Looking for strange particles in ALICE

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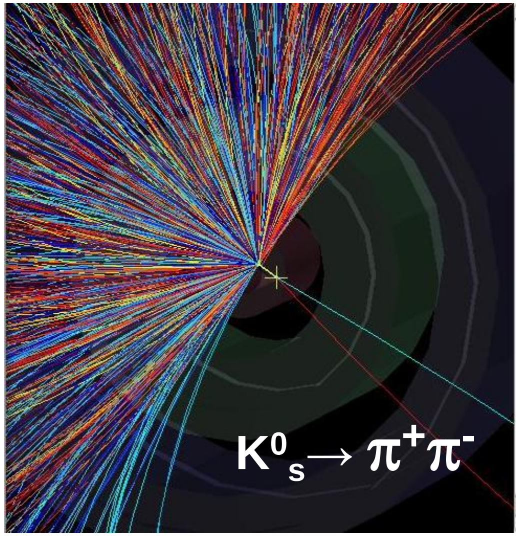
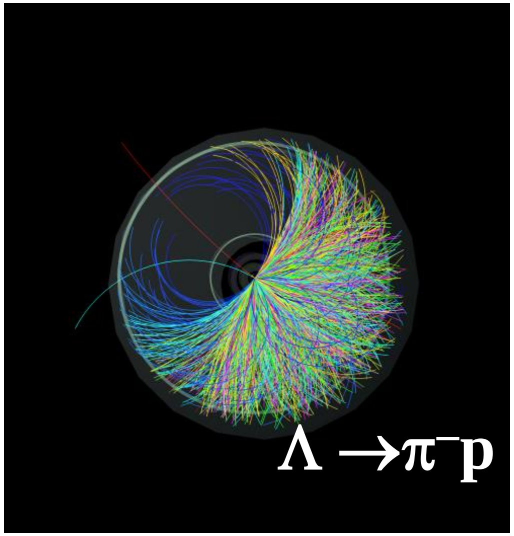
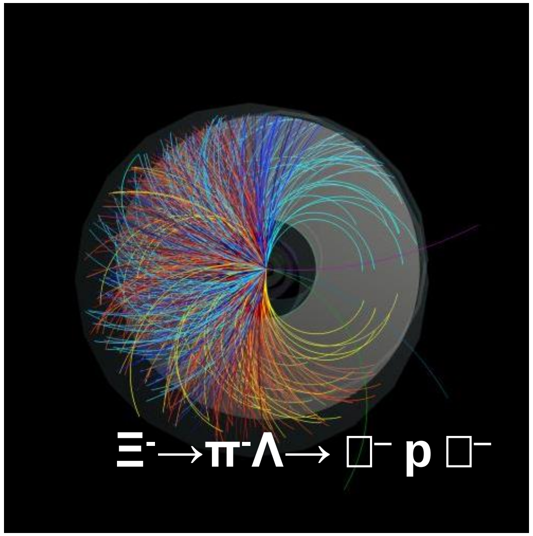
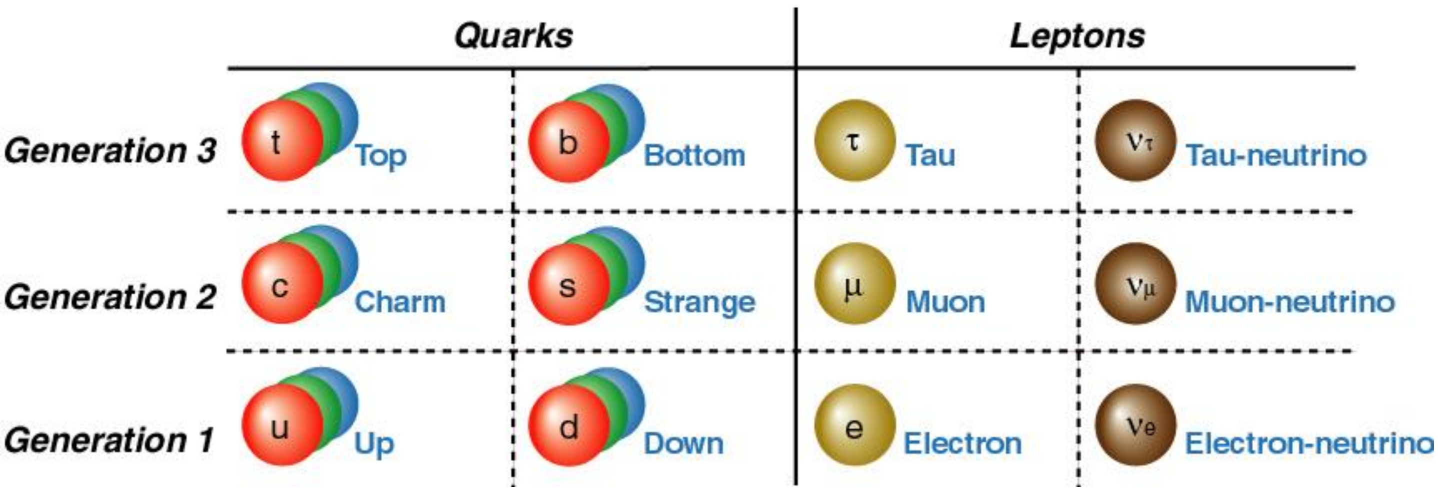




