Recent Hadronic Resonance Measurements at ALICE

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on behalf of the ALICE Collaboration
28 June 2016
Motivation

• pp and p–Pb collisions:
  – Baseline measurements for A–A
  – Input for event generators
  – $R_{pPb}$: system size dependence

• In-Medium Energy Loss:
  – $R_{AA}$: Study flavor dependence

• Shapes of Particle $p_T$ Spectra:
  – Hydrodynamics: particle masses determine shapes of spectra
  – Recombination: possible baryon/meson differences

• Properties of Hadronic Phase…
Hadronic Phase

- Reconstructible resonance yields may be changed by hadronic scattering processes after chemical freeze-out:
  - **Regeneration:** pseudo-elastic scattering of decay products
    - e.g., $\pi K \rightarrow K^* \rightarrow \pi K$
  - **Re-scattering:**
    - Resonance decay products undergo elastic scattering
    - Or pseudo-elastic scattering through a different resonance (e.g. $\rho$)
    - Resonance not reconstructed through invariant mass
• Reconstructible resonance yields may be changed by hadronic scattering processes after chemical freeze-out:
  – **Regeneration:** pseudo-elastic scattering of decay products
    • e.g., $\pi K \rightarrow K^* \rightarrow \pi K$
  – **Re-scattering:**
    • Resonance decay products undergo elastic scattering
    • Or pseudo-elastic scattering through a different resonance (e.g. $\rho$)
    • Resonance not reconstructed through invariant mass

• Final yields at kinetic freeze-out depend on
  – Initial Yields: chemical freeze-out temperature
  – Elapsed time between chemical and kinetic freeze-out
  – Resonance lifetime
  – Scattering cross-sections of decay products

• Re-scattering and regeneration expected to be **most important for** $p_T < 2 \text{ GeV}/c$ (UrQMD)
ALICE Detector

TPC: Tracking and PID through $dE/dx$

TOF: PID through particle time of flight

V0 (scintillators): centrality estimate through V0 multiplicity

ITS (silicon): Tracking and Vertexing
ρ⁰ Reconstruction

- Analyzed in pp and Pb–Pb collisions at 2.76 TeV
- Subtract like-charge combinatorial background
- Fit with residual background + cocktail (K₀, K*, ω, f₀, f₂)
- Peak Model: Relativistic Breit-Wigner × Phase Space × Mass-Dependent Efficiency × Söding Interference Term

ρ⁰

\[ \frac{u\bar{u}+d\bar{d}}{\sqrt{2}} \quad \text{B.R. } \sim 100\% \]

- \( m = 770 \text{ MeV}/c^2 \)
- \( \Gamma = 150 \text{ MeV}/c^2 \)

NEW RESULT

\[ \text{Counts } \times 10^6 / (0.02 \text{ GeV}/c^2) \]

ALICE Preliminary

0.5 < \( p_T \) < 1 GeV/c

ALI-PREL-107636

Knospe
Other Resonances

\( \pi^- \rightarrow K^+ \)
\( m = 896 \text{ MeV}/c^2 \)
\( \Gamma = 47.4 \text{ MeV}/c^2 \)
\( \text{B.R.} = 66.6\% \)

\( s\bar{s} \rightarrow \pi^+ \)
\( m = 1019 \text{ MeV}/c^2 \)
\( \Gamma = 4.266 \text{ MeV}/c^2 \)
\( \text{B.R.} = 48.9\% \)

\( \Xi^* \rightarrow \Xi^- \rightarrow \pi^+ \)
\( m = 1532 \text{ MeV}/c^2 \)
\( \Gamma = 9.1 \text{ MeV}/c^2 \)
\( \text{B.R.} = 66.7\% \)

\( \Sigma^{*+} \rightarrow \pi^- \)
\( m = 1383 \text{ MeV}/c^2 \)
\( \Gamma = 36.0 \text{ MeV}/c^2 \)
\( \text{B.R.} = 87\% \)

