UNIVERSITÀ
DEGLI STUDI
DI TORINO

Feasibility study of the Λ(1520) decay in Λ e^+e^- at BESIII

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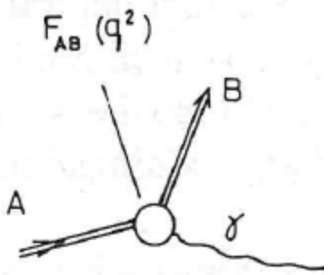
Overview

- Analysis motivation
- Analysis strategy
- Discriminating variables
- Conclusions

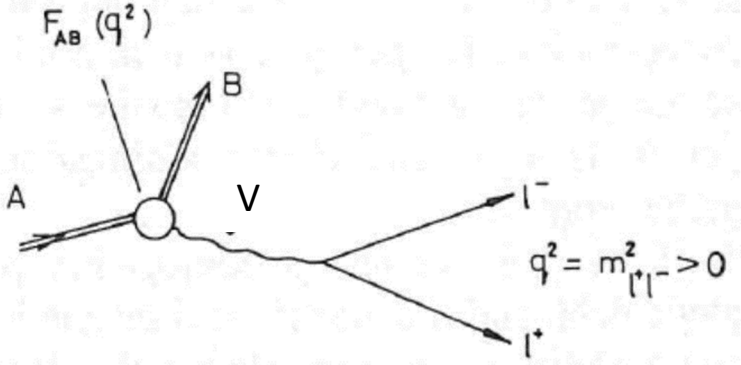
Analysis Motivation

- Test of the Extended Vector Meson Dominance model [1]
  - Vector mesons have the same quantum numbers of the photons: 1^-
  - The Λ(1520) can decay to a photon or to a vector meson (V) that produces the lepton pair
- Λ(1520)-> γ Λ decay was already seen [2]
- The decay Λ(1520)->V Λ ->e^+e^- Λ has not yet been observed
- It is expected that Br(Λ(1520)-> Λ e^+e^-)/ Br(Λ(1520)-> Λ γ) = 10^{-2}
- In principle a study of the lepton pair invariant mass can provide information on the nature of the vector meson



[1]

A = Λ(1520)
B = Λ



[1] L. G. Landsberg, Phys. Rep. 128, 301 (1985).

[2] Phys. Rev. Lett. 21, 1715 (1968)

Data Samples and Signal Events

- Exploiting the large J/ψ sample, we search for the decay J/ψ->Λ(1520)$\bar{\Lambda}$ with Λ(1520)->Λe^+e^-
- Number of J/ψ events recorded by BESIII: 10^{10}
- Upper Limit for the branching ratio of the decay J/ψ->Λ(1520)$\bar{\Lambda}$ -> γΛ$\bar{\Lambda}$ decay: < $4.1 * 10^{-6}$ [1]
- Expected ratio Br(Λ(1520)-> Λ e^+e^-)/ Br(Λ(1520)-> Λ γ) = 10^{-2}
- Br(Λ->p π) = 0.64
- Expected Λ$e^+e^-\bar{\Lambda}$ events in BESIII J/ψ sample: $10^{10} * 4.1 * 10^{-6} * 10^{-2} * 0.64^2 = 164$
- Feasibility study on:
  - 10^4 MonteCarlo signal events
  - 10^9 MonteCarlo generic J/ψ decays (background events)

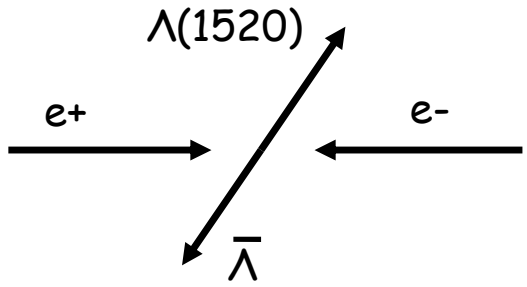
[1] Phy.rev.D86 (2012) 032008

Analysis Strategy

The decay J/ψ->Λ(1520)$\overline{\Lambda}$ is a 2-body decay.

