Λ and $\overline{\Lambda}$ Production at CERN-SPS Energies

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for the NA49 Collaboration

- Data sets
- Particle spectra
- Energy dependence
- Model predictions
- $\overline{\Lambda}/\Lambda$ and $\overline{\Lambda}/\overline{p}$ ratios
- Summary

Motivation

- Search for the evidence of the onset of deconfinement

  → Energy scan program started in '99 at CERN (40, 80 and 158 AGeV)

  → Search for anomalies in the energy dependence of physical observables; here: strangeness in hyperons

- Lambda hyperons contain 30-60% of the s-quarks (depending on energy)

  → With Lambdas we can study simultaneously strangeness production and the effect of net baryon density

  → Extract the Lambda excitation function

Neutral Strange Particles @ 158 AGeV

Data sets: central Pb+Pb

380k @ 40 AGeV
300k @ 80 AGeV } (7.2% most central)
400k @158 AGeV (10% most central)

Neutral strange particles are identified by their decay topology:

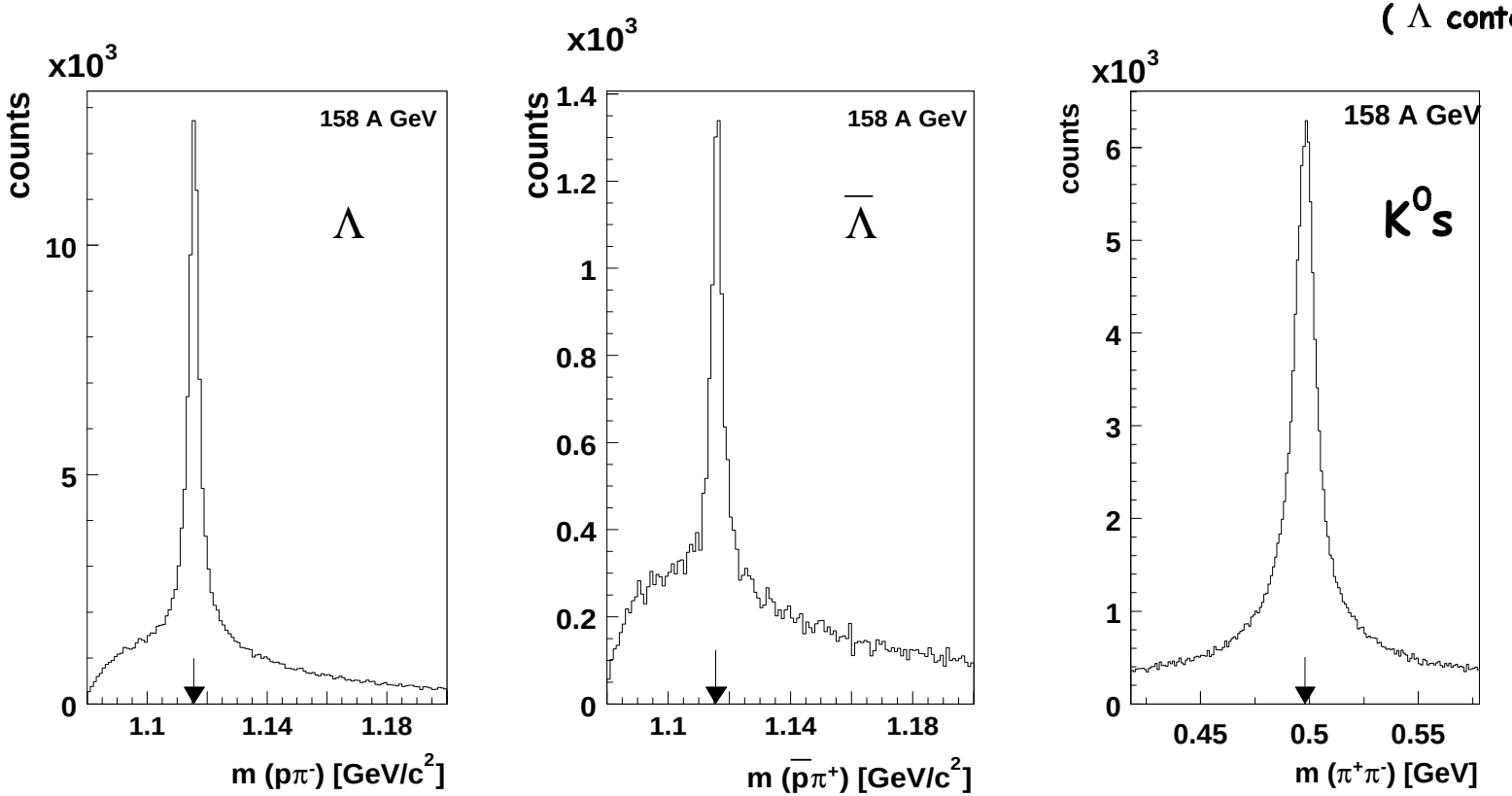
$\Lambda \rightarrow p + \pi^-$ (64.1 %)

$K^0s \rightarrow \pi^+ + \pi^-$ (68.6 %)

(Λ contain Σ^0)

