

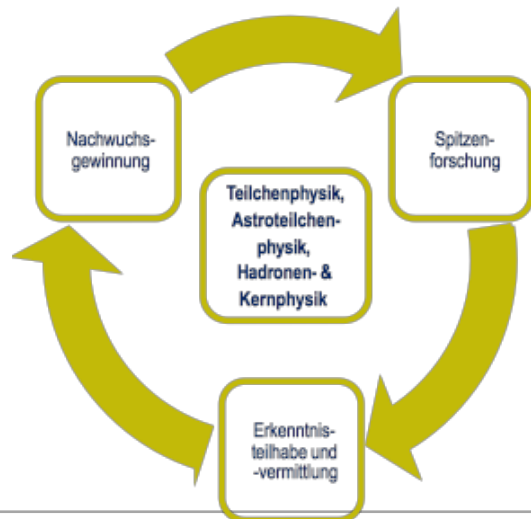
# Netzwerk Teilchenwelt



NETZWERK  
TEILCHENWELT

# Netzwerk Teilchenwelt

- Funded by German Ministry of Education and Research since 2010
- **KONTAKT2 stands for**
  - **Communication** of research in Particle-, Astroparticle-, Hadrons and Nuclearphysics
  - **Participation** of the Public
  - **Promotion** of the next generation of scientists
- Part of ErUM (Erforschung von Universum und Materie) research framework



- **Joint outreach for Particle Physics**
  - Bundle existing activities
  - Share structures and programs
  - Synergy effects
  - High visibility and impact of outreach
- **Target groups:** high school students, teachers, general public
- Collaboration with **LHC-ErUM-FSP office**

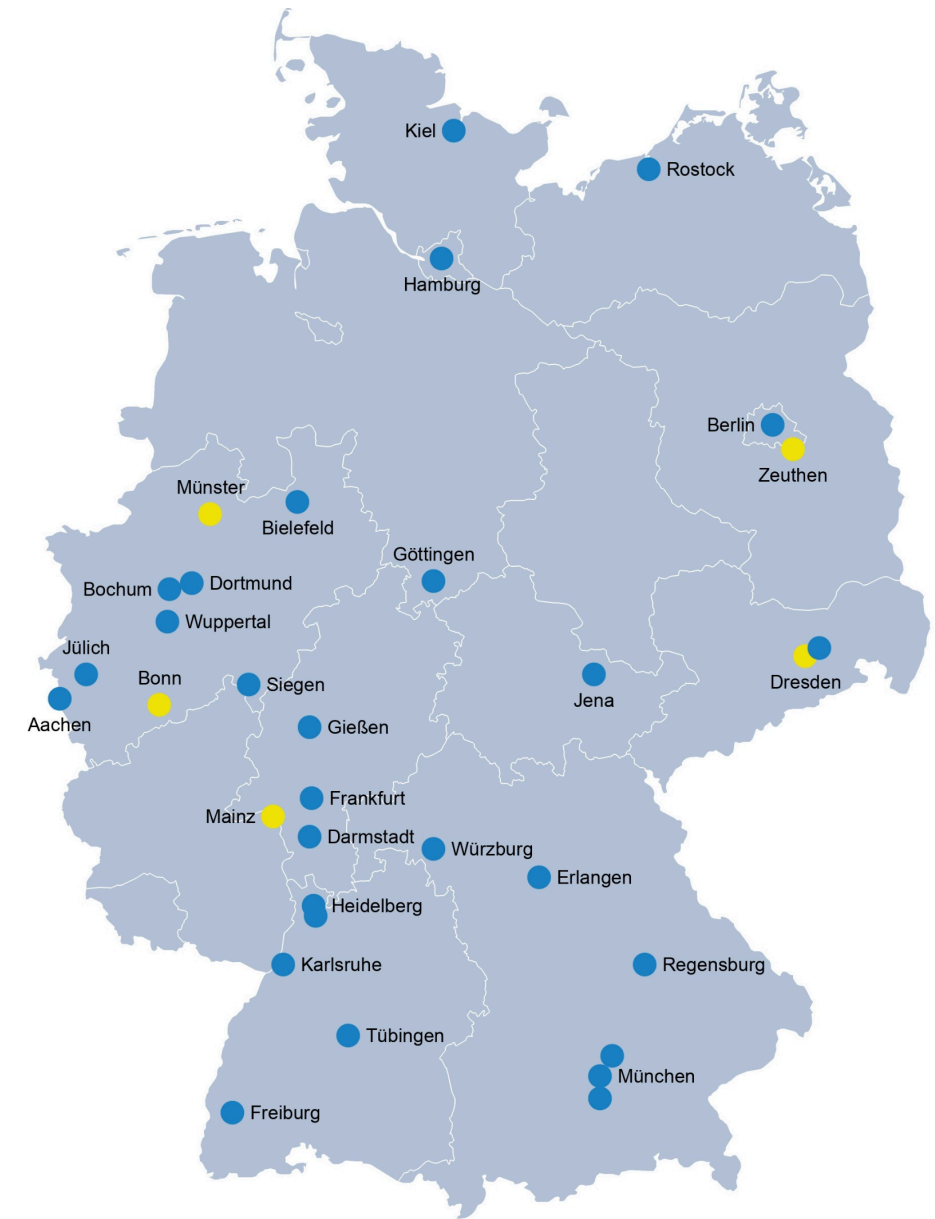


# Netzwerk Teilchenwelt

- **Over 30 locations:** universities/research labs & CERN
- **Facilitators:** ~150 PhD & Master students
- **Site contacts**
  - Local contact persons
  - Organize Masterclasses/Workshops
  - Maintain contact to schools & high school students



©Svitlana Semerenkov, Standorttreffen 2023 in Bonn



# Netzwerk Teilchenwelt

- Project coordination at TU Dresden (+ DESY / CERN)
- Team = project coordination + 3 hubs in Bonn, Mainz & Münster



# Facilitators

- ~ 150 **PhD and Master** students
- Guide Masterclasses, supervise students' research projects
- Influence students' career-related aspirations and choices
- Reimbursement of expenses and travel cost
- Get training on communication, didactics, presentation techniques



# Multistep Program for High School Students



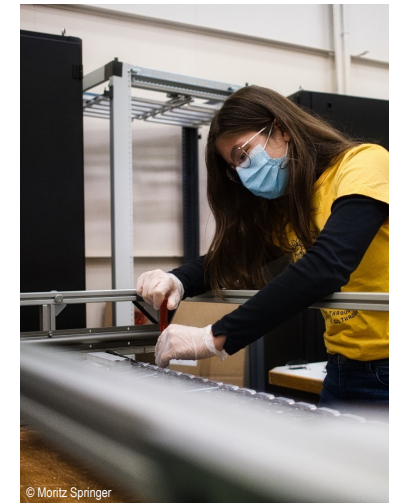
Masterclasses at school, university, research institute or museum



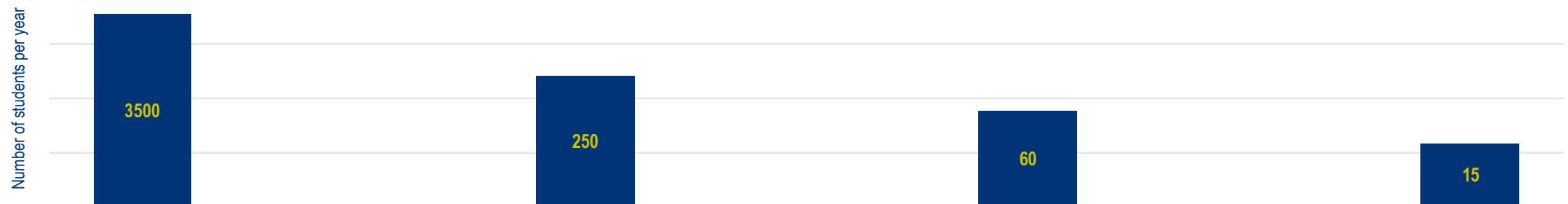
Active engagement, detector projects



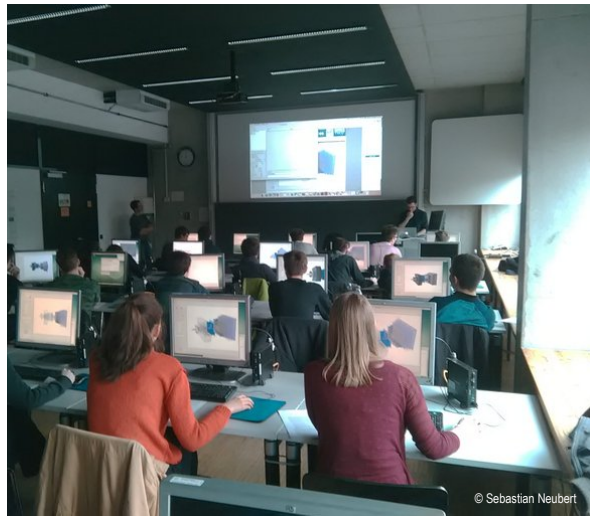
CERN workshops / Particle physics academy in Mainz



Research projects at CERN or research institute



# Multistep Program for High School Students



Masterclasses at school, university, research institute or museum

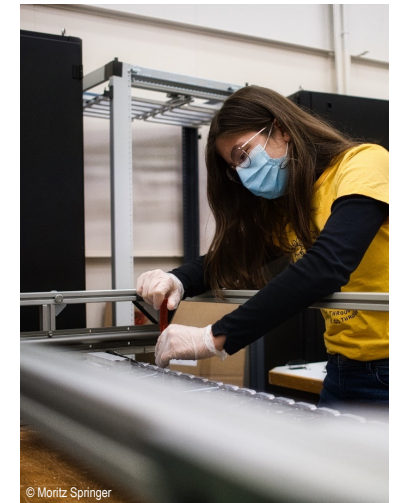
Number of students per year



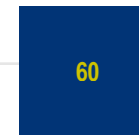
Active engagement, detector projects



CERN workshops / Particle physics academy in Mainz



Research projects at CERN or research institute



# Masterclasses

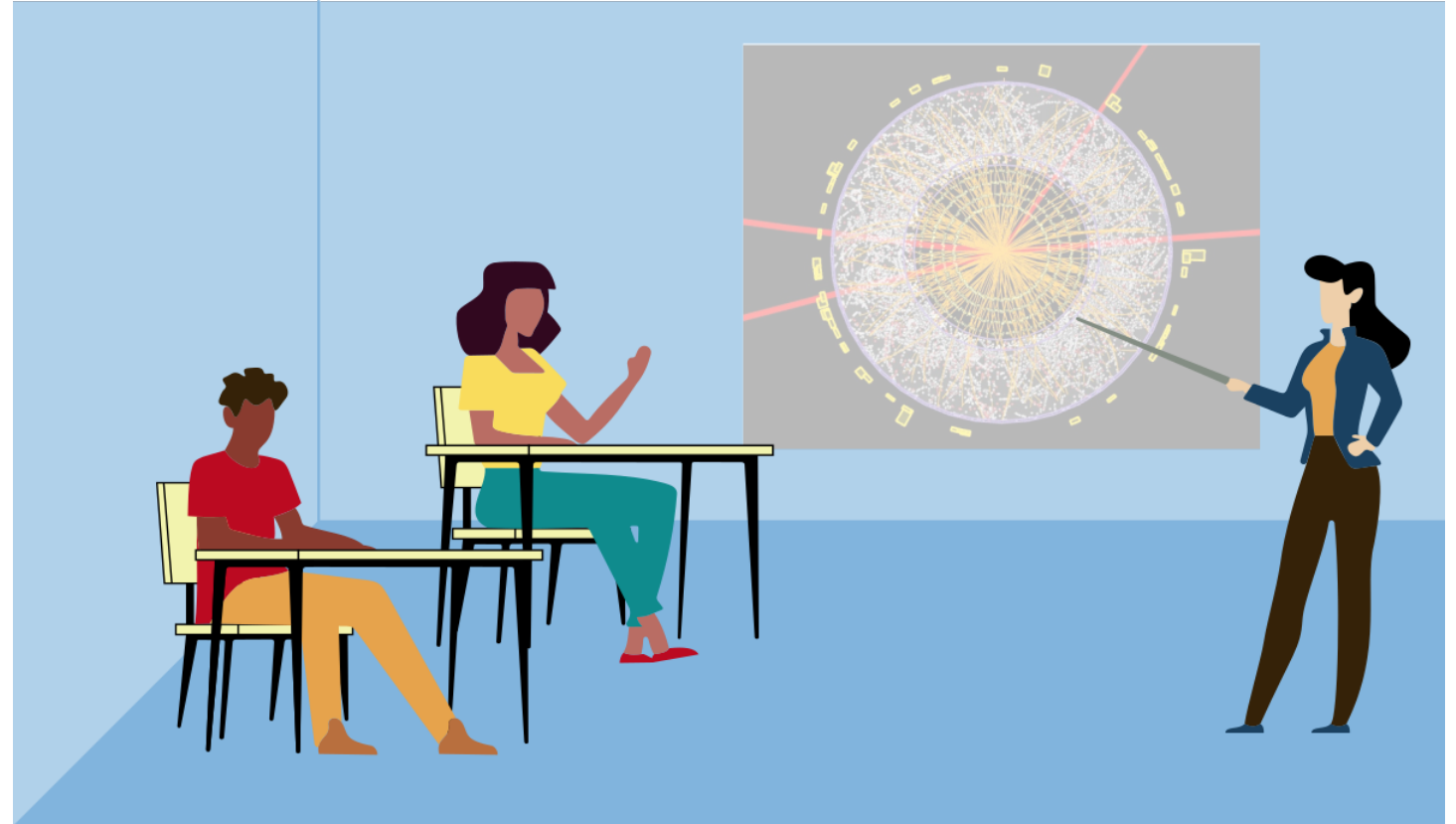
- 1-Day event
- In **Schools, Student labs, museums or research institutes** (or online as Masterclass@home)

