Track Crossing Correction

- Motivation
- Analysis Details
- Effect of Pt-ordering
- Identification of bins effected by track crossing
- Elimination of these effected bins by flipping adjacent bins
- Summary plots

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Motivation - Track Crossing and its Effect

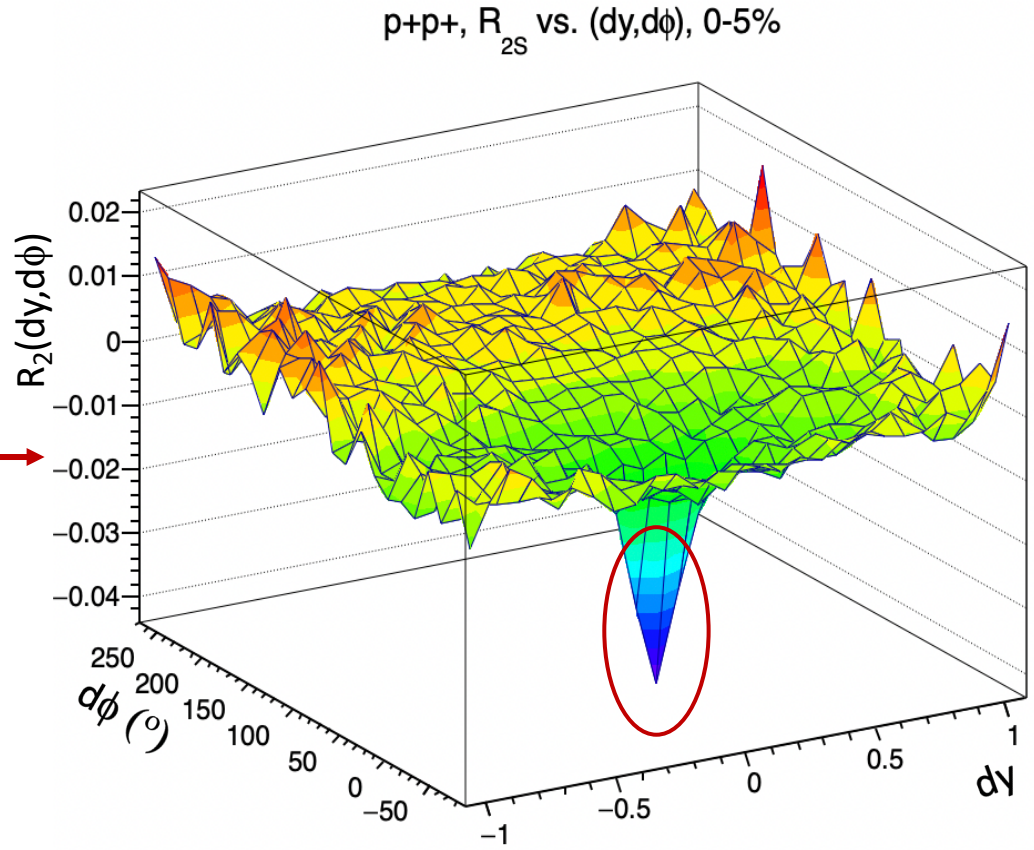
Reason for track crossing:

- BES-I tracking code does not share space-points between track segments.
- Thus some tracks have fewer space points then they should because of a neighbouring pair.
- Imposition of track quality cuts thus results in a pair-inefficiency for nearby particles.
- This causes the crossing "hole" for small (dy, dϕ).
- We can correct for this with standard techniques (Tarini thesis, WSU).

Analysis details:

- First example shown is proton pairs at 27 GeV
- Analysis in |y|<0.5, centrality from primary multiplicity inside 0.5<|η|<1.0 (refmult3)
- Denominator in correlation function (R_2) obtained by mixing 10 events (convolution also being used)

$$R_2(dy,d\phi) = \frac{\rho_2}{\rho_1\rho_1} - 1$$



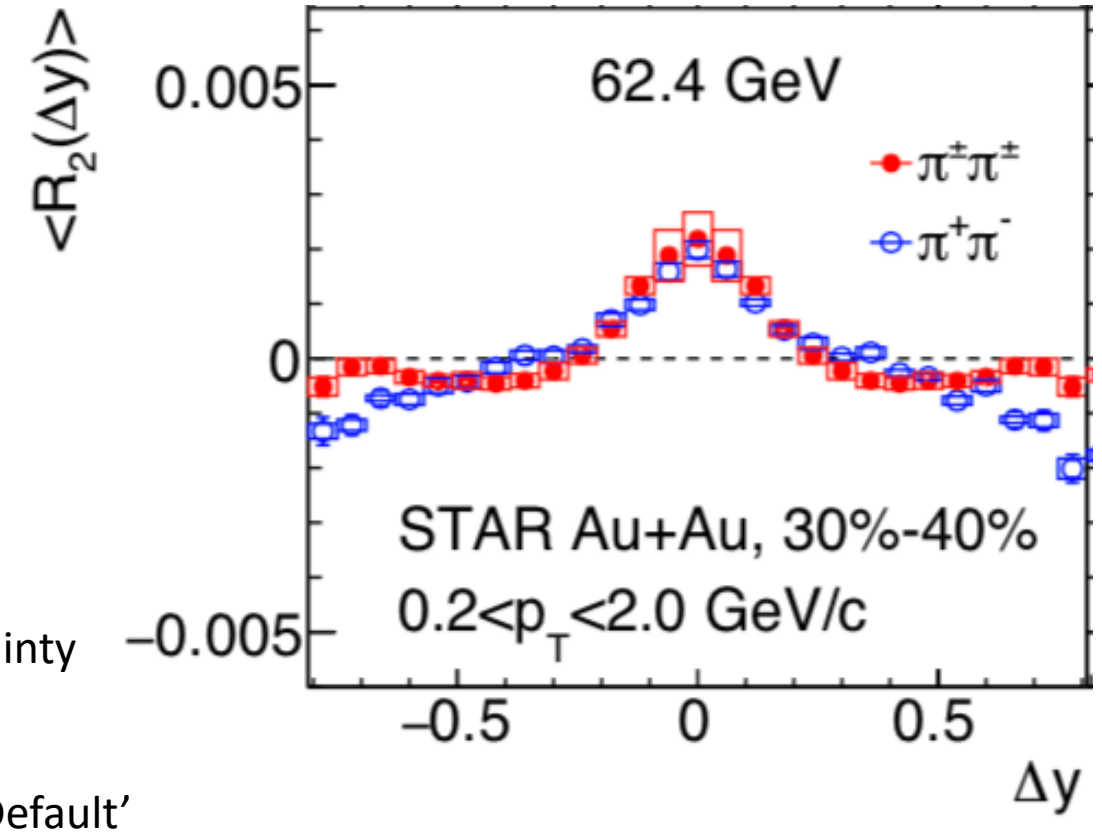
Example: p+p+ for 0-5% centrality of Au-Au collisions at $\sqrt{s_{NN}}$ 27 GeV .

Outline of the Track Crossing Correction Procedure

Brief outline of the procedure:

- Use pT-Ordering (Tarini thesis, WSU) to put all crossing pairs on same side of $d\phi = 0$.
- Detected the bins that need to be flipped/reflected.
- Flipped clean bins from the other side of the hole.

STAR (S. Jowzaee), Phys. Rev. C **101**, 014916 (2020)



The need to correct for crossing introduces systematic uncertainty which we evaluate using different correction approaches.

- A default minimal but complete correction is defined as 'Default'
- An extended correction region (also a complete correction) is also defined and called 'Default+'

Track Crossing Effect and PT - Ordering

Not all particles that are near each other “cross”.

- Cases **A** and **C** in the fig. do not show TC (track crossing) but cases **B** and **D** do show TC depending on the charge and p_T of the particle.

- pt-order each pair to move the hole on one side of dϕ=0 for LS (like sign) pairs and ULS (unlike sign) pairs:
  - LS positive (e.g. p+p+) : dϕ = -dϕ if dpt>0
  - LS negative (e.g. p-p-) : dϕ = -dϕ if dpt<0
  - ULS plots do not require pt-ordering.

