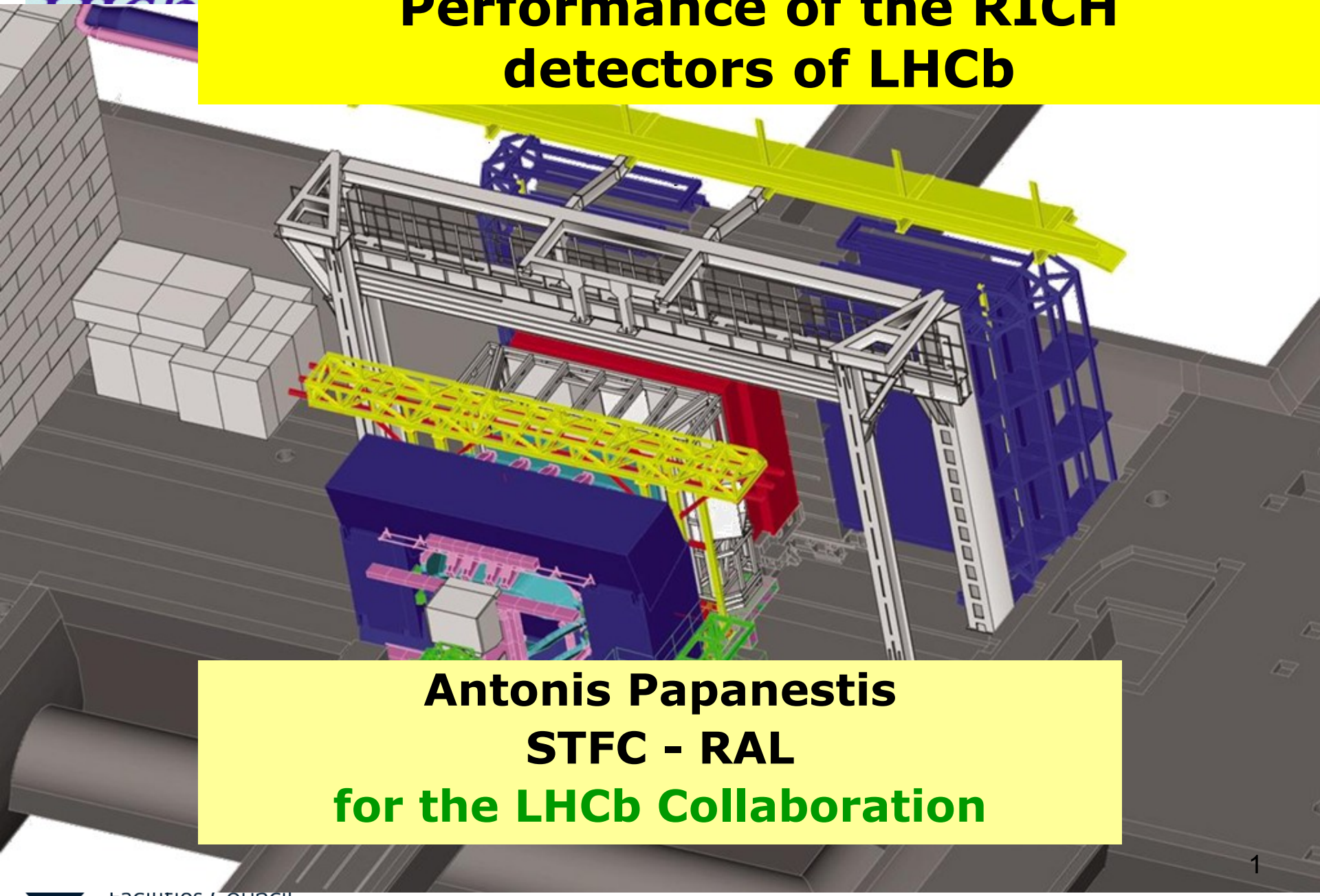
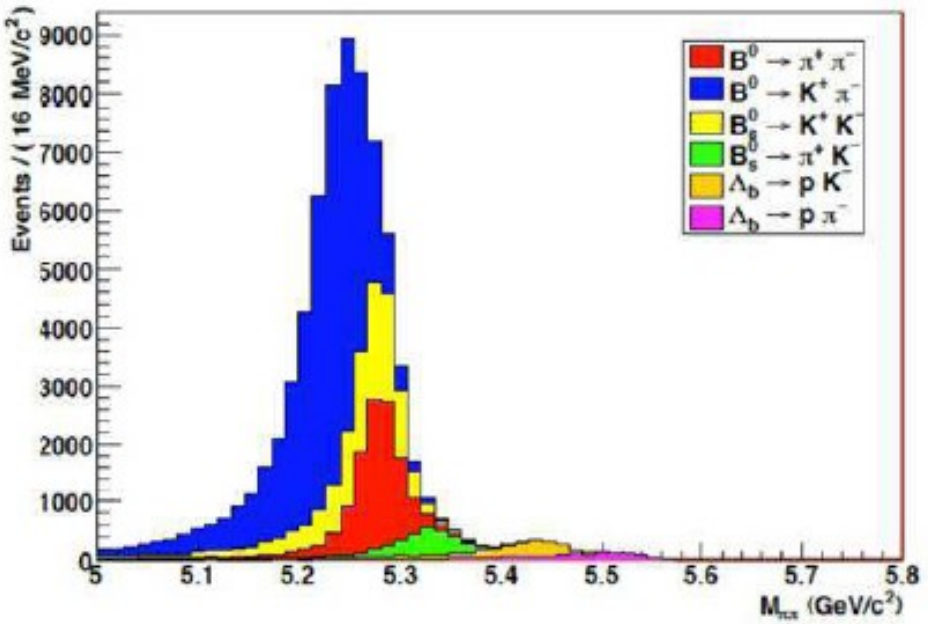
Performance of the RICH detectors of LHCb



Antonis Papanestis
STFC - RAL
for the LHCb Collaboration

Outline

- Detector description:
  - See previous talk by Davide Perego.
- Cherenkov angle resolution
  - Alignment
  - Corrections for the magnetic field distortions.
- Particle identification
  - PID algorithm.
- Small selection of physics results that depend on particle ID.



