

INTERNATIONAL MASTERCLASSES HANDS ON PARTICLE PHYSICS

www.physicsmasterclasses.org

LHC Data to School Children

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ICNFP 02.09.2013, Kolymbari



What is a Particle Physics Masterclass?

- As in a masterclass in the arts, students work with an expert.
- Expert = particle physicist.
- Instead of, say, a violin, the subject is particle physics data analysis.



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 (2 – 5 inst. + CERN/Fermilab)

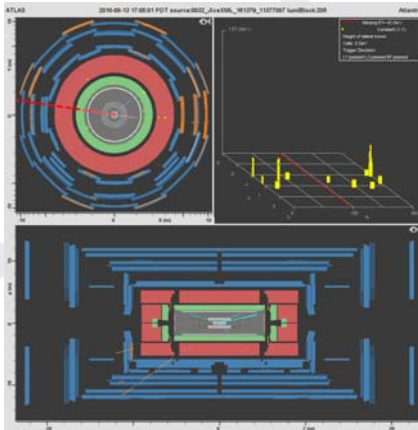
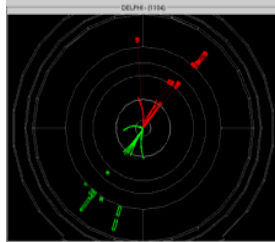
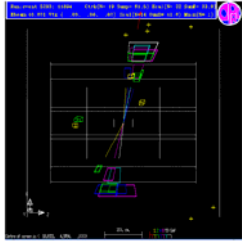


Motivation

- Why Masterclasses?
 - Make modern **particle physics data available** to students
 - Let **students explore** fundamental forces and building blocks of nature
 - Demonstrate the **scientific research process**
 - **Stimulate students' interest** in science
(proven in refereed evaluation Physics Education 42 (2007) 636-644)
 - offer **authentic experience** and add valuable experiences to physics education at school
 - Inform students about the **new age of exciting discoveries** in particle physics



Brief History



- Idea from UK, 1996 (R.Barlow et al.)
- 2005: Adopted by EPPOG/IPPOG for all Europe
- IPPOG – International Particle Physics Outreach Group <http://ippog.web.cern.ch/>
- Use of LEP data
 - OPAL Identifying Particles
 - DELPHI Hands on CERN
- 2006: U.S. joined program (QuarkNet)
- 2011: LHC-based Masterclasses only



Running in 37 countries!

New countries in 2013:

Romania Turkey

Cyprus Palestine

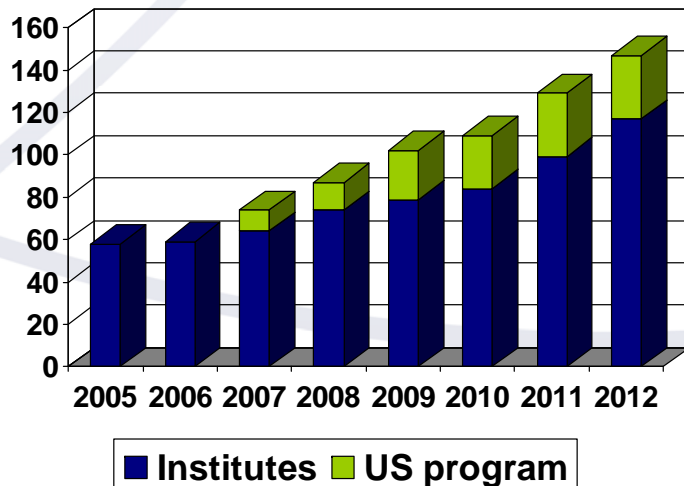
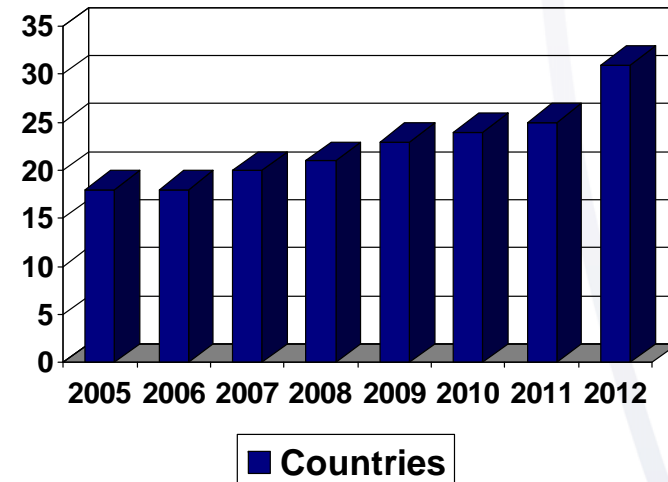
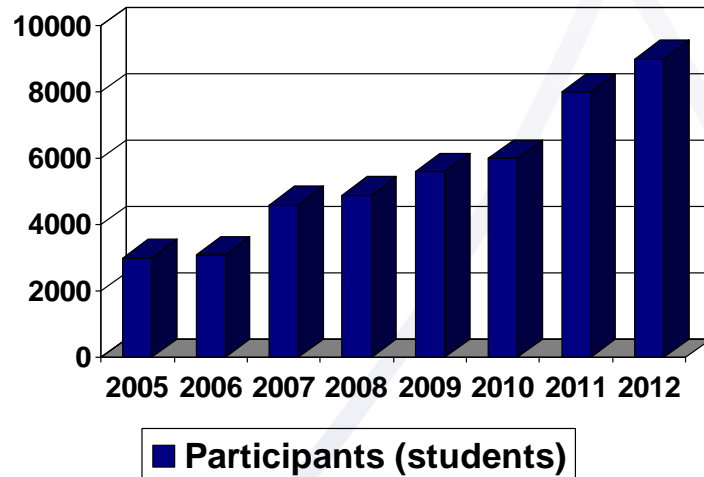
Egypt Australia



stepmap.de



Participation Statistics



In 2013:

- 10.000 students
- 130 institutes + 30 in U.S. program
- 37 countries



Sample Agenda

LOCAL TIME:

8:30 - 9:00

9:00 - 10:00

10:30 - 11:30

12:00 - 13:00

13:00 - 15:00

15:00 - 16:00

16:00 - 17:00

ACTIVITY:

registration & welcome

introduction to Particle Physics

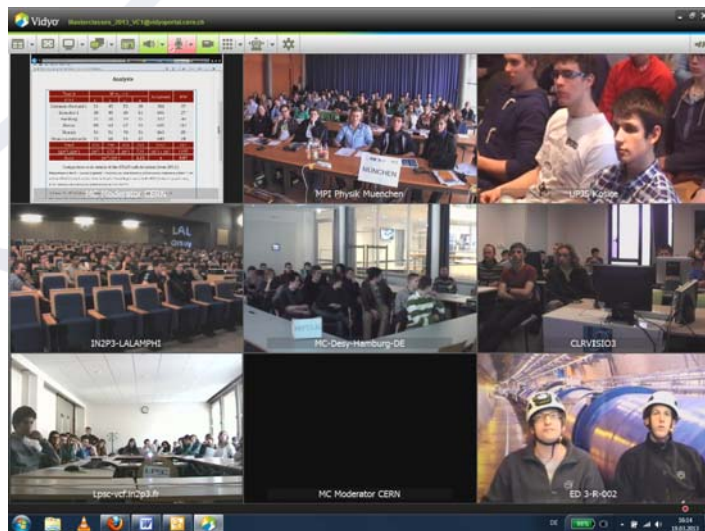
second talk or tour

lunch

data analysis, including introduction

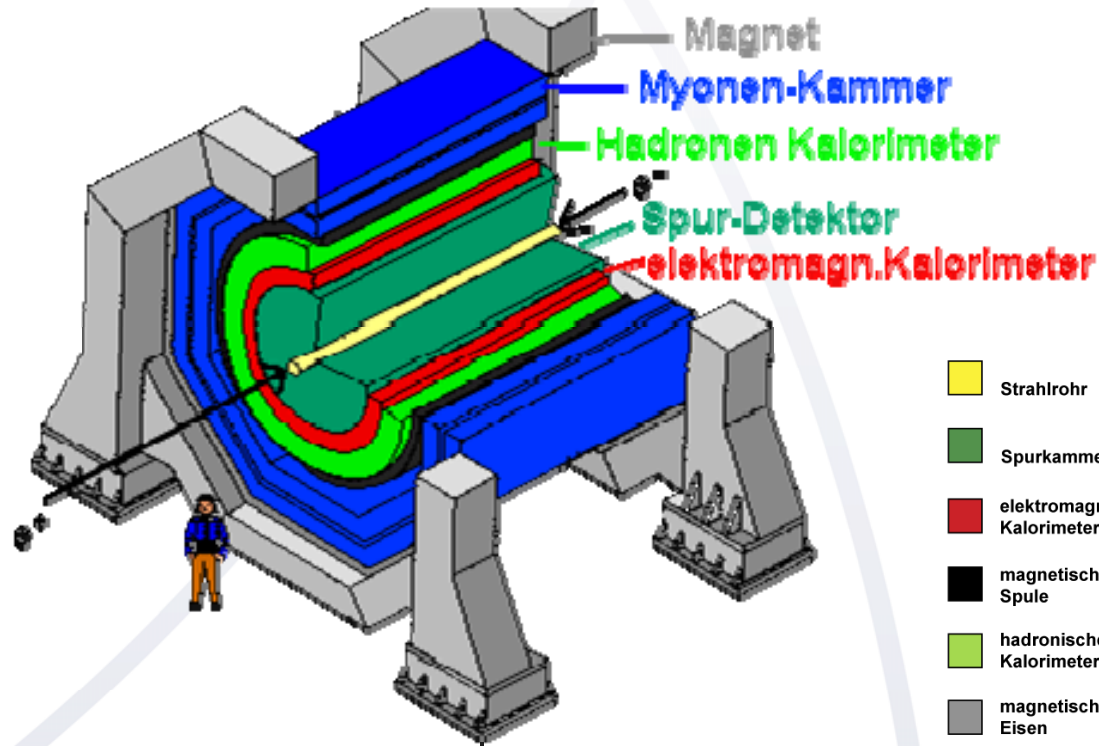