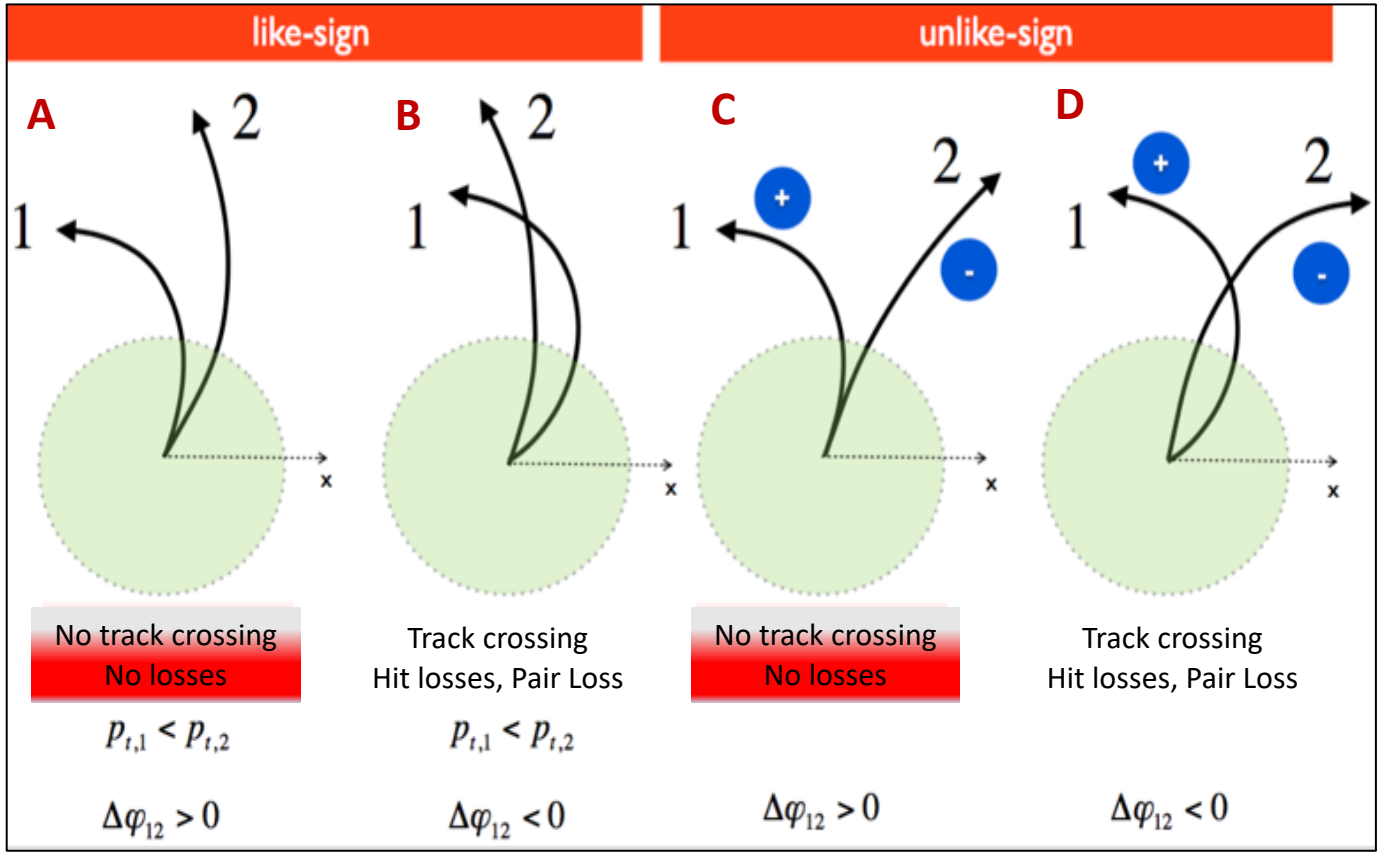


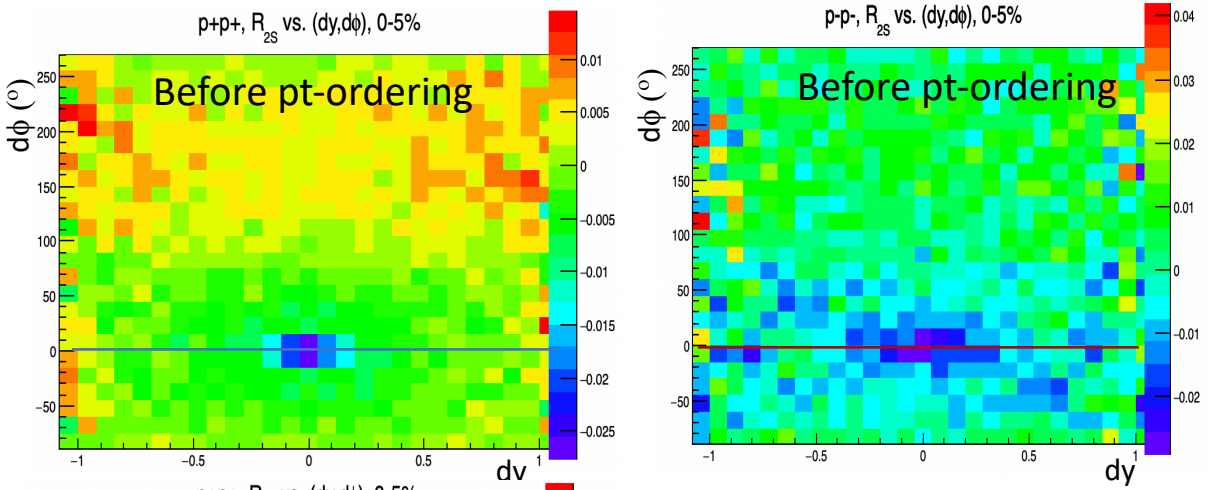
Image from P. Pujahari

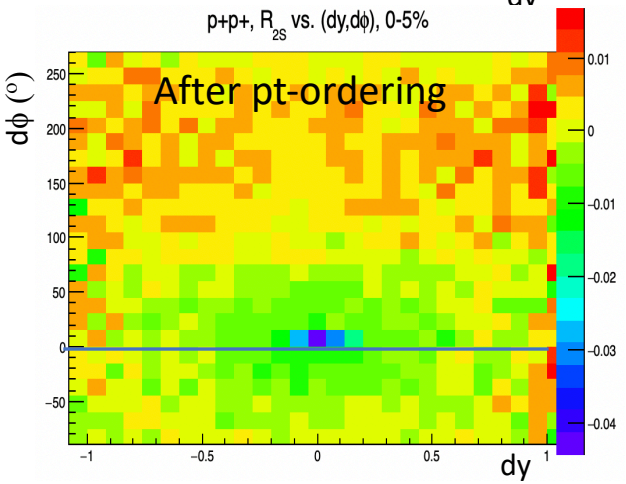
Effect of PT-ordering

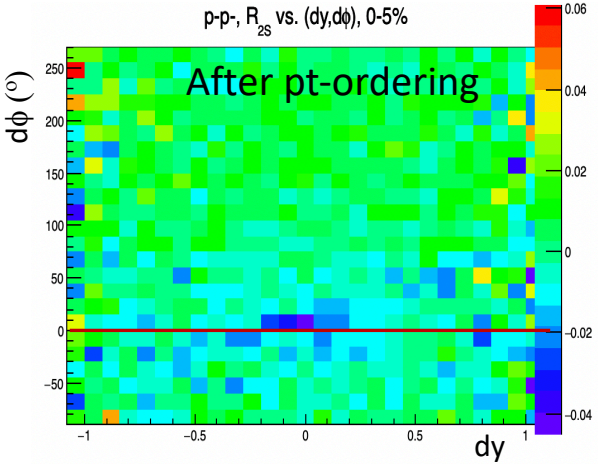
p_T - ordering applied to bring the affected region on one side of dϕ = 0 for like signs and unlike signs.

Like sign: Affected region is brought just above dϕ = 0.
Unlike sign: Affected region is brought just below dϕ = 0.

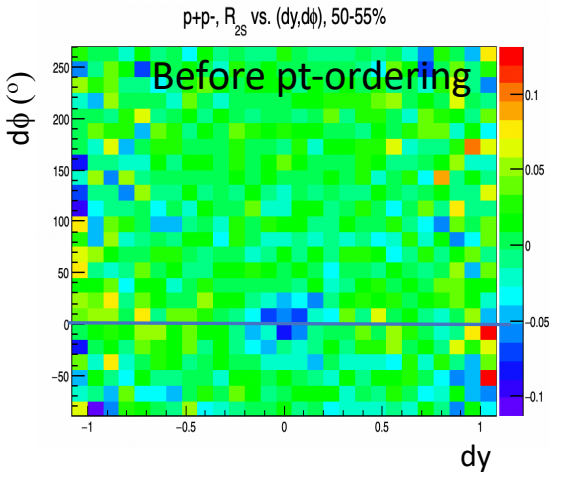
LS (p+p+ and p-p-)

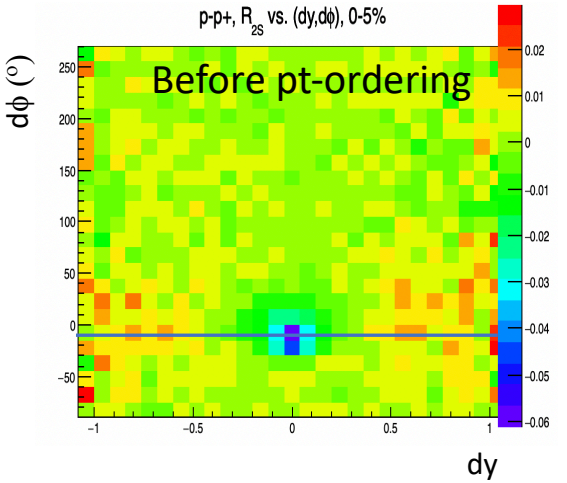


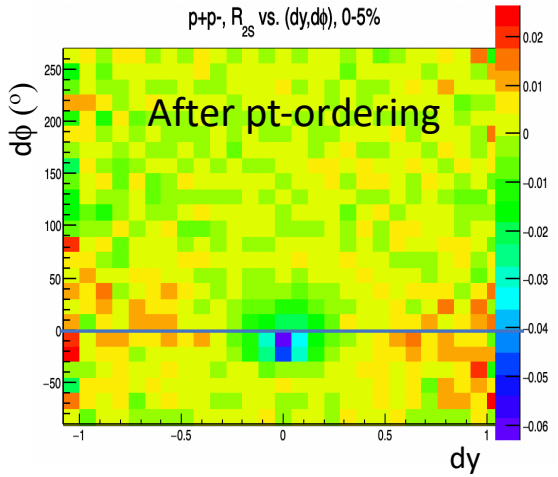


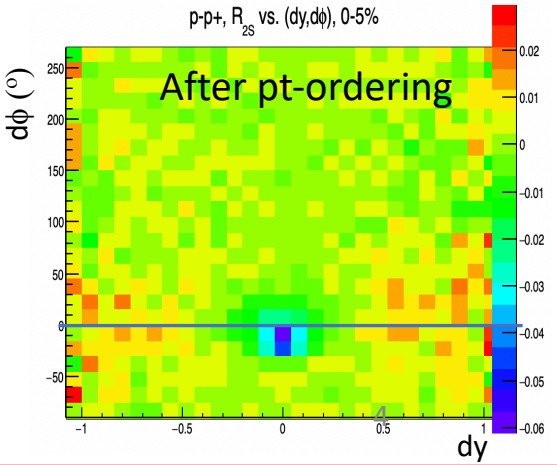


ULS (p+p- and p-p+)







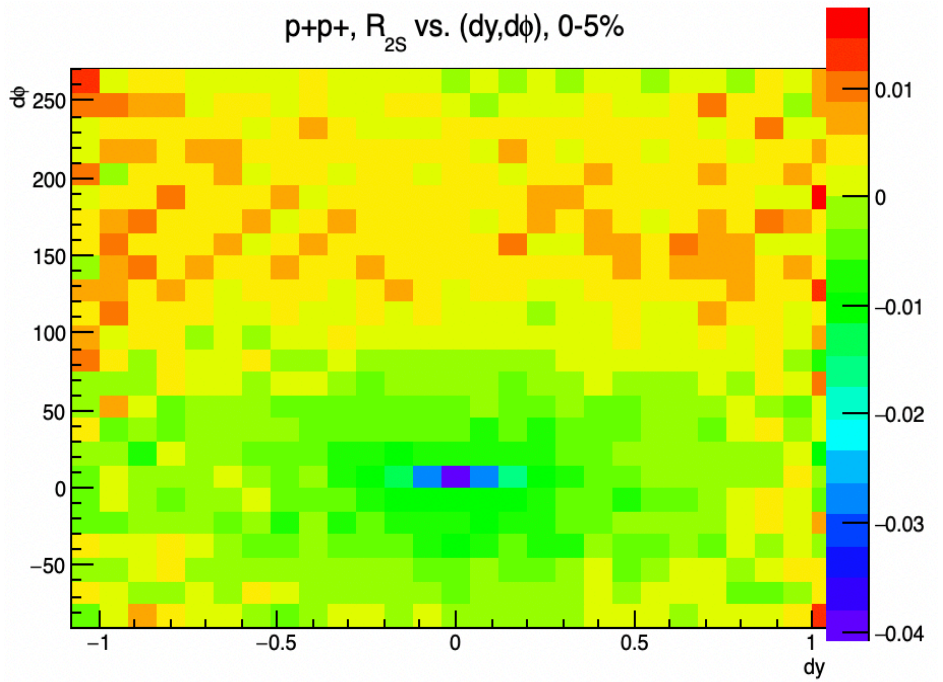


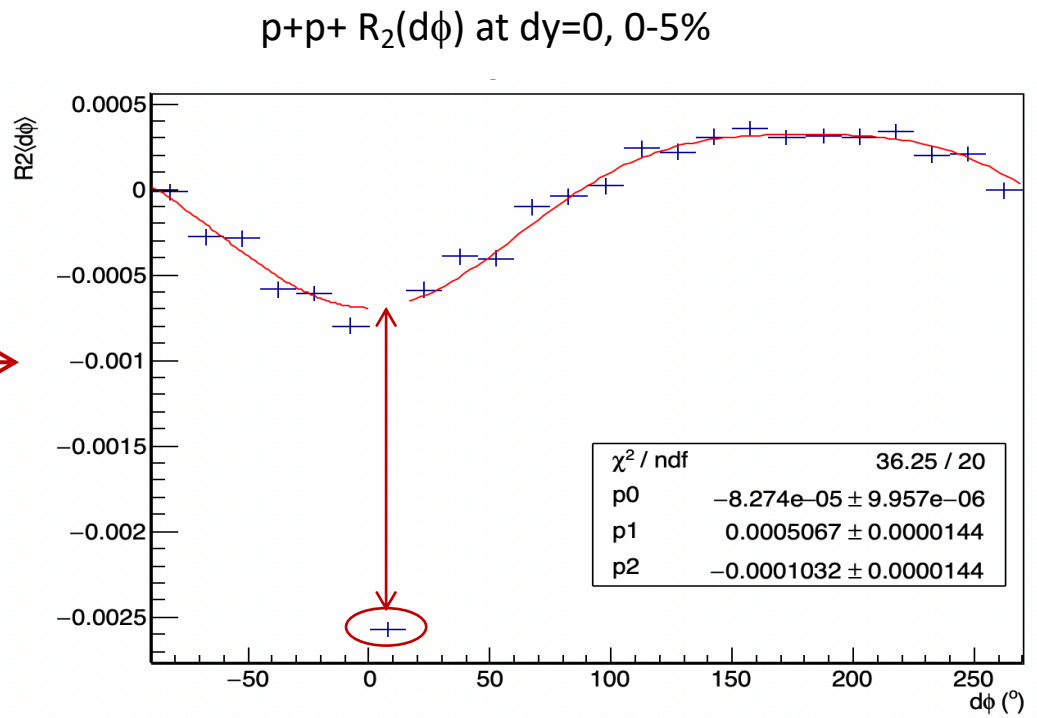
Identification of bins effected by TC

- Fitted the two-particle correlation function $R_2(d\phi)$ for the slice corresponding to dy=0 using the function **$p_0 - p_1 \cos(d\phi) + p_2 \cos(2d\phi)$** (rejecting the point at $d\phi$=0) . The **only goal of this fit** is to get rid of contributions from momentum conservation (-cos($d\phi$)) and elliptic flow (cos(2$d\phi$)) to guide the eye for detecting the crossing hole.