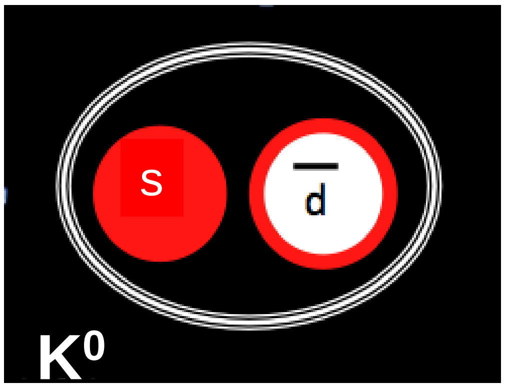


Today's periodic system of the fundamental building blocks



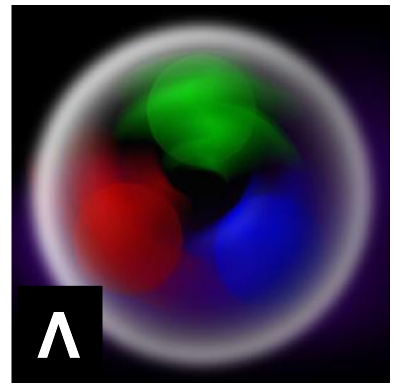
What are strange particles ?

meson



$d\bar{s}$, $\bar{d}s$

baryon



uds

hadrons (baryons or mesons) containing at least one strange (s) quark

We will be looking for neutral strange particles, which travel some distance (mm or cm) from the point of production (collision point) before they decay into two oppositely charged particles

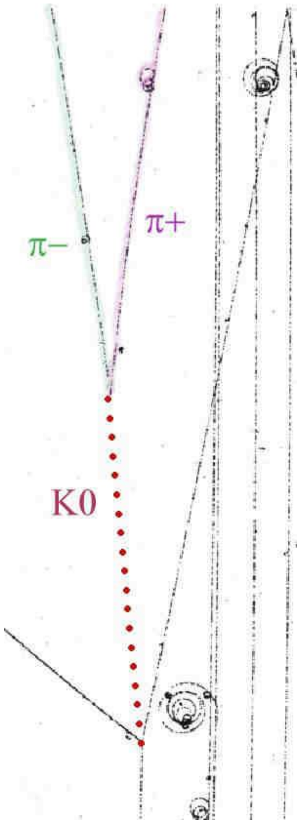
$K^0_s \rightarrow \pi^+\pi^-$

τ = 0.89 x10^{-10} s
cτ = 3x10^{10} cm s^{-1} x8.9x10^{-11} s
2.67 cm from the point of interaction

