A Dalitz Plot Analysis of $\omega \to 3\pi$ Decay

Chris Zeoli

Florida State University

cpz11@my.fsu.edu

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Overview

- Goals
- G12 Data
- Fit Function in Brief
- Analysis
- Next Steps

Goals

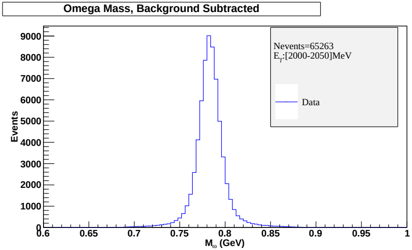
Main Goal

- Fit a modified Khuri-Treiman (KT) Model for the $\omega \to 3\pi$ decay.
- Fit the decay amplitude via event-based likelihood fits using AmpTools framework.
- Compare fit parameters with known results from other models

CLAS G12 Data

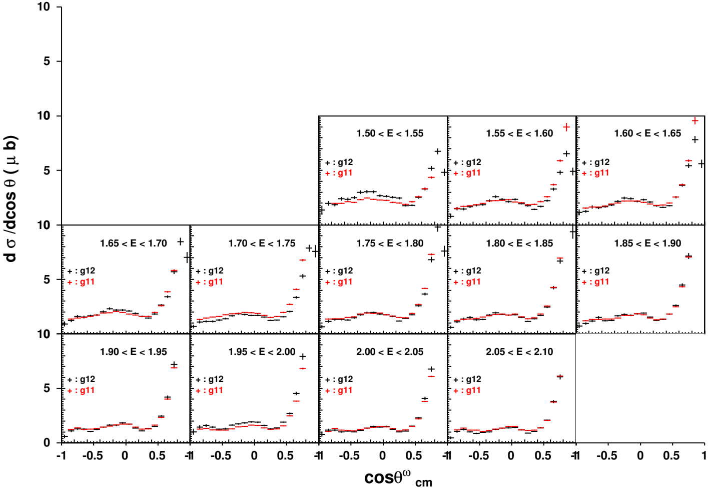
Data	Total Events
-data	8,200,000
-genMC	14,000,000
-accMC	1,500,000

Average Acceptance $\approx$ 0.107



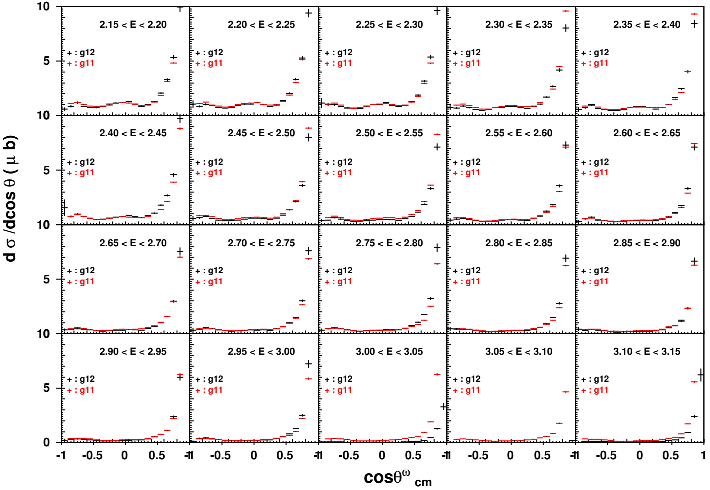
- G12 data covers incoming photon energy range E_γ:[1150-5400]MeV
- Have G12 x-section E_γ:[1150-3800]MeV, extending to 5400MeV, need G12 SDME's still
- We use G11 x-section, SDME's data; range E_γ:[1107.4-3828.9]MeV
- We consider bins in range E_γ:[1150-3800]MeV

G12, G11 Cross-Section Comparison



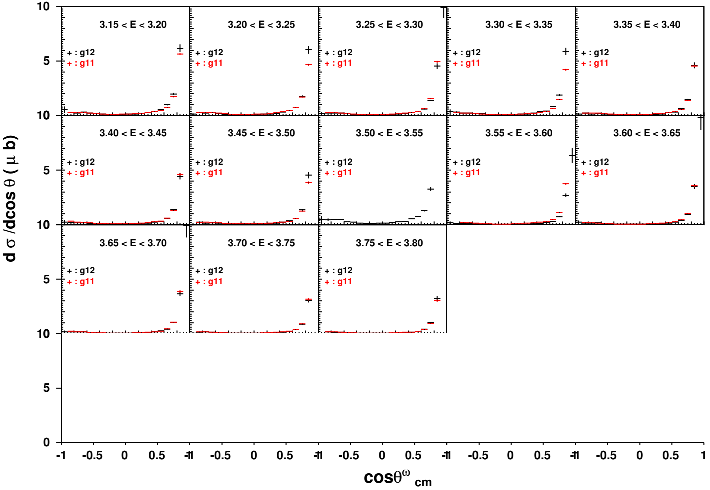
$E\gamma$:[1500-2010]MeV, Zulkaida Akbar

G12, G11 Cross-Section Comparison



$E\gamma$:[2150-3150]MeV, Zulkaida Akbar

G12, G11 Cross-Section Comparison



$E\gamma$:[3150-3800]MeV, Zulkiada Akbar

Paper for Model

JLAB-THY-14-1960

Dispersive Analysis of $\omega/\phi \to 3\pi$, $\pi\gamma^*$

I.V. Danilkin,[1,*] C. Fernández-Ramírez,[1] P. Guo,[2,3] V. Mathieu,[2,3] D. Schott,[4] M. Shi,[1,5] and A. P. Szczepaniak[1,2,3]
(Joint Physics Analysis Center)
[1]*Center for Theoretical and Computational Physics, Thomas Jefferson National Accelerator Facility, Newport News, VA 23606*
[2]*Center for Exploration of Energy and Matter, Indiana University, Bloomington, IN 47403*
[3]*Physics Department, Indiana University, Bloomington, IN 47405*
[4]*Department of Physics, The George Washington University, Washington, DC 20052*
[5]*Department of Physics, Peking University, Beijing 100871, China*
(Dated: September 30, 2014)

The decays $\omega/\phi \to 3\pi$ are considered in the dispersive framework that is based on the isobar decomposition and sub-energy unitarity. The inelastic contributions are parametrized by the power series in a suitably chosen conformal variable that properly account for the analytic properties of the amplitude. The Dalitz plot distributions and integrated decay widths are presented. Our results indicate that the final state interactions may be sizable. As a further application of the formalism we also compute the electromagnetic transition form factors of $\omega/\phi \to \pi^0\gamma^*$.

arXiv:1409.7708v1 [hep-ph] (2014)

Illustration

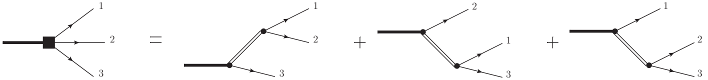


FIG. 1: Isobar decomposition.

