Baryon number transport at LHC energies with the ALICE experiment

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Physics at the LHC 2011,
5-11 June 2010, Perugia

Outline

- Baryon number transport
  - Theoretical models
  - Previous experimental results
- Data Analysis
  - Data sample
  - Track selection
- Corrections
  - Absorption
  - Background
  - Feed down
- Results

Baryon number transport

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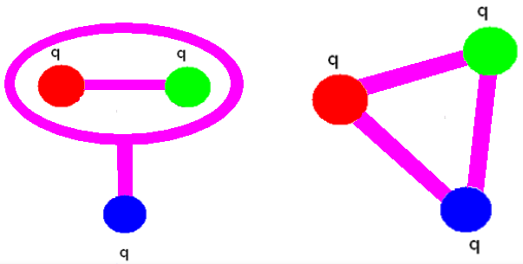
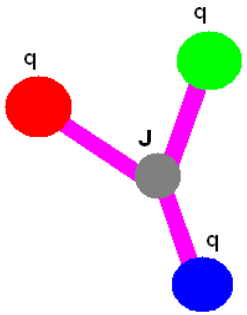
Constituent quark model

- Baryons are described as quark-diquark pairs



String junction model

- Valence quarks are connected via nonperturbative configuration of gluon field (SJ)



- Probability of BN transfer thorough rapidity interval is $\approx \exp(\alpha-1).\Delta y$
- α depends on configuration in which BN is transported
  - Diquark (CQM)
  - SJ accompanied by diquark
  - SJ accompanied by quark
  - SJ itself

$\alpha \approx$	
Diquark	-1/2
SJ accompanied by diquark	-1/2
SJ accompanied by quark (Rossi&Veneziano)	1/2
SJ itself	1/2
SJ itself (Kopeliovich)	1

B.Z.Kopeliovich, Sov. J. Nucl. Phys. 45, (1987) 1078

G.C.Rossi, G.Veneziano, Nucl. Phys. B123, (1977) 507

Previous experimental results

Physics at the LHC 2011,
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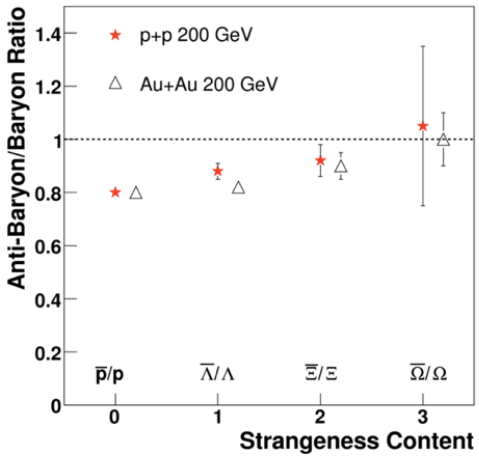
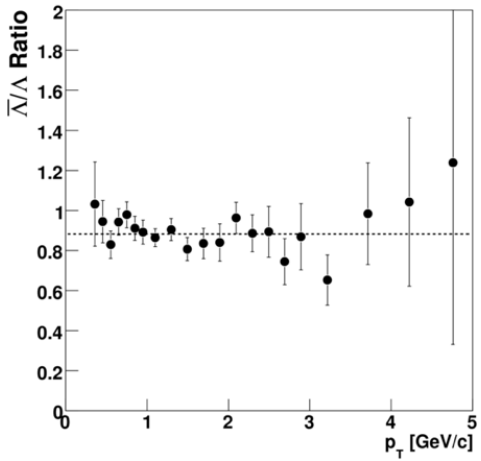
STAR: Phys. Rev. C 75 (2007) 64901

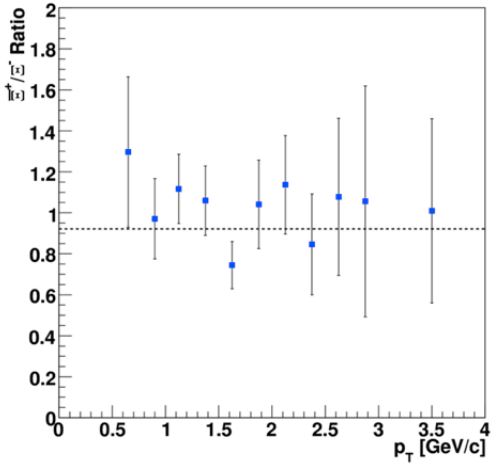
ALICE: Phys. Rev. Lett. 105, 072002 (2010)

Results from STAR

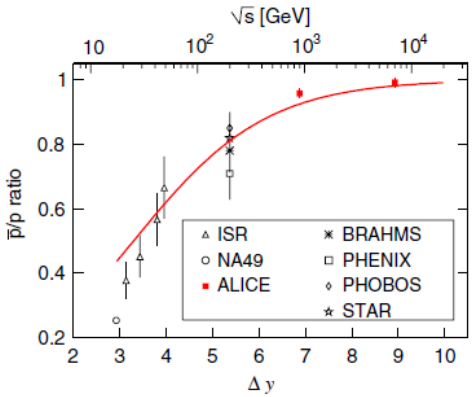


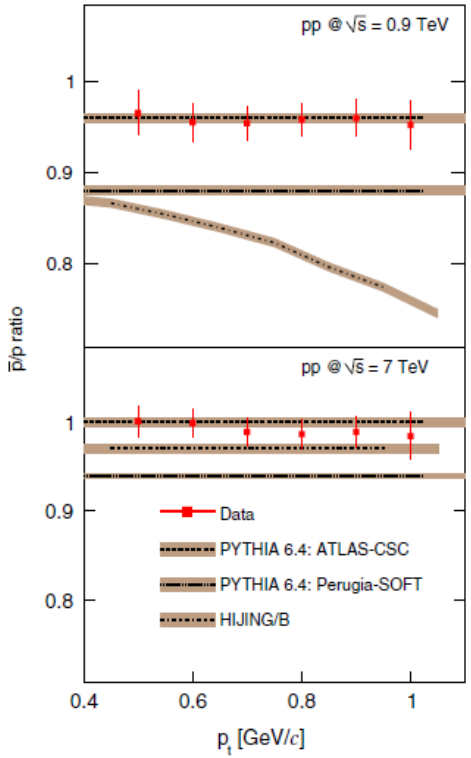
- Increase of mid-rapidity ratio with strangeness measured on STAR (and others)
- Flat p_t dependence of ratio
- Scenario with α_{SJ}=1 disfavored by ALICE results
- Energy dependence of mid rapidity ratio goes to unity for high energies



