Pseudoscalar Meson Electroproduction Above the Resonance Region

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Abstract

One principal motivation for studying exclusive reactions is that they provide a new class of observables, called off-diagonal parton distributions, for the internal structure of the nucleon. The study of exclusive reactions provides a probe of nucleon structure complementary to purely inclusive studies. The simplest, and possibly the most promising, type of experiment is exclusive electroproduction of pseudoscalar mesons at small $t$, and at large $Q^2$ and $W$. We show that using the CLAS spectrometer at JLAB and with beam energies between 4 and 6 GeV, we can obtain good quality electroproduction data that will improve our understanding of nucleon structure.
1. Physics Motivations

The structure of the nucleon revealed in hard processes is described by parton distributions. Traditionally, the internal structure of the nucleon has been studied (CERN, SLAC, DESY) through inclusive scattering of high energy leptons in the deep inelastic scattering (DIS) limit, i.e. at large $Q^2$, $\nu$, and fixed Bjorken $x = Q^2/2m_p\nu$, where $Q^2$ and $\nu$ are the mass squared and energy of the virtual photon. For example, unpolarized DIS provided the first evidence that quarks carry only about 45% of the nucleon momentum via measurements of the structure function $F_1(x, Q^2)$, or the corresponding parton densities $q(x, Q^2)$. Recent measurements have focused on the leading-twist structure function $g_1(x, Q^2)$, which is roughly proportional to the inclusive spin asymmetry on a longitudinally polarized target. Polarized DIS measurements of $g_1(x, Q^2)$, or the relevant helicity densities $\Delta q(x, Q^2)$, have revealed that only about 30% of the nucleon’s spin is carried by the quark’s intrinsic spin \[1\].

Processes where at least one hadron is detected in the final state offer several distinct advantages over inclusive processes alone \[2\], and references therein. Particularly interesting is the chirally odd structure function $h_1(x, Q^2)$, or the appropriate transversity densities $\delta q(x, Q^2)$ \[3, 4\]. Together with $F_1(x, Q^2)$ and $g_1(x, Q^2)$, $h_1(x, Q^2)$ is necessary for a complete description of the quark structure of the nucleon in high-energy processes. The structure function $h_1(x, Q^2)$ has never been measured. Chirally odd quark distributions are difficult to measure because they are suppressed in totally inclusive deep inelastic scattering. However, the asymmetry for semi-inclusive leptoproduction of pions off transversely polarized target contains a contribution from $h_1(x, Q^2)$ that is enhanced at low $x$. Another motivation for the measurement of $h_1(x, Q^2)$ is a sensitivity to the role of relativistic effects in the nucleon state, and a possible sensitivity \[2\] to gluon contributions to the spin of the proton.

Exclusive electroproduction of mesons from nucleons has become a field of growing interest \[5, 6, 7\] since a full factorization theorem has been proved \[8, 9, 10\]. It has been shown that exclusive meson production at large $Q^2$ and small $t$ factorizes into a hard scattering coefficient, a quark-antiquark distribution amplitude of the meson, and an off-diagonal quark (or gluon) distribution that describes the “soft” physics in the nucleon. The proof of factorization applies when the virtual photon is longitudinally polarized. It has been also shown \[8\] that transverse polarization of the photon implies a power suppression in $Q$ relative to the case of longitudinal polarization. The theorem applies to the production of mesons at all $x$. Therefore, off-diagonal (also called off-forward \[9\] or non-forward \[10\]) parton distributions allow the description of certain exclusive reactions in the framework of QCD.

For longitudinally polarized vector mesons, the relevant parton densities are the unpolarized ones, $q(x, Q^2)$. For transversely polarized vector mesons, the parton densities are the quark transversity densities, $\delta q(x, Q^2)$. The original hope \[8\] that $h_1(x, Q^2)$ may be measured via production of transverse vector mesons has, unfortunately, not come true because in hard scattering processes such a transition is forbidden \[11, 12\]. For the pseudoscalar mesons, the relevant parton densities are the
quark helicity densities, $\Delta q(x, Q^2)$, which are not suppressed at large $x$. Hence, the polarized parton densities can be probed in unpolarized collisions.

It is clear that the study of exclusive and semi-inclusive reactions provides a probe of nucleon structure complementary to purely inclusive studies. In particular, we should study exclusive reactions at low $t$, and at high $Q^2$ and $W$, in the region of validity of QCD factorization theorems, and also in the transition region where standard partonic model may no longer be valid. One can then probe in a novel way the soft part of a proton, and elucidate the transition between soft and hard scattering processes.

