Partial wave analysis of the reaction $\gamma p \longrightarrow p K^- K^+ \pi^0$ in low-mass region

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Data

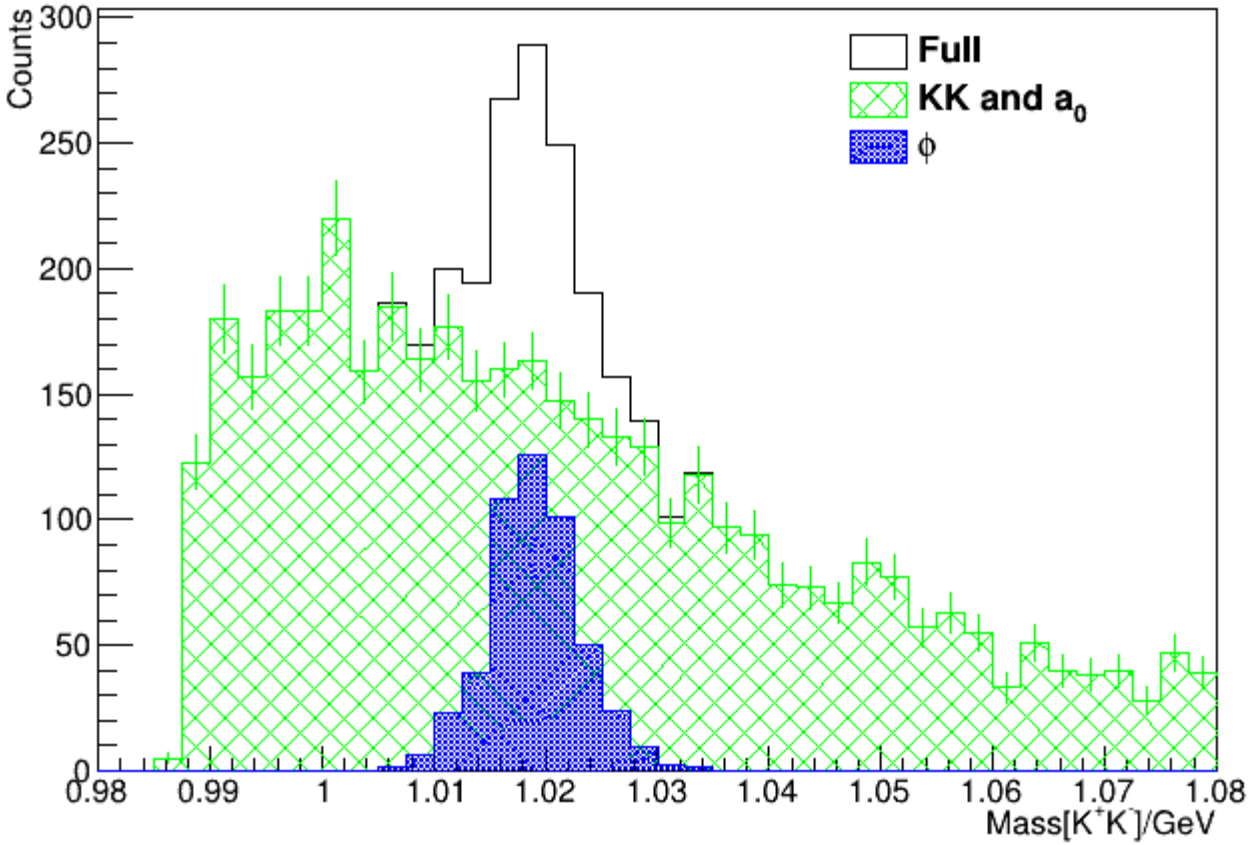
Dataset:

- Spring 2018 data

Restrictions:

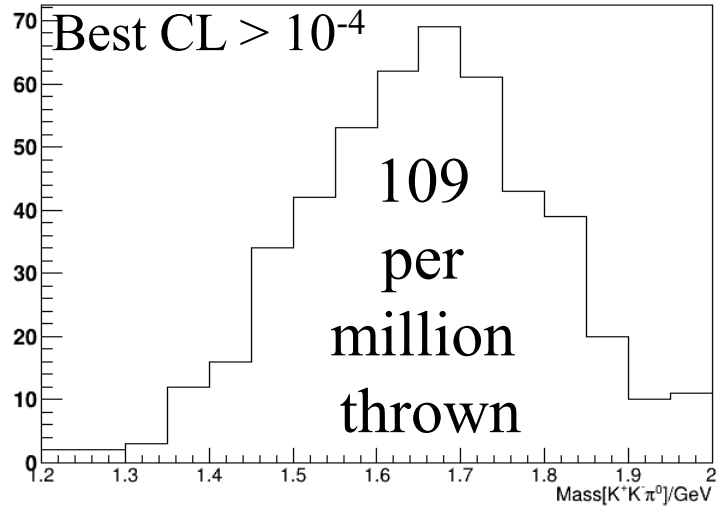
- Incident photon timed to be within central peak
- Only best Confidence Level (*CL*) per event kept
- *CL* must be above 10^{-4}
- Kaons must be seen in TOF
- Kaons must have momentum < 3 GeV
- Missing mass within 3 standard deviations of central peak
- 0.12 GeV < Mass[π^0] < 0.15 GeV

