Status of Study of Λ-p Azimuthal Correlations with respect to the Participant Plane in Search for CVE at RHIC/STAR

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Supported in part by:

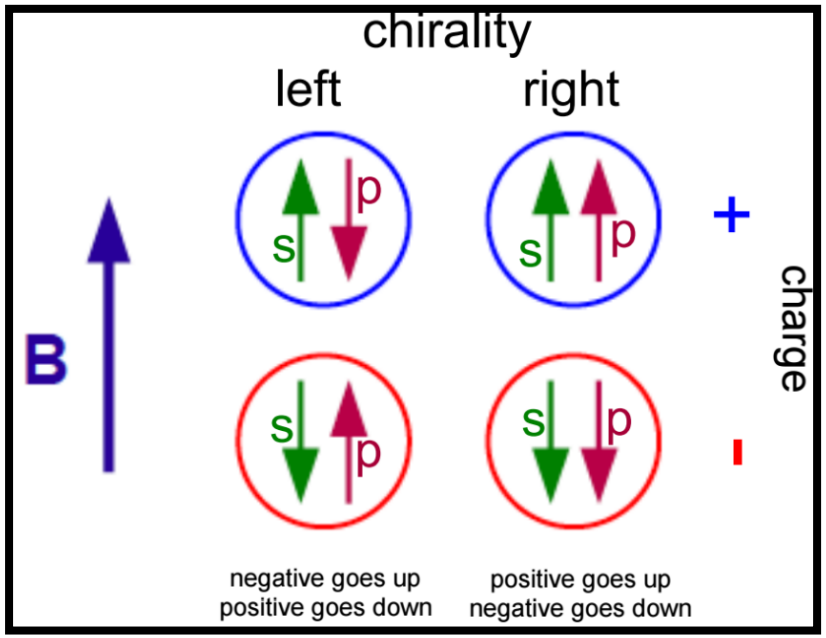
Content

- What is CME/CVE and How do we Observe it?
- Method
  - Reconstruction of Lambda
  - Purity & Efficiency Corrections
  - Checks
- AMPT Results
- Summary

Chiral Magnetic Effect

- Magnetic Field + Chirality Imbalance = Current

spin alignment in B-field:
opposite directions for opposite charges



courtesy of P.Sorensen

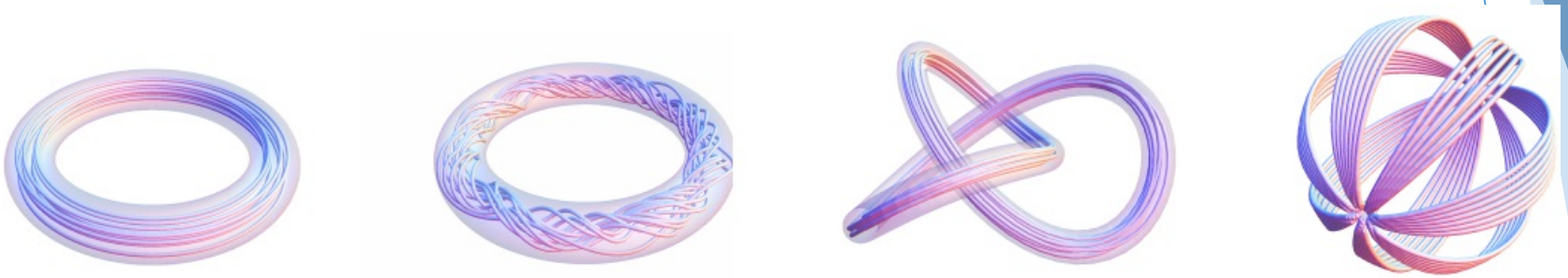
handedness:
momentum and spin, aligned or anti-aligned

- An excess of right or left handed quarks lead to a current flow along the magnetic field.

$$\vec{J} = \frac{e^2}{2\pi^2}\,\mu_5\,\vec{B}$$

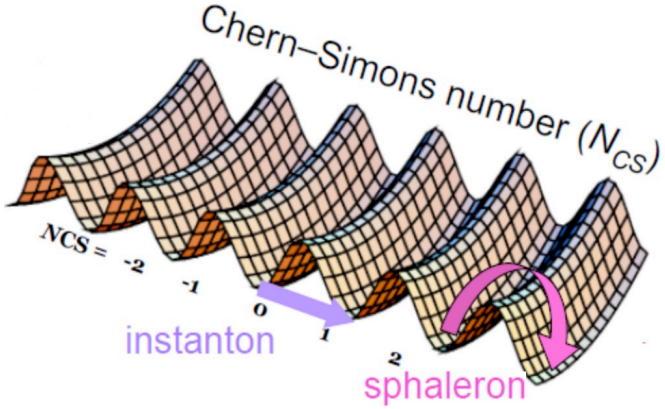
CME – Related to Intrinsic Property of QCD

- Strong B Field and Exotic Effects



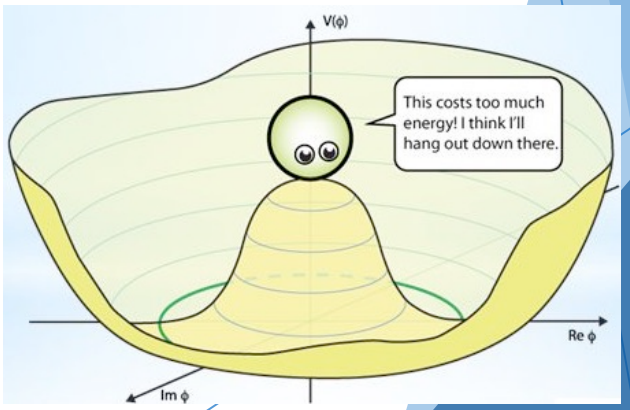
Y. Hirono, D. E. Kharzeev and Y. Yin PRD 92,125031 (2015)