Isobar Model

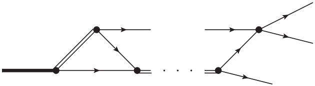


FIG. 2: Crossed channel rescattering effects.

consequence of elastic unitarity
requirement of model

Model

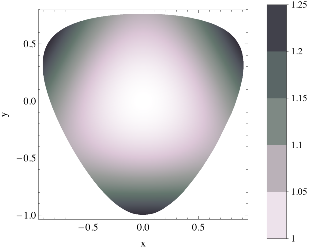
$$F(s) = \Omega(s)\left(\frac{1}{\pi}\int_{s_\pi}^{s_i} ds'\,\frac{\rho(s')\,t^*(s')}{\Omega^*(s')}\,\frac{\hat{F}(s')}{s'-s} + \Sigma(s)\right). \tag{31}$$

The Decay Amplitude

$$\Sigma(s) = \sum_{i=0}^{\infty} a_i\,\omega^i(s) \tag{29}$$

inelastic contribution
($a_0 =$ IgorParameter)

Dalitz Analysis



Expected Dalitz Plot

$$
\begin{aligned}
x &= \frac{\sqrt{3}}{Q}(T_1 - T_2) = \frac{\sqrt{3}(t-u)}{2M(M-3\,m_\pi)}, \\
y &= \frac{3\,T_3}{Q} - 1 = \frac{3(s_c - s)}{2M(M-3m_\pi)}\,. \qquad (38)
\end{aligned}
$$

Lorentz Invariant Variables

$$
\begin{aligned}
x &= \sqrt{z}\cos\theta \\
y &= \sqrt{z}\sin\theta
\end{aligned}
$$

$$
|F_{par}(z,\vartheta)|^2 = |N|^2\big(1 + 2\,\alpha\,z + 2\,\beta\,z^{3/2}\sin(3\vartheta) + 2\,\gamma\,z^2 + 2\,\delta\,z^{5/2}\sin(3\vartheta) + \mathcal{O}(z^3)\big) \qquad (40)
$$

Dalitz Plot Amplitude Expansion

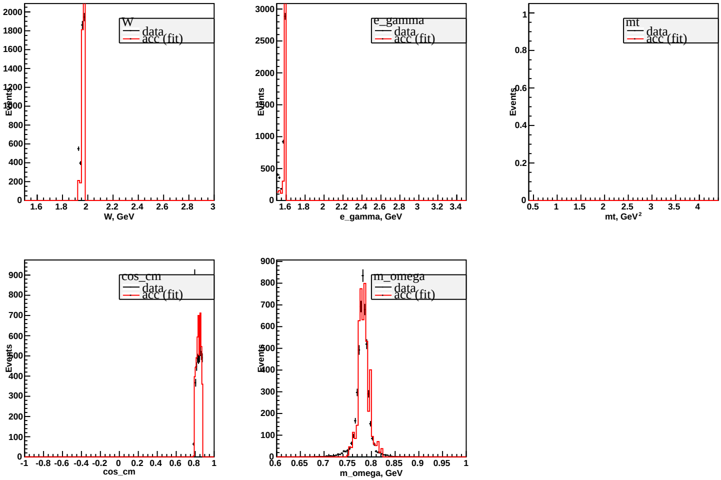
Dalitz Plot Parameter Comparison

$$|F_{par}(z,\vartheta)|^2 = |N|^2\big(1 + 2\,\alpha\,z + 2\,\beta\,z^{3/2}\sin(3\vartheta) + 2\,\gamma\,z^2 + 2\,\delta\,z^{5/2}\sin(3\vartheta) + \mathcal{O}(z^3)\big) \qquad (40)$$

TABLE I: Dalitz Plot parameters and $\sqrt{\bar{\chi}^2}$ of the polynomial parametrization (40) for $\omega \to 3\pi$. In addition to our results we also show the selected results from Niecknig et al. [37] (dispersive study with incorporated crossed-channel effects) and Terschlusen et al. [19] (Lagrangian based study with the pion-pion rescattering effects).

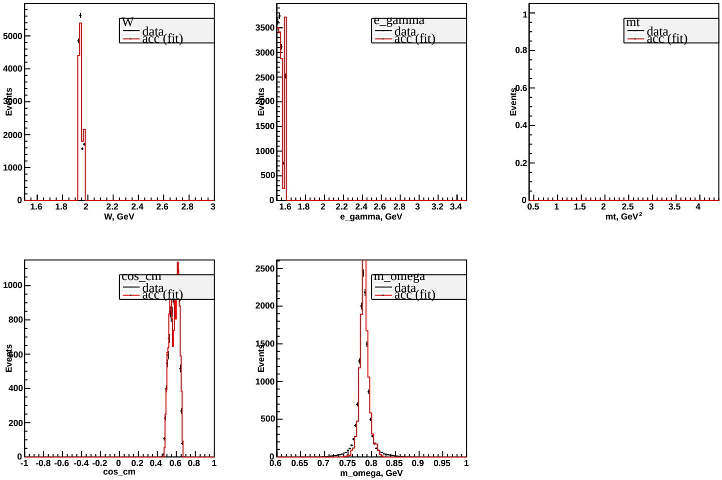
	$\alpha \times 10^3$	$\beta \times 10^3$	$\gamma \times 10^3$	$\delta \times 10^3$	$\sqrt{\bar{\chi}^2} \times 10^3$
This paper ($\hat{F} = 0$)	136	-	-	-	3.5
This paper (full)	94	-	-	-	3.2
Niecknig et al. [37]	84...96	-	-	-	0.9...1.1
Terschlusen et al. [19]	202	-	-	-	6.6
This paper ($\hat{F} = 0$)	125	30	-	-	0.74
This paper (full)	84	28	-	-	0.35
Niecknig et al. [37]	74...84	24...28	-	-	0.052...0.078
Terschlusen et al. [19]	190	54	-	-	2.1
This paper ($\hat{F} = 0$)	113	27	24	-	0.1
This paper (full)	80	27	8	-	0.24
Niecknig et al. [37]	73...81	24...28	3...6	-	0.038...0.047
Terschlusen et al. [19]	172	43	50	-	0.4
This paper ($\hat{F} = 0$)	114	24	20	6	0.005
This paper (full)	83	22	1	14	0.079
Niecknig et al. [37]	74...83	21...24	0...2	7...8	0.012...0.011
Terschlusen et al. [19]	174	35	43	20	0.1

