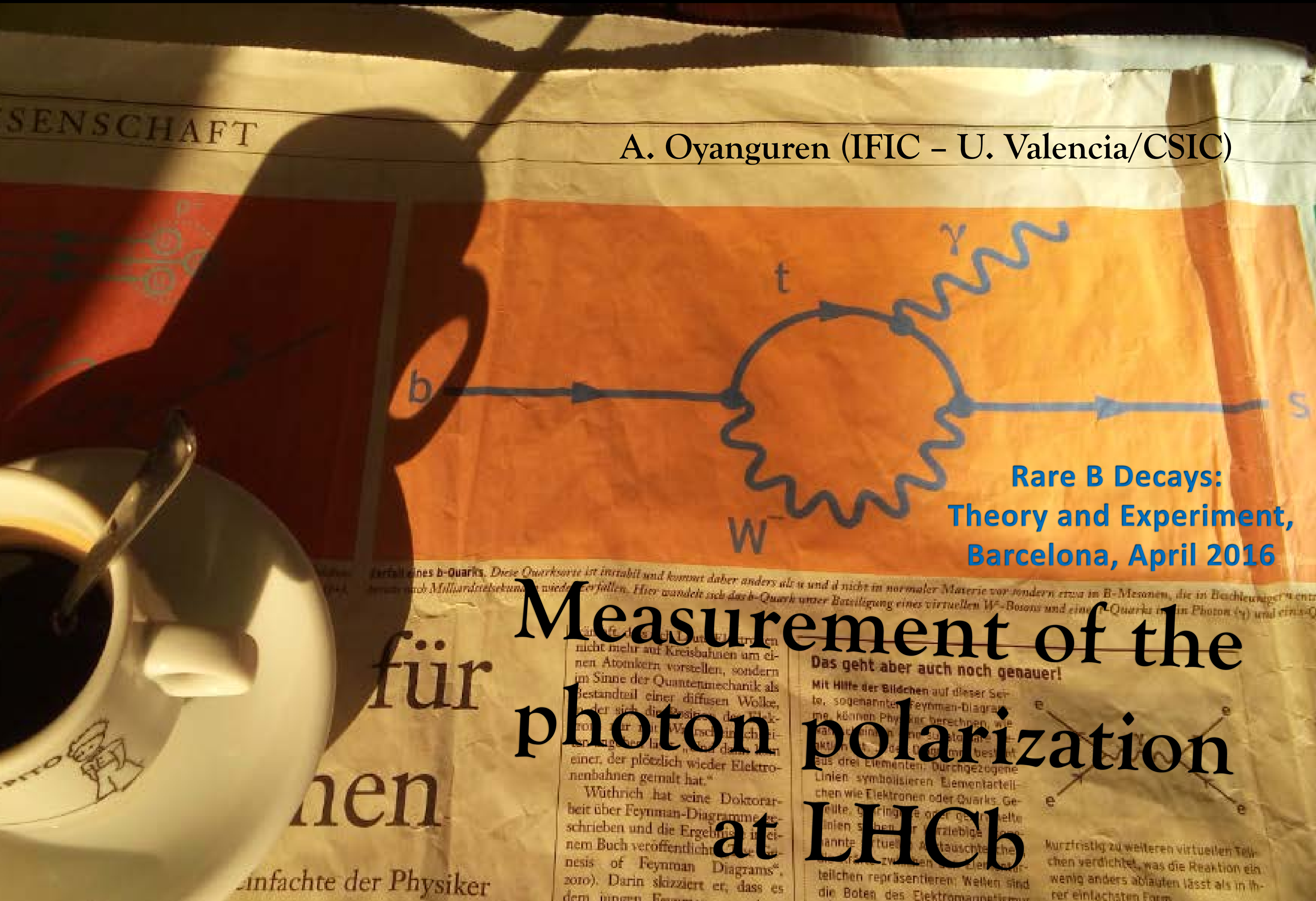
Measurement of the photon polarization at LHCb

A. Oyanguren (IFIC – U. Valencia/CSIC)

Rare B Decays:
Theory and Experiment,
Barcelona, April 2016



Outline

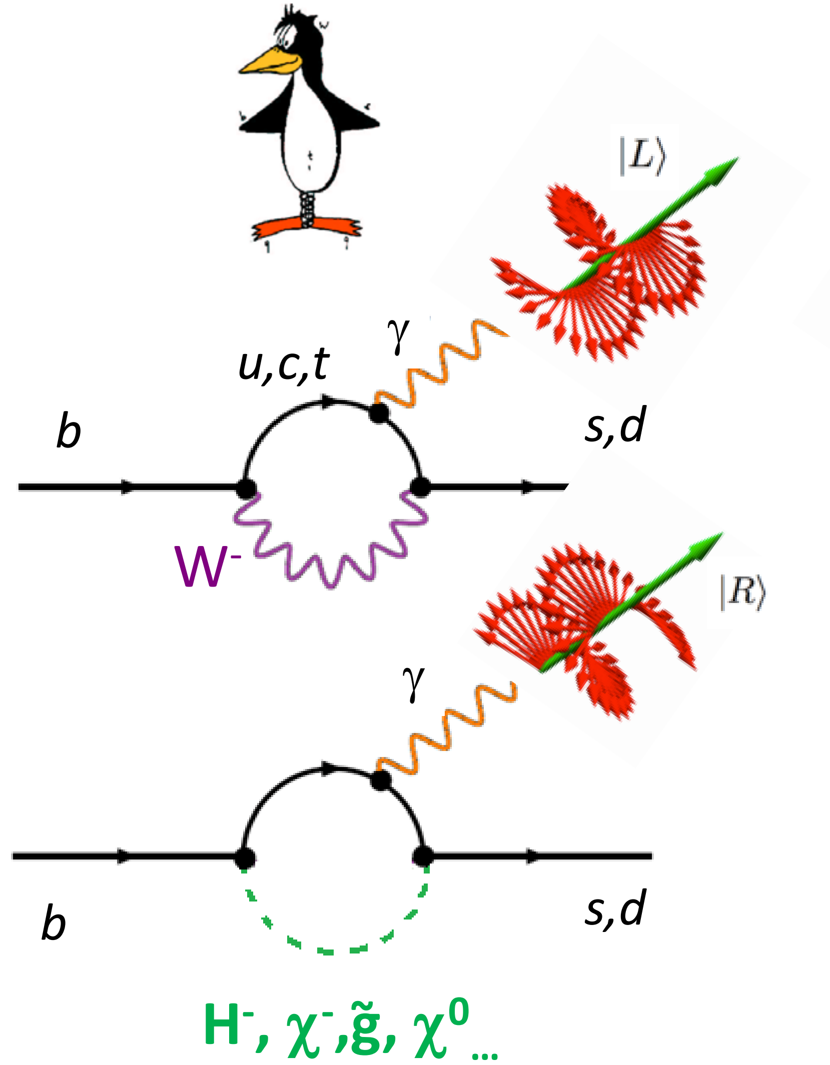
- Motivation
- $B^+ \to K^+ \pi^- \pi^+ \gamma$
- $B^0 \to K^{*0} e^+ e^-$
- $B_s \to \phi\gamma$
- b-baryons: $\Lambda_b \to \Lambda\gamma$, $\Xi_b \to \Xi\,\gamma$, $\Omega_b \to \Omega\gamma$
- Conclusions

Motivation

→ Photons in ***b* →*s*γ** are predicted to be left-handed in the SM (small corrections of order m_s/m_b ~ 2%)

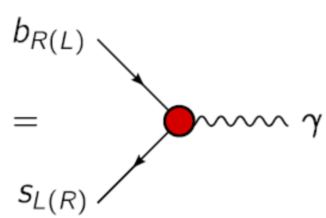
→ Some new physics models, particularly **Left-Right Symmetric Models,** predict an anomalous component of polarized photons

[D. Atwood, M. Gronau and A. Soni, PRL79(97)185]
[M. Gronau, D. Pirjol, PRD66(02)054008]
[F. Yu, E. Kou, C. Lü, JHEP12(2013)102]



→ Involved Wilson coefficient: **$C_7^{(\prime)}$**

$\mathcal{O}_7^{(\prime)} =$



$$\mathcal{O}_7^{(\prime)} = \frac{m_b}{e}(\bar{s}\sigma_{\mu\nu}P_{\mathrm{R(L)}}b)F^{\mu\nu}$$

Motivation

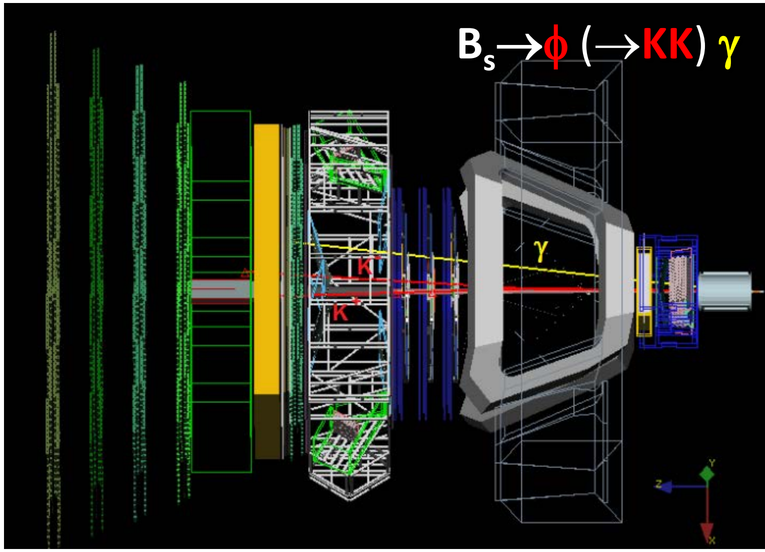
How to access **the photon polarization** in *b*-hadron decays?

- **Time dependent analyses, using $B\text{-}\overline{B}$ interference of mixing and decay:**
  - Final common state for neutral B and $\overline{B}$: $B_{(s)} \to V\gamma$, $V \to KK$, $\pi\pi$
  - B_s more profitable ($\Delta\Gamma_s >> \Delta\Gamma_d$)
  - @ LHCb: V to charged tracks, better no π^0's, no K_s 's (Ex: ~~$B_d \to K^{*0}$ ($K_s\pi^0$)γ~~)
  - $B_s \to \phi\gamma$, $B_d \to \rho\gamma$, $B_d \to \omega\gamma$
  - Observables: TD decay widths, TD CP asymmetries
  - Use of flavour tagging (C, S mixing param.) reduces a lot the statistics (ε_{eff}~5%)

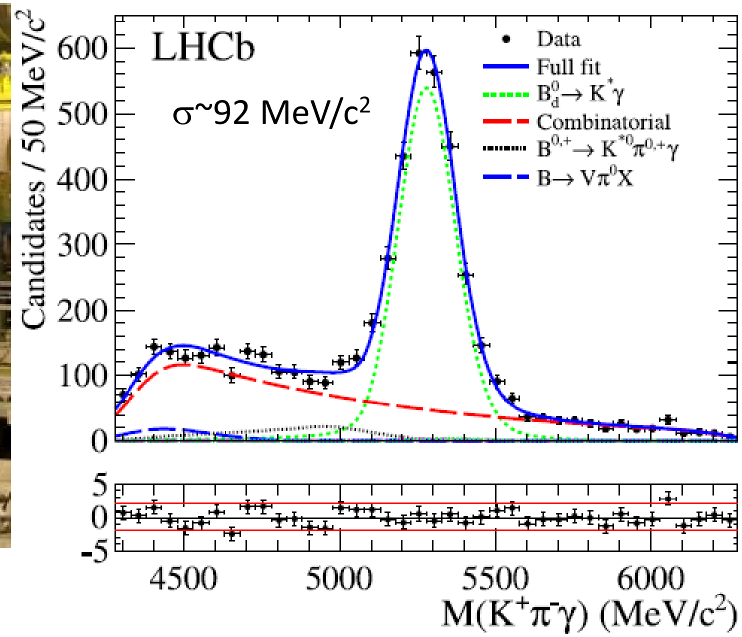
- **Angular analyses:**
  - $B_{(s)}$ to three-body + γ decays ($B^+ \to K^-\pi^+\pi^+\gamma$) **[PRL 112(2014)161801]**
  - Decays of b-baryons ($\Lambda_b \to \Lambda\gamma$ ...)
  - Decays with an electron pair in the final state $\gamma \to e^-e^+$
    with γ real: radiative decays with converted photons ($B_{(s)} \to V\gamma(\to e^-e^+)$)
    or virtual: $B \to K^*e^+e^-$ analyzed in the low q^2 region **[JHEP04(2015)064]**

Motivation

Radiative decays @ LHCb:



[Nuc. Phys. B 867 (2013) 1-18]



First measurements @ LHCb :

