Multiplicity dependence of Two-particle correlations in p+p collisions at the LHC with ALICE

JIHYUN Bhom
University of Tsukuba

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Outline

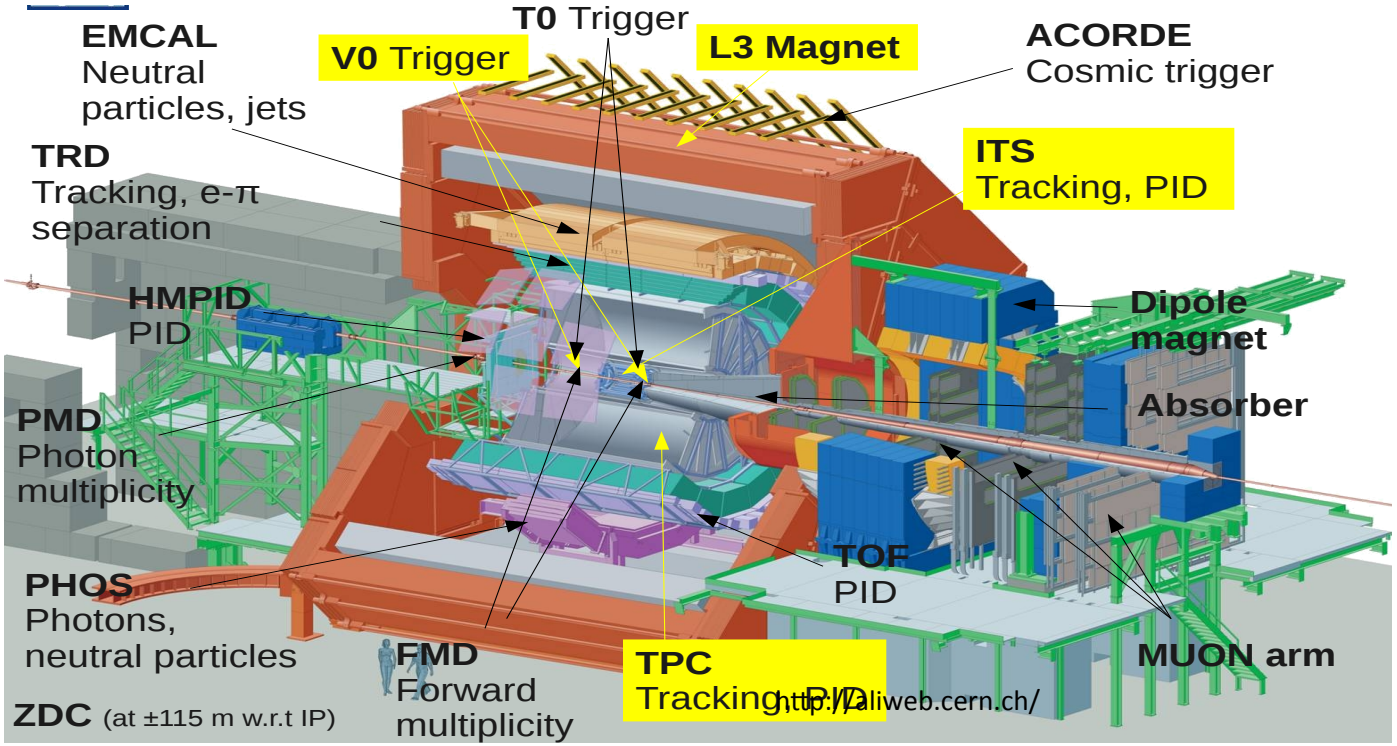
- Introduction
  -ALICE
- Two-particle correlations
  -Correlation Function Definition(C_2)
  -Observation with multiplicity dependence of C_2
  -Method
  -Results with multiplicity dependence of rescaled-C_2
  -Slice $\Delta\varphi$ projection of rescaled-C_2
- Conclusion

Motivation

ALICE is designed to study heavy-ion collisions and also proton-proton collisions.

- p-p collisions are very important as reference for R_{AA} and I_{AA}.
- There could be small but hot & dense matter created in high-multiplicity p-p events

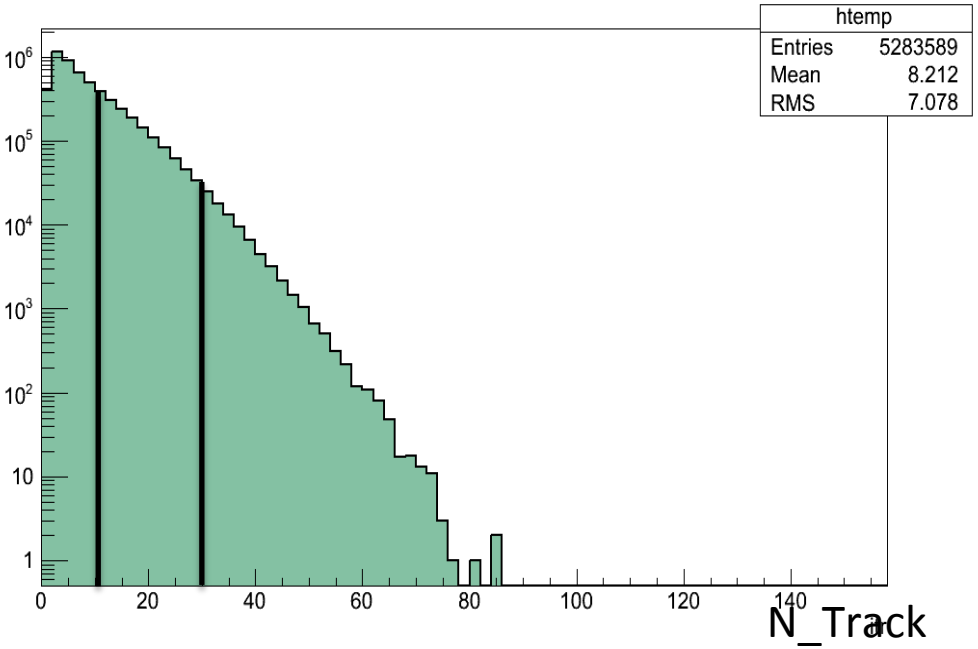
A Large Ion Collider Experiment



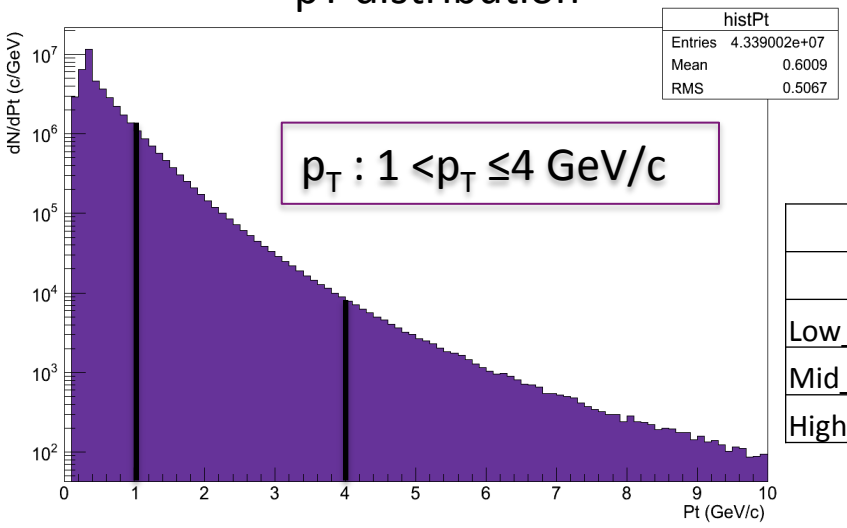
Event Selection

LHC10c_pass3_ P+P collisions_7.0TeV
ESD
TPC
Event cut: |Vz|<10cm
Event: 5M(5,283,589)
MB_trigger
Main track cut: track quality
cuts(χ^2(4),DCA(2cm),#ofcluster/track(70)
$|\eta|<1.0$ and $p_T > 0.15$GeV/c