Analysis: Kinematics



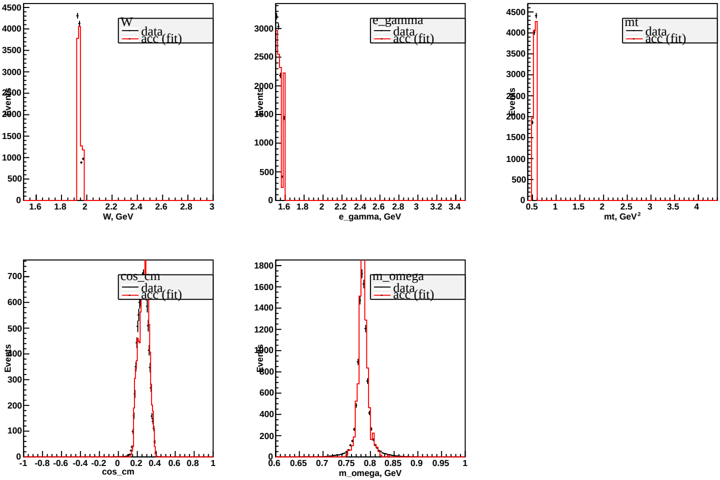
$E\gamma$:[1500-1600]MeV and t:[0.100-0.200]GeV^2

Analysis: Kinematics



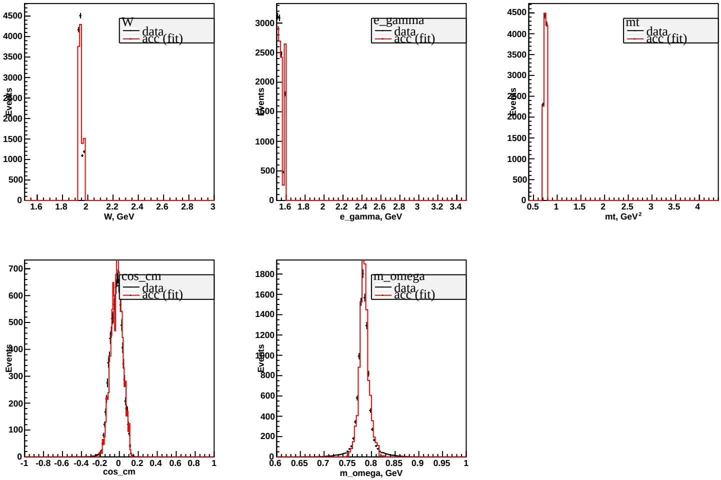
$E\gamma$:[1500-1600]MeV and t:[0.300-0.400]GeV^2

Analysis: Kinematics



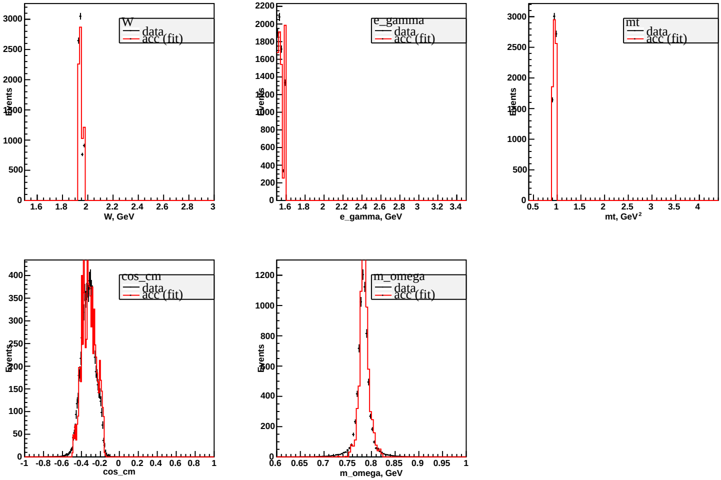
$E\gamma$:[1500-1600]MeV and t:[0.500-0.600]GeV^2

Analysis: Kinematics



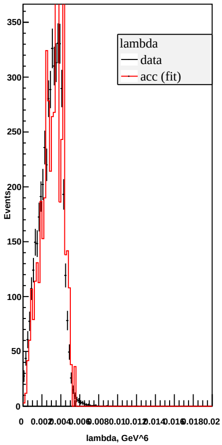
$E\gamma$:[1500-1600]MeV and t:[0.700-0.800]GeV^2

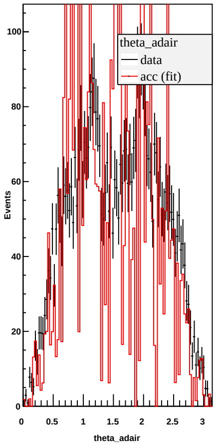
Analysis: Kinematics

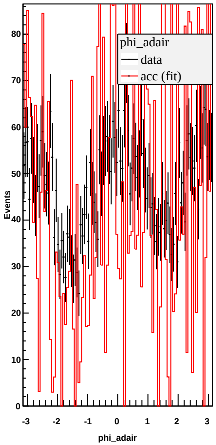


$E\gamma$:[1500-1600]MeV and t:[0.900-1.000]GeV^2

Analysis: Kinematics

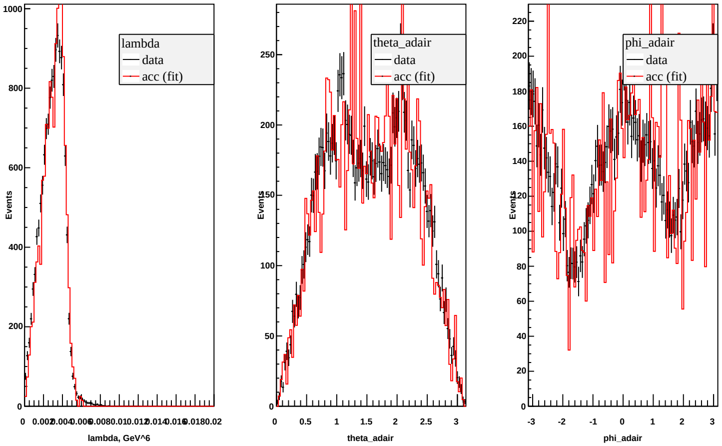






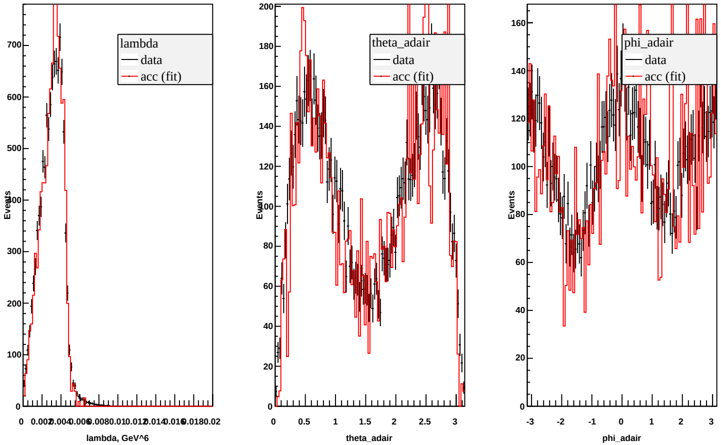
$E\gamma$:[1500-1600]MeV and t:[0.100-0.200]GeV^2