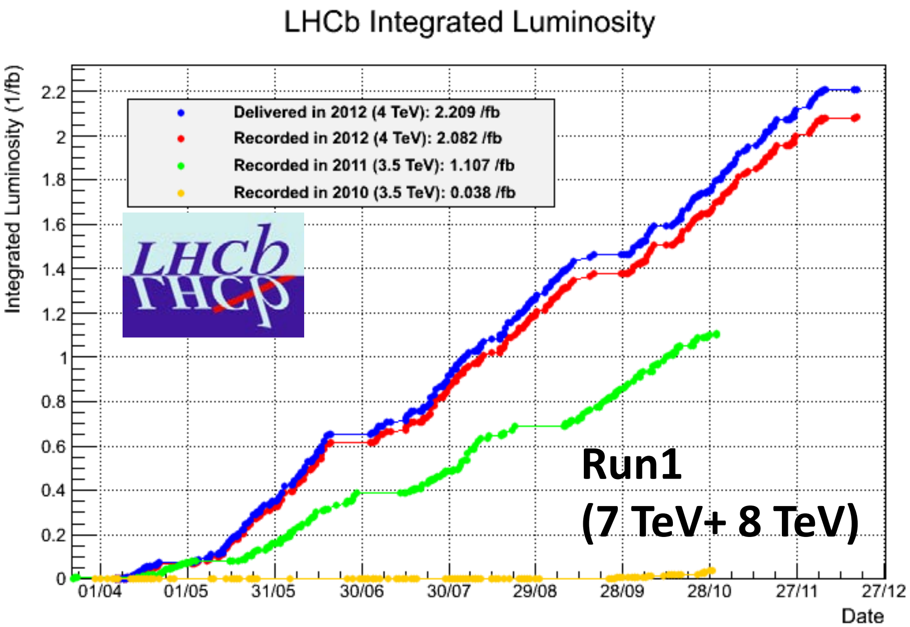
$$\frac{\mathcal{B}(B^0 \to K^{*0}\gamma)}{\mathcal{B}(B_s^0 \to \phi\gamma)} = 1.23 \pm 0.06\ (\text{stat.}) \pm 0.04\ (\text{syst.}) \pm 0.10\ (f_s/f_d)$$

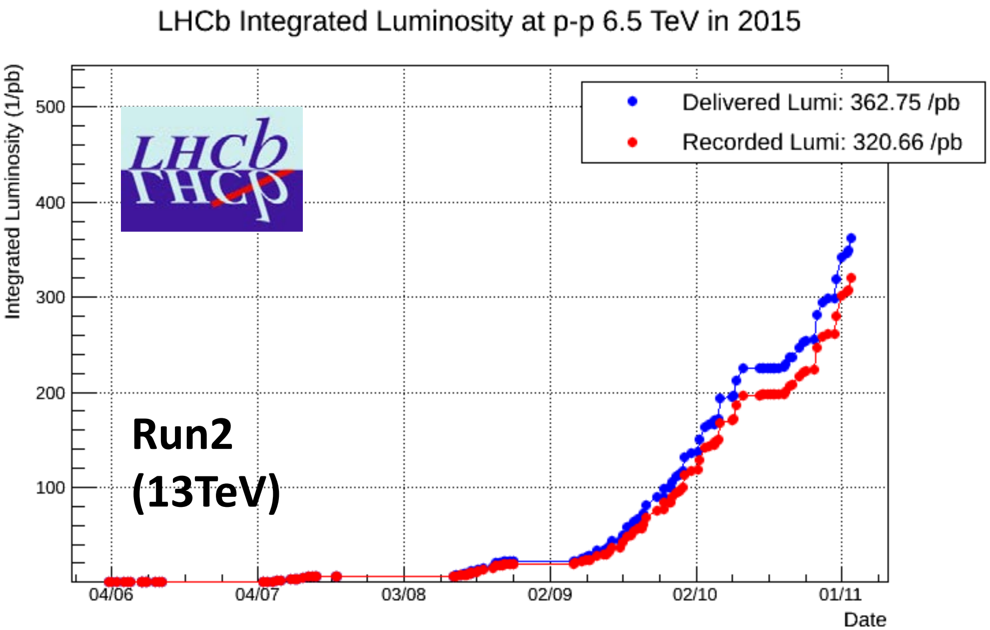
$$\mathcal{A}_{CP}(B^0 \to K^{*0}\gamma) = (0.8 \pm 1.7\ (\text{stat.}) \pm 0.9\ (\text{syst.}))\%.$$

5279 ± 93 $B_d \to K^*\gamma$
691 ± 36 $B_s \to \phi\gamma$

(this with 1fb^{-1}, update with 3fb^{-1} soon)

Motivation





LHCb working well, expected 8 fb^{-1} at the end of Run2

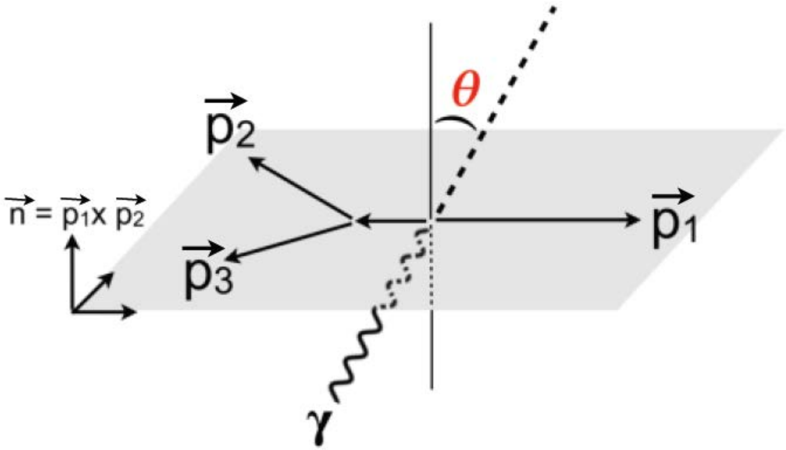
(also gain from B production at higher centre-of-mass energy)

Measuring the photon polarization with:

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

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

- The photon polarization can be measured in $B_{(s)}$ to three body + γ decays
$\to$ the decay plane defines the direction of the photon



- The **photon polarization parameter λ_γ**

$$\lambda_\gamma \equiv \frac{|c_R|^2 - |c_L|^2}{|c_R|^2 + |c_L|^2}$$

expected to be -1 ($\bar{B}$) or +1 (B) with corrections of $(m_s/m_b)^2$
(C_R, C_L right and left amplitudes)

- It can be extracted by studying the three body decay of a K_J (J^P) resonant state in **$B \to K_{res}$** γ radiative decays [Kou et al, PRD83 (2011) 094007; Gronau et al, PRL88 (2002) 051802]

Ex: the 1^+ states **K_1(1270)** and **K_1(1400)**, decaying into $K\pi\pi$ final state (via $K^*\pi$ and ρK modes)

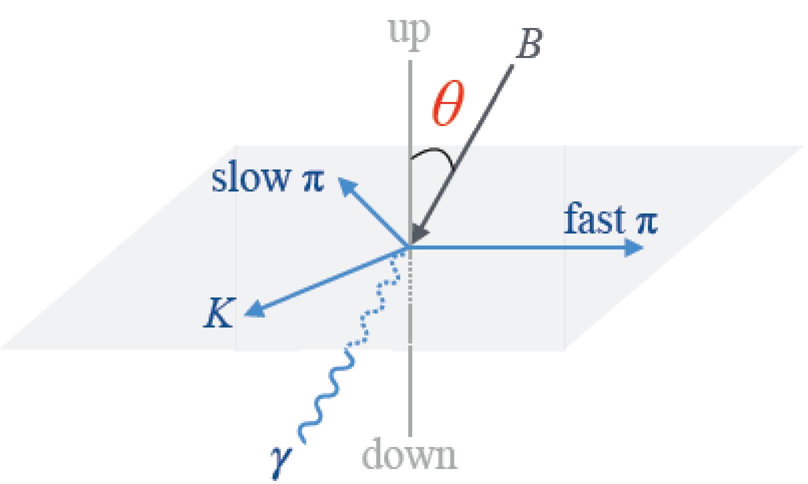
$B^+ \to K^+\pi^-\pi^+\gamma$

- For a radiative **$B \to K_{res}\gamma$**, with the K_{res} a three body decay **$K_{res} \to P_1P_2P_3$**

$$\frac{d\Gamma(\overline{B} \to \overline{K}_{res}\gamma \to P_1P_2P_3\gamma)}{ds\, ds_{13}\, ds_{23}\, d\cos\theta}$$

with $s_{ij}=(p_i+p_j)^2$; $s=(p_1+p_2+p_3)^2$

is the sum of the helicity amplitudes



The **Up-down asymmetry A_{UD}**

$$\boxed{\mathcal{A}_{up-down} = \frac{\int_0^1 d\cos\theta \frac{d\Gamma}{d\cos\theta} - \int_{-1}^0 d\cos\theta \frac{d\Gamma}{d\cos\theta}}{\int_{-1}^1 d\cos\theta \frac{d\Gamma}{d\cos\theta}} \propto \lambda_\gamma}$$

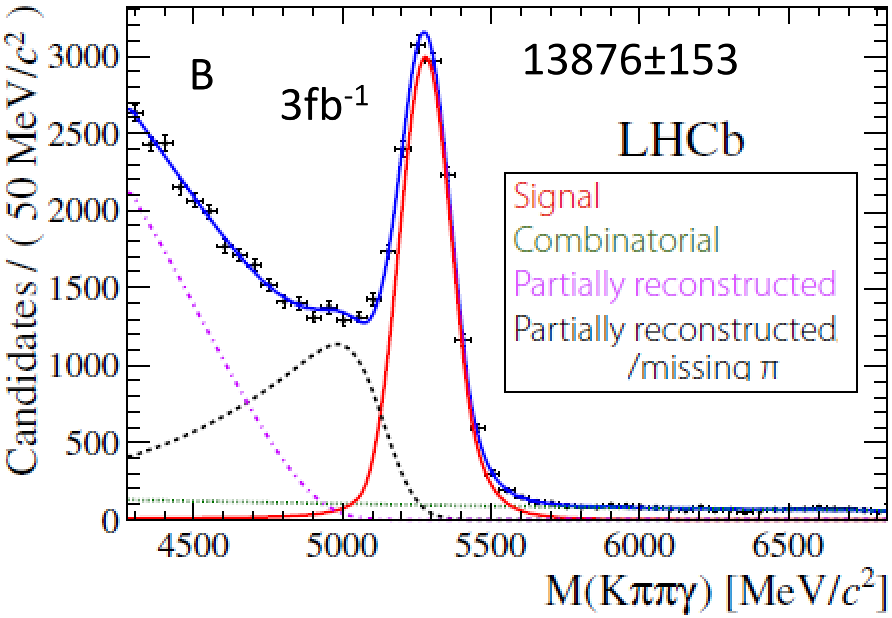
Allows to extract the photon polarization information

$\to$ Need to count the number of events with photon emitted above/below the $\vec{p}_1\vec{p}_2$-plane and subtract them.

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

[PRL 112, 161801 (2014)] **(3fb^{-1})**

- Reconstruct a kaon resonance from three charged tracks: two pions of opposite sign and a kaon, plus a **high E_T photon.**



(Kππ from 1.1-1.9 GeV)

Up-down asymmetry: **A_{UD}**

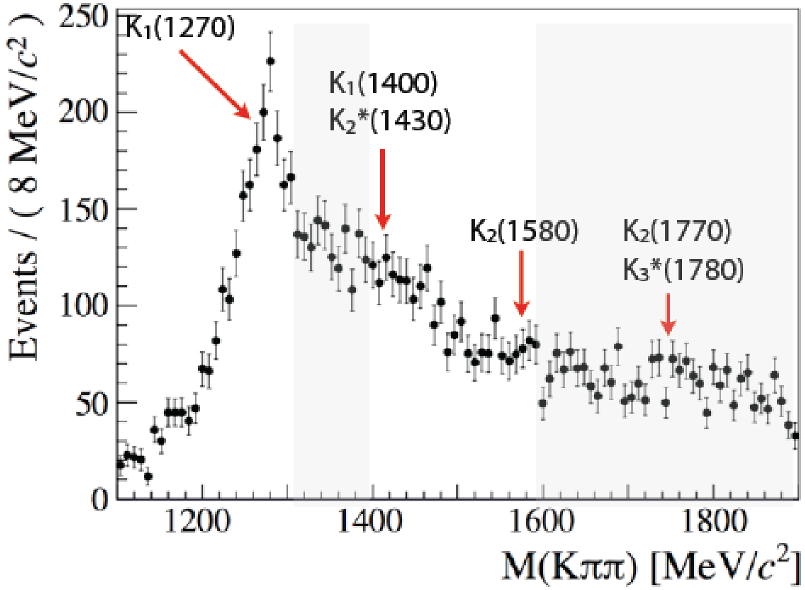
$$\mathcal{A}_{UD} = \frac{N(K\pi\pi\gamma)_{\cos\theta>0} - N(K\pi\pi\gamma)_{\cos\theta<0}}{N(K\pi\pi\gamma)_{\cos\theta>0} + N(K\pi\pi\gamma)_{\cos\theta<0}}$$