Q-factors to separate $\varphi\pi$ from $K^+K^-\pi^0$ and $a_0\pi^0$ events

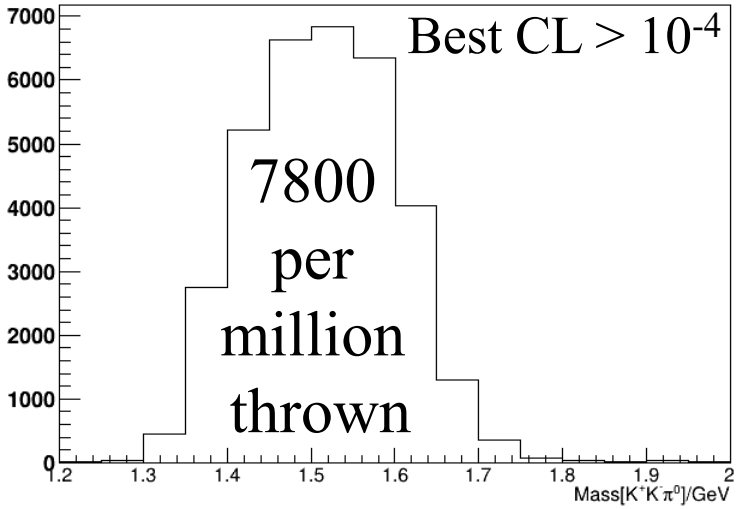


Contamination study (4.4 million thrown)

