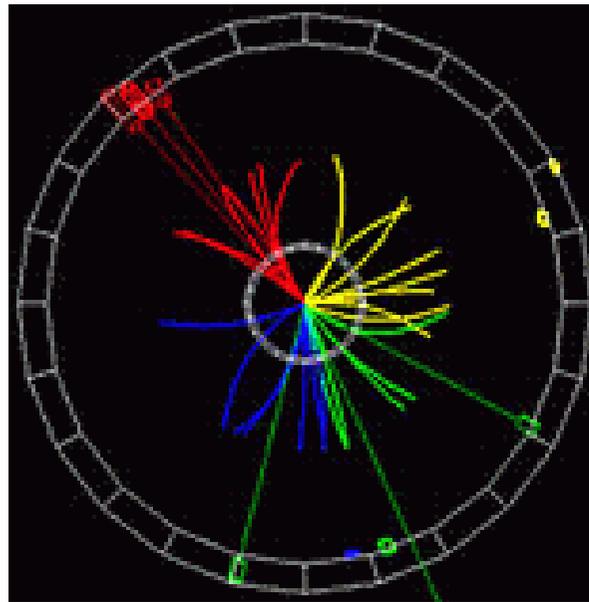


EPPOG International Masterclasses ***“Hands on Particle Physics”***

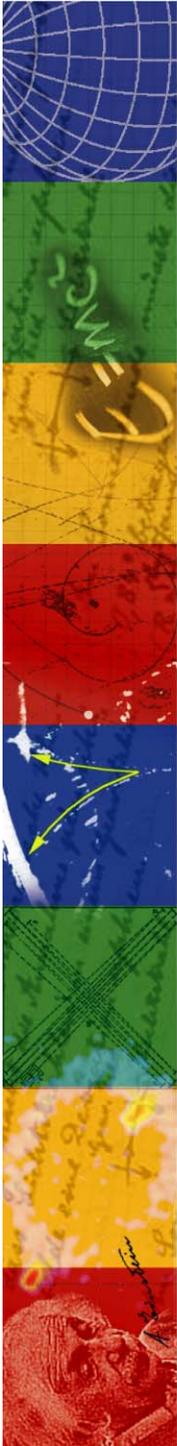
www.physicsmasterclasses.org



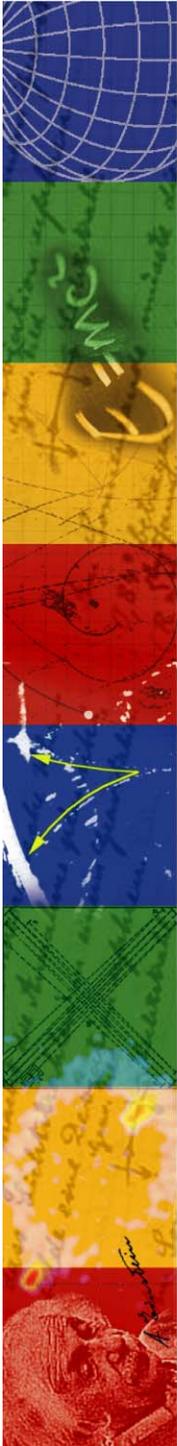
Incontri di Fisica, INFN-LNF, 9.10.2009
Uta Bilow, TU Dresden

Outline

- Introduction
- History
- Participation
- A masterclass day for students
- Press review
- Evaluation
- Future plans



Introduction



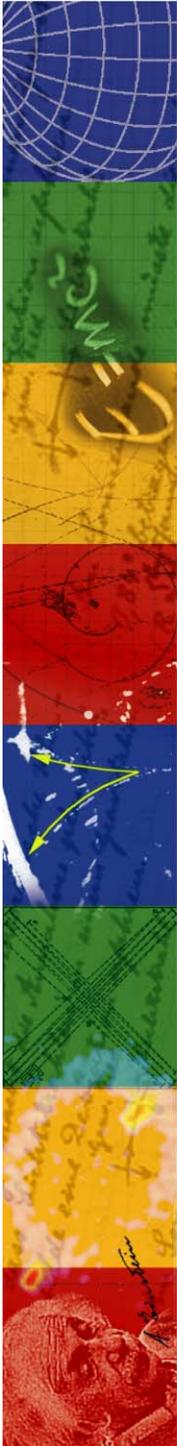
"Hands on Particle Physics"
International Masterclasses

Introduction



"Hands on Particle Physics"
International Masterclasses

Introduction

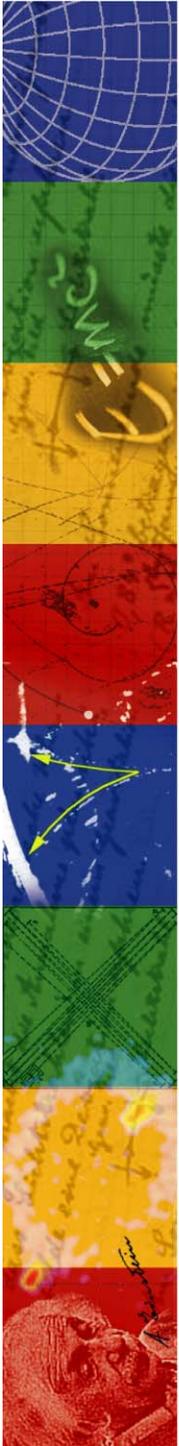


Introduction

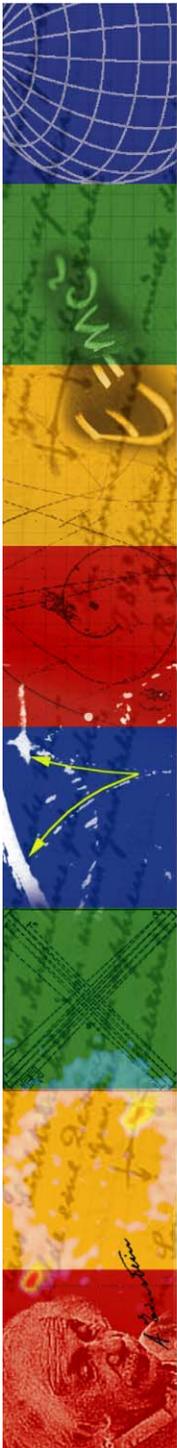


"Hands on Particle Physics"
International Masterclasses

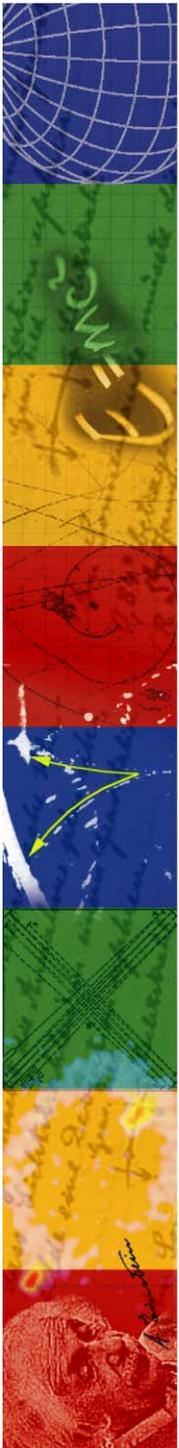
Introduction



Introduction



Introduction



"Hands on Particle Physics"
International Masterclasses

History

- 1997: started in U.K.
- 2005: 1. International EPPOG-Masterclasses
- 2009: large subprogram in USA

Central Organisation: Prof.
Michael Kobel, TU Dresden

Project Manager: Dr. Uta
Bilow, TU Dresden



European Particle Physics Outreach Group



The screenshot shows the EPPOG website. At the top left is a logo consisting of a grid of colored dots. Below it is a navigation menu with links for Members, Activities, Resources, Meetings, Links, and Contact Us. A search bar is also present. The main content area features a map of Europe with several countries highlighted in green. Below the map is a section titled "The European Particle Physics Outreach Group" with a list of bullet points describing its mission and composition.

E P P O G
European Particle Physics Outreach Group

Members
Activities
Resources
Meetings
Links
Contact Us

Members

News

Click on the map to get info on the member countries

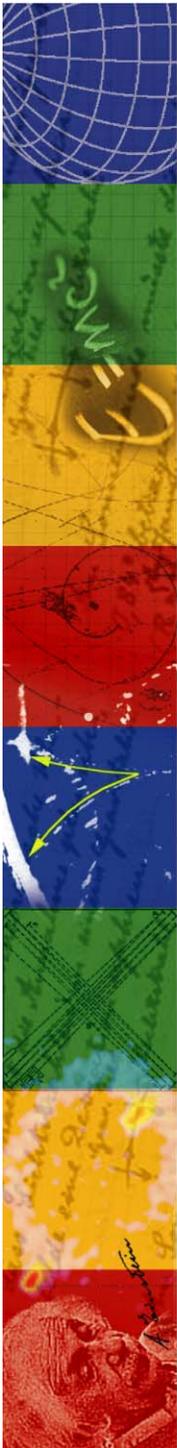
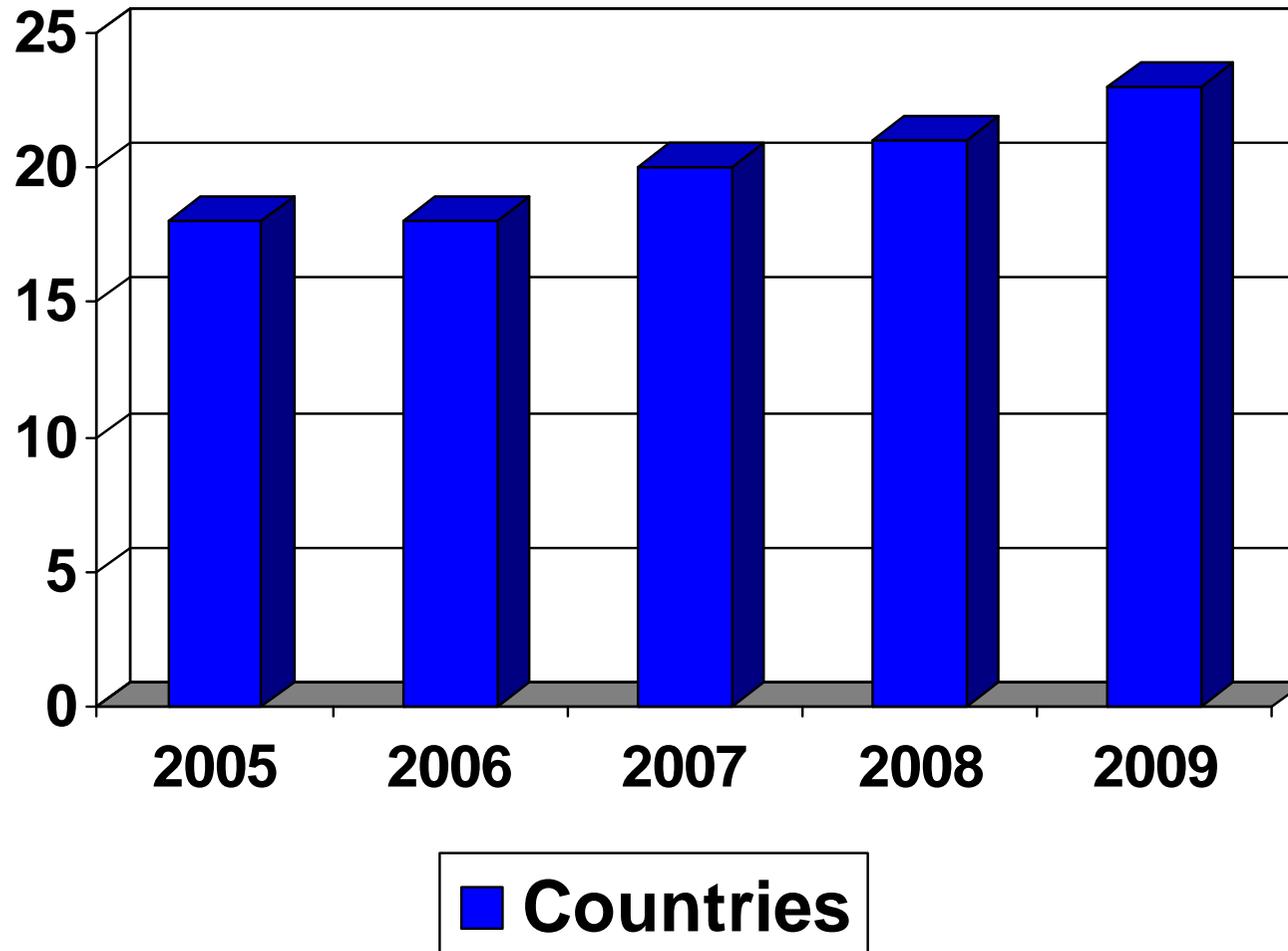
The European Particle Physics Outreach Group

- promotes the outreach activities of particle physics institutes and laboratories in the CERN Member States.
- acts as a forum for the exchange of ideas and experiences related to particle physics outreach.
- was formed under the joint auspices of the European Committee for Future Accelerators (ECFA) and the High Energy Particle Physics Board of the European Physical Society (EPS-HEPP Board).
- is composed of
 - one member nominated by the particle physics community of each CERN Member State (normally the responsible person for outreach activities in the state concerned).
 - one member each from DESY and CERN, appointed by the managements of those laboratories.
 - additional representatives from particle physics experiments, astroparticle physics and non-Member States of CERN.

