JOINT INSTITUTE FOR NUCLEAR RESEARCH

14th Collaboration Meeting
of the BM@N Experiment at NICA
JINR, Dubna, Russia, May 13-15, 2025

Status of hyperon analysis in run 8 (Xe + CsI)

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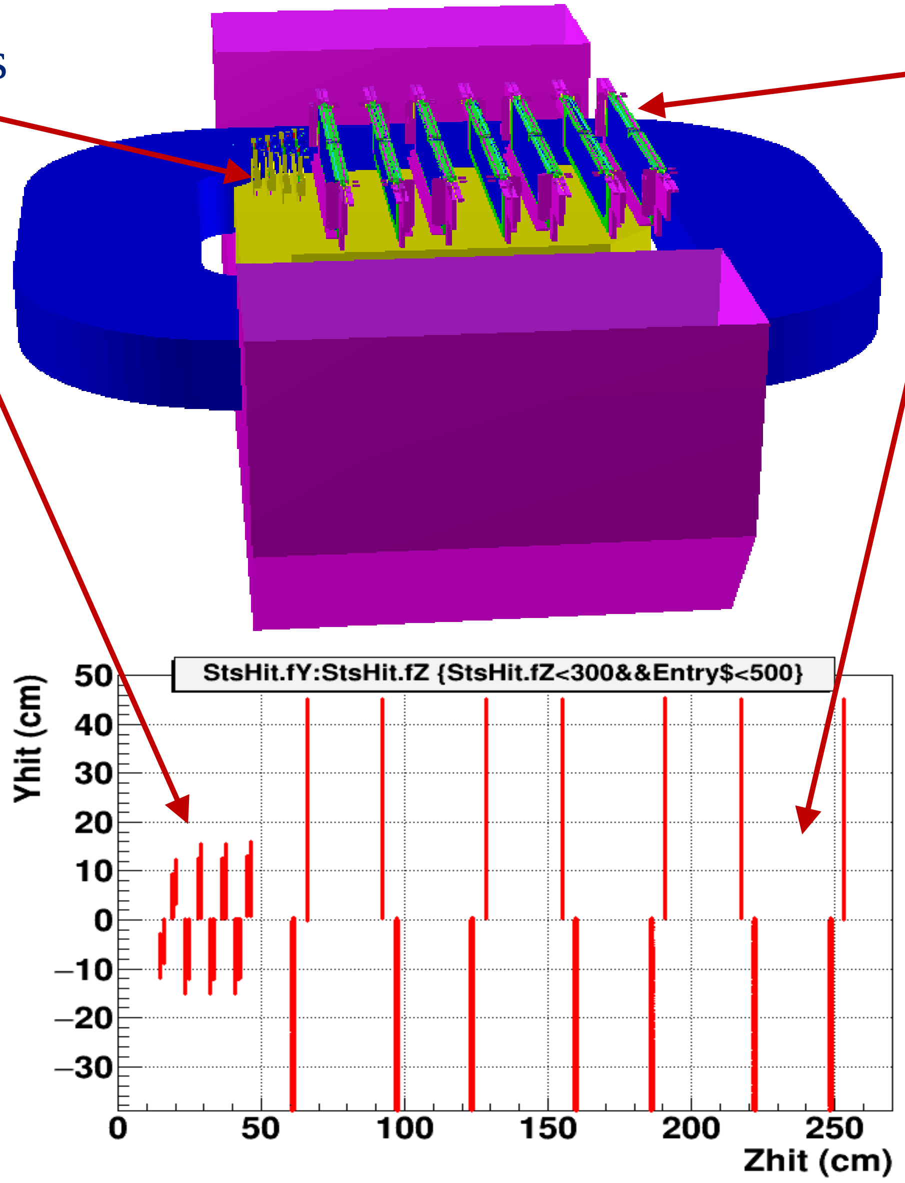
Outline

- BM@N configuration
- Reconstruction of strange particle decays
- Some results from STAR
- Towards physics analysis: Monte Carlo efficiency and m_T- spectra
- Experimental data: m_T and y- spectra
- Systematic effects
- Reconstruction improvement (Ξ^- selection)
- Summary and next steps

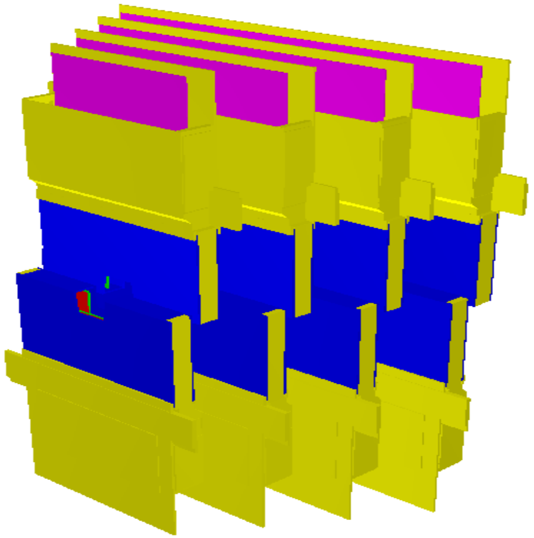
Detector geometry in Run 8

Si stations

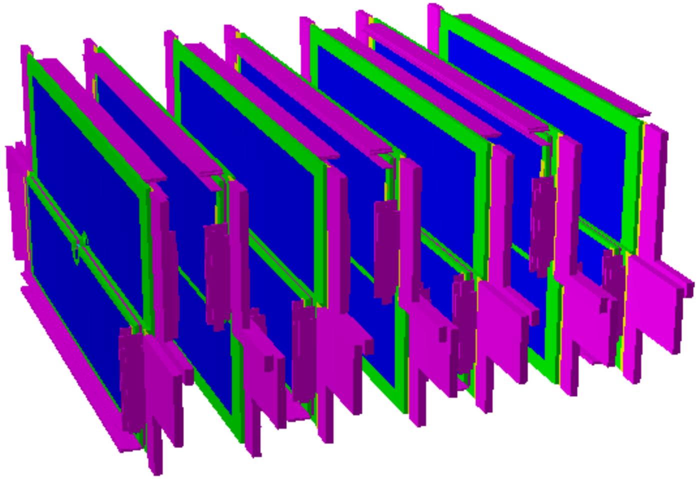
GEMs



Si stations

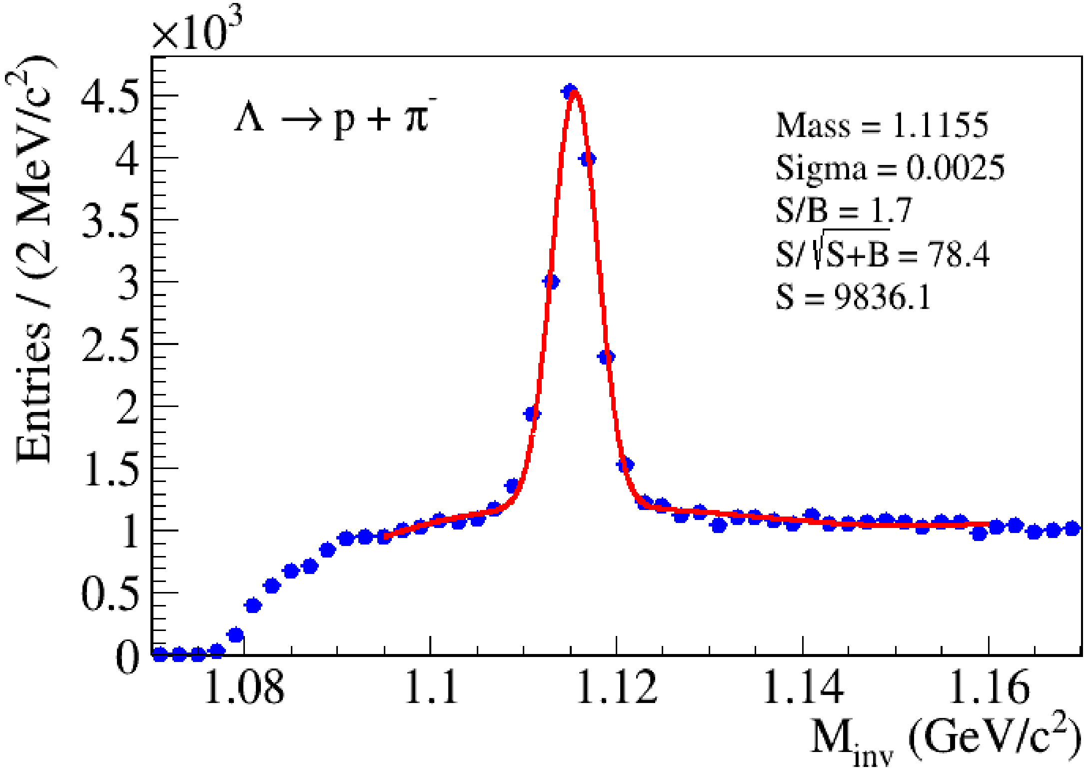


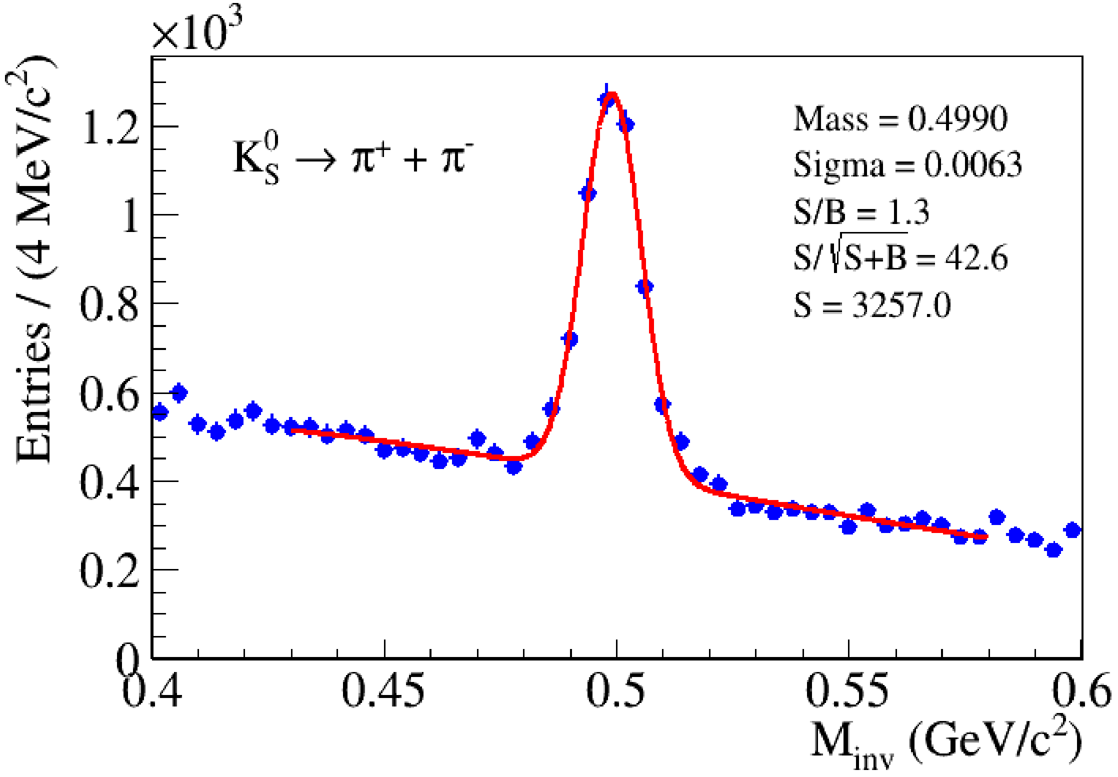
GEMs



Reconstruction of strange particle decays

Run 7830





Towards physics analysis

Steps towards physics analysis

JHEP

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Statistics: 260 mln. events

Strangeness production in $\sqrt{s_{NN}} = 3$ GeV Au+Au collisions at RHIC

The STAR collaboration

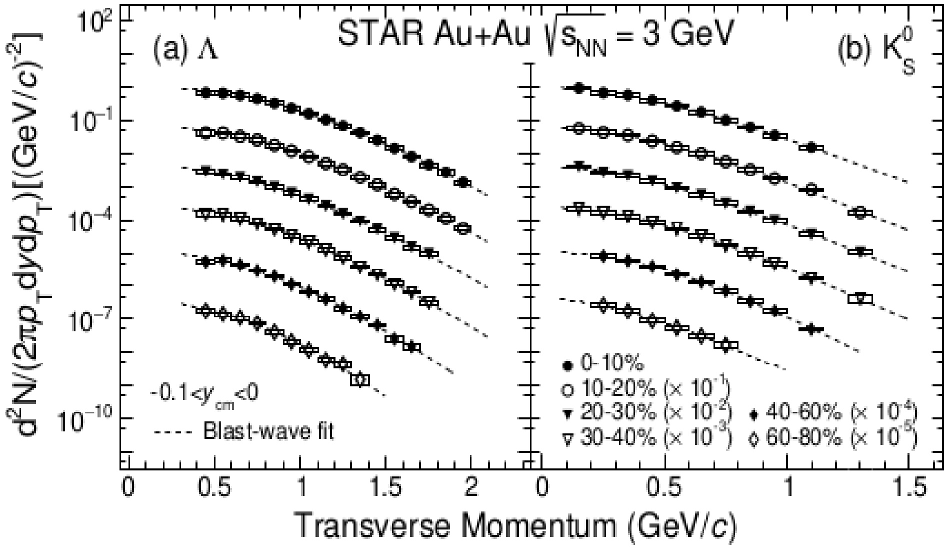


Figure 2. Transverse-momentum spectra of Λ (a) and K^0_S (b) at mid-rapidity from different centrality bins in Au + Au collisions at $\sqrt{s_{NN}} = 3$ GeV. The spectra are scaled by consecutive factors of 10^{-1} for each centrality bin as indicated in the legend. The vertical lines and boxes represent the statistical and systematic uncertainties, respectively. The dashed curves represent fits to the data using the blast-wave model.

