Measuring Intrinsic Partonic Transverse Momentum via Two-Particle Correlations at PHENIX

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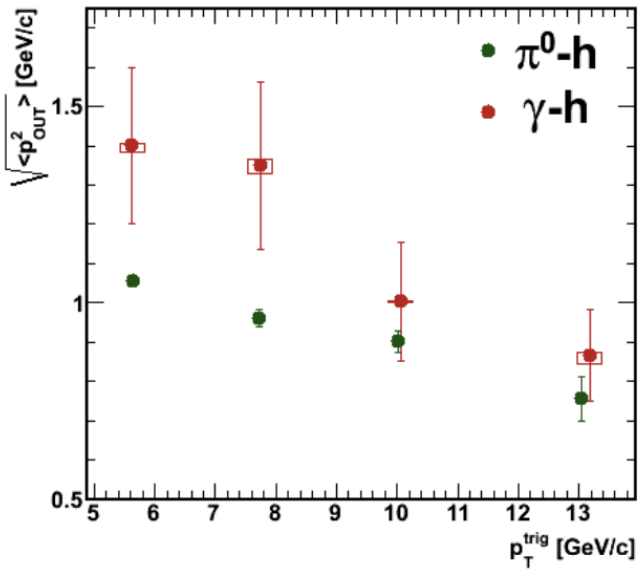
Probing QCD Factorization Breaking

- Back to back hadron production gives sensitivity to non-perturbative physics
- In two particle correlations, intrinsic partonic transverse momentum and hadron p_T transverse to jet axis are non-perturbative effects

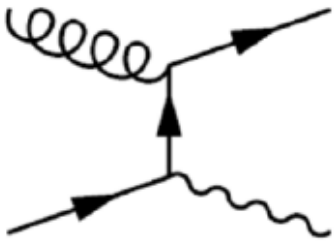
- Rogers and Mulders 2010 paper predicts QCD non-perturbative factorization breaking in back to back hadroproduction from p+p collisions (PRD 81,094006 (2010))



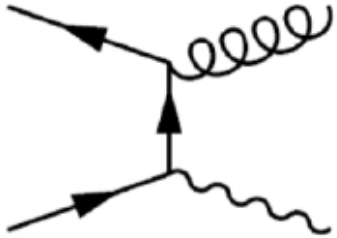
(PHENIX) PRD 82,072001 (2010)

Direct Photons

- Comparing direct photon-hadron production to back to back hadroproduction
- 3 non-perturbative functions instead of 4 (2 PDFs and 1 FF)
- Therefore factorization breaking effects expected to be larger in back to back hadroproduction



