New Observations of Beauty Baryon Decays at LHCb

Team-Based Summer Student Project by
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Summer Student Session
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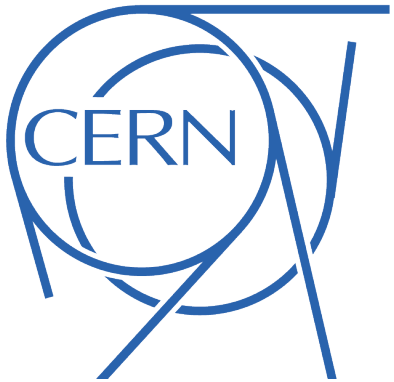


Contents

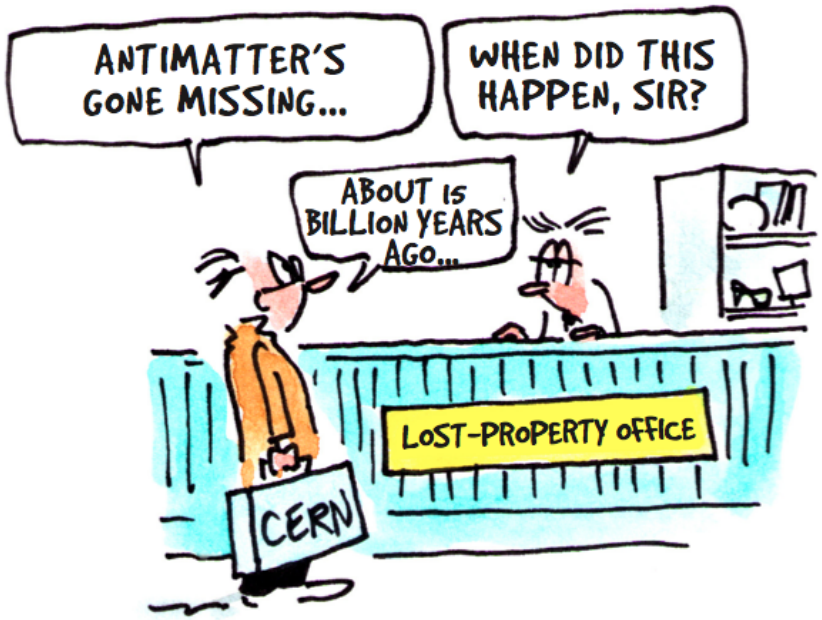
Motivation for new observations of Λ_b^0 decays

Motivation

- CP violation in baryons not observed yet
- gain better understanding of QCD
- beauty baryons not well-known yet
- baryons important for background understanding of many processes

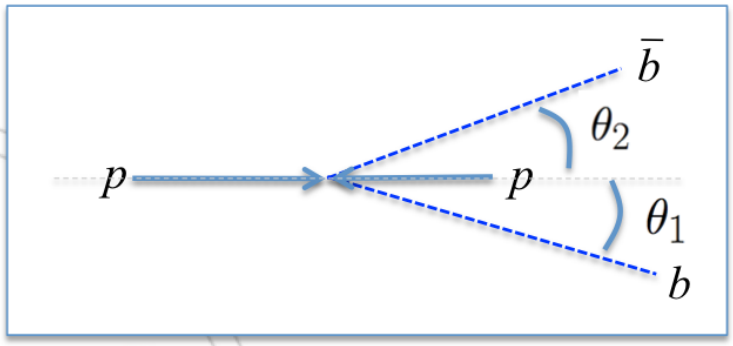
The decays we analyze:

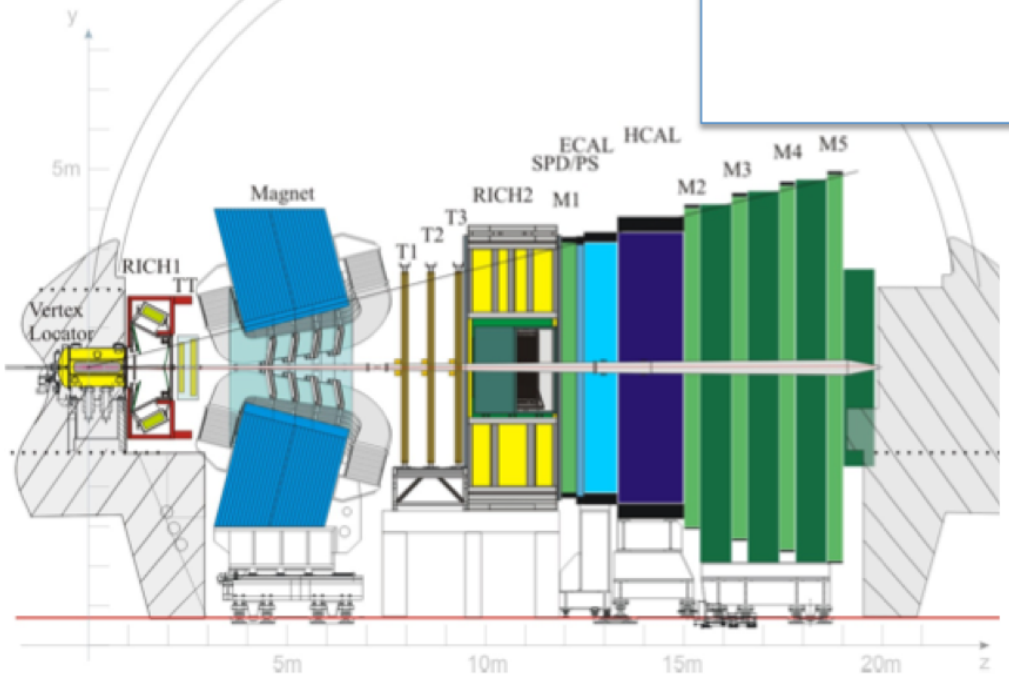
$$\Lambda_b^0 \to \Lambda_c^+ K^- K^+ \pi^-$$
$$\Lambda_b^0 \to \Lambda_c^+ \bar{D}_0 K^-$$
$$\Lambda_b^0 \to \Lambda_c^+ \bar{p} p \pi^-$$

