First results
& Prospects
for Charm Physics @ LHCb

Vanya BELYAEV (Nikhef, Amsterdam)
on behalf of LHCb Collaboration

NIKHEF

LHCb

Outline

- Why (open) Charm?
- The first results
  - Open Charm peaks
  - Open Charm cross-section
- Perspectives
  - Mixing & CP violation
    - yCP, A_{CP}
  - Rare decays

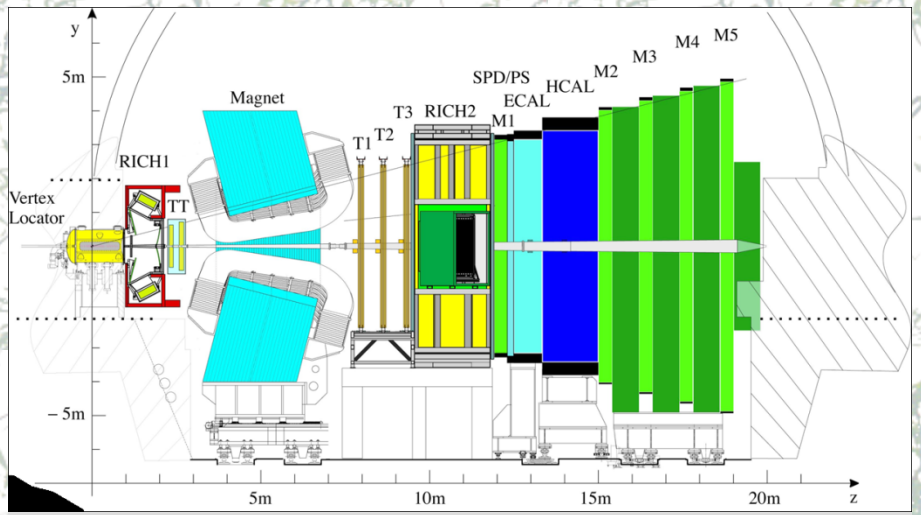
For LHCb results on J/ψ see talk by *Giovanni Passaleva,* Prompt J/ψ and b →J/ψX production in pp-collision at √s=7TeV, track#5, 22 July 9:30

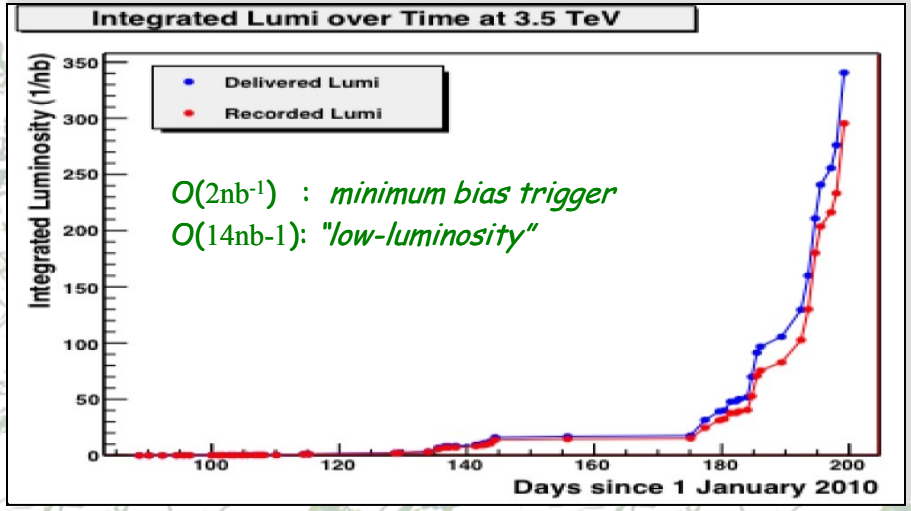
Why charm?

- Charm production in *forward region* $2<y<5$ at LHC energy is an unique & unexplored domain
- *Rare decays* ($D^0 \to \mu^+\mu^-$), *mixing* and *CP-violation* are well suitable for NP search
- Deep understanding of charm is nessessery for many crucial measurement with beauty

  $D^0 \to K_s\pi\pi$ decay model for GGSZ-measurement of *angle-γ* of Unitarity Triangle through $B \to DK$
- Collecting experience, testing tools & skills, warming up for analyses of beauty