$\sigma_\Lambda \approx$ 2 MeV

$\sigma_{K0s} \approx$ 4 MeV



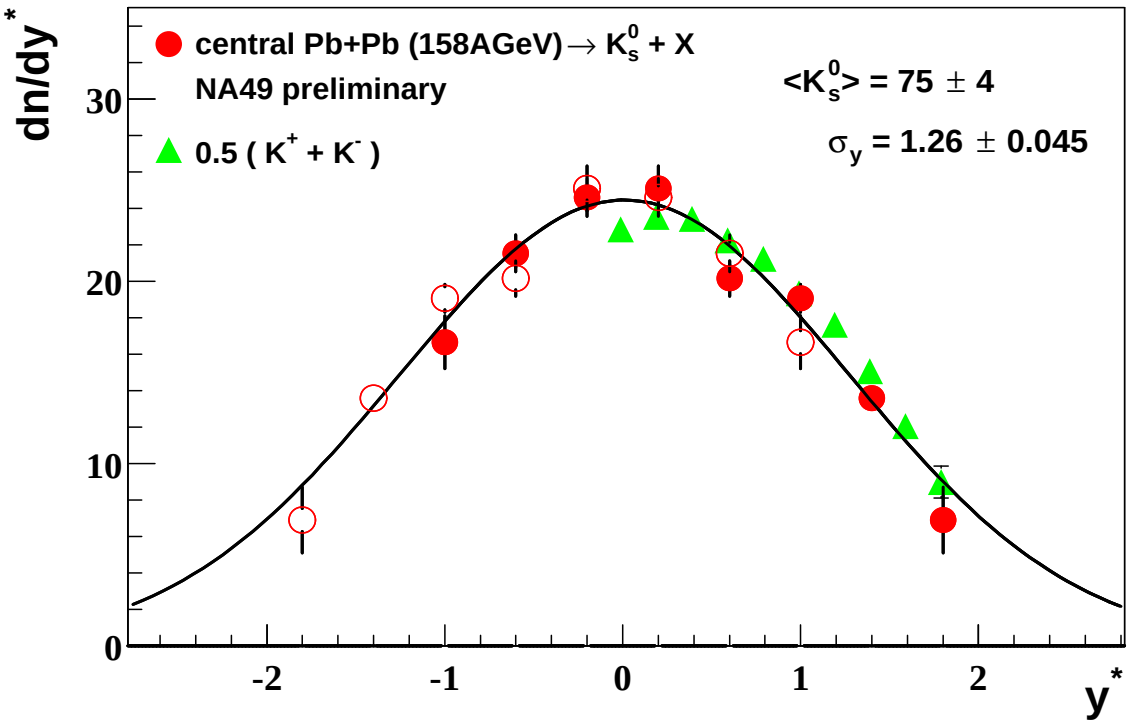
Data Analysis

Corrections for
- Background
- Geometrical acceptance
- Efficiency
- Branching fraction
- Weak-decay feed-down correction

Comparison with charged Kaons (identified by dE/dx)

Analysis checks:

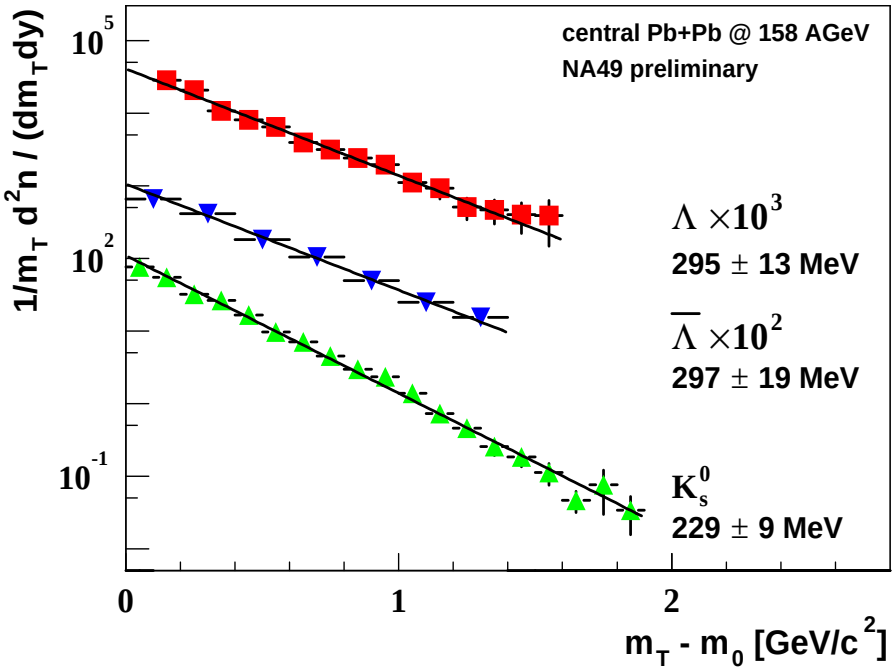
- Lifetime (not shown) o.k.
- K^0_s



Slope Parameter

E896: PRL 88(02)062302
NA45: W. Schmitz, SQM2001
WA97: Eur.Phys.J. C14(99)633
STAR: nucl-ex/0203016
Phenix: nucl-ex/0204007
E895: J.L. Klay, PhD Thesis