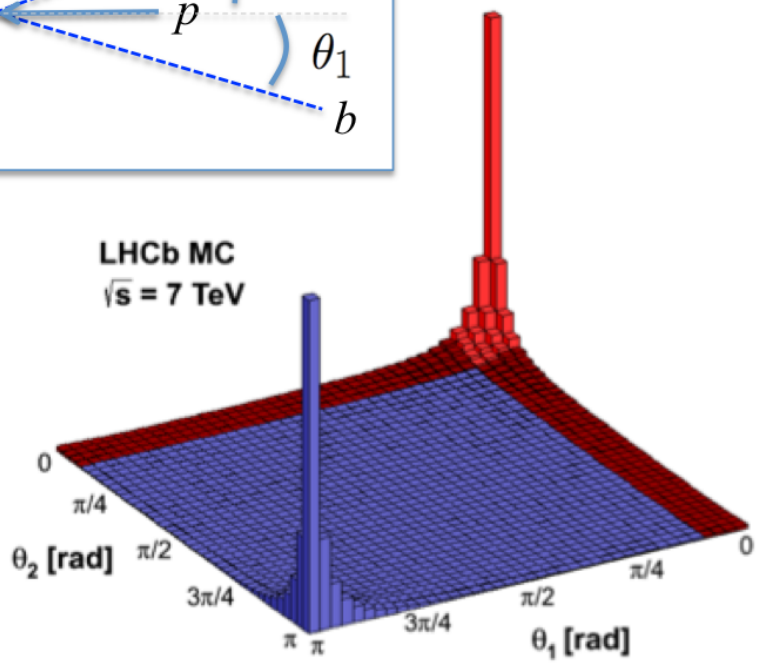


LHCb Detector: Designed for beauty physics

- b-$\bar{b}$-pairs most likely produced in forward or backward direction
- Detector parts: high precision vertex locator ("VELO"), Cherenkov detectors for particle identification, Silicium-detectors for tracking, electromagnetic and hadronic calorimeters, muon system
- Dipole Magnet (integrated field 4 Tm) can run with both polarities



