KSETA Doktorandenschule Durbach, 23.02.2016

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

Dr. Ulrike Schnoor Universität Freiburg

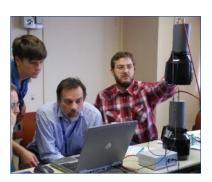


1. Motivation and Goals for public outreach

2. Content Ideas for outreach activities

3. Activities in the Netzwerk Teilchenwelt











What kids think I do

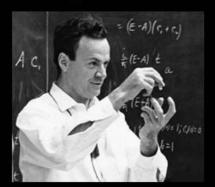
## Physicist



What my wife thinks I do



What I thought I would do



What I think I do



What society thinks I do



What I actually I do

### Motivation for Outreach

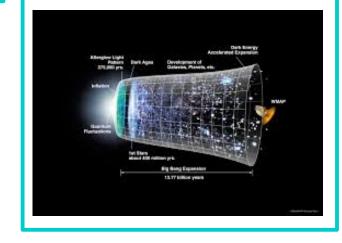
**Spread the word:** Inspiring potential future physicists



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



**Self-Motivation:** Reminding yourself of the bigger picture

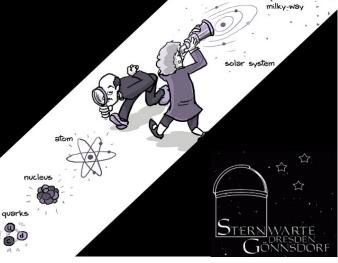


#### **Pay back:** Society invests in science – inform the public about achievements and discoveries

# 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

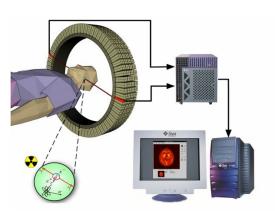




LAS

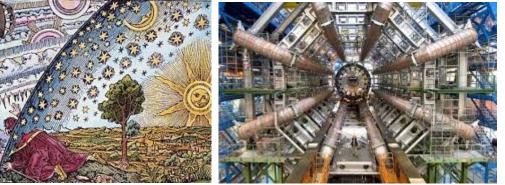
A

EXPERIMENT



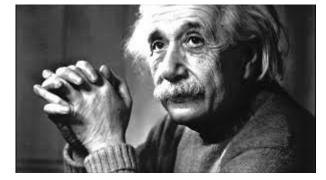
# Content Ideas

 $\rightarrow$  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  $\dots \rightarrow$  your idea next?

# Meaning of physics findings



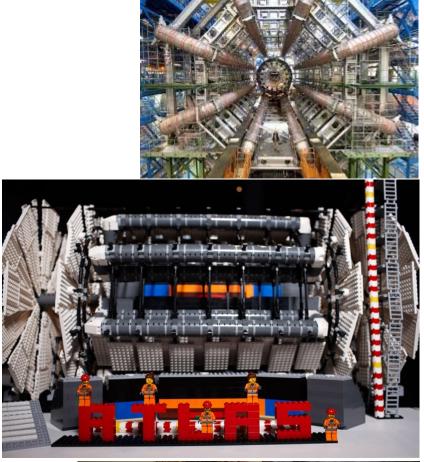
Explain the meaning of results
 Which questions does it answer, which doesn't it?
 How does it effect everyday life?

- What does it imply for our view of the world?
- How does it integrate with other results?

 $\rightarrow$  Scientific knowledge is part of cultural endevour  $\rightarrow$  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

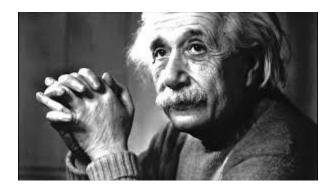




# Life as physicists



- Clear up common misconceptions ( $\rightarrow$  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