Monte Carlo simulation of the invariant mass for B->hh decays

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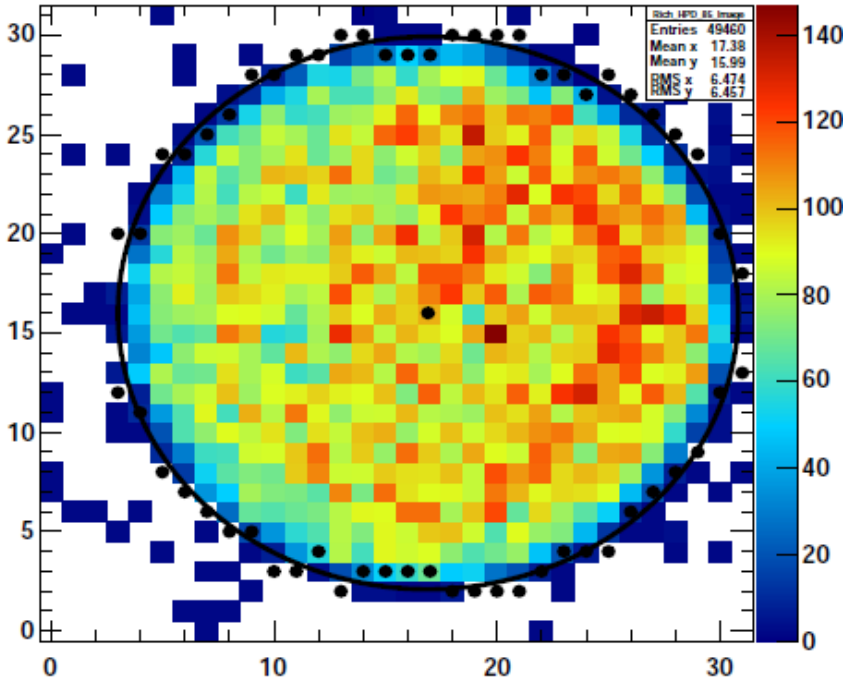
Anode image fitting

- Position of the photocathode image on the anode can change.
- Anode images are cleaned and a Sobel filter is used to detect the edge.
- Automated procedure, updates the position of the photo-cathode centre in Conditions Database



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Magnetic field corrections

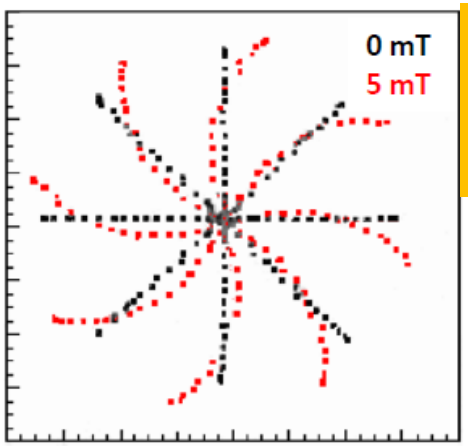
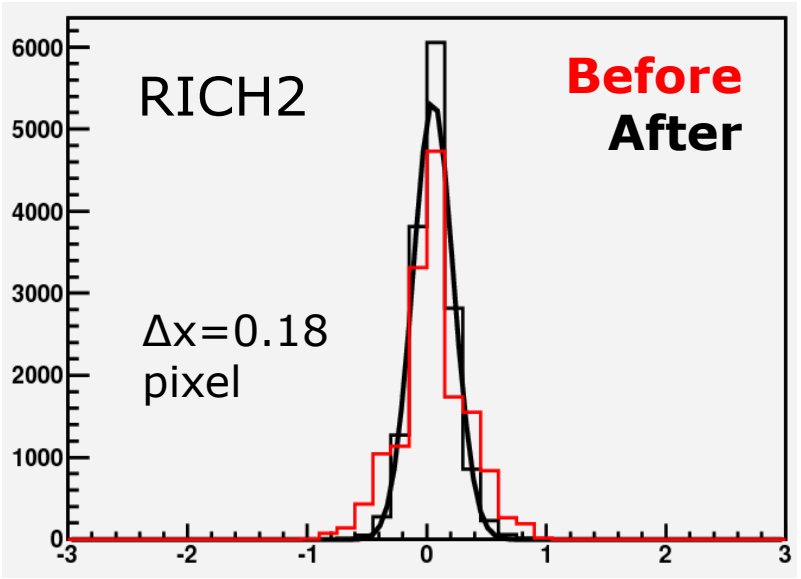
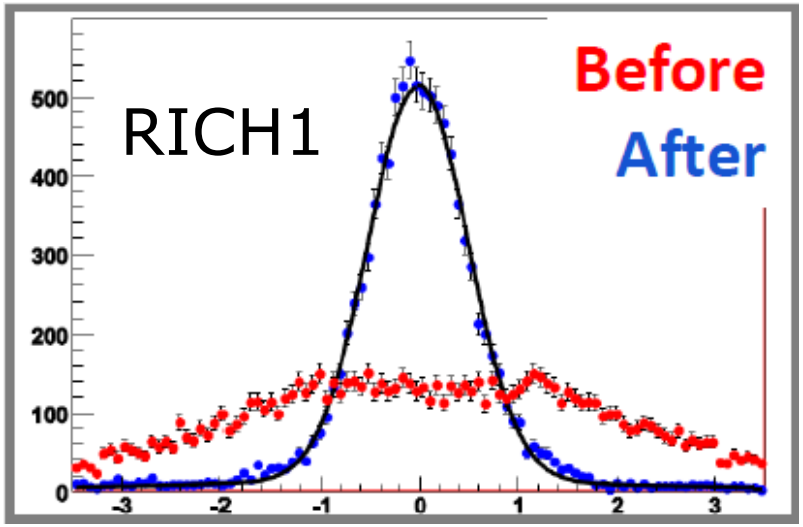


Image distortion due to magnetic field





Projection of test pattern without and with magnetic field to extract correction parameters

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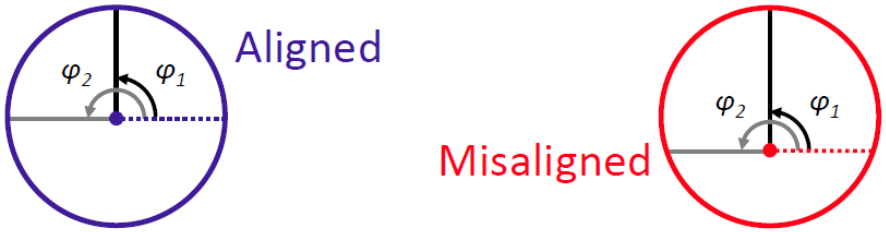
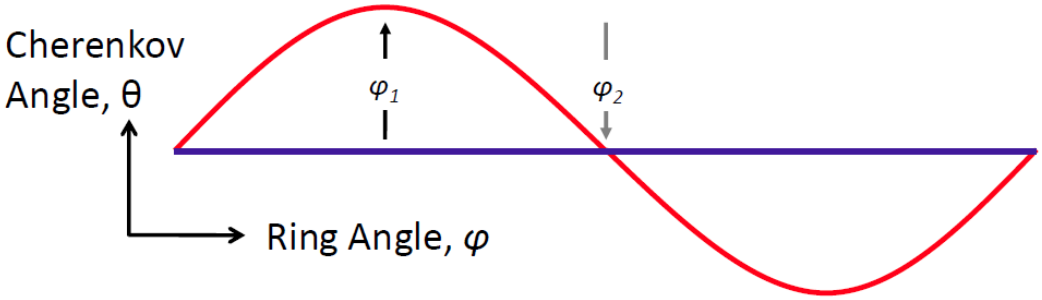
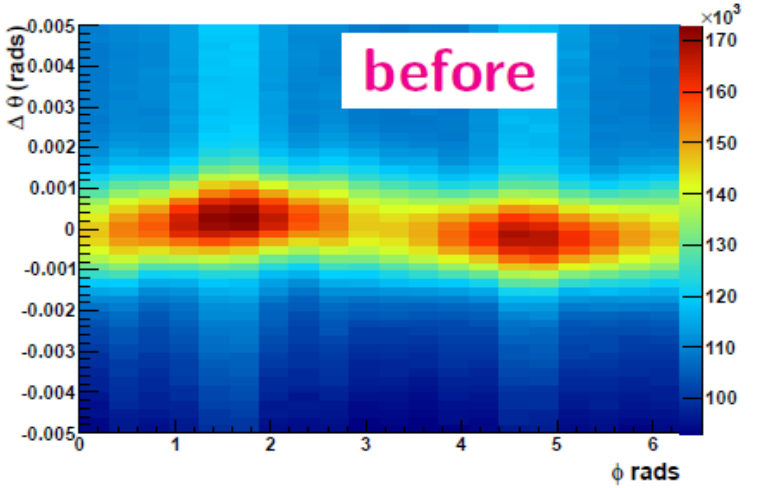
Alignment

