

# Students work like Astroparticle Scientists

## International Cosmic Day and Cosmic@Web

Carolin Schwerdt

FAIR-GSI, Darmstadt, 23. Mai 2019

# International Cosmic Day

- brings together different astroparticle-physics outreach and education projects from all over the world
- one day event, once a year (usually in November)
- goal: Students work like a scientist in a international collaboration
- each group performs measurements with own detectors or analyse data
- topic: zenith angle dependence of atmospheric muons
- <http://icd.desy.de>



Discover Cosmic Rays

# INTERNATIONAL COSMIC DAY

November 29 | 2018

Scientists worldwide are committed to school projects in order to give students insights into their research and answer questions like:

What are cosmic particles?  
Where do they come from?  
How can they be measured?

Become a Scientist for a Day  
Discover the world of cosmic rays like an astroparticle physicist.

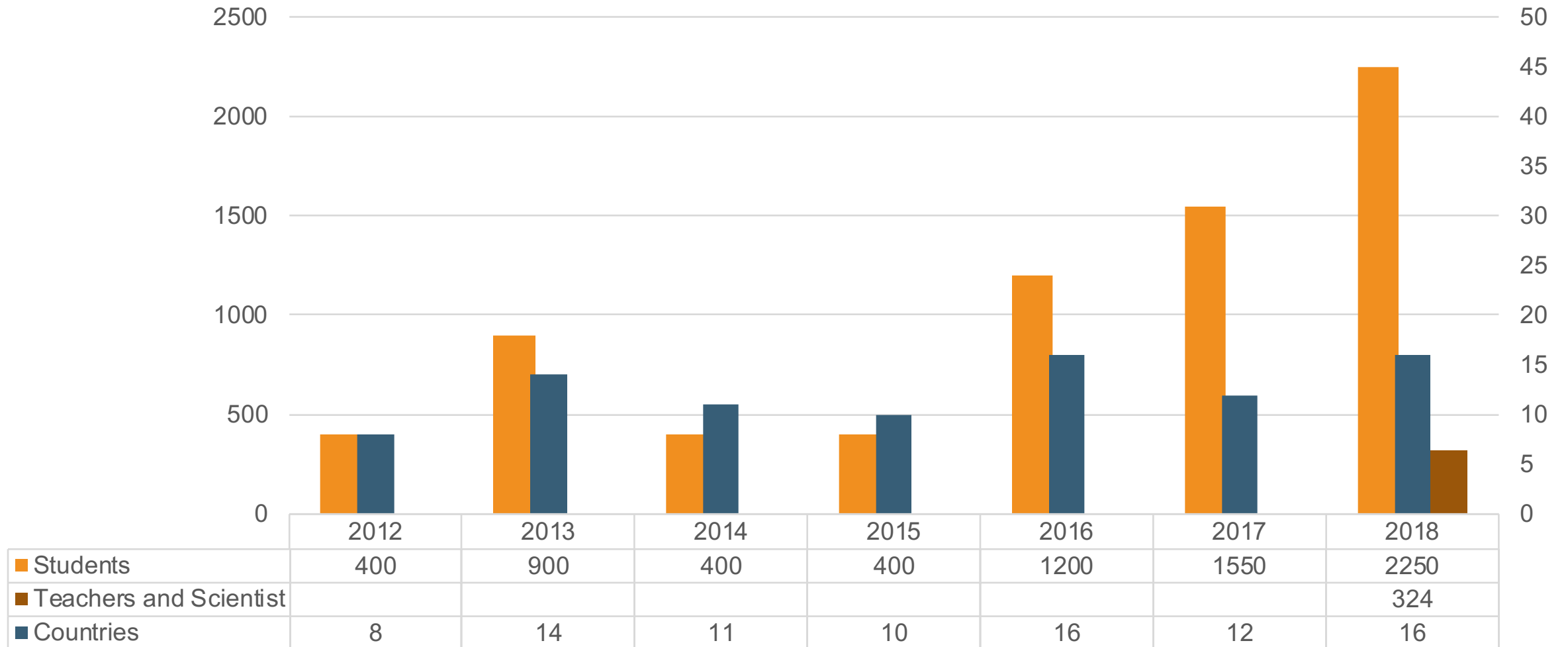
Image Credit: DESY, Science Communication Lab

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



# Participants ICD

## Growing Event



# Video Conference at the ICD

## Innovations 2018

- more video conferences with fewer participants per session offered
  - in each session was a chair and a scientist
  - the scientist presents the results of a scientific experiment (analyze data regarding the same question of zenith angle dependence like the student groups)
  - represented scientific experiment were: ATLAS, IceCube, Fermi
- If you know of any scientific experiments that would like to contribute to this, let me know

# Video Conference at the ICD

## Innovations 2018

- more video conferences with fewer participants per session offered
- joint session at the beginning of the (european) day
  - everyone could dial in
  - welcoming words to everyone
  - explanation of the tasks of the day
  - live stream to Polarstern
- if you have an idea for a live stream this year, let me know

# Video Conference at the ICD

## Innovations 2018

- more video conferences with fewer participants per session offered
- joint session at the beginning of the (european) day
- we want to keep both for the next ICD

Discover Cosmic Rays

# INTERNATIONAL COSMIC DAY

November 29 | 2018

10:00 Video connection between EEE headquarters

10:05 Greetings from Prof. L.Cifarelli

10:20 Dr. M.Trimarchi "Welcome to ICD 2018"

10:30 Dr. P.La Rocca "Introduction to cosmic rays: measuring the zenith angle distribution of air shower particles"

11:00 Data Analysis

Become a Scientist for a Day  
Discover the world of cosmic rays like  
an astroparticle physicist.