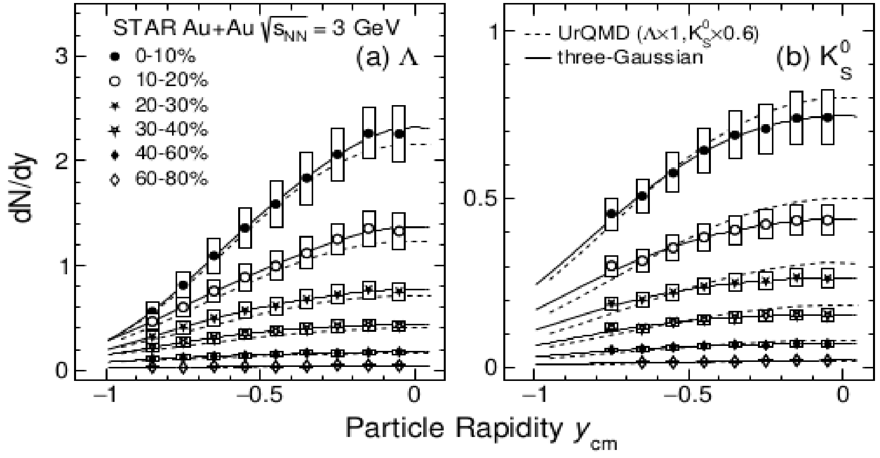
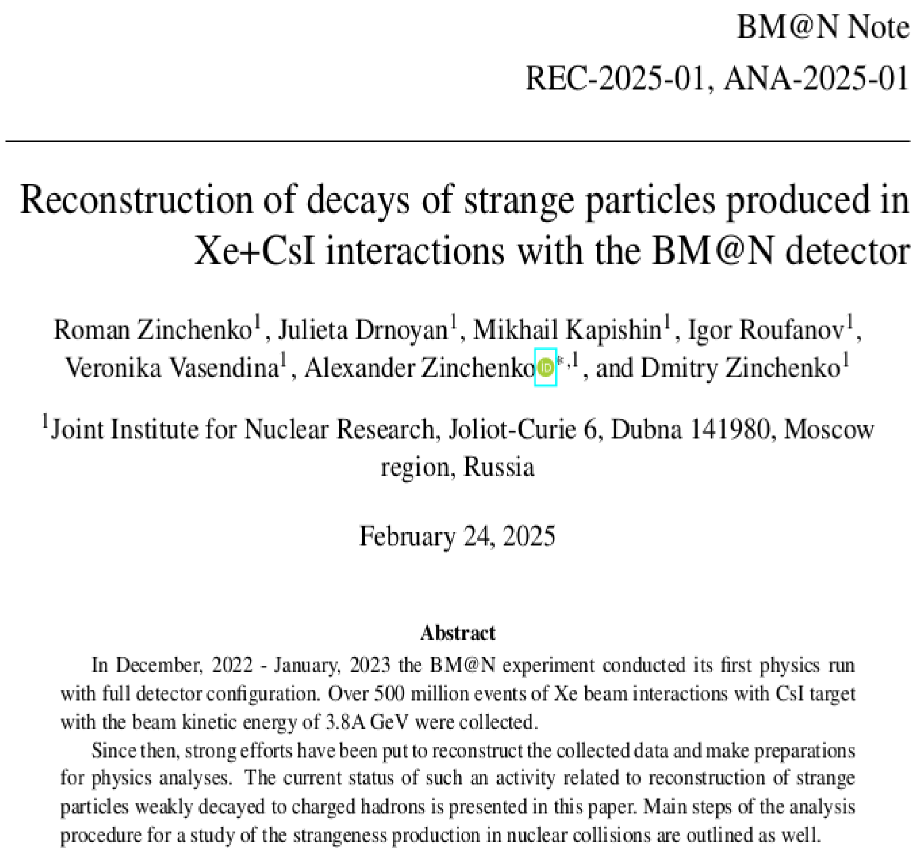


Figure 3. The rapidity dependence of dN/dy of particles for different centrality bins in Au+Au collisions at $\sqrt{s_{NN}} = 3$ GeV. The vertical lines and boxes represent the statistical and systematic uncertainties, respectively. The solid lines represent the three-Gaussian function that fit the data points. The dashed lines are the calculations from hadronic transport model UrQMD [42].

Steps towards physics analysis



BM@N Note

REC-2025-01, ANA-2025-01

Reconstruction of decays of strange particles produced in Xe+CsI interactions with the BM@N detector

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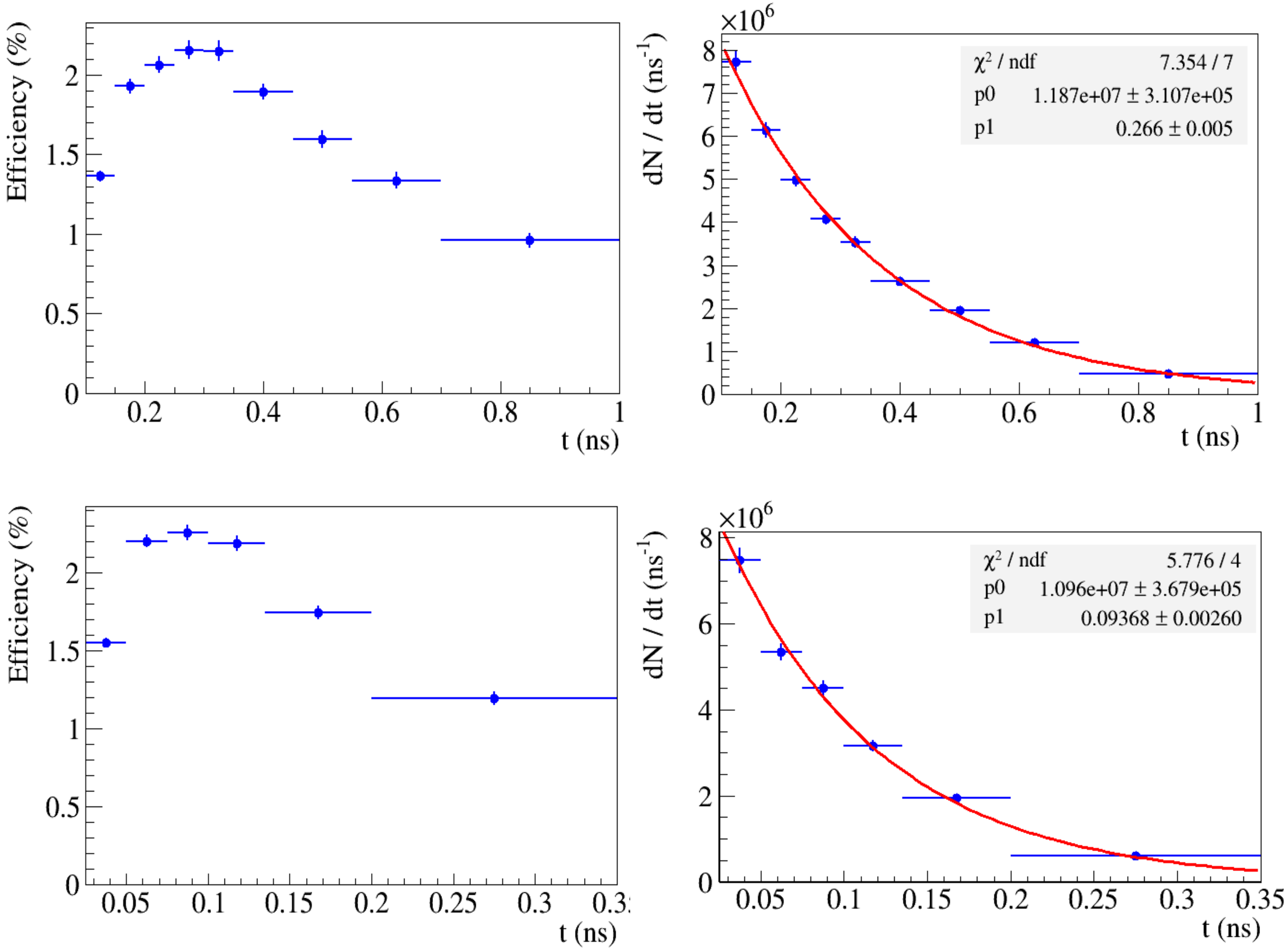
February 24, 2025

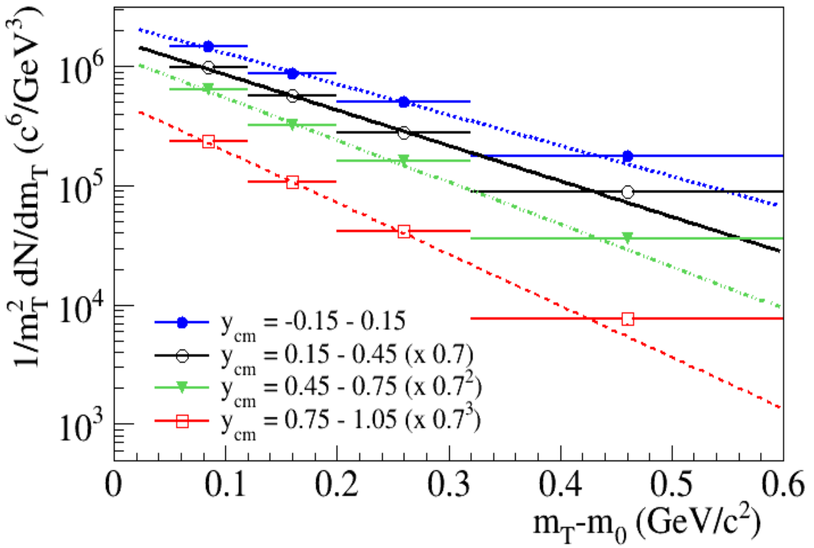
Abstract

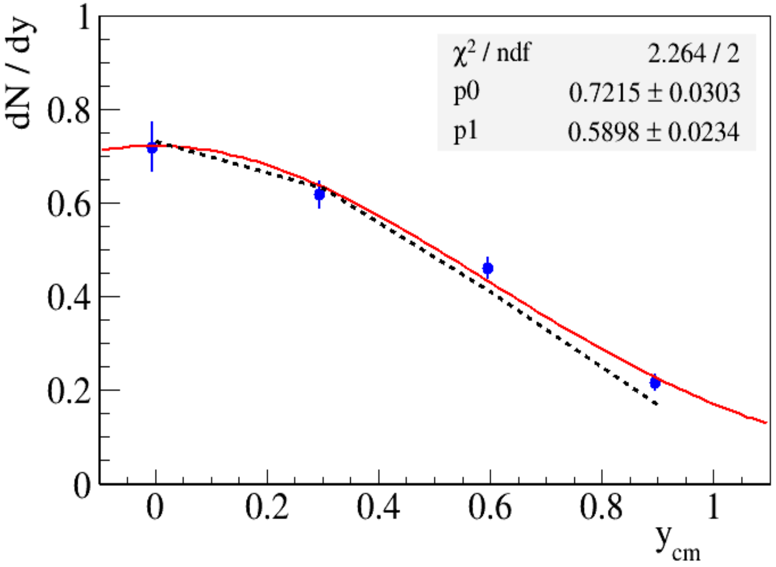
In December, 2022 - January, 2023 the BM@N experiment conducted its first physics run with full detector configuration. Over 500 million events of Xe beam interactions with CsI target with the beam kinetic energy of 3.8A GeV were collected.

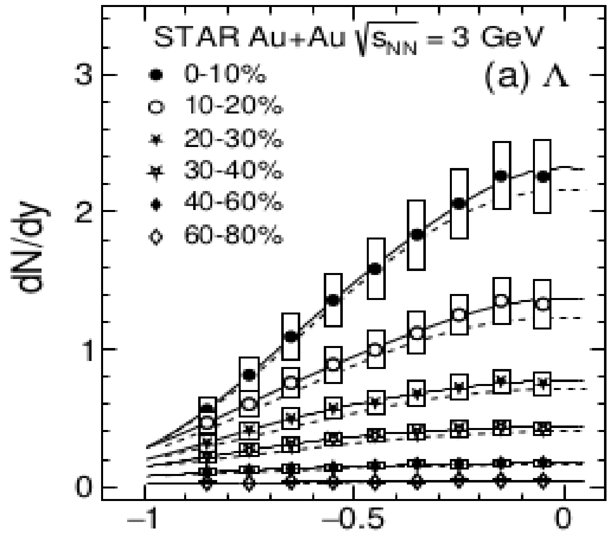
Since then, strong efforts have been put to reconstruct the collected data and make preparations for physics analyses. The current status of such an activity related to reconstruction of strange particles weakly decayed to charged hadrons is presented in this paper. Main steps of the analysis procedure for a study of the strangeness production in nuclear collisions are outlined as well.

