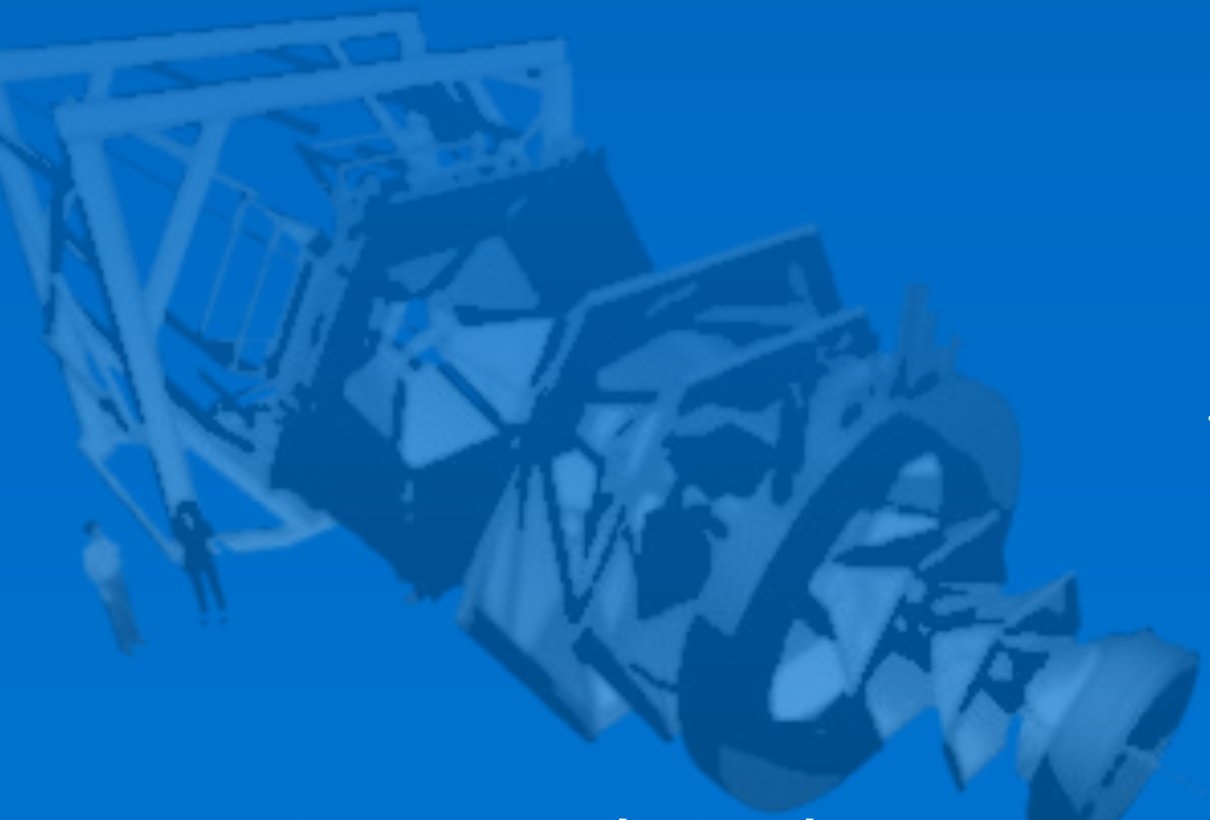
Technische Universität München

Σ^0 Production in p + Nb Reactions at E = 3.5 GeV



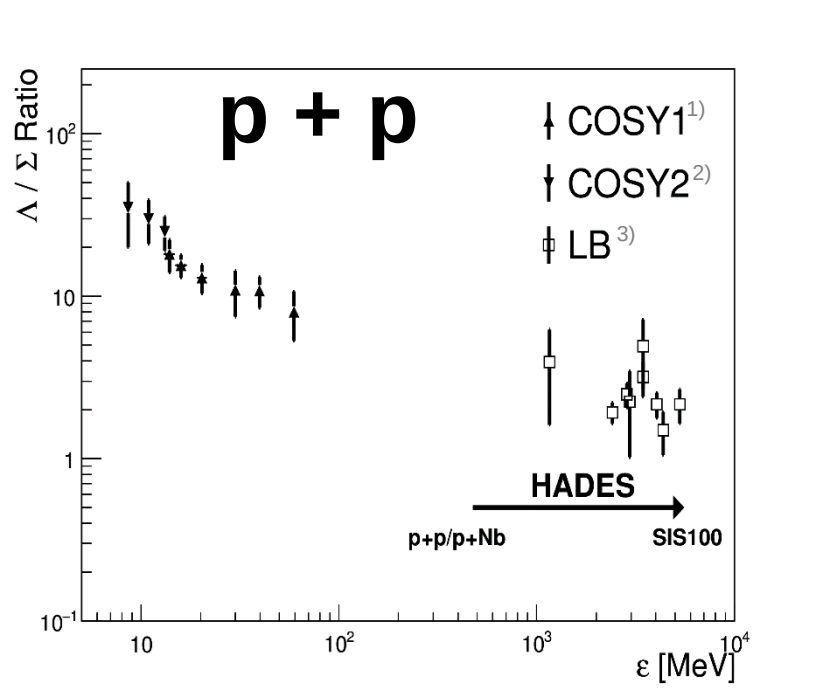
Tobias Kunz
for the HADES Collaboration

Strangeness in Quark Matter, 09-15 July 2017, Utrecht

Role of the Σ^0 Hyperon

$m_{\Sigma^0} = 1192.642 \pm 0.07$ MeV/c²
I(J^P) = 1(1/2$^+$)
$c\tau = 2.2 \cdot 10^{-11}$ m
$\Sigma^0 \rightarrow \Lambda^0\gamma$ (99.0 %)
$\Sigma^0 \rightarrow \Lambda^0 e^+ e^-$ (0.5 %)

Σ^0



Can we detect Σ^0 in HADES?

K^0, K^*, $K^{\pm}$, Λ, Σ^+, Ξ production in p + p, p + A, A + A

Hypernuclei for Λ but not for Σ^0?

Hyperon transition form factors?

Σ-N Interaction

No $\frac{\Lambda}{\Sigma^0}$ data available for p + A

1) P. Kowina et al. Eur. Phys. J., A22:293–299, 2004
2) S. Sewerin et al., Phys. Rev. Lett., 83:682–685, 1999
3) Landolt-Boernstein, Springer, 409 P., New Series 12, 1988

