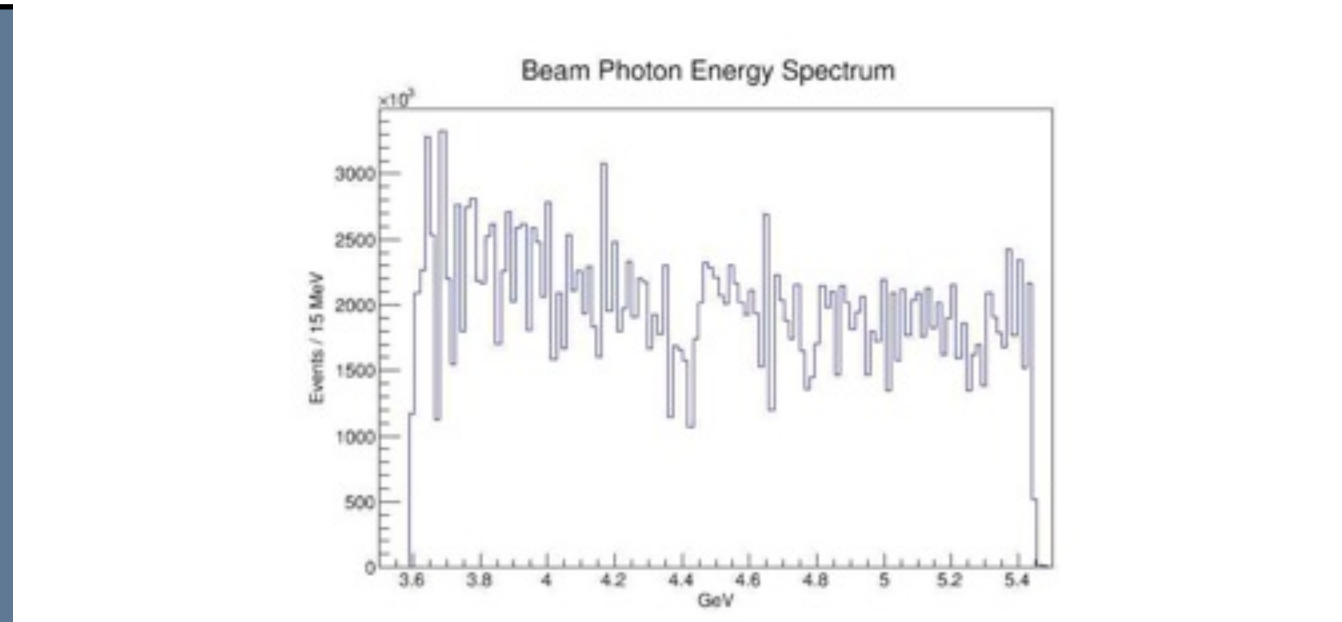
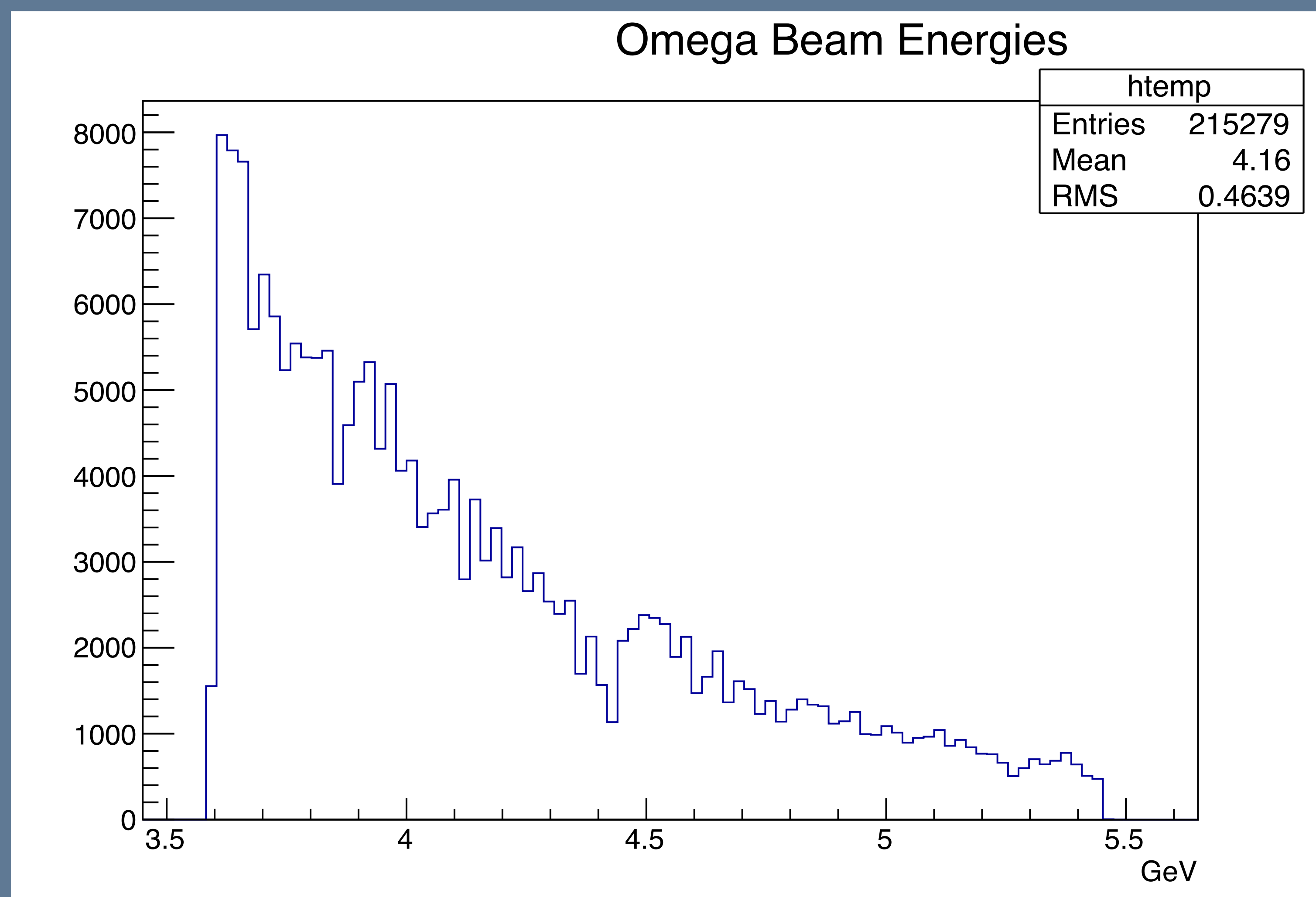
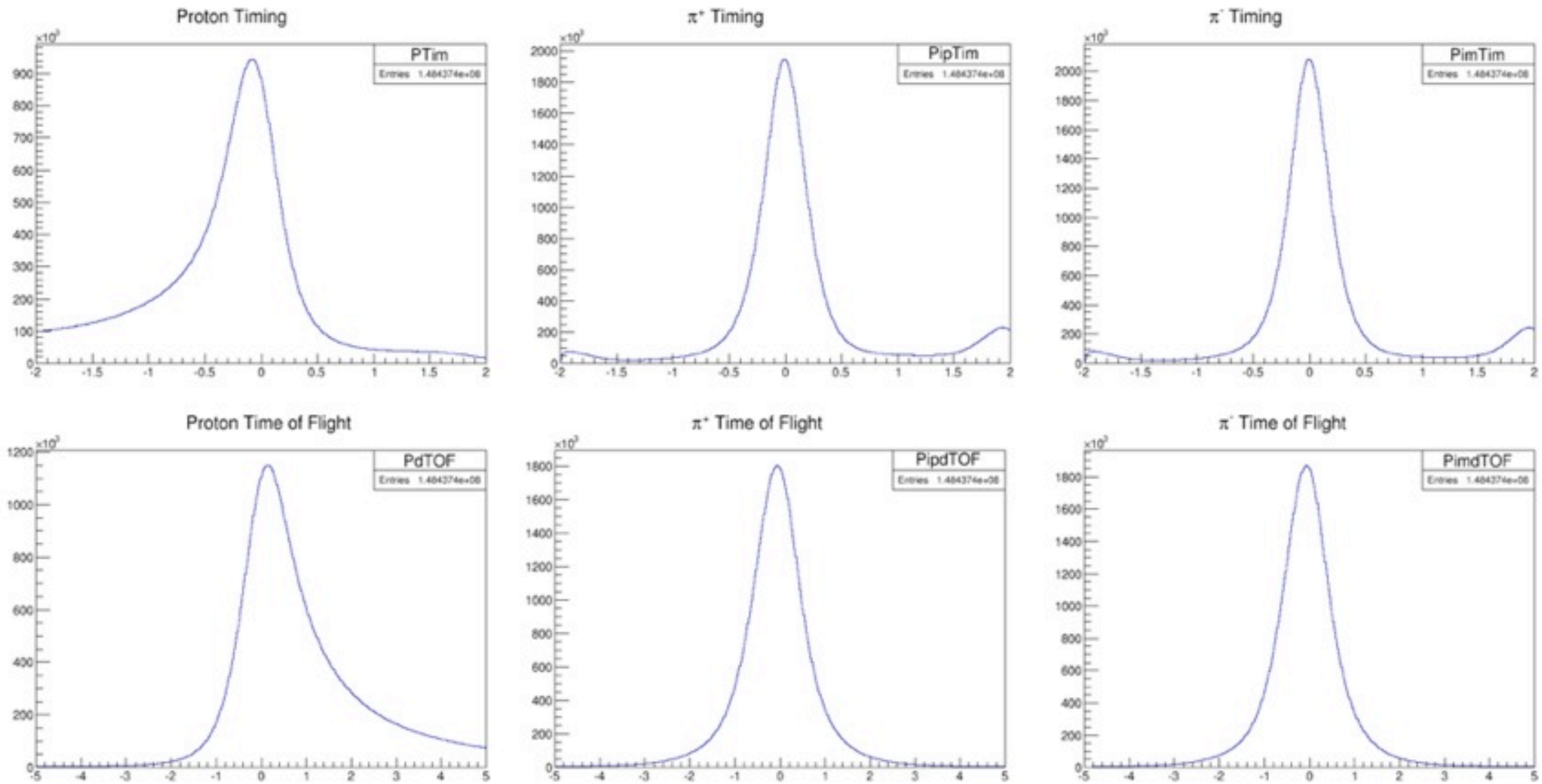
$\gamma p \rightarrow (\pi^0)\pi^+\pi^- p$