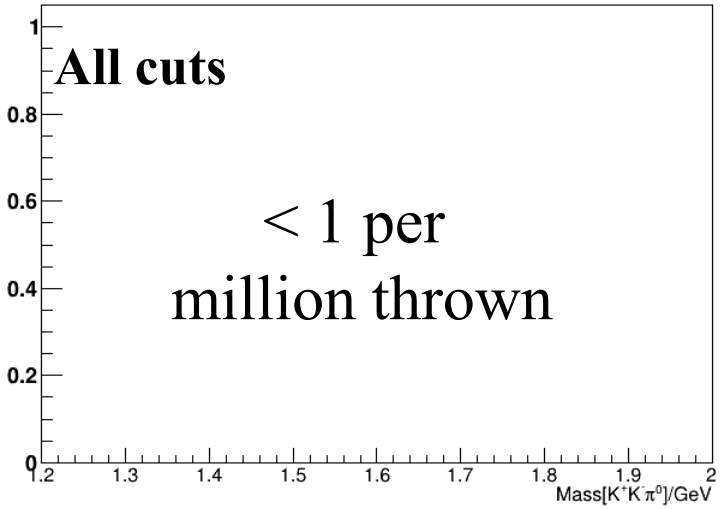
$\pi^+\pi^-\pi^0$ seen as $K^+K^-\pi^0$



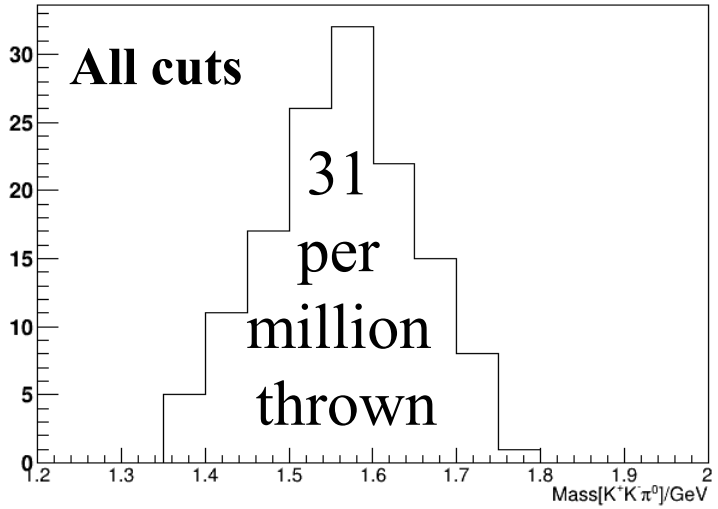
$K^+\pi^-\pi^0$ seen as $K^+K^-\pi^0$



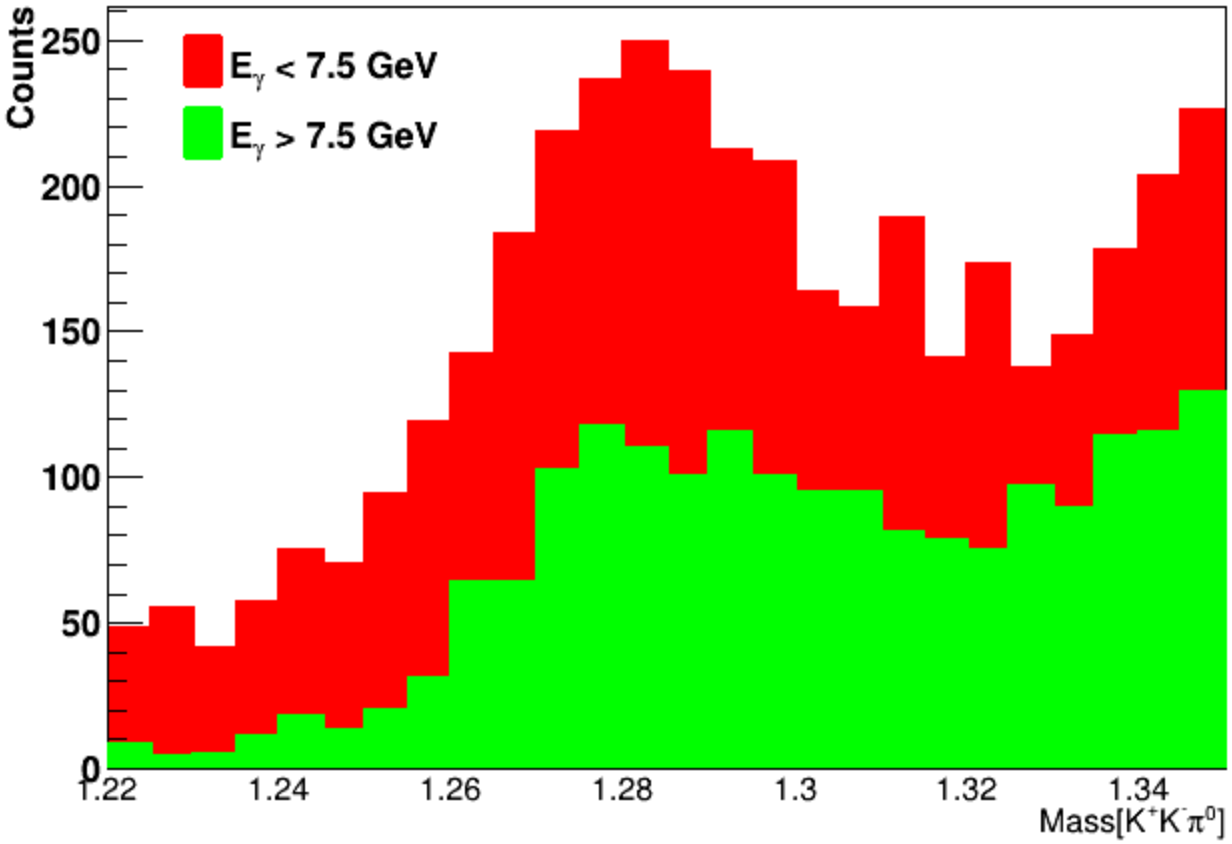
$\pi^+\pi^-\pi^0$ seen as $K^+K^-\pi^0$



$K^+\pi^-\pi^0$ seen as $K^+K^-\pi^0$



Additional E_γ cut

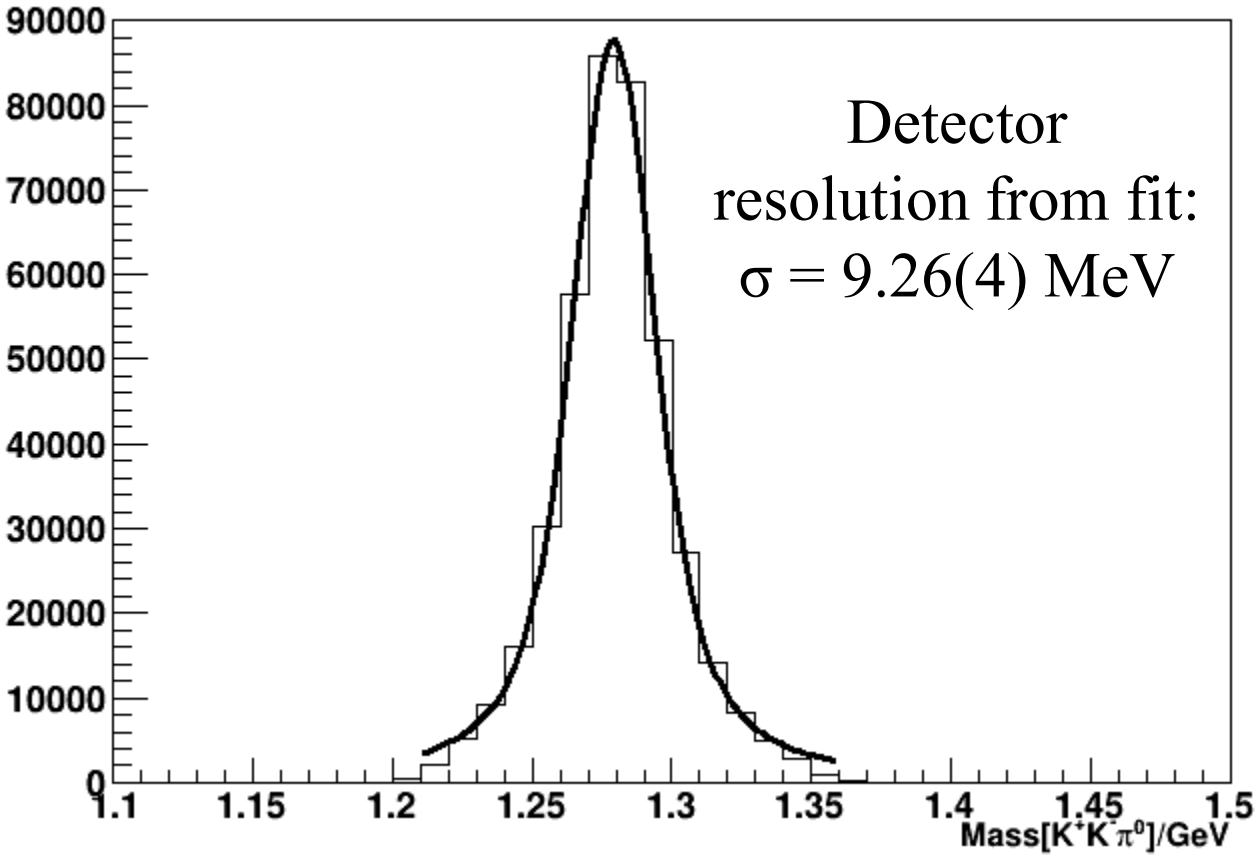


For now, only using events with E_γ below 7.5 GeV

Detector resolution study

- Used gen_amp to simulate $f_1(1285)$ signal
- Generated 4 million events
- Fit with Voigt profile:
  - Center set to PDG value
  - Width locked to PDG value

Detector resolution study



PWA

$$\gamma\, p \longrightarrow p\, R$$

R = Meson resonance

PWA

$$\gamma p \longrightarrow p R \longrightarrow p I b$$

I = isobar
b = bachelor

PWA

$$\gamma p \longrightarrow p R \longrightarrow p I b \longrightarrow p \pi^0 K^- K^+$$

PWA

$$\gamma p \longrightarrow p R \longrightarrow p I b \longrightarrow p \pi^0 K^- K^+$$

- Isobar I can decay to $K^- K^+$ or $K^{\pm} \pi^0$
