Measurement of Transition Form Factor of η meson with WASA detector at COSY

Himani Bhatt

For WASA - at - COSY Collaboration,

IIT Bombay, India







Outline



- Transition Form Factor
- Experimental Set-up
- > Analysis for $\eta \rightarrow e^+e^-\gamma$
 - Background studies
 - Kinematic studies
 - Preliminary Results
- Summary and outlook



Introduction



- How quarks and gluons are confined inside the nucleon ?
- The study of phenomenological characteristics of hadrons should lead to better understanding of QCD .

Transition Form Factor

• Transition Form Factor $F(q^2)$ is defined as :

$$\frac{d\Gamma}{dq^2} = \left| \frac{d\Gamma}{dq^2} \right|_{\text{pointlike}} \left| F(q^2) \right|^2$$

where , $|d\Gamma/dq^2|$ is experimentally measured and $|d\Gamma/dq^2|_{poinlike}$ is the theoretically calculated transition probability for a point like meson.

• One can use the Dalitz decay of $\eta \rightarrow \gamma^* \gamma \rightarrow l^+ l^- \gamma$.

$$q^2 = m_{l^+ l^-}^2$$



Transition Form Factor



Vector Meson Dominance Model (VMD) describes the q² dependency of the transition form factor. (L. G. Landsberg, Phys. Rep. 128, 301(1985))

$$F^{VDM}(q^{2}) = \sum_{V} \frac{g'_{PV\gamma}}{2g_{V\gamma}} \frac{M_{V}^{2}}{M_{V}^{2} - q^{2}} \qquad F_{P}(q^{2}) \qquad F_{P}(q^{2}) \qquad F_{V}(q^{2}) \qquad F$$

• The transition form factor of a scalar meson is parameterized using the pole approximation

$$F = \frac{1}{1 - \frac{q^2}{\Lambda^2}} \approx 1 + \frac{q^2}{\Lambda^2}$$

• Additionally one can determine the slope of the transition form factor

$$b_{\eta} = \frac{dF_{\eta}}{dq^2} \bigg|_{q^2=0} = \frac{1}{\Lambda^2}$$



Transition Form Factor



Earlier results by investigating the Dalitz decays : $\eta \rightarrow e^+e^-\gamma$ and $\eta \rightarrow \mu^+\mu\gamma$

Experiments	b _η / GeV ⁻²
Lepton-G ¹	1.9 ± 0.04
NA60 ²	$1.95 \pm 0.17 \pm 0.05$
SND ³	1.6 ± 2.0
HADES ⁴	2.30 - 1.3 + 0.4



VDM predicts $b_{\eta} = 1.8 \text{ GeV}^{-2}$

Hence the measurements also test VMD

R. Djeliadin, et al., Phys. Lett. B 94 (1980) 548.
 R. Arnaldi et. al , Phys. Lett .B 677(2009), 260-266).
 M.N. Achsov et. al. , Phys. Lett. B 504 (2001) 275 -281
 B. Spruck , GSI Scientific Report, 2008



Experimental set up





- WASA (Wide Angle Shower Apparatus) at COSY (Juelich , Germany) is a 4π detector
- Data analyzed with reaction :

 $pp \rightarrow pp\eta \ (e^+e^-\gamma)$, at beam kinetic energy 1.4 GeV.







- ► Event Selection for Dalitz decay (pp \rightarrow pp η \rightarrow pp $e^+e^-\gamma$).
 - Two charged tracks in FD
 - Two charged tracks in CD having opposite charge
 - One neutral track in CD with $E_{dep} > 180 \text{ MeV}$
- Invariant Mass is obtained by summing the reconstructed masses of the decay products of η meson (e⁺, e⁻, γ).
- > Missing Mass is obtained as following:

$$MM_{pp}^{2} = (E_{beam} - E_{p_{1}} - E_{p_{2}})^{2} - (\vec{p}_{beam} - \vec{p}_{p_{1}} - \vec{p}_{p_{2}})^{2}$$

where, E_p and \vec{p} are energy and momentum of scattered proton.



Simulations studies

Counts/ 10 MeV



10⁷ events generated using Pluto event generator.



Channel	Cross section
$\eta \rightarrow e^+ e^- \gamma$	6.8×10 ⁻⁵
$\eta ightarrow \pi^+\pi^-\gamma$	4.68 ×10 ⁻⁴
$\eta \rightarrow \pi^+ \pi^- \pi^0$	2.2 ×10 ⁻³
$\eta \rightarrow \gamma \gamma$	3.9 ×10 ⁻³
$pp ightarrow pp \; \pi^+\pi^-\pi^0$	0.02
$pp ightarrow pp \; \pi^+\pi^-$	1

cross section of signal and background.



Invariant Mass (GeV/c^2)



Analysis



Data from the production run April 07



9



Kinematic studies



Conditions are used to suppress the background coming from direct pion production





Kinematic studies



Conditions are used to suppress the pion background coming from η decays





Suppression of $\eta \rightarrow \gamma \gamma$



- $\eta \rightarrow \gamma \gamma$ reaction contributes as background due to external conversion of one of the photon at beam pipe.
- An orientation angle (Φ_V)* of plane of e⁺ and e⁻ with respect to magnetic field has been calculated.



* PhD Dissertation by Torsten Dahms (Stony Brook University for PHENIX), 2008



Preliminary Results





After conditions









- ✤ Large amount of pion background has been removed successfully.
- 270 ± 18 , η Dalitz events have been reconstructed .
- ✤ For further cleaning the data, use of kinematic fitting is being investigated.
- ✤ To increase the statistics we are analyzing new pp data taken in Oct-2008.



Suppression of $\eta \rightarrow \gamma \gamma$

Angular orientation of the plane v (vector product of p_{e+} and p_{e-}) define as follows:

$$\Phi_V = \cos^{-1}\left(\frac{\vec{w}\cdot\vec{u}_a}{|\vec{w}||\vec{u}_a|}\right)$$

where, $\vec{u} = \frac{\vec{p}_{e^+} + \vec{p}_{e^-}}{|\vec{p}_{e^+} + \vec{p}_{e^-}|}$ is the apparent decay plane of the conversion pair. $\vec{v} = \vec{p}_{e^+} \times \vec{p}_{e^-}$, $\vec{w} = \vec{u} \times \vec{v}$ and $\vec{u}_a = \frac{\vec{u} \times \hat{z}}{|\vec{u} \times \hat{z}|}$