Analysis: Kinematics



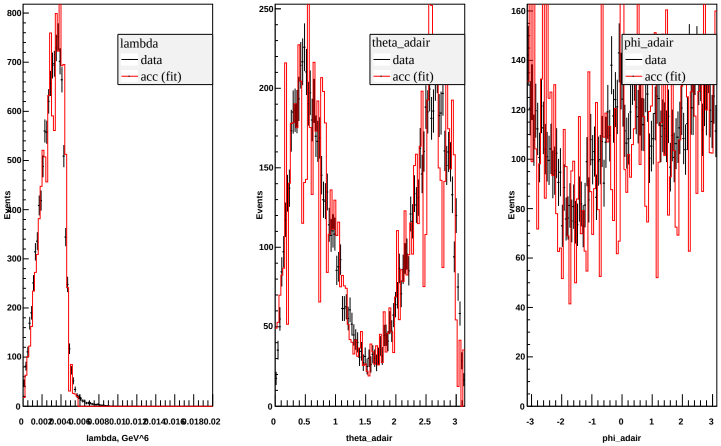
$E\gamma$:[1500-1600]MeV and t:[0.300-0.400]GeV^2

Analysis: Kinematics



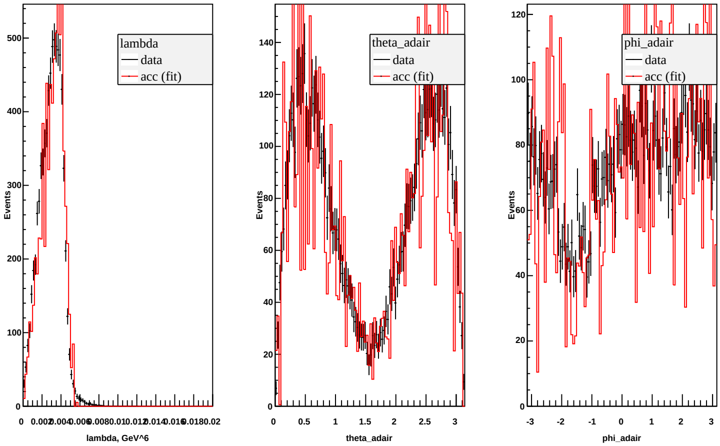
$E\gamma$:[1500-1600]MeV and t:[0.500-0.600]GeV^2

Analysis: Kinematics



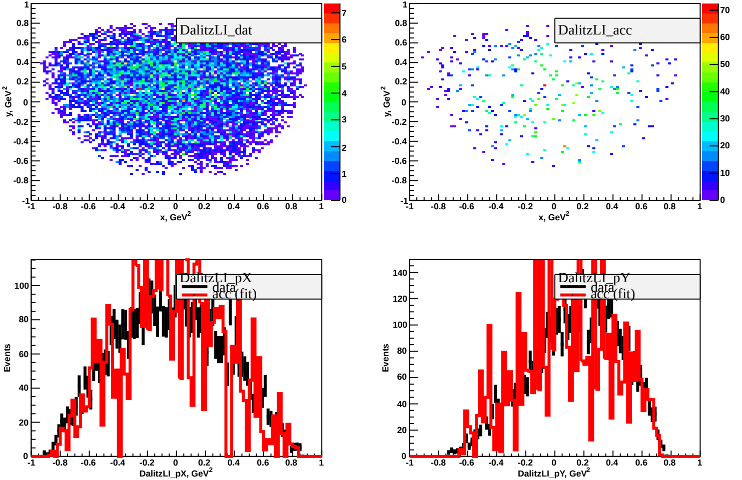
$E\gamma$:[1500-1600]MeV and t:[0.700-0.800]GeV^2

Analysis: Kinematics



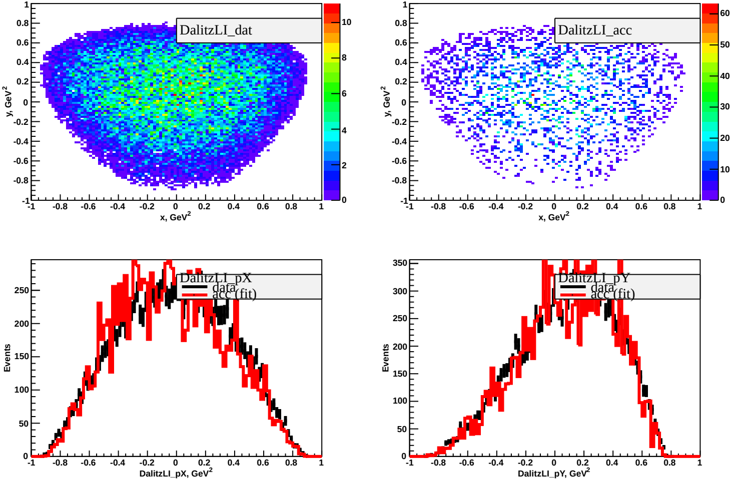
$E\gamma$:[1500-1600]MeV and t:[0.900-1.000]GeV^2

Analysis: Kinematics



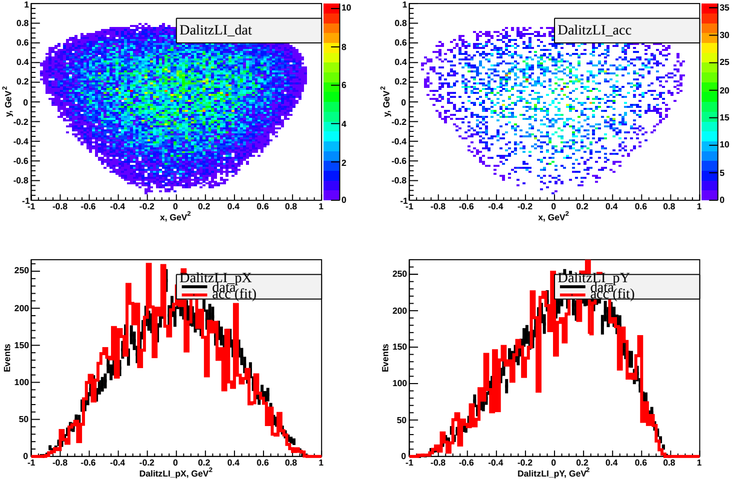
$E\gamma$:[1500-1600]MeV and t:[0.100-0.200]GeV^2