- 32 members
- Italian representative: Catia Peduto (INFN press office)



Participation



Participation 2009

23 nations

USA

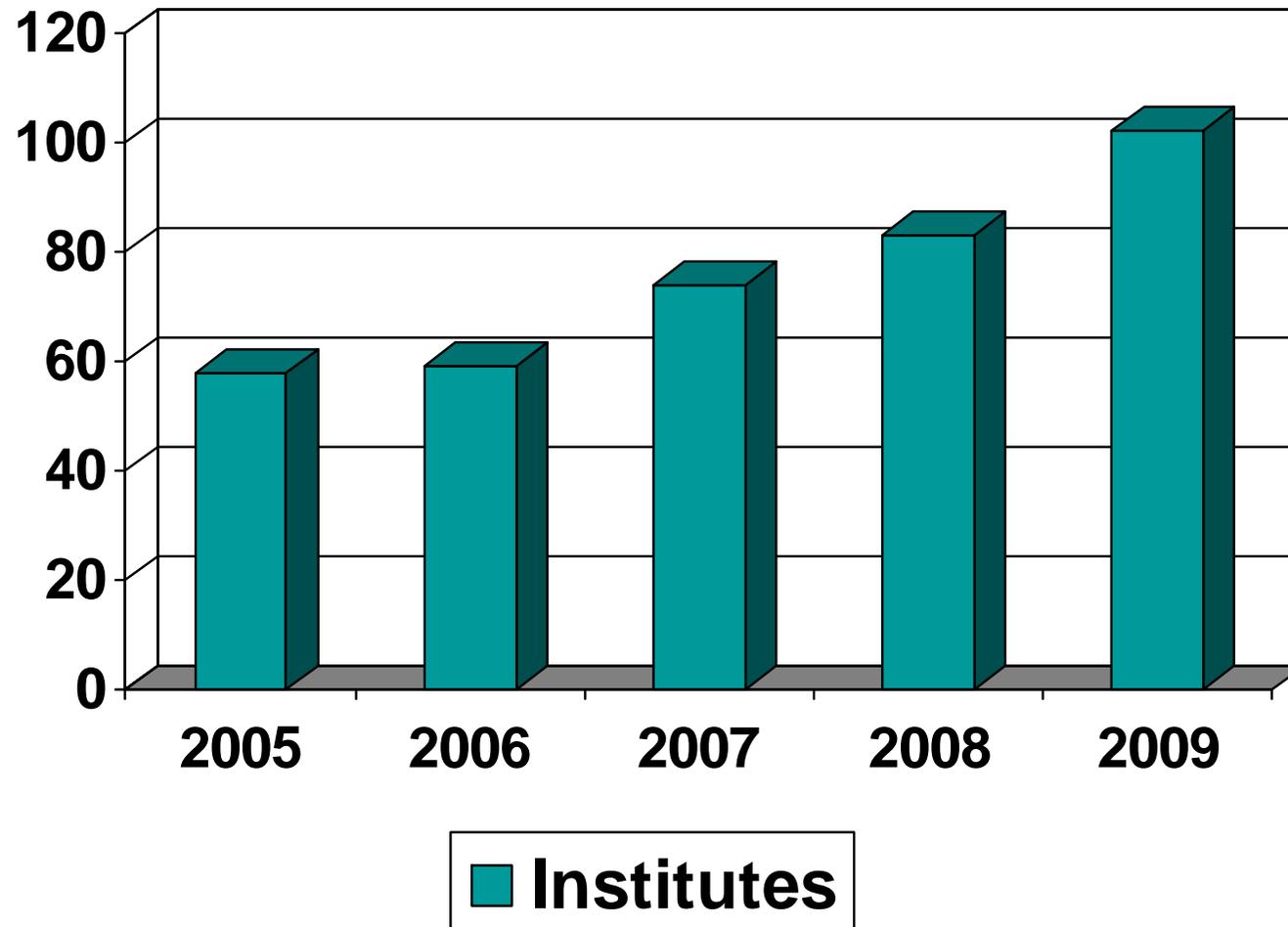
Brazil



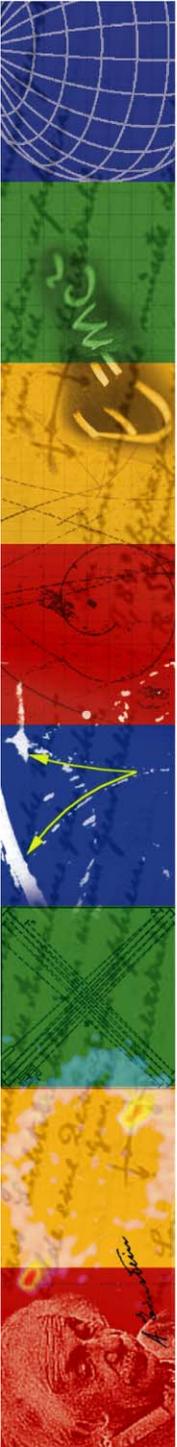
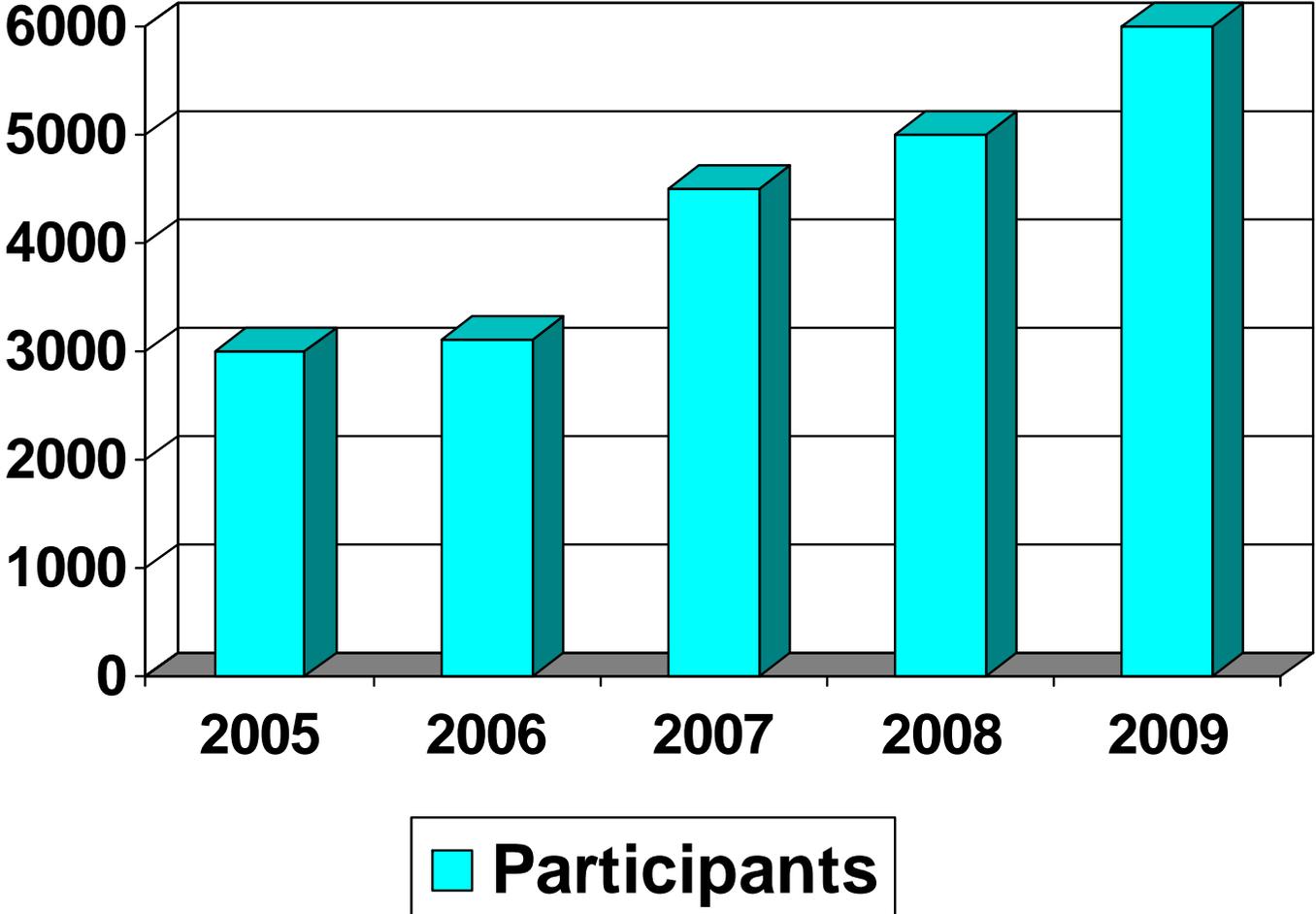
South Africa

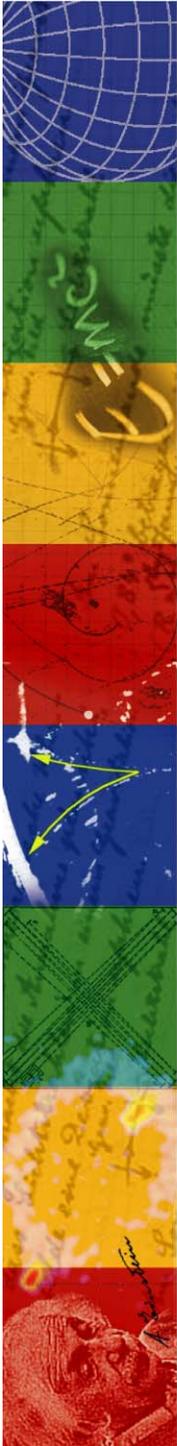
"Hands on Particle Physics"
International Masterclasses

Participation



Participation



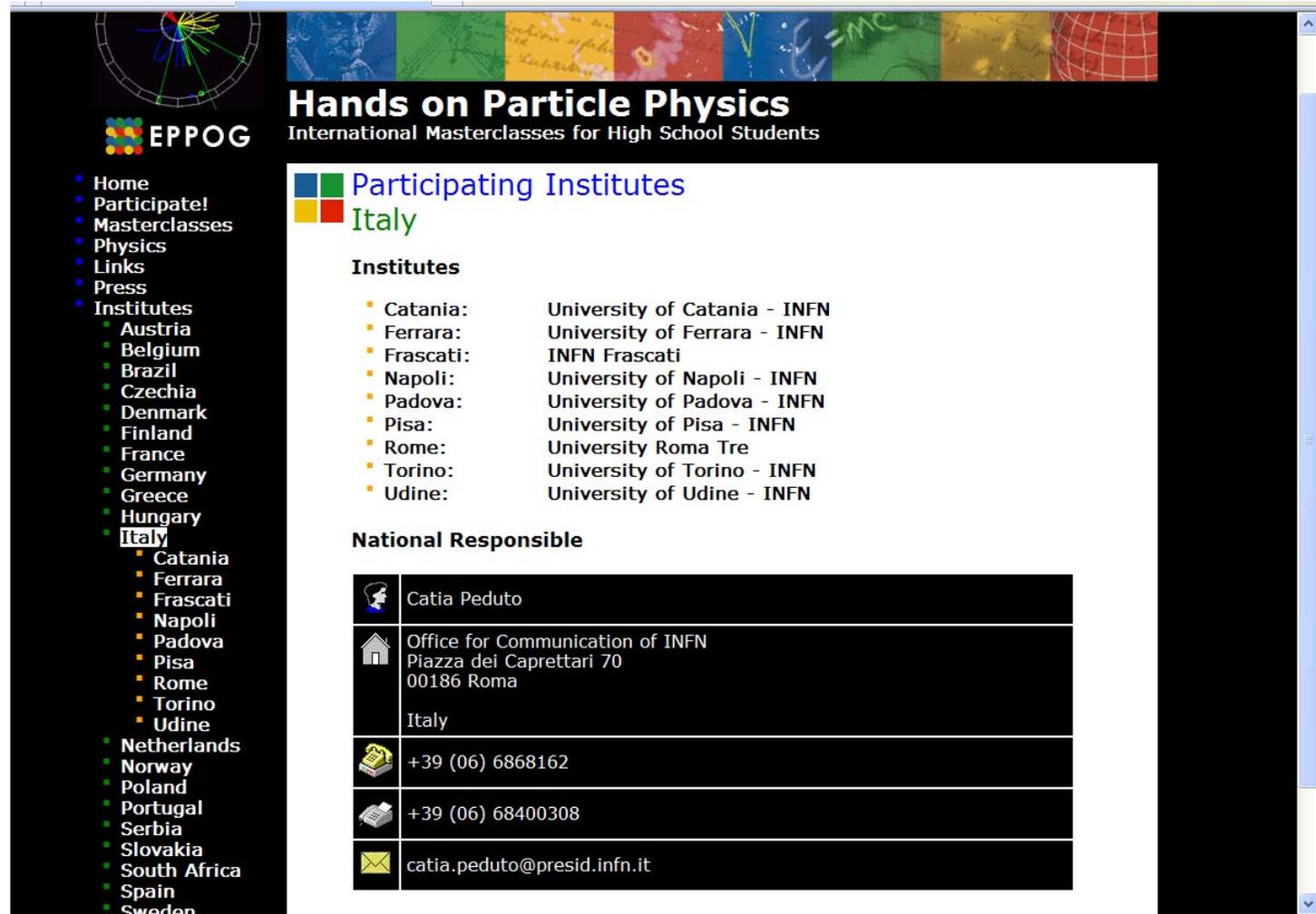


Italy



"Hands on Particle Physics"
International Masterclasses

Italy



EPPOG

Hands on Particle Physics
International Masterclasses for High School Students

- Home
- Participate!
- Masterclasses
- Physics
- Links
- Press
- Institutes
 - Austria
 - Belgium
 - Brazil
 - Czechia
 - Denmark
 - Finland
 - France
 - Germany
 - Greece
 - Hungary
 - Italy**
 - Catania
 - Ferrara
 - Frascati
 - Napoli
 - Padova
 - Pisa
 - Rome
 - Torino
 - Udine
 - Netherlands
 - Norway
 - Poland
 - Portugal
 - Serbia
 - Slovakia
 - South Africa
 - Spain
 - Sweden

