Search for NP and QCD tests with the LHCb data

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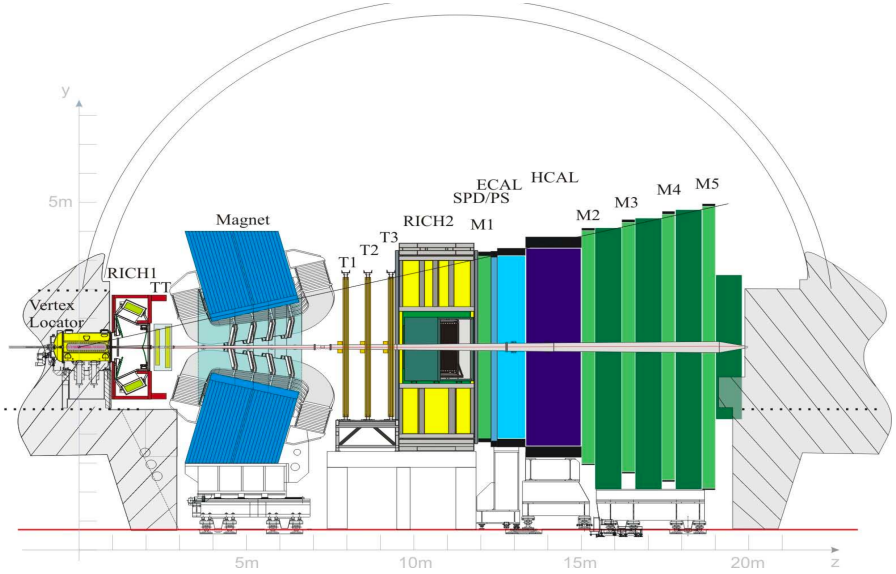
Outline

- Framework : physics topics in the LHCb LAL group
- Search for NP
- QCD & charmonia
- All the internships !

The LHCb LAL group

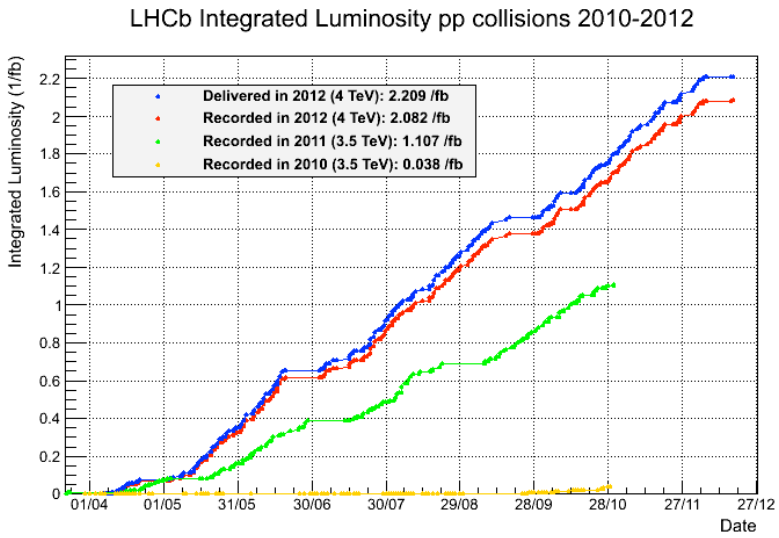
~ 10 physicists
~ 3 PhD students
..and Master students



- Calorimeter Font-end electronics
- Slow Control electronics
- L0 Calorimeter trigger
- Calorimeter software
- Tracking
- Physics !

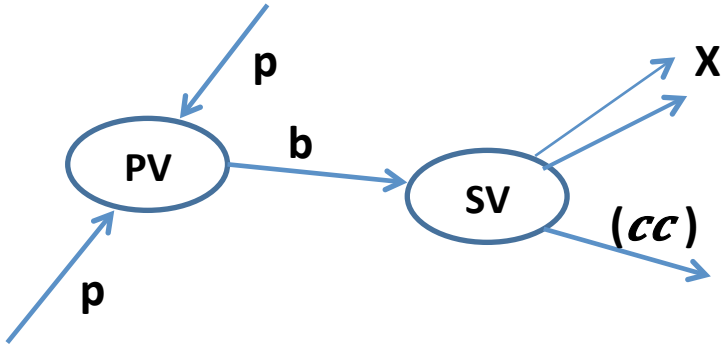
Physics topics in the LHCb LAL group

- Charmonia cross section measurements
- **Hadronic decays of charmonia**
- **$B_s \rightarrow n\phi$**
- **Search for $B \rightarrow D_s(2317)\pi$**
- B cross section measurements
- B_c physics
- γ angle measurement ($B^0 \rightarrow DK^{*0}$)
- **Search for NP in $B \rightarrow K^{*0}ll$**
- Search for NP in $D \rightarrow hh'\mu\mu$
- $B \rightarrow D^*\tau\upsilon$



