

# **Hands-on: ALICE masterclass**

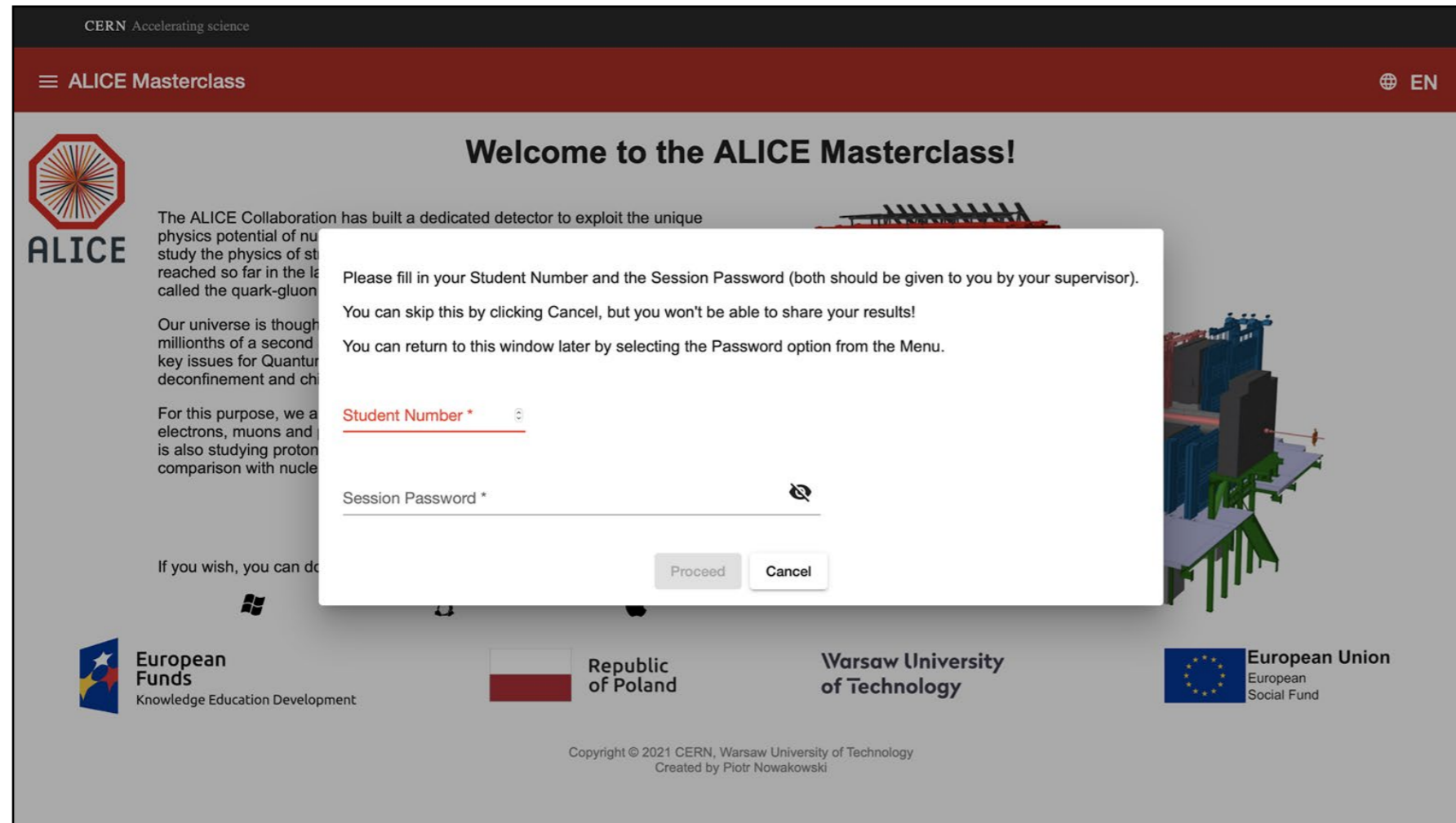
**Fabio Colamaria, Domenico Colella**

**Bari, 14/03/2025**

# Hands-on – Introduzione

Login su:

<https://alice-web-masterclass.app.cern.ch/?password=password-per-nulla-creativa>



CERN Accelerating science

ALICE Masterclass EN

## Welcome to the ALICE Masterclass!

The ALICE Collaboration has built a dedicated detector to exploit the unique physics potential of nuclei. It will study the physics of strongly interacting matter reached so far in the laboratory, called the quark-gluon plasma.

Our universe is thought to have spent a few millionths of a second in this state. Key issues for Quantum Chromodynamics are deconfinement and chiral symmetry breaking.

For this purpose, we are studying collisions of heavy ions, such as lead, at the Large Hadron Collider. We are also studying proton-proton collisions to compare with nuclear effects.

If you wish, you can download the ALICE Masterclass app.

Please fill in your Student Number and the Session Password (both should be given to you by your supervisor).  
You can skip this by clicking Cancel, but you won't be able to share your results!  
You can return to this window later by selecting the Password option from the Menu.

Student Number \*

Session Password \*

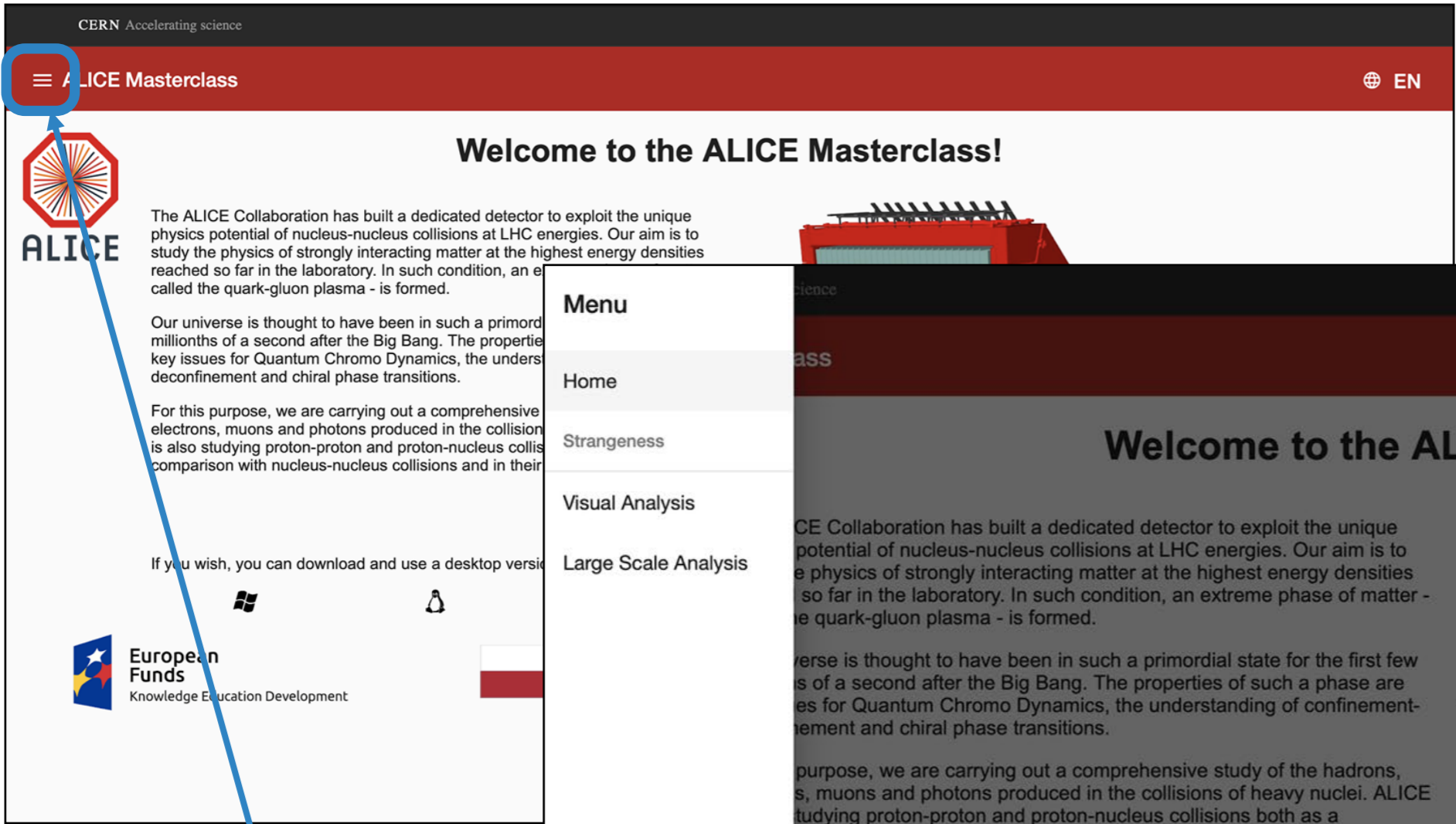
Proceed Cancel

European Funds Knowledge Education Development  
Republic of Poland  
Warsaw University of Technology  
European Union European Social Fund

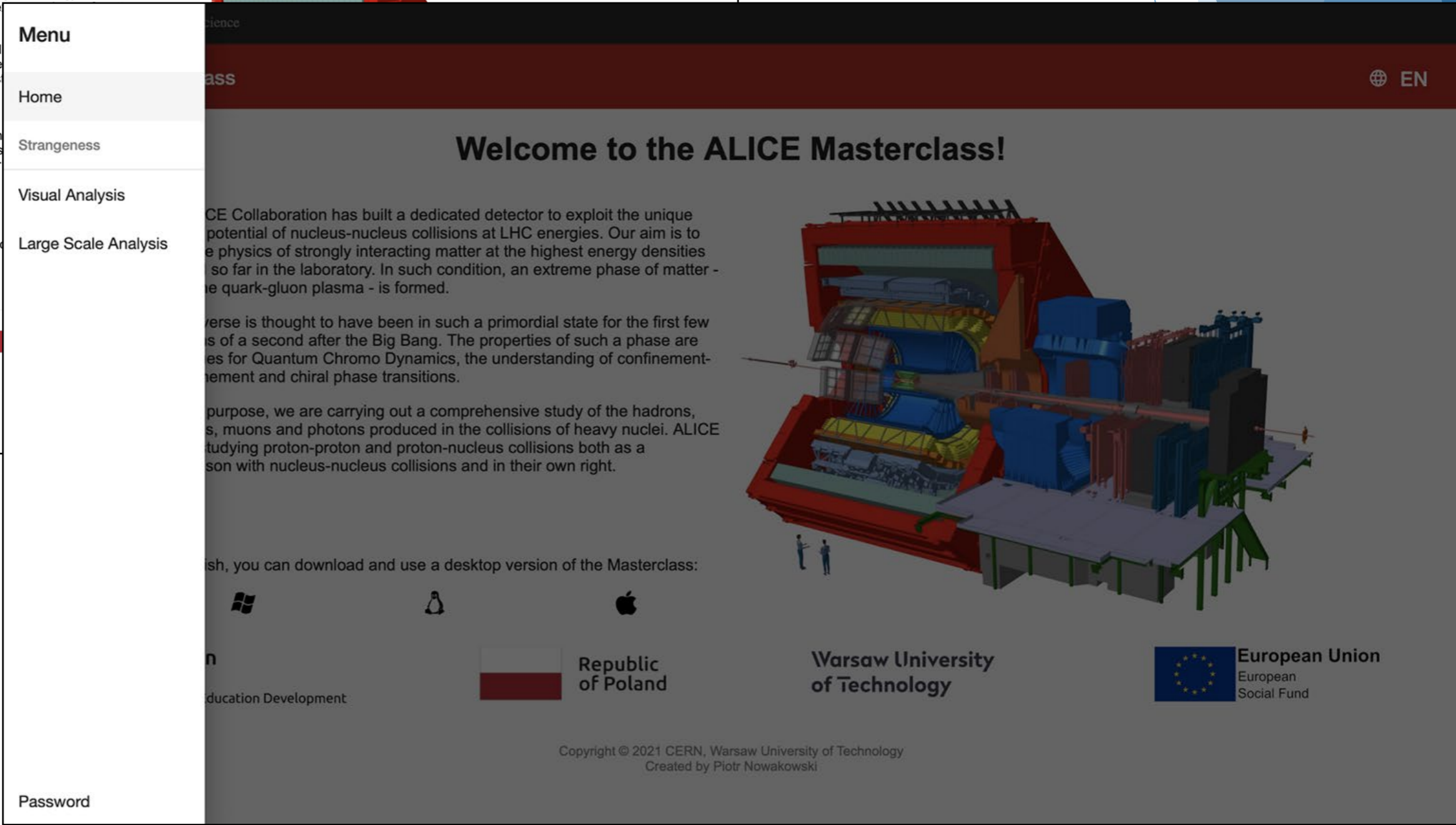
Copyright © 2021 CERN, Warsaw University of Technology  
Created by Piotr Nowakowski

