# Search for mini-QGP in pp using high multiplicity FVTX trigger

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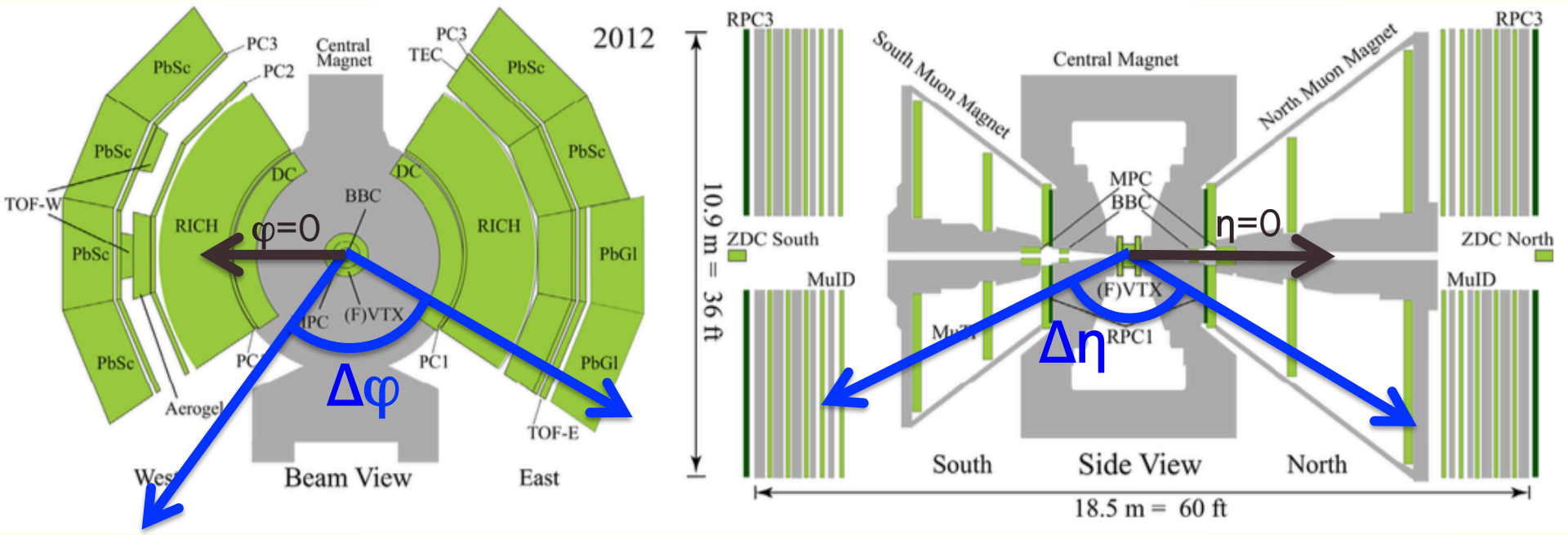
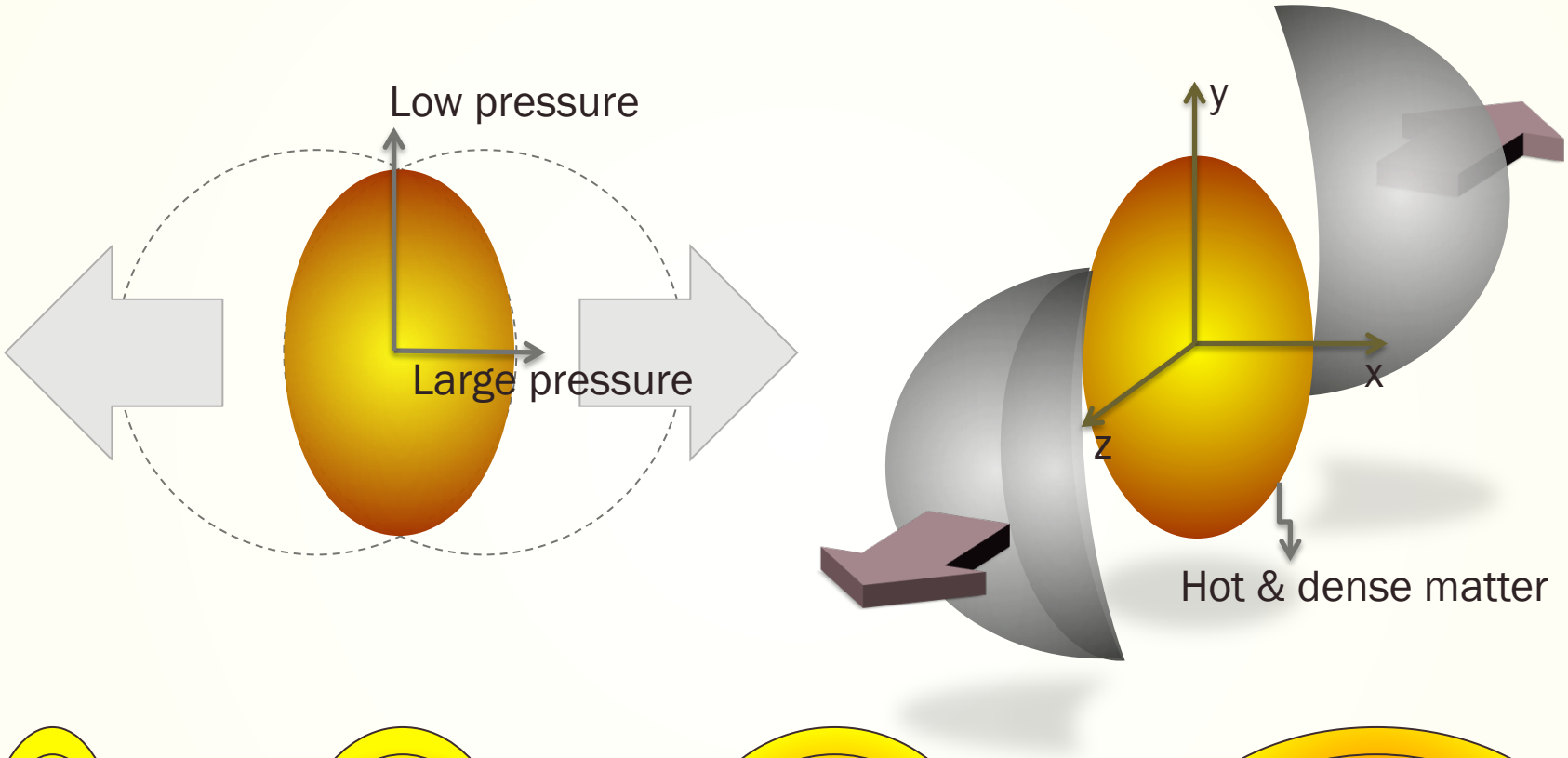
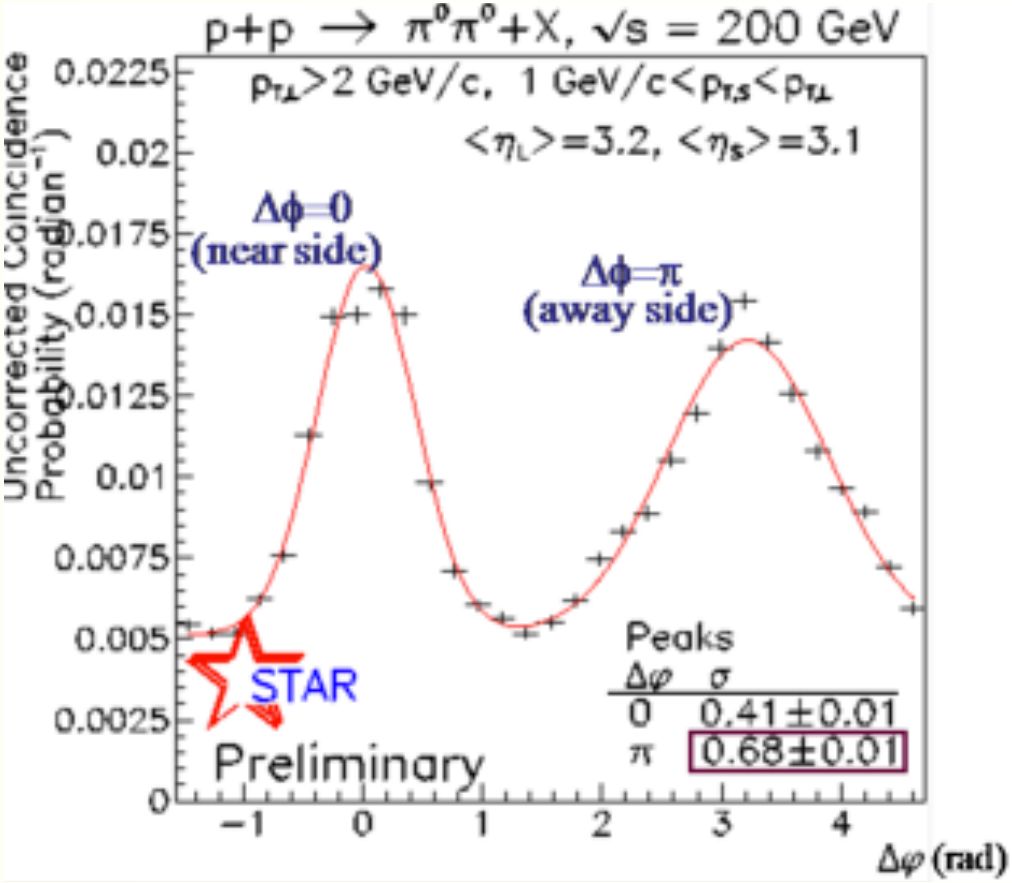
# PHENIX coordinate system