Role of the Σ^0 Hyperon

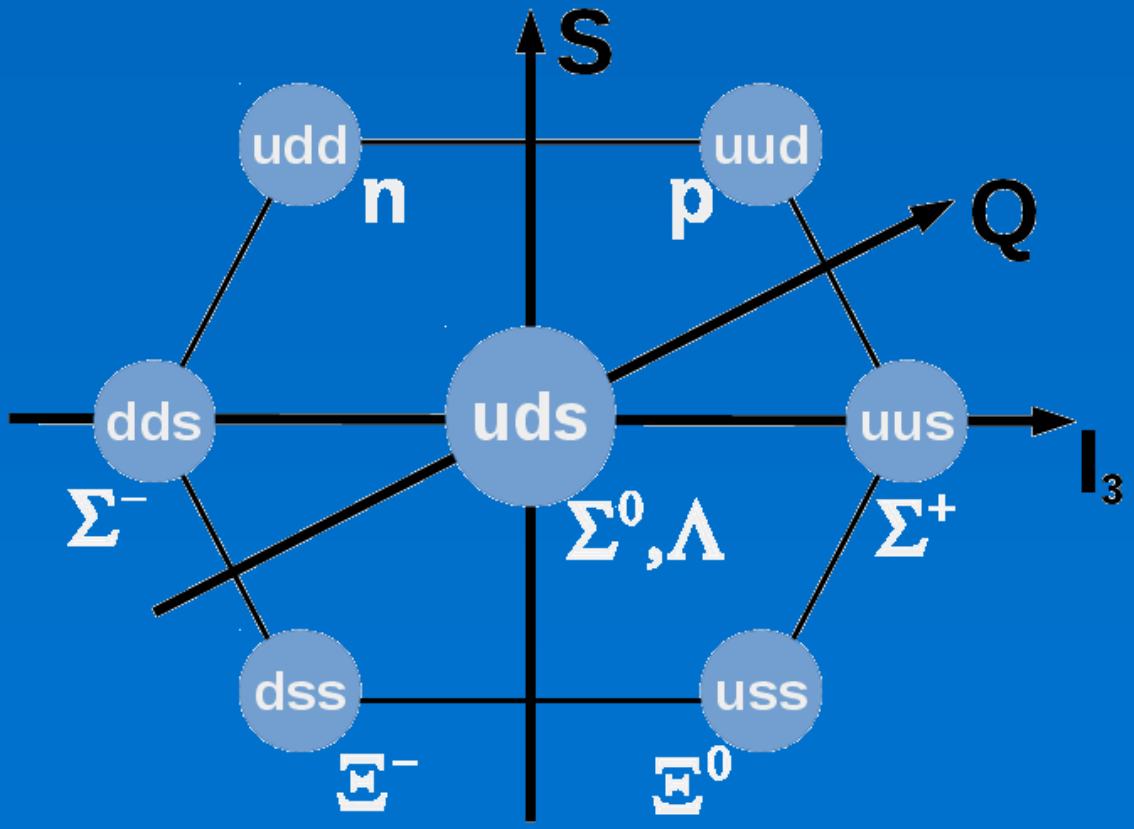
Λ_{dir}: Direct production

Λ_{Σ^0}: Λ originating from Σ^0 decays

UrQMD
GiBUU

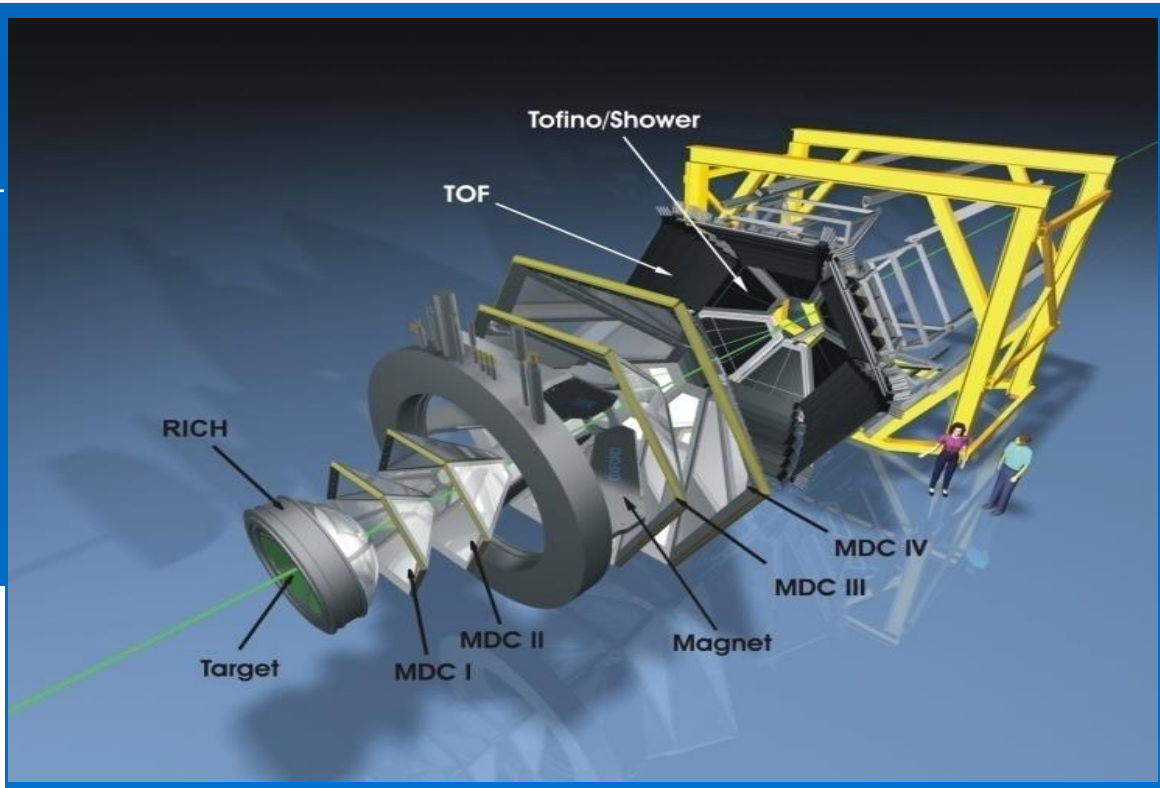
THERMUS

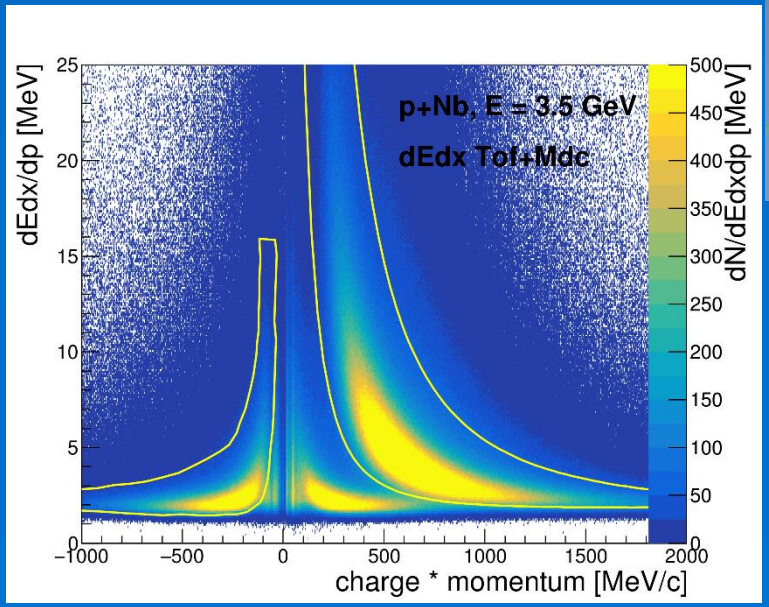
Data for
p + p



The HADES Experiment

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

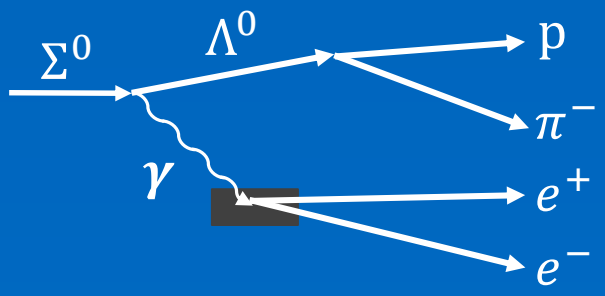




p + Nb, E_{kin} = 3.5 GeV N = $4.21 \cdot 10^9$ evt

reconstructed N = $1.3 \cdot 10^6$ Λ

Strategy for Σ^0 Search

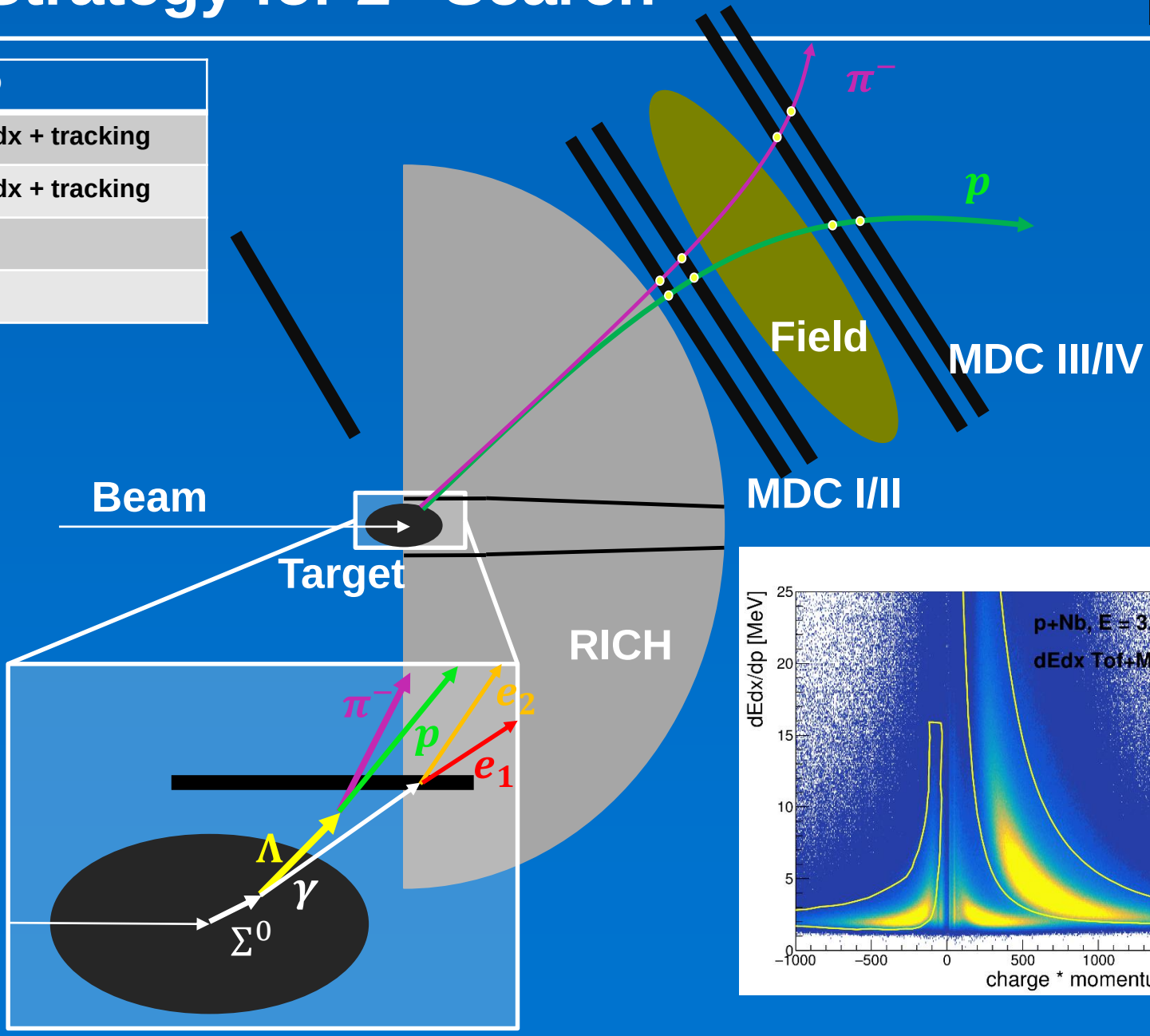


No Calorimeter

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

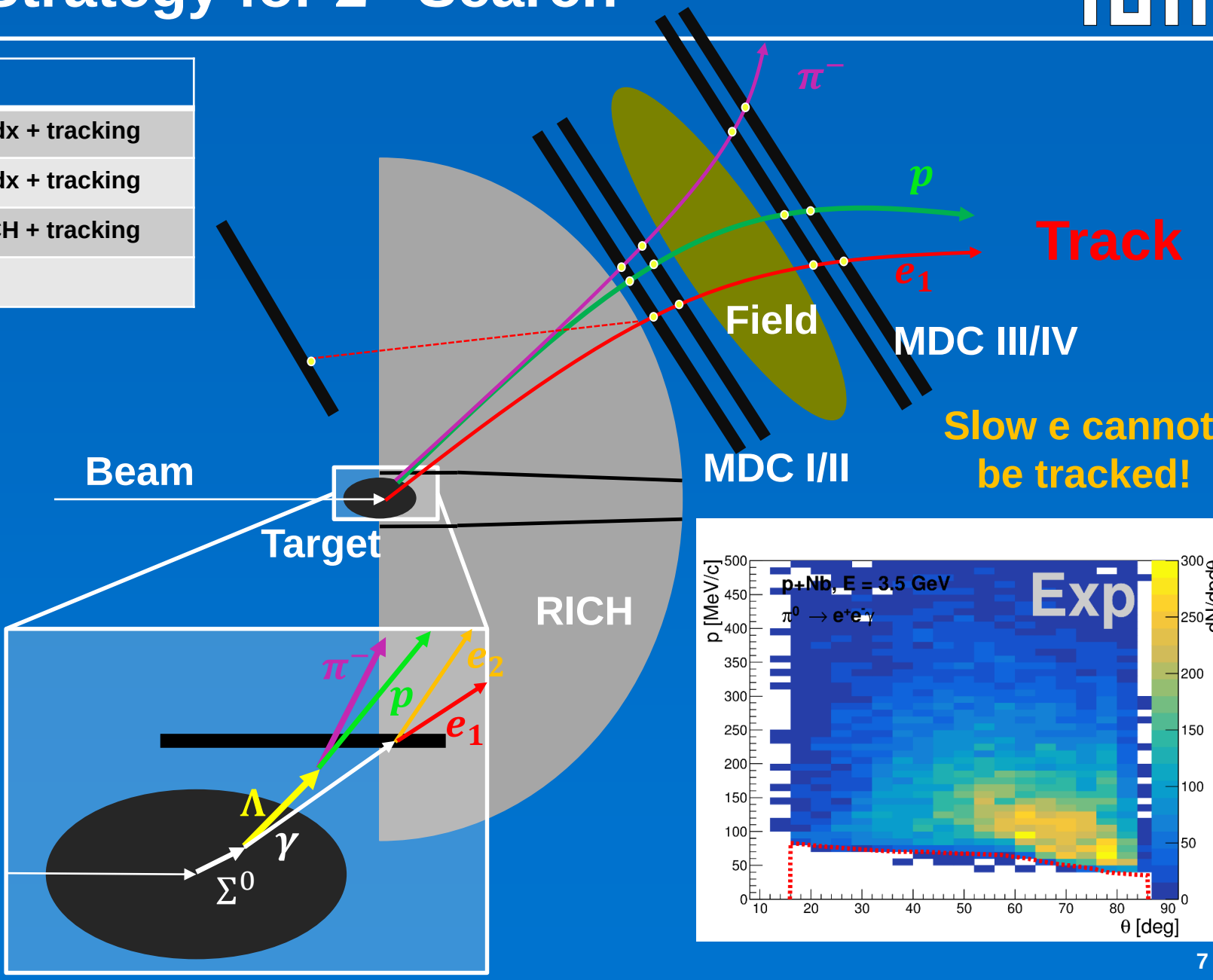
Strategy for Σ^0 Search

Particle	PID
p	dEdx + tracking
π^-	dEdx + tracking



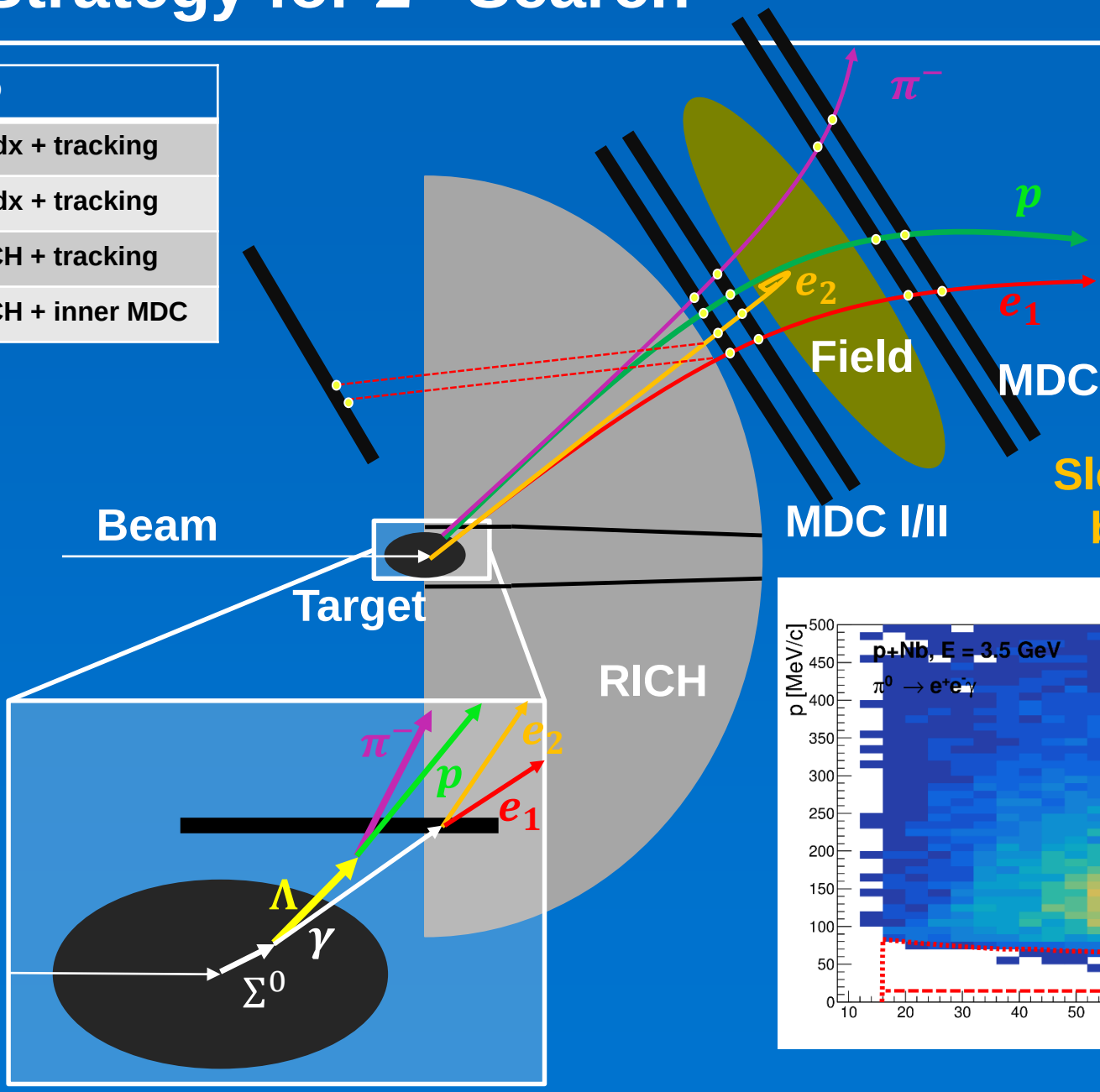
Strategy for Σ^0 Search

Particle	PID
p	dEdx + tracking
π^-	dEdx + tracking
e_1	RICH + tracking



Strategy for Σ^0 Search

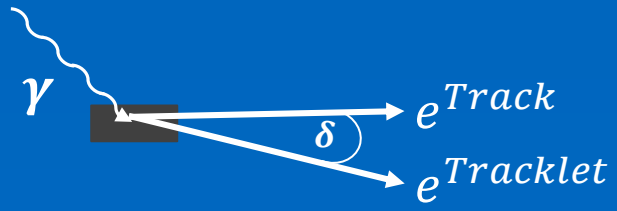
Particle	PID
p	dEdx + tracking
π^-	dEdx + tracking
e_1	RICH + tracking
e_2	RICH + inner MDC



Tracklet ≠ Track

Slow e cannot be tracked!