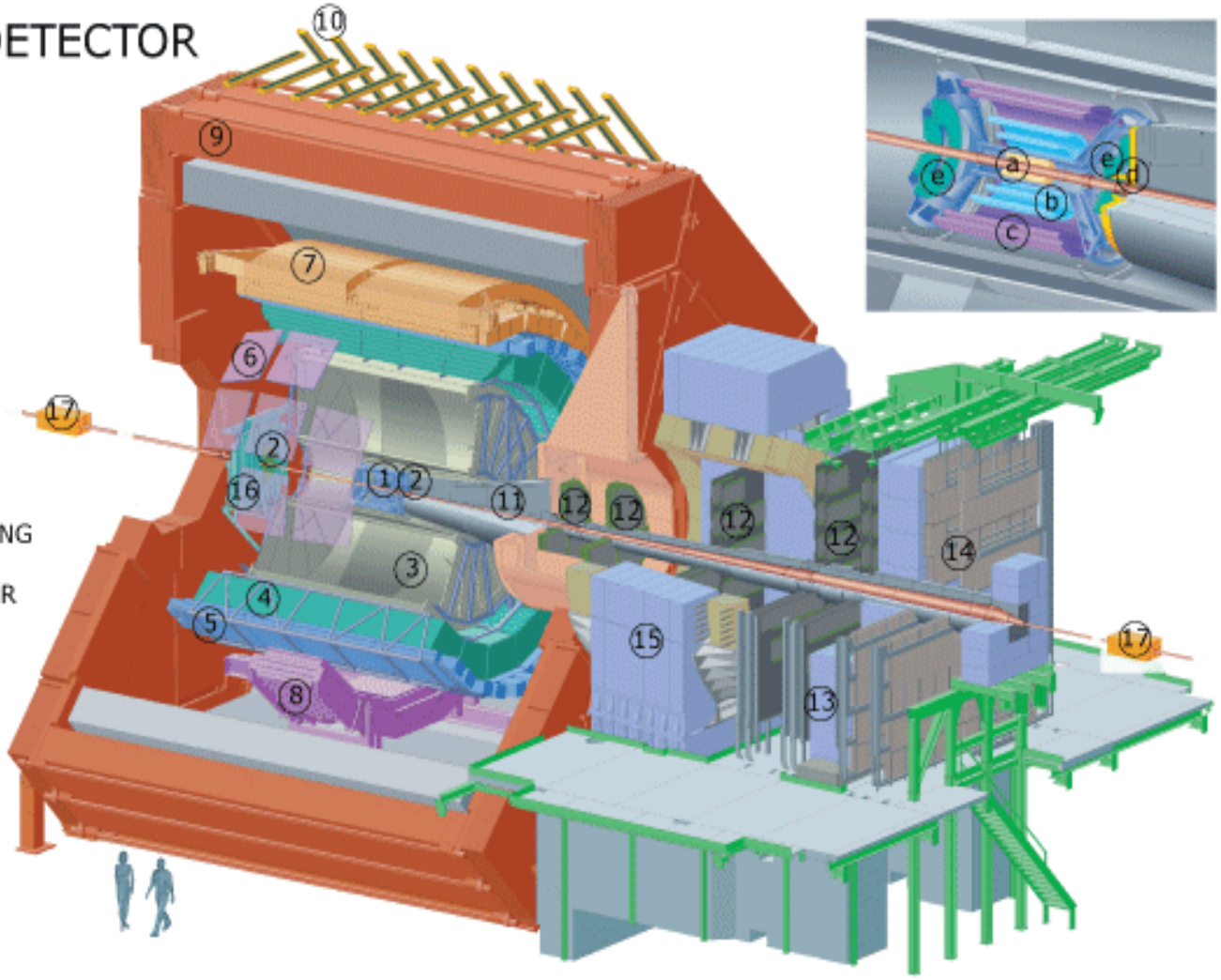


Results from ALICE





THE ALICE DETECTOR

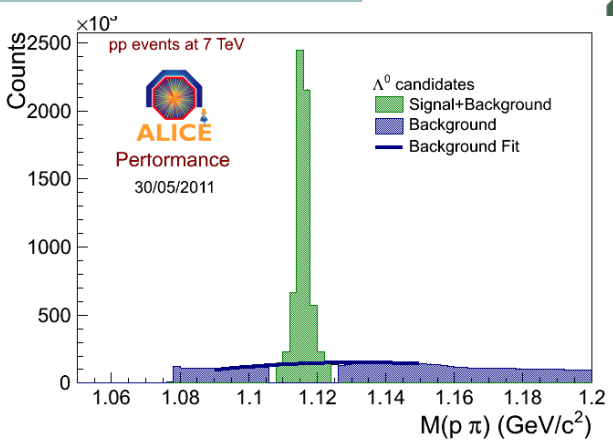


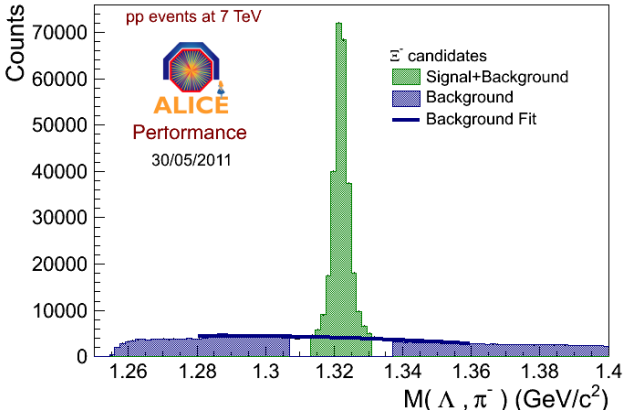
Track selection

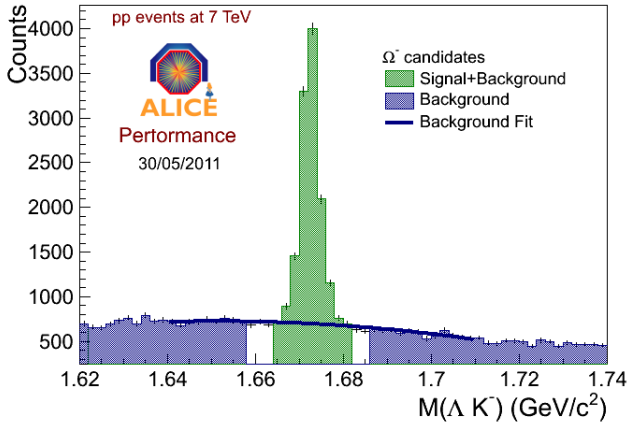
Track Selection – Quality cuts	
Number of TPC clusters	> 80
Number of TPC clusters (dE/dx)	> 80
TPC refit	Yes

Hyperons selection
Topological selections
PID on daughter tracks
M(Ξ) rejection for Ω
M(K_S^0) rejection for Λ

Phase space			
	Λ	Ξ	Ω
|y|	< 0.8		
p_t (GeV/c)	0.5 < p_t < 5.5		1.0 < p_t < 5.5







Corrections

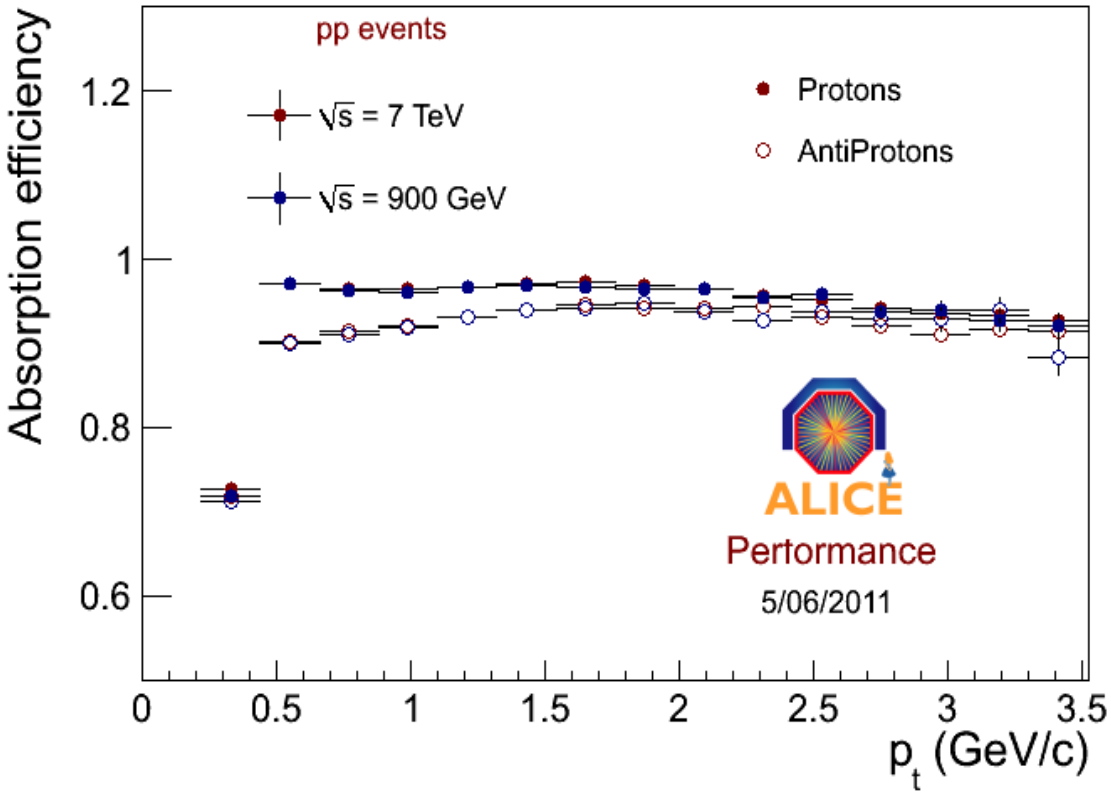
- The TPC of the ALICE experiment is symmetric around mid-rapidity and has full azimuthal coverage.
- As a consequence, many detector effects such as the acceptance, the reconstruction and the particle identification ones are the same for particles and anti-particles and thus cancel out in the ratio.
- Effects which we need to correct for are absorption (Λ, Ξ, Ω) and secondary produced particles (Λ)
- To first order feed down effects cancel out in the ratio

Corrections summary - 7TeV							
Source	Mode	Λ[%]	Ξ^- [%]	Ω^- [%]	Λbar[%]	$\bar{\Xi}^+$ [%]	$\bar{\Omega}^+$ [%]
Absorption	MC	5.4			10.6		
Background	Data	28-13	0		14	0	