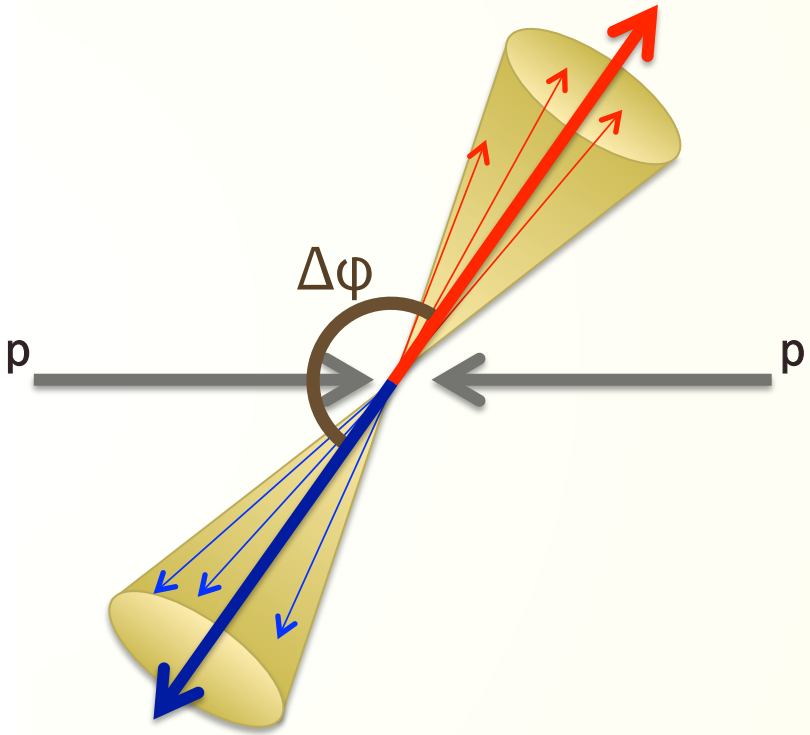


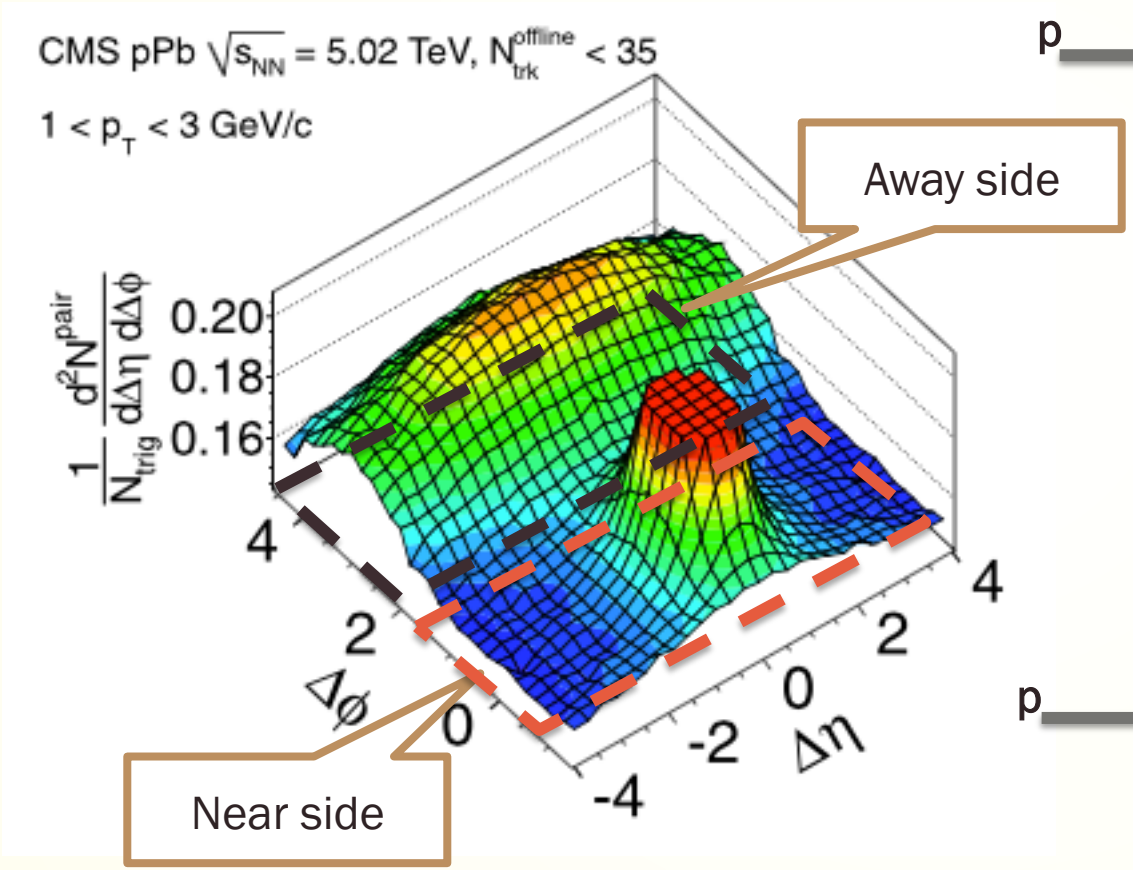
# Elliptic flow of heavy ion collision

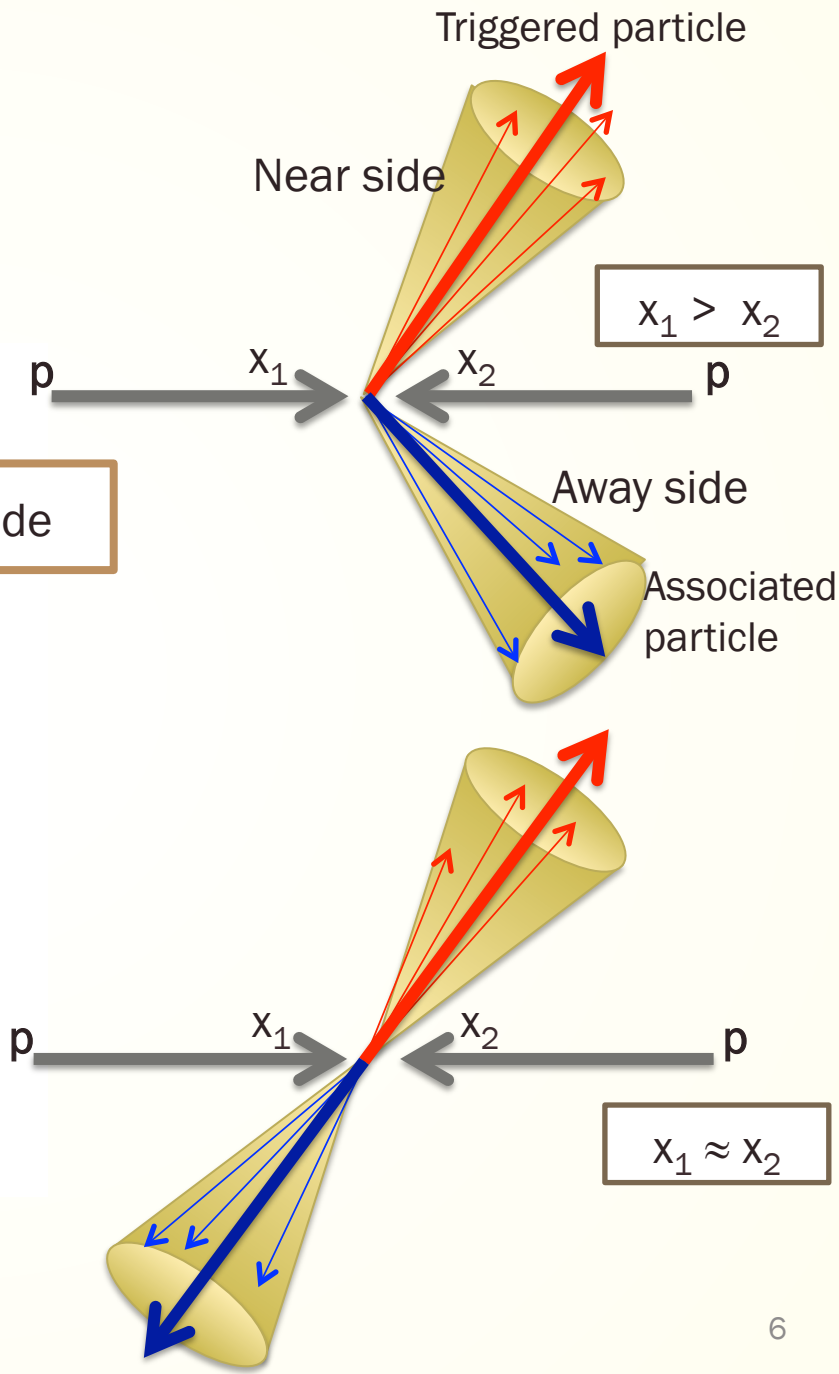


# Two particle correlation



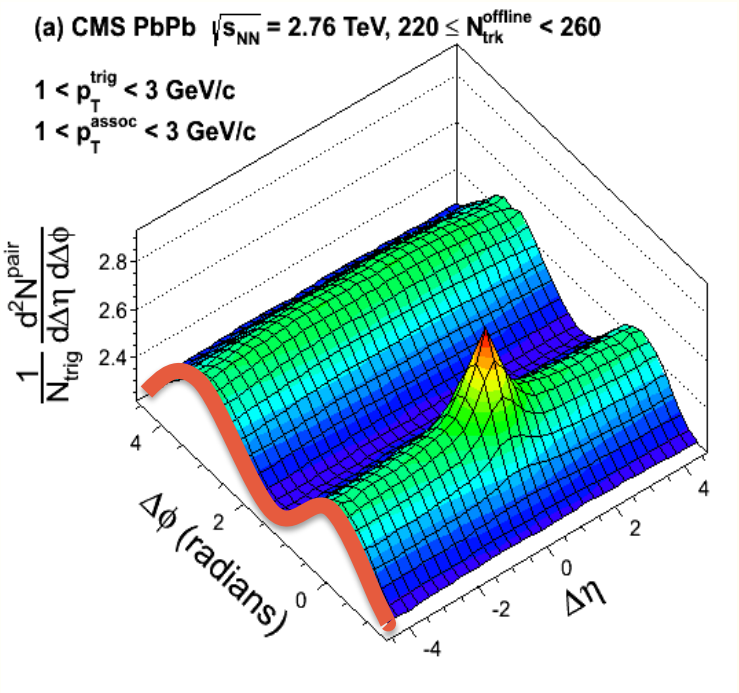

CMS pPb $\sqrt{s_{NN}}$ = 5.02 TeV, $N_{trk}^{offline}$ < 35
1 < $p_T$ < 3 GeV/c
$\frac{1}{N_{trig}} \frac{d^2N^{pair}}{d\Delta\eta\, d\Delta\phi}$
0.20
0.18
0.16
Away side
Near side
$\Delta\phi$
$\Delta\eta$
4
2
0
-2
-4


Triggered particle
Near side
$x_1 > x_2$
p
$x_1$
$x_2$
p
Away side
Associated particle
p
$x_1$
$x_2$
p
$x_1 \approx x_2$

