Study of Excited Ξ Baryons in $\bar{p}p$-Collisions with $\overline{\text{P}}$ANDA

Authors:

Jennifer Pütz, Albrecht Gillitzer, James Ritman

Abstract

Understanding the excitation pattern of baryons is indispensable for a deep insight into the mechanism of non-perturbative QCD. Up to now only the nucleon excitation spectrum has been subject to systematic experimental studies while very little is known on excited states of double or triple strange baryons.

In studies of antiproton-proton collisions the $\overline{\text{P}}$ANDA experiment is well-suited for a comprehensive baryon spectroscopy program in the multi-strange and charm sector. A large fraction of the inelastic $\bar{\text{p}}\text{p}$ cross section is associated to final states with a baryon-antibaryon pair together with additional mesons, giving access to excited states both in the baryon and the antibaryon sector.

In the present study we focus on excited Ξ states. For final states containing a $\Xi\,\bar{\Xi}$ pair cross sections up to the order of μb are expected, corresponding to production rates of $\sim 10^6$/d at a Luminosity $L = 10^{31}\,\text{cm}^{-2}\,\text{s}^{-1}$ (5% of the full value). A strategy to study the excitation spectrum of Ξ baryons in antiproton-proton collisions will be discussed. The reconstruction of reactions of the type $\bar{\text{p}}\text{p} \to \Xi\,^*\,\bar{\Xi}$ (and their charge conjugated) with the $\overline{\text{P}}$ANDA detector will be presented based on a specific exemplary reaction and decay channel.

Contents

1 Motivation

2 Event generation

first key words!!!!

- parameter for evt generation table 2.1

Table 2.1: Parameter for event generation

Parameter	Value
Beam momentum	4.6 GeV/c^2
Production	PHSP
Tracking	Ideal
Particle ID	Ideal

- beam momentum: 100 MeV over threshold
- assumed: highest cross section (Quelle!!!!!!)
- Software Framework: Pandaroot 2.2

Table 2.2: Used software versions

Software	Version
FairSoft	mar15
FairRoot	v-15.03a
PandaRoot	trunk revision 28555
Geant	3
Genfit	1

- for signal: 1.5 Mio events
- decay channel shown in picture 2.1
- add particle to evt.pdl (code sniplet 2.1 with values table 2.3 from [1] (Source!!!!)

Listing 2.1: sniplet from evt.pdl

Table 2.3: Values for $\Xi\,(1820)^-$ and $\bar{\Xi}\,(1820)$ from [1]

Particle	J	I	P	Charge	Mass	Width
$\Xi\,(1820)^-$	$\frac{3}{2}$	$\frac{1}{2}$	(-1)	(-1)	(1.823 ± 5)GeV/c^2	(0.024 ± 6) GeV
$\bar{\Xi}\,(1820)$	$\frac{3}{2}$	$\frac{1}{2}$	(-1)	1	(1.823 ± 5)GeV/c^2	(0.024 ± 6) GeV

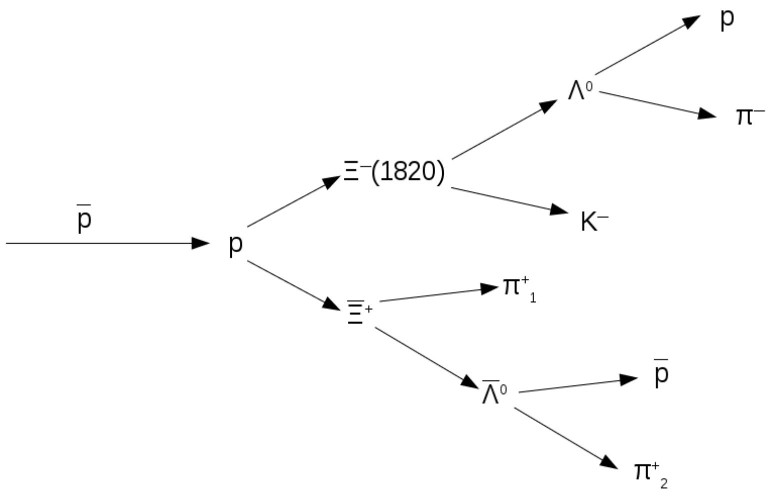
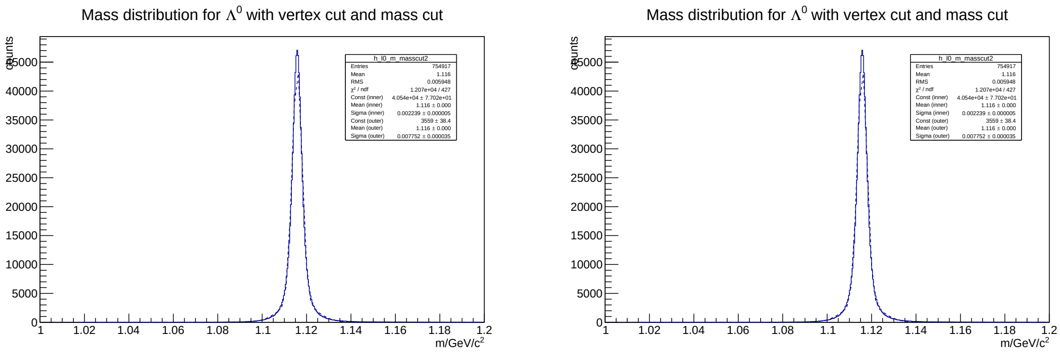


