Universitat de Barcelona

Institut de Ciències del Cosmos

Radiative B Decays in LHCb

International Meeting on Fundamental Physics

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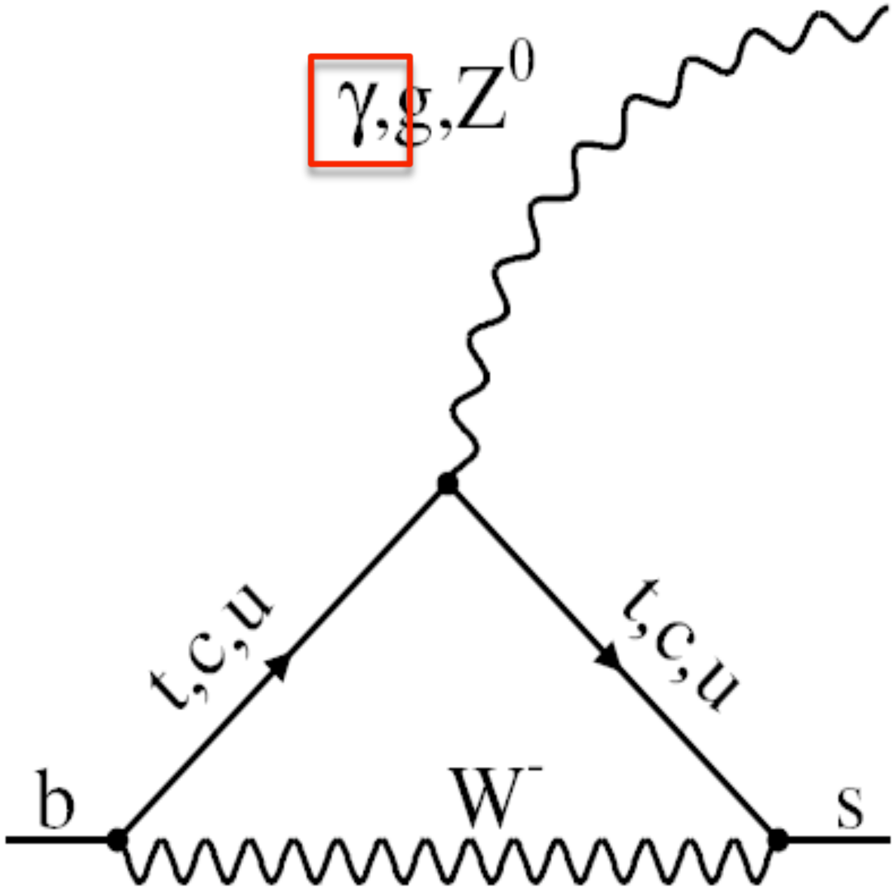
γ,g,Z0
t,c,u
t,c,u
b
W-
s

Penguin decays of B mesons

- In the SM, flavor-changing neutral currents (FCNC) are forbidden
- Effective FCNC are introduced by penguin diagrams.
  - Combinations of CKM matrix elements
  - Sensitive to new physics (NP)

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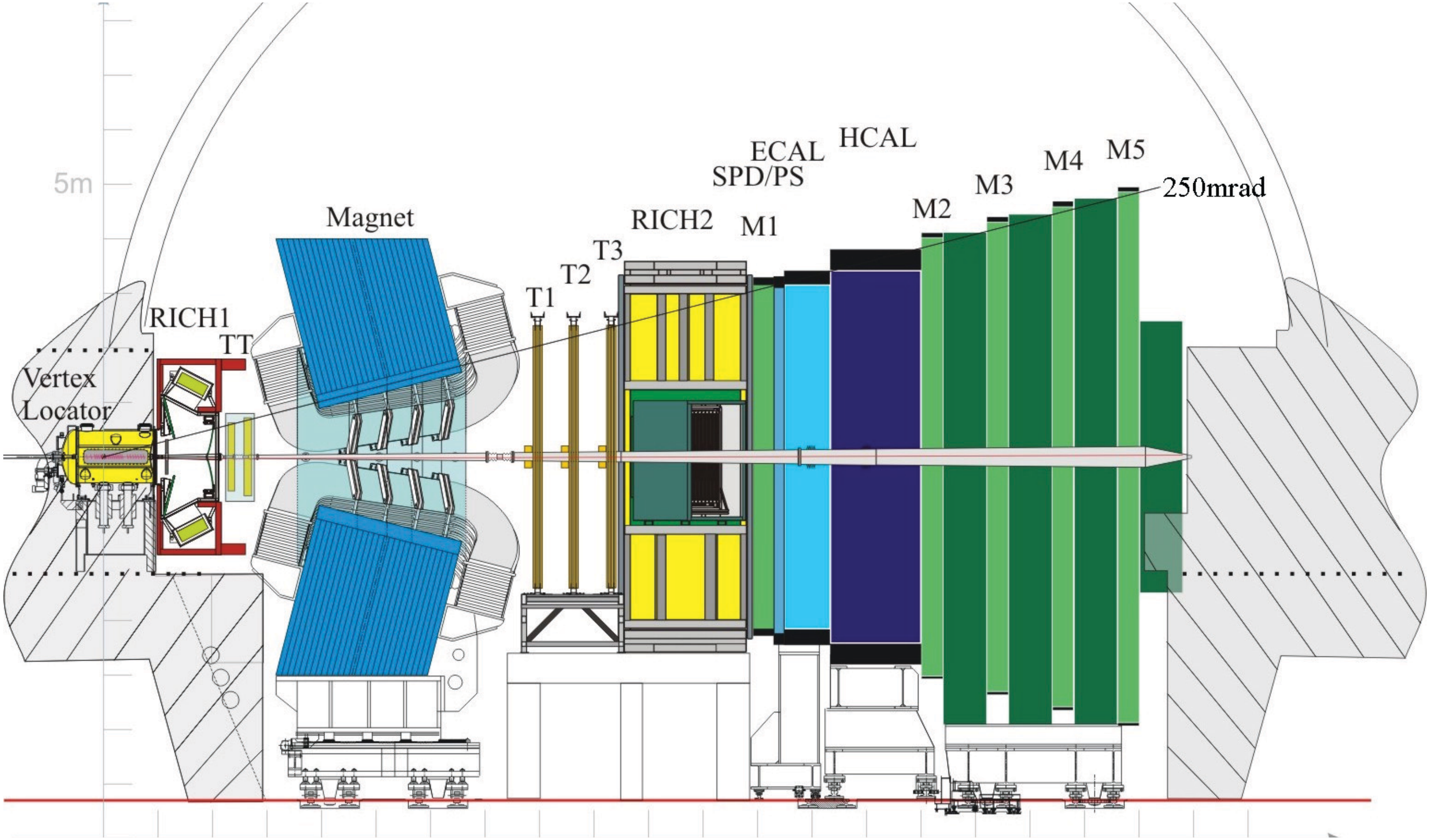
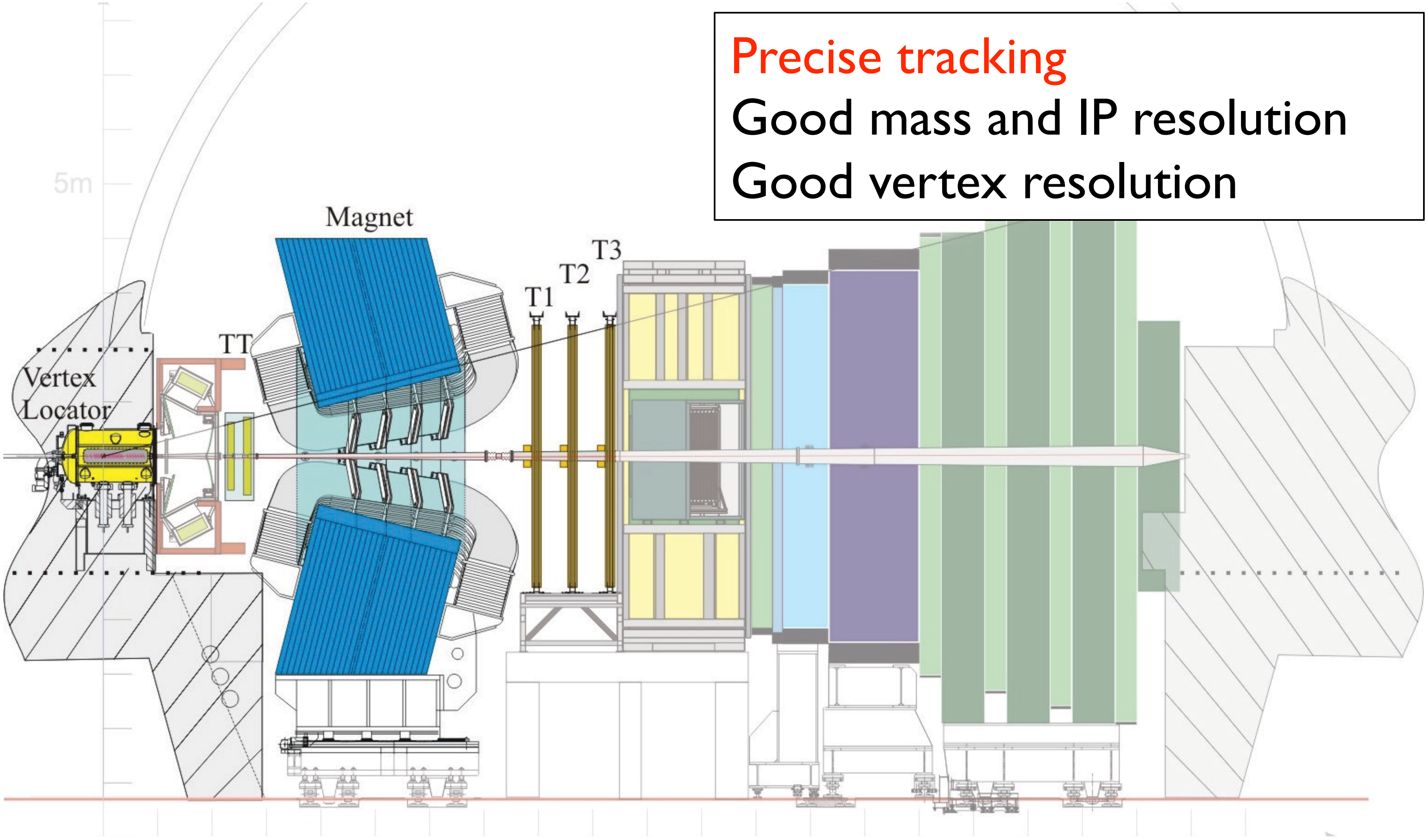
The LHCb experiment