# Second harmonics coefficient of Fourier transformation

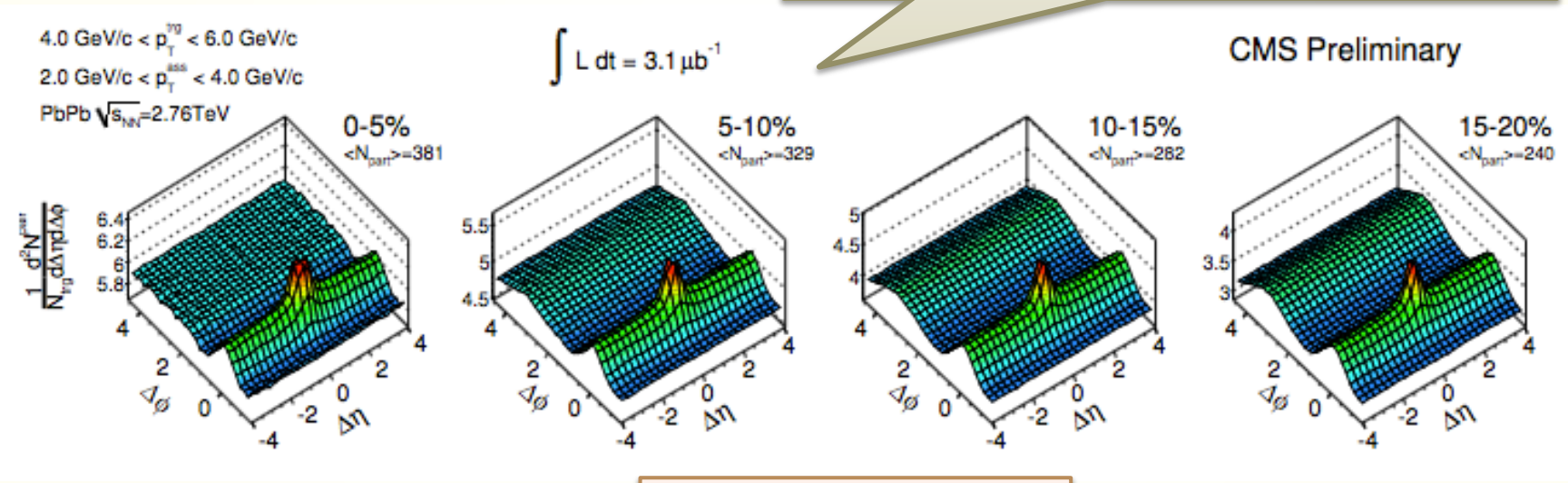
Elliptic flow

$$\frac{1}{N_{trig}}\frac{dN^{pair}}{d\Delta\phi} \sim 1 + 2(v_2)^2 \cos(2\Delta\phi)$$



# (Jet)Near-side ridge structure

**Ridge structure supposed to be…**
1. Evidence of QGP (Collective flow)
2. Initial geometry

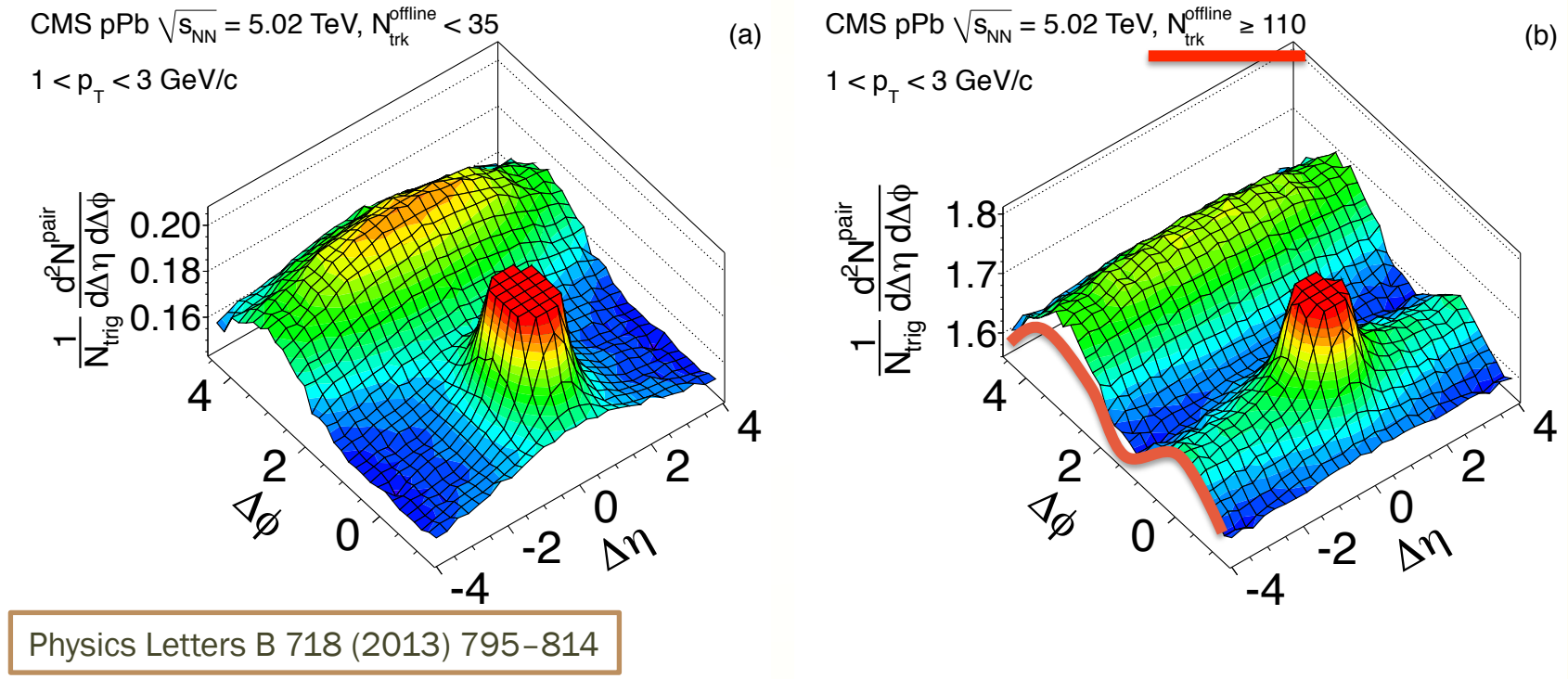



Centrality

# QGP formed only in AA(?)

- Quark gluon plasma found in AA collisions.
- p+A, d+A
  - Small systems.
  - References for cold nuclear matter effects.
- p+p
  - Reference for free from QGP
- Now it cannot be sure.

# pPb ridge structure CMS experiment

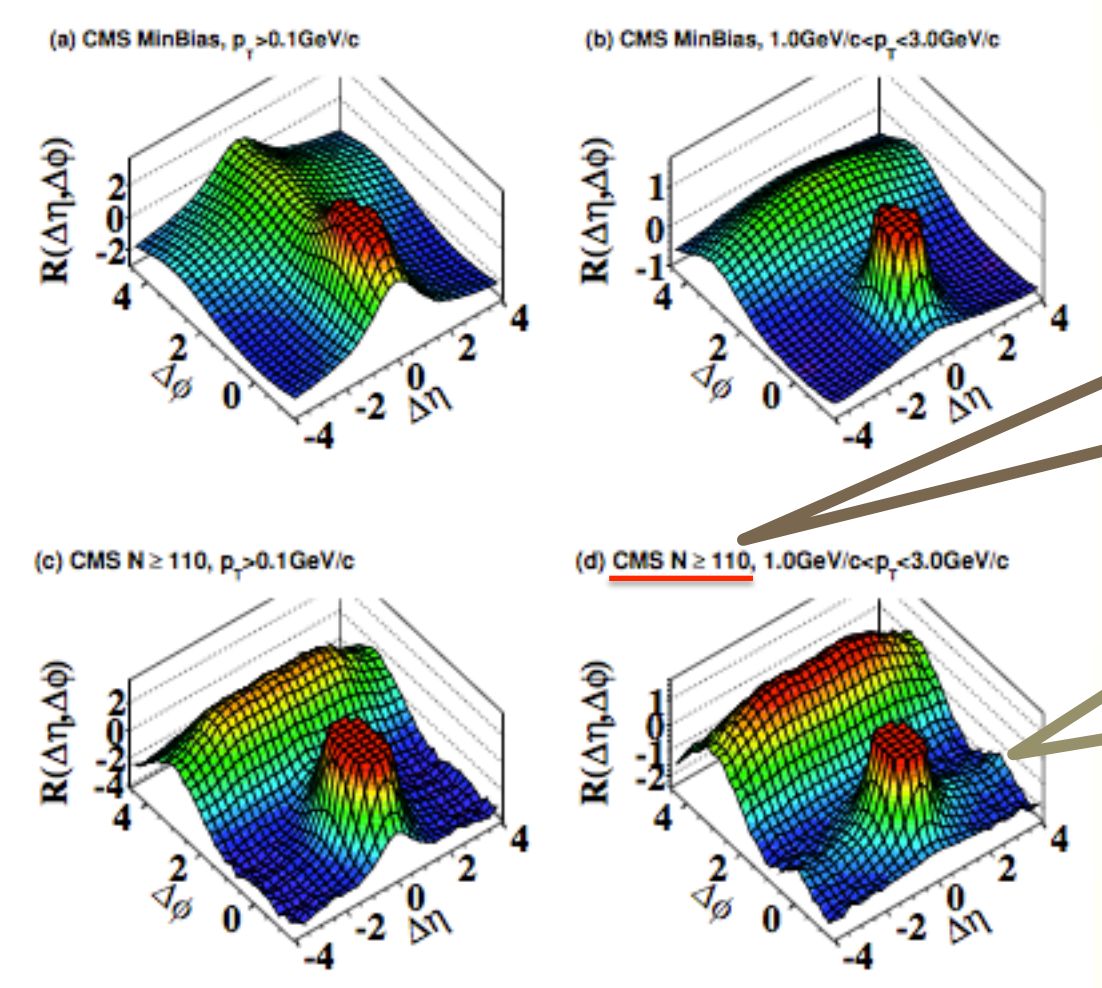



Physics Letters B 718 (2013) 795–814

Recently, CMS reported that they found near side long range ridge structure in p-Pb collision, especially events which **total number of detected particles are larger than 110.**

