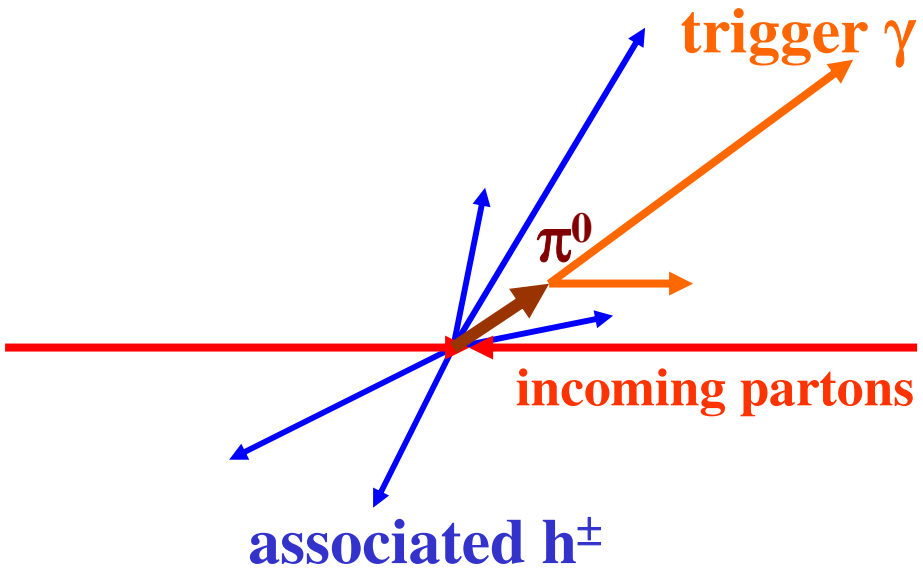
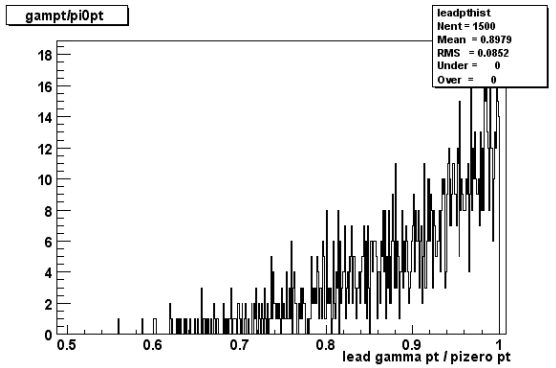
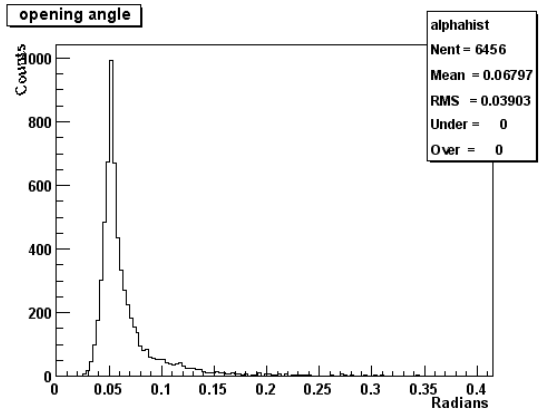
Using Trigger Photons to Identify Jets

