

First observation of Σ^0 production in proton induced reaction on a nuclear target

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Tobias Kunz for the HADES Collaboration

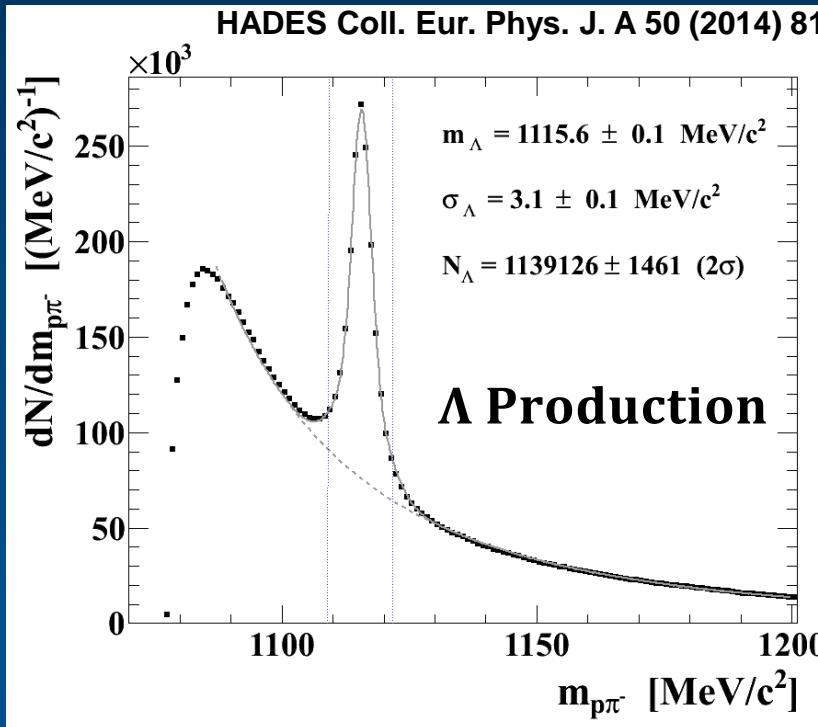


Can we detect Σ^0 in HADES ?

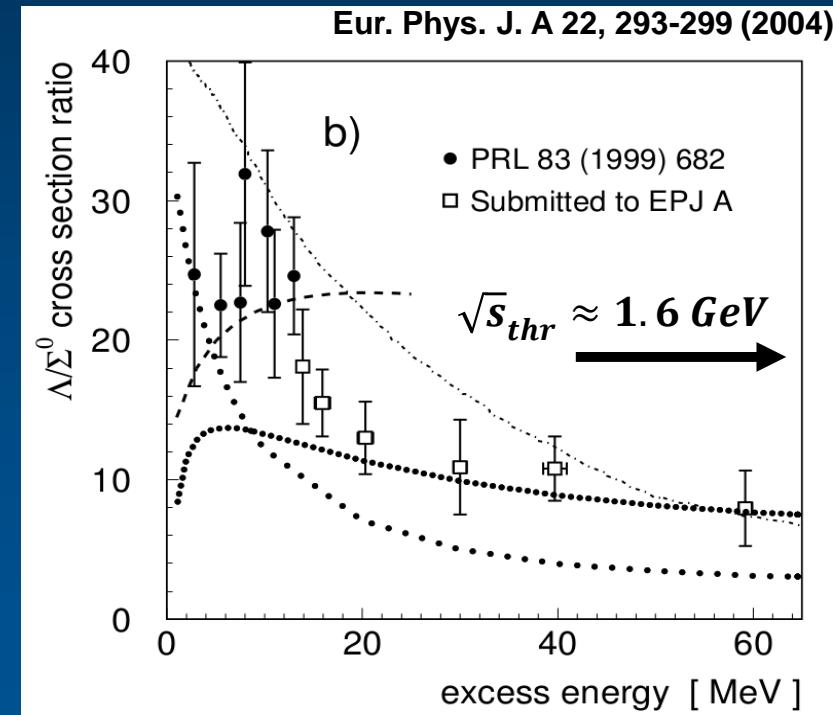
$K^0, K^*, K^\pm, \Lambda^0, \Sigma^+, \Xi^-$ production in $p + p$,
 $p + A, A + A$

Hypernuclei for Λ but not for Σ

$$\begin{aligned} m_{\Sigma^0} &= 1192.642 \pm 0.07 \text{ MeV/c}^2 \\ I(J^P) &= 1(1/2^+) \\ c\tau &= 2.2 \cdot 10^{-11} \text{ m} \\ \Sigma^0 \rightarrow \Lambda^0 \gamma &\quad (99.0 \%) \\ \Sigma^0 \rightarrow \Lambda^0 e^+ e^- &\quad (0.5 \%) \end{aligned}$$



$p + \text{Nb}$ ($E = 3.5 \text{ GeV}$), $\sqrt{s_{NN}} \approx 3.2 \text{ GeV}$

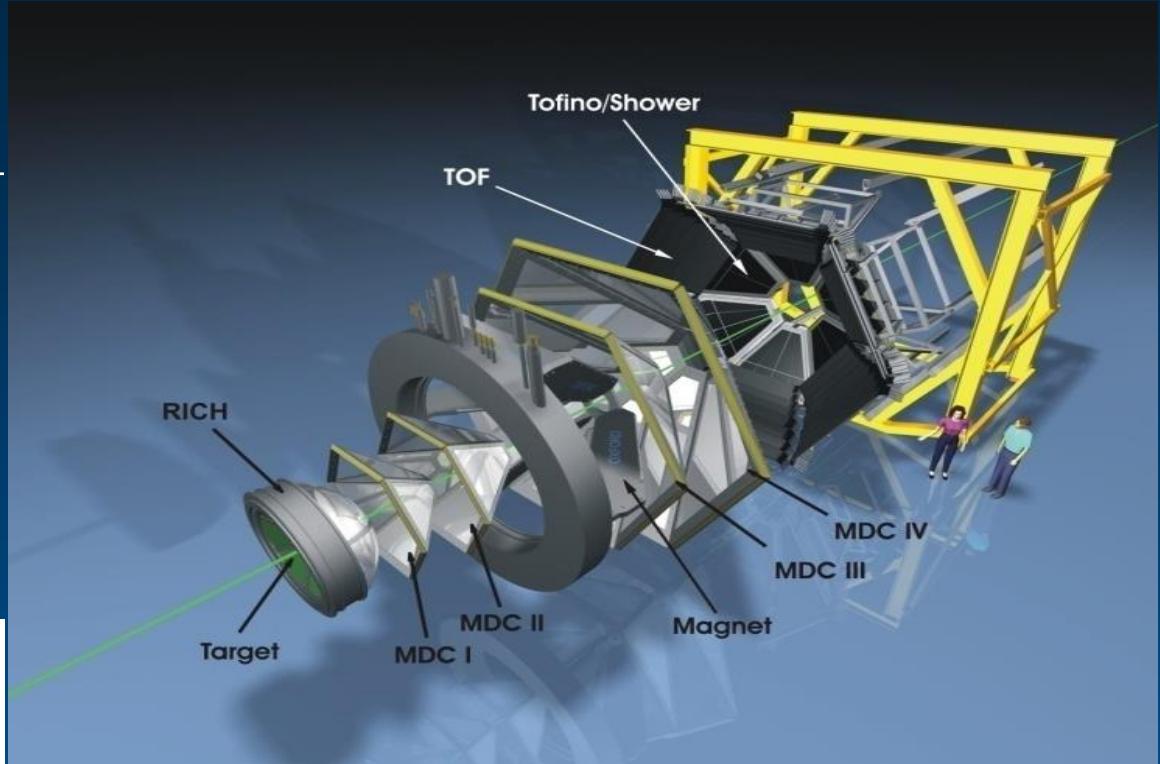
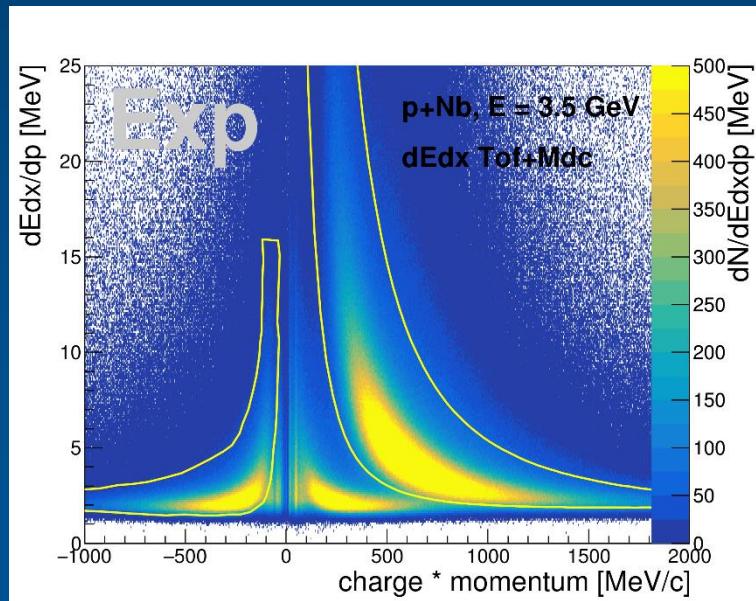


No $\frac{\Lambda}{\Sigma}$ data available for $p + A$

The HADES Spectrometer

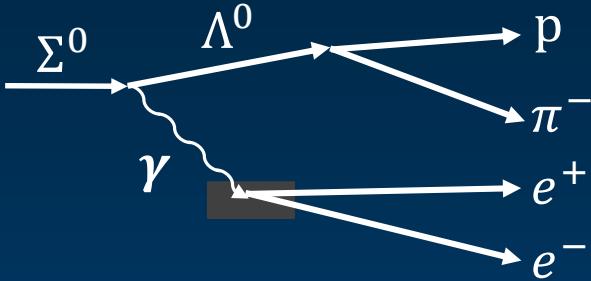
Observable Detektor

Observable	Detektor
p	MDC (Magnet)
β	TOF(ino)
dE/dx	MDC / TOF(ino)
e^+/e^-	RICH/ Pre-Shower