\( \Sigma^{*-} \rightarrow \pi^+ \)
\( m = 1387 \text{ MeV}/c^2 \)
\( \Gamma = 39.4 \text{ MeV}/c^2 \)
\( \text{B.R.} = 87\% \)

\( \Lambda \)

NEW

ALICE Preliminary
\( \text{Pb-Pb} \) \( \sqrt{s_{NN}} = 5.02 \text{ TeV} \)
\( 0-90\% \)

Counts / (0.01 GeV/c^2)

\( K^*(892)^0 \)
\( 2.0 < p_T < 3.0 \text{ GeV}/c \)
\( \text{Data (stat. uncert.)} \)
\( \text{Breit-Wigner Fit} \)
\( \text{Residual BG} \)

\( \phi(1020) \)
\( 2.5 < p_T < 2.8 \text{ GeV}/c \)
\( \text{Data (stat. uncert.)} \)
\( \text{Voigtian Peak Fit} \)
\( \text{Residual BG} \)

\( \Xi^*(1385)^+ \)
\( -0.5 < y_{CMS} < 0, 2.0 < p_T < 2.5 \text{ GeV}/c \)
\( \text{Data (MEM subtracted)} \)
\( \text{Voigtian fit} \)
\( \text{Residual background} \)
Ratios to Stable Hadrons (pp)

- Ratios in pp: **new ALICE** measurements of $\rho^0/\pi$ at 2.76 TeV, $K^{*0}/K$ and $\phi/K$ at 13 TeV:
  - No energy dependence through 2-3 orders of magnitude
Ratios to Stable Hadrons

- Suppression of $\rho^0/\pi$ and $K^*/K$ in central Pb–Pb w.r.t. peripheral, pp, p–Pb, thermal model
  - Suggests that re-scattering is dominant over regeneration
  - Well described by EPOS w/ UrQMD
- $K^*/K$ in small systems:
  - Decreasing trend observed in p–Pb (slope not consistent with 0)
  -Multiplicity-dependent suppression in pp
- No suppression of $\phi/K$, no strong centrality dependence
  - Central Pb–Pb consistent w/ thermal model
  - Lifetime of $\phi \sim 10 \times$ longer than $K^*$, $\sim 35 \times$ longer than $\rho^0$ → re-scattering effects not significant
  - Ratio in p–Pb consistent with trend from pp to peripheral Pb–Pb
- Additional Material: See backup slides for $\rho^0 R_{AA}$ and multiplicity dependence of $K^*$
  $p_T$ spectra in pp collisions at 7 TeV.
\[ \rho^0/\pi \text{ Ratio vs. } \rho_T \]

- **In Pb–Pb:**
  - Fair description by EPOS3 with UrQMD
  - Central: EPOS without UrQMD overestimates ratio at low \( p_T \)
    \( \rightarrow \) reduction of \( \rho^0 \) yield due to re-scattering
  - Peripheral: both EPOS calculations describe low-\( p_T \) ratio
- **In pp:** see backup for comparisons to PYTHIA, PHOJET

NEW RESULT

**ALICE Preliminary**

\[ \rho^0/\pi \text{ Ratio vs. } \rho_T \]

**Central Pb–Pb**

- EPOS3, PRC93 (2016) 1, 014911
- EPOS3 without UrQMD

**Peripheral Pb–Pb**

- EPOS3, PRC93 (2016) 1, 014911
- EPOS3 without UrQMD
Properties of Hadronic Phase

- Toy Model: assume any K*\(^0\) that decays before kinetic freeze-out is lost due to re-scattering, neglect regeneration and time dilation
  - Exponential decrease in yield (\(\tau = 4.2 \text{ fm/c}\))
  - Use MB pp as initial value, central Pb–Pb as final value → lifetime of hadronic phase \(\Delta t \geq 1.5 \text{ fm/c}\)

