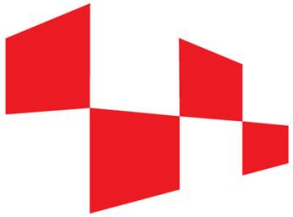
Transverse Sphericity and di-hadron angular correlations (update)

CORRELATION PAG

FILIP ERHARDT



HrZZ
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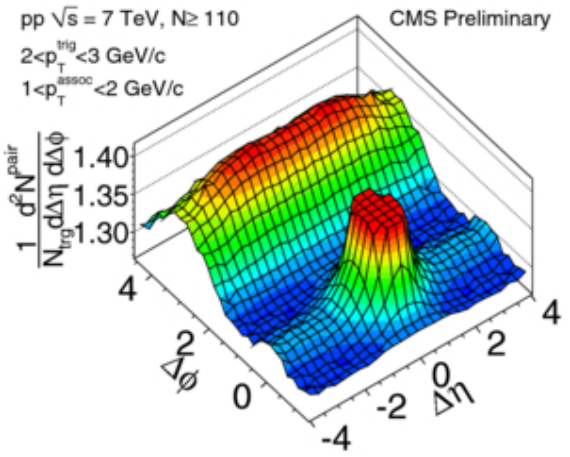
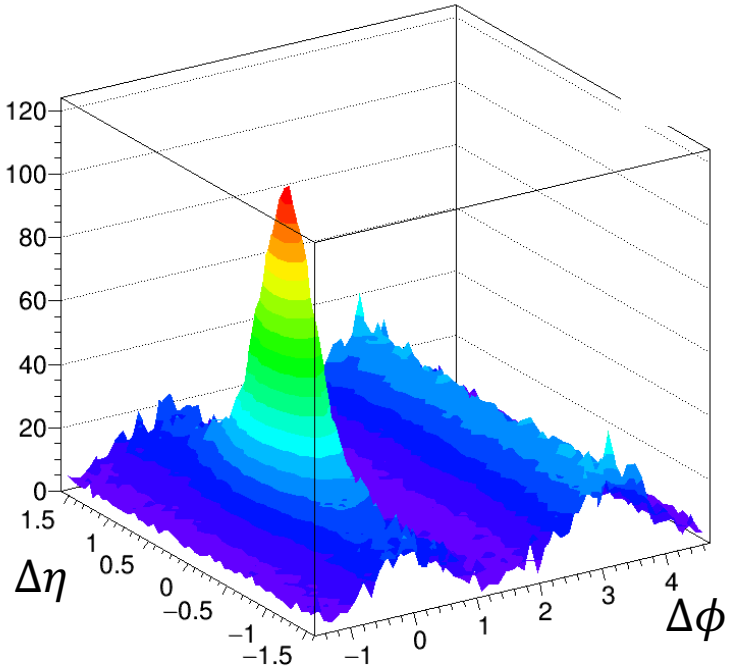
Reminder

- Use transverse Sphericity (momentum space event shape variable) to study 2 particle angular correlations.
- Possibly as a way of enhancing some structures (reducing jet background) focusing on the near-side ridge.

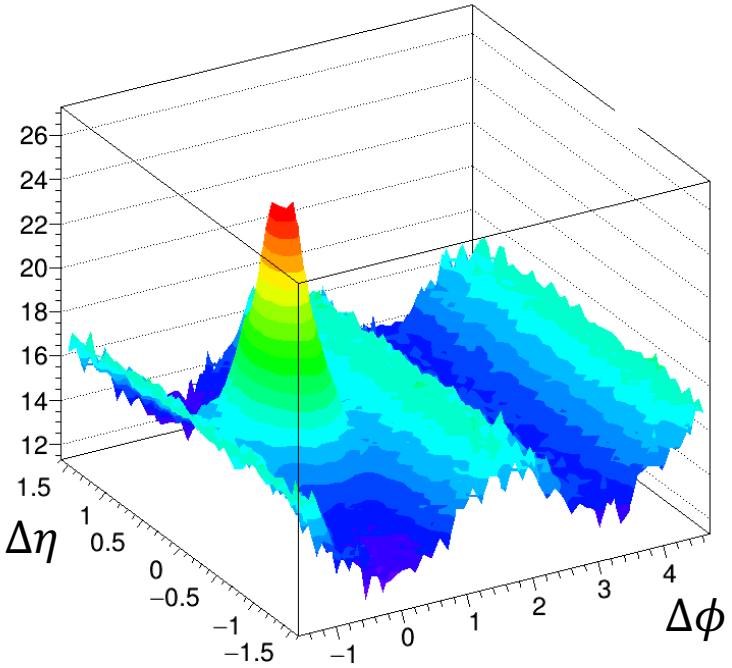


Correlation function in different ST bins

Events with 15% highest and lowest transverse sphericities



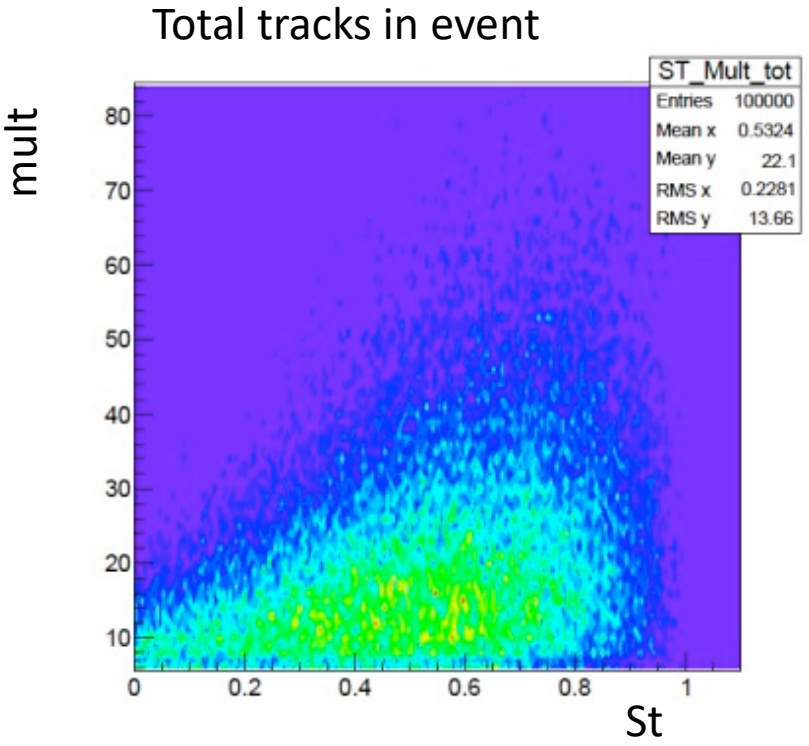
$0.0 < S_T < 0.351$



$0.795 < S_T < 1.0$

Sphericity-multiplicity correlations

How correlated are ST and multiplicity?
Does it make sense to use ST as a variable when we have mult?



Sphericity-multiplicity correlations

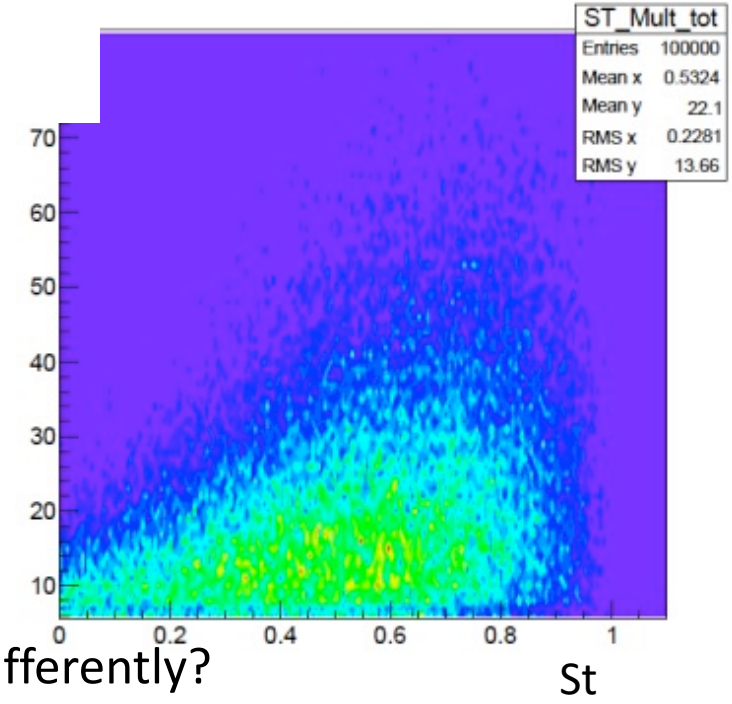
Put a number on it, Calculate **linear** correlation coefficient ($0 \leq |r| \leq 1$):

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[\, n\Sigma x^2 - (\Sigma x)^2 \,][\, n\Sigma y^2 - (\Sigma y)^2 \,]}}$$

Roughly:

- $0 \leq |r| \leq 0.3$ no or weak correlation
- $0.3 \leq |r| \leq 0.7$ moderate correlation
- $0.7 \leq |r| \leq 1$ strong correlation

Total tracks in event



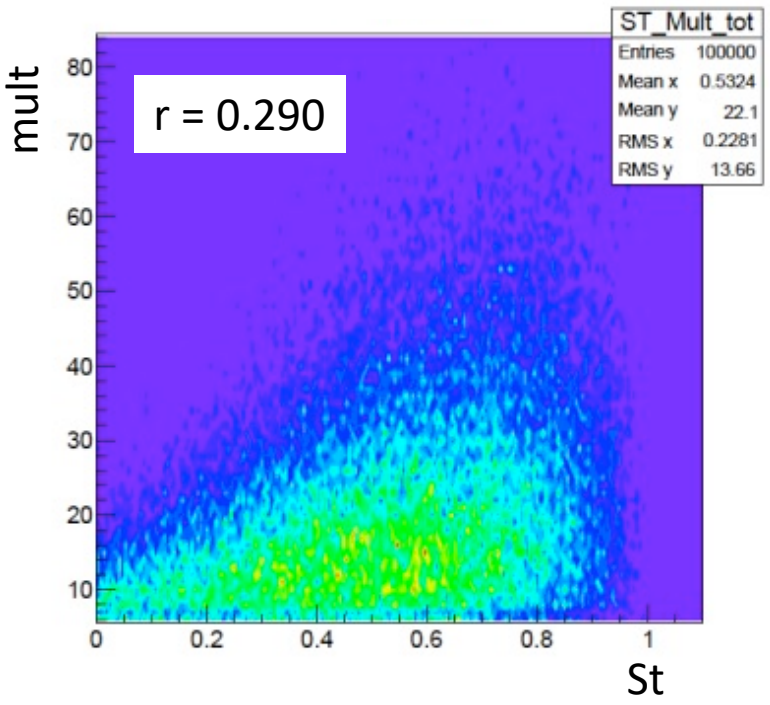
Do different definitions of “multiplicity” correlate differently?

Sphericity-multiplicity correlations

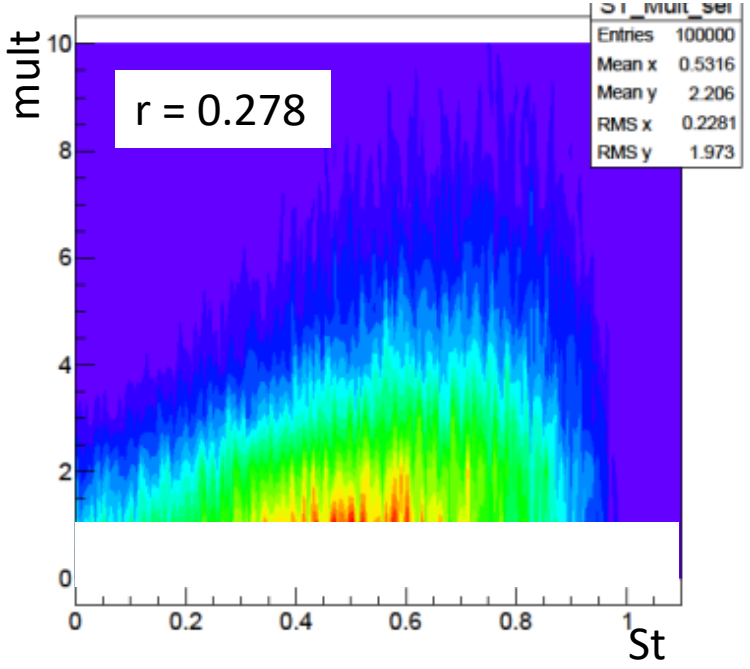
Using total number of tracks in event and number of tracks that pass selection

All tracks from $|\eta| < 0.9$, $0.15 < p_t < 10\,\frac{GeV}{c}$, charged and filterbits 5+6

Total tracks in event



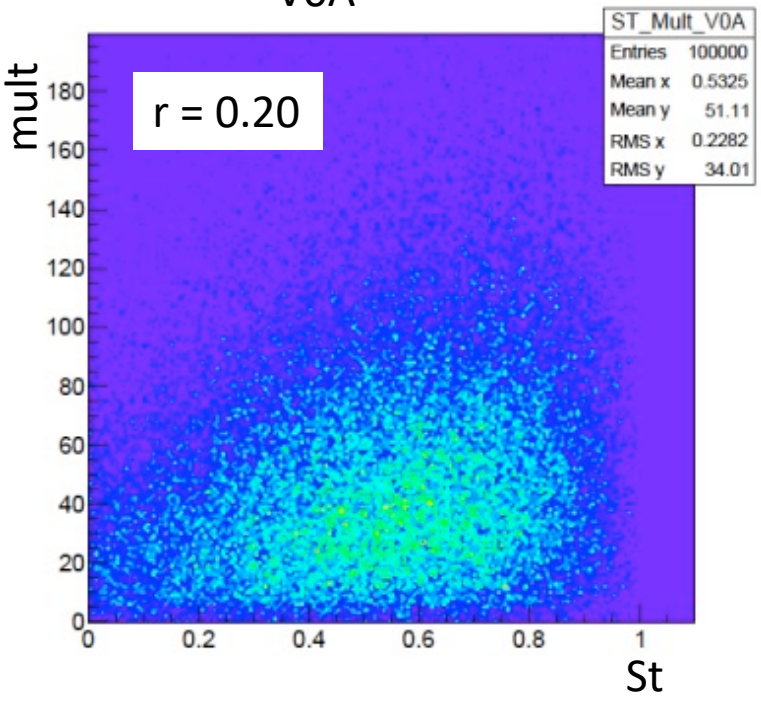
Only tracks used in analysis(stricter cuts)



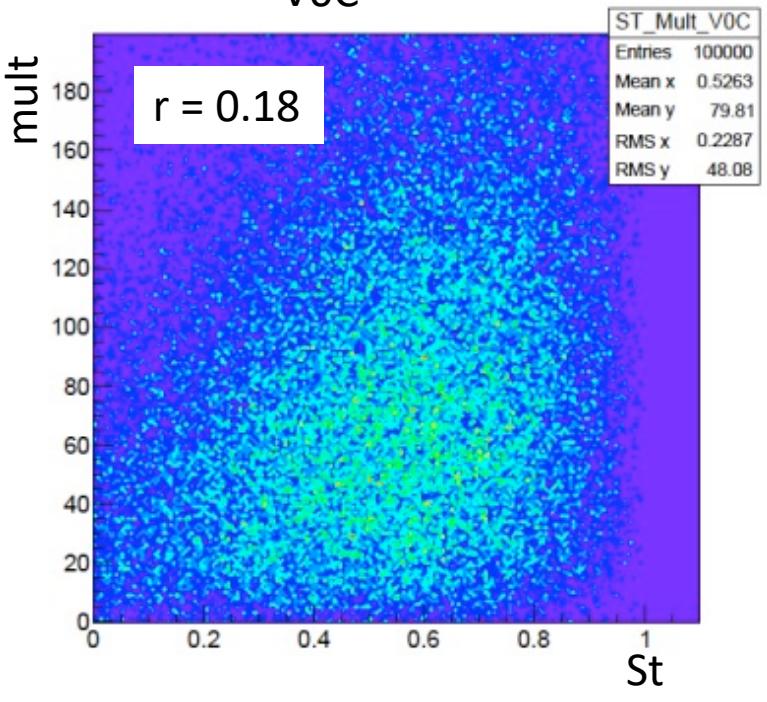
Sphericity-multiplicity correlations

Using V0A and V0C detectors as multiplicity estimators?
very similar so not needed!

