Astroparticle Outreach at DESY

Discover Cosmic Rays

Carolin Schwerdt
CCOC Seminar, online
March 15, 2022

HELMHOLTZ SPITZENFORSCHUNG FÜR GROSSE HERAUSFORDERUNGEN

DESY.

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

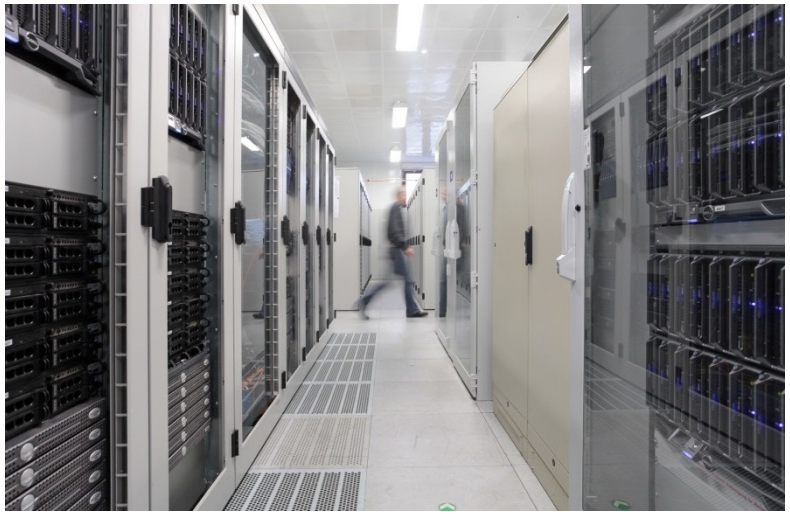
- Accelerators
- Photon Science
- Particle Physics
- Astroparticle Physics

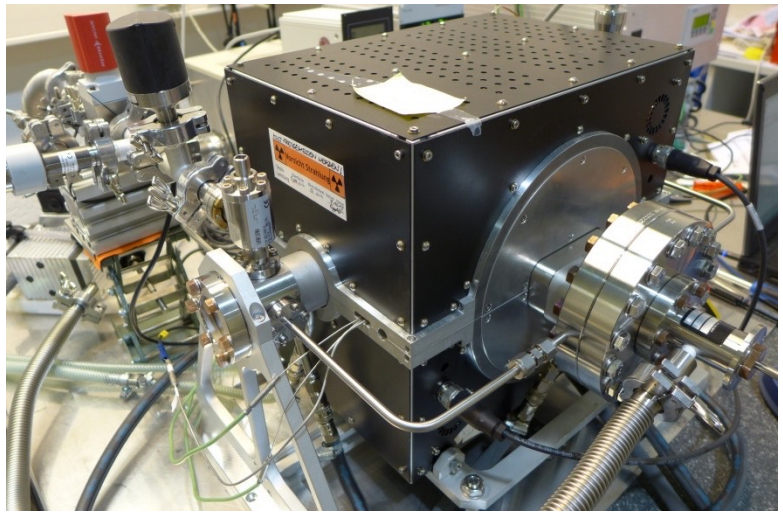
https://www.desy.de/about_desy/annual_reports/

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

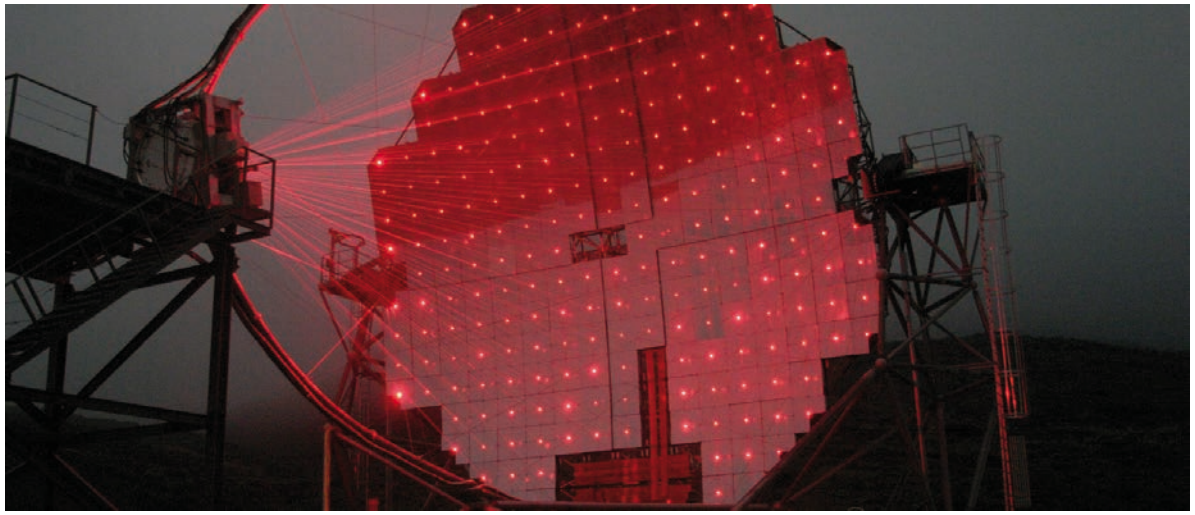
https://www.youtube.com/watch?v=xpshlU-6n40

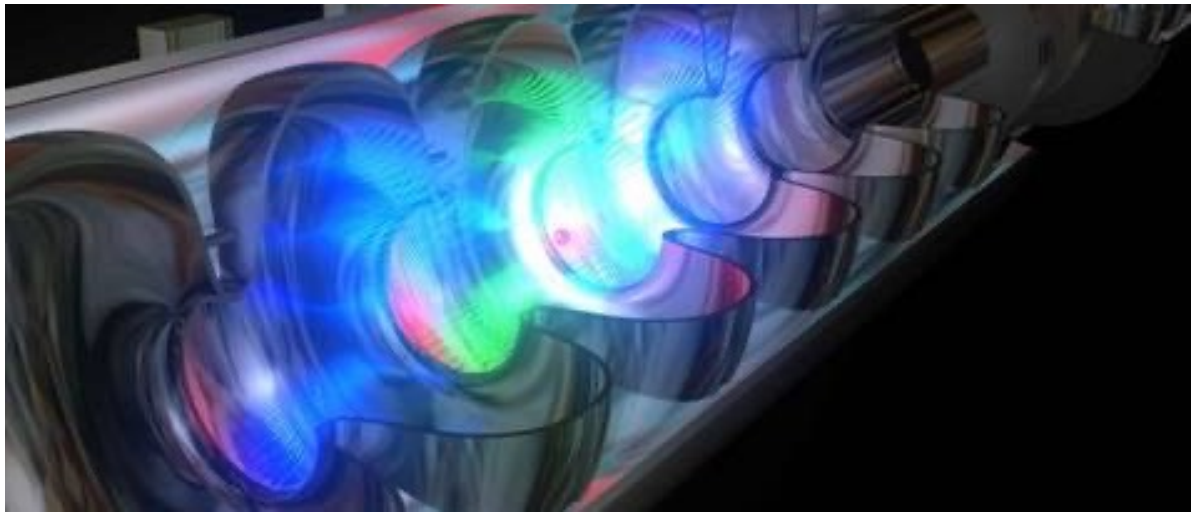
Particle Physics

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

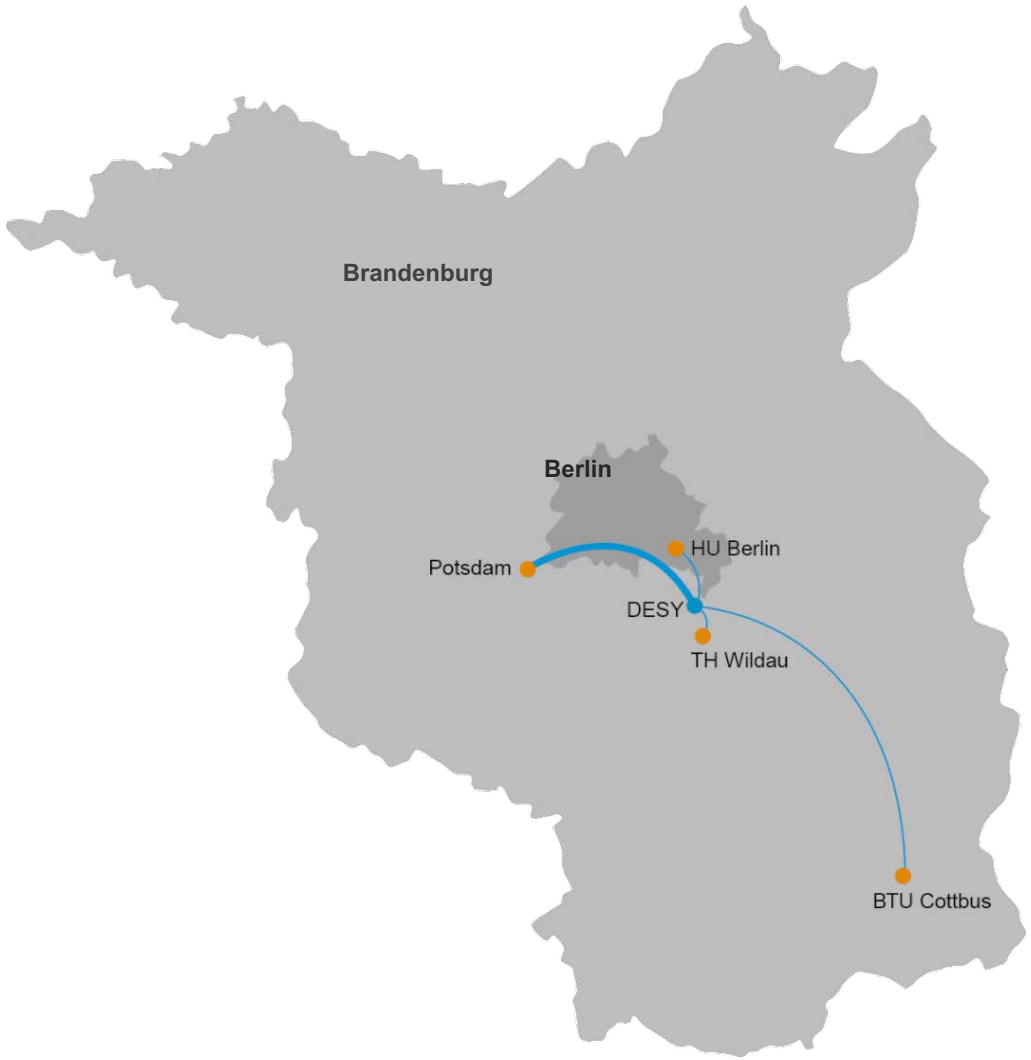
Accelerators

- 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’

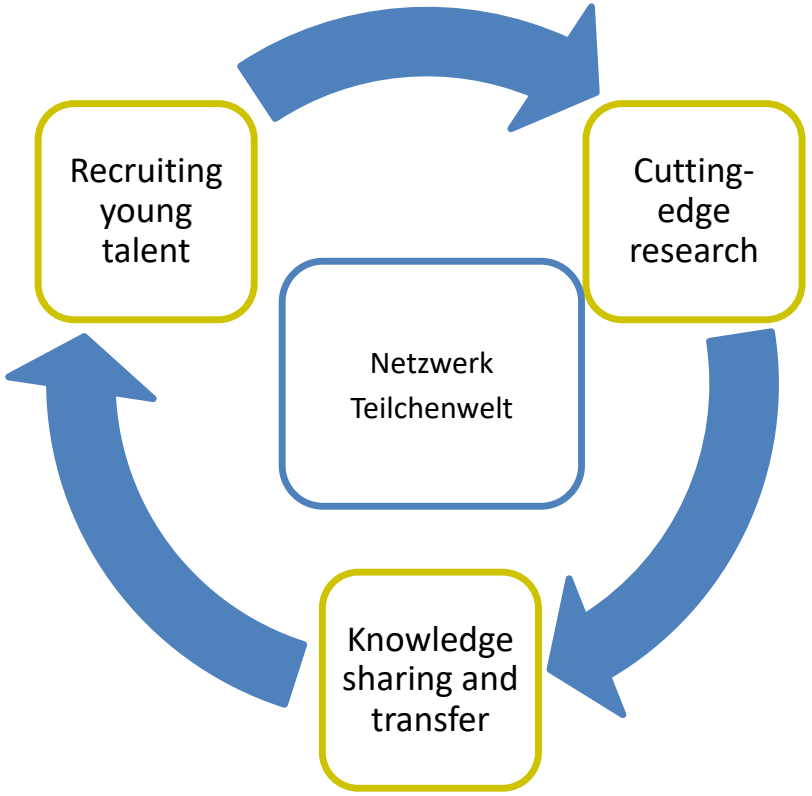
- education project: own research questions, conduct investigations, analyze data, report results
- for interested school students (age 15 to 19)
- PhDs supervise the young researchers
- standard: 2 weeks internship
- also mentoring of “Jugend forscht” - reports (contest for highly gifted young people)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

