

Three-Particle Jet-Like Azimuthal Correlations

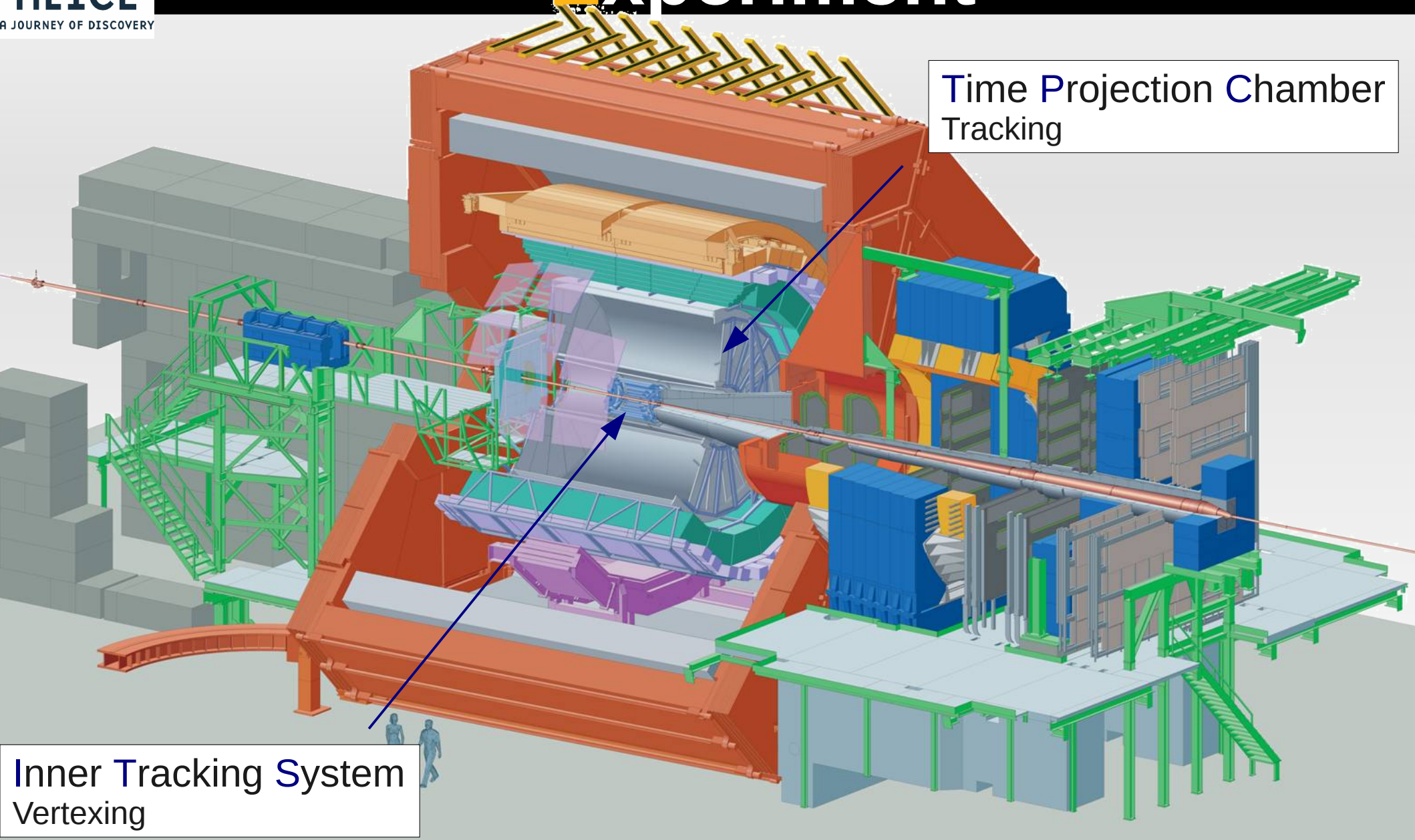
Jason Glyndwr Ulery
University of Frankfurt
High-pT Physics at LHC
26 March 2012



A Large Ion Collider Experiment

A JOURNEY OF DISCOVERY

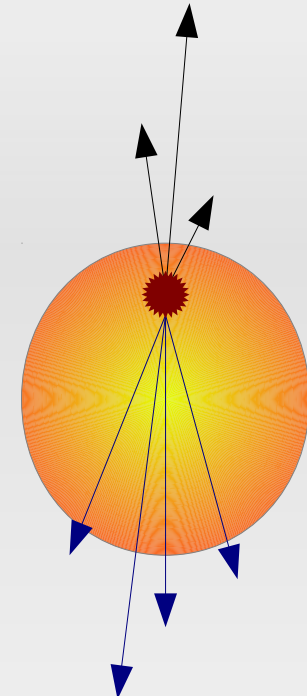
Time Projection Chamber
Tracking



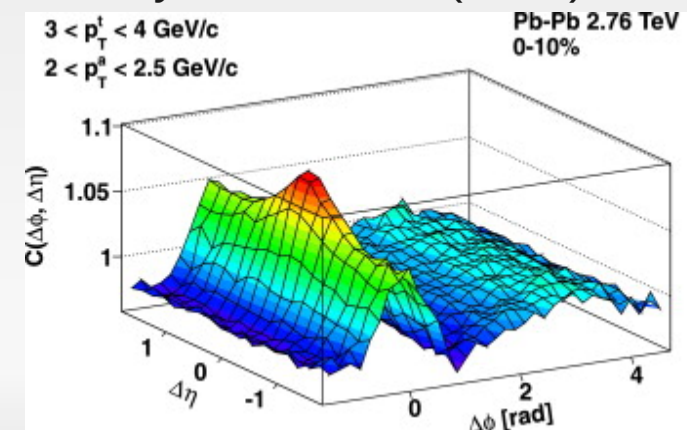
Inner Tracking System
Vertexing

Motivation

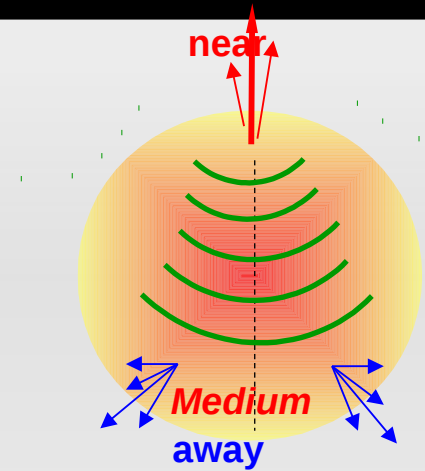
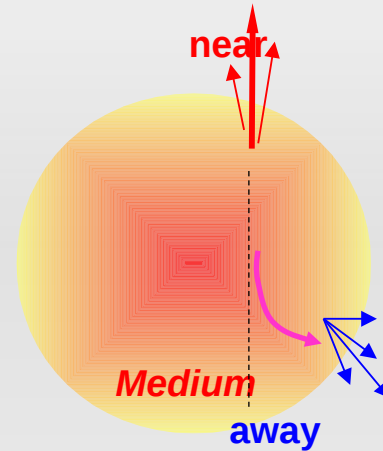
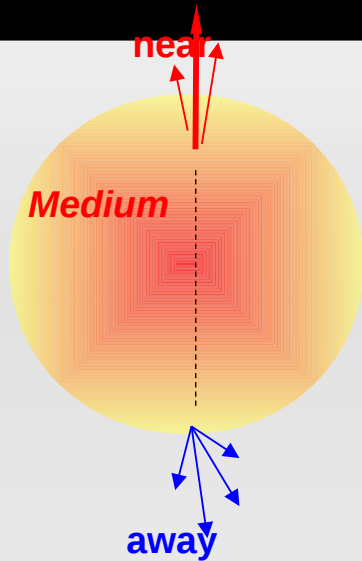
- Information about away-side structure.
 - Mach-cone
 - Cerenkov gluon radiation
 - Deflected Jets
 - deflected by radial flow
 - path length dependent energy loss
- Different flow subtraction systematics than 2-particle correlations.



