Estimation of background for photon-hadron correlations in proton-lead collisions at $\sqrt{s_{\mathrm{NN}}}$=5.02 TeV

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Direct γ-hadron correlations

- γ-hadron correlations measure the fragmentation function, which may be modified by energy loss in the QGP
- The photon energy is not affected by the QGP – gives information about the parton energy prior to QGP interaction
- Hadrons arise from partons fragmenting into jets
- Goal: measure γ_{direct}-hadron correlations; detector sees γinclusive-hadron correlations
- γ_{decay}-hadron correlations can be unfolded to get γ_{direct}-hadron correlations from the data as done in [1]:

$$Y(\Delta\phi) = \frac{1}{N^{\gamma\mathrm{inc}}} \frac{\mathrm{d}N_{\gamma\mathrm{inc}} - \pi^0}{\mathrm{d}\Delta\phi}$$

$$Y_{\mathrm{direct}} = \frac{R_\gamma Y_{\mathrm{inc}} - Y_{\mathrm{decay}}}{R_\gamma - 1}$$

Decay photon spectrum

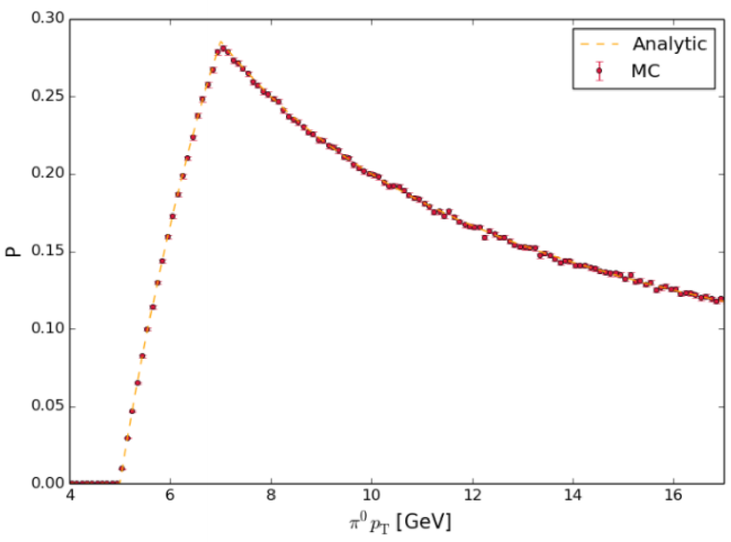
- Calculate decay $\frac{\mathrm{d}\sigma^\gamma}{\mathrm{d}p_T^\gamma}$ from π^0 using $\frac{\mathrm{d}\sigma^{\pi^0}}{\mathrm{d}p_T^{\pi^0}}$ and the joint probability distribution $P(p_T^{\pi^0}, p_T^\gamma)$ (similar procedure for η)

$$\frac{\mathrm{d}\sigma^\gamma}{\mathrm{d}p_T^\gamma} = \int dp_T^{\pi^0} P(p_T^{\pi^0}, p_T^\gamma) \frac{\mathrm{d}\sigma^{\pi^0}}{\mathrm{d}p_T^{\pi^0}}$$

- For the photon cross section in $a < p_T^\gamma < b$, the joint probability distribution is integrated across the entire π^0 p_T range:

$$\left.\frac{\mathrm{d}\sigma^\gamma}{\mathrm{d}p_T^\gamma}\right|_{a<p_T^\gamma<b} = \frac{1}{b-a}\int_0^\infty \mathrm{d}p_T^{\pi^0} \frac{\mathrm{d}\sigma^{\pi^0}}{\mathrm{d}p_T^{\pi^0}} \times P(p_T^{\pi^0}, a, b)$$

- The joint probability can be calculated analytically and gives the "sharkfin" distribution, which depends on the p_T^γ range:



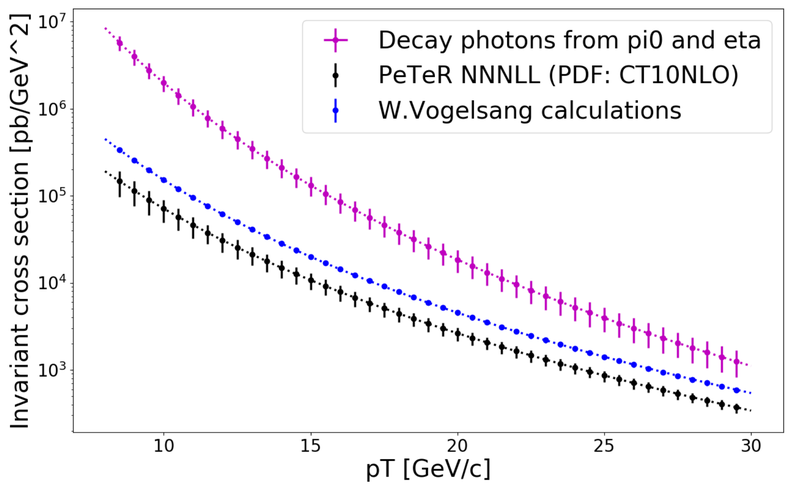
$$P(x = p_T^{\pi^0}, a = \min p_T^\gamma, b = \max p_T^\gamma)$$
$$= \begin{cases} 0, & x < a \\ 2(x-a)/x, & a < x < b \\ 2(b-a)/x, & x > b \end{cases}$$