- Resonance R decay angles analyzed in the Gottfried-Jackson frame
- Isobar decay angles analyzed in the helicity frame
- Amplitude function used:

$$a_{Jlsm} \sum_{\lambda} D^{J*}_{m\lambda}(\varphi_{GJ}, \theta_{GJ}) D^{s*}_{\lambda 0}(\varphi_h, \theta_h) \langle l 0 s \lambda | J \lambda \rangle$$

- a_{Jlsm} are the complex fit coefficients
- AmpTools used for PWA
- Breit-Wigner amplitude for the $a_0(980)$ isobar:

$$\frac{m_0 \Gamma}{{m_0}^2 - m^2 - i m_0 \Gamma}$$

E852 waves

The E852 collaboration performed a PWA of the $f_1(1285)$ within the reaction $\pi^- p \longrightarrow K^+ K^- \pi^0 n$

"A non-interfering isotropic background wave was included at each mass bin to simulate the cumulative effect of numerous small waves that were omitted from the fit." *- E852 Collaboration, Physics Letters B 516 (2001) 264-272*

Included waves (below 1.375 GeV):

- $J^{PC} = 0^{-+}$, decay mode = $a_0(980)\pi^0$
- $J^{PC} = 1^{++}$, decay mode = $a_0(980)\pi^0$

