



Istituto Nazionale di Fisica Nucleare



ALICE

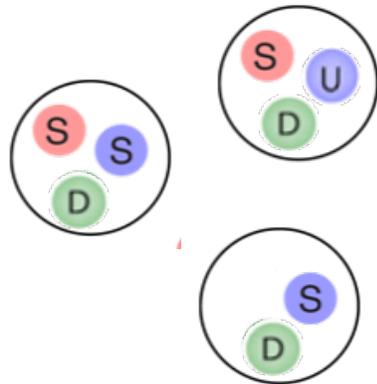
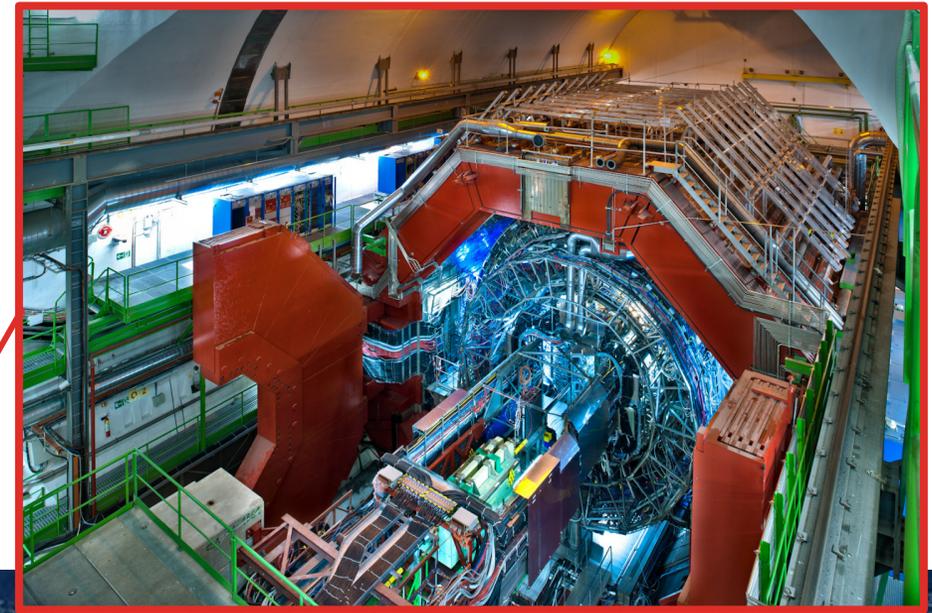
MASTERCLASS
ALICE 2023

HANDS-ON SESSION

Pietro Antonioli, Francesca Ercolessi, Nicolò Jacazio,
Giovanni Malfattore, Sofia Strazzi

Esercizio

L'esercizio proposto consiste nella **ricerca di particelle strane** prodotte da collisioni di protoni e nuclei di piombo in **LHC** e registrate dall'esperimento **ALICE**



Da dove vengono le particelle strane?

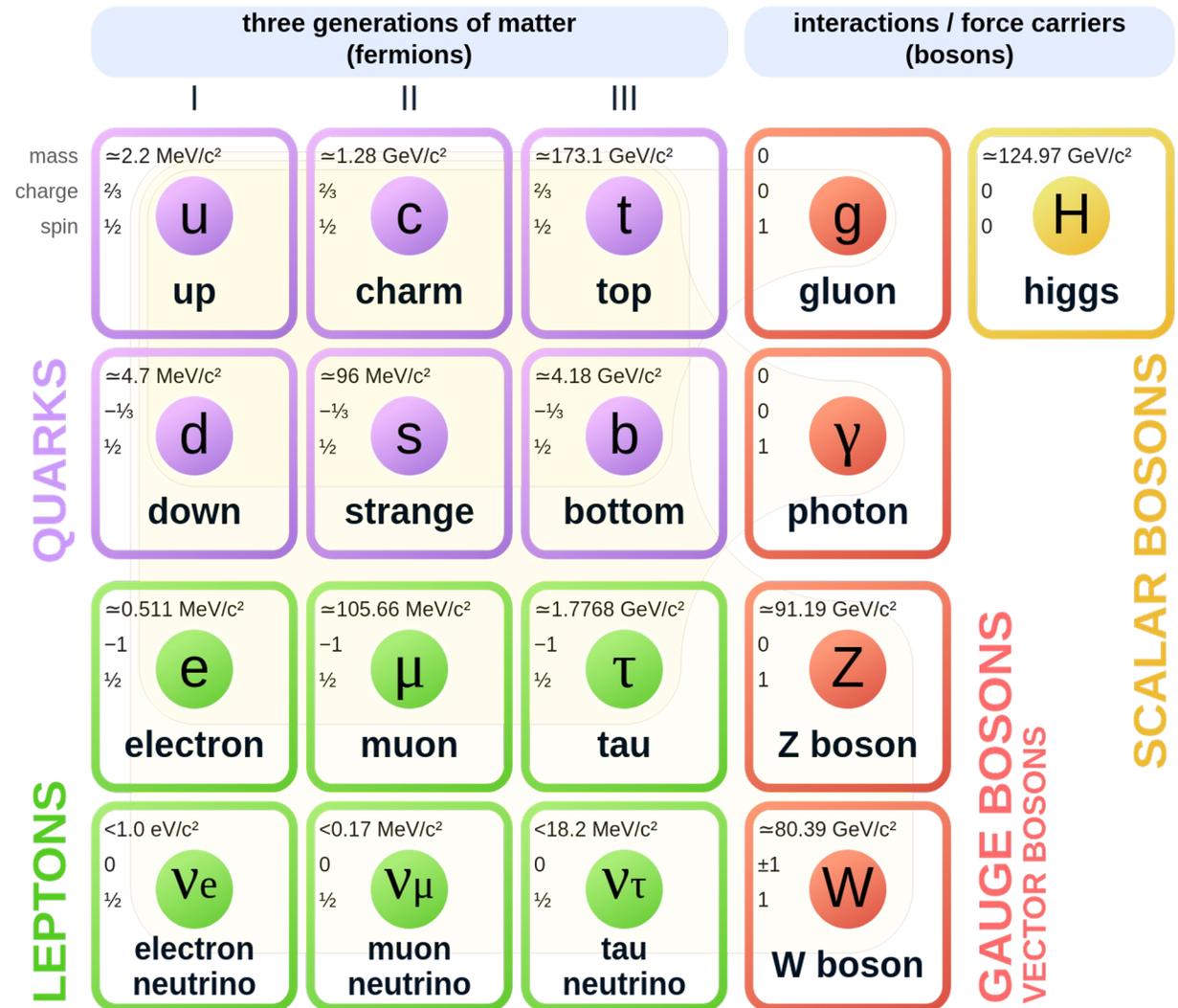
MODELLO STANDARD

Descrive tre delle quattro interazioni fondamentali:

1. Forte
2. Elettromagnetica
3. Debole

e tutte le particelle elementari!

Standard Model of Elementary Particles



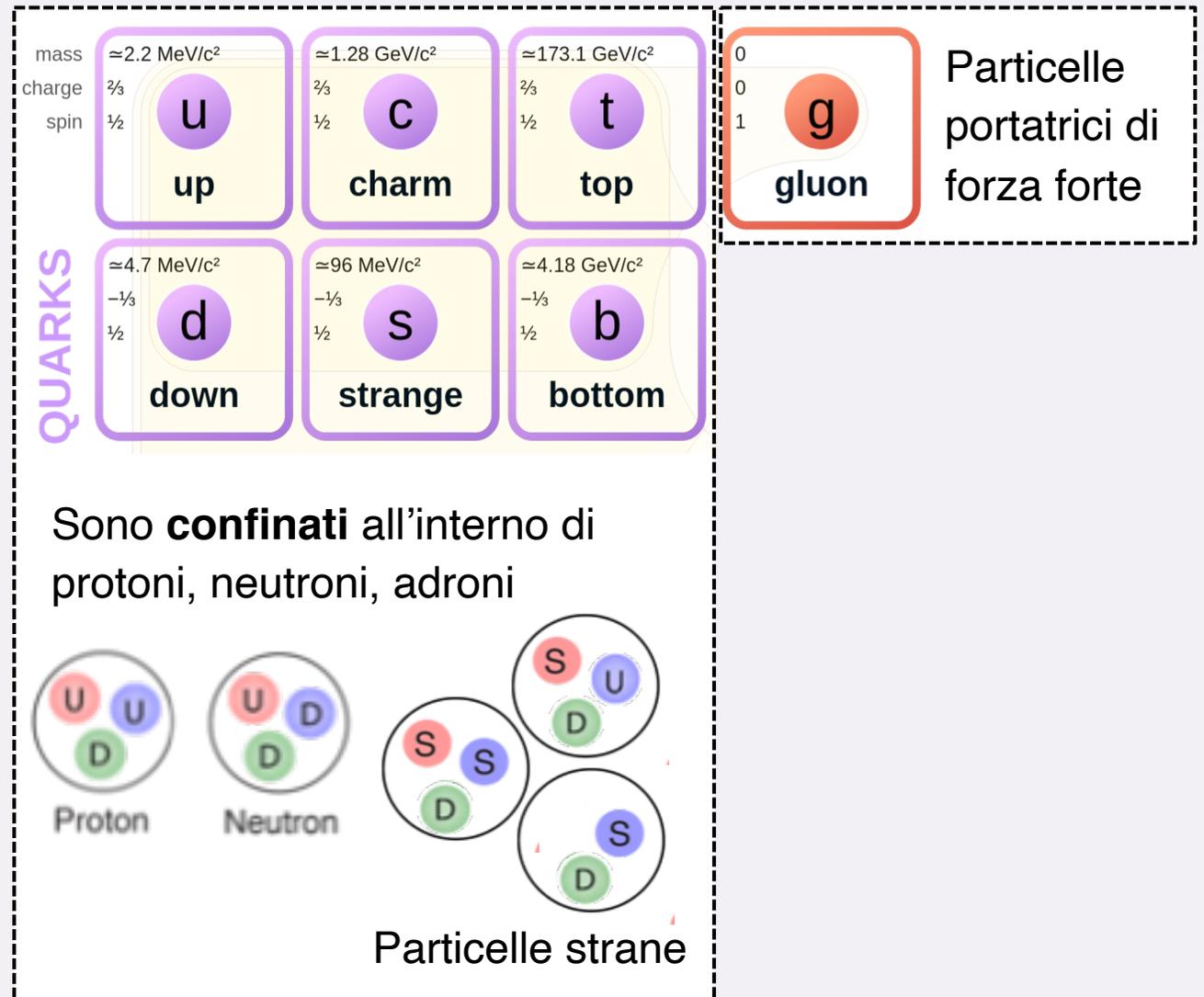
Da dove vengono le particelle strane?

MODELLO STANDARD

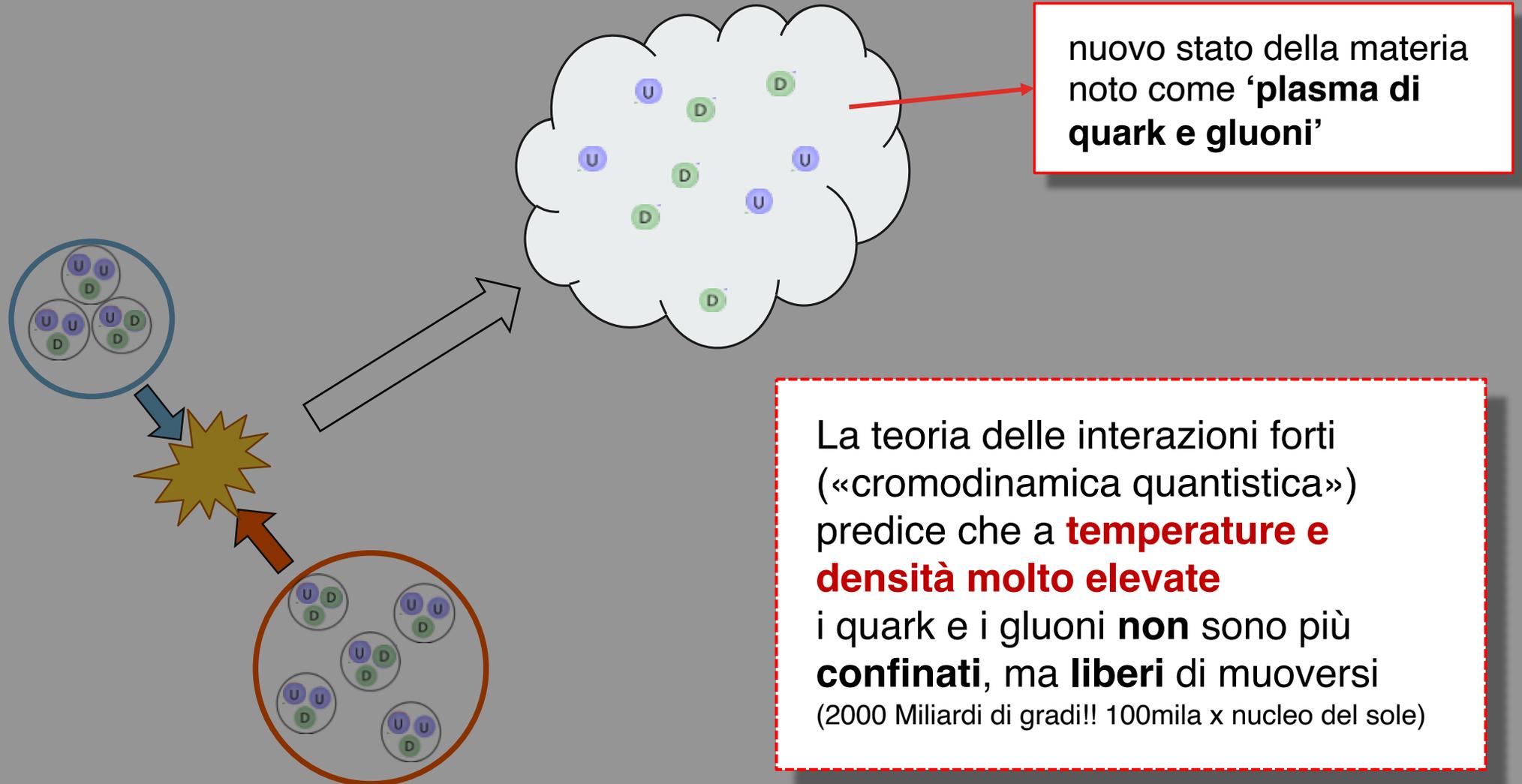
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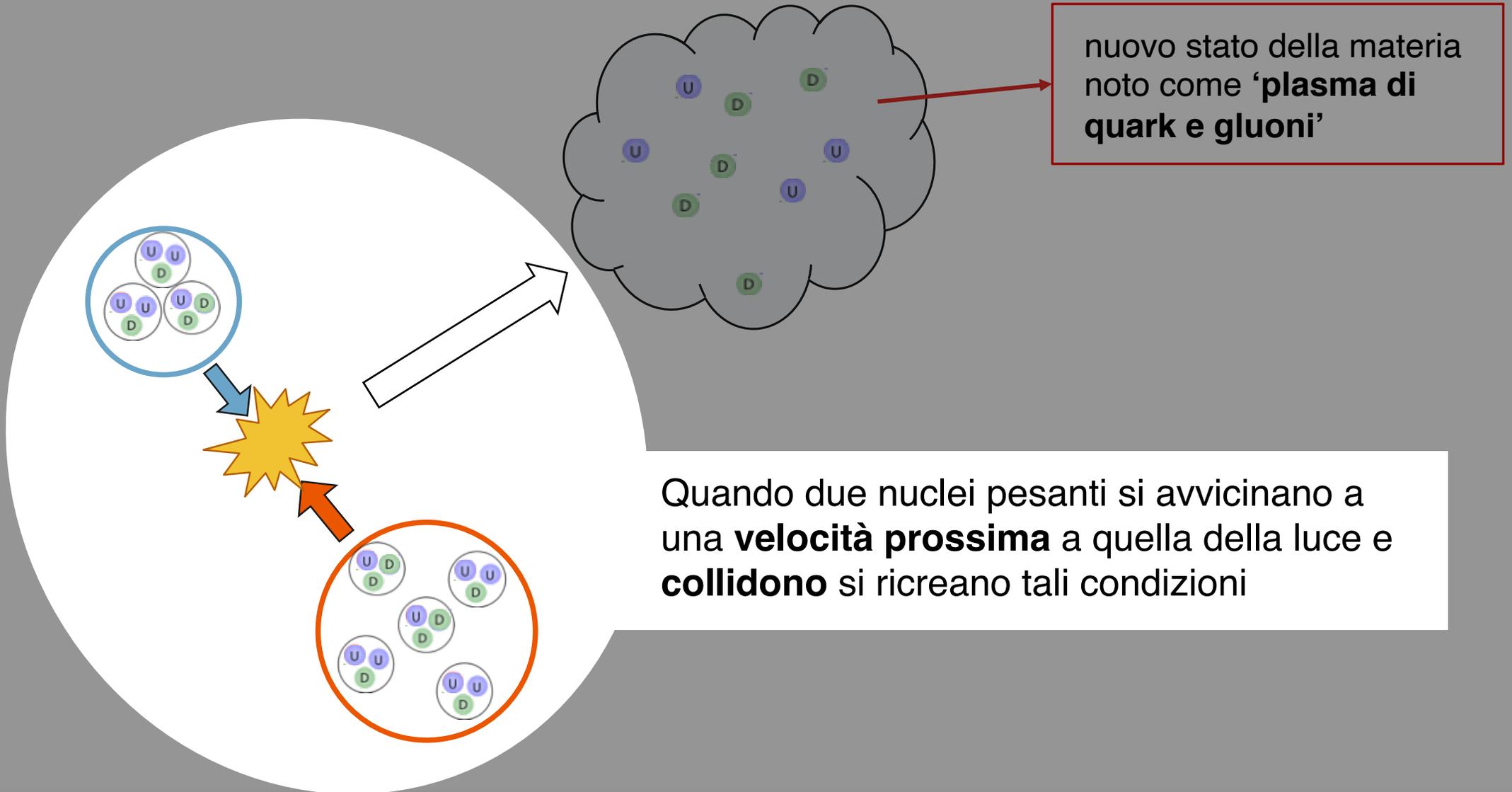
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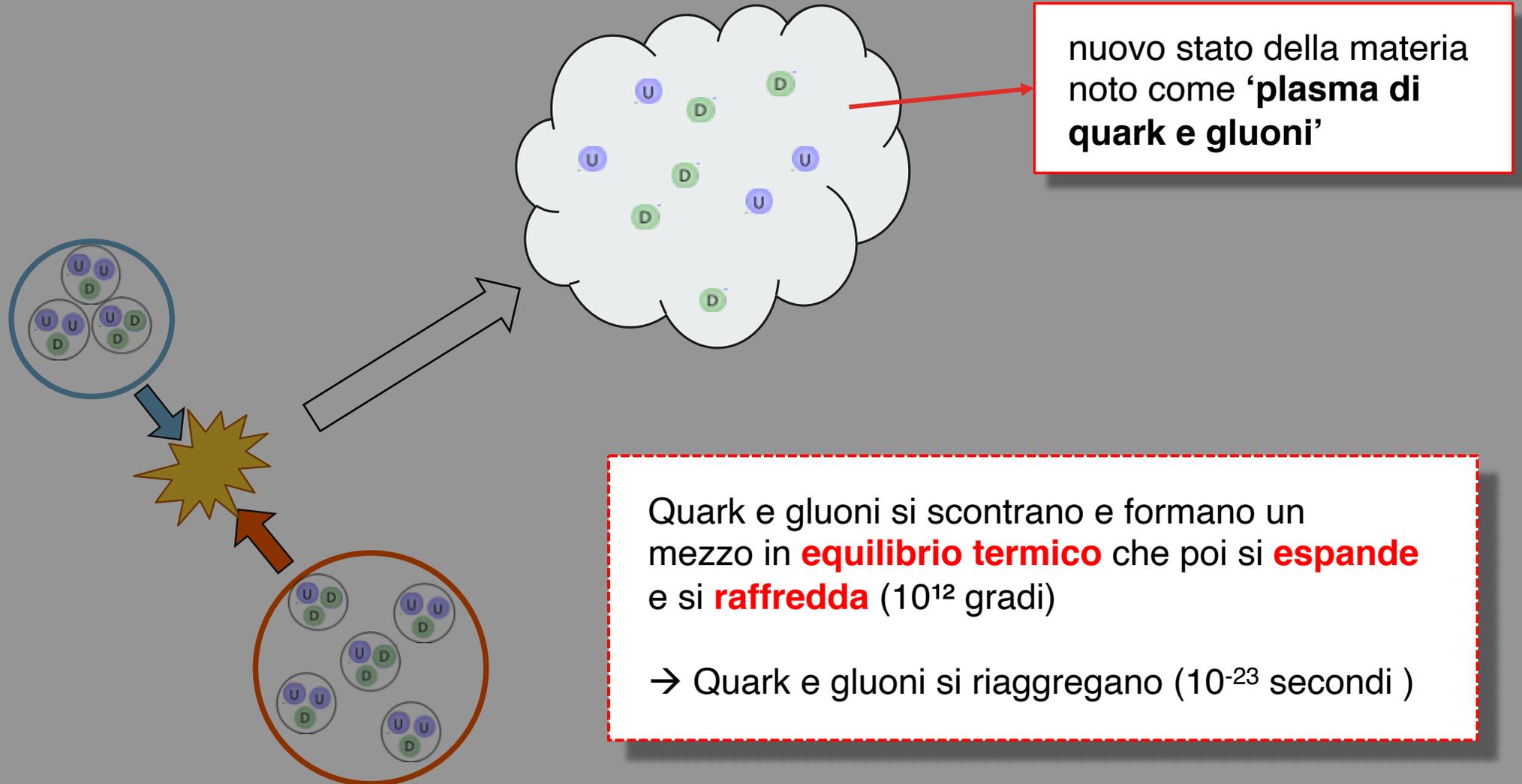
Stranezza e Quark Gluon Plasma



