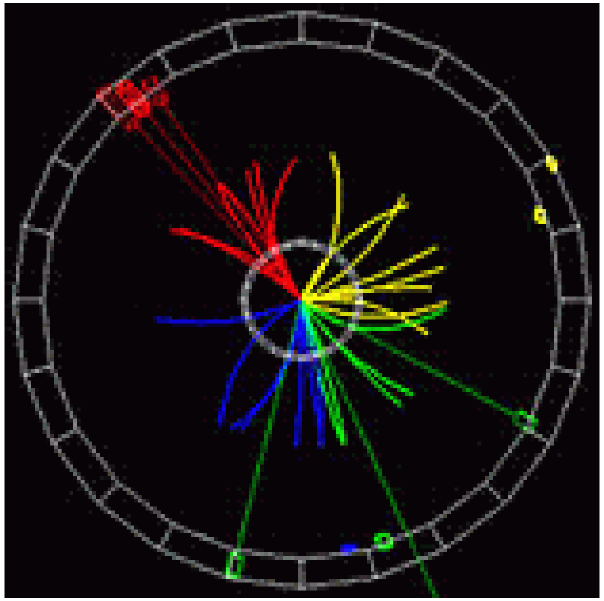
EPPOG International Masterclasses "Hands on Particle Physics"

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

Introduction

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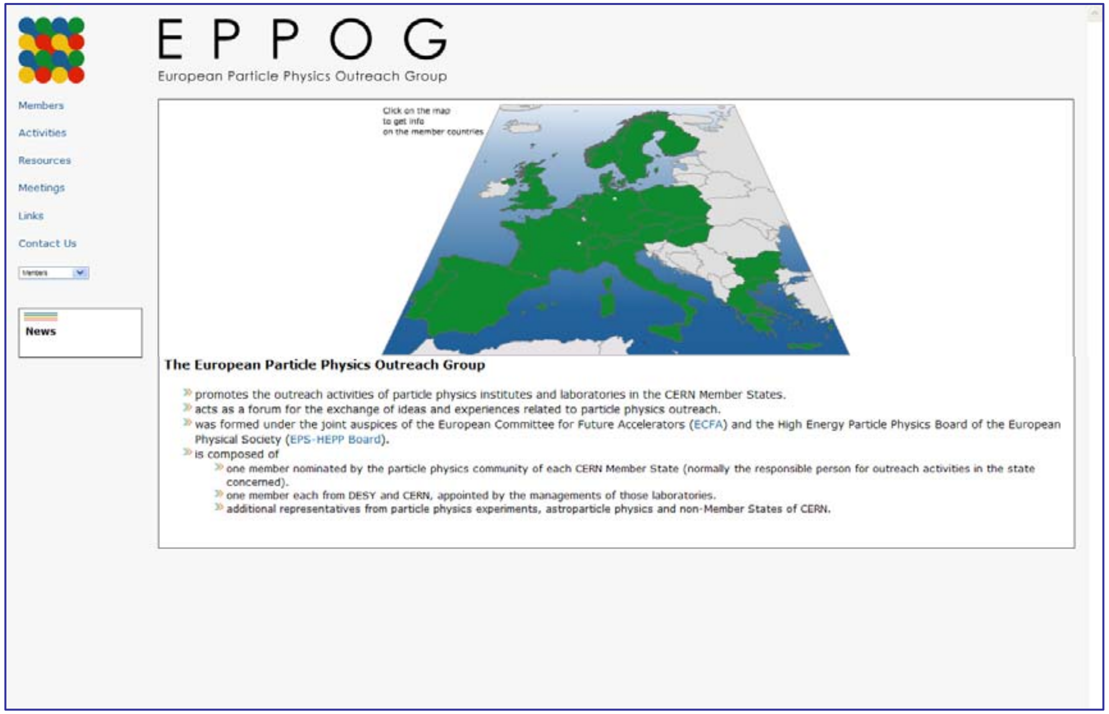
History

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

Central Organisation: Prof. Michael Kobel, TU Dresden

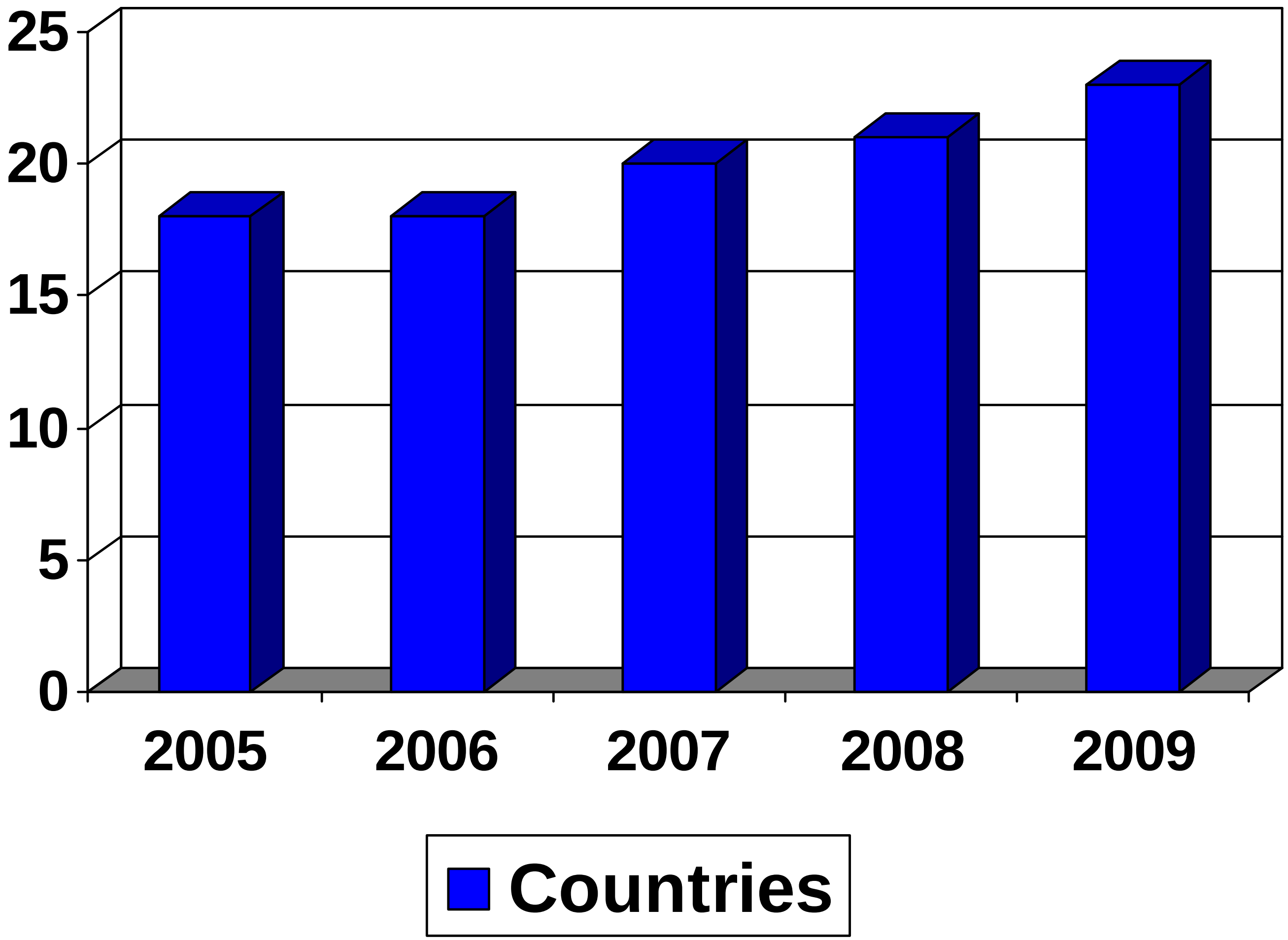
Project Manager: Dr. Uta Bilow, TU Dresden

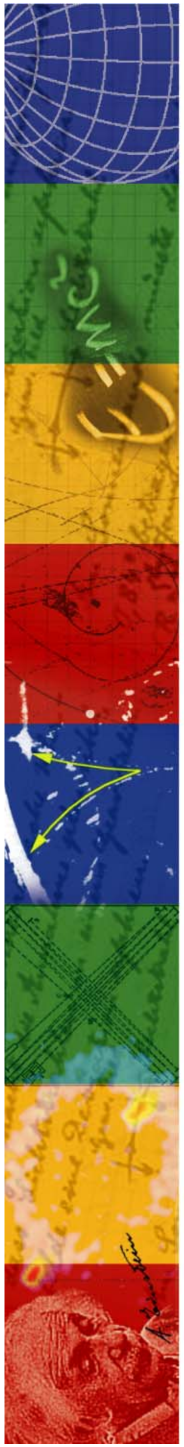
European Particle Physics Outreach Group