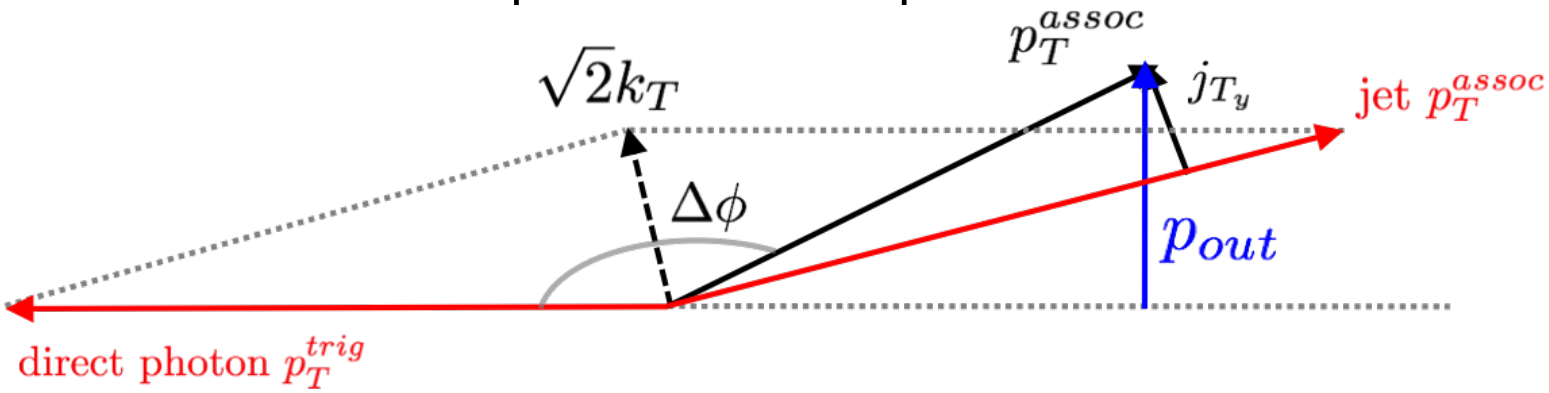
$qg \to q\gamma$



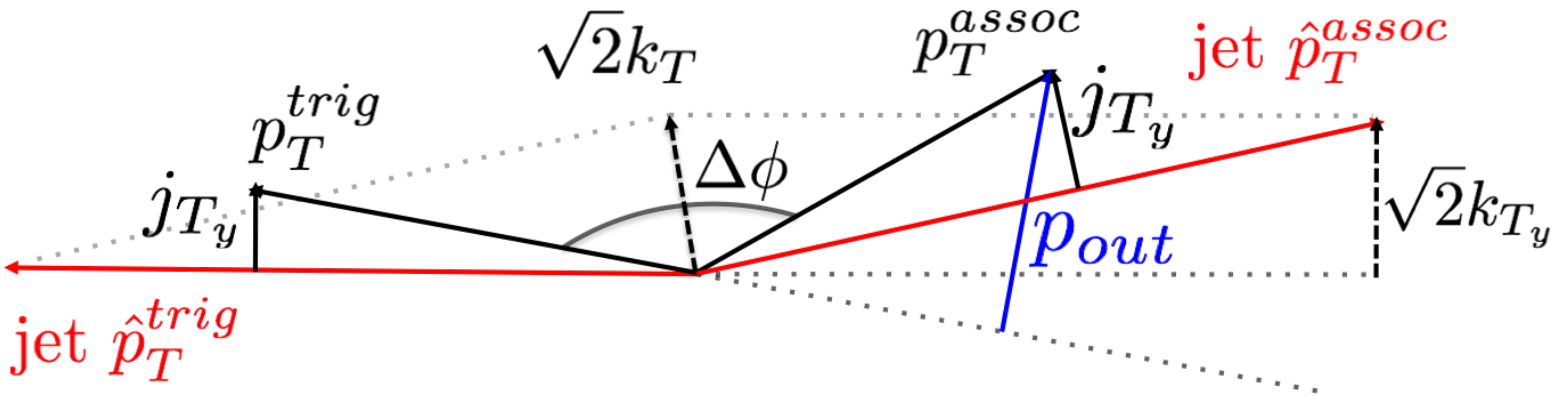
$q\bar{q} \to g\gamma$

Nearly Back to Back Hadron Angular Correlations

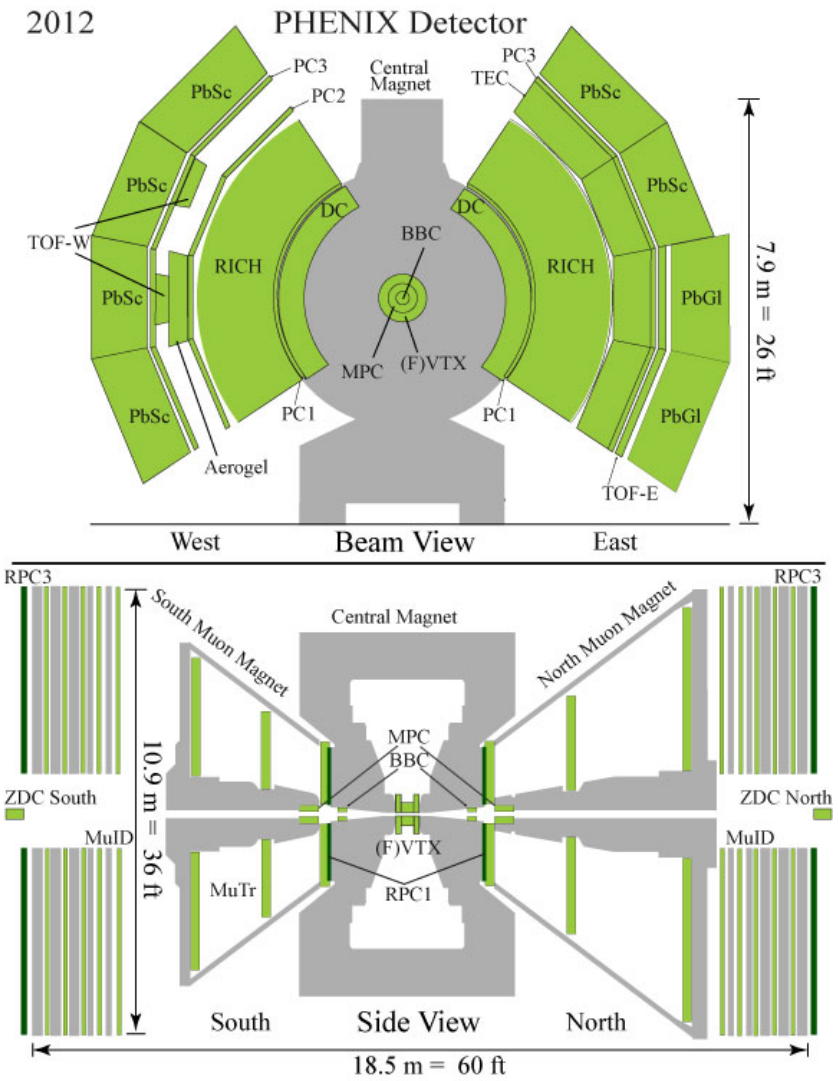
Direct photon-hadron production



Back to back hadroproduction



PHENIX Experiment



- Two Central Arms ($|\eta| < 0.35$, $\phi \approx \pi/2$ rads)
  - EMCal
  - Drift Chamber
- Identify π^0-h$^{\pm}$ correlations via $\pi^0 \to \gamma\gamma$ reconstruction