Absorption correction

- By absorption we mean the interaction of particle with material resulting in the disappearence of the first.
- Correction factors were extracted from MC
  - Rely on proper description of material budget
  - Rely on proper description of cross section in the transport code
  - Geant-3 cross section overestimates the data.
  - Fluka cross section which is in good agreement with data taken into account

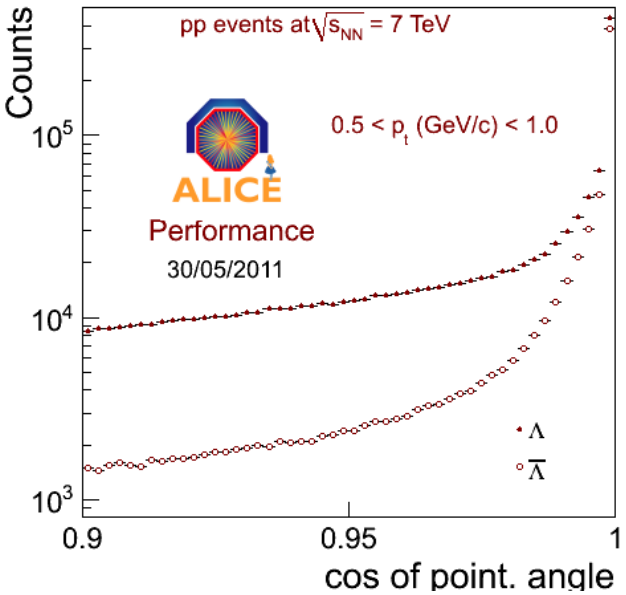
G. Bendiscioli and D. Kharzeev, Riv. Nuovo Cimento Soc. Ital. Fis. 17, 1 (1994)

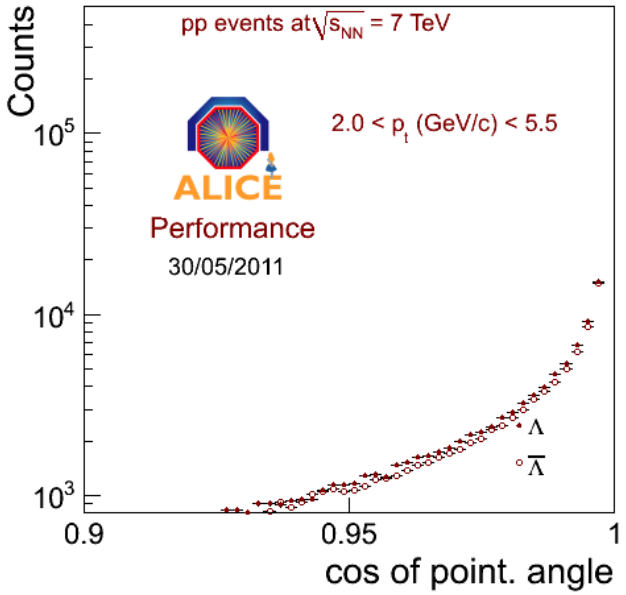


Correction for background

Λ

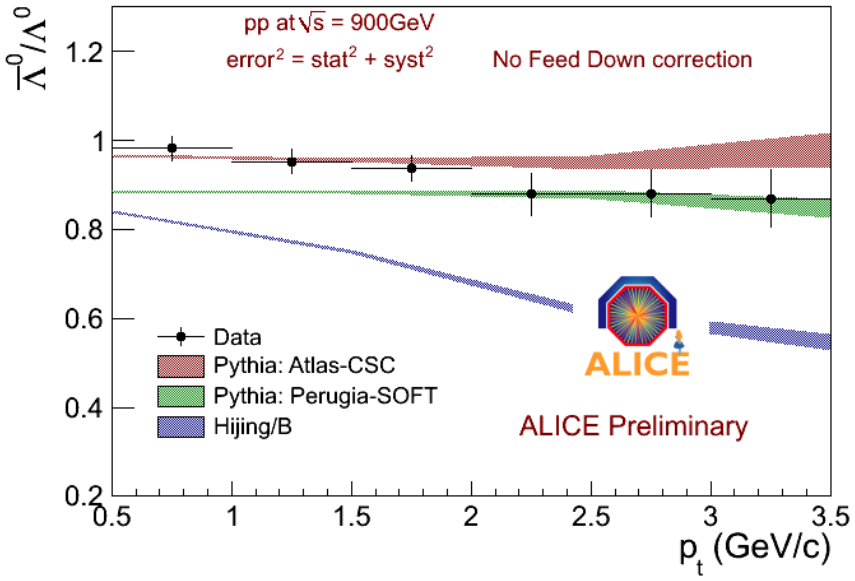
- Correcting for secondary Λ created from material by kaons
- Difference between Λ and anti-Λ is visible in cosine of pointing angle distribution
- The effect is more pronounced at low pt values.
- Fit is searching for fractions corresponding to MC template histograms

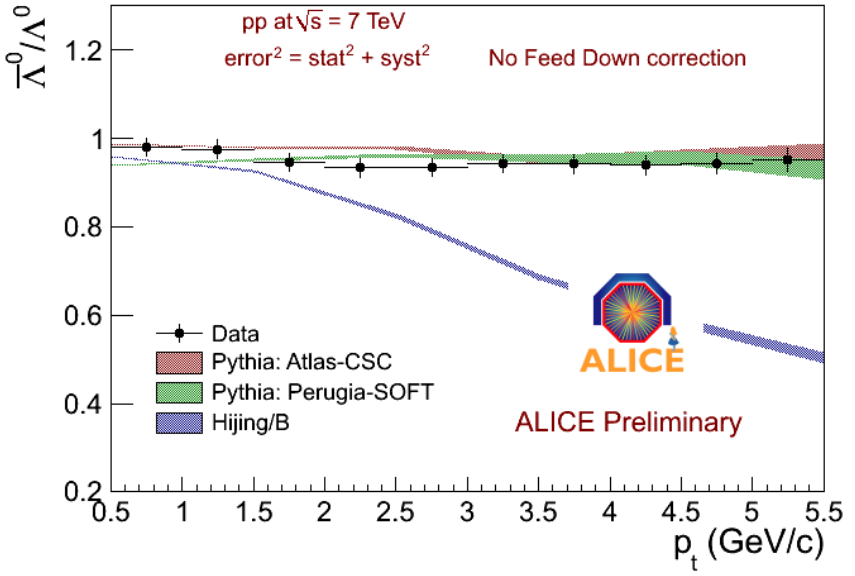




Λbar / Λ p_t dependence

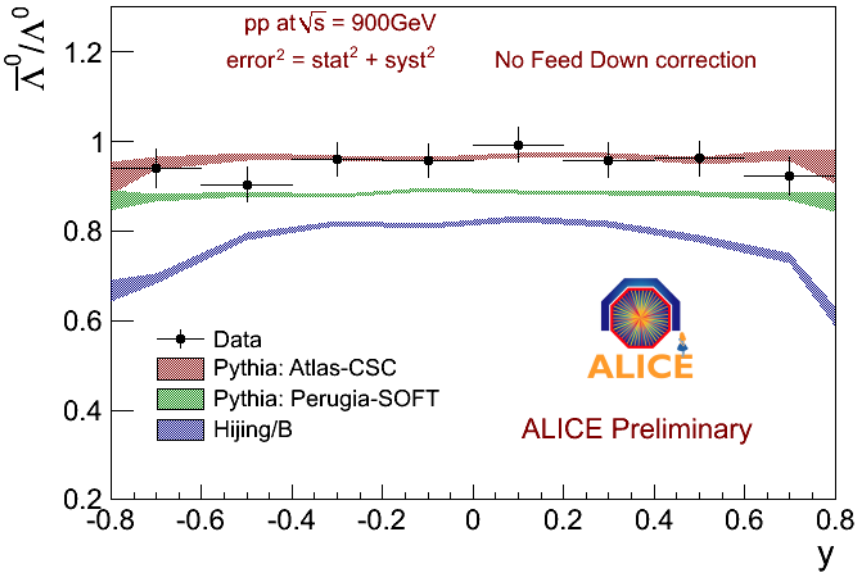
- Preliminary result show no sign of transverse momentum dependence
- Experimental points are compared with different model predictions that include variation of BN transport mechanisms:
  - HIJING-B predicts a decrease of the ratio with increasing p_t not seen in p+p collisions.
  - The different PYTHIA tunes describes the data well.

