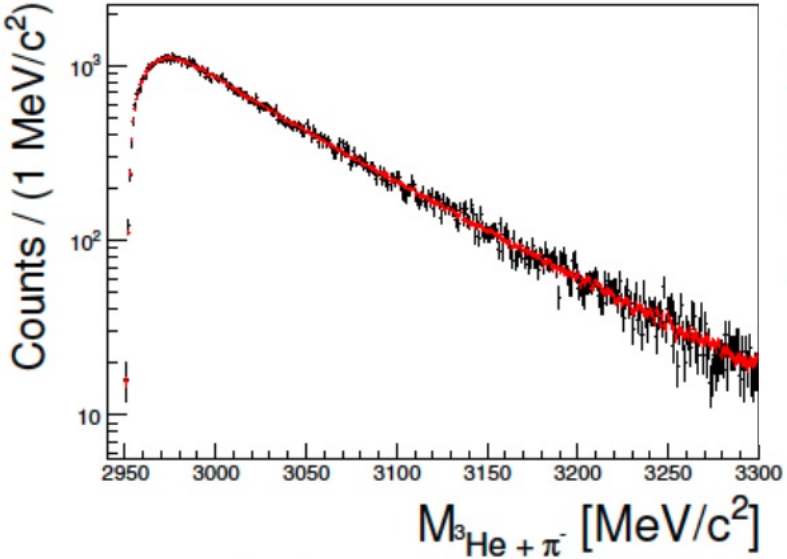
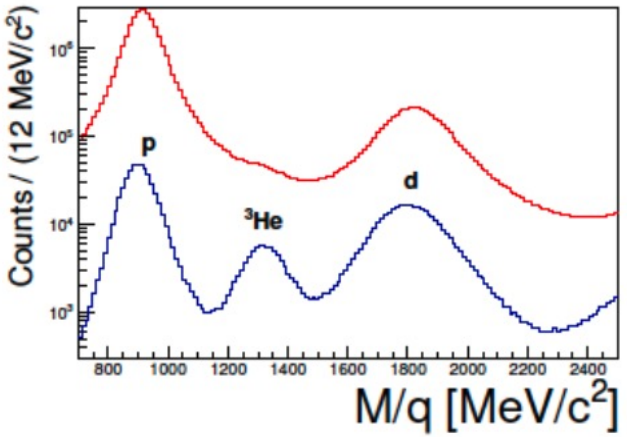
Recent Results on Hypermatter from HADES

Manuel Lorenz

Goethe-University Frankfurt

JULY 2015 CERN





Upper limit:

$M_{UL} = 1.04 \text{ x } 10^{-3}$

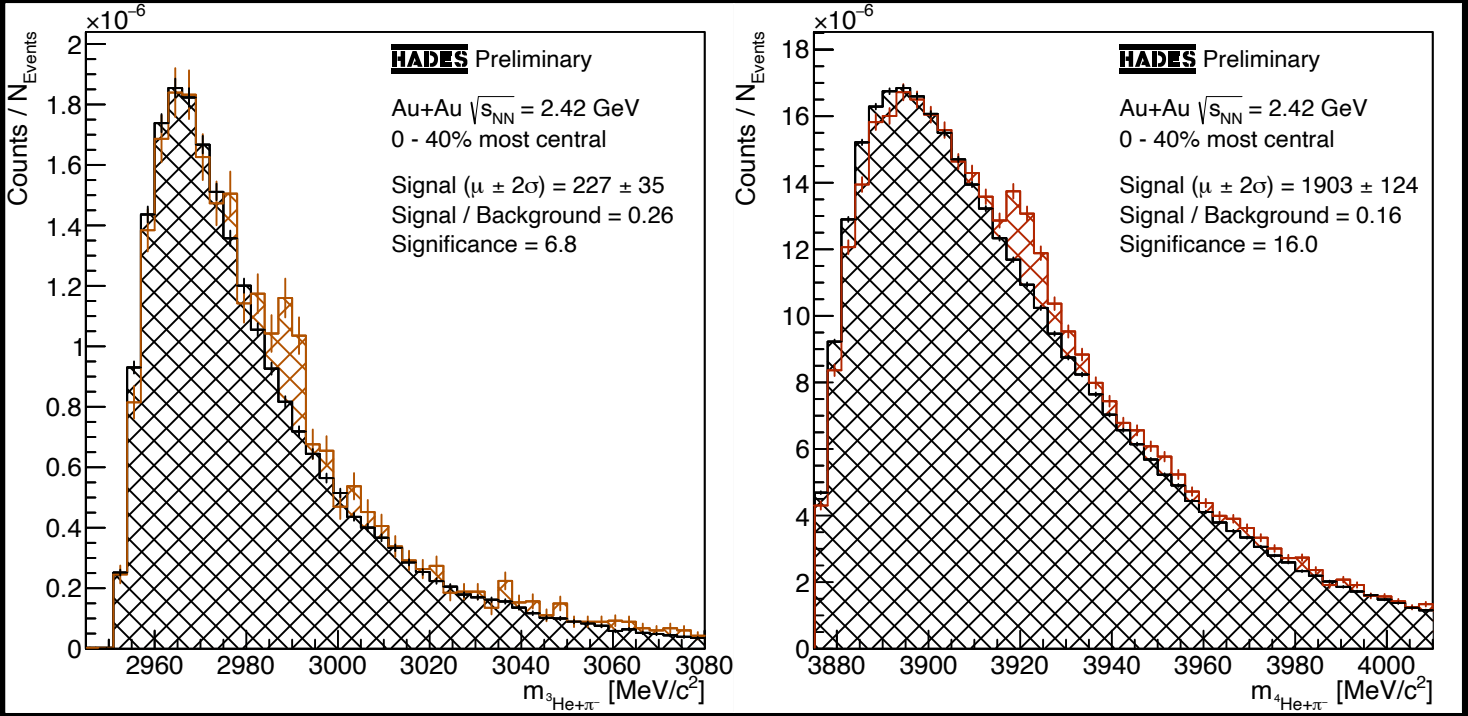
$^{3}_{\Lambda}\text{He}/\Lambda < (2.5 \pm 0.3) \text{ x } 10^{-2}$

Future plans:

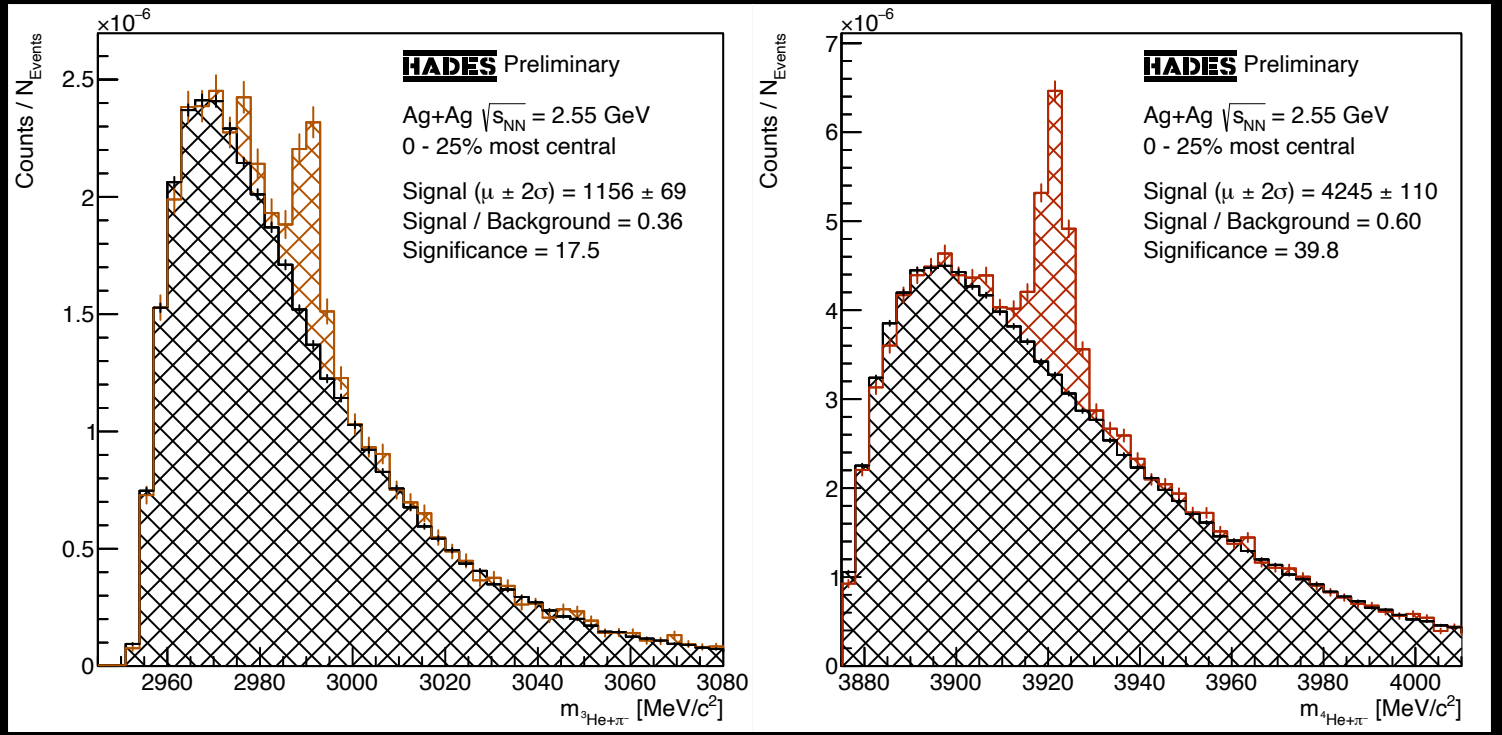
Investigate Au+Au @ 1.23 AGeV data (lower energy but heavier system) and 3 body decay channel

