$\Lambda K$ and $\Xi^{-}K^{\pm}$ femtoscopy in Pb-Pb collisions at 2.76 TeV from ALICE

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on behalf of the ALICE Collaboration
Motivation

➢ Study femtoscopic \( \Lambda K \) correlations
   • Result from strong final-state interactions (FSI)
➢ Characterize \( \Lambda K \) pair emission region
➢ Extract \( \Lambda K \) interaction scattering parameters
   • Never before measured
➢ \( \Xi^- K^\pm \) study to investigate difference in \( \Lambda K^+ \) and \( \Lambda K^- \)

| \( \Lambda K^+ \) | \( uds + \bar{us} \) | \( S=0 \) |
| \( \Lambda K^- \) | \( uds + \bar{us} \) | \( S=-2 \) |
| \( \Xi^- K^+ \) | \( dss + \bar{us} \) | \( S=-1 \) |
| \( \Xi^- K^- \) | \( dss + \bar{us} \) | \( S=-3 \) |
Femtoscopy

- Exploit two-particle correlations of hadrons
- Probe space-time freeze-out structure at femtometer scale \((10^{-15} \text{ m})\)
- Measure “regions of homogeneity” \([1]\)
- Unique environment to measure nuclear scattering parameters

**Theory**

- Koonin-Pratt Equation \([2,3]\)

\[
C(P, k^*) = \int S_P(r^*) |\Psi(k^*, r^*)|^2 d^3r^*
\]

- \(S_P(r^*)\) = source distribution
- \(\Psi(k^*, r^*)\) = two-particle wave-function
- \(k^* = |k^*|\) = momentum of one particle in pair rest frame

**Experiment**

\[
C(k^*) = \frac{A(k^*)}{B(k^*)}
\]

- \(A(k^*)\) : signal distribution (same-event)
- \(B(k^*)\) : reference distribution (mixed events)
Theoretical Fit Function

- Lednický and Lyuboshitz formulation \[^{[4]}\]
  - Isotropic Gaussian profile & effective range approximation

\[
\Psi(k^*, r^*) = e^{-ik^* \cdot r^*} + f^S(k^*) \frac{e^{ik^* r^*}}{r^*}
\]

\[
f^S(k^*) = \left( \frac{1}{f_0^S} + \frac{1}{2} d_0^S k^*^2 - ik^* \right)^{-1}
\]

\[
\sigma = 4\pi |f^2|
\]

- Nice analytic form

\[
C(k^*) = 1 + \sum_S \rho_S \left[ \frac{1}{2} \left| \frac{f^S(k^*)}{R} \right|^2 \left( 1 - \frac{d_0^S}{2\sqrt{\pi R}} \right) + \frac{2\Re f^S(k^*)}{\sqrt{\pi R}} F_1(2k^* R) - \frac{\Im f^S(k^*)}{R} F_2(2k^* R) \right]
\]

- \( f_0^S \) – complex scattering length
- \( d_0^S \) – effective range of interaction
- \( R \) – source size
Residual Correlations

- Measured CF is combination of primary signal and transformed residuals \[^{[5]}\]

- \(\lambda_{ij}\) control strength of contribution

\[
C_{\text{measured}}(k^*_\Lambda K) = \mathcal{N} \left( 1 + \lambda'_{\Lambda K} [C_{\Lambda K}(k^*_\Lambda K) - 1] + \sum_{i,j} \lambda'_{ij} [C_{ij}(k^*_\Lambda K) - 1] \right)
\]

\[
\lambda'_{ij} = \lambda_{\text{Fit}} \lambda_{ij}
\]

\[
\sum_{i,j} \lambda'_{ij} = \lambda_{\text{Fit}} \sum_{i,j} \lambda_{ij} = \lambda_{\text{Fit}}
\]

- Modeling parent CF
  - Assume same \(R, f_0^S, d_0^S\) as \(\Lambda K\) system
  - \(\Xi^- K^\pm\) data or Coulomb-only simulation

\[
C_{ij}(k^*_\Lambda K) \equiv \frac{\sum C_{ij} \left(k^*_{ij}\right) T \left(k^*_{ij}, k^*_\Lambda K\right)}{\sum T \left(k^*_{ij}, k^*_\Lambda K\right)}
\]