- Vacuum Transitions

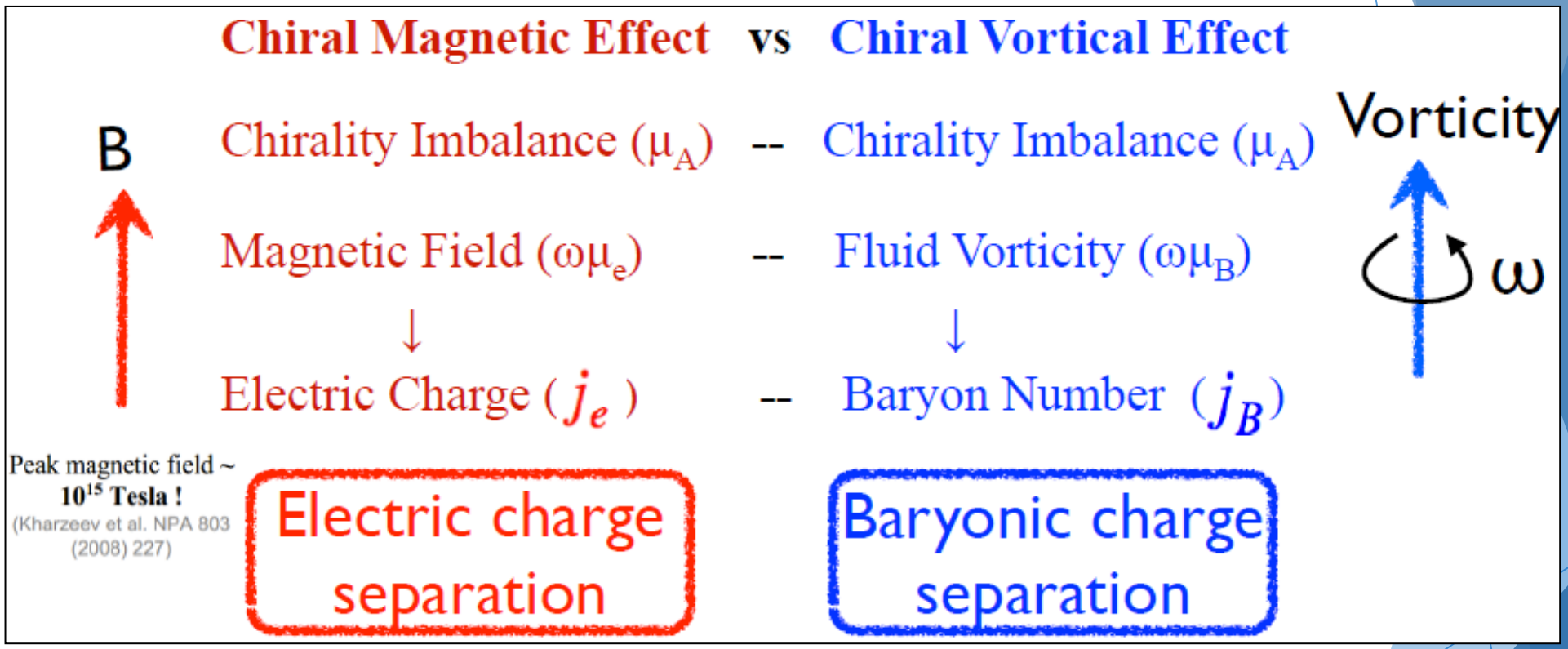


D. Diakonov, Prog. Part. Nucl. Phys. 51, 173 (2003)

Chiral Symmetry Restoration



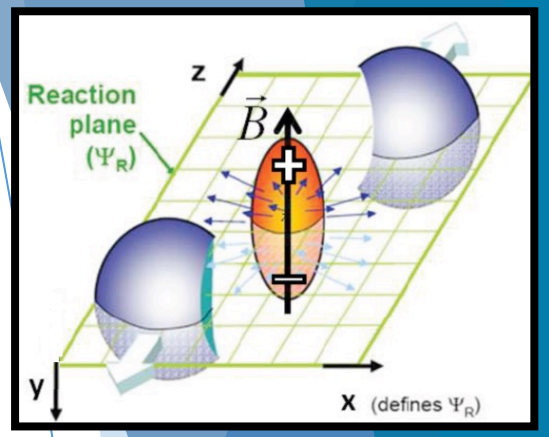
Chiral Vortical Effect



D. Kharzeev, D. T. Son, PRL 106 (2011) 062301

- Measure Λ-p± correlation to search for CVE

CME/CVE Observable: γ Correlator



$$\frac{dN_\alpha}{d\phi} \propto 1 + 2v_{1,\alpha}\cos(\Delta\phi) + 2v_{2,\alpha}\cos(2\Delta\phi) + \cdots$$

$$+ 2a_{1,\alpha}\sin(\Delta\phi) + 2a_{2,\alpha}\sin(2\Delta\phi) + \cdots$$

$\Delta\phi = \phi - \Psi_{RP}$

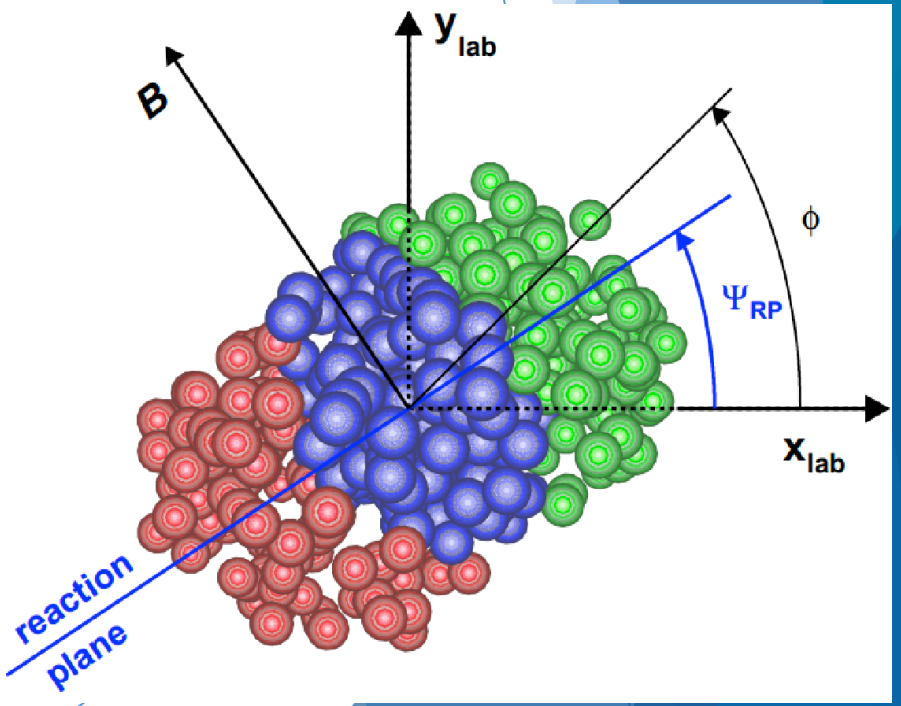
$$\gamma_{112} = \langle \cos(\phi_\alpha + \phi_\beta - 2\psi_{RP}) \rangle$$
$$= \left[\langle v_{1,\alpha} v_{1,\beta} \rangle + B_{in}\right] - \left[\langle a_\alpha a_\beta \rangle + B_{out}\right]$$

S. Voloshin, PRC 70 (2004) 057901

$$\gamma_{132} = \langle \cos(\phi_\alpha - 3\phi_\beta + 2\Psi_{RP}) \rangle$$

Basic Information for Analysis

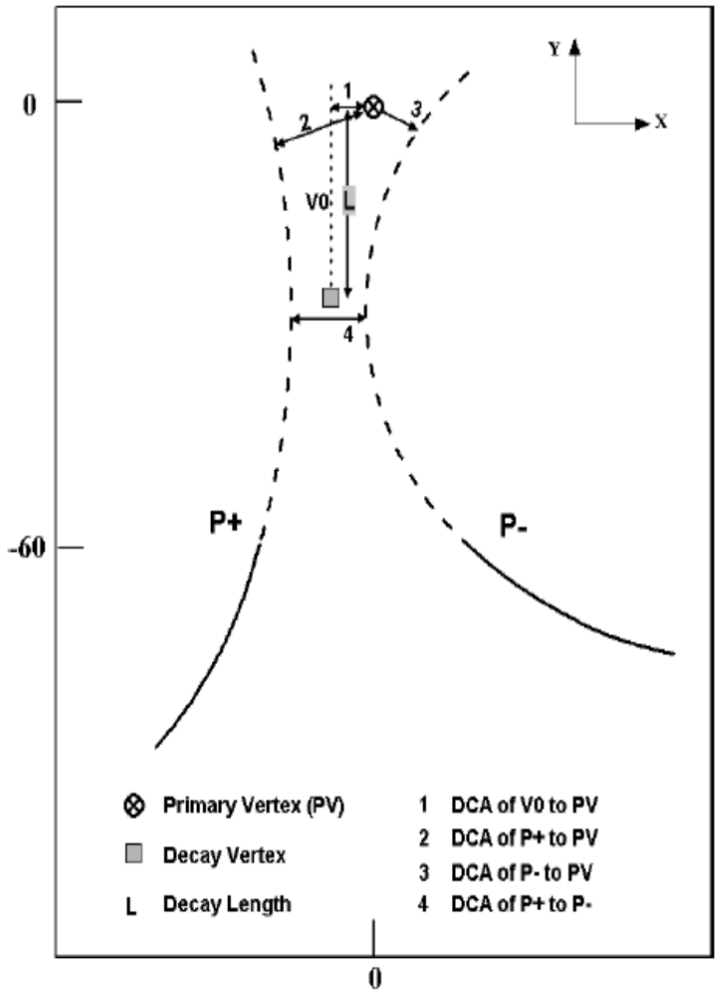
- Data Set: Au+Au at $\sqrt{s_{NN}}$ = 27 GeV from 2018
- Main Detector Used: STAR Time Projection Chamber (TPC)
  - Centrality Selection – Glauber Model
  - Event Plane Measurement
    - EtaSub Method (for v_2): Eta Range - $0.1 < |\eta| < 1.0$
  - Identify Proton and Pion Tracks