local combination and discussion

video conference with CERN or Fermilab

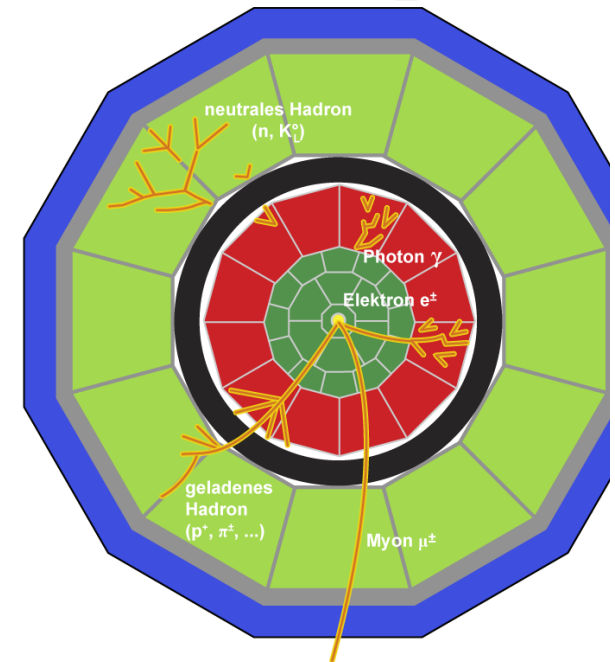


Learn to identify particles

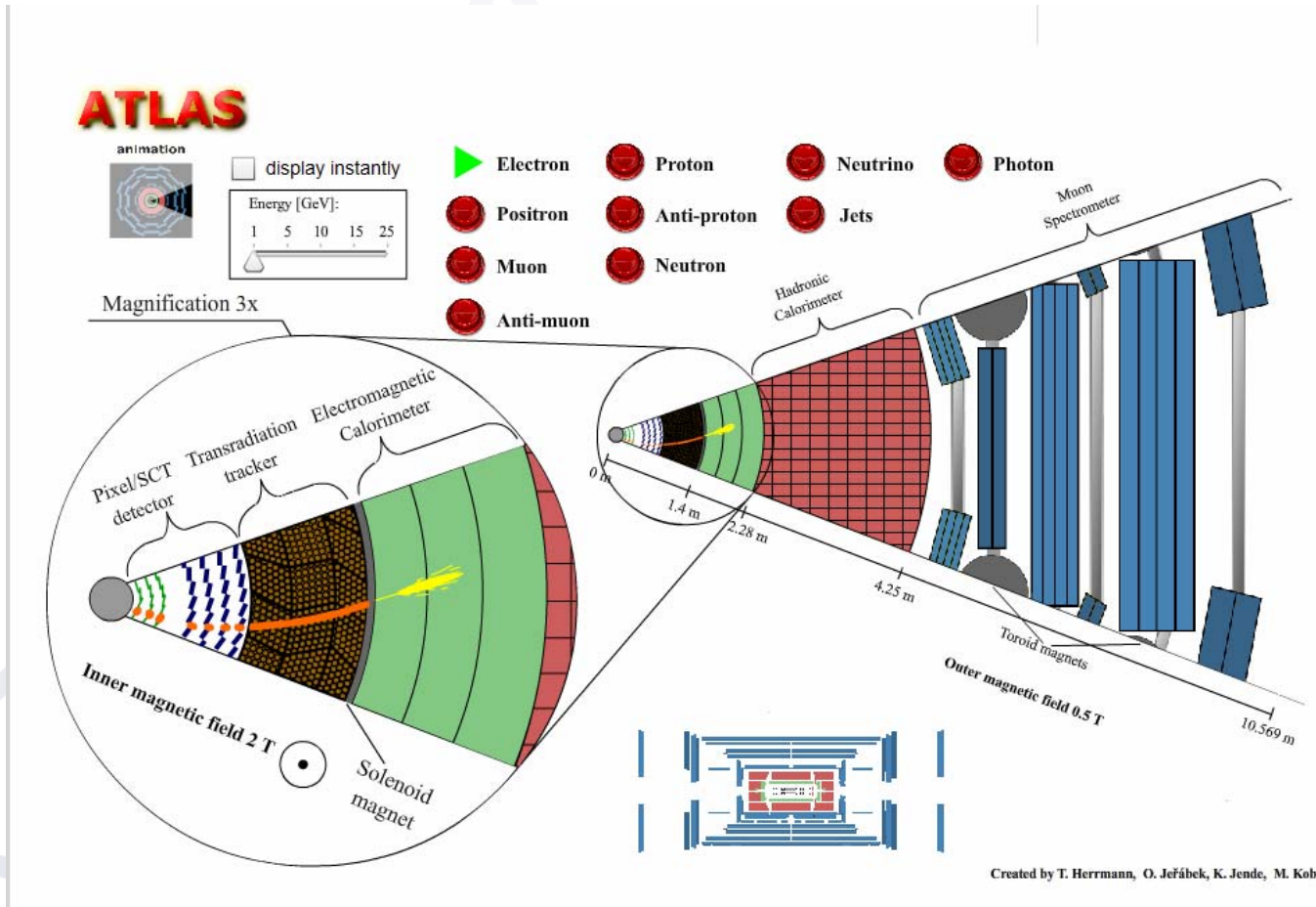
- Onion-like detectors
- Characteristic pattern for each particle type



- Strahlrohr
- Spurkammer
- elektromagnetisches Kalorimeter
- magnetische Spule
- hadronisches Kalorimeter
- magnetisches Eisen
- Myonen-Kammer