Track/Tracklet reconstruction



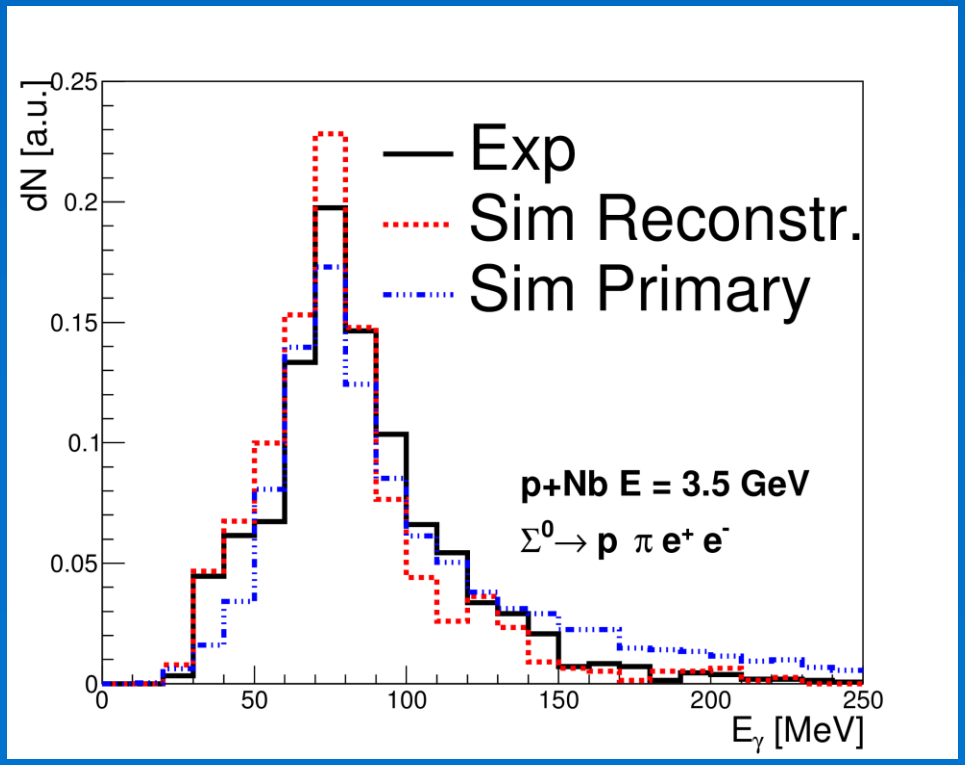
e^{Track}: θ,ϕ,p,E

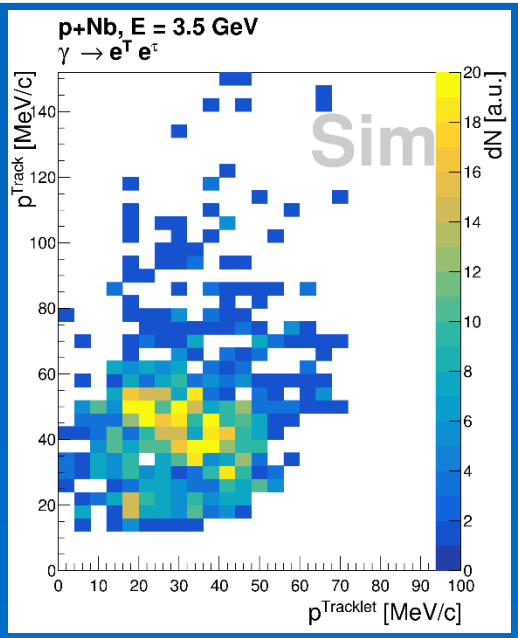
$e^{Tracklet}$: θ,ϕ

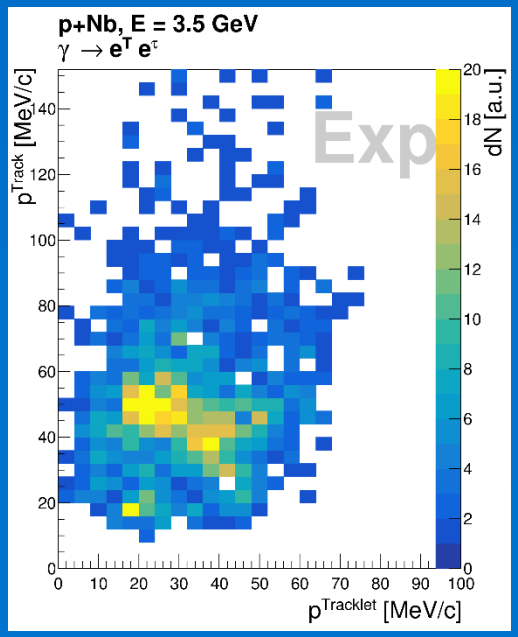
Opening Angle δ

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

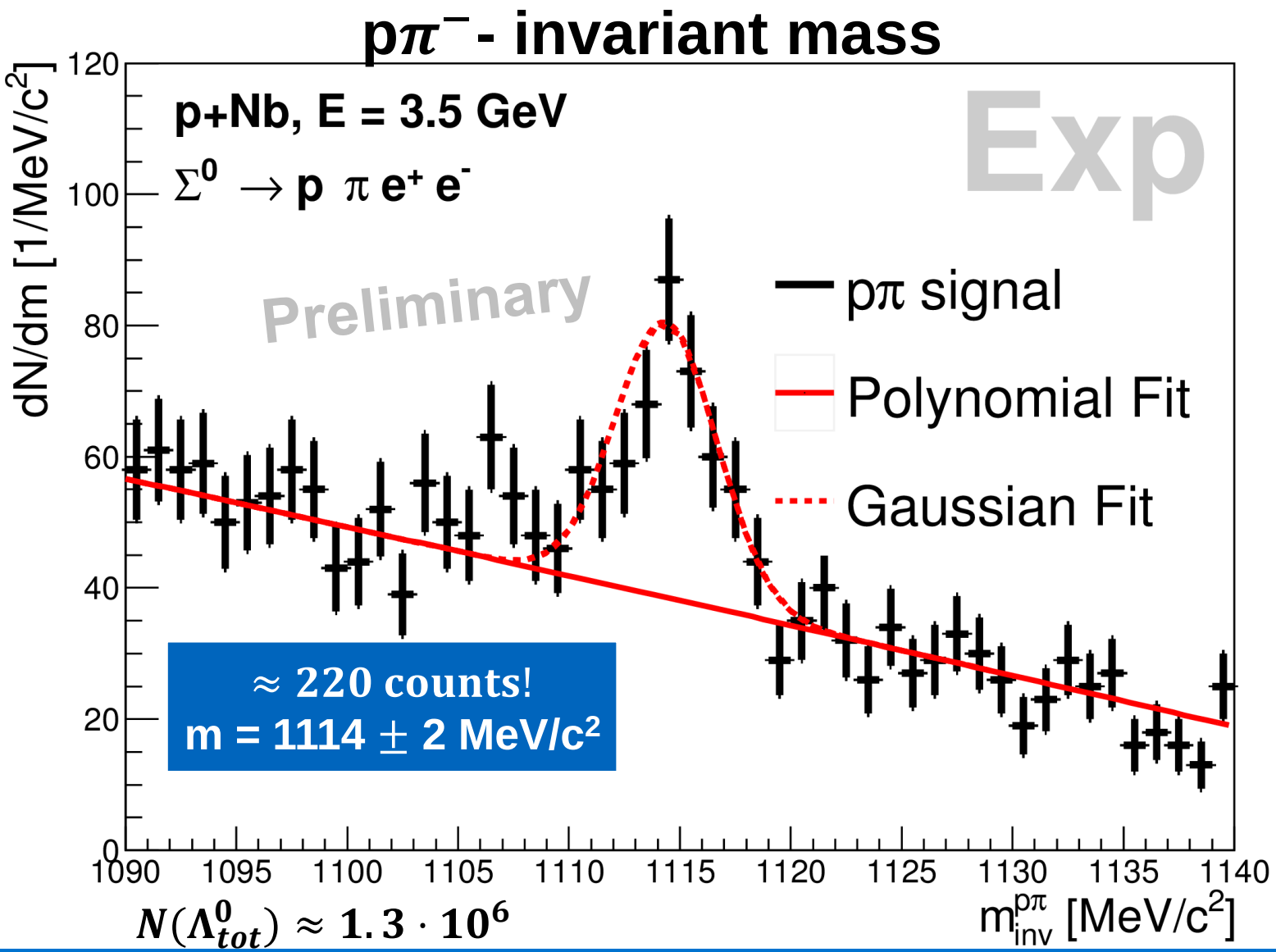
→ **Calculate $p^{Tracklet}$**



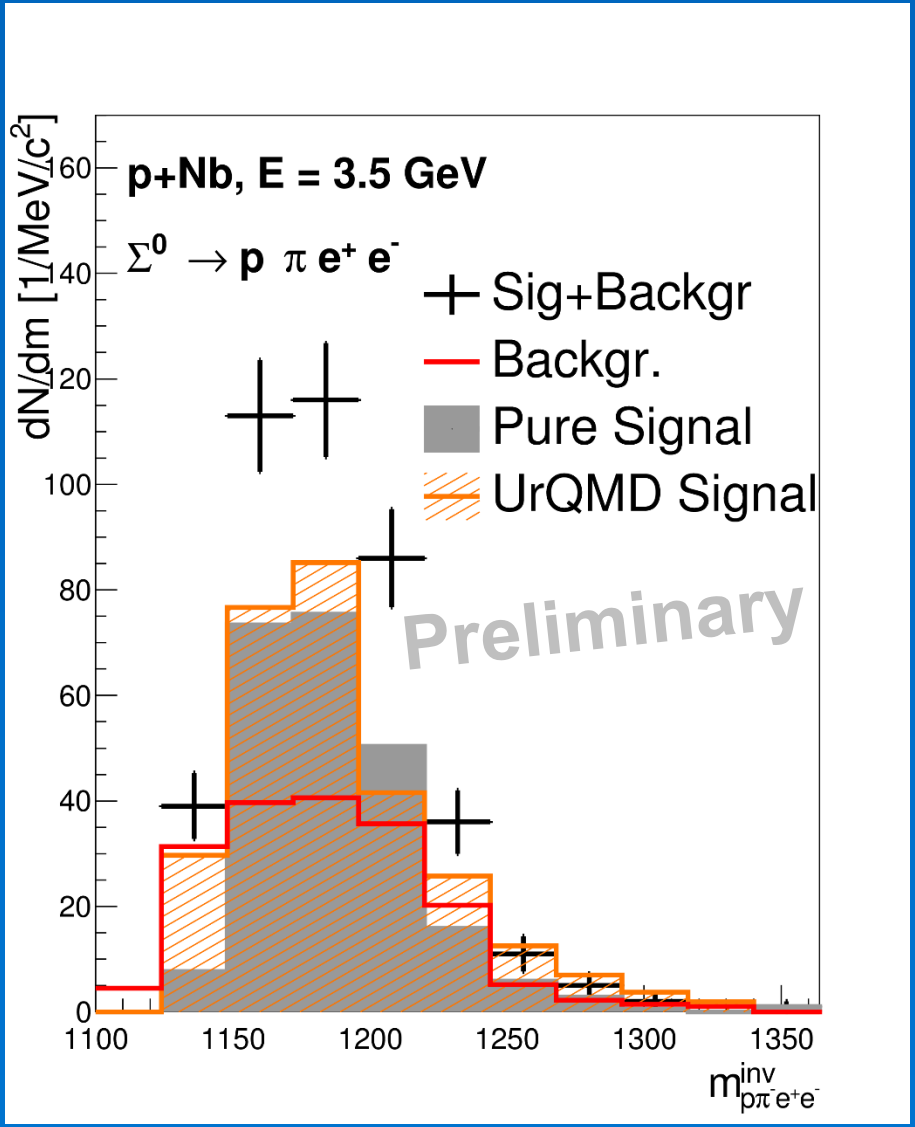


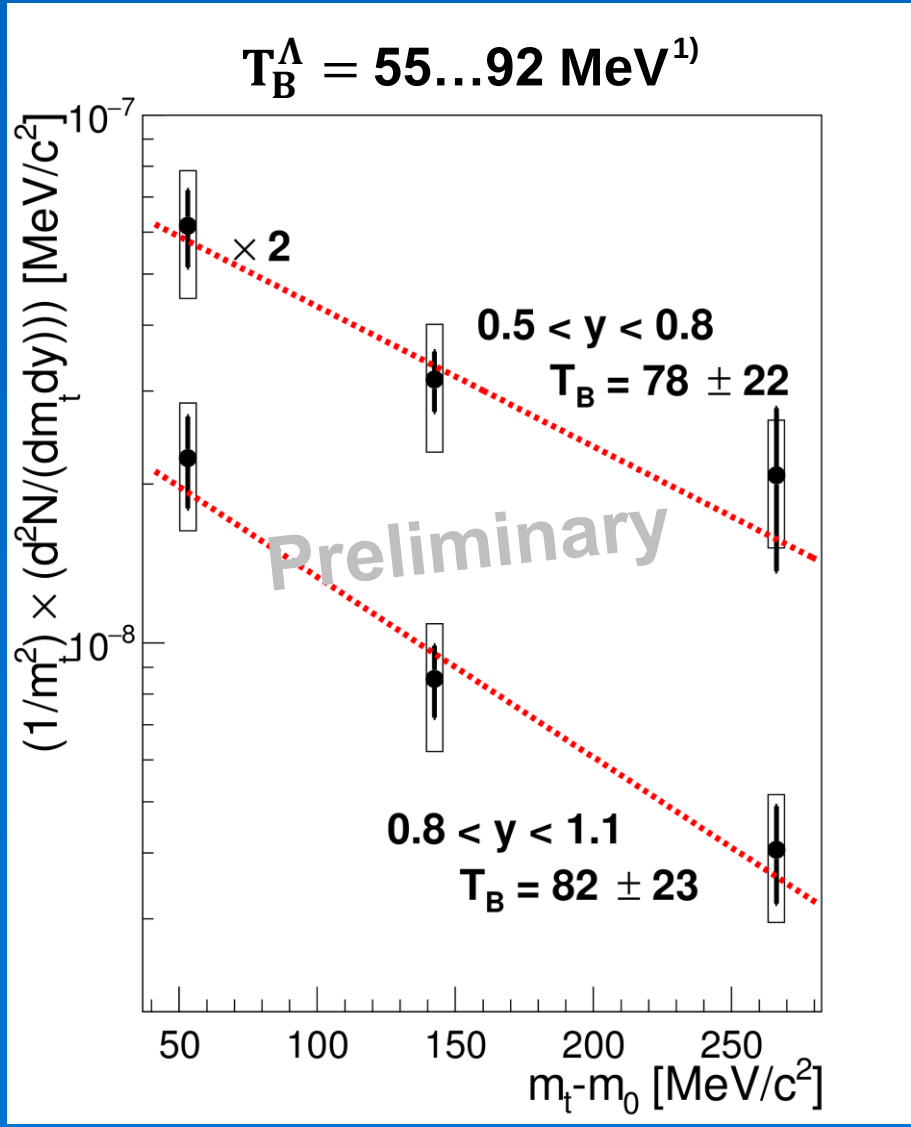