$\Lambda \rightarrow \pi^- p$

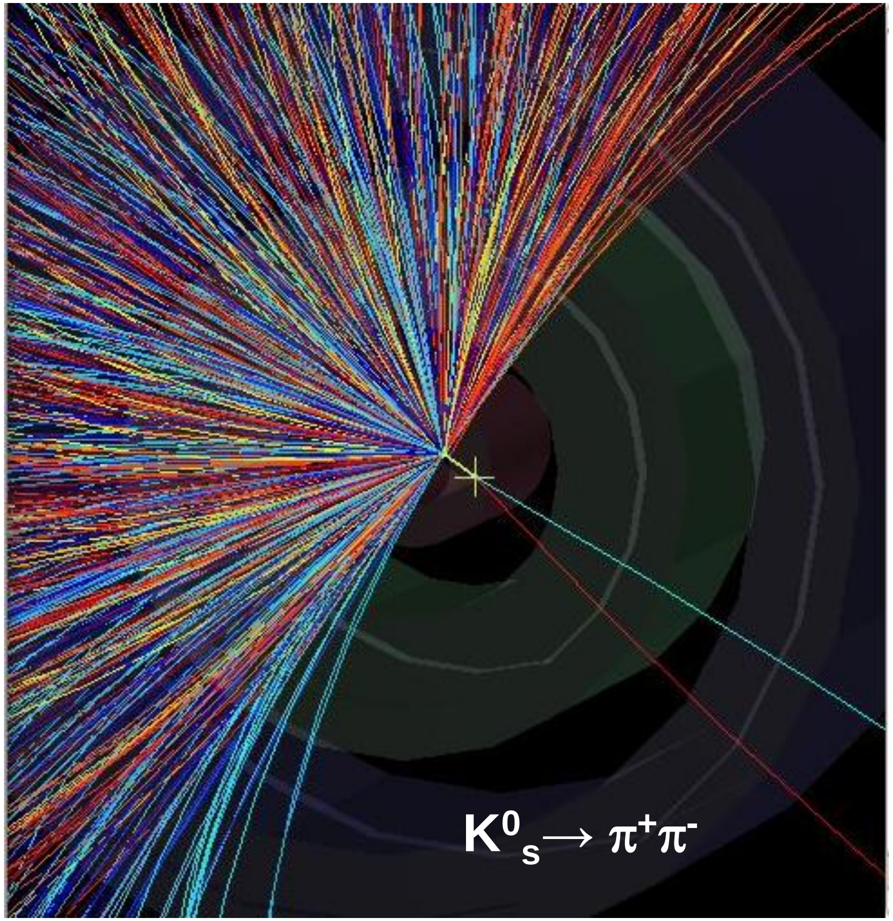
$\bar{\Lambda} \rightarrow \pi^+ \bar{p}$

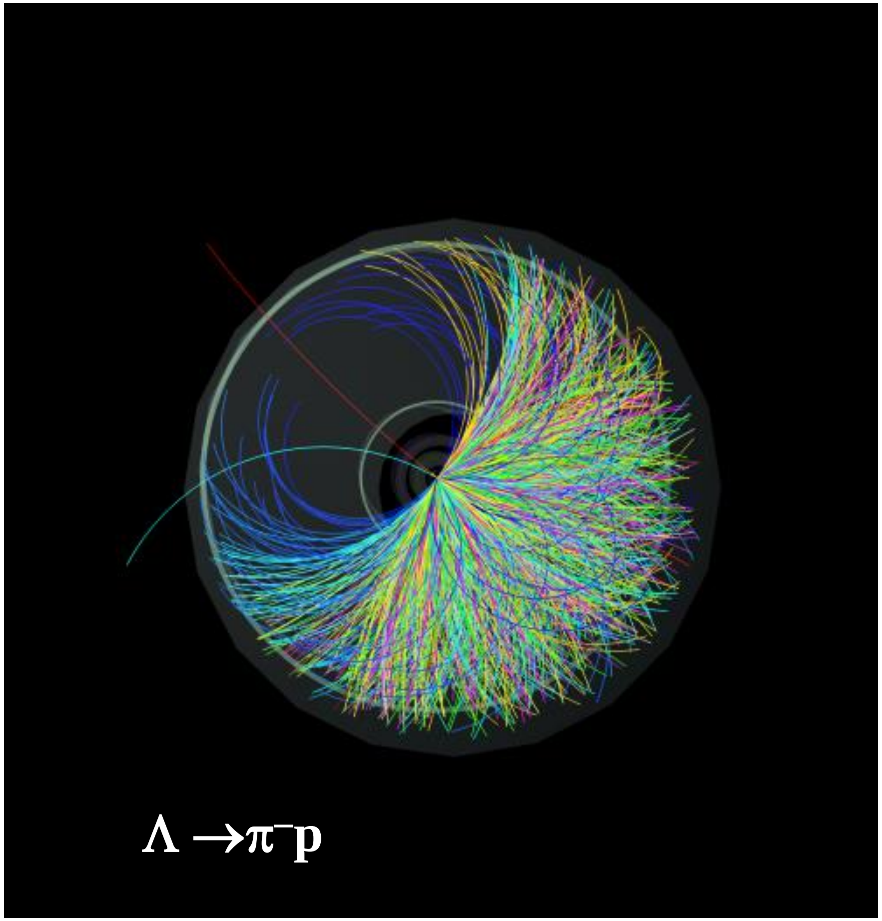
τ = 2.6 x10^{-10} s
cτ = 3x10^{10} cm s^{-1} x2.6x10^{-10} s
7.2 cm distance from the point of interaction



