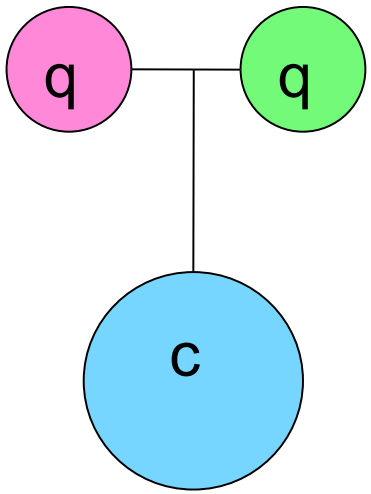
Charm baryon spectroscopy at collider experiments

2014 Aug. 8th Workshop at J-PARC

Kenkichi Miyabayashi

(Nara Women's University)

Introduction : charm baryon



- Thought to be a good place to check if “di-quark” is behaving as a good degree of freedom to form hadrons.
- One of the constituent quark is heavy, correlation between the remained light quarks would become clear.

In collider experiments

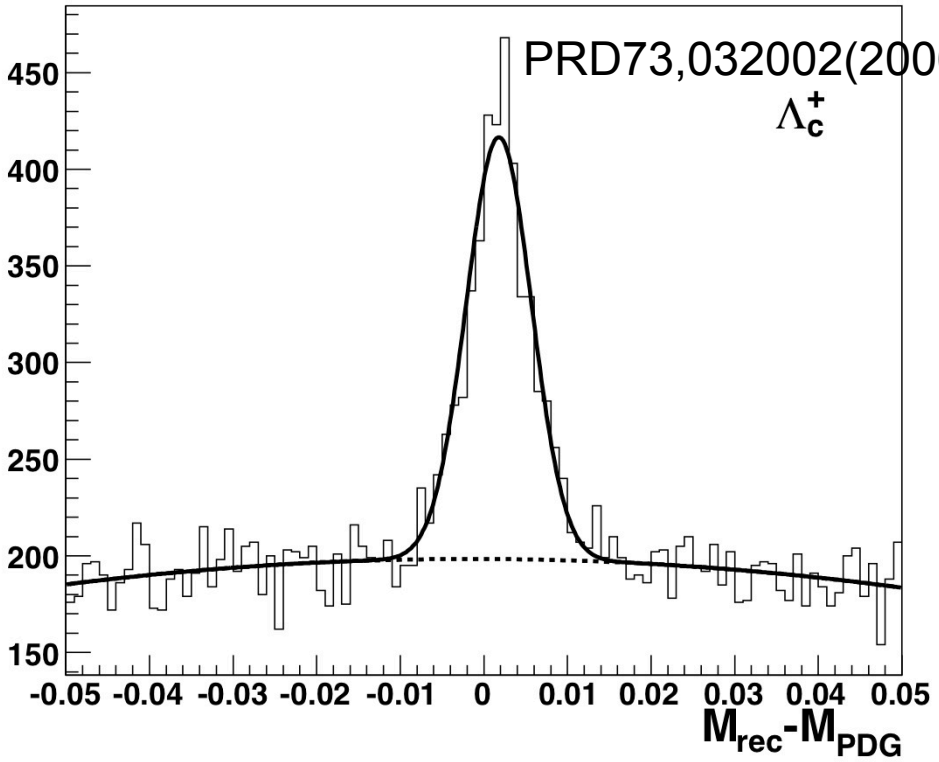
Basically, exclusive reconstruction.

1. Reconstruct grand state charm baryon (typical example is Λ_c) or strange baryon caused by charm weak decay.
2. Add $\pi^{\pm}$, $\pi^+\pi^-$, $K^-\pi^+$, … to see the invariant mass spectrum.

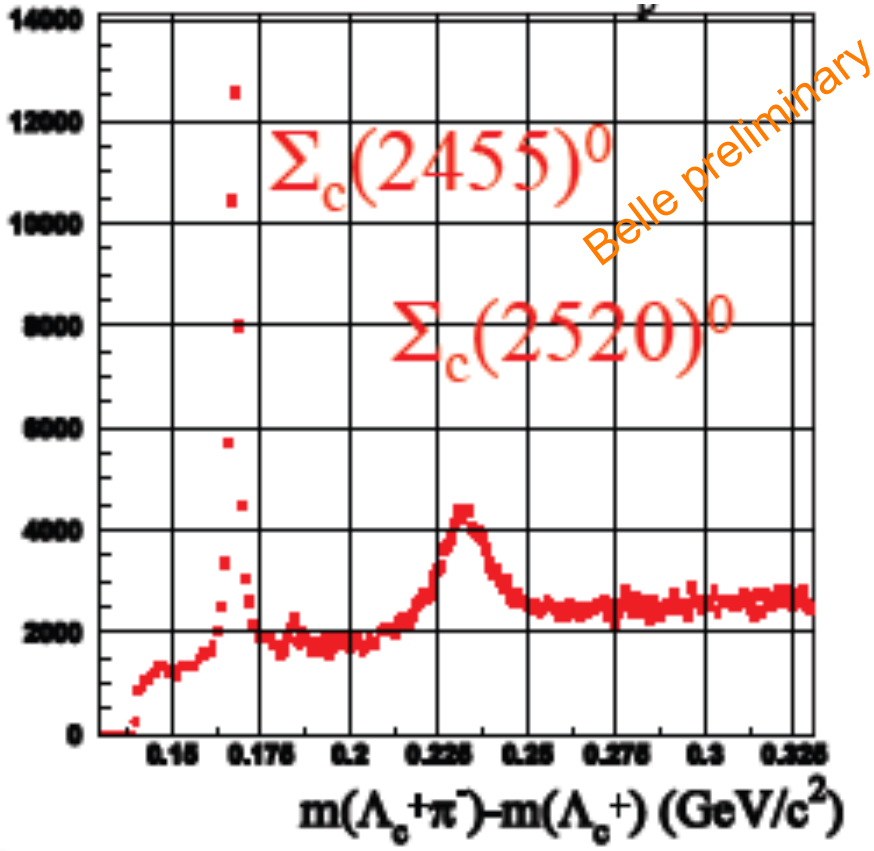
Specifying proper final state (decay mode) is essential to go this way.