- Inserite il vostro “Student Number”
  - Corrisponde al numero riportato sulle vostre credenziali WiFi
- Inserite la “Session Password”: **password-per-nulla-creativa**
  - Se utilizzate il link in alto, dovrebbe essere automaticamente riportata
- Cliccate su “Proceed”

# Hands-on – Introduzione



Pulsante per il menù principale



# Hands-on – Introduzione

**Fase 1**  
Costruire la  
distribuzione di  
massa invariante

**Fase 2**  
Misurare il tasso di  
produzione

The screenshot shows the ALICE Masterclass website. On the left, a 'Menu' sidebar contains the following items: 'Home', 'Strangeness', 'Visual Analysis', and 'Large Scale Analysis'. The 'Visual Analysis' and 'Large Scale Analysis' items are highlighted with blue rounded rectangles. Blue arrows point from the text 'Fase 1' to the 'Visual Analysis' item and from 'Fase 2' to the 'Large Scale Analysis' item. The main content area features a dark red header with 'EN' in the top right. Below the header, the text reads 'Welcome to the ALICE Masterclass!' followed by a 3D cutaway illustration of the ALICE detector. The footer includes logos for the Republic of Poland, Warsaw University of Technology, and the European Union, along with copyright information: 'Copyright © 2021 CERN, Warsaw University of Technology. Created by Piotr Nowakowski'. A 'Password' field is visible at the bottom left of the page.

# Hands-on – Introduzione

**Fase 1**  
Costruire la  
distribuzione di  
massa invariante

**Fase 2**  
Misurare il tasso di  
produzione

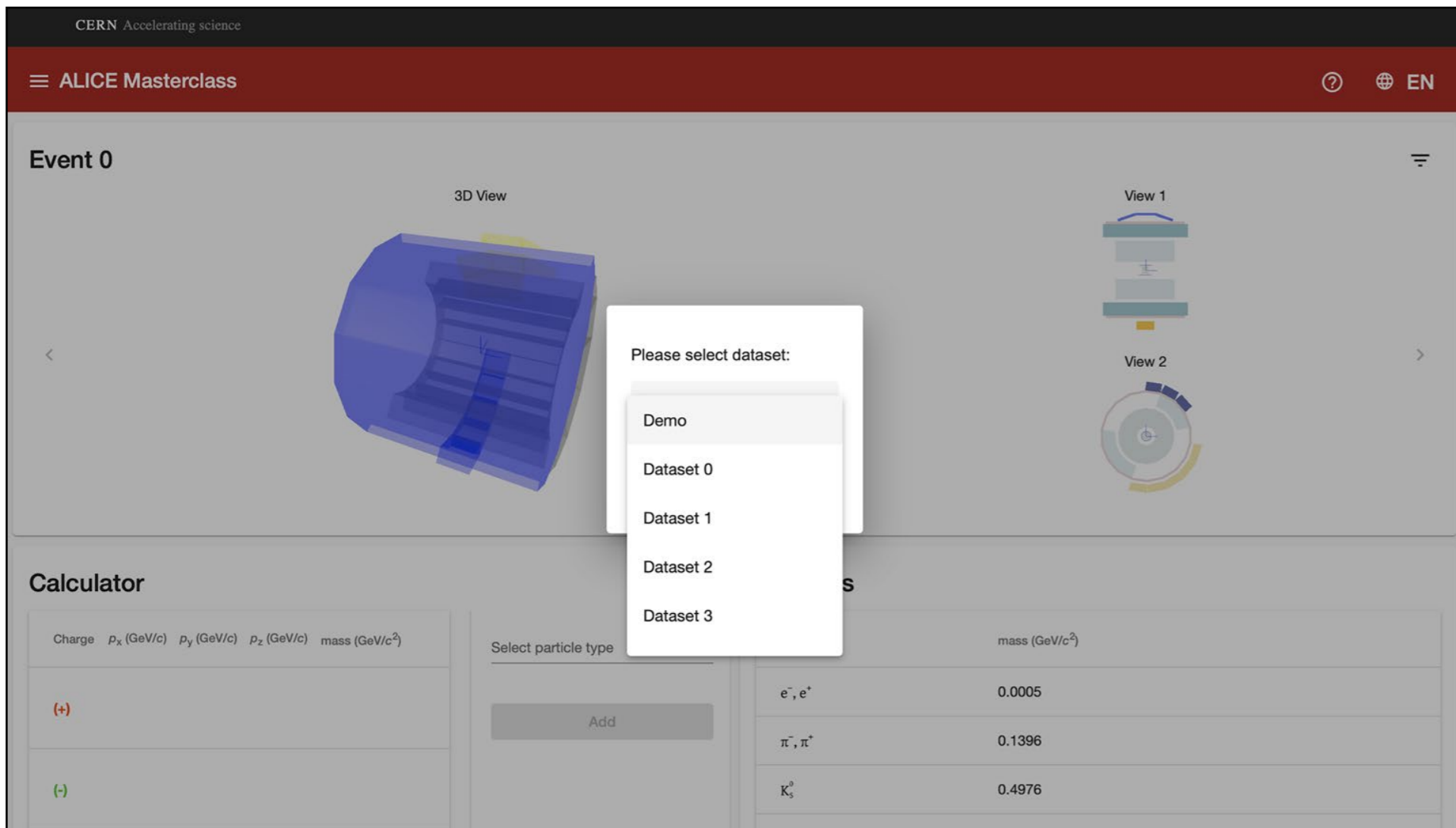
The screenshot shows the ALICE Masterclass website. On the left, a 'Menu' sidebar contains the following items: 'Home', 'Strangeness', 'Visual Analysis', and 'Large Scale Analysis'. A blue circle highlights 'Visual Analysis', with a blue arrow pointing from the 'Fase 1' text to it. A grey circle highlights 'Large Scale Analysis', with a grey arrow pointing from the 'Fase 2' text to it. The main content area features a dark red header with 'EN' in the top right. Below the header, the text reads 'Welcome to the ALICE Masterclass!' followed by a 3D cutaway illustration of the ALICE detector. The footer includes logos for the Republic of Poland, Warsaw University of Technology, and the European Union, along with copyright information: 'Copyright © 2021 CERN, Warsaw University of Technology. Created by Piotr Nowakowski'. A 'Password' field is visible at the bottom left of the page.

# Hands-on – Fase 1

19 dataset totali:

Il vostro corrisponde al resto della divisione del vostro “Student Number” per 19

- Student number: 14 → dataset 14
- Student number: 21 → dataset 2
- Student number: 43 → dataset 5



The screenshot shows the ALICE Masterclass interface. At the top, it says "CERN Accelerating science" and "ALICE Masterclass". The main area is titled "Event 0" and features a "3D View" of the detector. A dropdown menu is open, asking "Please select dataset:" with options: "Demo", "Dataset 0", "Dataset 1", "Dataset 2", and "Dataset 3". Below the 3D view is a "Calculator" section with a table for particle properties.

Charge	$p_x$ (GeV/c)	$p_y$ (GeV/c)	$p_z$ (GeV/c)	mass (GeV/c <sup>2</sup> )
(+)				
(-)				

Select particle type	mass (GeV/c <sup>2</sup> )
$e^-, e^+$	0.0005
$\pi^-, \pi^+$	0.1396
$K_s^0$	0.4976

**Selezionate il dataset assegnato sulla corrispondente schermata**

# Hands-on – Fase 1

CERN Accelerating science

ALICE Masterclass

Event 0

3D View

View 1

View 2

Calculator

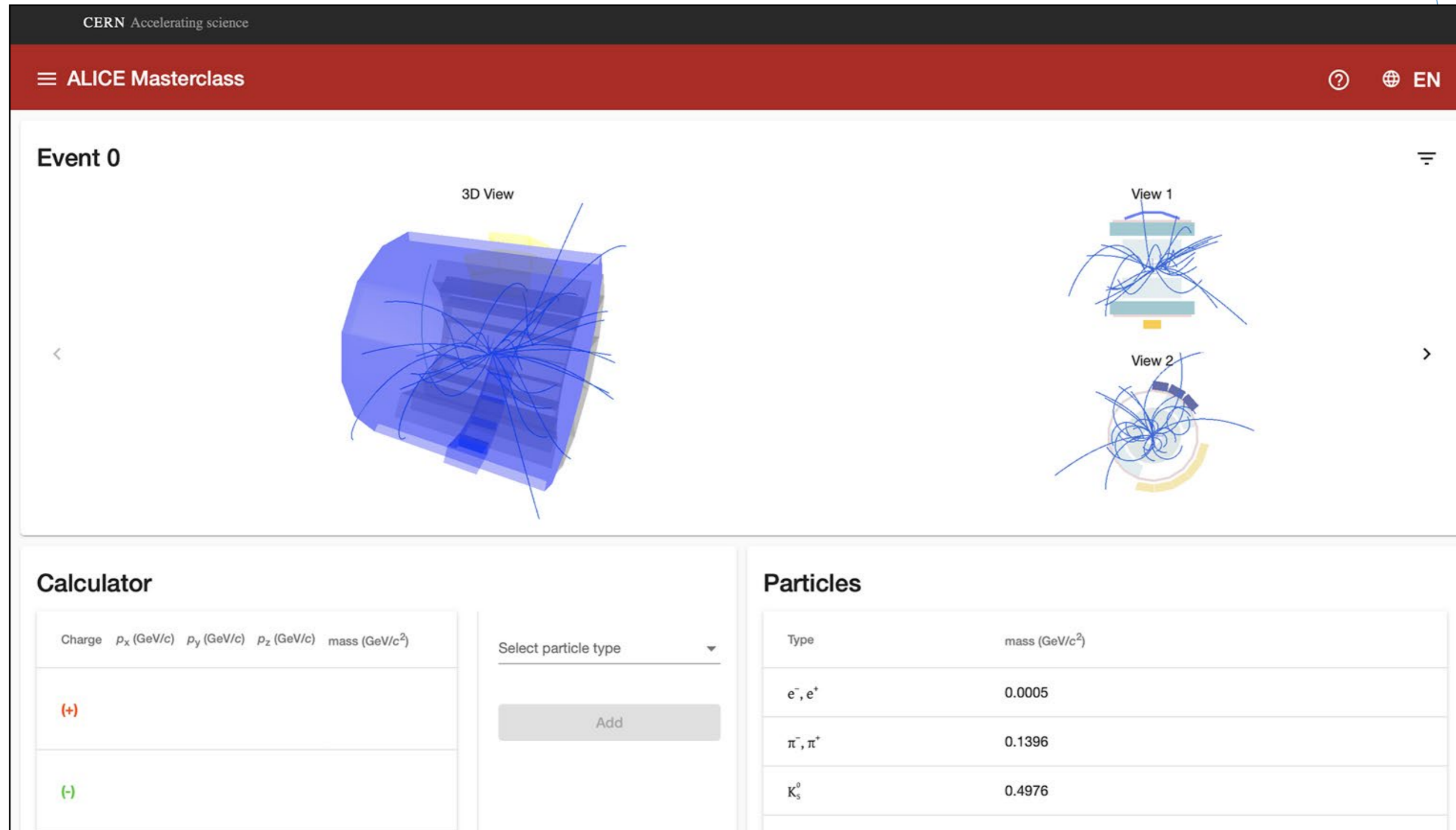
Charge	$p_x$ (GeV/c)	$p_y$ (GeV/c)	$p_z$ (GeV/c)	mass (GeV/c <sup>2</sup> )
(+)				
(-)				