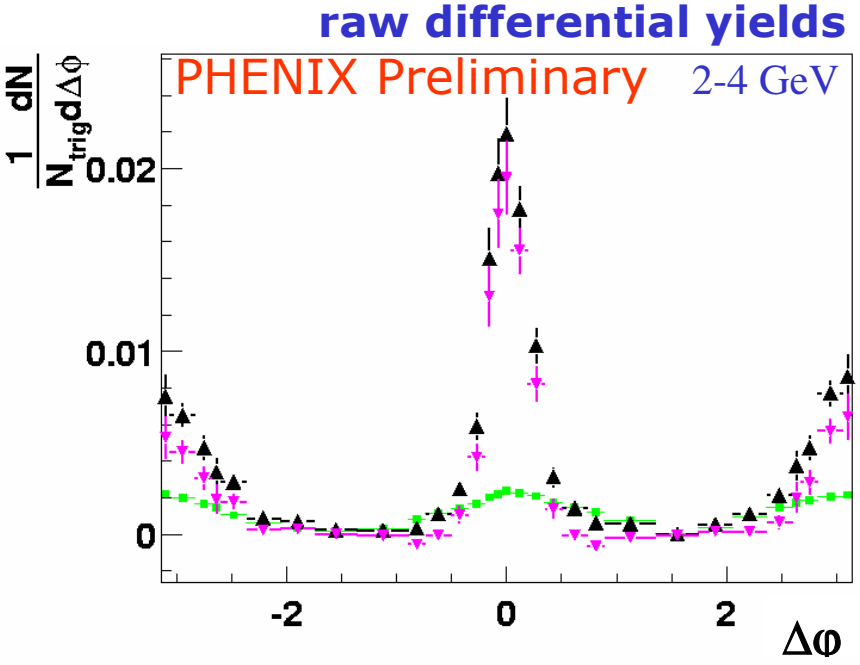






- **Select events with a photon of pt > 2.5 GeV.**
  - **Mostly γ's from decay of a high pt π^0**
- **Lie approximately along underlying jet axis.**
- **Then look at distributions in (φ,η) space of the charged hadrons relative to these trigger photons.**
- **Since events are triggered, we are studying the structure of high-pt events only**
  - **In particular, you don't see what happens to all the missing events.**

Looking at Angular Correlations



- black = pair distribution
- green = mixed event pair distribution
- purple = bkg subtracted distribution

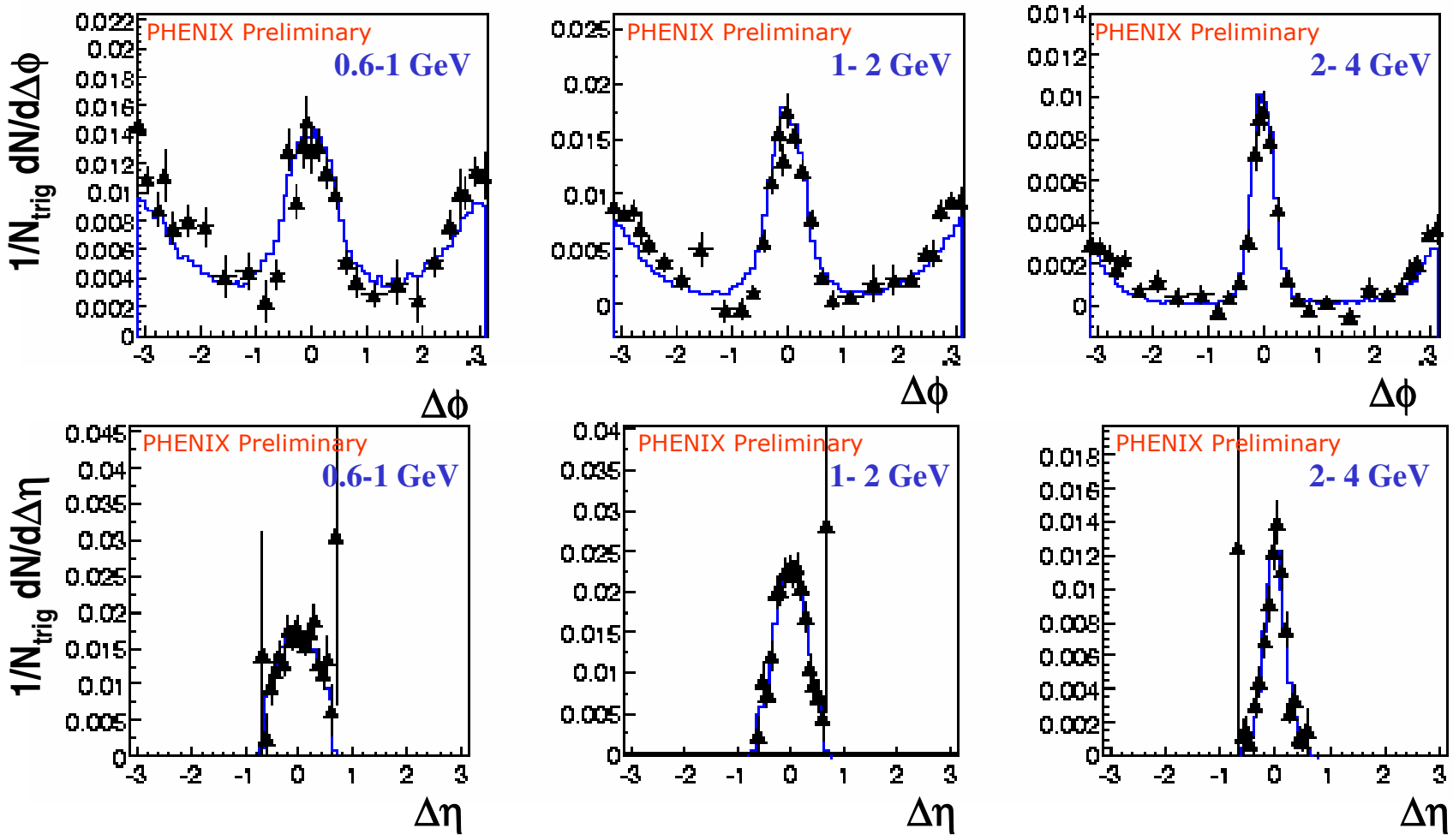
We fit the below formula, assuming that the distributions in p-p are given by a flat background plus PYTHIA.

