KSETA Doktorandenschule

Durbach, 23.02.2016

Particle physics outreach - telling (young) people what our work is all about

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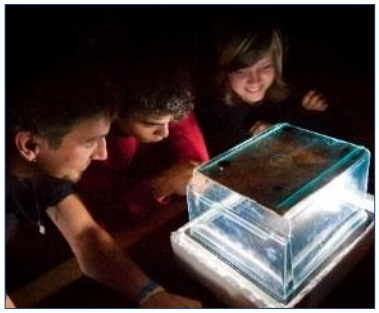
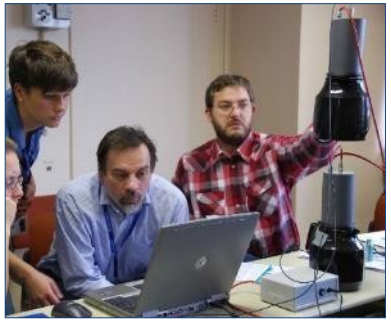
NETZWERK TEILCHENWELT

1. Motivation and Goals for public outreach

2. Content Ideas for outreach activities

3. Activities in the Netzwerk Teilchenwelt





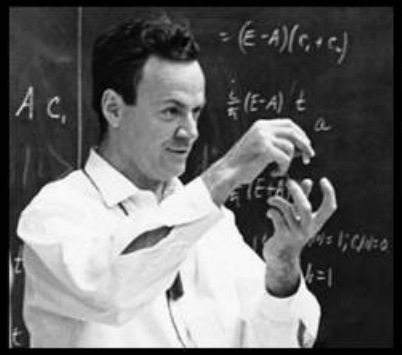
Physicist

What kids think I do

What my wife thinks I do

What society thinks I do

What I thought I would do



What I think I do

What I actually I do

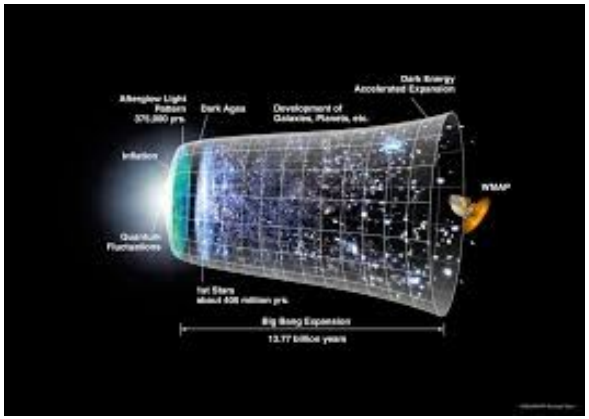
https://manyworldstheory.files.wordpress.com/2012/11/physics2.jpg

Motivation for Outreach

Spread the word:
Inspiring potential future physicists

Raise awareness:
Fundamental research is for everyone: part of human culture

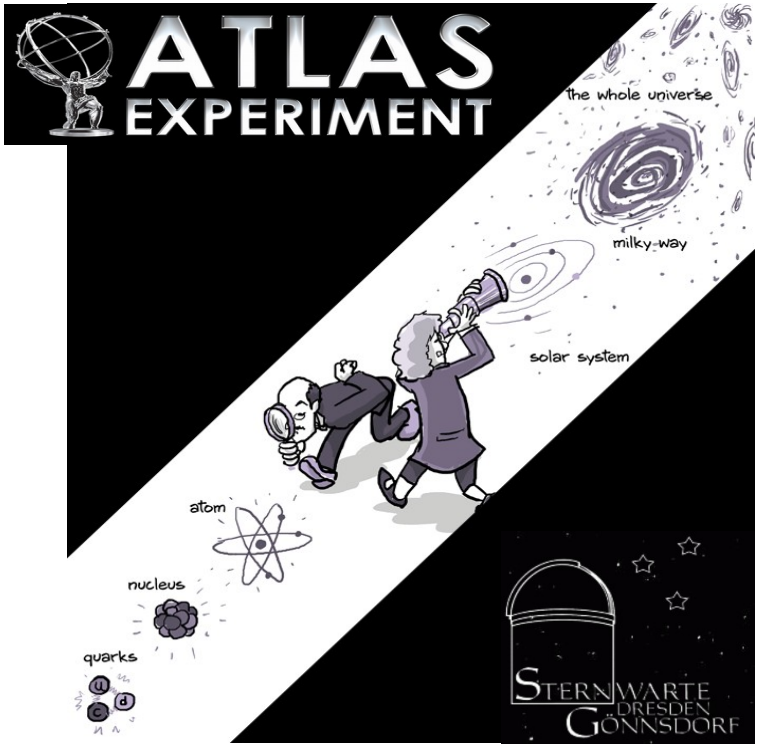
Self-Motivation:
Reminding yourself of the bigger picture

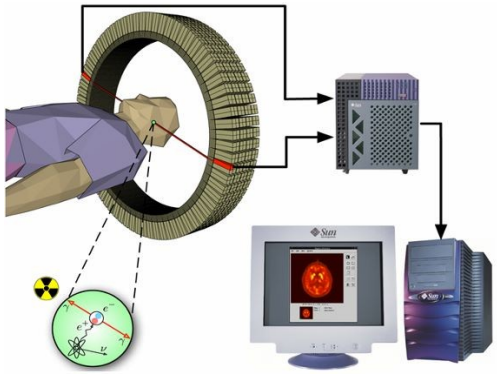


Pay back:
Society invests in science – inform the public about achievements and discoveries

Goals and challenges

- Inform without presuming any background knowledge
- Use words instead of maths
- Use analogs from everyday life
- Use models and pictures
- Parallels to
  - everyday experiences
  - more familiar fields
  - previous knowledge



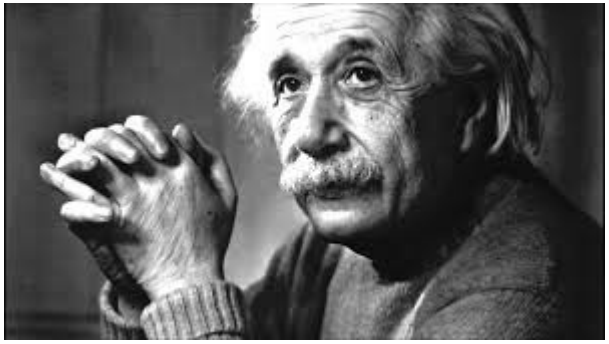


Content Ideas

→ what do you find exciting about your work?



- Explain the meaning of results
- Teach scientific methods
- Talk about life as a physicist
- …



Some examples from LHC experiments, astroparticle/cosmology community are given in this talk

… → your idea next?