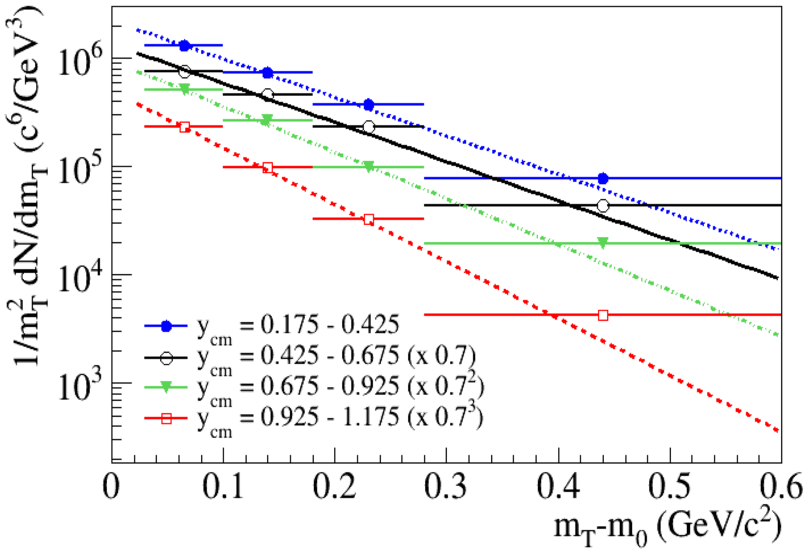


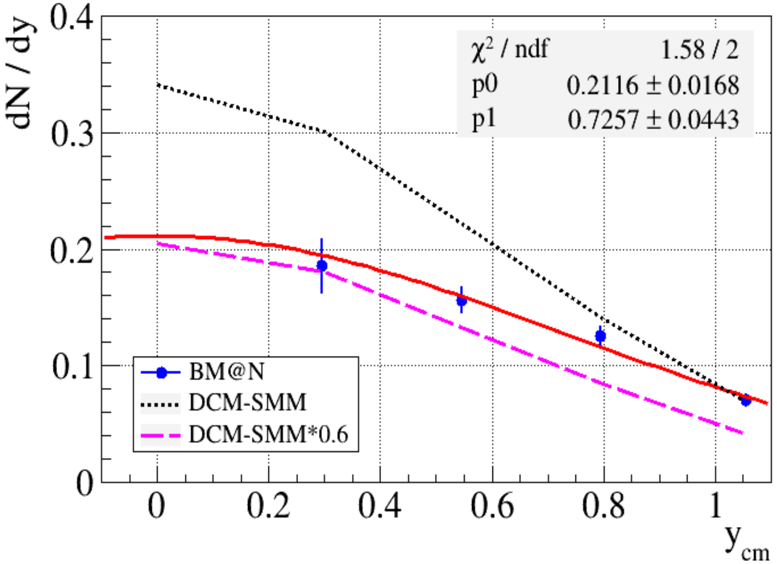
Steps towards physics analysis

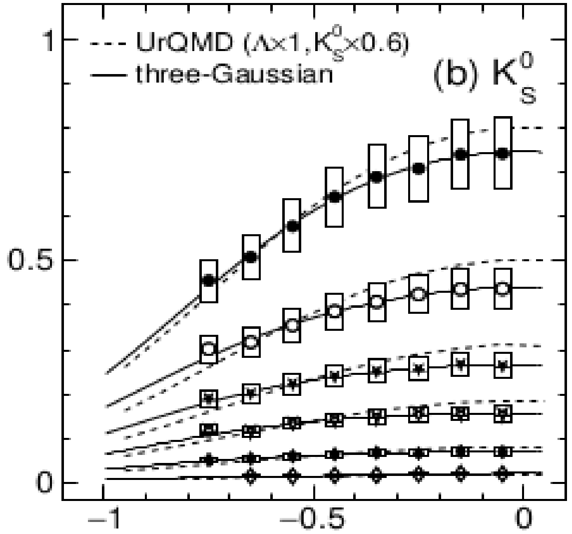




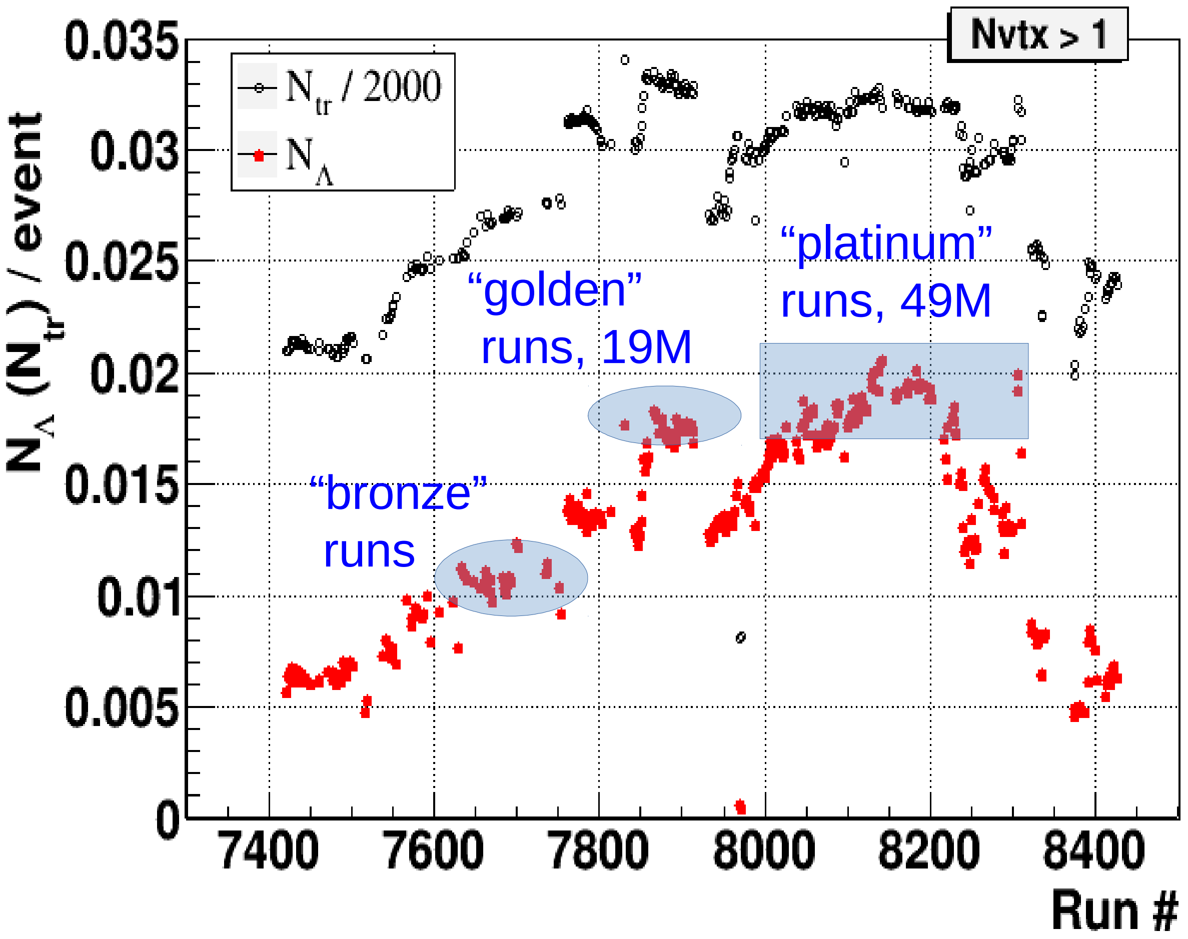


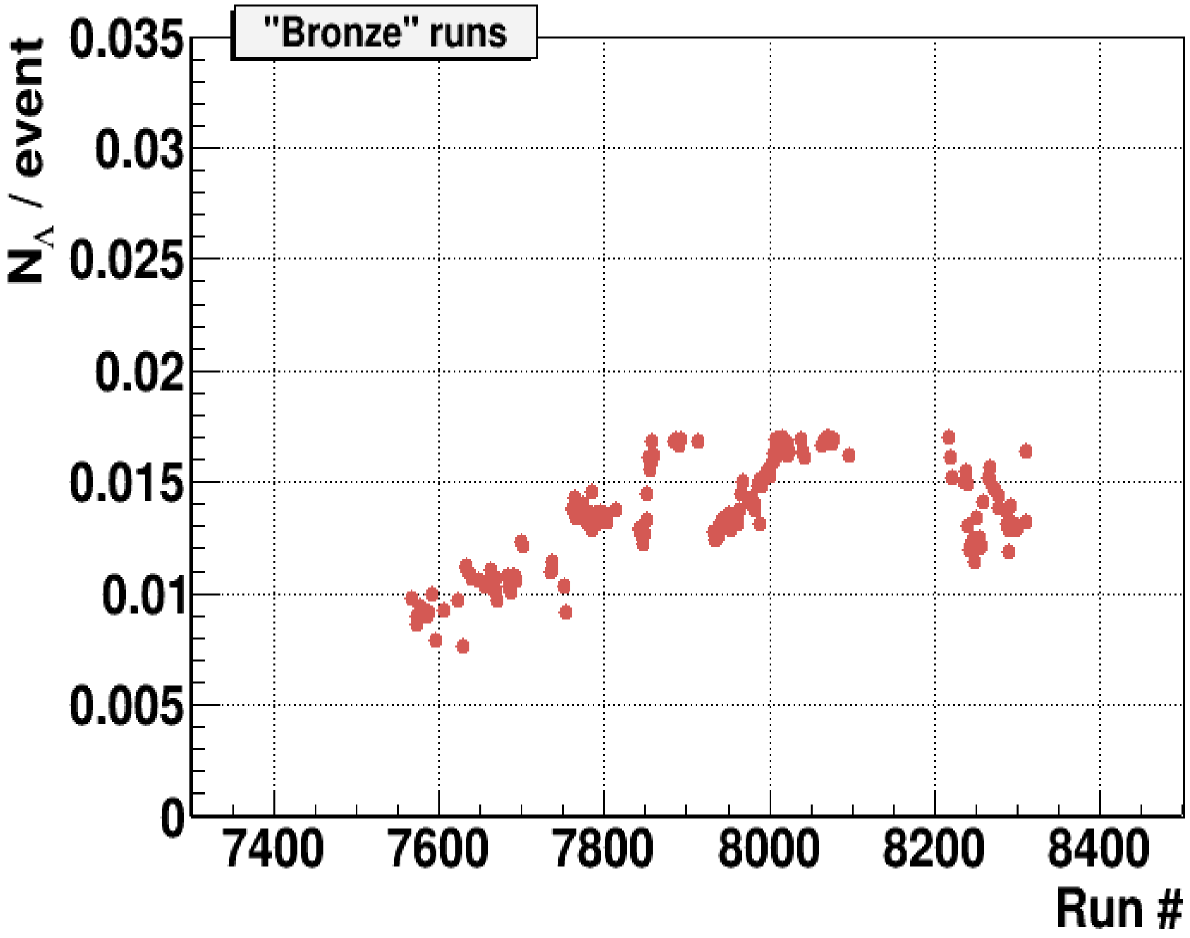






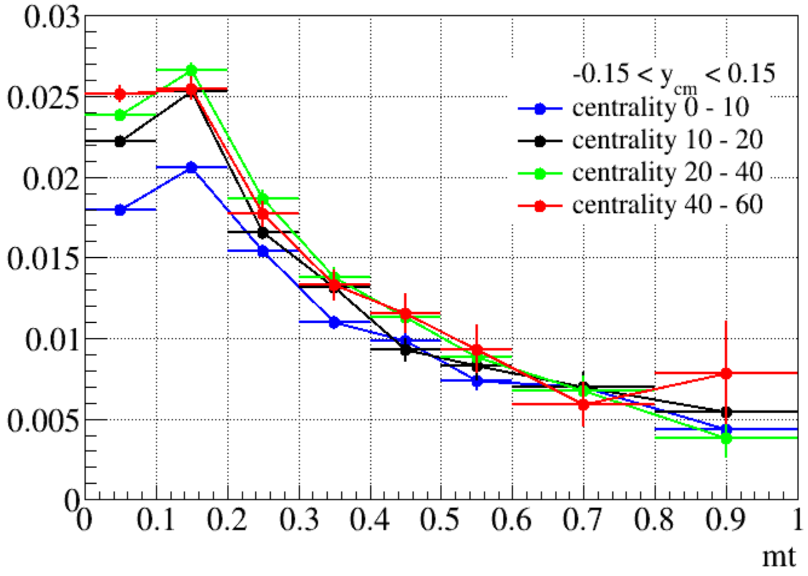
Steps towards physics analysis

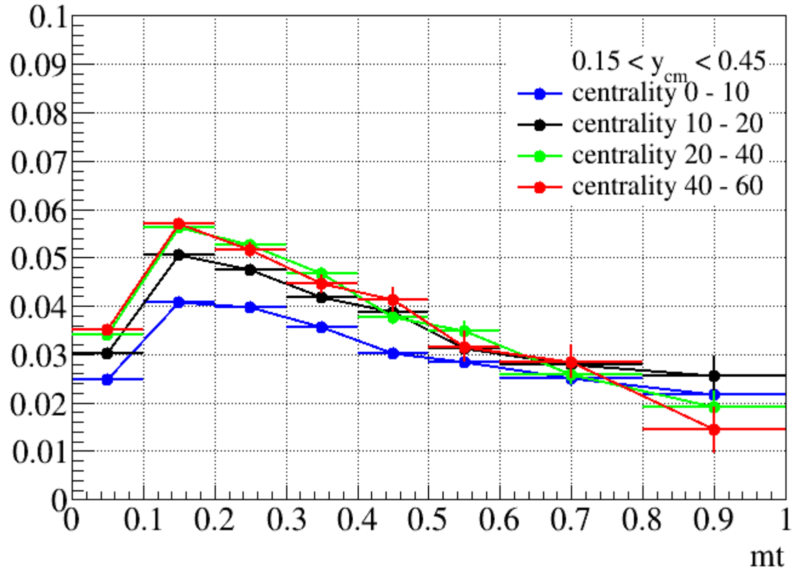


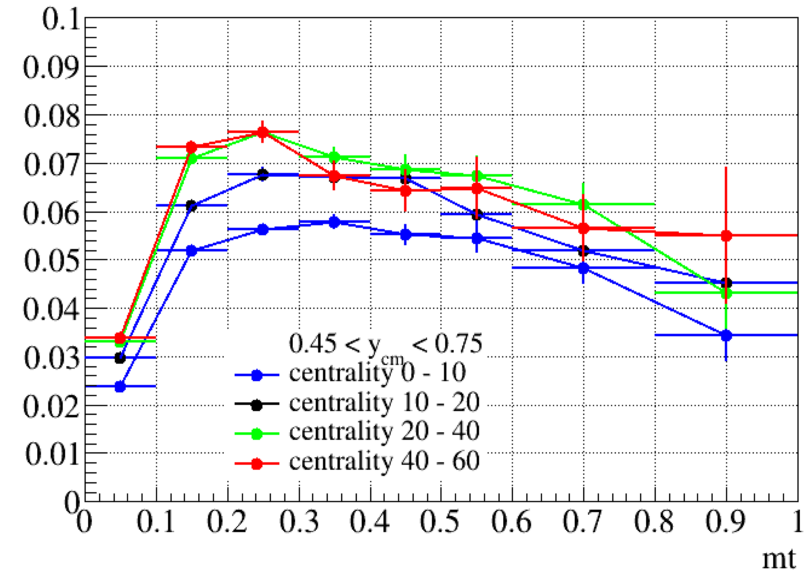


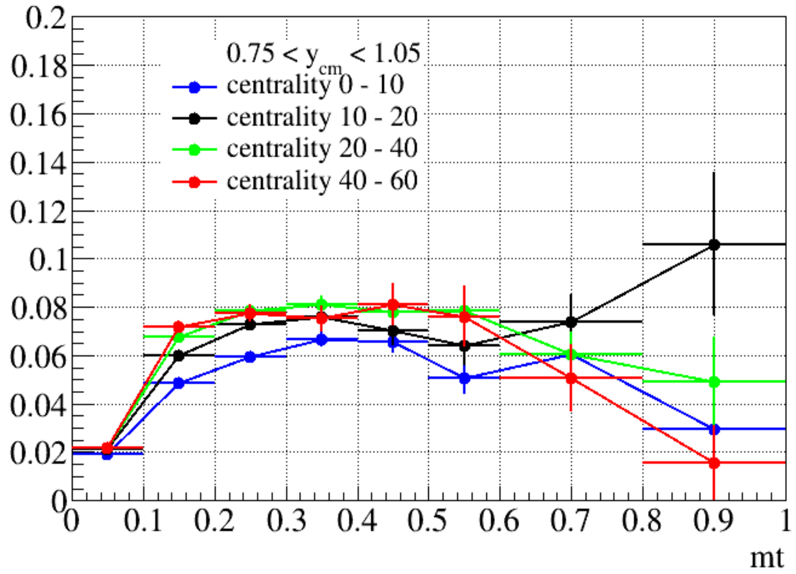
“Golden” and “platinum” runs: 100 runs with N_Λ/event > 0.017,
~68M events with reconstructed vertex (N_{vtx} >1)

Λ: efficiency (10M DCM-SMM)