Eur.Phys.J. A49 (2013) 146

Hypernuclei Signals Au+Au @ 2.4 GeV



Hypernuclei Signals at Ag+Ag @ 2.55 GeV



Larger significance → focus on this data set in the talk

Outline:

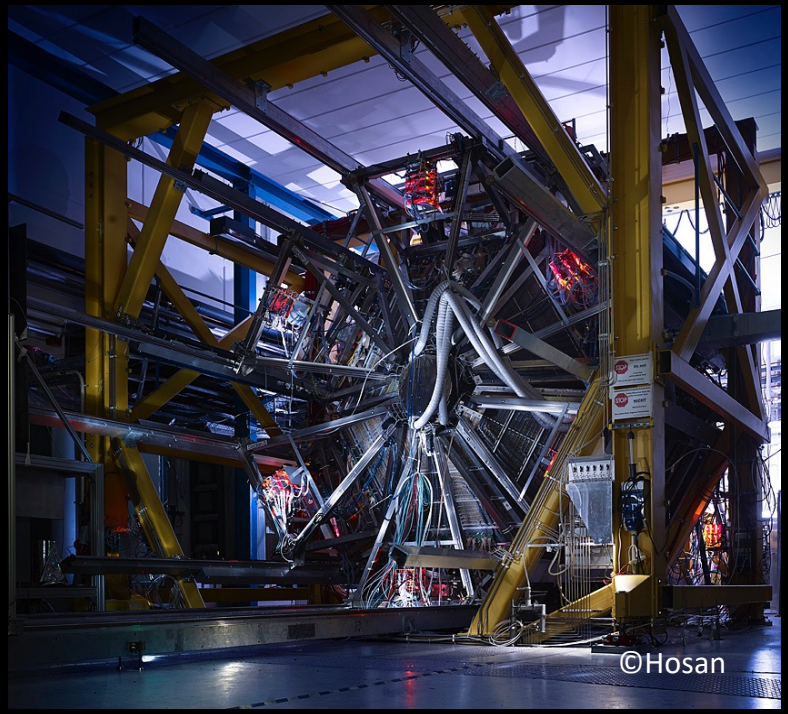
HADES and Weak Decay Topology Recognition

Kinematic Distributions and Yields

Decay Curves and <Lifetimes>

Energy and Centrality Excitation Functions

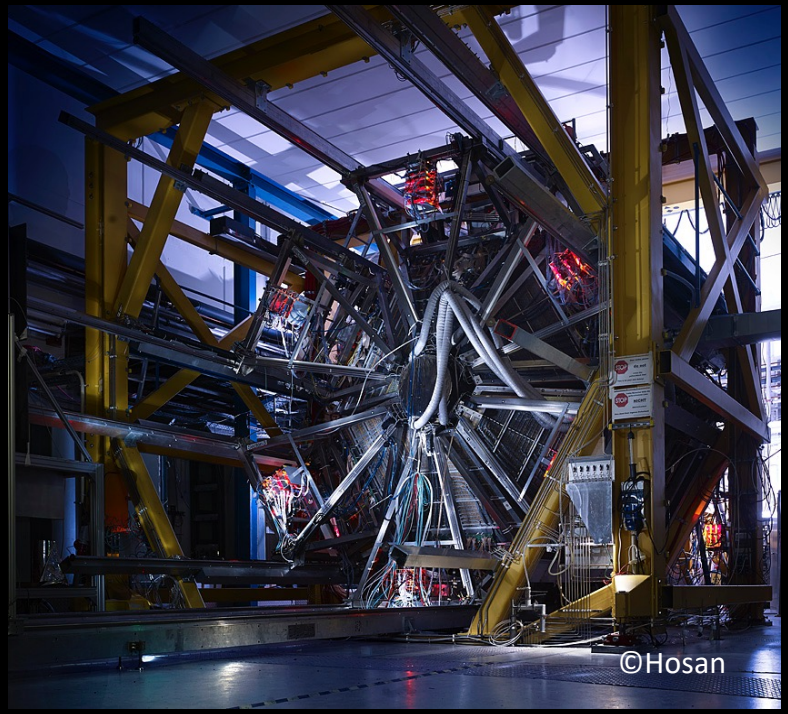
HADES and Ag+Ag@$\sqrt{s_{NN}}$=2.55 GeV:



Selected Events: N_{events}= 6 x 10^9

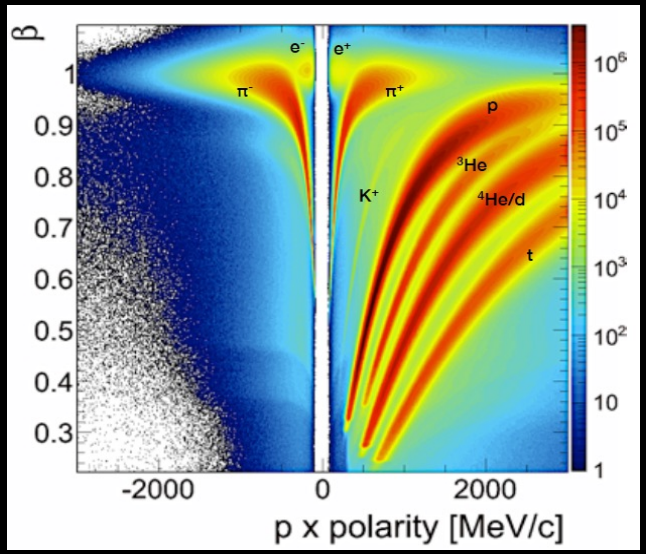
Fast detector: 16 kHz Ag+Ag
Large acceptance: full azimuthal and polar angle coverage of Θ = 18° – 85°

HADES and Ag+Ag@$\sqrt{s_{NN}}$=2.55 GeV:



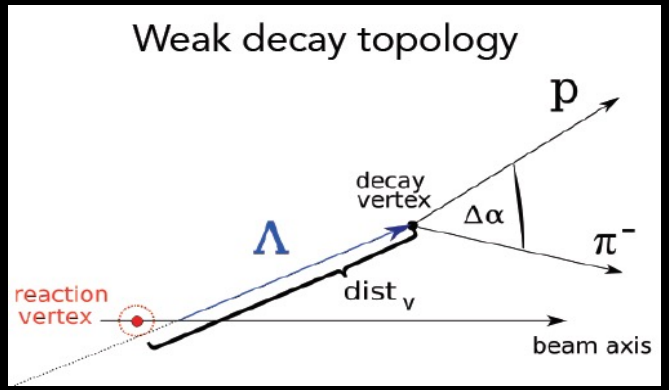
Fast detector: 16 kHz Ag+Ag
Large acceptance: full azimuthal and polar angle coverage of **Θ** = 18° – 85°

Selected Events: N_{events}= 6 x 10^9

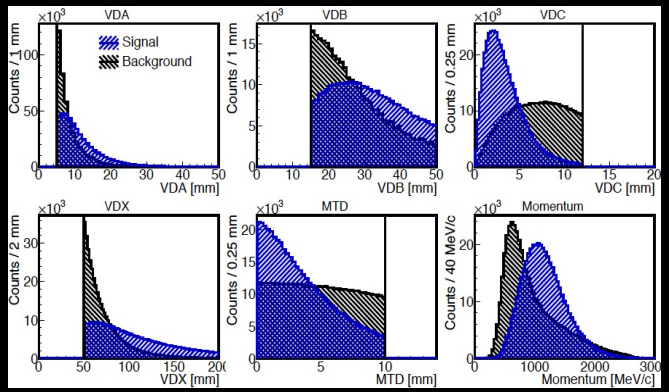


Baryon dominated:
p ≈ 50, p_{bound}≈ 20, π ≈ 30, K^+ ≈ 0.1, K^- ≈10^{-3}

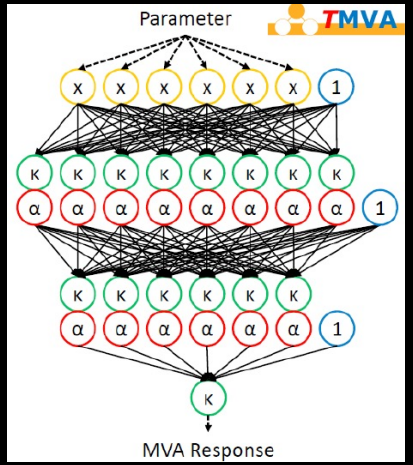
Weak Decay Topology Recognition with Neural Networks