Participating Institutes

Italy

Institutes

- Catania: University of Catania - INFN
- Ferrara: University of Ferrara - INFN
- Frascati: INFN Frascati
- Napoli: University of Napoli - INFN
- Padova: University of Padova - INFN
- Pisa: University of Pisa - INFN
- Rome: University Roma Tre
- Torino: University of Torino - INFN
- Udine: University of Udine - INFN

National Responsible

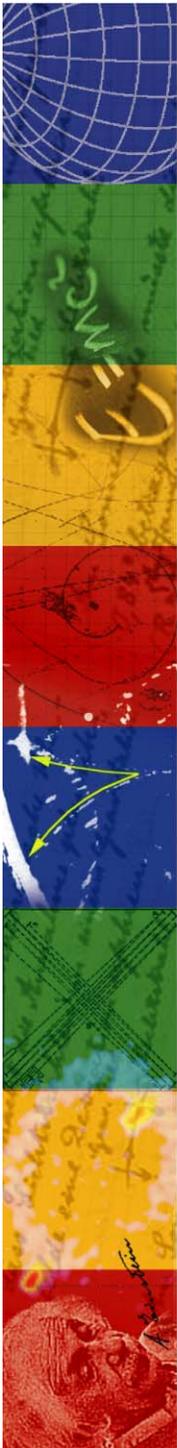
	Catia Peduto
	Office for Communication of INFN Piazza dei Caprettari 70 00186 Roma Italy
	+39 (06) 6868162
	+39 (06) 68400308
	catia.peduto@presid.infn.it

Italy

Italian students in Masterclasses 2009

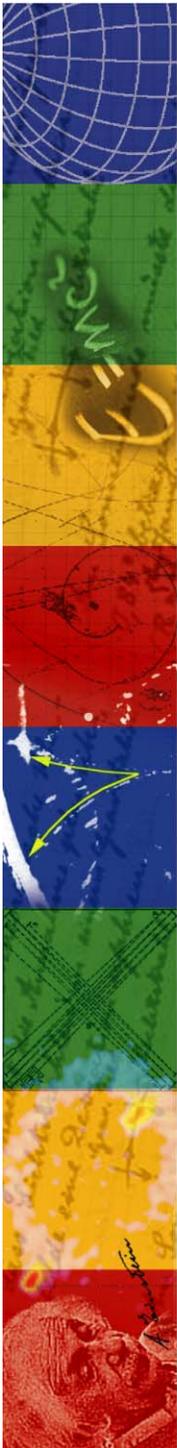
Catania:	60
Ferrara:	125
Frascati:	40
Napoli:	120
Padova:	330
Pisa:	80
Roma:	90
Torino:	80

$\Sigma = 925$ students



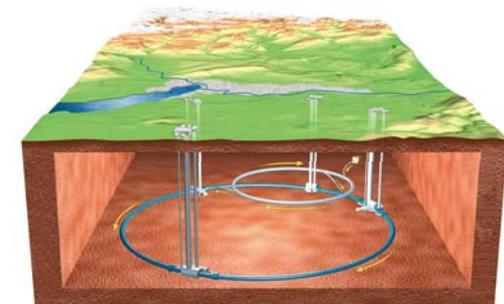
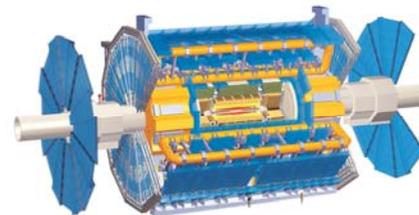
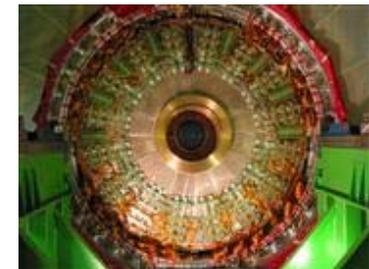
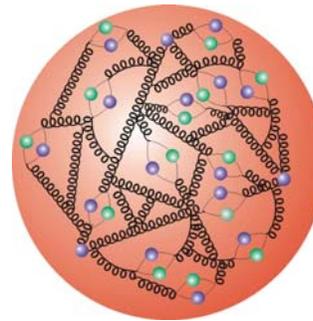
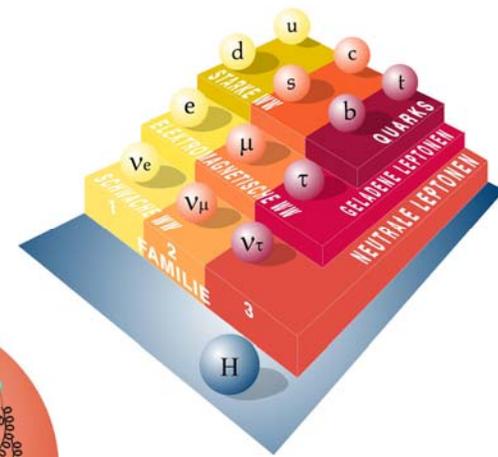
Why Masterclasses?

- Stimulate interest in science
- Demonstrate the scientific research process
- Make data from modern particle physics experiments available for students
- Explore the fundamental forces and building blocks of nature



Agenda

- Lectures
 - Standard model, Accelerators, Detectors
 - institute's activities, cosmology etc.
- Lunch with physics students and tutors
- Exercises
- Video conference

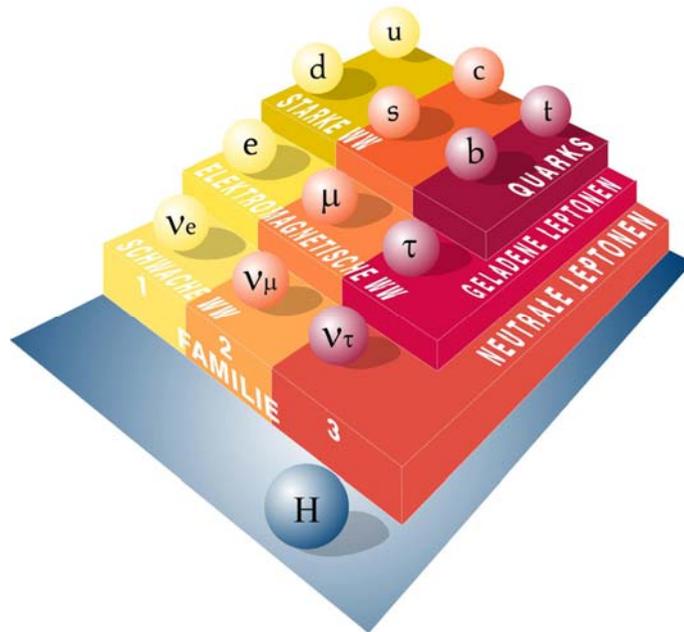


Exercises

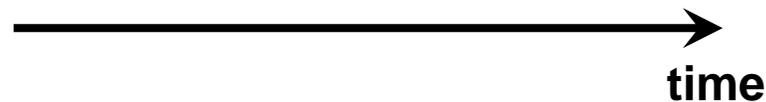
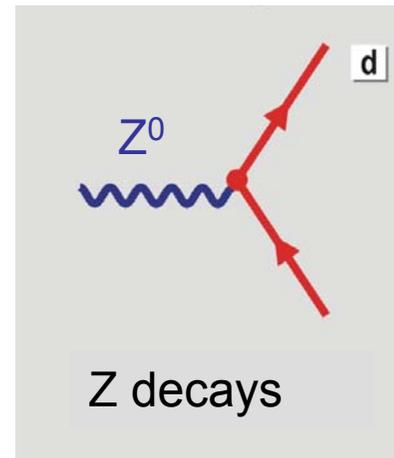
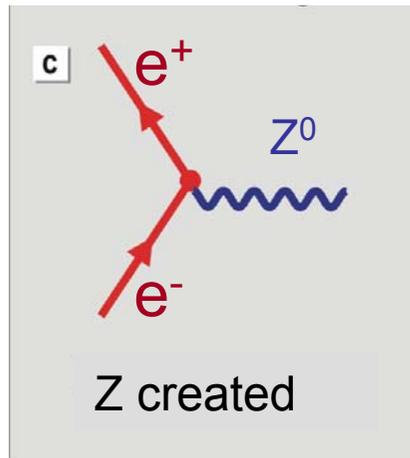


- PC-pool
- working in pairs
- Introduction
- working largely independently
- 10 tutors / 100 students

Exercises



- Z^0 -decays at LEP
- Lifetime: 3×10^{-25} seconds



$$Z^0 \rightarrow e^+e^-$$

$$Z^0 \rightarrow \mu^+\mu^-$$

$$Z^0 \rightarrow \tau^+\tau^-$$

$$Z^0 \rightarrow 2q$$

Exercises

Measurement of branching ratios

$$Z^0 \rightarrow e^+e^-$$

$$Z^0 \rightarrow \mu^+\mu^-$$

$$Z^0 \rightarrow \tau^+\tau^-$$

$$Z^0 \rightarrow 2q$$



Exercises

Hands on Particle Physics - Windows Internet Explorer

//www.physicsmasterclasses.org/physics/physics.htm

Konvertieren ▾ Auswählen

Infos zu Google Te... Masterclass Orient... wie im letzten Jahr... EPPOG - Hands ...

- Ident. Particles
- Particle Physics
- BaBar
- Le Monde des P.
- KworkQuark
- Teilchentour I
- Teilchentour II
- LHC
- Unischule
- Links
- Press
- Institutes
- Imprint

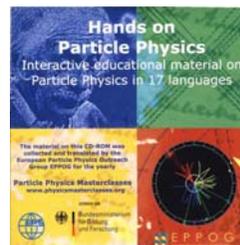
• Which forces hold them together?
 • How do these forces work?
 • How far have the secrets of forces and matter been understood so far?

Find the answers to these and other questions by browsing, reading, and working through some of the educative materials on particle physics which is collected here. Most of the material contains interactive elements, some even real particle physics events for making your own measurements, and understanding particle physics "hands-on". The material was collected for the EPPOG Particle Physics Masterclasses, where some of the measurements form the practical exercises for high school students spending a day at one of the [Research Institutes](#). More info on the teaching systems, which are suited for a wide range of readers, is accessible via the menu in the left column.