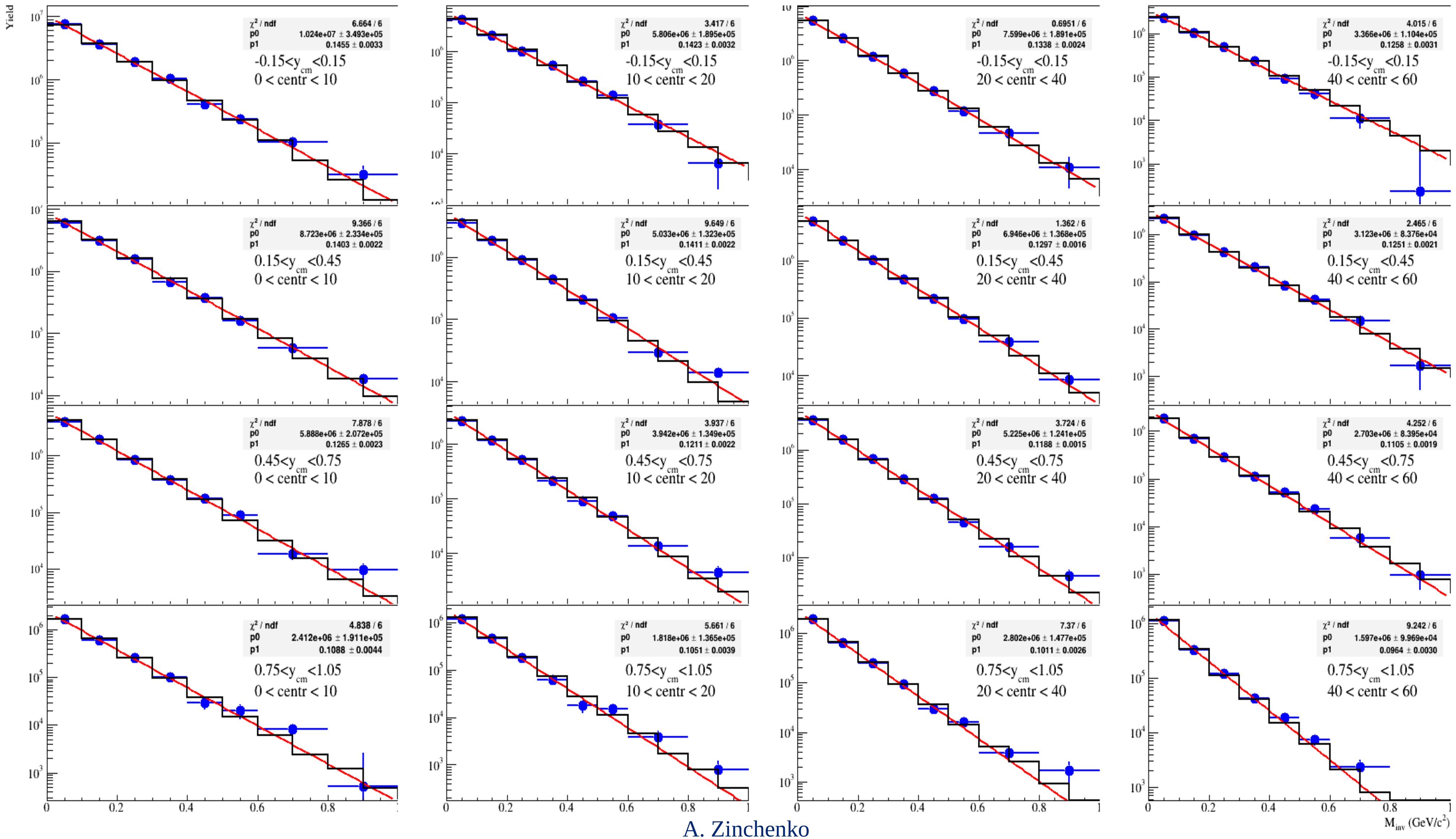




Λ: yield in *y* and centrality (Fitted MC - DCM-SMM)

Centrality →

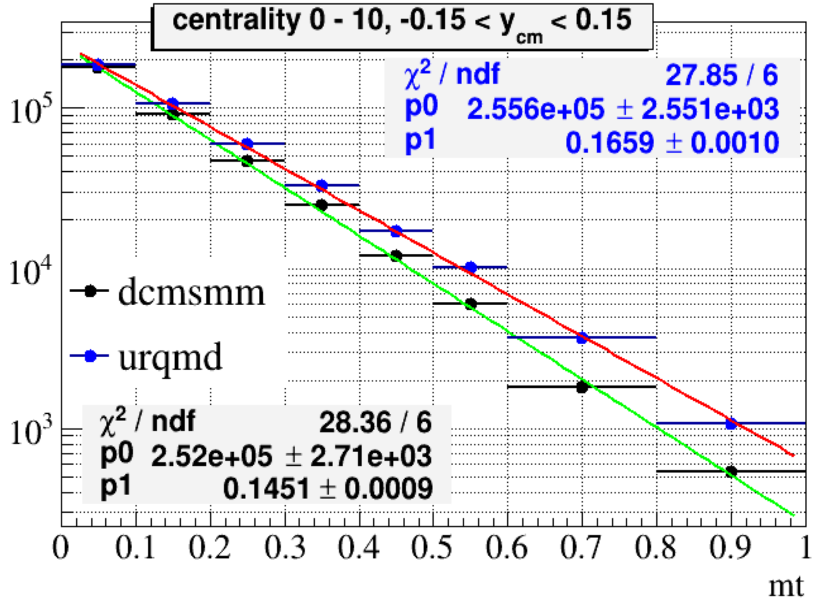
← Rapidity

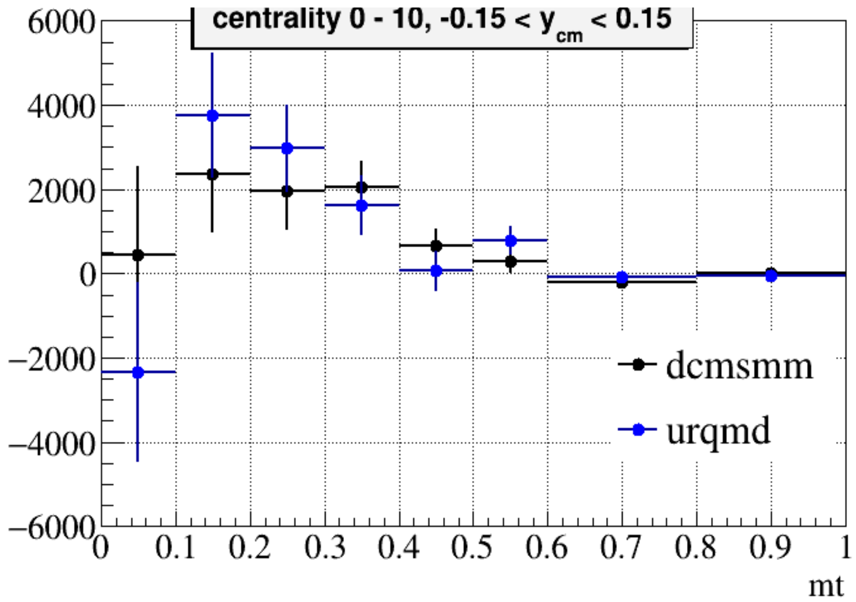


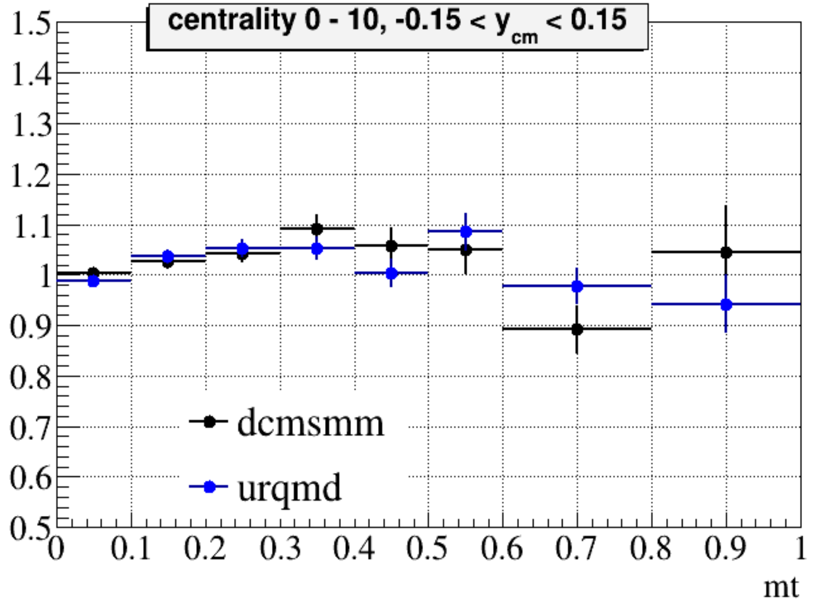
Λ: *dN/dy* and *Teff* vs *y* and centrality (MC)

DCM dN/dy reco / DCM dN/dy gen UrQMD *dN/dy* gen (tracks and *b0*) *Teff* DCM reco / *Teff* UrQMD gen)	Centrality 0 – 10%	Centrality 10 – 20%	Centrality 20 – 40%	Centrality 40 – 60%
$-0.15 < y_{cm} < 0.15$ Urqmd	2.41 +- 0.11 2.44 +- 0.01 2.72 +- 0.02 2.95 +- 0.01 0.146 +- 0.003 0.164 +- 0.001	1.53 +- 0.07 1.61 +- 0.01 1.61 +- 0.02 1.74 +- 0.01 0.142 +- 0.003 0.159 +- 0.001	0.88 +- 0.03 0.90 +- 0.01 0.82 +- 0.01 0.83 +- 0.01 0.134 +- 0.002 0.155 +- 0.001	0.36 +- 0.02 0.37 +- 0.01 0.27 +- 0.01 0.28 +- 0.01 0.126 +- 0.003 0.144 +- 0.001
$0.15 < y_{cm} < 0.45$	1.97 +- 0.06 2.06 +- 0.01 2.33 +- 0.02 0.140 +- 0.002 0.156 +- 0.001	1.31 +- 0.04 1.38 +- 0.01 1.42 +- 0.02 0.141 +- 0.002 0.154 +- 0.001	0.78 +- 0.02 0.79 +- 0.01 0.73 +- 0.01 0.130 +- 0.001 0.147 +- 0.001	0.33 +- 0.01 0.34 +- 0.01 0.25 +- 0.01 0.125 +- 0.001 0.137 +- 0.001
$0.45 < y_{cm} < 0.75$	1.17 +- 0.05 1.22 +- 0.01 1.52 +- 0.02 0.127 +- 0.002 0.140 +- 0.001	0.85 +- 0.03 0.89 +- 0.01 1.00 +- 0.02 0.121 +- 0.002 0.135 +- 0.001	0.52 +- 0.02 0.54 +- 0.01 0.55 +- 0.01 0.119 +- 0.002 0.129 +- 0.001	0.25 +- 0.01 0.25 +- 0.01 0.20 +- 0.01 0.111 +- 0.002 0.119 +- 0.001
$0.75 < y_{cm} < 1.05$	0.40 +- 0.04 0.42 +- 0.01 0.67 +- 0.01 0.109 +- 0.004 0.116 +- 0.001	0.33 +- 0.03 0.37 +- 0.01 0.53 +- 0.01 0.105 +- 0.004 0.106 +- 0.001	0.23 +- 0.02 0.25 +- 0.01 0.34 +- 0.01 0.101 +- 0.003 0.098 +- 0.001	0.12 +- 0.01 0.13 +- 0.01 0.15 +- 0.01 0.096 +- 0.003 0.086 =- 0.001