- Identify isolated direct photon-h$^{\pm}$ correlations with isolation and tagging cuts

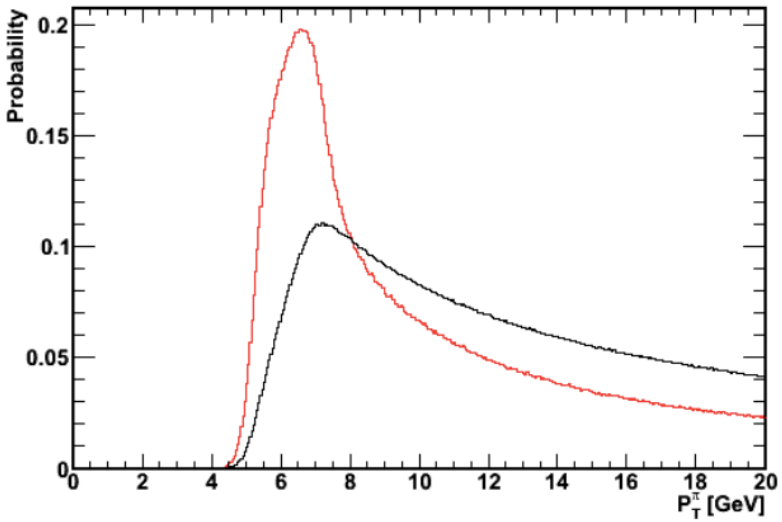
Statistical Subtraction Method

- Statistically subtract isolated decay component

$$Y_{dir}^{iso} = \frac{1}{R'_{\gamma} - 1}\left(R'_{\gamma} Y_{inc}^{iso} - Y_{dec}^{iso}\right)$$

- Weighted by factor $R'_{\gamma} = N_{inc}^{iso}/N_{dec}^{iso}$
- Estimate decay component by mapping isolated π^0s with a probability Green's function to isolated decay photons