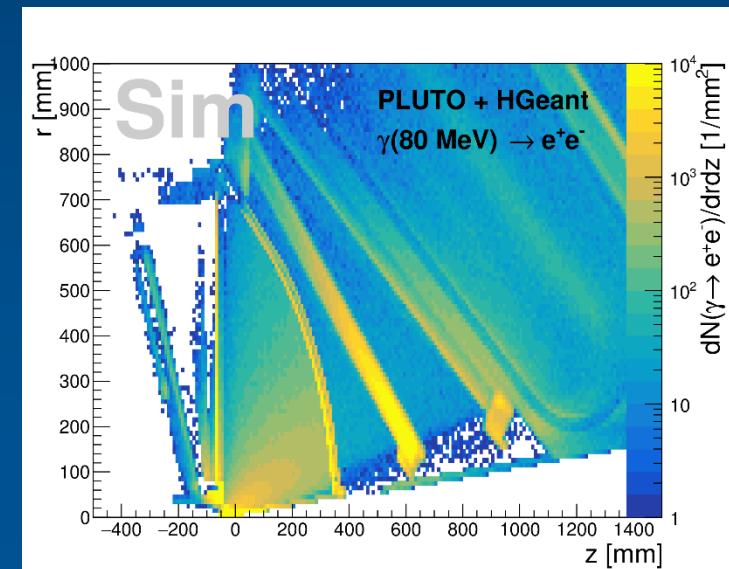
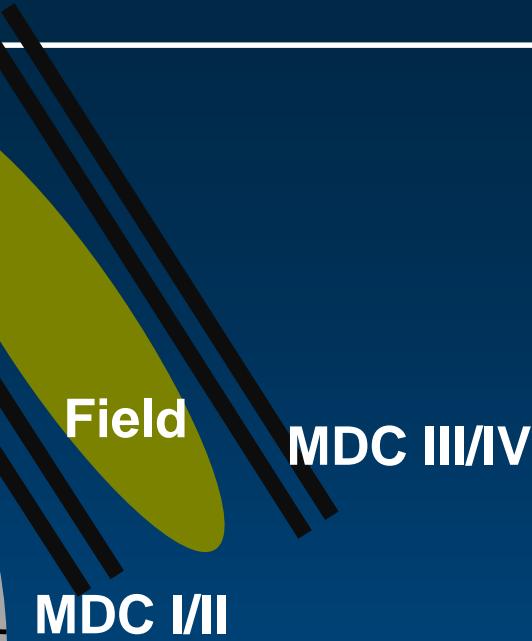
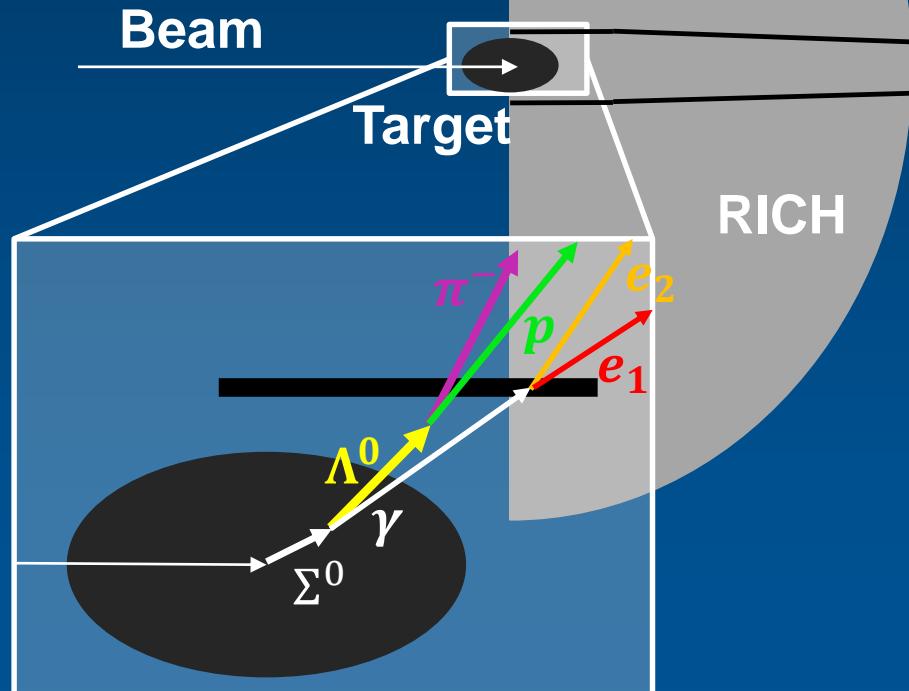
$p + \text{Nb}, E_{\text{kin}} = 3.5 \text{ GeV}$ $N = 4.21 \cdot 10^9 \text{ evt}$
reconstructed $N = 1.4 \cdot 10^6 \Lambda^0$

Strategy for Σ^0 Search



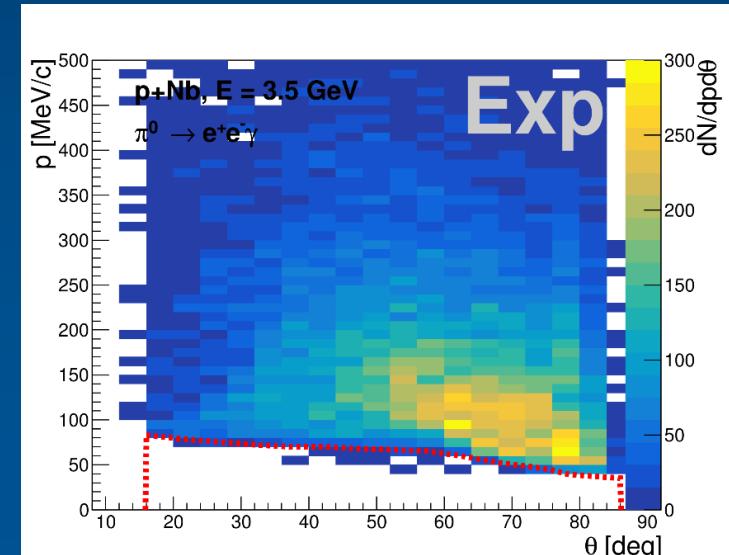
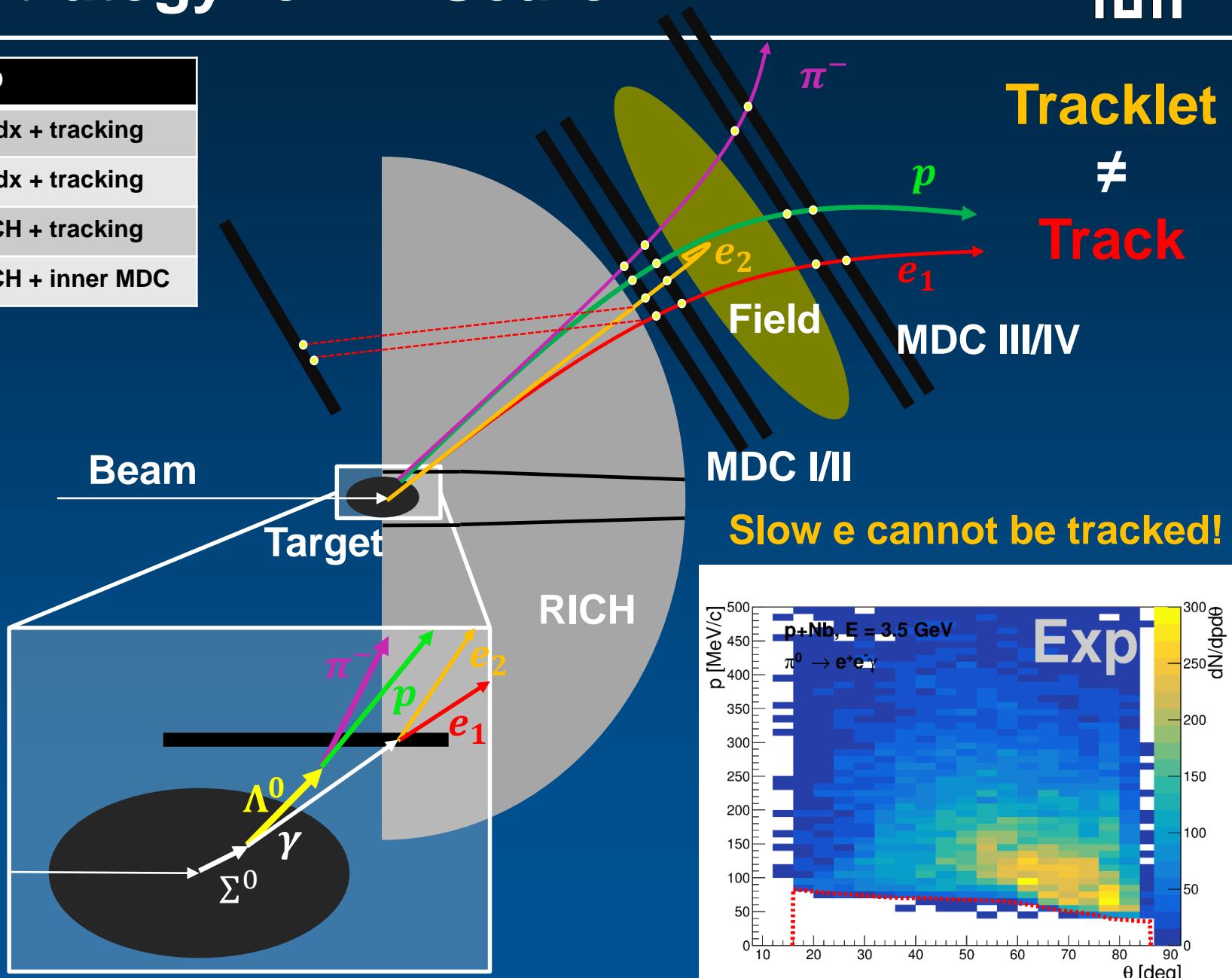
No Calorimeter

3% $\gamma \rightarrow e^+ e^-$ near target

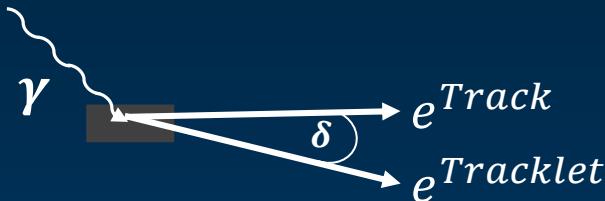


Strategy for Σ^0 Search

Particle	PID
p	dEdx + tracking
π^-	dEdx + tracking
e_1	RICH + tracking
e_2	RICH + inner MDC



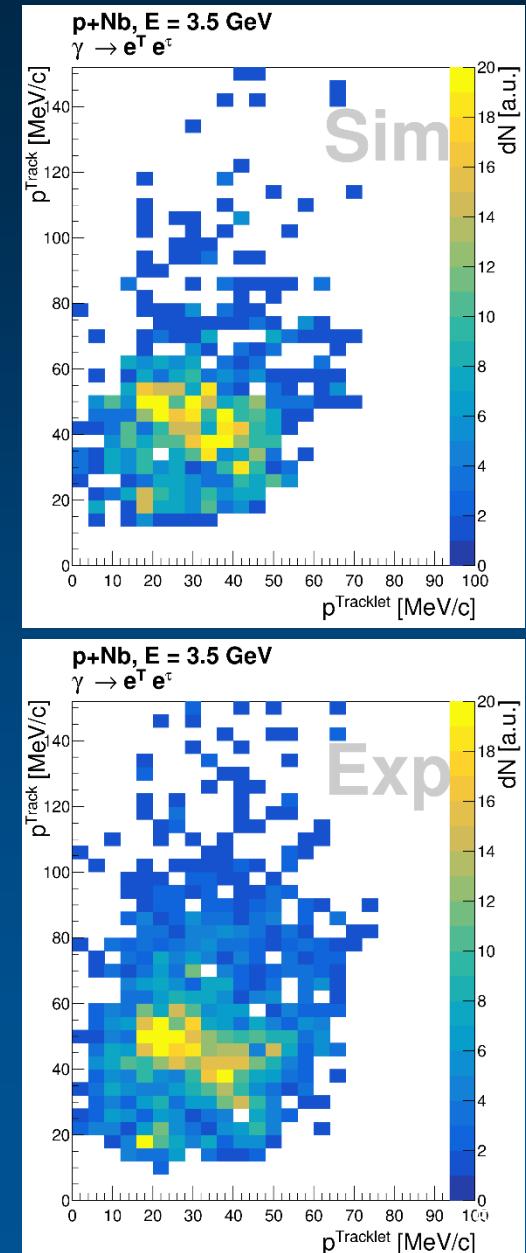
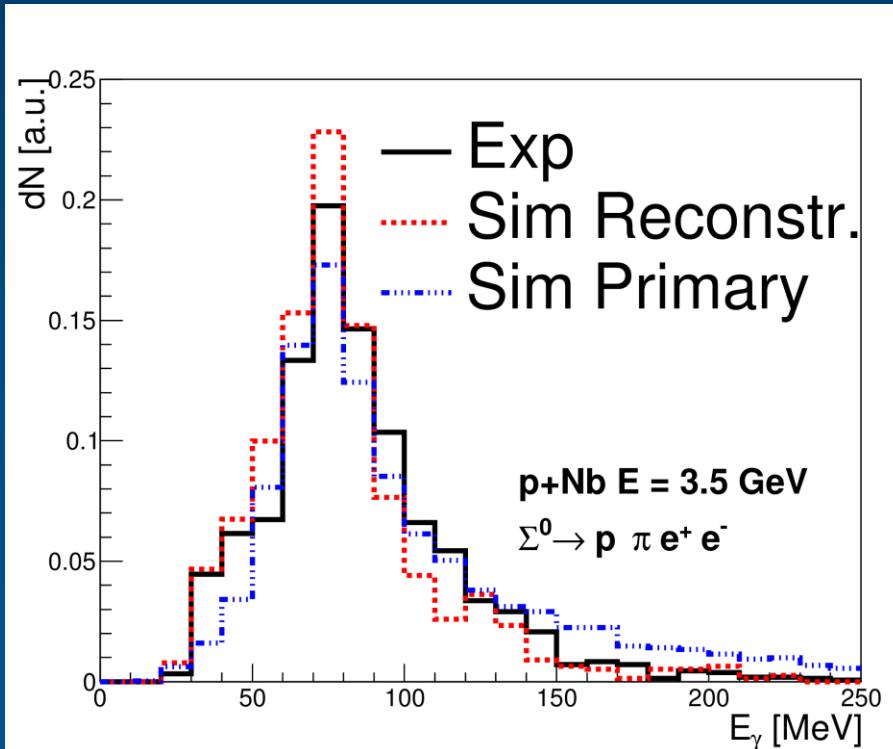
Track/Tracklet reconstruction