Meaning of physics findings

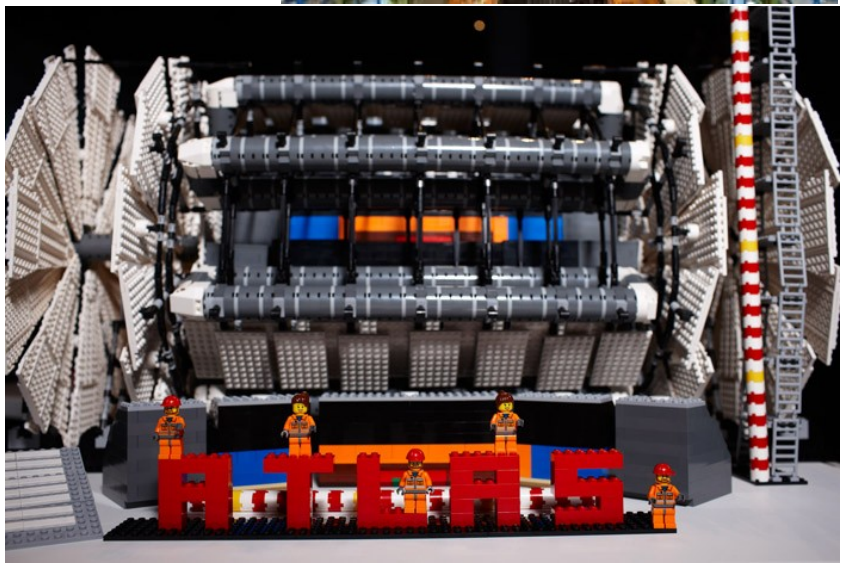
- Explain the meaning of results
  - Which questions does it answer, which doesn't it?
  - How does it effect everyday life?

- What does it imply for our view of the world?

- How does it integrate with other results?

→ Scientific knowledge is part of cultural endevour
→ Knowledge transfer belongs to basic research like technology transfer to applied research

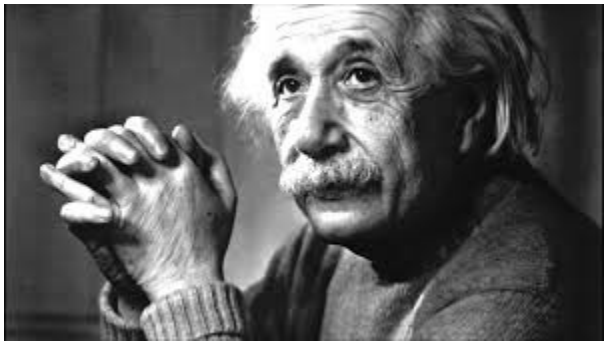
Scientific method(s)



- Helps to explain how new discoveries are made
- Emphasis on
  - Experimental efforts
  - Statistical scrutiny
  - Interpretation
- Interplay between theory and experiment

Life as physicists

- Clear up common misconceptions (⟶ reach students)
- Potential point of contact
- In Particle Physics especially:
  large, international collaborations



vs.

Potential audiences/occasions

- High School Students
- Public talk (e.g. at university, community setting, …)
  = large audience
- Science event (exhibition, open lab, "long night of science", …)
  = personal conversations
- Your friends and family

Netzwerk Teilchenwelt

- Multi-level program for
  - high school students, aged 15-19
  - teachers/trainers
- at schools, school labs, science centers…
  - 170 – 200 events p.a.
- 26 research labs + CERN
- central organization: TU Dresden
- Bringing data from LHC experiments and from astroparticle physics to schools
  - Since 2010: ATLAS and CMS
  - Since 2011: ALICE, CosMO and Kamiokanne
  - Since 2013: LHCb
  - Since 2014: Auger MC (own development)
  - Since 2014: participation in IceCube MC

The Concept

High school students and teachers are „scientists for one day“

- as close as possible to current research
  - experience how scientists explore nature
- own „hands-on“ activities
  - Hear ⟶ forget // see ⟶ remember // do ⟶ understand

Get insight into scientific research process

- use the same tools and methods like scientists
- theory & experiment
- direct contact with (young) physicists

- stimulate students´ interest in physics
- raise fascination for particle physics
- understand fundamental research as fundamental knowledge for society

Four Levels of Activities

Research Projects

CERN

Qualification

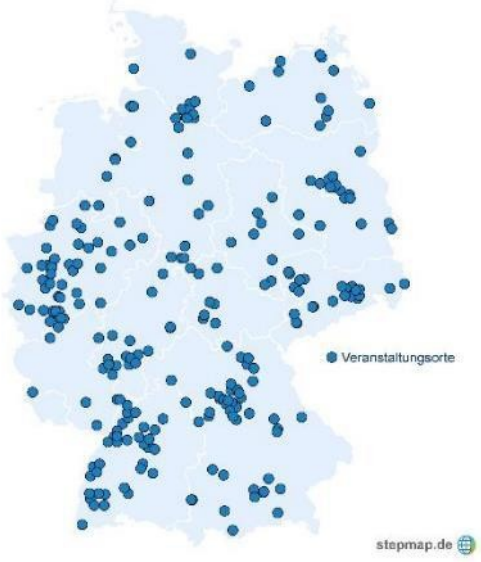
Basic

Students

Teachers

Particle physics Masterclasses

- 1 day in schools, also school labs, exhibitions (~120 p.a.)
- Facilitators = PhD students
- Agenda:
  - Introductory talk (Standard Model, accelerators, detectors)
  - Measurement with LHC data using event displays (ATLAS, CMS, ALICE, LHCb)
- Tasks: identify events, create histograms, data quality investigation
- Possible also for teachers



Example: Analysis with real LHC data

www.physicsmasterclasses.org/index.php?cat=physics

ATLAS
- W path (W^+/W^- + H⟶WW)
- Z path (Z, Z', …)

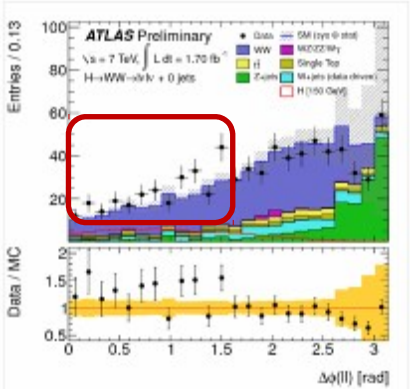
CMS
- J/Ψ data quality
- W,Z,H analysis

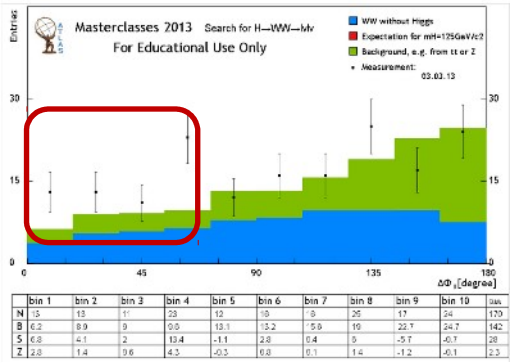
ALICE
- Strange Particles
- Modification Factor R_{AA}

