Results on Rare Five-Track Decay Modes of the Ω^- Hyperon

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Decay Channels

Fully Reconstructed 5-track (Used for normalization):

$$\Omega^- \to \Lambda^0 K^-$$
$$\to \pi^+\pi^-\pi^-$$
$$\to p\pi^-$$

Signal Mode (Contribution of quark diagrams: tree, penguin, double gluon):

$$\Omega^- \to \Xi^-\pi^+\pi^-$$
$$\to \Lambda^0\pi^-$$
$$\to p\pi^-$$

Resonance process:

$$\Omega^- \to \Xi^{0*}_{1530}\pi^-$$
$$\to \Xi^-\pi^+$$
$$\to \Lambda^0\pi^-$$
$$\to p\pi^-$$

Muon Mode (Flavor changing neutral current):

$$\Omega^- \to \Xi^-\mu^+\mu^-$$
$$\to \Lambda^0\pi^-$$
$$\to p\pi^-$$

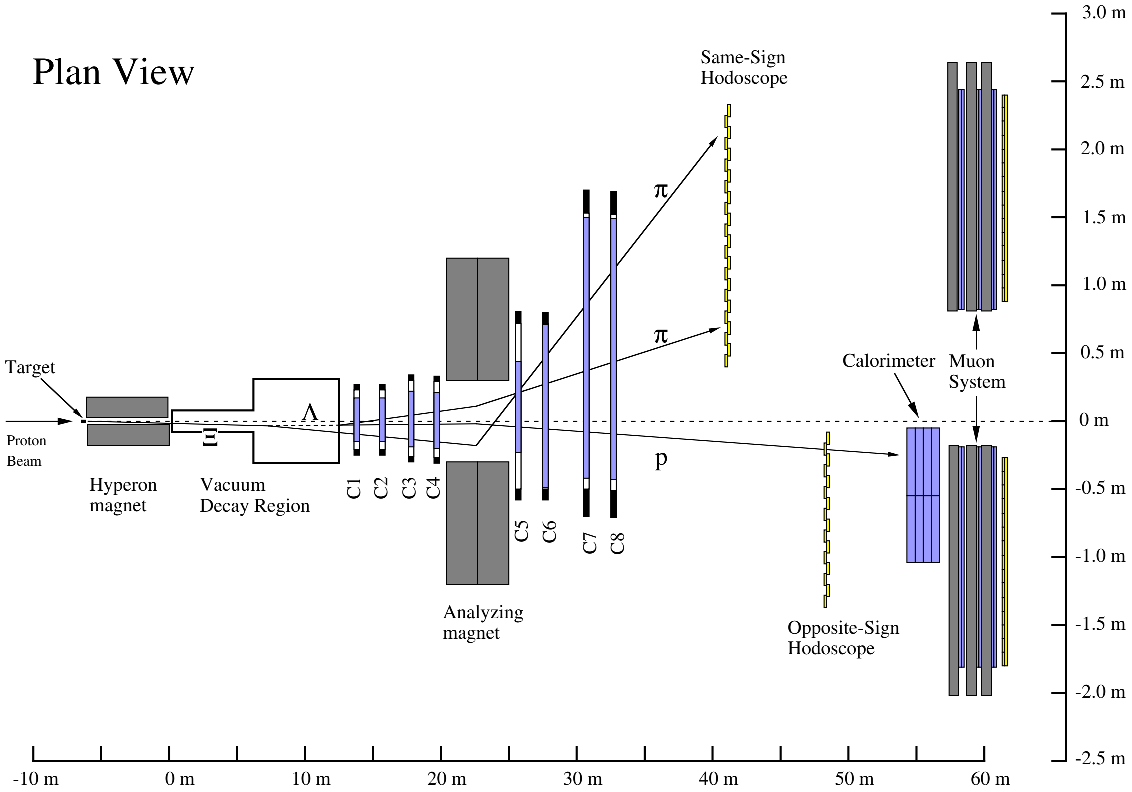
Antiparticle Modes (Tests of CP and CPT)

Previous Observations

- Previously 4 $\Omega^- \to \Xi^-\pi^+\pi^-$ events observed by M. Bourquin, et al., 1984.
- $\Omega^- \to \Xi^-\pi^+\pi^-$ hard to distinguish from $\Omega^- \to \Xi^{0*}_{1530}\pi^-$ where $\Xi^{0*}_{1530} \to \Xi^-\pi^+$
- PDG Branching Ratios (based on the same 4 events with different normalizations)

Assumed Mode	Branching Ratio
$\Omega^- \to \Xi^-\pi^+\pi^-$	$4.3^{+3.4}_{-1.3} \times 10^{-4}$
$\Omega^- \to \Xi^{0*}_{1530}\pi^-$	$6.4^{+5.1}_{-2.0} \times 10^{-4}$

