INTERNATIONAL MASTERCLASSES HANDS ON PARTICLE PHYSICS

http://physicsmasterclasses.org/neu/index.php?cat=press

Yiota Foka

For IPPOG Masterclass group

IICFP 12.06.2012 Kolymbari, Crete

INTERNATIONAL MASTERCLASSES
hands on particle physics

Outline

IPPOG: aims and activities

IPPOG outreach collection:

recommended tools and materials for formal and informal education settings

How to bring the exciting world of particle physics

to students of all ages, teachers and the general public.

How to benefit from the work of IPPOG and join in its activities.

http://physicsmasterclasses.org/neu/index.php?cat=press

IPPOG

IPPOG: International Particle Physics Outreach Group

It is a network of particle physicists, researchers, informal science educators, engaged in worldwide outreach and informal science education for particle physics.

IPPOG's aim is to raise awareness, understanding and standards of global outreach efforts in particle physics and general science.

Masterclasses

IPPOG initiated several major worldwide activities, such as the well-established “International Particle Physics Masterclasses”.

The Masterclasses is an educational activity that brings the excitement of cutting-edge particle physics research into the classroom.

Each year, since 2005, thousands of high school students in many countries all over the world come to universities or research centres near to their school for one day in order to be “scientists for a day” and unravel the mysteries of particle physics.

Masterclasses in a nutsell

The International Masterclasses

- provide the opportunity for 15- to 19-year old students to discover particle physics
- are organized every year in March over 4 weeks
- are organized by TU Dresden and an international steering group in the framework of the International Particle Physics Outreach Group (IPPOG)

In 2012, 10000 students from 130 institutions in 31 countries took part in the popular event over 4 weeks

INTERNATIONAL MASTERCLASSES
hands on particle physics

Aims of Masterclasses

The aim is to get insight into topics and methods of basic research

The aim is NOT TO TEACH particle physics

Program of the day

School-children get out of school for one day and come to a university or research centre near to the school

- Attend lectures
- Visit a lab

- Perform measurements on real data from particle physics experiments at CERN
- Discuss results locally, prepare presentation, perform a quiz

- Participate in an international video conference (moderated by CERN or Fermilab) to discuss the results with other groups that did the same measurements

Masterclass methods

- **Tools:** Event display programs, software tools and analysis methods are demonstrated by tutors and quickly mastered by students.

- **Measurement:** Students use the tools to measure various properties of some known particles, such as the weak gauge bosons W and Z and hadrons (Jpsi, Upsilon, Lambda, K-short).

- **Interpretation**:
- The concept of invariant mass is first used to identify and measure masses and widths of short-lived particles.
- It is then applied to look for new particles (Higgs) or new state of matter (Quark-Gluon Plasma)
- The fractions of W+ and W- events are interpreted in terms of quark structure of the proton….

Videoconference

- At the end of each day, the participants join in a videoconference moderated by CERN or Fermilab for discussion and combination of their results using tools as in our international research collaborations.

- The combined results are then compared to recent results published by the experiments.

Participation

Masterclasses 2012 in numbers

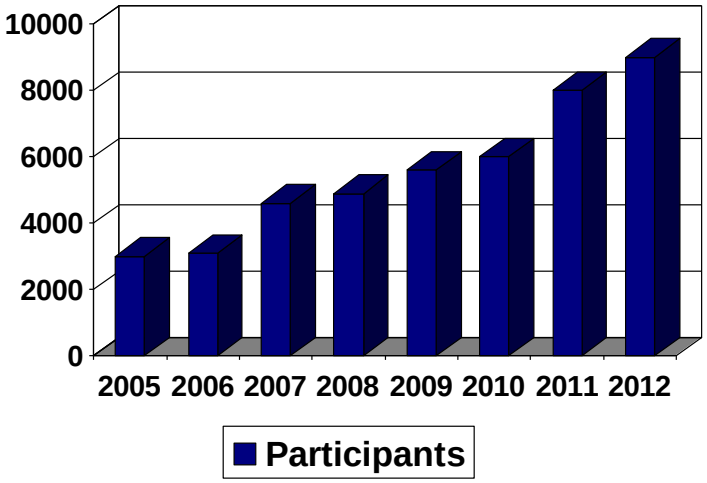
Period: 28.2. – 24.3.2012 (21 days) (10 in U.S.)

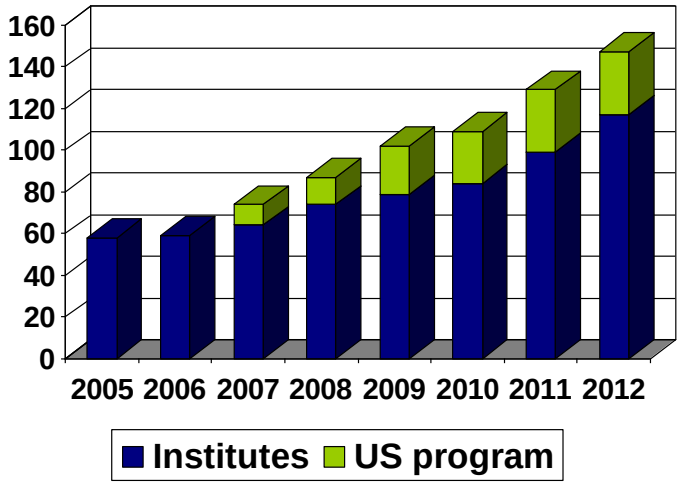
- 143 Masterclasses (30)
  - ALICE: 13 (0)
  - ATLAS W: 42 (0)
  - ATLAS Z: 53 (13)
  - CMS: 35 (18)
- 36 video conferences with CERN (11 with Fermilab)
- 21 moderators (8)
- 117 institutes registered (30)

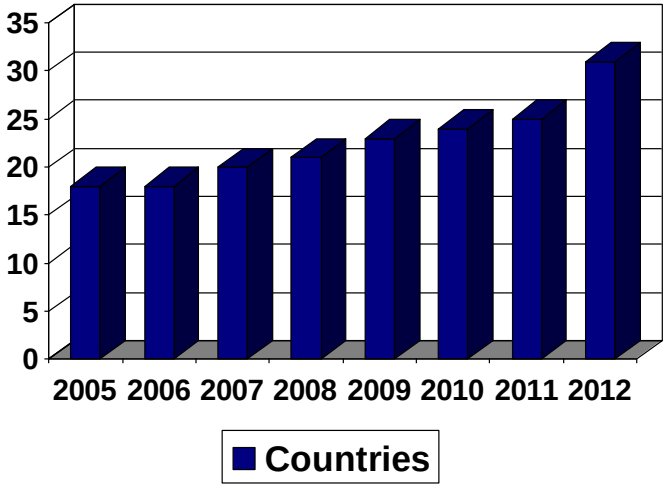
The same Masterclasses were also performed „locally“ (teacher days)

INTERNATIONAL MASTERCLASSES
hands on particle physics

Participation







Interest expressed for 2013:

- India (Mumbai)
- China
- Australia
- Georgia
- Romania
- Cyprus
- middle east?

International Particle Physics Outreach Group

INTERNATIONAL MASTERCLASSES
hands on particle physics

How is it organised?

Masterclasses in practise

The steering group contacts the national representatives who contact universities and research institutes of their countries.

The universities invite schools of their area for one day.

Interested school children are selected or whole classroom participates.

Role of Masterclass Steering Group

- The steering group oversees the project and coordinates the activities

- Contacts the national representatives who contact the universities and schools.

- Prepares the exercises and quiz
- Provides material in web pages (translations in different languages)
- Provides CDs with material
- Prepares videoconference
- Prepares tutors
- Prepares moderators

- Feedback and surveys

Masterclass web page and material

Web page

http://physicsmasterclasses.org/neu/index.php?cat=press

Several Masterclass packages are on the web

together with support material for the tutors (scientists at universities) and moderators

- Explain the physics
- Explain how to set it up (technical)

- Suggestions on the discussion of the results
- Quiz

International Masterclasses – hands on particle physics

INTERNATIONAL MASTERCLASSES

hands on particle physics

facebook

Name:
International Particle Physics Masterclasses

Hands on Particle Physics Masterclasses
ORGANISATION

Welcome in the organisation section of the IPPOG Masterclasses!
Here, we hope to provide you with all that you'll need in order to organise an event that students, teachers and staff will never forget.
Therefore, you can find:

- an **introduction** to the overall organising scheme
- some example **lectures**
- information on the **measurements**
- a **manual** for the video conference, including information on the new quiz
- **corporate material** to prepare e.g. invitation letters or participation certificates
- english **press release**
- german **press release**

We also provide information how we would like to

- present participating institutes on our website or how you can
- contribute in translating the exercises.

International Particle Physics Outreach Group

Hands on Particle Physics Masterclasses
Schedule 2012

The central element of International Masterclasses 2012 will be the International Masterclass weeks from 27.02.12 - 24.03.12, where each day up to five out of about 130 institutes participate. In addition, U.S. institutes have their own Masterclasses, and separate Institute Masterclasses take place, distributed over the whole year. For details on registration and travel to the institutes see: Participation. Some institutes will also hold a teachers day (similar program, but without video conference).

	Mon, March 5	Tue, March 6	Wed, March 7	Thu, March 8	Fri, March 9	Sat, March 10
topic		VC 1: ATLAS W	VC 1: ATLAS Z	VC 1: ATLAS Z	VC 1: ATLAS Z	VC 1: ATLAS W
moderators		Kate, Ulrike	Christian, Philipp	Ruth, Michael	Katharine, Boris	André, Guilherme
		Orsay	Grenoble	Roma Tre	Belgrade	Covilhã
		Valencia	Berlin/DESY, Zeuthen	Barcelona	Prague/Letohrad	Aveiro
		DESY, Hamburg	Tübingen	Vienna Univ.	Brookhaven	Braga
			Poznan	Thessaloniki	Oslo	Lisboa IST
				Brookhaven		São Tomé
topic		VC 2: ALICE	VC 2: ALICE	VC 2: CMS	VC 2: CMS	VC 2: CMS
moderators		Leticia, Peter	Leticia, Constantin	Katharine, Paul	Sarah, Sho	Ruth, Sho
		Oslo	Prague CTU	Palaiseau	Santander	Antwerpen

Hands on Particle Physics Masterclasses

PHYSICS

- What are the fundamental building blocks of matter?
- How can I identify them?
- 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.

ALICE	-	×	-	×	×	-	×	-	-	×	-	-	×	-	-	-	-
ATLAS	-	×	×	×	×	-	×	×	-	×	×	×	×	×	×	-	-

Hands on Particle Physics Masterclasses
MEASUREMENTS

Measurements are available from the web and from DVDs which will be sent out to all Masterclasses institutes. During the measurements students evaluate event displays from proton-proton collision at LHC. Four different packages with data from one of three experiments at the LHC are available:

- ALICE
- ATLAS
- CMS

ALICE

The measurement with ALICE data can be found here. The ALICE measurement includes:

- Measurement of strange particles based on their decay pattern
- Event animations from real pp data at 900 GeV and 7 TeV
- Event animations from PbPb simulated data (at the moment); soon real data too
- Available in English, French, Italian, German, Czech, and Portuguese.

Supporting material:

- Instructions for tutors, including proposed outline for the day, proposed questions and answers (2011 version; will be updated soon).
- A **spreadsheet** for local combination of results can be found here (2011 version; will be updated soon)
- Film and presentation on "Heavy Ion Physics and ALICE experiment"
- Animation of the ALICE experiment and detector elements
- Animation of Pb+Pb collision creating QGP from a model (URQMD)

Some moderators

The moderators 2012 are:

Kate Shaw (ATLAS)

Katharine Leney (ATLAS)

André David (CMS)

José Guilherme Milhano (Theory Unit)

Paul Laycock (ATLAS)

Andrée Robichaud-Veronneau (ATLAS)

Ulrike Schnoor (ATLAS)

Kilian Rosbach (ATLAS)

Sarah Boutle (CMS)

Ruth Pöttgen (ATLAS)

Boris Lemmer (ATLAS)

Michael Hauschild (ATLAS)

Leticia Cunqueiro (ALICE)

Pasquale di Nezza (ALICE)

Peter Jacobs (ALICE)