LHCb
- Charm lifetime

TOTEM (to come)
- pp diffraction pattern

- Rich spectrum of tasks
  - Check data quality
  - Event displays, identify particles
  - Histograms (mass, angles)
  - Draw conclusions
- Freely accessible for education purposes
- Continuously following research progress
  - 2012: simulated Higgs events
  - 2013: real Higgs candidates

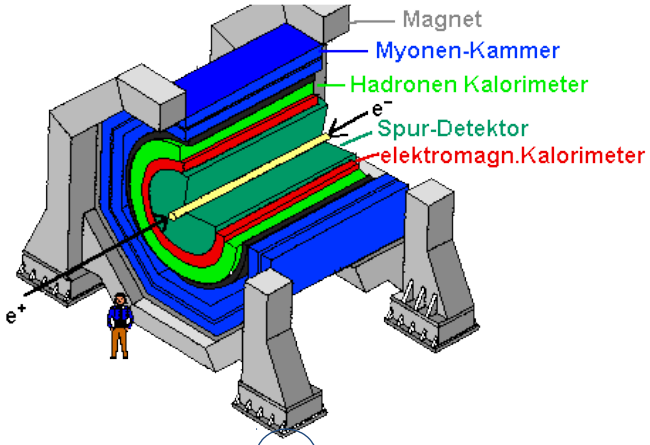




Masterclass with ATLAS data: W path

http://atlas.physicsmasterclasses.org/en/wpath.htm

1



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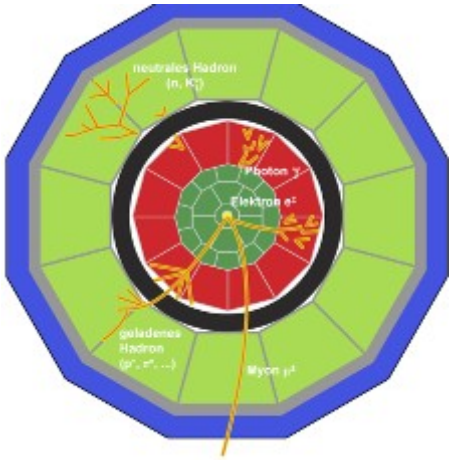

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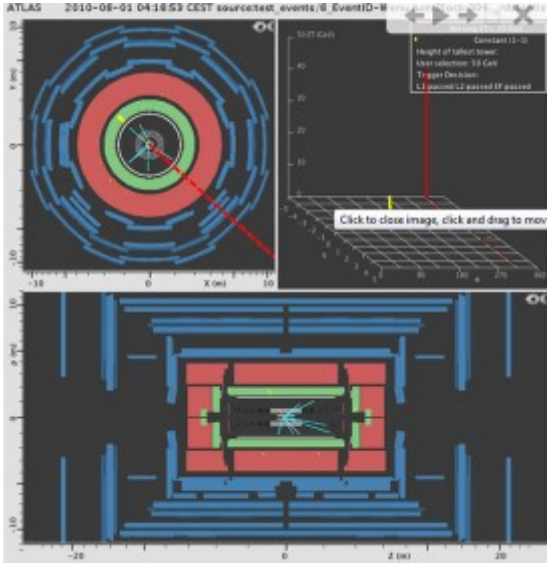

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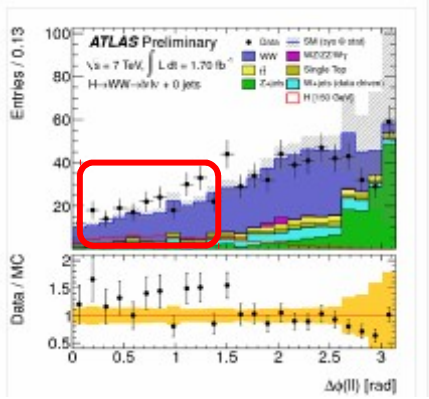
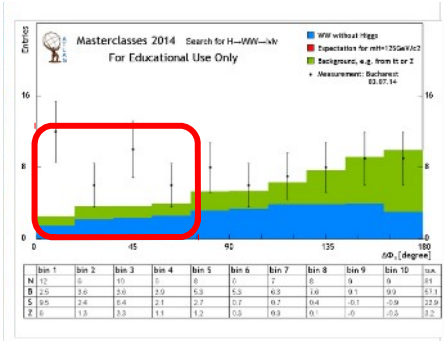




Higgs signal accumulates at small angles

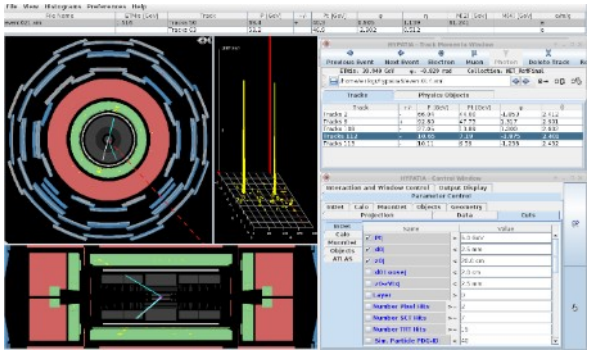
decay of W bosons ⟶ structure ot the proton

Masterclass with ATLAS data: Z path

http://atlas.physicsmasterclasses.org/en/zpath.htm

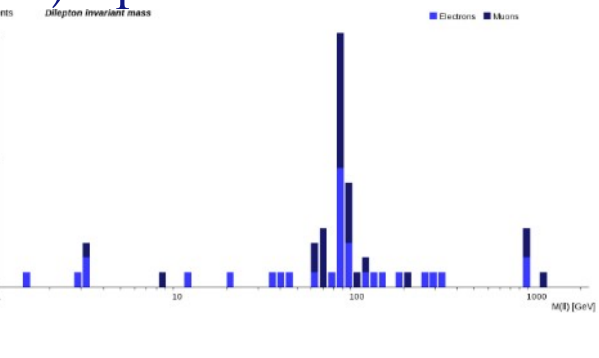
1) Identify events:

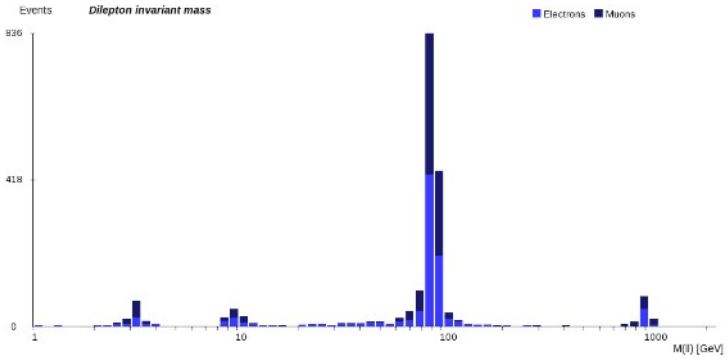
ll, 4l, γγ

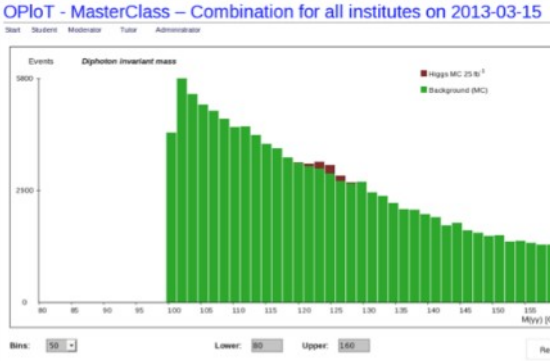


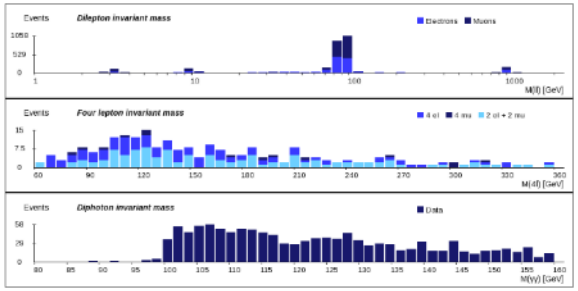
2) Calculate invariant mass

3) Upload results









– Measure mass and width of known particles: Z^0,J/y,U

→ Search for new force / new gauge boson: Z‘

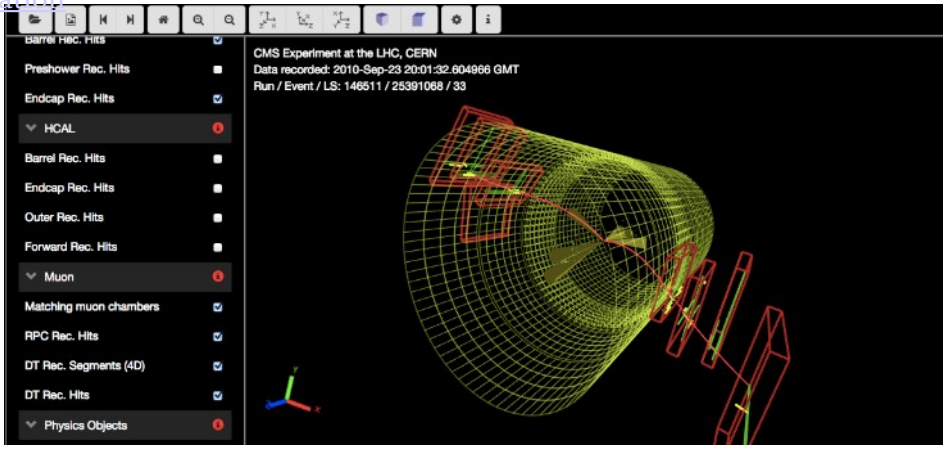
– Provide insight into the process of discovering the Higgs at CERN

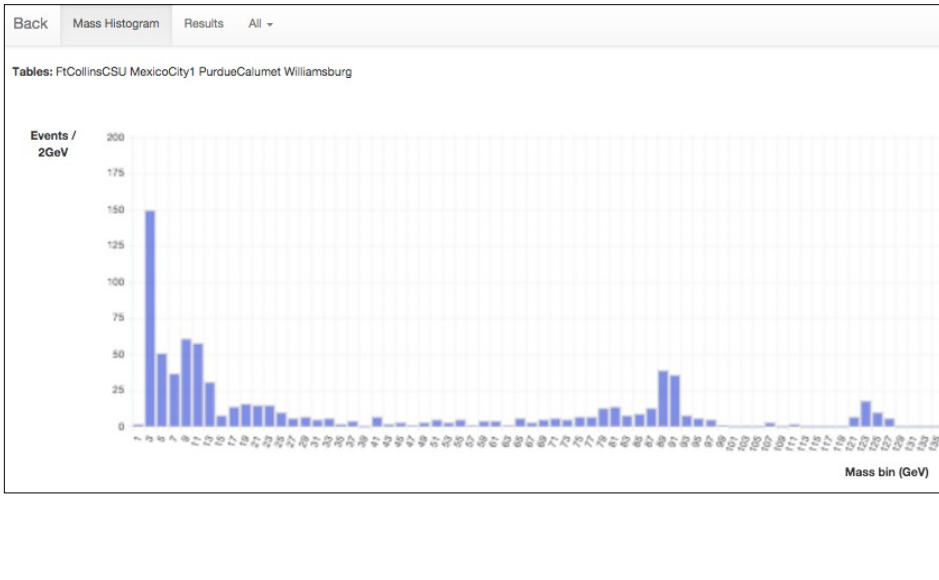
→ Explain concepts of statistics, modeling, signal significance

Masterclass with CMS data: W, Z, H measurements

https://quarknet.i2u2.org/page/cms-masterclass-2016-documentation

- 3D event display
- Students characterize W, Z, and Higgs candidates
- Create mass plot of standard model particles that decay into 2 leptons, plus Higgs
- Ratios W+/W-, e/m
- 3000 events – with misfits, surprises, interpretation