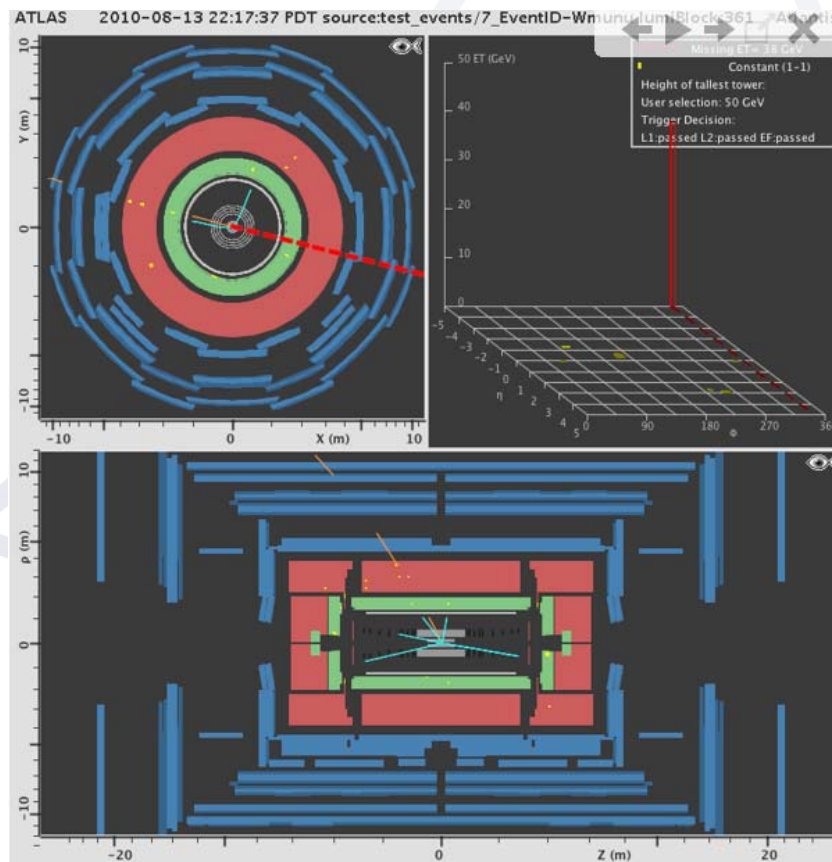
Introduction to Particle Identification



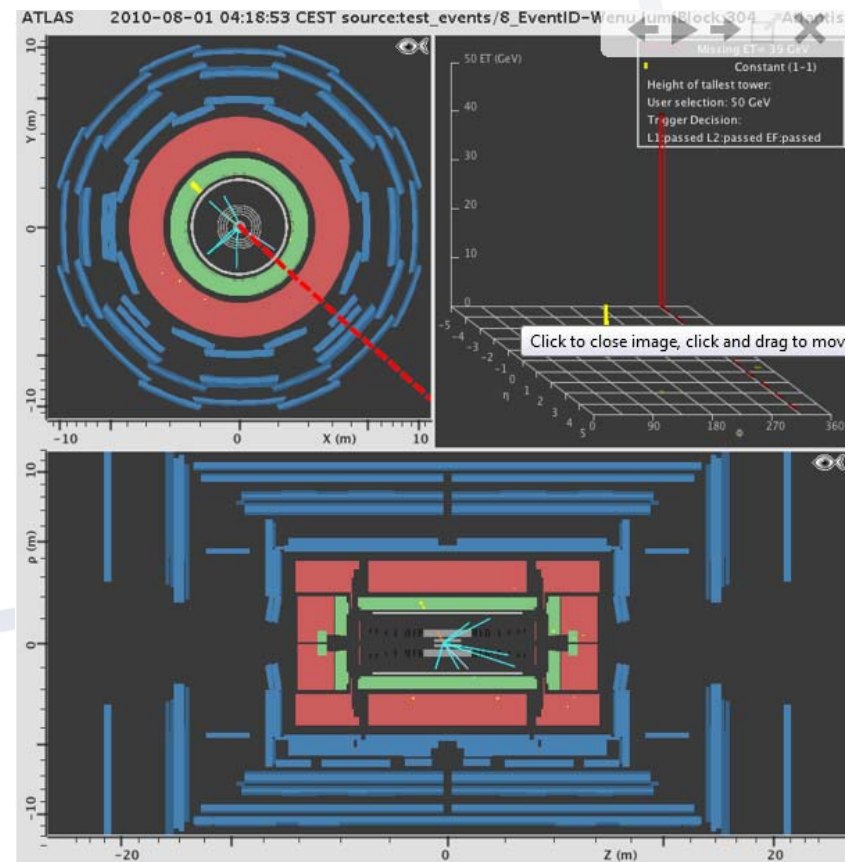
Event examples from ATLAS W path

6000 events can be analysed by students (50 per group of 2 students) = 6 institutes with 40 students each