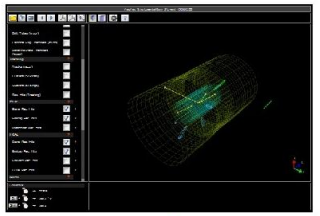
Masterclass_Dresden_2012

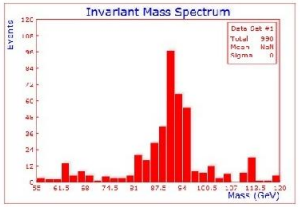
International Masterclass am 19.3.2012

General Idea

Example: CMS W/Z Investigation

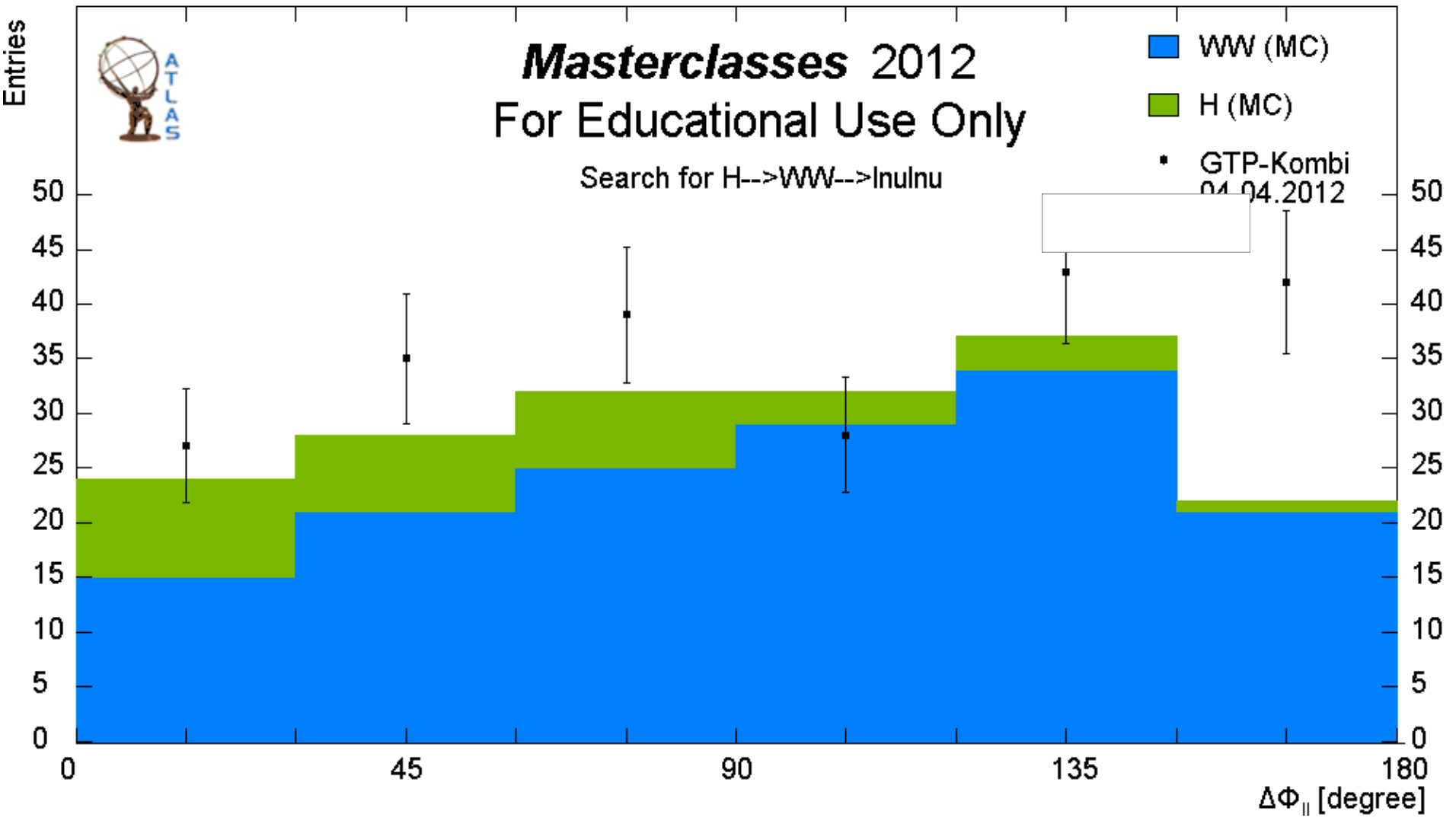
- 1900 Events:
  - W and Z
  - Background
  - “Mystery” events 2-12 GeV
- Students sort events by:
  - Lepton flavor (e or μ).
  - Candidacy (W or Z).
  - Charge (W+ or W-).
- Find:
  - W+/W-.
  - e/μ.
  - Z mass.
  - W/Z (challenge).





Masterclass 2012 measurements

ATLAS W measurement



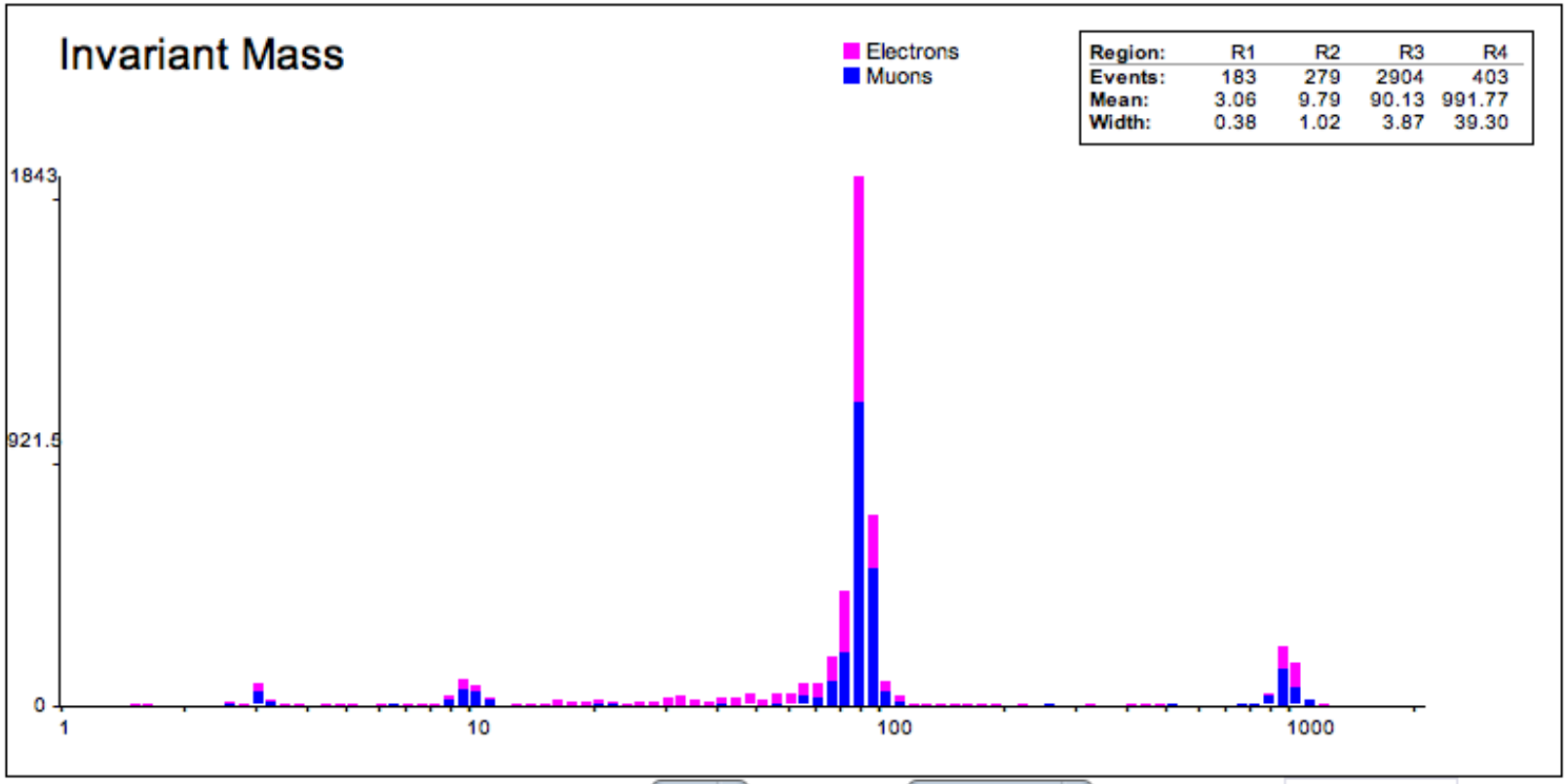
International Particle Physics Outreach Group

ATLAS Z measurement

OPIoT - MasterClass – Combination for all institutes on 09.03.2012

Start Student Moderator Administrator

Choose new date

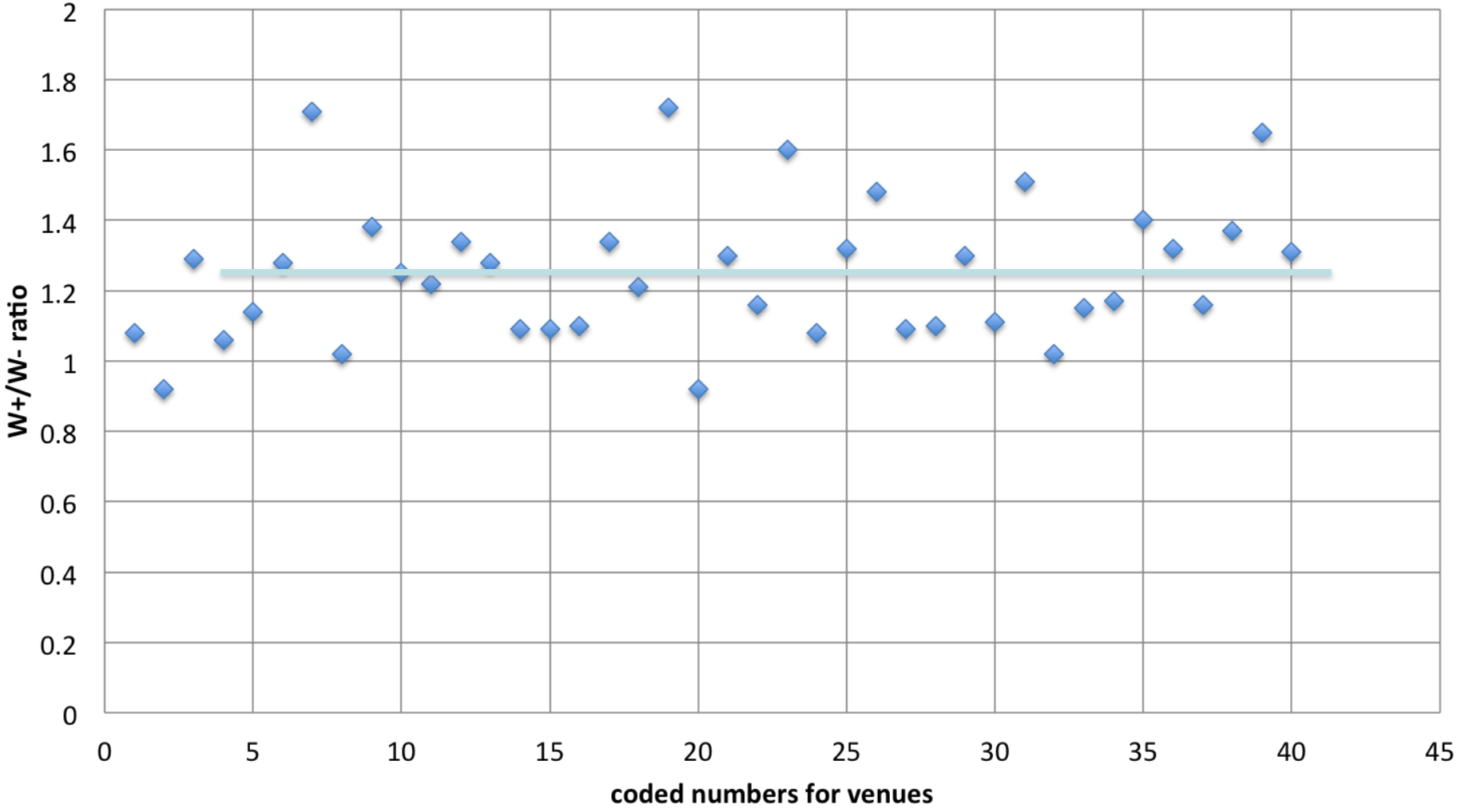


Bins: 100 X-Axis: Logarithmic Refresh

R1 Min:	2.0	R2 Min:	7.0	R3 Min:	80.0	R4 Min:	900.0
R1 Max:	4.0	R2 Max:	13.0	R3 Max:	100.0	R4 Max:	1100.0

INTERNATIONAL MASTERCLASSES
hands on particle physics

ATLAS W measurement



CMS measurement

EditGrid

Spreadsheet / qnmasterclasses / CMS WZ lodz

File Edit View Format Insert Data Share Publish Collaborate Macro Help

H26

	A	B	C	D	E	F	G	H	I	J	K
1	mc_no.	electron	muon	W+ cand	W- cand	W cand	Z cand	"zoo"			
2	1	60	40	28	28	19	17	12			
3	2	36	20	34	14	0	9	0			
4	3	43	43	14	15	32	10	9			
5	4	31	22	14	9	11	12	4			
6	5	64	36	41	36	9	4	6			
7	6	57	31	23	43	17	8	7			
8	7	19	34	24	22	1	3	0			
9	8	29	28	9	30	5	3	3			
10	9	14	37	8	13	24	4	1			
11	10	49	61	22	42	21	11	3			
12	11										
13	12	53	59	24	22	7	7	44			
14	13										
15	14	55	65	64	49	96	8	3			
16	15	38	13	4	5	3	3	35			
17	16	40	61	1	5	41	18	36			
18	17	36	65	21	33	46	21	4			
19	18	31	18	9	30	5	0	4			
20	19	22	24	22	18	49	3	11			
21		677	657	362	414	386	141	182	<-- Institute Totals		
22											
23											
24	Z cand masses		<-- make one contiguous list below A24					e/mu =		W+/W- =	
25	3.03							1.03044140030441		0.8743961352657	
26	11.18			To make mass plot:							
27	17.37			http://freyr.phys.nd.edu/~karmgard/histogram							
28	11.1			http://www.shodor.org/interactivate/activities/Histogram							
29	14.84										
30	17.01										
31	67.61										

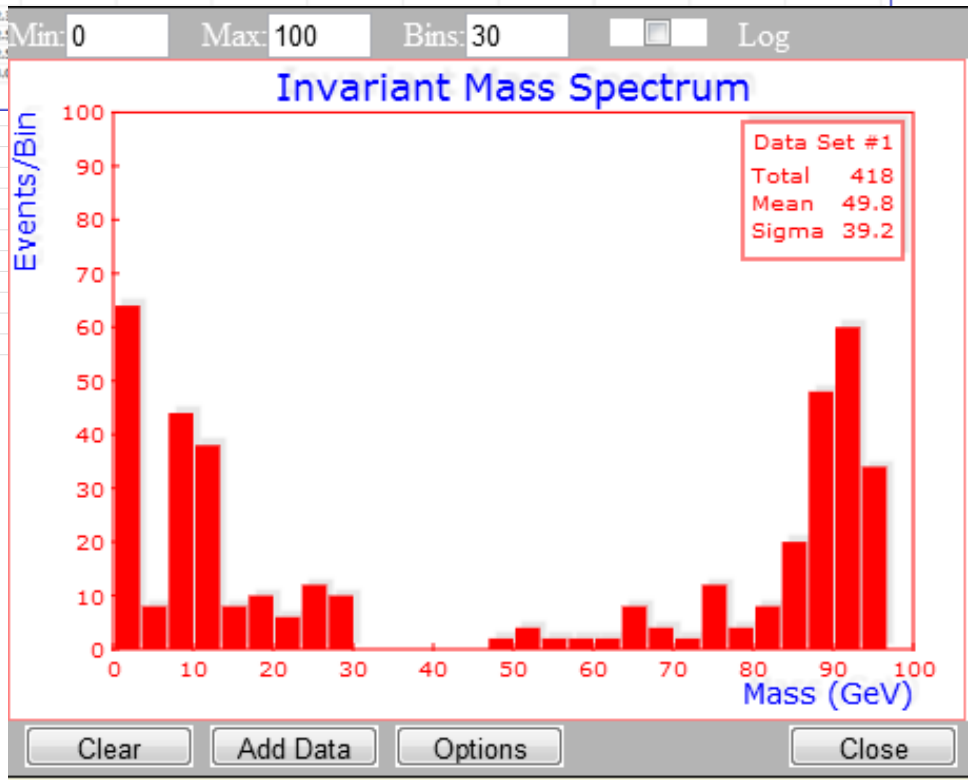
CMS W/Z Measurement Results Date:

Institute	electron	muon	W+ cand	W- cand	W cand	Z cand	"zoo"	e/mu	W+/W-
Padova 1	148	80	97	74	25	26	132	1.85	1.31
Split	741	880	358	296	180	178	596	0.84	1.21
Trieste	318	301	176	182	96	59	85	1.06	0.97
Lodz	677	657	362	414	386	141	182	0.87	0.87
Geneve CERN	355	375	385	318	15	103	25	0.95	1.21
	2239	2293	1378	1284	702	507	1020	0.98	1.07

Z cand masses

<-- make one contiguous list below A13

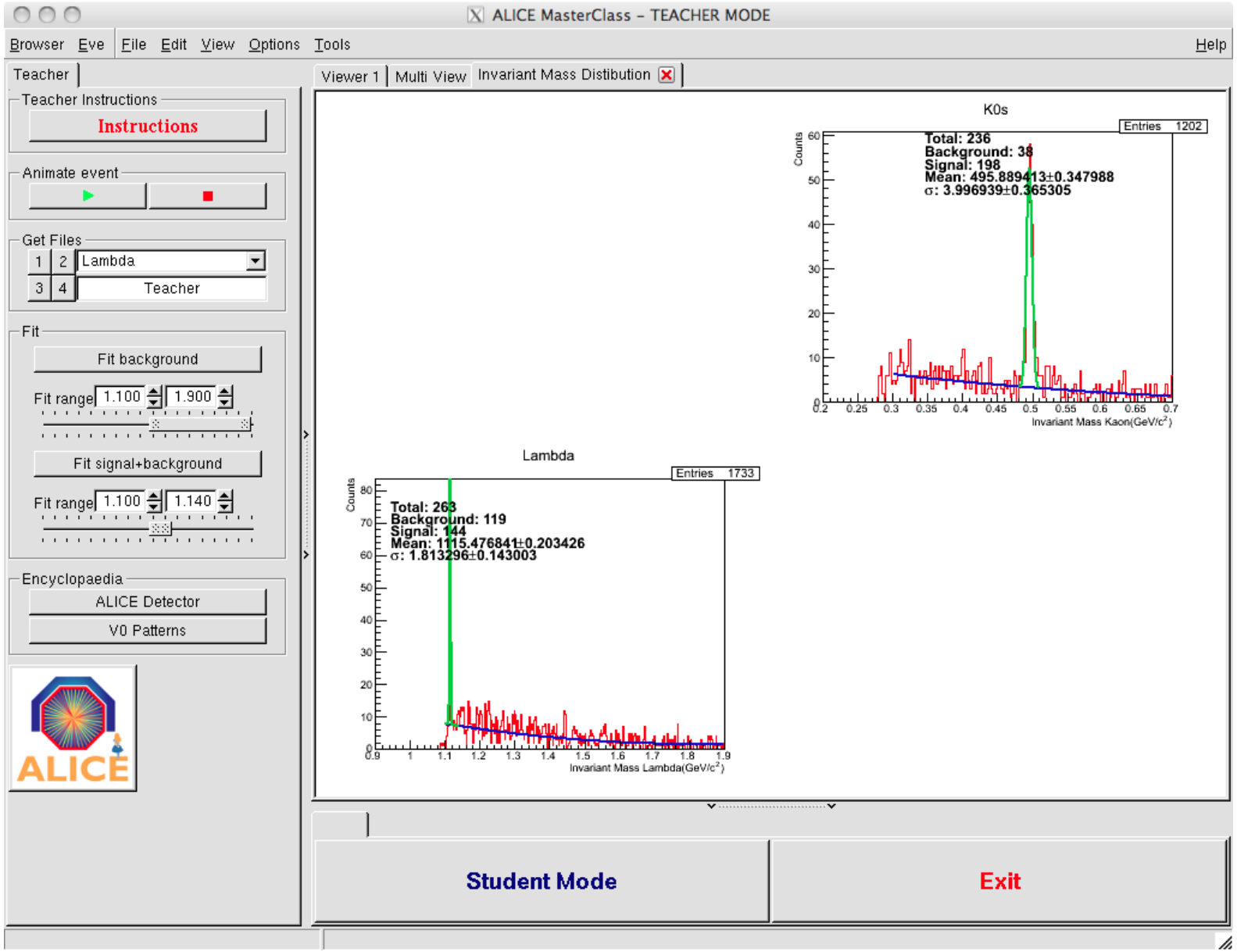
To make mass plot:
http://freyr.phys.nd.edu/~karmgard/histogram/
http://www.shodor.org/interactivate/activities/Histogram/



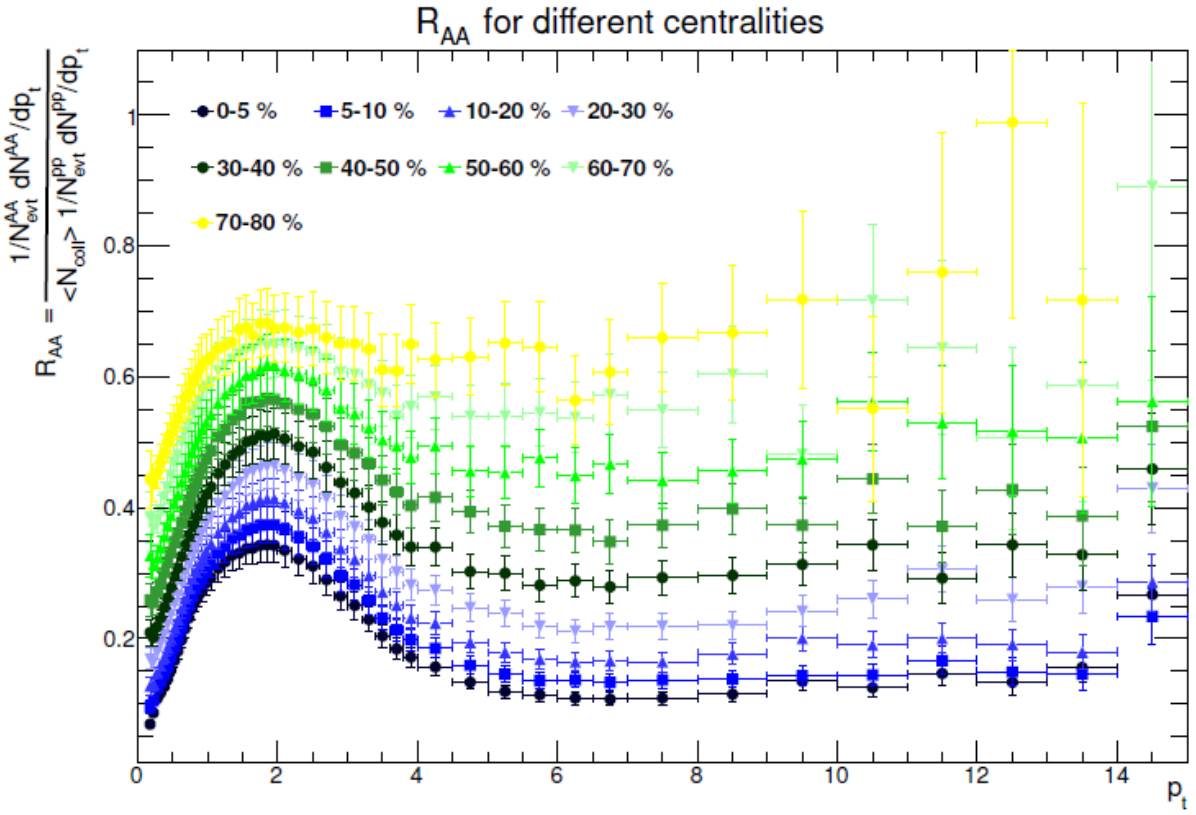
Adoption 2012

- 46 masterclass institutes in 18 countries
- Summer 2012 in Beijing, Melbourne, Sydney, and . . .

ALICE strange particle measurement



ALICE RAA measurement



→ close to the published result!

Videoconferences

Features:

- Moderators lead discussion
- Icebreaker questions
- Presentation and discussion of results
- Use Indico

Apparent Results:

- Many compliments, some bad experiences
- Tools/Vidyo replacing EVO mostly worked well

Materclass and Press

IQBAL PITTALWALA/UC RIVERSIDE/CONTRIBUTED IMAGE

UC Riverside physics Professor Bill Gary, standing on left, and San Jacinto High School teacher Mark Bonnard assist San Jacinto High physics students, left to right, Jensine Junus, Anna Sivils, Jesus Mondragon Legorreta and Cristina Millar, analyze particle physics data from the European Center for Nuclear Research.

2 of 2

How did the quiz work?

What about the students?

Nantes

The new concept of the video conference – *how did it work out?*

Laurenz Widhalm, Austria

General Feedback from Moderators

Masterclass aims in detail

Aims of Masterclass

- On a basic level: students should (e.g. via lectures)
  - be *informed* (not taught) about
    - the new age of exciting discoveries in particle physics (HEP);
      big questions/possible discoveries at the Large Hadron Collider and in the "masterclass" experiment
    - central findings of hep research in last ~30 years
      (standard model, building blocks, forces, charges,…)
    - status of "masterclass" experiment (ATLAS, CMS, ALICE or LHCb)

  - get insight in the way hep research is organized
    - in international collaborations
    - in dialogue/exchange of experiment and theory
    - wrt. methods of discovery of new phenomena
      (counting methods, mass peaks, etc.)
    - methods or and reasons for calibrating detectors

Aims of Masterclass

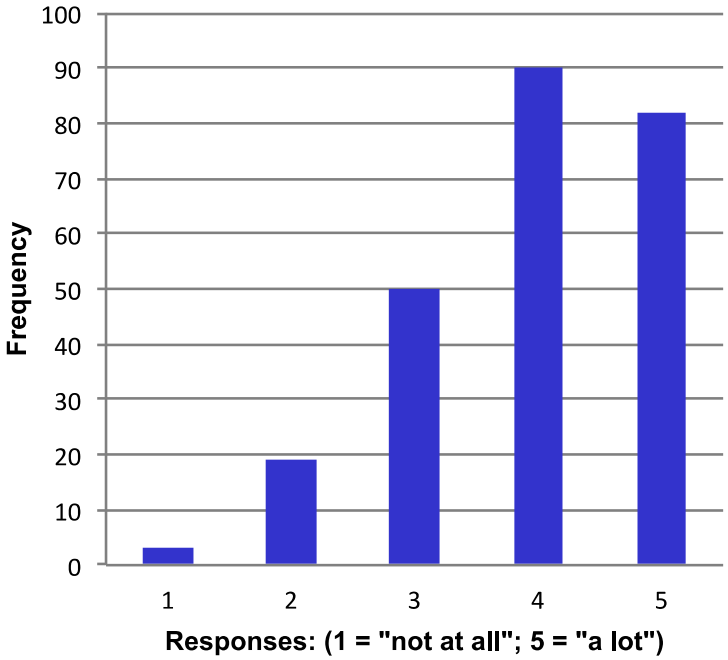
- Students should *learn* themselves to
  - identify different particles via their pattern in detectors
  - categorize events of (LEP and) LHC in pre-defined final states
  - do a measurement of a physics observable
    (LEP: e.g. Z branching fraction, ratios of branching fractions;
    LHC: e.g. ratio of W+ / W-)
  - interpret this measurement and get basic insights from it
    using theoretical/phenomenological arguments
    (lepton universality, number of color charges, proton structure)
  - combine results (different groups, different experiments) to improve results
  - identify events which would be candidates for new physics
    and qualitatively understand pre-conditions for claiming a discovery
    (e.g. WW or ZZ events as Higgs candidates, 3 lepton events as SUSY candidates)

Aims of Masterclass

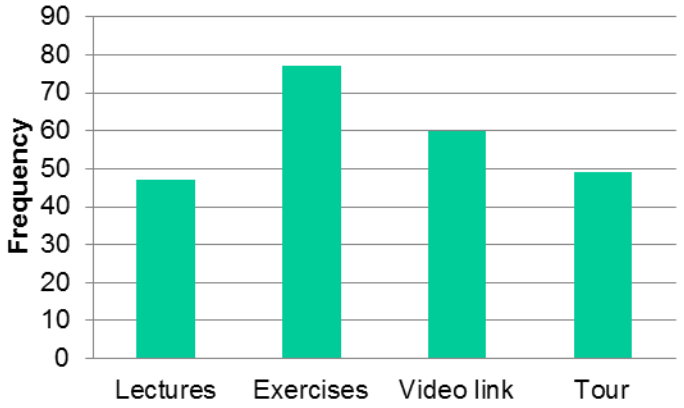
- Get the feeling that they:
  - understand the basic principles about how particles are identified
  - are able to perform themselves some of the measurements, which the scientists currently do, on a somewhat simplified level
  - are able to draw conclusions from these measurements
  - understand the way modern particle physics research is organized
- get the impression that
  - topics of fundamental research in natural science are interesting
  - its results are relevant as cultural knowledge of mankind

From U.S. Surveys (not yet complete)

Prelim: How did you like the masterclass you attended today?

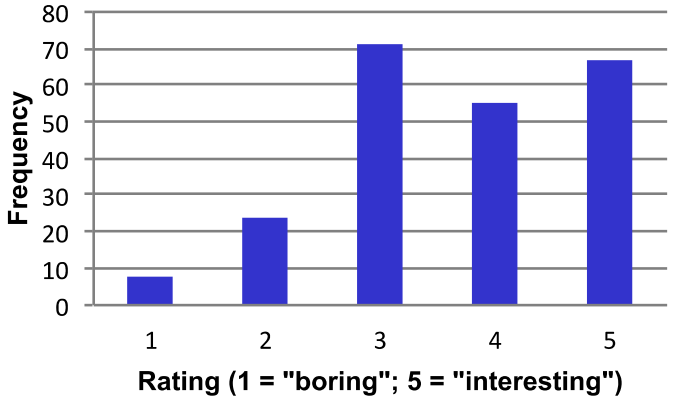


Prelim: What did you like *best* about the masterclass?



Note "plushy" Higgs boson (discovery claimed by students)

Prelim: Video link rating



International Particle Physics Outreach Group

What are our aims, after all?

