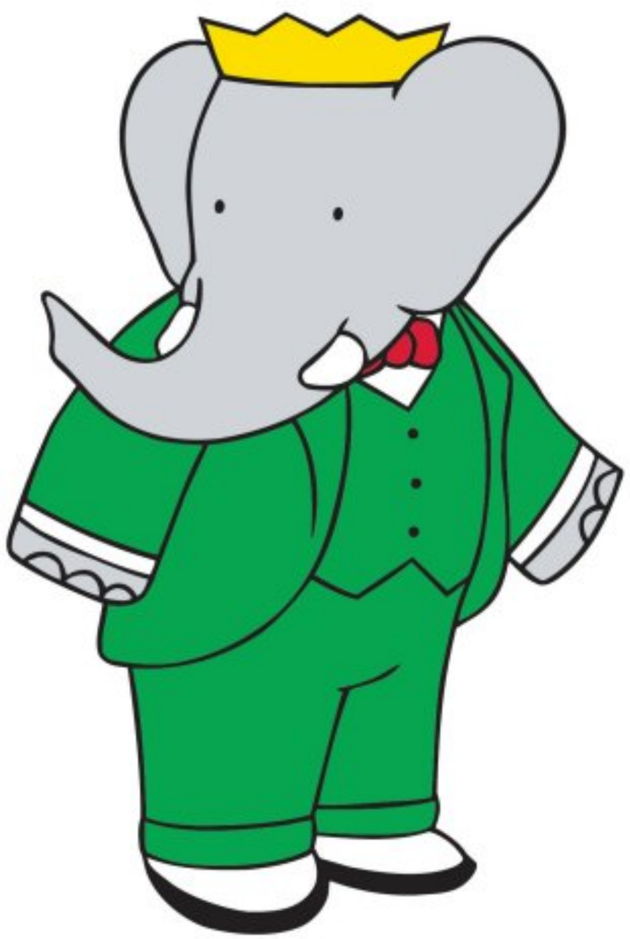
Search for the rare $B^- \to \Lambda\bar{p}\nu\bar{\nu}$ decay at the BABAR experiment



Robert Seddon
McGill University

Canadian Association of Physicists Congress
Sudbury, 16 June 2014

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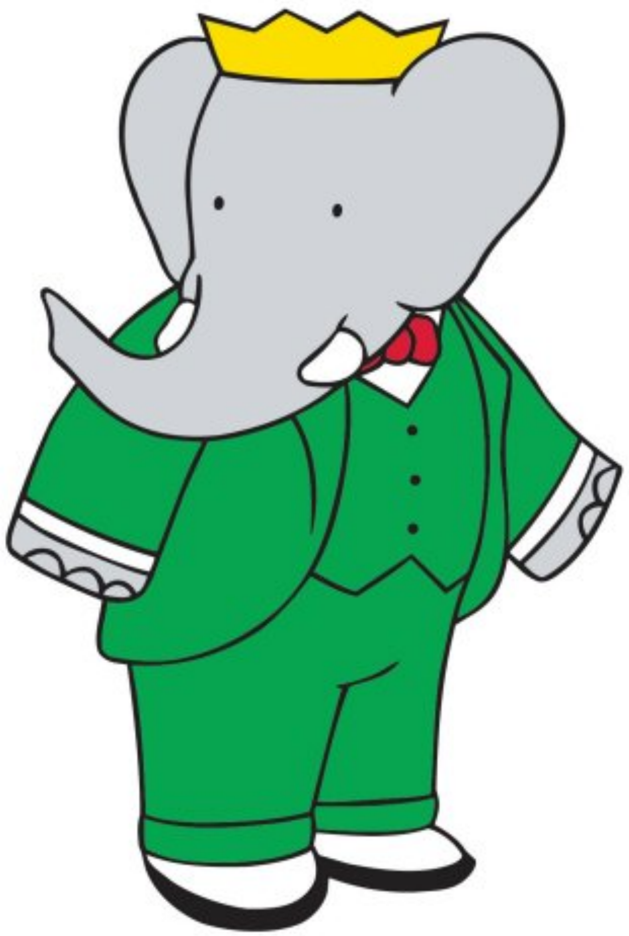
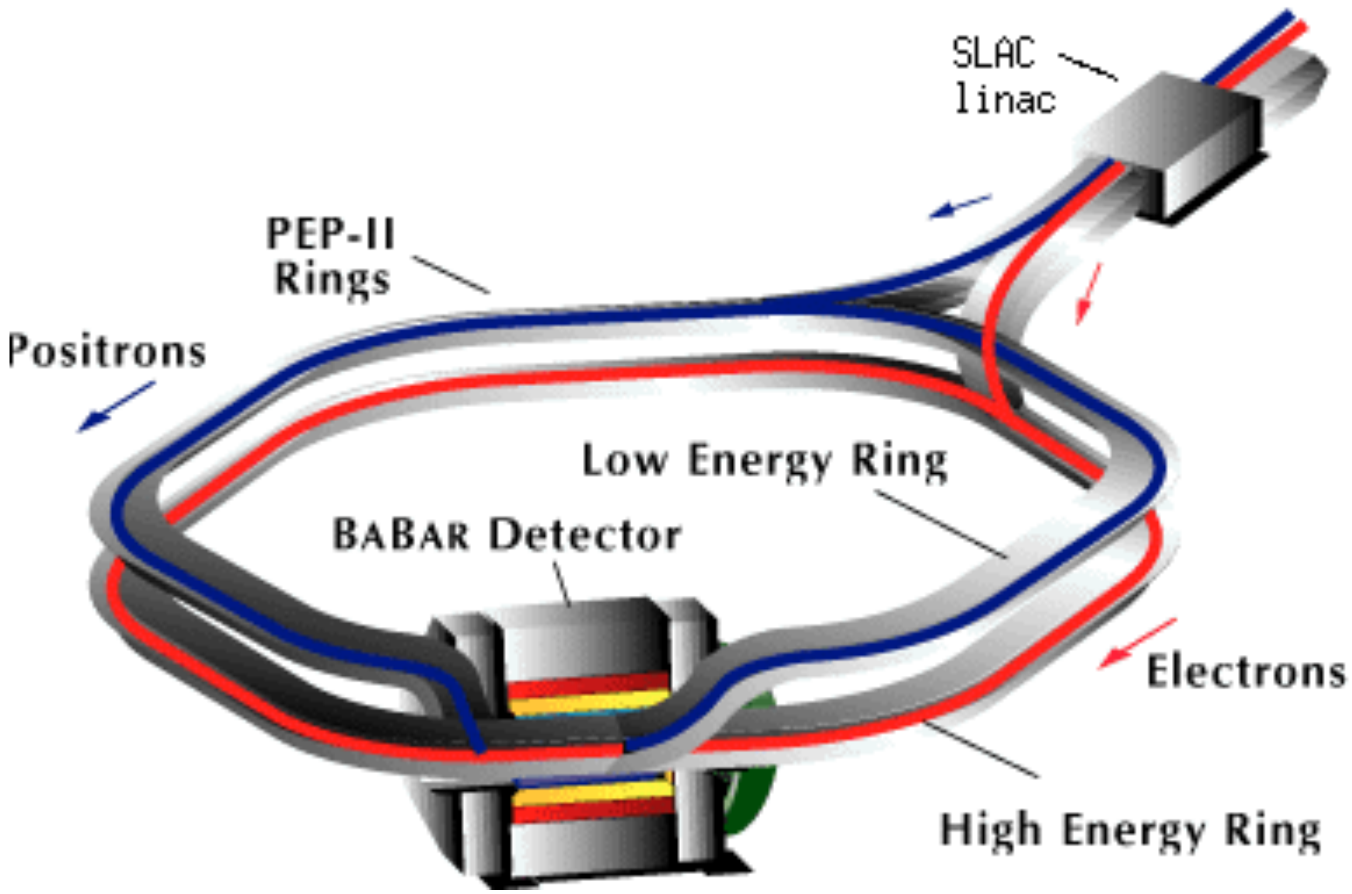