A measurement of the differential cross section $\sigma(t, W, Q^2)$ for the reactions $e^- + p \rightarrow e^- + \pi^+(K^+) + n(\Lambda^o)$ at beam energies $4.0, 4.5, 5.0, 5.5$ and $6.0$ GeV was proposed and discussed [13]. Data will be collected simultaneously for $\pi^+, \pi^0$ and $K^+$ exclusive electroproduction using the CLAS detector at JLAB in the following kinematical region: $Q^2 > 1$ GeV$^2$ and $W > 2$ GeV. In the following sections existing data, cross section, detailed simulation, reconstruction and analysis of charged pions electroproduction will be discussed.

2. Cross Section

The procedure of extracting a virtual photon cross section $\sigma_{\gamma p}$ from the observed electroproduction cross section is based on the one-photon approximation. In this procedure electrons are regarded as providing a beam of virtual photons ($\text{flux } \Gamma$) of known polarization $\epsilon$, mass squared $Q^2$, and energy $\nu$. Electroproduction reactions can be described in terms of form factors that are generalizations of the form factors observed in elastic electron-proton scattering, or in terms of cross sections that are extensions of the photoproduction cross sections. The most general form of the differential cross section $\sigma$ for the reactions

$$e^- + p \rightarrow e^- + \pi^+(K^+) + n(\Lambda^o)$$

(1)

can be written in terms of four structure functions (unpolarized data) [14]:

$$\sigma_{\gamma p}(W^2, Q^2, t, \phi) = \sigma_T + \epsilon \sigma_L + \epsilon \sigma_{TT} \cos 2\phi + \sqrt{\epsilon(\epsilon + 1)/2} \cdot \sigma_{LT} \cos \phi$$

(2)

where $\sigma_T$, $\sigma_L$, $\sigma_{TT}$, and $\sigma_{LT}$ are functions of the variables: $Q^2, W^2 = 2m_p\nu - Q^2 + m_p^2$, and $t \equiv (p_{\gamma e} - p_{\pi,K})^2 - t_{\min}$ (or $\theta^*$, the angle between the virtual photon and the meson in the hadronic center of mass $W$). The dependence on the azimuthal angle $\phi$ (angle of the meson relative to the electron scattering plane: $\phi \equiv \phi^*$) is shown explicitly in eq. (2). The parameter $\epsilon$ is the polarization of the virtual photon $\epsilon = [4E_{\text{beam}}(E_{\text{beam}} - \nu) - Q^2]/[4E_{\text{beam}}(E_{\text{beam}} - \nu) + 2\nu^2 + Q^2]$. The term $\sigma_T$ represents the cross section for transverse photons, $\sigma_L$ represents the cross section for longitudinal photons, $\sigma_{TT}$ is the interference between the transverse amplitudes, and $\sigma_{LT}$ is the interference between transverse and longitudinal amplitudes. The terms $\sigma_{TT}$ and $\sigma_{LT}$ approach zero as $t \rightarrow 0$, and the terms $\sigma_L$ and $\sigma_{LT}$ vanish as $Q^2 \rightarrow 0$. In eq. (2),
the structure functions \( \sigma_T \) and \( \sigma_{TT} \) can be further decomposed into two parts: \( \sigma_\perp \) corresponds to incident photons polarized perpendicular to the hadronic plane, and \( \sigma_\parallel \) corresponds to photons polarized parallel to the hadronic plane: \( \sigma_T = (\sigma_\parallel + \sigma_\perp)/2 \), \( \sigma_{TT} = (\sigma_\parallel - \sigma_\perp)/2 \) and \( \sigma_{LT} = 2\text{Re}(A_L A_T^*) \).

**Transversely polarized target.** In eq. (2) we took explicitly into account the helicities of the virtual photon and ignored the helicities of ingoing and outgoing nucleon [14]. By taking into account the nucleon spin, \( \sigma_\parallel = |A_\parallel^N|^2 + |A_\parallel^F|^2 \), \( \sigma_\perp = |A_\perp^N|^2 + |A_\perp^F|^2 \), and \( \sigma_{LT} = 2\text{Re}(A_L^N A_L^F + A_F^N A_F^*) \), where N and F refer to nucleon flip and non-flip amplitudes, respectively. In the \( t \) channel, the contributions to \( A_{\parallel,\perp} \) come only from natural parity exchange, and contributions to \( A_{N,F}^\parallel \) and \( A_{N,F}^\perp \) come only from unnatural parity exchange. Using a transversely polarized target one obtains six more structure functions which are the imaginary parts of products of non-flip and flip amplitudes \( \text{Im}(A_N A_{L,F}^*) \).