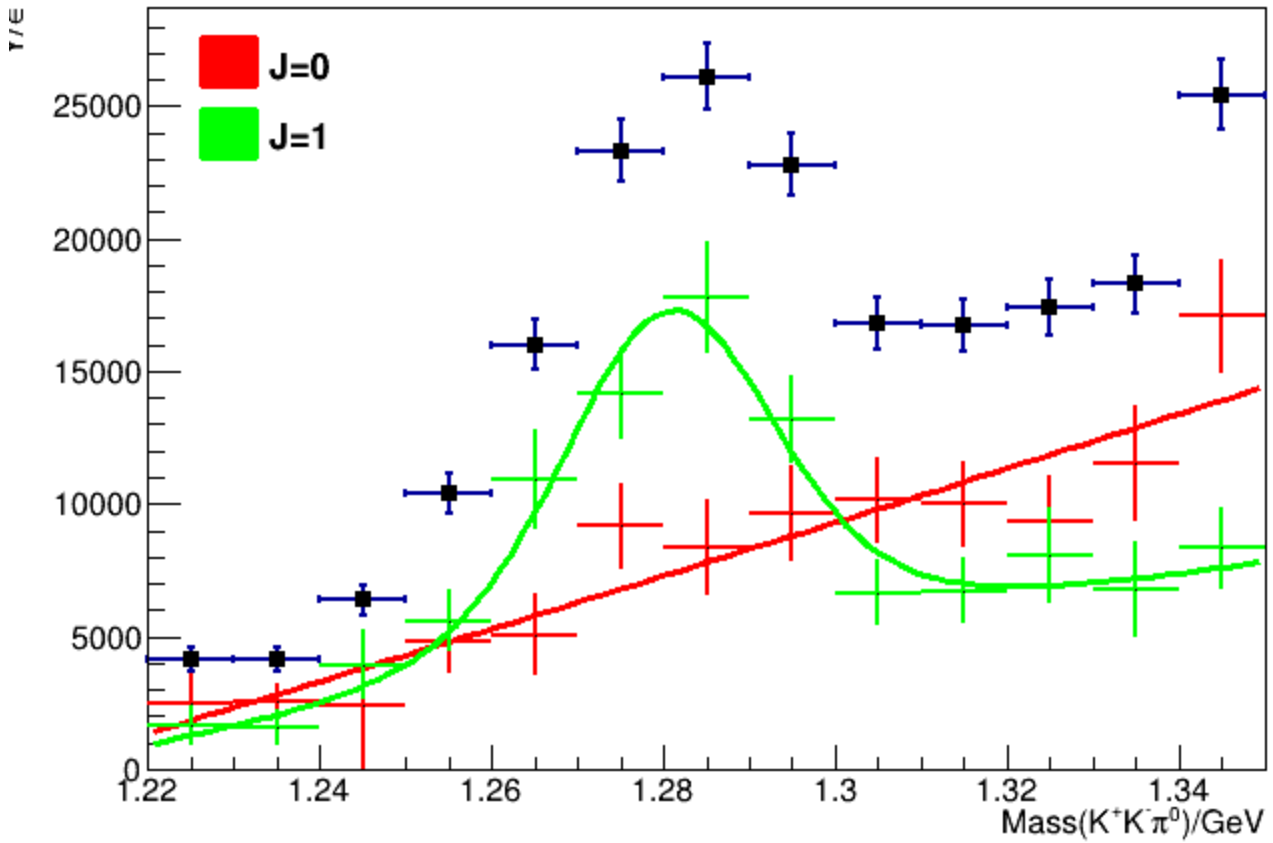
PWA fitting procedure

Previously, we have had difficulty including J=0 terms within coherent sums. The J=0 terms tended to completely dominate.

- Used E852-type background (floating complex number for each mass bin) added incoherently with any other waves
- All non-background waves are added coherently
- We use a two-step seeding procedure to help keep the J=0 contribution from taking over:
  - The initial fit omits the non-background J=0 amplitude
  - Final fit is seeded with results of the first fit, with additional J=0 amplitude added in

ASU

PWA results using the same set of waves as E852



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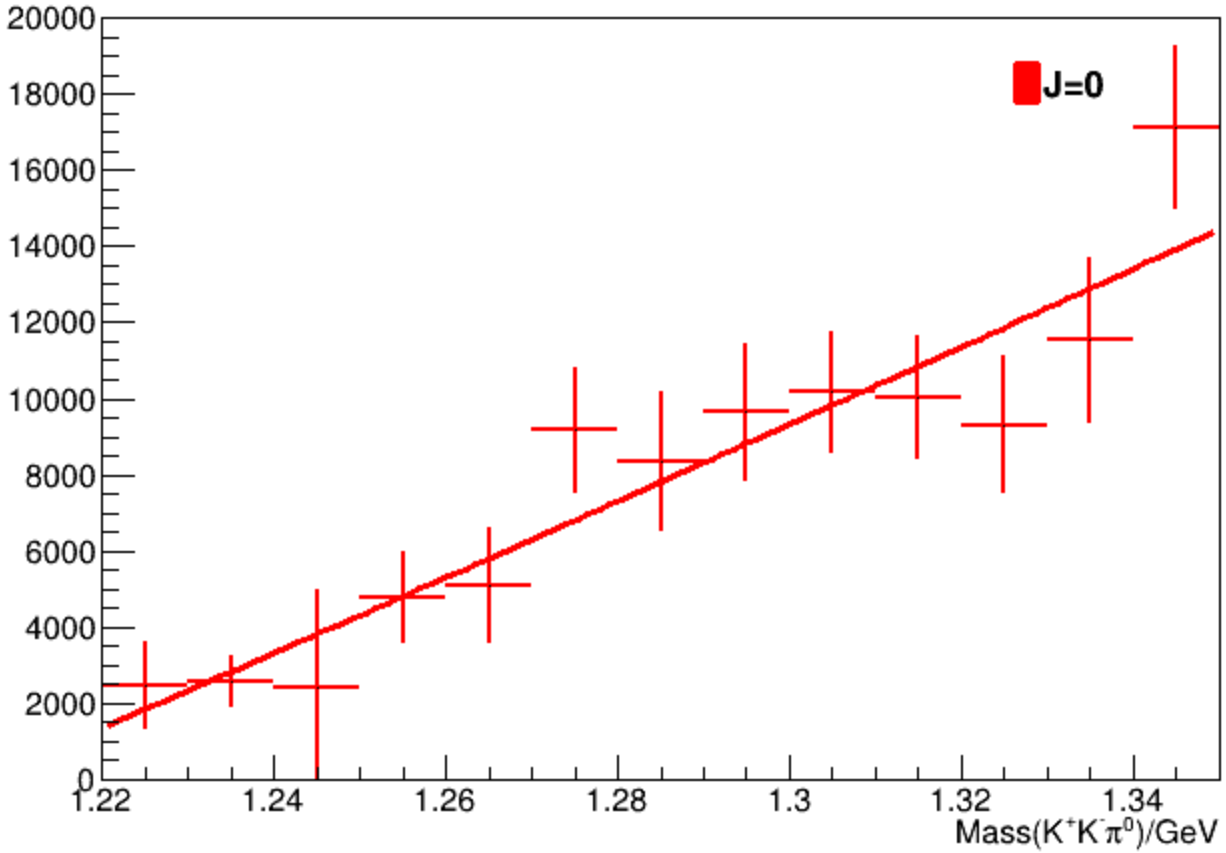