E877, Phys.Rev. C56 (1997) 3254

Λ / $\bar{\Lambda}$ Reconstruction

- Protons and Pions Identification
- Topological Cuts to Reconstruct Lambdas



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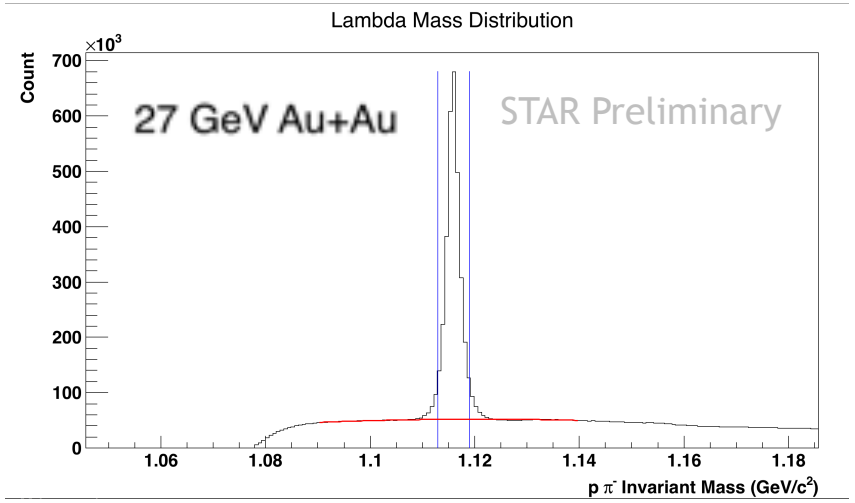
Purity & Efficiency Corrections

- Purity Corrections: Use Polynomial Fit to Model Backgrounds for Λ / $\bar{\Lambda}$ Reconstruction



Note: Blue lines are the mass cuts for Lambda;
Red Line is the Background Fit

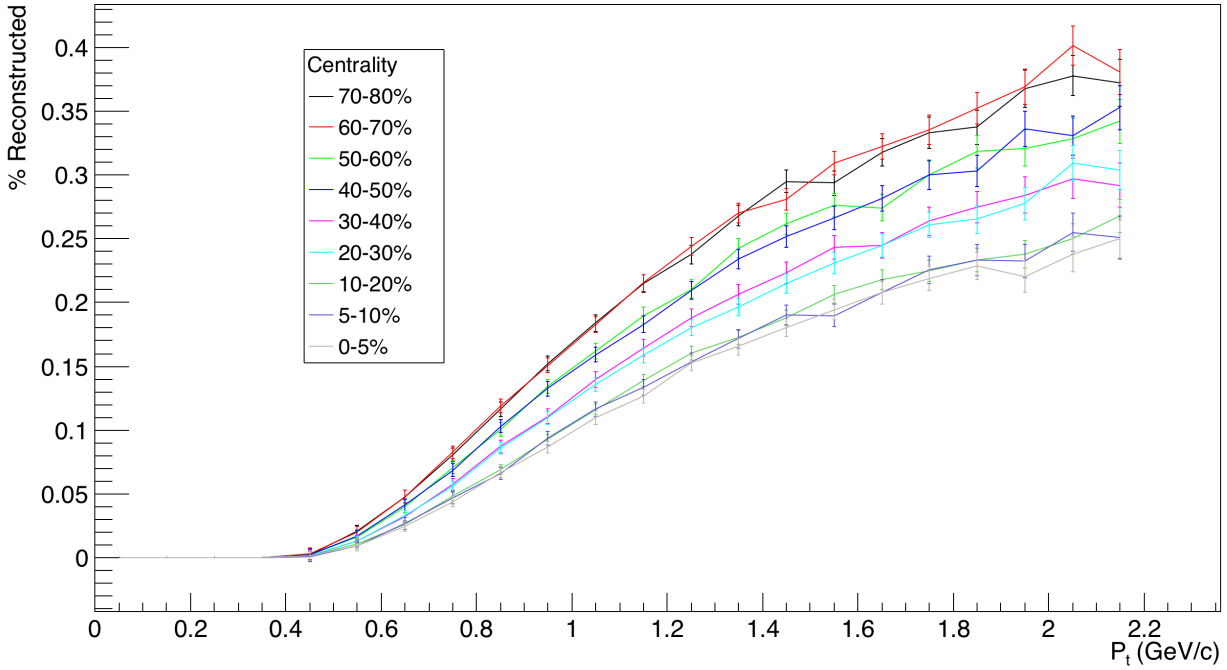
Purity for Centrality 30-40% P_t = 1.1-1.2 GeV/c:

$$\frac{N_\Lambda}{N_\Lambda + N_{Background}} = 0.863$$

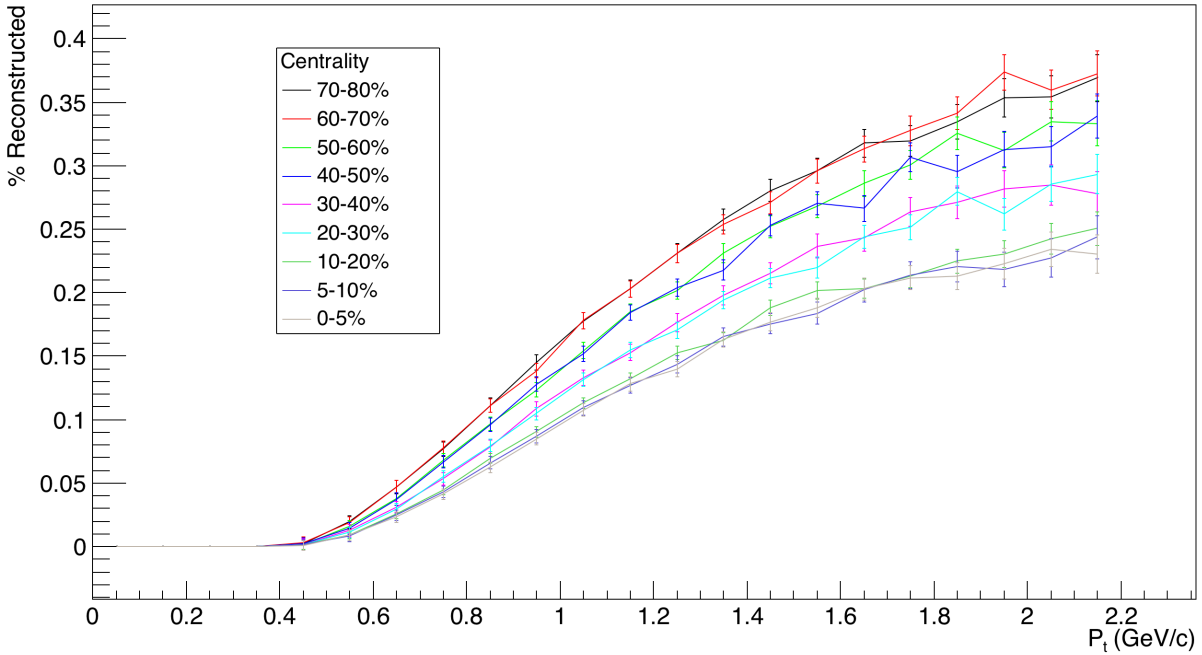
Purity & Efficiency Corrections

- Efficiency Corrections:
  - Embed Λ / $\bar{\Lambda}$ Tracks into real data
  - Compare # Reconstructed Embedded Tracks vs. Actual Embedded Tracks

Λ



$\bar{\Lambda}$



AMPT Results

These results are part of the feasibility study to examine the methods, and similar analyses with STAR data are ongoing

Also, for Λ-p correlations results, they serve as a baseline to compare STAR data results with.