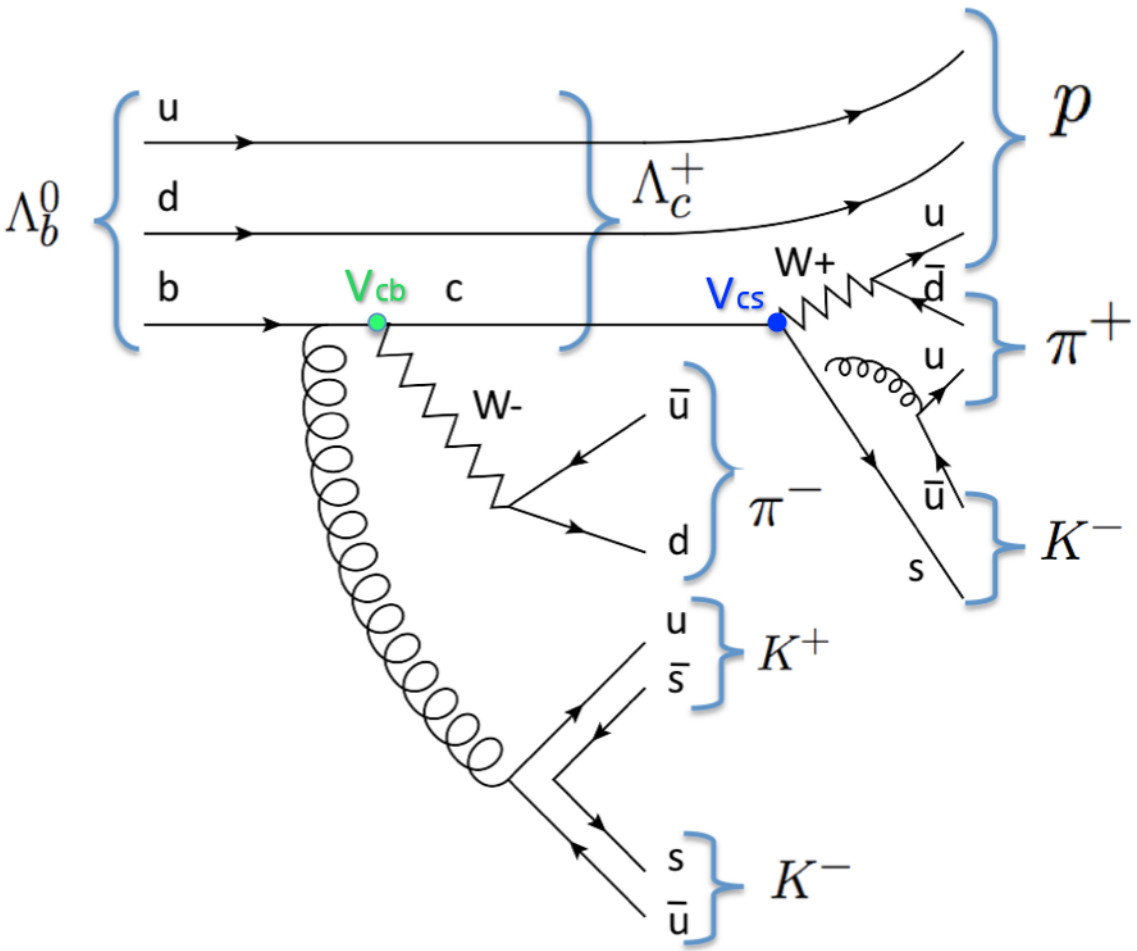




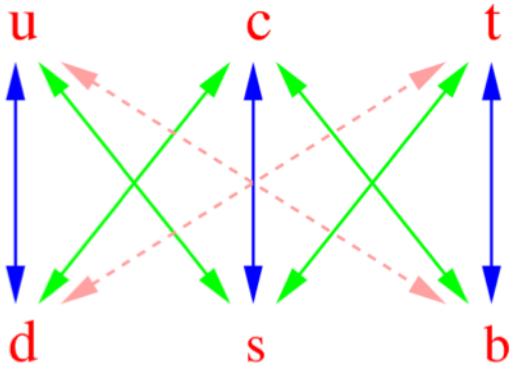
Example of yet unobserved Λ_b^0 decay

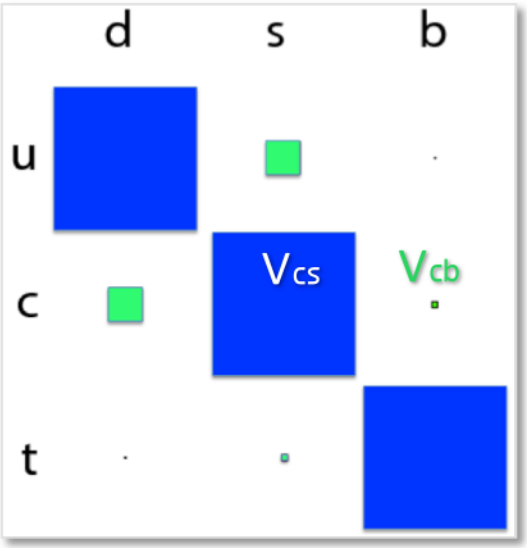
Example decay:

$\Lambda_b^0 \to \Lambda_c^+ K^- K^+ \pi^-$, Λ_c^+ recognized by $\Lambda_c^+ \xrightarrow{5\%} p K^- \pi^+$



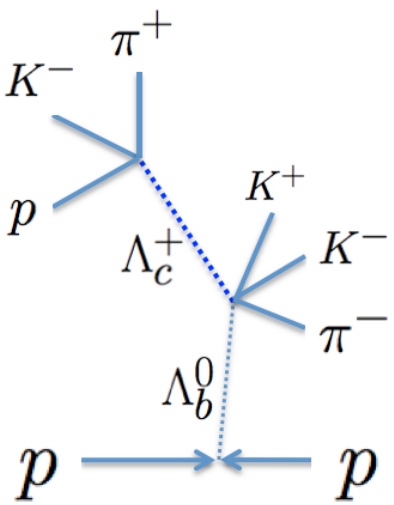
CKM quark mixing





First steps of analysis: how to find a new decay

Example decay: $\Lambda_b^0 \to \Lambda_c^+ K^- K^+ \pi^-$, $\Lambda_c^+ \to p K^- \pi^+$



"Pre-filtering" the raw LHCb data:

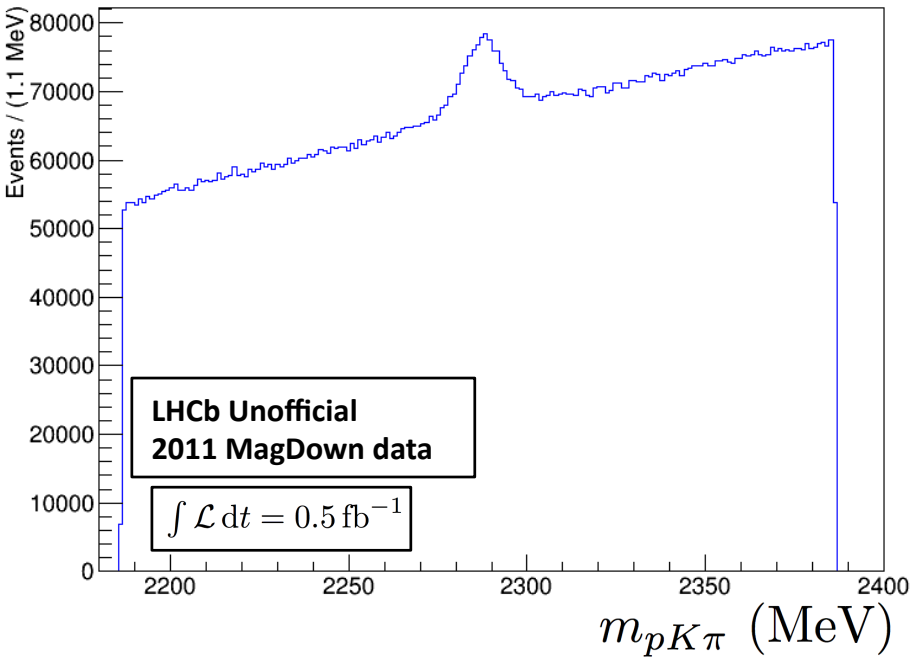
- charged particles reconstructed in the detector
- decay topology (vertices)
- loose kinematic and particle identification selection

Need to prove that particles come from the proposed decay
$\Rightarrow$ Identify decay pattern by selecting characteristic features ("cuts" on variables)

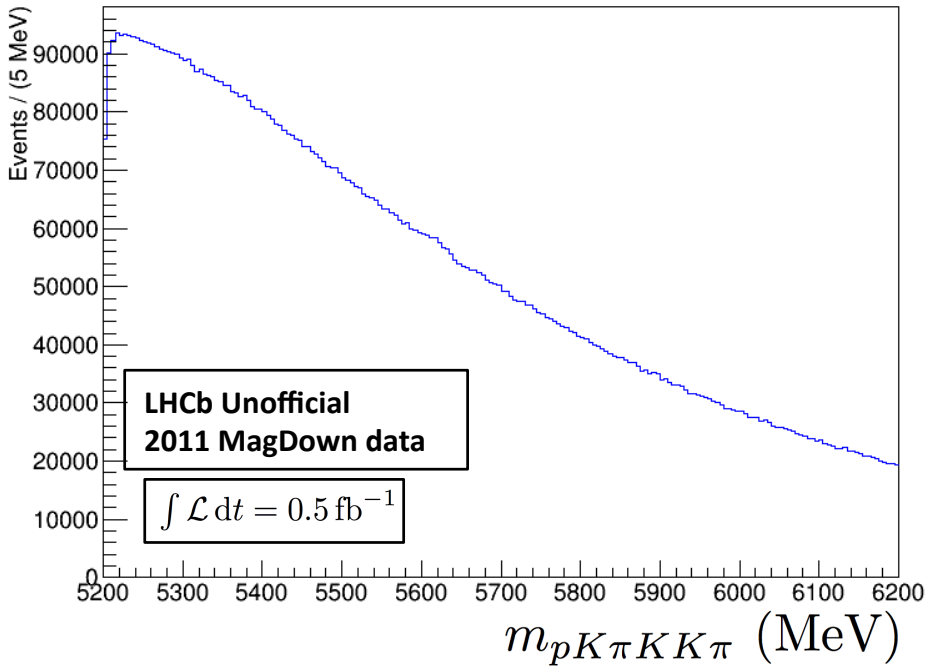
First steps of analysis: how to find a new decay

Raw mass spectrum after pre-selection (without any cuts):

Invariant mass of $pK\pi$
(without any cuts)



Invariant mass of $\overbrace{pK\pi}^{\Lambda_c} KK\pi$
(without any cuts)