High multiplicity events

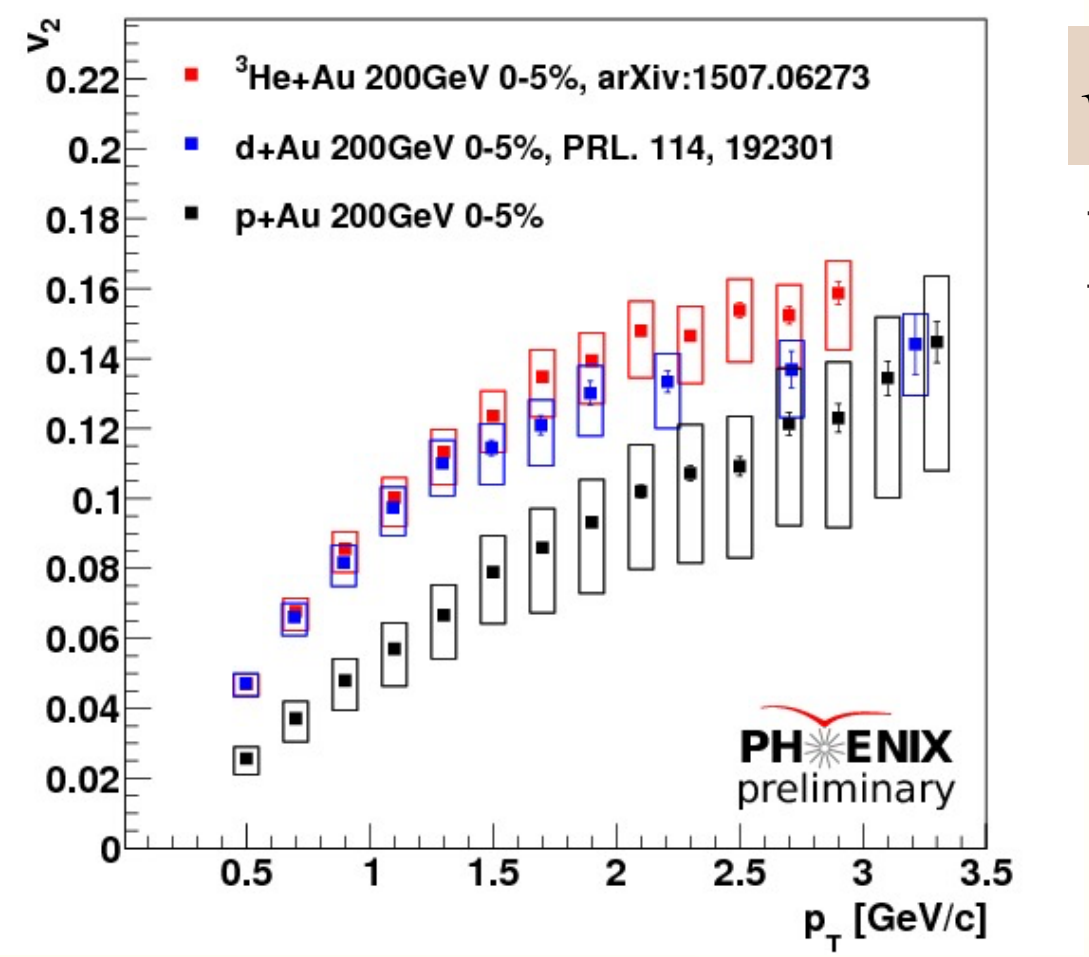
# pp ridge structure CMS experiment




Near side long range ridge structure is found from high multiplicity events.

Near side long range ridge structure in pp 7TeV

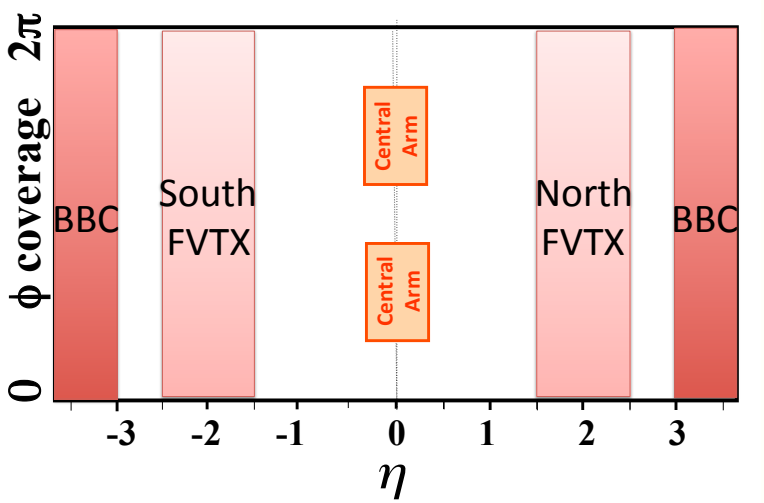
# PHENIX p+Au d+Au $^3$He+Au

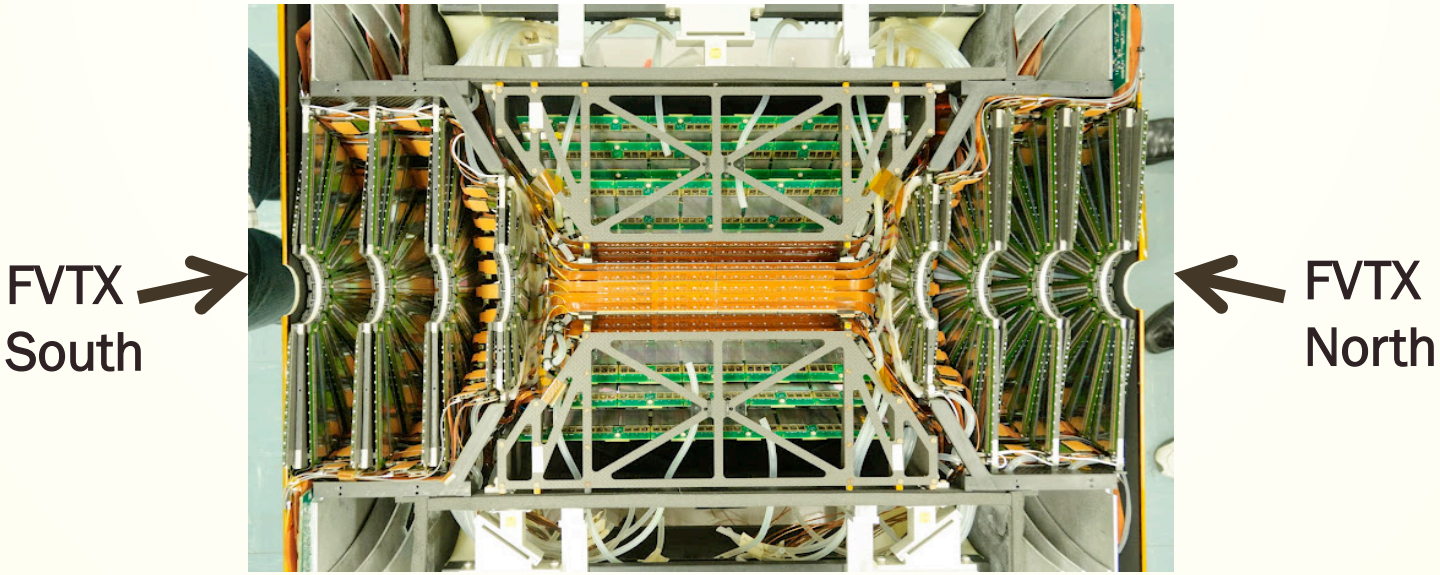



$$v_2^{pAu} < v_2^{dAu} \leq v_2^{^3HeAu}$$

This ordering is expected from initial state.

# FVTX trigger system

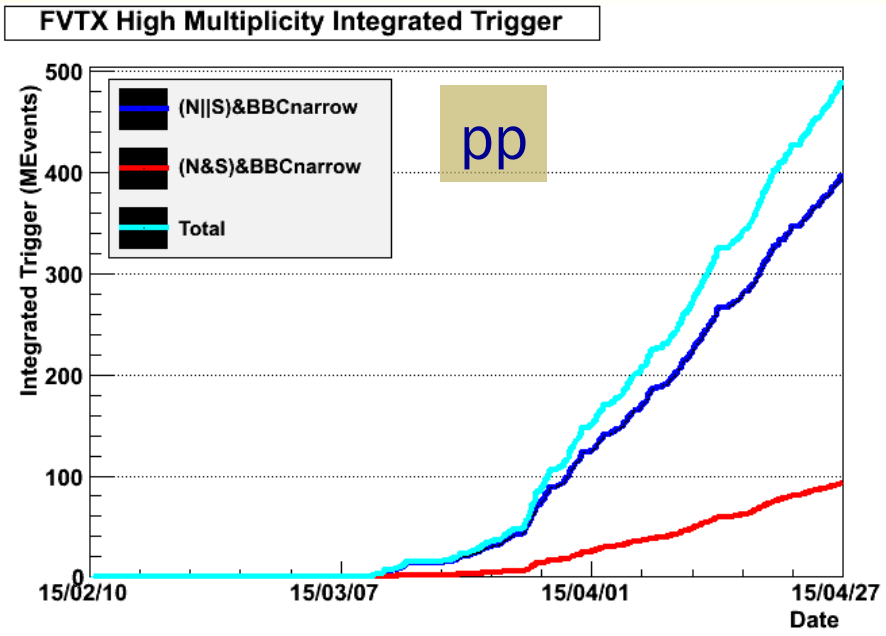


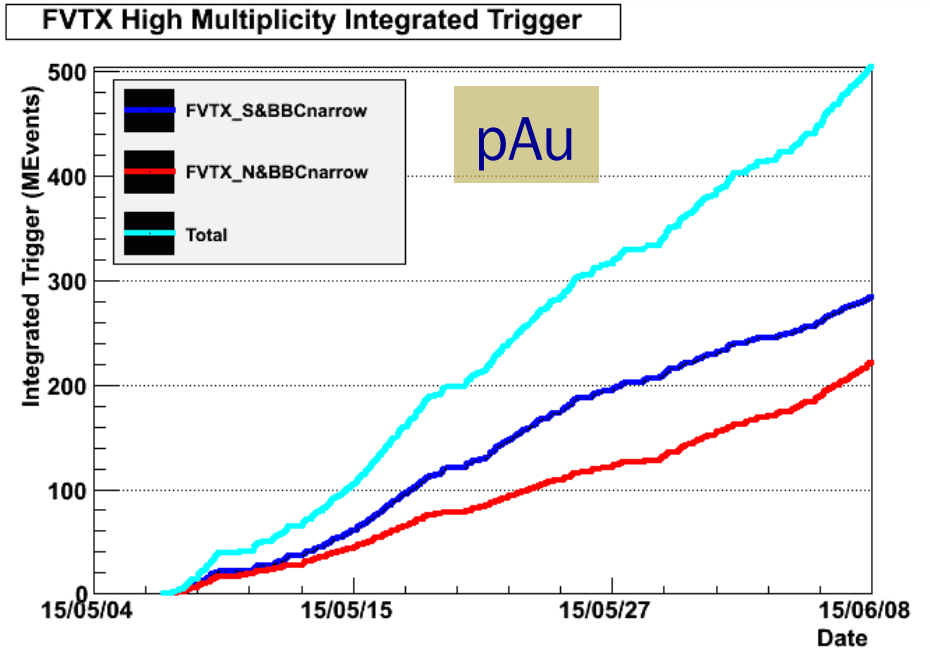



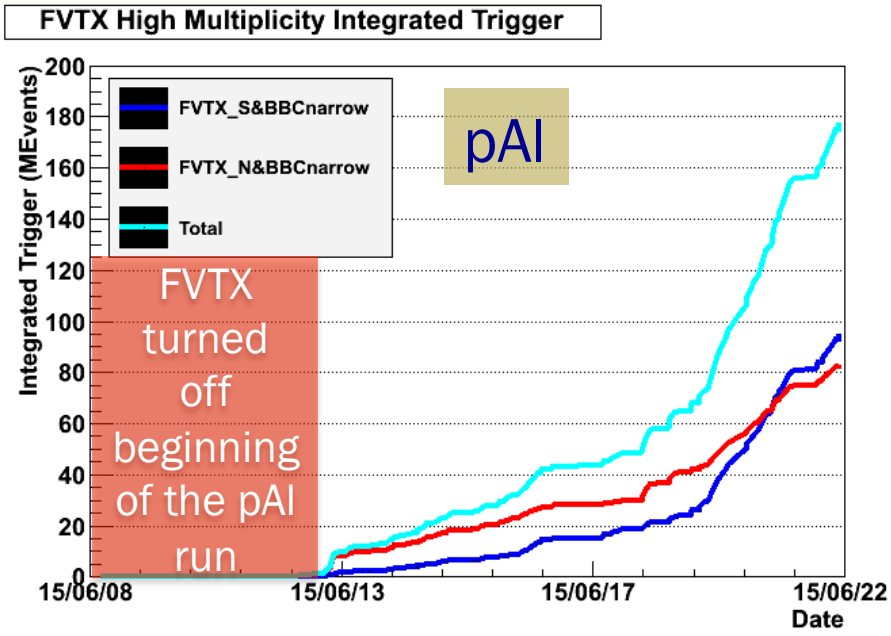
# Why FVTX?

