDay](#)

A vertical poster for International Cosmic Day. The top section has a black background with the text 'Discover Cosmic Rays' in white, followed by 'INTERNATIONAL COSMIC DAY' in large, bold, blue and pink letters. A circular stamp on the right says '10 YEARS International Cosmic Day'. Below this is a blue-tinted image of Earth from space. The date 'November 10 | 2021' is written in white. A text block in the center reads: 'Cosmic particles, these unnoticed particles that surround us all the time, are the focus of this day. Students, teachers and scientists get together to talk and learn about Cosmic Rays and answer questions like:'. To the right, a list of questions is shown: 'What are cosmic particles?', 'Where do they come from?', 'How can they be measured?', and 'And what can we learn from them?'. At the bottom left, a white box contains the text: 'If you want to know more about the secrets they bring with and to be part of this collaboration, get here more information:'. Below this box are the URLs 'https://icd.desy.de' and 'https://www.facebook.com/InternationalCosmicDay'. The bottom of the poster features a row of logos: IPhG, Netzwerk Teilchenwelt, DESY, Fermilab, and QuarkNet. The text 'Image Credit: DESY, Science Communication Lab' is at the bottom right.

Discover Cosmic Rays

INTERNATIONAL COSMIC DAY

10 YEARS International Cosmic Day

November 10 | 2021

Cosmic particles, these unnoticed particles that surround us all the time, are the focus of this day. Students, teachers and scientists get together to talk and learn about Cosmic Rays and answer questions like:

What are cosmic particles?
Where do they come from?
How can they be measured?
And what can we learn from them?

If you want to know more about the secrets they bring with and to be part of this collaboration, get here more information:

<https://icd.desy.de>
<https://www.facebook.com/InternationalCosmicDay>

Image Credit: DESY, Science Communication Lab

IPhG
International Particle Physics Outreach Group

Netzwerk
TEILCHENWELT

DESY

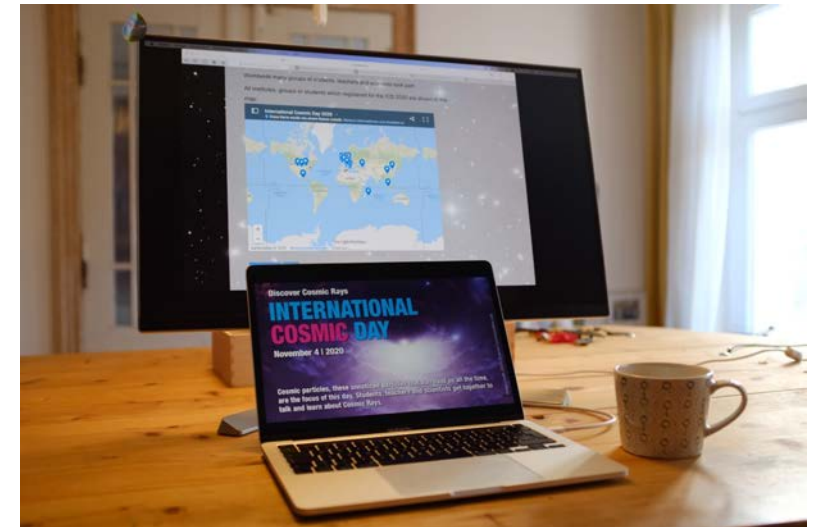
Fermilab

QuarkNet

Idea of the ICD

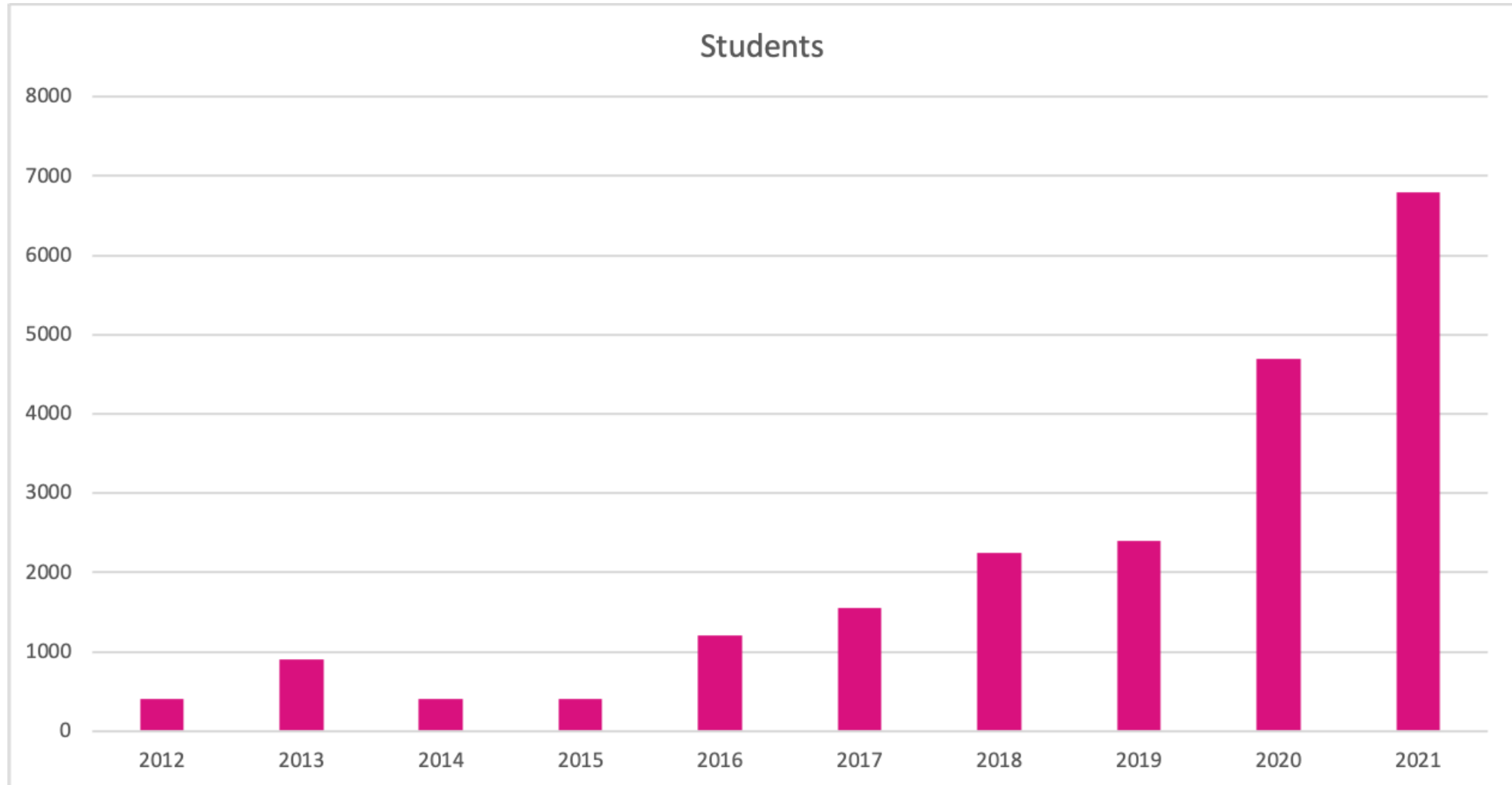
How it works?

- once a year, at one day, work on the same topic worldwide
- this offers young people:
 - opportunity for exchange in videocalls
 - participate in a common framework, as in an international collaboration
- teachers and scientists are asked to design a program for a group of young people (local activities)
- ICD team provide the common framework, provide materials, connect the different groups with each other, selfie and drawing test, Kahoot quiz



