

# Understanding charge independent correlations on $\eta_1-\eta_2$ versus $\phi_1-\phi_2$ for proton-proton di-jet events

*Lanny Ray*

STAR Event Structure Physics Working Group

August 2004

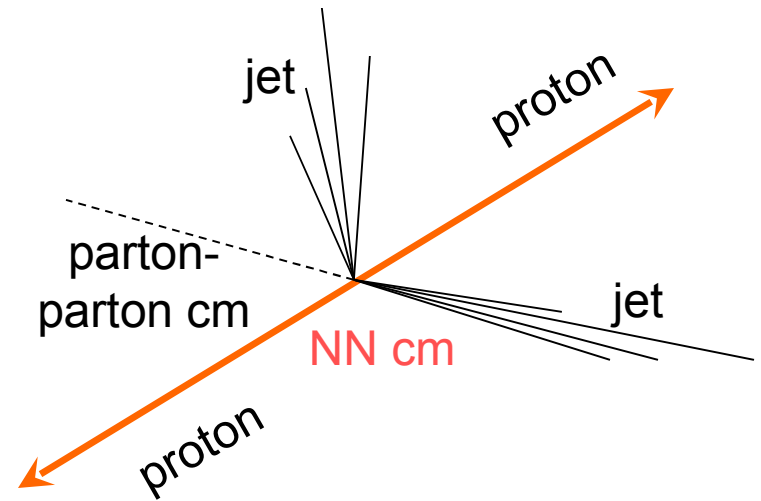
- In this first write-up I will explain how hard partonic scattering in p-p collisions appears in  $\eta_1-\eta_2$  versus  $\phi_1-\phi_2$  correlation space.
- Technical details associated with constructing the correlations from data will be addressed in a following ppt.

## Typical p-p collision producing two jets, more-or-less back-to-back:

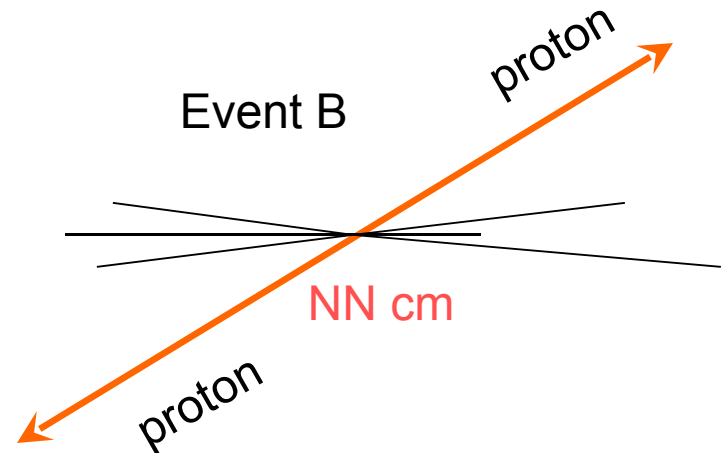
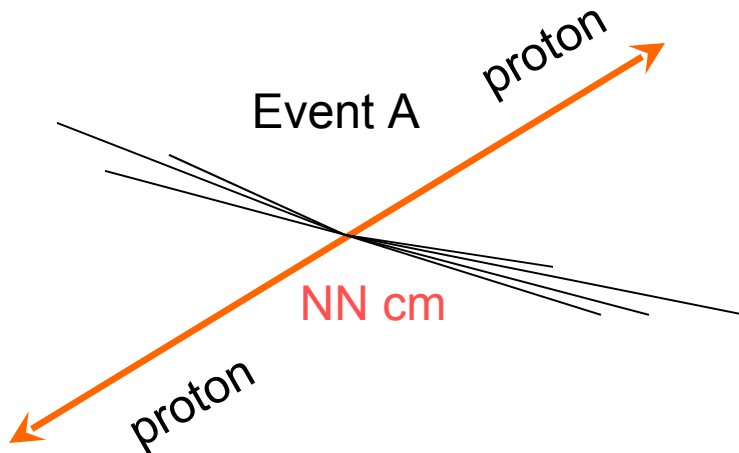
The jets are not exactly back-to-back due to differences between the parton momenta in each proton both along, and transverse to the beam direction.

