Early stage Low-mass $K^+K^-\pi^0$ study

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
- Missing mass within 3 standard deviations of central peak
- 0.12 GeV < Mass[π^0] < 0.15 GeV
- Mass[$K^+K^-\pi^0$] < 1.32
- Incident photon energy: 5.4 GeV< E_γ <9 GeV

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Need to study and remove $\varphi\pi$ contamination

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- Kaons must be seen in TOF
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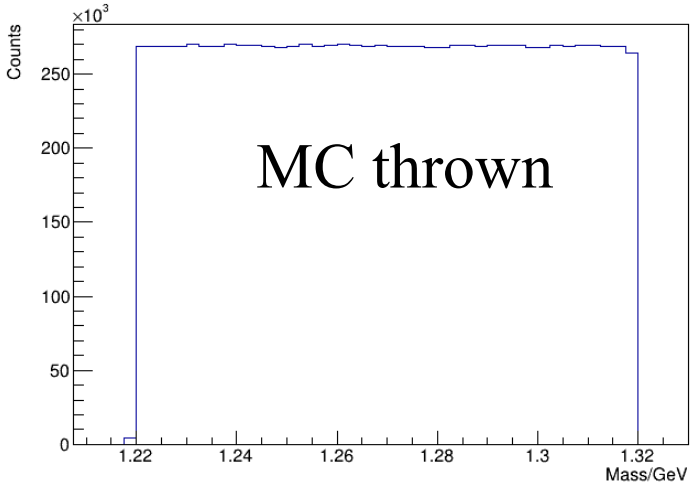
- Incident photon energy: 5.4 GeV< E_γ <9 GeV

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

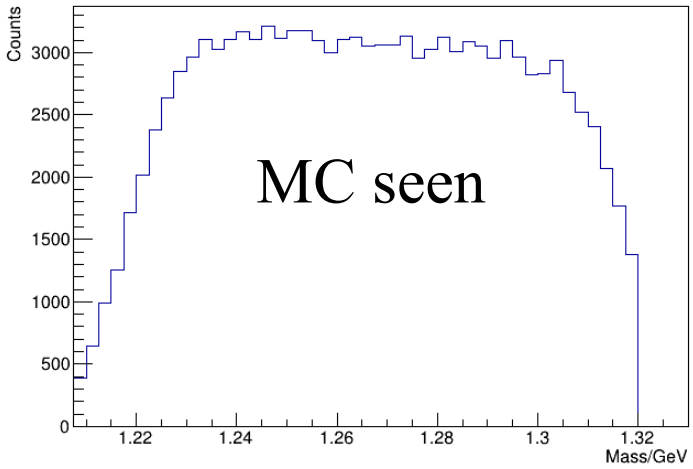
The event generator:

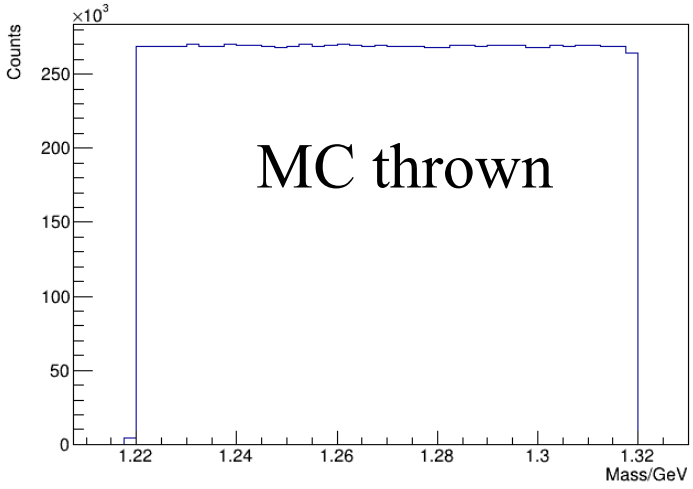
- Flat in mass between 1.22 and 1.32
- Modified *t*-slope to match the data
- Used actual data to model photon energy spectrum
  - Will need to use normalization distribution in next round of generator refinement
- Over 10 million thrown events

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


MC thrown
Counts
×10³
250
200
150
100
50
0
1.22
1.24
1.26
1.28
1.3
1.32
Mass/GeV

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


Counts
3000
2500
2000
1500
1000
500
0
1.22
1.24
1.26
1.28
1.3
1.32
Mass/GeV
MC seen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×10³
250
200
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1.22
1.24
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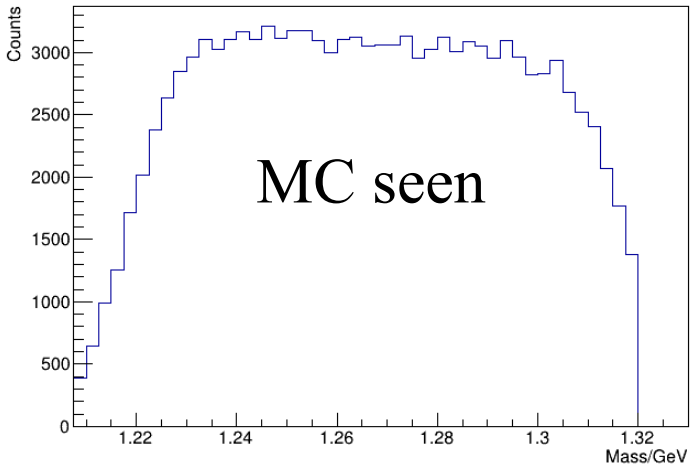
$K^+K^-\pi^0$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1.24
1.26
1.28
1.3
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Mass/GeV
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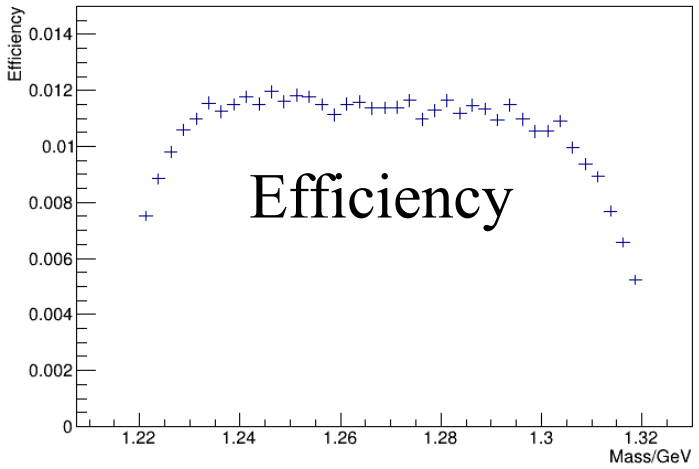
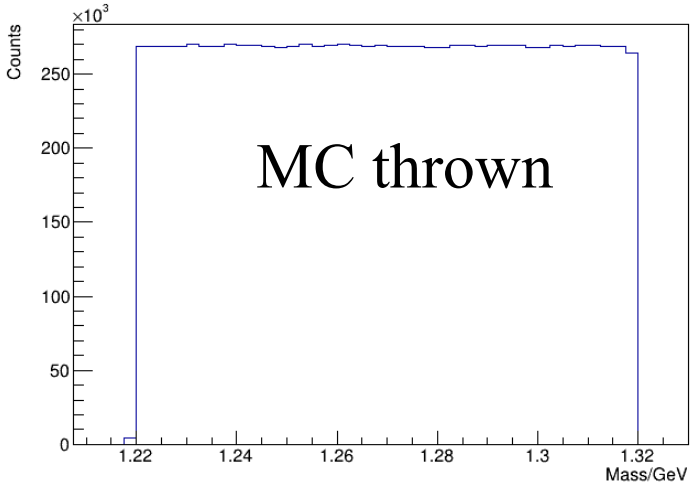

Efficiency
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
1.22
1.24
1.26
1.28
1.3
1.32
Mass/GeV
Efficiency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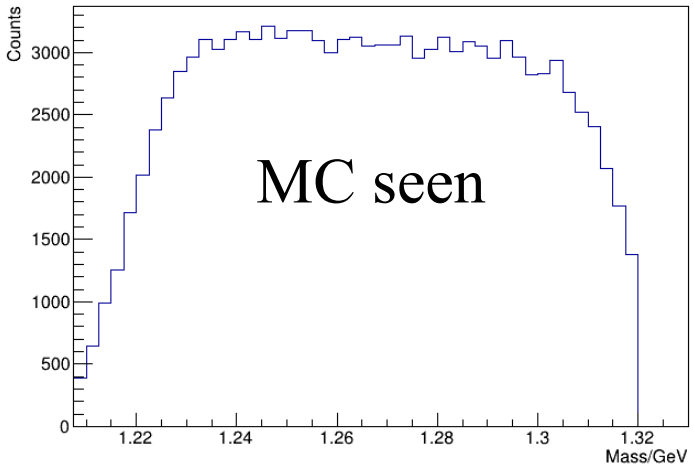
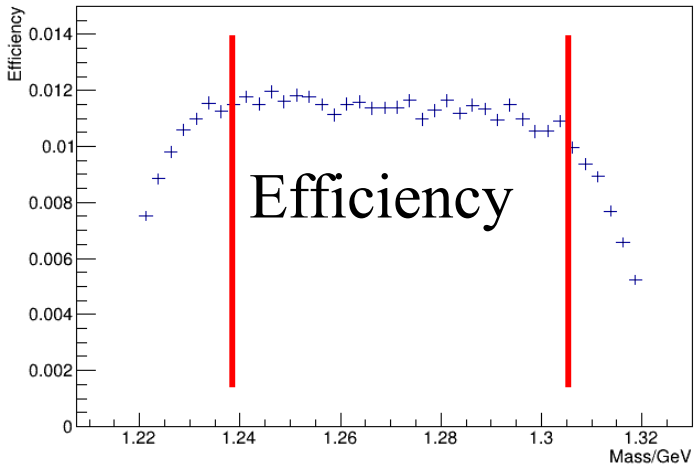
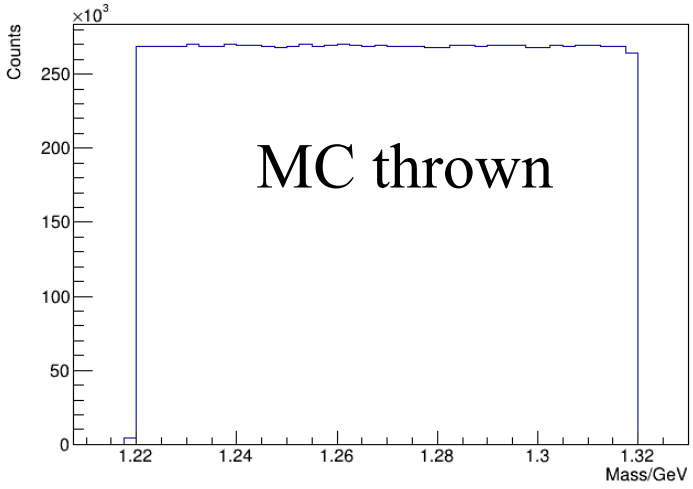
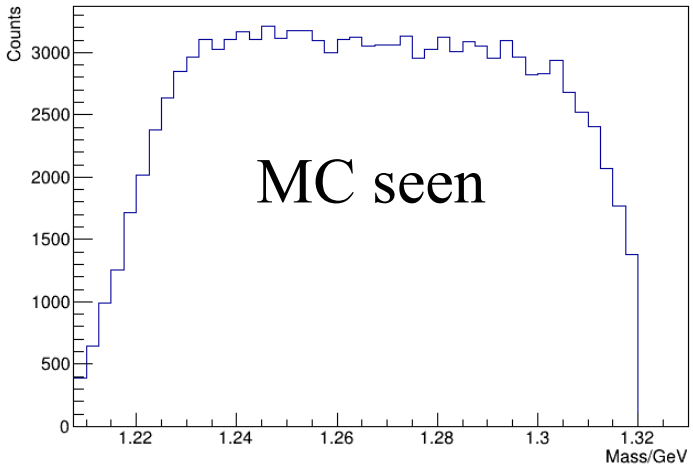