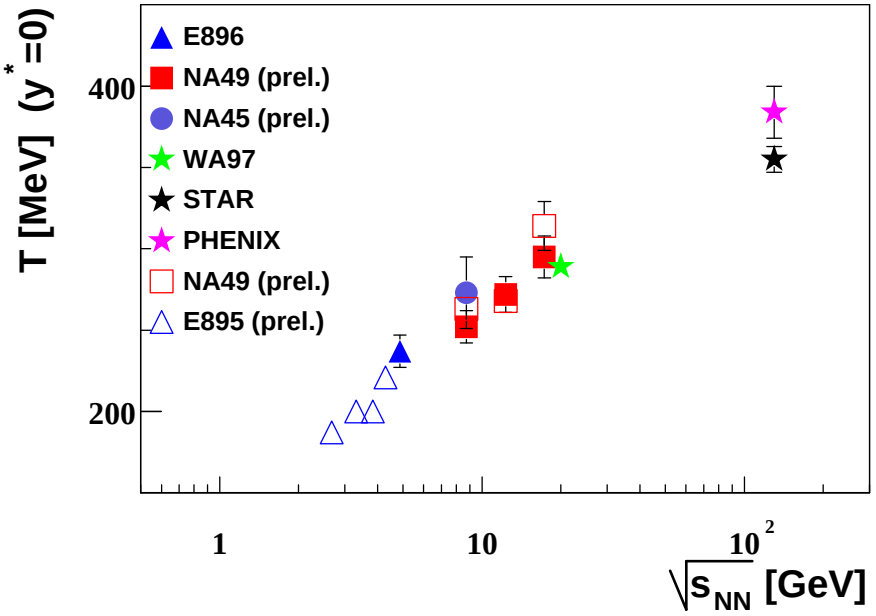
m_T spectra @ 158 AGeV for $|y^*| \leq 0.4$



NA49: T(K^+)= 232±3±6 MeV
T(K^-)= 226±3±6 MeV

$$\frac{1}{m_T}\frac{d^2n}{d(m_T)dy} \propto \exp\left(\frac{-m_T}{T}\right)$$

filled symbols: Λ
open symbols: p

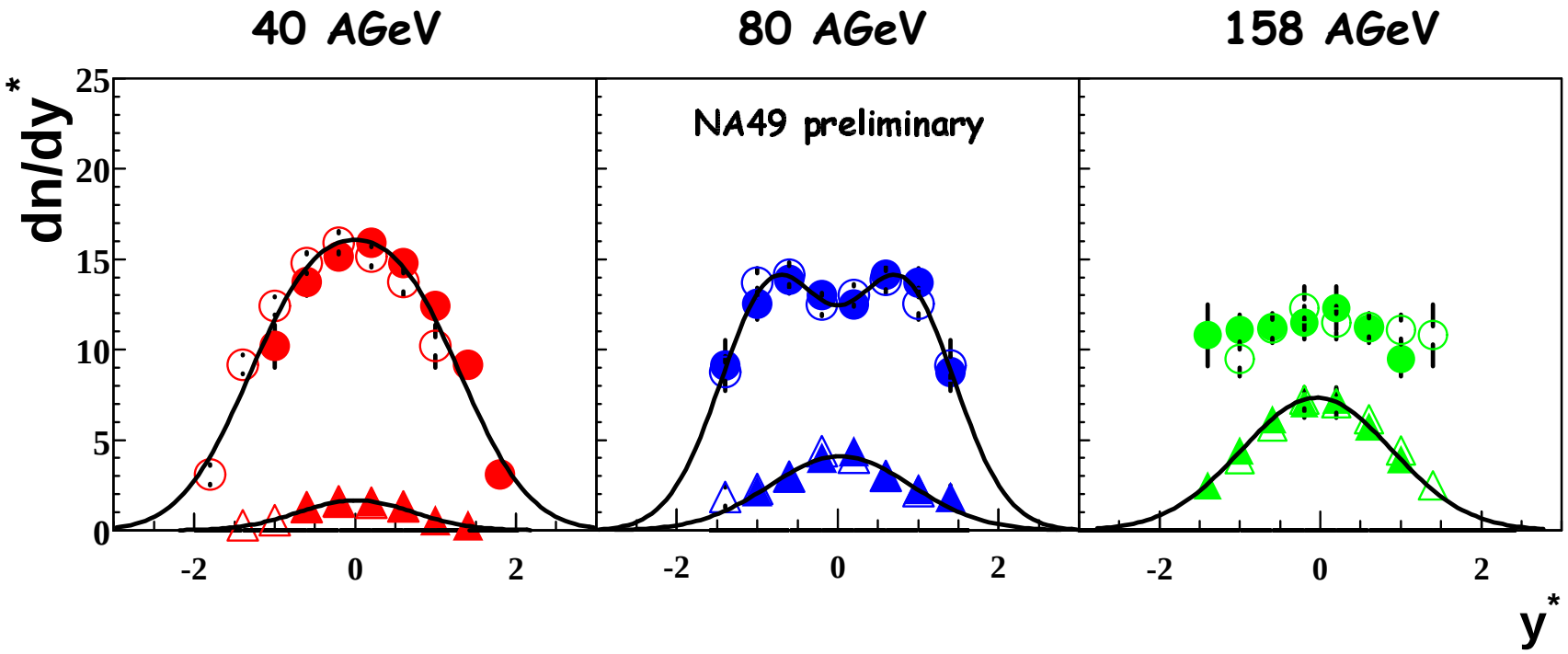


Inverse slope increases with increasing energy
-> Transverse flow increases with energy
-> Similar behavior of p, Λ and $\overline{\Lambda}$