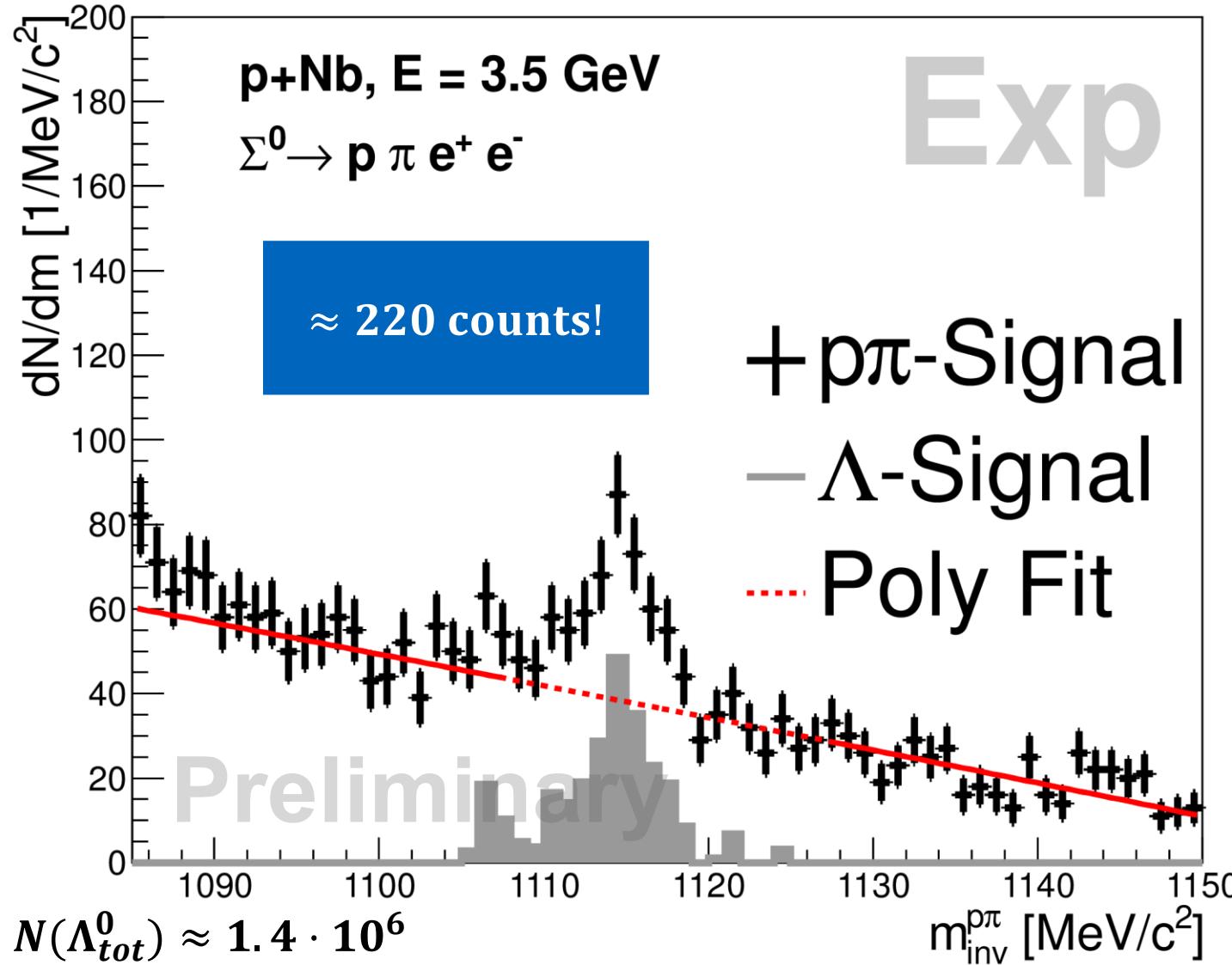
$e^{Track}: \theta, \phi, p, E$
 $e^{Tracklet}: \theta, \phi$
Opening Angle δ

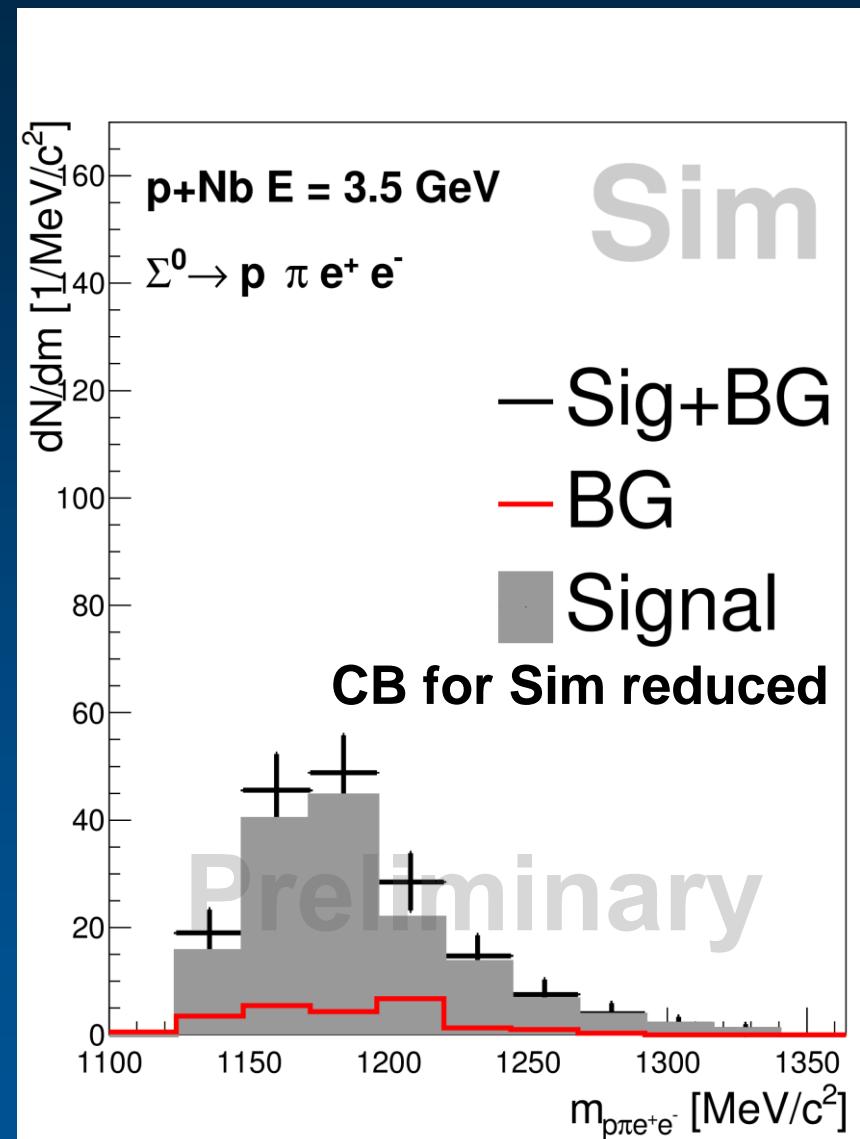
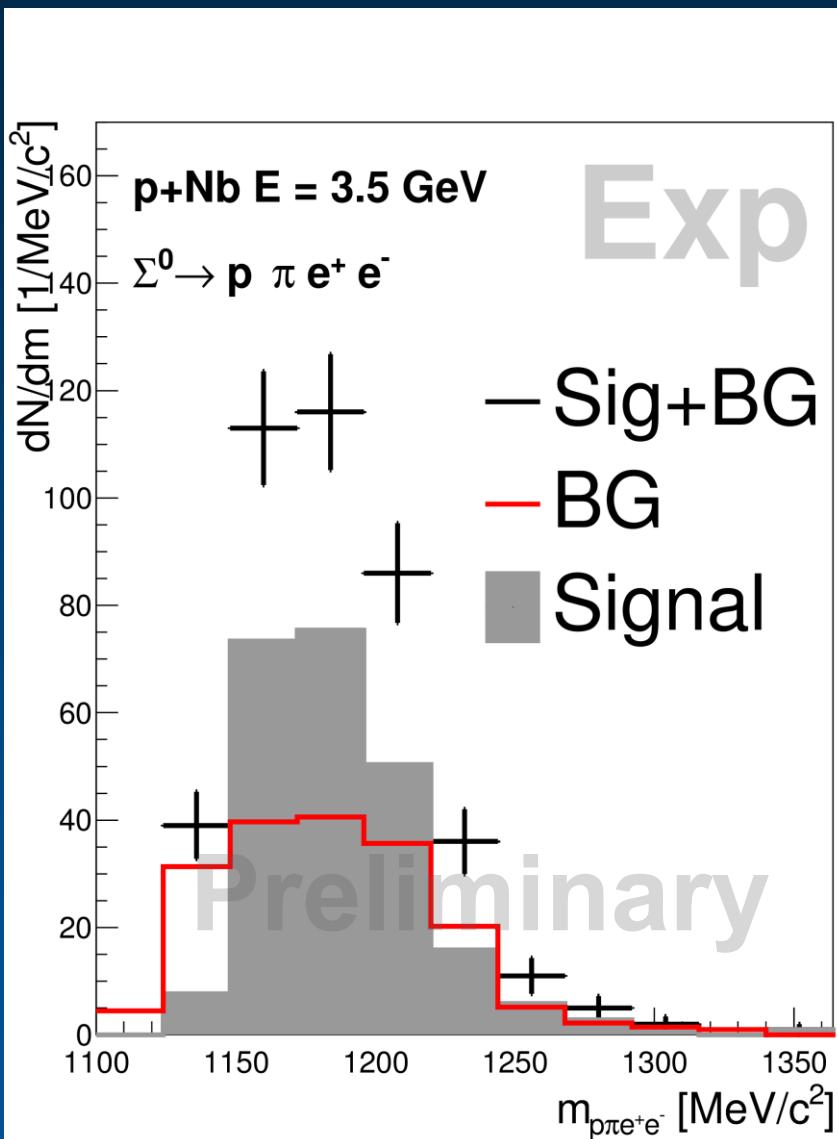
Event Hypothesis: $E_\gamma \approx 77$ MeV, e^{Track} , $e^{Tracklet}$, δ