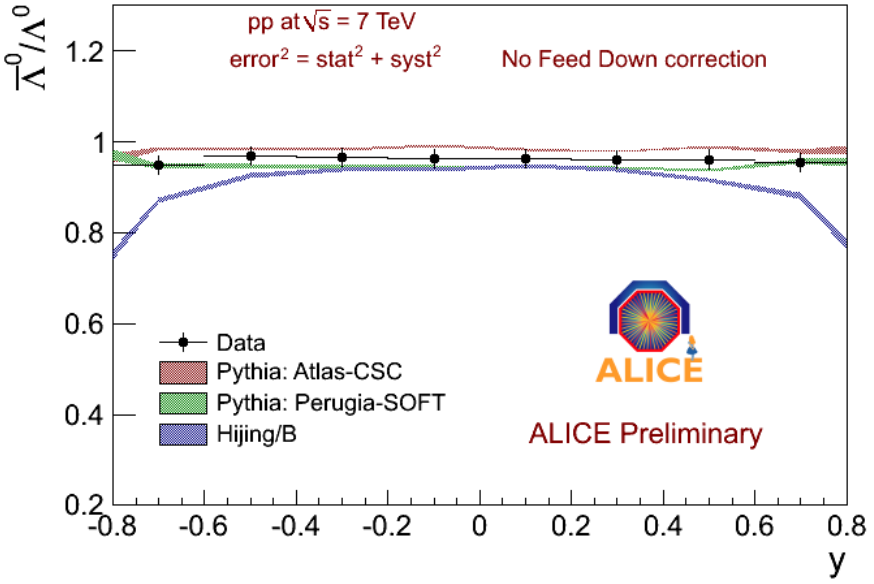




Λbar / Λ rapidity dependence

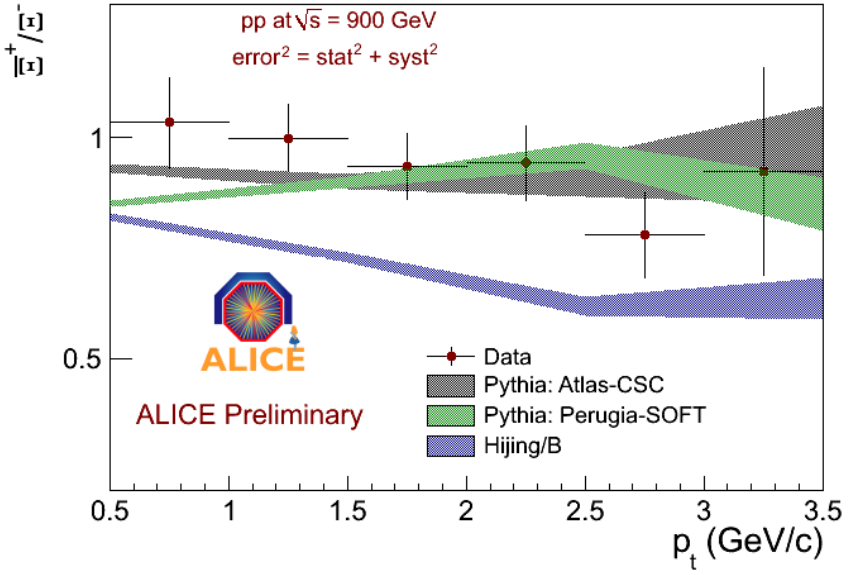
- Preliminary result show no sign of rapidity dependence
- Experimental points are compared with different model predictions that include variation of BN transport mechanisms:
  - HIJING-B clearly underestimates the y dependence
  - The different PYTHIA tunes describe the data well.

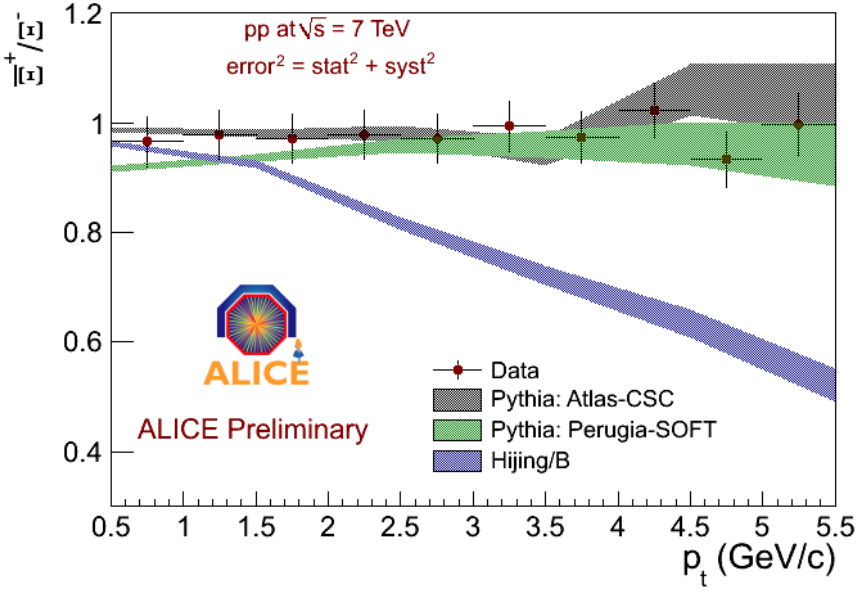




Ξ^{+} bar / Ξ^{-} p_t dependence

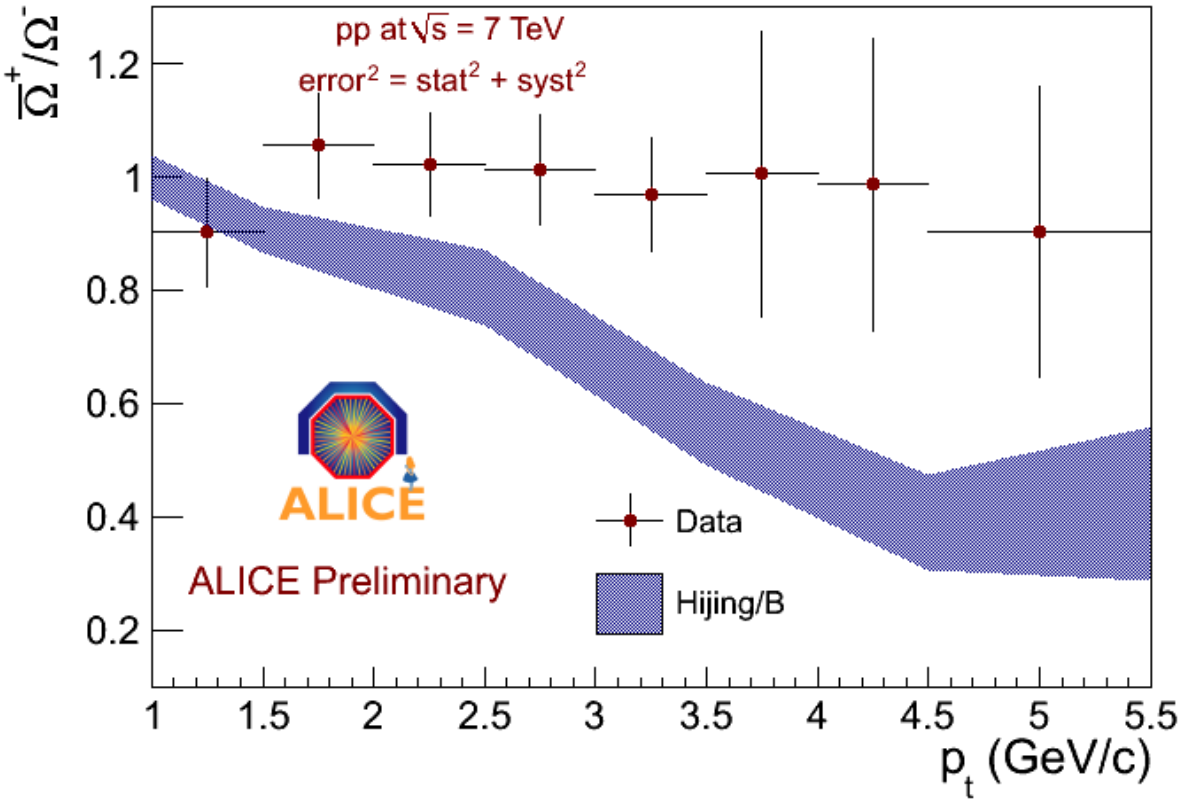
- Preliminary result show no sign of transverse momentum dependence
- Experimental points are compared with different model predictions that include variation of BN transport mechanisms:
  - HIJING-B predicts a decrease of the ratio with increasing p_t not seen in p+p collisions.
  - The different PYTHIA tunes describes the data well.