For simplicity I only consider two-jet events in this tutorial.

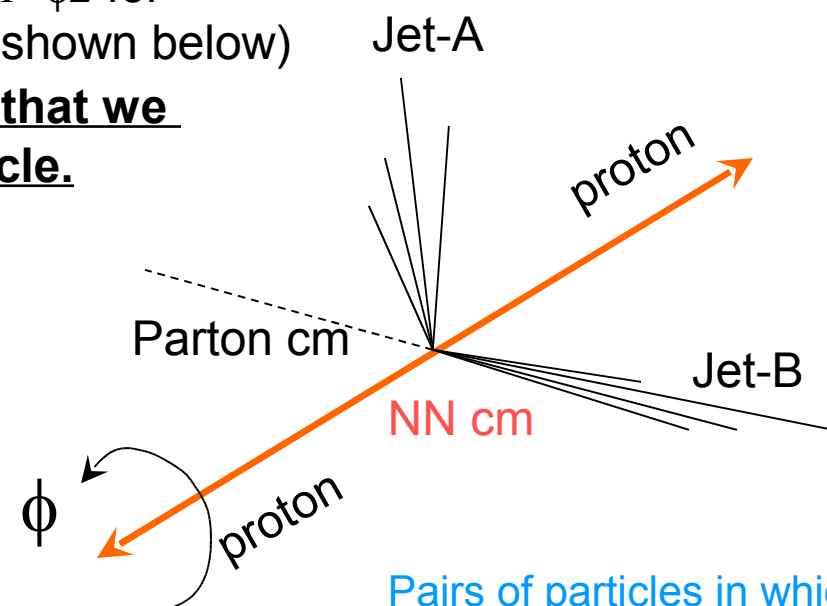
Other events may have back-to-back jets. In general observed jets will vary in pseudorapidity location as permitted by the acceptance.



parton-parton cm is NOT same as NN cm

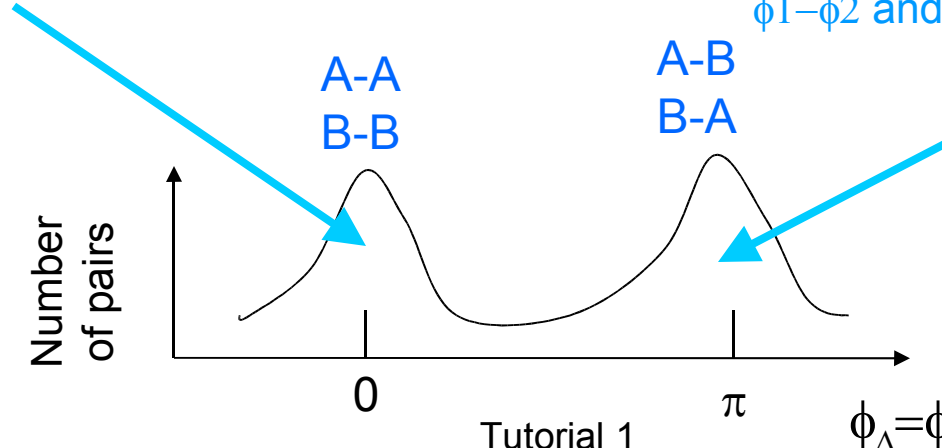


Consider all pairs of particles in each event and compute the relative azimuth  $\phi_1 - \phi_2$  for each pair. Construct a histogram (shown below) of number of pairs on  $\phi_1 - \phi_2$ . **Note that we do not use a special trigger particle.**