## 1. Introductory talks

2. **Hands-on with real data** from (Astro-)particle physics experiments

3. **Result** answers initial research question

4. **Optional: Video conference**





# The Idea Behind Masterclasses

## "Scientist for a day"

Close to current research

Own "hands-on" activities (listen = forget, see = remember, do = understand)

## Insight into the research process

Use of relevant methods and tools

Comparisons between experiment and theory

## Authentic & new experiences

Analysis of real scientific data

Meeting and discussion with scientists

Possibility for students to **qualify for workshops** (e.g. by tutoring other Masterclasses)



# Why is this called a “Masterclass”?



As in a Masterclass in the arts, students work with an expert

**Expert = particle physicist**

**Violin = particle physics data analysis**

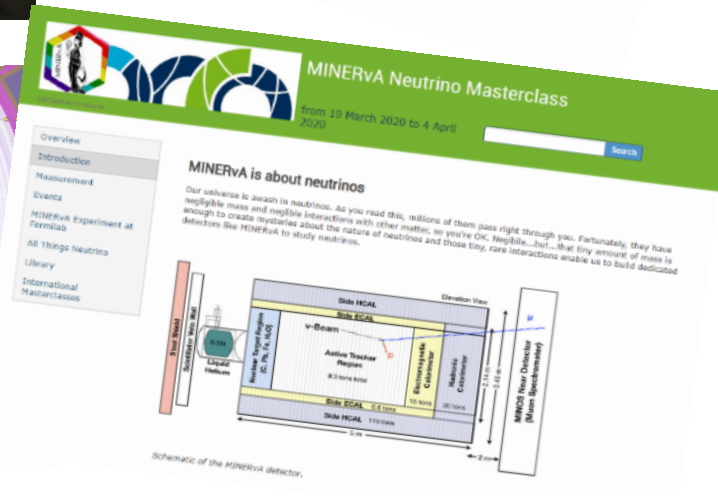
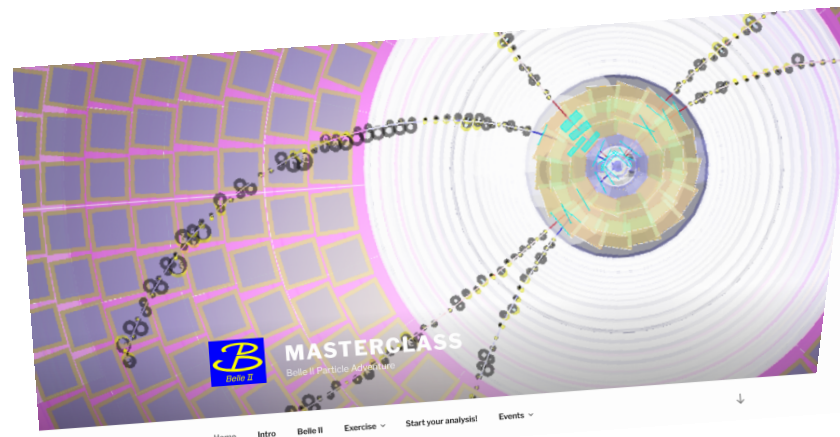
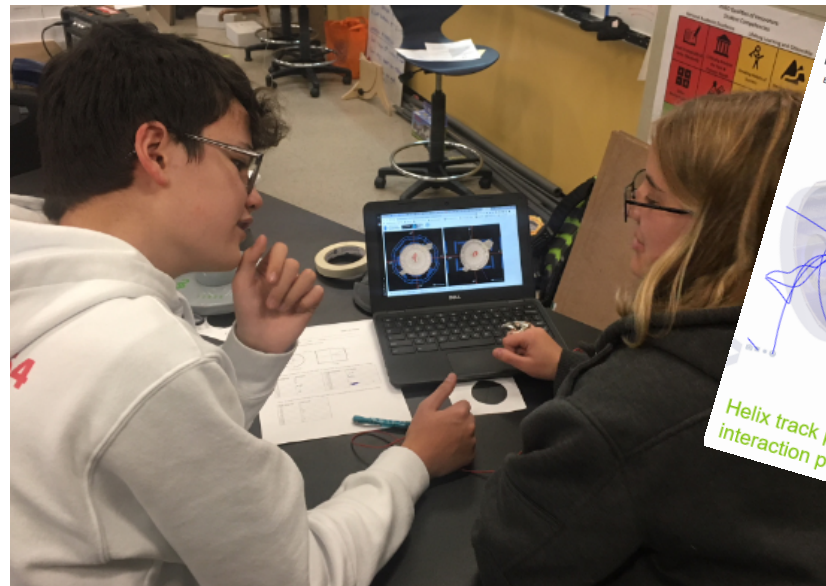
# Broad Physics Scope

## Today:

- LHC Experiments
- MINERvA
- Belle II
- Particle Therapy
- Nuclear Astrophysics
- Machine Learning
- [IceCube](#)
- [Pierre Auger](#)
- [DarkSide](#)

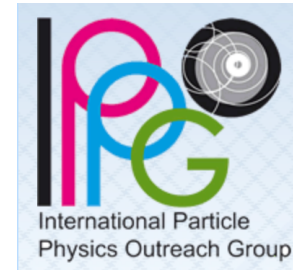
## Under development:

- NOvA
- MicroBooNE
- CB Masterclass
- ...

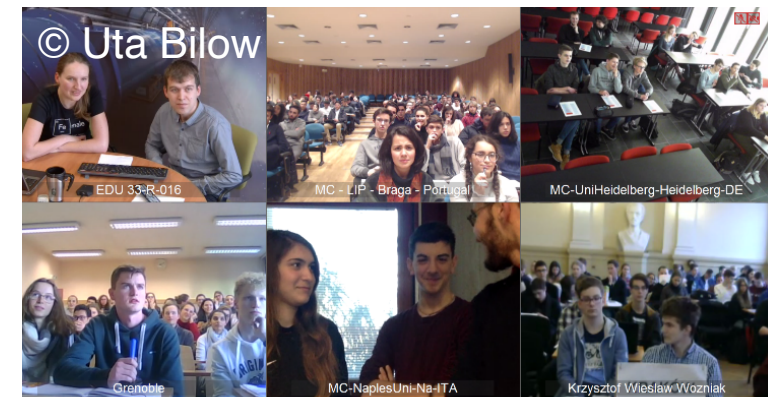


# Concept of International Masterclasses

- Organized by **International Particle Physics Outreach Group**
- Sample Agena:



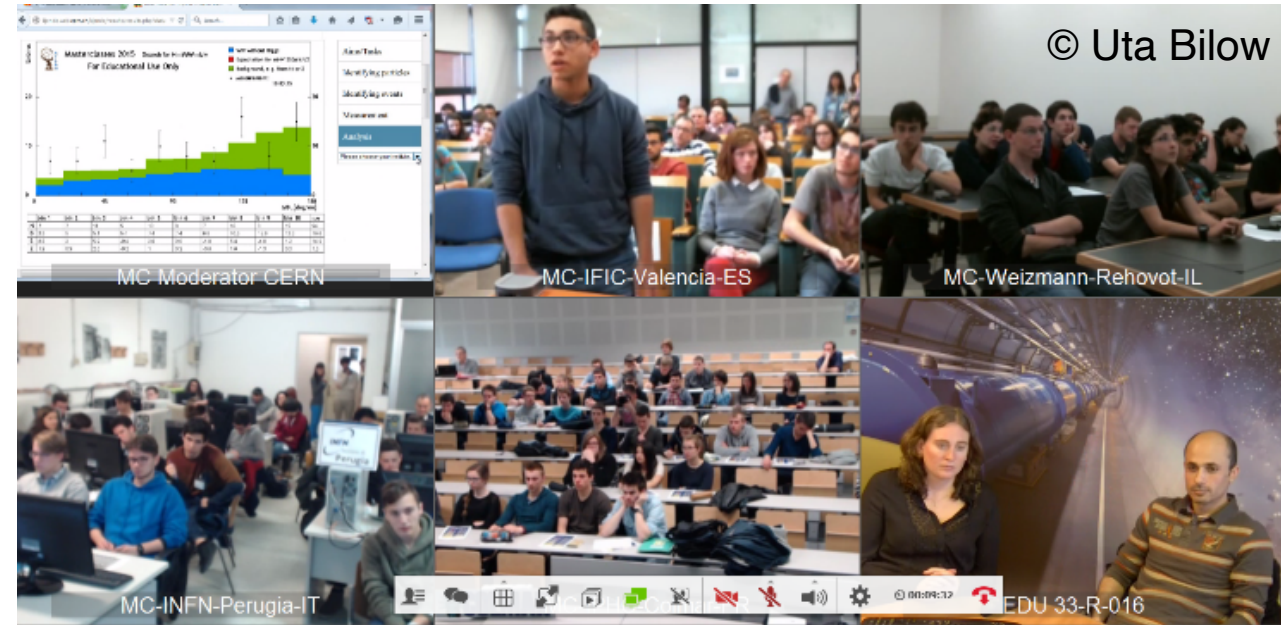
- 8:30 - 9:00 Registration & Welcome
- 9:00 - 10:00 Introduction to Particle Physics
- 10:30 - 11:30 Introduction to the Experiment/Lab tour
- 12:00 - 13:00 Lunch
- 13:00 - 15:00 Data analysis
- 15:00 - 16:00 Local combination + Discussion
- 16:00 - 17:00 International video conference



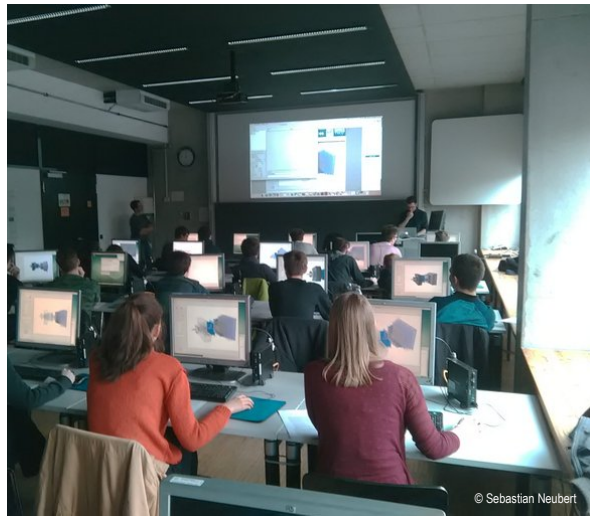
# International Masterclasses Video Conference

- 45-60 min
- 3-5 institutes, reflecting international collaboration
  - Same measurement, different data
- 2-3 Moderators (PhD students, Postdocs)
- Moderation centers: CERN, Fermilab, KEK, GSI, TRIUMF
- Agenda
  - Welcome
  - Combination and discussion of results
  - General Q & A
  - Quiz

**You are welcome to join the community of moderators!**  
(see [list of CERN moderators for IMC 2022](#))



# Multi-step Program for High School Students



Masterclasses at school, university, research institute or museum

Number of students per year



Active engagement, detector projects



CERN workshops / Particle physics academy in Mainz



Research projects at CERN or research institute



# Student Experiments on Astroparticle Physics

- Experiments exist at many sites ([Wiki](#))
- Use for MC or workshop
- Teachers borrow them for school



# CERN Project Weeks

- Students work within research group 2 weeks on their own small project
- Supervised by researcher at CERN
- Report → „Facharbeit“/ Jugend Forscht/ ...
- Social activities, tours etc.
- [Link to this years program](#)





# Fellow Program

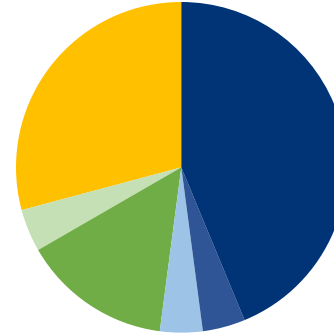
● Physics   ● Physics teacher  
● PhD   ● STEM  
● Medicine   ● High school



SCHOOL



RESEARCH GROUPS



- **Promotion of next generation scientists/STEM students**
- 150 people, 50% female
- Mainly **alumni of CERN workshops**
- Close connection between highly motivated students and research groups
  
- **Central offers:** Fellow physics schools (HEP, detectors), “Ask the expert” sessions (online), national physics conference attendance, etc.
  