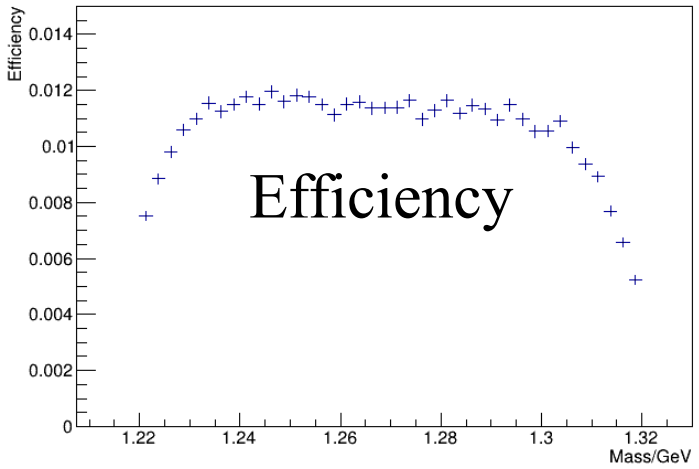


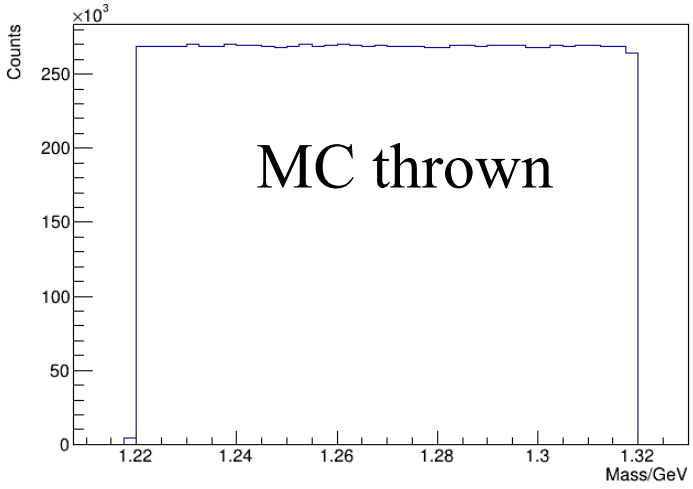


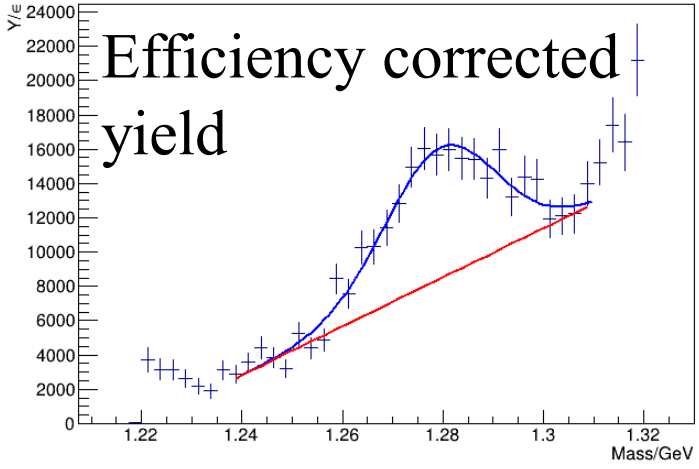
Fairly flat over region 1.24 to 1.31 GeV

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



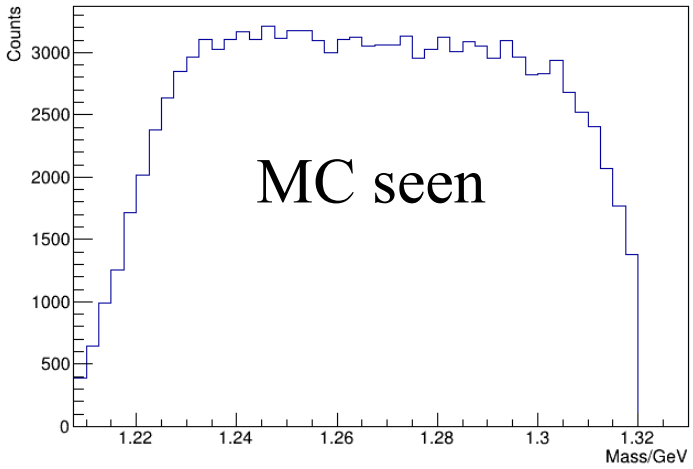


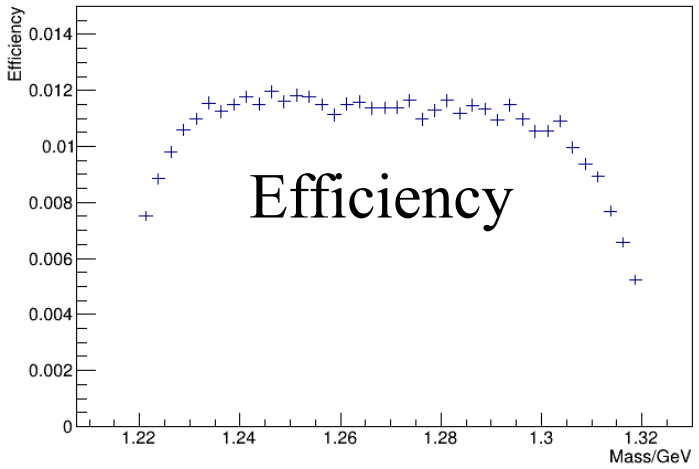


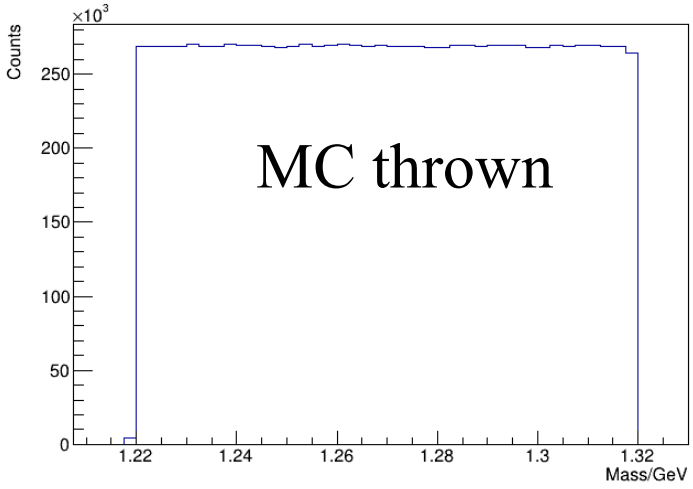


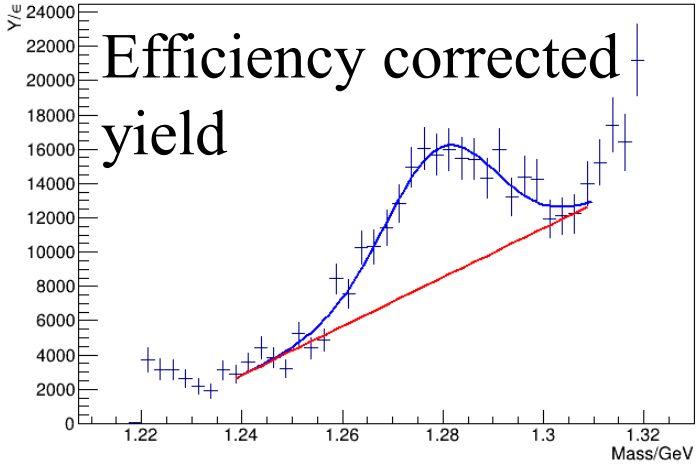
Background subtracted peak is 22% of total counts

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





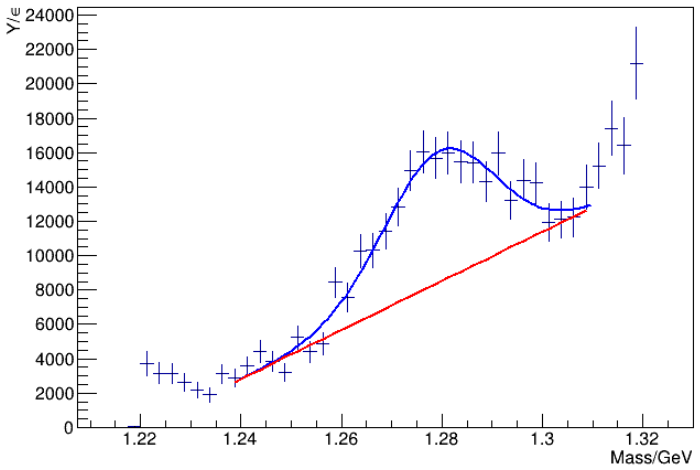




Center = 1279(2) MeV

FWHM = 24(5) MeV

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



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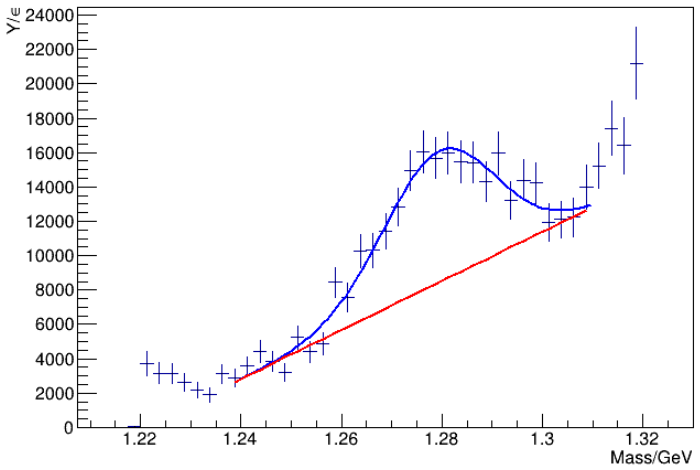

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No PDG meson state at 1280 MeV
But…

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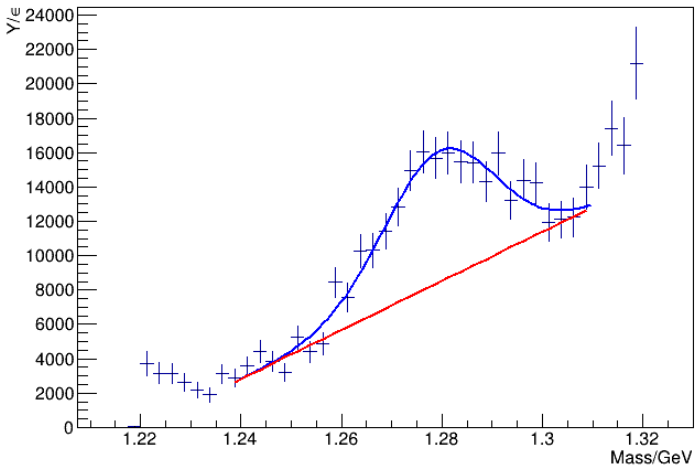

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Photoproduction and Decay Modes of the x(1280) Meson

Show affiliations

Dickson, Ryan ; Schumacher, Reinhard

A meson of mass m_x=1281 MeV and a FWHM of γ_x=18 MeV is seen at Jefferson Lab with CLAS in photoproduction off the proton using real photons in the energy range between 1.9 GeV and 3.4 GeV. Both the $f_1(1285)$ and the poorly-known $\eta(1295)$ are candidates for this observed state. The decay modes seen are x->η&+circ;&-circ;, K^+K^0&-circ;, K^-K^0&+circ;, and K^+K^-0 with a substantial fraction going through $a_0(980)\pi$. No signal is seen in x->0γ. The relative branching fraction $\gamma_{KK\pi}/\gamma_{\eta\pi\pi}$ is consistent with world data for the $f_1(1285)$ state. The unseen 0γ decay mode is not consistent with the $f_1(1285)$ state, however, and may be more consistent with the η(1295). Angle and energy dependencies of the measured cross-sections are in fair agreement among the observed decay modes.