Information on AMPT Data:

Version of AMPT: SM v2.25t4cu

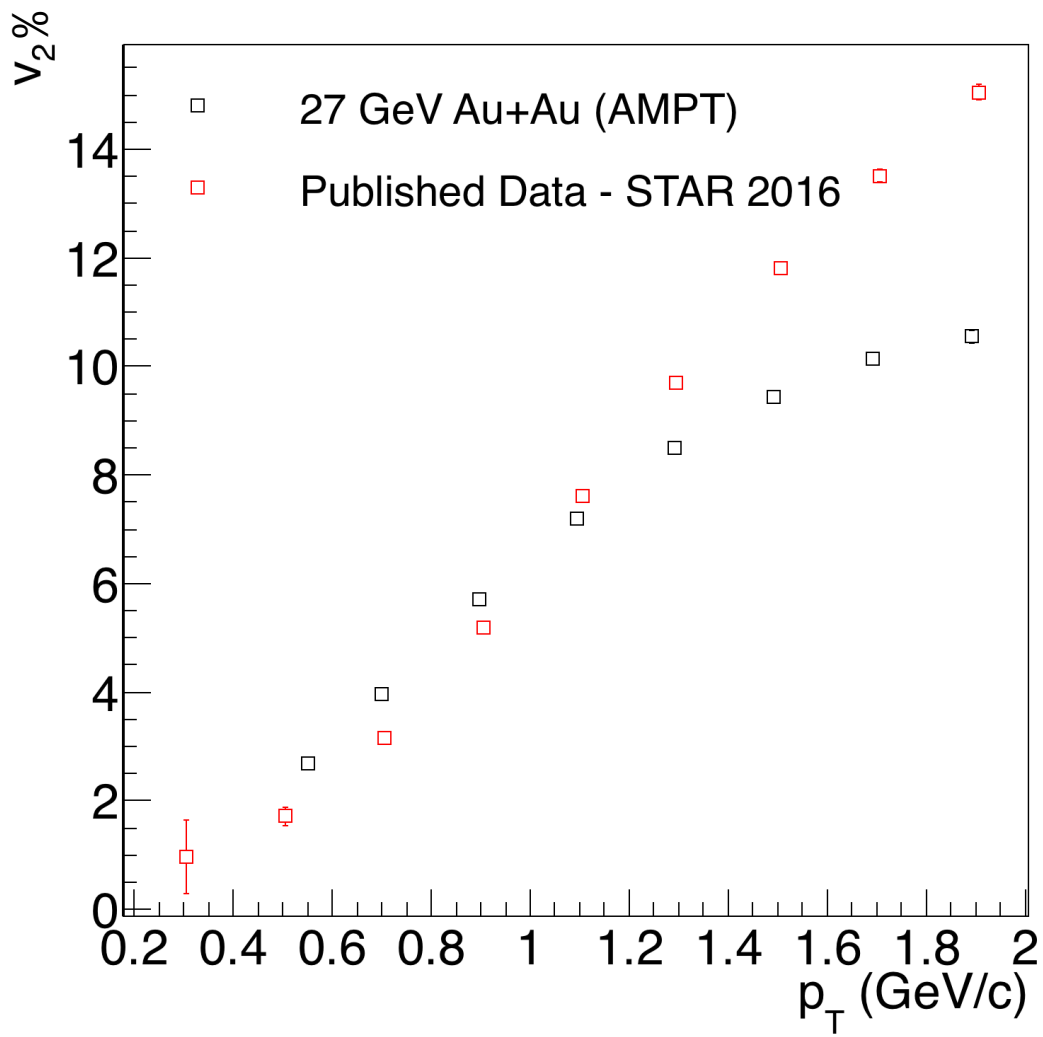
Parton Cross Section: 3 mb

AMPT - v_2 vs. p_T for Centrality 10-40%

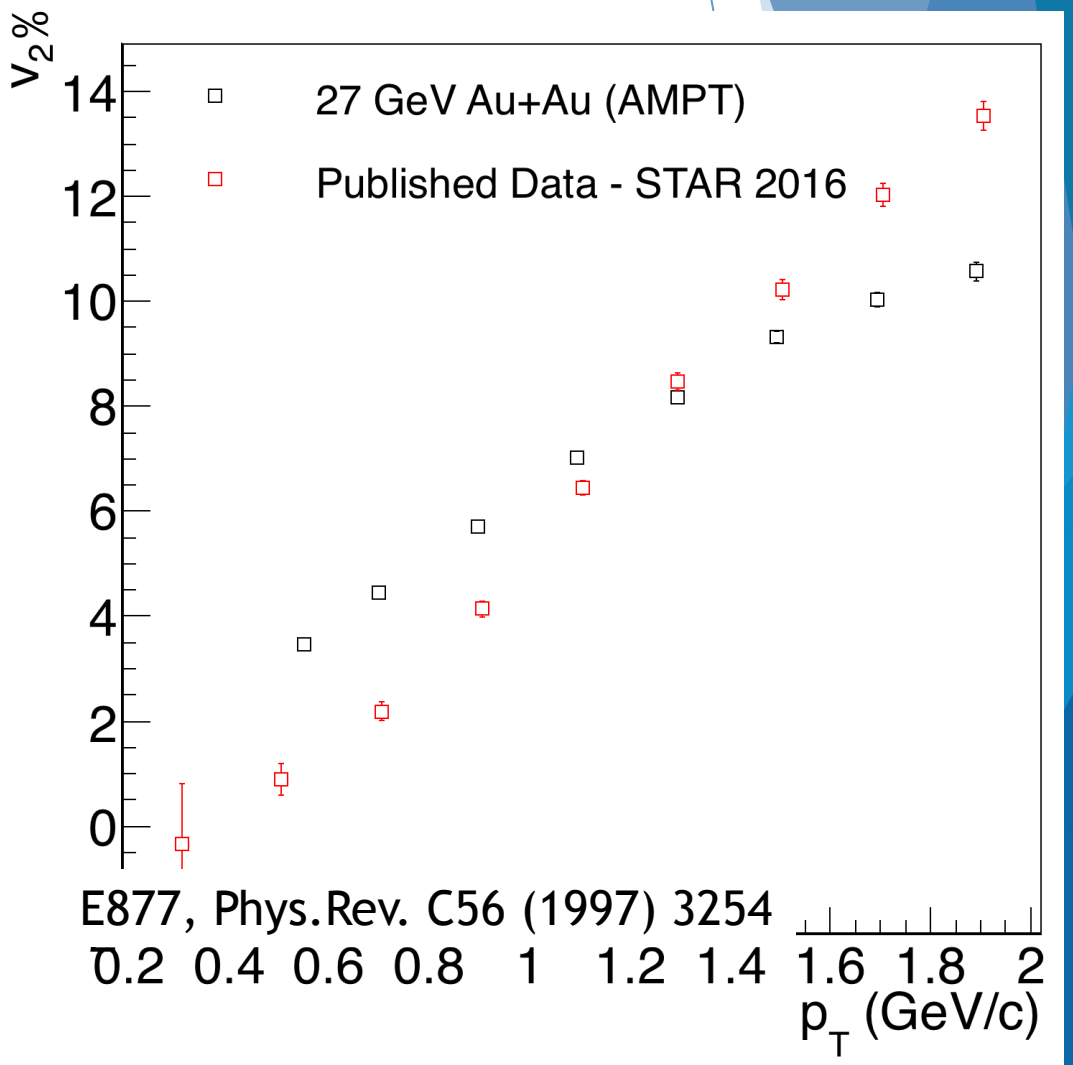
Note – AMPT model has not been tuned to match real data
shown only as an example of what it would be like for real data analysis