Λ: Boltzman fits of m_T spectra in MC

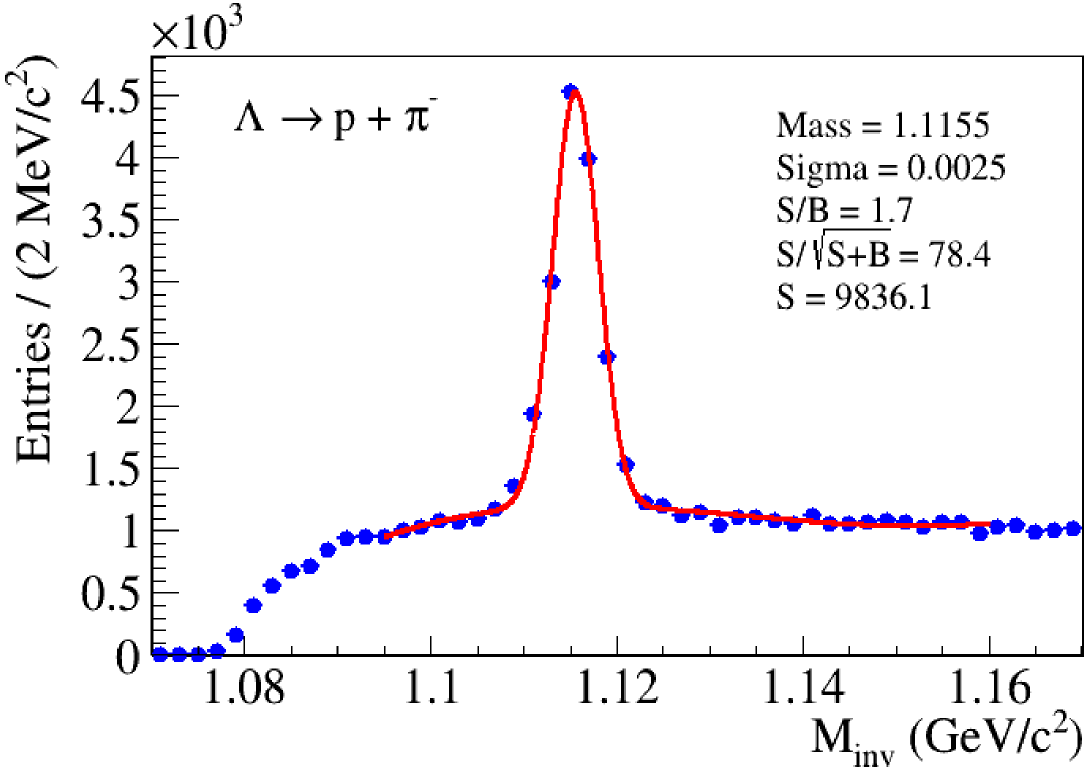




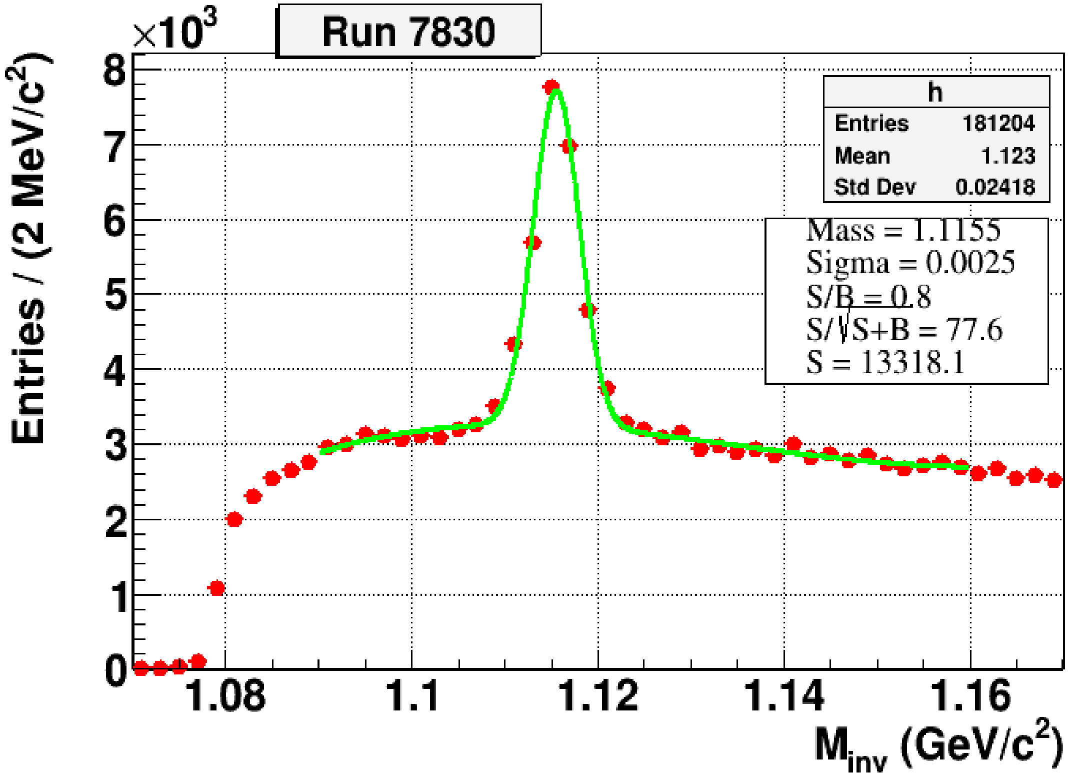


Soften the cuts to increase the signal

Run 7830



Maximum significance for all events

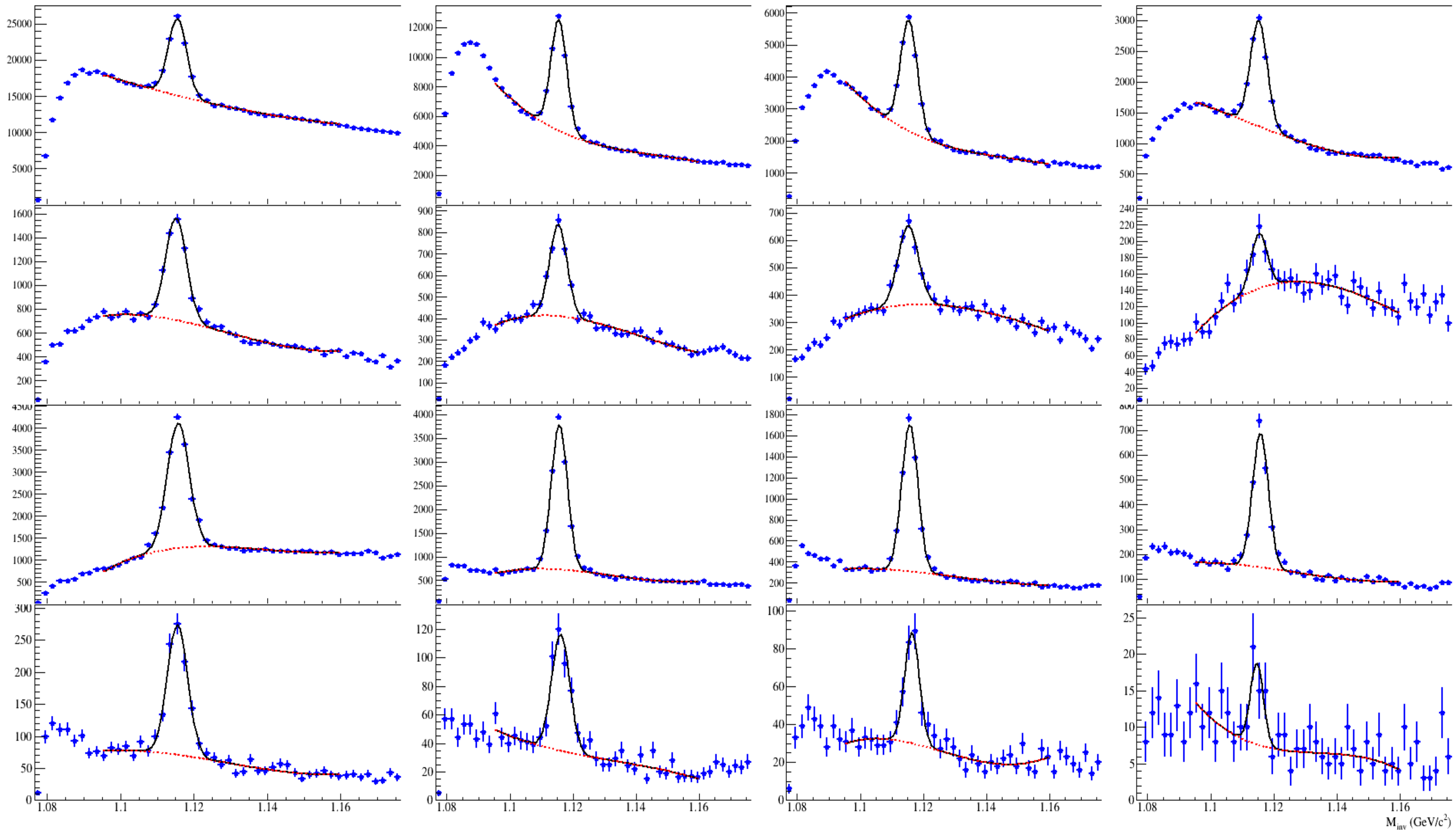


Maximum significance for 10-20% centrality

Λ: M_{inv} from exp. data (fitted background)

Centrality 0-10%,
y = -0.15 – 0.15,
8 m_T bins

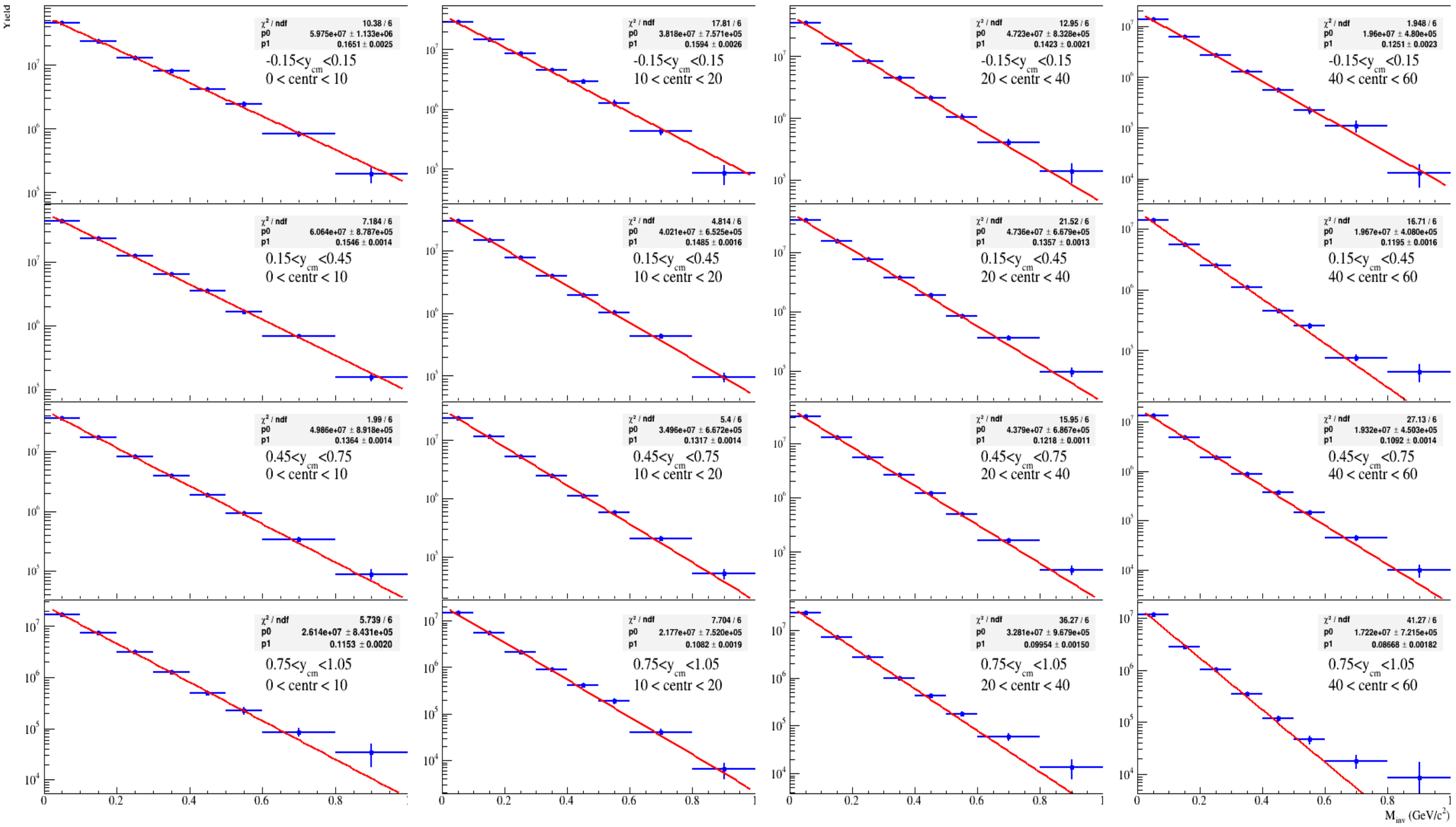
Centrality 40-60%,
y = 0.75 – 1.05,
8 m_T bins



Λ: yield in y (Fitted data)

Centrality →

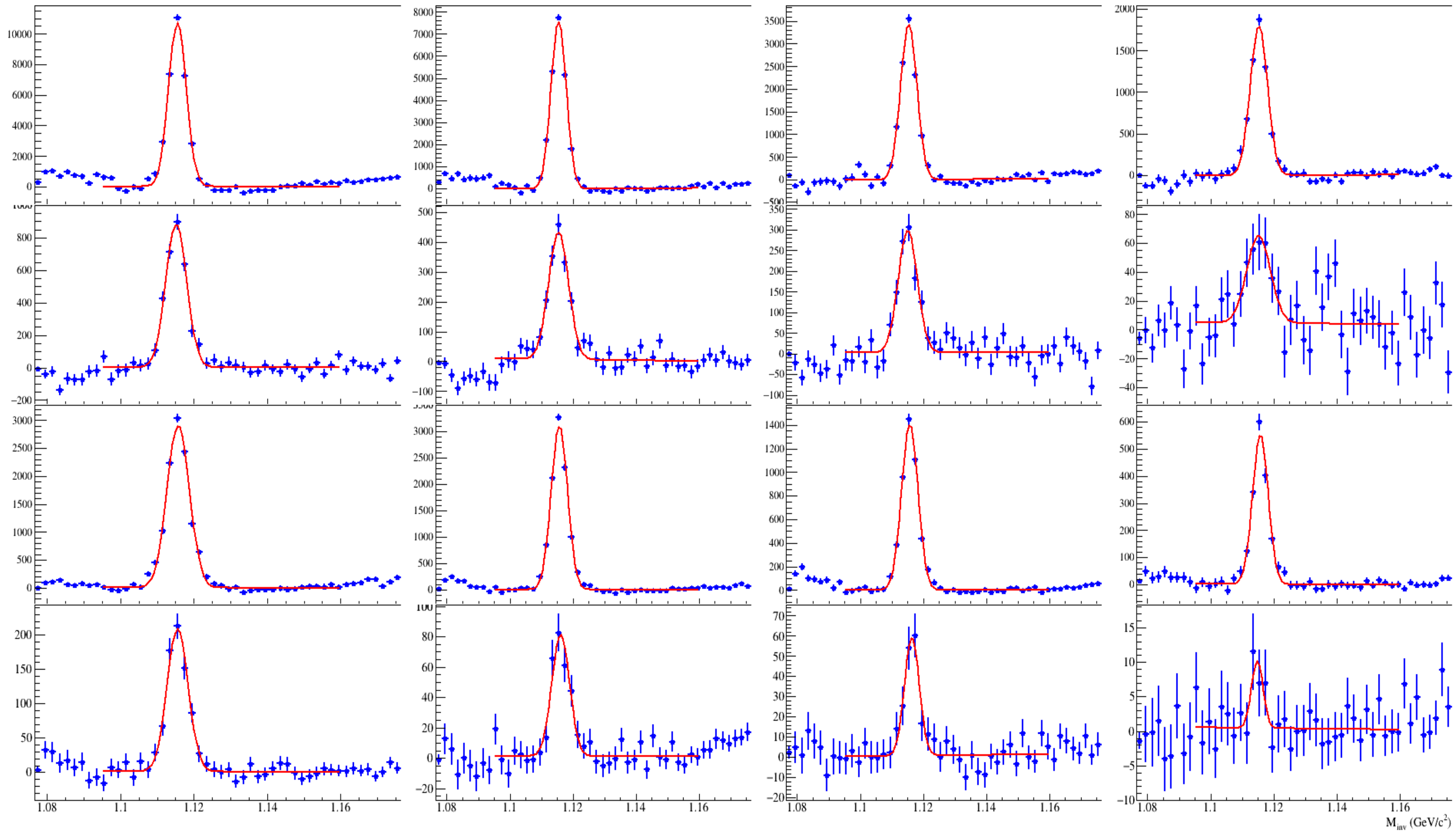
← Rapidity



Λ: M_{inv} from exp. data (mixed background)