Outline

- The BaBar experiment
- $B^- \to \Lambda\bar{p}\nu\bar{\nu}$ - theory and motivation
- Analysis method - hadronic tag reconstruction
- Analysis method - signal selection
- Preliminary results
- Conclusion and next steps

The BABAR experiment - PEP-II collider

PEP-II: Located at the SLAC National Accelerator Laboratory, California. Provides electrons and positrons for collision inside BABAR detector.



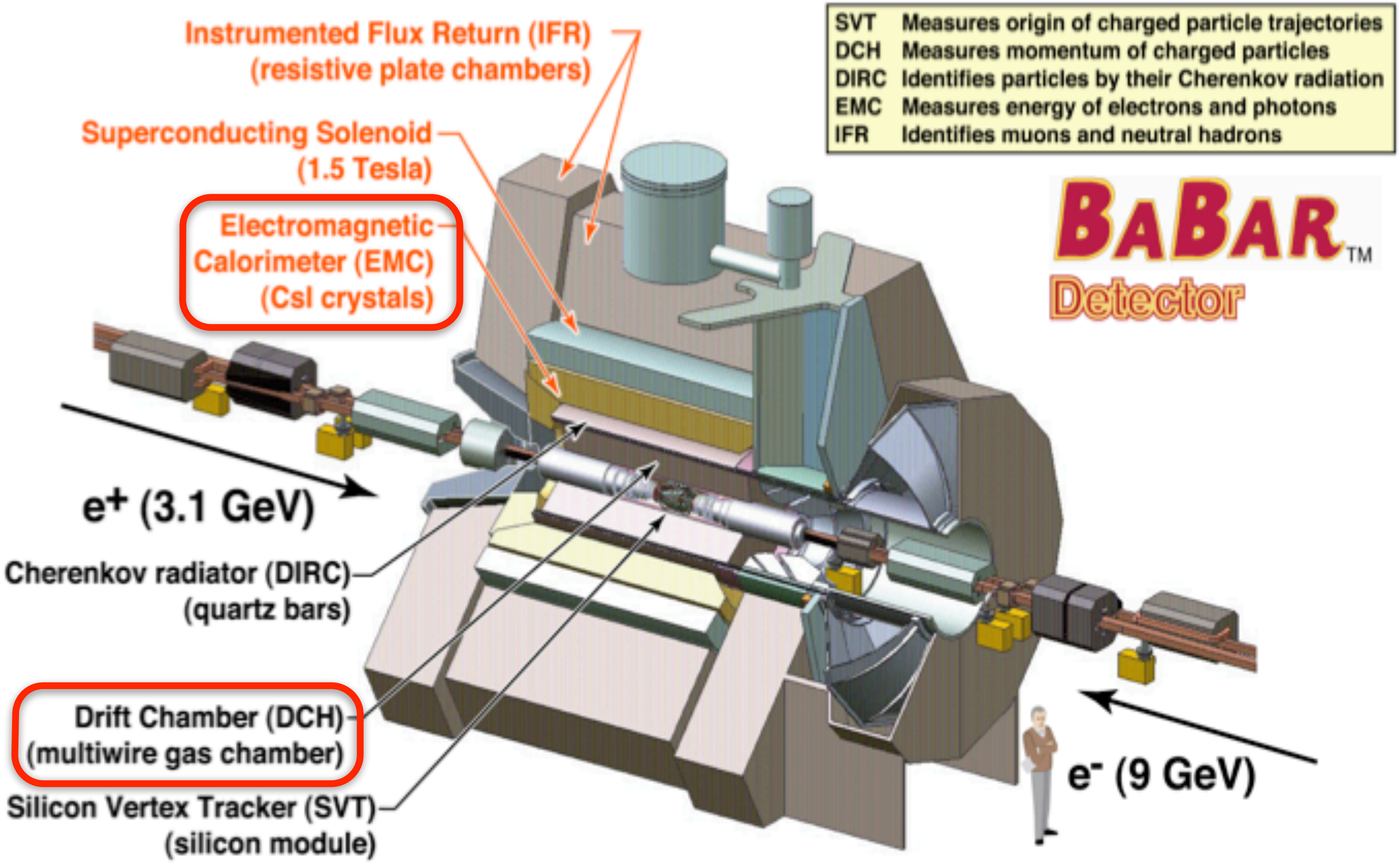
•High energy ring - 9.0 GeV electrons
•Low energy ring - 3.1 GeV positrons

•Collide at CoM energy 10.58 GeV - mass of the Υ(4S) resonance ($b\bar{b}$ quark-antiquark pair)

•Υ(4S) decays 96% to $B\bar{B}$ (B^+B^- or $B^0\bar{B}^0$) - "B factory".

