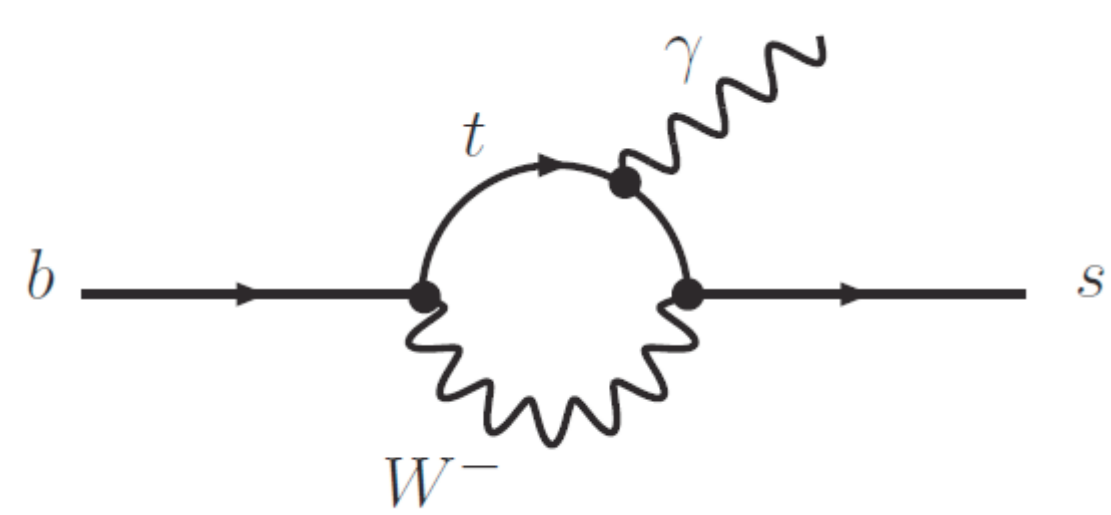


Introduction

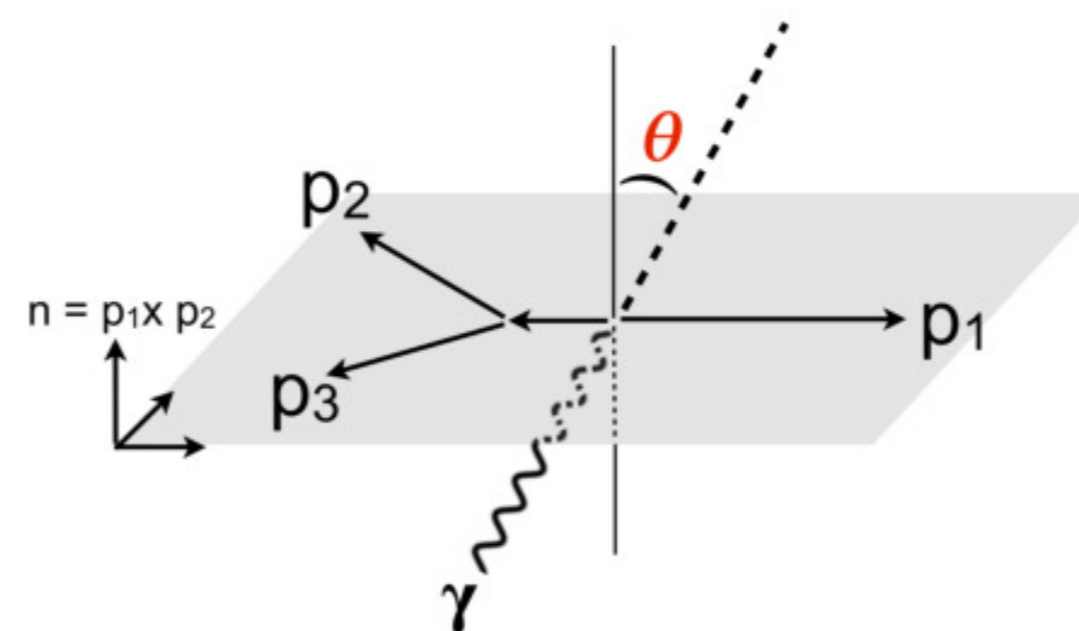
We study for the first time the flavour-changing neutral-current radiative $B^+ \rightarrow K^+ \pi^- \pi^+ \gamma$ decay at LHCb, looking for new physics effects that may arise in the $b \rightarrow s \gamma$ electroweak penguin loop, and could affect CP asymmetry and photon polarization. The aim of this study is to provide the first measurement of \mathcal{A}_{CP} and set the basis for the investigation of photon polarization in radiative decays at LHCb.

