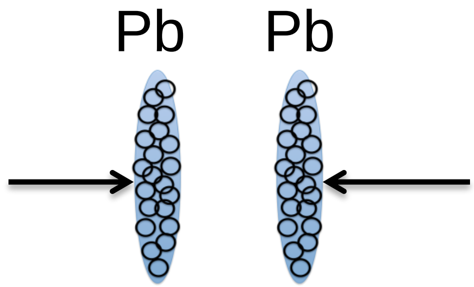
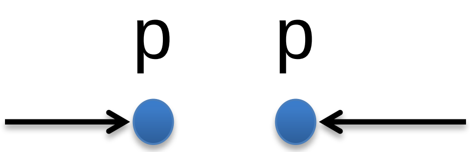
Fresh news from the 5TeV pPb run at the LHC with CMS

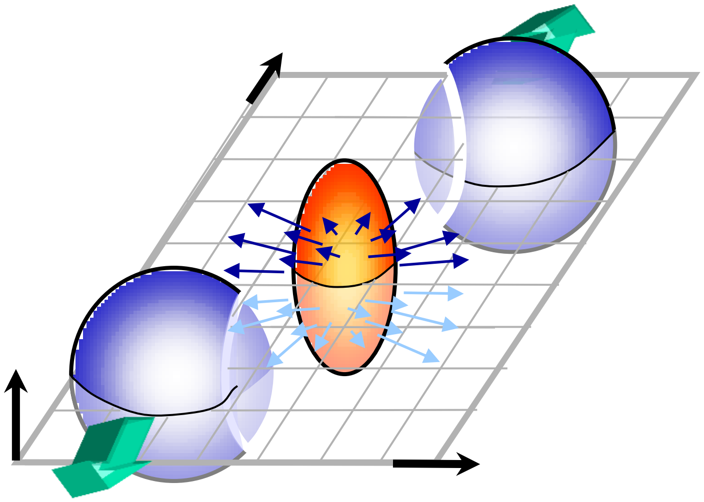
Dragos Velicanu

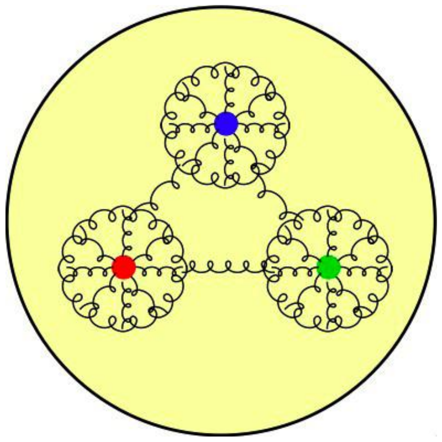
Goal

Goal: To understand initial conditions of pPb collisions through long range correlations of produced charged particles









Goal

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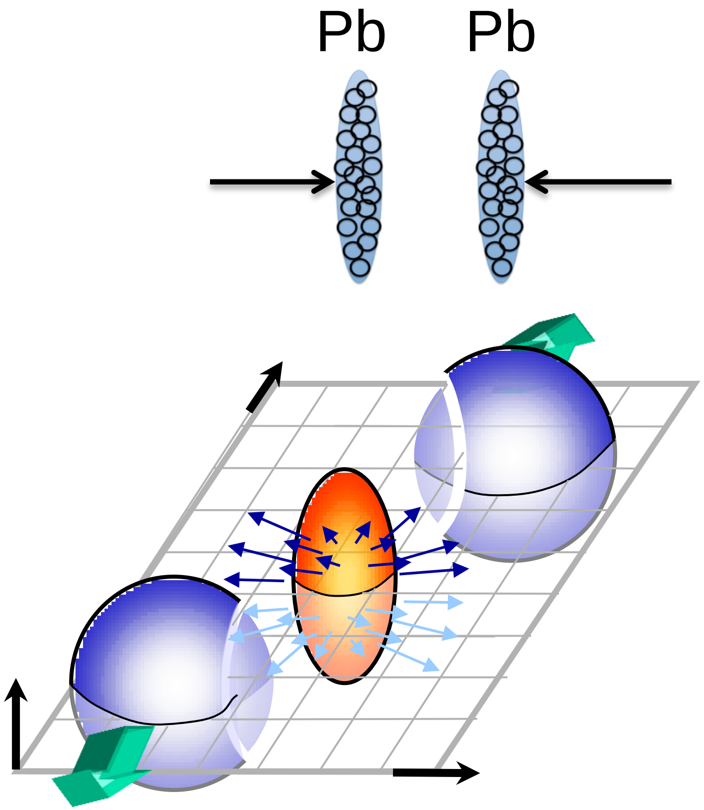
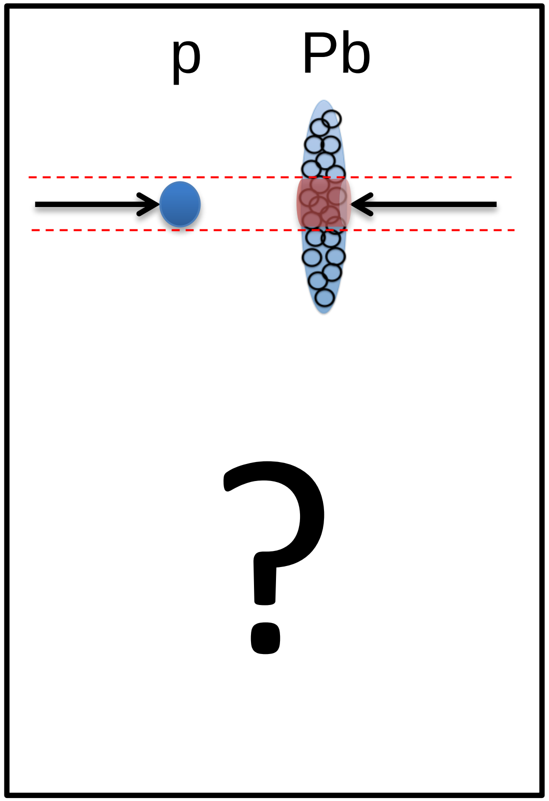
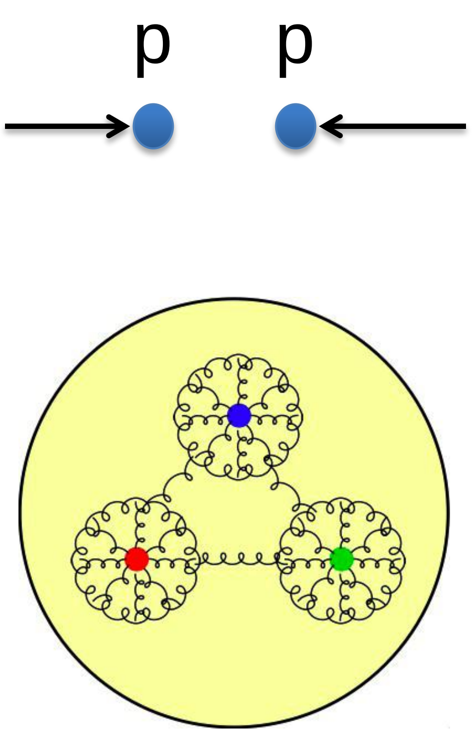
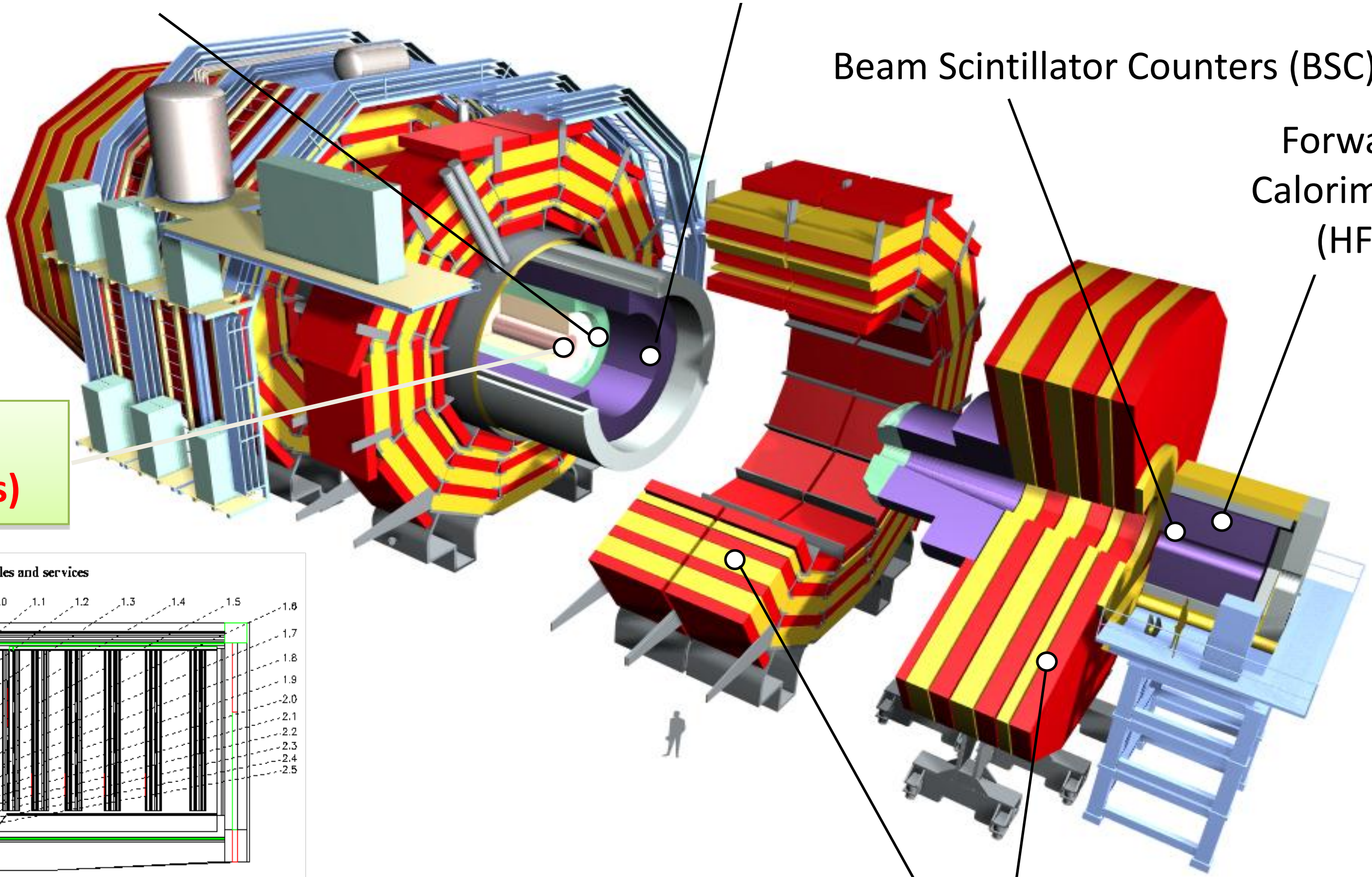
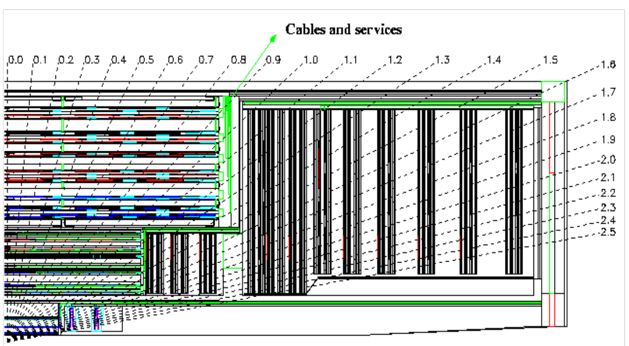






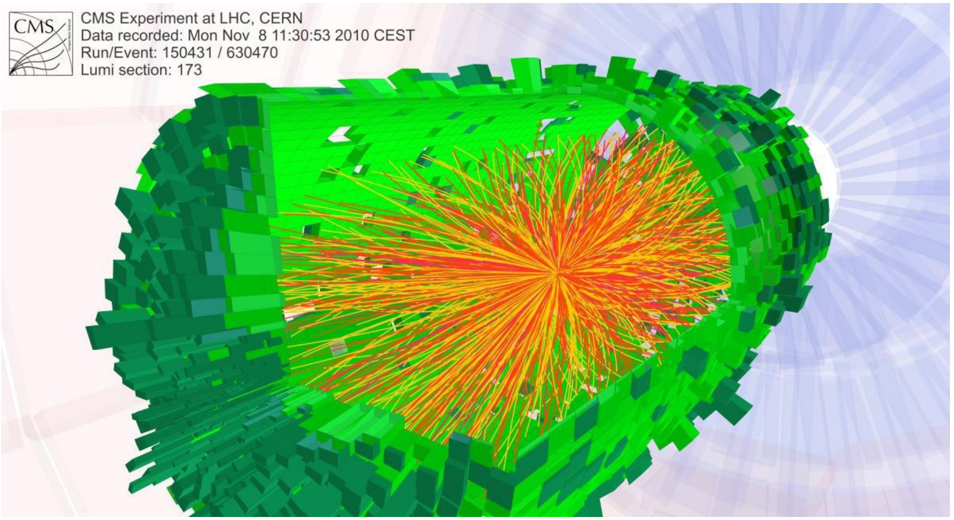
Compact Muon Solenoid

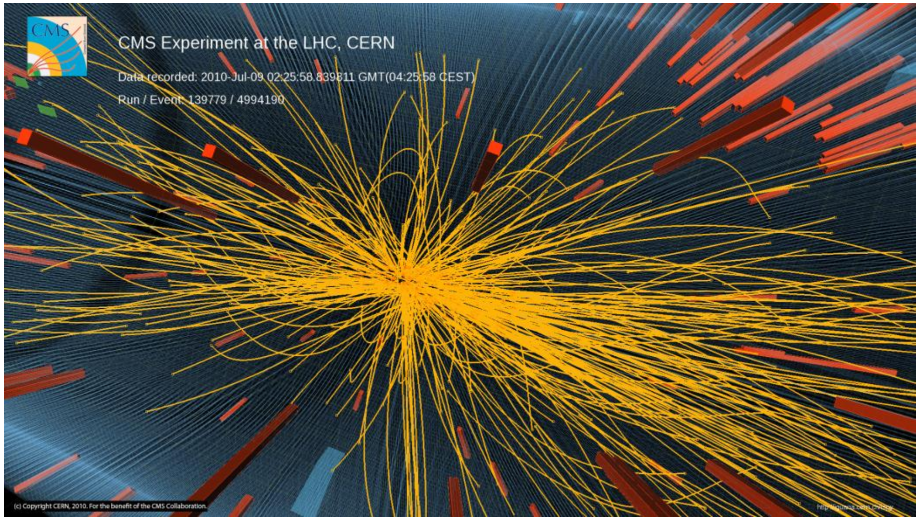




Very large coverage for tracking ($|\Delta\eta|$ up to 5.0)!

