Centrality dependence of Λ^0 and $\bar{\Lambda}^0$ directed flow at BES energies

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Past presentation:
FCV Parallel Section, STAR Collab. Meeting Oct 2023
https://drupal.star.bnl.gov/STAR/system/files/xiatong_star_colab_oct.pdf

STAR
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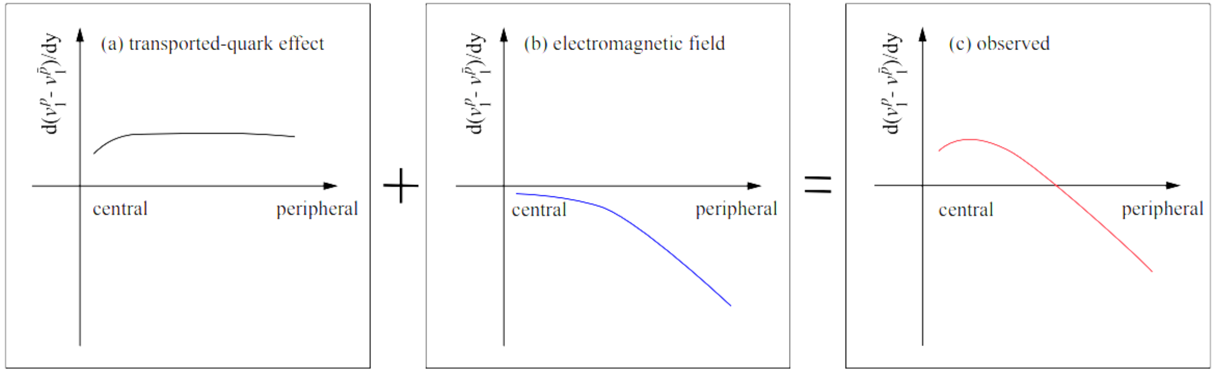
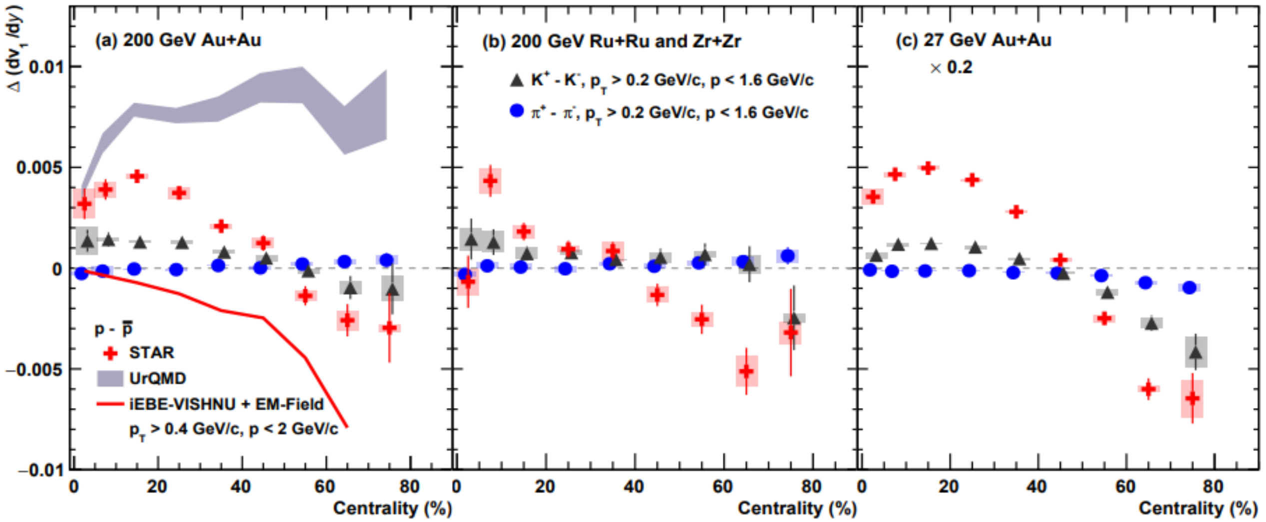
Motivation

- STAR v_1 paper[1] shows that protons and kaons $\Delta(dv_1/dy)$ values change signs from central to peripheral
  - Qualitatively consistent with transported quark + EM effects dominated by Faraday induction/Coulomb effect



- **Is $\Lambda^0/\bar{\Lambda}^0$ subject to the same effects?**
  - When $\Lambda^0/\bar{\Lambda}^0$ is formed, magnetic field may no longer exist, but its constituent quarks are subject to EM effects
  - Assuming coalescence sum rule, v_1 splitting between Λ^0 and $\bar{\Lambda}^0$ may be considered the combination of kaon and proton v_1 splitting

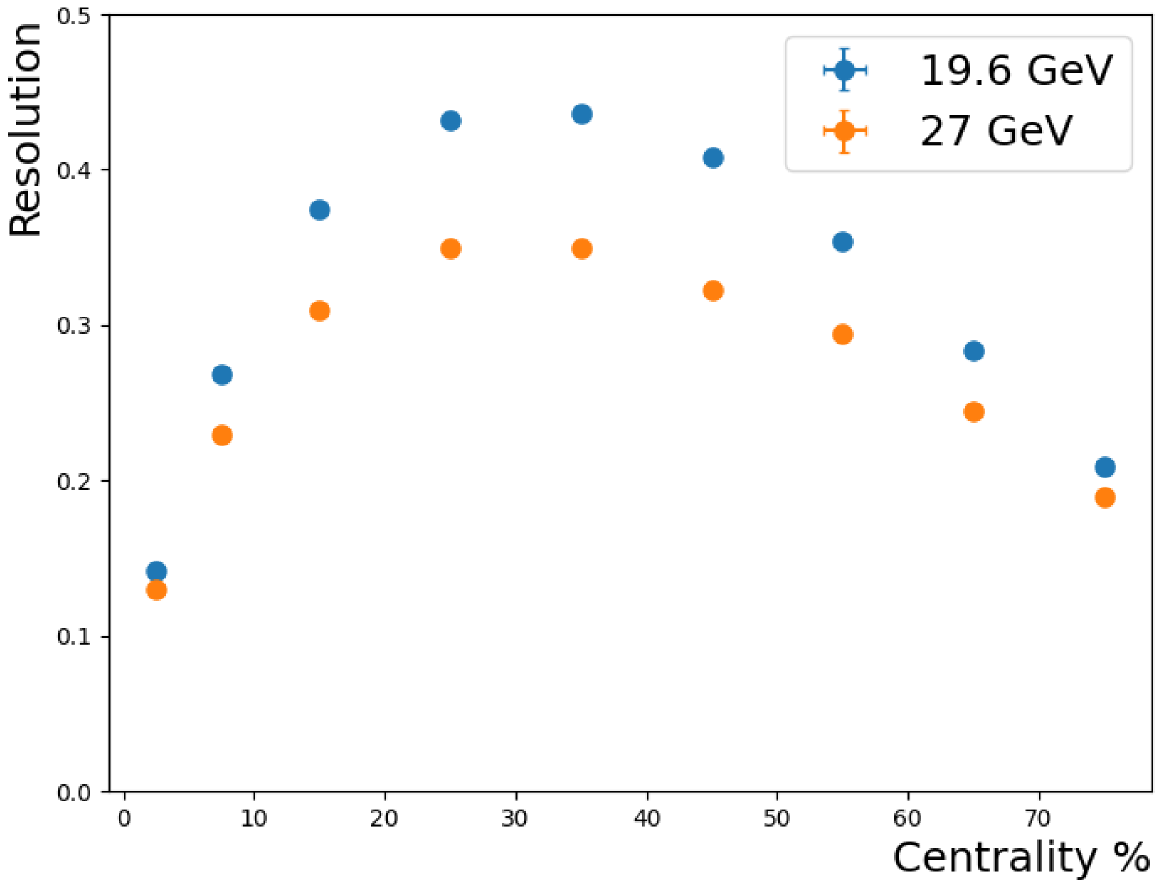


$$\Delta\left(\frac{dv_1}{dy}\right)_{[\Lambda^0(uds)-\bar{\Lambda}^0(\bar{u}\bar{d}\bar{s})]} \sim \Delta\left(\frac{dv_1}{dy}\right)_{[p(uud)-\bar{p}(\bar{u}\bar{u}\bar{d})]} - \Delta\left(\frac{dv_1}{dy}\right)_{[K^+(u\bar{s})-K^-(\bar{u}s)]}$$