Hands-On-Cern	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
A Keyhole to the Birth of Time				X						X		X		X	X							
Identifying Particles				X		X	X		X					X								X

www.physicsmasterclasses.org

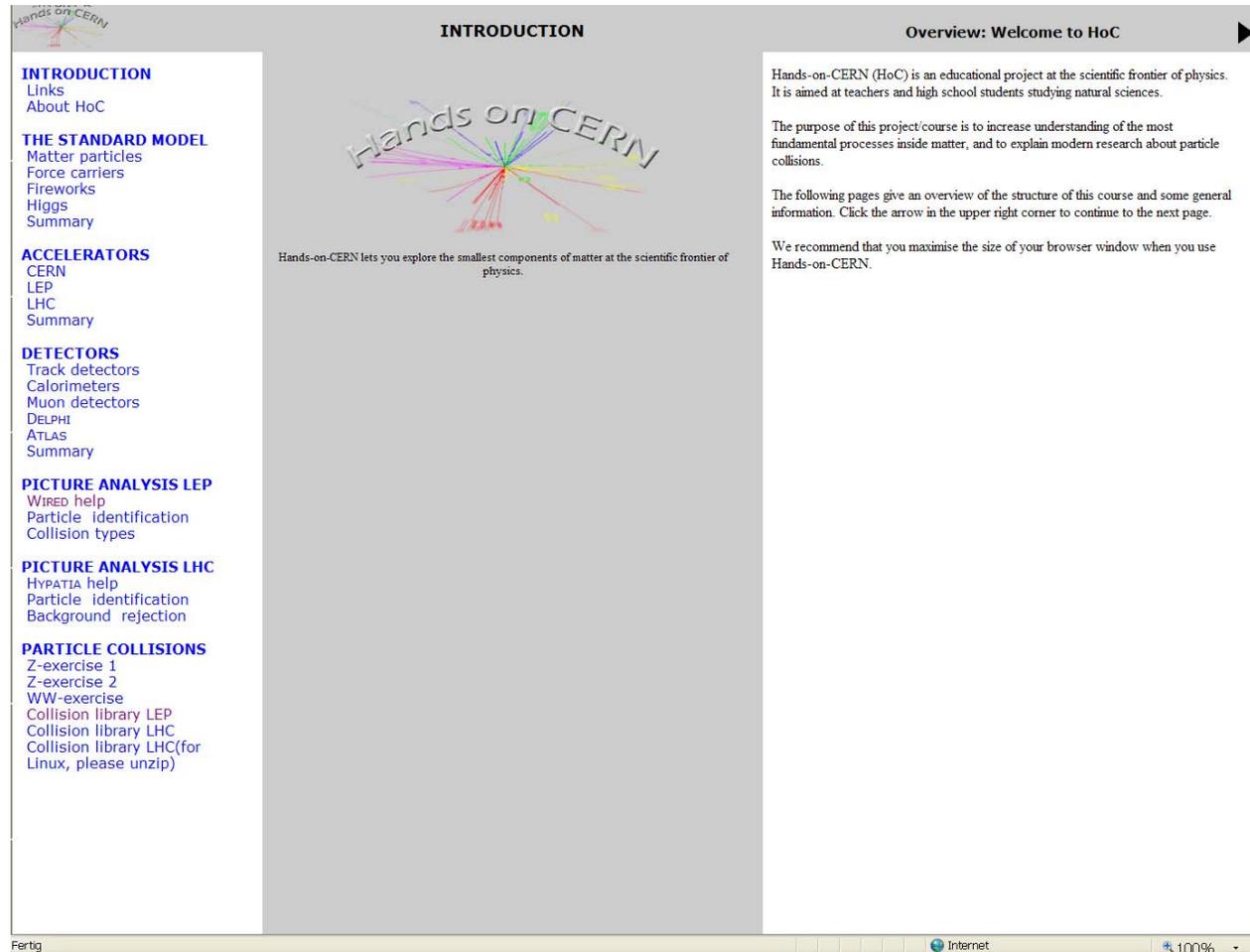
CD



"Hands on Particle Physics"
International Masterclasses

Exercises

Hands-on-CERN (DELPHI)



The screenshot shows a web browser window displaying the 'Hands on CERN' website. The page is titled 'INTRODUCTION' and features a navigation menu on the left side. The menu includes sections for 'INTRODUCTION', 'THE STANDARD MODEL', 'ACCELERATORS', 'DETECTORS', 'PICTURE ANALYSIS LEP', 'PICTURE ANALYSIS LHC', and 'PARTICLE COLLISIONS'. The main content area displays the 'Hands on CERN' logo and a brief introduction to the project. A right-hand sidebar contains an 'Overview: Welcome to HoC' section with a right-pointing arrow. The browser's status bar at the bottom shows 'Fertig', 'Internet', and '100%'.

INTRODUCTION
Links
About HoC

THE STANDARD MODEL
Matter particles
Force carriers
Fireworks
Higgs
Summary

ACCELERATORS
CERN
LEP
LHC
Summary

DETECTORS
Track detectors
Calorimeters
Muon detectors
DELPHI
ATLAS
Summary

PICTURE ANALYSIS LEP
WIRED help
Particle identification
Collision types

PICTURE ANALYSIS LHC
HYPATIA help
Particle identification
Background rejection

PARTICLE COLLISIONS
Z-exercise 1
Z-exercise 2
WW-exercise
Collision library LEP
Collision library LHC
Collision library LHC(for Linux, please unzip)

INTRODUCTION

Hands on CERN

Hands-on-CERN lets you explore the smallest components of matter at the scientific frontier of physics.

Overview: Welcome to HoC

Hands-on-CERN (HoC) is an educational project at the scientific frontier of physics. It is aimed at teachers and high school students studying natural sciences.

The purpose of this project/course is to increase understanding of the most fundamental processes inside matter, and to explain modern research about particle collisions.

The following pages give an overview of the structure of this course and some general information. Click the arrow in the upper right corner to continue to the next page.

We recommend that you maximise the size of your browser window when you use Hands-on-CERN.

Exercises

Hands-on-CERN (DELPHI)

WIRED - ECP/IPT - DELPHI - WWW Interactive Remote Event Display - Window

http://www.physicsmasterclasses.org/exercises/hands-on-cern/wired/ch/cern/wired/html/z0_1998_01.l

Konvertieren Auswählen

WIRED - ECP/IPT - DELPHI - WWW...

Event information			Event Selection	
Ecms	Nr tracks	Energy	Run/Event (year)	
96	25	93.9	83024/05950 (98)	

DELPHI - (657)

Mouse

Rotate Zoom

Views

End view Side view

Reset

DELPHI Barrel

VbDet TrDet

EMCal HaCal

MuDet

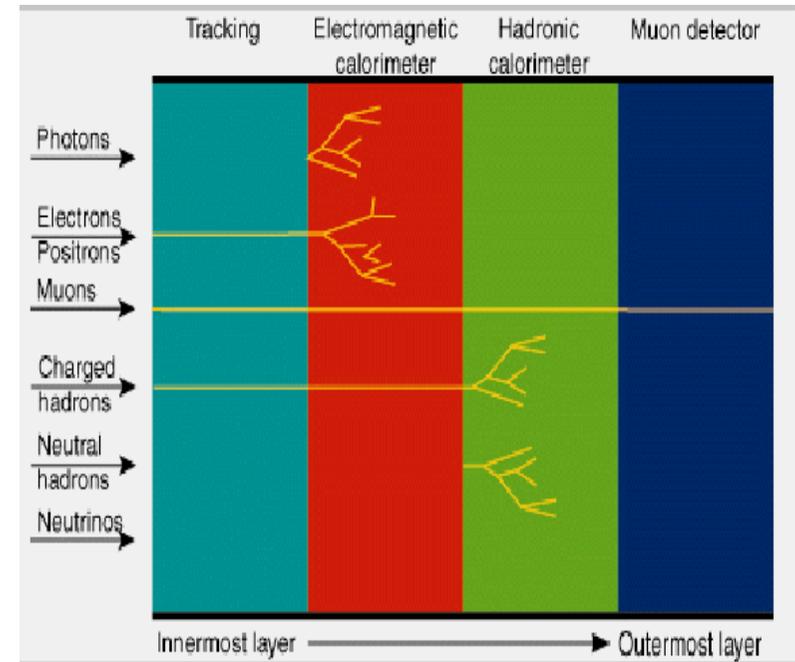
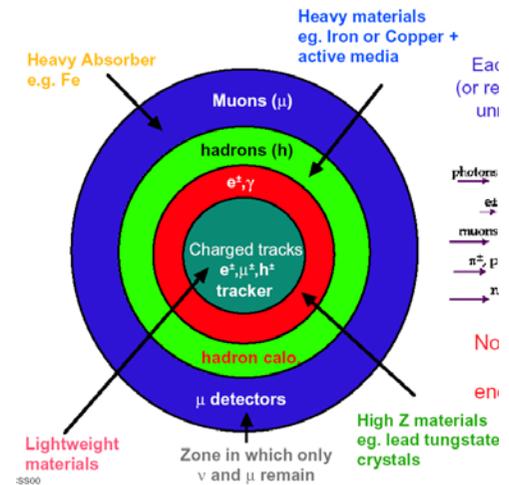
DELPHI Forward

EMCal HaCal

MuDet

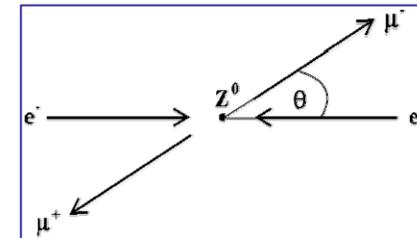
WIRED Development Team, ECP/IPT
Copyright 1996, CERN, Geneva, Switzerland

1 out of 1000 events

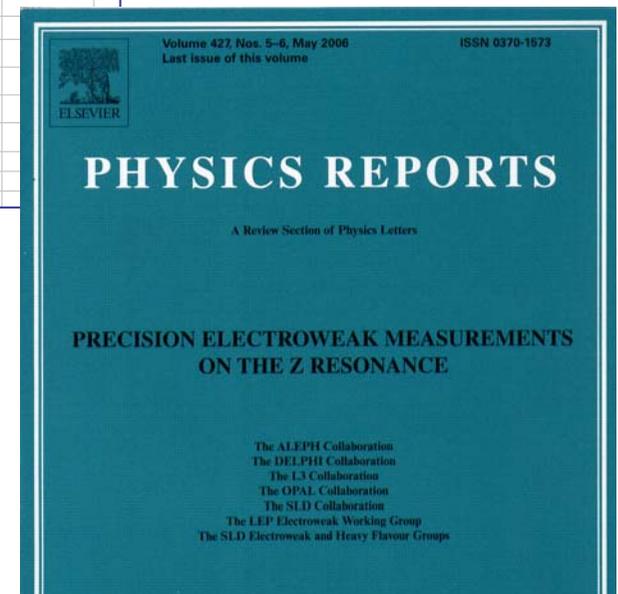


Exercises

	A	B	C	D	E	F	G
1	Group	Electrons	Myons	Taus	Quarks		
2	A (1-100)	4	6	4	86		
3	B (101-200)	2	2	2	94		
4	C (201-300)	3	3	3	91		
5	D (301-400)	2	7	4	87		
6	E (401-500)	3	5	4	88		
7	F (501-600)	3	10	7	80		
8	G (601 -700)	6	5	3	86		
9	H (701-800)	3	4	7	86		
10	I (801-900)	1	2	5	92		
11	J (901-1000)	4	0	4	92		
12							
13							
14	Sum all	Sum e	Sum μ	Sum τ	Sum q		
15	1000	31	44	43	882		
16	Sum corr	Sum e corr	Sum μ	Sum τ	Sum q		
17	1018,6	49,6	44,0	43,0	882,0		
18	Stat. Uncertainty	8,9	6,6	6,6	29,7		
19							
20	Fract. of Visible	e / all	μ / all	τ / all	q / alle	q / ((e+μ+τ)/3)	
21		0,049	0,043	0,042	0,866	19,4	
22	Stat. Uncertainty	0,009	0,006	0,006	0,011	2,1	
23							
24							
25	Theory	0,04212	0,04212	0,04212	0,8736	20,74	
26							
27	LEP Result	0,04200	0,04204	0,04208	0,8738	20,77	
28	Uncertainty	0,00005	0,00008	0,00010	0,0012	0,03	
29							
30							
31							



LEP results published in:
Physics Report, May 2006



Exercises

Identifying Interesting Particle Physics Events at LEP

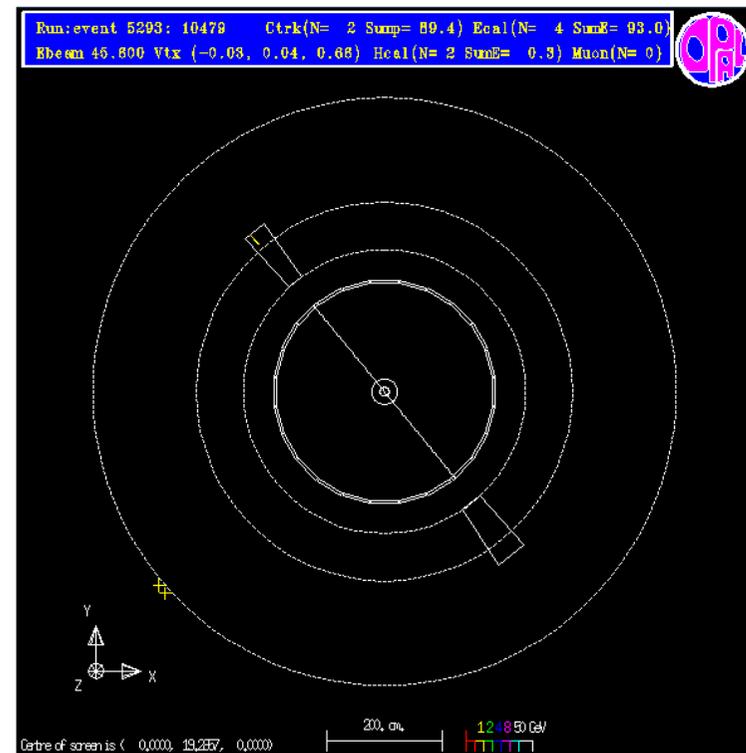
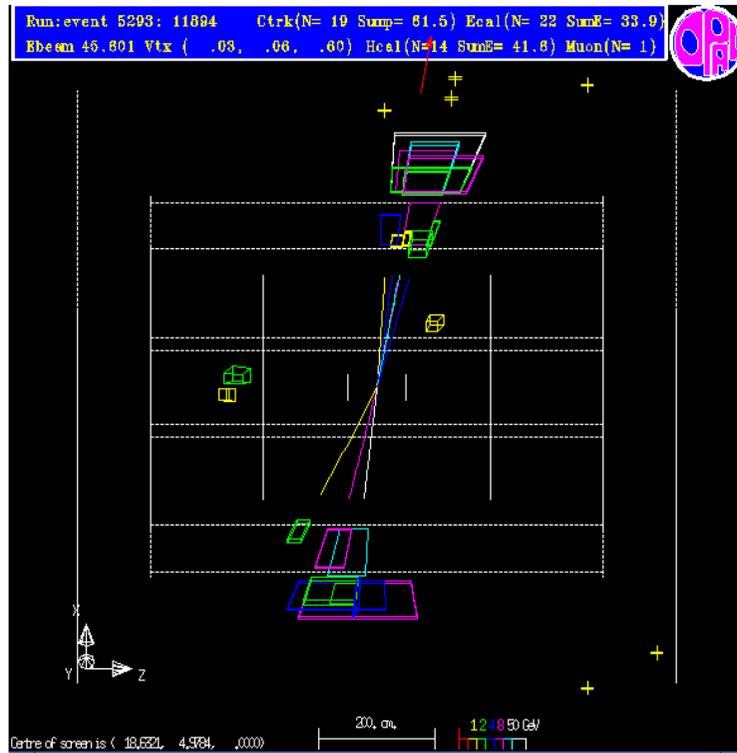
The purpose of these web pages is to allow you to identify some interesting particle physics interactions or "events" for yourself. These events were observed using experiments called [OPAL](#), and [ATLAS](#) at [CERN](#), near to Geneva. The Opal Experiment ran from 1989-2000 at [LEP](#) (Large Electron-Positron Collider) which was at the time the largest particle accelerator of the world. The ATLAS detector is located at the new LHC (Large Hadron Collider). In the LHC, in contrast to LEP, the colliding beams consisting of protons.

