



TECHNISCHE  
UNIVERSITÄT  
DRESDEN

DRESDEN  
concept



Fakultät Mathematik und Naturwissenschaften, Fachrichtung Physik, Institut für Kern- und Teilchenphysik

# Particle Physics Education

## R-ECFA meeting Germany

Michael Kobel  
TU Dresden

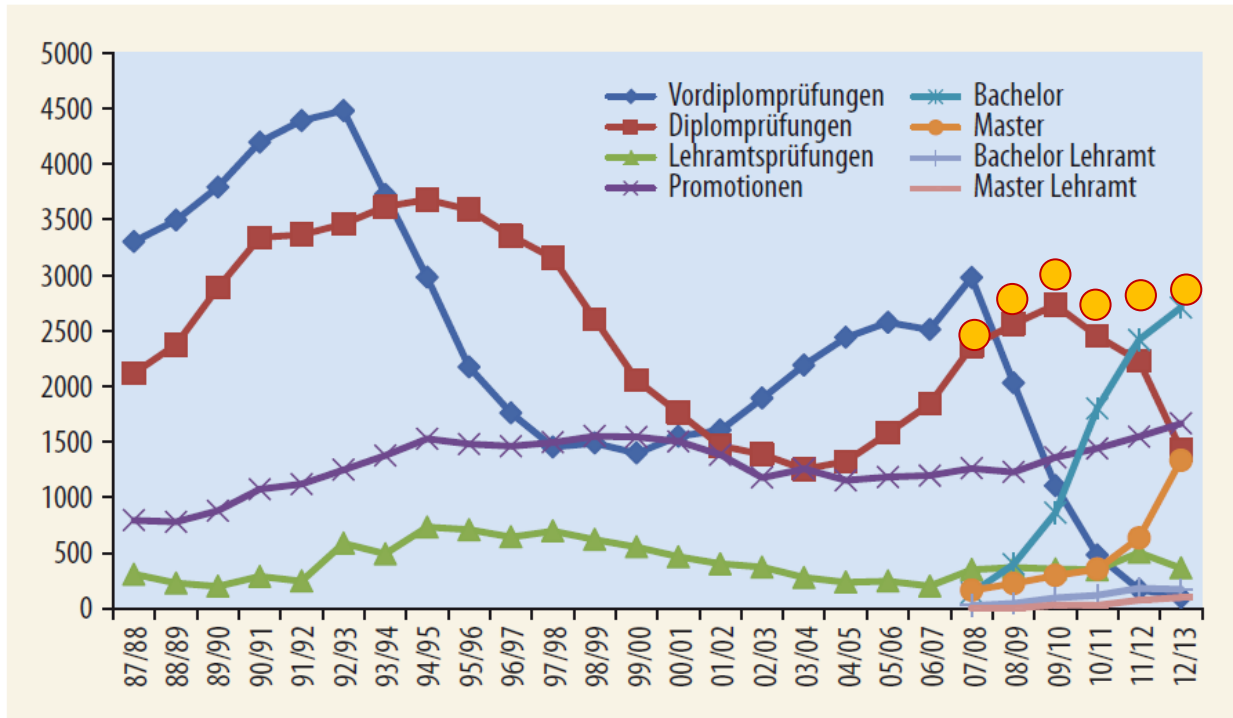
Bonn, 9. May 2014

# OUTLINE

1. Education at Universities
2. Education for high school students and teachers

## University Education in Physics

- ✓ All German Universities have moved to Bachelor / Master in **Physics**
  - Some early, some late: # Master exams just crossing over # Diploma
  - Record 2013: 1600 Ph.D. exams (foreign Ph.D. students filling fluctuations)