LHCb: forward spectrometer

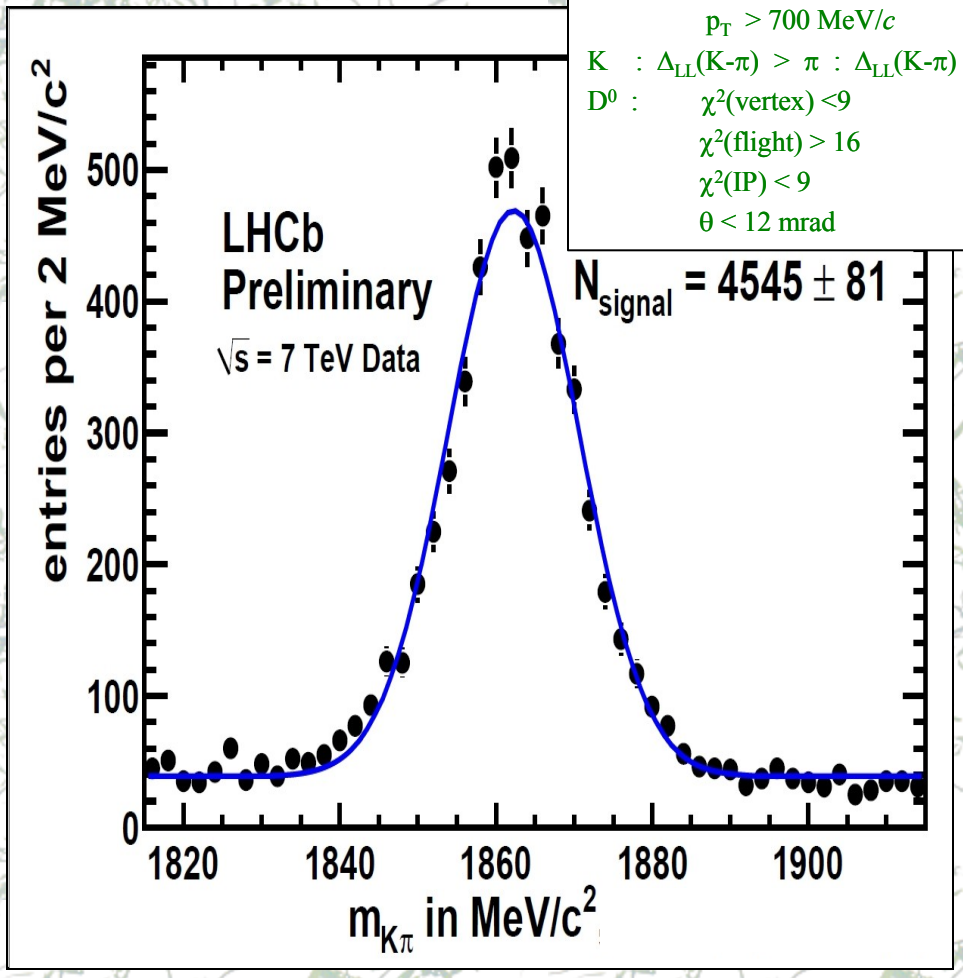




- Selection of good tracks: χ^2(track)/DoF
- Use RICH to separate kaons from pions: $\Delta_{LL}(K-\pi)$ for kaons, $\Delta_{LL}(\pi-K)$ for pions
- Pointing criteria for final state particles:
  - large χ^2 for impact parameter χ^2(IP)
- Pointing criteria for mother particle
  - small χ^2 for impart parameter χ^2(IP)
  - small angle θ between momentum and vector from origin to decay vertex
- Large lifetime of charm particle
  - "large" χ^2 of vertex separation: χ^2(flight)
  - "large" lifetime ct

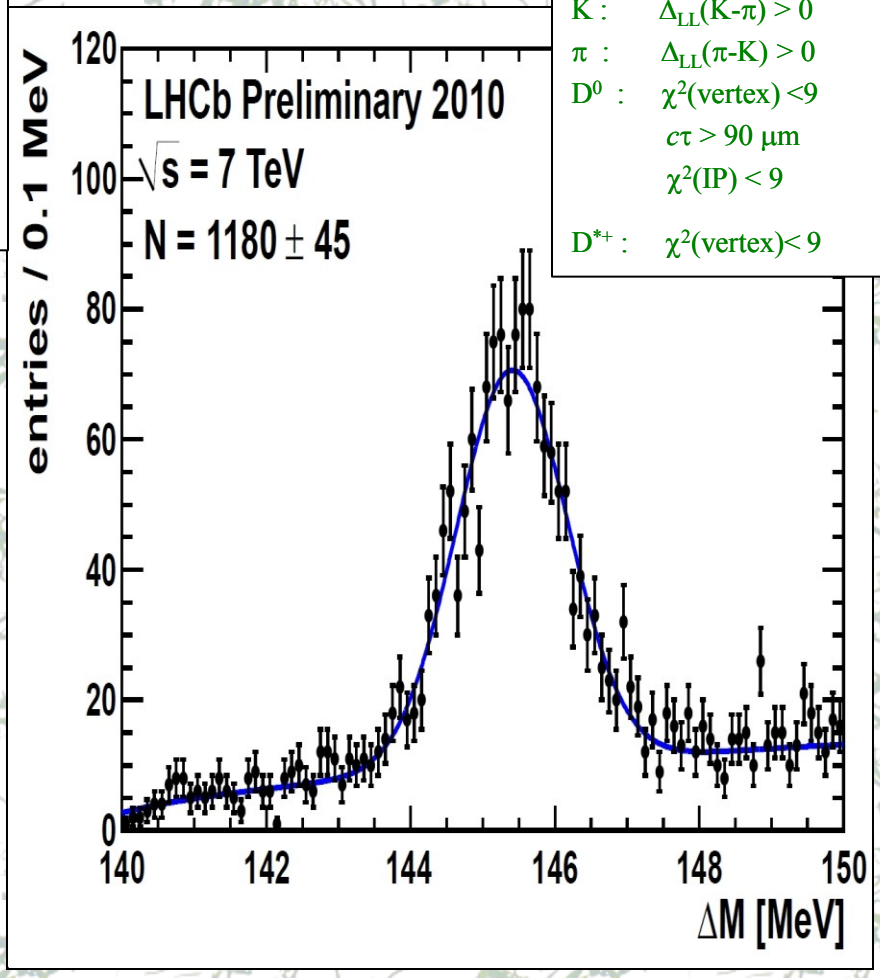
$D^0 \to K^- \pi^+$ and $D^{*+} \to (D^0 \to K^- \pi^+)\pi^+$

K,π : χ^2(track)/DoF < 9
χ^2(IP) > 9
p_T > 700 MeV/c
K : $\Delta_{LL}(K-\pi) > \pi : \Delta_{LL}(K-\pi)$
D^0 : χ^2(vertex) <9
χ^2(flight) > 16
χ^2(IP) < 9
θ < 12 mrad



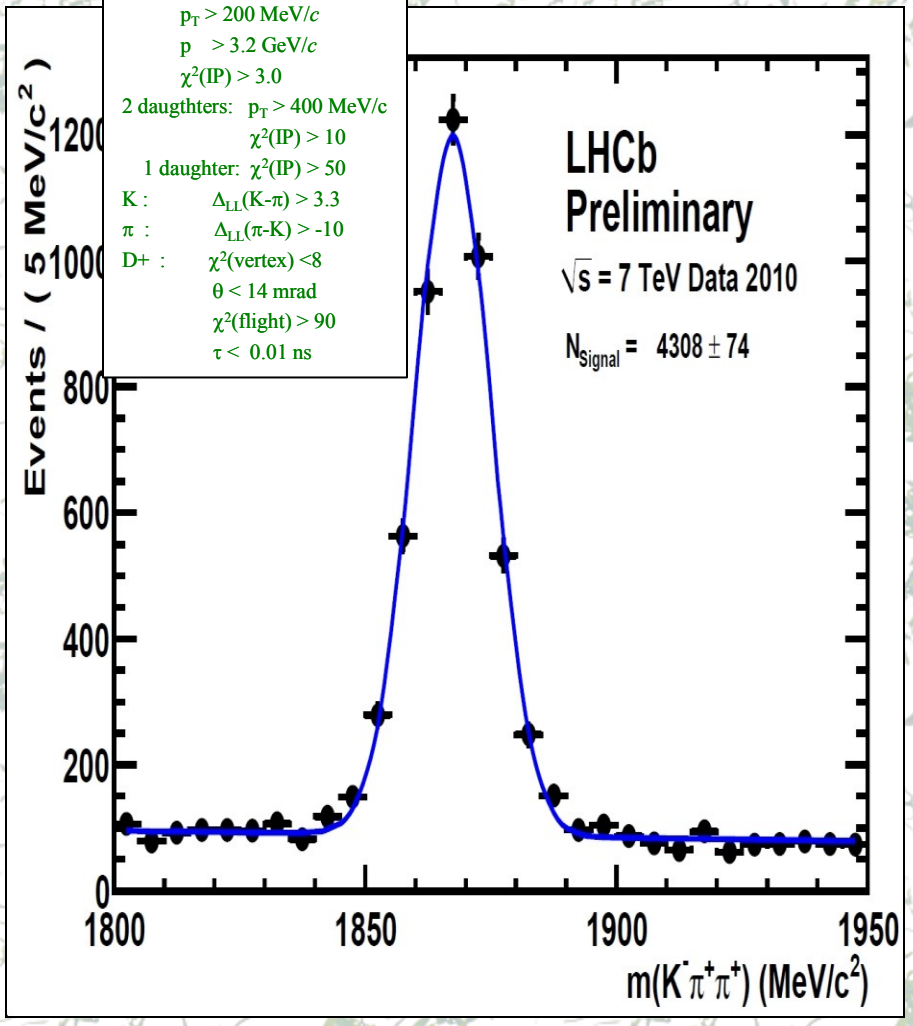
K,π : χ^2(track)/DoF < 10
K,π_D : χ^2(IP) > 9
K : $\Delta_{LL}(K-\pi) > 0$
π : $\Delta_{LL}(\pi-K) > 0$
D^0 : χ^2(vertex) <9
$c\tau$ > 90 μm
χ^2(IP) < 9