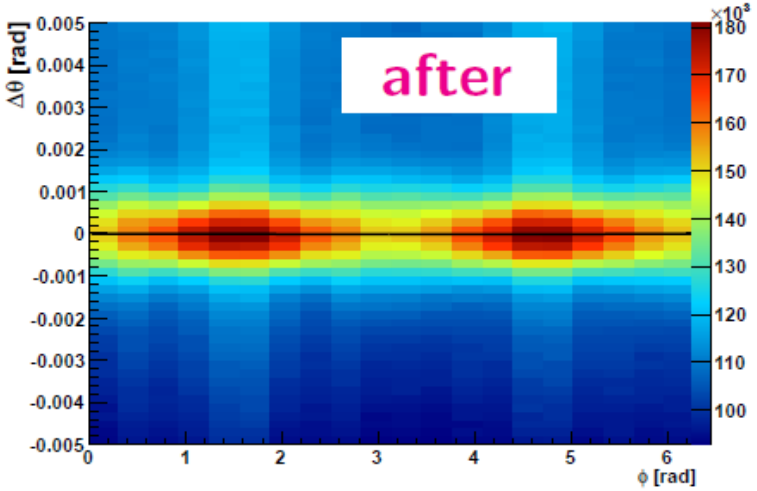
Detector	RICH1	RICH2
Si sensors	196	288
Photo-detectors	196	288
Mirrors	20	96



Seen as a distribution $\Delta\theta = A\sin\varphi + B\cos\varphi$:







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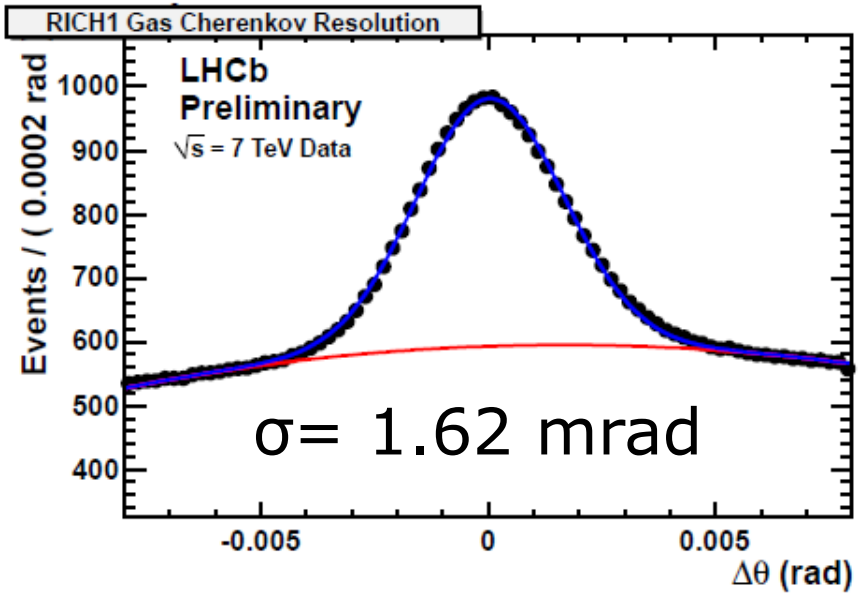
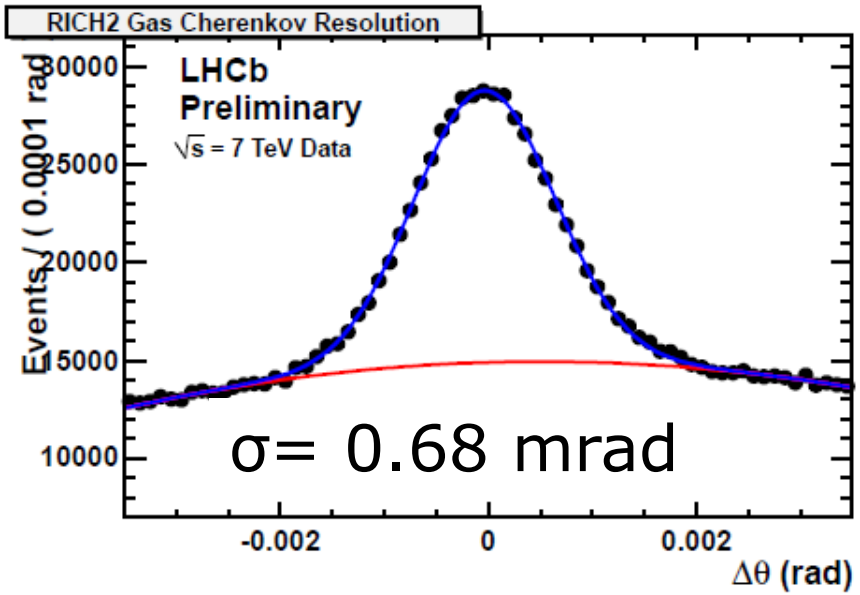
Cherenkov angle resolution (i)