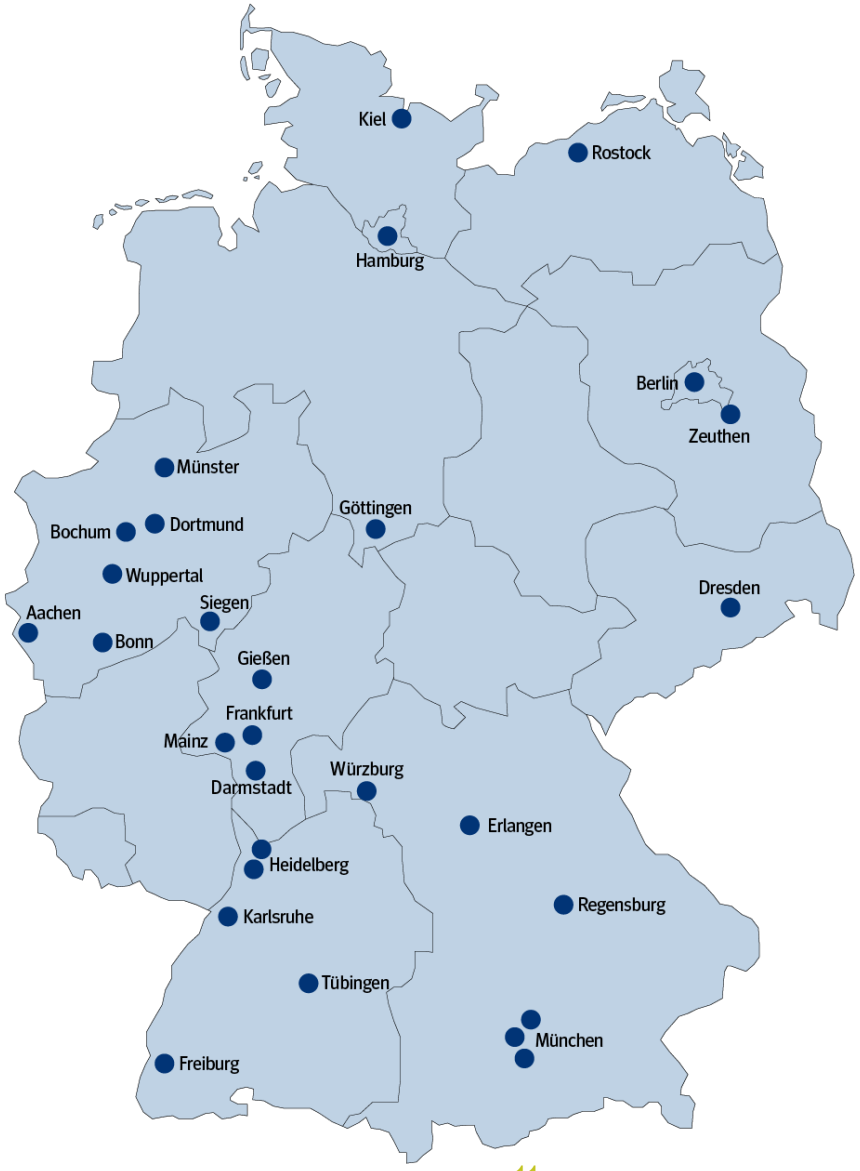
- German Education Network for Particle and Astroparticle Physics, Hadron & Nuclear Physics
- between scientists, school students (age 15-19) and teachers at schools, school labs, museums etc.



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



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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

Win^4 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."

Win^4 Situation for all involved

Teachers…

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

Win^4 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

Win^4 Situation for all involved

University and Research Institution…

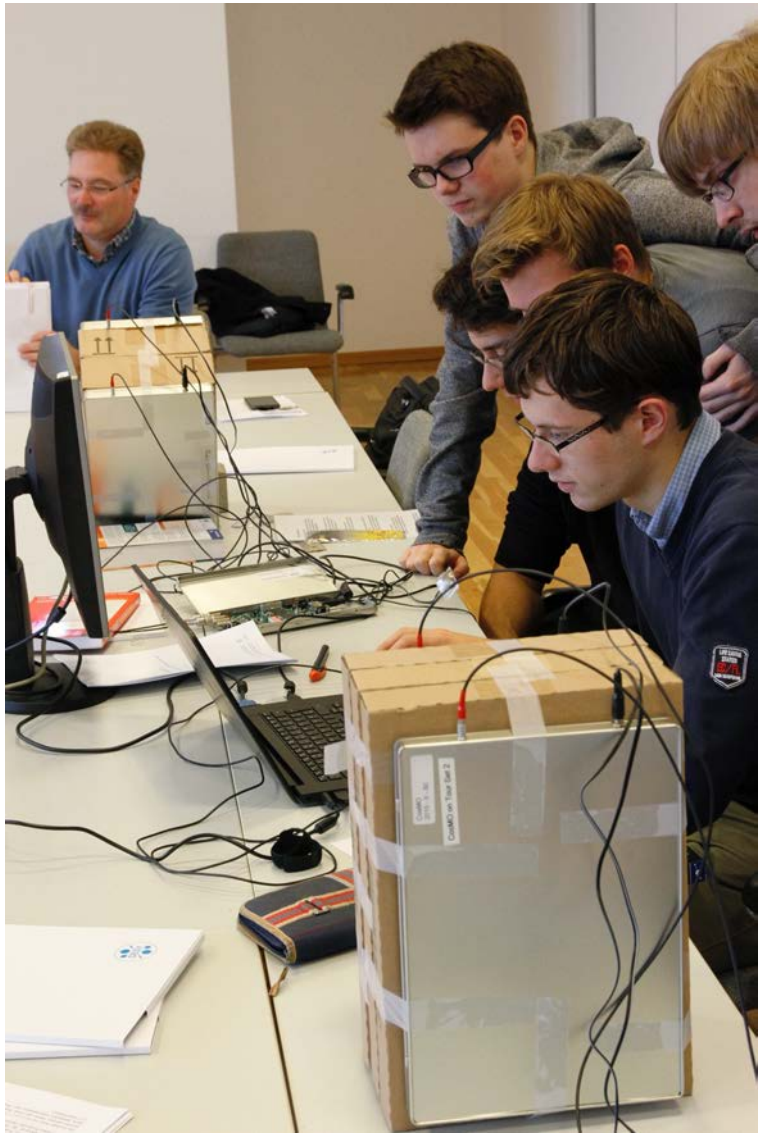
- Carrying own research to schools and public
- Long-term contacts with future students
- Support: organization, material

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

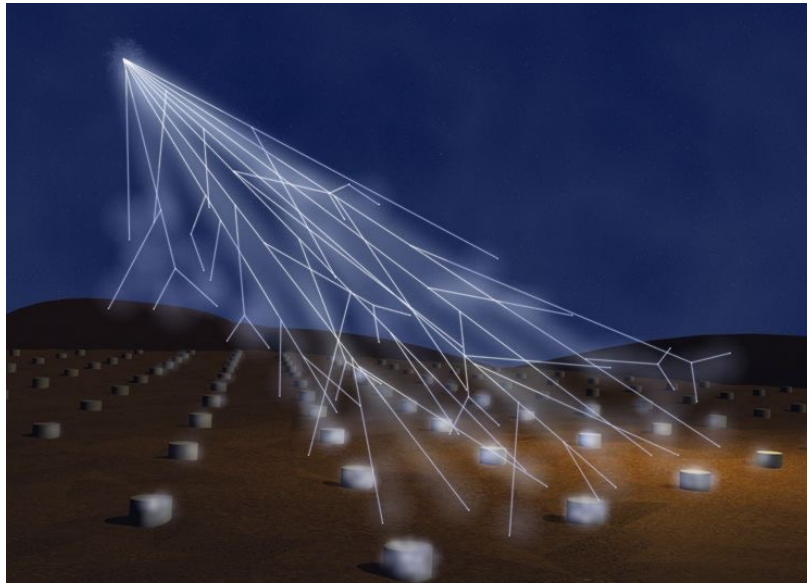
- One-day event in schools or scientific institution
- lead by PhD and Master students

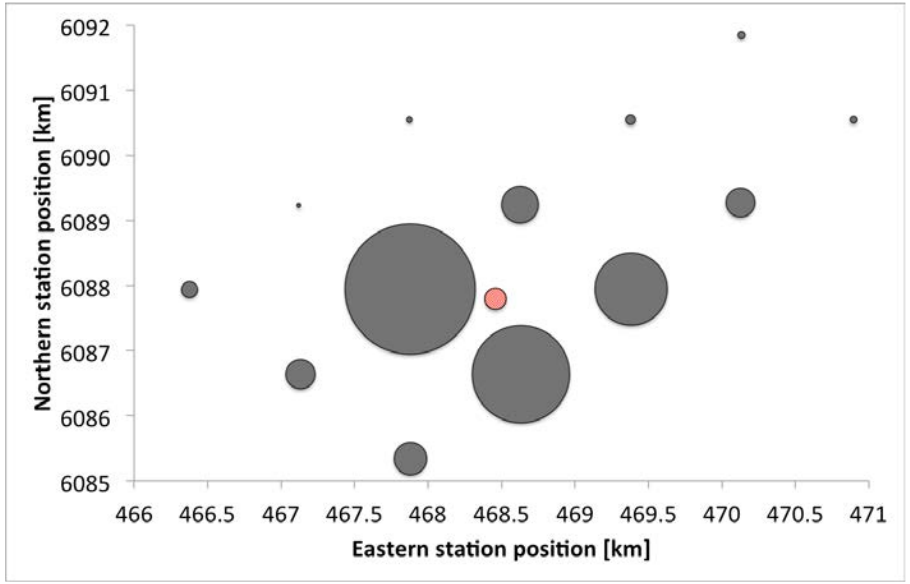
Young people...

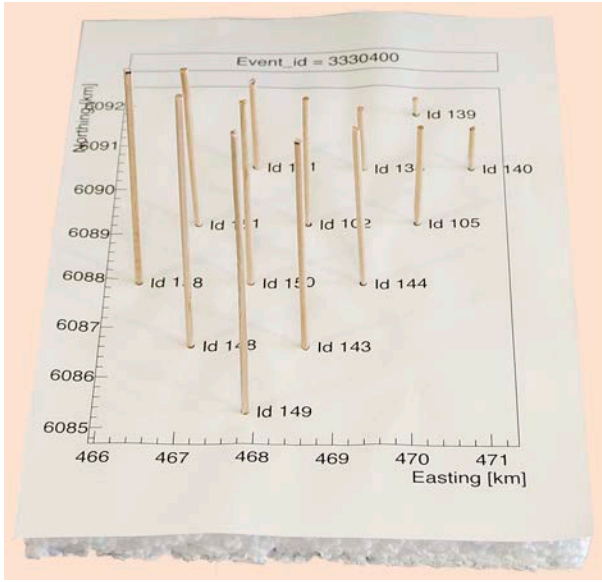
- understand how information about cosmic rays is obtained from an experiment and the measured data
- can experience part of the work on the experiment themselves
- understand the necessity of computer work and programming
- can better understand how to continue with the research work afterwards

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

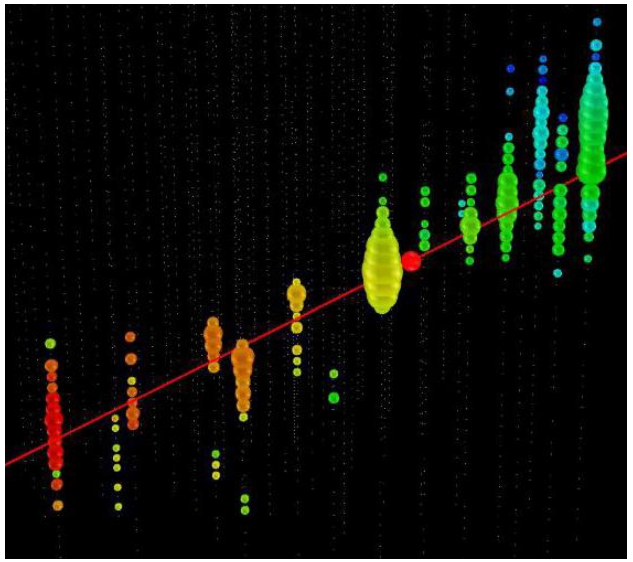




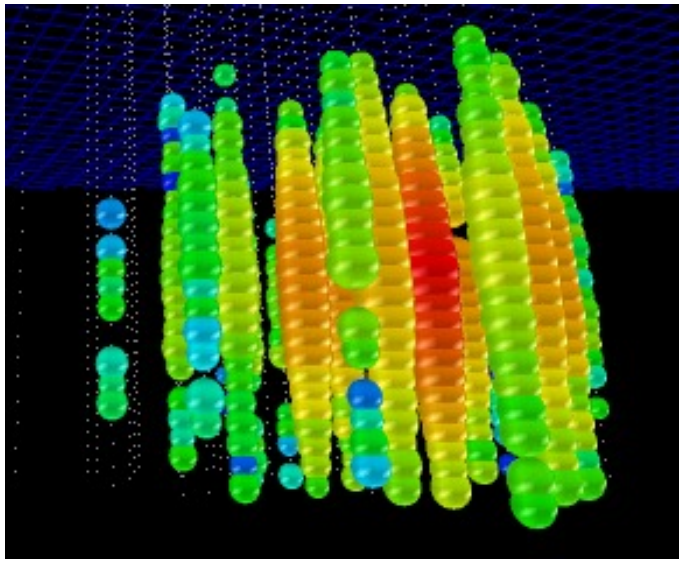


IceCube MasterClass
AN AUTHENTIC ASTROPHYSICS RESEARCH EXPERIENCE

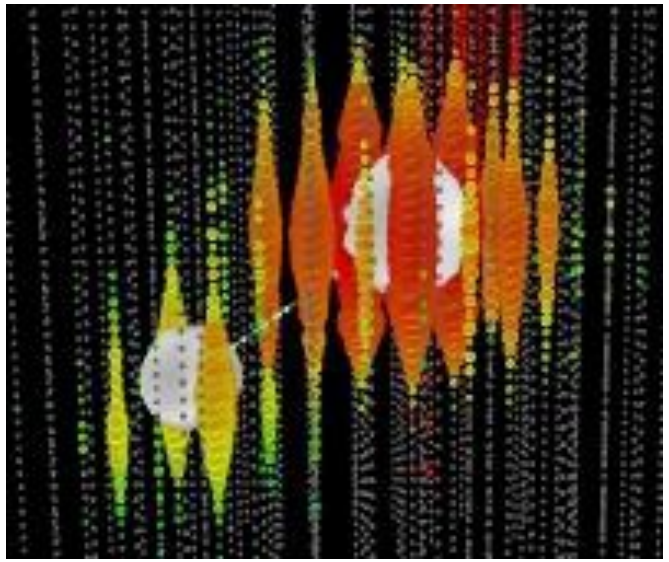
- distinguishing signatures and filtering neutrinos
- interface with already filtered data is provided
- https://masterclass.icecube.wisc.edu/de