The emphasis is very much on your active participation. I have tried to explain as simply as possible a few important things you need to know about our experiment and the different types of events that can occur. But the main parts are where you play the role of "particle detective" and identify for yourself pictures of different types of event.

Table of Contents

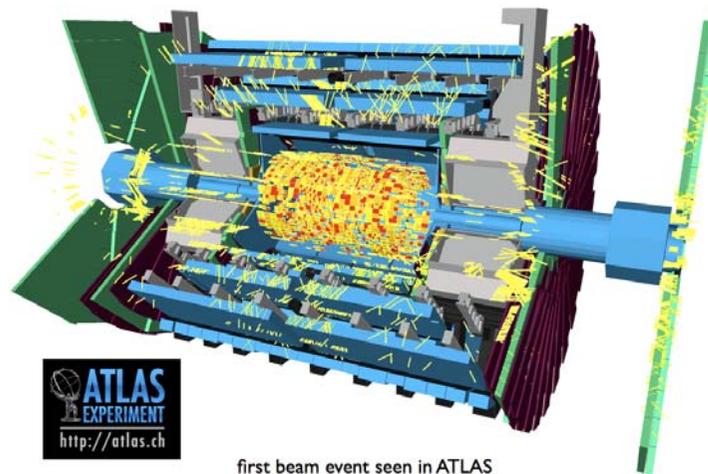
-  [Introduction](#)
-  [The Opal Detector and How to Understand the Event Pictures](#)
-  [The ATLAS Detector and How to Understand the Event Pictures](#)
-  [The Challenge \(Part 1\)](#)
-  [How to Identify Events Containing a Particle-Antiparticle Pair](#)
-  [The Challenge \(Part 2\)](#)
-  [How to Identify Events Containing a Pair of W Particles](#)
-  [The Challenge \(Part 3\)](#)
-  [The Challenge \(Part 4\)](#)
-  [How to Identify Slightly More Complicated Types of Event](#)
-  [The Challenge \(Part 5\)](#)
-  **A Different Sort of Challenge: Making Measurements**
-  [Measuring \$Z^0\$ decays at LEP](#)
-  [Measuring \$Z^0\$ decays at LHC](#)
-  **NEW** [Measuring W decays](#)

Exercises



Exercises

- LHC start up in Sept. 2008
- Include LHC in masterclasses
- lectures
- exercises



first beam event seen in ATLAS



Exercises

The screenshot displays the HYPATIA software interface, which is used for particle physics data analysis. It consists of three main windows:

- HYPATIA - Canvas Window:** Shows a top-down view of the detector's cross-section. The detector is represented by concentric rings of different colors (red, green, blue, yellow). A central region is dark red. Numerous tracks are visible, originating from the center and extending outwards. The axes are labeled X (m) and Y (m), ranging from -10 to 10.
- HYPATIA - Track Momenta Window:** Displays a table of track momenta. The table has columns for Track ID, Energy (E [GeV]), sign (+/-), Transverse Momentum (Pt [GeV]), azimuthal angle (ϕ), and pseudorapidity (θ). The tracks are numbered from 0 to 57.
- HYPATIA - Control Window:** Contains controls for the visualization. It has three sections: Projection, Interaction, and Cut. The Cut section has a checkbox for $|Pt| > 1.0$ GeV. There are also radio buttons for End-View, Side-View, Zoom, and Pick.

The Windows taskbar at the bottom shows the Start button, system tray icons, and the current time as 13:21.

Track	E [GeV]	+/-	Pt [GeV]	ϕ	θ
Tracks 0	4.79	-	1.89	0.969	1.976
Tracks 1	9.93	+	9.55	1.657	2.864
Tracks 2	3.01	-	1.97	2.931	2.286
Tracks 3	9.68	-	9.53	5.591	0.176
Tracks 6	2.84	-	2.09	5.716	2.401
Tracks 8	15.99	+	3.87	1.763	1.815
Tracks 10	226.22	+	156.02	3.916	2.332
Tracks 13	3.47	-	3.46	5.614	0.066
Tracks 16	23.07	+	5.29	1.664	1.802
Tracks 17	4.81	+	3.92	5.744	0.617
Tracks 18	2.87	+	2.34	5.811	0.617
Tracks 20	1.45	-	1.41	5.031	0.252
Tracks 21	1.54	+	1.18	5.502	2.447
Tracks 24	1.80	-	1.43	5.474	0.650
Tracks 25	3.74	+	3.43	5.885	0.410
Tracks 27	2.08	+	1.26	3.099	2.224
Tracks 28	3.21	+	2.35	5.639	2.394
Tracks 31	4.07	-	3.25	5.934	0.647
Tracks 33	3.30	-	2.73	5.863	0.593
Tracks 34	13.69	+	2.63	0.567	1.377
Tracks 35	16.51	-	11.15	5.458	2.312
Tracks 36	6.21	-	1.23	0.444	1.372
Tracks 38	1.29	-	1.28	2.515	0.098
Tracks 40	2.33	-	2.28	5.334	2.933
Tracks 41	31.72	+	10.77	0.937	1.917
Tracks 42	1.75	-	1.66	5.430	2.820
Tracks 43	9.81	-	2.08	0.394	1.357
Tracks 44	18.70	-	17.91	1.645	2.849
Tracks 45	3.09	-	2.36	5.514	2.440
Tracks 46	6.68	-	1.20	0.555	1.390
Tracks 47	6.84	+	4.51	5.606	2.291
Tracks 49	4.41	+	1.57	1.471	1.934
Tracks 50	55.55	-	33.71	3.095	2.223
Tracks 54	73.74	+	20.00	1.666	1.846
Tracks 55	8.75	+	8.64	5.702	0.160
Tracks 57	16.35	-	9.74	3.117	2.209

Video Conference

- Introduction by moderators
- Combination of results
- Discussion
- Quiz
- Q+A-Session

	Mo, March 16th	Tu, March 17th	We, March 18th	Th, March 19th	Fr, March 20th	Sa, March 21st
topic	Z0	Z0 + as	Z0	Z0	Z0	Z0
Moderator	Peter Zoe	Peter Vicki	Matthew Tom	Matthew Zoe	Matthew Julia	Zoe Tom
	Innsbruck	Paris	Rome	São Paulo	Barcelona	Paris
	Warsaw	Nitra	Oslo	Pisa	Debrecen	Heraklion
	Lodz	Katowice	Torino	Siegen	Graz	Lisboa IST
	Helsinki	Stockholm	Ferrara	Palaiseau	LAL	Lisboa FCUL
		München	Prague	Padova	Amsterdam	Coimbra
		Ferrara				Covilhã

	Mo, March 23rd	Tu, March 24th	We, March 25th	Th, March 26th	Fr, March 27th	Sa, March 28th
topic	Z0	Z0	Z0	Z0 + as	Z0 + as	Z0
Moderator	Michael Julia	Peter Sue	Sue Tom	Vicki Michael	Sam Tom	Michael Sam
	Poznan	Trnava	Freiburg	Uppsala	Zaragoza	Porto FCUP
	Wuppertal	Berlin/DESY Zeuthen	Würzburg	Zilina	Granada	Johannesburg
	Heidelberg	Kopenhagen	Aachen	Banska Bystrica	Bratislava	HEPHY Wien
	Bern	DESY Hamburg	Faro	Szekesfehervar	Brookhaven Nat. Lab.	
	Zürich	Trencin	U. California Riverside	Palaiseau	Belgrade	
	Athens Demokritos				Uni Wien (FNAL videoconference)	

	Mo, March 30th	Tu, March 31st	We, April 1st	Th, April 2nd	Fr, April 3rd
topic	Z0	Z0	Z0 + as	Z0	Z0
Moderator	Vicki Sue	Peter Michael	Sue Sam	Vicki Julia	Julia Sam
	Dresden	Athens Ilisia	Kosice	Thessaloniki	Presov
	Erlangen	Rio de Janeiro	Mons	Santander	Bergen
	Valencia	Budapest	Athens Zografou	Lund	Göttingen
	Krakow	London		Bonn	Santiago de Compostela

Moderators 2009



**Jula
Draeger**
(CMS
Experiment)



**Zoe
Matthews**
(ALICE
Experiment)



**Sue
Cheatham**
(ATLAS
Experiment)



**Sam
Harper**
(CMS
Experiment)



**Michael
Hauschild**
(ATLAS
Experiment)



**Vicki
Moeller**
(ATLAS
Experiment)



**Peter
Steinbach**
(ATLAS
Experiment)



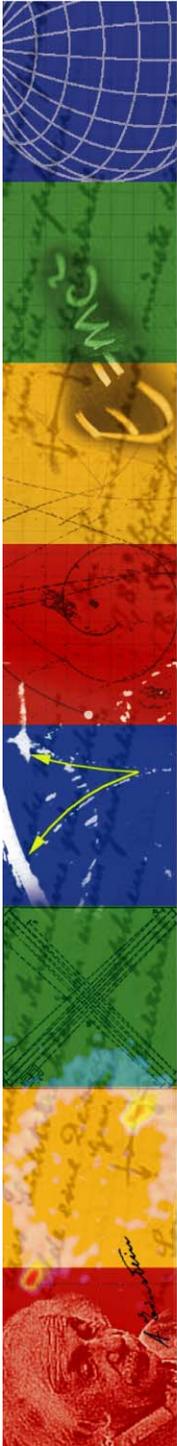
**Matthew
Tamsett**
(ATLAS
Experiment)



**Tom
Whyntie**
(CMS
Experiment)

Video Conference

EVO video



"Hands on Particle Physics"
International Masterclasses

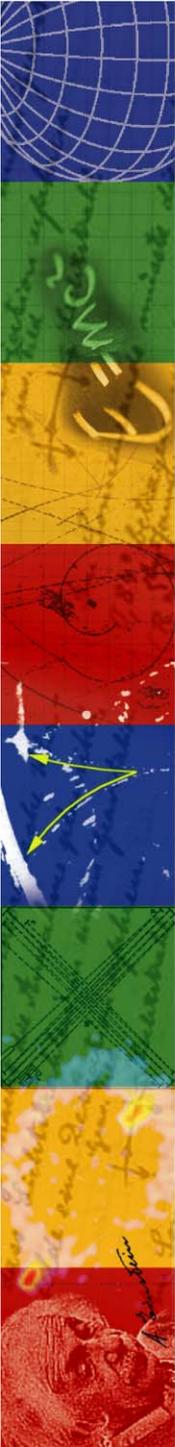
Video Conference

global combination of results

http://www.physicsmasterclasses.org/downloads/Zcombine

http://www.physicsmasterclasses.org/downloads/Zcombine.xls

	A	B	C	D	E	F	G	H	I
1	Town (COUNTRY)	0: DELPHI 1: OPAL	Electrons	Myons	Taus	Quarks		enable institutes	OPAL institut
2	Athens (GR)	1	30	40	30	900		1	1
3	Berlin (DE)	1	30	45	45	880		1	1
4	Bruxelles (BE)	0	40	50	40	870		1	0
5	Budapest (HU)	0	50	40	50	860		1	0
6	Catania(IT)	0	30	40	50	880		1	0
7	Ioannina(GR)	1	20	30	40	910		1	1
8	xx(YY)								0
9			e	μ	τ	q	all	6	3
10	Sum (corr)		248	245	255	5300	6048		
11	Stat. Uncertainty		30	27	28	126			
12									
13	Fract. of Visible		e / all	μ / all	τ / all	q / all	q / ((e+ μ + τ)/3)		
14	Athens (GR)	1	0,047	0,039	0,029	0,884	22,9		
15	Berlin (DE)	1	0,047	0,044	0,044	0,864	19,1		
16	Bruxelles (BE)	0	0,040	0,050	0,040	0,870	20,1		
17	Budapest (HU)	0	0,050	0,040	0,050	0,860	18,4		
18	Catania(IT)	0	0,030	0,040	0,050	0,880	22,0		
19	Ioannina(GR)	1	0,032	0,030	0,040	0,899	26,8		
20	xx(YY)	0	0,000	0,000	0,000	0,000	0,0		
21	DELPHI		0,040	0,043	0,047	0,870	20,1		
22	Statistical Uncertainty \pm		0,006	0,006	0,007	0,011	2,0		
23	Systematic Uncertainty \pm		0,008	0,005	0,005	0,008	1,9		
24	OPAL		0,042	0,038	0,038	0,883	22,5		
25	Statistical Uncertainty \pm		0,008	0,006	0,006	0,010	2,5		
26	Systematic Uncertainty \pm		0,007	0,006	0,006	0,014	2,5		
27	Combination		0,041	0,041	0,042	0,875	21,1		
28	Statistical Uncertainty \pm		0,005	0,004	0,005	0,008	1,6		
29	Systematic Uncertainty \pm		0,006	0,004	0,004	0,007	1,5		
30									



Question 1

Our detector shows a signal *only* in the hadronic calorimeter (no signal in the tracker, electromagnetic calorimeter or muon chambers). Therefore, this signal is most likely

Nuestro detector muestra señal solamente en el calorímetro hadrónico (no en el detector de trazas, calorímetro electromagnético, ni cámaras de muones). Por lo tanto, esta señal es probablemente debida a

Il rivelatore ha un segnale nel calorimetro adronico e nessun segnale nel rivelatore centrale e nelle camere per muoni. Cosa stiamo osservando?