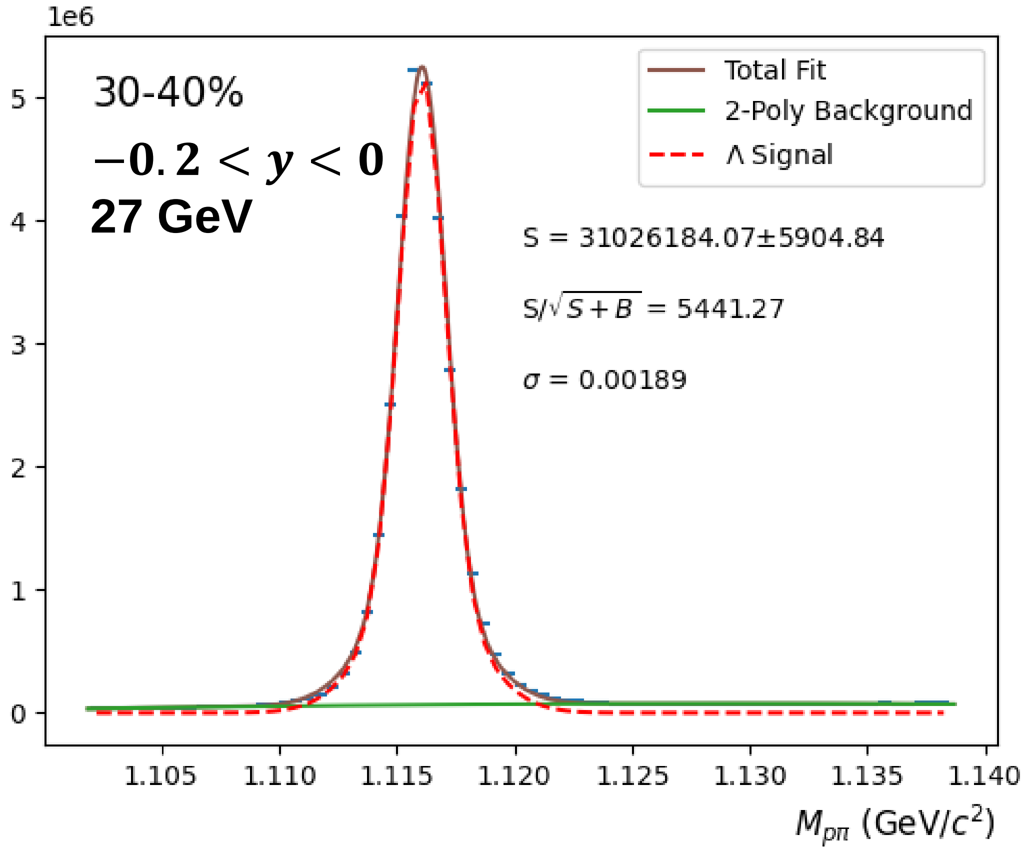
1.https://arxiv.org/pdf/2304.03430.pdf

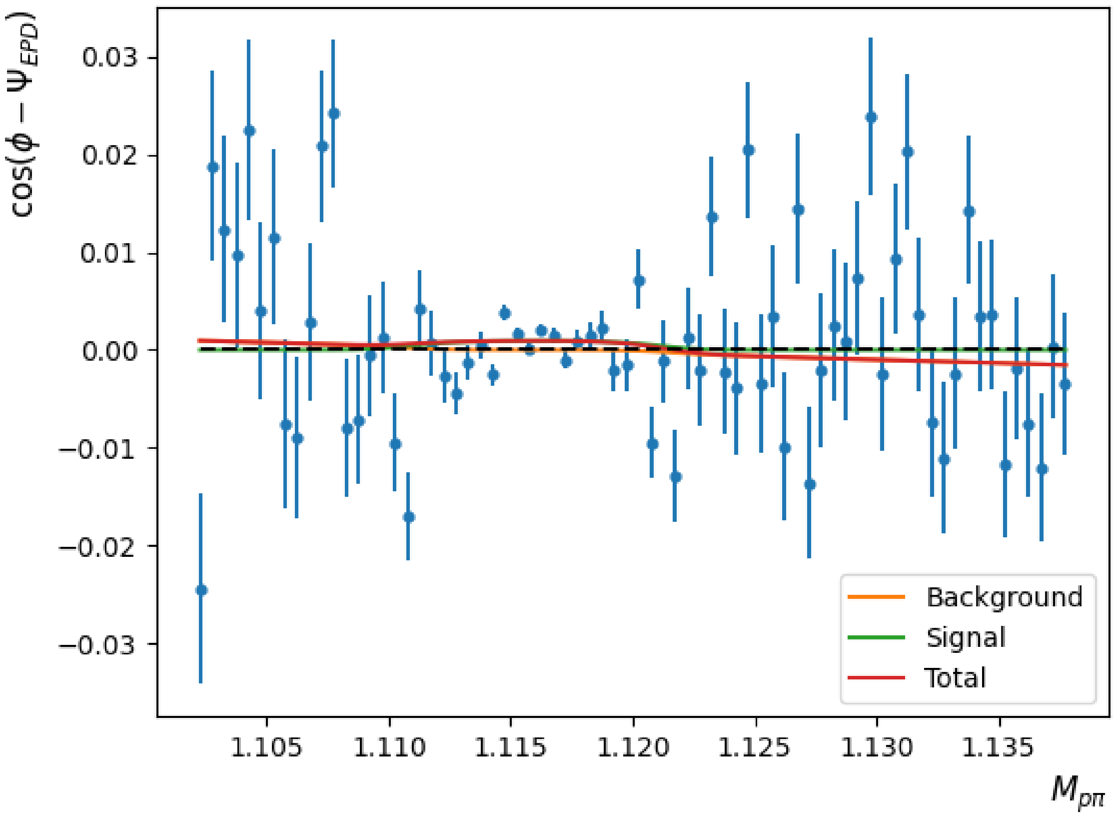
Event selection and event plane reconstruction

- Event cut:
  - $|v_z| < 70$ cm
  - $\sqrt{v_x^2 + v_y^2} < 2$ cm
  - Official bad runs and pile up cut
- Track cut:
  - nHitsFit > 15
  - 0.04 < dEdxError < 0.12
  - KFParticle PID criteria
- Event plane reconstruction:
  - Reconstructed using EPD
  - In addition to standard StEpdEpFinder phi-weighting and EP-flattening:
    - Using v_1 as eta weights for 1st order EP
    - Flattening EP distributions for each run day