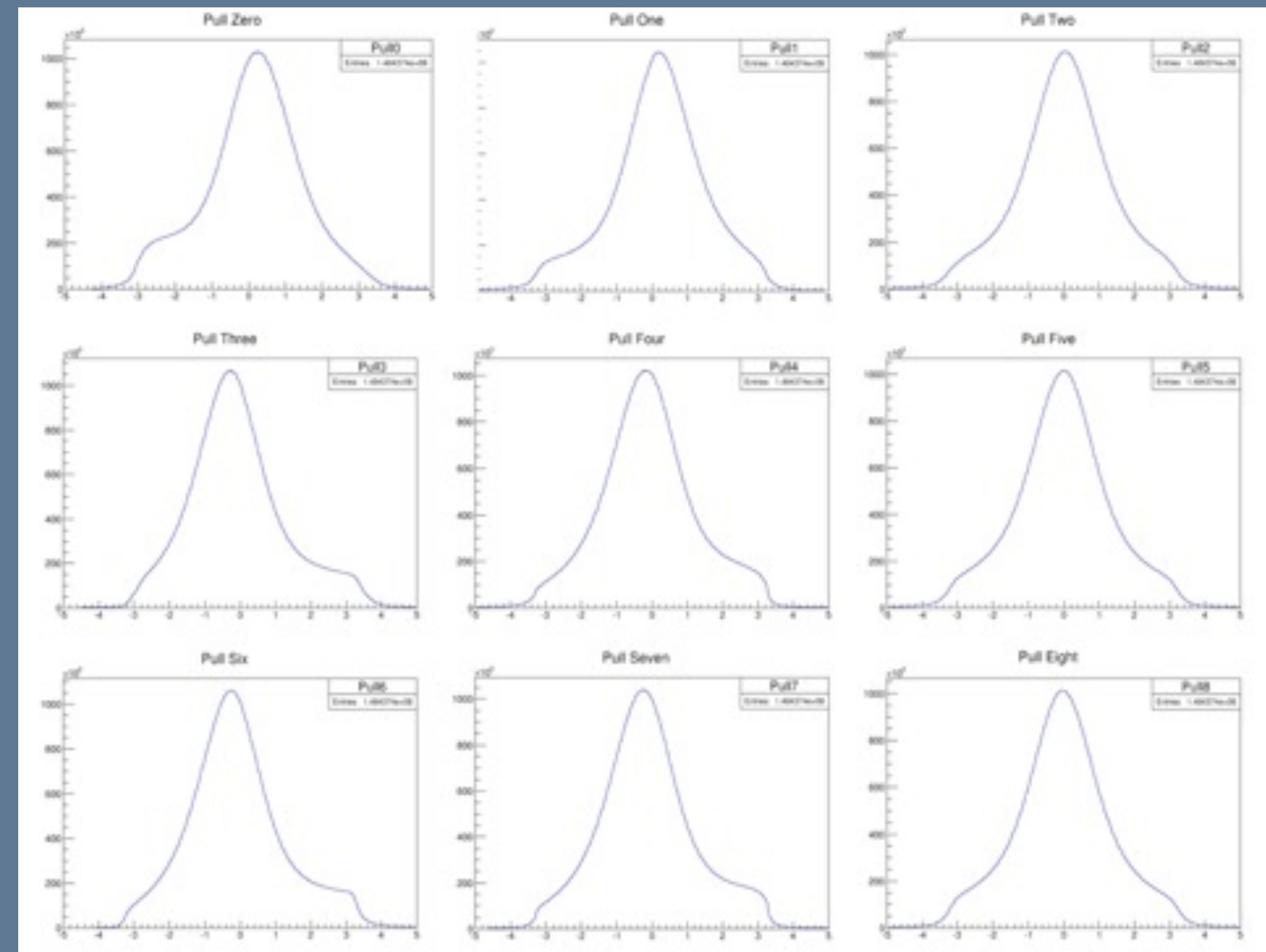


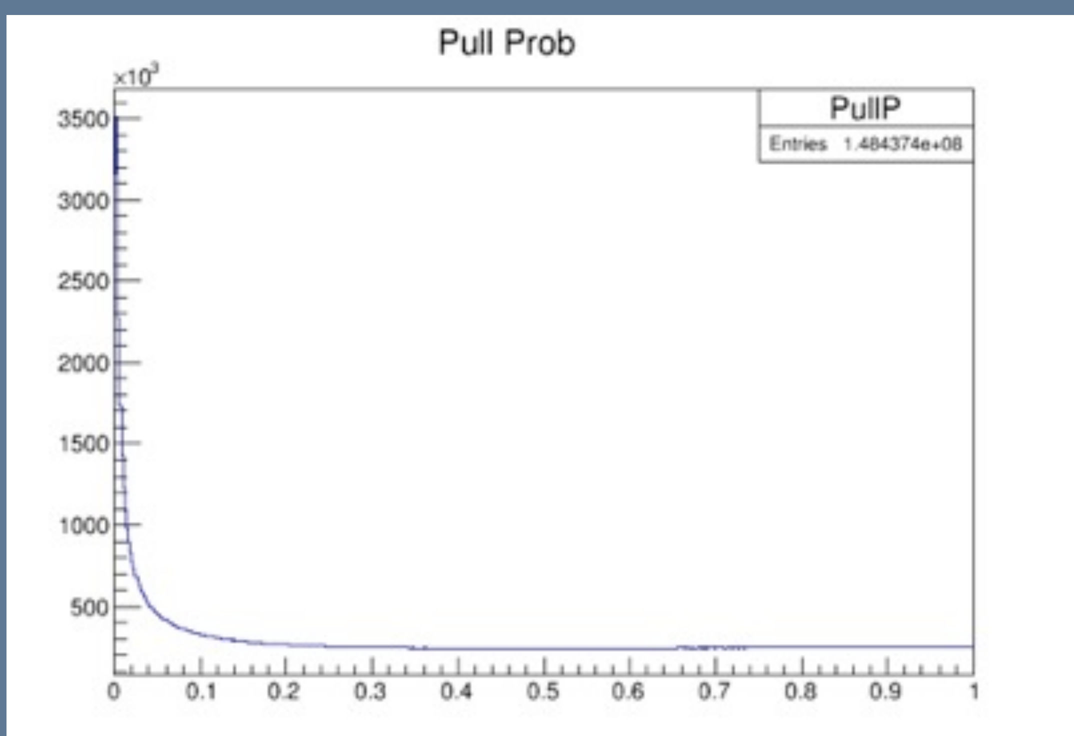
We also performed cuts on the particles timing (ToF), which is the difference between the time of flight measured (ToF-SC) and the calculated through the pathlength assuming a given ID mass. We used $(dTOF\,\pi^{+})^2+(dTOF\,\pi^{-})^2<4, (dTOF\,p)^2+(dTOF\,\pi^{-})^2<4$



Kinematical Fit to π^0

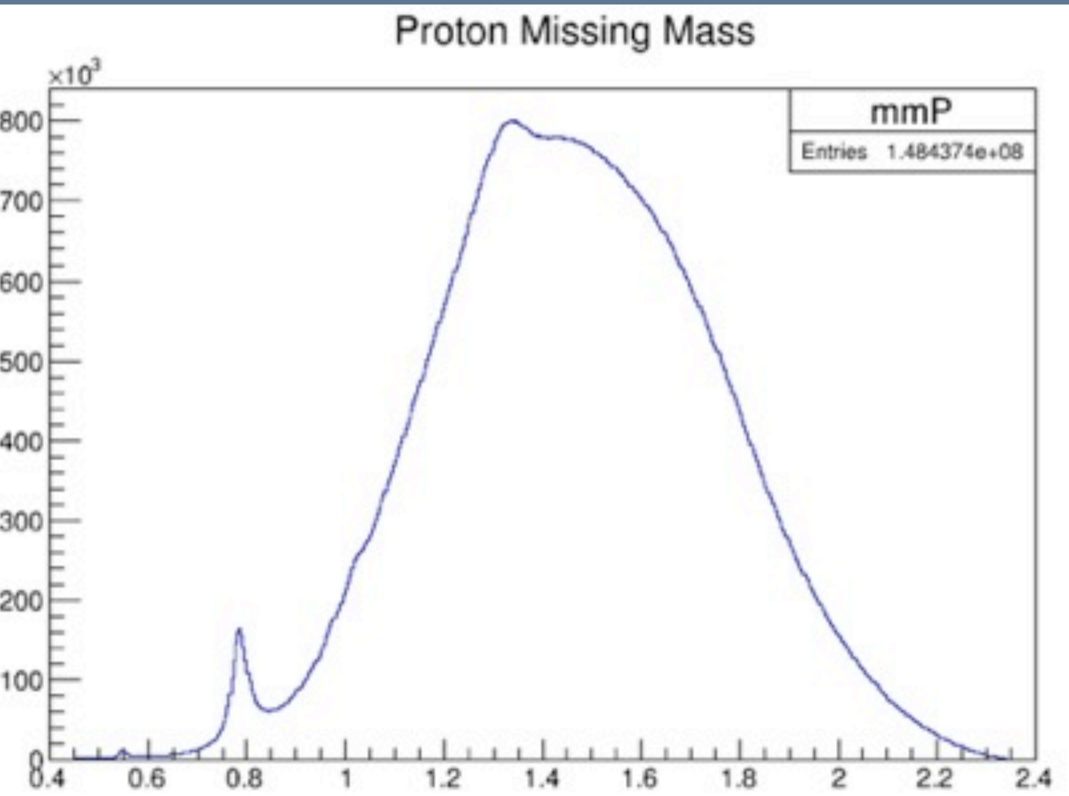
using standard g12 KF -> see g12 general procedures note

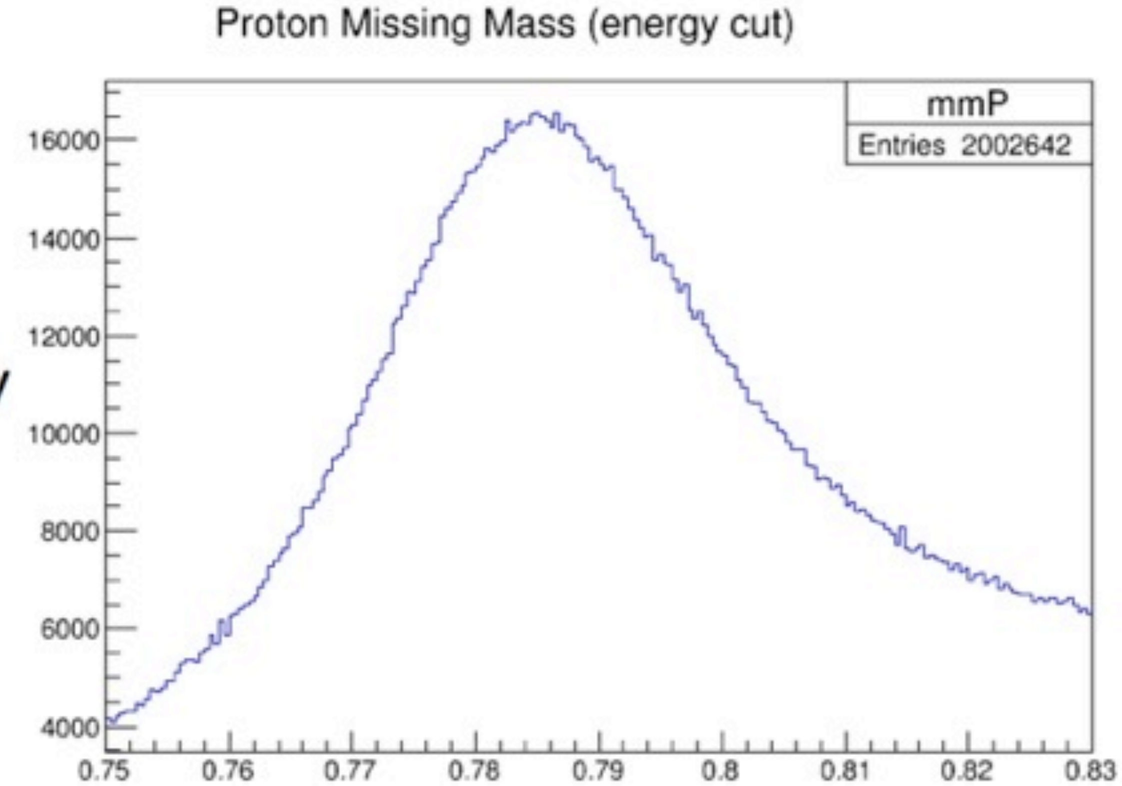




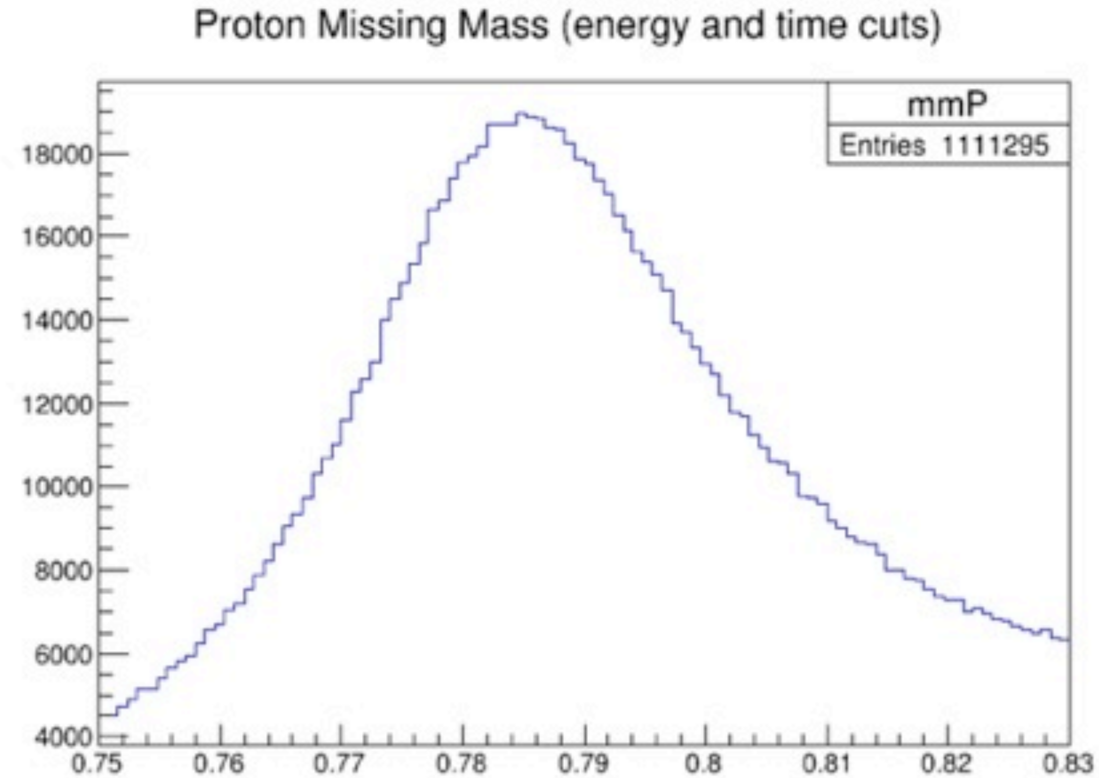
$\gamma p \rightarrow (\pi^0)\pi^+\pi^- p$