In our experiment CM's reference system and laboratory's reference system coincide, so we expect that Λ(1520) and $\overline{\Lambda}$ are back-to-back and their momentum in module is:

$$|p| = \frac{\sqrt{[M^2-(m_1+m_2)^2(M^2-(m_1-m_2)^2)]}}{2M} = 806\ MeV\ .$$



So we search for the best discriminating variables taking advantage of this particular kinematic

Event Reconstruction

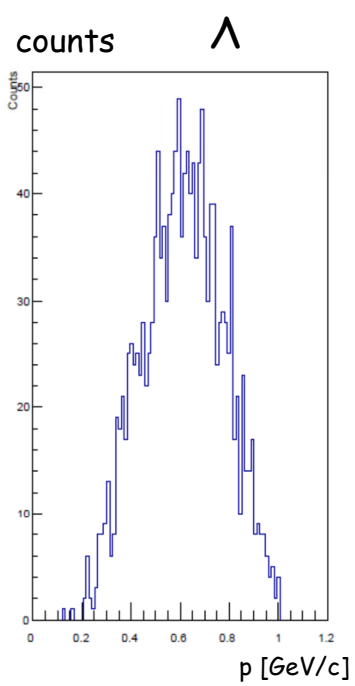
Request:

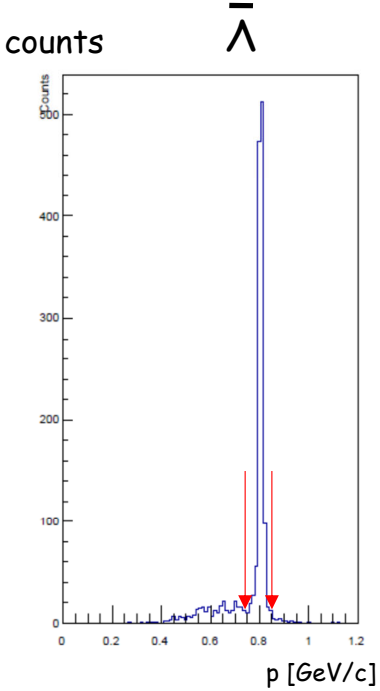
- 6 well reconstructed tracks
  - without cut on the impact parameter because the Λ fly before decaying
  - with $\cos\Theta < 0.93$
- Total charge = 0
- Λ and $\bar{\Lambda}$ reconstructed combining 2 opposite charged tracks, assigning the proton mass to the track that has higher probability of being a proton according to the PID algorithm
- $\Lambda(1520)$ reconstructed adding 2 opposite charged tracks to the Λ
  - The electron's mass is assigned to the 2 charged tracks.
- J/ψ reconstructed from $\Lambda(1520)\bar{\Lambda}$ pair
- No PID's probability selections are applied to maximize the signal's efficiency
- Candidate reconstruction efficiency:
  - Signal: 0.154
  - Background: $5.5*10^{-5}$