- Make students feel like a researcher for one day
  - They do „measurements“ (!), not exercises
  - They feel able to „do it themselves“
  - They understand the basic concepts
- They understand the meaning of their measurement
  - What did they find out?
  - Where does it play a role in our Universe?
- They understand the scientific process
- Not try to teach the whole Standard Model in one day

  but just fascinate by sharing authentic fundamental research

Improving: issues to consider

- Stability of measurement tasks
  - Pro: easier organisation
  - Contra: exciting to follow what scientists do
- Severity of measurement tasks .vs. upcoming boredom
  - Work harder in few events or go through many events ?
  - Be as close as possible to scientists ‘ real way of working

    or just measuring the same quantities differently (by visual inspection)

- How to assure that students understand
  - what questions scientists are after?
  - how scientists solve these in practice?
- How to balance between
  - use of automatic tools (danger: black box)
  - real, but tedious hands-on working (curvature, zooming, counting…)

Improving: issues to consider

- Diversity versus Unification
  - wrt tools for histogramming and combining
- How to assure that 120 institutes can join in?
  - normally by far not all experts, need some stability
- International use .vs. local use
  - One measurement version for both? Or two variants?
  - One website for both (via „metro plan“) or two?
- How to really test the tools before the events?

International Particle Physics Outreach Group

Funding

- Helmholtz-Alliance (until end of 2012): coordinator
- BMBF (ending 6/2012): upgrade on LHC data, DVDs
- EPS HEP Division: DVDs
- Plus in kind contributions (CERN, moderators, …)

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IPPOG International Masterclasses

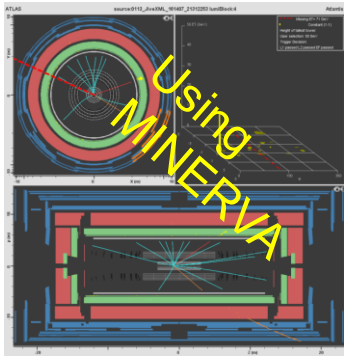
Report of New Measurements Working Group

International Particle Physics Outreach Group

INTERNATIONAL MASTERCLASSES

hands on particle physics

ATLAS W-Path



- „real data“ preselected events (W → ℓn)
- W charge asymmetry ➔ structure of the proton
- 5 *simulated* H →WW ➔ search for yet undiscovered

For 2012:

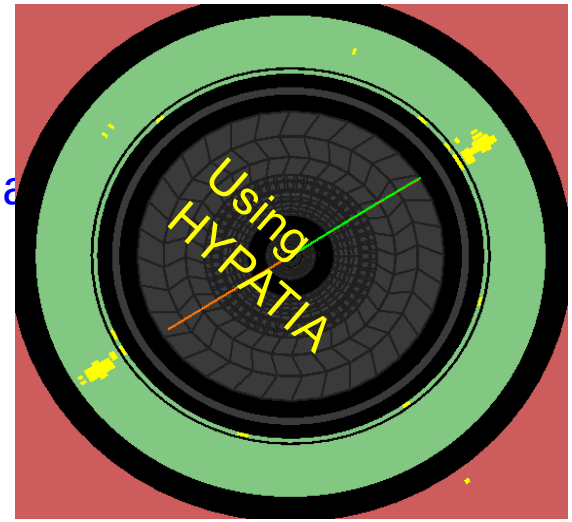
- 10 000 *real data* preselected events (~ 2000 W → ℓn)
- different set of data for each institute, can be compared for consistency and combined in the video conference.
- include 250 *candidates* WW + 0 jets at an early stage of the selection, (i.e. including considerable background)
- too early for 2012? Fallback solution: MC data

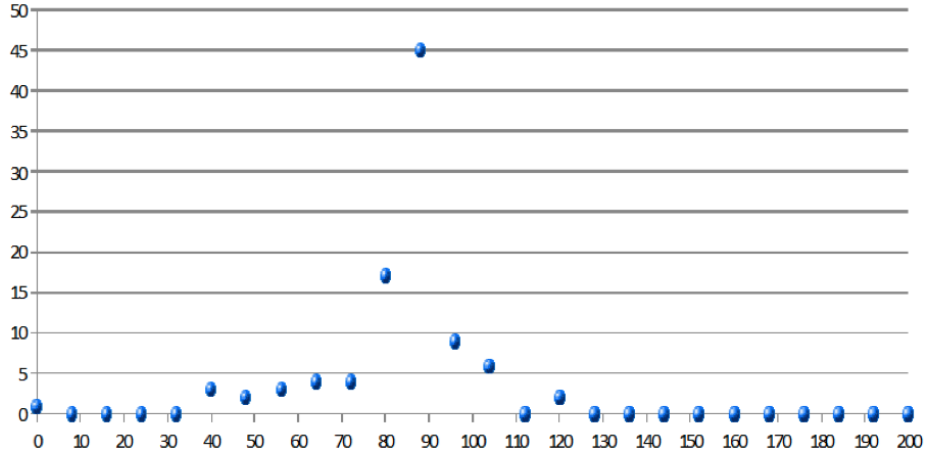
→students measure opening angle between 2 leptons and combine their results in histogram for angular distribution

ATLAS Z-Path

- 700 *real data* preselected events (~ 300 Z → ℓℓ)
- Find Dilepton events → calculate invariant mass
- 300 *simulated* Z´ → ℓℓ → search for yet undiscovered
- Derive mass spectrum

- Discuss importance of invariant mass concept
- Discuss meaning of finite width
- Discuss meaning of new mass peaks (Z´, not shown a





International Particle Physics Outreach Group

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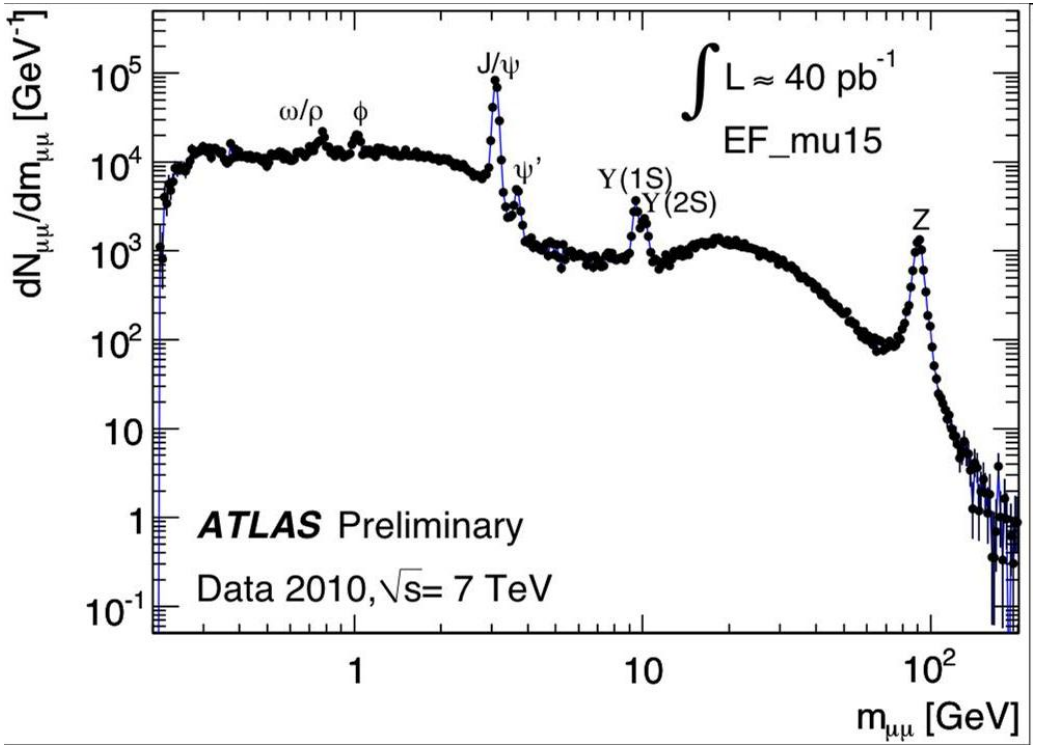
ATLAS Z-Path

Plans for 2012:

- larger data sample
- Also J/Psi and Upsilon
- Identify search for dilepton events
- php tool for mass plots under development



International Particle Physics Outreach Group

INTERNATIONAL MASTERCLASSES
hands on particle physics

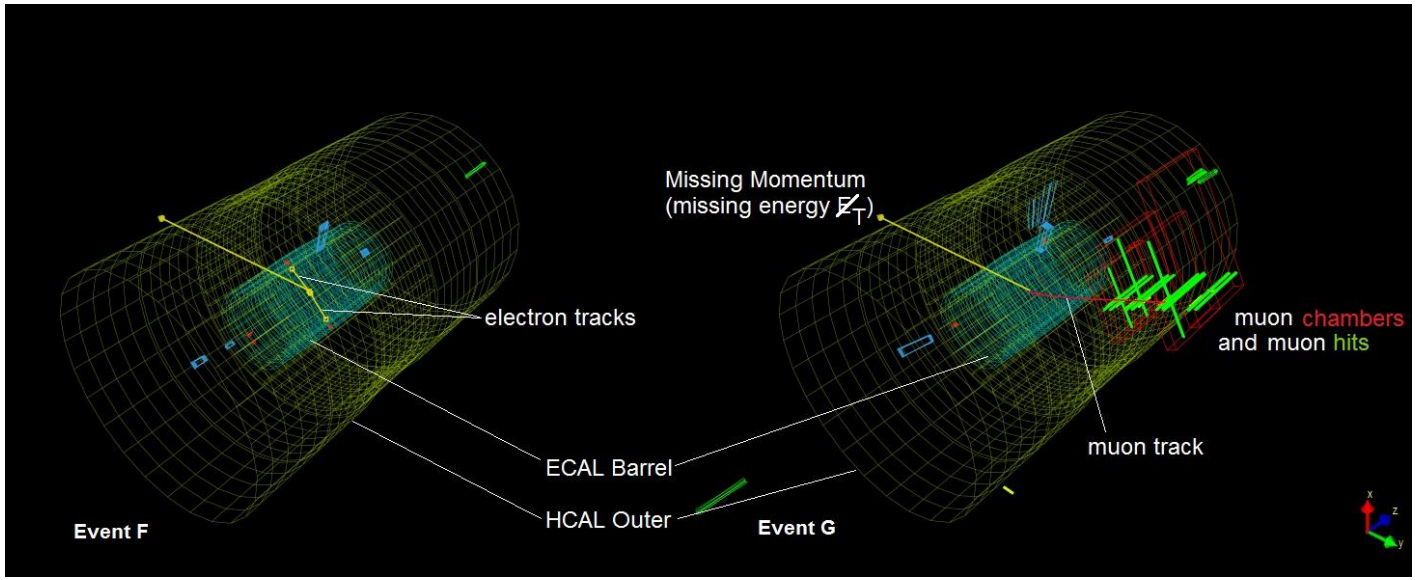
iSpy Online

New Features for W/Z:

- Missing Et vector
  - And slider
- Changes in controls
  - Numbers of objects – gone
  - Electron tracks moved

Explore:

- Development version

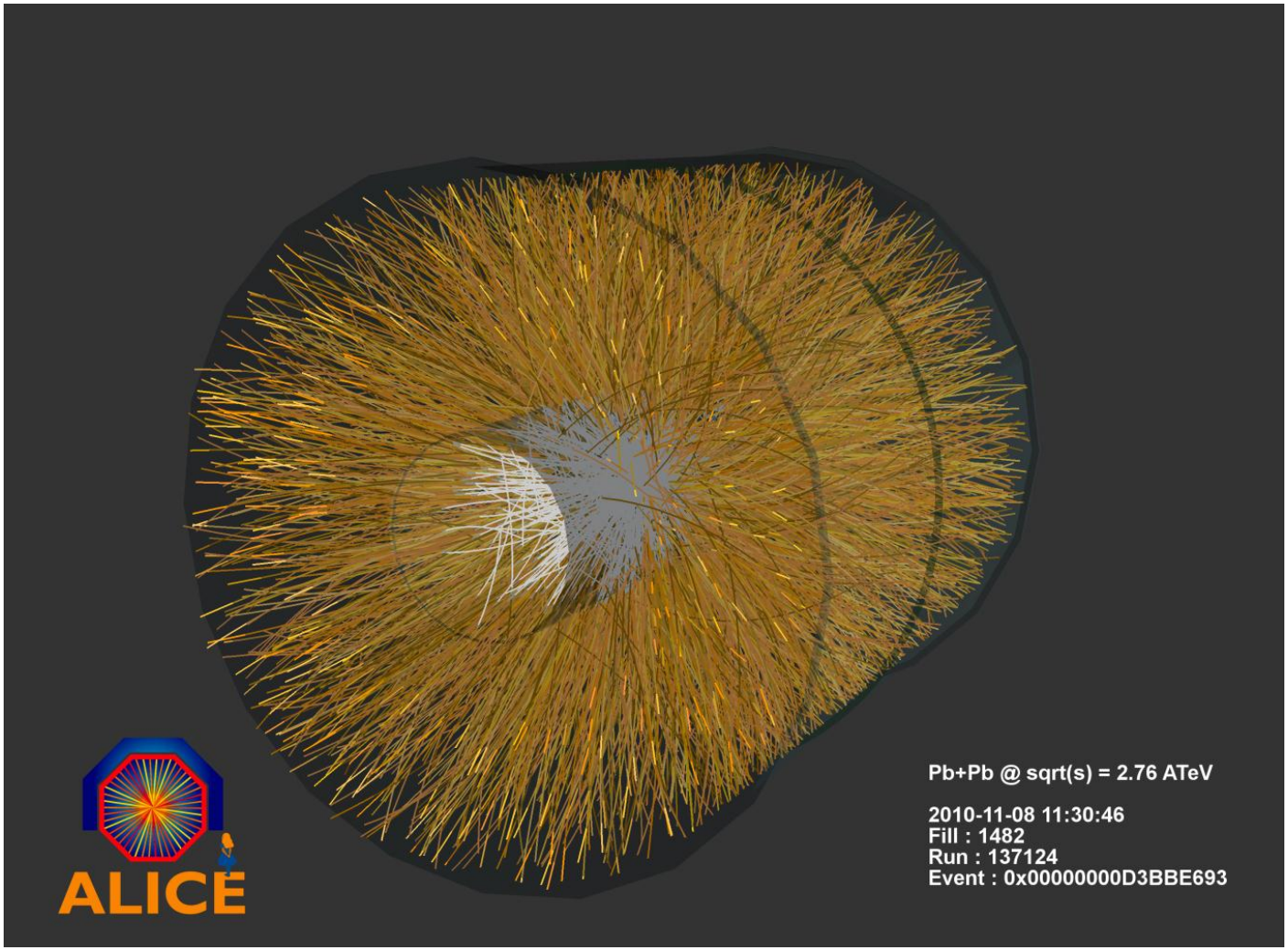


ALICE measurements

ALICE

"Heavy-ion" experiment at LHC (study Lead-on-Lead collisions)

Investigation of quark-gluon plasma properties



ALICE measurements

Physics Motivation: Looking for Quark-Gluon Plasma

- How to create it? In high energy collisions of Lead-on-Lead
- How to “see it”? Look for its “card-visit” (its signature)

Signatures of QGP: special features in PbPb compared to “normal matter” (pp)

- Huge temperature and density
- Strange particle enhancement
- Energy Loss: Nuclear modification factor RAA

Experimental Observables

- We have no “thermometer”; use particle ratios
- “Count” strange particles (K0s, Λ, Ξ-) in PbPb and pp; compare
- “Count” charged particles in PbPb and pp; compare

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hands on particle physics

ALICE measurements

The tools

- Simplified event display, close to the real one used at the experiment
- Visual analysis of small event sample
- Large statistics analysis including background and “writing code”

The data

- First LHC data (900 GeV proton proton) : develop / run masterclasses 2011
- 7 TeV proton proton data in 2012
- 2.76 TeV Pb-Pb data in 2012

Excercise 1: decay patterns of strange particles
developed 2010-11

Excercise 2: momentum spectra of unidentified particles (RAA)
developed 2012

INTERNATIONAL MASTERCLASSES
hands on particle physics

International Particle Physics Outreach Group

INTERNATIONAL MASTERCLASSES

hands on particle physics

ALICE 3 days on the 2012 schedule

looking for strange particles

R_{AA} exercise

Tue, March 6	Wed, March 7	Thu, March 22
VC 2: ALICE	VC 2: ALICE	VC 1: ALICE
Leticia, Peter	Leticia, Constantin	Guilherme, Pasquale
Oslo	Prague CTU	Clermont-Ferrand
Bergen	Copenhagen	Geneva CERN
Heidelberg	Nantes	São Paulo
Frankfurt		Nantes
Darmstadt		Santiago de Compostela

Goals

Introduce basic consepts; try to keep number of required physics and analysis concepts to a minimum

Two step analysis approach

- introduce the idea in a visual, hands-on analysis
- large scale analysis close to what we do in real life

→ let‘s write some analysis code together!