Measured number of track distribution



pT distribution

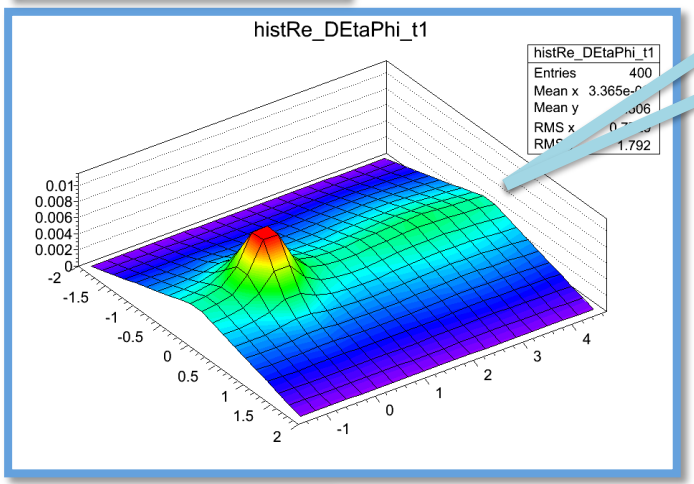


		N of Event	
	Minimum Bias	5283589	
Low_Mt(6)	0<#of track≤15 ➔ <# of track>=6	4423097	14.2-100%
Mid_Mt(21)	15<#of track≤30➔ <# of track>=21	675847	1.4-14.2%
High_Mt(36)	30<#of track ➔ <# of track>=36	72884	0-1.4%

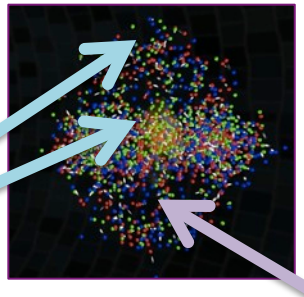
Correlation Function Definition(C_2)

ALICE p-p$\sqrt{s_{NN}}$=7TeV
Min Bias
$1<p_{T,Trig}\leq 4$GeV/c
$1<p_{T,Associ}\leq 4$GeV/c

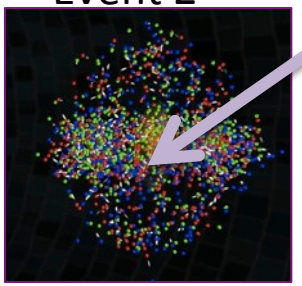
$$S(\Delta\eta,\Delta\phi)=\frac{1}{N^{same}}\frac{d^2N^{same}}{d\Delta\eta d\Delta\phi}$$



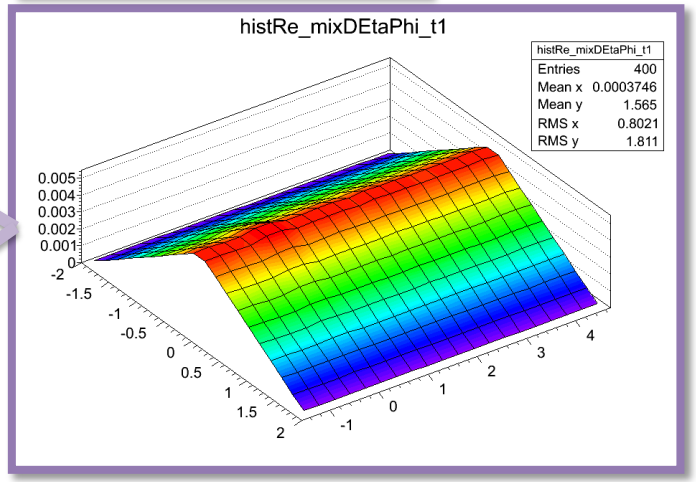
Event 1



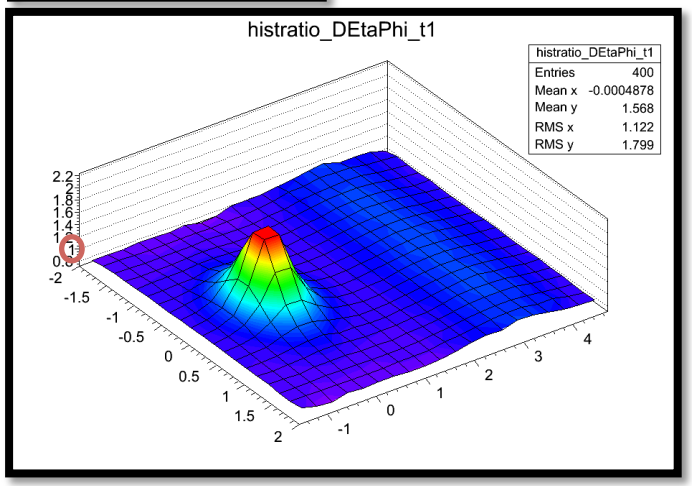
Event 2



$$B(\Delta\eta,\Delta\phi)=\frac{1}{N^{mixed}}\frac{d^2N^{mixed}}{d\Delta\eta d\Delta\phi}$$



$$C_2(\Delta\eta,\Delta\phi)=\frac{S(\Delta\eta,\Delta\phi)}{B(\Delta\eta,\Delta\phi)}$$



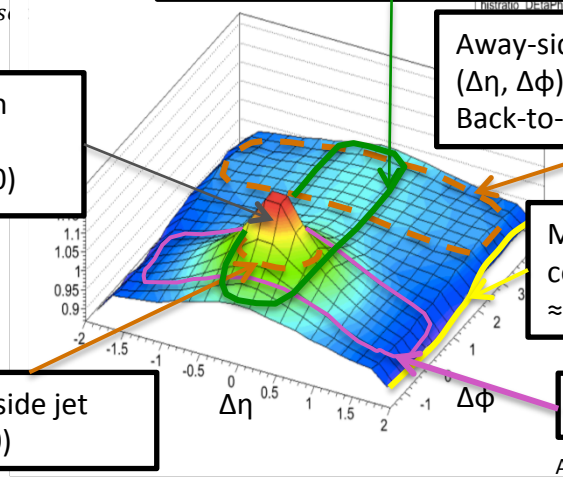
$\Delta\phi=\phi_{Trig}-\phi_{Ass}$
$\Delta\eta=\eta_{Trig}-\eta_{Ass}$

ϕridge:
Resonances, string fragmentation

Away-side jet
(Δη, Δϕ)≈(0,π):
Back-to-back jets

Bose-Einstein
correlations
(Δη, Δϕ)≈(0,0)

Momentum
conservation
≈-cos(Δϕ)➔Flow(v_2)