Rapidity Spectra for Λ and $\overline{\Lambda}$

● Λ

▲ $\overline{\Lambda}$ x4



-> Λ rapidity spectra becomes broader with energy

-> Λ broader than $\overline{\Lambda}$

NA49 preliminary	$< \Lambda >$	$< \overline{\Lambda} >$
40 AGeV	45.6 ± 3.4	0.74 ± 0.06
80 AGeV	47.4 ± 3.7	2.26 ± 0.35
158 AGeV	49 ± 5	4.3 ± 0.3

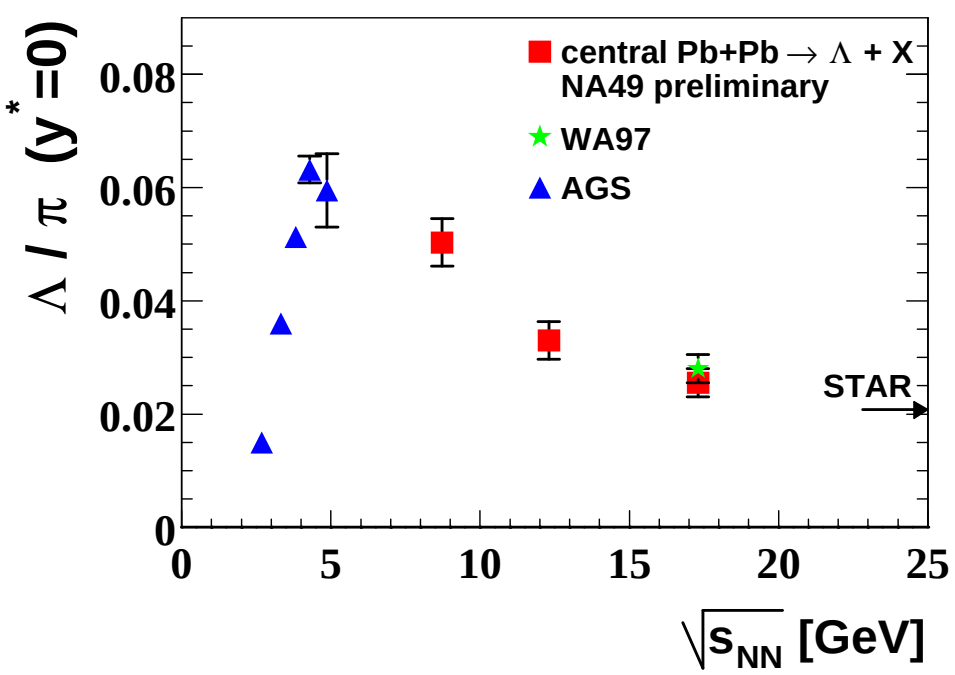
Energy Dependence I

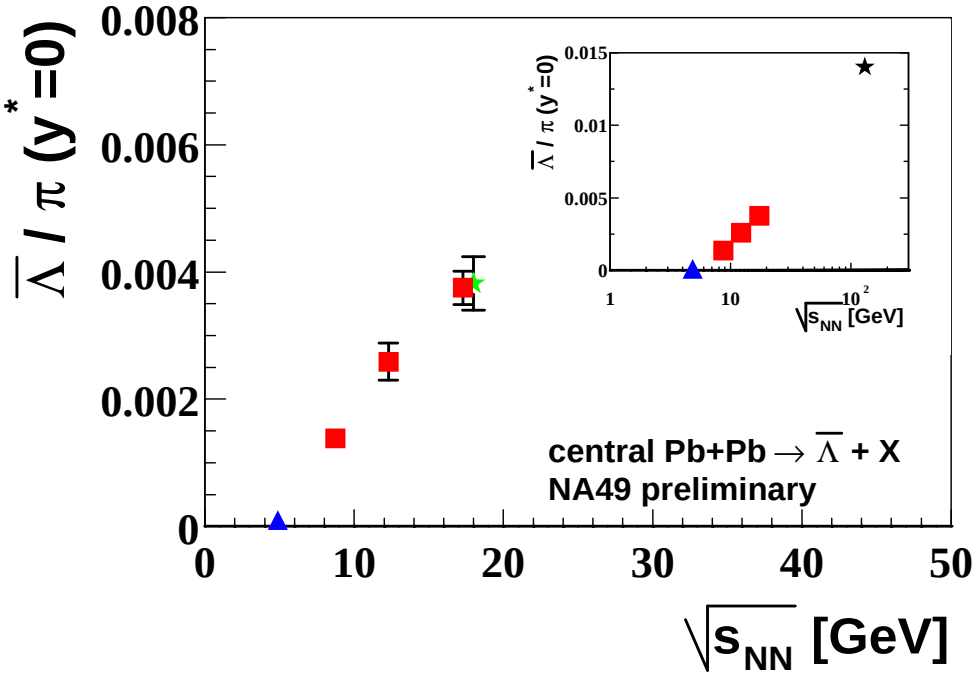
E895: G. Rai, QM99
E896: PRL 88(02)062302
WA97: QM99
STAR: nucl-ex/0203016