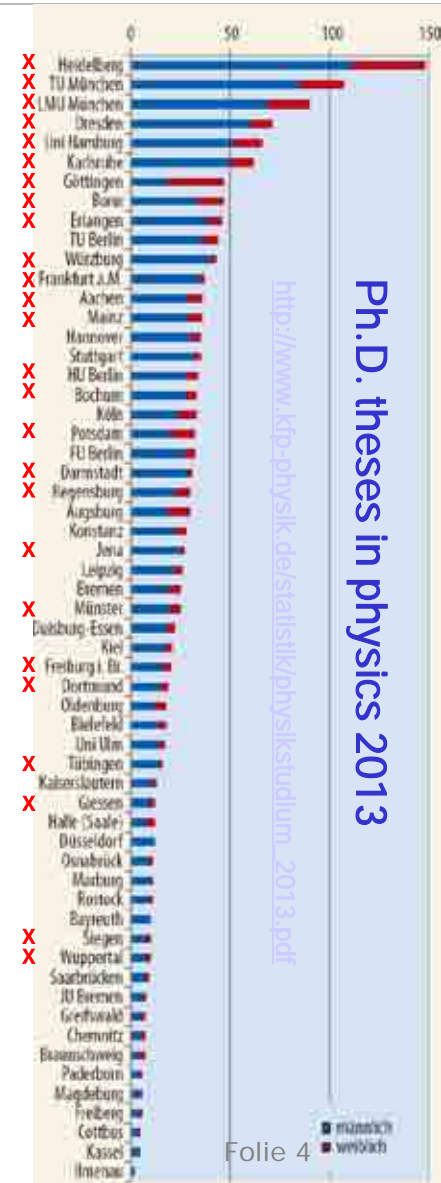
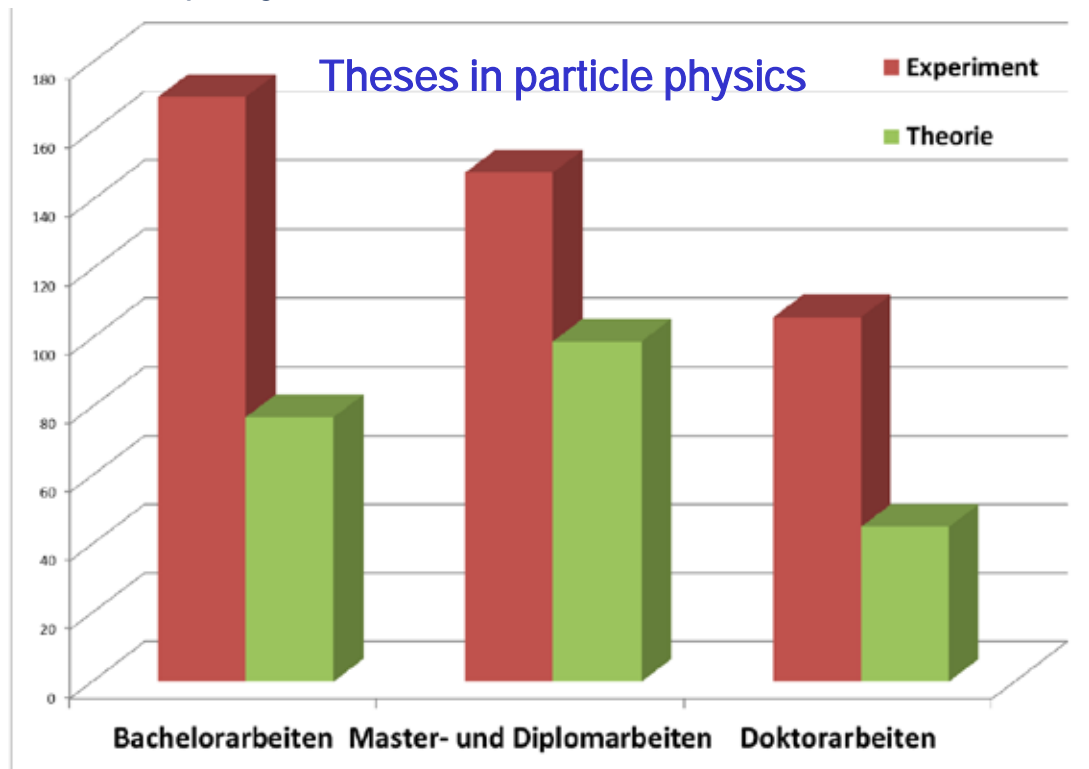
● Sum  
 Master + Diploma  
 ~ 2800 / year

Number of successful physics exams

[http://www.kfp-physik.de/statistik/physikstudium\\_2013.pdf](http://www.kfp-physik.de/statistik/physikstudium_2013.pdf)