2010	2011	2012
0.038 fb^{-1}	1.11 fb^{-1}	2.21 fb^{-1}

Charmonium states from b-hadron decays and B_s via decays to φφ



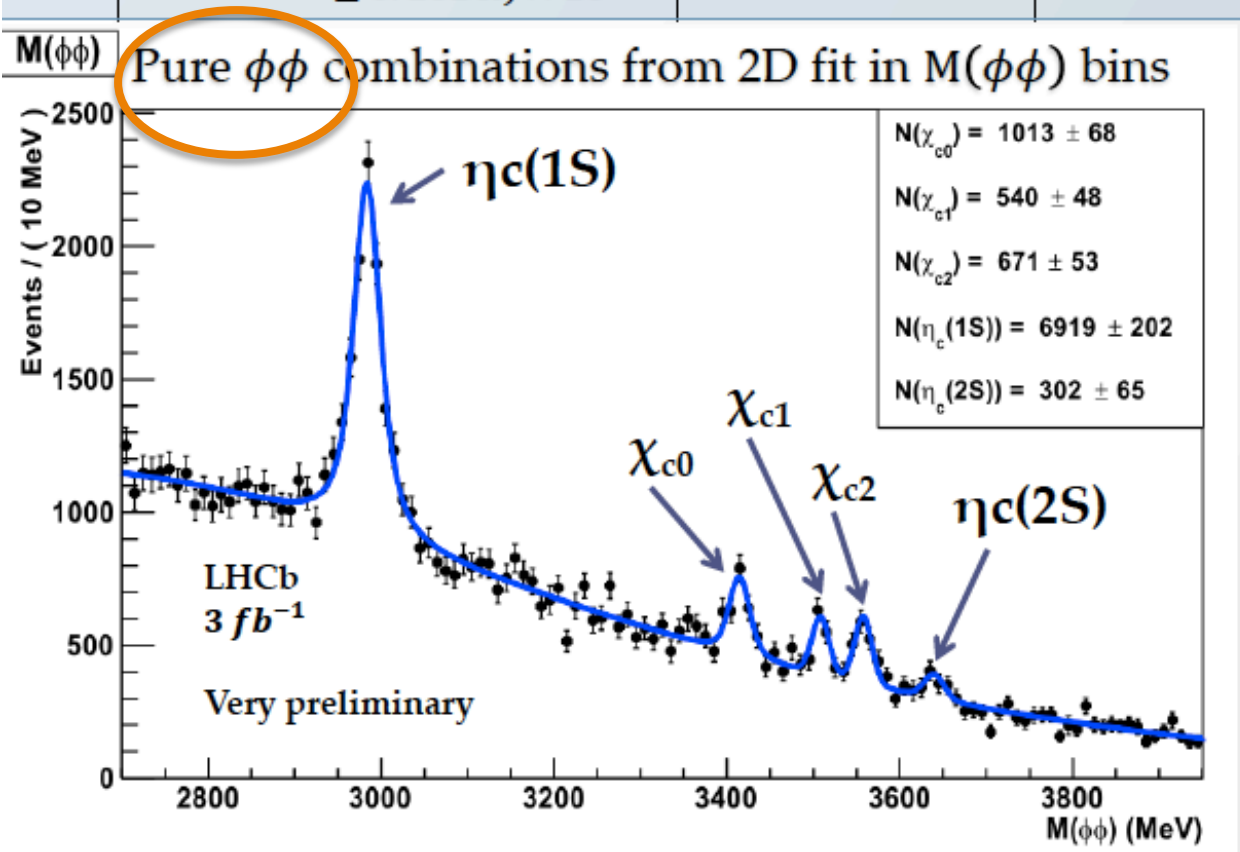
Status of charmonia BR measurements

	$BR(B^0\|B^\pm \to (c\bar{c})X)$	$BR(B^0\|B^\pm\| b-baryons \to (c\bar{c})X)$	BR to φφ
$\eta_c(1S)$	-	-	$(1.76 \pm 0.20) \times 10^{-3}$
χ_{c0}	-	-	$(7.7 \pm 0.7) \times 10^{-4}$
χ_{c1}	$(3.86 \pm 0.27) \times 10^{-3}$	$(1.4 \pm 0.4) \times 10^{-2}$	$(4.2 \pm 0.5) \times 10^{-4}$
χ_{c2}	$(1.4 \pm 0.4) \times 10^{-3}$	-	$(1.12 \pm 0.10) \times 10^{-3}$
$\eta_c(2S)$	-	-	-

- Decays of $J^{PC}=1^{--}$ states to $\phi\,\phi$ are forbidden
- Signals from ηc and χc families observed
- Measure ratios, **systematic uncertainties partially cancels**

Inclusive η_c and χ_c production

	Results $BR(b \to (c\bar{c})X)$	PDG $BR(B^0\|B^\pm \to (c\bar{c})X)$	PDG $BR(B^0\|B^\pm\|b-baryons \to (c\bar{c})X)$	Theory prediction (M.Beneke, F.Maltoni)
χ_{c0}	$(1.64 \pm 0.12 \pm 0.11 \pm 0.40BR) \times 10^{-3}$	-	-	$(0.17 \pm 0.56) \times 10^{-3}$