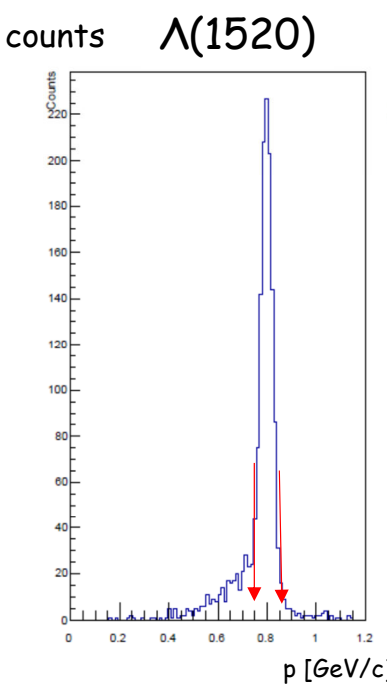
Reconstructed Particles Momenta

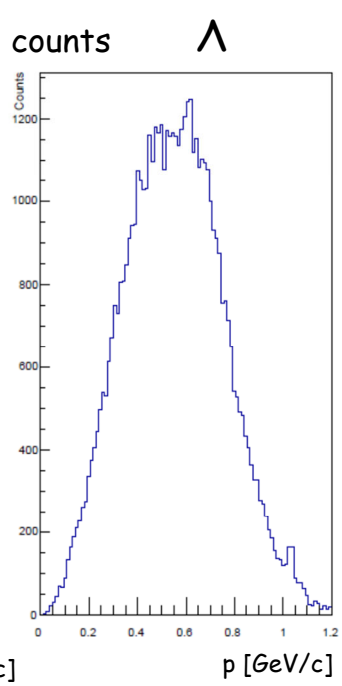
Signal

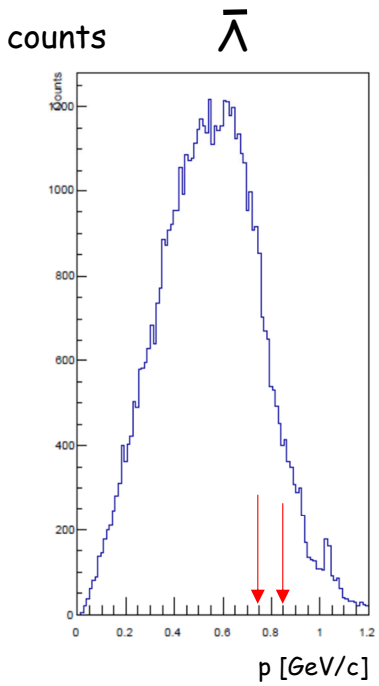
Background

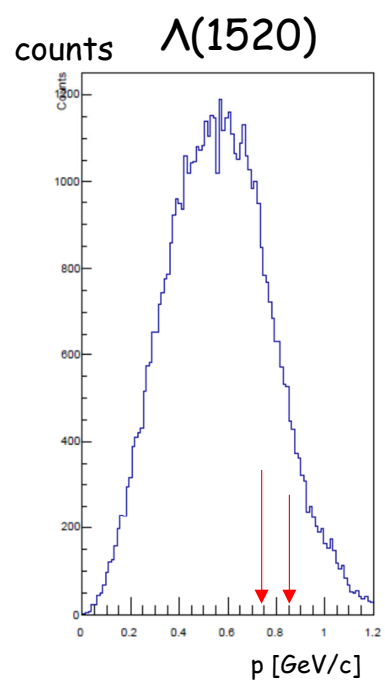












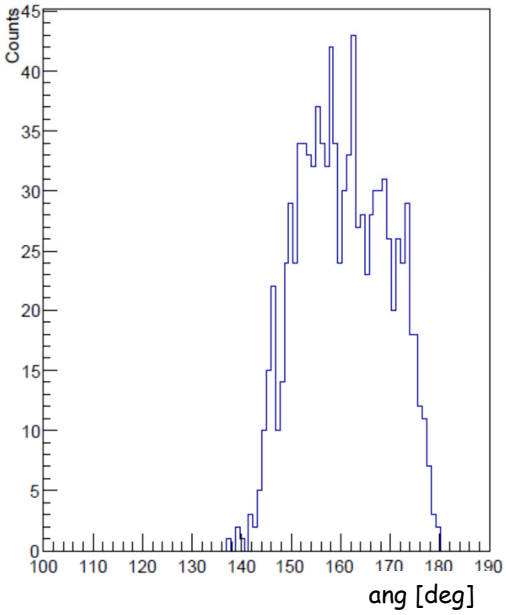
The arrows on the plots show the cuts on $\bar{\Lambda}$ and Λ(1520) momenta that are good discriminating variables due to the different shapes of their distribution. In the signal plot they peak at the expected values (806 MeV)