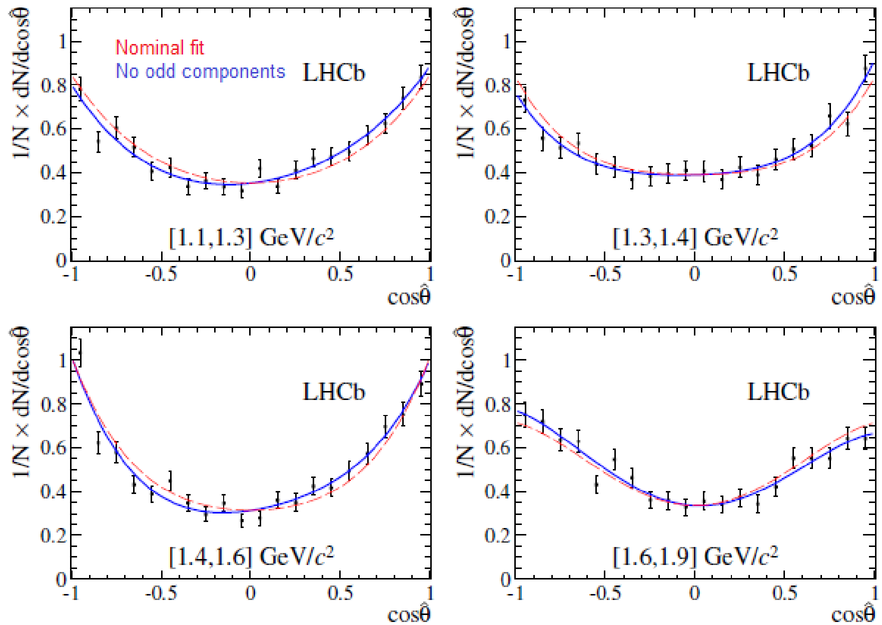
$\rightarrow$ Many kaon resonances with different properties are expected to contribute

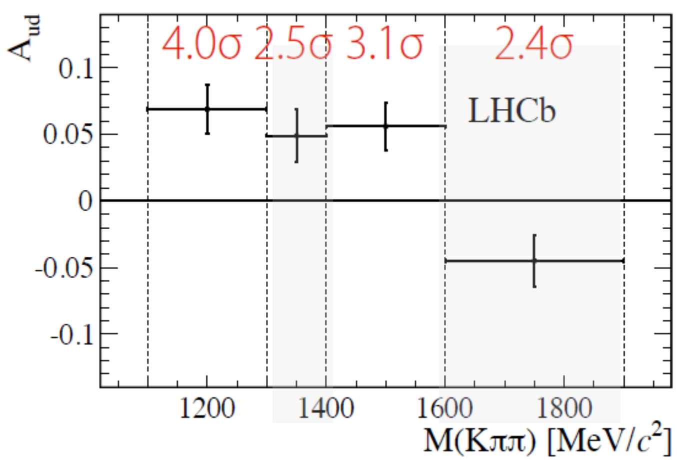
$\rightarrow$ **A_{UD}** studied in several m(Kππ) regions , fitting m_B and the cosθ distribution.

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

Background substracted $K\pi\pi$ spectrum:







→ λ_γ differs from 0 at 5.2σ
First evidence of photon polarization in *b* →*s* transitions!

[PRL 112, 161801 (2014)]

(but this cannot be translated easily in R, L amplitudes…)

[G. Veneziano, CERN-THESIS-2015-287]

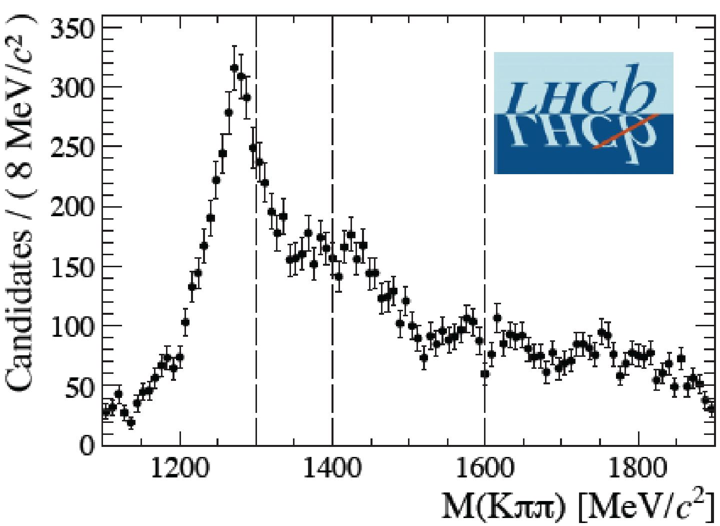
$B^+ \to K^+\pi^-\pi^+\gamma$

- At present performing an amplitude analysis on the $K\pi\pi$ system to disentangle the different resonant contributions (3-dimensions: $m^2_{K\pi\pi}$, $m^2_{K\pi}$, and $m^2_{\pi\pi}$)

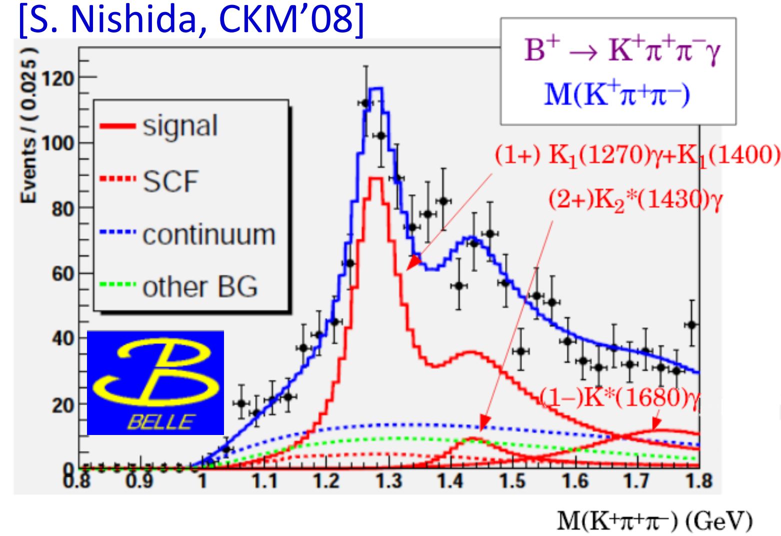
$$\mathcal{PDF}_{X\to K\pi\pi} = \underbrace{\epsilon(\vec{m})}_{\text{efficiency}} \times \underbrace{\eta(\vec{m})}_{B\to K\pi\pi\gamma \text{ phase-space}} \times \sum_{J^P} \left| \sum_k f_k \, \mathcal{A}_k^{J^P}(\vec{m}) \right|^2$$

k indicates the resonance
J^P is the spin-parity
$\mathcal{A}_k^{J^P}$ is the amplitude
f_k defines a fraction and a phase

$\vec{m} = m^2_{K^+\pi^-\pi^+}, m^2_{K^+\pi^-}, m^2_{\pi^+\pi^-}$



[S. Nishida, CKM'08]



And including the angular observables

[Belle, PRL 101 (2008), 251601]
[BaBar, PRD 93 (2016), 052013]

Measuring the photon polarization with:

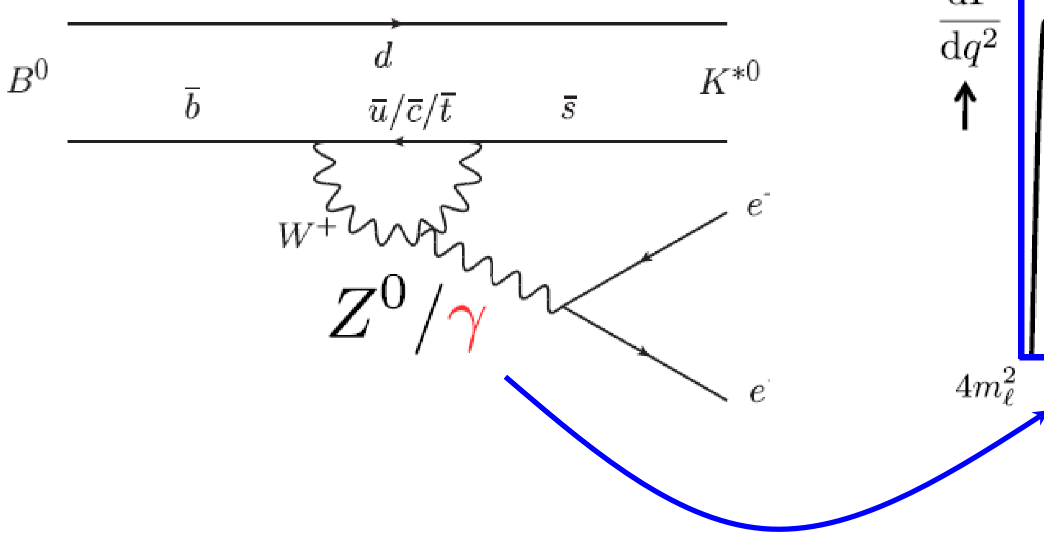
$$B^0 \rightarrow K^{*0} e^- e^+$$

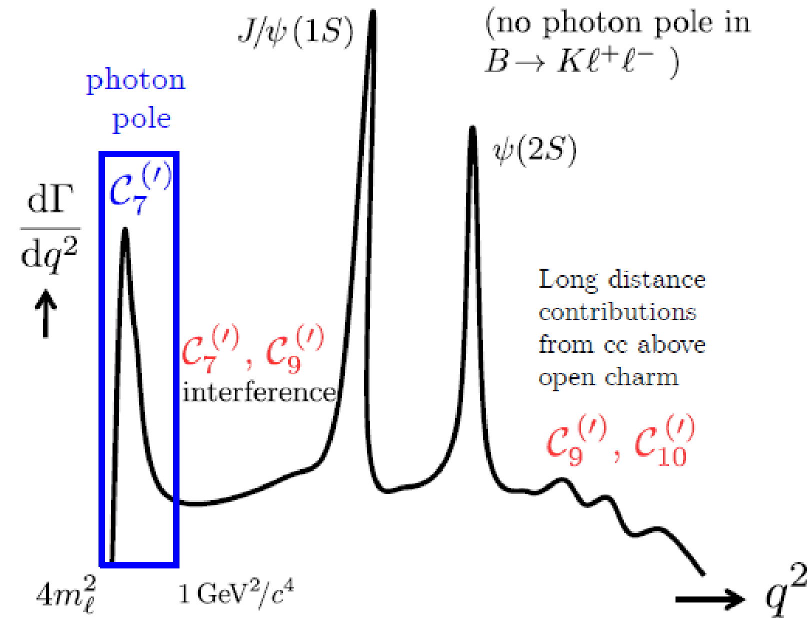
$B^0 \rightarrow K^{*0} e^- e^+$

- Measurement of angular observables of the $B^0 \rightarrow K^* e^- e^+$ in the low $q^2 <$ 1GeV^2

  [JHEP04(2015)064] **($3fb^{-1}$)**

$\rightarrow$ Virtual γ decaying in an observable $\ell^- \ell^+$ pair



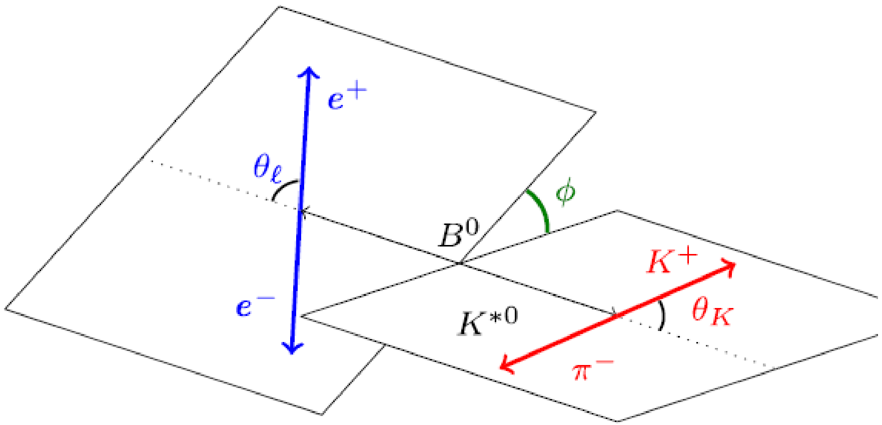


$\rightarrow$ Sensitive to the photon polarization due to the photon pole (for $B \rightarrow V\, \ell^- \ell^+$)

$\rightarrow$ Requires to go very low in the q^2 region $\rightarrow$ **electrons**

