$\Upsilon\ p \rightarrow \pi^{+}\ \pi^{-}\ \pi^{+}\ n$
Amplitude Analysis

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Amplitude Analysis

- The intensity can be written

$$I(\vec{x}) = \frac{dN}{d\vec{x}} = \sum_{\alpha=1}^{N_{sums}} \left| \sum_{\beta=1}^{N_{amps;\alpha}} V_{\alpha,\beta} A_{\alpha,\beta}(\vec{x}) \right|^2$$

  - In this case, only one sum: $\pi^+ \pi^- \pi^+$ no polarization
- For each uniquely named amplitude in the configuration file, a complex parameter $V_{\alpha,\beta}$ is created
  - $a_1(1.23) - width\ 0.4$
  - $a_2(1.318) - width\ 0.105$
  - $\pi_1(1.60) - width\ 0.2$
  - $\pi_2(1.67) - width\ 0.259$

Amplitudes

- Parts of the amplitude may be factorized

$$A_{\alpha,\beta}(\vec{x}) = \prod_{i=1}^{N_{factors;\alpha,\beta}} a_i(\vec{x}; \overrightarrow{\theta_i})$$

  - Angular distribution
  - Breit-Wigners

Amplitudes

X: $a_1 \rightarrow \rho\pi$ S-wave

$a_2 \rightarrow \rho\pi$ D-wave

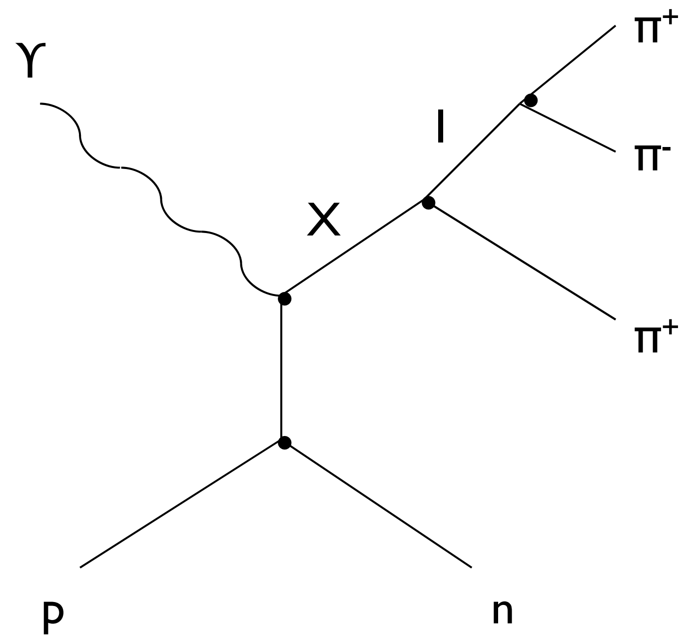
$\pi_1 \rightarrow \rho\pi$ P-wave

$\rightarrow f_2\pi$ S-wave