Stranezza e Quark Gluon Plasma



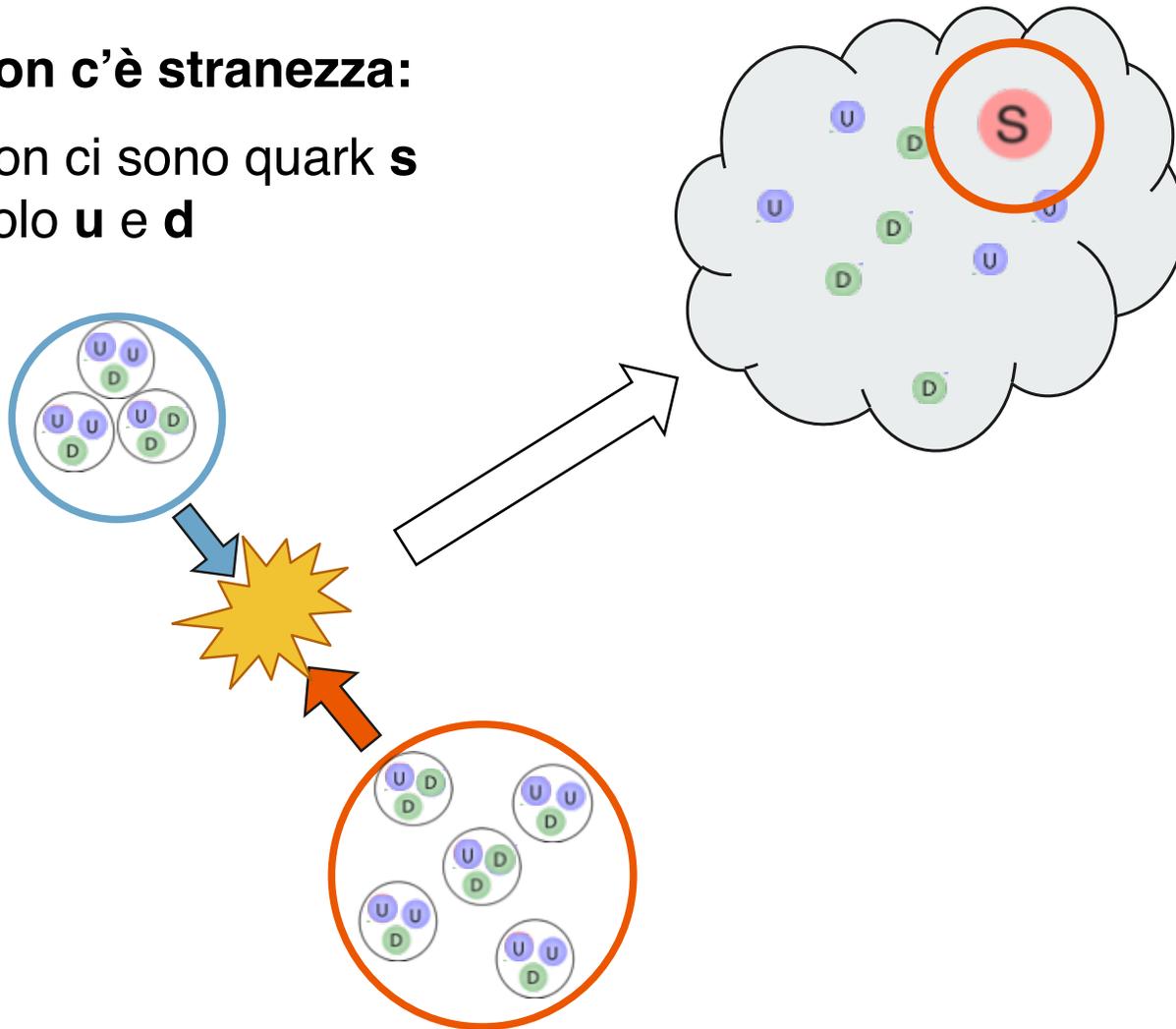
Stranezza e Quark Gluon Plasma



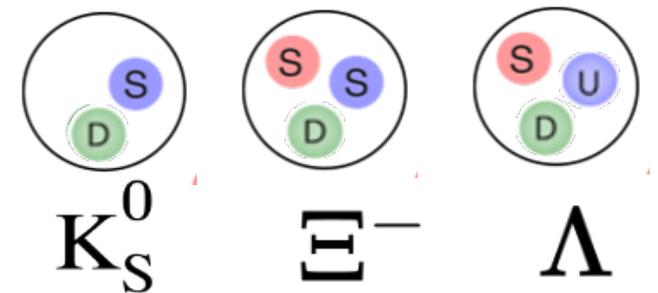
Stranezza e Quark Gluon Plasma

Non c'è stranezza:

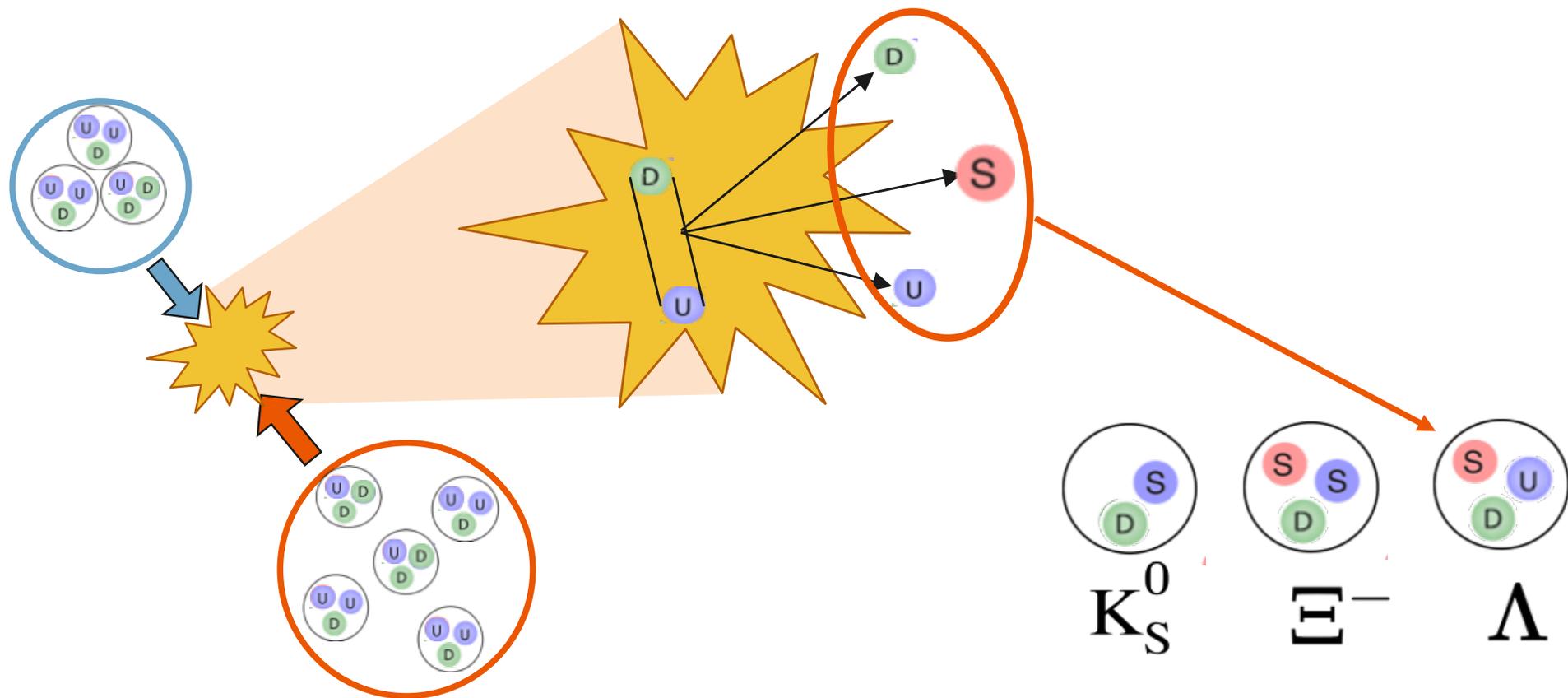
Non ci sono quark **s**
Solo **u** e **d**



s creati dall' E_k dei nuclei collidenti



Stranezza e Quark Gluon Plasma

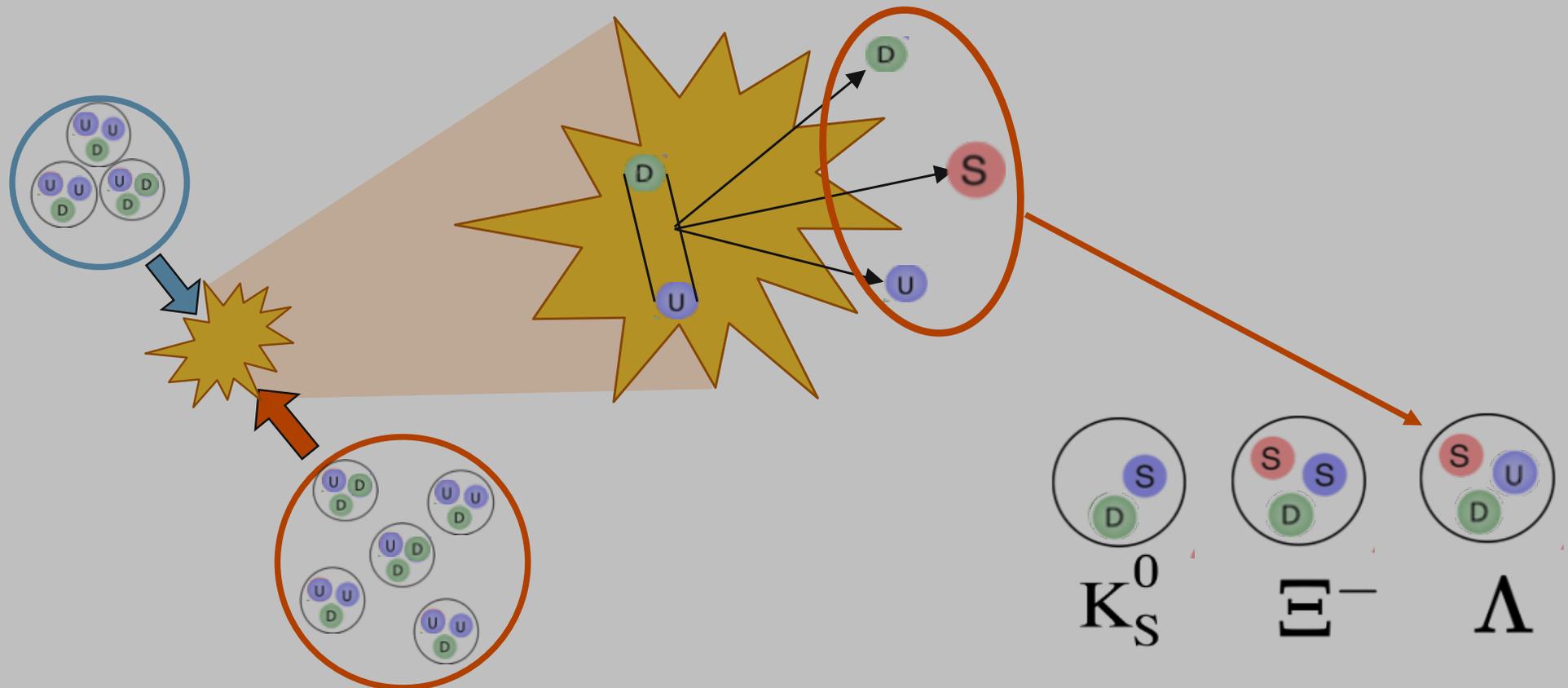


Stranezza e Quark Gluon Plasma

Prova sperimentale dell'esistenza
del Quark Gluon Plasma (QGP)



AUMENTO DI STRANEZZA

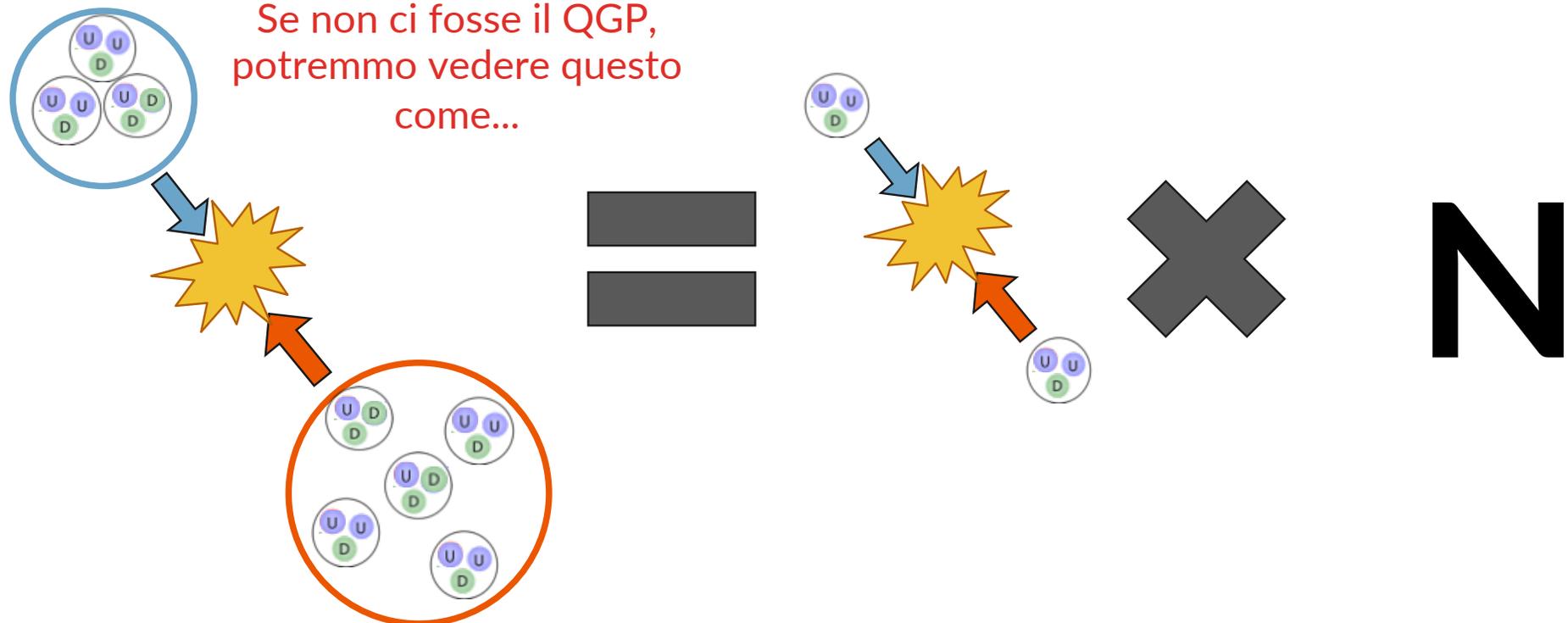


Stranezza e Quark Gluon Plasma

Prova sperimentale dell'esistenza
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AUMENTO DI STRANEZZA