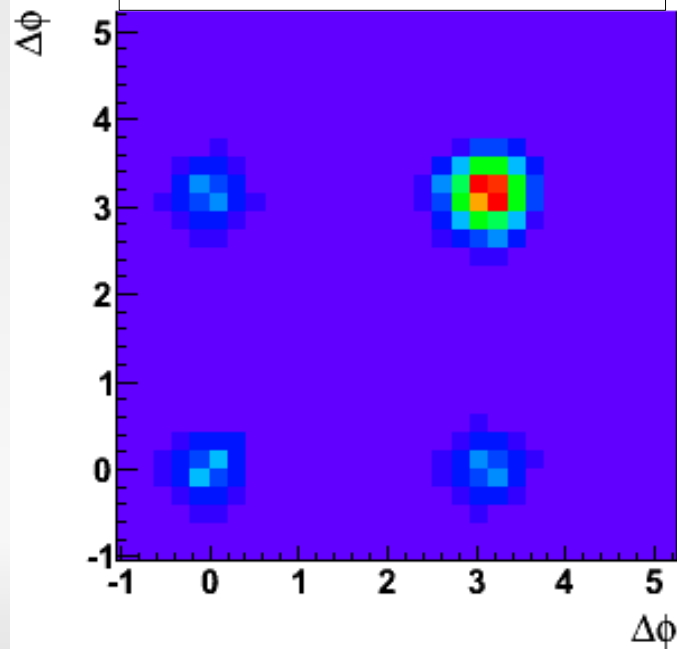
Phys.Lett. B708 (2012) 249



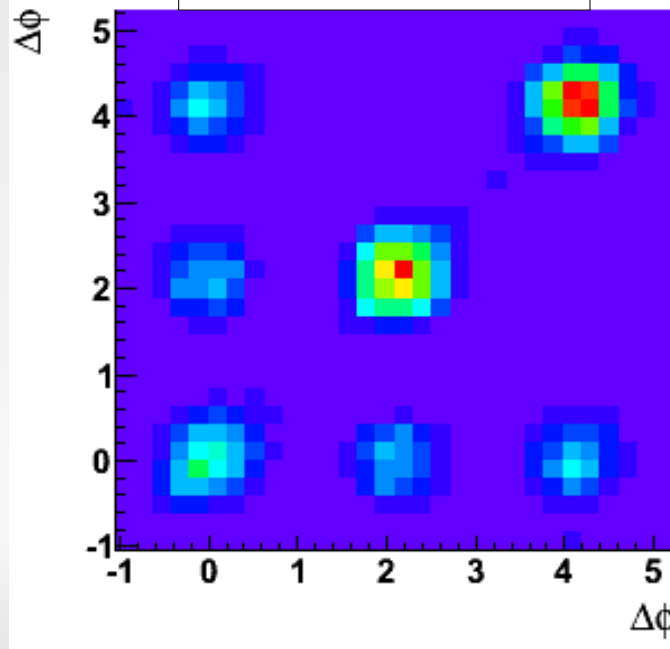
Motivation II



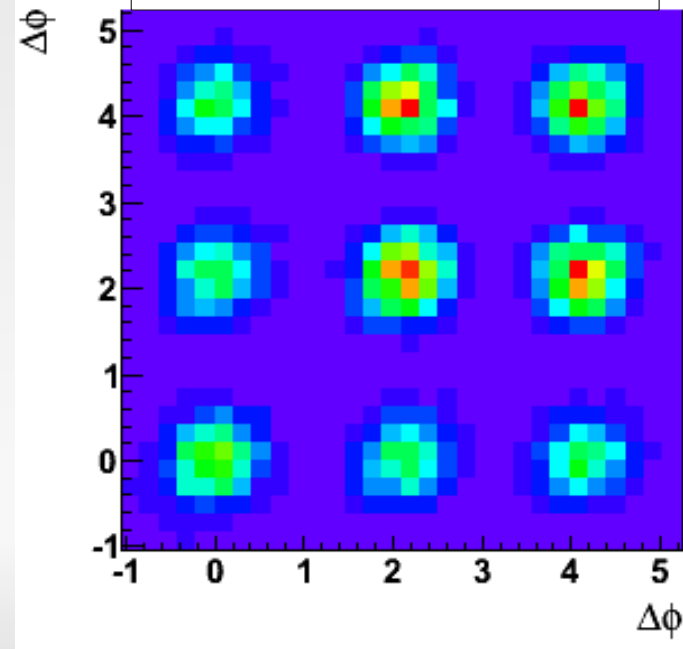
Unmodified Di-Jet



Deflected Jet



Conical Emission

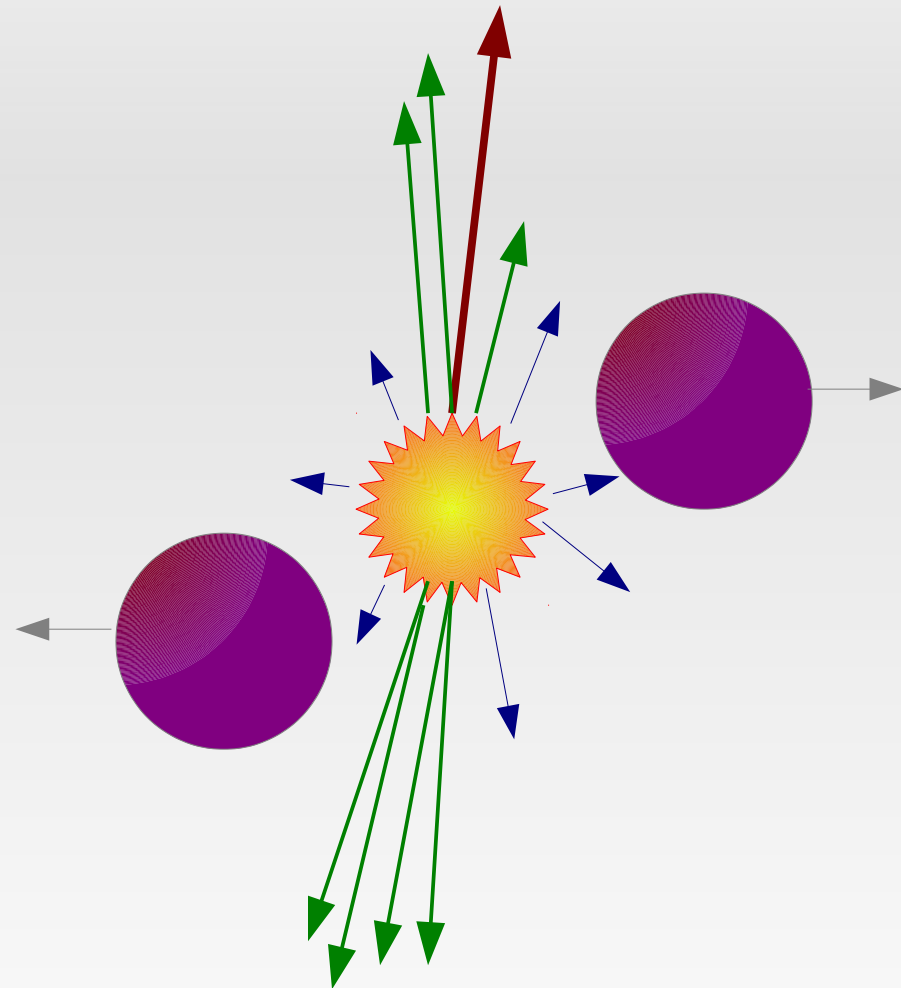


3-Particle Correlations

- Select an intermediate or high- p_T **trigger particle**.
- Look at relative angles between **trigger** and 2 other particles.

