Open Science – Best Practice in Sharing the Research Process with the Public

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Science = Cultural Curiosity

- Consider the prerequisites
  - Not everybody has (same) scientific background
  - But everybody has human curiosity
- Share the fascination of scientific questions
  - Don‘t be shy to ask fundamental questions
  - But don‘t try to explain all details
- Draw the big picture
  - Start from the Known to the Unknown
  - Convey the „beauty of science“
- Address the relevance for all
  - Relate to everybody‘s world
  - „Applications“ can be twofold:
    - Cultural Knowledge
    - Technology Transfer

Mikrokosmos

Makrokosmos

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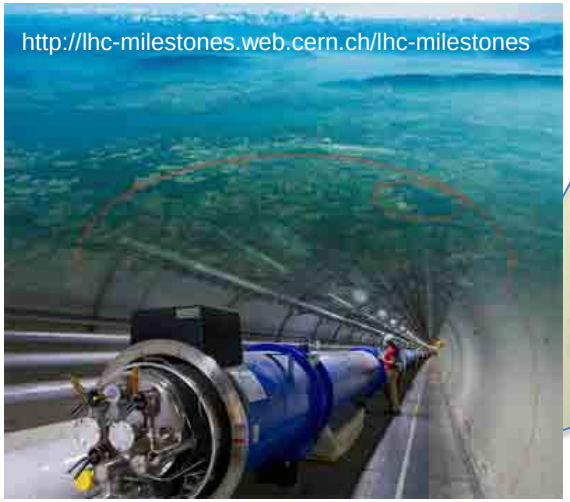
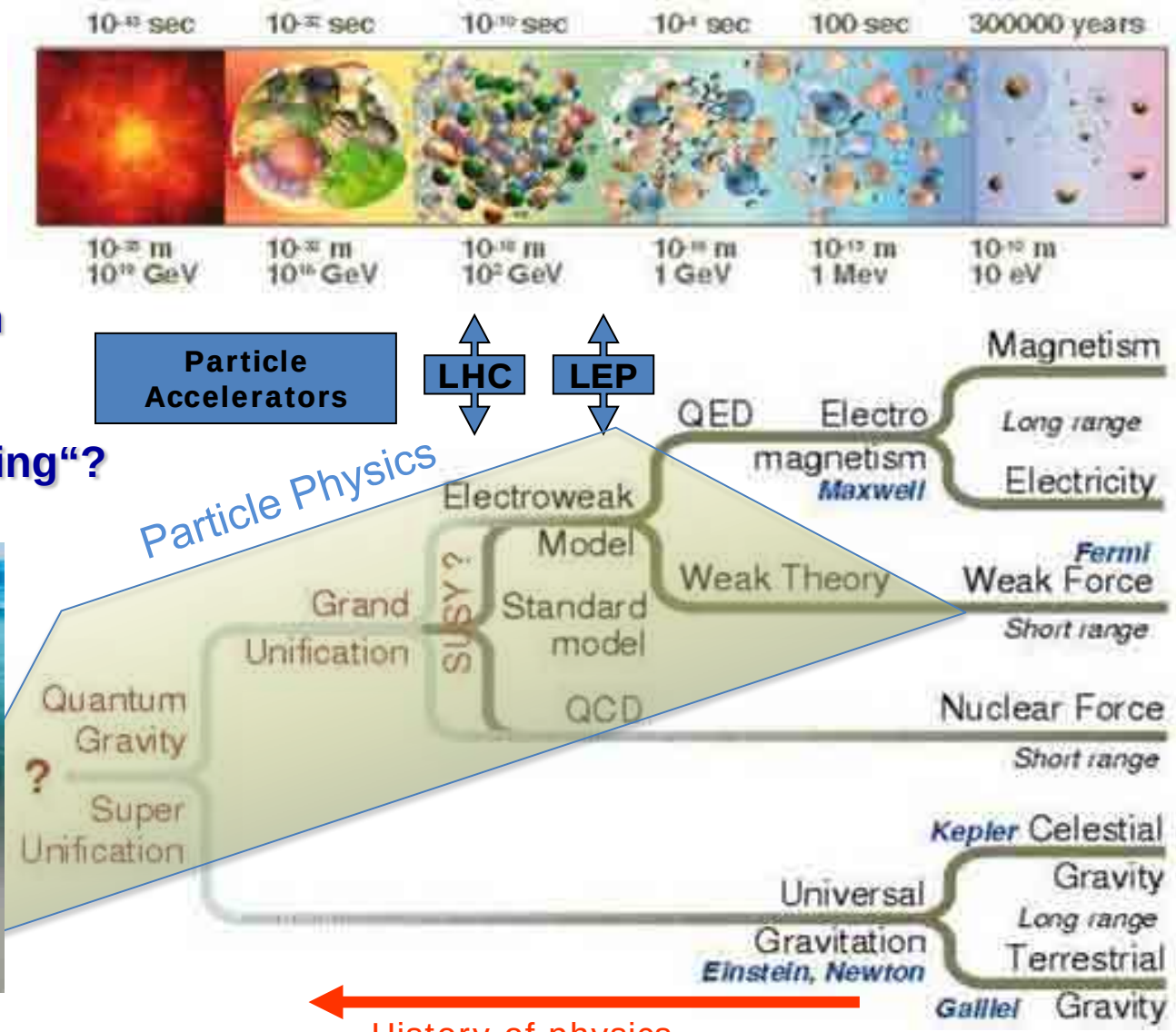
Drawing the big picture