Typical run

RICH 1



RICH 2



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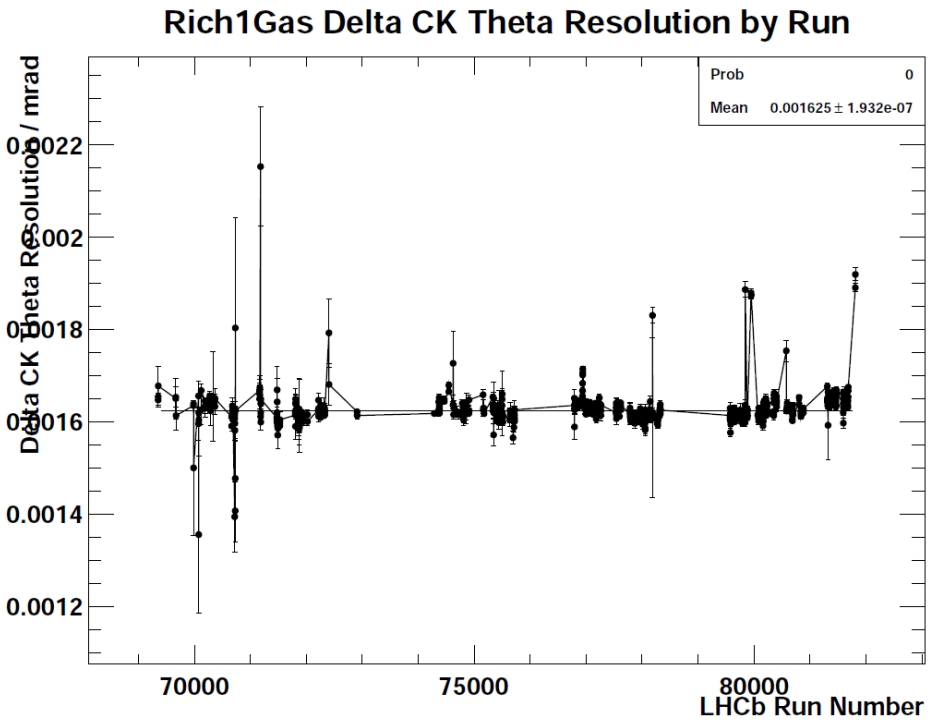
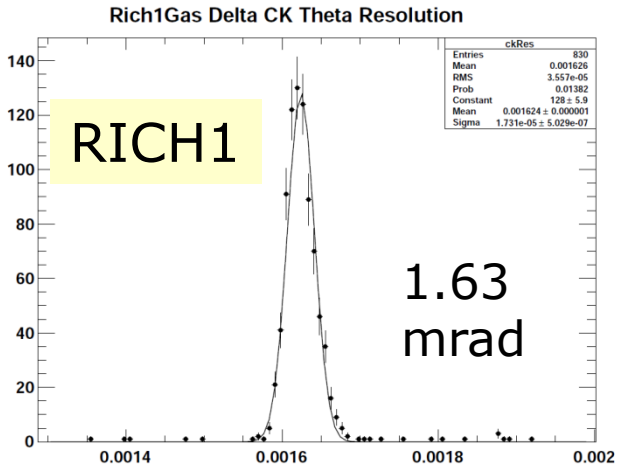
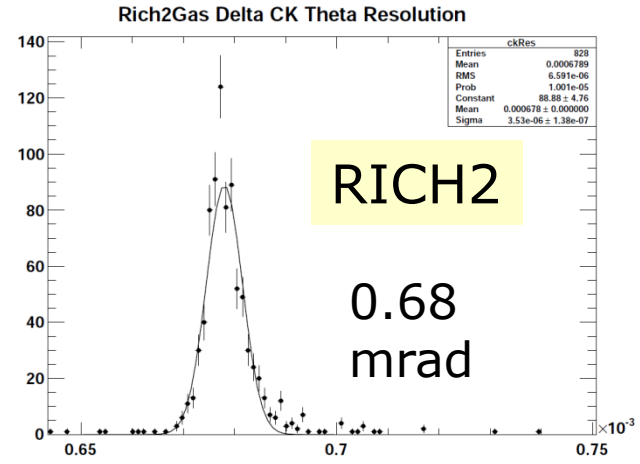
Cherenkov angle resolution (ii)

Resolution distribution of all 2010 runs
Very good stability in time



Resolution in time





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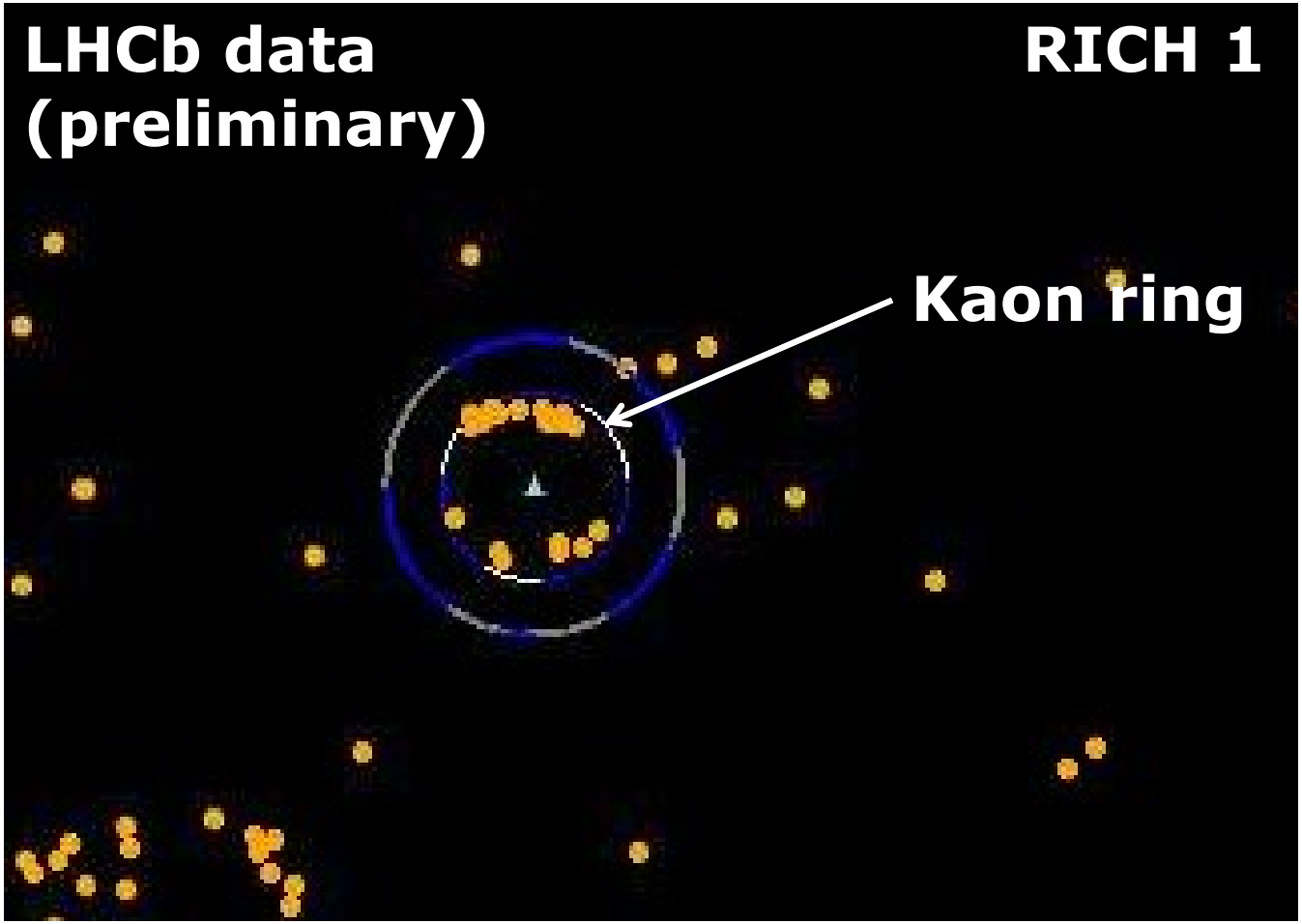
Particle ID performance