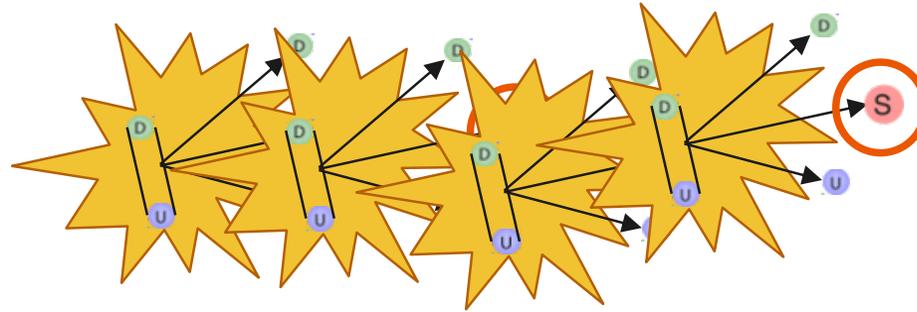


Stranezza e Quark Gluon Plasma

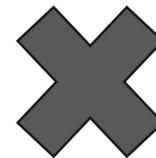
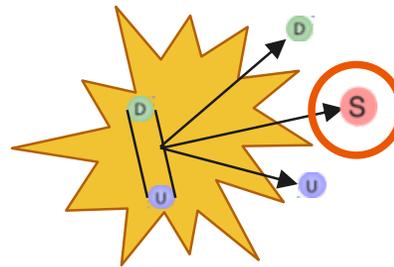
Prova sperimentale dell'esistenza
del Quark Gluon Plasma (QGP)

—————> **AUMENTO DI STRANEZZA**

Pb-Pb



p-p



N

Stranezza e Quark Gluon Plasma

Prova sperimentale dell'esistenza
del Quark Gluon Plasma (QGP)



AUMENTO DI STRANEZZA

$$\frac{\text{Pb-Pb}}{\text{p-p} \times N} > 1$$

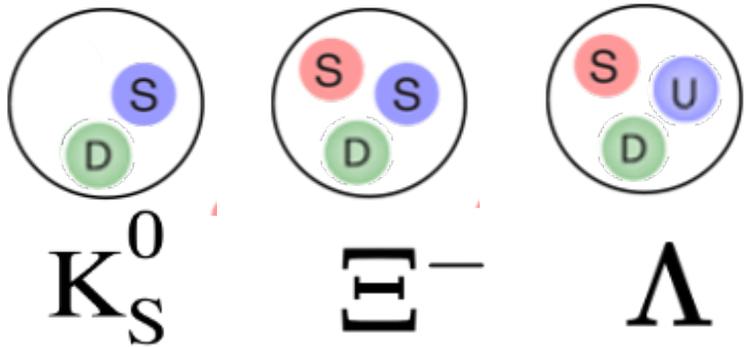
C'è aumento di stranezza!
Si è formato il QGP

$$\frac{\text{Pb-Pb}}{\text{p-p} \times N} = 1$$

Non c'è un effetto collettivo

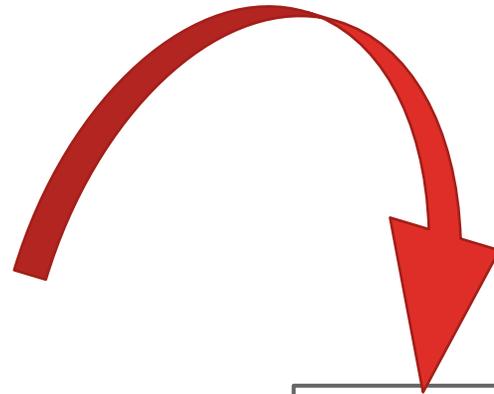
Come le riveliamo?

Come misuriamo le particelle strane

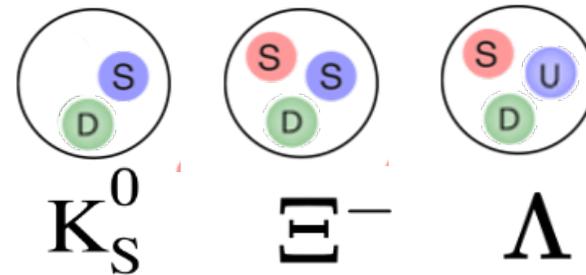
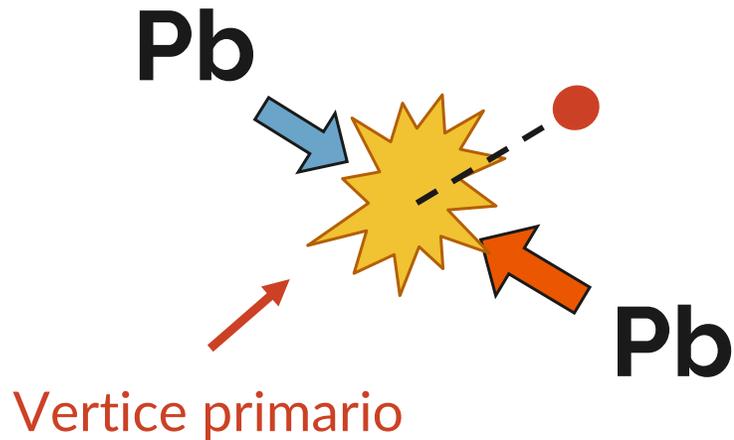


Come rivelare le particelle strane

Le particelle strane **percorrono alcuni centimetri** dal punto di interazione per poi decadere



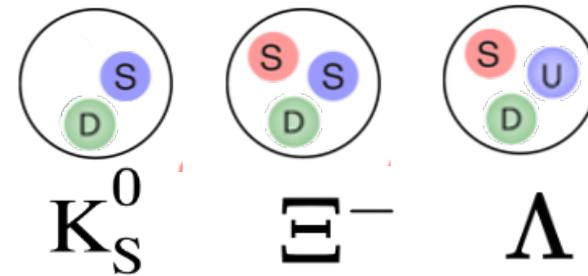
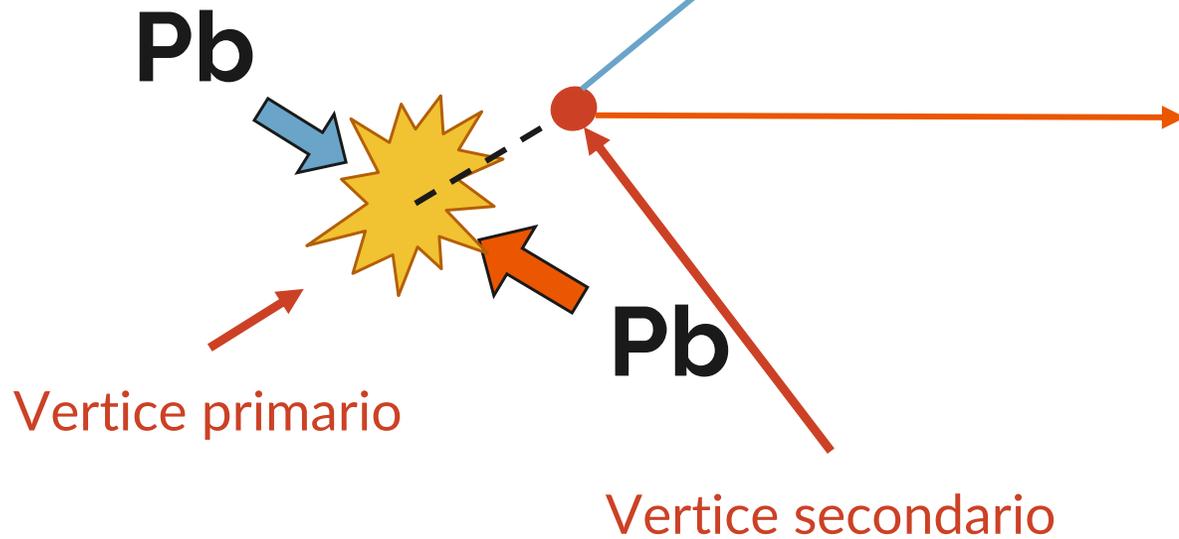
Identificazione dei prodotti di decadimento



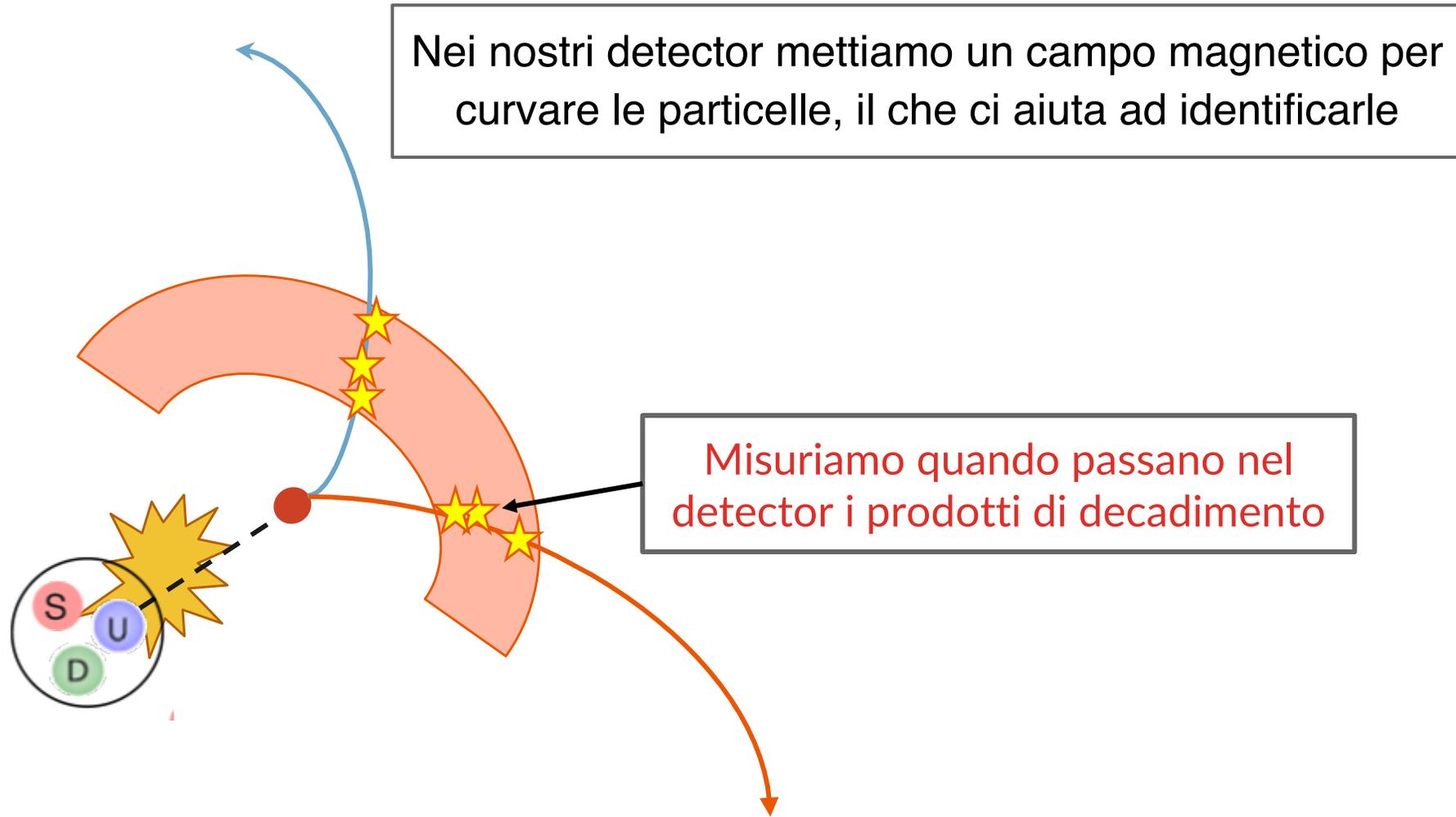
Come rivelare le particelle strane

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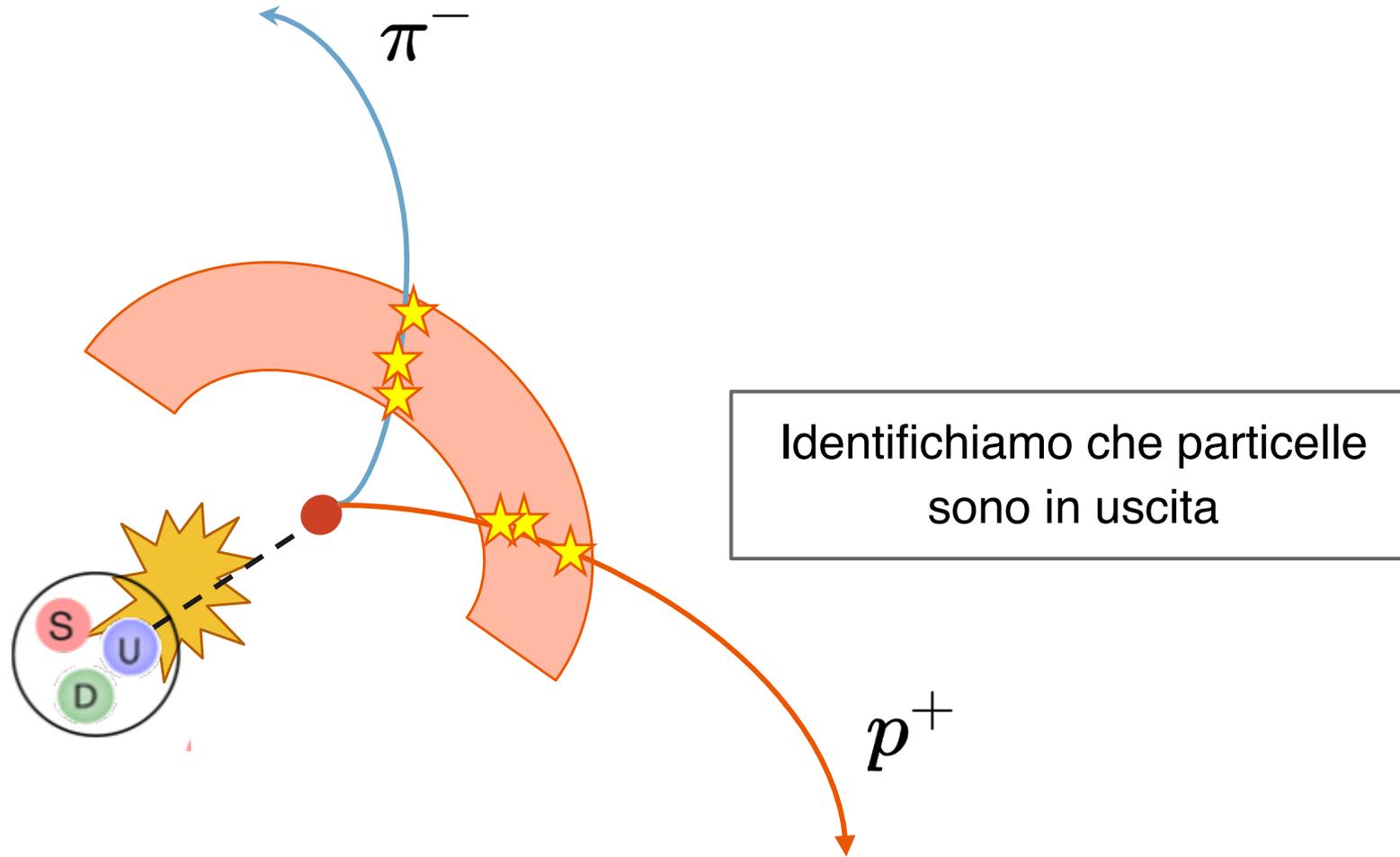
I prodotti del decadimento variano in base alla particella



Come rivelare le particelle strane



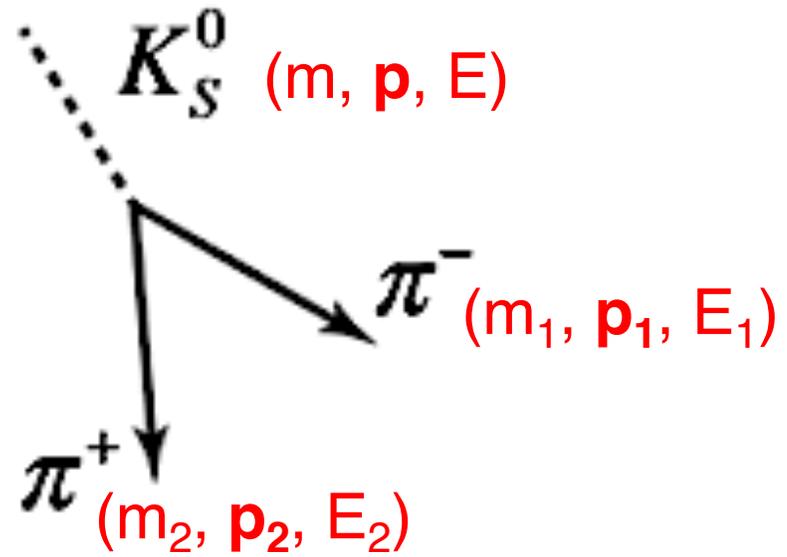
Come rivelare le particelle strane



**Il metodo della
massa invariante**

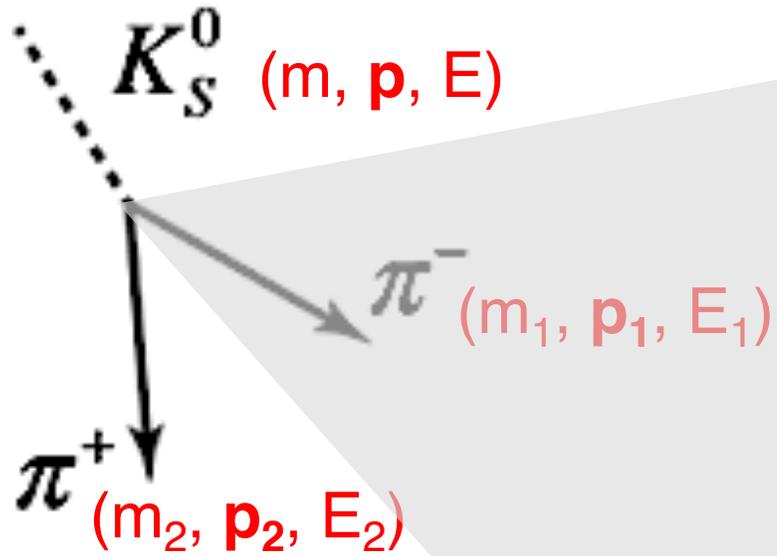
**Esercizio
sull'aumento
di stranezza**

Il metodo della massa invariante



$$K_S^0 \rightarrow \pi^+ + \pi^-$$

Il metodo della massa invariante



$$K_S^0 \rightarrow \pi^+ + \pi^-$$

$$E = E_1 + E_2$$

Conservazione dell'**energia**

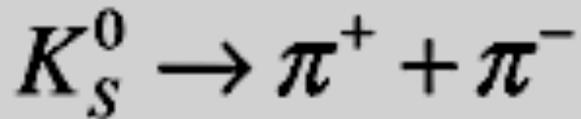
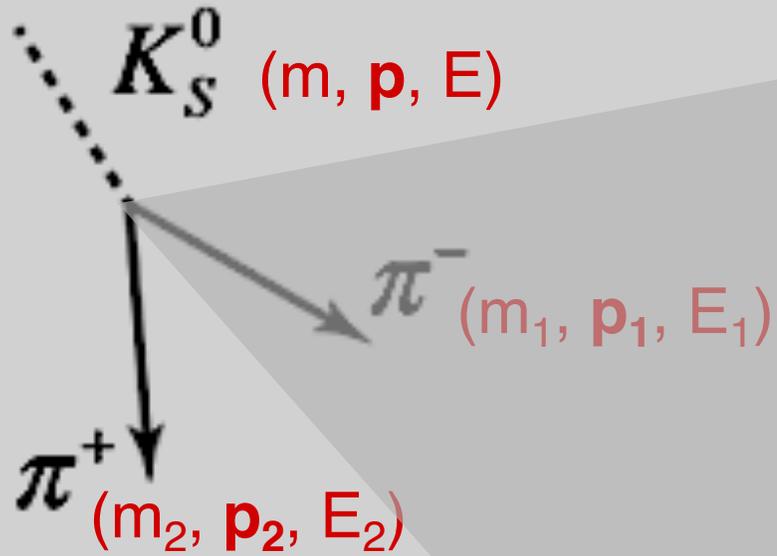
$$\mathbf{p} = \mathbf{p}_1 + \mathbf{p}_2$$