- **Start with the Known**
  - **Electromagnetism**
  - **Gravity**
- **End with the Unknown**
  - **Origin and fate of the universe**
  - **„Theory of everything“?**





History of physics
Back to the Big Bang

Open Science = Authentic Science

- Make public into scientists for a day
  - Active „hands-on“ involvement
    - hear = forget, see = remember, do = understand
    - boil down to essentials for enabling own measurements
  - As close as possible to current research
    - follow up what scientists have recently done
- Get insight into research process
  - use original methods and tools
  - compare the results to theories
- Authentic experience
  - Analyse real scientific data
  - Meet and discuss with active scientists

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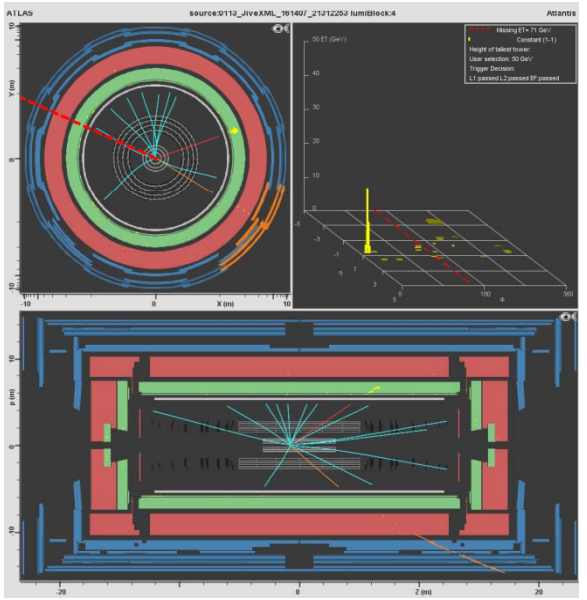
The Science Masterclass Idea

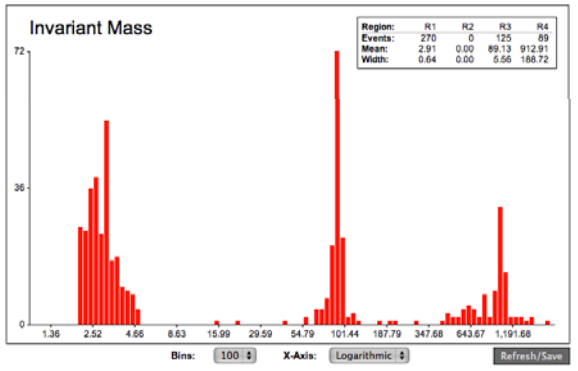
❖ Particle Physics Masterclass

- Target: 16-19 year-old students, teachers, general public
- Introduced and guided by scientists („masters“)
- Work (in pairs) on real data from CERN
  - Classify ~ 100 particle collision images, each
  - Combine: compare abundance or plot spectra
  - Draw conclusions, get insights



❖ Possible Masterclass (MC) Formats

- **Institute MC:** 1 day at research institute
  - Original idea from UK, since 1996
- **International MC:** moderated video conference
  - Organized since 2005 by IPPOG
- **Local MC:** Ph.D. students bring data to venues
  - Since 2010 in Germany and elsewhere