Reconstructed states with Λ_c

$\Lambda_c \rightarrow pK^-\pi^+$

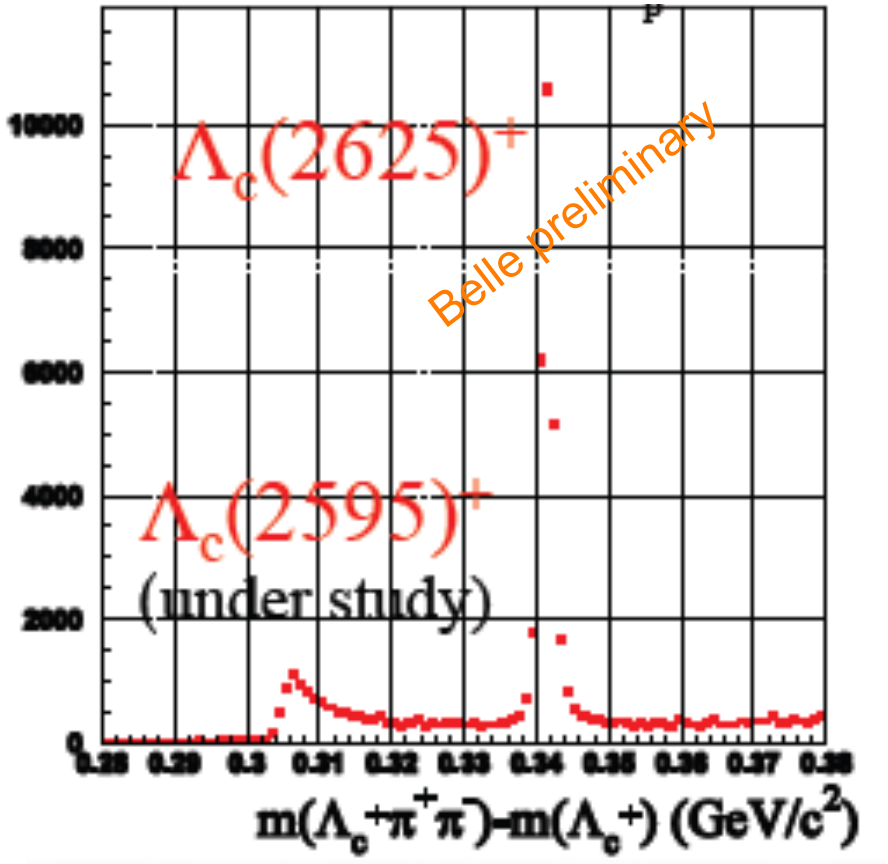


$\Sigma_c \rightarrow \Lambda_c^+\pi^-$ observed

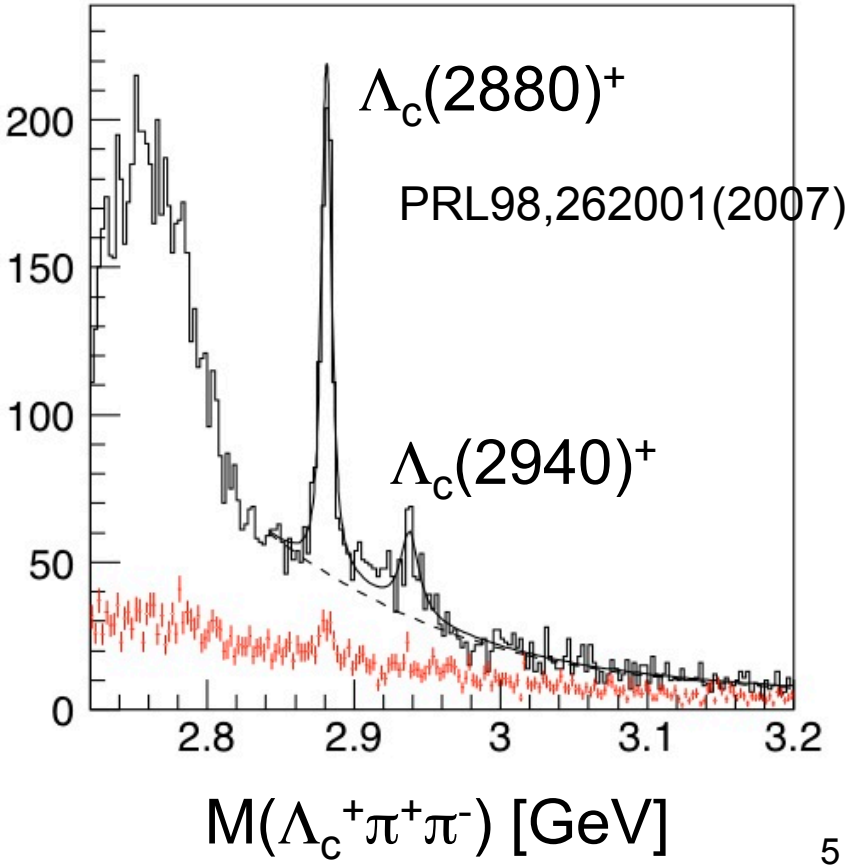


Reconstructed states with Λ_c(cont.)

