WG 3 summary
Rare B,D,K decays

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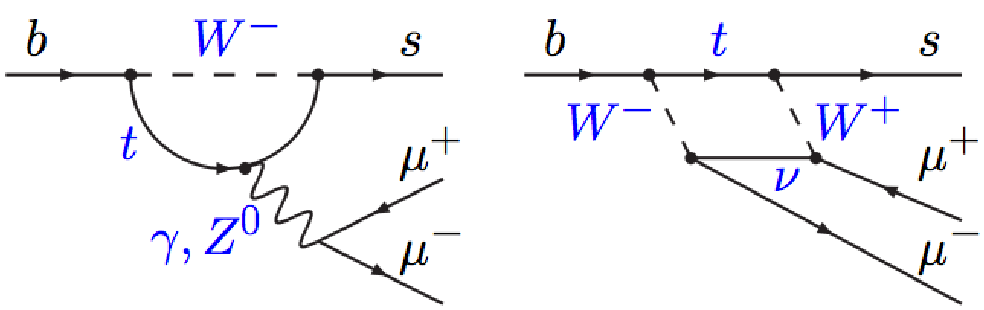
Matthew Moulson, Justine Serrano

CKM 2016, Mumbai

Disclaimer

- Particularly dense sessions: 28 contributions!!!!
- Impossible to be exhaustive in 30 min… this talk in an advertisement for the parallel talks ☺

b → sℓℓ



$b \to s\ell\ell$

Phenomenology of b → sℓℓ

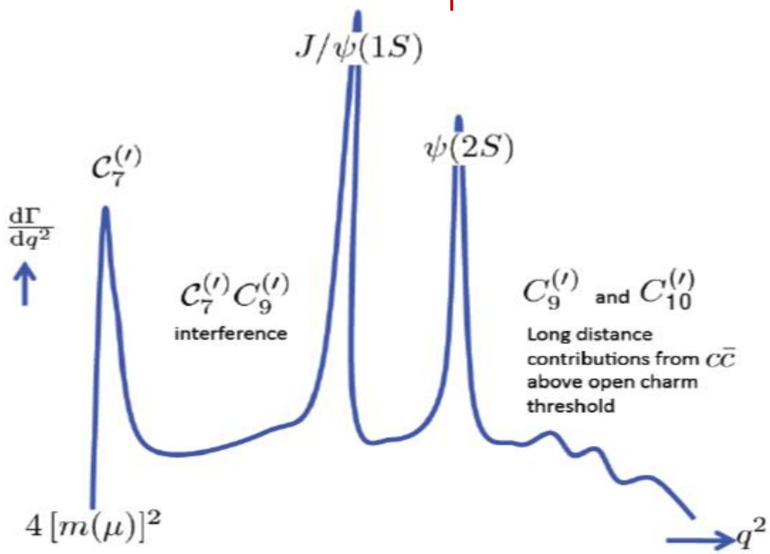
- b → sℓℓ decays can theoretically be described by effective hamiltonian

$$\mathcal{H}_{\text{eff}} = -\frac{4G_F}{\sqrt{2}} V_{tb} V_{ts}^* \sum_i (C_i \mathcal{O}_i + C_i' \mathcal{O}_i')$$

left-handed part (for $C_i \mathcal{O}_i$); right-handed part, suppressed in SM (for $C_i' \mathcal{O}_i'$)

i=1,2 Tree
i=3-6,8 gluon penguin
i=7 photon penguin
i=9,10 electroweak penguin
i= S,P Scalar, Pseudo scalar penguin

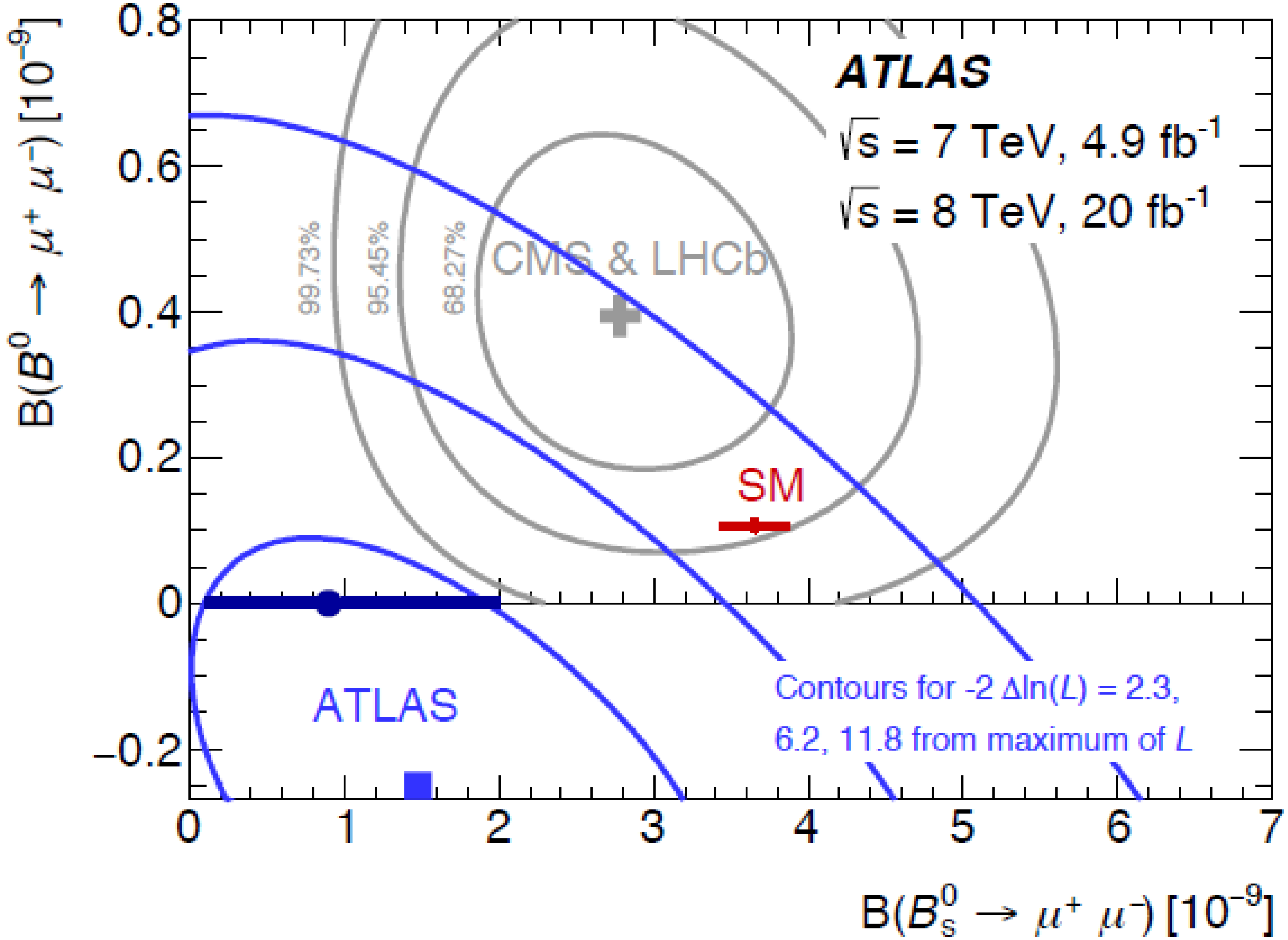
- Operators O_i depends on hadronic form factors, which usually dominate theoretical uncertainties
- Wilson coefficient C_i describe short distance effects, they are sensitive to NP



