Charmless Baryonic B-Decays at BaBar

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on behalf of the BaBar Collaboration

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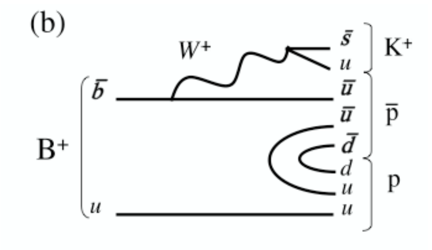
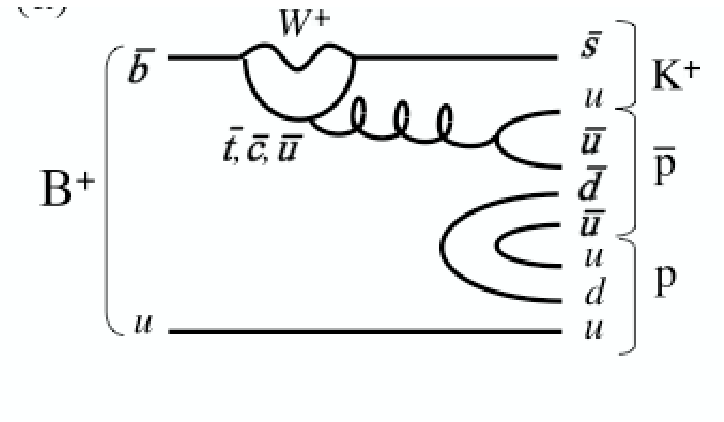
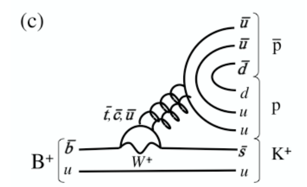
Why Baryonic B Decays?

- one the weak side, same as mesonic decays just with and extra $q\bar{q}$ pair from the vacuum
  - the hadronic part is a bit more complicated
- some of the hadronic physics is itself interesting… for instance looking for new baryonic or baryon-antibaryon states
- for final states with $\Lambda \rightarrow p\pi$, we can study T-violation (hep-ph/0509245)
  - for $B^0 \rightarrow \bar{\Lambda} p \pi^+$, this is predicted to be ~10%
  - expected to be smaller for $B \rightarrow \Lambda \bar{\Lambda} K$





Example: $B^+ \rightarrow p\bar{p}K^+$



Baryonic B Decays: Decay Rates

Decay rates are larger the more bodies we have

2-body<<3-body<4-body<5-body (probably)

$$p\bar{p}(<10^{-7}) << p\bar{p}K(6\times10^{-6}) < p\bar{p}K\pi(???)$$

$$p\bar{\Lambda}(???) << p\bar{\Lambda}\pi(3\times10^{-6}) < p\bar{\Lambda}\pi\pi(???)$$

$$\Lambda\bar{\Lambda}(<3\times10^{-7}) << \Lambda\bar{\Lambda}K(3\times10^{-6}) < \Lambda\bar{\Lambda}K\pi(???)$$

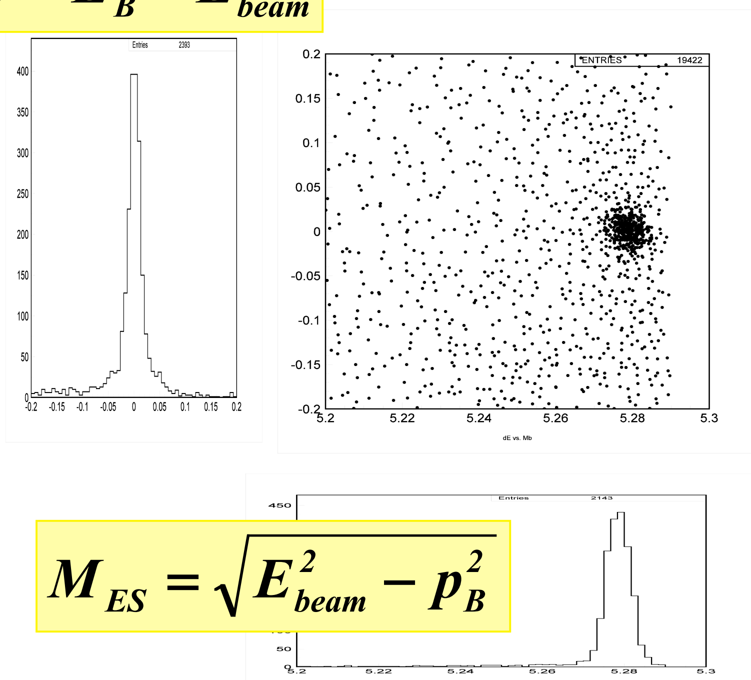
$$p\bar{p}(<10^{-7}) << p\bar{p}D(1\times10^{-4}) < p\bar{p}D\pi(5\times10^{-4})$$

In this talk, I will only discuss the 3-body decays and I'll focus mostly on our new measurement of $B\to\Lambda\bar{\Lambda}h$

