Isolated photon cross section for √s = 5.02 TeV p-Pb with ALICE

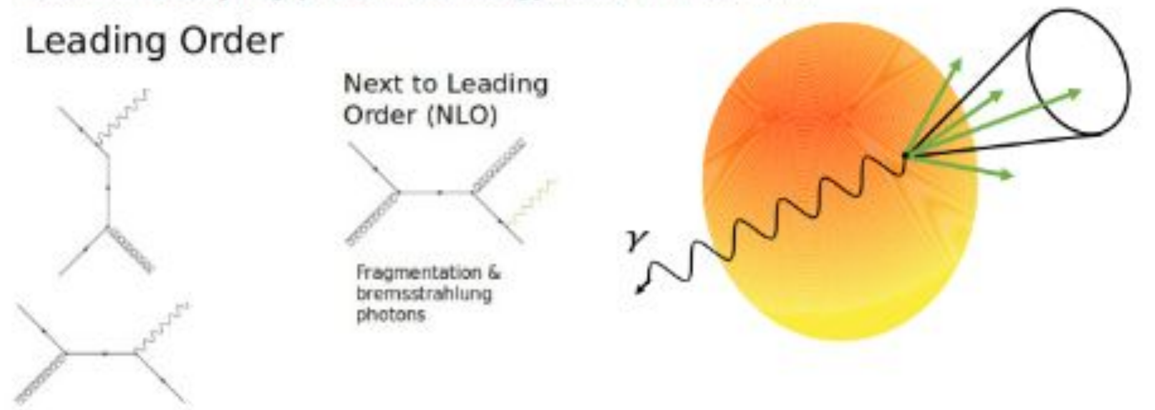
Dhruv Dixit, Dr. Barbara Jacak

University of California, Berkeley

Nuclear Science & Security Consortium

Background

- Photons do not strongly interact
- High energy prompt photons constrain the kinematics of the hard-scattered parton (quark or gluon)
- Photon production reflects parton distribution functions
- Tool for studying partonic energy loss in medium



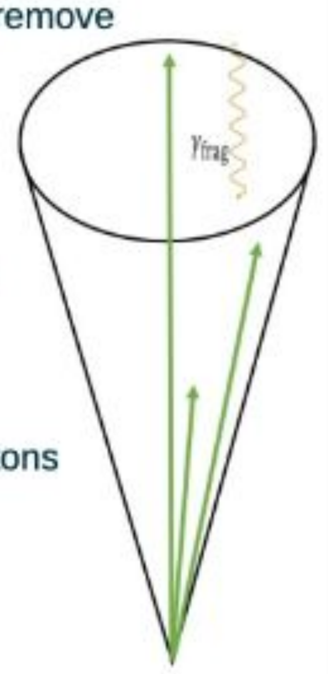
Analysis

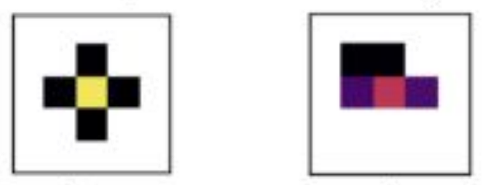
Cross-section recipe:

$$\frac{d^2\sigma}{dp_T d\eta} = \frac{N_{ev} \times P}{\mathcal{L}_{int} \times \varepsilon_\gamma^{iso}} \times \frac{d^2N}{N_{ev} dp_T d\eta}$$

- N_{ev} is the number of events which passed my event selection criteria: EG1 or EG2 trigger (if event has both EG1 or EG2, only the lowest fired trigger is counted), $|Z_v| < 10$ cm, and pile up rejection
- P is the isolated photon purity, which is applied as a weight when filling the cluster p_T
- $\frac{d^2N}{N_{ev} dp_T d\eta}$ is the event normalized differential cluster distribution (cluster spectra)
- $d\eta = 2\pi / \Delta\phi\Delta\eta$
- $\mathcal{L}_{int}$ is the integrated luminosity calculated using $\mathcal{L}_{int} = \frac{N_{ev}^{EGi} \times R_{trig}^{EGi}}{\sigma_{MB}}$ and $R_{trig}^{EGi} = \left(\frac{1}{N_{ev}^{EGi}} \frac{dN_{clus}^{EGi}}{dp_T}\right) / \left(\frac{1}{N_{ev}^{MB}} \frac{dN_{clus}^{MB}}{dp_T}\right)$ which are the trigger rejection factors (RF)
- ε_γ^{iso} is the isolated photon global efficiency. It is the ratio of all reconstructed isolated photons divided by all generated photons