Publication: American Physical Society, 2009 APS April Meeting, May 2-5, 2009, abstract id. Q10.004

Pub Date: May 2009

Bibcode: 2009APS..APRQ10004D

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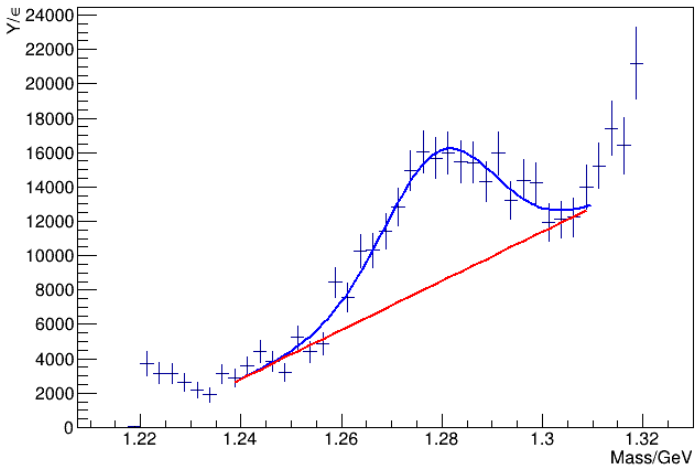

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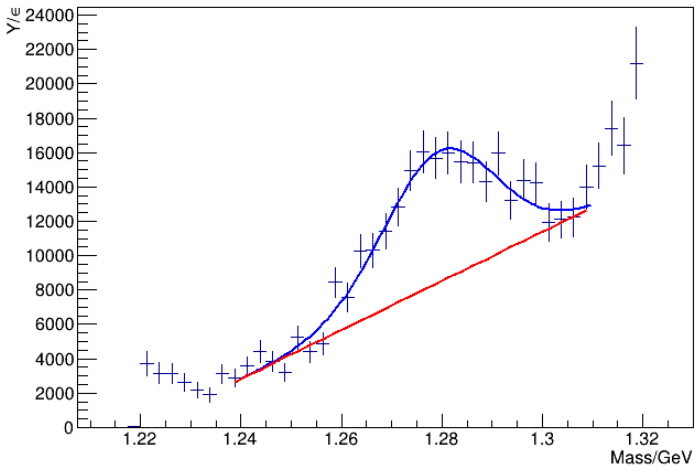

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Sent email to Reinhard asking what came of the CMU study of this x(1280) bump. Waiting for response.

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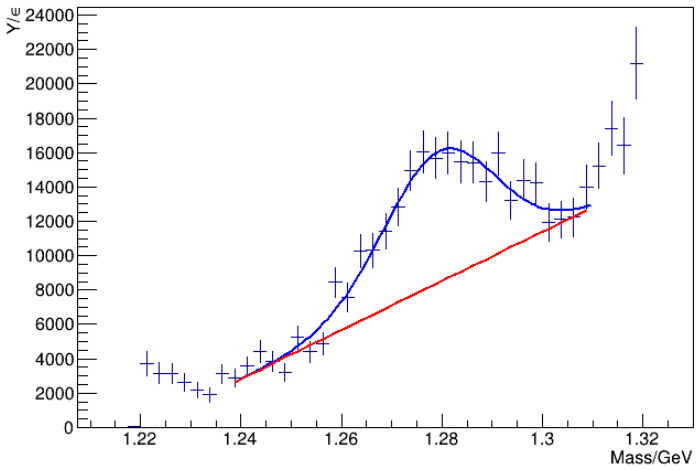

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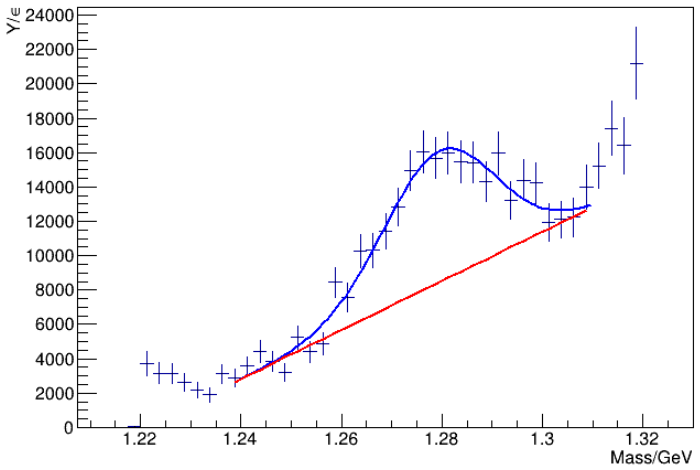

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Definition of (θ,φ) and (θ_H,φ_H)

- The (θ,φ) angles defined from polar and azimuthal angles of the K^+K^- isobar in the Gottfried-Jackson frame of $K^+K^-\pi^0$ system: z-axis coincident with the incident photon and y-axis normal to the production plane

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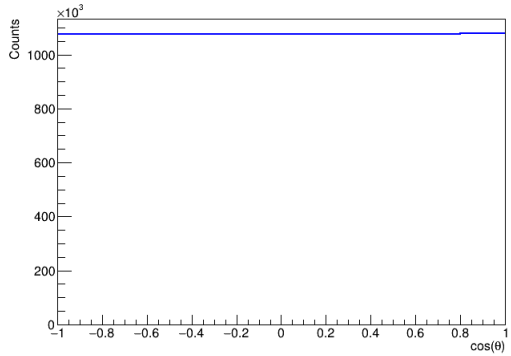
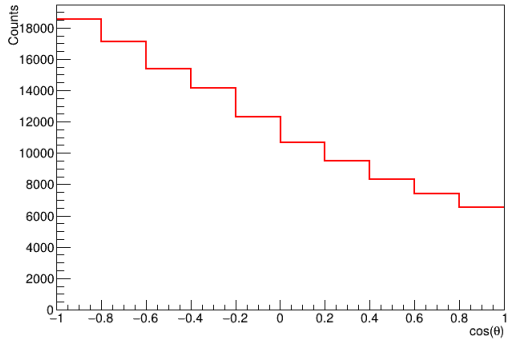
- The (θ_H,φ_H) angles defined from polar and azimuthal angles of the K^+, in the helicity frame of the K^+ K^- : z_H-axis coincident with the K^+ K^- and the y-axis normal to the production plane