Weak decays : strangeness is not conserved

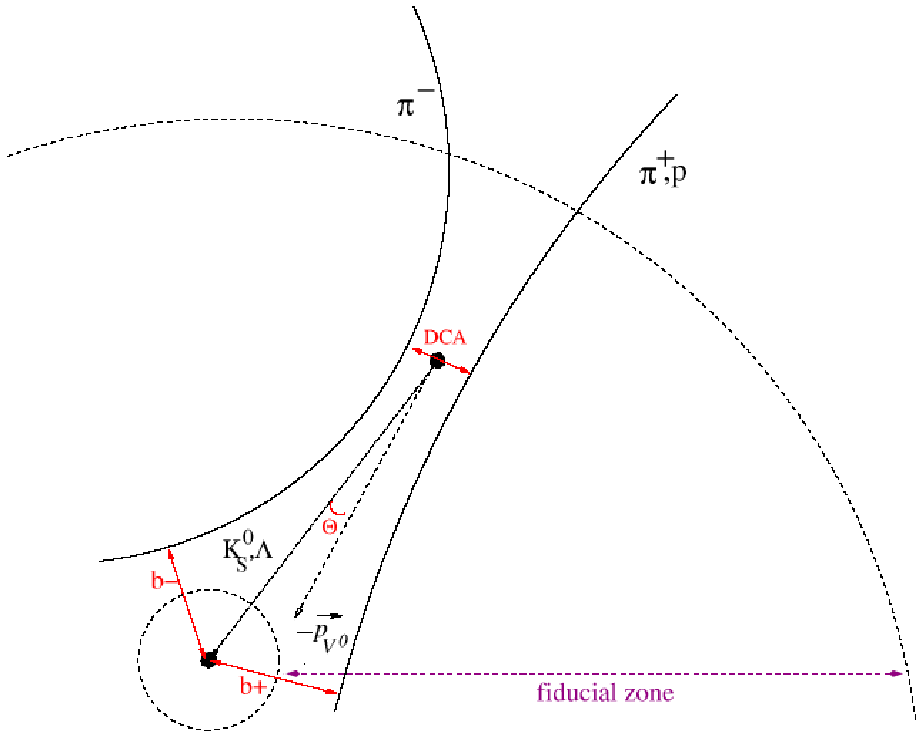
How do we find V0s ?





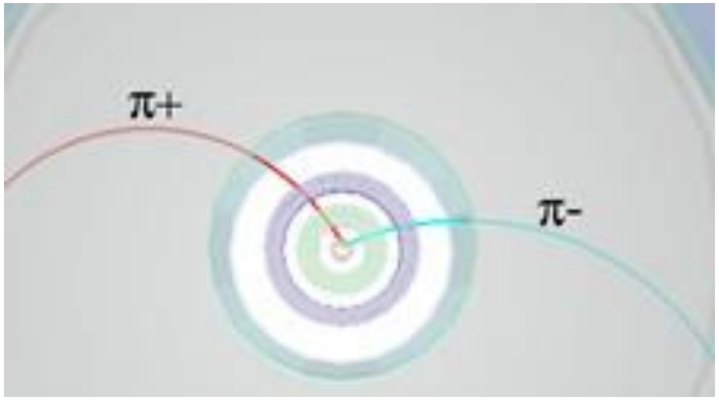
We look for two opposite tracks, having the same origin, which is not the interaction (collision) point