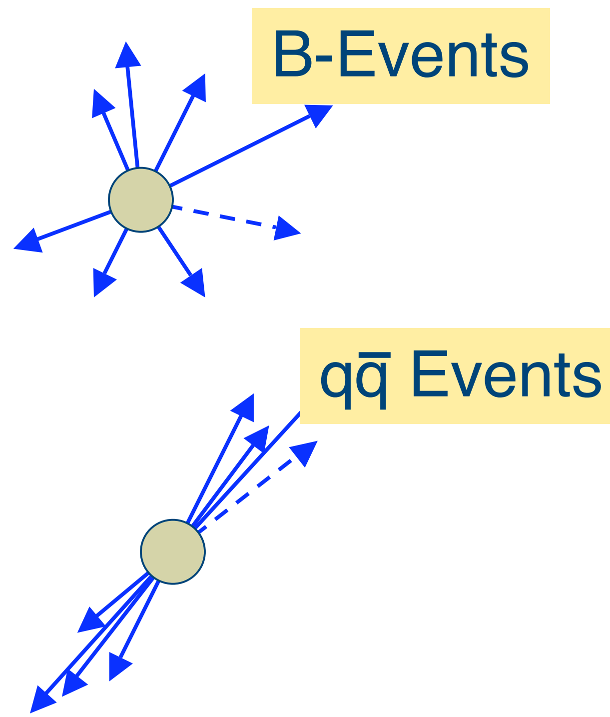
Basic Analysis Strategies…

3 tools to separate signal from background events:
beam-energy substituted mass (m_{ES}), energy difference (ΔE),
and the shape of the event

$$\Delta E = E_B - E_{beam}$$



$$M_{ES} = \sqrt{E_{beam}^2 - p_B^2}$$

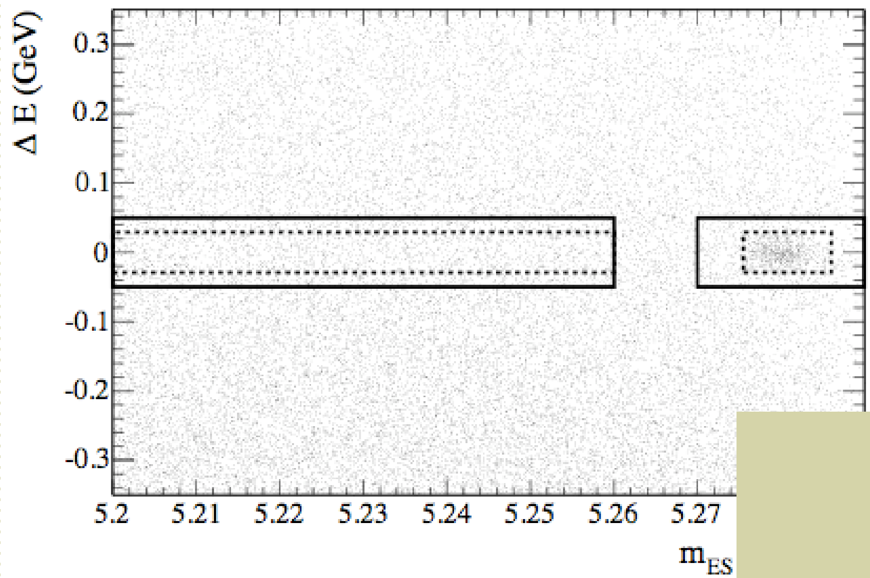


Extracting Branching Fractions: 3(or more)-Body Decays

- we don't know *a priori* what the distribution of decays is
- if the efficiency were uniform over the Dalitz plot, this wouldn't matter…but it typically varies a bit
- to correct for the changing efficiency and extract the correct inclusive BR, we either:
- fit for the signal yield in different DP bins, correcting each yield by the efficiency
- use the sPlots technique, weighting each event by efficiency:

$$BR = \sum_{i}^{N} \frac{W_i}{\varepsilon_i N_{BB} B_{sub}}$$

$B^+ \rightarrow p\bar{p}K^+$: Selection & Decay Rate



- PID requirements on both protons and kaon
- event shape variables combined into a Fisher, cut
- $5.27 < m_{ES} < 5.29$ GeV/c^2
- fit ΔE in bins of M(pp)

charmless results (charmonium subtracted):