- **Local offers:** internships, excursions, invitation to outreach events, colloquia, regulars´ table, etc.



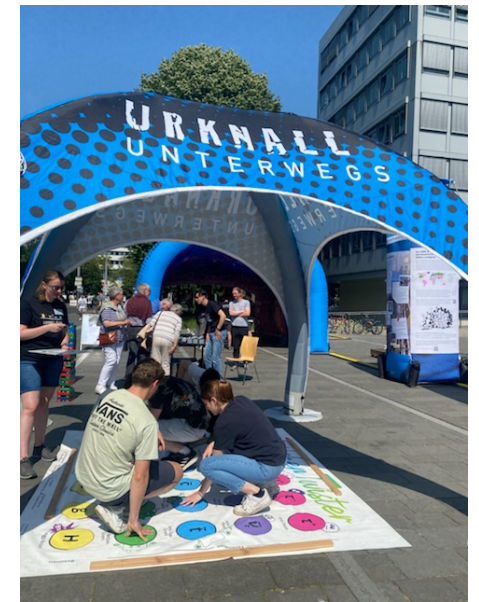
# Teachers as Multipliers

- **Development of material**
  - [Teaching material for schools](#), 4 volumes (>20k printed, >35k downloaded)
  - [Portal Leifi Physik](#): Chapter on particle physics
  - [Particle profile cards](#)
  - [GeoGebra Analysis of Bubble Chamber images](#)
  - [Context material](#)
- **Teacher training „Forschung trifft Schule“**, funded by Hans-Riegel-Stiftung Bonn
  - 2-day training: Introduction to particle physics, 6 trainings p.a.
  - Summer School at CERN: 6 days, once per year



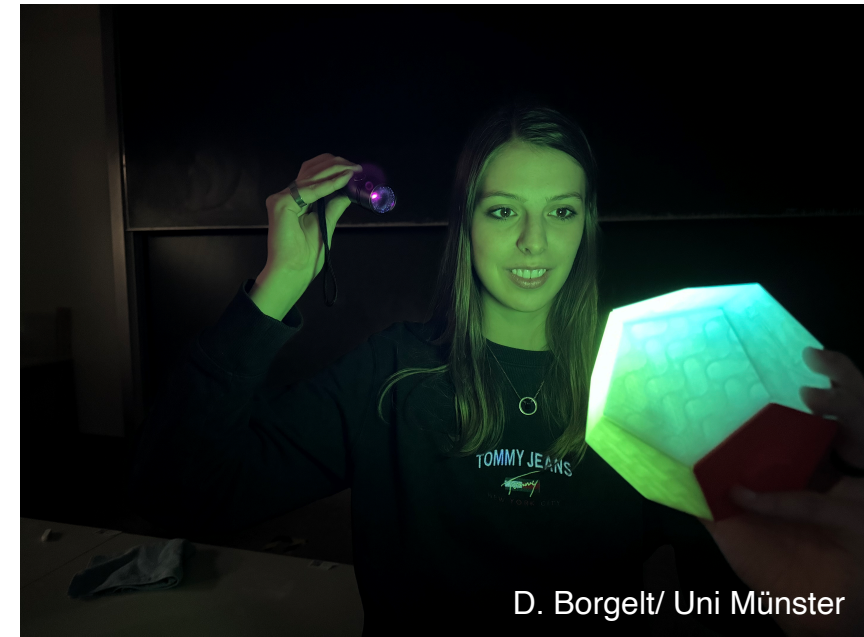
# Big Bang On The Road

- **interactive mobile exhibition module**
  - Tunnel: time travel in five steps through the history of the universe (texts)
  - Columns: Interactions and methods, spin-offs (texts)
  - Pavilion with games (Particle Twister, Particle Quark-Tower, Button Machine, Lego)
- **Target audience:** general public, people with less affinity for science
- **Contact:** Sarah Kästner, [sarah.kaestner@tu-dresden.de](mailto:sarah.kaestner@tu-dresden.de)
- <https://www.teilchenwelt.de/angebote/urknall-unterwegs/>



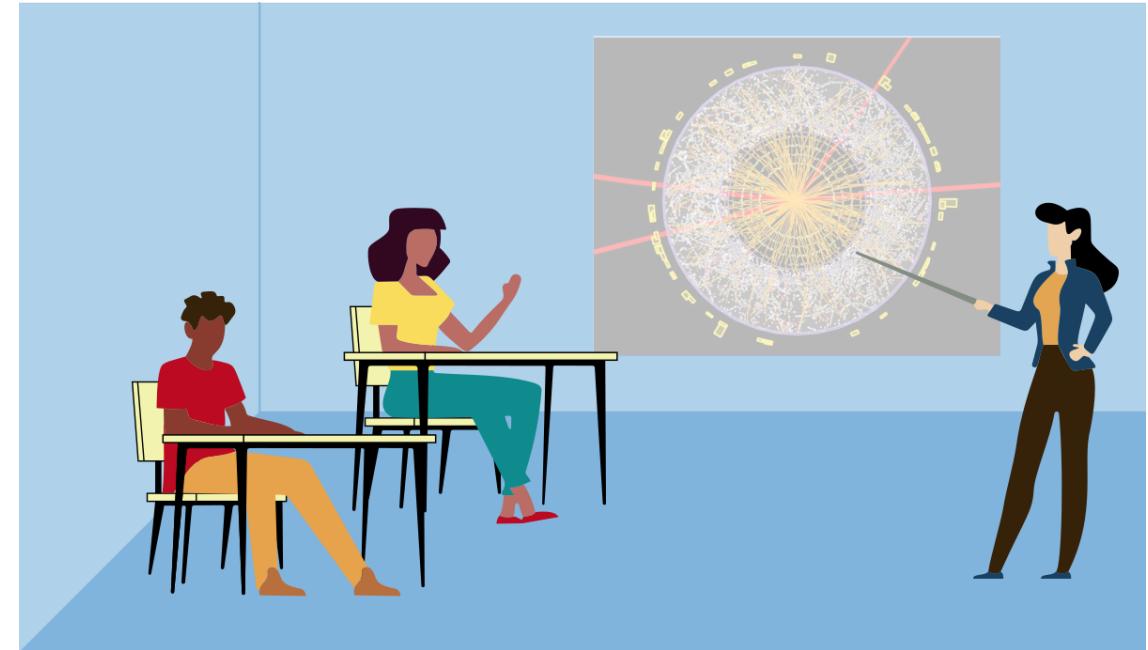
# Workshops for young students (U15)

- Young = **Year 7-10 High school** (before no/little physics taught)
- **Unexperienced or very young groups:** Pictures/Videos of the experiments + story telling + built cloud chamber
- **More advanced groups:** Talk on astroparticle physics + build their own cloud chambers in pairs
- **Additional hands-on experiments & demonstration materials** e.g. 3D-quarks, particle zoo, large cloud chamber + small experiments from physics collection @ your university



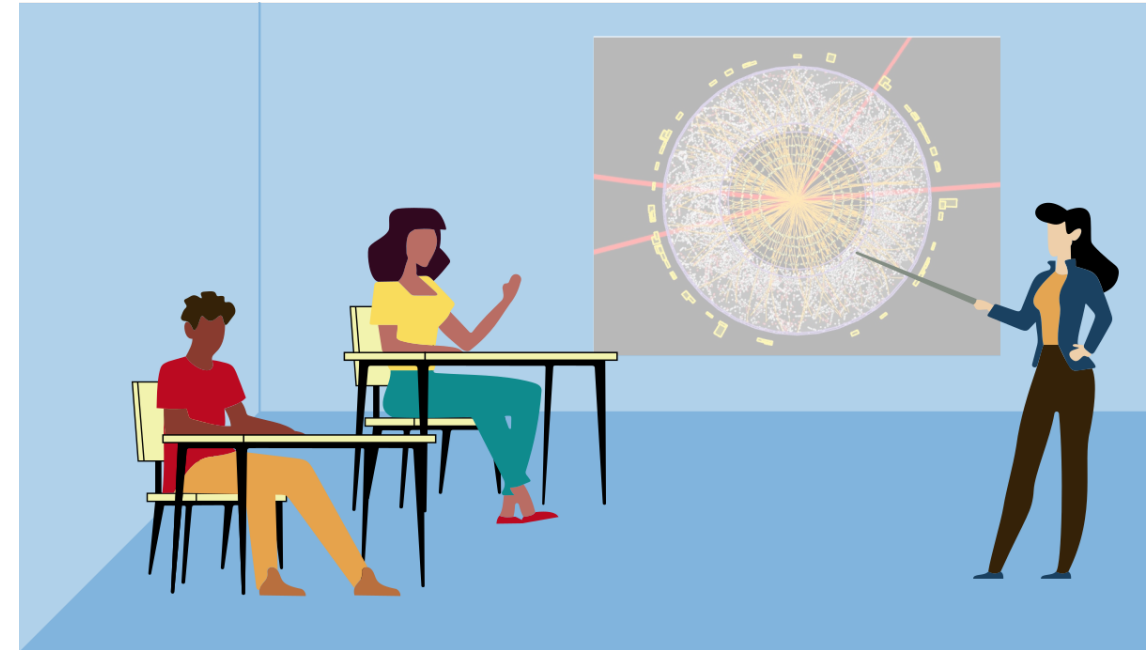
# Why Join?

- Become a **Facilitator**
- Perform **Masterclasses** or supervise research projects
  - Be a **role model**
  - Talk about your research
  - Acquire **soft skills**, for personal and professional development
  - Experience **interest in own research**
  - Practice supervision
  - You are **paid with a fee of 50-100€** (for a 1-day event) + traveling costs



# How to Join?

- Talk to your site contact-person ([Overview Sites](#))
- Register Database (Name, Address, E-Mail, Site, Date of birth, ... ) - Info necessary to pay Professional fees
- Slack-channel: [teilchenwelt.slack.com](https://teilchenwelt.slack.com)
- [Register](#) on the Wiki page



# Material for Facilitators

- [Teilchenwelt-Wiki page on Masterclasses](#)
- Material for the measurements [NTW](#) or [IMC](#)
  - Data
  - Event Displays
  - Handouts
  - Guide lines
- [Collections of slides \(german\)](#) incl. interactive elements
- Guideline [didactic concepts](#) for Masterclasses
- Online introduction course ([german](#) [englisch](#)) for particle physics Masterclasses (P-word: Teilchenphysik!)
  - [Excercise sheet](#) on the course



English material: <https://uni-bonn.sciebo.de/s/PA83895MdofZ6M8>

# Particle Profile Cards / Quartet

- Increase Activity
- Sort, discuss, get familiar to the particle quantities
- Appeal to other senses
- <https://www.teilchenwelt.de/material/materialien-fuer-lehrkraefte/teilchensteckbriefe/>
- [Instruction, concept and ideas](#)





# The Particle Zoo

- Distribute & refer to throughout the MC
- Combine with cards & play games

**THE PARTICLE ZOO – IT'S YOUR TURN**

1. Take your particles and sort by mass!
2. Get together in 4 groups:
  1. group: W boson, Higgs boson, top quark, Z boson, top antiquark, bottom quark (bottom antiquark)
  2. group: Gluon, photon, muon antineutrino, electron neutrino, tau antineutrino, tau neutrino
  3. group: Proton, neutron, electron, electron antineutrino, up quark, down quark
  4. group: Charm quark, strange quark, muon neutrino, muon