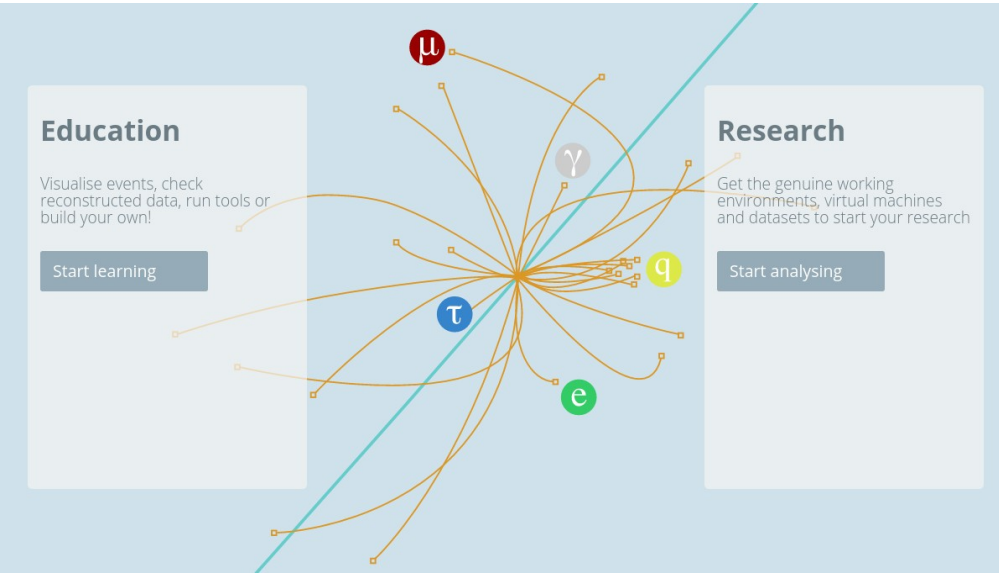
CERN Open Data Portal

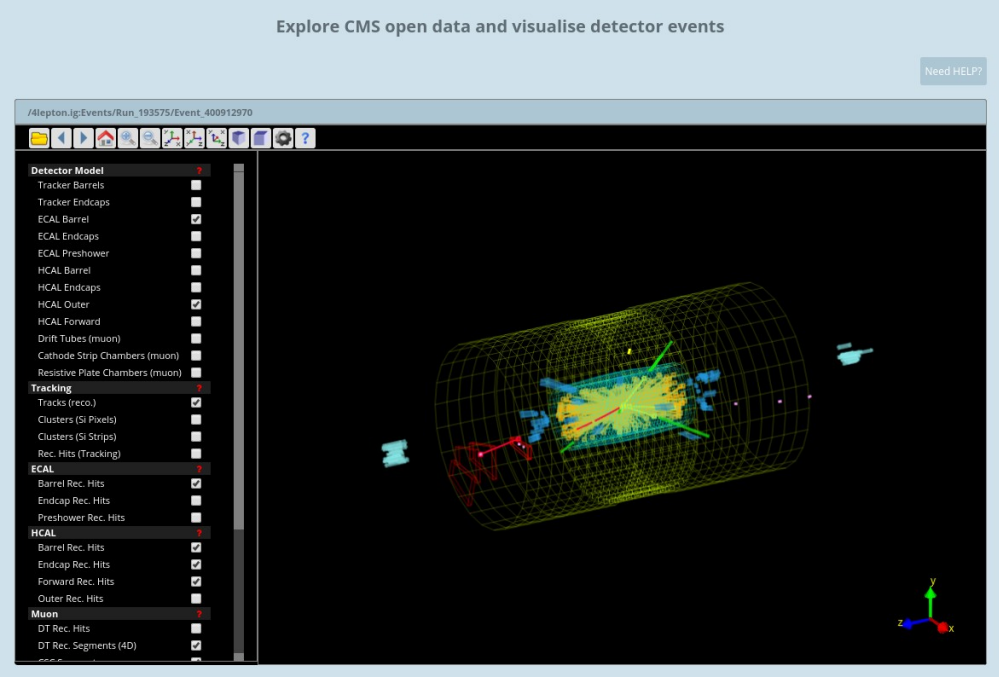
Goal: Provide access to LHC data to the public for training and outreach exercises
→ Share data AND analysis tools (CernVM)

Education:
Links to Masterclasses and other (existing) outreach material (e.g. ATLAS Higgs Machine Learning challenge, CMS online analysis tool VISPA, CMS e-Lab)