$N(B^+ \rightarrow ppK^+) = 433 \pm 33$

$BR(B^+ \rightarrow ppK^+) = (6.7 \pm 0.5 \pm 0.4) \times 10^{-6}$

$A_{ch}(B^+ \rightarrow ppK^+) = -0.16 \pm 0.8 \pm 0.04$

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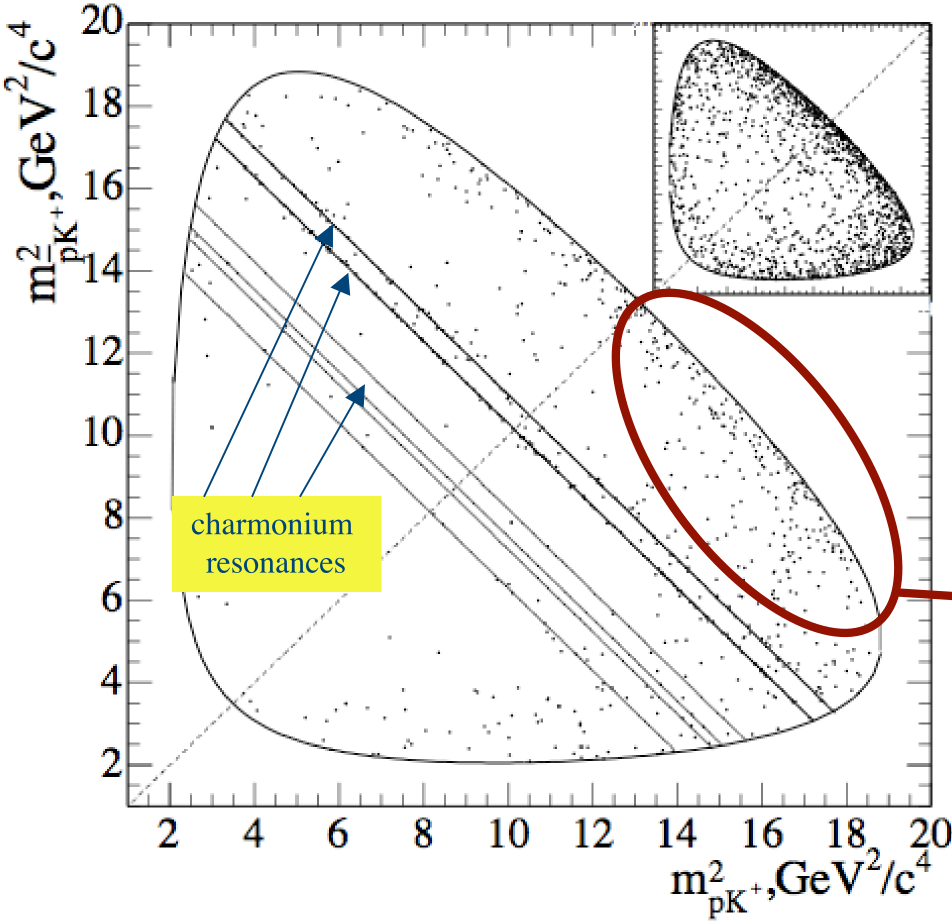
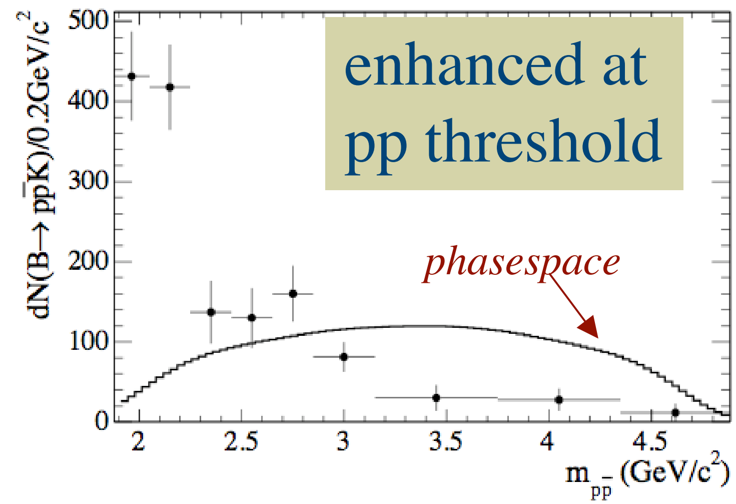
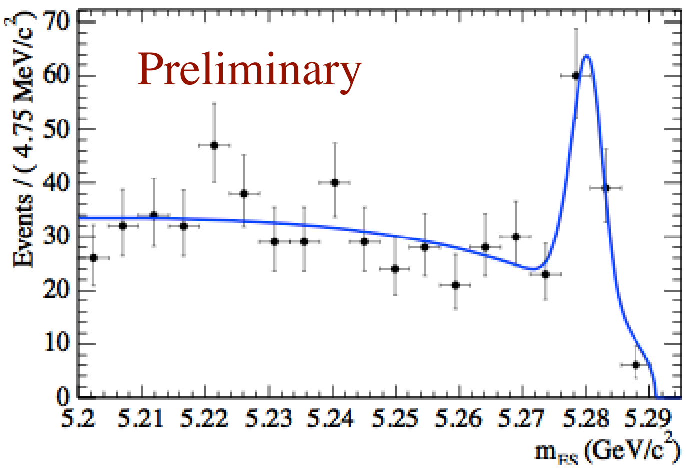
$B^+ \to p\bar{p}K^+$: Angular Distribution