E917: PRL 87(01)242301

$\pi = 1.5(\pi^+ + \pi^-)$

Particle ratios at mid-rapidity





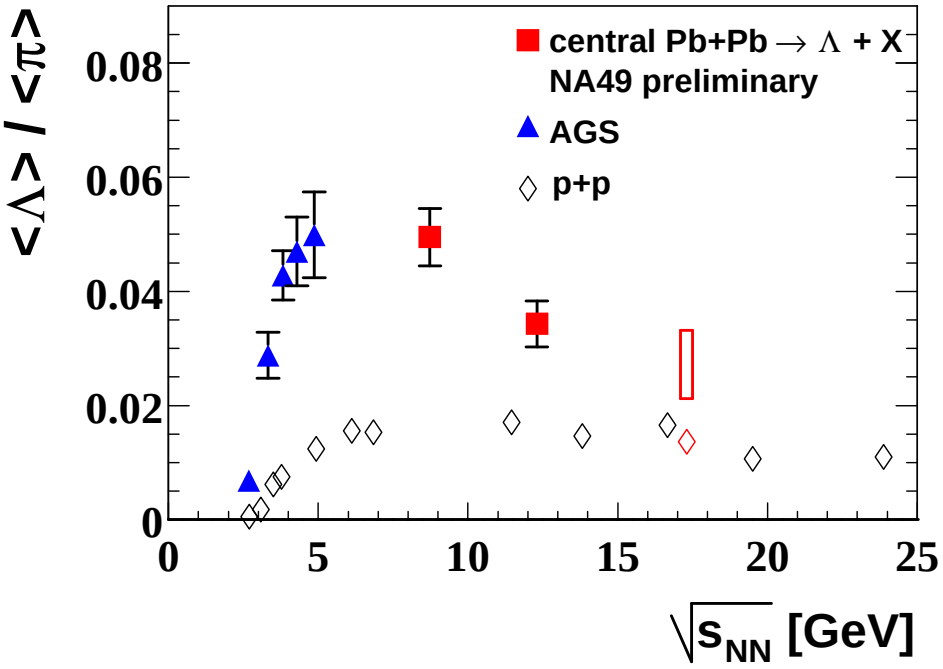
-> Highest ratio
at or above top AGS energies

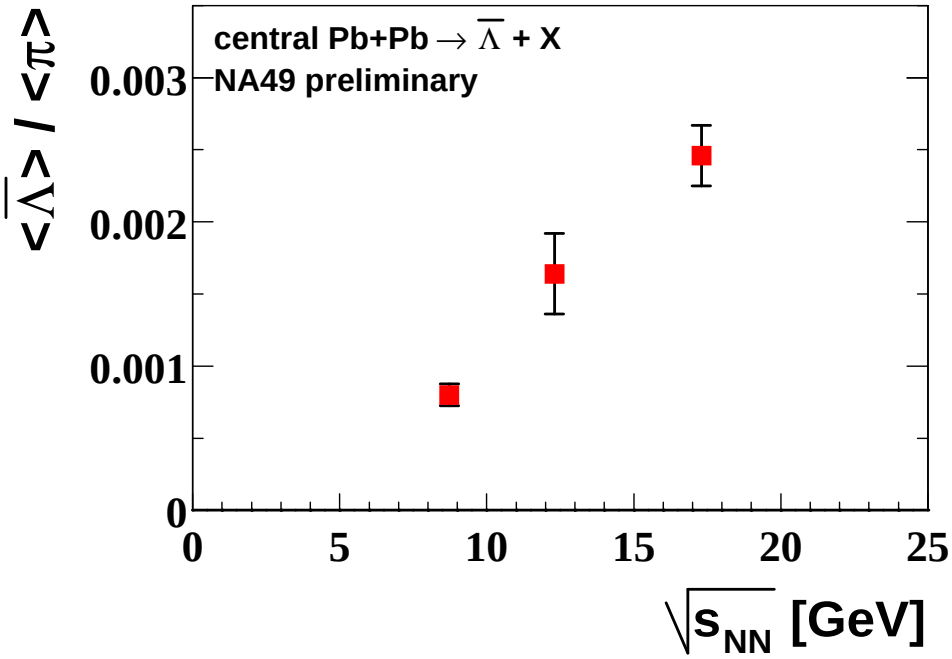
-> monotonic increase
(little or no structure)

Energy Dependence II

E895: C. Pinkenburg, QM2001
top AGS: Phys.Rev.C64(01)024901
pp Data: M. Gazdzicki, D.Röhrich,
Z.Phys. C65(95)215 and
Z.Phys. C71(96)55