The analysis is performed on the 2012 data sample, corresponding to an integrated luminosity of $\sim 2 \text{ fb}^{-1}$ collected in pp collisions at 8 TeV center of mass energy. The signal sample contains all possible intermediate kaon resonances in the hadronic $K^+ \pi^- \pi^+$ system.



The up-down asymmetry[†] \mathcal{A}_{UD} , obtained counting the number of photons in the *up* and *down* hemispheres with respect to the plane defined by the hadronic system, is expected to be proportional to the polarization of the photon λ_γ .

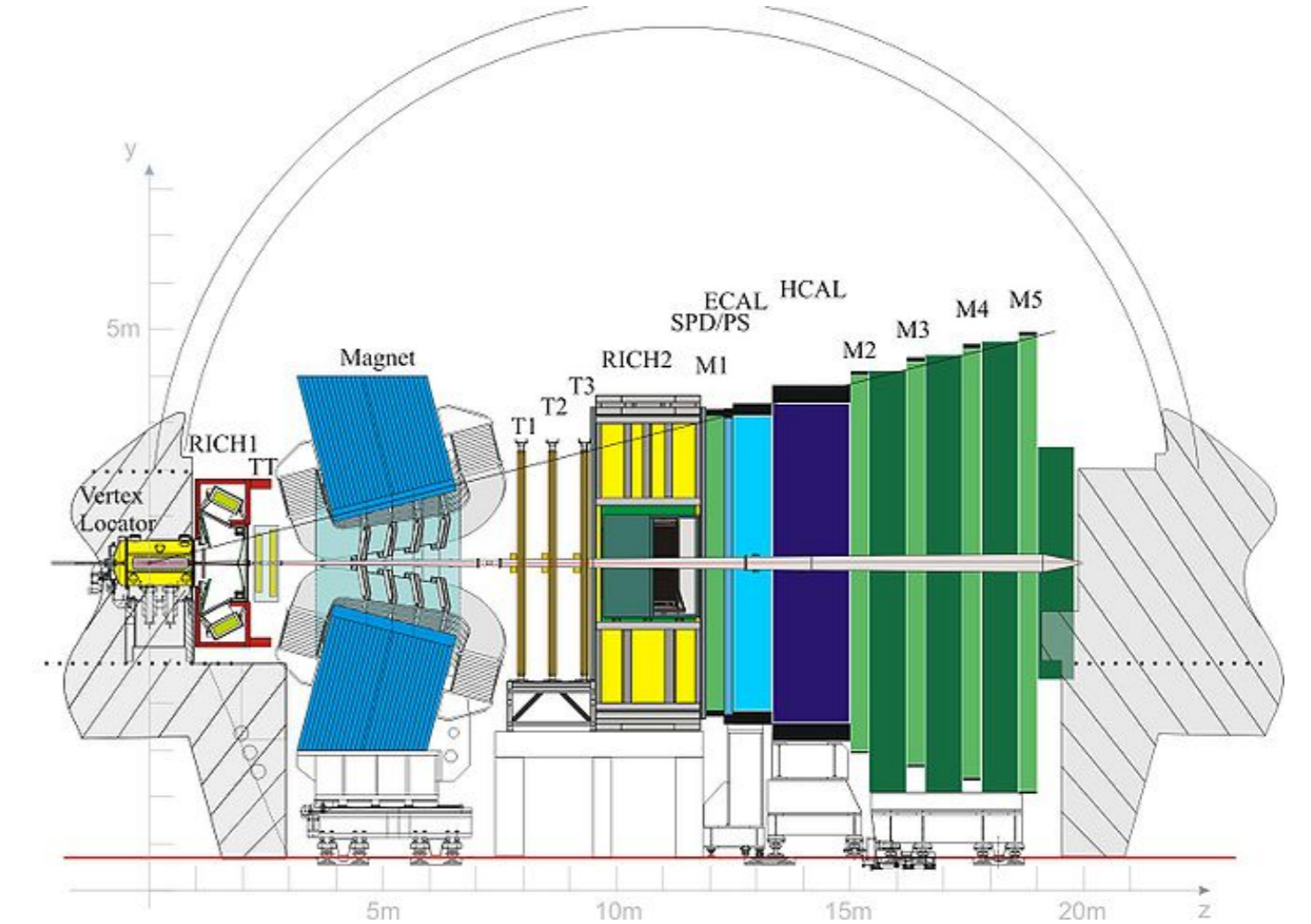
With further development of theoretical predictions, the asymmetries obtained in this analysis may be used to extract a value for photon polarization. This would be the first measurement of such quantity, and could help constraining the effects of physics beyond the Standard Model in the $b \rightarrow s \gamma$ sector.