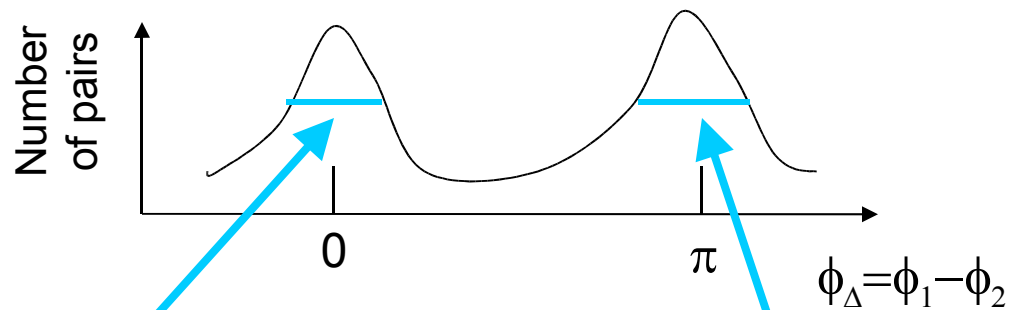
Pairs of particles within jet-A and within jet-B have relatively small values of  $\phi_1 - \phi_2$  and contribute here:

Pairs of particles in which one particle is taken from one jet and the other particle is taken from the other jet have relatively large values of  $\phi_1 - \phi_2$  and contribute here:



Construct histogram using all pairs from all events.

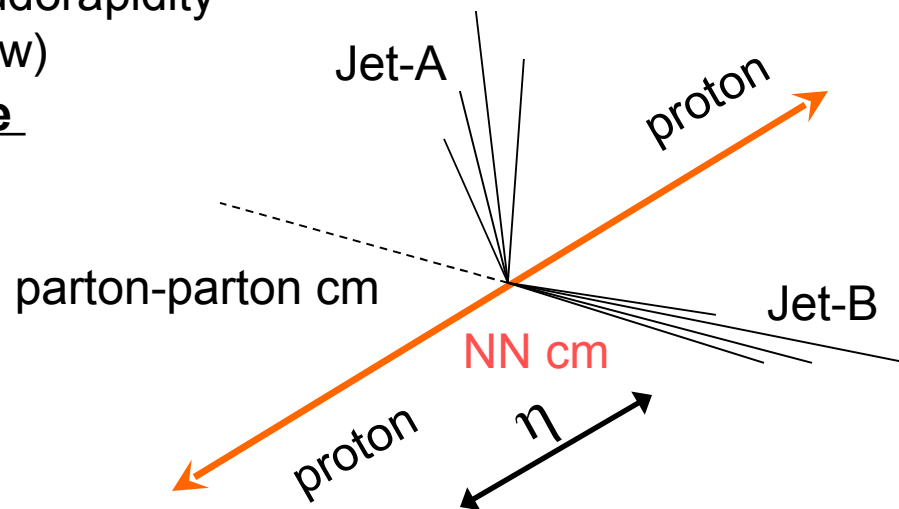
Width of  $\phi_1 - \phi_2$  peaks at small and large relative azimuth:



Width of small relative angle peak reflects the angular width of the parton fragmentation process.

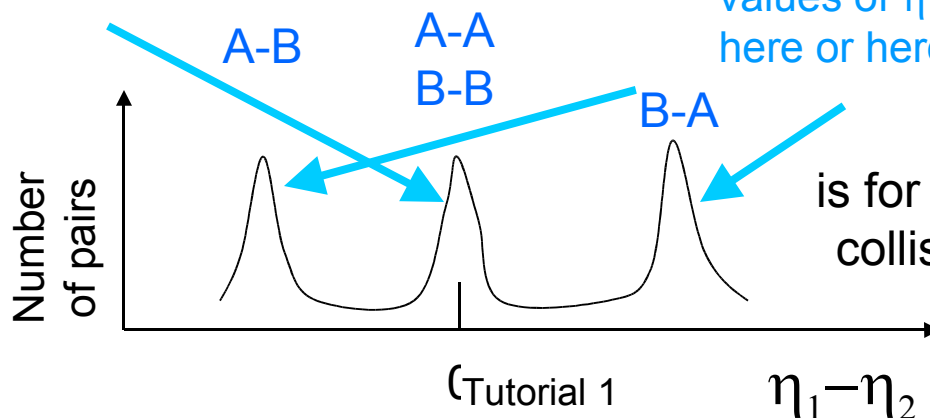
Width of large angle peak is due to parton fragmentation cone plus any scatter away from  $180^\circ$  in the relative azimuth angle between the “centroids” of the two jets in each event.