Results in several parameters

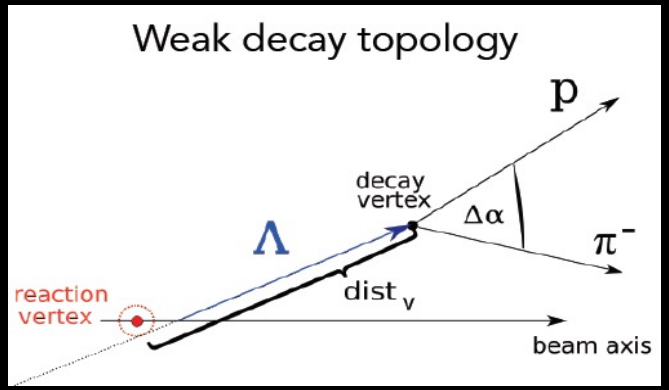


Which can be feed into an ANN

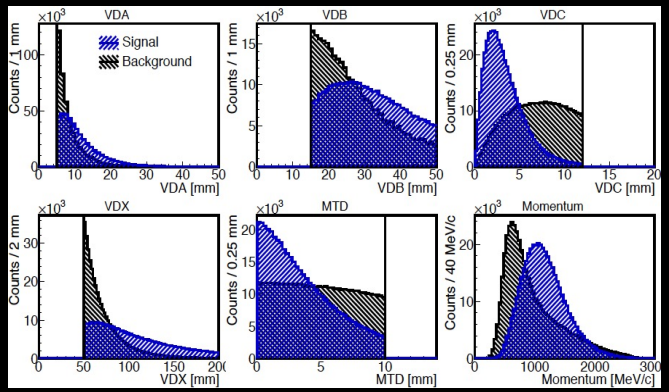


MA S. Spies, PhD F. Kornas, Phys.Lett. B793 (2019) 457-463

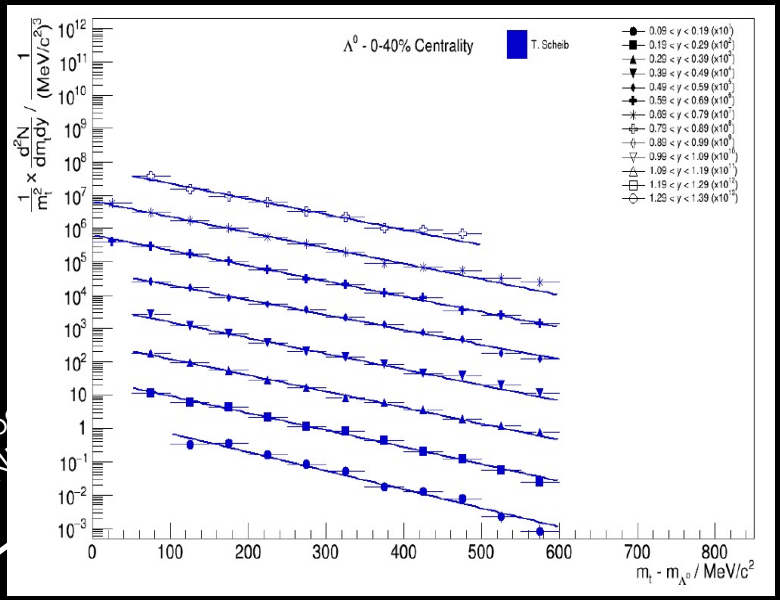
Weak Decay Topology Recognition with Neural Networks



Results in several parameters

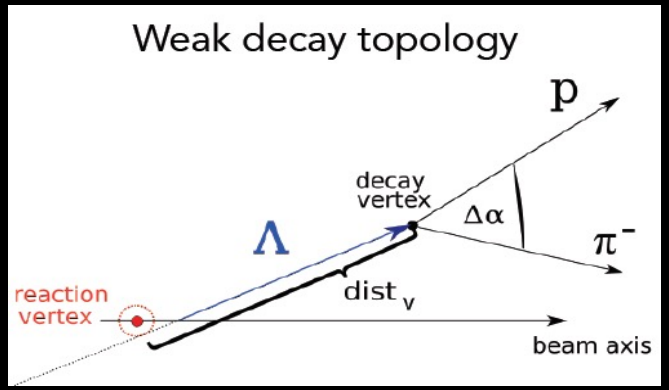


Which can b
into an AN

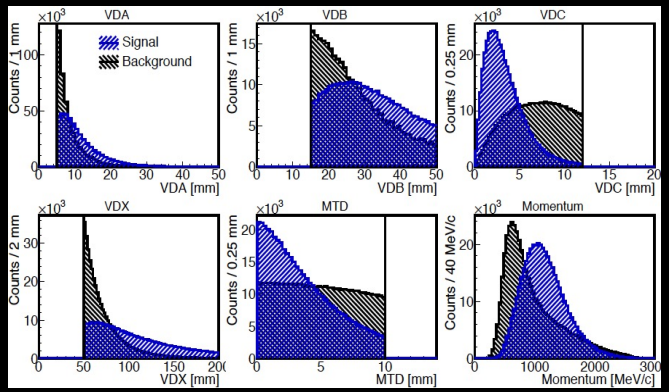


MA S. Spies, PhD F. Kornas, Phys.Lett. B793 (2019) 457-463

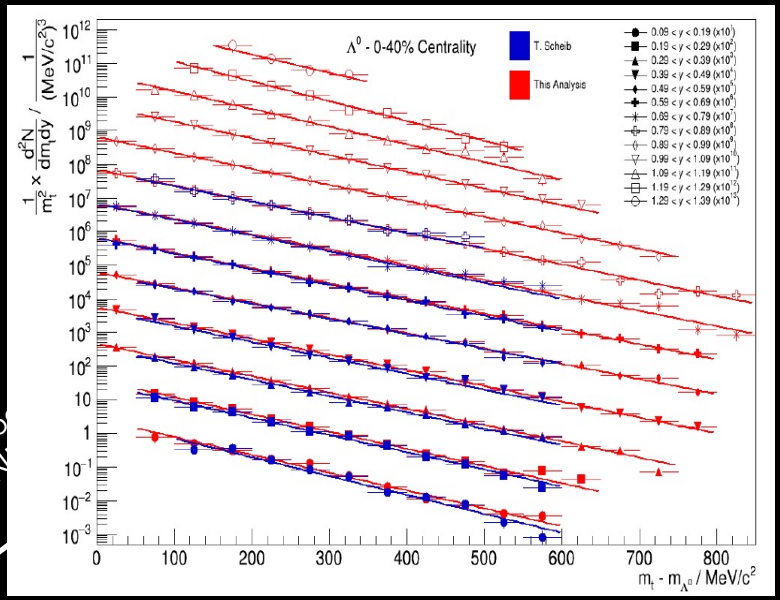
Weak Decay Topology Recognition with Neural Networks



Results in several parameters



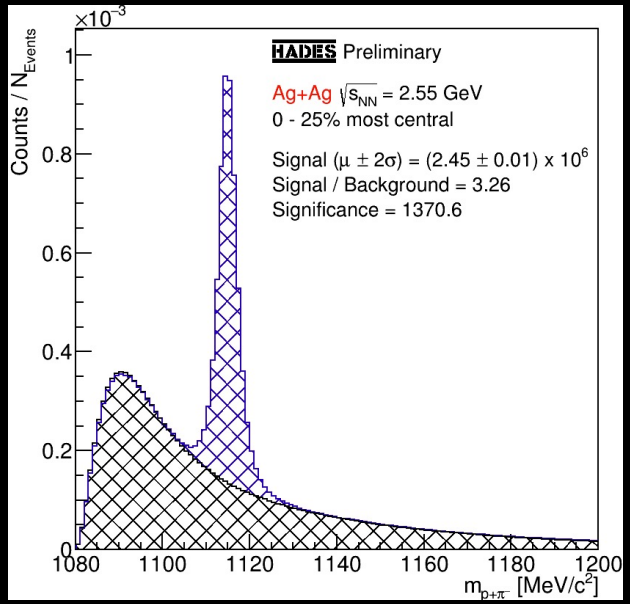
Which can b
into an AN



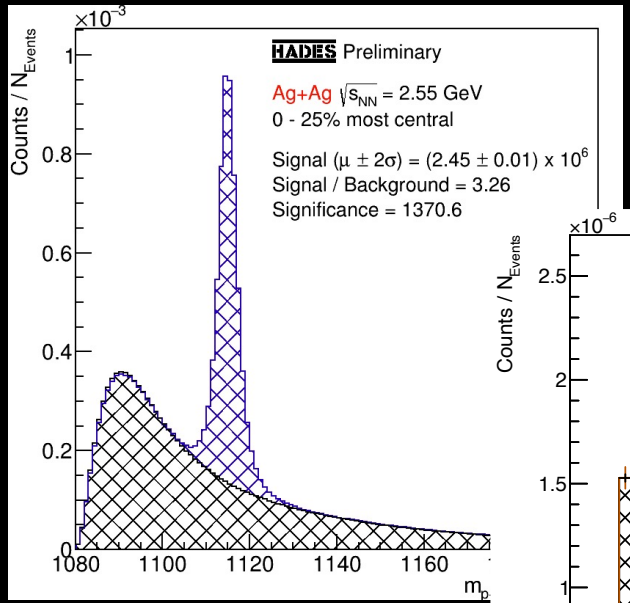
ANN in combination with pre-selection on topology parameters improves performance
→ reduction of uncertainty for 4π yield extraction.

