INTERNATIONAL MASTERCLASSES HANDS ON PARTICLE PHYSICS

http://physicsmasterclasses.org/

Daniel Kikoła, Łukasz Graczykowski, Małgorzata Janik, Rafał Sarnecki, Patryk Marcinkowski, Pasquale Di Nezza, Yiota Foka

International MasterClasses

A wealth of results!!

Higgs !!! QGP !!!

Excitement in the field!!

How to best share this excitement with the broader public ?

In particular with the new generation, students, high-school children…

The "International Masterclasses" project is

an educational activity that brings the excitement of cutting-edge particle physics research into the classroom !!

International Particle Physics Outreach Group

INTERNATIONAL MASTERCLASSES

hands on particle physics

http://physicsmasterclasses.org

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International Masterclasses

10th International Masterclasses 2014

Each year about 10.000 high school students in 40 countries come to one of about 200 nearby universities or research centres for one day in order to unravel the mysteries of particle physics. Lectures from active scientists give insight in topics and methods of basic research at the fundaments of matter and forces, enabling the students to perform measurements on real data from particle physics experiments themselves. At the end of each day, like in an international research collaboration, the participants join in a video conference for discussion and combination of their results. See here for media coverage.

International Masterclasses 2014 will take place from 12.3. - 12.4.2014, including **U.S. Masterclasses**.

Discover the world of Quarks and Leptons with real data

- get out of school for one day and come to a nearby university or research centre
- get insight into topics and methods of basic research at the fundaments of matter and forces
- perform measurements on real data from particle physics experiments at CERN
- participate in an international video conference for discussion of results

IPPOG

The MasterClass project was developed within the framework of **IPPOG: International Particle Physics Outreach Group**.

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

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

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

International Particle Physics Outreach Group

MasterClasses Coordination

The MasterClass project is coordinated by TU Dresden,Germany and prepared by an international steering committee where the LHC experiments and Fermilab participate.

The project is supported by several sponsors:

International Masterclasses

Since 2005, each year, thousands of high-school pupils

(last classes of high-school) come for one day,

to near by universities or research centres, all over the world,

in order to be “scientists for a day” and share the excitement of research.

The aim - insight into topics and methods of basic research

Hands-on experience using real data and analysis methods.

First with LEP data, then LHC data

International Particle
Physics Outreach Group

Masterclass in a nutsell

Outline of a typical day

How to join

Existing material

Data analysis and results

In 2014, 10 000 students from 160 institutions in 40 countries took part in this popular event over 5 weeks in March and April

http://physicsmasterclasses.org

Program of the day

School-children are invited by a university or research centre near to their school for one day.

Every day a maximum of 5 institutes from all over the world participate performing the same measurement.

Depending on the time zone, CERN or Fermilab moderate a common video-conference at the end of the event.

Institutes, measurements, moderators

Hands on Particle Physics Masterclasses
SCHEDULE 2014

The central element of International Masterclasses 2014 will be the International Masterclass weeks from 12.03.14 - 12.04.14, where each day up to five out of about 160 institutes participate. At the end of each day they have a video conference with **moderators** at CERN.

In addition, video conferences with Fermilab are held, see **schedule**, and **separate Institute Masterclasses** take place, distributed over the whole year. Some institutes will also hold a **teachers day**.

Download the schedule 2014 as .pdf file

12.03. - 15.03.	17.03. - 22.03.	24.03. - 29.03.	01.04. - 05.04.	07.04. - 11.04.

	Mon, March 31	Tue, April 01	Wed, April 02	Thu, April 03	Fri, April 04	Sat, April 05
topic		VC 2: ALICE R_{AA}	VC 2: CMS	VC 2: ALICE	VC 2: ATLAS Z	VC 2: ALICE
moderators		Michael W., Jason	Sarah, Michael P.	Pasquale, Leticia	Anna, Duc	Alice, Stefania
		Frankfurt	Budapest Wigner	São Paulo	Marseille	Warsaw
		Darmstadt	Brussels Vrije U.	Heidelberg	Grenoble	Geneva CERN
		Prague CTU	Firenze	Orsay IPN	Dortmund	Cape Town iThemba
		Cairo	Catania	Nantes	Katowice	Cairo

Program of the day

- Introductory lectures
- Visit of a lab or experiment

CERN-PHOTO-201404-070-14

- Hands-on session
  - Instructions and interactive demo
  - Perform measurements on real data from LHC experiments
  - Merge and discuss results locally
  - Prepare presentation
  - Perform a quiz
- Participate in an international video conference


MasterClass @ CERN, 2014

Videoconference

- At the end of each day, all 5 participating institutes that did the same analysis 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.

Videoconference

Warsaw, 2014

Features:

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

Even with this simple procedure pupils get the message that this is not one person's job….
….and statistics matters!!

Master class

chaired by Ralf Averbeck (GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE)), Philipp Luettig (Johann-Wolfgang-Goethe Univ. (DE)), Michael Weber (CERN), Jason Adrian Kamin (Johann-Wolfgang-Goethe Univ. (DE))

Tuesday, 1 April 2014 from **16:00** to **17:25** (Europe/Zurich)
at **Other Institutes**

Description The vidyo room for this conference can be reached via this link:

https://vidyoportal.cern.ch/flex.html?roomdirect.html&key=ye8a5NXdyHJM

https://indico.cern.ch/event/310680/

Tuesday, 1 April 2014

16:00 - 16:05 Introduction *5'*
Speakers: Jason Adrian Kamin (Johann-Wolfgang-Goethe Univ. (DE)), Michael Weber (CERN)

16:05 - 16:08 Overview of the day in Frankfurt *3'*
Speakers: Frankfurt Masterclass Group, Philipp Luettig (Johann-Wolfgang-Goethe Univ. (DE))

16:08 - 16:11 Overview of the day in Prag *3'*
Speakers: Prague Masterclass Group, Barbara Trzeciak (Czech Technical University in Prague)

16:11 - 16:14 Overview of the day in Darmstadt *3'*
Speakers: Darmstadt Masterclass Group, Ralf Averbeck (GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE))

16:14 - 16:17 Overview of the day in Cairo *3'*
Speakers: Cairo Masterclass Group, Abdel Tawfik (ECTP)

16:17 - 16:21 Results from Frankfurt *4'* ( )
Speakers: Frankfurt Masterclass Group, Philipp Luettig (Johann-Wolfgang-Goethe Univ. (DE))
Material: **Slides**

16:21 - 16:25 Results from Prague *4'*
Speakers: Prague Masterclass Group, Barbara Trzeciak (Czech Technical University in Prague)
Material: **Slides**

16:25 - 16:29 Result from Darmstadt *4'* ( )
Speakers: Darmstadt Masterclass Group, Ralf Averbeck (GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE))
Material: **Slides**

16:29 - 16:33 Results from the Cairo *4'* ( )
Speakers: Cairo Masterclass Group, Abdel Tawfik (ECTP)

Masterclass methods

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

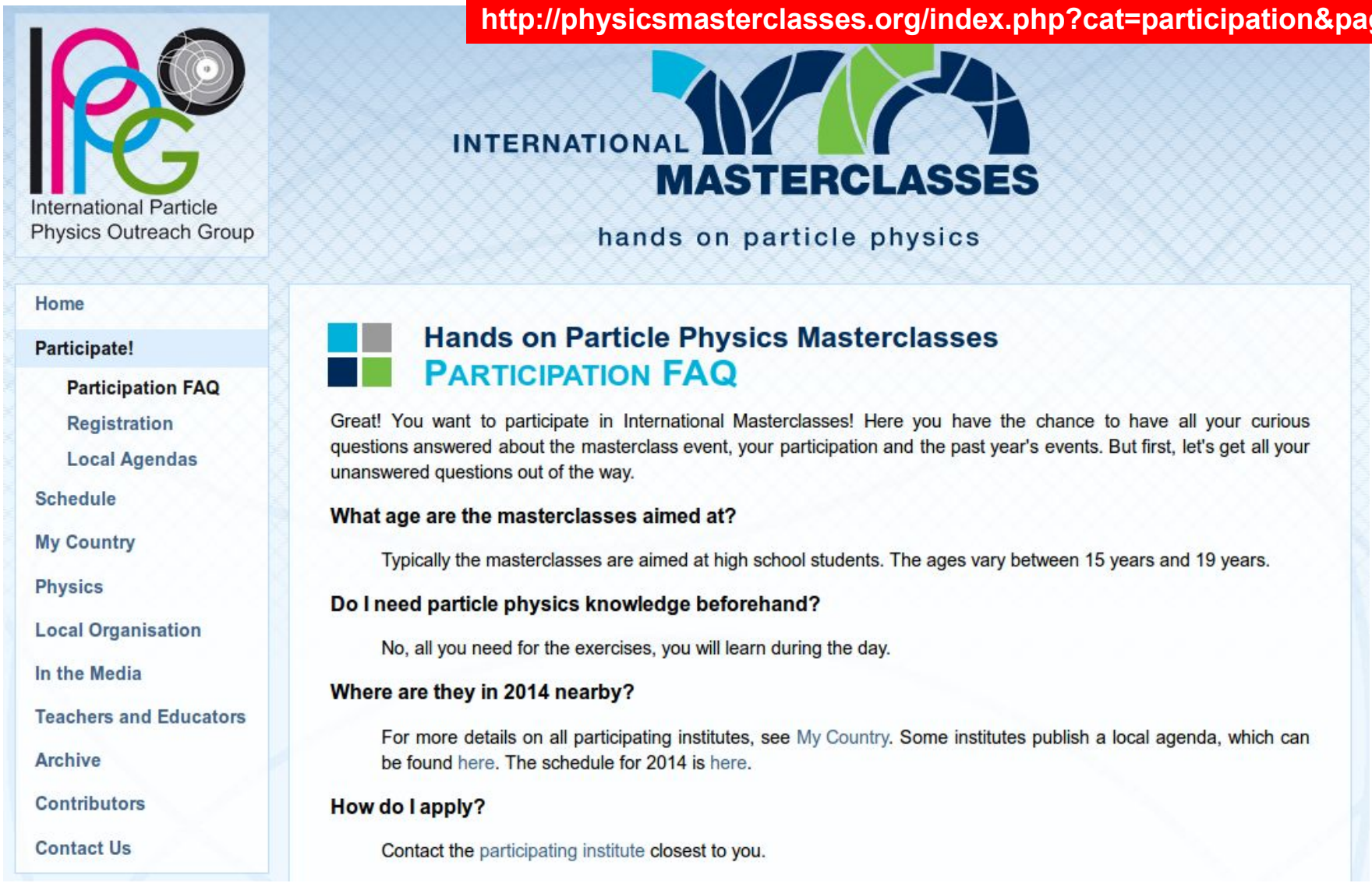
- **Measurement:** Students use the tools to measure various properties of some known particles, such as the weak gauge bosons W and Z and hadrons (J/psi, Upsilon, Lambda, K-short).

- **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….

How is it organised?

The international steering committee (coordination by Dresden) prepares the event and necessary material

http://physicsmasterclasses.org/index.php?cat=participation&page=faq



Masterclass preparation

The coordinators and steering group prepare the event

• Contact the national representatives who contact the universities and schools of their countries.

