

Direct Photon and π^0 Identification in Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV in the STAR Experiment

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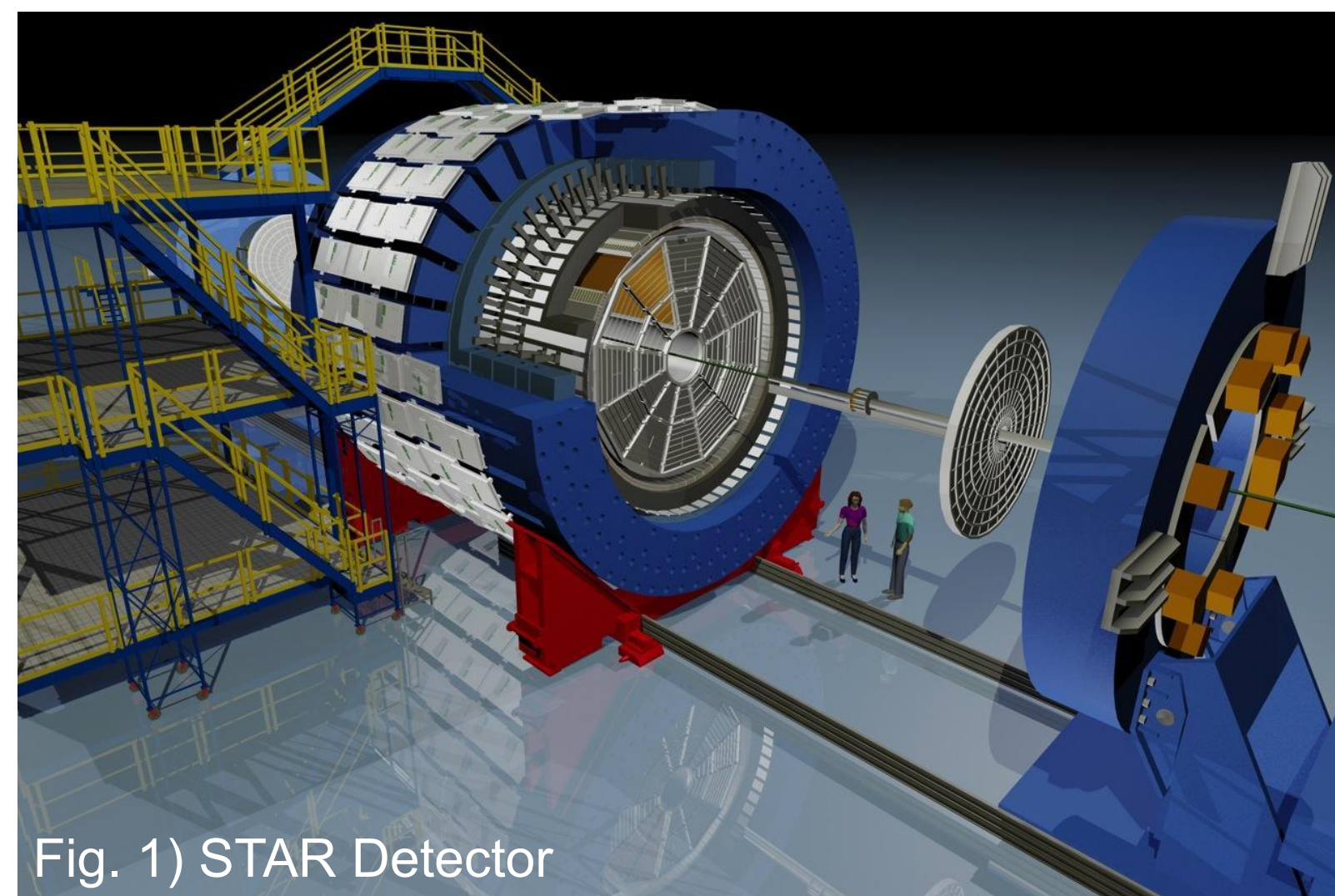


Abstract

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 π^0 , using the 13 nb $^{-1}$ of $\sqrt{s_{NN}} = 200$ GeV Au+Au data recorded in 2014 by the STAR experiment.