Opening Angle between Λ(1520) and $\bar{\Lambda}$

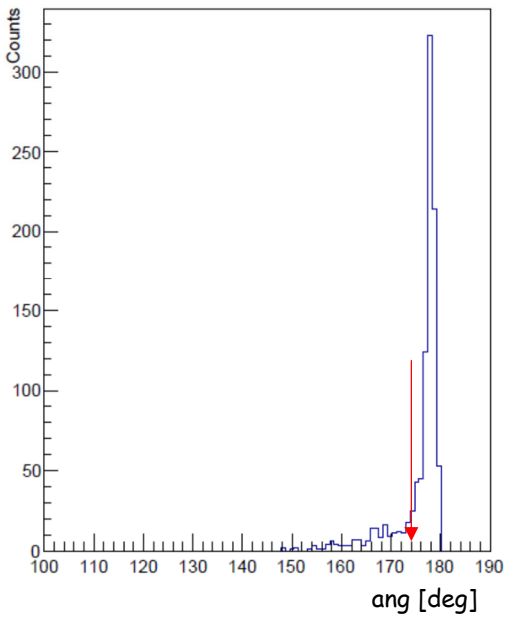
Applied selections: 0.75 GeV/c< $p_{\bar{\Lambda}}$ <0.85 GeV/c
0.75 GeV/c < $p_{\Lambda(1520)}$ < 0.85 GeV/c