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

Participation





Participation 2009

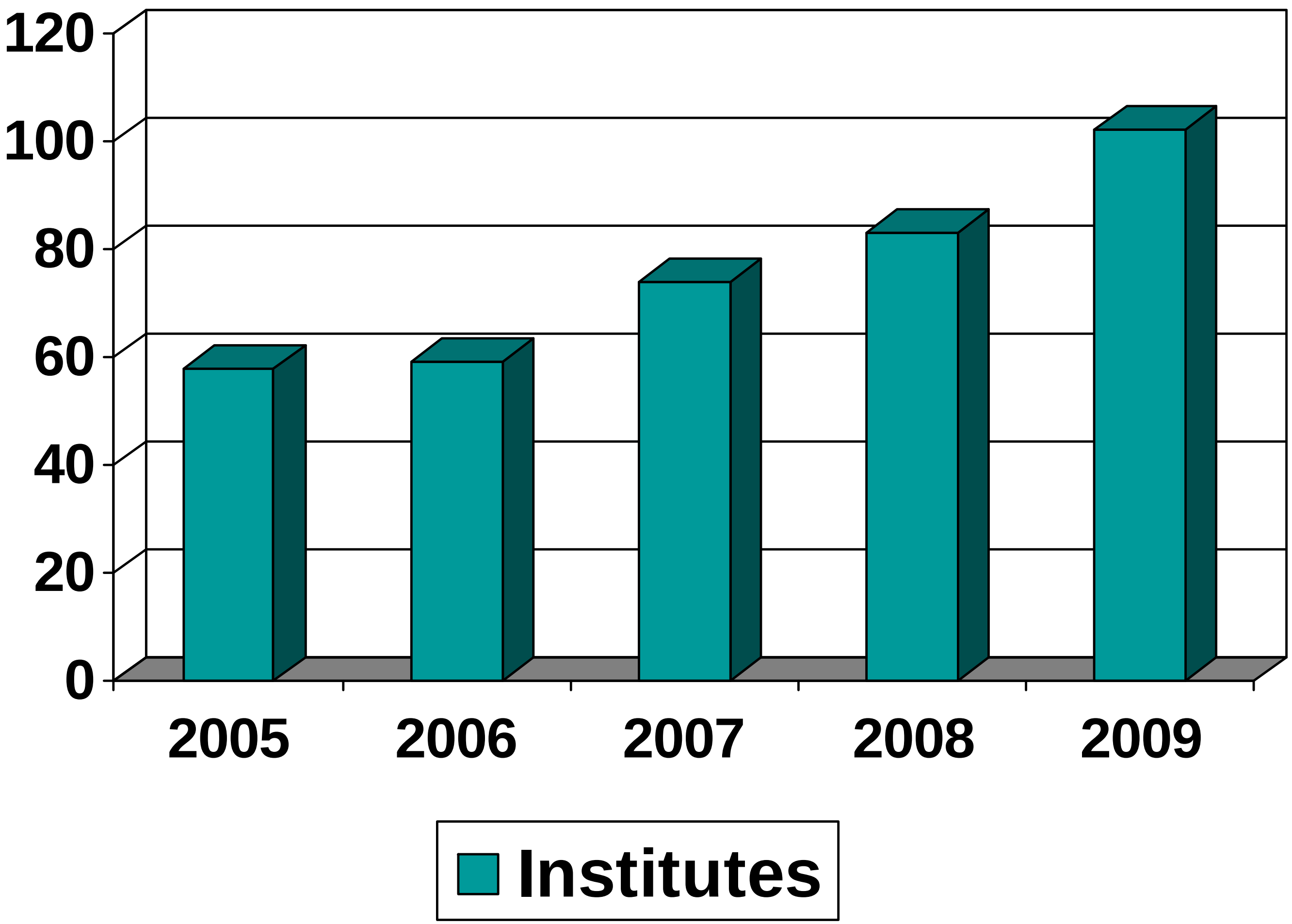
23 nations

USA

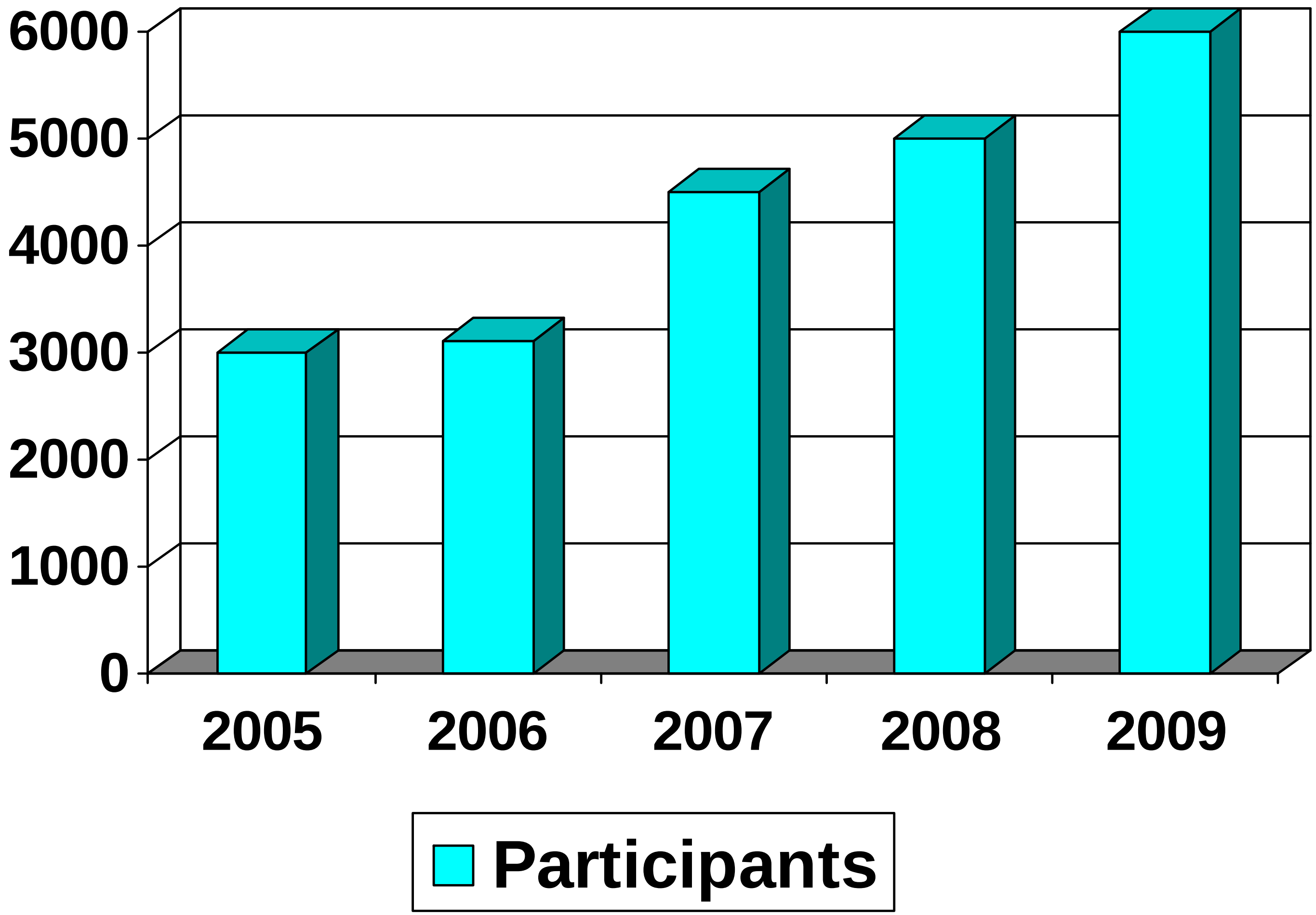
Brazil

South Africa

Participation



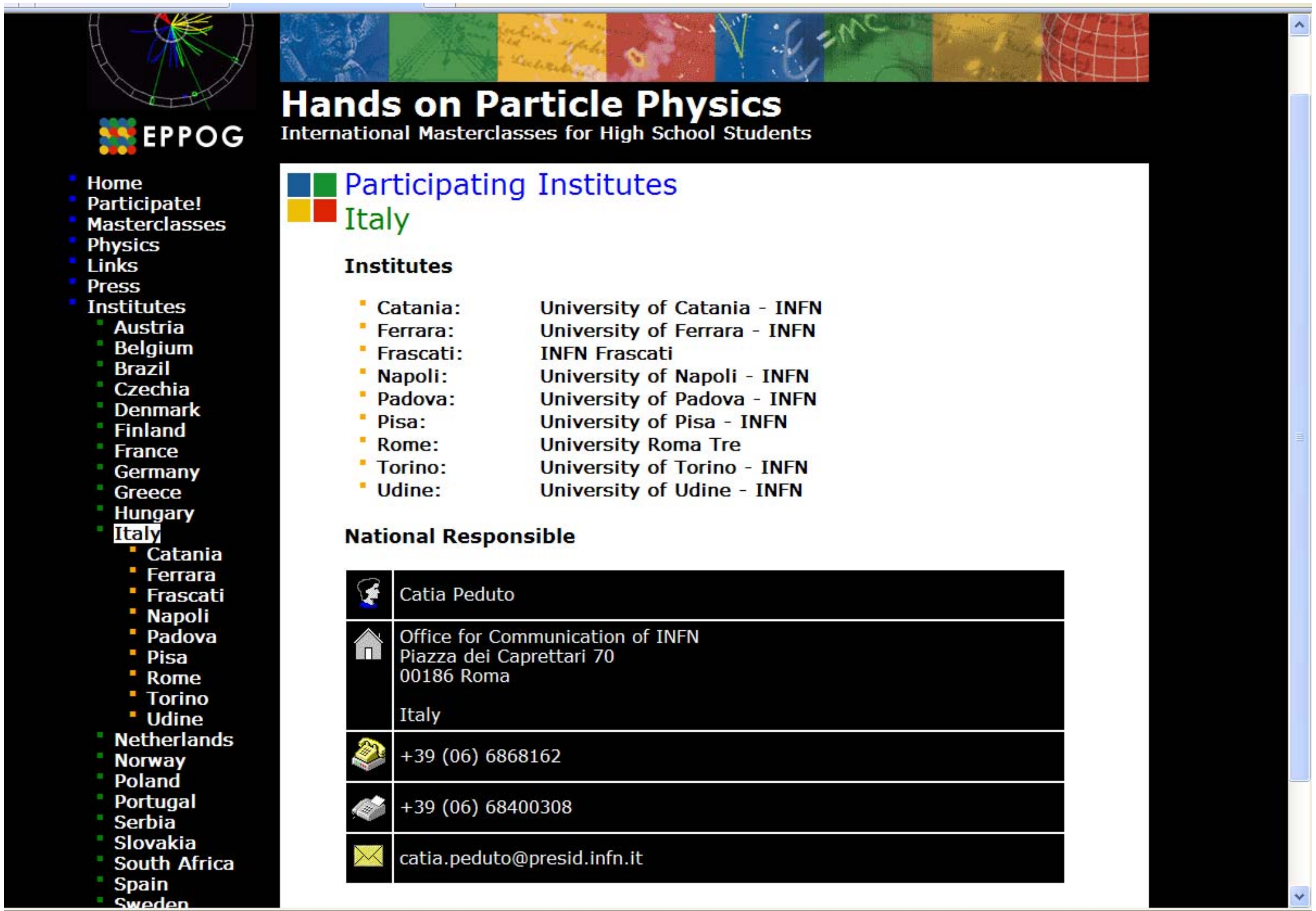
Participation



Italy

ITALIA
Mar Ligure
Mar Adriatico
Mar Tirreno
MARE MEDITERRANEO
SARDEGNA
SICILIA
VALLE D'AOSTA
PIEMONTE
LIGURIA
LOMBARDIA
TRENTINO ALTO ADIGE
VENETO
EMILIA-ROMAGNA
TOSCANA
UMBRIA
MARCHE
LAZIO
ABRUZZO
MOLISE
CAMPANIA
PUGLIA
BASILICATA
CALABRIA
Torino
Aosta
Milano
Genova
Bologna
Firenze
Pisa
Padova
Ferrara
Venezia
Trieste
Udine
Ancona
Perugia
Roma
Napoli
Bari
Cagliari
Palermo
Catania
Messina
Ljubljana
Zagreb
Sarajevo
Bern
Tunis