Figure 2.1: Simulated decay channel



(a) a (b) b

Figure 2.2: test! exchange pictures

Figure 2.3: Dalitz plot for simulation. On x axis is the mass square of Λ^0 and K^- and on the y axis there is the mass square of $\bar{\Xi}$ and K^-

```
add p Particle Xi(1820)- 23314 1.8230000e+00 2.4000000e-02
    2.0000000e-01 -3 3 0.0000000e+00 23314
add p Particle anti-Xi(1820)+ -23314 1.8230000e+00 2.4000000e-02
     2.0000000e-01 3 3 0.0000000e+00 -23314
```

- plot of transverse momentum against longitudinal momentum in figure 2.2
- Dalitz plots for simulation figure 2.3

3 Analysis

Here is all the stuff of the analysis!

3.1 Final state particle

-final state particle: proton, antiproton, π^-, π^+, K^- and K^+ mesons

-reconstructed in Detector

-only particles with more then 3 hits either in one of the subdetectors (reason: 3 hits define circle; fourth hit point gives a validation for track hypothesis)

- ideal PID (reason!!!)

-reco efficiency in table 3.1

3.2 Reconstruction of Λ^0 and $\bar{\Lambda}^0$

3.2.1 Combination

-only final state particle with more than 3 Hits

-daughter particles for Λ^0: proton an π^- meson

-daughter particles for $\bar{\Lambda}^0$: $\bar{p}$ and π^+ here π_2^+

-for c.c. chain: Λ^0: proton and π_2^-; $\bar{\Lambda}^0$: $\bar{p}$ and π^+

-performing a mass window cut with width of 0.3GeV/c^2

Table 3.1: reco efficiency and momentum resolution

final state	N/%	$\frac{\sigma p}{p}$/%
π^-		
π_1^+ ($\bar{\Xi}$)		
π_2^+ ($\bar{\Lambda}^0$)		
K^-		
p		
$\bar{p}$		

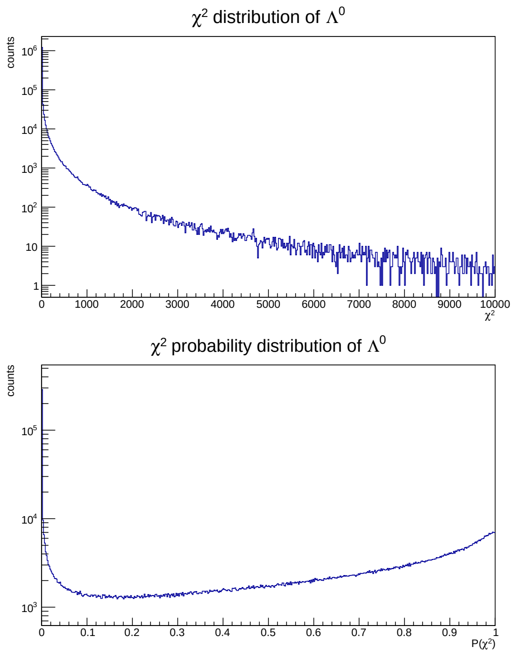


Figure 3.1: upper: χ^2 distribution; lower: χ^2 probability distribution

3.2.2 Fitting

- fitting particles to common vertex with PndKinVtxFitter
  - χ^2 and χ^2-Probability distiribution shown in figure 3.1
  - features in probability distribution are not coming from vertex fitting. There is still a problem with covariance matrices.
  - fit information are given to PndKinFitter with mass constraint
  - only select particles with prob bigger than 0.01 for both fitters
  - scheme in figure 3.2
  -if there is more than one particle, choose best candidate