<table>
<thead>
<tr>
<th>Pair System</th>
<th>(\lambda)-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>0.527</td>
</tr>
<tr>
<td>(\Sigma^0 K^+)</td>
<td>0.111</td>
</tr>
<tr>
<td>(\Xi^0 K^+)</td>
<td>0.039</td>
</tr>
<tr>
<td>(\Xi^- K^+)</td>
<td>0.050</td>
</tr>
<tr>
<td>Other</td>
<td>0.226</td>
</tr>
<tr>
<td>Fakes</td>
<td>0.048</td>
</tr>
</tbody>
</table>

\(\Xi^0 K^+\) Residuals
\(\lambda = 0.039\)

13 June 2019
Jesse T. Buxton (OSU) | SQM 2019
Non-femtoscopic Background

- Significant non-femtoscopic background at large $k^*$
- Effect due primarily to particle collimation associated with elliptic flow $[6]$  
  - Results from mixing events with unlike event-plane angles
- THERMINATOR 2 simulation to model and account for in fit
Results: CFs with Fits

- All analyses fit simultaneously across all centralities
  - For each centrality $R$ and $\lambda_{\text{Fit}}$ shared among all systems
  - Unique set of scattering parameters for each $\Lambda K$ charge combination ($\Lambda K^+, \Lambda K^-, \Lambda K^0_S$)
- Residual contributions from resonance feed-down included
- Non-femtoscopic background and momentum resolution corrections applied
Results: Fit Parameters

- $\Re f_0$ is positive for $\Lambda K^-$ and $\Lambda K^0_s$ → attractive strong interaction
- $\Re f_0$ is negative for $\Lambda K^+ \rightarrow$ repulsive strong interaction
$\Xi^-K^\pm$ Data vs. Coulomb Only

- **Magenta** = Coulomb-only band
  - Spanned by two Coulomb-only CFs

- $\Xi^-K^+$ cannot be described with only Coulomb
  - Strong force showing?
Outlook

- Inclusion of strong and Coulomb interactions
  - No nice analytic form
  - Must integrate by hand

\[ \Psi_{k^*}(\mathbf{r}^*) = e^{i\delta_c} \sqrt{A_c(\eta)} \left[ e^{-ik^* \cdot \mathbf{r}^*} F(-i\eta, 1, i\xi) + f_c(k^*) \frac{\tilde{G}(\rho, \eta)}{r^*} \right] \]

\[ f_c(k^*) = \left[ \frac{1}{f_0} + \frac{1}{2} d_0 k^*^2 - \frac{2}{a_c} h(\eta) - i k^* A_c(\eta) \right]^{-1} \]
Summary

➢ ΛK femtoscopic analysis presented for Pb-Pb collisions at 2.76 TeV
   • First measurement of ΛK scattering parameters
   • Pair emission source radii extracted for 0-10%, 10-30%, and 30-50% centralities

➢ Ξ\(^{-}\)K\(^{±}\) femtoscopic analysis introduced for Pb-Pb collisions at 2.76 TeV
   • Goal to help explain striking difference in ΛK\(^{+}\) and ΛK\(^{-}\) correlations observed at low \(k^*\)
   • A Coulomb-only fit cannot describe the data
Thank you
References


BACKUP
Non-femtoscopic Background

\[ \Lambda K^+ \oplus \bar{\Lambda} K^-, \ 0-10\% \]
- THERM. Bgd.
- ALICE

\[ \Lambda K^- \oplus \bar{\Lambda} K^+, \ 0-10\% \]
- THERM. Bgd.
- ALICE

\[ \Lambda K_S^0 \oplus \bar{\Lambda} K_S^0, \ 0-10\% \]
- THERM. Bgd.
- ALICE

\[ \Lambda K^+ \oplus \bar{\Lambda} K^-, \ 10-30\% \]
- THERM. Bgd.
- ALICE

\[ \Lambda K^- \oplus \bar{\Lambda} K^+, \ 10-30\% \]
- THERM. Bgd.
- ALICE

\[ \Lambda K_S^0 \oplus \bar{\Lambda} K_S^0, \ 10-30\% \]
- THERM. Bgd.
- ALICE

\[ \Lambda K^+ \oplus \bar{\Lambda} K^-, \ 30-50\% \]
- ALICE Preliminary

\[ \Lambda K^- \oplus \bar{\Lambda} K^+, \ 30-50\% \]