- B → K* ℓℓ : C_7 C_9 C_{10}
- B → ℓℓ : C_{10} C_S C_P
- B → X_s γ : C_7

Global fits favoured $C_9^{NP} \sim -1$

$B_{(s)} \to \mu\mu$

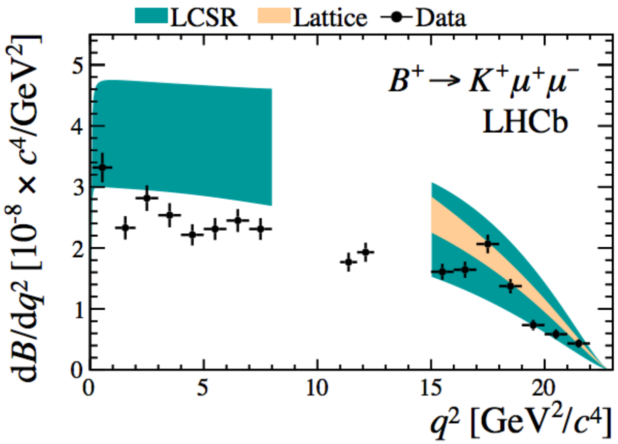


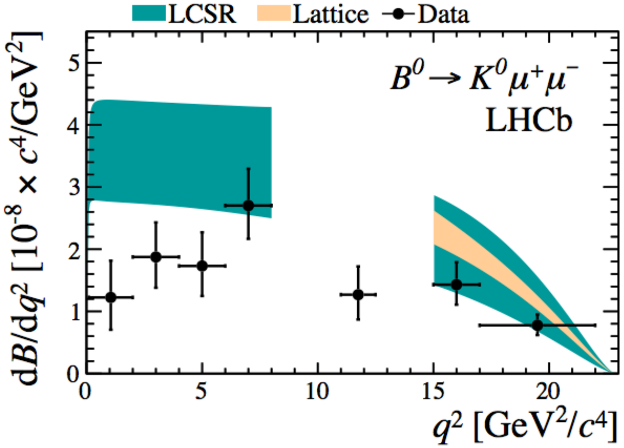
ATLAS has entered the game!

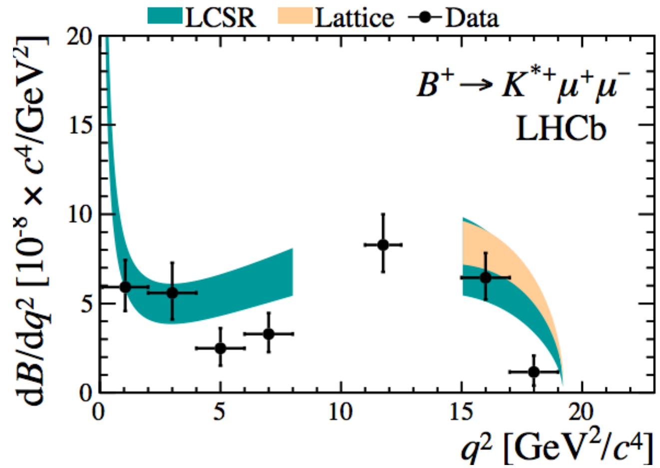
Adrian Bevan, Niladribihari SAHOO, Matteo Rama