Similarly, use all pairs of particles in each event and for each pair compute the relative pseudorapidity  $\eta_1 - \eta_2$ . Construct a histogram (shown below) of number of pairs on  $\eta_1 - \eta_2$ . **Note that we do not use a special trigger particle.**



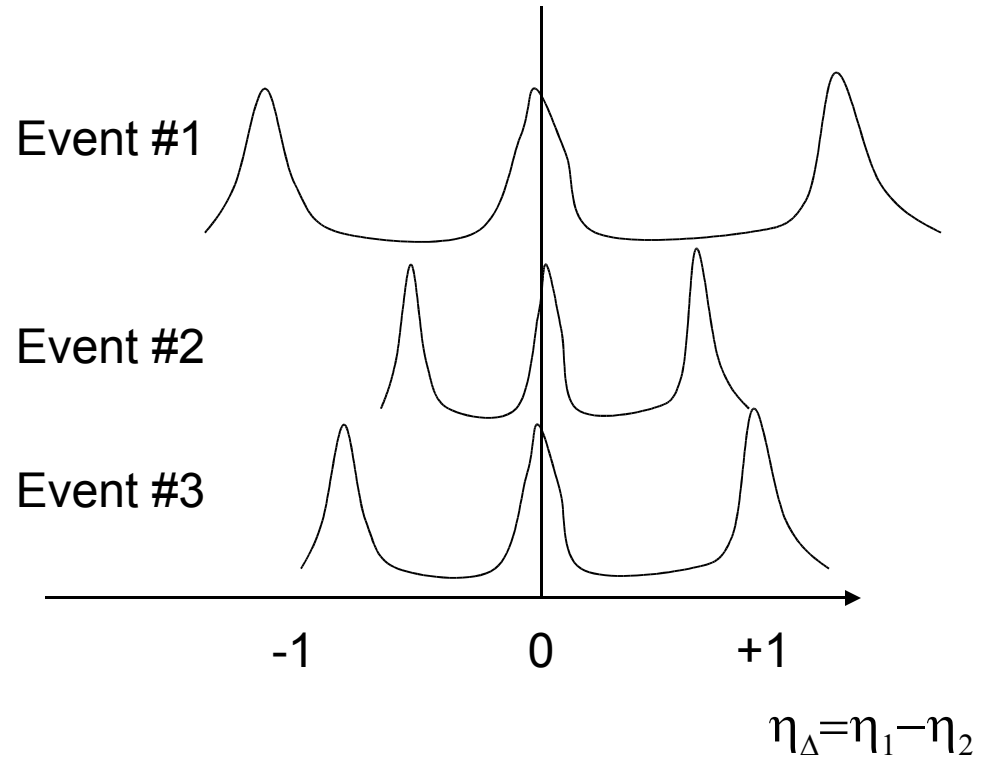
Pairs of particles from within Jet-A and from within Jet-B have relatively small values of  $\eta_1 - \eta_2$  and contribute here:

Pairs of particles in which one particle is taken from one jet and the other particle is taken from the other jet have finite positive or negative values of  $\eta_1 - \eta_2$  and contribute here or here:

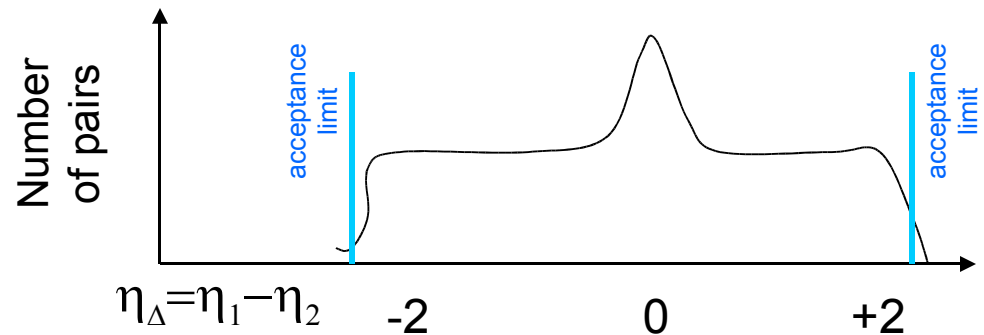


This histogram is for the individual two-jet p-p collision event shown above

$\eta_1 - \eta_2$  for pairs of particles from other two-jet events also produce peaks symmetric about 0 but at different positive and negative values. The peak at 0 due to pairs of particles taken within the same jet accumulates for all events.