Particle ratios for total yields

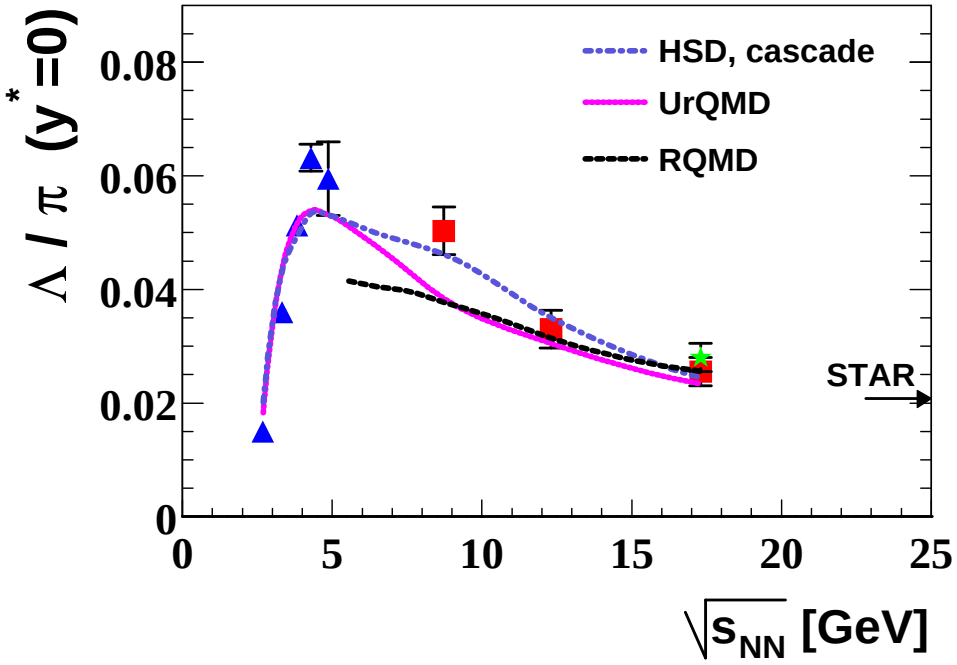


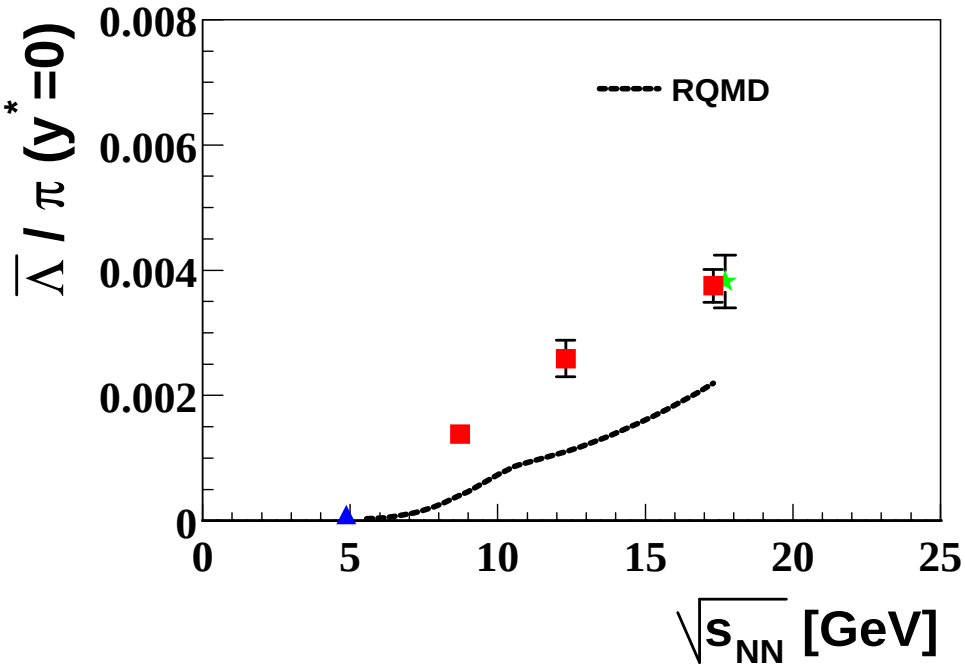


-> Non-monotonic energy dependence

-> continuous rise

Model Predictions





UrQMD (version 1.3): H. Weber, E. Bratkovskaya, H. Stöcker, nucl-th/0205030

HSD: E. Bratkovskaya, private communication

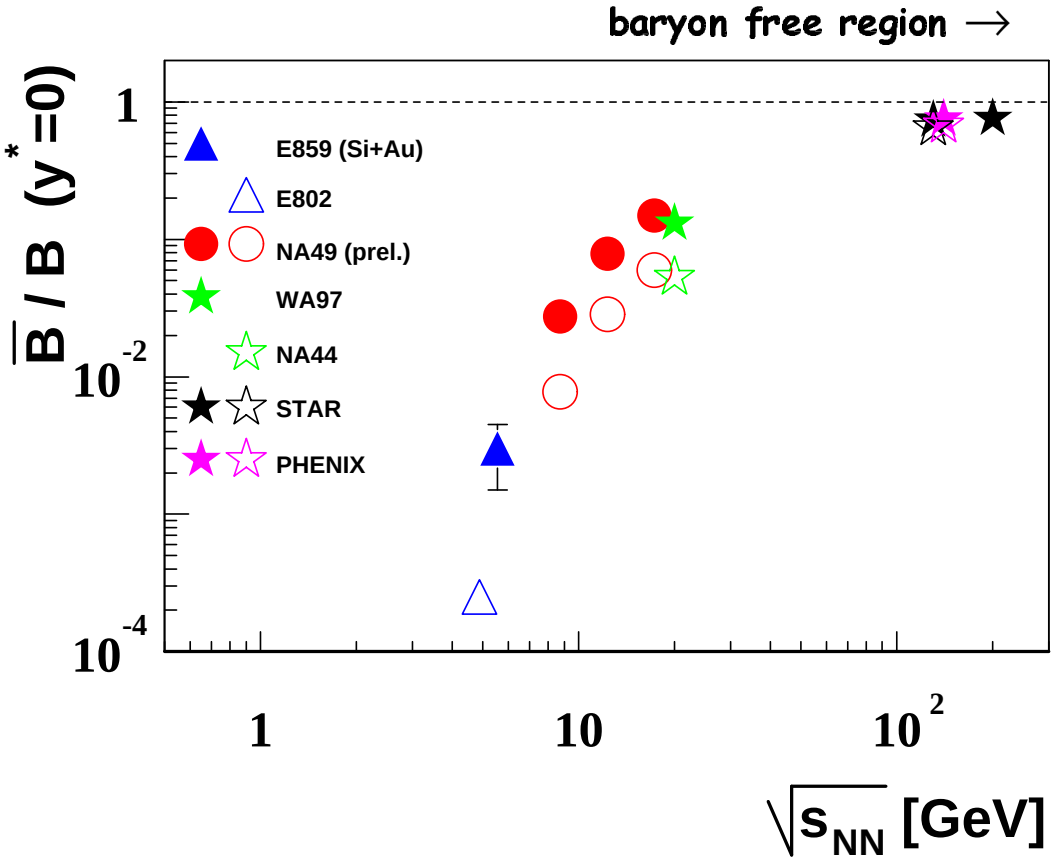
RQMD (version 2.3, color ropes implemented): N. Xu, private communication

$\bar{B}/B$ ratios at mid-rapidity

E859: Nucl.Phys. A590(95)179c
E802: PRL 81(98)2650
WA97: QM99
NA44: Phys.Lett. B471(99)6
STAR: nucl-ex/0203016
and G. van Buren, SQM01
Phenix: nucl-ex/0204007

