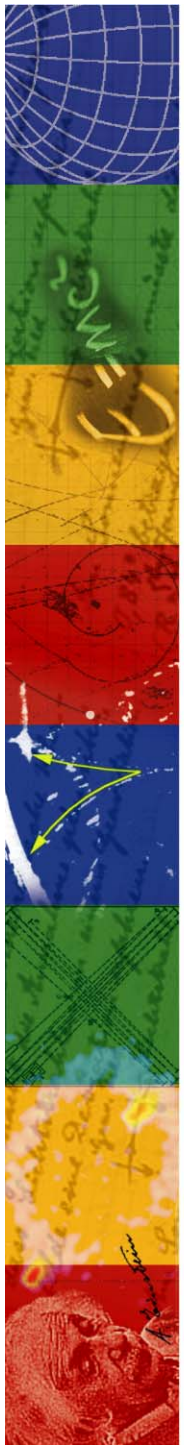

"Hands on Particle Physics"

International Masterclasses

International Masterclasses in Physics

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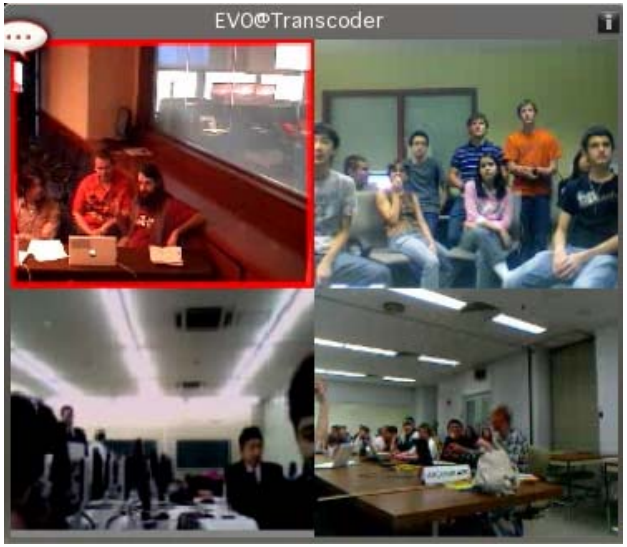


EPPOG

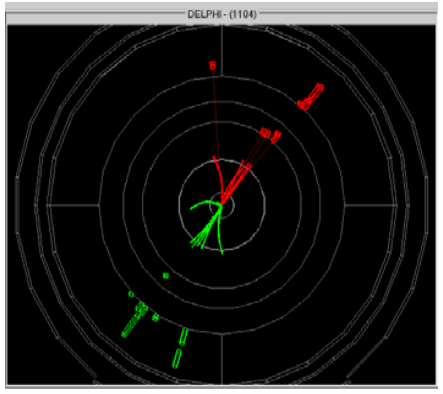
European Particle Physics Outreach Group

QuarkNet

What is the 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.

A Brief History

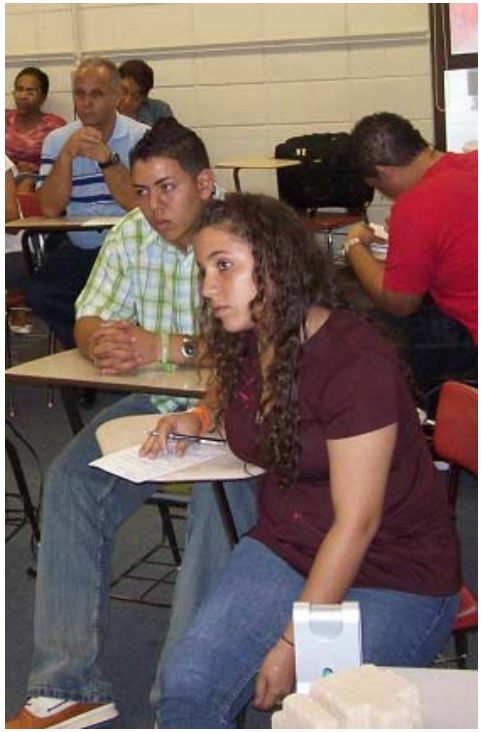


- 1996: Masterclasses begin in U.K.
  - Use OPAL Indentifying Particles and Lancaster Particle Physics Package
  - 7-8 Institutes
- 2005: Adopted by EPPOG for all Europe
  - Use OPAL Indentifying Particles and DELPHI Hands-On CERN
- 2006: U.S. joined program
- 2010: preparing to move the LHC-based Masterclasses

Masterclass Day – sample agenda

Times and details will vary

LOCAL TIME:	ACTIVITY:
8:00-8:30	Registration & Welcome
8:30-9:30	Introduction to Particle Physics
9:30-11:00	Tour
11:00-12:00	Introduction to Data Analysis
12:00-13:00	Lunch
13:00-15:00	Data Analysis
15:00-15:30	EVO Logon
15:30-16:30	EVO Video Conference
16:30-17:00	Evaluation & Closing



Video Conference

- Introduction by moderators
- Student Q & A
- Combination of results
- Discussion
- Quiz

	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

2010 Statistics

- 107 Masterclass Institutes (22 in U.S.)
  - Most had video conferences moderated from CERN (Fermilab in U.S.)
  - 20 participated with Fermilab
  - 2-6 Institutes per day
  - 18 days, 3 weeks in Feb-Mar
- 6500 students
- 24 countries
- Largest program in Europe; also:
  - United States
  - Brazil
  - South Africa
  - Japan