$$\Delta\phi_1 = \phi_{\text{Trigger}} - \phi_{\text{Associated},1}$$

$$\Delta\phi_2 = \phi_{\text{Trigger}} - \phi_{\text{Associated},2}$$



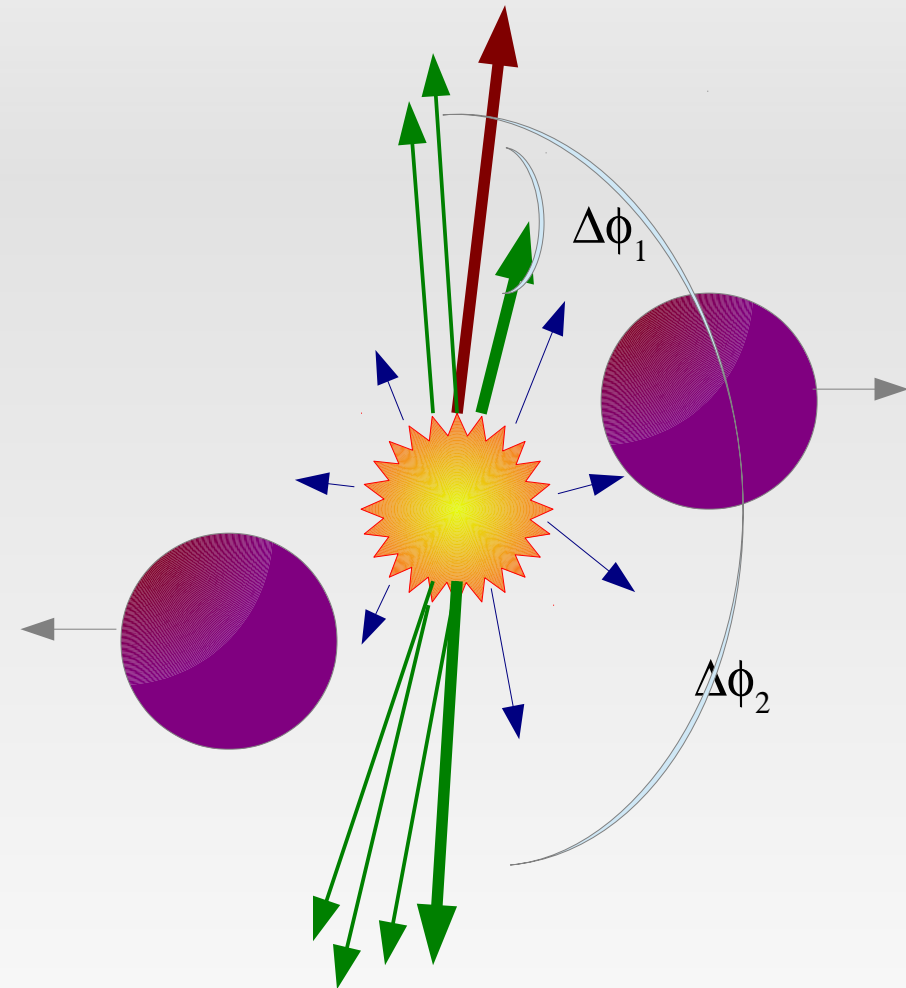
3-Particle Correlations

- Select an intermediate or high- p_T **trigger particle**.
- Look at relative angles between **trigger** and 2 other particles.

Both from jet:

$$\Delta\phi_1 = \phi_{\text{Trigger}} - \phi_{\text{Associated},1}$$

$$\Delta\phi_2 = \phi_{\text{Trigger}} - \phi_{\text{Associated},2}$$



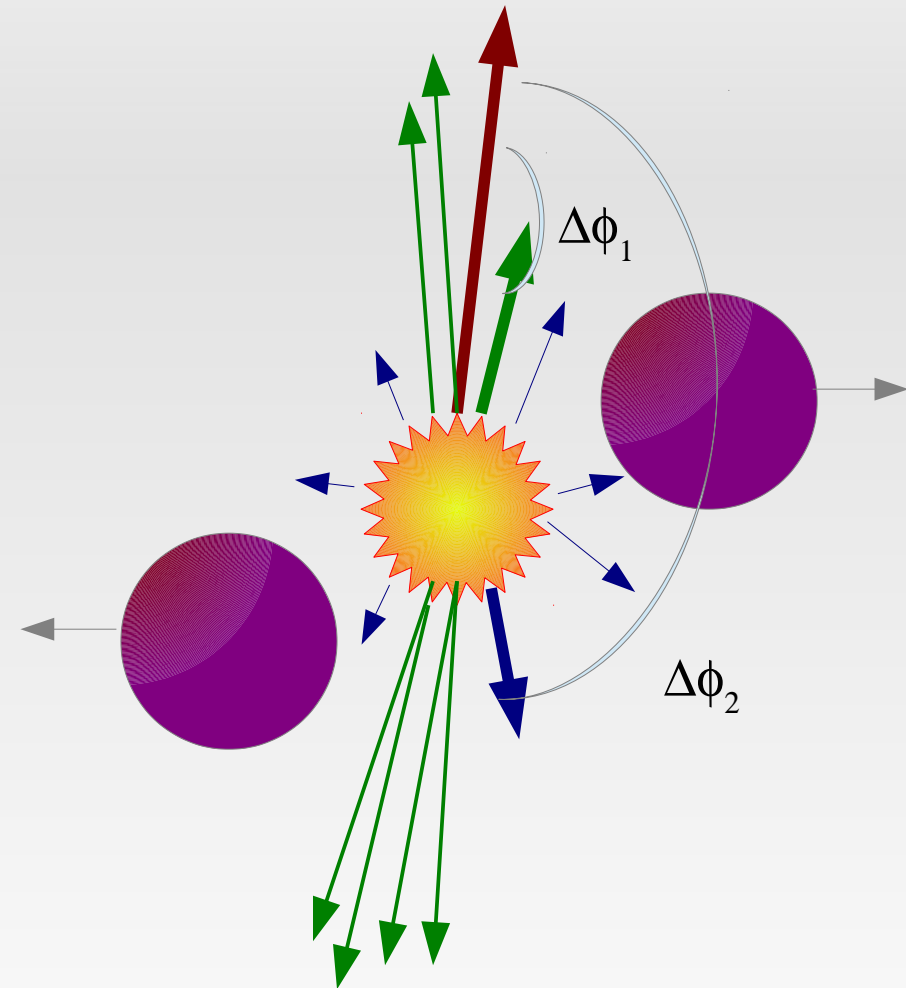
3-Particle Correlations

- Select an intermediate or high- p_T **trigger particle**.
- Look at relative angles between **trigger** and 2 other particles.

1 from jet and
1 from background:

$$\Delta\phi_1 = \phi_{\text{Trigger}} - \phi_{\text{Associated},1}$$

$$\Delta\phi_2 = \phi_{\text{Trigger}} - \phi_{\text{Associated},2}$$



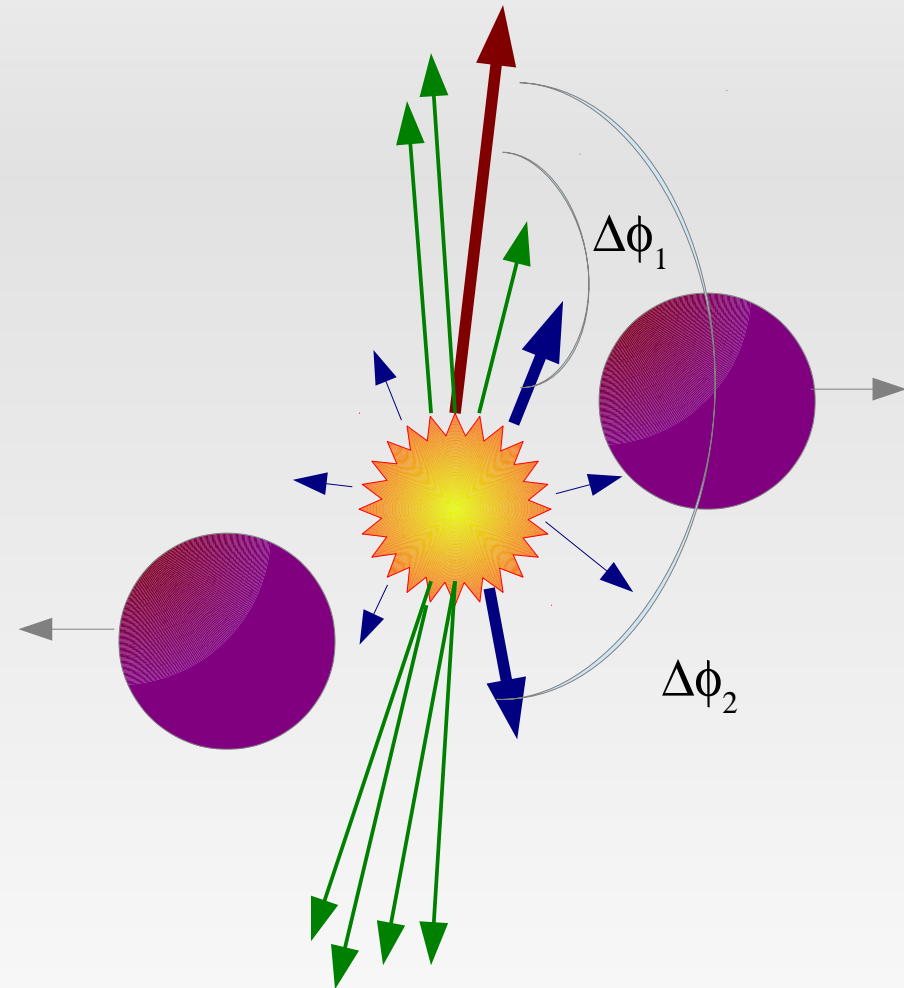
3-Particle Correlations

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Both from background:

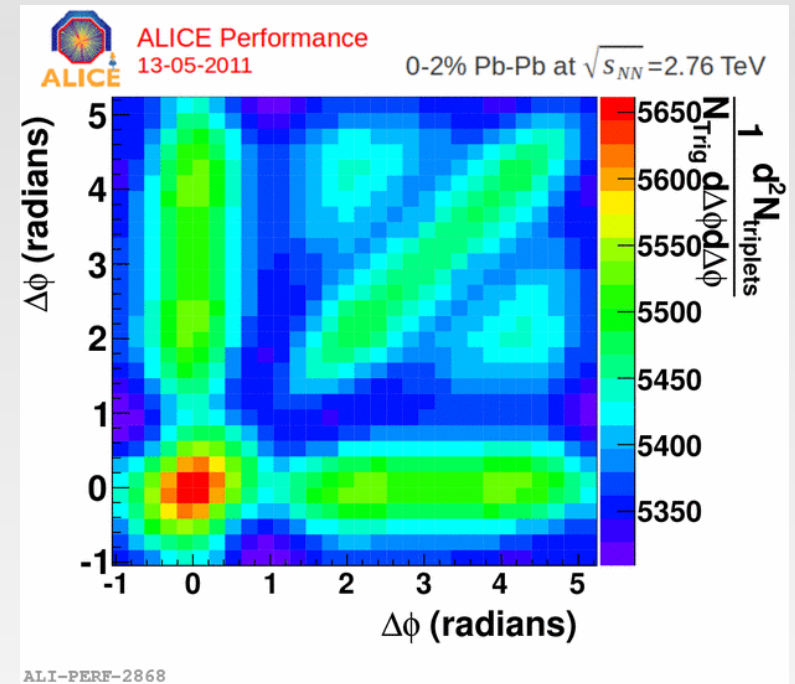
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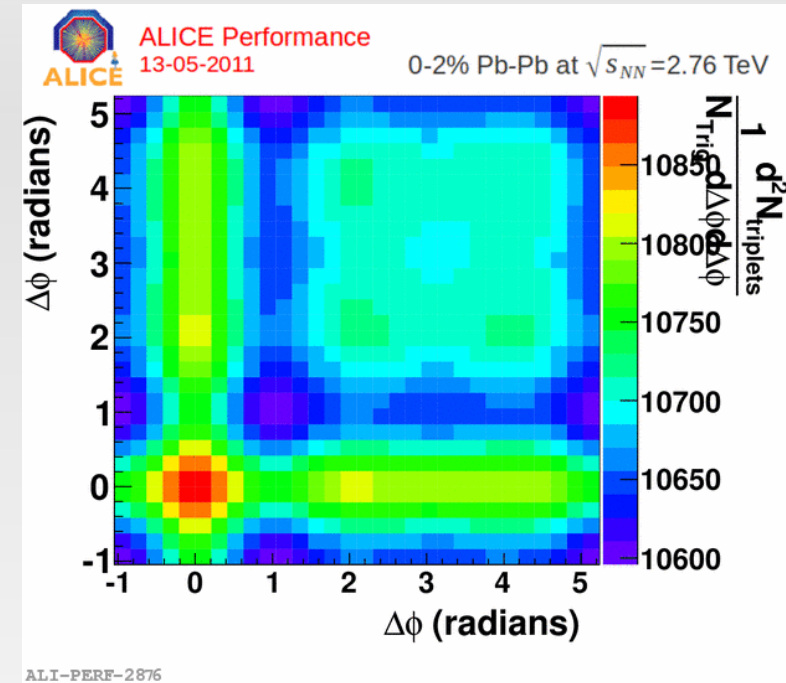
Unsubtracted Signal

- Contains
 - 3-particle jet-like correlations
 - 2-particle jet-like correlations
 - 2-particle flow correlations
 - 3-particle flow correlations
 - 3-particle correlation where 2 are jet-like correlated while 3rd is flow correlated



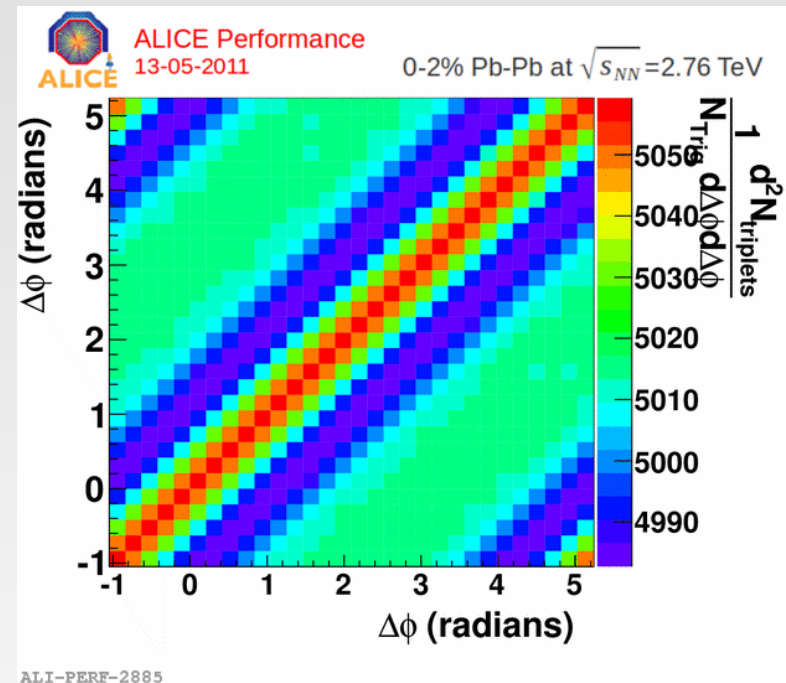
Trigger and Associated Correlated

- 2-particle correlation between trigger and associated particle.
- Contains 2-particle **jet-like** and **flow** correlations.
- Unsubtracted 2-particle correlations folded with 3rd from mixed events.
- Mixed event ZYAM assumption normalized on the 2-particle correlation.
 - ALICE flow values for ZYAM determination from v_2 , v_3 , and v_4 .



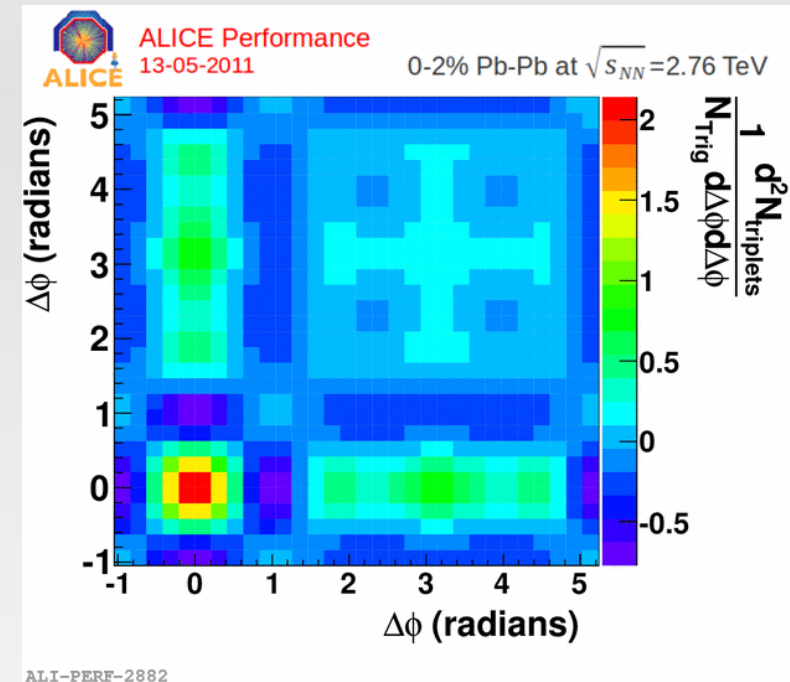
Associated-Associated Correlation

- 2-particle correlations between the two associated particles.
 - jet-like and flow correlations
 - Trigger particle mixed with pairs of associated from a different event.
- Normalized so background subtracted 3-particle correlation is ZYAM.