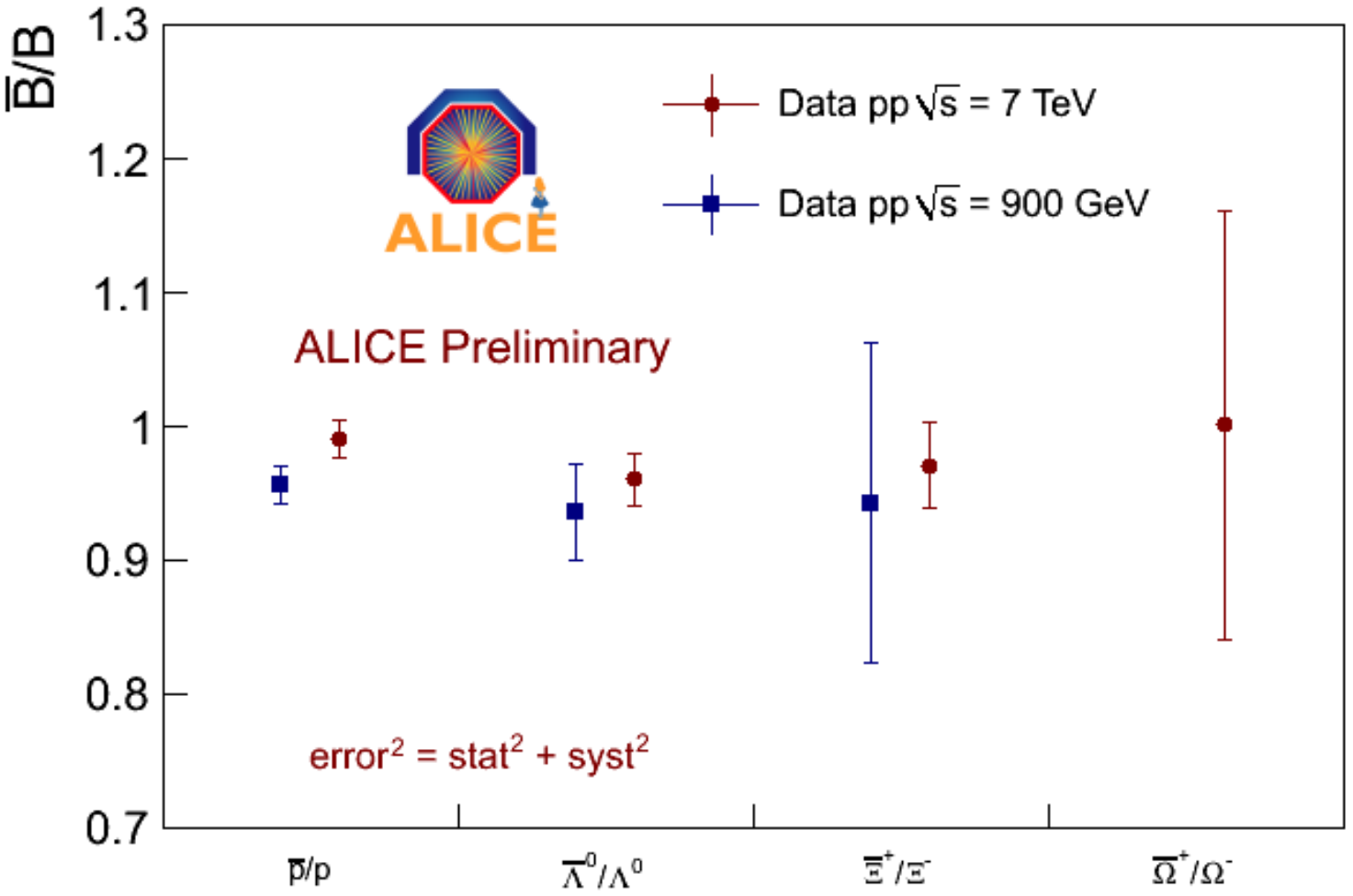


Ω^+ bar/ Ω^- p_t dependence

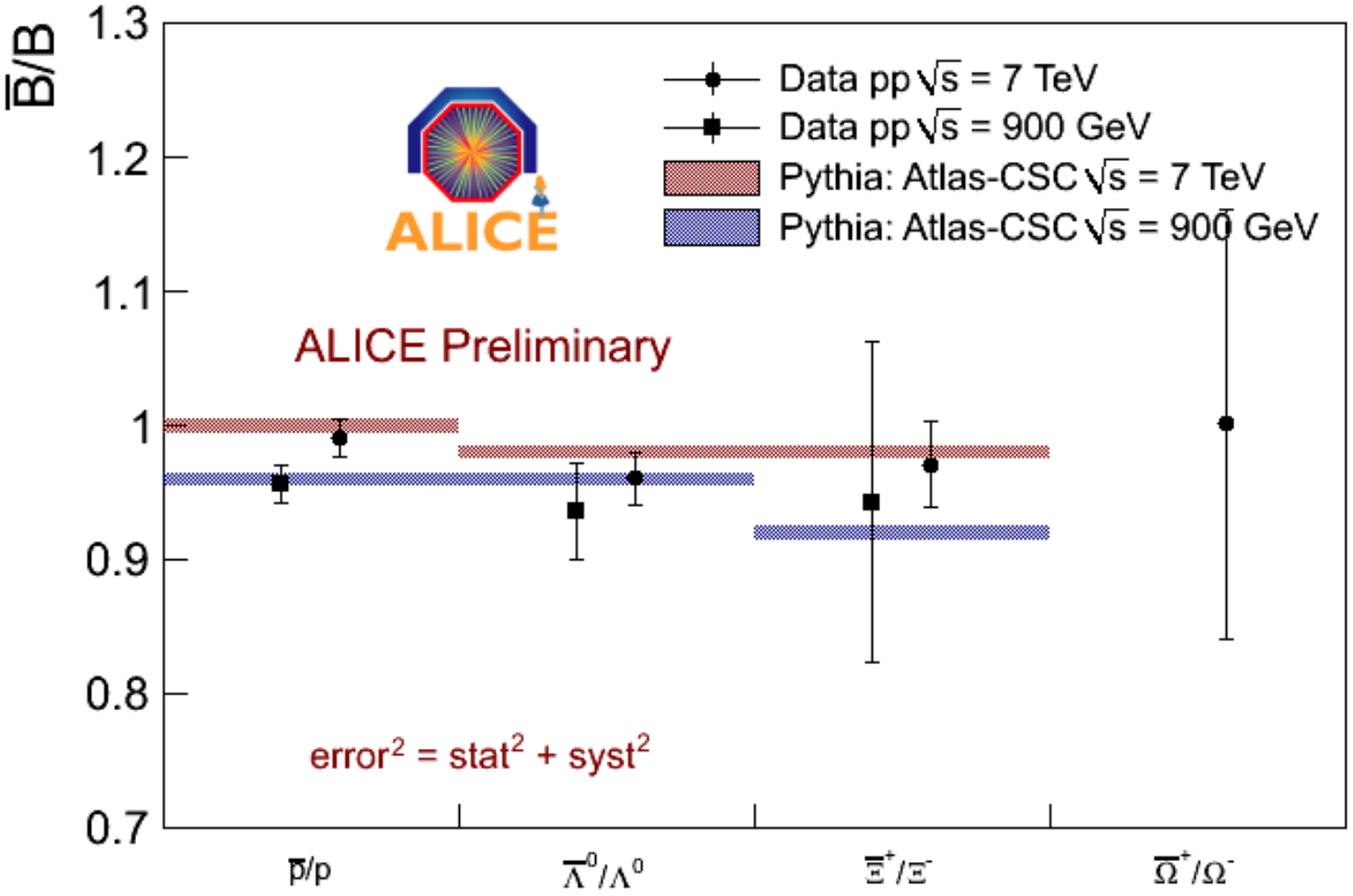
- Preliminary result show no sign of transverse momentum dependence
- Mid rapidity ratio is compatible with unity
- Experimental points are compared with prediction of HIJING-B
  - HIJING-B predicts a decrease of the ratio with increasing p_t - not seen in p+p collisions.