Distributions of cos(θ) and φ

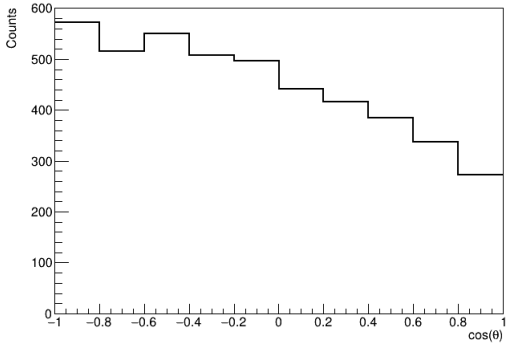
MC thrown



MC seen

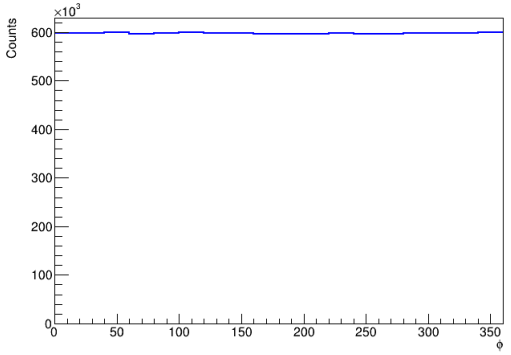


Real data

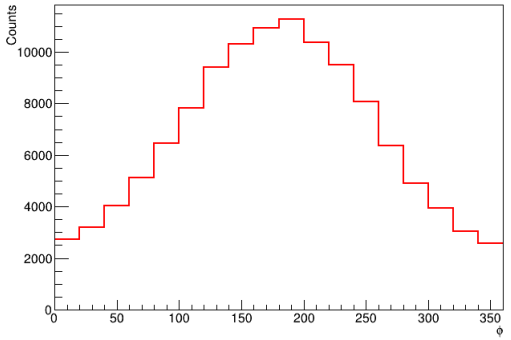


cos(θ) distributions

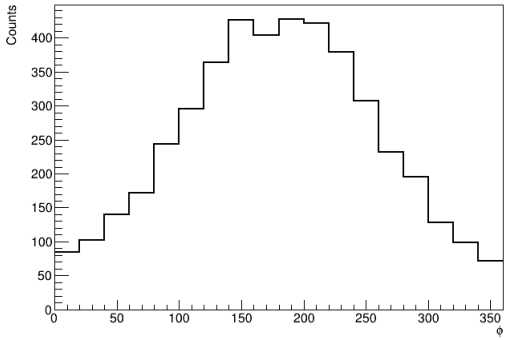
MC thrown



MC seen



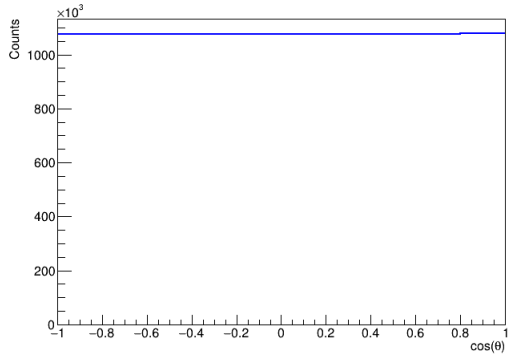
Real data



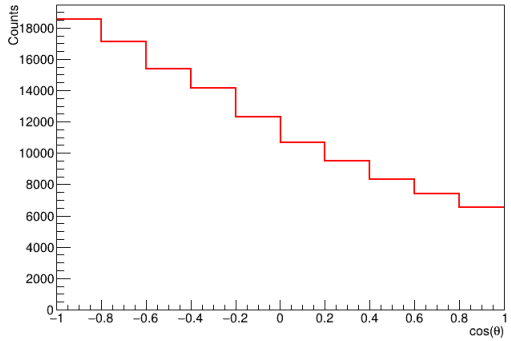
φ distributions

Distributions of cos(θ) and φ

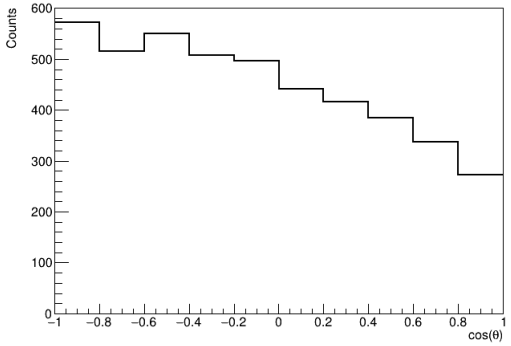
MC thrown



MC seen

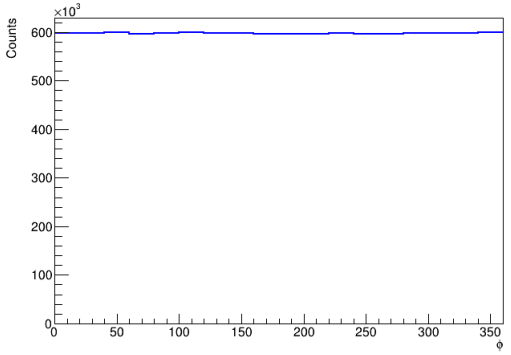


Real data



cos(θ) distributions

MC thrown



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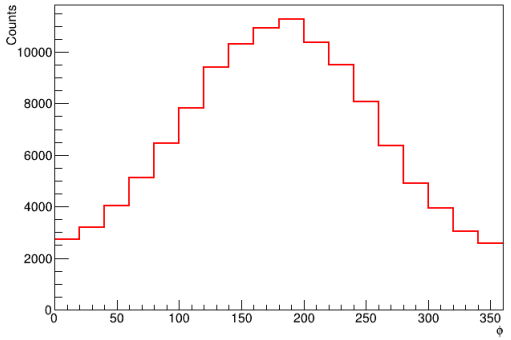

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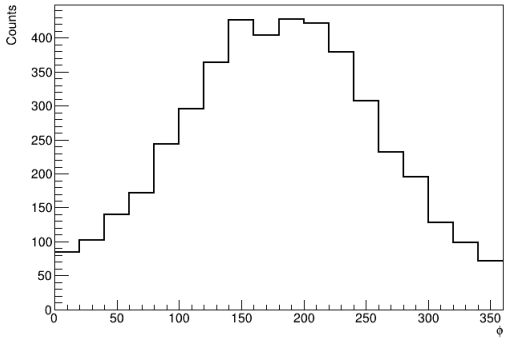
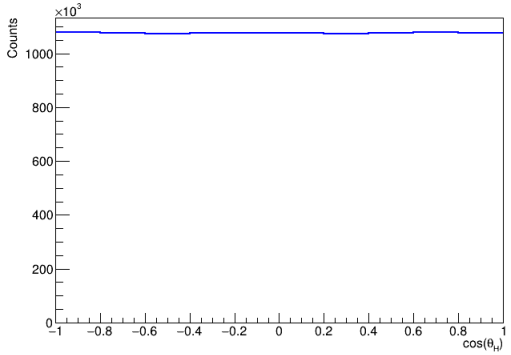


φ distributions

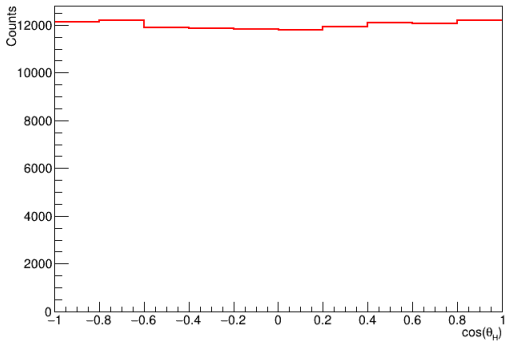
- Real data looks similar to detector accepted phase space

Distributions of $\cos(\theta_H)$ and φ_H

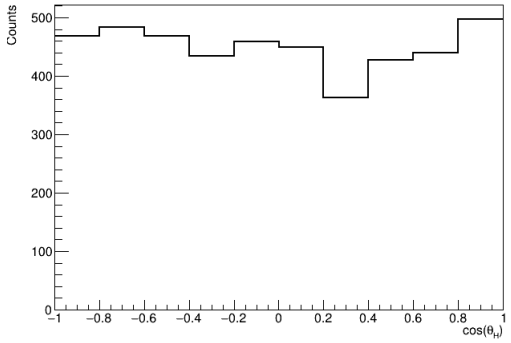
MC thrown



MC seen

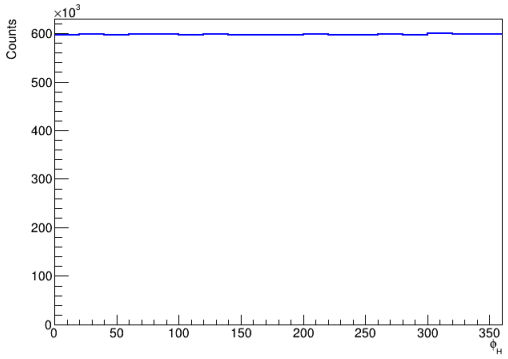


Real data

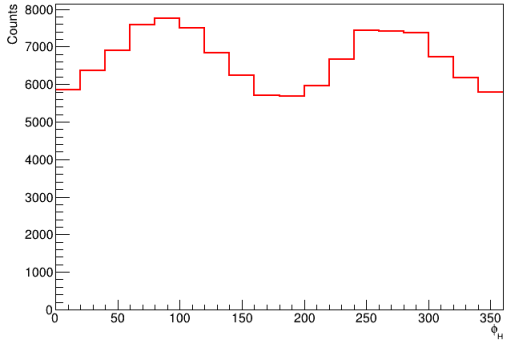


$\cos(\theta_H)$ distributions

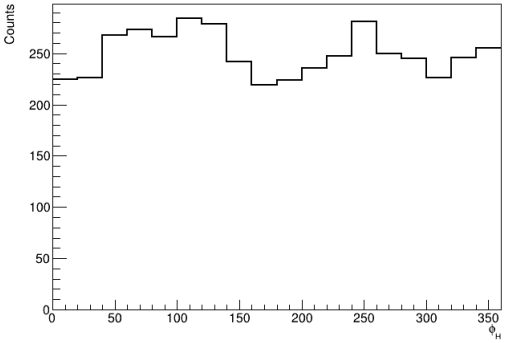
MC thrown



MC seen



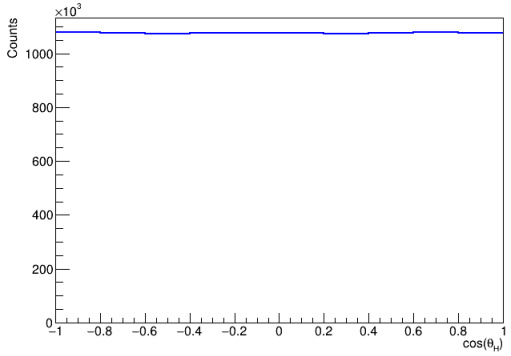
Real data



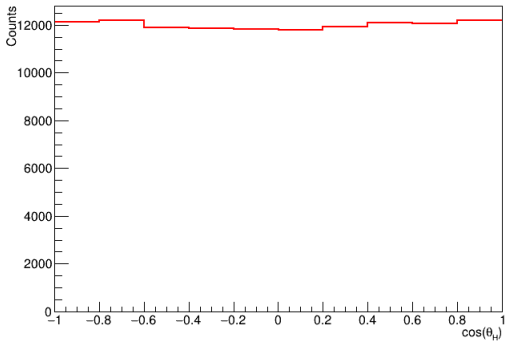
φ_H distributions

Distributions of $\cos(\theta_H)$ and φ_H

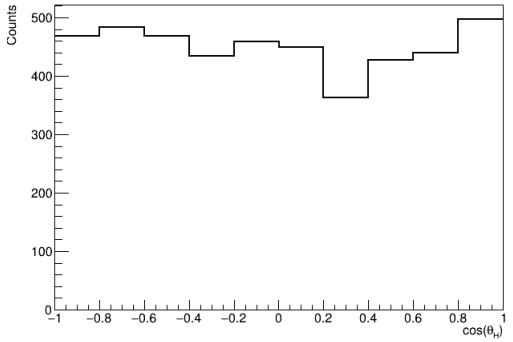
MC thrown



MC seen

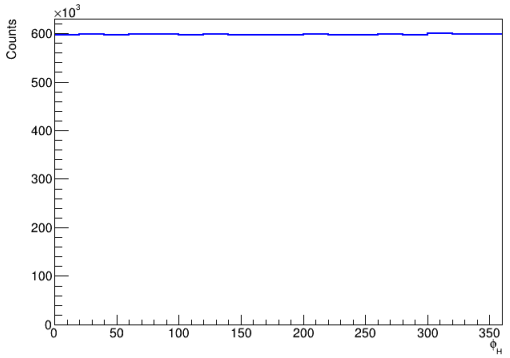


Real data

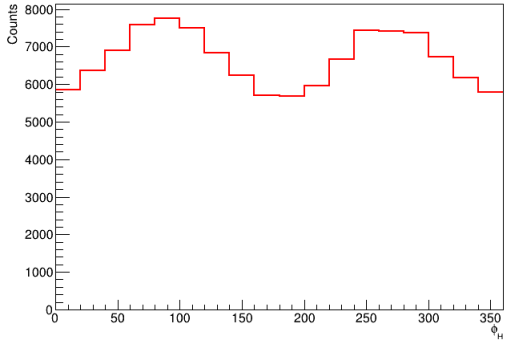


$\cos(\theta_H)$ distributions

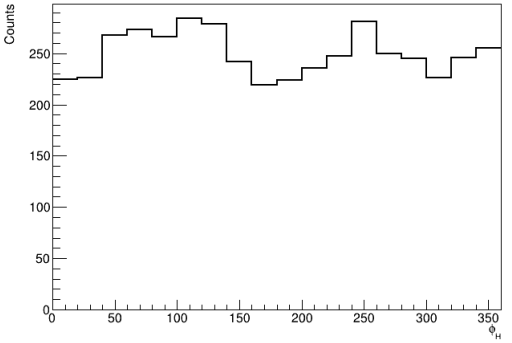
MC thrown



MC seen



Real data



φ_H distributions

- Real data looks similar to detector accepted phase space

Initial PWA setup

- Used PWA expressions:

$$a_{Jlsm} \sum_{\lambda} D^{J*}_{m\lambda}(\varphi_{GJ}, \theta_{GJ}) D^{s*}_{\lambda 0}(\varphi_h, \theta_h) \langle l0s\lambda | J\lambda \rangle,$$

Initial PWA setup

- Used PWA expressions:

$a_{Jlsm} \sum_{\lambda} D^{J*}_{m\lambda}(\varphi_{GJ}, \theta_{GJ}) D^{s*}_{\lambda 0}(\varphi_h, \theta_h) \langle l0s\lambda | J\lambda \rangle$, where the form under summation is from Salgado-Weygand and a_{Jlsm} are the coefficients of the fit

Initial PWA setup

- Used PWA expressions:

$a_{Jlsm} \sum_{\lambda} D^{J*}_{m\lambda}(\varphi_{GJ}, \theta_{GJ}) D^{s*}_{\lambda 0}(\varphi_h, \theta_h) \langle l0s\lambda | J\lambda \rangle$, where the form under summation is from Salgado-Weygand and a_{Jlsm} are the coefficients of the fit