Select particle type

Add

Particles

Type	mass (GeV/c <sup>2</sup> )
$e^-, e^+$	0.0005
$\pi^-, \pi^+$	0.1396
$K_S^0$	0.4976



Ogni dataset contiene un piccolo numero di collisioni (o ‘eventi’) preselezionati, in cui è presente un decadimento di un adrone strano

# Hands-on – Fase 1

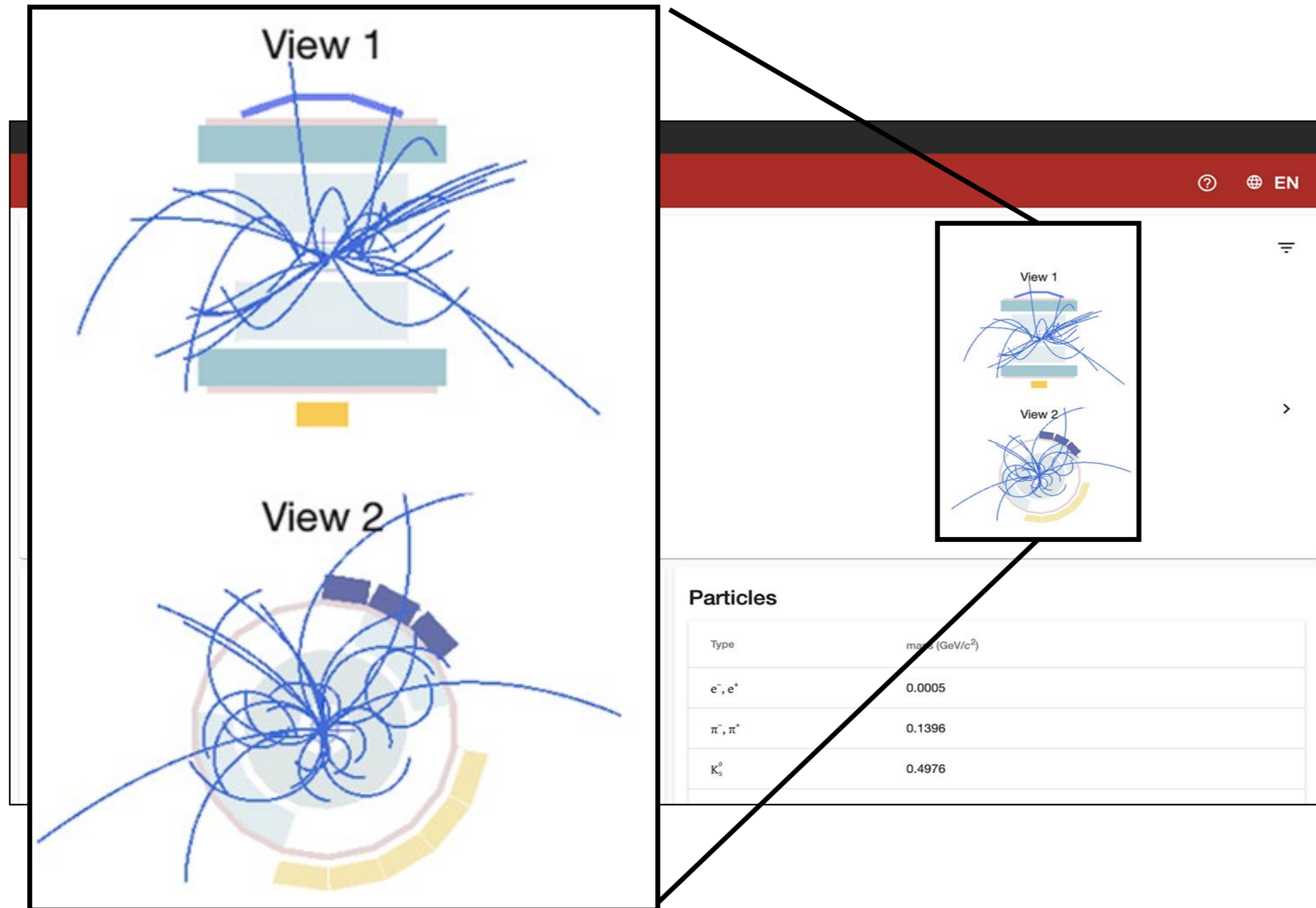
The screenshot displays the ALICE Masterclass interface for Event 0. At the top, the header includes 'CERN Accelerating science' and 'ALICE Masterclass' with navigation icons. The main content area is divided into three sections: a 3D view of the collision event, two 2D views (View 1 and View 2), and a calculator/particles section. The 3D view shows a blue detector structure with particle tracks. The 2D views show the same event from different perspectives. The calculator section has input fields for Charge,  $p_x$  (GeV/c),  $p_y$  (GeV/c),  $p_z$  (GeV/c), and mass (GeV/c<sup>2</sup>), along with a 'Select particle type' dropdown and an 'Add' button. The particles section is a table listing particle types and their masses.

Type	mass (GeV/c <sup>2</sup> )
$e^-, e^+$	0.0005
$\pi^-, \pi^+$	0.1396
$K_S^0$	0.4976

Per esplorare le varie collisioni utilizzate le frecce



# Hands-on – Fase 1



Ogni collisione contiene tante “tracce” di particelle ricostruite, di colore blu. In questa versione semplificata, le tracce relative a possibili “figlie” di adroni strane sono già identificate, e mostrate in colori diversi (rosso o verde).

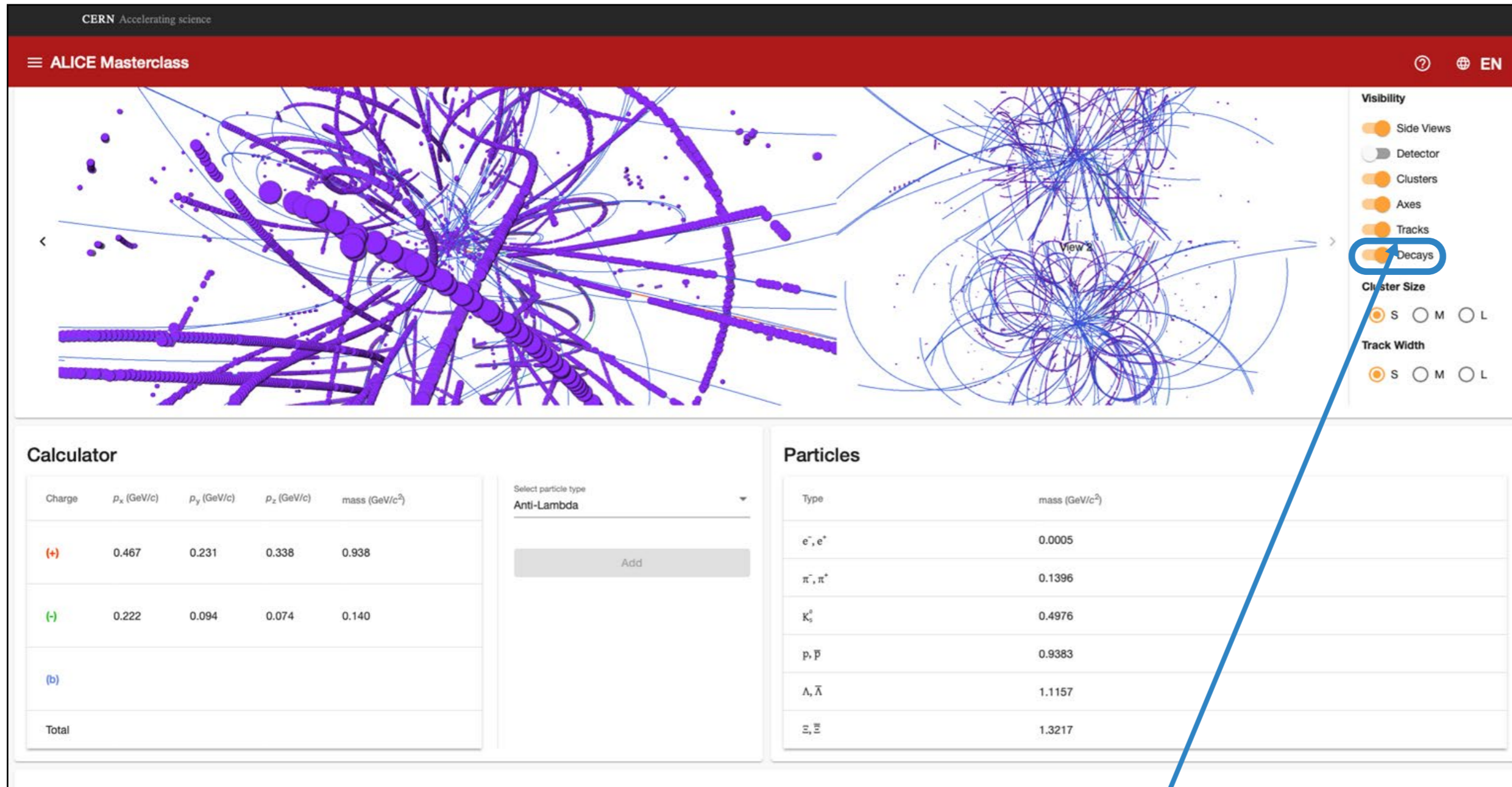
# Hands-on – Fase 1

The screenshot shows the ALICE Masterclass interface. At the top, there is a header with "CERN Accelerating science" and "ALICE Masterclass". The main content area is titled "Event 0" and features a "3D View" of a particle event, along with "View 1" and "View 2" thumbnails. A blue box highlights a menu icon in the top right corner. Below the event view, there is a "Calculator" panel with input fields for Charge,  $p_x$  (GeV/c),  $p_y$  (GeV/c),  $p_z$  (GeV/c), and mass (GeV/c<sup>2</sup>), and a "Select particle type" dropdown menu. To the right of the calculator is a "Particles" table.