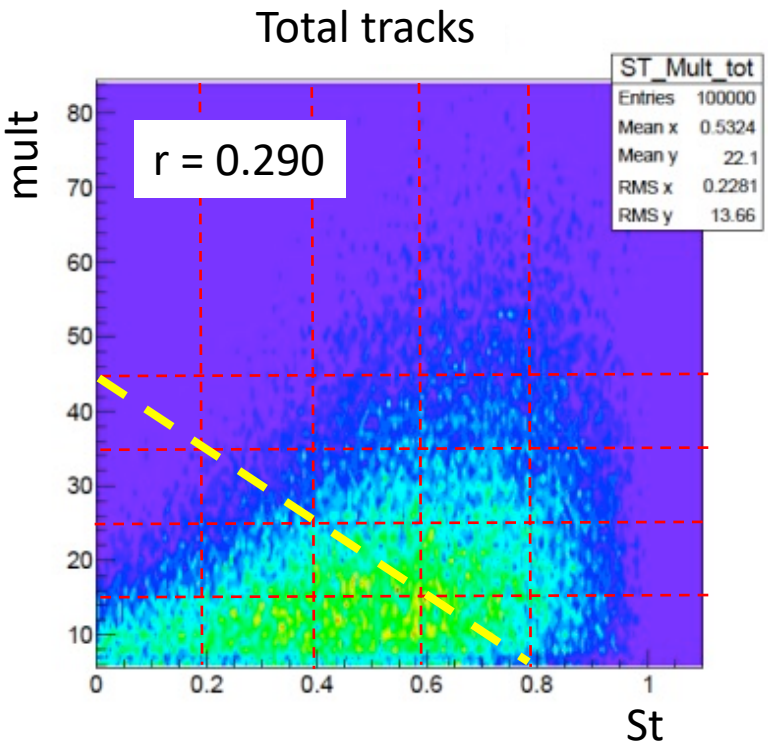
V0A



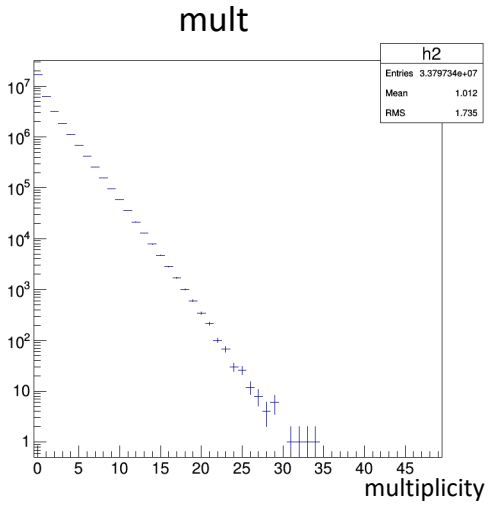
V0C

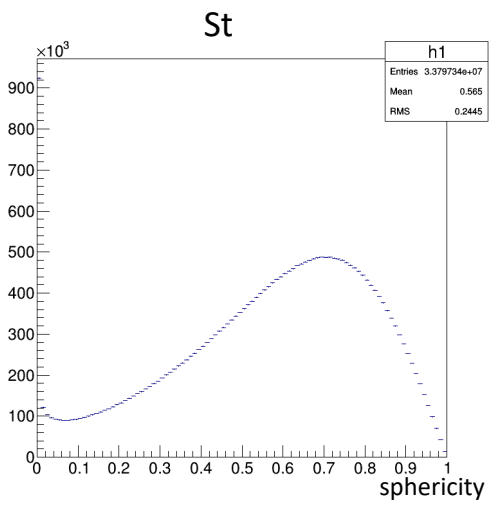


Sphericity-multiplicity correlations

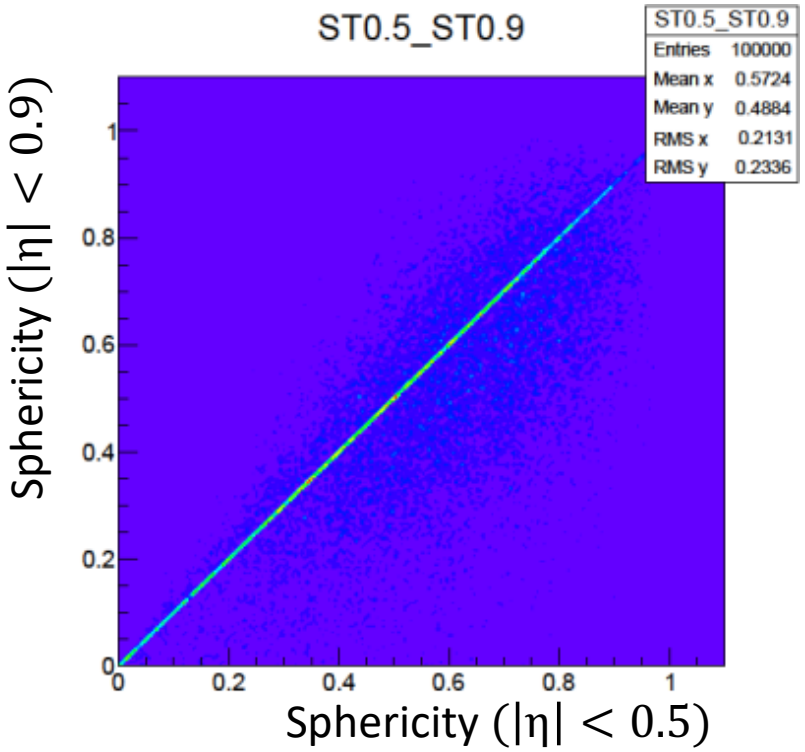


- All correlations are similar
- Higher mult ➔ (on average) higher St
- Opposite is not true
- Higher St ➔ high multiplicity
- Choosing high ST removes much less statistics than high multiplicity
- Which mult definition should be used?
- Possibly use a combination?





Stability of St with η

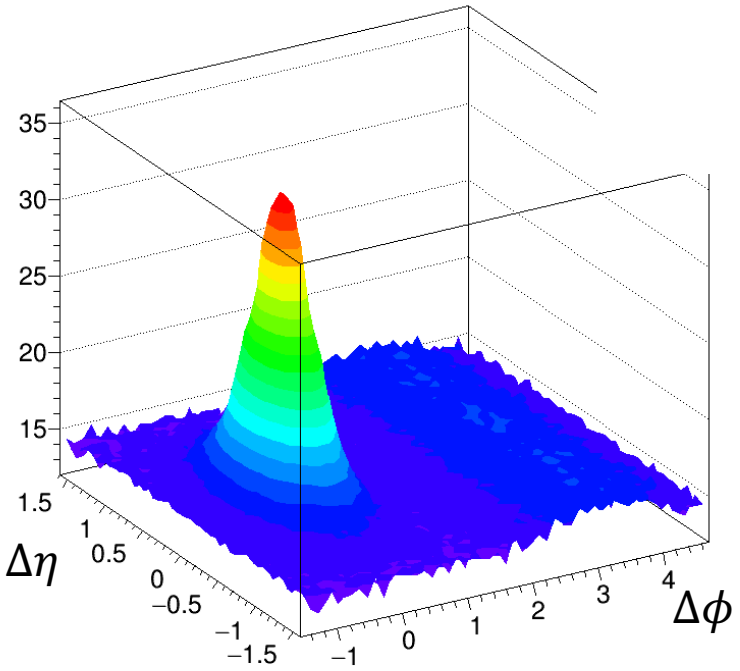


- Sphericity ($|\eta| < 0.9$) – Sphericity ($|\eta| < 0.5$) correlation
- Very high correlation coefficient
- Low dependence of Sphericity on $|\eta|$ cut
- $r = 1.00000$ (up to accuracy of float)

- Look into V2??

Preliminary measurements

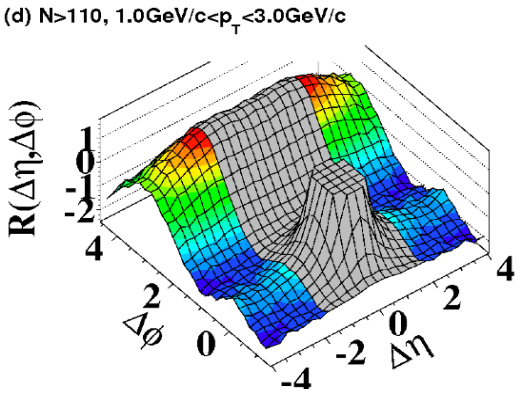
- LHC2010d data set
- 10 Runs 126403-126432
- Proton-proton collisions at $7TeV$
- $33 \cdot 10^6$ events analysed
- $1\ GeV/c < p_t < 3\ GeV/c$
  (all particles)
- $|\eta| < 0.8$
- Charged tracks
- Filter bits 5+6
- Mult definition: number of tracks that pass selection cuts (change to use %?)

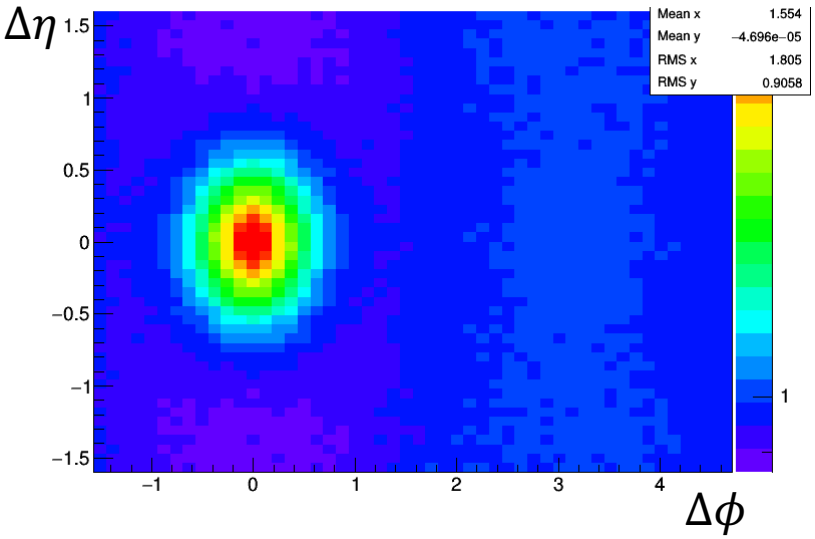


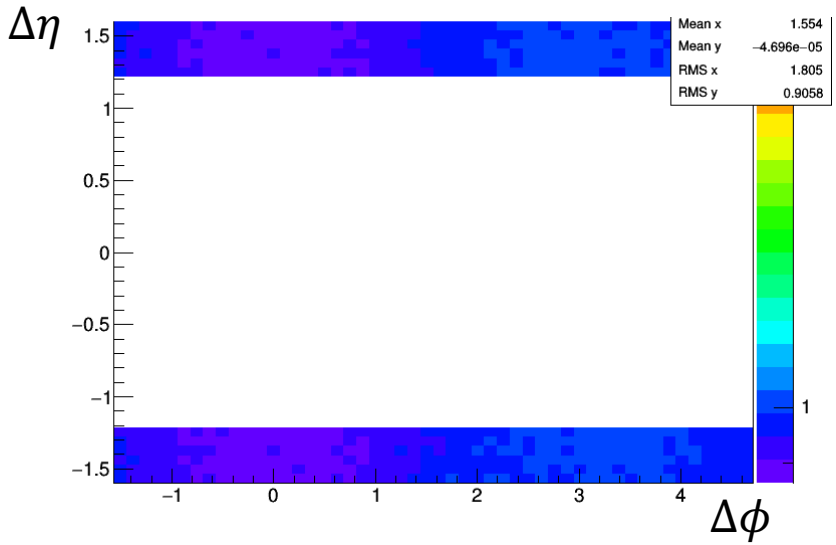
Correlation function minimum bias

Projections

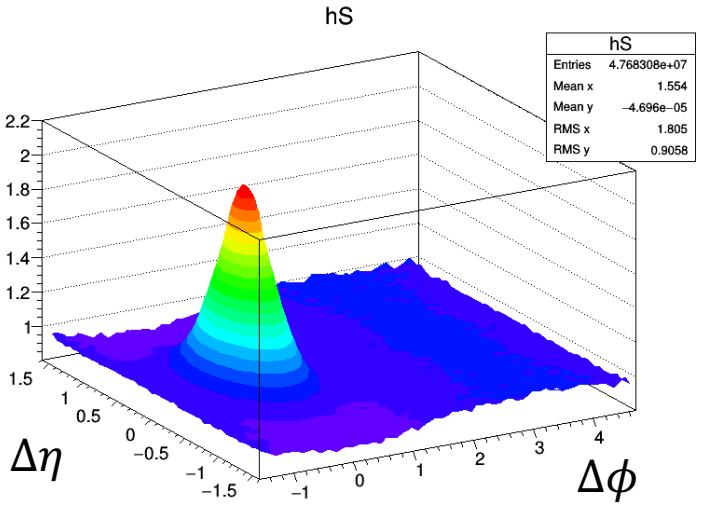
- Cut the most extreme $|\Delta\eta|$ values and make a projection onto $\Delta\phi$
- $1.2 < \Delta\phi < 1.5$