Full mass region →

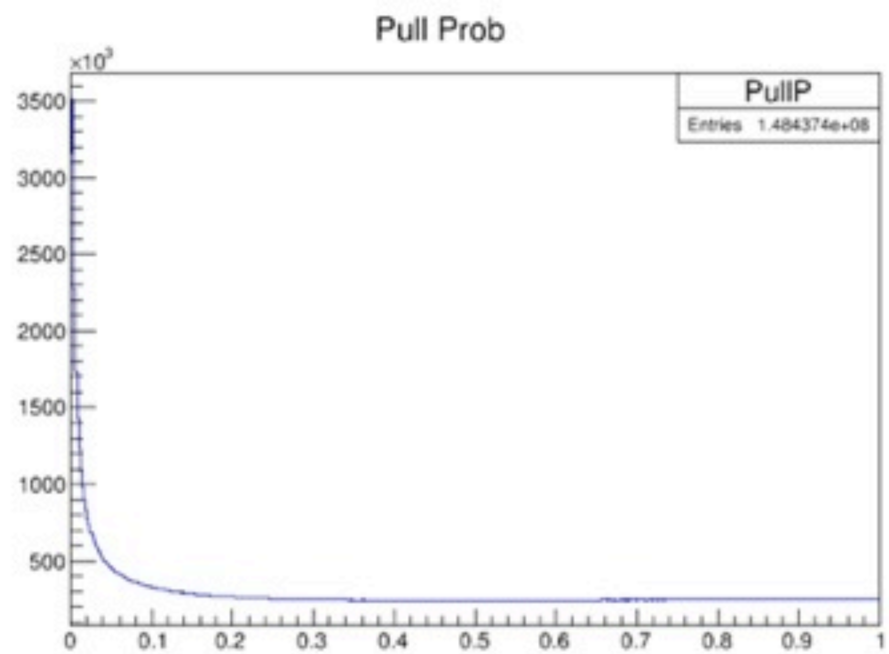


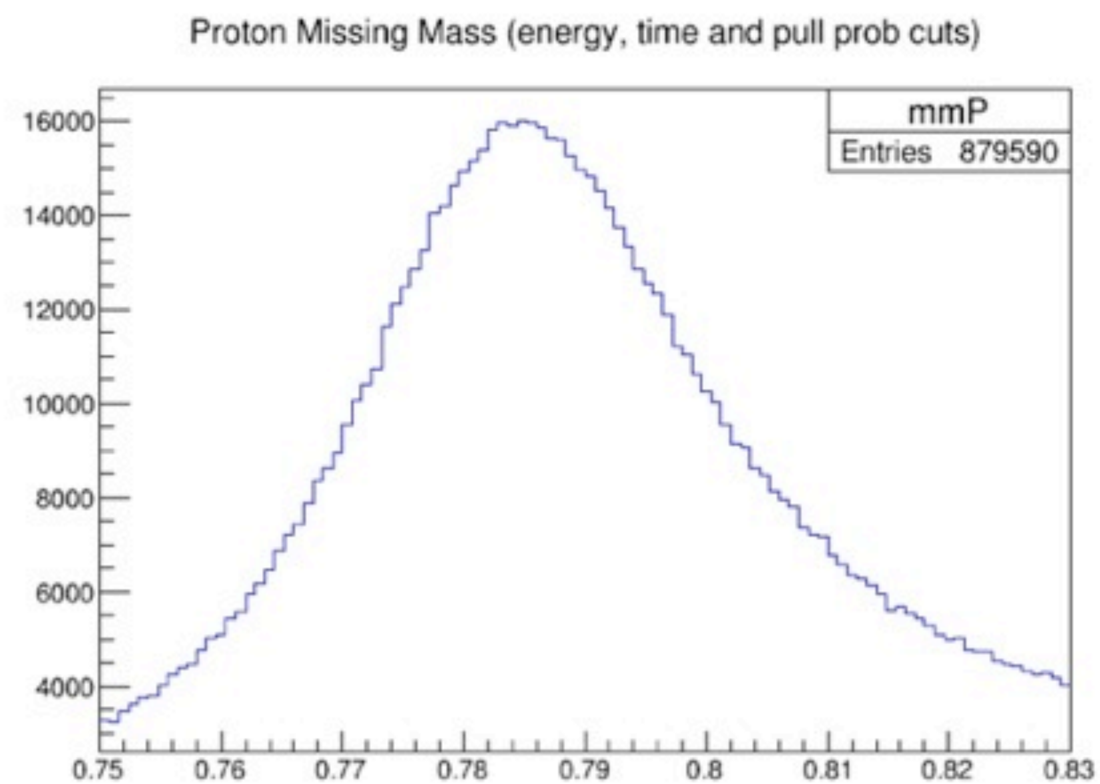


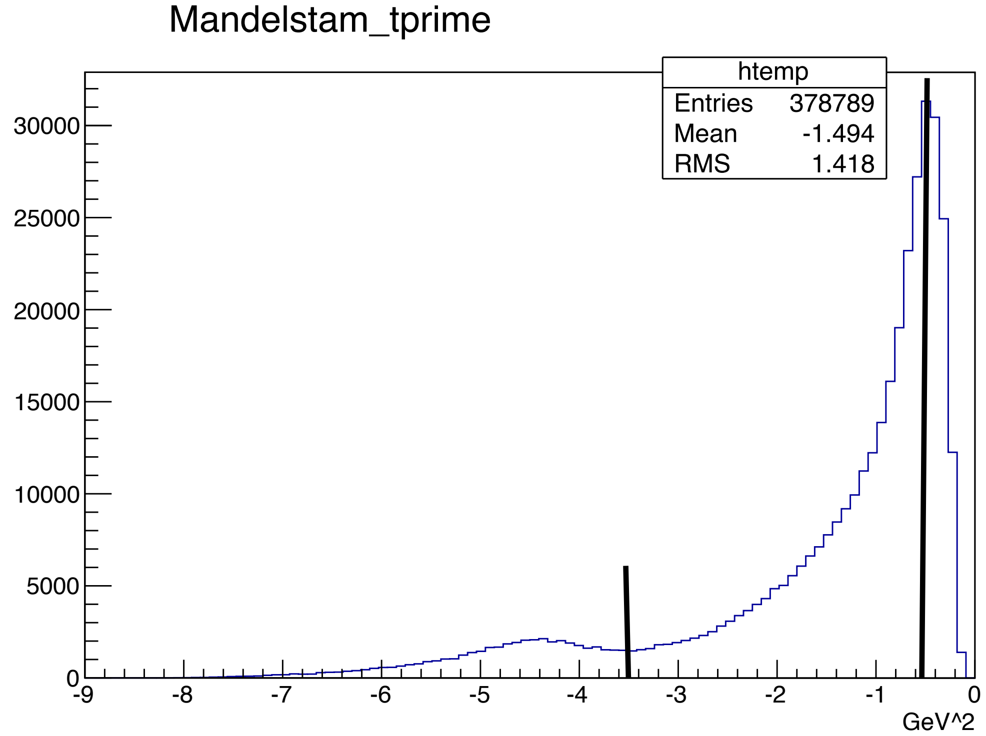
We will focus on the omega mass zone:
750 MeV < proton missing mass < 830 MeV
and perform the mentioned energy cut:
3.6 GeV < photon energy

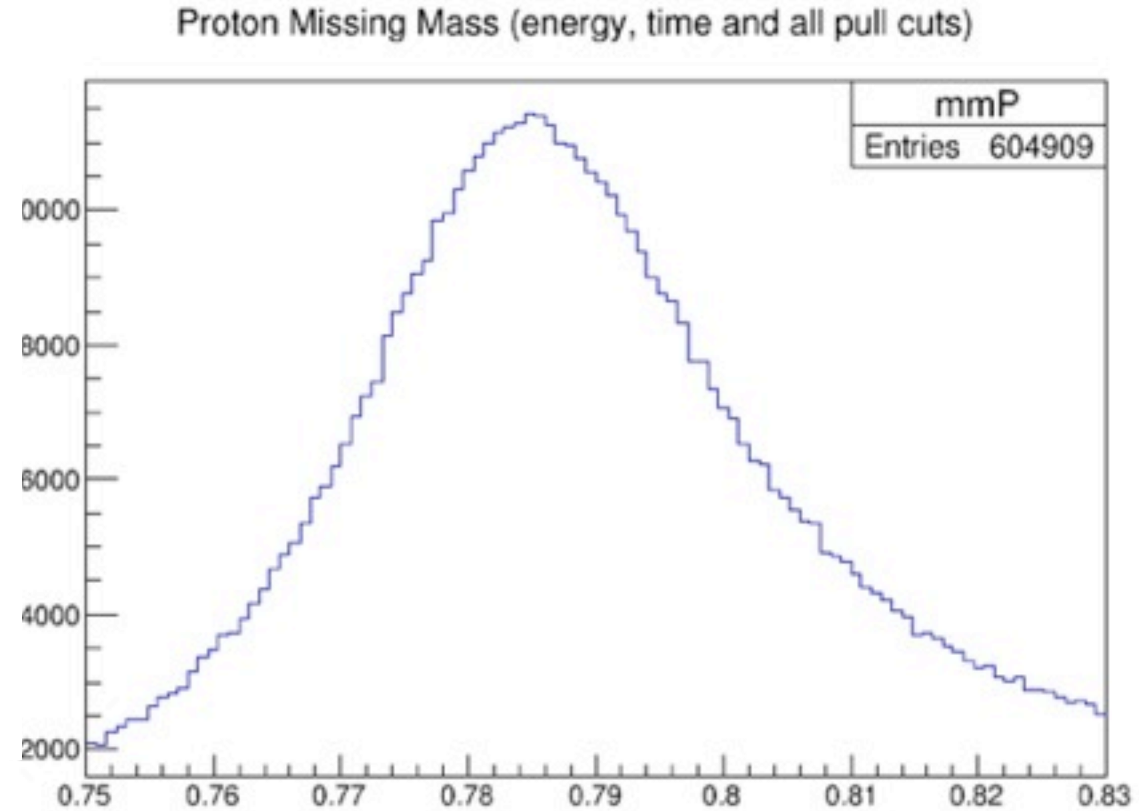


Then we impose Pull Prob > 0.15.