$B^0 \to K^{*0} e^- e^+$

- The differential decay rate depends on three angles: θ_ℓ, θ_K and ϕ



$$\frac{1}{\mathrm{d}(\Gamma+\bar{\Gamma})/\mathrm{d}q^2}\frac{\mathrm{d}^4(\Gamma+\bar{\Gamma})}{\mathrm{d}q^2\,\mathrm{d}\cos\theta_\ell\,\mathrm{d}\cos\theta_K\,\mathrm{d}\tilde{\phi}} =$$

$$\frac{9}{16\pi}\Big[\frac{3}{4}(1-F_{\mathrm{L}})\sin^2\theta_K + F_{\mathrm{L}}\cos^2\theta_K +$$
$$\left(\frac{1}{4}(1-F_{\mathrm{L}})\sin^2\theta_K - F_{\mathrm{L}}\cos^2\theta_K\right)\cos 2\theta_\ell +$$
$$\frac{1}{2}(1-F_{\mathrm{L}})A_{\mathrm{T}}^{(2)}\sin^2\theta_K\sin^2\theta_\ell\cos 2\tilde{\phi} +$$
$$(1-F_{\mathrm{L}})A_{\mathrm{T}}^{\mathrm{Re}}\sin^2\theta_K\cos\theta_\ell +$$
$$\frac{1}{2}(1-F_{\mathrm{L}})A_{\mathrm{T}}^{\mathrm{Im}}\sin^2\theta_K\sin^2\theta_\ell\sin 2\tilde{\phi}\Big]$$

$$\boxed{\mathrm{A}_{\mathrm{T}}^{(2)}(q^2\to 0) = \frac{2\mathcal{R}e(\mathcal{C}_7\mathcal{C}_7'^*)}{|\mathcal{C}_7|^2+|\mathcal{C}_7'|^2}}$$

$$\boxed{\mathrm{A}_{\mathrm{T}}^{\mathrm{Im}}(q^2\to 0) = \frac{2\mathcal{I}m(\mathcal{C}_7\mathcal{C}_7'^*)}{|\mathcal{C}_7|^2+|\mathcal{C}_7'|^2}}$$

access to the photon polarization information

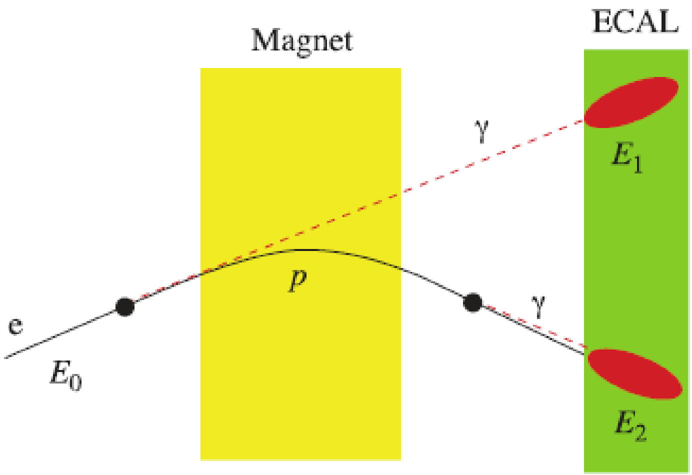
[D. Becirevic and E. Schneider Nucl. Phys. B 854 (2012) 321]

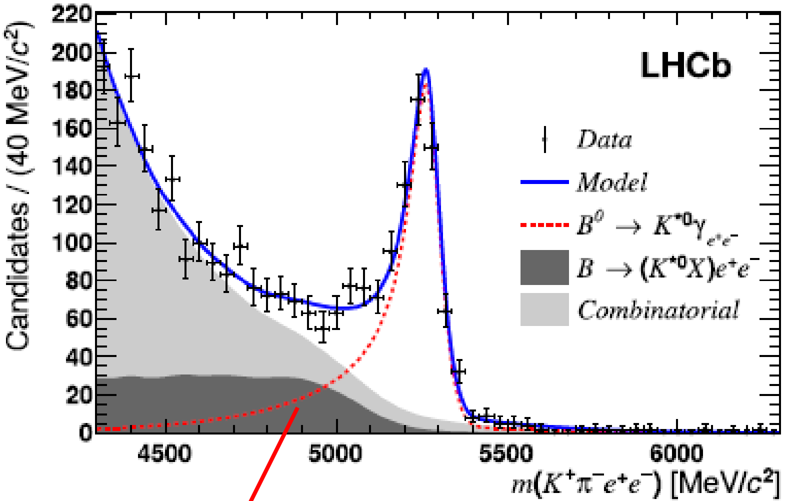
$$A_{\mathrm{T}}^{\mathrm{Re}} = \frac{4}{3}A_{\mathrm{FB}}/(1-F_{\mathrm{L}})$$

F_{L}: longitudinal polarization of the K*
(expected small at low q^2, $\gamma_\perp$ polarized)

$B^0 \to K^{*0} e^- e^+$

- Electrons are difficult to reconstruct since they loose energy by radiation: need **bremsstrahlung recovery**



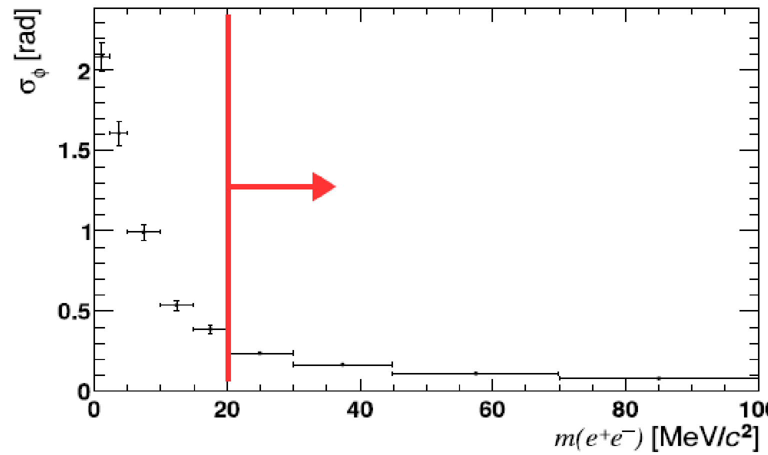


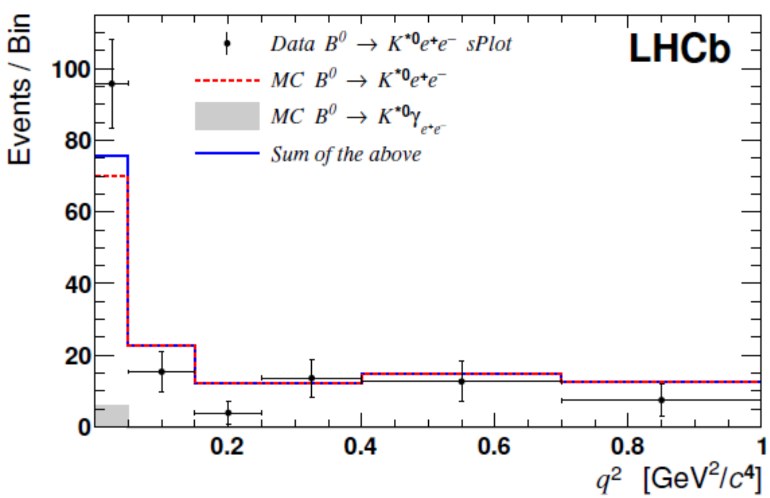
$\rightarrow$ adding neutral clusters from the ECAL , with E_T > 75MeV

Long radiative tail in the B mass distribution: controlled from $B \rightarrow K^*\gamma$ events ($\gamma \rightarrow e^- e^+$, with bremsstrahlung emission)

$B^0 \to K^{*0} e^- e^+$

- q^2 range driven by the experimental resolution in $\phi \to$ cut at $m(e^-e^+) > 20$ MeV





Reconstructed q^2 distribution

$\to$ $\boxed{q^2_{min} = 0.0004 \text{ GeV}^2}$

good also to suppress the $B \to K^*\gamma(\to e^-e^+)$ background

and

$\to$ $\boxed{q^2_{max} = 1 \text{ GeV}^2}$

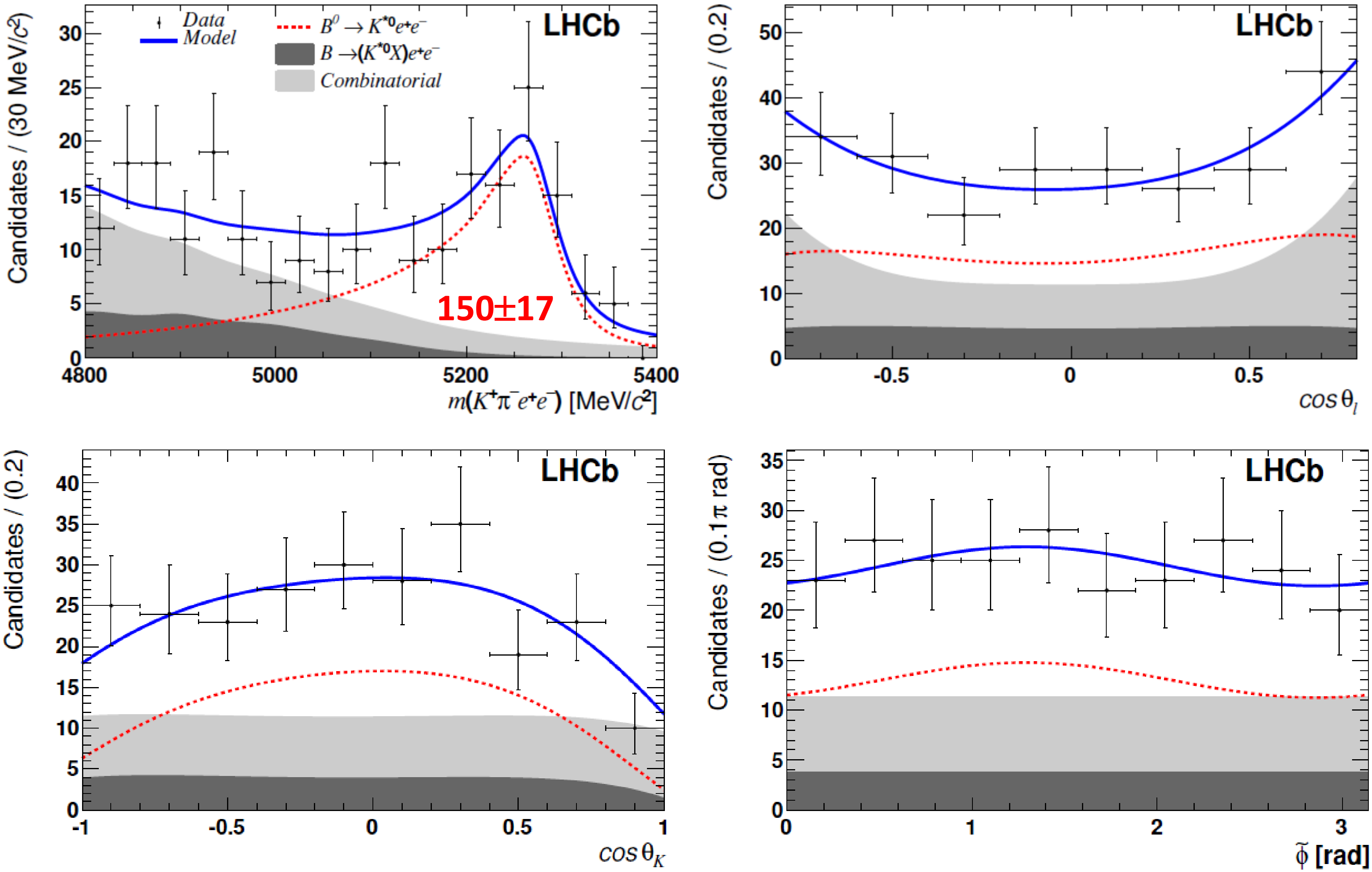
allowing to isolate $C_7^{(')}$ contributions

Unfolding reconstruction effects, the effective q^2 range is:

$\boxed{q^2 \in (0.0020(8), 1.12(6)) \text{ GeV}^2}$

$B^0 \rightarrow K^{*0} e^- e^+$

- 4-dimensional fit to $m(K^+\pi^- e^- e^+)$ and the three angles θ_ℓ, θ_K and ϕ:



$B^0 \to K^{*0} e^- e^+$

- The results of the fitted parameters (**A_T^{im}** and **$A_T^{(2)}$** being sensitive to the γ polarization):

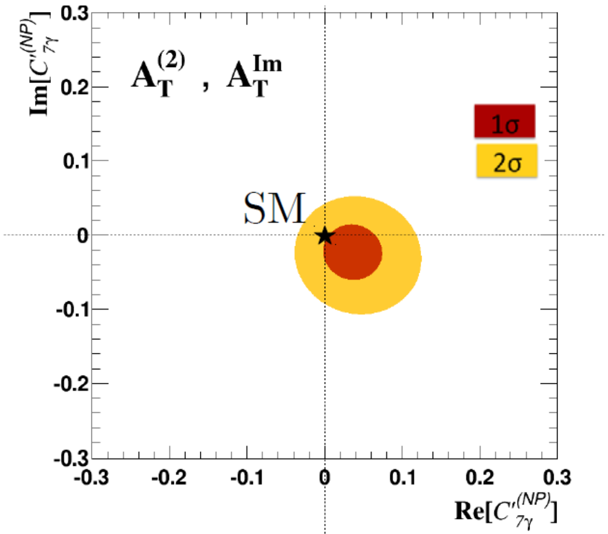
Results:

$$F_L = 0.16 \pm 0.06 \pm 0.03$$
$$A_T^{Re} = +0.10 \pm 0.18 \pm 0.05$$
$$A_T^{(2)} = -0.23 \pm 0.23 \pm 0.05$$
$$A_T^{Im} = +0.14 \pm 0.22 \pm 0.05$$

SM predictions:

$$F_L = 0.10^{+0.11}_{-0.05}$$
$$A_T^{Re} = -0.15^{+0.04}_{-0.03}$$
$$A_T^{(2)} = +0.03^{+0.05}_{-0.04}$$
$$A_T^{Im} = (-0.2^{+1.2}_{-1.2}) \times 10^{-4}$$

→ **Compatible with the SM predictions*:**



[Adapted from Jäger and Camalich arXiv:1412.3183]

The best sensitivity to $C_7^{(\prime)}$ up to date!