Analysis: Kinematics



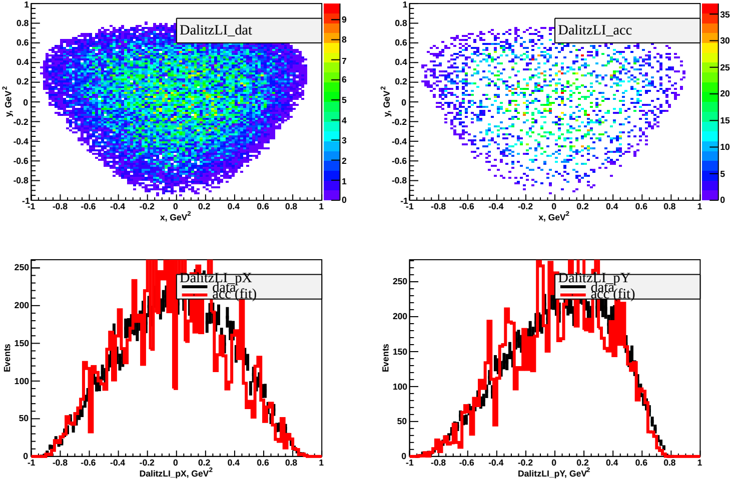
$E\gamma$:[1500-1600]MeV and t:[0.300-0.400]GeV^2

Analysis: Kinematics



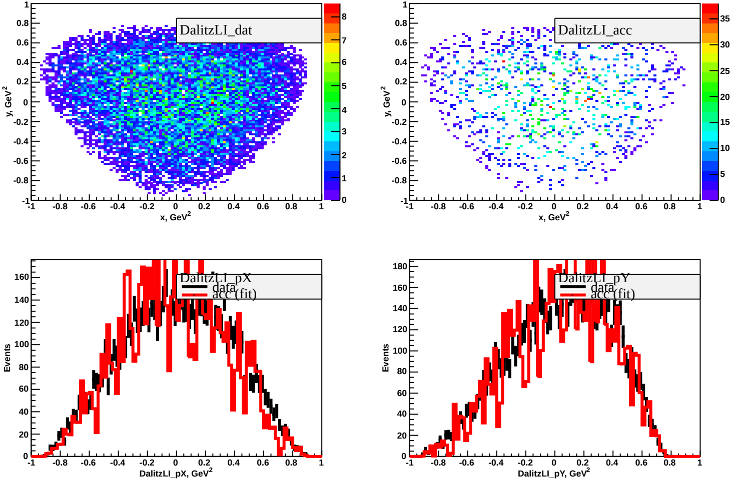
$E\gamma$:[1500-1600]MeV and t:[0.500-0.600]GeV^2

Analysis: Kinematics



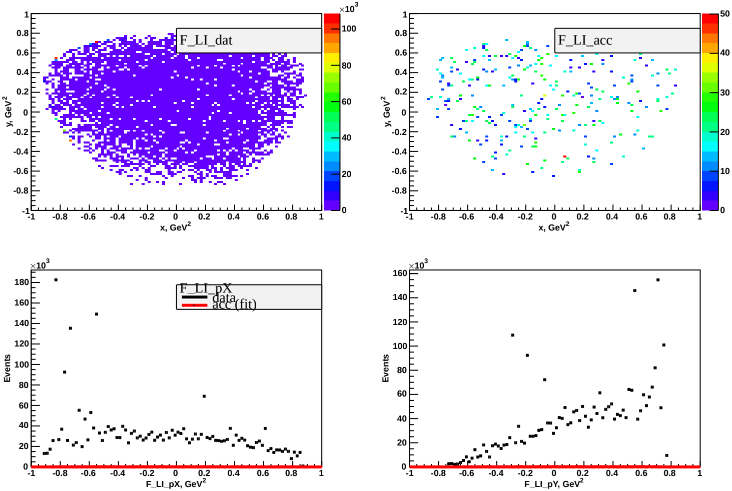
$E\gamma$:[1500-1600]MeV and t:[0.700-0.800]GeV^2

Analysis: Kinematics



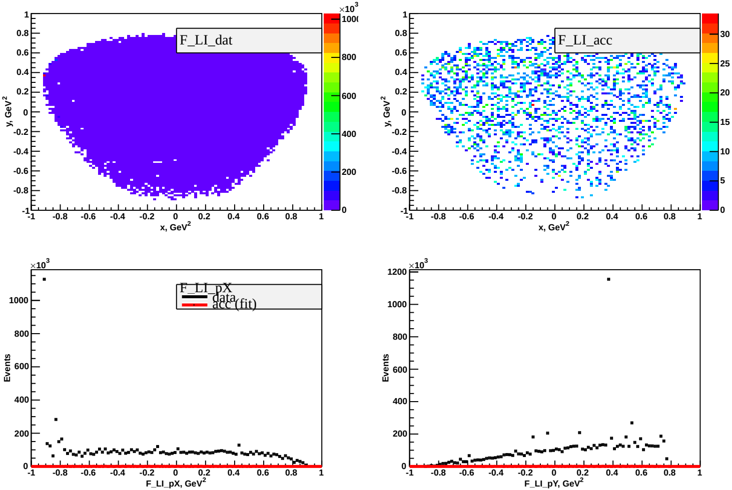
$E\gamma$:[1500-1600]MeV and t:[0.900-1.000]GeV^2

Analysis: Kinematics



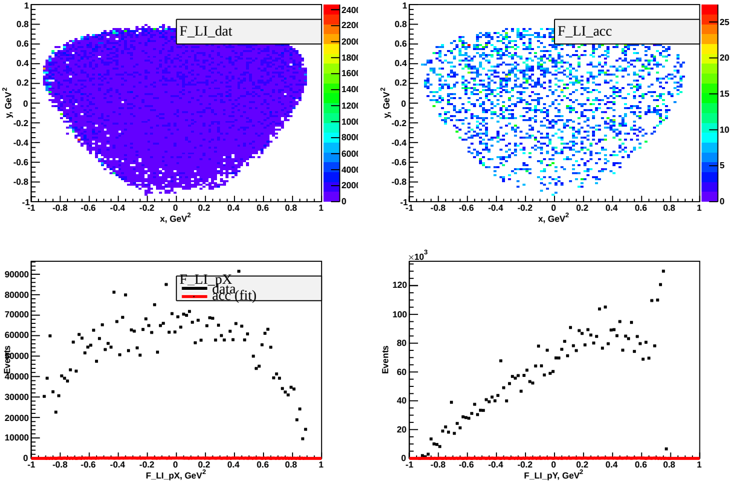
$E\gamma$:[1500-1600]MeV and t:[0.100-0.200]GeV^2