[†]Gronau, Y. Grossman, D. Pirjol, A. Ryd, PRL 88 (2002) 051802
 E. Kou, A. Le Yaouanc, A. Tayduganov, PRD 83 (2011) 094007

The LHCb detector

The LHCb detector is a single-arm spectrometer designed for precision studies of b physics in the forward direction.



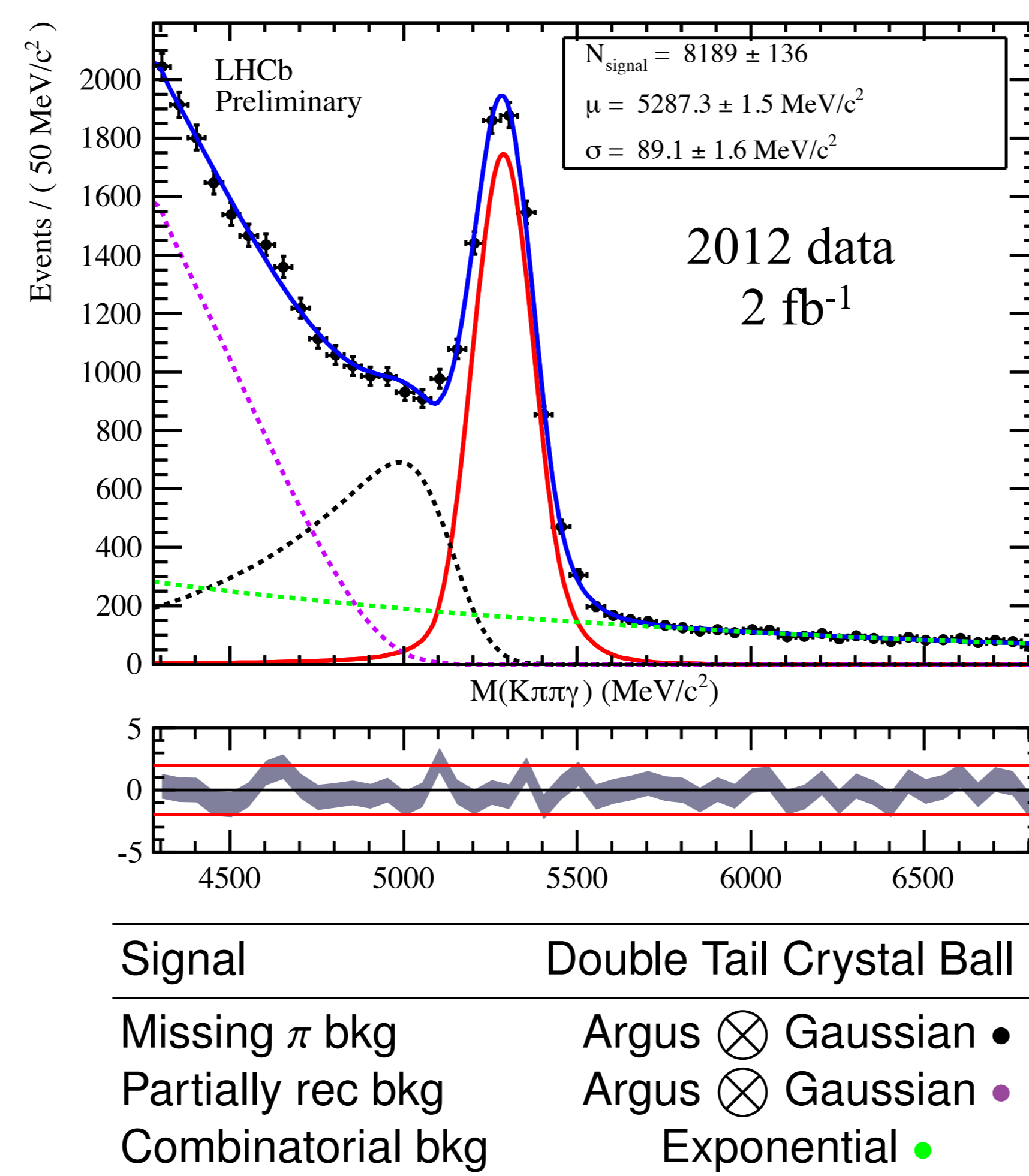
The detector is characterized by a large coverage in rapidity ($2 < \eta < 5$), an excellent tracking resolution ($\Delta p/p < 0.35 - 0.55\%$) and very good PID performances.