[JHEP04(2015)064]

[M. Borsato, CERN-THESIS-2015-219]

*leading order estimation, 5% accuracy for SM value

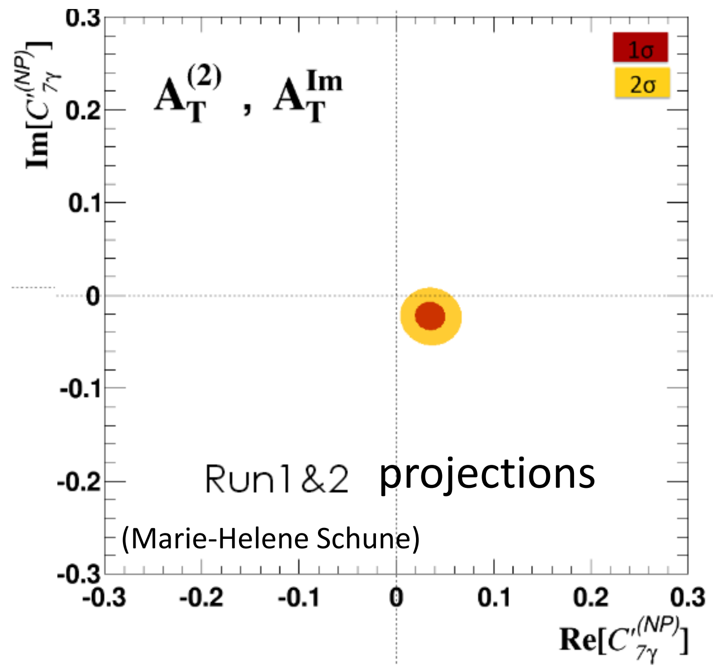
$B^0 \to K^{*0} e^- e^+$

- **Prospects for Run2:**

$\to$ Statistics of Run1 x (1 + ~ 4) (with same performance):
Run1 + Run2 ~ 750 $B \to K^* e^- e^+$ events

Improvements:
$\to$ Overconstrain the B kinematics and brem. emission
▸ Cut even lower than 1 GeV in q^2 reducing futher the combinatorial and partially reconstructed backgrounds, and being more sensitivity to the photon polarization.

$\to$ Add other observables: P'_4 P'_5 P'_6 and P'_8

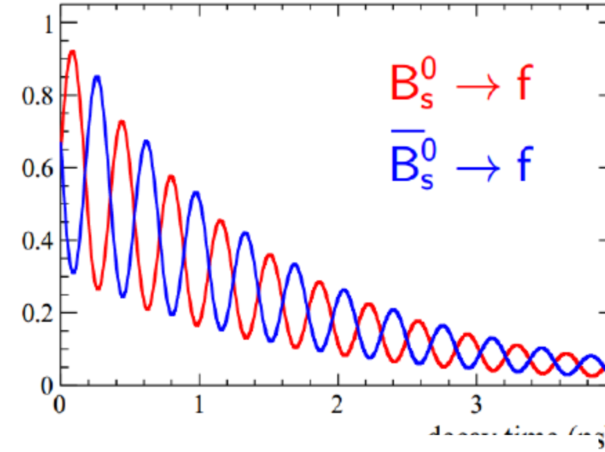


$\to$ The photon polarization could be measured to about 5 to 7 % !

Measuring the photon polarization with:

$$B_s \to \phi\gamma$$

$B_s \to \phi\gamma$



→ The time-dependent decay rate for $B_s \to \phi\gamma$ and $\overline{B}_s \to \phi\gamma$ decays is described by:

$$\Gamma_{\overset{(-)}{B}{}^0_s \to \phi\gamma}(t) =$$

$$= |A|^2 e^{-\Gamma_s t}\left(\cosh\frac{\Delta\Gamma_s t}{2} - \mathcal{A}^{\Delta}\sinh\frac{\Delta\Gamma_s t}{2} \pm \mathcal{C}\cos\Delta m_s t \mp \mathcal{S}\sin\Delta m_s t\right)$$

~ 0 in the SM

$$\boxed{\mathcal{A}^{\Delta} \approx \sin 2\psi \cos\varphi_s}$$

$$\boxed{\mathcal{S} \approx \sin 2\psi \sin\varphi_s}$$

~ 0 in the SM

φ_s= weak mixing phase (<< in the SM)

Fraction of anomalous polarized photons: $\tan\psi \equiv \left|\frac{\mathcal{A}(B_s \to \phi\gamma_L)}{\mathcal{A}(B_s \to \phi\gamma_R)}\right|$

$\Delta\Gamma_s = \Gamma_L - \Gamma_H = (0.081 \pm 0.011)\ ps^{-1}$

$\Gamma_s = 1/\tau_{Bs} = (0.6596 \pm 0.0046)\ ps^{-1}$

$B_s \to \phi\gamma$

$\rightarrow$ Untagged measurement of the time dependent $B_s \to \phi\gamma$ width:

$$\Gamma_{B_s^0}(t) = |A|^2 e^{-\Gamma_s t} \left(\cosh\frac{\Delta\Gamma_s t}{2} - \mathcal{A}^{\Delta} \sinh\frac{\Delta\Gamma_s t}{2}\right)$$

$$\approx |A|^2 e^{-\Gamma_{B_s \to \phi\gamma} t}$$ with

It can be seen as an "Effective lifetime" depending on the A^{Δ}

$$\Gamma_{B_s \to \phi\gamma} = \Gamma_s + \frac{\mathcal{A}^{\Delta}\Delta\Gamma}{2}$$

SM value: $A^{\Delta} = 0.047 \pm 0.025 + 0.015_{(\alpha_s)}$ [Muheim, Xie, Zwicky, PLB664(08)174]

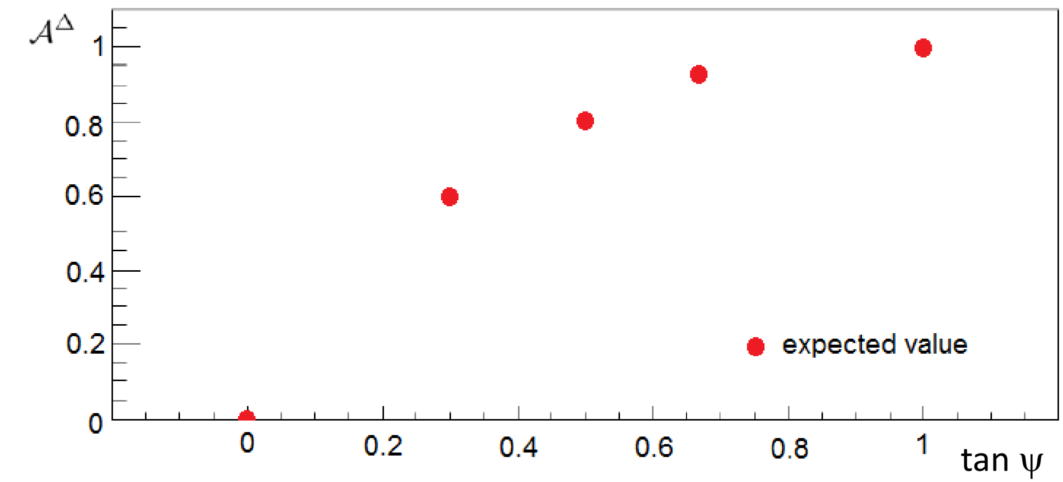
Left-Right Symmetric models: A^{Δ} up to ~ 0.7 [Atwood, Gronau and Soni, PRL79(97)185]

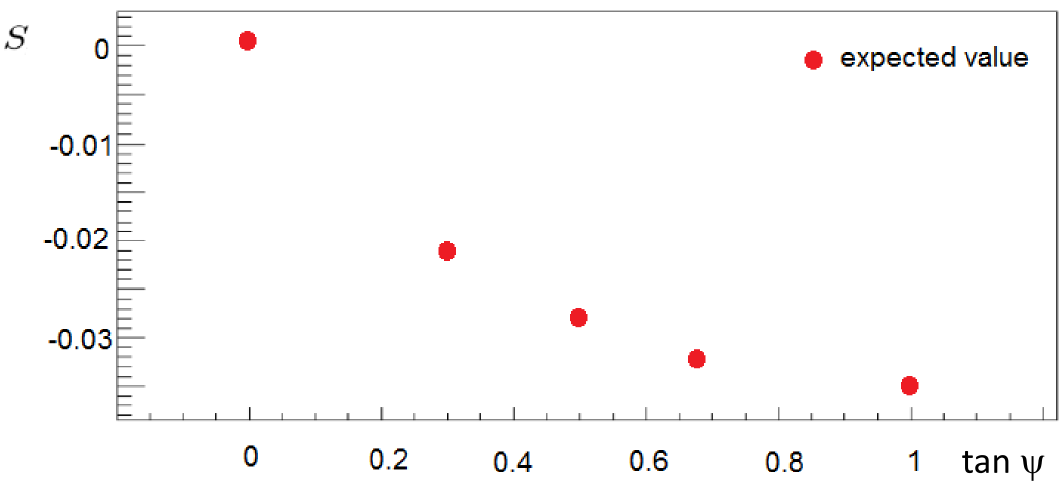
$\rightarrow$ Fraction of anomalous polarized photons ~ 40%

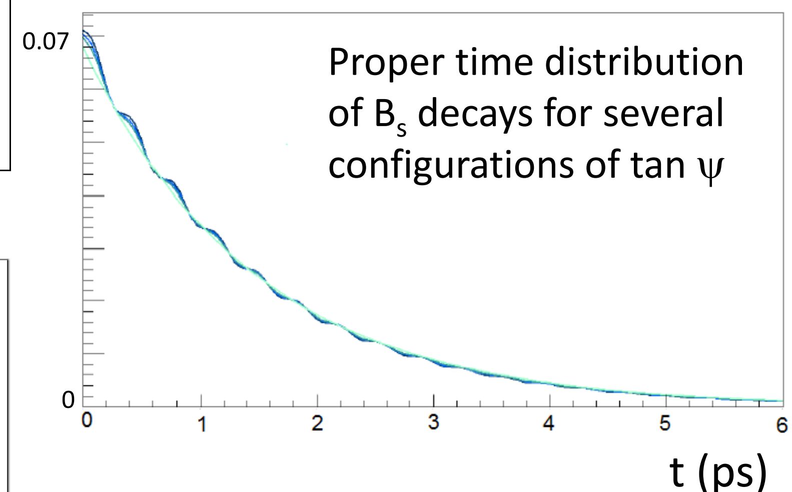
$B_s \rightarrow \phi\gamma$

- Dependence of A^{Δ} and S parameters with the fraction of anomalous polarized photons

$$\tan\psi \equiv \left| \frac{\mathcal{A}\left(B_s \rightarrow \phi\,\gamma_L\right)}{\mathcal{A}\left(B_s \rightarrow \phi\,\gamma_R\right)} \right|$$