Analysis: Kinematics



$E\gamma$:[1500-1600]MeV and t:[0.300-0.400]GeV^2

Analysis: Kinematics



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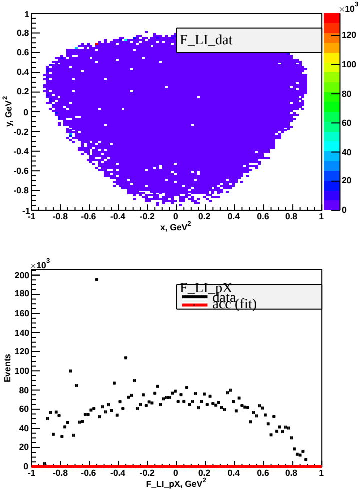

$E\gamma$:[1500-1600]MeV and t:[0.700-0.800]GeV^2

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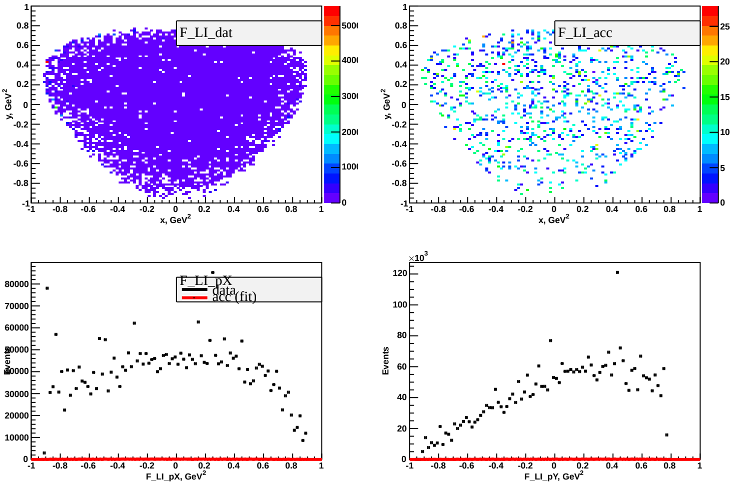
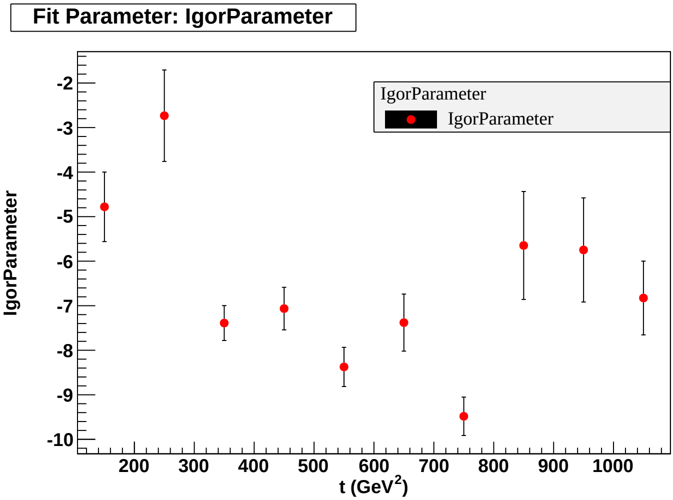


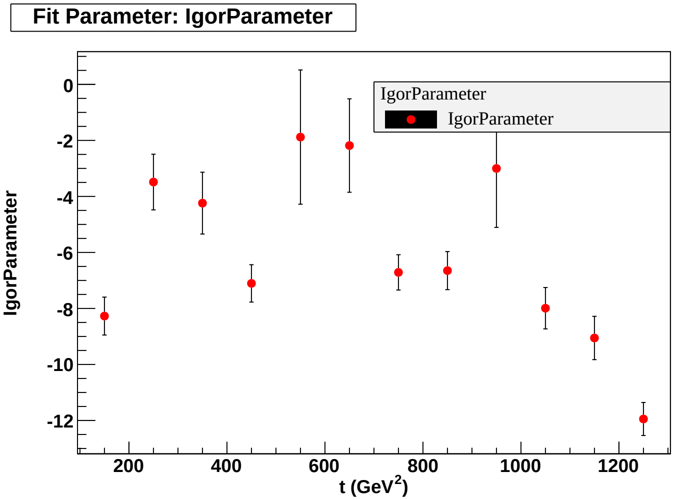
$E\gamma$:[1500-1600]MeV and t:[0.900-1.000]GeV^2

Analysis: Decay Amplitude Parameter (IgorParameter)



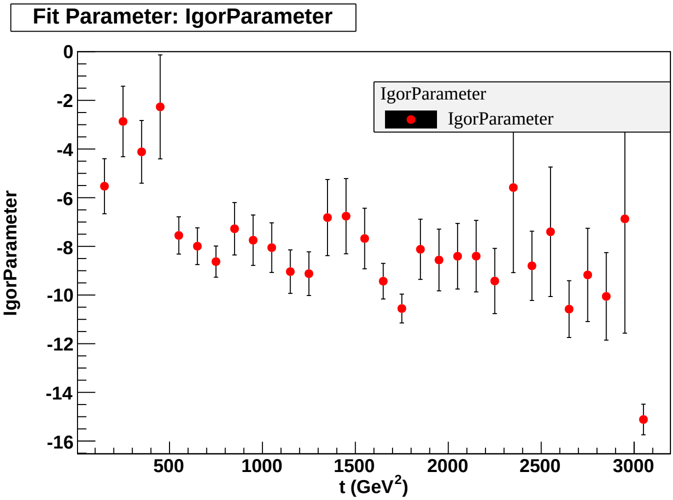
$E\gamma$:[1500-1600]MeV and t:[0.400-1.100]GeV^2

Analysis: Decay Amplitude Parameter (IgorParameter)



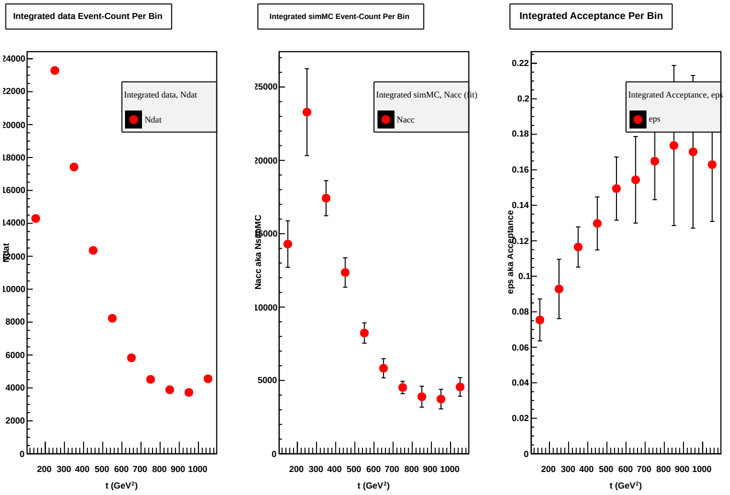
$E\gamma$:[2000-2100]MeV and t:[0.400-1.300]GeV^2