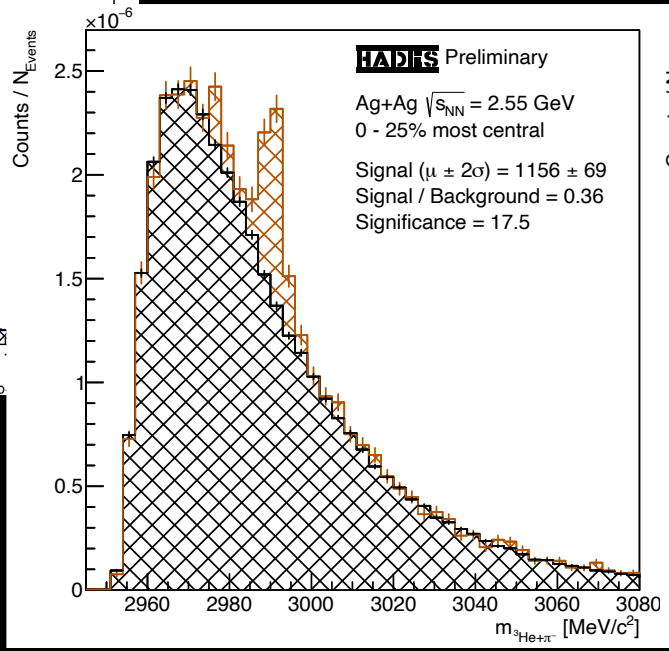
MA S. Spies, PhD F. Kornas, Phys.Lett. B793 (2019) 457-463