HyperCP Experiment



- HyperCP designed to measure CP violation in Ξ^- and Λ decays
- HyperCP Data Set (97 and 99 runs):

Mode	Reconstructed events[1]
$\Xi^- \rightarrow \Lambda^0\pi^-$	2490×10^6
$\Omega^- \rightarrow \Lambda^0 K^-$	19×10^6
$K^- \rightarrow \pi^-\pi^+\pi^-$	555×10^6

- Muon identification
- No EM calorimeter

[1] Includes corresponding antiparticle decay

$\Omega^- \to \Lambda^0 K^-$ (5-track) Selection Criteria

- 3 negative and 2 positive tracks
- All vertices within decay volume
- Ω^- vertex upstream of K^- and Λ^0 vertices
- Tracks form good vertices
- Total momentum between 120 and 220 GeV/c

■ $p\ \pi^-$ invariant mass within 3σ of Λ^0 mass

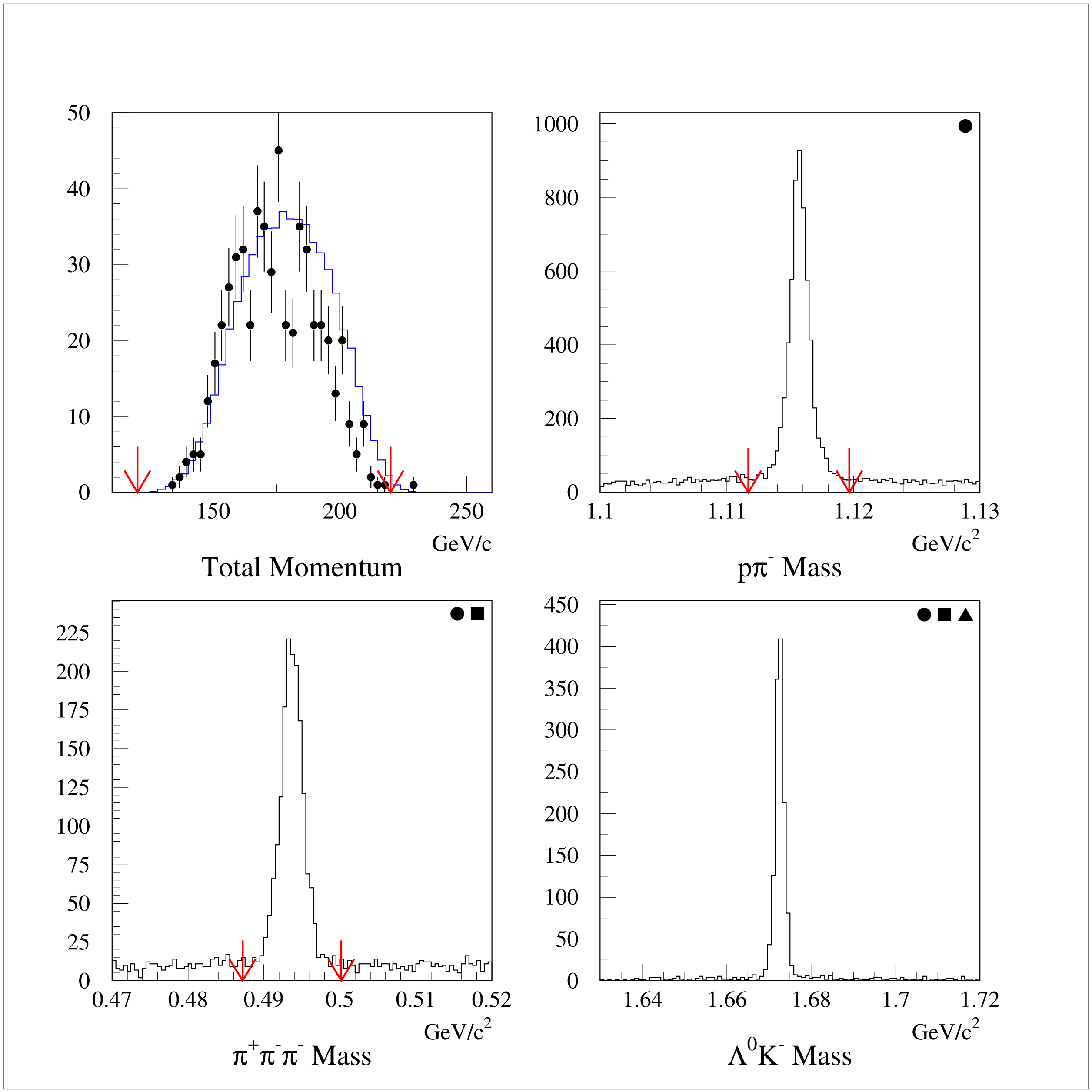
▲ $\pi^+\ \pi^-\ \pi^-$ invariant mass within 3σ of K^- mass