Image Credit: DESY, Science Communication Lab

Organizer:

Progetto EEE – La Scienza nelle Scuole  
Centro Studi E.Fermi, Roma

More information and registration:  
<http://icd.desy.de>  
<http://eee.centrofermi.it>



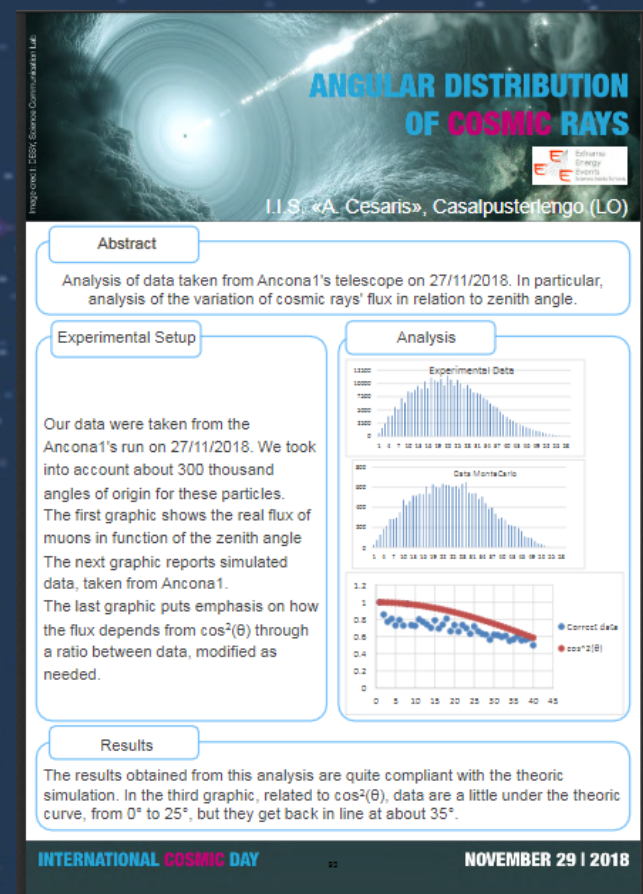
Example of  
advertising  
poster with the  
agenda of the  
event, similar  
for all EEE  
schools and  
with a central  
common part

# The EEE Project @ ICD 2018

- **58 Italian High School, 17 Local Researchers, 71 teachers and 680 students, distributed in 11 local sites:**

- Dipartimento di Fisica di Torino
- Dipartimento di Fisica di Salerno
- Dipartimento di Fisica di Bari
- Dipartimento di Fisica di Catania
- Liceo Volta, Lodi
- Liceo Fermi, Bologna
- Liceo Grassi, Savona
- Liceo Banzi Bazoli, Lecce
- IIS Levi, Quartu S.Elena
- Liceo Quadri, Vicenza
- Liceo Volta, Reggio Calabria

- **Data from EEE telescopes**





# The EEE Project @ ICD 2018



- 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

## 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.

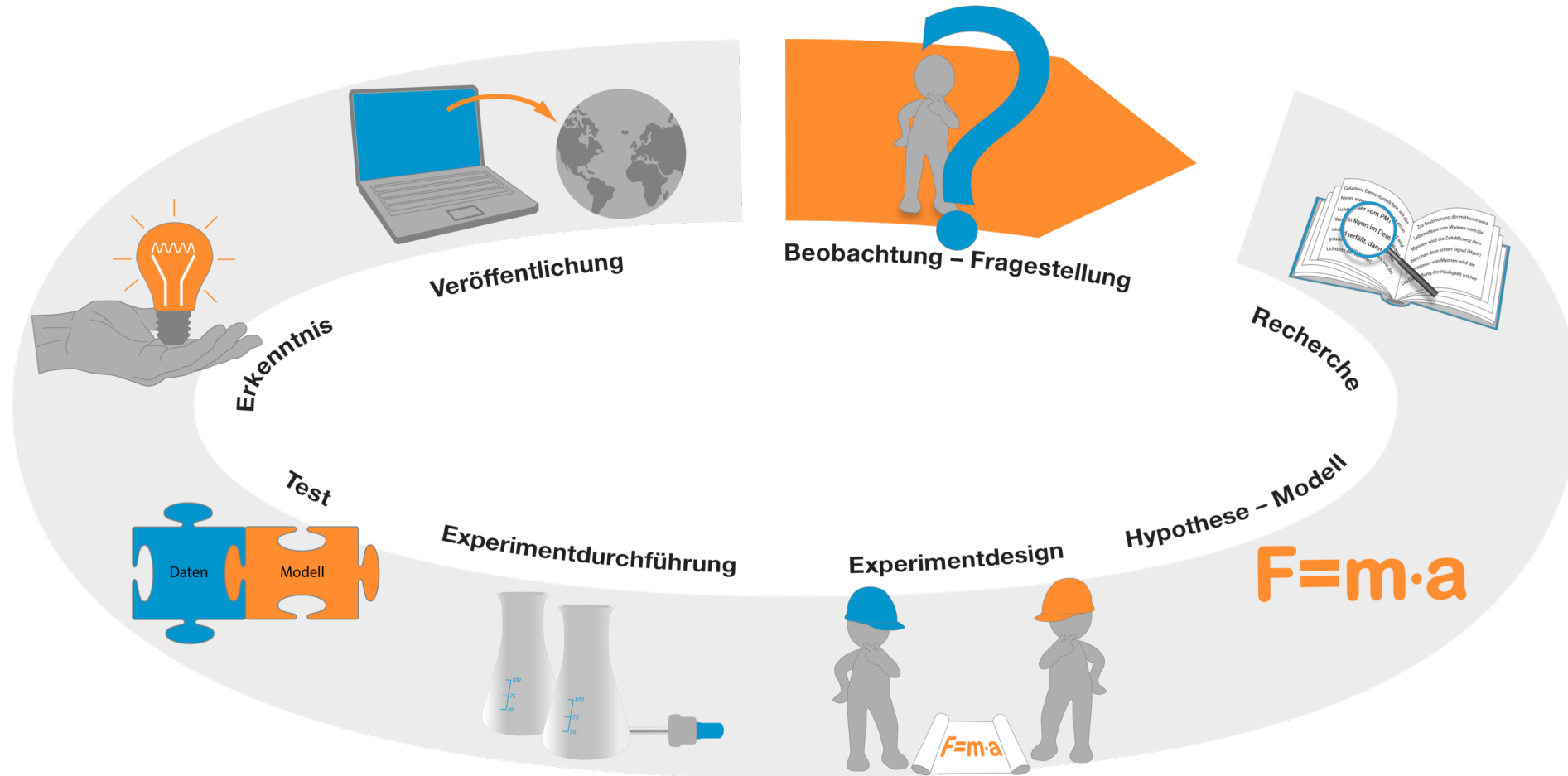
It is almost impossible for schools and teachers to arrange lessons about particle and astroparticle physics with the appropriate experiments. As can be seen in [Student Experiments](#), DESY has developed and produced a large number of CosMO and Kamiokannen experiments which were made available by DESY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

- show students all aspects of scientific work, not only focus on the experiment



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

#### 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

#### 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](#).

In order to measure the particle flux in the corresponding angle position and to exclude wrong signals, signals are only accepted if they fulfil the [coincidence](#) condition.