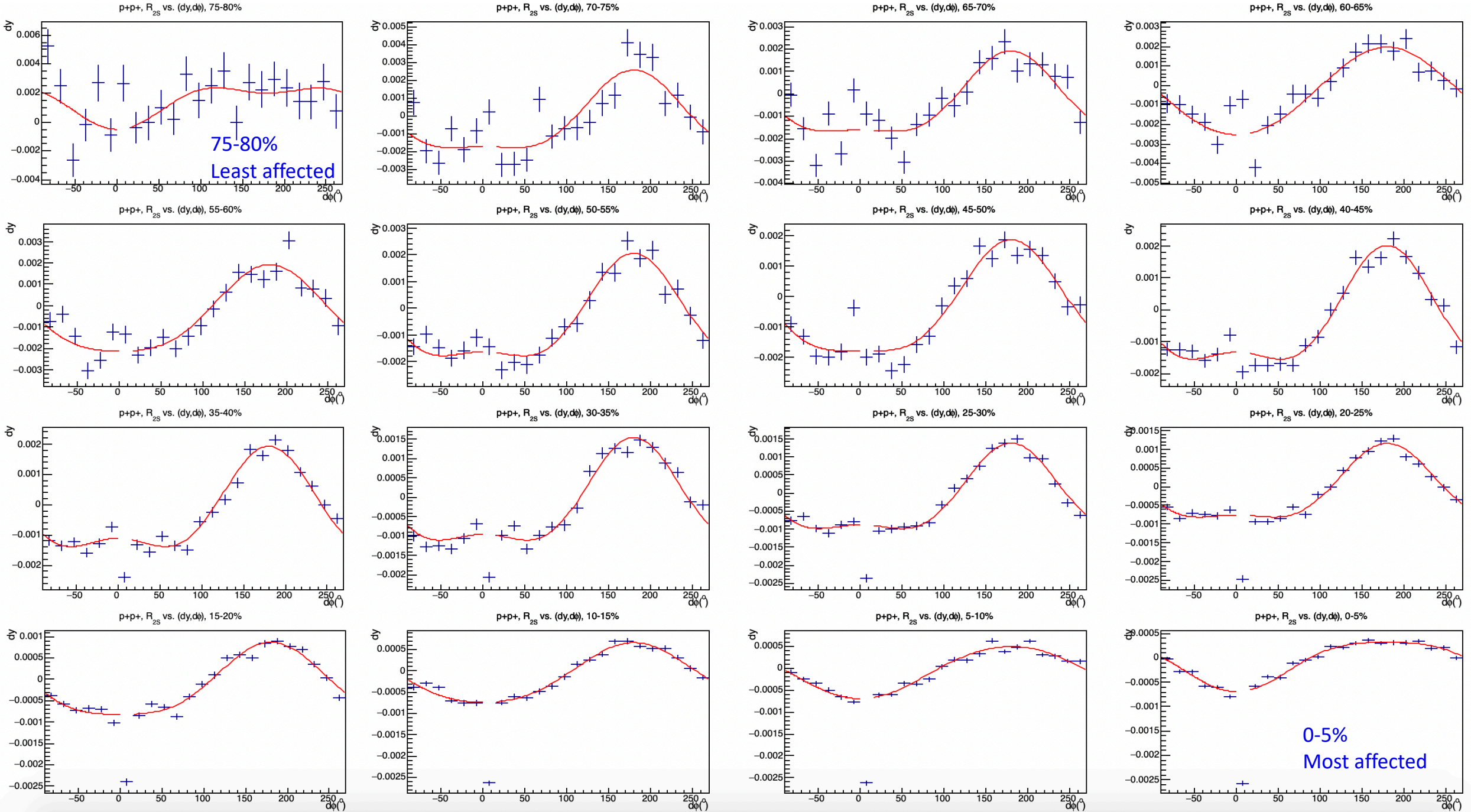
- Repeated these fits *vs* $d\phi$ in other dy bins to capture full range of hole in the relative rapidity direction.

Example: Range is |dy|< 0.06 and 0° < $d\phi$ < 15°.



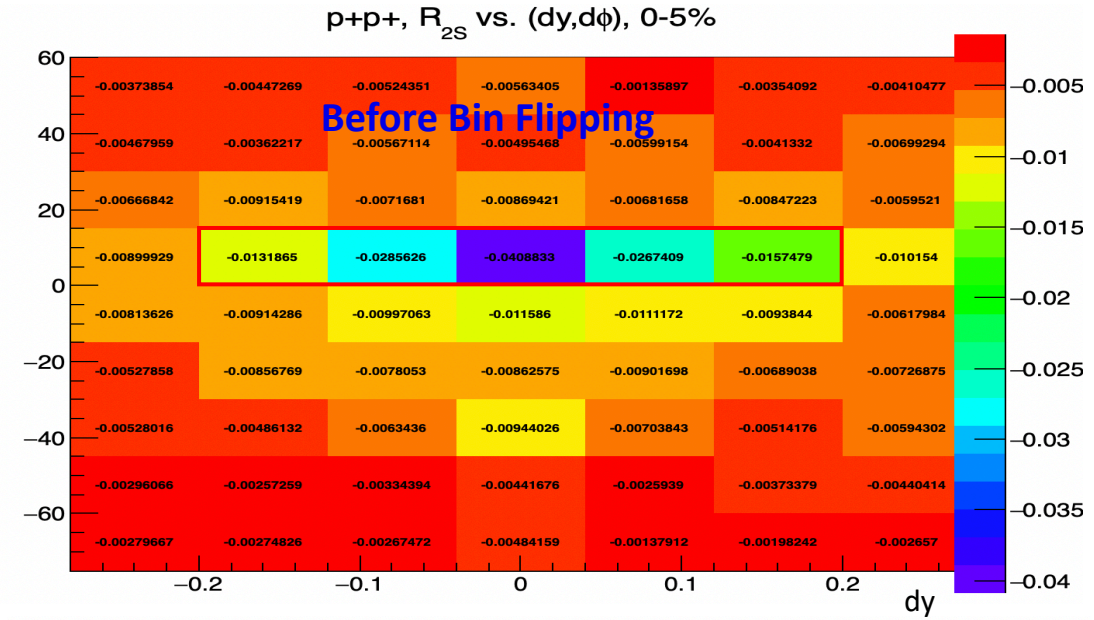


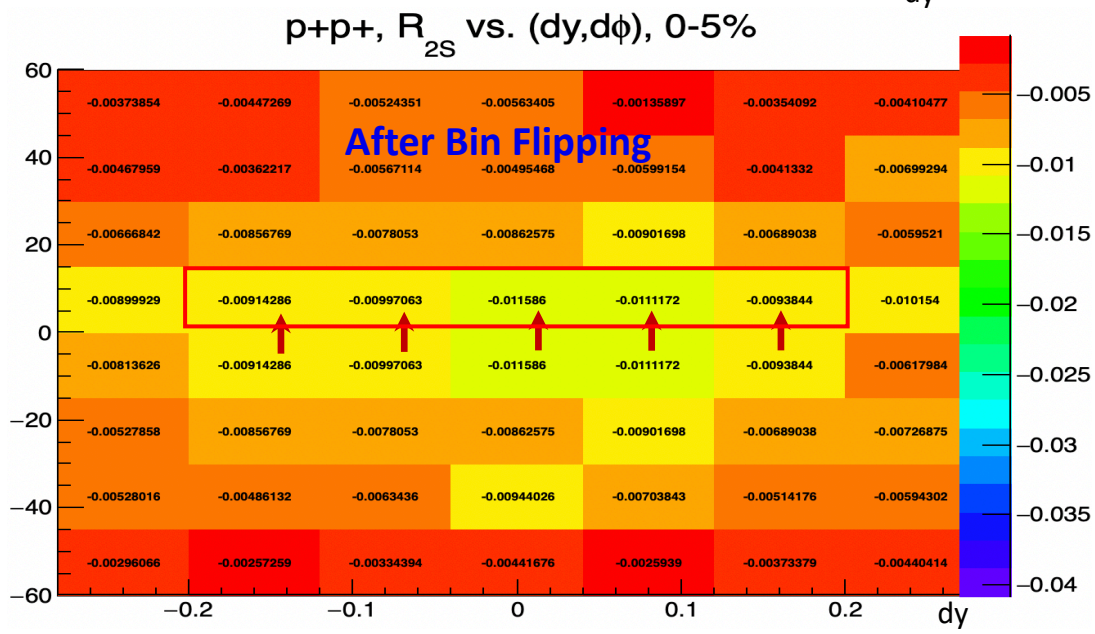
Depth of hole for different centralities