## ✓ Survey by Komitee für Elementar Teilchen KET (2013)

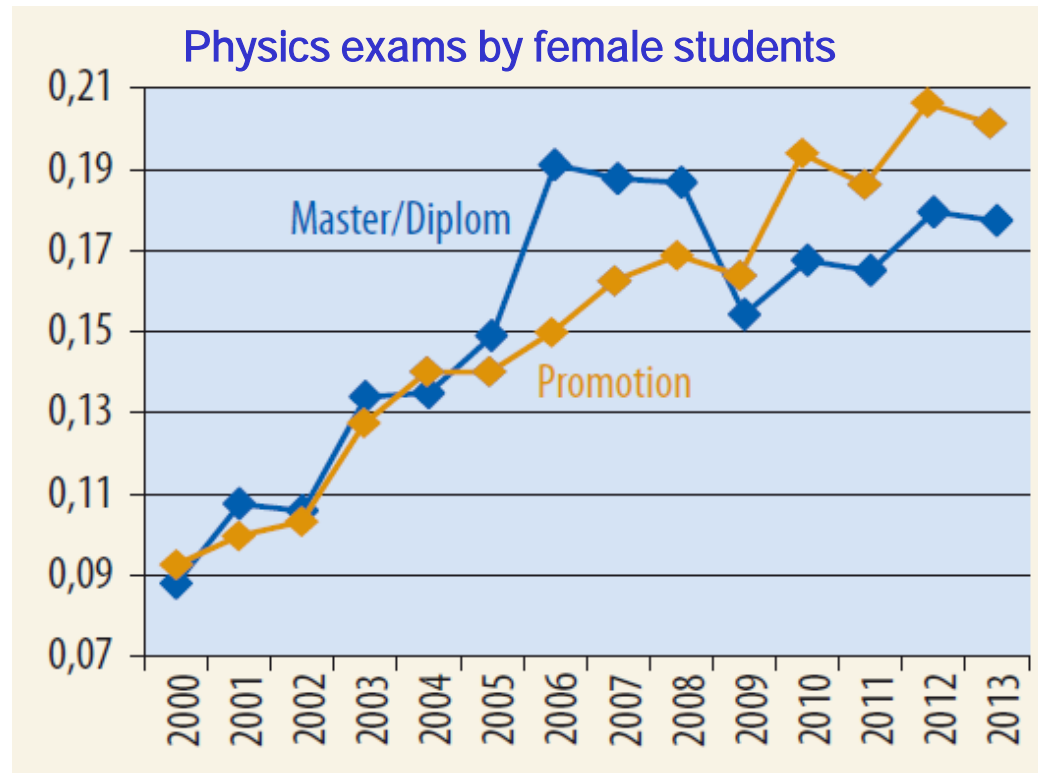
- 240 particle physics theses / 2800 bachelor/master total = 9%
- 150 particle physics Ph.D. / 1600 Ph.D. physics total = 9%
- 25% of particle physics Ph.D. theses from foreign students
- 670 Ph.D. students active (70% Experiment, 30% Theory)
- 2/3 third party financed (DFG, BMBF, ...), 1/3 financed locally



## Fraction of female young researchers

### ∨ Particle physics (KET survey)

- **23% Female young researchers (post-Doc + Ph.D.) in particle physics**
- > 20% female Ph.D. exams in physics
- > 18% female students passing master/diploma exam in physics



[http://www.kfp-physik.de/statistik/physikstudium\\_2013.pdf](http://www.kfp-physik.de/statistik/physikstudium_2013.pdf)

## ✓ Bachelor

- (nearly) all universities: **Particle and Nuclear Physics course**
  - § **(usually) mandatory in 3rd year of bachelor**
  - § Normally given as 4h lecture + 2 h exercises /week  
(sometimes including data analysis, eg. Aachen [arXiv: 1402.2836](https://arxiv.org/abs/1402.2836) )
  - § Universities w/o particle physics often invite lecturers from DESY or MPI
- universities with particle physics research
  - § **optional particle physics specialization in most (75%) places**
  - § **Bachelor thesis, fully integrated in local research groups**