D^{*+} : χ^2(vertex)< 9

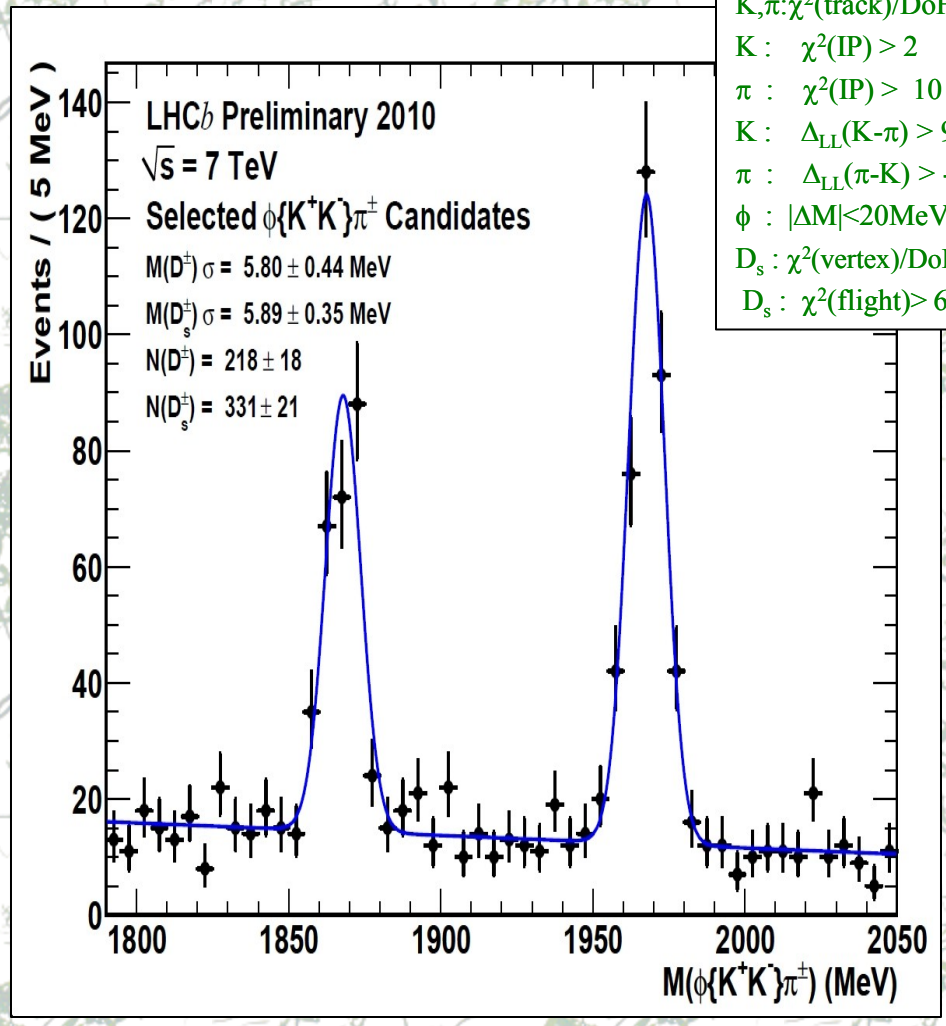


$D^+ \to K^- \pi^+ \pi^+$ and $D_s \to (\phi \to K^- K^+)\pi^+$

K,π : Prob(χ^2(track)) > 10^{-4}
p_T > 200 MeV/c
p > 3.2 GeV/c
χ^2(IP) > 3.0
2 daugthters: p_T > 400 MeV/c
χ^2(IP) > 10
1 daughter: χ^2(IP) > 50
K : $\Delta_{LL}(K-\pi) > 3.3$
π : $\Delta_{LL}(\pi-K) > -10$
D+ : χ^2(vertex) <8
θ < 14 mrad
χ^2(flight) > 90
τ < 0.01 ns



K,π:χ^2(track)/DoF<4
K : χ^2(IP) > 2
π : χ^2(IP) > 10
K : $\Delta_{LL}(K-\pi) > 9$
π : $\Delta_{LL}(\pi-K) > -2$
φ : $|\Delta M| < 20$MeV/c^2
D_s : χ^2(vertex)/DoF<5
D_s : χ^2(flight)> 67



From plots to cross-sections

Measure the cross-section in bins of p_T and rapidity

- Luminosity: $1.81 \pm 0.18 nb^{-1}$
- Efficiency:
  - Trigger: 'no-trigger'
  - Reconstruction Efficiency
    - Tracking efficiency from data
  - Particle Identification Efficiency
    - Determined on data using the clean K_s, Λ^0 and ϕ peaks
  - Selection efficiency: rely on Monte Carlo with the detailed cross-checks on data

$$\sigma = \frac{N_{\text{signal}}}{\varepsilon_{\text{tot}} B F \mathcal{L}_{\text{int}}}$$