Probability for isolated π^0 to decay to $5 < p_T^{\gamma} < 7$ GeV/c

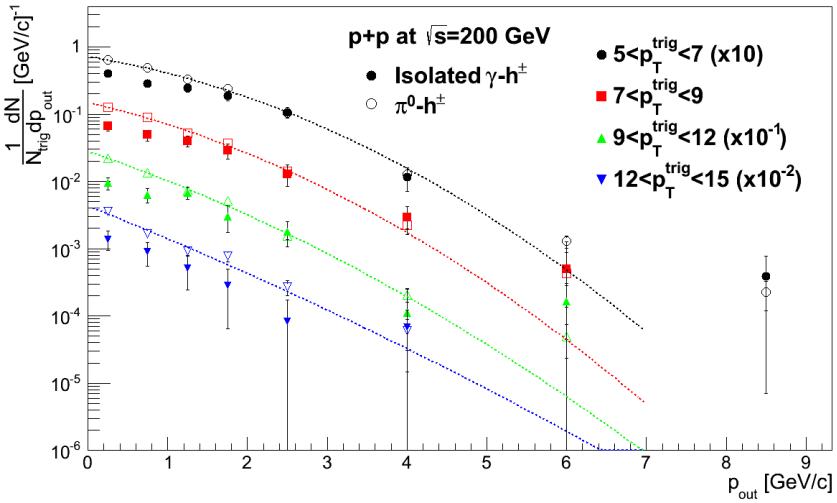


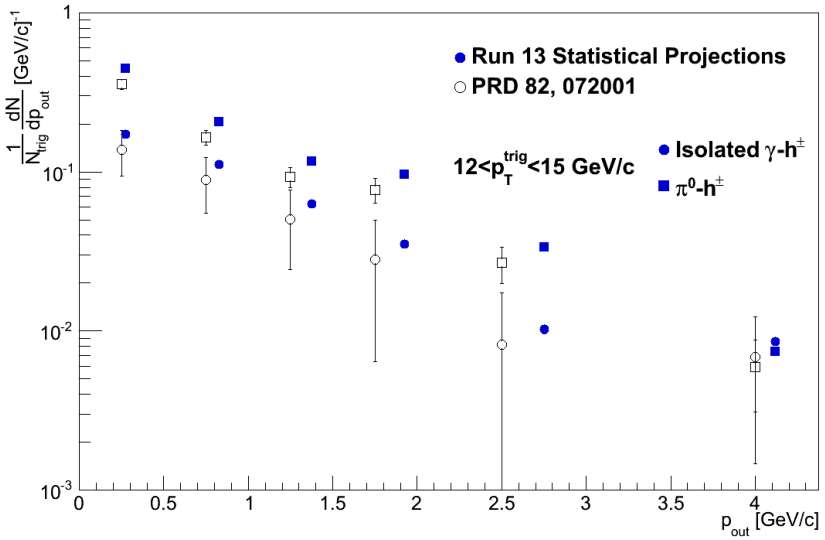
Black: No removal of tagged decay photons

Red: Removing tagged decay photons

Non-perturbative Sensitivity

- Expect small p_{out} to be sensitive to non-perturbative k_T and j_{T_y} effects
- Transition to power law/pQCD behavior at large p_{out}, generated by hard gluon radiation