# (Particle) Bingo

- Think about catchy description for 9 particles e.g.
  - **Neutrino:** I am a perfect thief - stealing momentum, but leaving no traces
  - **Higgs:** I am the particle's candy and chocolate - mainly responsible for their mass
- Play Bingo with the class
- Generate cards e.g. from <https://myfreebingocards.com/bingo-card-generator/preview/mfssub4>
- Can also be used on any other content/aspect

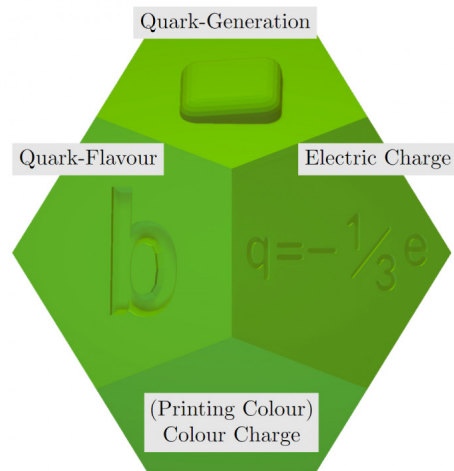
## Particle Bingo

3	6	5
2	7	9
1	8	4

myfreebingocards.com

# 3D Quark Puzzle

- Interactive puzzle on strong interaction
- Developed in LHCb working group of Prof. Neubert
- Form only color neutral states (meson or baryon)
- 3D print & documentation available on <https://github.com/lexner/Quark-Puzzle>



# Promotion Material

- **Various promotion materials available**
  - flyers, pens, post-cards
  - particle profile cards
  - fleece-bags, pens, particle-zoo buttons
- **T-Shirts for Facilitators**
  - women S-XL
  - men S-XXL
- **Ask your NTW contact on-site**



# Workshops for Facilitators

## The Basics 1x1 - On-boarding for new Facilitators

- Regular format every three month
- Next: Tue, Jun 4, 2024 10.00-11.00
- <https://indico.cern.ch/event/1200379/>

## Spotlight On - Introduction into one example Masterclass

- Regular format (always subsequent to on boarding event) with alternating topics
- Next: Today & Tue, Jun 4, new LHCb Masterclass & Quark Puzzle 11:00 - 12:00

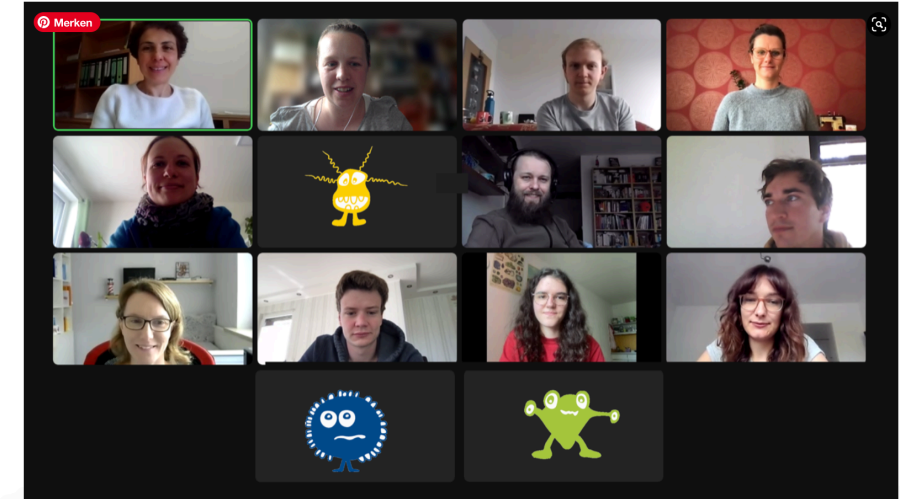
## Workshop on science communication & Masterclasses (in german):

- Facilitator's workshop, once per year, introduction to didactics, science communication & interactive methods for Masterclasses
- Autumn 2024 in Fulda

## Workshop on science communication & Masterclasses (in english):

- 14.-17. April 2024 in Bad Honnef: <https://indico.cern.ch/event/1360155/>

## Das kleine 1x1



# Fees Are Paid ...

...for **Masterclasses, cloud-chamber workshops, teacher trainings**

1-day event: up to 100€/Person + Traveling costs per Masterclass/Workshop

2-day events (also remotely): 150€ + Traveling costs

Exception: No fees paid for International Masterclasses

...for **supervision of student research projects**

...if you are a **PhD or Masterstudent from (Astro-) particle- or hadron physics**

... if they have been requested  $\leq 2$  weeks before the event by your local NTW contact person

# Teilchenwelt Website

- [Overview of sites & offers](#)
- [Calendar](#) of Netzwerk Teilchenwelt
  - Displays all events ( incl. MCs) at all sites
  - Event is displayed automatically if entered in database ([Instruction](#))

NETZWERK TEILCHENWELT Standort-Datenbank...

VERANSTALTUNGEN | INSTITUTIONEN | PERSONEN | BENUTZER | SESSION LEEREN | LOGOUT

Halle hansen.

### Veranstaltungen

Datenbank-Standard

Neue Veranstaltung eintragen

Beginn Tag	Titel	Ort	Veranstalter	NTW-Vertragsstatus	1 - 20 / 1561
[▼] 1 abste	sortieren...	sortieren...	sortieren...	sortieren...	Anzahl:
Suchen nach	Suchen nach...	Suchen nach...	Suchen nach...	Suchen nach...	20



Info für...



## Termine



### Auswahl einschränken

#### Kategorien

- Fortbildung
- Workshop
- Masterclass

#### Zielgruppen

- Lehrkräfte
- Studierende
- Vermittler
- Wissenschaftler
- Jugendliche

#### Entfernung

### September 2022

26.09.2022 13:00-17:00

#### **Fortbildung für Lehrkräfte zur Astroteilchenphysik in Bonn**

*Rheinische Friedrich-Wilhelms-Universität Bonn Nußallee 12, Bonn, Nordrhein-Westfalen*

Woraus besteht kosmische Strahlung? Wie und wo wird sie erzeugt? Wie können kosmische Teilchen erforscht und gemessen werden? Dies sind nicht nur für Wissenschaftler der Astroteilchenphysik spannende Fragen, sondern beschäftigen [...]

27.09.2022 09:00-14:00

#### **ForschungTrifftSchule@home: Astroteilchenphysik**

Wir laden Sie ein, mit uns einen Vormittag lang (9 – 14 Uhr) in die Astro(teilchen)physik einzutauchen. Wissenschaftler und Didaktiker geben Ihnen einen Einblick in die Grundlagen der Astrophysik, erläutern [...]

# Contact & Social Media

## Website

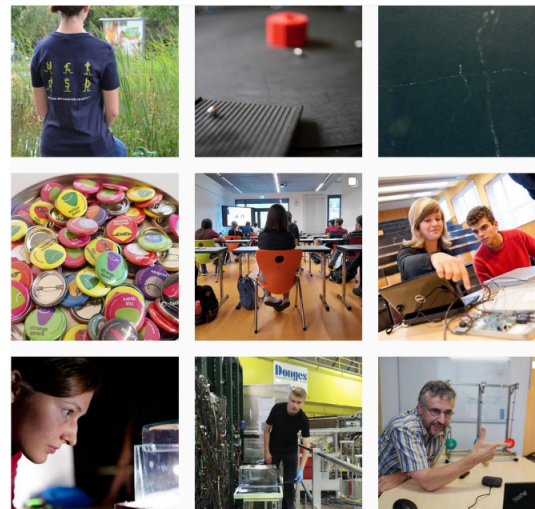
Magazin „teilchenwelten“ 3 x per year (Abo)



## Facebook



## Instagram



## YouTube-Videos „Netzwerk Teilchenwelt mit Moritz“





# Take Part!

- Become active in the Netzwerk Teilchenwelt outreach activities at your site
- Document new developments & give **Feedback to structures, format, content, ... in Teilchenwelt-Wiki**
- Share new material/concepts with other facilitators & sites
- **Exchange & Communicate** across all locations e.g. using slack, yearly meetings etc.
- If you are already a facilitator **take part in survey** so we can adapt better to your needs

# Questions?

- [Netzwerk Teilchenwelt Webseite](#)
- [Teilchenwelt-Wiki](#)



[https://www.instagram.com/  
netzwerkteilchenwelt](https://www.instagram.com/netzwerkteilchenwelt)



<https://www.facebook.com/netzwerkteilchenwelt>



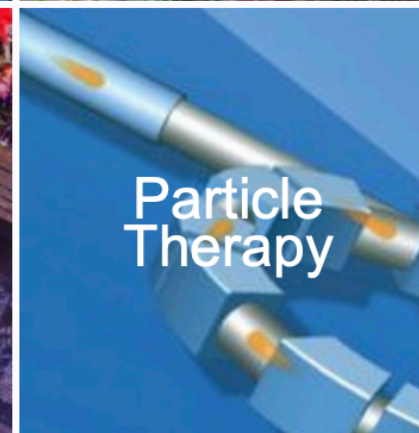
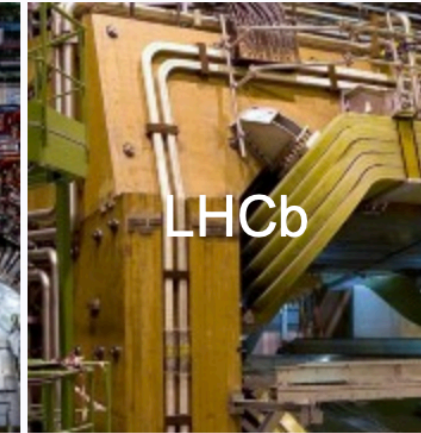
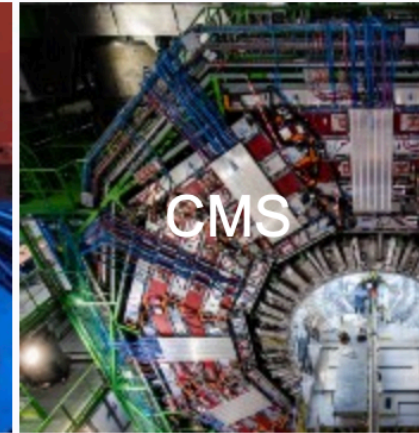
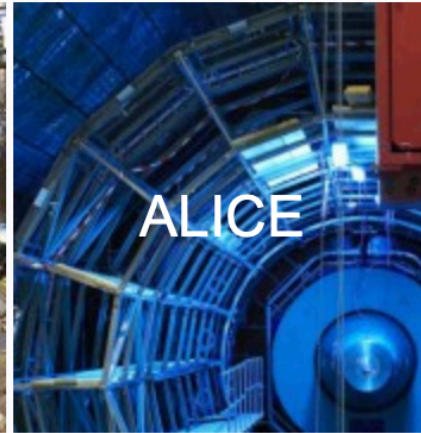
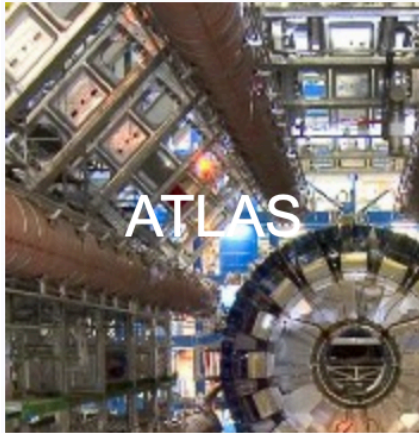
[mail@teilchenwelt.de](mailto:mail@teilchenwelt.de)