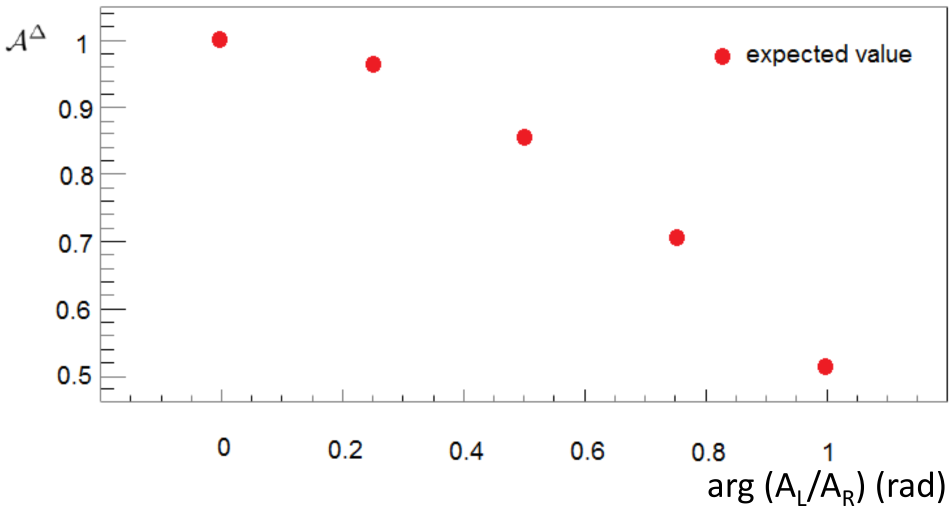


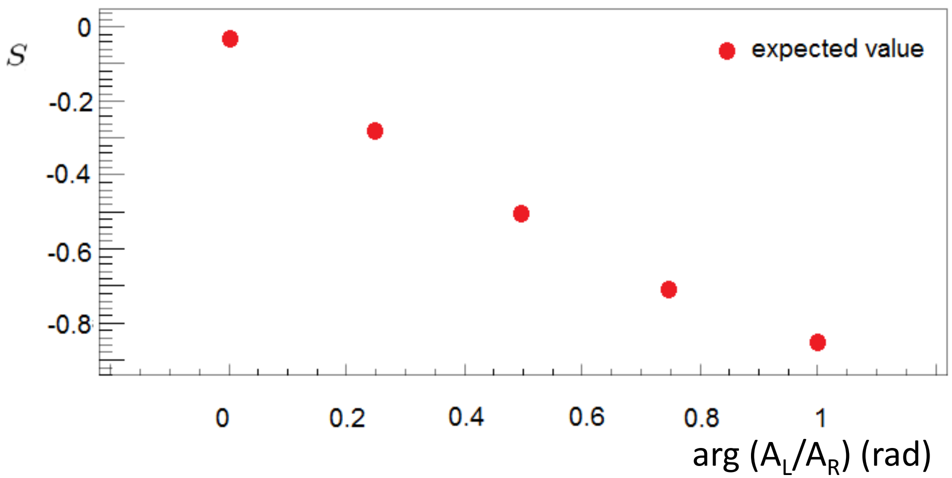


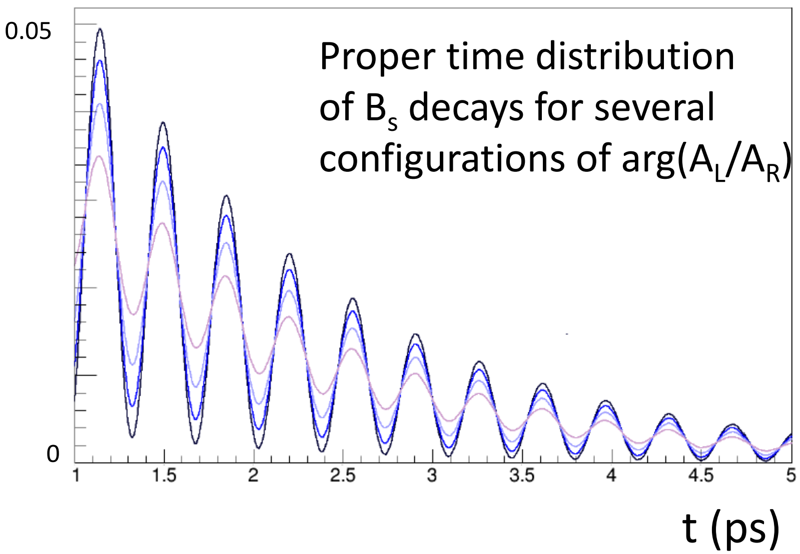


$B_s \to \phi\gamma$

- Dependence of $\mathcal{A}^{\Delta}$ and S parameters with the relative phase of anomalous polarized photons (assuming 50% of A_L)







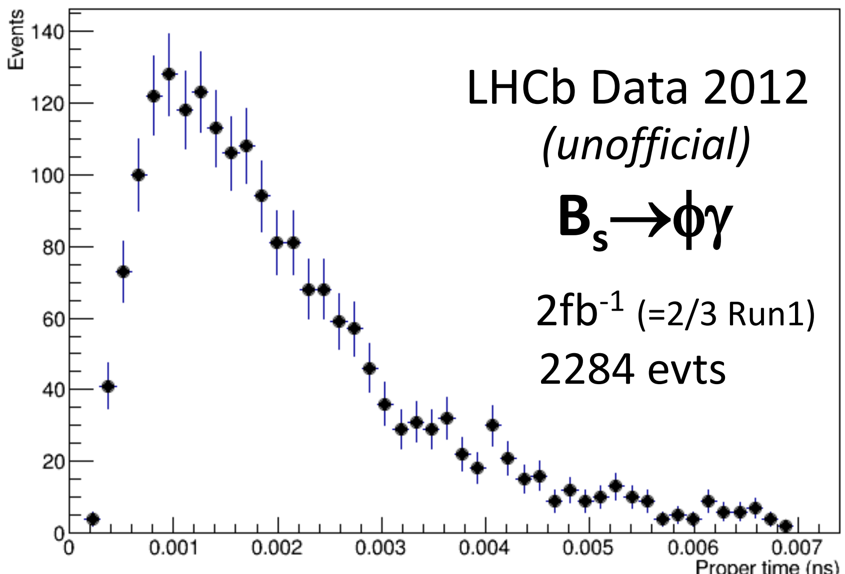
Proper time distribution of B_s decays for several configurations of arg(A_L/A_R)

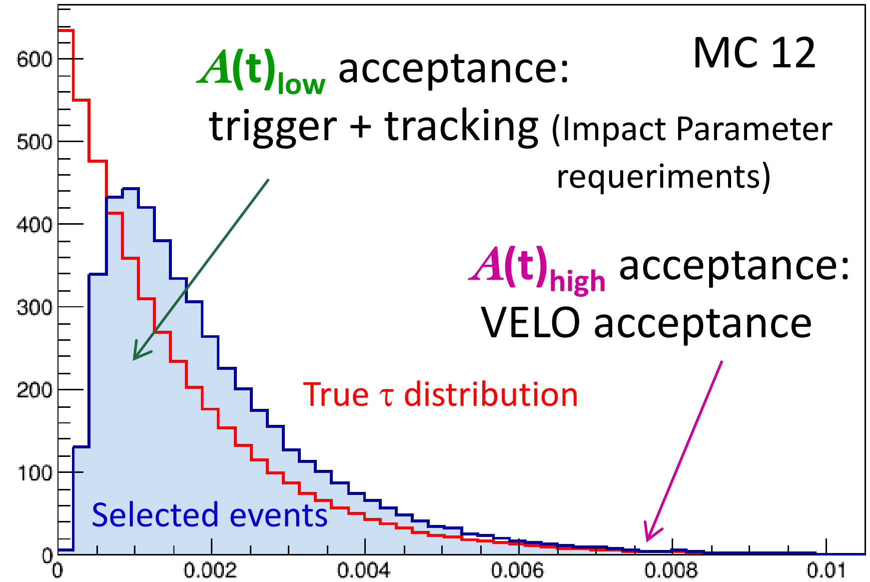
$B_s \to \phi\gamma$

→ Untagged measurement of the time dependent decay rate:

$$\Gamma_{Bs}(t_r)\ \text{measured} = \mathcal{A}(t) \cdot \Gamma_{Bs}(t; A^{\Delta}) \otimes R(t,t_r)$$

Untagged proper time distribution:





One of the main issues in this analysis concerns the determination of the acceptance:

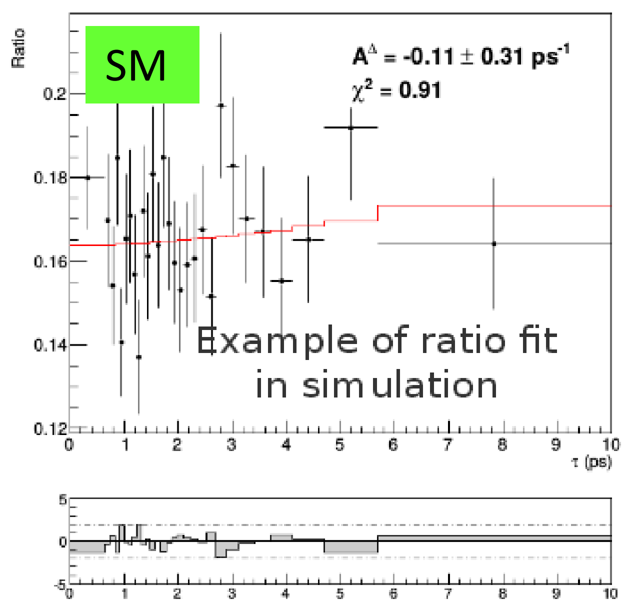
$$\mathcal{A}(t) = \frac{at^n}{1+at^n} \times (1+\beta t)$$

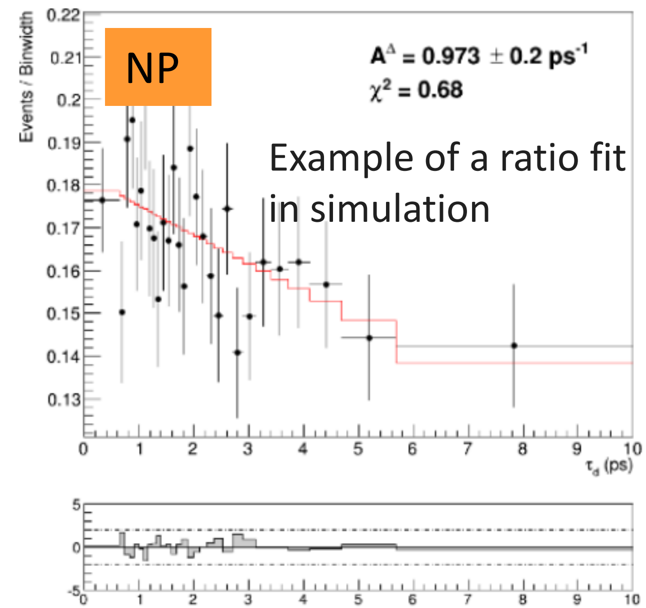
$B_s \to \phi\gamma$

→ $B \to K^*\gamma$ data is used to constrain the acceptance

→ **A^{Δ}** is extracted from a fit to the ratio of B_s/B_d decay widths, and from a direct fit:

The ratio gives the **$(\cosh(\Delta\Gamma_s\, t/2) + A^{\Delta} \sinh(\Delta\Gamma_s\, t/2)$** piece →

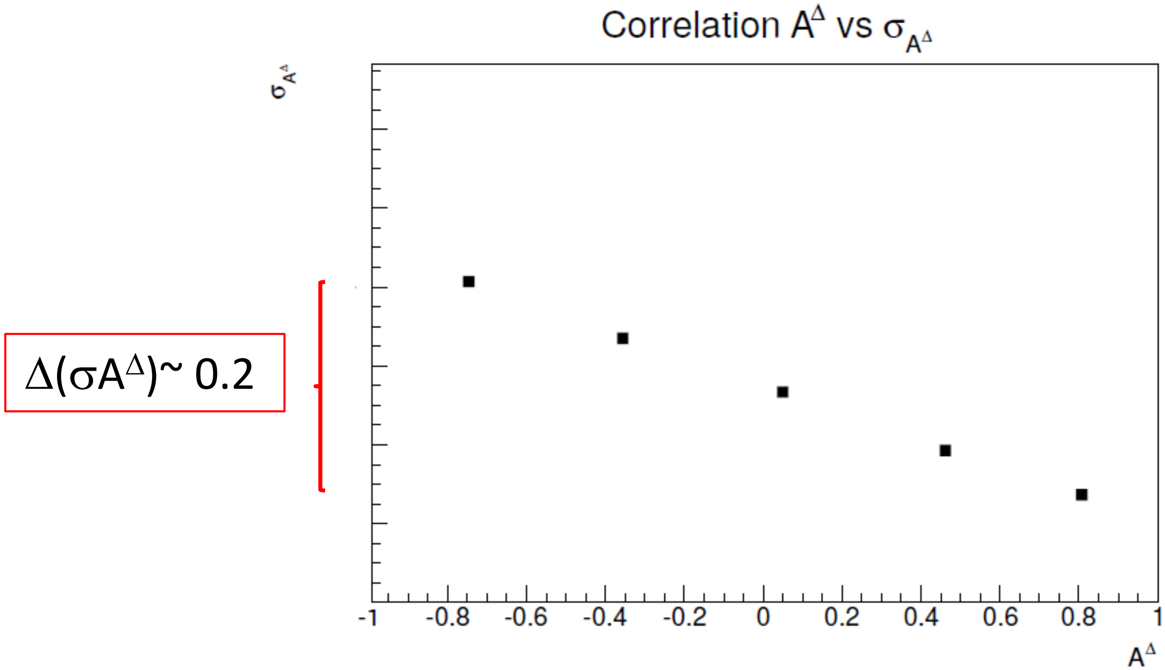




→ One needs to include uncertainties coming from the background subtraction, the statistics of the control sample, fitting procedure and acceptance assumptions