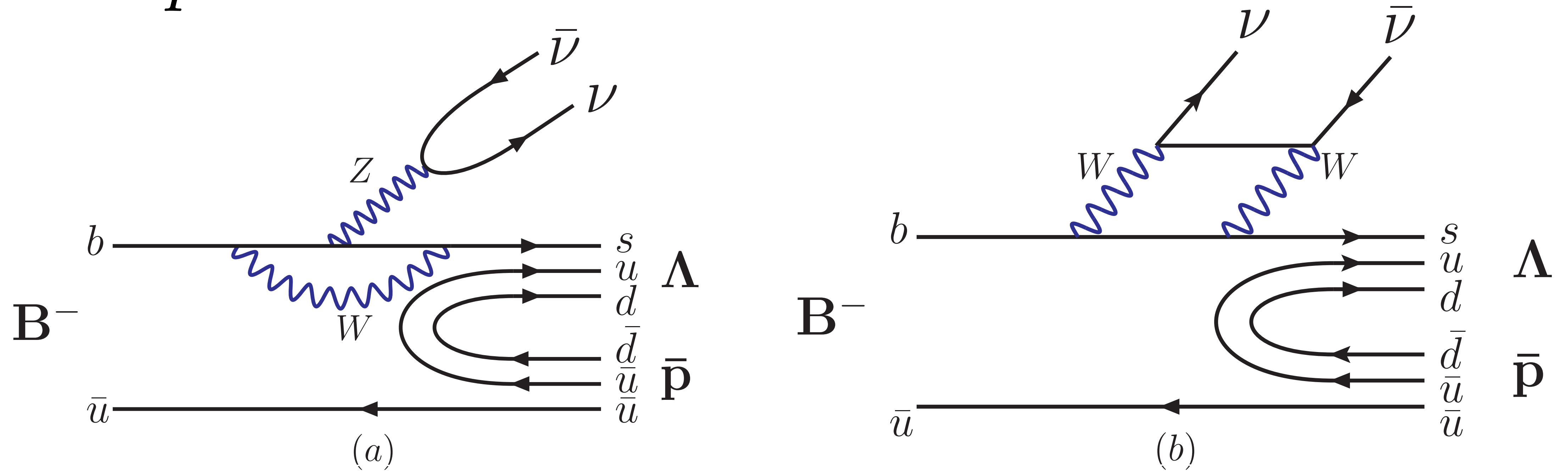
•BABAR collected data from 1999 to 2008
•Produced 471 million $B\bar{B}$ pairs
•429 fb^{-1} integrated luminosity at Υ(4S) resonance

The BABAR experiment - detector



Canadian groups: U. Victoria, UBC, U. de Montréal, McGill U.

$B^- \to \Lambda\bar{p}\nu\bar{\nu}$ - details and motivation



C.Q. Geng, Y.K. Hsiao.
Phys. Rev. D 85 (2012) 094019

Predict $\mathcal{B}(B^- \to \Lambda\bar{p}\nu\bar{\nu})$ = (7.9 ± 1.9) x 10^{-7}

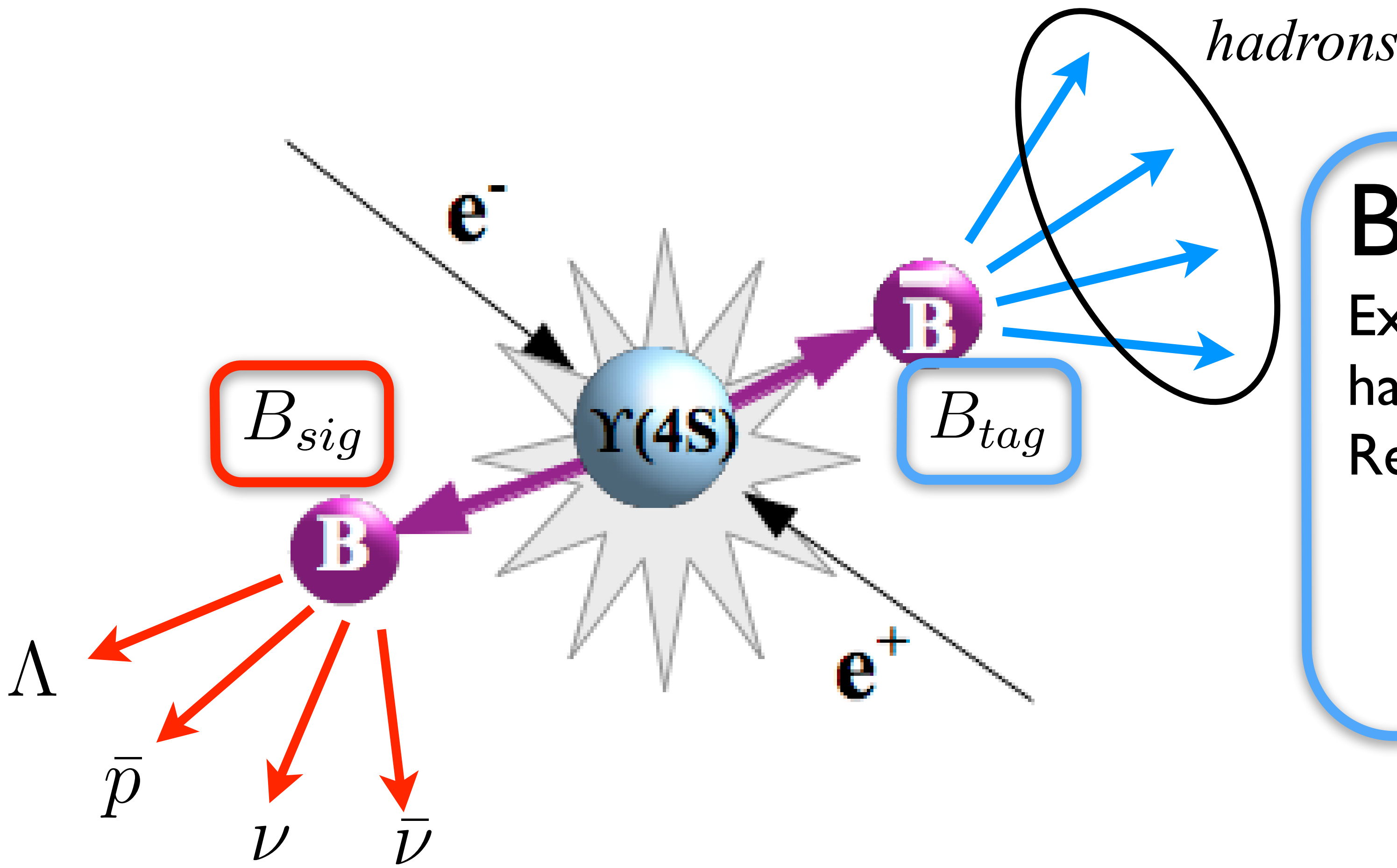
- Rare decay (suppressed by the standard model)
- New physics potentially hiding in loops - will affect branching fraction
- Amenable to further study: angular asymmetries, T-odd observables *etc.*

$B^- \to K^-\nu\bar{\nu}$

Measured: <3.7 x 10^{-5}
Predicted: (4.5 ± 0.7) x 10^{-6}
Phys. Rev. D 87 (2013) 112005

$$B^- \to \Lambda\bar{p}\nu\bar{\nu}$$
$$\Lambda \to p\pi^-$$ (63.9 ± 0.5)%

Analysis method - hadronic B_{tag} reconstruction



B_{tag}

Exclusively reconstruct from known hadronic decays.