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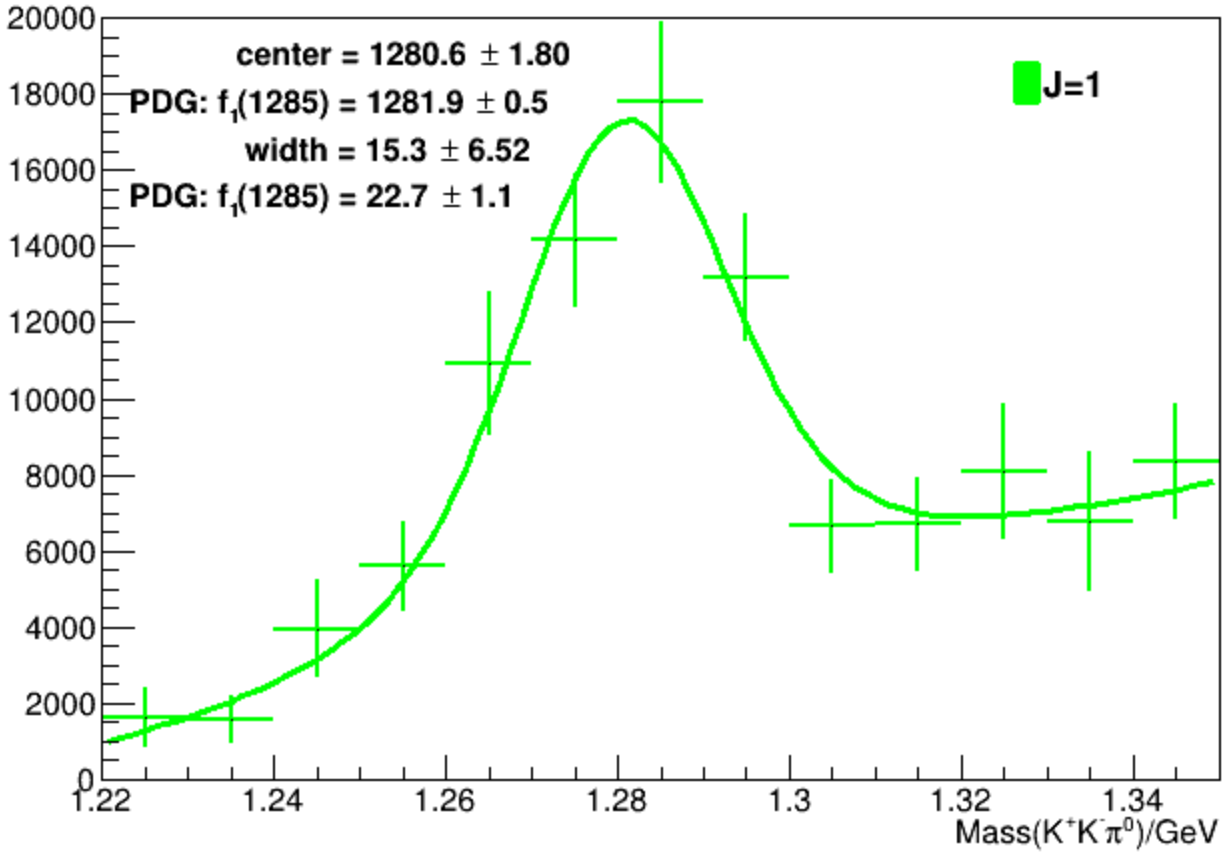
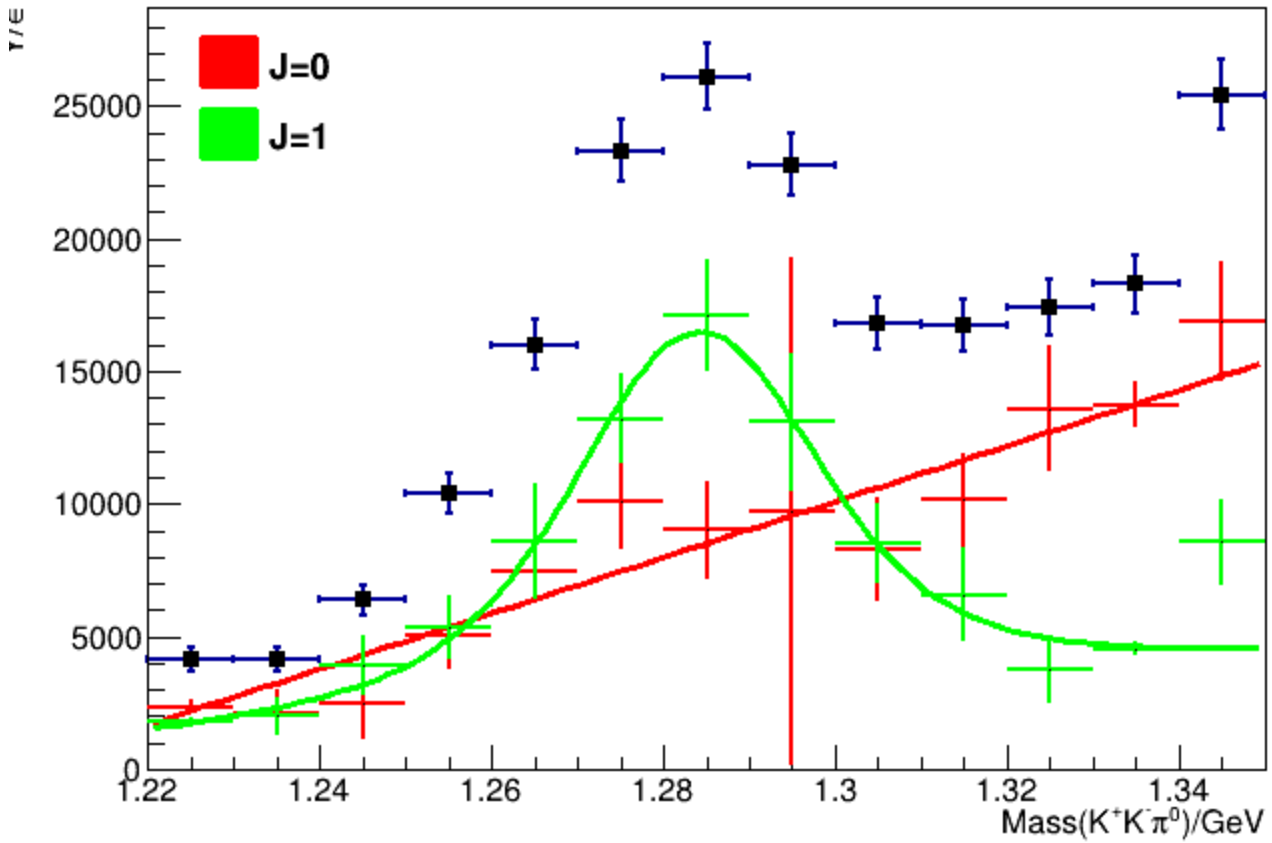