$B_s \to \phi\gamma$

Note the large correlations between the statistical uncertainty and the A^{Δ} value



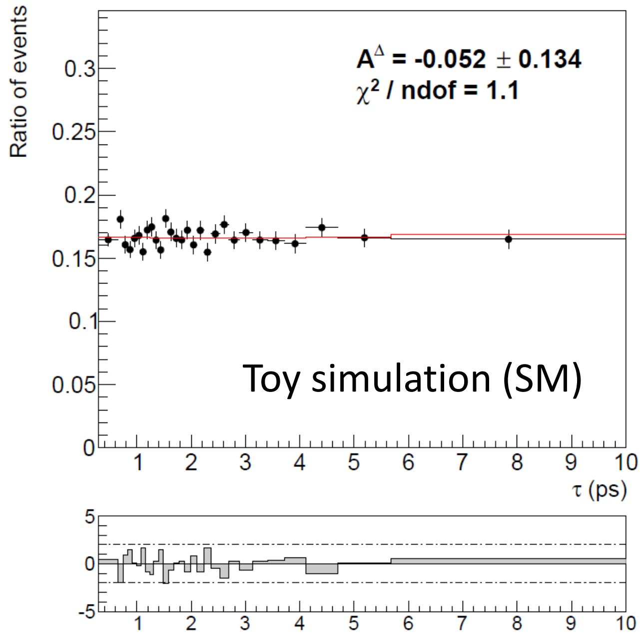
→ I.e., more precise measurements for non-SM photons

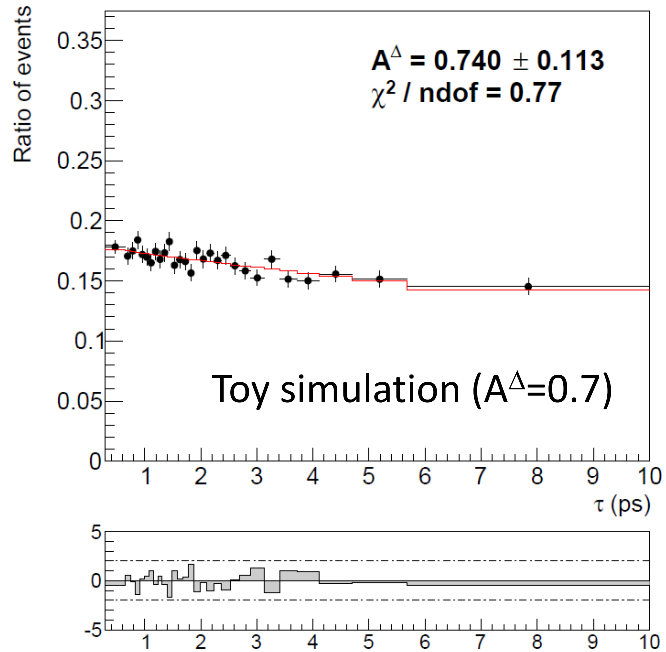
LHCb analysis almost completed, results with $3fb^{-1}$ expected for Summer

$B_s \to \phi\gamma$

Prospects for Run2:

~ 20000 $B_s \to \phi\gamma$ events for Ru1+Run2





$\boxed{\sigma_{A^\Delta}\ _{(SM)} \sim 0.13}$

(Systematic uncertainties expected of the same order)

$\underline{B_s \to \phi\gamma}$

→ Flavour tagging for B_s drastically reduces our data:

$\sigma(pp \to B_s + X) = 10.5 \pm 1.3\ \mu b$ [JHEP08(2013)11]

$\mathcal{B}(B_s \to \phi\gamma) = (3.5 \pm 0.4) \times 10^{-5}$

$\varepsilon_{reconstruction}\ (B_s \to \phi\gamma) \sim 1\%$

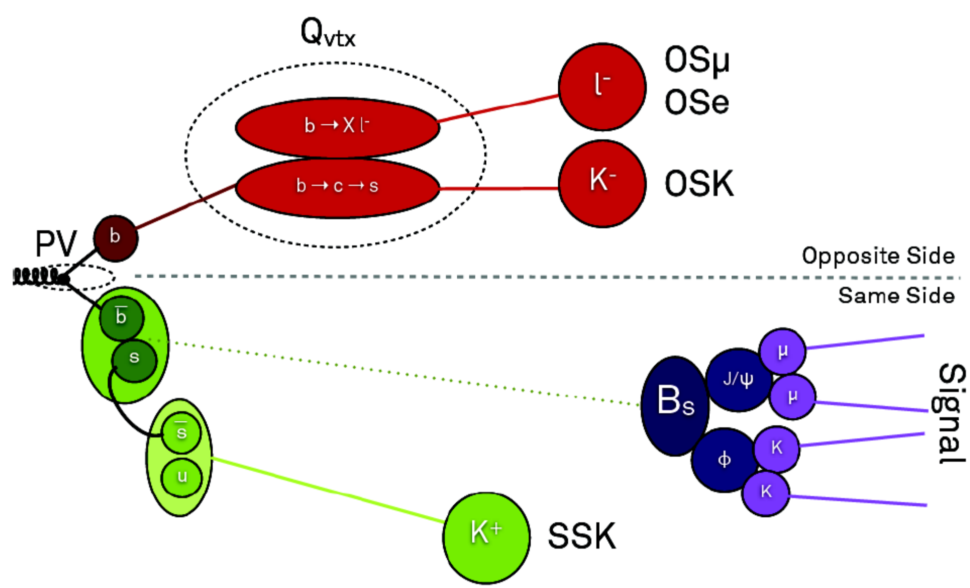
Tagging algorithms:

Same side (SS):

From fragmentation of the signal *b* (π for B, K for B_s)

Opposite side (OS):

From the opposite B:
- e, μ from semileptonic B decays,
- kaons from b → c → s,
- inclusive reconstruction of the opposite B vertex



[Eur. Phys. J. C 72(2012) 2022
LHCb-CONF-2012-026
LHCb-CONF-2012-033J
HEP11 (2014) 060]

+ ongoing improvements for Run2

→ $\boxed{N_{evts} \times \varepsilon_{tag}(1-2\omega)^2}$ We found for $B_s \to \phi\gamma$:

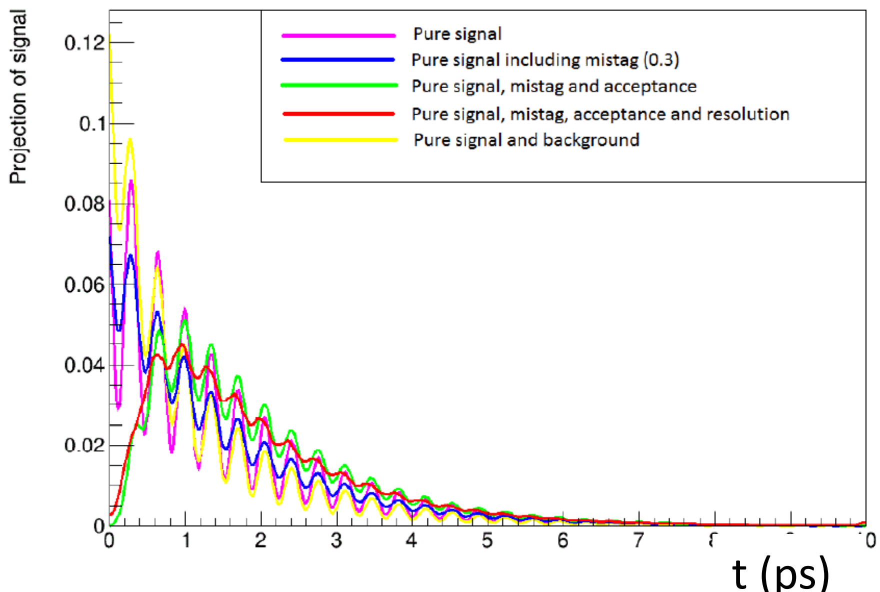
Tagging efficiency, $\varepsilon_{tag} \sim 75\%$
Mistag probability, $\omega \sim 36\%$

Effective efficiency: $\varepsilon_{eff} \sim$ **5.44%**

$B_s \rightarrow \phi\gamma$

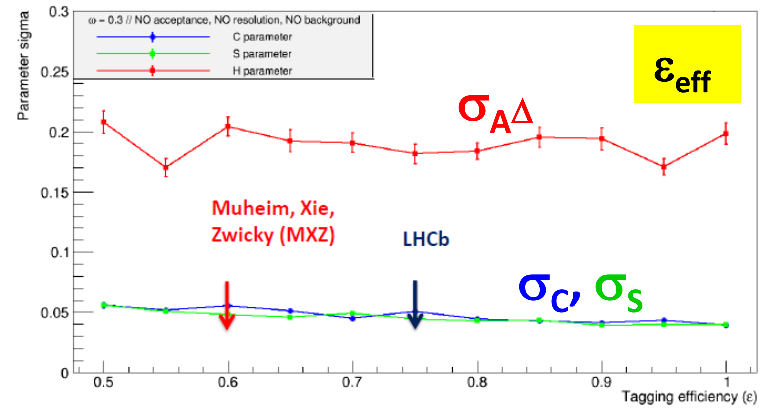
→Tagged measurement of the time dependent decay rate: **expected ~ 1000** events for Run1+Run2

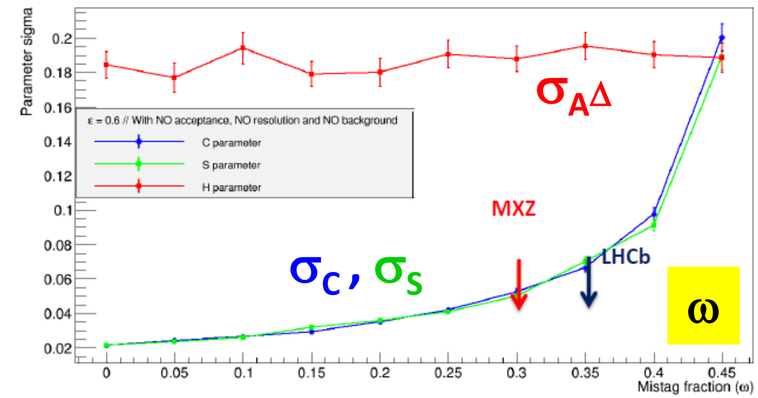
Simulation studies similar to **[Muheim, Xie, Zwicky PL B664(2008)174]**, including LHCb detector effects.

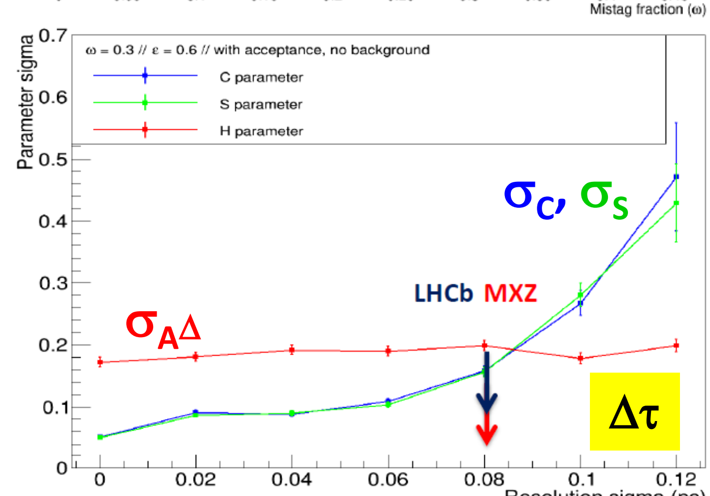


Including all the experimental effects:
(ω = 0.365 , ε_{tag} = 0.744)

σ_C ~0.17	σ_S ~0.17	$\sigma_{A\Delta}$ ~ 0.13







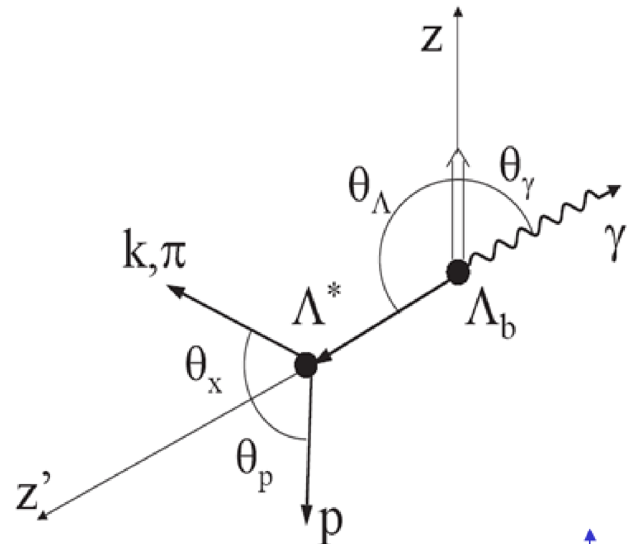
Measuring the photon polarization with:

b-baryons
(Λ_b, Ξ_b, Ω_b)