## ✓ Master (universities with particle physics research)

- **Particle physics as master specialization topic**
  - § Taken by 5-50% of all students, depending on university
  - § Broad range of lectures: physics, statistics, detectors, accelerators
  - § Always complemented by lab-courses (details see backup)
- **One-year research phase**
  - § Equivalent to former Diploma theses
  - § Often integrated in international experiments

## ✓ General features of structured Ph.D. programs

- Structured lecture and seminar programs, often with block courses
- Wide range of topics broadening the horizons of Ph.D. students
- Supervision agreements and independent co-supervisors
- Large variety of soft skill courses

## ✓ DFG research training groups „Graduiertenkollegs“ (homepages)

- Particle and Astro-particle Physics in the Light of LHC ([Aachen](#))
- „Mass, Spectrum, Symmetry – Particle Physics in the era of the LHC“ ([Berlin](#), [Dresden](#), [DESY in Zeuthen](#))
- Graduate School of Physics and Astronomy ([Bonn](#), [Köln](#))
- Mathematical Structures in Modern quantum Physics ([Göttingen](#))
- Quantum and Gravitational Fields ([Jena](#))
- Mathematics inspired by String Theory and QFT ([Hamburg](#))
- Analysis, Geometry and String Theory ([Hannover](#), [Potsdam](#))
- Particle Physics Beyond the Standard Model ([Heidelberg](#))
- Elementary particle physics at highest energy and precision ([Karlsruhe](#))
- Particle Physics at the energy frontier of New Phenomena ([Munich](#))
- Symmetry Breaking in Fundamental Interactions ([Mainz](#))
- Theoretical Astrophysics and Particle Physics ([Würzburg](#))

## ✓ Local Ph.D. Research Schools

- Max Planck IMPRS Elementary Particle Physics ([MPI Munich](#))
- School of Elementary Particle and Astroparticle Physics ([KIT Karlsruhe](#))

- ✓ Essential for Ph.d. students
- ✓ Examples:

- Helmholtz alliance schools
  - § Broad range
    - physics
    - statistics
    - programming...
  - § Meanwhile common with other Helmholtz-Alliances



- Autumn school Maria Laach (46th edition in 2014)
  - <http://maria-laach.physik.uni-siegen.de>
    - § Experiments and theory
    - § Own students talks
- 3 country Belgium-Netherland-Deutschland (BND) graduate school
  - <http://bnd-graduateschool.org> (26th edition in 2014)





- ✓ International Summer student programs
  - Mix of lectures and practical work
  - International atmosphere
  - Deeper than university courses
- ✓ Locations
  - HZDR Rossendorf (e.g. accelerator physics)
  - GSI Darmstadt
    - § Accelerator Physics & Technical R&D
    - § High Energy Nuclear Collisions
    - § Theory
  - DESY in Hamburg and Zeuthen
    - § 60% in HEP field (exp + theory)
    - § 2014: 500 applications for 110 places
- ✓ Training in science communication by prof. communicators and didactic experts
  - Workshops and certificates for  
> 100 Facilitators in education programs  
(Int. Masterclasses, Netzwerk Teilchenwelt)

## SUMMER STUDENTS.

DESY International Summer Student Program 2013  
July 16 to September 6



[www.teilchenwelt.de/aktuelles/nachrichten/netzwerker-machen-sich-fit-in-wissenschaftsvermittlung](http://www.teilchenwelt.de/aktuelles/nachrichten/netzwerker-machen-sich-fit-in-wissenschaftsvermittlung)

### Netzwerk Teilchenwelt / IPPOG International Masterclasses

- ✓ National and international effort, both lead in Germany by TU Dresden
  - Bring real astro-/particle physics data analysis to high schools
  - Organize in-service teacher training
  - International program 2014: 40 Countries and 199 participating institutes
  - National German program: largely extended scope and sustainable output