STAR, Phys. Rev. C **93** (2016) 14907

Λ



$\bar{\Lambda}$



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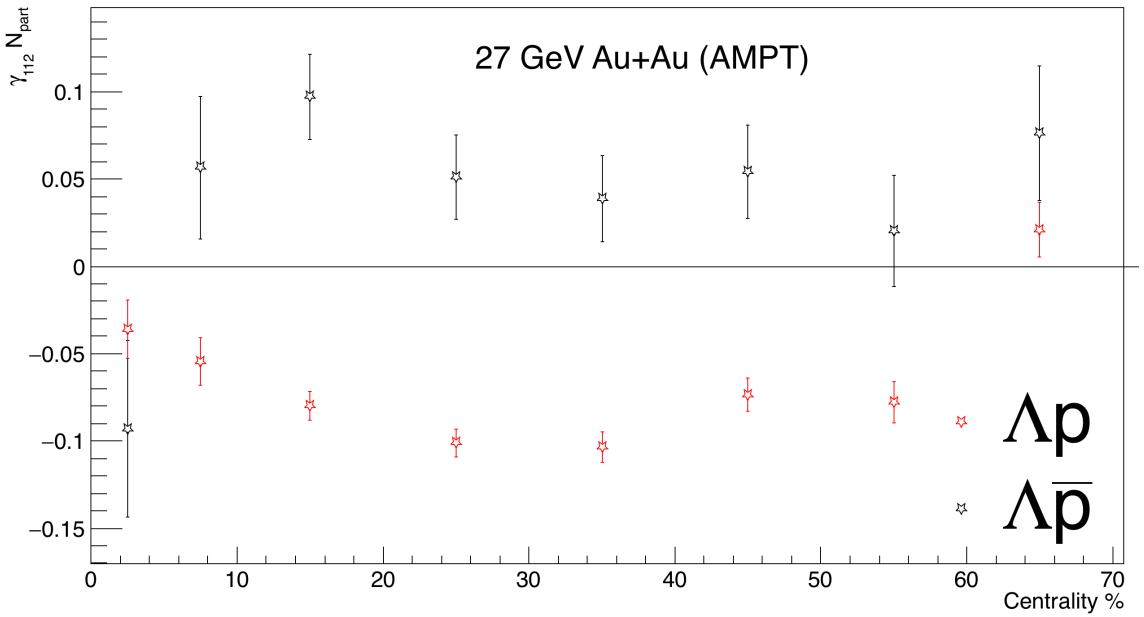
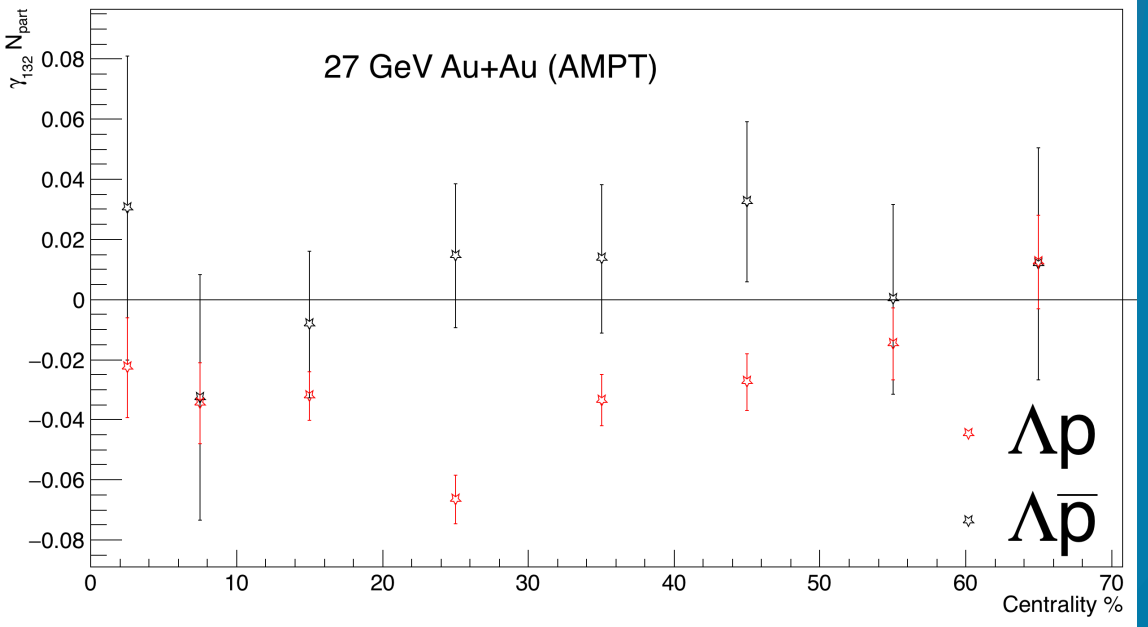
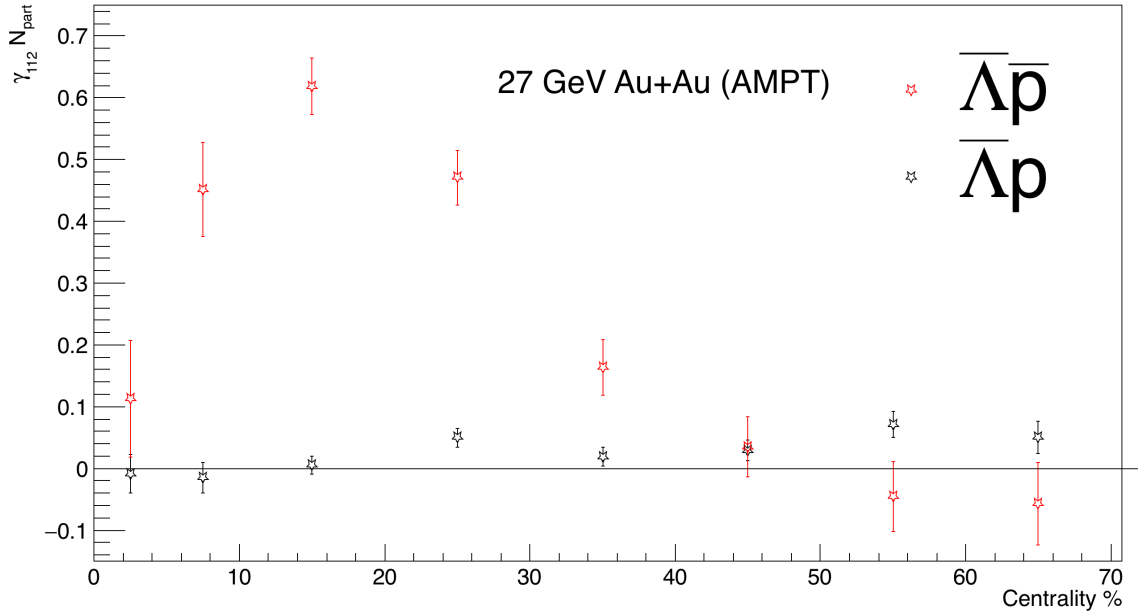
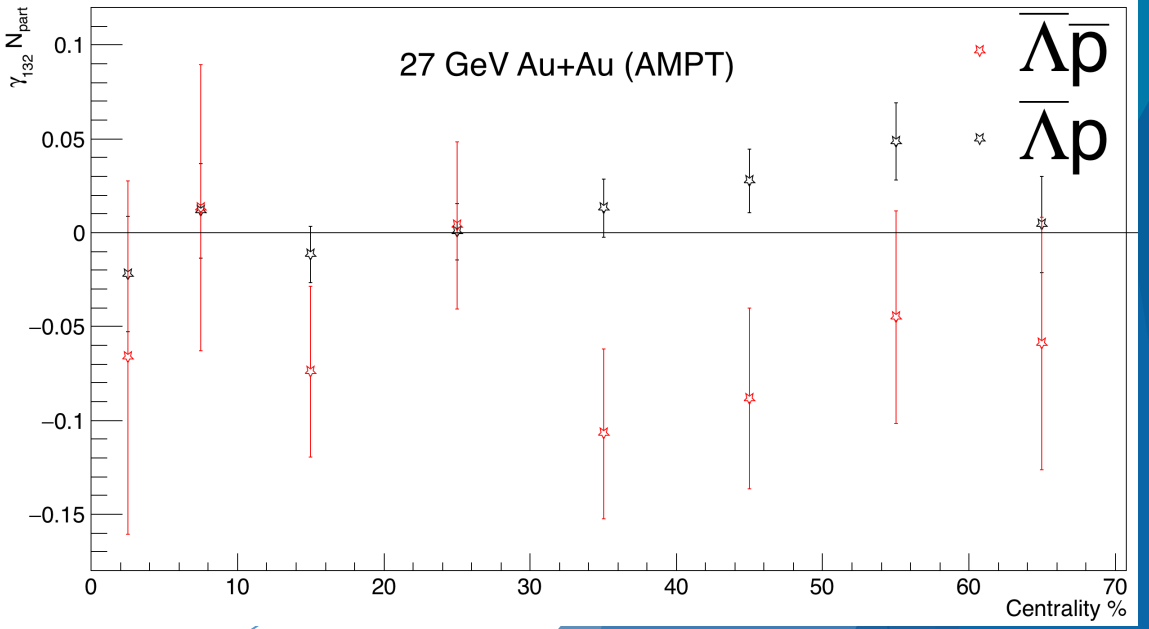
AMPT – Λ-p Correlations