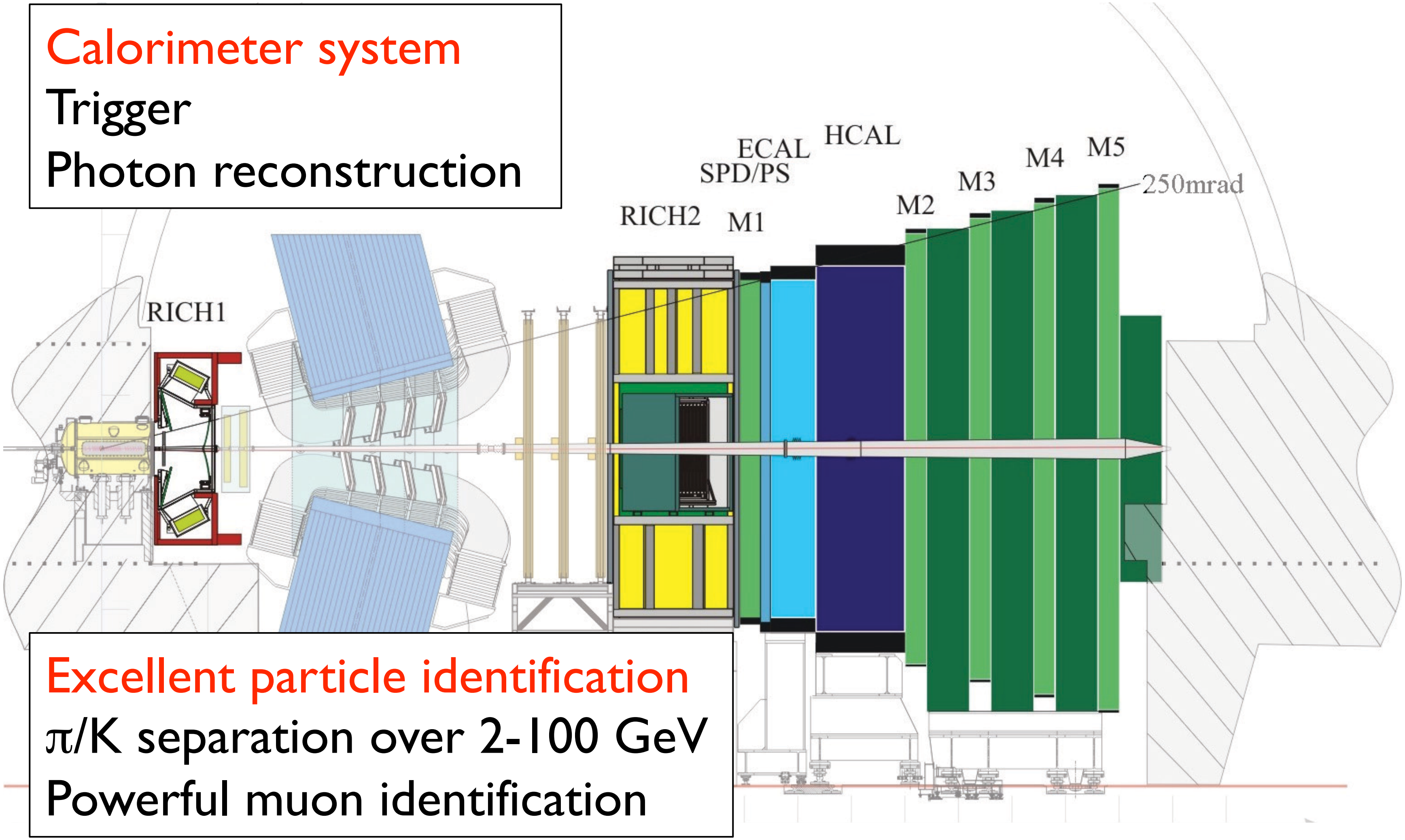


Tracking



Precise tracking
Good mass and IP resolution
Good vertex resolution

Particle identification



Calorimeter system

Trigger

Photon reconstruction

Excellent particle identification

π/K separation over 2-100 GeV

Powerful muon identification

Experimental challenges in LHCb

Trigger

Photon reconstruction

Backgrounds

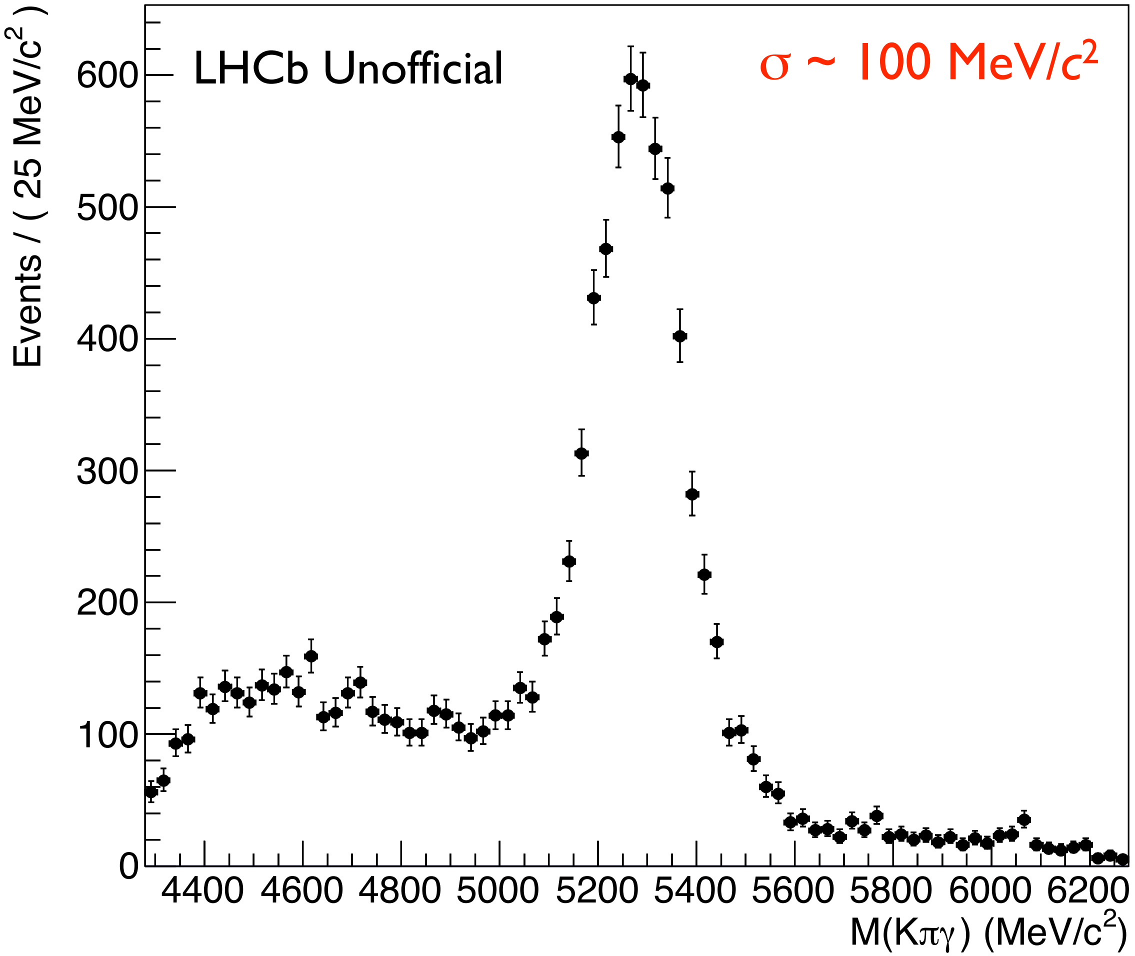
Trigger in LHCb

- High Level (Software) Trigger bandwidth is dominated by
  - Muon trigger (1/3)
  - Topological trigger (1/3)
- Topological trigger only uses tracks, K_S and Λ^0, so it doesn't take into account photons

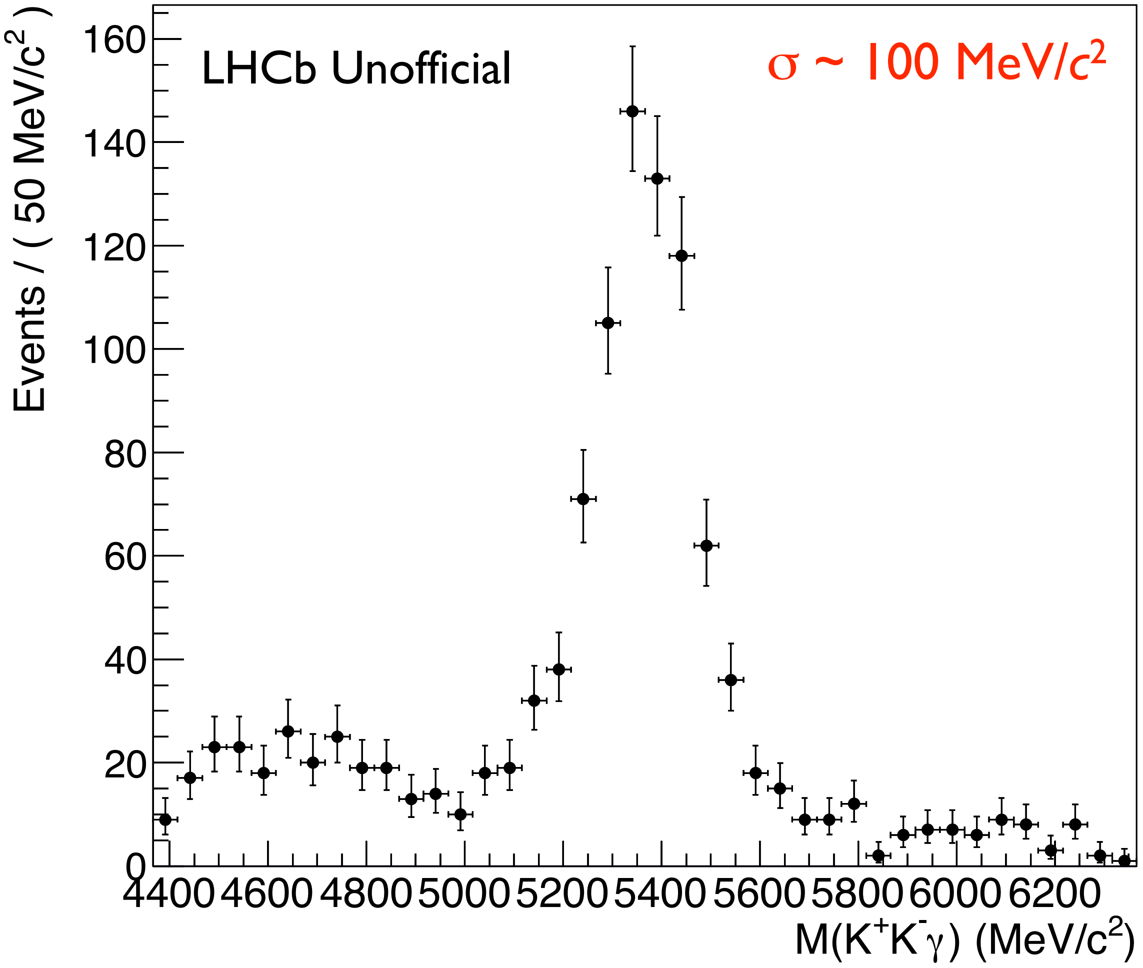
Trigger for radiative B decays

- In 2010
  - Exclusive lines for $B_s \to \phi\gamma$ and $B \to K^*\gamma$
- In 2011
  - Exclusive lines for $B_s \to \phi\gamma$ and $B^0 \to K^*\gamma$
  - Radiative topological trigger, which makes use of the photon information
- In 2012
  - Radiative topological trigger