Defining two particle correlation





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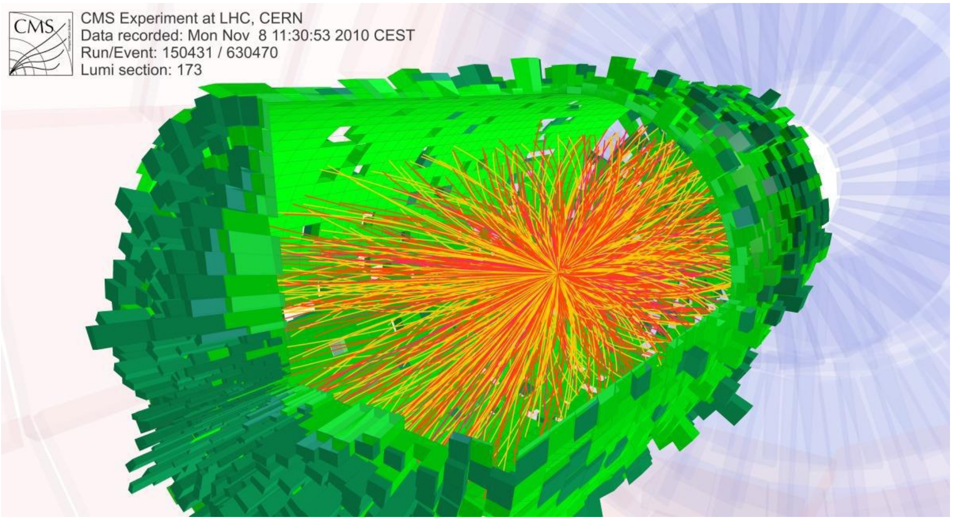
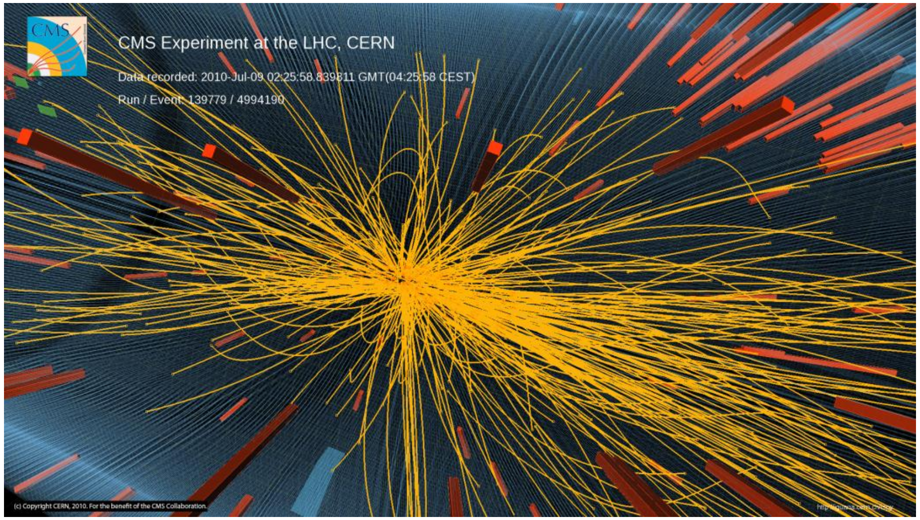
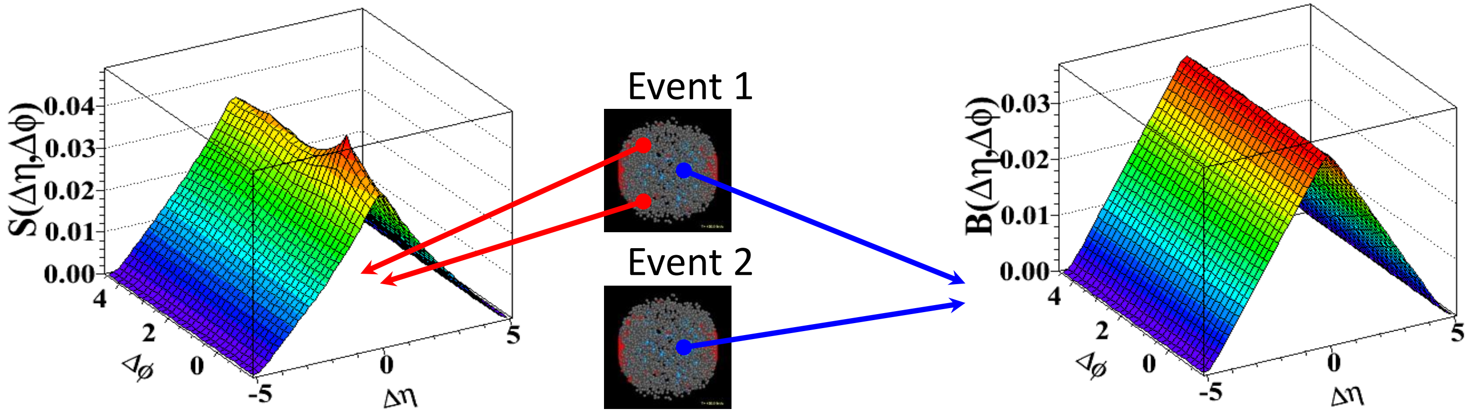




Signal pair distribution:

Background pair distribution:

same event pairs



mixed event pairs

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

$$B\left(\Delta\eta, \Delta\phi\right) = \frac{1}{N_{trig}} \frac{d^2 N^{mix}}{d\Delta\eta d\Delta\phi}$$

Defining two particle correlation

Divide Signal by Background

Associated hadron yield per trigger:

$$\frac{1}{N_{trig}}\frac{d^2N^{pair}}{d\Delta\eta d\Delta\phi} = B(0,0) \times \frac{S(\Delta\eta,\Delta\phi)}{B(\Delta\eta,\Delta\phi)}$$

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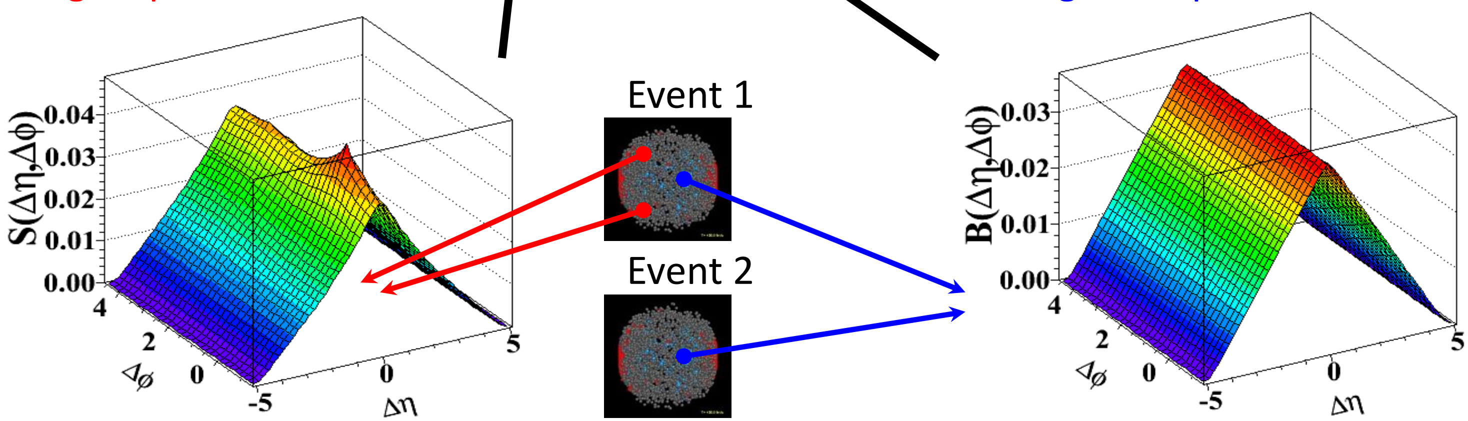

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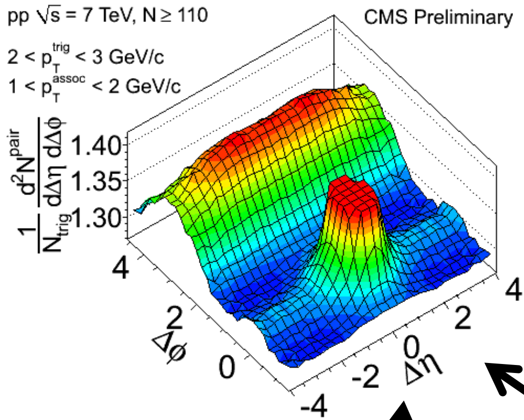
Defining two particle correlation

High multiplicity pp (N>110) $\sqrt{s} = 7\ TeV$



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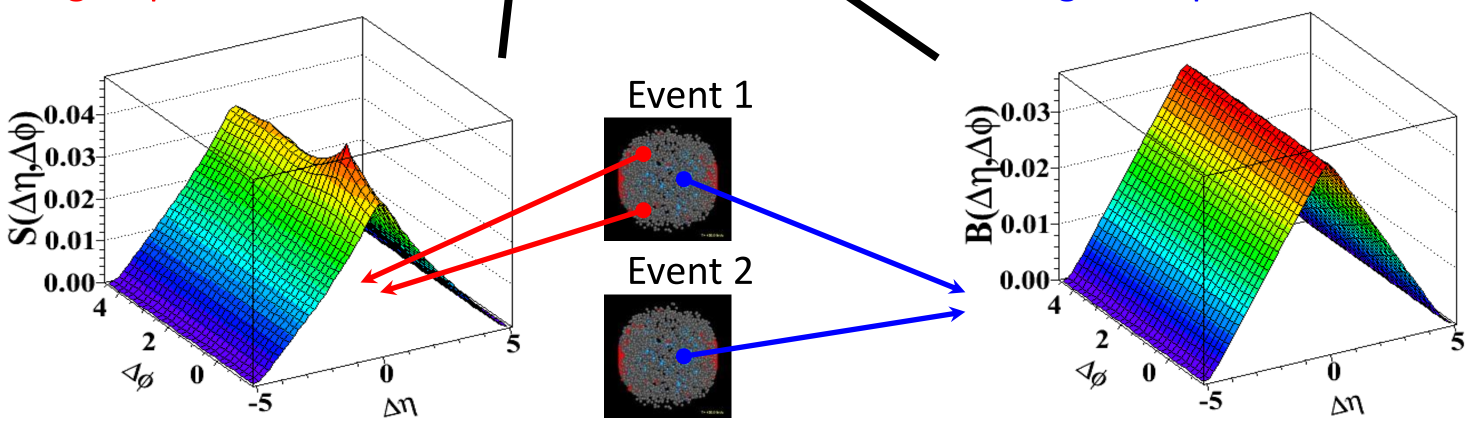

mixed event pairs

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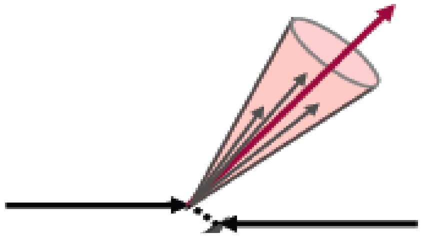
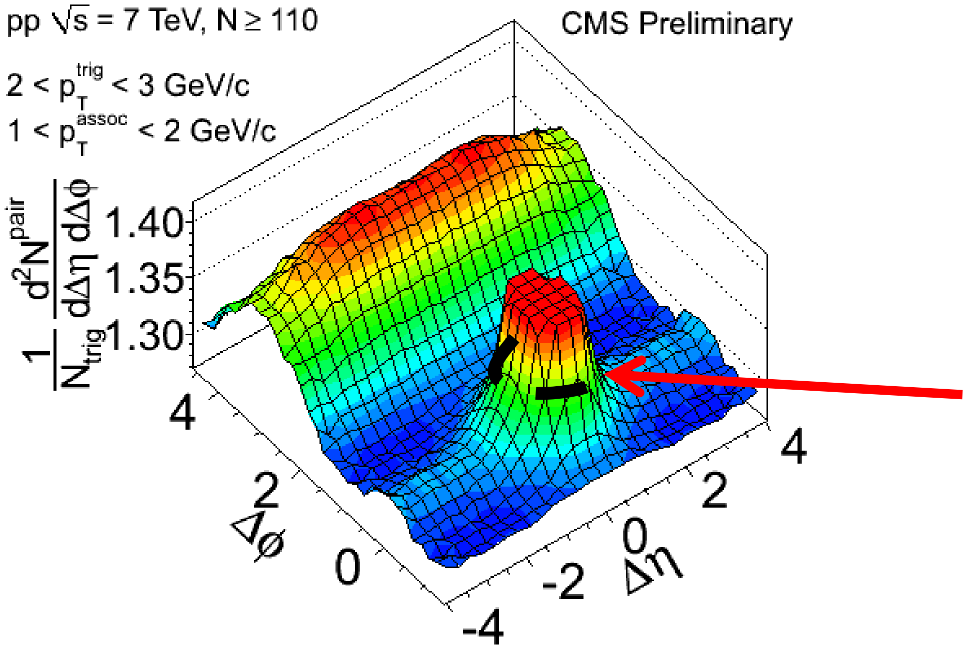
Understanding the correlation function