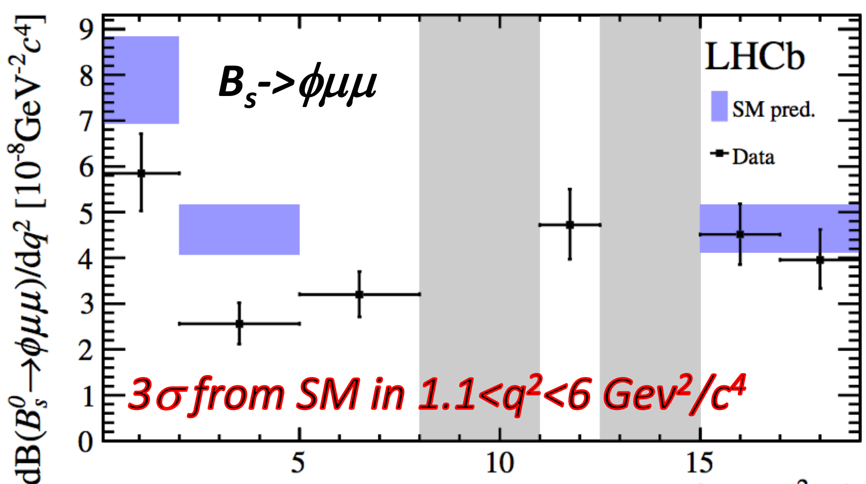
b → sμμ branching ratios

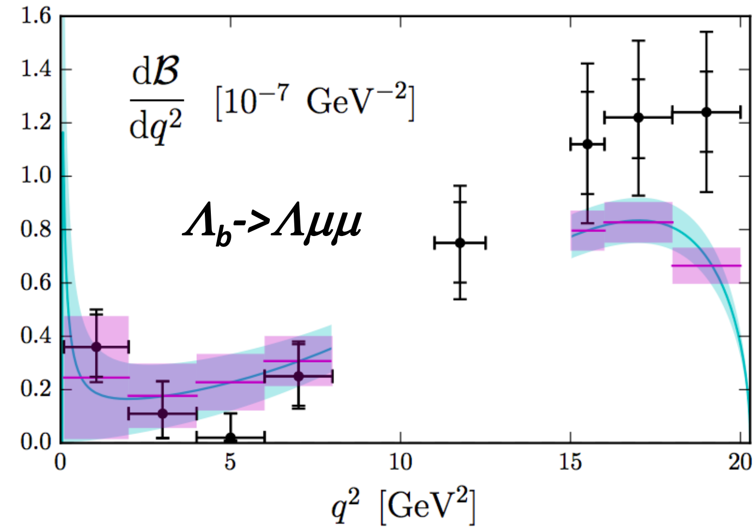
Measured *BR* are consistently lower than predicted in SM







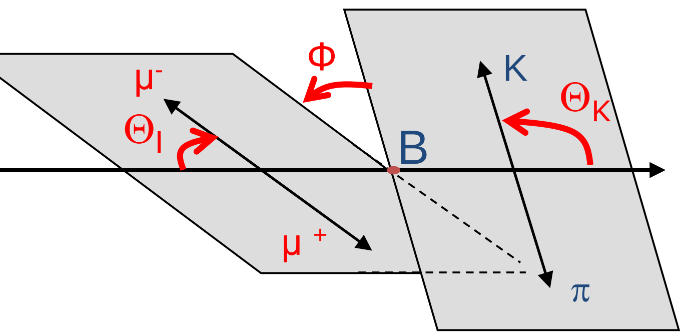




Francesco Polci

$B^0 \to K^{*0}\mu\mu$ angular observables

$$\frac{1}{\mathrm{d}(\Gamma+\bar{\Gamma})/\mathrm{d}q^2}\frac{\mathrm{d}^4(\Gamma+\bar{\Gamma})}{\mathrm{d}q^2\,\mathrm{d}\vec{\Omega}} = \frac{9}{32\pi}\Big[\frac{3}{4}(1-F_\mathrm{L})\sin^2\theta_K + F_\mathrm{L}\cos^2\theta_K$$
$$+\frac{1}{4}(1-F_\mathrm{L})\sin^2\theta_K\cos 2\theta_l$$
$$-F_\mathrm{L}\cos^2\theta_K\cos 2\theta_l + S_3\sin^2\theta_K\sin^2\theta_l\cos 2\phi$$
$$+S_4\sin 2\theta_K\sin 2\theta_l\cos\phi + S_5\sin 2\theta_K\sin\theta_l\cos\phi$$
$$+\frac{4}{3}A_\mathrm{FB}\sin^2\theta_K\cos\theta_l + S_7\sin 2\theta_K\sin\theta_l\sin\phi$$
$$+S_8\sin 2\theta_K\sin 2\theta_l\sin\phi + S_9\sin^2\theta_K\sin^2\theta_l\sin 2\phi\Big].$$



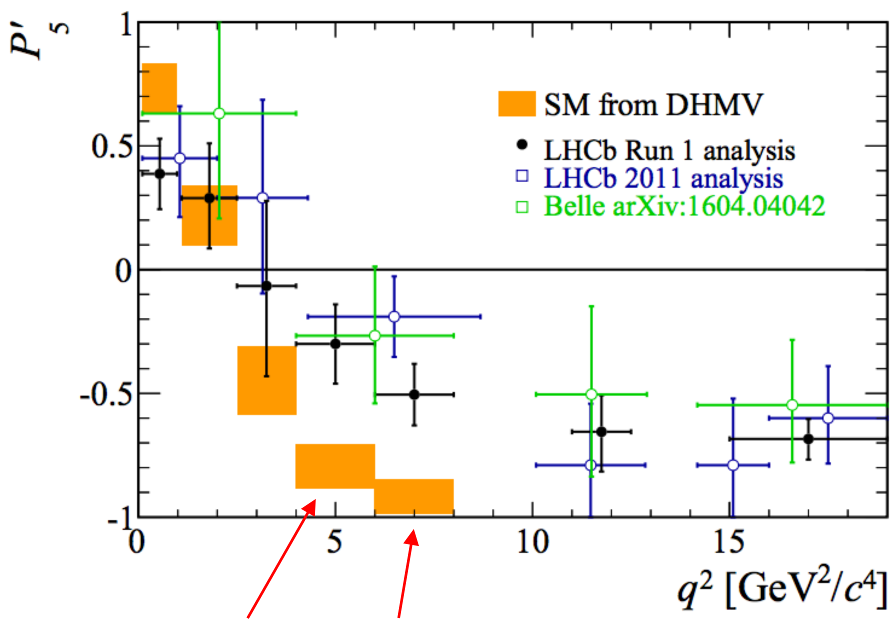
Observables (A_{FB}, F_L and S_j) are function of the Wilson coefficients.