Centrality 0-10%,
y = -0.15 – 0.15,
8 m_T bins

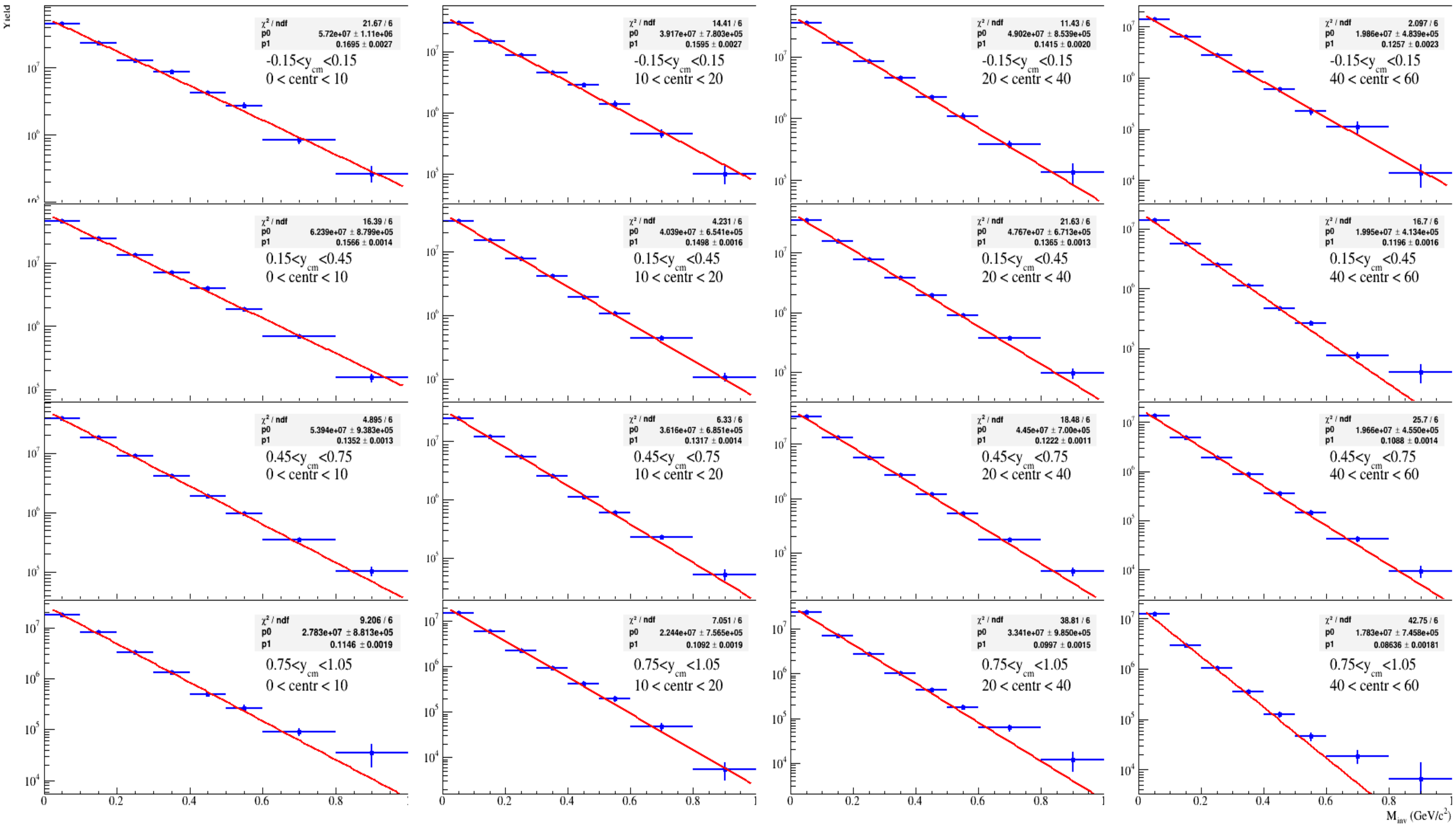
Centrality 40-60%,
y = 0.75 – 1.05,
8 m_T bins



Λ: yield in *y* (Mixed data)

Centrality →

← Rapidity



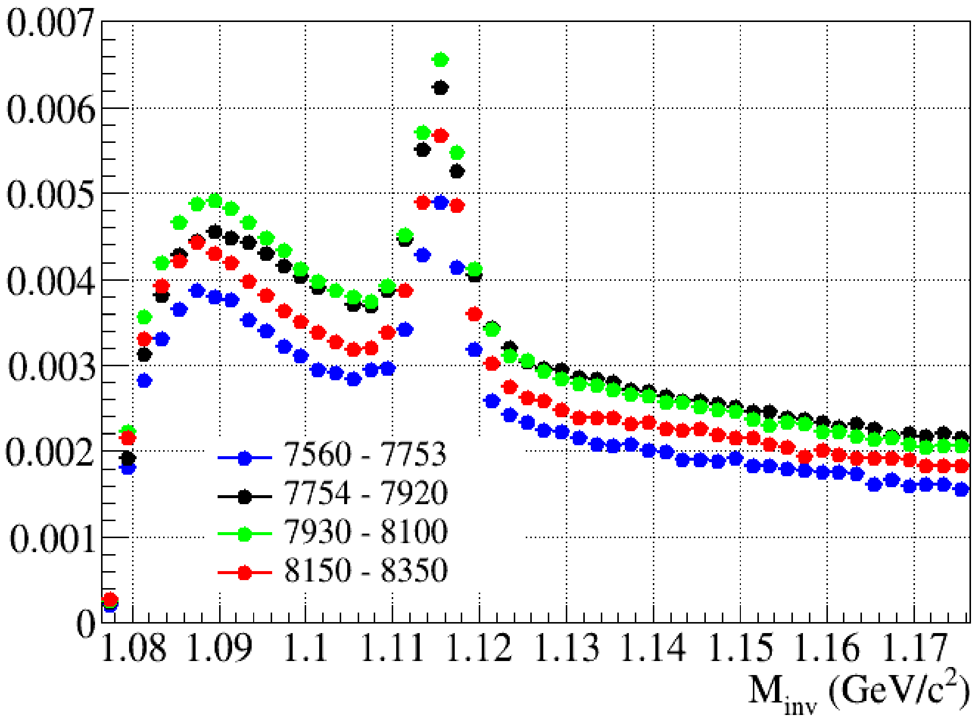
Λ: dN/dy and T_{eff} vs y and centrality (exp data)

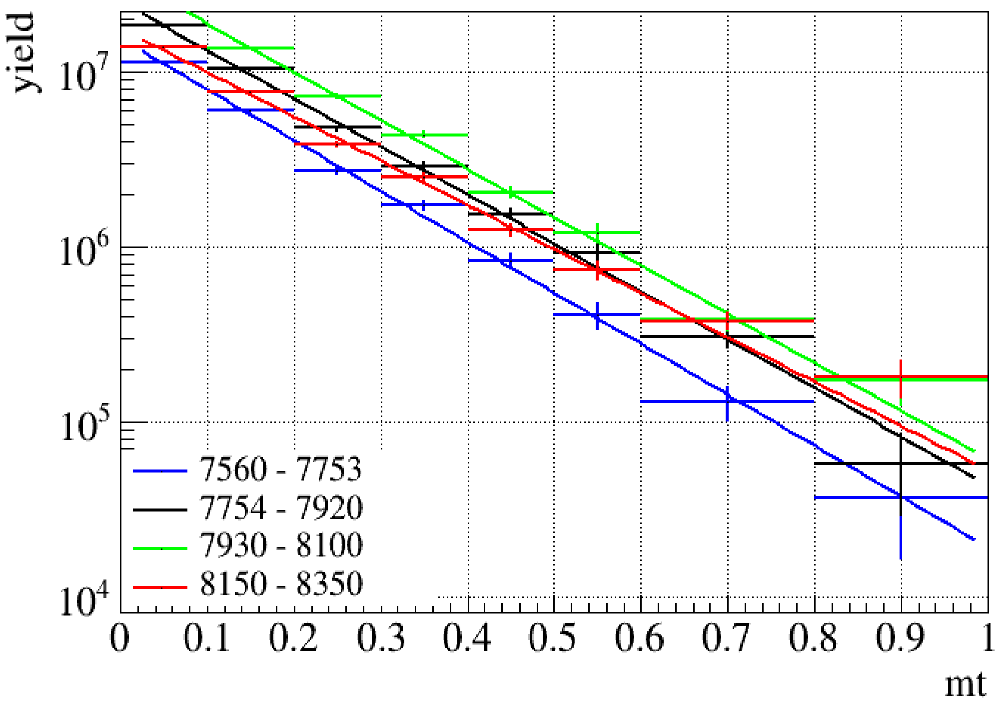
dN/dy and T_{eff} (fitted and mixed background)	Centrality 0 – 10%	Centrality 10 – 20%	Centrality 20 – 40%	Centrality 40 – 60%
$-0.15 < y_{cm} < 0.15$	2.38 ± 0.06 2.36 ± 0.07 0.165 ± 0.003 0.169 ± 0.003	1.47 ± 0.04 1.51 ± 0.04 0.159 ± 0.003 0.160 ± 0.003	0.72 ± 0.02 0.74 ± 0.02 0.142 ± 0.002 0.142 ± 0.002	0.27 ± 0.01 0.28 ± 0.01 0.125 ± 0.002 0.126 ± 0.002
$0.15 < y_{cm} < 0.45$	2.22 ± 0.04 2.32 ± 0.04 0.155 ± 0.001 0.157 ± 0.001	1.41 ± 0.03 1.43 ± 0.03 0.148 ± 0.001 0.150 ± 0.001	0.68 ± 0.01 0.69 ± 0.01 0.136 ± 0.001 0.137 ± 0.001	0.26 ± 0.01 0.26 ± 0.01 0.120 ± 0.001 0.120 ± 0.001
$0.45 < y_{cm} < 0.75$	1.56 ± 0.03 1.67 ± 0.04 0.136 ± 0.001 0.136 ± 0.001	1.06 ± 0.02 1.09 ± 0.03 0.132 ± 0.001 0.132 ± 0.001	0.55 ± 0.01 0.56 ± 0.01 0.122 ± 0.001 0.122 ± 0.001	0.23 ± 0.07 0.23 ± 0.06 0.109 ± 0.001 0.109 ± 0.001
$0.75 < y_{cm} < 1.05$	0.67 ± 0.03 0.70 ± 0.03 0.115 ± 0.002 0.115 ± 0.002	0.52 ± 0.02 0.54 ± 0.02 0.108 ± 0.002 0.109 ± 0.002	0.32 ± 0.01 0.34 ± 0.01 0.100 ± 0.002 0.100 ± 0.002	0.16 ± 0.01 0.16 ± 0.01 0.087 ± 0.002 0.086 ± 0.002

Λ: T_{eff} and dN/dy (exp data, 2 event samples N_{Λ} >< 0.018)

T_{eff} and dN/dy (<0.018 and >0.018)	Centrality 0 – 10%	Centrality 10 – 20%	Centrality 20 – 40%	Centrality 40 – 60%
$-0.15 < y_{cm} < 0.15$	0.166 ± 0.003 2.25 ± 0.08 0.166 ± 0.003 2.50 ± 0.08	0.159 ± 0.003 1.41 ± 0.05 0.161 ± 0.003 1.52 ± 0.05	0.141 ± 0.002 0.67 ± 0.02 0.144 ± 0.002 0.70 ± 0.02	0.126 ± 0.002 0.24 ± 0.01 0.124 ± 0.002 0.25 ± 0.01
$0.15 < y_{cm} < 0.45$	0.151 ± 0.002 2.15 ± 0.05 0.158 ± 0.002 2.32 ± 0.05	0.147 ± 0.002 1.37 ± 0.03 0.149 ± 0.002 1.44 ± 0.03	0.133 ± 0.002 0.63 ± 0.01 0.138 ± 0.002 0.67 ± 0.01	0.118 ± 0.002 0.23 ± 0.01 0.121 ± 0.002 0.24 ± 0.01
$0.45 < y_{cm} < 0.75$				
$0.75 < y_{cm} < 1.05$				

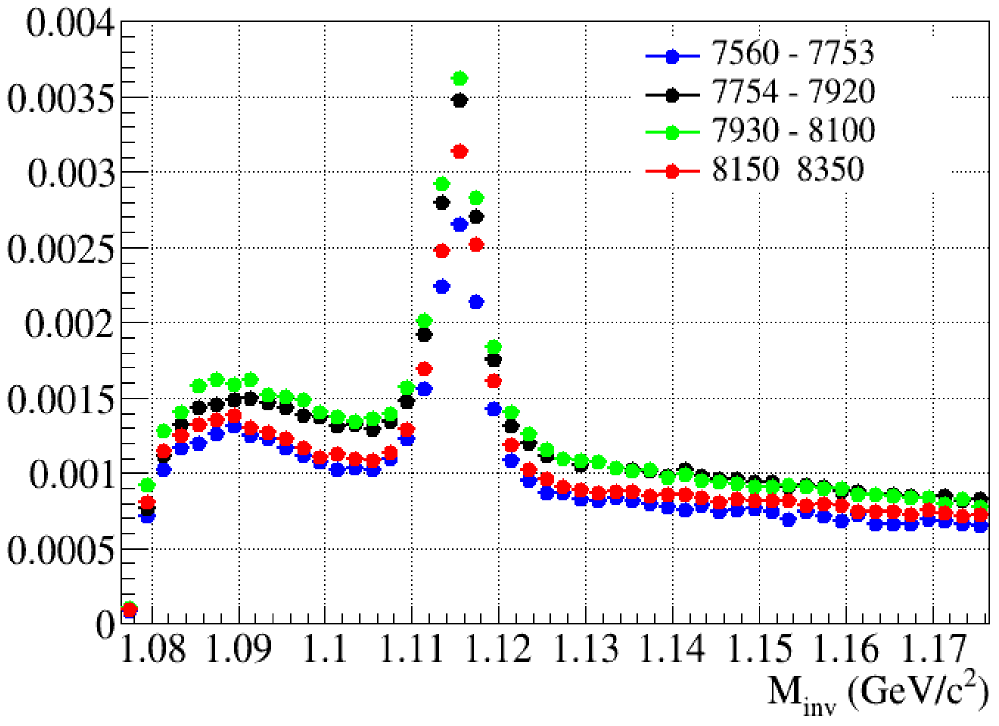
Λ: “bronze” runs (0 – 10%, y = -0.15 – 0.15)

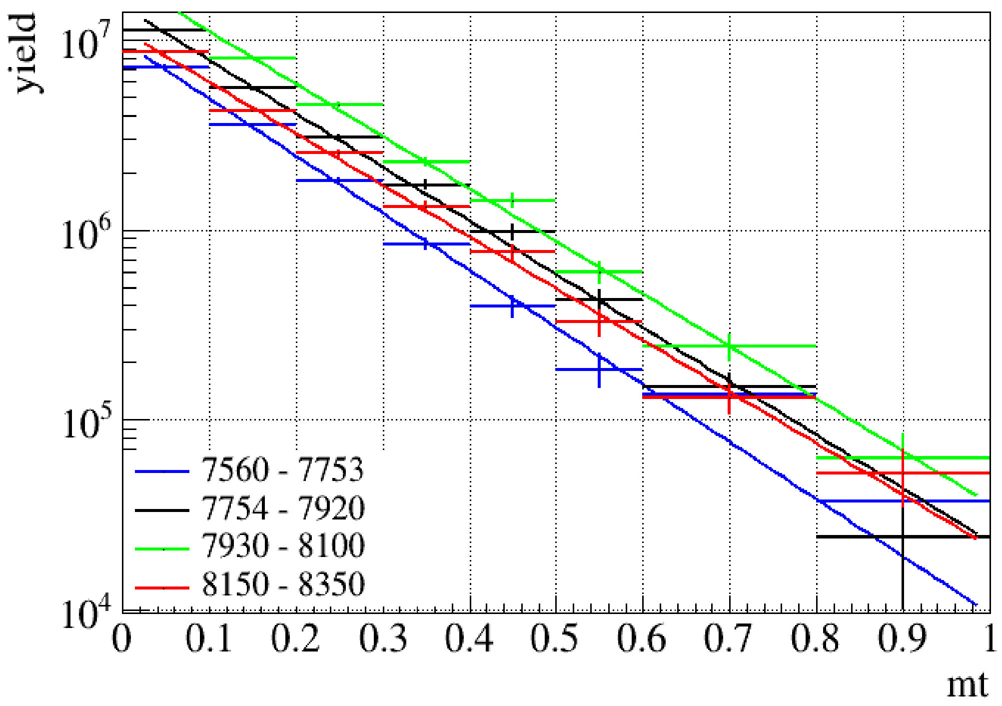




	7560 - 7753	7754 - 7920	7930 - 8100	8150 - 8350	Gold runs
T_{eff}	0.149 ± 0.003	0.157 ± 0.003	0.157 ± 0.002	0.172 ± 0.004	0.165 ± 0.003
d*N*/dy	1.50 ± 0.06	1.87 ± 0.07	2.06 ± 0.07	1.92 ± 0.08	2.38 ± 0.06