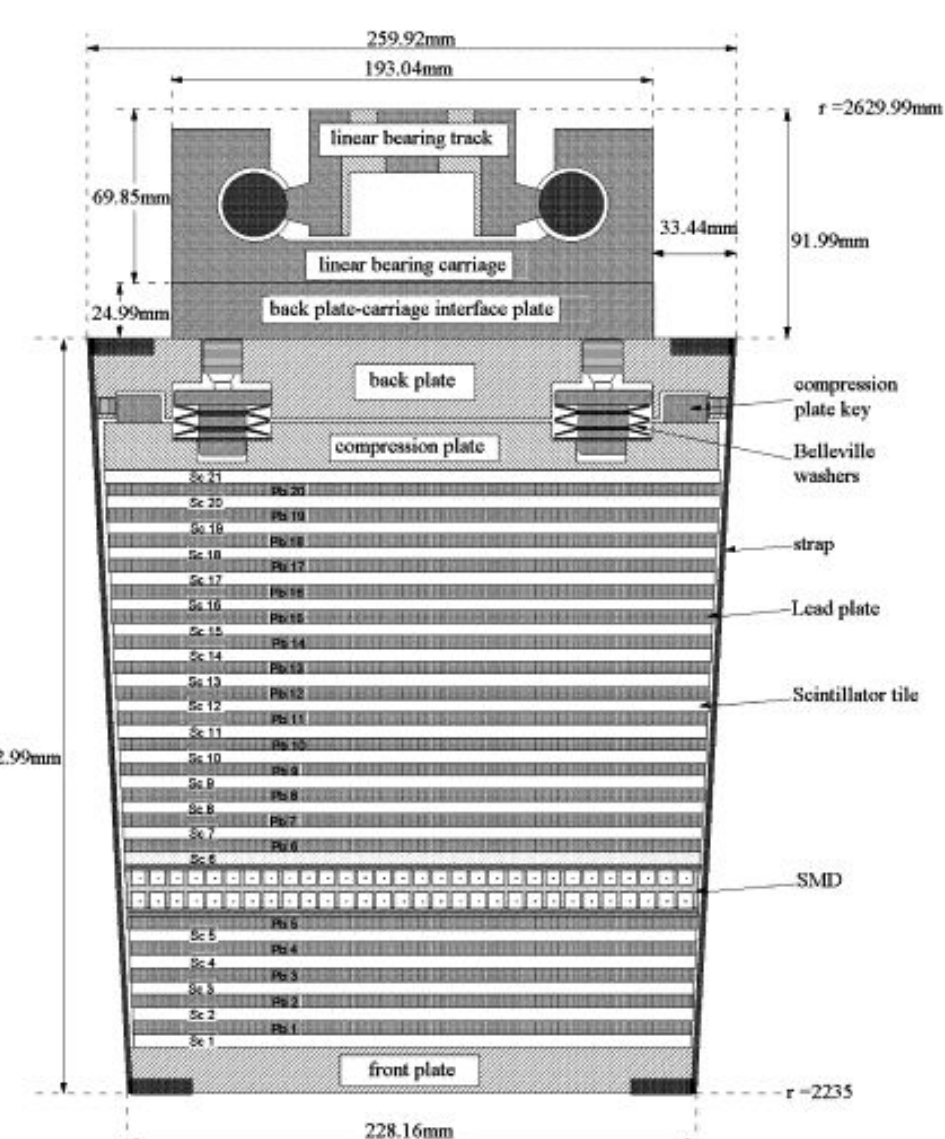
The STAR Detector

- The majority of the STAR volume is from the **Time Projection Chamber (TPC)**, covering $|\eta| < 1$ 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**.



BEMC

- The STAR BEMC is a **PbSc sampling calorimeter**.
- Each tower covers 0.05×0.05 in $\Delta\eta \times \Delta\phi$, with **4800 towers** total.
- The **Barrel Shower Maximum Detector (BSMD)** 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 $\sim 0.006 \Delta\eta$ and $\Delta\phi$** respectively 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 γ 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.