Step 1: Calculate correlations for Λ and $\bar{\Lambda}$ separately



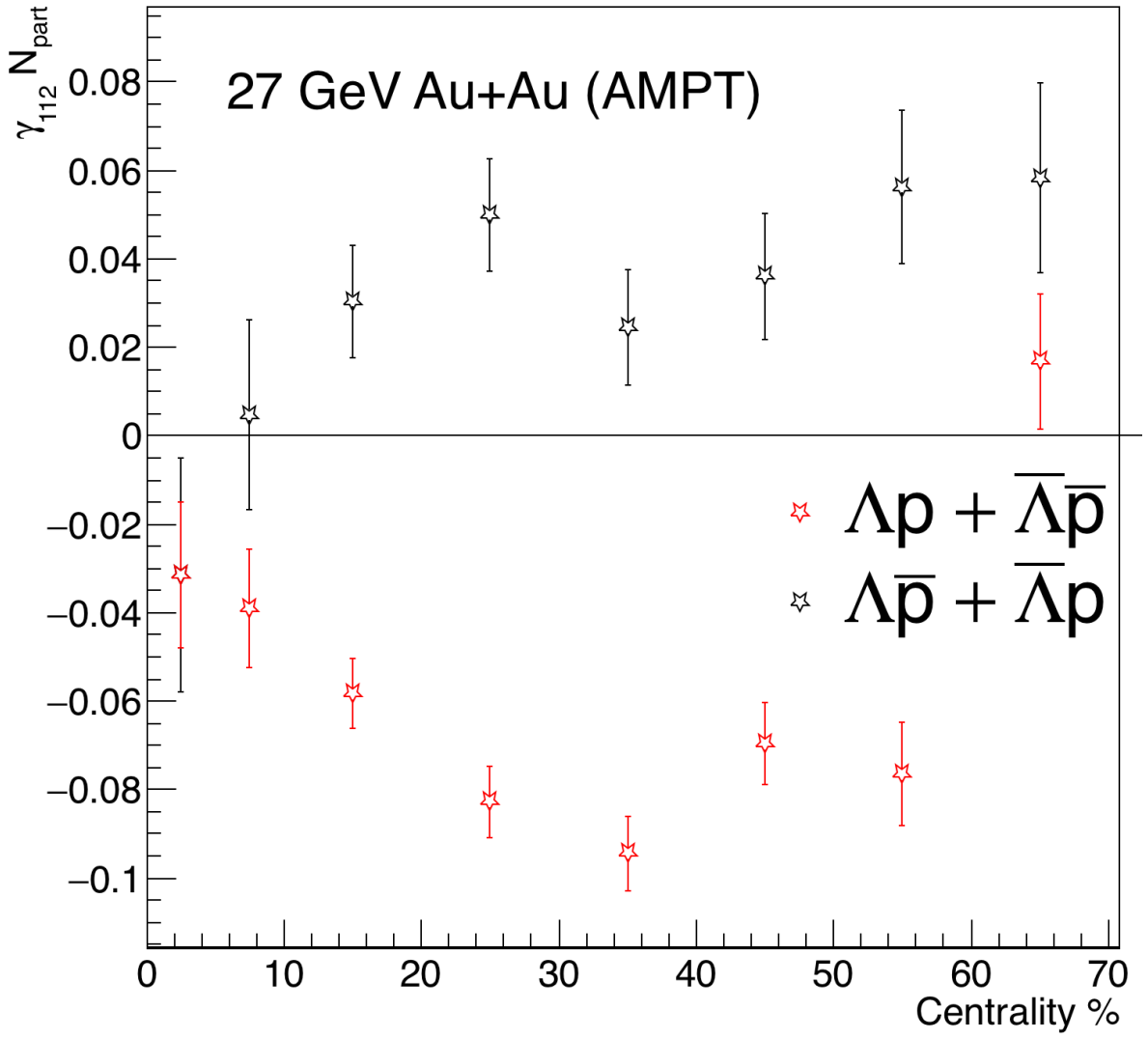


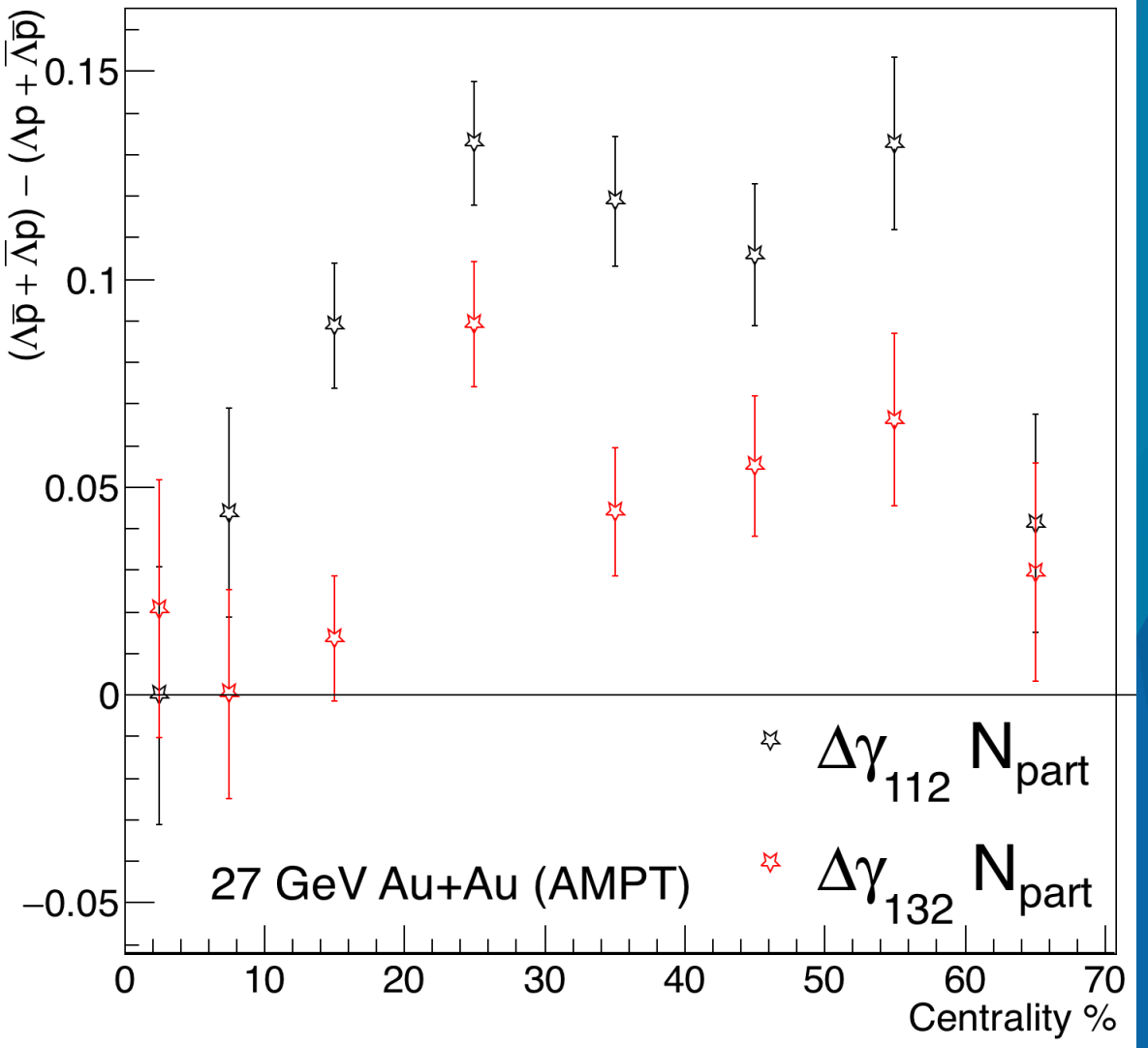




AMPT – Λ-p Correlations

Step 2: Average results for Λ and $\bar{\Lambda}$ to get full picture of baryonic charge separation
Step 3: Compare such results for γ_{112} (signal + background) and γ_{132} (mostly background)