- Very weak correlation between CNT(central rapidity) and BBC(forward rapidity).
- FVTX located closer to CNT than BBC
  - Can expect stronger correlation than BBC-CNT
  - FVTX high multiplicity is introduced by a new standard for event classification for pp.

# Run15 Integrated FVTX Trigger



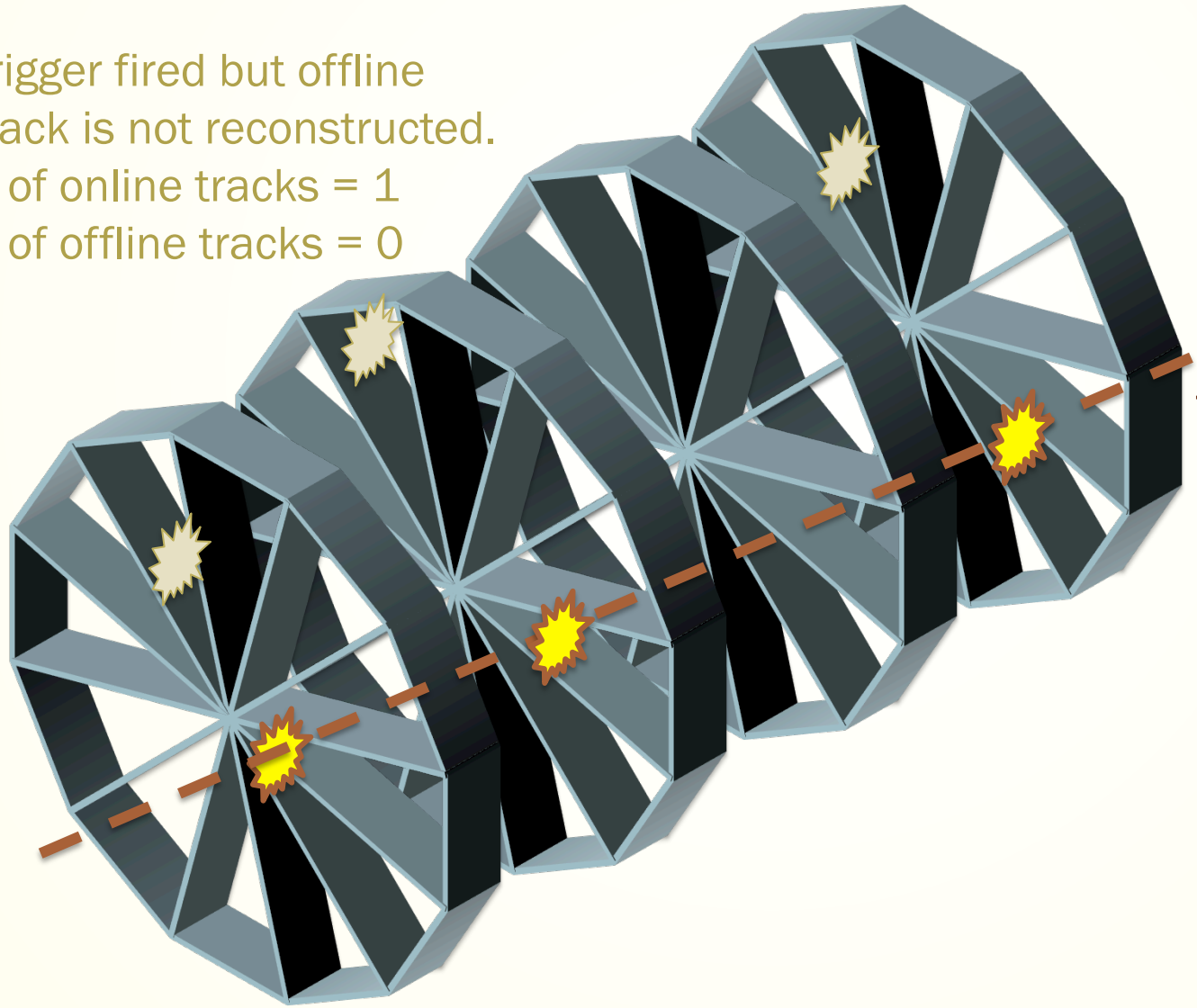




| | pp (AND +OR) | pAu (South) | pAl (South) |
|---|---|---|---|
| # Trigger | 500M | 300M | 90M |

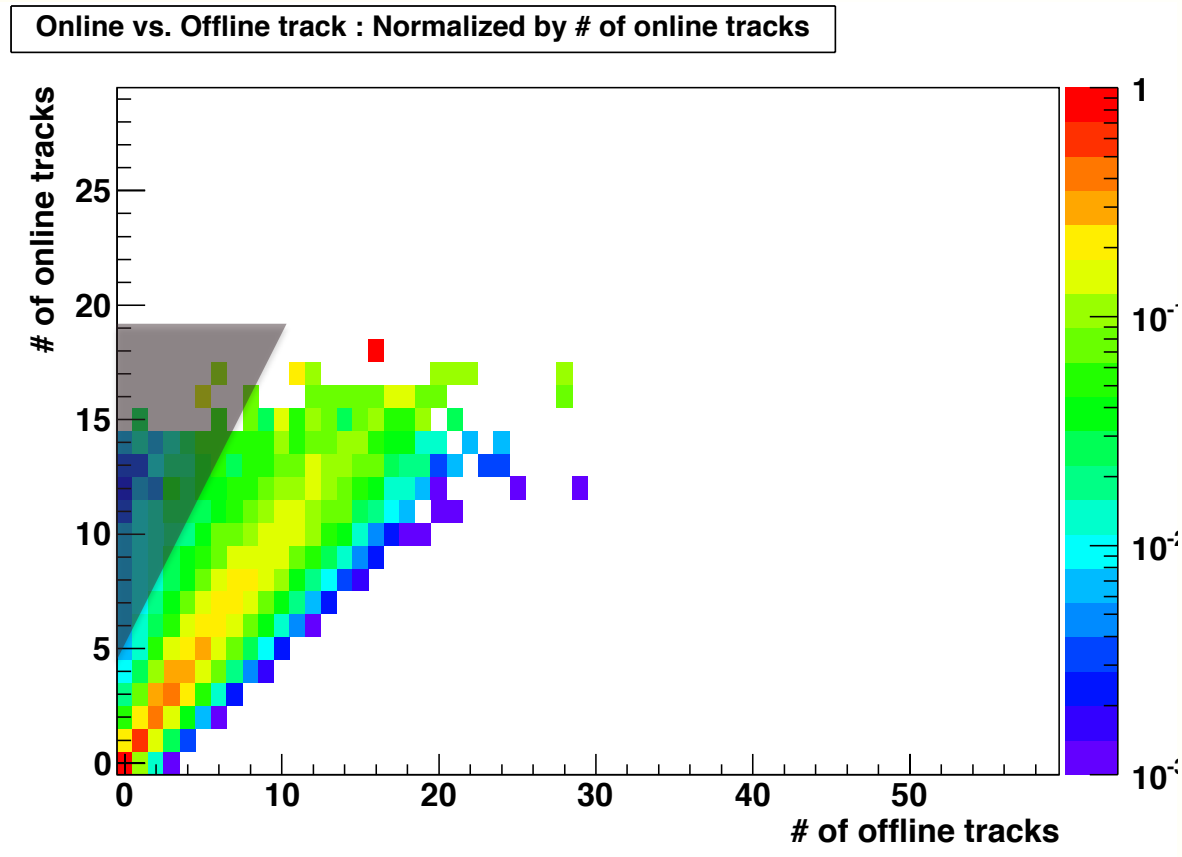
# Online vs. offline tracks

Trigger fired but offline track is not reconstructed.
# of online tracks = 1
# of offline tracks = 0



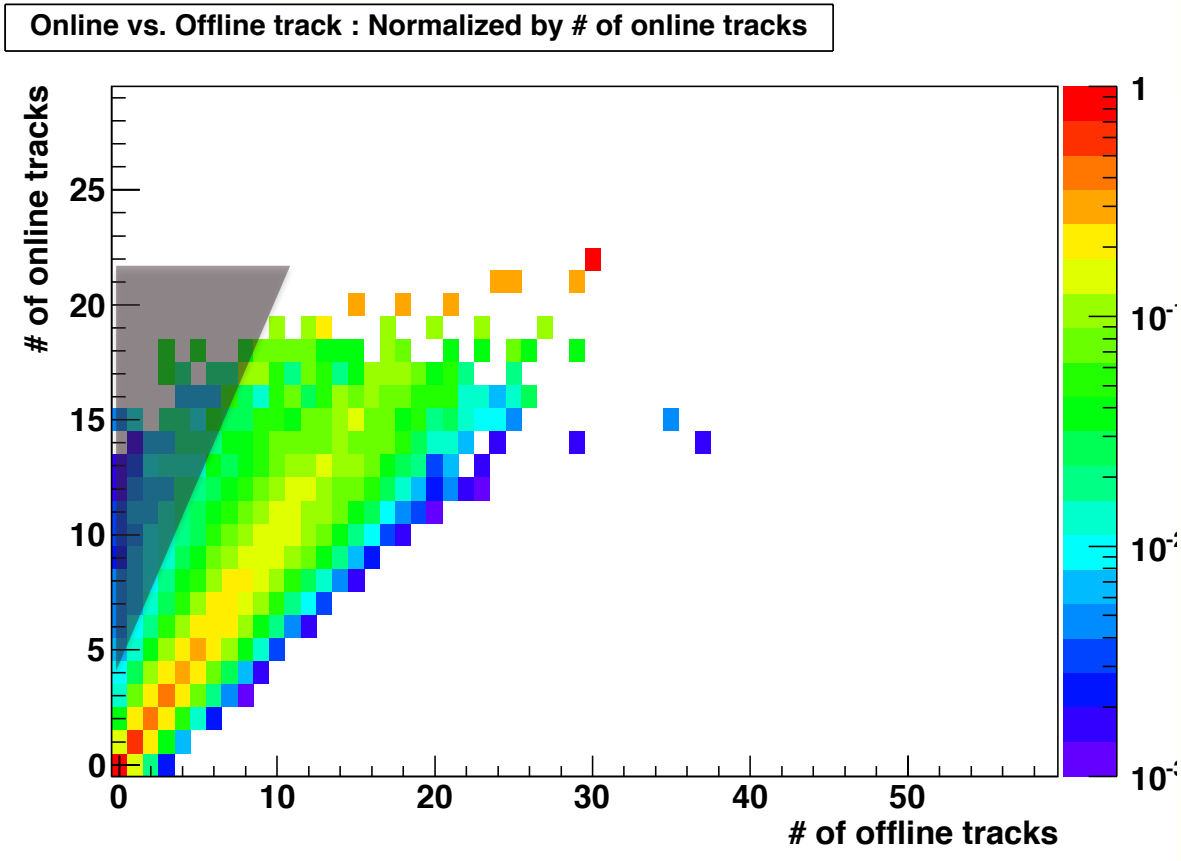
Trigger fired and also offline track reconstructed.
# of online tracks = 1
# of offline tracks = 1