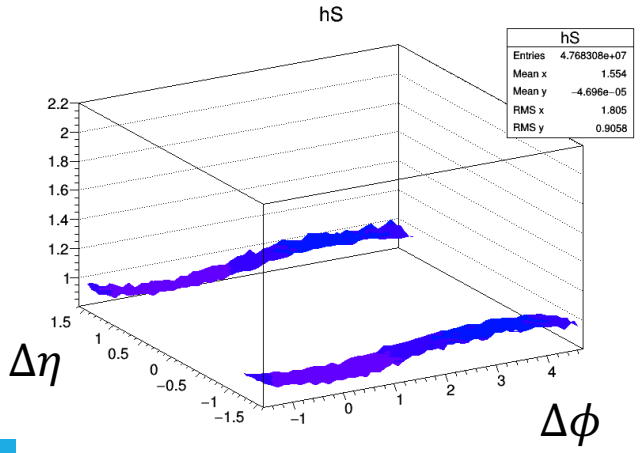






Projections





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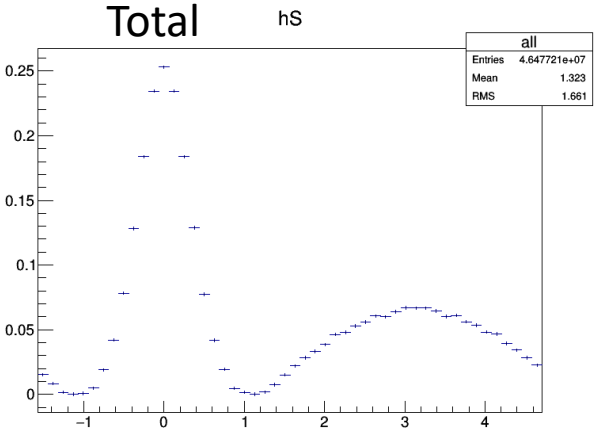

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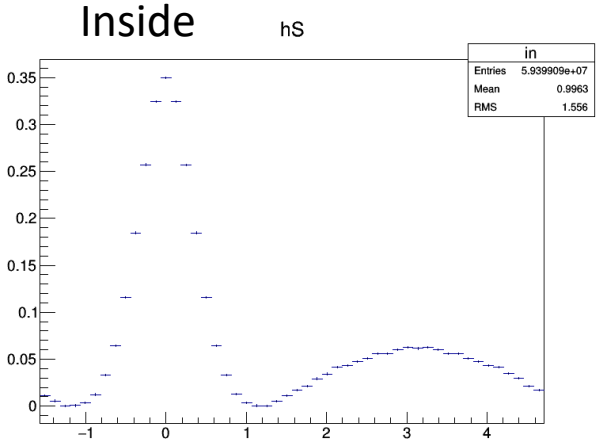

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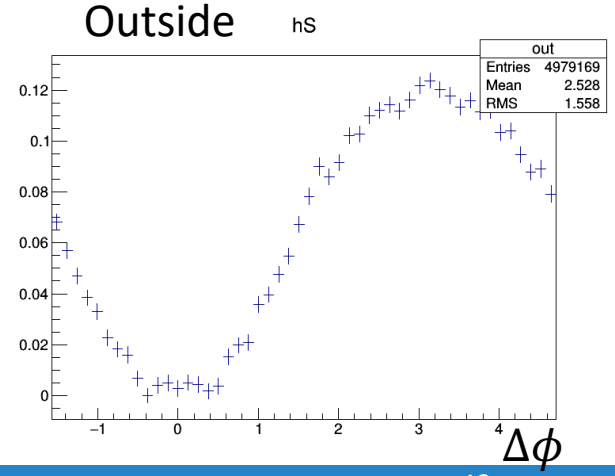
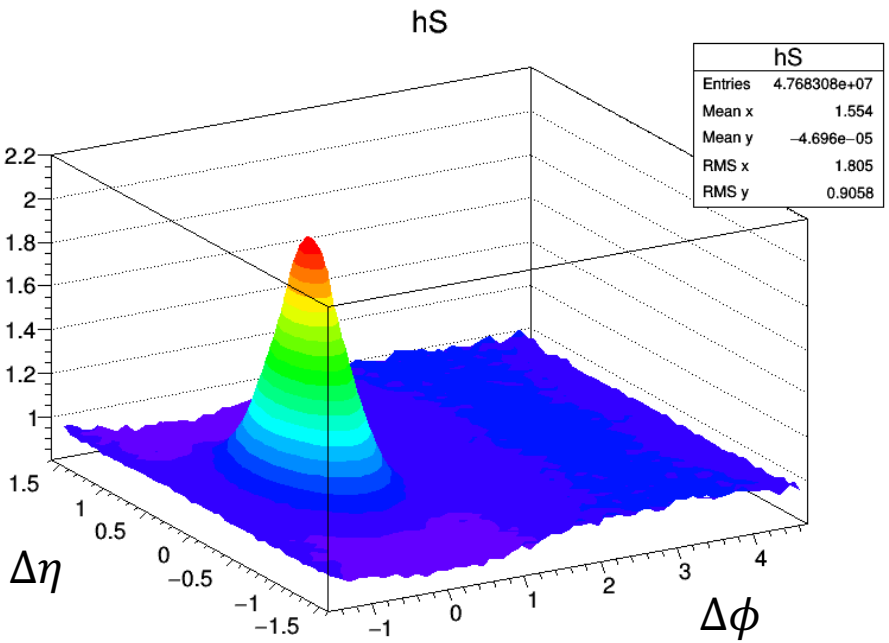
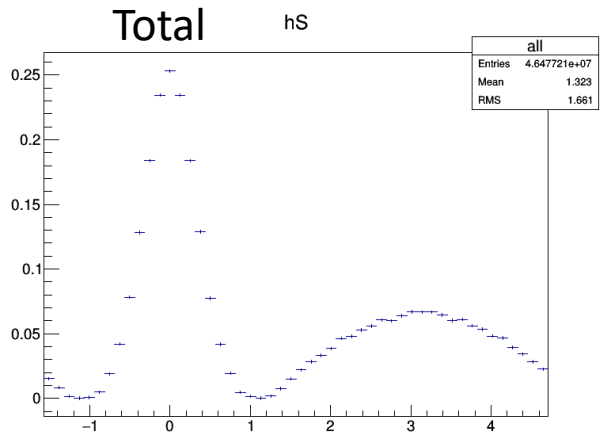
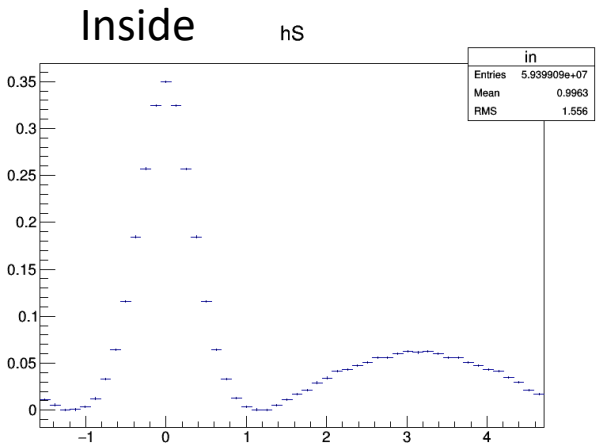
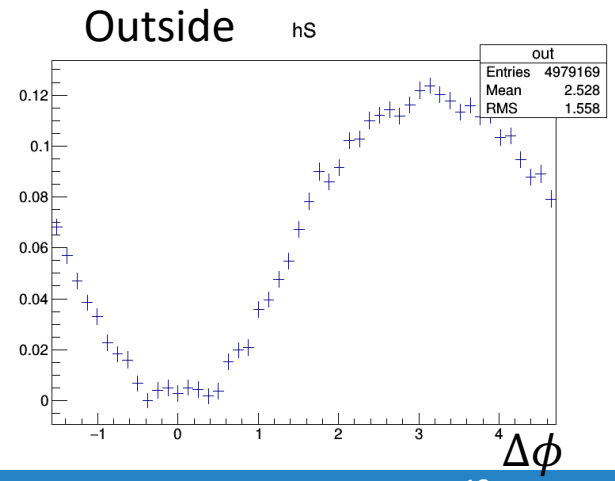