$$\frac{1}{N_{trig}}\frac{dN_{ch}}{d\Delta\phi} = A_{bkg} + A_{pythia}\left(\frac{1}{N_{pythia}}\frac{dN_{ch}^{pythia}}{d\Delta\phi}\right)$$

$$\frac{1}{N_{trig}}\frac{dN_{ch}}{d\Delta\phi} = A_{bkg}(1 + 2v_2^{trig}v_2^{ch}cos(2\Delta\phi)) + A_{pythia}\frac{1}{N_{pythia}}\frac{dN_{ch}^{pythia}}{d\Delta\phi}$$

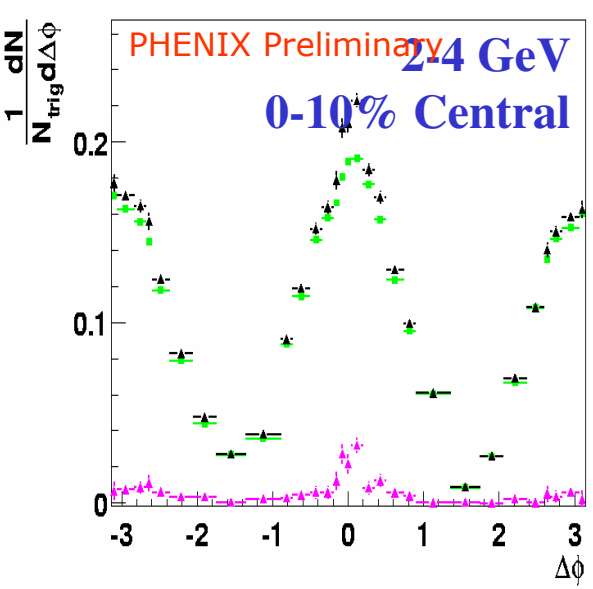
- Average Efficiency <ε> can be evaluated via Monte Carlo & Embedding.
- A_{bkg} parametrizes amount of flat background in triggered events.
- A_{pythia} is the amplitude of the PYTHIA signal
  - Measure of yield of associated particles from jet fragmentation

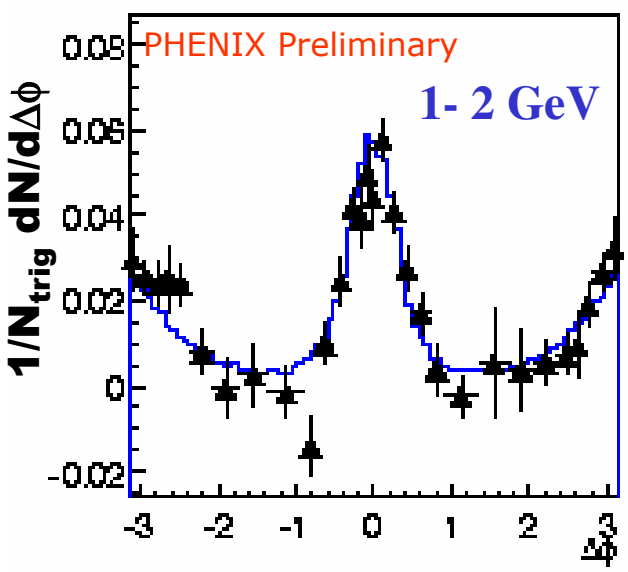
Angular Correlations (p+p)