$\pi_2 \rightarrow \rho\pi$ P-wave

Input BW_X and fit with production vertex as a function of the mass of X

Also fit angular distribution of the pions and the BW of the isobar



Amplitudes

X: $a_1 \rightarrow \rho\pi$ S-wave

$a_2 \rightarrow \rho\pi$ D-wave

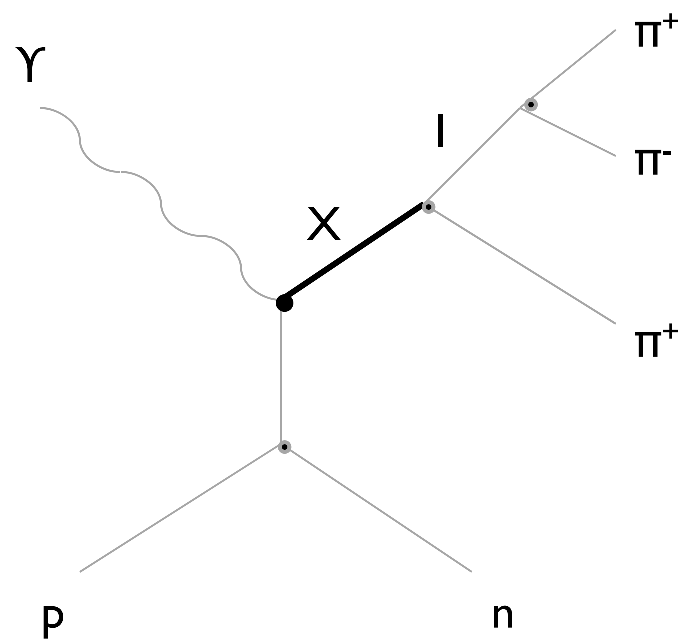
$\pi_1 \rightarrow \rho\pi$ P-wave

$\rightarrow f_2\pi$ S-wave

$\pi_2 \rightarrow \rho\pi$ P-wave

Input BW_X and fit with production vertex as a function of the mass of X

Also fit angular distribution of the pions and the BW of the isobar



Amplitudes

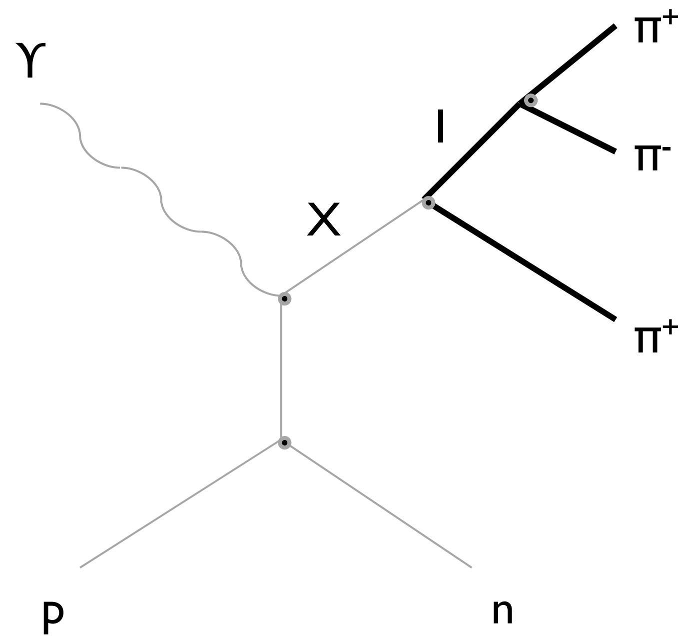
X: $a_1 \rightarrow \rho\pi$ S-wave

$a_2 \rightarrow \rho\pi$ D-wave

$\pi_1 \rightarrow \rho\pi$ P-wave

$\rightarrow f_2\pi$ S-wave

$\pi_2 \rightarrow \rho\pi$ P-wave



Input BW_X and fit with production vertex as a function of the mass of X

Also fit angular distribution of the pions and the BW of the isobar

Normalization Integrals

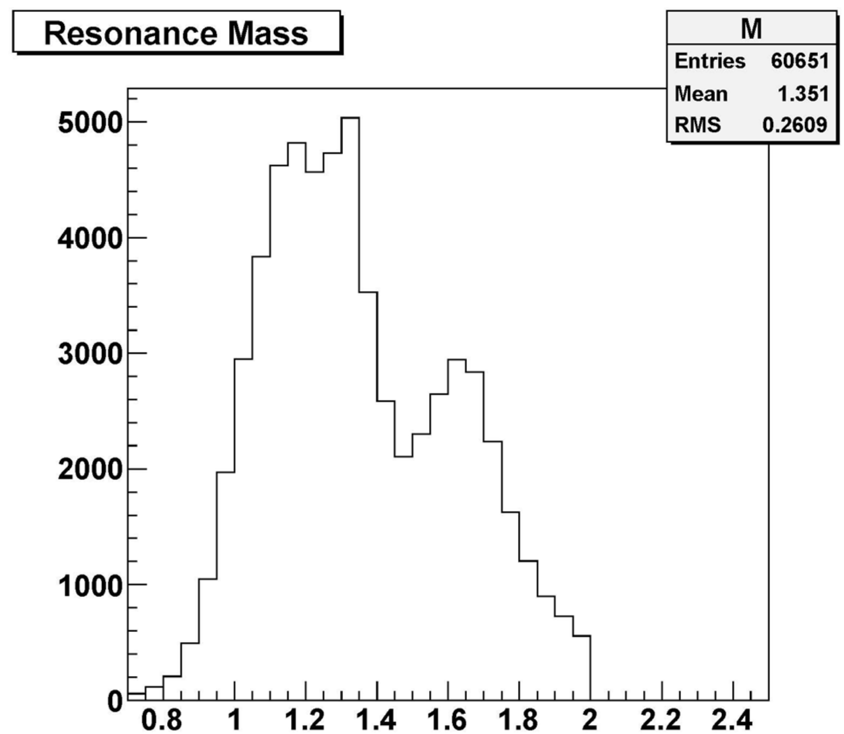
- Need to calculate normalization integrals