- Model of Torrieri, Rafelski, et al.: K*\(^0\)/K as function of \(T_{\text{ch}}\) and \(\Delta t\)
  - Assume \(\Delta t = 0\), Measured K*\(^0\)/K → \(T_{\text{ch}} = 120 \text{ MeV}\)
  - Assume \(T_{\text{ch}} = 156 \text{ MeV}\), Measured K*\(^0\)/K → \(\Delta t \geq 2 \text{ fm/c}\)

\[\frac{1}{100} \quad 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10 \quad 11 \quad 12 \quad 13 \quad 14 \quad 15\]

\(K^0/\bar{K}\) in ALICE Preliminary

\(\langle dN_{\text{ch}}/d\eta \rangle_{\text{lab}}^{1/3} \leq 0.5\)

\(\Gamma_{K^*} = 50 \text{ MeV}\)

\[\text{thermally produced}\]

\[\text{life[fm]}\]

- ALI-PREL-111229

Ratios to Stable Hadrons

- New measurements of $\Sigma^{*\pm}$ and $\Xi^{*0}$ in p–Pb collisions at 5.02 TeV
  - Measurements in progress for Pb–Pb collisions at 2.76 TeV
- No strong dependence of $\Sigma^{*\pm}/\Lambda$ on energy or system size
  - Values consistent with thermal model and PYTHIA predictions
- No system size dependence of $\Xi^{*0}/\Xi$ at LHC
  - Values in pp and p–Pb tend to be below thermal model predictions
• **New measurement** in pp collisions at 13 TeV
  
  • $p/\phi$ flat for central collisions for $p_T < 3$–$4 \text{ GeV}/c$
    - Consistent with hydrodynamic evolution, some recombination models can also describe it
  
  • $p/\phi$ in high-multiplicity $p$–Pb:
    - For $p_T > 1 \text{ GeV}/c$: similar to pp and peripheral Pb–Pb (not shown)
    - For $p_T < 1 \text{ GeV}/c$: decrease (flattening?) in $p/\phi$: hint of onset of collective behavior in high-multiplicity $p$–Pb?

**Graphical Data:**

- **ALICE**
- **NEW**
- pp 13 TeV INEL, Preliminary
- pp 7 TeV INEL
- p-Pb 5.02 TeV, 0-5%
- Pb-Pb 2.76 TeV, 0-10%

**Uncertainties:** stat. (bars), sys. (boxes)

**Equations and References:**

Mean $\langle p_T \rangle$

- **Central Pb–Pb:** $K^0$, $p$, $\phi$ have same $\langle p_T \rangle \rightarrow$ consistent with hydrodynamics
- **Small systems:**
  - p–Pb and pp: $\langle p_T \rangle$ values rise faster with mult. than Pb–Pb, reach similar values at high multiplicity as central Pb–Pb
- Different particle production mechanisms? Harder scattering?

$\langle dN_{\text{ch}} / d\eta_{\text{lab}} \rangle^{1/3}_{|\eta_{\text{lab}}| < 0.5}$

Uncertainties: stat.(bars), sys.(boxes)

ALICE $K^0 \phi p$

Pb–Pb $\sqrt{s_{\text{NN}}} = 2.76$ TeV

p–Pb $\sqrt{s_{\text{NN}}} = 5.02$ TeV

pp $\sqrt{s} = 7$ TeV (Preliminary)

- Central Pb–Pb: $K^0$, $p$, $\phi$ have same $\langle p_T \rangle \rightarrow$ consistent with hydrodynamics
- Small systems:
  - p–Pb and pp: $\langle p_T \rangle$ values rise faster with mult. than Pb–Pb, reach similar values at high multiplicity as central Pb–Pb
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NEW
Mean $\langle p_T \rangle$

- Central Pb–Pb: $K^*$, $p$, $\phi$ have same $\langle p_T \rangle$ \(\rightarrow\) consistent with hydrodynamics
- Small systems:
  - $p$–Pb and pp: $\langle p_T \rangle$ values rise faster with mult. than Pb–Pb, reach similar values at high multiplicity as central Pb–Pb
- Different particle production mechanisms? Harder scattering?
  - Mass ordering violated: $K^*$ and $\phi$ have larger $\langle p_T \rangle$ values than $p$ and $\Lambda$
  - Is there a baryon/meson difference, or do resonances not obey mass ordering?
Summary