$B^0 \to K^*\gamma$ in 2011



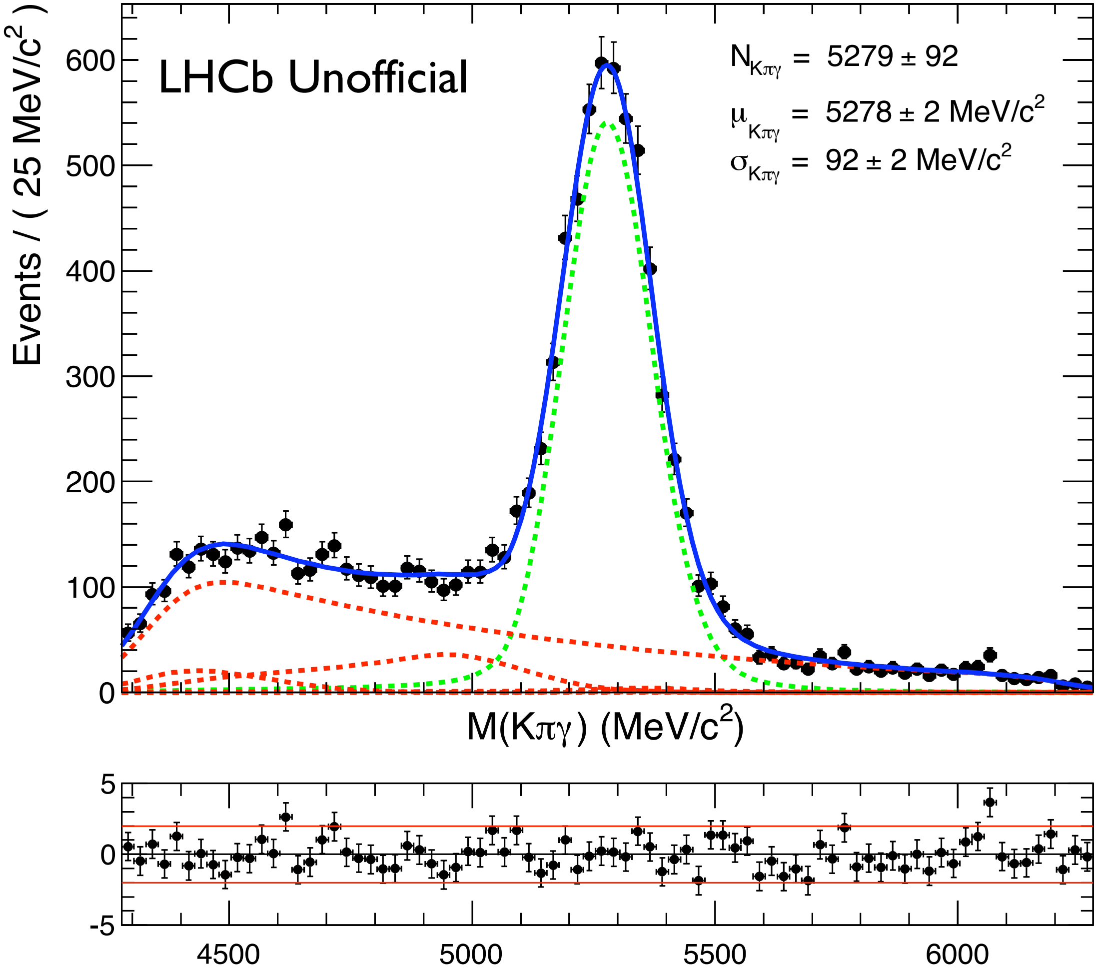
$B_s \to \phi\gamma$ in 2011



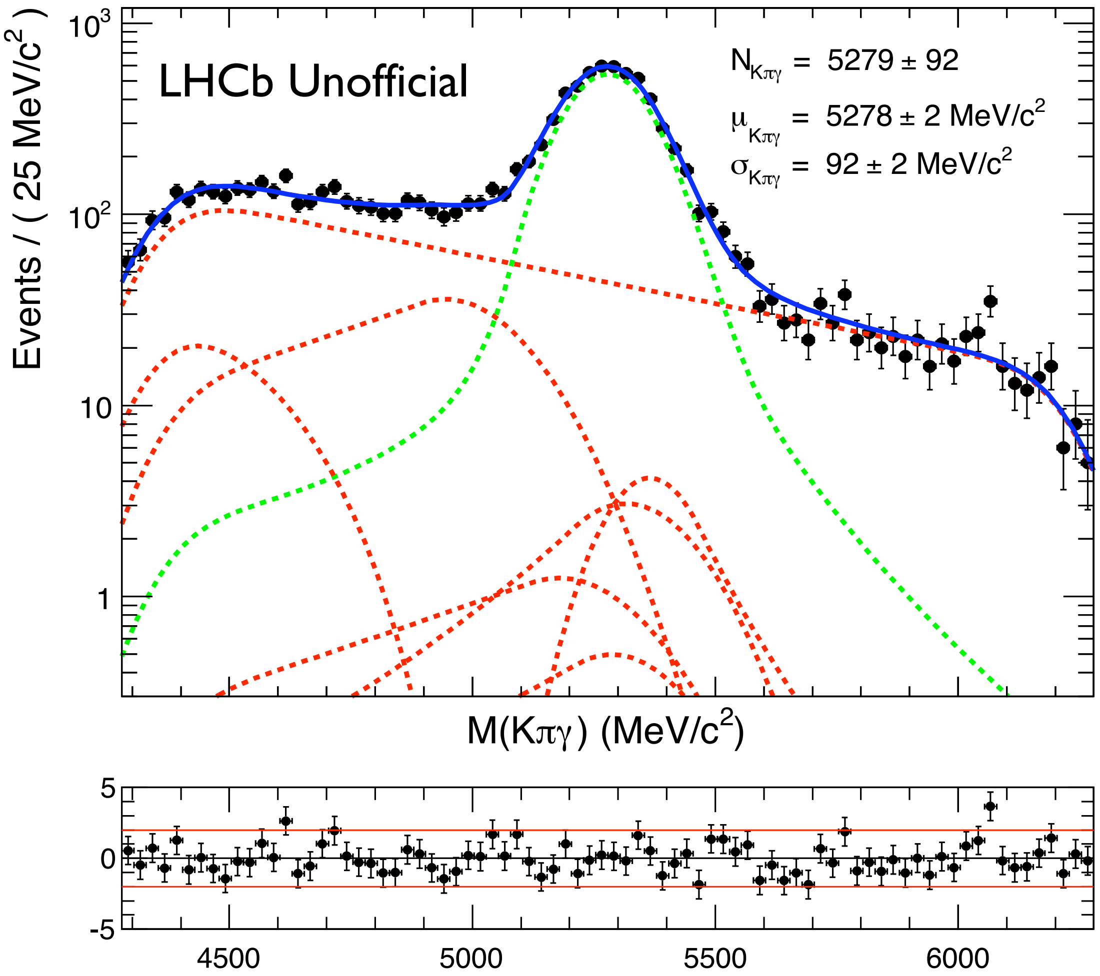
Background sources

- Combinatorial background
- Merged π^0
- Partially reconstructed *B* decays
- Baryonic radiative decays
- Signal cross-feed

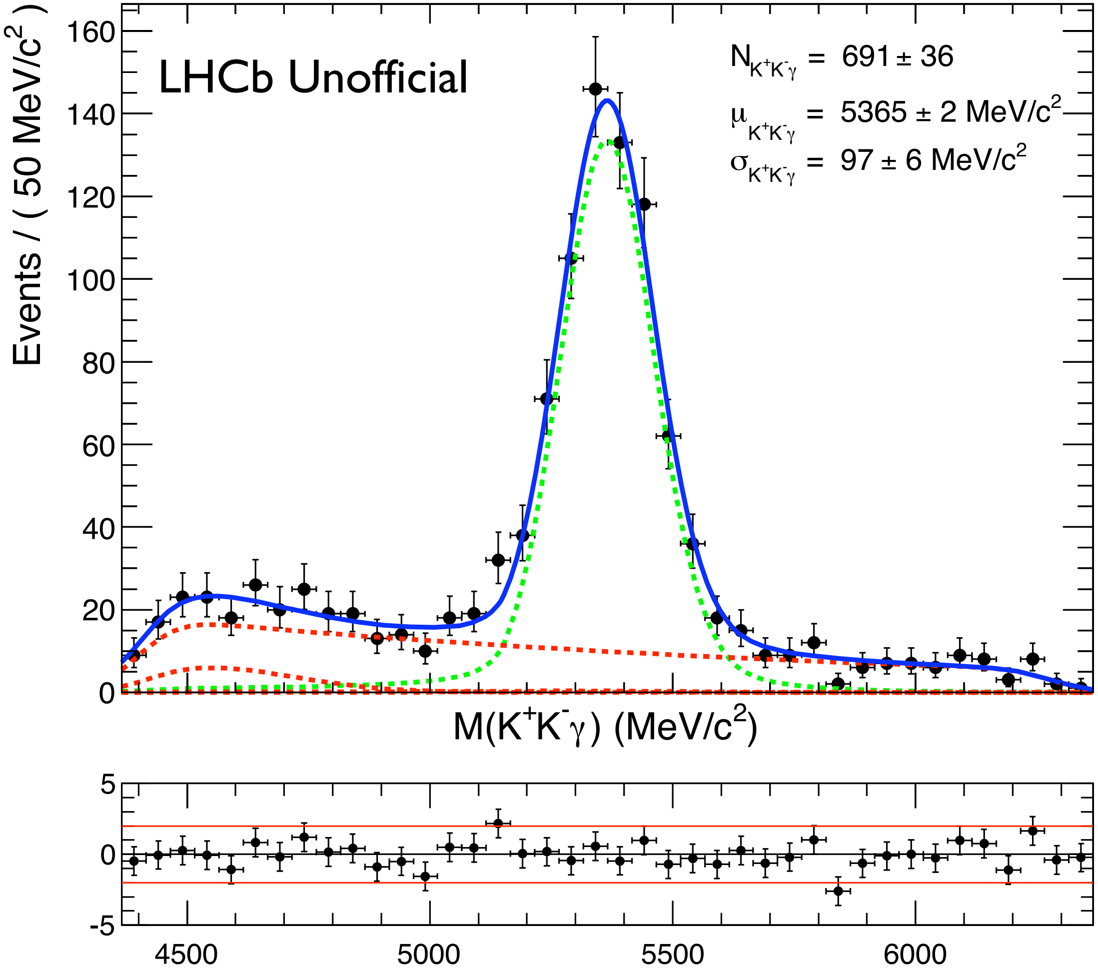
$B \to K^{*}\gamma$ in LHCb (1 fb^{-1})



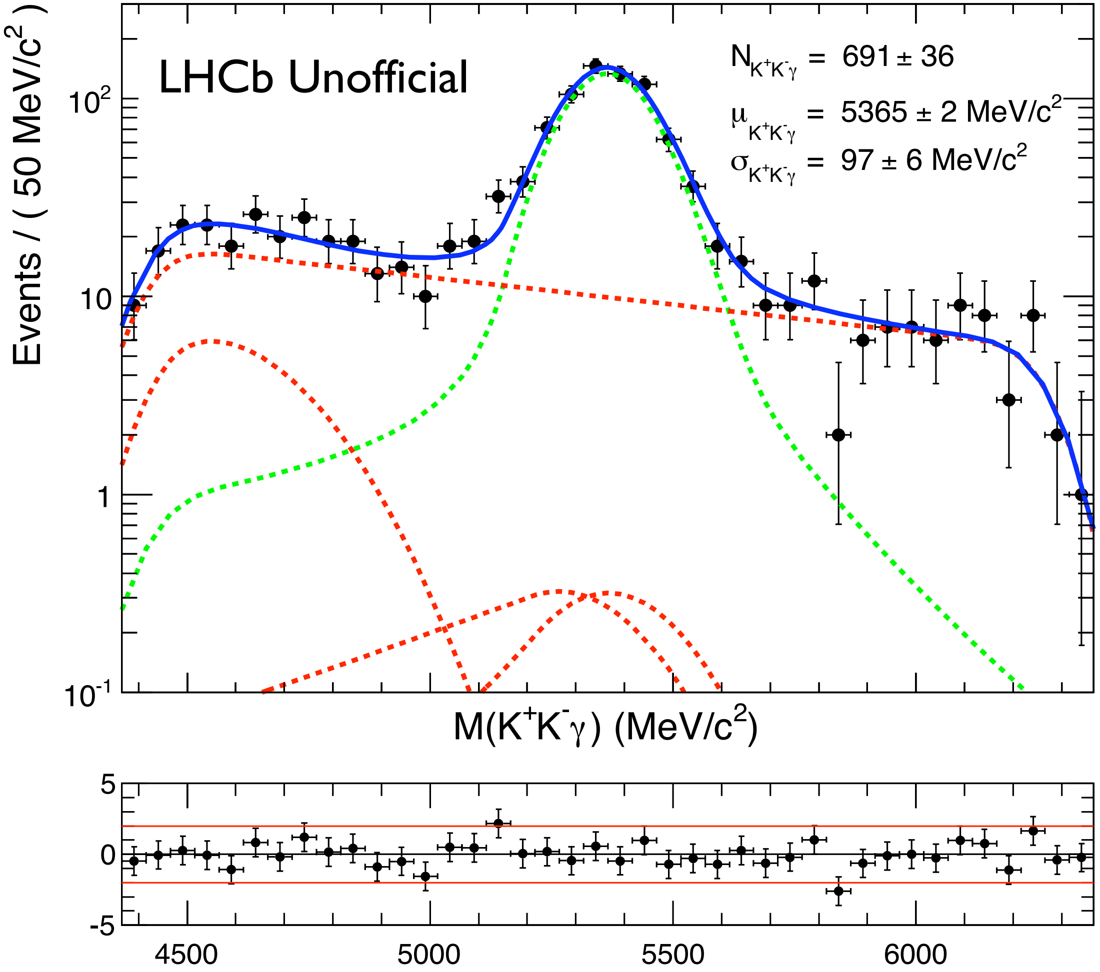
$B \rightarrow K^{*}\gamma$ in LHCb (1 fb^{-1})