Multiplicity = All, $0.0 < St < 1.0$

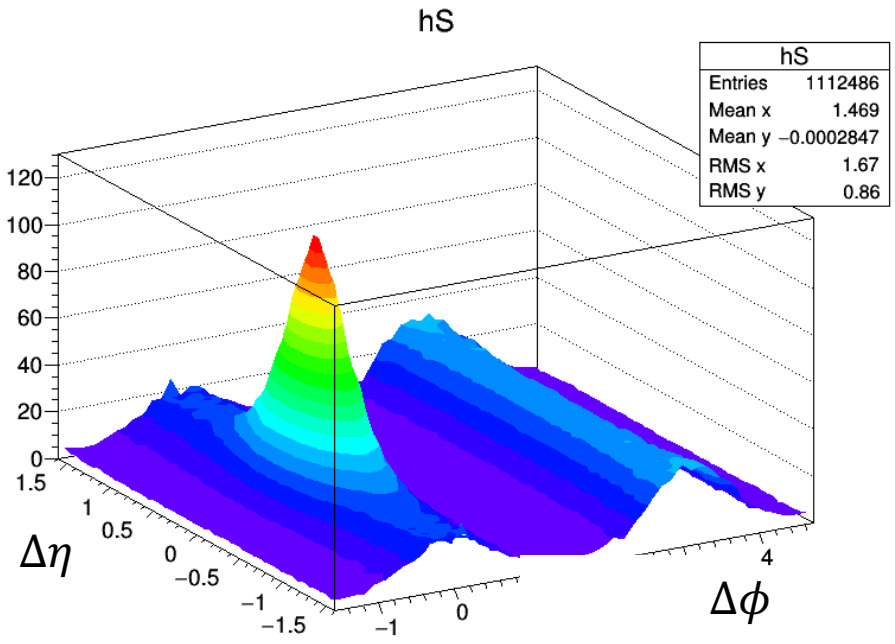


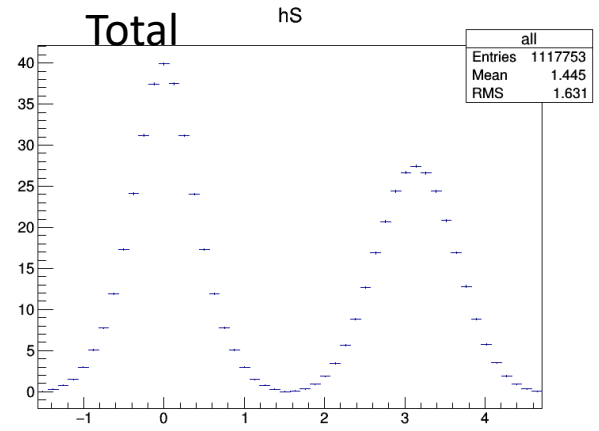


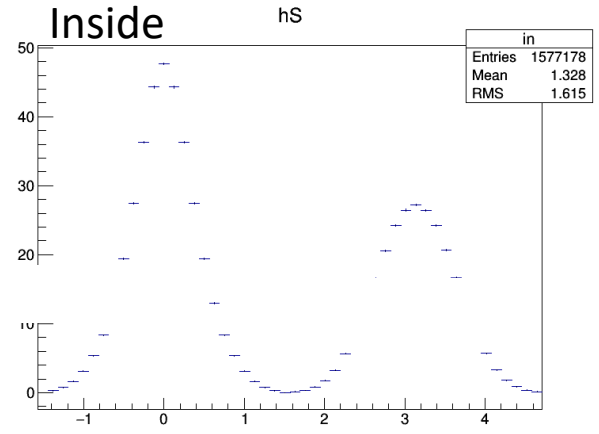


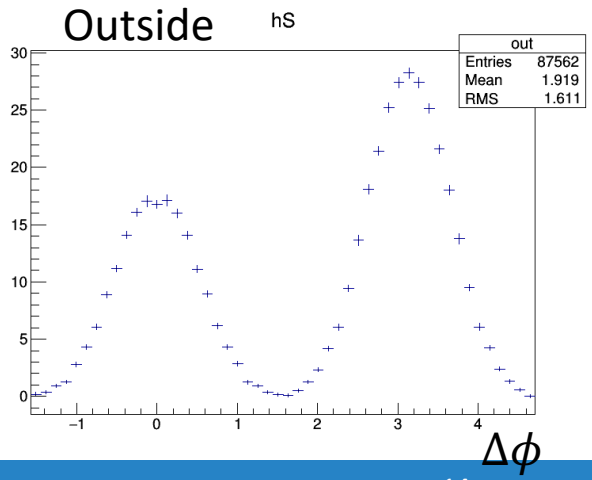


Multiplicity = All, $0.0 < St < 0.351$

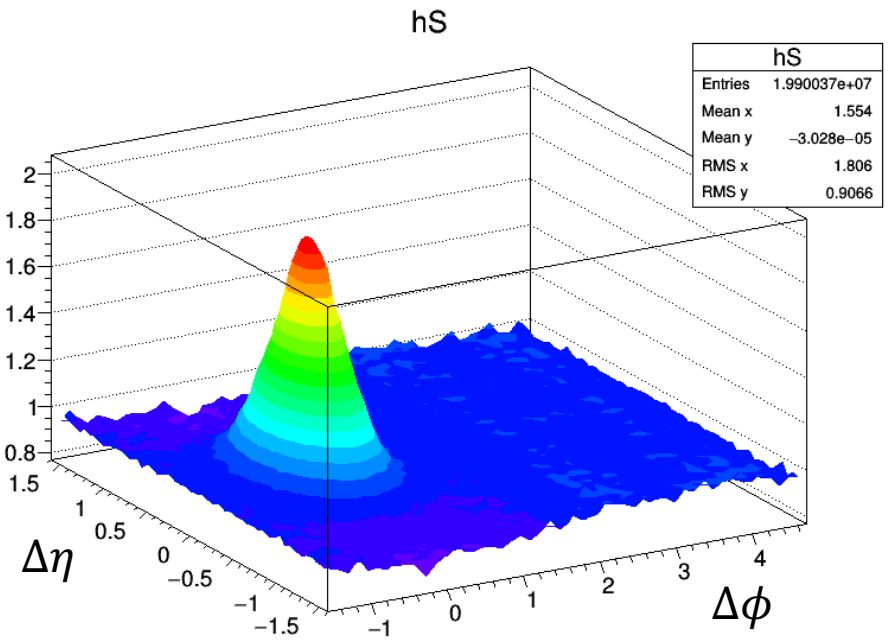


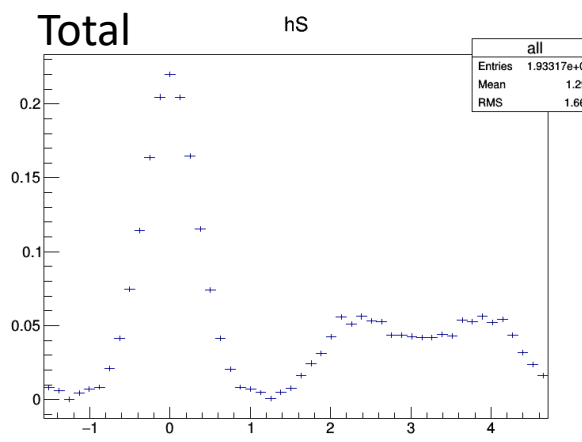


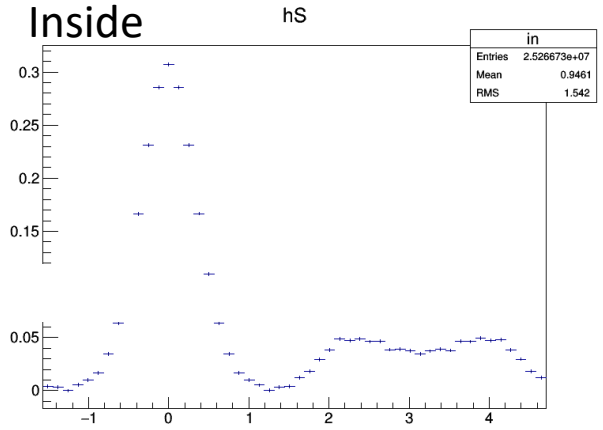


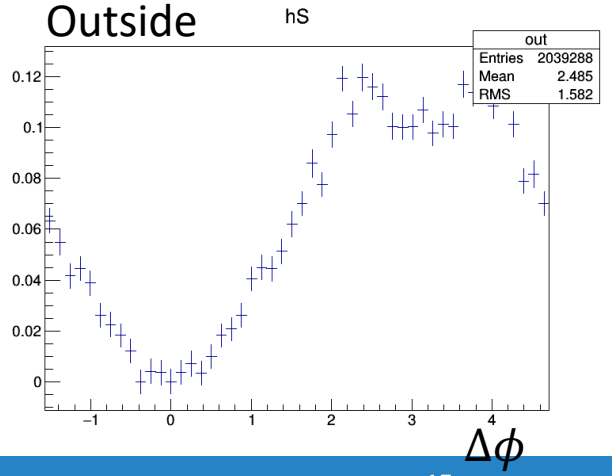


Multiplicity = All, $0.65 < St < 0.795$

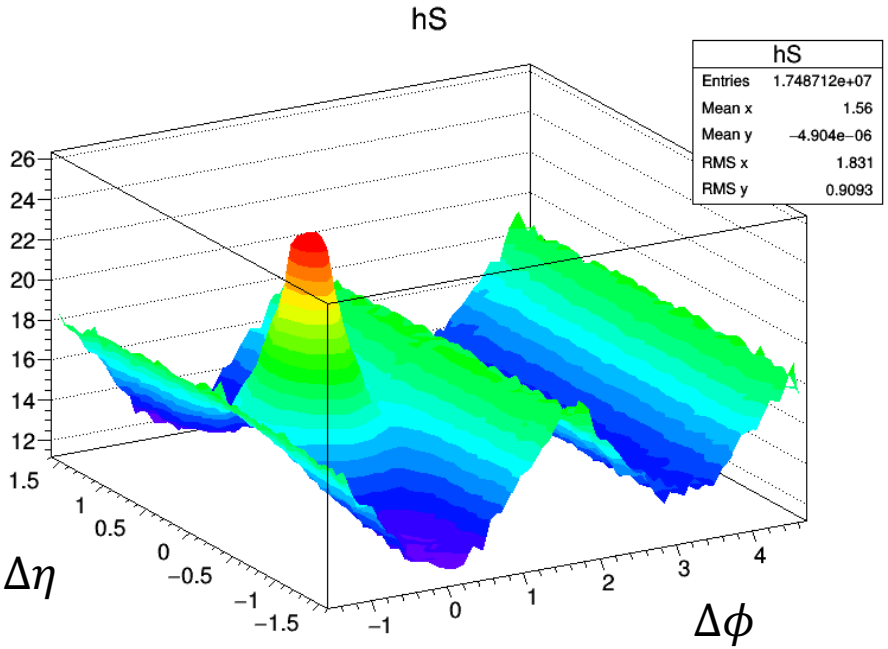


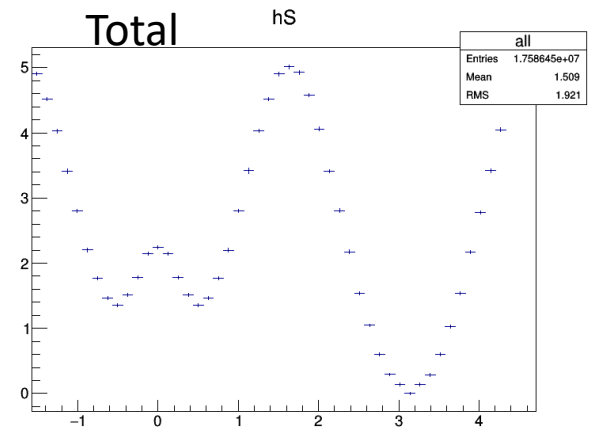


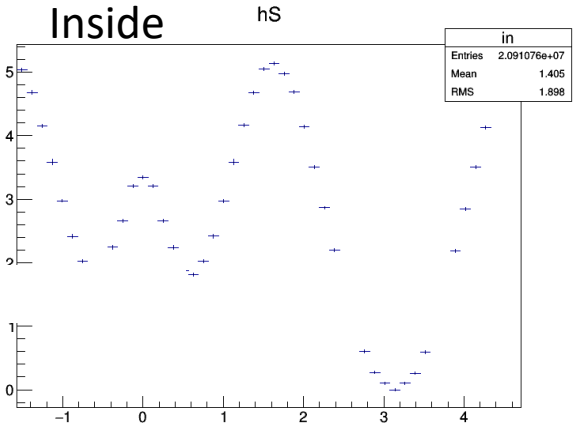


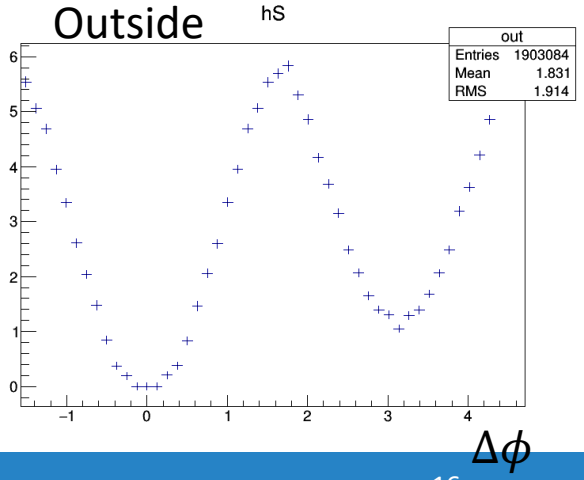


Multiplicity = All, $0.795 < St < 1.0$

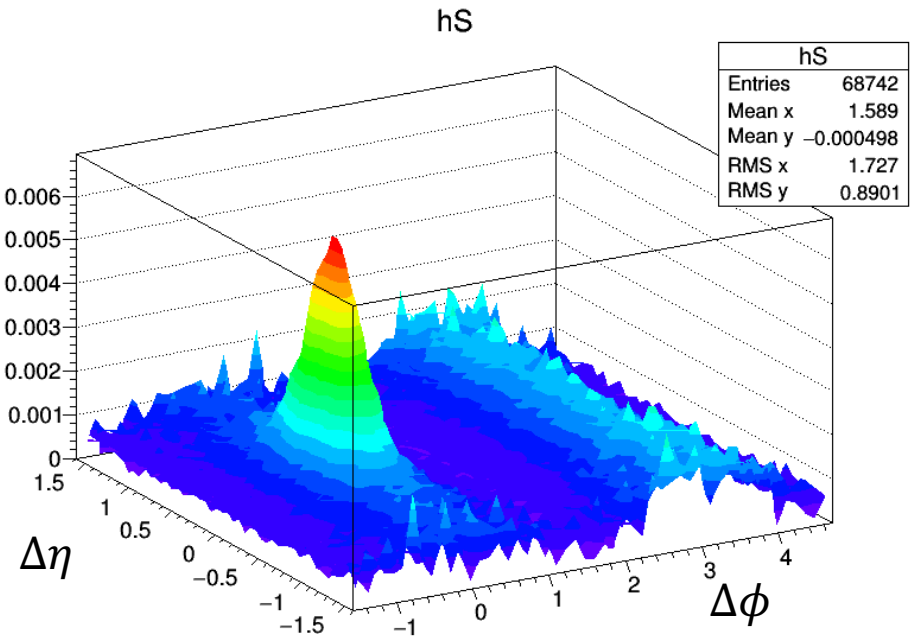








Multiplicity >10, $0.0 < St < 0.351$



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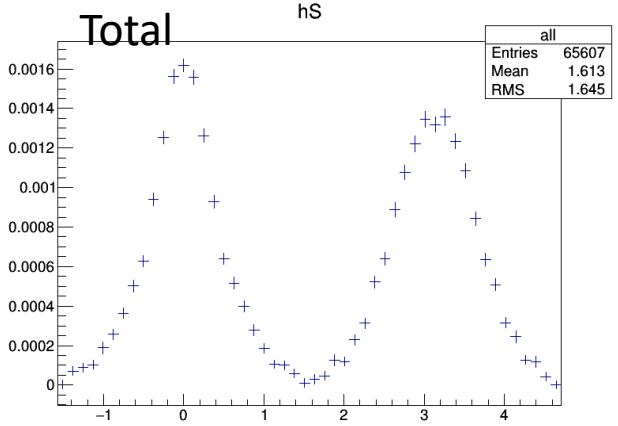

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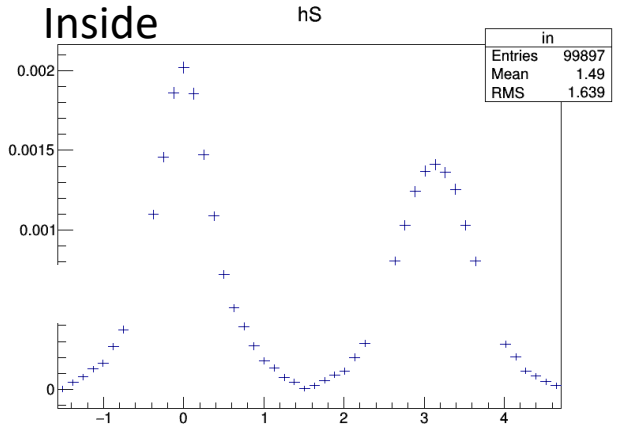

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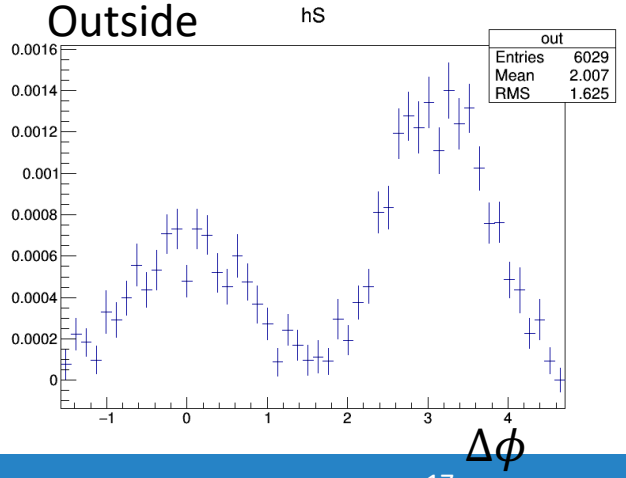
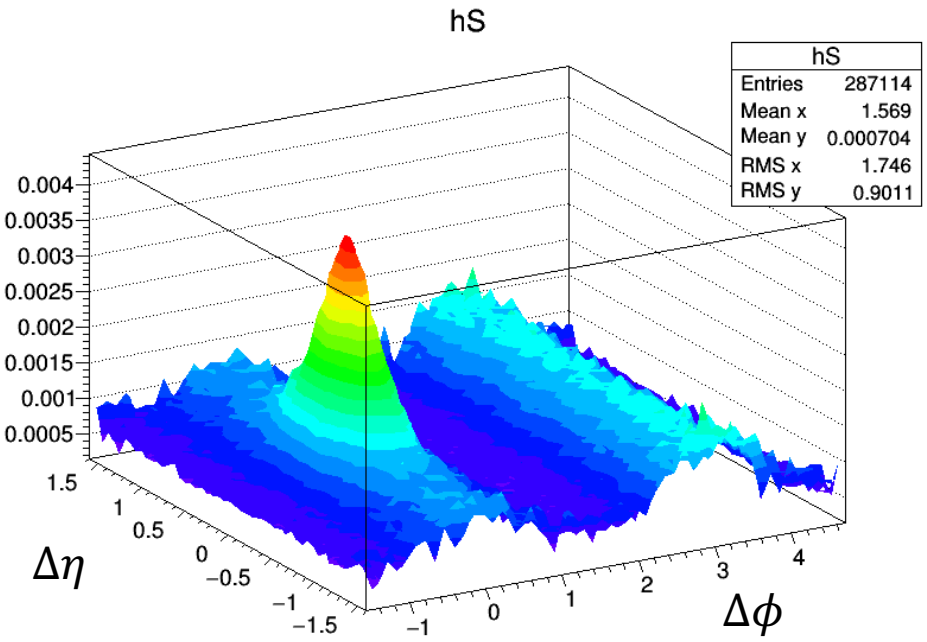


Multiplicity >10, $0.351 < St < 0.51$



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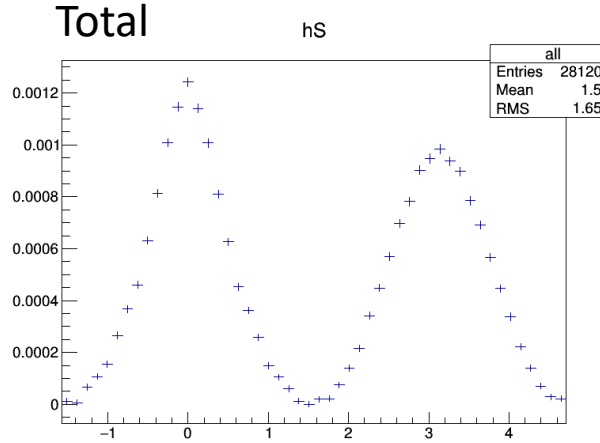