Determination of the pion form factor from electroproduction data requires the extraction of that part of the cross section which contains the spin-flip amplitudes, i.e. \( |A_F|^2 \) and \( |A_F^L|^2 \).

The “inverse” reaction to \( \gamma p \rightarrow \pi^+ n \) is the \( \pi^+ n \rightarrow \rho^0 p \). Good quality data [15] exist only for the reaction \( \pi^- p \rightarrow \rho^0 n \) at 17.2 GeV. The measured differential cross section, for the above reaction, as a function of \( \sqrt{t} \) shows a behavior one would expect for one-pion exchange mechanism (spin flip amplitude) which vanishes at \( t = 0 \). The most interesting observation for the \( \pi^- p \rightarrow \rho^0 n \) reaction is the presence of strong polarization effects [16], i.e. a large left-right polarized target asymmetry (presence of non-flip amplitudes) in the low \( t \) region. A sizable asymmetry was also observed [17] in \( \pi^+ \) photoproduction from a polarized target at 5 and 16 GeV. A typical value of the asymmetry is about \(-0.5\) in both experiments. This is very surprising since, according to general belief, this region should be dominated by one-pion exchange and should, therefore, show little or no polarization effects.

### 3. Simulation

We have used the SDA Package [18] to simulate the \( ep \rightarrow e\pi^+(K^+)n(\Lambda^0) \) reactions and to reconstruct the events accepted in the CLAS detector. In order to estimate rates we have used the following form for the differential cross sections [20]:

\[
\frac{d^2\sigma}{dQ^2dW} = \frac{\alpha W}{\pi(1-\epsilon)(s-m_p^2)^2Q^2} \cdot \frac{d\sigma_{\gamma p}(W, Q^2, \theta^*, \phi^*)}{d\Omega_{\pi,K}}
\]

where the first term is a flux \( \Gamma \) of virtual photons, the second term, \( \sigma_{\gamma p} \), represents the four structure functions as shown by eq. (2), and \( s \) is the center-of-mass energy squared \( s = m_p^2 + 2m_p E_{\text{beam}} \).

In our simulation we have used the measured cross section \( \sigma_{\gamma p} \) at \( Q^2 < 1 \text{ GeV}^2 \) [21] and extrapolated to higher \( Q^2 \) values with a simple pole form: \( \sim (1 + Q^2/0.462)^{-2} \).
A sample of 1.6 million events was generated in the $Q^2$ range from 1.2 to 3.2 $GeV^2$ and in $W$ range from 2.05 to 2.15 $GeV$ for 5 beam energies: 4.0, 4.5, 5.0, 5.5 and 6.0 $GeV$. Realistic trajectories of charged particles traversing the CLAS magnetic field were simulated, including multiple scattering and the drift cell spatial resolution of 250 $\mu$m. For the purpose of the present study, both the scattered electron and the meson had to be detectable in the trigger scintillation counters and in all layers of the drift chambers in a given sector. Additionally, we required that the outgoing electron is within the acceptance of the Čerenkov and Shower Counters. These requirements (acceptance) provide optimal trajectory reconstruction for both charged particles, and also a good missing mass resolution.

Hereafter, we refer to the number of the generated events weighted by the cross section (see eq.(3)) at a given luminosity as the number of produced events, $N_{\text{prod}}$. A fraction of the $N_{\text{prod}}$ events that would have been accepted by the geometry of the CLAS detector is not observed because of reconstruction inefficiencies and various other losses like: decaying pions (kaons), secondary interactions, radiative corrections, missing mass cut, etc. These losses depend on the event kinematics and can be corrected for on an event-by-event bases [19]. In the present study, to account for these losses, we have introduced a constant global weight factor $w_g = N_{\text{acc}}/N_{\text{obs}} = 1.4$.

During the reconstruction process we assumed that opposite sectors of the CLAS detector are not perfectly aligned, but are rotated relative to each other randomly by an angle of 1 mrad. We also have assumed that each nominal beam energy is randomly off by 0.1%. The $W$, $Q^2$, and $t$ regions were chosen to obtain sufficient acceptance for at least 4 of the beam energies.