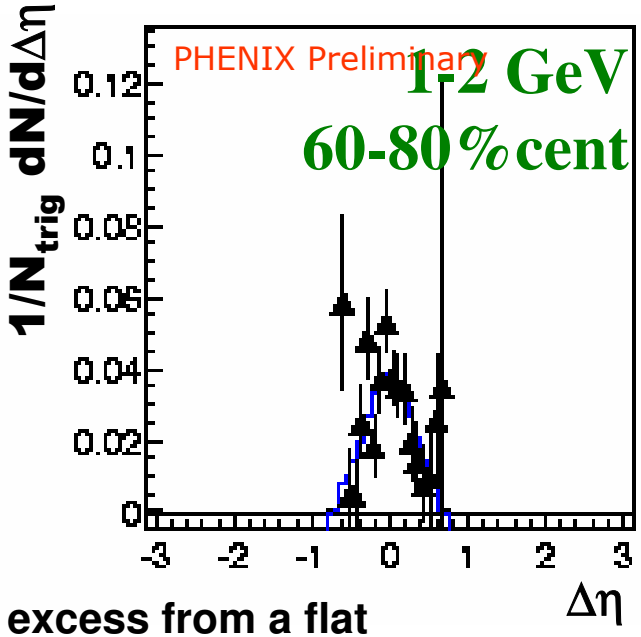


- Data points (black) are background subtracted and acceptance corrected.
- Blue is the PYTHIA monte carlo curve * a_{pythia} * $\langle\varepsilon\rangle$
- Very good agreement between PYTHIA and data in both $\Delta\phi$ and $\Delta\eta$.

Angular Correlations (Au+Au)