$\Lambda^0/\bar{\Lambda}^0$ reconstruction and flow extraction



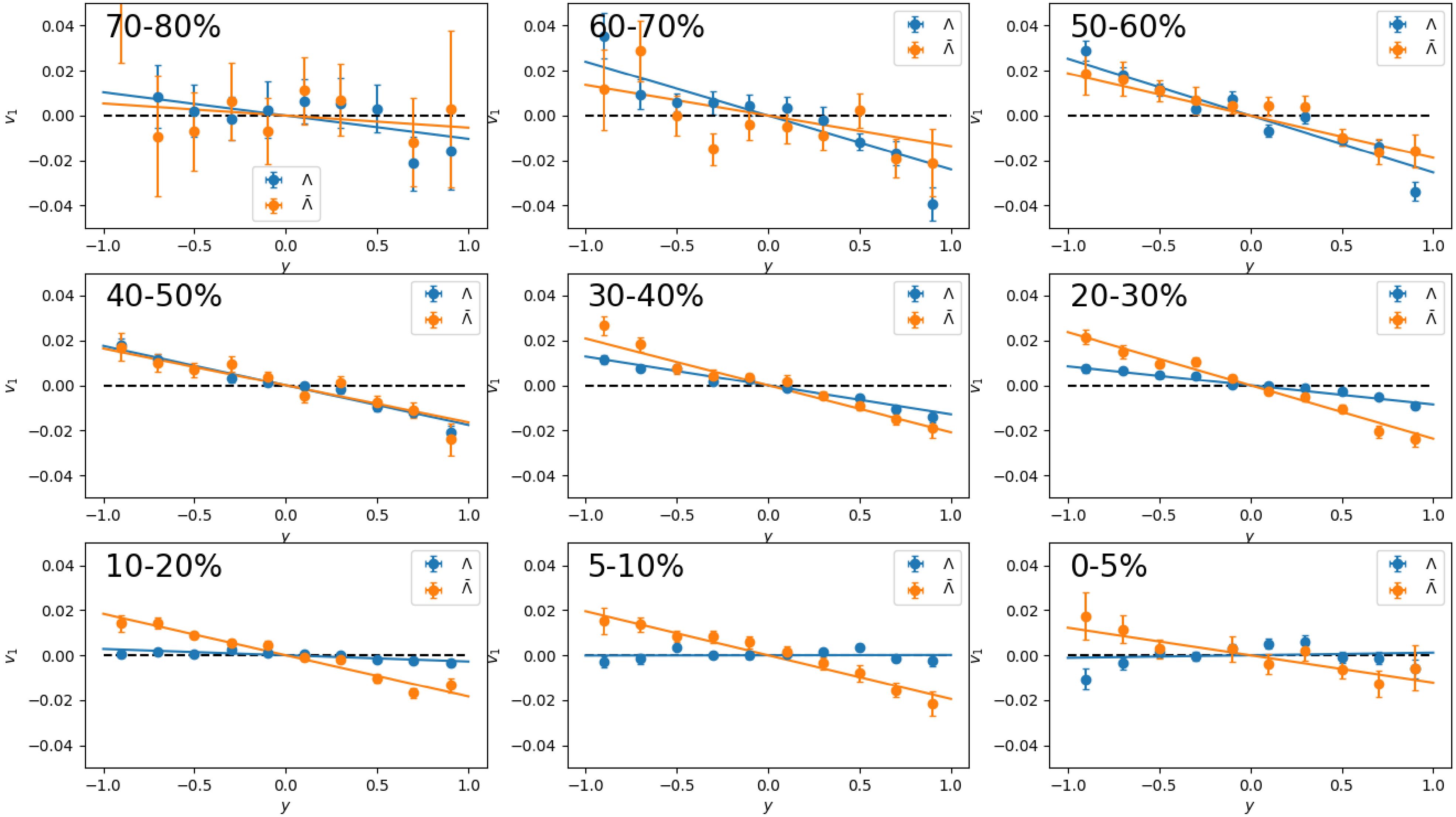


- $\Lambda/\bar{\Lambda}$ reconstructed using KFParticle:
  - SetChiPrimaryCut(10)
  - SetLCut(1.0)
- Fitted with double Gaussian+2nd order poly
- $0.4 < p_T < 2.8$ GeV/c

- v_1 extracted using v_1 vs $M_{\rm inv}$ method
- $v_{1,\rm total}(M_{\rm inv}) = \frac{\rm Signal}{\rm Signal+Bkg}(M_{\rm inv}) * v_{1,\rm signal} + \frac{\rm Bkg}{\rm Signal+Bkg}(M_{\rm inv}) * v_{1,\rm bkg}$
- $v_{1,\rm bkg}$ parametrized by first order poly

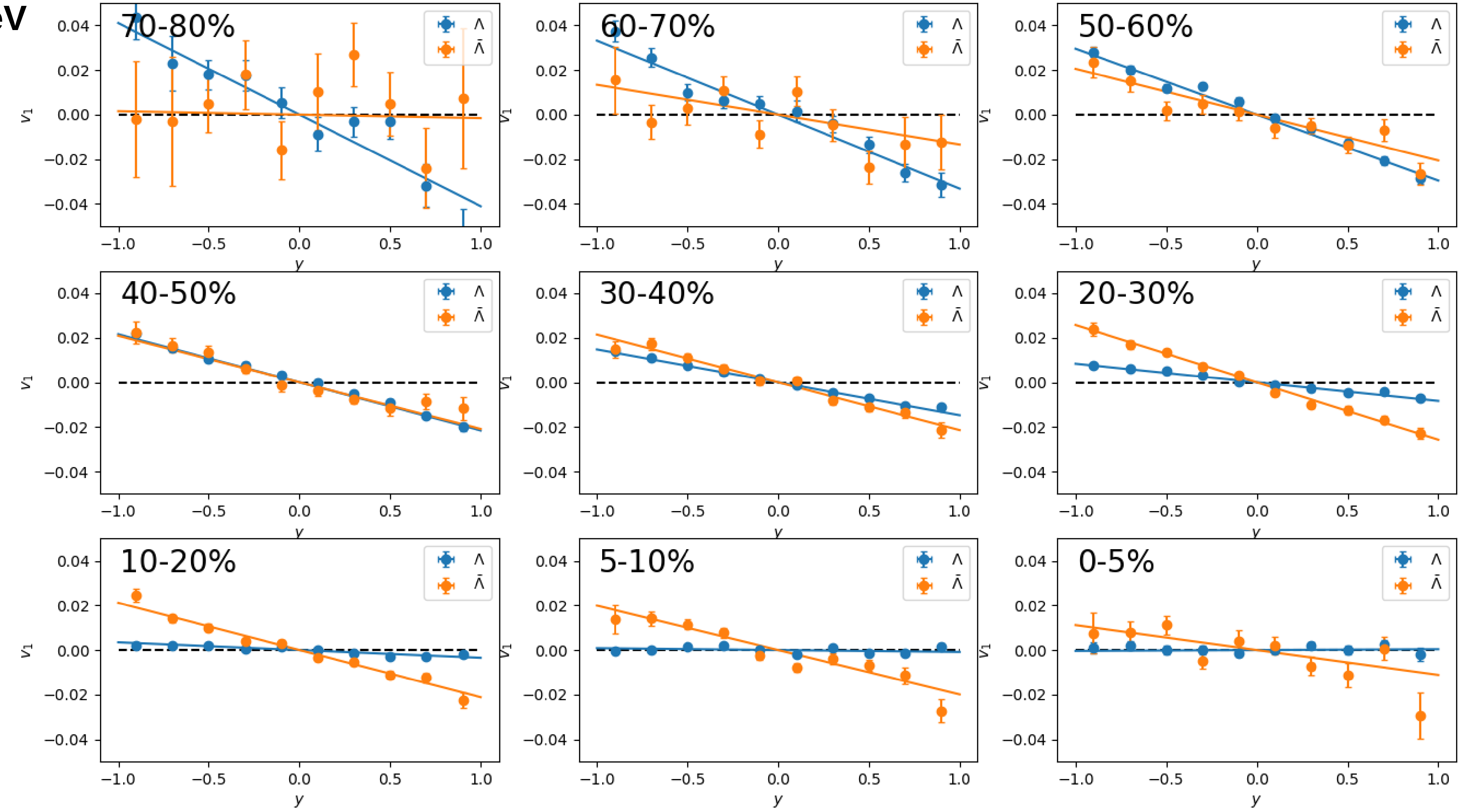
$\Lambda^0/\overline{\Lambda}^0\ v_1(y)$