**Rates.** In Table 1, using eq. (3), we show the expected rates of produced $N_{\text{prod}}$ and fully reconstructed $N_{\text{obs}}$ events with a run of 100 hours/$E_{\text{beam}}$ of the CLAS detector at a luminosity $L = 10^{34} cm^{-2} s^{-1}$ for $\Delta W = 2.05 - 2.15 GeV$ and $\Delta \Omega_\pi = 2\pi \int sin\theta_\pi^* d\theta_\pi^* = 0.377sr$ ($\theta_\pi^* < 20^o$). The analysis of the CLAS data taken at a beam energy of 4 $GeV$ shows that the rates for semi-inclusive electroproduction of charged pions are approximately larger by a factor of 15.

### 4. Particle Identification

To identify scattered electrons we first determine the clusters in the Shower Counter. Negative tracks (potential electrons) which match these clusters are selected. These tracks are then checked to determine whether the deposited energy in the cluster agrees with the track momentum. For our kinematical conditions, outgoing mesons have momenta ranging from 2.0 to 3.5 $GeV$, therefore the Time-of-Flight technique is not adequate. Hence, the outgoing mesons are identified using a missing mass technique. Our preliminary analysis of 4 $GeV$ CLAS data indicate that the background under the missing mass peak of the neutron is only about a few percent.

### 5. Analysis of Reconstructed Events

From the reconstructed (observed) events $N_{\text{obs}}$, we extract the $Q^2$ and $t$ (or $\theta^*$) dependence of the structure functions: $\sigma_T$, $\sigma_L$, $\sigma_{TT}$ and $\sigma_{LT}$ in a model independent
way. The procedure consists of fitting the form of the differential cross section in eq. (3) to the measured cross sections in a given kinematical bin \( \Delta Q^2 \Delta W \Delta \phi^* \). The structure functions \( \sigma_T + \epsilon \sigma_L \), \( \sigma_{TT} \) and \( \sigma_{LT} \) can be isolated experimentally using the \( \phi \) dependence of the cross section at a given beam energy. A separation of \( \sigma_T \) and \( \sigma_L \) requires data measured at different beam energies.

The measured cross section \( \left( \frac{\partial \sigma_{\gamma p}}{\partial \vec{k}} \right)_m \) has been obtained from \( N_{\text{obs}} \pm \sqrt{N_{\text{obs}}} \) in each bin \( \Delta \vec{k} = \Delta Q^2 \Delta W \Delta \theta^* \Delta \phi^* \) in the following way:

\[
\left( \frac{\partial \sigma_{\gamma p}}{\partial \vec{k}} \right)_m = \frac{N_{\text{obs}}(\Delta \vec{k}) \cdot w_g(E_b)_m}{A(\Delta \vec{k}, E_b) \cdot L_m(E_b) \cdot F_m(\Delta W, \Delta Q^2, E_b) \cdot \Delta \vec{k}_m}
\]

(4)

The average acceptance \( A_m(\Delta \vec{k}, E_b) \) in each bin \( \Delta \vec{k} \) and at each beam energy has been determined by generating at random 400 events/bin. These events were transformed into the lab system with a random rotation of the electron scattering plane around the beam direction, and were checked to determine if the outgoing electron and meson both lie within the geometry of the CLAS detector [19]. In Table 2, as an example, we show the acceptance as a function of the c.m. angles (\( \theta^* \), \( \phi^* \)) for \( \Delta W = (2.05 - 2.15) \text{ GeV} \), \( \Delta Q^2 = (2.0 - 2.2) \text{ GeV}^2 \) and \( E_{\text{beam}} = 4.5 \text{ GeV} \).

The measured flux \( F_m(\Delta W, \Delta Q^2, E_b) \), in eq. (4), was obtained by averaging over all events observed in a bin \( \Delta W \Delta Q^2 \) and for given beam energy. In Fig. 1 we show, as an example, the derived differential cross sections as a function of \( \phi^* \) and \( E_{\text{beam}} \) for one bin \( k \) of size \( \Delta \vec{k} \Delta W \Delta Q^2 \Delta t \). To extract the four structure functions from the measured cross sections in a bin \( k \), as shown in Fig. 1, we used the following functional form in the \( \chi^2 \) minimization procedure:

\[
f(\phi^*)_k = \sum_i \left( P_1 + P_2 \cdot \epsilon_i + P_3 \cdot \epsilon_i \cdot \cos 2 \phi^* + P_4 \cdot \sqrt{\epsilon_i(\epsilon_i + 1)}/2 \cdot \cos \phi^* \right)
\]

(5)

where the index \( i \) runs over the different beam energies.