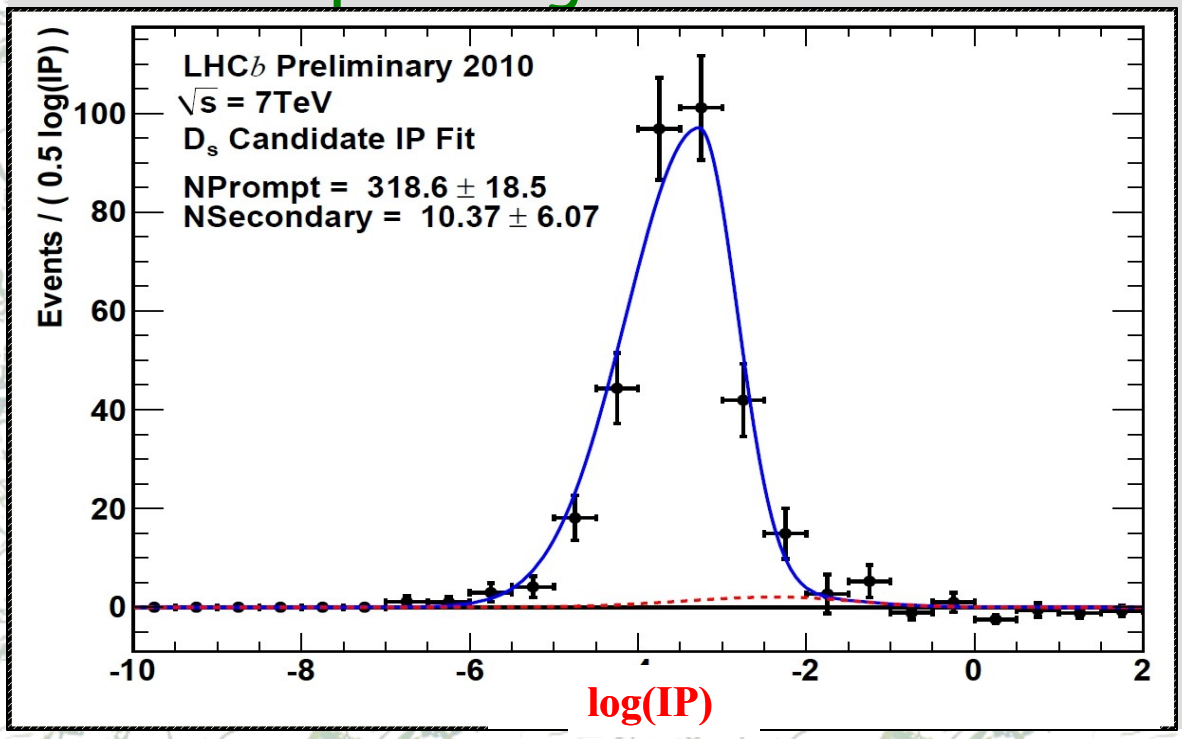
Eric van Herviinen
LHCb Trigger System, track #1, 22 July, 10:15

Silvia Borghi Performance of Tracking System of LHCb Experiment, track #1, 22 July, 11:36

Andrew Powell
ParticleID @ LHCb, track #1, 22 July, 14:00

Cascade charm $b \to c$

- There is cascade production of open charm in decays of $b \to (D, D^*, D_s)$
  - The pointing criteria of D-mesons: **log(IP)**

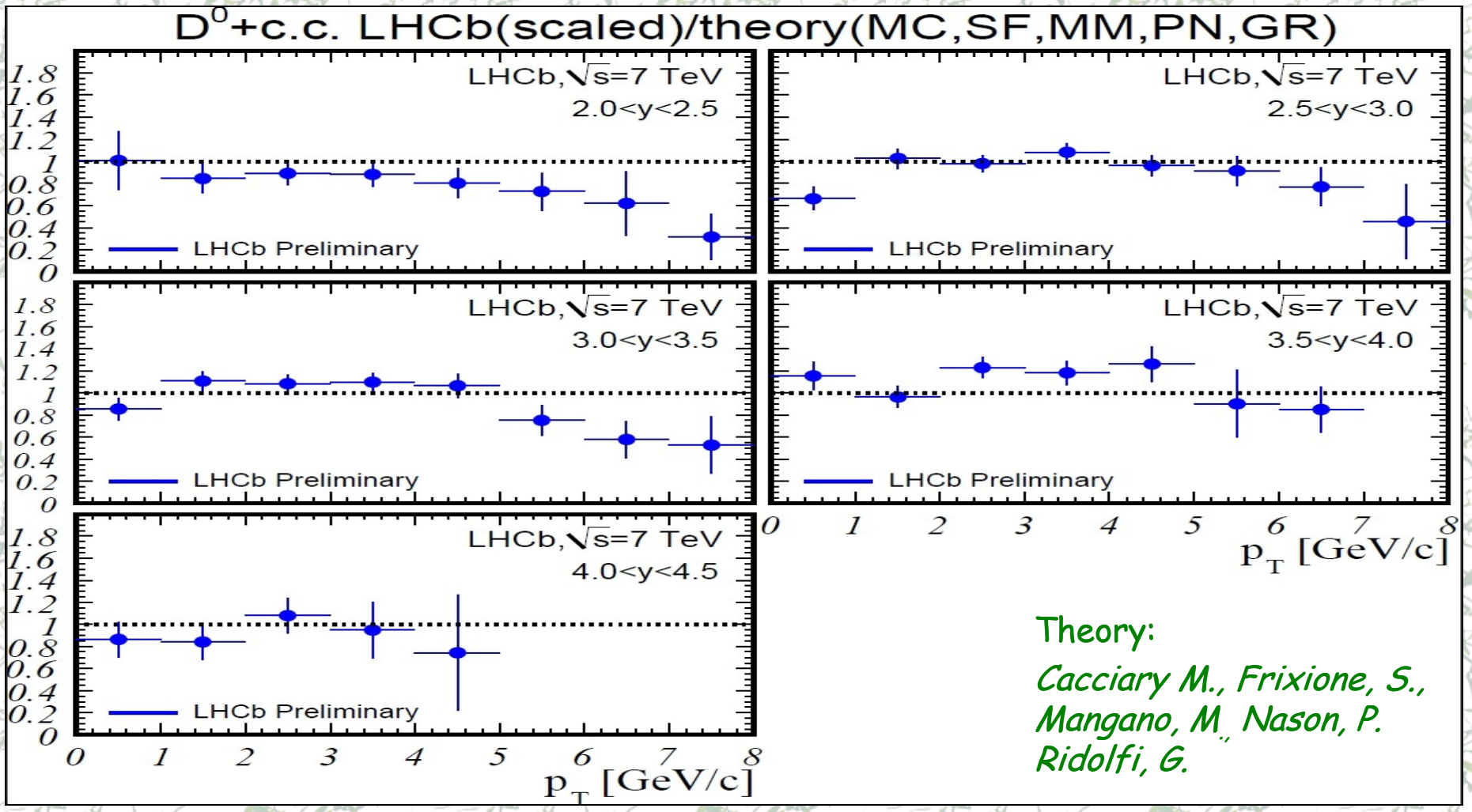


The similar technique has been used for measurement of beauty cross-section , see talk by *Sheldon Stone*, First physics results from LHCb, track #1, 23 July, 10:00