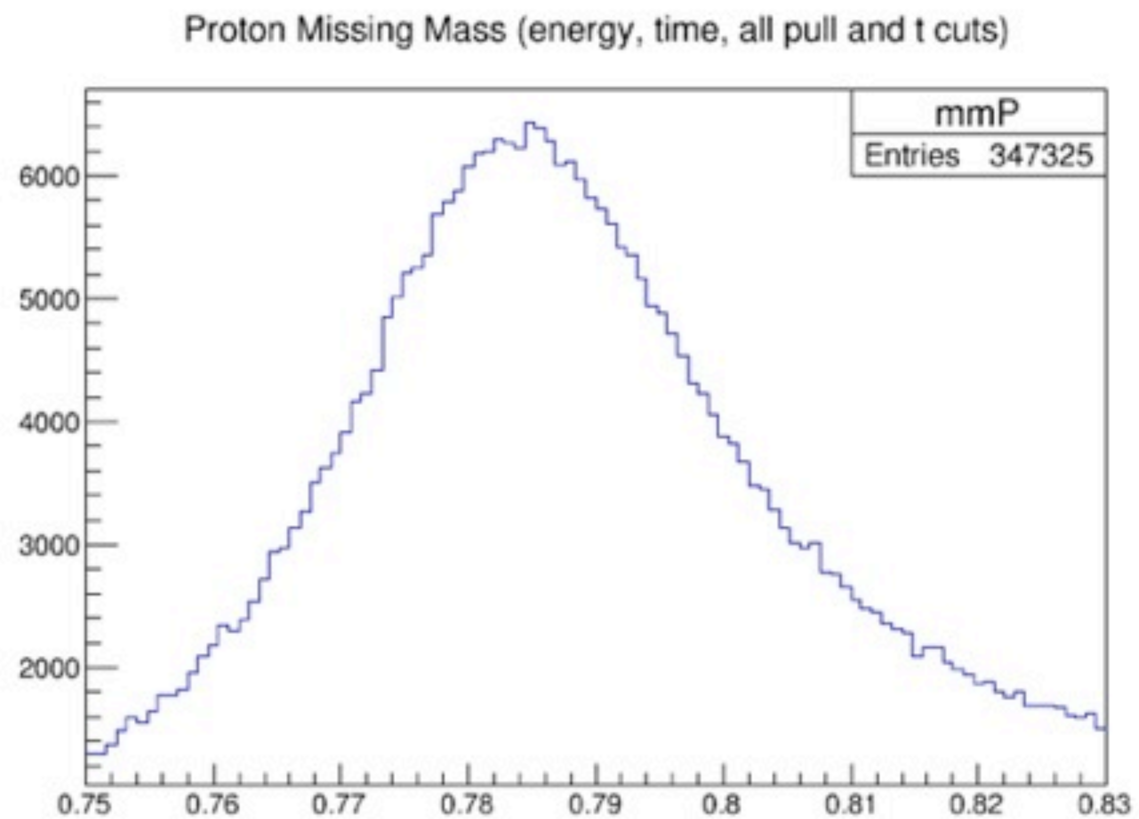






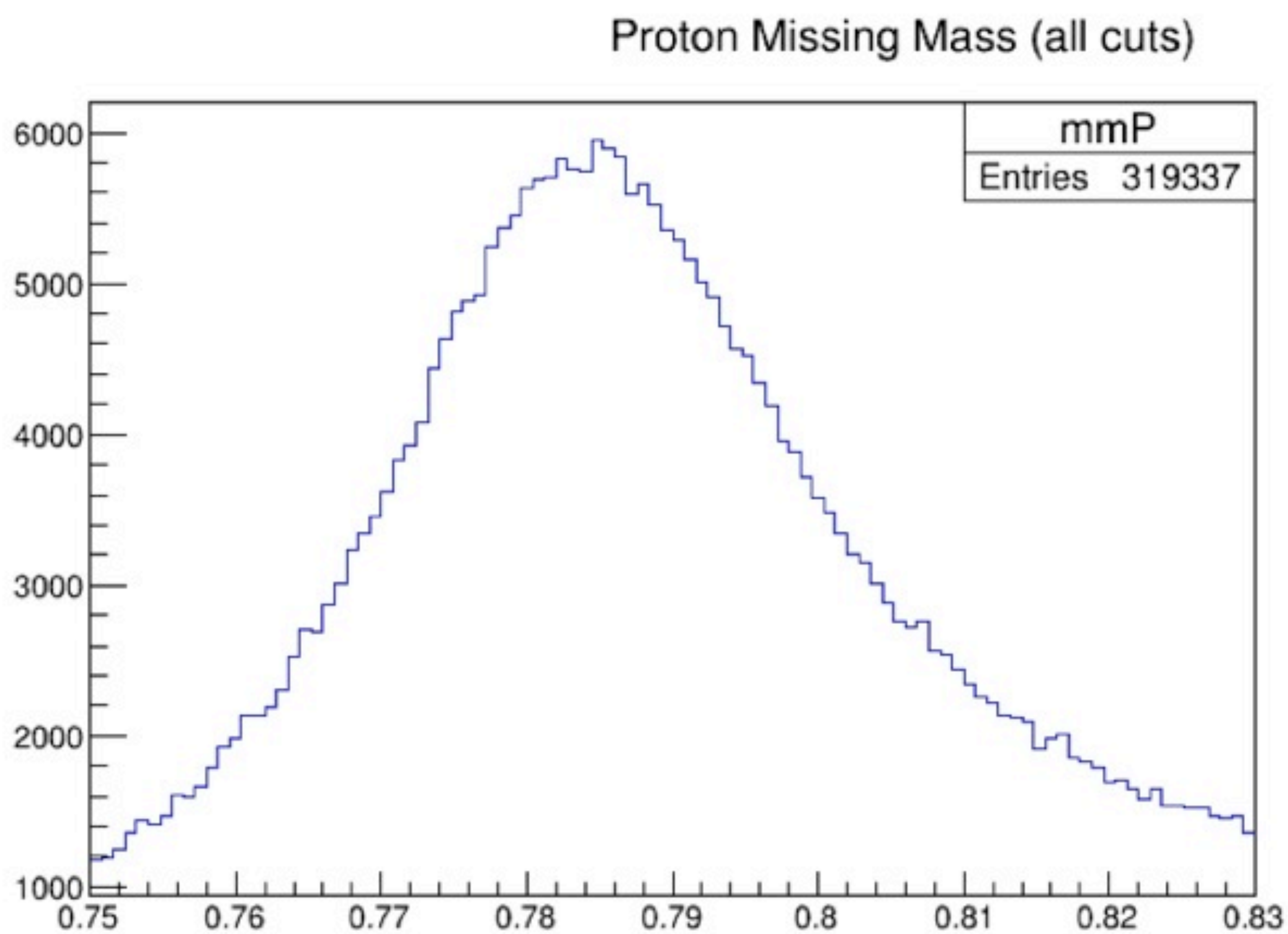


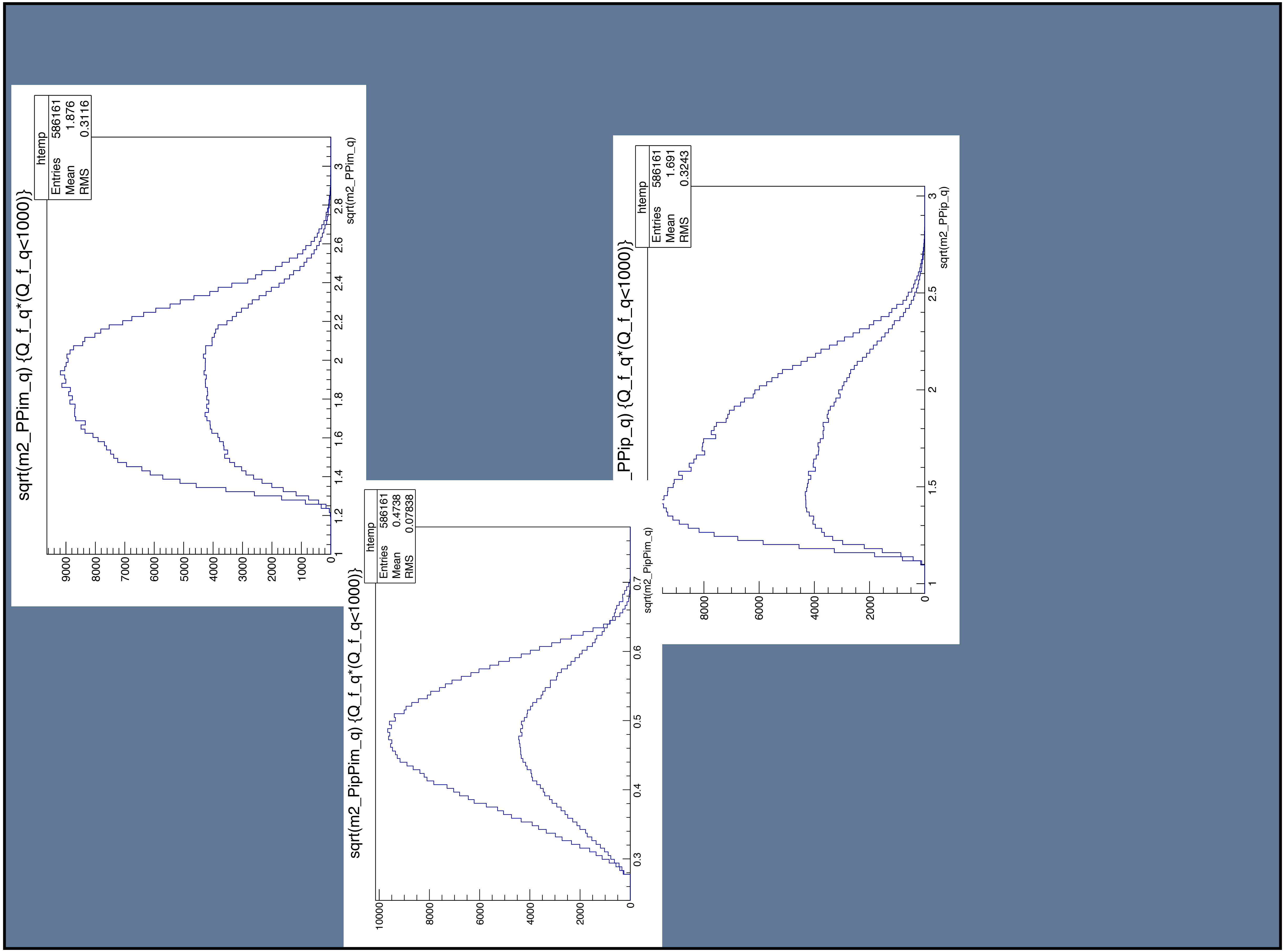
Also, a cut on the Mandelstam variable t' was performed: 3.5 < t' < -0.6

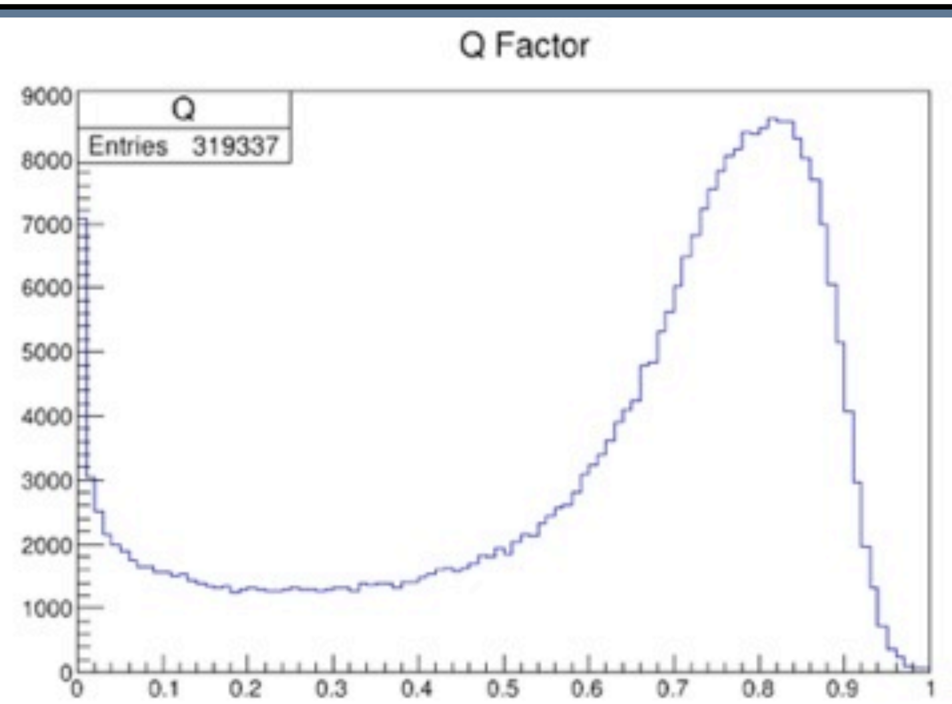


Finally, the fiducial and TOF knockout cuts are considered.

(standard g12 - see general note)

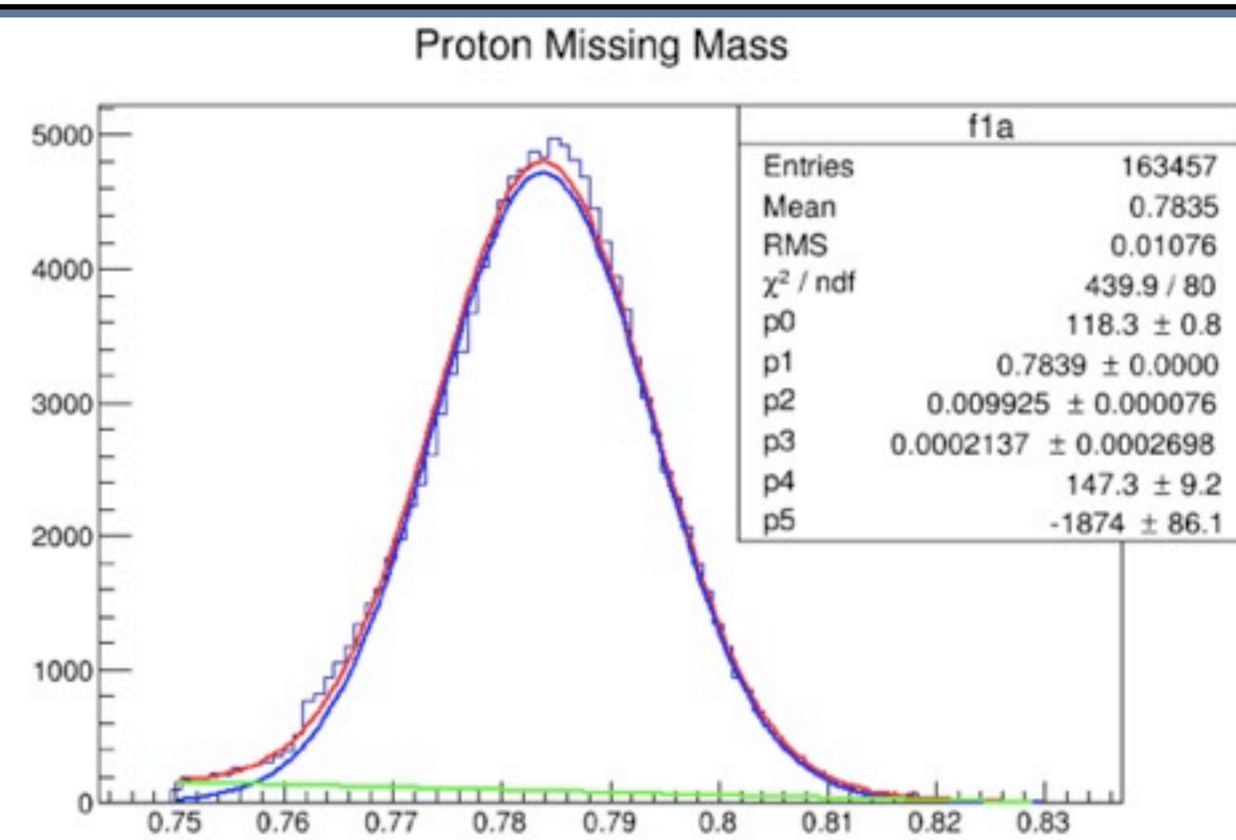


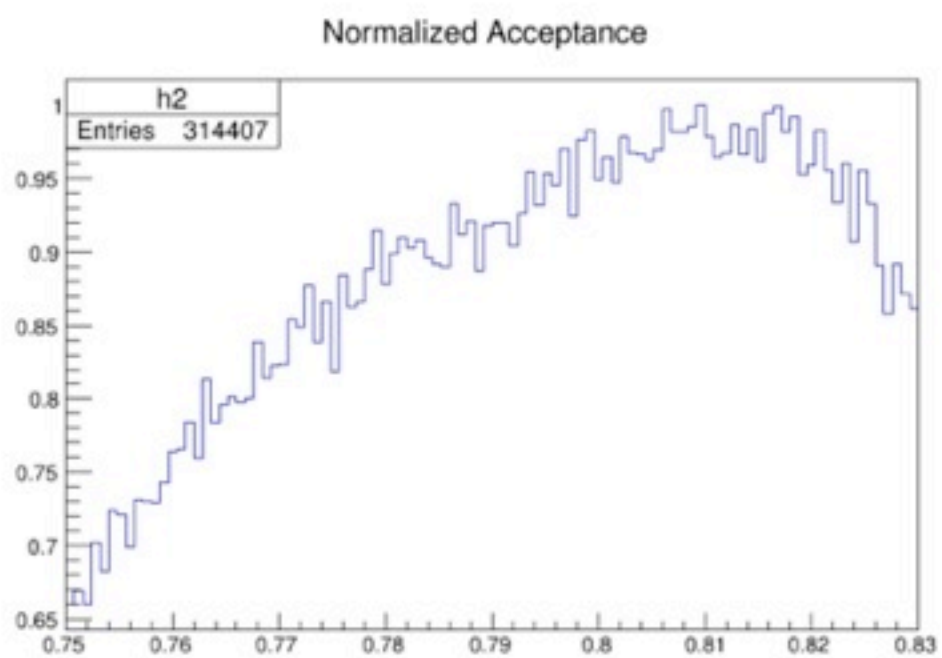

sqrt(m2_PPim_q) {Q_f_q*(Q_f_q<1000)}
htemp
Entries 586161
Mean 1.876
RMS 0.3116
sqrt(m2_PPim_q)
sqrt(m2_PipPim_q) {Q_f_q*(Q_f_q<1000)}
htemp
Entries 586161
Mean 0.4738
RMS 0.07838
sqrt(m2_PipPim_q)
_PPip_q) {Q_f_q*(Q_f_q<1000)}
htemp
Entries 586161
Mean 1.691
RMS 0.3243
sqrt(m2_PPip_q)