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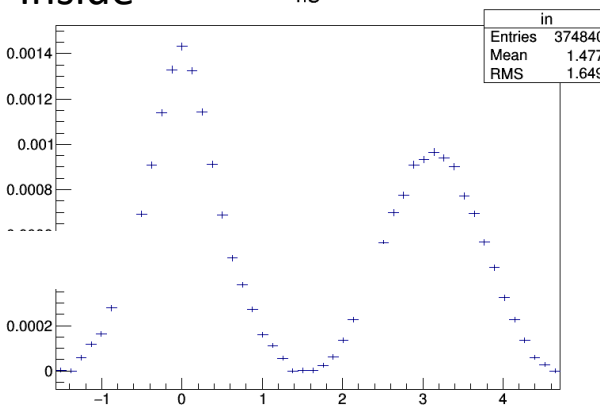

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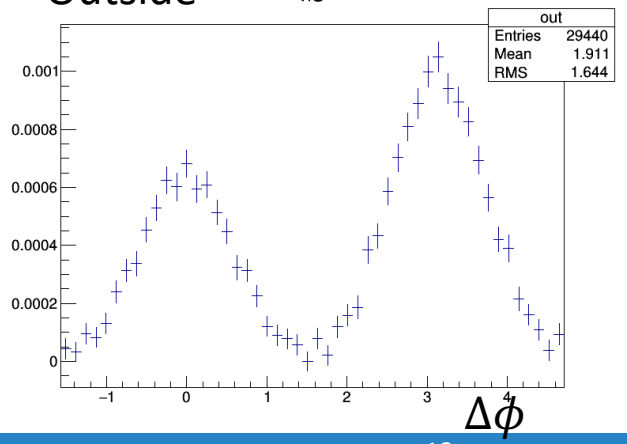
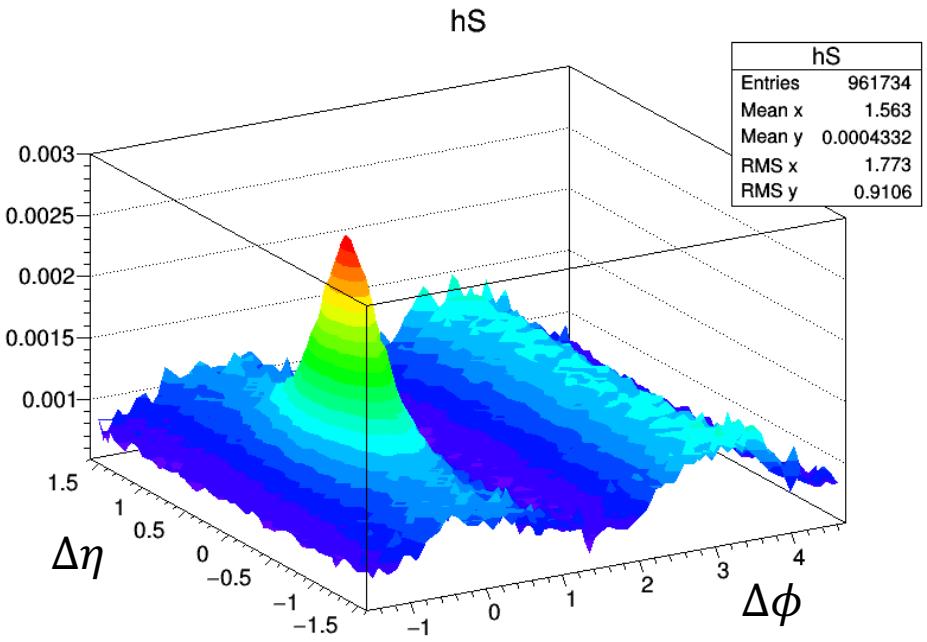


Multiplicity >10, $0.51 < St < 0.63$



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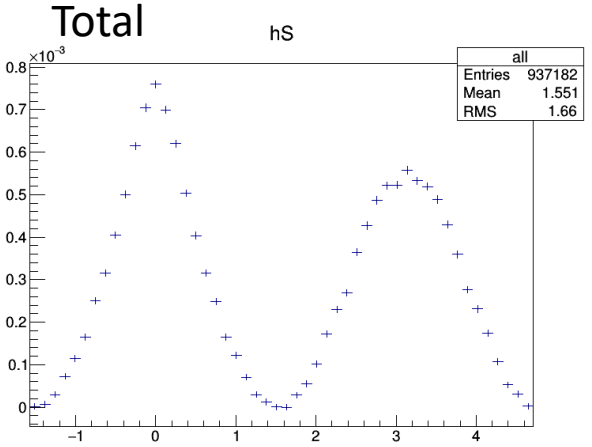

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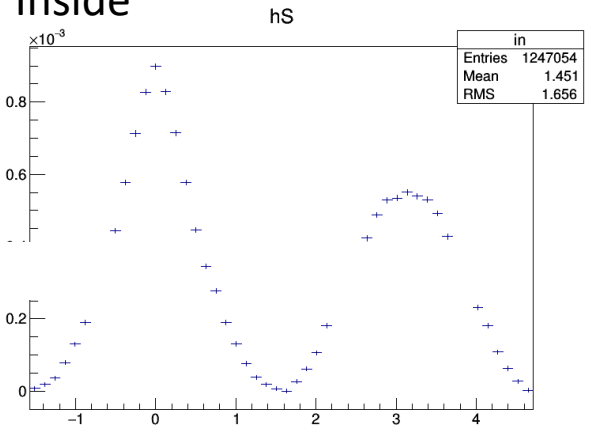

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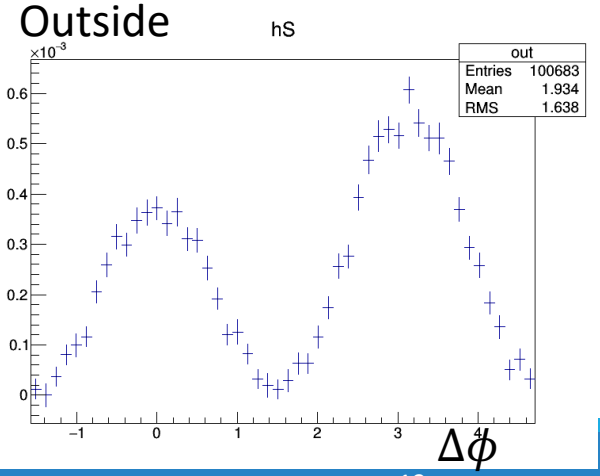
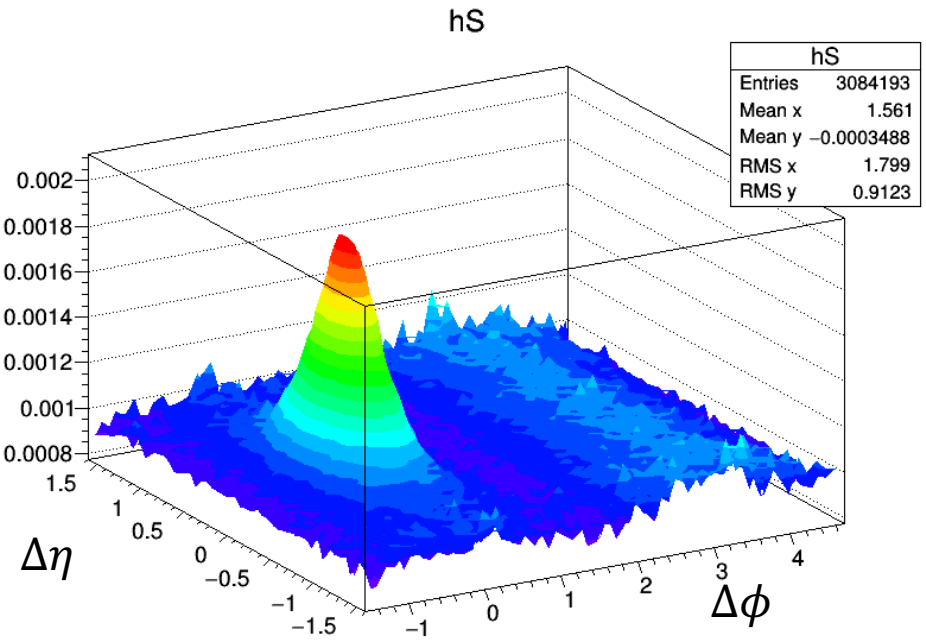


Multiplicity >10, $0.63 < St < 0.795$



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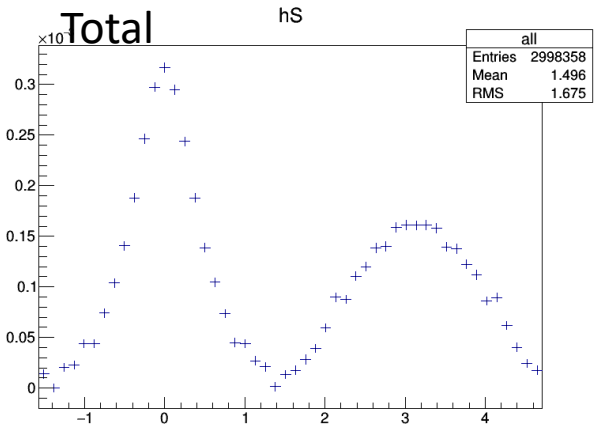

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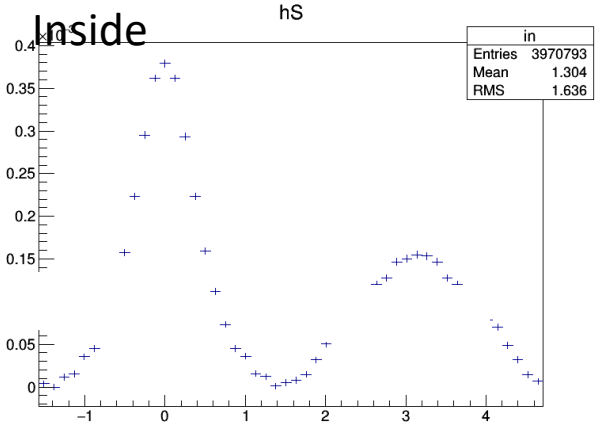

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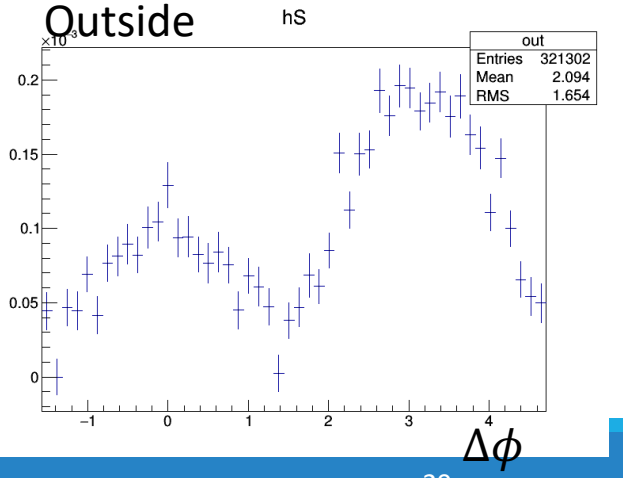
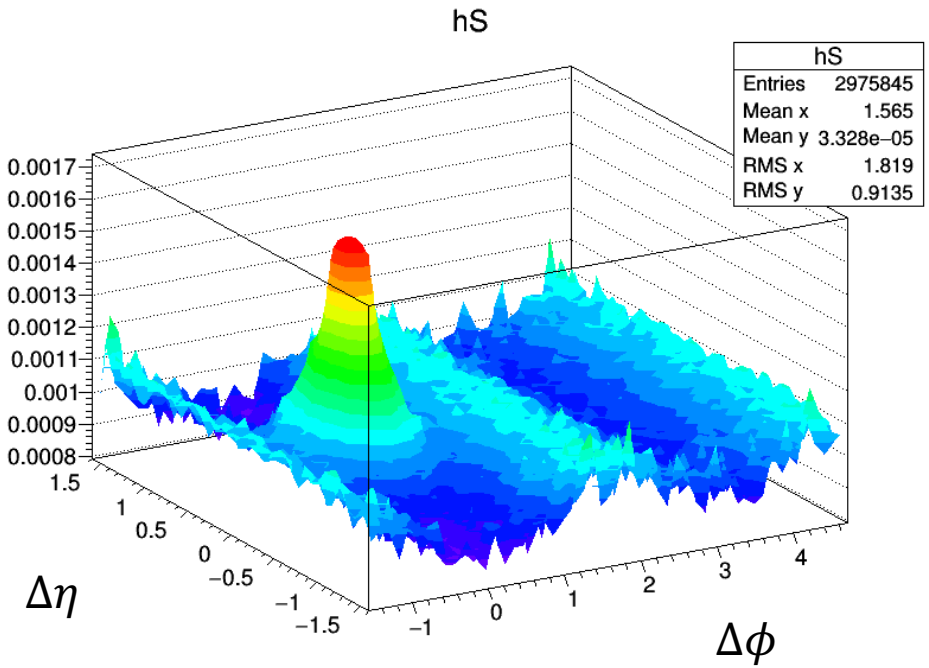
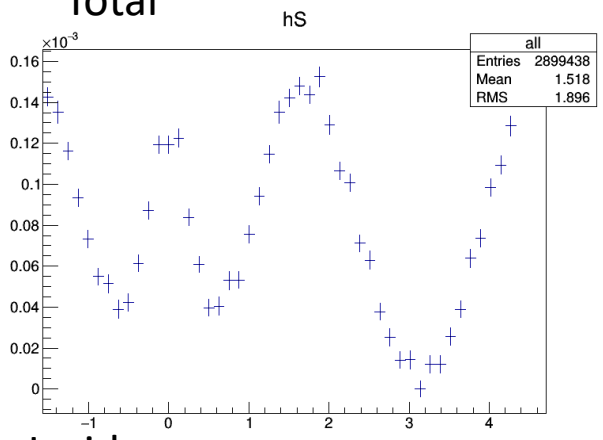