\[ \Lambda K_S^0 \oplus \bar{\Lambda} K_S^0, \ 30-50\% \]

\[ Pb-Pb \ \sqrt{s_{\text{NN}}} = 2.76 \text{ TeV} \]

\[ C(k^*) \]

\[ k^* \text{ (GeV/c)} \]
THERMINATOR 2 Background

- THERMINATOR 2: THERMal heavy Ion geneATOR 2
  - Statistical hadronization in relativistic heavy-ion collisions
  - Any freeze-out hypersurface + expansion velocity field can be implemented
- Demonstrates background is scale factor

\[
C_{f \text{ w/o Bgd}} = \frac{C_{f \text{ w . Bgd}}}{Bgd} \quad \rightarrow \quad C_{f \text{ th}} = \frac{C_{f \text{ exp}}}{F_{Bgd}} \quad \rightarrow \quad C_{f \text{ exp}} = C_{f \text{ th}} \cdot F_{Bgd}
\]

Simulation Only:
Interaction achieved by assuming scattering parameters, and weighting the numerators in the simulation
Results: CFs with Fits

\[ C(k^*) \]

\[ \Lambda K^+ \oplus \bar{\Lambda} K^- \quad 0-10\% \]
\[ \Lambda K^- \oplus \bar{\Lambda} K^+ \quad 0-10\% \]
\[ \Lambda K^0 \oplus \bar{\Lambda} K^0 \quad 0-10\% \]

\[ \Lambda K^+ \oplus \bar{\Lambda} K^- \quad 10-30\% \]
\[ \Lambda K^- \oplus \bar{\Lambda} K^+ \quad 10-30\% \]
\[ \Lambda K^0 \oplus \bar{\Lambda} K^0 \quad 10-30\% \]

\[ \Lambda K^+ \oplus \bar{\Lambda} K^- \quad 30-50\% \]
\[ \Lambda K^- \oplus \bar{\Lambda} K^+ \quad 30-50\% \]
\[ \Lambda K^0 \oplus \bar{\Lambda} K^0 \quad 30-50\% \]

ALICE Preliminary

Pb-Pb \( \sqrt{s_{NN}} = 2.76 \text{ TeV} \)

Primary \( \Lambda K \)
Non-femto. bgd.
Full fit

ALI-PREL-323722
$m_T$ Scaling of Radii

- Expect asymmetry $\mu_{out}$ in the outward direction
- Hydrodynamic response on higher $m_T$ particles
  - confines them to smaller homogeneity regions
  - pushes them further in the out direction
- Within 1D model used, a non-zero $\mu_{out}$ induces larger extracted source radii

\[ S_{ab}(r) \propto \exp \left( - \frac{[r_{out} - (\mu_{a,out} - \mu_{b,out})]^2}{2(R_{a,out}^2 + R_{b,out}^2)} \right) \times \exp \left( - \frac{r_{side}^2}{2(R_{a,side}^2 + R_{b,side}^2)} \right) \times \exp \left( - \frac{r_{long}^2}{2(R_{a,long}^2 + R_{b,long}^2)} \right) \]

Figure from [8]
Numerical Integration

- Numerically integrate Koonin-Pratt equation
  - Allows for offset $\mu_{\text{out}}$ to be implemented
- Increasing $\mu_{\text{out}}$ makes source appear larger

$$C(P, k^*) = \int S_P(r^*)|\Psi(k^*, r^*)|^2 d^3r^*$$

$$\Psi(k^*, x^*) = e^{-ik^* \cdot x^*} + f(k^*) \frac{e^{i k^* x^*}}{x^*}$$

$$S_{ab}(r) \propto \prod_{i=o,s,l} \exp \left( -\frac{[r_i - (\mu_{a,i} - \mu_{b,i})]^2}{2(R_{a,i}^2 + R_{b,i}^2)} \right)$$
Shifts with THERM. 2