The four parameters \( P_1, P_2, P_3, \) and \( P_4 \) are determined from the fit. The virtual photon polarization \( \epsilon_i \) was evaluated at the center of the \( \Delta W \) and \( \Delta Q^2 \) bins. Data with \( A(\Delta \vec{k}, E_b) < 2\% \) were excluded from the fit, see Table 1. The \( Q^2 \) dependence of the four structure functions and their statistical errors, derived from the fits, are summarized in Fig. 2 for pions only (see full circles with error bars). The dashed or solid curves in Fig. 2 represent the input to the Monte Carlo simulation. The full squares and the stars in Fig. 2 represent the currently available data [22]. The fitting procedure also includes the expected systematic errors in determining the luminosity \( L_m(E_b) \) of \( \leq 1\% \) and a global correction \( w_g(E_b)_m \) of \( \leq 2\% \); i.e., uncorrelated systematic errors at each beam energy setting. In addition to the above, we introduced a correlated systematic error (common to all beam energies) of about 3\%. The successful \( \sigma_L \) and \( \sigma_T \) separation was possible, in the above kinematical regions, once sufficient data were collected for at least 4 of the 5 beam energies.
6. Summary

A challenging problem in particle physics is to understand the transition from the “current” quarks and gluons appearing in the QCD Lagrangian to the degrees of freedom of low-energy QCD. One could take the approach that anything that can be calculated by pQCD can be called a hard process. All the rest would be soft. Soft interactions are usually understood as the interactions of hadrons at a relatively small scale (low $Q^2$ in $ep$ interactions or low $p_T$ in hadron-hadron interactions). The problem, however, is that what we calculate and what we measure are not the same. Soft interactions are not easily disentangled from hard ones [23]. That said, let us summarize here what we can measure in a model independent way.

Stage 0. Analyze the existing data taken at a beam energy of 4 GeV. Extract the $Q^2$ and $t$ dependences of the structure functions: $\sigma_T + \epsilon \sigma_L$, $\sigma_{TT}$, and $\sigma_{LT}$.

Stage 1. Take new data at beam energies: 4.5, 5.0, 5.5 and 6.0 GeV, and now disentangle the $\sigma_L$ and $\sigma_T$ cross sections.

Stage 2. Measure, for the first time, asymmetries for exclusive and semi-inclusive electroproduction on transversely polarized target. Technically, it is a challenging task to operate CLAS with the strong transverse magnetic field of a polarized target.

Conclusion

We have shown that using the CLAS spectrometer at JLAB and with beam energies between 4 and 6 GeV, we can obtain good quality electroproduction data that will improve our understanding of the nucleon structure as well as the hadronic properties of the photon. We emphasize the importance of studying both the $Q^2$ and $t$ dependencies of the various structure functions for $\pi^+$, $\pi^0$ and $K^+$ exclusive electroproduction. In order to access higher $W$ and $Q^2$ at higher beam energies, we need to design a new large acceptance detector in the forward direction.

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Figure 1: An example of the derived differential cross section as a function of $\phi^*$ and $E_{\text{beam}}$ for $Q^2 = 2.1\text{ GeV}^2$. 
Figure 2: The $Q^2$ dependence of the four structure functions and their statistical errors, derived from fits, for pions. Existing data [22]: $\sigma_L$ (□) and $\sigma_T$ (⋆)

$<W> = 2.1$ GeV and $\Theta^*_x < 20^\circ$
($\Delta W = 0.1$ and $\Delta Q^2 = 0.2$

$E_{beam} = 4.0, 4.5, 5.0, 5.5$ and $6.0$ GeV
(100hr/$E_{beam}$ at $L=10^{24}$ s$^{-1}$cm$^{-2}$)

- This Proposal
  Curves $\propto (1 + Q^2/0.462)^{-2}$
  P.R. D8 1978, p.92

Bebek et al., P.R. D17 (1978)1693
$<W,Q^2>$= (2.15,1.2), (2.65,2.0), (2.65,3.3)

- $\sigma_L$ ($\Theta^*_x < 10^\circ$)
- $\sigma_T$ ($\Theta^*_x < 10^\circ$)
Table 1: Expected rates of produced ($N_{\text{prod}}/100\text{hr}$) and reconstructed ($N_{\text{obs}}/100\text{hr}$) $\pi^+$ mesons using the CLAS detector at a luminosity of $10^{34} cm^{-2}s^{-1}$ for $\Delta W = (2.05 - 2.15) GeV$ and $\Delta\Omega_{\pi} = 0.377 sr$ ($\theta^*_\pi < 20^o$).