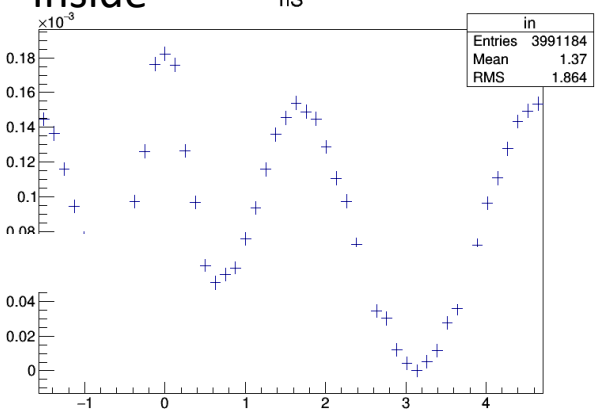
Multiplicity >10, $0.795 < St < 1.0$



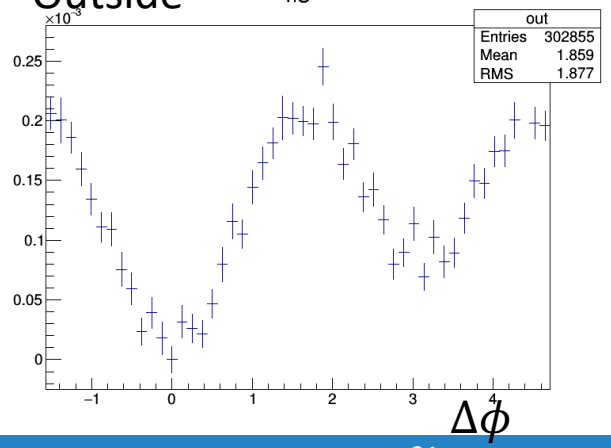
Total



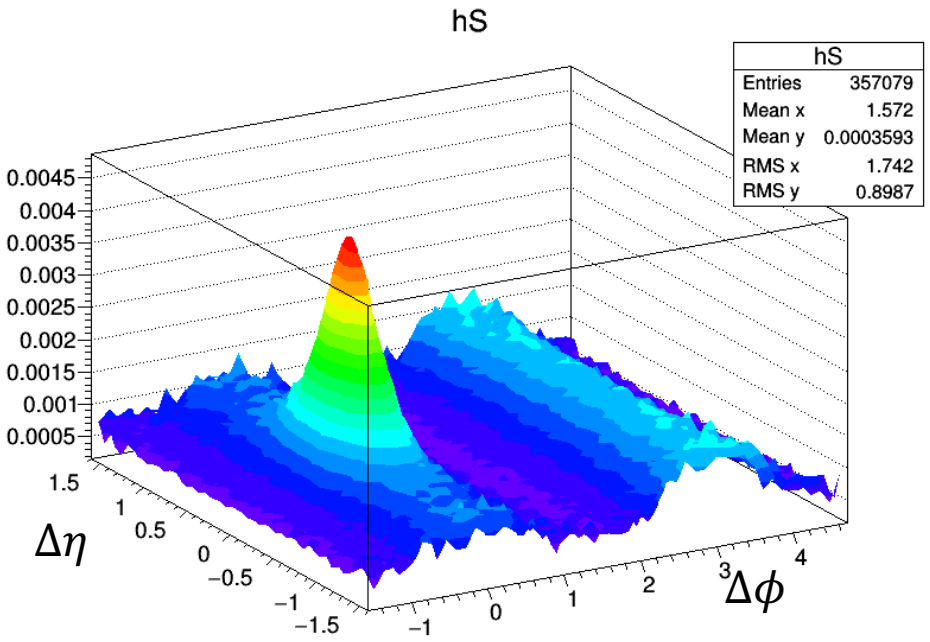
Inside



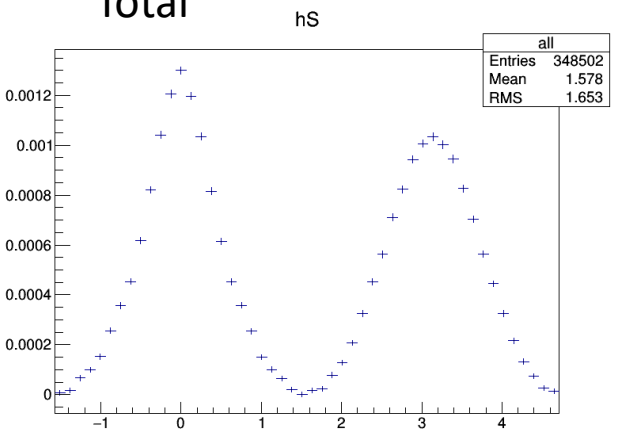
Outside



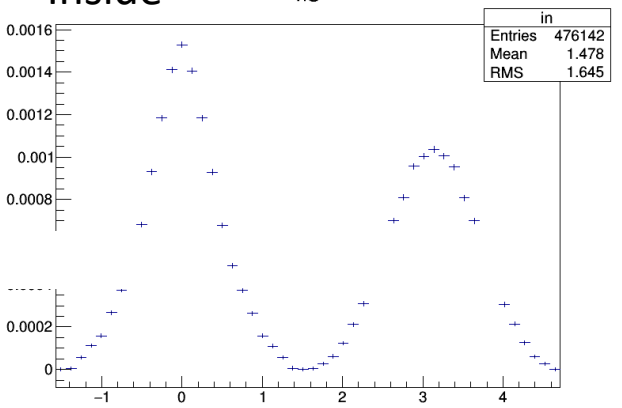
Multiplicity >10, $0.0 < St < 0.5$



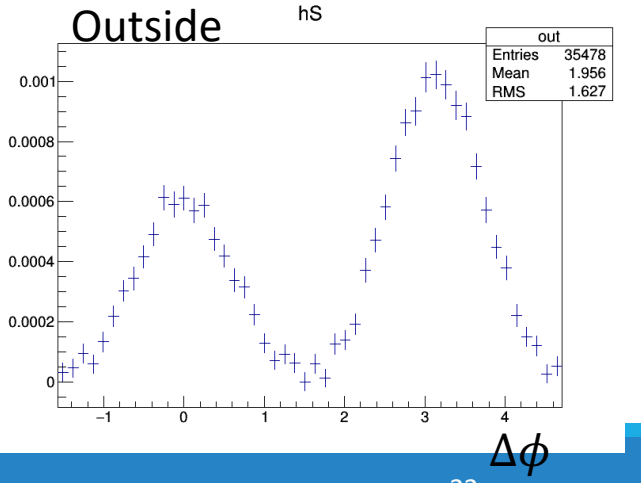
Total



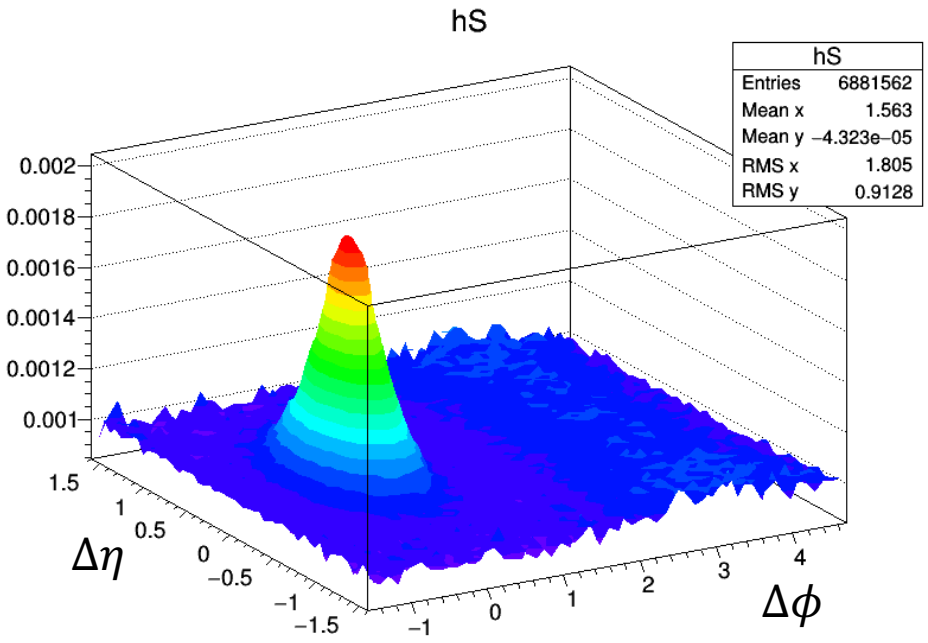
Inside

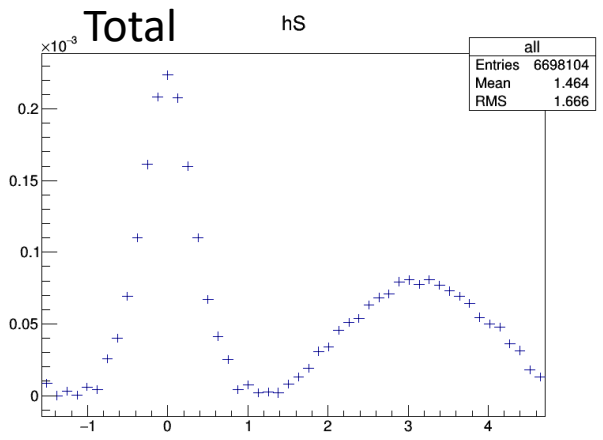


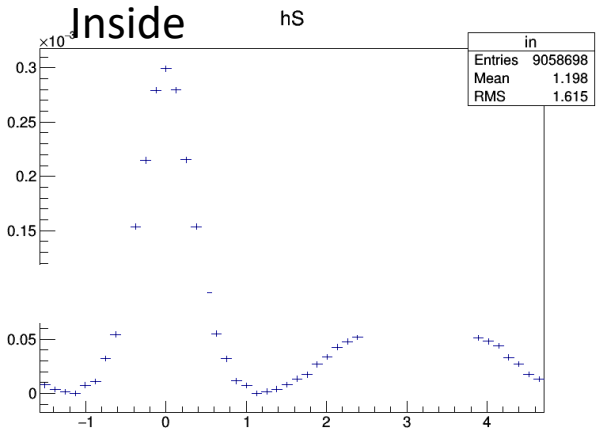
Outside

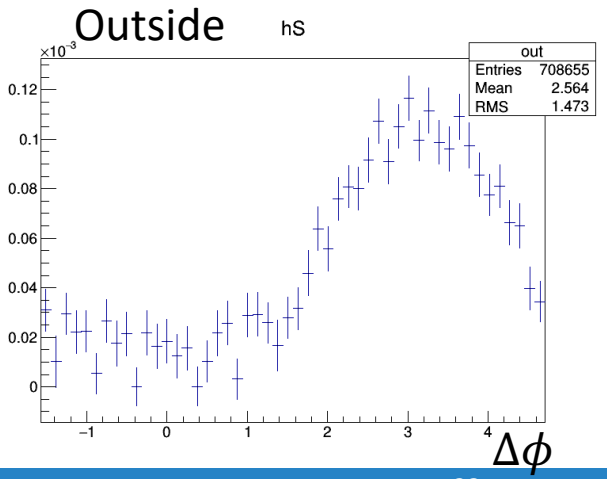


Multiplicity >10, $0.5 < St < 1.0$

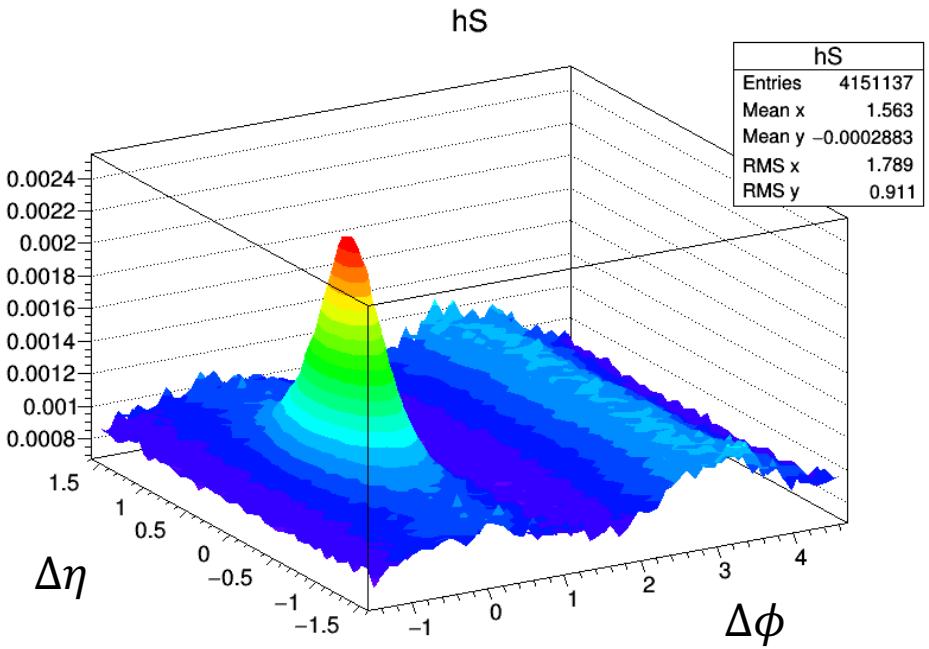


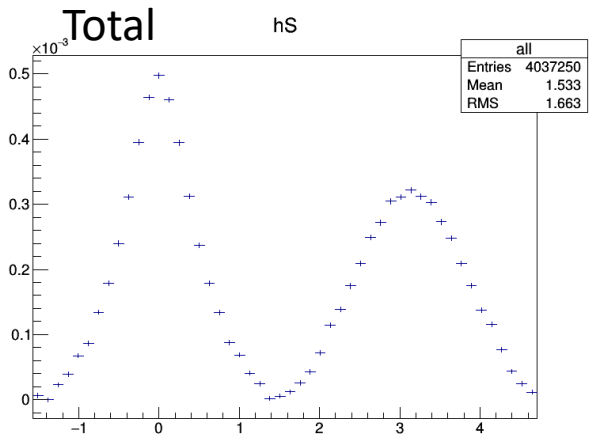


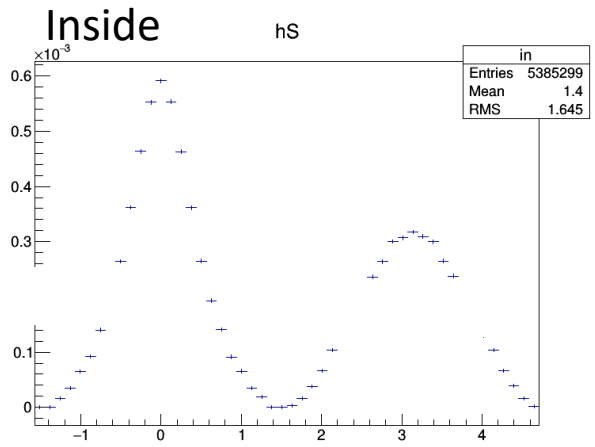


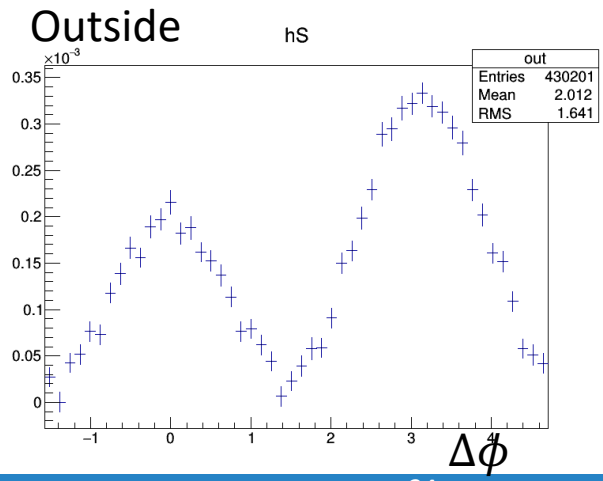


Multiplicity >10, $0.0 < St < 0.795$

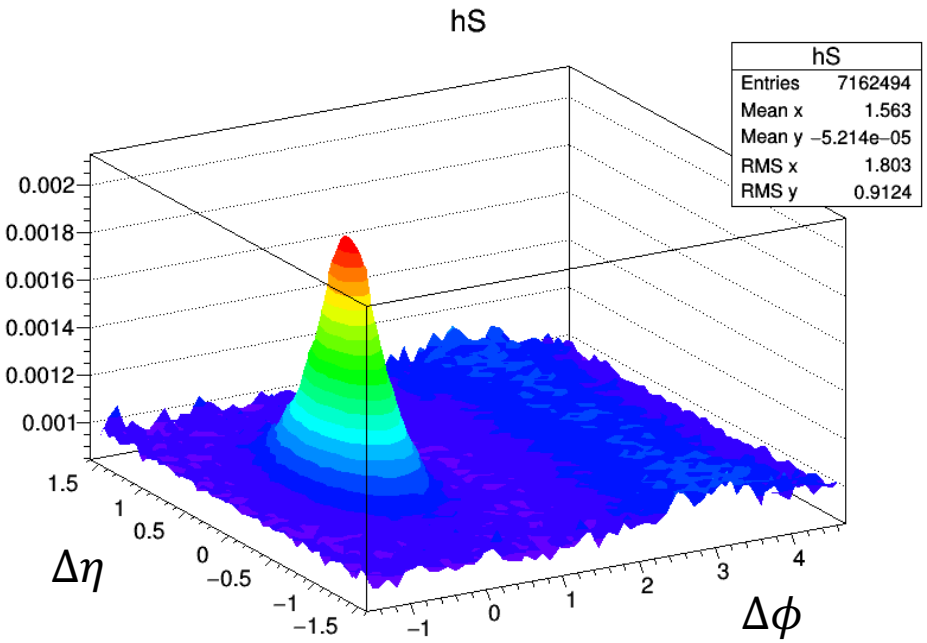


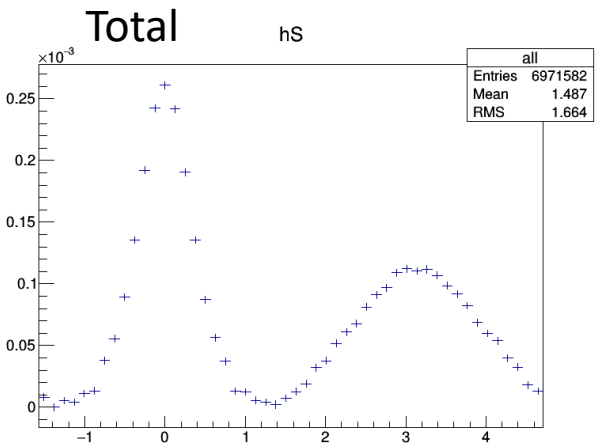


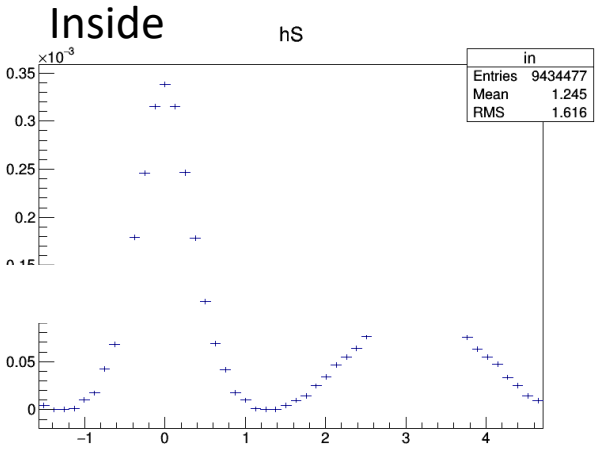


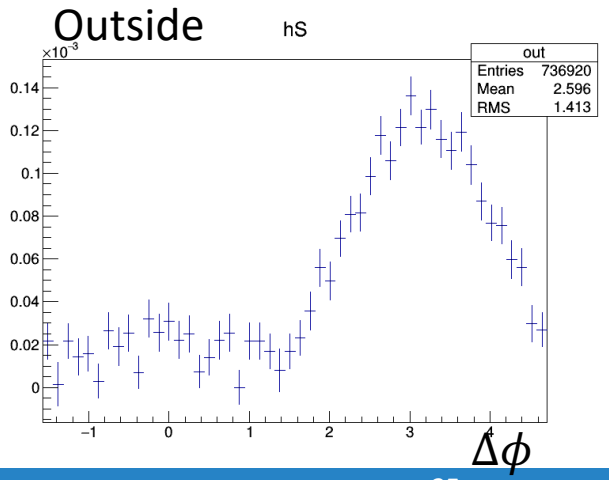


Multiplicity >10, $0.351 < St < 1.0$