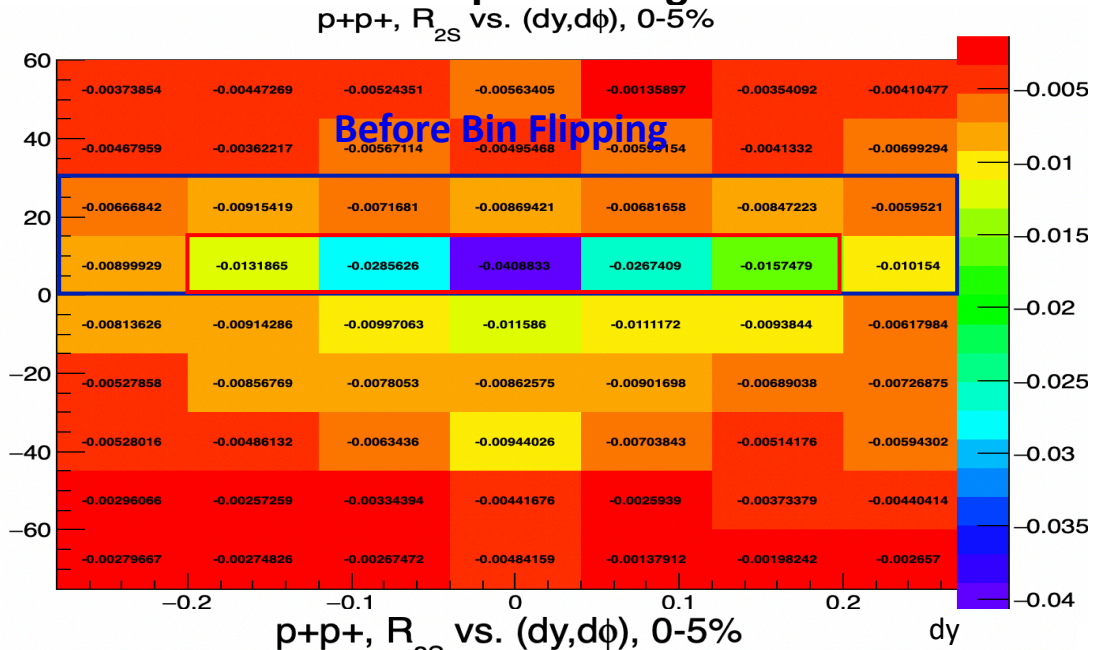
Bin Flipping: Like Signs

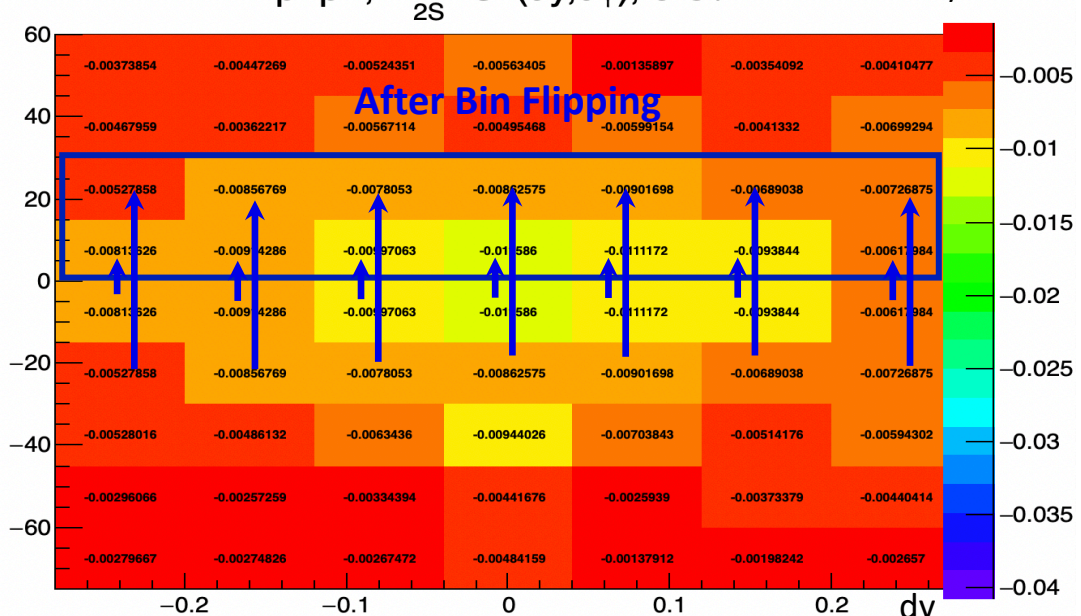
Default flip – Like Sign



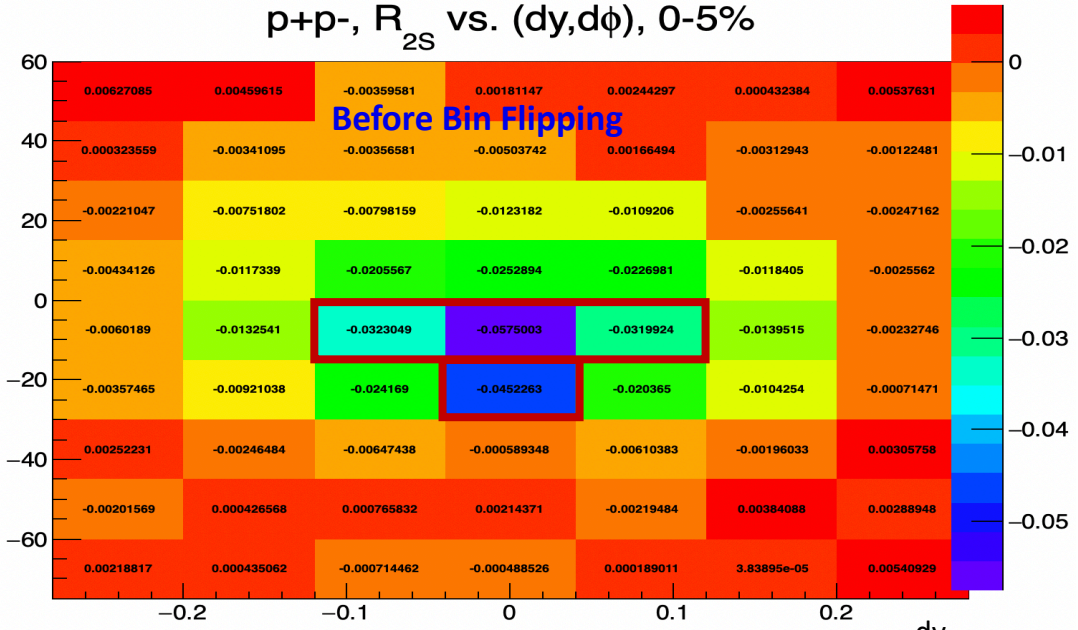


Default+ flip – Like Sign

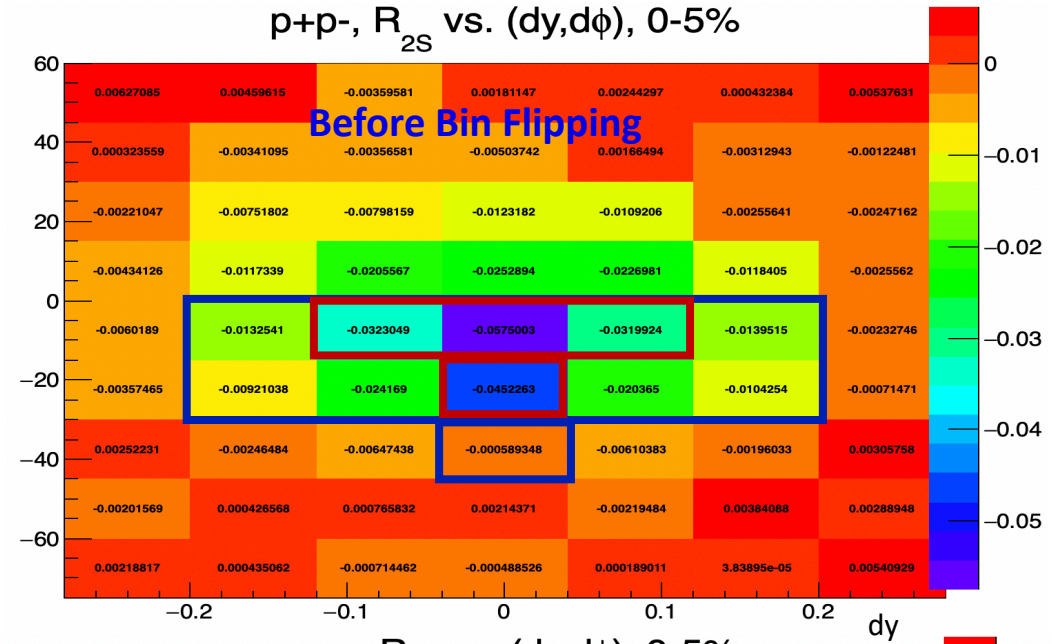


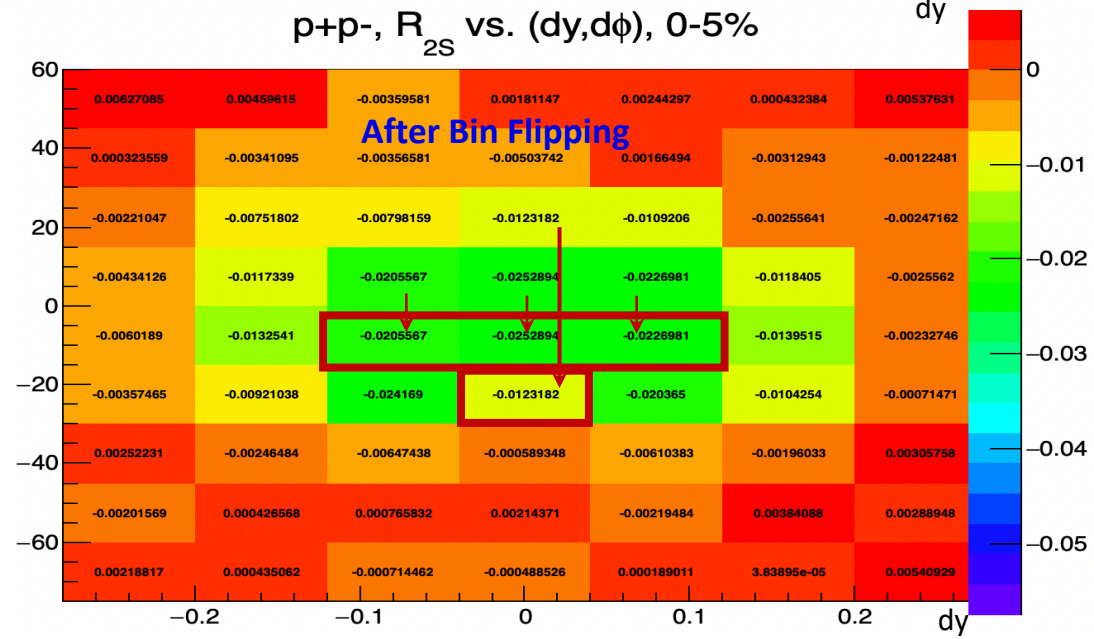


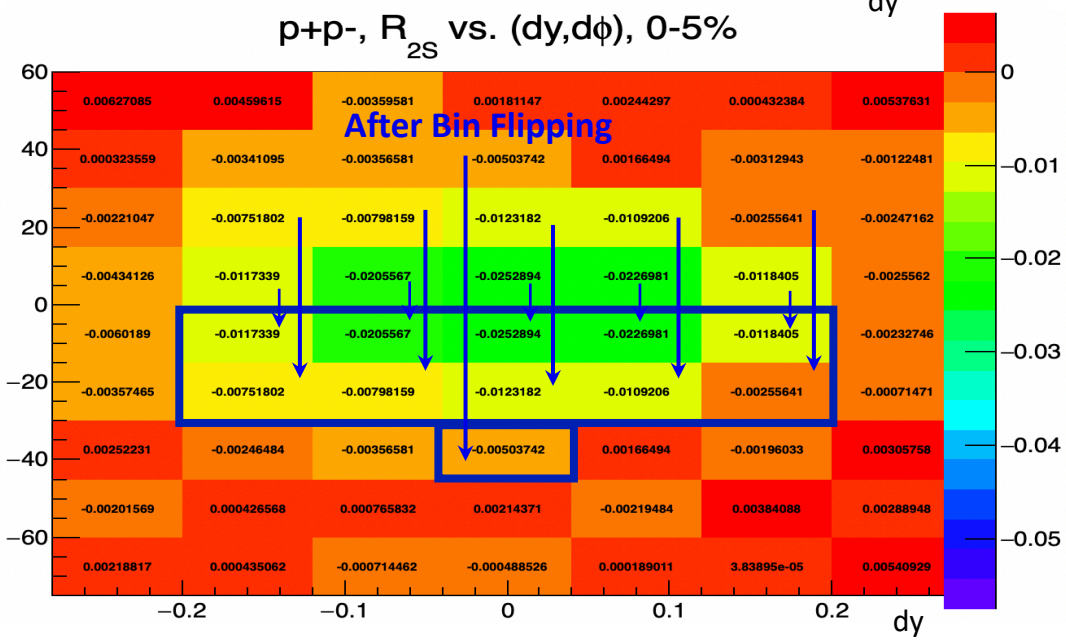
Bin Flipping – Unlike Sign



Default+ flip – Like Sign

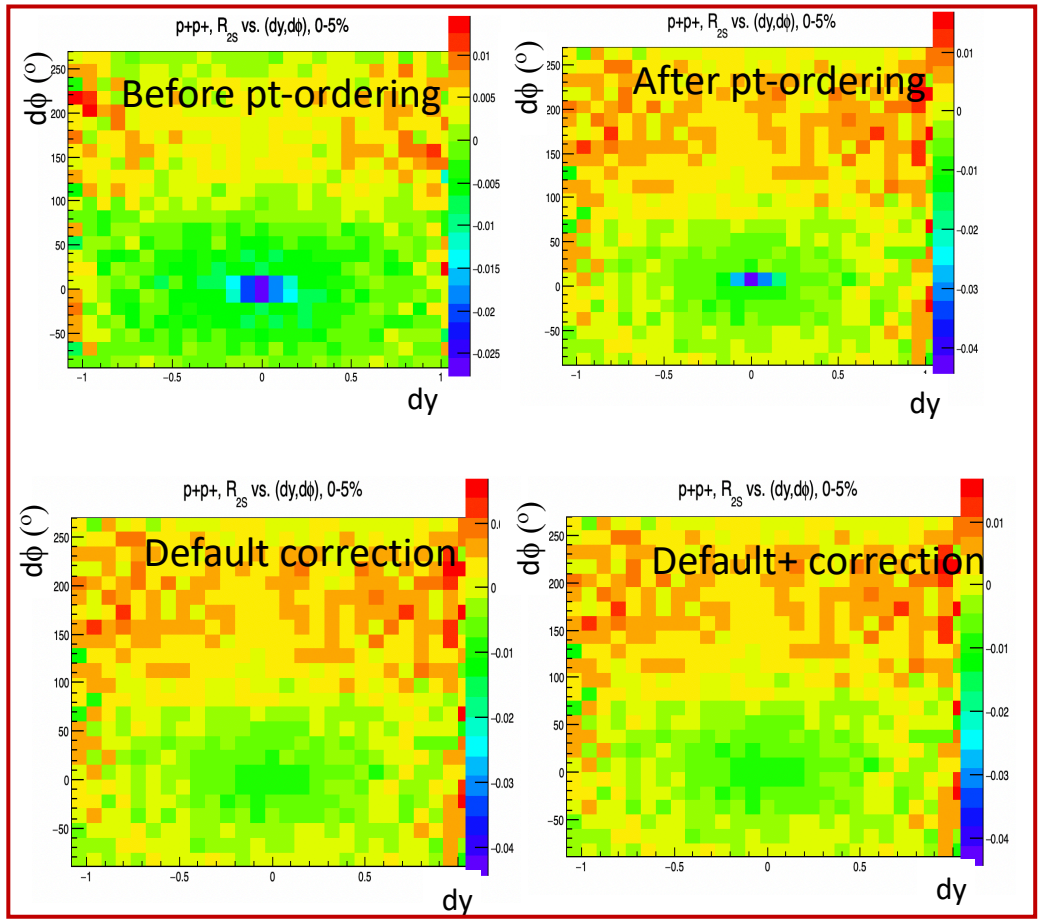




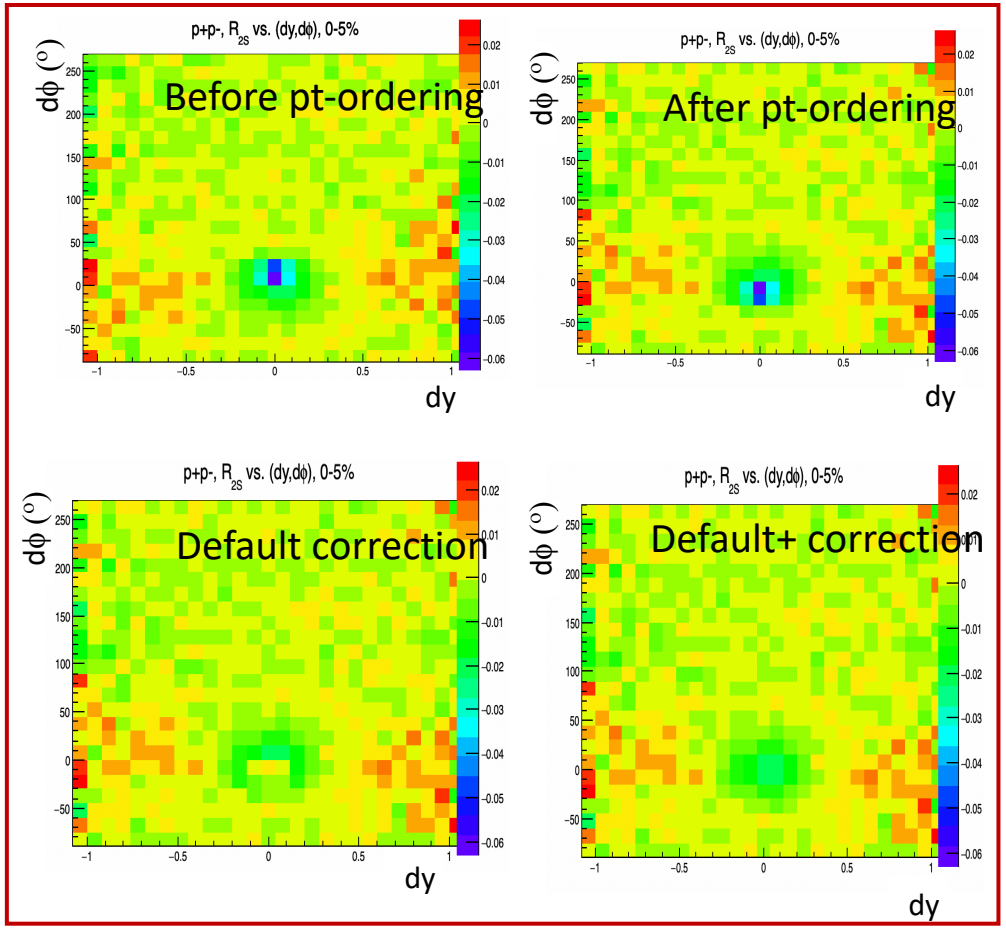


Comparison of $R_2(dy,d\phi)$ before and after correction

LS (p+p+)