- Used AmpTools for PWA

Initial PWA setup

- Used PWA expressions:

$a_{Jlsm} \sum_{\lambda} D^{J*}_{m\lambda}(\varphi_{GJ}, \theta_{GJ}) D^{s*}_{\lambda 0}(\varphi_h, \theta_h) \langle l 0 s \lambda | J \lambda \rangle$, where the form under summation is from Salgado-Weygand and a_{Jlsm} are the coefficients of the fit

- Used AmpTools for PWA
- Meson Resonance (R) = $KK\pi$ system

Initial PWA setup

- Used PWA expressions:

$a_{Jlsm} \sum_{\lambda} D^{J*}_{m\lambda}(\varphi_{GJ}, \theta_{GJ}) D^{s*}_{\lambda 0}(\varphi_h, \theta_h) \langle l0s\lambda | J\lambda \rangle$, where the form under summation is from Salgado-Weygand and a_{Jlsm} are the coefficients of the fit

- Used AmpTools for PWA
- Meson Resonance (R) = $KK\pi$ system
- Decay modeled as $R \rightarrow$ Isobar π, where Isobar $\rightarrow K\,K$

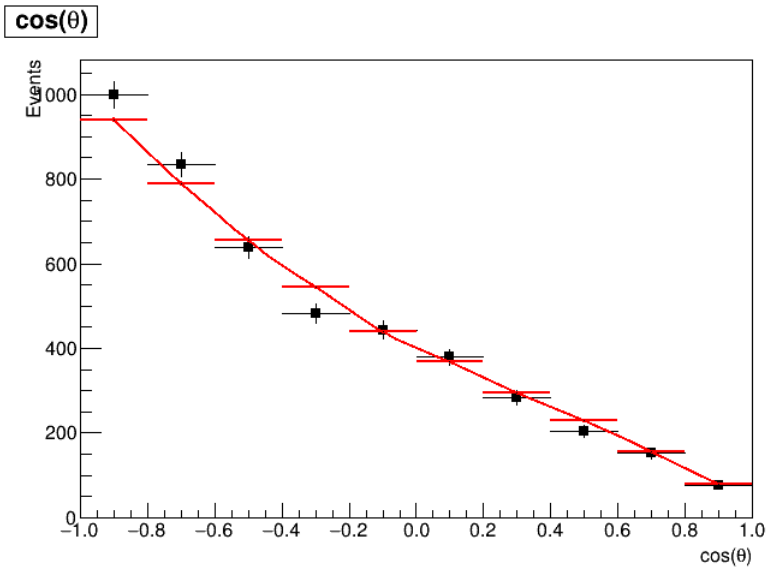
Initial PWA setup

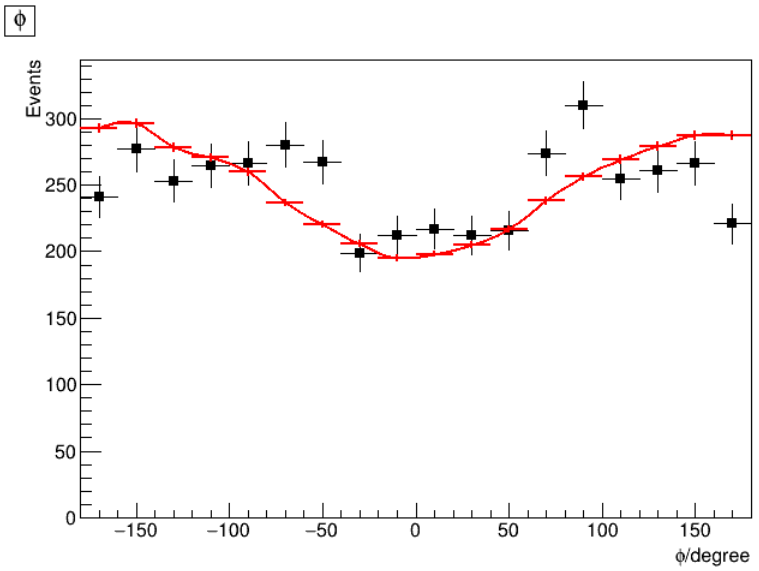
- Used PWA expressions:

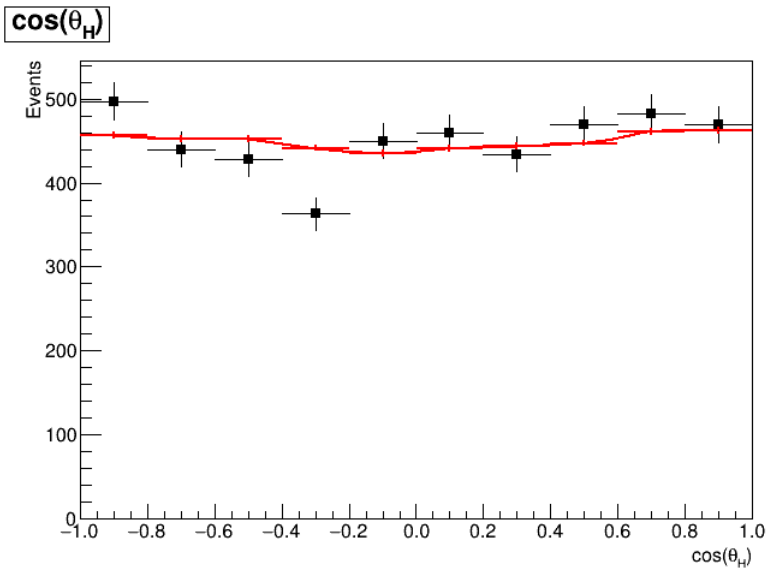
$a_{Jlsm} \sum_{\lambda} D^{J*}_{m\lambda}(\varphi_{GJ}, \theta_{GJ}) D^{s*}_{\lambda 0}(\varphi_h, \theta_h) \langle l0s\lambda | J\lambda \rangle$, where the form under summation is from Salgado-Weygand and a_{Jlsm} are the coefficients of the fit

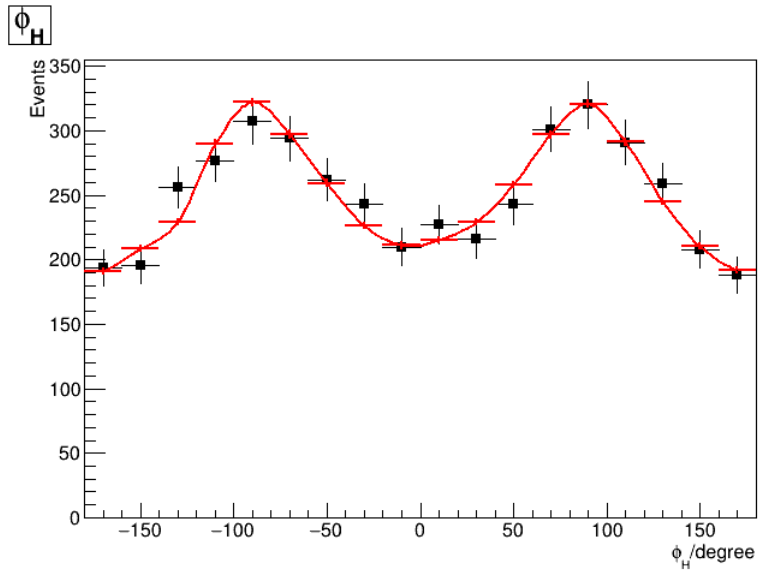
- Used AmpTools for PWA
- Meson Resonance (R) = $KK\pi$ system
- Decay modeled as $R \rightarrow$ Isobar π, where Isobar $\rightarrow K\,K$
- Coherently added:
  - j=0, with
    - l=0, s=0
    - l=1, s=1
  - j=1, with
    - l=1, s=0, m_j = -1,0,1
    - l=0, s=1, m_j = -1,0,1
    - l=1, s=1, m_j = -1,0,1

Initial PWA results









Initial PWA results

Fit fraction j=0, l=0, s=0	: 0.803564 +- -0.0154223
Fit fraction j=0, l=1, s=1	: 0.0151096 +- -0.00623058
Fit fraction j=1, l=1, s=0, m_j = -1	: 0.00870284 +- -0.00527657
Fit fraction j=1, l=1, s=0, m_j = 0	: 0.00602312 +- -0.0018275
Fit fraction j=1, l=1, s=0, m_j = 1	: 0.00372239 +- -0.00285835
Fit fraction j=1, l=0, s=1, m_j = -1	: 0.00440244 +- -0.00297814
Fit fraction j=1, l=0, s=1, m_j = 0	: 0.0824543 +- -0.0176945
Fit fraction j=1, l=0, s=1, m_j = 1	: 0.00265832 +- -0.00235178
Fit fraction j=1, l=1, s=1, m_j = -1	: 0.00107336 +- -0.00148959
Fit fraction j=1, l=1, s=1, m_j = 0	: 0.000656921 +- -0.00139304
Fit fraction j=1, l=1, s=1, m_j = 1	: 0.000604052 +- -0.00122445

Initial PWA results

By far, the most important contribution

Fit fraction j=0, l=0, s=0	: 0.803564 +- -0.0154223
Fit fraction j=0, l=1, s=1	: 0.0151096 +- -0.00623058
Fit fraction j=1, l=1, s=0, m_j = -1	: 0.00870284 +- -0.00527657
Fit fraction j=1, l=1, s=0, m_j = 0	: 0.00602312 +- -0.0018275
Fit fraction j=1, l=1, s=0, m_j = 1	: 0.00372239 +- -0.00285835
Fit fraction j=1, l=0, s=1, m_j = -1	: 0.00440244 +- -0.00297814
Fit fraction j=1, l=0, s=1, m_j = 0	: 0.0824543 +- -0.0176945
Fit fraction j=1, l=0, s=1, m_j = 1	: 0.00265832 +- -0.00235178
Fit fraction j=1, l=1, s=1, m_j = -1	: 0.00107336 +- -0.00148959
Fit fraction j=1, l=1, s=1, m_j = 0	: 0.000656921 +- -0.00139304
Fit fraction j=1, l=1, s=1, m_j = 1	: 0.000604052 +- -0.00122445

ASU

Initial PWA results

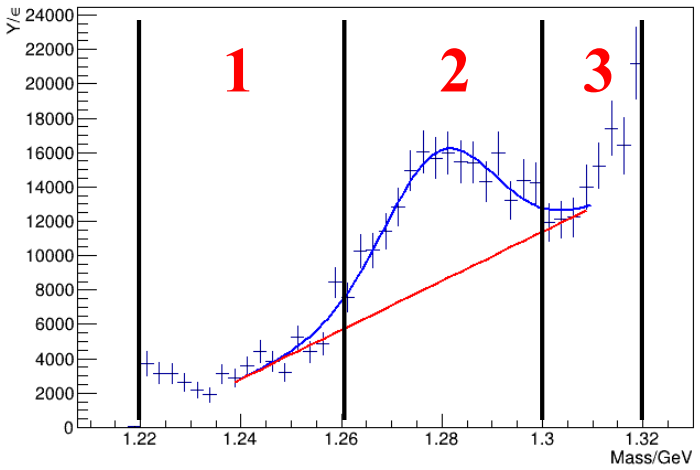
By far, the most important contribution

Fit fraction j=0, l=0, s=0	: 0.803564 +- -0.0154223
Fit fraction j=0, l=1, s=1	: 0.0151096 +- -0.00623058
Fit fraction j=1, l=1, s=0, m_j = -1	: 0.00870284 +- -0.00527657
Fit fraction j=1, l=1, s=0, m_j = 0	: 0.00602312 +- -0.0018275
Fit fraction j=1, l=1, s=0, m_j = 1	: 0.00372239 +- -0.00285835
Fit fraction j=1, l=0, s=1, m_j = -1	: 0.00440244 +- -0.00297814
Fit fraction j=1, l=0, s=1, m_j = 0	: 0.0824543 +- -0.0176945
Fit fraction j=1, l=0, s=1, m_j = 1	: 0.00265832 +- -0.00235178
Fit fraction j=1, l=1, s=1, m_j = -1	: 0.00107336 +- -0.00148959
Fit fraction j=1, l=1, s=1, m_j = 0	: 0.000656921 +- -0.00139304
Fit fraction j=1, l=1, s=1, m_j = 1	: 0.000604052 +- -0.00122445