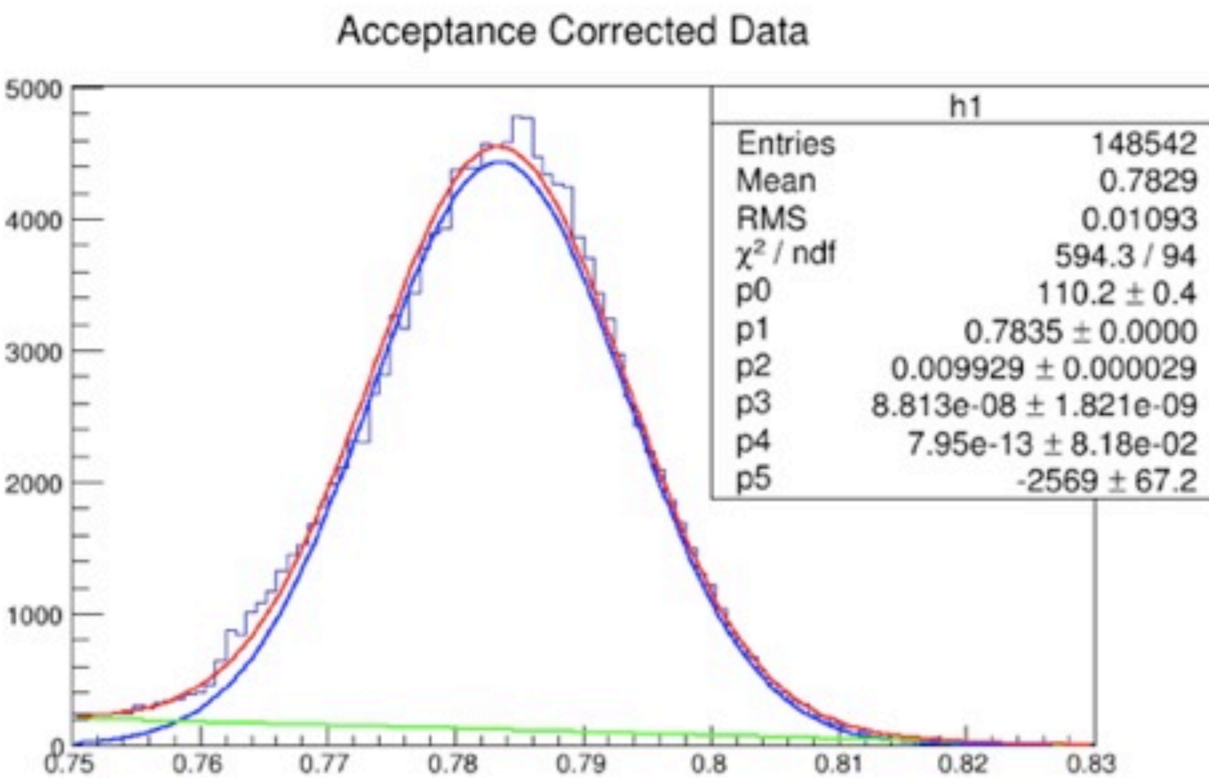


Qf > 0.7

(Qf as defined in Williams Thesis)







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)

Dispersive analysis of $\omega \to 3\pi$ and $\phi \to 3\pi$ decays

F. Niecknig, B. Kubis, and S. P. Schneider, Eur.Phys.J. **C72**, 2014 (2012).

Franz Niecknig, Bastian Kubis, Sebastian P. Schneider

Helmholtz-Institut für Strahlen- und Kernphysik (Theorie) and Bethe Center for Theoretical Physics, Universität Bonn, D–53115 Bonn, Germany

$$\frac{d^2\Gamma}{ds\,dt} = \frac{1}{(2\pi)^3}\frac{1}{32M^3}\frac{1}{3}P(s,t)\,|F(s,t,u)|^2$$

$$\text{P(s,t)} = \; s\,t\,u - m_\pi^2\left(M^2 - m_\pi^2\right)^2 .$$

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

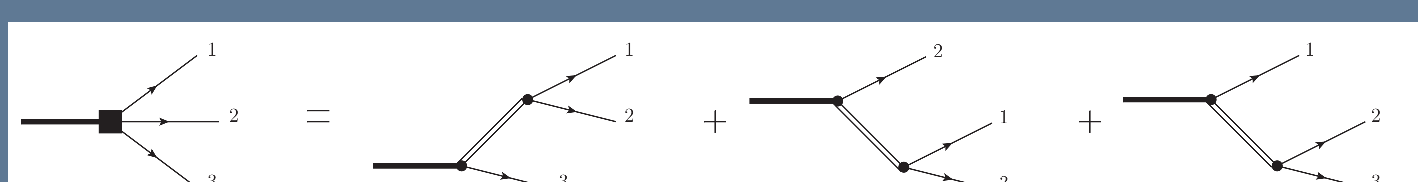


FIG. 1: Isobar decomposition.

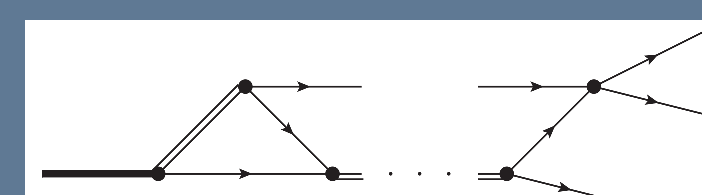


FIG. 2: Crossed channel rescattering effects.

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

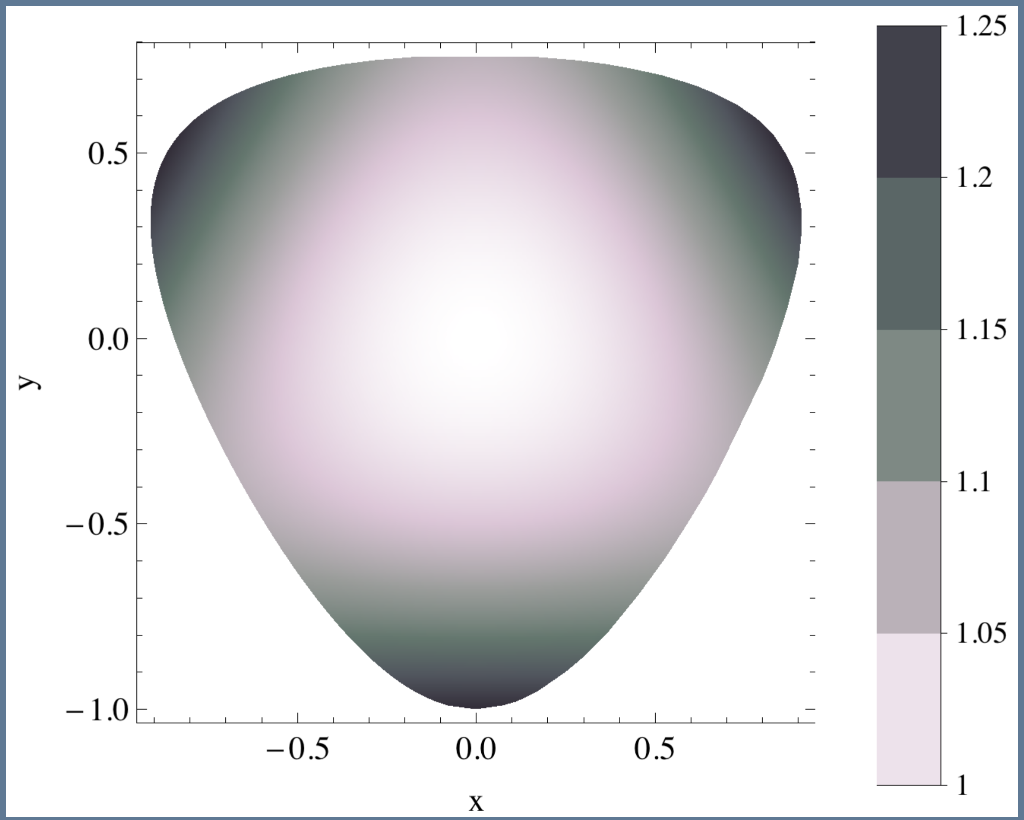
The variable

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

$$F(s,t,u) = F_o(s,t) + a_o F_1(s,t)$$

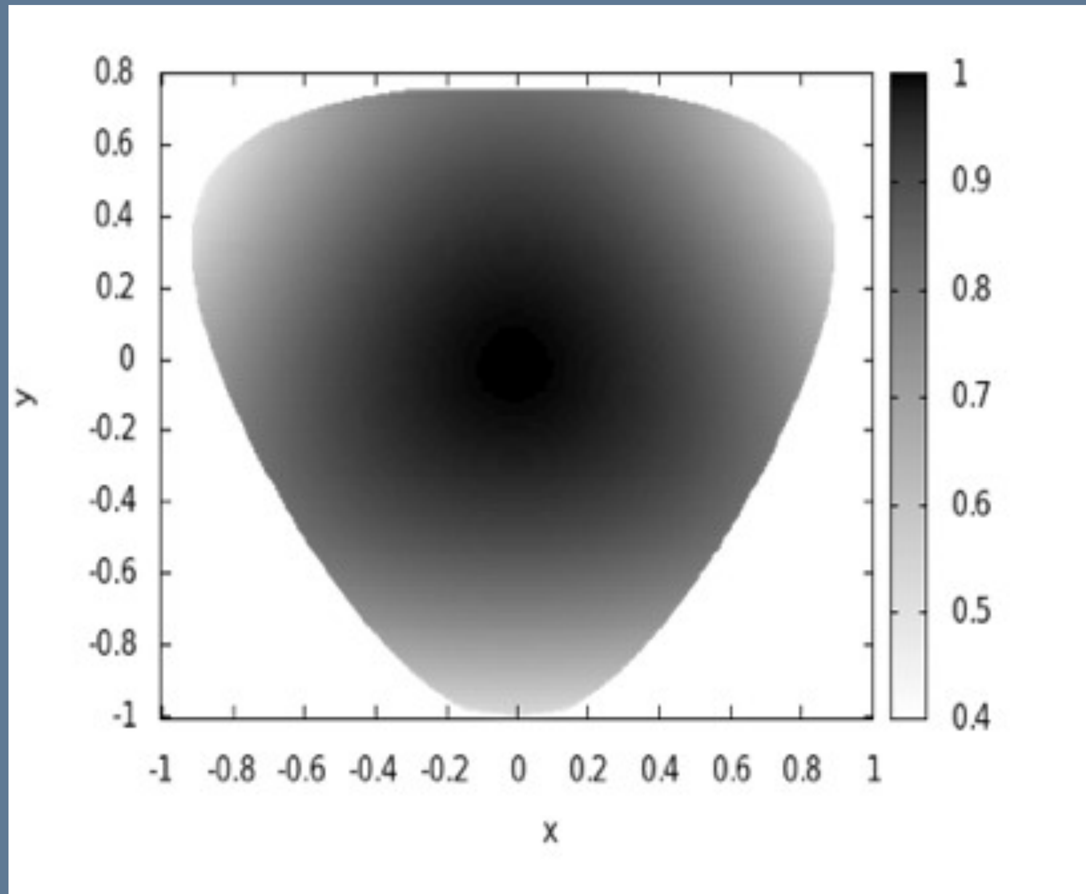
(code available in the web at: http://cgl.soic.indiana.edu/jpac/)

Dalitz Analysis in x vs y

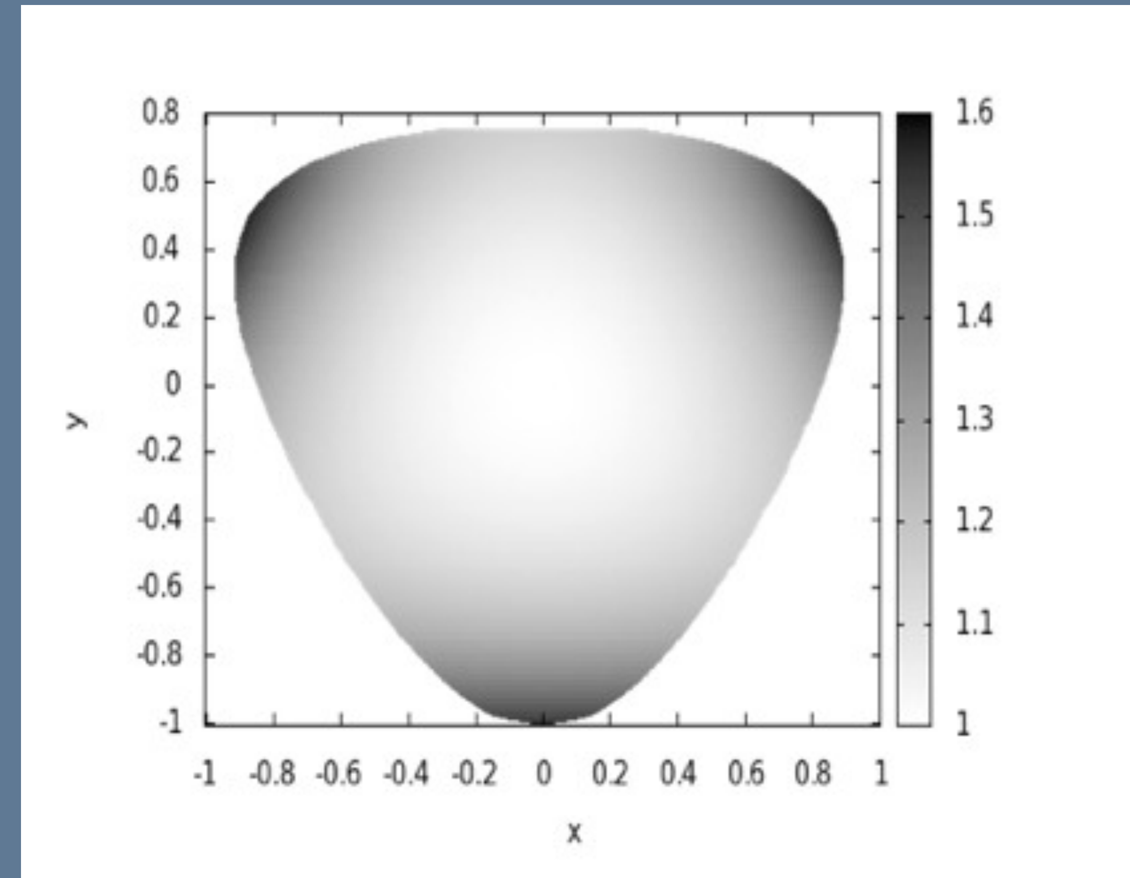


$$x = \frac{\sqrt{3}}{Q}(T_1 - T_2) = \frac{\sqrt{3}(t-u)}{2M(M-3\,m_\pi)},$$
$$y = \frac{3\,T_3}{Q} - 1 = \frac{3(s_c - s)}{2M(M-3m_\pi)}.$$