Bonn, 09.05.2014

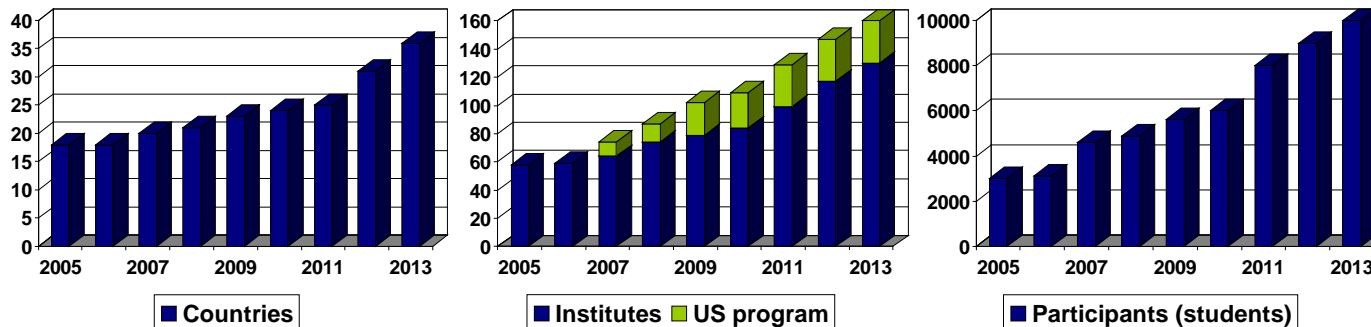


**NETZWERK  
TEILCHENWELT**




## ✓ Concept:

- 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)



2014 Coord.: QuarkNet / TU Dresden →

- 
- 11 video conf. with Fermilab
  - 39 institutes
  - 41 Masterclasses
    - 16 ATLAS
    - 25 CMS



- 48 video conf. with CERN
- 160 institutes
- 200 Masterclasses
  - 119 ATLAS
  - 46 CMS
  - 14 ALICE
  - 21 LHCb





## ATLAS

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



## CMS

- J/ $\Psi$  data quality
- W,Z,H analysis



## ALICE

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



## LHCb

- Charm lifetime

### ✓ Germany lead development of

- ATLAS + ALICE measurements



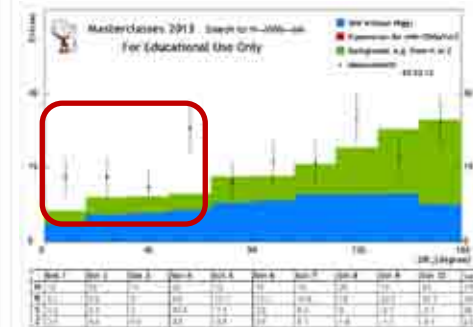
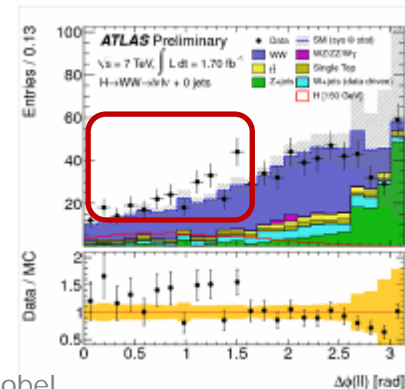
### ✓ Rich spectrum of tasks

- Check data quality
- Event displays, identify particles
- Histograms (Mass, angles)
- Draw conclusions