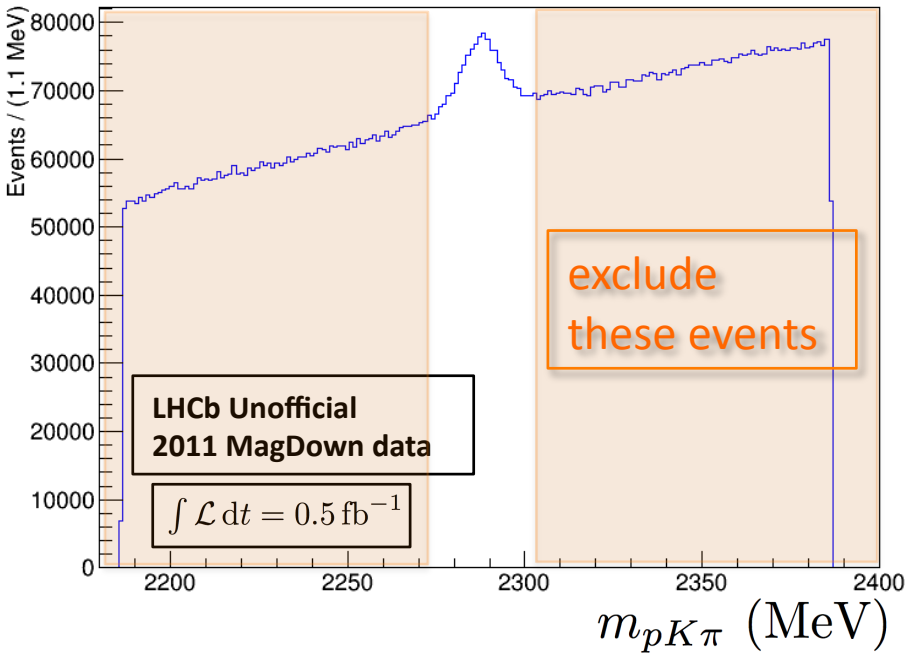


First steps of analysis: how to find a new decay

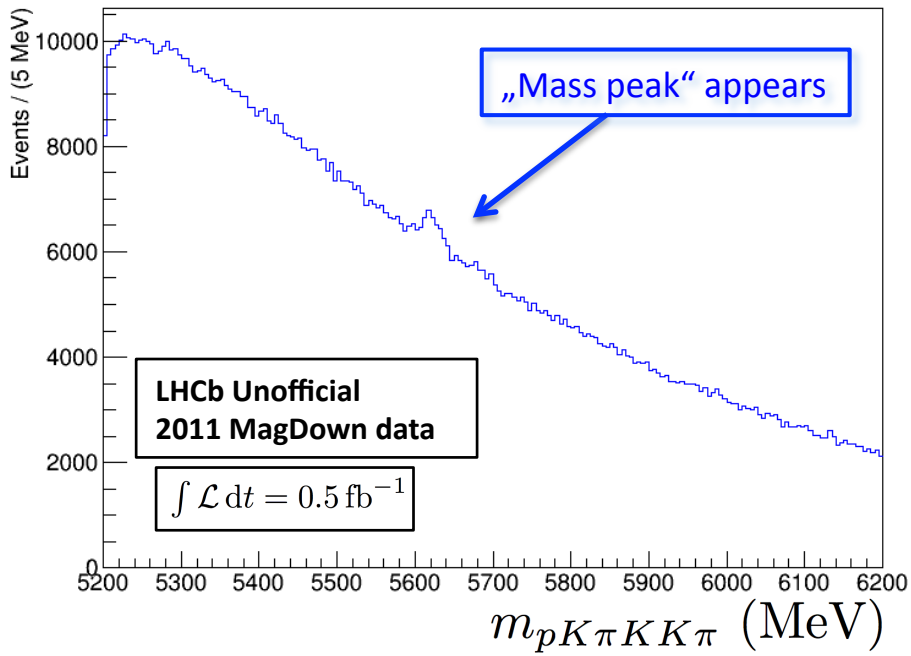
We know: $\Lambda_c^+ \to p\,K^-\,\pi^+$, $m_{\Lambda_c} = 2286.46 \pm 0.14$ MeV

$\Rightarrow$ apply cut on invariant mass of Λ_c daughters $pK\pi$:

Invariant mass of $pK\pi$
(without any cuts)