Require:

- one B_{tag}
- mass consistent with B meson
- charge is opposite that of B_{sig} daughters

B_{sig}

Everything else in the event, including missing energy, that isn't assigned to the B_{tag} is assumed to come from the B_{sig}

<u>Advantages:</u>

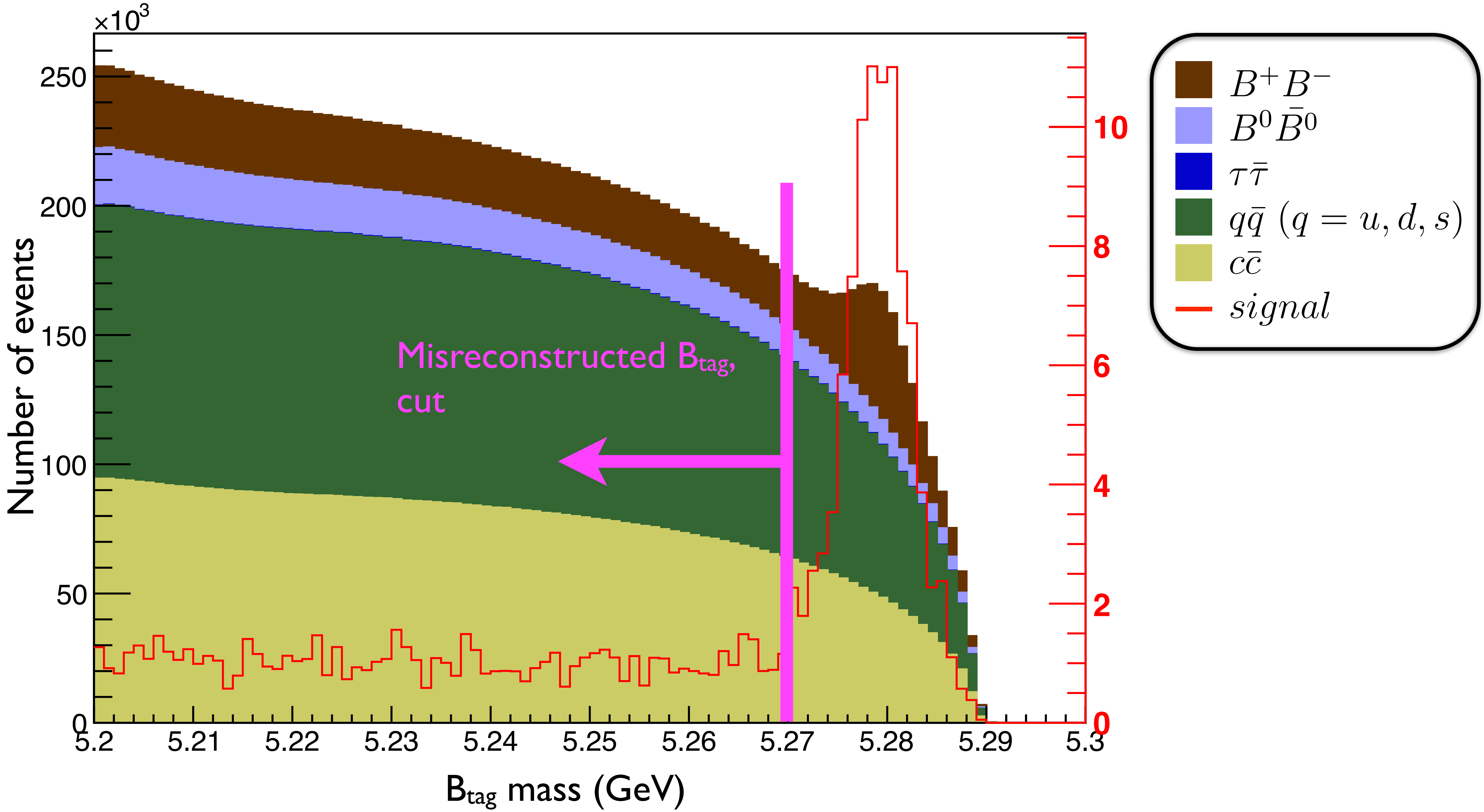
- Completely separates B_{tag} from B_{sig}
- Fully determines kinematics of B_{sig}
- Missing energy and all other particles assigned to B_{sig}
- Eliminates background