Conservazione della **quantità di moto**

Dalla relatività (supponendo $c=1$):

$$E^2 = \mathbf{p}^2 + m^2$$

Il metodo della massa invariante



$$E = E_1 + E_2$$

Conservazione dell'**energia**

$$\mathbf{p} = \mathbf{p}_1 + \mathbf{p}_2$$

Conservazione dell'

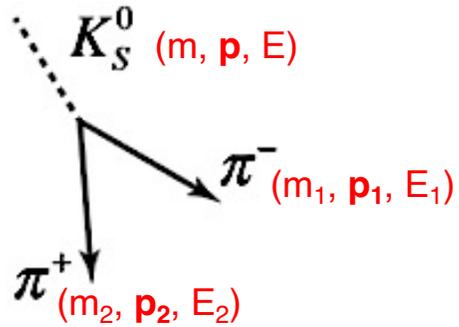
Dalla relatività (supponendo

$$E^2 = \mathbf{p}^2 + m^2$$

$$p = |\mathbf{p}|$$

modulo del vettore \mathbf{p} , cioè la lunghezza della freccia che rappresenta la quantità di moto

Il metodo della massa invariante



$$\begin{aligned} m^2 &= E^2 - p^2 \\ &= (E_1 + E_2)^2 - (\mathbf{p}_1 + \mathbf{p}_2)^2 \\ &= E_1^2 + E_2^2 + 2E_1E_2 - \mathbf{p}_1 \cdot \mathbf{p}_1 - \mathbf{p}_2 \cdot \mathbf{p}_2 - 2\mathbf{p}_1 \cdot \mathbf{p}_2 \\ &= m_1^2 + m_2^2 + 2E_1E_2 - 2\mathbf{p}_1 \cdot \mathbf{p}_2 \end{aligned}$$

Prodotti scalari

$$E = E_1 + E_2$$

Conservazione dell'**energia**

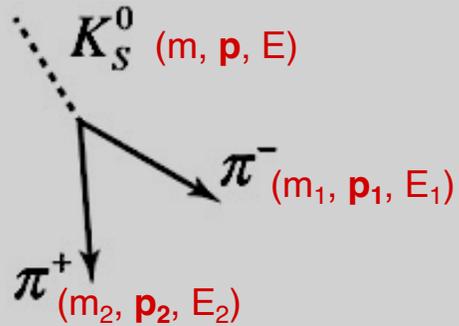
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Conservazione della **quantità di moto**

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$$E = E_1 + E_2$$

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$$\mathbf{p} = \mathbf{p}_1 + \mathbf{p}_2$$

Conservazione della quantità di moto

Dalla relatività (supponendo $c=1$):

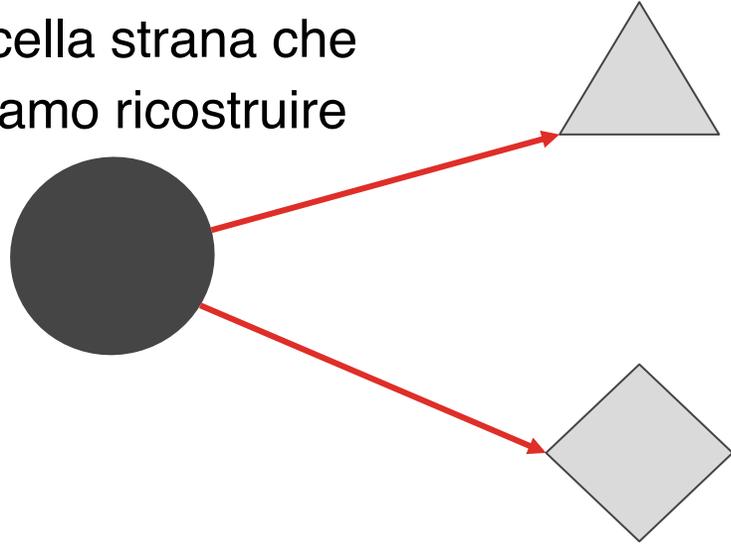
$$E^2 = p^2 + m^2$$

Le conosciamo grazie ai rivelatori che identificano le particelle

Le ricaviamo misurando il raggio di curvatura nel campo magnetico

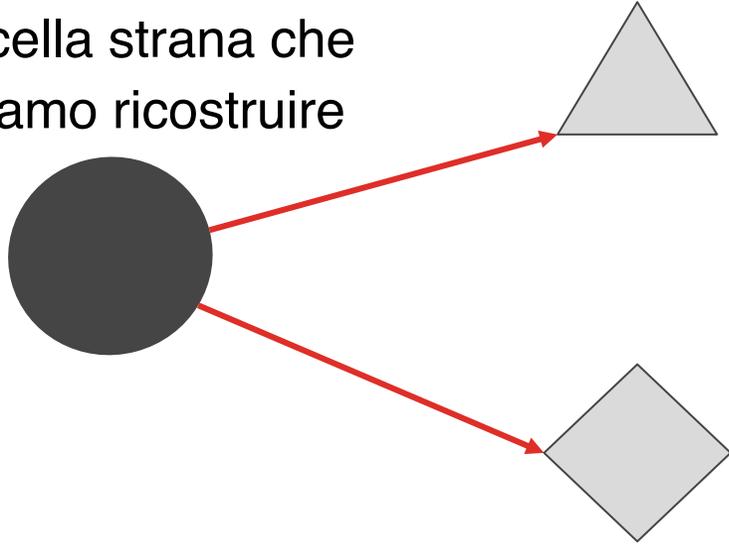
Il metodo della massa invariante

Particella strana che
vogliamo ricostruire

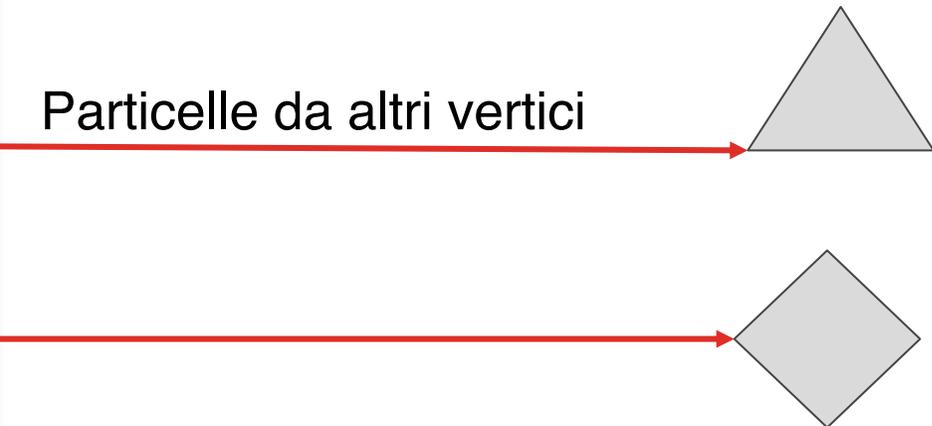


Il metodo della massa invariante

Particella strana che
vogliamo ricostruire

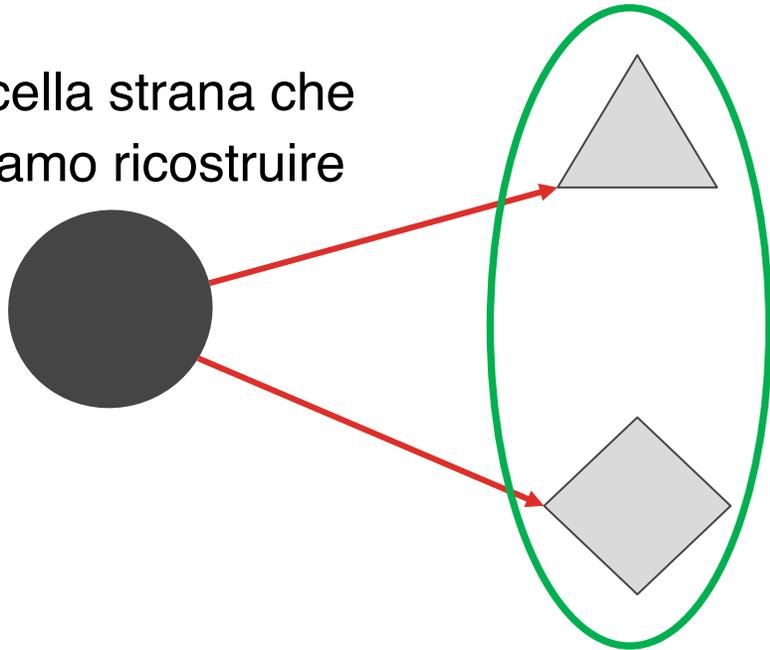


Particelle da altri vertici



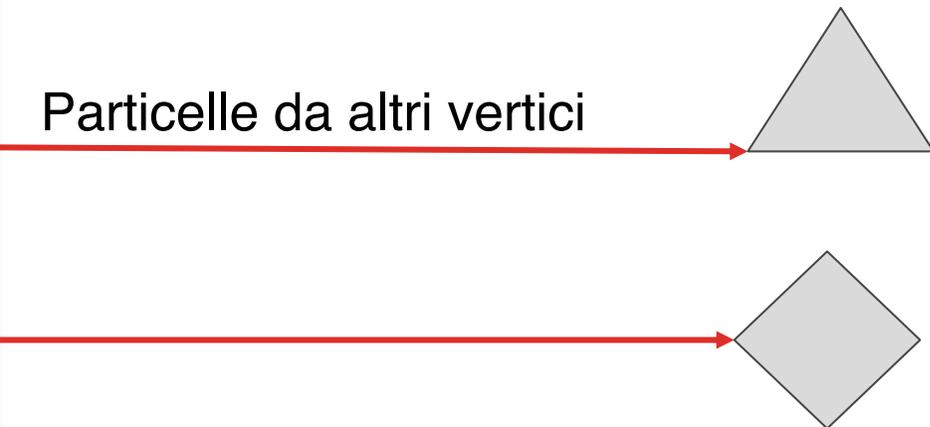
Il metodo della massa invariante

Particella strana che
vogliamo ricostruire



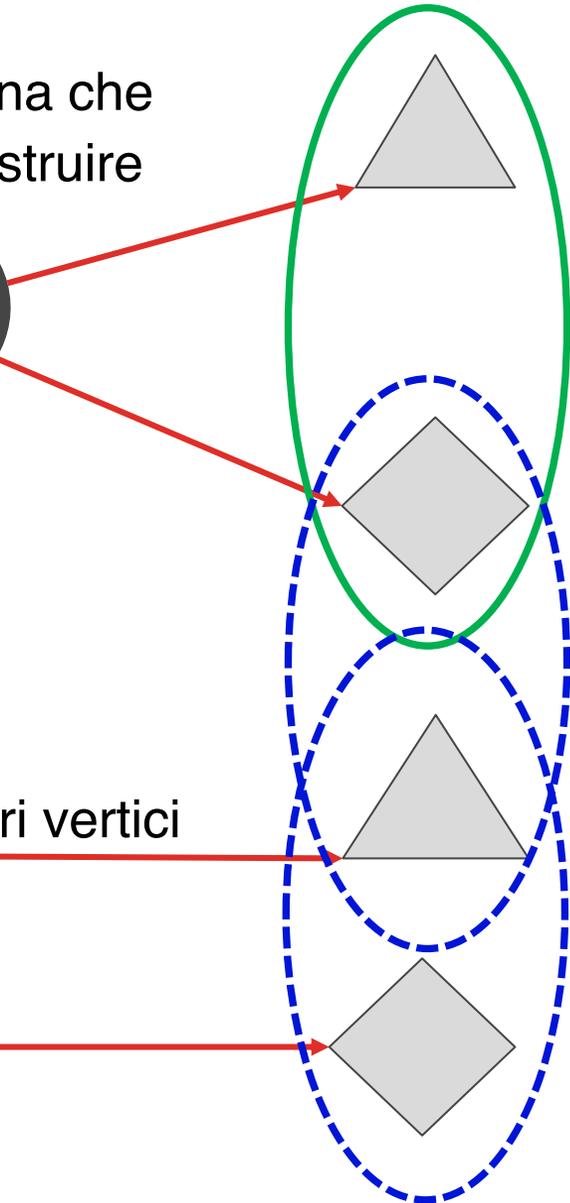
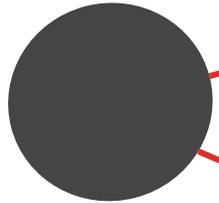
Segnale: Se le accoppio
“bene” mi dicono che vengono
dalla particella corretta

Particelle da altri vertici



Il metodo della massa invariante

Particella strana che vogliamo ricostruire

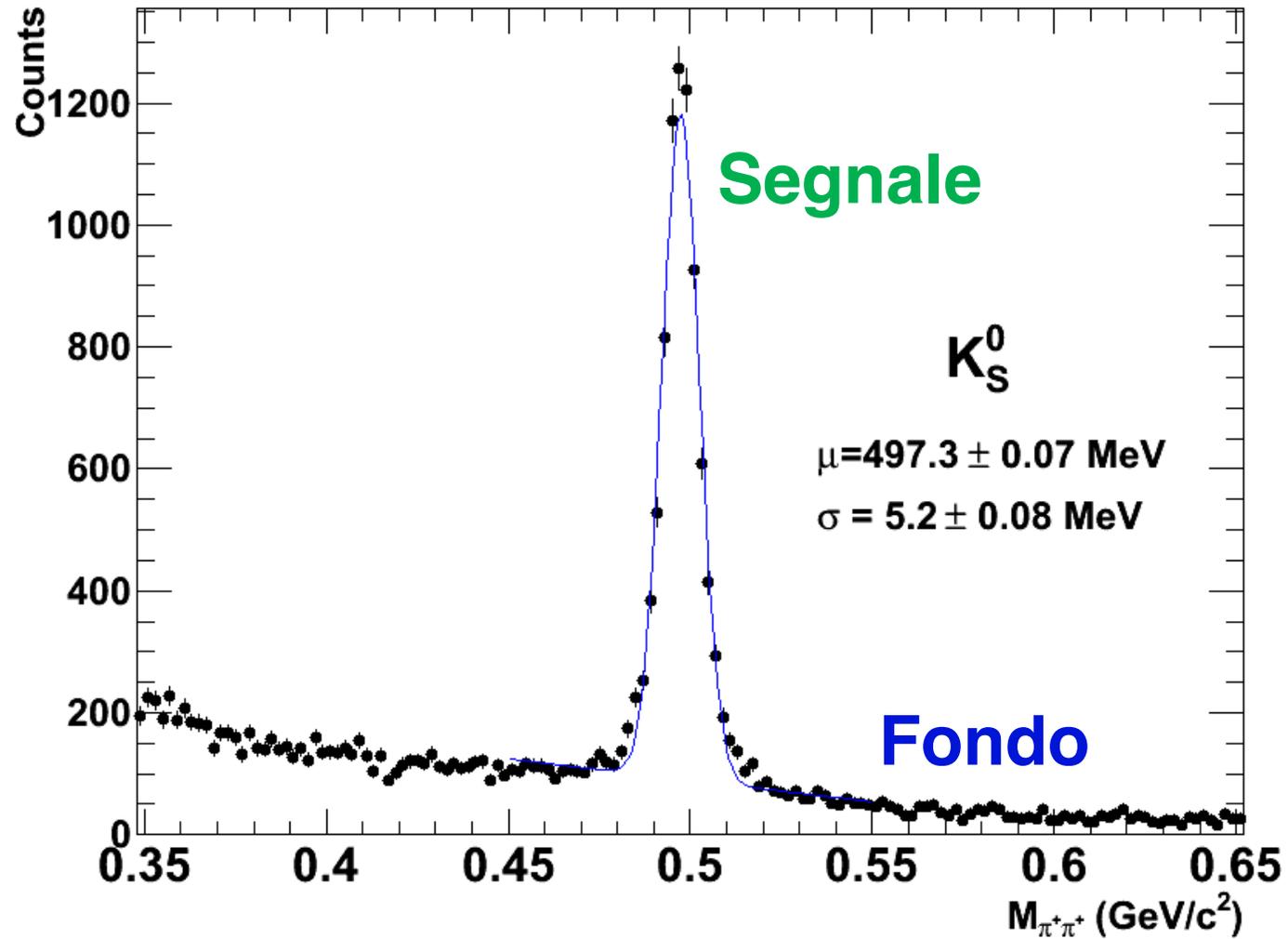


Particelle da altri vertici

Segnale: Se le accoppio "bene" mi dicono che vengono dalla particella corretta

Fondo: Se le accoppio male mi daranno un risultato casuale

Il metodo della massa invariante



**Istruzioni
pratiche**

**Esercizio
sull'aumento di
stranezza**



ALICE

Welcome to the ALICE Masterclass!