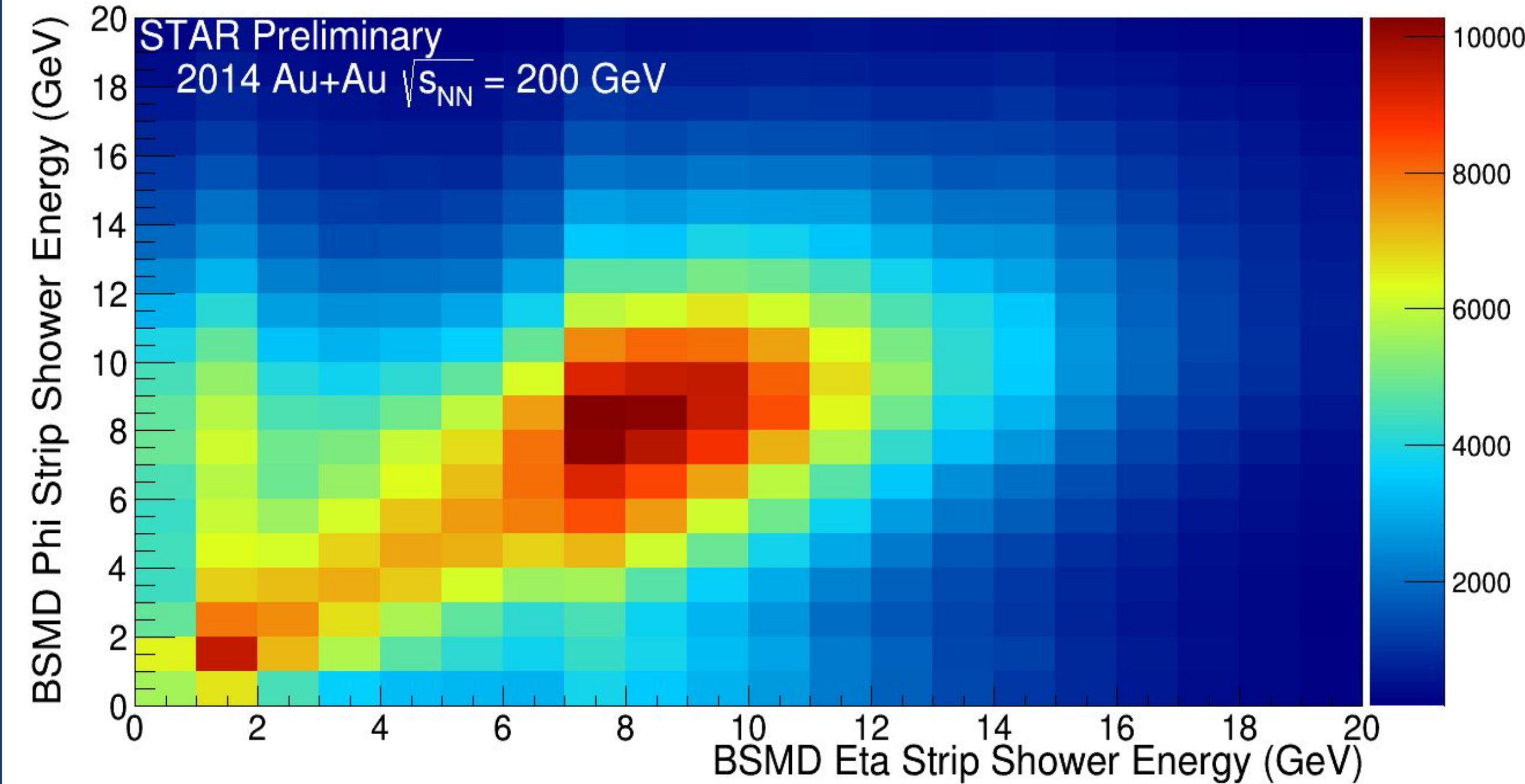


Fig. 4) Comparison between total energy deposited in the two BSMD strip layers for trigger showers with $E_{tow} > 8$ GeV. The two different layers are well calibrated with respect to one another (i.e. for the same trigger shower, both layers measure the same energy).

Photon Identification

Eq. 1)

$$TSP = \frac{E_{cluster}}{\sum_i e_i r_i^{1.5}}$$

$E_{cluster}$: Cluster energy

e_i : BSMD strip energy

r_i : distance of the strip from the center of the cluster

- 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,

- γ_{rich} ($0.2 < TSP < 0.6$, corresponding to a narrow shower)
- π^0_{rich} ($TSP < 0.08$, corresponding to a wider shower)