- A. a NEUTRON**
- B. a PION**
- C. an ELECTRON**
- D. a PHOTON**

Question 3

How do we see
“quarks” in a detector?

¿Cómo se observan
los “quarks” en un
detector?

Come osserviamo i
“quarks” in un
rivelatore?

- a. Not at all
- b. By their characteristic spiral trajectory
- c. Via “jets” of hadrons they generate
- d. As two individual straight tracks in opposite directions

- A. De ningún modo
- B. Por su trayectoria espiral, característica
- C. Mediante los “chorros” de hadrones que producen
- D. Como dos trazas rectas individuales en direcciones opuestas

- A. Sono invisibili
- B. Hanno una caratteristica traccia a spirale
- C. Formano “jets” di adroni
- D. Danno luogo a due tracce dritte in direzioni opposte

Question 6

Approximately how many times do the protons in the LHC fly around the accelerator ring in 1 second?

¿Cuántas vueltas por segundo dan , aproximadamente, en el acelerador, los protones en el LHC ?

Quanti giri dell'acceleratore LHC fanno all'incirca i protoni in un secondo?

- A. 1
- B. 100
- C. 10 000**
- D. 1 000 000

Question 7

Superconducting magnets bend the protons around the LHC ring. What do you think is the temperature of these magnets?

Imanes superconductores curvan los protones en el anillo del LHC. ¿Cuál es la temperatura de estos imanes, en su opinión?

I magneti superconduttori di LHC guidano 100,000 milioni di protoni lungo 27km. Quale pensate sia la loro temperatura? (degli magneti)

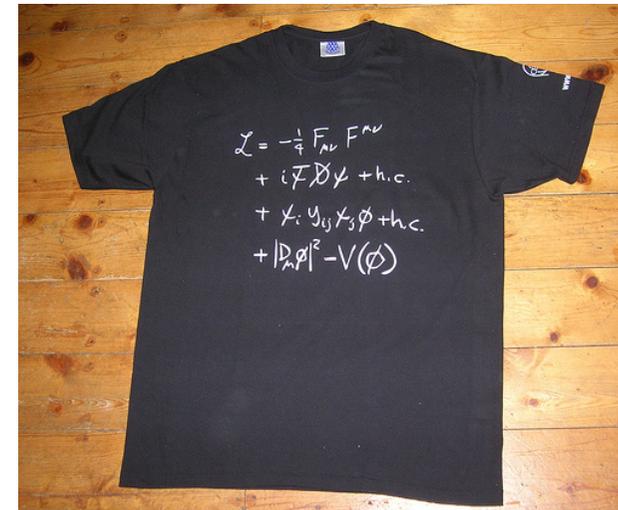
- A. Room temperature, 300K
- B. Colder than outer space, 1.9K
- C. Temperature of outer space, 2.7K
- D. 163.2K

- A. Temperatura ambiente, 300K
- B. Más frío que el espacio exterior, 1.9K
- C. La del espacio exterior, 2.7K
- D. 163.2K

- A. Temperatura ambiente, 300K
- B. Più freddi dello spazio, 1.9K
- C. Temperatura dello spazio, 2.7K
- D. 163.2K

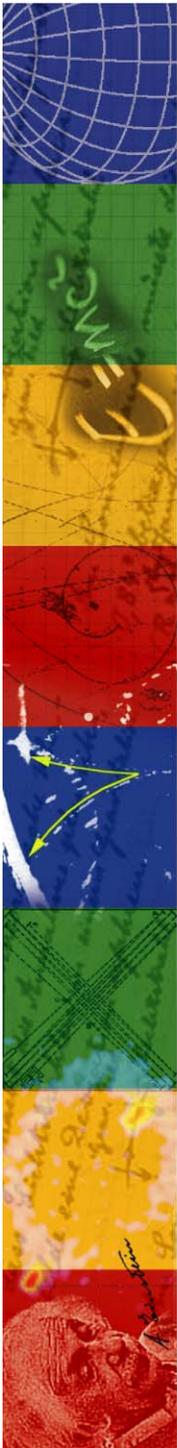
Quiz

Prizes funded by CERN



"Hands on Particle Physics"
International Masterclasses

Press review



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A day in our shoes

6 April 2009



A group from Rutherford Appleton Laboratory's program

While many students aren't introduced to particle physics until they reach university, the International Particle Physics Masterclasses are on a mission to change that, offering students between 16 and 18 years of age the chance to step into a researcher's shoes. This year's international program involves 6000 students from over 80 institutes in 23 countries, including much of Europe, with groups in Brazil, South Africa, and the US. A local sub-program run by Quarknet in the US includes another 22 institutes.

"Students should come as early as possible in contact with the fundamental questions about our universe, get their hands on real data, come in contact with scientists, and experience how fascinating physics can be," says Michael Kobel, the global organiser of the masterclasses. Within the European Particle Physics Outreach Group (EPPOG), he worked alongside Christine Sutton of the CERN Press Office and Erik Johansson of ATLAS to first extend the Particle Physics Masterclasses to Europe in 2005, the World

ATLAS e-News

"Hands on Particle Physics"
International Masterclasses

s - Higgs finds the Higg...

News of The ATLAS Experiment

Mapping the Secrets of the Universe

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ATLAS Higgs finds the Higgs at RAL

April 2009

On Friday, March 13th, British high school student Jonathan Higgs discovered the elusive Higgs boson among the simulated particle tracks in Minerva – a special form of ATLAS's event display program, Atlantis, designed for students in the International Particle Physics Masterclasses. While he didn't earn a Nobel Prize for his find students who performed well won t-shirts, decks of cards, and other rewards.

Michael Kobel, one of the physicists who extended the program across Europe, describes his motivation. "Students should come as early as possible in contact with the fundamental questions about our universe, get their hands on real data, come in contact with scientists, and experience how fascinating physics can be."

One of the British masterclasses was held at Rutherford Appleton Laboratory; they hosted a total of 500 students in three one-day programs from March 11th to 13th. It is one of the oldest sites for the program, starting up just a year after the first masterclasses were held in the UK in 1997. The rest of Europe got in on the fun in 2005, a special effort by the European Particle Physics Outreach Group for the World Year of Physics. The program was so successful that it continued the next year, incorporating the US's QuarkNet, a program with similar aims to connect high school students with real particle physics data.

In 2009, the International Particle Physics Masterclasses are held in most European countries, 13 US states, Brazil, and South Africa. Perhaps the most telling evidence of its success is the fact that enrolment has doubled from 3000 to 6000 since 2005. About half of the day is spent in lectures, learning all the basics of particle physics that the students will need when they are let loose with computer programs that allow them to analyse data from CERN. While events like Jonathan's Higgs are from simulations of particle events in ATLAS, they will be replaced by real events when the LHC turns on.

At the end of the day, students in many locations engage in video conferences using the California Institute of Technology's EVO system, the same program that many CERN physicists use to communicate with one another.

ATLAS news

Press review

MAGAZIN

EPPOG
European Particle Physics Outreach Group

PHYSIKDIDAKTIK

Schüler in die Wissenschaft

Wissenschaft zum Ausprobieren kommt bei Schülern grundsätzlich gut an, vor allem, wenn es sich um moderne Physik handelt. Bei dem vor fünf Jahren gestarteten internationalen Projekt Hands on Particle Physics Masterclasses können Jugendliche das Fachgebiet der Teilchenphysik kennenlernen und aktiv erleben. Vom 16. März bis 4. April hatten sie wieder Gelegenheit dazu.

In den vergangenen Jahren gab es hierzulande einen regelrechten Boom bei der Gründung von Schülerlaboren. Die mittlerweile mehr als 200 Einrichtungen bieten Forschung zum Ausprobieren, beispielsweise auf dem Gebiet der Chemie, der Biologie oder der Technik. Jugendliche können so außerhalb der Schule einen Zugang zu den Naturwissenschaften finden. Die Teilchenphysik jedoch entzieht sich diesem Konzept weitgehend. Denn die dazu nötigen riesigen Beschleuniger an Großforschungseinrichtungen wie dem CERN in Genf lassen sich nicht in kleinem Labormaßstab nachbauen. Bei den Schülerforschungstagen Hands on Particle Physics Masterclasses bekommen Jugendliche jedoch authentische und nachhaltige Einblicke in die Arbeit der Wissenschaftler. Sie arbeiten selber mit Originaldaten der Experimente des CERN.

Einmal im Jahr laden die an den Masterclasses beteiligten Universitäten und Institute Schüler ab Klasse 10 zu einem Forschungstag ein. Die meisten Jugendlichen haben wenig Vorkenntnisse. Doch im Gespräch mit den Wissenschaftlern und Studenten gelingt es rasch, Erkenntnisse der modernen Forschung zu vermitteln.

Die Schüler hören zunächst Vorträge über das Standardmodell der Teilchenphysik und lernen Aufbau und Funktion von Beschleunigern und Detektoren kennen. Antimaterie, Neutrinos, Higgs-Teilchen oder Schwarze Löcher sind Schlagworte, die bei den Teilchenerfahrern regelmäßig auf großes Interesse stoßen und in anschließenden Diskussionen erörtert werden.

Nach diesem Teil folgen die praktischen Übungen, in denen das frisch Gelernte zur Anwendung kommt. Wie die Bezeichnung Hands on zum Ausdruck bringt, können die Schüler selbst aktiv werden. Am PC analysieren sie Daten, die am Teilchenbeschleuniger LEP des CERN bei Kollisionen zwischen Elektronen und Positronen aufgenommen wurden. Praktisch diese Elementarteilchen aufeinander, so vernichten sie sich gegenseitig, und es entstehen neue Teilchen wie Myonen, Tauonen oder Quarks, die sich anhand ihrer charakteristischen Spuren im Detektor identifizieren lassen. In wahrer Detektivarbeit analysieren die Masterclasses-Teilnehmer jeweils Hunderte solcher Ereignisse.

Anschließend kombinieren sie ihre Resultate und interpretieren sie in Diskussionen mit den Forschern. Das Ergebnis: An ihren eigenen Messungen können die Schüler beispielsweise erkennen, dass Elektron, Myon

und Tauon sich ähnlich verhalten und daher zur selben Familie der Leptonen gehören. Grundlegende Erkenntnisse der Teilchenphysik können so selbst nachvollzogen werden.

In einer weiteren praktischen Übung lernen die Teilnehmer auch den neuen Large Hadron Collider (LHC) kennen. Zwar sieht er derzeit still, doch gibt es bereits Simulationen, an denen die Schüler Proton-Proton-Kollisionen untersuchen können. Im nächsten Jahr können die Schüler hoffentlich mit echten LHC-Daten rechnen.

Ein besonderer Höhepunkt erwartet die Teilnehmer am Ende eines solchen Schülerforschungstages: Da treffen Schülergruppen aus verschiedenen Ländern Eurogruppen zusammen. Außerdem schalten sich noch zwei Nachwuchswissenschaftler vom CERN zu, die die Konferenz in englischer Sprache moderieren. Für Teilchenphysiker sind solche virtuellen Konferenzen normal. Für die Schüler ist dieser Einblick in die Organisation moderner Forschung eine gänzlich neue Erfahrung. Aber in der Regel agieren sie selbstverständlich auf der ungewöhnlich großen Bühne, stellen vorzeitig ihre Ergebnisse vor und hören die Moderatoren am CERN mit Fragen zu deren Wertigkeit oder der Physik.