$B_s \rightarrow \phi\gamma$ in LHCb (1 fb^{-1})



$B_s \rightarrow \phi\gamma$ in LHCb (1 fb^{-1})



Measurements in LHCb

Ratio of branching fractions

Direct CP asymmetry

Branching fractions

- Low predicting power due to hadronization uncertainties

	$B^+ \to K^+\gamma\,(\times 10^{-5})$	$B^0 \to K^{*0}\gamma\,(\times 10^{-5})$	$B_s^0 \to \phi\gamma\,(\times 10^{-5})$
Theory	4.6 ± 1.4	4.3 ± 1.4	4.3 ± 1.4
CLEO	$3.76^{+0.89}_{-0.83} \pm 0.28$	$4.55^{+0.72}_{-0.68} \pm 0.34$	—
BABAR	$4.22 \pm 0.14 \pm 0.16$	$4.47 \pm 0.10 \pm 0.16$	—
Belle	$4.25 \pm 0.31 \pm 0.24$	$4.01 \pm 0.21 \pm 0.17$	$5.7^{+1.8}_{-1.5}\,^{+1.2}_{-1.1}$
HFAG	4.21 ± 0.18	4.33 ± 0.15	$5.7^{+2.1}_{-1.8}$

First LHCb measurement

- Ratio of radiative branching fractions

$$\frac{\mathcal{B}(B^0 \to K^{*0}\gamma)}{\mathcal{B}(B_s \to \phi\gamma)} = \frac{N_{sig}^{B^0\to K^{*0}\gamma}}{N_{sig}^{B_s\to\phi\gamma}} \frac{\mathcal{B}(\phi \to K^+K^-)}{\mathcal{B}(K^* \to K^+\pi^-)} \frac{f_s}{f_d} \frac{\epsilon_{B_s\to\phi\gamma}}{\epsilon_{B^0\to K^{*0}\gamma}}$$

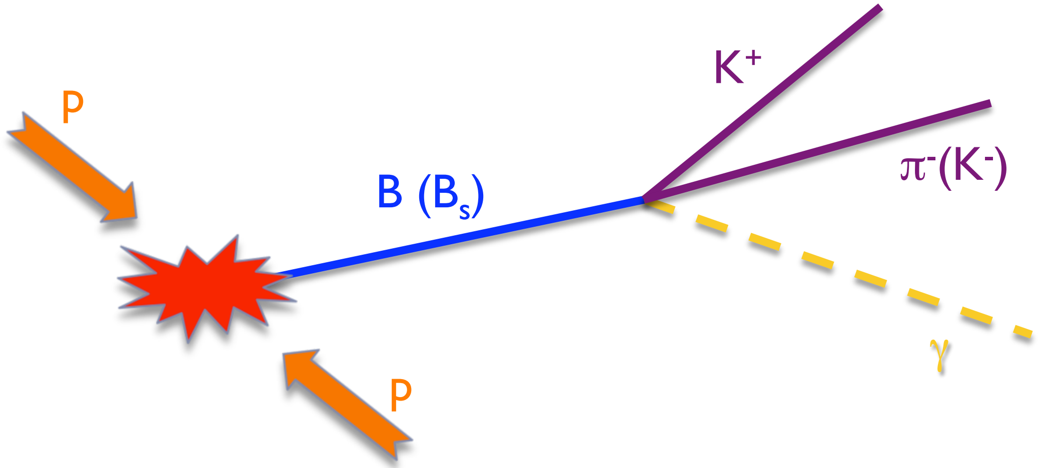
in a way that most systematic effects cancel

- Extract the $B_s \to \phi\gamma$ from the HFAG value of the $B \to K^*\gamma$ branching fraction

$$\mathcal{B}(B^0 \to K^{*0}\gamma) = (4.3 \pm 0.15) \times 10^{-5}$$

Systematics cancellation

- Achieved through the same candidate reconstruction and selection process:
  1. Build V meson from two oppositely charged tracks
  2. Select high E_T photons
  3. Combine the meson a with photon to build *B*



Extraction of the ratio of BRs

$$\frac{\mathcal{B}(B^0 \to K^{*0}\gamma)}{\mathcal{B}(B_s \to \phi\gamma)} = \boxed{\frac{N_{sig}^{B^0 \to K^{*0}\gamma}}{N_{sig}^{B_s \to \phi\gamma}}} \boxed{\frac{\mathcal{B}(\phi \to K^+K^-)}{\mathcal{B}(K^* \to K^+\pi^-)}} \boxed{\frac{f_s}{f_d}} \boxed{\frac{\epsilon_{B_s \to \phi\gamma}}{\epsilon_{B^0 \to K^{*0}\gamma}}}$$

- From fit to the data
- From PDG
- From LHCb measurement (arXiv:hep-ex/1111.2357v1)
- From simulation and data

Result with 370 pb^{-1}

arxiv:1202.6267

- Published 370pb^{-1}, 1fb^{-1} update in preparation

$$\frac{\mathcal{B}(B\to K^*\gamma)}{\mathcal{B}(B_s\to\phi\gamma)} = 1.12\pm 0.08\,(\mathrm{stat})\;^{+0.06}_{-0.04}\,(\mathrm{syst})\;^{+0.09}_{-0.08}\,(f_s/f_d)$$

$$\mathcal{B}(B_s\to\phi\gamma) = (3.9\pm 0.5)\times 10^{-5}$$

World best measurement!

- Compatible with previous result from Belle but with lower uncertainty

$$\mathcal{B}(B_s\to\phi\gamma) = (5.7^{+2.1}_{-1.8})\times 10^{-5}$$

Direct CP asymmetries

- Uncertainties due to form factors largely cancel
- In $B \rightarrow K^{*}\gamma$ CP asymmetry is suppressed by $m_{s,d}/m_b$
  - Theoretically, values of O(1%) with uncertainties ~0.5%
  - Experimental status from BaBar and Belle

$$\begin{aligned} \mathcal{A}^{0}_{CP} &= -(1.6 \pm 2.2 \pm 0.7)\% \\ \mathcal{A}^{+}_{CP} &= (1.8 \pm 2.8 \pm 0.7)\% \\ \mathcal{A}^{\text{combined}}_{CP} &= -(0.3 \pm 1.7 \pm 0.7)\% \end{aligned}$$

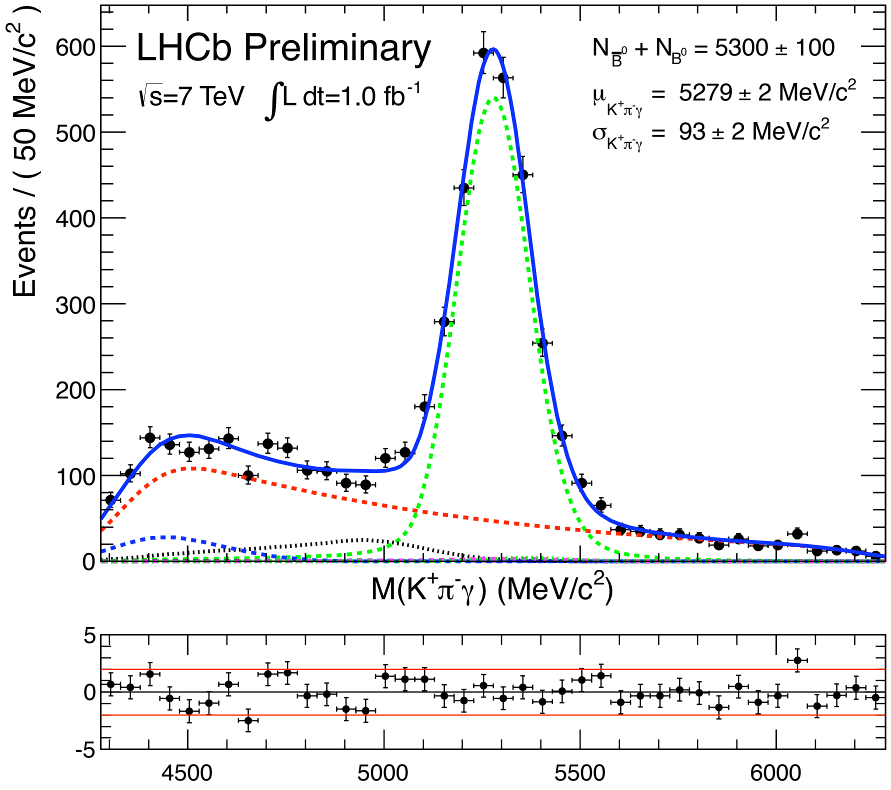
- In $B \rightarrow \rho\gamma$, one finds O(10%) predictions in the SM
  - More challenging experimentally

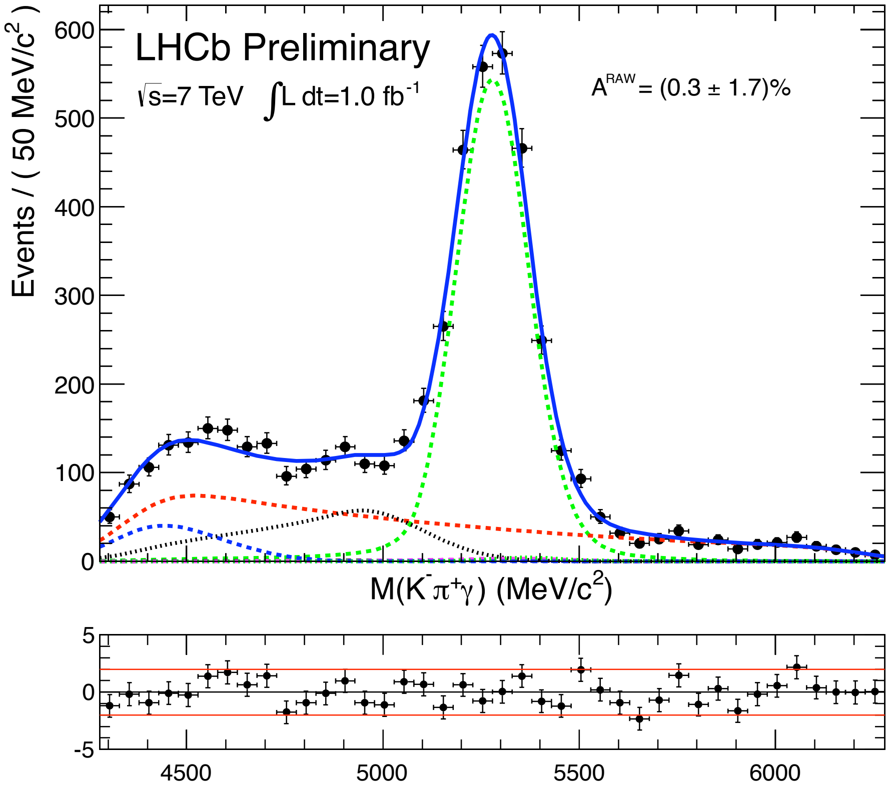
A_{CP} in $B \to K^{*}\gamma$

$$A_{\mathrm{CP}} = \boxed{A^{\mathrm{raw}}(B^0 \to K^{*0}\gamma)} - \boxed{A_D(K\pi) - \underset{\substack{\downarrow \\ \text{dilution factor due to oscillation}}}{\kappa} A_P(B^0)}$$