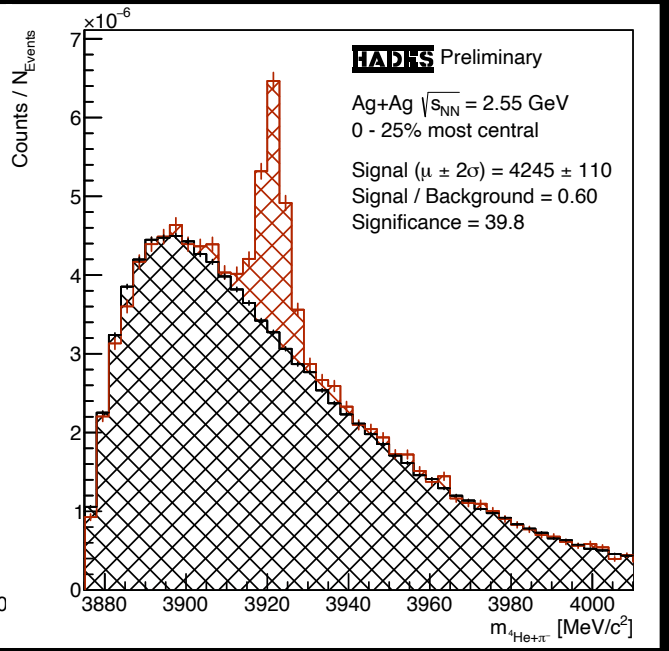
Hypernuclei Signals



Hypernuclei Signals

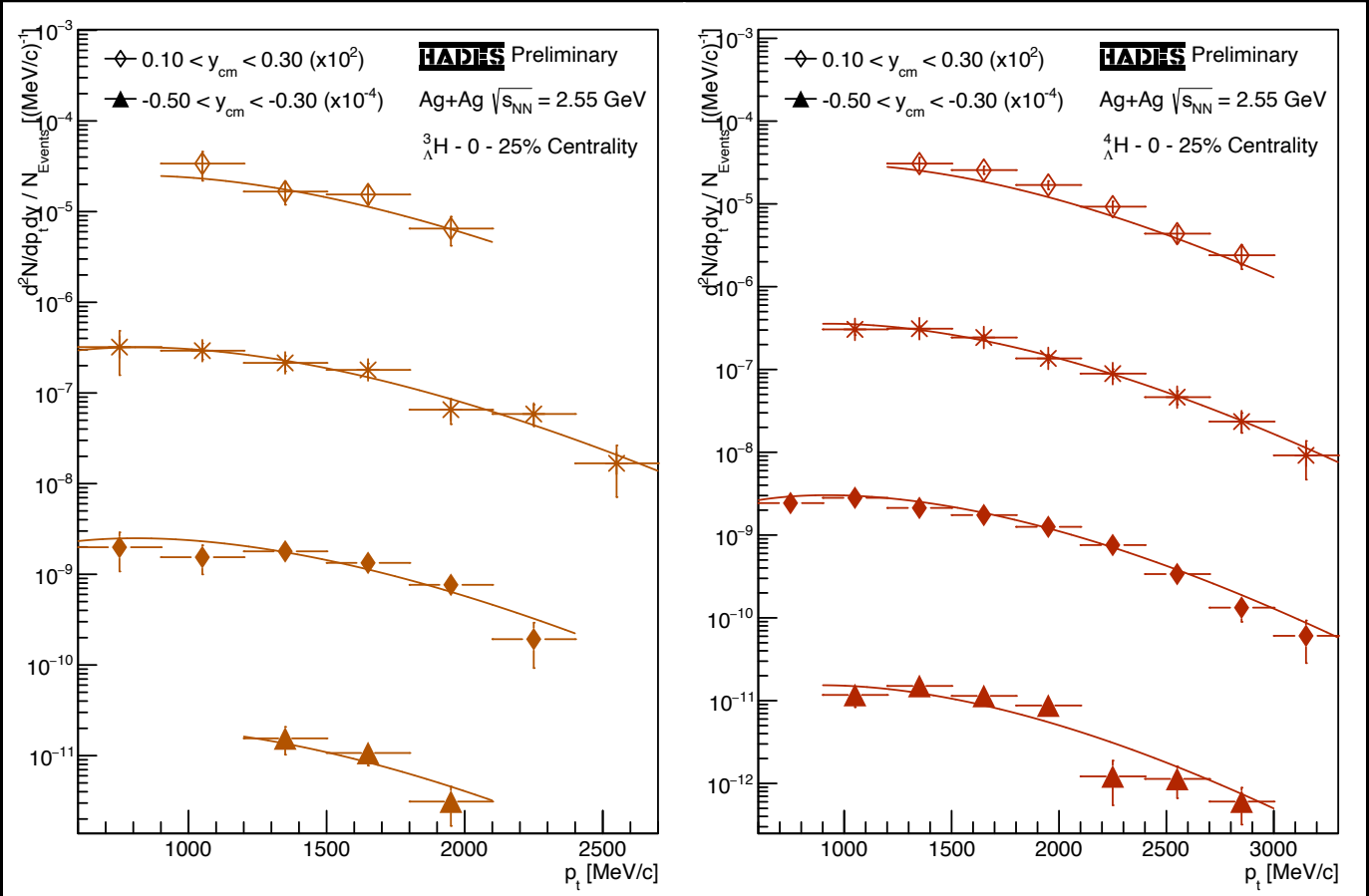




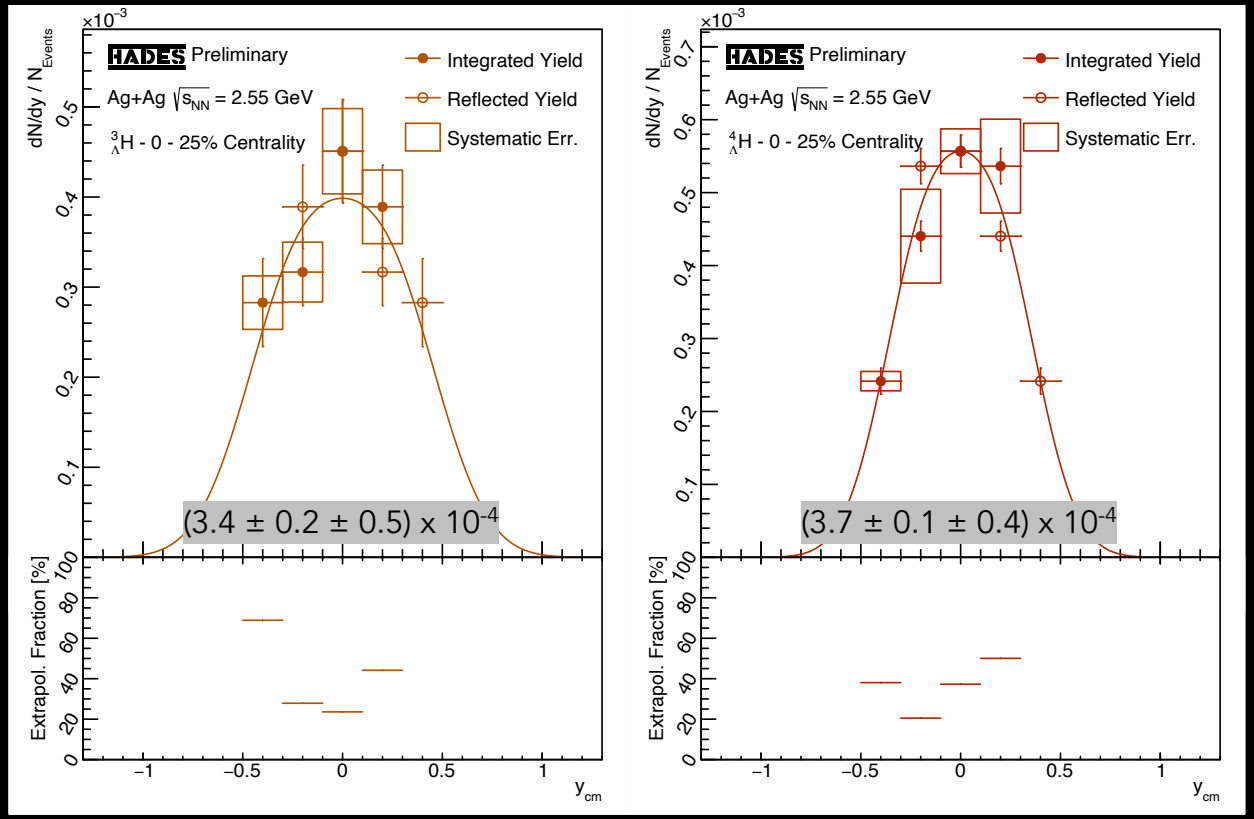


Kinematic Distributions and Yields

p_T - Spectra


0.10 < y_cm < 0.30 (x10^2)
-0.50 < y_cm < -0.30 (x10^-4)
HADES Preliminary
Ag+Ag √s_NN = 2.55 GeV
3ΛH - 0 - 25% Centrality
4ΛH - 0 - 25% Centrality
d²N/dp_t dy / N_Events [(MeV/c)^-1]
p_t [MeV/c]

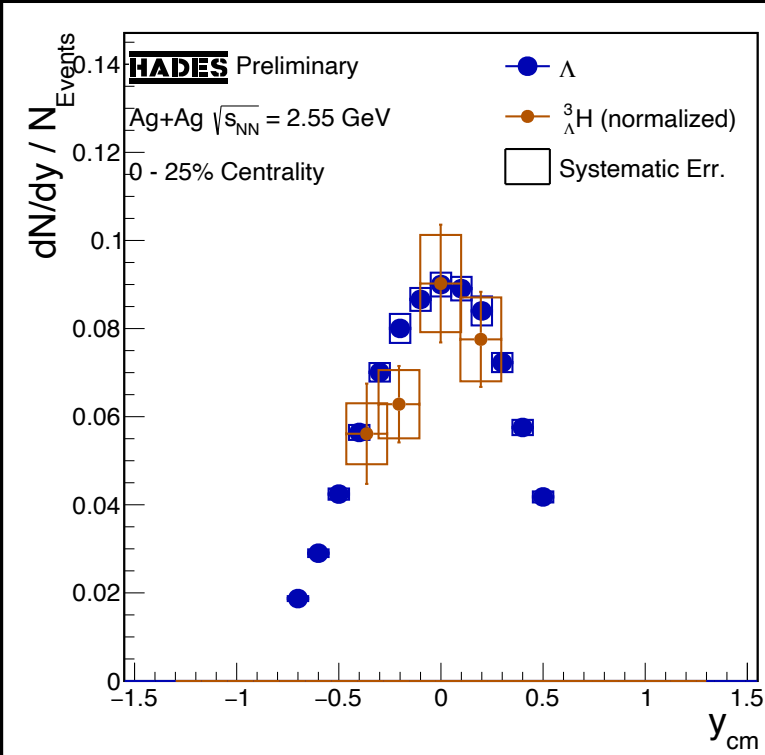
Rapidity Distributions

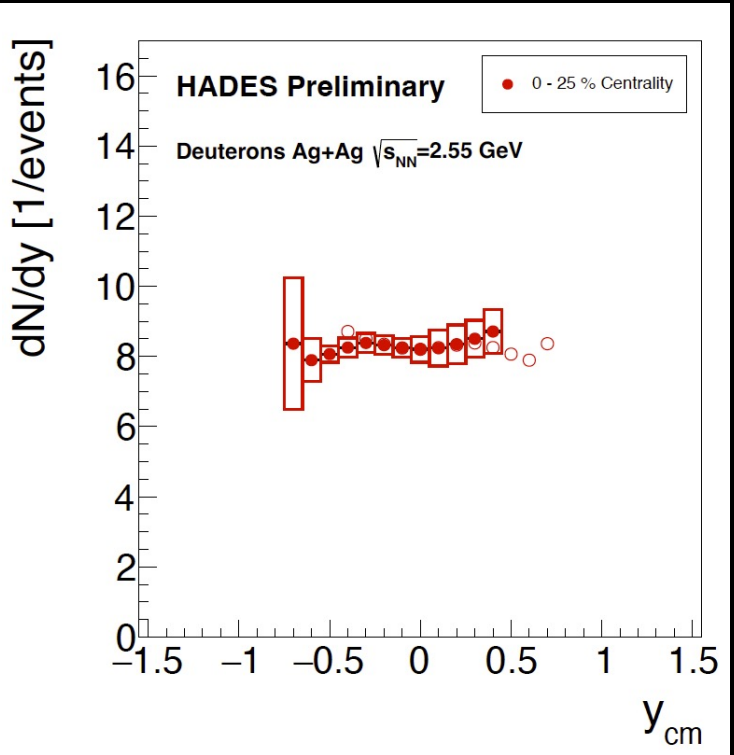


Bell-like shape, high yield of $^{4}_{\Lambda}H$ due to excited $^{4}_{\Lambda}H$ states?

(for details see B.Dönigus SQM 22 proceedings, to be published)

Rapidity Distributions Comparison to Λ and d

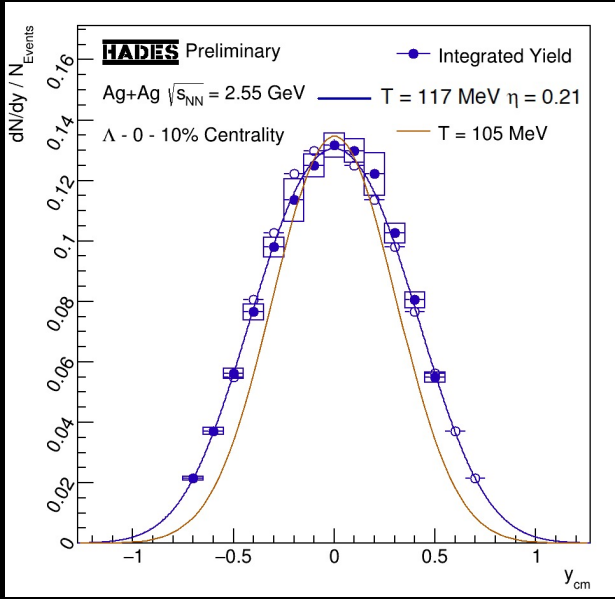




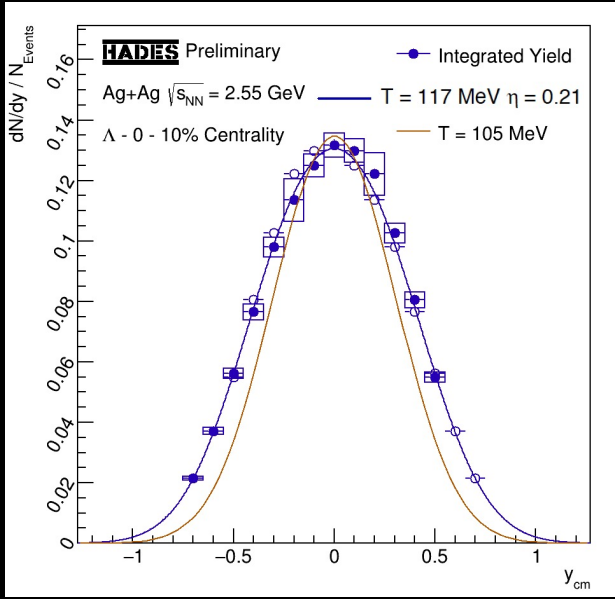
Shape of dN/dy distribution of $^3_\Lambda H$ similar to the one of the Λ, d show different shape.