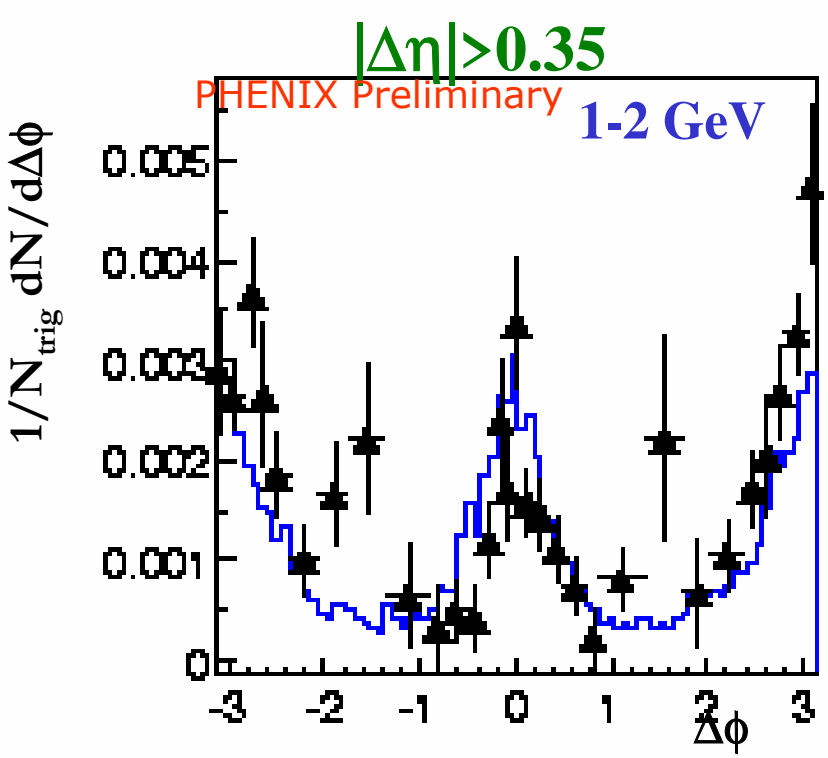


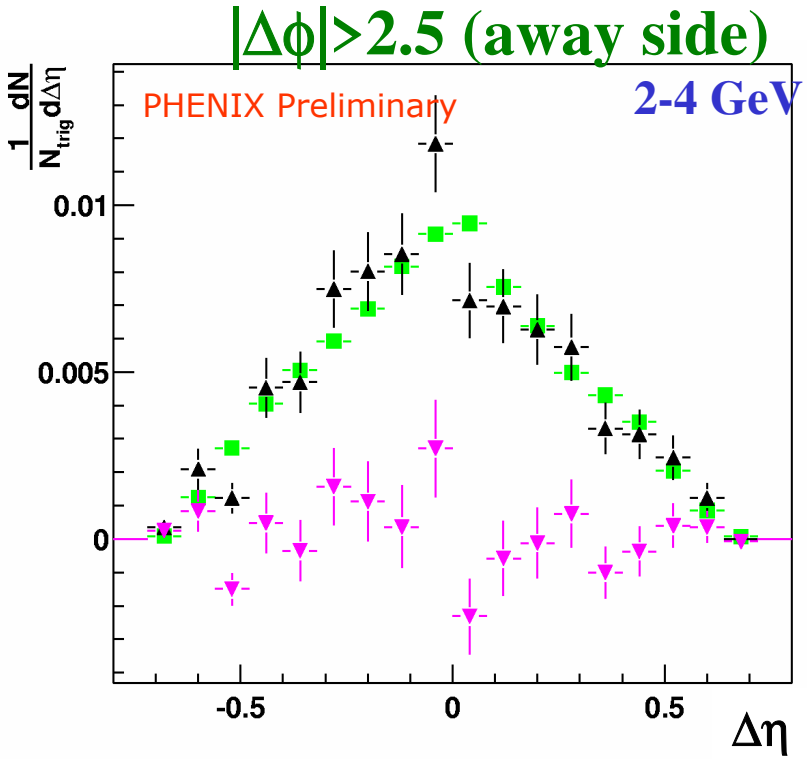
- **Also in Au+Au collisions there is a statistically significant excess from a flat distribution at all centralities and all pt bins.**
- **What are the sources of angular distributions from a high-pt photon?**
  - **Two possible sources of φ correlation to the reaction plane**
    - **Elliptic Flow, Jet Energy Loss**
    - **Assuming no correlation between above two effects, expect**

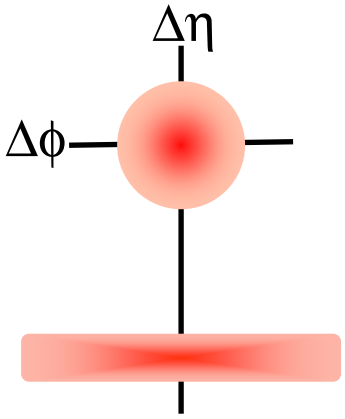
$$\frac{1}{N_{trig}}\frac{dN_{ch}}{d\Delta\phi} = A_{bkg}\left(1 + 2v_2^{trig}v_2^{ch}cos(2\Delta\phi)\right) + A_{pythia}\frac{1}{N_{pythia}}\frac{dN_{ch}^{pythia}}{d\Delta\phi}$$

  - **Resonances make small contributions at these high qt (checked in PYTHIA)**
  - **Have all other sources been excluded? What about those high-pt baryons?**

Shape in Angular Space (p+p)