University of Athens

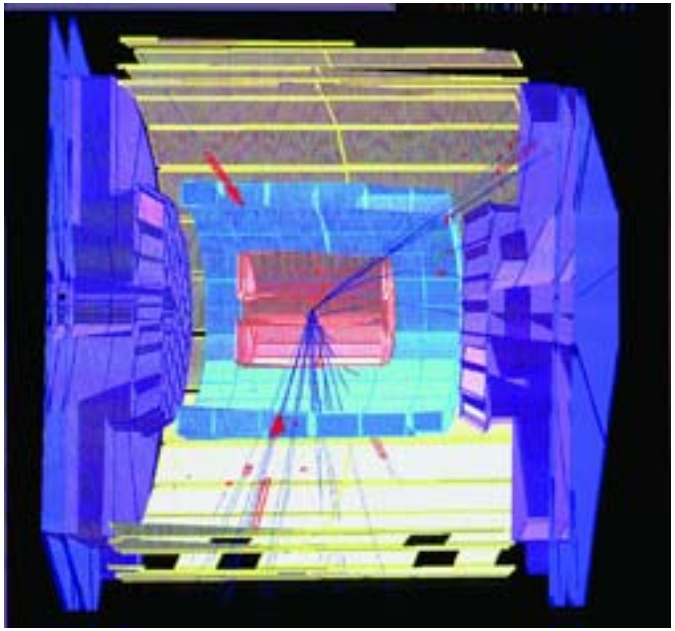
TU Dresden

DELPHI at LEP: Our Z Lab

The beam particles each had a total energy of 45.5 GeV:

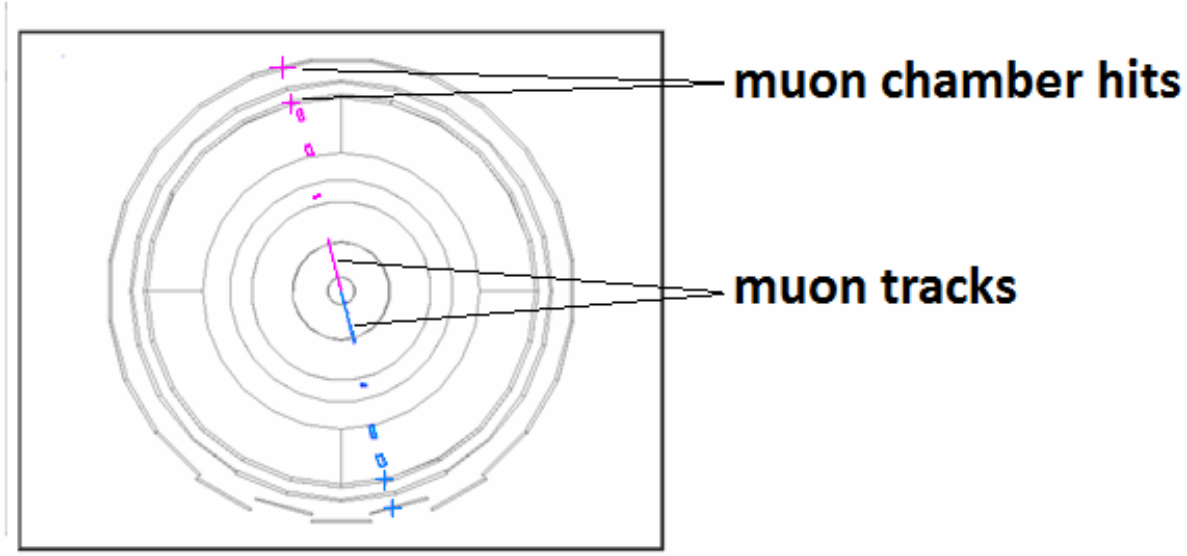
2 x 45.5 GeV = 91.1 GeV

91.1 GeV is the Z mass.

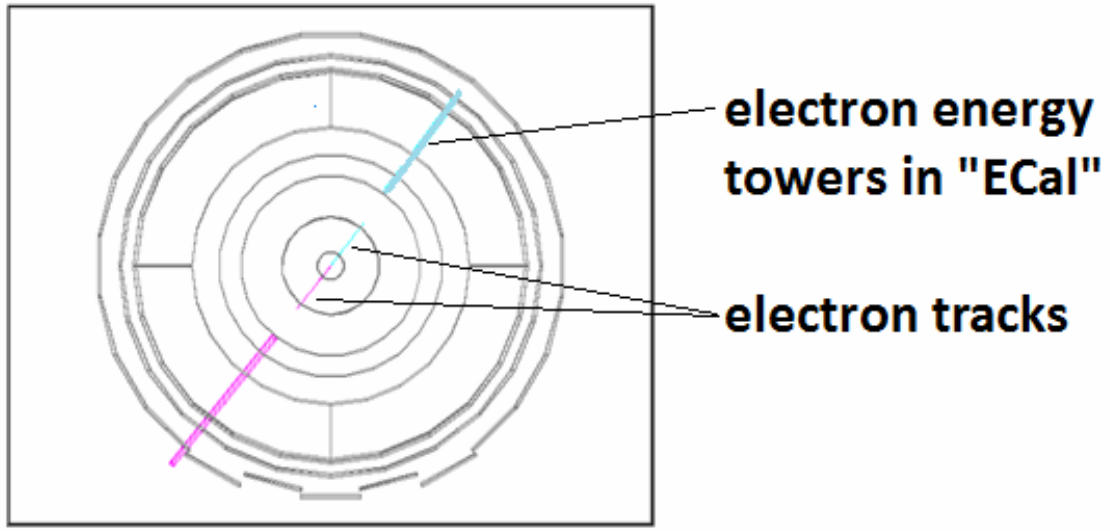


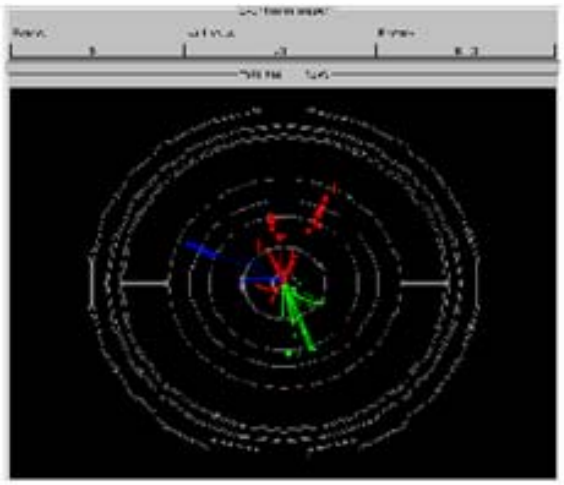
LEP built Z bosons—they promptly decayed. The detectors measured the stuff that came out of the decay.

Z → 2 muons

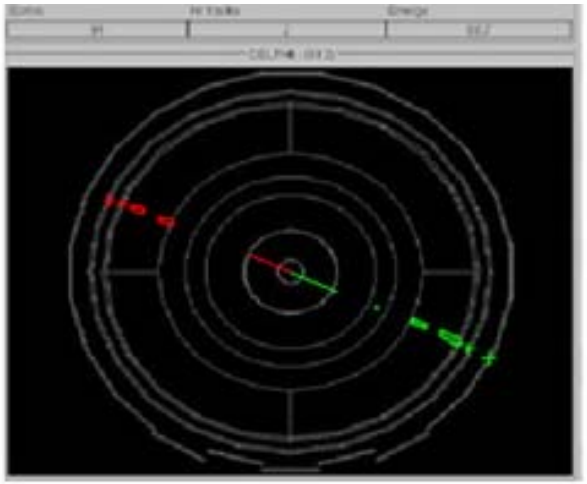


Z → 2 electrons





A.



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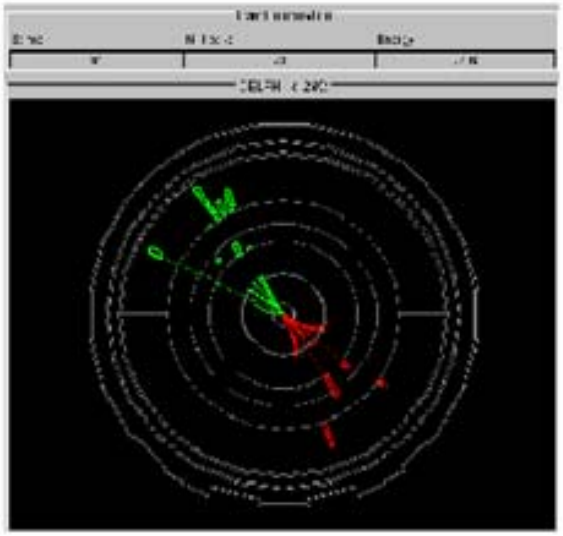
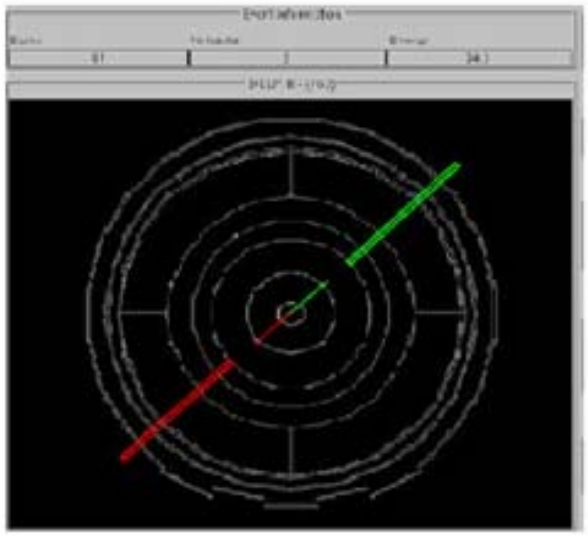


C.



D.

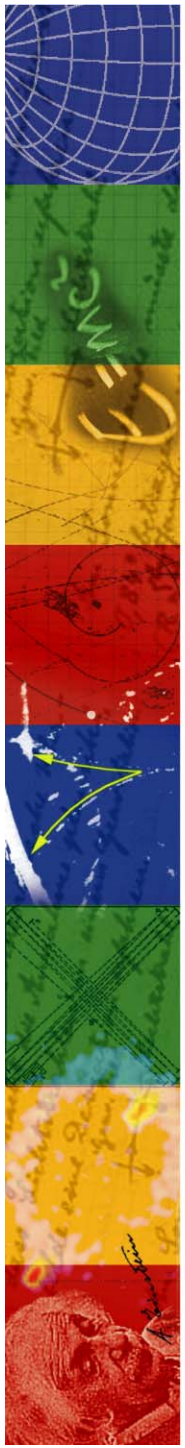
What's what?

Z → 2 electrons

Z → 2 muons

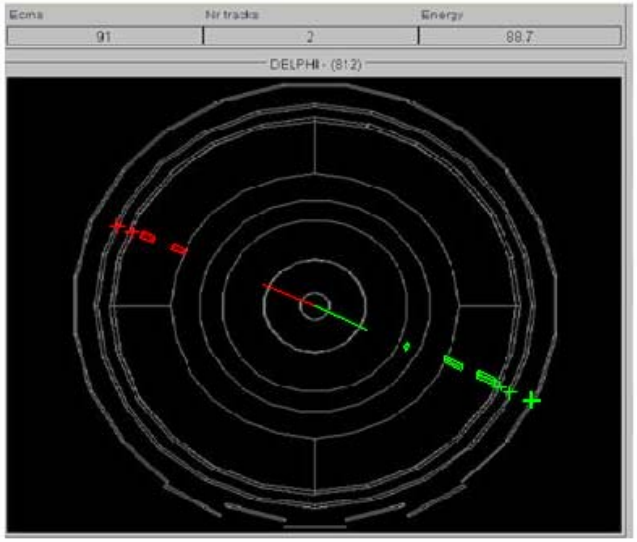
Z → other stuff

Decide with your partner(s)…and please keep a count.