• Prepare the analysis packages and quiz
• Provide material in web pages (translations in different languages)
• Provide CDs with material
• Prepare videoconference
• Prepare tutors and moderators via dedicated instructions material and meetings

•Feedback and surveys

Masterclass web page and material

Web page
http://physicsmasterclasses.org/

Several Masterclass packages are on the web together with support material for the tutors and moderators

- Information about physics
- Suggestions on the discussion of the results
- Quiz

How to set it up (technical)

Masterclass materials

International Masterclasses - bringing LHC data to school children
E14 Web of Conferences 71, 00017 (2014)
http://www.epj-conferences.org/articles/epjconf/pdf/2014/08/epjconf_icnfp2013_00017.pdf

International Particle Physics Masterclasses with LHC data
EPJ Web of Conferences 70, 00069 (2014)
http://www.epj-conferences.org/articles/epjconf/pdf/2014/07/epjconf_icfp2012_00069.pdf

International Masterclasses in the LHC era
http://cerncourier.com/cws/article/cern/57305

ATLAS MasterClass
E14 Web of Conferences 71, 00024 (2014)
http://www.epj-conferences.org/articles/epjconf/pdf/2014/08/epjconf_icnfp2013_00024.pdf

CMS MasterClass
E14 Web of Conferences 71, 00027 (2014)
http://www.epj-conferences.org/articles/epjconf/pdf/2014/08/epjconf_icnfp2013_00027.pdf

ALICE MasterClass
E14 Web of Conferences 71, 00057 (2014)
http://www.epj-conferences.org/articles/epjconf/pdf/2014/08/epjconf_icnfp2013_00057.pdf

Detailed instructions and documentation

International Particle Physics Outreach Group

INTERNATIONAL MASTERCLASSES

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Hands on Particle Physics Masterclasses
ORGANISATION

Welcome to the organisation section of International 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 including a **step-by-step list** for preparation
- some example **lectures**
- information on the **measurements**
- a **manual** for the video conference, including information on the quiz
- **corporate material** (logos, poster, invitation letters, participation certificates)
- english **press release 2014** (template)
- english **alternative press release 2014** (template)
- german **press release 2014** (template)
- french **press release 2014** (template)
- **CERN 60 years** (presentation)

We also provide information

- how we would like to present your institute on our website
- or how you can contribute in translating the measurement tasks.

Documentation is several languages

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 IPPOG 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 (Strange Particles)	-	×	-	×	×	-	×	×	-	×	-	-	×	-	-	-	-	-	-	-	-
ALICE (R_AA)	-	-	-	×	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ATLAS	-	×	×	×	×	-	×	×	-	×	×	×	×	×	×	-	-	×	-	-	-	-
CMS	-	-	-	×	×	-	×	-	×	×	-	×	×	-	×	-	-	-	×	×	×	-
LHCb	-	-	-	×	×	-	×	-	-	×	-	-	-	-	-	-	-	-	-	-	-	×

Masterclass preparation

What do you need?

- a group of students (aged 15 - 19)
- an inviting institute, providing the infrastructure
- at least 1 scientist, holding the lecture
- some tutors for students during the measurement (1 tutor per 10-15 students)
- a lecture hall
- PC-pool (students work in groups of 2)
- facility for video conferencing, if possible

MasterClass preparation

Step-by-step list to host MasterCalss in your institute (2014 example):

Oct: register with your preferred dates and measurement when contacted by organizers

Nov: preliminary schedule is created by organizers - make reservations for lecture hall with video conferencing facility and PC pool

Dec: check your profile on www.physicsmasterclasses.org, does it need an update?

Dec: prepare your local agenda and a link for registration

Jan: send invitation letters to schools and students

Feb: plan preparation talks

Feb: introduce tutors to measurement, use the material here

Feb: perform video test and prepare for the video conference, download the manual

immediately before your event:

- print tally analysis (or instruction) note to distribute to the students.
- print answer sheet for quiz
- print certificates of participation

after the event: send media coverage, photos, and lectures for our archive

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Hands on Particle Physics Masterclasses
MEASUREMENTS

Six different packages with data from one of four experiments at the LHC are available from the web:

- ALICE
- ATLAS
- CMS
- LHCb

Support material, presentations etc

ALICE

Two measurements with ALICE data are available.

Looking for strange particles in ALICE 2014 can be found here (go to "Installation"). For 2014 the same version as in 2013 will be used. The measurement includes:

- Visual identification of strange particles (V0s : Ks, Λ, anti-Λ) from their decay pattern, combined with calculation of their invariant mass.
- Analysis of large samples of lead-lead data in order to find the number of Ks, Λ, anti-Λs in different centrality regions
- Calculation of yields for Ks, Λ, anti-Λ and strangeness enhancement factors by comparing to proton-proton data
- Available in Czech, English, French, German, Greek, Italian, and Portuguese.

Supporting material:

- **Guide for Tutors**
- A **spreadsheet** for local combination of results can be found here and for combination of all results during the videoconference here

- 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)
- Animation of collisions and particle propagation in the detectors
- Animation on principle of operation of the main detector (TPC)
- ALICE cartoon

Measurement of the nuclear modification factor R_{AA} with ALICE 2014 can be found here. The measurement includes:

- Measurements of charged particle momentum distributions in pp and Pb-Pb collisions
- Event display based analysis of pp and Pb-Pb collisions
- Large scale numerical analysis of Pb-Pb collisions
- Available in English

Last year MasterCalss events:

ALICE: 14
LHCb: 21
ATLAS&CMS: 150

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 signatures

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

- Huge temperature and density
- Strange particle production
- Nuclear modification factor R_{AA}

Experimental Observables

- We have no "thermometer"; use particle ratios
- "Count" strange particles (K^0_s, Λ, Ξ-) in PbPb and pp; compare

ALICE MasterClass project

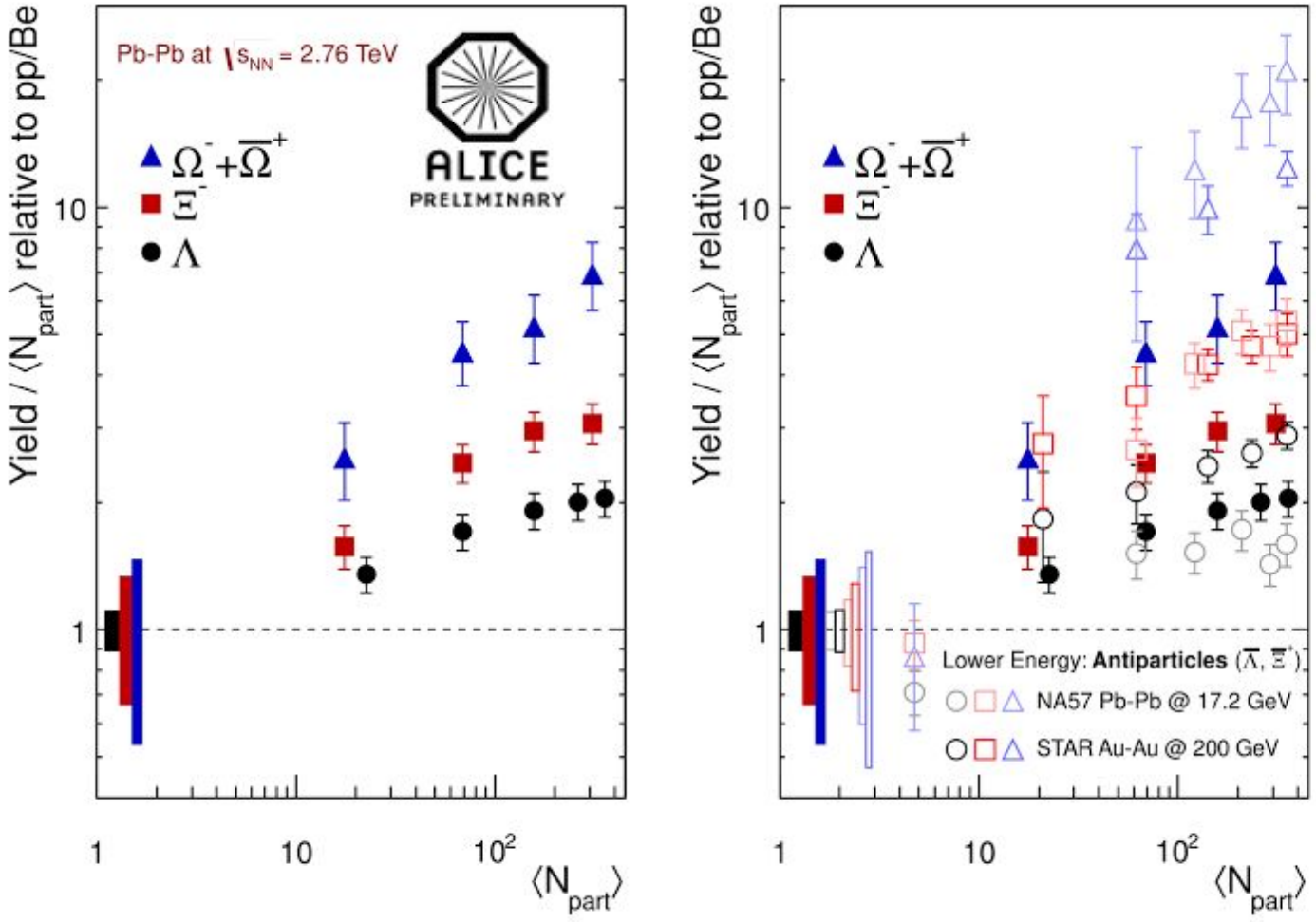
Tools

- Simplified event display, close to the real one used at the experiment
- Visual analysis of small event sample (10-15 events)
- Large statistics analysis including background subtraction (strangness production) and “writing code” (R_{AA})
- Strangeness production: http://aliceinfo.cern.ch/public/MasterCL/MasterClassWebpage.html
- R_{AA}: http://www-alice.gsi.de/masterclass/

ALICE MasterClass

Strangeness production:

http://aliceinfo.cern.ch/public/MasterCL/MasterClassWebpage.html



ALI-PREL-43394

ALICE MasterClass

http://aliceinfo.cern.ch/public/MasterCL/MasterClassWebpage.html

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Looking for strange particles in ALICE

1. Overview

The exercise proposed here consists of a search for strange particles, produced from collisions at LHC and recorded by the ALICE experiment. It is based on the recognition of their V0-decays, such as $K^0_S \rightarrow \pi^+\pi^-$, $\Lambda \rightarrow p + \pi^-$ and cascades, such as $\Xi^- \rightarrow \Lambda + \pi^-$ ($\Lambda \rightarrow p + \pi^-$). The identification of the strange particles is based on the topology of their decay combined with the identification of the decay products; the information from the tracks is used to calculate the invariant mass of the decaying particle, as an additional confirmation of the particle species.

In what follows the ALICE experiment and its physics goals are first presented briefly, then the physics motivation for this analysis. The method used for the identification of strange particles as well as the tools are described in detail; then all the steps of the exercise are explained followed by the presentation of the results; then all the steps of the exercise are explained followed by the presentation of the results as well as the method of collecting and merging all results. In the end the large scale analysis is presented.

2. Introduction.

ALICE (A Large Ion Collider Experiment), one of the four large experiments at the CERN Large Hadron Collider, has been designed to study heavy ion collisions. It also studies proton proton collisions, which primarily provide reference data for the heavy ion collisions. In addition, the proton collision data allow for a number of genuine proton proton physics studies. The ALICE detector has been designed to cope with the highest particle multiplicities anticipated for collisions of lead nuclei at the extreme energies of the LHC.

3. The ALICE Physics

Quarks are bound together into protons and neutrons by a force known as the strong interaction, mediated by the exchange of force carrier particles called gluons. The strong interaction is also responsible for binding together the protons and neutrons inside atomic nuclei.