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 *

5

Session Password *

Bologna2023



Proceed

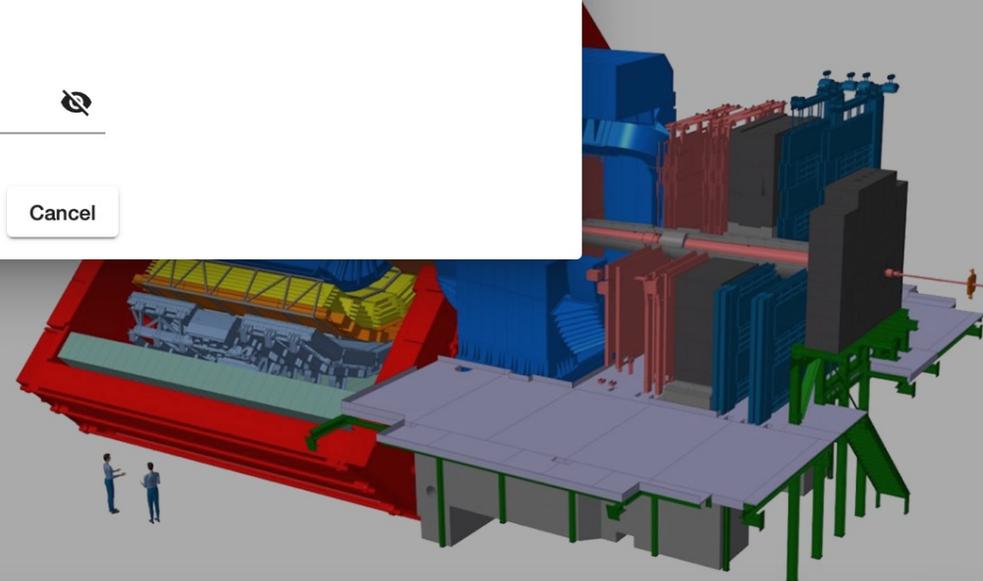
Cancel

The ALICE Collaboration has built a dedicated nucleus-nucleus collisions at LHC energies matter at the highest energy densities reach extreme phase of matter - called the quark-gluon plasma.

Our universe is thought to have been in a similar state a few microseconds second after the Big Bang. The properties of this state are studied through Heavy Ion Dynamics, the understanding of confinement.

For this purpose, we are carrying out a comparison of heavy ions and photons produced in the collisions of protons and heavy ions. Heavy ions and photons produced in the collisions of proton-nucleus collisions both as a comparison with nucleus-nucleus collisions and in their own right.

If you wish, you can download and use a desktop version of the Masterclass:





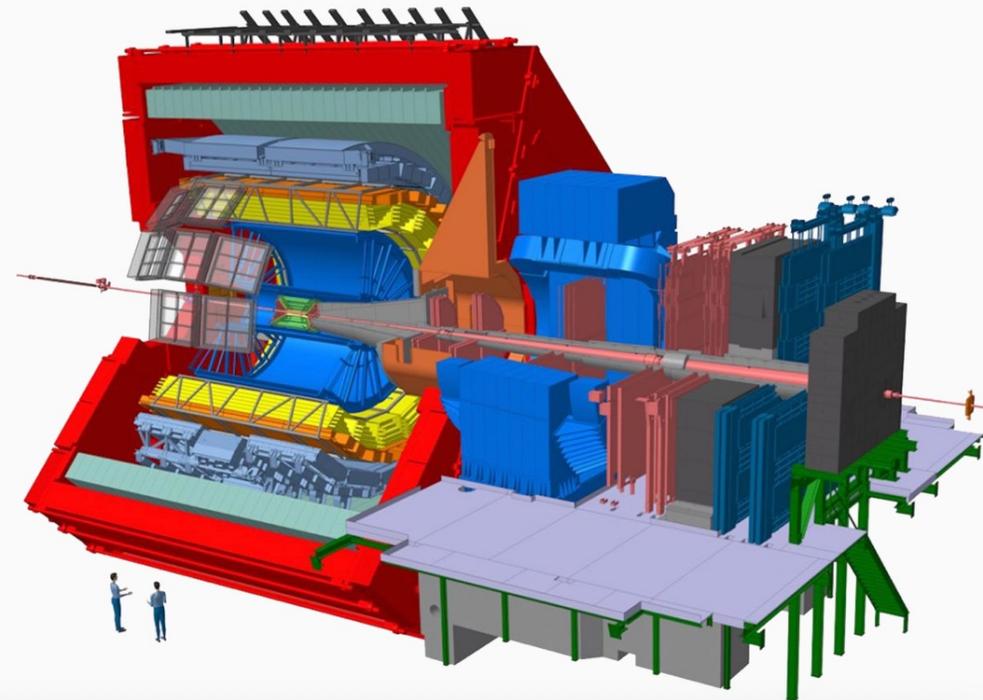
Welcome to the ALICE Masterclass!

The ALICE Collaboration has built a dedicated detector to exploit the unique physics potential of nucleus-nucleus collisions at LHC energies. Our aim is to study the physics of strongly interacting matter at the highest energy densities reached so far in the laboratory. In such condition, an extreme phase of matter - called the quark-gluon plasma - is formed.

Our universe is thought to have been in such a primordial state for the first few millionths of a second after the Big Bang. The properties of such a phase are key issues for Quantum Chromo Dynamics, the understanding of confinement-deconfinement and chiral phase transitions.

For this purpose, we are carrying out a comprehensive study of the hadrons, electrons, muons and photons produced in the collisions of heavy nuclei. ALICE is also studying proton-proton and proton-nucleus collisions both as a comparison with nucleus-nucleus collisions and in their own right.

If you wish, you can download and use a desktop version of the Masterclass:



ESERCIZIO 1: Identificare le particelle strane

Menu

Home

Strangeness

Visual Analysis

Large Scale Analysis

Big science

ass

EN

Welcome to the ALICE Masterclass!

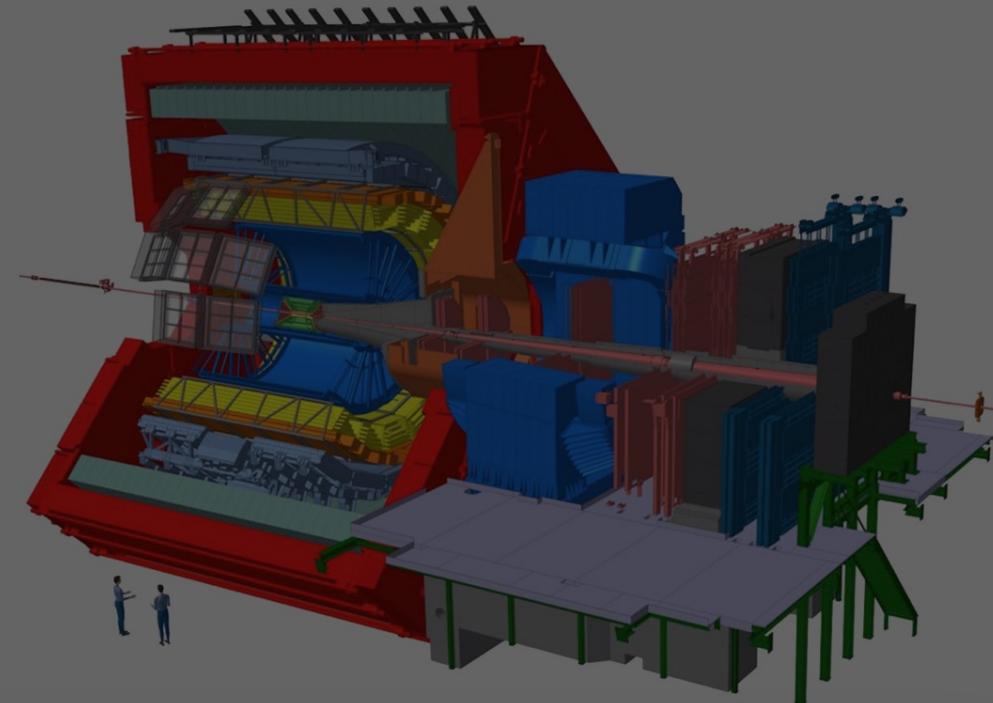
Il primo esercizio permette di visualizzare i singoli eventi e ricercare tra le tracce candidati per V0 e cascate

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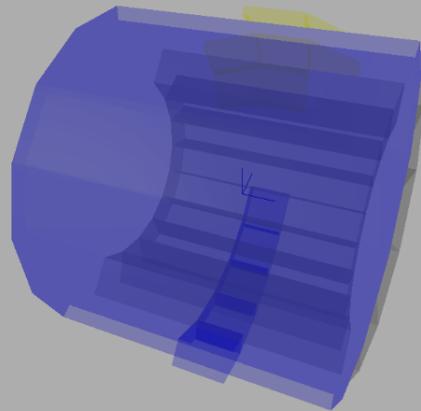
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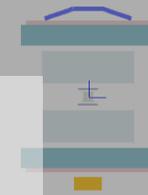


Event 0

3D View



View 1



View 2



Selezionate il set di dati con il numero della vostra coppia

Please select dataset:

- Demo
- Dataset 0
- Dataset 1
- Dataset 2
- Dataset 3

Calculator

Charge	p_x (GeV/c)	p_y (GeV/c)	p_z (GeV/c)	mass (GeV/c ²)
(+)				
(-)				
(b)				
Total				

Select particle type

Add

	mass (GeV/c ²)
e^-, e^+	0.0005
π^-, π^+	0.1396
K_S^0	0.4976
p, \bar{p}	0.9383

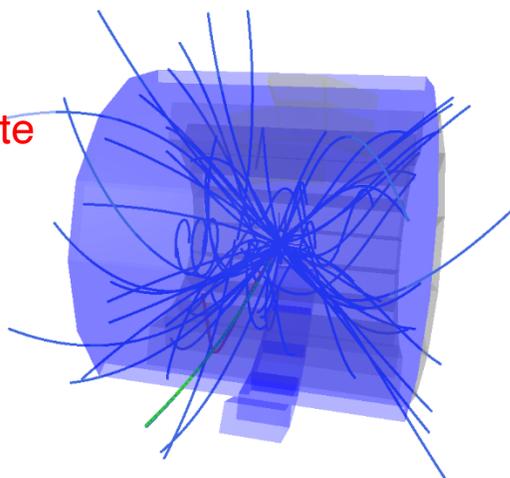
Event 1

Tre panoramiche del rivelatore ALICE



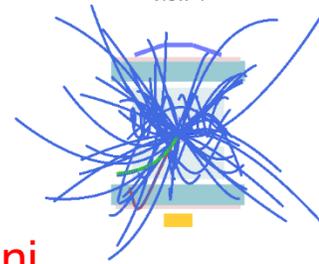
3D View

Cliccate e trascinate per farlo ruotare!



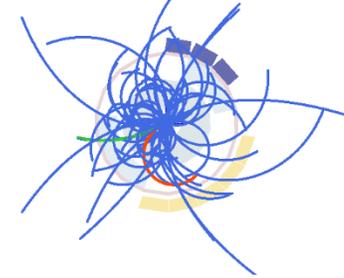
vista 3-dimensionale

View 1



proiezioni

View 2



Visibility

- Side Views
- Detector
- Axes
- Tracks
- Decays

Track Width

- S
- M
- L

Calculator

Charge	p_x (GeV/c)	p_y (GeV/c)	p_z (GeV/c)	mass (GeV/c ²)
(+)				
(-)				
(b)				
Total				

Select particle type

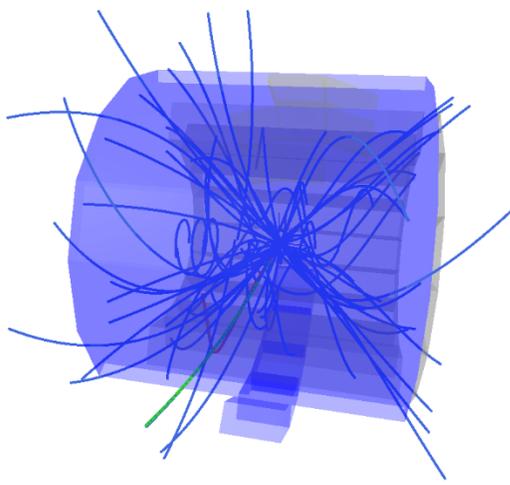
Add

Particles

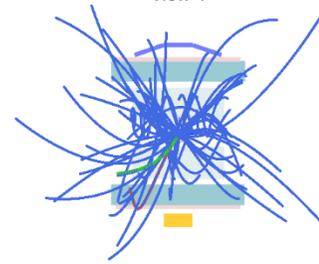
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K_S^0	0.4976
p, \bar{p}	0.9383
$\Lambda, \bar{\Lambda}$	1.1157
$\Xi, \bar{\Xi}$	1.3217

Event 1

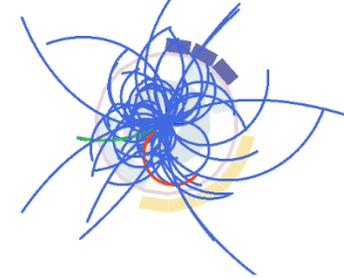
3D View



View 1



View 2



☰

Visibility

- Side Views
- Detector
- Axes
- Tracks
- Decays

Track Width

S M L

Accendete e spegnete i diversi pulsanti per visualizzare o rimuovere i diversi elementi

Calculator

Charge	p_x (GeV/c)	p_y (GeV/c)	p_z (GeV/c)	mass (GeV/c ²)
(+)				
(-)				
(b)				
Total				

Select particle type ▼

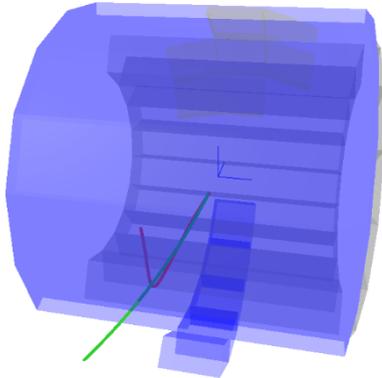
Add

Particles

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π^-, π^+	0.1396
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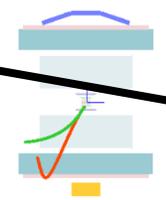
Event 1

3D View

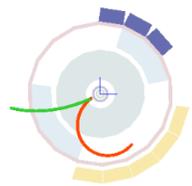


Spegnete questo per togliere le tracce e visualizzare solo i prodotti del decadimento (tracce verdi, rosse e blu)

View 1



View 2



Visibility

- Side Views
- Detector
- Axes
- Tracks
- Decays

Track Width

- S
- M
- L

Calculator

Charge	p_x (GeV/c)	p_y (GeV/c)	p_z (GeV/c)	mass (GeV/c ²)
(+)				
(-)				
(b)				
Total				

Select particle type

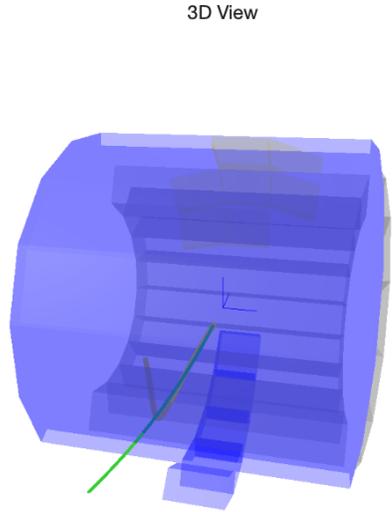
Add

Particles

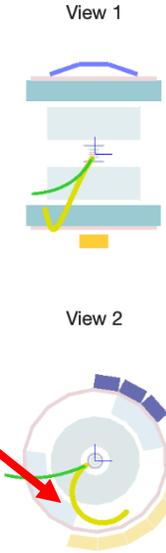
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p, \bar{p}	0.9383
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$\Xi, \bar{\Xi}$	1.3217

Event 1

TRACCIA ROSSA:
particella con
carica positiva



Cliccandogli sopra vedrete
apparire la quantità di moto e
la massa nella tabella sotto



- Visibility
- Side Views
 - Detector
 - Axes
 - Tracks
 - Decays
- Track Width
- S M L

Calculator

Charge	p_x (GeV/c)	p_y (GeV/c)	p_z (GeV/c)	mass (GeV/c ²)
(+)	-0.285	-0.221	-0.162	0.140
(-)				
(b)				
Total				

- Carica positiva
- Massa 0.140 GeV/c²

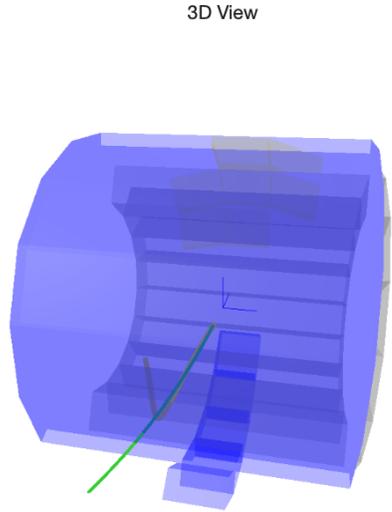
Di che particella si tratta?

Particles

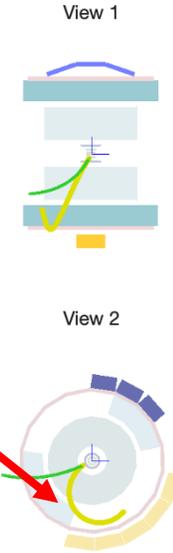
Type	mass (GeV/c ²)
e^-, e^+	0.0005
π^-, π^+	0.1396
K_S^0	0.4976
p, \bar{p}	0.9383
$\Lambda, \bar{\Lambda}$	1.1157
$\Xi, \bar{\Xi}$	1.3217

Event 1

TRACCIA ROSSA:
particella con
carica positiva



Cliccandogli sopra vedrete
apparire la quantità di moto e
la massa nella tabella sotto



Visibility

- Side Views
- Detector
- Axes
- Tracks
- Decays

Track Width

S M L

Calculator

Charge	p_x (GeV/c)	p_y (GeV/c)	p_z (GeV/c)	mass (GeV/c ²)
(+)	-0.285	-0.221	-0.162	0.140
(-)				
(b)				
Total				

- Carica positiva
- Massa 0.140 GeV/c²

Di che particella si tratta?