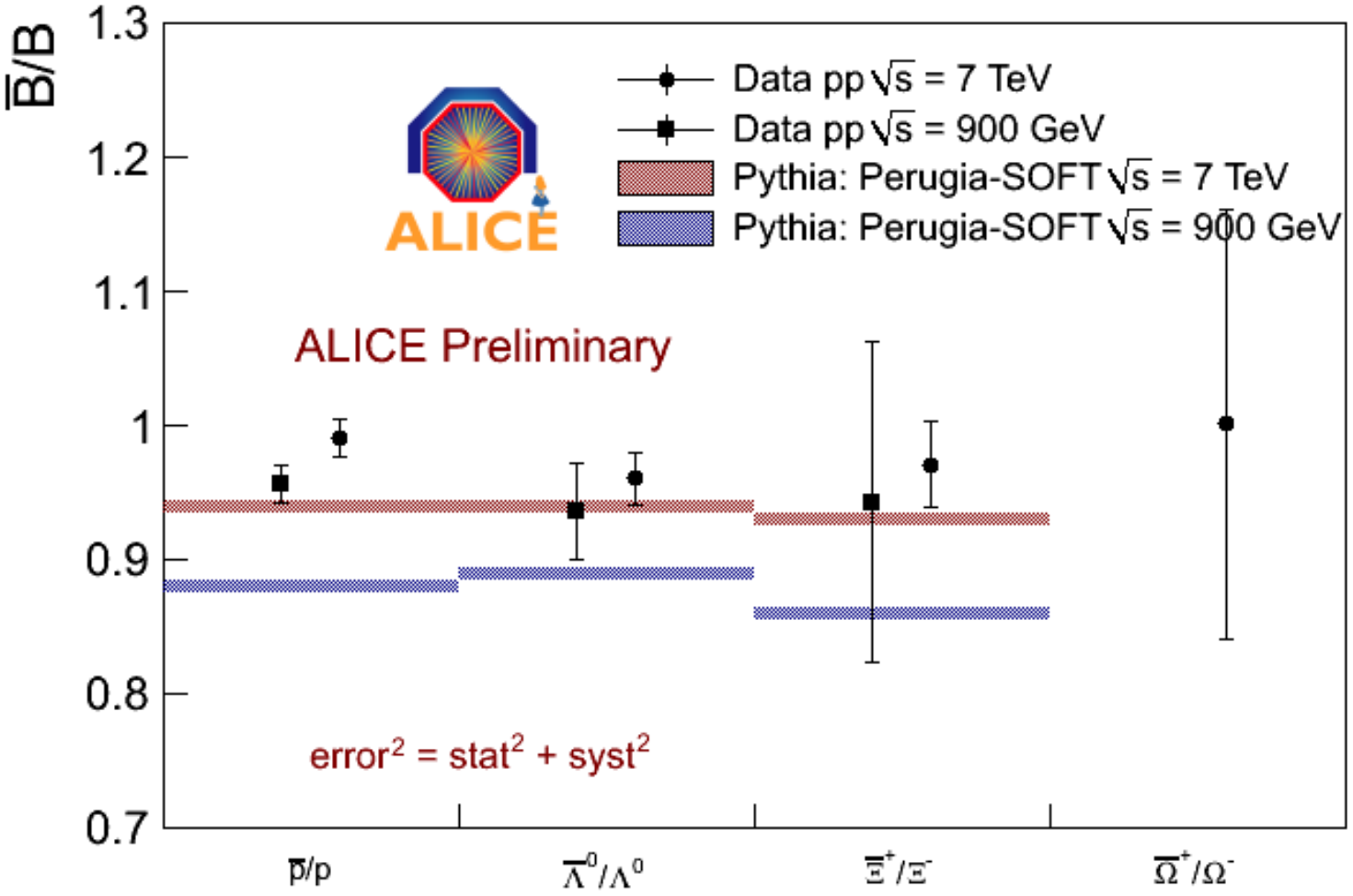
Strangeness dependence of mid rapidity ratios



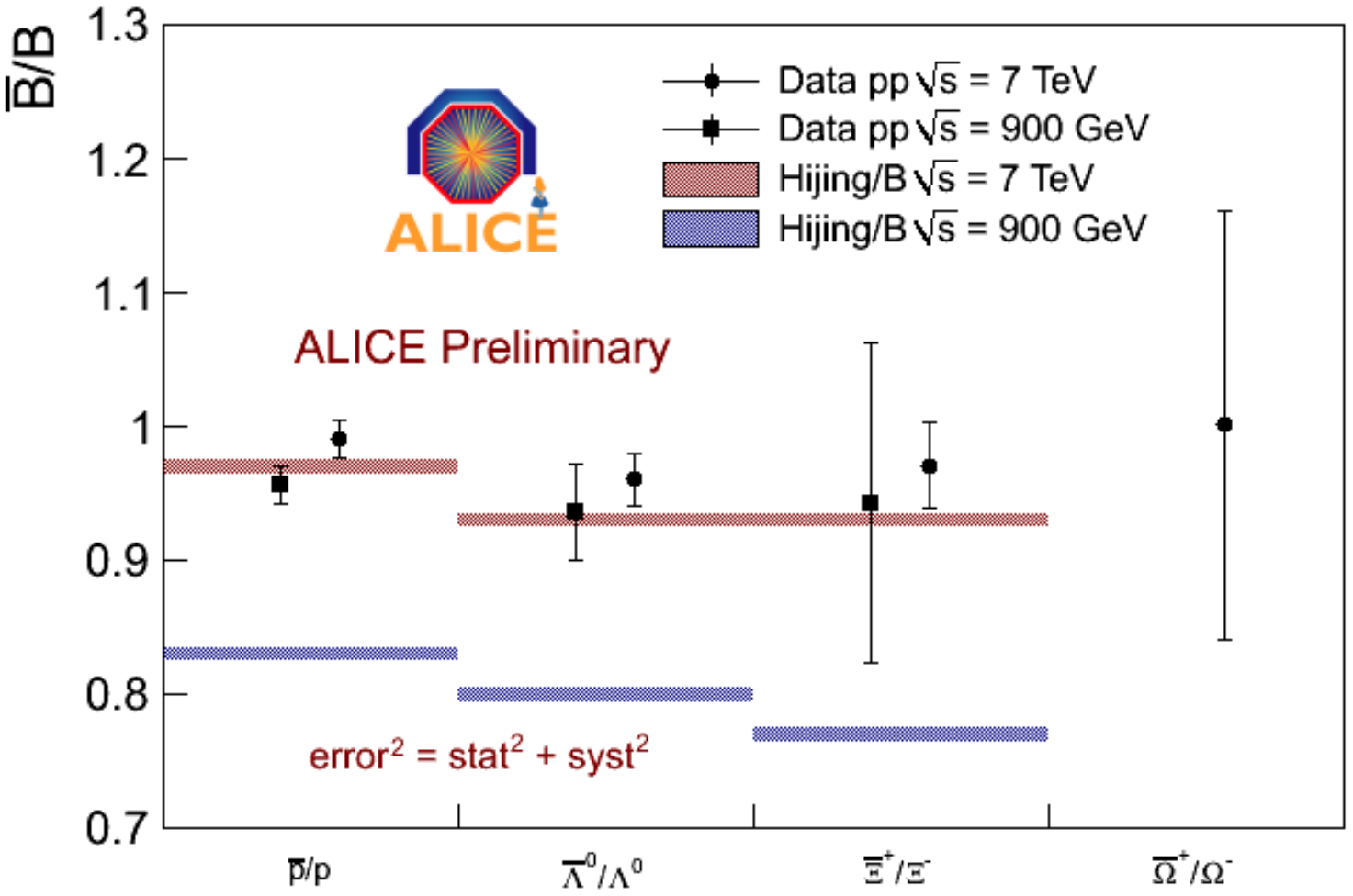
Strangeness dependence of mid rapidity ratios