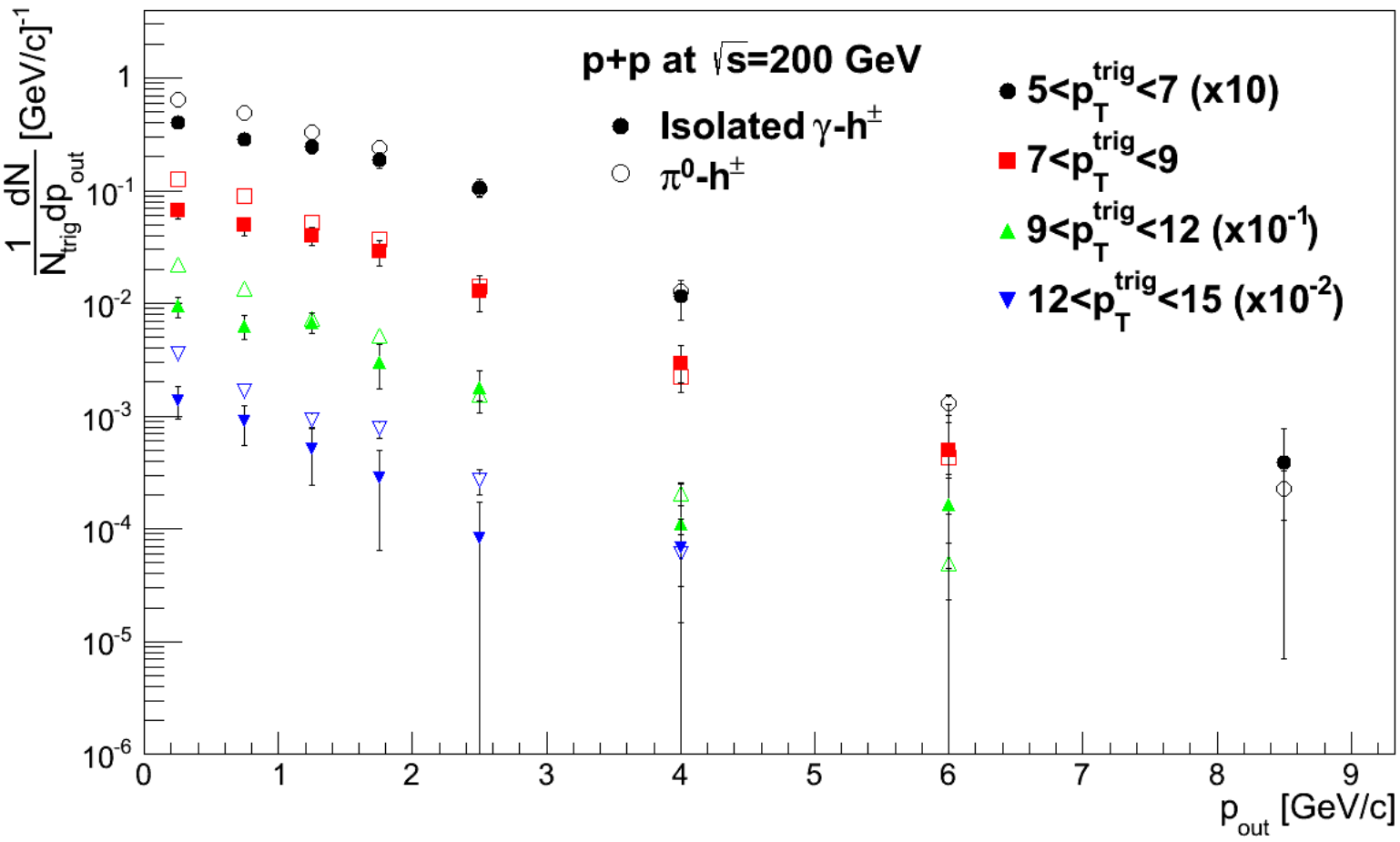
Run 13 statistical projections shifted for visibility