Λ^0 candidates with coincident $e^{\pm}$



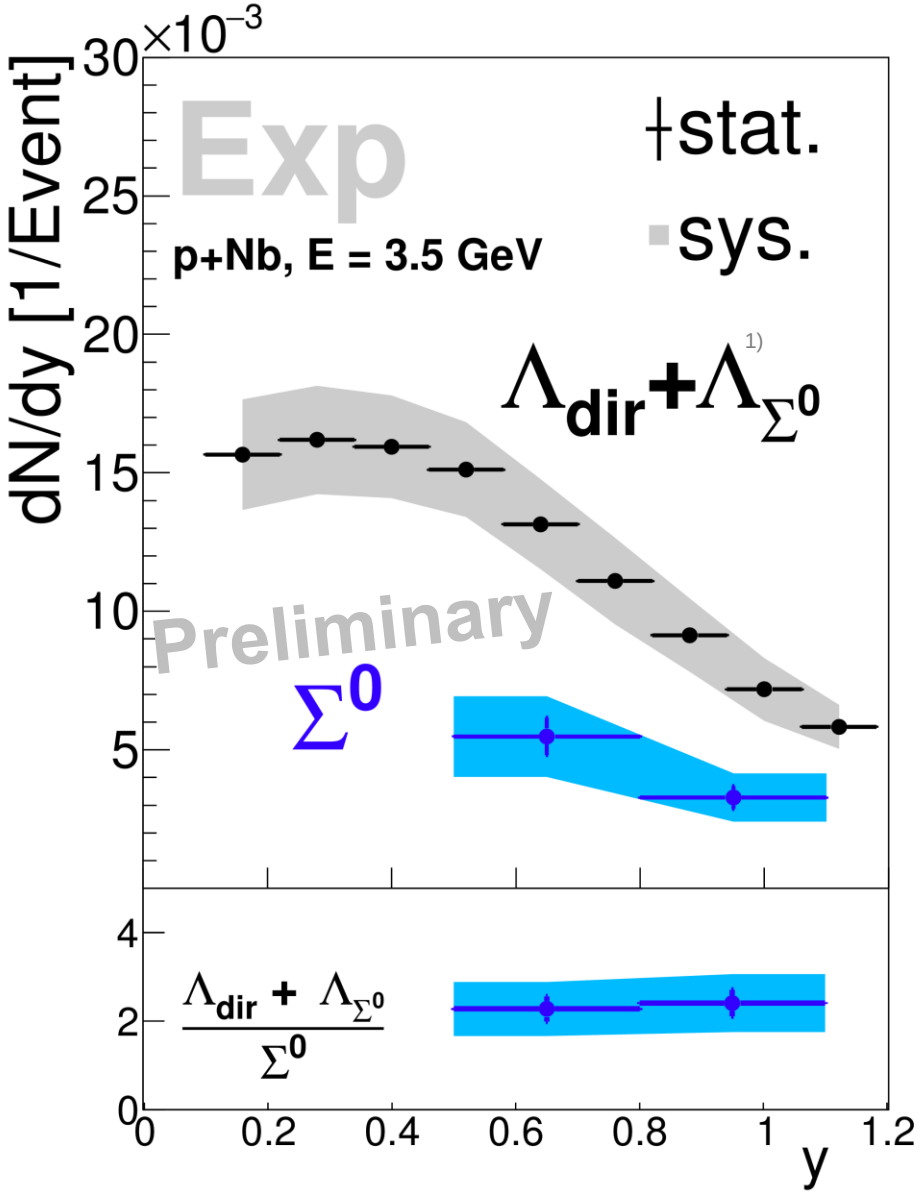
Σ^0 Signal





1) HADES Collaboration, Eur.Phys.J. A50 (2014)

$\Lambda_{dir} + \Lambda_{\Sigma^0} / \Sigma^0$ - Ratio



Measured in acceptance:

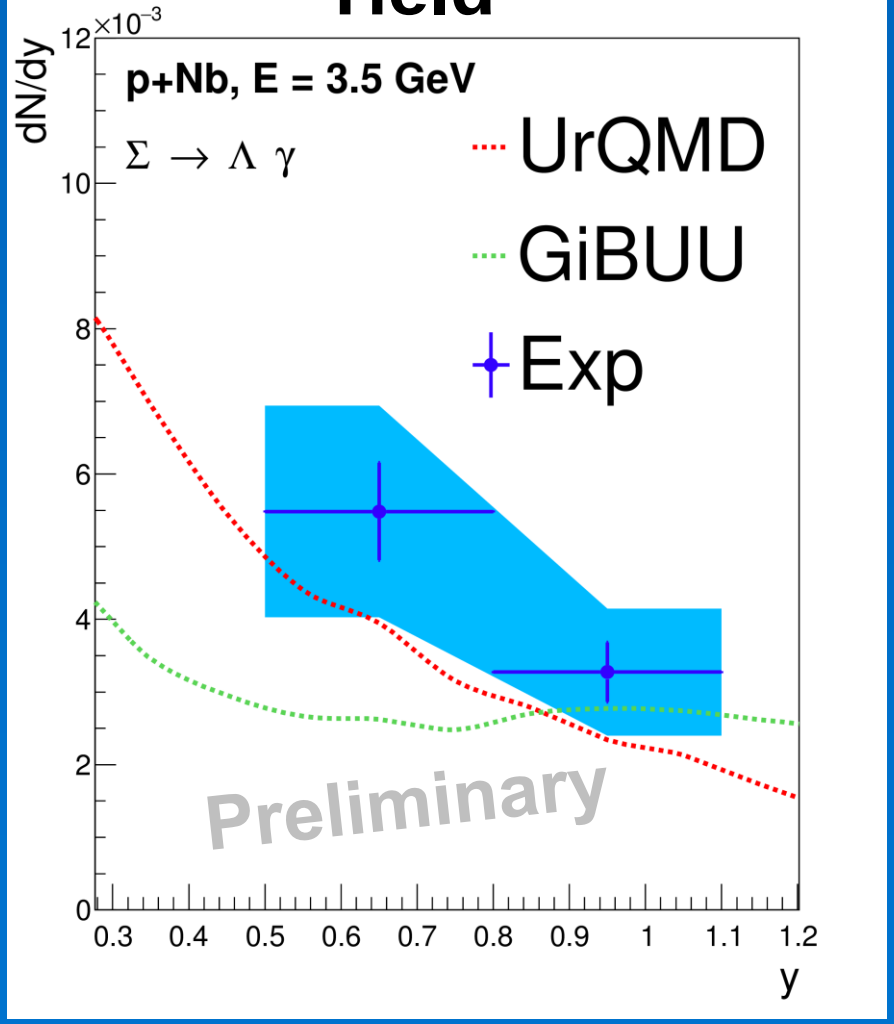
$$\frac{\Lambda_{dir}+\Lambda_{\Sigma^0}}{\Sigma^0} = 2.3 \pm (0.2)^{stat} \pm (0.7)^{sys}$$

$$\frac{d\sigma}{d\Omega}(\Sigma^0) = 2.3 \pm (0.2)^{stat} \pm (0.6)^{sys} \pm (0.2)^{norm}$$