Higher Λ_c in $\Lambda_c^-\pi^+\pi^-$

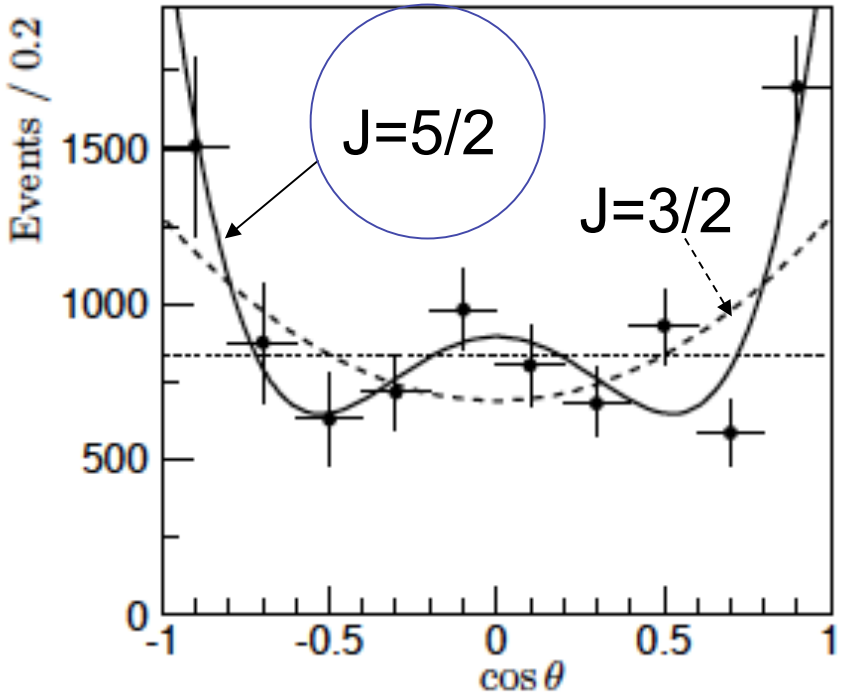


Select $\Sigma_c(2445)\,\pi$ to see $\Lambda_c^+\pi^+\pi^-$



Quantum number of $\Lambda_c(2880)^+$

PRL 98, 262001 (2007)

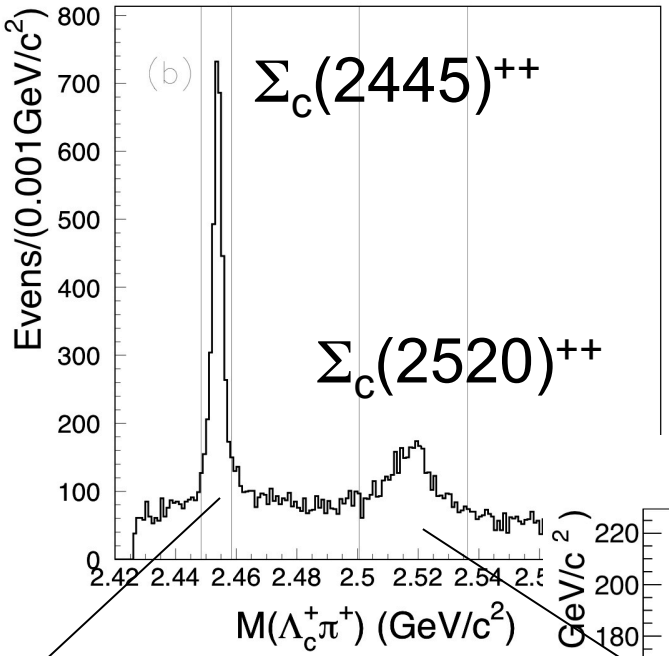


pion angular distribution

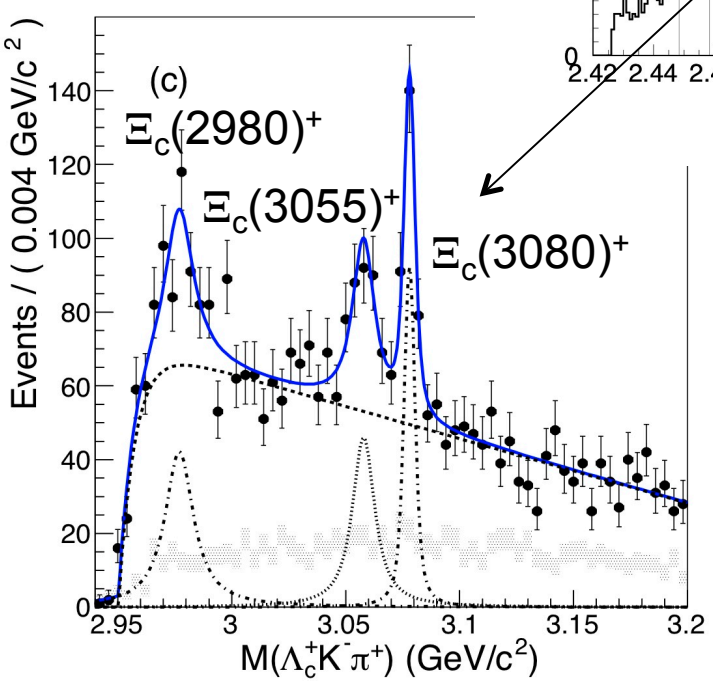
$$R \equiv \frac{\Gamma(\Sigma_c(2520)\pi)}{\Gamma(\Sigma_c(2455)\pi)}$$ is small, 0.225±0.062±0.025 → P-even.

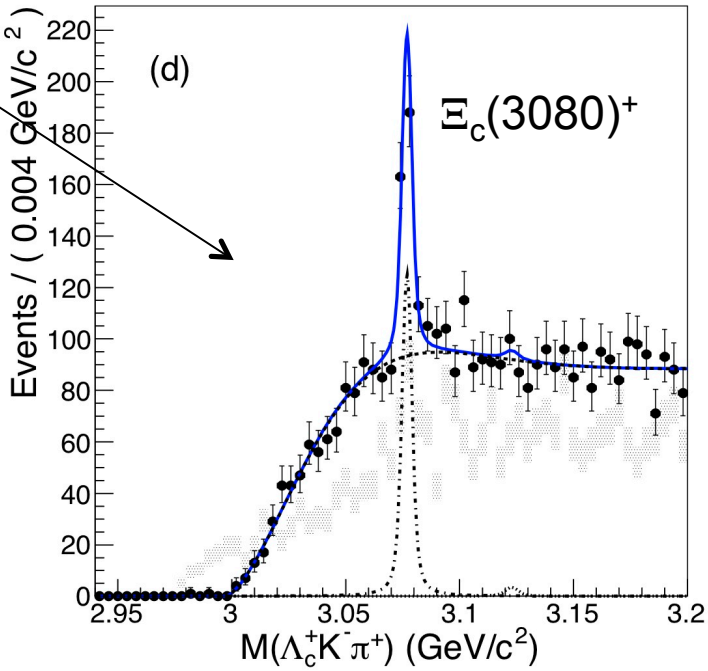
Reconstructed states with Λ_c(cont.[2])

PRD89,052003(2014)