The high-granularity calorimeter (ECAL+HCAL), of particular interest for radiative decays, is responsible for the identification of γ , π^0 , high- p_T e^\pm and hadrons, and for the L0 photon trigger.

Event selection

Track p	> 2000	MeV/c
Max track p_T	> 1200	MeV/c
Min track p_T	> 500	MeV/c
Track χ^2	< 3	
Track IP χ^2	> 25	
Track ghost probability	< 0.4	
Kaon ID: $\Delta \ln \mathcal{L}_{K-\pi}$	> 0	
Pion ID: $\Delta \ln \mathcal{L}_{K-\pi}$	< 5	
Resonance vertex χ^2	< 9	
Resonance mass window	[1100, 1900]	MeV/c ²
Photon E_T	> 3000	MeV
Photon confidence level	> 0.25	
Photon and tracks $\sum p_T$	> 5000	MeV/c
Photon/ π^0 separation	> 0.6	
B vertex χ^2	< 9	
B flight distance χ^2	> 100	
$K^+ \pi^- \pi^0$ mass	> 2000	MeV/c ²
$\pi^+ \pi^0$ mass	> 1100	MeV/c ²
Fiducial cut for \mathcal{A}_{CP}	$ p_x \leq 0.317(p_z - 2400)$	MeV/c