#### 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.

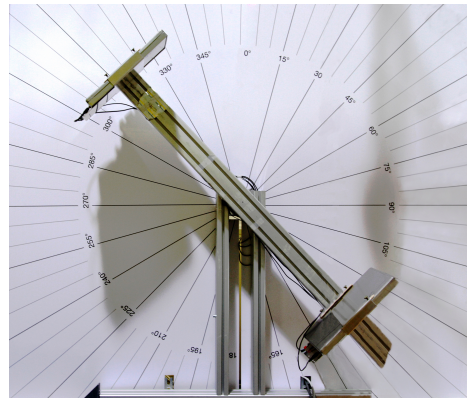
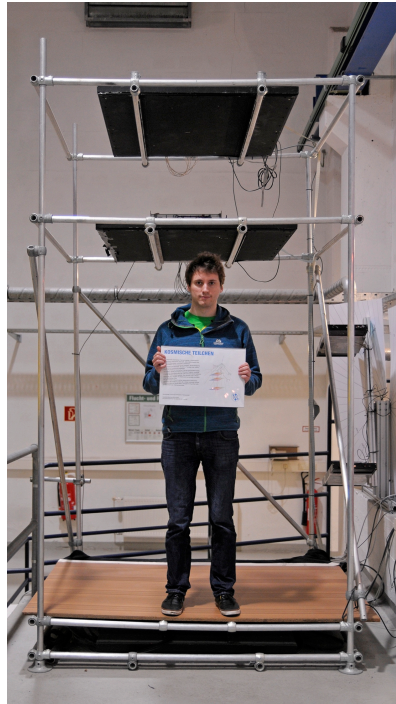
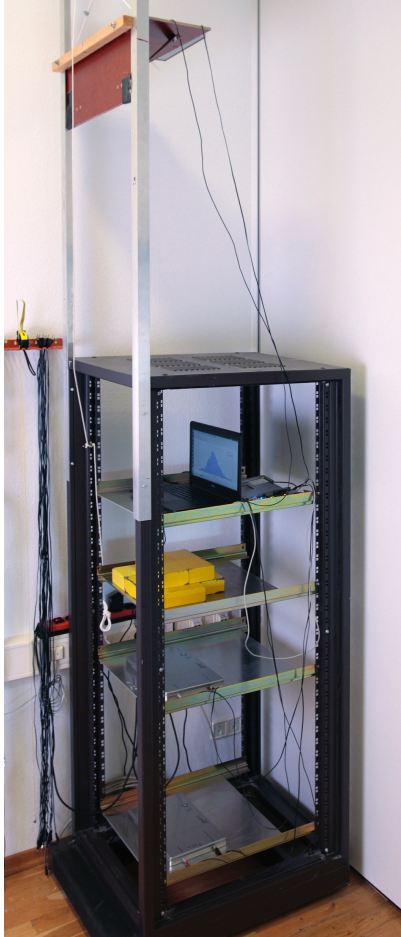


# Cosmic@Web

## Investigate Atmospheric Muons

9 experiments:

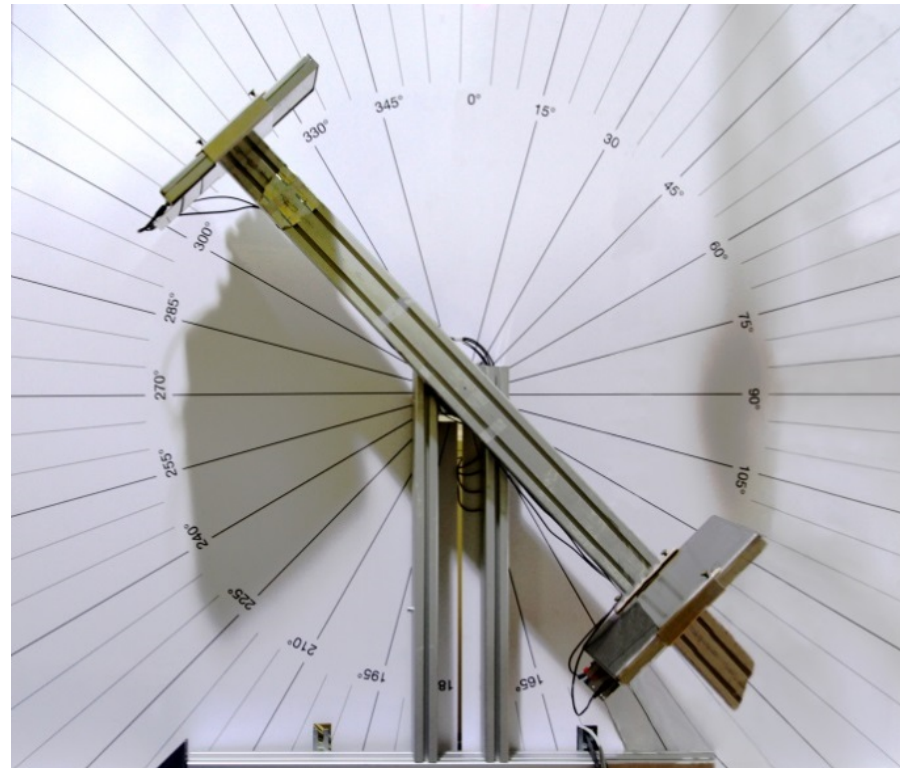
- lifetime and velocity
- geomagnetic effect
- zenith angle dependence
- rate in Germany, Armenia and Antarktis
- rate depending on weather conditions



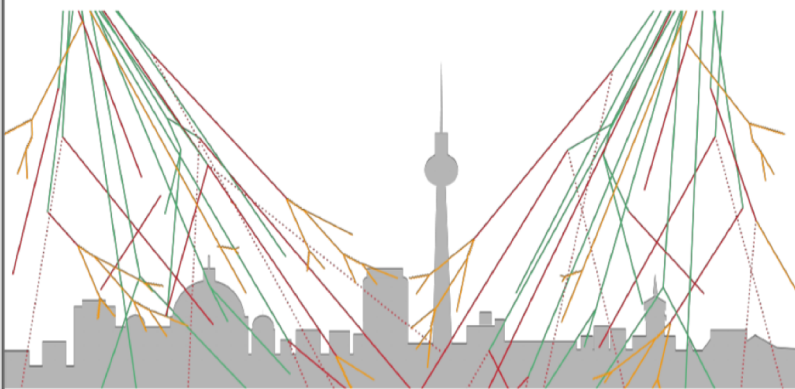
# CosMO-Mill

## Investigation of zenith angle dependence

- possibility to participate in ICD without own experiment on site
- instruction: <https://icd.desy.de/e12688/>