PWA results with additional J=1, L=0, S=1 waves included



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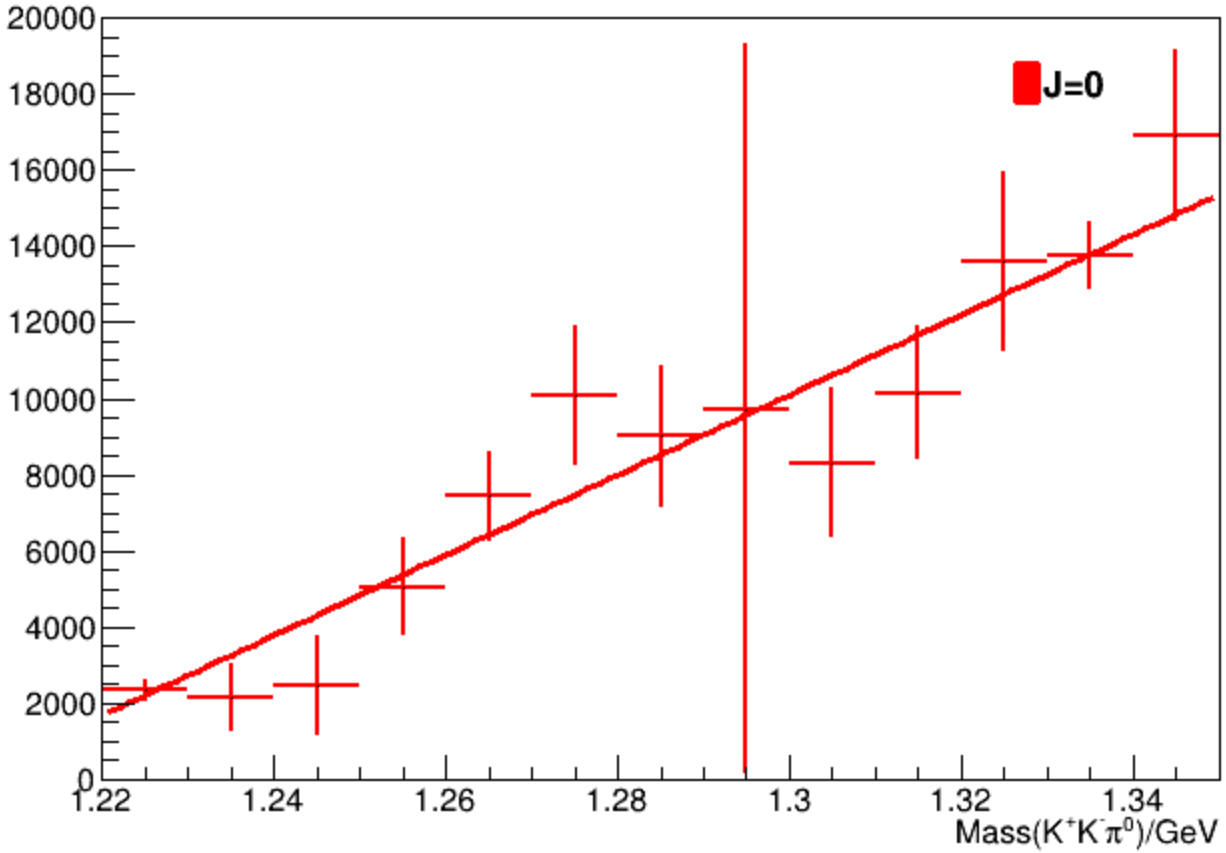