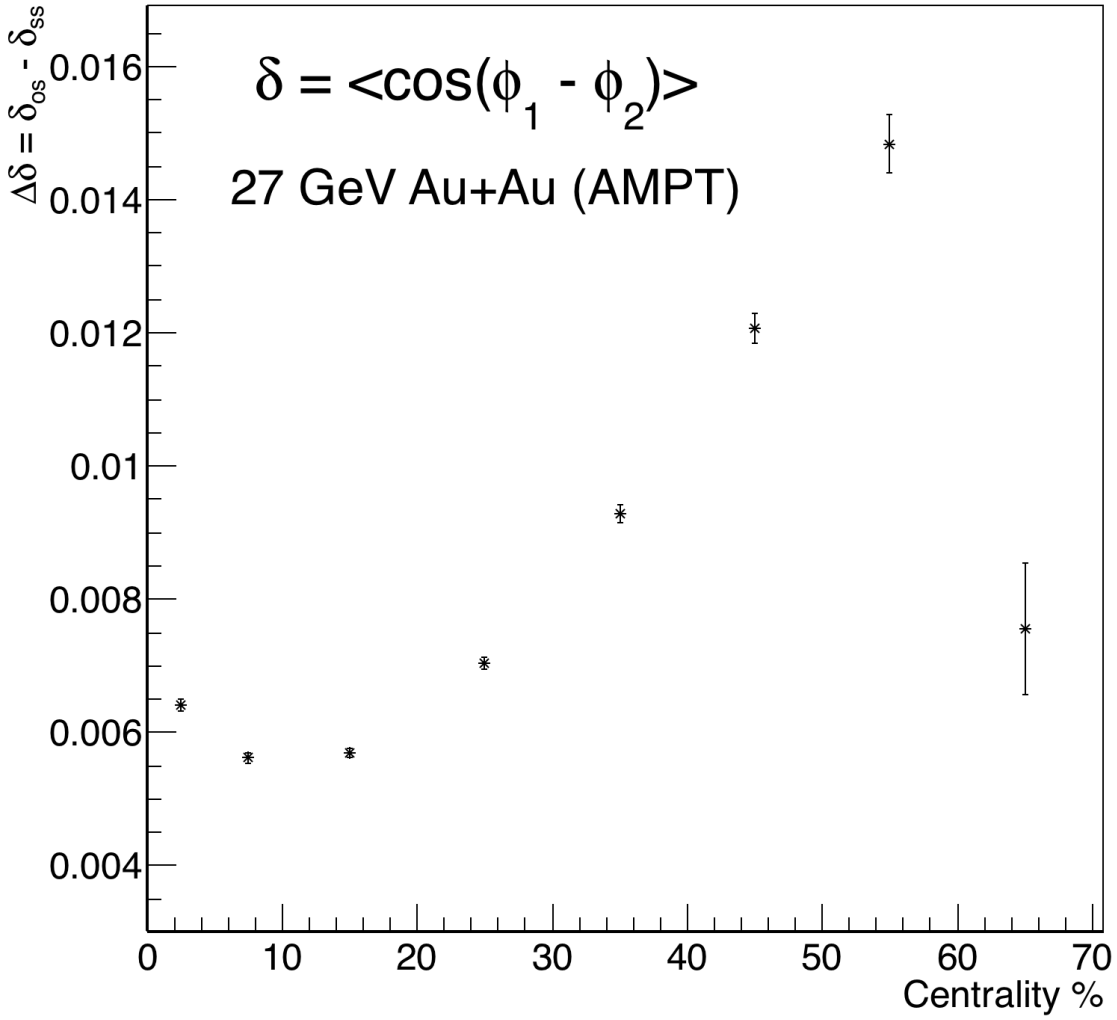


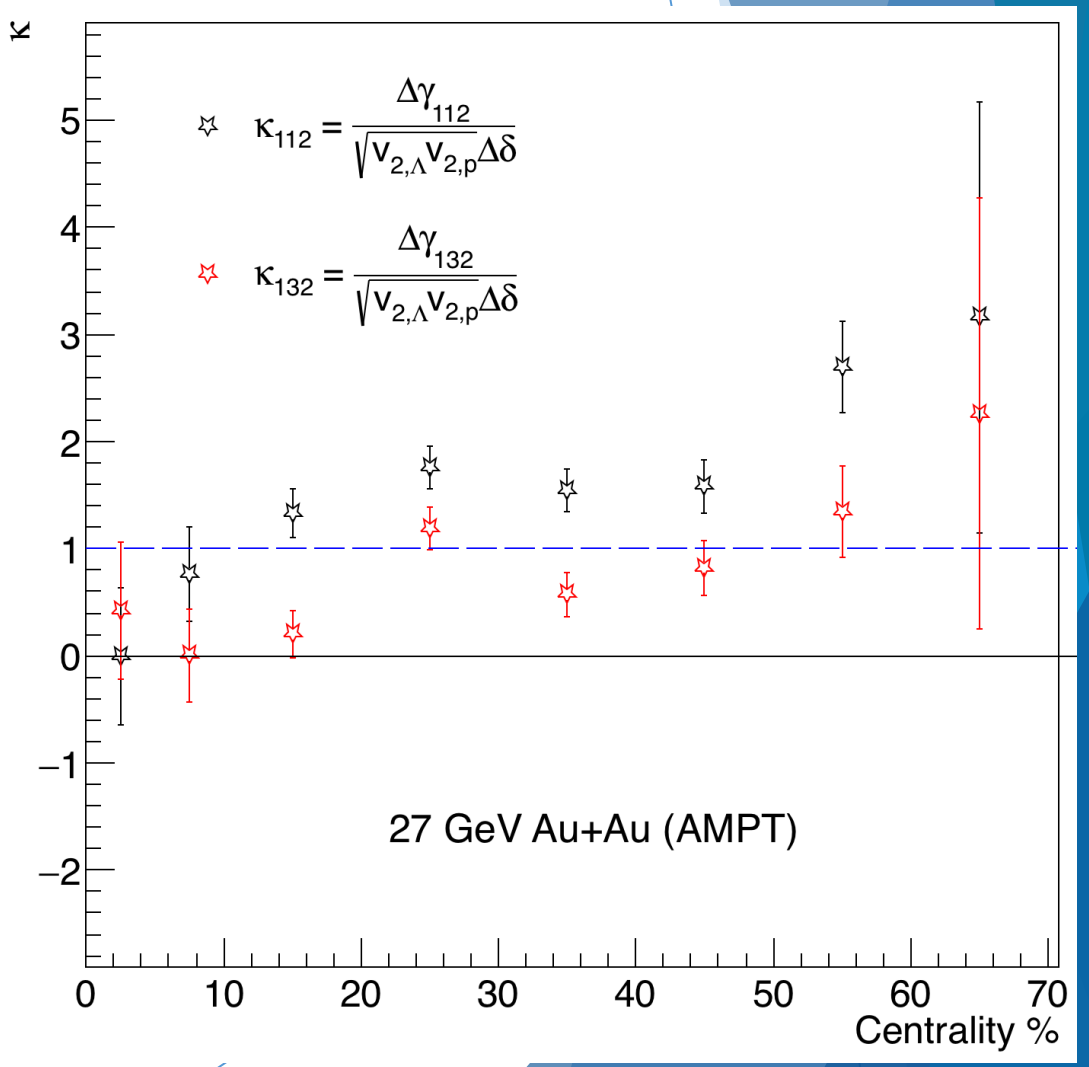


AMPT – Λ-p Correlations

Step 4: Normalize by v_2 and $\Delta\delta$ to obtain κ_{112} and κ_{132} that allow for easier comparisons across systems

In general, κ_{132} is close to unity, and κ_{112} is above κ_{132}.
The AMPT results provide a baseline for background contributions.