Type	mass (GeV/c <sup>2</sup> )
$e^-, e^+$	0.0005
$\pi^-, \pi^+$	0.1396
$K_s^0$	0.4976

Apertura pannello opzioni

# Hands-on – Fase 1



The screenshot displays the ALICE Masterclass interface. At the top, there is a red header with the text "CERN Accelerating science" and "ALICE Masterclass". Below the header, there are two main visualization panels. The left panel shows a complex network of purple tracks and clusters. The right panel shows a similar network but with a different view. A blue circle highlights the "Decays" option in the "Visibility" menu on the right. Below the visualization panels, there are two main sections: "Calculator" and "Particles".

**Calculator**

Charge	$p_x$ (GeV/c)	$p_y$ (GeV/c)	$p_z$ (GeV/c)	mass (GeV/c <sup>2</sup> )
(+)	0.467	0.231	0.338	0.938
(-)	0.222	0.094	0.074	0.140
(b)				
Total				

Select particle type  
Anti-Lambda  
Add

**Particles**

Type	mass (GeV/c <sup>2</sup> )
$e^-, e^+$	0.0005
$\pi^-, \pi^+$	0.1396
$K_S^0$	0.4976
$p, \bar{p}$	0.9383
$\Lambda, \bar{\Lambda}$	1.1157
$\Xi, \bar{\Xi}$	1.3217

Assicuratevi che l'opzione per visualizzare le possibili figlie degli adroni strani ("Decays") sia attiva

# Hands-on – Fase 1

Per rimuovere le tracce blu, (se ostruiscono la visuale), disattivate l'opzione 'Tracks'.  
Resteranno visibili solo le potenziali tracce figlie: **rossa (positiva)** e **verde (negativa)**  
Selezionatele cliccando su di esse nell'event display.

The screenshot shows the ALICE Masterclass event display interface. The top part displays two views of particle tracks: a 3D view on the left and a 2D view on the right. A control panel on the right allows adjusting visibility of various elements like Side Views, Detector, Clusters, Axes, Tracks, and Decays. Below the views are two panels: 'Calculator' and 'Particles'.

**Calculator**

Charge	$p_x$ (GeV/c)	$p_y$ (GeV/c)	$p_z$ (GeV/c)	mass (GeV/c <sup>2</sup> )
(+)	0.467	0.231	0.338	0.938
(-)	0.222	0.094	0.074	0.140
(b)				
Total				

**Particles**

Type	mass (GeV/c <sup>2</sup> )
$e^-, e^+$	0.0005
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$K_S^0$	0.4976
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$\Lambda, \bar{\Lambda}$	1.1157
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Nel pannello "calculator" vi appariranno le relative informazioni cinematiche, assieme alla massa invariante dell'adrone strano "madre" (riga "Total")

# Hands-on – Fase 1

The screenshot displays the ALICE Masterclass interface. At the top, there is a red header with the CERN logo and 'Accelerating science'. Below the header, the text 'ALICE Masterclass' is visible. The main area shows two views of particle tracks: a purple view on the left and a blue view on the right. A 'Visibility' panel on the right side allows users to toggle various elements: Side Views, Detector, Clusters, Axes, Tracks, and Decays. Below the tracks, there is a 'Calculator' panel with a table of particle properties and a 'Particles' panel with a list of particle types and their masses. A blue arrow points from the text below to the 'Particles' table.

Charge	$p_x$ (GeV/c)	$p_y$ (GeV/c)	$p_z$ (GeV/c)	mass (GeV/c <sup>2</sup> )
(+)	0.467	0.231	0.338	0.938
(-)	0.222	0.094	0.074	0.140
(b)				
Total				

Type	mass (GeV/c <sup>2</sup> )
$e^-, e^+$	0.0005
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$K^0$	0.4976
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Potete identificare la natura delle figlie (e della madre) confrontando il valore della massa con quello delle principali particelle note.

# Hands-on – Fase 1

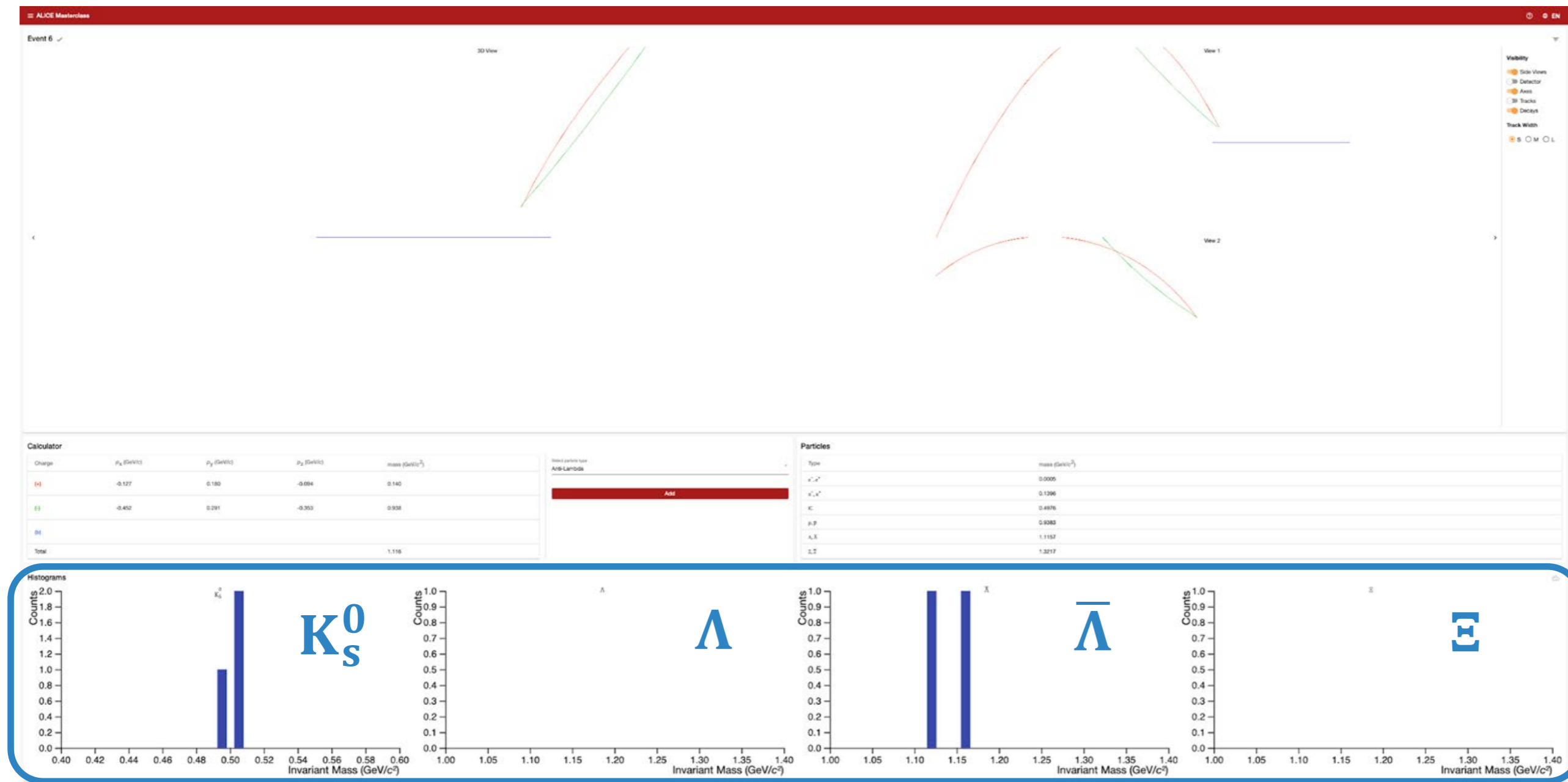
The screenshot displays the ALICE Masterclass interface. At the top, there is a red header with the CERN logo and 'Accelerating science' text. Below the header, the main area shows two views of particle tracks: a purple view on the left and a blue view on the right. A 'Visibility' panel on the right side allows users to toggle various elements: Side Views, Detector, Clusters, Axes, Tracks, and Decays. Below this, there are options for Cluster Size (S, M, L) and Track Width (S, M, L). At the bottom, there are two panels: 'Calculator' and 'Particles'. The 'Calculator' panel has a table with columns for Charge,  $p_x$  (GeV/c),  $p_y$  (GeV/c),  $p_z$  (GeV/c), and mass (GeV/c<sup>2</sup>). The 'Particles' panel has a table with columns for Type and mass (GeV/c<sup>2</sup>). A blue box highlights the 'Add' button in the 'Particles' panel, with an arrow pointing to it.

Charge	$p_x$ (GeV/c)	$p_y$ (GeV/c)	$p_z$ (GeV/c)	mass (GeV/c <sup>2</sup> )
(+)	0.467	0.231	0.338	0.938
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Type	mass (GeV/c <sup>2</sup> )
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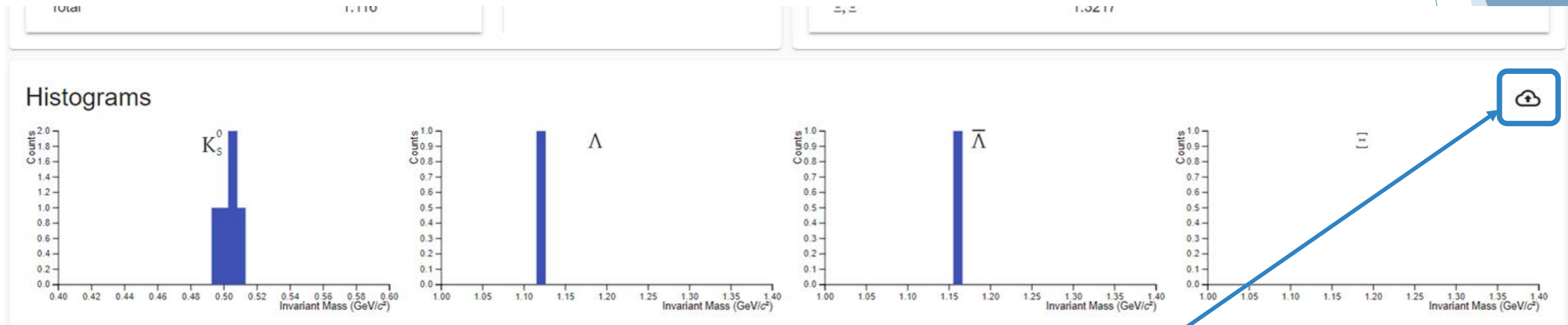
Quando avete identificato la natura della particella madre, selezionatela nell'elenco e cliccate su "Add".