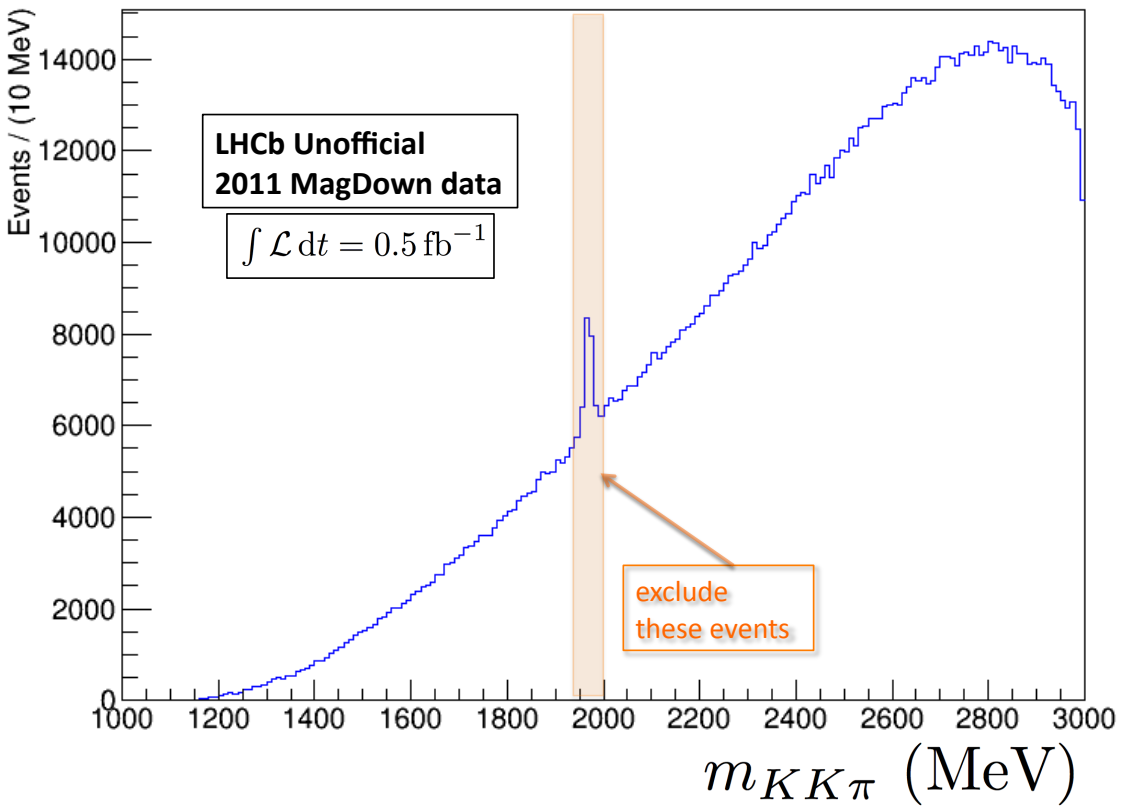
Invariant mass of $\overbrace{pK\pi}^{\Lambda_c} KK\pi$
(with cut on $m_{pK\pi}$)



First steps of analysis: how to find a new decay

Plot the invariant mass of $KK\pi$-system $\Rightarrow$ Why should the peak in the $\Lambda_c KK\pi$-system mass correspond to our proposed decay $\Lambda_b^0 \to \Lambda_c^+ K^+ K^- \pi^-$ and not to $\Lambda_b^0 \to \Lambda_c^+ D_s^-$ where $D_s^- \to K^+ K^- \pi^-$?
$\Rightarrow$ Exclude the region with D_s mass peak ($m_{D_s} = 1968.49 \pm 0.32$ MeV)

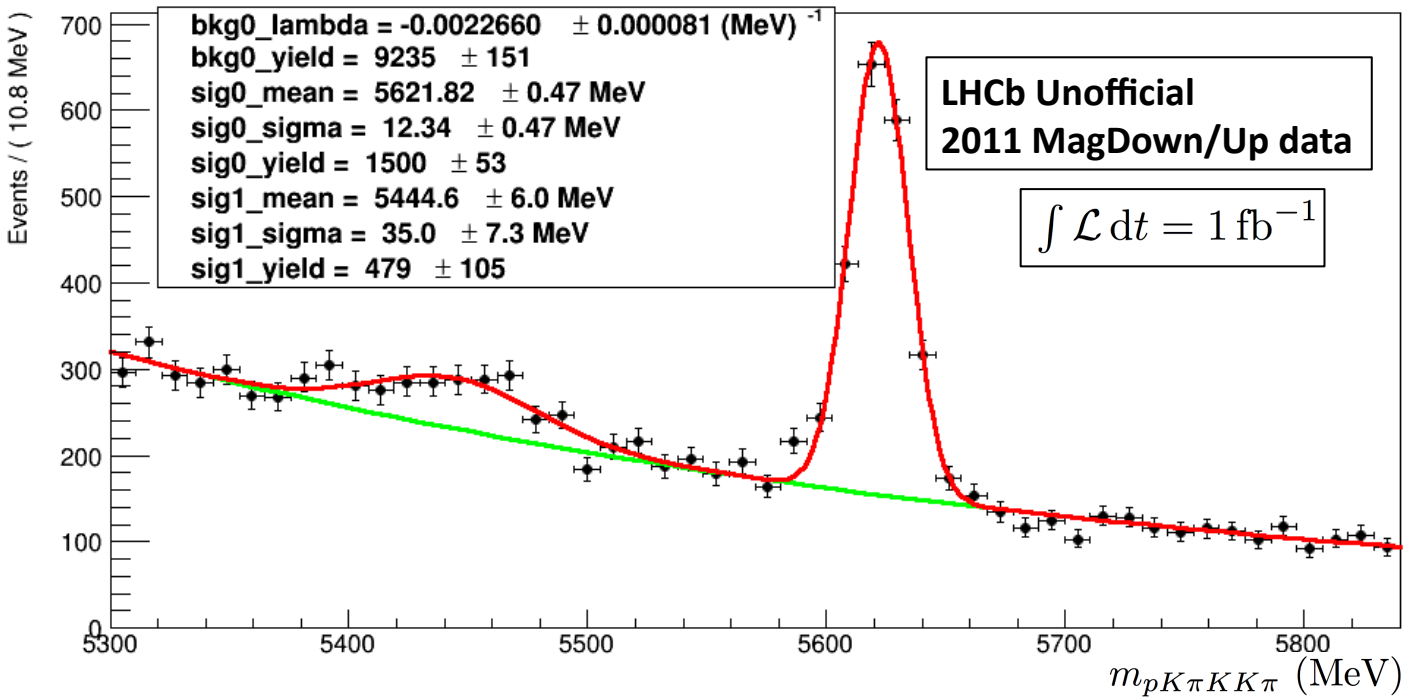
Invariant mass of $KK\pi$ system (with cut on $m_{pK\pi}$)