Number of Participating Students

Growing Event



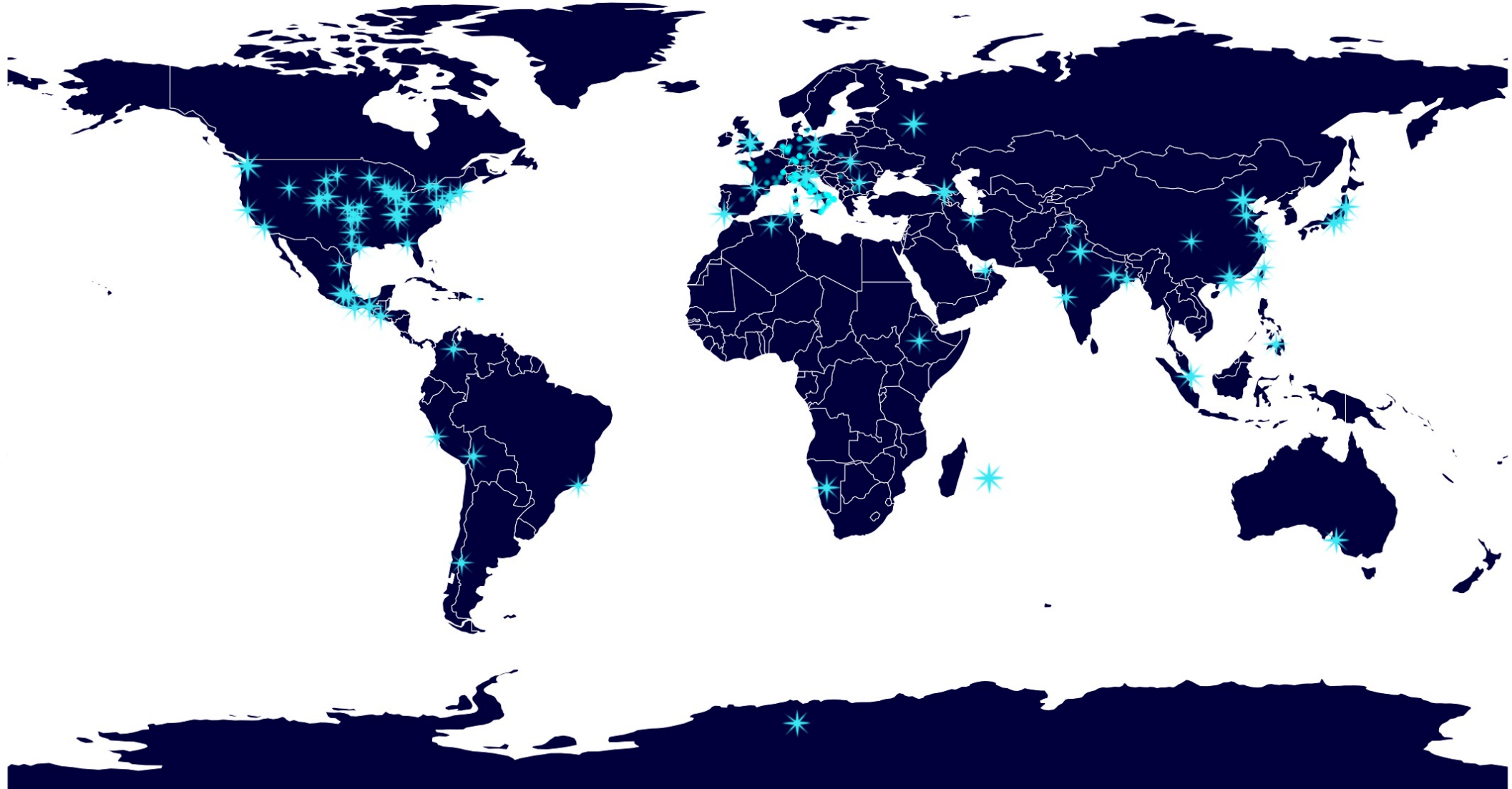
Participating Groups Worldwide

2021



Participating Groups Worldwide

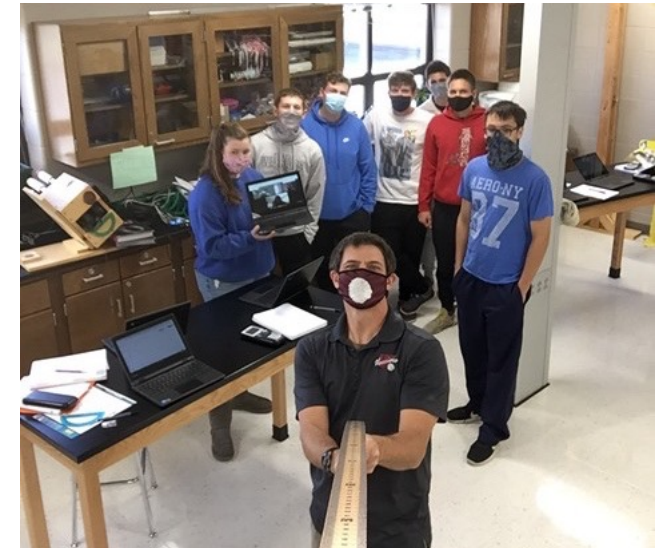
2012 - 2021



Activities for the ICD

What to do?