◆ Reconstructed Omega track within the aperture of the hyperon magnet

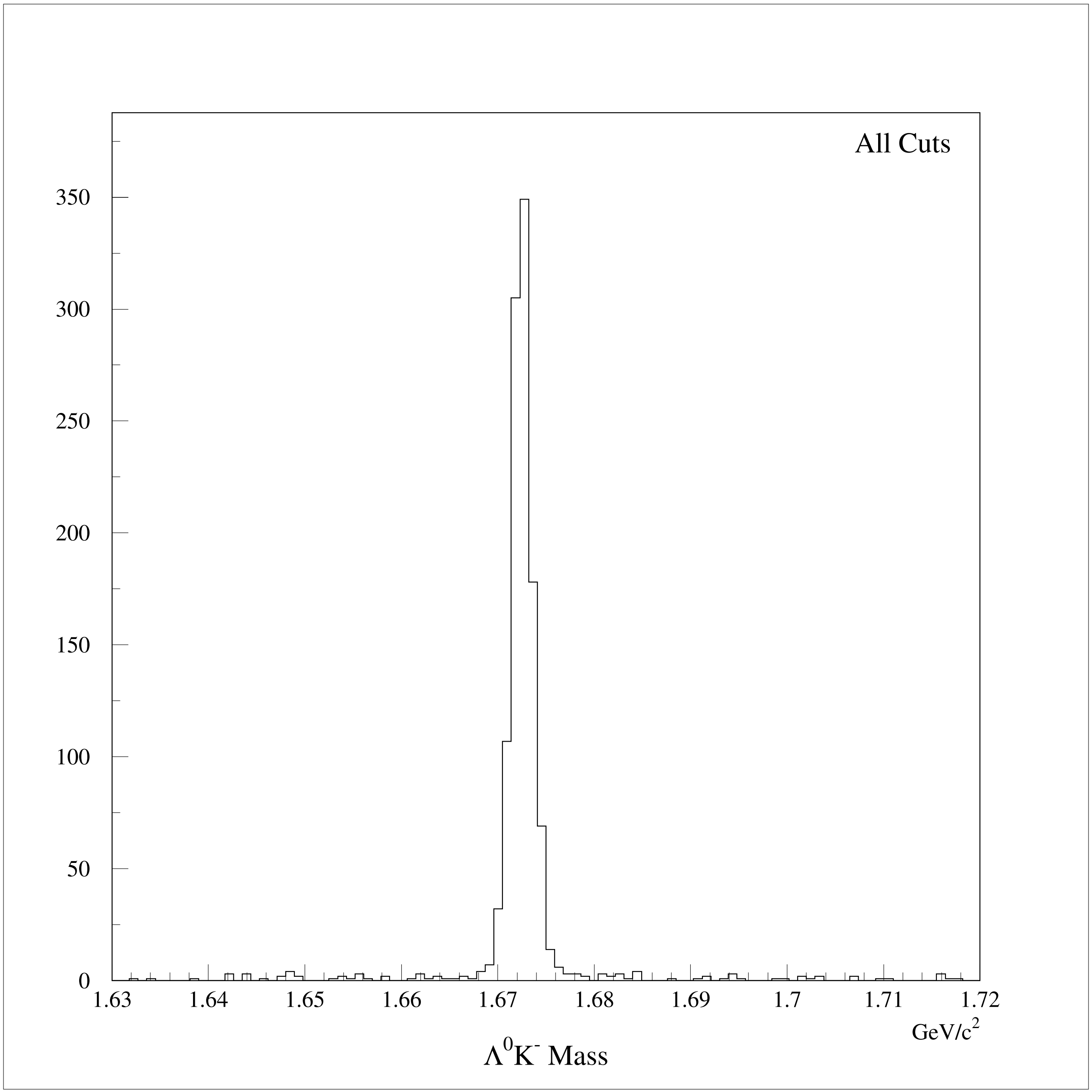
◆ No muon hodoscope hits

(Cuts grouped by symbols)