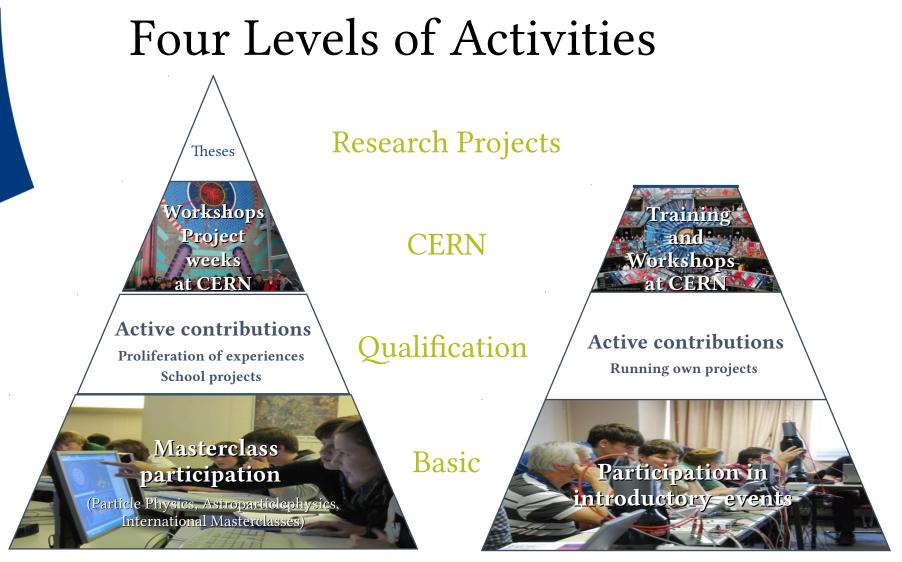
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# The Concept

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  $\rightarrow$  forget // see  $\rightarrow$  remember // do  $\rightarrow$  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