### ✓ Freely accessible for education purposes

### ✓ Continuously following research

- 2012: simulated Higgs events
- 2013: real Higgs candidates

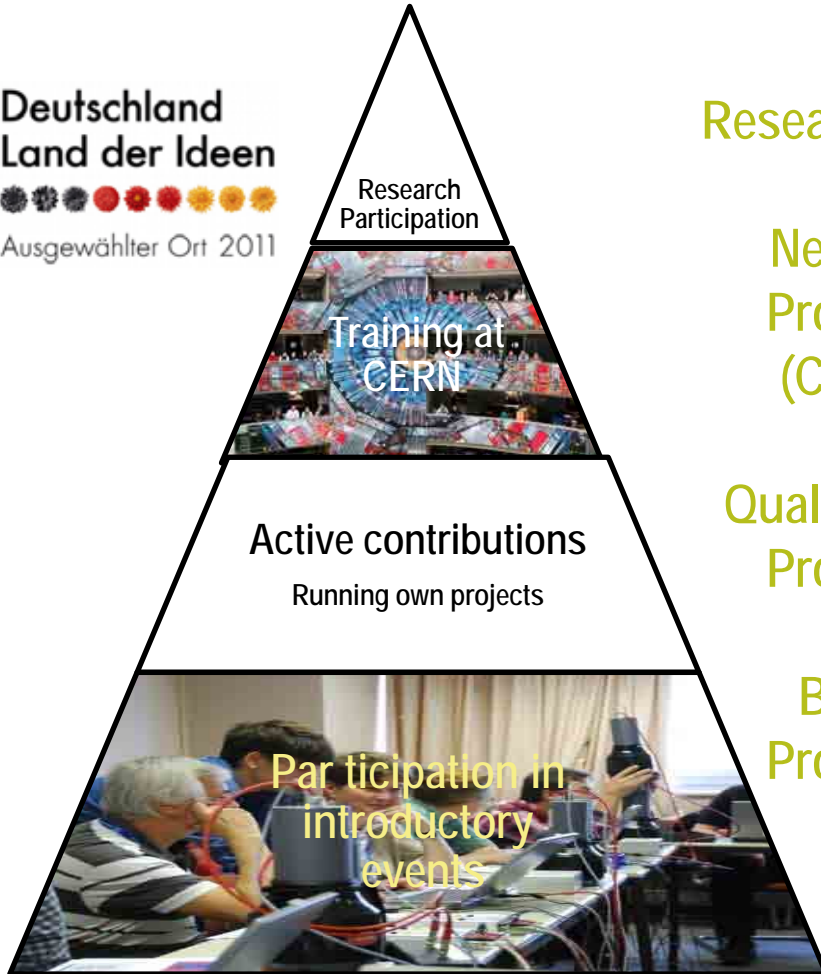




- ✓ Key concepts:
  - bring fascination out to the country-side (also far from institutes)
  - Offer 4 levels of specialization (from basic experiences to active research)
- ✓ 24 Institutes = all German Particle Physics Institut  
15 Institutes: Astroparticle Projects
- ✓ Basic program: > 100 events / year at schools  
= one every other school day somewhere in D
- ✓ 140 scientists involved  
40 local organizers, 100 facilitators (mostly Ph.D.-students)
- ✓ Since 2010 until end of 2013
  - ~ 14.000 students
  - ~ 470 in qualified network members
  - à 176 at CERN workshops
  - ~ 1.200 teachers
  - ~ 400 qualified network members
  - à 165 at CERN workshops