Research:
(CMS only) Datasets with tools and instructions for analysis

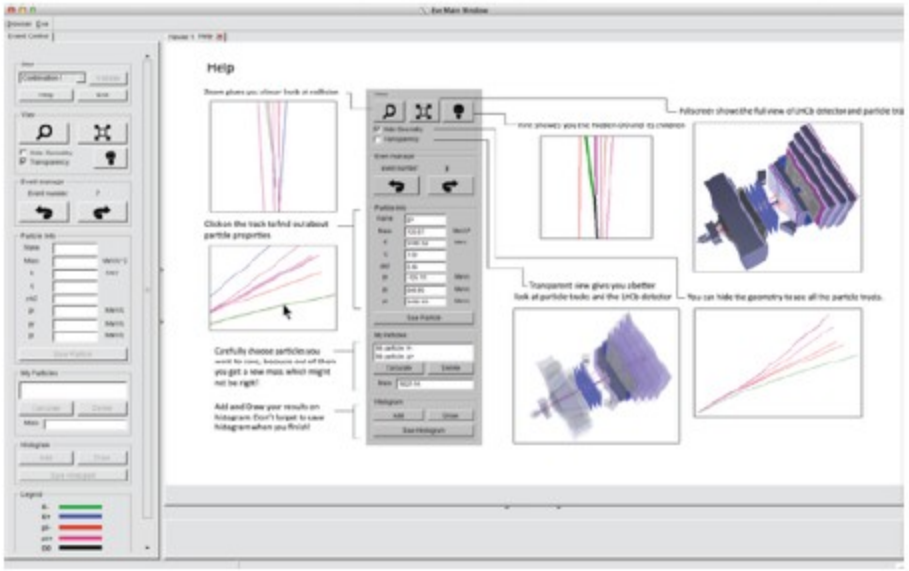
… work in progress …

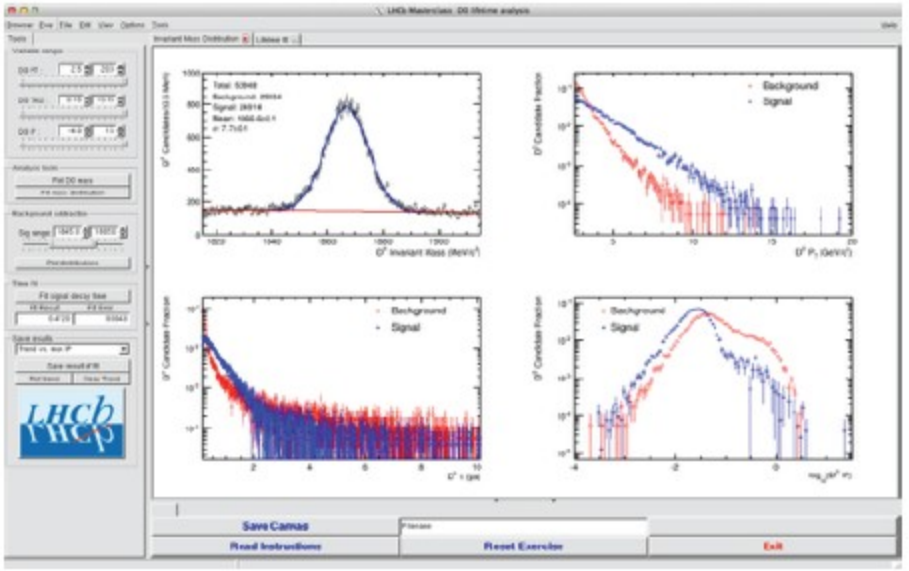




LHCb

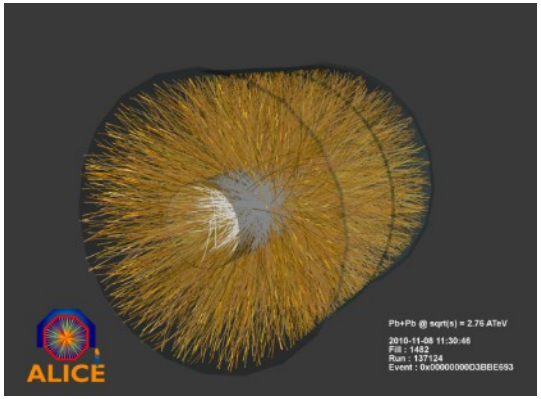
- LHCb student experience with > 20 institutes involved, EU and US for 2015/16
- Students search for $D^0 \rightarrow K\pi$ decay using an event display
- And perform a lifetime measurement at the 1% level

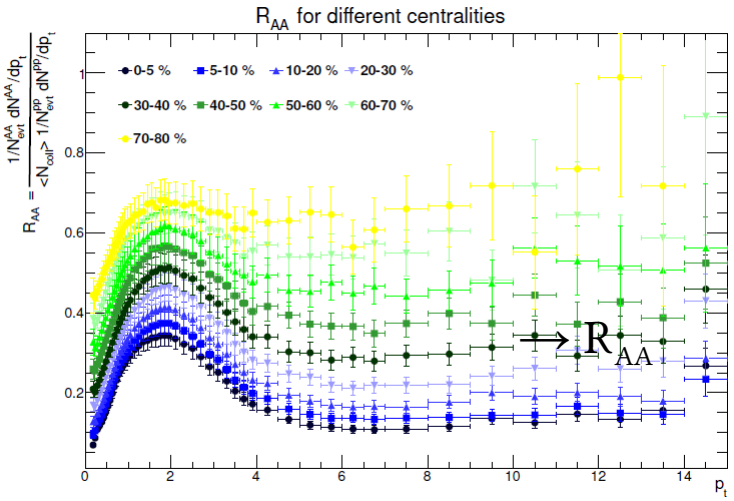




ALICE: nuclear modification factor

- ALICE: heavy-ion experiment at the LHC
  - study properties of deconfined matter: the Quark-Gluon Plasma
  - Pb-Pb collision ≠ independent pp collisions
- nuclear modification factor R_{AA}: $R_{AA} = \frac{Y(PbPb)}{N_{coll}\,Y(pp)}$
  - ratio of transverse-momentum distributions of charged particles in Pb-Pb and pp collisions, taking into account the collision geometry
  - R_{AA}<1 implies jet suppression in the QGP
- students‘ measurement
  - necessary concepts: measurement of
    - charged particle momentum
    - collision centrality
  - event-display based visual analysis simply via counting of tracks
  - ROOT based large scale analysis





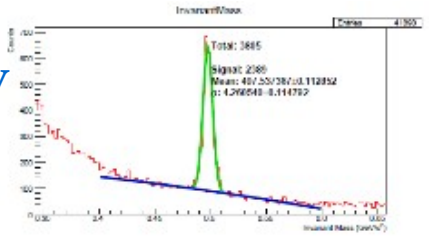
→ R_{AA} as a function of momentum in various Pb-Pb centrality classes

→ students discover jet suppression!

ALICE: Looking for strange particles

$K^0_s \rightarrow \pi^+\pi^-$ $\Lambda \rightarrow \pi^-p^+$ anti $\Lambda \rightarrow p^-\pi^+$

- Search for strange particles from their V0-decays
- Visual identification of V0s from their decay pattern & invariant mass calculation
- First part: → **ROOT-based simplified ALICE event display** visual analysis of ~ 15 events per group, merging of results

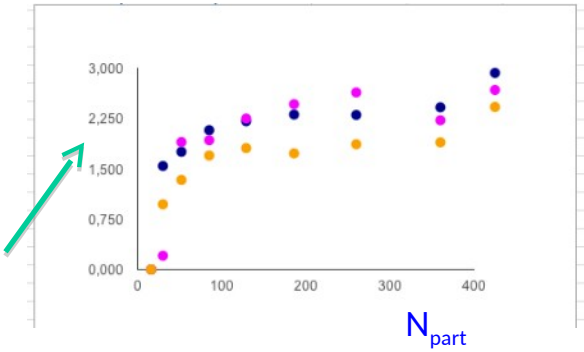


- Second part:
  Calculation of numbers of Ks, Λ , anti Λ from invariant mass distributions for different centrality regions in lead-lead collisions

- Concepts conveyed : invariant mass; centrality of PbPb collisions; background

- Results : observe strangeness enhancement in Pb-Pb collisions comparing with pp collisions

- Strangeness enhancement: the particle yield normalised by the number of participating nucleons in the collision N_{part}, and divided by the yield in proton-proton collisions



Astroparticle Projects in Netzwerk Teilchenwelt

Scintillator experiment „CosMo“ and „Kamiokanne“

- loan to schools (after teachers training)
- Variety of measurements:
  - angular distribution
  - coincidence
  - muon lifetime (2 signals within 20 µs)
  - study particle showers