$W \rightarrow \mu^- \nu$



$W \rightarrow e^- \nu$



Measurements done by counting

Venue: Schmalkalden Date: 09.07.2013



Comparison with ATLAS results

<http://arxiv.org/abs/1109.5141.pdf>

Total #	W → ... + ν				Background	WW	WW											
	e ⁺	e ⁻	μ ⁺	μ ⁻			no. 1		no. 2		no. 3		no. 4		no. 5		no. 6	
							event no	angle	event no	angle	event no	angle	event no	angle	event no	angle	event no	angle
525																		
group A	3	4	3	2	22	4	0	121	0	41	0	141	0	112				
group B	2	3	2	4	34	5	0	127	0	70	0	94	0	161	0	82		
group C	3	5	8	5	27	2	0	160	0	153								
group D	2	4	4	5	29	4	0	166	0	128	0	1	0	112				
group E	5	6	1	0	31	7	0	152	0	146	0	19	0	2	0	162		
group F	2	1	8	3	28	7	0	65	0	140	0	138	0	160	0	101	0	
group G																		
group H	6	5	4	3	26	7	0	127	0	240	0	75	0	176	0	140	0	
group I	2	3	6	5	27	4	0	166	0	128	0	1	0	112				
group J	5	0	3	0	33	1	0	131										
group K	9	1	1	3	32	4	0	127	0	174	0	35	0	97				
group L																		
group M	2	2	5	1	27	13	0	123	0	93	0	166	0	122	0	42	0	
group N																		
group O																		
group P																		
group Q																		
group R																		
group S																		
group T																		
Total	41	34	45	31	316	58												
Σ W ⁺ Σ W ⁻	W ⁺	86	W ⁻	65	W ⁺ + W ⁻	151												
Ratio	W ⁺ W ⁻		1.32	±	0.22													

Total	41	34	45	31	316	58
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Comparison with results of the ATLAS collaboration (from 2011):

Measurement of the W → lν and 2γ* → ll production cross sections in proton-proton collisions at $\sqrt{s}(\gamma\gamma) = 7$ TeV with the ATLAS detector^{*)} and Search for the Standard Model Higgs boson in the H → WW^(*) → lνlν decay mode using L7 Pb–Pb data collected with the ATLAS detector at $\sqrt{s} = 7$ TeV^{**)}

^{*)} Authors: The ATLAS Collaboration (Submitted on 5 Dec 2011); <http://arxiv.org/abs/1109.5141.pdf>

^{**)} Authors: The ATLAS Collaboration (24 Aug 2011); ATLAS-CONF-2011-134

	W → ... + ν				Background	WW cand.
	e ⁺	e ⁻	μ ⁺	μ ⁻		
Total	77885	52856	84514	55234	21930	469
Σ W ⁺ Σ W ⁻	W ⁺	162399	W ⁻	108090	W ⁺ + W ⁻	270489
Ratio	W ⁺ W ⁻		1.50	±	0.03	

[back](#)



Measurements with LHC data

- ATLAS
 - W path (Higgs \rightarrow WW)
 - Z path (discover Extra Z' Bosons)
- CMS
- ALICE
 - Looking for Strange Particles
 - R_AA
- in the future: LHCb, TOTEM, ...
- Expanded possibilities for students
 - More interactive e-learning tools as event displays
 - Options to do more than counting
 - Data quality investigations
 - Measurement of distributions in mass, angle etc.
- Follow up closely, what the scientists are doing
 - 2011: Exploit known Standard Model Processes, e.g.
 - W⁺/W⁻ ratio corresponding to (uud) quarks in proton
 - Understand mass peaks of J/Psi and Z
 - 2012: On the way to discover new particles
 - Higgs \rightarrow WW
 - Extra Z Bosons
 - ...

More details in the following presentations

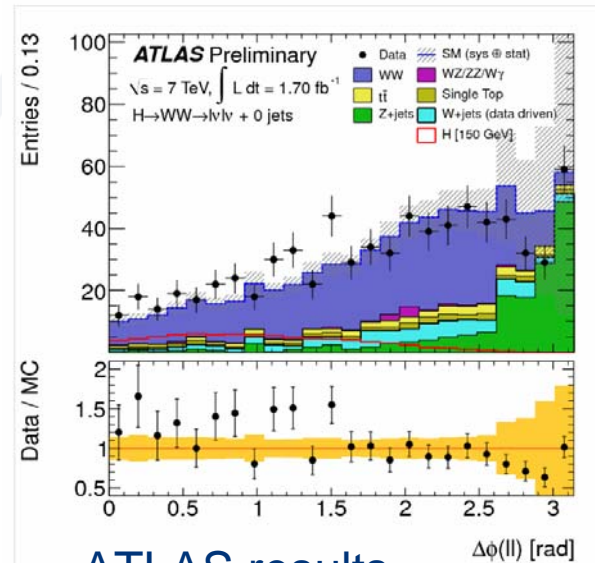
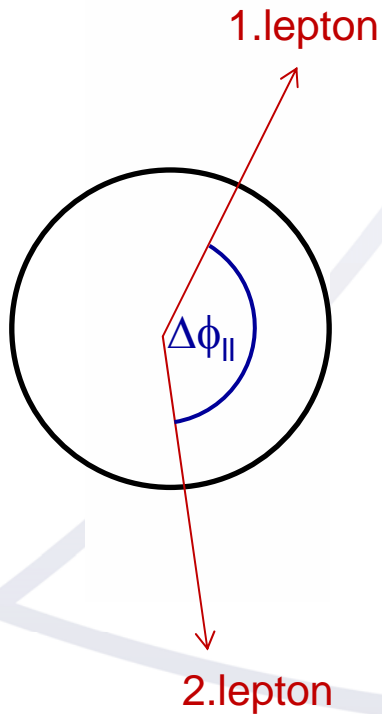
And: **TONIGHT!**

Demo session. Try it!