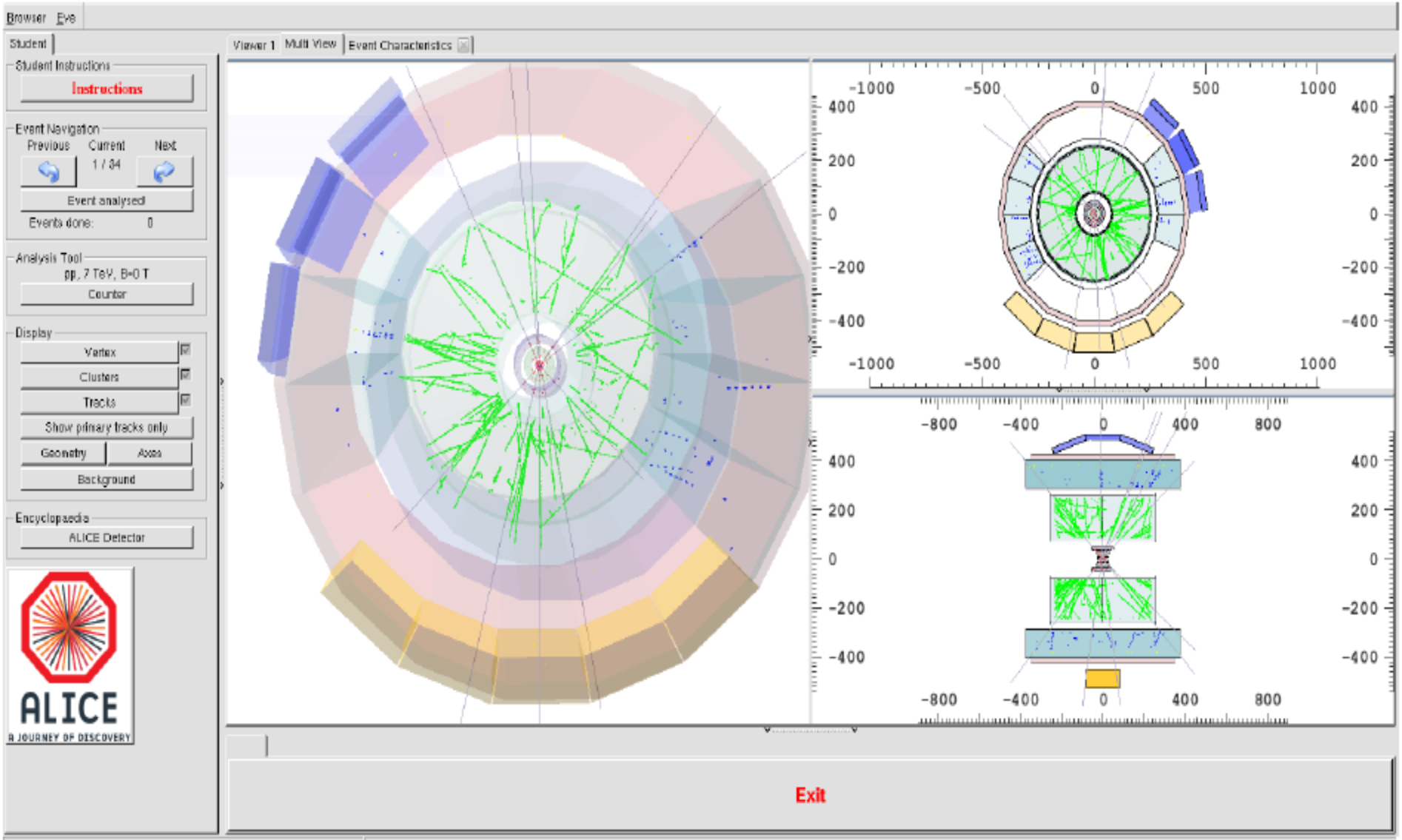
Emphasize the importance of collaborative work

- Different groups of students and institutes analyse different sets of events
- Combine, compare at the end

Visual analysis

Proton-proton (pp) event

Introduce concepts and visual analysis tools

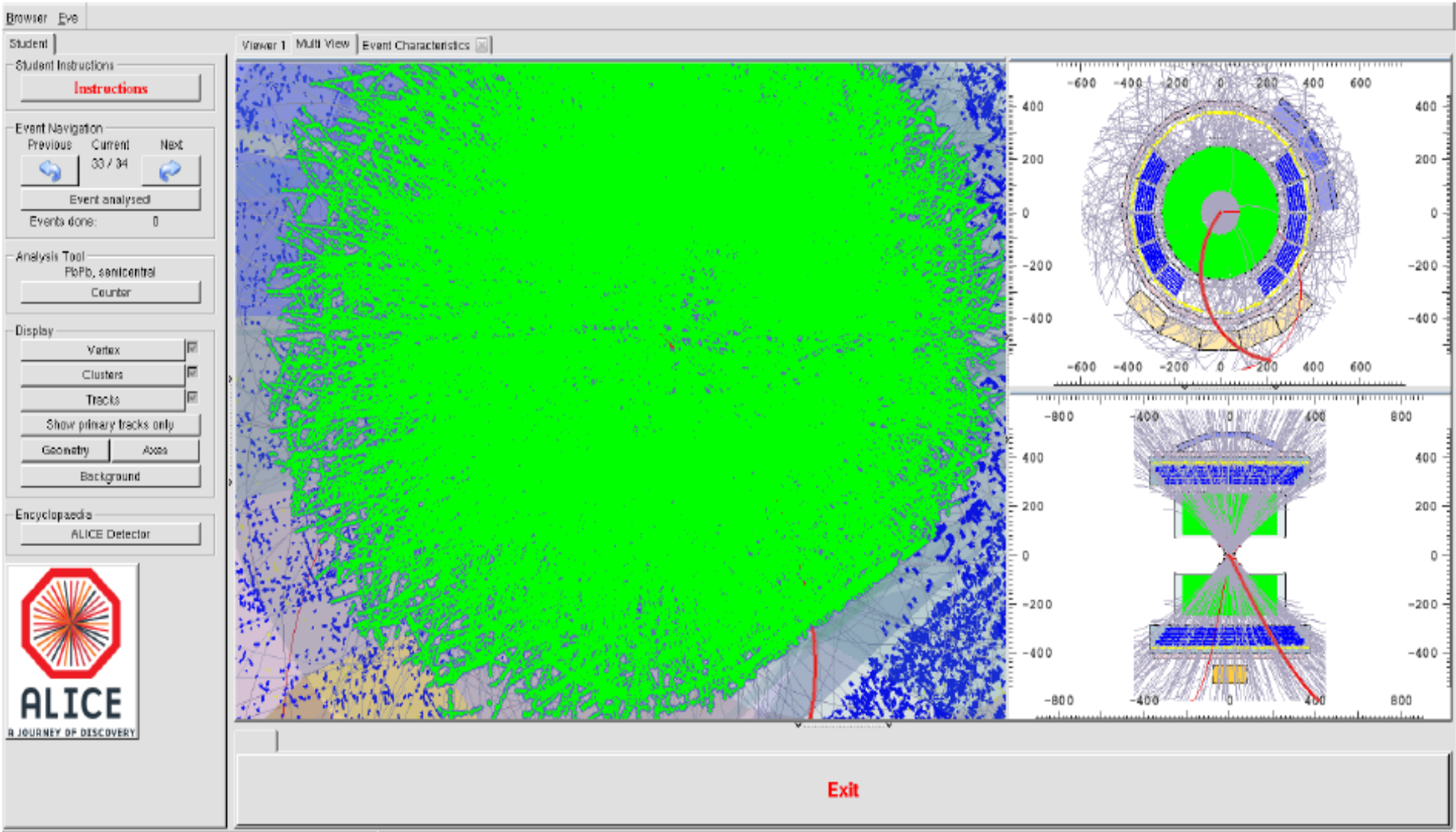


Visual analysis

Lead-Lead (PbPb) event

Visual impressions: PbPb is different than pp

Visual analysis has limits



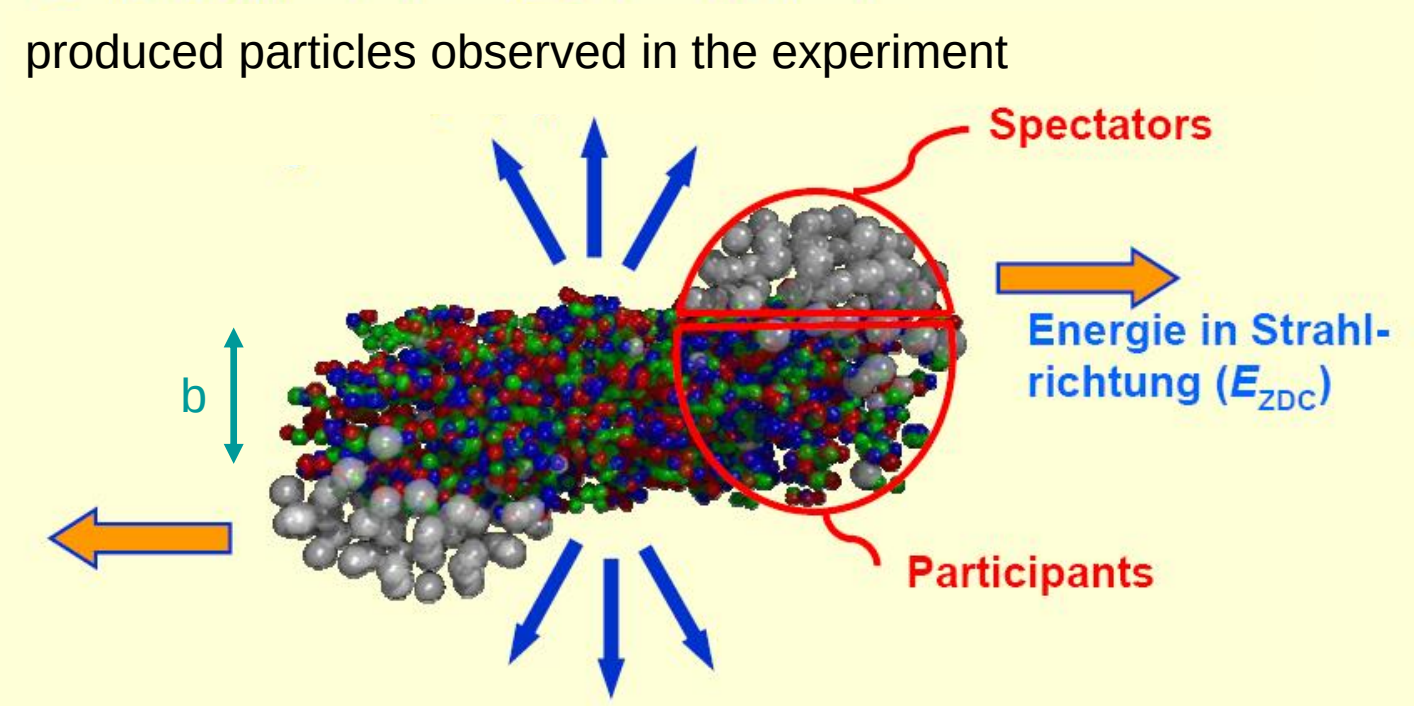
physics lesson

Pb-Pb collision ≠ many independent pp collisions

Comparison of pp events and Pb-Pb collisions with different collision geometries

Collision geometry

cartoon of a Pb-Pb collision



More central (head-on) collisions produce more particles (higher multiplicity)

Peripheral collisions produce small number or particles (proton-like)

Necessary concepts

Geometry of Lead-Lead Collisions (centrality)

Reconstruction of charged particle trajectories from hits in tracking detectors (ALICE TPC in this case)

easily explained in visual analysis

Step 1: Momentum measurement via curvature of tracks in a magnetic field

visual analysis

Momentum Spectra

not needed: particle identification, particle decays, quantum numbers …

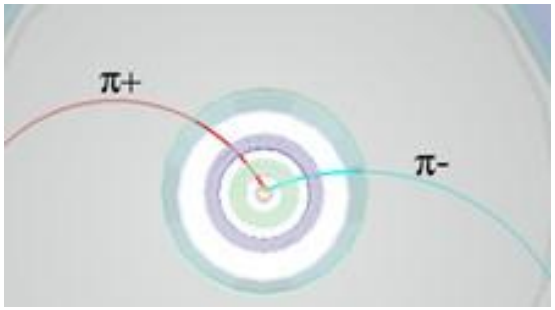
Step 2: Reconstruction of decay patterns (secondary vertices)

visual analysis: identify decay pattern

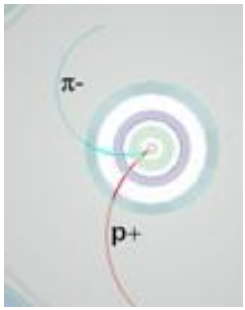
Strange Particle Decay Patterns

Excercise 1
Strange Particles

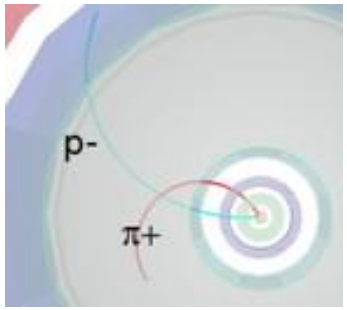
Visual identification of patterns of decays of strange particles