| $\Delta Q^2$ | $E_b = 4.0$ | $E_b = 4.5$ | $E_b = 5.0$ | $E_b = 5.5$ | $E_b = 6.0$ |
|--------------|-------------|-------------|-------------|-------------|-------------|
|              | $N_{\text{prod}}$ | $N_{\text{obs}}$ | $N_{\text{prod}}$ | $N_{\text{obs}}$ | $N_{\text{prod}}$ | $N_{\text{obs}}$ | $N_{\text{prod}}$ | $N_{\text{obs}}$ | $N_{\text{prod}}$ | $N_{\text{obs}}$ |
| 1.4 - 1.6    | 36349       | 43455       | 49217       | 53913       |
|              | 13226       | 13547       | 11511       | 6677        |
| 1.6 - 1.8    | 23494       | 28537       | 32698       | 36107       | 38980       |
|              | 8946        | 10395       | 10073       | 8091        | 5059        |
| 1.8 - 2.0    | 15564       | 19372       | 22451       | 25049       | 27130       |
|              | 5968        | 7566        | 7755        | 7283        | 5957        |
| 2.0 - 2.2    | 10527       | 13480       | 15805       | 17756       | 19441       |
|              | 3918        | 5440        | 5999        | 5975        | 5343        |
| 2.2 - 2.4    | 7262        | 9545        | 11399       | 12926       | 14175       |
|              | 2552        | 3987        | 4533        | 4692        | 4511        |
| 2.4 - 2.6    | 6881        | 8325        | 9571        | 10511       |
|              | 2855        | 3494        | 3738        | 3678        |
| 2.6 - 2.8    | 5011        | 6196        | 7182        | 8012        |
|              | 2017        | 2645        | 2942        | 3016        |
| 2.8 - 3.0    | 3682        | 4670        | 5472        | 6144        |
|              | 1419        | 1994        | 2311        | 2457        |
| 3.0 - 3.2    | 2734        | 3541        | 4219        | 4779        |
|              | 974         | 1487        | 1792        | 1960        |
Table 2: An example of the acceptance as a function of the c.m. angles \((\theta^*_\pi, \phi^*_\pi)\) for \(\Delta W = (2.05 - 2.15)\) GeV, \(\Delta Q^2 = (2.0 - 2.2)\) GeV\(^2\) and \(E_{\text{beam}} = 4.5\) GeV.

| \(\Delta \phi^*_\pi [^\circ]\) | \(\Delta \theta^*_\pi [^\circ]\) 0 - 5 | \(\Delta \theta^*_\pi [^\circ]\) 5 - 10 | \(\Delta \theta^*_\pi [^\circ]\) 10 - 15 | \(\Delta \theta^*_\pi [^\circ]\) 15 - 20 |
|--------------------------|-----------------|-----------------|-----------------|-----------------|
| 0 - 18                  | 0.72            | 0.70            | 0.67            | 0.68            |
| 18 - 36                 | 0.67            | 0.69            | 0.64            | 0.63            |
| 36 - 54                 | 0.68            | 0.66            | 0.57            | 0.51            |
| 54 - 72                 | 0.64            | 0.54            | 0.53            | 0.48            |
| 72 - 90                 | 0.64            | 0.59            | 0.48            | 0.45            |
| 90 - 108                | 0.64            | 0.55            | 0.45            | 0.39            |
| 108 - 126               | 0.68            | 0.52            | 0.43            | 0.39            |
| 125 - 144               | 0.70            | 0.58            | 0.46            | 0.41            |
| 144 - 162               | 0.64            | 0.60            | 0.52            | 0.44            |
| 162 - 180               | 0.63            | 0.66            | 0.60            | 0.42            |
| 180 - 198               | 0.67            | 0.61            | 0.57            | 0.41            |
| 198 - 216               | 0.66            | 0.60            | 0.56            | 0.41            |
| 216 - 234               | 0.64            | 0.55            | 0.44            | 0.34            |
| 234 - 252               | 0.64            | 0.55            | 0.49            | 0.36            |
| 252 - 270               | 0.63            | 0.52            | 0.50            | 0.45            |
| 270 - 288               | 0.67            | 0.59            | 0.52            | 0.43            |
| 288 - 306               | 0.67            | 0.61            | 0.54            | 0.46            |
| 306 - 324               | 0.69            | 0.63            | 0.53            | 0.56            |
| 324 - 342               | 0.73            | 0.69            | 0.66            | 0.59            |
| 342 - 360               | 0.68            | 0.71            | 0.66            | 0.70            |