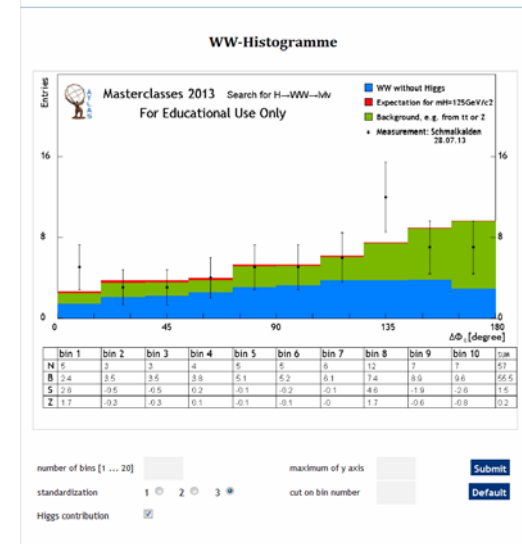


How to discover the Higgs via WW decay

A Higgs signal would accumulate at small values of $\Delta\phi_{ll}$



ATLAS results
(Higgs contribution in red)



Students' histogram



E-learning Platforms and Tools used

- ATLAS

- **Minerva** (M. Wieters, P. Watkins, T. McLaughlan et al)
based on ATLANTIS

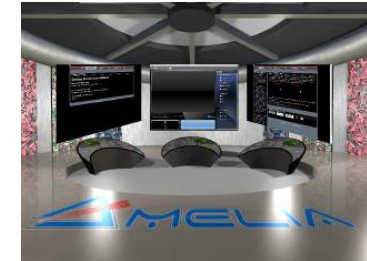
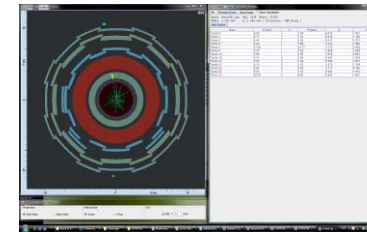
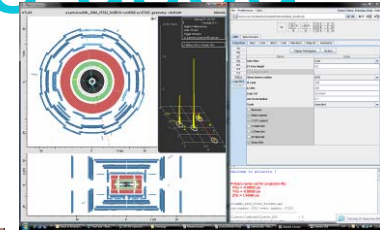
<http://atlas-minerva.web.cern.ch>

- **Hypatia** (C. Kourkoumelis et al.)
based on ATLANTIS

<http://hypatia.phys.uoa.gr>

- Under construction: **Amelia** (M. Barnett, J. Pequeno)

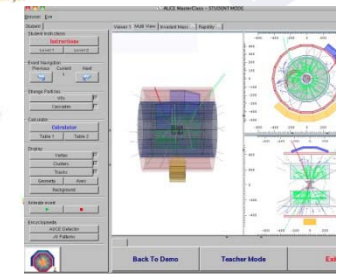
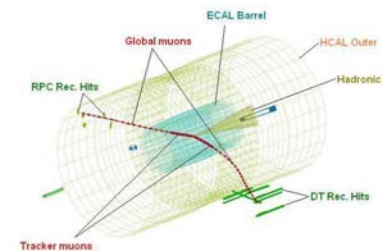
<http://amelia.sourceforge.net>



- CMS

- **iSpy online** (M. Hategan, K. Cecire et al.)
in collaboration with Quarknet (US)

www12.i2u2.org/elab/cms/event-display



- ALICE

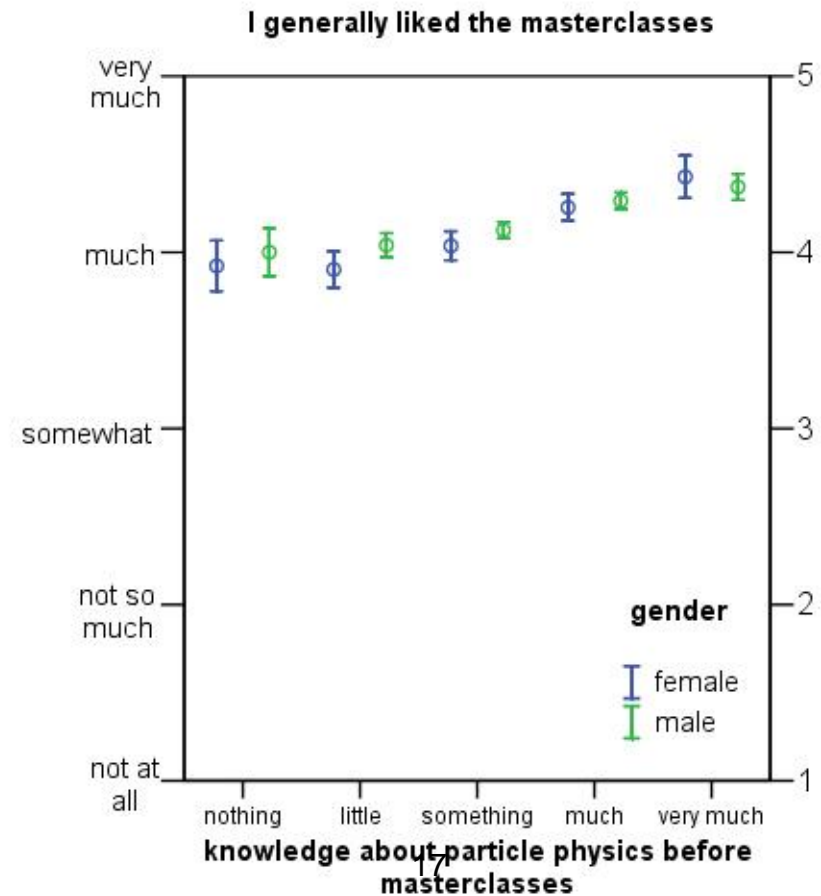
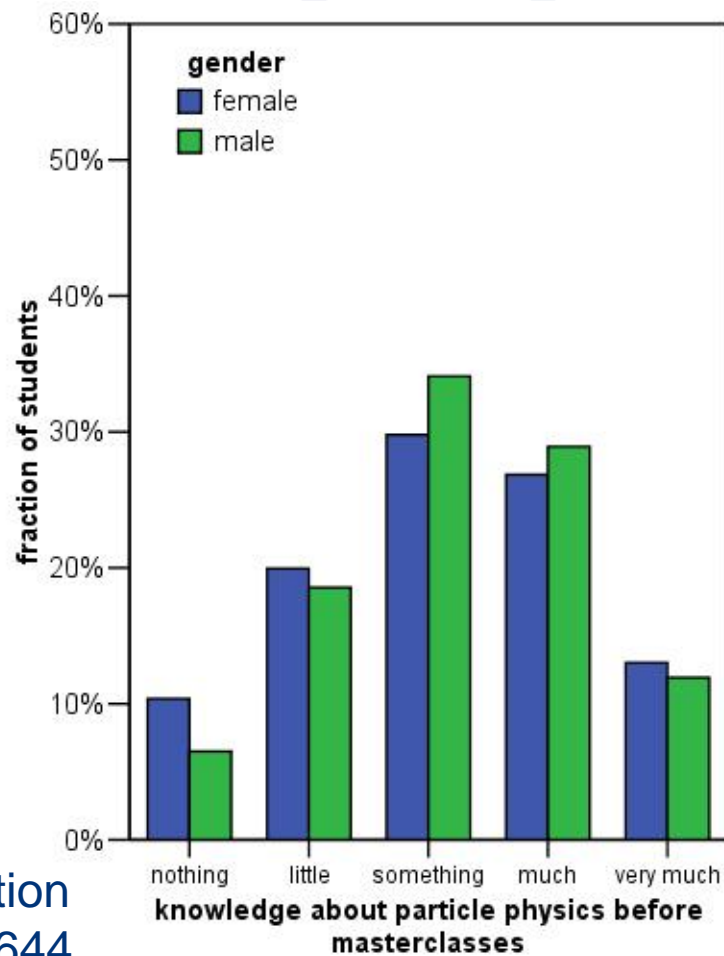
- **ALICE masterclass application** (P. Debski, Y. Foka et al.)
simplified ALICE event display in ROOT environment