#### 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 ( $W^+/W^- + H \rightarrow WW$ )
- Z path (Z, Z', ... )



- $CMS = I/\Psi dc$ 
  - $J/\Psi$  data quality
  - W,Z,H analysis



#### ALICE

- Strange Particles
- Modification Factor  $R_{AA}$



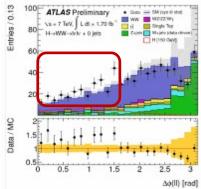
#### LHCb

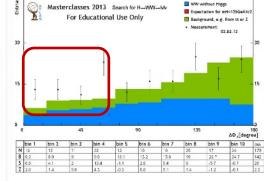
– Charm lifetime

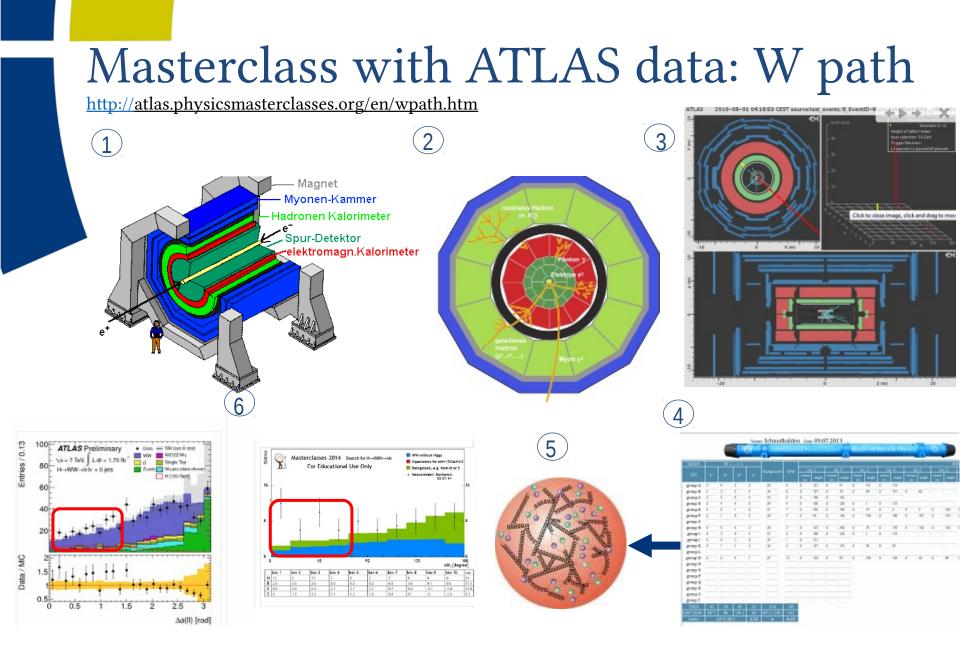


TOTEM (to come) – pp diffraction pattern

- 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





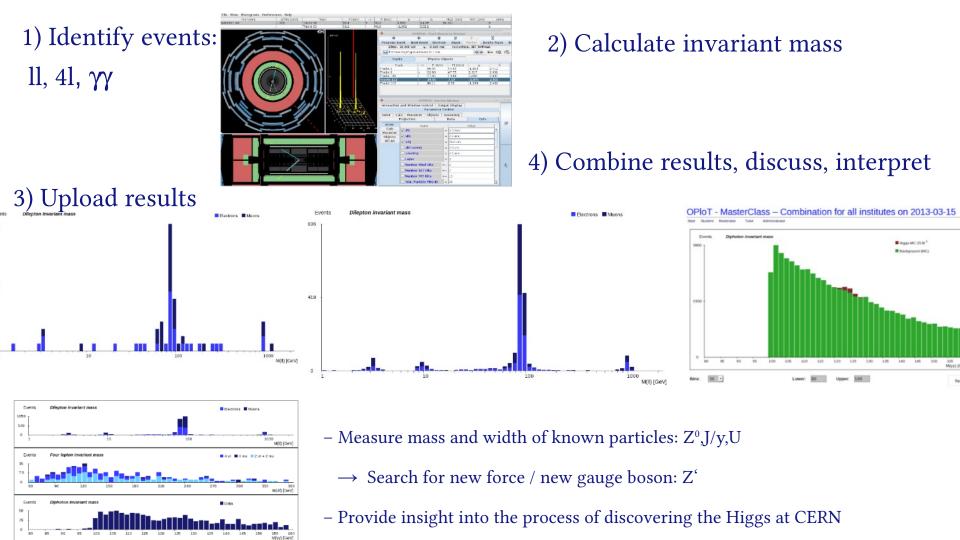


#### Higgs signal accumulates at small angles

decay of W bosons  $\rightarrow$  structure of the proton

# Masterclass with ATLAS data: Z path

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

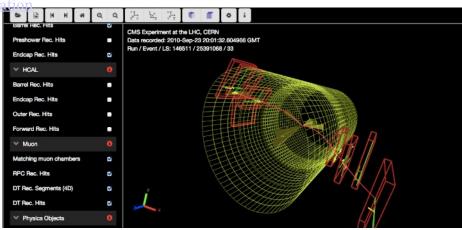


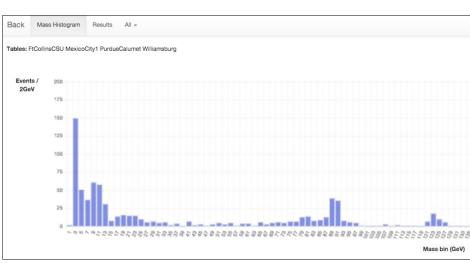
 $\rightarrow$  Explain concepts of statistics, modeling, signal significance

#### 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

 $\rightarrow$  Share data AND analysis tools (CernVM)