$K^0_s \rightarrow \pi^+\pi^-$

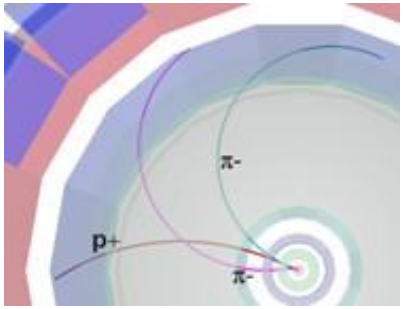


$\Lambda \rightarrow \pi^- p$



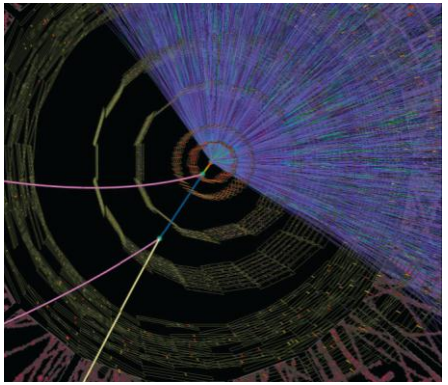
anti $\Lambda \rightarrow p^- \square^+$

Two opposite tracks from a secondary vertex



$\Xi^- \rightarrow \pi^- \Lambda \rightarrow \square^- p \square^-$

Bachelor (single track) and two opposite tracks coming from a secondary vertex



Simulated Pb Pb event

Analysis tools

Interactive!!!
Grab and rotate

Simplified ALICE event display

3 views of ALICE – 3D, rϕ, rz

Highlights decay patterns

Recognise from decay pattern

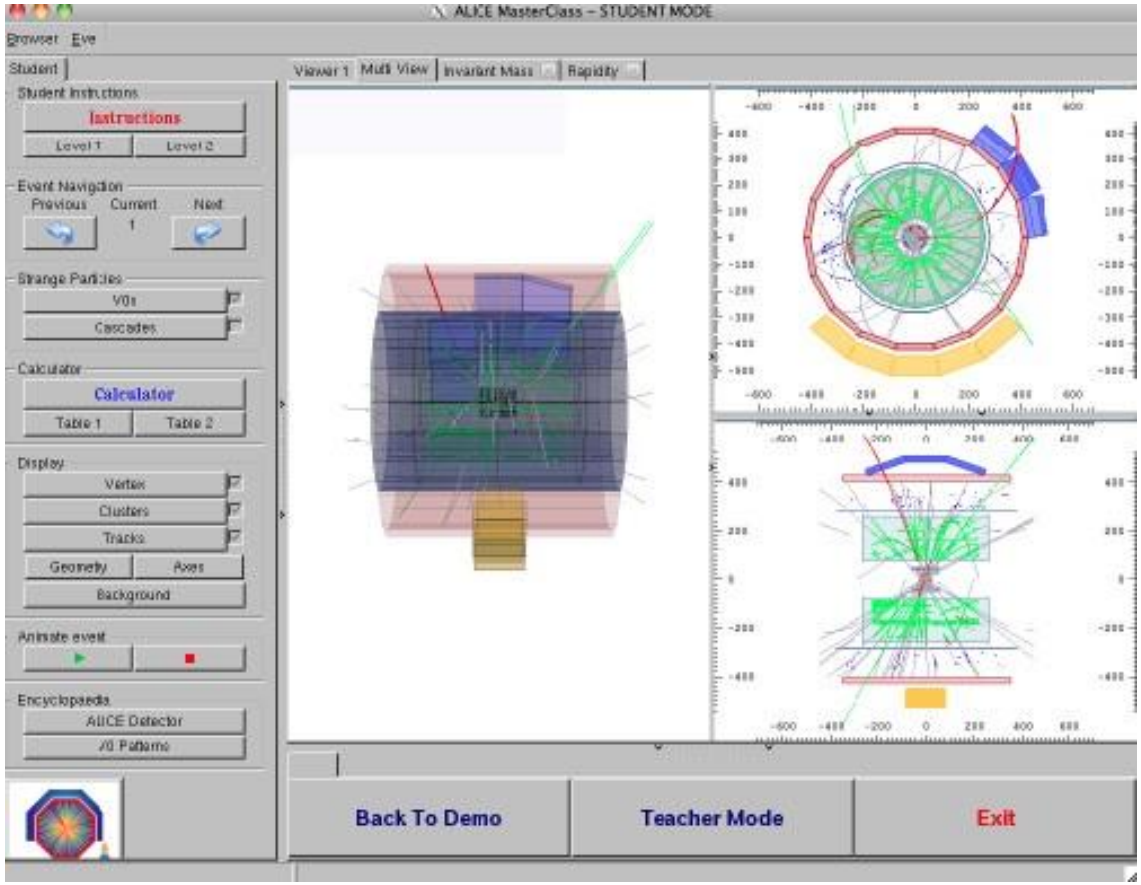
$K^0_s \rightarrow \pi^+\pi^-$
$\Lambda \rightarrow \pi^-p$
anti $\Lambda \rightarrow p^-\square^+$
$\Xi^- \rightarrow \pi^-\Lambda \rightarrow \square^- p \square^-$