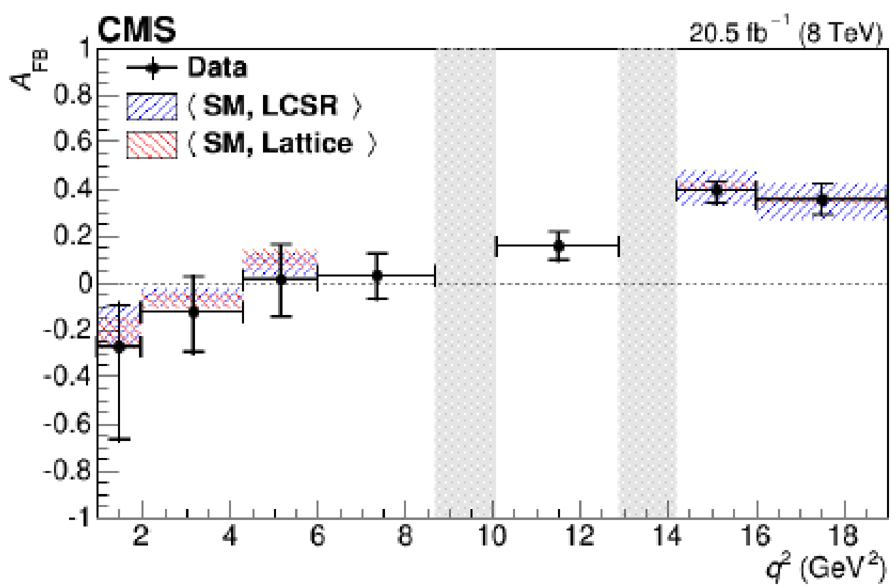
A cleaner set of observables, where hadronic form factor uncertainties cancels at the leading order, can be defined

$$P'_5 \equiv \frac{S_5}{\sqrt{F_L(1-F_L)}}$$

$B^0 \to K^{*0}\mu\mu$ results

- LHCb: Full angular analysis (θ_λ, θ_K, ϕ) of Run1 data ($3fb^{-1}$)
  $\Rightarrow$ access to A_{FB}, F_L, S_j, P'_i
- CMS: analysis uses the angles (θ_λ, θ_K) and the 8TeV data ($20.5\ fb^{-1}$)
  $\Rightarrow$ measure A_{FB}, F_L



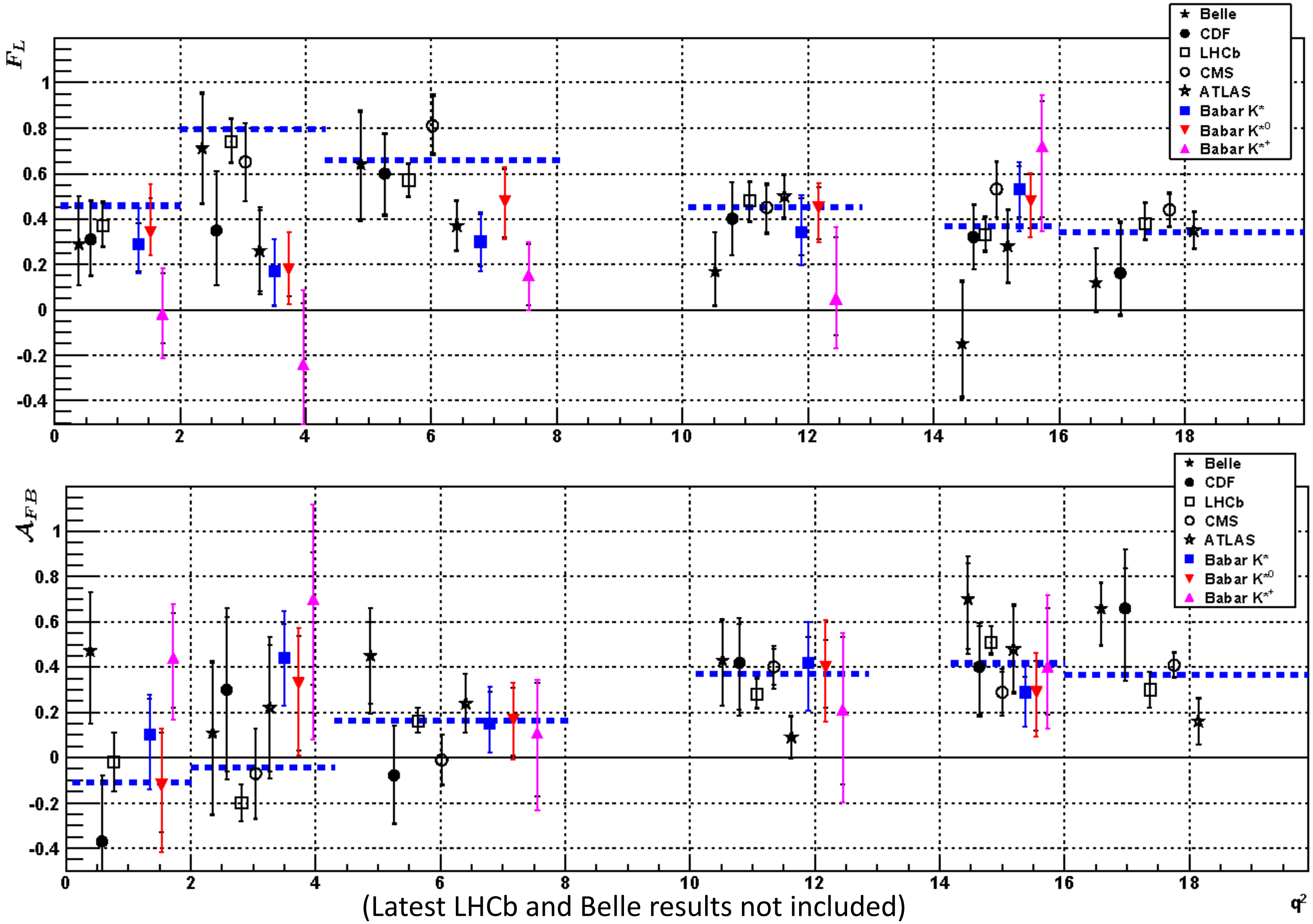


2.8 σ   3 σ

Global fit to *B->K*μμ* LHCb analysis is 3.4σ from SM

Francesco Polci,, Niladribihari Sahoo

- Babar: uses the angles (θ_λ, θ_K) $\Rightarrow$ measure A_{FB}, F_L. B+ modes have been added.
  - F_L smaller than SM in bin $1<q^2<6$ GeV^2
  - P_2 also measured and found 2 sigma bellow SM in bin $2<q^2<4.3$ GeV^2



(Latest LHCb and Belle results not included)