- The cross section is calculated by measuring the isolated photon yield, and correcting by the photon efficiency, purity and the luminosity
- Cluster from ALICE Electromagnetic calorimeter (EMCal) are filtered using various cuts to find photon candidates
- An isolation cut of $p_T^{iso,ch} < 1.5$ GeV/c is applied to remove background fragmentation and decay photons
- Shower shape cut helps reject decay photons from high momentum neutral pion decays
  - The shower shape is encoded in the geometric variable σ^2_{long}
  - Electromagnetic showers from decay photons looks elliptical, while showers from prompt photons appear to be circular

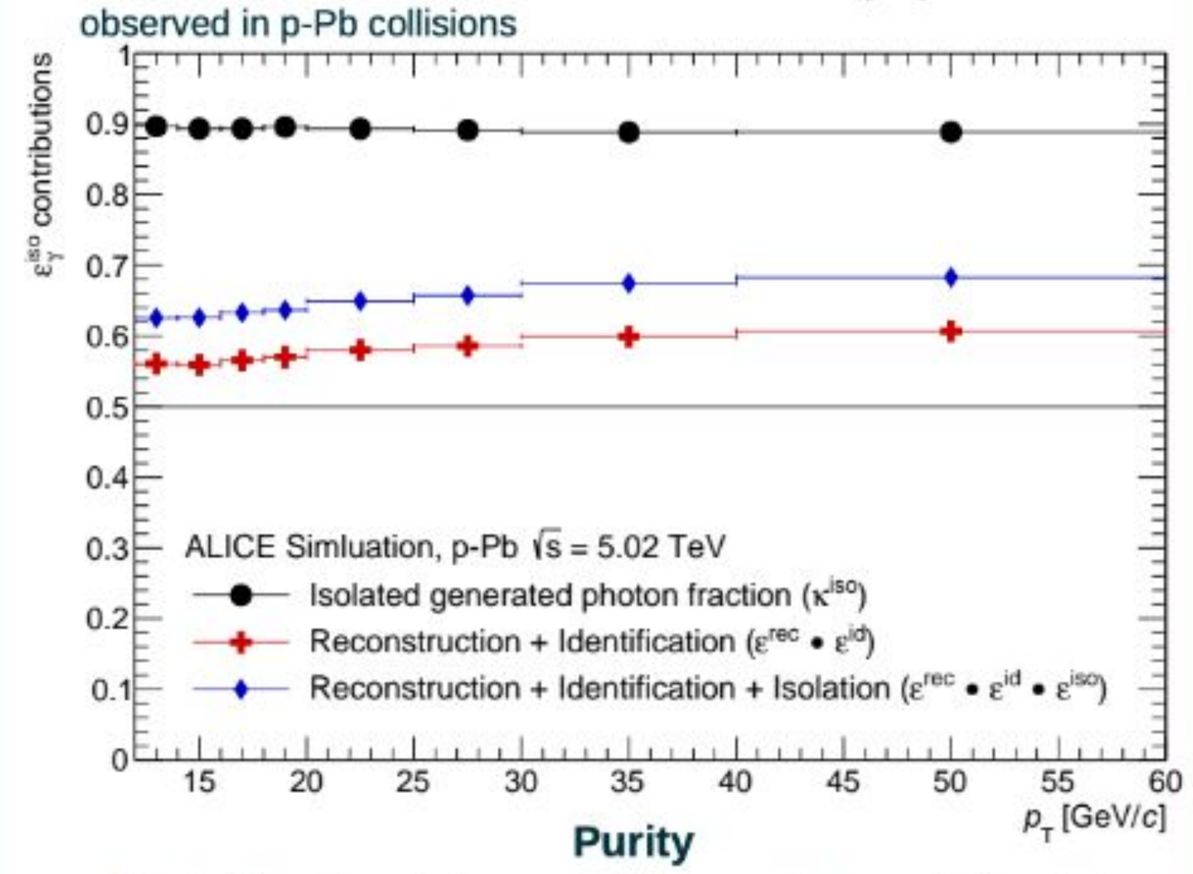




- The shower signal region, values of $0.1 < \sigma^2_{long} < 0.3$, is expected to consist of prompt photons