❖ Other science topics possible

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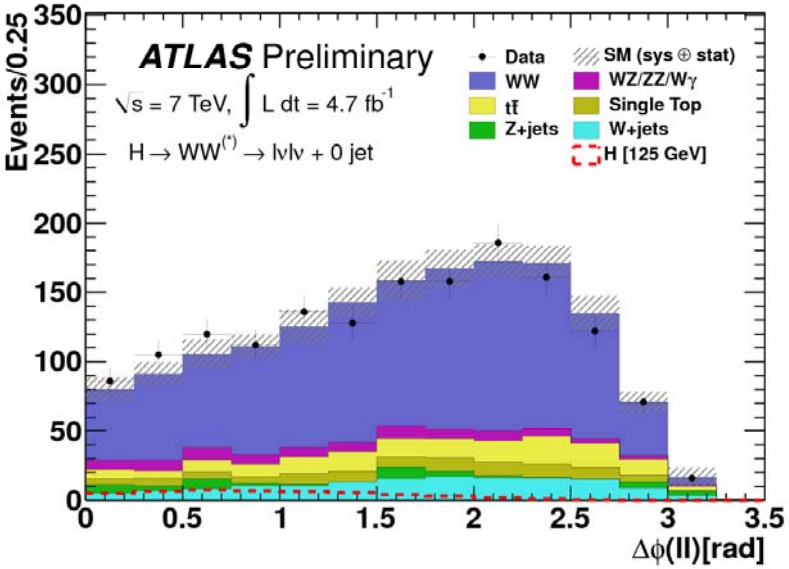
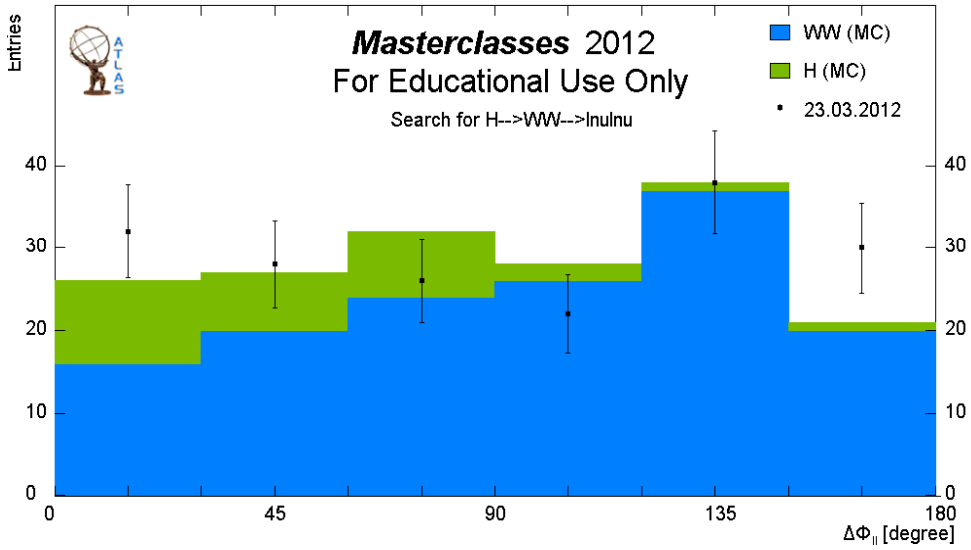
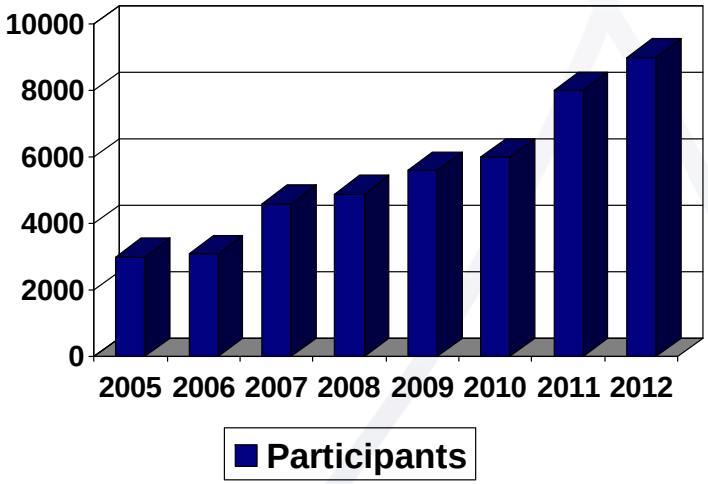
Measurement examples from CERN data