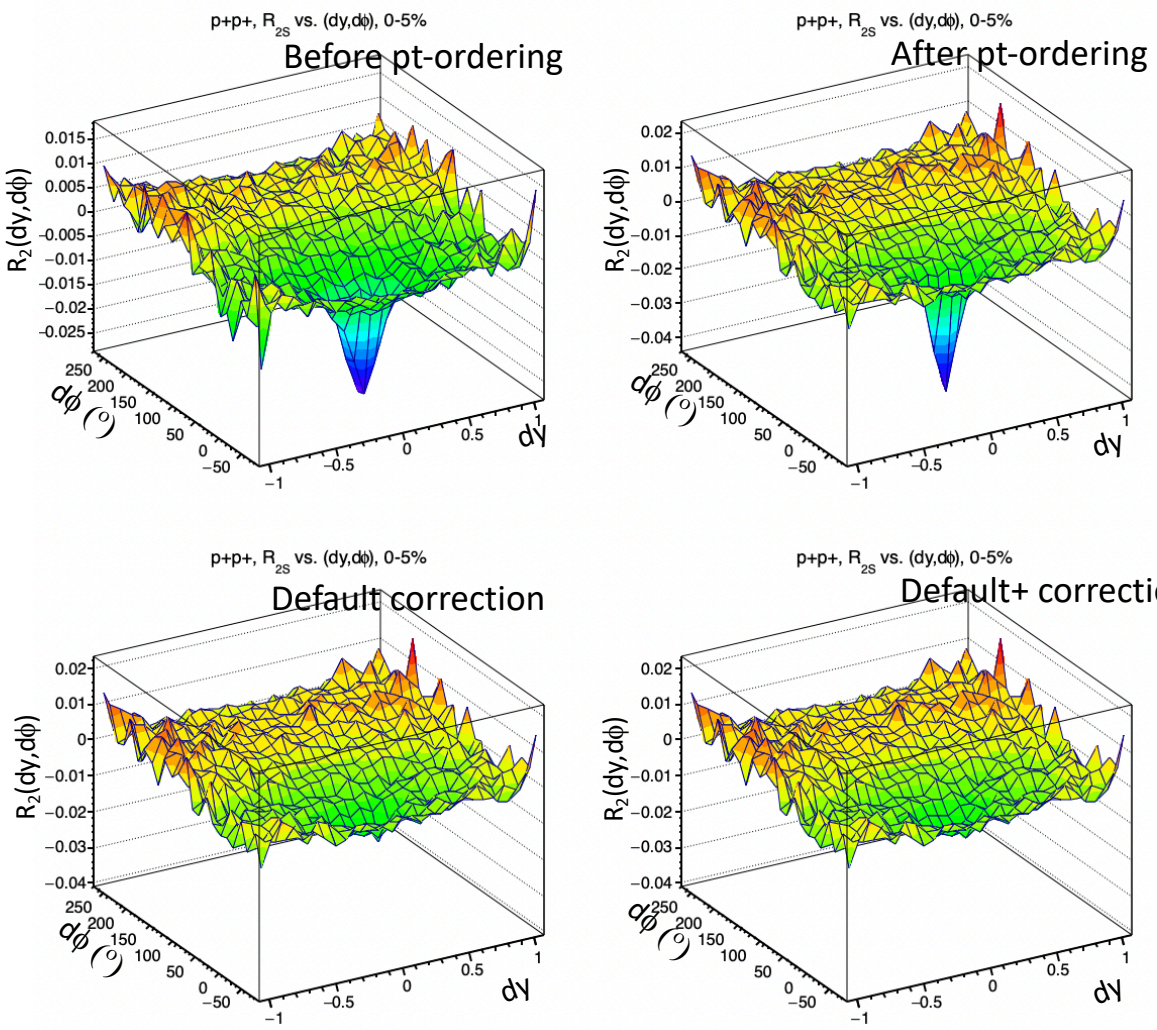
ULS (p+p-)



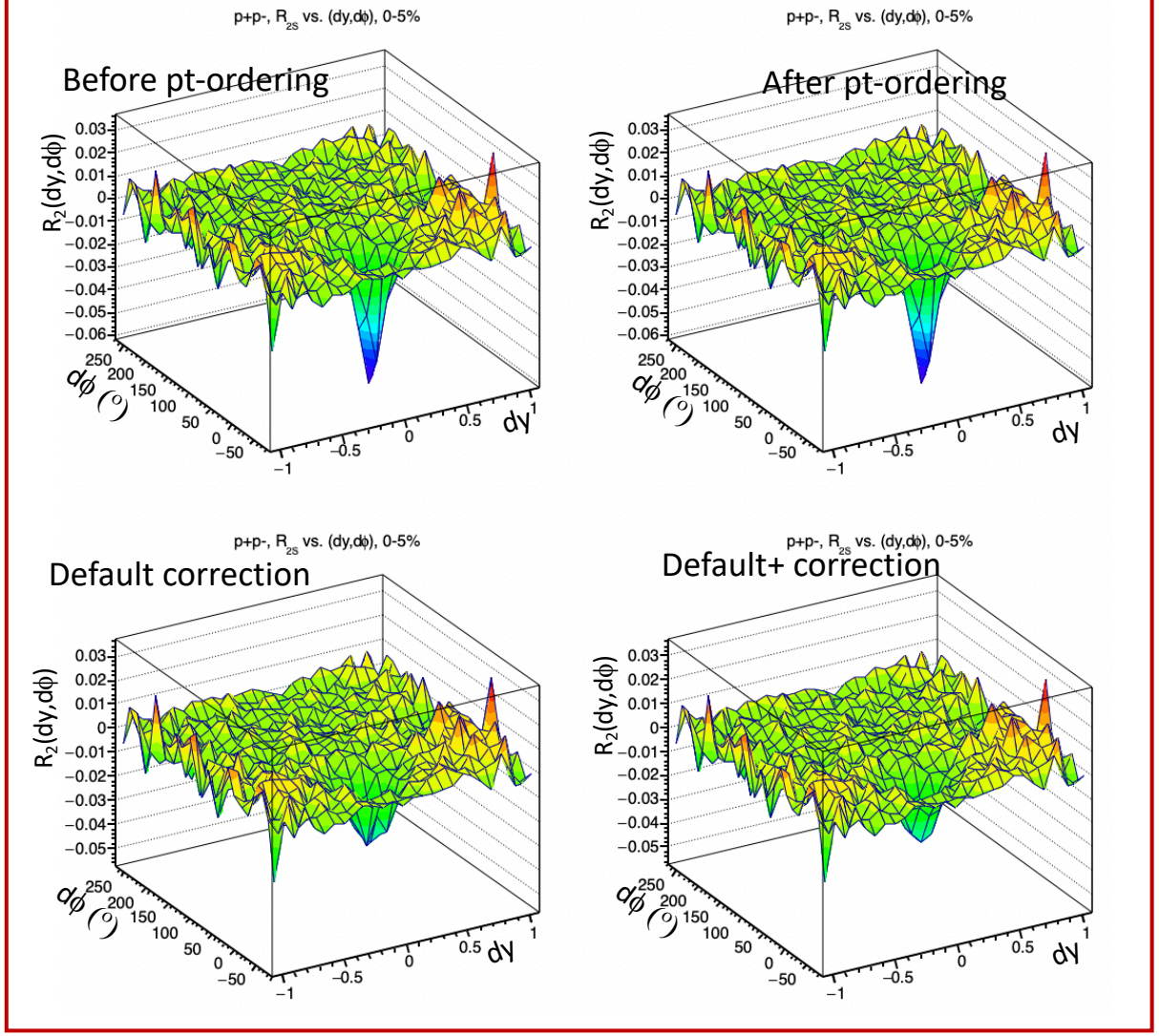
- Crossing hole in top row plots clearly fixed.
- Slight differences in bottom row plots are a component to the systematic uncertainty

Comparison of $R_2(dy,d\phi)$ before and after correction

LS (p+p+)

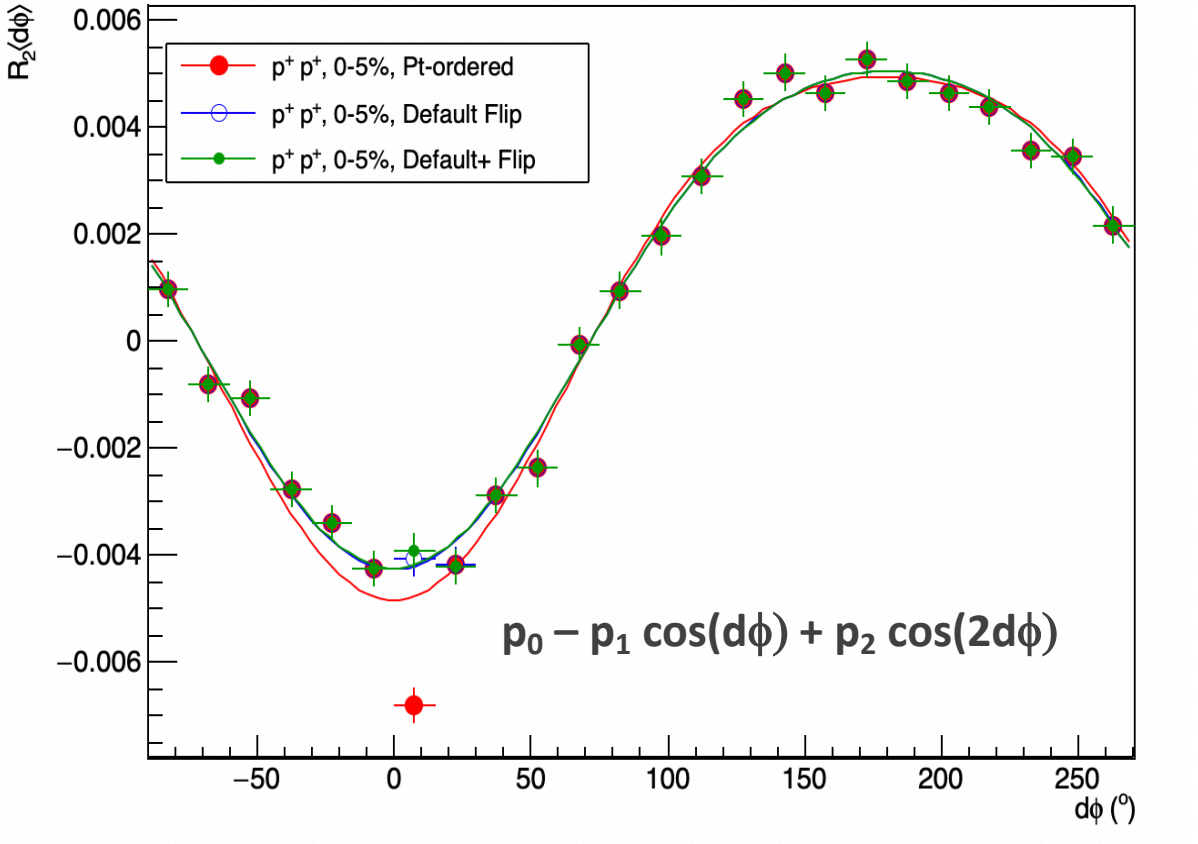


ULS (p+p-)