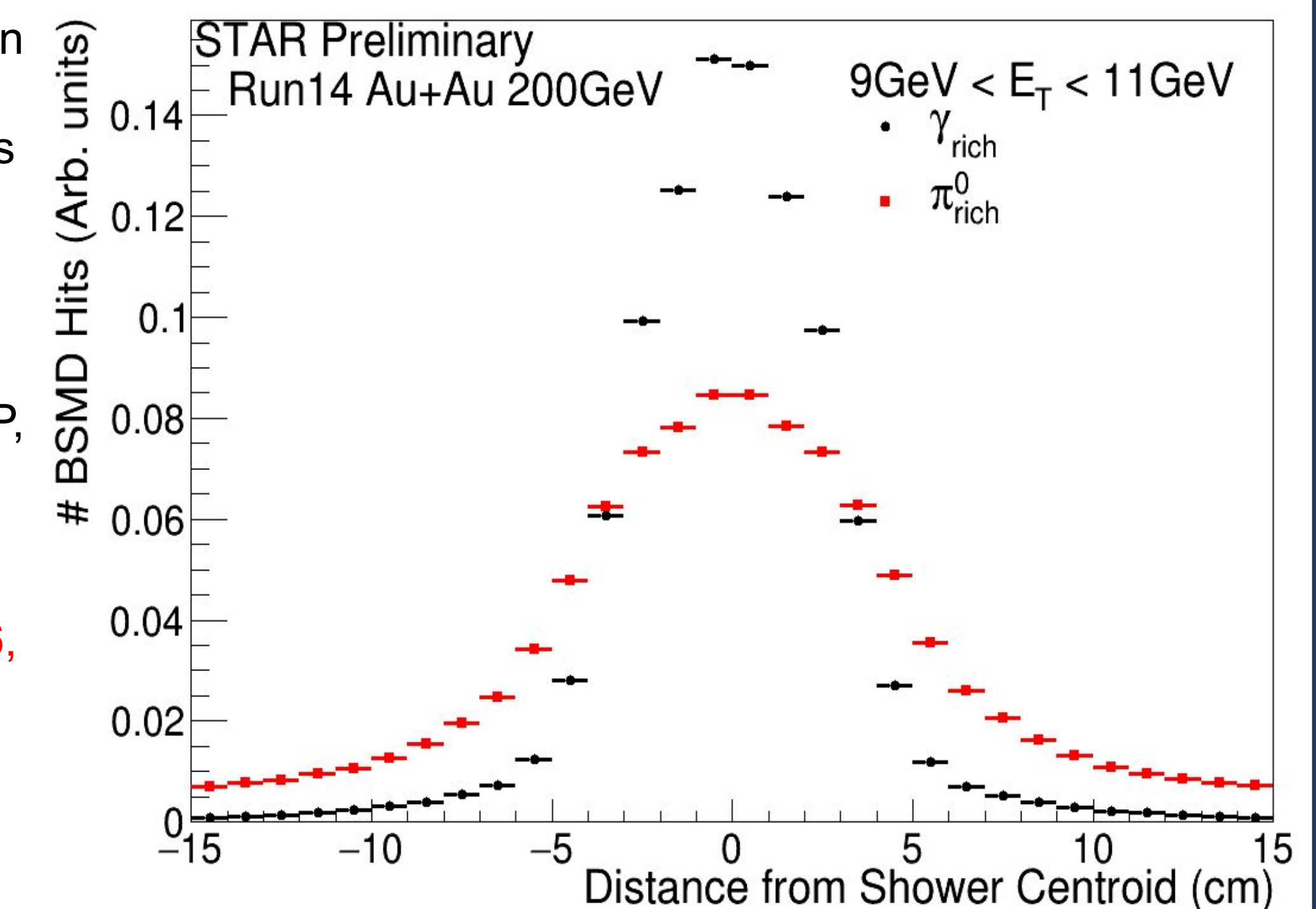


Fig. 5) Number of BSMD hits above threshold vs. distance from shower centroid in cm (strip width is ~ 1.5 cm), for the two different TSP selections. The π^0_{rich} population is selected to on average have wider showers, which is what one would expect for a $\pi^0 \rightarrow \gamma + \gamma$ decay compared to a single γ shower.

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).
- The trigger requirement is a single tower with $5.7 \text{ GeV} < E_{tow} < 30 \text{ GeV}$, and a neighboring tower with $1.7 \text{ GeV} < E_{tow} < 30 \text{ GeV}$, 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 π^0 events (whose most common decay channel is into two photons, leaving a spatially larger shower than that of a single direct photon).

