Direct Photon and π⁰ Identification in Au+Au Collisions at √s_{NN} = 200 GeV in the STAR Experiment

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Abstract

Jets recoiling from a direct-photon have long been seen as a golden probe of the quark gluon plasma created in relativistic heavy ion collisions, due to the ability to tightly constrain the initial hard scattering kinematics. Until recently, the ability to measure this channel and the ensuing observables at RHIC were largely statistics-limited, owing to the small cross-section of direct photon production compared to, for example, the most abundant di-jet cross-section. In this poster, we will present methods for identifying direct photons and π⁰, using the 13 nb⁻¹ of √s_{NN} = 200 GeV Au+Au data recorded in 2014 by the STAR experiment.

The STAR Detector

- The majority of the STAR volume is from the Time Projection Chamber (TPC), covering |η|<1 and 2π in φ, used for charged particle tracking.
- The Barrel ElectroMagnetic Calorimeter (BEMC), covering the same phase space as the TPC, is used for measuring energies of EM showers.
- The Barrel Shower Maximum Detector (BSMD), used for measuring the same phase space as the TPC, is embedded in the BEMC at a position where an EMC shower is at its largest transverse extent.
- The BSMD is made up of 2 layers of strips running in the η and φ direction, with resolution down to ~0.006η and 0.02π for the 2 different strip types.
- The spatial resolution of the BSMD allows γ identification based on the EM shower shape.

BSMD Details

- In order to use the BSMD for analyzing shower shape, proper calibration of the energy measured in the strips needs to be verified.
- Care must also be taken to only analyze the trigger shower in the BSMD, and not showers from, for example, another nearby y that is not correlated with the trigger particle.
- Using a BSMD hit threshold of 0.5 GeV (the threshold choice was data driven to optimize shower selection), the spatial extent of the shower is determined and all hits in this range are considered to be in the primary shower.
- The trigger requirement is a single tower with 5.7 GeV < E_{T} < 30 GeV, and a neighboring tower with 1.7 GeV < E_{T} < 30 GeV, for a total cluster trigger threshold of 7.4 GeV.
- Using this trigger, more than 20 million photon candidate events were recorded by STAR in 2014.
- This trigger provides an enhanced selection of direct photon events. Further analysis on the shower shape in the BSMD is required for discriminating direct photon and π⁰ events (whose most common decay channel is into two photons, leaving a spatially larger shower than that of a single direct photon).

Photon Trigger

- All of the events used are from a BEMC trigger that has been optimized for triggering on the large EM showers from direct photons (compared to the relatively small shower left by hadrons).
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Photons

- The technique for photon identification developed within STAR is known as the Transverse Shower Profile (TSP), with the formula given in Eq. 1 (see [1] for details).
- After calculating the TSP, different selections are made for:
  - TSP < 0.08, corresponding to a narrow shower
  - TSP > 0.2, corresponding to a wider shower

Eq. 1)

\[
\text{TSP} = \frac{E_{\text{cluster}}}{\sum_{i} E_{\text{strip}}^{i}}
\]

- Photon purity is between 60-85%, with purity increasing with E_{T}. Further statistical subtraction is done to remove contamination.
- Direct photon-recoil jet events will be used to make a measurement of x_{y} for anti-κ, R=0.4 jets and compare with a pp reference.

References

[1] Jet-like Correlations with Direct-Photon and Neutral-Pion Triggers at √s_{NN} = 200 GeV
Adamczyk et al. (STAR Collaboration) Physics Letters B 780 (2016)

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. 1913696.

The STAR Collaboration
https://drupal.star.bnl.gov/STAR/presentations