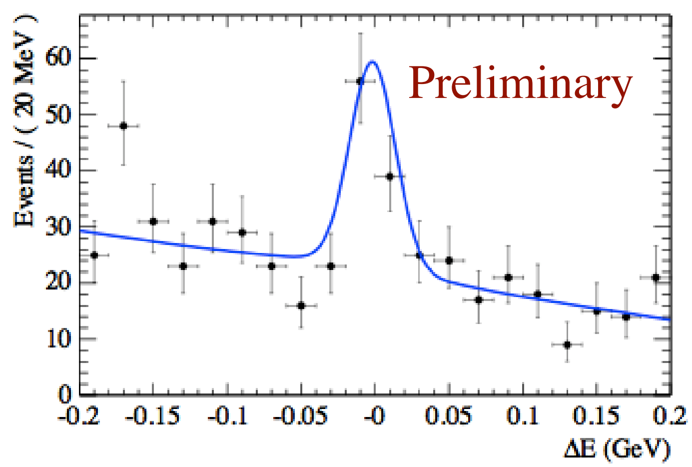




the enhancement is asymmetric…probably *not* a resonance, more likely fragmentation

$B^0 \rightarrow \bar{\Lambda} p \pi^+$: Selection & Decay Rate





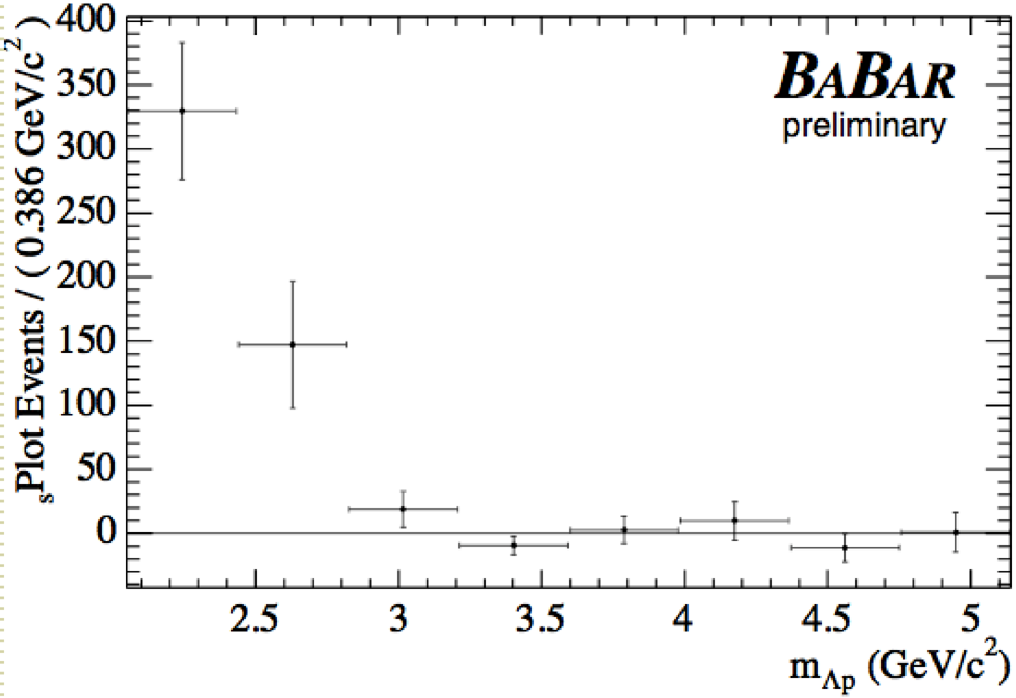
- PID requirements on both protons and π from B
- event shape variables combined into a Fisher, cut
- Λ mass and lifetime requirement
- $m_{ES}/\Delta E$ fit; use efficiency corrected sPlots to extract BR

Results:

$N(B^0 \rightarrow \Lambda p \pi^+) = 74 \pm 12$

$BR(B^0 \rightarrow \Lambda p \pi^+) = (3.3 \pm 0.5 \pm 0.3) \times 10^{-6}$

$B^0 \to \bar{\Lambda} p \pi^+$: Mass Distribution

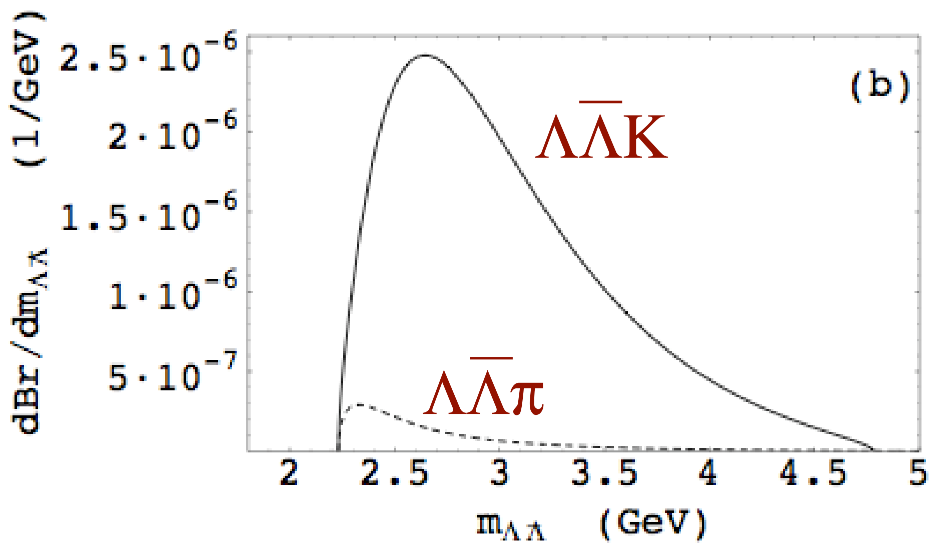


We can project the efficiency corrected weights onto the $M(\Lambda p)$ axis…again, observe an enhancement at threshold.