Muon Neutrino (data)



Elektronen Neutrino (data)



Tau Neutrino (simulation)

Particle detectors for own measurements

Developed for and distributed to 20 sites from the networkNetzwerk Teilchenwelt:

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

Cloud Chamber

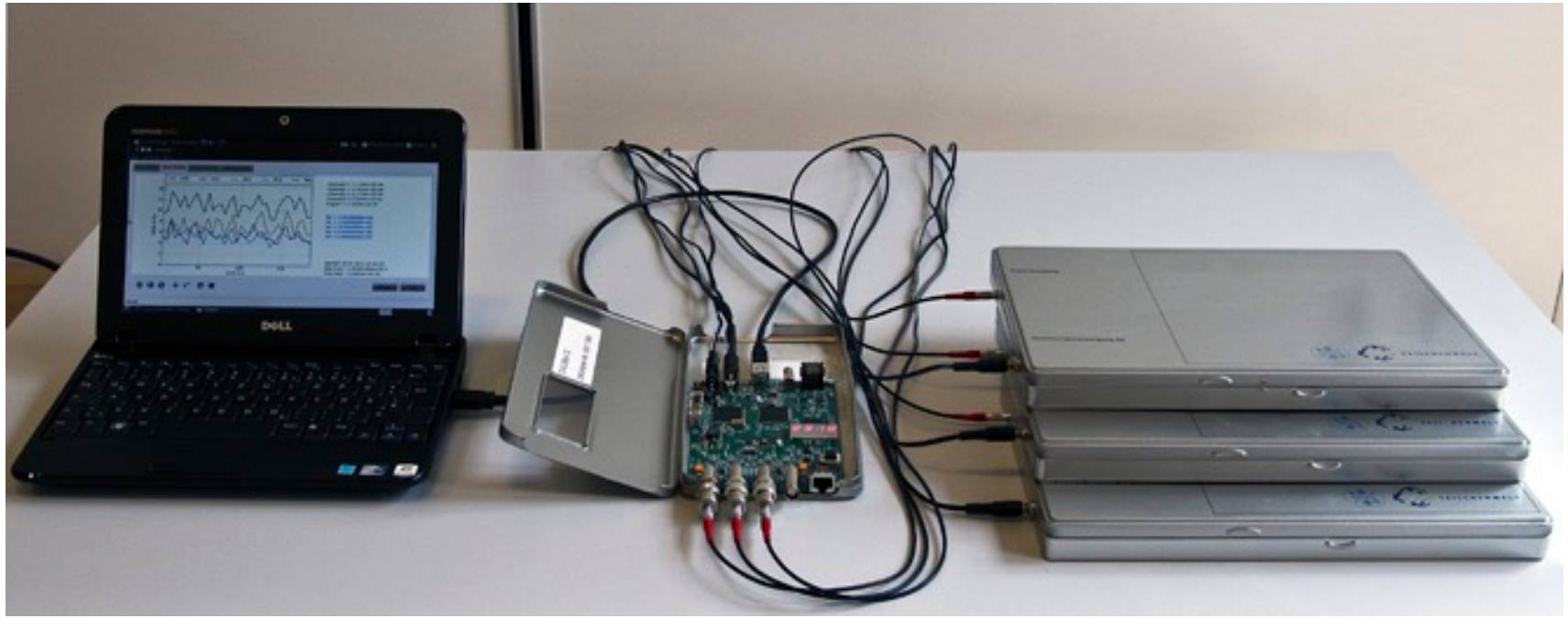
Self assembly set

- 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



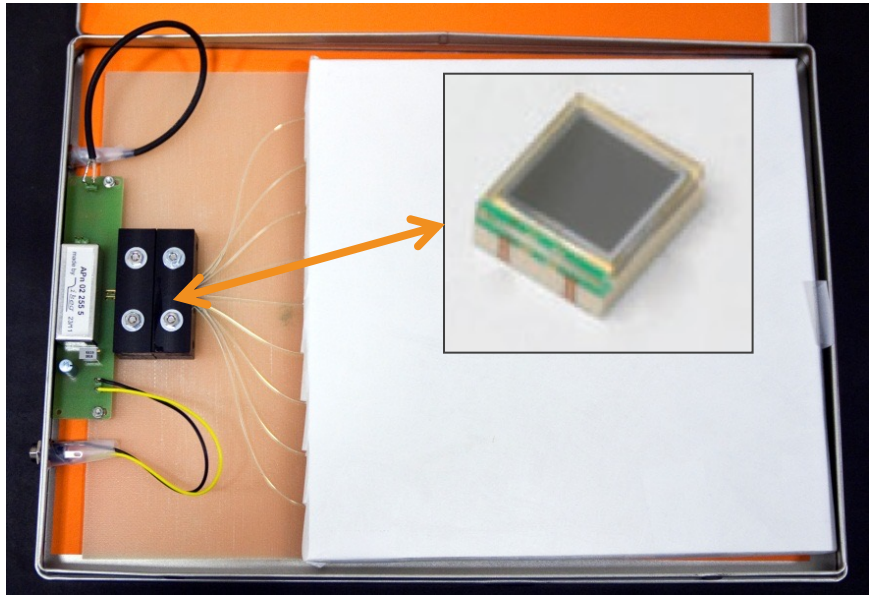
Components:

- 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

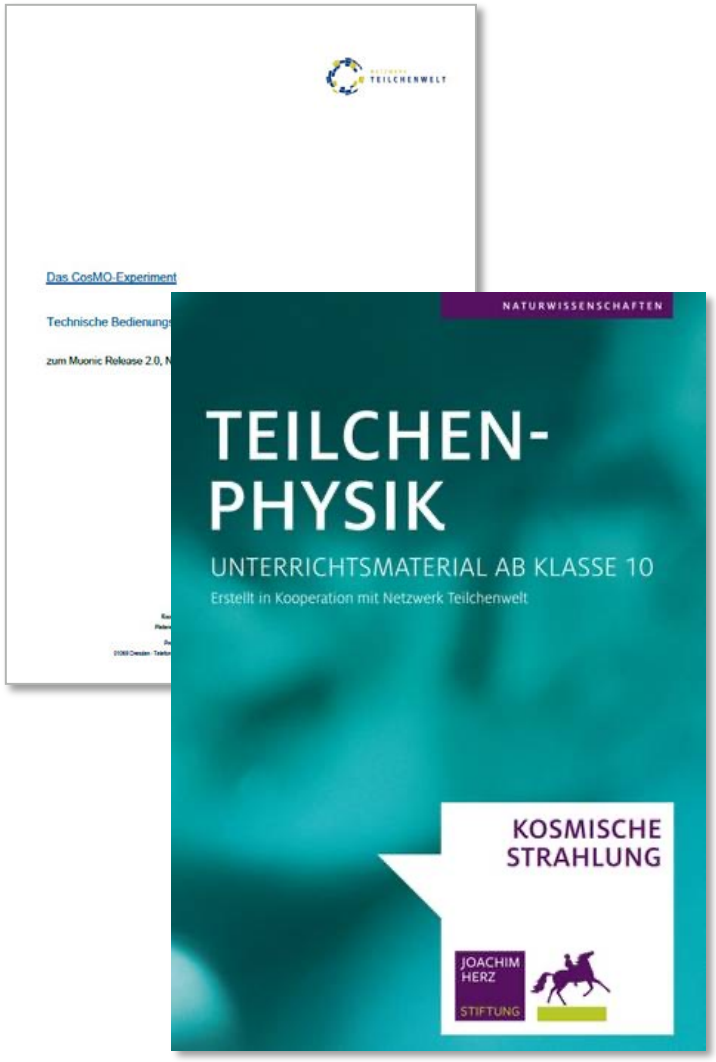
CosMO

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

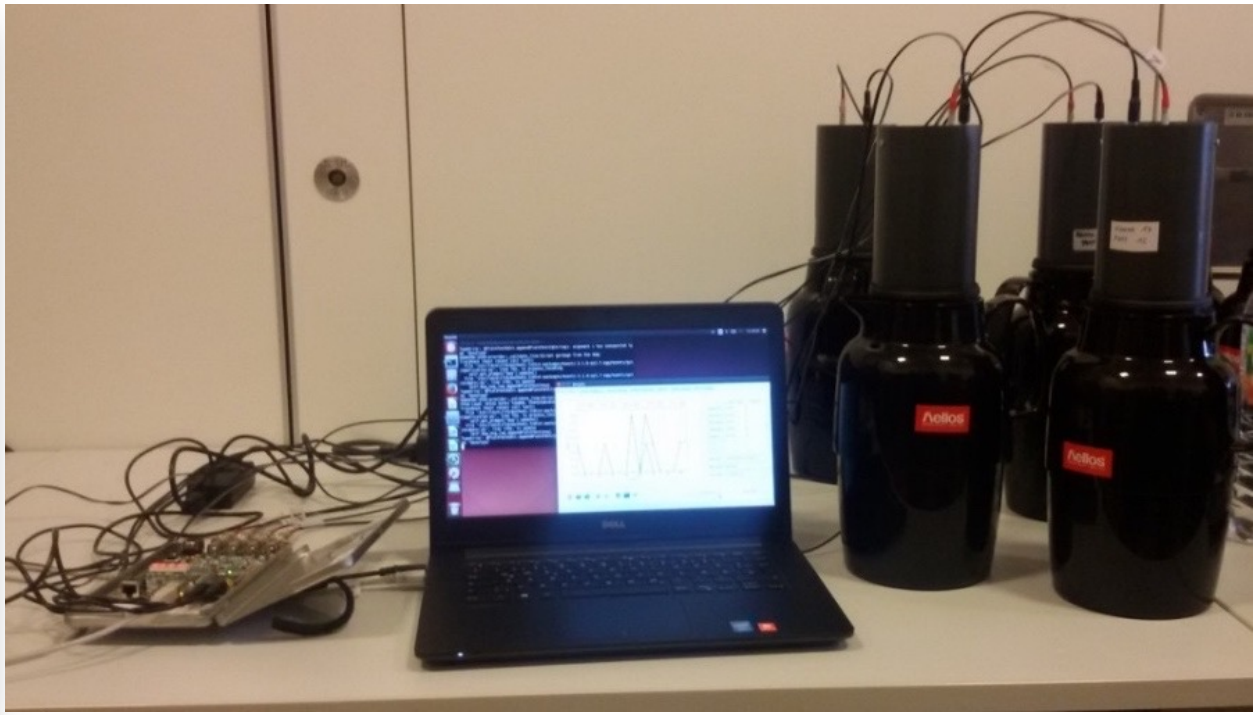
Components:

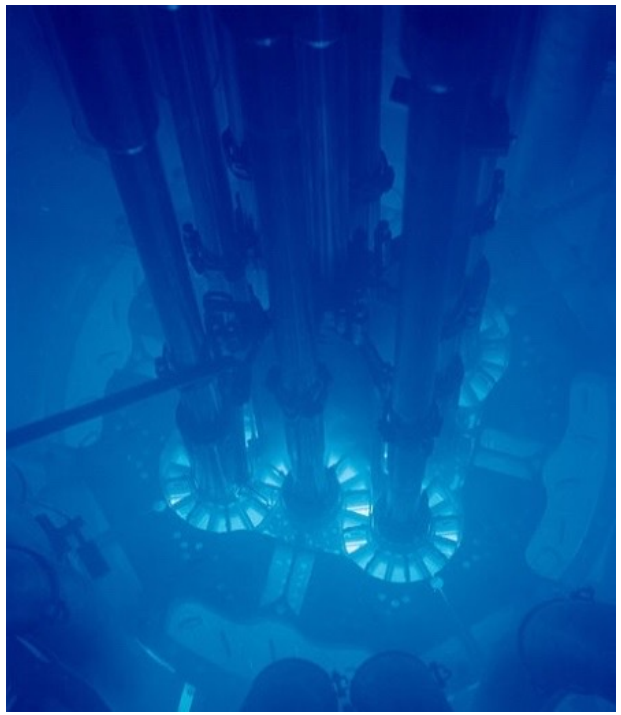
- 2 Cherenkov water counters
- measuring electronic from University Göttingen or DAQ from QuarkNet and Computer with “Muonic”