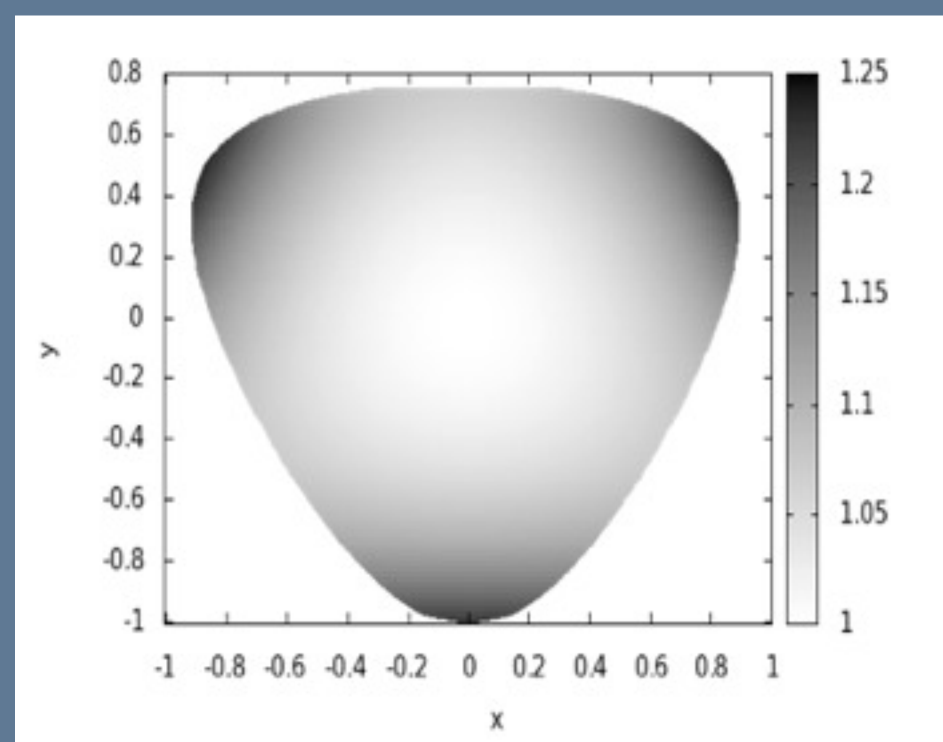
$a_o=0$



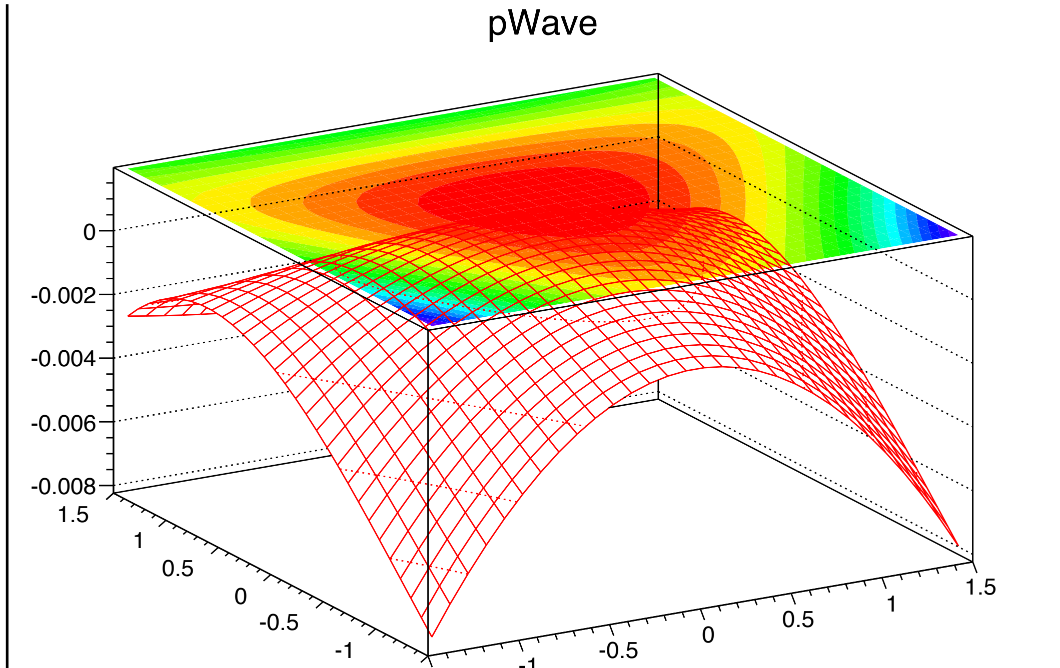
$a_o=-10$



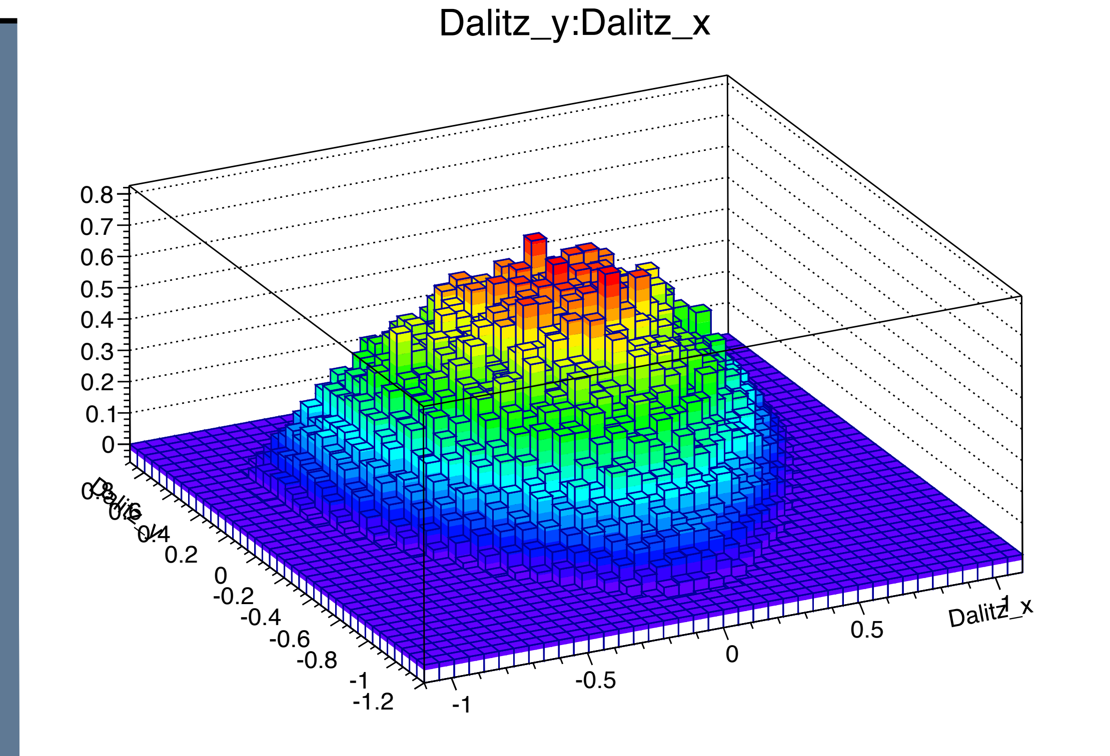
$a_o=10$

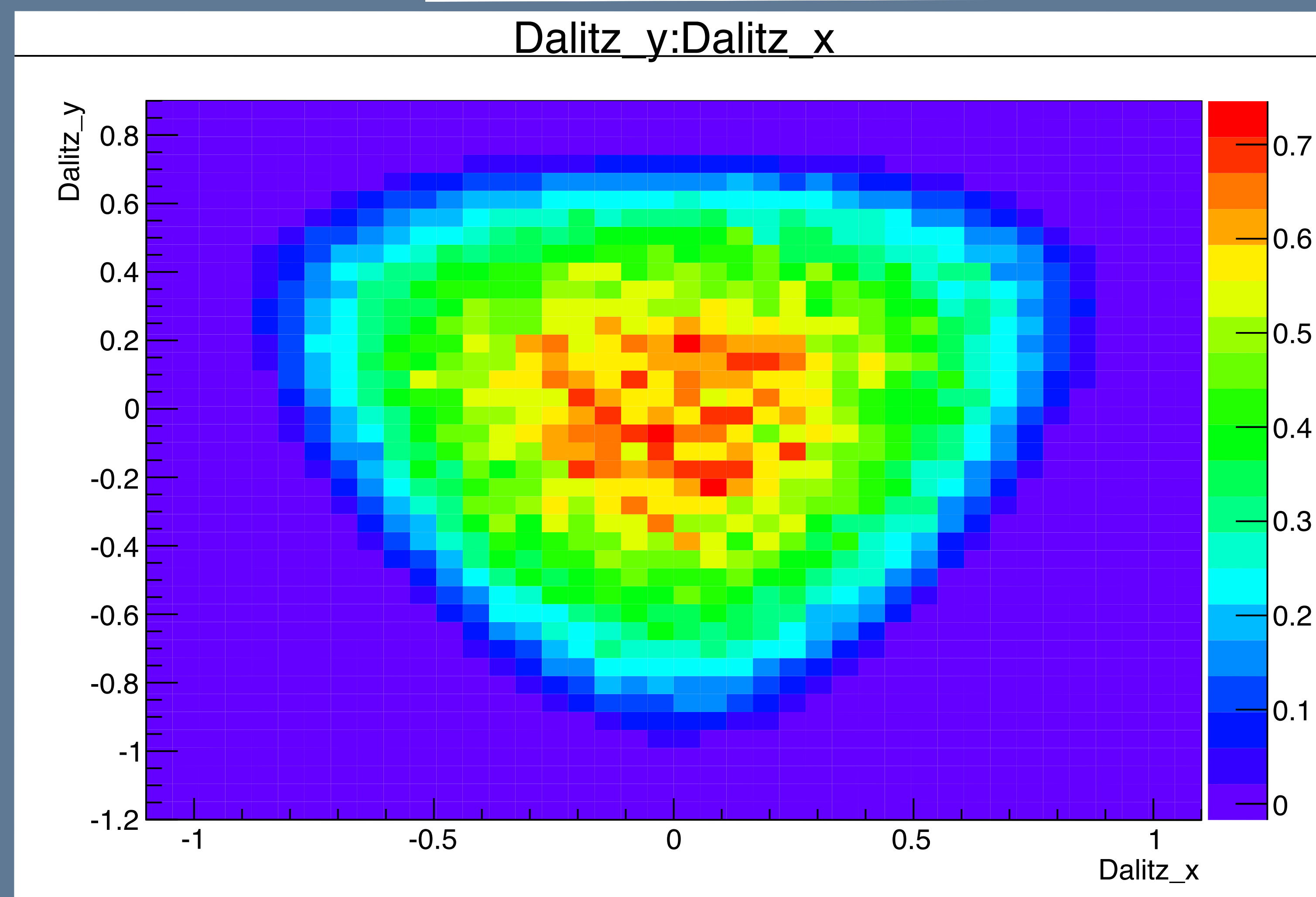


$a_o=0$



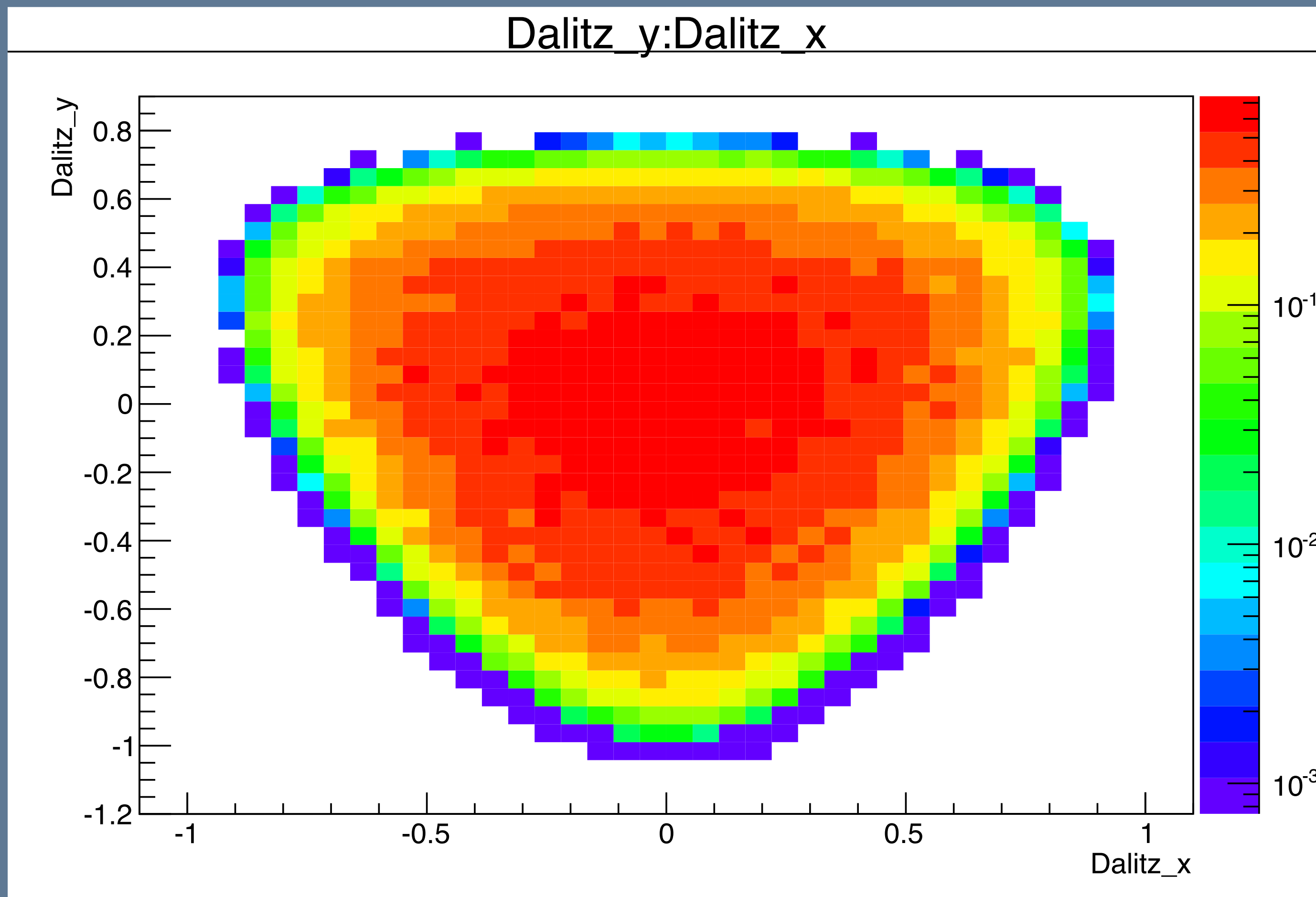
courtesy of I. Danilkin

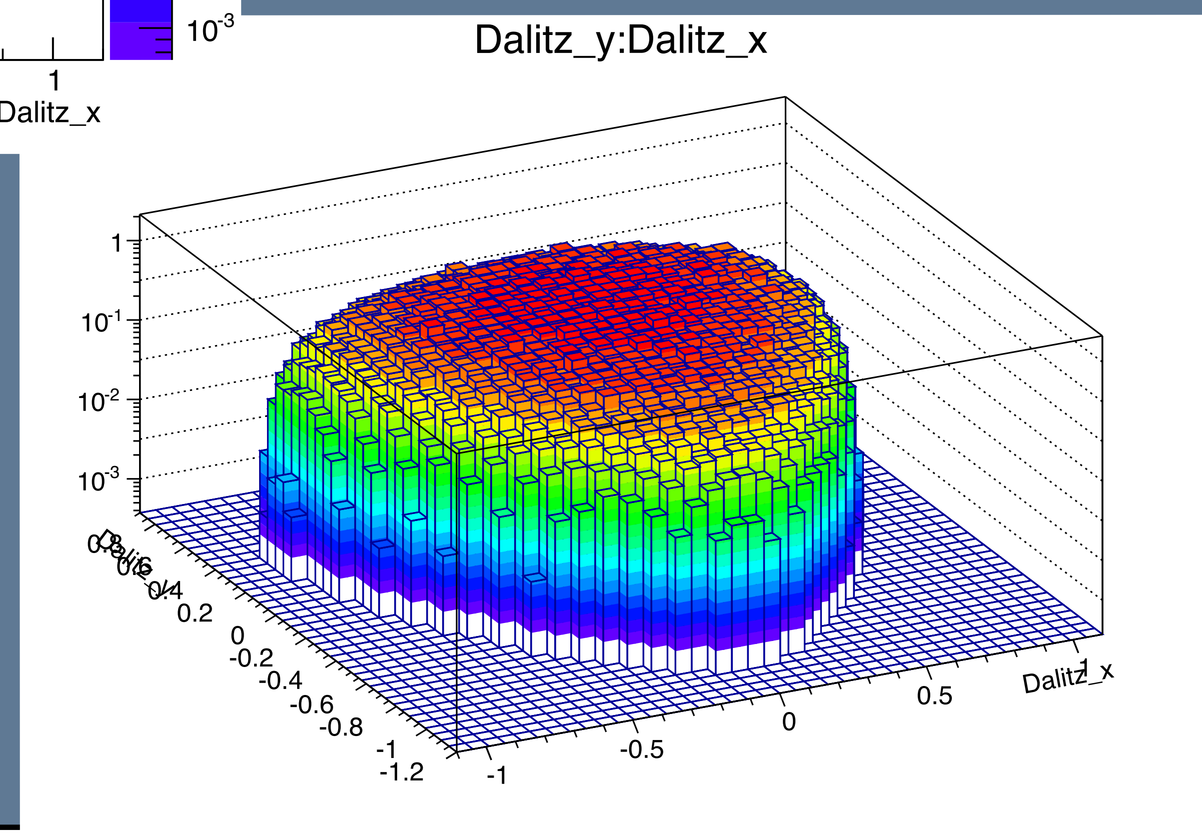


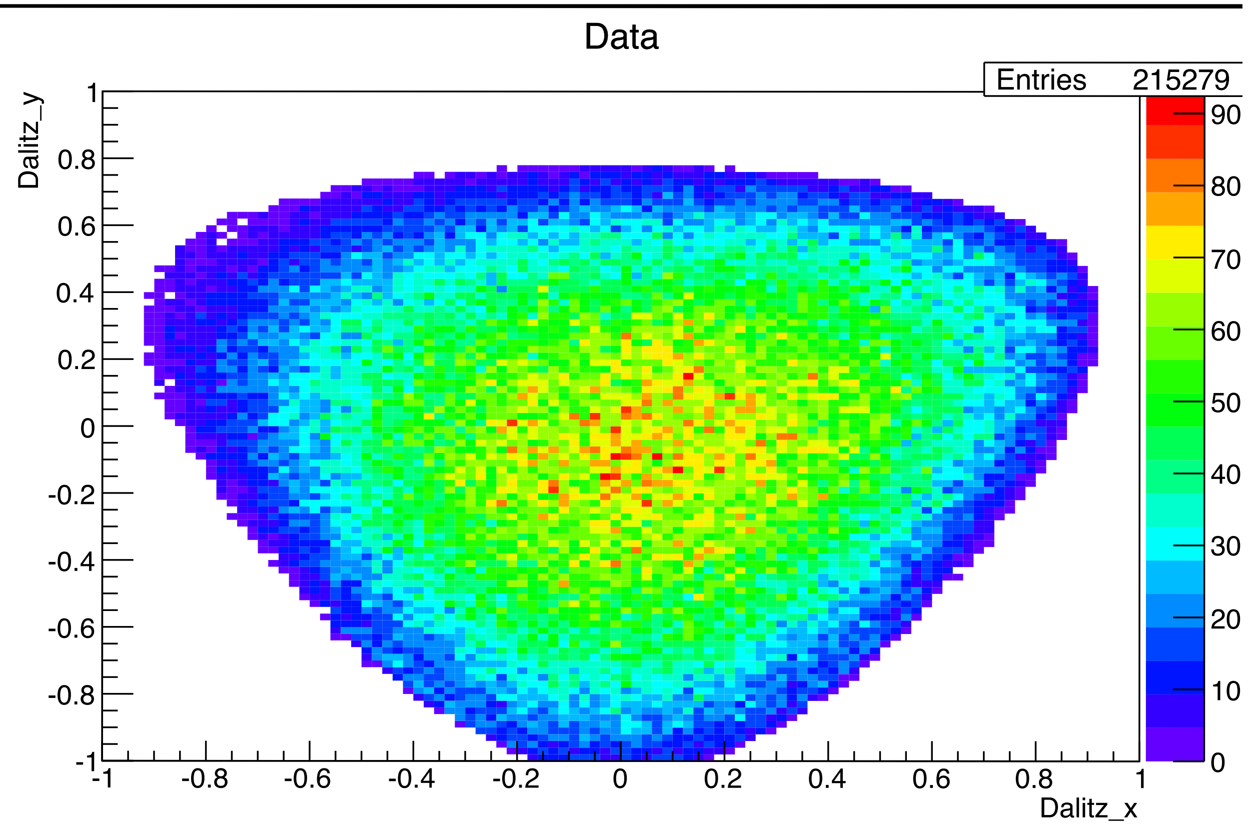


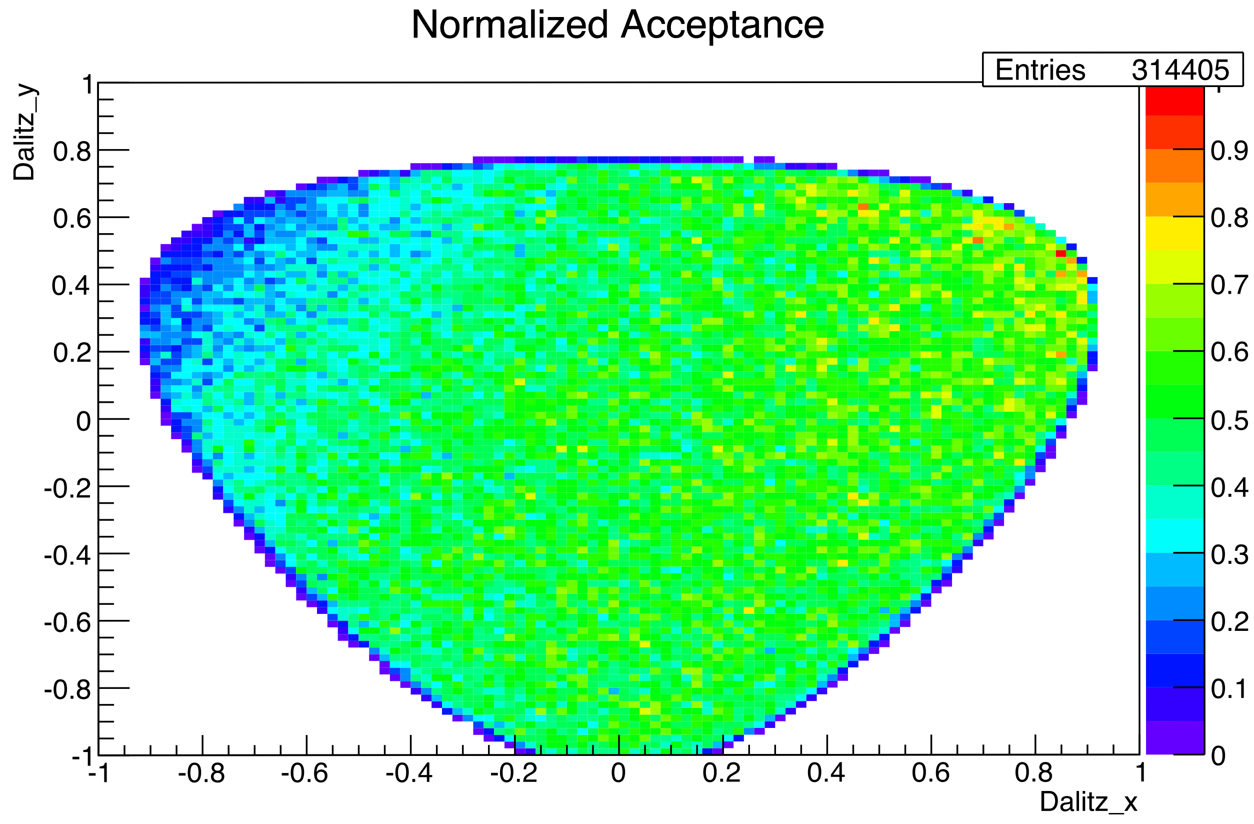
P(s,t) factor

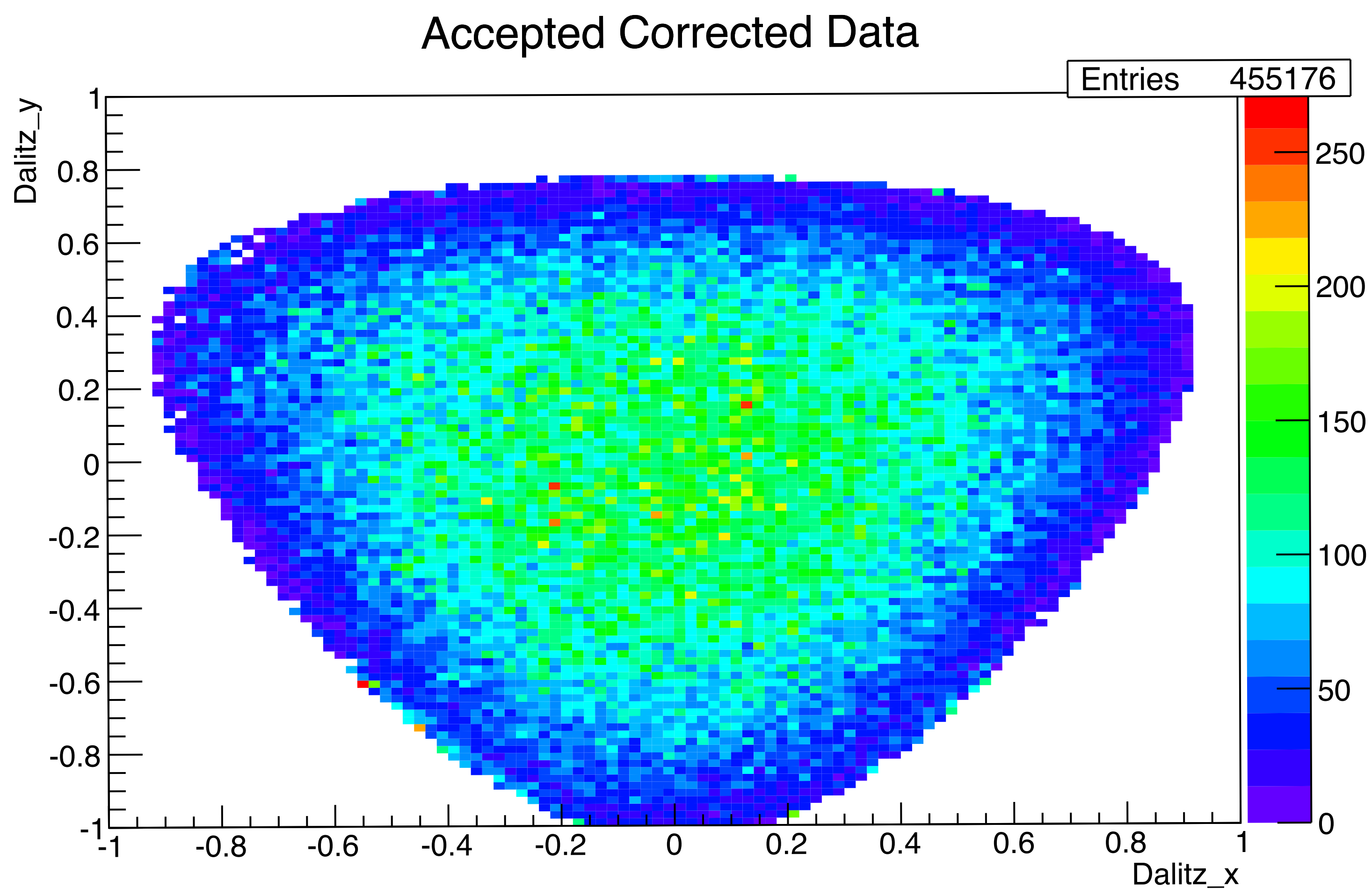
P-factor on log-z scale





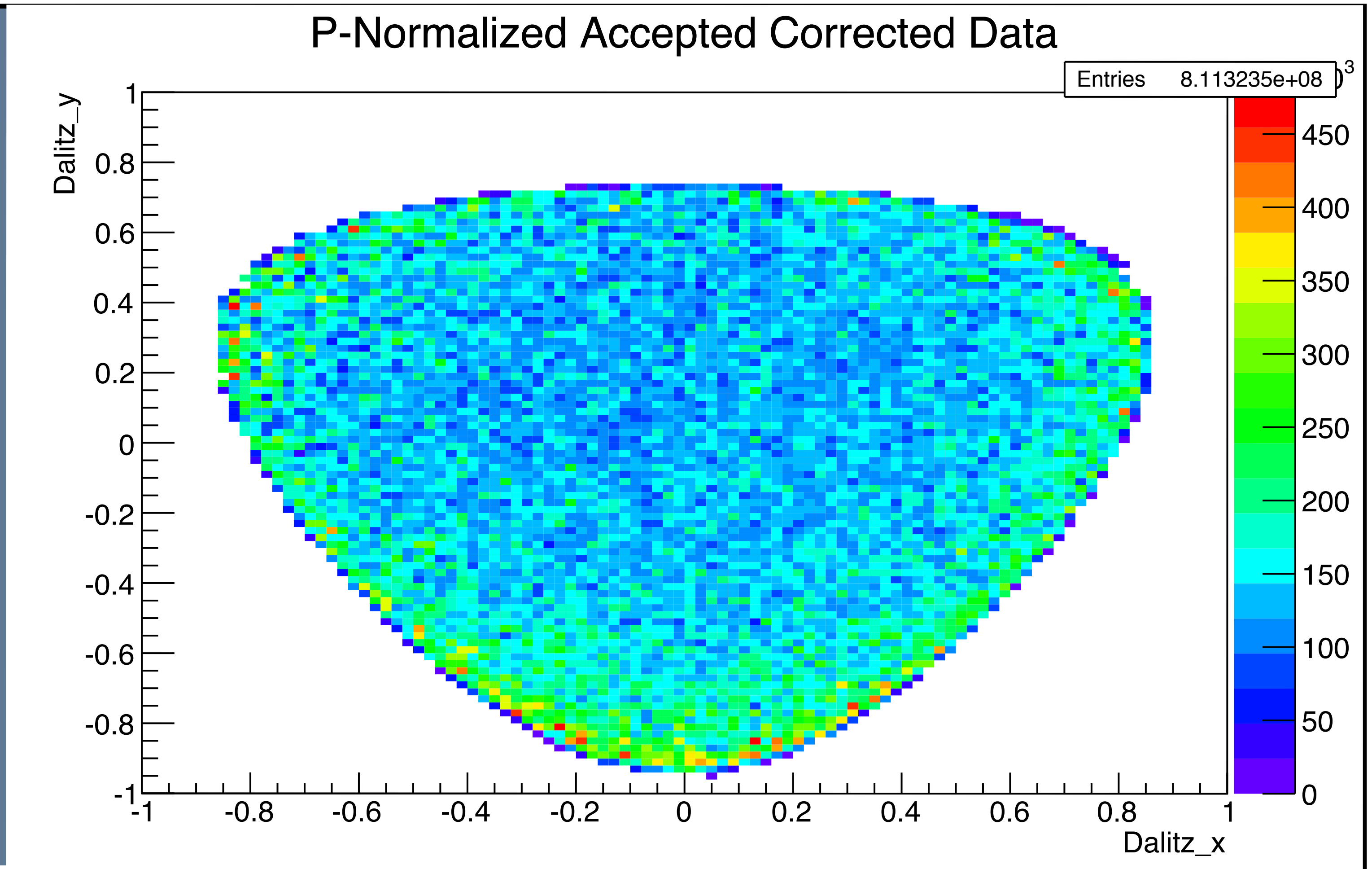

Data
Entries 215279
Dalitz_y
Dalitz_x

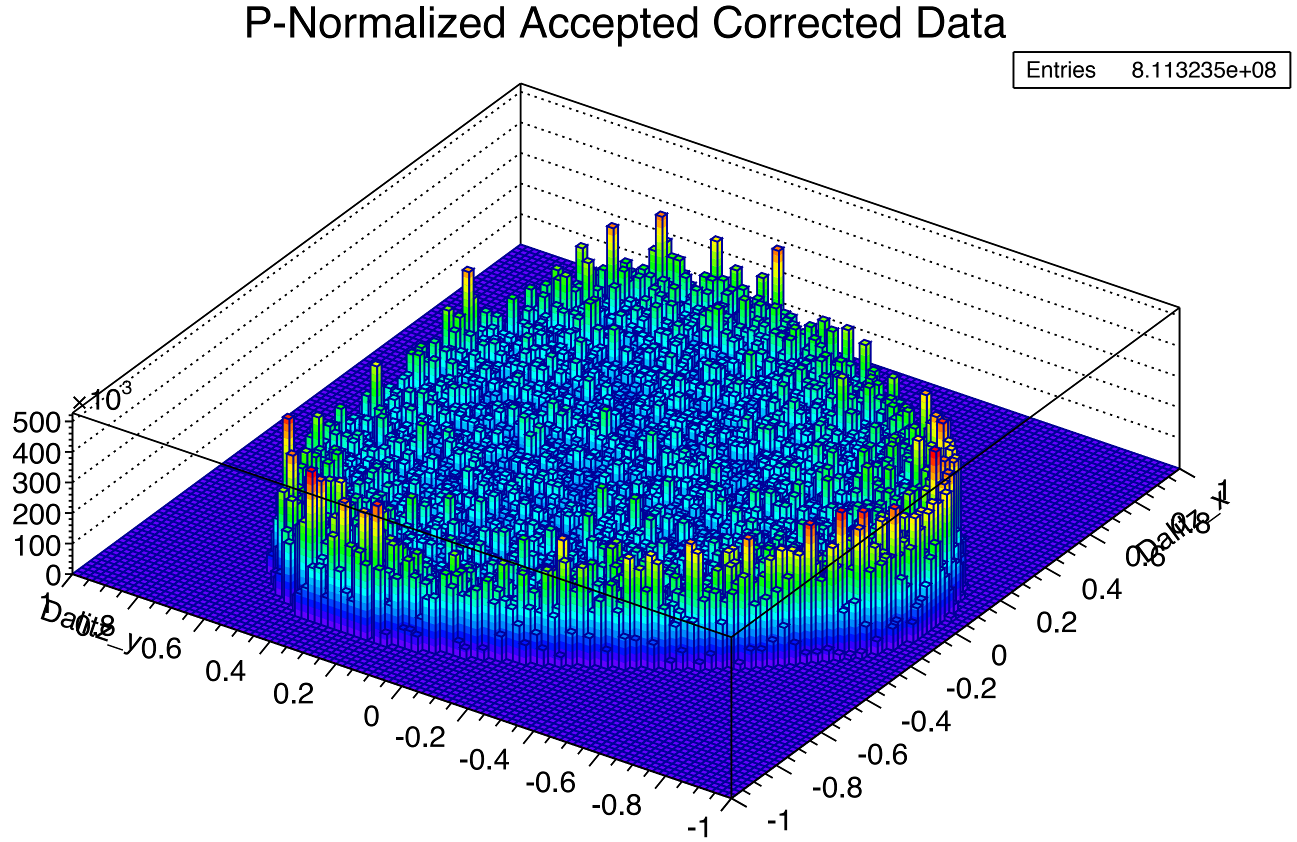

Normalized Acceptance
Entries 314405
Dalitz_y
Dalitz_x


Accepted Corrected Data
Entries 455176
Dalitz_y
Dalitz_x

g12 Data

$\gamma p \rightarrow (\pi^0)\pi^+\pi^- p$





Fit parametric model to data using the PyPWA framework - (generalShell module) see https://pypwa.jlab.org

Performing an Unbinned Extended Likelihood fit :

$$-ln\mathscr{L} = -\sum_{i=1}^{N} Q_i ln\left[I(\vec{x}_i, \vec{a})\right] + \frac{1}{N_g}\sum_{i=1}^{N_a} I(\vec{x}_i, \vec{a})$$

Minimized the negative log-likelihood on the model parameters

In our case:

$$I(sD, tD, \theta_{Adair}, \phi_{Adair}, \text{parameters}) = \text{production} * \text{decay}$$

3 Fitted Function

$$I(sD,tD,uD,\theta,\phi,\mathbf{A1},\mathbf{A2},\mathbf{A3},\mathbf{A4},\mathbf{A5}) = \mathbf{A1}*W(\theta,\phi,\mathbf{A2},\mathbf{A3},\mathbf{A4})*P(sD,tD,uD)*[F(sD,tD,uD,\mathbf{A5})]^2 \quad (15)$$