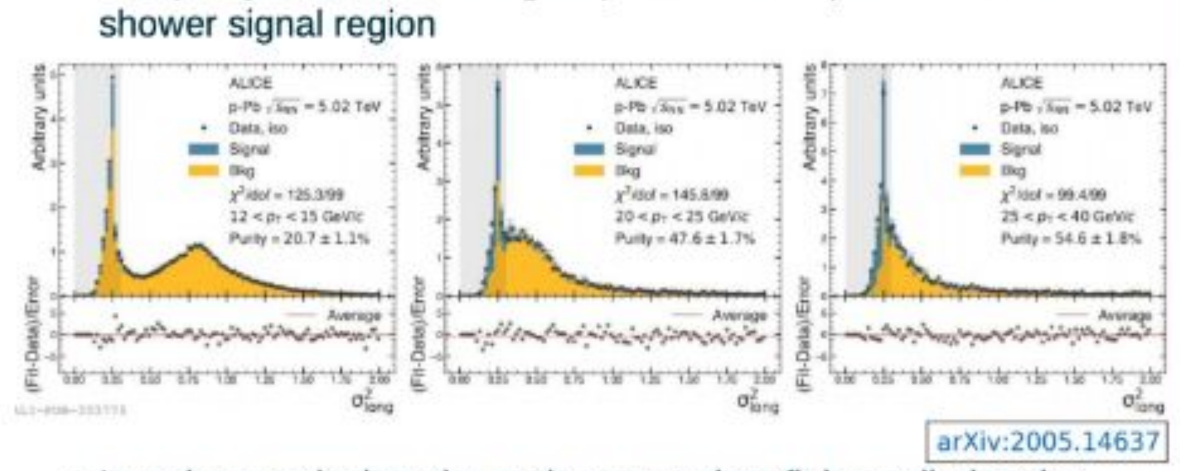
Isolated photon efficiency

- The efficiency is calculated the number of isolated reconstructed photons divided by number of isolated generated photons
- The efficiency is calculated using the pythia simulations embedded in DPMJET, which is used to simulate the underlying event observed in p-Pb collisions



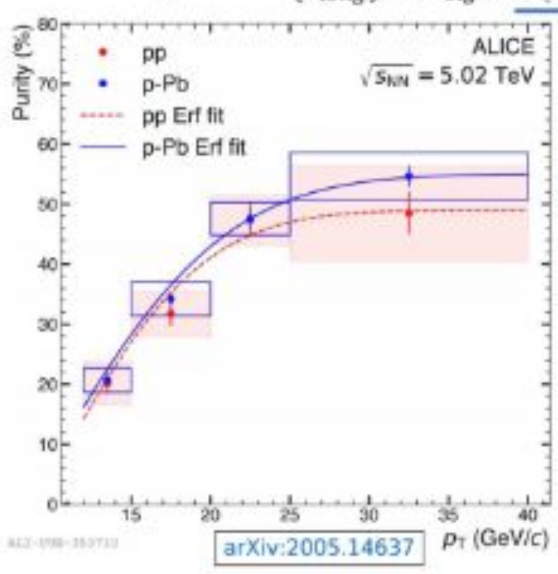
Purity

- Despite the attempts to remove decay and fragmentation photons, there is still a large background contribution in the shower signal region $0.1 < \sigma^2_{long} < 0.3$
- In order correct for the background photons in the shower signal region, the purity is calculated
- The purity is the ratio of signal photons to all photons in the shower signal region