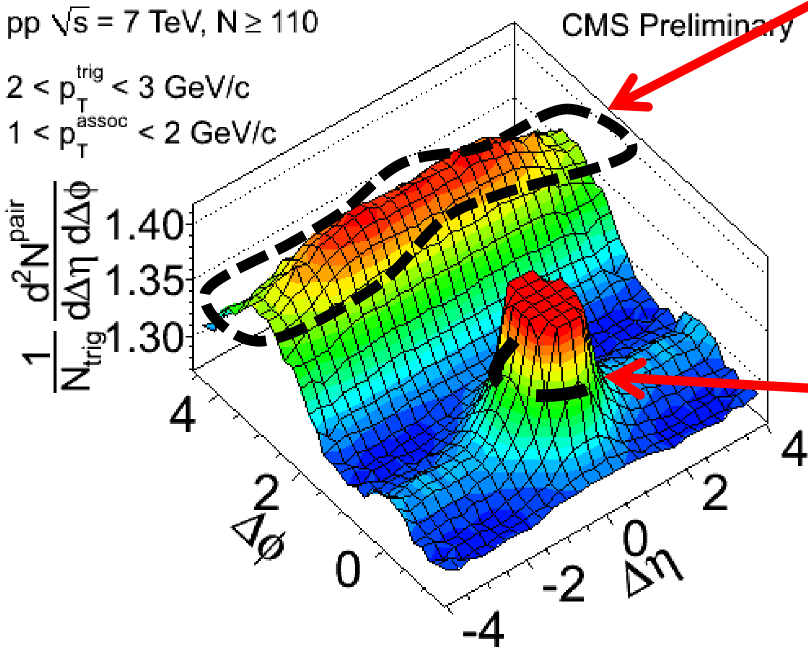


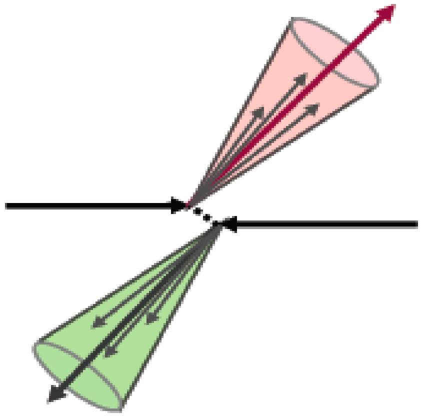


“Near-side” ($\Delta\phi$, $\Delta\eta$ ~ 0) correlations from single jets

Understanding the correlation function

“Away-side” ($\Delta\phi \sim \pi$)
back-to-back jet correlations

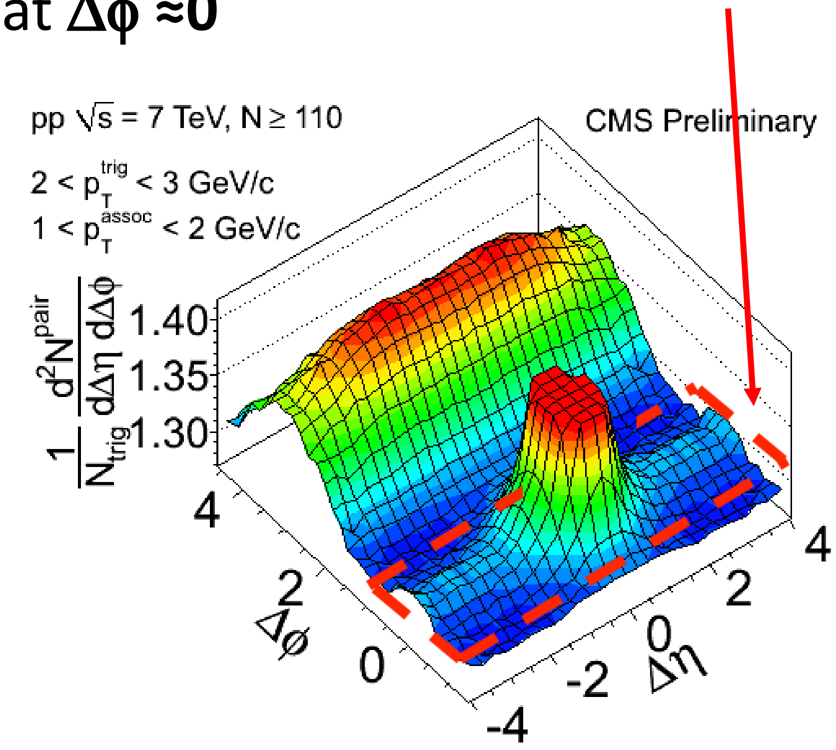




“Near-side” ($\Delta\phi$, $\Delta\eta \sim 0$)
correlations from single jets

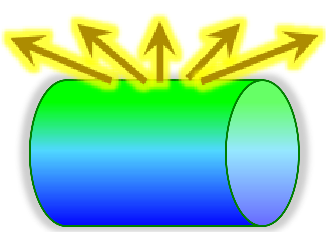
Understanding the correlation function

Striking "**ridge-like**" structure extending over $\Delta\eta$ at $\Delta\phi$ **≈0**

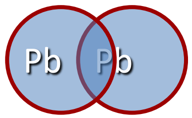


In high-multiplicity , N≥110 where:

N ≡ number of offline tracks with p_T>0.4 GeV/c

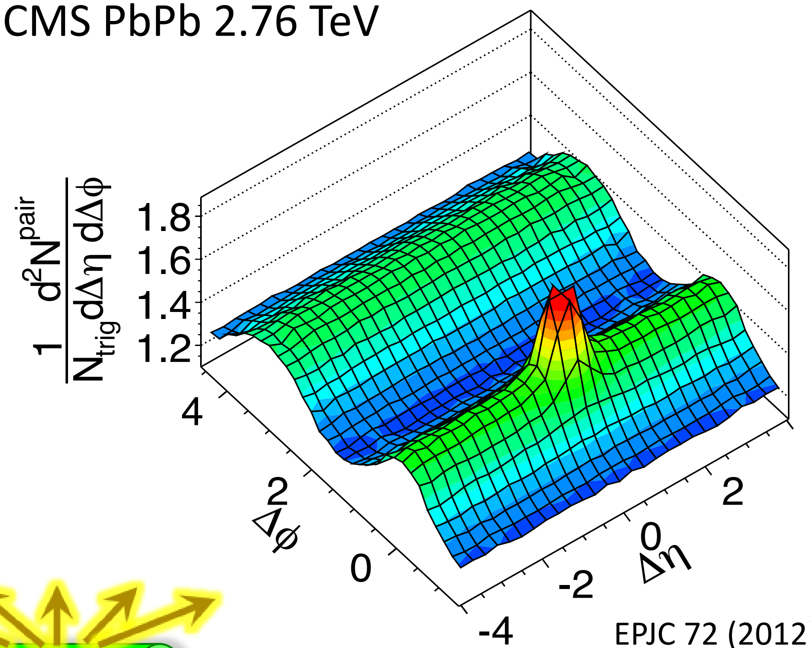


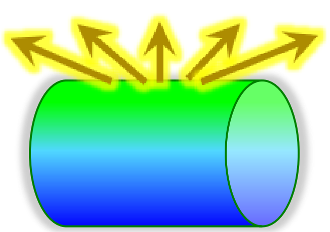
Understanding the correlation function



35-40% centrality

CMS PbPb 2.76 TeV





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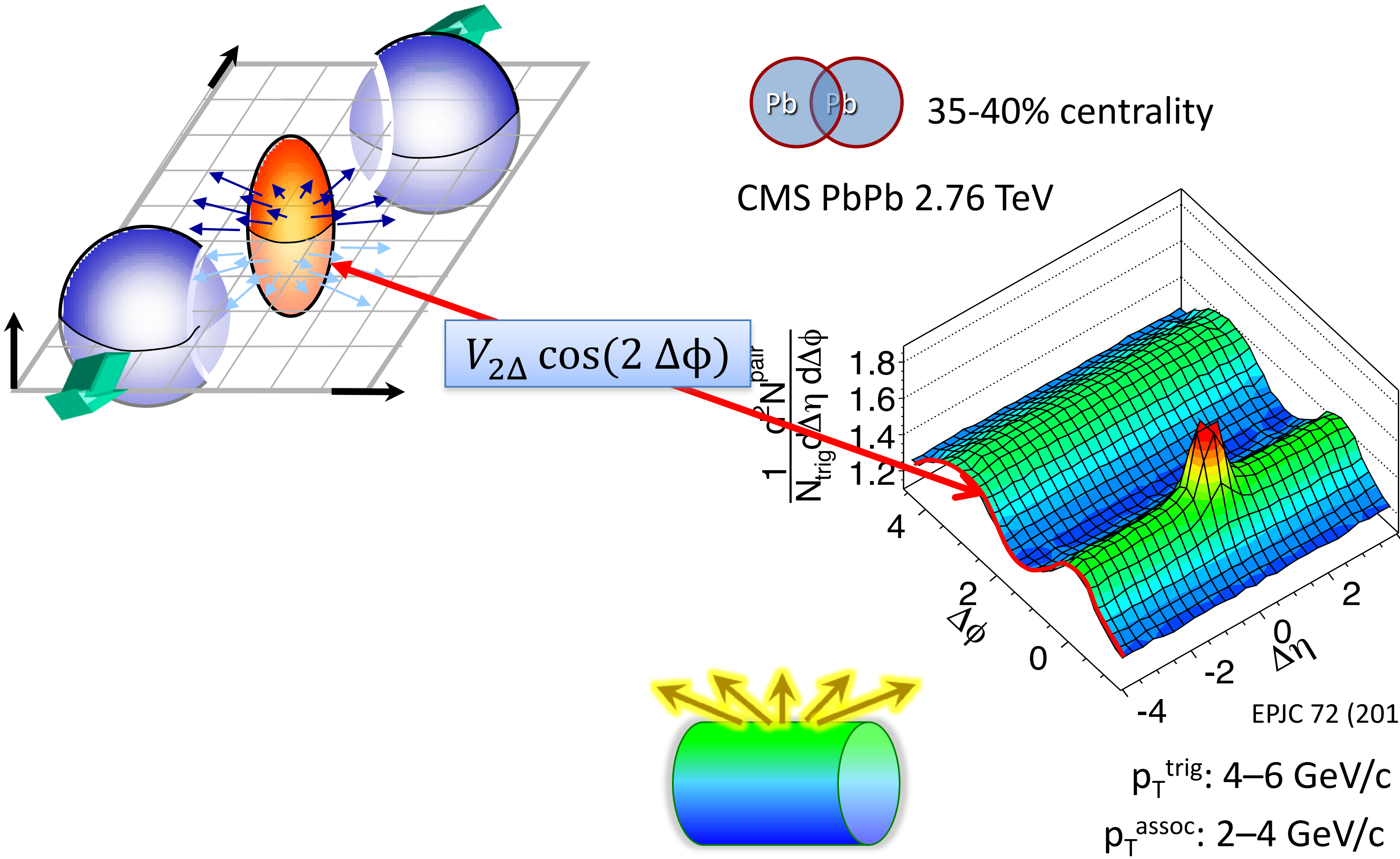
p_T^{trig}: 4–6 GeV/c

p_T^{assoc}: 2–4 GeV/c

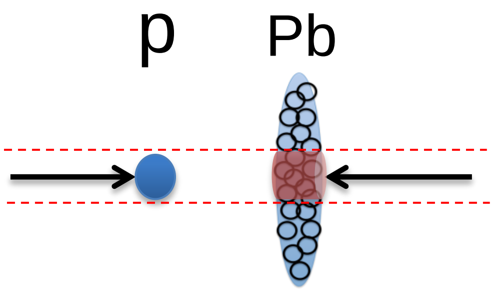
Understanding the correlation function



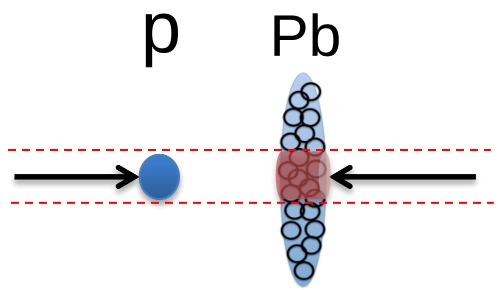
p_T^{trig}: 4–6 GeV/c

p_T^{assoc}: 2–4 GeV/c

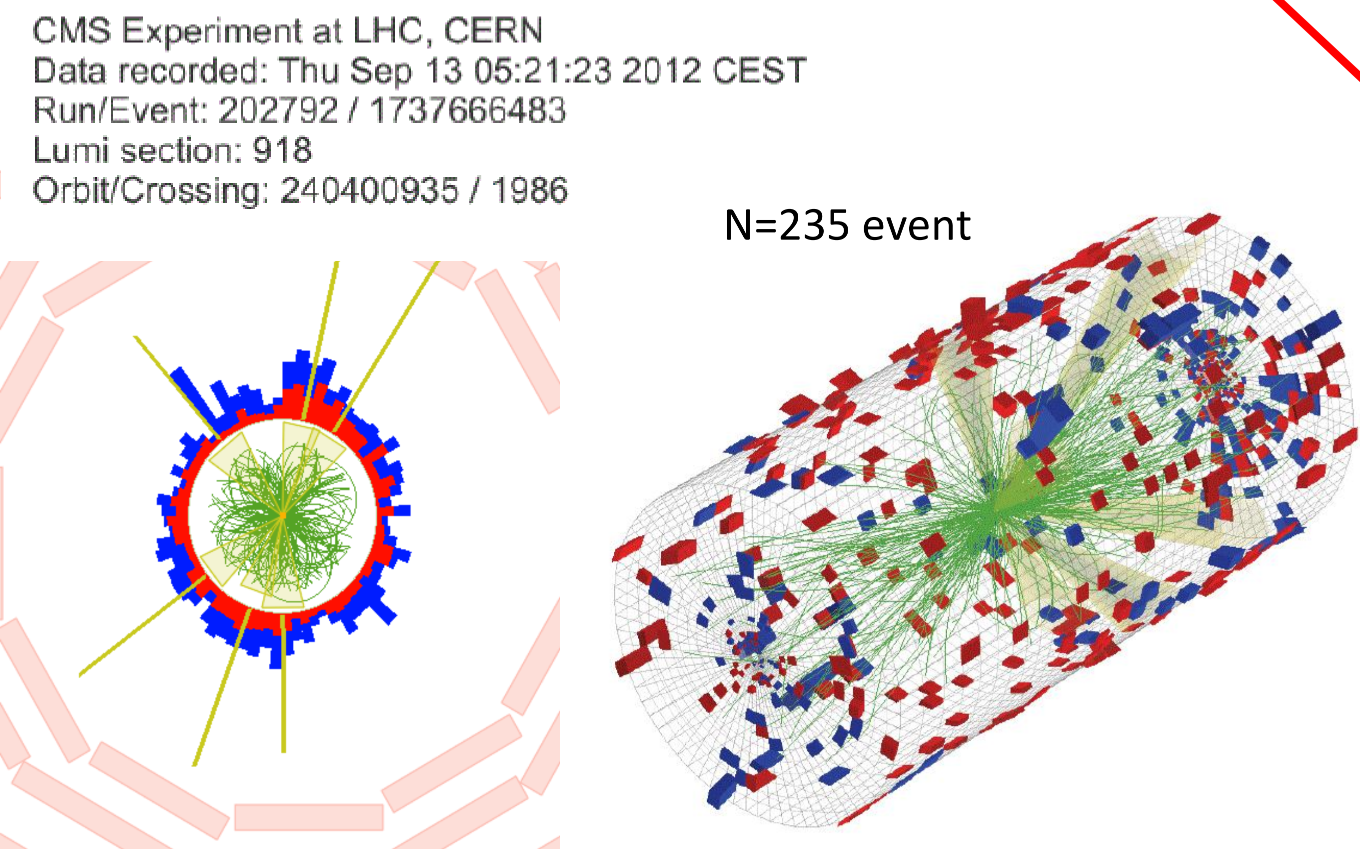
Any guesses for pPb correlations?

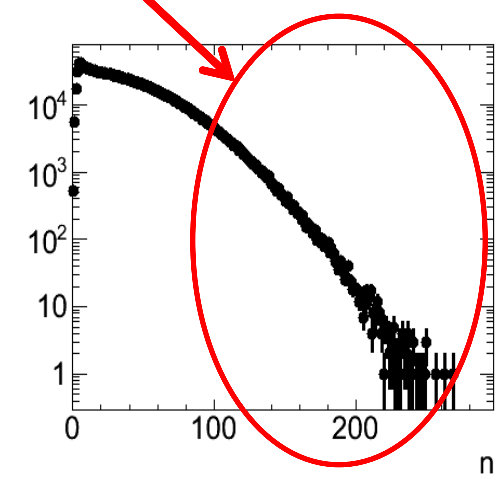


Any guesses for pPb correlations?