Even though we know that quarks are elementary particles that build up all known hadrons, no quark has ever been observed in isolation: the quarks, as well as the gluons, seem to be bound permanently together and confined inside composite particles, such as protons and neutrons. This is known as confinement. The exact mechanism that causes it remains unknown.

Although much of the physics of strong interaction is, today, well understood, two very basic issues remain unresolved: the origin of confinement and the mechanism of the generation of mass. Both are thought to arise from the way the properties of the vacuum are modified by strong interaction.

Event Display Mode

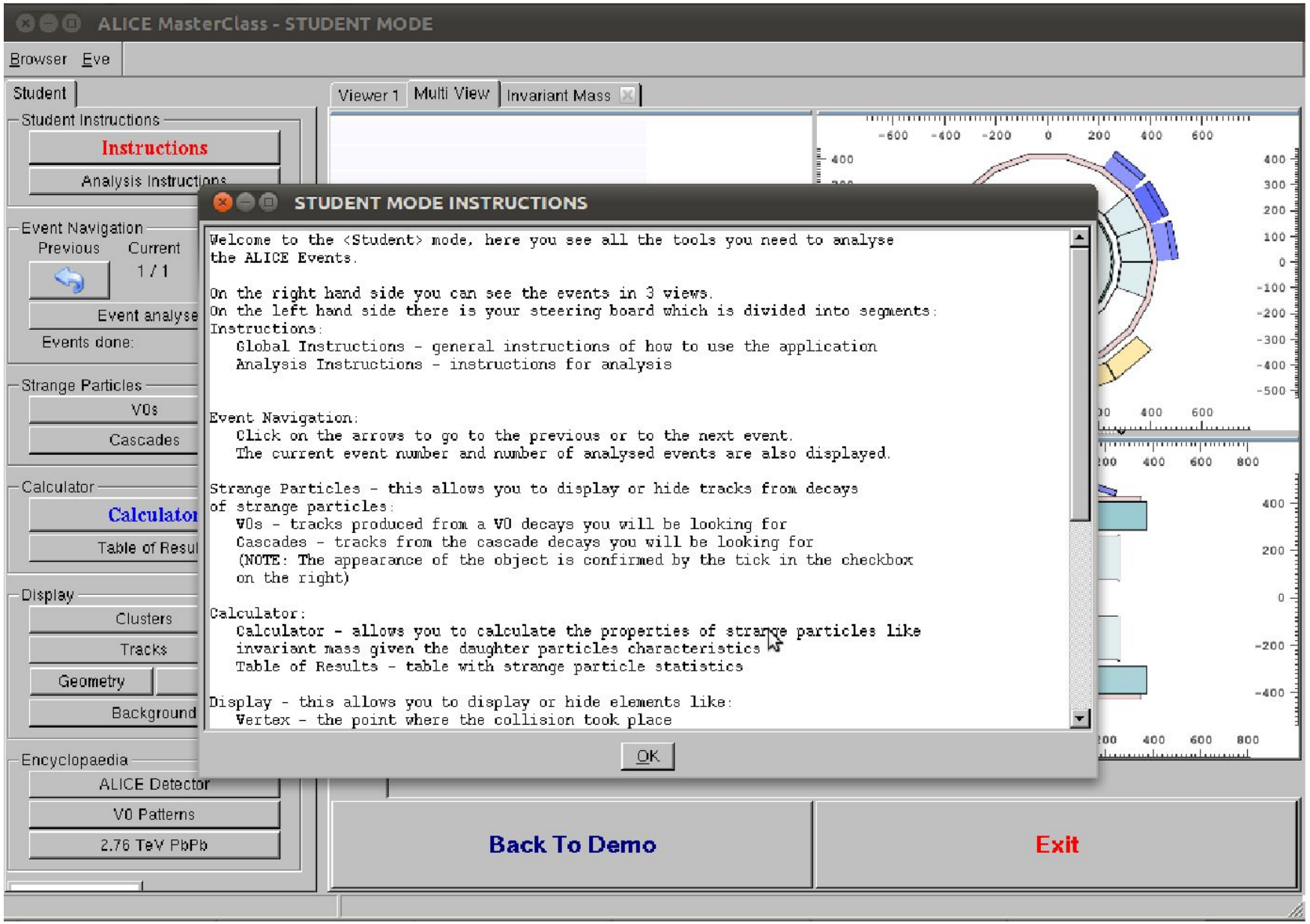
The exercise is done in the ROOT framework

Simplified version of ALICE Event Display, based on ROOT

Demonstration mode

Student mode for event analysis

Teacher mode: tips on merging data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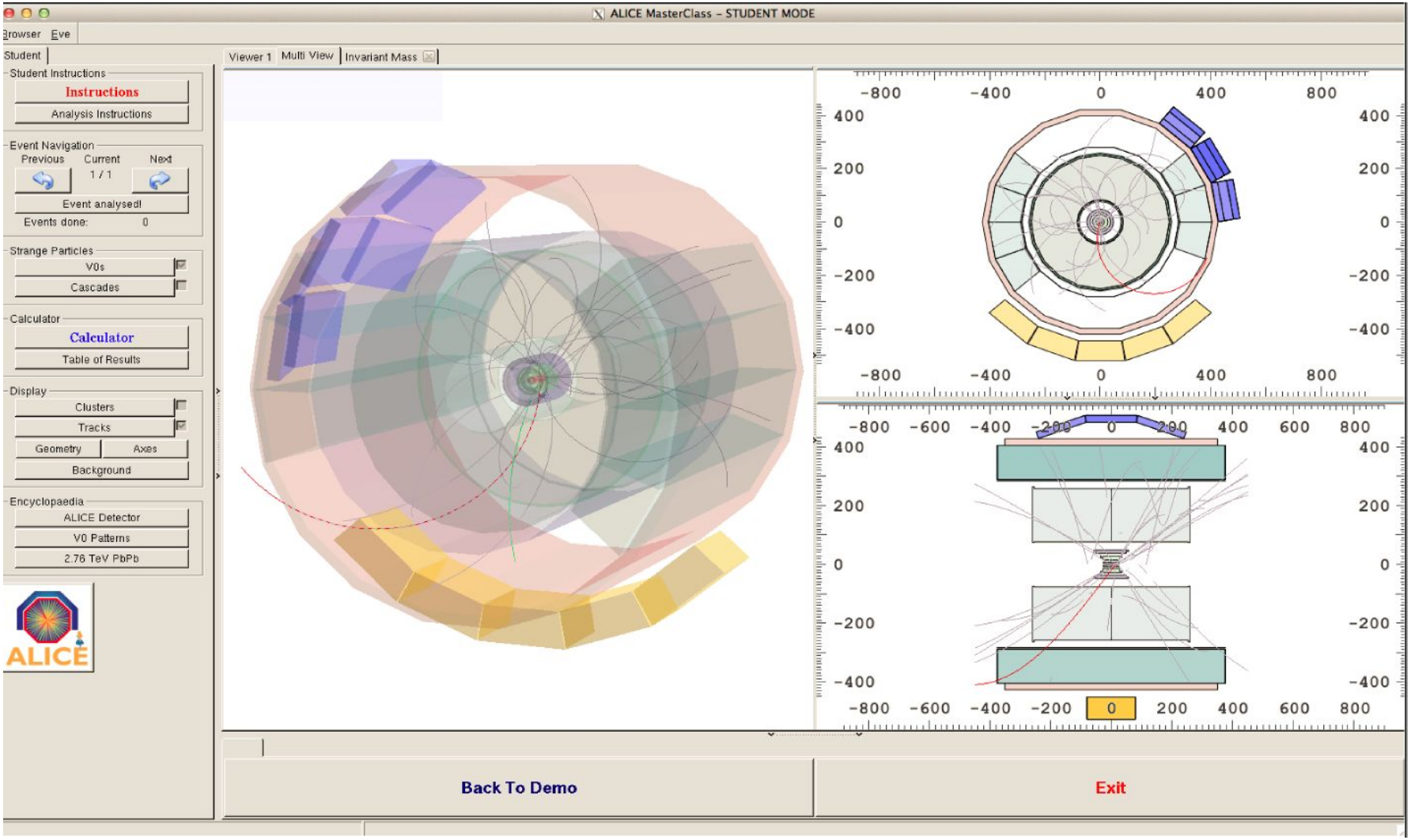
STUDENT MODE INSTRUCTIONS
Welcome to the <Student> mode, here you see all the tools you need to analyse
the ALICE Events.
On the right hand side you can see the events in 3 views.
On the left hand side there is your steering board which is divided into segments:
Instructions:
Global Instructions - general instructions of how to use the application
Analysis Instructions - instructions for analysis
Event Navigation:
Click on the arrows to go to the previous or to the next event.
The current event number and number of analysed events are also displayed.
Strange Particles - this allows you to display or hide tracks from decays
of strange particles:
V0s - tracks produced from a V0 decays you will be looking for
Cascades - tracks from the cascade decays you will be looking for
(NOTE: The appearance of the object is confirmed by the tick in the checkbox
on the right)
Calculator:
Calculator - allows you to calculate the properties of strange particles like
invariant mass given the daughter particles characteristics
Table of Results - table with strange particle statistics
Display - this allows you to display or hide elements like:
Vertex - the point where the collision took place
OK
Back To Demo
Exit

Visual analysis

Proton-proton event

Introduce concepts and visual analysis tools, fill histograms

Interactive!!!
Grab and rotate



Event display: Visual identification of V0 decays

The signature

V0 (and cascade) decays of strange hadrons (K^0_s, Λ, Ξ)

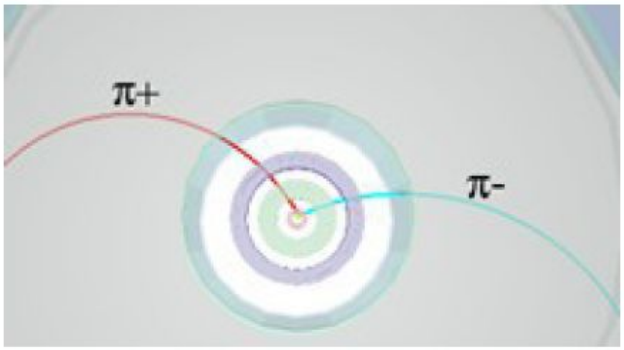
Use Event Display

to visually identify strange particles through the reconstruction of their decay patterns

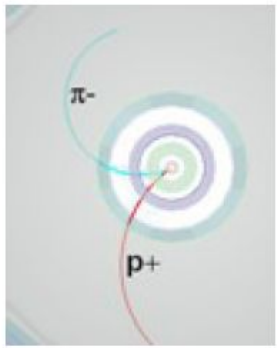
Didactic messages:

- Easy to understand and communicate some basic concepts
(i.e. behaviour of charged particles in magnetic field, particle identification techniques etc.)