- A^{raw} is extracted from fit
  - Simultaneous fit of the two flavors B^0 and $\bar{B}^0$
  - Observables: sum of yields and CP asymmetry
- A_P and A_D extracted from B→hh
- κ calculated from data

Raw asymmetry





$$A_{\mathrm{CP}}^{\mathrm{raw}} = 0.003 \pm 0.017\,(\mathrm{stat})$$

A_{CP} in B → $K^*\gamma$ in $1fb^{-1}$

- Putting all the results together we obtain

$$A_{\mathrm{CP}} = 0.008 \pm 0.017\,(\mathrm{stat}) \pm 0.009\,(\mathrm{syst})$$

- This result improves by 18% the most precise measurement up-to-date
- Compatible with the SM prediction

Prospects in LHCb

Direct CP asymmetries

b → dγ transitions

Photon polarization

Ongoing analyses

- Direct CP asymmetries
  - $B^+ \to K^{*0} \pi^+ \gamma$
  - $B^+ \to \phi K^+ \gamma$
- Studies of $B \to \rho\gamma$
  - Branching fractions
  - Access to V_{td} CKM matrix element

Photon polarization

- (Time dependent CP-violation parameters in $B_s \to \phi\gamma$)
- Up/down asymmetry and Dalitz analysis in $B \to K_1(K\pi\pi)\gamma$
- Angular distributions
  - $B^+ \to \phi K^+\gamma$
  - $\Lambda_b \to \Lambda\gamma$

Isospin asymmetry in B → $K^*\gamma$?

$$\Delta_{0+}(B^0 \to K^{*0}\gamma) = \frac{\Gamma(B^0 \to K^{*0}\gamma) - \Gamma(B^+ \to K^{*+}\gamma)}{\Gamma(B^0 \to K^{*0}\gamma) + \Gamma(B^+ \to K^{*+}\gamma)}$$

- Strong sensitivity to NP effects
  - New physics in C_7-$C_{7'}$ plane: *hep-ph/1104.3342*
  - Constrains on MSSM and mSUGRA
- Experimental challenges in LHCb arising from K_S or π^0 in charged K* decay

Summary

- Radiative B decays are sensitive probes to NP
- While BRs are difficult to predict theoretically, there is plenty of NP-sensitive observables
- The first results from LHCb have largely improved the previous results
- Many interesting prospects

Exciting times ahead!

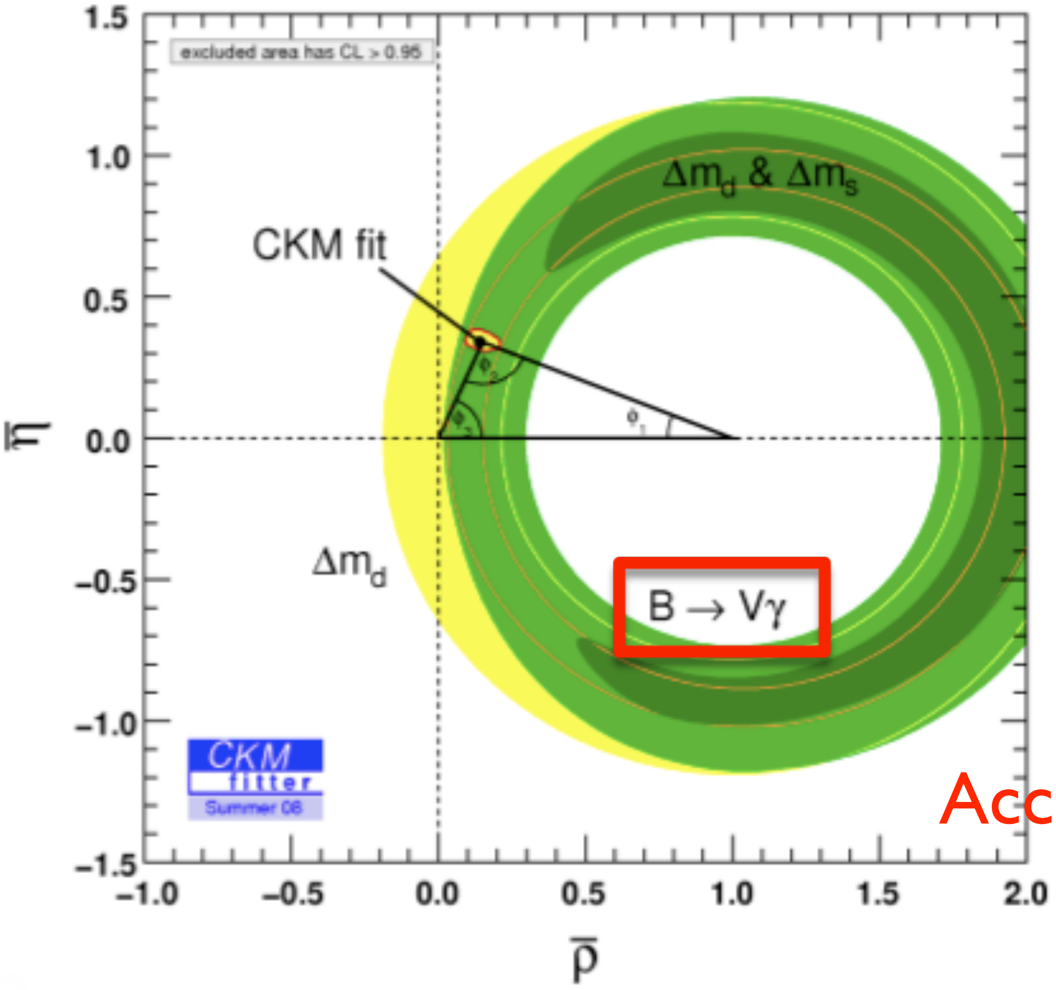
Thank you

Theoretical

Standard Model predictions

- Predictions on exclusive radiative B decays decays are difficult due to hadronization
- SCET is used to obtain deeper understanding of factorization theorems
  - Perturbative calculations completely known up to NLO, partially up to NNLO
  - Non-perturbative calculations performed with light cone sum rules

Branching fractions of b→dγ



Access to V_{td}

Photon polarization

$$\lambda_\gamma = \frac{|\mathcal{A}_R|^2 - |\mathcal{A}_L|^2}{|\mathcal{A}_R|^2 + |\mathcal{A}_L|^2}$$

- Admixture of photons with the "wrong" polarization can be large in SM extensions
  - Left Right Symmetric Model (LSRM), unconstrained MSSM, models with non-supersymmetric extra dimensions
- Measure as "null test", since photons are ~100% polarized in the SM

Time-dependent CP asymmetry

- Time evolution of B → $\Phi^{CP}\gamma$

$$\Gamma_{B^0_{(s)}\to\Phi^{CP}\gamma}(t) = |A|^2 e^{-\Gamma_{(s)}t}\Big(\cosh\frac{\Delta\Gamma_{(s)}t}{2} - \mathcal{A}^{\Delta}\sinh\frac{\Delta\Gamma_{(s)}t}{2} + \\ + \mathcal{C}\cos\Delta m_{(s)}t - \mathcal{S}\sin\Delta m_{(s)}t\Big)$$

$$\Gamma_{\bar{B}^0_{(s)}\to\Phi^{CP}\gamma}(t) = |A|^2 e^{-\Gamma_{(s)}t}\Big(\cosh\frac{\Delta\Gamma_{(s)}t}{2} - \mathcal{A}^{\Delta}\sinh\frac{\Delta\Gamma_{(s)}t}{2} - \\ - \mathcal{C}\cos\Delta m_{(s)}t + \mathcal{S}\sin\Delta m_{(s)}t\Big)$$

- Time-dependent CP asymmetry can be used to probe the photon polarization through the CP-violation parameters

Time-dependent CP-asymmetry

- In the SM

sum of $B_{(s)}$ mixing phase and CP-odd weak phases for right and left amplitudes

$$\mathcal{C} \approx 0$$

$$\mathcal{S} \approx \sin 2\psi \sin \varphi_{(s)}$$

$$\mathcal{A}^{\Delta} \approx \sin 2\psi \cos \varphi_{(s)}$$

$$\tan\psi \equiv \left| \frac{\mathcal{A}(\bar{B}_{(s)} \to \Phi^{CP}\gamma_R)}{\mathcal{A}(\bar{B}_{(s)} \to \Phi^{CP}\gamma_L)} \right| \longrightarrow \lambda_\gamma = \cos 2\psi$$

- Therefore, $\mathcal{S}$ and $\mathcal{A}^{\Delta}$ give access to the fraction of "wrongly"-polarized photons

Photon polarization in B^0

- $\Delta\Gamma/\Gamma$ is negligible, so terms proportional to $\mathcal{A}^{\Delta}$ vanish

$$\Gamma_{B^0\to\Phi^{CP}\gamma}(t) = |A|^2 e^{-\Gamma t}(1 + \mathcal{C}\cos\Delta m t - \mathcal{S}\sin\Delta m t)$$
$$\Gamma_{\bar{B}^0\to\Phi^{CP}\gamma}(t) = |A|^2 e^{-\Gamma t}(1 - \mathcal{C}\cos\Delta m t + \mathcal{S}\sin\Delta m t)$$

- Also one expects in the SM

CP-odd weak penguin phase

$$\varphi = \sin(2\beta - \phi_p)$$

- Therefore

$$\mathcal{S}_{B^0} = \sin 2\psi \sin 2\beta$$

Photon polarization in B$_s$

- $\Delta\Gamma/\Gamma$ is not negligible, and

$$\varphi_s = \sin(2\beta_s - \phi_p) \approx 0$$

so the term with S vanishes

$$\Gamma_{B_s^0 \to \Phi^{CP}\gamma}(t) = |A|^2 e^{-\Gamma_s t}(\cosh\frac{\Delta\Gamma_s t}{2} - \mathcal{A}^{\Delta}\sinh\frac{\Delta\Gamma_s t}{2})$$

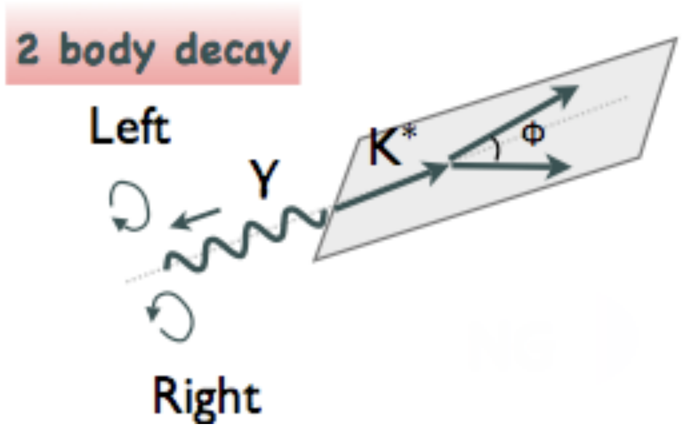
$$\Gamma_{\bar{B}_s^0 \to \Phi^{CP}\gamma}(t) = \Gamma_{B_s^0 \to \Phi^{CP}\gamma}(t)$$

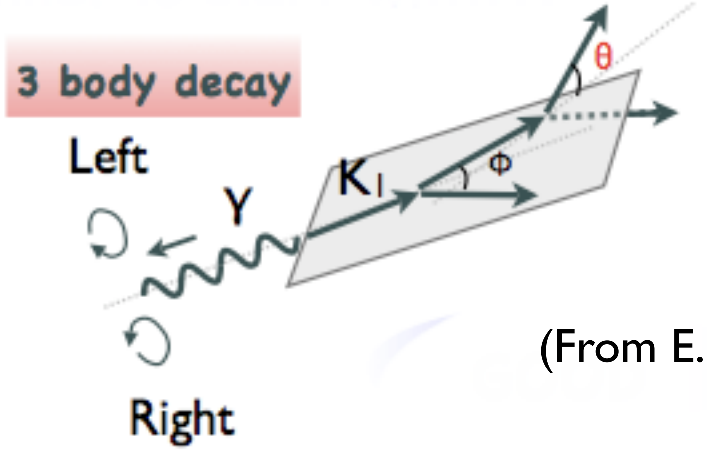
- Therefore

$$\mathcal{A}^{\Delta}_{B_s^0} \approx \sin 2\psi$$

Photon polarization in 3-body

- Why 3 body?