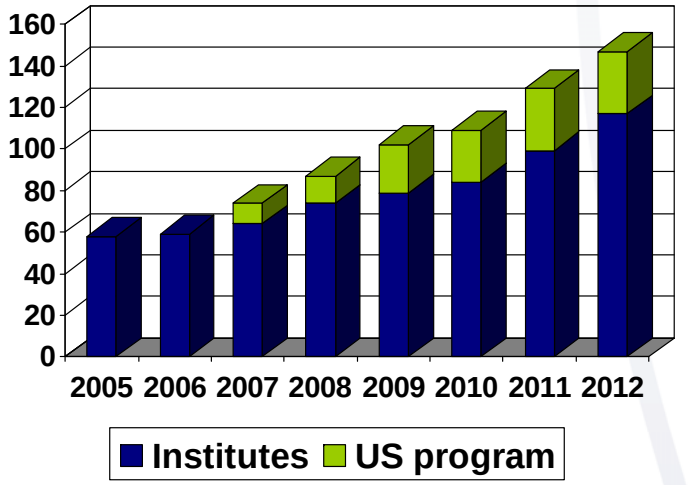
- Basic insights
  - Why do p-p collisions produce more W^+ than W^- ?
    → Proton structure !
    - 2 u-quarks: positive electric charge -> emit W^+
    - 1 d-quark: negative electric charge -> emit W^-
- Cutting edge research: Higgs → $W^+ W^-$ → $l^+\nu\, l^-\nu$





International Masterclasses in 33 countries





Each year 4 weeks in spring, next 25.2. – 22.3.2013
www.physicsmasterclasses.org

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Evaluation in Physics Education 42 (2007) 636