Systematics

- Absolute luminosity: overall 10%
- Trigger efficiency/ "no-trigger" negligible
- Tracking efficiency: extract from data, conservatively: 3%/track
- Selection efficiency: variation of cuts, compare data and Monte Carlo: 0.5-4%
- Charm from beauty: ~5%
- Signal extraction, fits, binning effects: ~3%
- Particle ID efficiency: from data, cross-checked with no-PID selections: ~3%

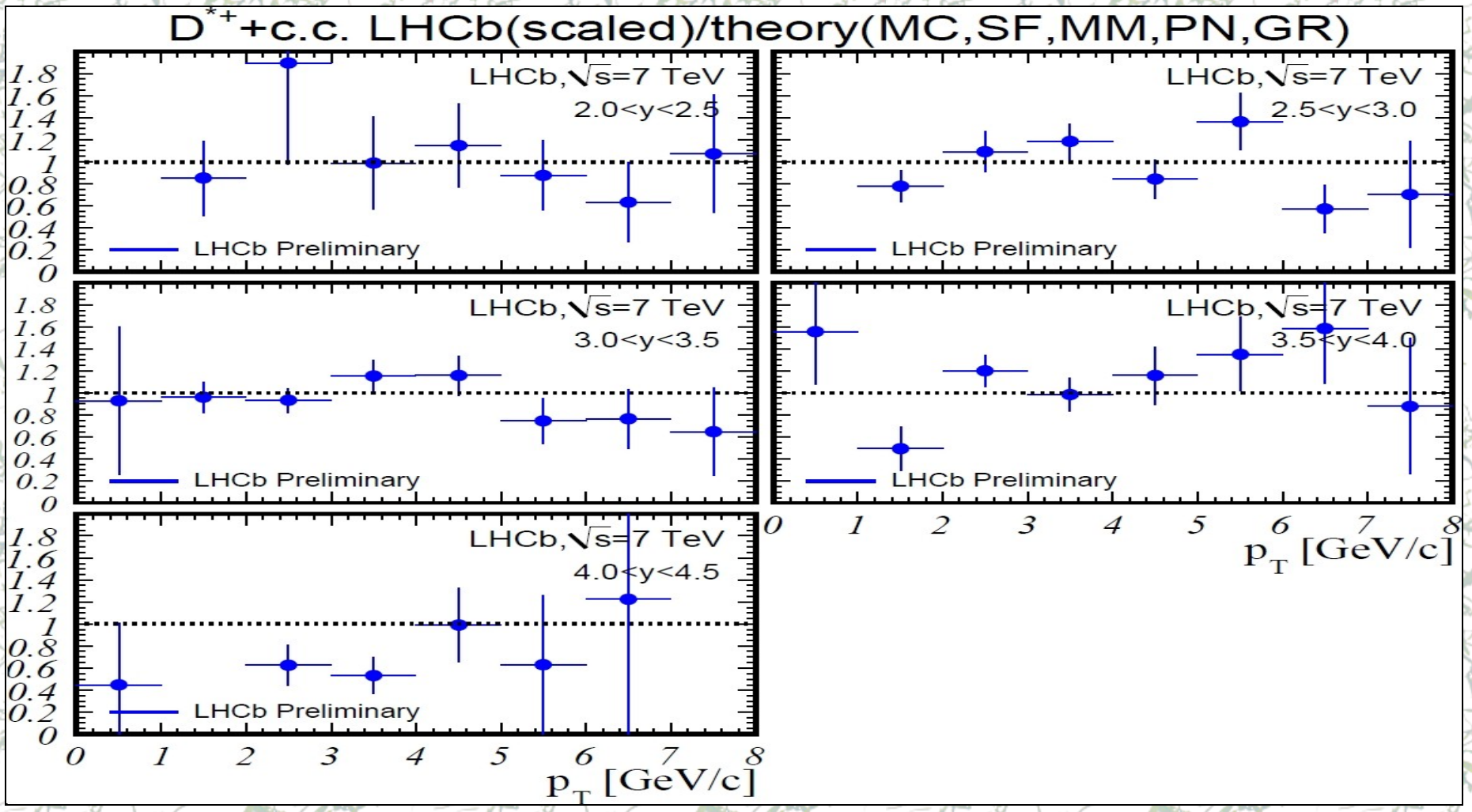
D^0 cross-section "shape"



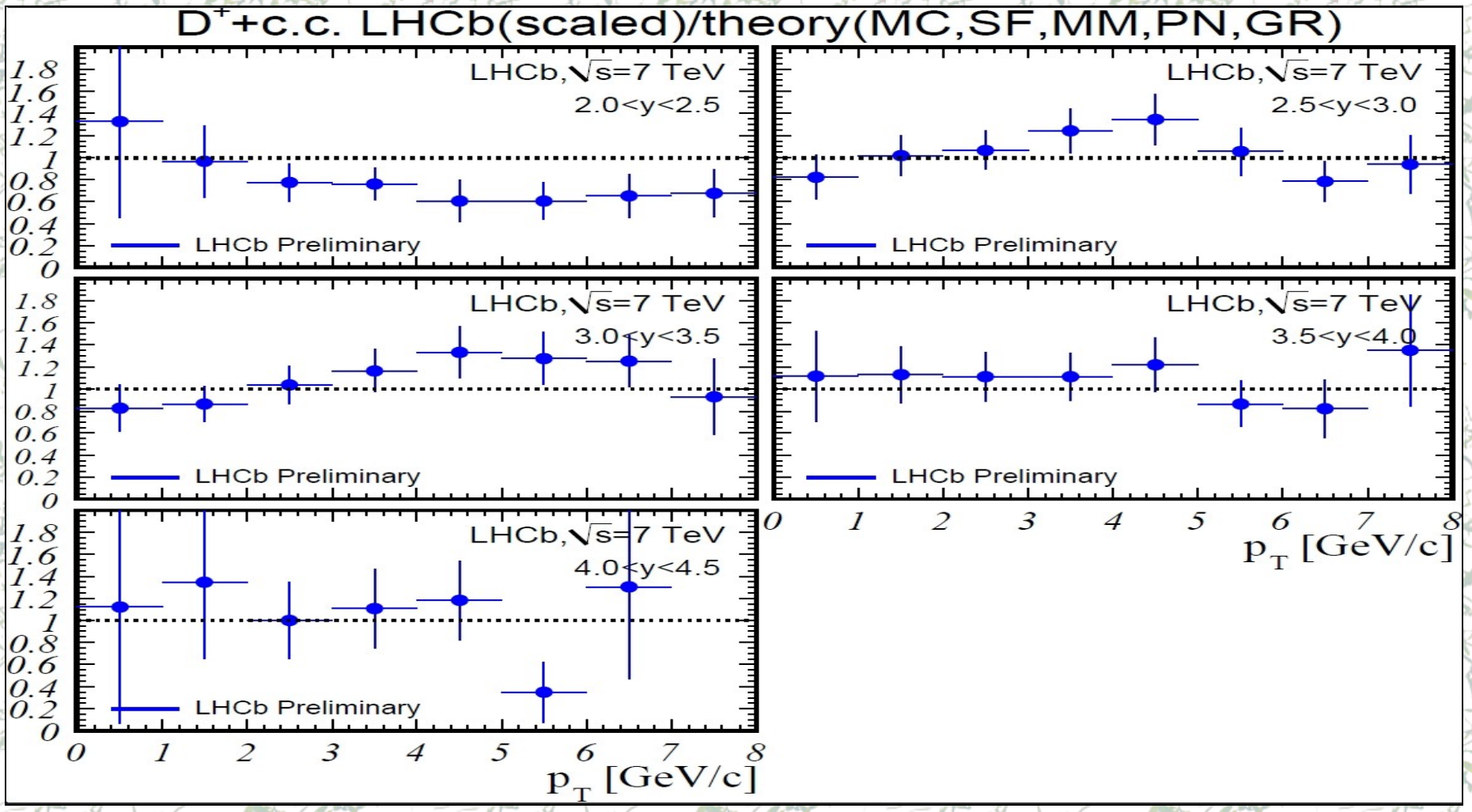
Theory:

Cacciary M., Frixione, S., Mangano, M., Nason, P. Ridolfi, G.

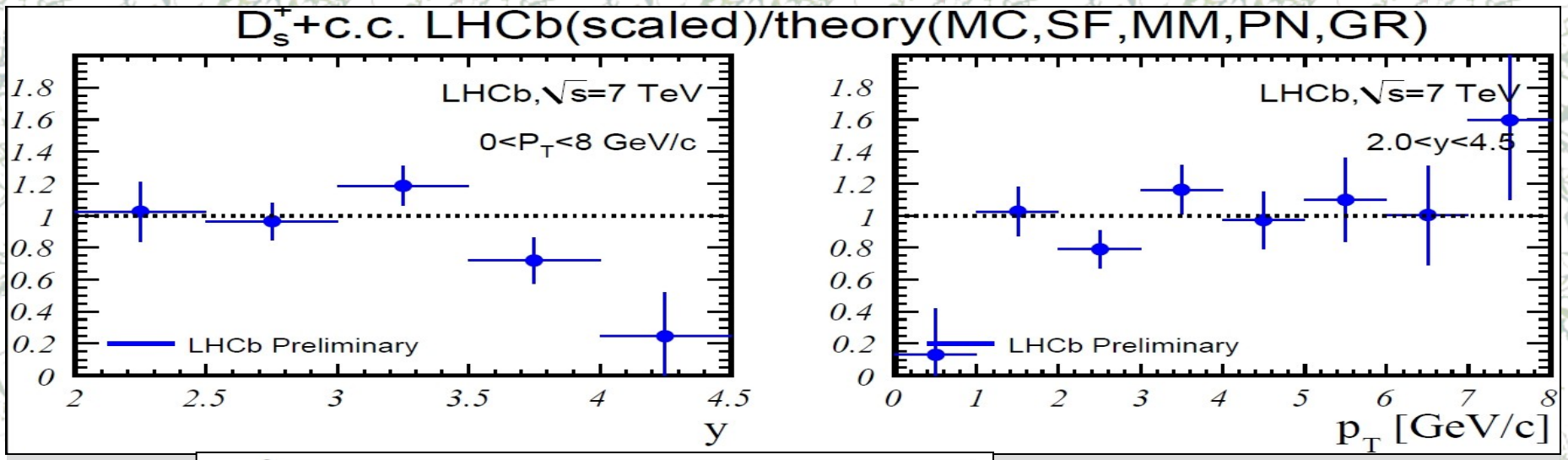
D^{*+} cross-section

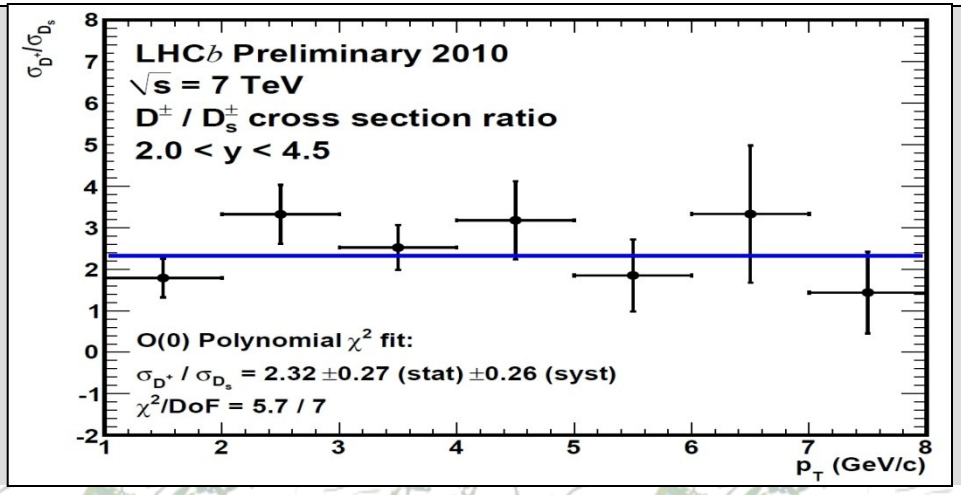


D^+ cross-section

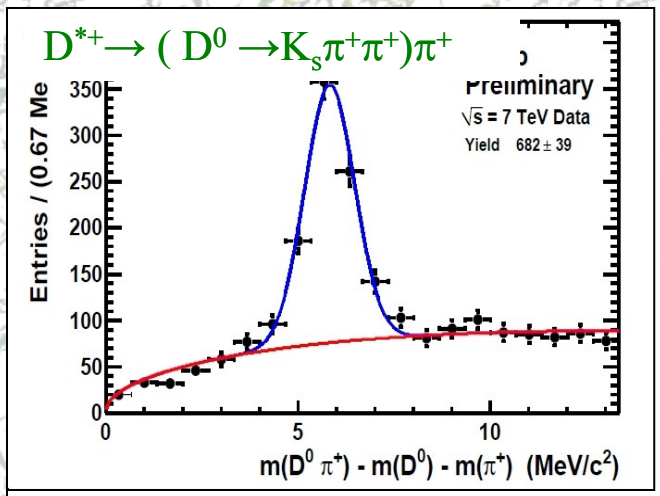


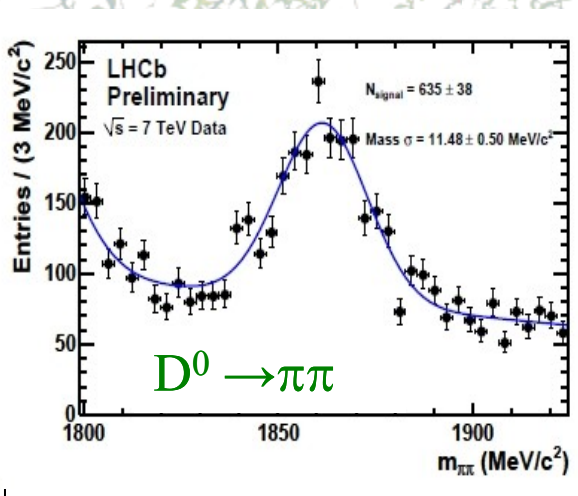
D_s cross-section

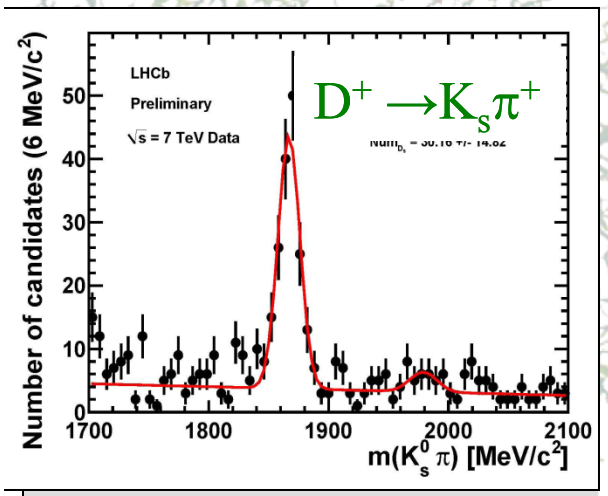


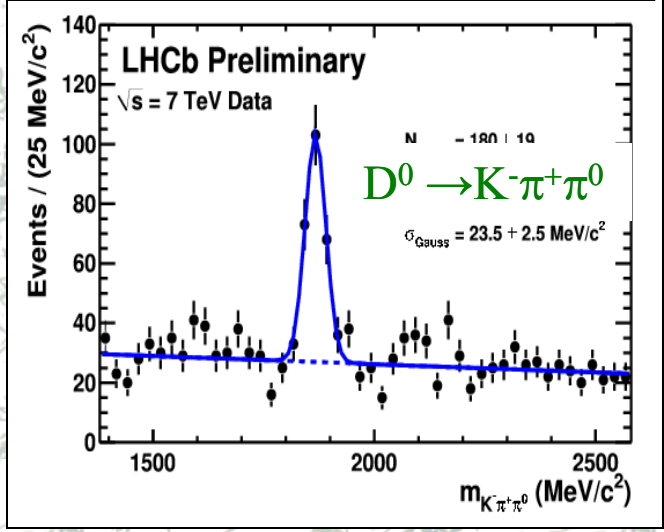


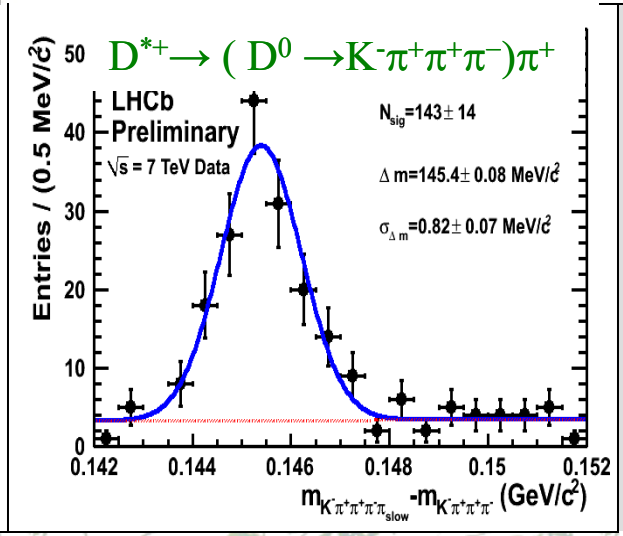
Other Charm peaks





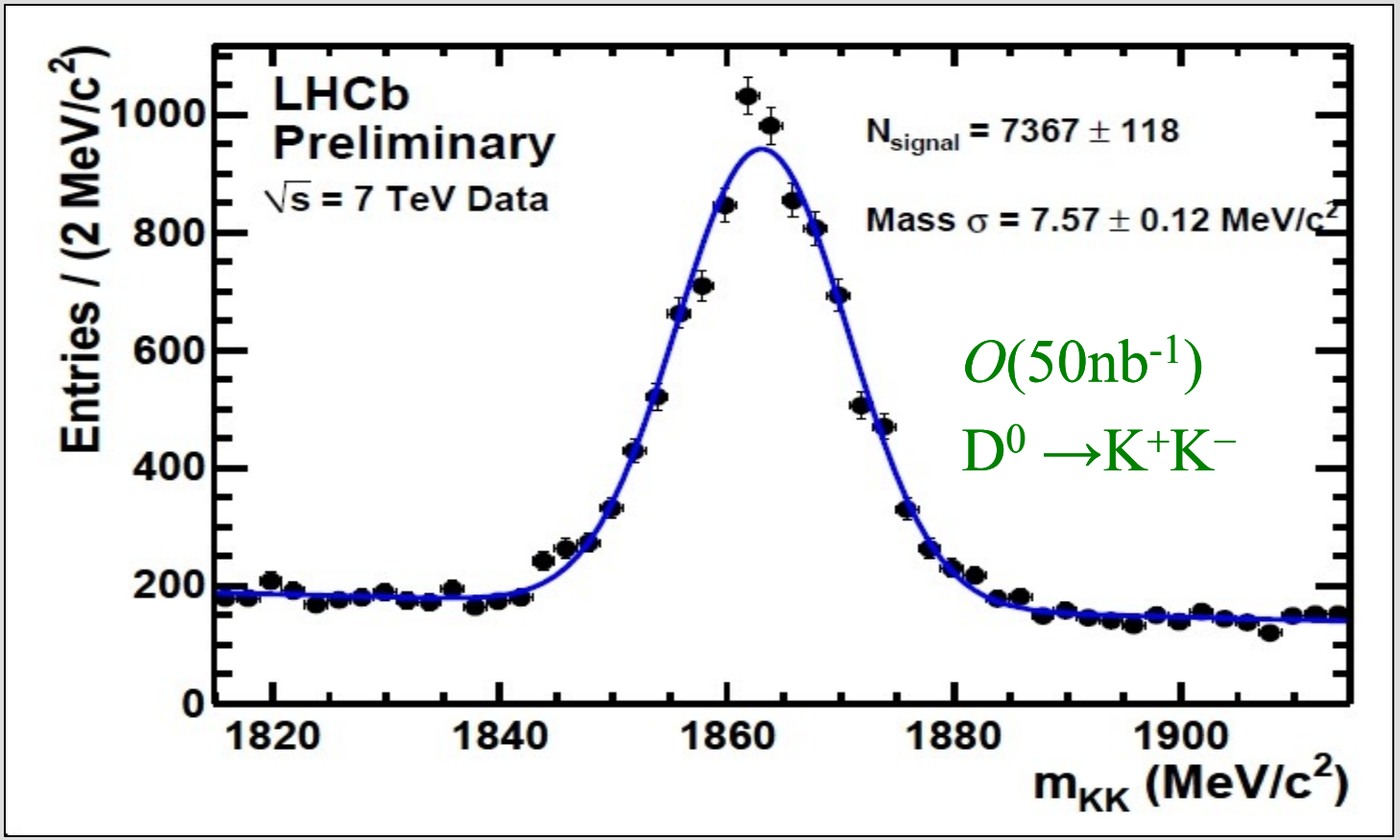






Prospects with Charm

- Huge yields are expected for $O(100\text{pb}^{-1})$



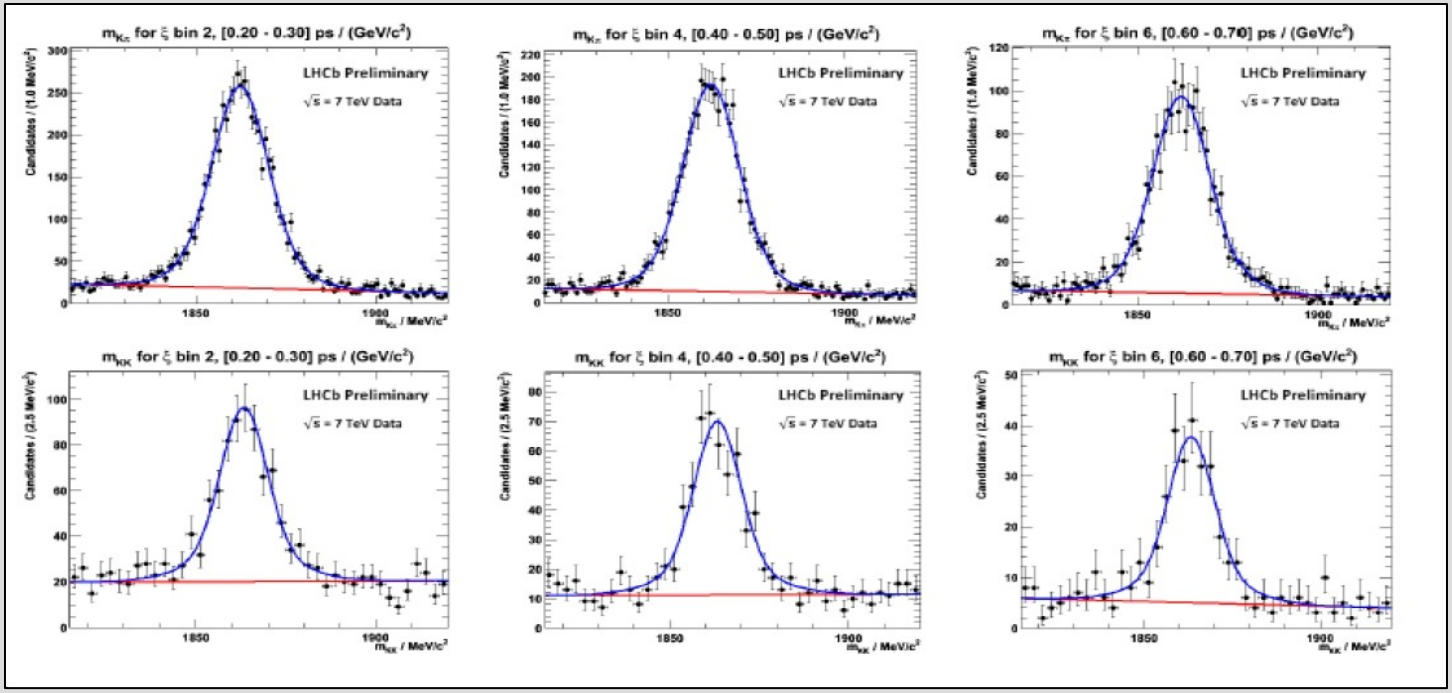
Probe New Physics in charm