- Lednicky Fit
  - $\lambda = 1.000$
  - $R = 5.080$
  - $Re[0] = 1.160$
  - $Im[0] = 0.510$
  - $d0 = 1.080$
  - Norm = 1.001

- $N^\text{exp} \left( \frac{X - \mu_{\text{Out}}}{4R_{\text{Out}}} \right)$
  - $\mu_{\text{Out}} = 9.990e-01$
  - $R_{\text{Out}} = 5.002e+00$

- Lednicky Fit
  - $\lambda = 1.000$
  - $R = 5.191$
  - $Re[0] = 1.160$
  - $Im[0] = 0.510$
  - $d0 = 1.080$
  - Norm = 1.001

- $N^\text{exp} \left( \frac{X - \mu_{\text{Out}}}{4R_{\text{Out}}} \right)$
  - $\mu_{\text{Out}} = 3.003e+00$
  - $R_{\text{Out}} = 5.000e+00$

- Lednicky Fit
  - $\lambda = 1.000$
  - $R = 5.709$
  - $Re[0] = 1.160$
  - $Im[0] = 0.510$
  - $d0 = 1.080$
  - Norm = 1.002

- $N^\text{exp} \left( \frac{X - \mu_{\text{Out}}}{4R_{\text{Out}}} \right)$
  - $\mu_{\text{Out}} = 6.001e+00$
  - $R_{\text{Out}} = 5.001e+00$
\[ \Psi_{k^*}(r^*) = e^{i\delta_c} \sqrt{A_c(\eta)} \left[ e^{-ik^* \cdot r^*} F(-i\eta, 1, i\xi) + f_c(k^*) \frac{\tilde{G}(\rho, \eta)}{r^*} \right] \]

\[
 f_c(k^*) = \left[ \frac{1}{f_0} + \frac{1}{2} d_0 k^* \eta - \frac{2}{a_c} h(\eta) - ik^* A_c(\eta) \right]^{-1}
\]

\[
 h(\eta) = 0.5[\psi(i\eta) + \psi(-i\eta) - \ln(\eta^2)]
\]

\[
 \psi(z) = \Gamma'(z)/\Gamma(z)
\]

\[
 \delta_c = \text{Coulomb s-wave phase shift}
\]

\[
 A_c(\eta) = \text{Coulomb penetration factor}
\]

\[
 \tilde{G} = \sqrt{A_c(G_0 + iF_0)}
\]

\[
 F_0 \ (G_0) = \text{regular (singular) s-wave Coulomb functions}
\]

\[
 \rho = k^* r^*
\]

\[
 \eta = (k^* a_c)^{-1}
\]

\[
 \xi = k^* \cdot r^* + k^* r^*
\]

\[
 = \rho \ (1 + \cos \theta^*)
\]

\[
 a_c = (\mu z_1 z_2 e^2)^{-1}
\]
Analysis Details
Analysis Overview

➢ Charged tracks identified with TPC and TOF detectors
   • Purity $K^\pm \approx 97\%$

➢ Neutral V0s identified from decay products
   • $\Lambda \rightarrow p\pi^-$ (Purity $\approx 95\%$)
   • $K^0_S \rightarrow \pi^+\pi^-$ (Purity $\approx 98\%$)

➢ Misidentification cuts
   • Remove $K^0_S$ contamination in $\Lambda(\bar{\Lambda})$ and vice versa

➢ V0 shared daughter cut

➢ Pair cuts
   • Shared daughter
   • Average separation
     ➢ V0 Daughter-V0 Daughter ($\Lambda K^0_S$)
     ➢ V0 Daughter-Track ($\Lambda K^\pm$)
# K± Selection

## Kinematic range

| | 
|---|---|
| $|\eta|$ | < 0.8 |
| $p_T$ | $0.14 < p_T < 1.5$ GeV/c |

## Track quality and selection

<table>
<thead>
<tr>
<th>FilterBit</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of clusters in the TPC</td>
<td>&gt; 80</td>
</tr>
<tr>
<td>$\chi^2/N_{DOF}$ for (ITS, TPC) clusters</td>
<td>&lt; (3.0, 4.0)</td>
</tr>
<tr>
<td>DCA to primary vertex (XY, Z)</td>
<td>&lt; (2.4, 3.0) cm</td>
</tr>
<tr>
<td>Remove particles with any kink labels</td>
<td>true</td>
</tr>
<tr>
<td>N$\sigma$ to primary vertex</td>
<td>&lt; 3.0</td>
</tr>
</tbody>
</table>