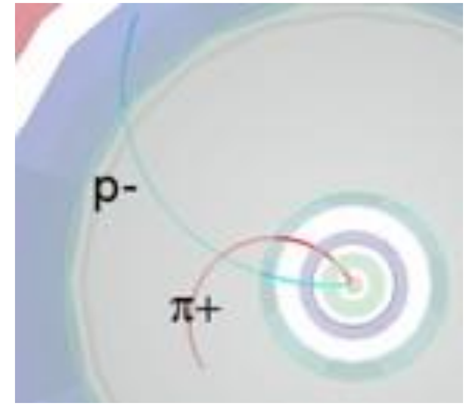
How do we find V0s ?



We look for two opposite tracks, having the same origin, which is not the interaction (collision) point

How do we identify each V0?



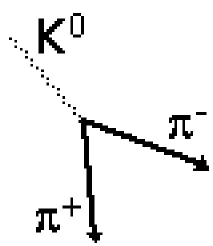


$K^0_s \to \pi^+\pi^-$

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

anti $\Lambda \to p^-$□$^+$

$K^0 \to \pi^+ + \pi^-$



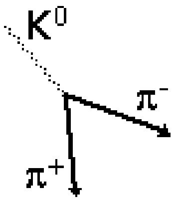
V0 decay :
a neutral particle (no track) gives suddenly two tracks

P = Q·B·R
P momentum
Q electric charge
B magnetic field
R radius of curvature

Identify V0s from the decay topology

How do we identify each V0?

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



Calculate the (invariant) mass

Energy conservation $E = E_1+E_2$

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

Total energy $E^2 = p^2c^2 + m^2c^4$

c=1 $E^2 = p^2 + m^2$

$E = E_1+E_2$ $E_1^2 = p_1^2 + m_1^2$ $E_2^2 = p_2^2 + m_2^2$

$E^2 = p^2 + m^2$ $m^2 = E^2 - p^2 =(E_1+E_2)^2 -(p_1+p_2)^2 = m_1^2 + m_2^2 +2E_1E_2 - 2\,\mathbf{p}_1 . \mathbf{p}_2$

Calculate the mass of the initial particle from the values of the mass and the momentum of the final particles

Particle Identification (done by a number of PID detectors) ⇨ m_1 m_2

Radius of curvature of the particle tracks due to magnetic field ⇨ p_1 p_2

P=Q·B·R (P momentum, Q electric charge, R radius of curvature, B magnetic field)

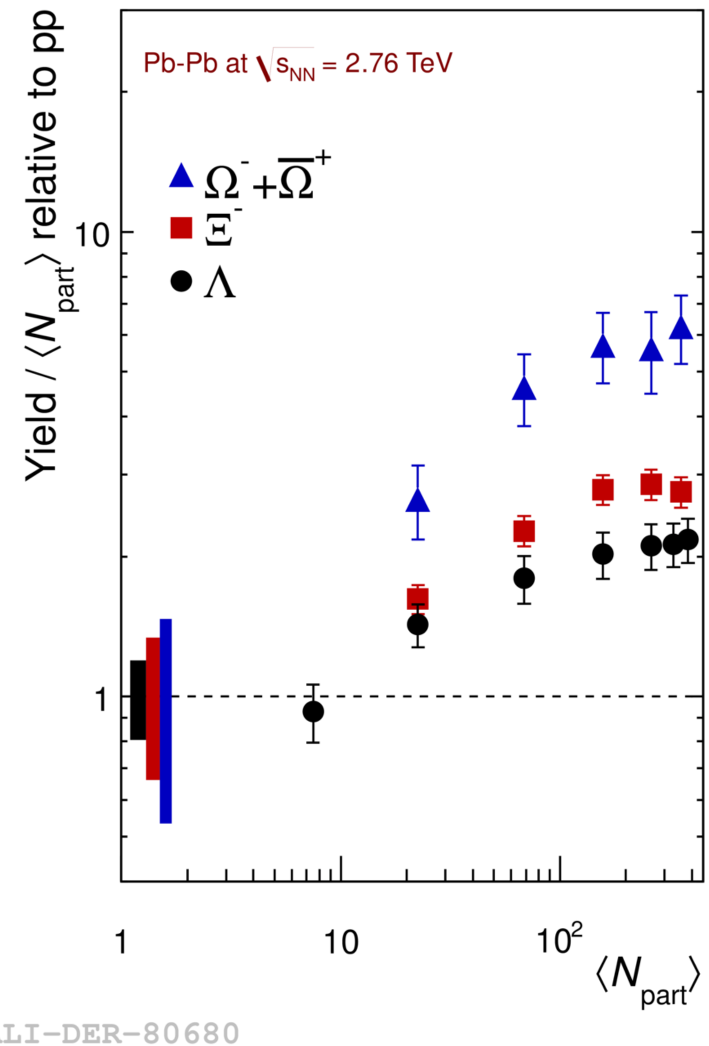
1^{st} part
Identification of V0s (K_s, Λ, anti-Λ) in pp collisions