# Hands-on – Fase 1



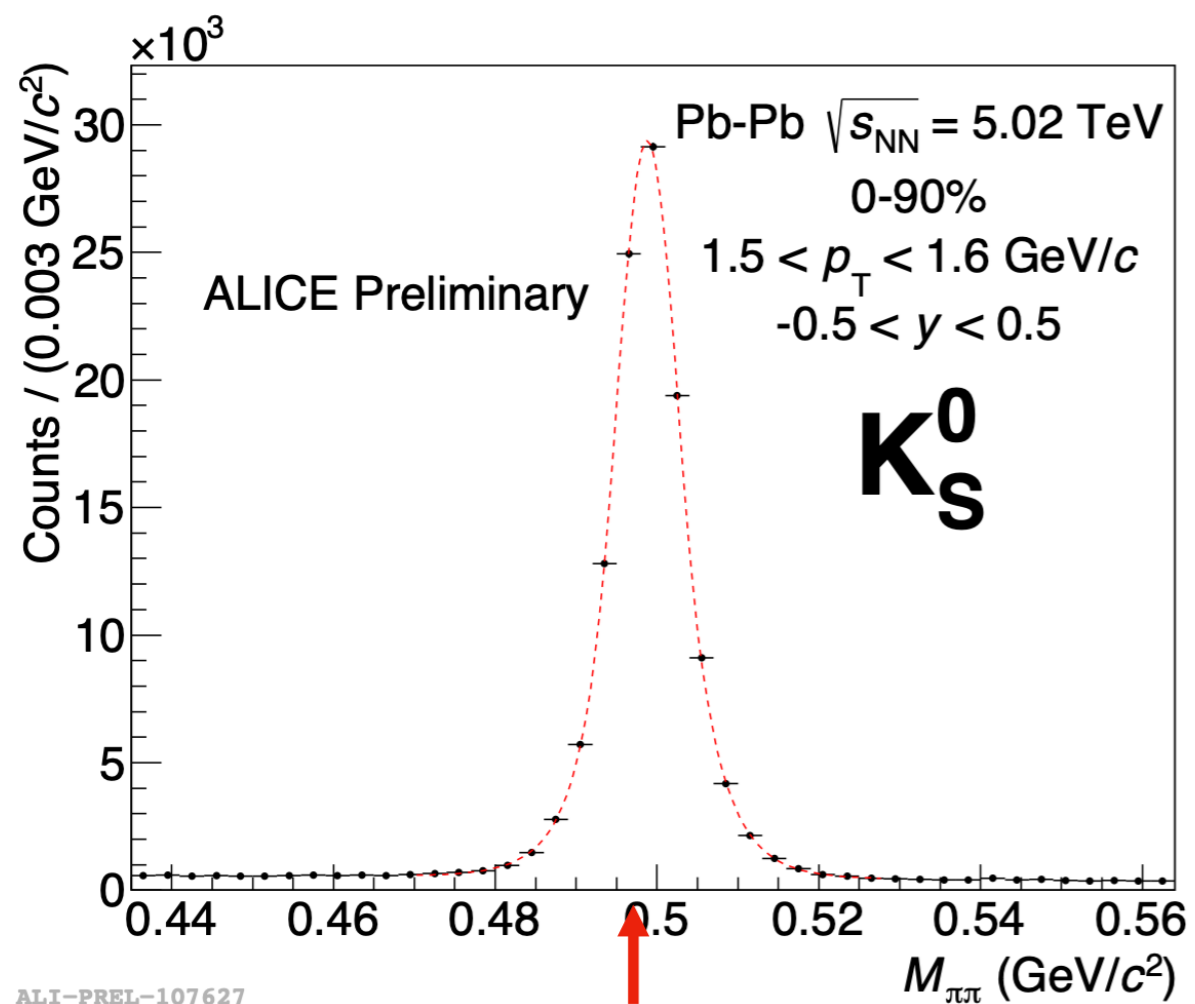
Aggiungendo candidate, queste vi compariranno nei rispettivi plot, che riportano la distribuzione di massa invariante per le potenziali particelle strane ricostruite

# Hands-on – Fase 1

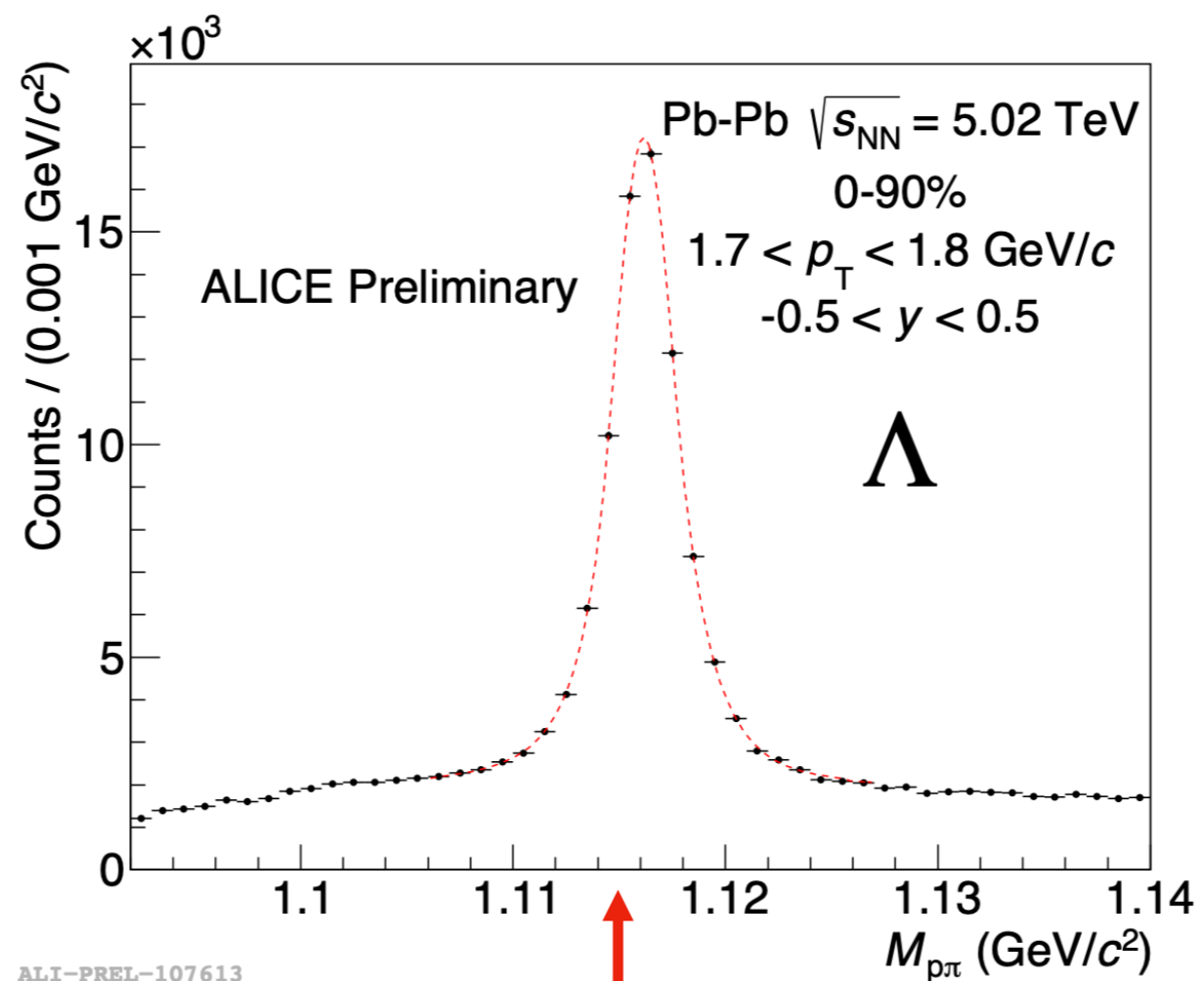


Quando avete terminato di analizzare l'intero dataset (e solo allora), cliccate sull'icona in alto a destra per condividere i risultati





**Massa reale:  $497,614 \pm 0,024 \text{ MeV}/c^2$**



**Massa reale:  $1115,683 \pm 0,006 \text{ MeV}/c^2$**

**Distribuzioni di massa invariante “ufficiali” misurate dalla  
Collaborazione ALICE su un campione (enormemente più  
grande) di collisioni piombo-piombo**

# Hands-on – Fase 2

## Fase 1

Costruire la distribuzione di massa invariante

Menu

- Home
- Strangeness
- Visual Analysis
- Large Scale Analysis

Password



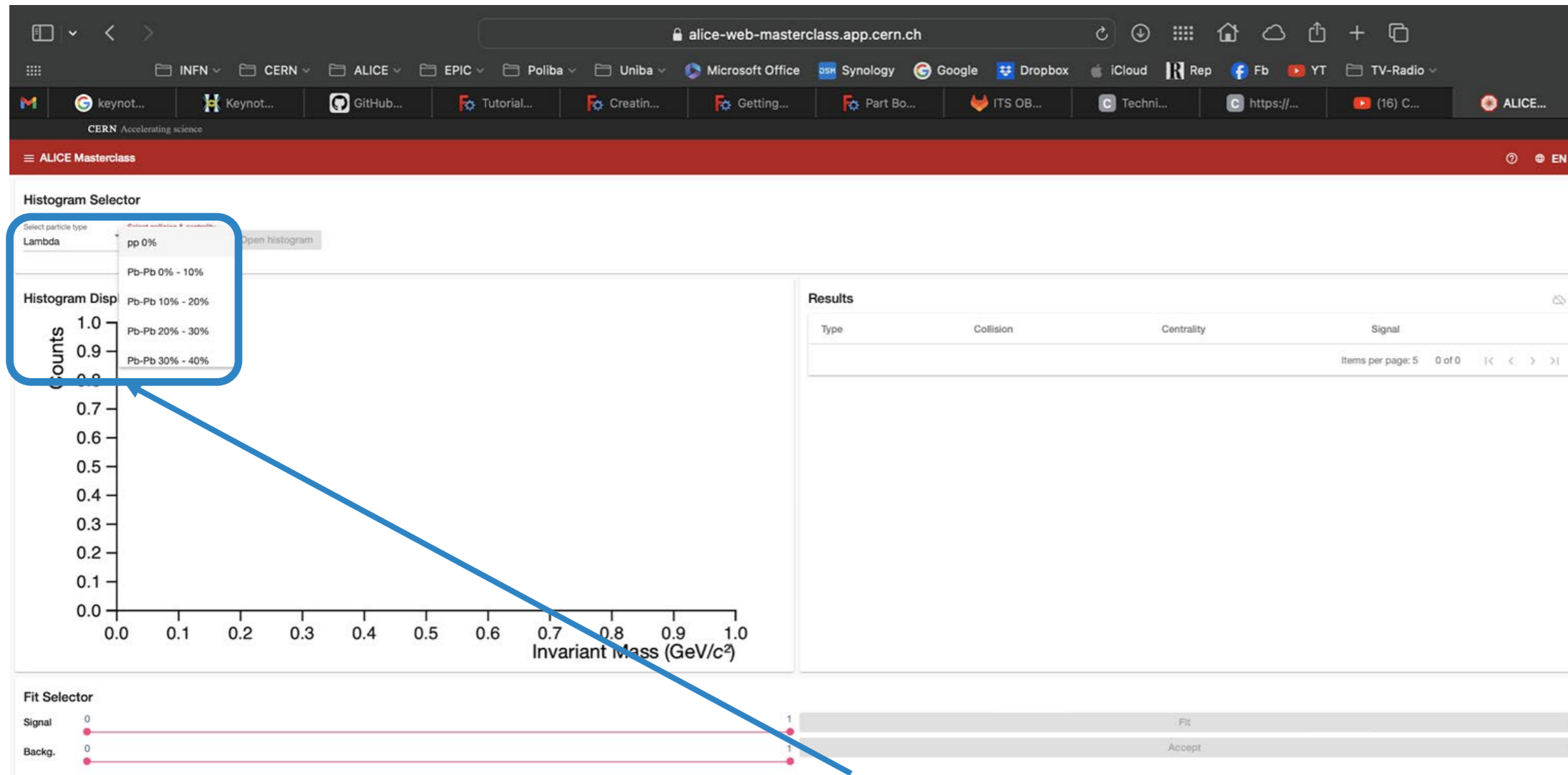
## Fase 2

Misurare il tasso di produzione

The screenshot shows the ALICE Masterclass website. At the top right, there is a language selector 'EN'. The main heading is 'Welcome to the ALICE Masterclass!'. Below this, there is introductory text about the ALICE Collaboration and the quark-gluon plasma. A 3D cutaway diagram of the ALICE detector is shown on the right. At the bottom, there are logos for the Republic of Poland, Warsaw University of Technology, and the European Union. A copyright notice at the bottom reads 'Copyright © 2021 CERN, Warsaw University of Technology Created by Piotr Nowakowski'.