$\Omega^- \to \Lambda^0 K^-$ (5-track) Selection Criteria



Observed $\Omega^- \to \Lambda^0 K^-$ (5-track) Events

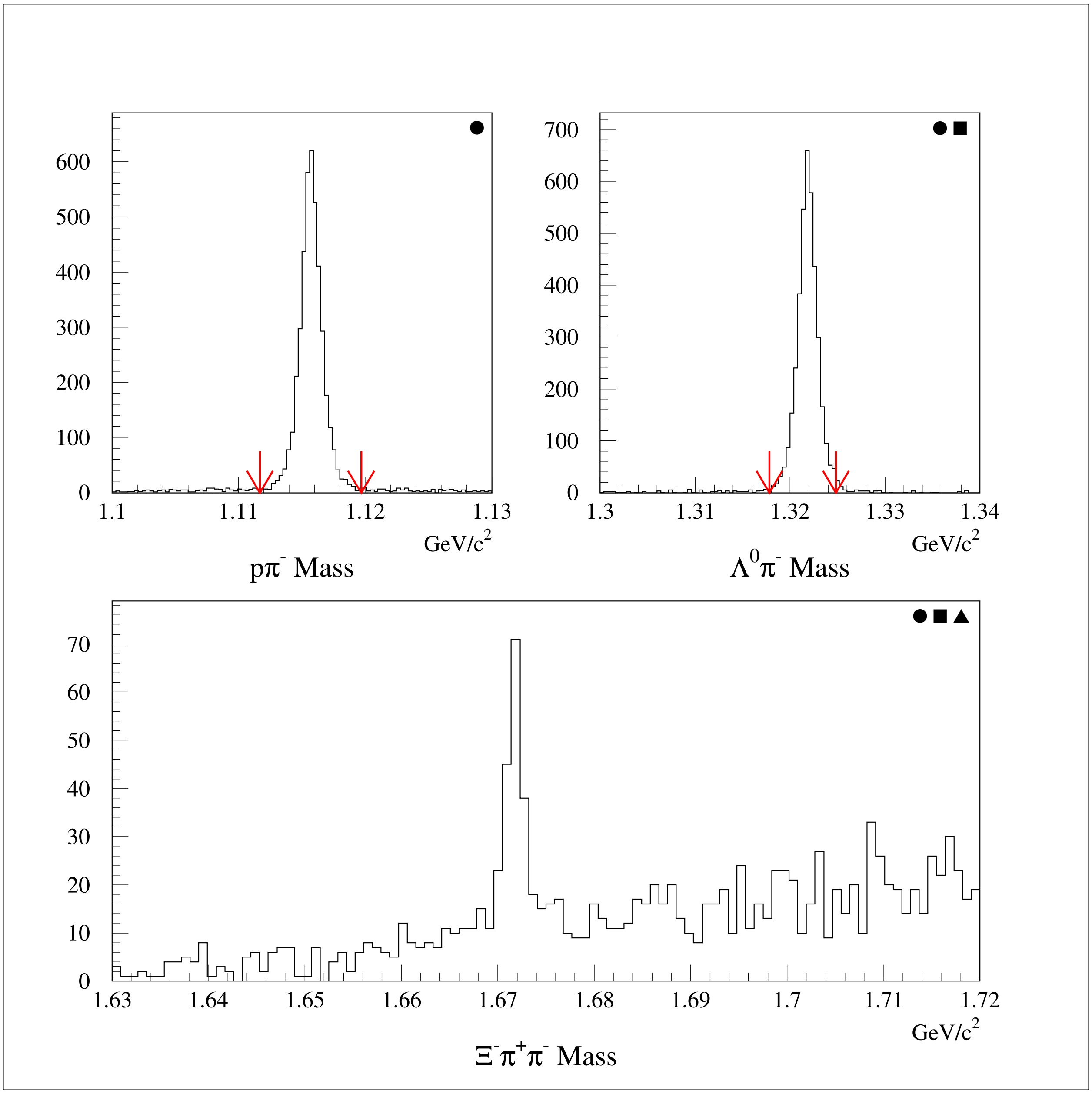


$\Omega^- \to \Xi^-\pi^+\pi^-$ Selection Criteria

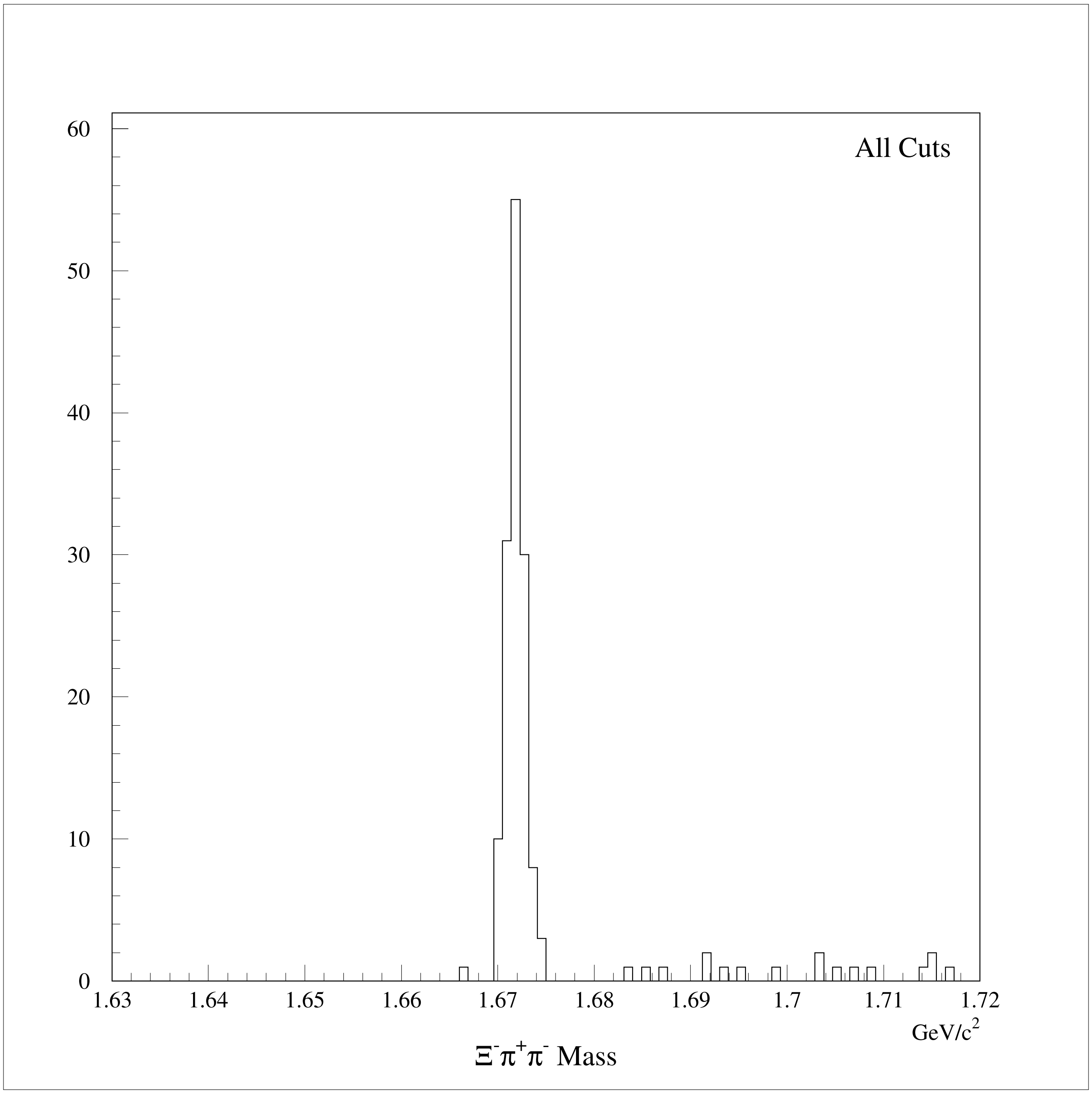
- ● 3 negative and 2 positive tracks
- ● All vertices within decay volume
- ● Ω^- vertex upstream of Ξ^- vertex
- ● Ξ^- vertex upstream of Λ^0 vertex
- ● Tracks form good vertices
- ● Total momentum between 120 and 220 GeV/c
- ■ $p\ \pi^-$ invariant mass within 3σ of Λ^0 mass
- ▲ $\Lambda^0\ \pi^-$ invariant mass within 3σ of Ξ^- mass
- ⧫ Reconstructed Omega track within the aperture of the hyperon magnet
- ⧫ No muon hodoscope hits

(Cuts grouped by symbols)