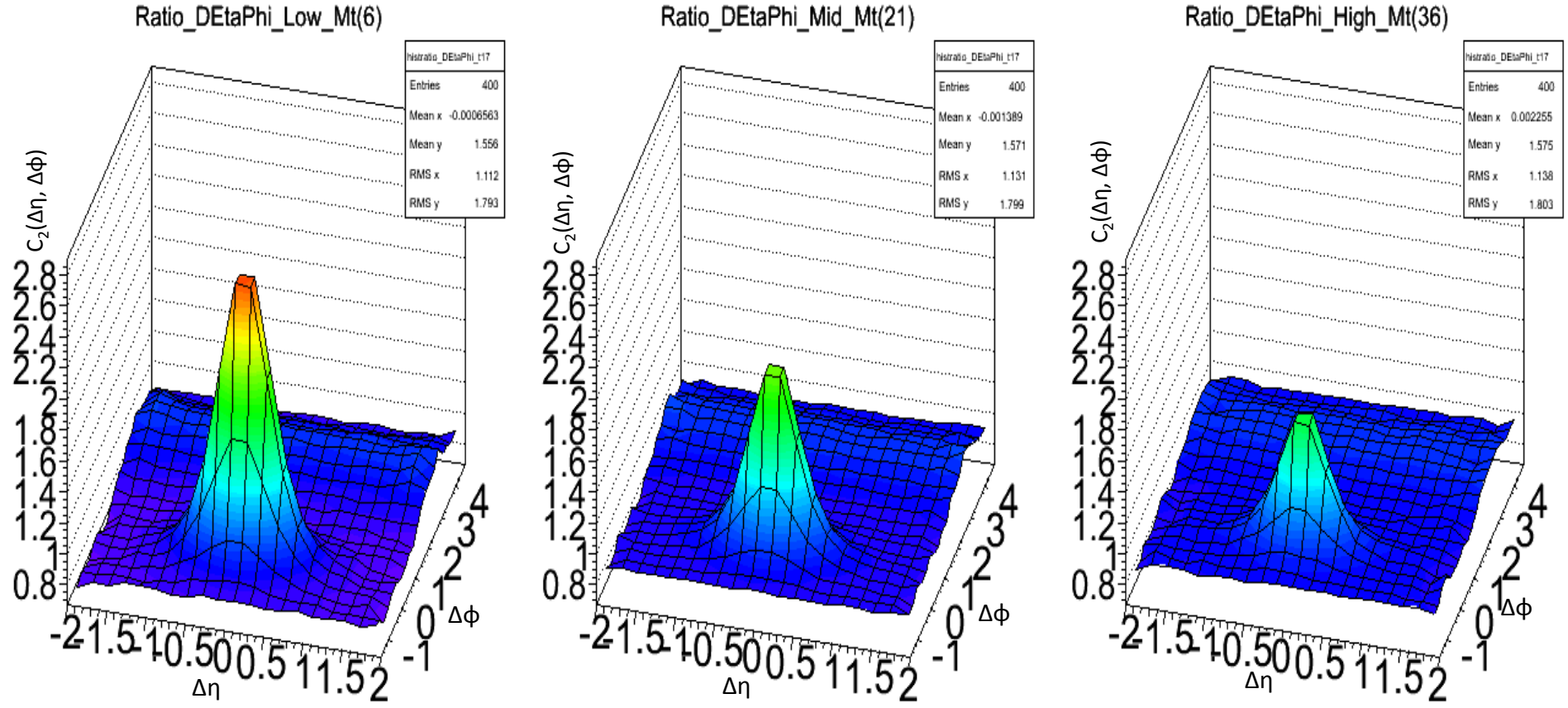
Near-side jet
(Δϕ≈0)

Ridge

ALICE p-p$\sqrt{s_{NN}}$=7TeV
Minimum Bias **C_2**
$0.15<p_{T,Trig}\leq 1$GeV/c
$0.15<p_{T,Associ}\leq 1$GeV/c

Observation with multiplicity dependence of C_2

ALICE p-p$\sqrt{s_{NN}}$=7TeV
C_2
$1<p_{T,Trig}\leq 4$GeV/c
$1<p_{T,Associ}\leq 4$GeV/c

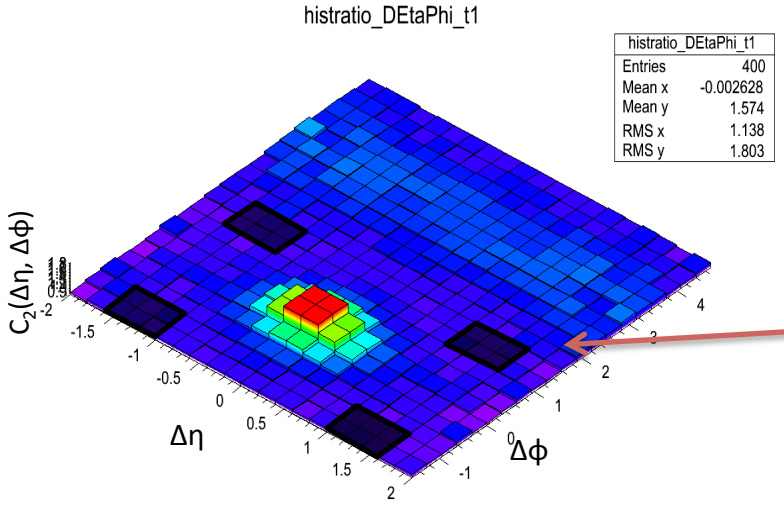


Mult.-dependence of Two-dimensional (2-D) C_2 charged hadrons as a function of Δη and Δϕ for $1<p_{T,Trig}\leq 4$GeV/c, $1<p_{T,Associ}\leq 4$GeV/c, pp collisions at √s = 7 TeV (<# of Track>=6, 21, 36).

- C_2 shows various physics information including HBT, mini-jet, di-jet, phi-ridge and ridge...
- The shapes are different for different multiplicity classes.

Method

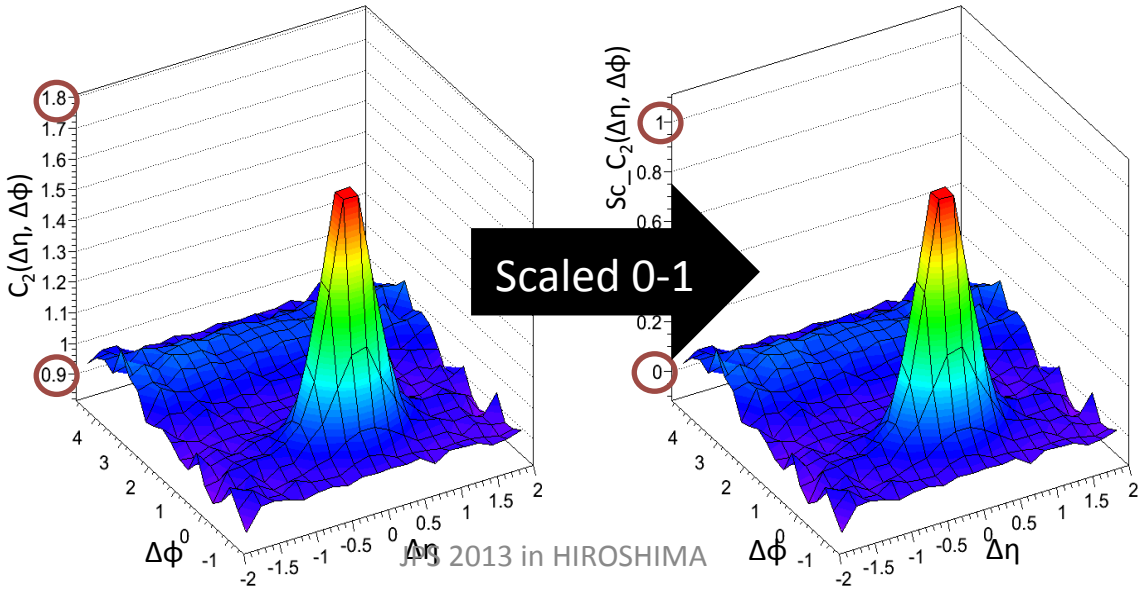
-To normalize $C_2$for study jet shape



1. To subtract uncorrelated part.
   - -Determine the Minimum.
   - ➔C_2-Min
   - Min: Average of minimum of 4 black area, $1.0 \leq |\Delta\eta| \leq 1.5$, $1.0 \leq |\Delta\varphi| \leq 1.5$.
2. To scale 0-1.
   - Scaling factor = Max – Min
   - Max: Around (0,0), Near-side-peak.