**Zenith angle dependence  
of Cosmic muons**




**Measurement and analysis  
with the CosMO experiment and Cosmic@Web**

Status: October 2018  
Contact: [cosmicatweb@desy.de](mailto:cosmicatweb@desy.de)

Carolin Schwerdt  
Wissenschaftliche Koordinatorin Cosmic-Projekte | DESY  
[carolin.schwerdt@desy.de](mailto:carolin.schwerdt@desy.de)  
Platanenallee 6 | 15738 Zeuthen | Germany



NETZWERK  
TEILCHENWELT

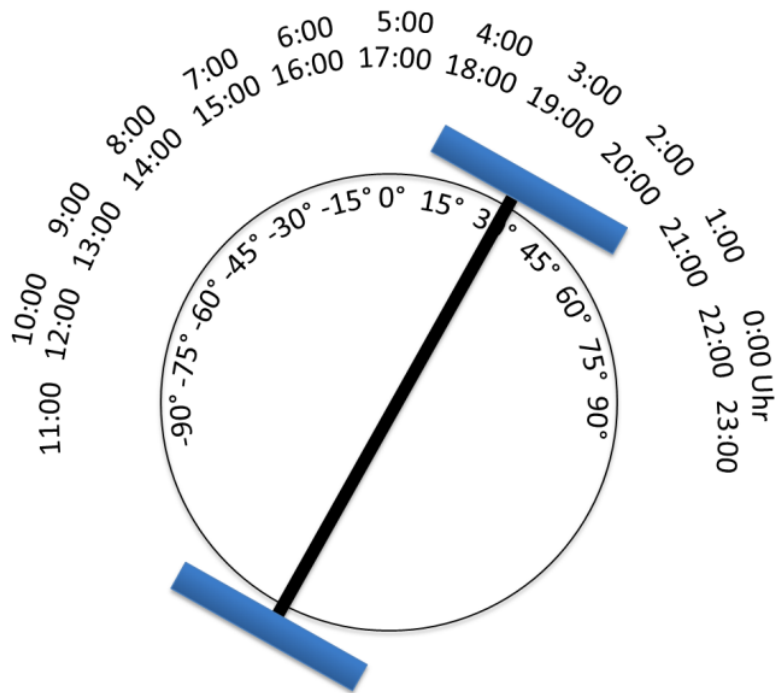


# CosMO-Mill

## Investigation of zenith angle dependence

Location: Zeuthen