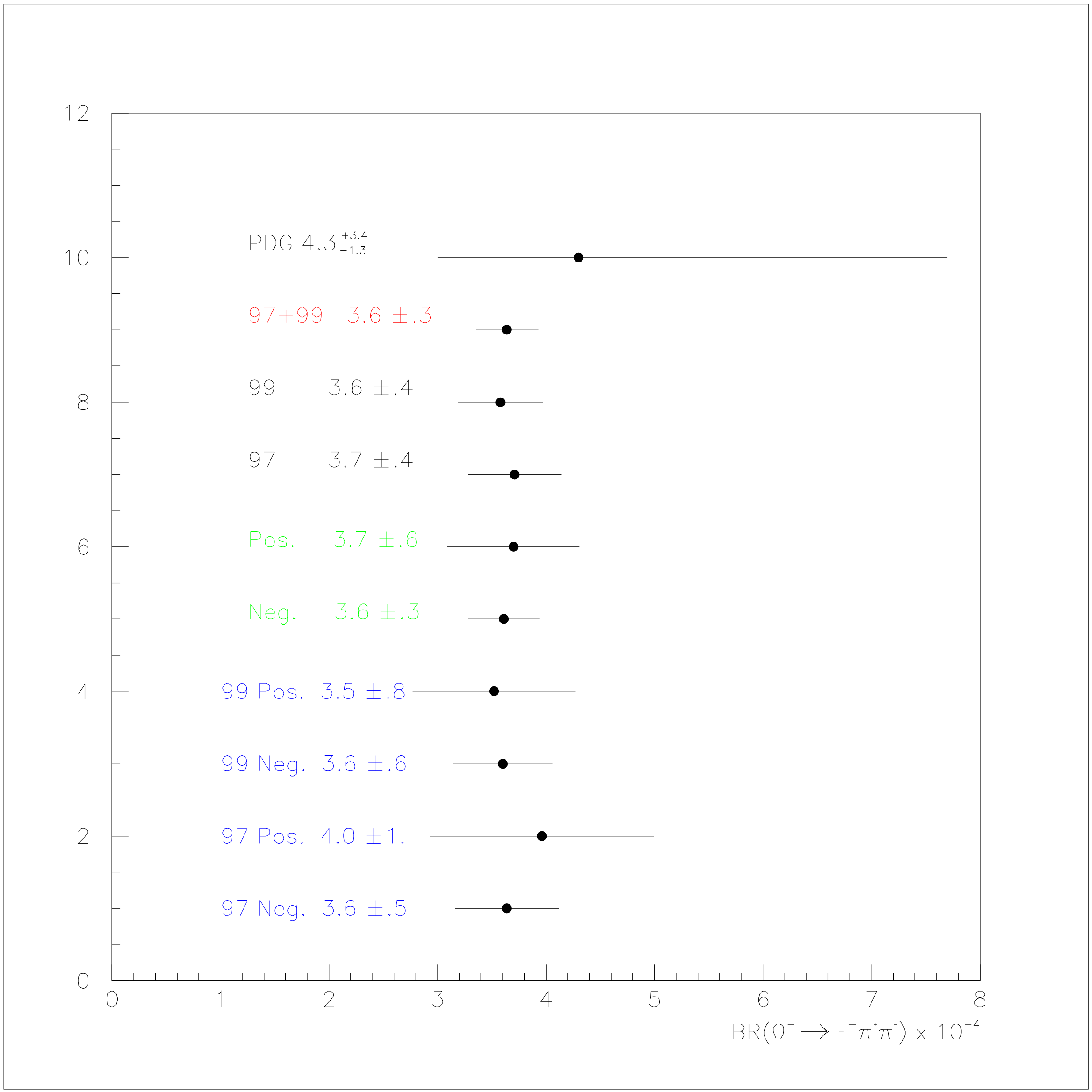
$\Omega^- \to \Xi^-\pi^+\pi^-$ Selection Criteria (continued)



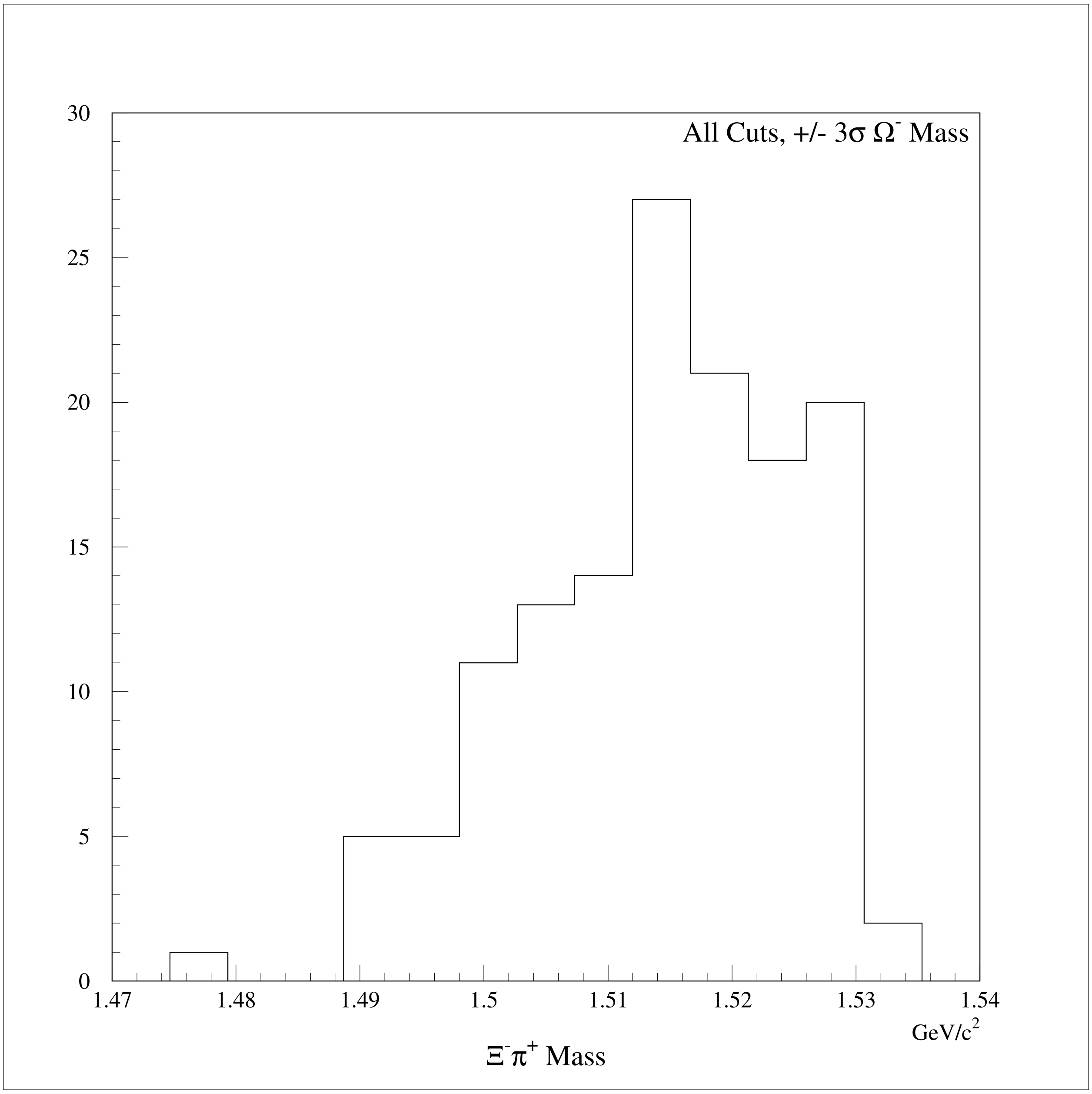
Observed $\Omega^- \to \Xi^- \pi^+ \pi^-$ Events