χ_{c1}	$(1.61 \pm 0.14 \pm 0.10 \pm 0.41BR) \times 10^{-3}$	$(3.86 \pm 0.27) \times 10^{-3}$	$(1.4 \pm 0.4) \times 10^{-2}$	$(0.89 \pm 2.06) \times 10^{-3}$
χ_{c2}	$(0.74 \pm 0.05 \pm 0.05 \pm 0.18BR) \times 10^{-3}$	$(1.4 \pm 0.4) \times 10^{-3}$	-	$(1.51 \pm 3.46) \times 10^{-3}$



$\eta_c(2S)$ in b-hadron decays is seen for the first time in $\eta_c(2S) \to \phi\phi$ decay mode

$$\frac{BR(b \to \eta_c(2S)X)}{BR(b \to \eta_c X)} \times \frac{BR(\eta_c(2S) \to \phi\phi)}{BR(\eta_c \to \phi\phi)}$$

$$= 0.044 \pm 0.009 \pm 0.007$$

Branching fraction of $B_S \to \phi\phi$ decay mode

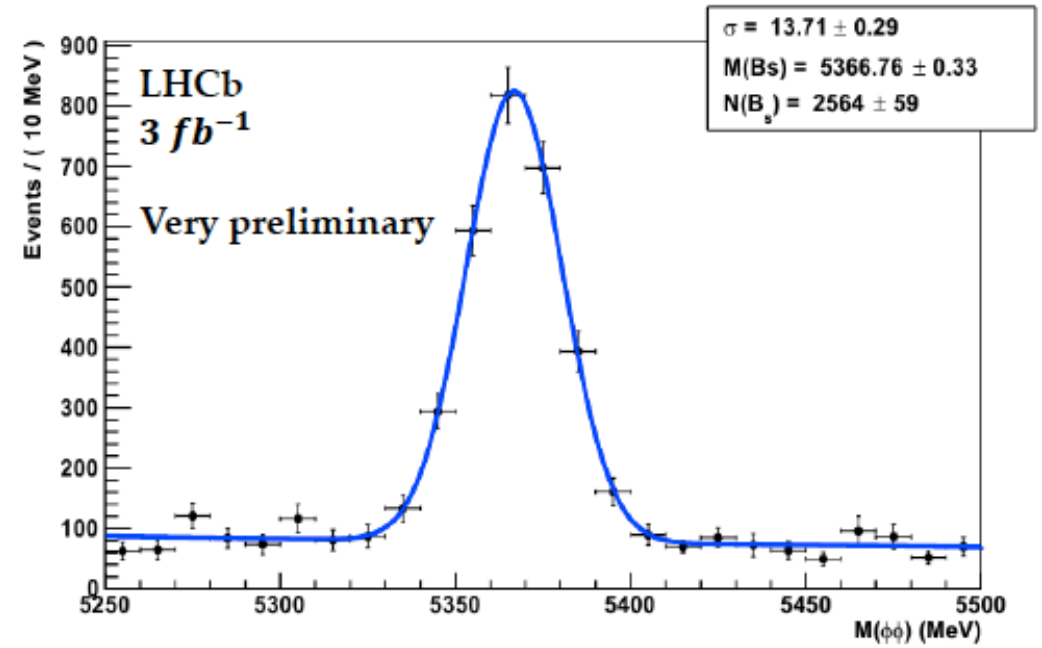
$$BR(B_s^0 \to \phi\phi) = \frac{N_{B_s^0}}{N_{\eta_c}} \times \frac{\varepsilon_{\eta_c}}{\varepsilon_{B_S^0}} \times \frac{BR(b \to \eta_c X) \cdot BR(\eta_c \to p\overline{p})}{BR(b \to J/\psi\, X) \cdot BR(J/\psi \to p\overline{p})} \times \frac{BR(\eta_c \to \phi\phi)}{BR(\eta_c \to p\overline{p})} \times BR(b \to J/\psi\, X) \times BR(J/\psi \to p\overline{p}) \times BR(\overline{b} \to B_s^0)$$