Kamiokannen

Counter:

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

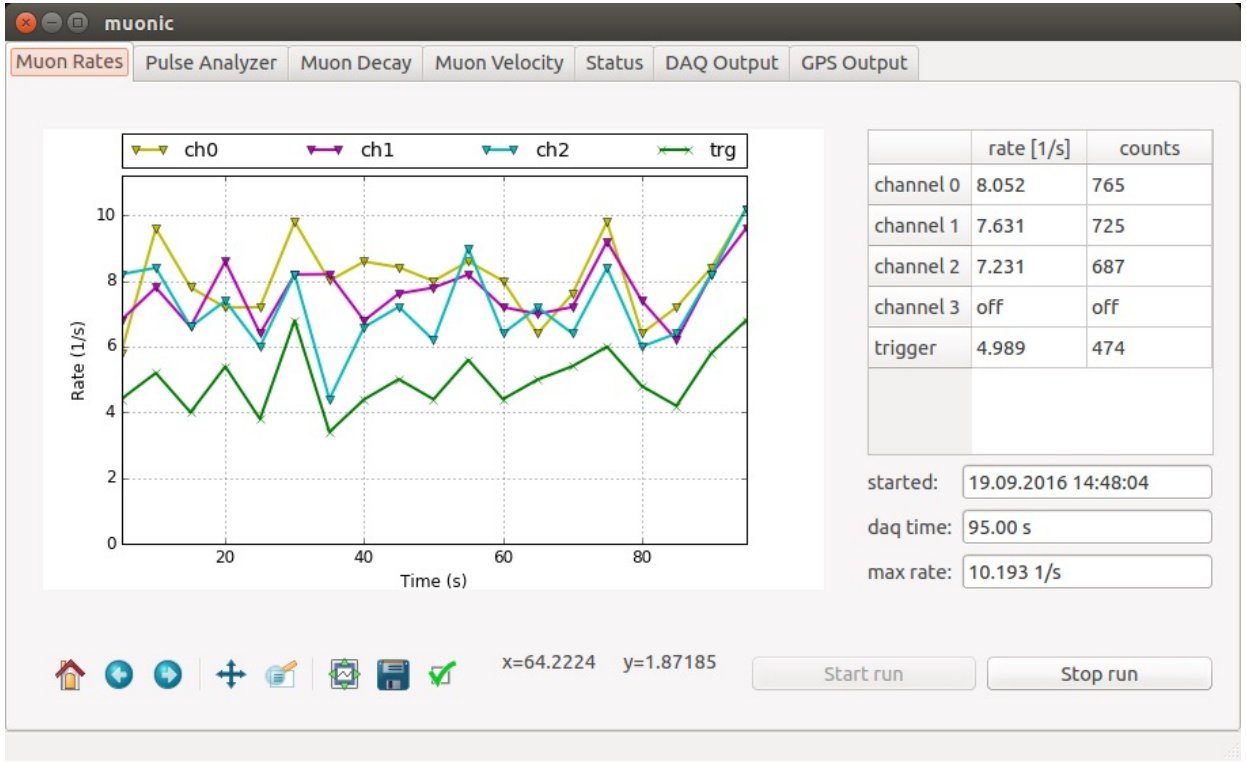




Muonic

Analysis software for measurement and investigation of cosmic particles

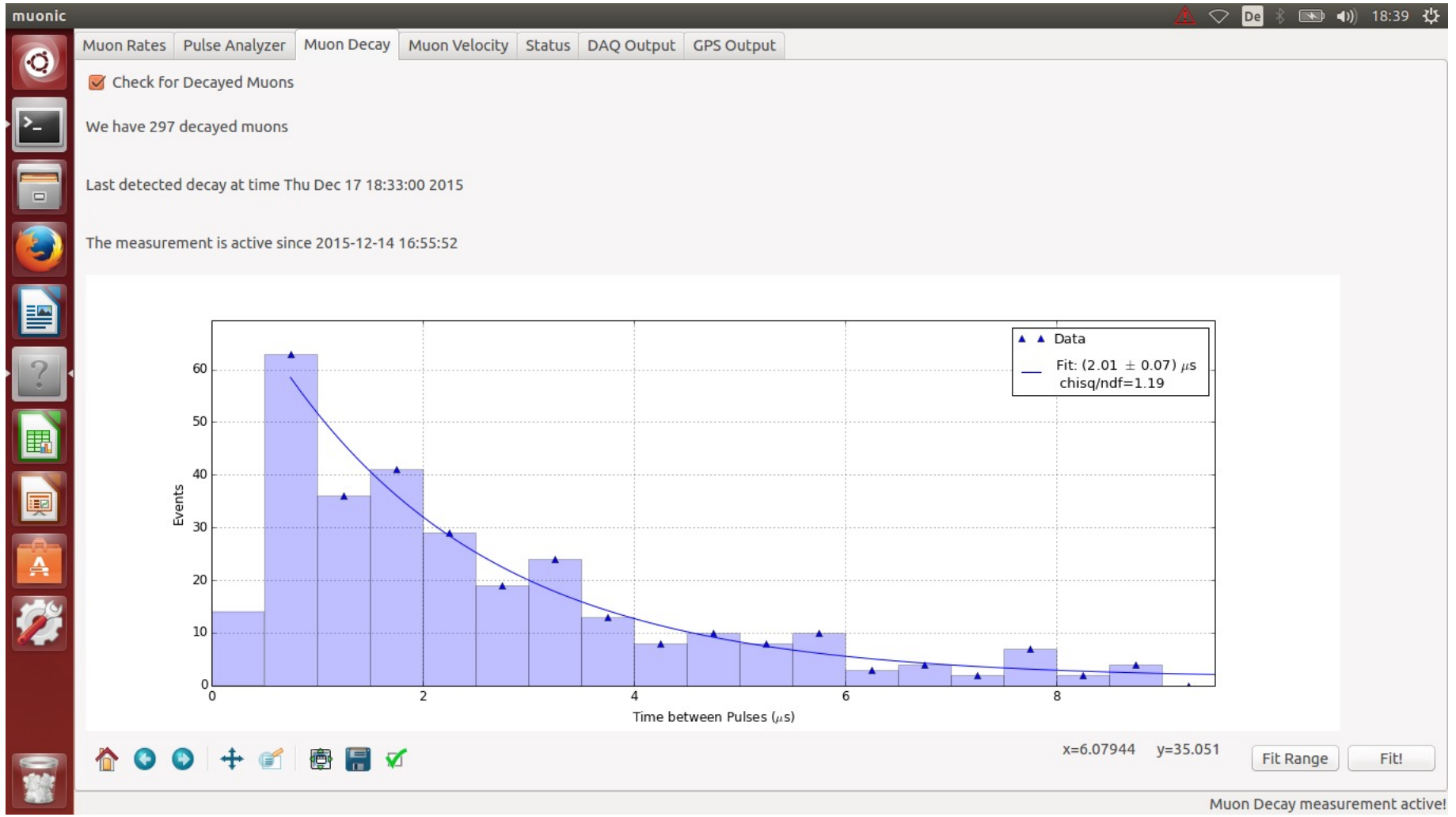
- python software developed by DESY
- interface to communicate with QuarkNet DAQ cards
- to perform simple analysis of the measured data
- python graphical user interface (in English)
- German documentation for teachers and students



https://github.com/NetzwerkTeilchenwelt/muonic4

Muonic

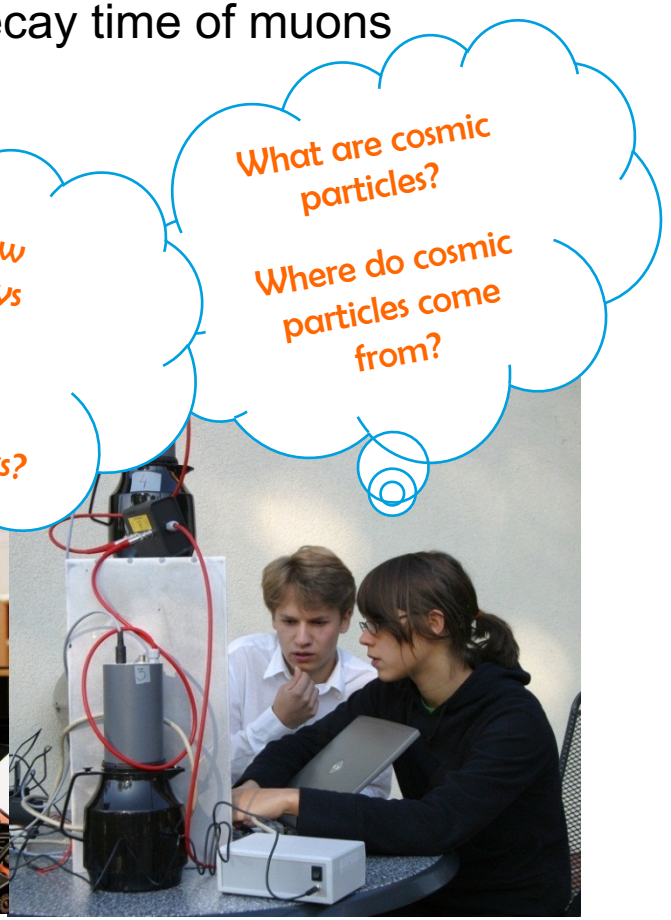
Measurement of the decay time and determination of the lifetime of muons



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

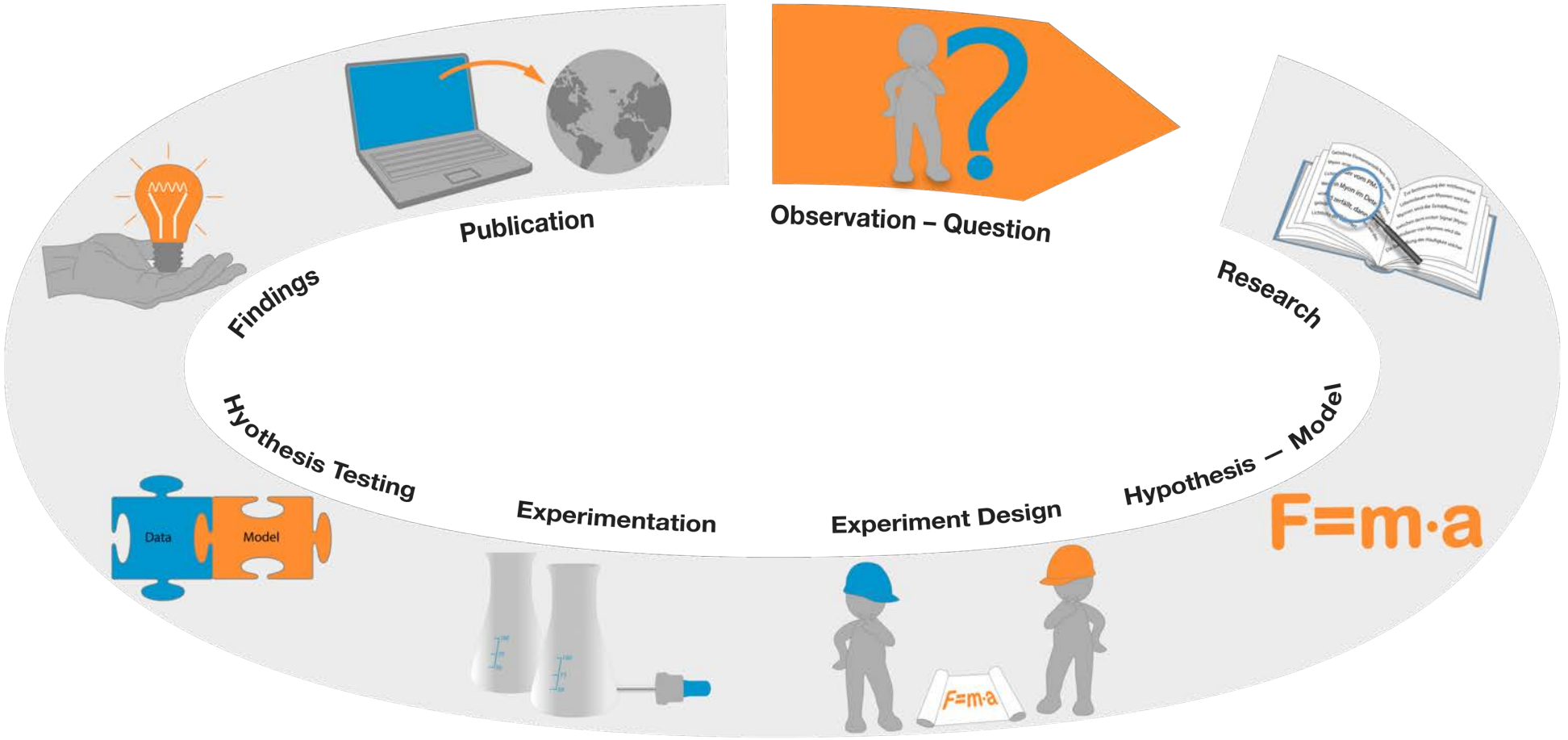
Analysis of Data from Cosmic Particles

- 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

Work like a Scientist

From the Question to the Publication



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

Cosmic@Web

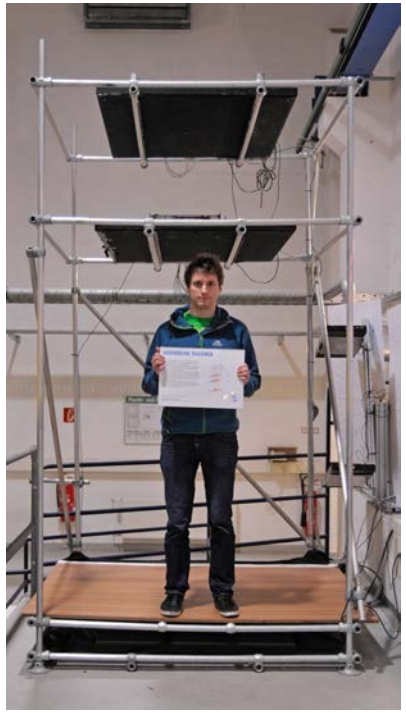
Learning Platform for Students

Provides:

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

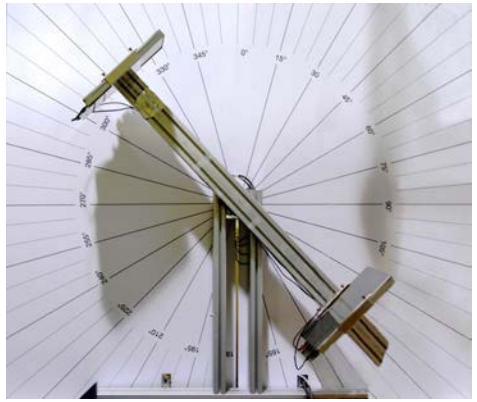
Cosmic@Web

Investigate Athmospheric Muons



9 experiments:

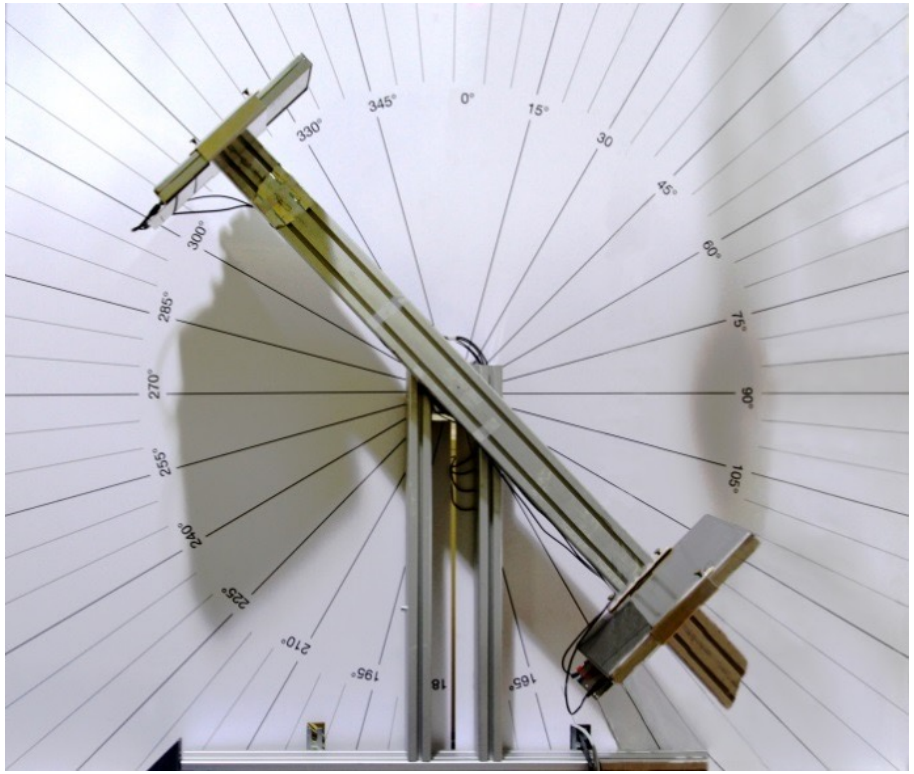
- lifetime of muons
- geomagnetic effect
- zenith angle dependence
- rate in Germany, Armenia and Antarktis
- rate depending on weather conditions



CosMO-Mill

Investigation of zenith angle dependence

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

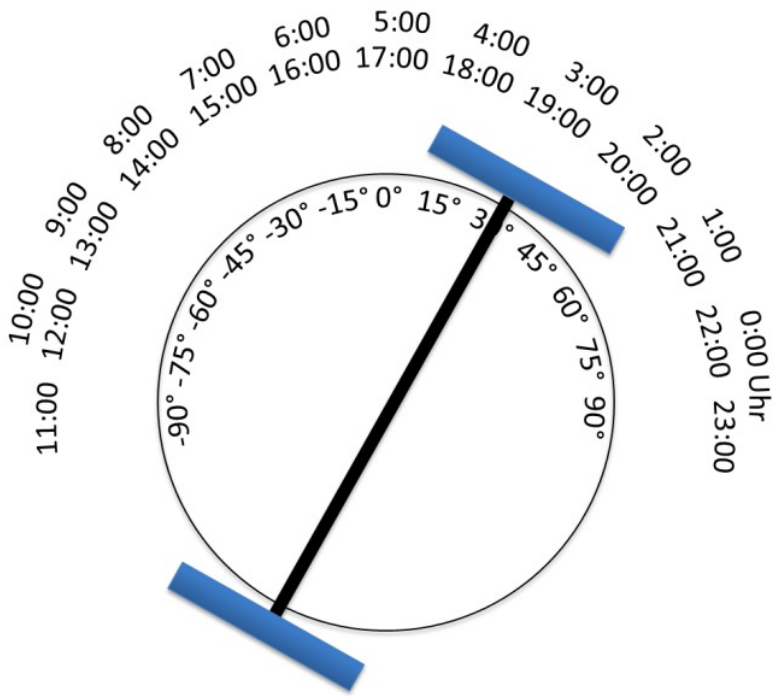


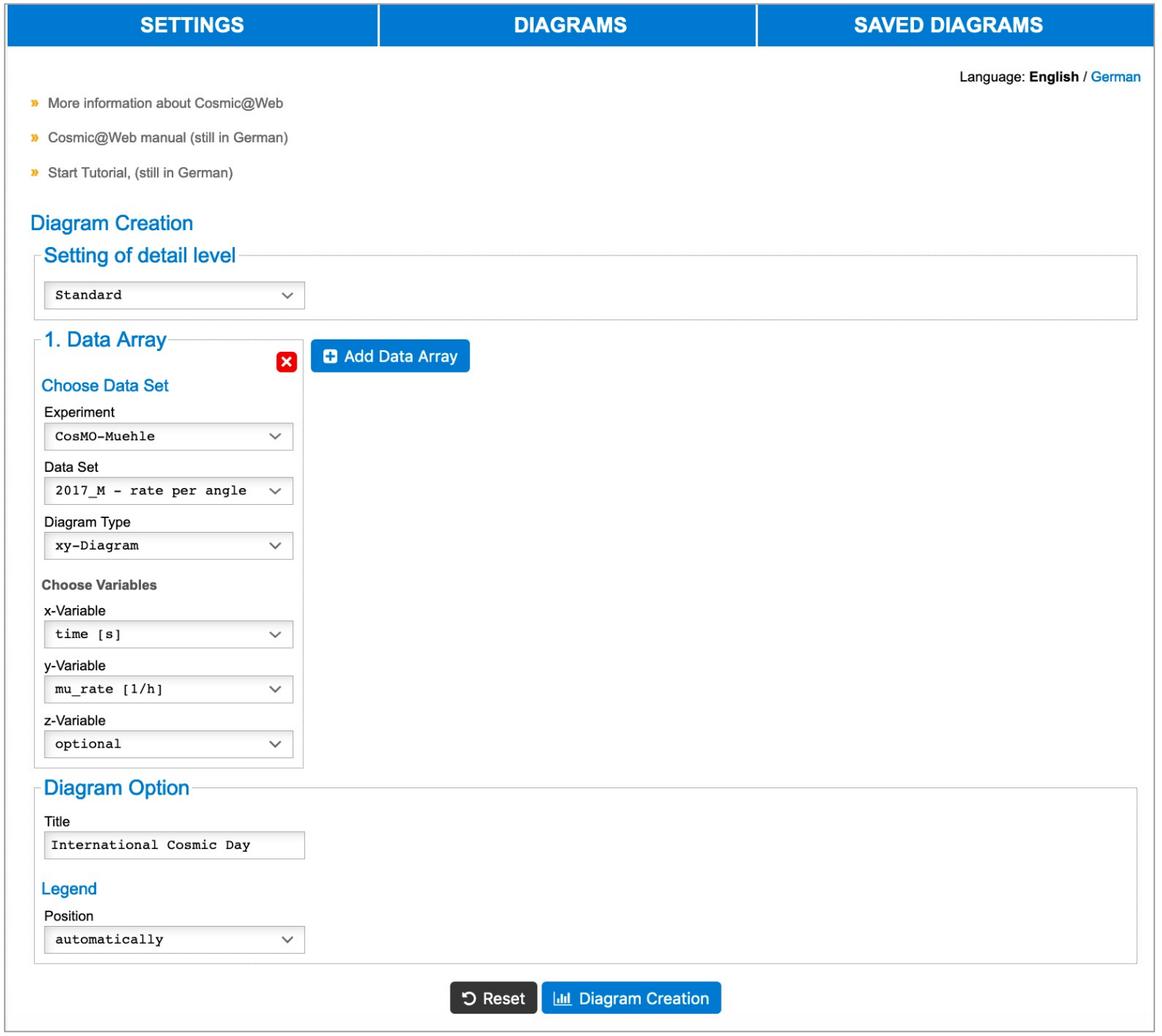
CosMO-Mill

Investigation of zenith angle dependence

Location: Zeuthen

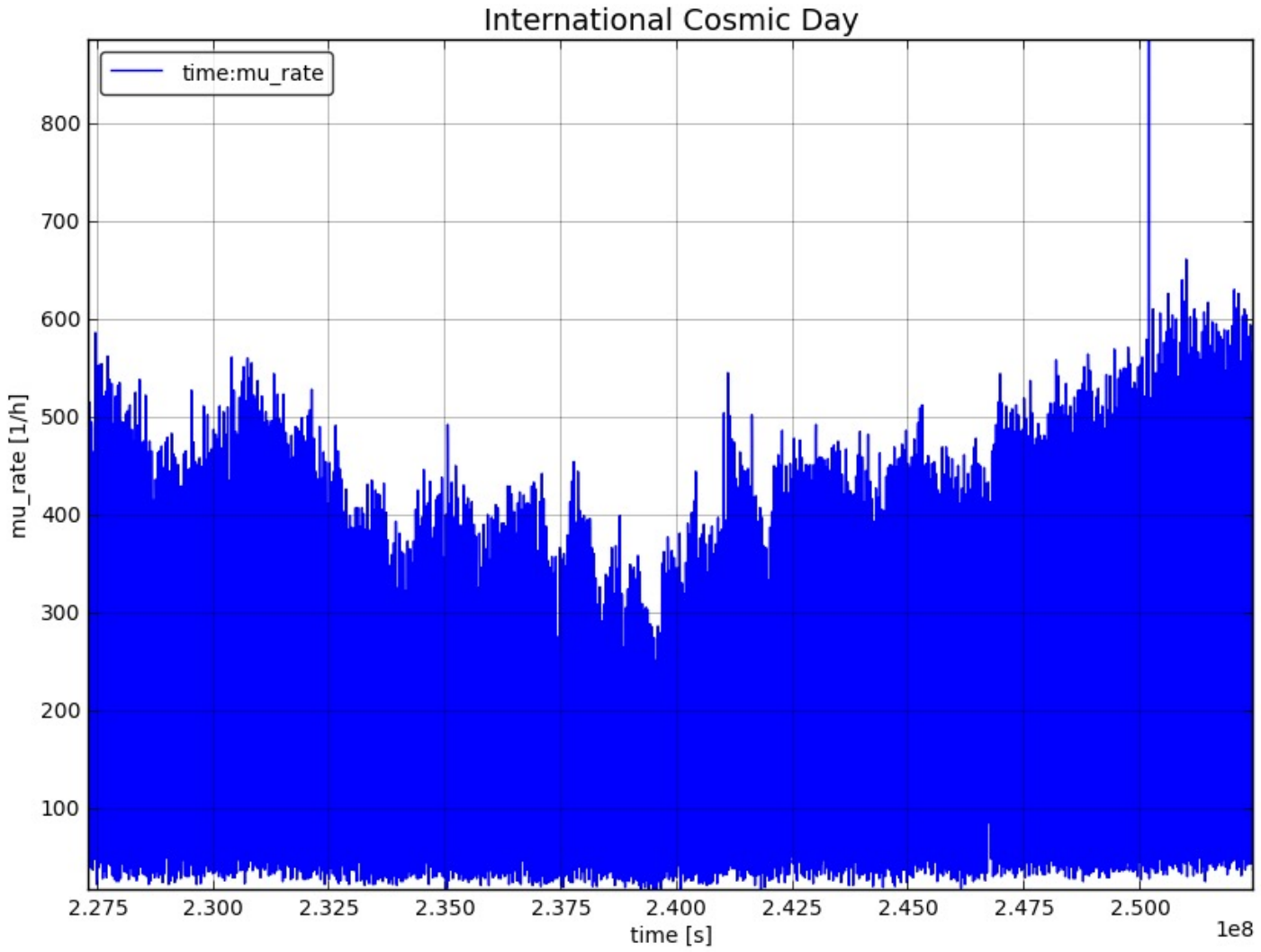
Mill changes its position every hour by 15°