Italy



NEW: INFN Roma / Università degli Studi di Roma „La Sapienza"

Italy

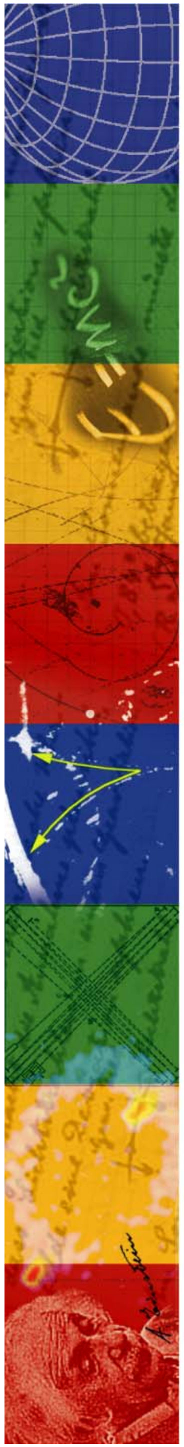
Italian students in Masterclasses 2009

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

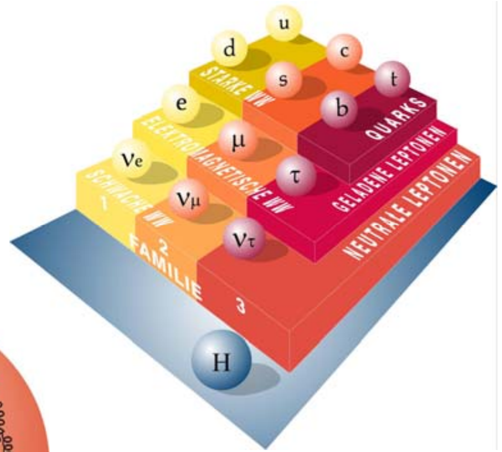
$\sum$ = 925 students

Why Masterclasses?

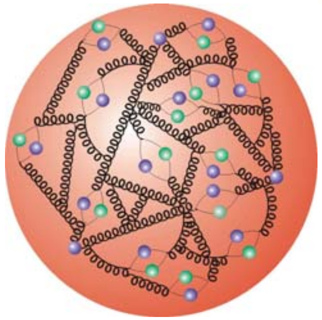
- Stimulate interest in science
- Demonstrate the scientific research process
- Make data from modern particle physics experiments available for students
- Explore the fundamental forces and building blocks of nature

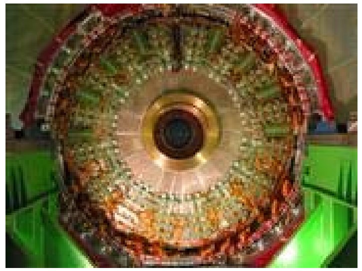


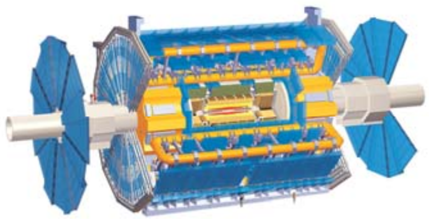
Agenda

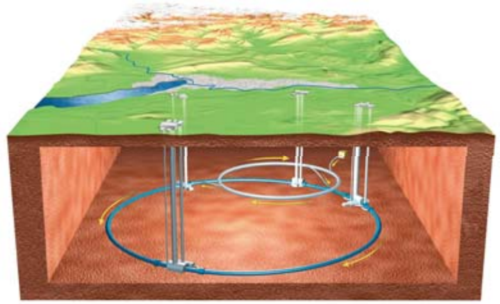


- Lectures
  - Standard model, Accelerators, Detectors
  - institute´s activities, cosmology etc.
- Lunch with physics students and tutors
- Exercises
- Video conference





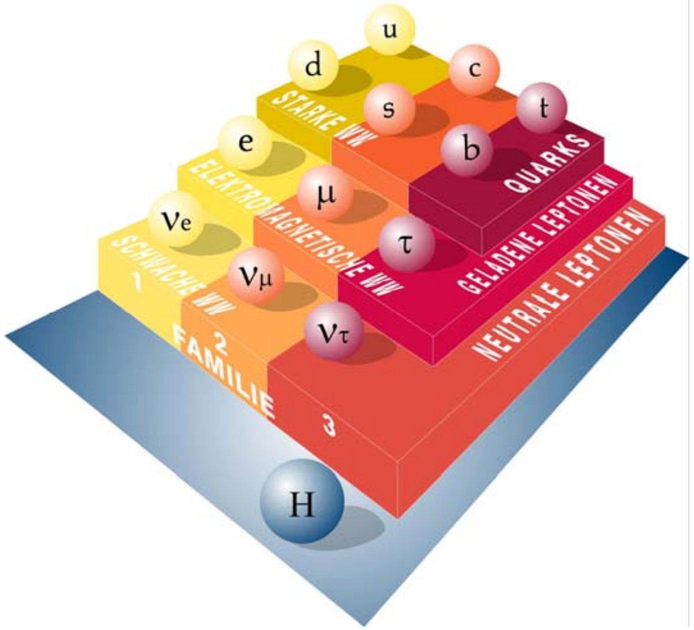




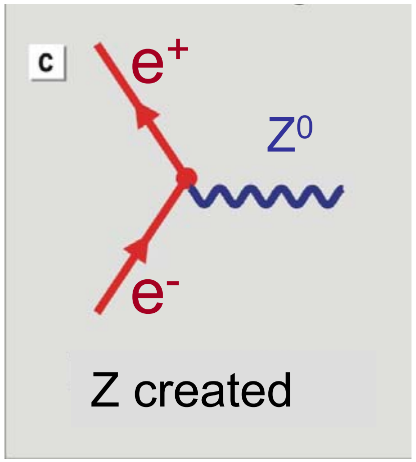
Exercises

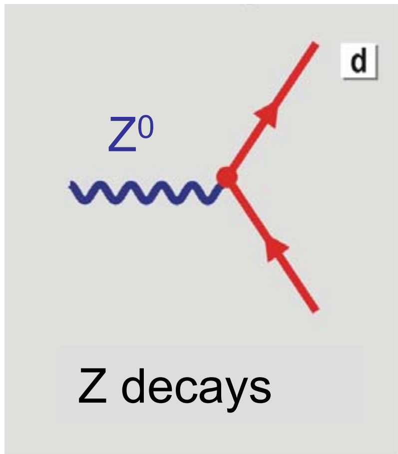
- PC-pool
- working in pairs
- Introduction
- working largely independently
- 10 tutors / 100 students

Exercises



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





time

$$Z^0 \rightarrow e^+e^-$$
$$Z^0 \rightarrow \mu^+\mu^-$$
$$Z^0 \rightarrow \tau^+\tau^-$$
$$Z^0 \rightarrow 2q$$