from MC

From fit

From $p\overline{p}$ analysis

All from PDG



Different sources of systematic uncertainty

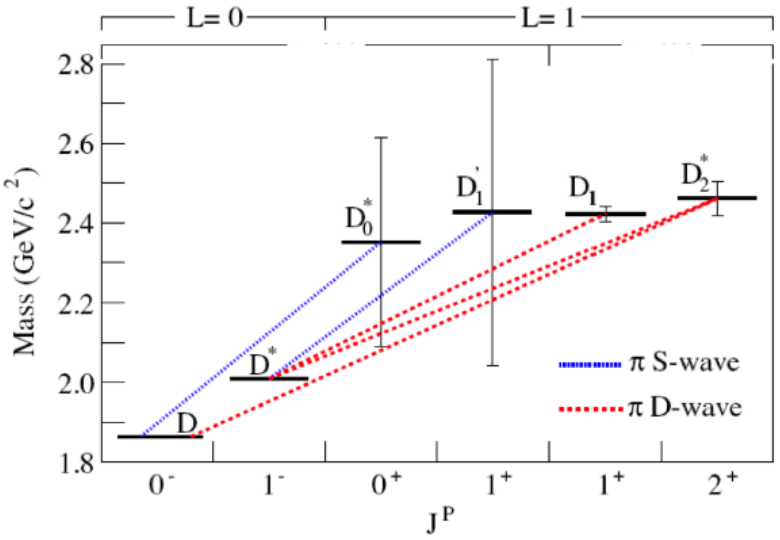
$$BR(B_S \to \phi\phi) = (1.92 \pm 0.07 \pm 0.09 \pm 0.50BR) \times 10^{-5}$$

Presented in LHCb, will be published

$$CDF: \quad 1.8^{+0.6}_{-0.4} \times 10^{-5}$$

Search for $B_s \rightarrow D_s(2317)\pi$

- There are 2 doublets of D** states (L=1 excitation)