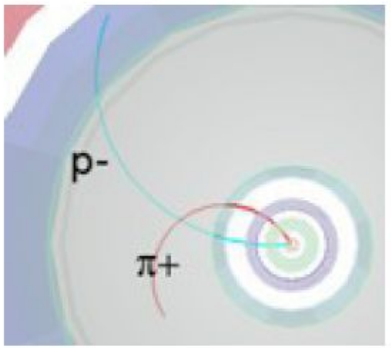
- Easy to explain how you “see the strange particles”



K0s→ π+π-

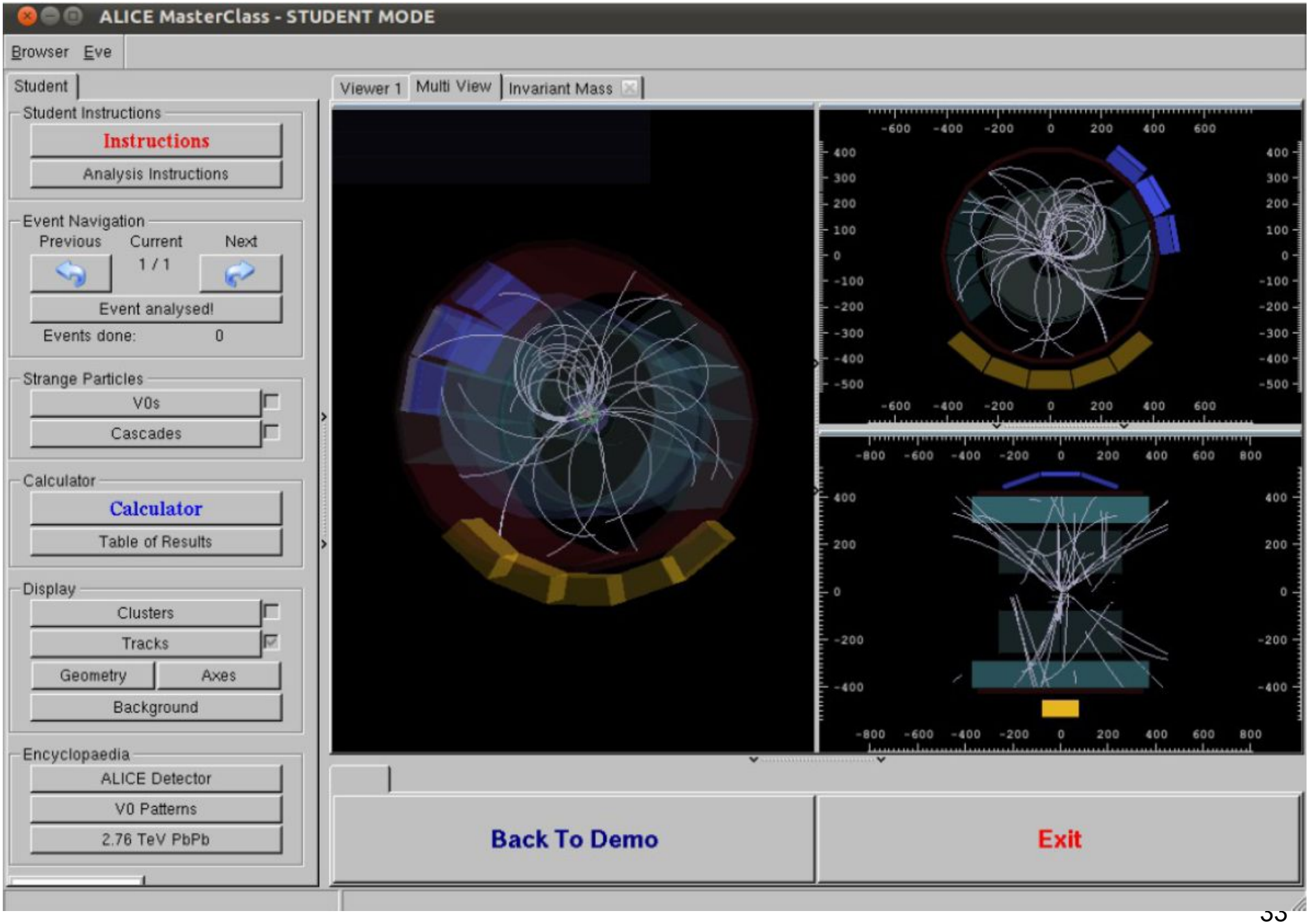


$\Lambda \rightarrow \pi^- p$



anti $\Lambda \rightarrow p\text{-}\pi+$

Two opposite tracks from a secondary vertex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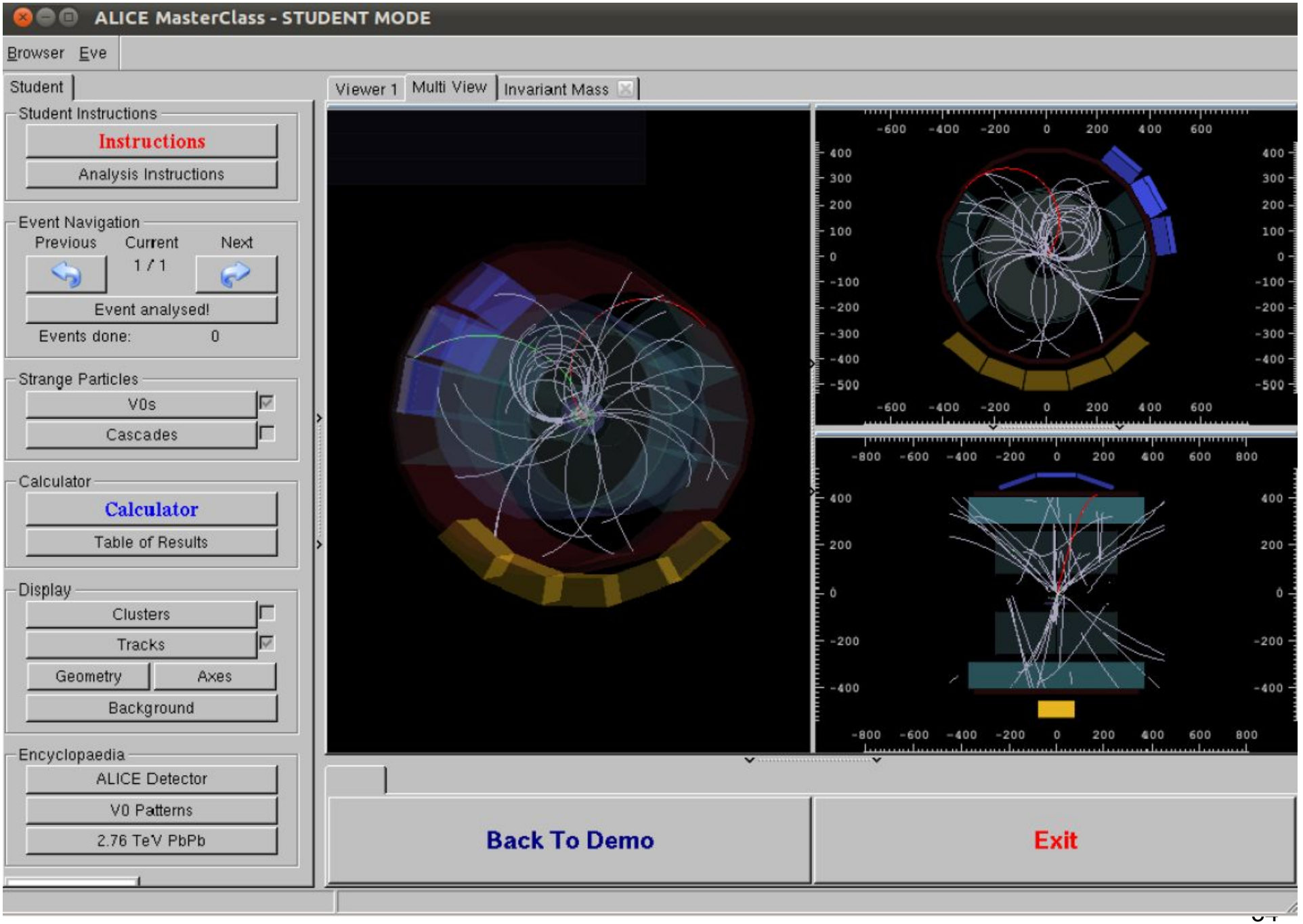
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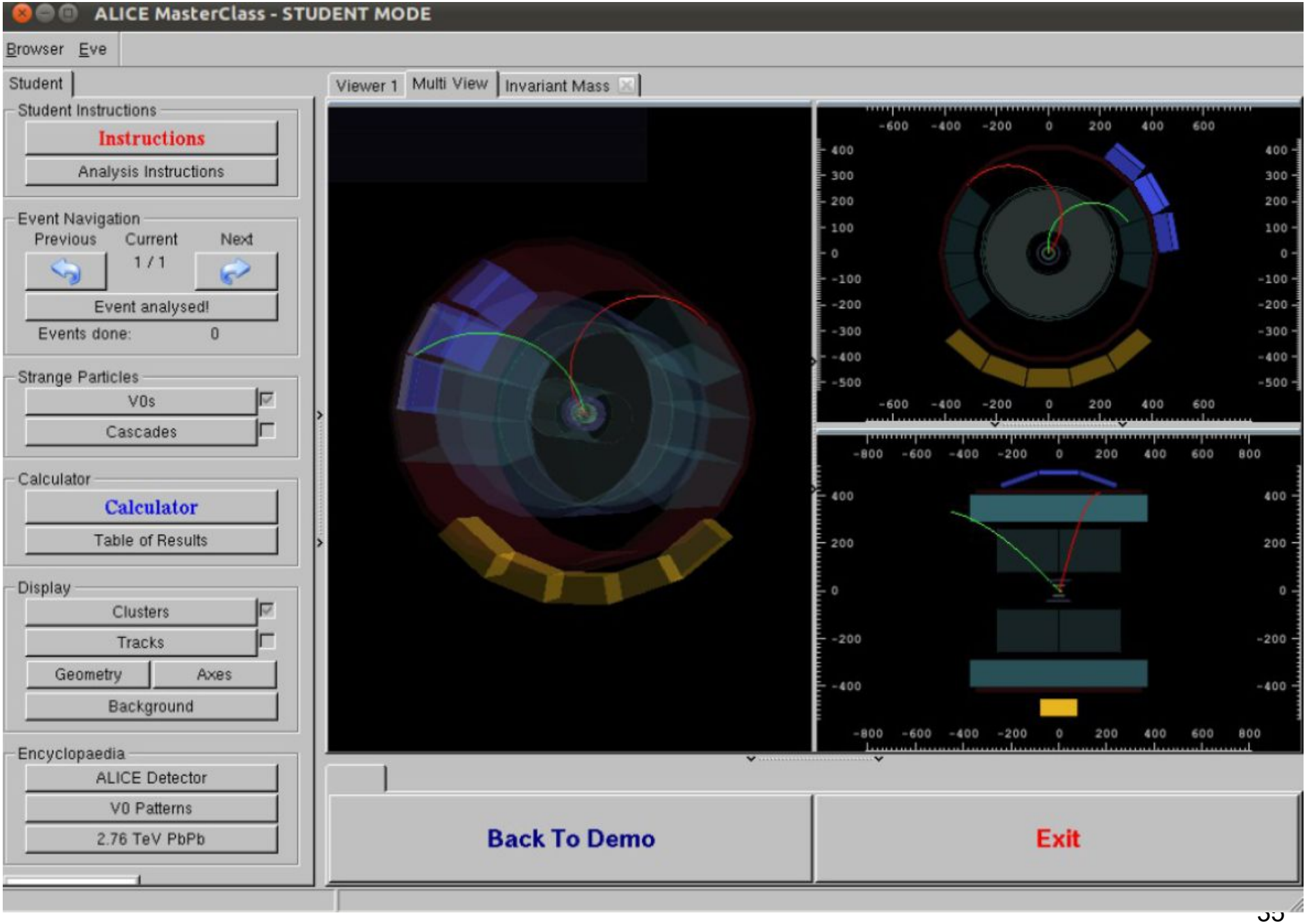
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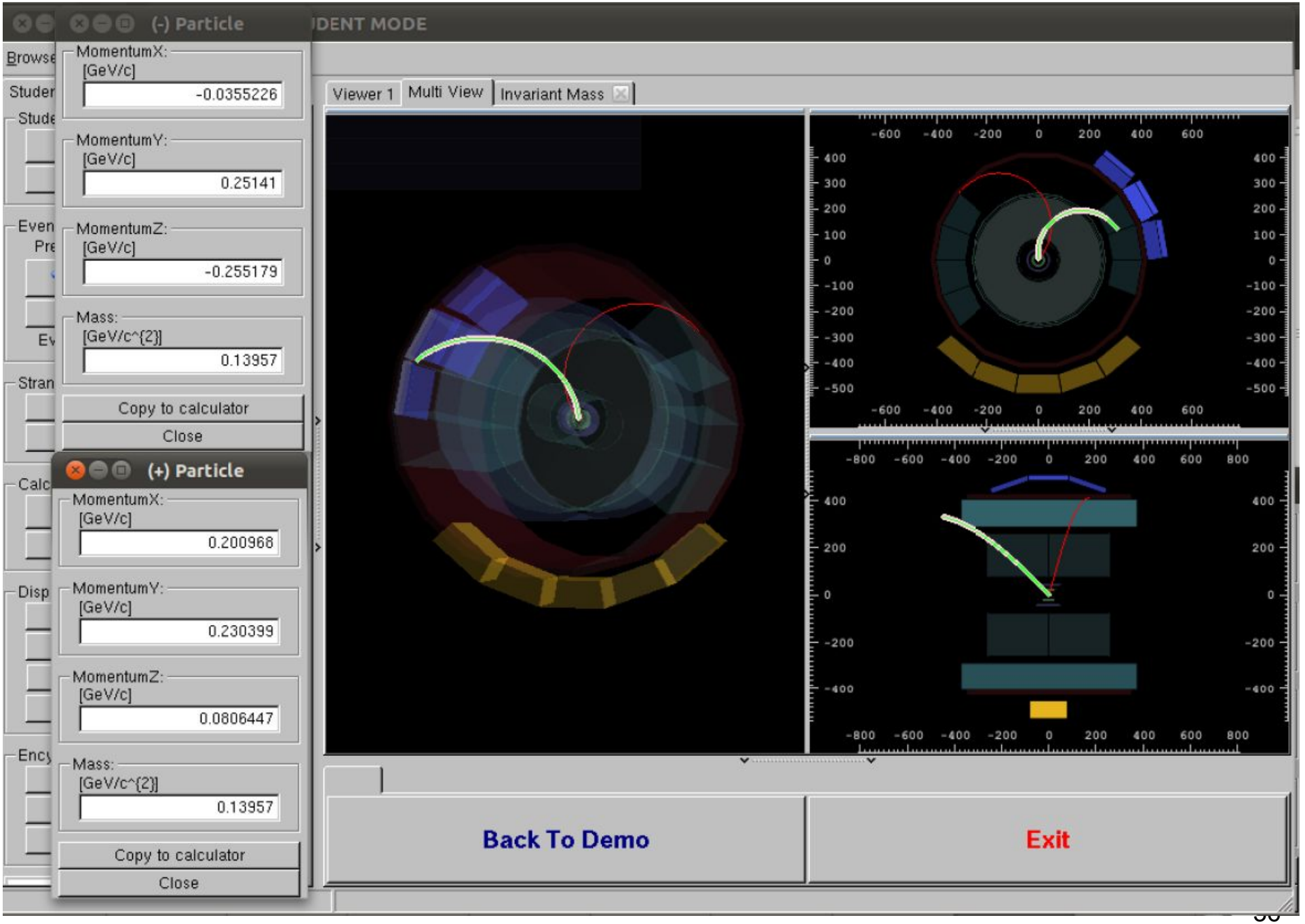
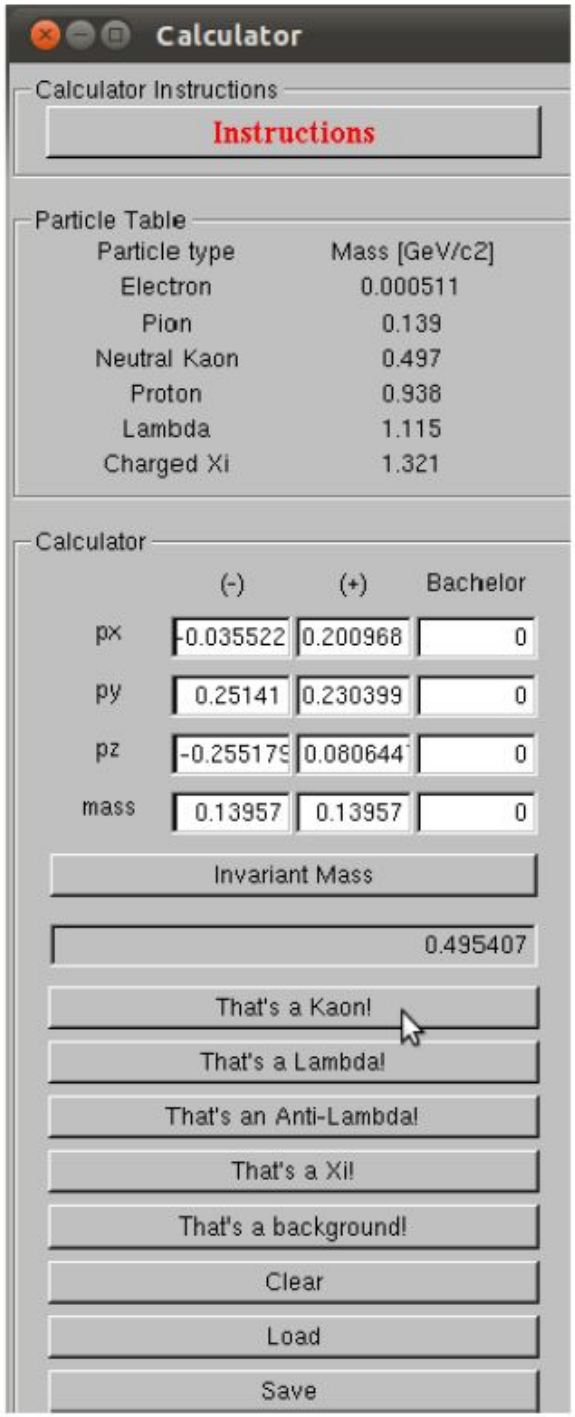
Back To Demo
Exit