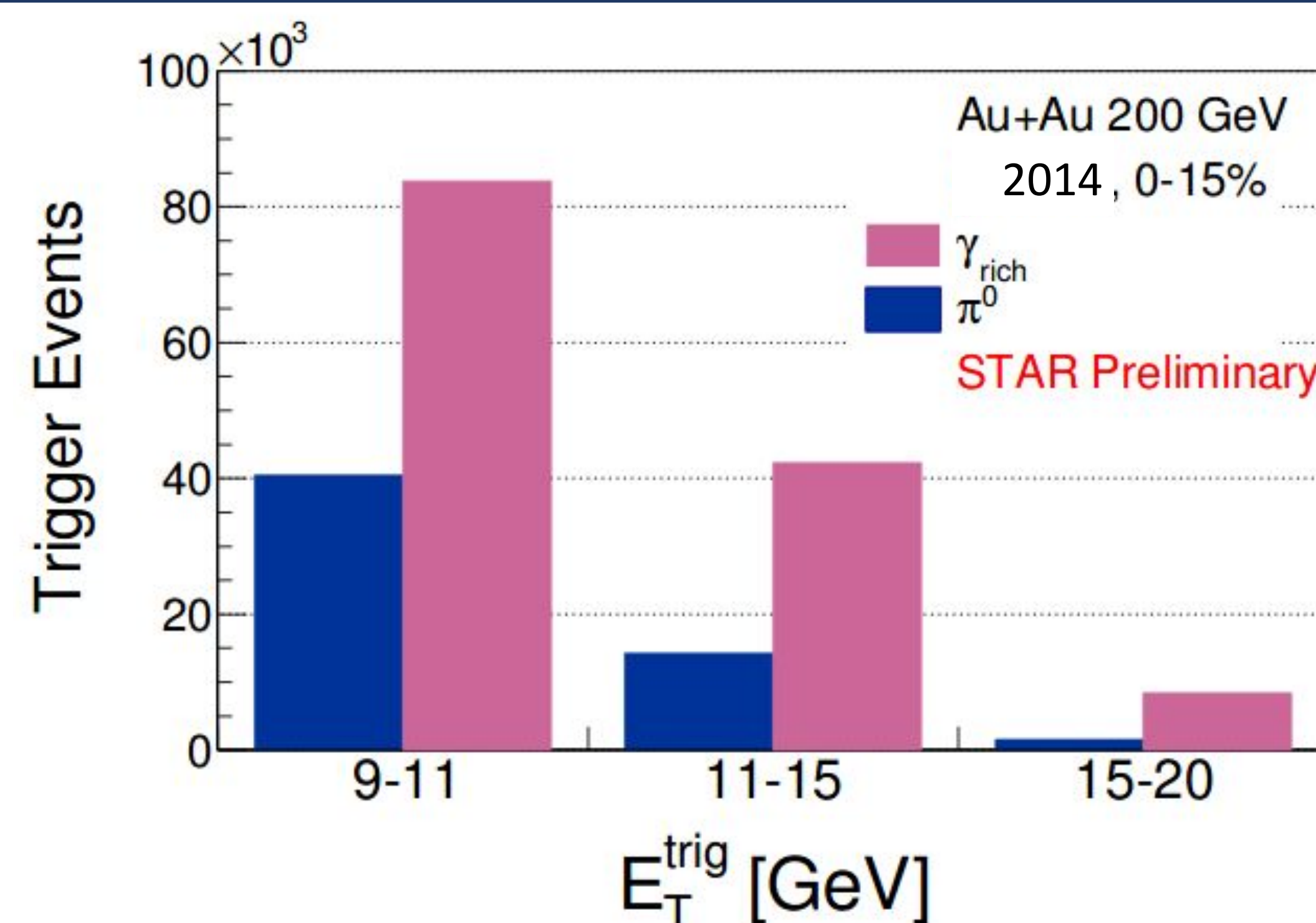


Fig. 3) Number of triggered events for different E_T ranges for 0-15% central collisions after making TSP selections.

Outlook

- The ability to identify direct photons at STAR using the TSP method has been demonstrated previously [1].
- 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 $x_{J\gamma}$ for anti- k_T $R=0.4$ jets and compare with a pp reference.

References

[1] "Jet-like Correlations with Direct-Photon and Neutral-Pion Triggers at $\sqrt{s_{NN}} = 200$ GeV" Adamczyk *et al.* (STAR Collaboration) Physics Letters B 760 (2016)

Acknowledgments

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