$B \to \Lambda\bar{\Lambda}h$ Decays: What we know…

•Geng and Hsiao have a paper dedicated to these modes (hep-ph/0503264)
Predict: $Br(B^+ \to \bar{\Lambda}\Lambda K^+) = 2.8\text{x}10^{-6}$ and $Br(B^+ \to \Lambda\bar{\Lambda}\pi^+) = 1.7\text{x}10^{-7}$
•Geng and Hsiao also have a prediction for the invariant mass distribution…

…again, we expect to see the threshold enhancement

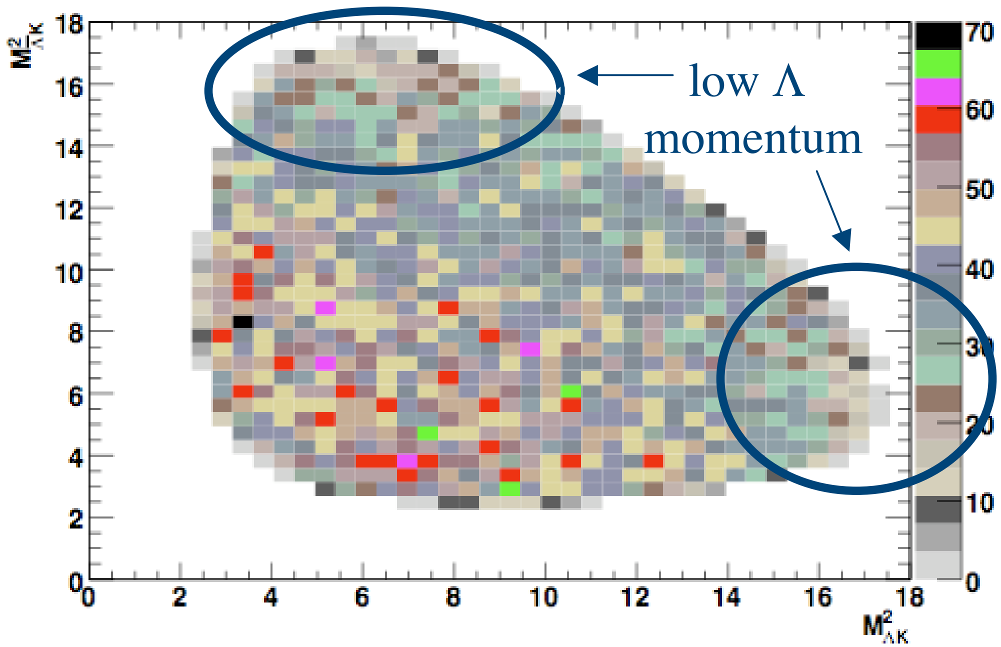


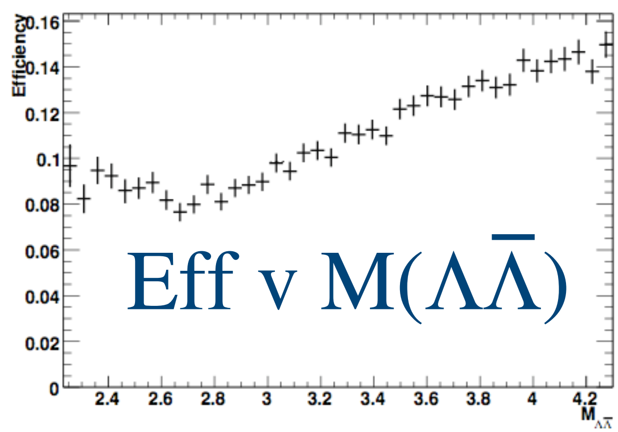
$B^+ \to \Lambda\bar{\Lambda}h^+$ Selection

- Lambdas are formed from two charged tracks with:
  - $1.1136 < M(\Lambda) < 1.1184$ GeV
  - lifetime significance (2D) > 2.5 sigma
  - NO PID requirement for the proton from the Lambda decay
- loose PID requirements on the bachelor track
- event shape variables combined into a neural network and cut on
- veto charmonium: remove $2.85 < M(\Lambda) < 3.15$ and $3.315 < M(\Lambda) < 3.735$ GeV
- $|\Delta E| < 0.1$ GeV, $m_{ES} > 5.21$ GeV (these go in the fit)
- phase space average efficiency ~11% for $\bar{\Lambda}\Lambda K$ and 10% for $\bar{\Lambda}\Lambda\pi$

$B^+ \to \Lambda\bar{\Lambda}K^+$ Efficiency

…after all cuts, this is the efficiency over the DP.