(-) Particle
MomentumX:
[GeV/c]
-0.0355226
MomentumY:
[GeV/c]
0.25141
MomentumZ:
[GeV/c]
-0.255179
Mass:
[GeV/c^{2}]
0.13957
Copy to calculator
Close
(+) Particle
MomentumX:
[GeV/c]
0.200968
MomentumY:
[GeV/c]
0.230399
MomentumZ:
[GeV/c]
0.0806447
Mass:
[GeV/c^{2}]
0.13957
Copy to calculator
Close
Viewer 1
Multi View
Invariant Mass
Back To Demo
Exit

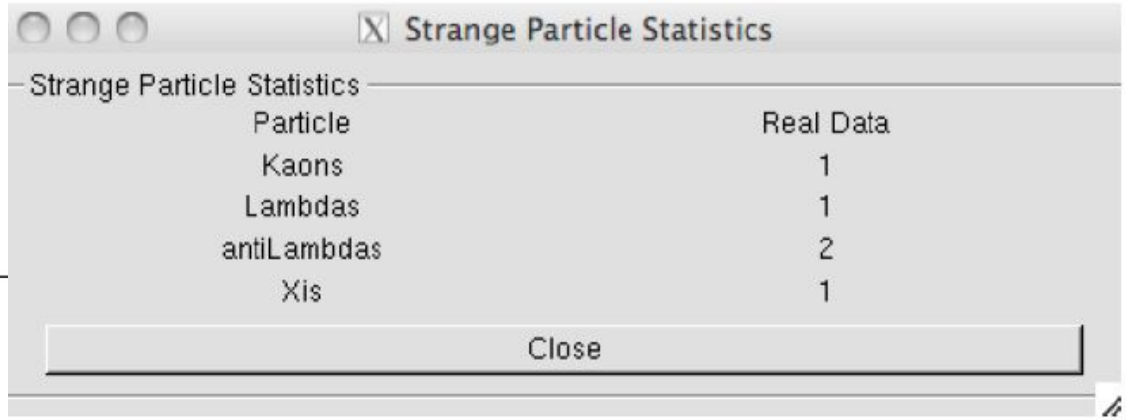
Invariant mass calculation

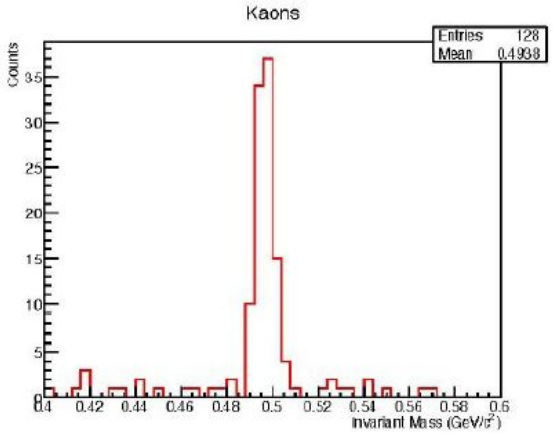
- 497 MeV $\pm$ 13 MeV it is a K_0^s
- 1115 MeV $\pm$ 5 MeV and the daughter particles are a proton and a negative pion then it is a Λ.
- 1115 MeV $\pm$ 5 MeV and the daughter particles are an antiproton and a positive pion then it is an anti-Λ.
- For a cascade decay, if the mass calculated from the 3 tracks is 1321 $\pm$ 10 MeV then it is a Ξ.