- Resonance Suppression:
  - Central Pb–Pb: $\rho^0$ & $K^*$ suppressed (re-scattering)
    - $\phi$ not suppressed (longer lifetime)
    - From $K^*/K^-$ ratio: lower limit on lifetime of hadronic phase: 2 fm/c
    - Described by EPOS (with UrQMD)
  - p–Pb: $K^*/K$ and $\phi/K$ ratios follow trend from pp to peripheral Pb–Pb
  - pp: $K^*/K$ suppressed at high multiplicity

- $p/\phi$ ratio:
  - Flat vs. $p_T$ for central Pb-Pb ($p_T<3$-4 GeV/c), consistent with hydrodynamics
  - Hint of flattening at low $p_T$ in high-mult. p–Pb: possible onset of collective effects?

- Mean $p_T$:
  - $<p_T>$ in pp and p–Pb and follow different trends w.r.t. Pb–Pb
  - For central Pb–Pb: $<p_T(K^0)> \approx <p_T(p)> \approx <p_T(\phi)>$ consistent with hydrodynamics
  - Mass ordering violated for pp, p–Pb, peripheral Pb–Pb: $<p_T(K^0,\phi)> > <p_T(p,\Lambda)>$
    - Baryon/meson difference?
Outlook

- Measurements in progress:
  - $\rho^0$ in p–Pb
  - $K^*0$ & $\phi$ vs. multiplicity in pp collisions at 7 and 13 TeV
  - $K^*0$ & $\phi$ in new Pb–Pb data (5.02 TeV)
  - $\Sigma^0$ in pp collisions at 7 TeV
  - $\Sigma^{*\pm}$ and $\Xi^{*0}$ in Pb–Pb collisions at 2.76 TeV
  - $\Lambda(1520)$ in pp, p–Pb, and Pb–Pb collisions

- EPOS predicts strong $\Lambda(1520)$ suppression (cf. $\rho^0$ and $K^*0$)
Additional Material
Resonance Reconstruction

- Resonances measured in pp (0.9, 2.76, 7, 13 TeV), p–Pb (5.02 TeV), and Pb–Pb (2.76, 5.02 TeV) collisions

<table>
<thead>
<tr>
<th>Particle</th>
<th>Mass (MeV/$c^2$)</th>
<th>Width (MeV/$c^2$)</th>
<th>Decay</th>
<th>Branching Ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho^0$</td>
<td>770</td>
<td>150</td>
<td>$\pi^-\pi^+$</td>
<td>100</td>
</tr>
<tr>
<td>$K^{*0}$</td>
<td>896</td>
<td>47.4</td>
<td>$\pi^-K^+$</td>
<td>66.7</td>
</tr>
<tr>
<td>$\phi$</td>
<td>1019</td>
<td>4.27</td>
<td>$K^-K^+$</td>
<td>48.9</td>
</tr>
<tr>
<td>$\Sigma^{*+}$</td>
<td>1383</td>
<td>36.0</td>
<td>$\pi^+\Lambda$</td>
<td>87</td>
</tr>
<tr>
<td>$\Sigma^{*-}$</td>
<td>1387</td>
<td>39.4</td>
<td>$\pi^-\Lambda$</td>
<td>87</td>
</tr>
<tr>
<td>$\Lambda(1520)$</td>
<td>1520</td>
<td>15.7</td>
<td>$K^-p$</td>
<td>22.5</td>
</tr>
<tr>
<td>$\Xi^{*0}$</td>
<td>1532</td>
<td>9.1</td>
<td>$\pi^+\Xi^-$</td>
<td>66.7</td>
</tr>
</tbody>
</table>
\( \rho^0: \) Söding Interference Term