<u>Disadvantages:</u>

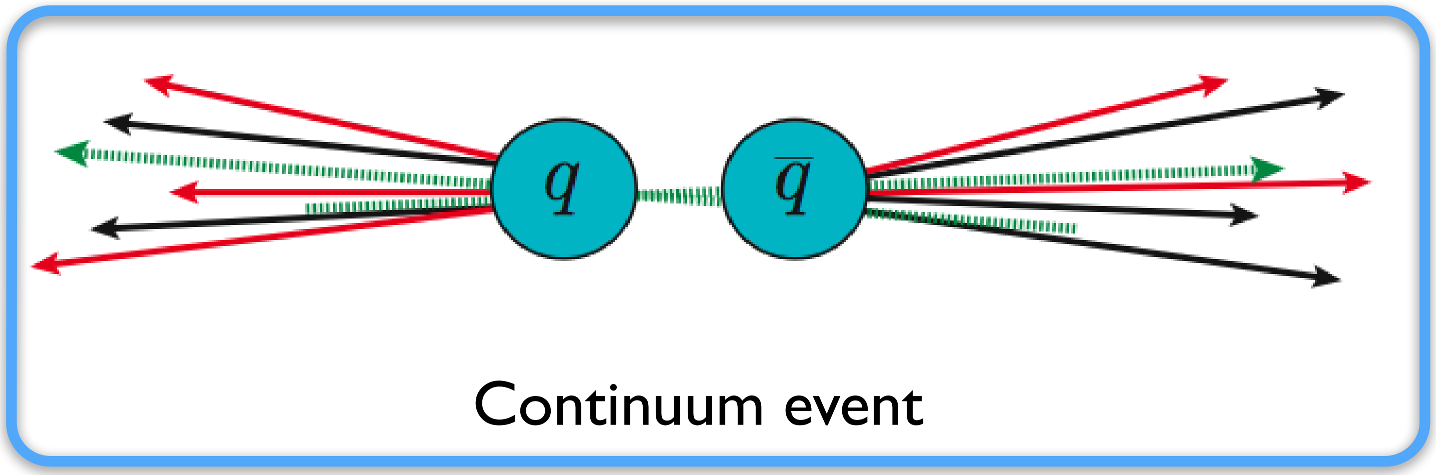
- Low efficiency

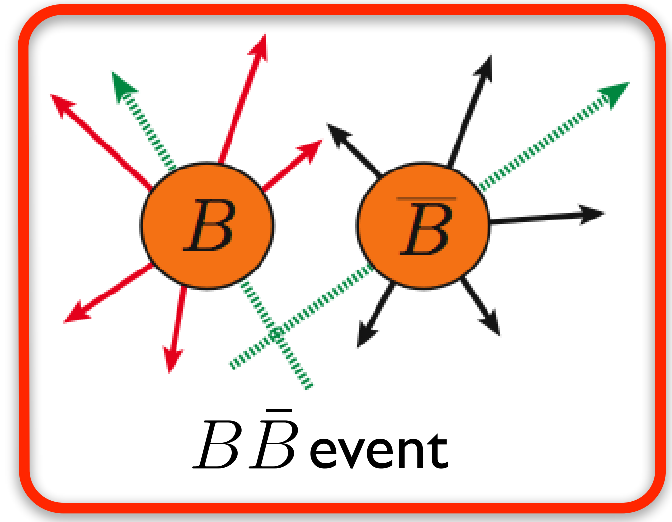
Analysis method - Monte Carlo simulation

- Use Monte Carlo data and detector simulation to perform analysis.
- Signal Monte Carlo weighted to match theoretically-predicted phase space constraints.