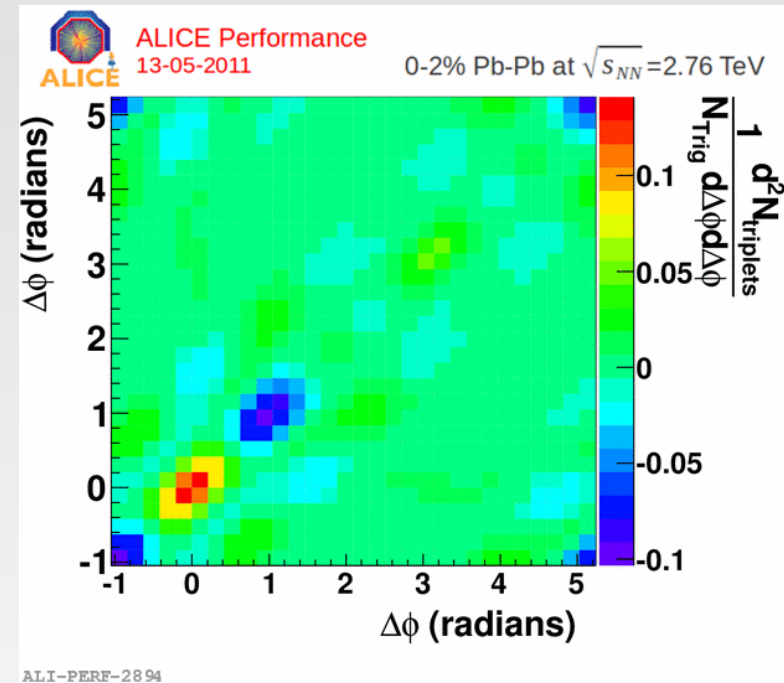
Trigger-Associated Jet-Like Flow

- Jet-like correlation can be flow correlated with the 3rd particle.
- Background subtracted 2-particle jet-like correlation folded with the flow distribution.
 - Uncertainty in the jet-like flow, trigger v_n used.
 - ALICE flow values for v_2 , v_3 , and v_4 used.



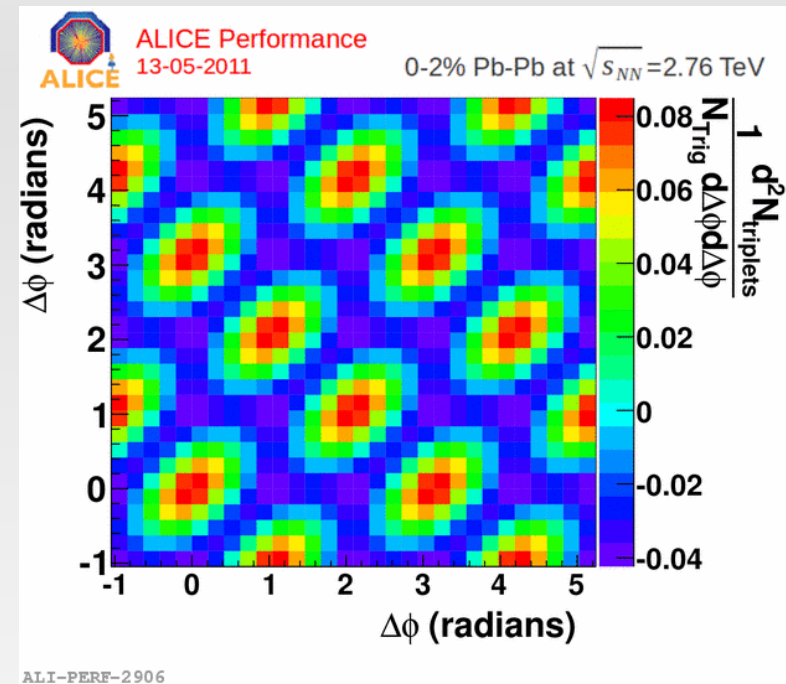
Associated-Associated Jet-Like X Flow

- Background subtracted associated-associated distribution is jet-like and may flow with trigger particle.
- Non-flow structure on the associated-associated correlation modulated with the flow between trigger and associated.
 - ALICE flow values for v_2 , v_3 , and v_4 used

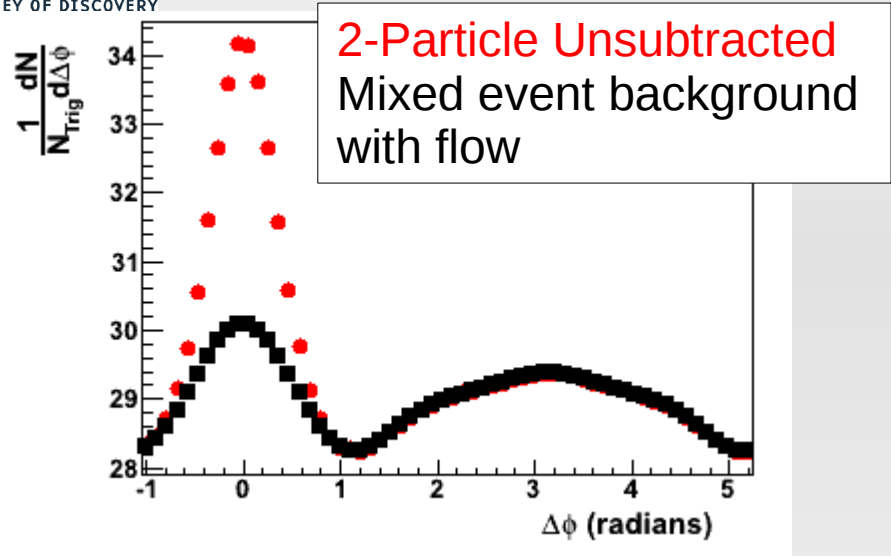


3-Particle Flow

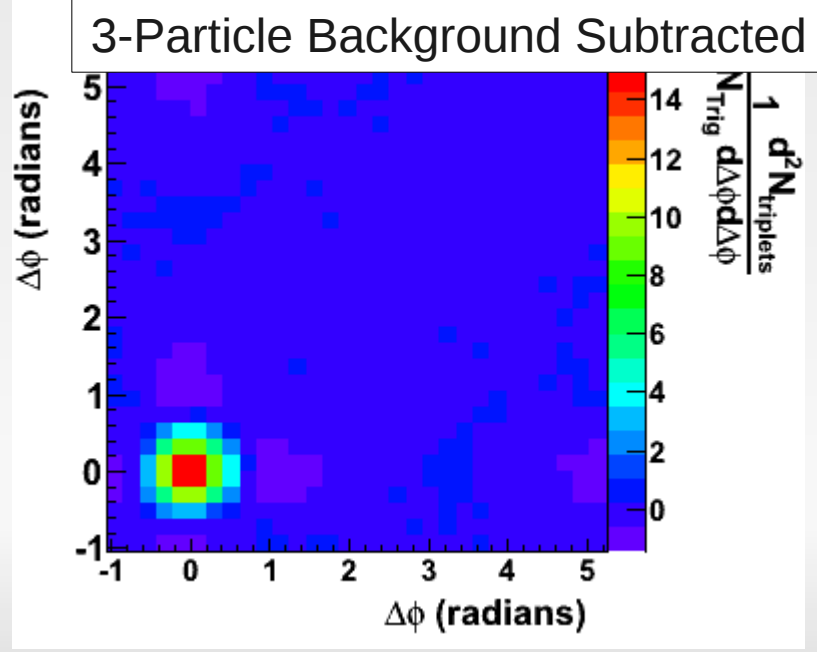
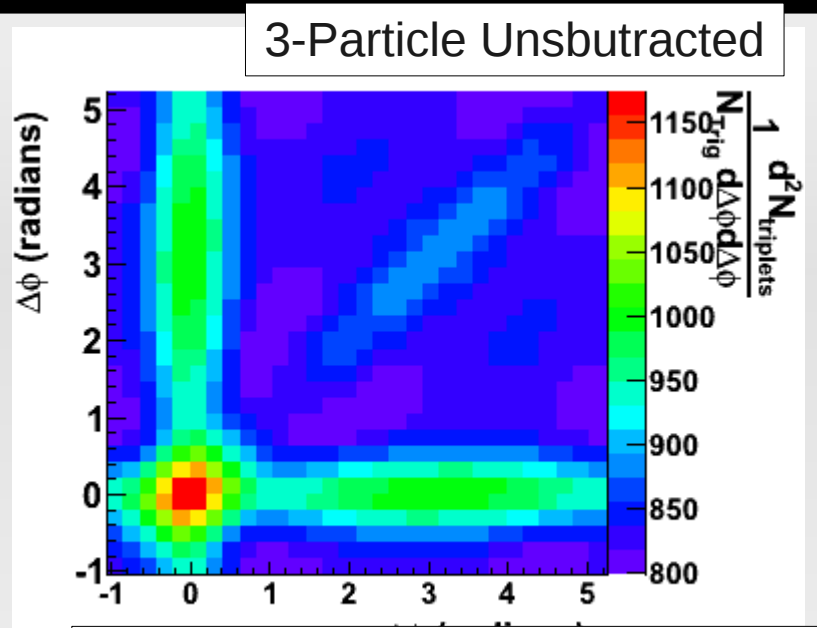
- All three particles can be flow correlated.
- When considering v_2 , v_3 , and v_4 flow components the 3-particle flow contains terms for:
 - $v_2^T v_2^{A1} v_4^{A2}$
 - $v_2^T v_4^{A1} v_2^{A2}$
 - $v_4^T v_2^{A1} v_2^{A2}$