In diesem Frühjahr gab es bei den Hands on Particle Physics Masterclasses mit weltweit mehr als 6000 Schülern eine Rekordbeteiligung. Damit hat sich die Teilnehmerzahl innerhalb von vier Jahren verdoppelt. Der große Zuspruch verwundert nicht, muß man sich in Erinnerung, mit welch riesigen öffentlichen Interesse der Start des neuen Beschleunigers LHC verfolgt wurde. Auch die separaten Fortschrittsstage für Lehrkräfte, die mehrere Institute seit dem vergangenen Jahr anbieten, werden regelmäßig gut besucht. Über einführende Vorträge und die aktive Beschäftigung mit CERN-Daten hinaus erhalten die Lehrer dort Anregungen, wie

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Physik in unserer Zeit

"Hands on Particle Physics"
International Masterclasses

20. Jahrgang • Nr. 7 | 21. April 2009

Dresdner Universitätsjournal

TECHNISCHE UNIVERSITÄT DRESDEN

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Forschungsnetzwerk ... Seite 3

Ausfragt: Wie fühlen sich ausländische
Studenten an der TUD? ... Seite 4

Ausgebildet: Beim Lernen motiviert
vor allem die Praxis ... Seite 5

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Begeistert von Teilchenphysik

UNI-TAG
am 16. Mai 2009
<http://tu-dresden.de/unitag>

Dr. Thomas Bürger
Honorarprofessor

Am 9. April 2009 wurde Dr. Thomas Bürger vom Rektor der TU Dresden zum Honorarprofessor an der Fakultät Sprach-, Literatur- und Kulturwissenschaften ernannt. Die Ernennung erfolgte für das Lehrgebiet »Neuere deutsche Literatur- und Kulturgeschichte (Schwerpunkt: Buchwissenschaft)«. Mit der Beteiligung an der Lehre werden die engen Arbeitsbeziehungen zwischen der Universität und der Sächsischen Landesbibliothek – Staats- und Universitätsbibliothek Dresden (SLUB) weiter intensiviert. Die Gutachter bestätigen Dr. Bürger eine fundierte buch-, bibliografische- und literaturwissenschaftliche Publikationsfähigkeit, die von einem ungewöhnlich breiten wissenschaftlichen Interesse zeugt und eine ungewöhnlich breit angelegte

Schüler forschen
selber herausfinden. Das Rüstzeug dazu erhielten sie bereits vormittags, in Vorträgen. In ihr trafen die Dresdner Teilnehmer auf Schüler aus Erlangen, Valencia und Kroatien.

»Hands on Particle Physics Masterclass Ende März in Dresden: Aufmerksam schauen die Schüler zu, wie Professor Michael Kobel ihre Ergebnisse am PC zusammenfasst. Foto: IKTP/Schwartz

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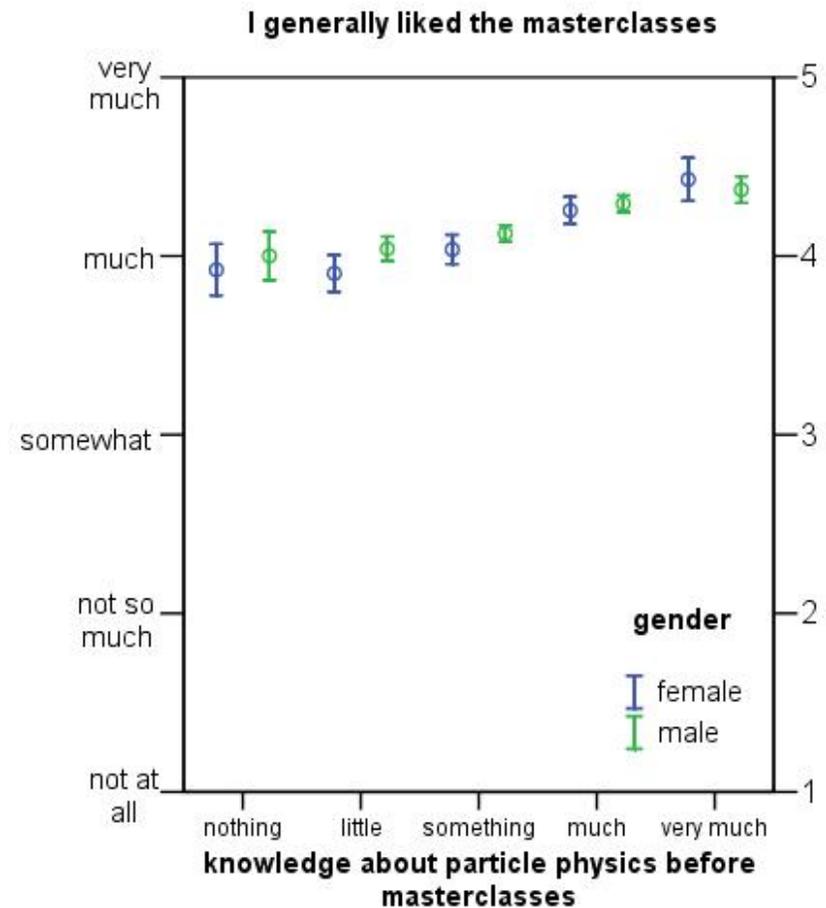
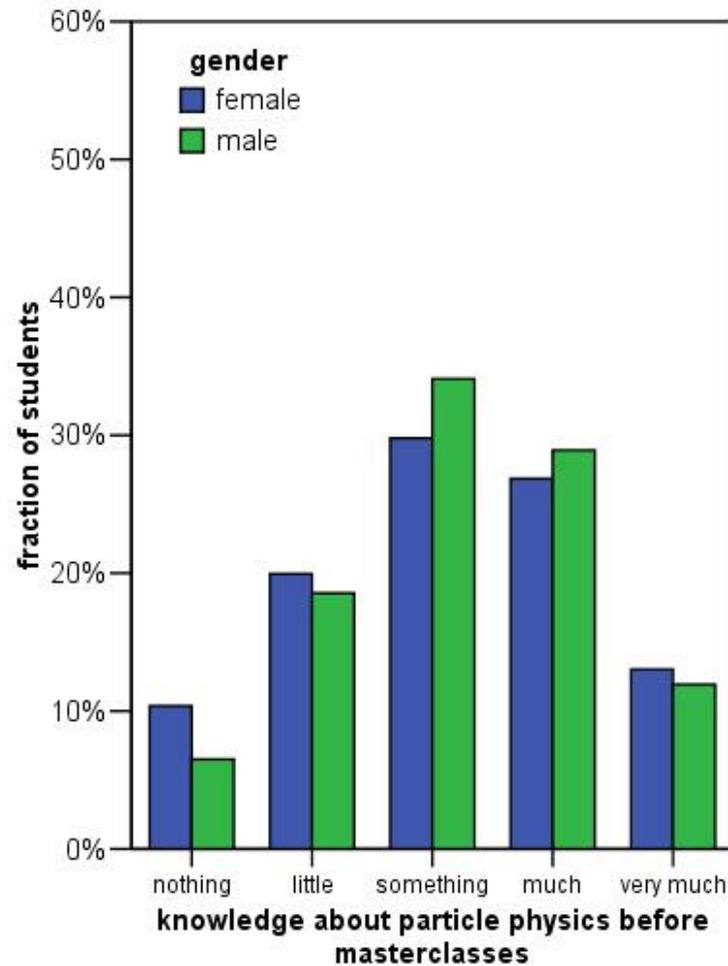
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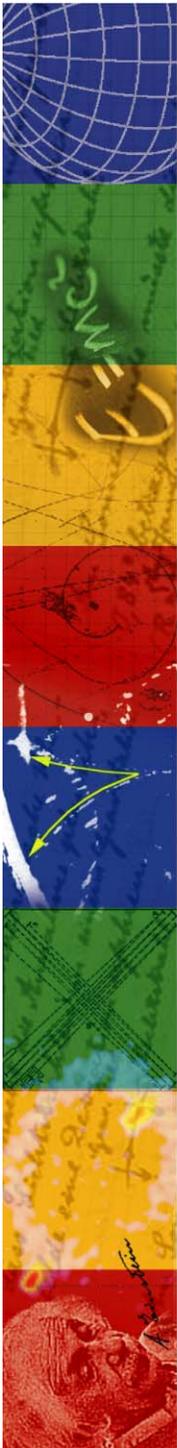
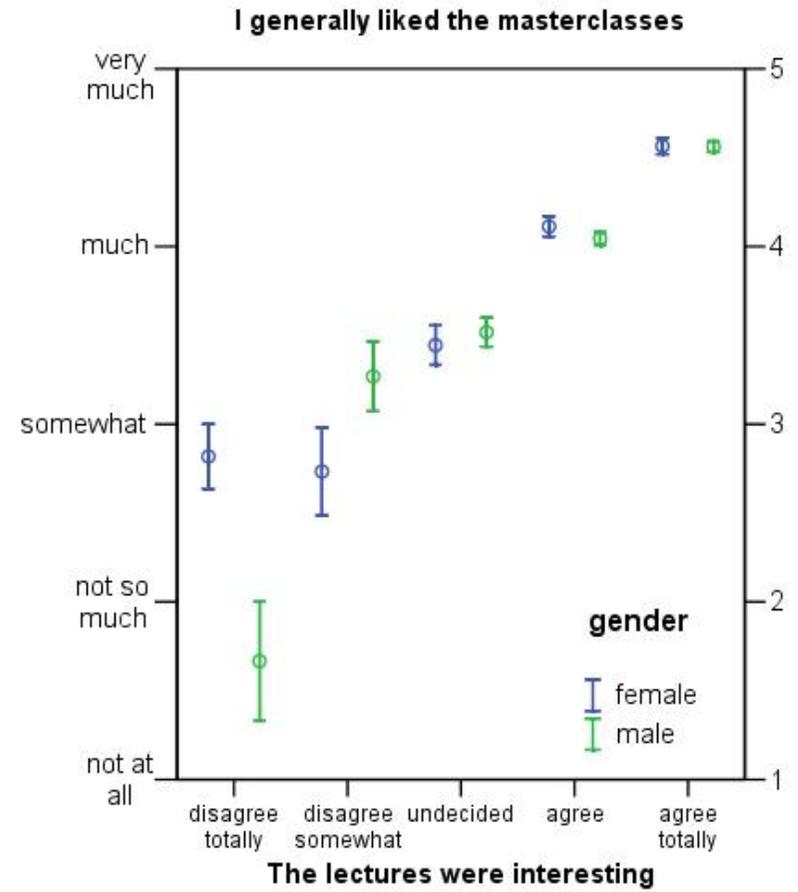
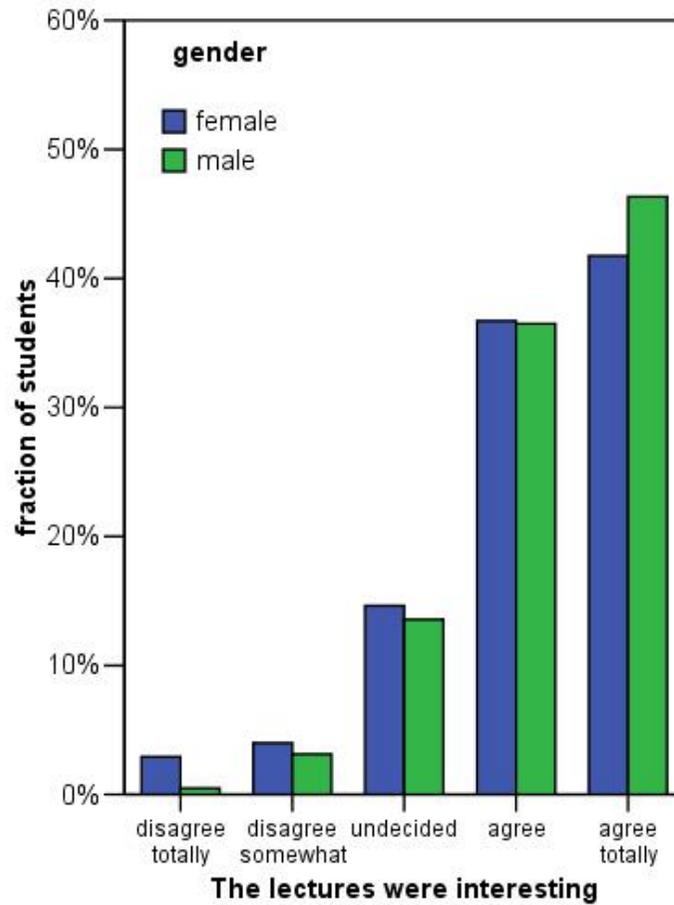
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Evaluation