# Hands-on – Fase 2

In questa fase, a partire dalle distribuzioni di massa invariante misurate da ALICE, verrà calcolato il numero di adroni strain prodotti per collisione piombo-piombo (o protone-protone)

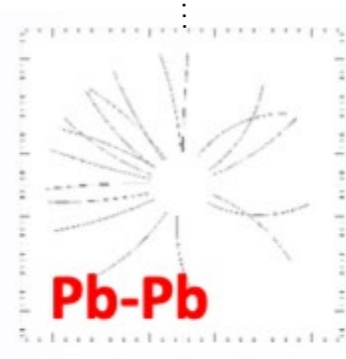
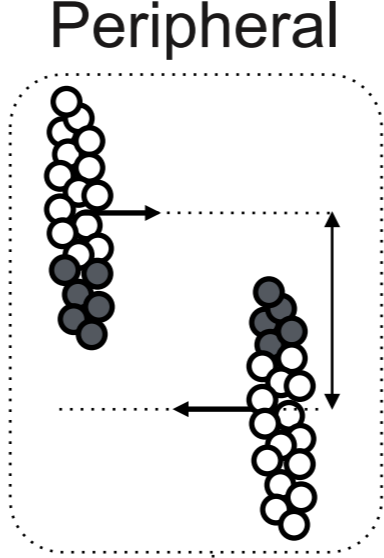
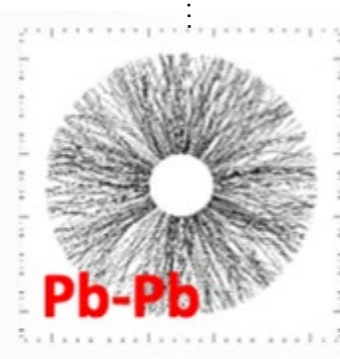
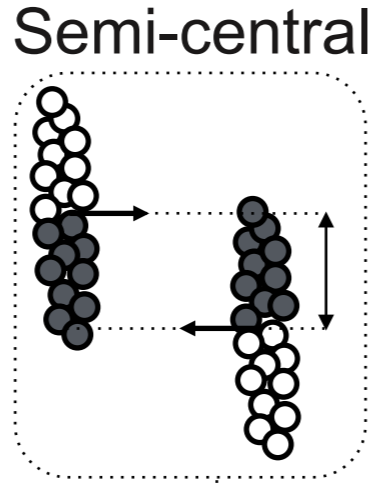
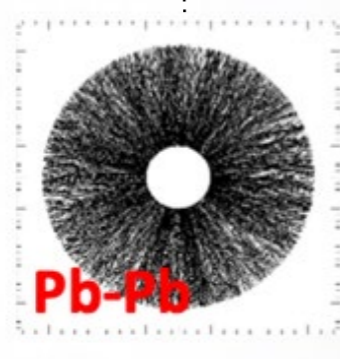
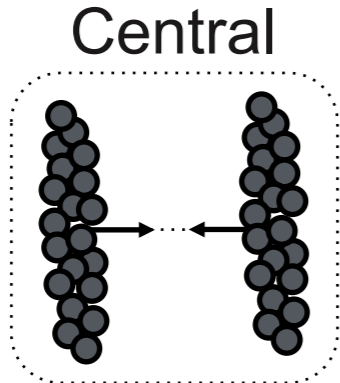


Selezionate la particella da analizzare

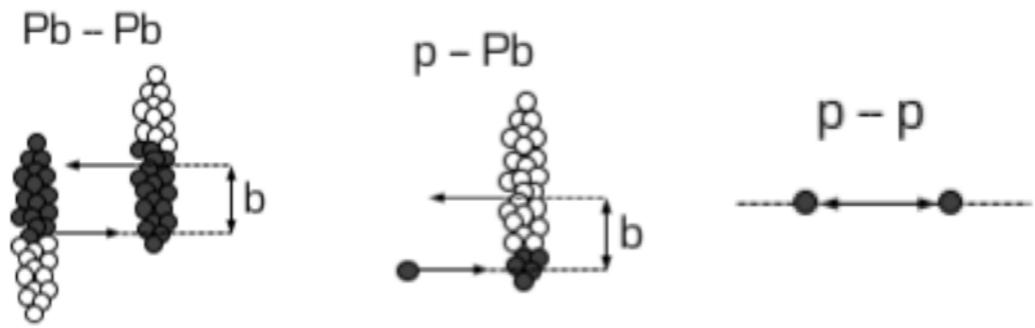
(dividete il vostro ID per 3 e prendetene il resto:  $0 = K^0_s$ ,  $1 = \Lambda$ ,  $2 = \bar{\Lambda}$ )