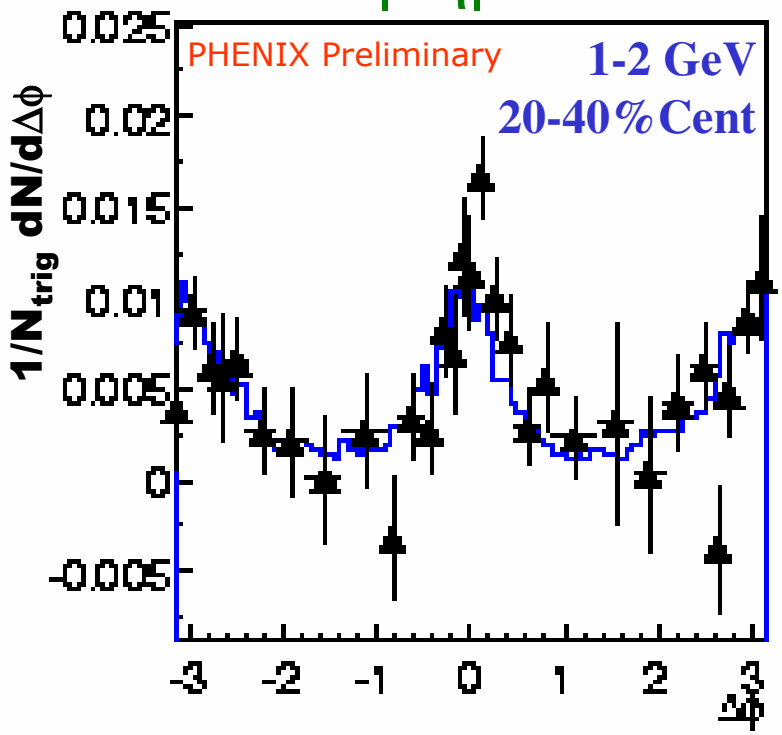




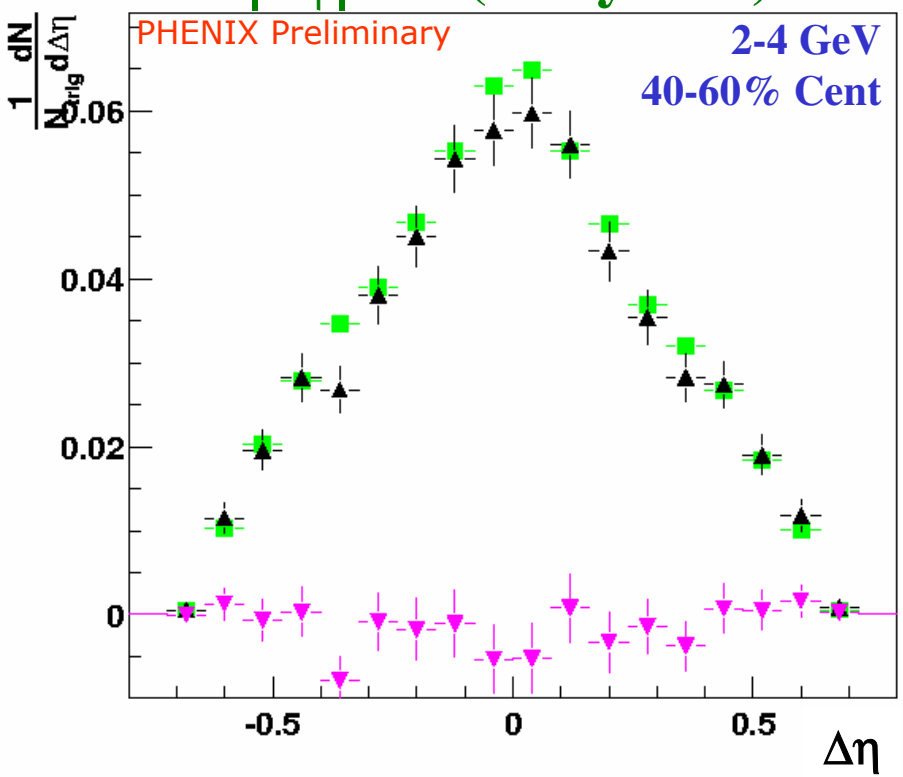
- We make |Δη| cuts in our p-p Data and PYTHIA.
- Small |Δη|, near-side jet remains, but large |Δη| suppresses it.
- Our data is well described by PYTHIA even with the cuts. Implies the shape measured matches a jet-like shape in both η and φ, near and away in Δη.
- Away side consistent with flat.
- Exactly the expectation jet behavior:
  - One jet falls in PHENIX acceptance, away side jet has η determined from x1, x2 and angle of outgoing partons