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



NETZWERK  
TEILCHENWELT

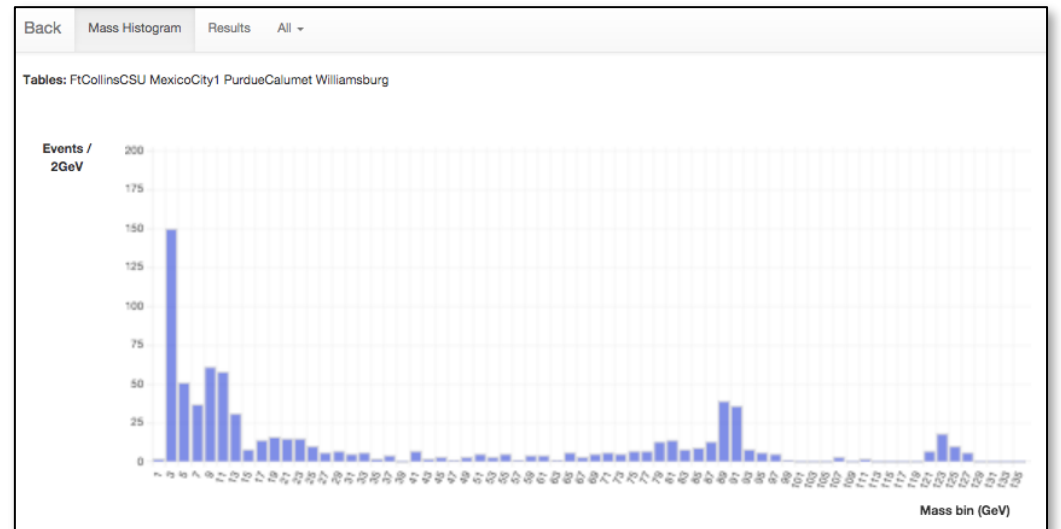
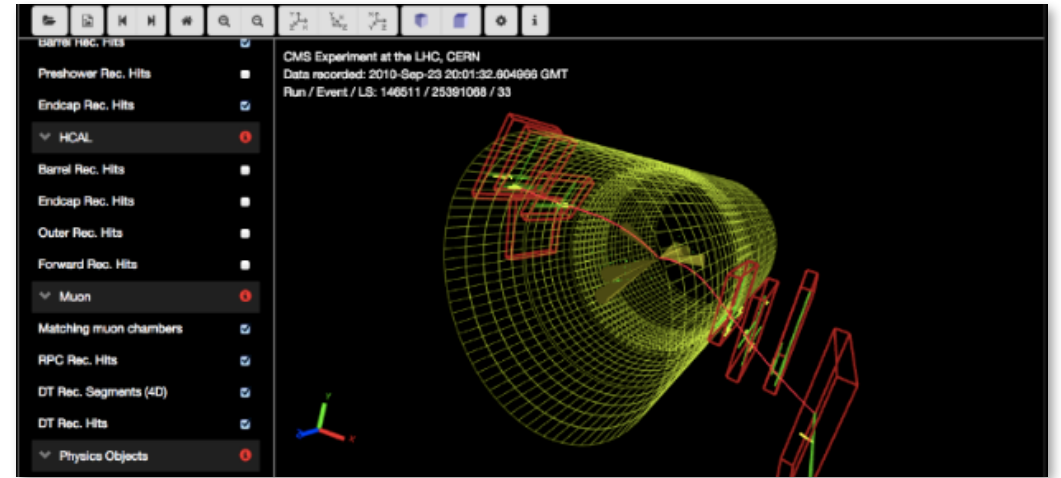
# International Masterclasses 2024



# CMS WZH measurement

- WebGL 3D event display
- 1-, 2-, and 4-lepton events
- Students characterize W, Z, and Higgs candidates
- Create 2-l and 4-l mass plots of standard model particles, plus Higgs
- Ratios  $W^+/W^-$ ,  $e/m$

<https://web.quarknet.org/mc/cms/imc2021/cms.html>



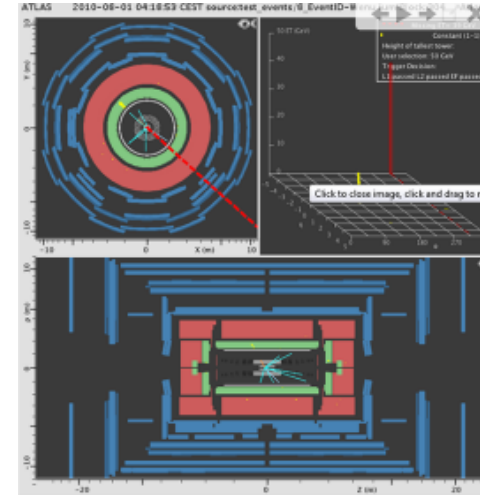
# ATLAS W path

Students analyze event displays (50 collision events per pair of students)

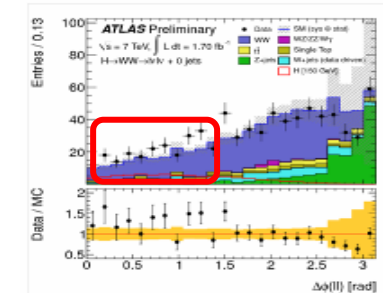
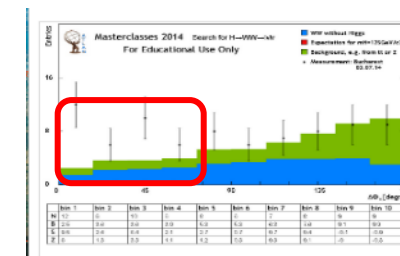
2 tasks:

- Identify W bosons, determine type and electric charge of leptons
- Resulting  $W^+/W^-$  is used to reveal the inner structure of the proton (and compared to results from ATLAS)
- Identify W pairs and measure azimuthal opening angle  $\Delta\phi_{ll}$
- Resulting histogram is used to provide insight into Higgs discovery process at CERN

<https://atlas.physicsmasterclasses.org/en/wpath.htm>

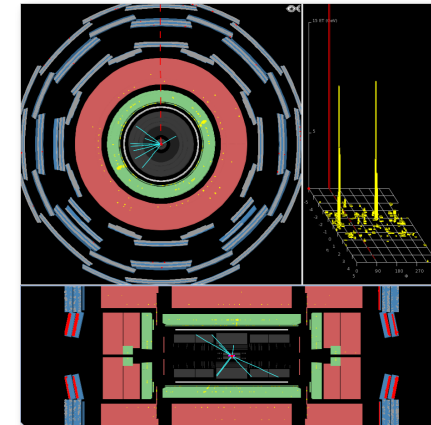


Total #	W → ... + ν				Background
	e <sup>+</sup>	e <sup>-</sup>	μ <sup>+</sup>	μ <sup>-</sup>	
532					
group A	9	4	10	1	24
group B	11	12	13	10	19
group C	5	3	1	1	19
group D	7	4	11	5	21
group E	11	10	3	2	31
group F	15	3	3	1	26
group G	6	4	3	5	27
group H	15	10	3	2	13
group I	5	3	3	4	5
group J	4	0	1	0	21
group K	5	1	5	3	18
group L	4	7	4	2	31



# ATLAS Z path

- Students search for 2-lep,  $\gamma\gamma$ , or 4-lep events
- Calculate invariant mass, upload results to a plotting tool
- Results are combined, invariant mass distributions are built



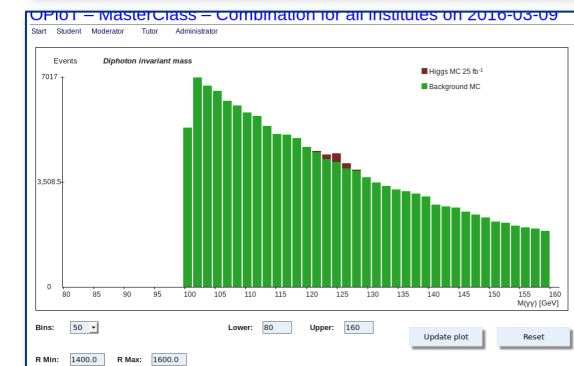
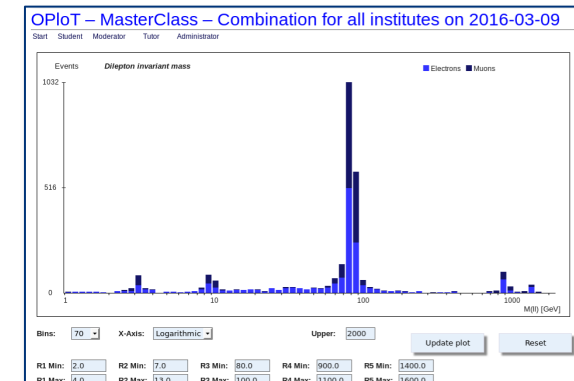
## 2-lep invariant mass distribution:

- Resonance peaks of known particles:  $Z^0$ ,  $J/\Psi$ ,  $\Upsilon$
- Search for new particles:  $Z'$ , graviton

## 4-lep, di-photon:

- Provide insight into the process of discovering the Higgs at CERN
- Explain concepts of statistics, modelling, signal significance

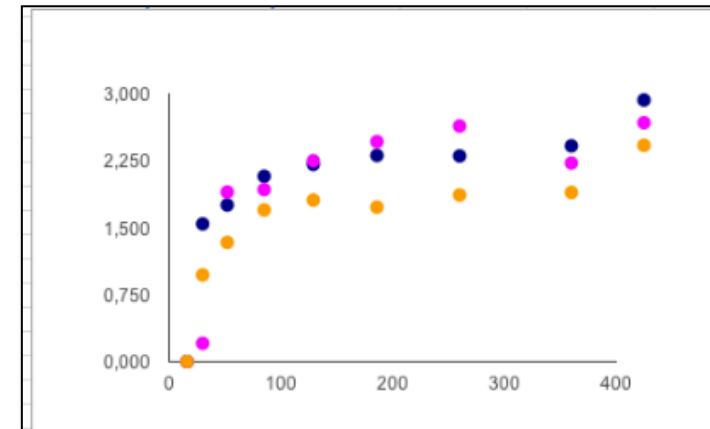
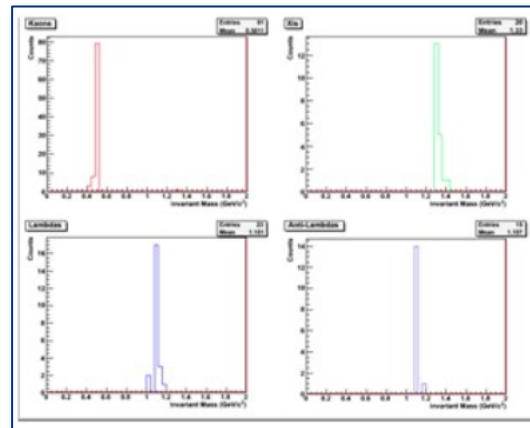
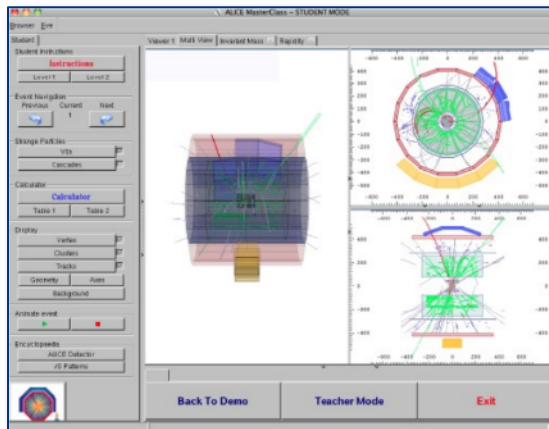
<https://atlas.physicsmasterclasses.org/en/zpath.htm>



# ALICE I: Looking for Strange Particles

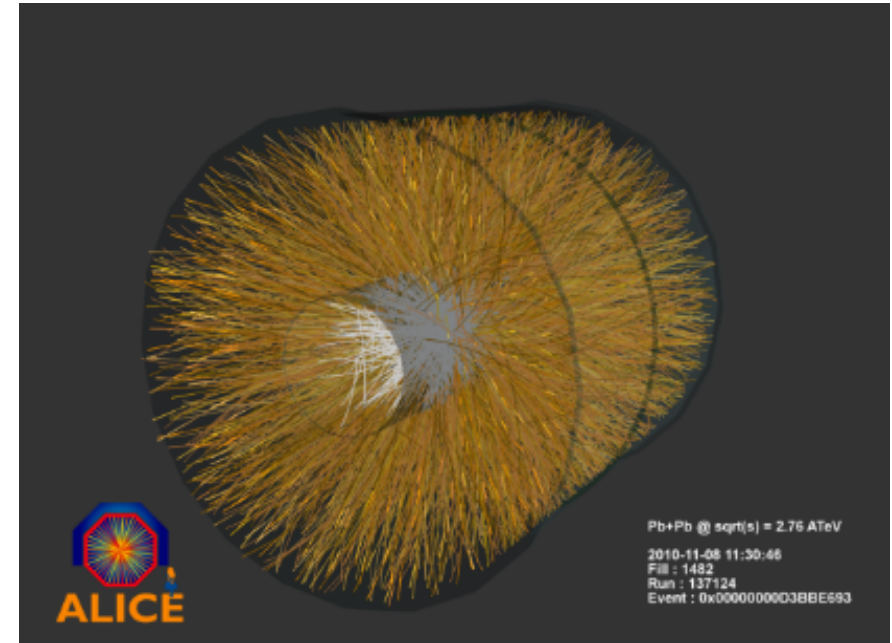
- Visual identification of V0s from decay pattern, invariant mass calculation
- First part: visual analysis of  $\sim 15$  events per group
- Second part: Calculation of numbers of Ks,  $\Lambda$ , anti  $\Lambda$  from invariant mass distributions (fit gaussian/polynomial to peak/background; subtract background) for different centrality regions in lead-lead collisions
- Concepts conveyed: invariant mass; centrality of PbPb collisions; background
- Results: observe strangeness enhancement in PbPb collisions comparing with pp collisions