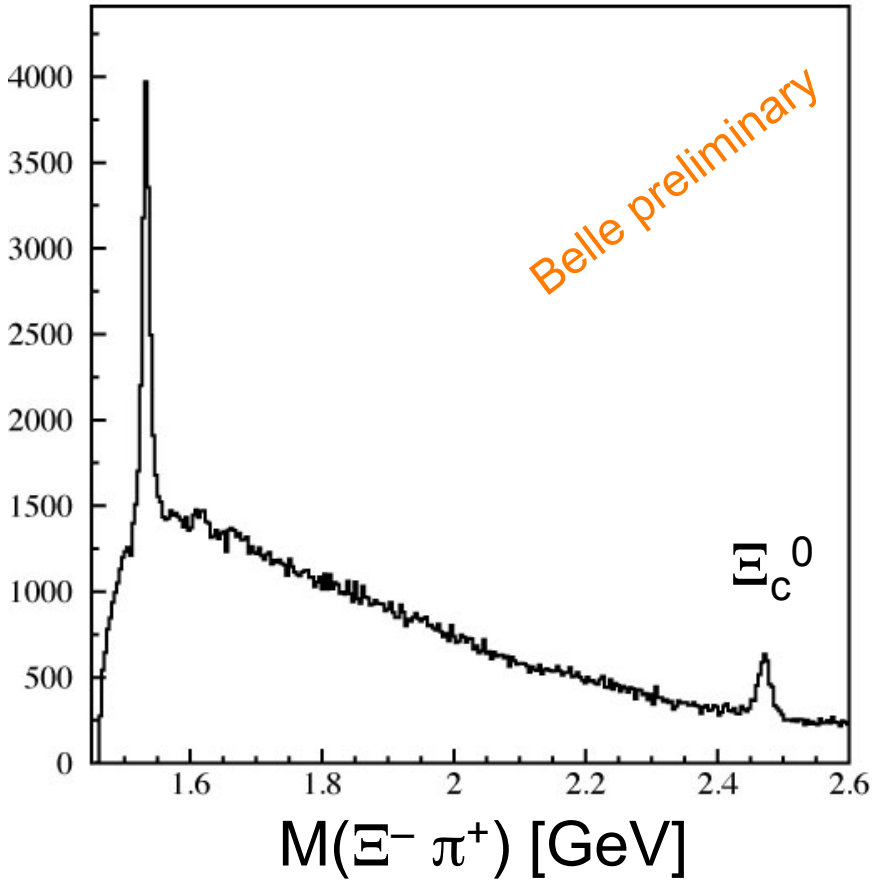


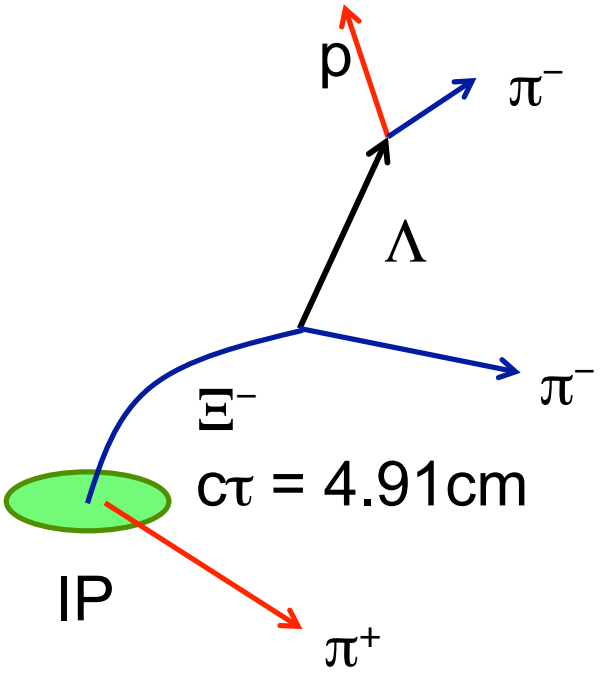
$\Lambda_c^+K^-\pi^+$ final state has been visited.





Reconstructed states with Ξ_c^0

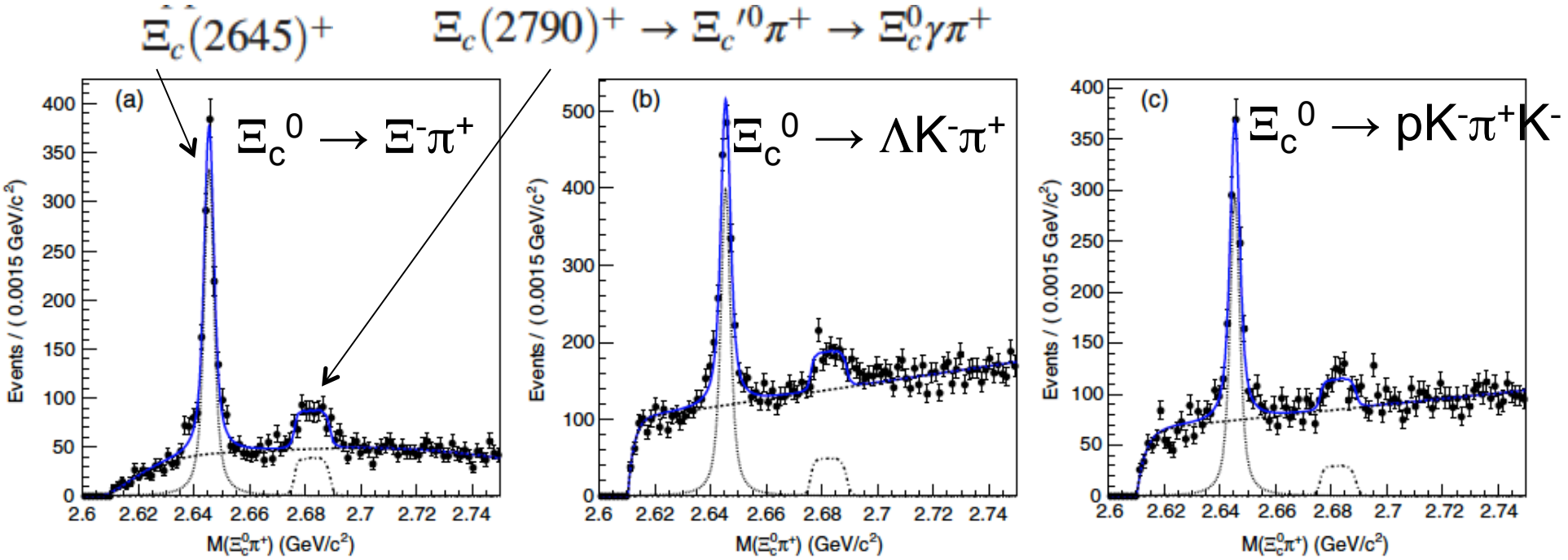




Ξ_c^0 is reconstructed in $pK^-\pi^+K^-$ and $\Lambda K^-\pi^+$ as well.