- Accounts for Bose-Einstein correlations between pions produced in \( \rho \) decays and other identical pions nearby in phase space

\[
f_i(m) = C \left( \frac{m_0^2 - m^2}{m \Gamma(m)} \right) f_s(m)
\]

- Used for
  - ALICE for \( \rho^0 \) in ultra-peripheral collisions: see talk of O. Villalobos Baillie, SQM 2016
$\rho^0 \ p_T$ Spectra

ALICE Preliminary

$\sqrt{s_{NN}} = 2.76$ TeV

$\rho \rightarrow \pi^+\pi^- \ |y|<0.5$

NEW RESULT

Levy-Tsallis fit

0-20% $\times 2^3$

20-40% $\times 2^2$

40-60% $\times 2^1$

60-80% $2^0$

pp $\times 2^{-1}$

$\frac{d^2N}{dp_T\,dy}$ (GeV/c)$^{-1}$

$\rho_T$ (GeV/c)
\( \rho^0 \) in pp collisions at 2.76 TeV: all models predict softer spectrum than observed

- PHOJET, PYTHIA ATLAS-CSC, & PYTHIA Monash 2013 tend to under-predict yields for \( p_T > 1 \) GeV/c
- PYTHIA D6T over-predicts yield for \( 2 < p_T < 5 \) GeV/c
- PYTHIA Perugia 11 describes data within uncertainties for \( p_T > 1 \) GeV/c
$\rho^0/\pi$ Ratio vs. $p_T$ (pp)

- Measured $\rho^0/\pi$ ratio in pp collisions at 2.76 TeV compared to models:
  - PYTHIA D6T and ATLAS-CSC over-predict
  - PHOJET and PYTHIA Perugia 11 under-predict
  - Best Description by PYTHIA Monash 2013

![Graph showing $\rho/\pi$ ratio vs. $p_T$ with data points and theoretical predictions.](ALI-PREL-107733)
New measurements at 2.76 TeV
- High $p_T$: consistent with light $h^\pm$
- Consistent with other mesons over wider $p_T$ range than $\rho$
- Distorted by radial flow and suppression at low $p_T$

$$R_{AA}(p_T) = \frac{\text{Yield}(A-A)}{\text{Yield}(pp) \times \langle N_{\text{coll}} \rangle}$$
**$K^*$ and $\phi$ Reconstruction**

- Analyzed in pp collisions at 0.9, 7 (vs. multiplicity), 13 TeV; p–Pb collisions at 5.02 TeV; Pb–Pb collisions at 2.76 & 5.02 TeV
- Subtract mixed-event or like-charge combinatorial backgrounds
- Polynomial residual background
- Peaks: Breit-Wigner ($K^*$) or Voigtian ($\phi$)

**$K^*$**
- $d\bar{s}$
- B.R. = 66.6%
- $m = 896$ MeV/$c^2$
- $\Gamma = 47.4$ MeV/$c^2$

**$\phi$**
- $s\bar{s}$
- B.R. = 48.9%
- $m = 1019$ MeV/$c^2$
- $\Gamma = 4.266$ MeV/$c^2$

**Data**
- ALICE Preliminary
- $\sqrt{s} = 13$ TeV (min. bias)
- Data (stat. uncert.)
- Breit-Wigner Peak Fit
- Residual BG
- $1.2 < p_T < 1.4$ GeV/$c$

**NEW**
- pp 13 TeV
- ALICE Preliminary

**NEW**
- $\phi$
- pp $\sqrt{s} = 13$ TeV (min. bias)
- Data (stat. uncert.)
- Voigtian Peak Fit
- Residual BG
- $1.1 < p_T < 1.2$ GeV/$c$
**K*^0 and \( \phi \) Reconstruction**

- Analyzed in pp collisions at 0.9, 7 (vs. multiplicity), 13 TeV; p–Pb collisions at 5.02 TeV; Pb–Pb collisions at 2.76 & 5.02 TeV
- Subtract mixed-event or like-charge combinatorial backgrounds
- Polynomial residual background
- Peaks: Breit-Wigner (K*^0) or Voigtian (\( \phi \) )