Ratio_DEtaPhi_<#ofTrack>=36

Scaled_Ratio_DEtaPhi_<#ofTrack>=36

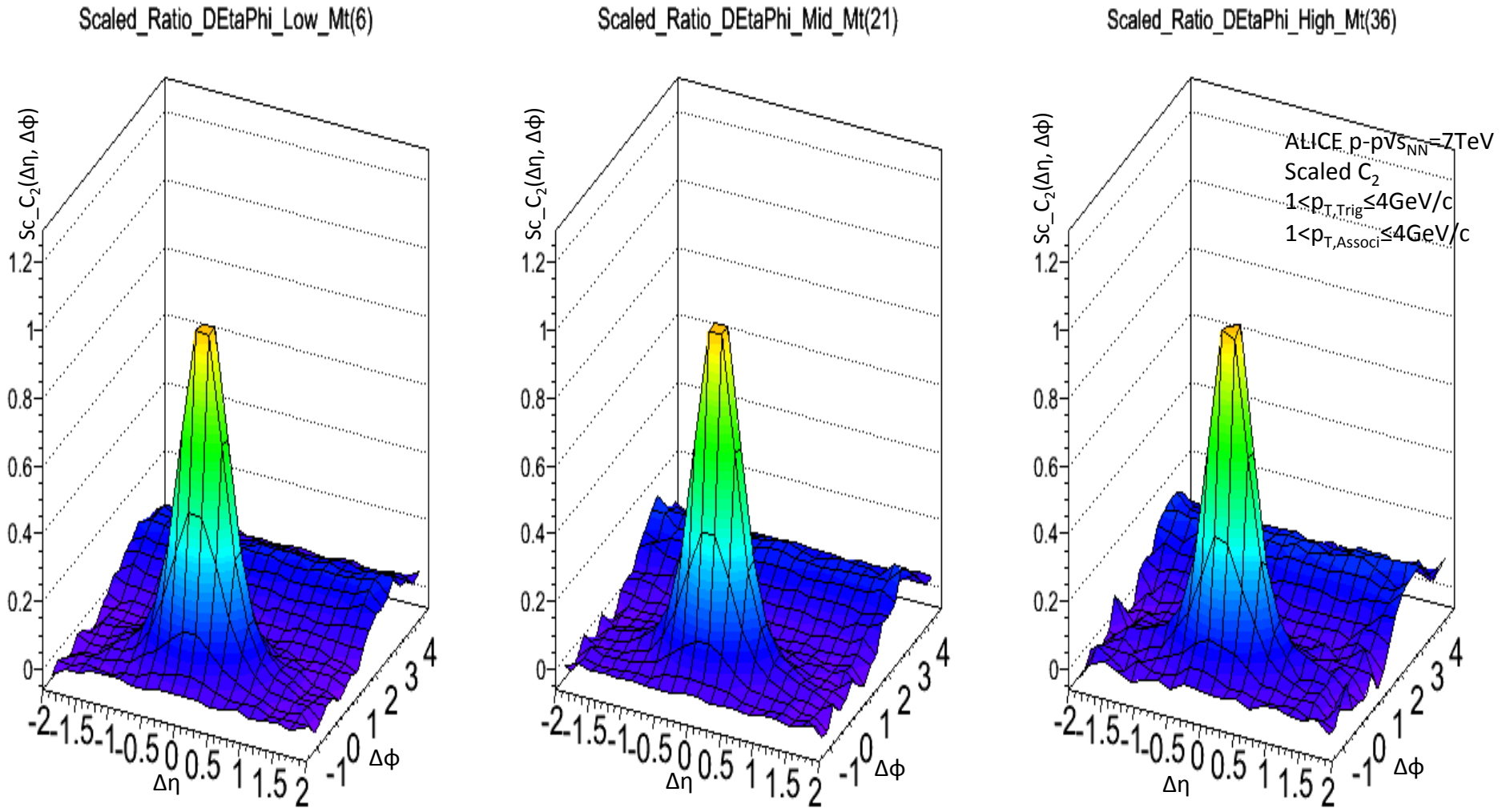


ALICE p-p$\sqrt{s_{NN}}$=7TeV
C_2
$1<p_{T,Trig}\leq 4$GeV/c
$1<p_{T,Associ}\leq 4$GeV/c
<# of Track>=36

ALICE p-p$\sqrt{s_{NN}}$=7TeV
Scaled C_2
$1<p_{T,Trig}\leq 4$GeV/c
$1<p_{T,Associ}\leq 4$GeV/c
<# of Track>=36