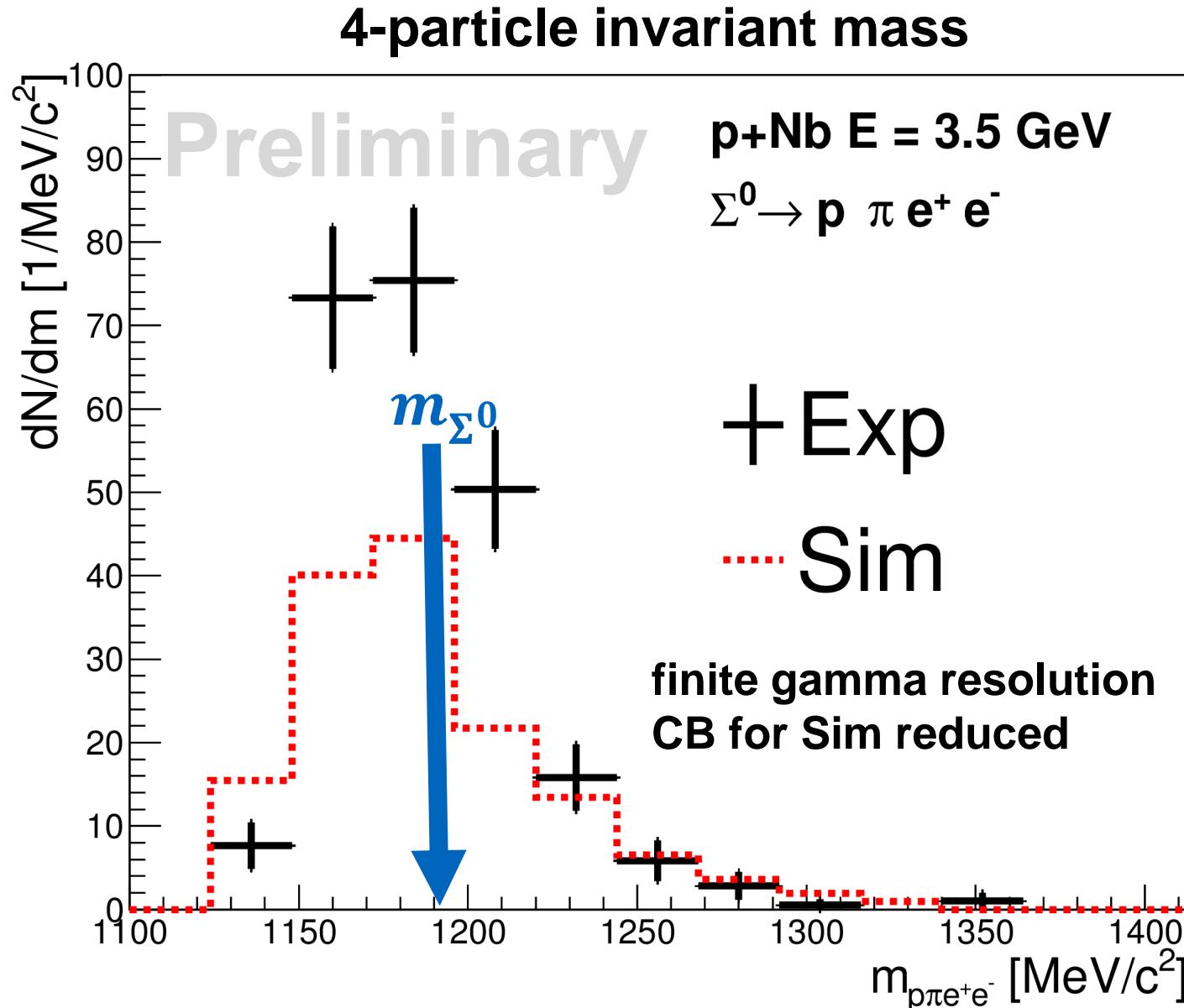
→ Calculate $p^{Tracklet}$



p π^- - invariant mass

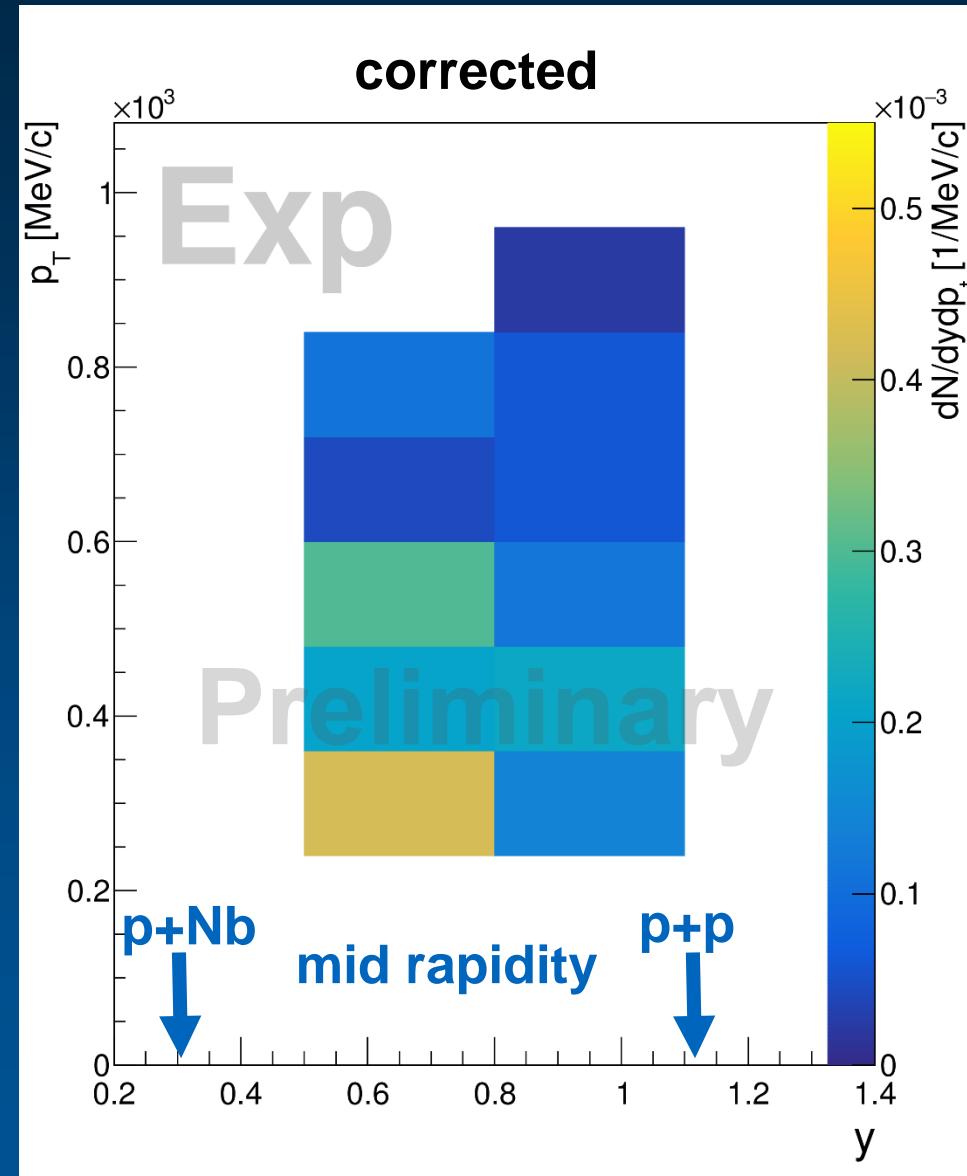
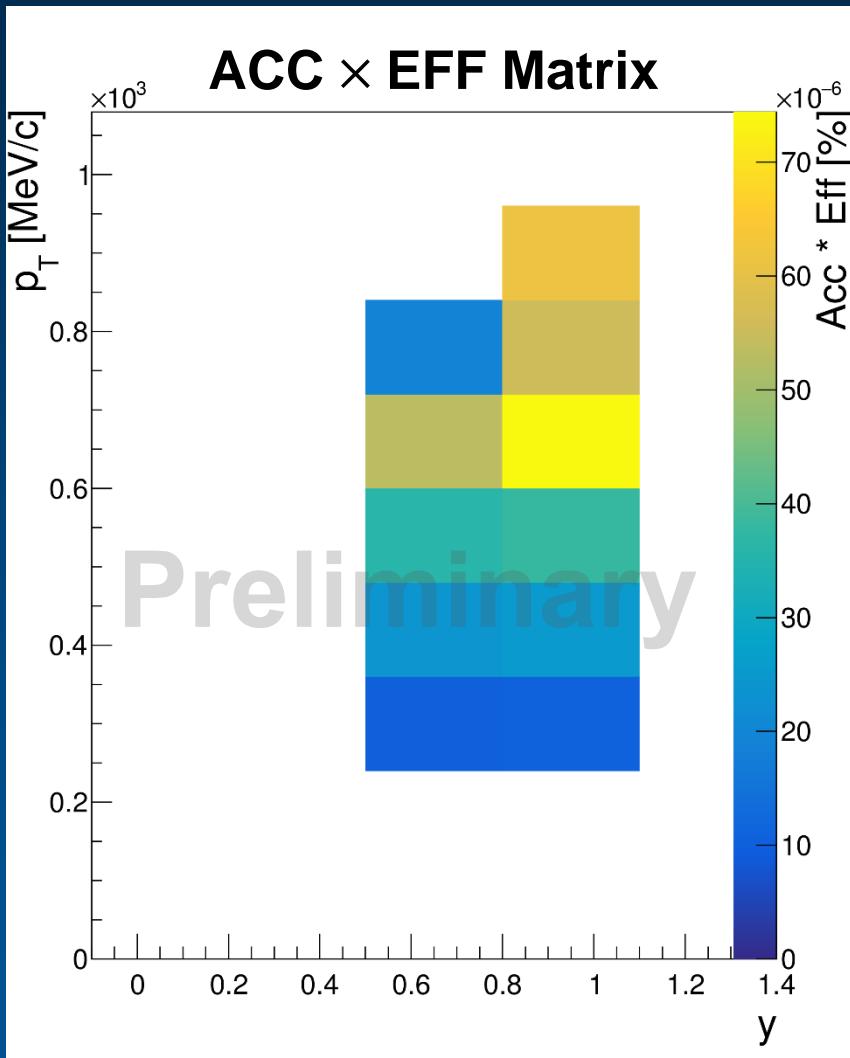