Calculate invariant mass

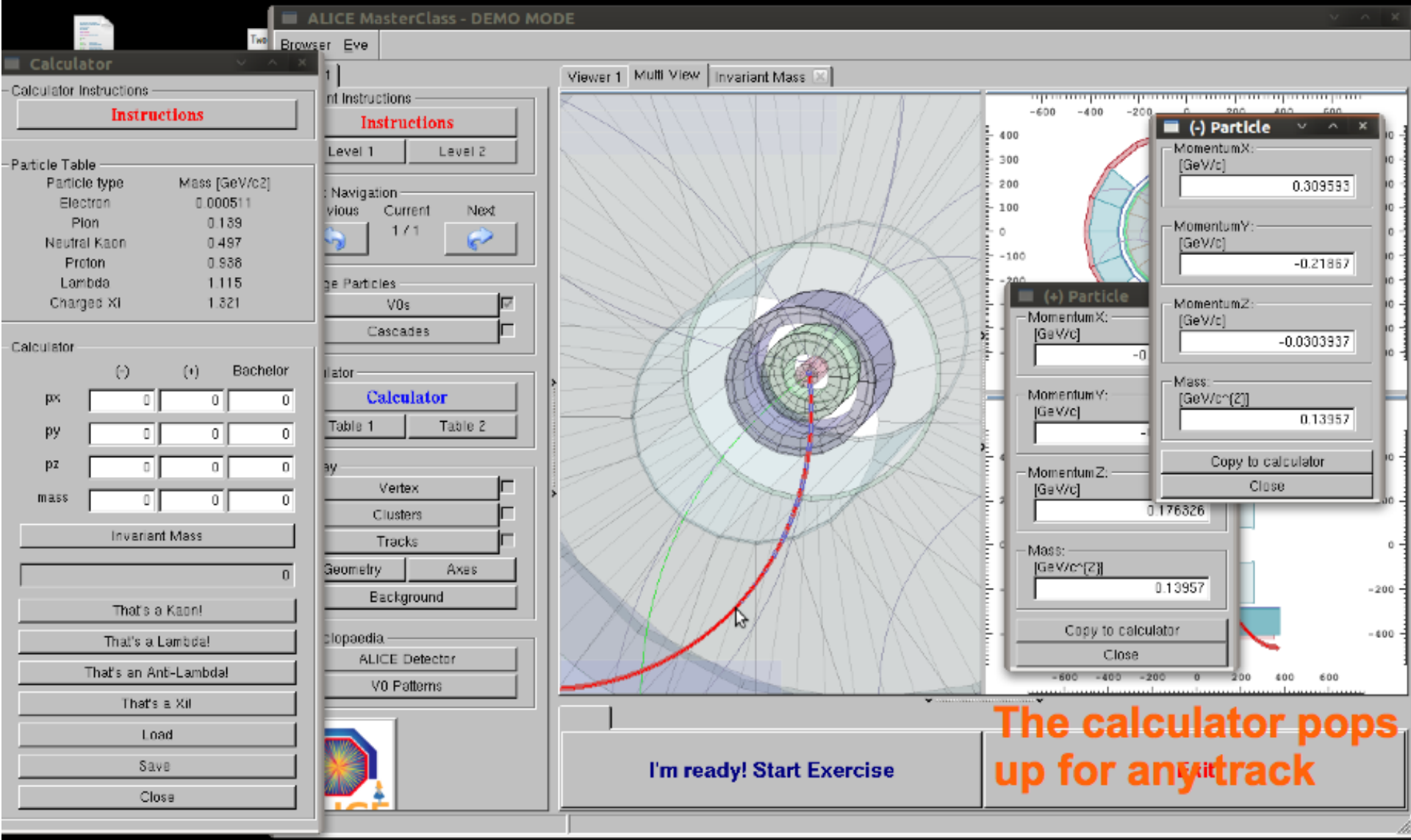
Classify according to mass

Fill tables

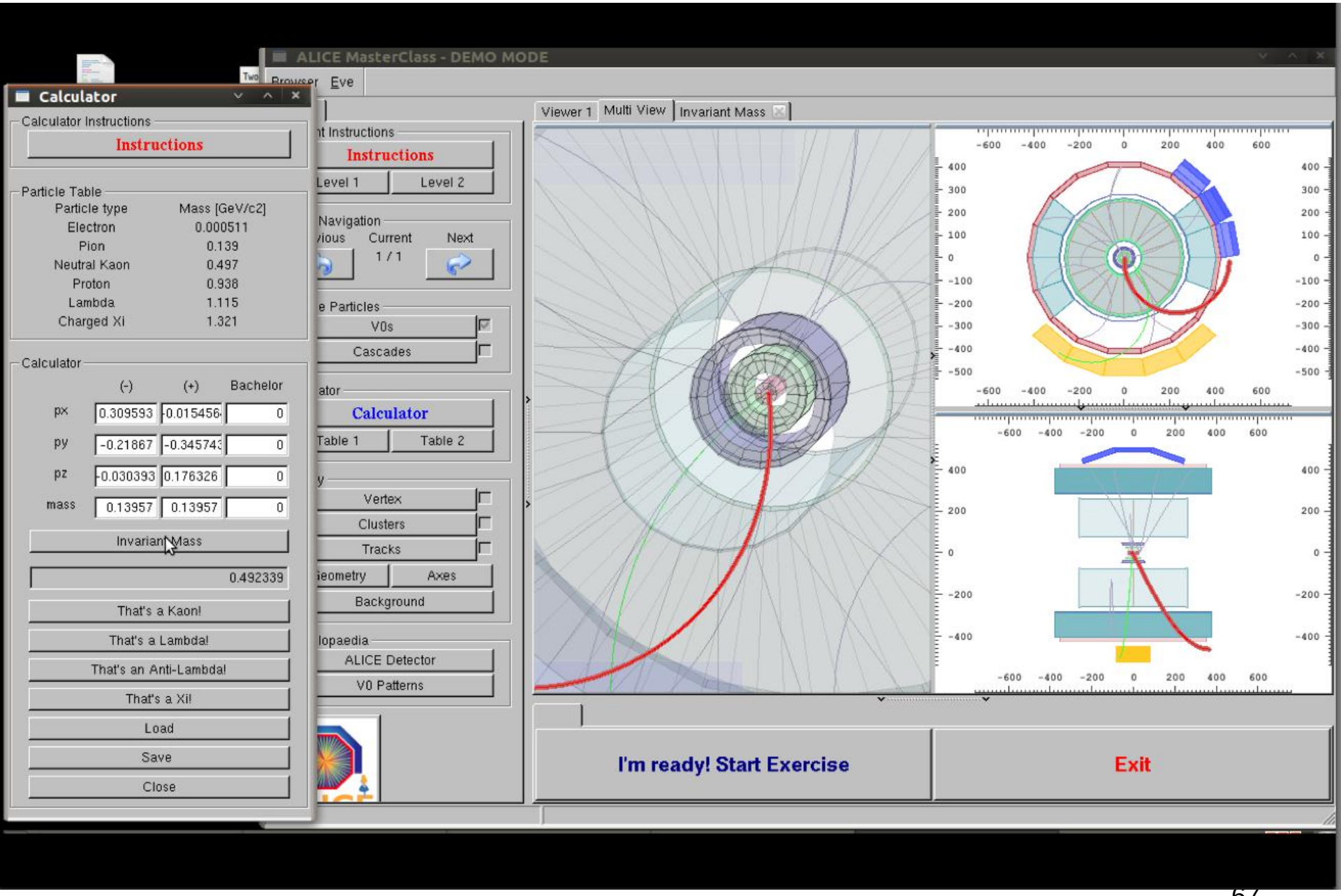
Fill histograms

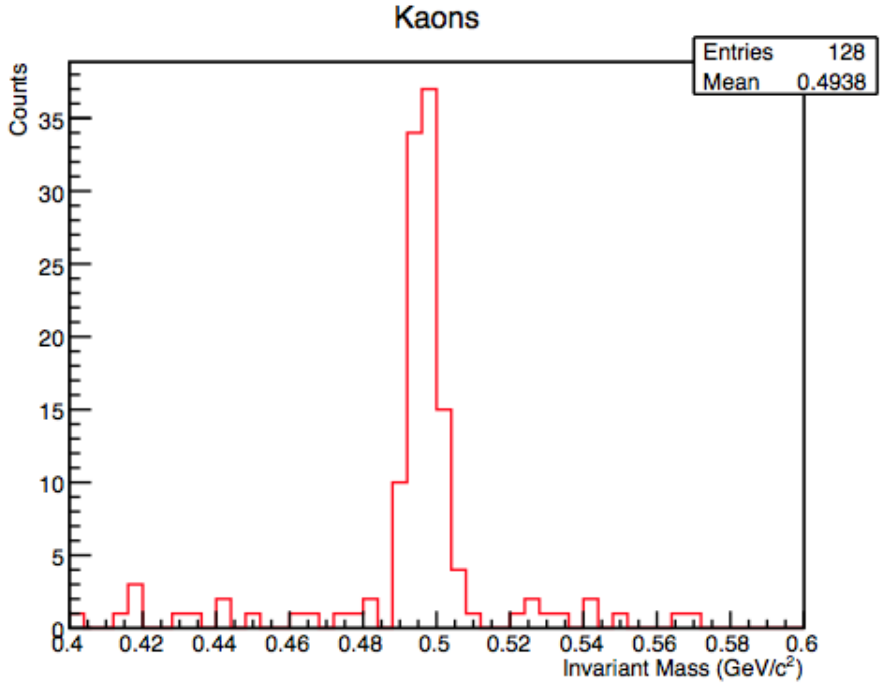


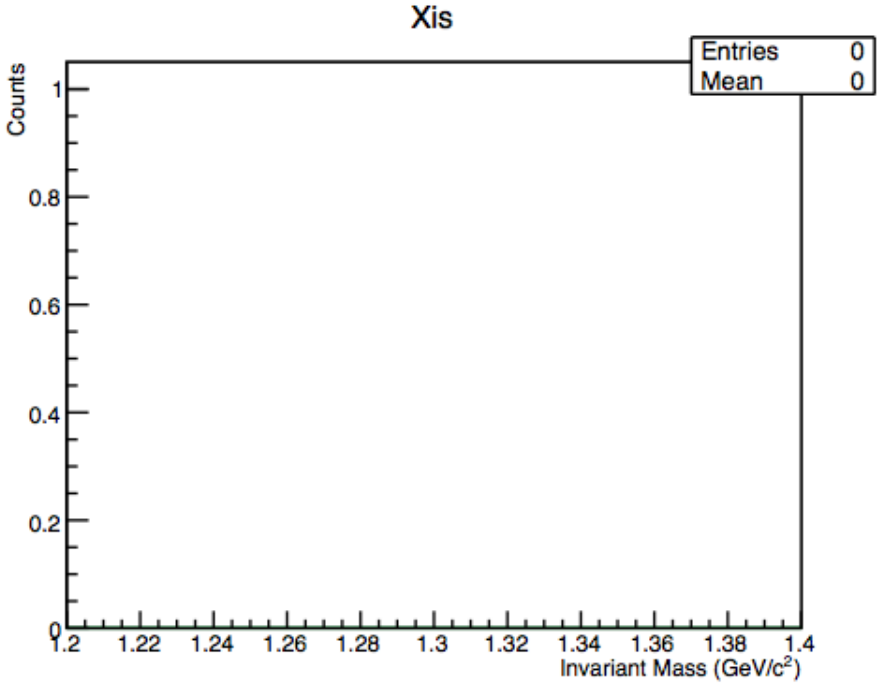
MasterClass Application

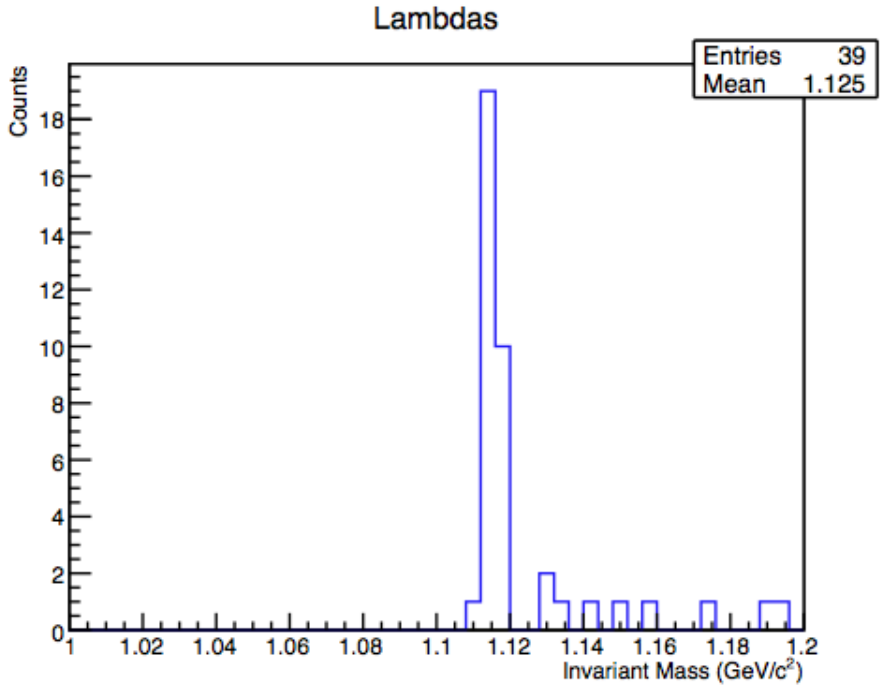


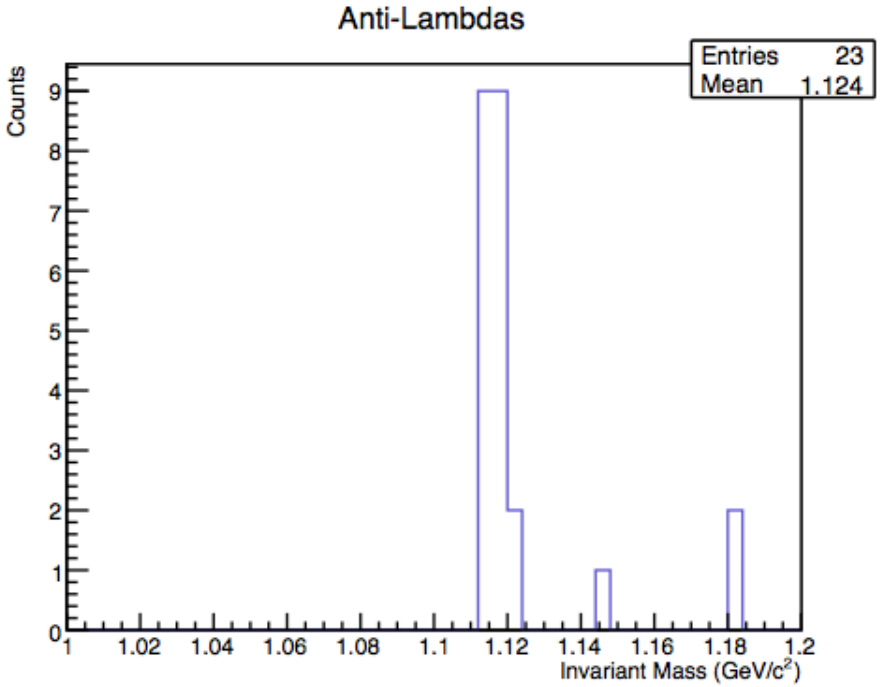
The calculator pops up for any track


ALICE MasterClass - DEMO MODE
Browser
Eve
Calculator
Calculator Instructions
Instructions
Particle Table
Particle type
Mass [GeV/c2]
Electron
0.000511
Pion
0.139
Neutral Kaon
0.497
Proton
0.938
Lambda
1.115
Charged Xi
1.321
Calculator
(-)
(+)
Bachelor
px
0.309593
-0.015456
0
py
-0.21867
-0.345743
0
pz
-0.030393
0.176326
0
mass
0.13957
0.13957
0
Invariant Mass
0.492339
That's a Kaon!
That's a Lambda!
That's an Anti-Lambda!
That's a Xi!
Load
Save
Close
Instructions
Level 1
Level 2
Navigation
Current
Next
1 / 1
Particles
V0s
Cascades
Calculator
Table 1
Table 2
Vertex
Clusters
Tracks
Axes
Background
ALICE Detector
V0 Patterns
Viewer 1
Multi View
Invariant Mass
I'm ready! Start Exercise
Exit


Kaons
Entries 128
Mean 0.4938
Counts
Invariant Mass (GeV/c²)

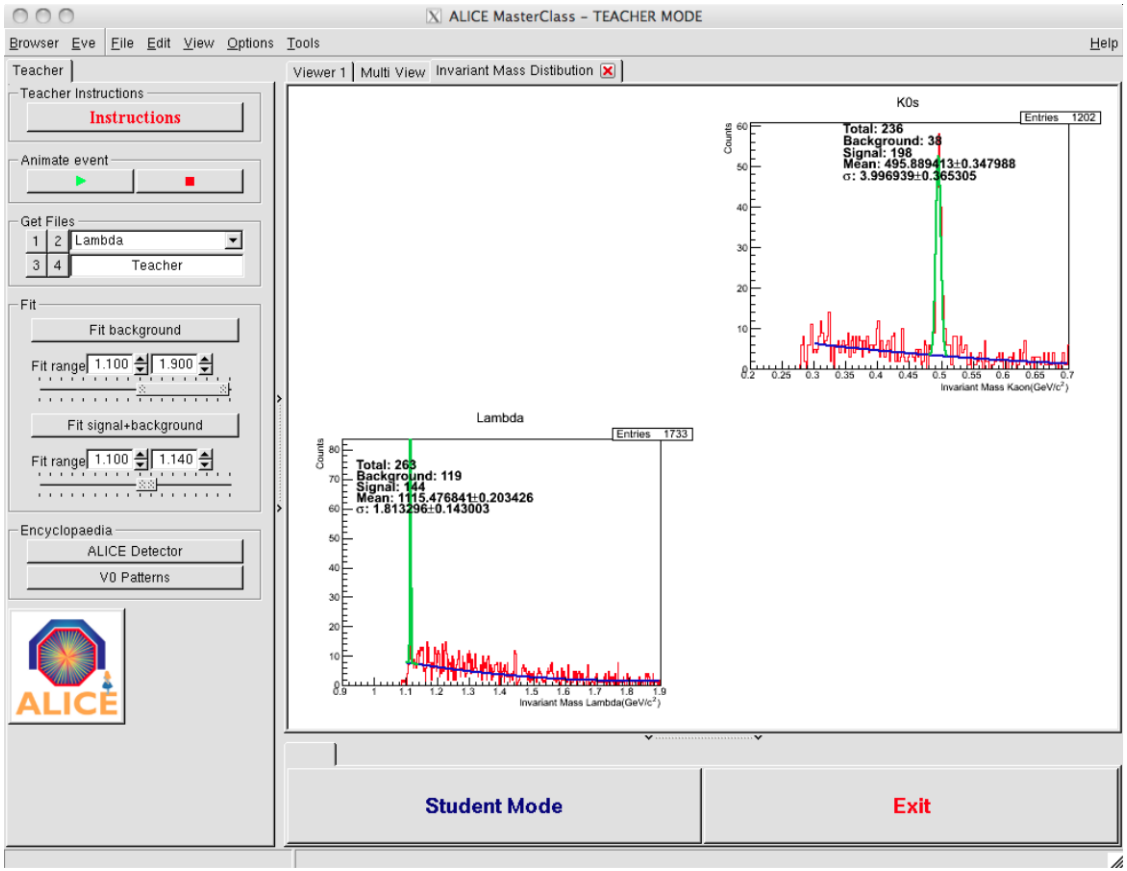

Xis
Entries 0
Mean 0
Counts
Invariant Mass (GeV/c²)


Lambdas
Entries 39
Mean 1.125
Counts
Invariant Mass (GeV/c²)


Anti-Lambdas
Entries 23
Mean 1.124
Counts
Invariant Mass (GeV/c²)

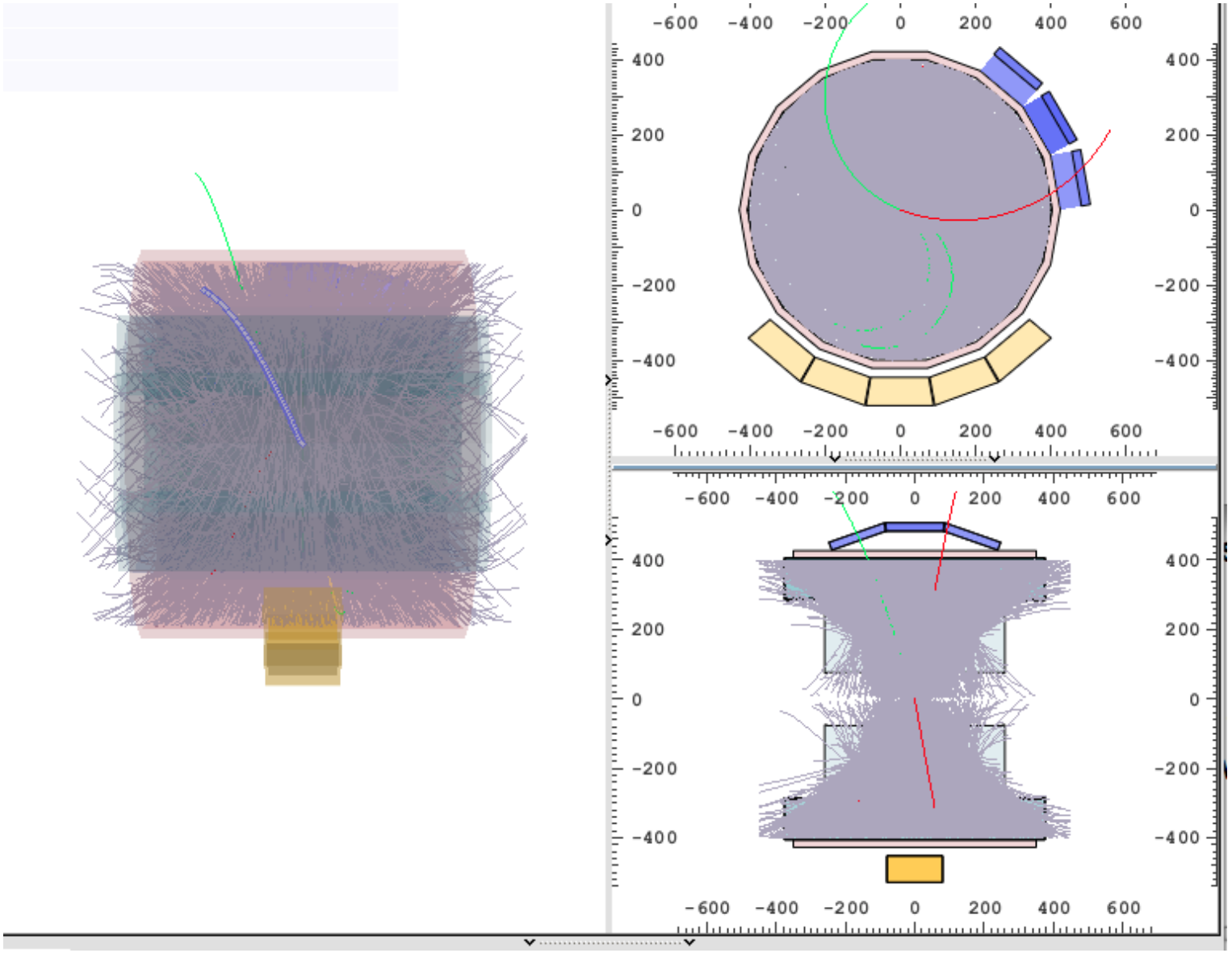
Strange Particles Extended

- New in 2012: 2nd part of exercise, more realistic
- Analyse big event sample (2000 events)
- Invariant mass histograms for Ks, Lambda, anti-Lambda
- Introduce background, background subtraction
- Get number of Ks, Lambda, anti-Lambda after background subtraction