Exercises

Measurement of branching ratios

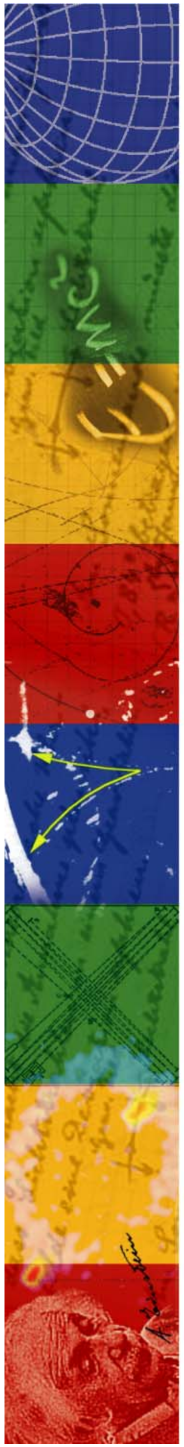
$Z^0 \rightarrow e^+e^-$

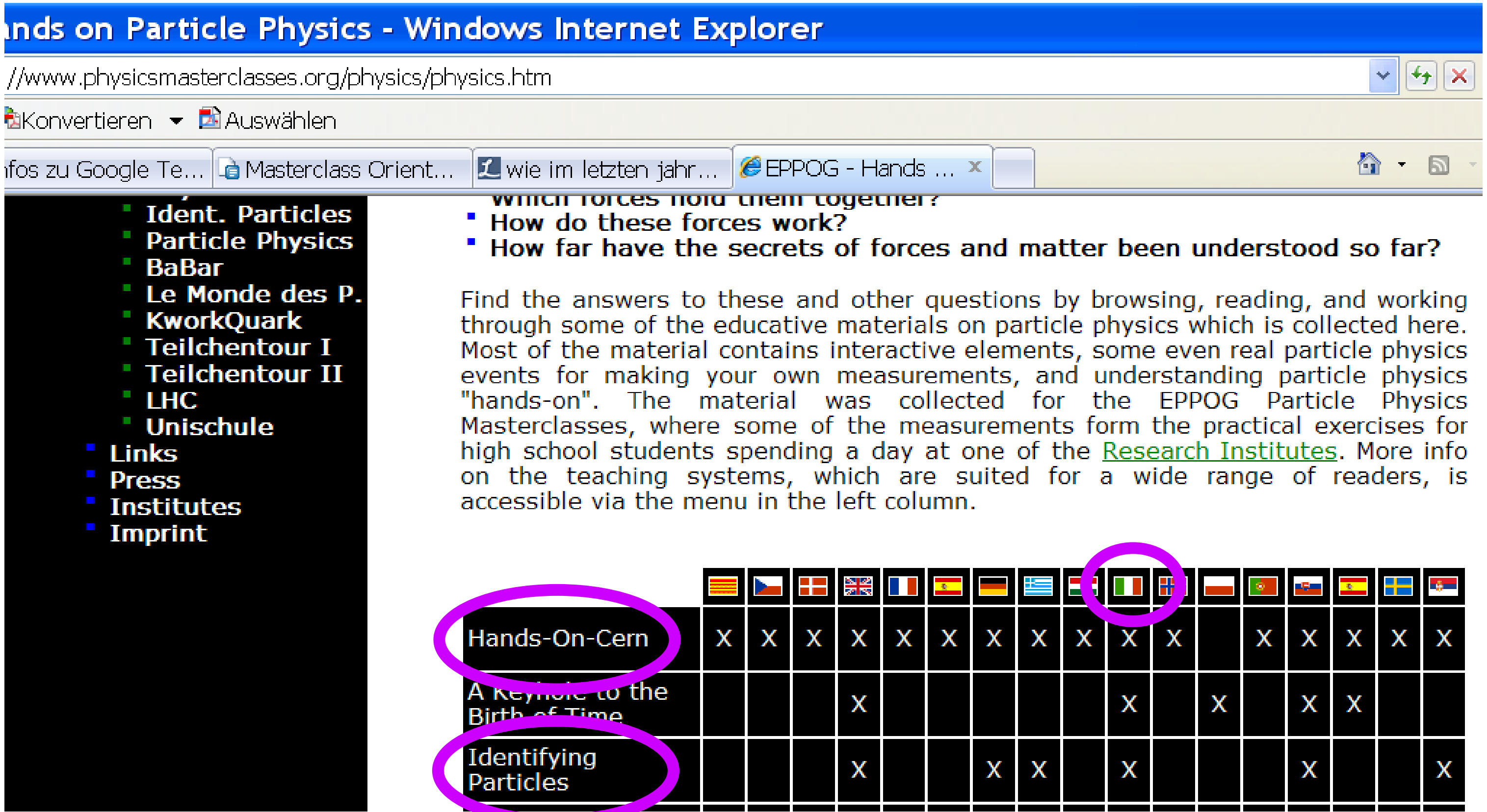
$Z^0 \rightarrow \mu^+\mu^-$

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

$Z^0 \rightarrow 2q$

Exercises





Hands-On-Cern	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

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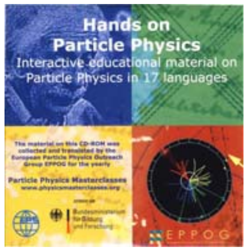
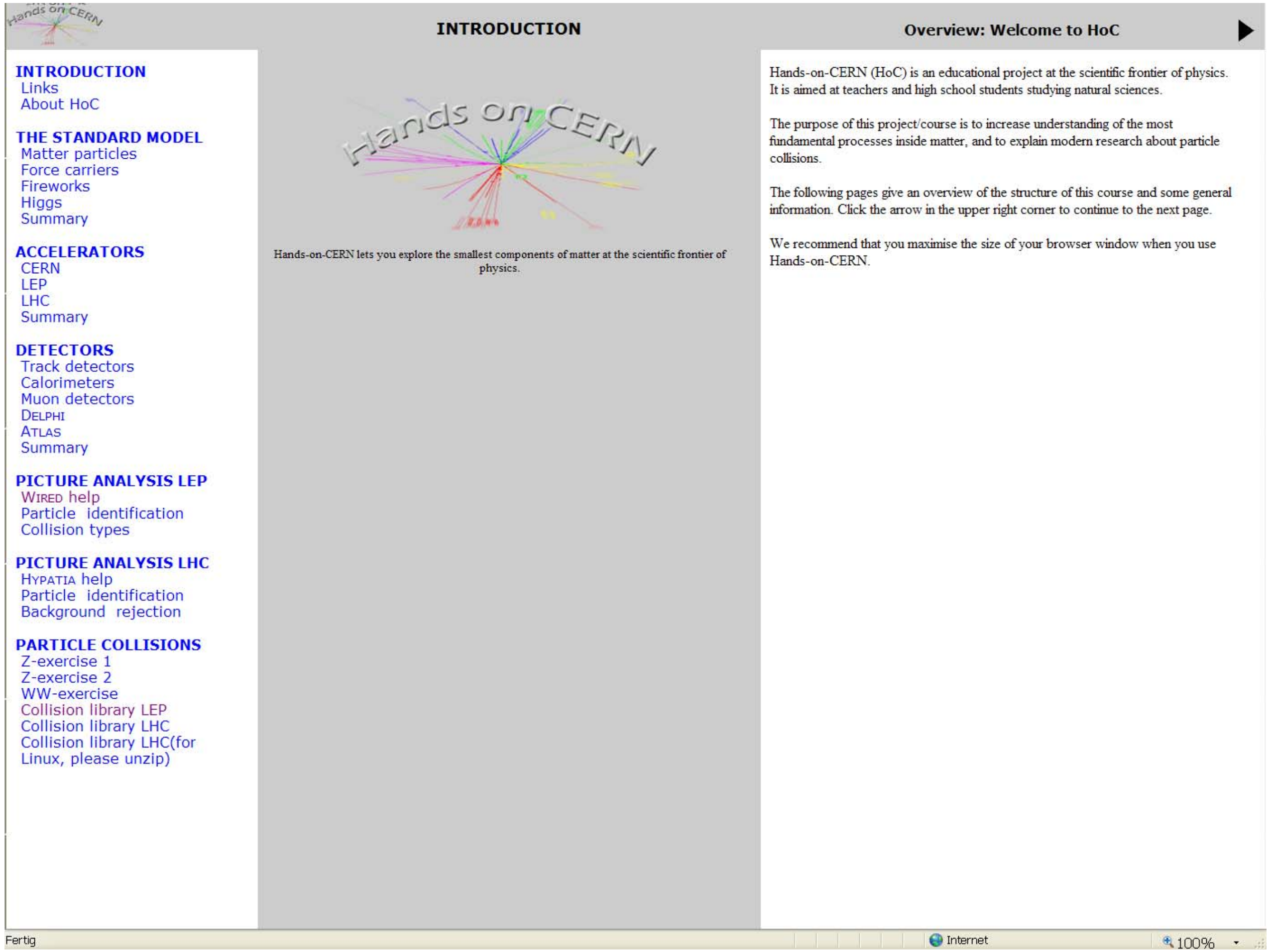
CD



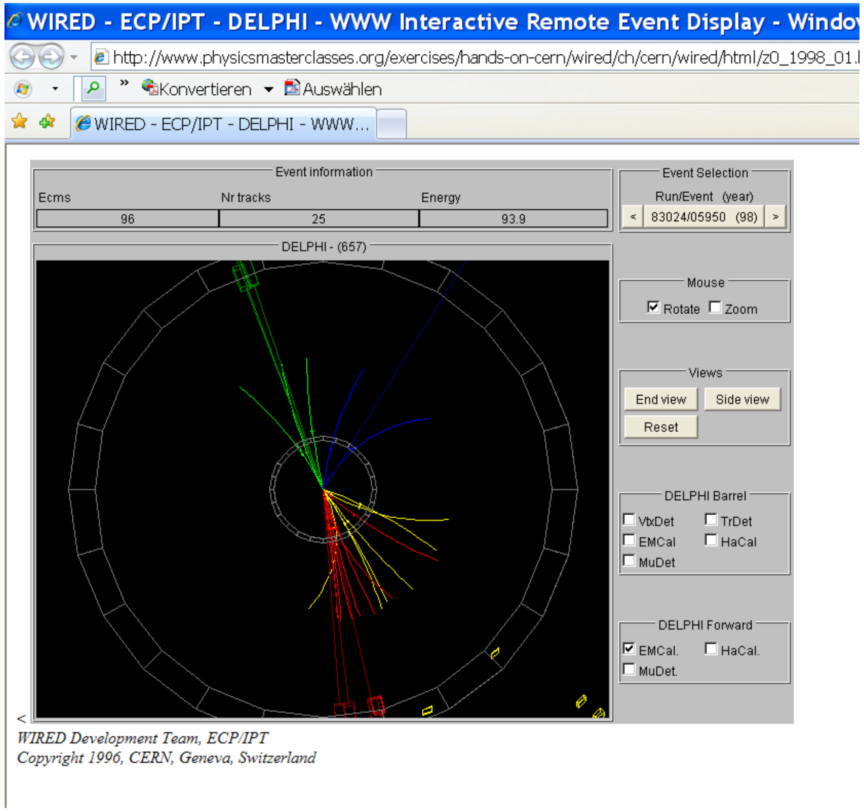
Exercises

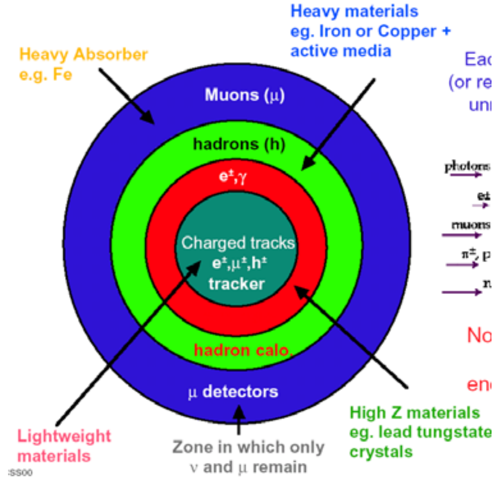
Hands-on-CERN (DELPHI)