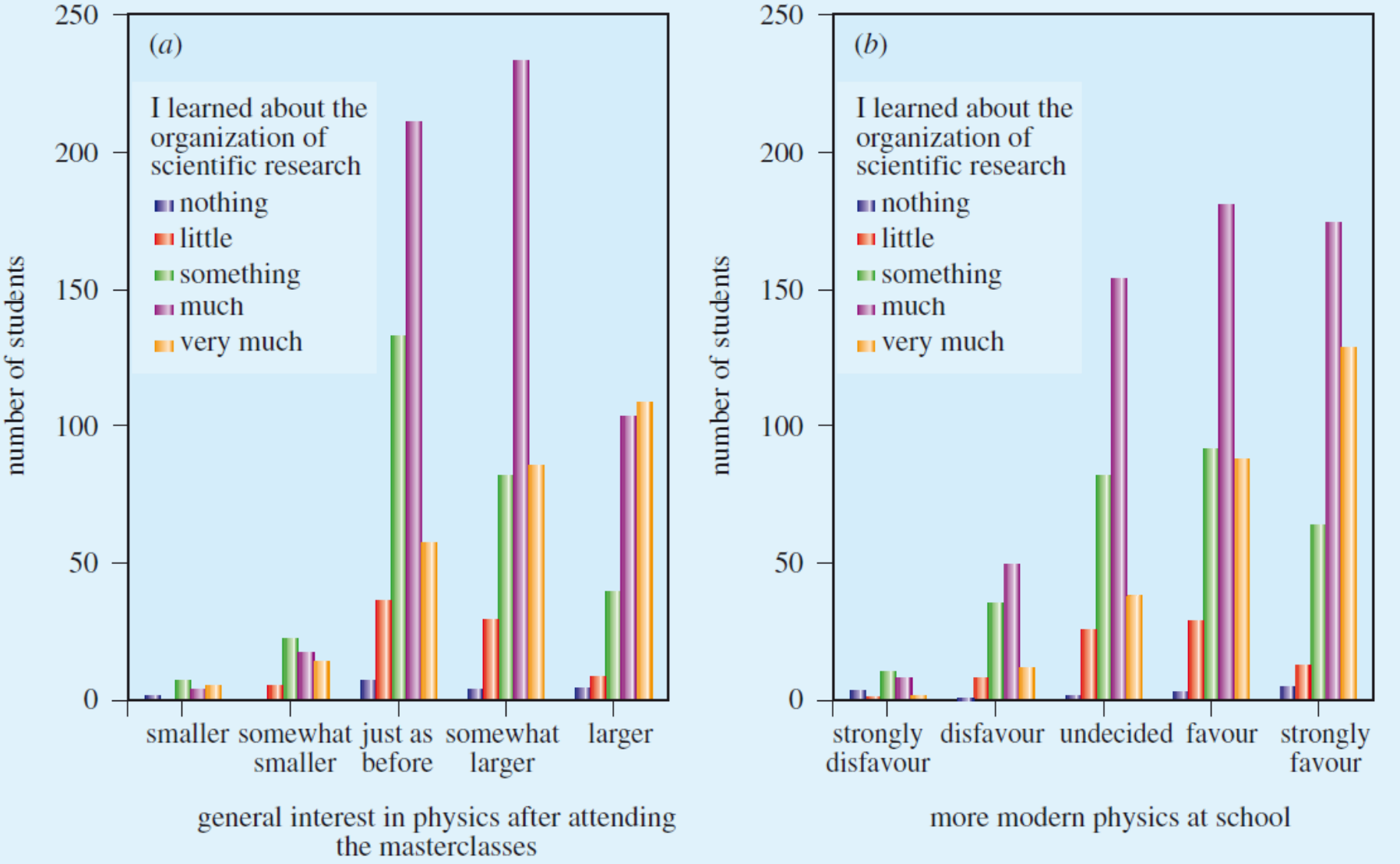


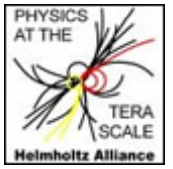
Figure 8. (*a*) The general increase of interest in physics, and (*b*) the wish for more modern physics at school after attending the masterclasses. The five columns show how much the participants reported to have learned about the organization of scientific research.

Funding of International Masterclasses

- Central Organisation for IPPOG:
  - Project Coordination Europe / Africa / Asia (west)
    - **Coordinator:** Helmholtz Alliance Germany (since mid 2008) , CERN (from 2013)
    - **Infrastructure and student assistents:** TU Dresden
  - Project coordination America / Australia / Asia (east): US-Quarknet

- In-Kind
  - Personnel: **IPPOG**, local **institutes, CERN-IT EVO/Vidyo team**
  - Prizes: **CERN**
  - CDs, Brochures: **EPS** + national resources

- Upgrade for LHC data: 2010-2012
  - Personnel in ATLAS, CMS, ALICE
    - **Didactic Ph.D. student:** German Wolfgang-Gentner program @ CERN
    - **Technical support and trials:** German BMBF LHC communication project



BACKUP

Masterclass Day (sample agenda)

LOCAL TIME:	ACTIVITY:
8:30-9:00	Registration & Welcome
9:00-10:00	Introduction to Particle Physics
10:30-11:30	Second Talk or Tour
12:00-13:00	Lunch
13:00-15:00	Data Analysis, including Introduction
15:30-16:30	Information about Particle Physics, studying Physics,…
16:30-17:30	Video Conference

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Other Big Programs using real CERN data

---------- masterclass – like ----------

- UK National Particle Physics Masterclasses
  - www.particlephysics.ac.uk/teach/master-classes.html
  - at 19 institutes, 25-30 events / year (mostly March/April)

- German „Netzwerk Teilchenwelt“ (Dresden et al.)
  - www.teilchenwelt.de (masterclasses, cosmic rays and more)
  - 22 institutes send Ph.D. students to schools (> 100 / year !)

---------- other formats ----------

- Interactions in Understanding the Universe I2U2 (FNAL et al.)
  - Among it: CMS E-lab: www18.i2u2.org/elab/cms/home/project.jsp
  - student-led, teacher-guided online project in the class-room

- Learning with ATLAS@CERN (Athens et al. : finished)
  - www.ea.gr/ep/lacern and www.learningwithatlas-portal.eu
  - develop frameworks and educational resources for teachers and students

More

- PATHWAY to Inquiry Based Science Teaching (Bayreuth et al.)
  - www.pathway-project.eu
    www.bayceer.uni-bayreuth.de/pathway/en/allgemein/gru/html.php
  - educational resources,teaching practices and instructional models for teachers
  - Covering all sciences, also HEP(Athens),

- DISCOVER THE COSMOS (Athens, CERN, Dresden, Birmingham…)
  - www.discoverthecosmos.eu
  - innovative ways to involve teachers and students in eScience in particle physics and astronomy
  - Original data from: International masterclasses, Hands-on Universe, …

- LHC Masterclasses at Science Centres (Oslo)
  - Collaboration w/ at least 4 science centres in Norway

- … for sure more (Poland, Canada, …) …

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