Preliminary Branching Ratio for $\Omega^{\pm} \to \Xi^{\pm}\pi^{+}\pi^{-}$



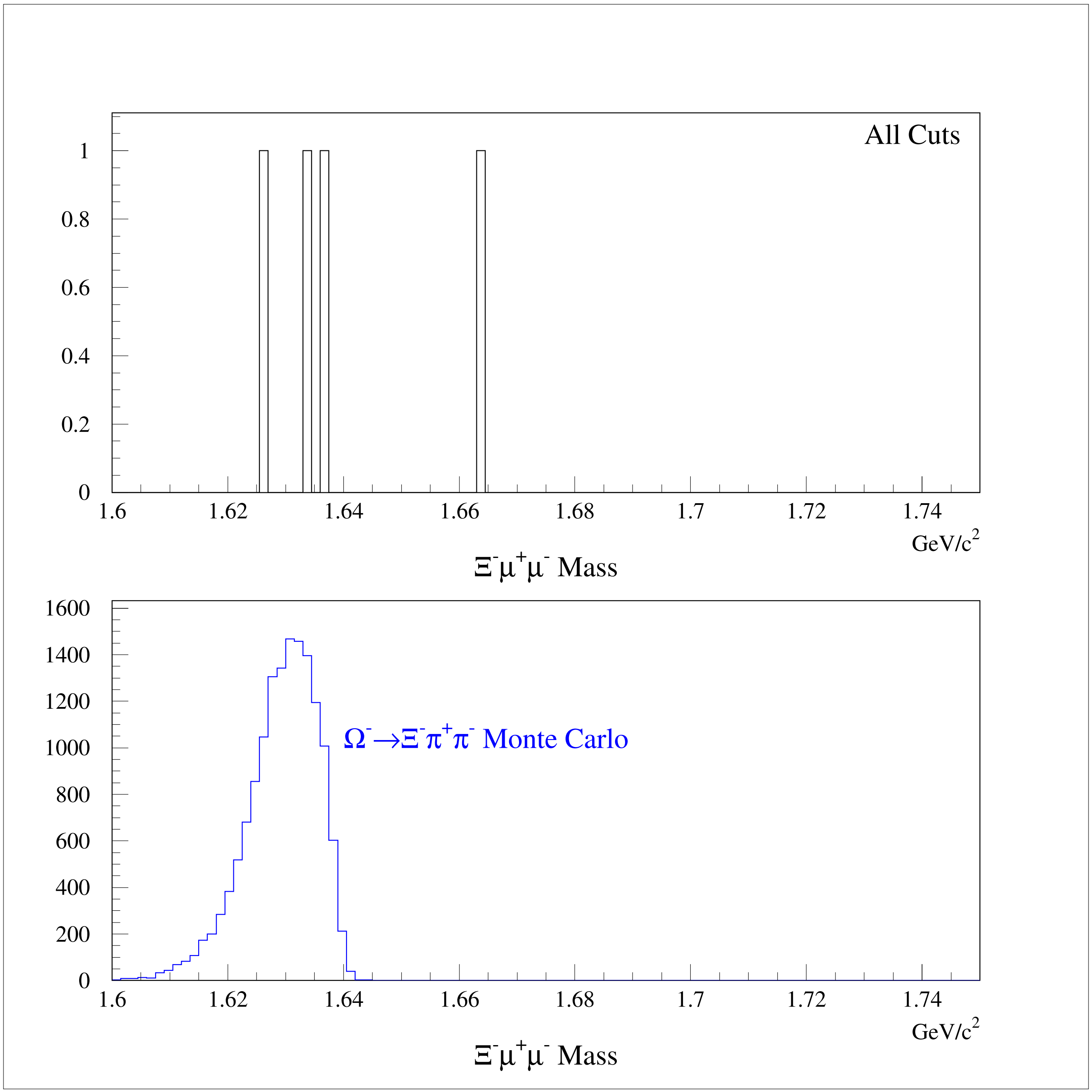
Resonance Process in $\Omega^- \to \Xi^- \pi^+ \pi^-$ Events