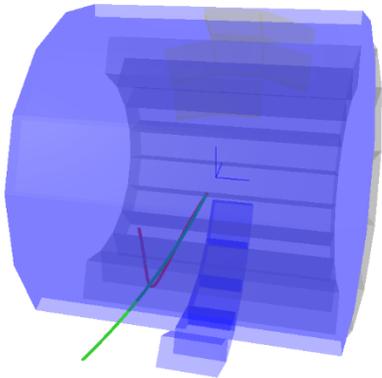
Particles

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

Event 1

TRACCIA VERDE:
particella con
carica negativa

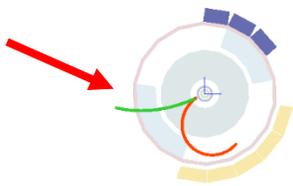
3D View



View 1



View 2



Visibility

- Side Views
- Detector
- Axes
- Tracks
- Decays

Track Width

- S
- M
- L

Calculator

Charge	p_x (GeV/c)	p_y (GeV/c)	p_z (GeV/c)	mass (GeV/c ²)
(+)	-0.285	-0.221	-0.162	0.140
(-)	-1.230	-0.566	-0.317	0.938
(b)				
Total				

Select particle type

Add

Carica negativa
Massa 0.938 GeV/c²

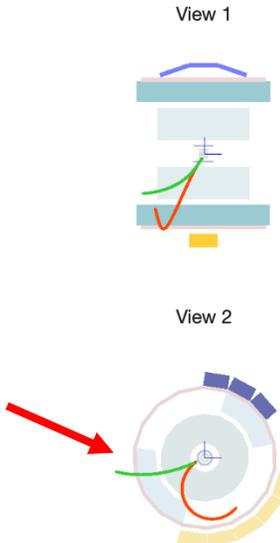
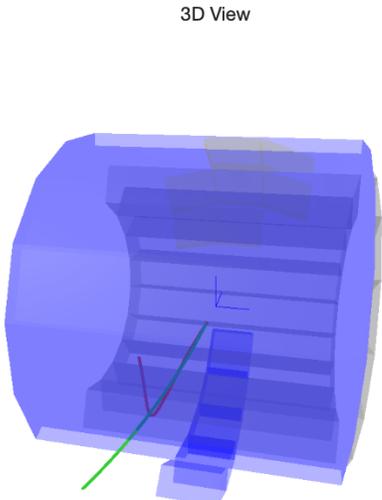
Questa che particella è?

Particles

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

Event 1

TRACCIA VERDE:
particella con
carica negativa



- Visibility**
- Side Views
 - Detector
 - Axes
 - Tracks
 - Decays
- Track Width**
- S
 - M
 - L

Calculator

Charge	p_x (GeV/c)	p_y (GeV/c)	p_z (GeV/c)	mass (GeV/c ²)
(+)	-0.285	-0.221	-0.162	0.140
(-)	-1.230	-0.566	-0.317	0.938
(b)				
Total				

Select particle type ▼

Add

Carica negativa
Massa 0.938 GeV/c²

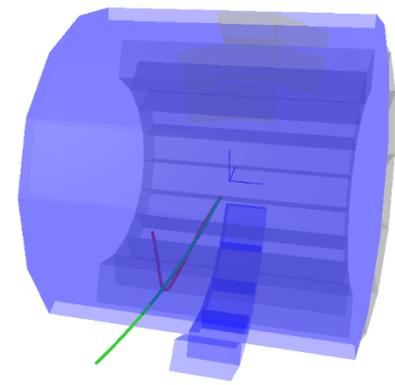
Questa che particella è?

Particles

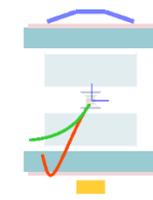
Type	mass (GeV/c ²)
e^-, e^+	0.0005
π^-, π^+	0.1396
K_S^0	0.4976
p, \bar{p}	0.9383
$\Lambda, \bar{\Lambda}$	1.1157
$\Xi, \bar{\Xi}$	1.3217

Event 1

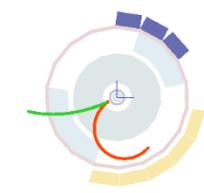
3D View



View 1



View 2



Visibility

- Side Views
- Detector
- Axes
- Tracks
- Decays

Track Width

- S
- M
- L

Adesso che

- avete **ricostruito la massa invariante** della particella iniziale
- sapete in cosa è **decaduta**

Cliccate su «select particle type» e **trovate la particella giusta!**

Calculator

Charge	p_x (GeV/c)	p_y (GeV/c)	p_z (GeV/c)	mass (GeV/c ²)
(+)	-0.285	-0.221	-0.162	0.140
(-)	-1.230	-0.566	-0.317	0.938
(b)				
Total				1.119

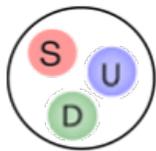
Massa invariante

- Select particle type
- Kaon
 - Lambda
 - Anti-Lambda
 - Xi
 - Background

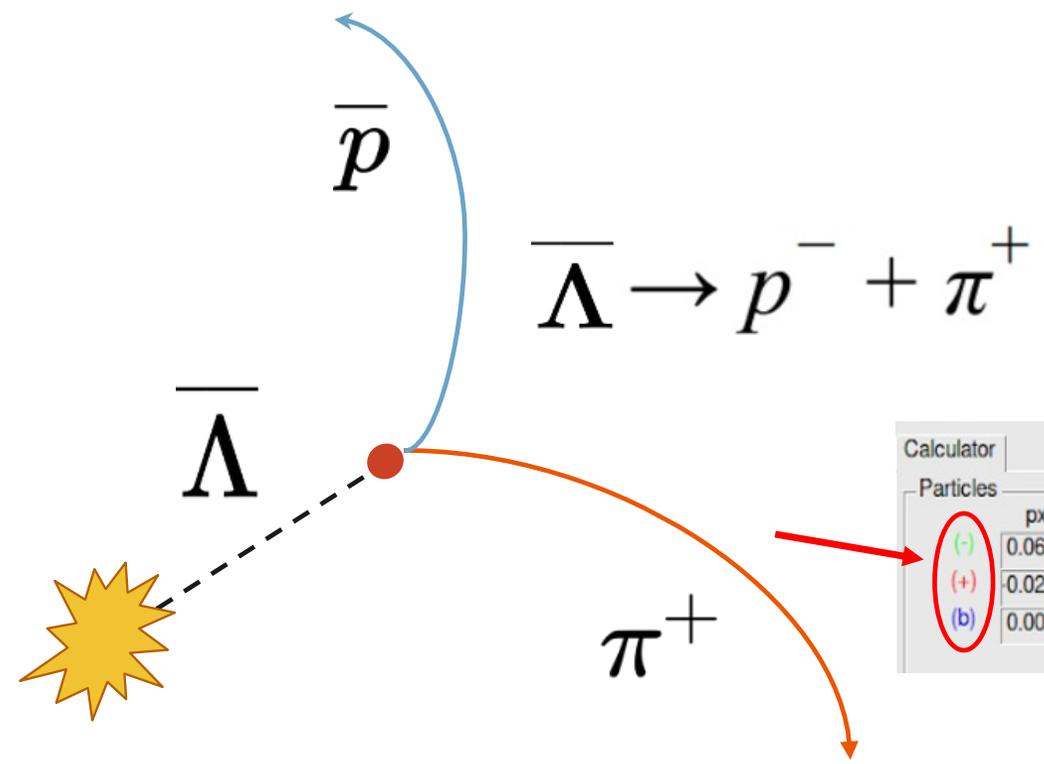
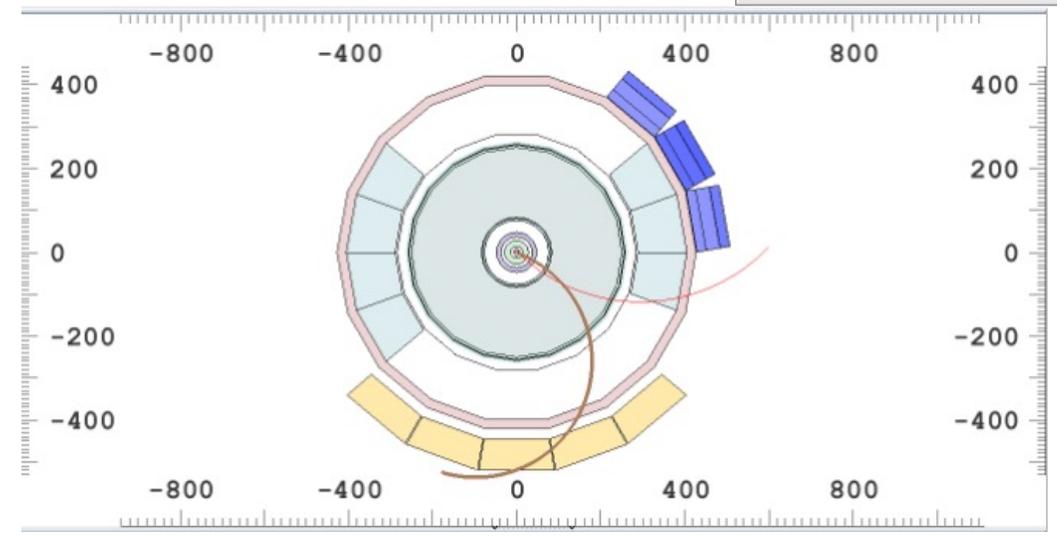
Particles

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

Barioni strani $\bar{\Lambda}$



Particle Info	
e^-, e^+	0.0005 GeV/c ²
π^+, π^-	0.1396 GeV/c ²
K_S^0, \bar{K}^0	0.4976 GeV/c ²
p, \bar{p}	0.9383 GeV/c ²
$\Lambda, \bar{\Lambda}$	1.1157 GeV/c ²
$\Sigma^+, \Sigma^0, \Sigma^-$	1.0217 GeV/c ²



Calculator

Particles	px	py	pz	m
(-)	0.0669	1.2864	1.1513	0.9383
(+)	0.0275	0.2801	0.0939	0.1396
(b)	0.0000	0.0000	0.0000	0.0000

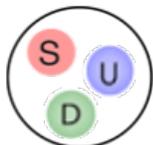
Operations

Instructions

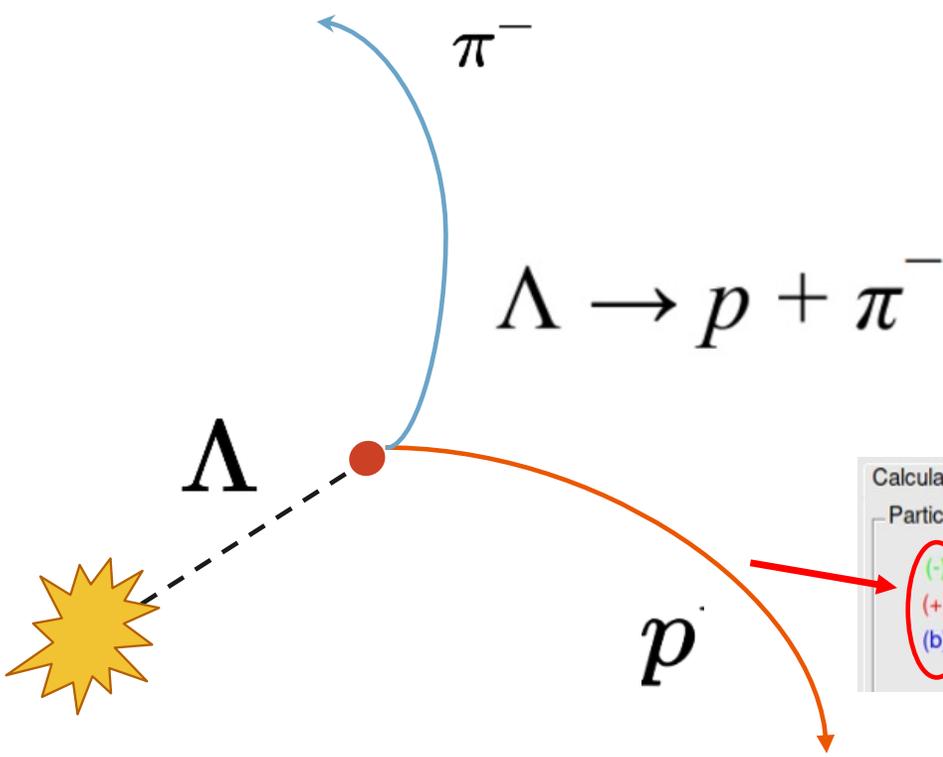
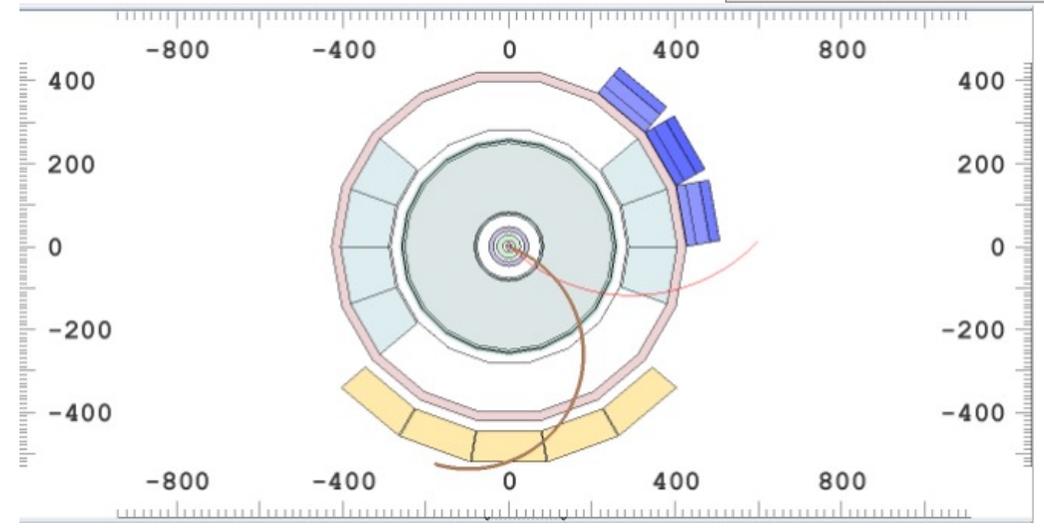
Inv. mass 1.12072

Choice

Barioni strani Λ



Particle Info	
e^-, e^+	0.0005 GeV/c ²
π^+, π^-	0.1396 GeV/c ²
K^0_s, \bar{K}^0_s	0.4976 GeV/c ²
p, \bar{p}	0.9383 GeV/c ²
$\Lambda, \bar{\Lambda}$	1.1157 GeV/c ²
$\Sigma^+, \Sigma^0, \Sigma^-$	1.3217 GeV/c ²



$$\Lambda \rightarrow p + \pi^-$$

Calculator

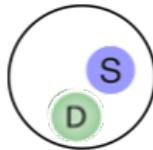
Particles	px	py	pz	m
(-)	0.1999	0.2139	-0.0614	0.1396
(+)	-0.5549	0.8776	-0.6402	0.9383
(b)	0.0000	0.0000	0.0000	0.0000

Operations

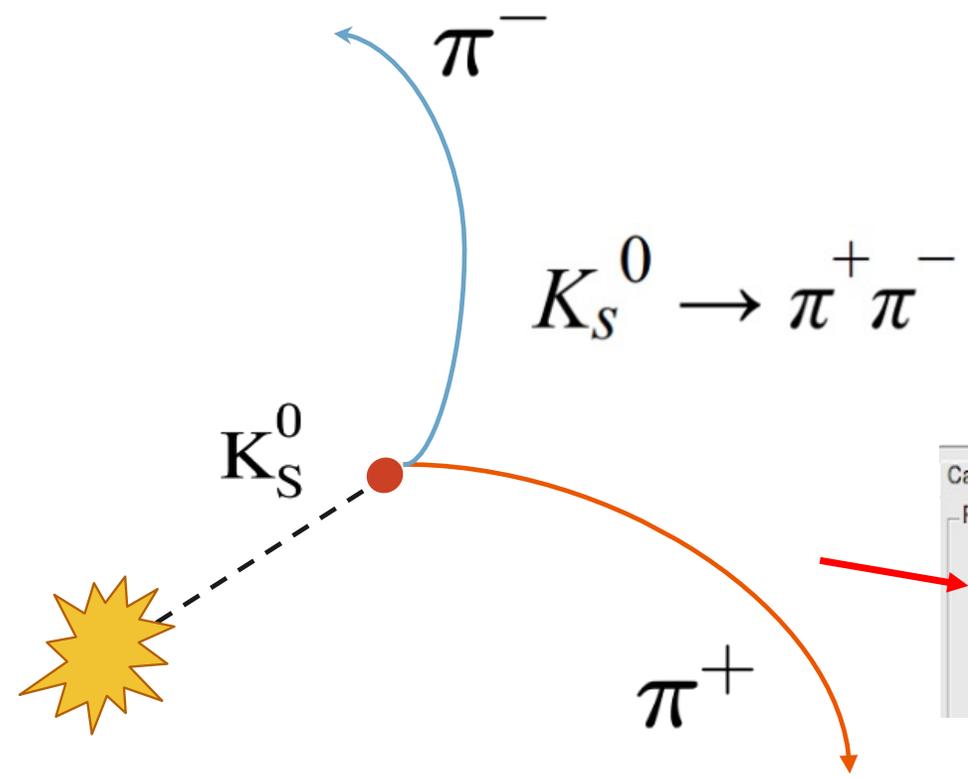
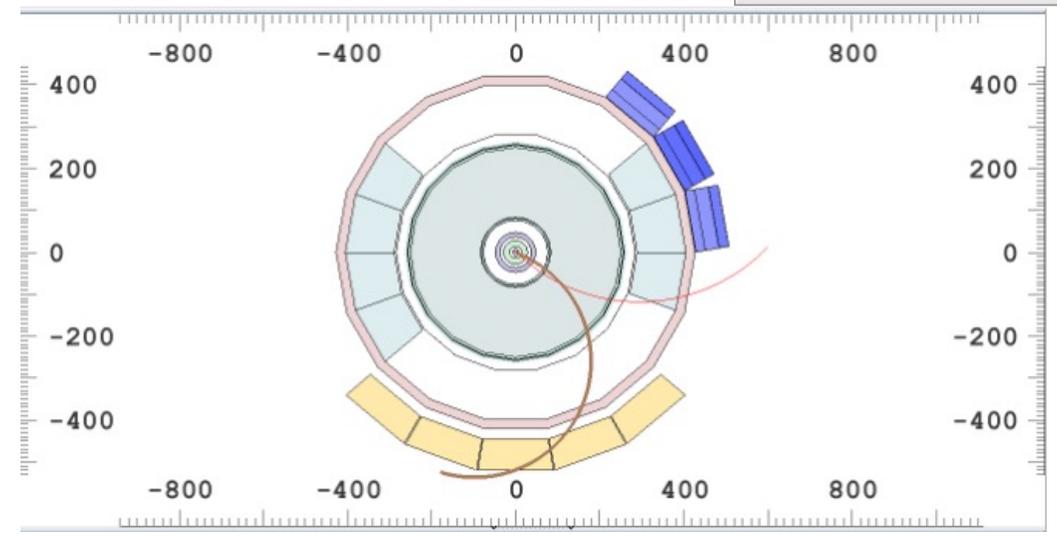
Inv. mass: 1.12072