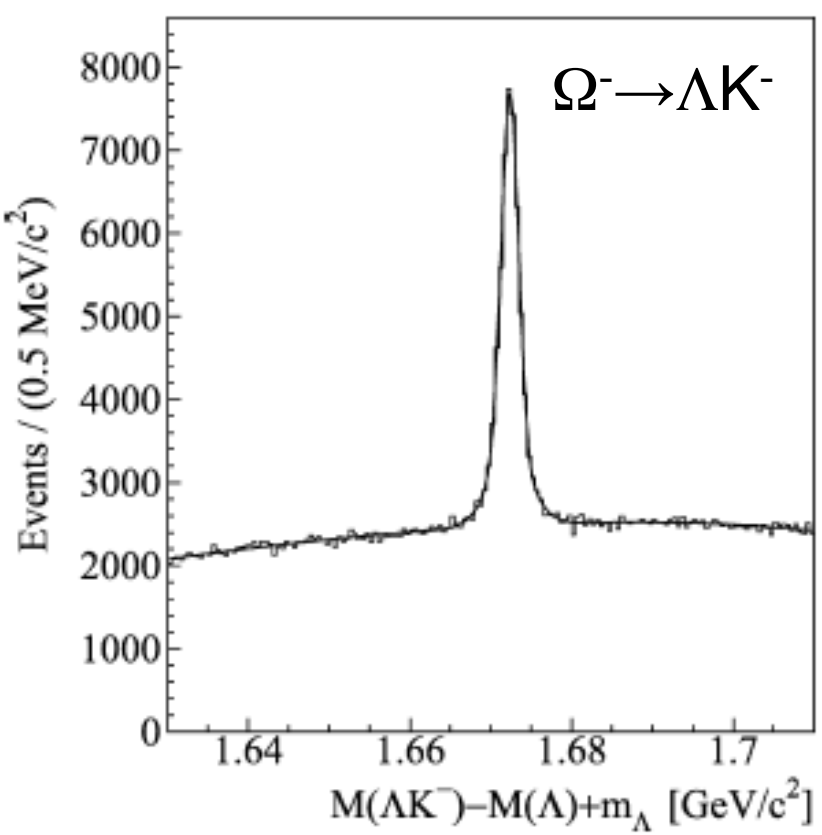
Reconstructed states with Ξ_c^0(cont.)

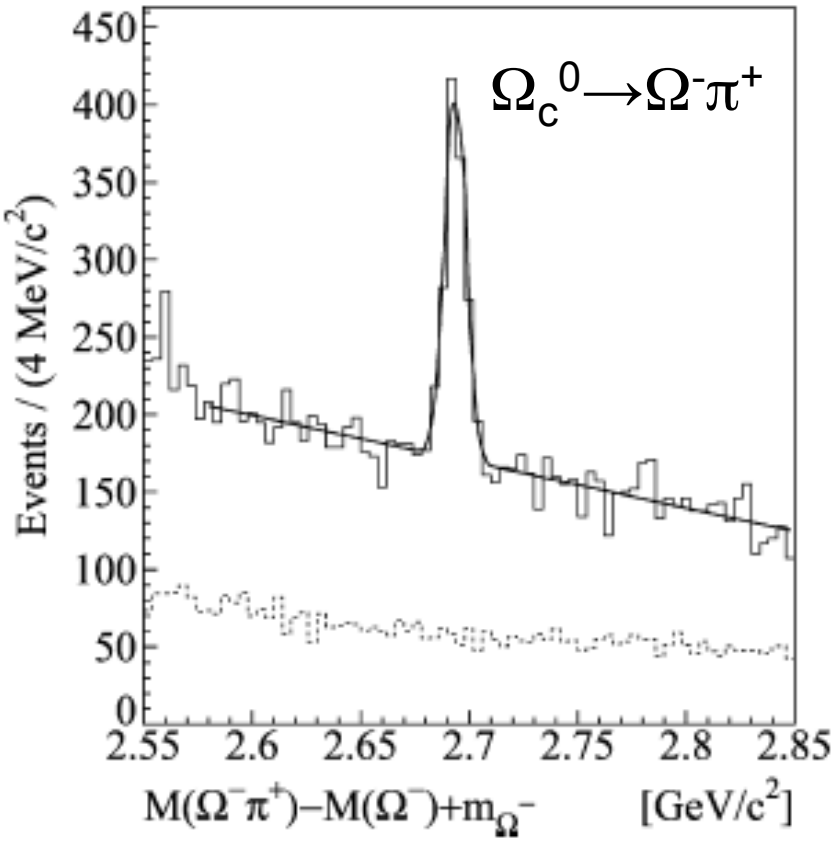
PRD89,052003(2014) $\Xi_c^0\,\pi^+$ has been visited.