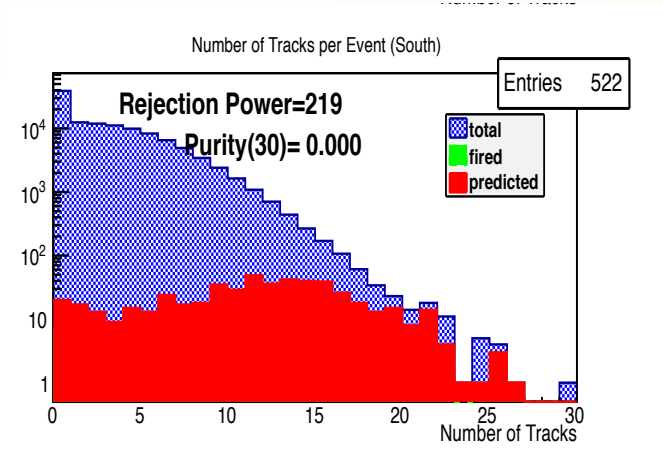
# pp 200GeV North



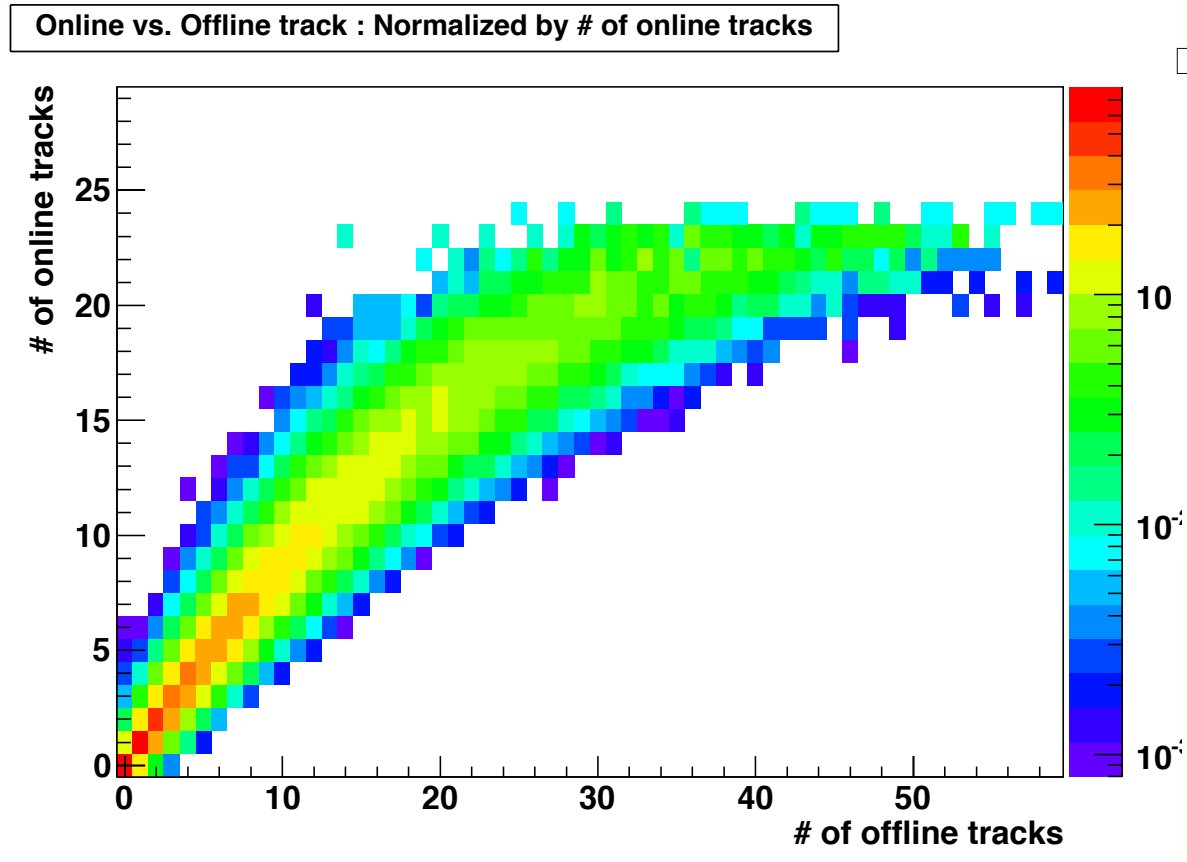

We can find some off-diagonal part constantly except for the Au-going side and Al-going side.

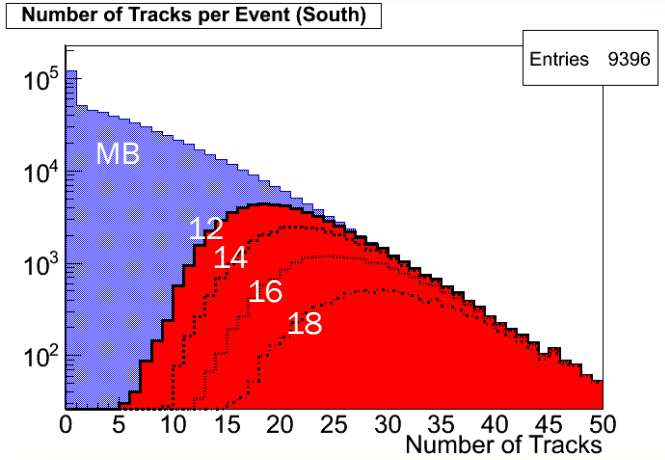
# pp 200GeV South



# pAu 200GeV South (Au-going)



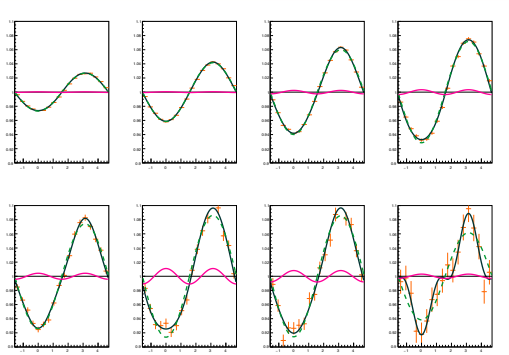




In the pAu Au-going side, we cannot find off-diagonal area and tail.

# Summary for online vs. offline study

- We can find off-diagonal area except for Au-going side and Al-going side.
- Still in the middle of studying.

# Correlation function



Centrality 20%-100%

1. Calculate $\Delta\varphi$

$$\Delta\phi = \phi_{associated} - \phi_{triggered}$$

2. Mix event & Real event
   - Remove limited acceptance effect
   - Get 3 particles from other events
3. Correlation function

$$C(\Delta\phi,\Delta\eta) = \frac{\int N_{trk,M}\, d\phi\, d\eta}{\int N_{trk,R}\, d\phi\, d\eta} \frac{N_{trk,R}(\Delta\phi,\Delta\eta)}{N_{trk,M}(\Delta\phi,\Delta\eta)}$$

We deal with projection to phi plane of 2D histogram.

This example is BBCs CNT correlation function.

# $v_n$ calculation

1. Get the fitting function

$$F(\Delta\phi) = N_0(1 + \sum_{n=1}^{3} 2C_n \cos(n\Delta\phi))$$

2. $c_n$ include 2 $v_n$ parameters : $C_n = v_n^a * v_n^b = C_n^{ab}$
3. To calculate $v_n$, need 3 sub combinations

$$C_n^{ab} = v_n^a * v_n^b$$
$$C_n^{bc} = v_n^b * v_n^c$$
$$C_n^{ac} = v_n^a * v_n^c$$

$$v_n^a = \sqrt{\frac{C_n^{ab} C_n^{ac}}{C_n^{bc}}}$$

Ex ) a=BBCs, b=BBCn, c=CNT
a=FVTXn, b=FVTXs ..