Results with multiplicity dependence of rescaled-C_2

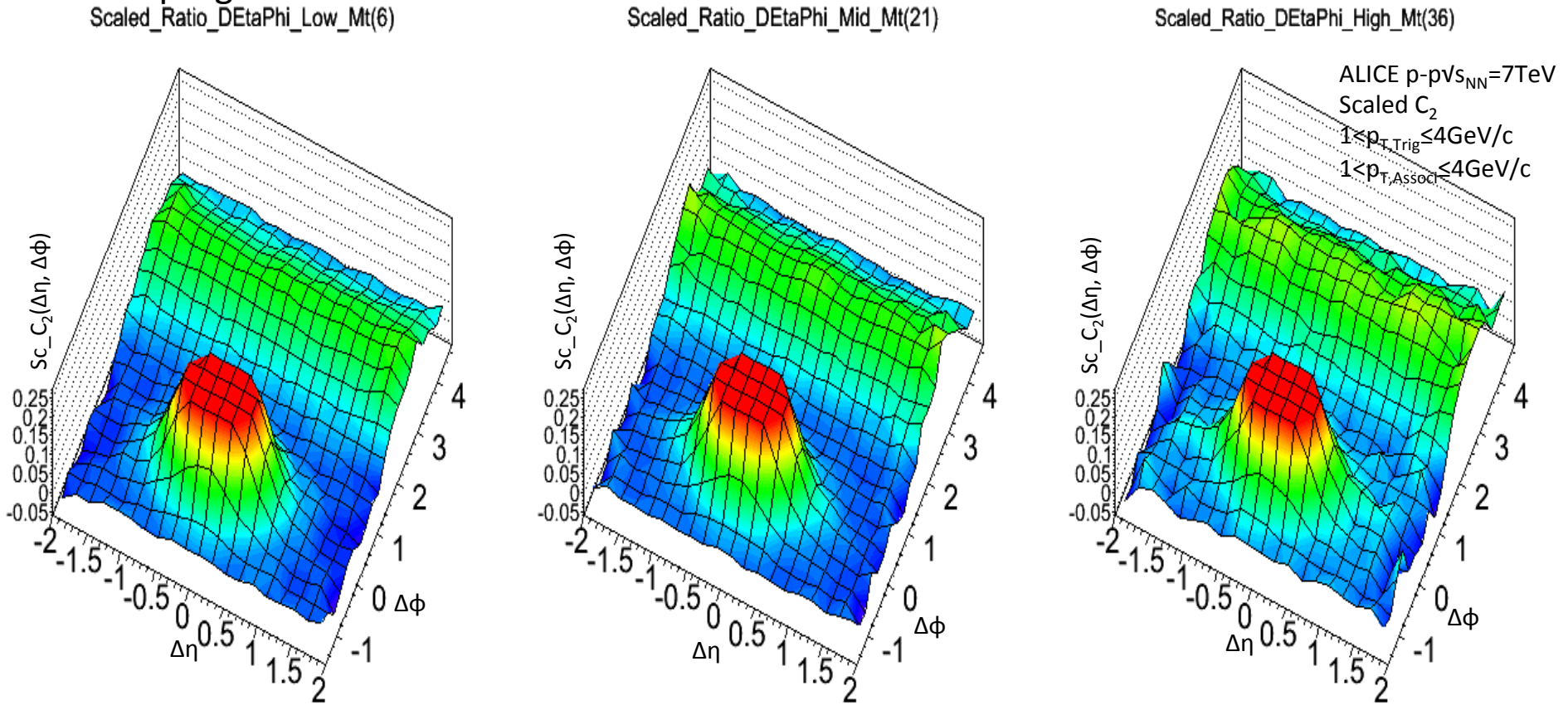
Work in progress



Mult.-dependence of 2-D Scaled C_2 charged hadrons as a function of Δη and Δϕ for $1<p_{T,Trig}\leq 4$GeV/c, $1<p_{T,Associ}\leq 4$GeV/c, pp collisions at √s = 7 TeV (<# of Track>=6, 21, 36).

Results with multiplicity dependence of rescaled-C_2

Work in progress



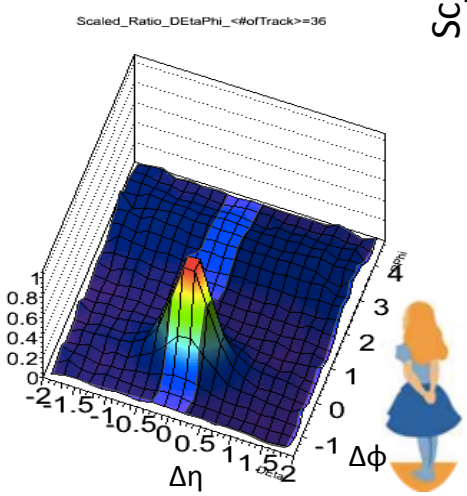
Mult.-dependence of 2-D rescaled-C_2 charged hadrons as a function of Δη and Δϕ for $1<p_{T,Trig}\leq 4$GeV/c, $1<p_{T,Associ}\leq 4$GeV/c, pp collisions at √s = 7 TeV with jet peak cut off for better demonstration of the ridge(<# of Track>=6, 21, 36).

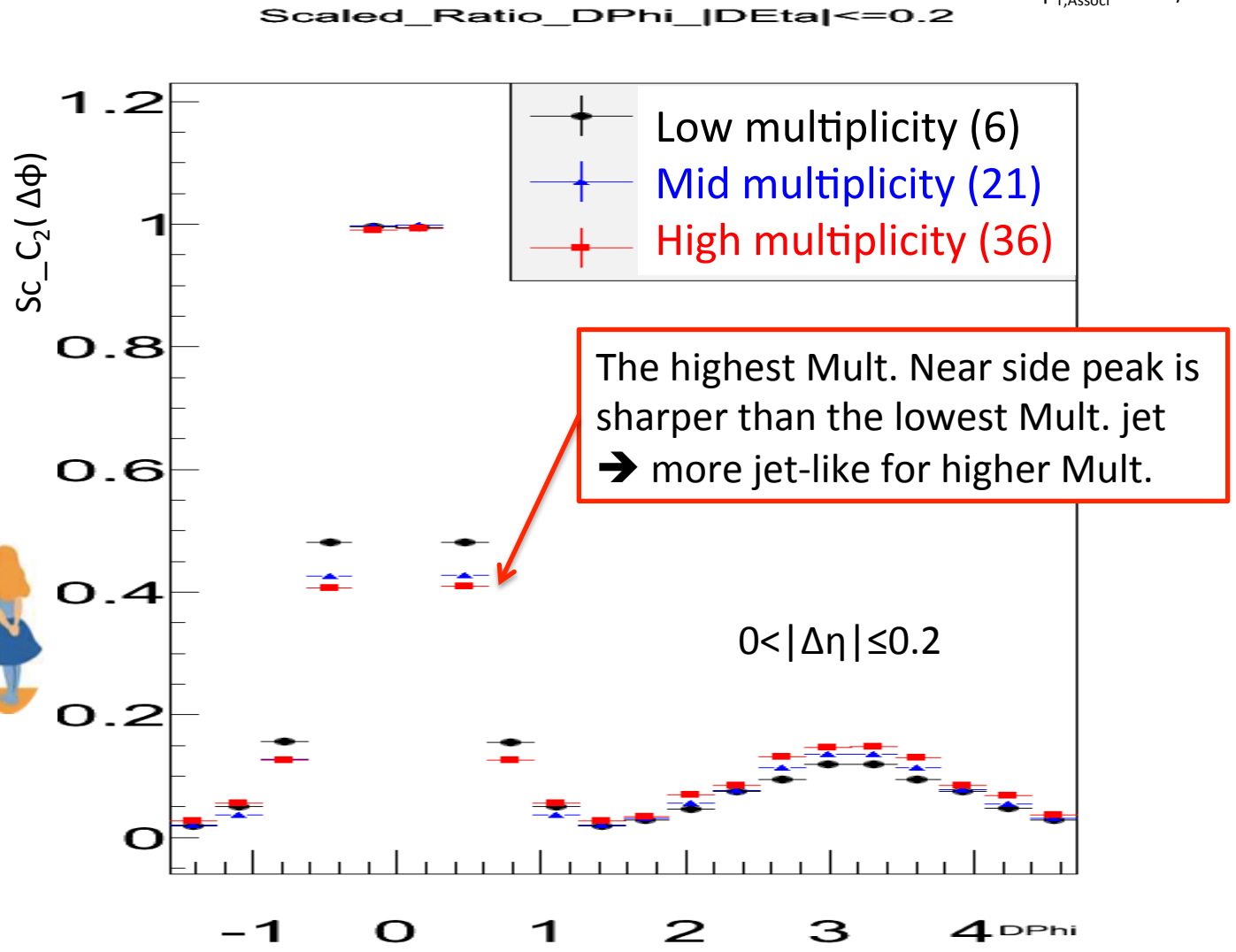
- Comparison between 3 multiplicity classes are done.
- High multiplicity p-p events are more "jet-like".
- Possible indication of "ridge" is seen at high-multiplicity.