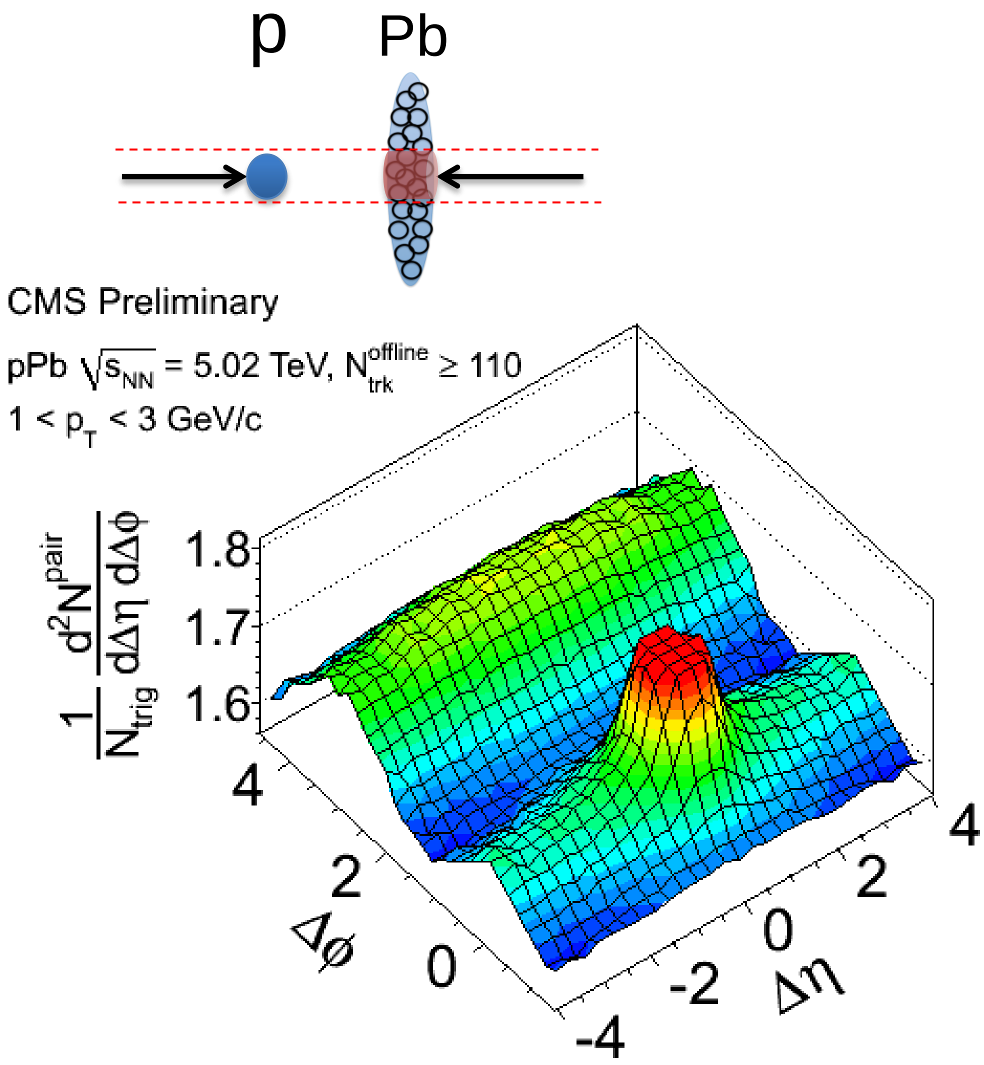


What do we expect to see in (high-multiplicity) pPb?

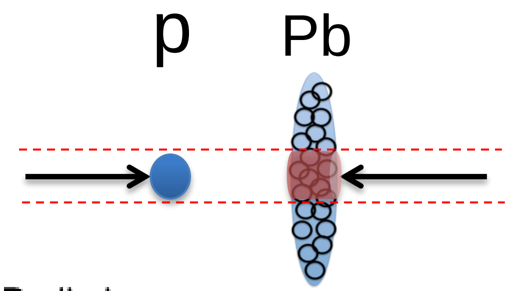


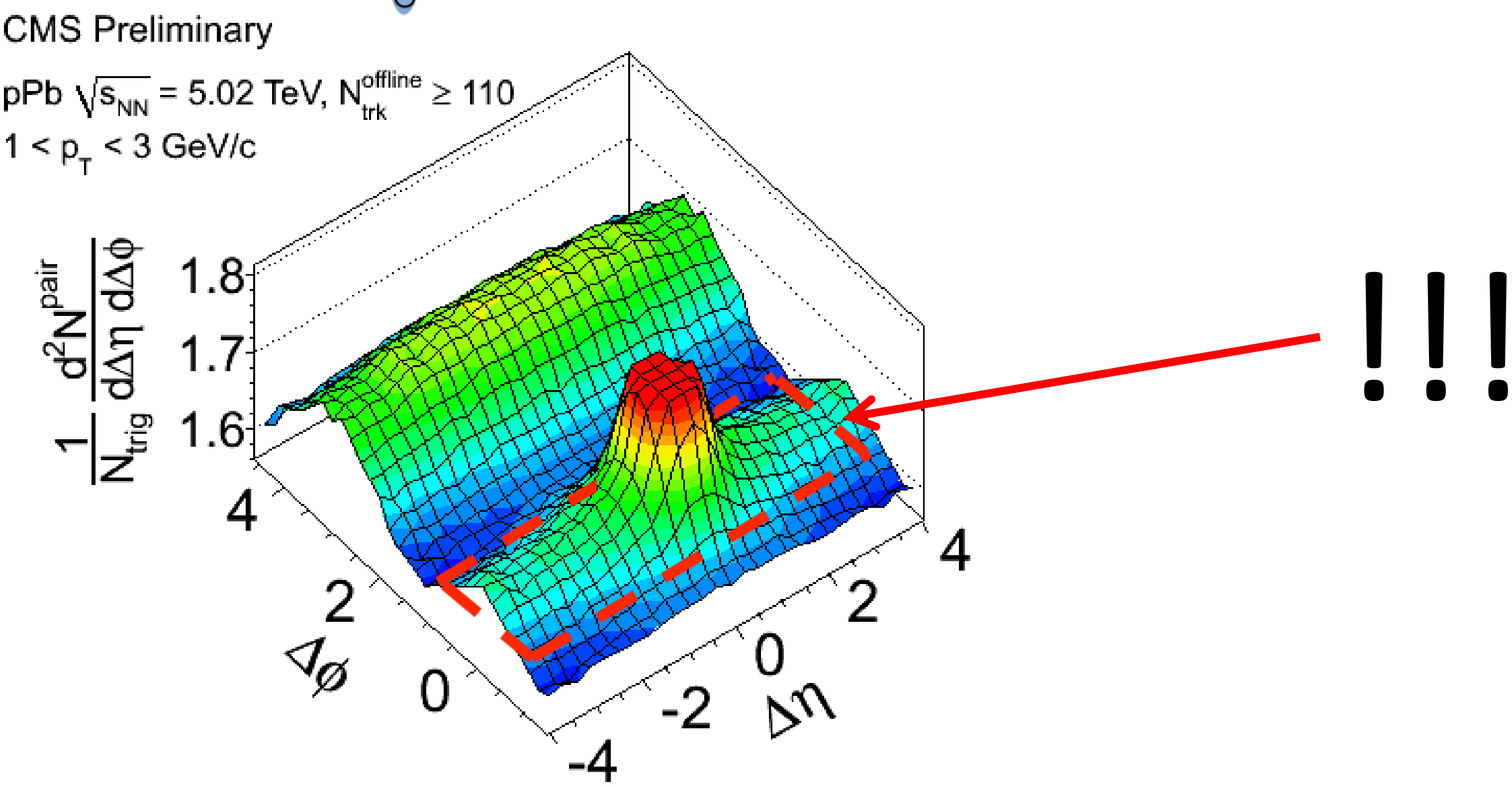


A ridge!


p
Pb
CMS Preliminary
pPb $\sqrt{s_{NN}}$ = 5.02 TeV, $N_{trk}^{offline} \geq 110$
1 < p_T < 3 GeV/c
$\frac{1}{N_{trig}} \frac{d^2N^{pair}}{d\Delta\eta\, d\Delta\phi}$
1.8
1.7
1.6
4
2
0
$\Delta\phi$
-4
-2
0
2
4
$\Delta\eta$

A ridge!


p
Pb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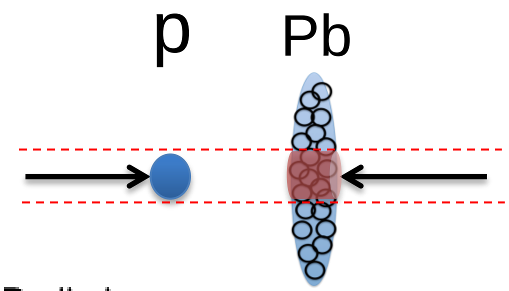
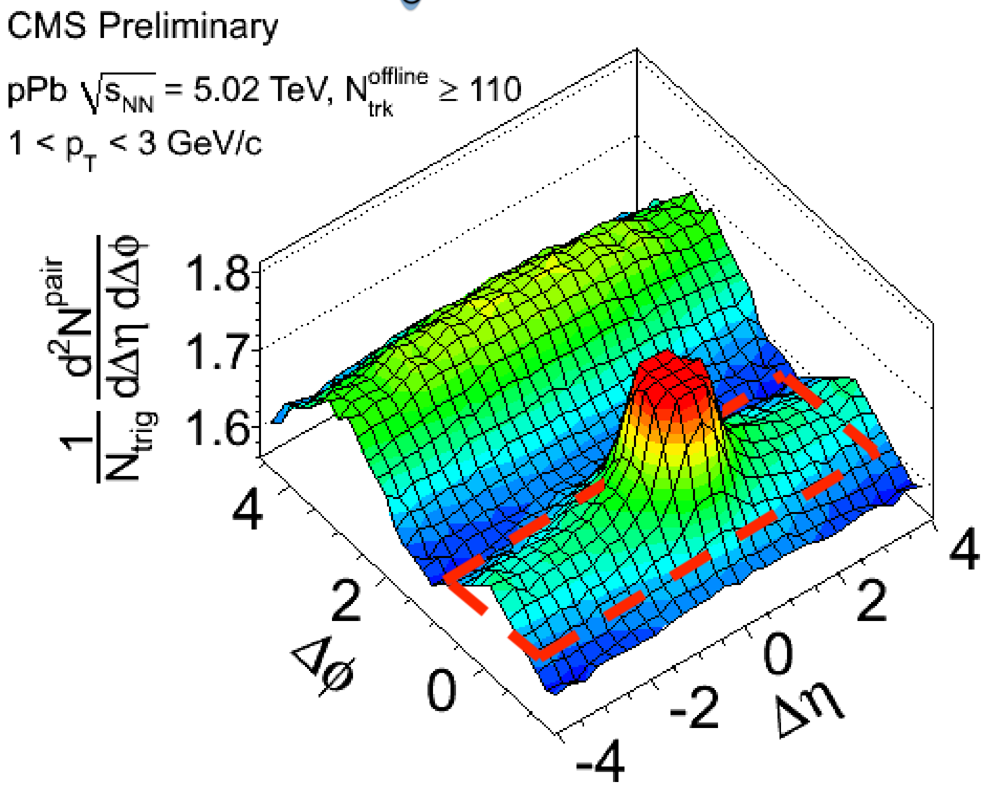
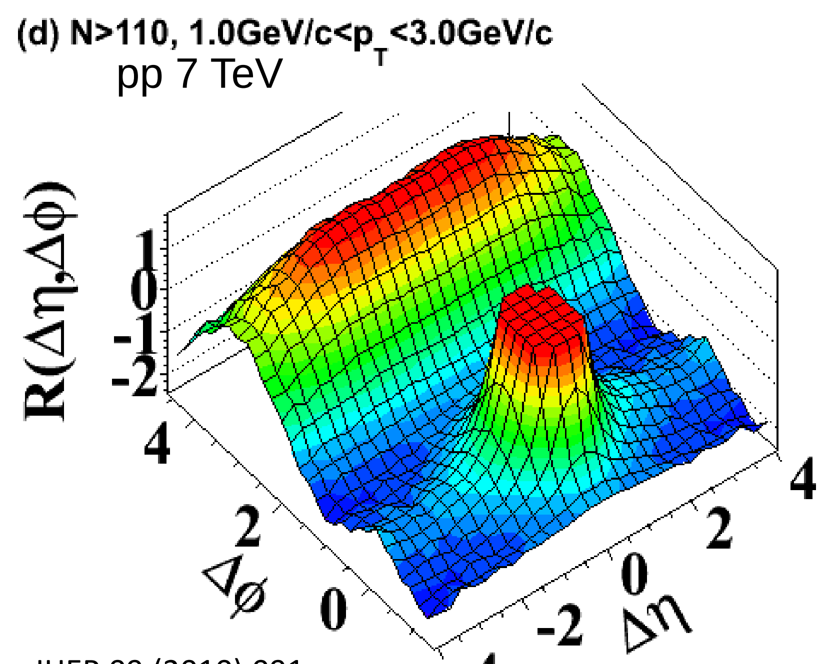
$\frac{1}{N_{trig}} \frac{d^2N^{pair}}{d\Delta\eta\, d\Delta\phi}$
1.8
1.7
1.6
4
2
$\Delta\phi$
0
-4
-2
0
2
4
$\Delta\eta$
!!!

A (relatively big) ridge!



Phisical origin still unclear





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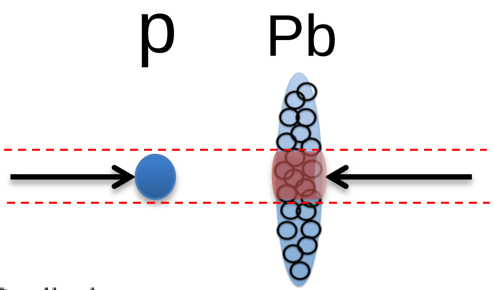
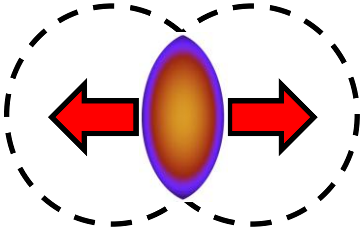
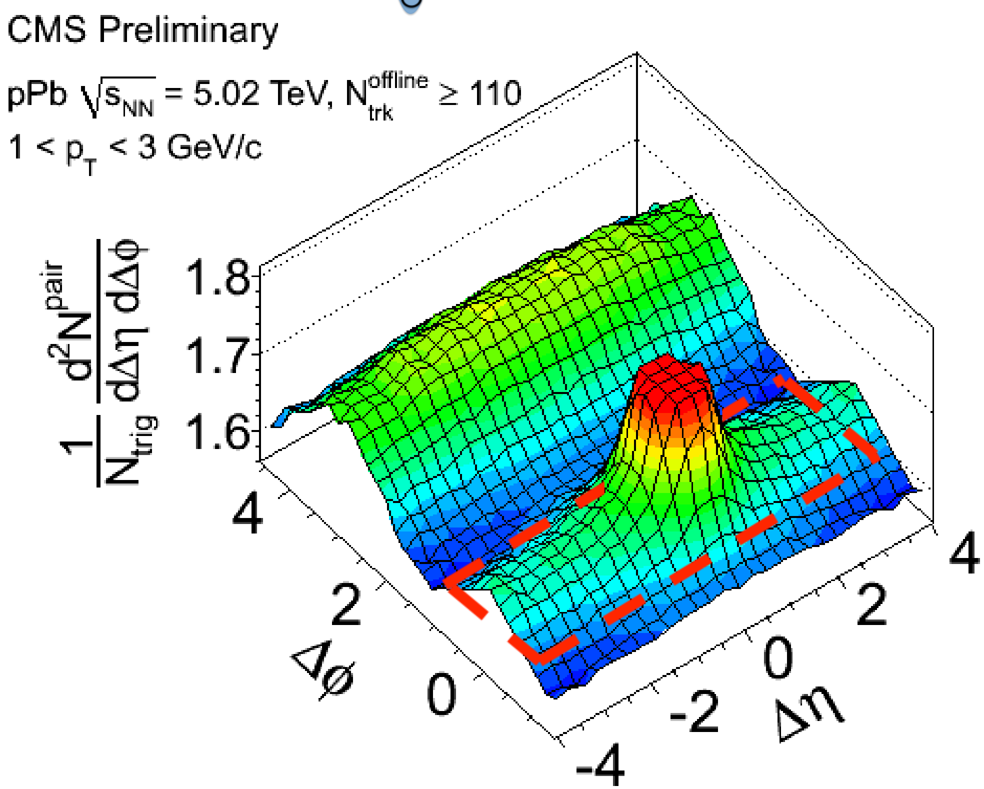
Much bigger than pp