Shape in Angular Space (Au+Au)

$|\Delta\eta|>.35$



$|\Delta\phi|>2.5$(away side)



- Even in Au+Au, our data are described well by PYTHIA for cuts in "near" $\Delta\eta$ and "far" $\Delta\eta$.
- This implies we see a correlation in both $\Delta\eta$ and $\Delta\phi$ simultaneously.
- Only one centrality shown, but is true for all centralities.
- The away side $\Delta\eta$ correlation is flat.
- In conclusion, in p-p and Au-Au we see a signal above a flat background which is consistent with a jet-like hypothesis, across all centralities for many tests of the $\Delta\eta$, $\Delta\phi$ correlations.

Cross Checking Analysis

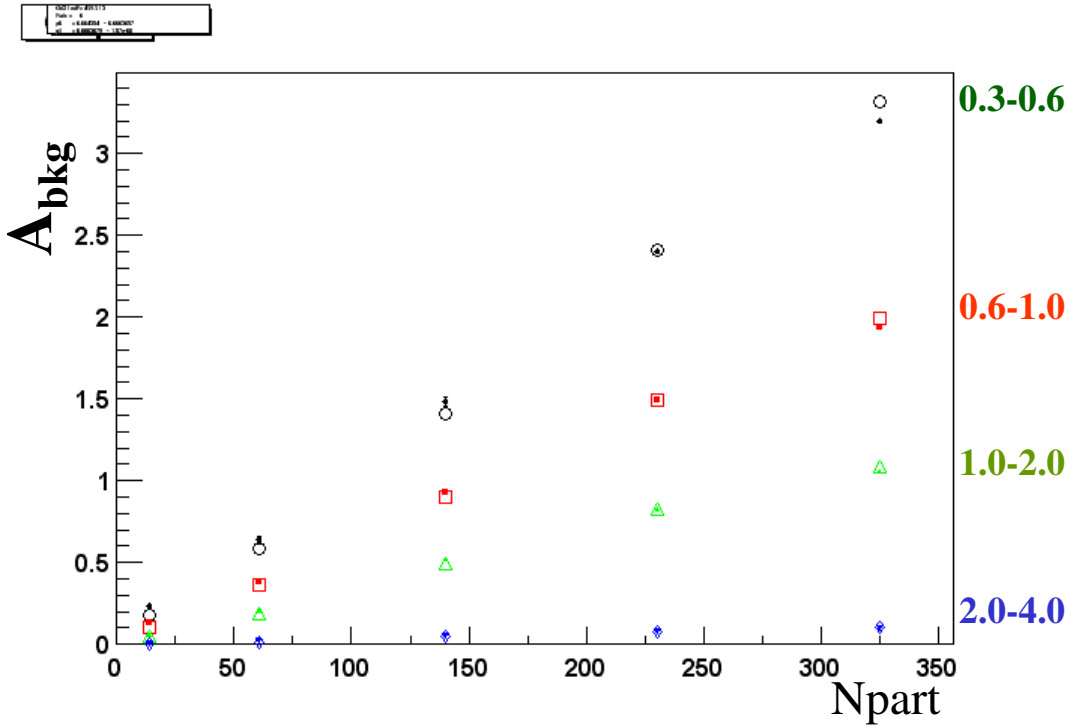
1st stage analysis (Fit Driven, optimized for jet detection)

1. We took p-p reference (PYTHIA fit) and tried lots of different fits to test for jet contributions in Au-Au
2. Our main hypothesis which we pursued was whether the correlation could be simply described by jet + flat bkg + cosine modulation
   1/Ntrig dN/ddphi = nbkg(1 + 2*v2ch*v2trig*cos(2dphi)) + jet
3. Our values for jet yields, background level, and cosine modulation were extracted from the fit values - but this assumes that our functional form correctly describes the data
4. I think that this was enough to come up with a rough picture of some of what goes on at high-pt:
   1. There seems to be jetlike structure and at least some high-pt particles come from them
   2. These high-pt particles have a v2 wrt reaction plane - jet quench modifies pt(ϕ^R)
   3. When you see them, they, ie, there are energetic partons fragmenting in vacuum

2nd stage analysis (Measure Everything Absolutely, optimized for jet modifications)