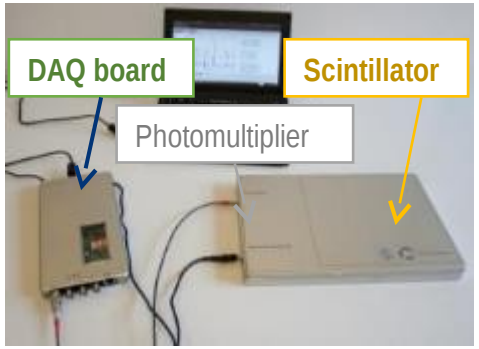
Cloud chamber sets

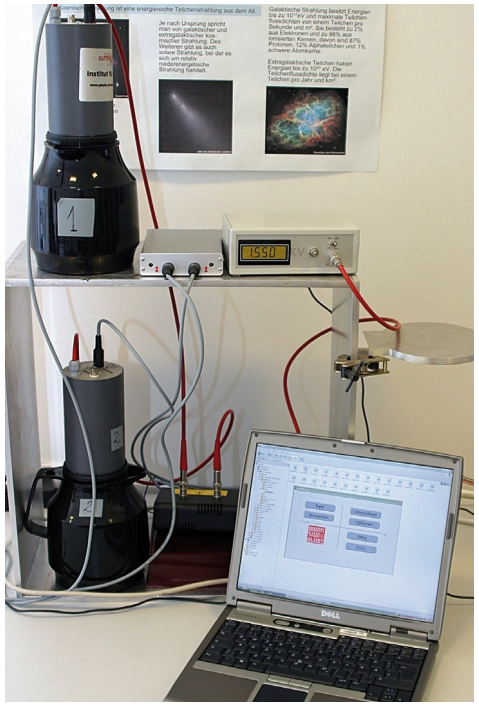
Web experiments

Auger data

New portal: cosmic@web at DESY 2016

International Cosmic Day





Astroparticle Physics: Turn your phone into a cosmic ray detector

App for detection of ultra-high energy cosmic rays

- Rare events
- Large radii
  ⟶ Proof of concept for using smart phones for detection arXiv:1410.2895/ astro-ph
- Potential for outreach:
  - High sense of participation
  - Fascinating field of physics

CRAYFIS
cosmic rays found in smartphones

"Modern smartphones contain high-resolution cameras with digital sensors which are sensitive to the particles in a cosmic ray shower. They know where they are (GPS) and can upload their data (wi-fi). Most importantly, there are 1.5 billion active smartphones spread across the planet. Essentially, this detector has already been deployed; all that is missing is the app to collect the data!"

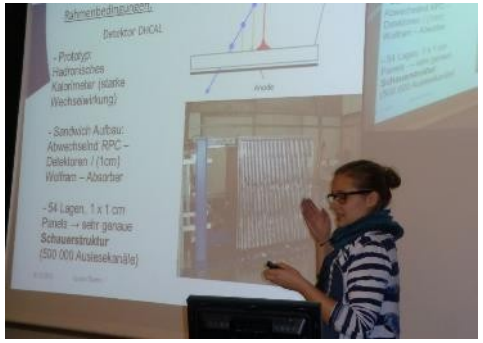
Workshops + Project Weeks at CERN

- **Students**
  - 60 s. in two annual workshops (3 days)
  - 10 s. in project weeks
  - own research projects, e.g. Medipix detector, CLOUD, ATLAS trigger system,
    lifetime B-Meson, LHC beam steering,
    ASACUSA, track finding, …
  - **Teachers**
  - 40 t. in two annual workshops (5 days)
    - big motivation for activities
    - very effective training for teachers in modern physics

Research Projects

2015 : „Untersuchungen der Fragmentationen und Entstehungsprodukte von Antiproton-Titankern-Kollisionen sowie Annihilationen in Photoplatten“ und „Untersuchungen der Teilchenproduktionen und -bahnen bei der Injektion von Antiprotonen im AD“

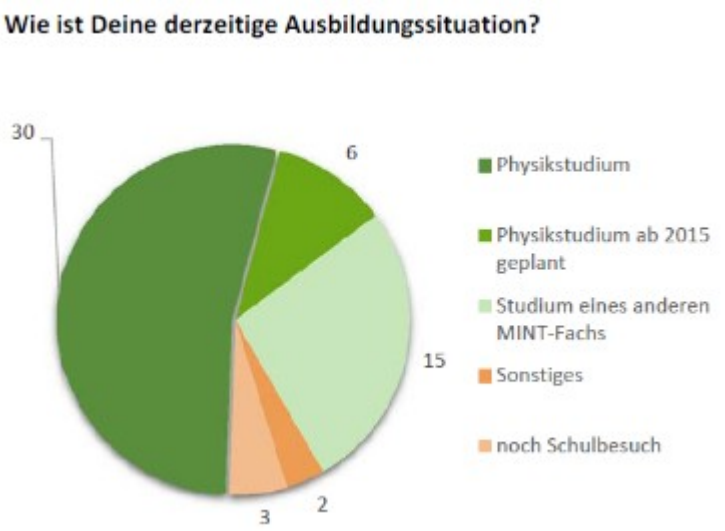
- research projects for 3 -10 months
- often part of final school examinations
- work on own measurements,
  possible continuation at project week
- tutors: PhD students/ physicists
  at universities and teachers
- Several awards (2-4 per year!)
  - „Jugend forscht“
  - Dr. Hans Riegel-Fachpreis
  - Von Ardenne Physikpreis



www.teilchenwelt.de/mitmachen/jugendliche/projekt-,%20fach-und%20forschungsarbeiten/

Student Alumni

- > 100 participants of CERN Workshop
- own activities
- yearly meeting
- evaluation in July 2014:
  - Consolidating decision to study physics: *„NTW helped me a lot in deciding to study physics. I learned how exciting physics can be, outside of school.“*
  - 2/3 studying physics



Material development

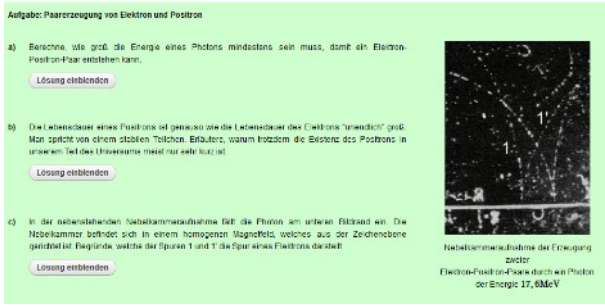
- Supporting material for facilitators and teachers
- Particle Profiles
- Background information and worksheets
- Freely available as
  - Printed versions
  - Download as pdf

www.teilchenwelt.de/material

More material development

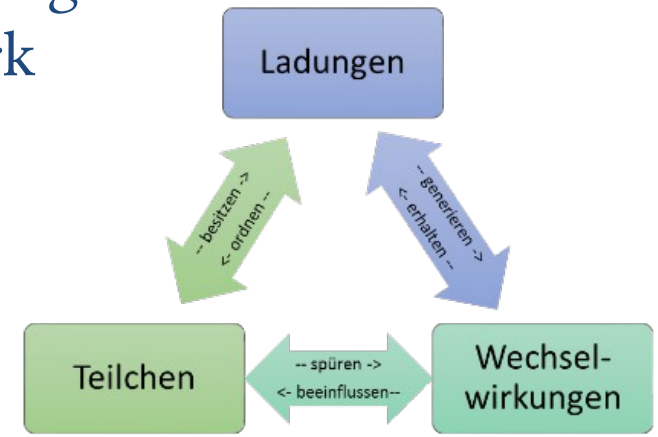
- www.LEIFIphysik.de
- Hosting Largest German Physics Portal for schools
- Netzwerk Teilchenwelt: Correction and Update of particle physics section

www.leifiphysik.de/themenbereiche/teilchenphysik



New Teaching Material

- particle physics for schools, comprising > 300 pages of texts, exercises and work sheets on:
  - Interactions, charges and particles
  - Research methods in HEP
  - Cosmic rays
  - Micro courses