Strangeness dependence of mid rapidity ratios



Strangeness dependence of mid rapidity ratios

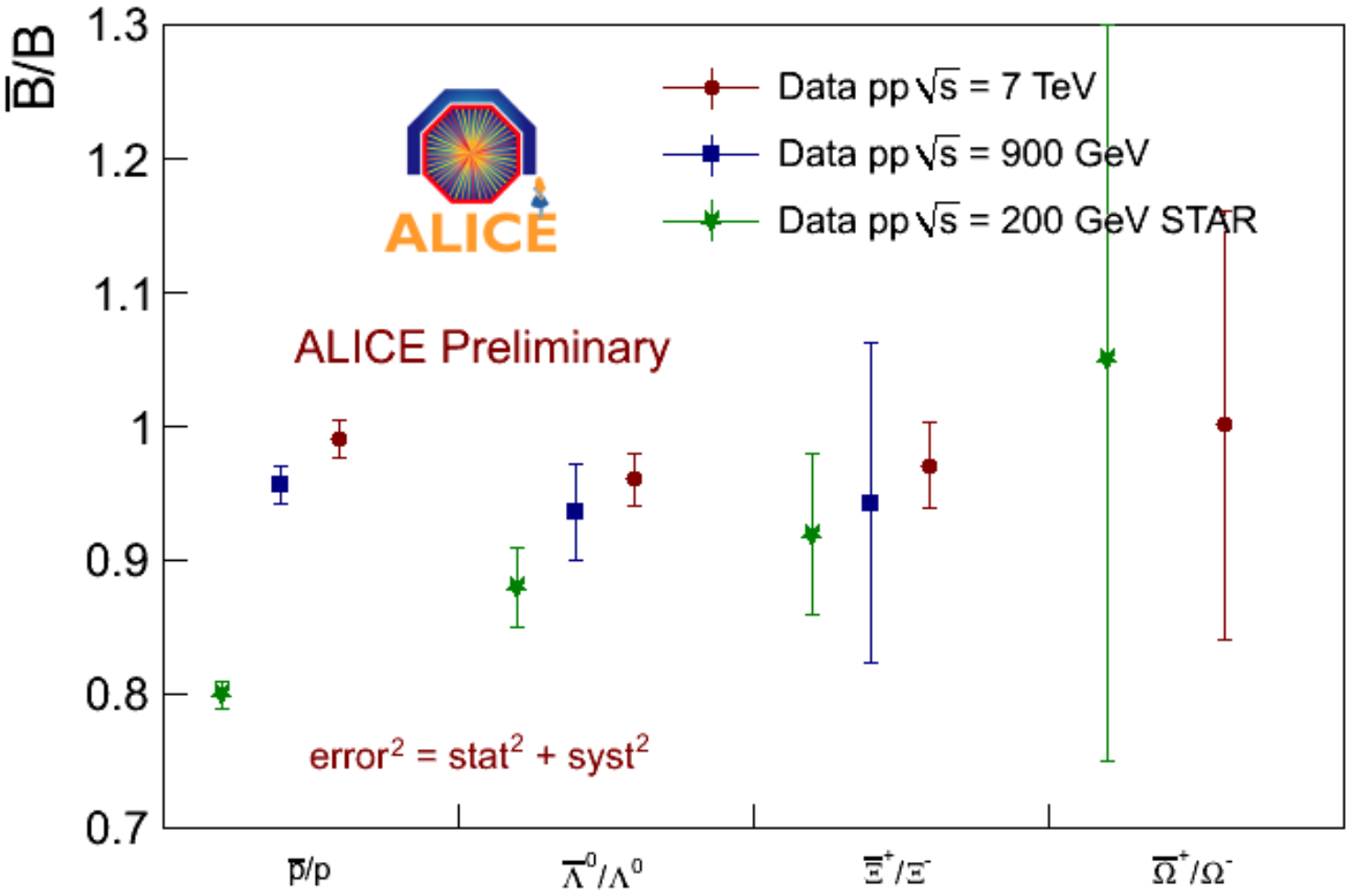


Summary

- We measured the antibaryon – baryon ratio for 900 GeV and 7 TeV at the LHC.
- Preliminary results show no evidence of rapidity or transverse momentum dependence

Backup

Strangeness dependence of mid rapidity ratios

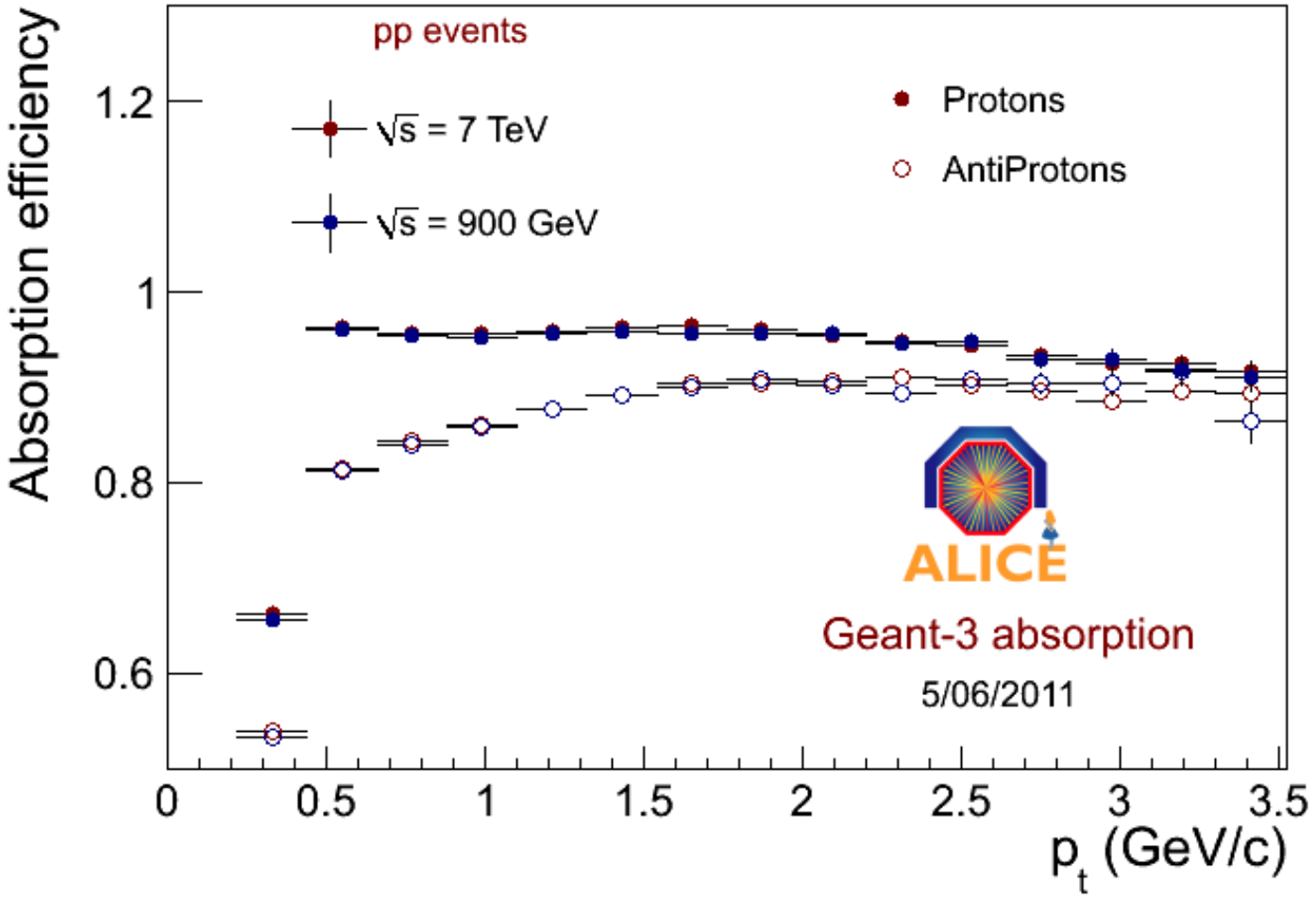


Signal/Background extraction

- Signal extracted separately for pt (Ω) or y – pt (Ξ, Λ) bins from invariant mass distributions
- Background increasing with |y| and decreasing with pt
- Background in areas $> \mu \pm 6\sigma$
- Signal + Background in $< \mu \pm 4\sigma$