Choice: Select particle type

Mesoni strani K_S^0



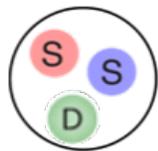
Particle Info	
e^-, e^+	0.0005 GeV/c ²
π^+, π^-	0.1396 GeV/c ²
K_S^0	0.4976 GeV/c ²
p, \bar{p}	0.9383 GeV/c ²
$\Lambda, \bar{\Lambda}$	1.1157 GeV/c ²
$\Xi, \bar{\Xi}$	1.3217 GeV/c ²



Calculator				
Particles	px	py	pz	m
(-)	0.3865	-0.1513	-0.2185	0.1396
(+)	0.4607	-0.4363	0.1066	0.1396
(b)	0.0000	0.0000	0.0000	0.0000

Operations	
Inv. mass	0.491751
Choice	Select particle type

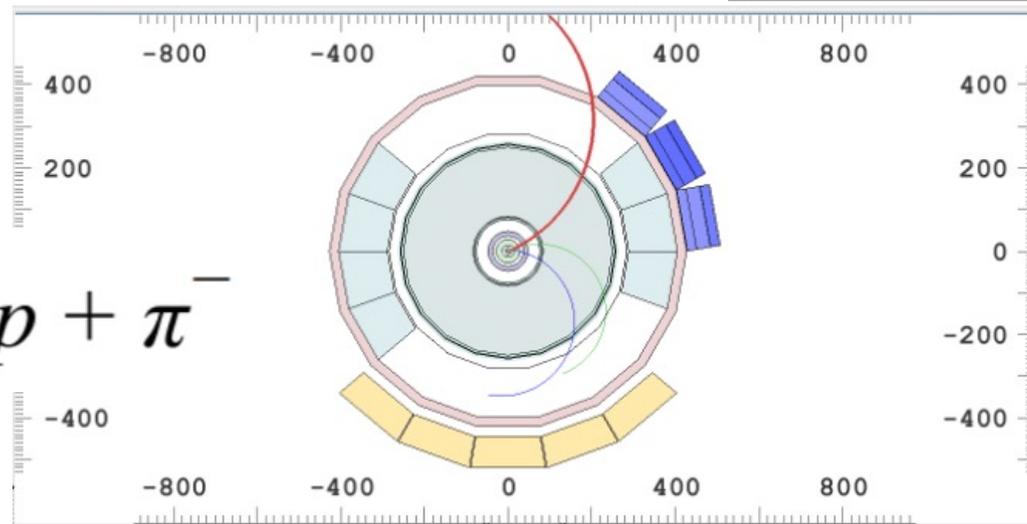
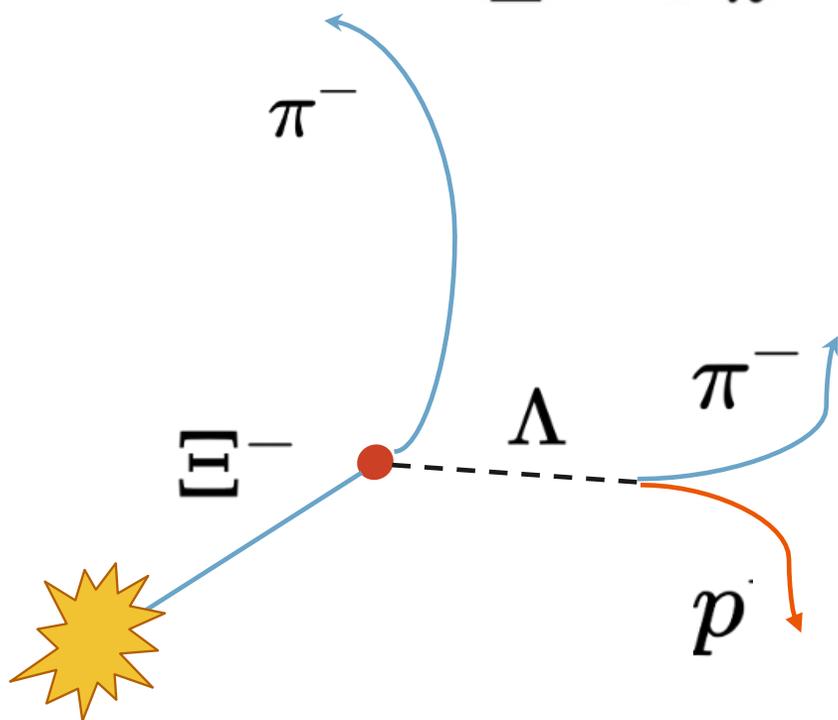
Barioni strani $[\Xi]$



Particle Info	
e^-, e^+	0.0005 GeV/c ²
π^+, π^-	0.1396 GeV/c ²
K_S^0, \bar{K}^0	0.4976 GeV/c ²
p, \bar{p}	0.9383 GeV/c ²
$\Lambda, \bar{\Lambda}$	1.1157 GeV/c ²
$\Xi^-, \bar{\Xi}^+$	1.3217 GeV/c ²

$$\Xi^- \rightarrow \pi^- + \Lambda$$

$$\Lambda \rightarrow p + \pi^-$$

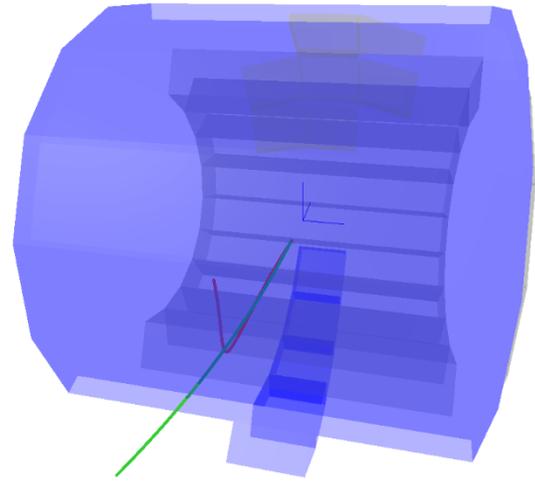


Calculator				
Particles	px	py	pz	m
(-)	0.2219	0.0937	0.0744	0.1396
(+)	0.4670	0.2309	0.3378	0.9383
(b)	0.2616	0.0396	0.1024	0.1396

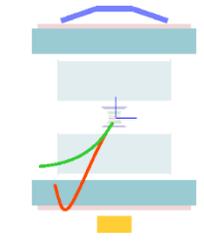
Operations	
Inv. mass	1.31972
Choice	Select particle type

Event 1

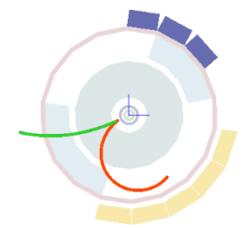
3D View



View 1



View 2



Visibility

- Side Views
- Detector
- Axes
- Tracks
- Decays

Track Width

- S
- M
- L

Calculator

Charge	p_x (GeV/c)	p_y (GeV/c)	p_z (GeV/c)	mass (GeV/c ²)
(+)	-0.285	-0.221	-0.162	0.140
(-)	-1.230	-0.566	-0.317	0.938
(b)				
Total				1.119

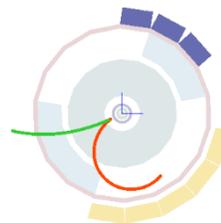
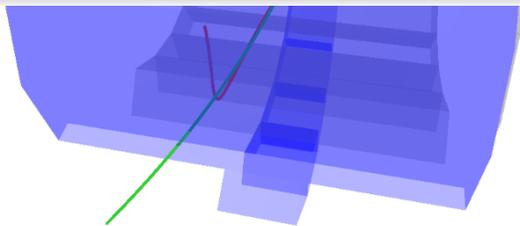
Select particle type
Anti-Lambda

Add



Particles

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



S M L

Calculator

Charge	p_x (GeV/c)	p_y (GeV/c)	p_z (GeV/c)	mass (GeV/c ²)
(+)	-0.285	-0.221	-0.162	0.140
(-)	-1.230	-0.566	-0.317	0.938
(b)				
Total				1.119

Select particle type

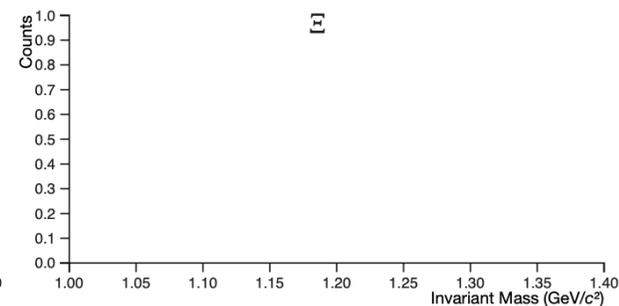
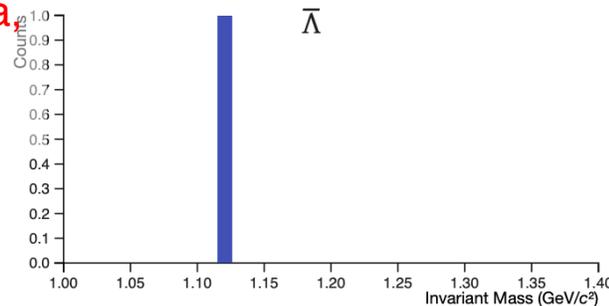
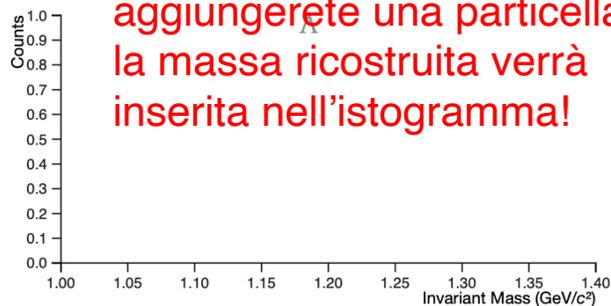
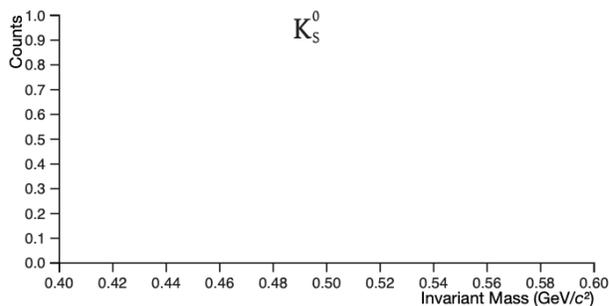
Anti-Lambda

Add

Particles

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

Histograms

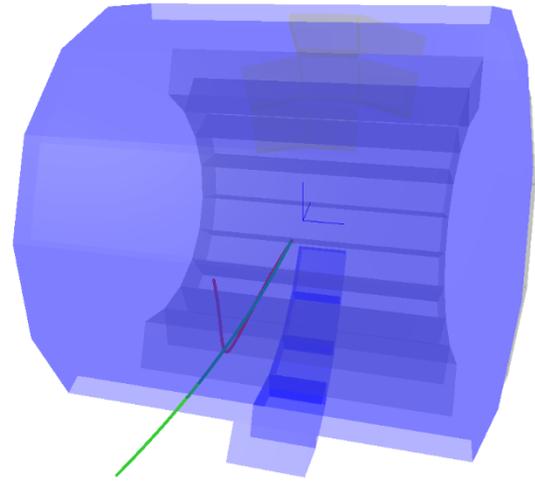


Ogni volta che
aggiungerete una particella
la massa ricostruita verrà
inserita nell'istogramma!

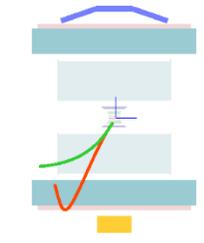


Event 1

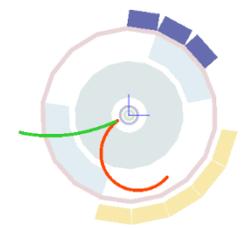
3D View



View 1



View 2



Visibility

- Side Views
- Detector
- Axes
- Tracks
- Decays

Track Width

- S
- M
- L



Cliccate sulla freccetta per passare al prossimo evento

Calculator

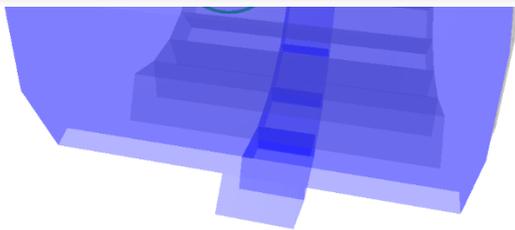
Charge	p_x (GeV/c)	p_y (GeV/c)	p_z (GeV/c)	mass (GeV/c ²)
(+)	-0.285	-0.221	-0.162	0.140
(-)	-1.230	-0.566	-0.317	0.938
(b)				
Total				1.119

Select particle type
Anti-Lambda

Add

Particles

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



S M L

Calculator

Charge	p_x (GeV/c)	p_y (GeV/c)	p_z (GeV/c)	mass (GeV/c ²)
(+)	0.211	-0.104	-0.053	0.140
(-)	-0.196	-0.141	-0.123	0.140
(b)				
Total				0.500

Select particle type

Kaon

Add

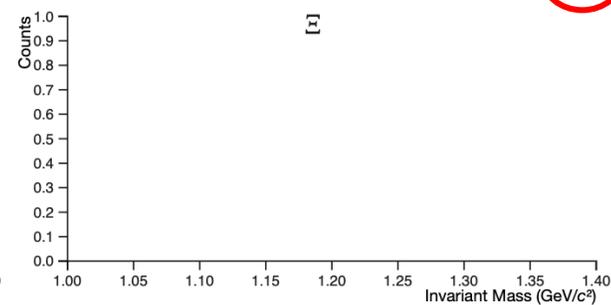
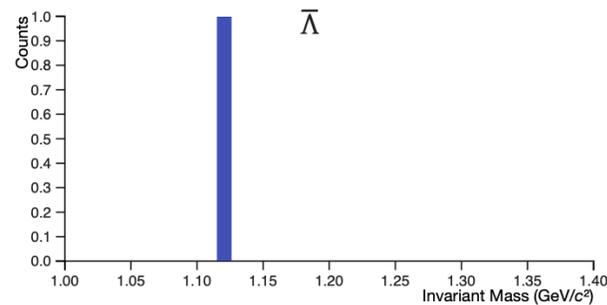
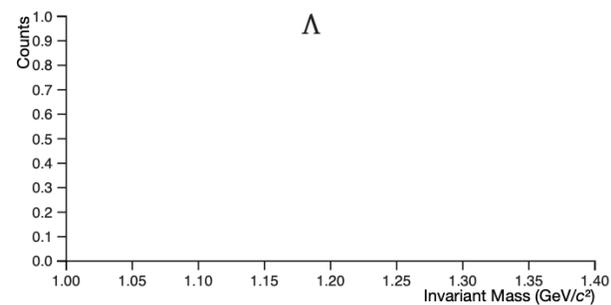
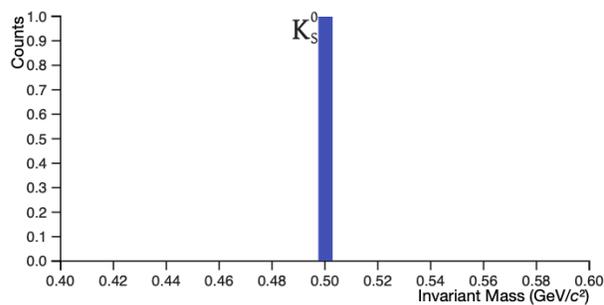
Particles

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

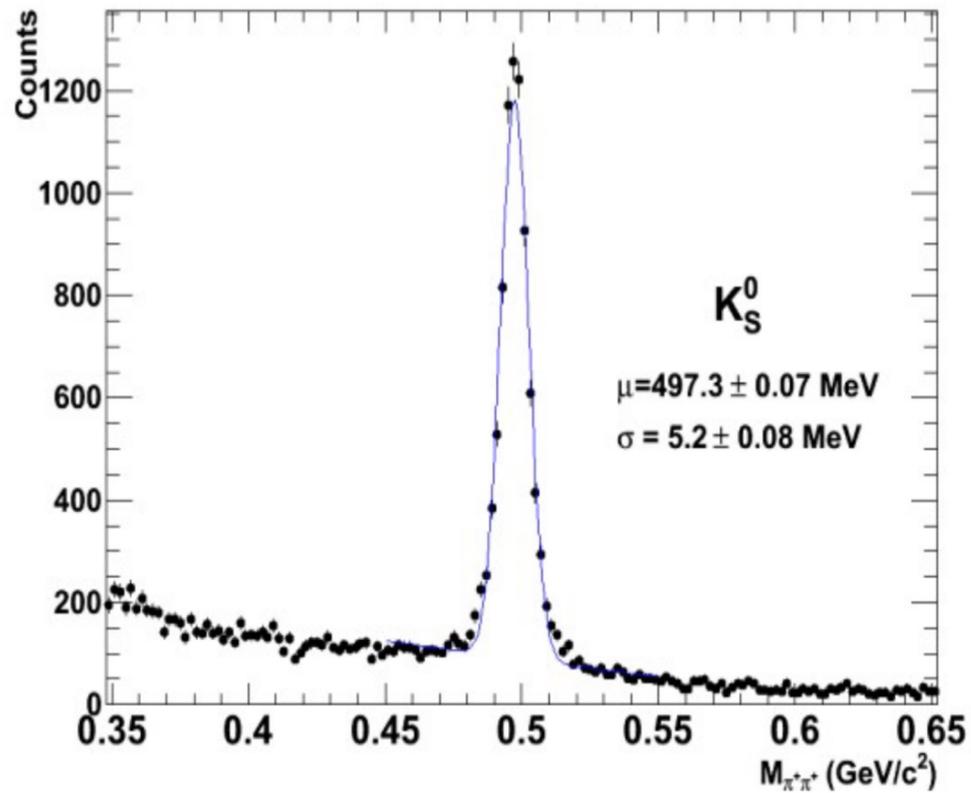
Quando avrete analizzato tutti gli eventi e riempito gli istogrammi ricordatevi di caricare i dati cliccando sulla nuvoletta



Histograms



Nella realtà noi abbiamo a che fare con **milioni di eventi**... non possiamo selezionarli a mano con l'event display!



E' difficile essere precisi e selezionare le tracce che vengono dallo stesso vertice
→ le tracce accoppiate a volte sono sbagliate

Nella distribuzione di massa le tracce accoppiate male sono il fondo e viene individuato e sottratto dal segnale grazie ad un fit!