Full statistics fit



More than 8000 events are observed

$$N = 8189 \pm 136$$

\mathcal{A}_{CP} fit

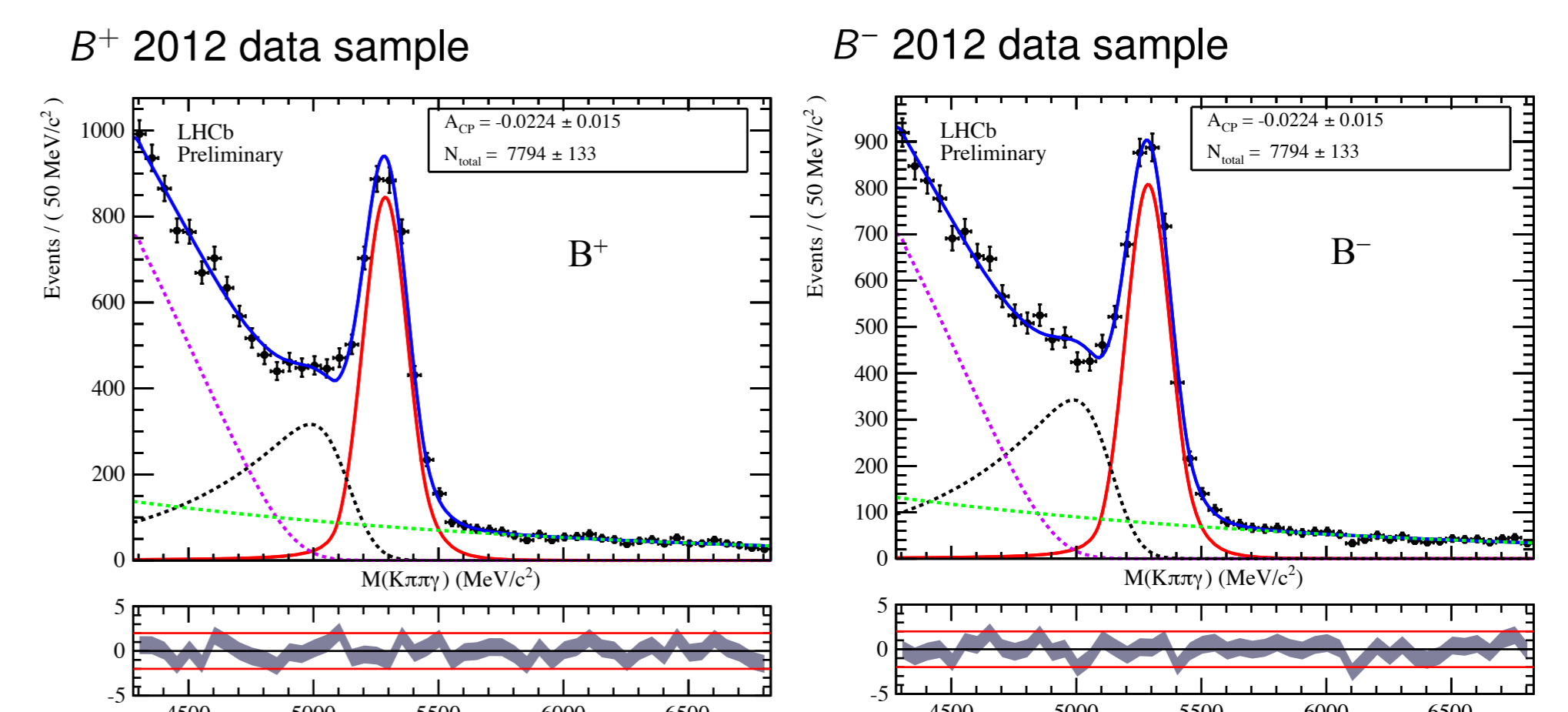
\mathcal{A}_{CP} asymmetry is obtained fitting simultaneously the B^+ and B^- data samples according to the formula

$$N^\pm = \frac{1}{2} N (1 \mp \mathcal{A}_{CP}^{\text{raw}})$$

From the fit we extract the value

$$\mathcal{A}_{CP}^{\text{raw}} = -0.022 \pm 0.015$$

Raw CP asymmetry has to be corrected for detection and production asymmetries, studied in other decay channels at LHCb.



Up-down asymmetry fit

\mathcal{A}_{UD} is obtained fitting simultaneously in the categories defined by the sign of the B mesons and the direction of the photons according to