27 GeV

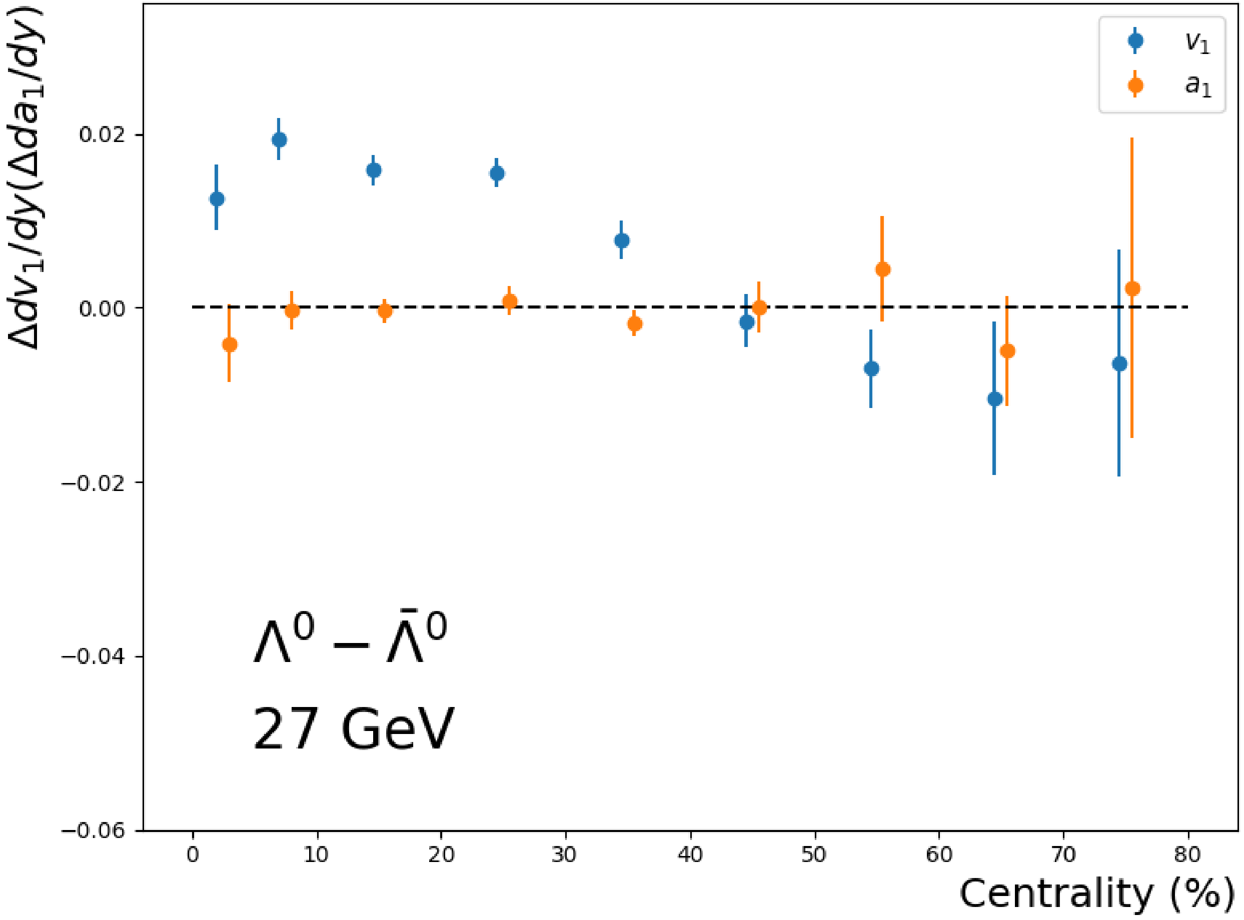


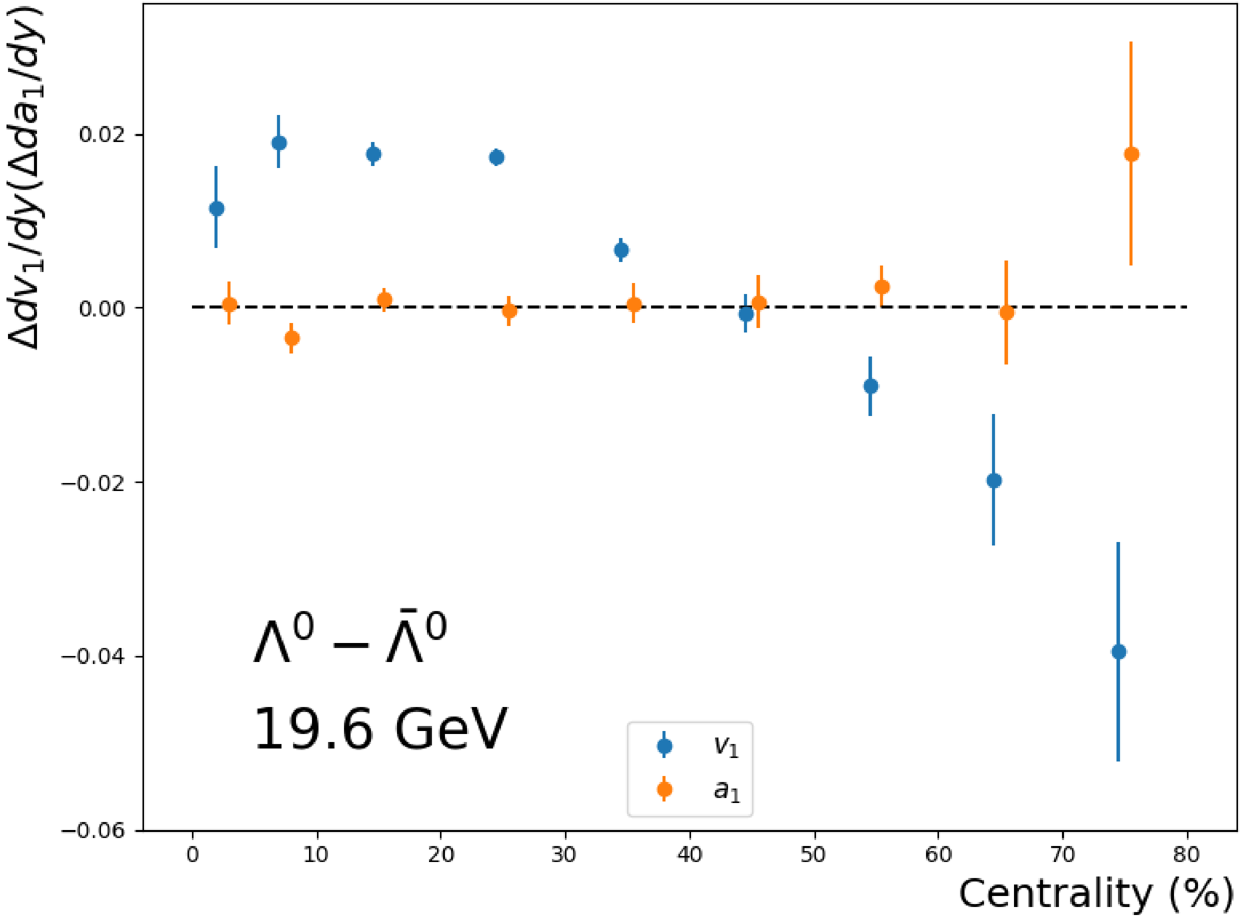
$\Lambda^0/\overline{\Lambda}^0\ v_1(y)$