Per ciascuna particella, dovete studiare tutti i range di centralità

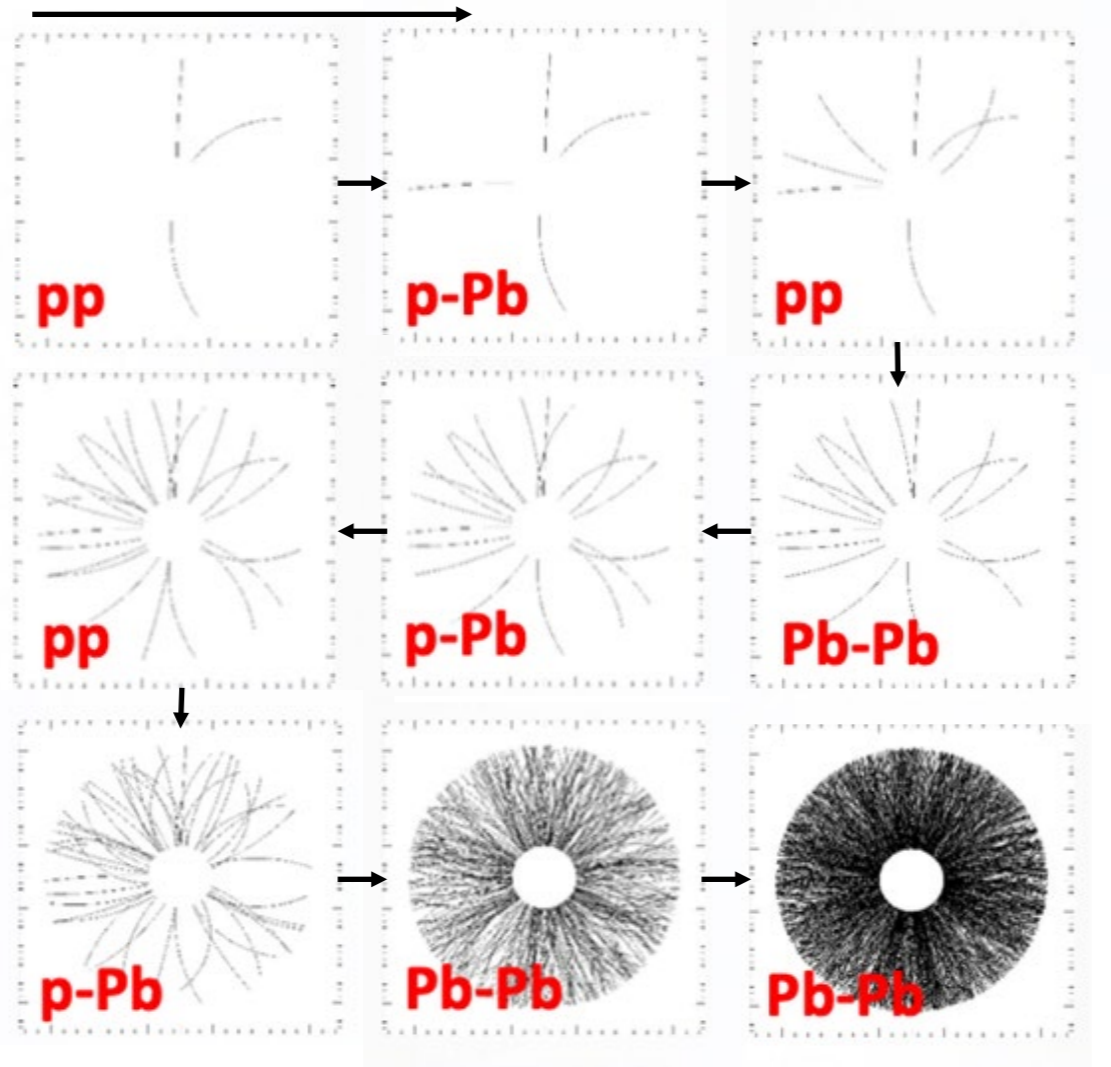
# Hands-on – Fase 2



# Hands-on – Fase 2



Increasing multiplicity

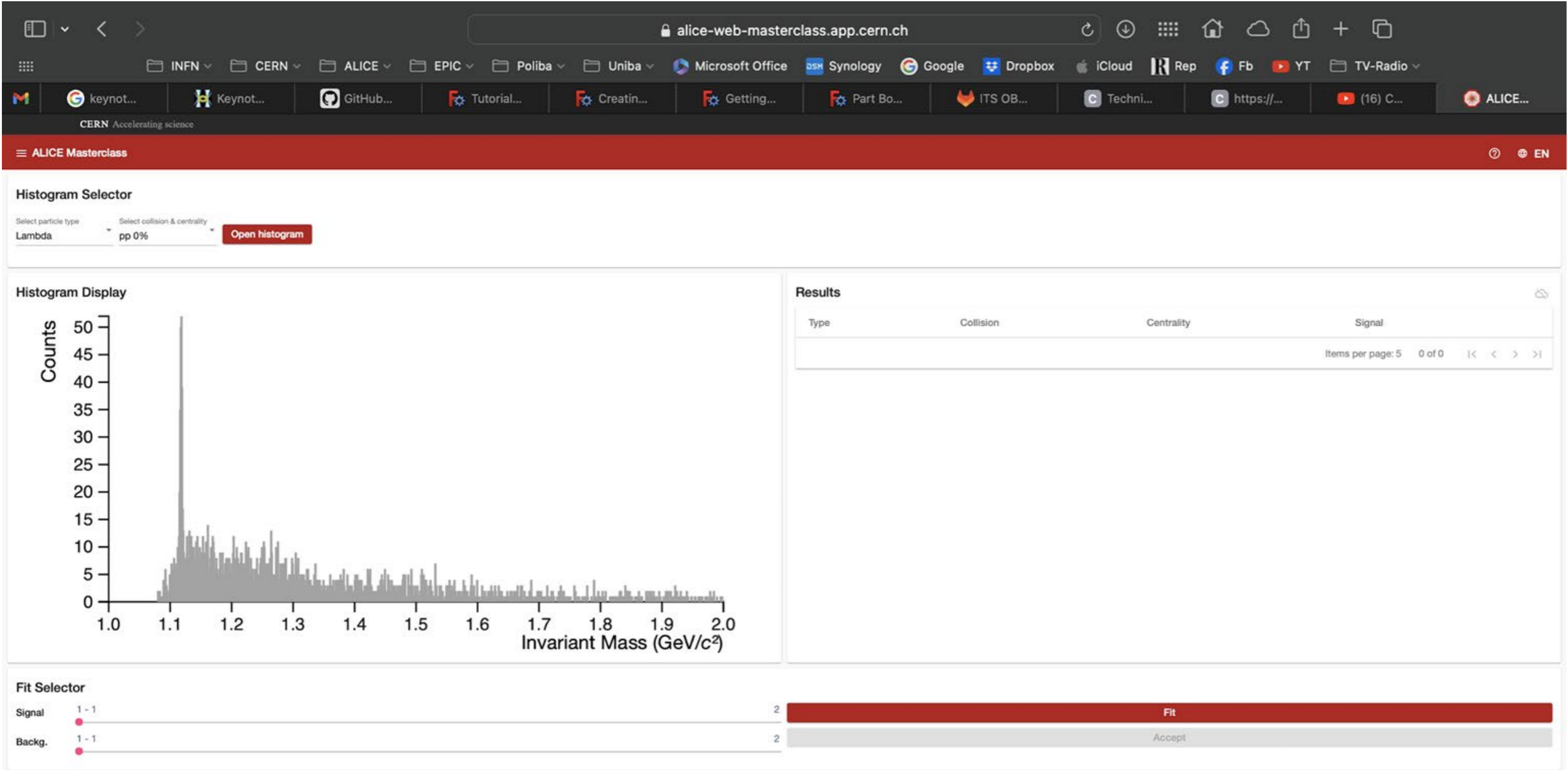


# Hands-on – Fase 2

The screenshot shows the ALICE Masterclass web interface. At the top, there is a navigation bar with the ALICE Masterclass logo and language options (EN). Below this is the 'Histogram Selector' section, which includes dropdown menus for 'Select particle type' (set to Lambda) and 'Select collision & centrality' (set to pp 0%). A red button labeled 'Open histogram' is highlighted with a blue circle and an arrow pointing to the 'Histogram Display' section. The 'Histogram Display' section shows a plot of 'Counts' (y-axis, 0.0 to 1.0) versus 'Invariant Mass (GeV/c<sup>2</sup>)' (x-axis, 0.0 to 1.0). To the right of the plot is the 'Results' section, which contains a table with columns for 'Type', 'Collision', 'Centrality', and 'Signal'. Below the table, there is a pagination control showing 'Items per page: 5' and '0 of 0'. At the bottom of the interface is the 'Fit Selector' section, which includes two horizontal sliders for 'Signal' and 'Backg.' (Background), both currently set to 0. The 'Fit' and 'Accept' buttons are visible to the right of the sliders.

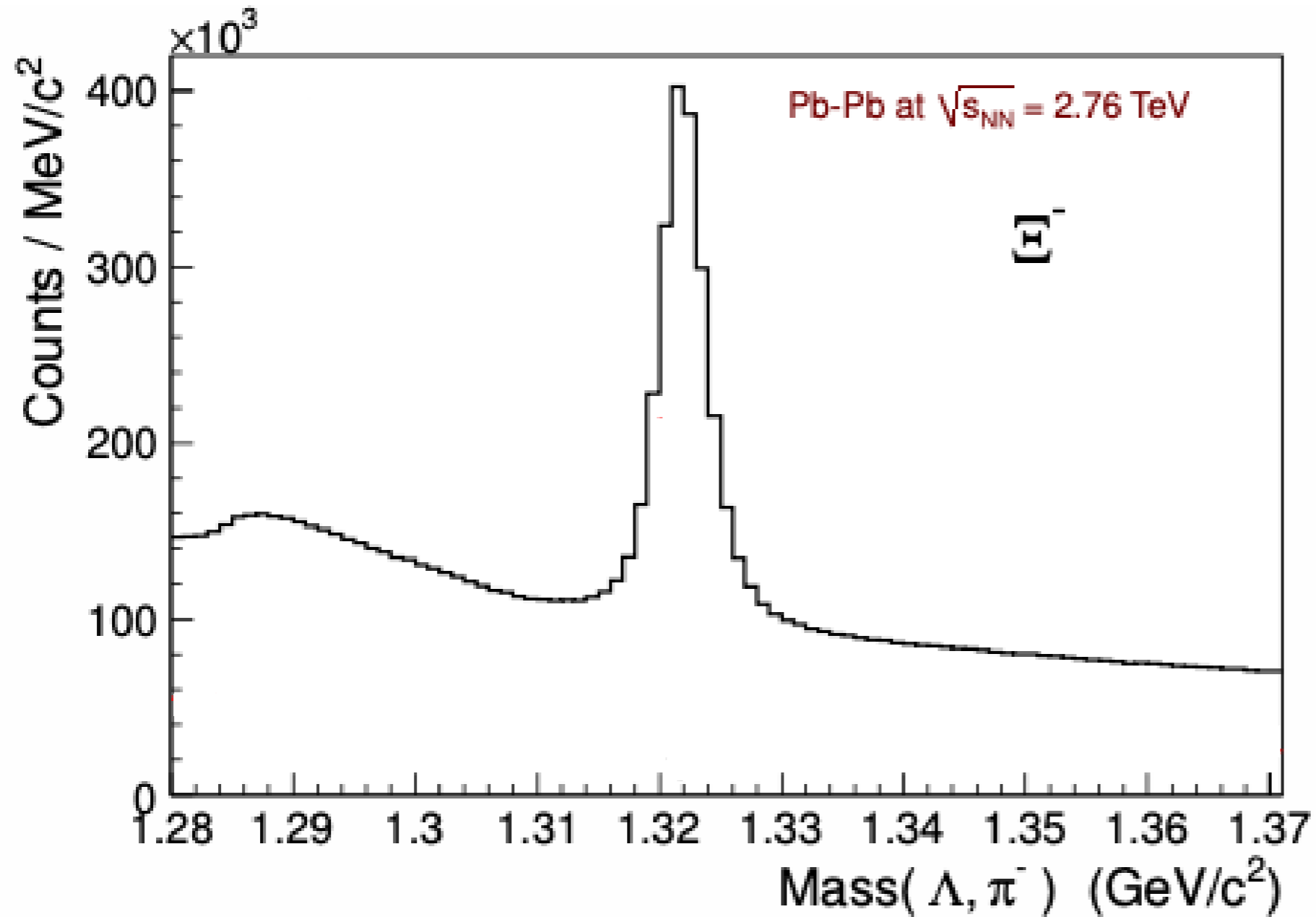
Aprite gli istogrammi corrispondenti (uno per volta)

# Hands-on – Fase 2



Esempio di istogramma per la  $\Lambda$ , in collisioni protone-protone

## Hands-on – Fase 2



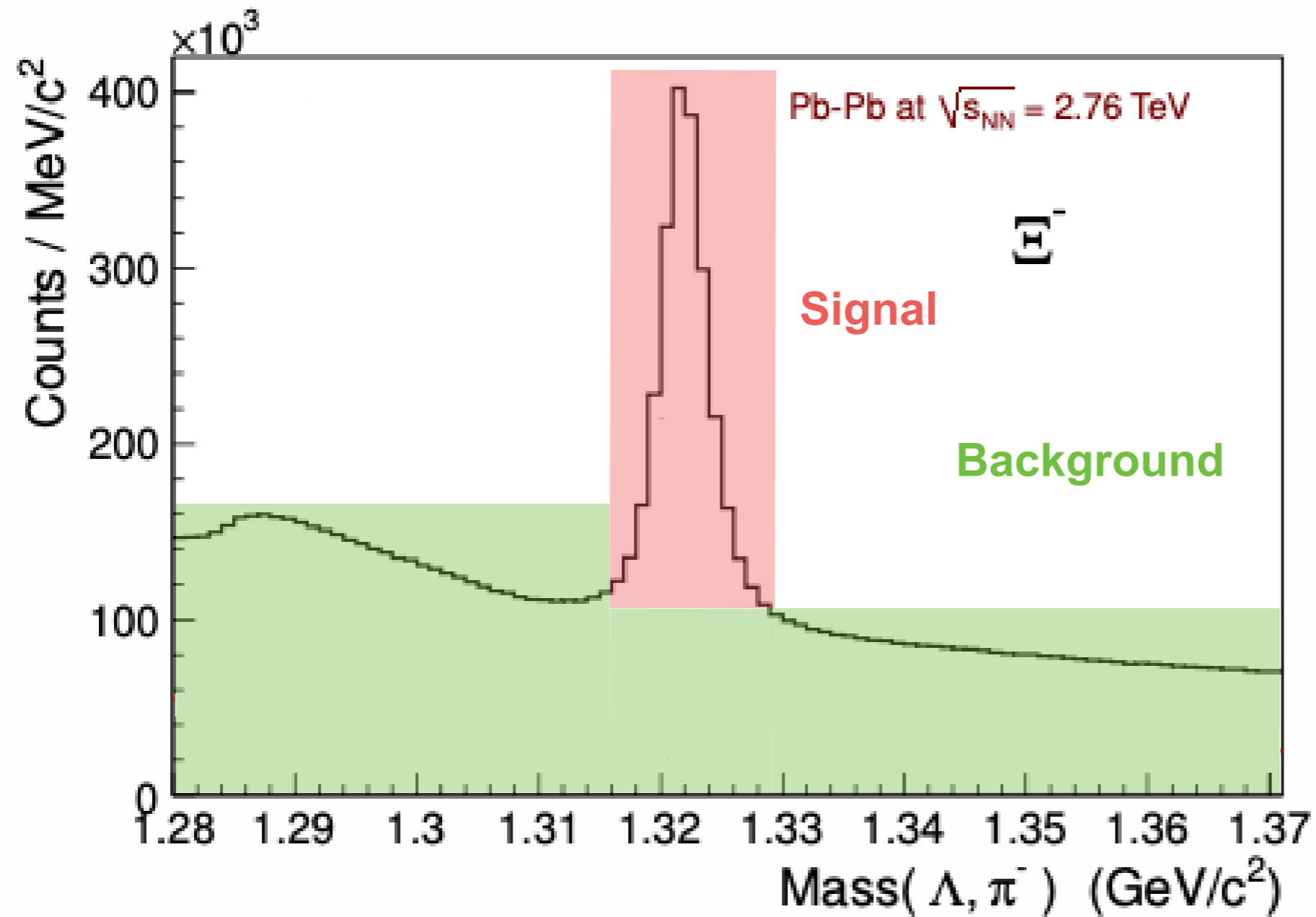
Solo alcune delle entrate dell'istogramma corrispondono a vere particelle, dal cui decadimento abbiamo ricostruito le figlie.

Queste sono contenute nel «**picco di segnale**», vicino al vero valore di massa.

Il resto delle entrate corrisponde a particelle inesistenti, di **fondo**, ottenute combinando tracce positive e negative che non sono prodotte nel decadimento



## Hands-on – Fase 2



Solo alcune delle entrate dell'istogramma corrispondono a vere particelle, dal cui decadimento abbiamo ricostruito le figlie.

Queste sono contenute nel «**picco di segnale**», vicino al vero valore di massa.

Il resto delle entrate corrisponde a particelle inesistenti, di **fondo**, ottenute combinando tracce positive e negative che non sono prodotte nel decadimento

# Hands-on – Fase 2

The screenshot displays the ALICE Masterclass web interface. At the top, the browser address bar shows `alice-web-masterclass.app.cern.ch`. Below the browser tabs, the page header includes the CERN logo and "ALICE Masterclass".