Signal

counts $\Lambda\bar{\Lambda}$

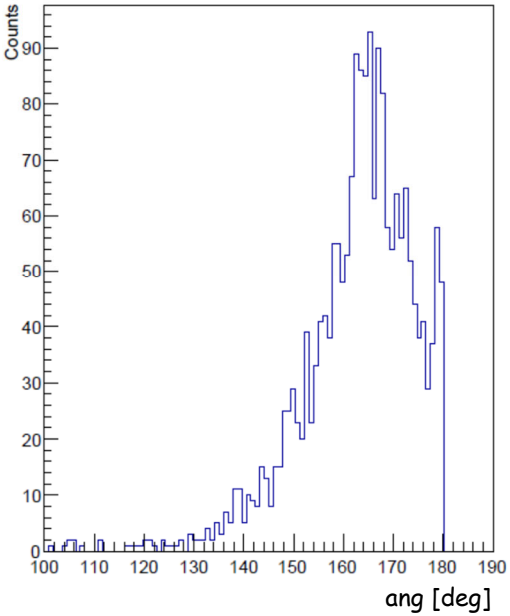


counts $\Lambda(1520)\bar{\Lambda}$

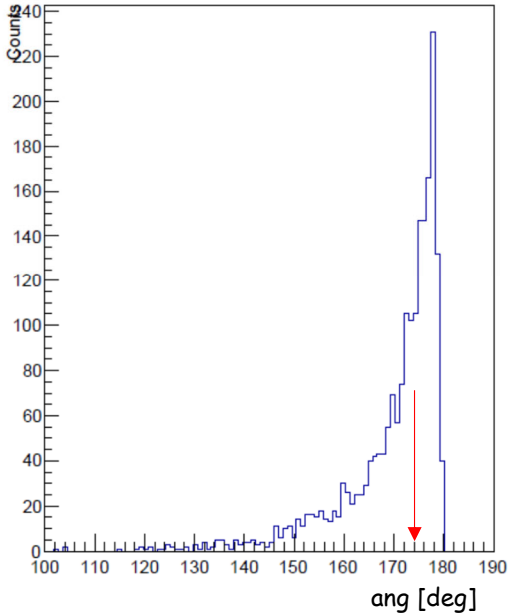


Background

counts $\Lambda\bar{\Lambda}$



counts $\Lambda(1520)\bar{\Lambda}$

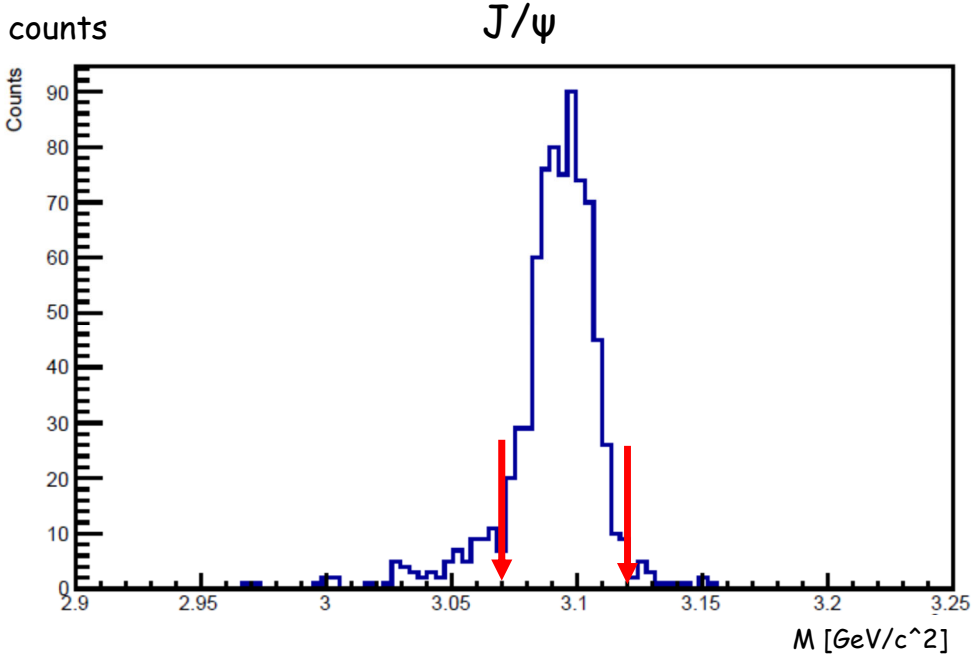


The angle between Λ(1520) and $\bar{\Lambda}$ peaks at 180° as expected for signal events and it is again a good discriminating variable. The red arrow on the plot shows the applied cut.
The angle between Λ and $\bar{\Lambda}$ doesn't peak at 180° as expected.

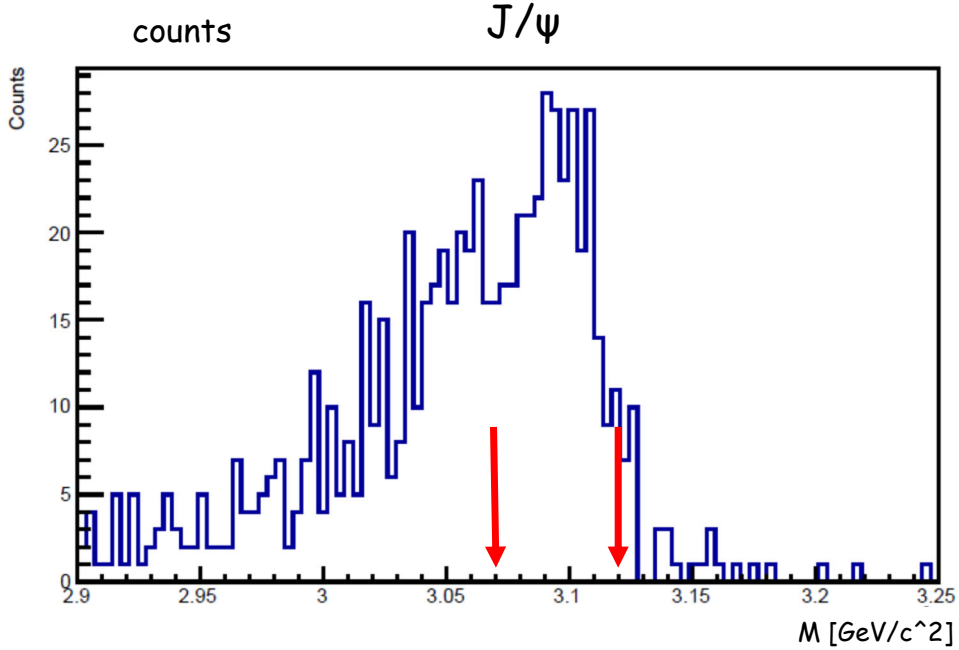
J/ψ Invariant Mass

Applied selections: 0.75 GeV/c < $p_{\bar{\Lambda}}$ < 0.85 GeV/c
0.75 GeV/c < $p_{\Lambda(1520)}$ < 0.85 GeV/c
opening angle > 175°