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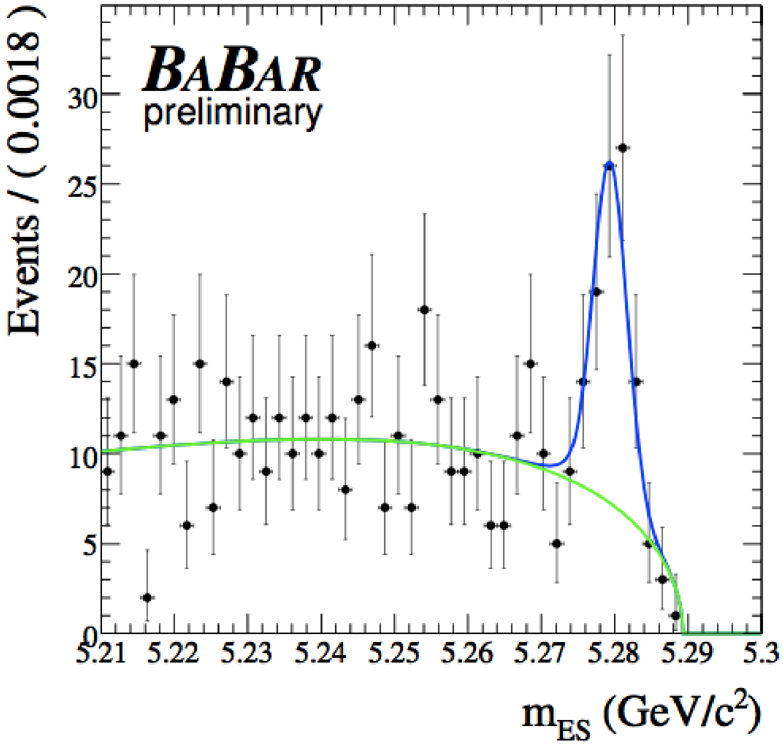
Fit Results: $B^+ \to \Lambda\bar{\Lambda}K^+$



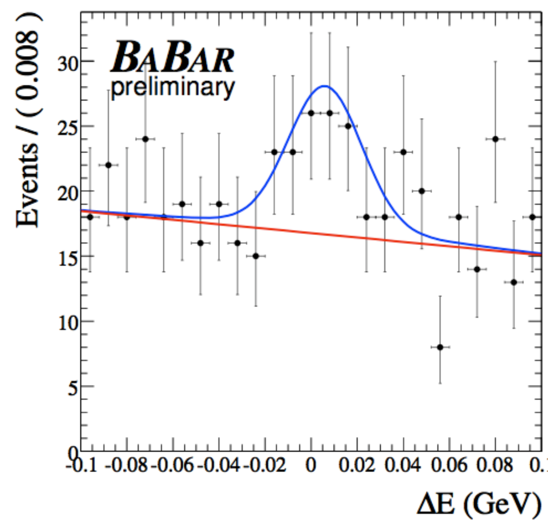
N_{sig}=62.7±9.7

$\mu(\Delta E)$=6.1±2.8 MeV

$\sigma(\Delta E)$=15.9±0.2 MeV

$\mu(m_{ES})$=5.2793±0.0004 GeV

$\sigma(m_{ES})$=2.3±0.3 MeV



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$B^+ \to \Lambda\bar{\Lambda}K^+$: BR and Systematics

Using this method, we obtain:

$$BR(B^+ \to \Lambda\bar{\Lambda}K^+) = (4.8 \pm 0.8 \pm 0.5) \times 10^{-6}$$

The primary systematic errors:

- Tracking: 5.2%
- Lambda Efficiency: 4.6%
- Efficiency Variation over DP: 4.3%
- Smaller contributions from: PID, B-counting, Λ BR
- Total Systematic Error: 8.5%

Belle: $BR(B^+ \to \Lambda\bar{\Lambda}K^+) = (2.9 \pm 0.9) \times 10^{-6}$ hep-ex/0406068