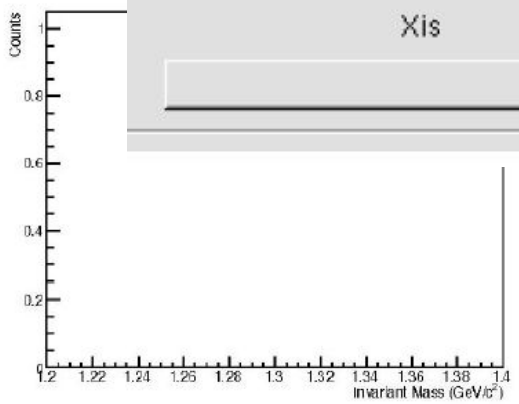


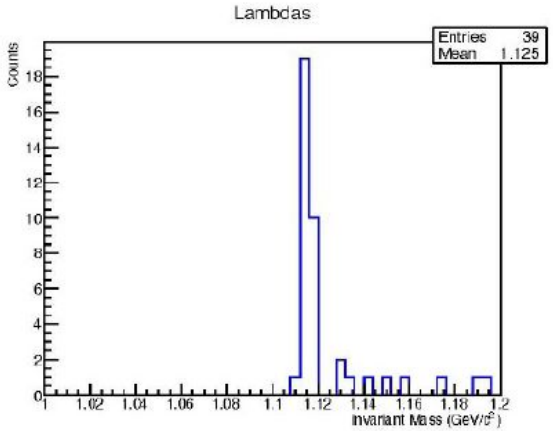
Results of visual analysis

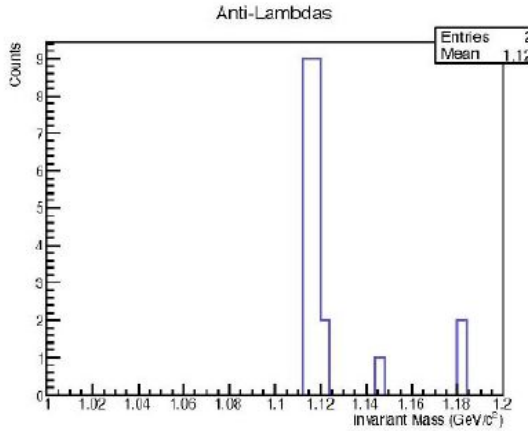
Table and histograms summarize the results - particles found by students

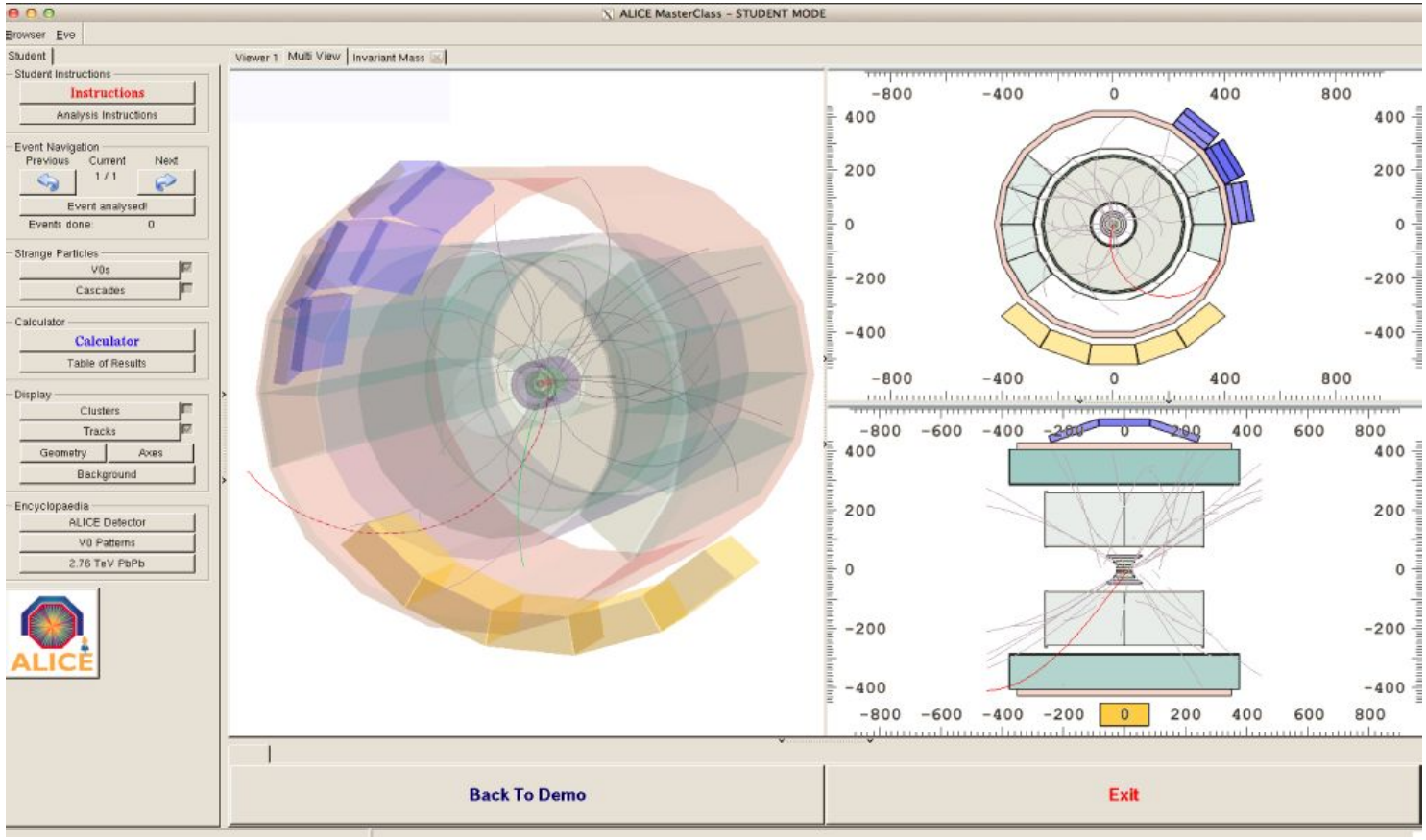








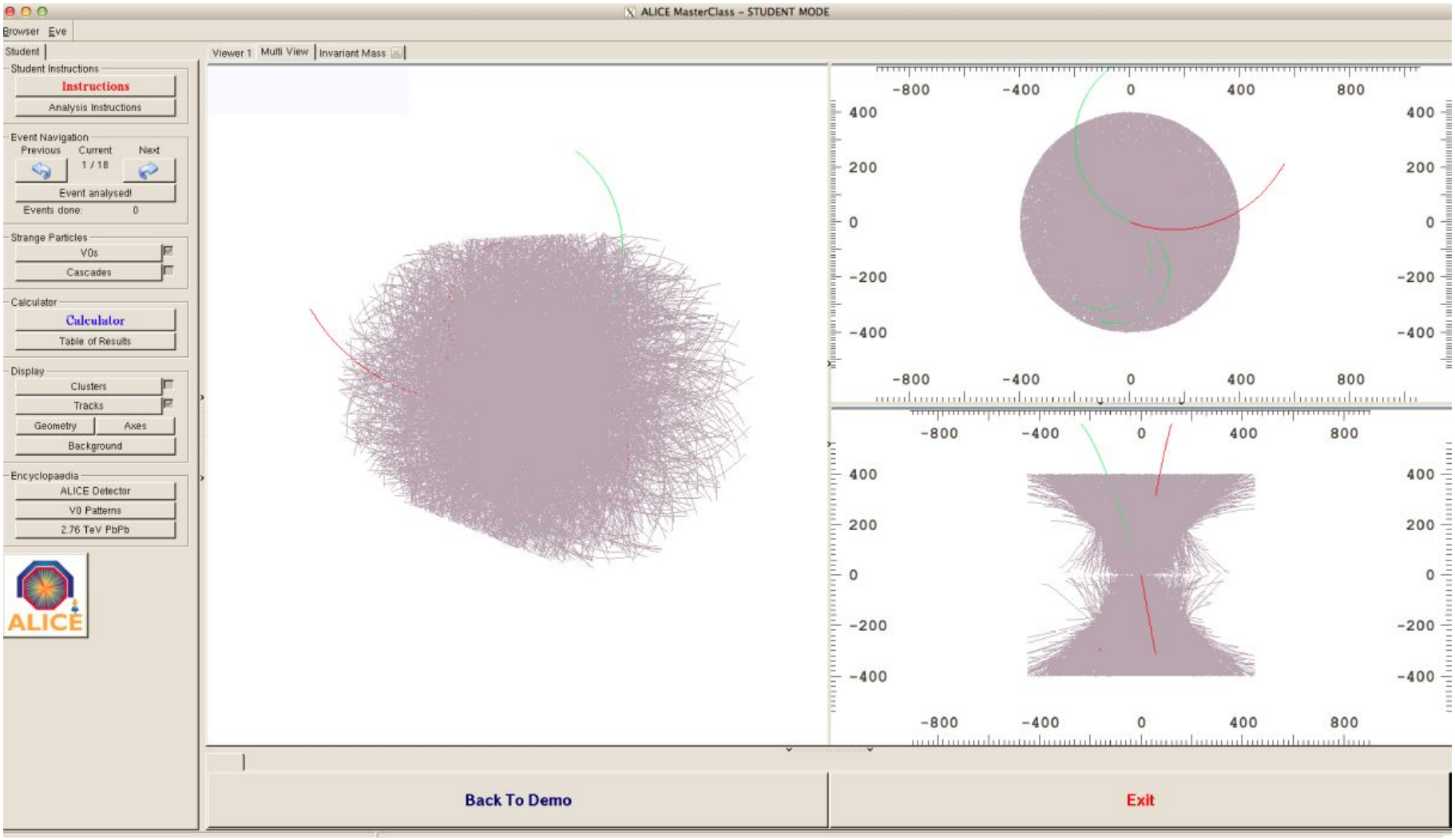




Clearly, we need more statistics → x 10 000 000

Lead-Lead event

Visual impressions: PbPb is different than pp. Visual analysis has limits



but useful for testing/debugging algorithms

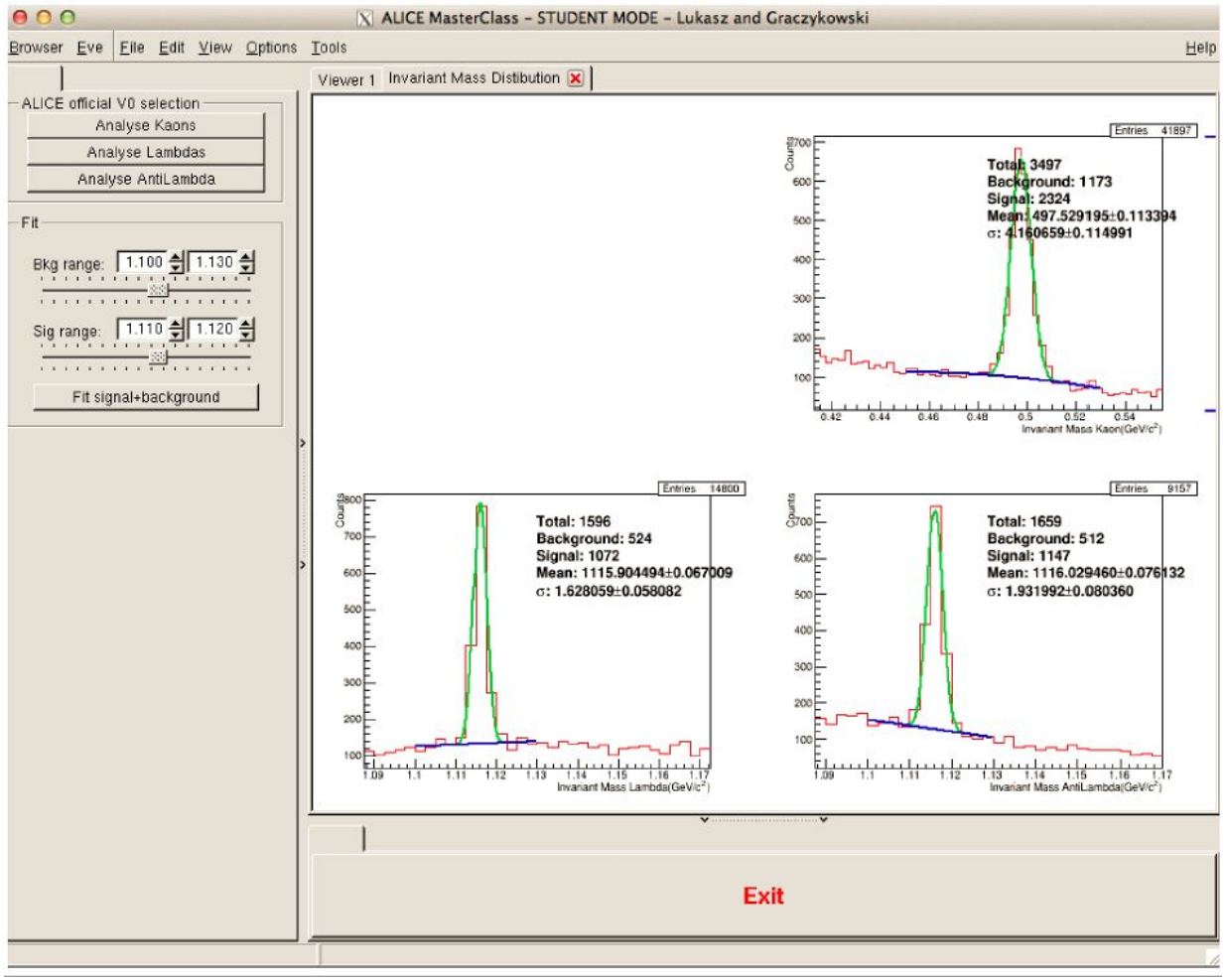
Event display in the Control Room

Large Statistics Analysis

- Analyze 20000 events looking for K^0_s, Lambdas, antilambdas
  Note background!