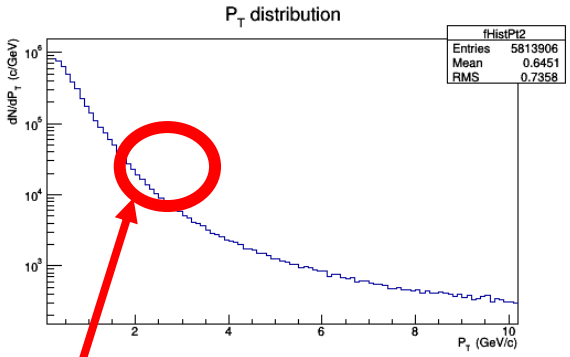


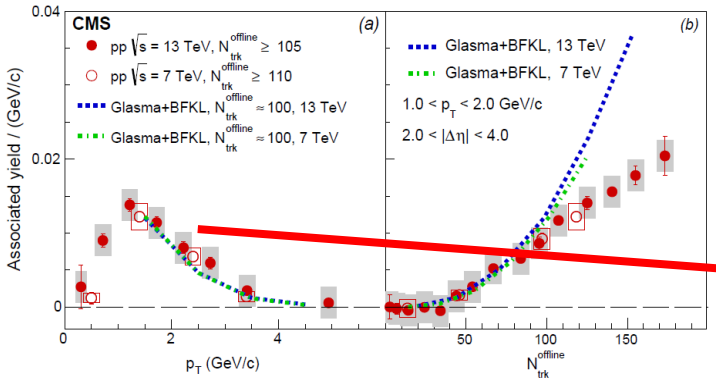


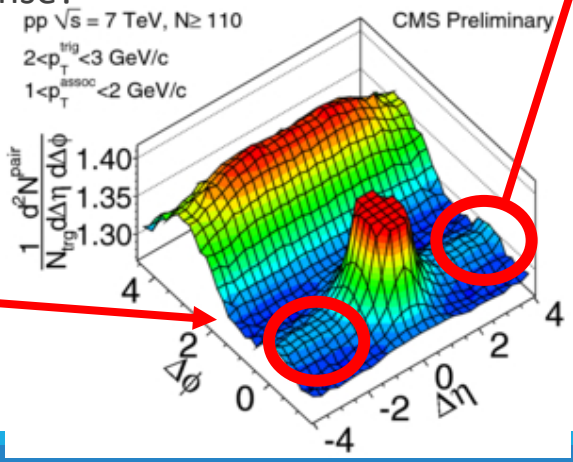


Future prospects and ideas

- Other ways of removing peak?
  - Lowest $\Delta\eta$ cut out
  - Or fit function onto jet peak shape and removed that way
  - or ratio between events bins of different mult/ST
- Draw projections on same axes
  - How should zyam be calculated for drawing histos on same axes?
- MC simulations
- Pt of “ridge particle pairs” make sense?







Backup

Transverse sphericity (ST)

- Momentum space event shape variable
- Scalar with values $S_T \in [0,1]$

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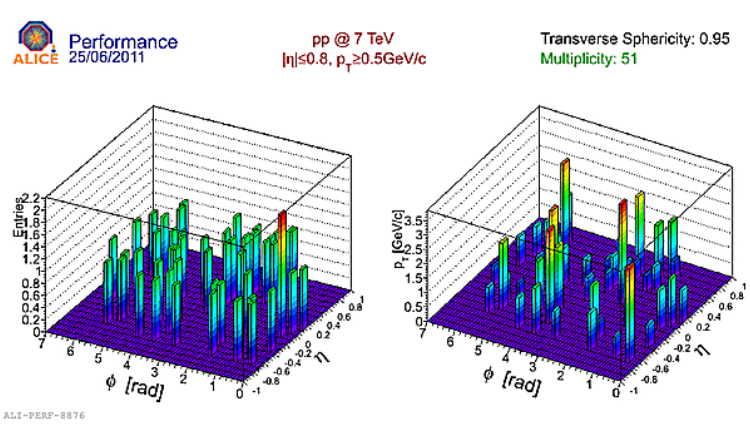
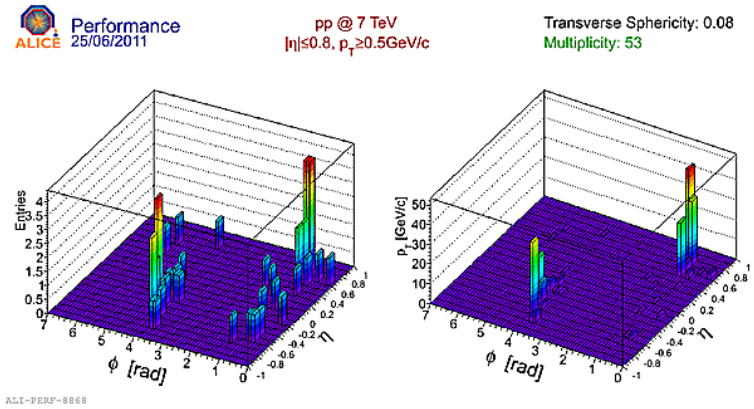
Transverse momentum matrix with eigenvalues $\lambda_1 > \lambda_2$

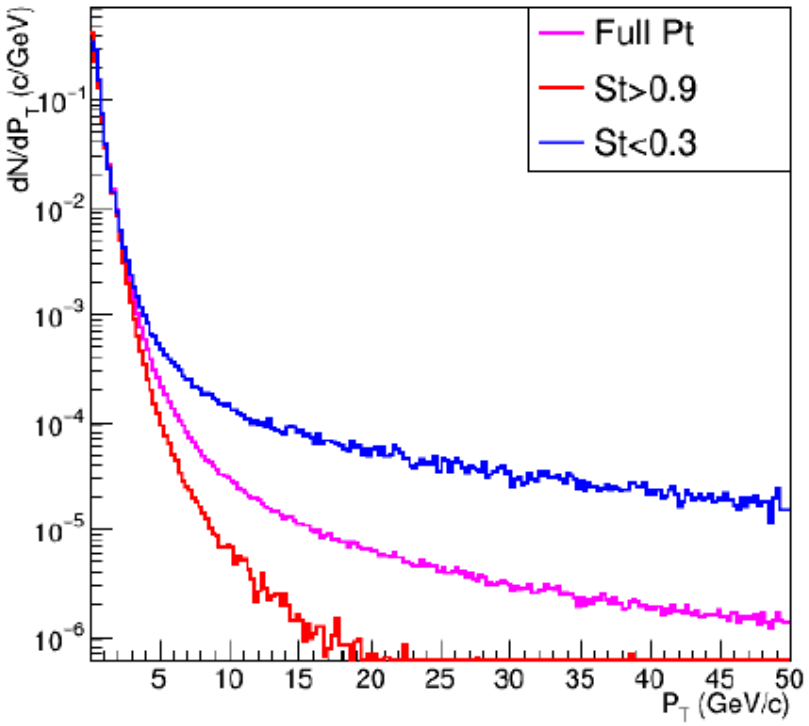
$$S_{xy}^{L} = \frac{1}{\sum_i p_{T\,i}} \sum_i \frac{1}{p_{Ti}} \begin{pmatrix} p_{x\,i}^2 & p_{x_i} p_{y_i} \\ p_{y_i} p_{x_i} & p_{y_i}^2 \end{pmatrix}$$