First steps of analysis: how to find a new decay

After applying more cuts (e.g. particle identification variables, impact parameters) and excluding the D_s a clear Λ_b peak is measurable. The peak on the left represents the decay $\Lambda_b \to \Sigma_c K K \pi$, where $\Sigma_c \to \Lambda_c \pi$ and one π is missed.

Invariant mass of $\Lambda_c K K \pi$ (with all preselection cuts)



Next step after this preselection

Apply a BDT (Boosted Decision Tree) to exploit correlations between variables for highest signal to background ratio for final measurement.

Contents

Success in a Team-Based Project

Why teams are successful:

- communication
- feedback
- recognition and motivation
- flexibility to adapt for new tasks
- organization and self-organization

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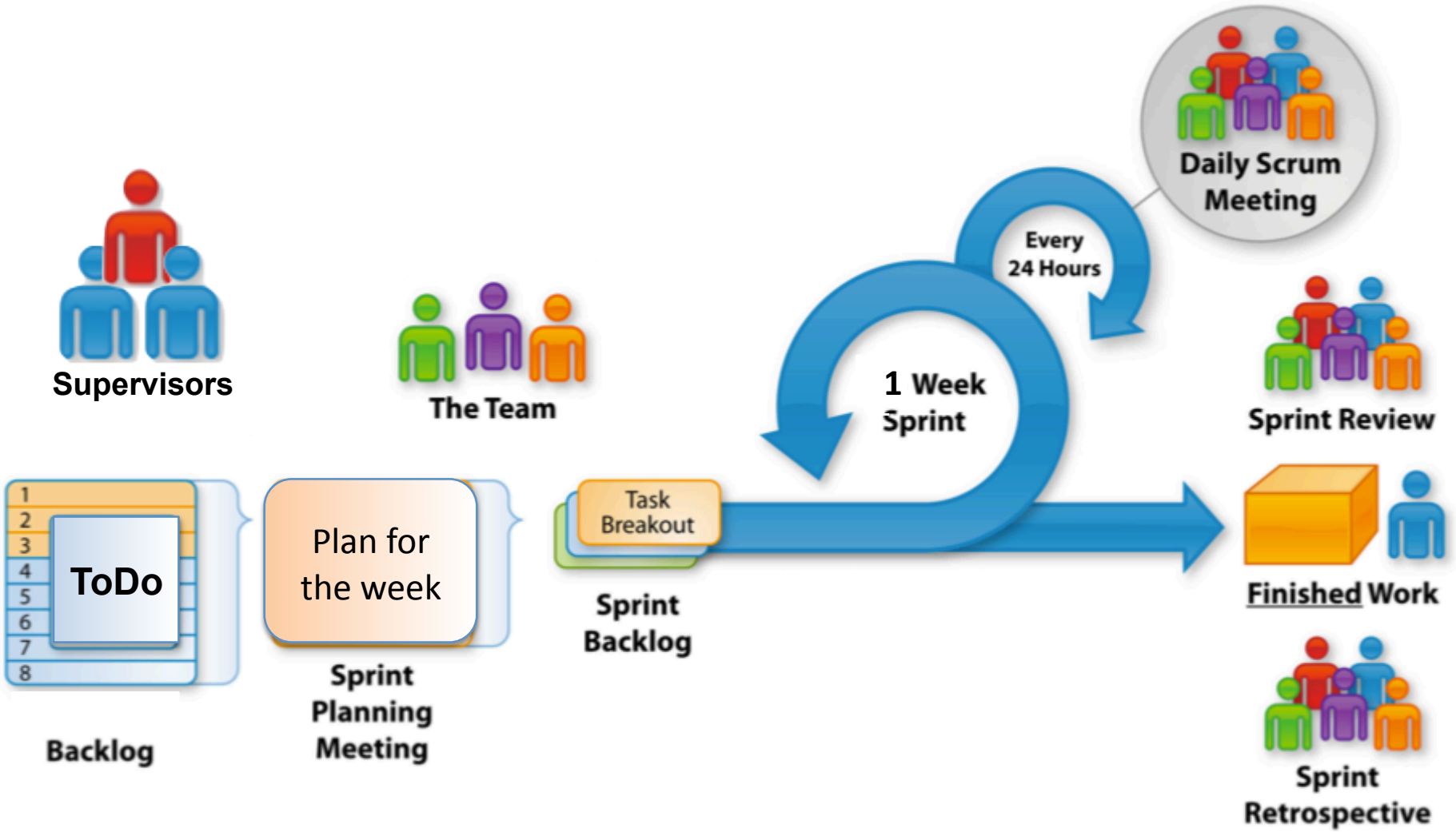
How to achieve this:

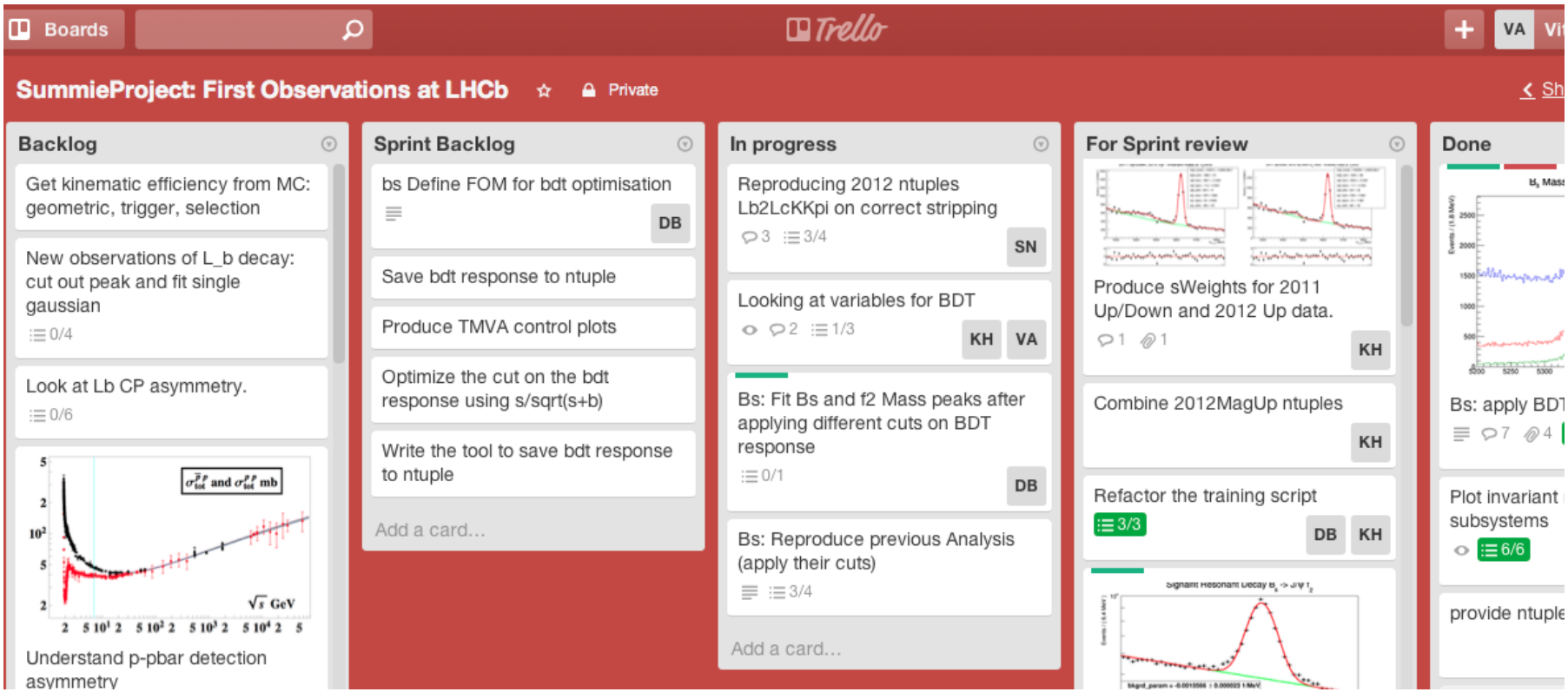
- daily **planned** face-to-face communication
- regular **planned** feedback rounds
- inspect and track progress, make problems visible
- enable repeatability and reproducibility for analysis strategy
- split the work into clear defined small projects or pieces

“Scrum”: a framework for managing team work



Trello: a useful tool for organizing work

- provides a nice overview of the to-do list, helps to organize your own work
- each (small) task is assigned to a "card"
- "lists" for sorting tasks into categories
- one can add certain members, make comments on cards, attach files



Acknowledgement

Thank you all for your attention and a great time!

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