$ACC \times EFF = \text{reconstr.} / \text{primary}$

Efficiency $\approx 10^{-5}$



Systematic Uncertainties

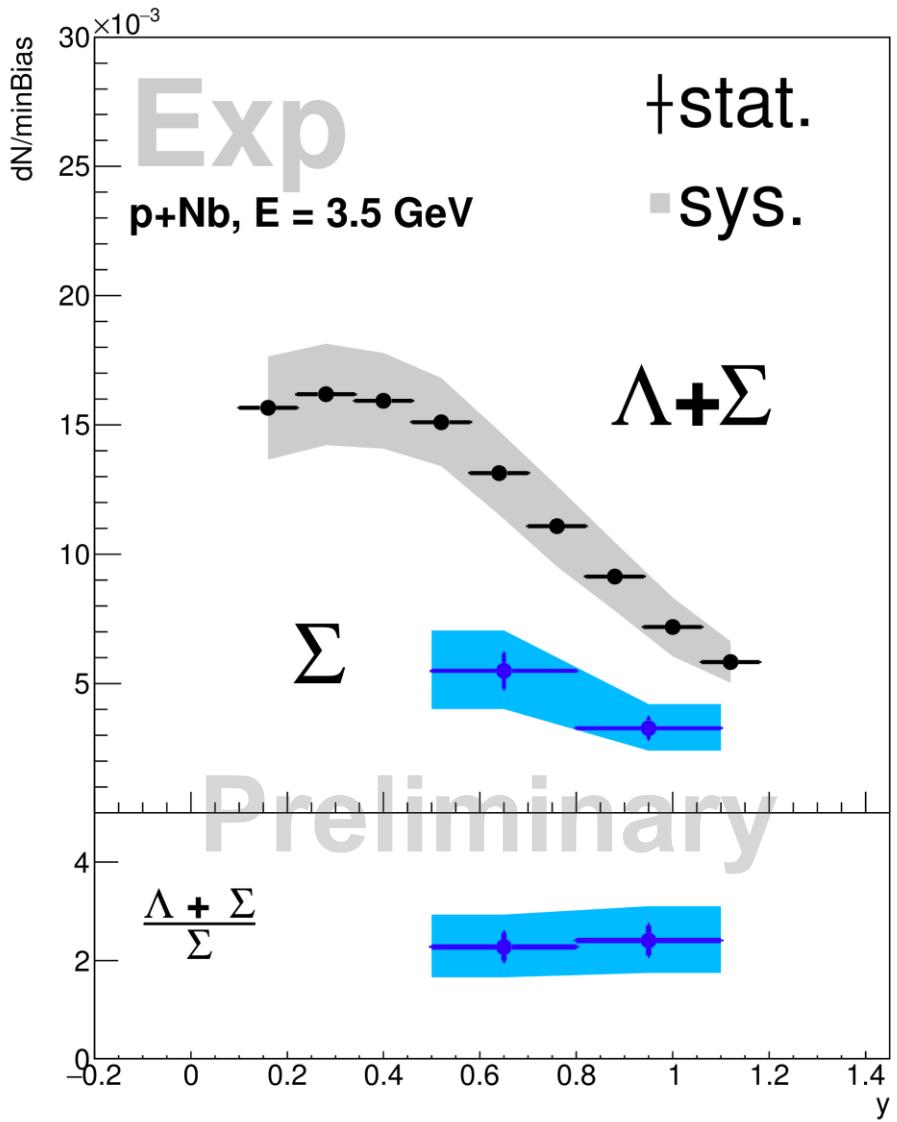
Sys Errors	Value
e^+ / e^- ID ¹⁾	25 %
Λ ID ²⁾	4.4 - 4.9 %
γ Reco	-10.2 + 3.1%
Backgr. substr.	7.7 %
Quadratic sum	30 %

- Use published errors for Λ and e^\pm reconstr.

1) HADES Coll., Phys. Lett. B 731 (2014)

2) HADES Coll., Eur. Phys. J. A 50 (2014) 81

- Add additional terms
 - γ -tracklet-reconstruction
 - background subtraction

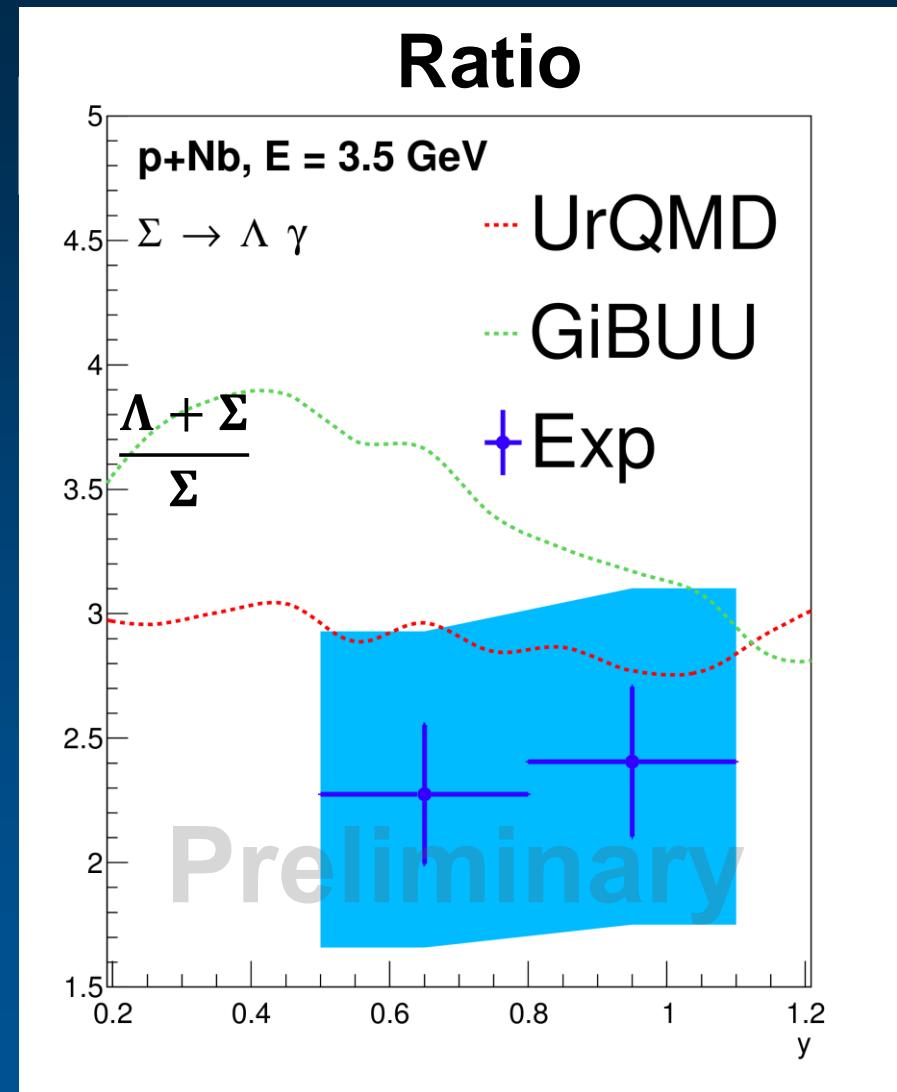
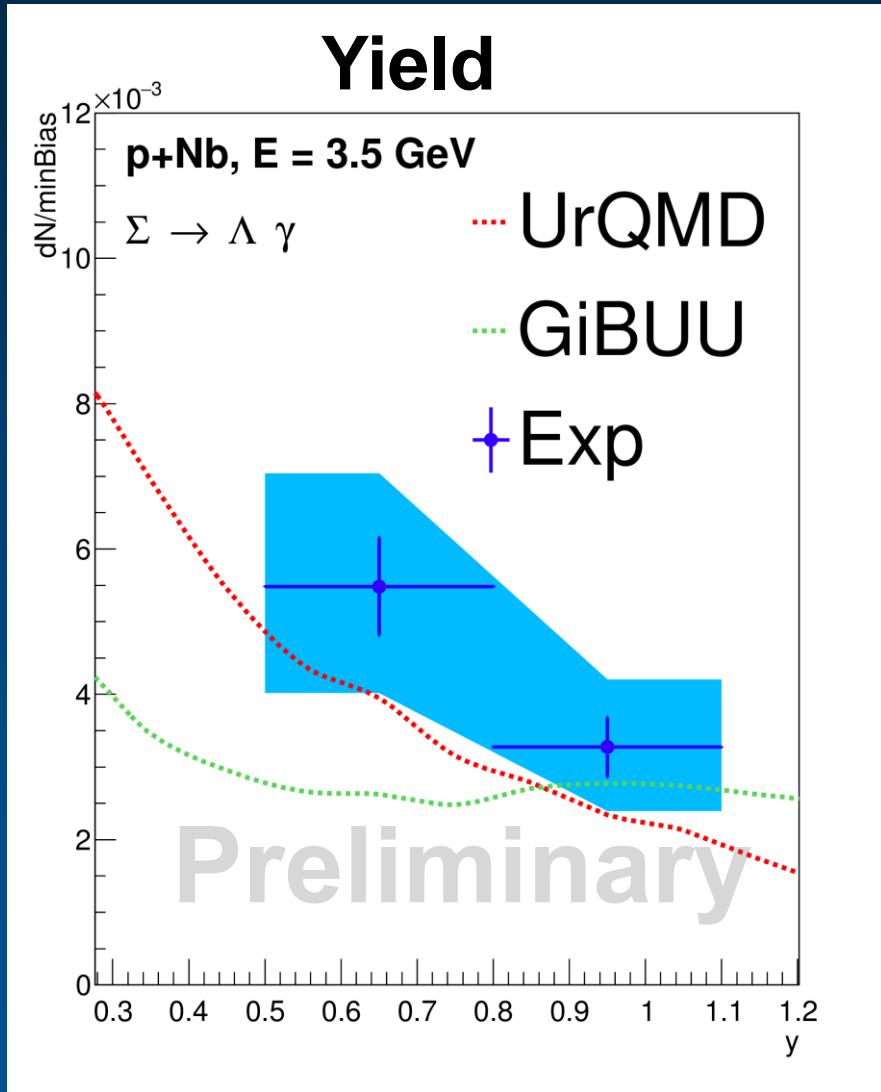


Measured in acceptance:

$$\frac{\Lambda + \Sigma}{\Sigma} = 2.3 \pm (0.2)^{\text{stat}} \pm (0.7)^{\text{sys}}$$