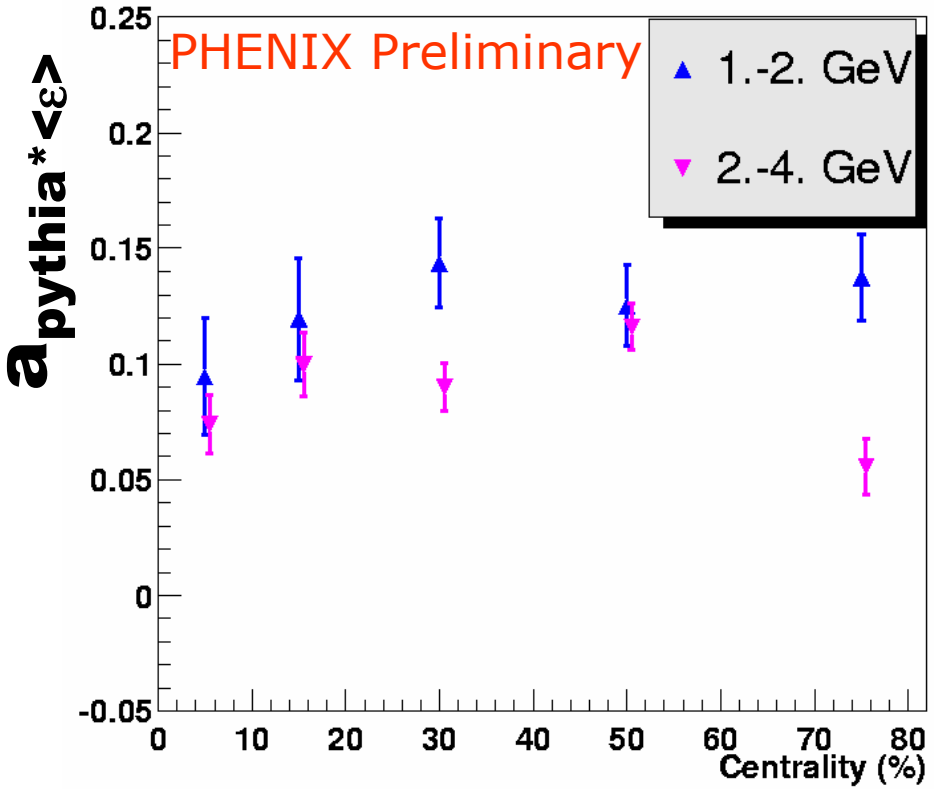
1. Will allow for a strong, independent cross-check (totally different analysis technique)
2. Measure the absolute soft background level by just counting the number of particles in minbias collisions (works better for central,where there are more soft collisions)
3. Measure v2 of both leading photon and associated particles using the reaction plane
4. Put these in the differential yield, subtract, and look at what is left. Modified jet signal?

Estimating Background



•nbkg fit values scale roughly with Npart
slopes of straight line fits to nbkg vs. npart should be the num. bkg particles per pair at that pt
•Have tried pythia only fit, pythia+v2, fitting only around dphi=0. All fit values within <1%
•Simply taking background from minbias is consistent to within a few %
•nbkg derived from fits gives a good measure of the absolute background levels - insensitive to reasonable guesses for the functional form of fit
•Does not assume that there is no yield in the 90 degree dphi region

Behavior of Near Side Jet



- **Near Side Jet seems to be fit well by PYTHIA for all centralities.**
- **No obvious centrality dependence is observed.**
  - **Fit amplitude approximately flat.**
  - **No strong discrepancy seen in near side width from PYTHIA expectation.**
- **Away side behavior under careful study.**

Summary & Conclusions

- **RHIC has had some very interesting observables at high pt:**
  - **Suppression of High-Pt inclusive spectra**
  - **Abundance of High-Pt baryons**
  - **v_2 large out to very high pt**
  - **Jet Identified, possibly suppressed on the away side.**
- **There are many more interesting measurements to be made now that we know how to identify jets in heavy ion collisions**
  - **Will prove to be a powerful discrimator between models, I think**
- **But…. Outstanding remaining question: is this dense matter deconfined?**