Analysis: Decay Amplitude Parameter (IgorParameter)



$E\gamma$:[2500-2600]MeV and t:[0.400-3.100]GeV^2

Analysis: Decay Amplitude Acceptance (IgorParameter)



$E\gamma$:[1500-1600]MeV and t:[0.400-1.100]GeV^2

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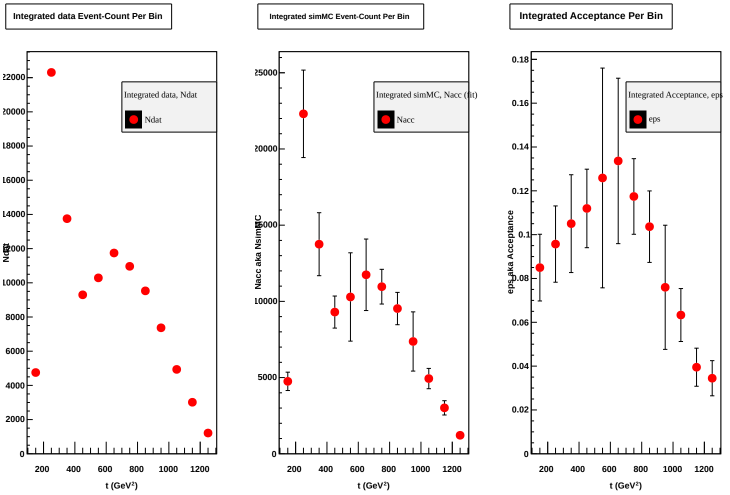
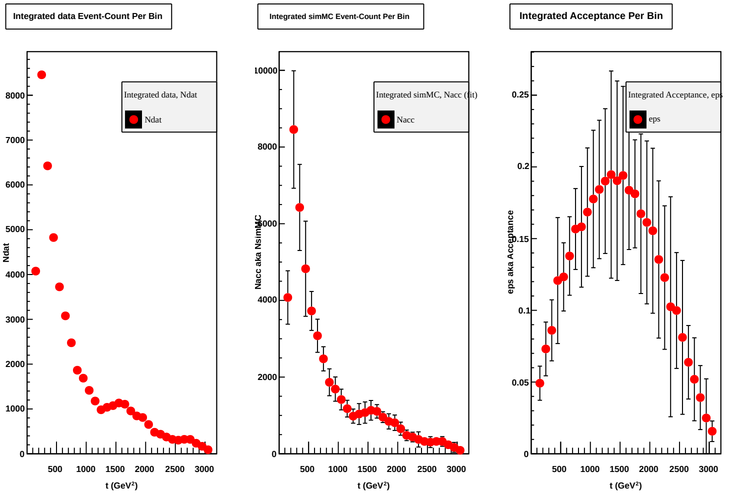


$E\gamma$:[2000-2100]MeV and t:[0.400-1.300]GeV^2

Analysis: Decay Amplitude Acceptance (IgorParameter)

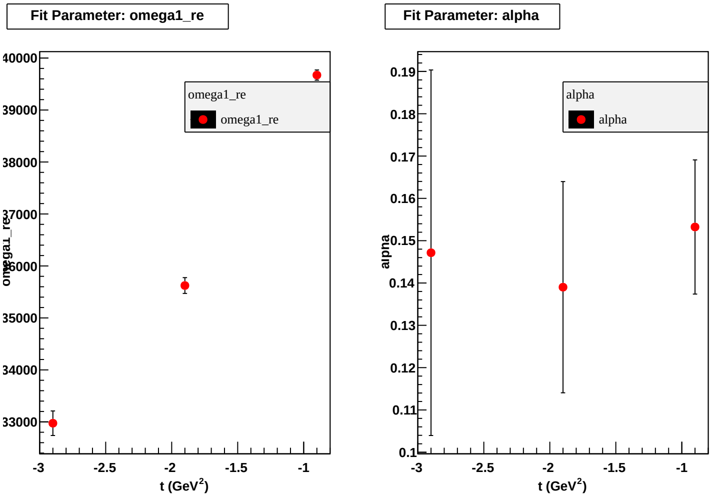


$E\gamma$:[2500-2600]MeV and t:[0.400-3.100]GeV^2

Next Steps

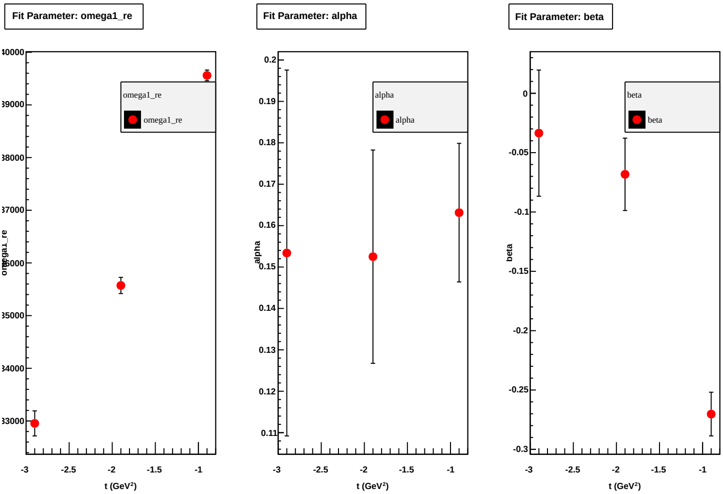
- discussed

Analysis: Dalitz Plot Parameter (α)