Mill changes its position every hour by  $15^\circ$



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

##### 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

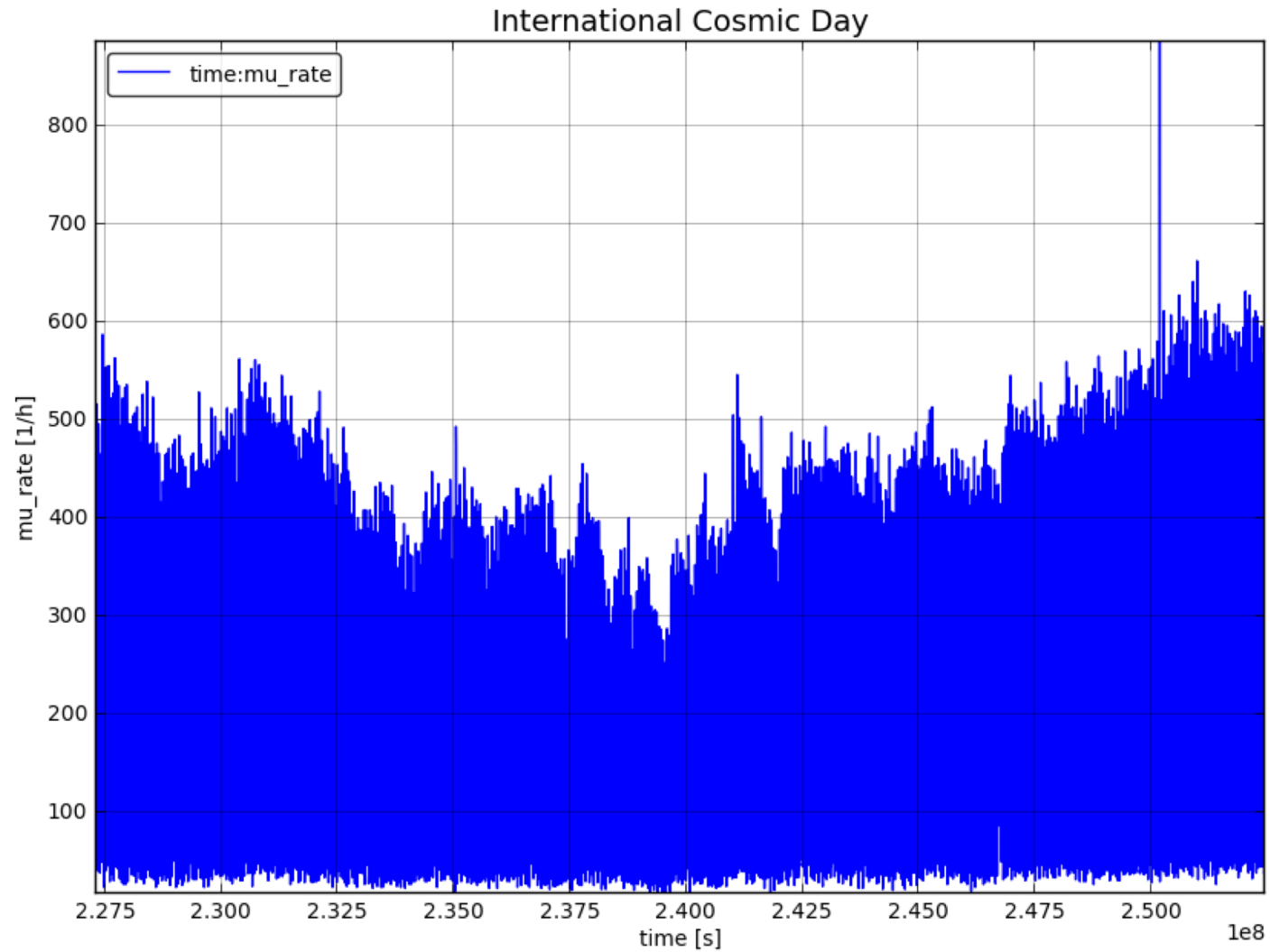
Title: International Cosmic Day

#### Legend

Position: automatically

# CosMO-Mill

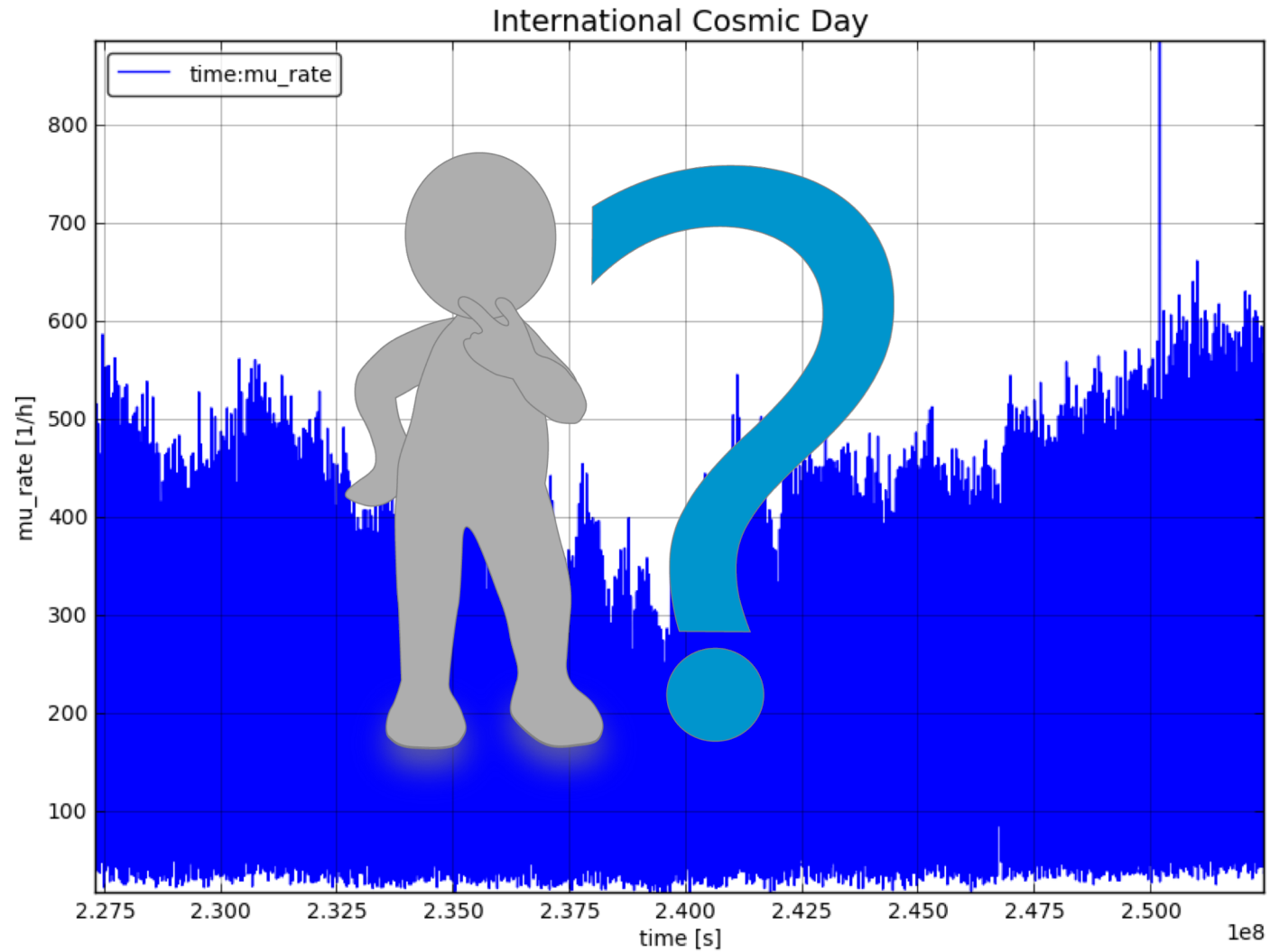
## Investigation of zenith angle dependence





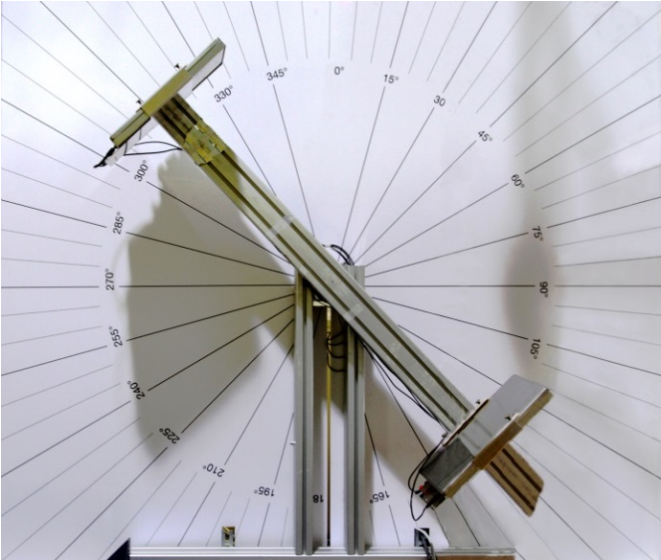
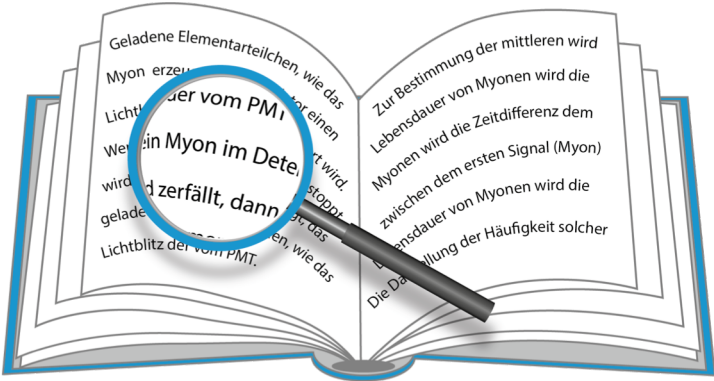
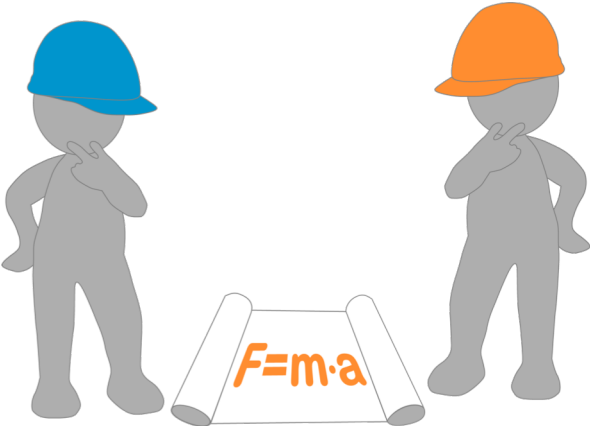
# CosMO-Mill