19.6 GeV
NEW

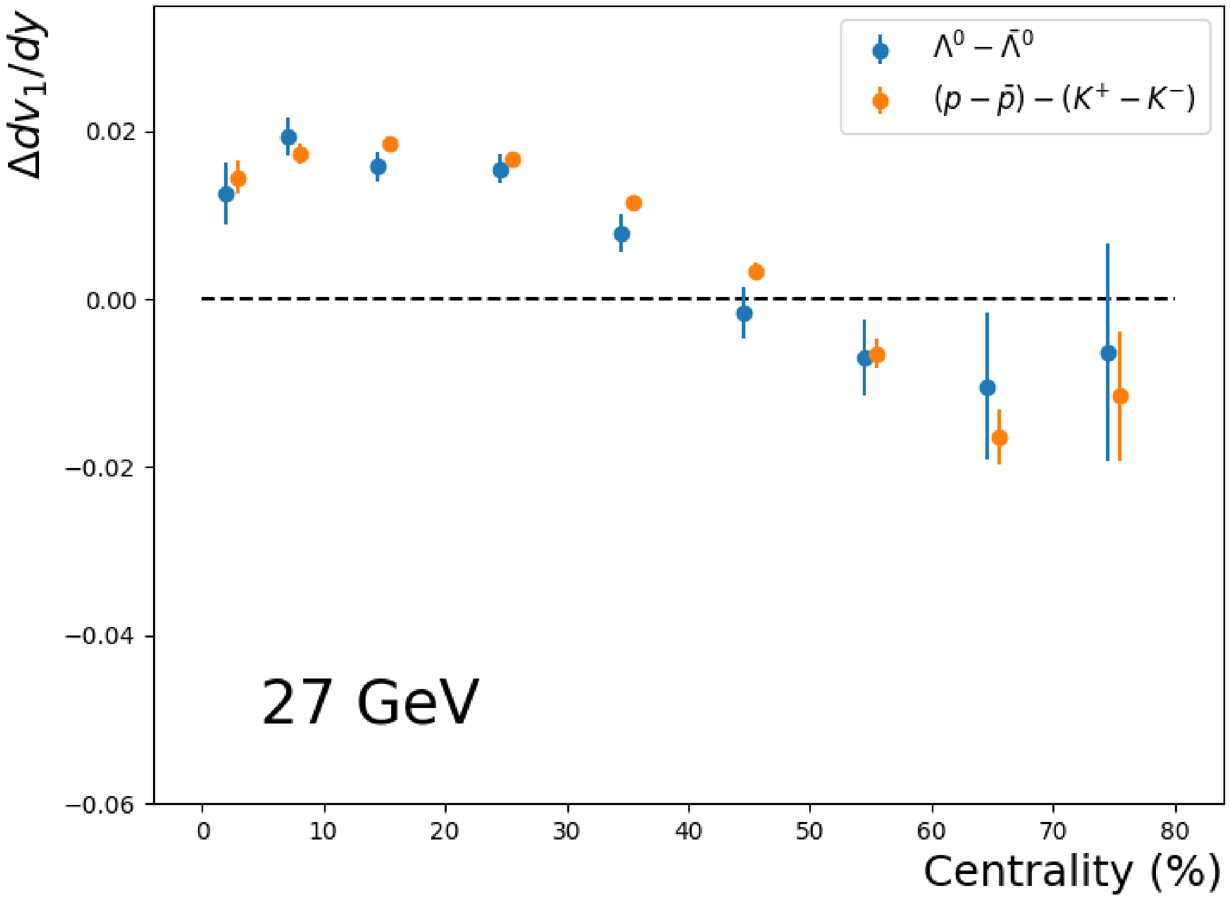


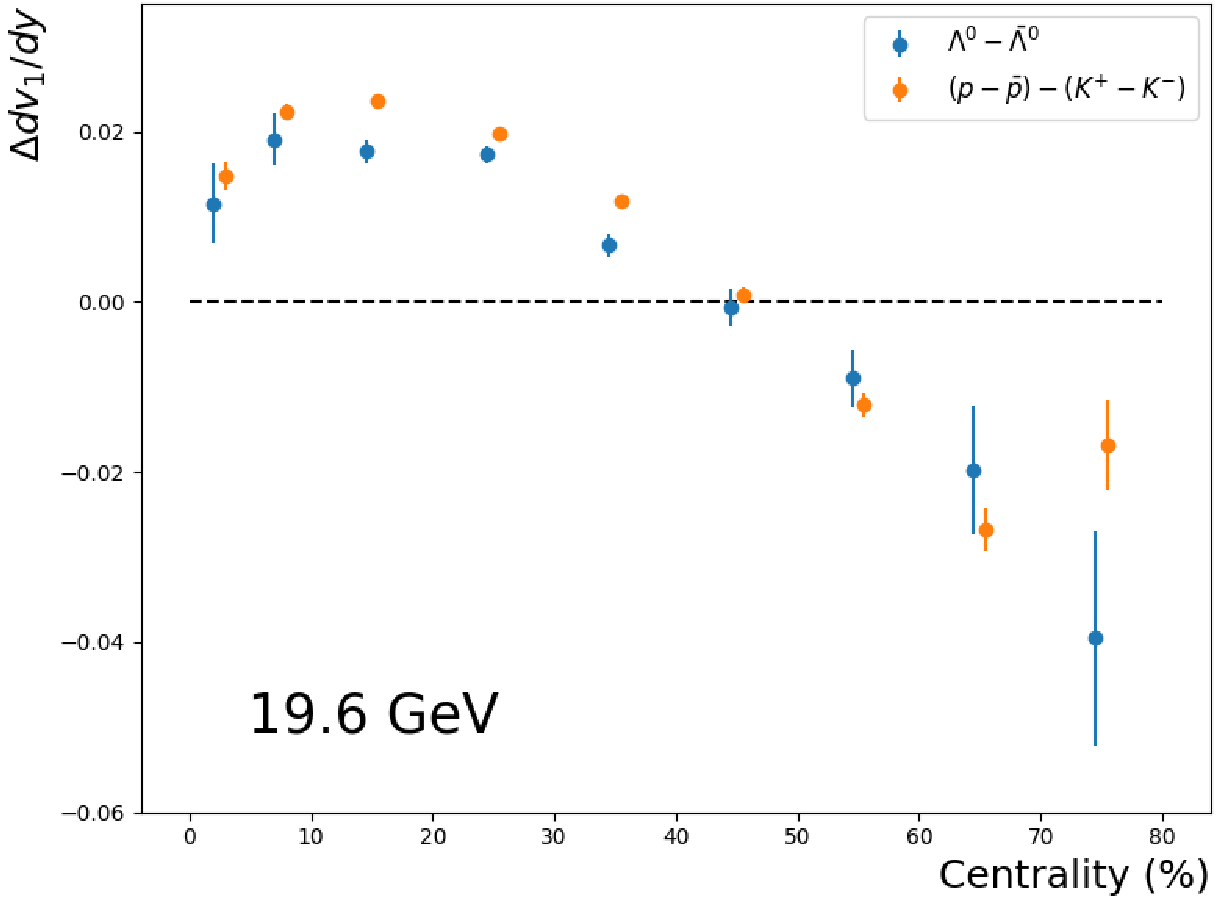
$\Lambda^0/\overline{\Lambda}^0$ $\Delta(dv_1/dy)$ ($\Delta(da_1/dy)$)