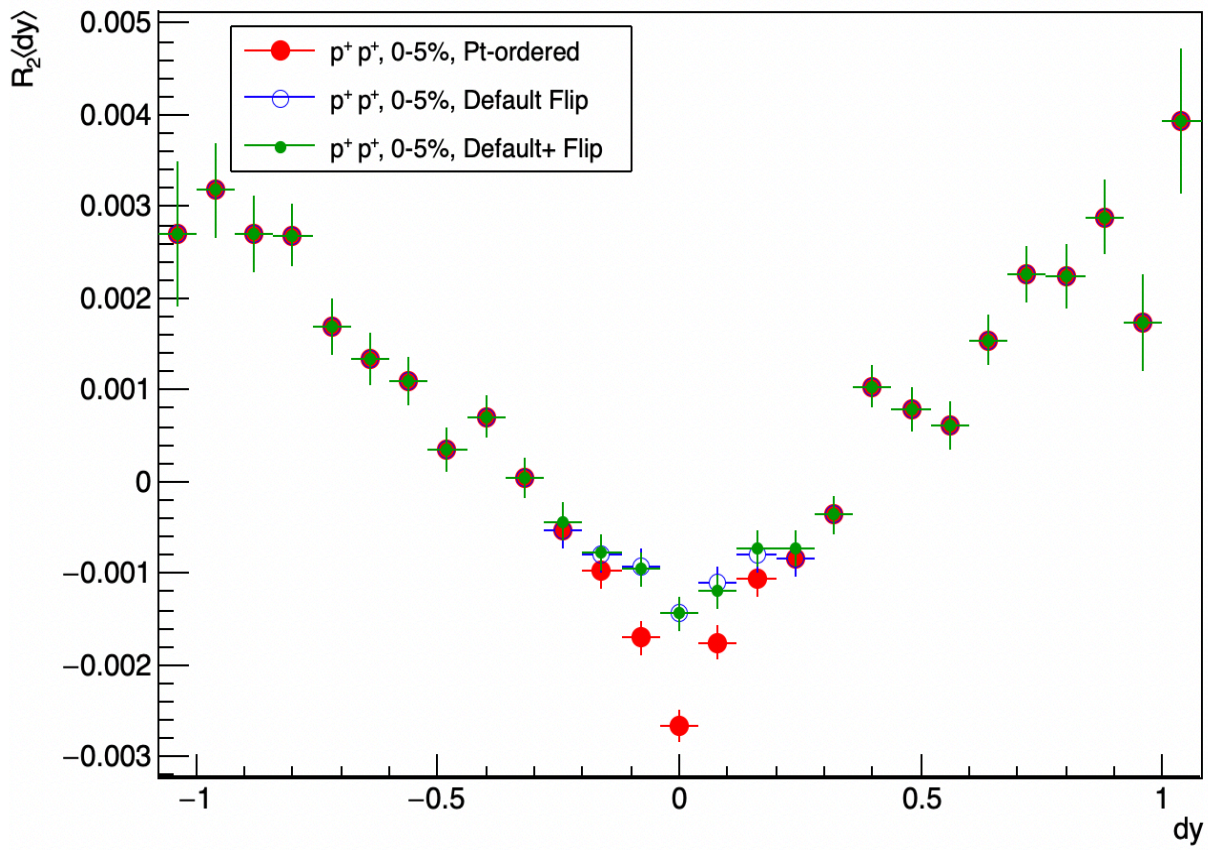


$R_2(d\phi)$ and $R_2(dy)$ – all cases overlaid for 0-5% centrality p+p+

$R_2(d\phi)$



$R_2(dy)$



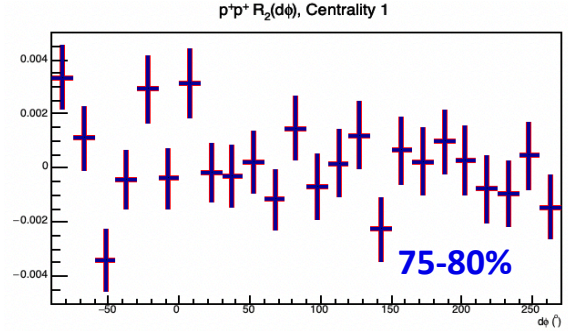
Projections before and after the corrections look better.
Good agreement of our results with Ayeh's published values.

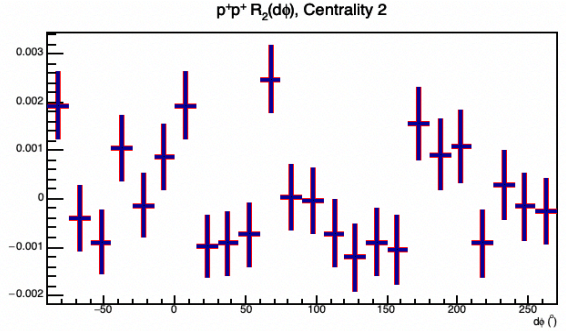
Summary table for new flip class for protons listing the range of dy, dϕ

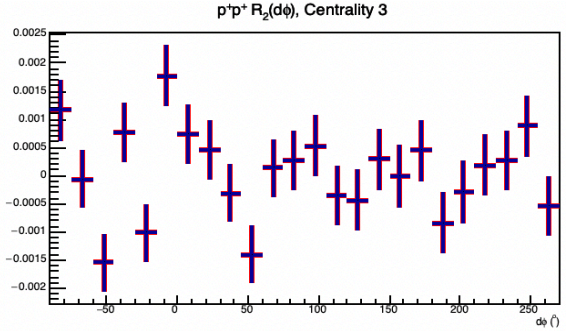
Pair-type	All Beam Energy - 27 dy bins and 24 dϕ bins						
	7.7 GeV	11.5 GeV(s)	14.5 GeV(s)	19.6 GeV(s)	27 GeV(s)	39 GeV(s)	62.4 GeV
p+p+	30-35%, |dy|<0.12 $0^o < d\phi < 15^o$	40-45%, |dy|<0.12 $0^o < d\phi < 15^o$	25-30%, |dy|<0.12 $0^o < d\phi < 15^o$	35-40% |dy|<0.12 $0^o < d\phi < 15^o$	35-40%, |dy|<0.2 $0^o < d\phi < 15^o$	35-40%, |dy|<0.2 $0^o < d\phi < 15^o$	40-45%, |dy|<0.12 $0^o < d\phi < 15^o$
p+p-	10-15%, |dy|<0.12 $-15^o < d\phi < 0^o$	35-40%, dy<0.04 $-15^o < d\phi < 0^o$	55-60%, |dy|<0.12 $-15^o < d\phi < 0^o$	70-75%, |dy|<0.12 $-30^o < d\phi < 0^o$	60-65%, |dy|<0.12 $-30^o < d\phi < 0^o$	60-65%, |dy|<0.12 $-30^o < d\phi < 0^o$	65-70%, |dy|<0.12 $-30^o < d\phi < 0^o$
p-p+	No crossing	45-50%, |dy|<0.12 $-30^o < d\phi < 0^o$	50-55%, |dy|<0.12 $-30^o < d\phi < 0^o$	65-70%, |dy|<0.12 $-30^o < d\phi < 0^o$	70-75%, |dy|<0.2 $-30^o < d\phi < 0^o$	60-65%, |dy|<0.12 $-30^o < d\phi < 0^o$	65-70%, |dy|<0.12 $-30^o < d\phi < 0^o$
p-p-	No crossing	No crossing	No crossing	10-15%, |dy|<0.04 $0^o < d\phi < 15^o$	20-25%, |dy|<0.12 $0^o < d\phi < 15^o$	30-35%, |dy|<0.12 $0^o < d\phi < 15^o$	30-35%, |dy|<0.12, $0^o < d\phi < 15^o$

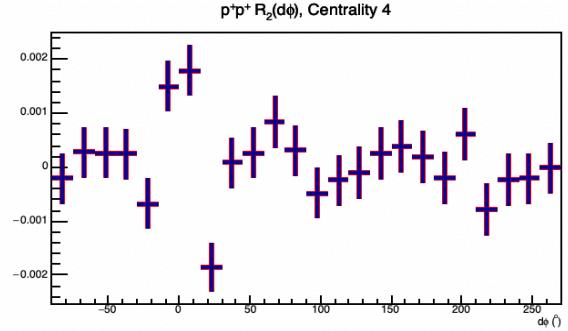
Summary table used as reference to write a class to perform these corrections for all energies and pair types.
Other tables exist for other pair types (not shown here).

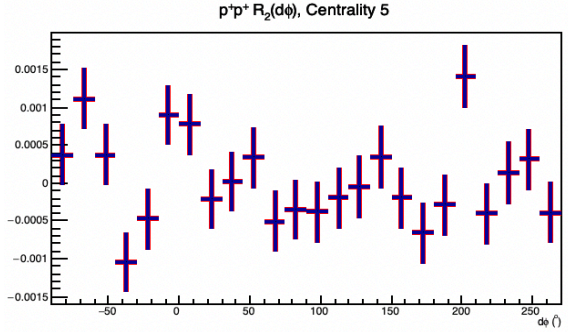
Residual of fitted slices of R2(dϕ) at dy=0 (pt-ordered in red and default correction in blue)

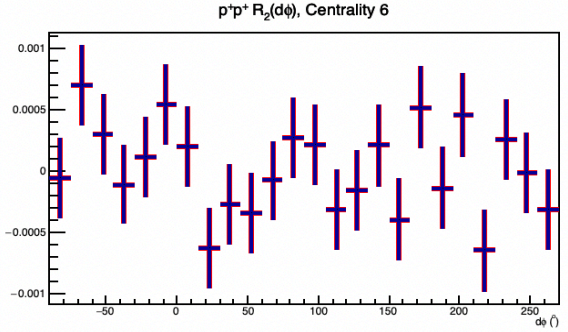


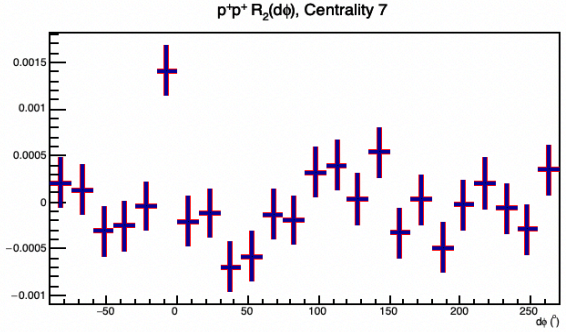


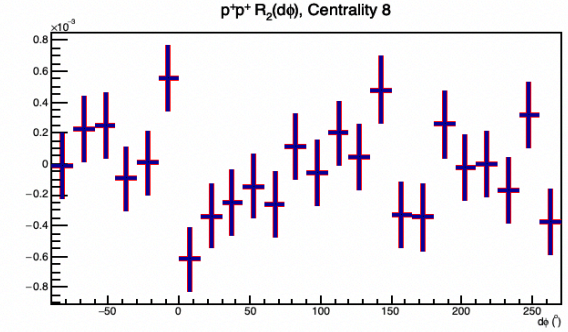


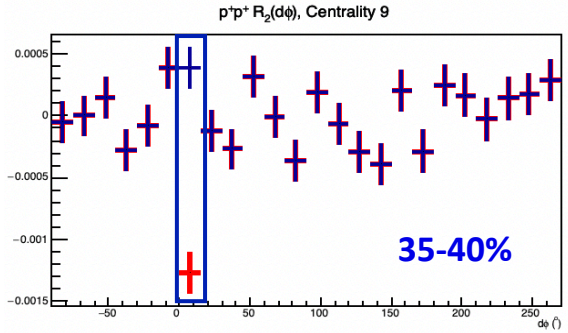


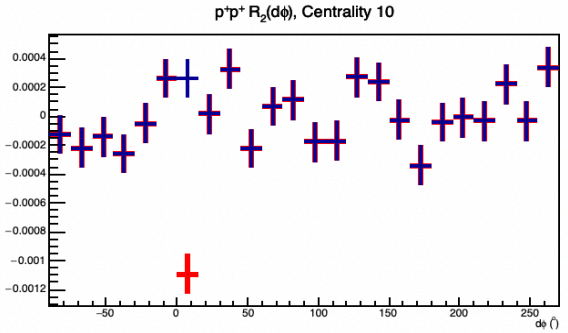


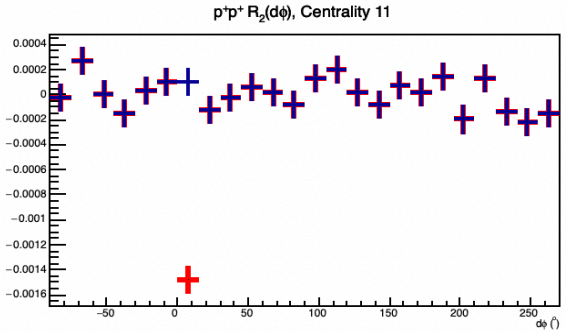


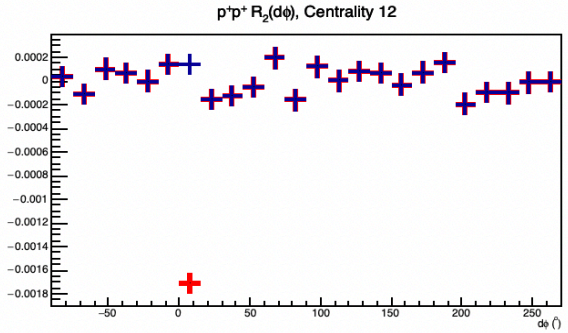


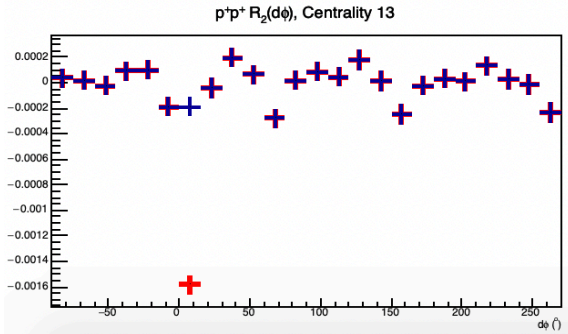


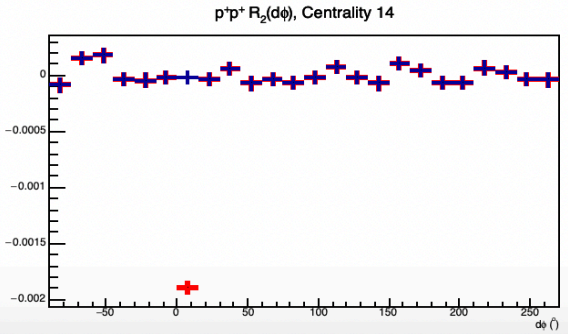


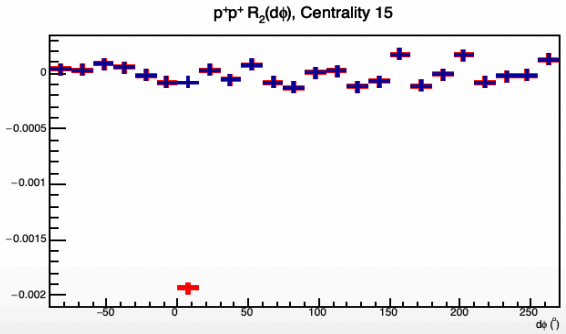


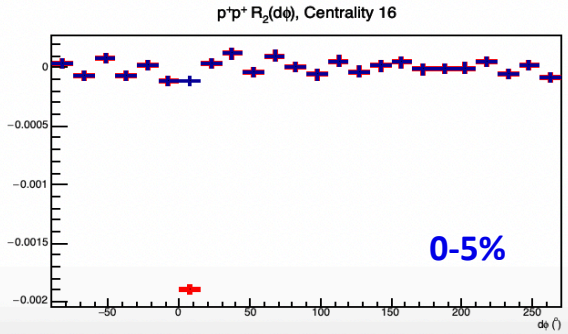












Charge combinations of Kp, Kπ and pπ compared before and after track correction (27 GeV for 0-5% centrality)