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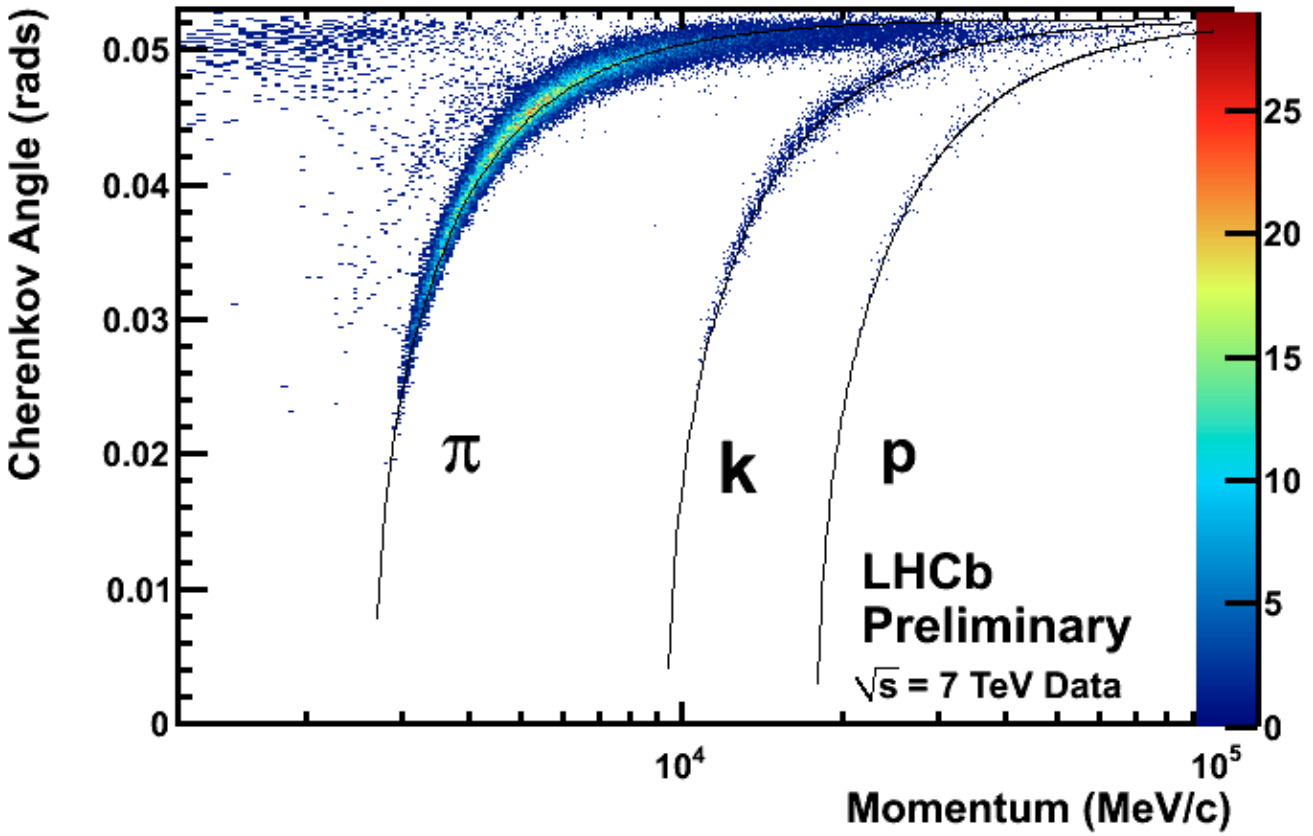
Using isolated rings

Cherenkov angle vs momentum in RICH1



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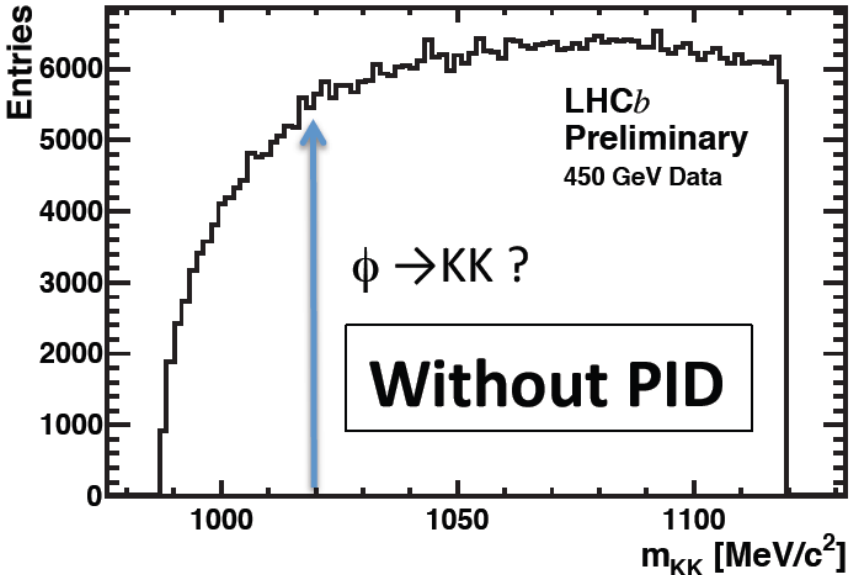
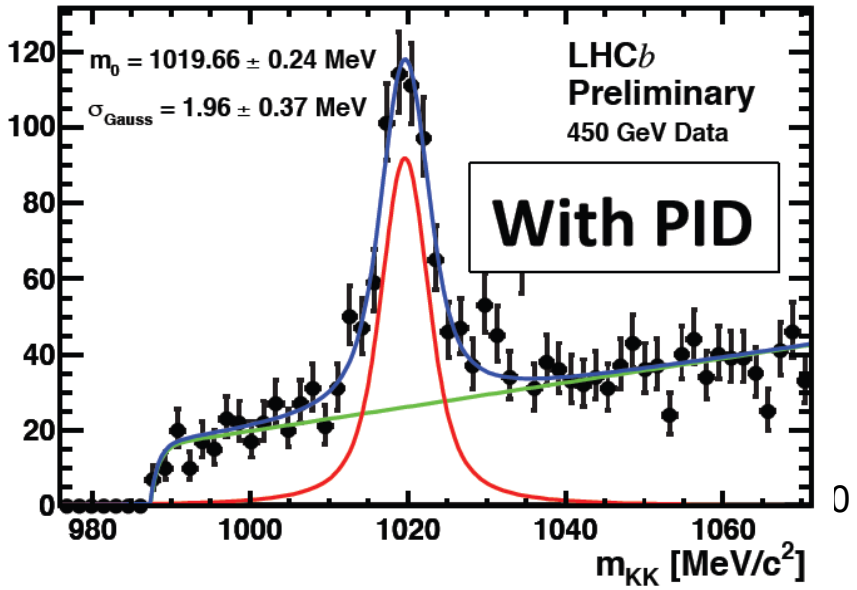
PID algorithm

- Global event likelihood algorithm.
- Likelihood function includes expected contributions from signal plus background for every pixel.
- Signal photons come from the track that generated the ring, background can be noise or Cherenkov light from other tracks.
- The whole event is considered as a whole.
- Performs better than methods that treat every track separately, especially at high occupancies with overlapping rings.