whre W is the Schilling et al. spin dendity matrix (no-polarization):

$$W(\theta,\phi,\mathbf{A2},\mathbf{A3},\mathbf{A4}) = \quad (16)$$

$$\frac{3}{4\pi}\left[0.5*(1-\mathbf{A2}) + 0.5*(3*\mathbf{A2}-1)cos^2(\theta) - \sqrt{2}*\mathbf{A3}*sin2(\theta)cos(\phi) - \mathbf{A4}*sin^2(\theta)cos2(\phi)\right] \quad (17)$$

and θ, ϕ are Adair's angles. P is a kinematic factor given by:

$$P(sD,tD,uD) = sD*tD*uD - m_\pi^2\left[M^2 - m_\pi^2\right]^2 \quad (18)$$

wherre sD, tD, uD are the Mandelstam variables of the decay such that:
$sD = (p_X - p_{\pi^+})$ t $D = (p_X - p_{\pi^-})$ and u $D = (p_X - p_{\pi^0})$.
and $p_X = p_{\pi^+} + p_{\pi^-} + p_{\pi^0}$, M is the mass of the three pion system and m_π the mass of the pion (plus).
F (sD,tD,uD,**A5**) is Igor Danilkin et al. amplitude given for a call to his fortran code.

MC was generated with a t-slope of 3 GeV^{-2} to match data low t distributions. - all t are included in current fits. (future analysis of t dependence is planned).

Preliminary Fits results

All	A2	A3	A4	A5
3.5-4.0	0.315	-0.016	-0.021	-12.53
4.0-4.5	0.315	-0.016	-0,021	-12.78
4.5-5.0	0.315	-0.016	-0.021	-12.82
5.0-5.5	0.191	0.018	-0.007	-12.8

nonF	A2	A3	A4
3.5-4.0	0.27	-0.018	-0.023
4.0-4.5	0.28	-0.026	-0,068
4.5-5.0	0.29	-0.022	-0.039
5.0-5.5	0.31	0.016	-0.021

F	A2	A3	A4	A5
3.5-4.0	0.194	-0.016	-0.007	0 (fixed)
3.5-4.0	0.299	-0.018	-0,08	1 (fixed)
3.5-4.0	0.191	-0.018	-0.007	-12.8 (fixed normalization)