CosMO-Mill

Investigation of zenith angle dependence



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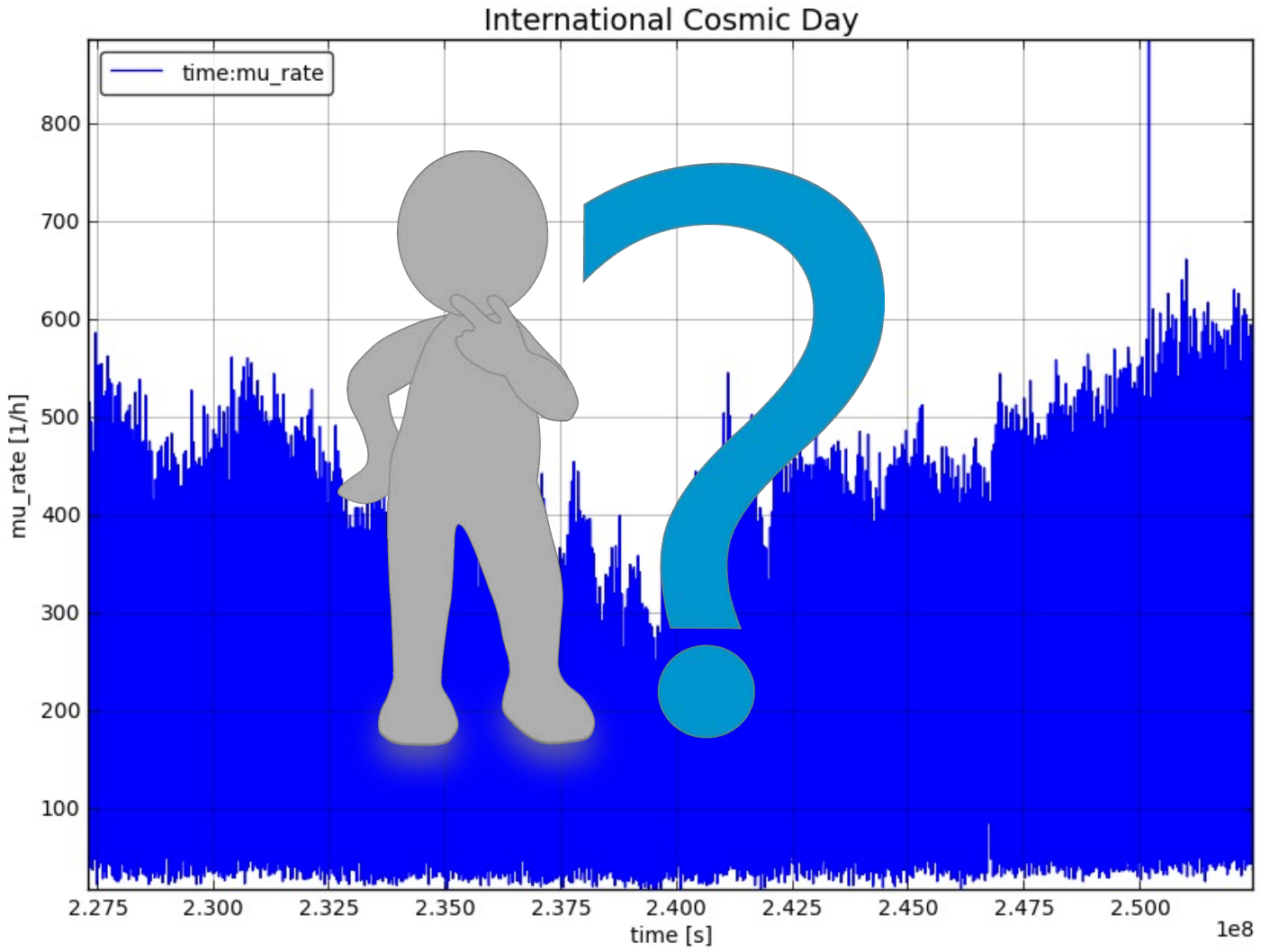
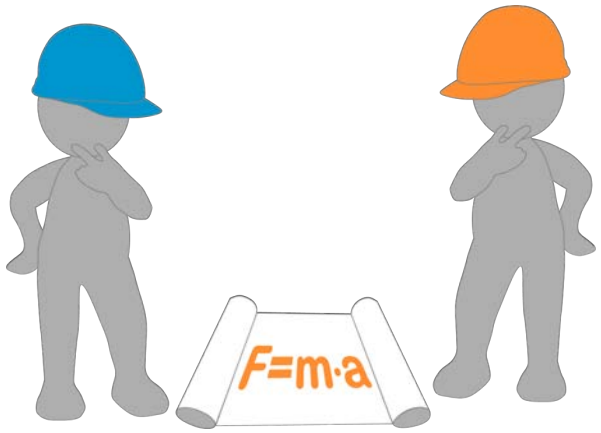
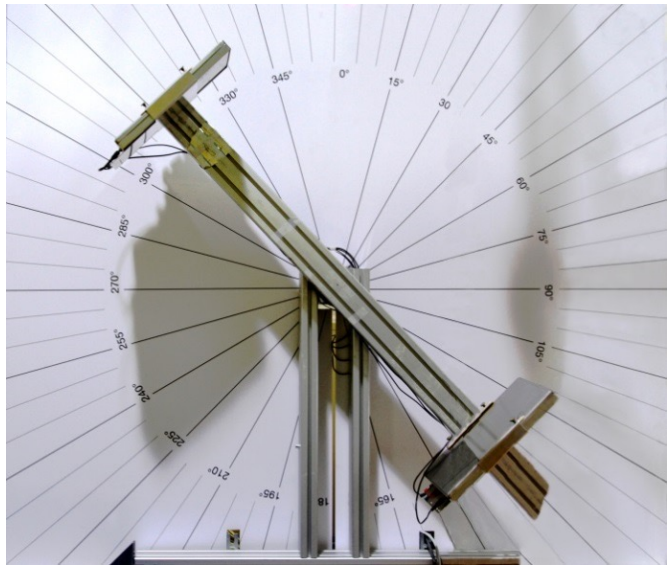


CosMO-Mill

Investigation of zenith angle dependence



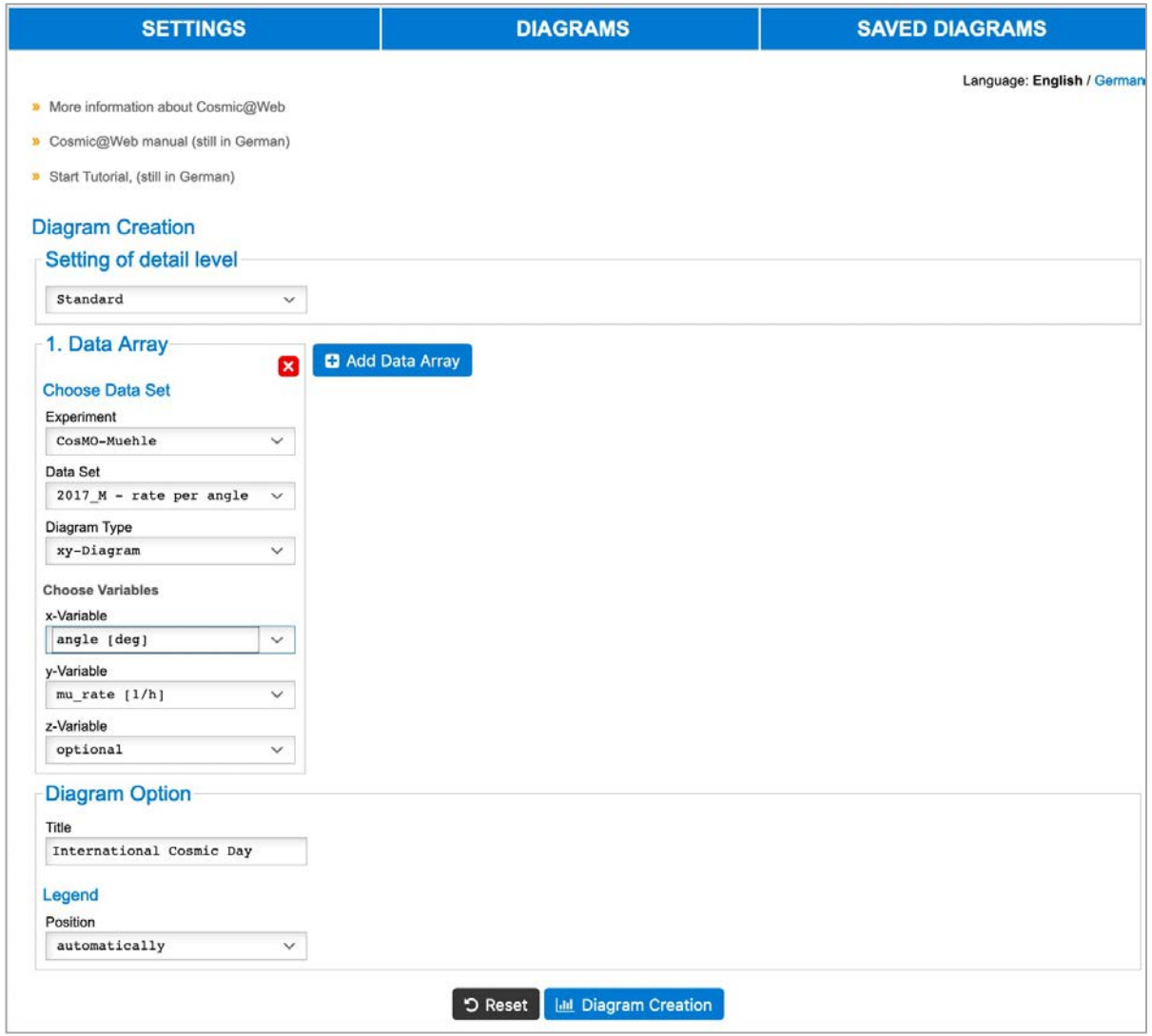


Dataset CosMO Mill

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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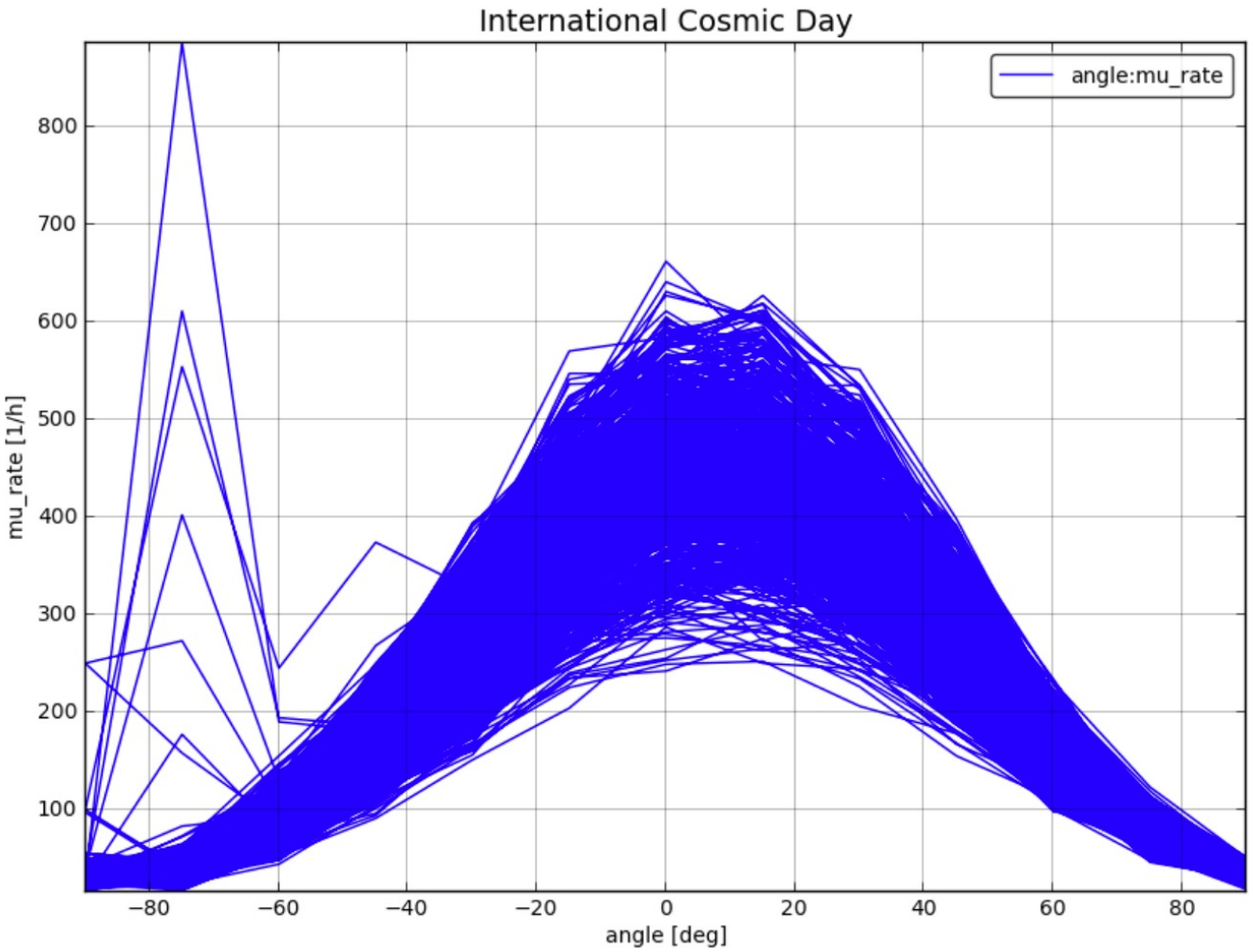
Investigation of zenith angle dependence