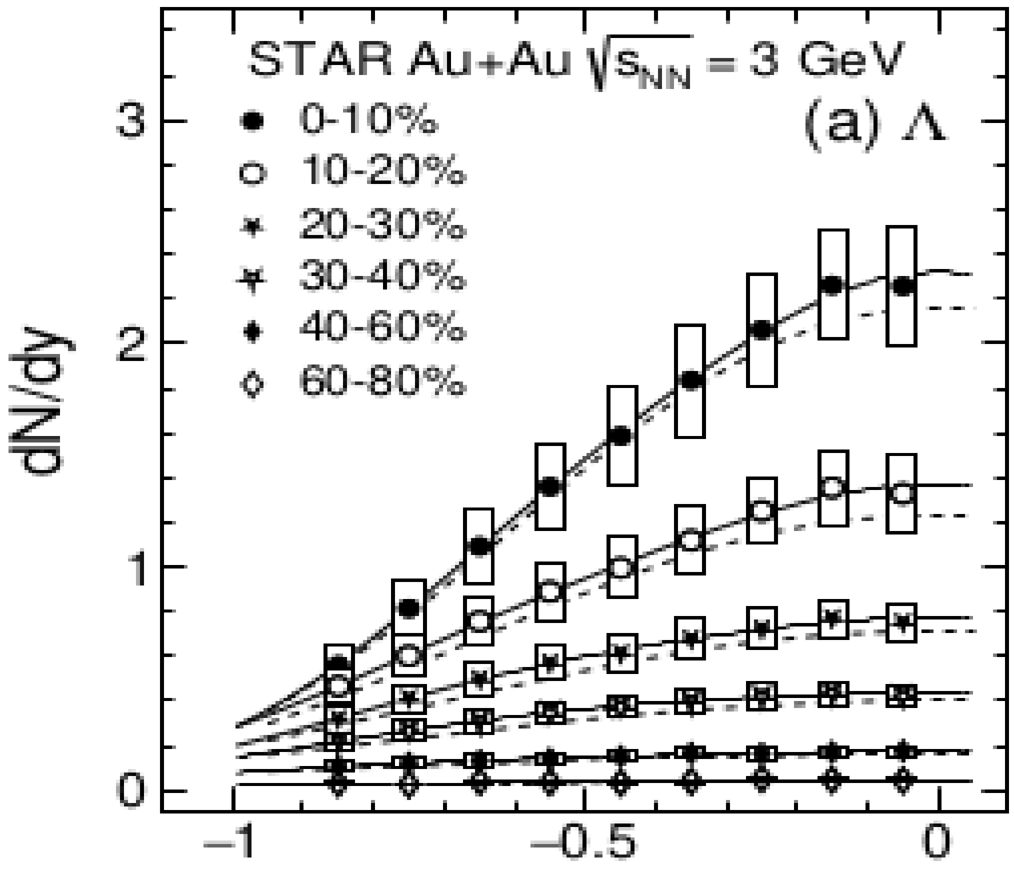
Λ: “bronze” runs (10 – 20%, y = -0.15 – 0.15)

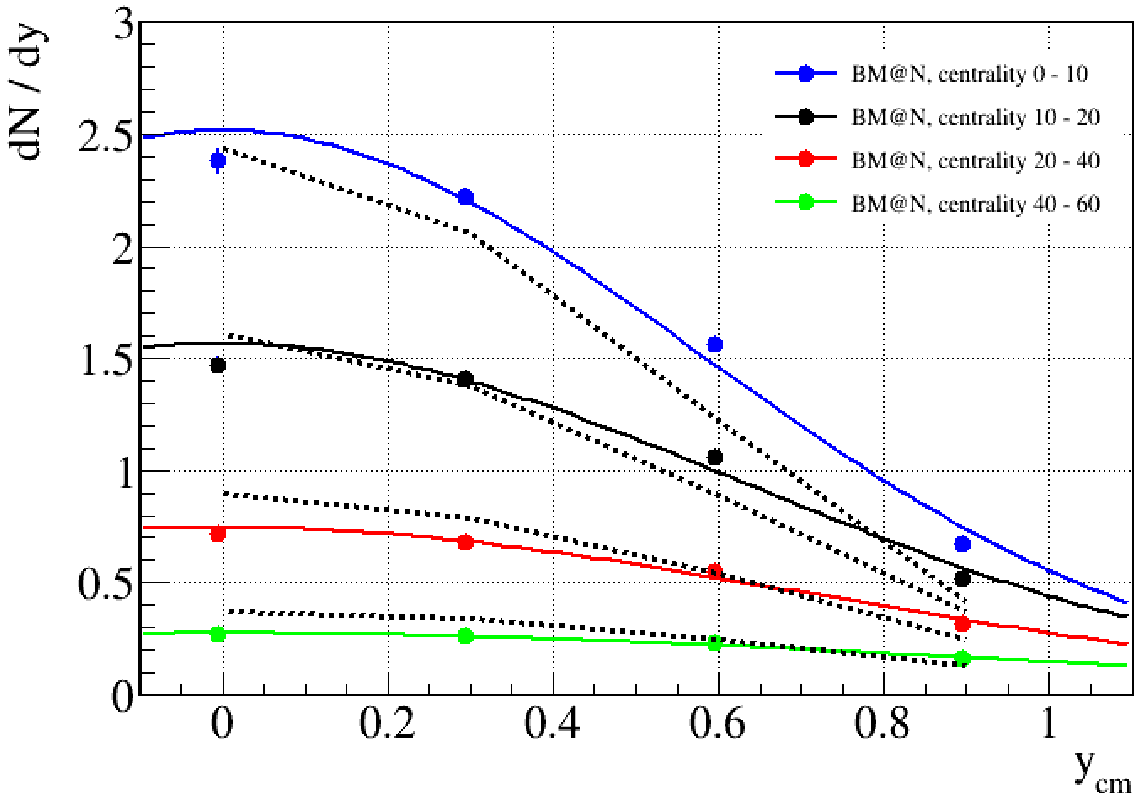




	7560 - 7753	7754 - 7920	7930 - 8100	8150 - 8350	Gold runs
T_{eff}	0.144 ± 0.003	0.154 ± 0.003	0.157 ± 0.003	0.160 ± 0.004	0.159 ± 0.003
d*N*/dy	0.94 ± 0.04	1.16 ± 0.04	1.24 ± 0.04	1.16 ± 0.04	1.47 ± 0.04

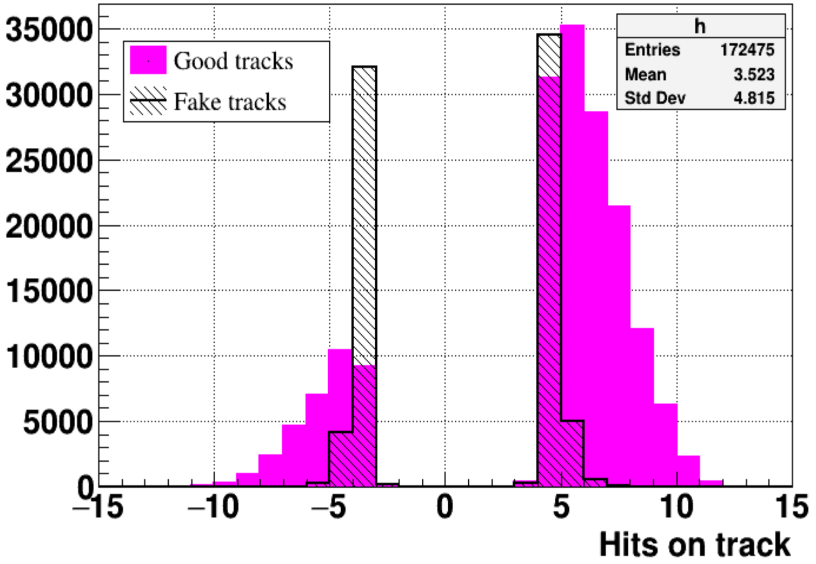
Λ: rapidity spectra

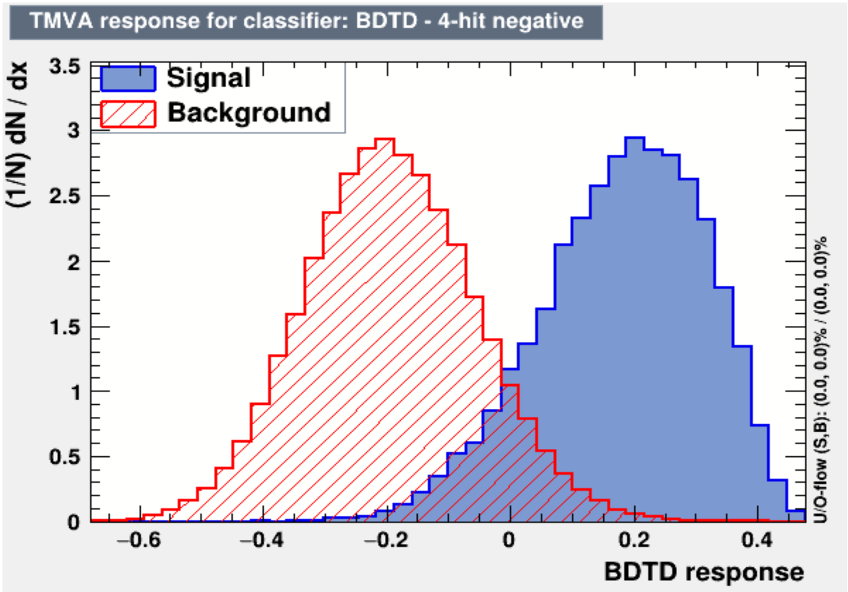


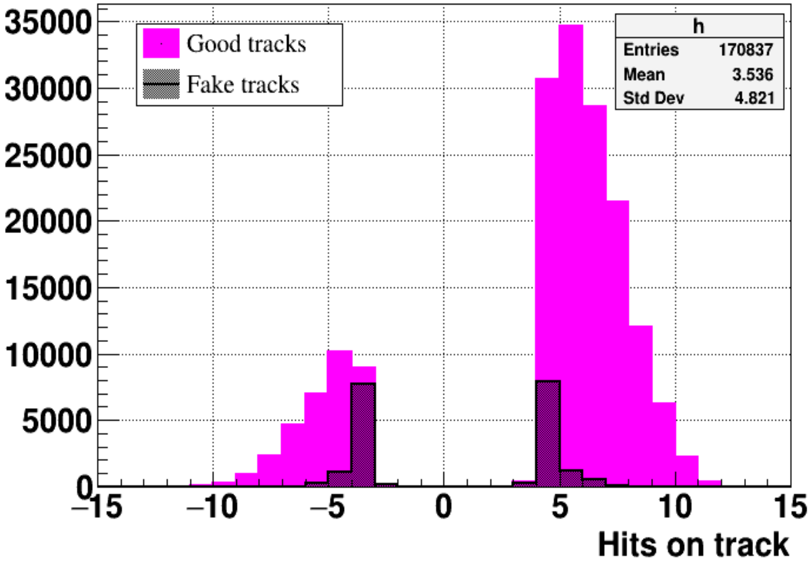


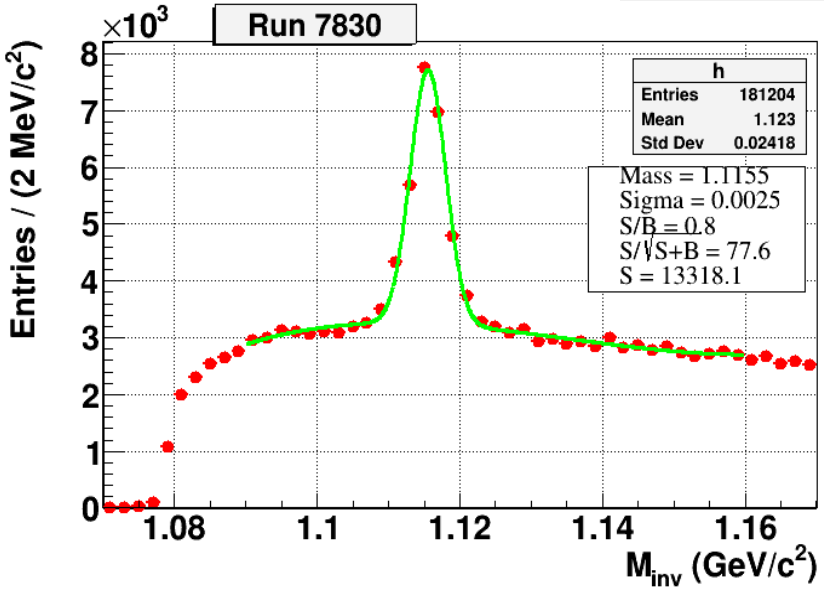
Towards better reconstruction

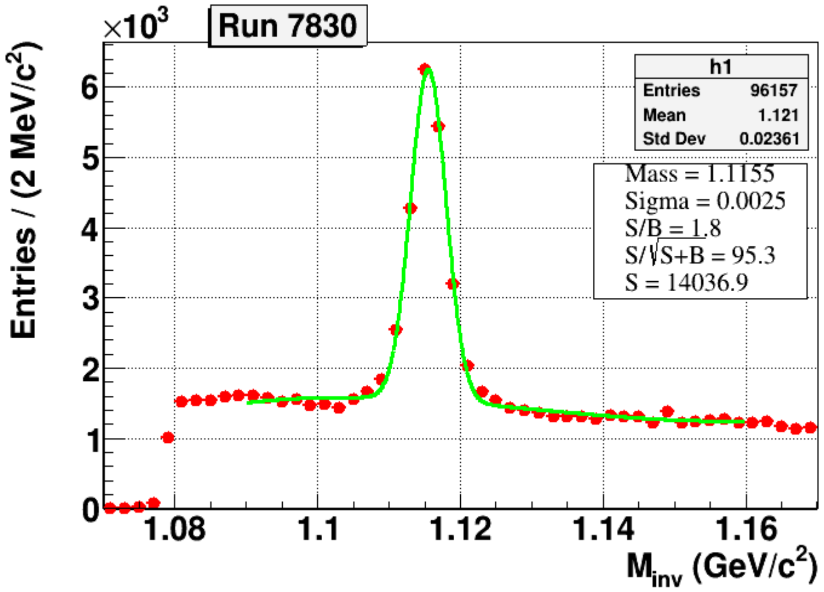
Using TMVA for good / fake track discrimination