"Hands on
Internatior

More…



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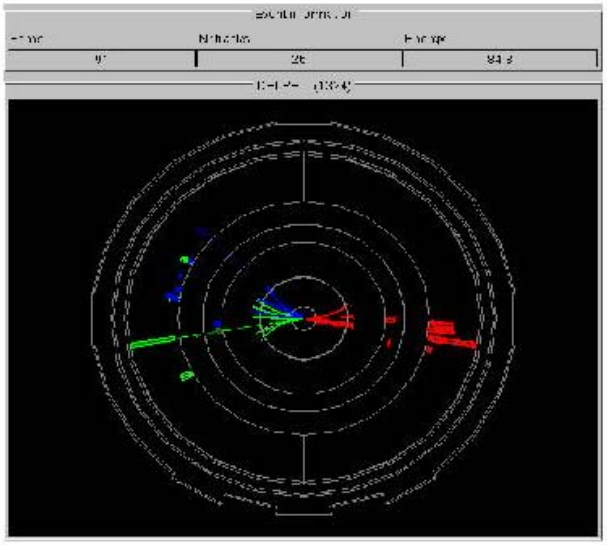

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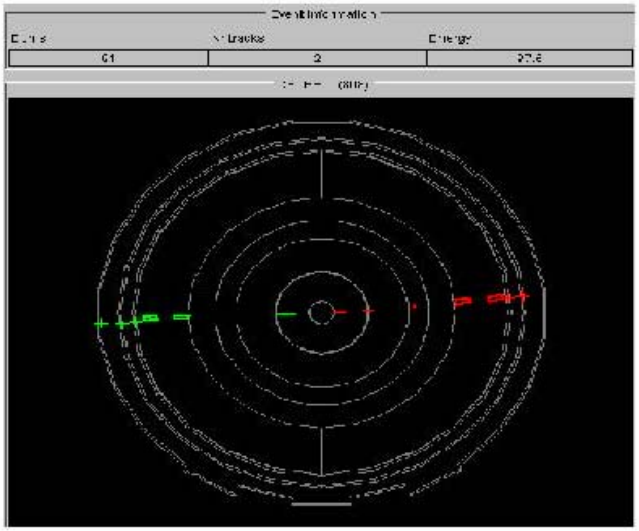

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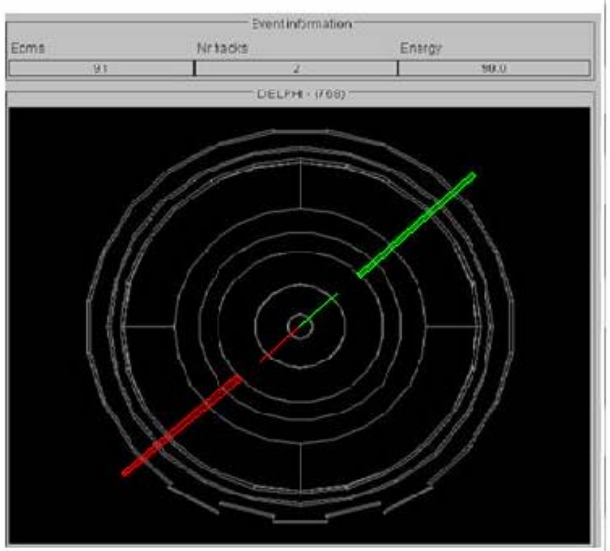
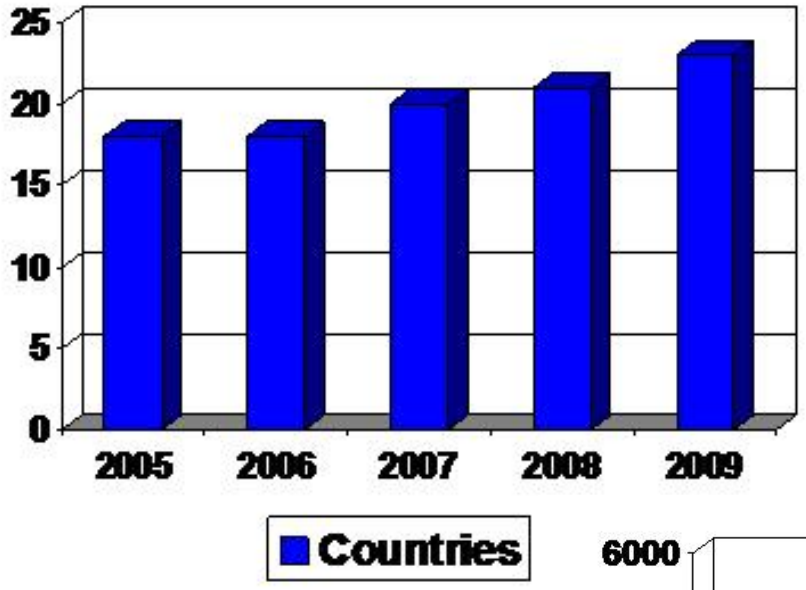
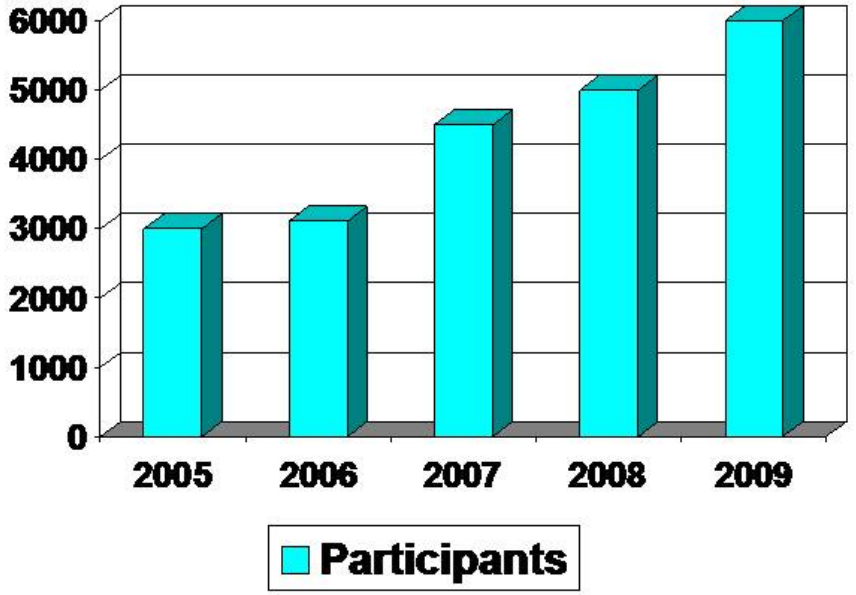