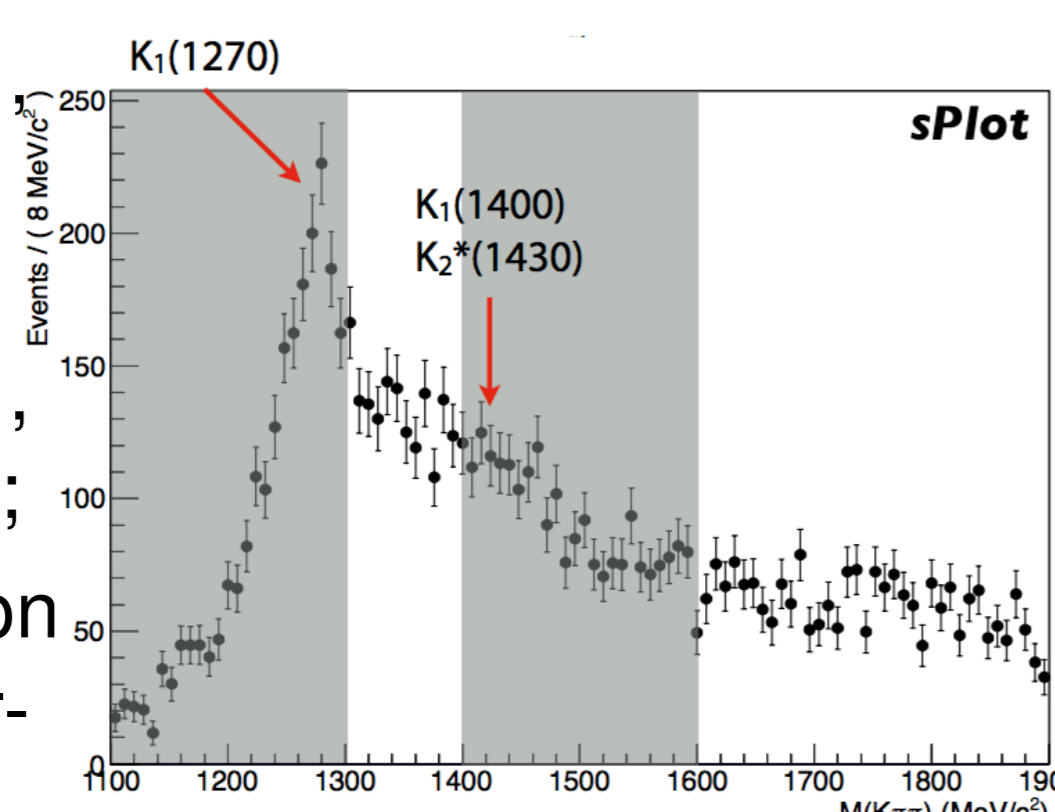
$$U^\pm = \frac{1}{4} N^\pm (1 \pm \mathcal{A}_{UD}^\pm)$$