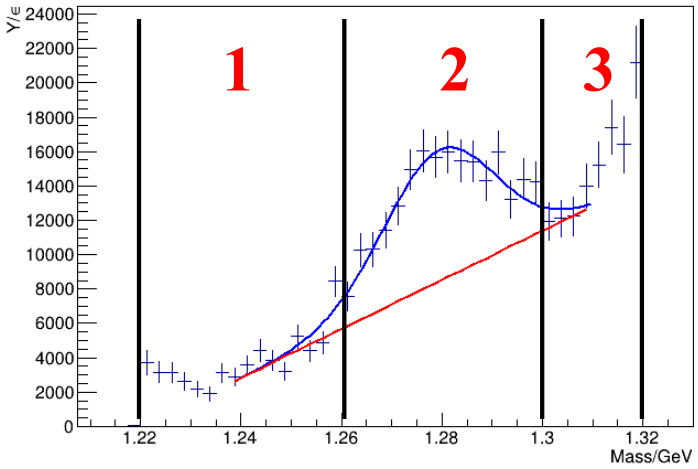
Is $x(1280)$ a $J = 0$ or 1 ?

ASU

PWA over 3 mass regions

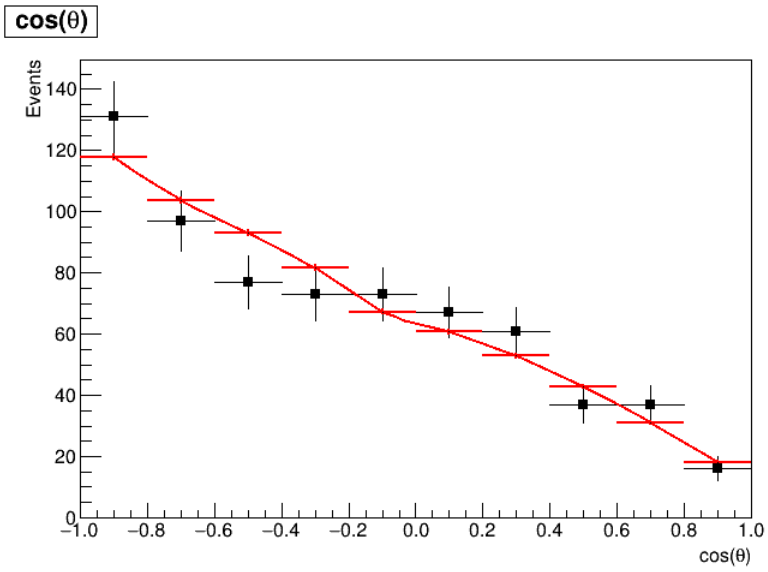


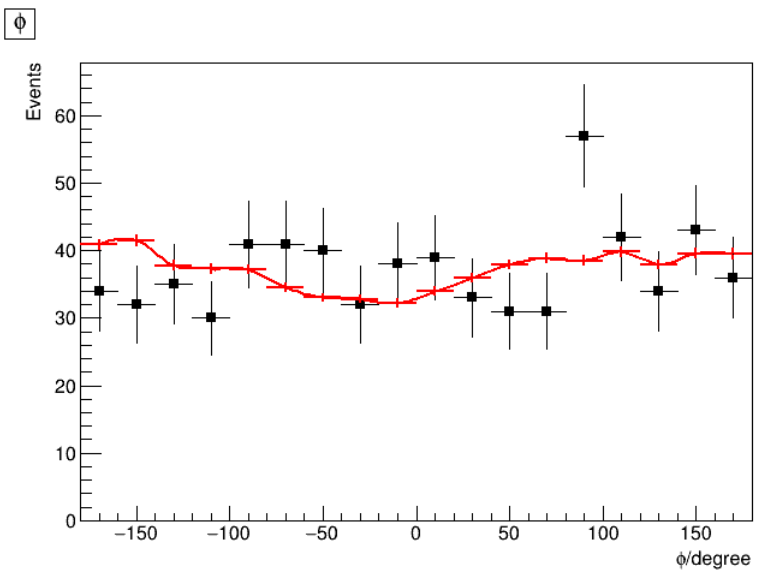
PWA over 3 mass regions

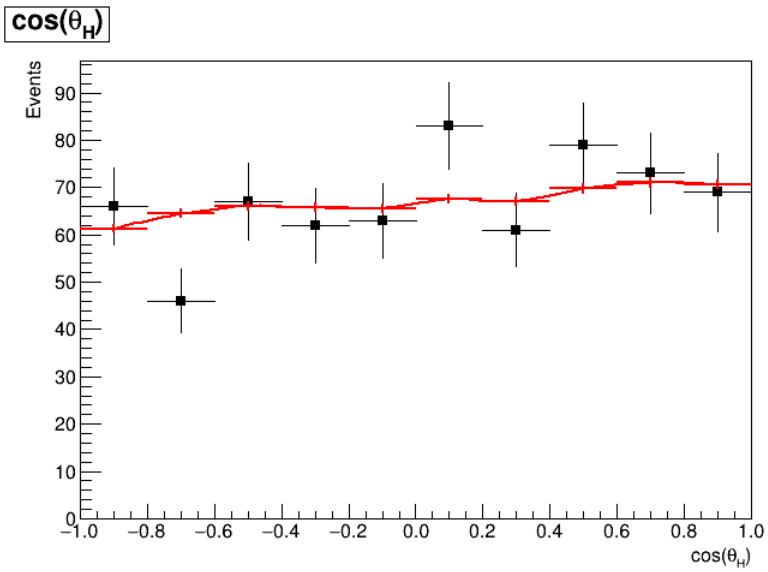


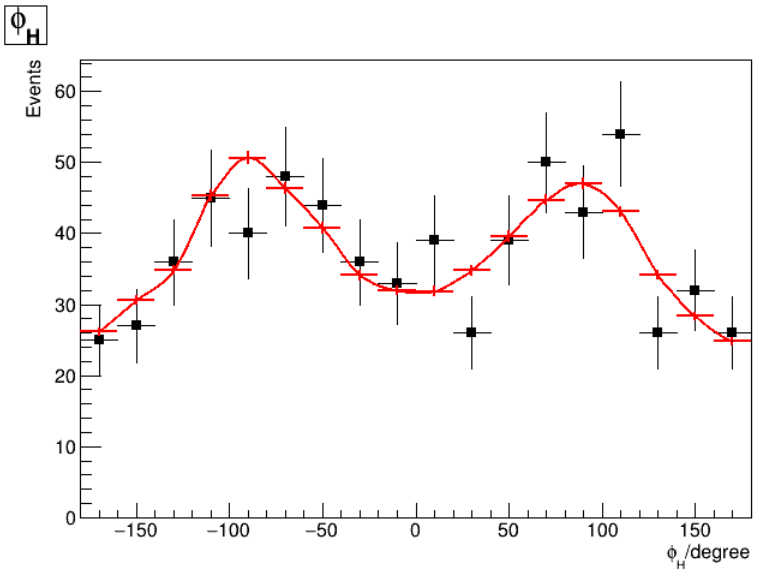
- If $x(1280)$ is $J\neq0$, fit fraction of $J=0$ in region 2 should decrease relative to the other regions