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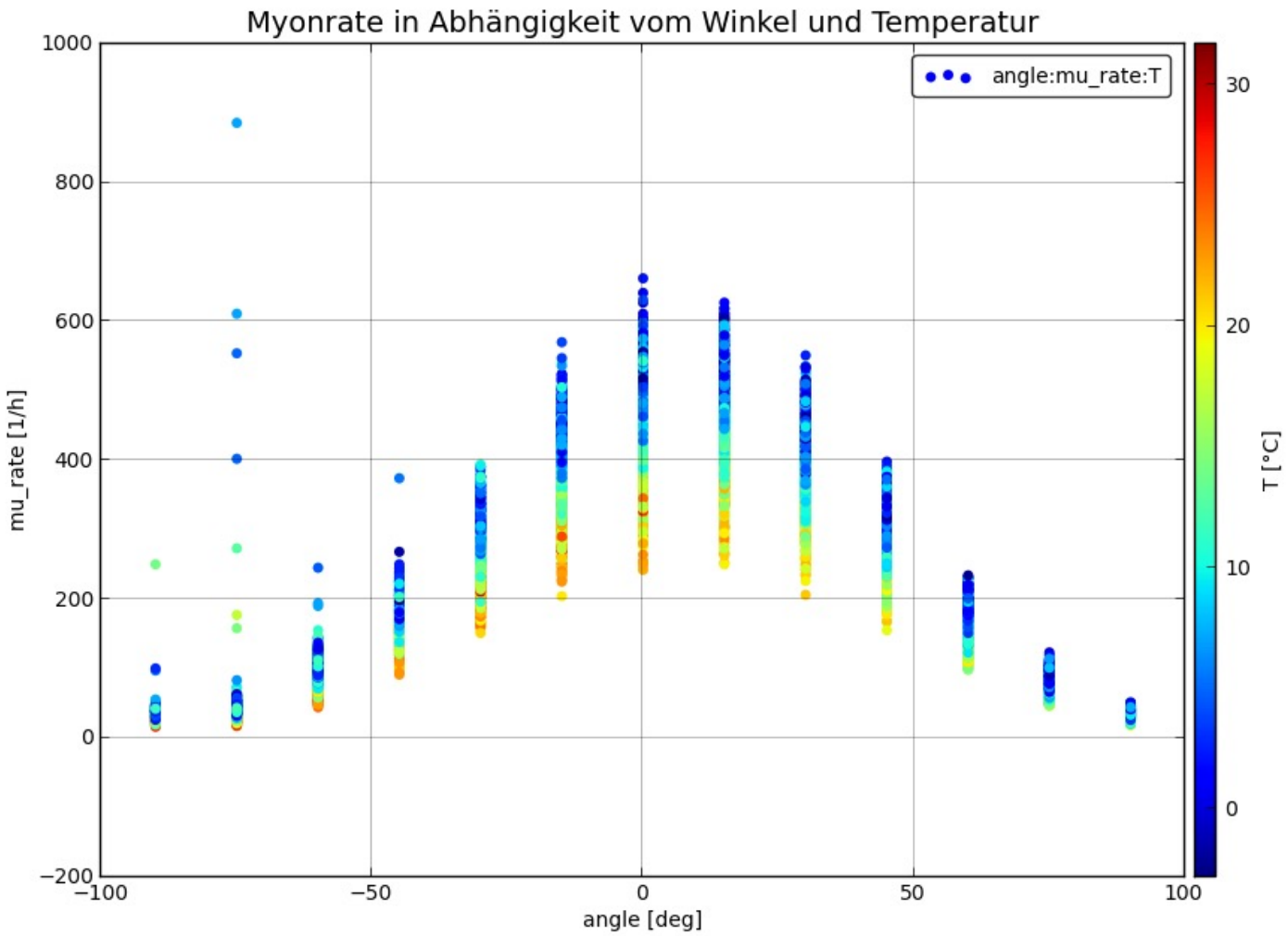
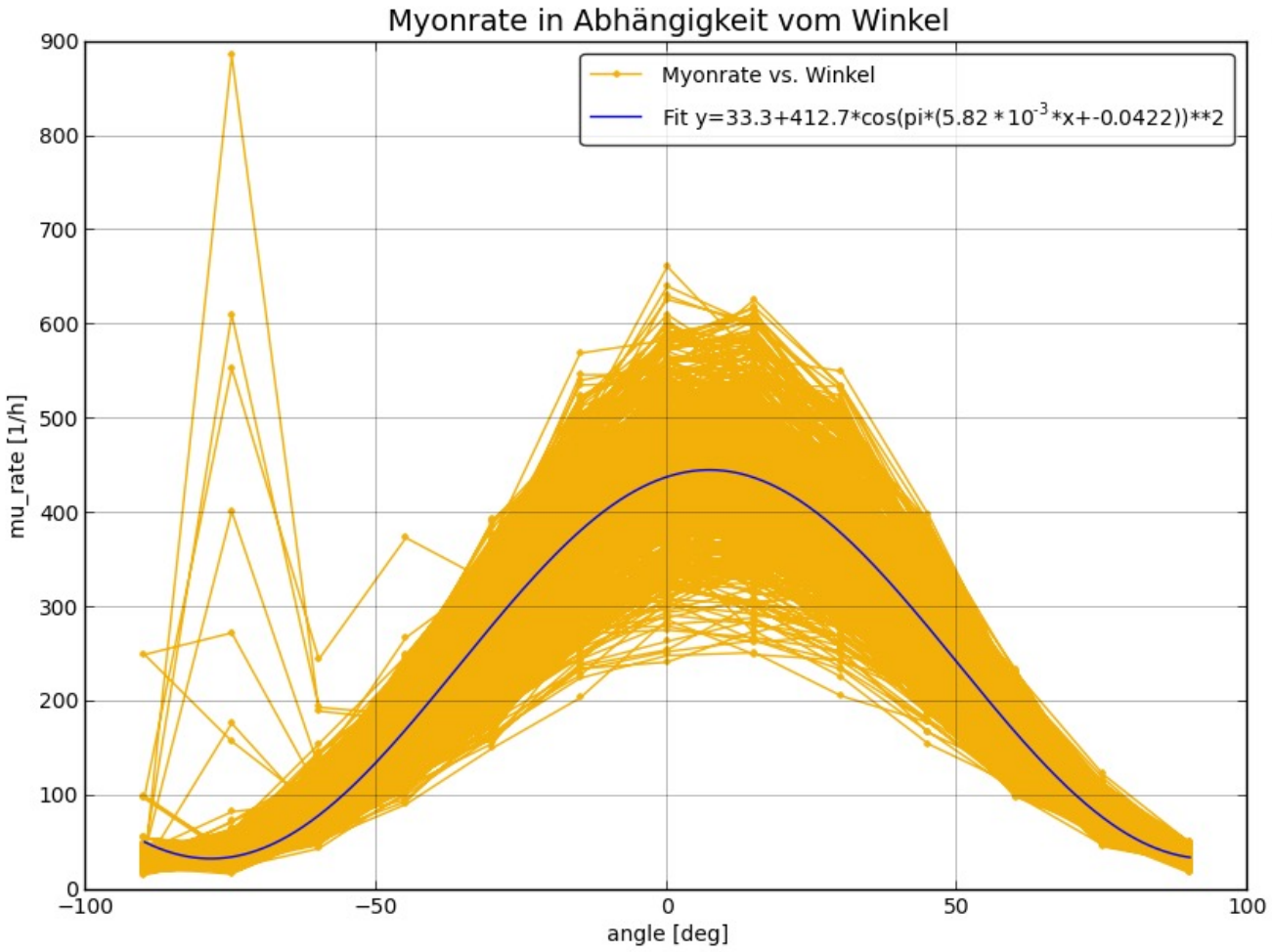
Investigation of zenith angle dependence



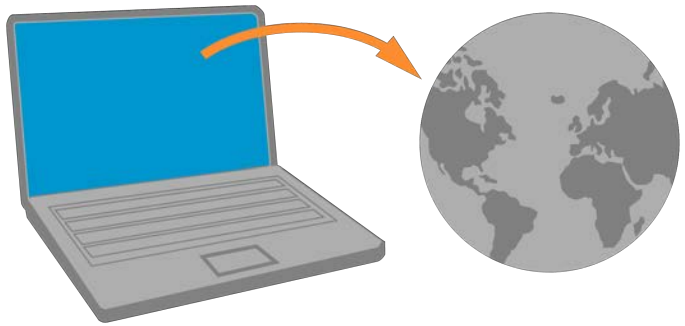
CosMO-Mill

Investigation of zenith angle dependence



y=p[0]+p[1]*cos(pi*(p[2]*x+p[3]))**2
χ^2/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

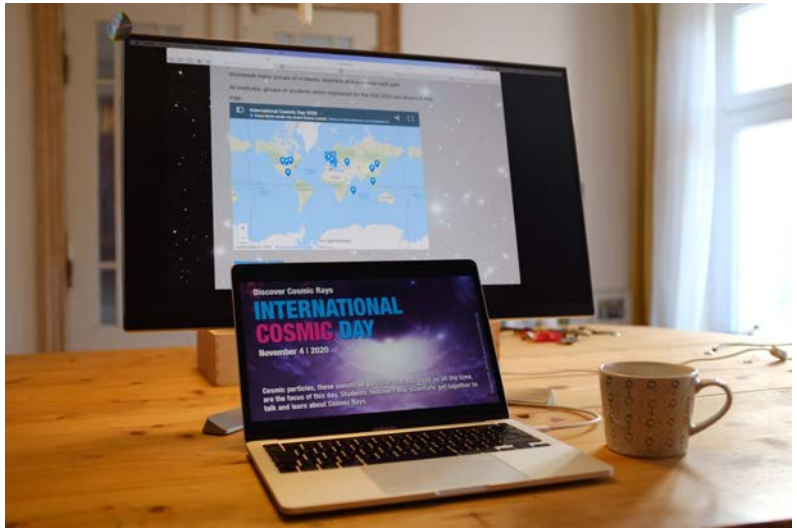
About

- 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

Idea of the ICD

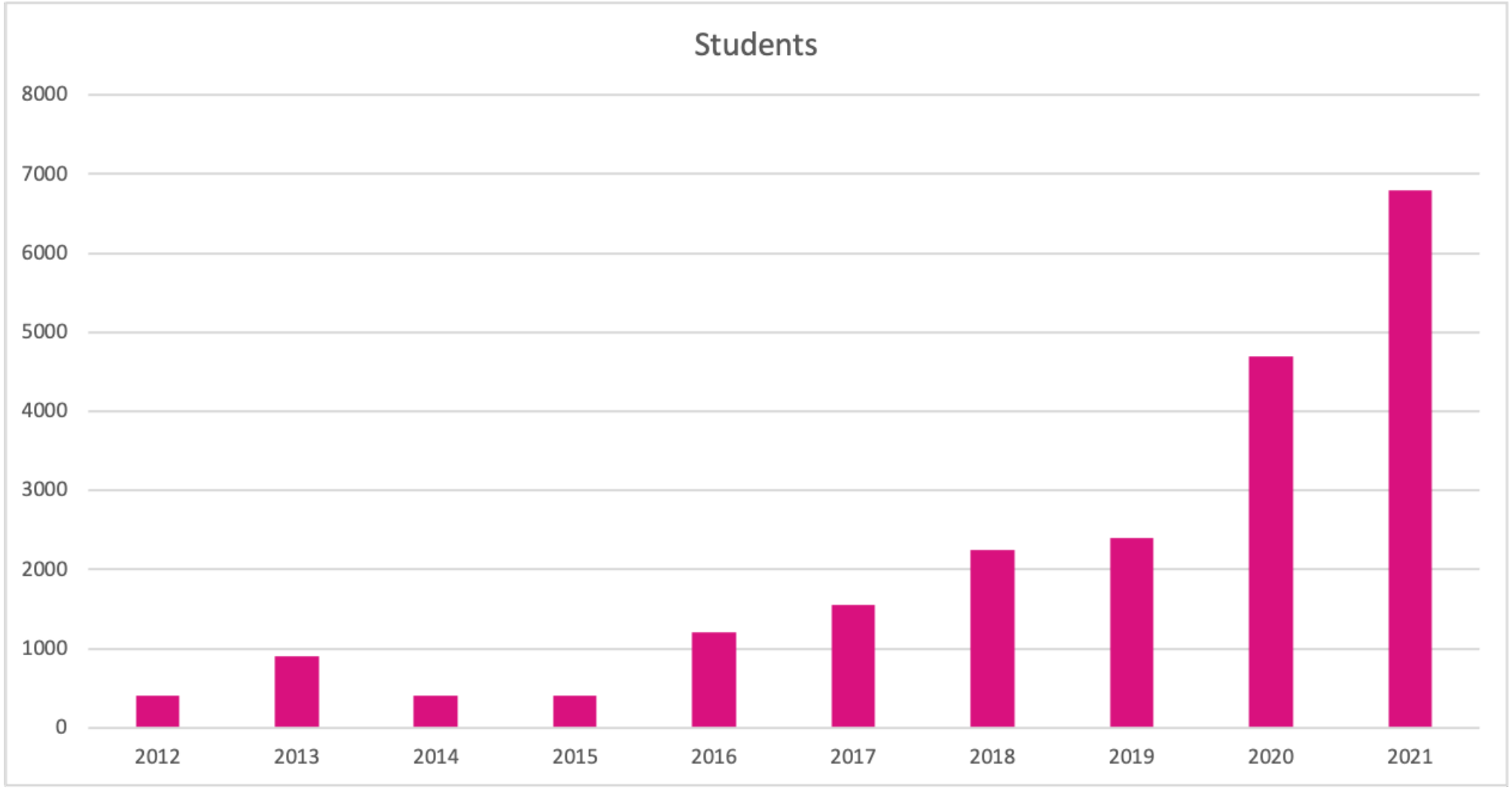
How it works?