$$\int \eta\left(\vec{\Omega}\right) I\left(\vec{\Omega}\right)\, d\vec{\Omega}$$

- Where $\eta\left(\vec{\Omega}\right)$ is the detector acceptance
- Generate flat data sample
  - Pass through detector and reconstruction

Data

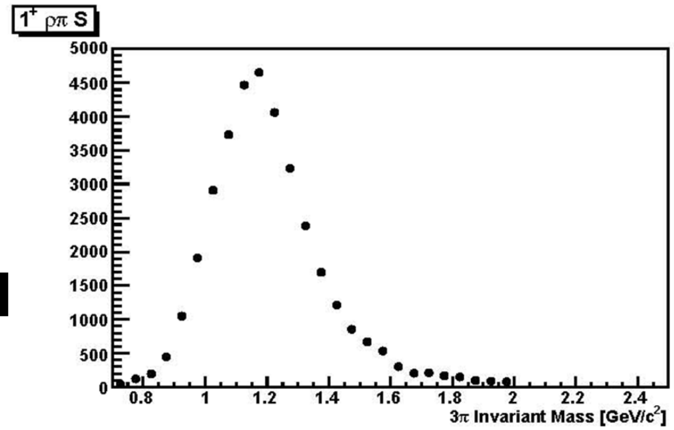
- Generate (60k) data with amplitudes
  - Pass through genr82hddm, hdgeant, mcsmear, full reconstruction code
- Generate (280k) flat data for normalization integrals
  - Also passed through detector and reconstructed

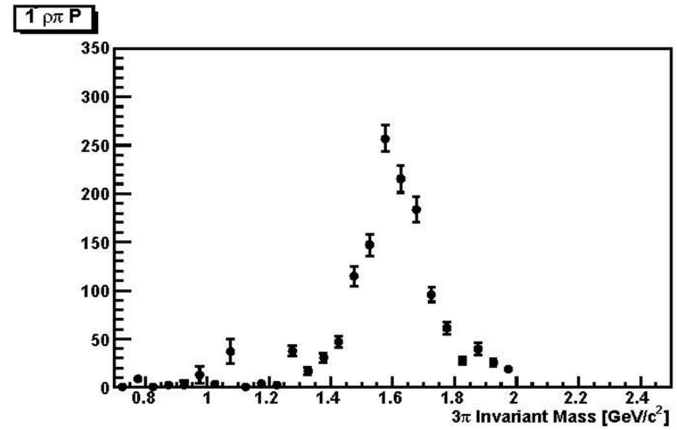


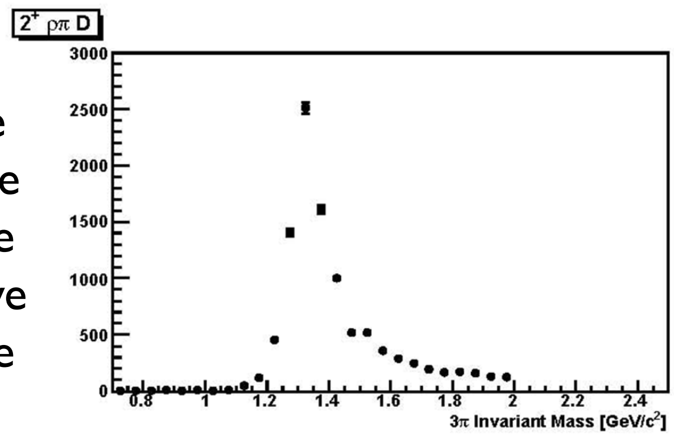
3π Invariant Mass [GeV/c^2]