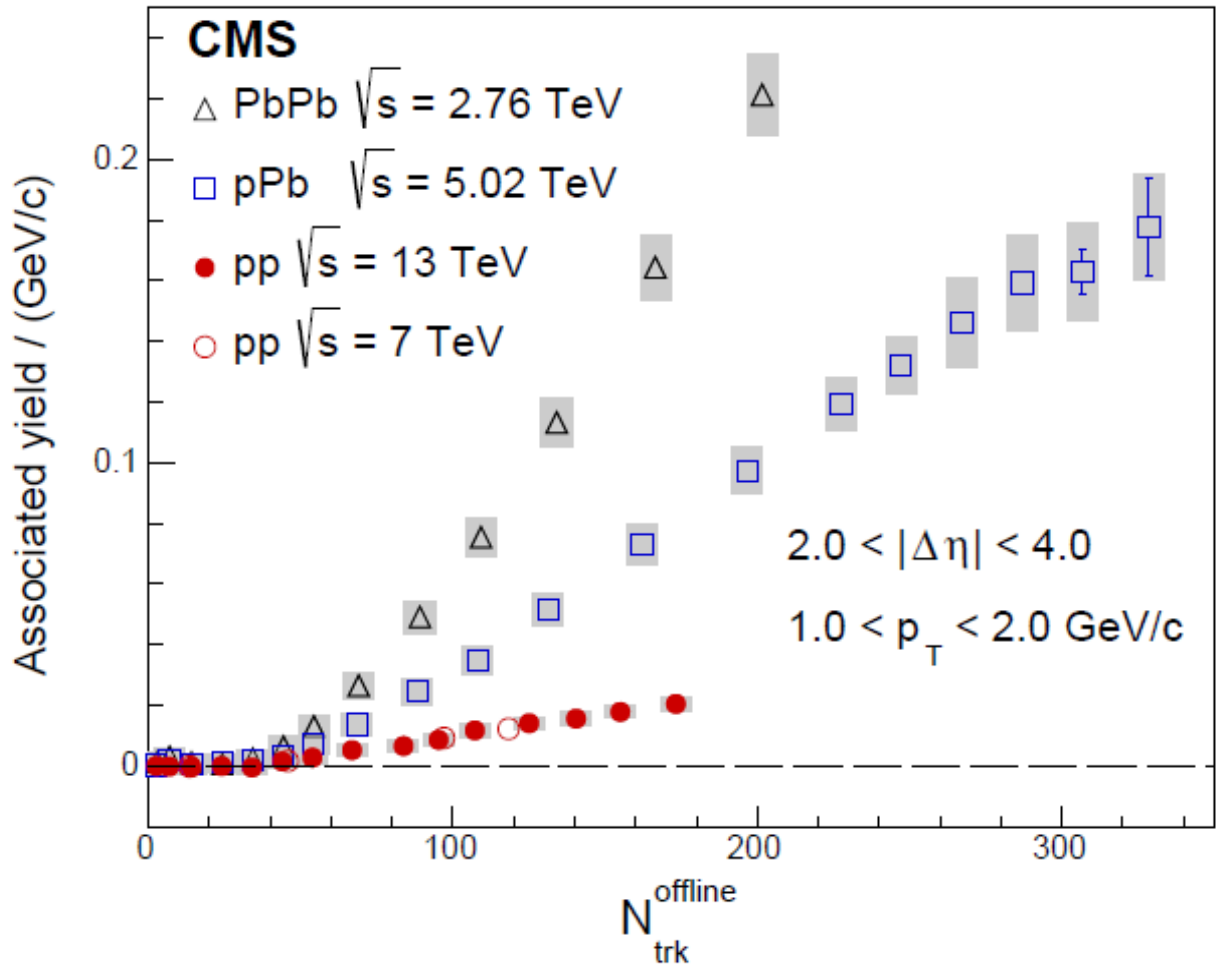
$$S_T = \frac{2\lambda_2}{\lambda_1 + \lambda_2} \Rightarrow S_T = \begin{cases} \approx 0 & \text{Pencil-like} \\ \approx 1 & \text{Isotropic} \end{cases}$$

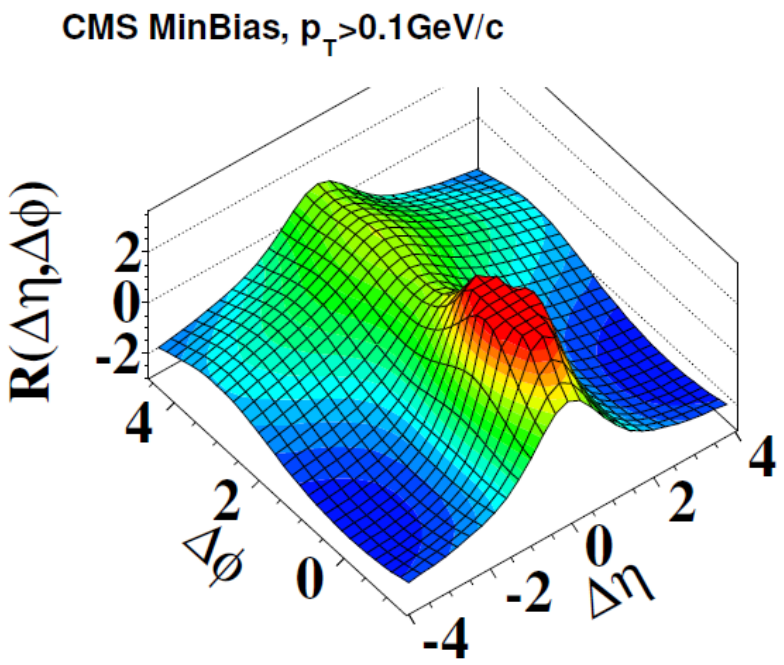


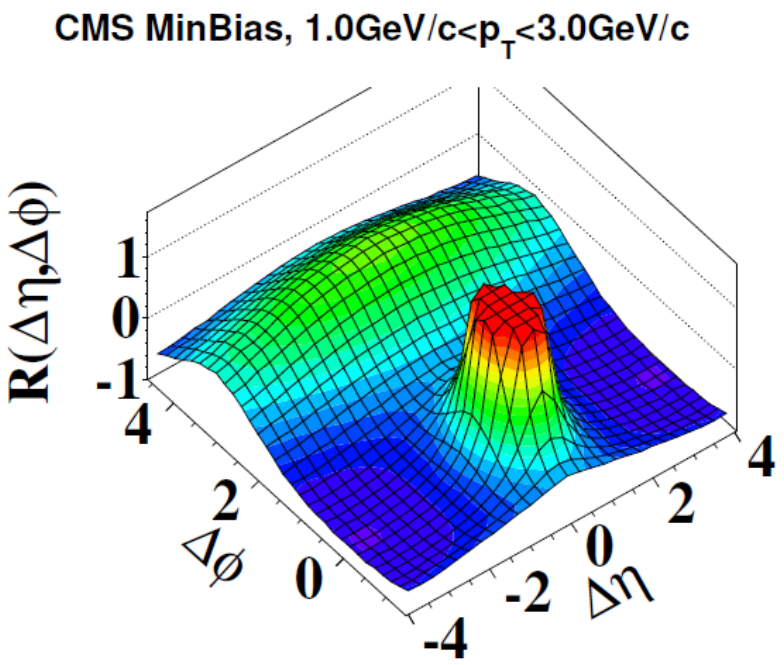


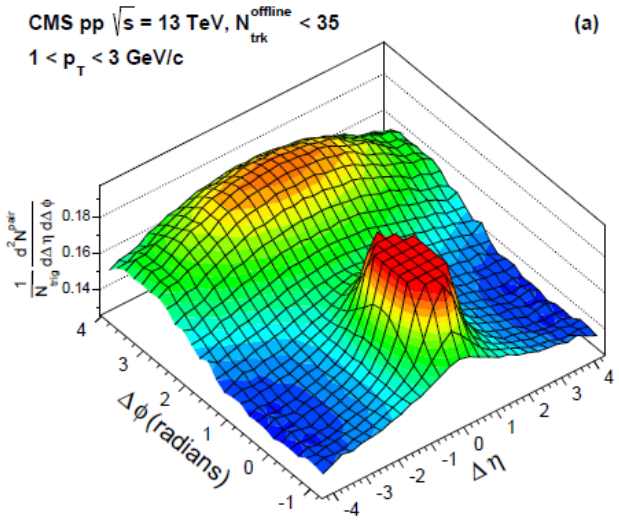
Plan: Study the correlation function structures using transverse sphericity.

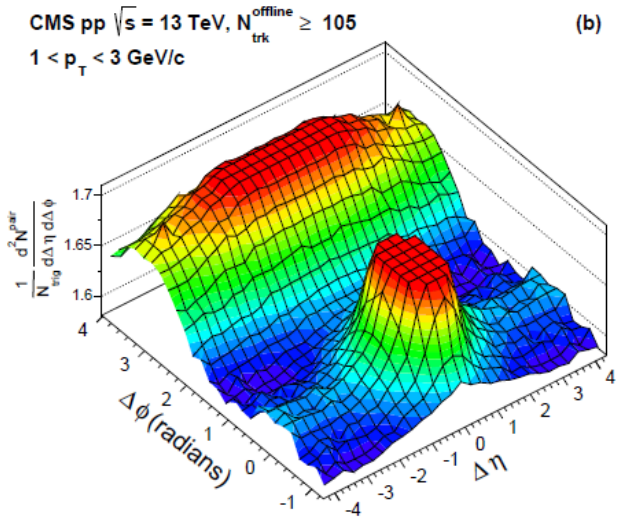

Full Pt
St>0.9
St<0.3
dN/dP_T (c/GeV)
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
5
10
15
20
25
30
35
40
45
50
P_T (GeV/c)

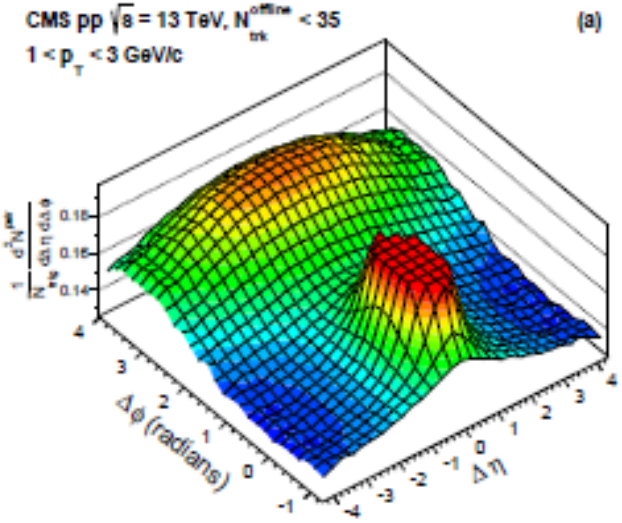

CMS
PbPb √s = 2.76 TeV
pPb √s = 5.02 TeV
pp √s = 13 TeV
pp √s = 7 TeV
2.0 < |Δη| < 4.0
1.0 < p_T < 2.0 GeV/c
Associated yield / (GeV/c)
0
0.1
0.2
0
100
200
300
N_trk^offline

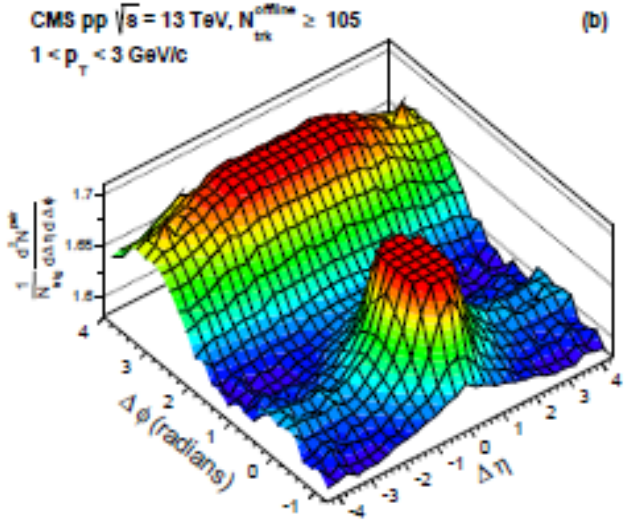

CMS MinBias, p_T>0.1GeV/c
R(Δη,Δφ)
2
0
-2
4
2
0
Δφ
-4
-2
0
2
4
Δη


CMS MinBias, 1.0GeV/c<p_T<3.0GeV/c
R(Δη,Δφ)
1
0
-1
4
2
0
Δφ
-4
-2
0
2
4
Δη

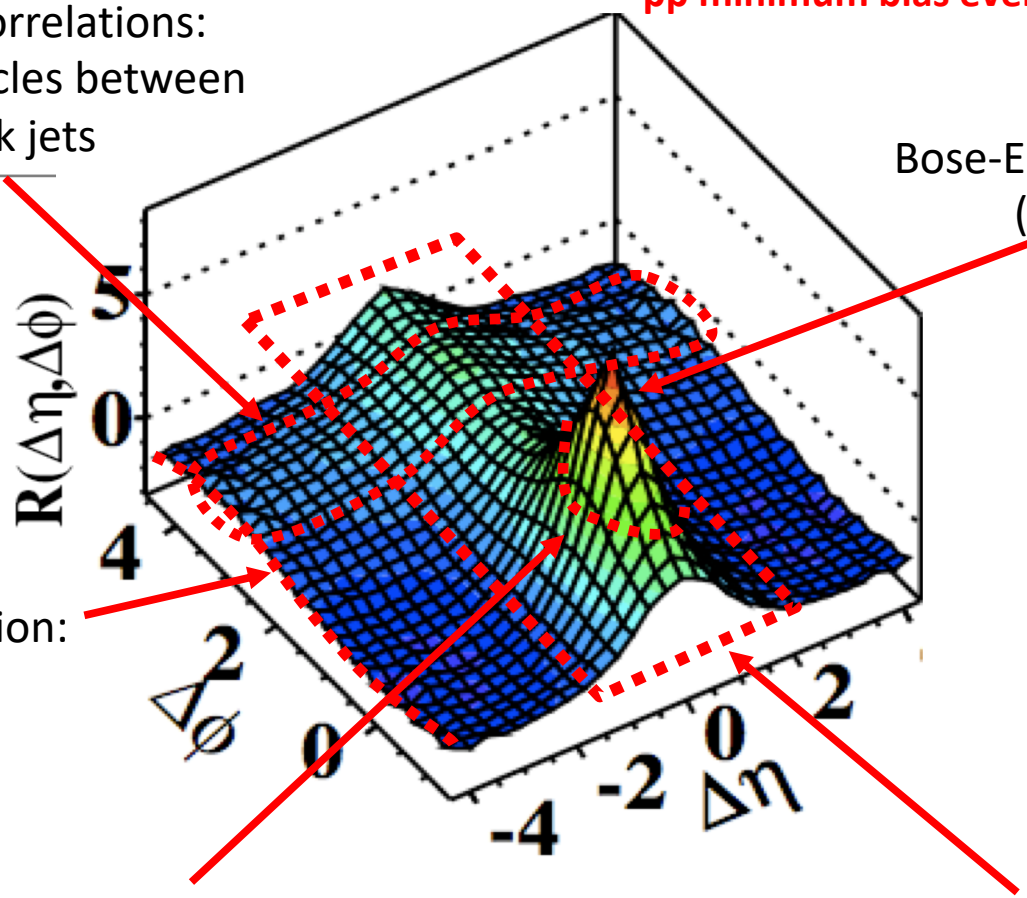

CMS pp √s = 13 TeV, N_trk^offline < 35
1 < p_T < 3 GeV/c
(a)
Δφ (radians)
Δη


CMS pp √s = 13 TeV, N_trk^offline ≥ 105
1 < p_T < 3 GeV/c
(b)
Δφ (radians)
Δη


CMS pp √s = 13 TeV, N_trk^offline < 35
1 < p_T < 3 GeV/c
(a)
Δφ (radians)
Δη


CMS pp √s = 13 TeV, N_trk^offline ≥ 105
1 < p_T < 3 GeV/c
(b)
Δφ (radians)
Δη

Long and short range correlations



"Away-side" jet correlations:
Correlation of particles between back-to-back jets

Bose-Einstein correlations:
$(\Delta\phi,\Delta\eta) \sim (0,0)$

Momentum conservation:
$\sim \cos(\Delta\phi)$

"Near-side", $\Delta\phi \sim 0$ jet peak:
Correlation of particles within a single jet

Short-range correlations
Resonances, string or cluster fragmentation