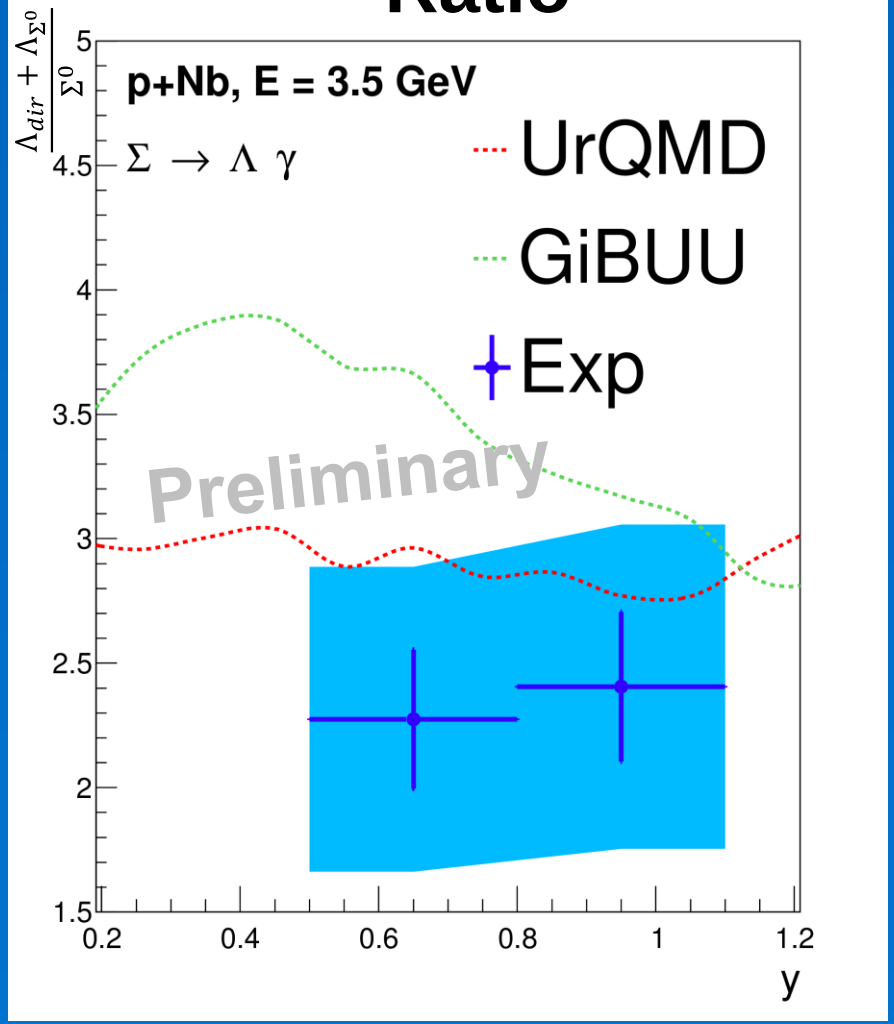
1) HADES Collaboration, Eur.Phys.J. A50 (2014)

Compare to Transport Models

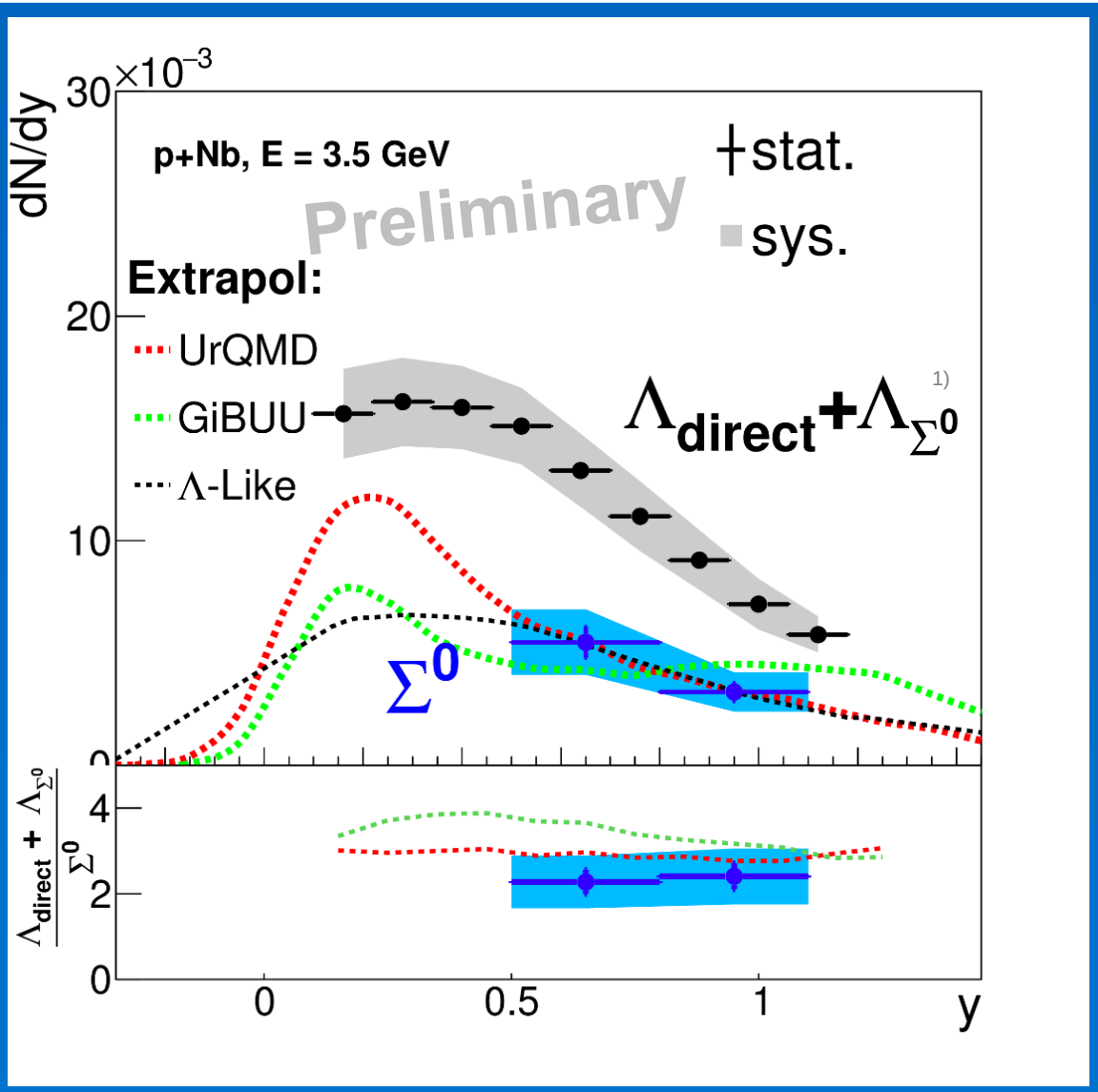
Yield



Ratio



Extrapolation

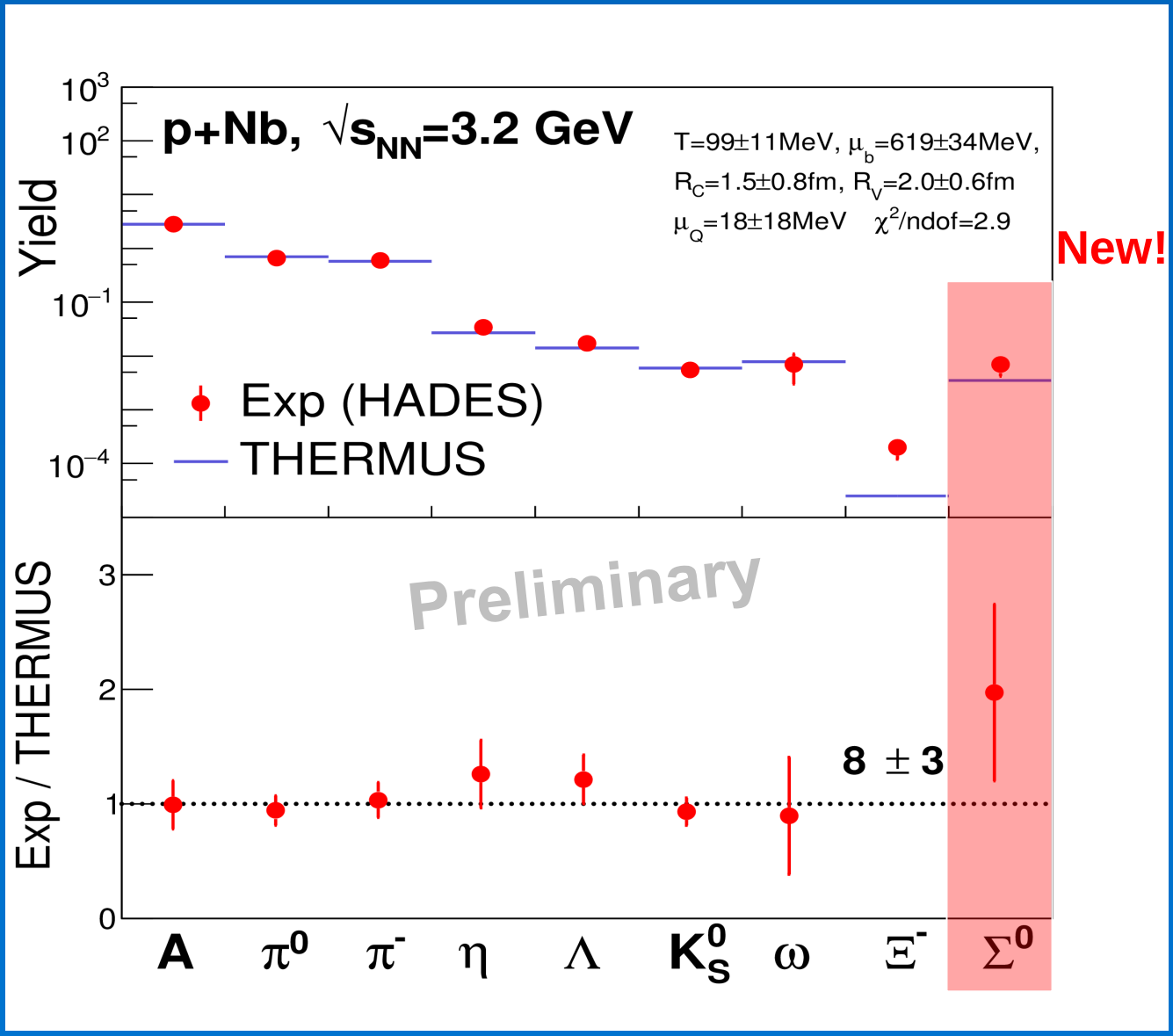


χ^2-Fit for different shapes to Exp

	Yield / 10^3	Scaling
UrQMD	8.6	1.4
GiBUU	7.3	1.6
Λ-Like	5.2	0.4

1) HADES Collaboration, Eur.Phys.J. A50 (2014)