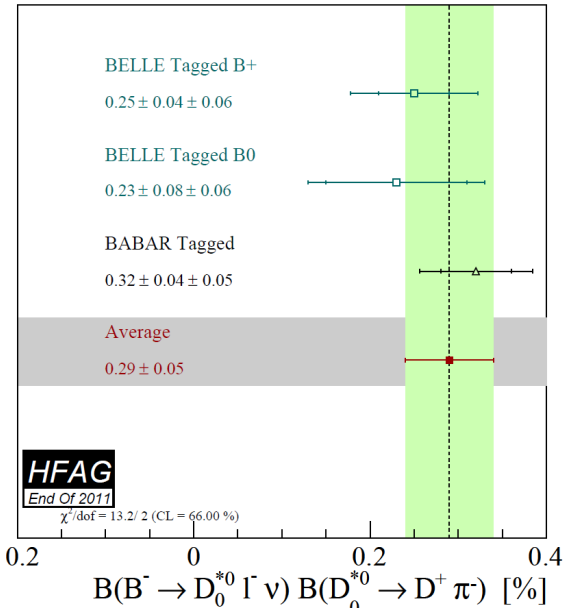


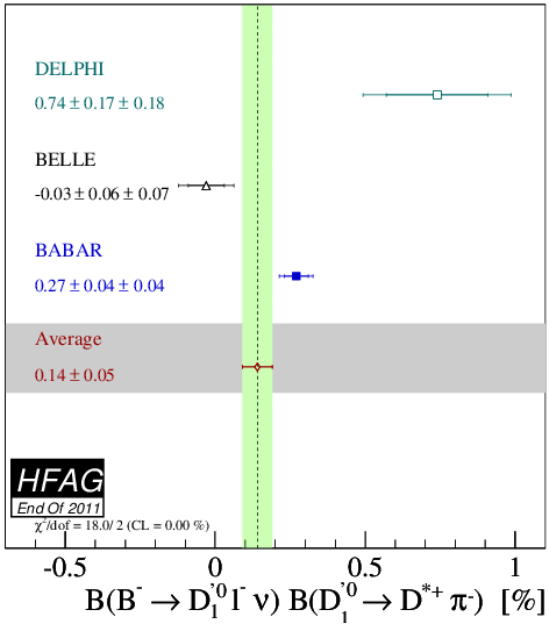
- $j^p=(1/2)^+$: $D_0^*(0^+)$ and $D_1'(1^+)$, large widths
- $j^p=(3/2)^+$: $D_1(1^+)$ and $D_2^*(2^+)$, narrow widths

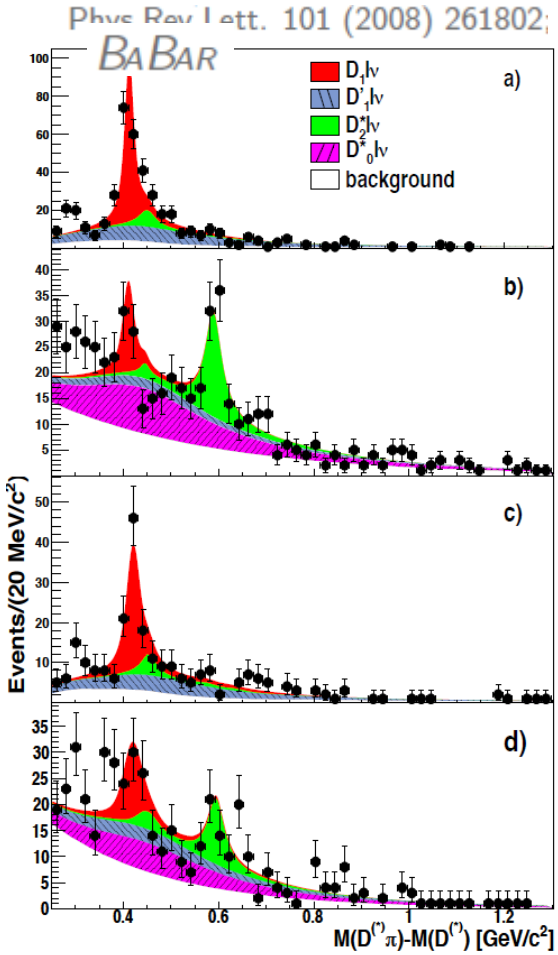
- Some problems are observed in B → D** semileptonic decays : While Babar, Belle and theory predictions are in good agreement for the narrow states, the situation is pretty unclear for the broad ones

B → D** semileptonic

- Belle and Babar in disagrement for B → D_1' l ν
- Broad states are vey difficult to measure







- According to theory, the production of broad resonances should be much smaller than the narrow ones, this is not what it is experimentally observed ('1/2 vs 3/2 puzzle'). See e.g. arXiv:1206.5869 for details.

To try to solve the puzzle : the B_s and D_s

- In the Ds system, the states $j^p=(1/2)^+$ are narrow as their masses are below the $D^{(*)}$ K threshold!