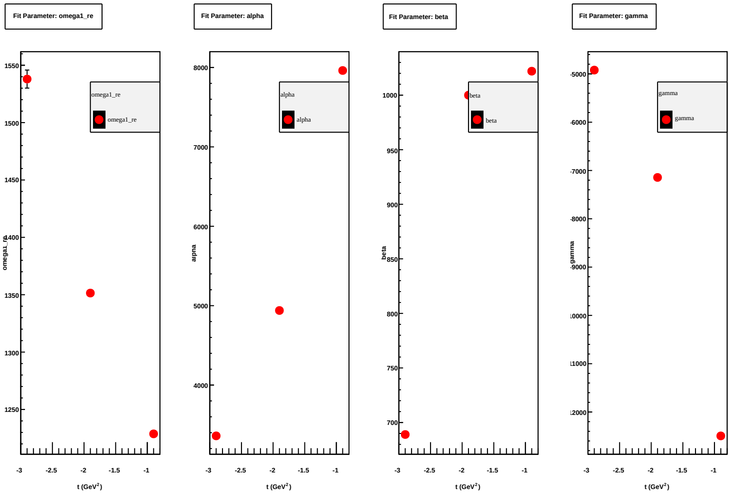
$E\gamma$:[2500-3000]MeV and t:[0.400-3.400]GeV^2

Analysis: Dalitz Plot Parameters (α,β)



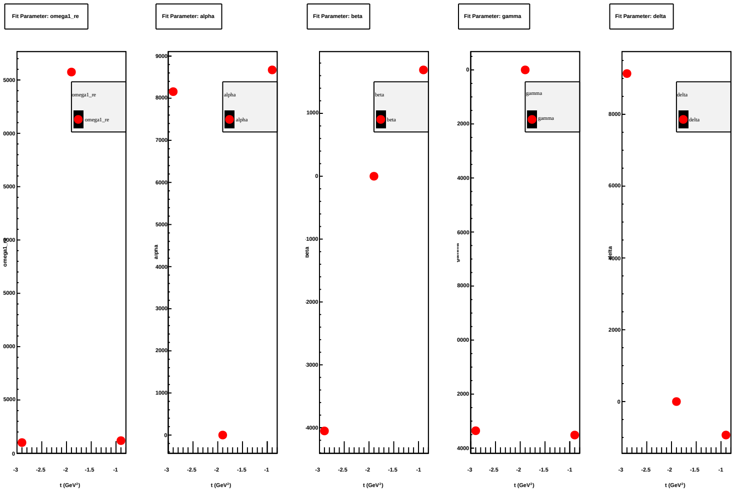
$E\gamma$:[2500-3000]MeV and t:[0.400-3.400]GeV^2

Analysis: Dalitz Plot Parameters (α,β,γ)



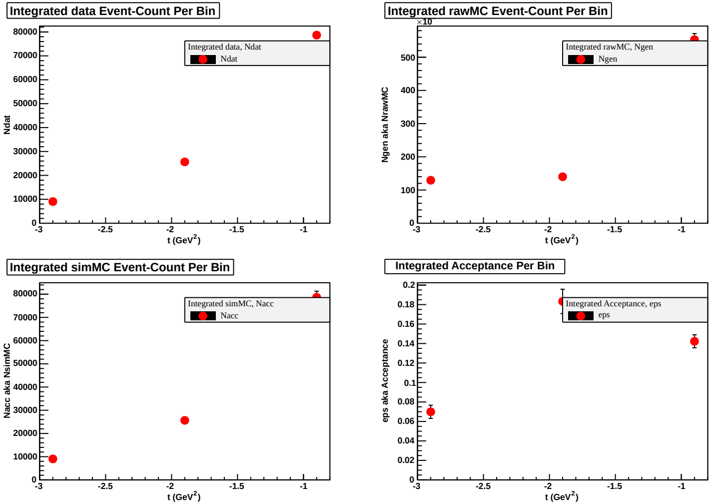
$E\gamma$:[2500-3000]MeV and t:[0.400-3.400]GeV^2

Analysis: Dalitz Plot Parameters (α,β,γ,δ)



$E\gamma$:[2500-3000]MeV and t:[0.400-3.400]GeV^2

Analysis: Integrated Populations and Acceptance



$E\gamma$:[2500-3000]MeV and t:[0.400-3.400]GeV^2

The Decay Amplitude

$$F(s) = \Omega(s)\left(\frac{1}{\pi}\int_{s_\pi}^{s_i} ds'\,\frac{\rho(s')\,t^*(s')}{\Omega^*(s')}\,\frac{\hat{F}(s')}{s'-s} + \Sigma(s)\right). \tag{31}$$

KT Amplitude

$$\Sigma(s) = \sum_{i=0}^{\infty} a_i\,\omega^i(s) \tag{29}$$

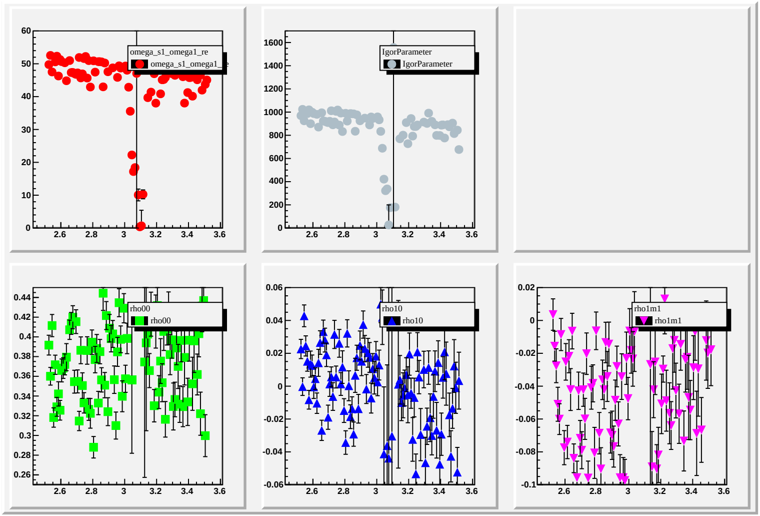
inelastic contribution

$$\omega(s) = \frac{\sqrt{s_i - s_E} - \sqrt{s_i - s}}{\sqrt{s_i - s_E} + \sqrt{s_i - s}} \tag{30}$$

dispersion relation

a_0 = "IgorParameter"

Previous Parameter Values and Errors, $E\gamma$:[2500-3500]MeV



Note: Broken paddle, $E\gamma$:[3000-3100]MeV

Previous Comments by Mike P., Adam S., Igor D. and Carlos S.

- Fitted values are unstable. Have 8M data and 1.5M MC accepted, Need at lest the same amount of of acc-MC and data.
- Could you bin in t? Your rho parameters are t dependent and that trend will reflect in your fits and in the Igor's parameter that you will finally want to extract.
- Adam suggested that you may have too many parameters in the fit, as rho00 is also part of the overall normalization.

Comments by Mike P., Adam S., Igor D. and Carlos S.

- 4) It will be good to start with a fit using $F = 1$ (w/o Igor correction), and extract the rho parameters in that way to compare with $g11$ results, and then include the new Igor parameter.

- 5) Igor's parameter should be independent of production, i.e. on Ebeam and t.