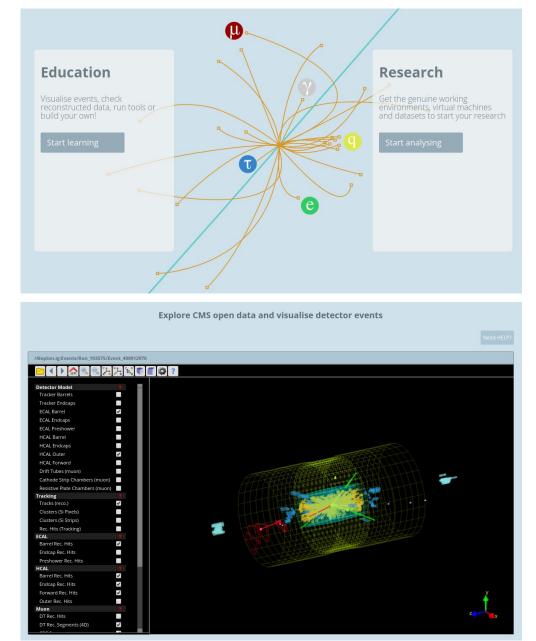
#### **Education:**

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 ...

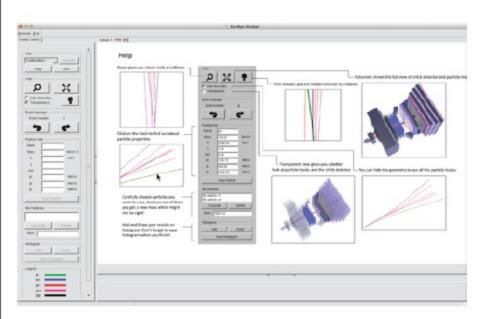


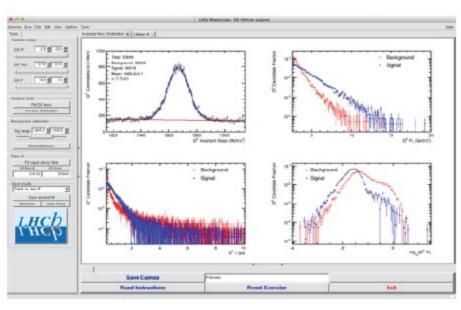
## LHCb

- 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

#### Seicento ragazzi con Masterclass



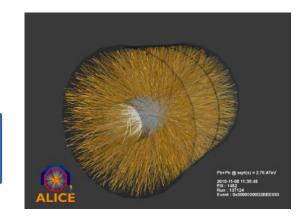


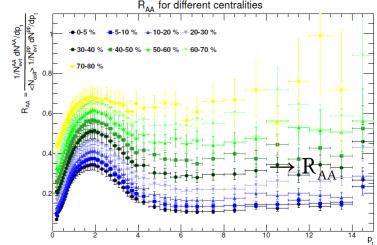


# ALICE: nuclear modification factor

- 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  $R_{AA^{:}} = \frac{Y(PbPb)}{N_{coll}Y(pp)}$ 
  - ratio of transverse-momentum distributions of charged particles in Pb-Pb and pp collisions, taking into account the collision geometry
  - R<sub>AA</sub><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  $\rightarrow R_{AA}$  as a function of momentum in various Pb-Pb centrality classes

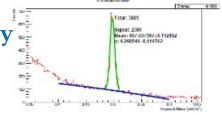
 $\rightarrow$  students discover jet suppression!





## ALICE: Looking for strange particles

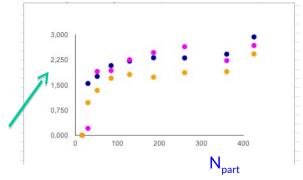
- Search for strange particles from their V0-decays
- Visual identification of V0s from their decay pattern & invariant mass calculation
- First part: → ROOT-based simplified ALICE event display visual analysis of ~ 15 events per group, merging of results



• Second part:

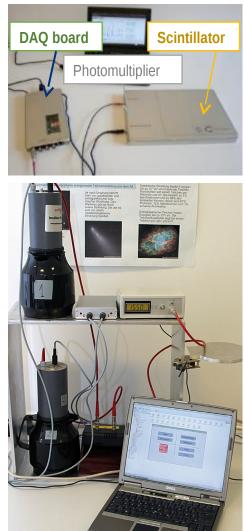
Calculation of numbers of Ks,  $\Lambda$ , anti  $\Lambda$  from invariant mass distributions for different centrality regions in lead-lead collisions