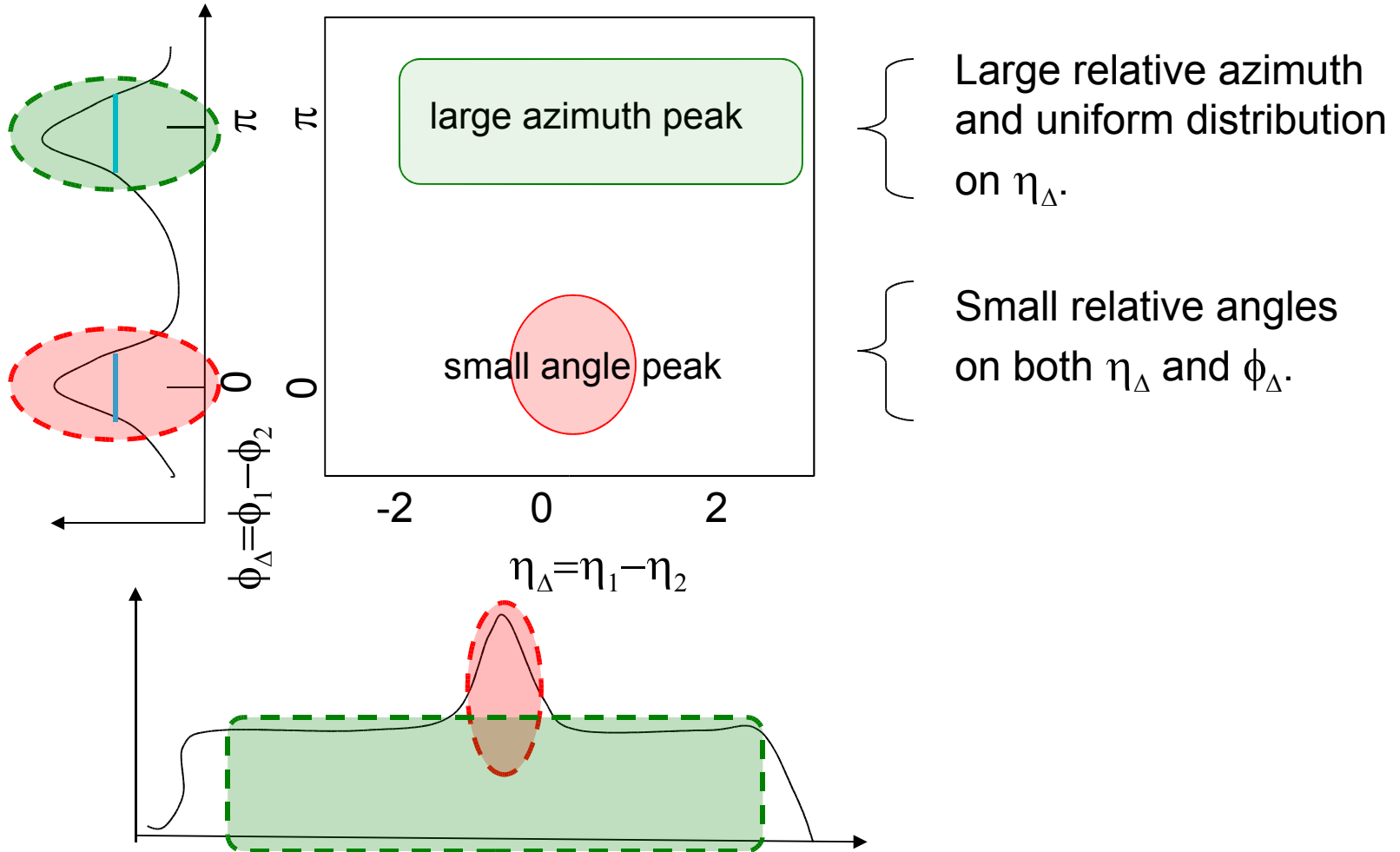


Summing these individual event histograms over all events results in a strong peak at  $\eta_1 - \eta_2 = 0$  reflecting the average pseudorapidity width of all jets in the events. The peaks associated with pairs of particles from different jets are distributed across the full acceptance.