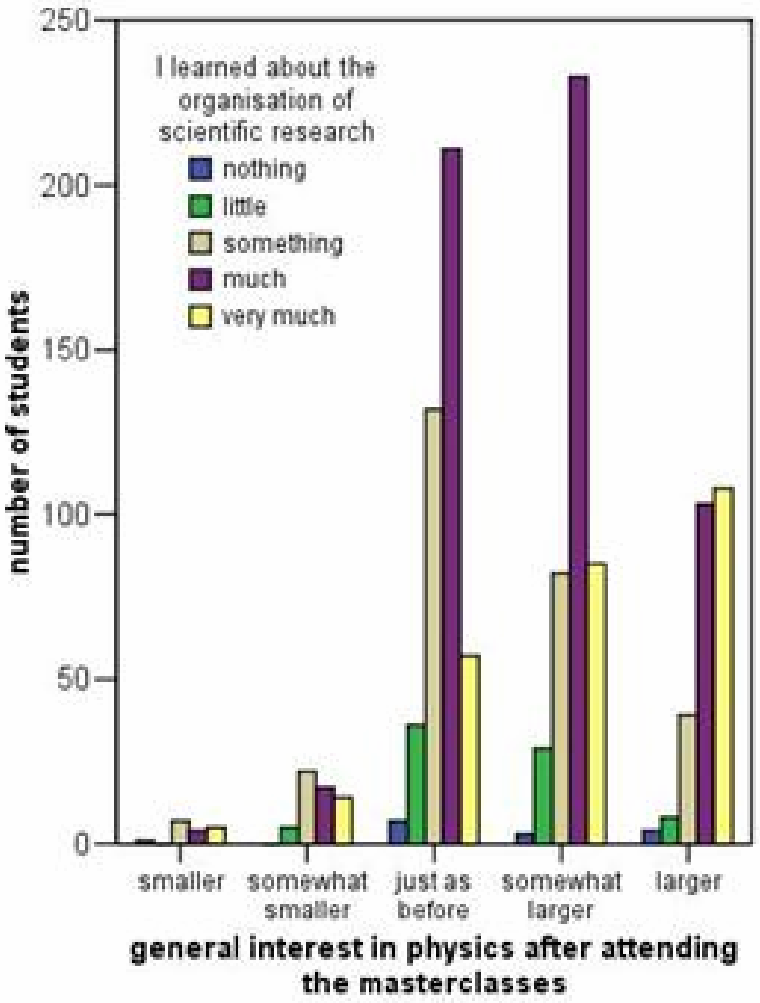
D.