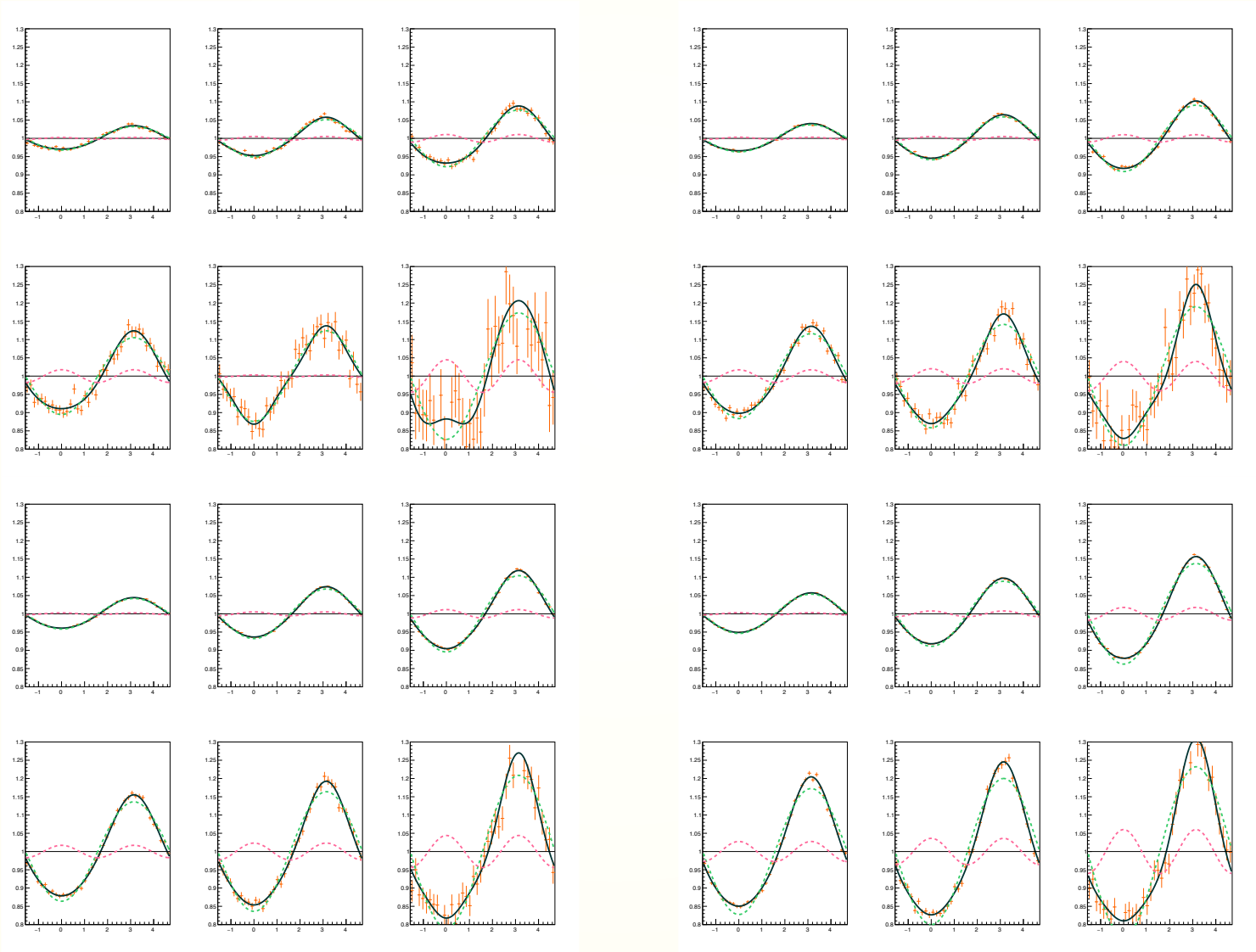
# CNT FVTXs correlation functions

0-1%

1-5%

5-20%

20-100%



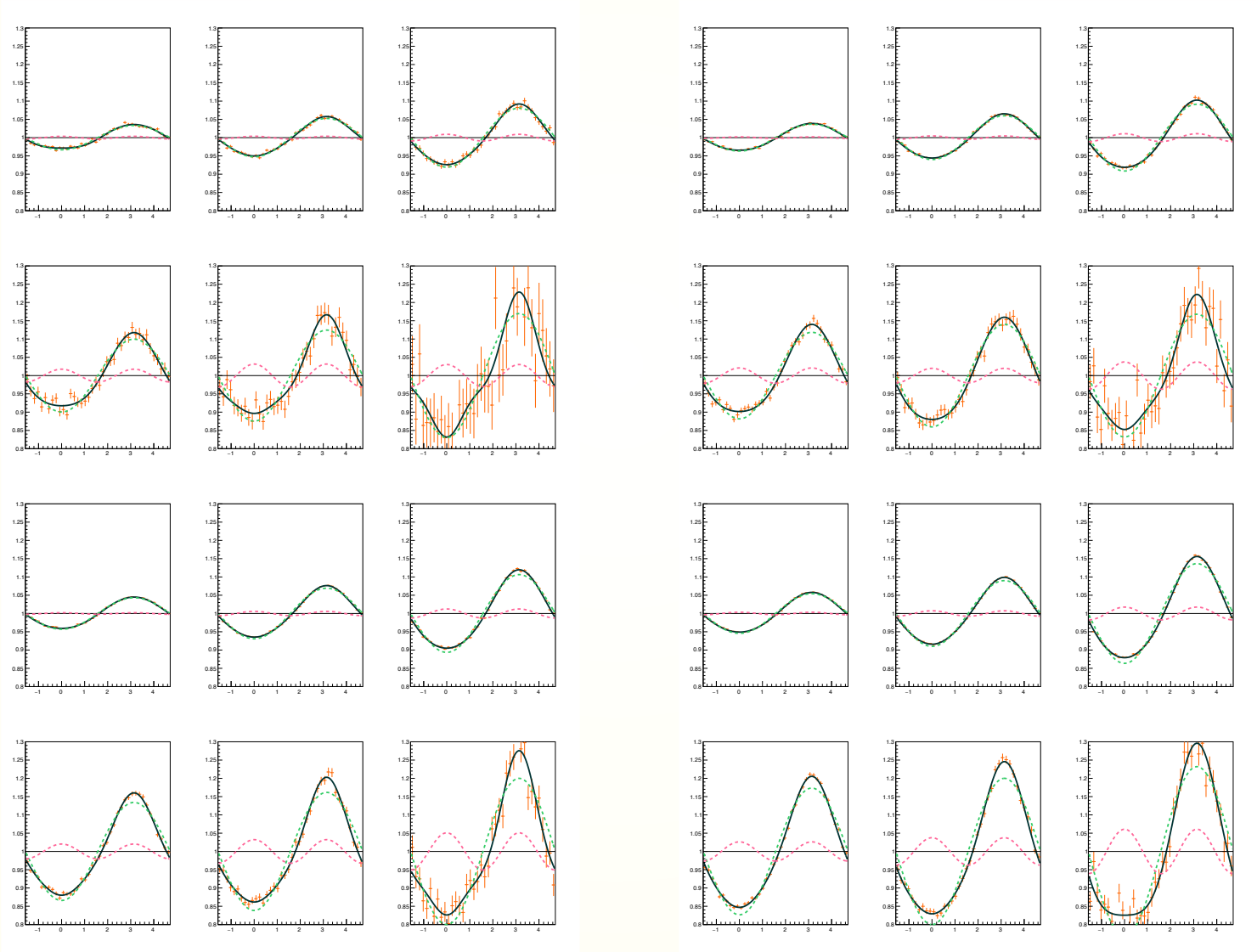
# CNT FVTXn correlation functions

0-1%

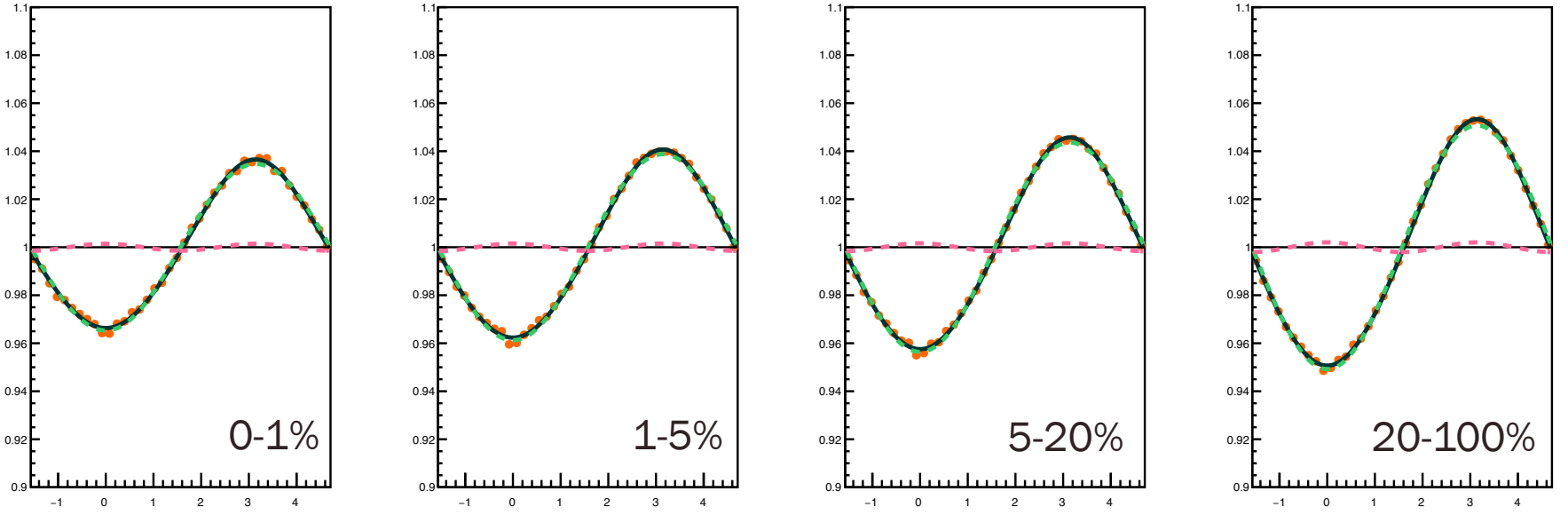
1-5%

5-20%

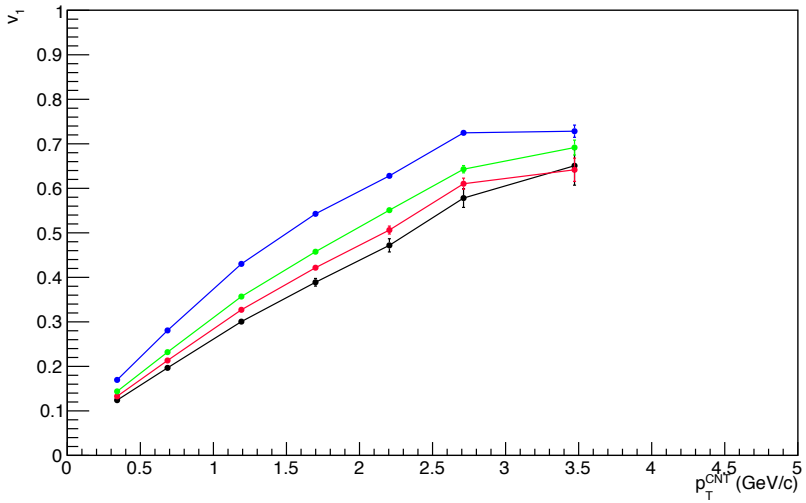
20-100%



# FVTXs FVTXn correlation

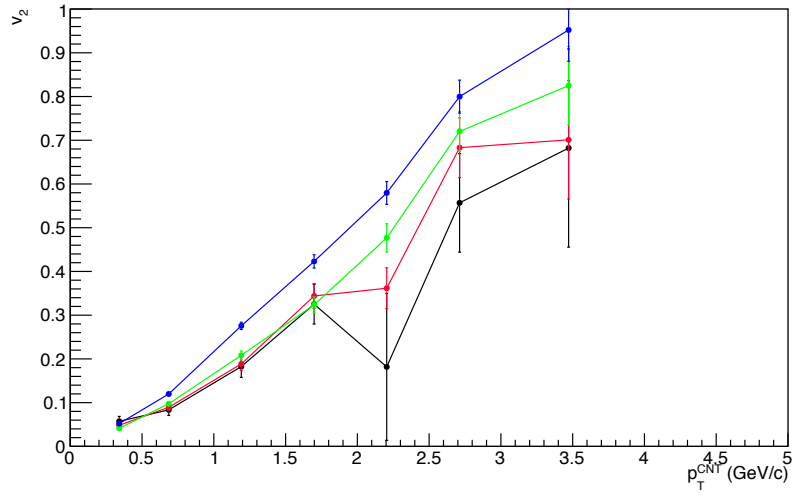


# $v_n$ result of CNT




0-1% (highest multiplicity)
1-5%
5-20%
20-100%

- Minimum bias event
- FVTX multiplicity event class




- Finite $v_2$ observed
- Could be biased

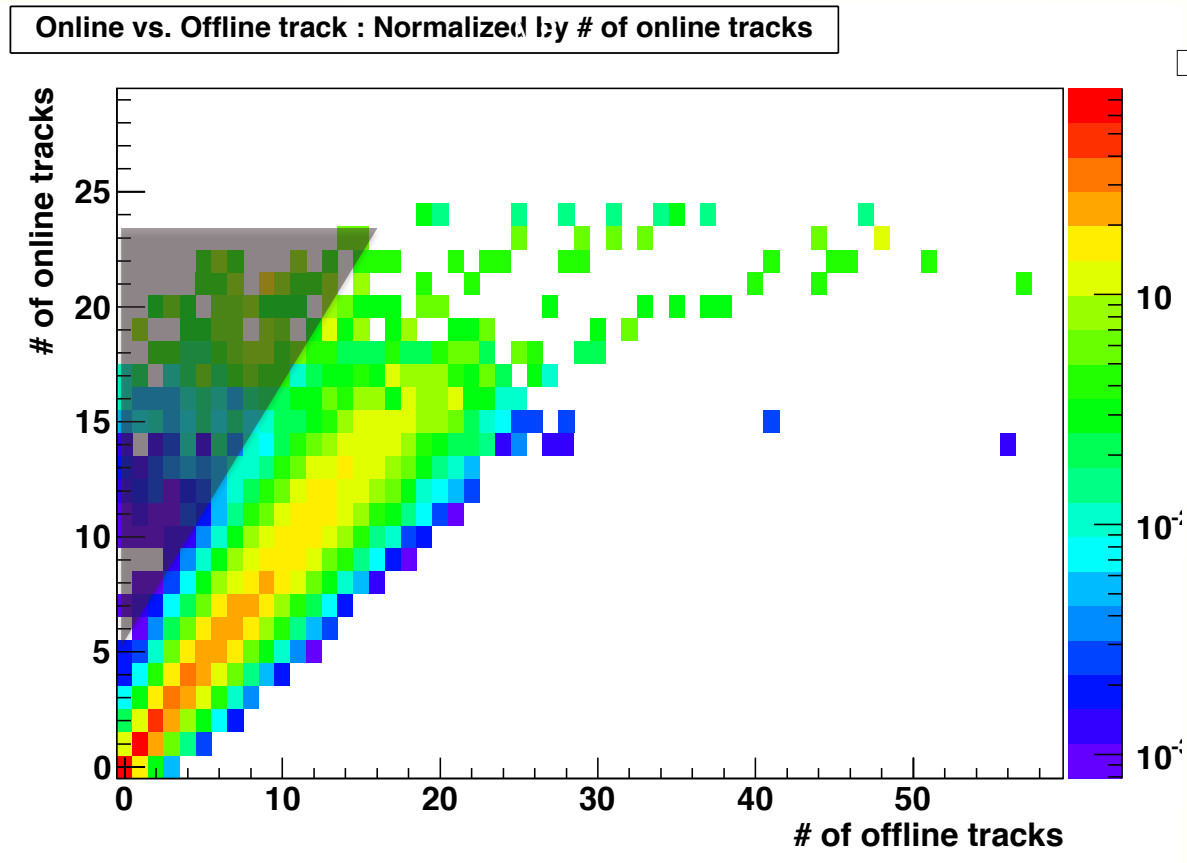
# Future plan

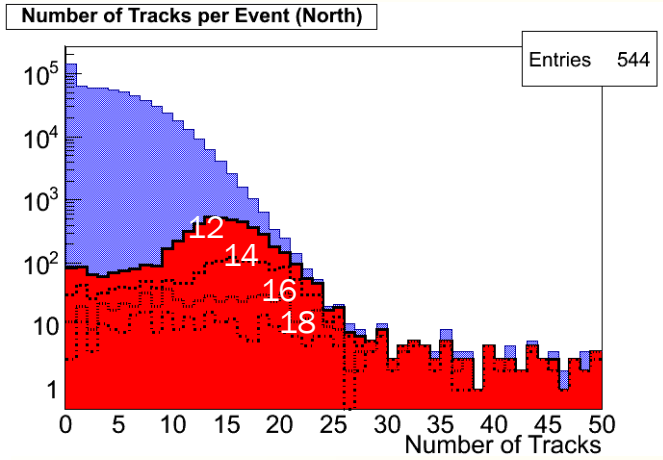
- From $v_2$ result get the physics out of it.
- Improvement performance of FVTX trigger for the future use.

2015 Japan Korea PHENIX collaboration meeting