$\Lambda_b \to \Lambda\gamma$

- Exploiting the angular correlations between the polarized initial state and the final state:

[Mannel, Recksiegel, J.Phys. G24 (1998) 979-990;
Hiller, Kagan, PRD 65, 074038 (2002)]

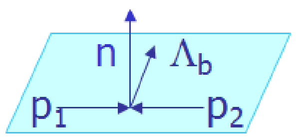


For Λ_b decaying into Λ^0(1115) with J=1/2:

$$\boxed{\frac{d\Gamma}{d\cos\theta_\gamma} \propto 1 - \alpha_\gamma P_{\Lambda_b} \cos\theta_\gamma}$$

$$\boxed{\frac{d\Gamma}{d\cos\theta_p} \propto 1 - \alpha_\gamma \alpha_{p,1/2} \cos\theta_p}$$

$$\boxed{\alpha_\gamma = \frac{P(\gamma_L) - P(\gamma_R)}{P(\gamma_L) + P(\gamma_R)}}$$



$P_{\Lambda b}$ is the Λ_b polarization

$\alpha_{p,1/2}$ is the weak decay parameter

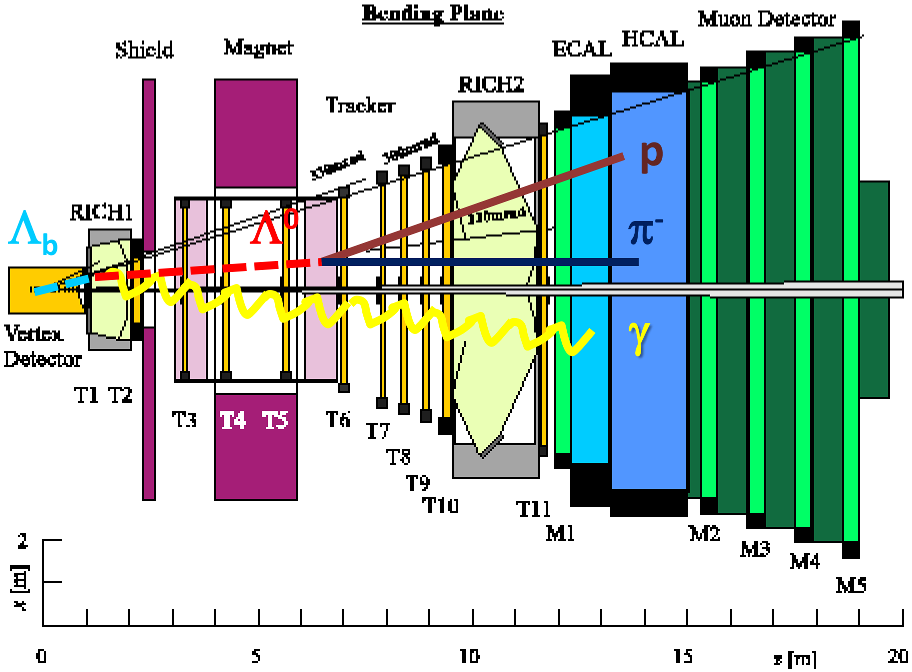
α_γ is the photon polarization

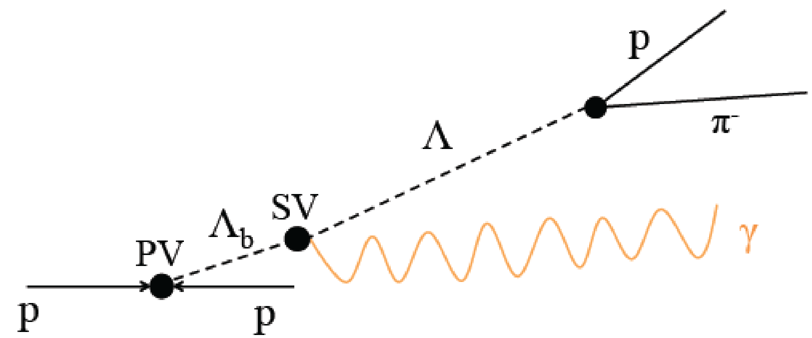
$\rightarrow$ The Λ_b transverse production polarization has been found to be small:
$P_{\Lambda b}$ =0.06 $\pm$ 0.07 $\pm$ 0.02 [PLB724 (2013)27] $\rightarrow$ No sensitivity in $\cos\theta_\gamma$

$\rightarrow$ $\alpha_{p1/2}$ = 0.642 $\pm$ 0.013 [PDG2014] $\rightarrow$ **access to α_γ via the angular distribution of the proton**

$\Lambda_b \to \Lambda\gamma$

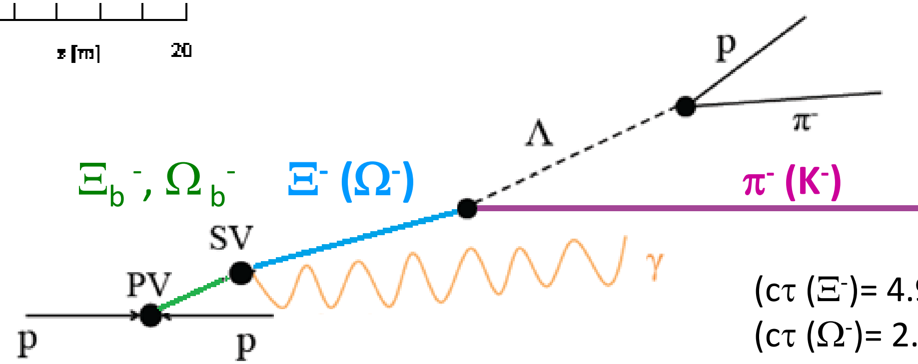
$\rightarrow$ **Experimental challenge:** the Λ_b decay vertex cannot be reconstructed due to the long lifetime of the Λ^0 baryon ($c\tau$ = 7.89 cm)





★ Another possibility:
to use stranger b-baryons:
$\Xi_b^- \rightarrow \Xi^- \gamma$, $\Omega_b^- \rightarrow \Omega^- \gamma$

[L. Oliver, J.-C. Raynal, and R. Sinha, Phys.Rev. D82 (2010) 117502]



($c\tau$ (Ξ^-)= 4.9 cm)
($c\tau$ (Ω^-)= 2.5 cm)

Heavy baryon track + one pion or kaon track to constraint the vertex

$\Xi_b^- \to \Xi^- \gamma$

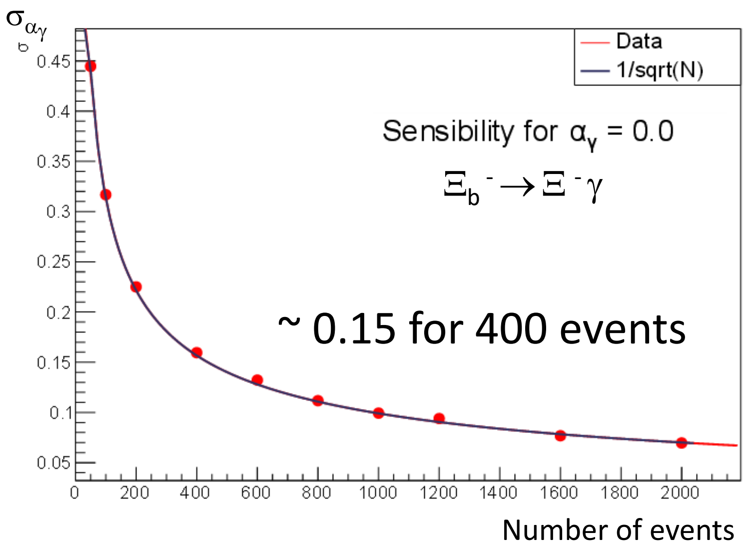
- Angular distribution for the $\Xi_b^- \to \Xi^- \gamma$:

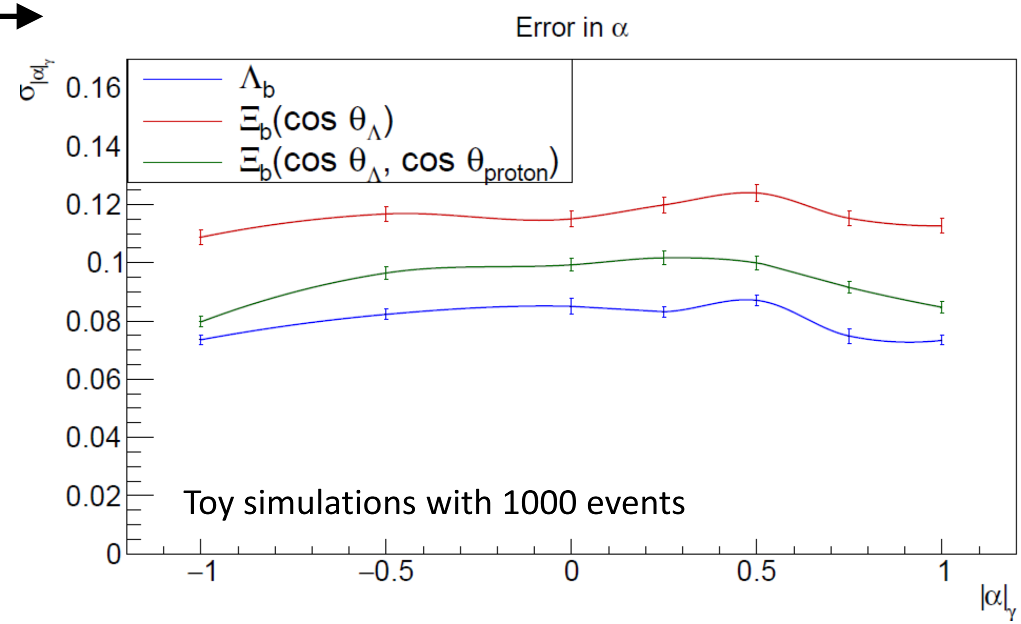
$$\Gamma_{\Xi_b}(\theta_\Lambda, \theta_p) = \frac{1}{4}\left(1 - \alpha_\gamma \alpha_\Xi \cos\theta_\Lambda + \alpha_\Lambda \cos\theta_p \left(\alpha_\Xi - \alpha_\gamma \cos\theta_\Lambda\right)\right)$$

Integrating over $\cos\theta_p$: $\Gamma_{\Xi_b} = \frac{1}{4}\left(1 - \alpha_\gamma \alpha_\Xi \cos\theta_\Lambda\right)$

α_Λ =-0.458± 0.012 [PDG2014]

Similar sensitivity to the photon polarization as the $\Lambda_b \to \Lambda\gamma$ channel if one uses information of the two angles





$\Xi_b^- \to \Xi^- \gamma$

- Expected number of events:

$$N_{sig} = 2 \times \mathcal{L}_{int} \times \sigma(pp \to H_b) \times BR_{\mathrm{TOTAL}} \times \epsilon_{geo+reco}$$

	$\sigma(pp \to \mathrm{H}_b)^{14\mathrm{TeV}}$ [1]	$\mathrm{BR}(\mathrm{H}_b \to \mathrm{H}\gamma)$ [2]	$\mathrm{BR}(\Xi^-[\Omega^-] \to \Lambda^0\pi^-[K^-])$ [3]	$\Lambda^0 \to p\pi^-$ [3]	$\epsilon_{geo+reco}$	N[Run II] $5\mathrm{fb}^{-1}$	N[2016] $1.5\mathrm{fb}^{-1}$
$\Lambda_b \to \Lambda^0\gamma$	85 μb	$10^{-4} - 10^{-6}$ [4]	—	0.64	0.0015	81600-816	24500-245
$\Xi_b^- \to \Xi^-\gamma$	12 μb	$10^{-4} - 10^{-6}$	1.0	0.64	0.0006	2100-21	630-6
$\Omega_b^- \to \Omega^-\gamma$	0.11 μb	$10^{-2} - 10^{-4}$	0.67	0.64	0.0006	1280-13	383-4

$\rightarrow$ Depending on the BR and the channel, one could have hundreds of events already this year

$\rightarrow$ Trigger prepared for $\Lambda_b \to \Lambda\gamma$, $\Xi_b \to \Xi\gamma$, $\Omega_b \to \Omega\gamma$

$\rightarrow$ Good angular resolution at LHCb, effect on $\sigma_{\alpha\gamma}$ small

$\rightarrow$ Other experimental effects (acceptance, background contamination) in study

1. [HEPHY-PUB-609, arXiv:1009.2731]
2. [arXiv:hep-lat/0310035v2]
3. [PDG]
4. Measured upper limit: $< 10^{-3}$ [CL 90 %]

Conclusion

- The **photon polarization** is being measured **at LHCb** using several channels and different observables

- Important to constrain $\mathbf{C_7^{(\prime)}}$ in NP scenarios, it is usually set to zero in global fits

- Difficult analyses due to the γ/e reconstruction in pp collisions, but we did it $\rightarrow$ **NP constraints more precise than the ones from B-factories!**

- Working hard in **new and improved measurements**

- **Run 2** data already coming …

Stay tuned, there is much to come… !

Thank you!