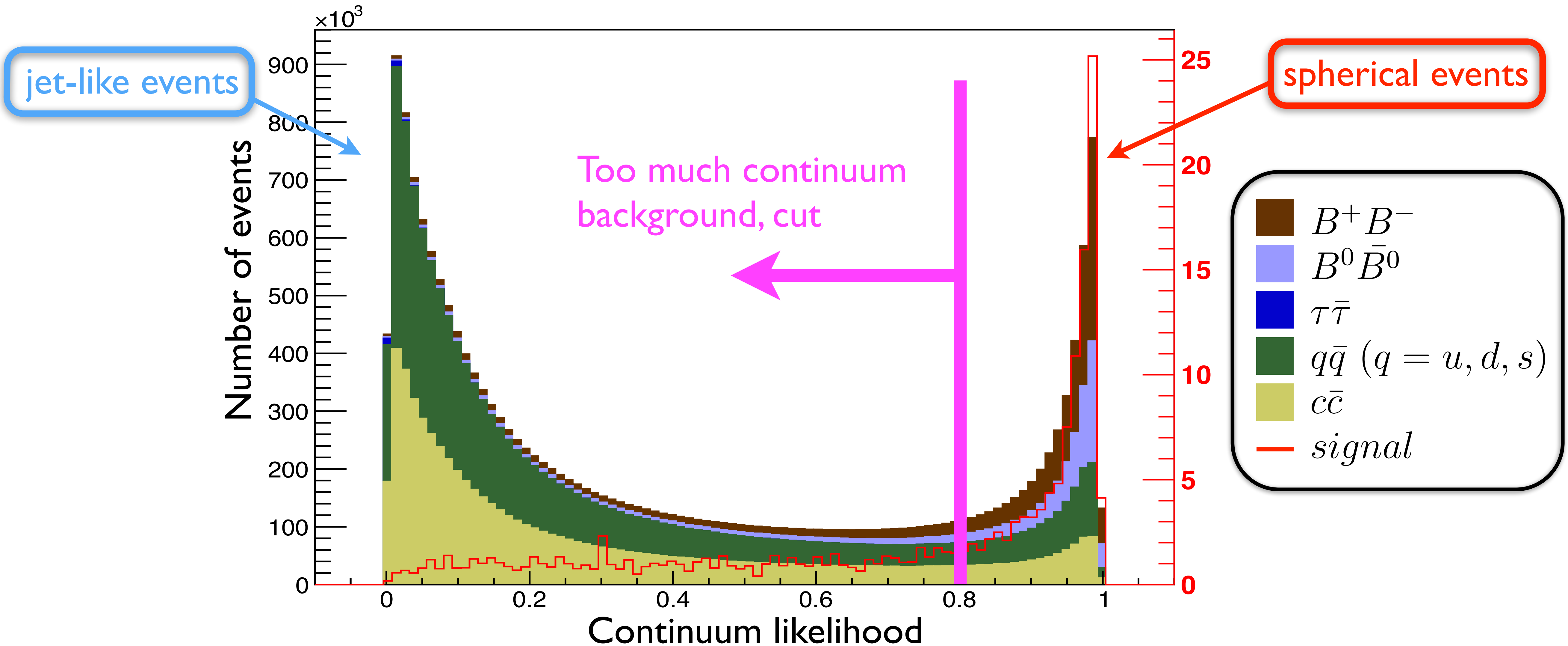


Analysis method - continuum suppression





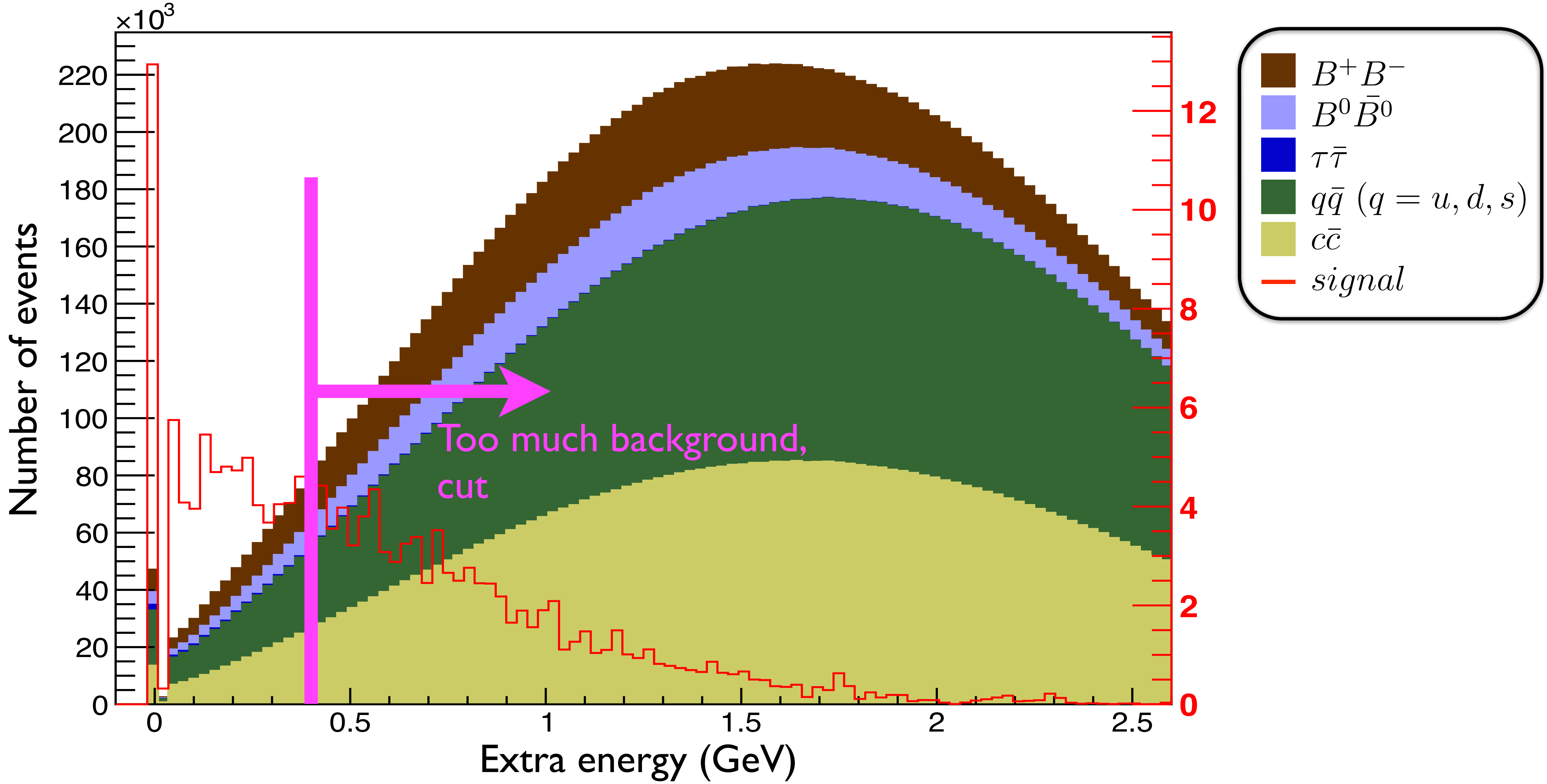
Use a multivariate likelihood to measure the shape of the event:



Analysis method - extra energy

Extra energy - in theory represents energy deposits from neutral particles, in reality can be:

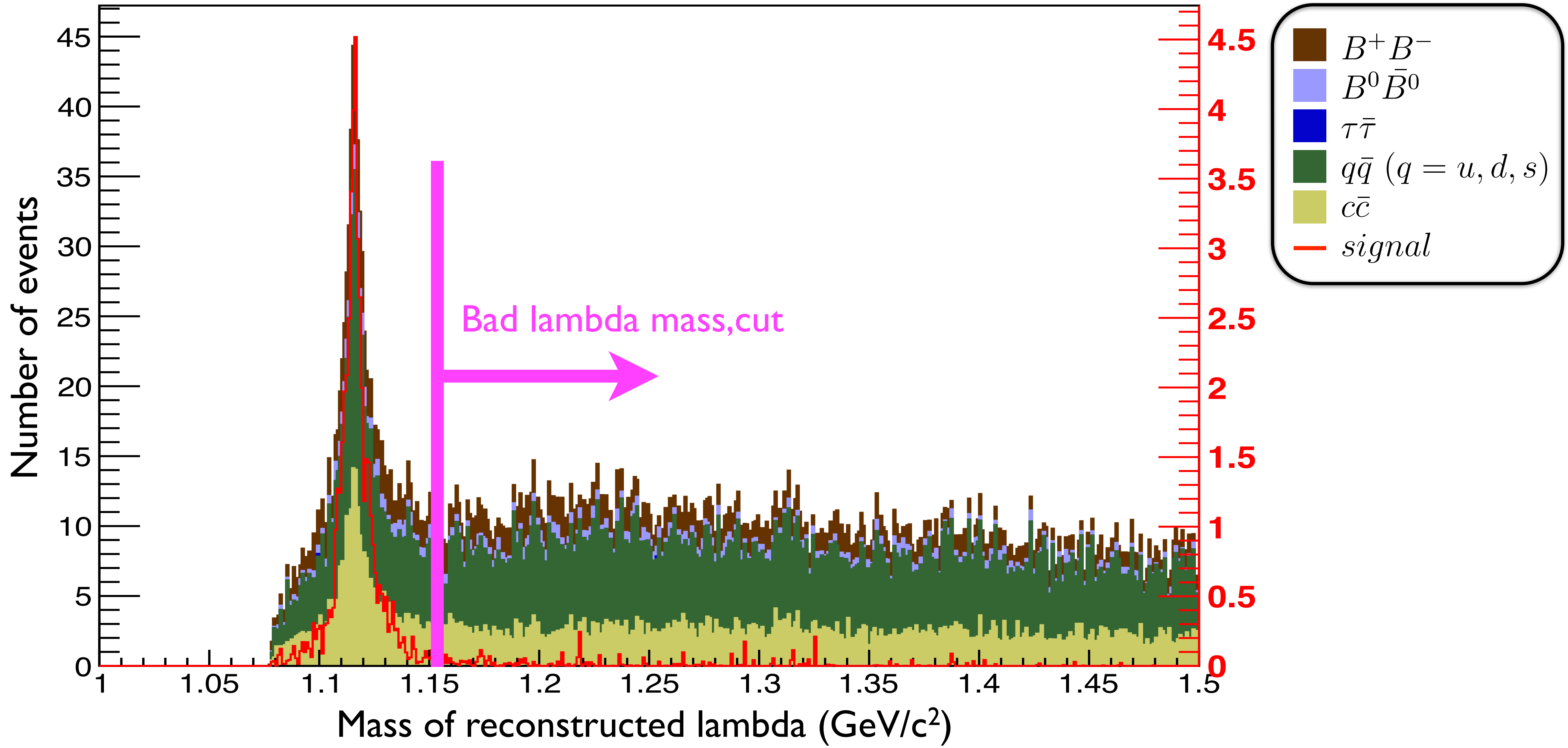
- showers from decay products
- misassignment of B-meson daughters
- real neutral particles



Analysis method - PID, lambda reconstruction

$$B^- \to \Lambda \bar{p} \nu \bar{\nu}$$
$$\hookrightarrow p\pi^-$$

Useful constraints in this decay:
- Require three charged tracks
- Identify (anti)protons, remaining charged track must be the pion
- Require good lambda mass from proton and pion (m_Λ = 1.116GeV)



Analysis method - distance of closest approach

DOCA = extrapolated distance of closest approach to interaction point.