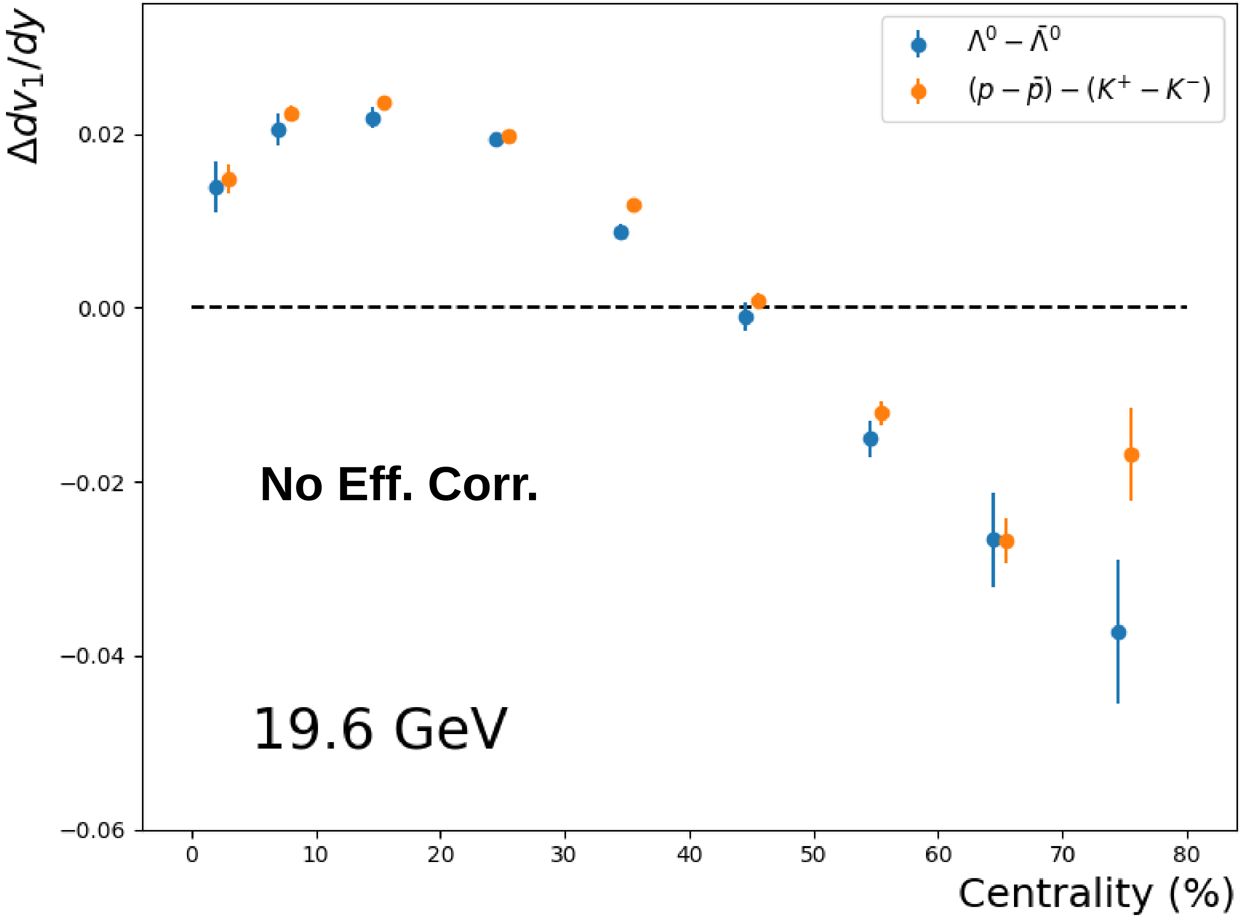


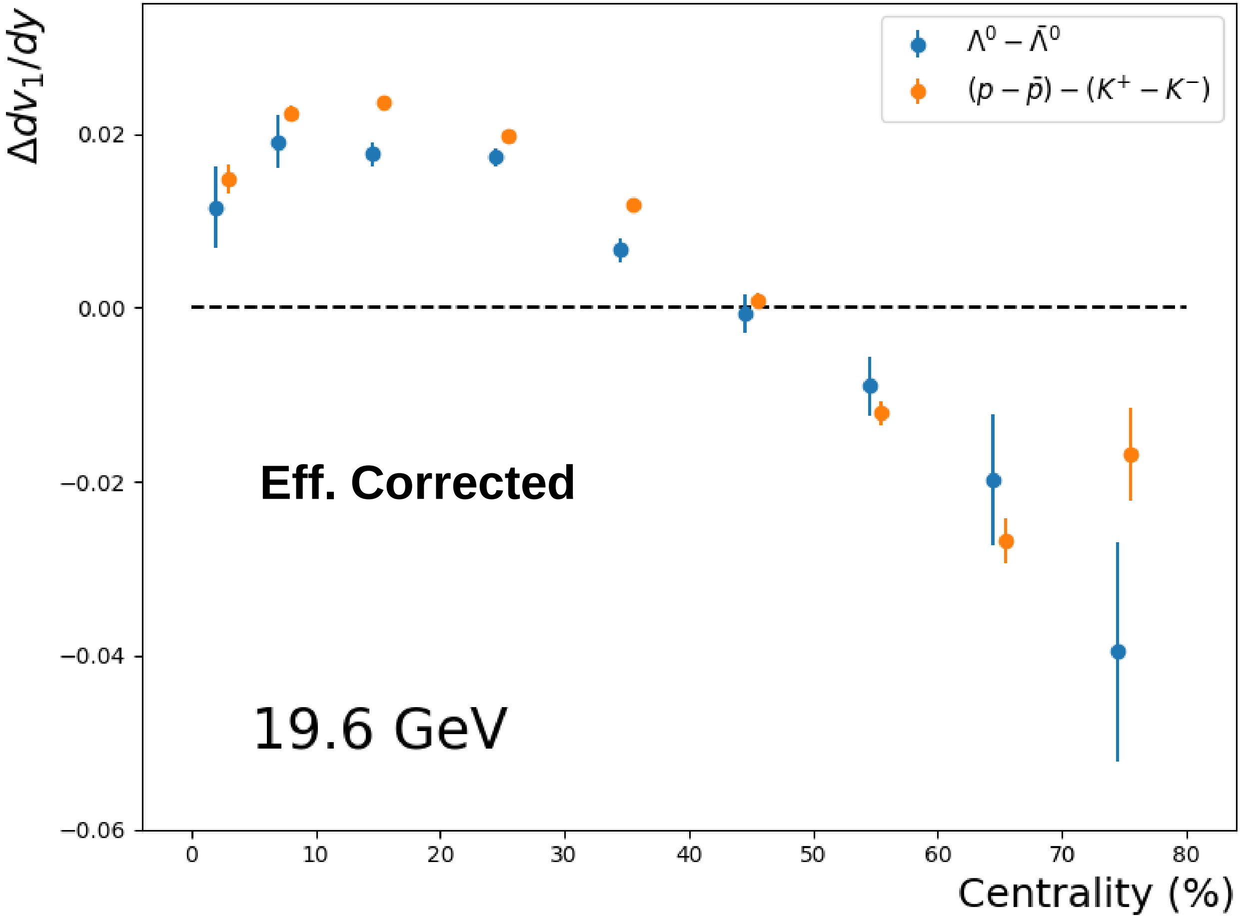
$\Lambda^0/\overline{\Lambda}^0 \Delta(dv_1/dy)$: Coalescence sum rule