- Visual analysis of small samples (~15 events) of pp
- Find V0s with “V0 finder”
- Calculate invariant mass (with “calculator”)
- Classify in corresponding histograms
- Merge all results at the end of the 1^{st} part
- Comment on width of the peak, background events

2^{nd} part
Strangeness enhancement in lead-lead collisions

- Analysis of “large” event samples from lead collisions
- Find number of K_s, Λ, anti-Λ in different centrality regions
- Students’ job: do appropriate fits to signal and background
- Results are sent to a server; for each case the average of all values corresponding to each case is taken into account
- Particle yields are calculated
- Strangeness enhancement is calculated taking into account particle yields in proton collisions

Strangeness enhancement : one of the first signals of QGP



Enhancement increases with number of strange quarks in the hadron (Ω has 3, Ξ has 2, Λ has 1)

Particle yield for Pb-Pb collisions/ the number of participants

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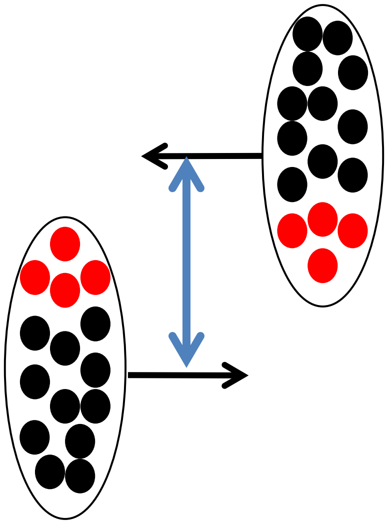
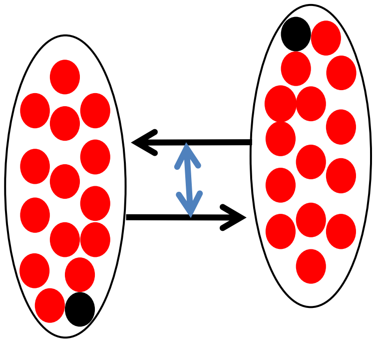
Particle yield for proton-proton collisions / 2

Geometry of a Pb-Pb collision



- Peripheral collision
  - Large distance between the centres of the nuclei
  - Small number of participants
  - Few charged particles produced (low multiplicity)