Reconstructed states with Ω_c^0

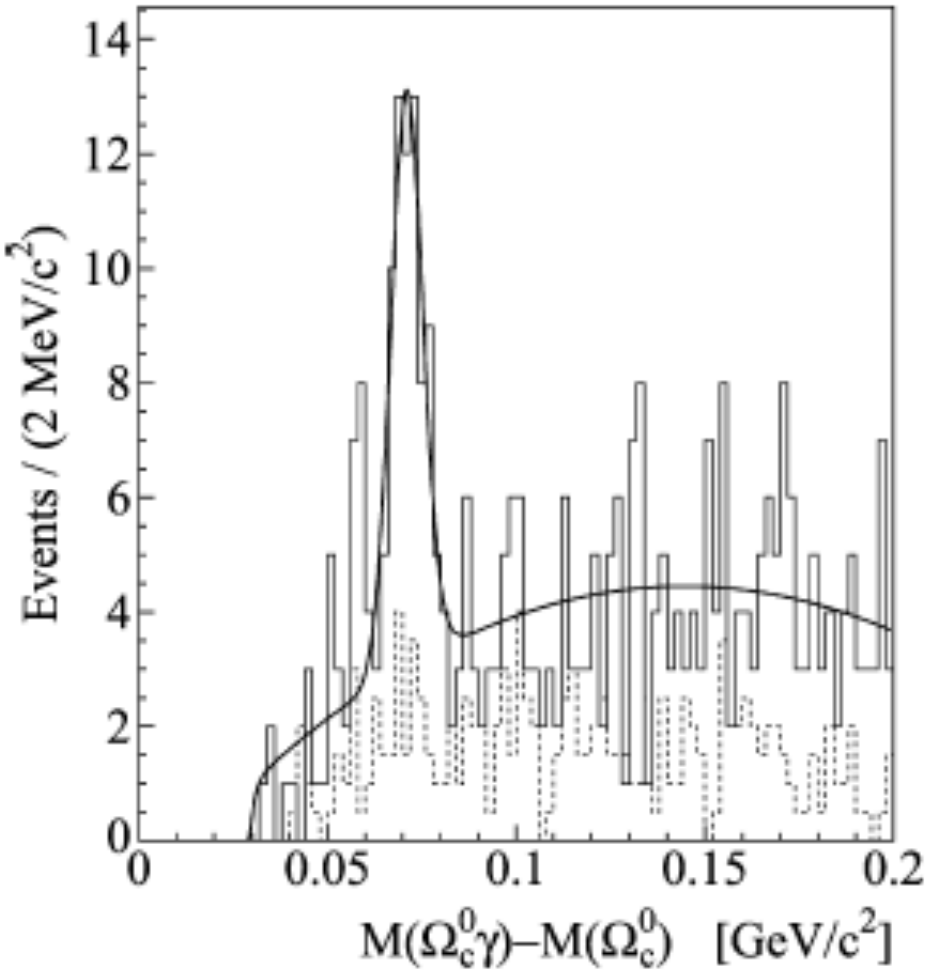
PLB672,1(2009)





$\Omega_c^0(2770) \rightarrow \Omega_c^0 \gamma$

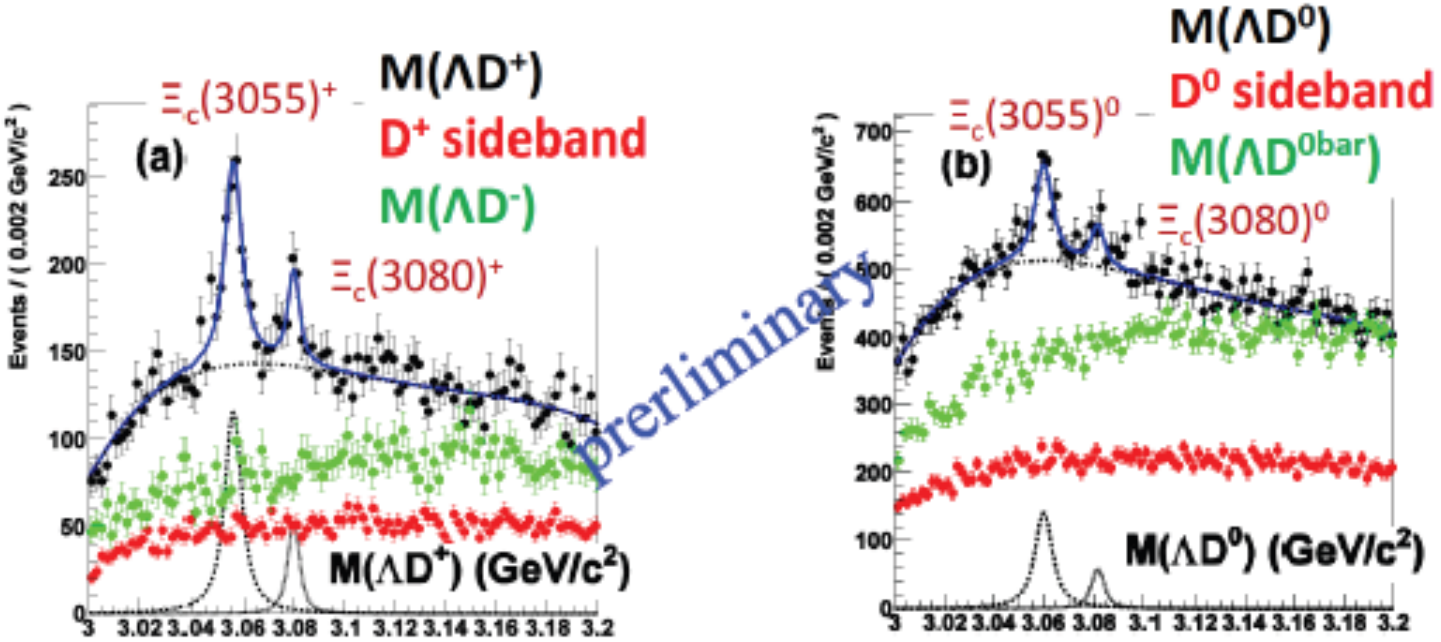
PLB672,1(2009)



States seen in ΛD mode

- $\Xi_c(3055)^+$ (11.7σ), $\Xi_c(3080)^+$(4.7σ) in ΛD^+
  - Further confirmation of $\Xi_c(3055)^+$
- $\Xi_c(3055)^0$ (7.6σ) , $\Xi_c(3080)^0$ (2.6σ) in ΛD^0
  - First observation of $\Xi_c(3055)^0$