<https://alice-masterclass.web.cern.ch/>

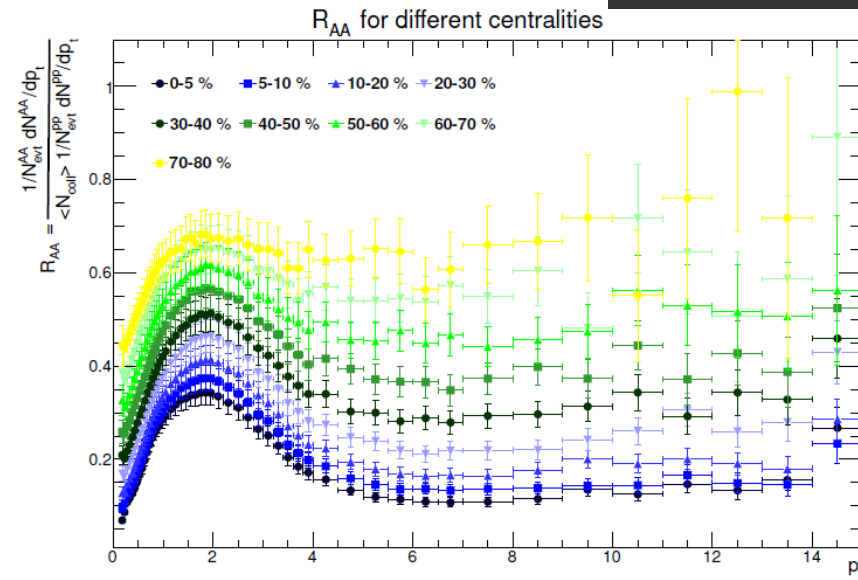


# ALICE II: Nuclear Modification Factor

- Event-display based visual analysis
- RAA simply via counting of tracks
- ROOT based large scale analysis
- RAA as a function of momentum in various Pb-Pb centrality classes
- Students discover jet suppression!



<http://www-alice.gsi.de/masterclass/>

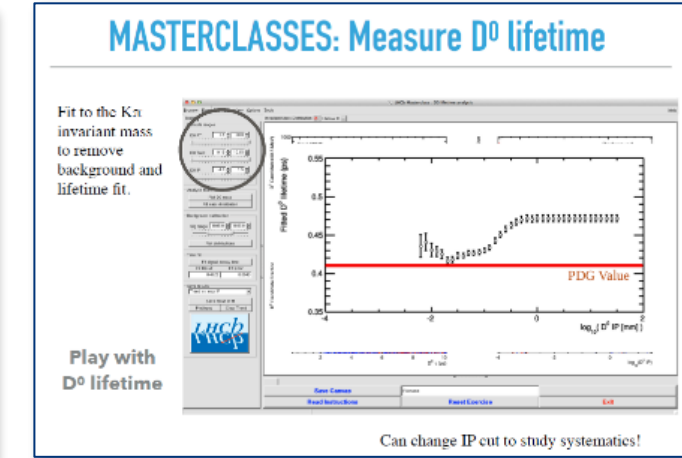
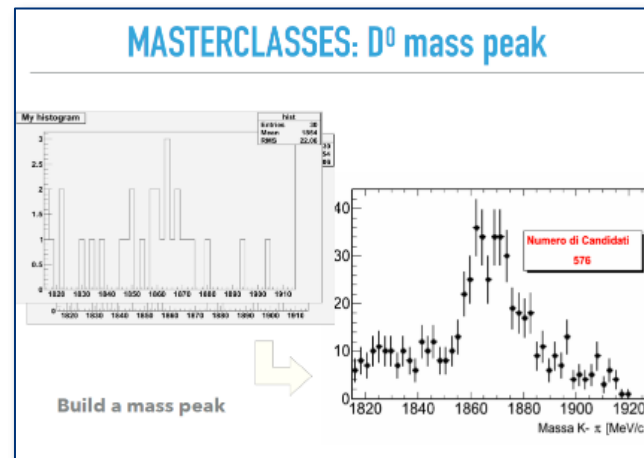
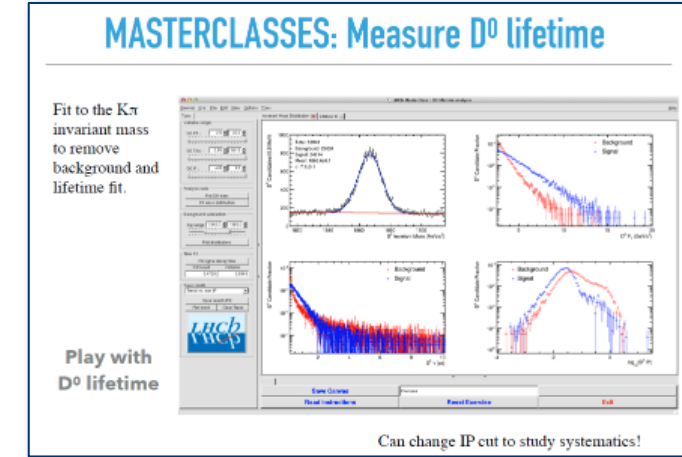
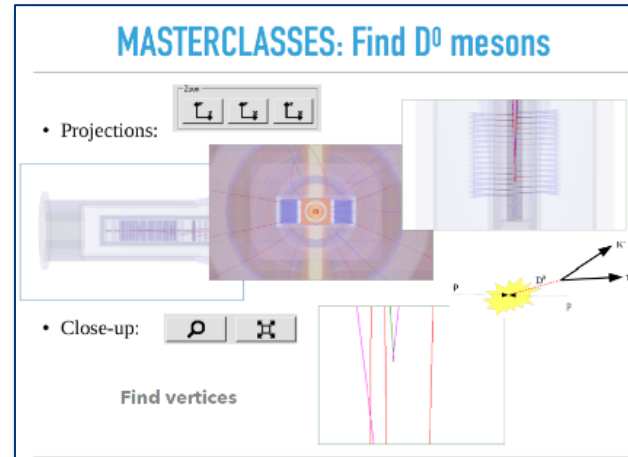




# LHCb Masterclass

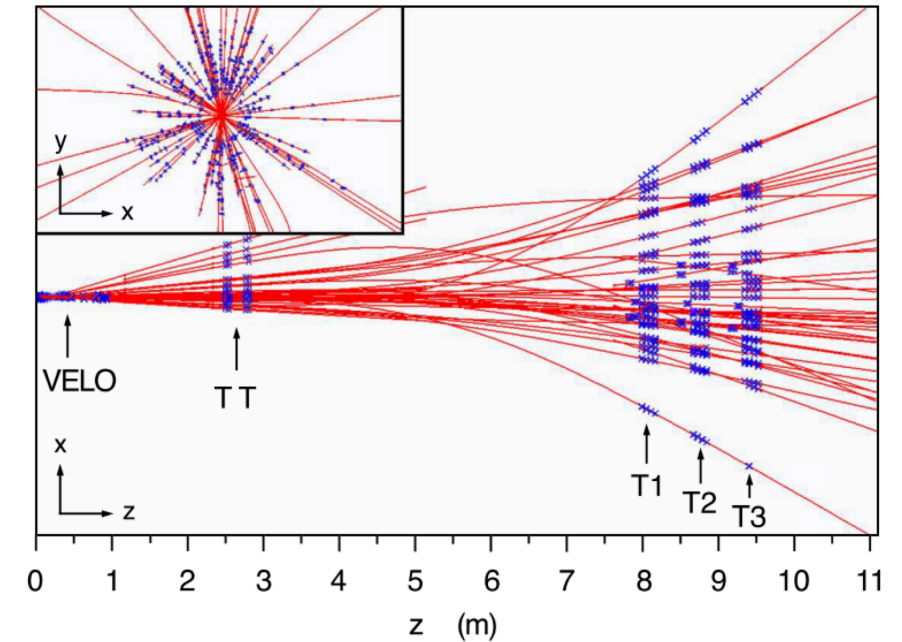
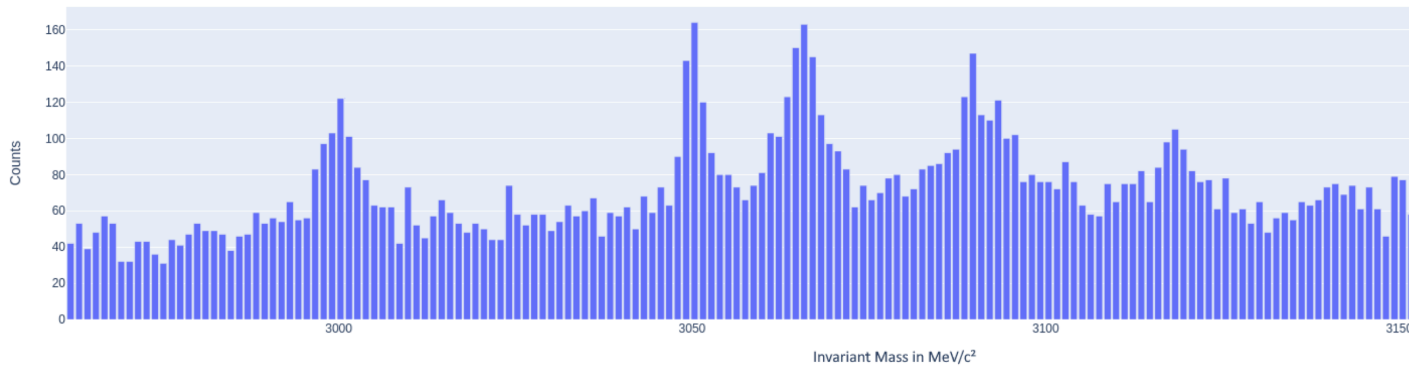
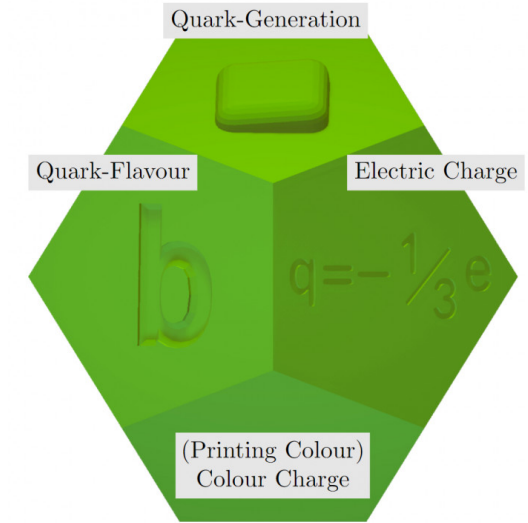
- Students search for the  $D^0 \rightarrow K\pi$  decay using an event display
- Students perform a lifetime measurement at the 1 % level
- Live merging of histograms from all groups

<https://lhcb-public.web.cern.ch/en/LHCb-outreach/masterclasses/en/>



# New LHCb MC & Quark Puzzle


- Aim at understanding the origin of matter
- Interactive elements e.g. quark puzzle
- Search for new  $\Omega_c^0$  resonances
- Concept of modern data analysis
- Classify events applying filters to the data on i.e. the impact parameter
- Look at invariant mass spectrum
- Interpret peaks and compare with official LHCb results



# Particle Therapy Masterclass

- Particle treatment planning
- highlights some of the benefits for society from the technology developed for particle physics research

