University of Illinois at Urbana-Champaign

Degree of Doctor of Physics

Drell-Yan at COMPASS rocks it!

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To whom it may concern

Abstract

Dear Barbara Badelek, hereafter my abstract

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Chapter 1

Measurement of the Left Right Asymmetry in the Drell-Yan Process

Introduction about L/R asym. In this Chapter.... Define AN

1.1 Event Selection

The cuts in the event selection were chosen to ensure the final state consisted of dimuons resulting from a pion collision in the transversely polarized target. The event selection was initial filtered from miniDSTs to μDSTs using the criteria of at least two muons in the final state. The following event selection is performed on these μDSTs where the events used come from the slot1 production. A summary of the number of events remaining after each cut is shown in figure 1.1.

- Two oppositely charged particles from a common best primary vertex. The criteria for a primary vertex is any vertex with an associated beam particle. In case of multiple common vertices the best primary vertex was determined by CORAL tagging the vertex as best primary (PHAST method PaVertex::IsBestPrimary()). If CORAL did not tag any of the common vertices as the best primary the vertex with the smallest spatial chi^2 value was used as the best primary vertex.

- A dimuon trigger fired. A dimuon trigger firing means there are at least two particles in coincidence in this event. The dimuon triggers used were a coincidence between two particles in the large angle spectrometer, LAS-LAS trigger, or a particle in the large angle spectrometer and a particle in the Outer hodoscope in the small angle spectrometer, LAS-Outer trigger. The LAS-Middle trigger was used a veto on beam decay muons. This is because the LAS-Middle trigger was found to have many events resulting from a beam pion decaying to a muon.

- Both particles are muons. A muon was defined as having crossed 30 radiation lengths of material between the particles first and last measured points. This criteria has been previously determined to be effective at distinguishing between muons and hadrons. In the final production no detectors were used from upstream of the hadron absorber so the absorber is not included in the determination of material crossed.
- The first measured point for both particles is before 300 cm and the last measured point is after 1500 cm. This cut ensures both particles have positions upstream of the first spectrometer magnet and downstream of the first muon filter.
- The timing of both muons is defined. This checks that the time relative to the trigger time is determined for both muons so further timing cuts can be performed.
- Both muons are in time within 5 nanoseconds. This cut helps rejected uncorrelated muons.
- The muon tracks reduced chi^2 are individually less than 10. This cut ensure track quality.
- A validation that each muon crossed the trigger it was associated as having triggered. This trigger validation cut was performed by extrapolating (PHAST Method PaTrack::Extrapolate()) each muon track back to the hodoscopes it fired and determining if the muon crossed the geometric acceptance of both hodoscopes.
- The event does not occur in the bad spill or run list.
- The Drell-Yan kinematics are physical. That is the beam and target x-Bjorken are between 0 and 1 and x-Feynman is between -1 and 1.
- The transverse momentum of the virtual photon is between 0.4 and 5.0 GeV/c. The

lower limit ensures azimuthal angular resolution is sufficient and the upper cut is minimal and ensure physical kinematics.

- The vertex originated within the z-positions of the transversely polarized targets defined by the target group (-294.5< Z_{vertex} <-239.3 or -219.5< Z_{vertex} <-164.3 cm).
- The vertex is within the radius of the target defined as 1.9 cm.

1.2 Extraction of Asymmetries

1.2.1 Geometric Mean

The number of physics counts, N, detected from any particular target with any polarization can be written as

$$\mathrm{N} = \mathrm{L} * \sigma * \mathrm{a}, \tag{1.1}$$

where L is the luminosity, σ is the cross-section to produce such an event and a is the acceptance. In simple words, the number of counts detected is the number of chances for an event to occur times the probability for an event to occur and that the event will be detected. To get spin-dependent counts for the left, right asymmetry, the target, polarization and left or right direction relative to the spin should be included in the counts formula. Generically this can be written