Region 1 PWA results

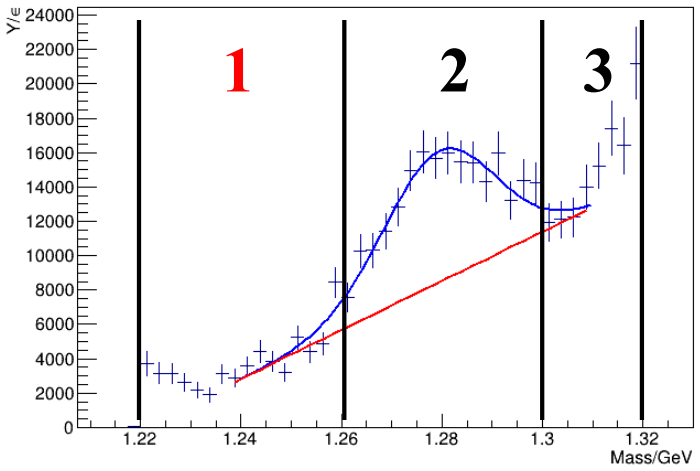








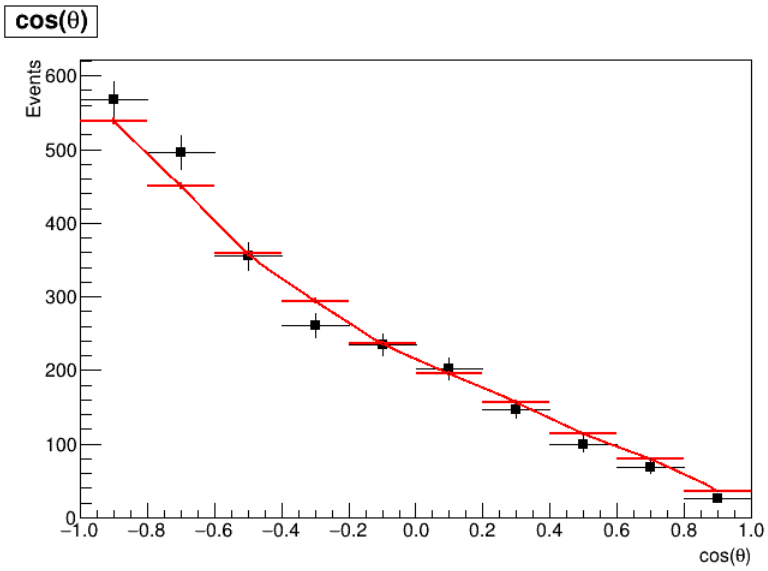
Region 1 PWA results

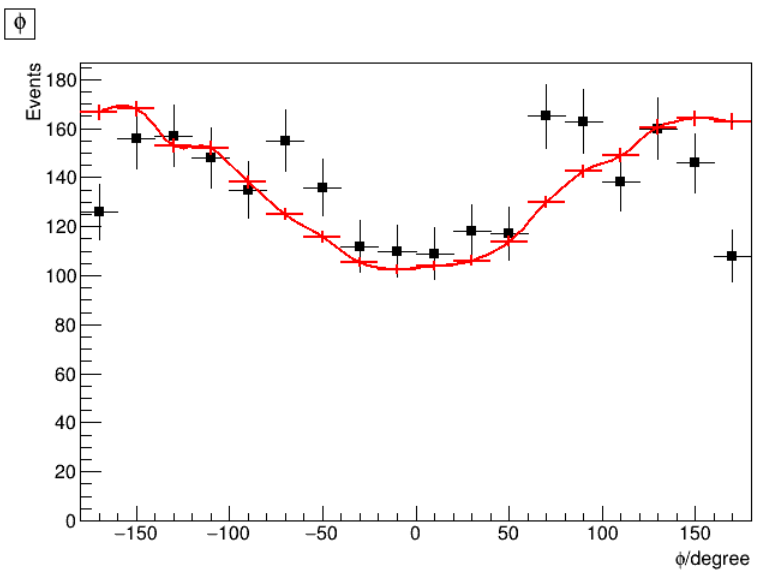


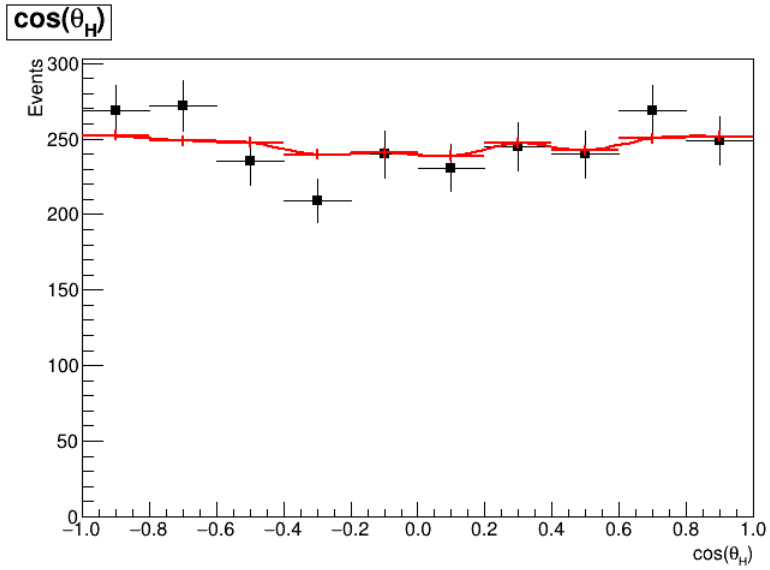
Region 1

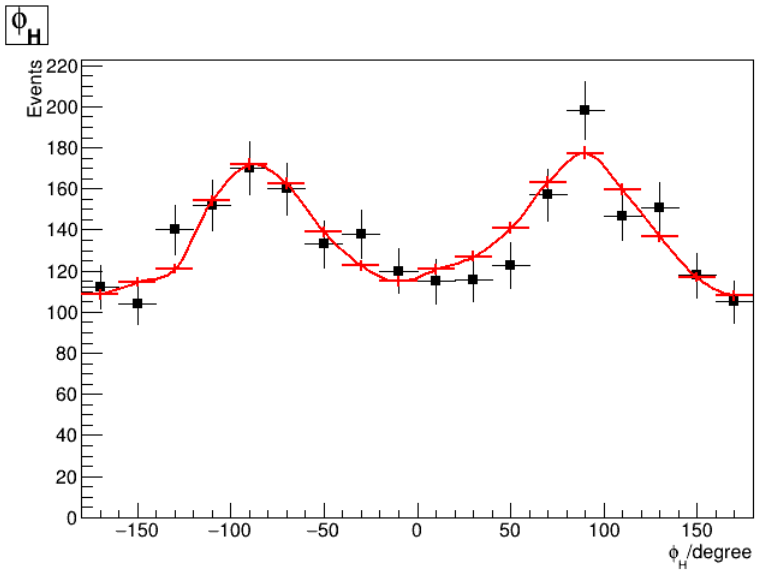
Fit fraction j=0, l=0, s=0 : 0.755485 +- -0.270702
Fit fraction j=0, l=1, s=1 : 0.0458552 +- -0.194178
Fit fraction j=1, l=1, s=0, m_j = -1 : 0.0061852 +- -0.00818622
Fit fraction j=1, l=1, s=0, m_j = 0 : 0.0381819 +- -0.0266231
Fit fraction j=1, l=1, s=0, m_j = 1 : 0.0145478 +- -0.0132996
Fit fraction j=1, l=0, s=1, m_j = -1 : 0.00891352 +- -0.00847945
Fit fraction j=1, l=0, s=1, m_j = 0 : 0.0341858 +- -0.025853
Fit fraction j=1, l=0, s=1, m_j = 1 : 0.0151747 +- -0.0114261
Fit fraction j=1, l=1, s=1, m_j = -1 : 0.0250261 +- -0.0154815
Fit fraction j=1, l=1, s=1, m_j = 0 : 0.00637649 +- -0.00966565
Fit fraction j=1, l=1, s=1, m_j = 1 : 0.0156042 +- -0.0123044

Region 2 PWA results

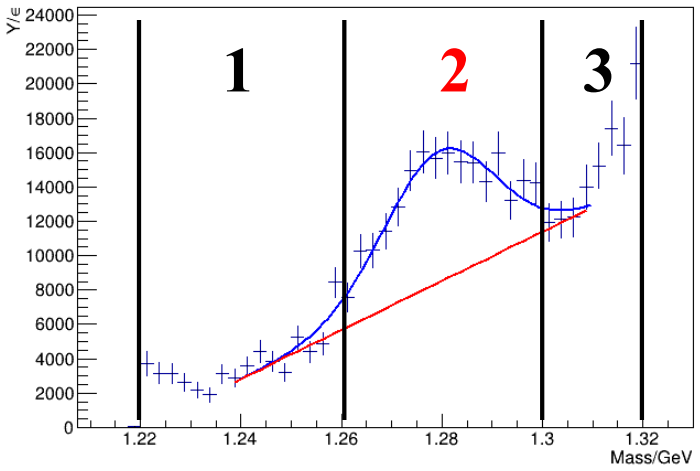








Region 2 PWA results



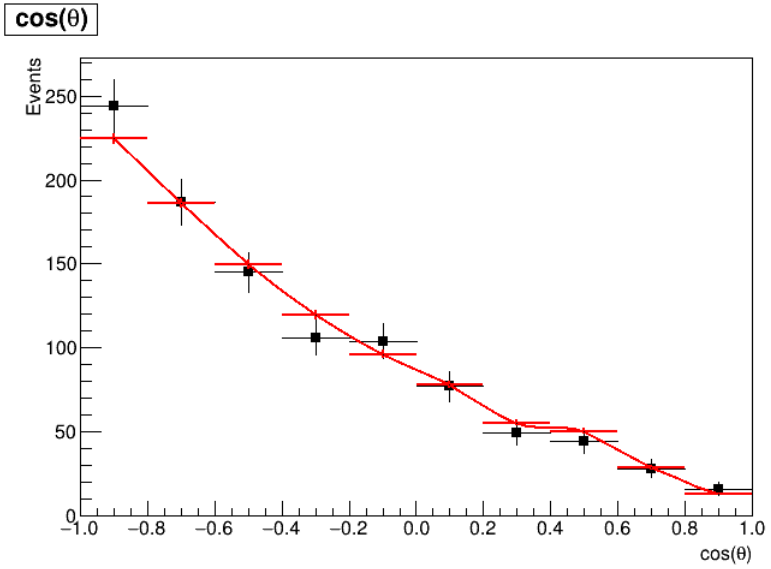
Region 1

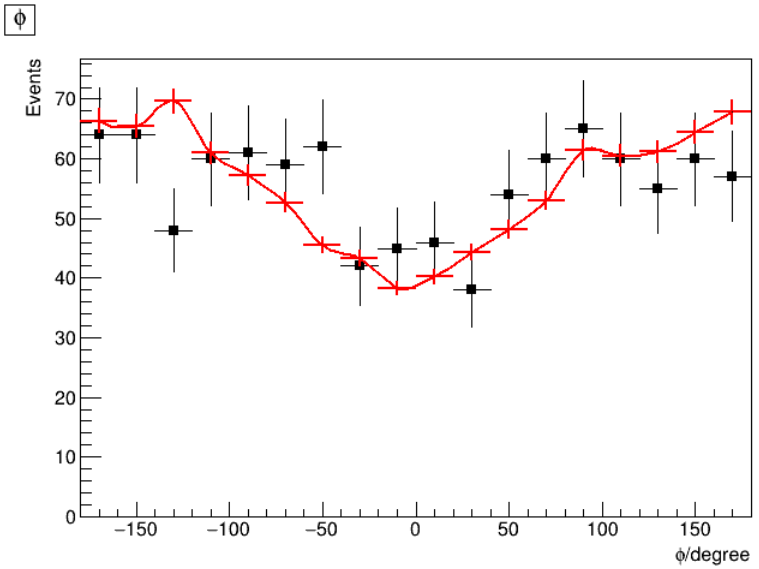
Fit fraction j=0, l=0, s=0 : 0.755485 +- -0.270702
Fit fraction j=0, l=1, s=1 : 0.0458552 +- -0.194178
Fit fraction j=1, l=1, s=0, m_j = -1 : 0.0061852 +- -0.00818622
Fit fraction j=1, l=1, s=0, m_j = 0 : 0.0381819 +- -0.0266231
Fit fraction j=1, l=1, s=0, m_j = 1 : 0.0145478 +- -0.0132996
Fit fraction j=1, l=0, s=1, m_j = -1 : 0.00891352 +- -0.00847945
Fit fraction j=1, l=0, s=1, m_j = 0 : 0.0341858 +- -0.025853
Fit fraction j=1, l=0, s=1, m_j = 1 : 0.0151747 +- -0.0114261
Fit fraction j=1, l=1, s=1, m_j = -1 : 0.0250261 +- -0.0154815
Fit fraction j=1, l=1, s=1, m_j = 0 : 0.00637649 +- -0.00966565
Fit fraction j=1, l=1, s=1, m_j = 1 : 0.0156042 +- -0.0123044