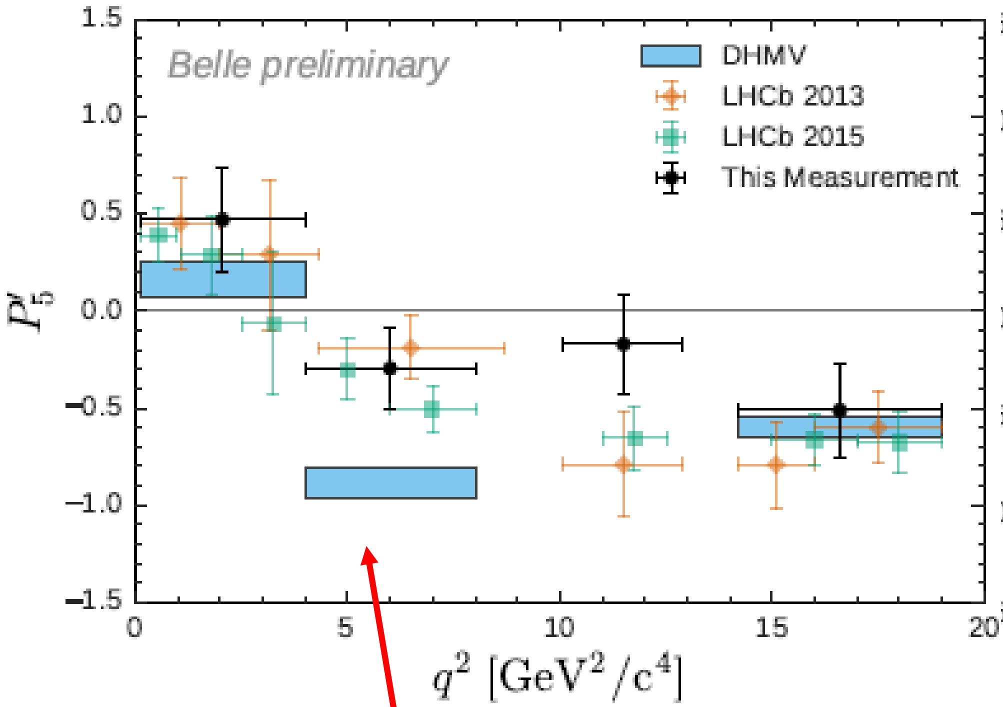
Eli Ben Haim

- Belle: Uses the three angles (θ_λ, θ_K, ϕ) with folding technique.
  $\Rightarrow$ access to A_{FB}, F_L , S_j, P'_i , and also Qi observables $\langle Q_i \rangle = \langle P_i^\mu \rangle - \langle P_i^e \rangle$

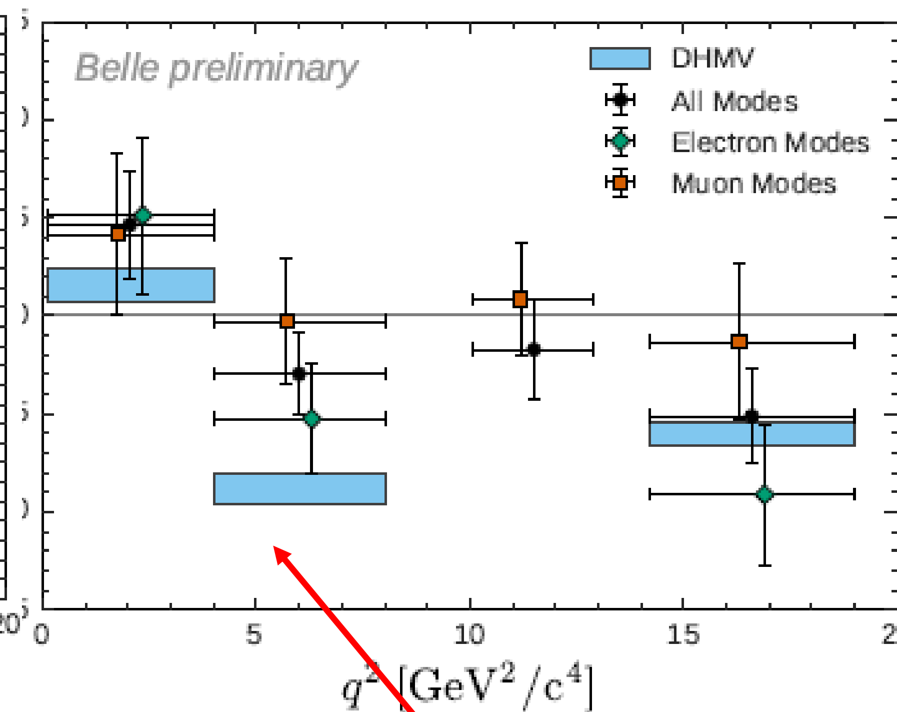
Simon Wehle

New!

Combining electron and muons:



Separating electrons and muons:



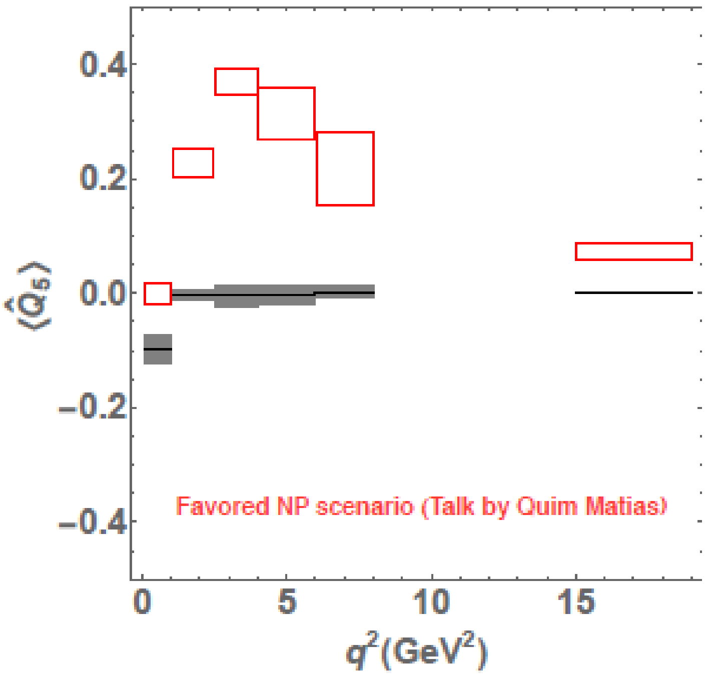
tension at 2.5σ from SM

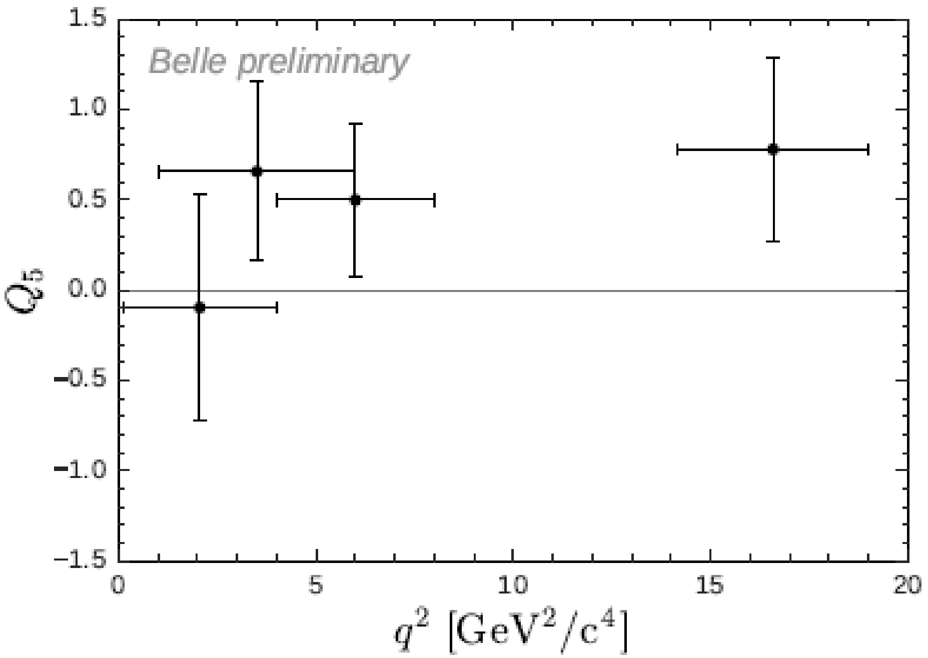
tension at 2.6σ for the muons
tension at 1.1σ for the electrons