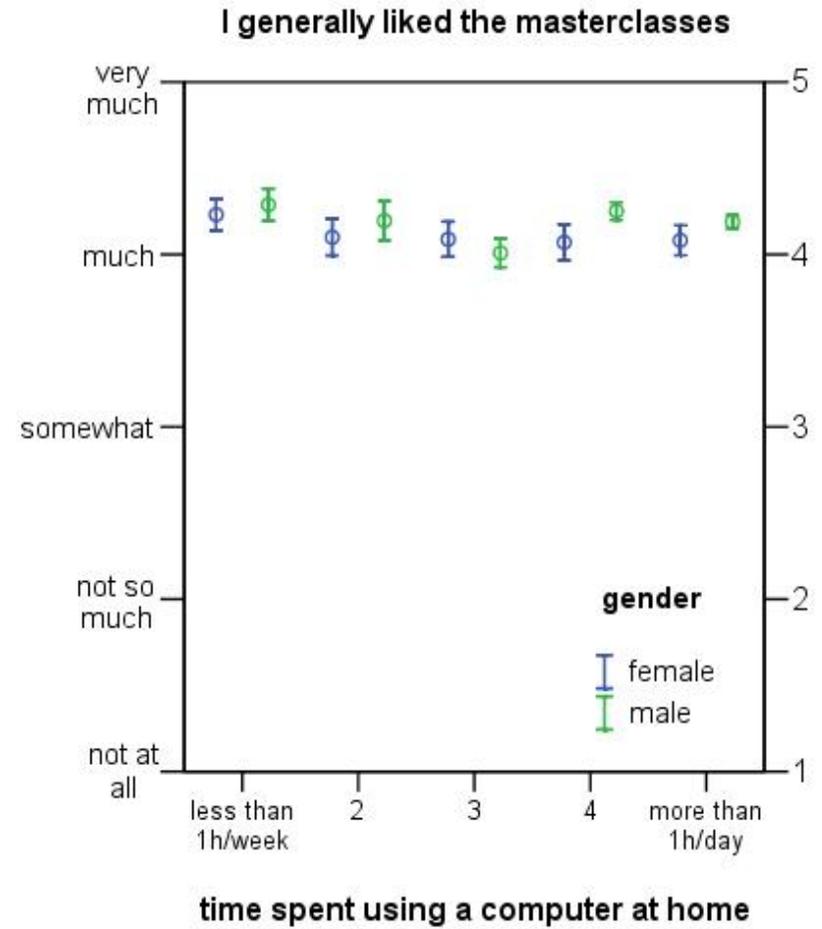
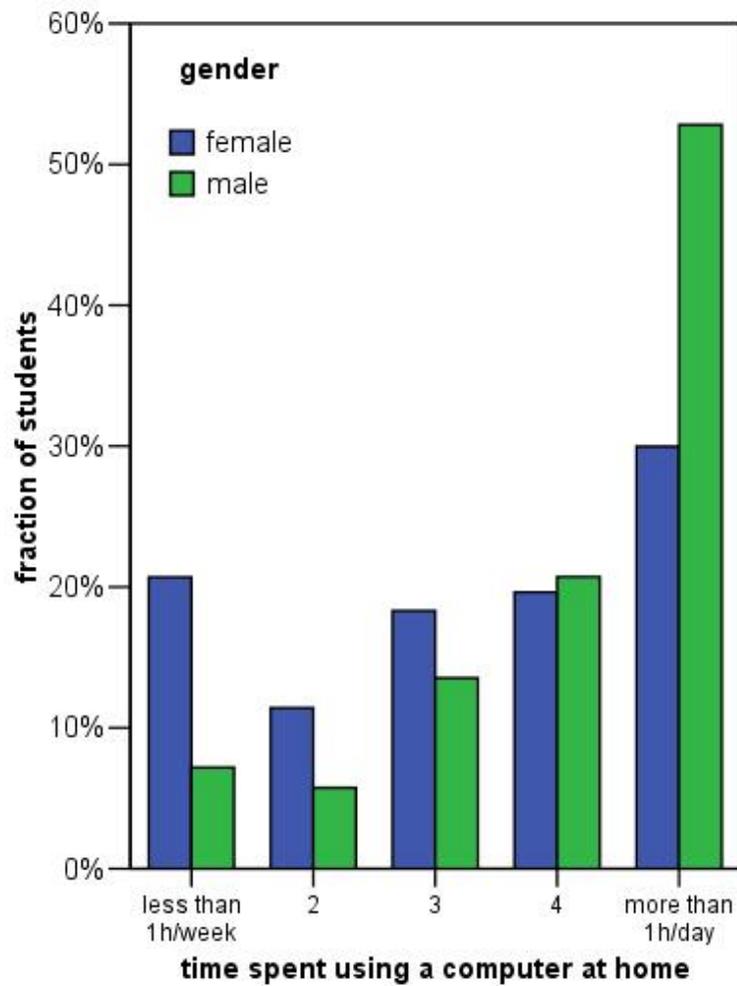
- „Physical Education“ June 2007
- K.E. Johansson, M. Kobel, D. Hillebrandt, K. Engeln and M. Euler
- 373 female / 825 male students, aged 16 to 19, 18 countries



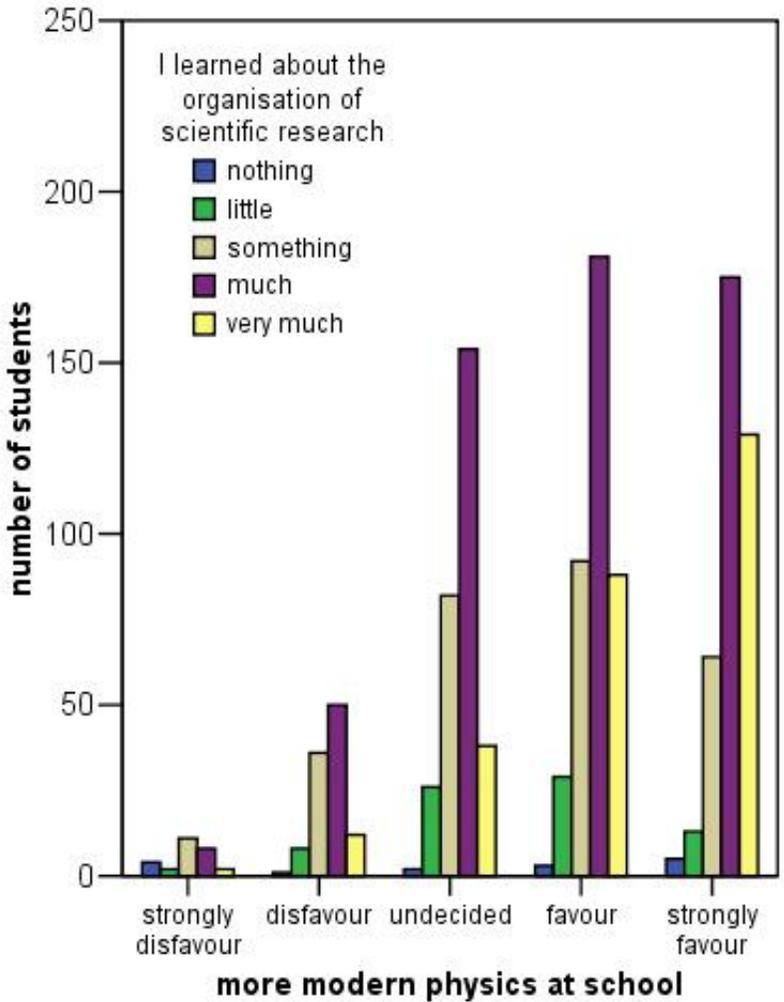
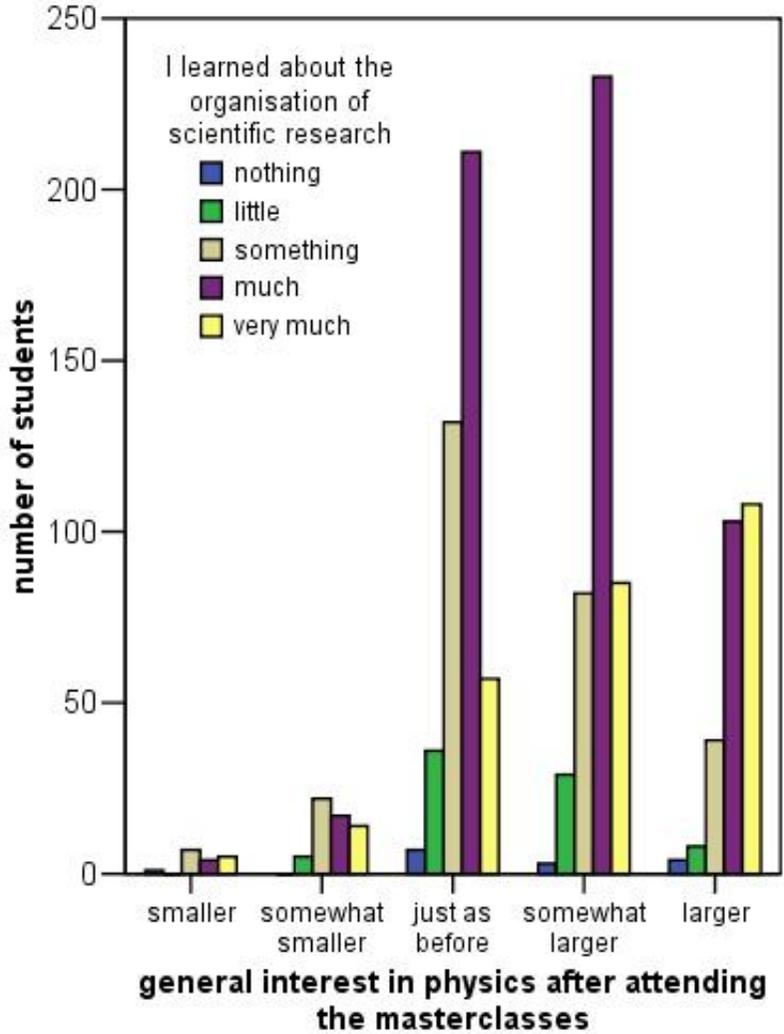
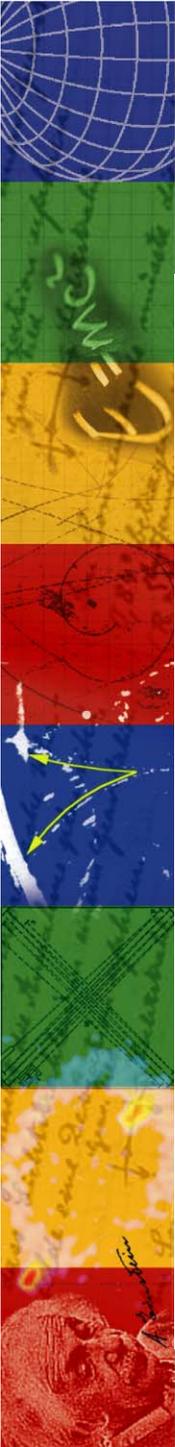
Evaluation



Evaluation

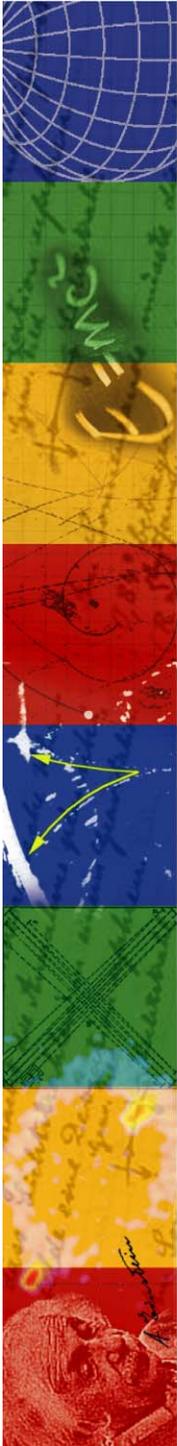


Evaluation



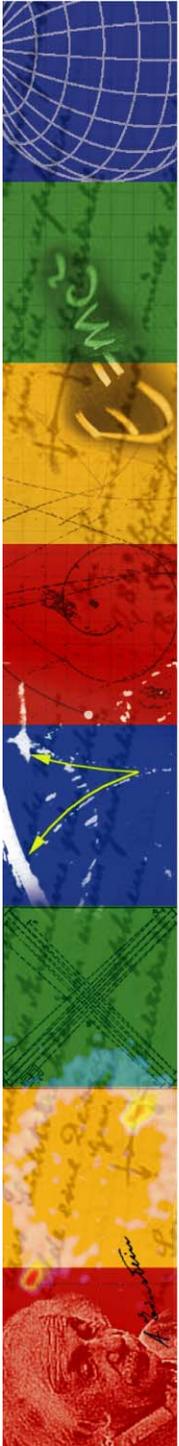
Evaluation

- Outstanding appreciation
- Independent of gender and pre-knowledge
- Important: lectures
- More modern physics at school



Future plans

- Masterclasses at school
- 4 hours
- Ph.D. student and teacher
- Small groups (~ 20 students)
- No video conference



Future plans

- National program in Germany „Netzwerk Teilchenwelt“ in the framework of „Lernwelten der Physik“
- Application in preparation
- Hierarchical program for teachers and students
- 4 levels with decreasing number of participants
 - Basic training: 400 teacher + 6000 students / year
 - Reinforcement program
 - Active Cooperation
 - Research: 5 teachers + 30 students / year

Masterclasses 2010

- 17.2. – 5.3.2010
- Contact institute near to you
- Some institutes hold special teacher day



www.physicsmasterclasses.org



Institute for Nuclear and Particle Physics, TU Dresden