- Fit background

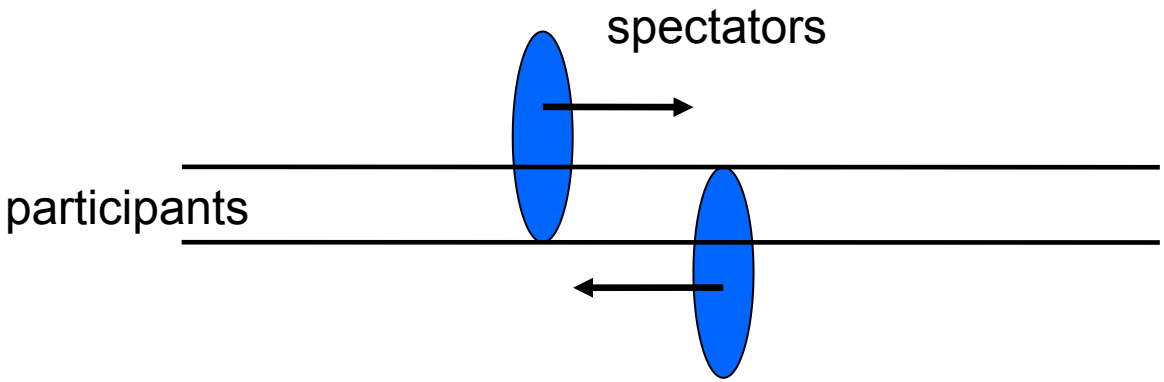
- Fit peak



Analysis in Centrality Classes

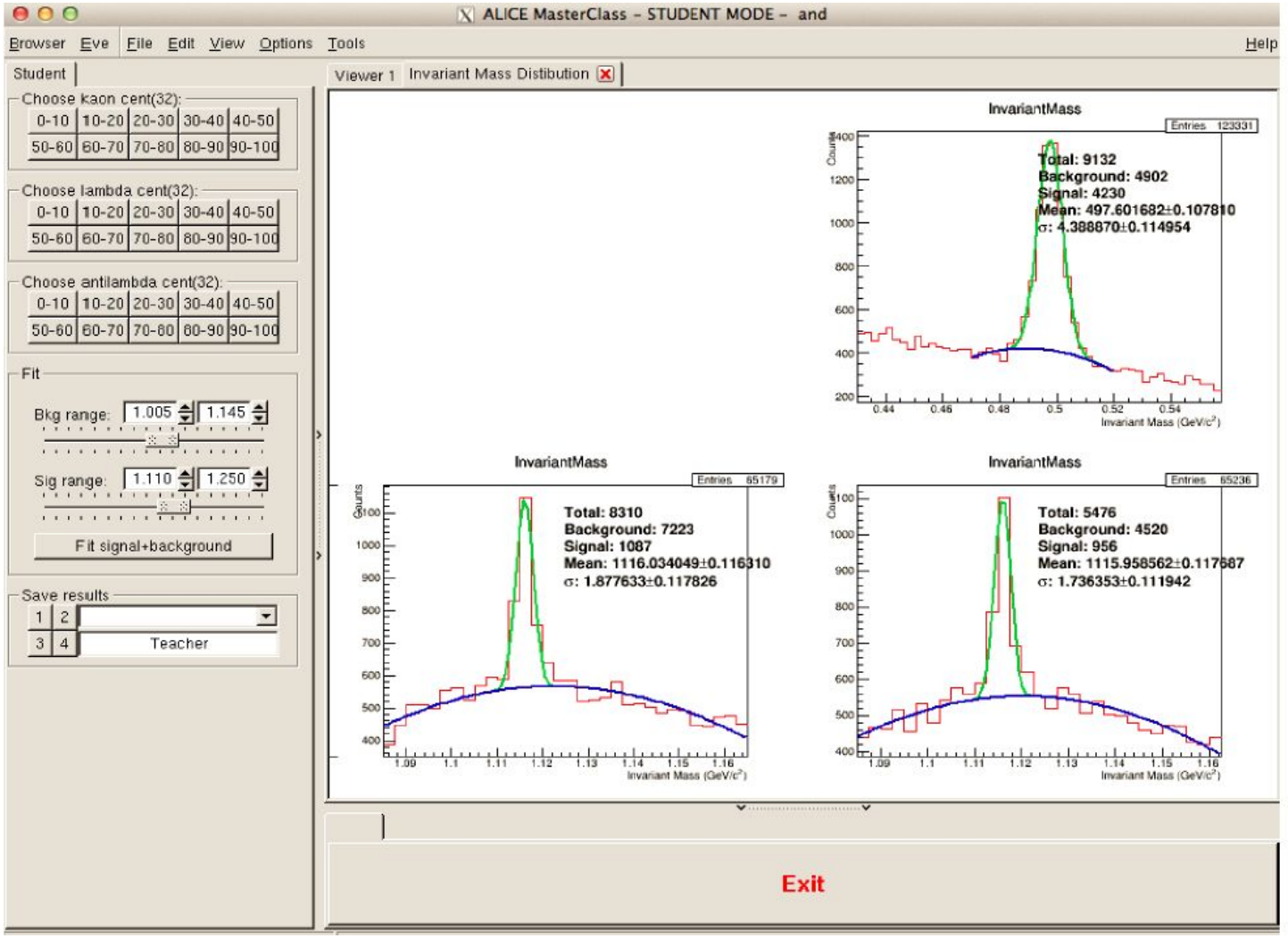
Create large data samples for V0 (K0s and Lambda) analysis

Create files for different centrality classes of Pb+Pb



Analysis in Centrality Classes

Perform large-scale analysis for different centralities



Presentation of results

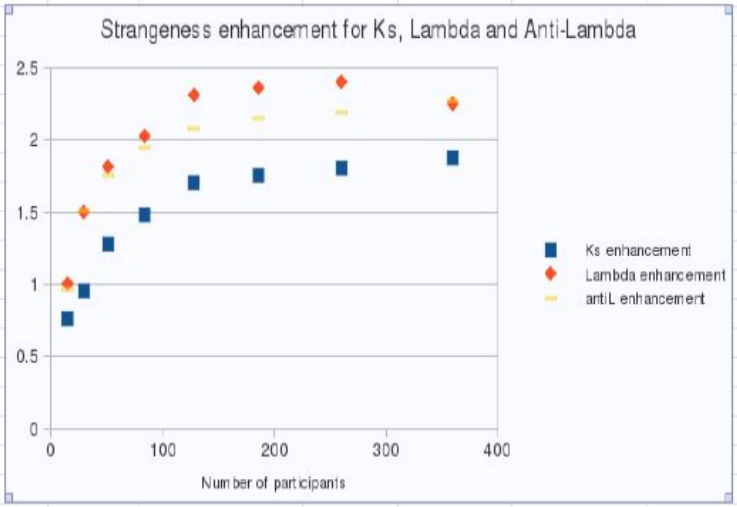
EditGrid Welcome, alice-masterclass Preferences | Logout — Home | Spreadsheets | Data

Spreadsheet / alice-masterclass / centr-results-Nantes

File Edit View Format Insert Data Share Publish Collaborate Macro Help

L16

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	centrality	<Npart>	Nevents	NKs	efficiency K:	yield Ks	Ks enhancement	Nlambda	efficiency L	Yield Lambda	Lambda enhancement	Nantilambda	effic antiL	yield antiLam
2	0-10	360	213	4648.33	0.26	83.9352353	1.86522745208191	1060.43	0.2	24.892689470154	2.24137308393249	1069.60	0.2	25.107981220657
3	10--20	260	290	4409.78	0.26	58.4851164	1.79954204357387	1172.69	0.21	19.255952380952	2.40069223051395	1069.23	0.21	17.55715548819
4	20-30	186	302	3568.50	0.29	40.7456040	1.75249909759925	899.40	0.22	13.537025888019	2.3591477820218	818.91	0.22	12.325543210552
5	30-40	129	310	2454.75	0.29	27.3053392	1.69335437307603	625.08	0.22	9.165350778254	2.30305448425213	562.11	0.22	8.2420984033887
6	40-50	85	302	1372.44	0.29	15.6706725	1.4748868261623	352.07	0.22	5.2990166566325	2.02079003017735	338.64	0.22	5.0968748289639
7	50-60	52	300	719.72	0.29	8.27266922	1.27271834168386	173.80	0.2	2.8966666666666	1.80567676515813	168.00	0.2	2.8
8	60-70	30	315	390.13	0.35	3.53859804	0.94362614611062	87.20	0.2	1.3841269841269	1.4955450936002	87.65	0.2	1.3912231559290
9	70-80	16	350	137.23	0.26	1.50799200	0.753996003996	34.45	0.2	0.4921428571428	0.99704792776106	33.12	0.2	0.4731092436974



Efficiency and acceptance correction factors and p+p yield provided → direct comparison with published results possible

Strangeness enhancement: the particle yield normalised by the number of participating nucleons in the collision, and divided by the observed yield in proton-proton collisions.

Students' tasks

- Learn the tools (the whole class)

  The tutors show on a screen the tools of the analysis programme (menus, buttons, calculator, invariant mass calculation, histograms); explain how to use them. Tutors and students analyse together examples of Ks, Λ, anti-Λ decays and calculate the invariant mass.

- Visual analysis (individually)

  Students work by themselves at computers, in groups of 2 or 3; they look at 15 events, find the V0s, classify them, update tables and histograms; save results on a file.

- Collection of results from visual analysis (the whole class)

  The tutors collect the results from each group and merge them. See next section.

- Introduction to large scale analysis (the whole class)

  Tutors instruct the students how to analyse a large event sample, fit curves to the background and the signal and find the number of events in the peak. They all together find the number of Ks, Λ, anti-Λ in a large sample of pp events and then in a large sample of lead events.

- Find V0s in different centrality regions

  Students work by themselves at computers, in groups of 2 or 3; each group is assigned a centrality region and they have to find the number of Ks, Λ, anti-Λ in this region.

- Collection of results from large scale analysis; calculation of yields and strangeness enhancement.