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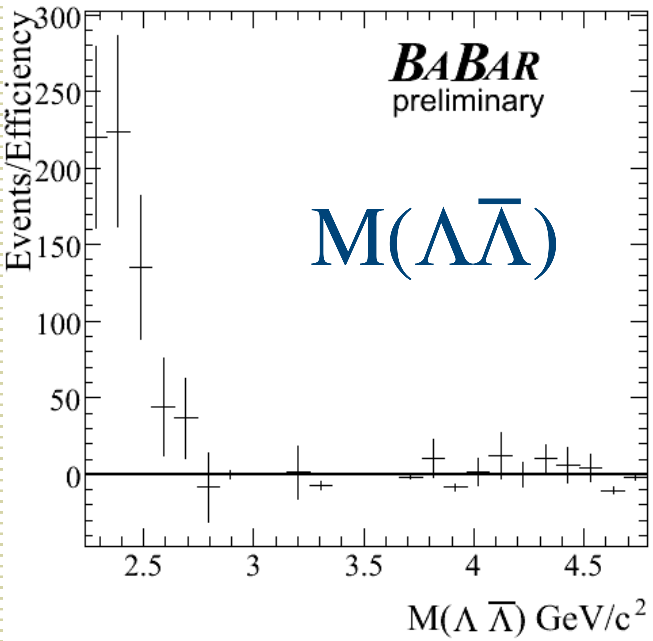
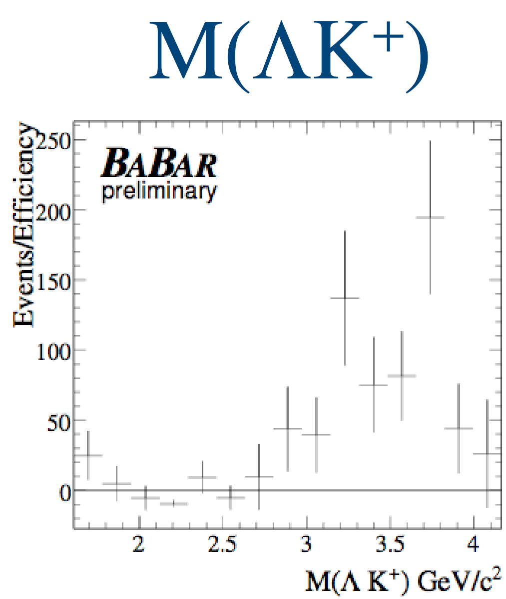
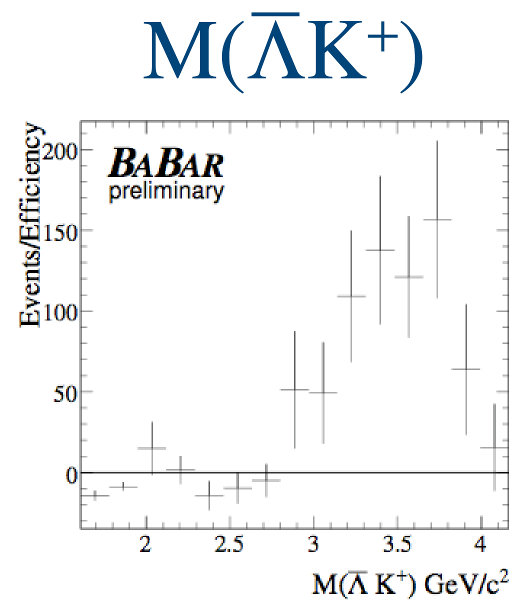
$B^+ \to \Lambda\bar{\Lambda}K^+$: Mass Projections