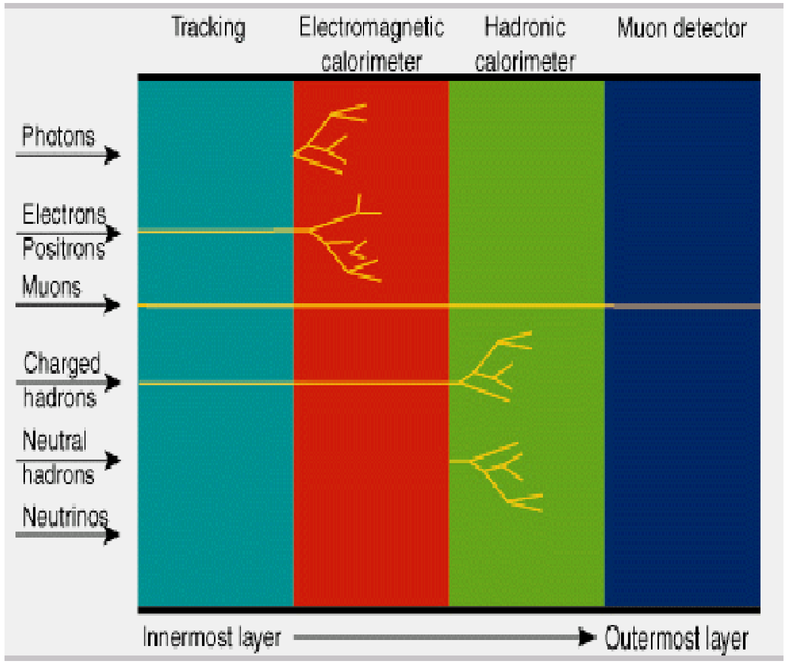
Exercises

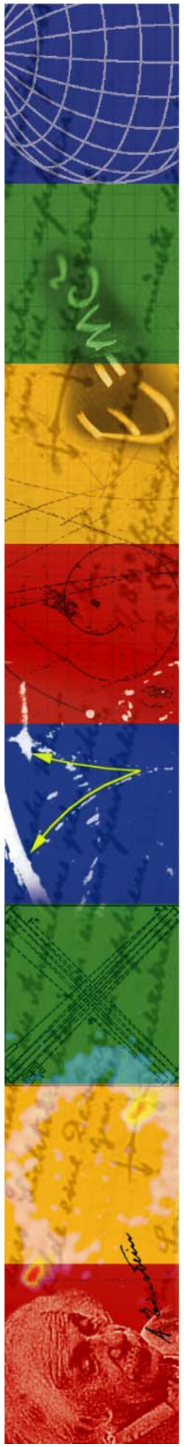
Hands-on-CERN (DELPHI)





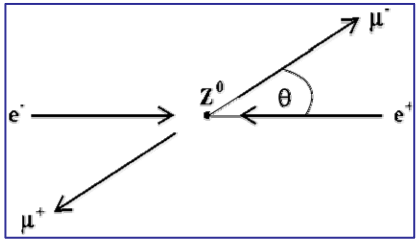
1 out of 1000 events





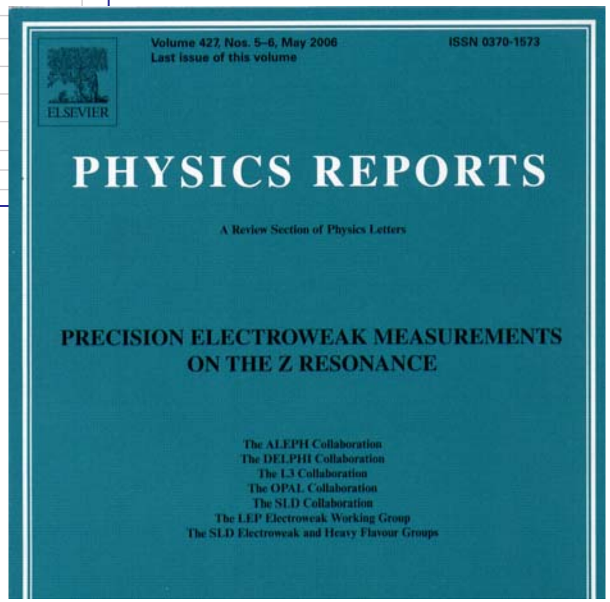
Exercises

	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 (**L**arge **E**lectron-**P**ositron Collider) which was at the time the largest particle accelerator of the world. The ATLAS detector is located at the new LHC (**L**arge **H**adron **C**ollider). 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.

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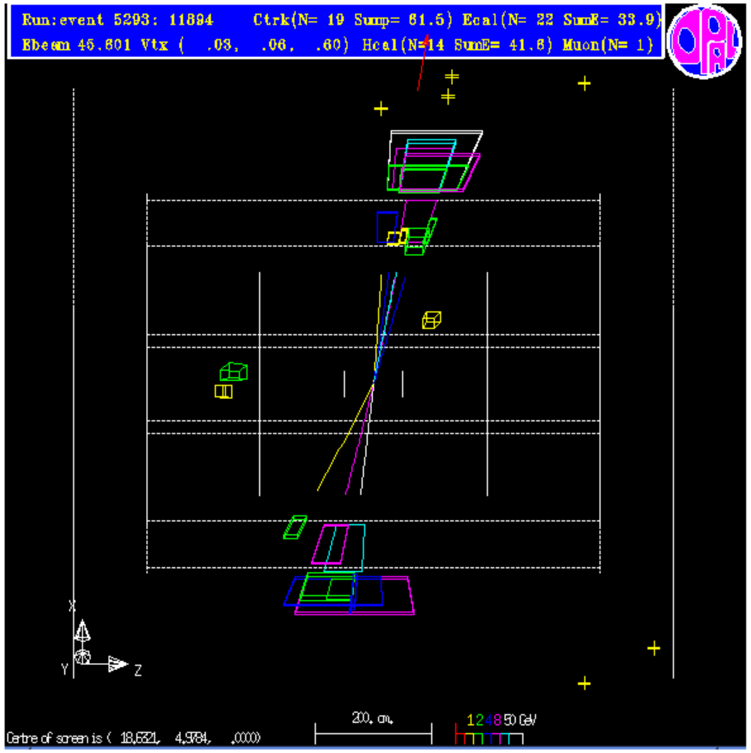
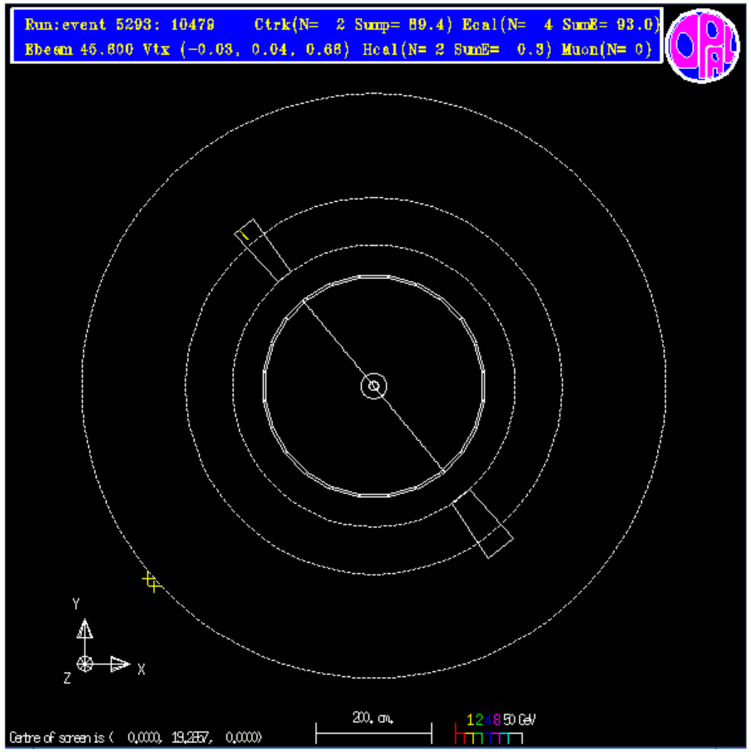


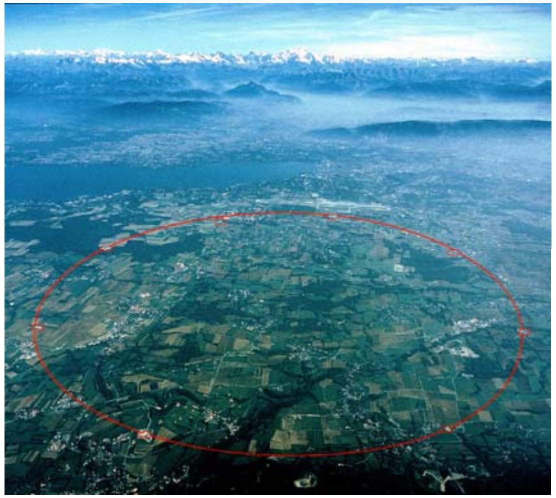
Run:event 5293: 11894 Ctrk(N= 19 Sump= 61.5) Ecal(N= 22 SumE= 33.9)
Ebeam 45.601 Vtx (.03, .06, .60) Hcal(N=14 SumE= 41.6) Muon(N= 1)
200. cm.
12 4 8 50 GeV

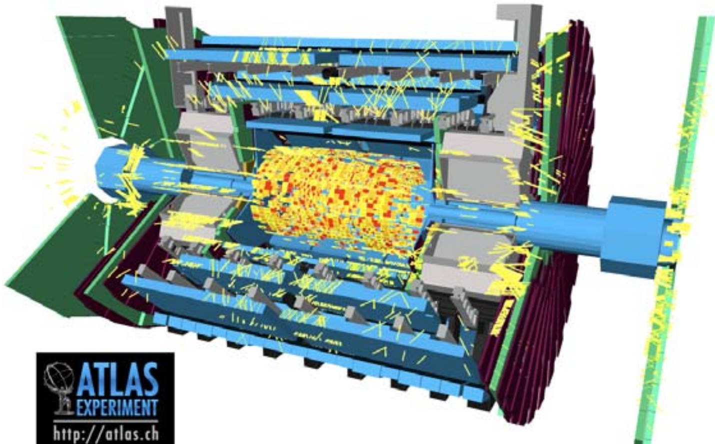


Run:event 5293: 10479 Ctrk(N= 2 Sump= 89.4) Ecal(N= 4 SumE= 93.0)
Ebeam 45.600 Vtx (-0.03, 0.04, 0.66) Hcal(N= 2 SumE= 0.3) Muon(N= 0)
200. cm.
12 4 8 50 GeV