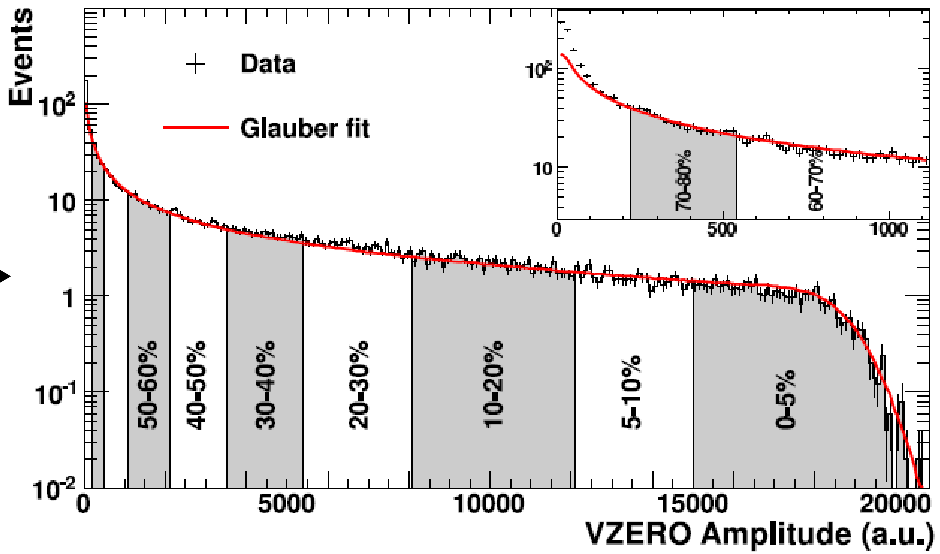


- Central collision
  - Small distance between the centres of the nuclei
  - Large number of participants
  - Many charged particles produced (high multiplicity)

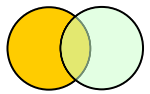
Centrality of Pb-Pb collisions

Distribution of the signal amplitude of V0 (plastic scintillators)

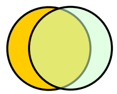
red line : described by model (Glauber)



Centrality	$dN_{ch}/d\eta$	$\langle N_{part} \rangle$	$(dN_{ch}/d\eta)/(\langle N_{part} \rangle/2)$
0%–5%	1601 ± 60	382.8 ± 3.1	8.4 ± 0.3
5%–10%	1294 ± 49	329.7 ± 4.6	7.9 ± 0.3
10%–20%	966 ± 37	260.5 ± 4.4	7.4 ± 0.3
20%–30%	649 ± 23	186.4 ± 3.9	7.0 ± 0.3
30%–40%	426 ± 15	128.9 ± 3.3	6.6 ± 0.3
40%–50%	261 ± 9	85.0 ± 2.6	6.1 ± 0.3
50%–60%	149 ± 6	52.8 ± 2.0	5.7 ± 0.3
60%–70%	76 ± 4	30.0 ± 1.3	5.1 ± 0.3
70%–80%	35 ± 2	15.8 ± 0.6	4.4 ± 0.4