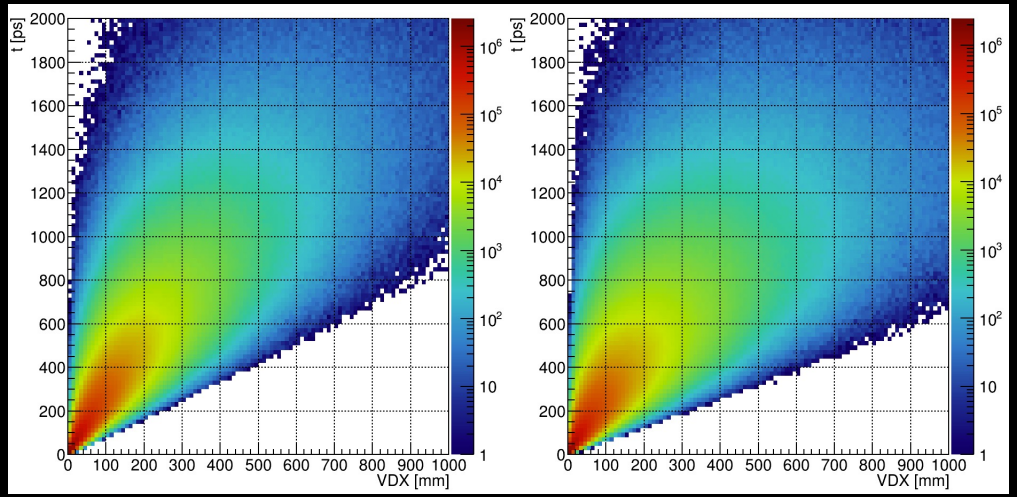
Decay Curves and <Lifetimes>

Λ-Decay Curve: Effect of the Source Model

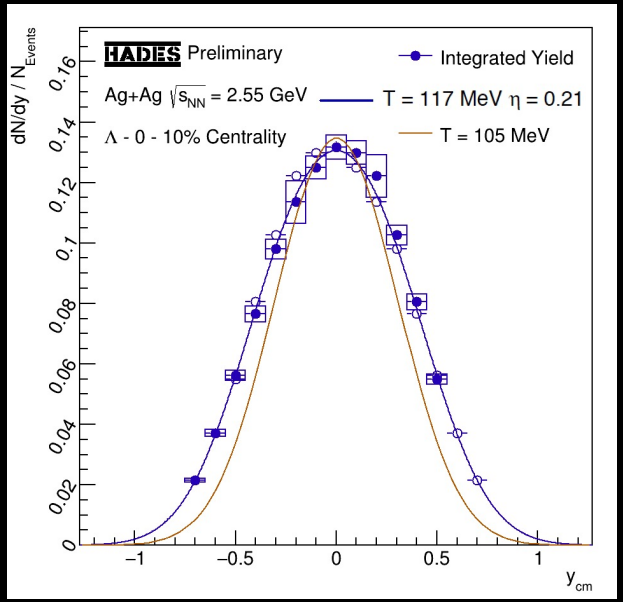


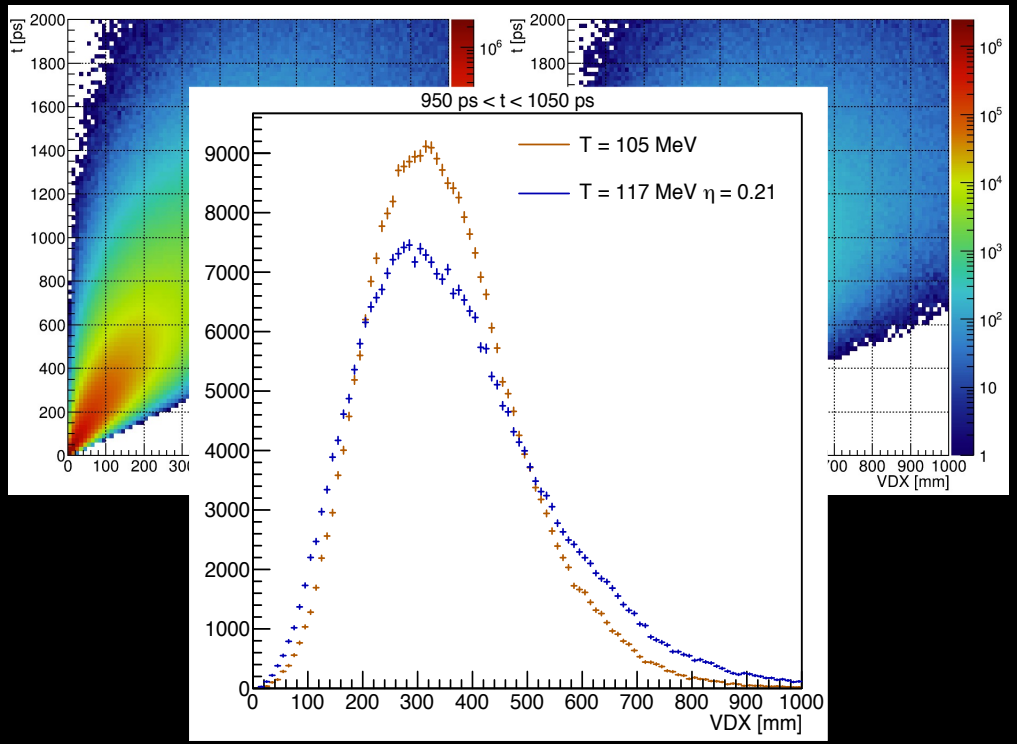
Λ-Decay Curve: Effect of the Source Model



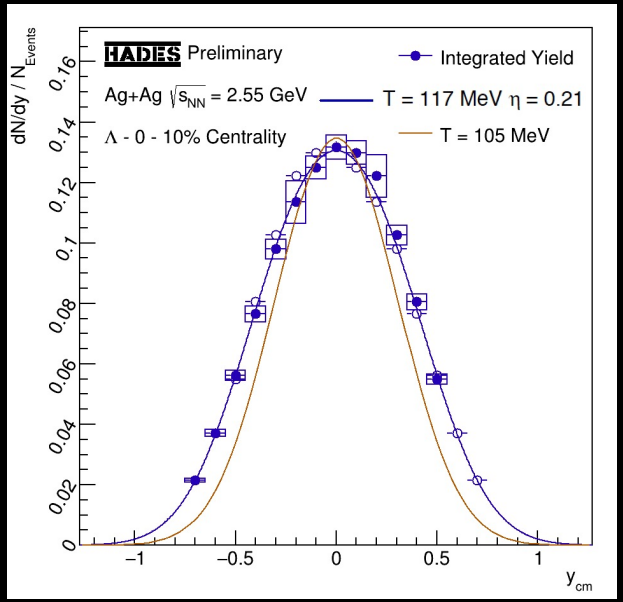


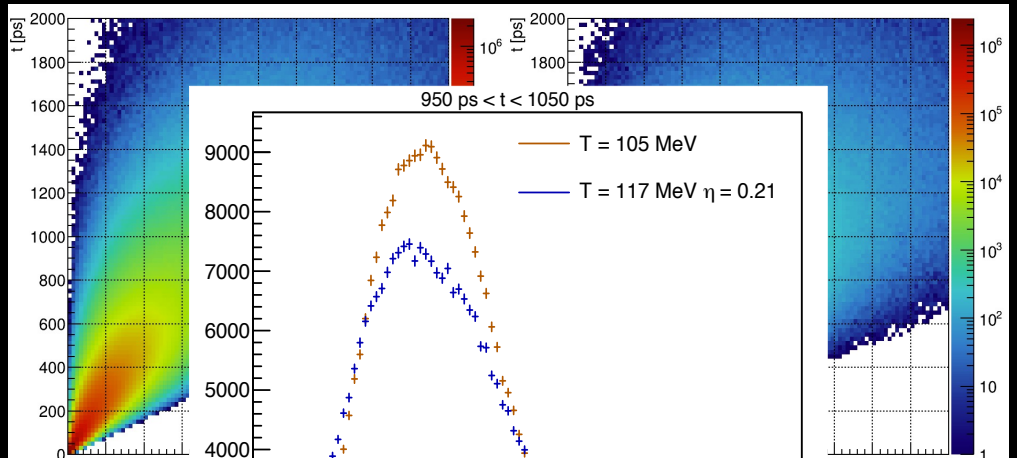
Λ-Decay Curve: Effect of the Source Model