- 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<sub>part</sub>, and divided by the yield in proton-proton collisions



## Astroparticle Projects in Netzwerk Teilchenwelt

- Scintillator experiment "CosMo" and "Kamiokanne"
- Ioan 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



"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

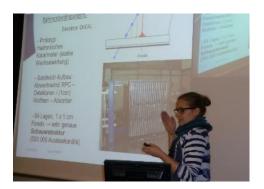








2015 : "Untersuchungen der Fragmentationen und Entstehungsprodukte von Antiproton-Titankern-Kollisionen sowie Annihilationen in Photoplatten" und "Untersuchungen der Teilchenproduktionen und -bahnen bei der Injektion von Antiprotonen im AD"



#### **Research Projects**

- 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-u nd%20forschungsarbeiten/

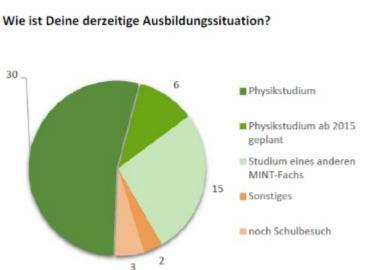


### Student Alumni

- > 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



ANWENDUNGEN DER TEILCHENPHYSIK MEDIZIN

#### Positronen-Emissions-Tomographie (PET)

Die PLT ist eine Dagnoseneetholos, mit der sich unter anderem Tunnore sichtung michen lassen. Herfür wird den Patienten eine Plassigiet gespritzt, die Postmoren ausender (ein Bicz-Pu-Sichtun), Dube handet ist sich mitst um eine spezielle Zuckerförung, in der FlachAbme durch das nachatike lostop <sup>TM</sup> ersetzt wurden (Honz-Dessoygkurse). Da Turnozellen mitrit Zucker verbrauchen als grunnde Zellen, simmt eit sich intersonderte in Turnogeweichz.

#### Tumortherapie mit Hadronen

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**Beschrottung des Preizesse** 

## More material development

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

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#### www.leifiphysik.de/themenbereiche/teilchenphysik

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#### daabe: Paarerzeugung von Elektron und Positro

Berechne, wie groß die Energie eines Photons mindestans sein muss, damb ein Elektron Position-Paar entstehe

Lósung einhienden

Die Lebenschuer eines Positions ist genauso wie die Lebenschuer des Elektrons "unendlich" croß-Nan spricht von einem stabilen Teilchen. Erläutere, warum trotzdem die Existenz des Postrons ungerem Teil des Universums meist nur sehr kurz ist

Lösung einblender

Losung einblenden

der neberalehenden Nebelkammeraufnahme fält die Photon am unleren Bildrand ein. Di Nobelkammer befindet sich in einem homogenen Magnetfeld, welches aus der Zeichenebene gerichteilist Begründe welche der Spuren 1 und 1 die Spureines Elektrons dasseit.



# 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  $\rightarrow$  school
- Multi-level programme

#### International Masterclasses

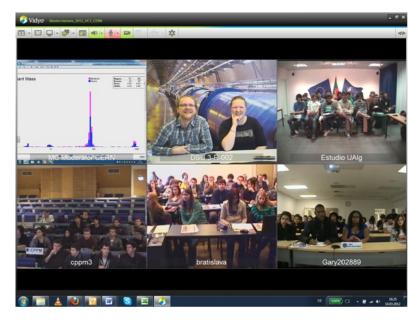
- Worldwide, 45 countries
- ~ 260 Masterclasses / year
- High school students  $\rightarrow$  lab
- Video conference with CERN or Fermilab



#### **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
- $\rightarrow$  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
- $\rightarrow$  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, ...)







ORGINALSCHAUPLATZ www.teilchenwelt.de www.physicsmasterclasses.org SCHIRMHERRSCHAFT **DPG** PROJEKTLEITUNG TECHNISCHE UNIVERSITÄT DRESDEN GEFÖRDERT VOM Bundesministerium für Bildung und Forschung JOACHIM HERZ STIFTUNG