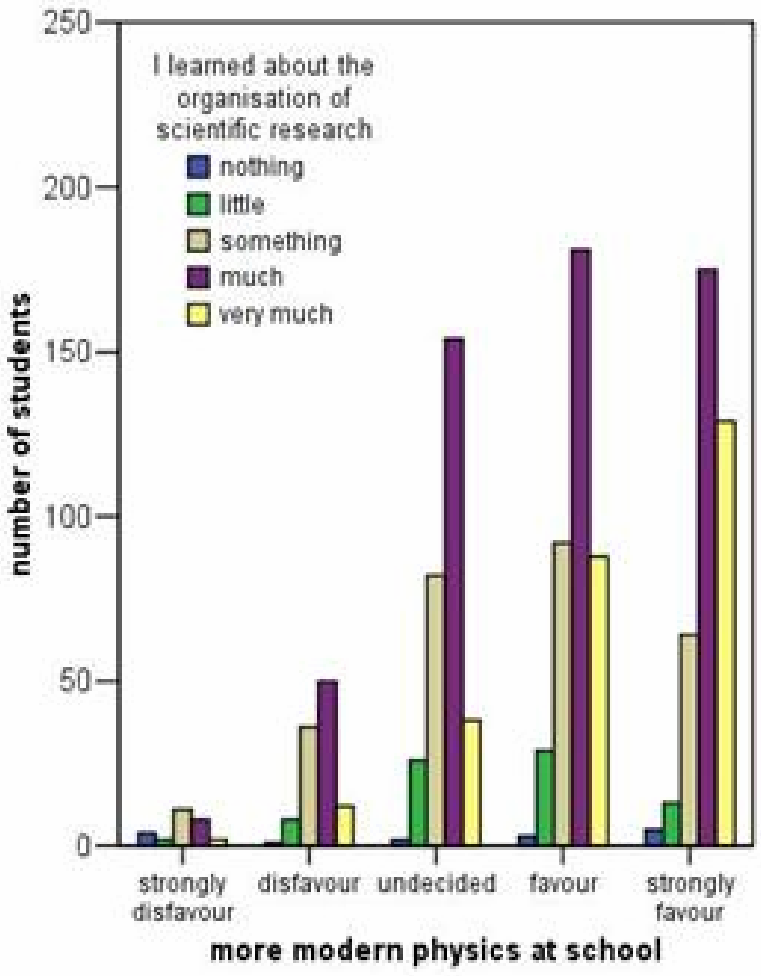
Masterclass growth to 2010



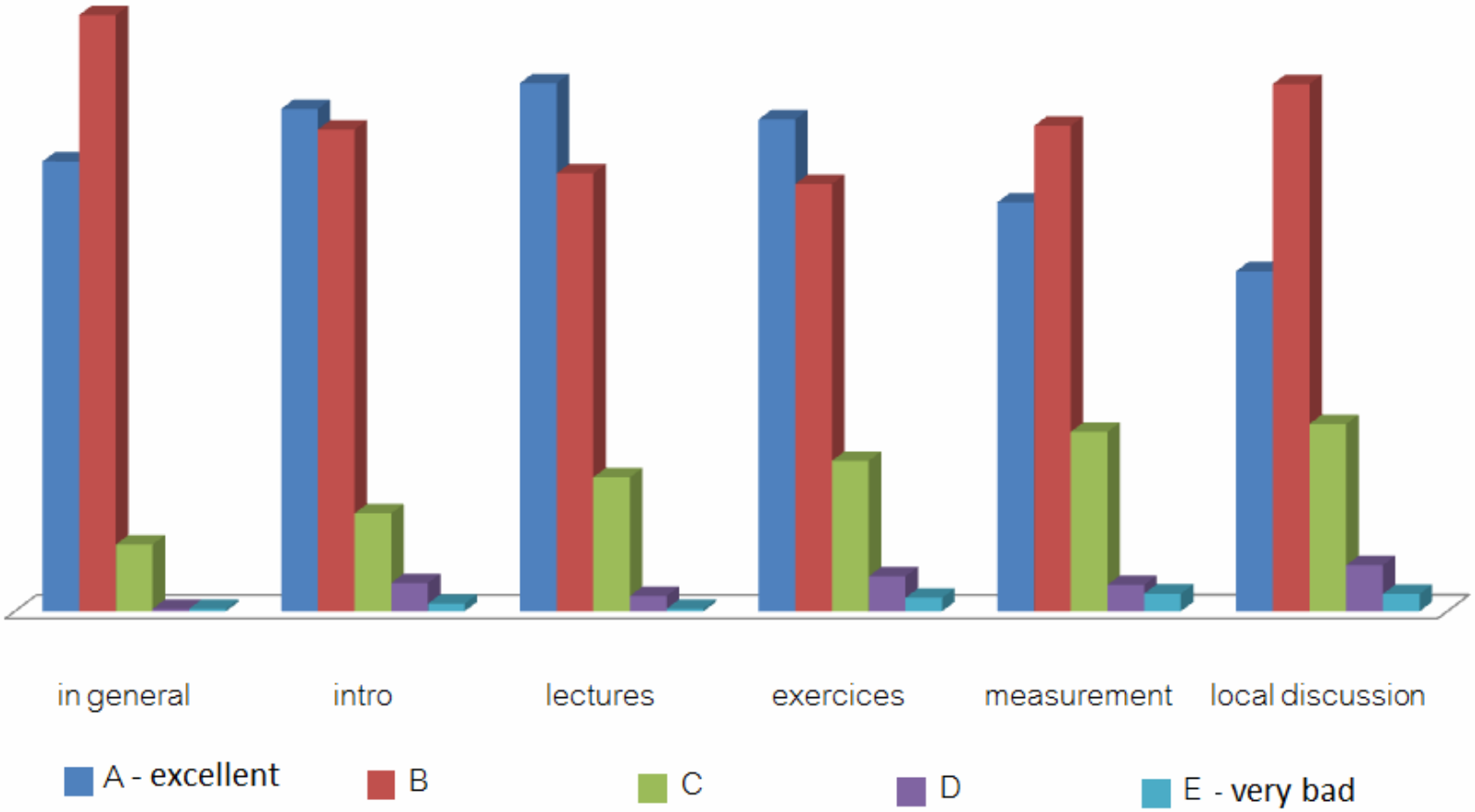


From student survey, 2007

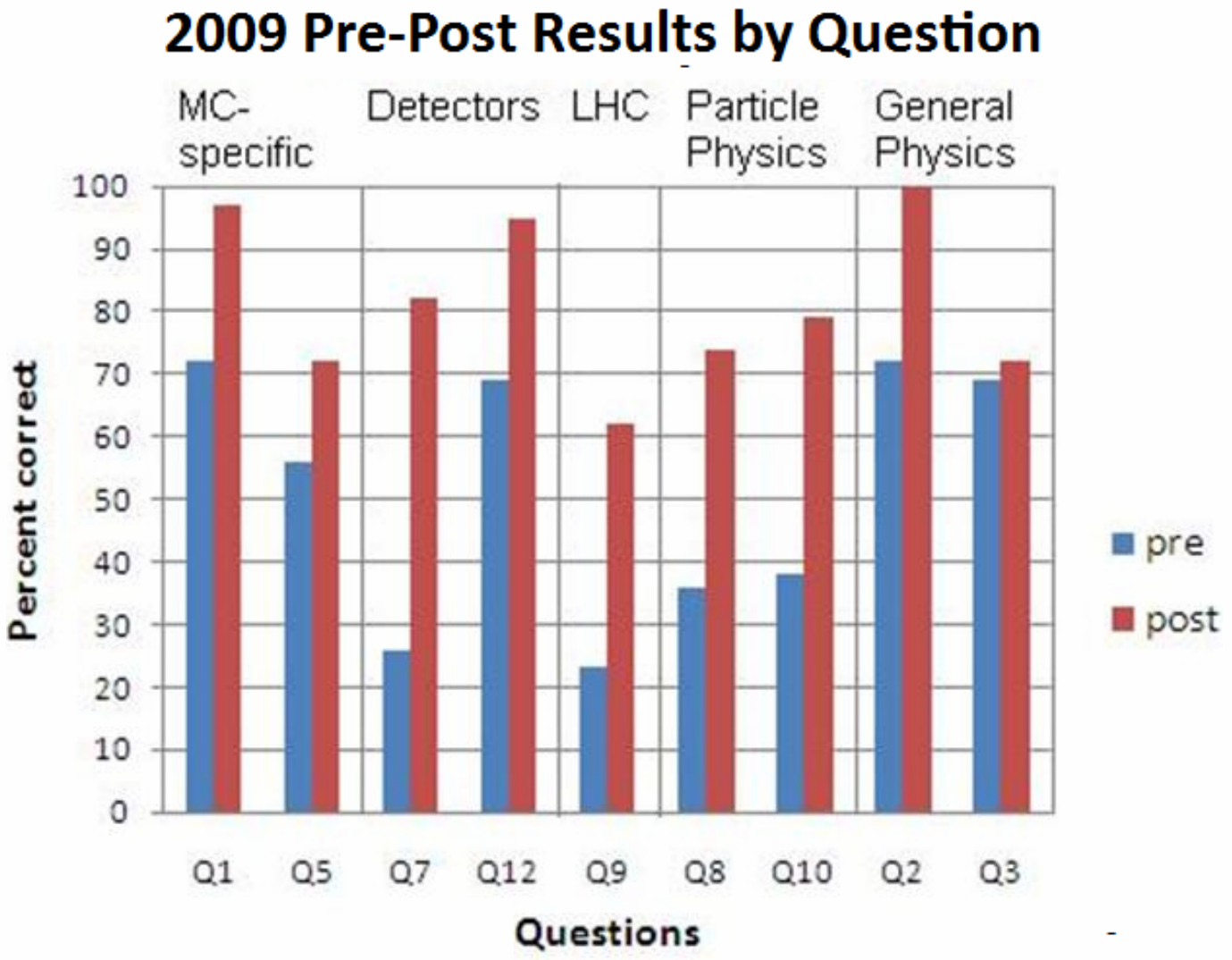




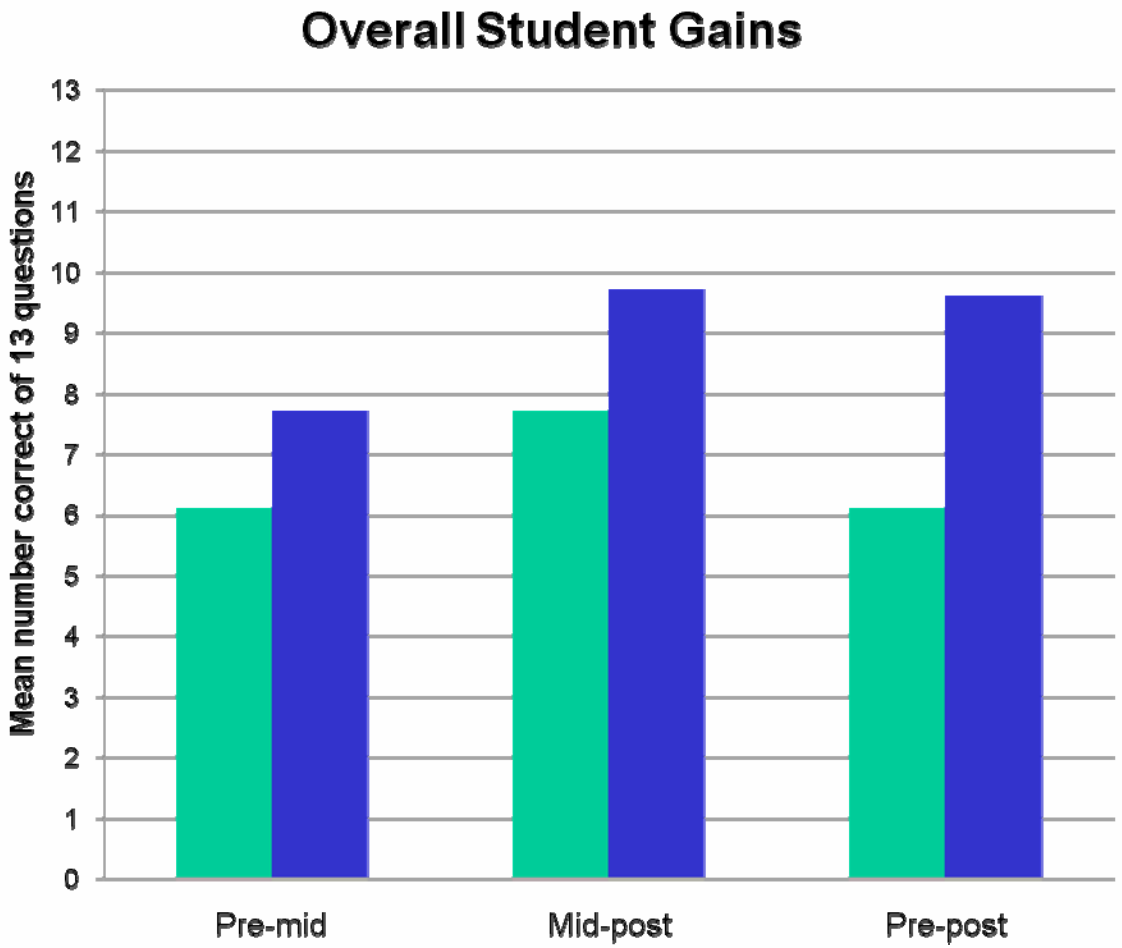
From student survey, 2009



Student gains on content, 2009



2009 Pre-Post Quiz – Overall Result



Based on results from 10 teachers with 90 students

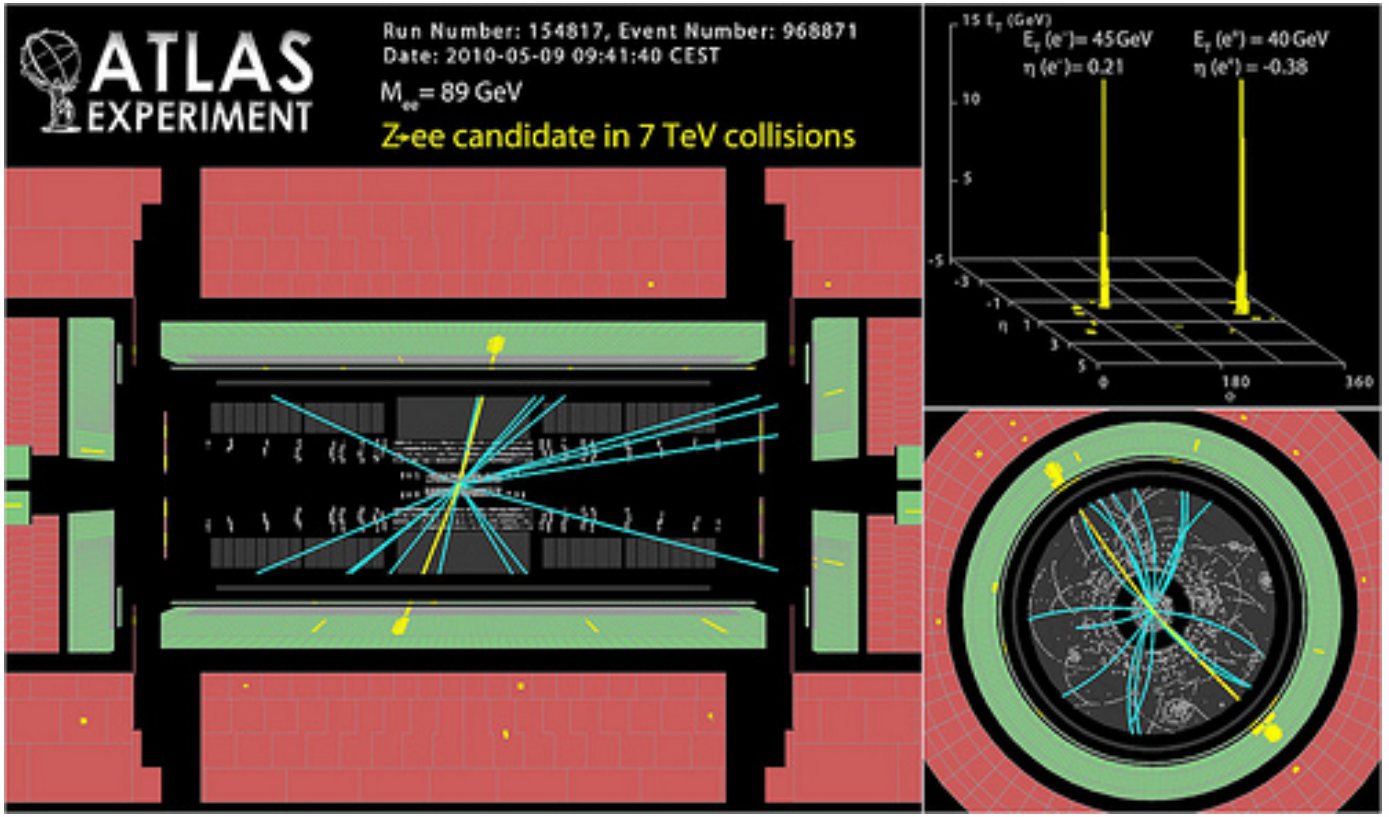
Pre-test: given before clasroom prep

Mid-test: given between classroom prep and MC

Post-test: given within week after MC

Plans beyond 2010

- **LHC Masterclass**
- Students look at Z- and W-decays
- Test the new accelerator and detectors
- This is what physicists are doing right now…



Masterclass model

- Advantages
  - Student engagement and excitement
  - Begin to see data as scientists do
  - Concentrated learning of content
- Applicability
  - Other data available
  - Expand use in particle physics vertically and horizontally
  - Use in other branches of physics?
- More study
  - In particle physics
  - In new fields

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- For assistance and guidance:
  - Christine Kourkoumelis
  - Michael Kobel
  - Uta Bilow
  - Marge Bardeen
  - Peter Watkins
  - Jean Young
- For their work on masterclasses:
  - Moderators and mentors
  - QuarkNet Masterclass fellows
  - High School teachers
  - Our great high school students
  - Many more