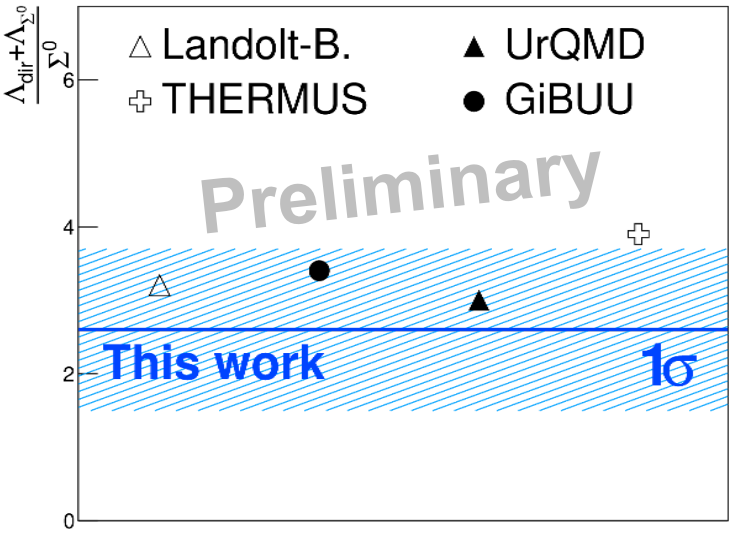
Compare to THERMUS



HADES Collaboration, Eur.Phys.J. A52 (2016) no. 6,

Results and Uncertainties

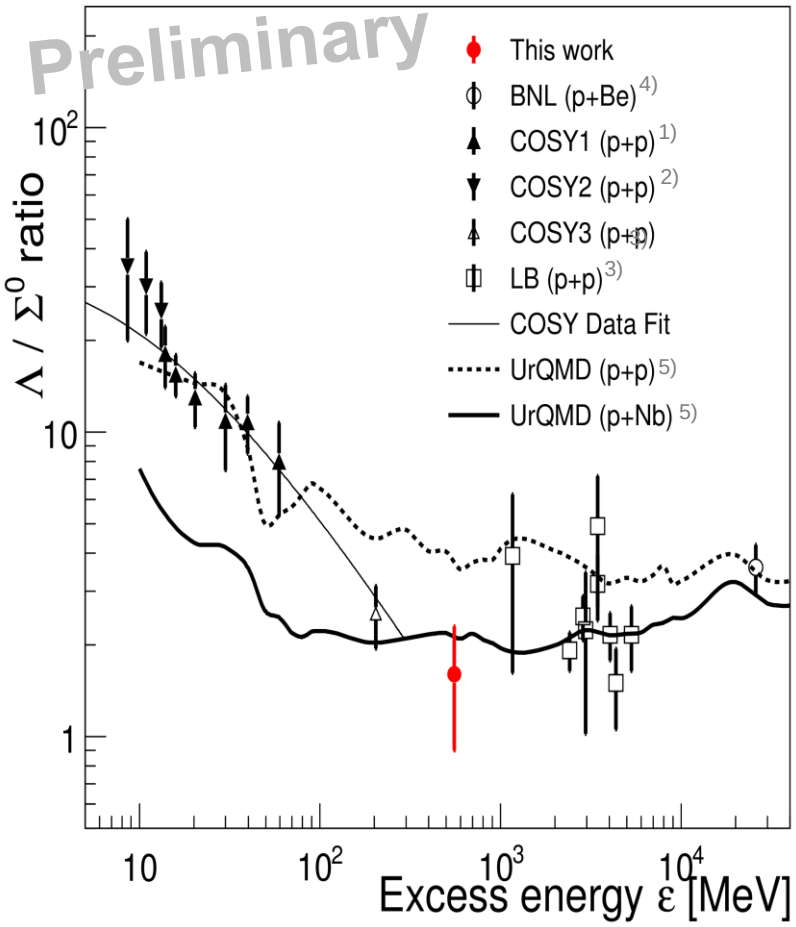
	0.5 < y < 1.1	Full y
Yield / 10^3	2.7 ± 0.7	6.2 ± 2.5
$\frac{d\sigma}{d\Omega}(\Sigma^0)$ [mb]	2.3 ± 1.2	5.8 ± 2.3
Ratio $\frac{\Lambda_{dir}+\Lambda_{\Sigma^0}}{\Sigma^0}$	2.3 ± 0.6	2.6 ± 1.1



UrQMD [1)]	$\frac{\Lambda_{dir}+\Lambda_{\Sigma^0}}{\Sigma^0} = 3.0$
GiBUU [2)]	$\frac{\Lambda_{dir}+\Lambda_{\Sigma^0}}{\Sigma^0} = 3.4$
THERMUS [3)]	$\frac{\Lambda_{dir}+\Lambda_{\Sigma^0}}{\Sigma^0} = 3.9$

1) S. A. Bass et al. Prog. Part. Nucl. Phys., 41:255–369, 1998
2) O. Buss et al., Phys. Rept., 512:1–124, 2012
3) S. Wheaton et al., Co. Phys. Com., 180:84–106, 2009

Result



$$N(\Sigma^0) \text{ reconstructed: } \approx 220$$

$$\sigma_{p+A}^{tot}(\Sigma^0) = 5.8 \pm 2.3 \text{ mb}$$

$$\frac{\Lambda_{dir}}{\Sigma^0} = 1.6 \pm 0.7$$

New data point for p + A!

1) P. Kowina et al. Eur. Phys. J., A22:293–299, 2004
2) S. Sewerin et al., Phys. Rev. Lett., 83:682–685, 1999
3) Landolt-Boernstein, Springer, 409 P., New Series 12, 1988
4) M.W. Sullivan et al., Phys. Rev., D36:674, 1987
5) S. A. Bass et al. Prog. Part. Nucl. Phys., 41:255–369, 1998

