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Measurement of the neutral pion cross section in proton-proton collisions at $\sqrt{s} = 200\ GeV$ with PHENIX

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This study used the PHENIX electromagnetic calorimeters (EMCal), which have an azimuthal coverage of $90° + 90°$ and pseudo-rapidity coverage of ± 0.35. The data were collected during the proton-proton run in 2001–2002 at RHIC using the minimum bias (MB) from beam–beam counters (BBC) and newly installed EMCal triggers. The EMCal trigger was essential in enhancing the sample of neutral pions at high p_T. This trigger has two types: 2x2 non-overwrapping tower sum (0.8 GeV threshold) and 4x4 overwrapping tower sum (2 and 3 GeV thresholds). For higher p_T, this work is based upon the data collected via the 2x2 trigger whose rejection factor was 90. We will report only the measurement performed with the lead scintillator sampling calorimeter.

Figure 1 shows sample invariant mass spectra for two photons. Above a p_T of ~ 3 GeV/c, the ratio of the combinatorial background to the signal was $\sim$ 10%. To extract the number of π^0 in each p_T bin, several functions were used to fit to the combinatorial background over a variety of fit ranges. The systematic error was estimated from the variation of these fits and the run-to-run stability of the yield.

The acceptance, efficiency, and smearing correction was obtained by a Monte Carlo simulation which was tuned using results from the test beam measurements and the data itself. The systematic error was estimated from the change in the correction factor when the parameters were varied within their errors. Using the MB data, the π^0 efficiency of the 2x2 trigger was determined to plateau at 80% above a p_T of $\sim$3 GeV/c. A systematic error of 10% was assigned to this quantity by comparing it to the result from a Monte Carlo simulation which included the measured efficiencies for the tiles in the trigger. The bias for π^0 detection arising from the MB trigger condition was measured to be 75%, independent of p_T up to a p_T of $\sim$5 GeV/c using the sample data collected with a 4x4 trigger which, unlike the 2x2 trigger, did not impose the MB requirement. The MB trigger efficiency of 51% was obtained from a PYTHIA+GEANT simulation. We assigned a normalization error of 30% based on the difference between the cross section measured from a van der Meer/vernier scan and the total (elastic+inelastic) p+p cross section.

Figure 1 shows a comparison of an NLO pQCD calculation[1)] using the formalism of Adversa *et al.*[2)]

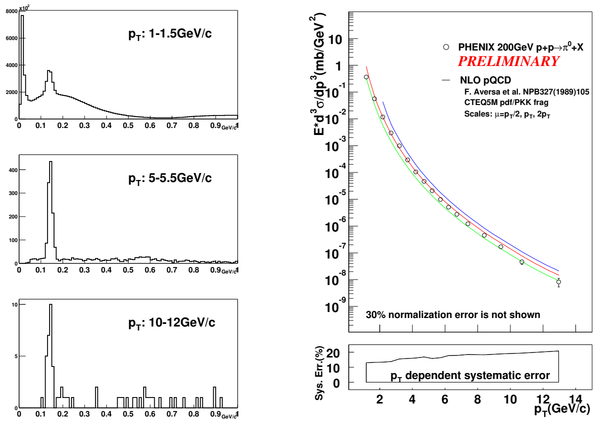

Fig. 1. [left] Invariant mass spectrum for p_T ranges of 1 to 1.5 GeV/c (top), 5 to 5.5 GeV/c (middle), and 10 to 12 GeV/c (bottom). [right] The inclusive neutral pion cross section (open circle) and comparison of NLO pQCD calculation using $p_T/2$ (top line), p_T (middle line), and $2p_T$ (bottom line) renormalization and factorization scales.

with the CTEQ5M parton distribution functions[3)] and the PKK fragmentation functions[4)]. The data for the lower p_T range is shown from the MB trigger samples to avoid the larger systematic error of the 2x2 trigger samples. Over the full p_T range, this calculation is consistent with our measurement within the systematic errors. The UA1 collaboration measured the $(h^+ + h^-)/2$ production cross section in the p–$\bar{p}$ collisions at $\sqrt{s} = 200$ GeV in the ± 2.5 rapidity range[5)]. When scaled to our rapidity range and corrected for the particle composition using ISR results[6)], our measurement is consistent with the UA1 measurement over their measured p_T range of 1 to 6 GeV/c.

The NLO pQCD calculation with a set of parton distribution and fragmentation function is consistent with our measurement over the full p_T range of 1 to 13 GeV/c within the systematic error and the scale selection.

References

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