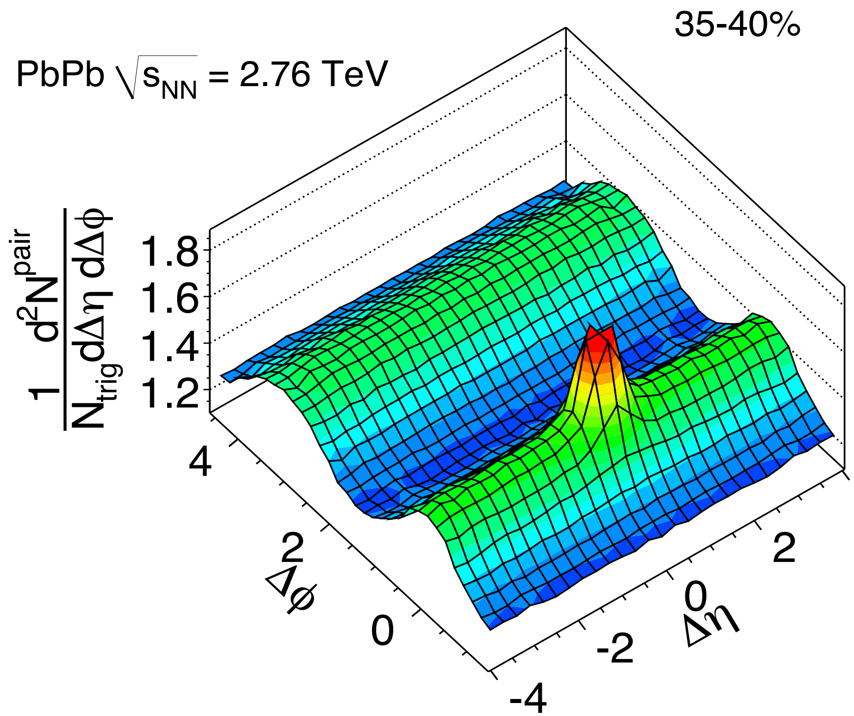
A (relatively big) ridge!



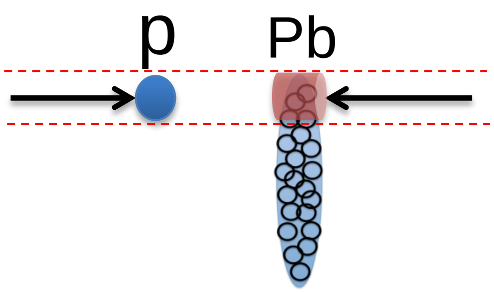
Initial-state geometry
+
collective expansion





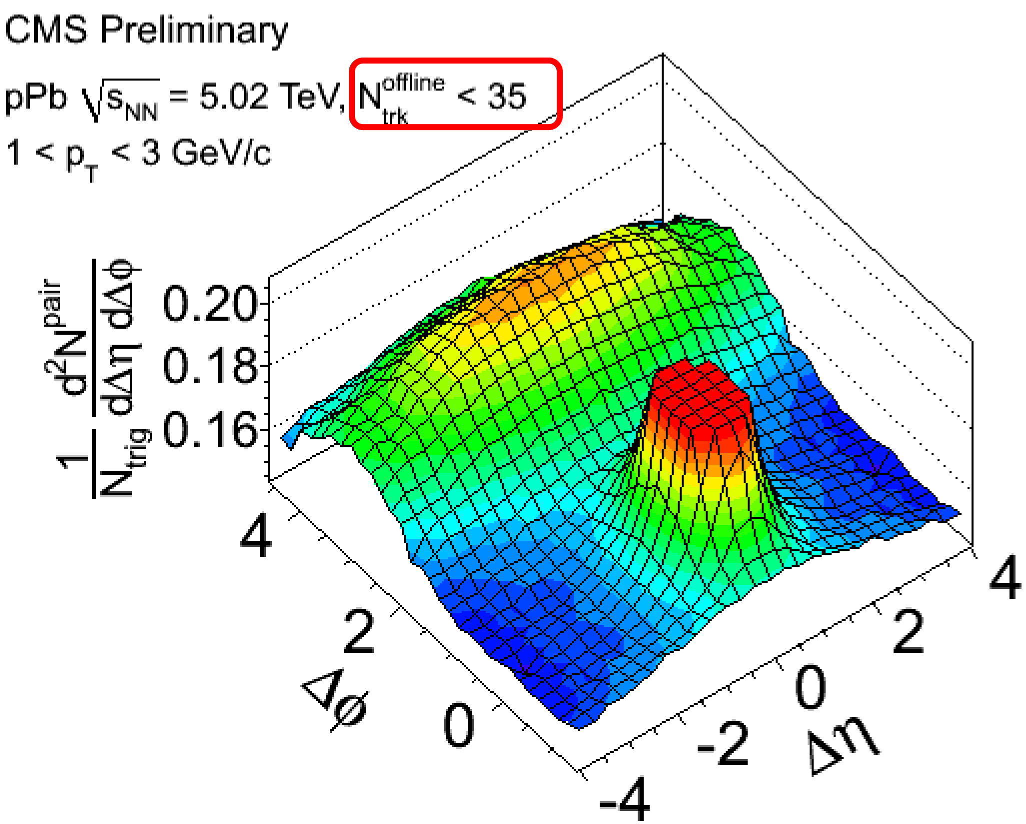


Multiplicity Evolution

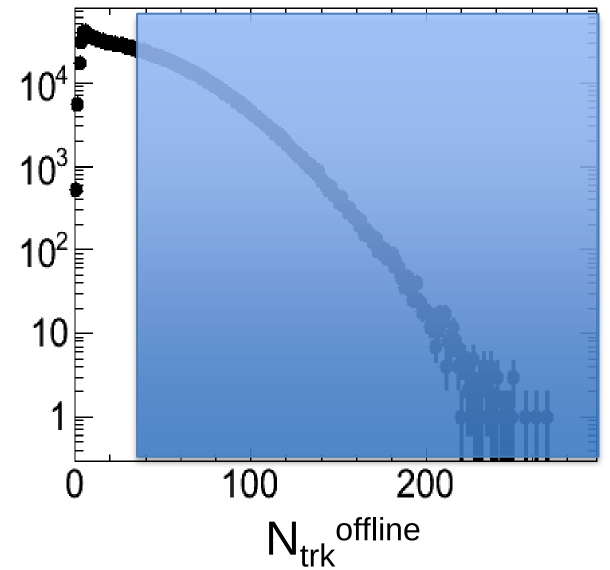


Low multiplicity

Low transverse density

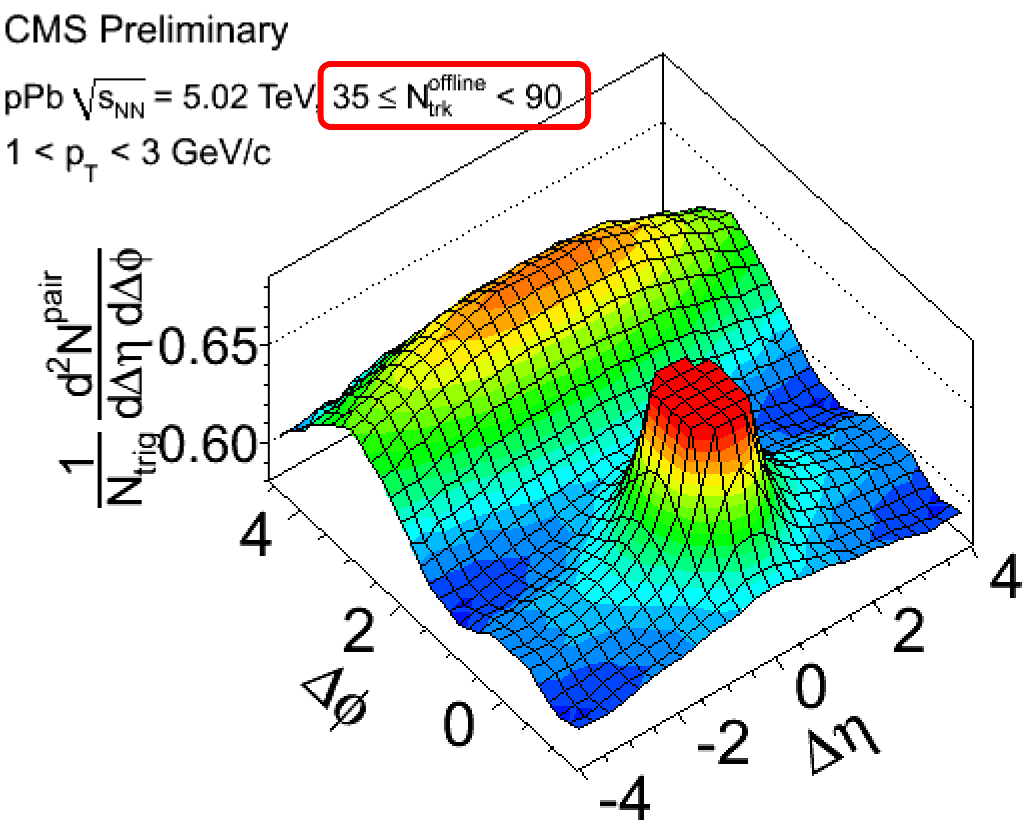


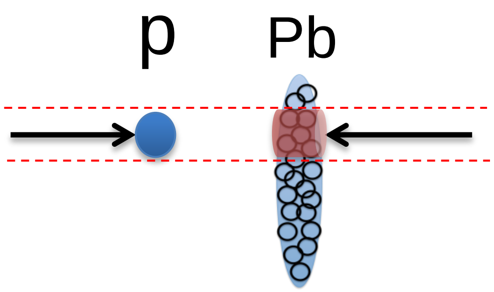
Divide into 4 multiplicity bins:



Multiplicity Evolution

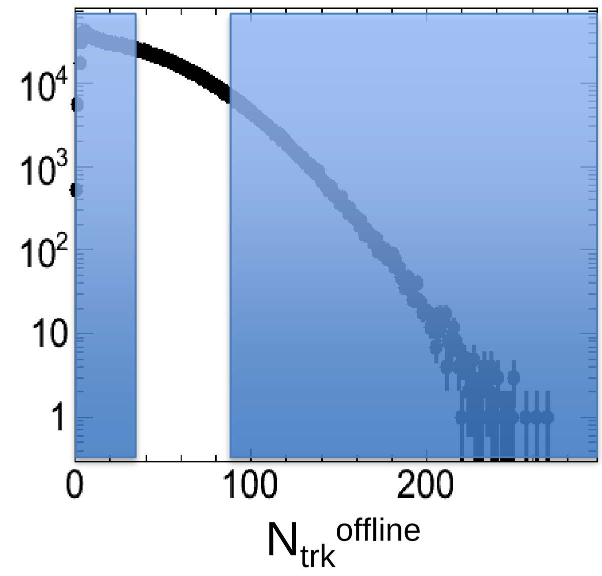
Increasing multiplicity





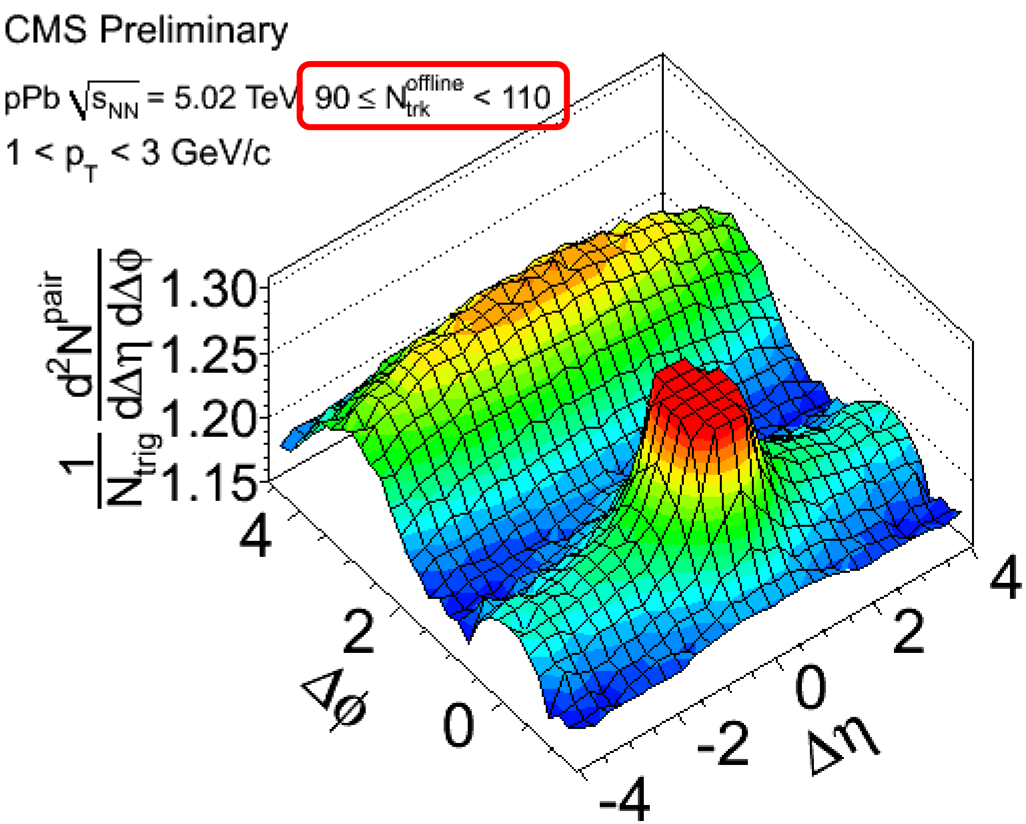
Increasing transverse density

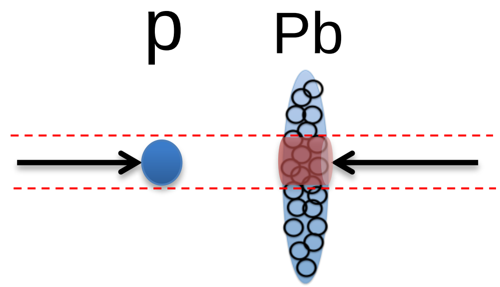
Divide into 4 multiplicity bins:



Multiplicity Evolution

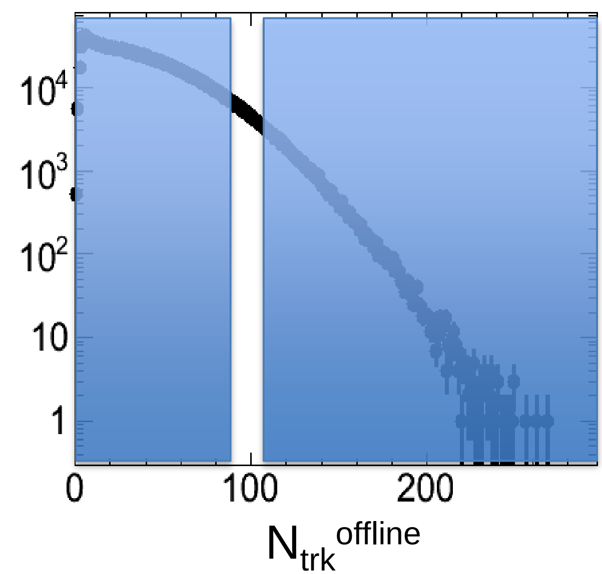
Increasing multiplicity





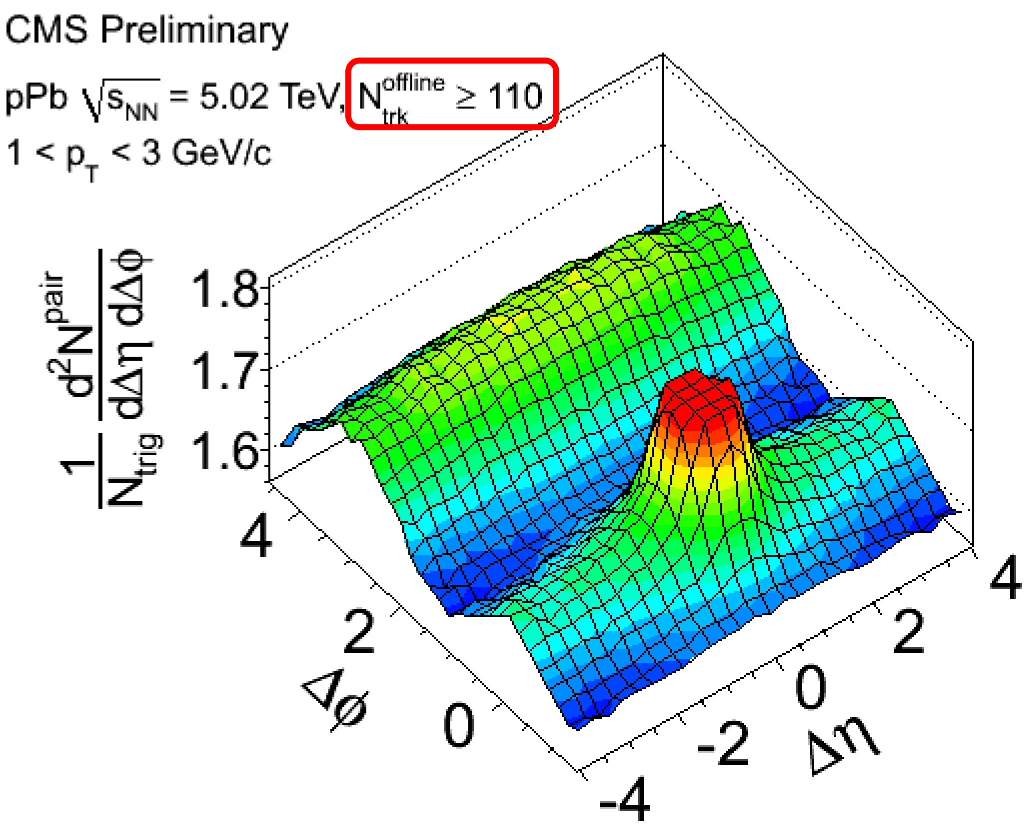
High transverse density

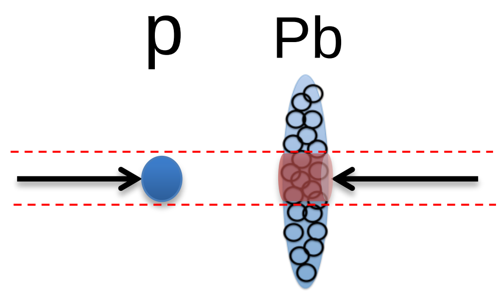
Divide into 4 multiplicity bins:



Multiplicity Evolution

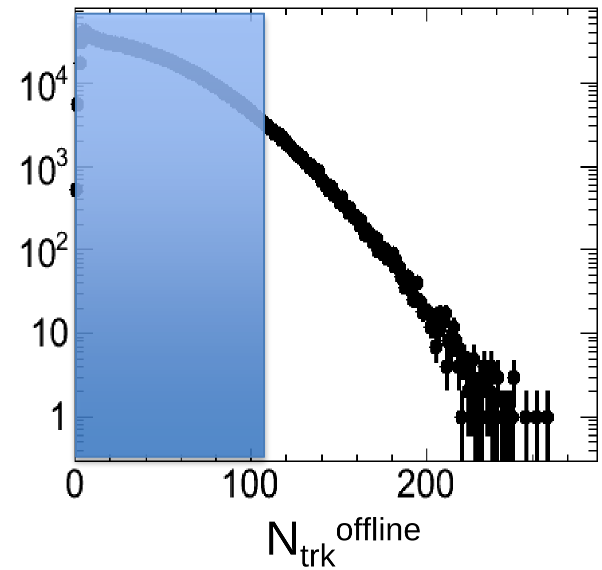
Increasing multiplicity





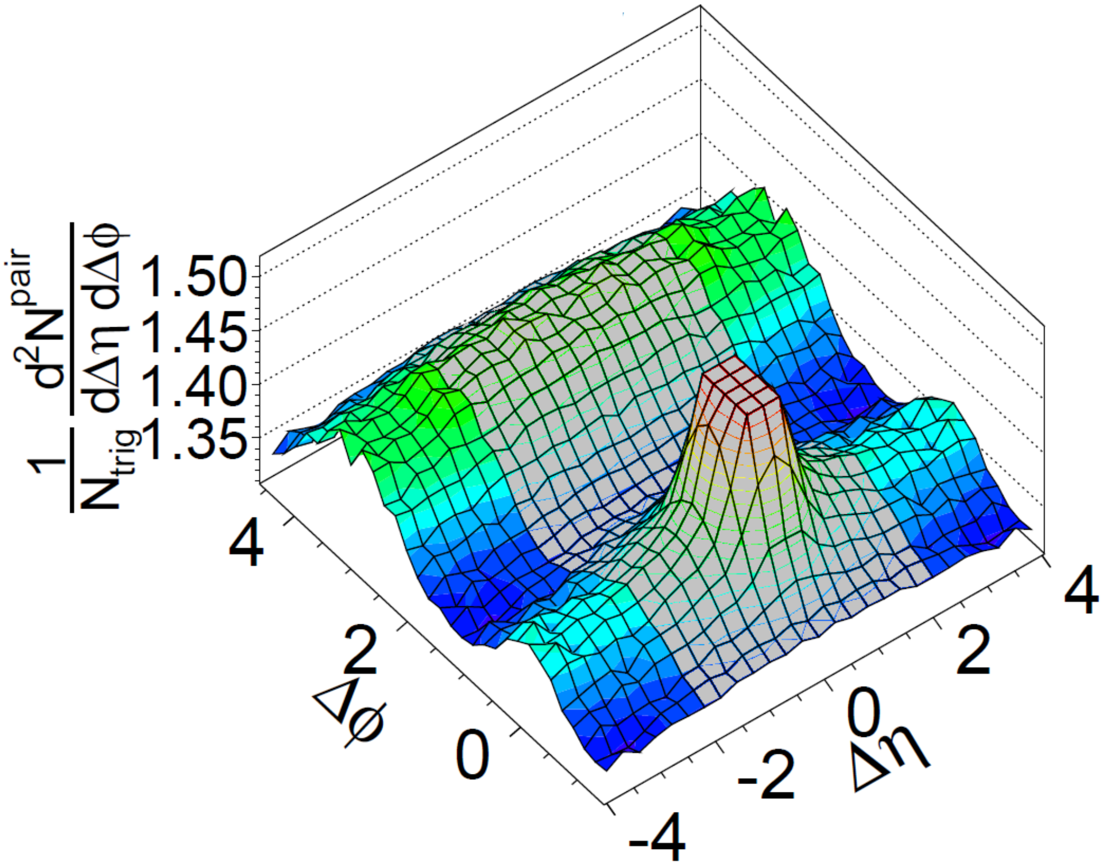
Highest transverse density

Divide into 4 multiplicity bins:



Quantitative evolution of ridge effect

Want to use the same approach as in pp ridge paper for apples-“apples” comparison



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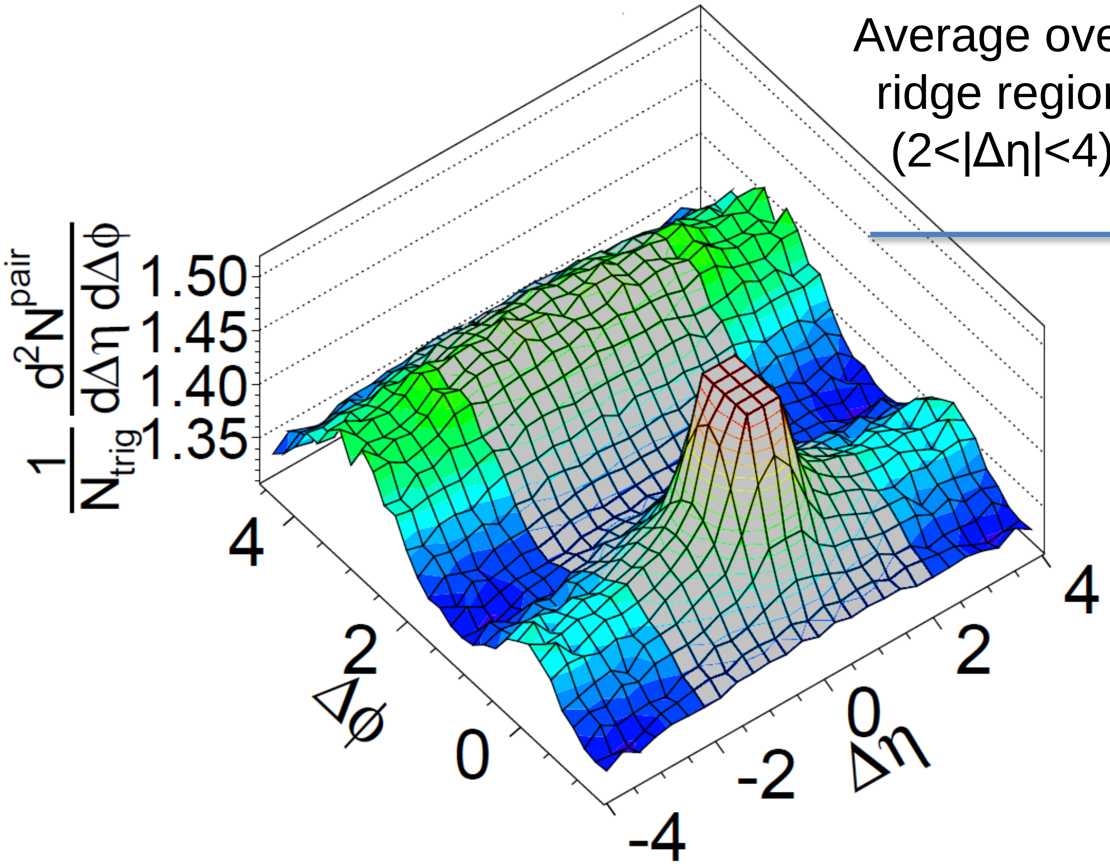
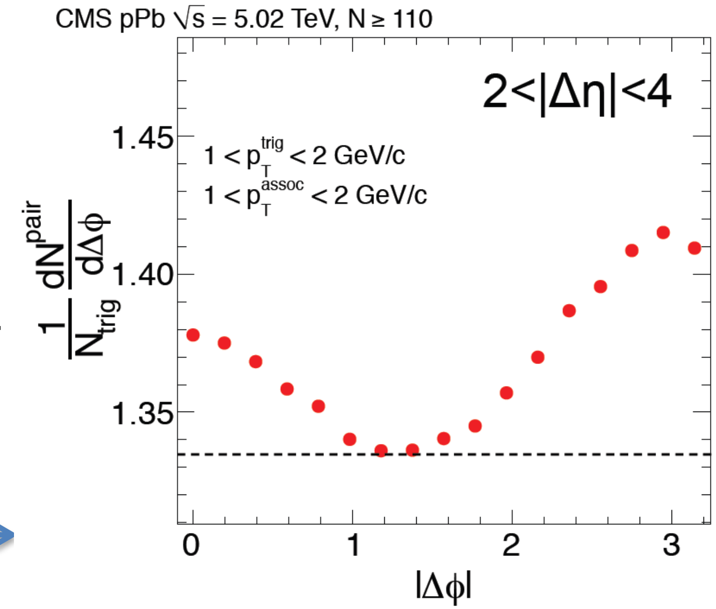


Average over ridge region (2<|Δη|<4)



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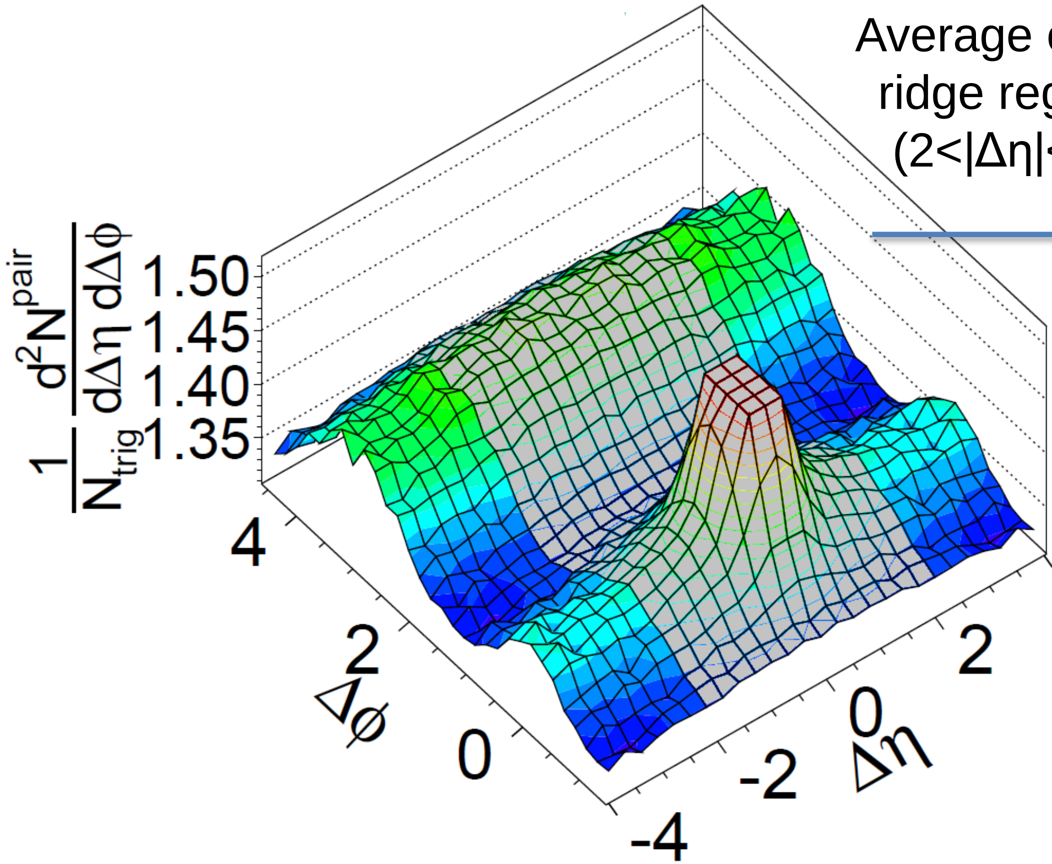