$B^0 \to K^{*0}\mu\mu$ results

- Also measure the variables Qi which test lepton flavor universality

$$\langle Q_i \rangle = \langle P_i^{\mu} \rangle - \langle P_i^{e} \rangle$$

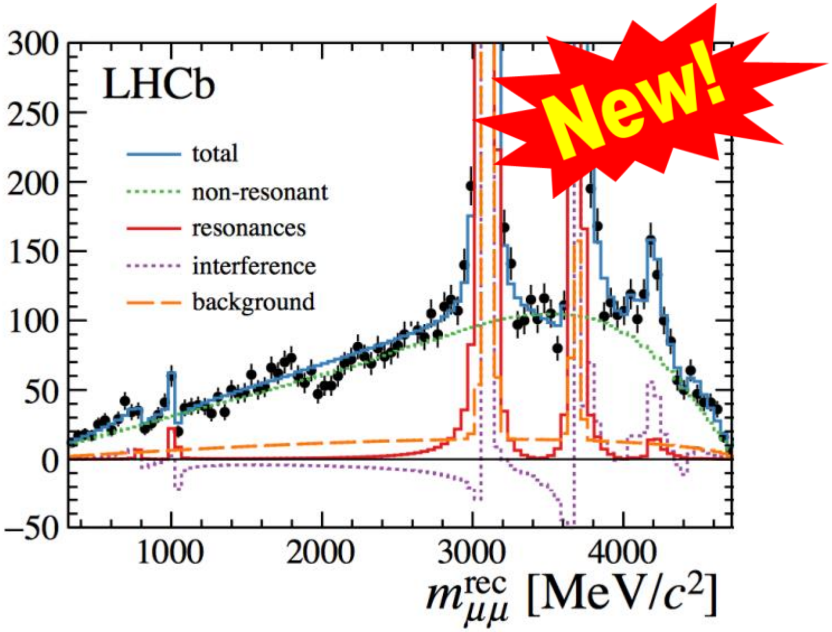


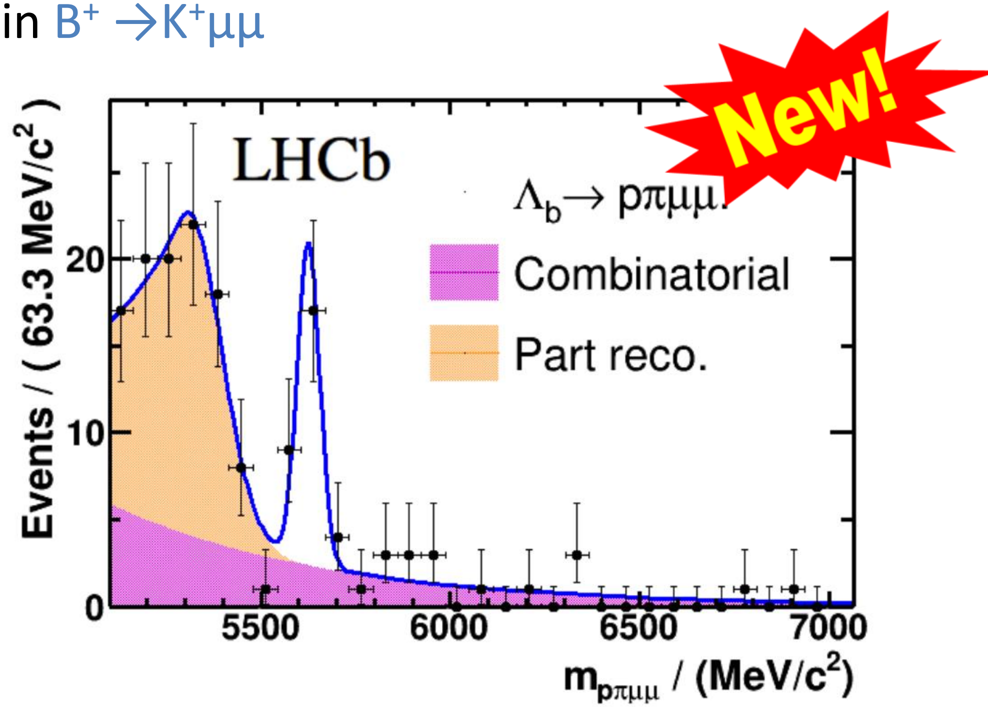


Some more results

- Differential BR measurement of B→K*(892)μμ removing S-wave contribution
- B→ Kπ μμ BR and angular analysis in the $K_{0,2}$*(1430) region
- Differential BR of $B^+ \to \pi^+$ μμ : first observation of b → d transition
- Angular analysis of $B_s \to \phi$ μμ and $\Lambda_b \to \Lambda$ μμ
- Angular analysis of $B^0 \to$ K*ee
- $\Lambda_b \to$ pπμμ : First observation (5.5s) of a baryonic b → d transition
- Evaluation of charm contributions in $B^+ \to K^+$μμ

Francesco Polci



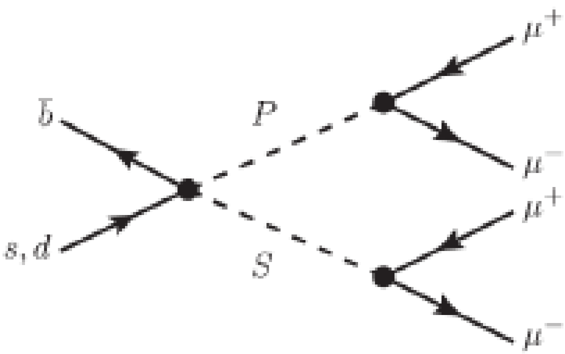


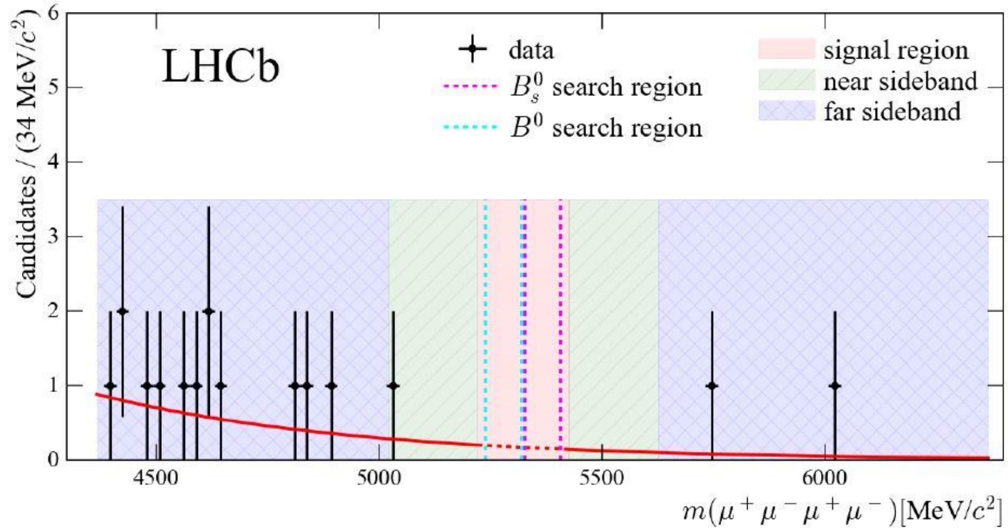
$B_{(s)} \to \mu\mu\mu\mu$

New!

Matteo Rama

SUSY decay channel





Set 95% CL upper limits with phase space model:

$BF(B_s^0 \to \mu^+\mu^-\mu^+\mu^-) < 2.5 \times 10^{-9}$

$BF(B^0 \to \mu^+\mu^-\mu^+\mu^-) < 6.9 \times 10^{-10}$

Improved by a factor 6.4 (B_s^0) and 9.5 (B^0) compared to previous limits

Set 95% CL upper limits for MSSM model with $m_{P(S)} = 214.3$ MeV (2.5 GeV) (*):

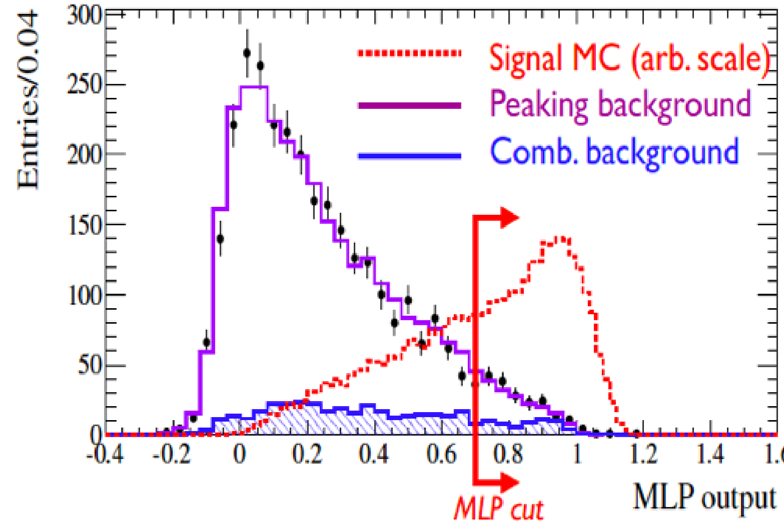
$BF(B_s^0 \to SP \to 4\mu) < 2.2 \times 10^{-9}$

$BF(B^0 \to SP \to 4\mu) < 6.0 \times 10^{-10}$

(*) compared to phase space model: tiny change of reconstruction efficiency due to different **p** distribution of muons