$$\mathrm{N}^{\uparrow(\downarrow)}_{\text{target,Left(Right)}} = \mathrm{a}^{\uparrow(\downarrow)}_{\text{target,spectrometer direction}} * \mathrm{L}^{\uparrow(\downarrow)}_{\text{target}} * \sigma_{\text{Left(Right)}}, \tag{1.2}$$

where $^{\uparrow(\downarrow)}$ denotes the target polarization, $_{\text{target}}$ is either the upstream or downstream target $_{\text{Left(Right)}}$ is left or right of the spin direction and $_{\text{spectrometer direction}}$ denotes which side of the spectrometer the event was detected on.

The previous definitions of the detected counts all depend on the spectrometer acceptance. This is a problem because the spectrometer acceptance can change with time and space and therefore can be dependent on the physical kinematics which produced the event. Such

	W07	W08	W09	W10	W11	W12	W13	W14	W15	WAll
AllData	19410	19184	19654	20707	31371	23563	20561	13154	7697	175301
GoodSpills	15947	14899	16217	16895	23041	20184	16026	11796	7422	142427
xPion_xN_xF	15932	14886	16200	16885	23022	20171	16013	11794	7414	142317
0.4<qT<5	14342	13385	14609	15239	20667	18101	14365	10588	6636	127932
TargetZ-cut	4256	4024	4330	4552	6369	5503	4411	3130	2028	38603
TargetRadius	4175	3950	4257	4474	6252	5414	4334	3078	1987	37921

Figs 1.1 Events

dependences can cause unphysical false asymmetries in the measurement of A_N and must therefore be removed or must included as systematic effects.

The geometric mean asymmetry method is a way to determine the left, right asymmetry without acceptance effects from the spectrometer. It is defined as

$$\frac{1}{\mathrm{P}}\frac{\sqrt{N^{\uparrow}_{\text{target,Left}}N^{\downarrow}_{\text{target,Left}}}-\sqrt{N^{\uparrow}_{\text{target,Right}}N^{\downarrow}_{\text{target,Right}}}}{\sqrt{N^{\uparrow}_{\text{target,Left}}N^{\downarrow}_{\text{target,Left}}}+\sqrt{N^{\uparrow}_{\text{target,Right}}N^{\downarrow}_{\text{target,Right}}}}, \tag{1.3}$$

where P represents the fraction of polarized partons. Using Eq. 1.2 for the definition of counts, the geometric mean asymmetry is

$$\frac{1}{\mathrm{P}}\frac{\kappa\sqrt{\sigma_{Left}\sigma_{Left}}-\sqrt{\sigma_{Right}\sigma_{Right}}}{\kappa\sqrt{\sigma_{Left}\sigma_{Left}}+\sqrt{\sigma_{Right}\sigma_{Right}}}, \tag{1.4}$$

where κ is a ratio of acceptances defined as

$$\frac{\sqrt{\mathrm{a}^{\uparrow}_{\text{target,Jura}}\mathrm{a}^{\downarrow}_{\text{target,Saleve}}}}{\sqrt{\mathrm{a}^{\uparrow}_{\text{target,Saleve}}\mathrm{a}^{\downarrow}_{\text{target,Jura}}}}. \tag{1.5}$$

Here the detection side of spectrometer is specified by looking down the beam line as either Jura to mean left or Saleve to mean right. These relations of Jura is left and Saleve is right are only strictly true if in the target frame the polarization is pointing straight up or straight down. In particular if the beam particle and the target polarization do not make a right angle in the laboratory frame this relation will no longer be strictly true but is an approximation for ease of notation.

Relation 1.5 is equal to A_N if κ is equal to one. However time effects can vary κ from unity. These effects are estimated through false asymmetry analysis and included in the systematics. Equation 1.3 is therefore to a good approximation an acceptance free method to determine A_N. It is also defined for the upstream and downstream targets independently and therefore can used as a consistency check between the two targets.

1.3 Systematic Studies

1.4 Results

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Chapter 2

References