Outlook: HADES Upgrade

Photon detector for RICH

→ MAPMTs

→ Close pair eff.↗

→ Single e eff.↗

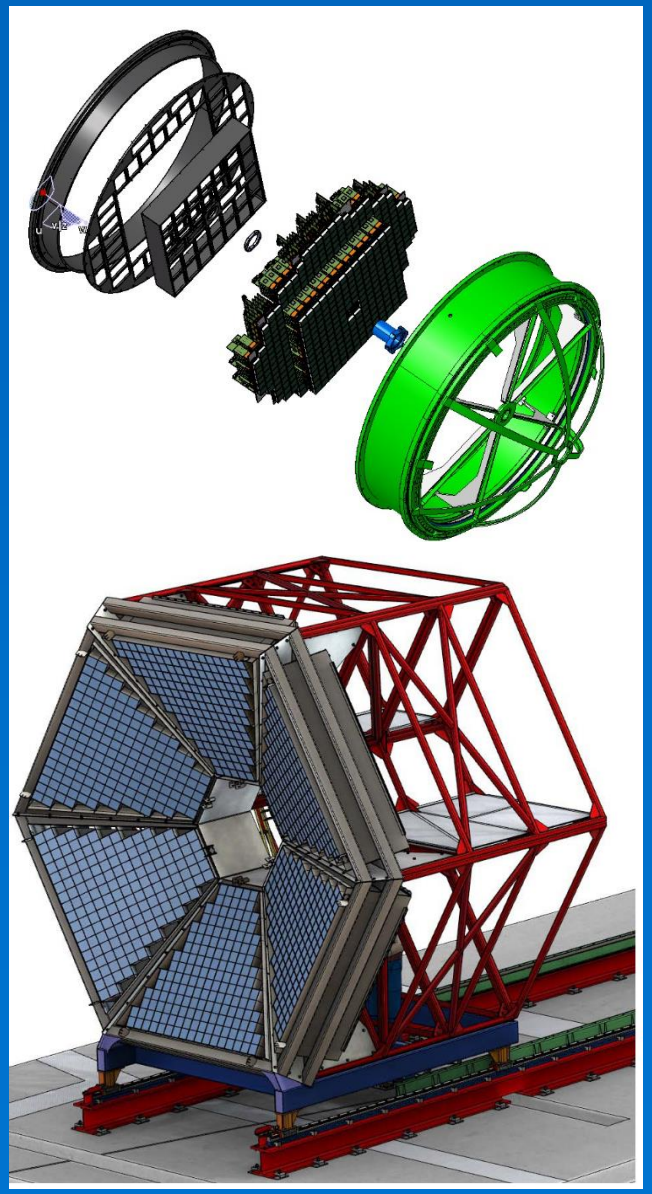
Electromagnetic Calorimeter

→ Direct detection of

$\Sigma^0 \rightarrow \Lambda\gamma$

Forward Straw Tube Tracker

→ Bigger acceptance for Λ

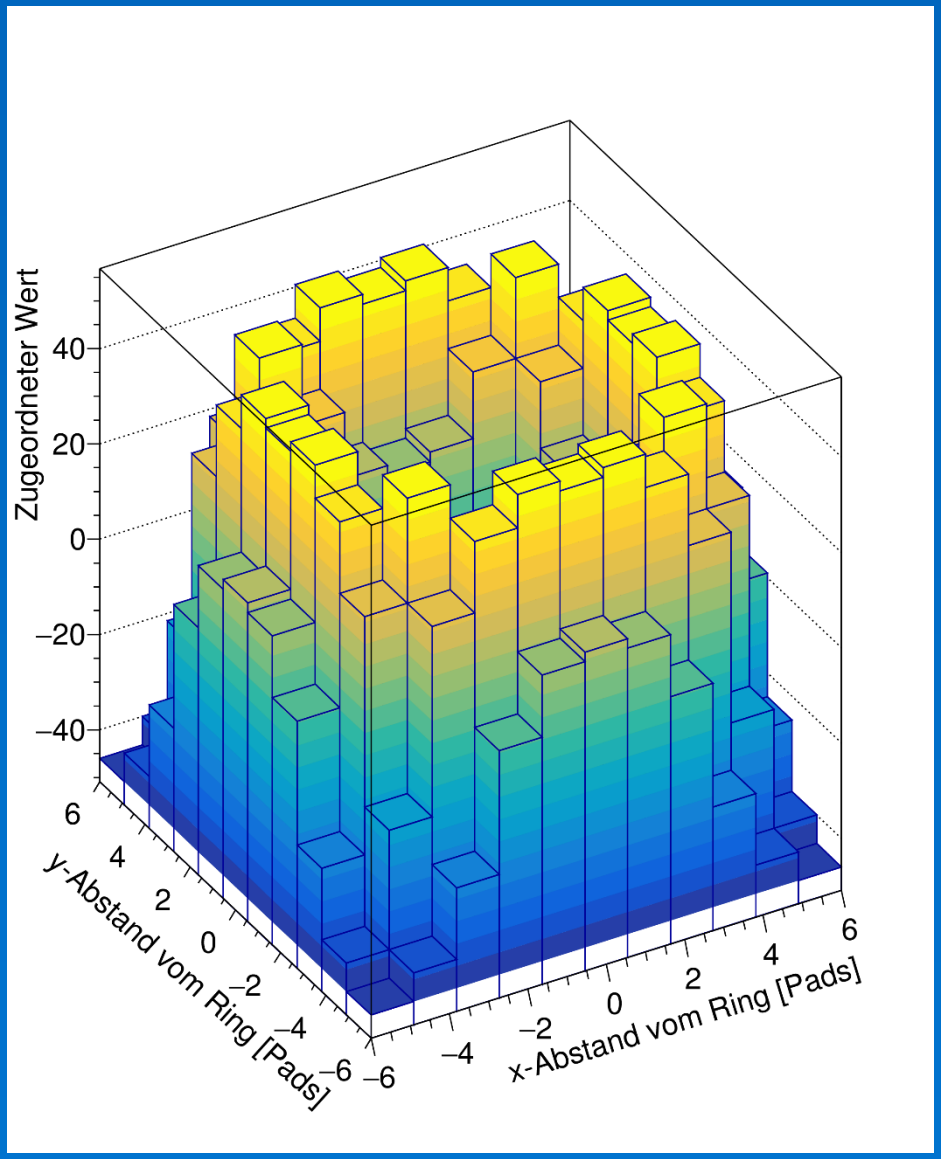


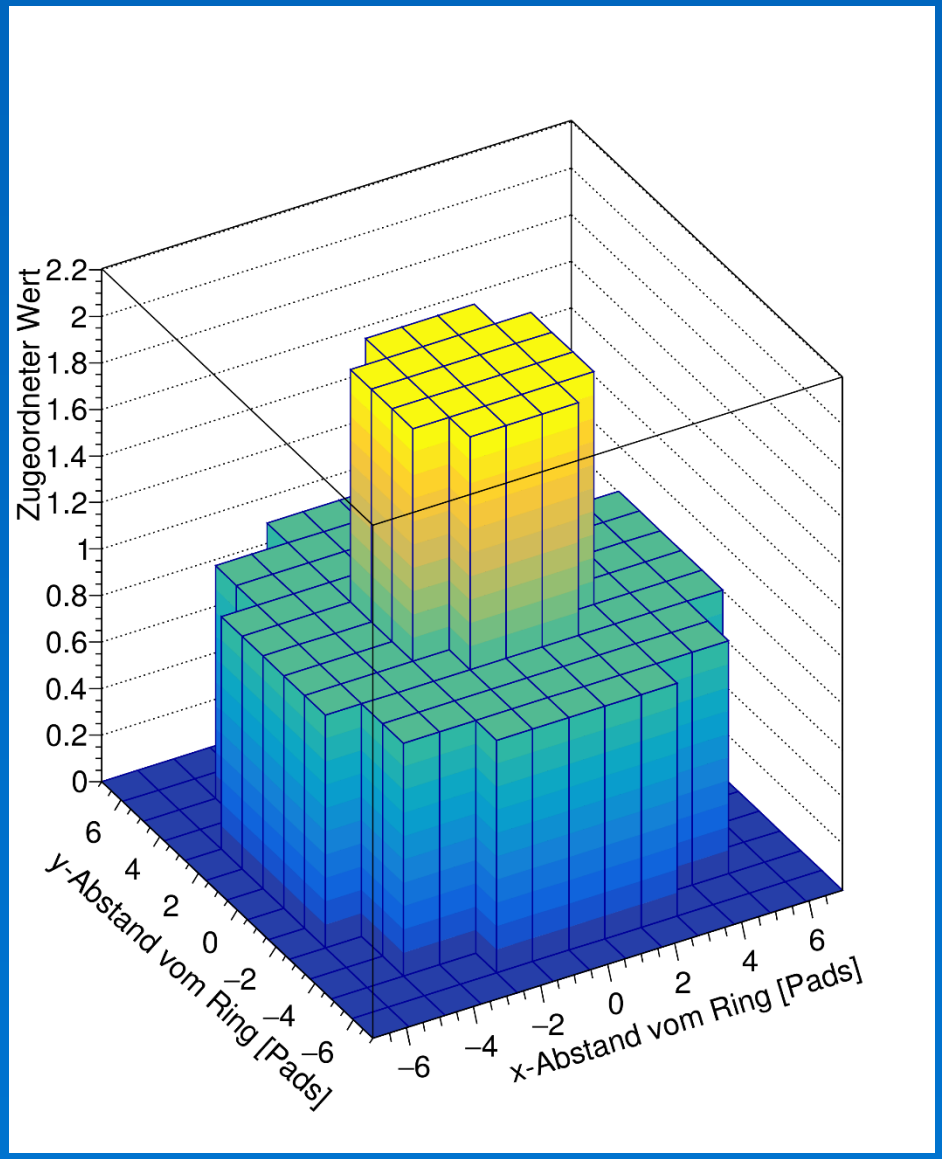
Thank you for your attention

Errors	Value [%]
Normalization	11.2
e^+/e^- ID[1)]	25
Λ ID[2)]	4.4 - 4.9
Backgr. subtr.	7.7
Extrapolation	28.1
Statistical	8.6

1) HADES Coll., Phys. Lett. B 731 (2014)
2) HADES Coll., Eur. Phys. J. A 50 (2014) 81

Ring Mask


Zugeordneter Wert
40
20
0
−20
−40
y-Abstand vom Ring [Pads]
6
4
2
0
−2
−4
−6
x-Abstand vom Ring [Pads]
−6
−4
−2
0
2
4
6

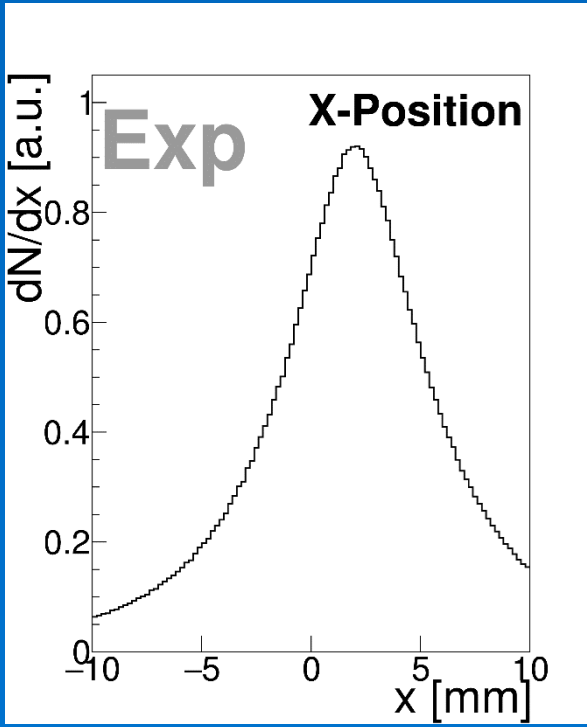

Zugeordneter Wert
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
y-Abstand vom Ring [Pads]
6
4
2
0
−2
−4
−6
x-Abstand vom Ring [Pads]
−6
−4
−2
0
2
4
6

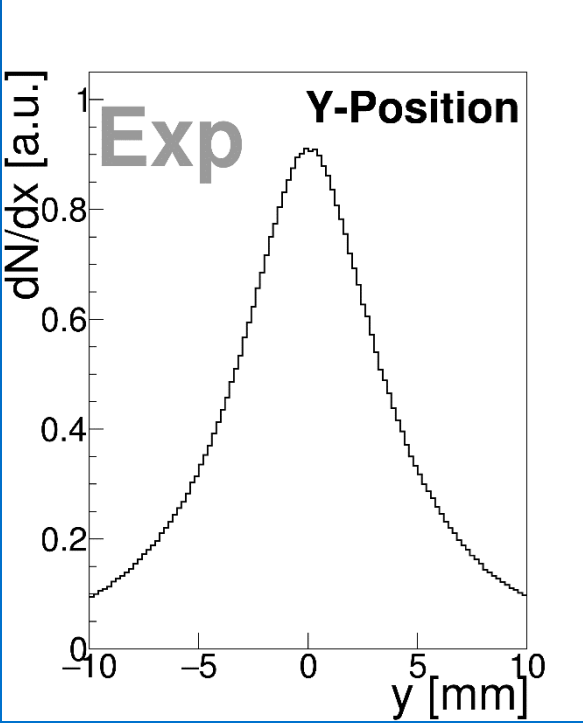
Uncertainties

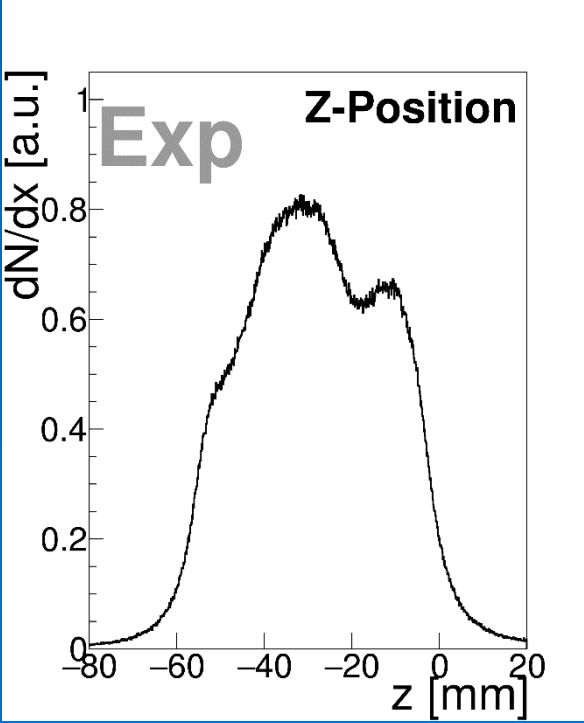
Errors	Value [%]
Normalization	11.2
e^+/e^- ID[1)]	25
Λ ID[2)]	4.4 - 4.9
Backgr. subtr.	7.7
Extrapolation	28.1
Statistical	8.6

1) HADES Coll., Phys. Lett. B 731 (2014)
2) HADES Coll., Eur. Phys. J. A 50 (2014) 81

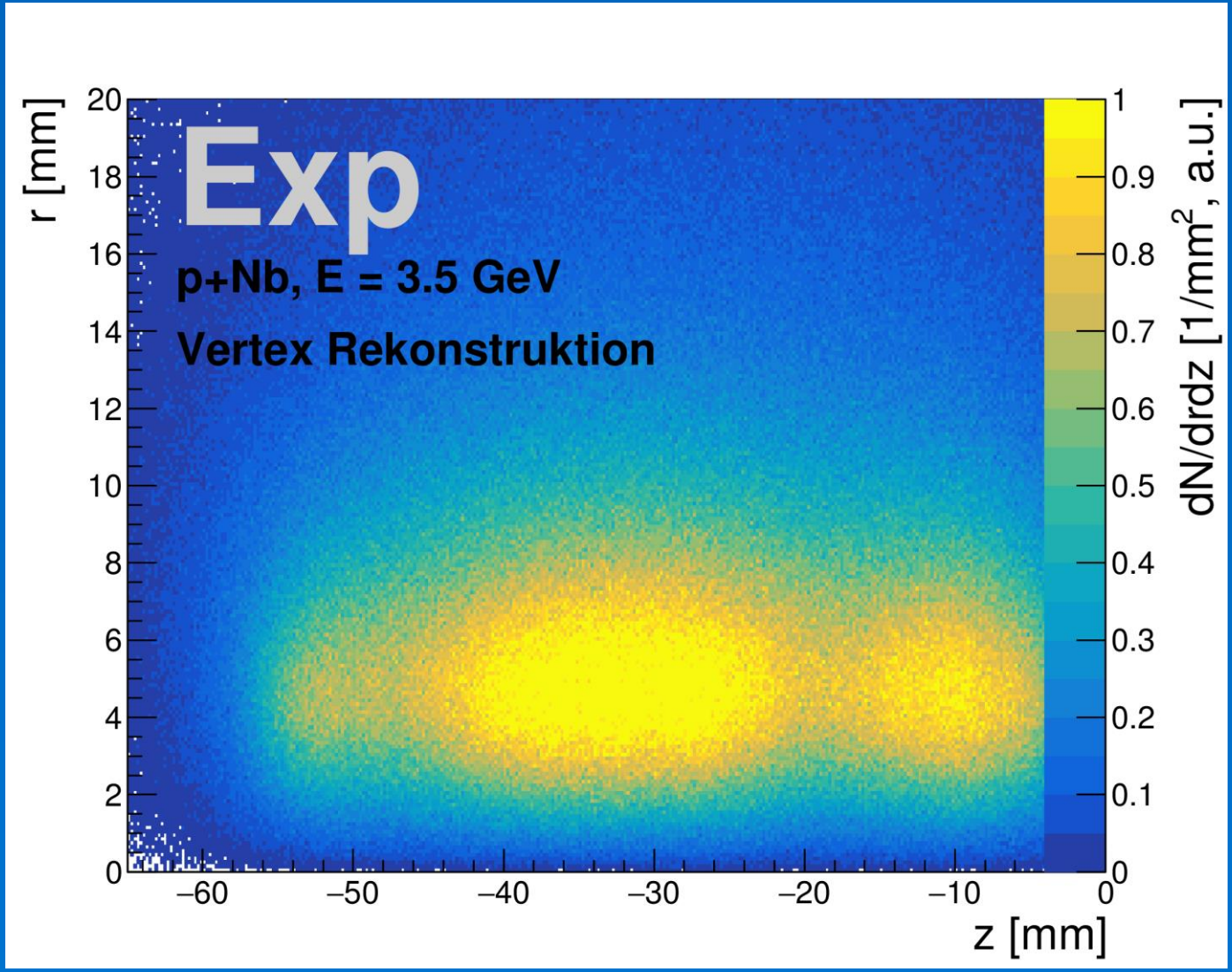
Vertex XYZ


Exp
X-Position
dN/dx [a.u.]
x [mm]