Expected in 4π :

$$\frac{\Lambda + \Sigma}{\Sigma} \approx 3$$

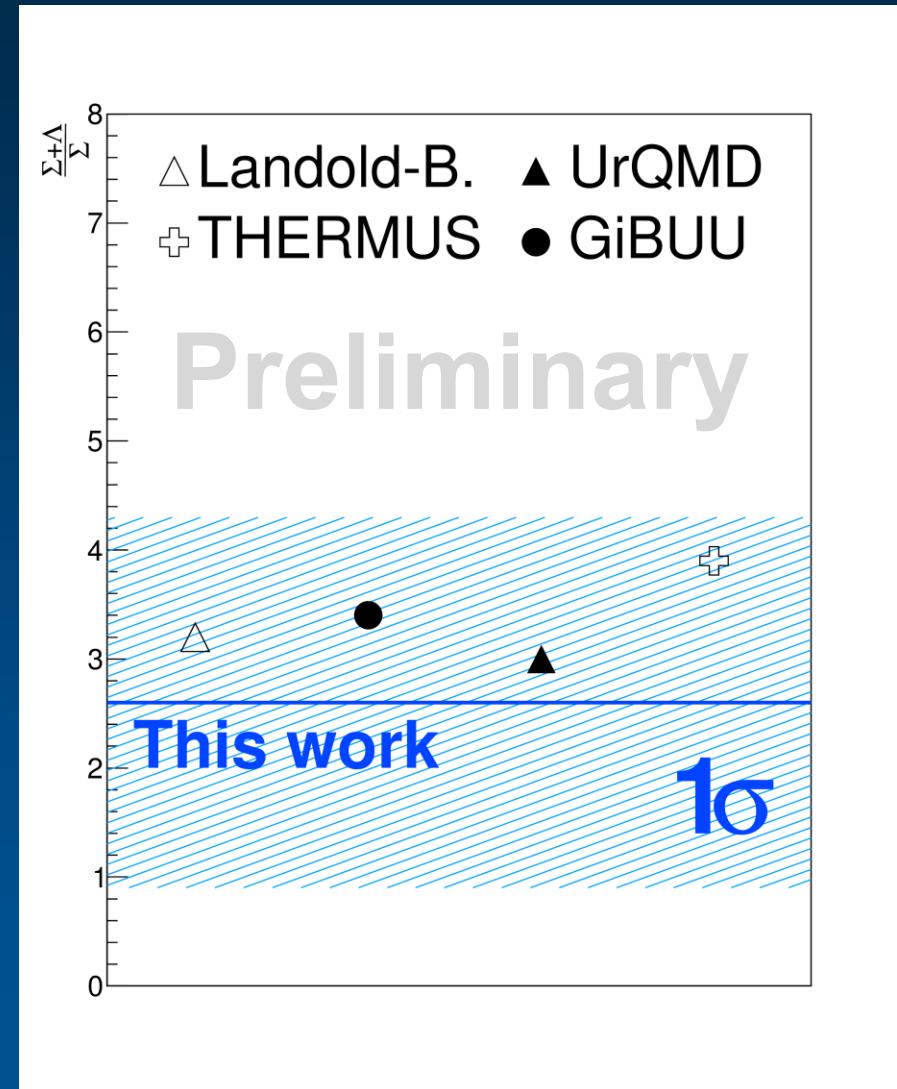
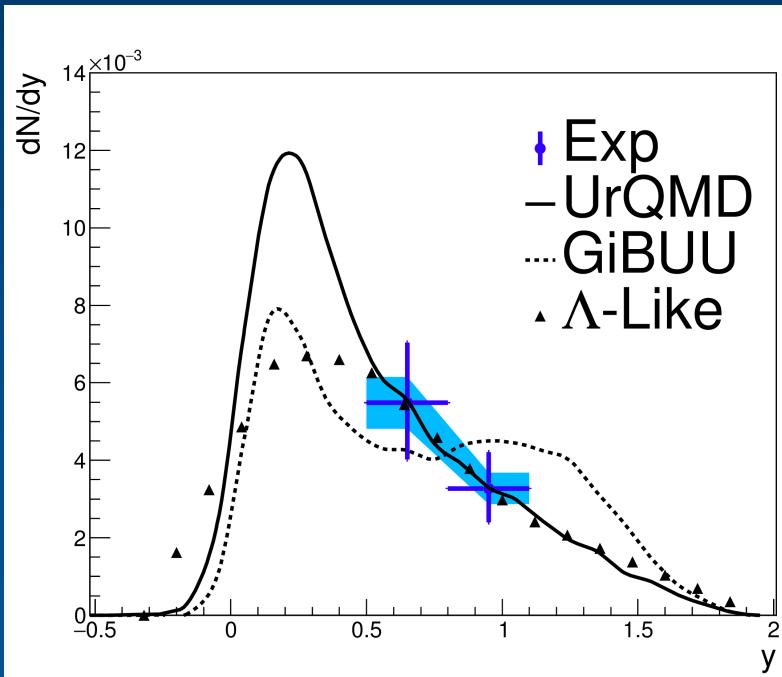


Extrapolation to 4π

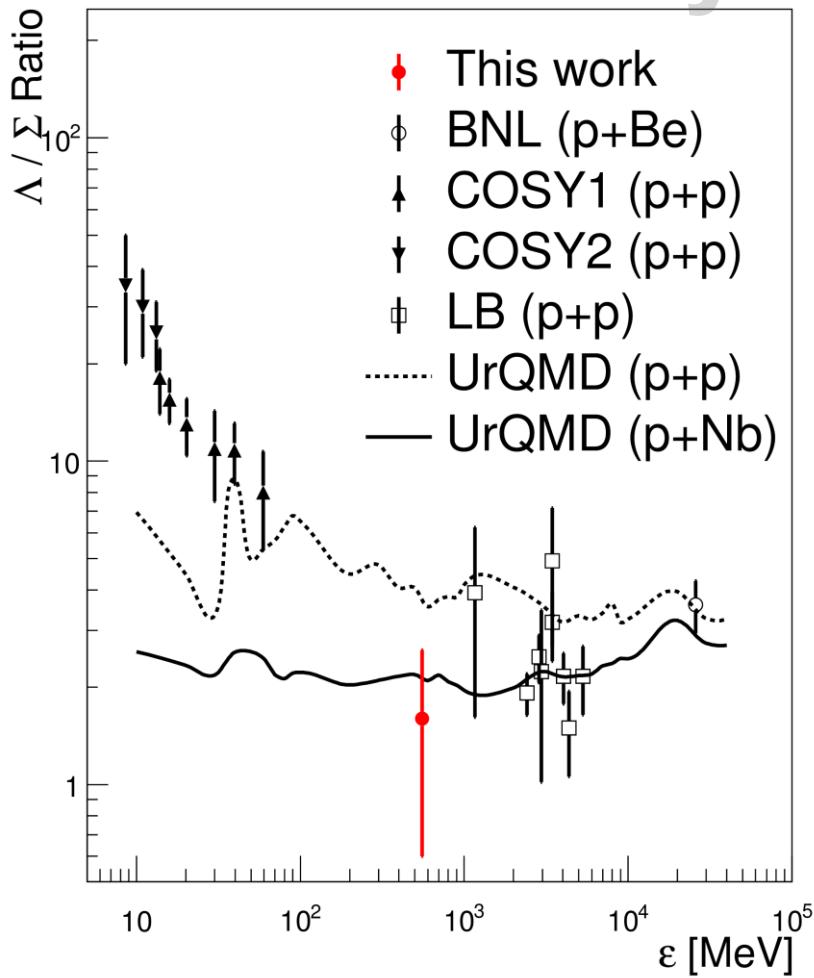
Models for extrapolation:

- GiBUU
- UrQMD
- Λ -Exp data

χ^2 -Fit for different shapes to Exp:



Preliminary



$N(\Sigma^0)$ reconstructed: ≈ 220

$$\sigma_{p+A}^{tot}(\Sigma^0) = 5.8 \pm (0.5)^{stat} \pm (3.9)^{sys} \text{ mb}$$

$$\frac{\Lambda}{\Sigma} = 1.6 \pm 1.0$$

First measurement in p + A!