Belle preliminary



Note

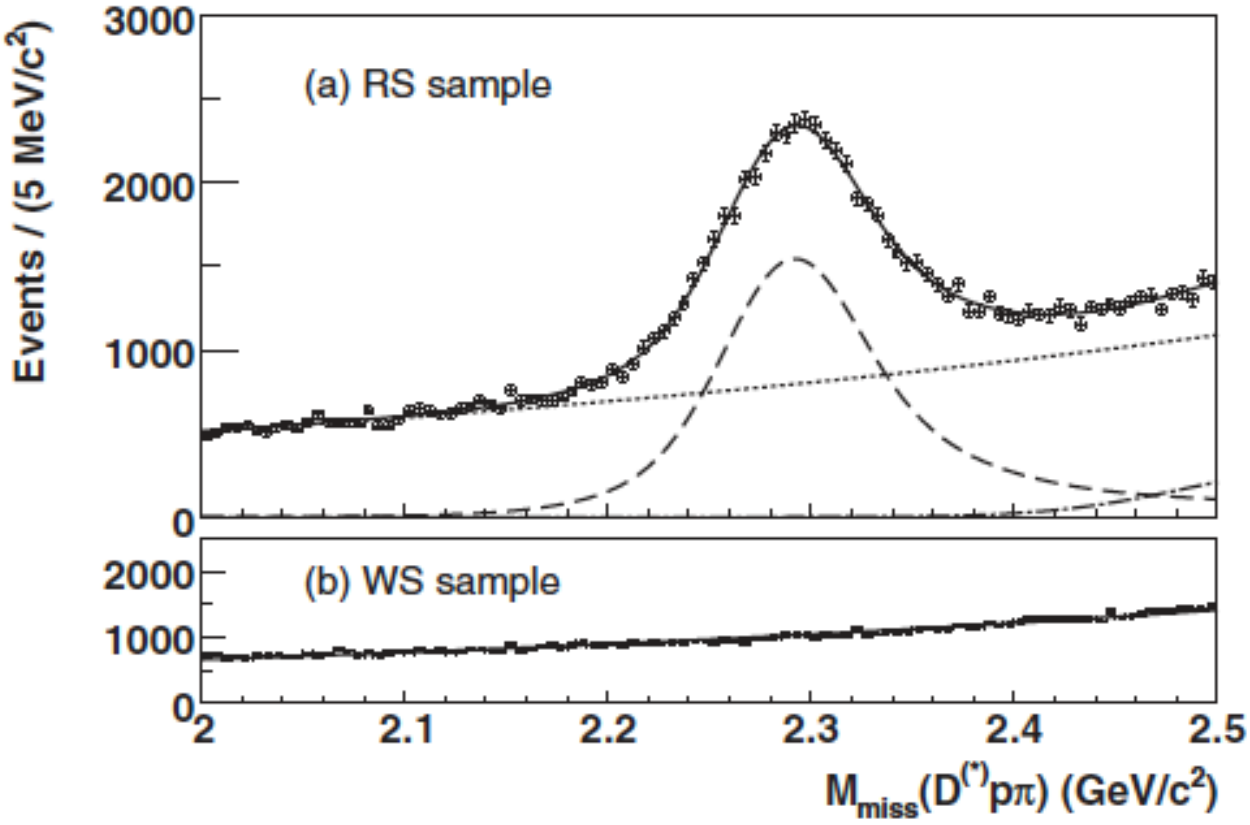
- (Grand state charm baryon) + $\pi^{\pm}$, $\pi^{+}\pi^{-}$, $K^{-}\pi^{+}$ and γ have been visited by experiments.
- For many states, mass and width were poorly known, B-factory results have been updating them.
- For more-body decays, piloting input is needed to specify the final state (otherwise just swim in combinatorial background).
- For most of cases, branching fractions are poorly known. When we try to get information from the production rate, decay from higher states (feed-down) would become a problem
- Even PDG Br($\Lambda_c \rightarrow pK\pi$), several underlying assumptions. New model-independent approach published from Belle.

Tag $D^{(*)-}\,\bar{p}\,\pi^+$ to get M_{miss}

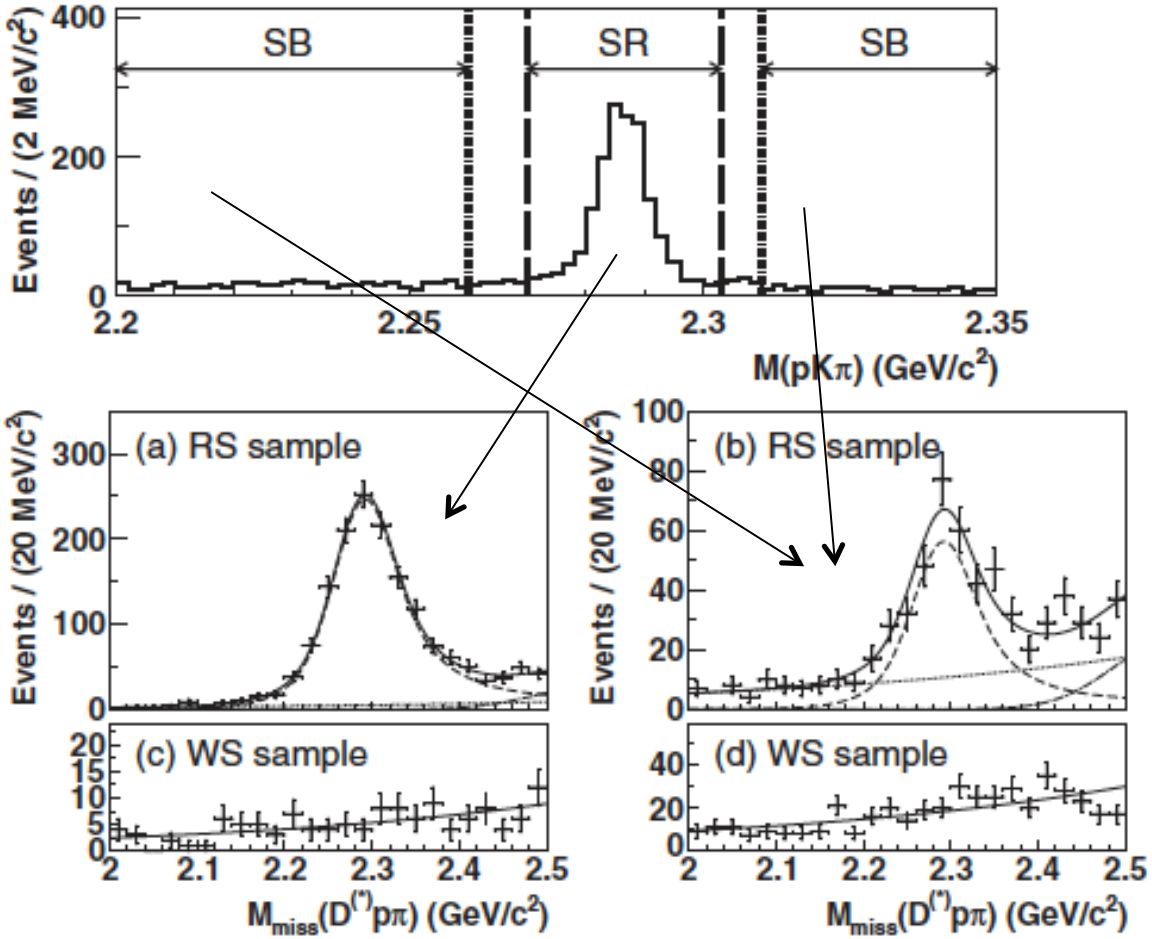
$$e^+e^- \to c\bar{c} \to D^{(*)-}\bar{p}\pi^+\Lambda_c^+$$