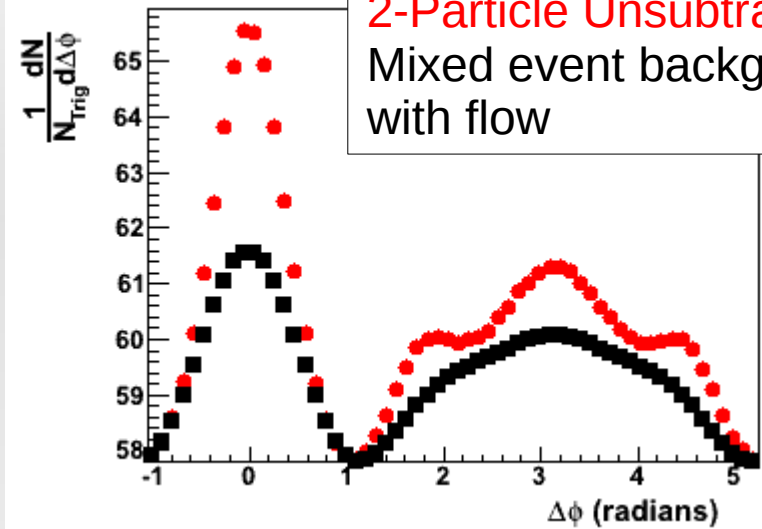
Toy Model



- Simulation of a single jet on a flowing background.
- v_2 , v_3 , and v_4 included in the background.

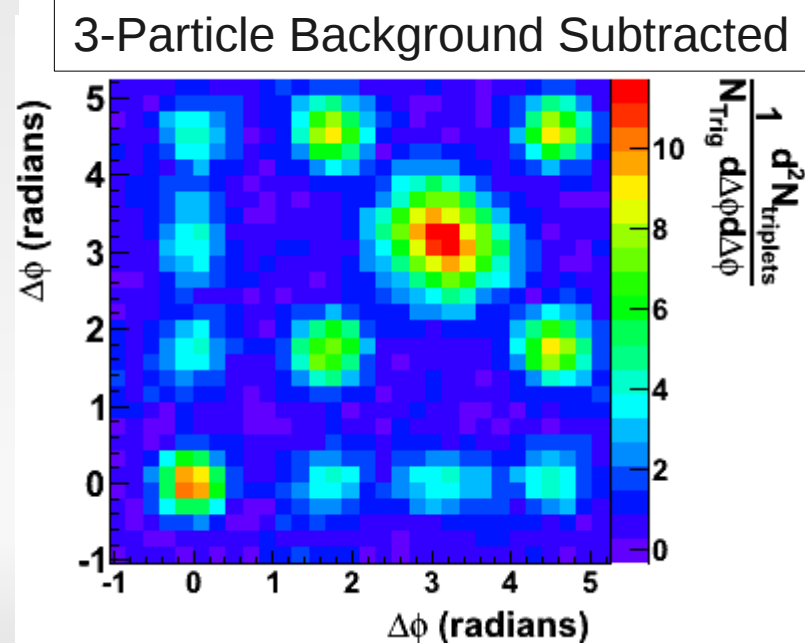
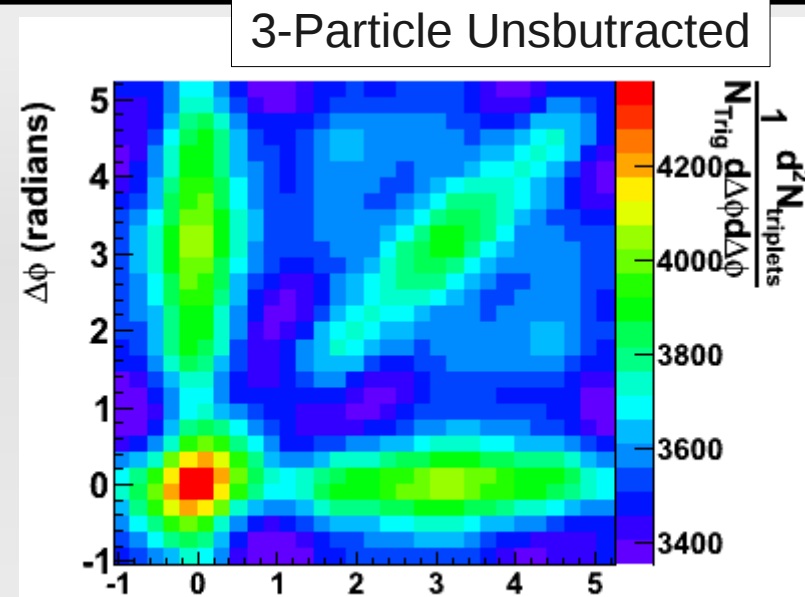


Toy Model II



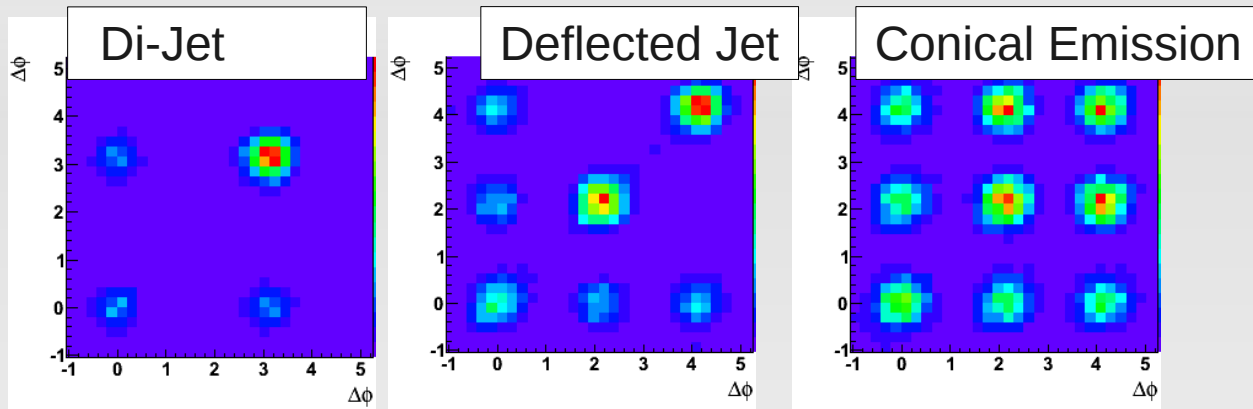
2-Particle Unsubtracted
Mixed event background
with flow

- Away-side either back-to-back jet or cone (50% prob.).
- v_2 , v_3 , and v_4 included in the background.

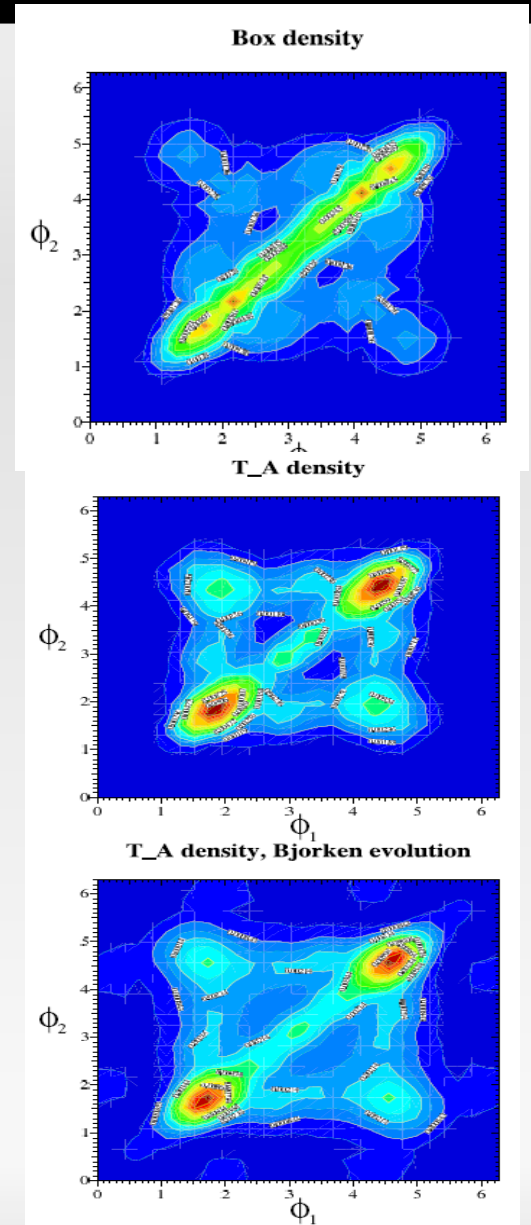


Cone in Hydro

Renk, Ruppert,
Phys. Rev. C76, 014908 (2007)