Thank you for your attention



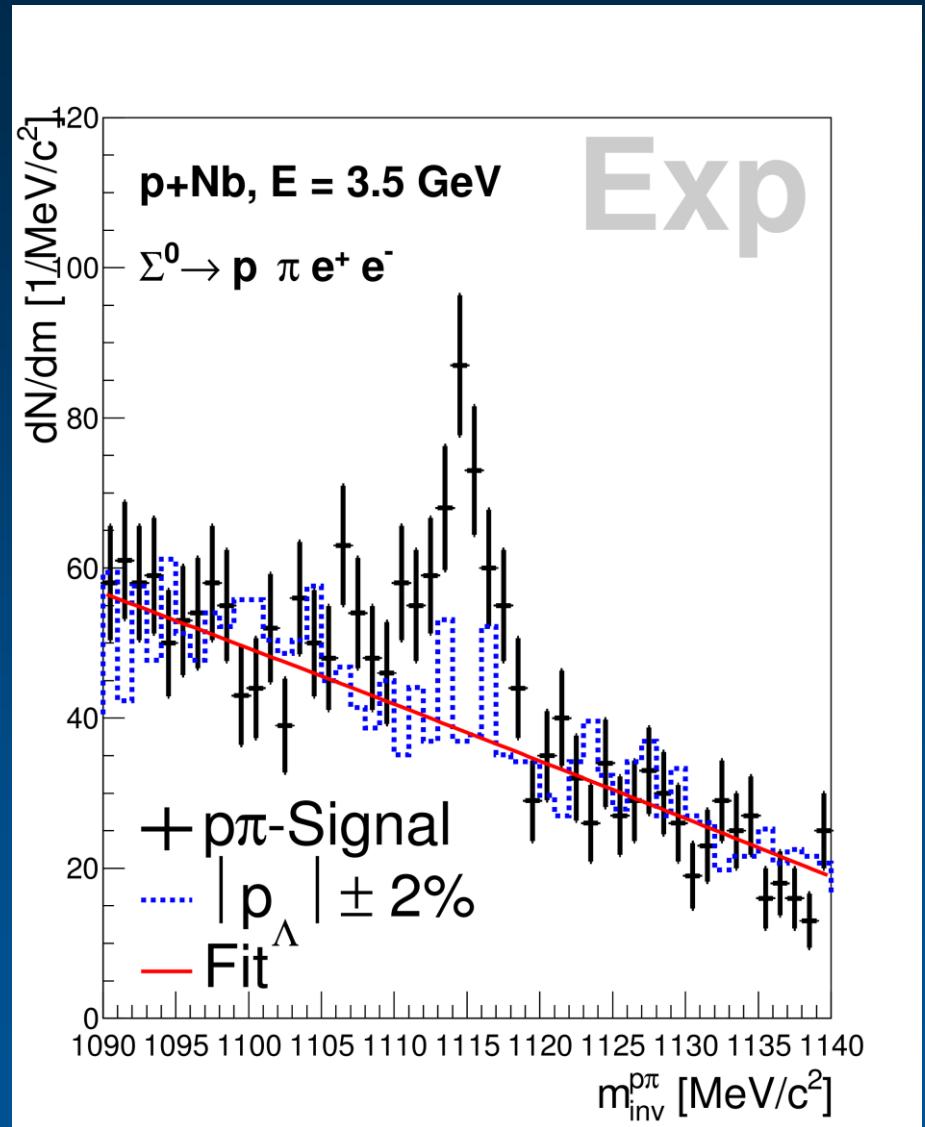
Backup

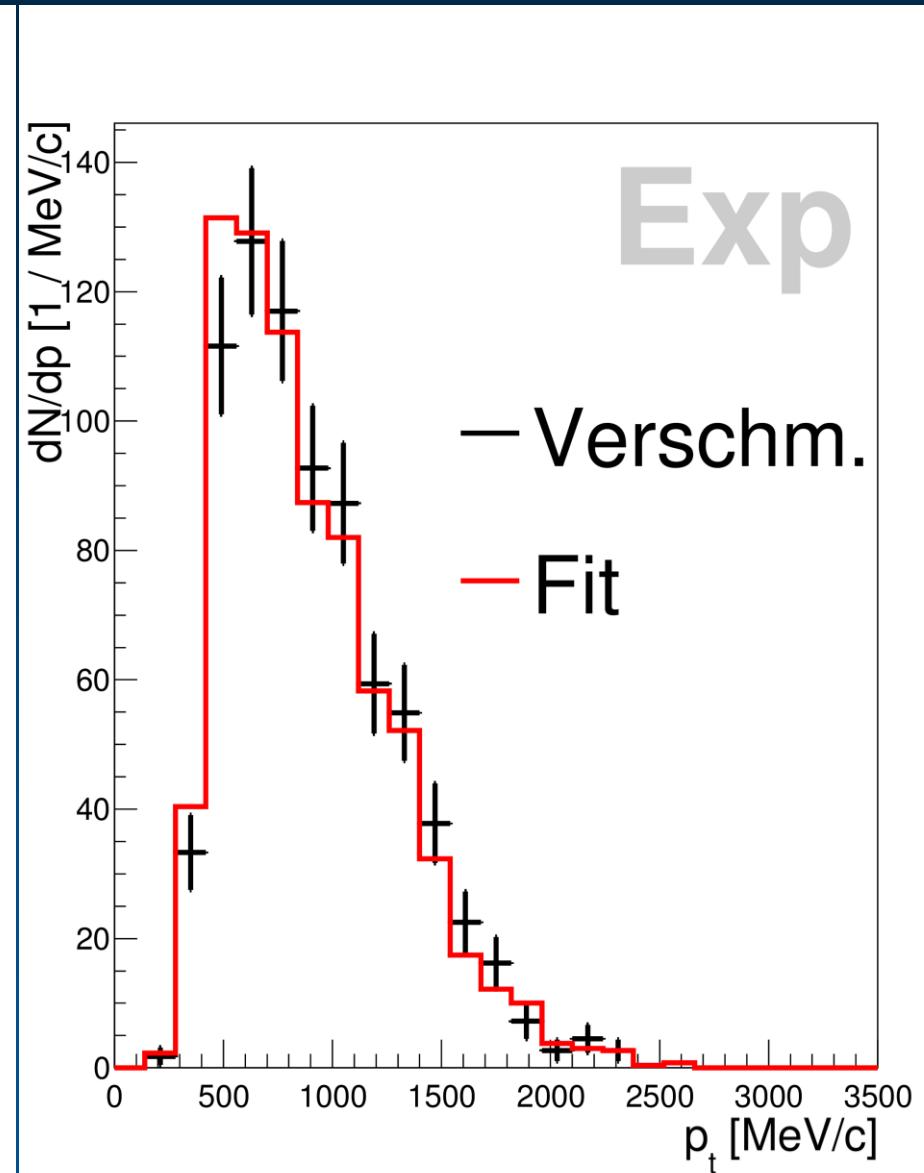
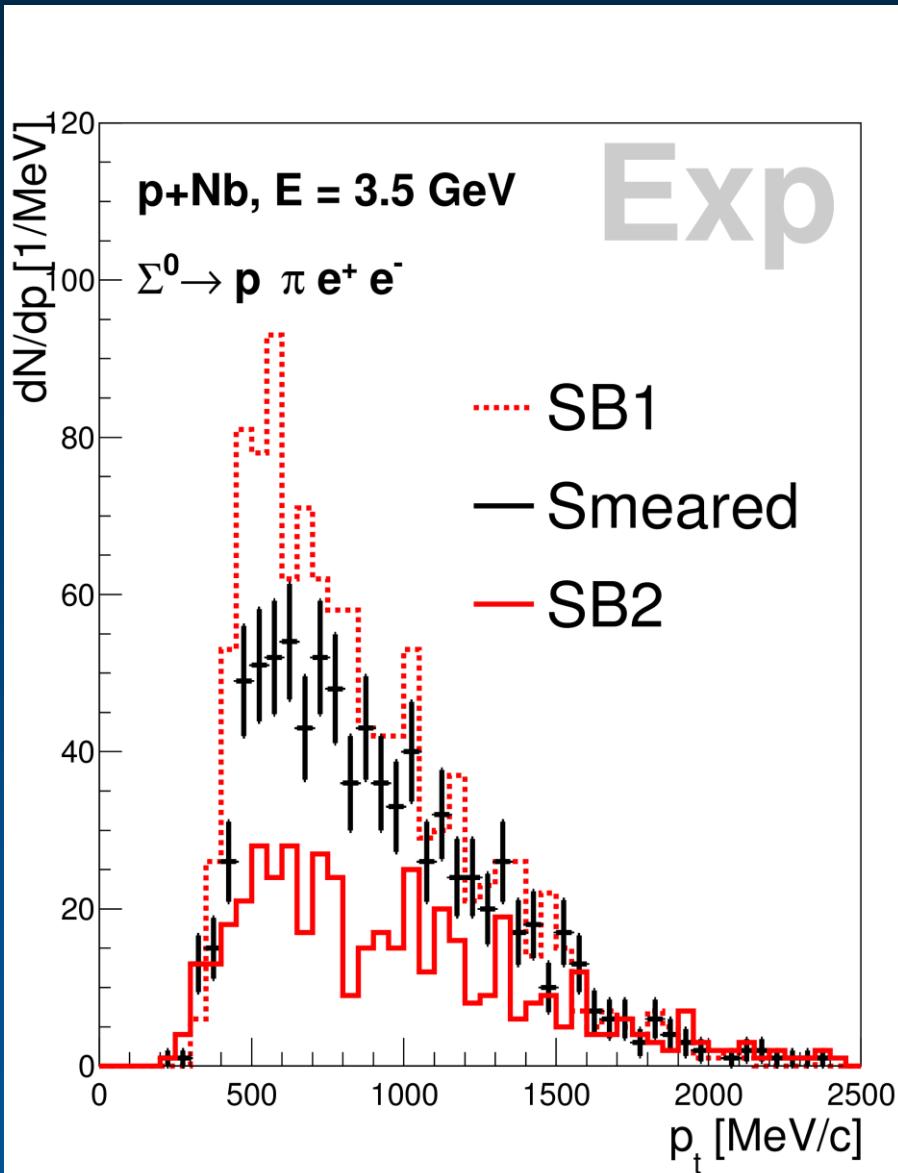
Preliminary

Preliminary

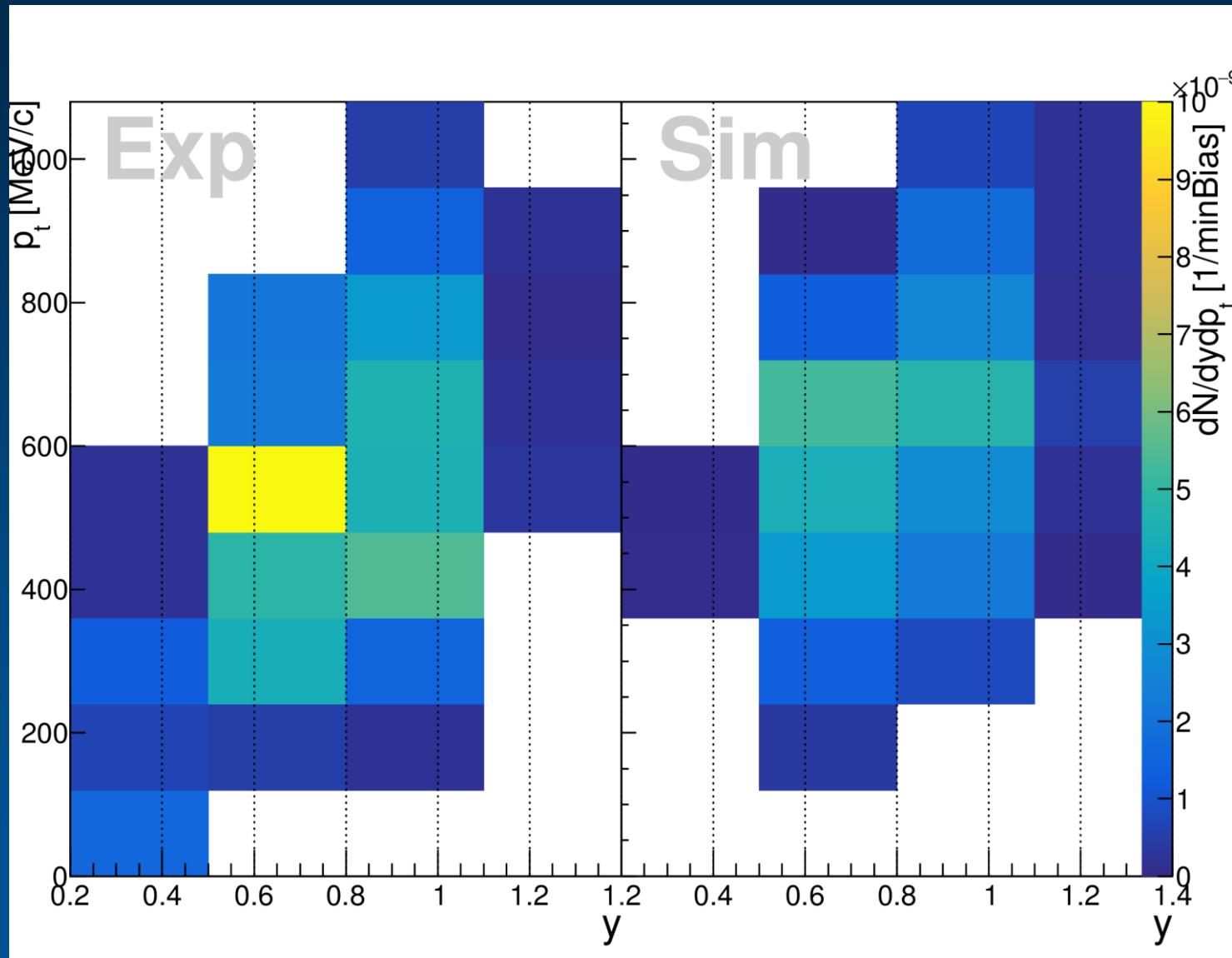
- Smear p_π and p_p until Λ peak disappears
- 3 regions: SB1, SB2 and S
- Reproduce S_{smeared} with SB1 & SB2