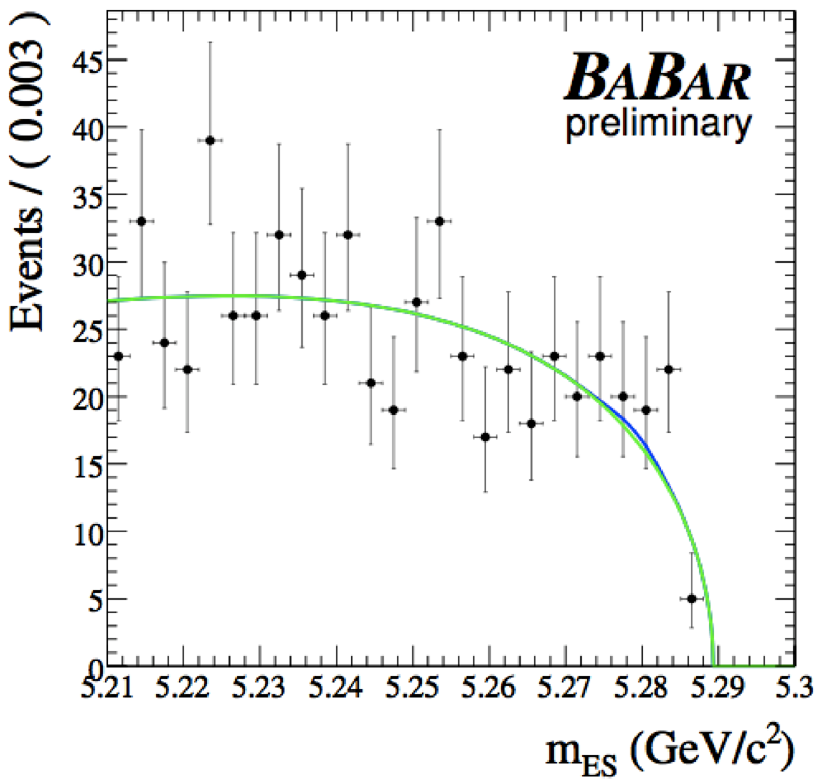


All plots are efficiency corrected





Fit Results & BR: $B^+ \to \Lambda\bar{\Lambda}\pi^+$

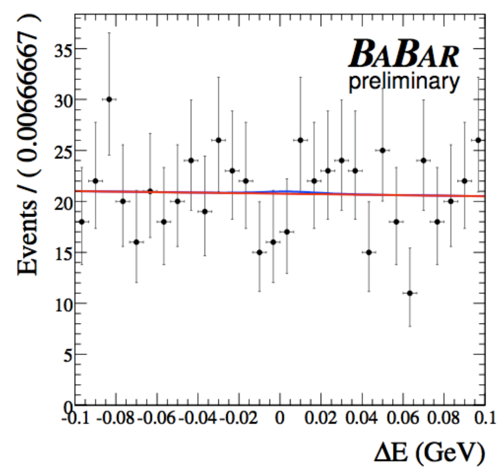


$N_{sig}=1.5^{+5.2}_{-4.7}$

<11.5 @ 90%

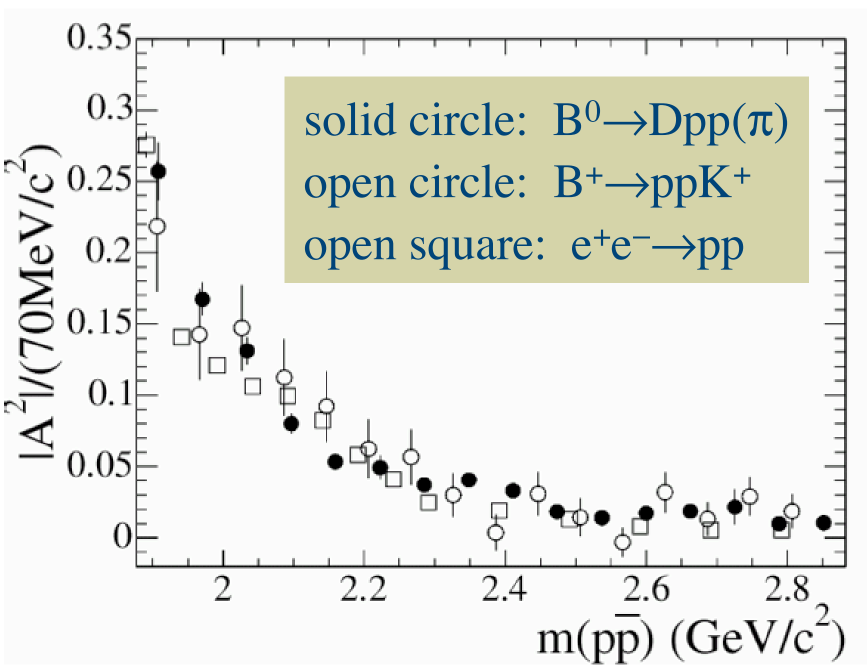
$BR(B^+ \to \Lambda\bar{\Lambda}\pi^+) < 1.3\times10^{-6}$

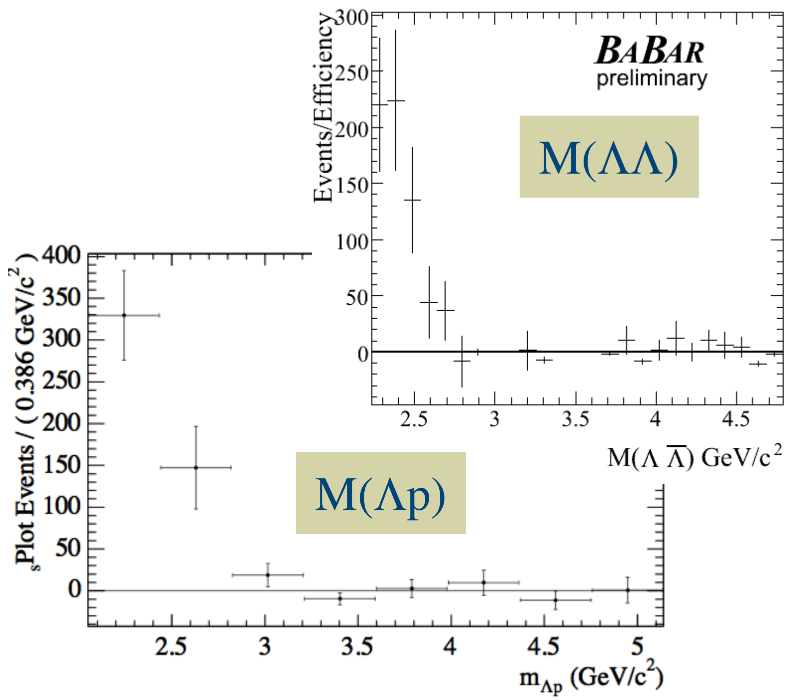
Including systematics..assumes $\Lambda\bar{\Lambda}$ distribution same as $\Lambda\bar{\Lambda}K$



Baryonic B Decays: Threshold Enhancements

- In all modes we've studied, we see a large enhancement at the di-baryon threshold





Summary and Conclusions

- We have measured the rates:

  $BR(B^0 \rightarrow \Lambda p \pi^+) = (3.3 \pm 0.5 \pm 0.3) \times 10^{-6}$

  $BR(B^+ \rightarrow p p K^+) = (6.7 \pm 0.5 \pm 0.4) \times 10^{-6}$

  $BR(B^+ \rightarrow \Lambda \Lambda K^+) = (4.8 \pm 0.8 \pm 0.5) \times 10^{-6}$

  $BR(B^+ \rightarrow \Lambda \Lambda \pi^+) < 1.3 \times 10^{-6}$

- We see clear peaking at the baryonic-antibaryon threshold in all modes
  - the pp enhancement is seen in other processes as well
- It will be interesting with more statistics to study these modes further:
  - direct and TD-CPV measurements of all modes
  - triple product measurements of the modes with Lambdas