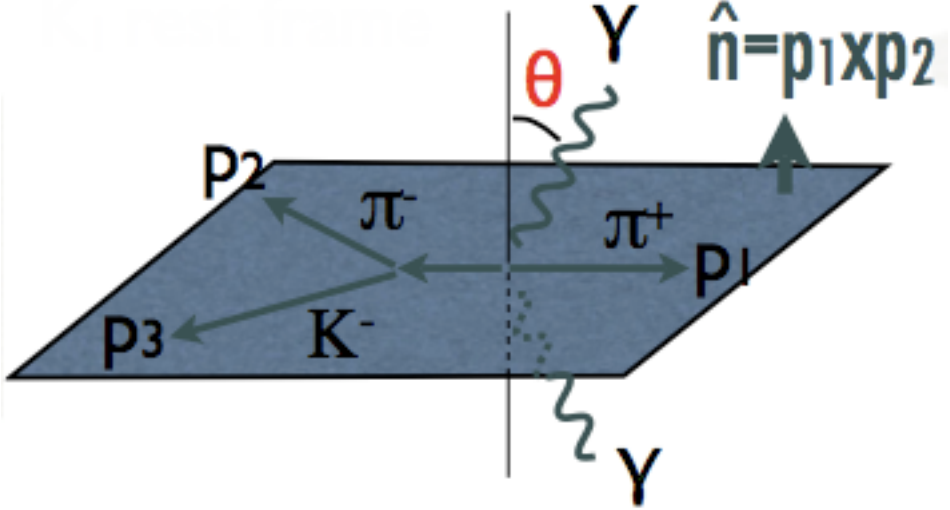
(From E.Kou)

Symmetric along the helicity axis

Angle wrt to the plane

$B \rightarrow K_1(K\pi\pi)\gamma$ with Gronau method

- Up/down asymmetry (*Gronau, Grossman, Pirjol, Ryd hep-ph/0107254*)



$$\mathcal{A}=\frac{\int_0^{\pi/2} \mathrm{d}\,|\mathcal{M}|^2\,\mathrm{d}\,\theta-\int_{\pi/2}^{\pi} \mathrm{d}\,|\mathcal{M}|^2\,\mathrm{d}\,\theta}{\int_0^{\pi} \mathrm{d}\,|\mathcal{M}|^2\,\mathrm{d}\,\theta}$$

B→K$_1$(Kππ)γ with Gronau method

$$\mathcal{A} = \frac{\int_0^{\pi/2} \mathrm{d}\,|\mathcal{M}|^2\,\mathrm{d}\,\theta - \int_{\pi/2}^{\pi} \mathrm{d}\,|\mathcal{M}|^2\,\mathrm{d}\,\theta}{\int_0^{\pi} \mathrm{d}\,|\mathcal{M}|^2\,\mathrm{d}\,\theta}$$

$$= \boxed{\frac{\langle \mathrm{Im}(\hat{n}\cdot(\vec{J}\times\vec{J}^*))\rangle}{\langle|\vec{J}|^2\rangle}}\,\boxed{\frac{|C'_{7\gamma}|^2 - |C_{7\gamma}|^2}{|C'_{7\gamma}|^2 + |C_{7\gamma}|^2}}$$

Helicity amplitude

Polarization parameter λ

$B\rightarrow K_1(K\pi\pi)\gamma$ with DDLR method

- The polarization information is both in the angular distribution and in the Dalitz distribution (*E.Kou, Le Yaouanc, A.Tayduganov, PRD83 (2011)*)
- Simplify the analysis using the ω variable

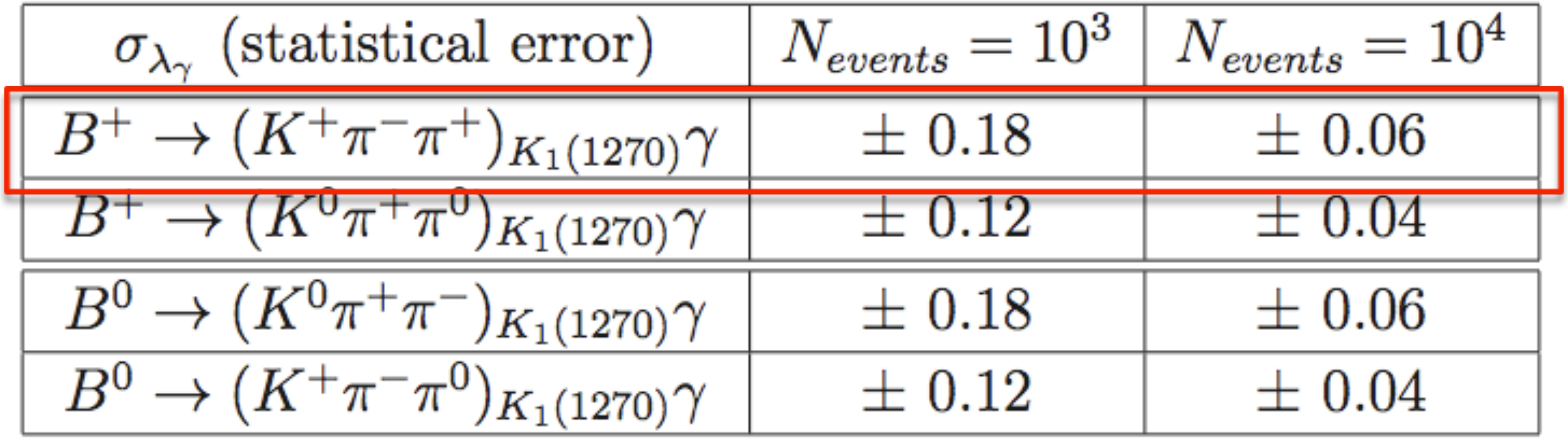
$$\omega(\boxed{s_{13}, s_{23}}, \boxed{\cos\theta)} \equiv \frac{2\,\mathrm{Im}(\hat{n}\cdot\boxed{(\vec{J}\times\vec{J}^*})) \boxed{\cos\theta}}{\boxed{|\vec{J}|^2}\boxed{(1+\cos^2\theta)}}$$

$$\downarrow$$

$$\lambda = \frac{\langle\omega\rangle}{\langle\omega^2\rangle}$$

$B \to K_1(K\pi\pi)\gamma$ with DDLR method

- Usage of $K_1(1270)\gamma$, observed by Belle
- Hadronic information (*J*) extracted from data
  - Model independent analysis helps reduce uncertainties



σ_{λ_γ} (statistical error)	$N_{events} = 10^3$	$N_{events} = 10^4$
$B^+ \to (K^+\pi^-\pi^+)_{K_1(1270)}\gamma$	$\pm\ 0.18$	$\pm\ 0.06$
$B^+ \to (K^0\pi^+\pi^0)_{K_1(1270)}\gamma$	$\pm\ 0.12$	$\pm\ 0.04$
$B^0 \to (K^0\pi^+\pi^-)_{K_1(1270)}\gamma$	$\pm\ 0.18$	$\pm\ 0.06$
$B^0 \to (K^+\pi^-\pi^0)_{K_1(1270)}\gamma$	$\pm\ 0.12$	$\pm\ 0.04$

Photon polarization in $B^+ \to \phi K^+ \gamma$

- Use angular distribution to extract λ (*Orlovsky, Shevchenko, PRD77 2008*)
- Strong interference between the partial waves in the (ϕK) system with K in the vector state is necessary
  - If not, interference pattern becomes too complicated to extract experimental results

Photon polarization in Λ_b

- $\Lambda_b \rightarrow \Lambda\gamma$ decays also allow to access photon polarization from angular analysis (*Legger, Schietinger hep-ph/0605245*)
  - $J(\Lambda_b) = ½$
  - Λ_b are expected to be polarized in the LHC
- Two decay topologies
  - $\Lambda_b \rightarrow \Lambda^0(\pi p)\gamma$ with $J(\Lambda^0(1115)) = ½$
  - $\Lambda_b \rightarrow \Lambda^*(pK)\gamma$

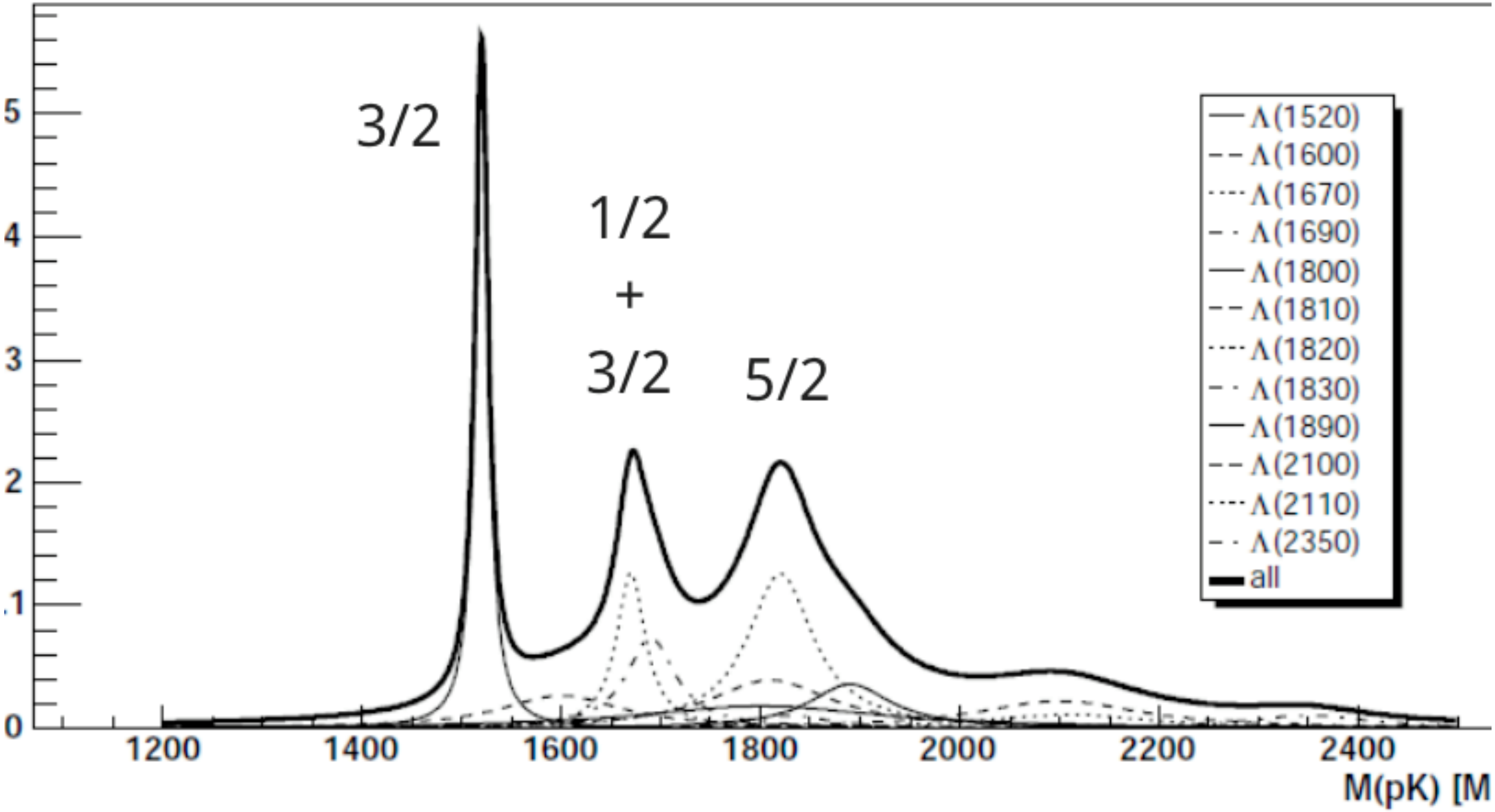
$\Lambda_b \rightarrow \Lambda^0(1115)\gamma$