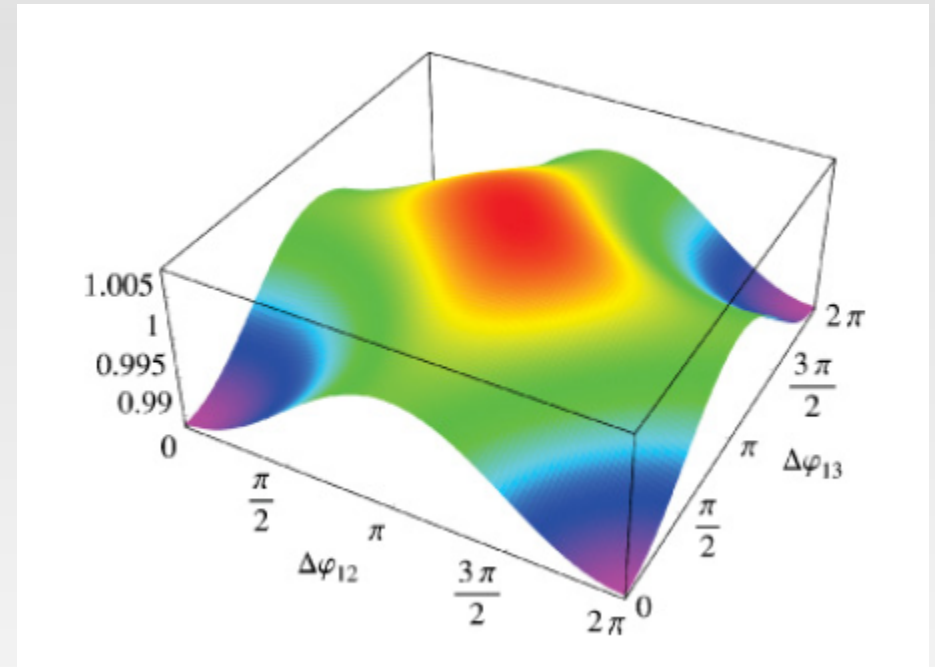
- Toy model expectations along with expectation for a cone in an hydrodynamically expanding medium.



Statistical Momentum Conservation

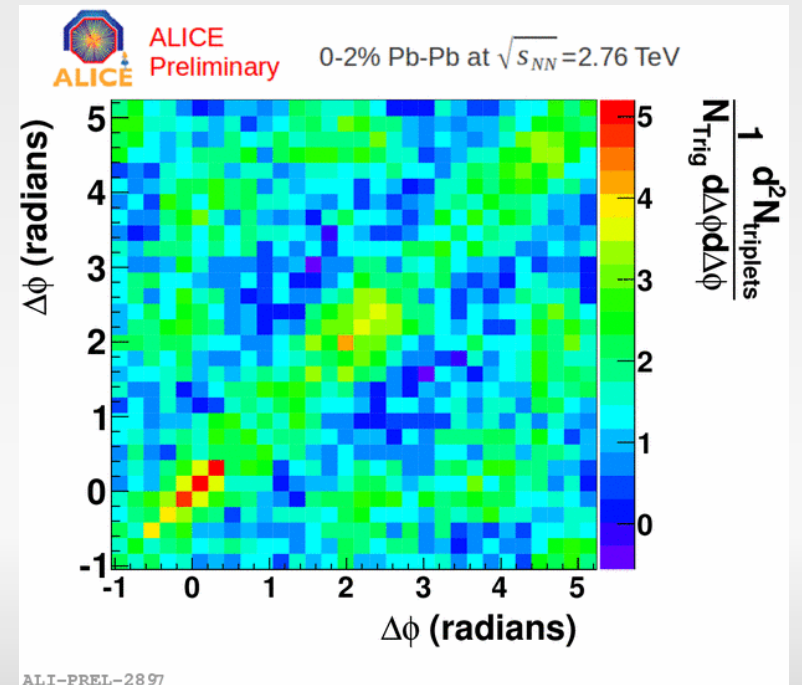
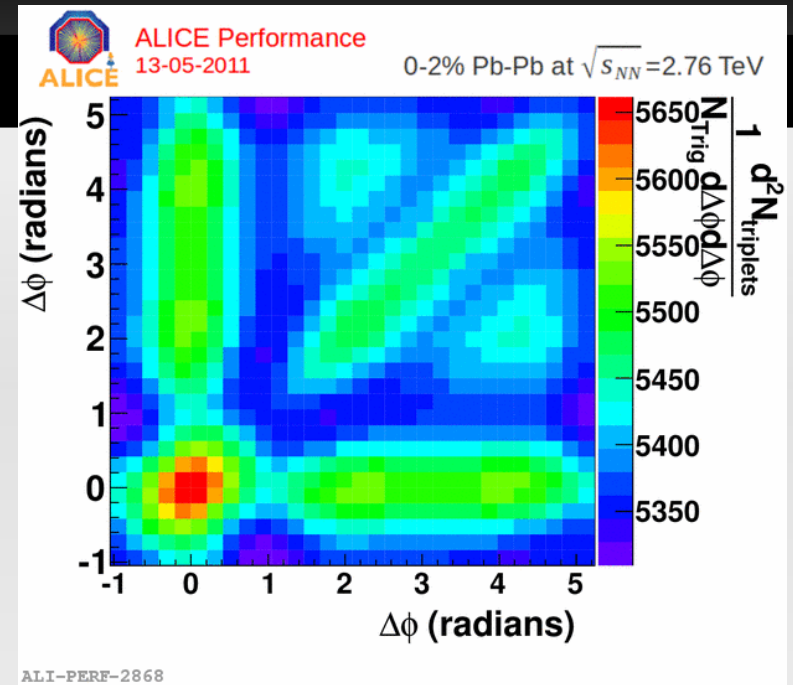
- Away-side 3-particle correlation was computed.
- Assumes trigger momentum is statistically distributed through all particles in the event.

N. Borghini, Phys. Rev. C 75, 021904(R) (2007)



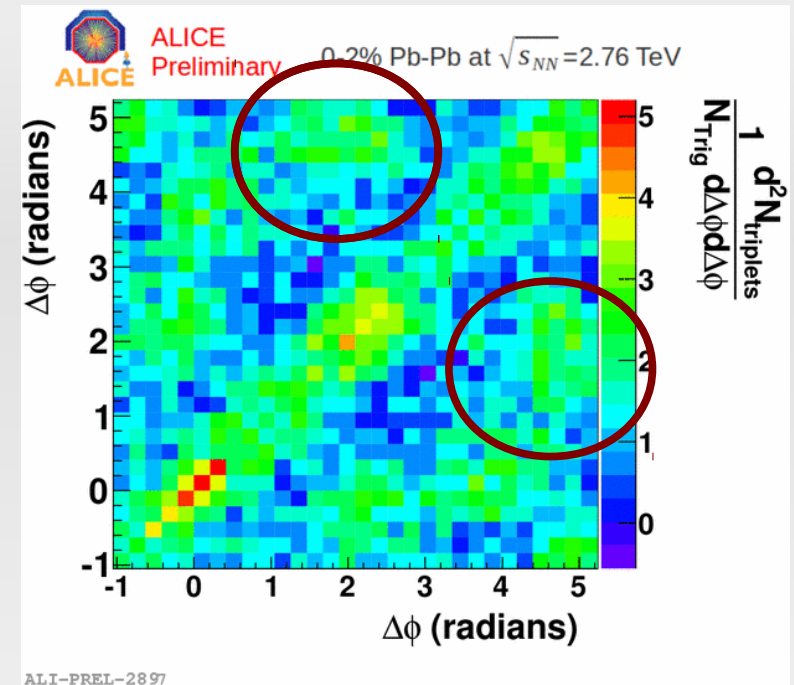
Data Results

- 0-2% Pb-Pb
- $2.5 < p_T^{\text{Trig}} < 4 \text{ GeV}/c$
- $1 < p_T^{\text{Assoc}} < 2 \text{ GeV}/c$
- Half ALICE 2-particle flow values used for v_2 , v_3 , and v_4 .
- Signal to background $\sim 1/1000$
- Contribution to the 2-particle signal not straight forward and depends on spread of away-side with respect to detector $\Delta\eta$ acceptance.