- Two states: $D_{s0}(2317)^+$ (0+), which mainly decays into $D_s\ \pi^0$ and $D_{s1}(2460)^+$ (1+), which decays into Ds π^0, Ds γ or Ds $\pi\ \pi$ (4.3±1.3%)

- Use B_s hadronic decay :

  $BR(B_s \rightarrow D_{s0}(2317)^+\pi^-)$ with $D_{s0}(2317)^+ \rightarrow D_s^+\ \pi^0$

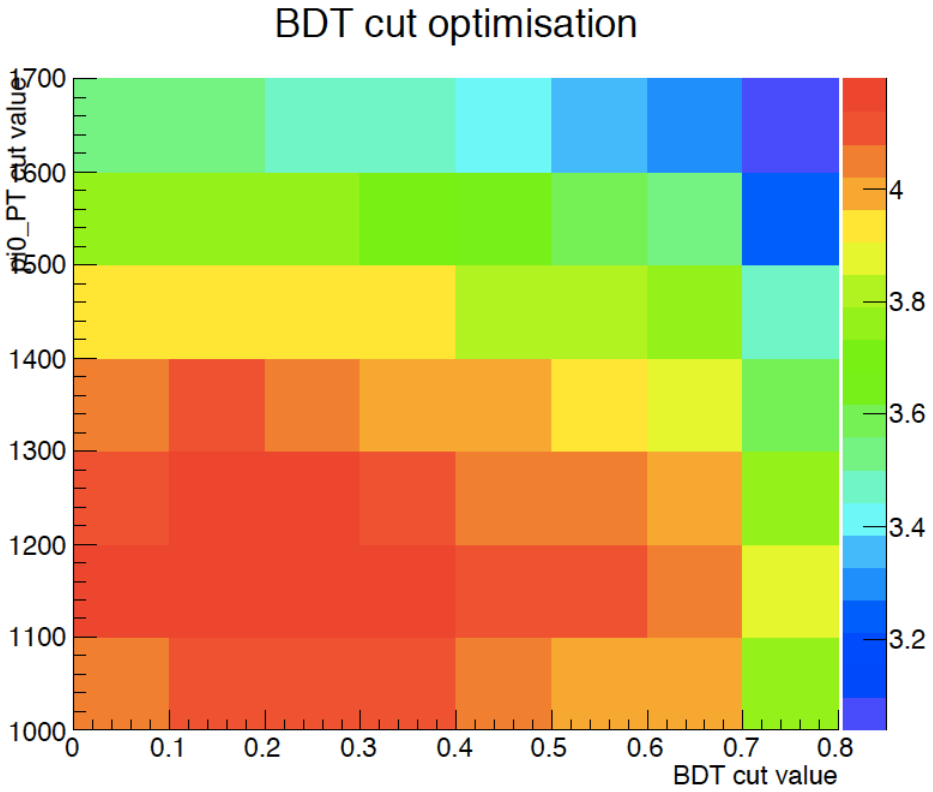
- In fact :

$$\frac{BR(B_s \rightarrow\ D_s^{0+}(2317)\pi^-)\ \times \mathrm{BR}(D_s^{0+}(2317) \rightarrow D_s^+\pi^0) \times BR(D_s^+ \rightarrow KK\pi^+)}{BR(B_s \rightarrow\ D_s^+\rho^-)\ \times BR(D_s^+ \rightarrow KK\pi^+) \times BR(\rho^- \rightarrow \pi^0\pi^-)}$$

Status :

- Selection using a Boosted Decision Tree improved wrt previous one : better MC modeling

- Optimization of the cuts in a 2D plane (BDT cut value, π^0 p_T cut value)