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**Graphs**

- **(a)** 
  - NSD x 1
  - 0-20% x 4
  - 20-40% x 2
  - 40-60% x 1/2
  - 60-80% x 1/4
  - 80-100% x 1/8
  - ALICE, p-Pb \( \sqrt{s_{\text{NN}}} = 5.02 \text{ TeV} \)
  - \(-0.5 < y < 0\)
  - \( p_T (\text{GeV/c}) \)

- **(b)** 
  - NSD x 1
  - 0-5% x 16
  - 5-10% x 8
  - 10-20% x 8
  - 20-40% x 2
  - 40-60% x 1/2
  - 60-80% x 1/4
  - 80-100% x 1/8
  - ALICE, p-Pb \( \sqrt{s_{\text{NN}}} = 5.02 \text{ TeV} \)
  - \(-0.5 < y < 0\)
  - \( p_T (\text{GeV/c}) \)

---

Multiplicity Dependence \((K^*0)\)  

- \(K^*0\) measured in pp collisions at 7 TeV in 9 multiplicity bins  
  - Multiplicity measured in ALICE V0: \(-3.7 < \eta < -1.7\) and \(2.8 < \eta < 5.1\)  
  - \(K^*0\) measured in \(|y| < 0.5\)

- Low \(\rightarrow\) high multiplicity: spectra harden

- Same shapes for \(p_T > 4\) GeV/c

- Similar behavior for other Hadrons: see also talk of R. Derradi de Souza, SQM 201

NEW RESULT

**K**

NEW RESULT

\(K^0\)s

**NEW RESULT**

\(1/N_{\text{ev}}d^2N/dp_T\) (GeV\(c^2\))

\(1/N_{\text{ev}}d^2N/dp_T\) (GeV\(c^2\))

Ratio to INEL>0

Ratio to INEL>0

\(p_T\) (GeV/c)
φ Nuclear Modification

• In Pb–Pb:
  – Shape differences between $p$ and $φ$ due to differences in reference ($pp$) spectra
  – Strong suppression of all hadrons at high $p_T$

$$R_{AA}(p_T) = \frac{\text{Yield(A–A)}}{\text{Yield(pp)×<N_{coll}>}}$$

• In $p$–Pb:
  – No suppression of $φ$ w.r.t. $pp$ for $p_T > 1.5$ GeV/c
  – Intermediate $p_T$: Cronin peak for $p$, smaller peak for $φ$
  – Possible mass dependence or baryon/meson differences in $R_{pPb}$
Ratios to Stable Hadrons

- Ratios in pp: new ALICE measurements of $\rho^0/\pi$ at 2.76 TeV, $K^{*0}/K$ and $\phi/K$ at 13 TeV:
  - No energy dependence through 2-3 orders of magnitude
- Ratios in larger collision systems:
  - No clear dependence of $\phi/K$ on energy or system size at RHIC and LHC
  - Suppression of $K^{*0}/K$ observed…

- Ratios in larger collision systems:  
  - No clear dependence of $\phi/K$ on energy or system size at RHIC and LHC  
  - Suppression of $K^{*0}/K$ observed…
Non-equilibrium Model

- Chemical non-equilibrium statistical hadronization model
- Factors $\gamma_q \neq 1$ and $\gamma_s \neq 1$ that modify u/d and s pair yields w.r.t. equilibrium values
  - $\gamma_q \neq 1$ when "source of hadrons disintegrates faster than the time necessary to re-equilibrate the yield of light quarks present."
- Gives ~flat $K^*/K$ ratio, may be inconsistent with measured $K^0/K^-$
• Combined fits of $\pi^\pm$, $K^\pm$, and (anti)protons in Pb–Pb collisions
- Combined fits of $\pi^\pm$, $K^\pm$, and (anti)protons in Pb–Pb collisions
Resonance Suppression