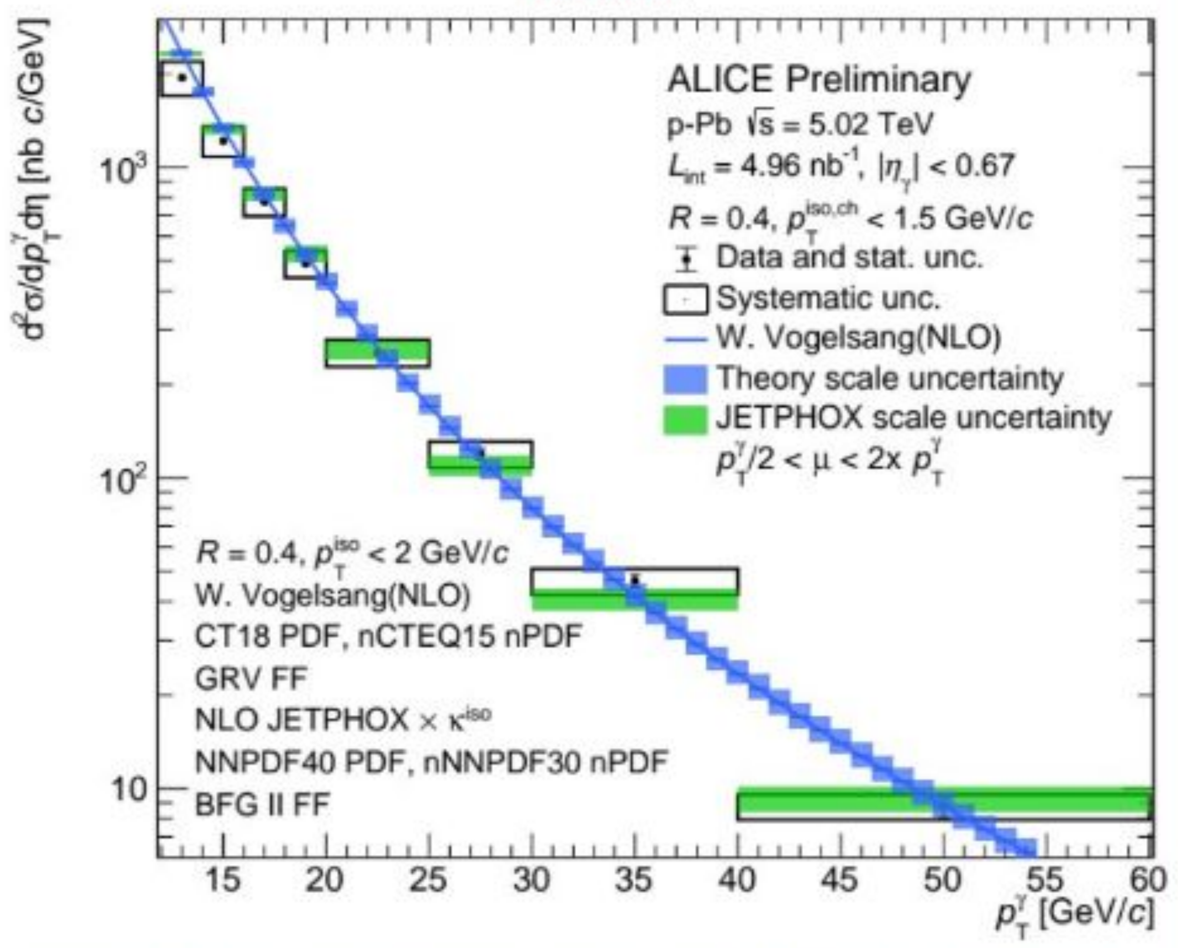
- In order to calculate the purity, a template fit is applied to the shower shape distribution as seen in the figure above
- The background template is created using data corrected by a di-jet simulation, while the signal template is created with a gamma-jet simulation
- The shower shape distribution is fit to a linear combination of signal and background templates:

$$N^{observed}(\sigma^2_{long}) = N_{sig} \times S(\sigma^2_{long}) + (N - N_{sig}) \times B(\sigma^2_{long})$$