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Calibration samples

- To determine ID and mis-ID rates pure samples of particles are needed:
  - $K^{\pm}$, $\pi^{\pm}$, p
  - Identified without the use of any PID.
- Exploit:
  - V0-decays
    - $K^0_s \rightarrow \pi^+\pi^-$
    - $\Lambda^0 \rightarrow p\pi^-$
  - Resonances
    - $\phi(1020) \rightarrow K^+K^-$

Selected via kinematic cuts alone

'Tag-and-Probe' : PID applied to 'tag' track, unbiased 'probe' used to assess K performance

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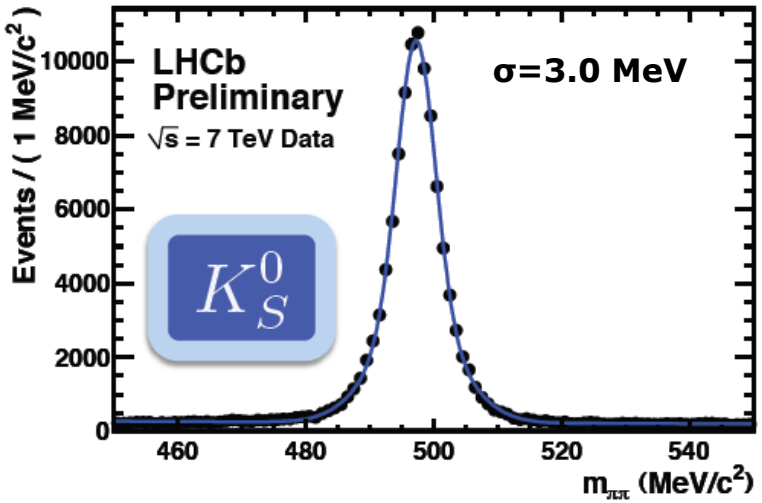
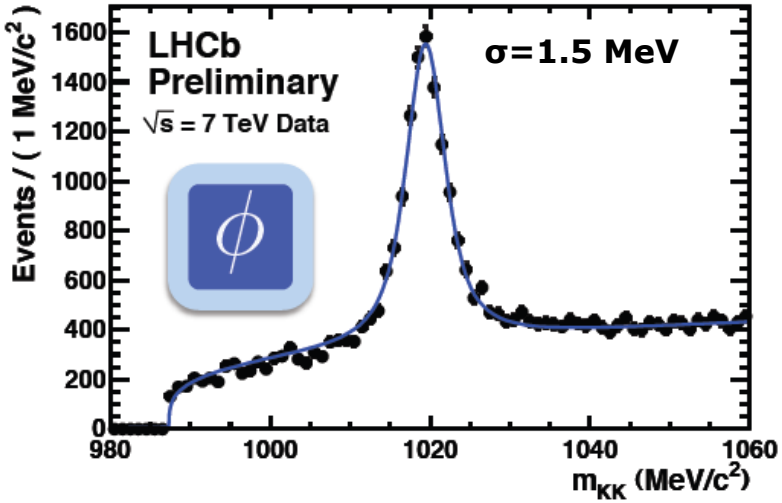
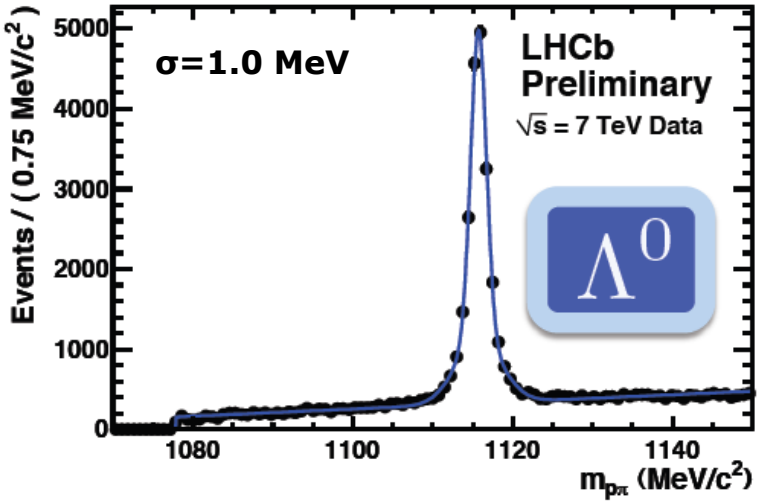
Particle samples







- High purity obtainable in V0's
- Dominant background present in Inclusive ϕ sample
- Extract true kaon distributions through 'sPlots' technique†

†Nucl. Inst. & Meth. A 555 (2005) 356-369

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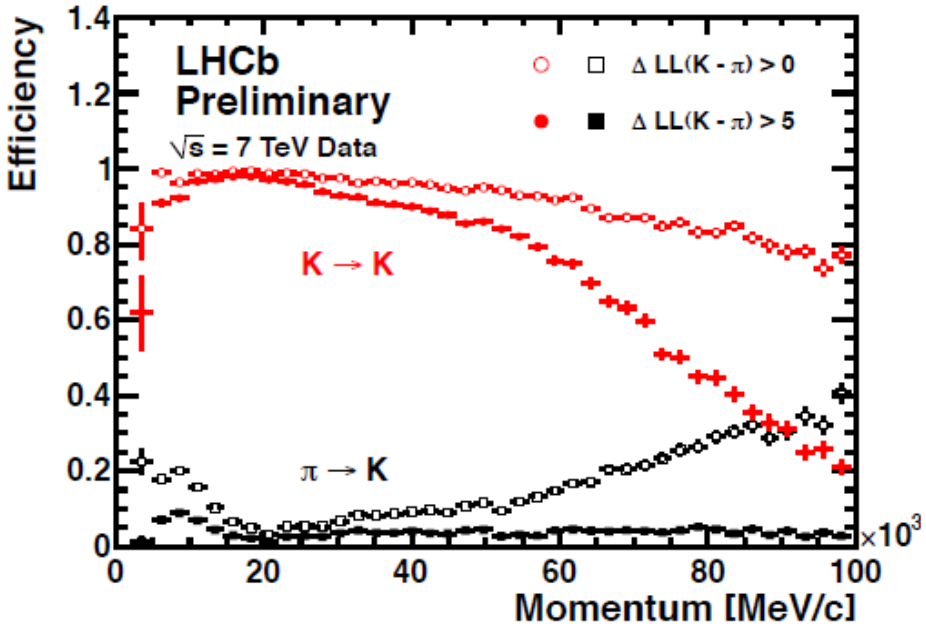
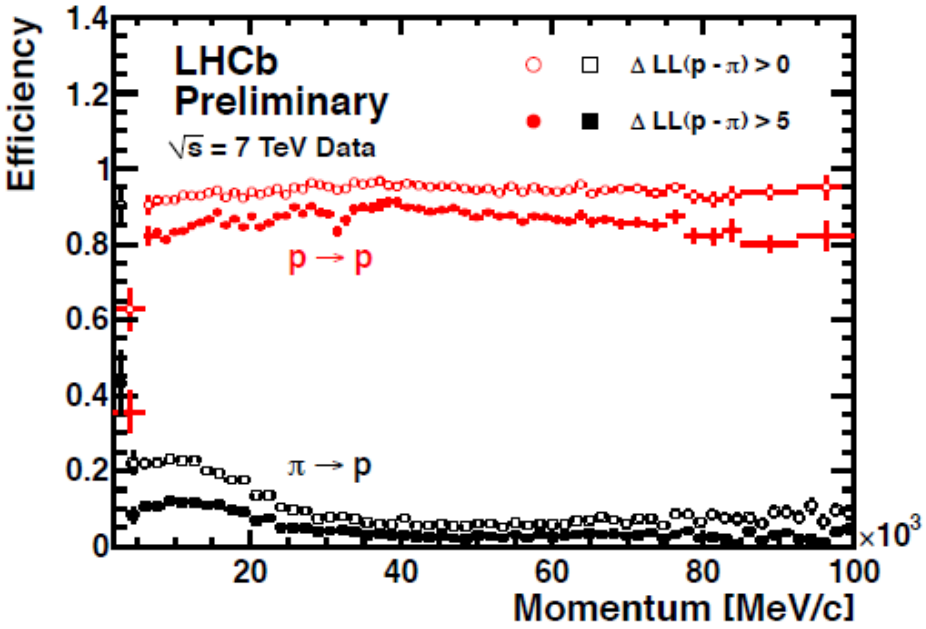
PID performance