- Does $K^{*0}$ suppression depend on $p_T$? UrQMD: re-scattering strongest for $p_T < 2$ GeV/c.
- Expected $p_T$ distribution from blast-wave model:
  - **Shape**: parameters ($T_{\text{kin}}$, $n$, $\beta$) from combined fits of $\pi/K/p$ in Pb–Pb (*)
  - **Normalization**: $K$ yield $\times$ $K^{*0}/K$ ratio from thermal model ($T_{\text{ch}} = 156$ MeV)
- Central: $K^{*0}$ suppressed for $p_T < 3$ GeV/c, but **no strong $p_T$ dependence**
- Peripheral: $K^{*0}$ not suppressed
- No suppression of $\phi$

\*PRC 88 044910 (2013)
No significant mass or width shifts observed.
No centrality dependence of mass or width.
**Σ**± and **Ξ***0 Reconstruction

- Analyzed in **pp** collisions at 7 TeV & **p–Pb** collisions at 5.02 TeV (**Pb–Pb** collisions at 2.76 TeV in progress)
- Subtract mixed-event combinatorial background
- Polynomial residual background
- Peaks: Breit-Wigner (**Σ**±) or Voigtian (**Ξ***0)

**Σ**±:
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  - **uus**: \( m = 1383 \text{ MeV}/c^2 \)
  - **dds**: \( m = 1387 \text{ MeV}/c^2 \)
  - B.R. = 87%
  - \( \Gamma = 36.0 \text{ MeV}/c^2 \)
  - \( \Gamma = 39.4 \text{ MeV}/c^2 \)

**Ξ***0:
- **uus**: \( m = 1532 \text{ MeV}/c^2 \)
  - B.R. = 66.7%
  - \( \Gamma = 9.1 \text{ MeV}/c^2 \)
- **dd**: \( m = 1532 \text{ MeV}/c^2 \)
- **us**: \( m = 1532 \text{ MeV}/c^2 \)

**Σ**± and **Ξ***0 Reconstruction

<table>
<thead>
<tr>
<th>System</th>
<th>Mass (MeV)</th>
<th>Width (MeV)</th>
<th>BR (%)</th>
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<tbody>
<tr>
<td><strong>Σ</strong>±</td>
<td>1383</td>
<td>36.0</td>
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$\Sigma^{*\pm}$ and $\Xi^{*0}$ Reconstruction

- Analyzed in pp collisions at 7 TeV & p–Pb collisions at 5.02 TeV (Pb–Pb collisions at 2.76 TeV in progress)
- Subtract mixed-event combinatorial background
- Polynomial residual background
- Peaks: Breit-Wigner ($\Sigma^{*\pm}$) or Voigtian ($\Xi^{*0}$)

**NEW RESULT**

$\Sigma(1385)^+$ p-Pb, $\sqrt{s_{\text{NN}}} = 5.02$ TeV $-0.5 < y_{\text{CMS}} < 0$

V0 Multiplicity classes (Pb side)

ALICE Preliminary

Uncertainties: stat. (bars), syst. (boxes)
• Reconstruction in pp 2.76, 7, & 13 TeV; p–Pb 5.02 TeV, and Pb–Pb 2.76 TeV
• Decay channel: $\Lambda(1520)\rightarrow pK^-$
  – Decay products identified using TPC and TOF
• Mass from invariant-mass fits in pp and p–Pb: good agreement with vacuum value
• More information can be found in this poster from Quark Matter 2014: https://indico.cern.ch/event/219436/session/2/contribution/197/material/poster/0.pdf
• Reconstruction in pp 7 TeV
• Decay channel: $\Sigma^0 \rightarrow \Lambda \gamma$
  – Photon identified through measurement of its conversion, and in PHOS (calorimeter)
• More information can be found in this poster from Quark Matter 2014: https://indico.cern.ch/event/219436/session/2/contribution/196/material/slides/0.pdf