- 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

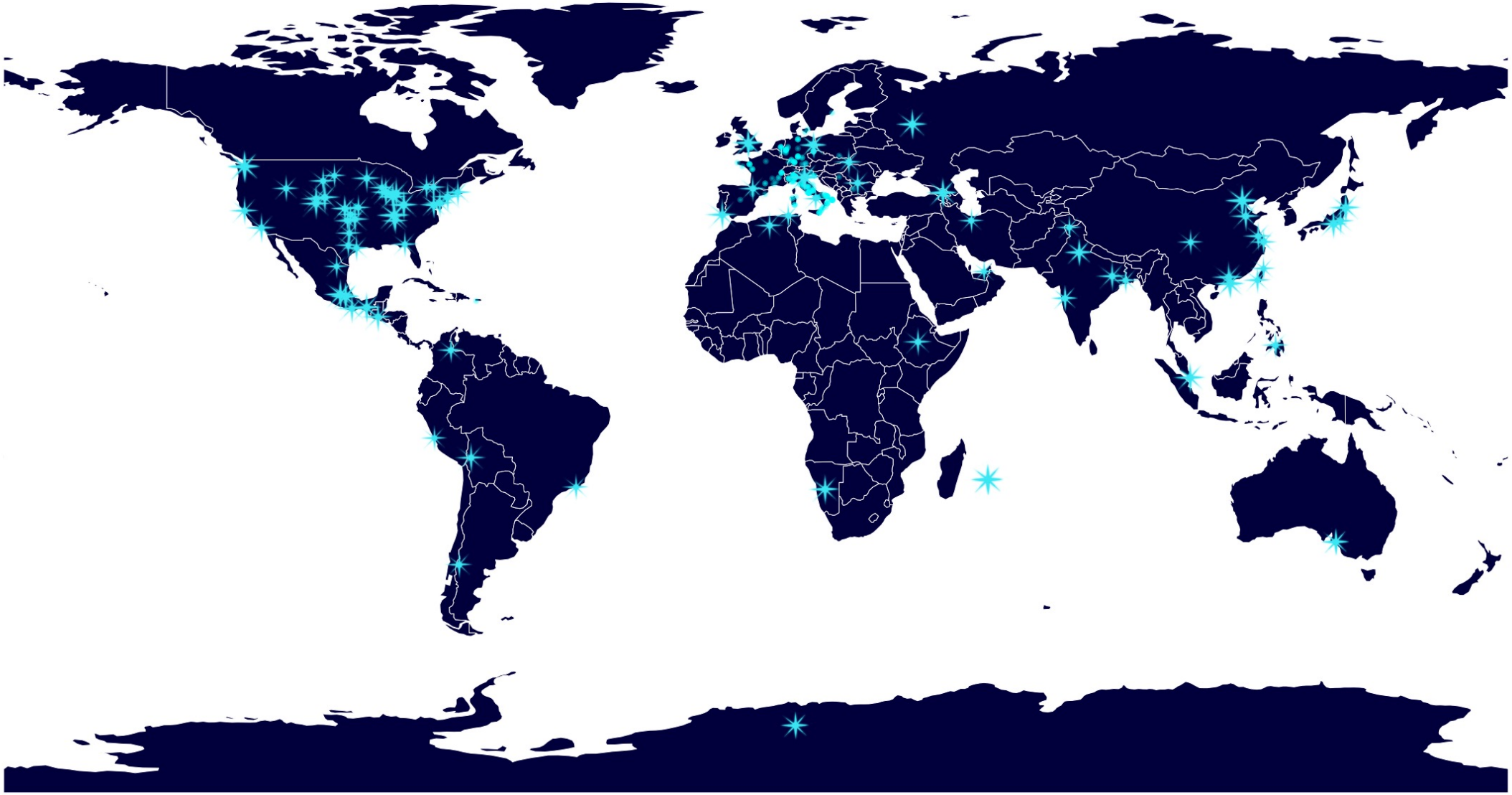


Participating Groups Worldwide

2021

Participating Groups Worldwide

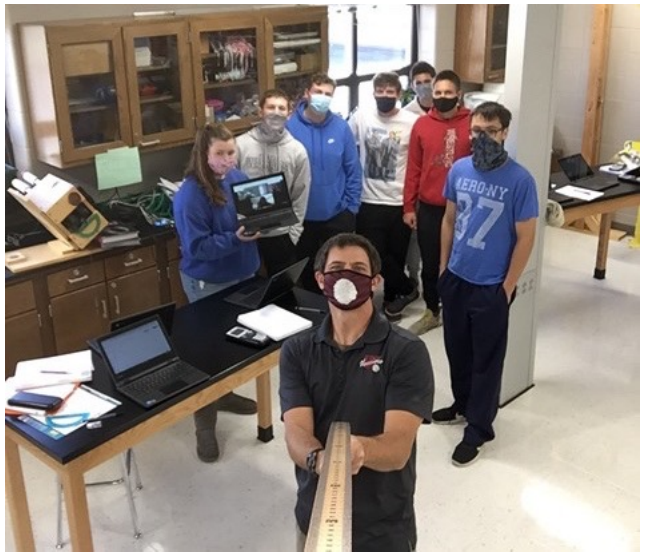
2012 - 2021



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



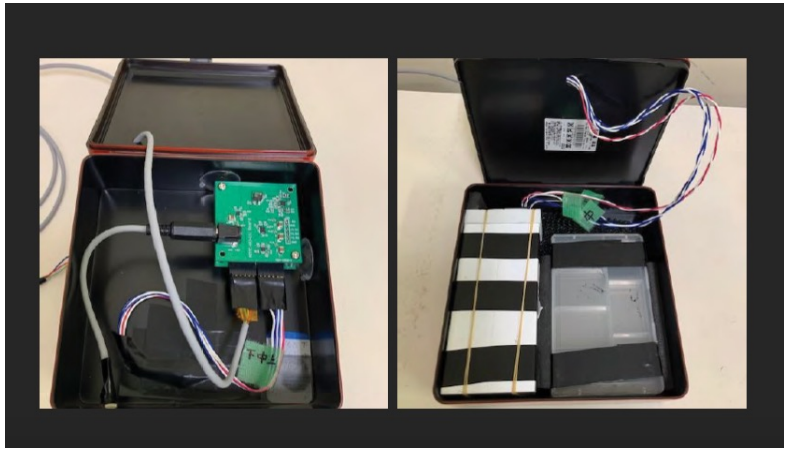
Direct Measurement of Cosmic Particles

Use your Own Detector - Examples

OCRA, ITALY

Cosmos à l'École, FRANCE

INFN, ITALY



tan-Q, JAPAN

QuarkNet, USA

Impressions from ICD

Welcome Call 2021: greetings from all participating countries

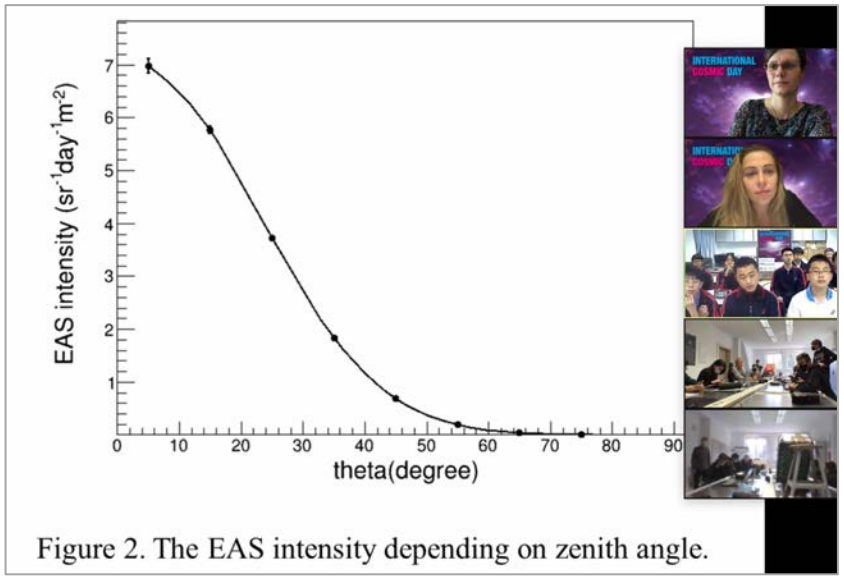
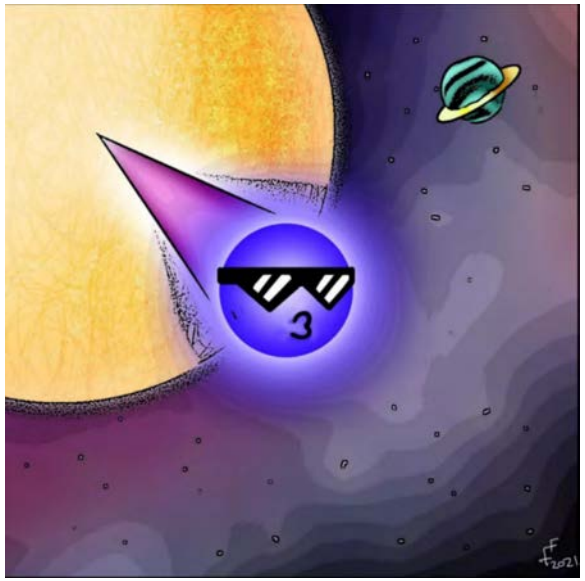


Figure 2. The EAS intensity depending on zenith angle.

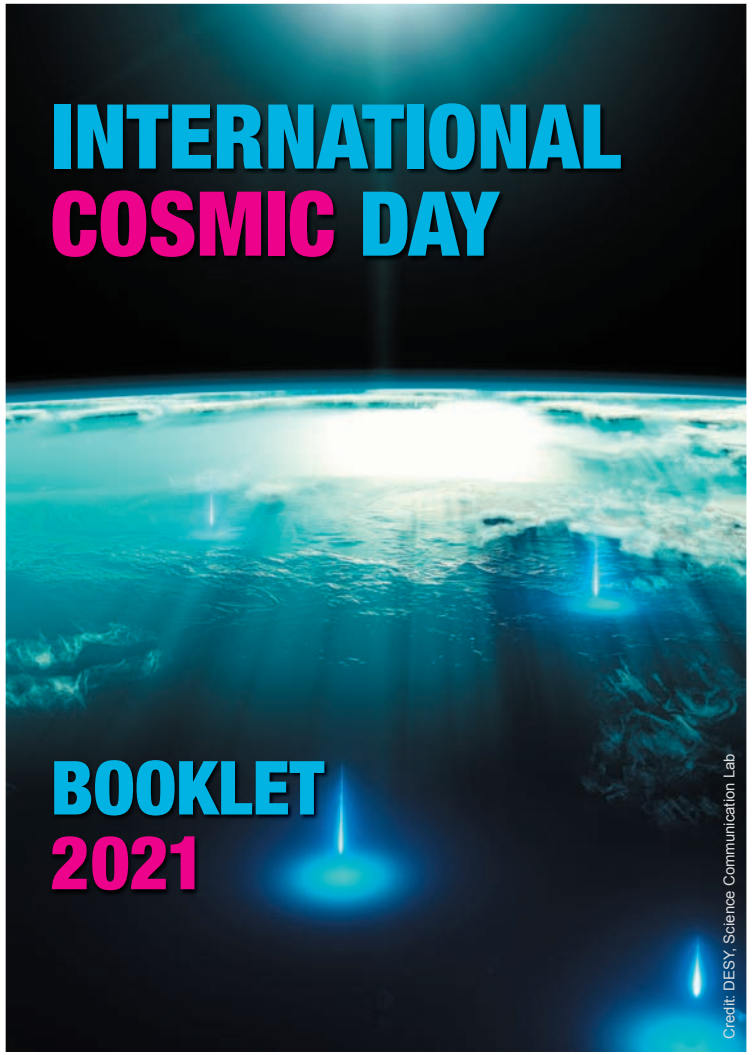
Video Call: exchange and discussion of results between 5 participating groups



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

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INTERNATIONAL COSMIC DAY

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Many Thanks

NETZWERK TEILCHENWELT

PROJEKTLEITUNG

TECHNISCHE UNIVERSITÄT DRESDEN

PARTNER

CERN DESY

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DPG

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GEFÖRDERT VOM

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