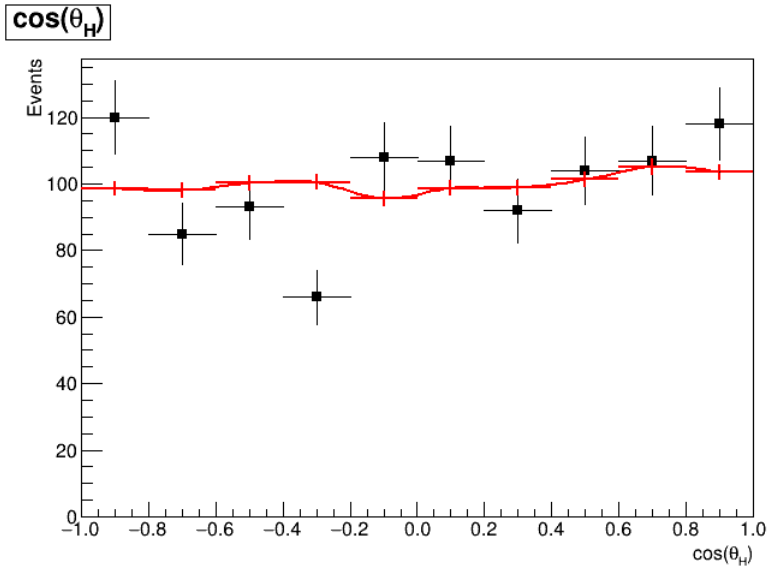
Region 2

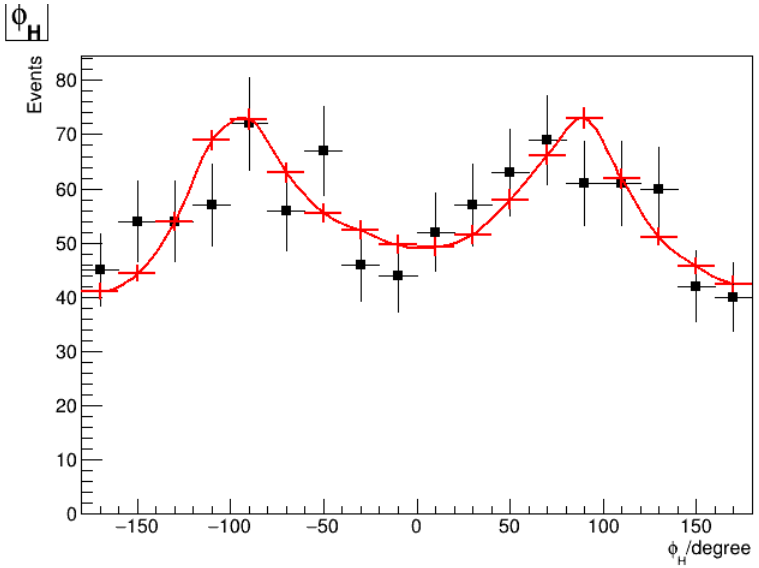
Fit fraction j=0, l=0, s=0 : 0.824834 +- -0.17209
Fit fraction j=0, l=1, s=1 : 0.00481546 +- -0.0289436
Fit fraction j=1, l=1, s=0, m_j = -1 : 0.00287929 +- -0.00362665
Fit fraction j=1, l=1, s=0, m_j = 0 : 0.00922431 +- -0.00378745
Fit fraction j=1, l=1, s=0, m_j = 1 : 0.01217 +- -0.00801337
Fit fraction j=1, l=0, s=1, m_j = -1 : 0.00408659 +- -0.00355879
Fit fraction j=1, l=0, s=1, m_j = 0 : 0.105621 +- -0.0267424
Fit fraction j=1, l=0, s=1, m_j = 1 : 0.0028925 +- -0.00297443
Fit fraction j=1, l=1, s=1, m_j = -1 : 0.000537718 +- -0.00118739
Fit fraction j=1, l=1, s=1, m_j = 0 : 0.00209243 +- -0.00381629
Fit fraction j=1, l=1, s=1, m_j = 1 : 0.00314316 +- -0.00324201

Region 3 PWA results

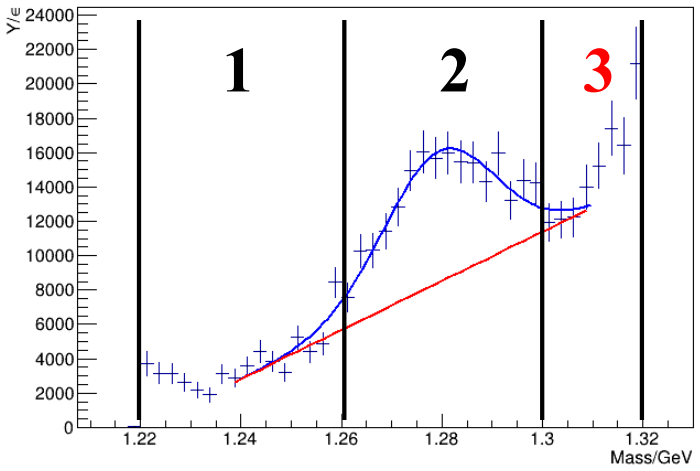








Region 3 PWA results



Region 1

Fit fraction j=0, l=0, s=0 : 0.755485 +- -0.270702
Fit fraction j=0, l=1, s=1 : 0.0458552 +- -0.194178
Fit fraction j=1, l=1, s=0, m_j = -1 : 0.0061852 +- -0.00818622
Fit fraction j=1, l=1, s=0, m_j = 0 : 0.0381819 +- -0.0266231
Fit fraction j=1, l=1, s=0, m_j = 1 : 0.0145478 +- -0.0132996
Fit fraction j=1, l=0, s=1, m_j = -1 : 0.00891352 +- -0.00847945
Fit fraction j=1, l=0, s=1, m_j = 0 : 0.0341858 +- -0.025853
Fit fraction j=1, l=0, s=1, m_j = 1 : 0.0151747 +- -0.0114261
Fit fraction j=1, l=1, s=1, m_j = -1 : 0.0250261 +- -0.0154815
Fit fraction j=1, l=1, s=1, m_j = 0 : 0.00637649 +- -0.00966565
Fit fraction j=1, l=1, s=1, m_j = 1 : 0.0156042 +- -0.0123044

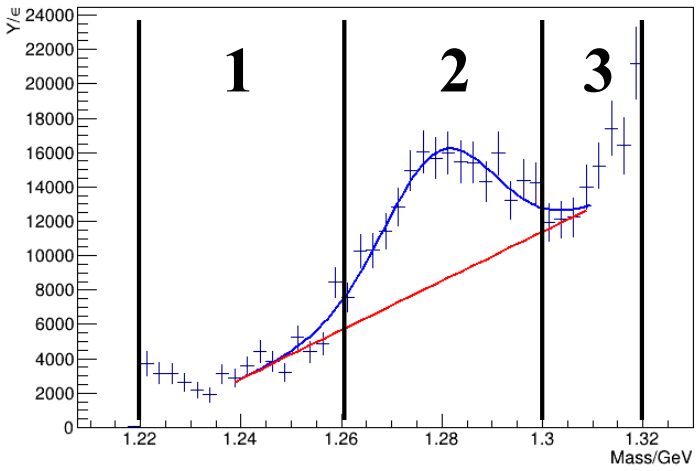
Region 2

Fit fraction j=0, l=0, s=0 : 0.824834 +- -0.17209
Fit fraction j=0, l=1, s=1 : 0.00481546 +- -0.0289436
Fit fraction j=1, l=1, s=0, m_j = -1 : 0.00287929 +- -0.00362665
Fit fraction j=1, l=1, s=0, m_j = 0 : 0.00922431 +- -0.00378745
Fit fraction j=1, l=1, s=0, m_j = 1 : 0.01217 +- -0.00801337
Fit fraction j=1, l=0, s=1, m_j = -1 : 0.00408659 +- -0.00355879
Fit fraction j=1, l=0, s=1, m_j = 0 : 0.105621 +- -0.0267424
Fit fraction j=1, l=0, s=1, m_j = 1 : 0.0028925 +- -0.00297443
Fit fraction j=1, l=1, s=1, m_j = -1 : 0.000537718 +- -0.00118739
Fit fraction j=1, l=1, s=1, m_j = 0 : 0.00209243 +- -0.00381629
Fit fraction j=1, l=1, s=1, m_j = 1 : 0.00314316 +- -0.00324201

Region 3

Fit fraction j=0, l=0, s=0 : 0.850564 +- -0.164146
Fit fraction j=0, l=1, s=1 : 0.0104863 +- -0.084152
Fit fraction j=1, l=1, s=0, m_j = -1 : 0.0194442 +- -0.0133443
Fit fraction j=1, l=1, s=0, m_j = 0 : 0.00899986 +- -0.00572817
Fit fraction j=1, l=1, s=0, m_j = 1 : 0.0131453 +- -0.0104488
Fit fraction j=1, l=0, s=1, m_j = -1 : 0.0115804 +- -0.00781986
Fit fraction j=1, l=0, s=1, m_j = 0 : 0.072999 +- -0.0413188
Fit fraction j=1, l=0, s=1, m_j = 1 : 0.0085873 +- -0.00689471
Fit fraction j=1, l=1, s=1, m_j = -1 : 0.000705245 +- -0.00232508
Fit fraction j=1, l=1, s=1, m_j = 0 : 0.00087639 +- -0.00304636
Fit fraction j=1, l=1, s=1, m_j = 1 : 0.00147296 +- -0.00319896

PWA over 3 mass regions



Region 1

Fit fraction j=0, l=0, s=0 : 0.755485 +- -0.270702
Fit fraction j=0, l=1, s=1 : 0.0458552 +- -0.194178
Fit fraction j=1, l=1, s=0, m_j = -1 : 0.0061852 +- -0.00818622
Fit fraction j=1, l=1, s=0, m_j = 0 : 0.0381819 +- -0.0266231
Fit fraction j=1, l=1, s=0, m_j = 1 : 0.0145478 +- -0.0132996
Fit fraction j=1, l=0, s=1, m_j = -1 : 0.00891352 +- -0.00847945
Fit fraction j=1, l=0, s=1, m_j = 0 : 0.0341858 +- -0.025853
Fit fraction j=1, l=0, s=1, m_j = 1 : 0.0151747 +- -0.0114261
Fit fraction j=1, l=1, s=1, m_j = -1 : 0.0250261 +- -0.0154815
Fit fraction j=1, l=1, s=1, m_j = 0 : 0.00637649 +- -0.00966565
Fit fraction j=1, l=1, s=1, m_j = 1 : 0.0156042 +- -0.0123044

Region 2

Fit fraction j=0, l=0, s=0 : 0.824834 +- -0.17209
Fit fraction j=0, l=1, s=1 : 0.00481546 +- -0.0289436
Fit fraction j=1, l=1, s=0, m_j = -1 : 0.00287929 +- -0.00362665
Fit fraction j=1, l=1, s=0, m_j = 0 : 0.00922431 +- -0.00378745
Fit fraction j=1, l=1, s=0, m_j = 1 : 0.01217 +- -0.00801337
Fit fraction j=1, l=0, s=1, m_j = -1 : 0.00408659 +- -0.00355879
Fit fraction j=1, l=0, s=1, m_j = 0 : 0.105621 +- -0.0267424
Fit fraction j=1, l=0, s=1, m_j = 1 : 0.0028925 +- -0.00297443
Fit fraction j=1, l=1, s=1, m_j = -1 : 0.000537718 +- -0.00118739
Fit fraction j=1, l=1, s=1, m_j = 0 : 0.00209243 +- -0.00381629
Fit fraction j=1, l=1, s=1, m_j = 1 : 0.00314316 +- -0.00324201

Region 3

Fit fraction j=0, l=0, s=0 : 0.850564 +- -0.164146
Fit fraction j=0, l=1, s=1 : 0.0104863 +- -0.084152
Fit fraction j=1, l=1, s=0, m_j = -1 : 0.0194442 +- -0.0133443
Fit fraction j=1, l=1, s=0, m_j = 0 : 0.00899986 +- -0.00572817
Fit fraction j=1, l=1, s=0, m_j = 1 : 0.0131453 +- -0.0104488
Fit fraction j=1, l=0, s=1, m_j = -1 : 0.0115804 +- -0.00781986
Fit fraction j=1, l=0, s=1, m_j = 0 : 0.072999 +- -0.0413188
Fit fraction j=1, l=0, s=1, m_j = 1 : 0.0085873 +- -0.00689471
Fit fraction j=1, l=1, s=1, m_j = -1 : 0.000705245 +- -0.00232508
Fit fraction j=1, l=1, s=1, m_j = 0 : 0.00087639 +- -0.00304636
Fit fraction j=1, l=1, s=1, m_j = 1 : 0.00147296 +- -0.00319896

Title