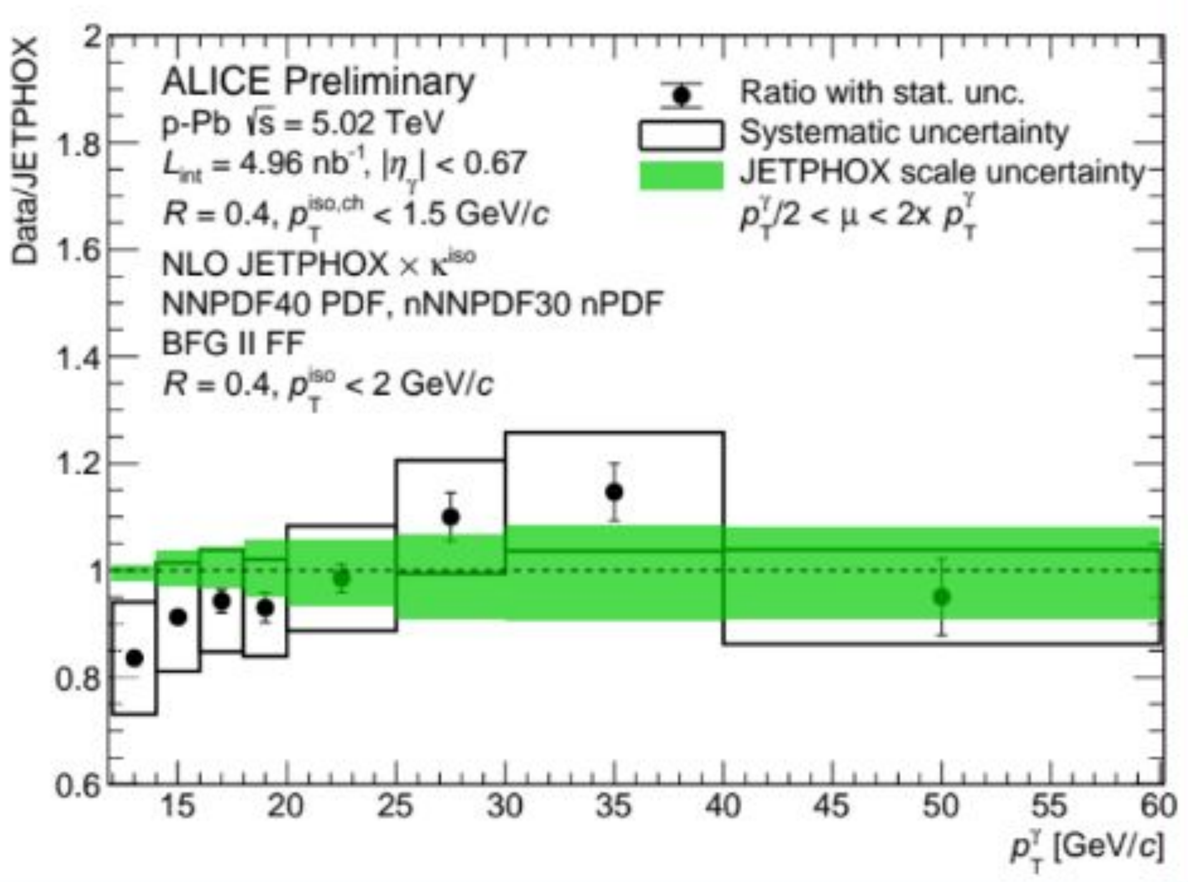


- The purity is the ratio of signal photons to all photons in the shower signal region
- Purity is fit to a 3-parameter error function which helps capture quickly rising behavior at low, and avoid bin edge effects

Results



- Isolated photon cross section compared with JETPHOX calculation and NLO pQCD prediction from Dr. W. Vogelsang is shown above
- The boxes represent the systematic uncertainty for the cross section, while the filled boxes represent the scale uncertainty
- The JETPHOX calculation uses nNNPDF30 as the nuclear parton distribution function (nPDF) for the Pb nucleus, NNPDF40 for the proton parton distribution function (PDF), and BFG II for the fragmentation function
- The NLO pQCD by Dr. Vogelsang uses nCETQ15 as the nPDF, CT18 as the proton PDF, and GRV as the fragmentation function
- Within one standard deviation of the uncertainties, the data agrees with the NLO pQCD predictions and the JETPHOX predictions for all the bins except the first bin
- The comparison is better quantified in the ratio data/JETPHOX shown below
- The ratio shows good agreement between data and JETPHOX within uncertainties



Conclusion

- Isolated photon cross section was measured for p-Pb collisions at an energy of 5.02 TeV
- The cross section was compared with NLO pQCD and JETPHOX, both having different nPDF, PDF, and fragmentation function
- There was good agreement between the measured cross section and NLO pQCD as well as JETPHOX within uncertainties

Future work

- Next step is to measure the isolated photon cross section for pp collisions at an energy of 5.02 TeV and calculate the nuclear modification factor (R_{pPb}) to compare the pp and p-Pb cross sections in order to study nuclear effects
- Compare the 5.02 TeV p-Pb cross section to one measured at 8.16 TeV in order to study the effect of changing the collision energy on the photon production
- Compare the R_{pPb} to R_{PbPb} in order to study differences between p-Pb collisions compared to Pb-Pb collisions

Glossary

1. Parton: quark or gluon
2. Parton distribution function (PDF): functions which give the probability to find partons in a hadron as a function of the fraction x of the proton's momentum carried by the parton. PDFs used for the entire nucleus are called nuclear PDFs (nPDFs)
3. Fragmentation function: non-perturbative functions describing the formation of hadrons
4. Jet: a narrow cone of hadrons and other particles produced by the hadronization of a parton
5. Hadronization: process of formation of hadrons from partons
6. Gamma-jet: two partons hard scatter and create back-to-back photon and jet pair
7. Dijet: two partons hard scatter and create back-to-back jets
8. Underlying event: additional interactions of two particle beams at a collision point beyond the main collision under study
9. NLO: next to leading order
10. pQCD: perturbative quantum chromo-dynamics
11. p_T: transverse momentum
12. Nuclear modification factor: pp measurement is scaled by one or two lead nucleic and compared to p-Pb or Pb-Pb in order to study nuclear effects

Acknowledgments

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