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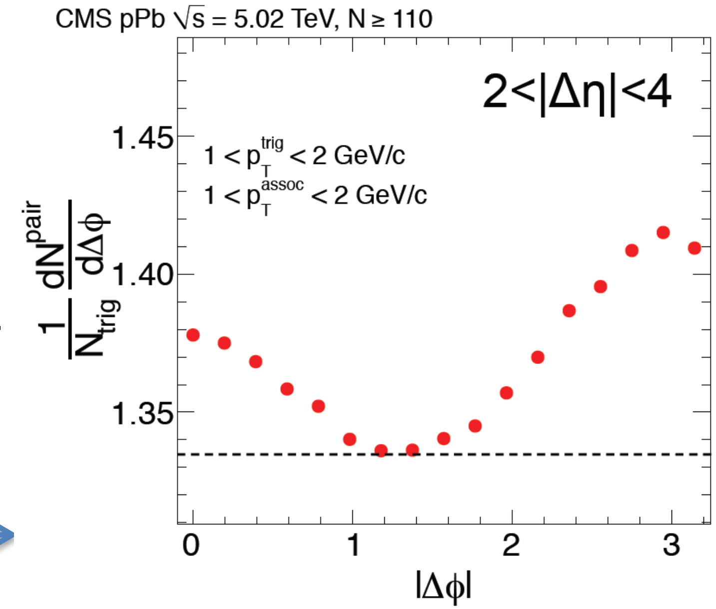
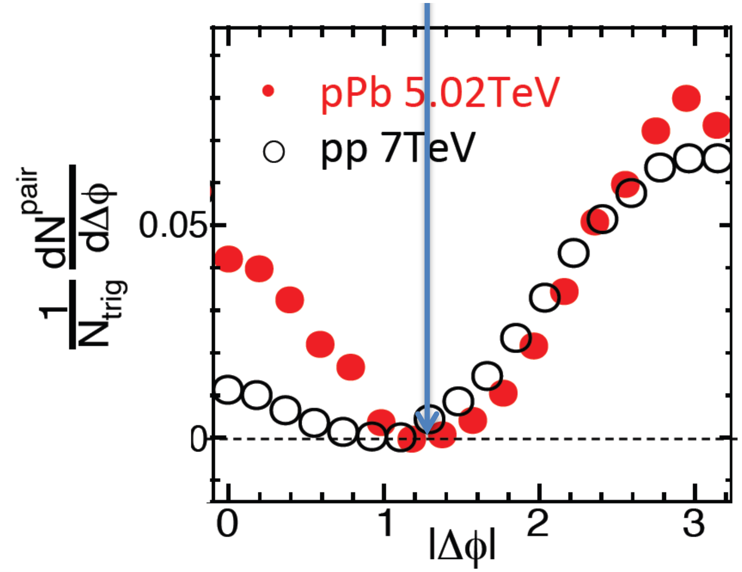




Multiplicity and pT dependence

Multiplicity

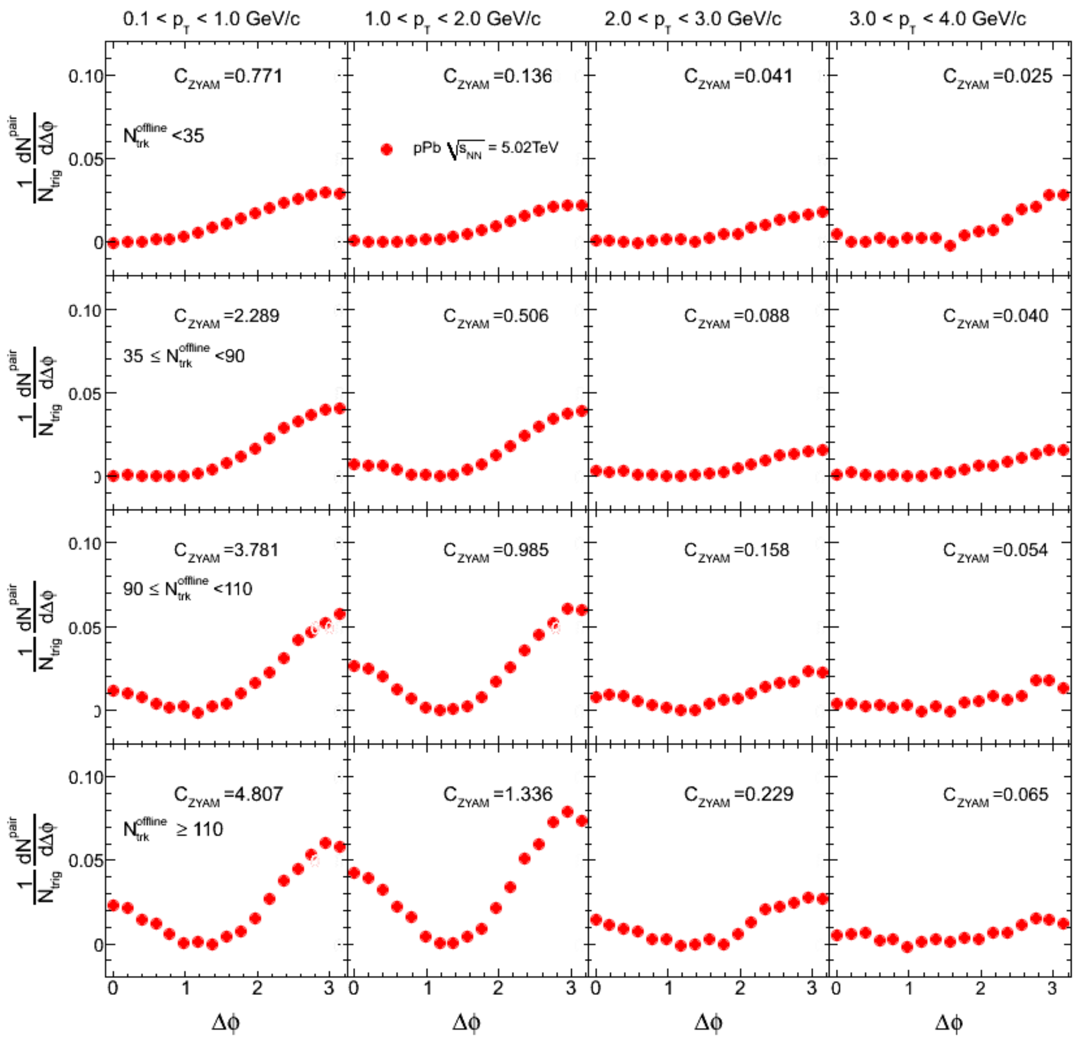
N<35

35<N<90

90<N<110

N>110

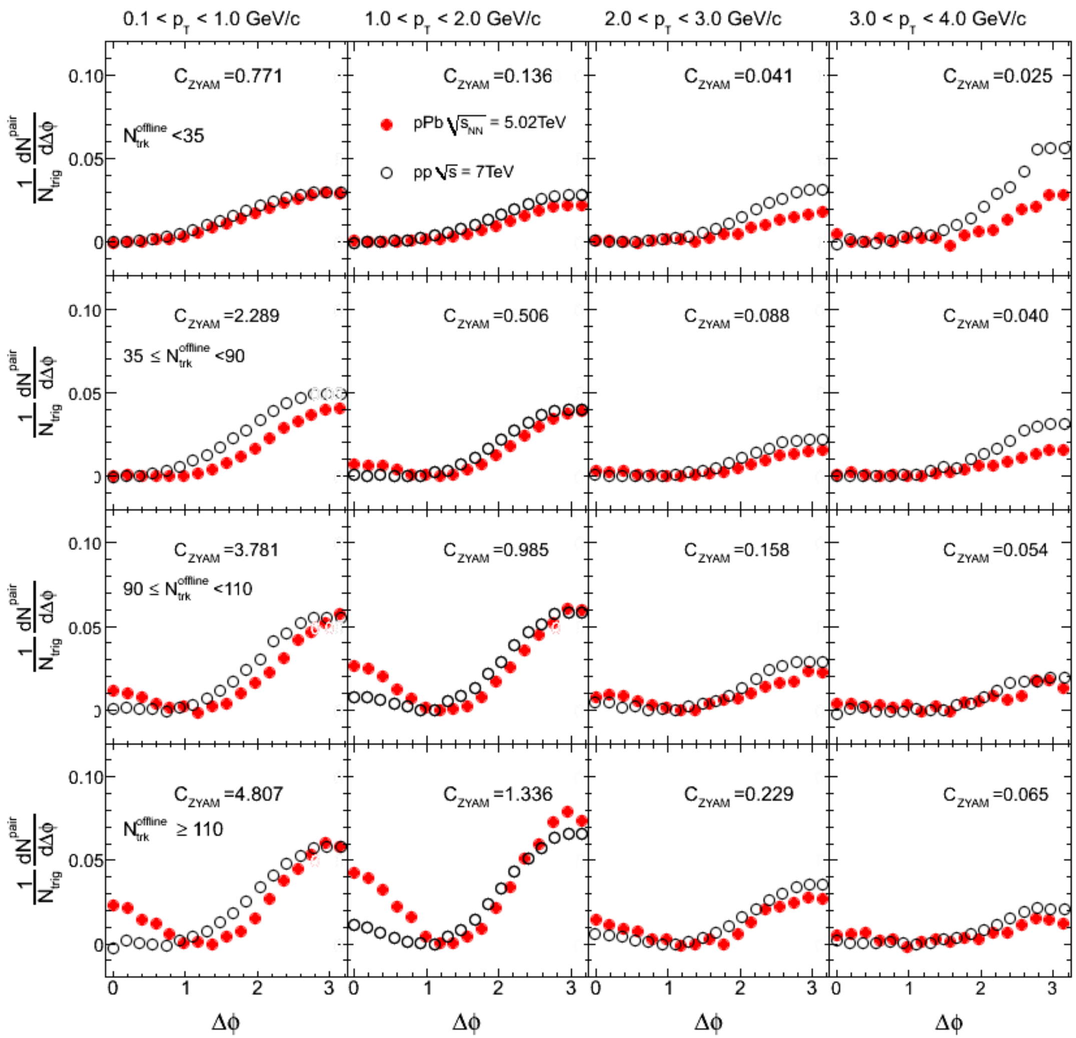
0 – 1   1 – 2   2 – 3   3 – 4 p_T (GeV/c)



CMS Preliminary

Multiplicity and pT dependence

Multiplicity ↓ ↓	0 – 1	1 – 2	2 – 3	3 – 4	p_T (GeV/c)
N<35					
35<N<90					
90<N<110					
N>110					