**Deutschland  
Land der Ideen**  
Ausgewählter Ort 2011



**Teachers**

**Research work**

**Network  
Program  
(CERN)**

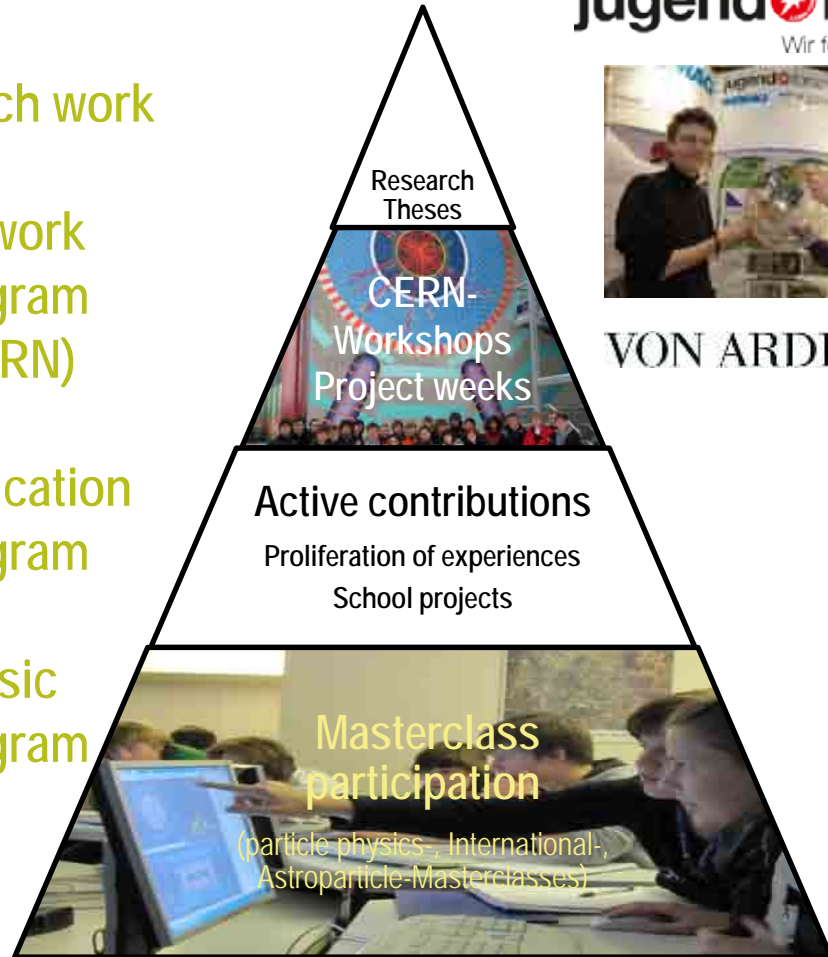
**Qualification  
Program**

**Basic  
Program**

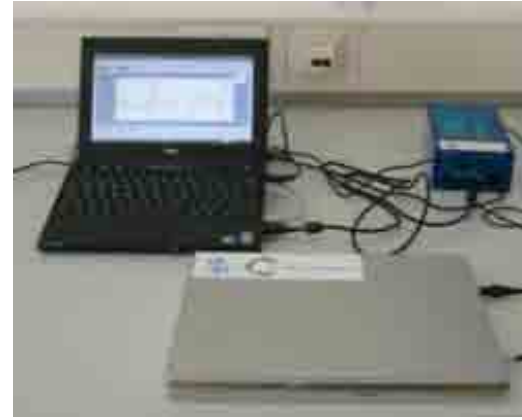
**jugend forscht**  
Wir fördern Talente.



**VON ARDENNE**



**Students**



- ✓ Cosmic ray detectors: Kamiokande (Mainz, Wuppertal, Göttingen) and Scintillation Counter „CosMO“ (DESY)
- ✓ To be let to schools after teacher's training for own data taking:
  - Measurements of angular distributions,  $\mu$  lifetime, shielding
  - Data analysis (test of theoretical models)
  - Software development (data taking, graphics)
- ✓ Also: Build Your own cloud chamber
  - instructions and - if needed - material to let
- ✓ New types of masterclasses in test phase
  - Auger (cosmic showers): by Wuppertal + test in Netzwerk
  - Icecube (neutrino events): Mainz participating, test in May



✓ Supporting material for Netzwerk activities: [www.teilchenwelt.de/material](http://www.teilchenwelt.de/material)

- for facilitators
- for teachers



✓ Contributions to [www.LEIFIphysik.de](http://www.LEIFIphysik.de) portal

- Largest German Physics Portal for schools hosted by <http://joachim-herz-stiftung.de>
- To be online soon: update particle physics [www.leifiphysik.de/themenbereiche/teilchenphysik](http://www.leifiphysik.de/themenbereiche/teilchenphysik)
- Under development: teaching material in workshop series with Netzwerk teachers

§ Dresden 11/13

§ CERN 04/14

...





Obligatory (at least some part. physics)	Optional	no particle physics
Baden-Württemberg	Berlin	Niedersachsen
Bayern (6 h)	Brandenburg	Sachsen
Bremen	Hessen	Thüringen
Hamburg	Rheinland-Pfalz (10 h)	
Mecklenburg-Vorpommern	Saarland	
NRW (12 resp. 6 h)	Sachsen-Anhalt (4 h)	
	Schleswig- Holstein (8 h)	

school curricula overview: <http://www.kmk.org/dokumentation/lehrplaene/uebersicht-lehrplaene.html>  
 Details i(n German): <https://indico.cern.ch/event/284169/session/1/material/0/3.pdf>

# People involved in a sustainable education network



The organisation team...



... Teacher training at CERN ...