## K± identification

### PID Probabilities

| | 
|---|---|
| K | > 0.2 |
| $(\pi, \mu, p)$ | < (0.1, 0.8, 0.1) |
| Most probable particle type (fMostProbable =) | Kaon (3) |

### TPC and TOF N$\sigma$ Cuts

| | 
|---|---|
| $p < 0.4$ GeV/c | $N_{\sigma K,TPC} < 2$ |
| $0.4 < p < 0.45$ GeV/c | $N_{\sigma K,TPC} < 1$ |
| $0.45 < p < 0.80$ GeV/c | $N_{\sigma K,TPC} < 3$  $N_{\sigma K,TOF} < 2$ |
| $0.80 < p < 1.0$ GeV/c | $N_{\sigma K,TPC} < 3$  $N_{\sigma K,TOF} < 1.5$ |
| $p > 1.0$ GeV/c | $N_{\sigma K,TPC} < 3$  $N_{\sigma K,TOF} < 1$ |
# K± Misidentification Cuts

<table>
<thead>
<tr>
<th>K± selection - Misidentification Cuts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electron Rejection:</strong> Reject if</td>
</tr>
<tr>
<td><strong>Pion Rejection:</strong> Reject if:</td>
</tr>
<tr>
<td>$p &lt; 0.65 \text{ GeV/c}$</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>$0.65 &lt; p &lt; 1.5 \text{ GeV/c}$</td>
</tr>
<tr>
<td>$p &gt; 1.5 \text{ GeV/c}$</td>
</tr>
</tbody>
</table>
Λ(Λ) Reconstruction

\[ \Lambda \rightarrow p\pi^- (\bar{\Lambda} \rightarrow \bar{p}\pi^+) \]
- \( c\tau = 7.9 \text{ cm} \)
- Branching ratio \( \sim 64\% \)
- Purity(Λ) \( \sim \) Purity(\( \bar{\Lambda} \)) \( \sim 95\% \)

\( \Lambda \) reconstruction

| \(|\eta|\) | < 0.8 |
| --- | --- |
| \( p_T \) | > 0.4 GeV/c |
| \(|m_{\text{inv}} - m_{\text{PDG}}|\) | < 3.8 MeV |
| DCA to prim. vertex | < 0.5 cm |
| Cosine of pointing angle | > 0.9993 |
| OnFlyStatus | false |
| Decay Length | < 60 cm |
| Shared Daughter Cut | true |
| Misidentification Cut | true |

Daughter Cuts (π and p)

| \(|\eta|\) | < 0.8 |
| Number of clusters in the TPC | > 80 |
| Daughter status | kTPCrefit |
| DCA \( \pi p \) Daughters | < 0.4 cm |

\( \pi \)-specific cuts

| \( p_T \) | > 0.16 GeV/c |
| DCA to prim vertex | > 0.3 cm |

TPC and TOF \( N_\sigma \) Cuts

| \( p \) | \( N_\sigma_{\text{TPC}} < 3 \) |
| \( p > 0.5 \text{ GeV/c} \) if TOF & TPC available | \( N_\sigma_{\text{TPC}} < 3 \) & \( N_\sigma_{\text{TOF}} < 3 \) |
| \( p > 0.5 \text{ GeV/c} \) else | \( N_\sigma_{\text{TOF}} < 3 \) |

\( p \)-specific cuts

| \( p_T \) | > 0.5(p) \( \left| 0.3(\bar{p}) \right| \) GeV/c |
| DCA to prim vertex | > 0.1 cm |

TPC and TOF \( N_\sigma \) Cuts

| \( p \) | \( N_\sigma_{\text{TPC}} < 3 \) |
| \( p < 0.8 \text{ GeV/c} \) if TOF & TPC available | \( N_\sigma_{\text{TPC}} < 3 \) & \( N_\sigma_{\text{TOF}} < 3 \) |
| \( p > 0.8 \text{ GeV/c} \) else | \( N_\sigma_{\text{TOF}} < 3 \) |
$K_s^0 \to \pi^+\pi^-$