INTERNATIONAL MASTERCLASSES
hands on particle physics

The problem with Lead-Lead events



Outline of exercise

•Students (each group): Visual analysis of 30 events – tables + invariant mass histograms
•Institute (all groups): Add up numbers / merge histograms
30-event samples for visual analysis, 7 TeV proton-proton (6)
5-event sample Pb-Pb (1)

•Students (each group): Analysis of 2000 events - invariant mass histograms
•Students (each group): Try to fit background / peak / subtract -> find number of particles
•Institute (all groups): Merge histograms
•Institute (all groups): Fit background / peak / subtract -> find number of particles
2000 event samples 7 TeV proton-proton (7)
1500 event sample lead-lead

•Calculate yields of each particle type
(assumptions on initial number of events from which the sample has been extracted
correction factors for efficiency)

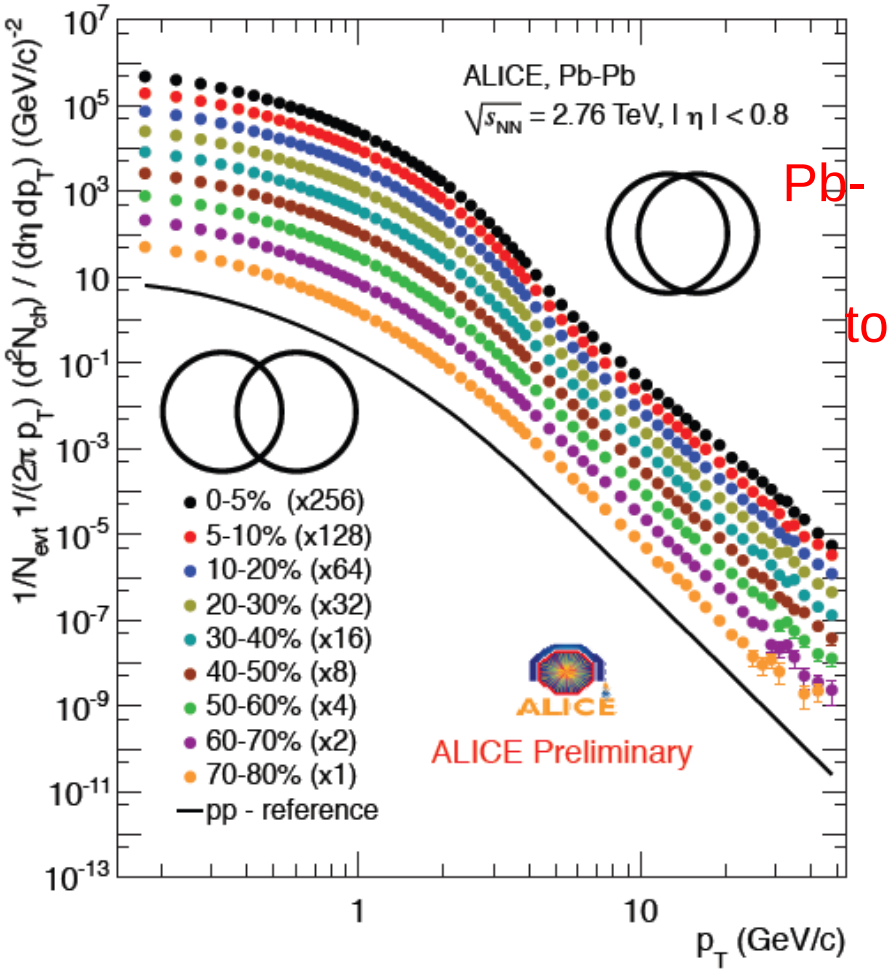
Excercise 2
Transverse momentum spectra

Transverse momentum spectra

transverse momentum spectra of unidentified, primary charged particles

- yield increases from pp to Pb-Pb collisions
- yield increases from peripheral to central Pb collisions
- spectral shape seems change as well

how can this be quantified?

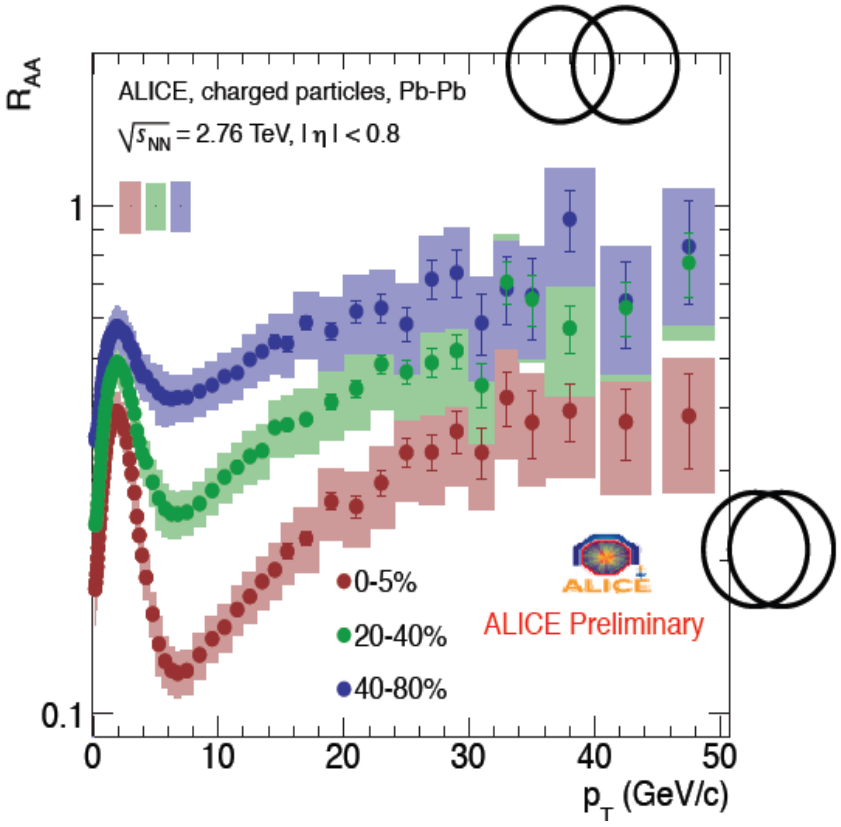


Pb-

to

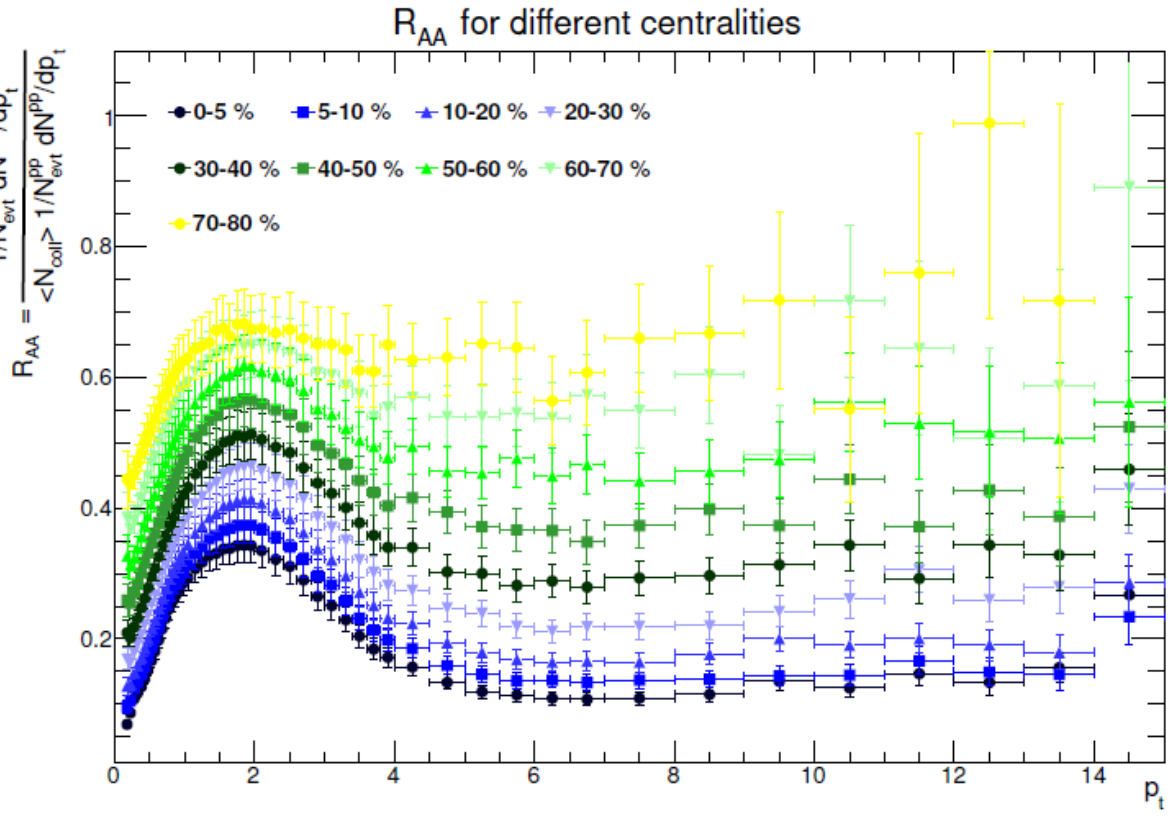
Nuclear modification factor RAA

- divide spectrum measured in Pb-Pb by spectrum from pp scaled with the number of equivalent pp collisions, $\langle N_{coll} \rangle$
  - nuclear modification factor
    $R_{AA} = yield(Pb-Pb) / \langle N_{coll} \rangle$ yi
  - $R_{AA} = 1$ if a Pb-Pb collision is equivalent to $\langle N_{coll} \rangle$ independent pp collisions
  - ALICE: $R_{AA} < 1$ with a strong centrality and p_T dependence!



Large scale analysis: result

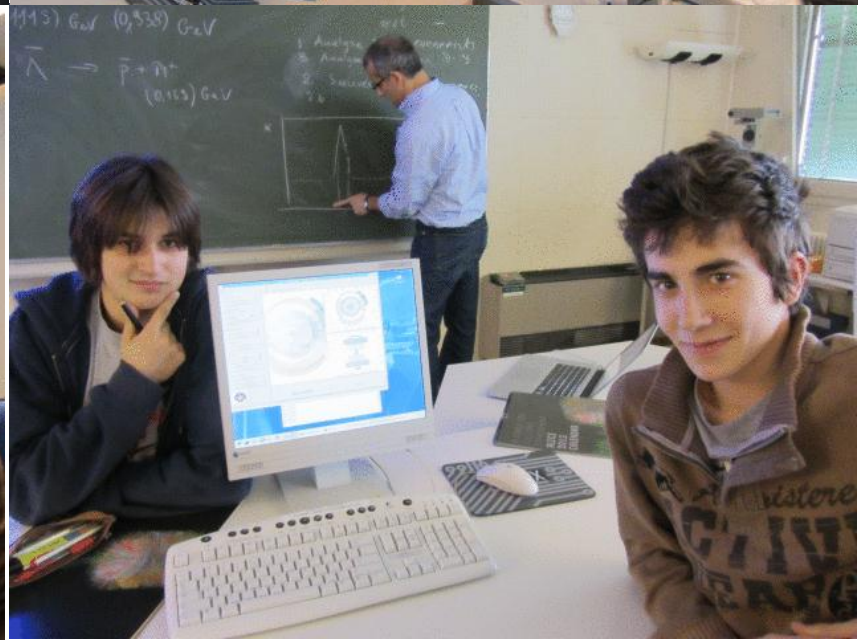
results produced by the first student group working on this new ALICE exercise:



→ close to the published result!

http://www.facebook.com/pages/Os-aceleradores-de-part%C3%ADculas-na-sala-de-aula/100928783362350



http://cdsweb.cern.ch/record/1438735

IPPOG Masterclass Held At Heidelberg

by Rainer Schicker. Published: 16 March 2012

Masterclasses IPPOG Heidelberg ALICE

Each year the International Particle Physics Outreah Group (IPPOG) organises a student Masterclass programme with high energy physics institutes. Kirchoff-Institute at Heidelberg University, Germany, an ALICE member, held their Masterclass in early March. The classes allow students of 17 - 18 in age to visit a research institute and to analyse real physics data. Contributing institutes then connect with each other via videoconference, allowing the students to discuss their results, methods, and experience. The aim of the classes is to encourage enthusiasm for and increase knowledge of high energy physics in potential young scientists.

Rainer Schicker, of the Physikalisches Institute, Heidelberg, summarises their Masterclass:

Rainer Schicker

The Masterclass Students Heidelberg University

The Heidelberg ALICE Masterclass took place on March 6th at the Kirchhoff-Institute. About 30 students participated in this Masterclass, in which the main theme was the creation of the universe. The programme started in the morning with an overview of astrophysical measurements of cosmological significance, such as the Hubble constant, microwave background, and the rotational

ALICE MATTERS

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2012 ALICE Masterclasses

by Polly Bennett. Published: 30 March 2012

IPPOG ALICE Masterclasses

The ALICE Masterclasses took place on March 22nd as part of the ' International Masterclasses: Hands on Particle Physics' programme run by **IPPOG**, the International Particle Physics Outreach Group. In a visit to CERN, high school students from the Lycée International de Ferney were provided with an introduction to CERN and the ALICE experiment before carrying out an exercise analysing real ALICE data. The day finished with a light-hearted quiz in the style of the game show *'Who Wants To Be A Millionaire?'*

The analysis session took place at the CERN Training Centre. Working in pairs, and by using a simplified version of the ALICE event display, the pupils analysed data from proton and lead ion collisions recorded by ALICE last year. The aim of the exercise was to hunt for strange hadrons by identifying cascade and V0 decays.

Polly Bennett

The students during the analysis session

IPPOG aims to increase knowledge, understanding and enthusiasm for particle physics through outreach activities, of which the Masterclasses are the flagship event. The cornerstone of the Masterclass events is a videoconference, with other participating school