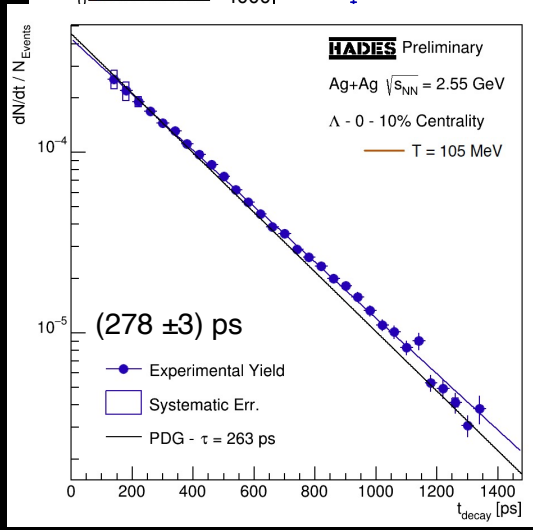


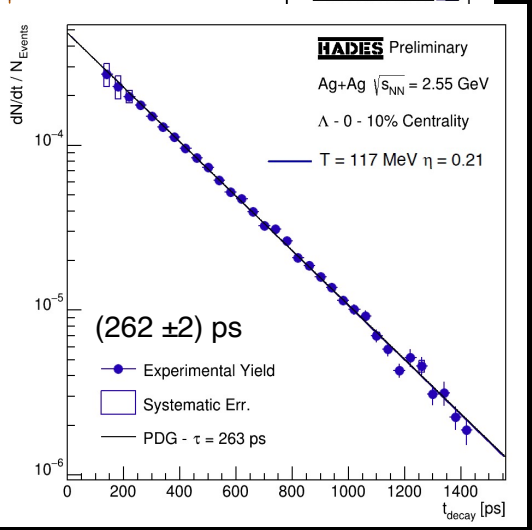


Λ-Decay Curve: Effect of the Source Model

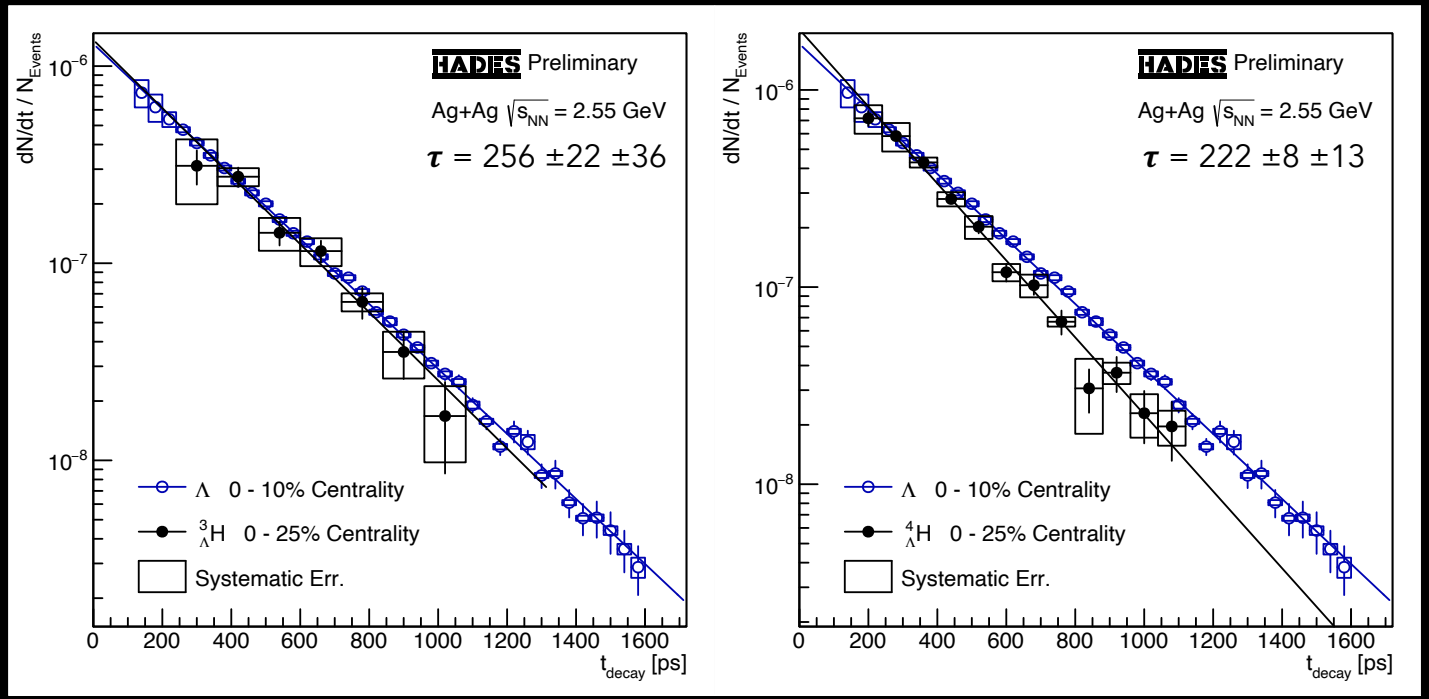








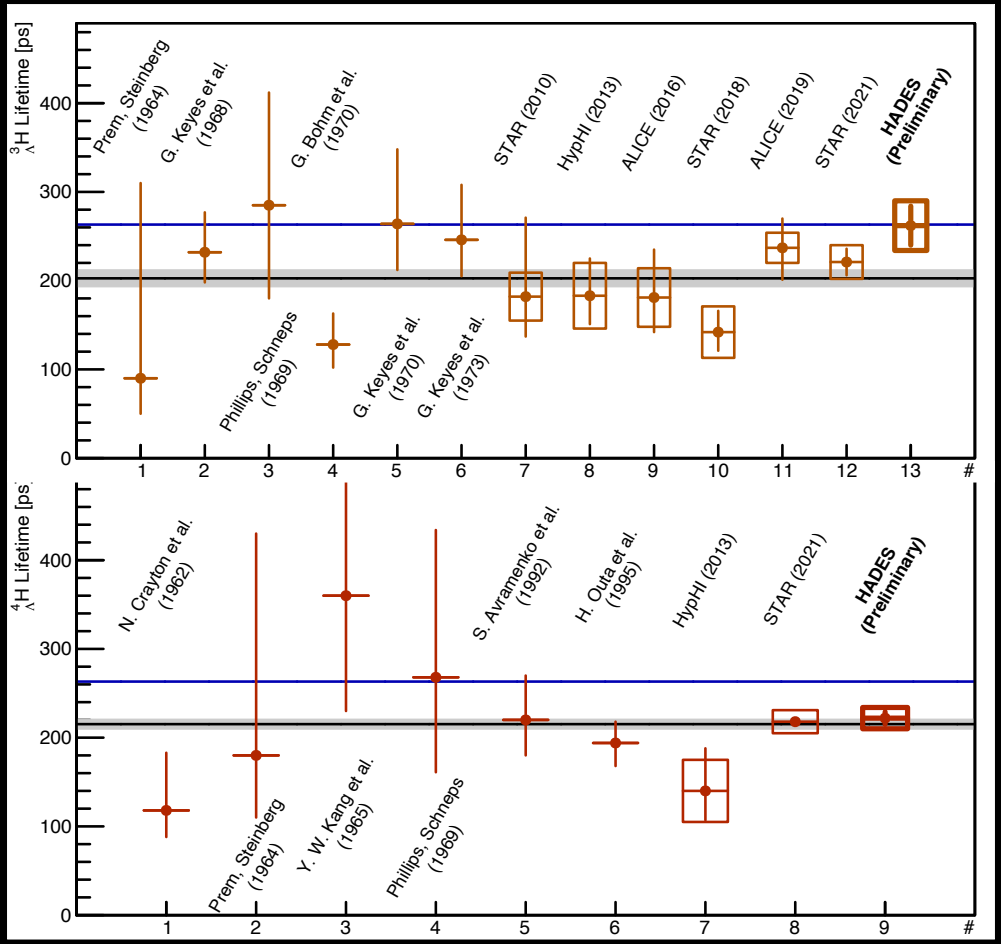
Hypernuclei Decay Curves



$^{3}_{\Lambda}H$ fifetime in agreement with free Λ, $^{4}_{\Lambda}H$ significantly lower.

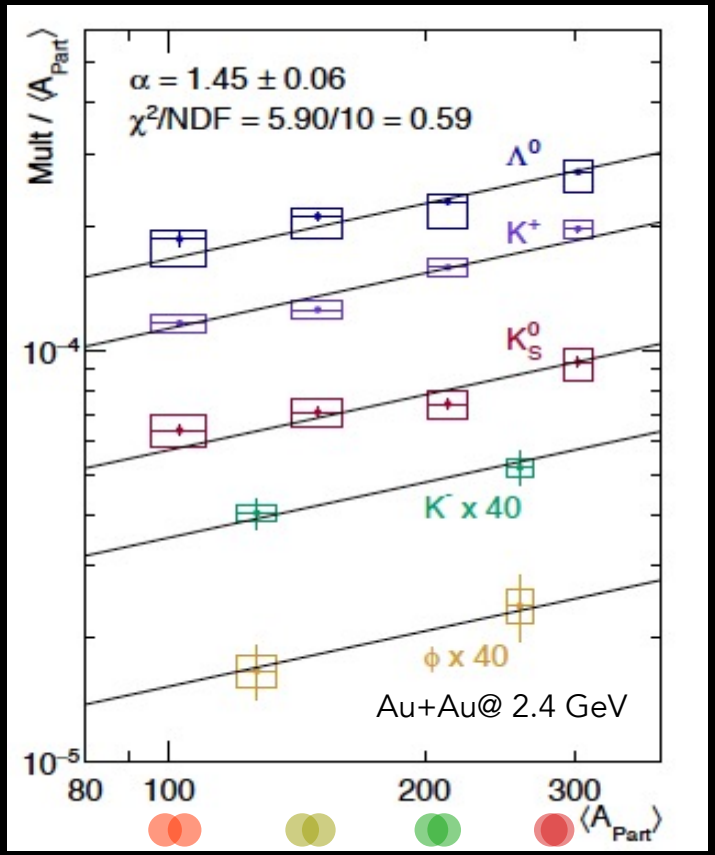
World Data: Lifetimes

Including the new HADES data the ${}^{4}_{\Lambda}H$ shows a 4.8 **σ** deviation compared to free Λ-lifetime.