Contact

- **Yiota Foka** - Yiota.Foka@cern.ch
- **Małgorzata Janik** - majanik@if.pw.edu.pl
- **Anna Zaborowska** - anna.zaborowska@cern.ch
- **Daniel Kikoła** - kikola@if.pw.edu.pl

Other educational resources

- http://ippog.web.cern.ch/resources

Age 6-9

- http://ippog.web.cern.ch/resources/2011/cms-comic-book-brochure-2006
- http://ippog.web.cern.ch/resources/2010/cernland

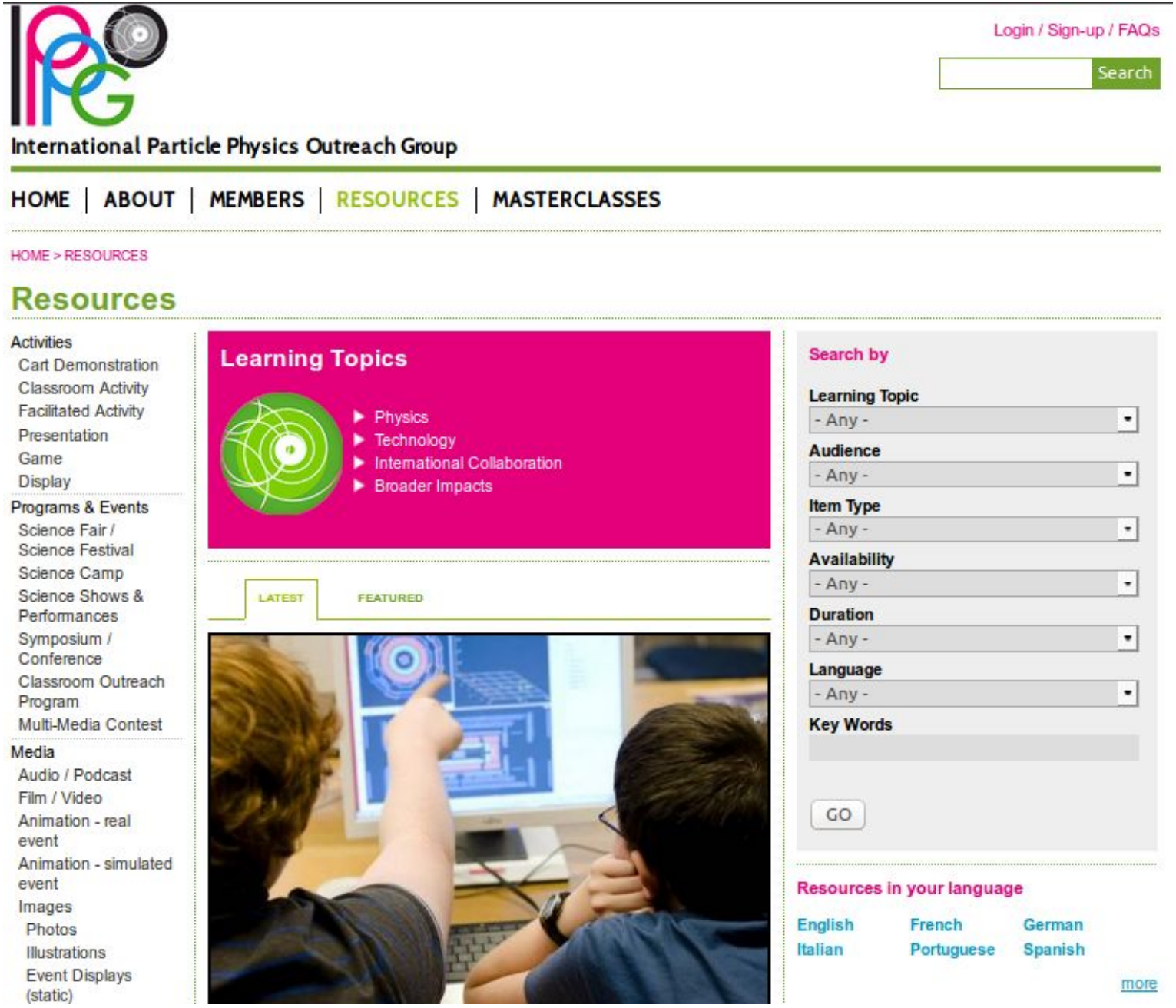
Age 9-12

- http://ippog.web.cern.ch/resources/2011/draw-me-physicist
- http://ed.fnal.gov/projects/scientists/
- http://ed.fnal.gov/projects/labyrinth/games/
- http://ippog.web.cern.ch/resources/2012/quark-poker
- http://ippog.web.cern.ch/resources/2011/cms-slice-july-2010-version
- http://ippog.web.cern.ch/resources/2011/grid-cafe-interactive
- http://ippog.web.cern.ch/resources/2011/little-book-big-bang-big-scientific-adventure
- http://ippog.web.cern.ch/resources/2011/alice-and-soup-quarks-and-gluons
- http://ippog.web.cern.ch/resources/2011/card-games-particles

Univeristy level

- http://ippog.web.cern.ch/resources/end-user-audience/18-25-years

http://ippog.web.cern.ch/resources



Backup

Hands on Particle Physics Masterclasses
INFORMATION FOR TEACHERS AND EDUCATORS

All material for International Masterclasses, including measurements and data, is free to use standalone and for any educational purpose, not only in the framework of International Masterclasses. If you are a teacher or an educator, you can use any material in school. The table below provides direct access to all material.

In various countries initiatives and programs exist that might provide support, e.g. a scientific facilitator to help in the classroom:

- U.S.: Quarknet
- Germany: Netzwerk Teilchenwelt
- UK: Contact Elizabeth Cunningham or Pete Watkins

Material can be used for other events like the Teachers Day

status as of April 2014

experiment	ATLAS		CMS	ALICE		LHCb
measurement	W path	Z path	WZH	Strange Particles	Nucl. Mod. Factor	D0 Lifetime
website	Link	Link	Link	Link	Link	Link
software	Download	Download	Link			
data sets	Link*	Link**				
combination of results	Link***	Link****				
guide for tutors	Download	Download	Download	Download	Download	Download
tally sheet	Download	Download	Download			
video tutorial			Video			
introductory talk			Download			
additional info	Link	Link	Link	Link	Link	Link

International Particle Physics Outreach Group

https://indico.cern.ch/event/311361/

International Masterclasses 2014 at CERN

chaired by Despina Hatzifotiadou (Universita e INFN (IT))

Saturday, 5 April 2014 from **09:00** to **17:00** (Europe/Zurich)
at **CERN**

Saturday, 5 April 2014

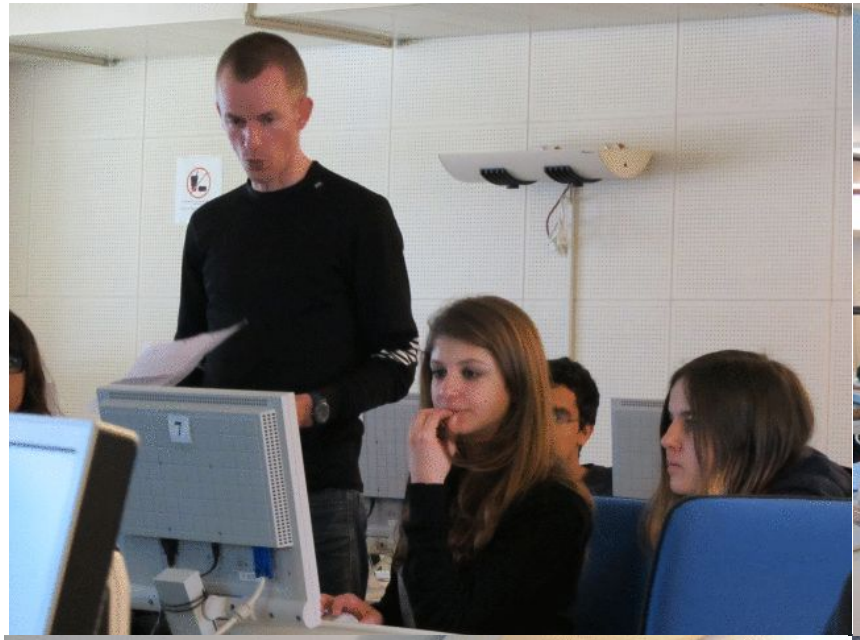
09:00 - 09:10	Accueil des participants au Point 2 *10'*
09:10 - 09:55	Introduction au CERN, le LHC et la physique des particules *45'* (3294-R-008) Speaker: Despina Hatzifotiadou (Universita e INFN (IT)) Material: **Slides**
10:00 - 10:45	L'experience ALICE (A Large Ion Collider Experiment) *45'* (3294-R-008) *A la recherche de particules étranges avec ALICE* Speaker: Giacinto De Cataldo (Universita e INFN (IT)) Material: **Slides**
10:45 - 11:45	Visit ALICE surface exhibition and ALICE cavern *1h0'* Speakers: Despina Hatzifotiadou (Universita e INFN (IT)), Giacinto De Cataldo (Universita e INFN (IT)), Panagiotis Charitos (Autonomous University of Puebla (MX))
12:00 - 12:15	Transport to CERN Restaurant 1 *15'*
12:15 - 13:15	Lunch (501)
13:15 - 13:25	Walk to training centre *10'*
13:30 - 15:15	Analysis exercise (Looking for strange particles with ALICE) *1h45'* (593) *rooms 23, 24* Speakers: Xitzel Sanchez Castro (Institut Pluridisciplinaire Hubert Curien (FR)), Despina Hatzifotiadou (Universita e INFN (IT)), Giacomo Volpe (CERN)
15:15 - 15:30	Discussion of results and preparation of results for videoconference *15'*
15:30 - 15:45	Walk to ATLAS *15'*
16:00 - 17:00	Videoconference *1h0'* (3162-1-K01)

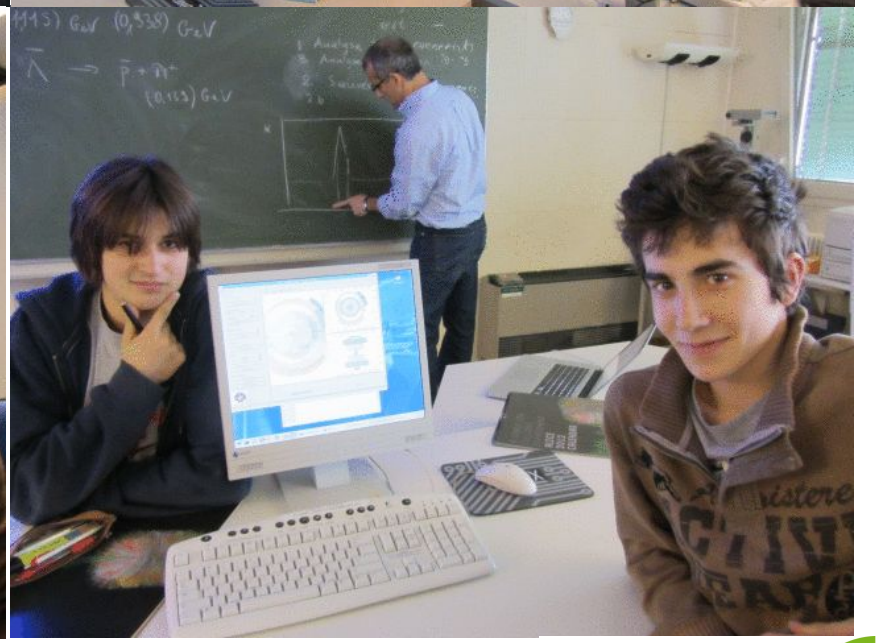
http://www.facebook.com/pages/Os-aceleradores-de-part%C3%ADculas-na-sala-de-aula/100928783362350

MasterClass 2012 @ IFUSP Sao Paulo

INTERNATIONAL MASTERCLASSES
hands on particle physics

MasterClass 2012 @ CERN





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

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