Signal



Background

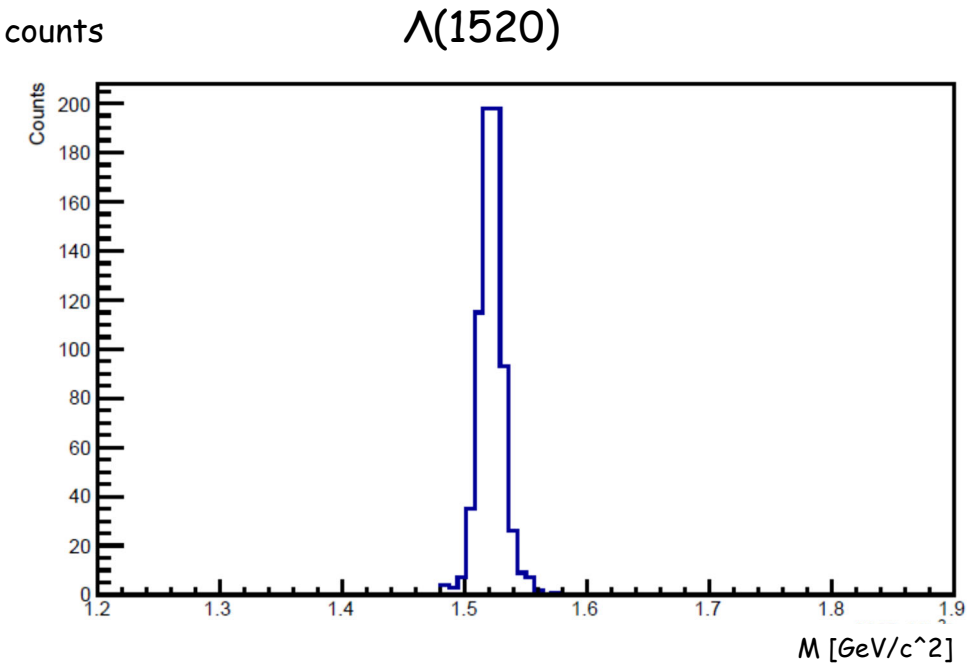


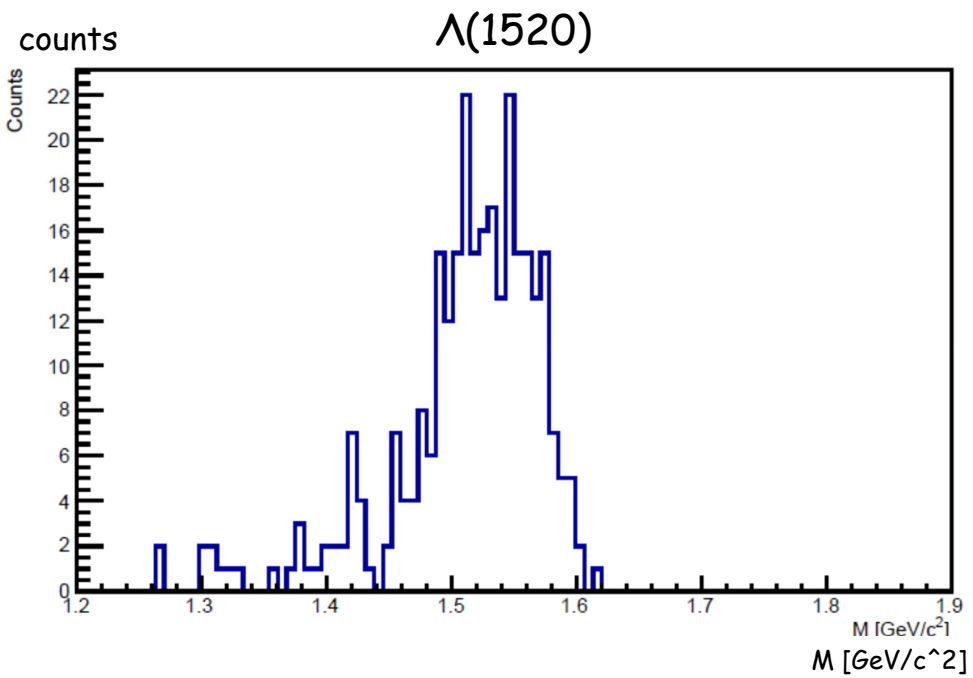
The J/ψ invariant mass for signal events peaks at J/ψ mass value and can be used to reduce background applying the red arrow cut.