Efficiency Correction





Summary

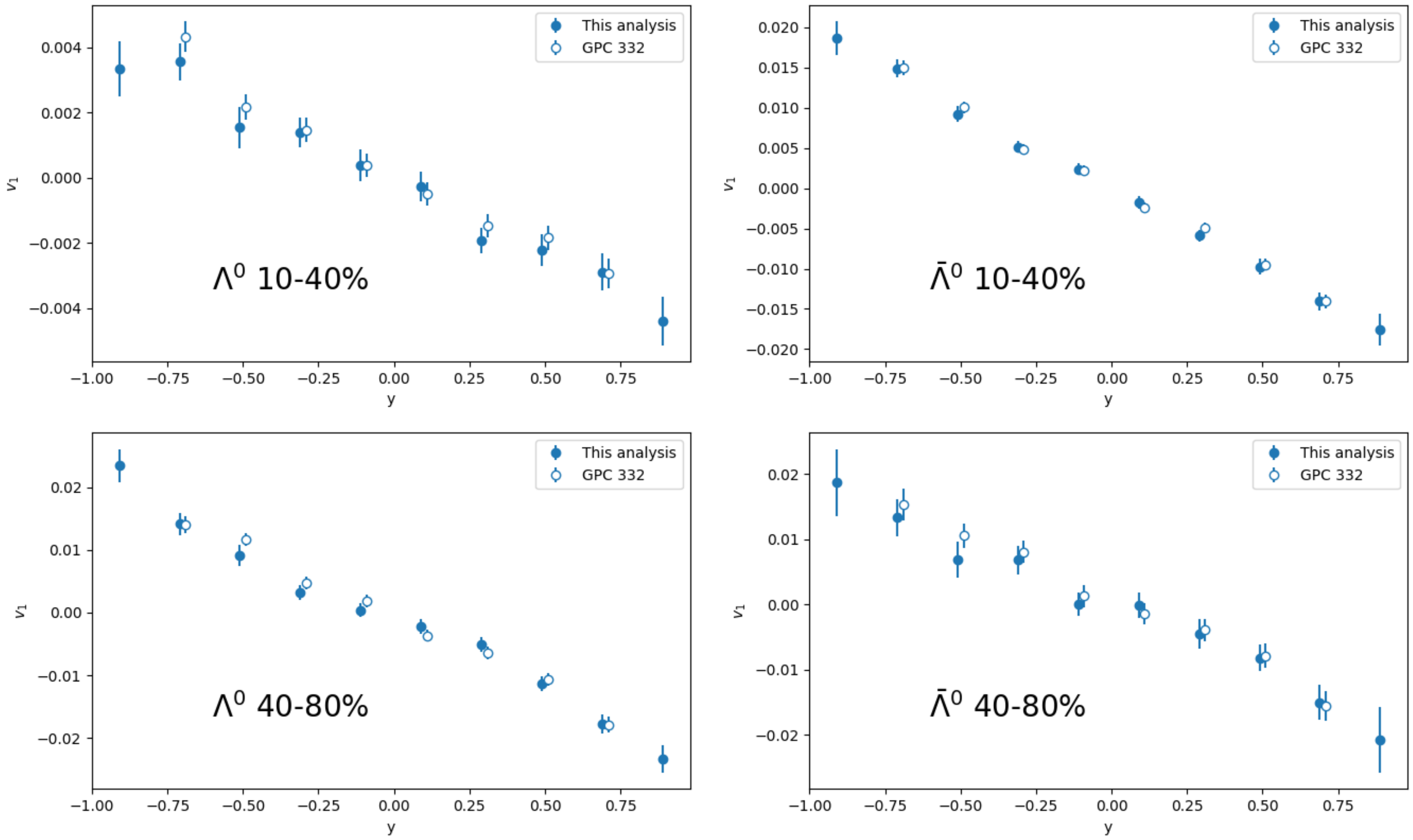
- We presented efficiency corrected $\Lambda^0/\overline{\Lambda}^0$ v_1 as a function of centrality at $\sqrt{s_{NN}} = 19.6, 27$ GeV. Negative $\Delta(dv_1/dy)$ observed at peripheral.

- Centrality dependence agrees with expectation from coalescence sum rule (combination of proton and kaon splitting)

Next:

- Scan the BES energies (start with 7.7 GeV collider dataset which has large v_1)

Backup



$\Lambda/\bar{\Lambda}\ v_1$ before efficiency correction consistent with another STAR paper

Backup

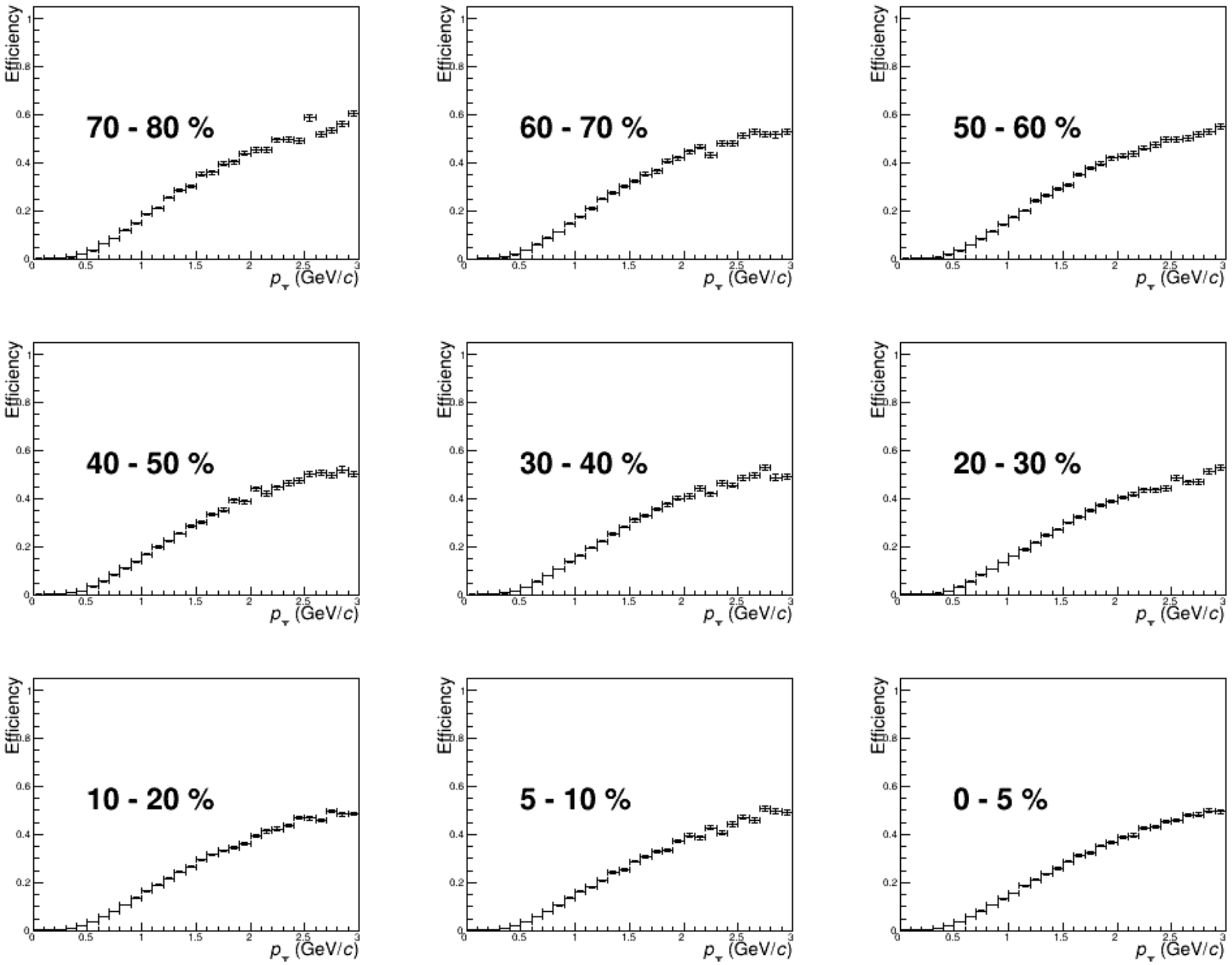
Method:

$$\text{profiles or histograms (cen}, y) = \sum_{p_T \text{ bin}} \text{profiles or histograms (cen, y}, p_T \text{ bin}) \times \frac{1}{\text{Efficiency}(p_T)}$$