- each group plan its own event
- activities:
 - discussions on cosmic particles
 - news about the latest research
 - direct measurement of cosmic particles
 - data analysis of cosmic particles
- formats:
 - Lectures
 - Masterclasses or Masterclasses@home
 - video transmissions to the classroom
 - tasks that the students can do in school or at home



Direct Measurement of Cosmic Particles

Use your Own Detector - Examples



OCRA, ITALY



Cosmos à l'École, FRANCE



tan-Q, JAPAN



QuarkNet, USA

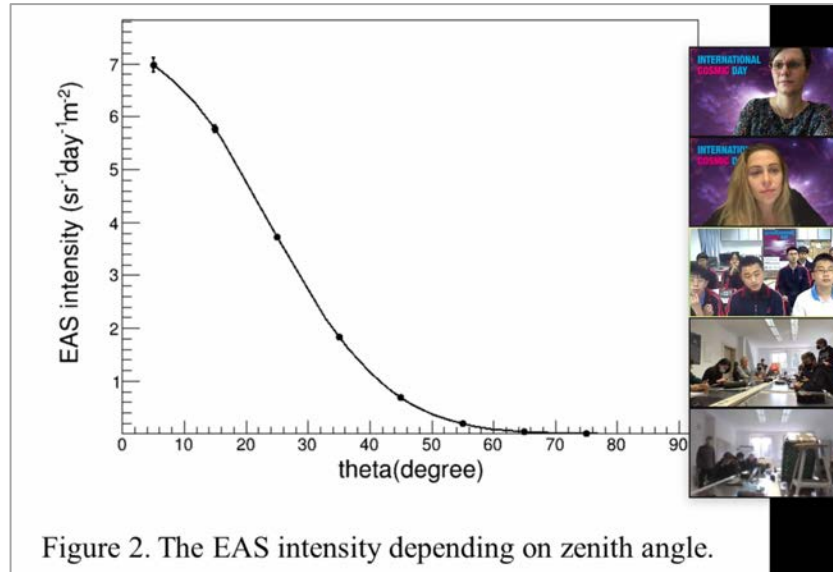


INFN, ITALY

Impressions from ICD



Welcome Call 2021:
greetings from all
participating countries



Video Call: exchange and
discussion of results between 5
participating groups



Winner of Drawing Contest
2022: Farbod from Iran

Publication of the Research Work at ICD

Booklet with all Contributions of the Participating Groups



INTERNATIONAL COSMIC DAY

DEAR YOUNG ICD-RESEARCHERS FROM

USA · IRAN · INDIA · PERU · ITALY ·
SPAIN · CHINA · JAPAN · RUSSIA · MEXICO · FRANCE ·
GERMANY · BULGARIA ·
ARGENTINA · SWITZERLAND · NETHERLANDS ·
UNITED KINGDOM,

thank you all for your participation and contribution to this year's International Cosmic Day (ICD)!

The 10th anniversary of ICD was truly a reason to celebrate: More than **6800 students from 17 countries** under the guidance of teachers and scientists made this day a successful celebration of physics. Participants from various institutions all over the globe such as schools, universities and research institutes performed experiments and attended lectures. We listened to scientists discuss their research and to students who presented their results - all to form a deeper understanding of the world we live in.

On this one day of the year you, the students, get the chance to become a part of the **science community**. To learn how the universe works we have to study the smallest particles as well as the largest celestial objects. Whether you analyzed data from an observatory or performed an experiment yourself: you all learned a lot about cosmic particles on that day.

We hope that the International Cosmic Day gave you an insight into **astroparticle physics**. Maybe you have become interested and it opens a new window for you to explore the universe.

This booklet contains the results of **your discoveries** and some information on the participating groups and the winners of the selfie and the drawing contest. If you want to learn more about astroparticle physics, you will also find web links for further information.

Greetings from
your ICD Team

3

INTERNATIONAL COSMIC DAY

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Many Thanks



Kontakt

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PARTNER



SCHIRMHERRSCHAFT



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GEFÖRDERT VOM



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