http://aliceinfo.cern.ch/static/Pictures/pictures_High_Resolution/MasterClassWebpage.html



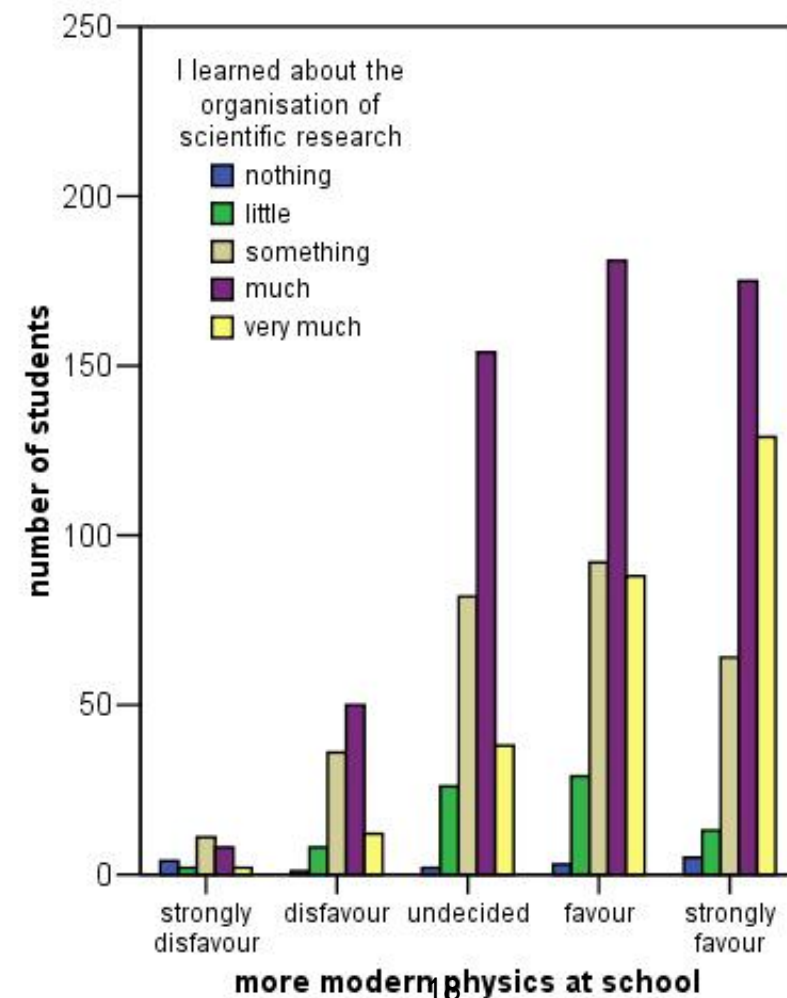
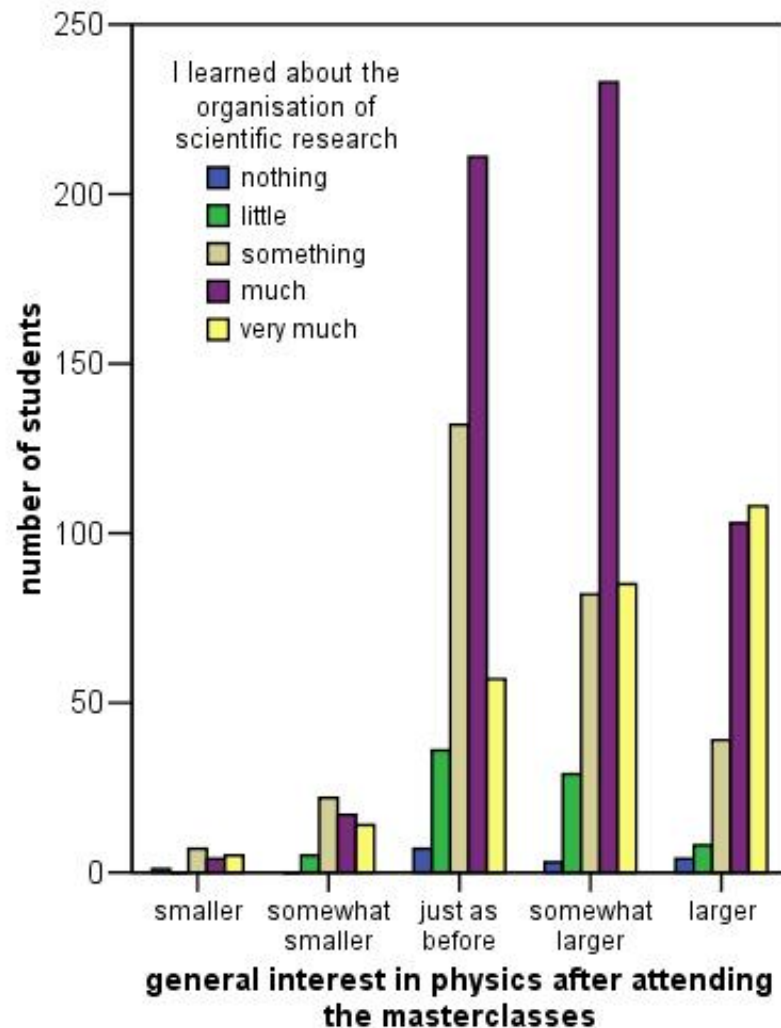
Refereed evaluation on Int. MC