3.2.3 Results

- mass distribution for different cuts see figure 3.3 and figure 3.4
  -performing a doulbe gaussian fit on cutted mass for Λ^0 and $\bar{\Lambda}^0$ (example see figure 3.5
  - result of massfit m = (1.116 ± 0.002) GeV/c^2

3.3 Reconstruction of Ξ and $\bar{\Xi}$

3.3.1 Combination

-similar scheme for Λ^0 and $\bar{\Lambda}^0$

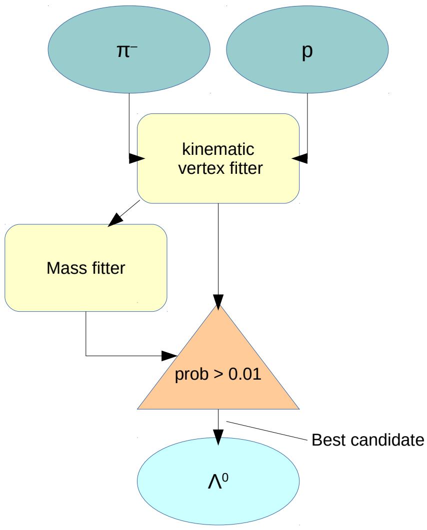


Figure 3.2: Scheme for Λ^0 reconstruction

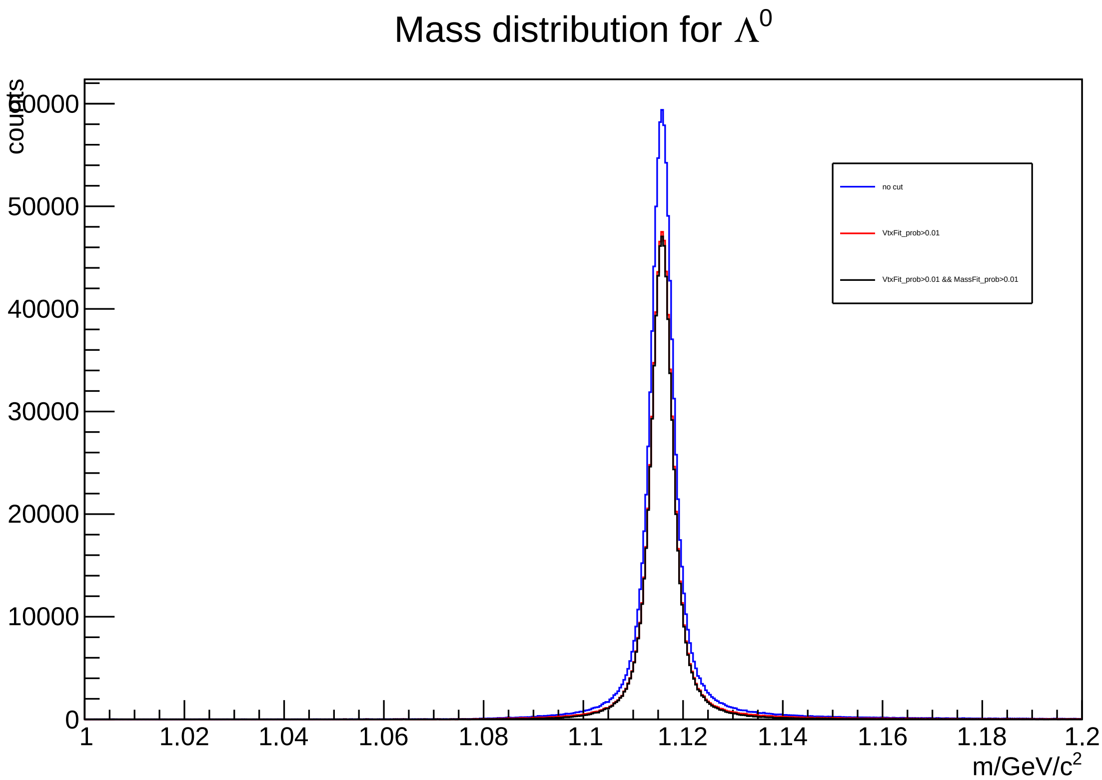


Figure 3.3: Mass distribution of Λ^0 for different cuts