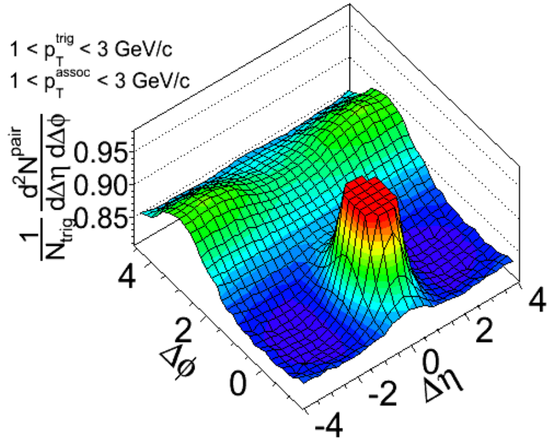


CMS Preliminary

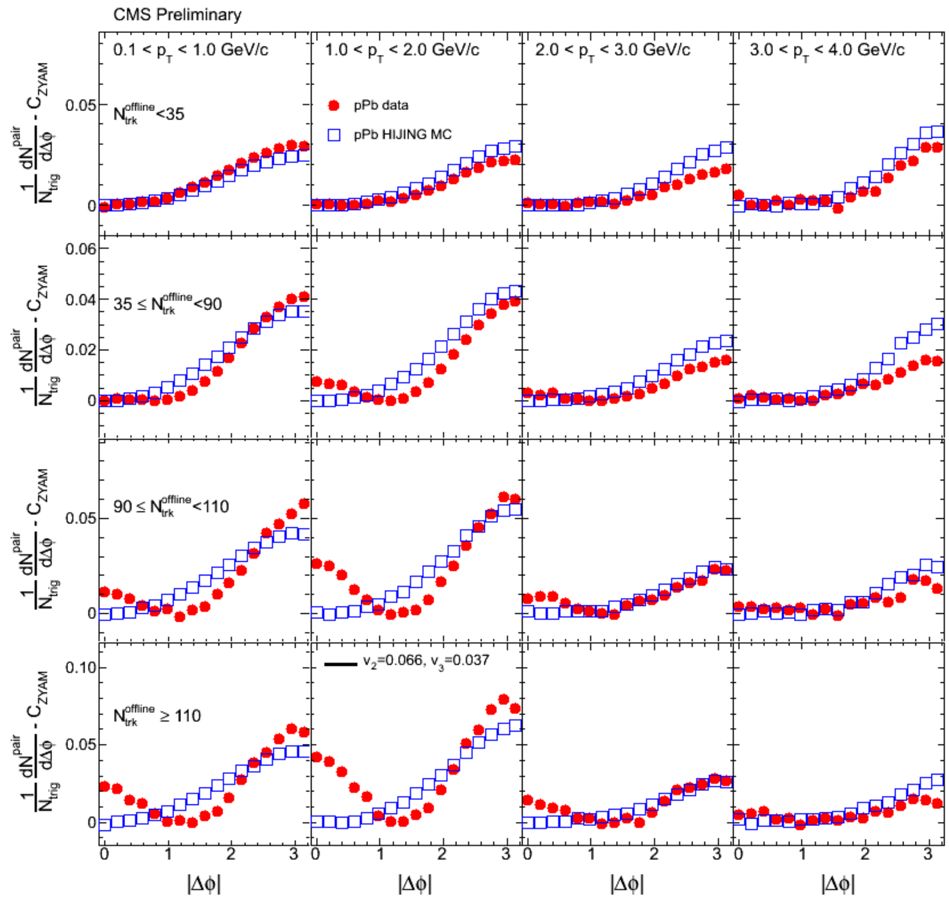
No ridge anywhere in pPb MC

Compare to AMPT and HIJING pPb

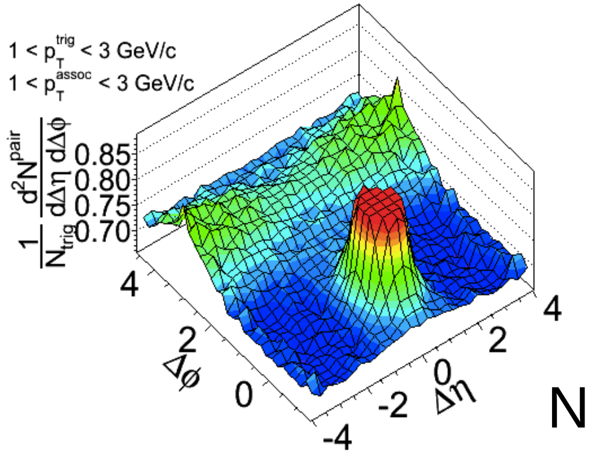
HIJING pPb, N>=120



Generator-level



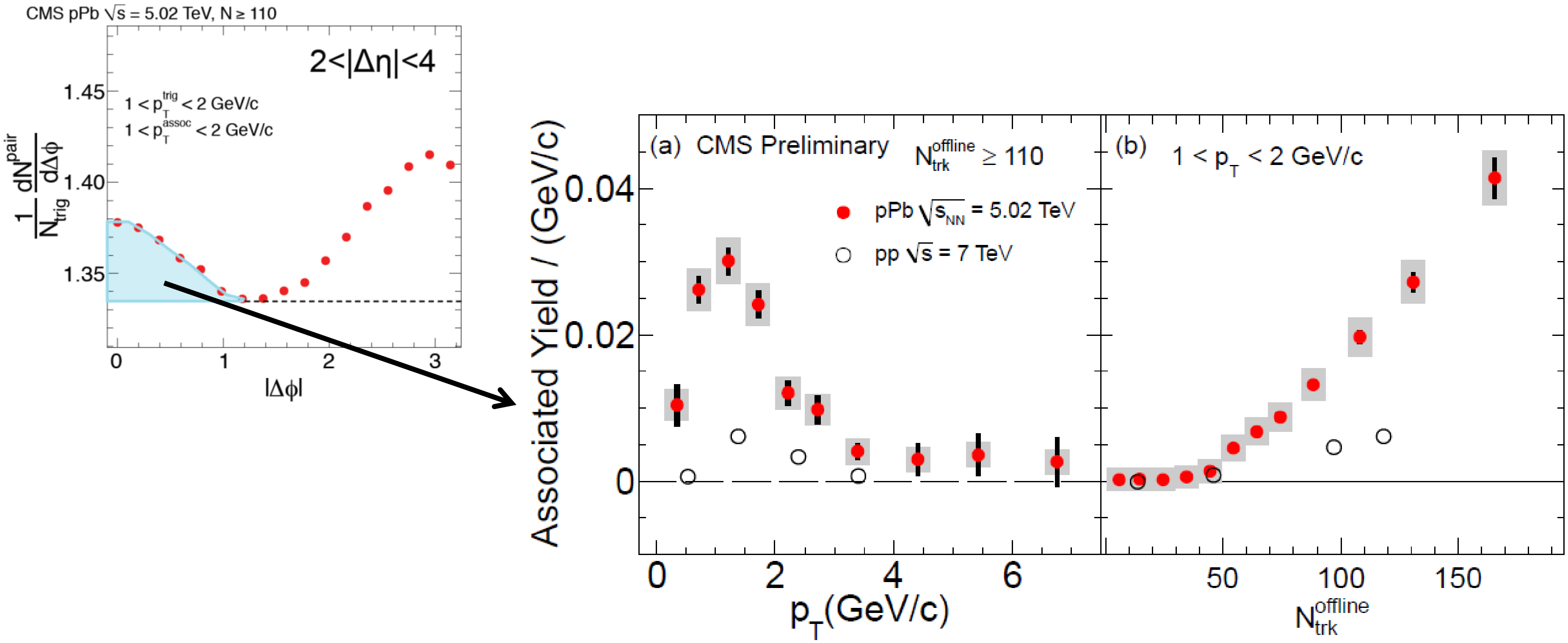
AMPT pPb, N>=100



No ridge in these pPb MC!

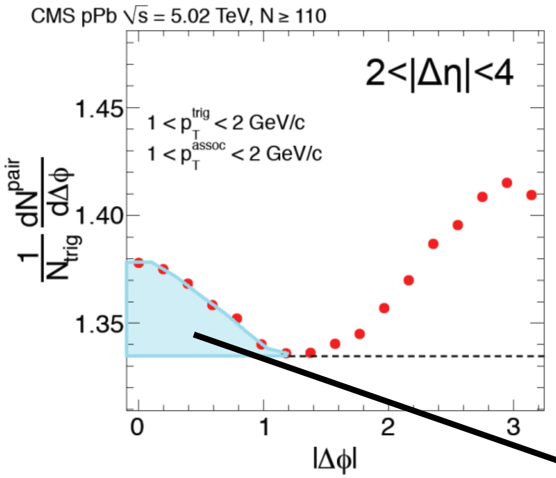
Ridge Associated Yield

ZYAM example

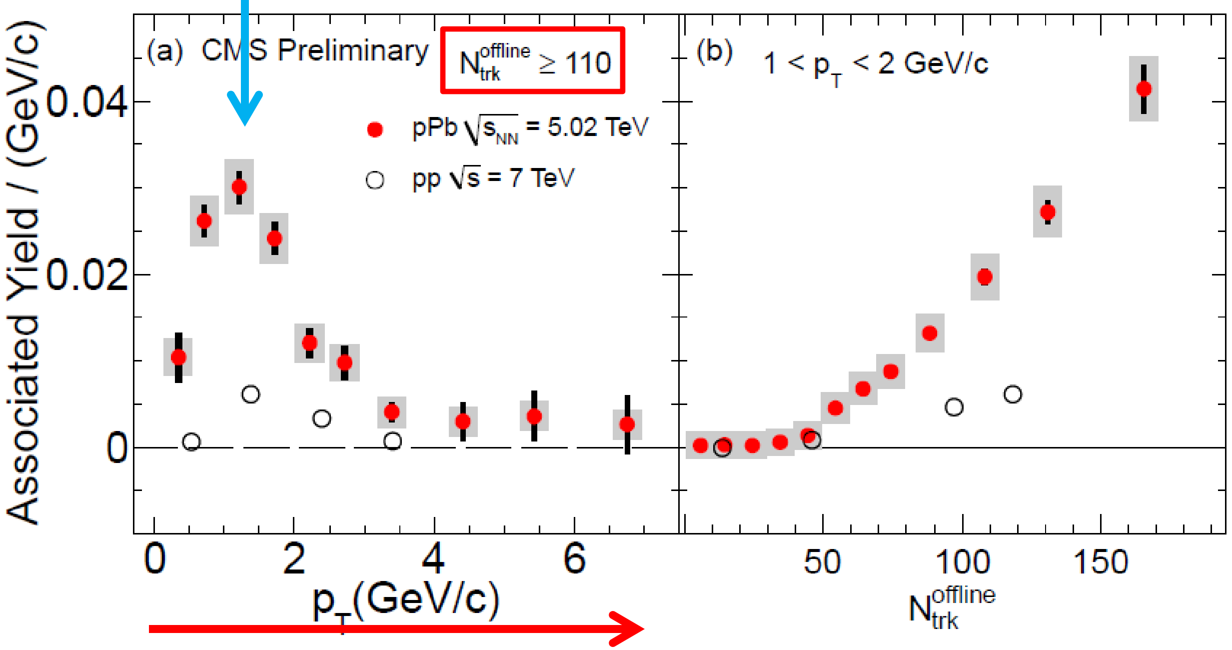


Ridge Associated Yield

ZYAM example

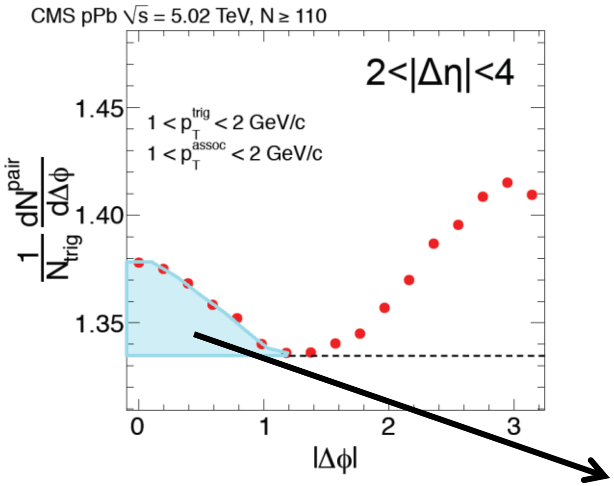


In the signal (N>110) region, the strength of the effect rises and falls with pT



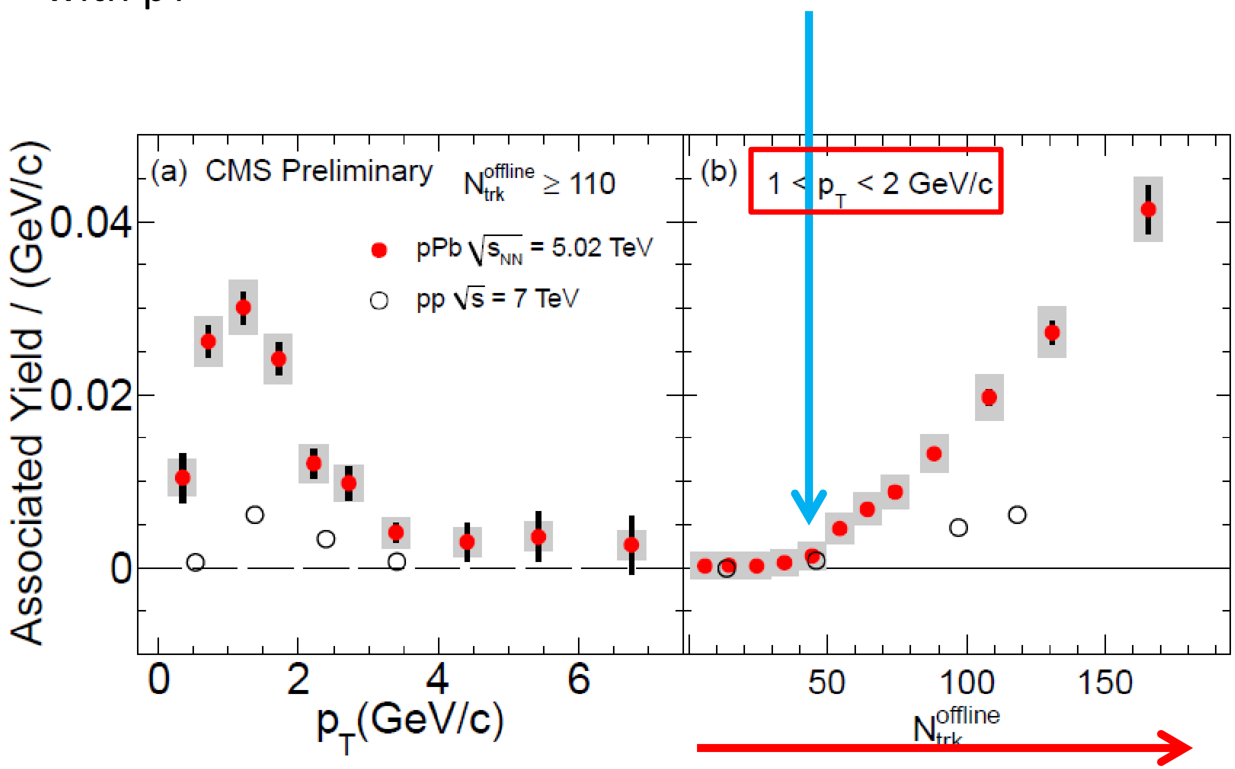
Ridge Associated Yield

ZYAM example



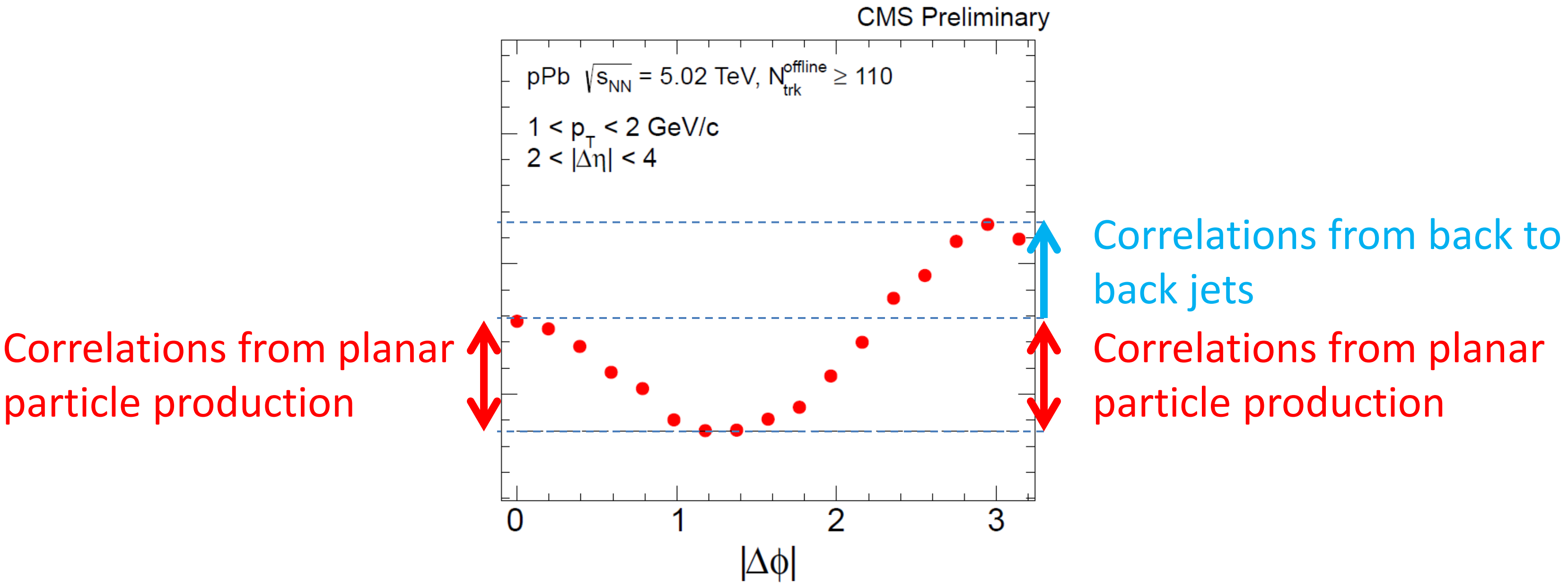
In the signal (N>110) region, the strength of the effect rises and falls with pT

In the p_T range where the yield is the strongest, the ridge turns on at N≈50



Summary and Conclusions

- A significant ridge is observed in high multiplicity (central) pPb collisions at 5 TeV
  - strong mechanism to produce particles in a plane
  - much larger than pp



Summary and Conclusions

- A significant ridge is observed in high multiplicity (central) pPb collisions at 5 TeV
  - strong mechanism to produce particles in a plane
  - much larger than pp
- Effect turns on slightly above average minimum bias multiplicity
- Effect rises and falls with pT
  - similar trend as observed in both PbPb and pp ridge before

Thank you LHC!

- All this came from a few hours of LHC pPb test running, only one fill! Hope for more surprises from full pPb run coming up in January!