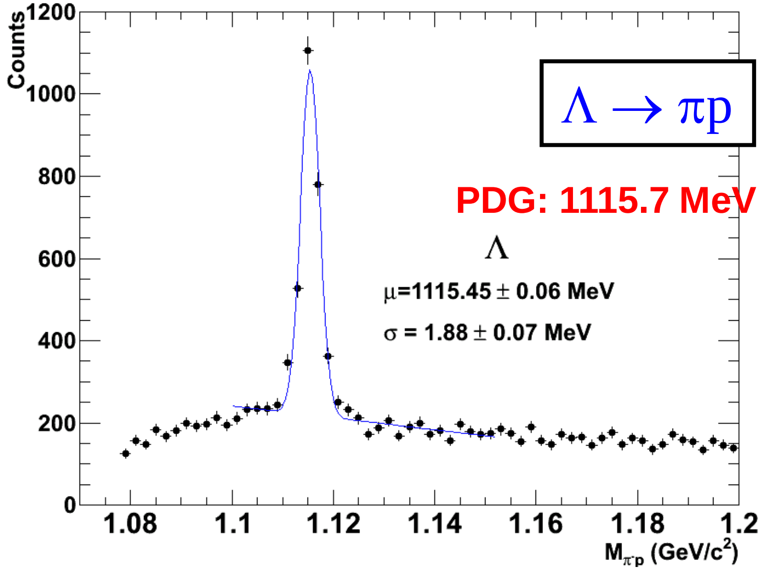


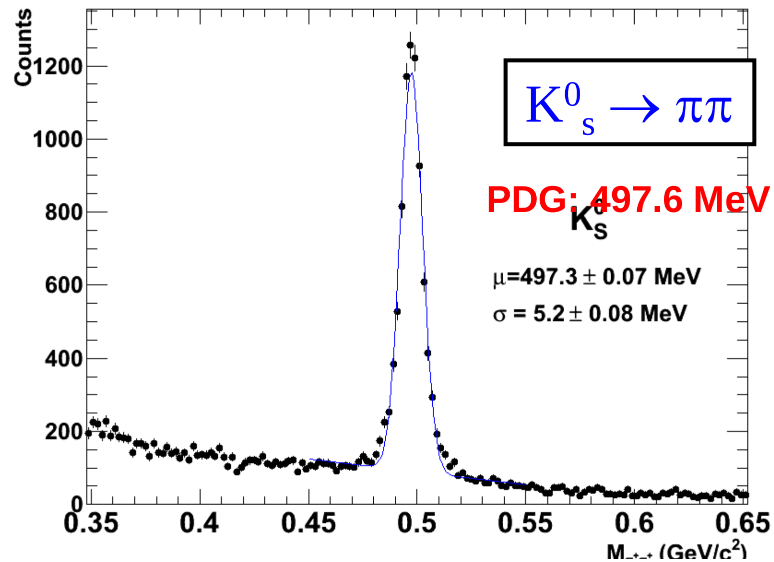
peripheral collisions

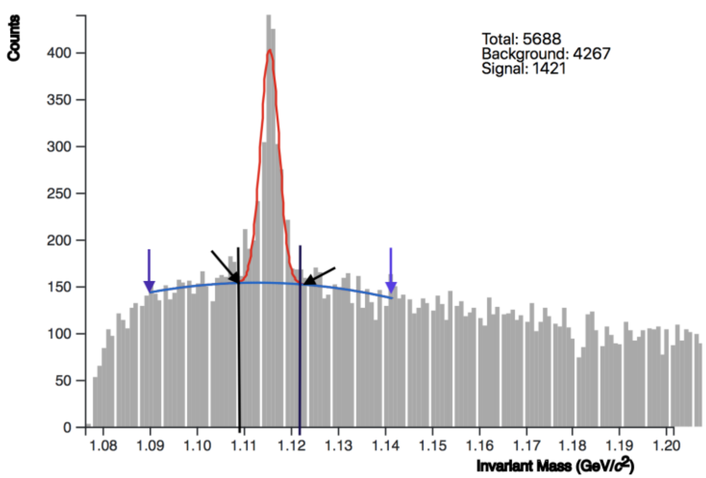


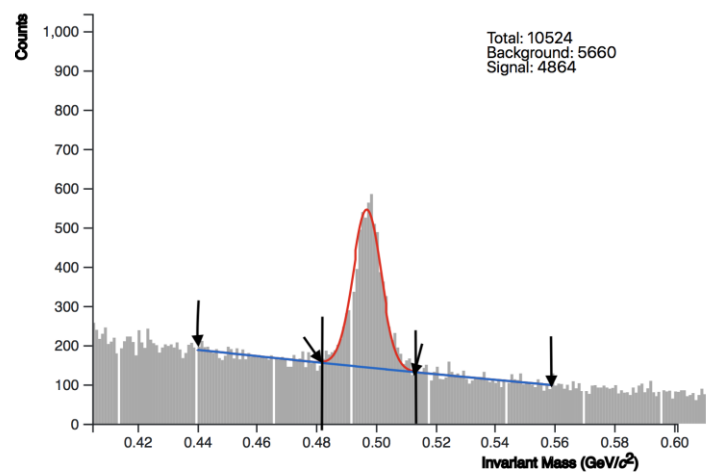
central collisions

Fit functions describing the invariant mass distributions









2nd degree polynomial for the background $f(x) = ax^2+bx+c$

Gaussian for the peak

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

Find the number of K_s, Λ, anti-Λ after subtraction of the background

Strangeness enhancement calculation

Yield : number of particles produced per interaction = Nparticles(produced)/Nevents

Efficiency = Nparticles(measured)/Nparticles(produced)*

Yield = Nparticles(measured)/(efficiency x Nevents)

K_s-Yield (pp) = 0.25 /interaction ; Λ-Yield(pp) = 0.0617 /interaction ; $\langle N_{part} \rangle = 2$ for pp

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

*assumption on efficiency values : to match yields in Analysis Note
Measurement of Ks and Λ spectra and yields in Pb–Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV with the ALICE experiment

*pp yields at 2.76 TeV from interpolation between 900 GeV and 7 TeV
Analysis Note “Ks, Λ and antiΛ production in pp collisions at 7 TeV”