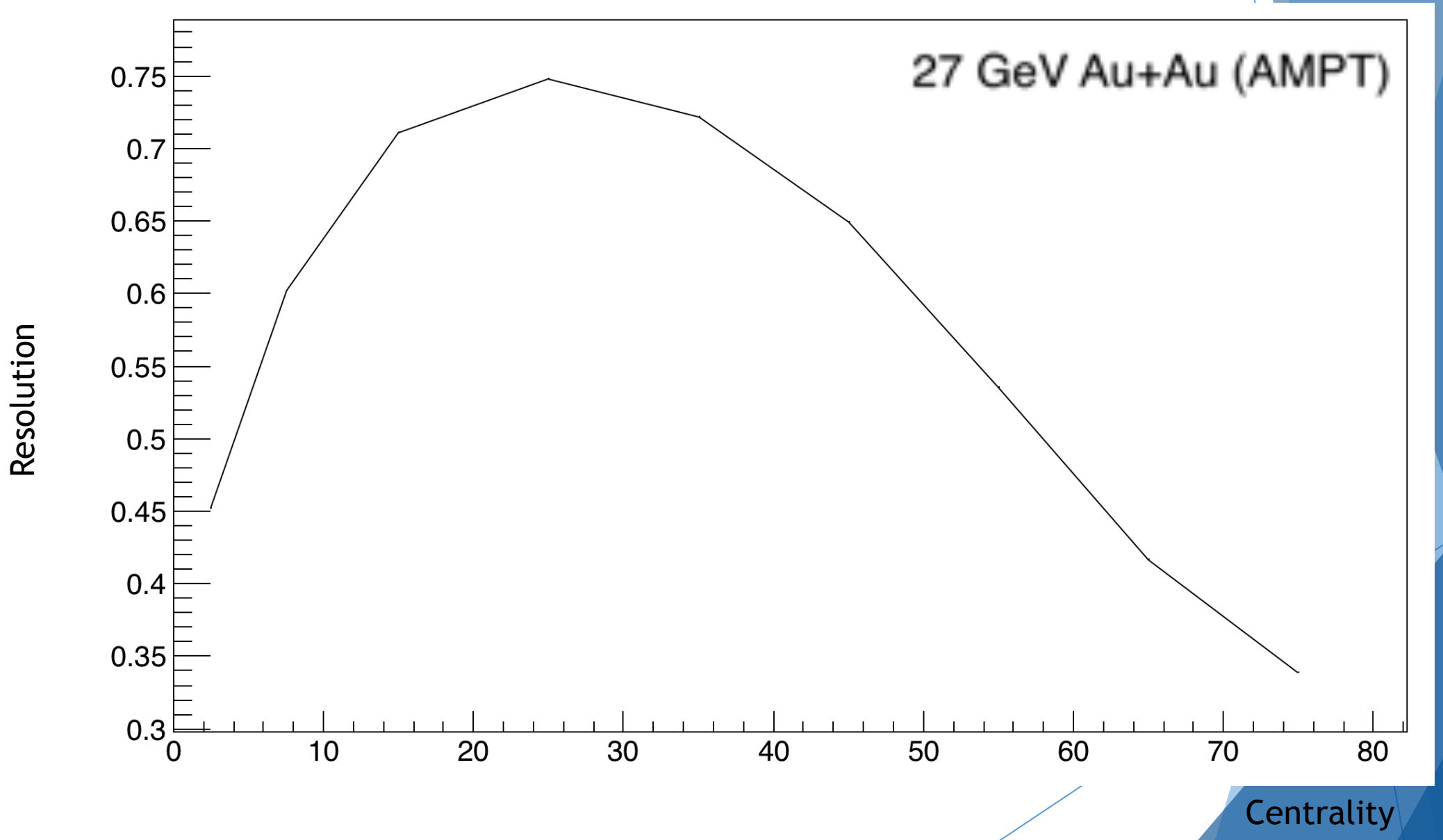


Summary

- Employed Baryonic Charge Separation in Search for CVE
- Studied Baseline for Background with AMPT
- Current Status for STAR Data Analysis:
  - $\Lambda / \bar{\Lambda}$ Reconstructed, Raw Correlators Computed
  - Purity & Efficiency have been obtained
- Next Steps:
  - Apply Corrections to Raw Results
  - Calculate Systematic Errors

Thank you!

Event Plane Resolution



Λ / $\bar{\Lambda}$ Reconstruction

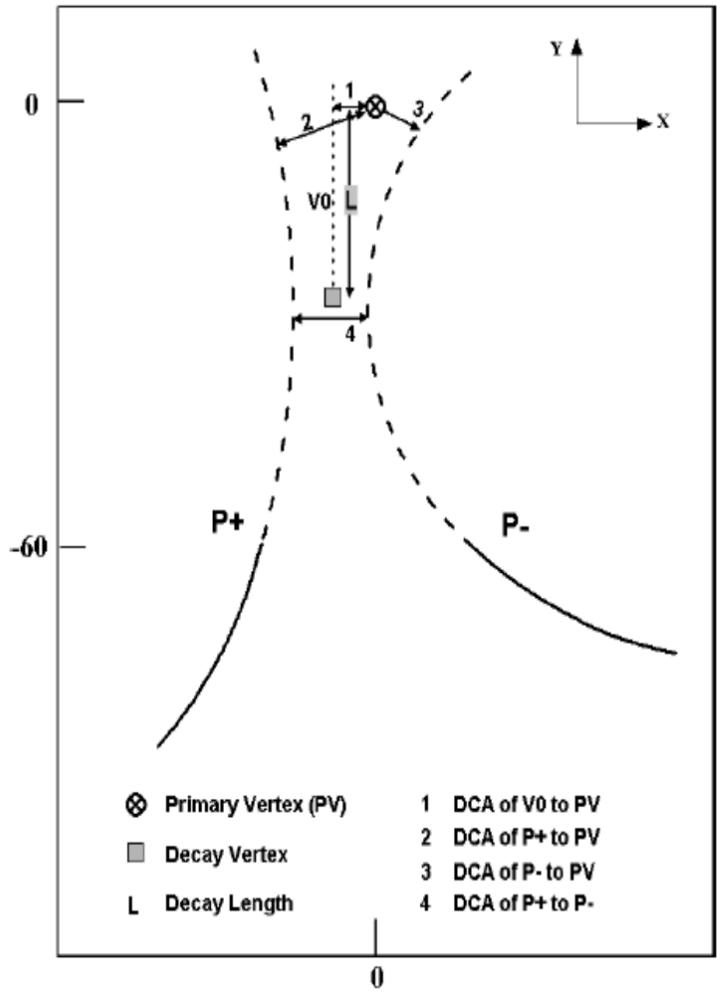
Centrality-Independent

- Proton
  - $|n\sigma| < 4$
  - 0.2 GeV/c < P_t < 2.0 GeV/c
- Lambda DCA < 3.5 cm

- Pion
  - $|n\sigma| < 4$
  - P_t > 0.2 GeV/c

We apply centrality-dependent quality cuts:

Centrality	Proton DCA	Pion DCA	Proton-Pion DCA	Lambda Decay Length
0-20%	> 0.4 cm	> 1.5 cm	< 0.9 cm	> 4.0 cm
20-40%	> 0.3 cm	> 1.3 cm	< 1.0 cm	> 3.5 cm
40-60%	> 0.2 cm	> 1.0 cm	< 1.1 cm	> 3.0 cm
60-80%	> 0.1 cm	> 0.8 cm	< 1.2 cm	> 2.5 cm



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Efficiency From Embedded Data

- Reconstructed Embedded Λ / $\bar{\Lambda}$ using the same topological cuts
- 2 types of Embedded Data – Flat MC P_t distribution vs. Exponential MC P_t distribution
- Flat MC P_t distribution: Sampling based on STAR Published Data 2019
- Binned Reconstructed & MC Tracks in 0.1GeV/c P_t bins
- Computed Efficiency per 0.1GeV/c P_t bins