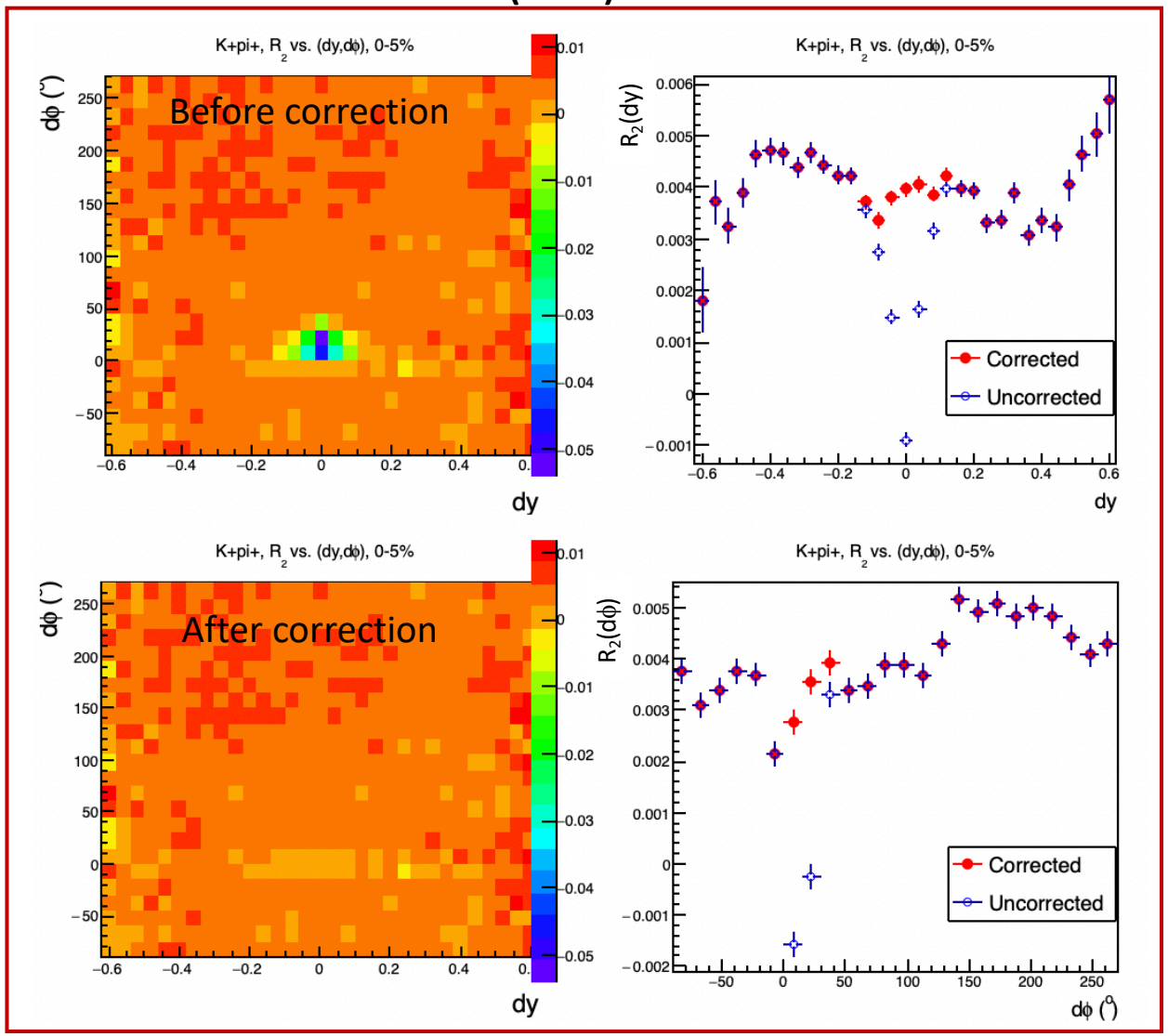
All these charged pair combinations are being studied by Launa di Carlo to measure the balance function.

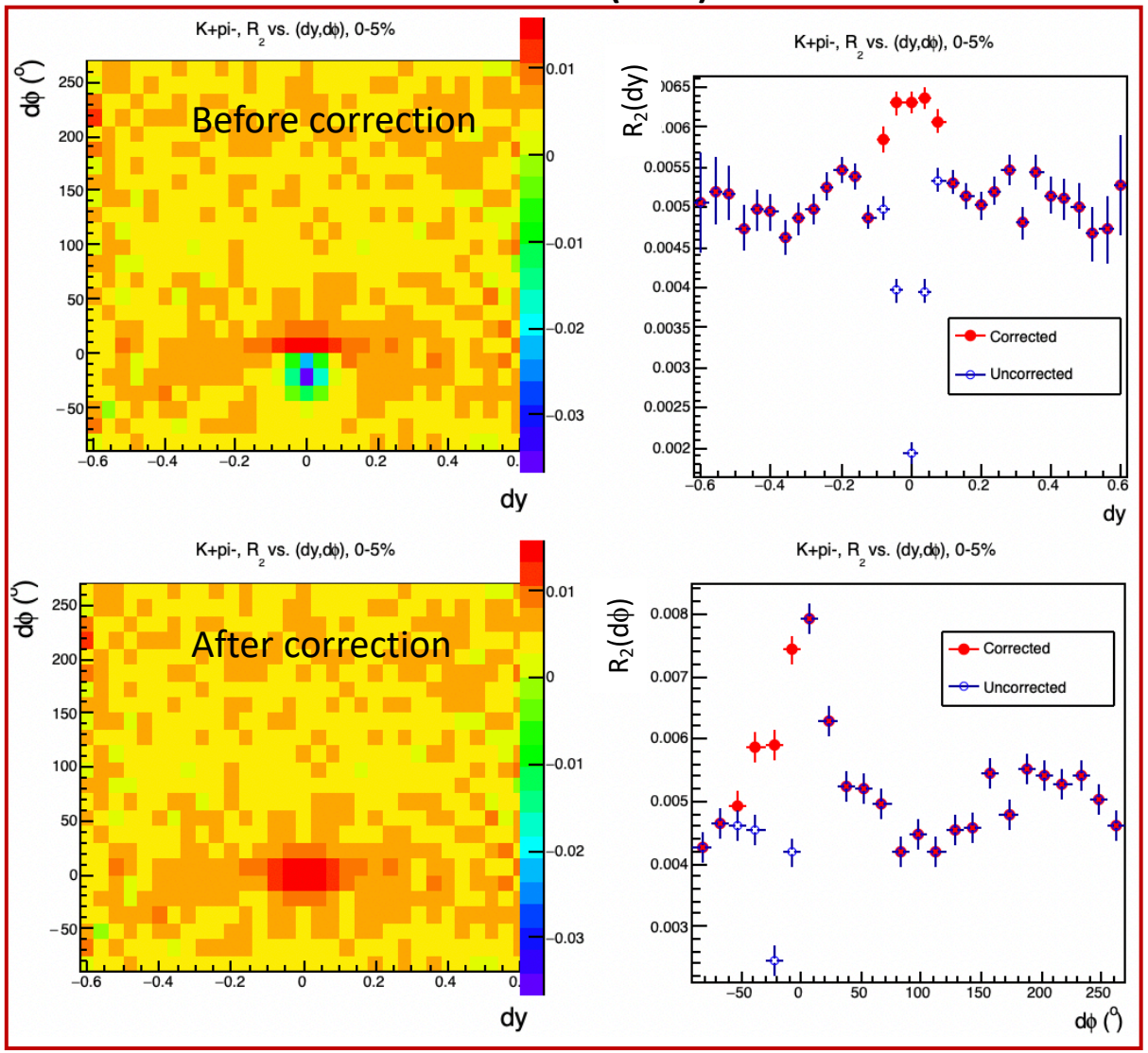
R2(dy,dϕ) 27 GeV, 0-5% centrality – comparing before and after correction

LS (K+π+)

Convolution

ULS (K+π-)

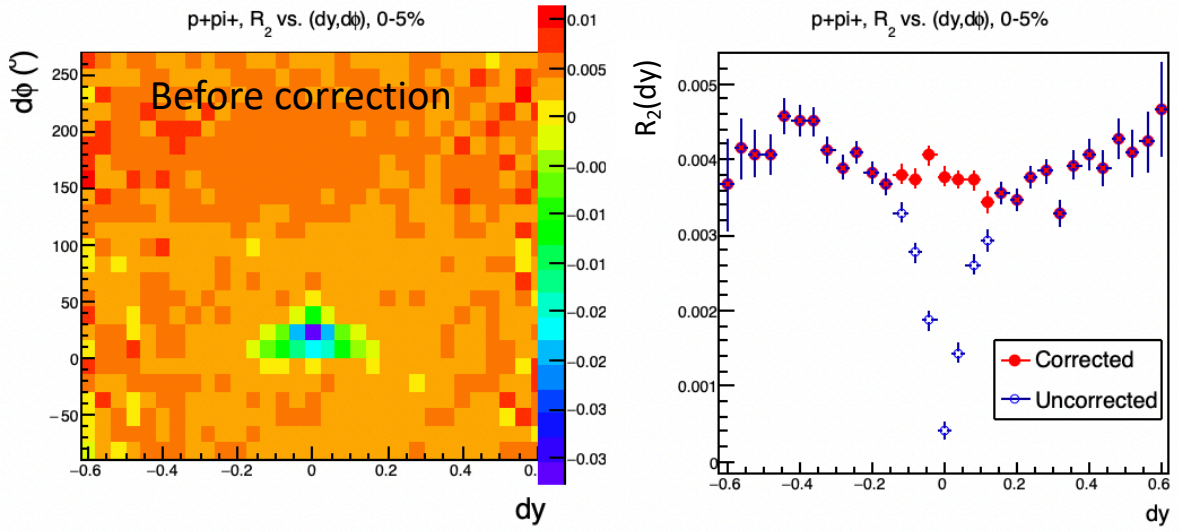




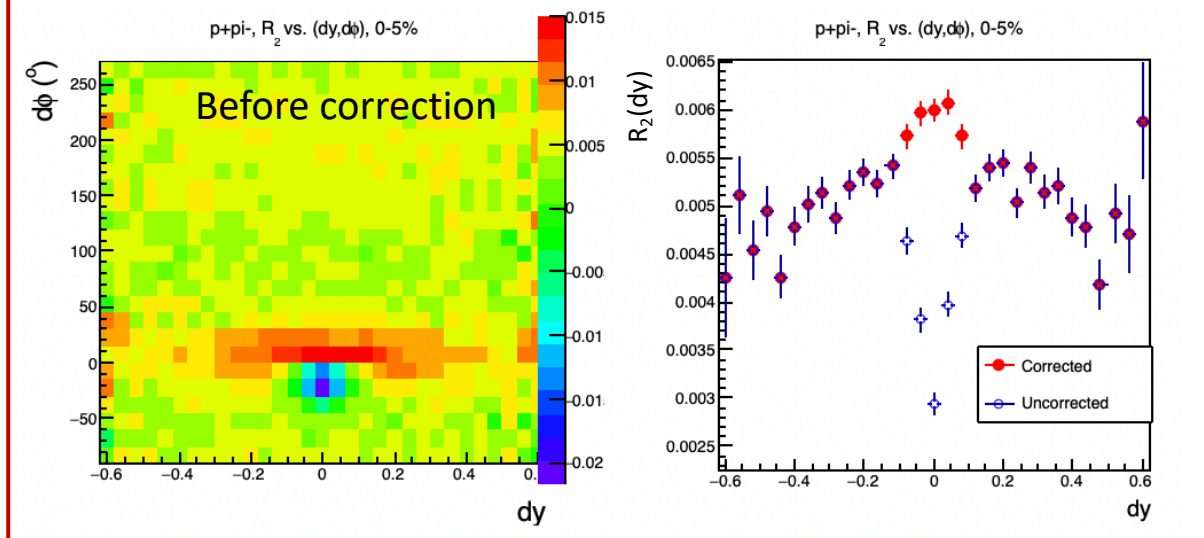
R2(dy,dϕ) 27 GeV, 0-5% centrality – comparing before and after correction

Convolution

LS (p+π+)