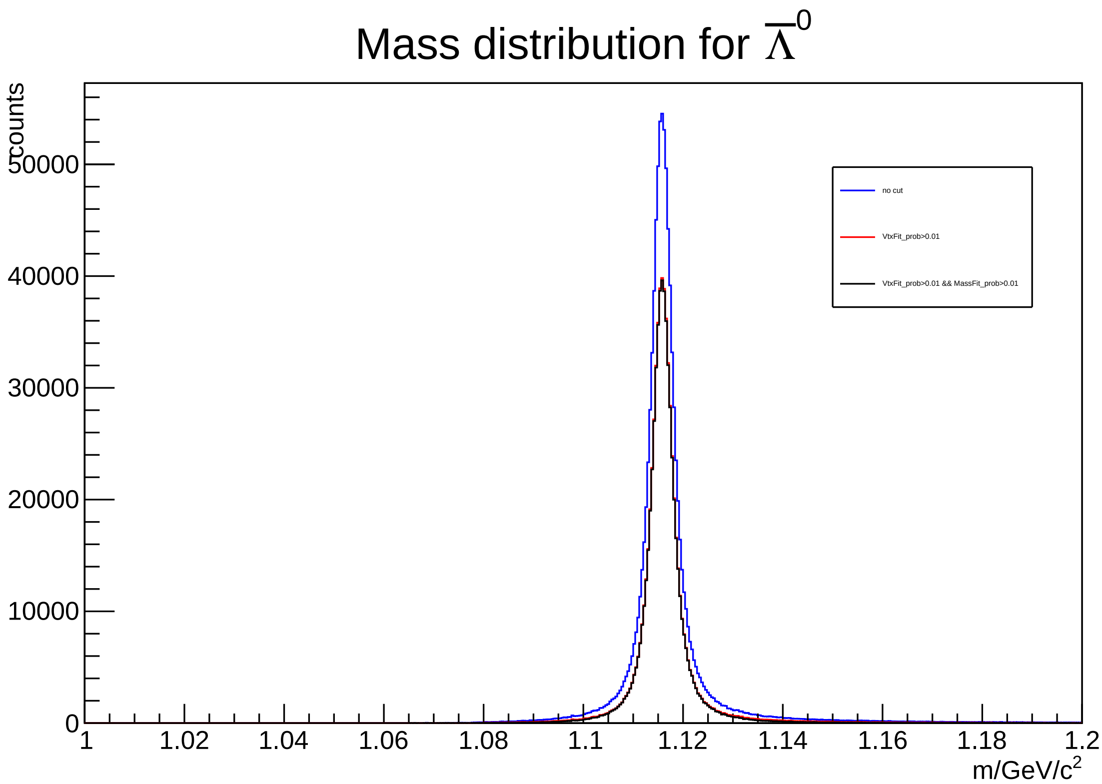


Figure 3.4: Mass distribution of $\bar{\Lambda}^0$ for different cuts

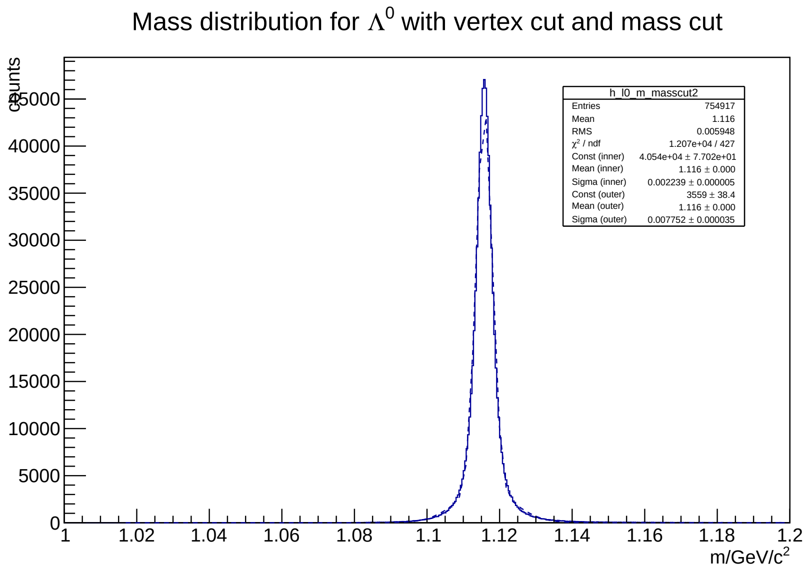


Figure 3.5: Mass fit with a double gaussian fit

-daughter particles for $\bar{\Xi}$: $\bar{\mathrm{p}}$ and π^+ here π_1^+
-daughter particles for Ξ: Λ^0 and π^- meson here π_1^+
-using best candidate from Λ^0 and $\bar{\Lambda}^0$
-π^+ and π^- with more than 3 Hits in one subdetector
-performing a mass window cut with width of 0.3GeV/c^2