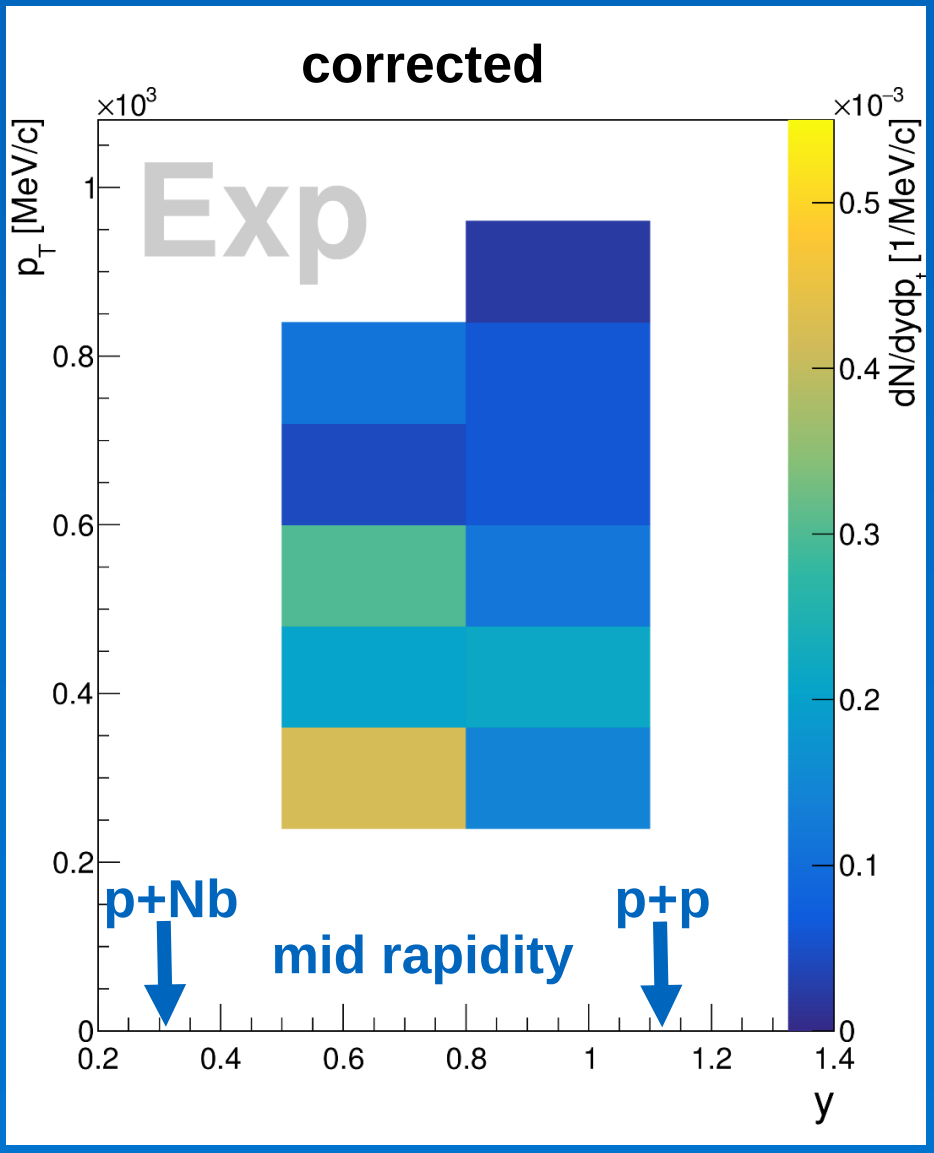

Exp
Y-Position
dN/dx [a.u.]
y [mm]

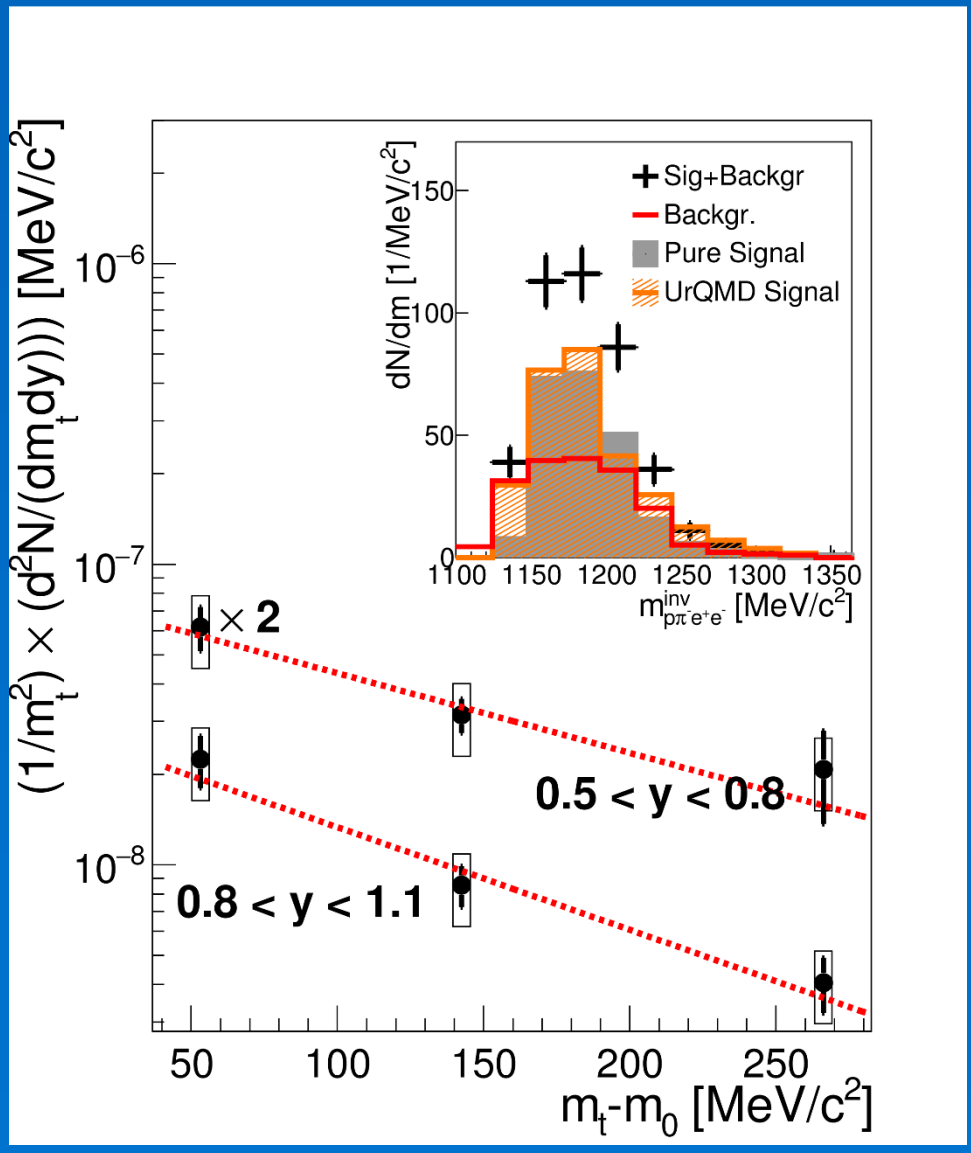

Exp
Z-Position
dN/dx [a.u.]
z [mm]

Vertex 2D

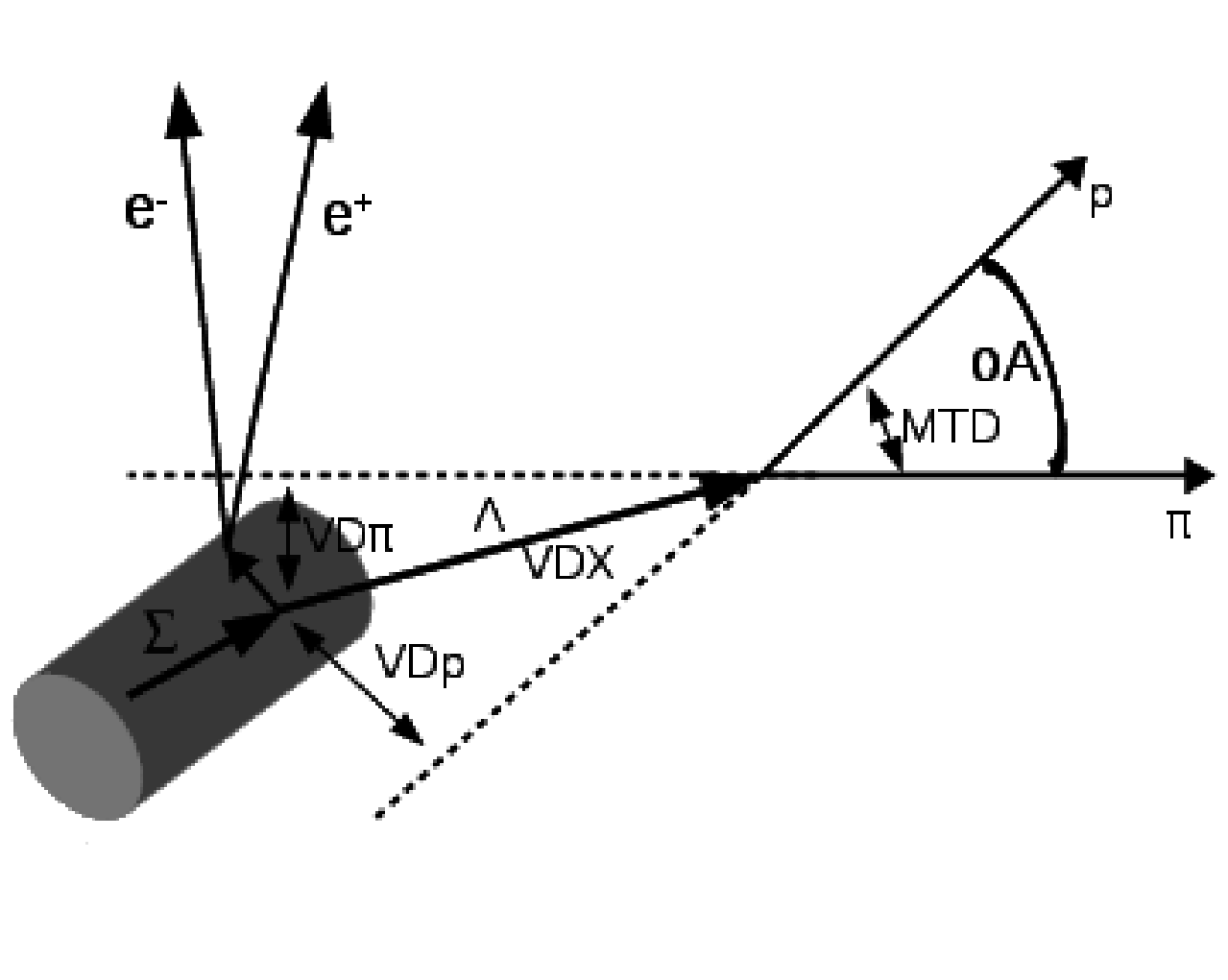

Exp
p+Nb, E = 3.5 GeV
Vertex Rekonstruktion
r [mm]
z [mm]
dN/drdz [1/mm², a.u.]
20
18
16
14
12
10
8
6
4
2
0
−60
−50
−40
−30
−20
−10
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

Σ^0 Signal





Topological Cuts



Background determination