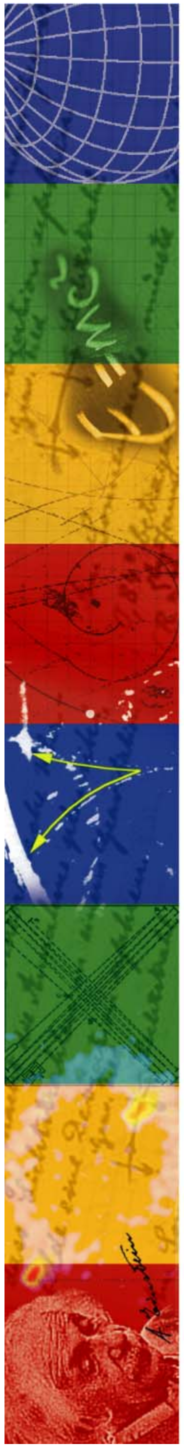
Exercises

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

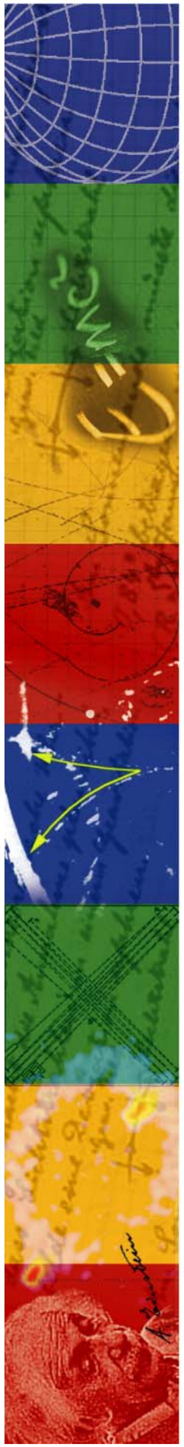


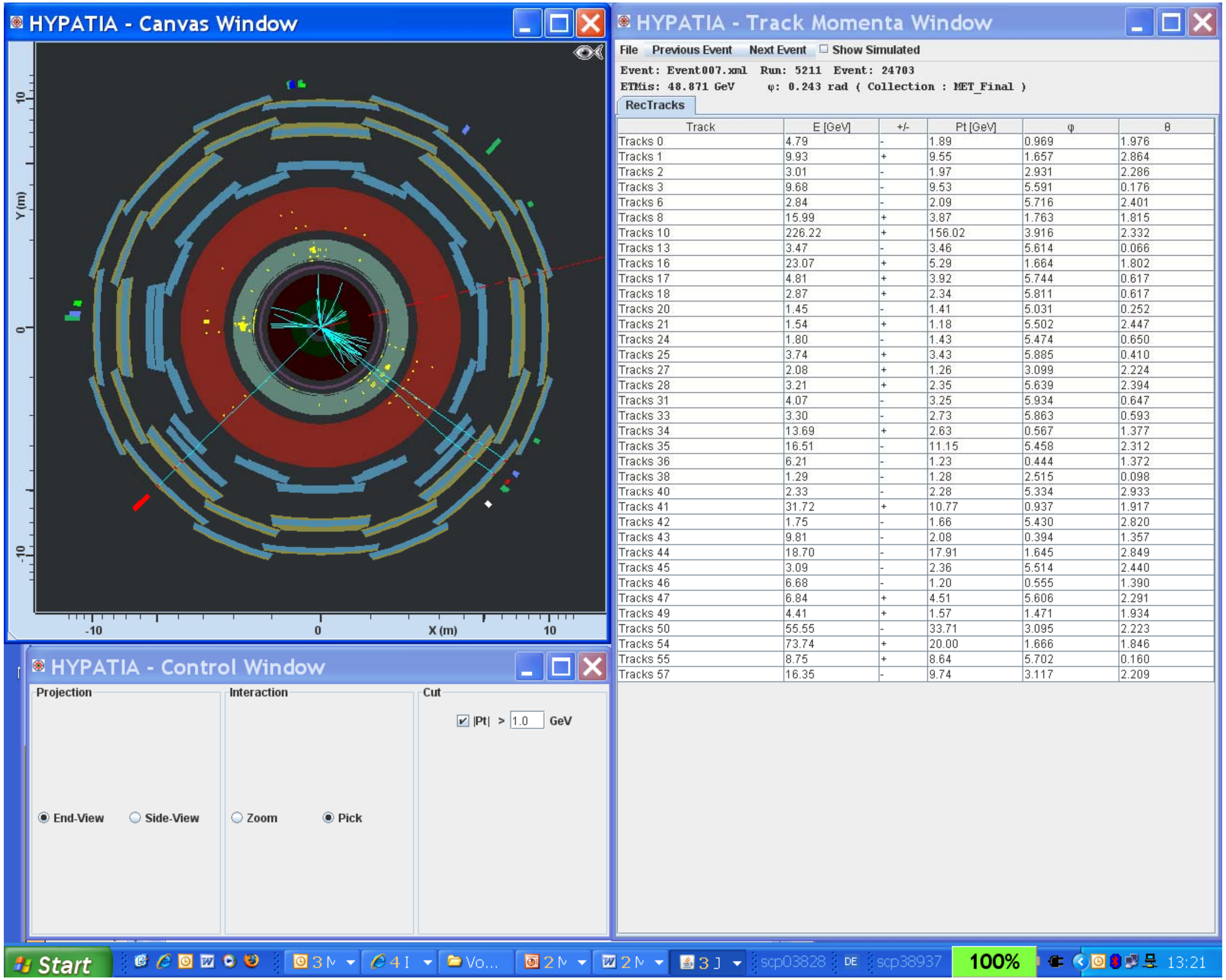


first beam event seen in ATLAS



Exercises





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**

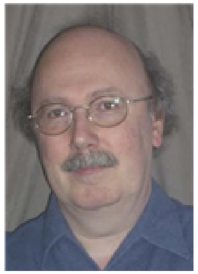
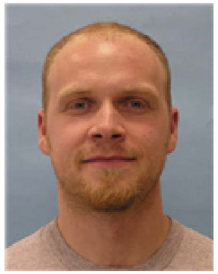
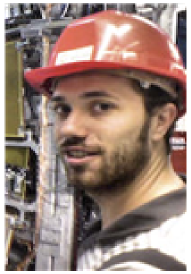
	Mo, March 16th	Tu, March 17th	We, March 18th	Th, March 19th	Fr, March 20th	Sa, March 21st
topic	Z0	Z0 + as	Z0	Z0	Z0	Z0
Moderator	Peter Zoe	Peter Vicki	Matthew Tom	Matthew Zoe	Matthew Jula	Zoe Tom
	Innsbruck	Paris	Rome	São Paulo	Barcelona	Paris
	Warsaw	Nitra	Oslo	Pisa	Debrecen	Heraklion
	Lodz	Katowice	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 28st
topic	Z0	Z0	Z0	Z0 + as	Z0 + as	Z0
Moderator	Michael Jula	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 Jula	Jula 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

Internet

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

Video Conference

global combination of results

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

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

Konvertieren Auswählen

http://www.physicsmasterclasses.or...

H7 fx 1

	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	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 ±*		*0,006*	*0,006*	*0,007*	*0,011*	*2,0*		
23	*Systematic Uncertainty ±*		*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 ±*		*0,008*	*0,006*	*0,006*	*0,010*	*2,5*		
26	*Systematic Uncertainty ±*		*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 ±*		*0,005*	*0,004*	*0,005*	*0,008*	*1,6*		
29	*Systematic Uncertainty ±*		*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 traccie 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)

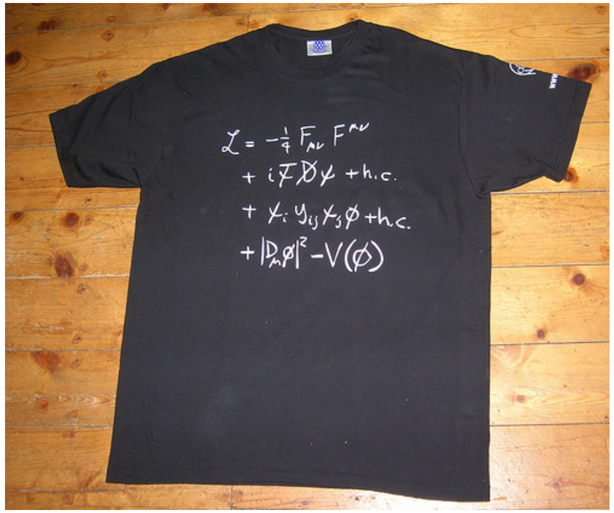
A. Room temperature, 300K
B. Colder than outer space, 1.9K
C. Temperature of outer space, 2.7K
D. 163.2K

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



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

s - Higgs finds the Higg...

News of The ATLAS Experiment

Mapping the Secrets of the Universe

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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.

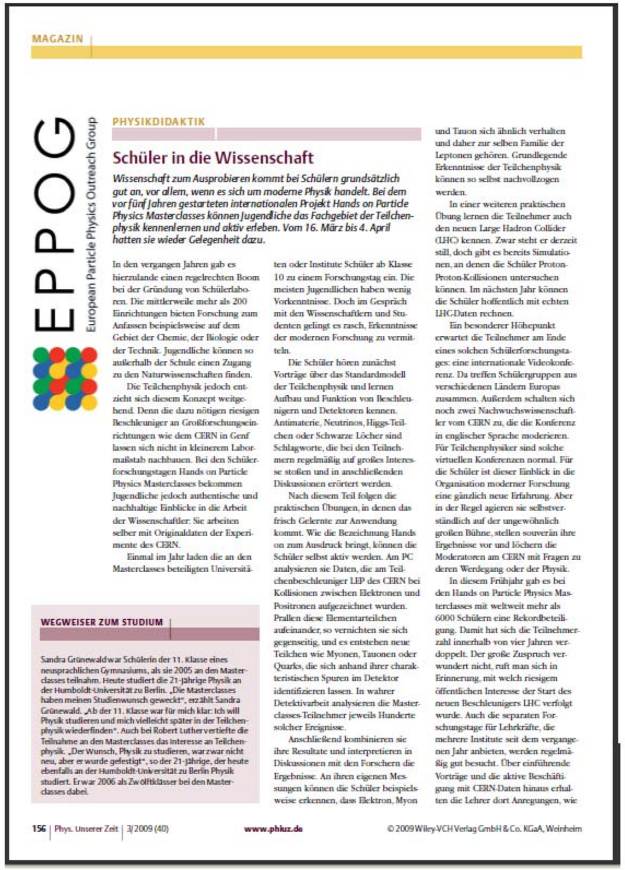
In 2009, the International Particle Physics Masterclasses are held in most European countries, 13 US states, Brazil, and South Africa. Perhaps the most telling evidence of its success is the fact that enrolment has doubled from 3000 to 6000 since 2005. About half of the day is spent in lectures, learning 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.

Related Items
- Check out the ATLAS fact sheets.
- ATLAS FAQs
- ATLAS eTours

ATLAS news

Press review


MAGAZIN

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.