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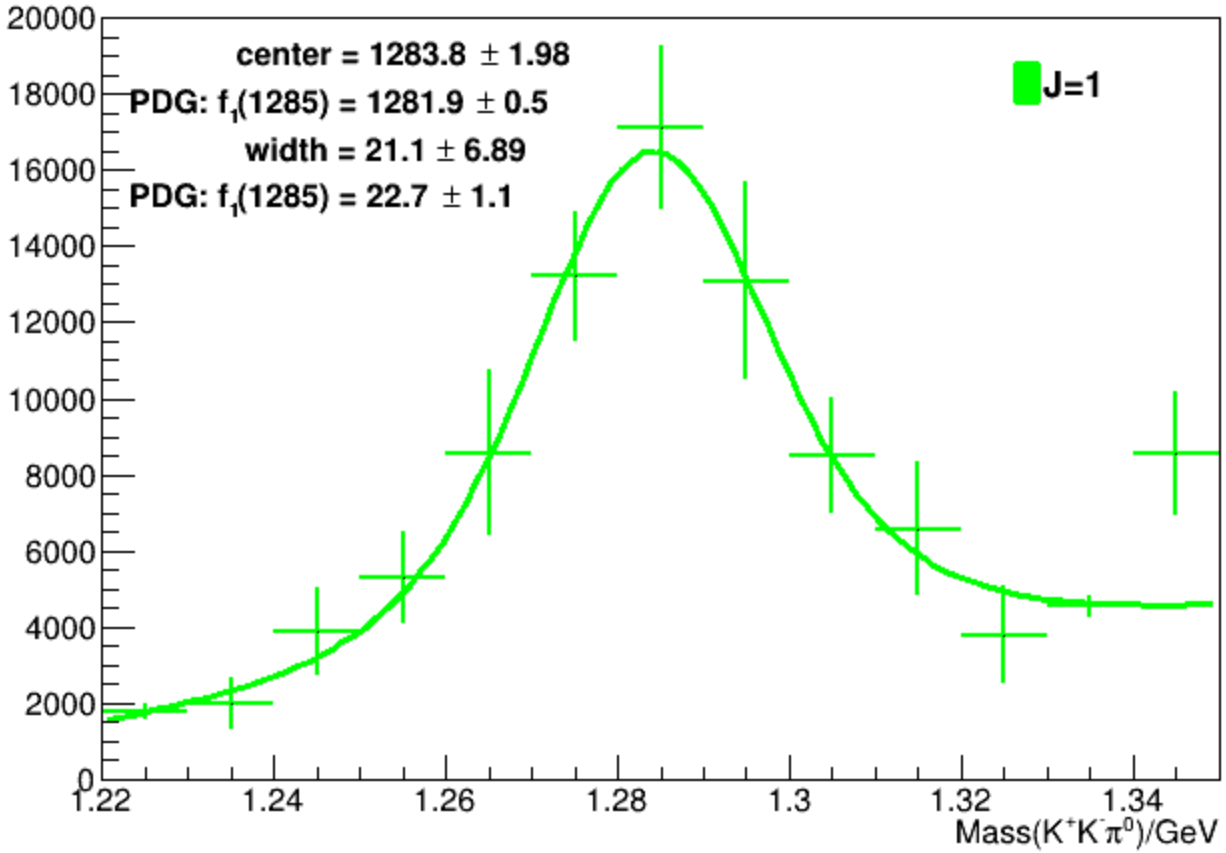

Some future work

- Further contamination studies
- I/O studies using gen_amp
- Improve statistics
- Seeding studies
- Phase motion studies
- Many more studies