- Two observables to access photon polarization
  - Photon angular distribution
  - Proton angular distribution
- Topology different than $B^0 \rightarrow K^*\gamma$
  - Λ^0 flies through the detector

$\Lambda_b \rightarrow \Lambda^*(X)\gamma$

- Several resonances over the pK threshold
  - Similar topology to $B^0 \rightarrow K^*\gamma$
  - Overlapping poorly known states w/different spins
- Two cases
  - J=½ is a parity conserving decay, has only one observable: photon distribution
  - J=3/2 is more complex, sensitivity depends on the ratio of the J=1/2 and J=3/2 states

$\Lambda_b \to \Lambda^*(X)\gamma$ cases



$\Lambda_b \rightarrow \Lambda^*(X)\gamma$ cases

- $\Lambda^*(1520)$ is well stablished
  - J=3/2, so maybe not sensitive to photon polarization
  - Small contamination from poorly known $\Lambda^*(1600)$
- $\Lambda^*(1670)$ and $\Lambda^*(1690)$ are not well known
  - $\Lambda^*(1670)$ is J=1/2 and $\Lambda^*(1690)$ is J=3/2
  - Contamination from other poorly known states
  - Can they be resolved?

Isospin asymmetry status

- **Theory predictions**

$$\Delta_{0-}(B^0 \to K^{*0}\gamma)_{\text{Kagan}} = (+8.0^{+2.1}_{-3.2})\% \times 0.3/T_1^{B\to K^*}$$

$$(T_1^{B\to K^*} \text{ estimates go from } 0.23 \pm 0.06 \text{ to } 0.38 \pm 0.06)$$

$$\Delta_{0+}(B^0 \to K^{*0}\gamma)_{\text{Matsumori}} = +(2.7 \pm 0.8)\%$$

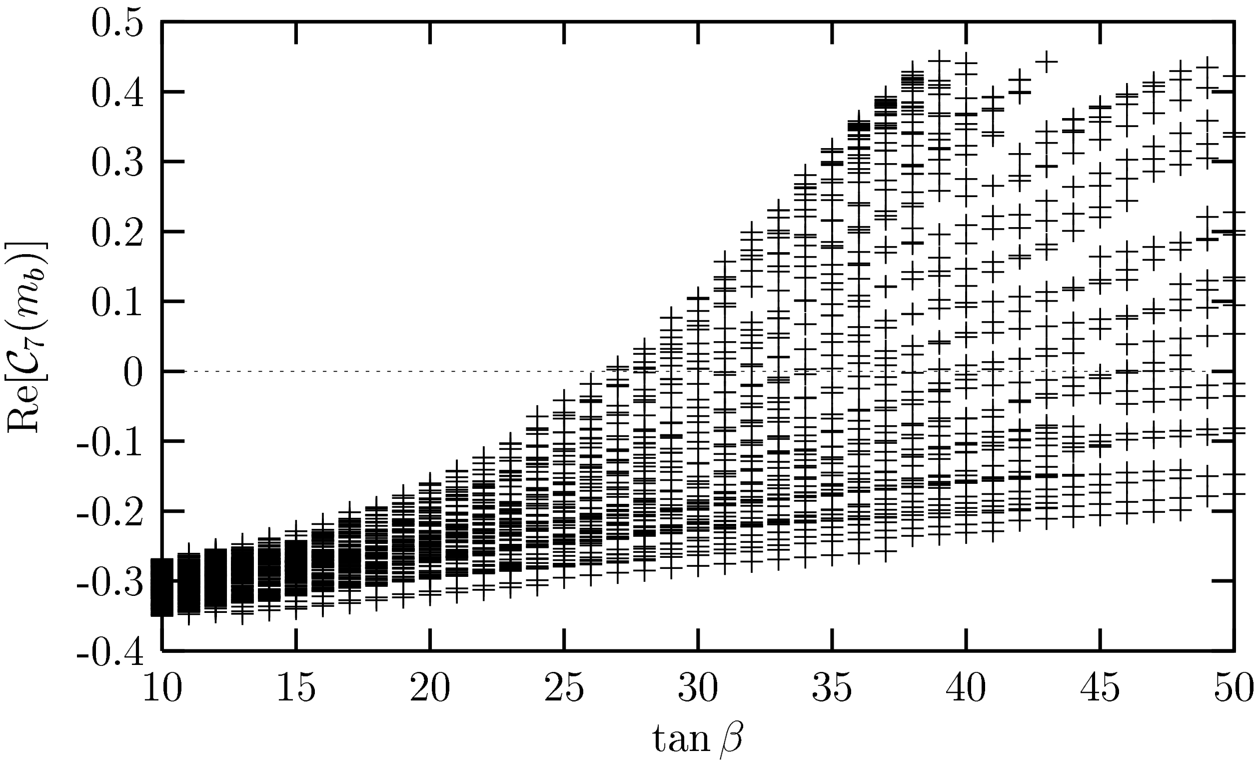
- **Experimental results**

$$\Delta_{0+}(B^0 \to K^{*0}\gamma)_{\text{Belle}} = +(1.2 \pm 4.4 \pm 2.6)\%$$

$$\Delta_{0-}(B^0 \to K^{*0}\gamma)_{\text{BaBaR}} = +(6.6 \pm 2.1 \pm 2.2)\%$$

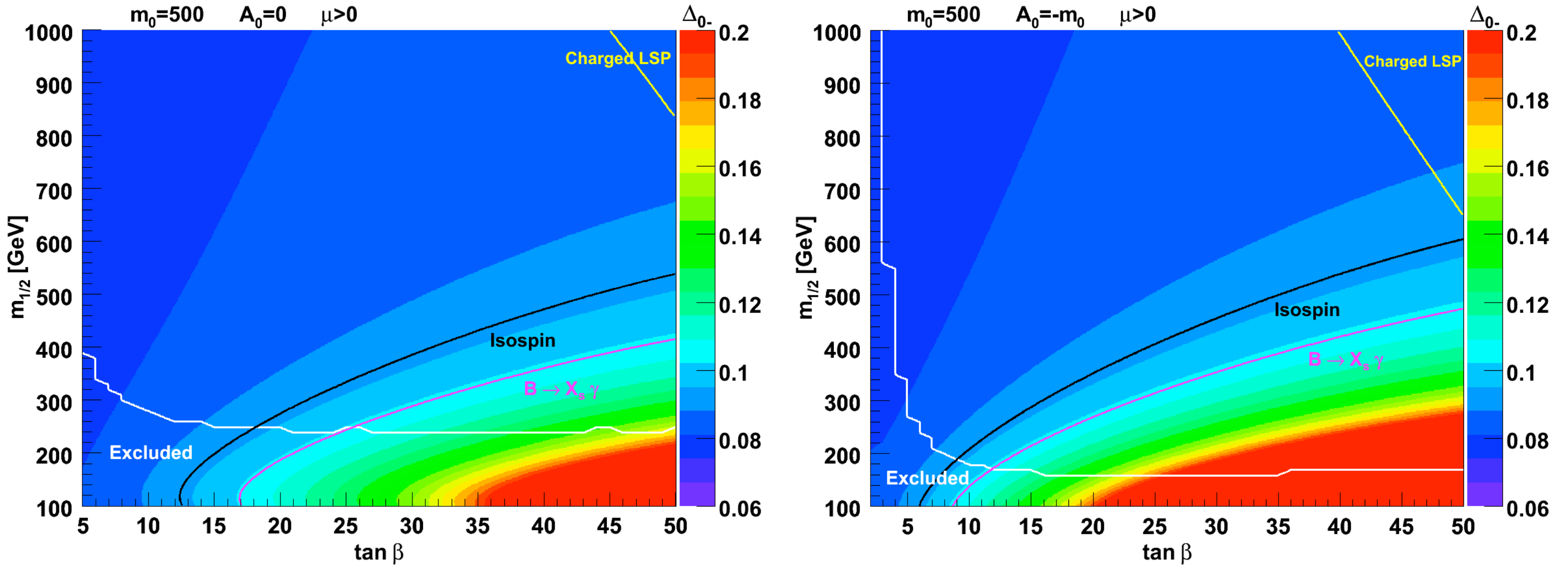
Isospin asymmetry and MSSM

- Positive values of Re(C_7), which flip the sign of Δ_{0-}, become more probable as tanβ increases



Isospin asymmetry and mSUGRA

- Constrain the mSUGRA parameter space
  - Isospin asymmetry is more restrictive than inclusive $B \to X_s \gamma$



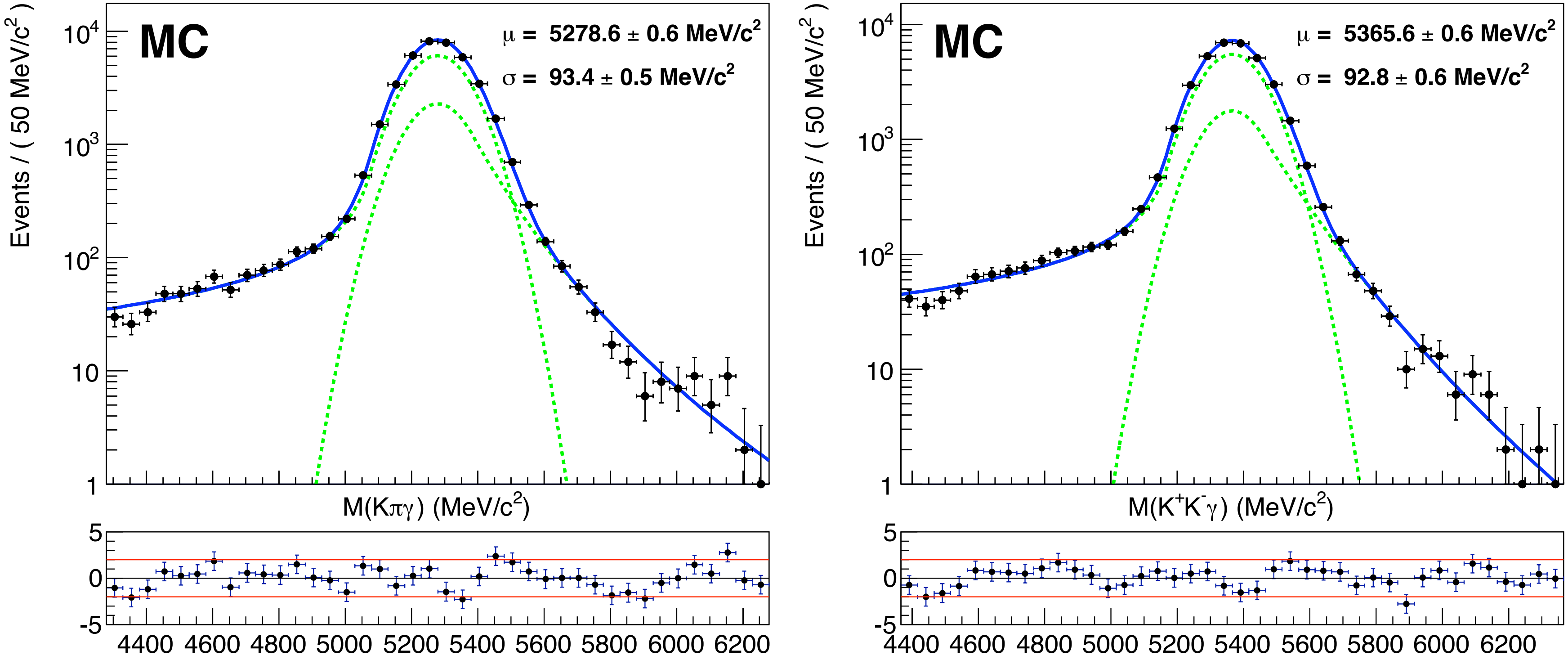
ArXiV:hep-ph/0608212

Experimental

Signal shape

- Combination of two Crystal Ball distributions (gaussian + potential tail)
  - Radiative effects at low mass
  - Error distribution of invariant B mass generates a tail at high masses