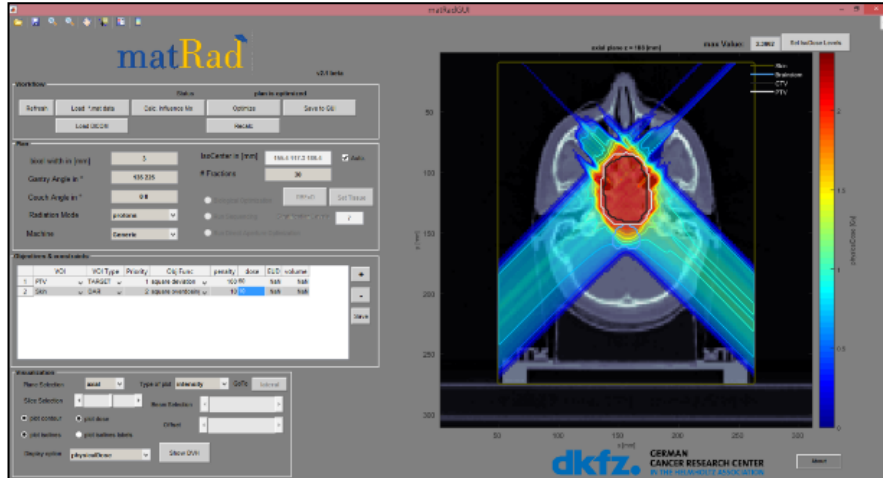
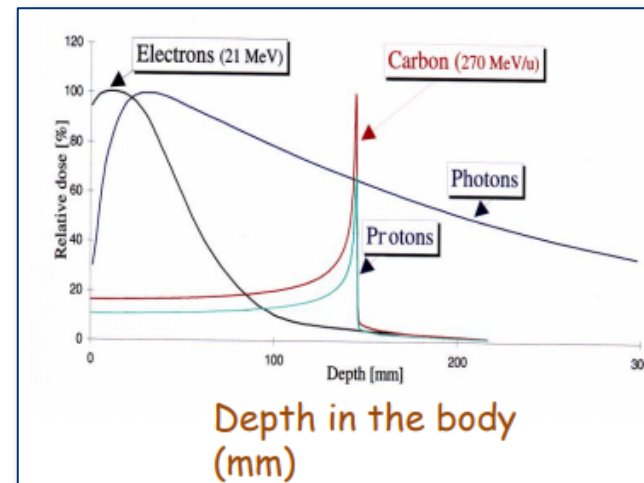
<https://indico.cern.ch/event/840212/>



Under development: Particle Therapy Masterclass (draft)

The Particle Therapy Masterclass demonstrates the direct impact of fundamental research on medical applications. This Masterclass Project allows participants to familiarise with the actual operation techniques used for cancer treatment employing x-rays, protons or carbon ions like a physical knife directed by software programs. A first dose can be given by a demo of a professional research software toolkit matRad showing the different steps for a treatment planning for cancer therapy.

The Particle Therapy Masterclass is integrated in the International Physics Masterclasses, a well-established outreach educational activity and flagship project of the International Particle Physics Outreach Group, **IPPOG**, spread around the world.

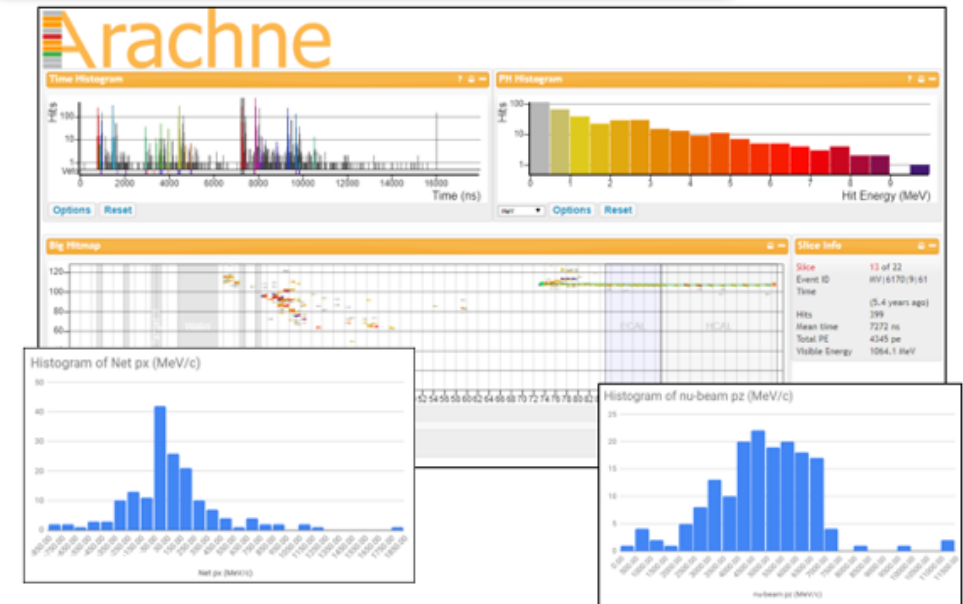
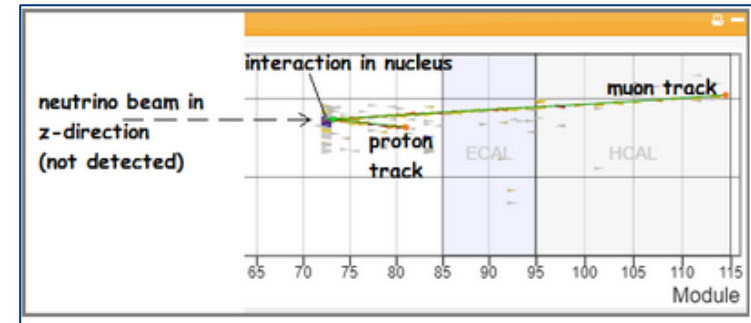
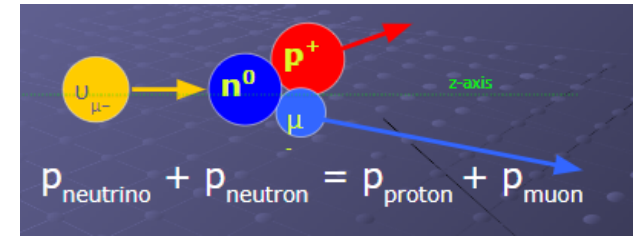


matRad software interface showing a 3D anatomical model of a head and neck with a particle beam entering the mouth. The interface includes various control panels for treatment planning parameters.

# MINERvA Masterclasses

- Measure carbon nucleus to test interaction model
- Discover Fermi motion
- Muon neutrinos interact with carbon target
- $\nu + n \rightarrow p + \mu$
- Measure  $p_x$  and  $p_y$  of proton and muon
- momentum distribution  $\rightarrow \Delta p$
- Fermi motion, nucleus is active place
- $\Delta p_x \rightarrow \Delta x \rightarrow$  bound on neutron motion  $\rightarrow$  radius of nucleus

<https://indico.fnal.gov/event/22340/>



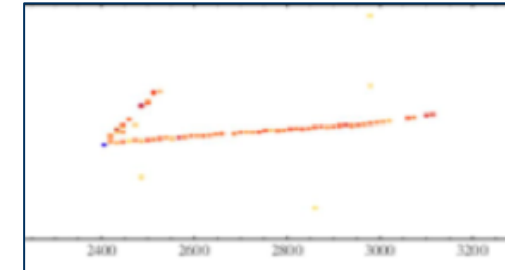
# NOvA Masterclass

- New Masterclass under development by Greg Pawlowski (QuarkNet mentor) , Mike Plucinski (Neutrino fellow), QuarkNet staff
- Find ratio of Neutral Current (NC) to Charged Current (CC) events
- Compare CC:NC in FD(Far Detector) vs in ND (Near Detector)→ evidence of oscillations
- Combine FD event display analysis (small number) with python notebook (many events from ND)
- Under development, concept tested with teachers
- Limited trial Masterclasses in IMC22

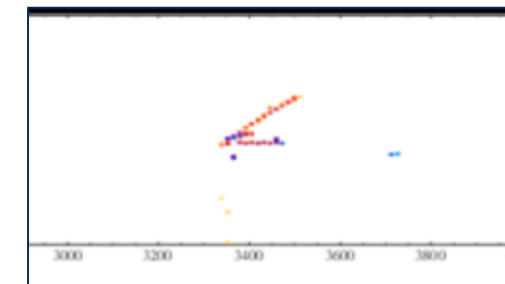
<https://quarknet.org/content/nova-masterclass-development-resources-links>



The 500-mile (800 km) subterranean path of the NOvA neutrino beam (Fermilab)



*CC event:  
muon (long)  
and proton  
(short)*

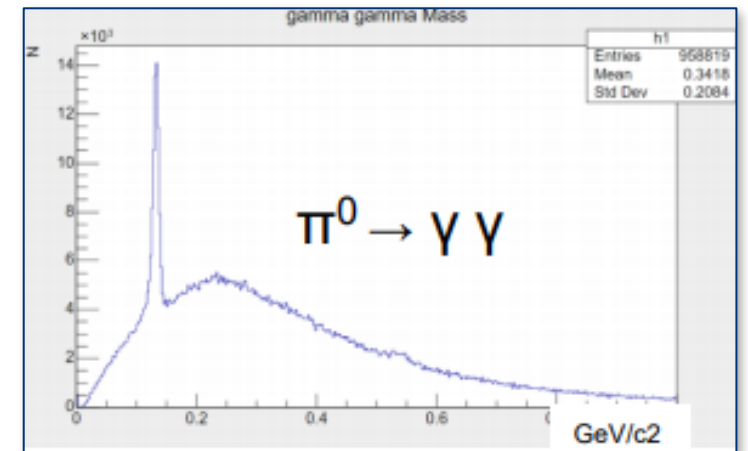
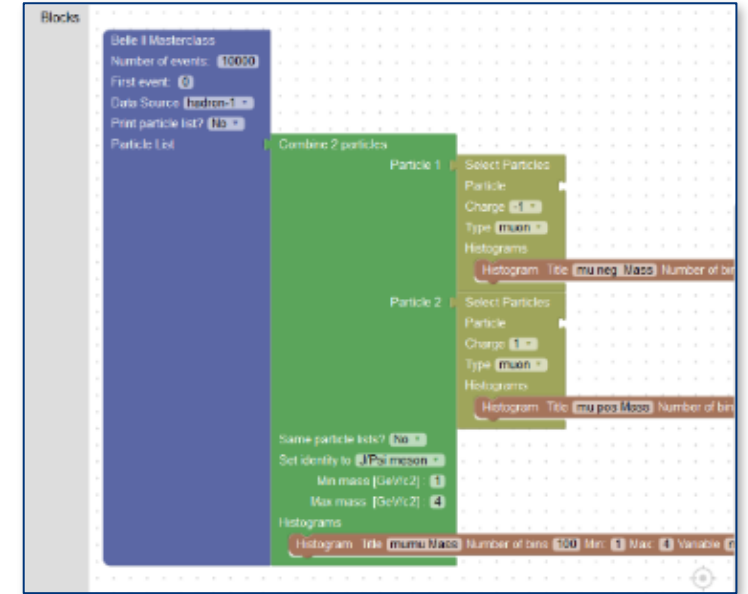
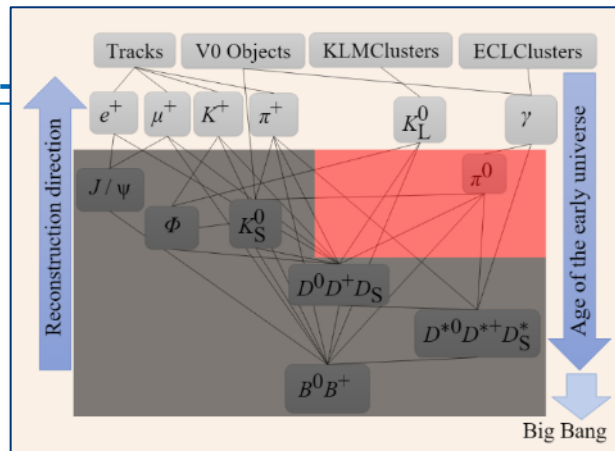


*NC event:  
short tracks,  
multiplicities*

# Belle II Masterclass „Reconstruction of B mesons“

- Shows students how to code B-physics analysis
- Students describe decays, make simple cuts, “discover” particles
- Visual code editor Blockly
- Running from the web or download virtual machine
- Analysis of 6M clean reconstructed events
- Basic/advanced level (fit peaks, determine width)
- Videoconference with KEK