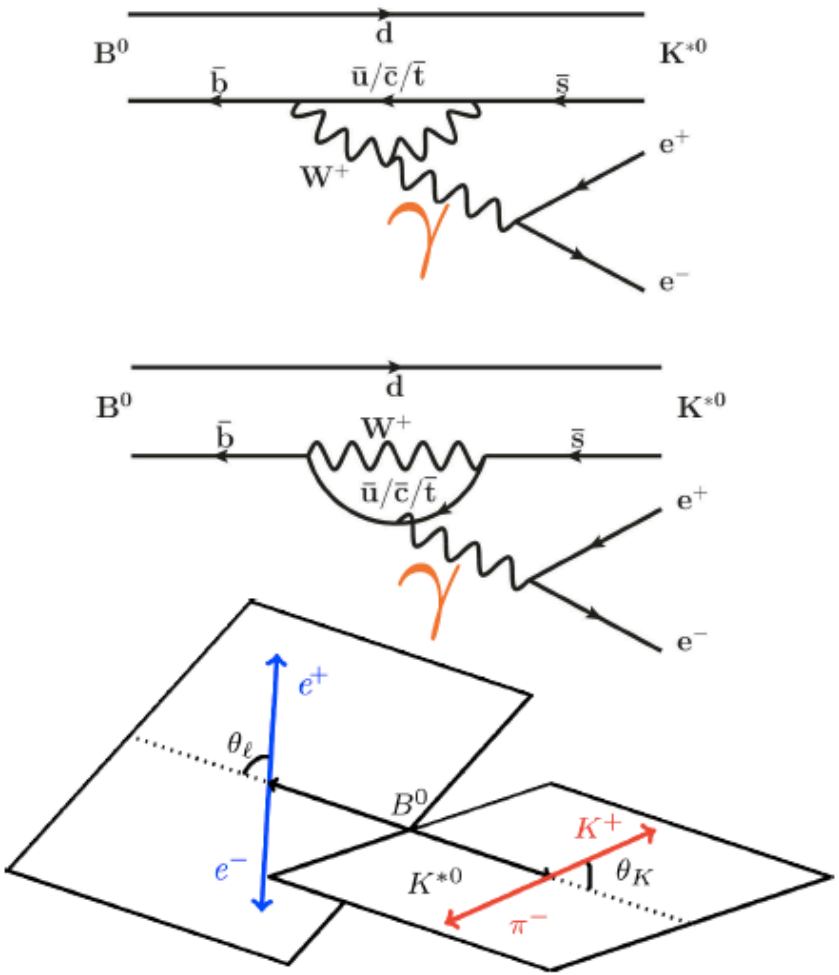
	NSignal	NBkgd
'Old' selection	75	252
Vitalii selection	73	203

- Start to look at the normalization mode : Bs→Ds ρ and to understand the physics backgrounds

Search for NP in B→K*ll

Focus on K*ee : complementary of B→K* μ μ in the low q2 region

- **Angular analysis** is cleaner than BR
- **one q^2 bin chosen:** $[0.0004, 1]\,\mathrm{GeV}^2$
- "clean" large recoil region
- electrons: can go lower in q^2
  completely negligible lepton mass
- small $F_\mathrm{L} \rightarrow$ more sensitivity to $\mathrm{A}_\mathrm{T}^{(2)}$, $\mathrm{A}_\mathrm{T}^{\mathrm{Im}}$
- photon pole contribution dominating
  $\rightarrow$ sensible to $\mathcal{C}_7$ Wilson coefficient
- above $1\,\mathrm{GeV}^2$ the μ mode has same sensitivity and higher yield in LHCb



Discussions with our theory colleagues in particular A. Korchin

=> Several publications :

Phys.Rev. D82 (2010) 034013

Contribution of low-lying vector resonances to polarization observables in $\bar{B}_d^0 \to \bar{K}^{*0} e^+ e^-$ decay

Alexander Yu. Korchin[1,*] and Vladimir A. Kovalchuk[1,†]

[1] *NSC 'Kharkov Institute of Physics and Technology', 61108 Kharkov, Ukraine*

+ other publications!

Asymmetries in $\bar{B}_d^0 \to \bar{K}^{*0} e^+ e^-$ decay and contribution of vector resonances

Alexander Yu. Korchin[1,*] and Vladimir A. Kovalchuk[1,†]

[1] *NSC 'Kharkov Institute of Physics and Technology', 61108 Kharkov, Ukraine*

Used by LHCb :

Measurement of the $B^0 \to K^{*0} e^+ e^-$ branching fraction at low dilepton mass

The LHCb collaboration[†]

In total !

	Level	LHCb LAL advisor	Date	Subject
Viktor Iakovenko	Joint PhD thesis	MHS	2010	Study of B_s meson Radiative Decay and Radiation Monitoring System at the LHCb experiment
Nazar Stefanyuk	Master student	Sergey Barsuk	2013	Charmonia $\rightarrow \varphi\varphi$
Taras Patlatyuk	Master student	Patrick Robbe	2013	40 MHz RO with PCIe (LHCb Upgrade)
Andrii Usachov	Master student	Sergey Barsuk	2014	Charmonia $\rightarrow \varphi\varphi$ & $B_s \rightarrow \varphi\varphi(\varphi)$
Vitalii Lysovskiy	Master student	MHS	2014	$B_s \rightarrow D_s(2317)\pi$