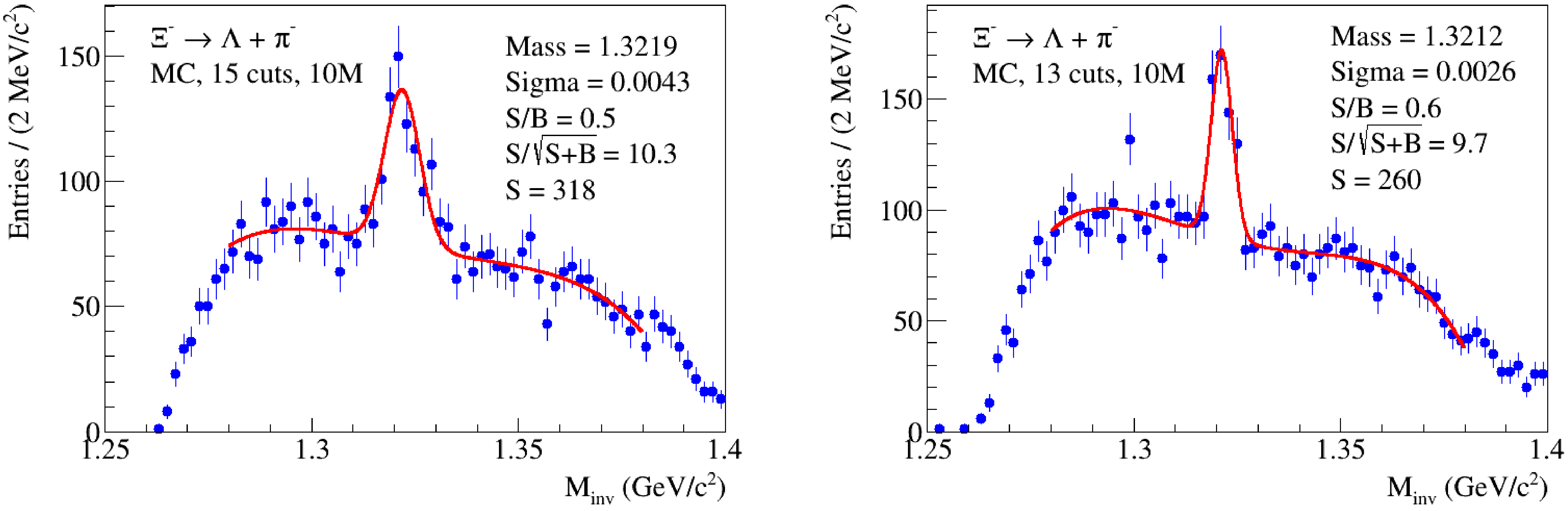




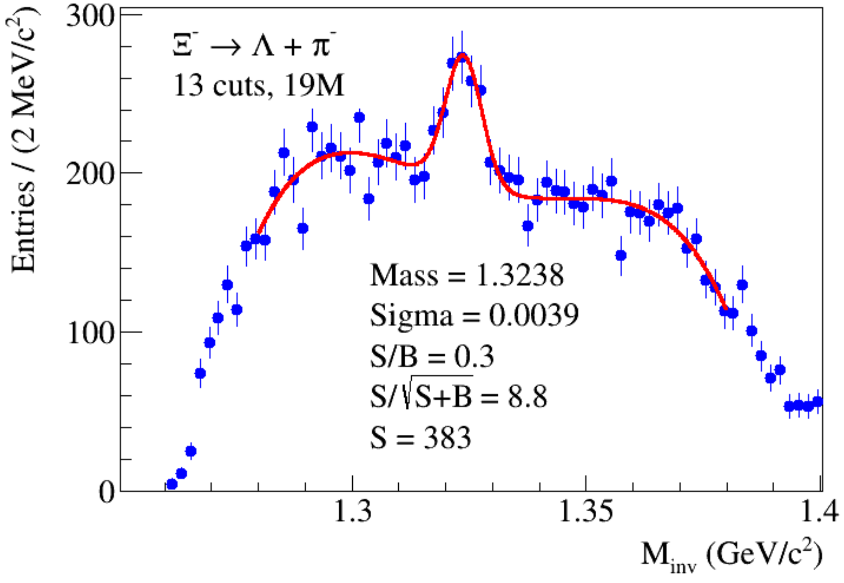


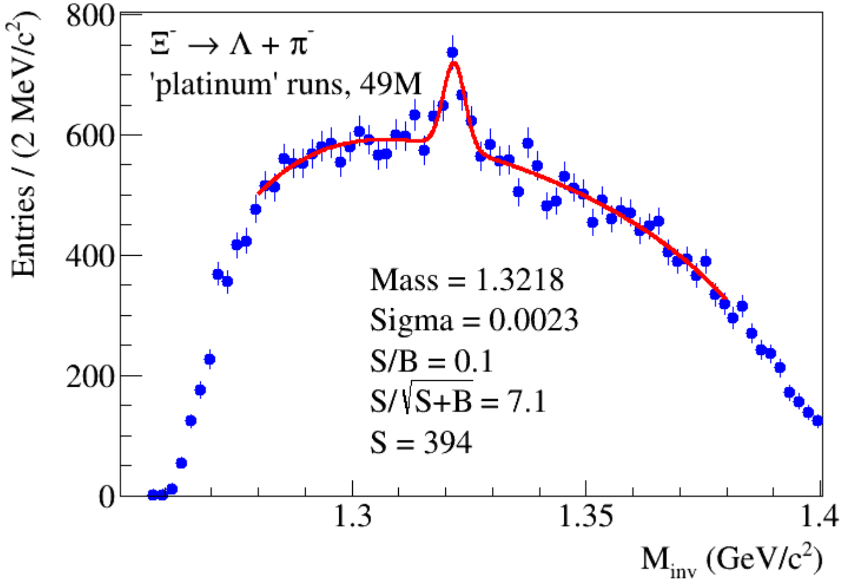
Ξ^- MC: 15 cuts vs 13 cuts

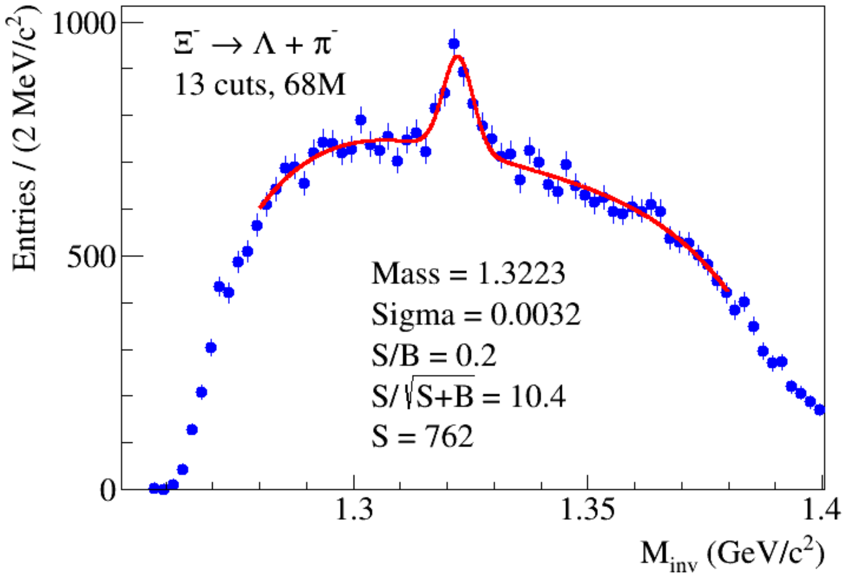
Generator: DCM-SMM, 10M events



Ξ^- : “golden&&platinum&&bronze” runs





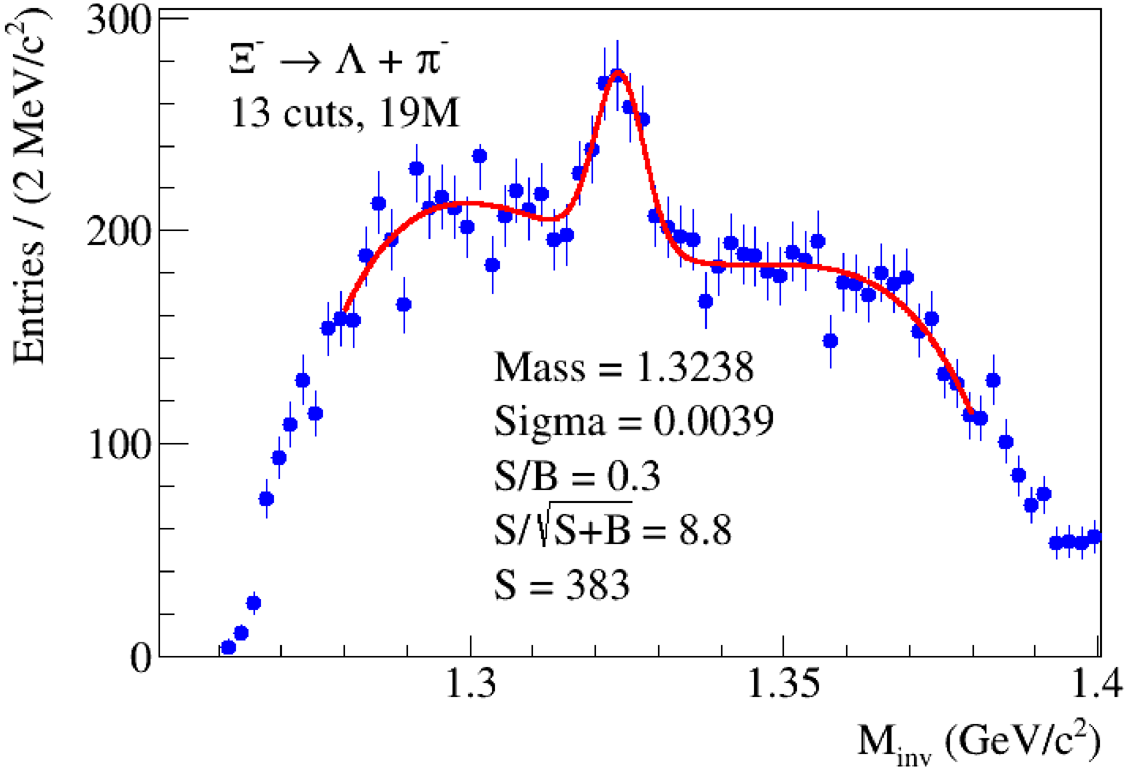


“Golden” runs, 19M

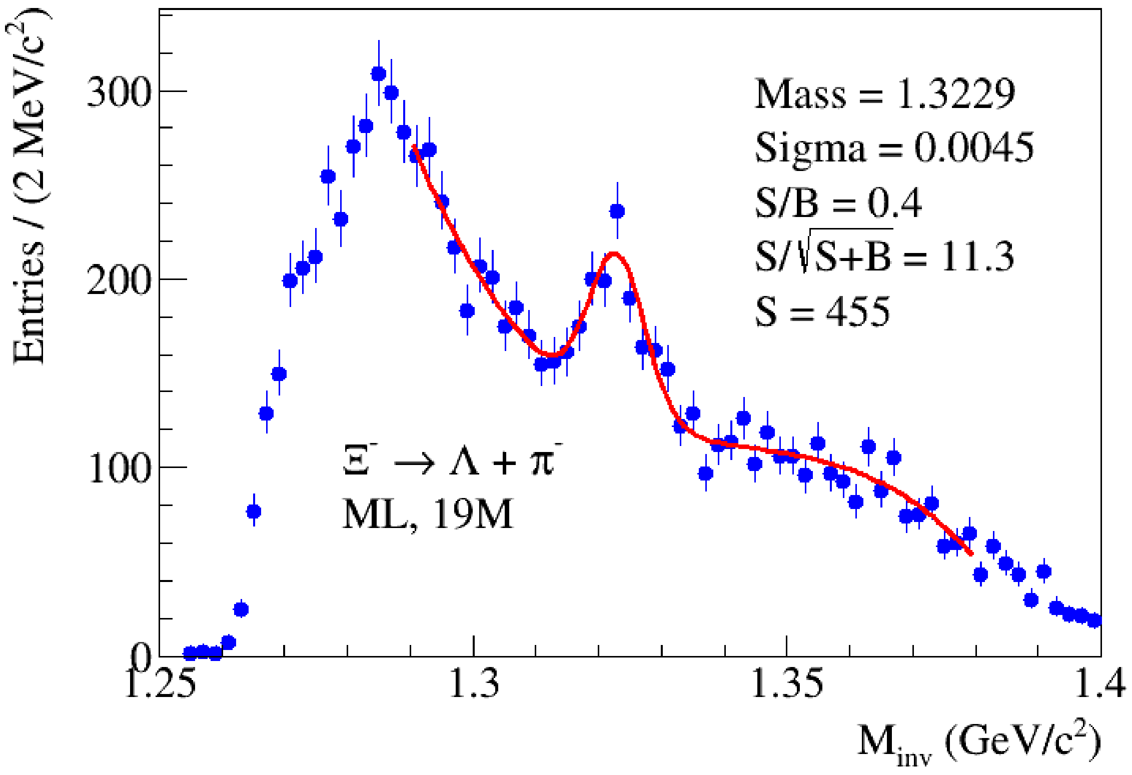
“Platinum” runs, 49M

“Golden” + “platinum” runs, 68M

Ξ^- : “golden” runs (19M)



W/o good / fake track discrimination



Using TMVA-BDTD for good / fake track discrimination

Summary and next steps

Summary

1. 10 mln. events of DCM-SMM have been produced – more simulated lambdas are needed to extract efficiencies.
2. 100 runs of experimental data with N_{Λ}/event > 0.017, ~60 mln. events with reconstructed vertex (N_{vtx} > 1) have been processed to obtain lambda mT spectra for 4 rapidity intervals and 4 centralitiies.
3. Some systematic effects were checked.
4. Procedures to produce physics distributions are available and tested.
5. Some steps toward reconstruction improvement were tested.

Next steps

1. Start writing the analysis note to facilitate the analysis process.
2. Do better evaluation of systematics (how to handle lambda yield variation in groups of runs – golden, platinum, bronze).
3. Perform some additional checks towards reconstruction improvement.

Backup slides

Detector (tracking) efficiency

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Strangeness production in $\sqrt{s_{\mathrm{NN}}} = 3$ GeV Au+Au collisions at RHIC

The STAR collaboration

Source	Λ	K_S^0
Topological cuts	0.7 – 3.4%	1.1 – 3.1%
Track selection	0.1 – 0.5%	0.6 – 4.6%
Tracking efficiency	10%	10%
Signal extraction	0.4 – 0.8%	0.1 – 0.7%
Extrapolation	3.6 – 11%	0.2 – 1.6%
Feed-down correction	0.4 – 0.8%	N/A
Total	10.8 – 15.3%	10.2 – 11.6%

Table 1. Summary of systematic uncertainties for the Λ and K_S^0 dN/dy measurements in 0-10% Au+Au collisions at $\sqrt{s_{\mathrm{NN}}} = 3.0$ GeV. The ranges indicate the variation of the systematic uncertainty among rapidity bins.