Detect only these

PRL113,042002(2014)



Then explicitly reconstruct $pK^-\pi^+$



PRL113,042002(2014)

PDG was 5.0±1.3%

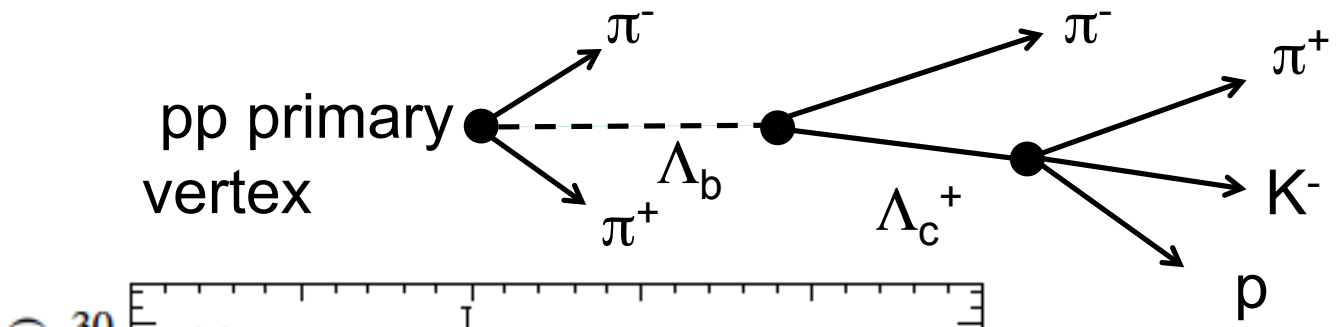
$$\mathcal{B}(\Lambda_c^+ \to pK^-\pi^+) = (6.84 \pm 0.24^{+0.21}_{-0.27})\%$$

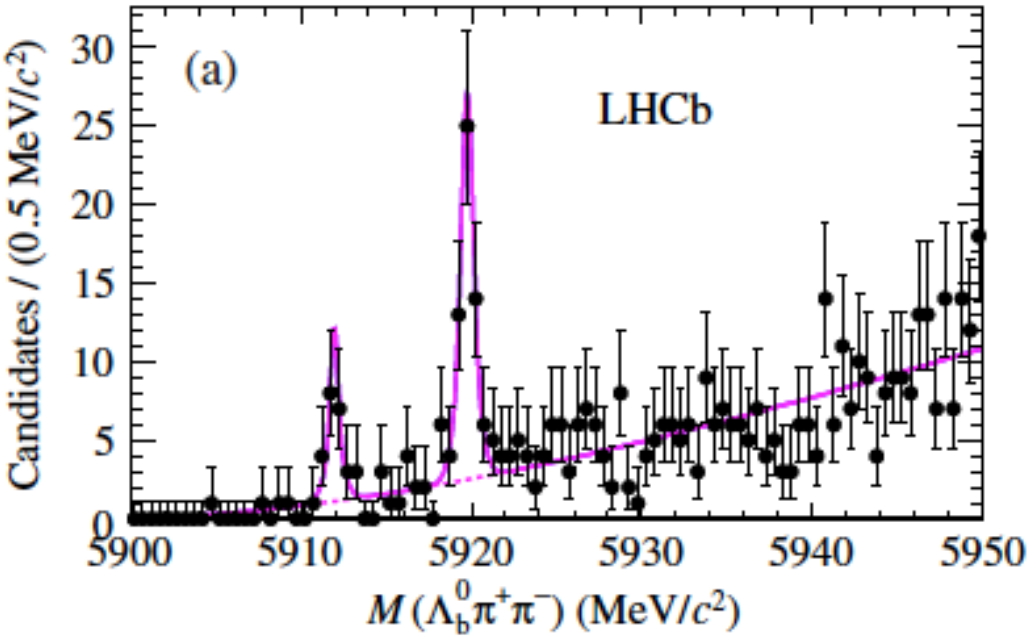
Note 2

- Seen in $\Lambda_c^+\pi^+K^-$ case, only $\Xi_c(3080)^+$ appears in $\Sigma_c(2445)^{++}$ K^- and $\Sigma_c(2520)^{++}$ K^-, while $\Xi_c(2980)^+$ and $\Xi_c(3055)^+$ appear only in $\Sigma_c(2445)^{++}$ K^-.
- In $\Lambda_c \rightarrow pK^-\pi^+$, three-body decays, intermediate states can be pK^{*0}, $\Delta^{++}K^-$ and so on.
- Does information of the composition about those intermediate states help to test theoretical model? (Tools to resolve those are in experimentalists' hand, Dalitz plot analysis, etc.)

As for bottom baryons

Results to be given from (mainly) LHCb experiments.





LHCb exited Λ_b observation
PRL109,172003(2012)

Summary

- In collider experiments, exclusive reconstruction is performed with utilizing 4π spectrometer.
- Thus if enough signal yield is obtained, J^P can be determined from decay products' angular distribution.
- (charm baryon) + $\pi^{\pm}$, $\pi^+\pi^-$, $K^-\pi^+$ and γ have been visited.
- For more-body decays, piloting input is needed to specify the final state.
- Decay intermediate states composition can be resolved, for example in $\Lambda_c \rightarrow pK^-\pi^+$ pK^{*0}, $\Delta^{++}K^-$ etc. Hope it examine theoretical model/calculation to see if di-quark picture works.
- As for bottom baryons, results to be given from LHC experiments (mostly LHCb).