- $c\tau = 2.7 \text{ cm } (15 \text{ m for } K^0_L)$
- Branching ration $\sim 70\%$
- Purity($K_s^0$) $\sim 98\%$

<table>
<thead>
<tr>
<th>$K_s^0$ reconstruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>$</td>
</tr>
<tr>
<td>$p_T$</td>
</tr>
<tr>
<td>$m_{PDG} - 13.677 \text{ MeV} &lt; m_{inv} &lt; m_{PDG} + 2.0323 \text{ MeV}$</td>
</tr>
<tr>
<td>DCA to prim. vertex</td>
</tr>
<tr>
<td>Cosine of pointing angle</td>
</tr>
<tr>
<td>OnFlyStatus</td>
</tr>
<tr>
<td>Decay Length</td>
</tr>
<tr>
<td>Shared Daughter Cut</td>
</tr>
<tr>
<td>Misidentification Cut</td>
</tr>
</tbody>
</table>

$\pi^\pm$ Daughter Cuts

| $|\eta|$ | $< 0.8$ |
| Number of clusters in TPC | $> 80$ |
| Daughter Status            | kTPCrefit |
| DCA $\pi^+\pi^-$ Daughters | $< 0.3 \text{ cm}$ |
| $p_T$                       | $> 0.15 \text{ GeV}/c$ |
| DCA to prim vertex         | $> 0.3 \text{ cm}$ |
| TPC and TOF $N\sigma$ Cuts |
| $p < 0.5 \text{ GeV}/c$    | $N_{TPC} < 3$ |
| $p > 0.5 \text{ GeV}/c$    | if TOF & TPC available $N_{TPC} < 3 \text{ & } N_{TOF} < 3$ |
|                           | else $N_{TOF} < 3$ |
Misidentification Cuts: V0s

- Remove $K^0_S$ contamination from $\Lambda(\bar{\Lambda})$ sample
  - Reject candidate if all of the following are satisfied (essentially, reject if candidate would pass as $K^0$):
    - $|m_{\text{inv},K^0_S \text{Hypothesis}} - m_{\text{PDG},K^0_S}| < 9.0 \text{ MeV}/c^2$
    - Pos. and neg. daughters pass $\pi$ cuts from $K^0_S$ reconstruction
    - $|m_{\text{inv},K^0_S \text{Hypothesis}} - m_{\text{PDG},K^0_S}| < |m_{\text{inv},\Lambda(\bar{\Lambda}) \text{Hypothesis}} - m_{\text{PDG},\Lambda(\bar{\Lambda})}|$

- Remove $\Lambda(\bar{\Lambda})$ contamination from $K^0_S$ sample
  - Similar to $\Lambda$ procedure above, reject if:
    - $|m_{\text{inv},\Lambda(\bar{\Lambda}) \text{Hypothesis}} - m_{\text{PDG},\Lambda(\bar{\Lambda})}| < 9.0 \text{ MeV}/c^2$
    - Pos. daughter passes $p+(\pi^+)$ cut from $\Lambda(\bar{\Lambda})$ reconstruction
    - Neg. daughter passes $\pi-(\bar{p}-)$ cut from $\Lambda(\bar{\Lambda})$ reconstruction
    - $|m_{\text{inv},\Lambda(\bar{\Lambda}) \text{Hypothesis}} - m_{\text{PDG},\Lambda(\bar{\Lambda})}| < |m_{\text{inv},K^0_S \text{Hypothesis}} - m_{\text{PDG},K^0_S}|$
Pair Cuts: $\Lambda K$

- **Shared daughter cut for pairs**
  - **V0-V0 Pairs** (i.e. $\Lambda K^0_S$ analyses)
    - Remove all pairs which share a daughter
    - Ex. $\Lambda$ and $K^0_S$ particles which share a $\pi^-$ daughter are excluded
  - **V0-Track Pairs** (i.e. $\Lambda K^\pm$ analyses)
    - Remove pairs if $K^\pm$ track is also used as V0 daughter
    - Only occurs if, for instance, $K^\pm$ is misidentified as $\pi$ or $p$ in the V0 reconstruction