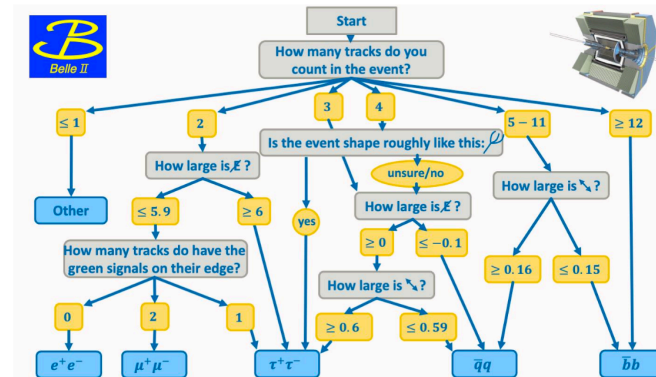
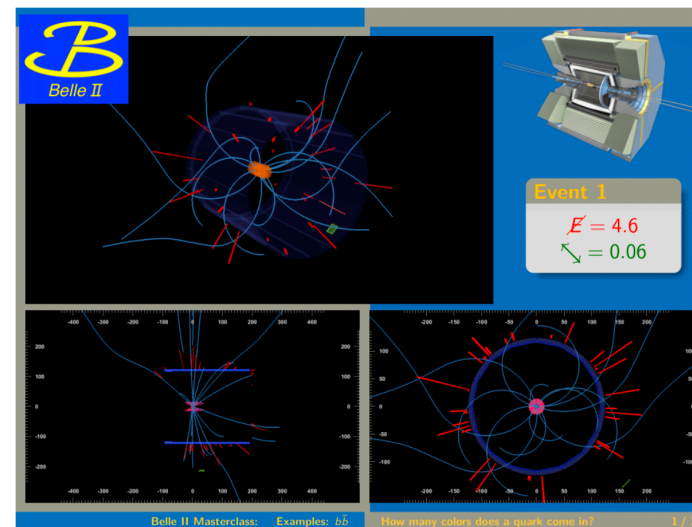
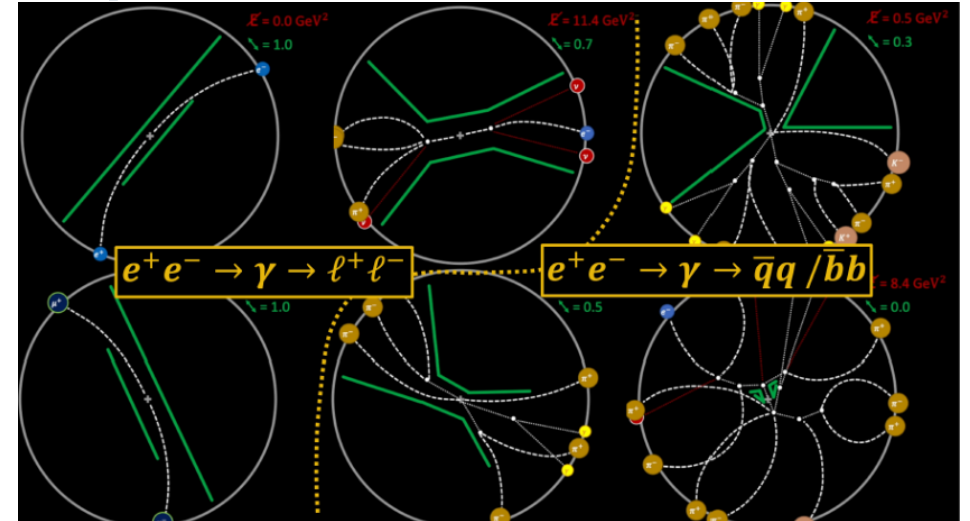
<https://belle2.ijs.si/public/home/reconstruct>



# Belle II Masterclass „How many colors does a quark come in?“

- Based on event displays
- Students classify event as  $l+l^-$  /  $qq$  /  $bb$
- Results are filled in online
- Derive  $R$ -value
- Deduce number of quark colors
- [Interactive color-combination minigame](#)
- 2 talks, work sheet, quizzes
- Available in English and German

<https://belle2.ijs.si/public/home/quark-colors/>

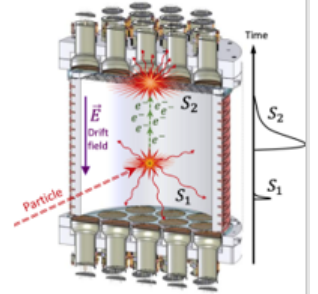


# Darkside Masterclass

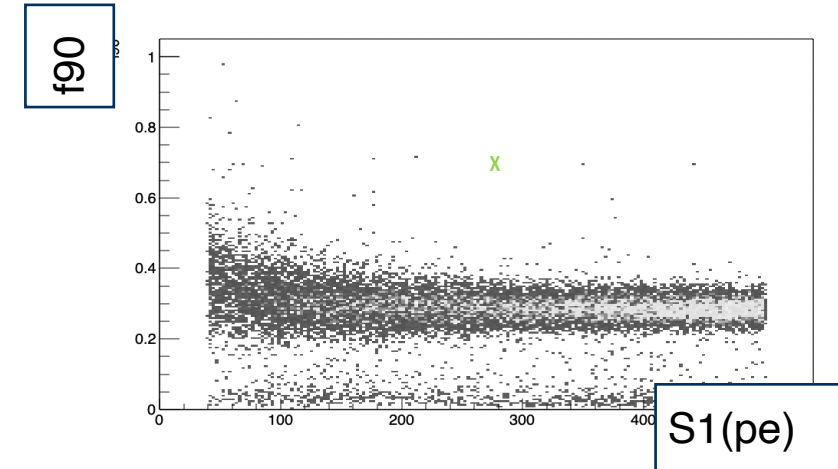
- By Francesca Carnesecchi, University and INFN of Bologna, Centro Fermi Roma, et al.
- Darkside experiment at Gran Sasso
- Dark Matter / WIMPs in a dual phase Ar TPC
- Talks on DM and Darkside experiment
- Data analysis via excel
- Reconstruction position part (few events): to exclude background signals
- Analysis of events (~20000) of background and few “good” WIMPs.
- Plot of f90 vs S1 and then apply some cuts: to select WIMPs signals
  
- <https://sites.google.com/unisa.it/darksidemasterclass/home-page>

## Darkside experiment: how to detect WIMP

- WIMP-nucleus elastic collisions revealed by a detector capable of unambiguously identifying a small number of nuclear recoils



- **Dual phase (gas + liquid) Argon TPC** for direct detection of WIMPs

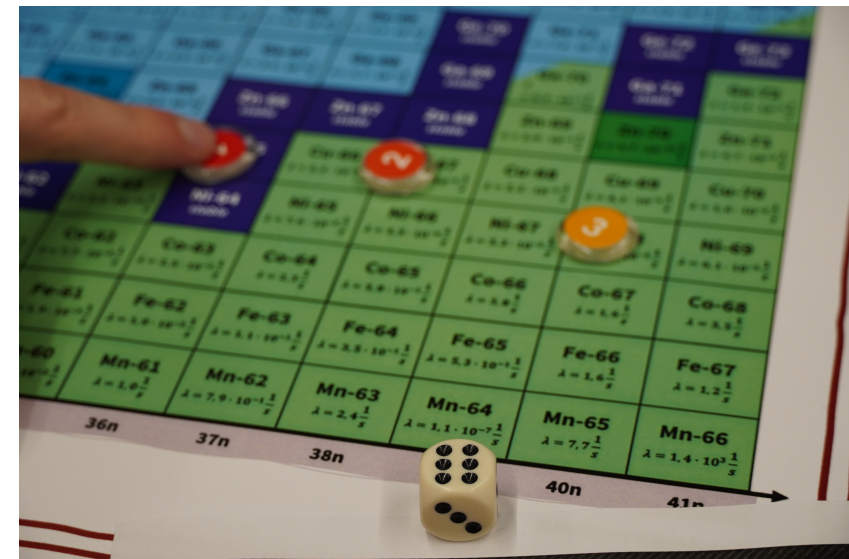




# Masterclass on Nuclear Astrophysics

- Fundamentals of nuclear physics: structure of nuclides, concept of (in)stability, nuclear reactions
- Stellar processes: The evolution of stars and their connection to nuclear reactions
- Nucleosynthesis
- Creation of light elements through nuclear fusion processes
- Formation of heavy elements through s- & r-processes
- Investigation of nuclear reactions: Insight into experimental nuclear physics, gamma spectroscopy, determination of thermonuclear reaction rates

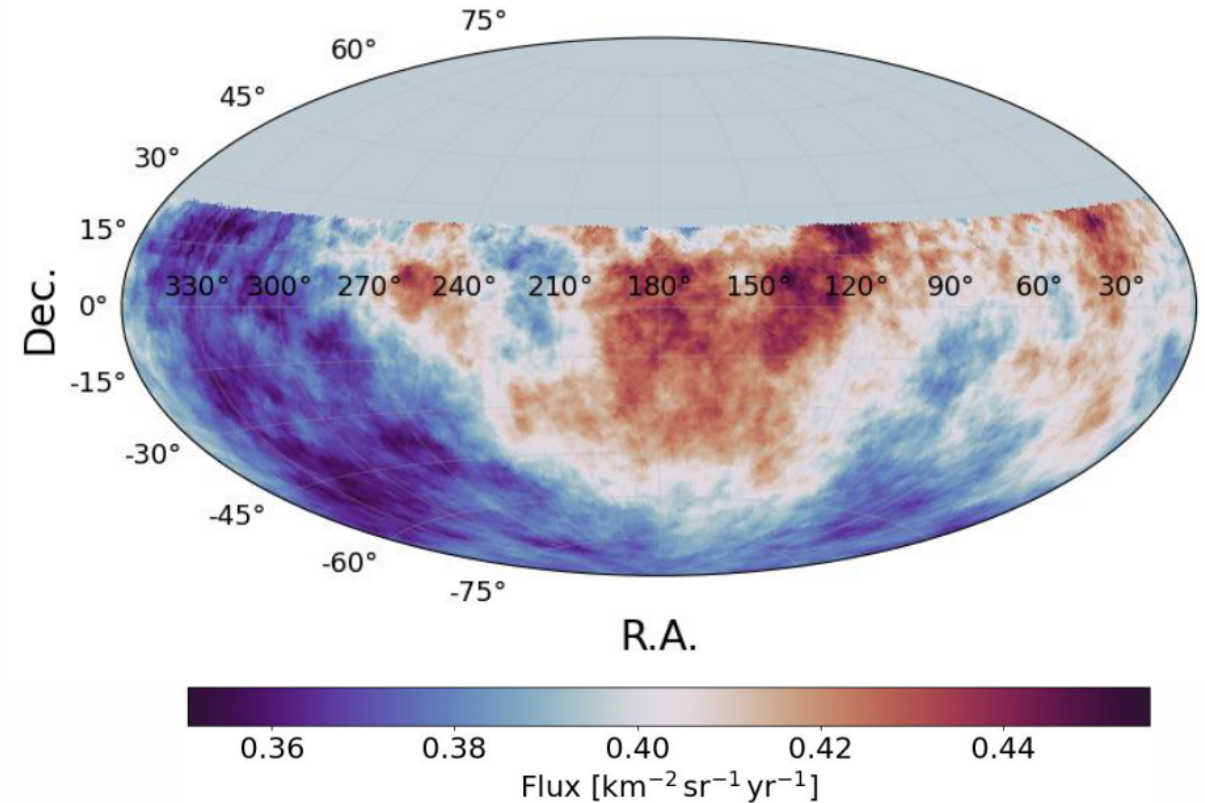
<http://mc.chetec-infra.eu/de/materials.html>



# Pierre Auger Open Data Masterclass

- Visualization of events using an interactive display of the observatory
- Separation of surface-detector stations with signal from those with background
- Visual reconstruction of the arrival direction of the primary cosmic ray
- Fitting the data to determine the energy of the primary cosmic ray
- Application of criteria to select events which point to the source
- Interpretation of sky maps in different coordinate systems

<https://augermasterclasses.lip.pt/>



# Video Conferences moderated by



© CERN



© Fermilab



# Examples for Student Research Projects

- Examples

[Deep Learning Models for Energy Estimation in CMS HGCAL L1 Trigger](#) (Felix Hansen)

[First data classification at the InGrid detector at the CAST experiment using deep learning](#) (Carolin Kohl)

[The AWAKE experiment](#) (Björn Dörschel)

[The effects of radiation on the CMS pixel detector](#) (Katharina Ploog)

[Machine-learning based identification of highly collimated electron pairs from boosted Z boson decays](#) (Sophia Veneris)

- Facilitators can participate in supervision
- Possible to pay fee



# Taxation of Fees

- None of the NTW activities are subject to compulsory insurance or employee relationships (like SHK jobs) → No social security contributions or taxes paid by TU Dresden
- Paid **fees** count as "Übungsleiterpauschale" and **are tax free up to in total 3000€/year since 2021**
- Nonetheless it counts as **income from independent work and has to be indicated as such in your tax declaration**
- <https://wiki.teilchenwelt.de/index.php?title=Honorare>