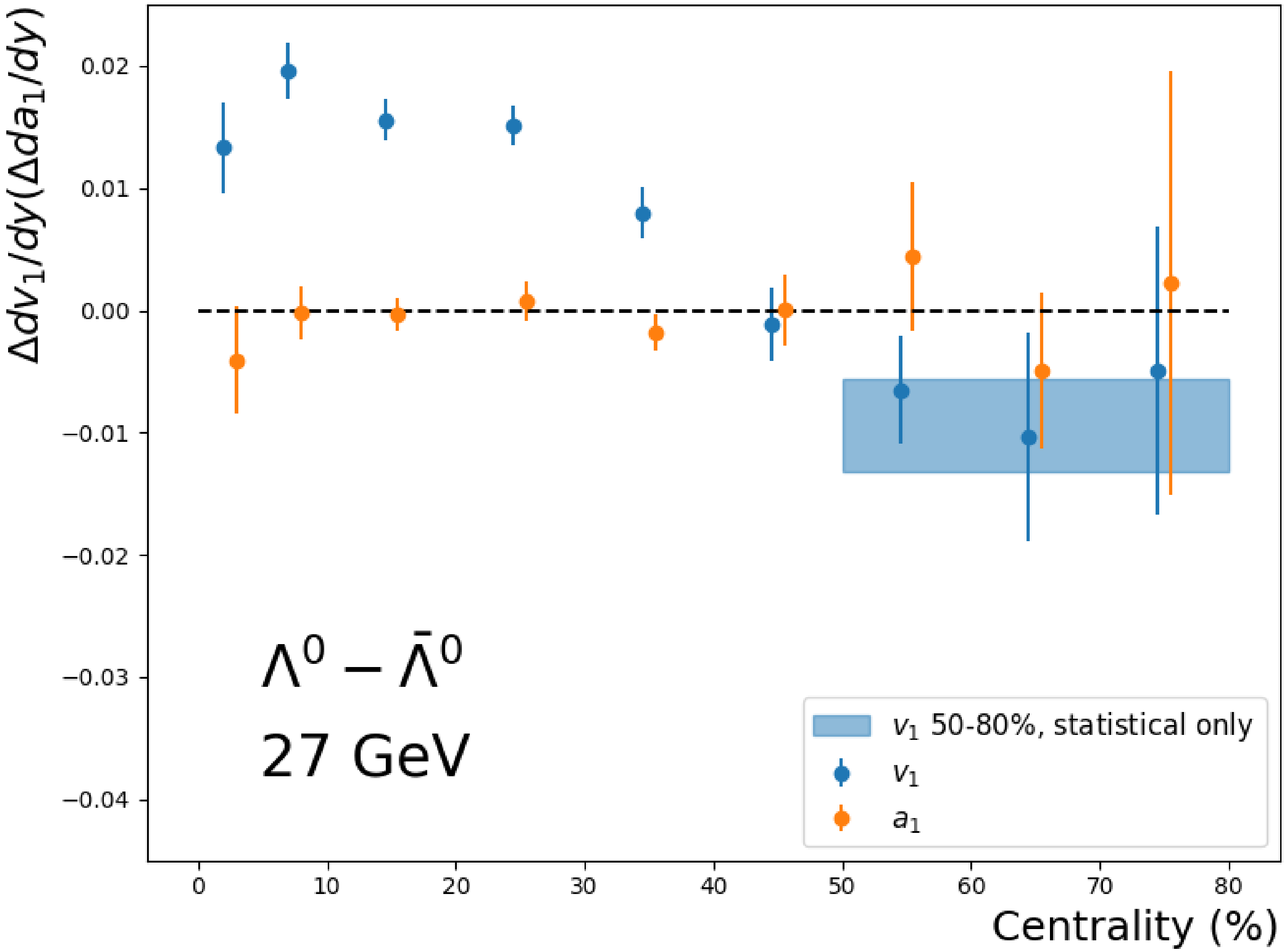
- Fill $\Lambda/\bar{\Lambda}$ invariant mass histograms and v_1 vs. inv. mass profiles in 9 (cen) x 10 (y) x 24 (p_T) = 2160 bins
- After obtaining $\Lambda/\bar{\Lambda}$ reco. efficiencies, for each centrality and y bin, combine the histograms/profiles of each p_T bin using inverse of efficiencies as weights
- Fit inv. mass distribution for each centrality and y bin, then extract v_1 using v_1 vs M_{inv} method.

Error Treatment:

- For combined v_1 profiles after efficiency correction, use original N_{eff} (that is, before efficiency correction) for error calculation.

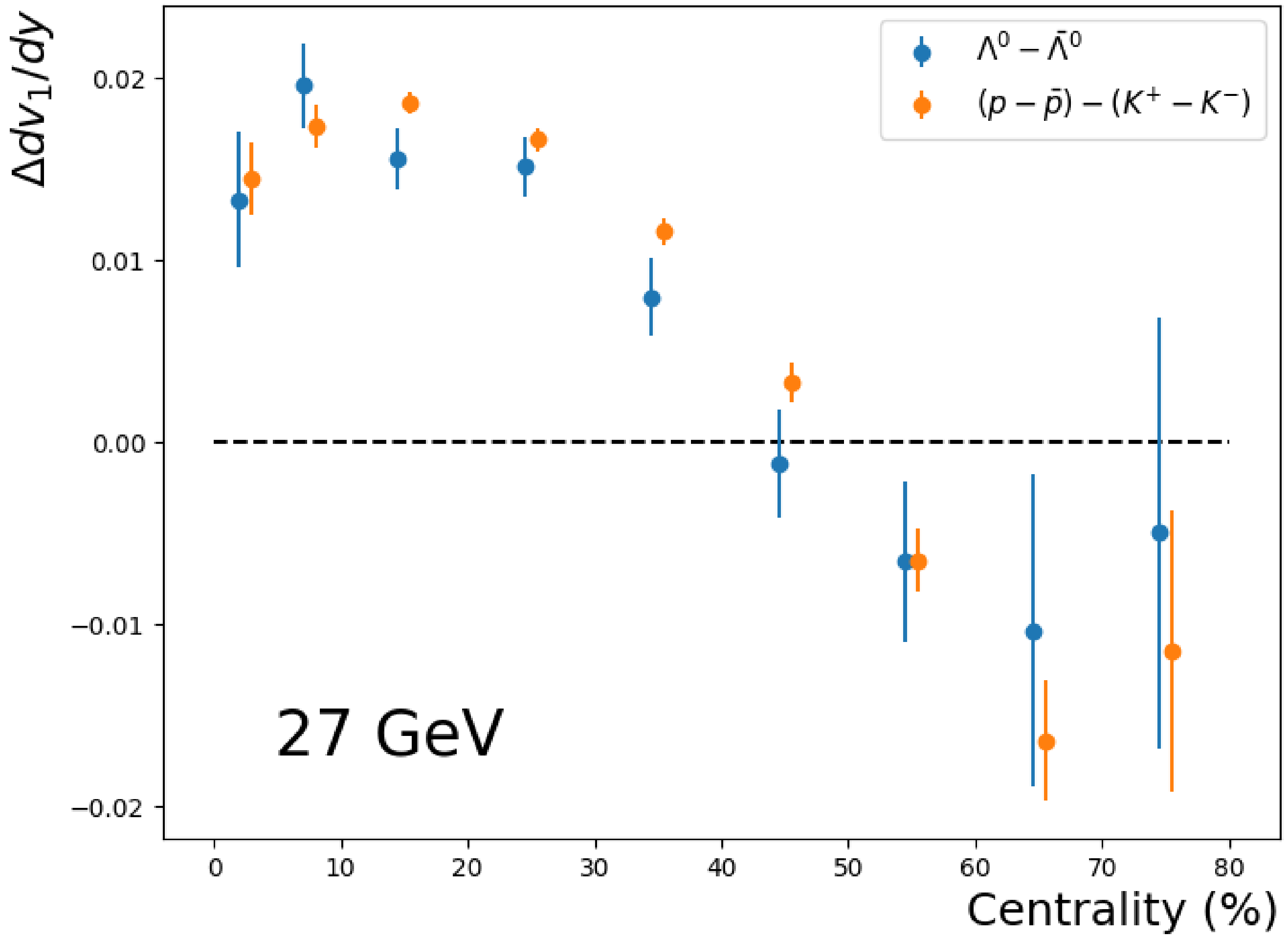


Backup



- $a_1(=< \sin(\phi - \Psi) >)$ splitting serves as a benchmark of residual detector effects. Consistency with 0 suggests proper detector correction
- $\Lambda^0/\overline{\Lambda}^0$ v_1 splitting also shows clear centrality dependence:
  - Affected by transported quarks in central events
  - Significant negative values (2.5σ) in peripheral events, suggesting dominance of Faraday+Coulomb

Backup



- $\Lambda^0/\overline{\Lambda}^0$ v_1 splitting agrees well with the naïve expectation from coalescence sum rule
- Suggests that Λ may also be subject to EM effects created in the QGP due to quark coalescence