Slice Δϕ projection of rescaled-C_2

ALICE p-p$\sqrt{s_{NN}}$=7TeV
Scaled C_2
$1<p_{T,Trig}\leq 4$GeV/c
$1<p_{T,Associ}\leq 4$GeV/c

Work in progress



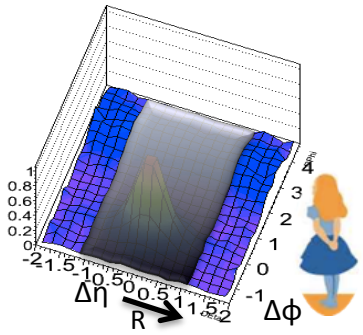


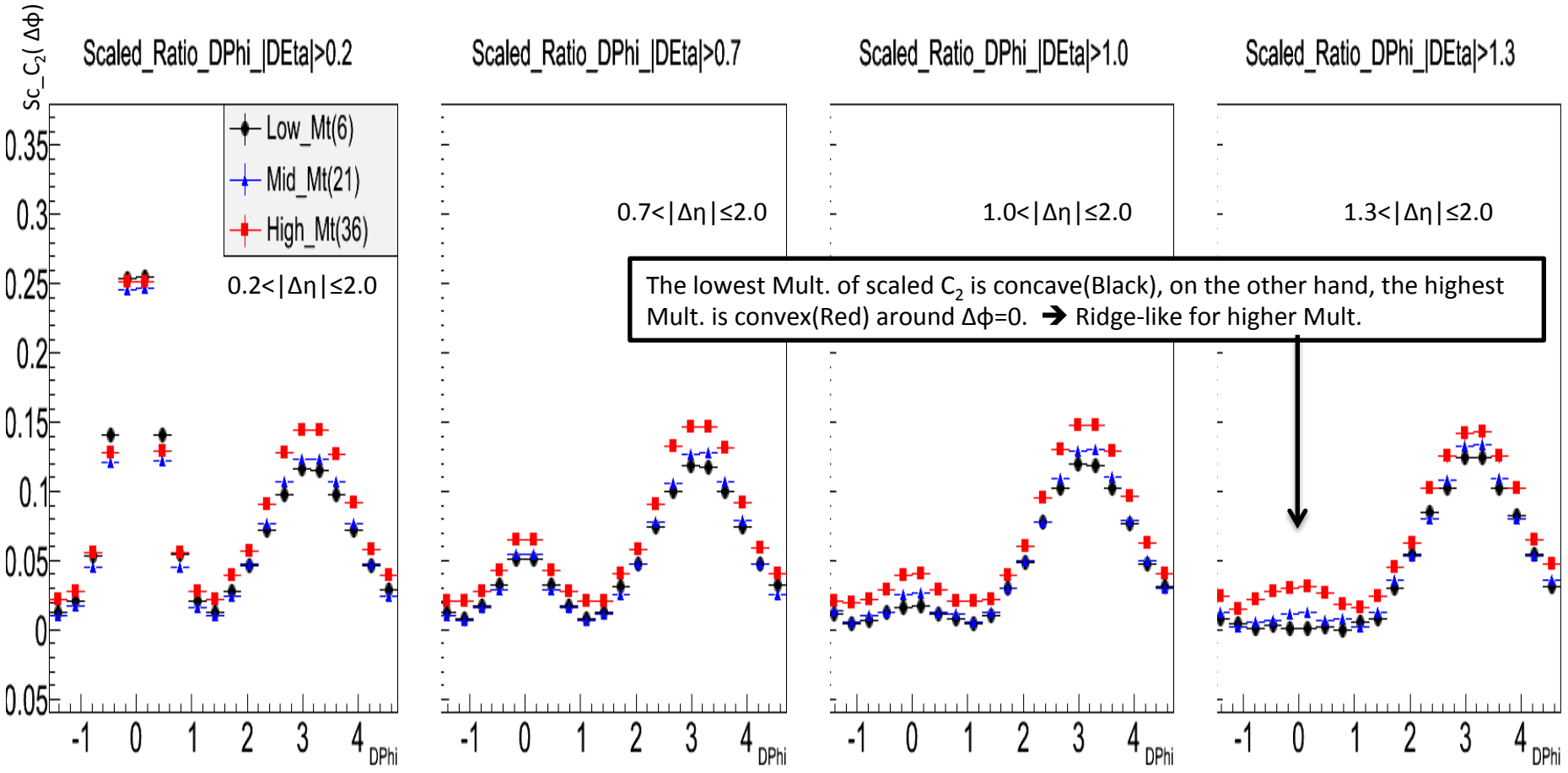
Short-range slice Δϕ projection of rescaled-C_2
The error bars correspond to statistical errors.

Slice Δϕ projection of rescaled-C_2

ALICE p-p$\sqrt{s_{NN}}$=7TeV
Scaled C_2
$1<p_{T,Trig}\leq 4$GeV/c
$1<p_{T,Associ}\leq 4$GeV/c

Work in progress





Long range slice Δϕ projection of resclaedC_2

Conclusion

1. ALICE is designed to study heavy-ion collisions and also proton-proton collisions.
   -p-p collisions are very important as a reference for I_{AA}, R_{AA}.
   -High multiplicity p-p collisions could provide small but high density system.

2. Mult.-Dep. of C_2
   -C_2 shows jet-like shape
   -The shapes are different for different multiplicity.

3. Mult.-Dep. of rescaled-C_2
   -Comparison with 3 multiplicity classes is done.
   -p-p events are more jet-like for high-multiplicity events.
   -Indication of ridge-like signal is seen for high-multiplicity events.

- Back up

Mult.-Dep. of C_2 by p_T_the Lowest_Mt(6)

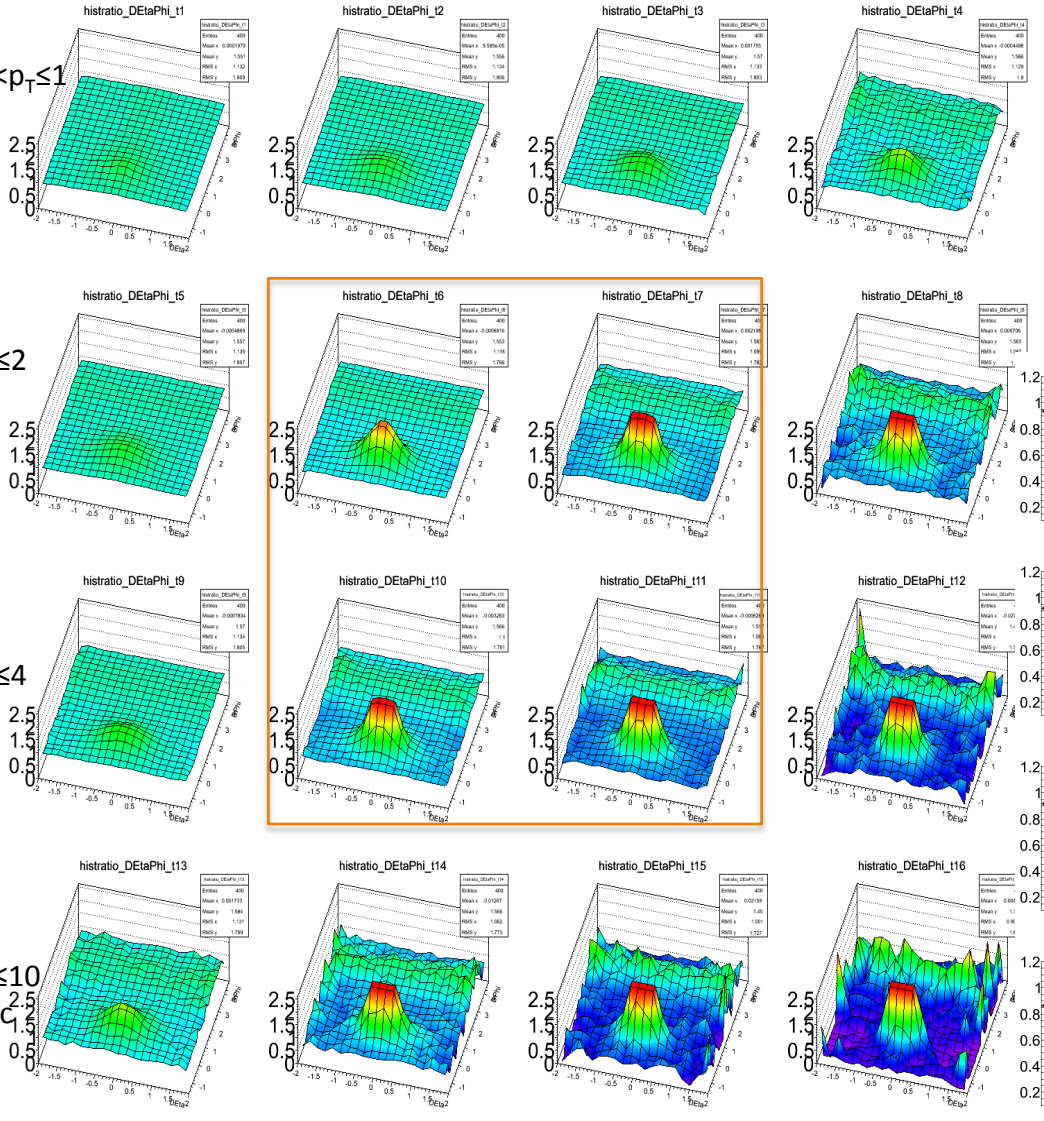
Associ: $0.15<p_T\leq1$ | $1<p_T\leq2$ | $2<p_T\leq4$ | $4<p_T\leq10$ GeV/c