filled symbols: $\bar{\Lambda}/\Lambda$

open symbols: $\bar{p}/p$



Measured by NA49 @ 158 AGeV (preliminary):

$\bar{p}/p$ = 0.06 ± 0.005

$\bar{\Lambda}/\Lambda$ = 0.15 ± 0.014

$\bar{\Xi}/\Xi$ = 0.22 ± 0.03

$\bar{\Omega}/\Omega$ = 0.48 ± 0.15

-> strong increase with energy due to decreasing baryon density

-> $\bar{\Lambda}/\Lambda$ and $\bar{p}/p$ ratios are different, maybe also in 4π ?

$\bar{\Lambda}$ / $\bar{p}$ Ratios

E917: PRL 87(01)242301
E859: J.Phys. G23(97)1897
Phenix: nucl-exp/0204007

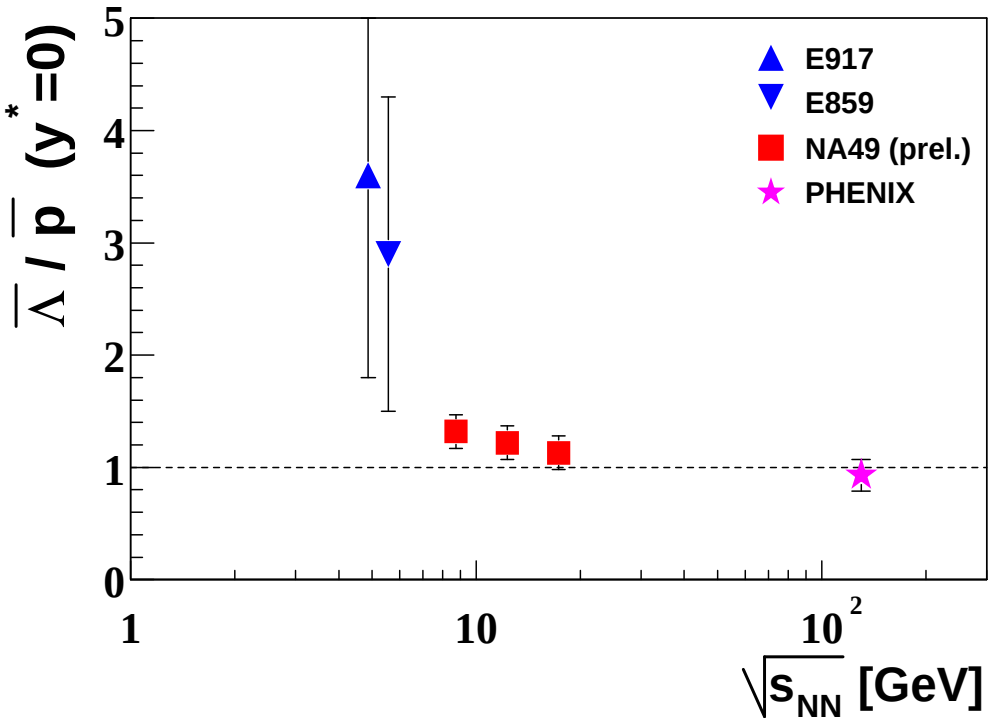
$\bar{\Lambda}/\bar{p} \sim (\bar{u}\,\bar{d}\,\bar{s}) / (\bar{u}\,\bar{u}\,\bar{d}) \sim \bar{s}/\bar{u}$