Energy and Centrality Excitation Functions

Excitation functions: Centrality



Phys.Lett. B793 (2019) 457-463

Strange particle yields rise stronger than linear with

$\langle A_{part} \rangle$ ($M \sim \langle A_{part} \rangle^{\alpha}$)

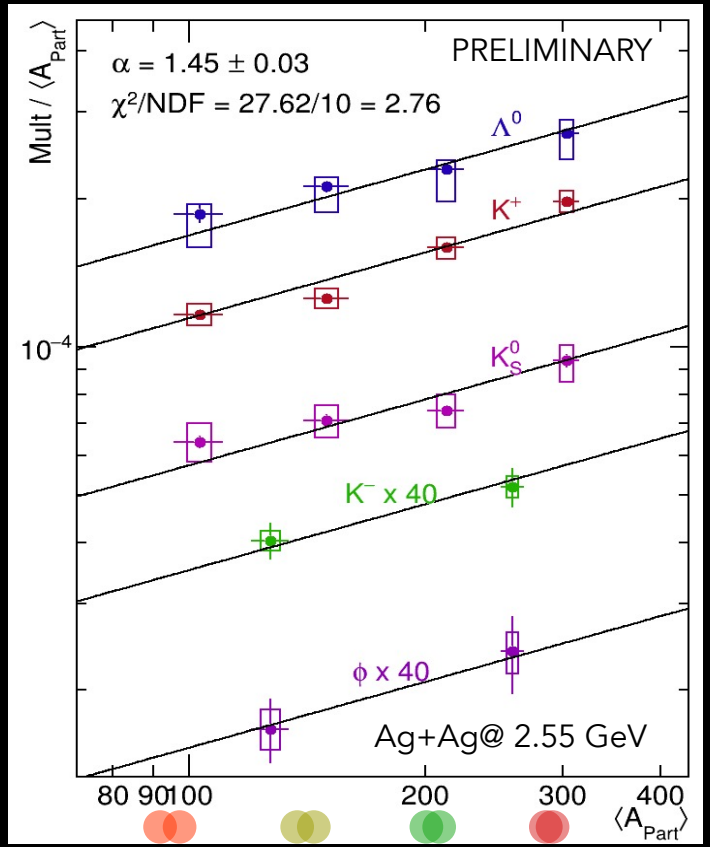
Universal $\langle A_{part} \rangle$ dependence of strangeness production

→ Hierarchy in production threshold not reflected in scaling

$NN \rightarrow NYK^+$: $\sqrt{s_{NN}} = 2.55$ GeV
$NN \rightarrow NNK^+K^-$: $\sqrt{s_{NN}} = 2.86$ GeV

Scaling with absolute amount of ssbar, not with individual hadron states.

Excitation functions: Centrality



Phys.Lett. B793 (2019) 457-463

Strange particle yields rise stronger than linear with

$\langle A_{part} \rangle$ ($M \sim \langle A_{part} \rangle^{\alpha}$)

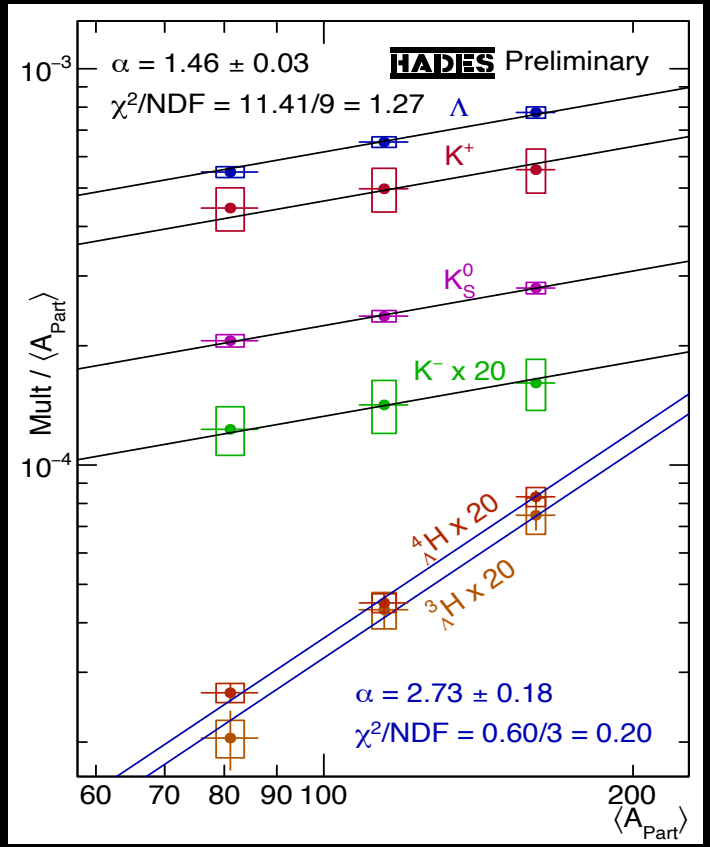
Universal $\langle A_{part} \rangle$ dependence of strangeness production

→ Hierarchy in production threshold not reflected in scaling

$NN \rightarrow NYK^+$: $\sqrt{s_{NN}} = 2.55$ GeV
$NN \rightarrow NNK^+K^-$: $\sqrt{s_{NN}} = 2.86$ GeV

Scaling with absolute amount of ssbar, not with individual hadron states.

Excitation functions: Centrality



Strange particle yields rise stronger than linear with

$\langle A_{part} \rangle$ ($M \sim \langle A_{part} \rangle^{\alpha}$)

Universal $\langle A_{part} \rangle$ dependence of strangeness production

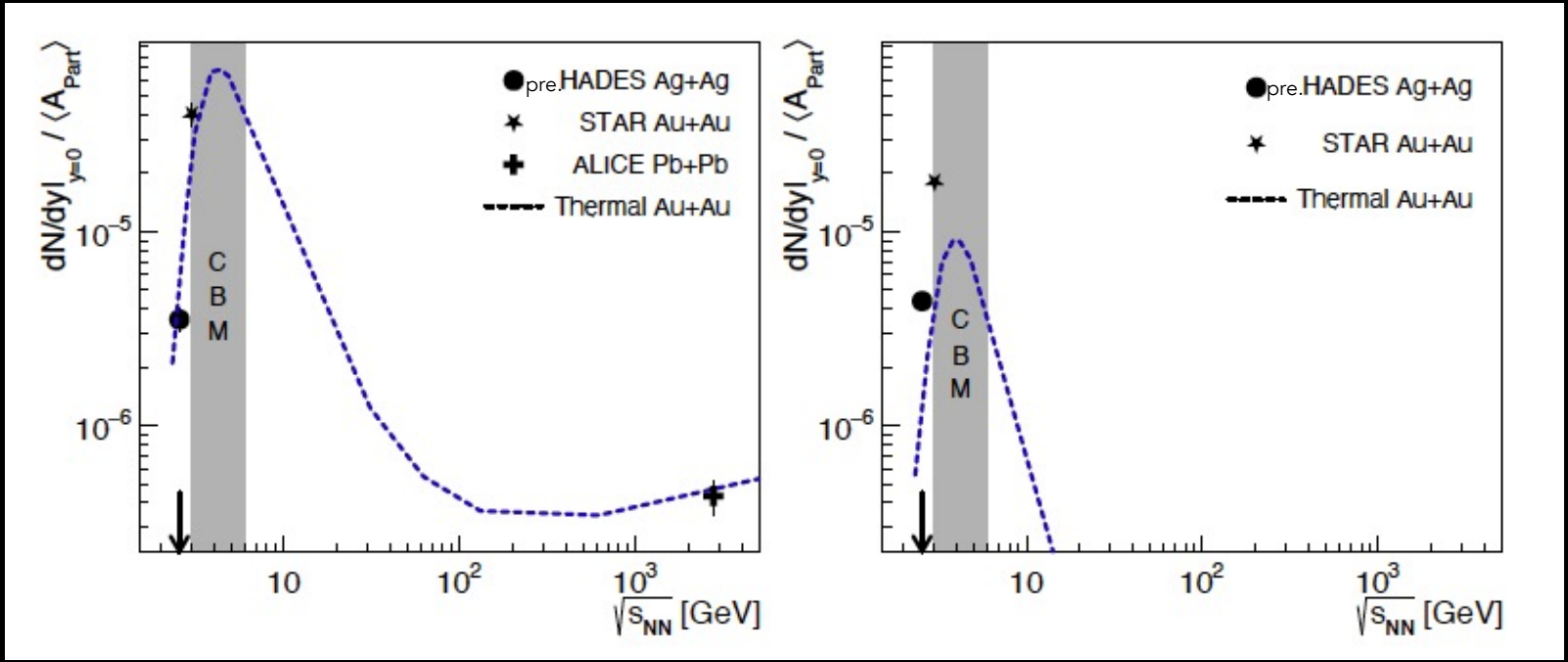
→ Hierarchy in production threshold not reflected in scaling

NN→NYK⁺: $\sqrt{s_{NN}}$= 2.55 GeV
NN→NNK⁺K⁻: $\sqrt{s_{NN}}$= 2.86 GeV

Scaling with absolute amount of ssbar, not with individual hadron states.

Hypernuclei yields scale stronger with centrality.

Excitation functions: Energy



Shift of Hyperhydrogen maximum due to excited ^{4}H states, which are not (yet) included in the SHM curve?

Phys. Lett. B, 754:360{372, (2016)., Phys. Rev. Lett.,128(20):202301, (2022)., Phys. Lett. B, 697:203{207, (2011).

Summary

Significant ${}^{3}_{\Lambda}H$ and ${}^{4}_{\Lambda}H$ signals in 0-25% most central Ag+Ag @2.55 GeV.

Bell-like dN/dy distribution of Hypernuclei.

${}^{3}_{\Lambda}H$ lifetime in agreement with free Λ, ${}^{4}_{\Lambda}H$ significantly lower.

Hints for importance of decays from excited-^{4}H states.

Stronger A_{part} scaling compared to other strange hadrons.