Summary and Outlook

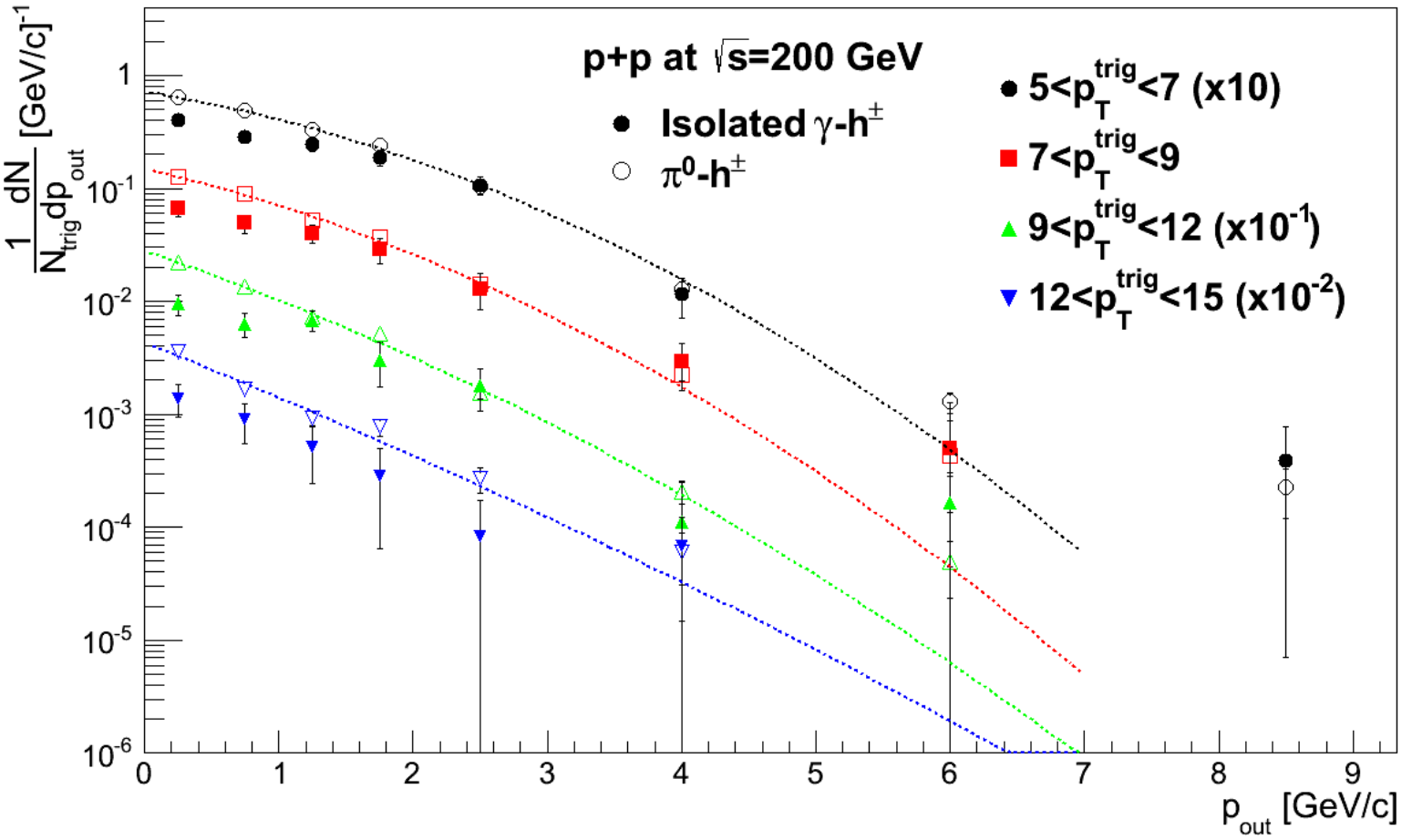
- Analysis from Run 12/13 $\sqrt{s} = 510$ GeV p+p nearly complete!
  - $\approx$380 [pb]$^{-1}$ compared to $\approx$70 [pb]$^{-1}$ from Run 5/6 $\sqrt{s} = 200$ GeV
- p_{out} distribution shows evidence of gaussian structure from effects due to non-perturbative k_T and j_{T_y} in both π^0-h$^{\pm}$ and direct photon-h$^{\pm}$ correlations
- Characterizing gaussian shape next step...
- Future: Compare to processes where no factorization breaking is expected (e.g. Drell-Yan Z or W production)

Back Up

Run 5/6 $\sqrt{s} = 200$ GeV PHENIX Results



Run 5/6 $\sqrt{s} = 200$ GeV PHENIX Results



π^0-h$^{\pm}$ correlations are fit with gaussian functions

Factorization Breaking

- Factorization breaking is only sensitive to an observable that is sensitive to non-perturbative transverse momentum
- p_{out} is sensitive to two non-perturbative transverse momenta: k_T and j_{T_y} from page 4
- No factorization breaking expected for Z production since there are only 2 colored objects for gluon exchange
- Perturbative partonic cross section still factorizes from non-perturbative, but non-perturbative functions no longer factorizable from each other
- Consequence: color entanglement! Non-perturbative functions are entangled across hadrons

Characterizing Gaussian Shapes

- In order to learn about possible factorization breaking, there are a number of quantities to calculate as a function of the hard scale
  - Gaussian width
  - Gaussian mean
  - $\sqrt{\langle p_{out}^2 \rangle}$