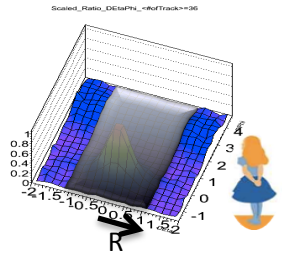
Trig: $0.15<p_T\leq1$

$1<p_T\leq2$

$2<p_T\leq4$

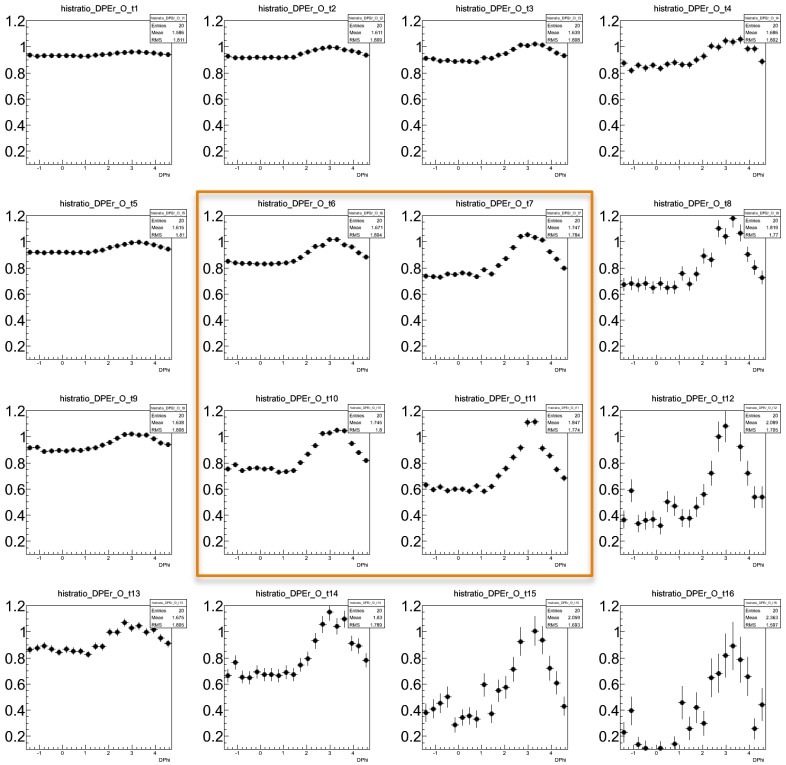
$4<p_T\leq10$ GeV/c





Slice $\Delta\phi$ projection of C_2

$1.3<|\Delta\eta|\leq2.0$



Mult.-Dep. of C_2 by p_T_the highest_Mt(36)

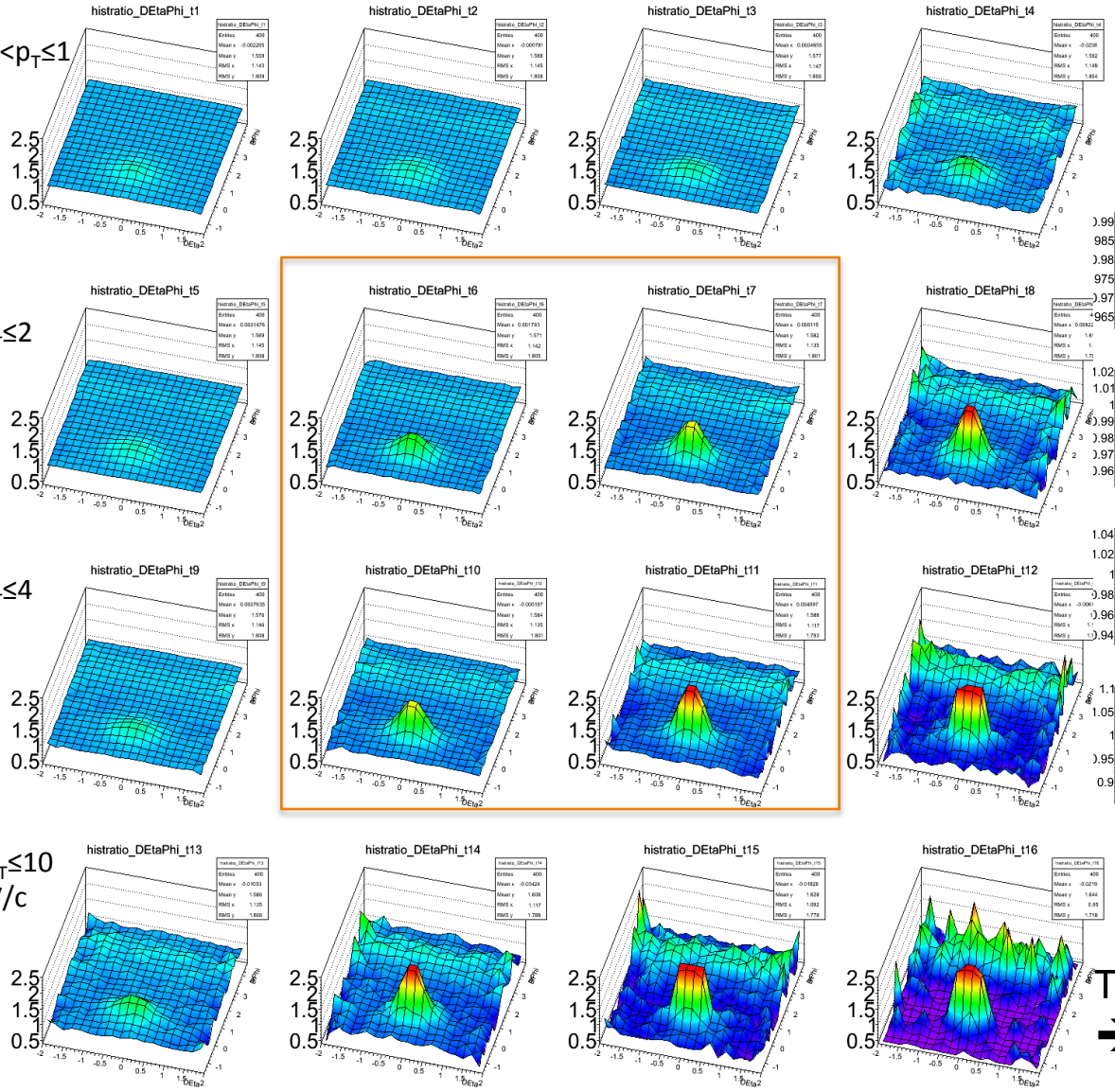
Associ: $0.15<p_T\leq1$ $1<p_T\leq2$ $2<p_T\leq4$ $4<p_T\leq10$ GeV/c