Still studying stability of fits: next steps

(ii) Circular polarization of helicity $\lambda_\gamma = \pm 1$:

$$W^{\pm}(\cos\theta, \phi) = W^0(\cos\theta, \phi) \pm P_\gamma W^3(\cos\theta, \phi) .$$

$$W^0(\cos\theta,\phi) = \frac{3}{4\pi}\left(\tfrac{1}{2}(1-\rho^0_{00}) + \tfrac{1}{2}(3\rho^0_{00}-1)\cos^2\theta - \sqrt{2}\,\mathrm{Re}\,\rho^0_{10}\sin 2\theta\cos\phi - \rho^0_{1-1}\sin^2\theta\cos 2\phi\right),$$

Schilling et al

$$W^3(\cos\theta,\phi) = \frac{3}{4\pi}\left(+\sqrt{2}\,\mathrm{Im}\,\rho^3_{10}\sin 2\theta\sin\phi + \mathrm{Im}\,\rho^3_{1-1}\sin^2\theta\sin 2\phi\right)$$

Parametrization of Dalitz intensity through:

$$x = \sqrt{z}\cos\vartheta\,, \quad y = \sqrt{z}\sin\vartheta\,, \qquad (39)$$

and fit the following polynomial expansion

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

Kubis et al

Preliminary Results and Things still to be done

• $\omega \rightarrow \pi^+\pi^-(\pi^0)$ events for $3.6 < E_{photon} < 5.4$ GeV have been extracted given a mass for the ω of 783.5 MeV and width of 9.92 MeV (PDG: 782.65,8.49). Sample with very small background.

• Comparison with theory has started:

- Data seems dominated by P-wave (as expected).
- The extra-terms of the three-body decay models are important at the edges of the Dalitz plots where acceptance/statistics are very limited.

Next steps:

- Study Fit stability.
- Introduce other parametrization (and polarization,...)
- Study Energy and t dependancies.