Results(1)

Signal: 698 events

Background: 290 events





The selection cuts on $p_{\bar{\Lambda}}$,$p_{\Lambda(1520)}$,opening angle and J/ψ invariant mass reduce the signal by 54.6% and the background by 99.5%

The total efficiency (reconstruction efficiency plus selection cuts) is

- $\frac{698}{10000} * 100 = 6.98\%$ for the signal
- $\frac{290}{10^9} * 100 = 2.9 * 10^{-5}\%$ for the background

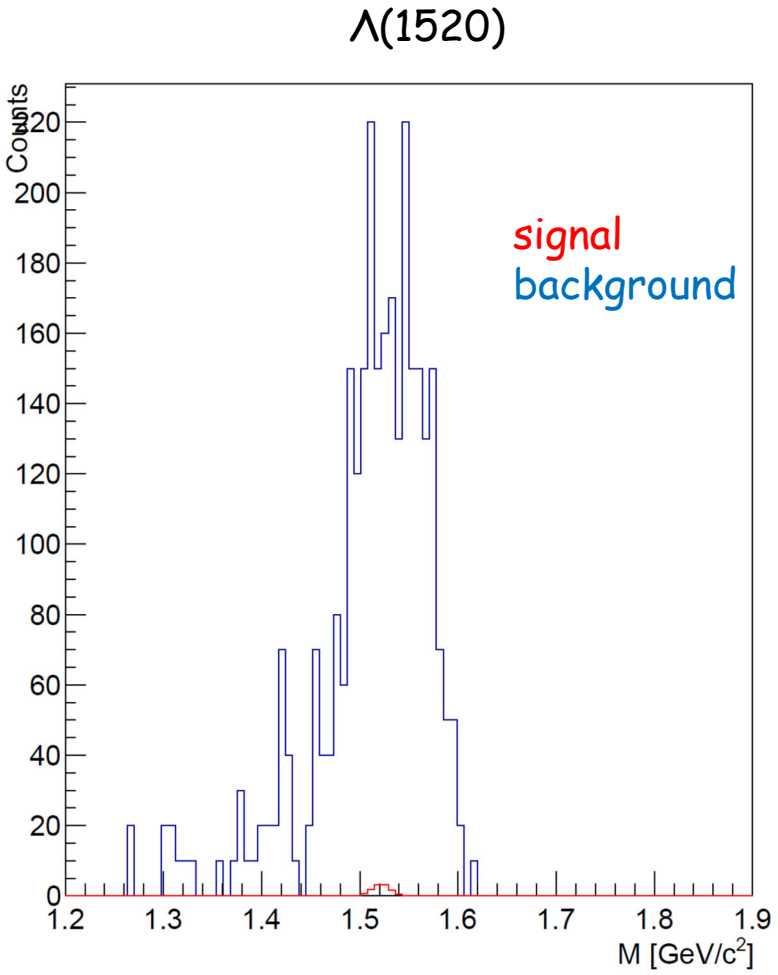
Results(2)

On a sample of 10^{10} J/ψ we expect:

- 164 * 0.0698 = 11.45 signal events
- 2900 background events

Conclusions:

- The signal is too small to be seen on top of the background
- In principle the resolution on momenta, angles, and invariant mass could be improved using a constrained kinematical fit and this could allow thighter cuts, but the number of signal events would still be to small compared to the background



Conclusions

- We have presented a feasibility study for the search of the $\Lambda(1520)\overline{\Lambda}\to\Lambda e^+e^-\overline{\Lambda}$ final state in the BESIII sample of 10^{10} J/ψ

- We have identified a set of discriminating variables taking advantage of the 2-body decay kinematic

- Unfortunately the expected signal is too small compared to the background