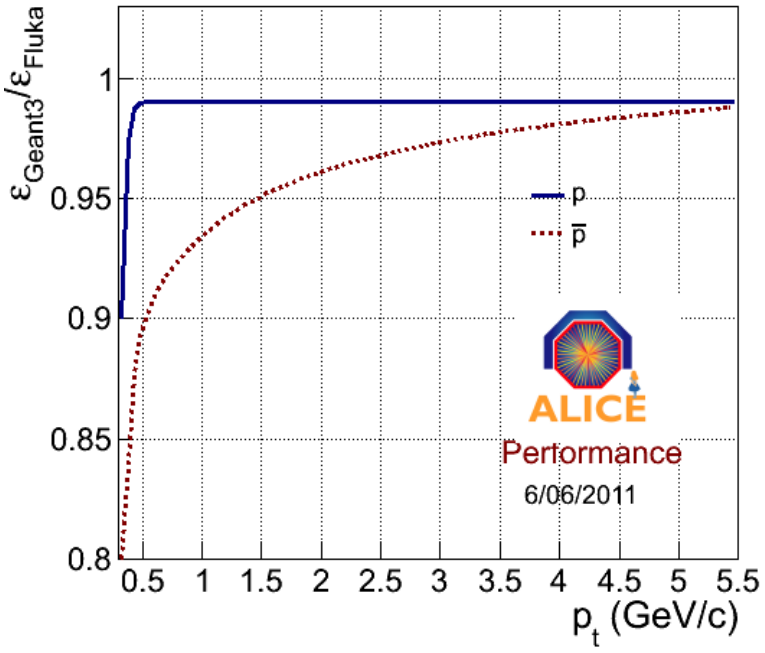
1. Fit of invariant mass distributions with sum of Gaussian and second order polynom => Gausian mean & width
2. Extract S+ B from integral of invariant mass distribution histogram
3. Extract Background
   - Bin counting
   - Fitting of areas simultaneously with split function (3-order polynom)
   - *Directly from first fit*

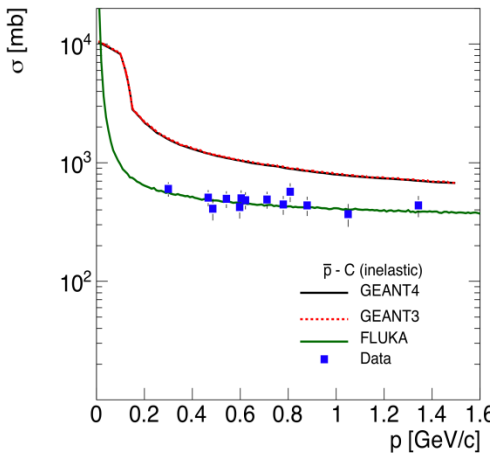
Geant 3 absorption

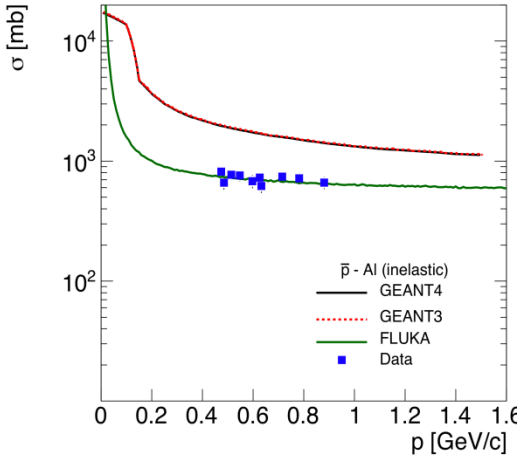


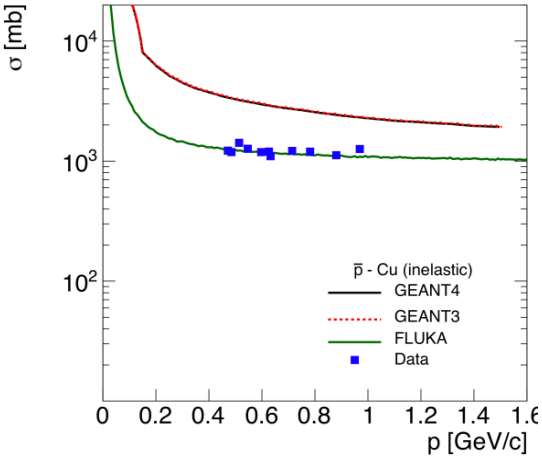
Cross section correction

- Fluka in good agreement with the data
- Clear disagreement between the experimentally measured values and the input curves of GEANT3-GEANT4 (data points lower by a factor of 2-3 depending on the momentum).
- Correction factors were extracted from local production and extrapolated to high p_t









Systematic uncertainties @ 900GeV

Source		Action	Λ	Ξ
Material budget		MC production with the material budget variation	0.5%	
Inelastic cross-section		10% uncertainty on the pbar inelastic cross-section	0.8%	
Variation of the cut ranges	PID	3σ - 4σ - 5σ cut	0.3-0.8%	2.0-7.0%
	$N_{clusters}$(TPC)	70 – 80 -90	0.7-1.2%	1.2-6.4%
	Vz	|Vz| < 8 – 10 -12 cm	0.1%	1.3-5.7%
	Inv mass cut	8 – 10 -12 MeV	0.3-0.4%	-
	Topological cuts		2.2-3.8%	4.96-16%
Corrections	Cross section	Extracted for pbar/p paper	<0.1%	
	Absorption	Maps from different productions	<0.1%	
	Background	?	x	-
	Feed-down	?	x	-
Signal/Background extraction		Extract signal using different methods	0.4%	0.2%
TOTAL			2.38-4.11%	5.6-19.6%

Systematic – topological cuts @ 900GeV

V0 Selection – Topological cuts	Λ
Cosine of pointing angle	0.5- 0.2
DCA Positive to prim. vertex	1.6-2.1
DCA Negative to prim. vertex	1.4-3.0
DCA btw daughters	0.5-0.1
R_{2D}	0.1-1.1
TOTAL	2.2-3.8

Cascade Selection – Topological cuts	Ξ
DCA Bachelor to prim. vertex	1.0-5.2
DCA Positive to prim. vertex	1.6-5.7
DCA Negative to prim. vertex	4.0 -7.0
DCA V0 to prim. vertex	0.1-4.8
R_{2D}(cascade decay)	1.2-4.0
R_{2D}(V0 decay)	1.4-6.5
Cosine of pointing angle(V0 in casc.)	0.15-2.5
DCA btw. V0 daughters in cascade	1.0-4.7
DCA btw. cascade daughters	0.8-3.2
Cosine of pointing angle(cascade)	0.2-5.5
TOTAL	4.96-16

Systematic uncertainties @ 7TeV

Source		Action	Λ	Ξ	Ω
Material budget		MC production with the material budget variation	0.5%		
Inelastic cross-section		10% uncertainty on the pbar inelastic cross-section	0.8%		
Variation of the cut ranges	PID	3σ - 4σ - 5σ cut	0.5-0-0.2%	0.25-0.55-1.1%	2.1-6.5%
	$N_{clusters}$(TPC)	70 – 80 -90	0.5-0.15-0.56%	1-0.2-3%	2.14-5.7%
	Vz	|Vz| < 8 – 10 -12 cm	0.5-0.1-0.3%	0.5-0.6-0.5%	1.8-8.0%
	Inv mass cut	8 – 10 -12 MeV	0.5-0.15-0.3%	-	3.1-7.5%
	Topological cuts		2.5-1.1-1.9%	2.6-2.3-3%	6.8-19.7%
Corrections	Cross section	Extracted for pbar/p paper	<0.1%		
	Absorption	Maps from different productions	<0.1%		
	Background	?	x	-	-
	Feed-down	?	x	-	-
Signal/Background extraction		Extract signal using different methods	0.4%	0.2%	0.3%
TOTAL			2.7-1.2-2.0	2.8-2.5-4.4	8.3 – 24.2

Systematic – topological cuts @ 7TeV

Cascade Selection – Topological cuts	Ξ	Ω
DCA Bachelor to prim. vertex	0.9-0.8-0.2	0.7-7.8
DCA Positive to prim. vertex	0.6-1.6-1.9	0.6-9.1
DCA Negative to prim. vertex	1.6-0.2-0.6	2.5-7.0
DCA V0 to prim. vertex	0.4-0.5-0.75	0.8-5.4
R_{2D}(cascade decay)	0.35-0.3-0.5	1.0 - 5.6
R_{2D}(V0 decay)	0.9-0.5-0.65	3.0-1.7
Cosine of pointing angle(V0 in casc.)	0.87-0.7-1.1	1.6-5.8
DCA btw. V0 daughters in cascade	0.2-0.5-0.5	3.4-5.6
DCA btw. cascade daughters	0.8-0.5-0.8	3.0-4.0
Cosine of pointing angle(cascade)	0.6-0.85-1.4	2.5-7.0
TOTAL	2.6-2.4-3	6.8-19.7

V0 Selection – Topological cuts	Λ
Cosine of pointing angle	1.5-0.2-0.5
DCA Positive to prim. vertex	0.4-1.1-1.5
DCA Negative to prim. vertex	1.8-0.3-0.8
DCA btw daughters	0.7-0.1-0.5
R_{2D}	0.5-0-0.6
TOTAL	2.5-1.1-1.9