## Investigation of zenith angle dependence



# CosMO-Mill

## Investigation of zenith angle dependence



### Dataset CosMO Mill

Parameter	Definition	SI-Unit	Example
<b>Webinterface</b>			
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

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  
angle [deg]

y-Variable  
mu\_rate [1/h]

z-Variable  
optional

#### Diagram Option

Title  
International Cosmic Day

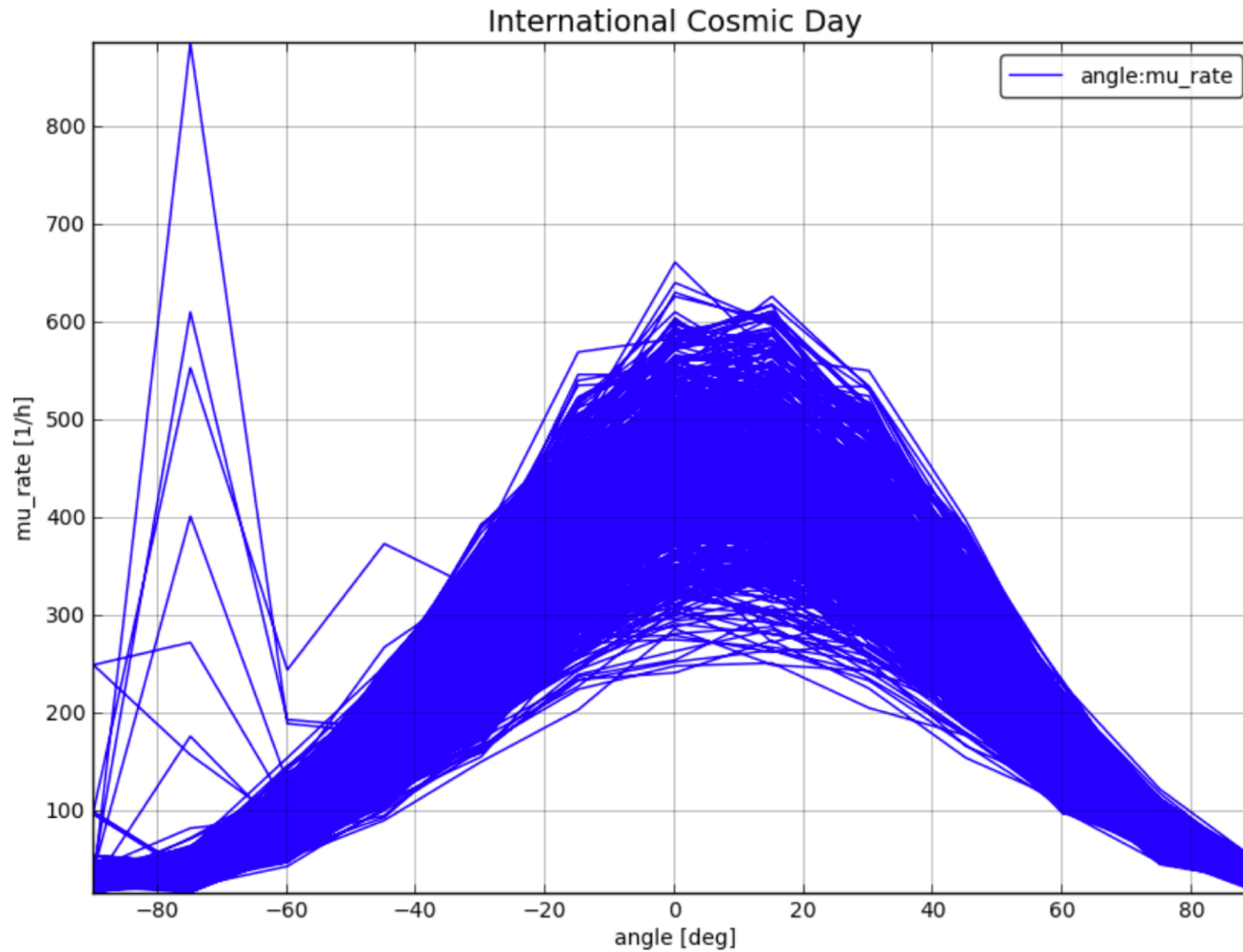
#### Legend

Position  
automatically

Reset    Diagram Creation

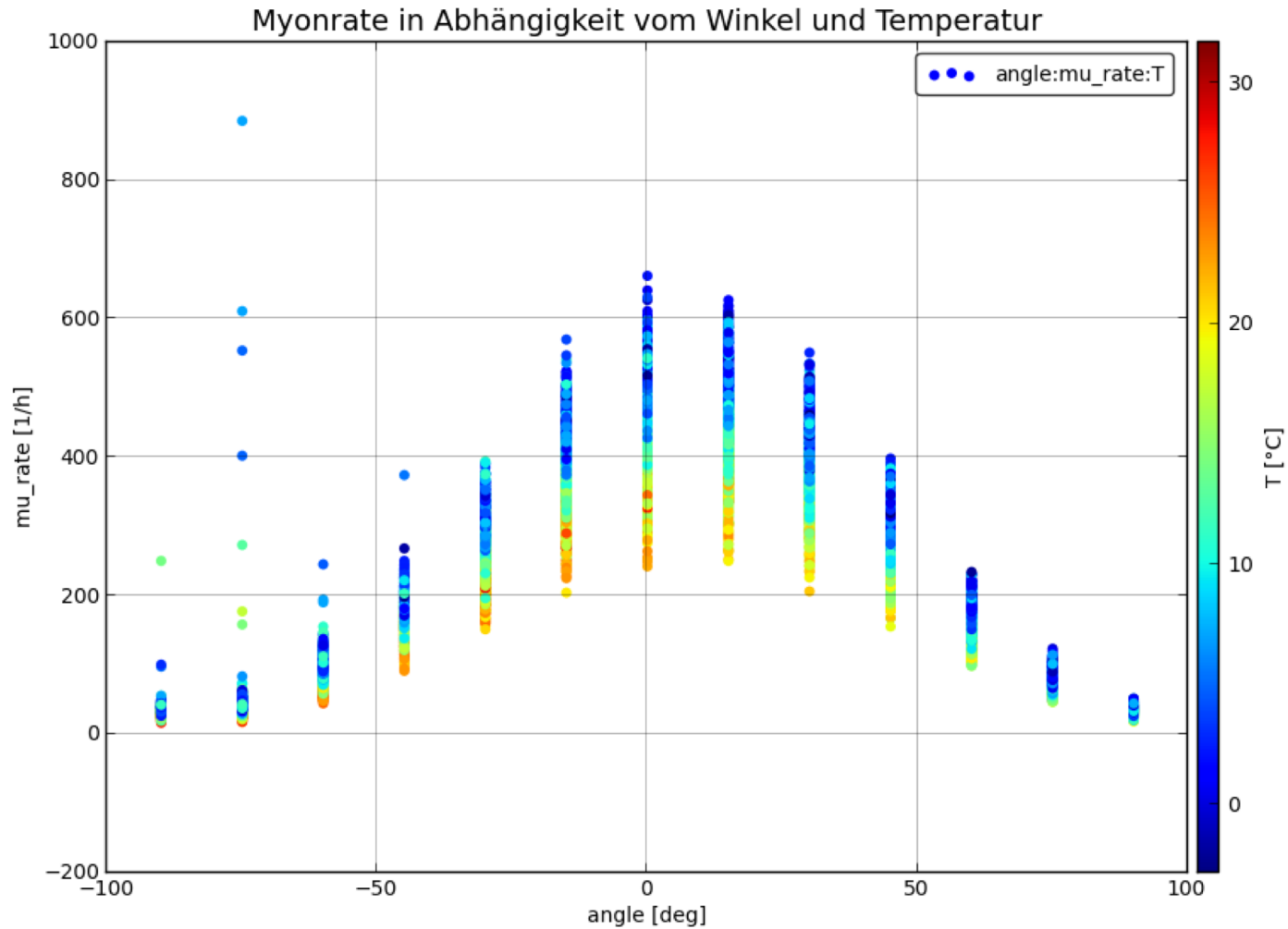
# CosMO-Mill

## Investigation of zenith angle dependence



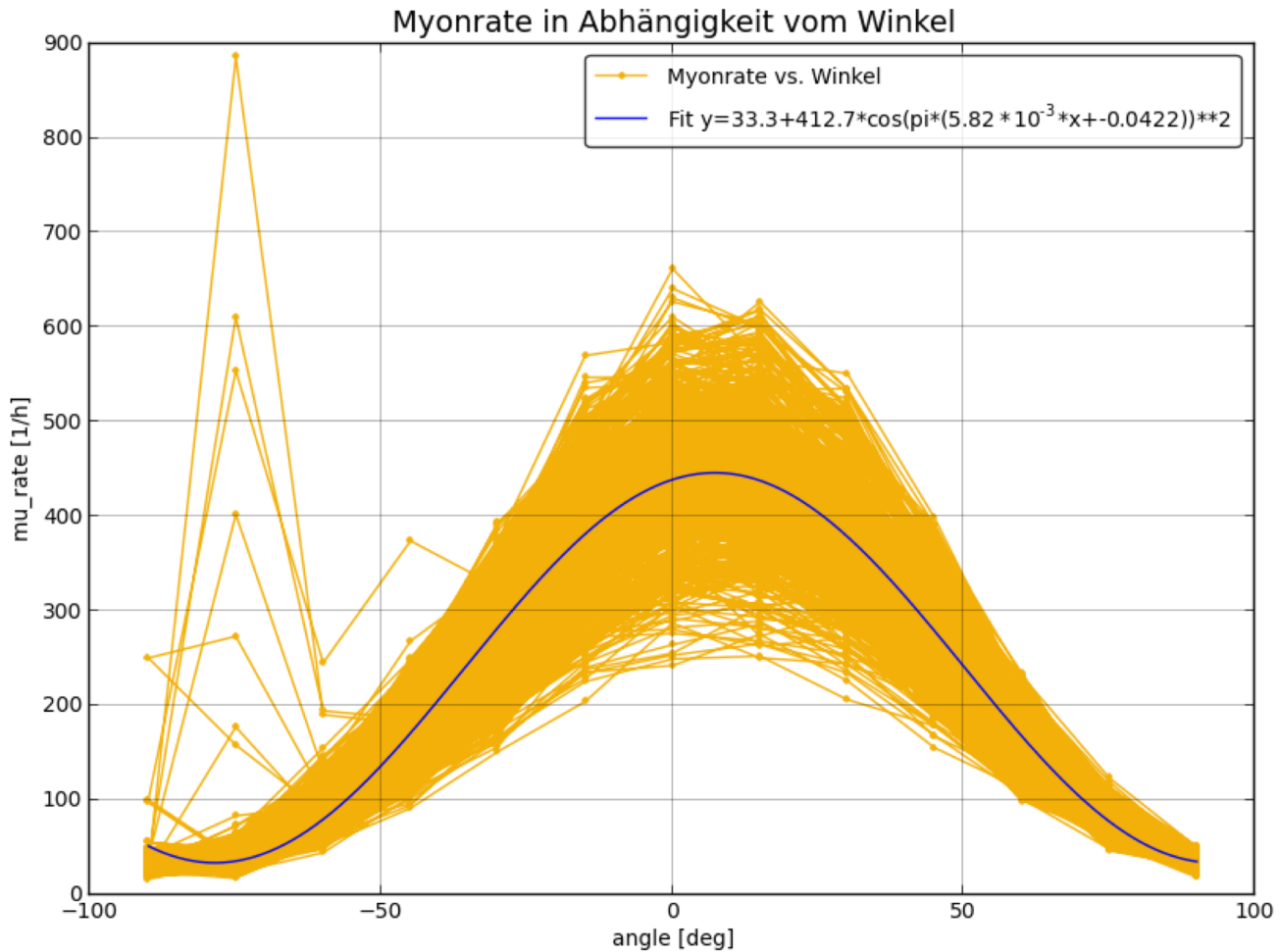
# CosMO-Mill

## Investigation of zenith angle dependence



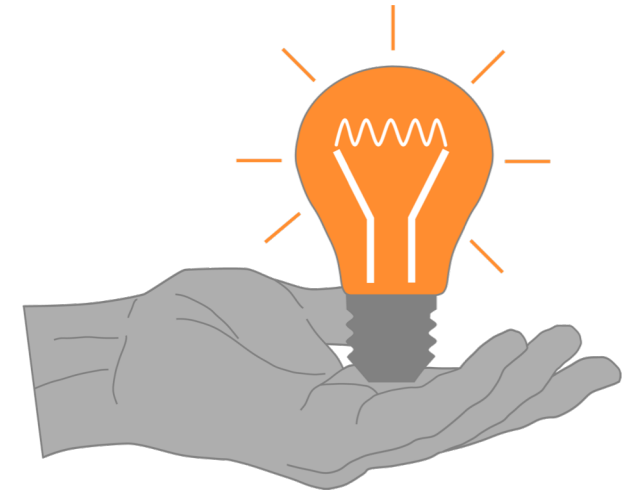
# CosMO-Mill

## Investigation of zenith angle dependence

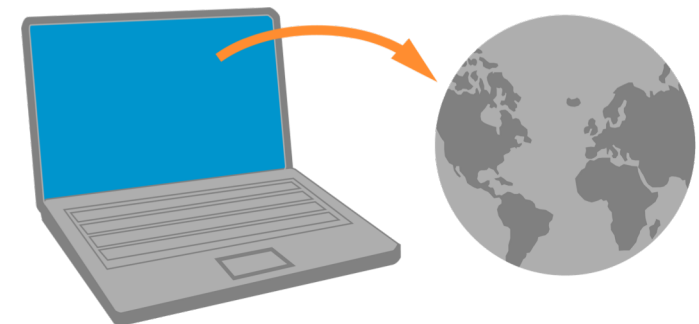


$$y = p[0] + p[1] \cdot \cos(\pi \cdot (p[2] \cdot x + p[3]))^2$$

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

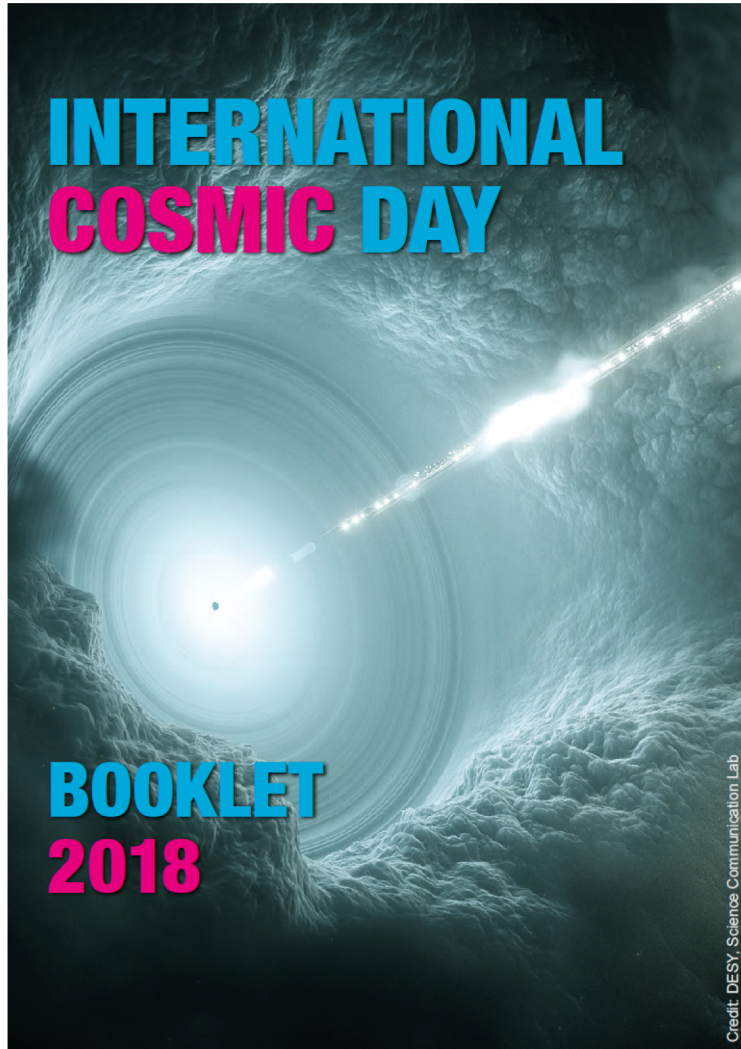


Rate of measured muons depends on temperature and zenith angle



# The Publication of the Research Work at ICD

Booklet with all Contributions of the Participating Groups