- severity: just right
- success independent of a-priori knowledge and gender



Most important correlation

- Understanding the scientific research process
- generates interest in (especially modern) physics



Organisation and Funding

- Central organisation at TU Dresden for IPPOG
Michael Kobel (Project leader), Uta Bilow
- Coordination Fermilab-based MCs (America, Far East, Australia)
Ken Cecire
- Steering group
- WG Video conference
- Contributions from:
 - Oslo University (Farid Ould Saada, M. Pedersen, M. Bugge et al.)
 - Quarknet (K. Cecire et al)
 - ALICE (Yiota Foka et al
 - ...
- Funding and in-kind contributions from:



Conditions for participation

- a group of students (aged 16 - 19)
- an inviting institute, providing the infrastructure
 - a lecture hall
 - several PC's available
 - if possible a room for a video conference
- at least 1 scientist, holding the lecture
- some tutors for students during the measurement
(1 tutor per 10 students, knowing particle physics)

No financial requirements!

- Further: Translation of at least one measurement into local language, if not existing so far

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



Contacts

- Central Organisation at TU Dresden, Germany
Coordinator: Uta Bilow uta.bilow@physik.tu-dresden.de
- Your National Responsible
See: Your Country at
www.physicsmasterclasses.org/index.php?cat=country
- www.physicsmasterclasses.org
For more information



Beyond International Masterclasses

all data is free to use for **any educational purpose** (not only in the framework of International Masterclasses)

1. International Masterclasses

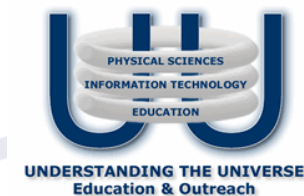
- organized by E/IPPOG since 2005
- once / year daily for 4-5 weeks
- students come to institutes worldwide
- video conference at the end of the day

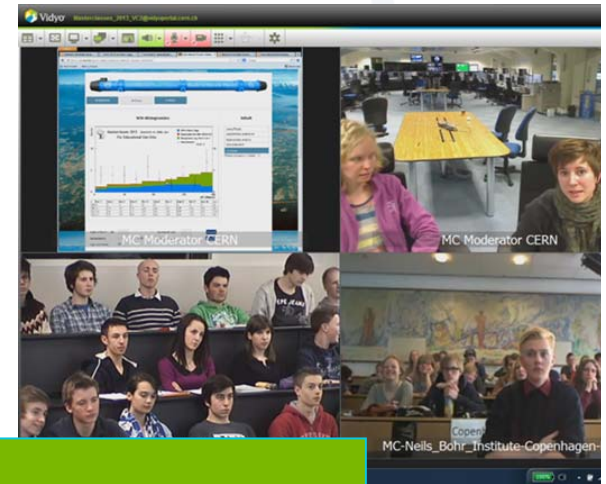
2. Local masterclasses at universities

- without video conference
- if date within IMC period not possible
- if institute wishes to organize more Masterclasses

3. Local masterclasses at schools

- Researchers bring data to school, science center, ...
- Also stand-alone by teacher possible
- National activities (Germany, I2U2, etc)





www.physicsmasterclasses.org