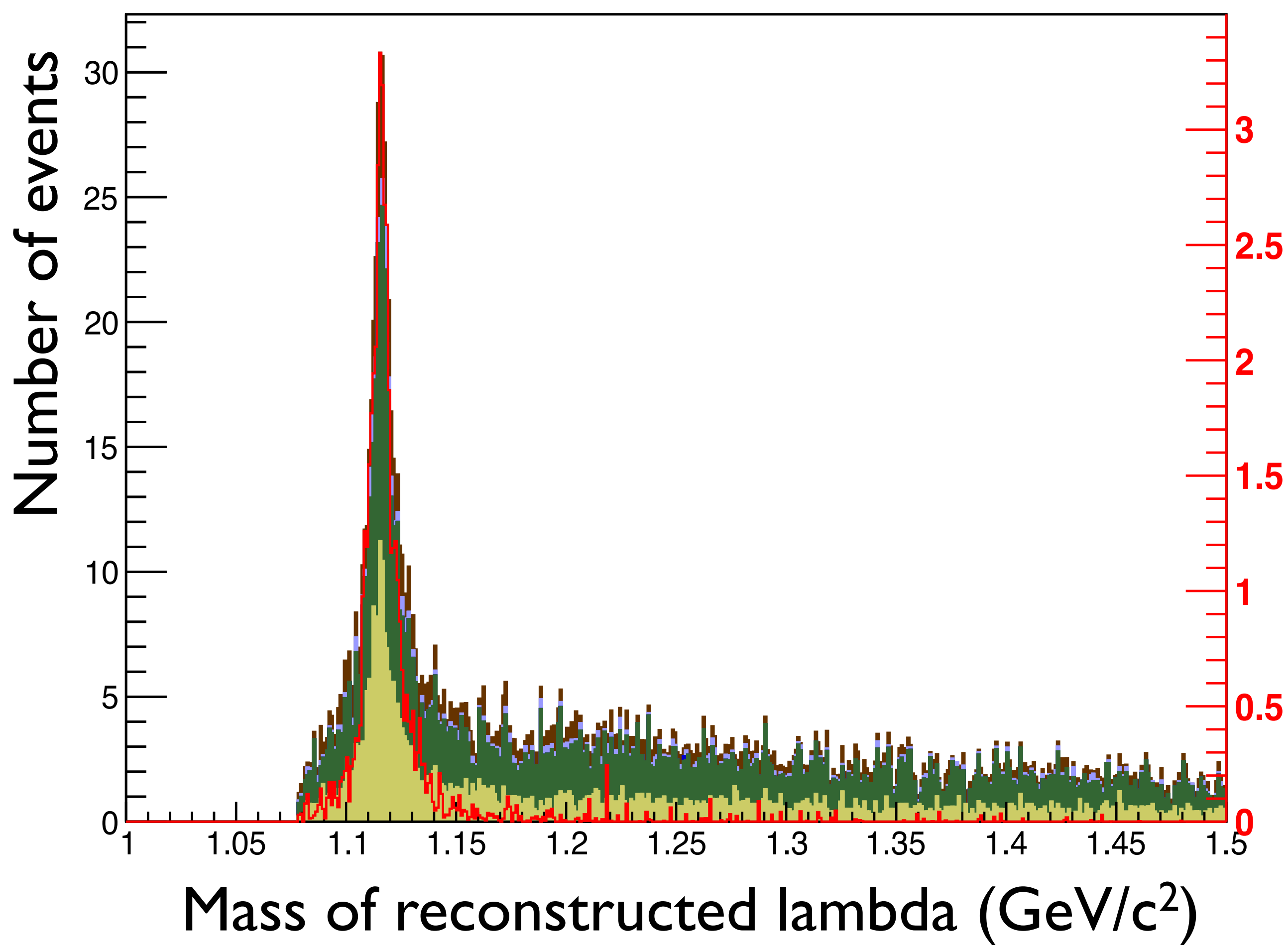
$$B^- \to \Lambda \bar{p} \nu \bar{\nu}$$
$$\Lambda \hookrightarrow p\pi^-$$

Expect:

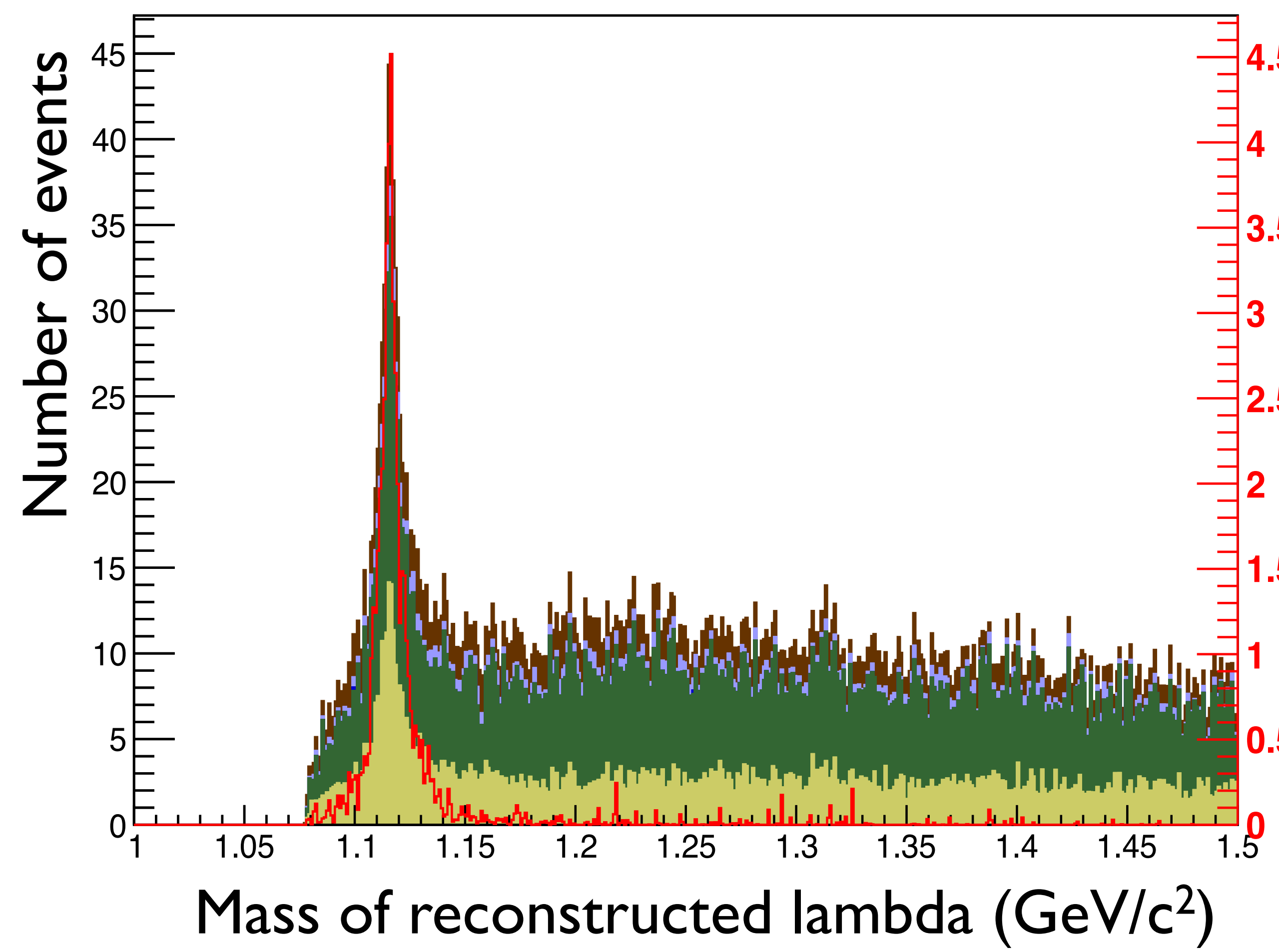
Lowest DOCA - proton from B
Middle DOCA - proton from lambda
Highest DOCA - pion