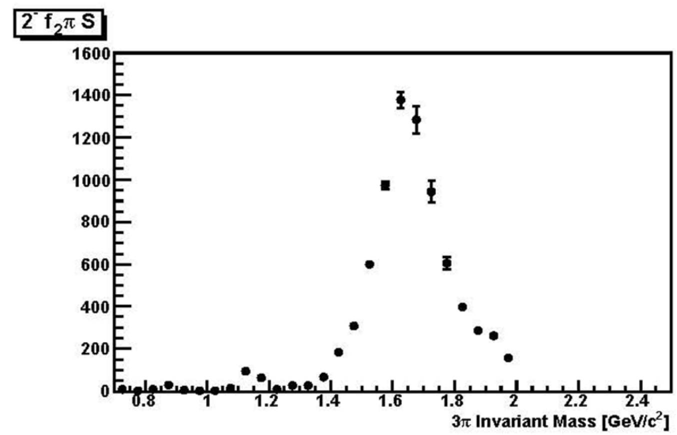
Generated Data

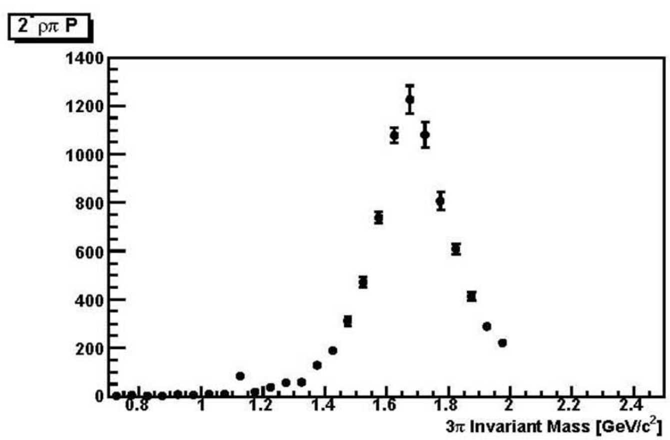
X: $a_1 \rightarrow \rho\pi$ S-wave
$a_2 \rightarrow \rho\pi$ D-wave
$\pi_1 \rightarrow \rho\pi$ P-wave
$\rightarrow f_2\pi$ S-wave
$\pi_2 \rightarrow \rho\pi$ P-wave

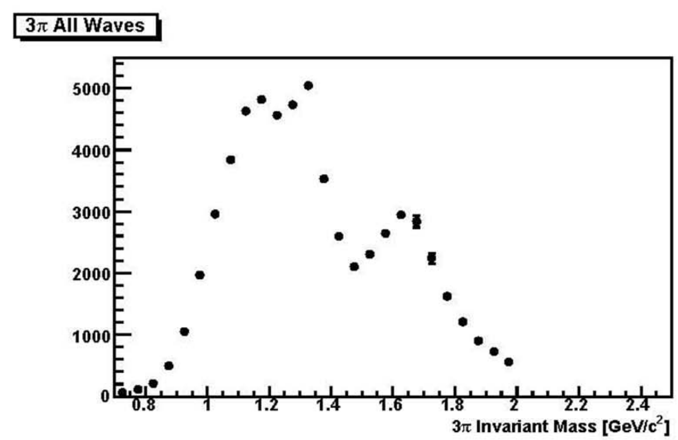












Reconstructed Data

X: $a_1 \rightarrow \rho\pi$ S-wave
$a_2 \rightarrow \rho\pi$ D-wave
$\pi_1 \rightarrow \rho\pi$ P-wave
$\rightarrow f_2\pi$ S-wave
$\pi_2 \rightarrow \rho\pi$ P-wave