EPPOG European Particle Physics Outreach Group

WEGWEISER ZUM STUDIUM

156 | Phys. Unserer Zeit | 3/2009 (40) www.phiuz.de © 2009 Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim

Physik in unserer Zeit


20. Jahrgang • Nr. 7 21. April 2009

Dresdner UniversitätsJournal

TECHNISCHE UNIVERSITÄT DRESDEN

Ausgebaut: Neues ZET bereichert Forschungsnetzwerk Seite 3
Ausgefragt: Wie fühlen sich ausländische Studenten an der TUD? Seite 4
Ausgebildet: Beim Lernen motiviert vor allem die Praxis Seite 5
Auserkoren: Zwei TUD-Wissenschaftler im Staatsoperetten-Beirat Seite 10

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

Dr. Thomas Bürger Honorarprofessor

Begeistert von Teilchenphysik

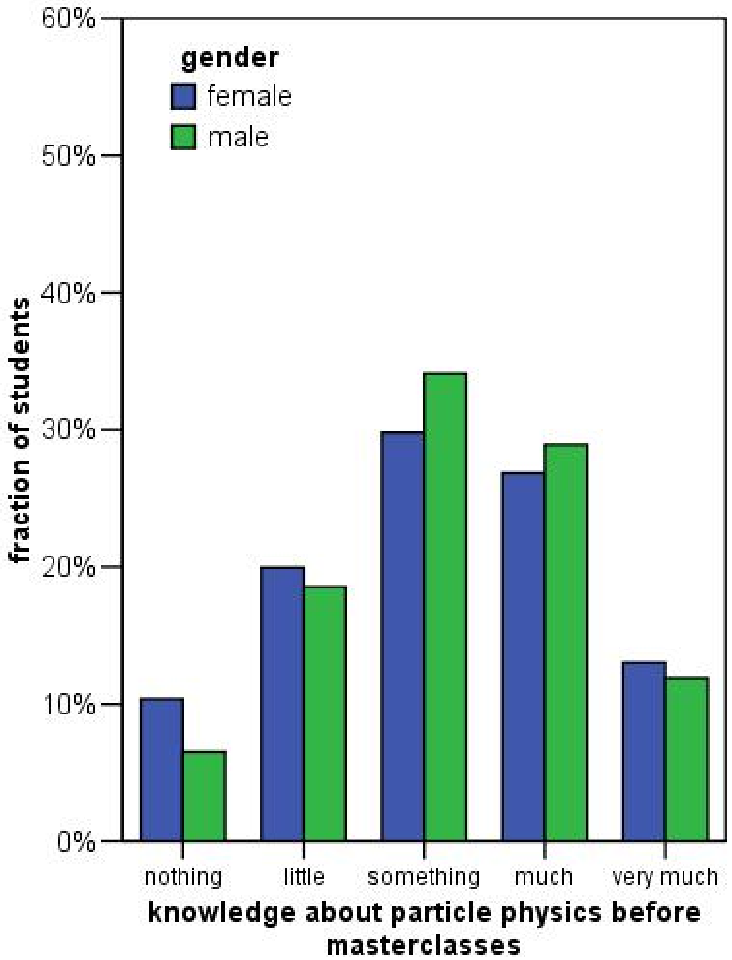
»Hands on Particle Physics Masterclasses« Ende März in Dresden: Aufmerksam schauen die Schüler zu, wie Professor Michael Kobel ihre Ergebnisse am PC zusammenführt. Foto: IKTP/Schwierz