$$UG = a \cdot SB1 + b \cdot SB2$$



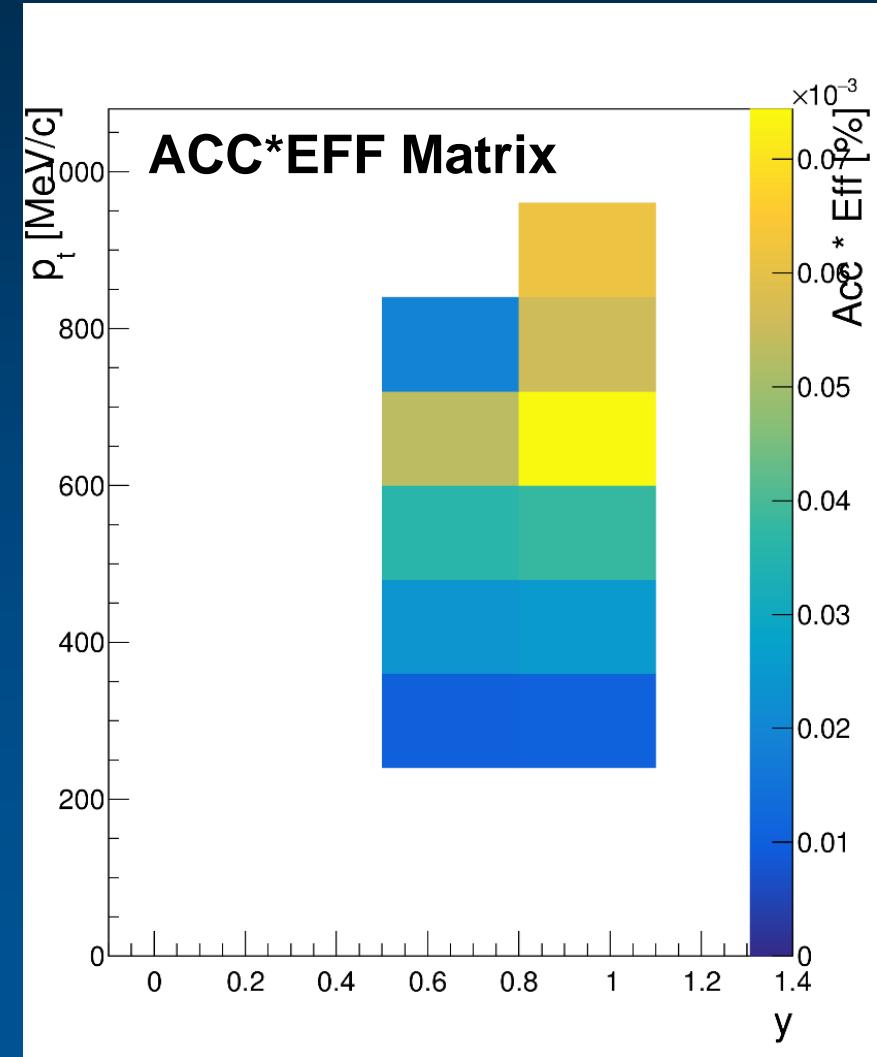
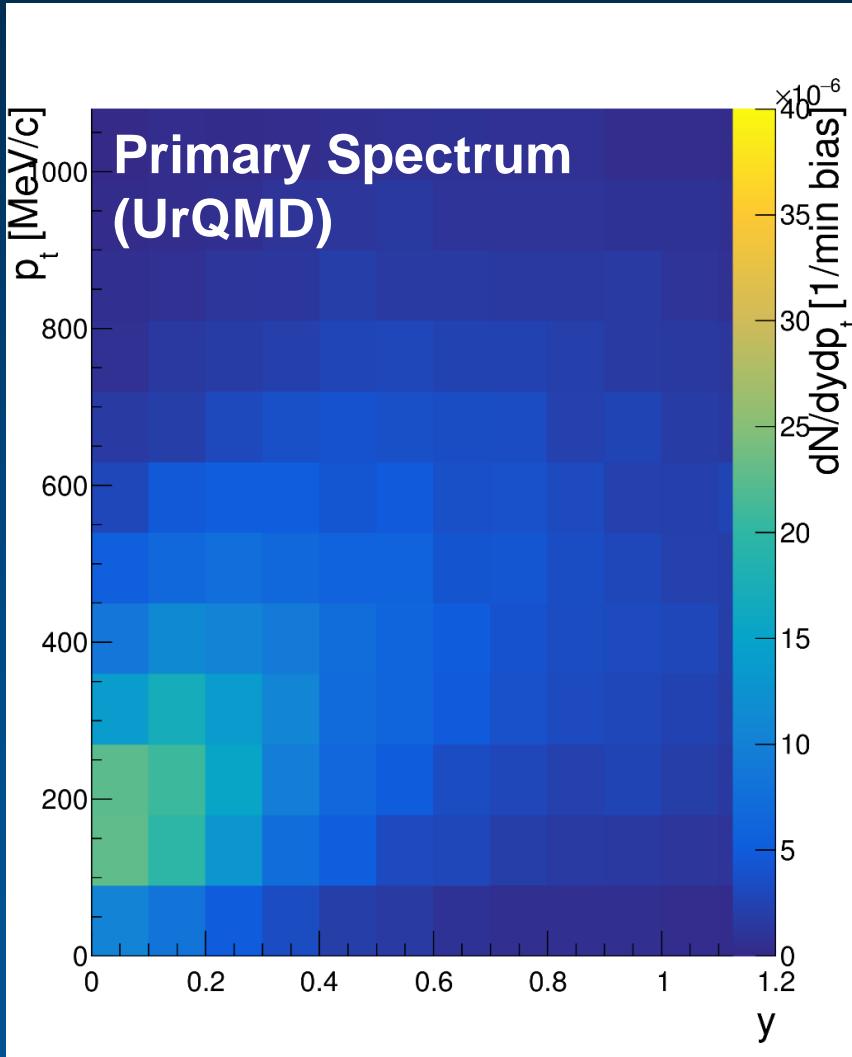


Background subtracted



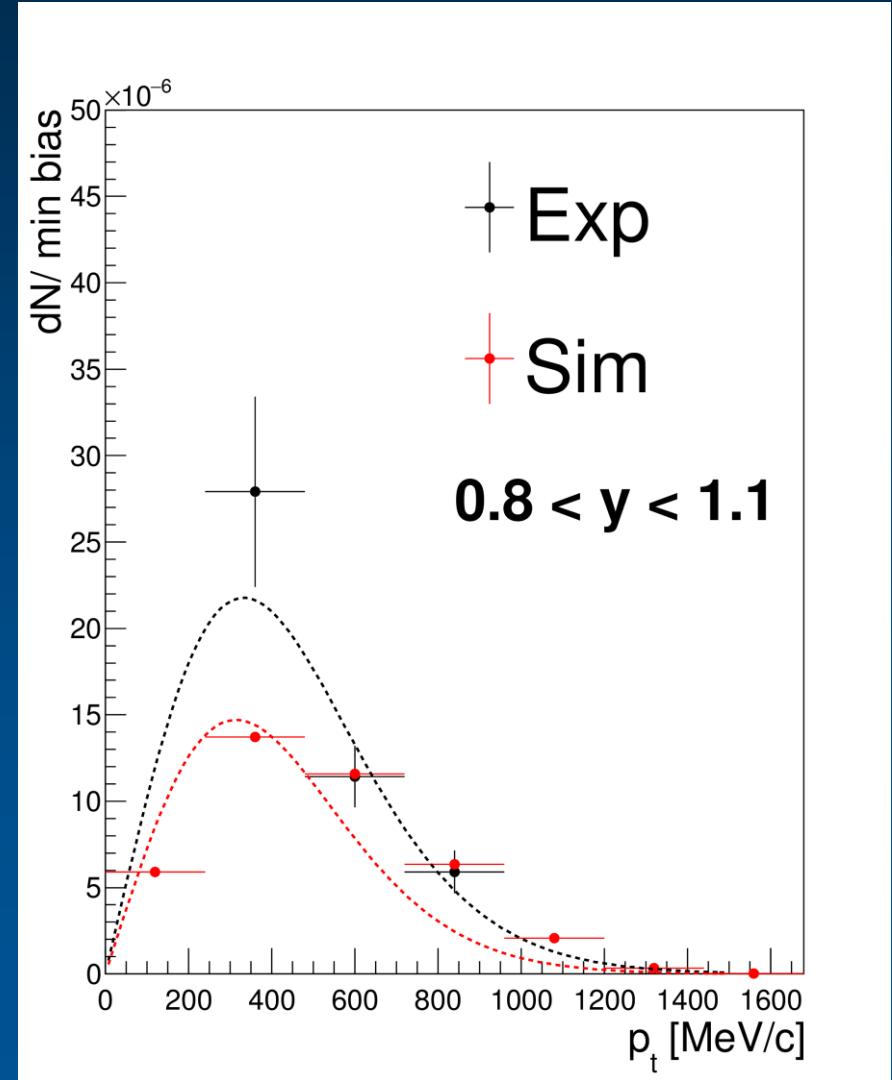
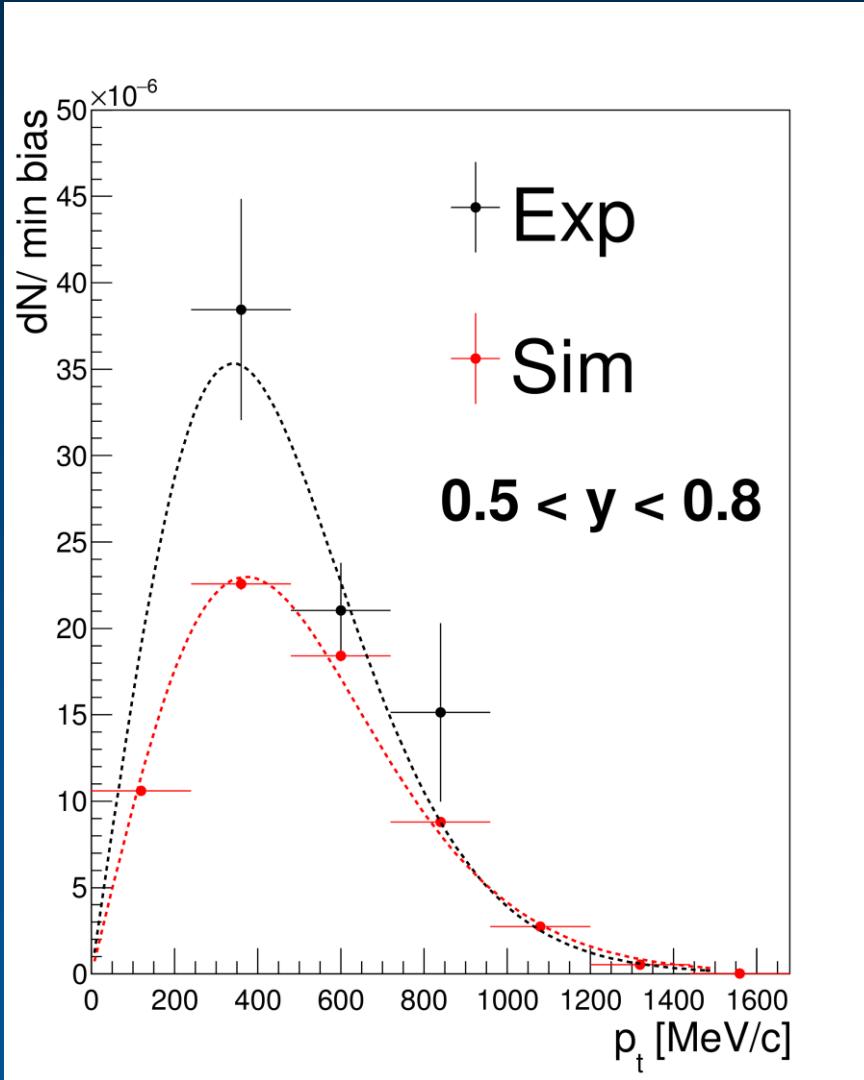
Acceptance & Efficiency

$\text{ACC}^*\text{EFF} = \text{reconstructed} / \text{primary}$
Efficiency $\approx 10^{-5}$



Extrapolation to small p_t

Extrapolate to small p_t using Boltzmann fit



Extrapolation to small p_t

Rapidity	Experiment	Simulation		
	T_B [MeV]	$\Delta N/\Delta y \cdot 10^{-5}$	T_B [MeV]	$\Delta N/\Delta y \cdot 10^{-5}$
$0.5 < y < 0.8$	$163,1 \pm 1,9$	8,71	$190,4 \pm 0,3$	6,23
$0.8 < y < 1.1$	$155,9 \pm 1,8$	5,22	$140,5 \pm 0,2$	3,31



Only a small rapidity range covered! Extrapolation?

What about the uncertainties?

Fit (χ^2) different shapes to two data points

	Full y
LB	3.2
GiBUU	3.4
UrQMD	3.0
THERMUS	3.9
This work	2.6 ± 1.7