3.3.2 Fitting

- fitting particles to common vertex with PndKinVtxFitter
  - fit information are given to PndKinFitter with mass constraint
  - only select particles with prob bigger than 0.01 for both fitters
  - scheme in figure 3.6
  -if there is more than one particle, choose best candidate

3.4 Reconstruction of Ξ(1820) and $\bar{\Xi}$(1820)

3.4.1 Combination

-daughter particles for Ξ (1820)$^-$: Λ^0 and K^- meson
-daughter particles for $\bar{\Xi}$ (1820): $\bar{\Lambda}^0$ and K^+
-using best candidate from Λ^0 and $\bar{\Lambda}^0$
-K^+ and K^- with more than 3 Hits in one subdetector
-performing a mass window cut with width of 0.3GeV/c^2

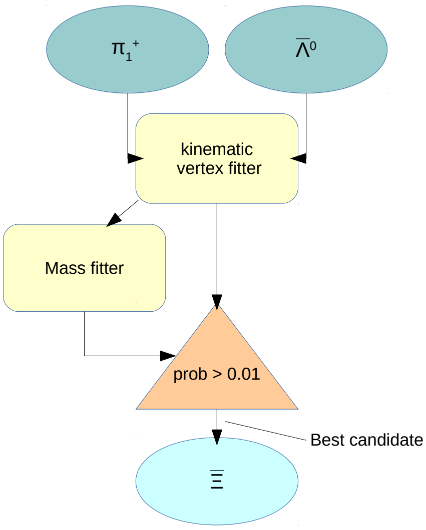


Figure 3.6: Scheme for $\bar{\Xi}$ reconstruction

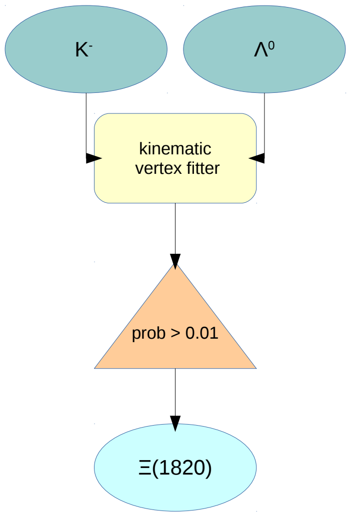


Figure 3.7: Scheme for $\Xi\,(1820)^{-}$ reconstruction

3.4.2 Fitting

- fitting particles to common vertex with PndKinVtxFitter
  - fit information are given to PndKinFitter with mass constraint
  - only select particles with prob bigger than 0.01 for both fitters
  - scheme in figure 3.7
  - if there is more than one particle, choose best candidate

3.5 Reconstruction of hole chain

3.5.1 combination

-using best candidate from $\Xi\,(1820)^{-}$ and $\bar{\Xi}$

  -for c.c : $\bar{\Xi}\,(1820)$ and Ξ

  -mass window of $0.3\mathrm{GeV}/c^2$

Figure 3.8: 4-constraint fit probability

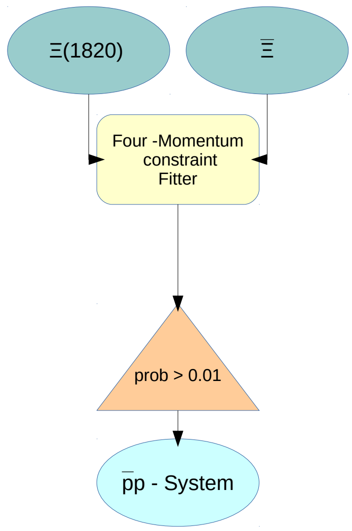


Figure 3.9: Scheme for 4-Constraint Fit

3.5.2 Fitting

-use PndKinFitter with four momentum constrained

-initial four momentum vector is

$$\left(\mathrm{p}_x,\, \mathrm{p}_y,\, \mathrm{p}_z,\, \mathrm{E}\right) = (0,\, 0,\, 4.6,\, 5.63)$$

-if probability is better than 1% keep candidate

-scheme shown in figure 3.8

4 Background

Bibliography

[1] J. B. et al., *Particle Data Group.* Phys. Rev. D86, 010001, 2012.