- Establishing a standardized terminology
- Finalized few weeks ago, will be printed and distributed to teachers
- Training for teachers planned

More Masterclasses…

Netzwerk Teilchenwelt

- Local Masterclasses in DE
- ~ 120 Masterclasses / year
- Scientist ⟶ school
- Multi-level programme

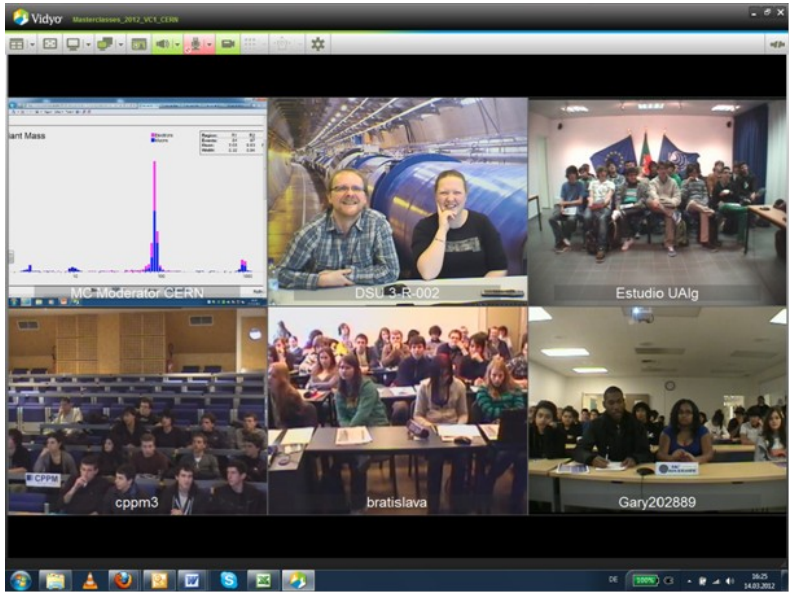
International Masterclasses

- Worldwide, 45 countries
- ~ 260 Masterclasses / year
- High school students ⟶ lab
- Video conference with CERN or Fermilab

INTERNATIONAL MASTERCLASSES
hands on particle physics

Concept of IMC

- High school students (15 – 19) are „scientists for one day“
- Get invited to a research institute or university
- Introductory talks (standard model, detectors, accelerators)
- 2 h measurement with LHC data
- International video conference (3 – 5 inst. + CERN/Fermilab)
- Students = international collaboration



International Masterclasses 2016

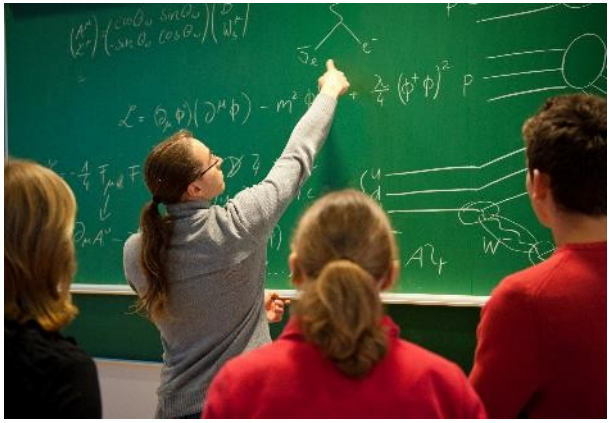
- Organized by IPPOG (*International Particle Physics Outreach Group: independent group of outreach representatives from countries at CERN*)
- 11.2. - 23.3.2016
- 45 countries involved

Coord.: QuarkNet / TU Dresden

- 42 institutes
- 48 Masterclasses
  - 35 CMS
  - 13 ATLAS
- 22 video conf. with Fermilab

- 170 institutes
- 246 Masterclasses
  - 134 ATLAS
  - 56 CMS
  - 32 LHCb
  - 24 ALICE
- 54 video conf. with CERN

How you can contribute

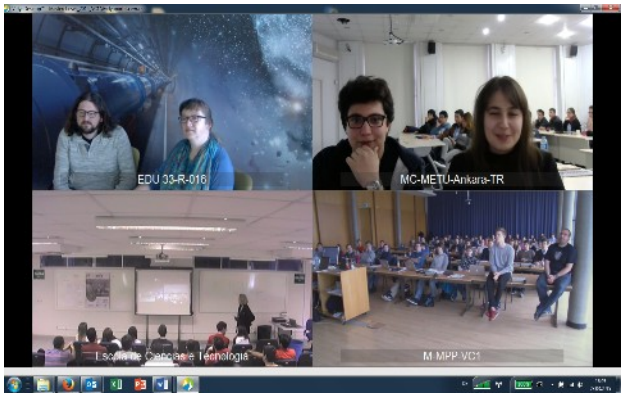


Netzwerk Teilchenwelt facilitator (Vermittler)

- Hold a Masterclass in a school
- or a cosmic ray project
- Supervisor of student´s research project

→ commitment is acknowledged with certificates (and fee)

International Masterclass tutor at your institute



Moderator at CERN

Training for facilitators

PhD students, Diploma and Master students

- facilitate Masterclasses and Cosmic Projects in schools

2,5 days workshops

- exchange of experience
- training in didactics + science communication

⟶ improve their soft skills

Benefits for all stakeholders

Students

- Inspired and fascinated by doing own measurements/research
- Meeting scientists (role model)
- Direct contact to research labs
- Alumni organisation

Teachers

- Training
- Exchange with colleagues and scientists
- Encouragement to include particle physics in school
- Material for lessons

Benefits for all stakeholders

Facilitators

- See the relevance of their work to society
- Soft skills: science communication, didactics
- Training provided (2.5 d workshop)
- Broader view: (particle – astro, theory – experiment)

Research labs

- Increased public appreciation and visibility
- Contact to future students
- Support (experiments, material, organisation, …)

www.teilchenwelt.de

www.physicsmasterclasses.org

ORGINALSCHAUPLATZ

CERN

SCHIRMHERRSCHAFT

DPG

PROJEKTLEITUNG

TECHNISCHE UNIVERSITÄT DRESDEN

GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

JOACHIM HERZ STIFTUNG

NETZWERK TEILCHENWELT