# THANK YOU

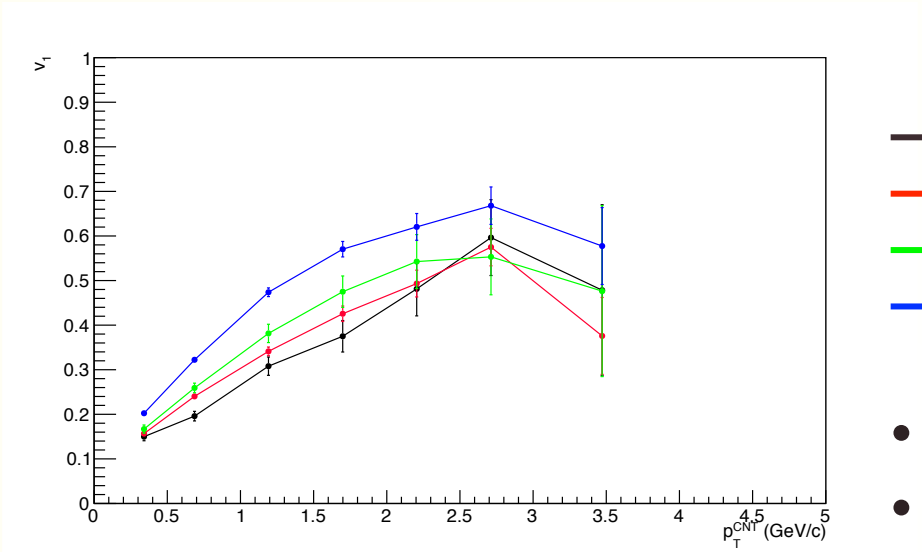
# pAu 200GeV North (p-going)



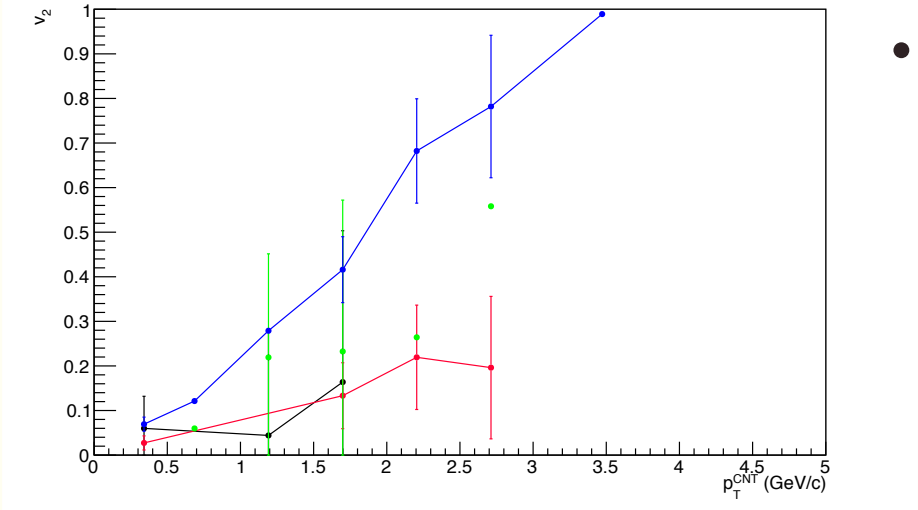

And also we can find a tail in pAu p-going side.

# CNT BBC correlation : CNT




0-1% (highest multiplicity)
1-5%
5-20%
20-100%

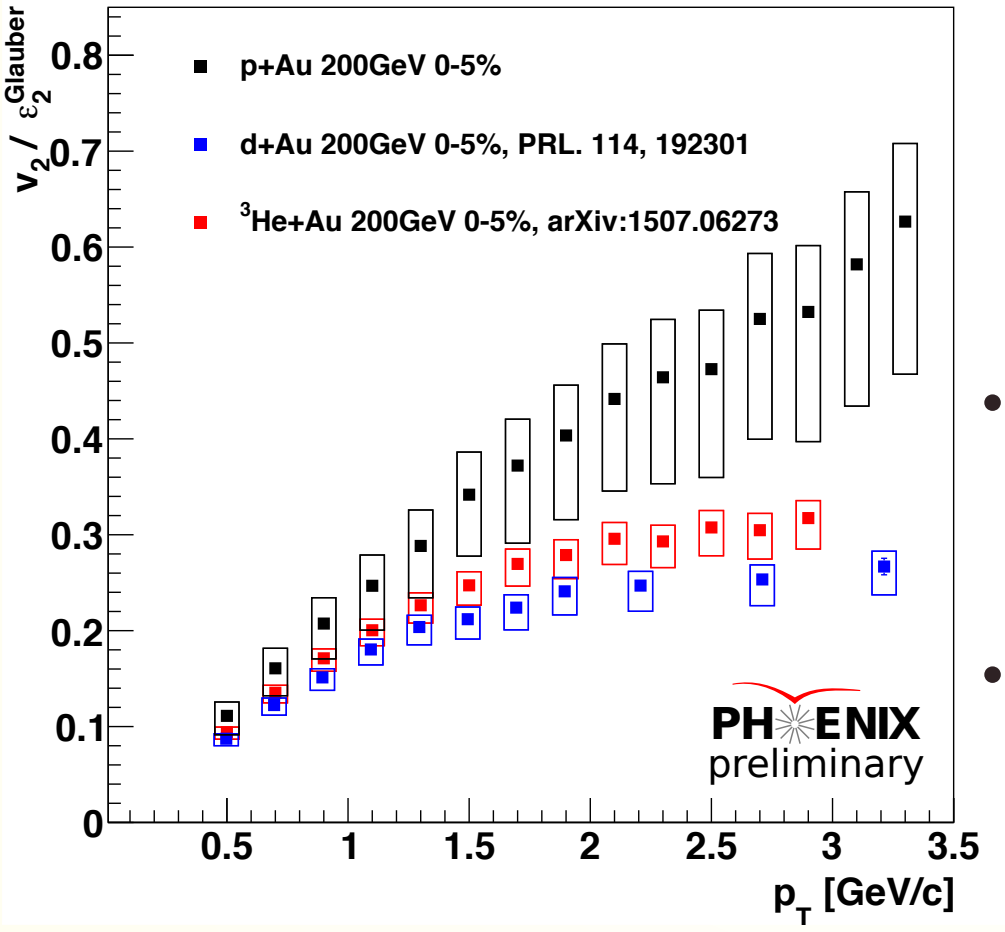
- Minimum bias event
- FVTX multiplicity event class




- Finite v2 observed

# Eccentricity Scaling

$\varepsilon_2$ : Glouber (Round nucleon)




$$\frac{v_2^{dAu}}{\varepsilon_2^{dAu}} < \frac{v_2^{^3HeAu}}{\varepsilon_2^{^3HeAu}} < \frac{v_2^{pAu}}{\varepsilon_2^{pAu}}$$

- The ordering now changes and p+Au becomes largest due to round nucleon assumed in Glouber calculation.
- Small system with shorter lifetime would not fully reflect initial geometry information