y_{CP} from lifetime difference between $D^0 \to KK$ and $D^0 \to K\pi$

Proper lifetime →

$D^0 \to K\pi$

$D^0 \to KK$



Probe New Physics in charm

- Mixing parameters x'^2 and y [LHCb-2007-049]

  $N(D^0 \to K\pi, \text{wrong sign}) = 2.5\times10^3 / 100\ pb^{-1}$ with B/S~2.5

- Search for direct CP-violation in $D^+ \to K^-K^+\pi^+$

- Search for rare $D^0 \to \mu^+\mu^-$

  expected UL 4×10^{-8} @ 90CL for 100 pb^{-1}

Summary

- LHCb is a great detector for charm physics
  - High Rate
  - Good momentum and spatial resolution
  - Particle identification
- LHCb has started successfully its charm physics program with the observation of charm peaks and measurement of open charm cross section
- Year 2k+10 and 2k+11
  - High statistics measurements in charm sector

Stay tuned

The basic principles of event selection

- Selection of good tracks: χ^2(track)/DoF
- Use particle identification to separate kaons from pions
  - "large" $\Delta_{LL}(K-\pi)$ for kaons,
  - "large" $\Delta_{LL}(\pi-K)$ for pions
- Pointing criteria for final state particles:
  - "large" χ^2 for impact parameter χ^2(IP)
- Pointing criteria for mother particle
  - "small" χ^2 for impart parameter χ^2(IP)
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  - "large" χ^2 of vertex separation: χ^2(flight)
  - "large" lifetime $c\tau$