## INTERNATIONAL COSMIC DAY

Dear Young ICD-Researchers,

Thank you for your participation and contribution to the 7th International Cosmic Day!

Over 2250 students, 200 teachers and 120 scientists from 16 countries have made this day possible.

Various cosmic particles constantly reach the Earth – particles that can provide insights into events happening in the depths of the universe. You – the ICD young researchers – studied cosmic rays for one day. For 24 hours around the globe, cosmic particles were at the center of interest. All over the world, we discussed questions like:

What are cosmic particles?

Where do they come from?

How can they be measured?

You all have done your measurements very well. It is great to see all the results, which show only small differences but many agreements.

We hope the International Cosmic Day gave you an insight into astroparticle physics – a young research field located at the interface between astrophysics, particle physics, astronomy and cosmology.

Maybe you have become interested and it opens a new window for you to explore the universe.

In this booklet you can find information about all participating groups, the results of your measurements and web links to more information about astroparticle physics.

**USA**

**ITALY**

**SPAIN**

**CHINA**

**SERBIA**

**MEXICO**

**FRANCE**

**SWEDEN**

**RÉUNION**

**GERMANY**

**DENMARK**

**AUSTRALIA**

**ARGENTINA**

**PHILIPPINES**

**UNITED KINGDOM**

**UNITED ARAB EMIRATES**

INTERNATIONAL COSMIC DAY 2018

## TABLE OF CONTENTS

1. Poster	1
2. All Participating Groups	2
2. Contributions	
2.1. China	3
2.2. Denmark	8
2.3. France	11
2.4. Germany	17
2.5. Italy	31
2.6. Mexico	127
2.7. Philippines	130
2.8. Réunion	132
2.9. Spain	134
2.10. United Kingdom	137
2.11. USA	141
2.12. Atlas	147
2.13. Fermi	151
2.14. IceCube	154
4. Summary	157
5. Learn More	159
6. Contacts	161

# Many Thanks



NETZWERK  
TEILCHENWELT

## Kontakt

**DESY.** Deutsches  
Elektronen-Synchrotron

[www.desy.de](http://www.desy.de)

Carolin Schwerdt  
Schülerlabor physik.begreifen | Netzwerk Teilchenwelt  
[carolin.schwerdt@desy.de](mailto:carolin.schwerdt@desy.de)  
Telefon: +49 33762 7-7264

PROJEKTLEITUNG



PARTNER



SCHIRMHERRSCHAFT



FÖRDERER

GEFÖRDERT VOM



DR. HANS RIEGEL-STIFTUNG