Signal shape



Background determination

- Shape of backgrounds fixed from MC
- Contamination of backgrounds
    - Fixed from MC in contaminations under the peak
    - Free in the case of partially reconstructed background

Ratio of yields

- Extracted from the fit
- Systematical uncertainties
  - Signal shape parameters
  - Fixed background shapes and contaminations
  - Trigger acceptance function

Ratio of efficiencies

- From MC / data

$$\frac{\epsilon^{B_s^0\to\phi\gamma}}{\epsilon^{B^0\to K^{*0}\gamma}} = \boxed{\frac{\epsilon^{B_s^0\to\phi\gamma}_{\mathrm{Trigger}}}{\epsilon^{B^0\to K^{*0}\gamma}_{\mathrm{Trigger}}} \times \frac{\epsilon^{B_s^0\to\phi\gamma}_{\mathrm{Acceptance}}}{\epsilon^{B^0\to K^{*0}\gamma}_{\mathrm{Acceptance}}} \times \frac{\epsilon^{B_s^0\to\phi\gamma}_{\mathrm{Reco\&SelNoPID}}}{\epsilon^{B^0\to K^{*0}\gamma}_{\mathrm{Reco\&SelNoPID}}}} \times \boxed{\frac{\epsilon^{B_s^0\to\phi\gamma}_{\mathrm{PID}}}{\epsilon^{B^0\to K^{*0}\gamma}_{\mathrm{PID}}}}$$

LHCb measurement with 1fb^{-1}

- Paper in preparation

$$\frac{\mathcal{B}(B^0 \to K^{*0}\gamma)}{\mathcal{B}(B_s^0 \to \phi\gamma)} = 1.31 \pm 0.08\,(\mathrm{stat}) \pm 0.04\,(\mathrm{syst}) \pm 0.10\,(f_s/f_d)$$

$$\mathcal{B}(B_s^0 \to \phi\gamma) = (3.3 \pm 0.3) \times 10^{-5}$$

World best measurement!

- Compatible with previous result from Belle but with lower uncertainty

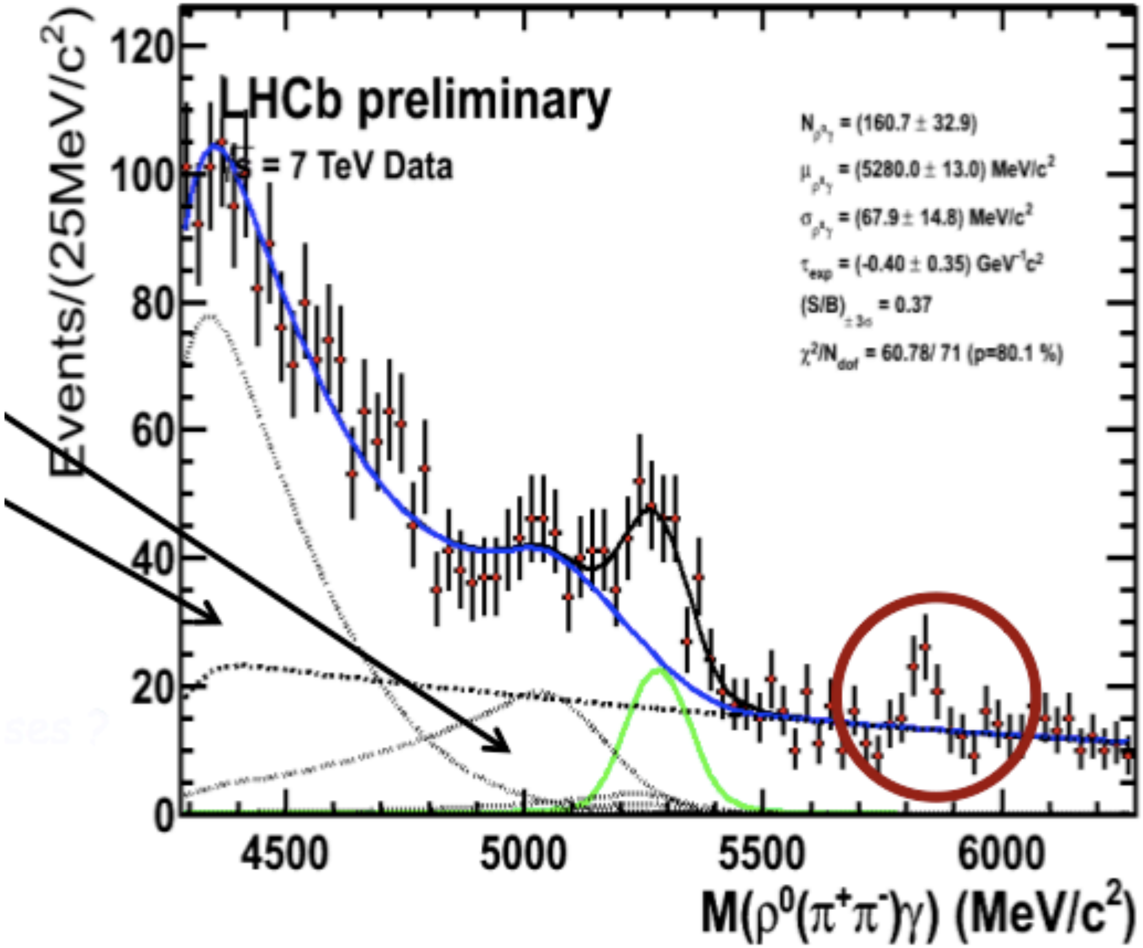
$$\mathcal{B}(B_s \to \phi\gamma) = (5.7^{+2.1}_{-1.8}) \times 10^{-5}$$

Systematics in A_{CP}

- From the fit model
  - Background shape and contamination
  - CP asymmetry of background
- Magnet polarity

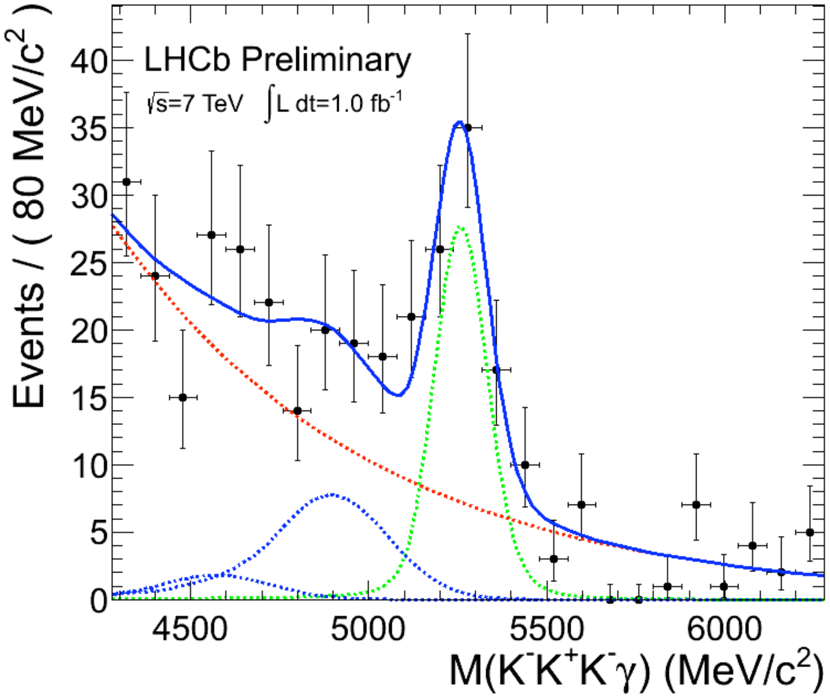
$B \to \rho\gamma$

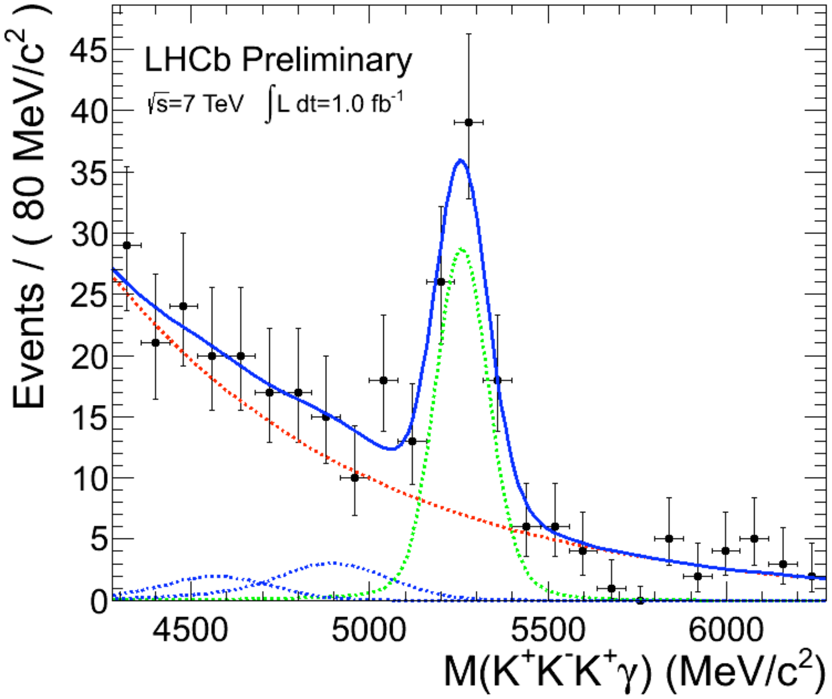
From O.Deschamps



$B^+ \to \phi K^+ \gamma$

From R.Vazquez





Triggering radiative B decays

- In 2010-2011
  - Exclusive lines for $B^0 \rightarrow K^* \gamma$ and $B_s \rightarrow \phi\gamma$
  - Inclusive ϕ line
- Since mid-2011
  - Radiative topological lines: topological HLT2 + photon information
  - Similar efficiency, triggers all 2track+photon decays

B→Vγ selections

		$B^0 \to K^{*0}\gamma$	$B_s^0 \to \phi\gamma$
Track χ^2		< 5	< 5
Track IP χ^2		> 25	> 25
Track p_{T}	(MeV/c)	> 500	> 500
Max track p_{T}	(MeV/c)	> 1200	> 1200
Kaon PID$_{K\pi}$		> 5	> 5
Kaon PID$_{Kp}$		> 2	> 2
Pion PID$_{K\pi}$		< 0	–
V meson vertex $\Delta\chi^2$		< 9	< 9
V meson ΔM_{PDG}	(MeV/c^2)	< 50	< 9
Photon E_{T}	(MeV)	> 2600	> 2600
Photon CL		> 0.25	> 0.25
π^0/γ separation		> 0.5	> 0.5
B candidate p_{T}	(MeV/c)	> 3000	> 3000
B candidate IP χ^2		< 9	< 9
B candidate DIRA	(mrad)	< 20	< 20
B candidate FD χ^2		> 100	> 100
B candidate ΔM_{PDG}	(MeV/c^2)	< 1000	< 1000
B candidate $\lvert\cos\theta_H\rvert$		< 0.8	< 0.8
B candidate isolation $\Delta\chi^2$		> 2	> 2

Trigger acceptance