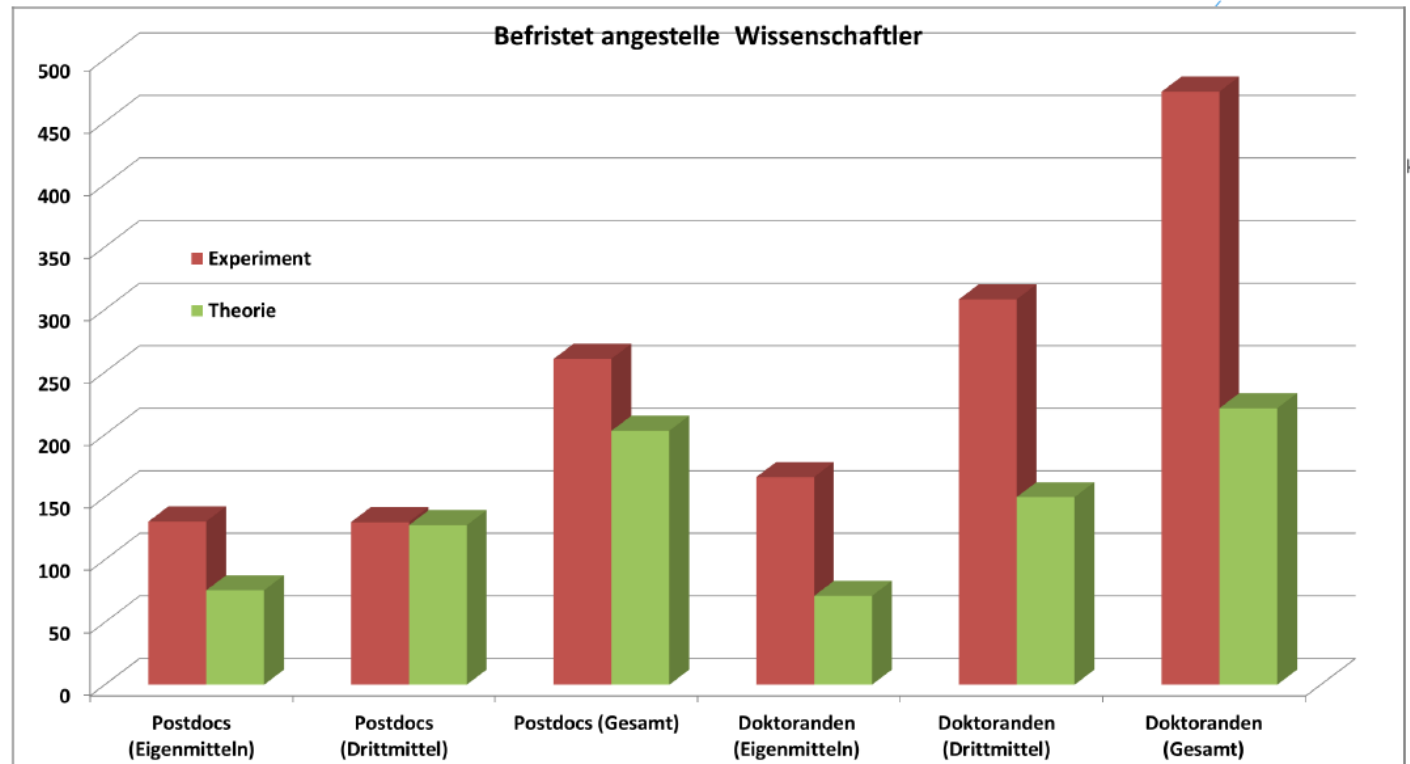
Bonn, 09.05.2014

... 1st Meeting of student-alumni ...

**THANK YOU FOR YOUR  
ATTENTION**

✓ 2013 survey of fixed term contracts (by Komitee für Elementar Teilchen KET)

- 670 Ph.D. students (70% Experiment, 30% Theory)
- 2/3 third party financed (DFG, BMBF, ...), 1/3 financed by universities
- 23% Female (average post-Doc + Ph.D.) > 15% female physics students



## Lab course tasks and master lectures (examples)

### ✓ Lab measurements (in bachelor and master)

- Muon life time and decay
- Particle detection: drift chamber, scintillation, X-Ray
- Data acquisition
- Accelerator (MAMI)
- Z decays, W mass and Higgs discovery
- Positronium
- Compton scattering
- Angular correlations
- Air showers
- Strangeness, Bubble chamber

### ✓ Master lectures

- Accelerators, detectors
- Astroparticle physics
- Data analysis
- Quantum field QCD, Eweak SUSY
- Flavor physics, top physics
- Hadron collider physics
- Higgs physics
- Neutrino physics