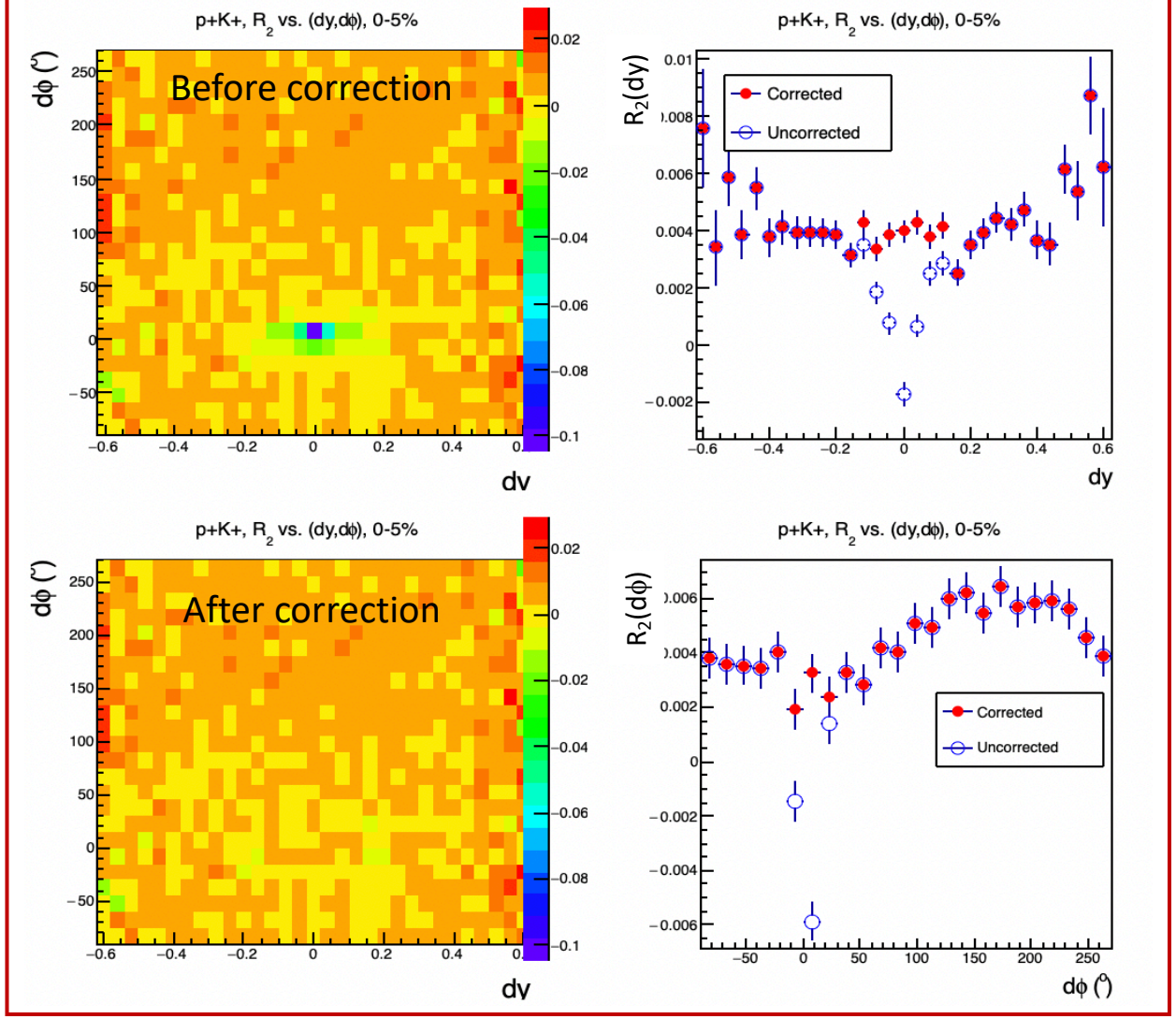


ULS (p+π-)

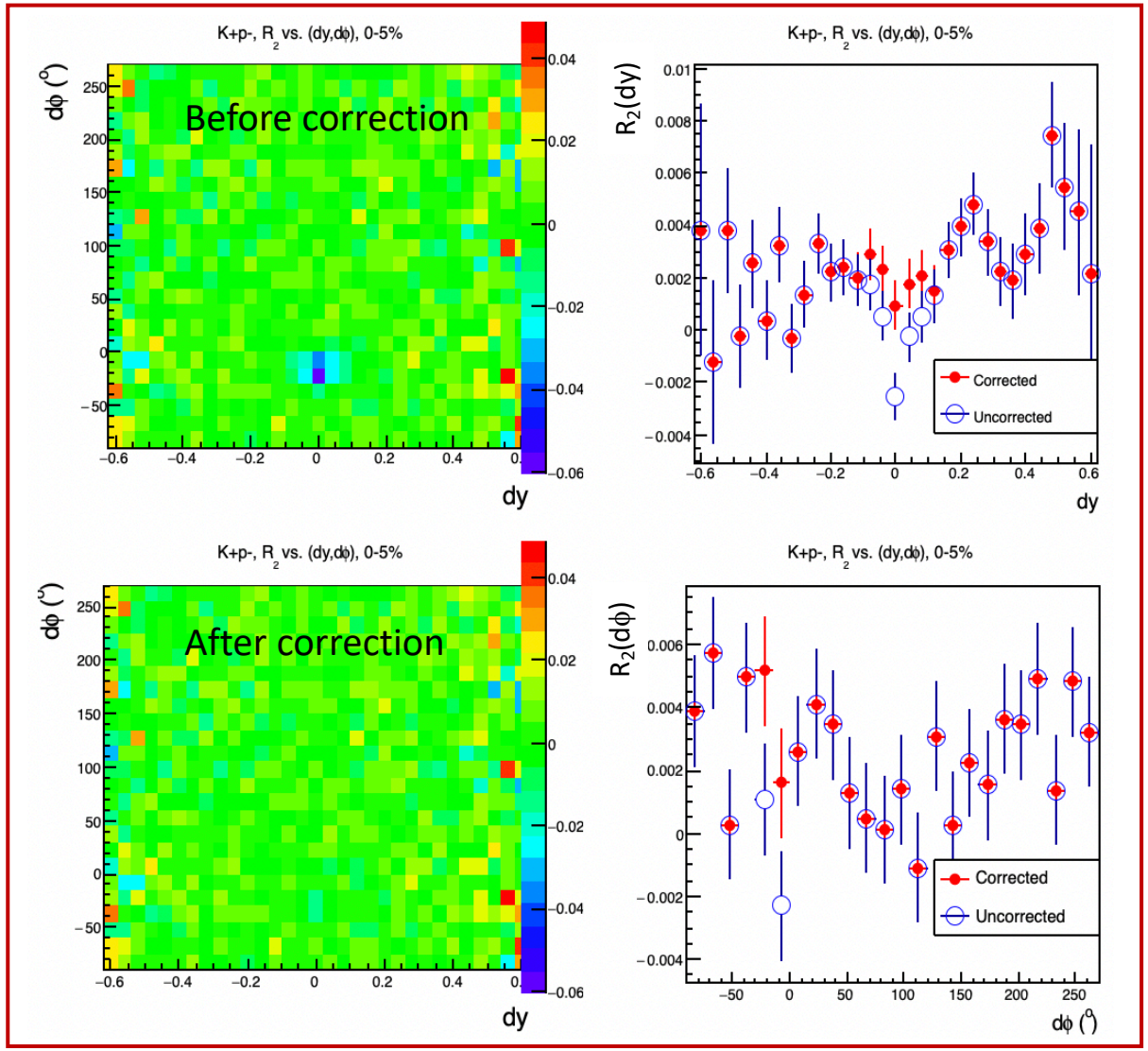


R2(dy,dϕ) 27 GeV, 0-5% centrality – comparing before and after correction

LS (K+p+)

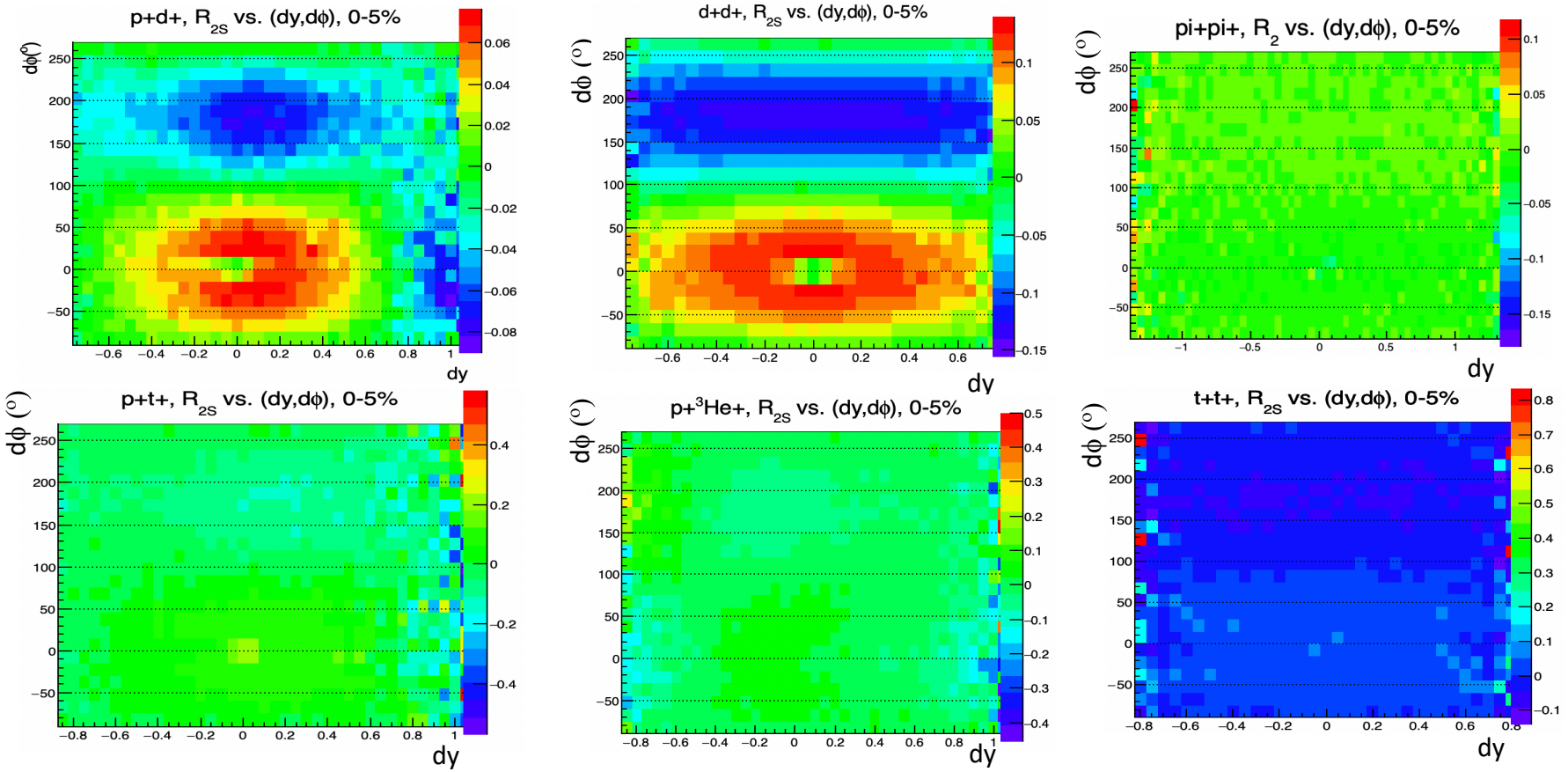


ULS (K+p-)



Preliminary track crossing in fixed target data

There is, of course, track crossing in the fixed target data at $\sqrt{s_{NN}}$ = 3.05 GeV.



Track crossing seen in fixed target 3.05 GeV data for pp, pd, and dd pairs (large multiplicity/event).
Presently finishing up the crossing correction for this dataset.

Summary – Future Goal

- Track crossing correction (Tarini Ph.D. Thesis, WSU) applied to collider and fixed target data.
- Studied and implemented track correction for all centralities of all particle pairs for Au-Au collisions in collider and fixed target mode.
    - Charge combinations of protons i.e. p^+p^+, p^+p^-, p^-p^+, and p^-p^-.
    - Charge combinations of kaons.
    - Charge combinations of pions
    - Various combinations of **Kπ** pairs i.e. $K^+\pi^+$, $K^+\pi^-$, $K^-\pi^+$, $K^-\pi^-$, π^+K^-, and π^-K^+.
    - Various combinations of **Kp** pairs i.e. K^+p^+, K^+p^-, K^-p^+, K^-p^-, p^+K^-, and p^-K^+.
    - Various combinations of **pπ** pairs i.e. $p^+\pi^+$, $p^+\pi^-$, $p^-\pi^+$, $p^-\pi^-$, π^+p^-, and π^-p^+.
    - Various combinations of protons with light nuclei i.e. p^+p^+, p^+d^+, p^+t^+, $p^+\,{}^3He^+$ and d^+d^+
- Nearly done - just tidying up the 3.05 GeV and light nucleus results now.

Thank you!