-> Interplay of production and annihilation processes

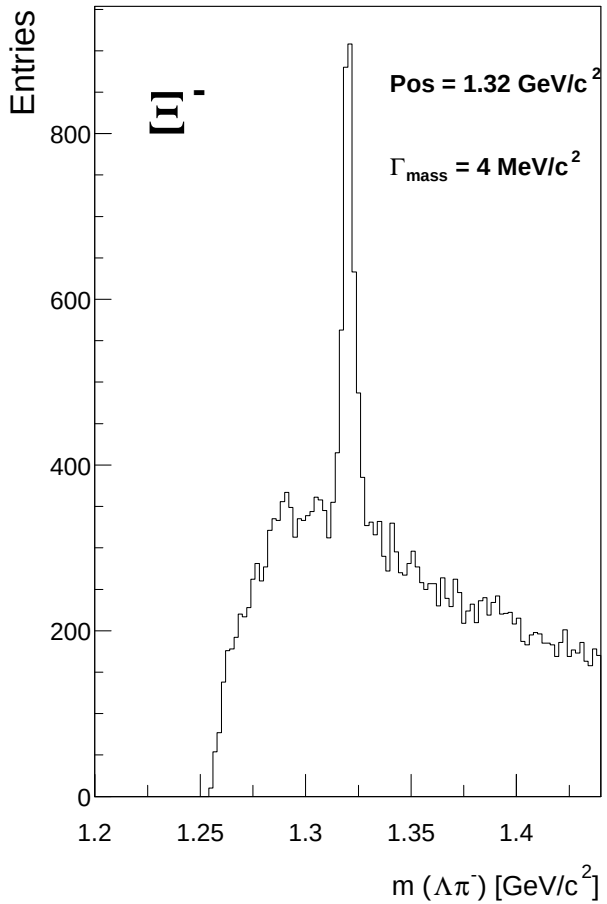
Evidence for the increase of the $\bar{\Lambda}/\bar{p}$ ratio with decreasing energy

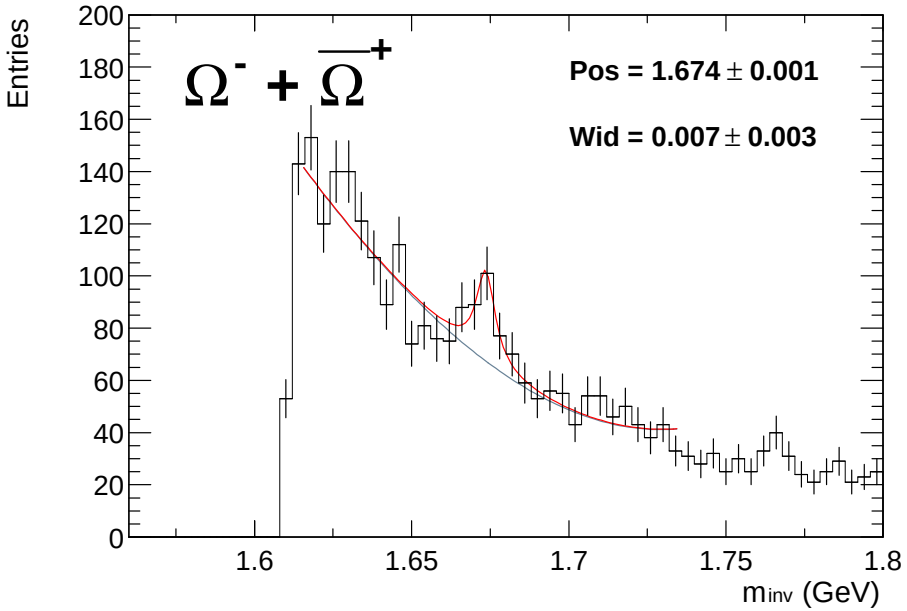
-> Is this trend also present for the total multiplicities ?

-> Soon 20 and 30 AGeV run



Outlook: Ξ and Ω Signal at 40AGeV





-> Soon: Energy dependence of multi-strange hyperons

Summary

- Results on Λ and $\bar{\Lambda}$ production in central Pb+Pb collisions at 40, 80 and 158 AGeV
- Λ/π ratio reaches a maximum around top AGS and 40 AGeV
- $\bar{\Lambda}/\pi$ ratio shows a monotonic increase

  -> Interplay of two effects: strangeness production and effect of baryon density
- $\bar{\Lambda}/\Lambda$ ratio increases with energy -> effect of net baryon density
- $\bar{\Lambda}/\bar{p}$ increases with decreasing energy
- Outlook
  - 20 and 30 AGeV run this Autumn
  - Energy dependence of multi-strange hyperons