$$D^\pm = \frac{1}{4} N^\pm (1 \mp \mathcal{A}_{UD}^\pm)$$

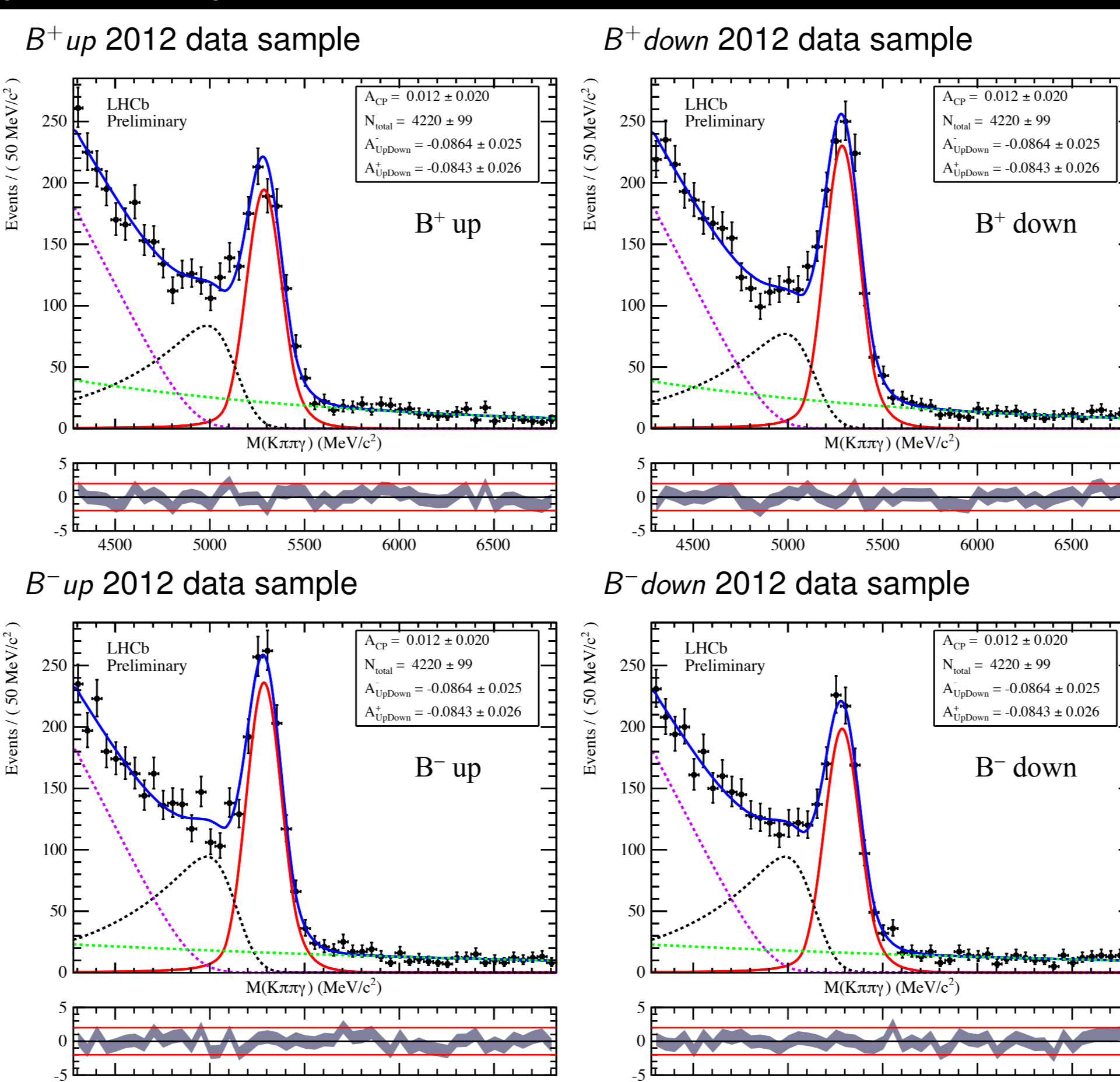
The values \mathcal{A}_{UD}^+ and \mathcal{A}_{UD}^- are fitted separately, then combined under the assumption that $|\lambda_\gamma|$ is the same for B^+ and B^- as expected in the Standard Model.

The fit is performed in the highlighted area of the $m_{K\pi\pi}$ spectrum:

- $m_{K\pi\pi} \in [1.1, 1.3] \text{ GeV}/c^2$ almost pure $K_1(1270)$ sample;
- $m_{K\pi\pi} \in [1.4, 1.6] \text{ GeV}/c^2$, suggested from theory[†];
- in the intermediate region \mathcal{A}_{UD} is diluted from interferences.



[†]Gronau et al, PRL 88 (2002) 051802



From the fit we extract the values

$$\mathcal{A}_{UD}^+ = -0.084 \pm 0.026$$

$$\mathcal{A}_{UD}^- = -0.086 \pm 0.025$$

Conclusions

The inclusive $B^\pm \rightarrow K^\pm \pi^\mp \pi^\pm \gamma$ decay has been studied in 2 fb^{-1} of data collected by the LHCb detector at 8 TeV center of mass energy.

The CP asymmetry of this channel has been extracted for the first time, and has been found to be compatible with zero:

$$\mathcal{A}_{CP} = -0.007 \pm 0.015 (\text{stat})_{-0.011}^{+0.012} (\text{syst})$$

Finally, the up-down asymmetry, has been studied for the first time in a region of interest in the $K\pi\pi$ mass spectrum, separately for B^+ and B^- . The combined value is 4.5σ away from zero, showing evidence for photon polarization in $b \rightarrow s \gamma$ transitions:

$$\mathcal{A}_{UD} = -0.085 \pm 0.019 (\text{stat}) \pm 0.004 (\text{syst})$$

This is equivalent to stating that evidence has been found of parity violation in such decays.