ESERCIZIO 2: riconoscere il segnale e il background

Menu

Home

Strangeness

Visual Analysis

Large Scale Analysis

Big science

Mass

EN

Welcome to the ALICE Masterclass!

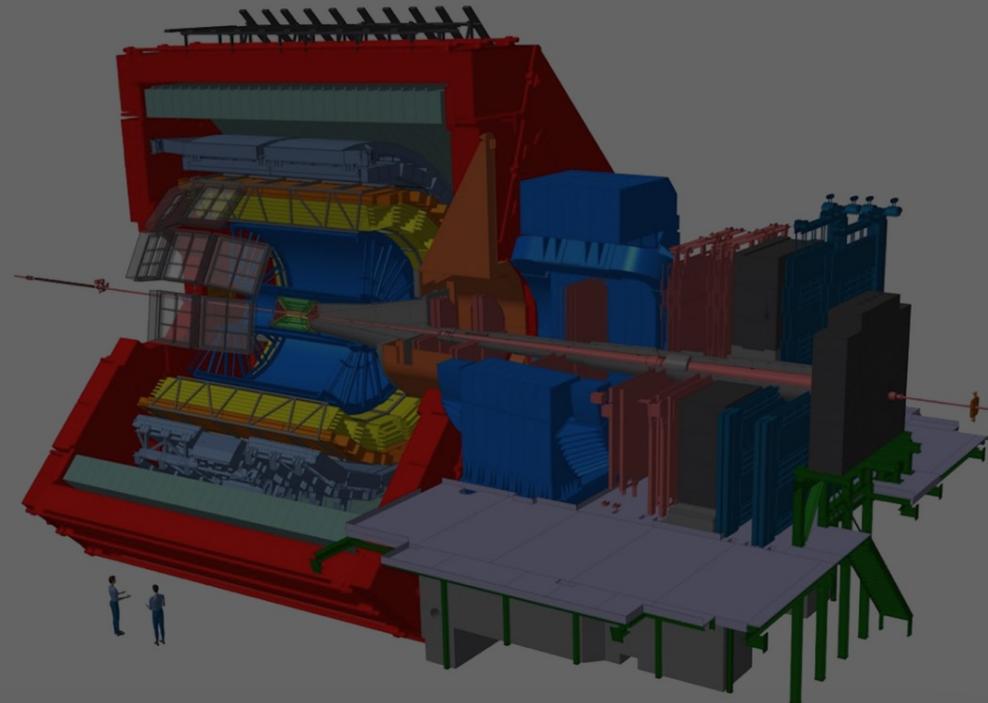
Il secondo esercizio permette di **estrarre le caratteristiche delle particelle mediante fit** alla distribuzione di massa invariante

The ALICE Collaboration has built a dedicated detector to exploit the unique physics potential of nucleus-nucleus collisions at LHC energies. Our aim is to study the physics of strongly interacting matter at the highest energy densities reached so far in the laboratory. In such condition, an extreme phase of matter - called the quark-gluon plasma - is formed.

The universe is thought to have been in such a primordial state for the first few millionths of a second after the Big Bang. The properties of such a phase are key issues for Quantum Chromodynamics, the understanding of confinement-deconfinement and chiral phase transitions.

For this purpose, we are carrying out a comprehensive study of the hadrons, electrons, muons and photons produced in the collisions of heavy nuclei. ALICE is also studying proton-proton and proton-nucleus collisions both as a comparison with nucleus-nucleus collisions and in their own right.

If you wish, you can download and use a desktop version of the Masterclass:



Histogram Selector

Select particle type

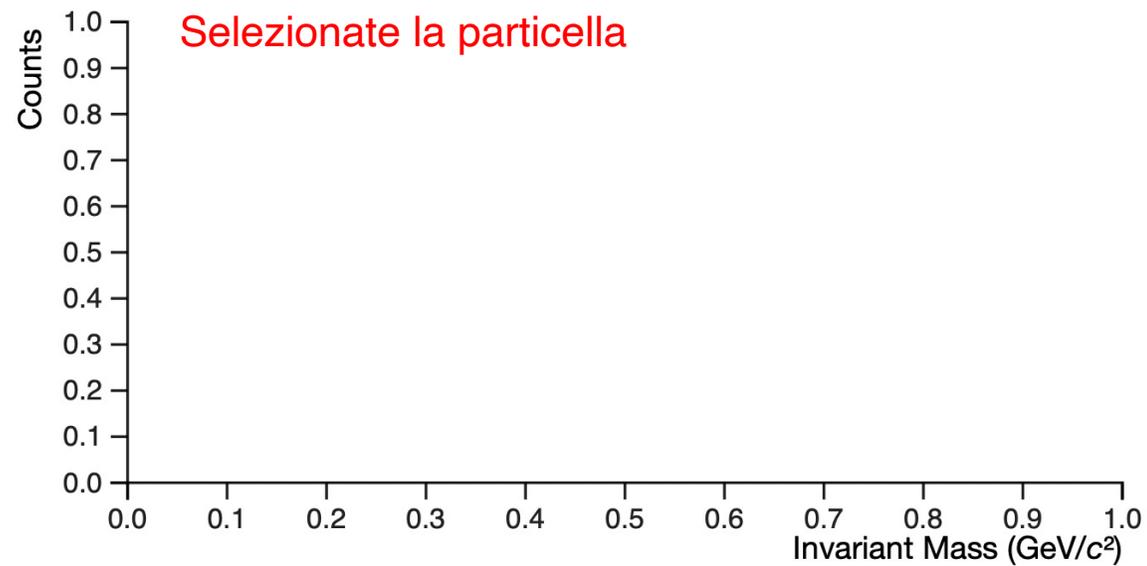
Kaon

Lambda

Anti-Lambda

Select collision & cent...

Open histogram



Results

Type	Collision	Centrality	Signal
Kaon	Pb-Pb	20% - 30%	4088
Kaon	Pb-Pb	30% - 40%	2947
Kaon	pp	0%	518
Kaon	Pb-Pb	0% - 10%	5173
Kaon	Pb-Pb	10% - 20%	4786

Items per page: 5 1 - 5 of 10 < >

Fit Selector



Fit

Accept

Histogram Selector

Select particle type

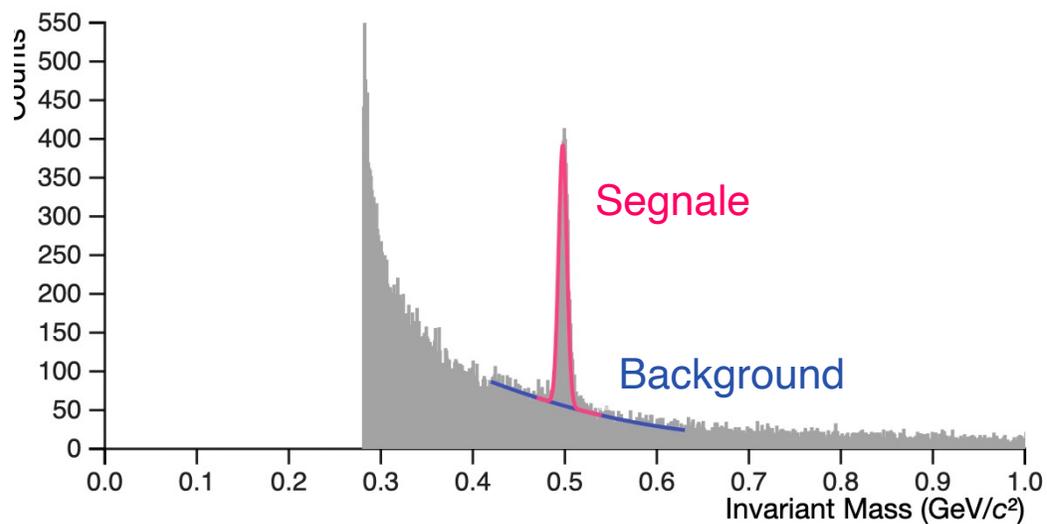
Kaon

Select collision & centrality

Pb-Pb 20% - 30%

Open histogram

Histogram Display



Results

Type	Collision	Centrality	Signal
Kaon	Pb-Pb	20% - 30%	4088

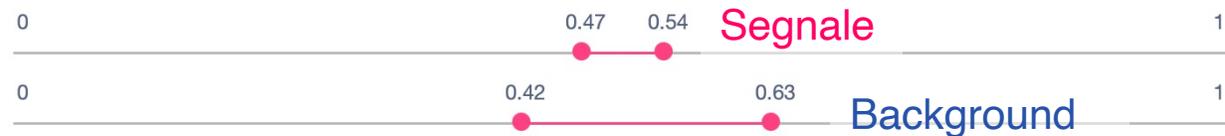
Items per page: 5 1 - 1 of 1

Fate un po' di prove, cliccate ogni volta su «fit» per visualizzarlo su grafico

Quando siete contenti del risultato cliccate su «accept»

Impostate il range in cui vi aspettate il segnale e il background

Fit Selector



Fit

Accept

Histogram Selector

Select particle type

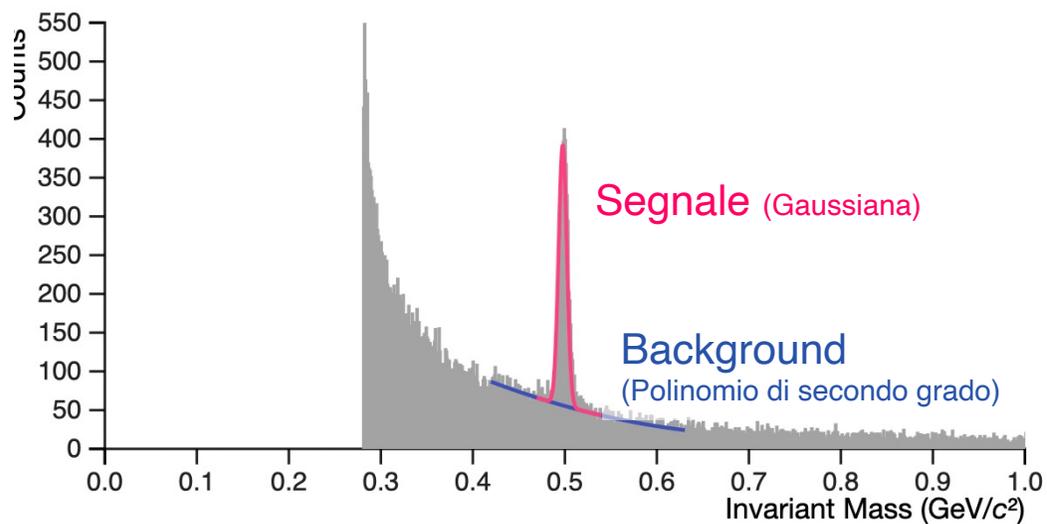
Kaon

Select collision & centrality

Pb-Pb 20% - 30%

Open histogram

Histogram Display



Results

Type	Collision	Centrality	Signal
Kaon	Pb-Pb	20% - 30%	4088

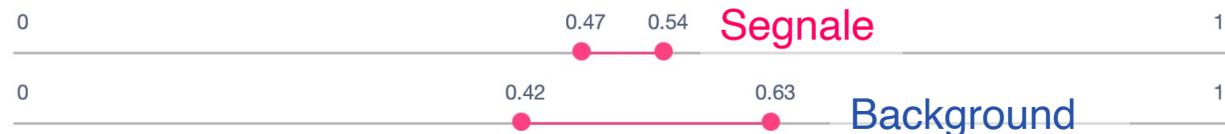
Items per page: 5 1 - 1 of 1 < >

Fate un po' di prove, cliccate ogni volta su «fit» per visualizzarlo su grafico

Quando siete contenti del risultato cliccate su «accept»

Impostate il range in cui vi aspettate il segnale e il background

Fit Selector



Fit

Accept

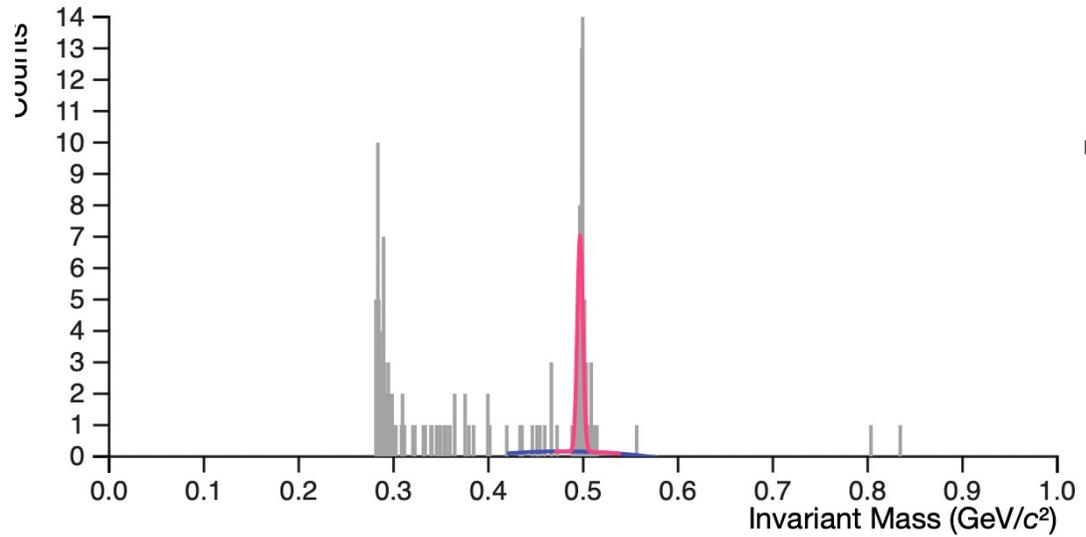
Histogram Selector

Select particle type
Kaon

Select collision & centrality
Pb-Pb 80% - 90%

Open histogram

Histogram Display



Total: 77
Signal: 77 ± 2
Background: 0
 $\mu : 0.4967$
 $\sigma : 0.0029$

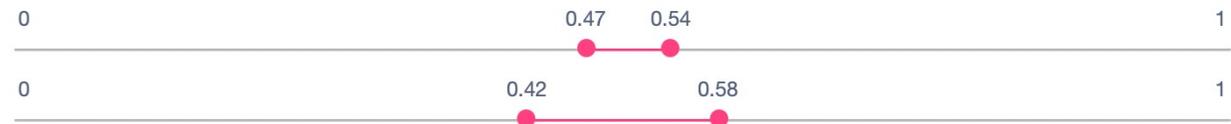
I risultati verranno salvati in tabella di volta in volta

Results

Type	Collision	Centrality	Signal
Kaon	Pb-Pb	40% - 50%	1653
Kaon	Pb-Pb	50% - 60%	930
Kaon	Pb-Pb	60% - 70%	518
Kaon	Pb-Pb	70% - 80%	214
Kaon	Pb-Pb	80% - 90%	77

Items per page: 5 6 - 10 of 10 |< < > >|

Fit Selector



Fit

Accept

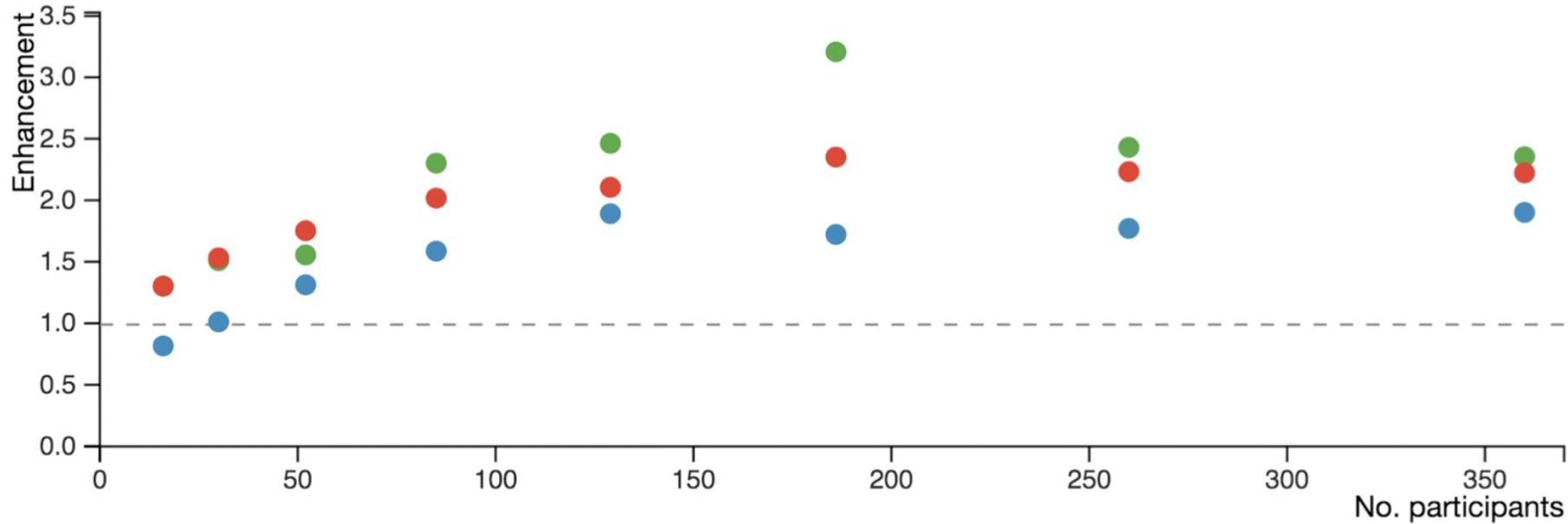
Histogram Selector

Select particle type
Kaon

Select collision & centrality
Pb-Pb 80% - 90%

Open histogram

Tutti i dati che caricherete **verranno uniti** insieme per ottenere il grafico con **l'aumento di stranezza** per le 3 particelle



Non dimenticatevi di caricare i dati!



Signal

1653

930

518

214

77

per page: 5

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**ORA TOCCA
A VOI!**

Informazioni utili

Particle Info

e^-, e^+	0.0005 GeV/c^2
π^+, π^-	0.1396 GeV/c^2
K_S^0	0.4976 GeV/c^2
p, \bar{p}	0.9383 GeV/c^2
$\Lambda, \bar{\Lambda}$	1.1157 GeV/c^2
$\Xi^-, \bar{\Xi}^+$	1.3217 GeV/c^2

$$K_S^0 \rightarrow \pi^+ \pi^-$$

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

$$\bar{\Lambda} \rightarrow \bar{p} \pi^+$$

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

\downarrow

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



**Vi sono piaciute le
attività?**

**Cosa possiamo
migliorare?**

Ditecelo qui!