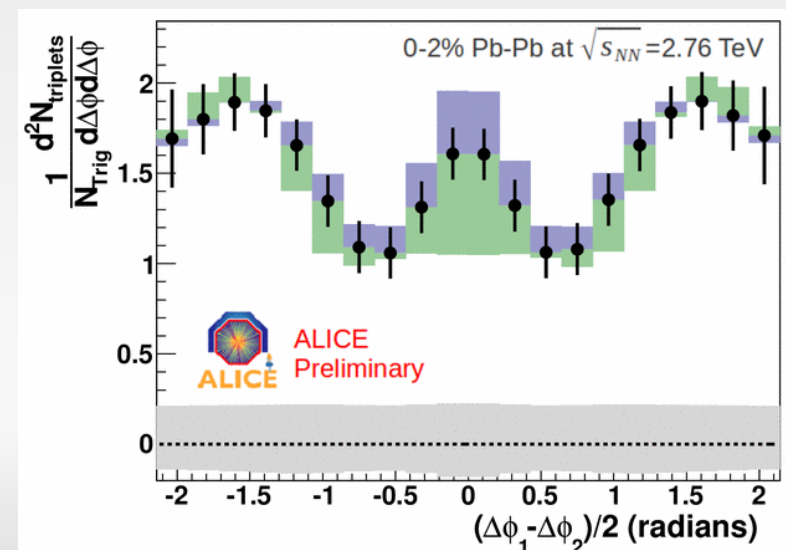
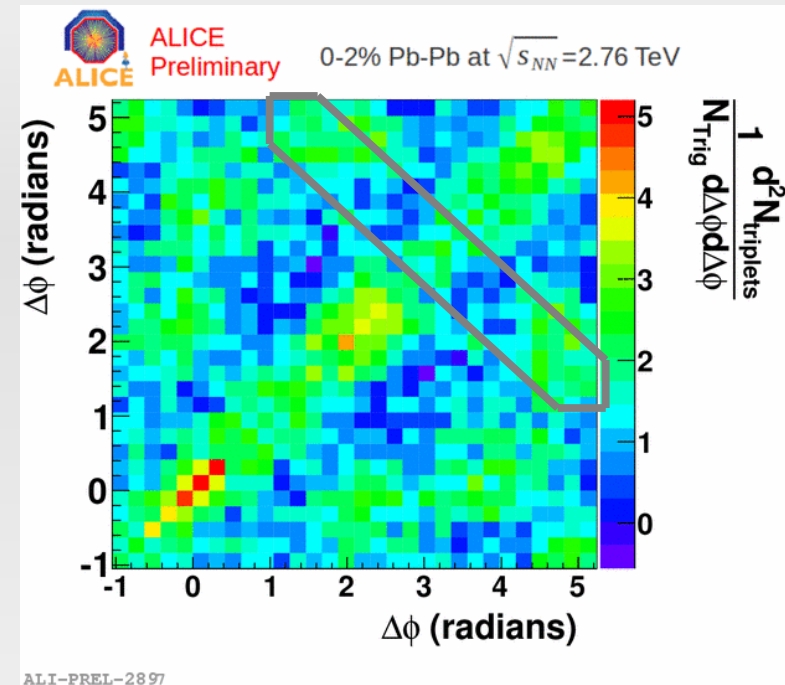
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- Half ALICE 2-particle flow values used for v_2 , v_3 , and v_4 .
- Side peaks expected for conical emission seen.

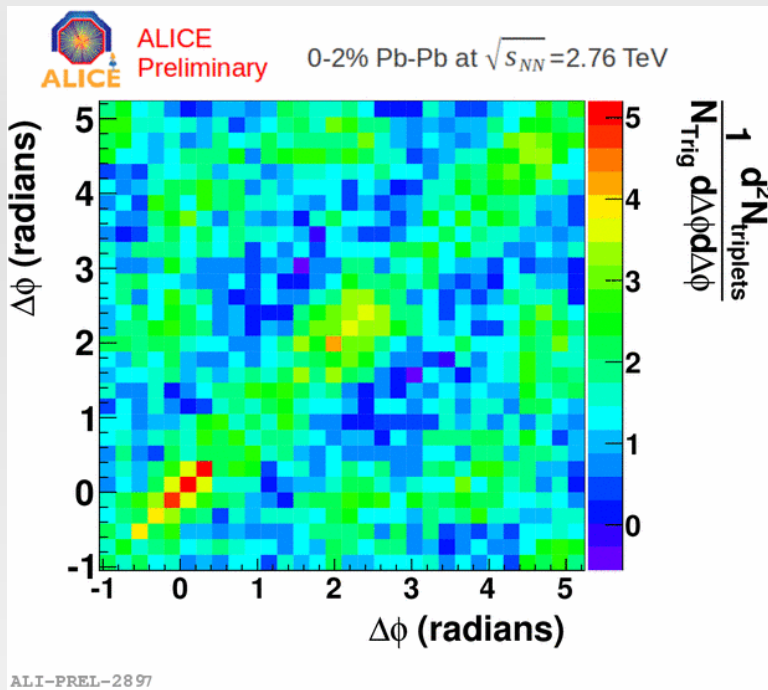


Data Results

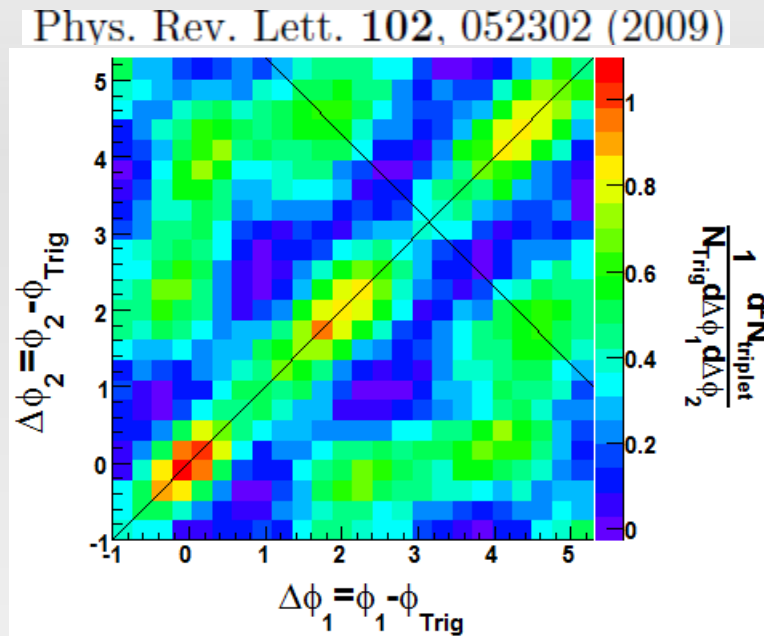
- 0-2% Pb-Pb
- $2.5 < p_T^{\text{Trig}} < 4 \text{ GeV}/c$
- $1 < p_T^{\text{Assoc}} < 2 \text{ GeV}/c$
- Systematic errors from:
 - Flow in **blue** and **green** varied between 0 and ALICE 2-particle cumulant
 - Normalization in gray



Comparison to STAR



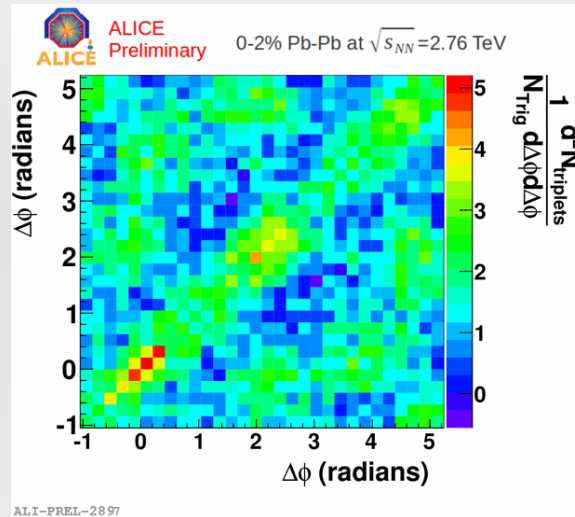
0-2%
 $2.5 < p_T^{\text{Trig}} < 4$
 $1 < p_T^{\text{Assoc}} < 2$
 Pb-Pb
 2.76 TeV



0-12%
 $3 < p_T^{\text{Trig}} < 4$
 $1 < p_T^{\text{Assoc}} < 2$
 Au+Au
 200 GeV

- Similar correlation shape seen in ALICE as was seen in STAR.
 - ALICE results include v_3 subtraction which was not included in the STAR analysis.

Summary



- Results shown for 0-2% most central collisions.
- Similar structure as was seen in STAR
- Results are consistent with conical emission.
- Stayed tuned to Hard Probes for more results.