- B^+B^-
- $B^0\bar{B}^0$
- $\tau\bar{\tau}$
- $q\bar{q}\ (q = u, d, s)$
- $c\bar{c}$
- $signal$

With DOCA cut - 81% real lambdas



Without DOCA cut - 67% real lambdas



Signal selection - preliminary results

B_{tag} side cuts:

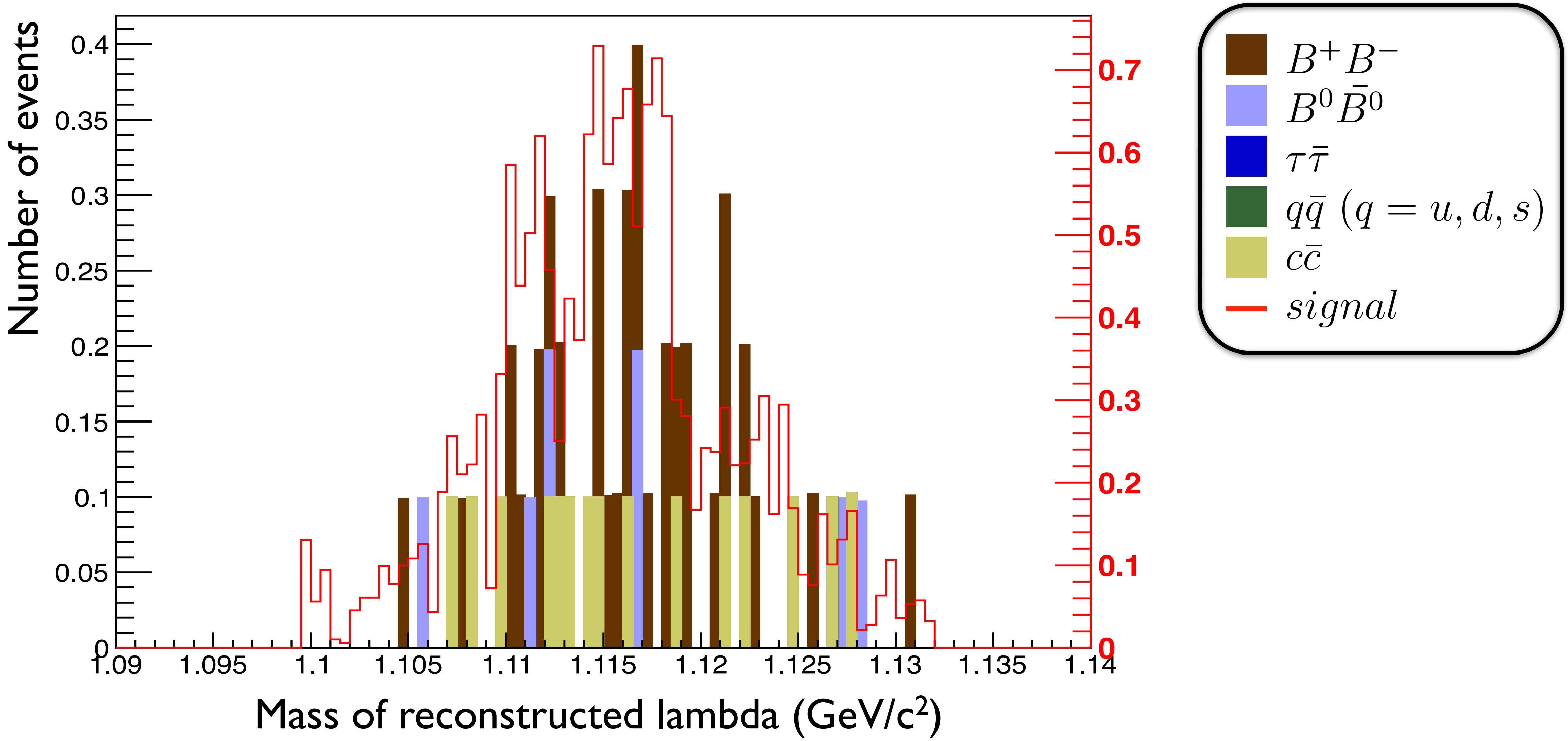
One B_{tag}
Correct charge
Reconstructed B mass
Continuum likelihood

B_{sig} side cuts:

Extra energy
Three charged tracks
Particle ID
Reconstructed lambda mass
Distance of closest approach
etc…

~7 background events
~0.04% signal efficiency

Expect branching fraction upper limit on the order of $<10^{-5}$.



Conclusion

•Searching for new physics in form of $B^- \to \Lambda\bar{p}\nu\bar{\nu}$ decay - never been experimentally measured before

•Rare decay - good probe to test for new physics

Next steps

•Finalise optimisation of signal selection cuts

•Quantify systematic errors

•Unblind data

•Measure branching fraction limit

•Publish