- **Average separation cuts**
  - $\Lambda K^0_S$
    - $\Delta r > 6.0$ cm for like sign daughters
    - No requirement, unlike signs
  - $\Lambda K^\pm$
    - $\Delta r > 8.0$ cm for like sign daughter and track
    - No requirement, unlike signs
**Ξ⁻ Reconstruction**

\[ \Xi^- \rightarrow \Lambda\pi^- \quad (\Xi^+ \rightarrow \bar{\Lambda}\pi^+) \]
- \( c\tau = 4.9 \text{ cm} \)
- Branching ratio \( \sim 99.9\% \)

**Purity(Ξ⁻) ~ 90%**
**Purity(Ξ⁺) ~ 92%**
# Ξ⁻ Reconstruction

## Ξ⁻ reconstruction

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>$</td>
<td>\eta</td>
</tr>
<tr>
<td>$p_T$</td>
<td>&gt; 0.8 GeV/c</td>
</tr>
<tr>
<td>$</td>
<td>m_{\text{inv}} - m_{\text{PDG}}</td>
</tr>
<tr>
<td>DCA to prim. vertex</td>
<td>&lt; 0.3 cm</td>
</tr>
<tr>
<td>Cosine of pointing angle</td>
<td>&gt; 0.9992</td>
</tr>
</tbody>
</table>

## Λ daughter cuts

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>DCA to prim. vertex</td>
<td>&gt; 0.2 cm</td>
</tr>
<tr>
<td>Cosine of pointing angle</td>
<td>&gt; 0.0</td>
</tr>
<tr>
<td>Cosine of pointing angle to Ξ decay vertex</td>
<td>&gt; 0.9993</td>
</tr>
<tr>
<td>OnFlyStatus</td>
<td>false</td>
</tr>
</tbody>
</table>

All other Λ and corresponding ($\pi$ and $p$) daughter cuts are same as in primary Λ selection.

## Bachelor $\pi$ cuts

<p>| | |</p>
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<thead>
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</thead>
<tbody>
<tr>
<td>$</td>
<td>\eta</td>
</tr>
<tr>
<td>$p_T$</td>
<td>&gt; 0.0 GeV/c</td>
</tr>
<tr>
<td>DCA to prim. vertex</td>
<td>&gt; 0.1 cm</td>
</tr>
<tr>
<td>Number of clusters in the TPC</td>
<td>&gt; 70</td>
</tr>
<tr>
<td>Daughter status</td>
<td>kTPCrefit</td>
</tr>
</tbody>
</table>

### TPC and TOF $N\sigma$ Cuts

<table>
<thead>
<tr>
<th>$p$</th>
<th>$N\sigma_{\text{TPC}}$</th>
<th>$N\sigma_{\text{TOF}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.5 GeV/c</td>
<td>if TOF &amp; TPC available</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>&gt; 0.5 GeV/c</td>
<td>else</td>
<td>$N\sigma_{\text{TPC}} &lt; 3$ &amp; $N\sigma_{\text{TOF}} &lt; 3$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 3</td>
</tr>
</tbody>
</table>
Pair Cuts: $\Xi^-K^\pm$

- Pair fails if
  - $K^\pm$ is a (misidentified) daughter of the $\Xi^-$
  - Bachelor $\pi$ is also a daughter of the $\Lambda$
- $\Xi$ shared daughter cut
  - Iterates through $\Xi$ collection to ensure no daughter is used by more than one $\Xi$
- Average separation cut for all daughters
  - $\overline{\Delta r} > 8.0$ cm for daughters of $\Xi^-$ and $K^\pm$ sharing the same charge
  - No requirement for unlike-charges
THERM. 2: Playing with flow

➢ Study how different anisotropic flow affects background
➢ THERM. 2 model includes flow effects in standard implementation (left)
➢ Introduce strong artificial anisotropic flow signals for more controlled study (right)
  • Sample emission angles from: \( P(\phi) = \frac{1}{2} [1 + \cos(n\phi)] \)
➢ Flow signal killed by randomizing emission