π / K



π / p



Improvement expected at the next reprocessing

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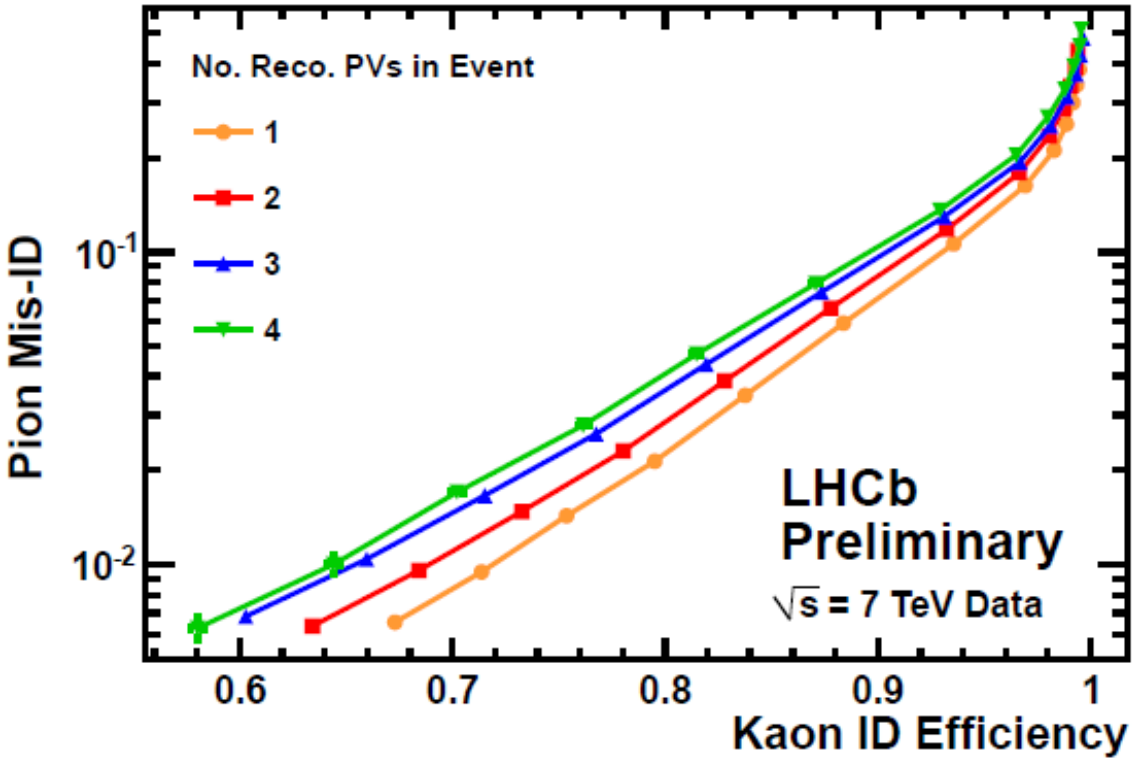
More on performance

Particle ID performance of the RICH detectors for different number of primary vertices



Robust performance in a challenging environment

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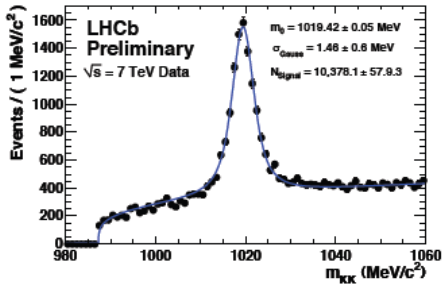
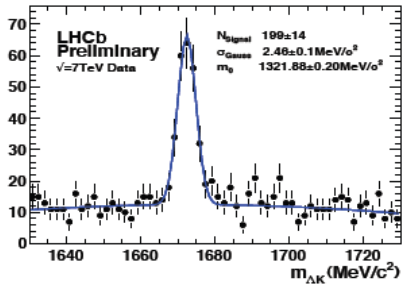
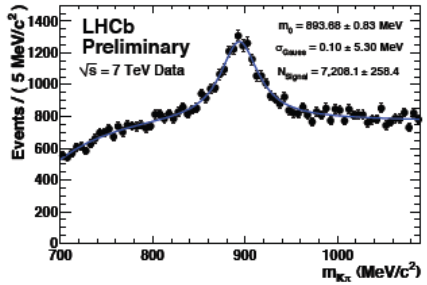
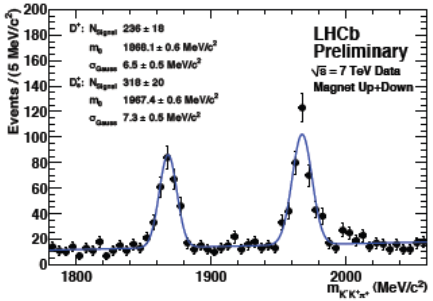
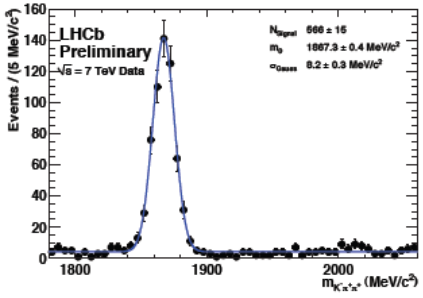
RICH physics potential