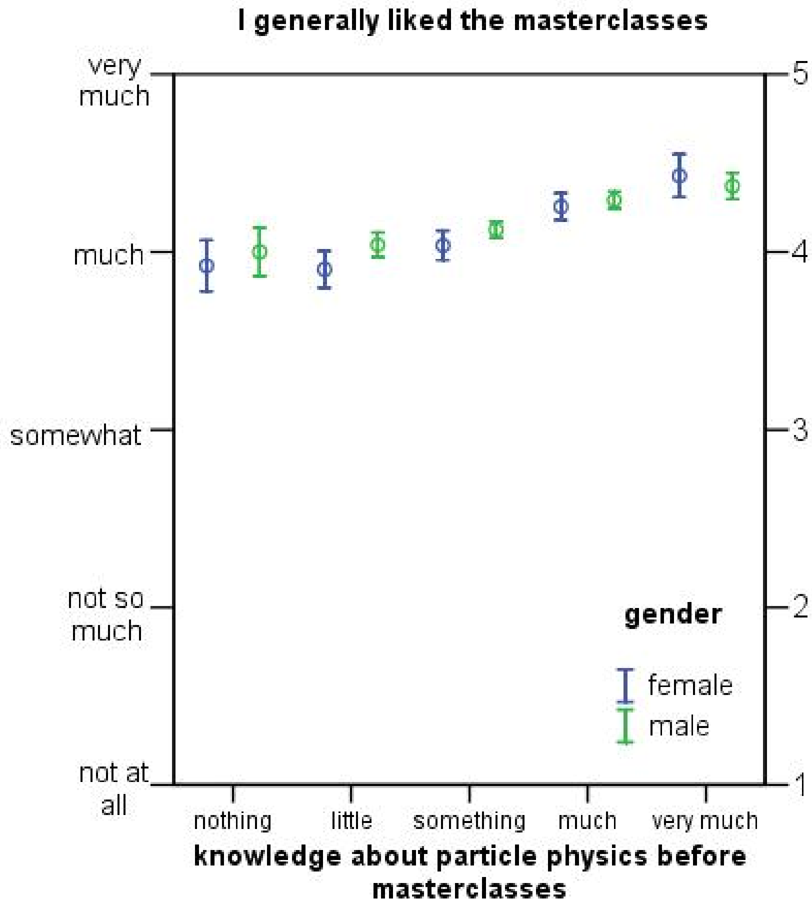
Schüler forschen

Universitätsjournal TU Dresden

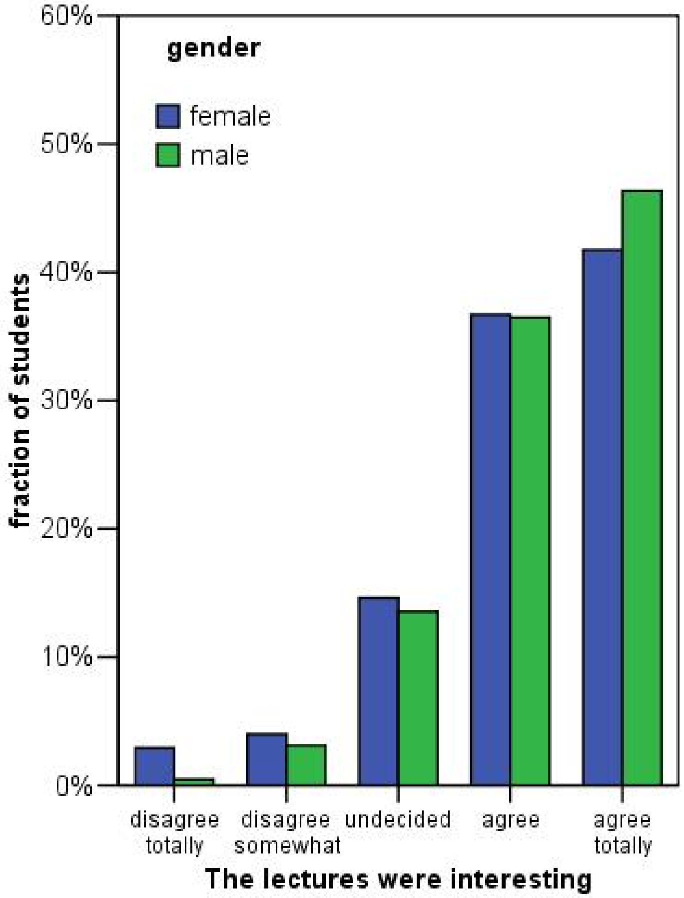
Evaluation

- „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

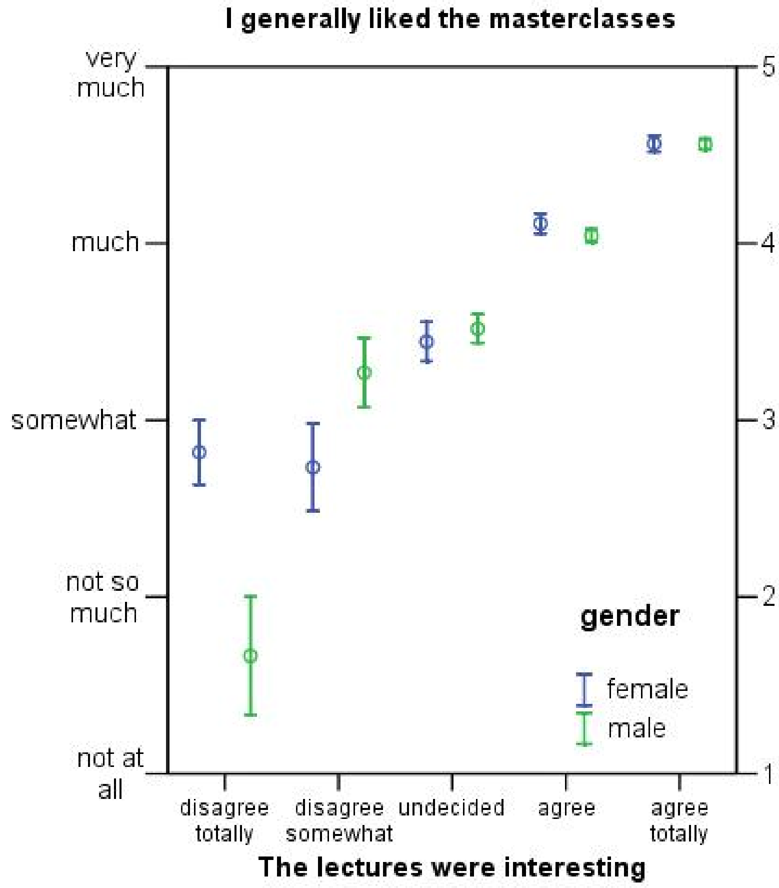




Evaluation

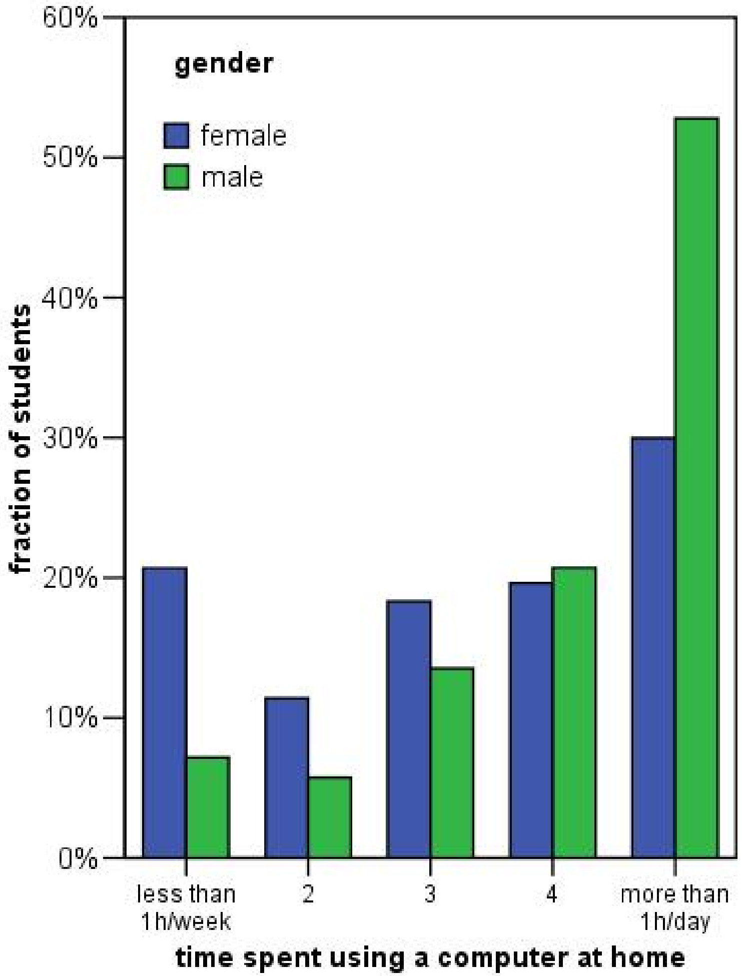


gender
female
male
fraction of students
60%
50%
40%
30%
20%
10%
0%
disagree totally
disagree somewhat
undecided
agree
agree totally
The lectures were interesting

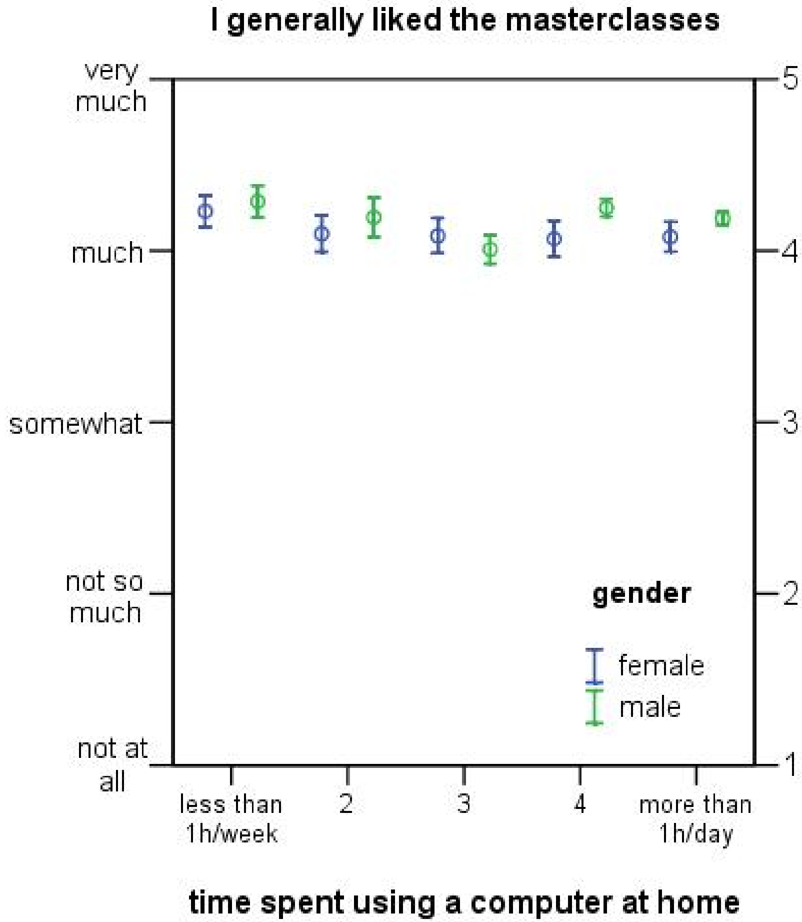


I generally liked the masterclasses
very much
much
somewhat
not so much
not at all
5
4
3
2
1
gender
female
male
disagree totally
disagree somewhat
undecided
agree
agree totally
The lectures were interesting

Evaluation



gender
female
male
fraction of students
60%
50%
40%
30%
20%
10%
0%
less than 1h/week
2
3
4
more than 1h/day
time spent using a computer at home



I generally liked the masterclasses
very much
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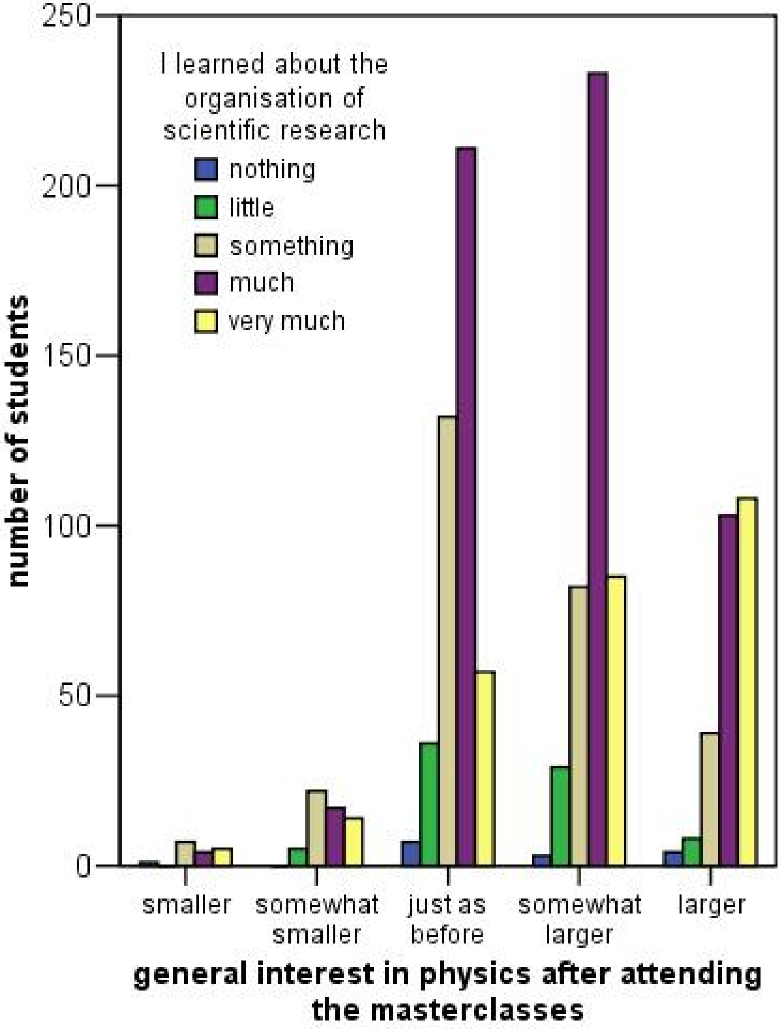
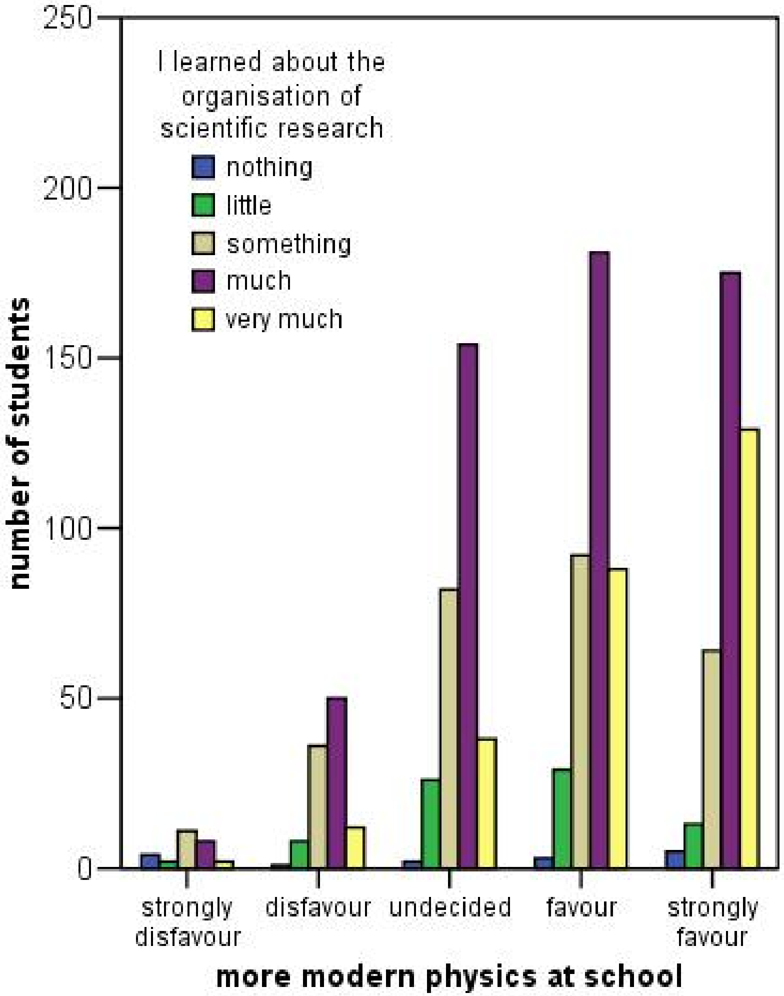
more than 1h/day
time spent using a computer at home

Evaluation


250
200
150
100
50
0
number of students
I learned about the organisation of scientific research
nothing
little
something
much
very much
smaller
somewhat smaller
just as before
somewhat larger
larger
general interest in physics after attending the masterclasses


250
200
150
100
50
0
number of students
I learned about the organisation of scientific research
nothing
little
something
much
very much
strongly disfavour
disfavour
undecided
favour
strongly favour
more modern physics at school

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