Trig: $0.15<p_T\leq1$

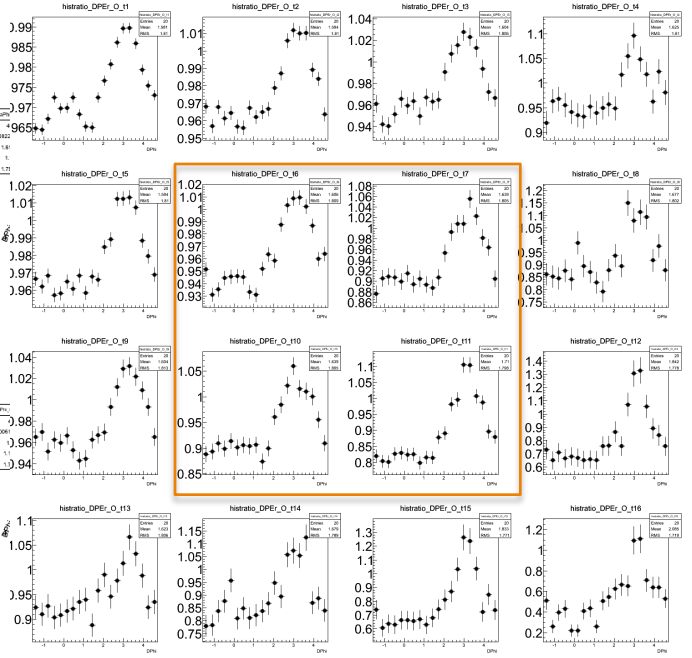
$1<p_T\leq2$

$2<p_T\leq4$

$4<p_T\leq10$ GeV/c



Slice $\Delta\phi$ projection of C_2
$1.3<|\Delta\eta|\leq2.0$



The reason selected p_T bin $1<p_T\leq4$
➔ Ridge-like for higher Mult.

Observation of Long-Range, Near-Side Angular Correlations in Proton-Proton Collisions at the LHC

Table 1: Number of events for each multiplicity bin used in the 7 TeV analysis with total integrated luminosity of 980 nb^{-1}. The multiplicity of offline reconstructed tracks, $N_{\mathrm{trk}}^{\mathrm{offline}}$, was counted within the kinematic cuts of $|\eta| < 2.4$ and $p_T > 0.4\,\mathrm{GeV}/c$. The last two columns list the average values of $N_{\mathrm{trk}}^{\mathrm{offline}}$ as well as the average of $N_{\mathrm{trk}}^{\mathrm{corrected}}$, the event multiplicity corrected for all detector and algorithm inefficiencies.

	Multiplicity bin ($N_{\mathrm{trk}}^{\mathrm{offline}}$)	Event Count	$\langle N_{\mathrm{trk}}^{\mathrm{offline}} \rangle$	$\langle N_{\mathrm{trk}}^{\mathrm{corrected}} \rangle$
	MinBias	21.43M	15.9	17.8
12.5-100%	$N_{\mathrm{trk}}^{\mathrm{offline}} < 35$	19.36M	13.0	14.1
3.1-12.5%	$35 \leq N_{\mathrm{trk}}^{\mathrm{offline}} < 90$	2.02M	45.3	53.1
1.7-3.1%	$90 \leq N_{\mathrm{trk}}^{\mathrm{offline}} < 110$	302.5k	96.6	111.7
0-1.7%	$N_{\mathrm{trk}}^{\mathrm{offline}} \geq 110$	354.0k	117.8	136.1

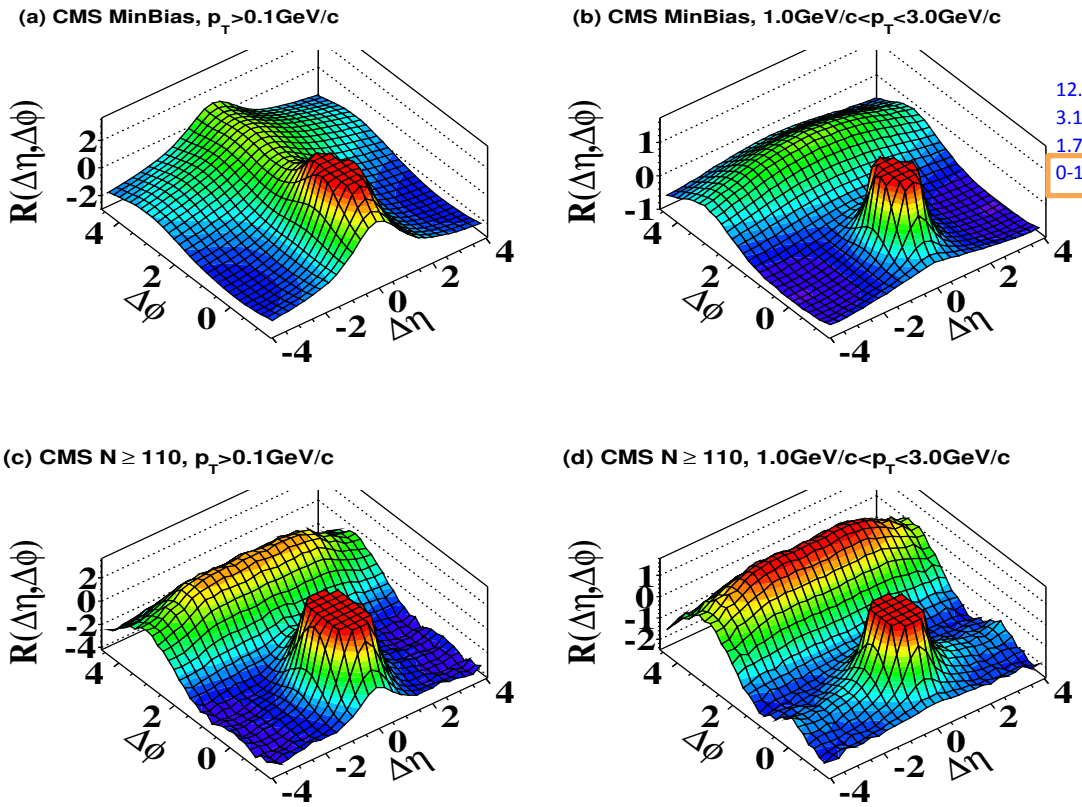


Figure 7: 2-D two-particle correlation functions for 7 TeV pp (a) minimum bias events with $p_T > 0.1\,\mathrm{GeV}/c$, (b) minimum bias events with $1 < p_T < 3\,\mathrm{GeV}/c$, (c) high multiplicity ($N_{\mathrm{trk}}^{\mathrm{offline}} \geq 110$) events with $p_T > 0.1\,\mathrm{GeV}/c$ and (d) high multiplicity ($N_{\mathrm{trk}}^{\mathrm{offline}} \geq 110$) events with $1 < p_T < 3\,\mathrm{GeV}/c$. The sharp near-side peak from jet correlations is cut off in order to better illustrate the structure outside that region.

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