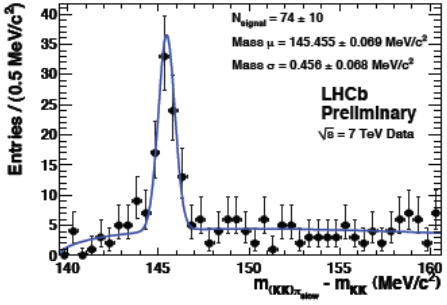












$$\phi \to K^+K^-$$

$$\Omega^- \to \Lambda K^-$$

$$K^*(892) \to K^\pm\pi^\mp$$

$$D^+ \to K^+K^-\pi^+$$

$$D^+ \to K^-\pi^-\pi^+$$

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

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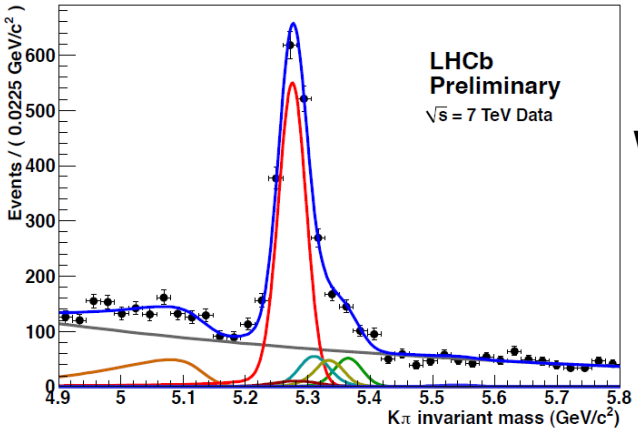
Physics analysis (i)

Measurement of direct CP violation in charmless charged two-body B decays at LHCb (LHCb-CONF-2011-011)

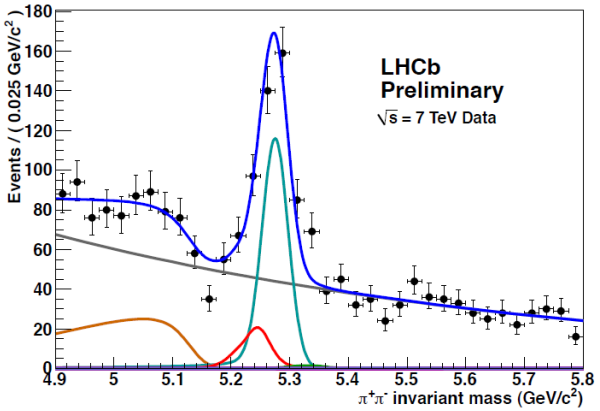
Without PID dominated by:

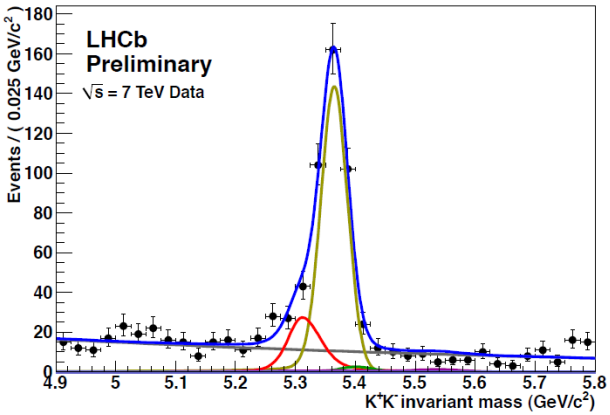
$B \to K\pi$



$B \to hh$

with kinematic cuts only





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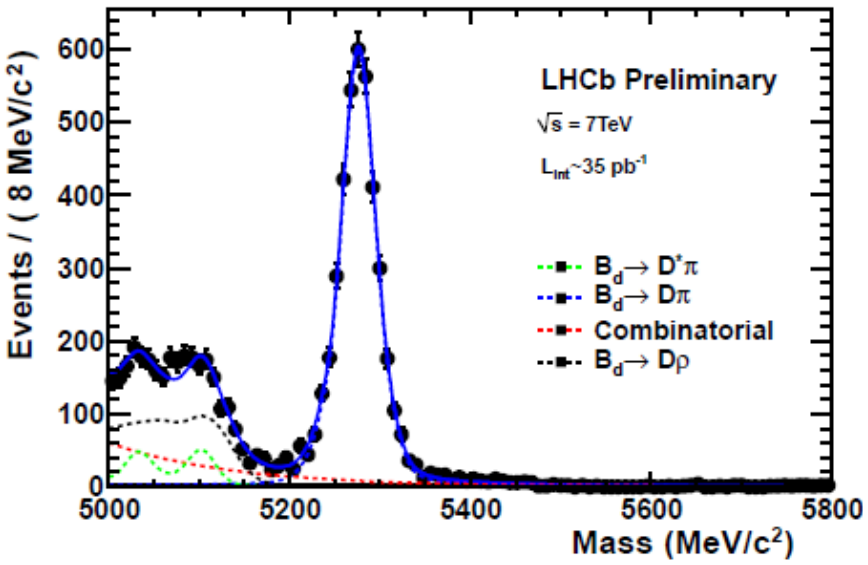
$B \to \pi^+\pi^-$

$B \to K^+K^-$

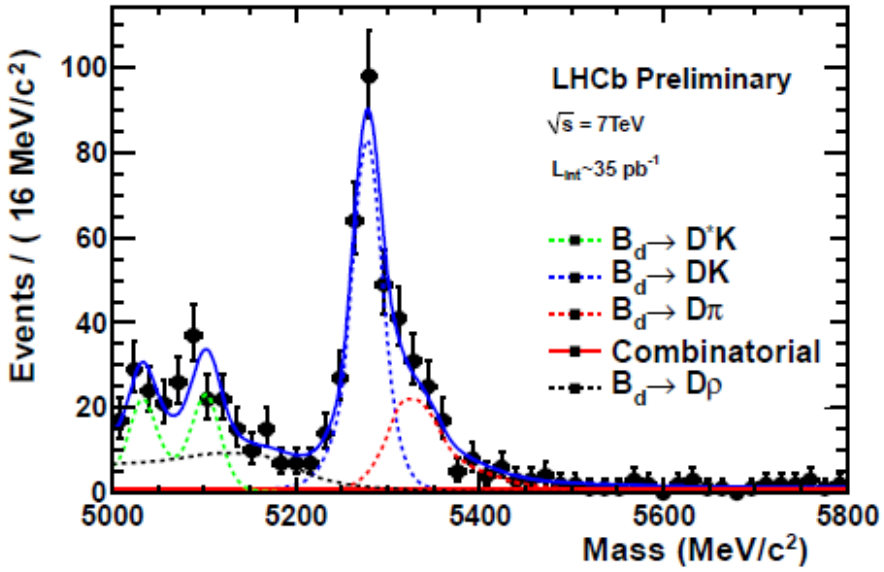
Physics Analysis (ii)

Measurement of the relative yields of the decay modes $B^0 \to D^- \pi^+$, $B^0 \to D^- K^+$, $B^0_s \to D^-_s \pi^+$, and determination of fs/fd for 7 TeV pp collisions (LHCb-CONF-2011-013)

No combinatorial background



$B_d \to D\pi$



$B_d \to DK$

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Conclusions

- The alignment and calibration of the LHCb RICH detectors has been successful, and the detector is performing according to expectations.
- The particle identification performance has been evaluated with data and looks very promising and further improvement is expected.
  - Robust performance in a high background environment.
- The ability to distinguish pions from kaons from protons over a wide momentum range using the RICH system is an essential part of many LHCb physics analyses.