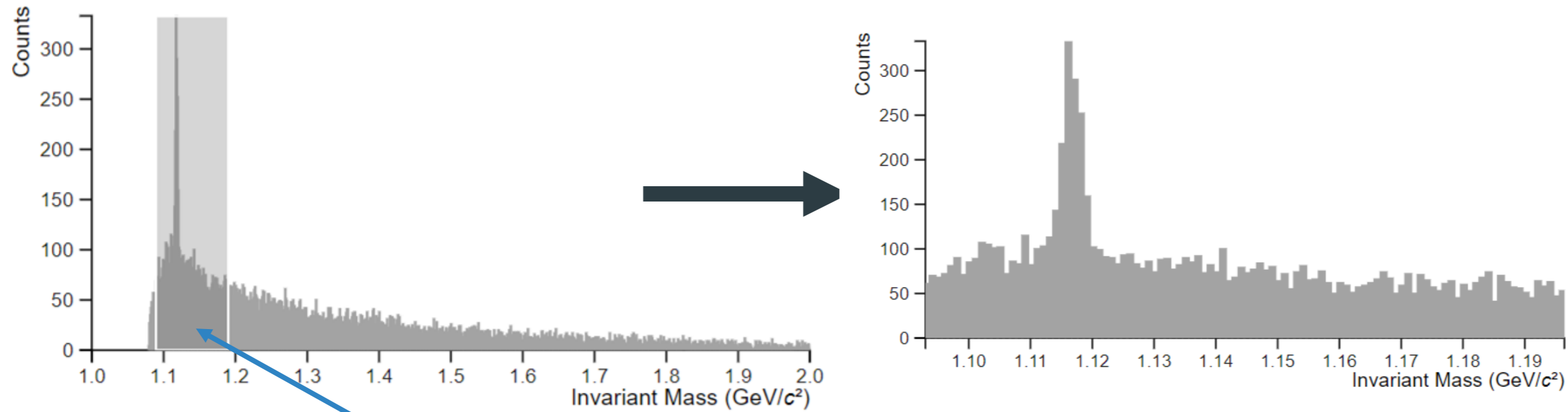
The main content area is divided into several sections:

- Histogram Selector:** Includes dropdown menus for "Select particle type" (set to "Lambda") and "Select collision & centrality" (set to "pp 0%"), with an "Open histogram" button.
- Histogram Display:** A plot showing "Counts" on the y-axis (0 to 50) versus "Invariant Mass ( $\text{GeV}/c^2$ )" on the x-axis (1.0 to 2.0). The histogram shows a sharp peak at approximately 1.1  $\text{GeV}/c^2$  and a broader background.
- Fit Selector:** A tool for defining fit regions. It shows two horizontal lines: a red line for "Signal" and a grey line for "Backg.". The signal region is defined by markers at 1.03 and 1.97, and the background region by markers at 1.02 and 1.91.
- Results:** A table with columns for "Type", "Collision", "Centrality", and "Signal". Below the table, it indicates "Items per page: 5" and "0 of 0".

At the bottom of the interface, there are two buttons: "Fit" (highlighted in red) and "Accept".

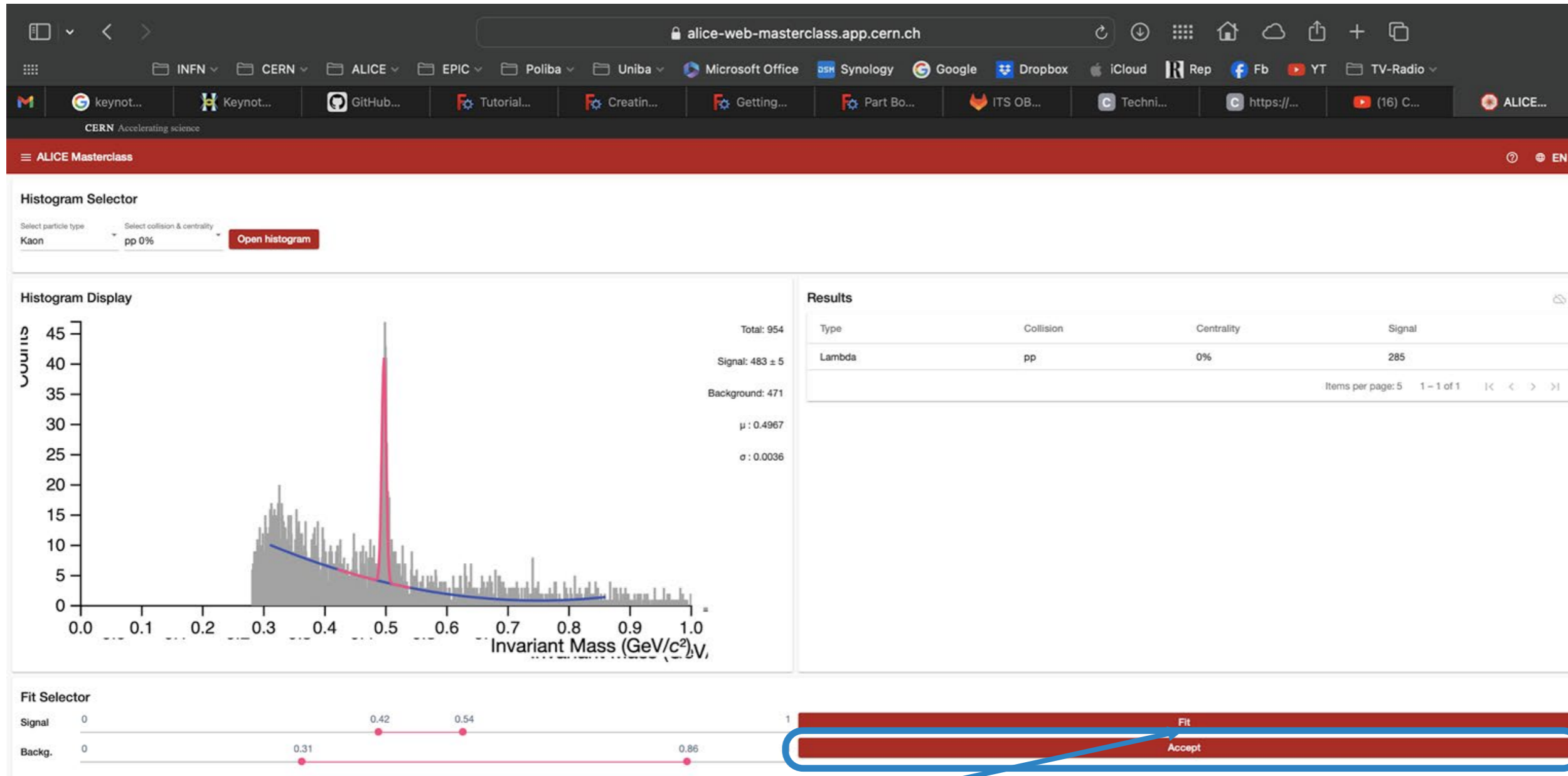
Modificate gli intervalli di massa invariante nei quali vi aspettate di trovare le vere candidate (il picco di segnale) e quelle non vere (il fondo combinatorio) e procedete cliccando su "Fit".

# Hands-on – Fase 2



Potete anche cliccare e trascinare il cursore su una regione dell'asse x per effettuare uno zoom della distribuzione in tale regione

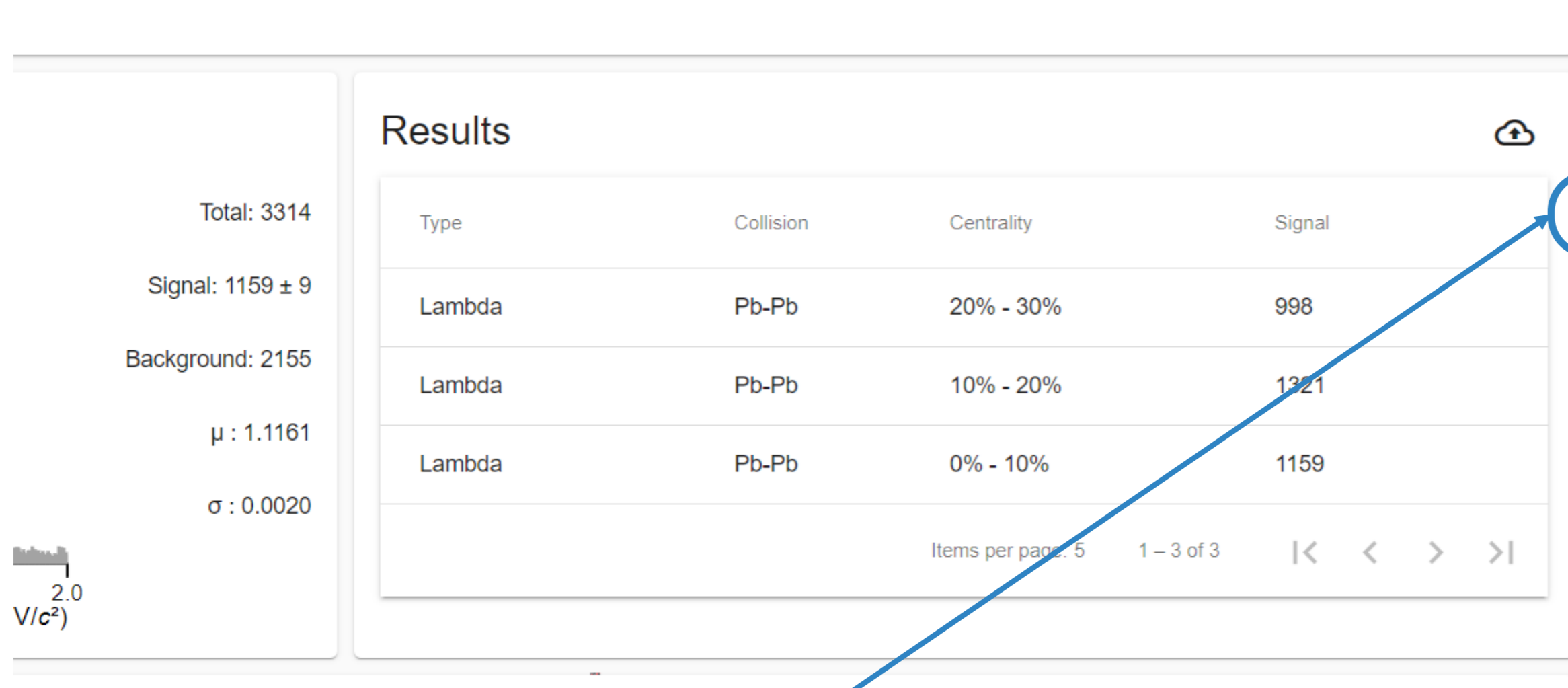
# Hands-on – Fase 2



Se siete contenti del fit (sia il picco, sia il resto della distribuzione, sono ben riprodotti) “accettate” il valore trovato.

In “Results”, otterrete il conteggio delle particelle di segnale ricostruite sul campione di dati analizzato. Poi ripeterete l’operazione per le altre centralità.

# Hands-on – Fase 2



Quando avete completato tutti i fit, cliccate sull'icona evidenziata per condividere i risultati

**In fase di discussione dei risultati condivisi, parleremo di come dare una interpretazione di fisica alle misure da voi effettuate**

# Hands-on – Fase 2