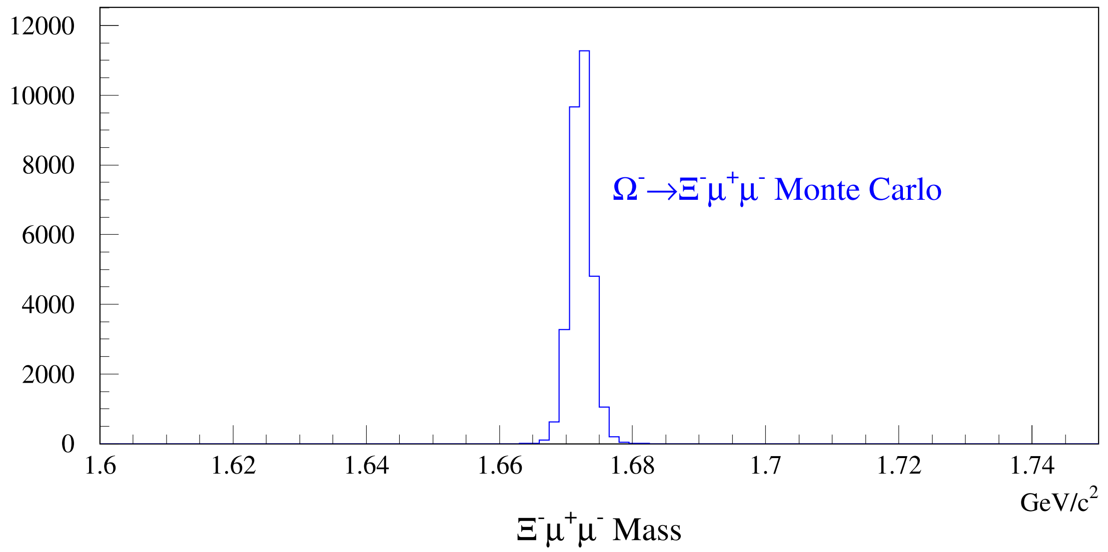


$\Omega^- \to \Xi^- \mu^+ \mu^-$ Selection Criteria

- 3 negative and 2 positive tracks
- All vertices within decay volume
- Ω^- vertex upstream of Ξ^- vertex
- Ξ^- vertex upstream of Λ^0 vertex
- Tracks form good vertices
- Total momentum between 120 and 220 GeV/c
- $p\ \pi^-$ invariant mass within 3σ of Λ^0 mass
- $\Lambda^0\ \pi^-$ invariant mass within 3σ of Ξ^- mass
- Reconstructed Omega track within the aperture of the hyperon magnet
- At least 1 muon track activate 2/3 PWCs in muon system
- Proton and pion tracks not activating 2/3 PWCs in muon system

Search For $\Omega \to \Xi^- \mu^+ \mu^-$





12000
10000
8000
6000
4000
2000
0
1.6
1.62
1.64
1.66
1.68
1.7
1.72
1.74
GeV/c2
Ω- → Ξ- μ+ μ- Monte Carlo
Ξ- μ+ μ- Mass

Conclusion

- With ∼35 times the number of previously observed $\Omega^- \rightarrow \Xi^-\pi^+\pi^-$ events, an improved measurement of the branching ratio is possible (statistical error $\sim 10\%$)
- Positive polarity data will further increase statistics with $\overline{\Omega}^+ \rightarrow \overline{\Xi}^+\pi^-\pi^+$ events and allow CP or CPT measurements by comparison with negative mode
- The larger sample will allow investigation of $\Omega^- \rightarrow \Xi^{0*}_{1530}\pi^-$ where $\Xi^{0*}_{1530} \rightarrow \Xi^-\pi^+$
- Limit will be set on the decay $\Omega^- \rightarrow \Xi^-\mu^+\mu^-$ (single event sensitivity $\sim 1 \times 10^{-4}$)