# Moving from 1D to 2D distributions...

Next we plot the number of pairs in two-dimensional bins on  $\eta_{\Delta}=\eta_1-\eta_2$  vs  $\phi_{\Delta}=\phi_1-\phi_2$  for every pair of particles in every event.



- So far I have only discussed making histograms of the number of particle pairs. For actual data analysis we must also account for the effects of detector acceptance, efficiency and single particle distributions.
- In other words, what would the number of pair histograms look like in the absence of dynamics, but assuming the same single particle distributions and detector acceptance.
- All of these effects are accounted for by dividing the pair number histograms, bin-by-bin, by analogous pair number histograms made from “mixed pairs” of particles taken from different but similar events.
- The resulting ratio is closely related to two-particle correlations – the principal object of interest.
- Correlation analysis details will be explained in another tutorial.



# Measured correlations in 200 GeV p-p collisions

We are now ready to describe some real STAR data:

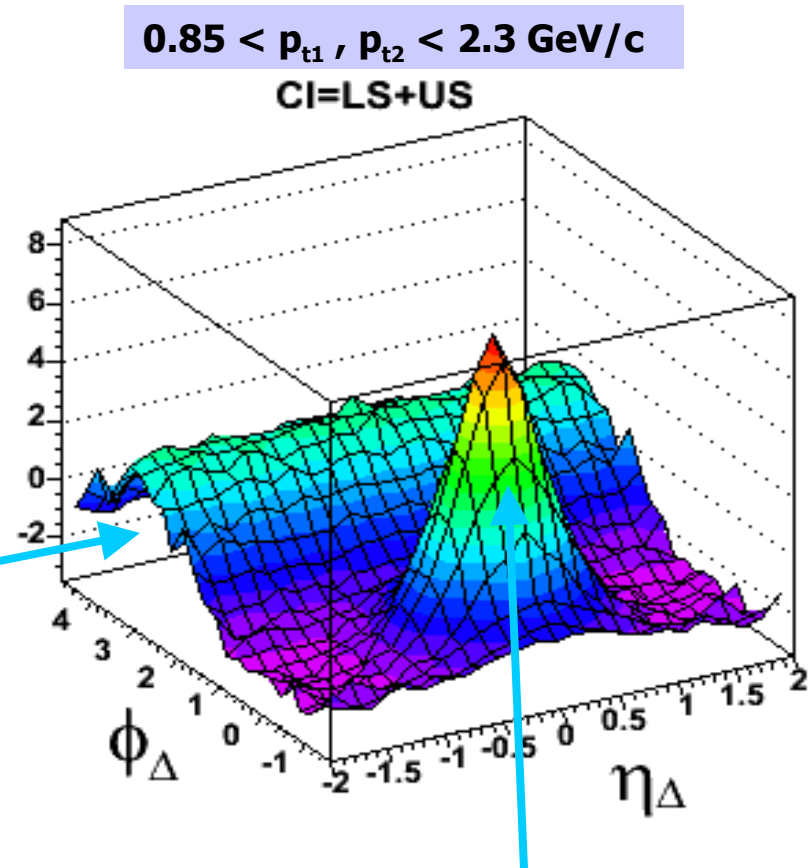
Putting the preceding structures together on  $(\eta_1 - \eta_2, \phi_1 - \phi_2)$  and dividing by a mixed pair histogram produces the 2D histogram ratio landscape shown here.

Large azimuth angle flat peak approximately independent of  $\eta_1 - \eta_2$

where:

$$\phi_{\Delta} = \phi_1 - \phi_2$$

$$\eta_{\Delta} = \eta_1 - \eta_2$$



Small angle symmetric peak from parton fragmentation (plus quantum correlations for identical particles).