- Decay photons calculated from published parameterizations of the measured π^0 and η spectra

Calculating γ_{direct} and R_γ

- Direct photon measurement in p-Pb collisions at 5.02 TeV is not yet available
- Estimate $R_\gamma = 1 + \gamma_{\mathrm{direct}}/\gamma_{\mathrm{decay}}$ via calculation
- 2 direct photon calculations:
  - PeTeR[2]: NNNLL resummed cross section for pp, scaled by $A = 208$
  - Independent calculation received from W. Vogelsang[3][4][5]

Photon spectra



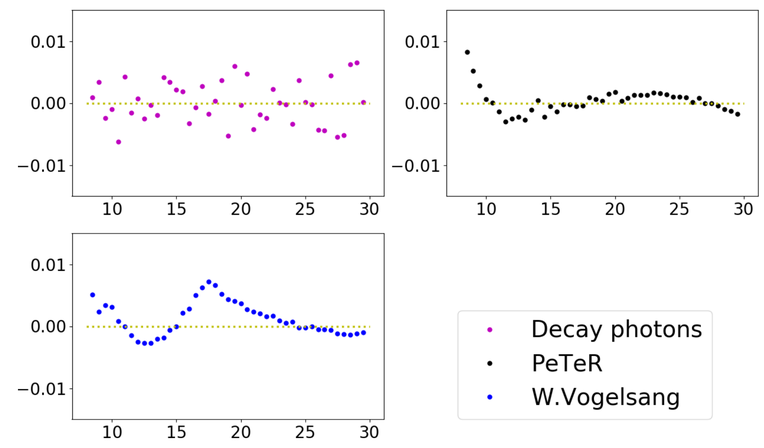
- Measurements and Tsallis function parameterizations of the π^0 and η spectra were published in [6]

$$\mathrm{Tsallis}(p_T) = \frac{A}{2\pi} \frac{(n-1)(n-2)}{nT(nT + m(n-2))} \times \left(1 + \frac{\sqrt{m^2 + p_T^2} - m}{nT}\right)^{-n}$$

- Parameters A, n, T have uncertainties from the fits
- Fit uncertainties of parameters A, n, T propagated by integrating 5000 times per bin
  - Each integration uses parameter values drawn from a Gaussian distribution (mean is given value, standard deviation is fit uncertainty)
  - The mean and standard deviation of the 5000 integration results were calculated for each p_T^γ bin
  - Gives $\frac{\mathrm{d}\sigma^\gamma}{\mathrm{d}p_T^\gamma}$ and the corresponding error for each bin
- Decay photons for π^0 and η are calculated separately, then added together to get the total decay photon spectrum

Fitting

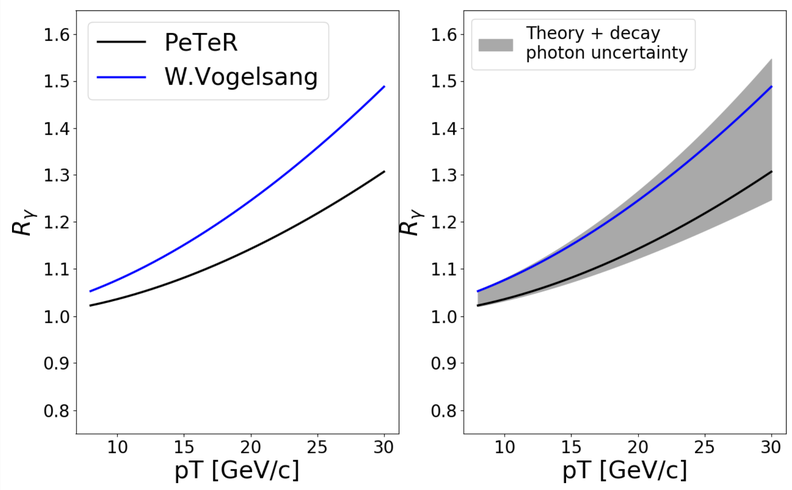
- Fit each γ_{direct} calculation and the γ_{decay} to a Tsallis function. Residuals:



- Calculate R_γ for each γ_{direct} calculation by dividing γ_{direct} by γ_{decay} and adding 1
- Combine 2 sources of systematic uncertainty:
  - Total spread between calculations
  - Errors from decay photon calculation

Calculated R_γ

$$R_\gamma = 1 + \frac{\gamma_{\mathrm{direct}}}{\gamma_{\mathrm{decay}}}$$



Conclusion

- Constructed R_γ using 2 γ_{direct} calculations and γ_{decay} from measured π^0 and η for 5.02 TeV p-Pb collisions
- R_γ ranges from $\sim$ 1.0 to $\sim$ 1.3 for the p_T range 8-20 GeV/c
- Uncertainty is dominated by spread of γ_{direct} calculations

References

[1] A. Adare, et al., Phys.Rev.C80 024908 (2010)
[2] T. Becher, C. Lorentzen and M. D. Schwartz, Phys.Rev.D86 054026 (2012)
[3] W. Vogelsang, Private communcation
[4] L. E. Gordon and W. Vogelsang, Phys.Rev.D48 3136 (1993)
[5] B. Jager, A. Schafer, M. Stratmann, W. Vogelsang, Phys.Rev.D67 054005 (2003)
[6] Find and cite ALICE neutral meson paper

Acknowledgements

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