B→ Kττ

- BR~10^{-7} in SM
- Use leptonic tau decays
- Apply cut on NN output to remove background from $B \to D^{(*)}(\to K\,\ell'^{-}\,\nu)\ell^{+}\nu$

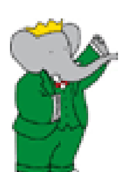


Eli Ben Haim

	e^+e^-	$\mu^+\mu^-$	$e^+\ \mu^-$
$N^i_{\rm bkg}$	49.4±2.4±2.9	45.8±2.4 ±3.2	59.2±2.8 ±3.5
$\epsilon^i_{\rm sig}(\times 10^{-5})$	1.1 ±0.2±0.1	1.3±0.2±0.1	2.1±0.2±0.2
$N^i_{\rm obs}$	45	39	92
Significance (σ)	-0.6	-0.9	3.7

Expected bkg → ($N^i_{\rm bkg}$)

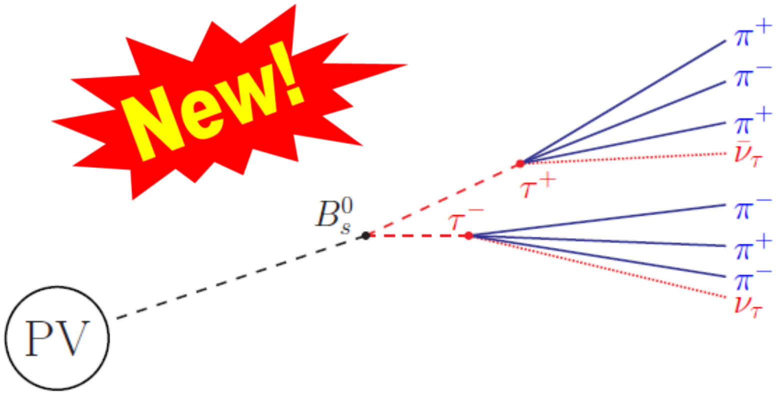
Observed events → ($N^i_{\rm obs}$)



$$B(B^+ \to K^+\tau^+\tau^-) = (1.31^{+0.66+0.35}_{-0.61-0.25})\times 10^{-3}$$

$$B(B^+ \to K^+\tau^+\tau^-) < 2.25\times 10^{-3} \text{(90\% CL UL)}$$

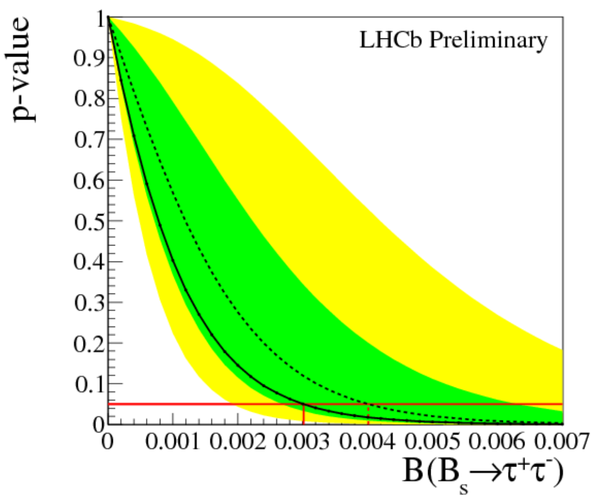
$B_{(s)} \rightarrow \tau\tau$



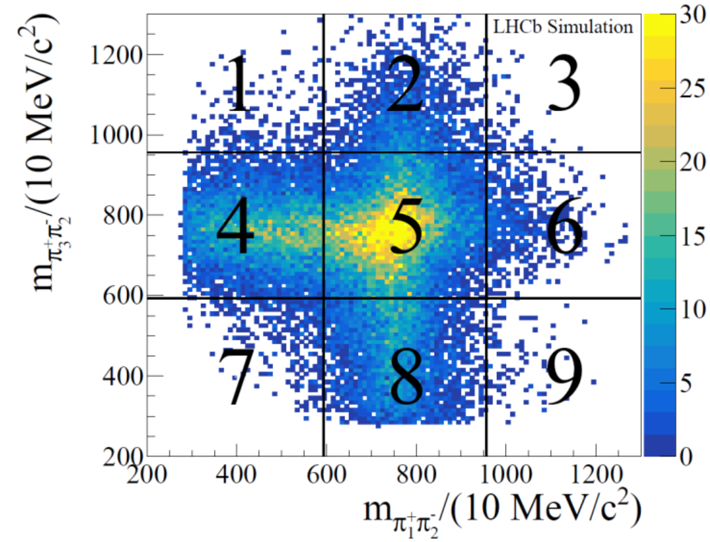
SM prediction:

$B(B_s \rightarrow \tau\tau)$ = (7.73±0.49) 10^{-7}

$B(B^0 \rightarrow \tau\tau)$ = (2.22±0.19) 10^{-8}



Signal/control regions defined from the Dalitz tau decay plane :



Paula Alvarez Cartelle, Matteo Rama

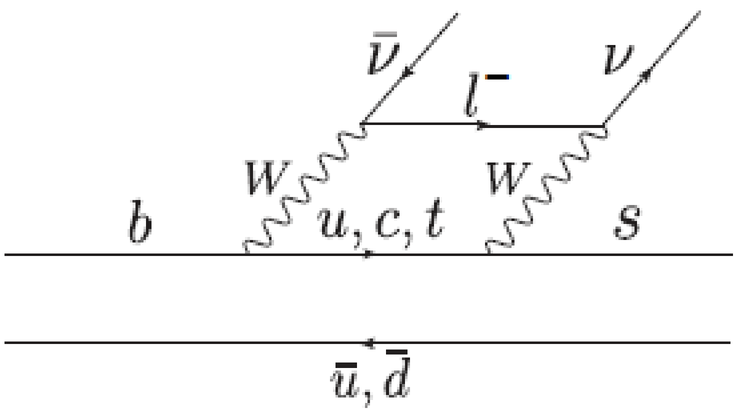
$B(B_s \rightarrow \tau\tau) < 2.4(3.0)\ 10^{-3}$ at 90 (95)% CL

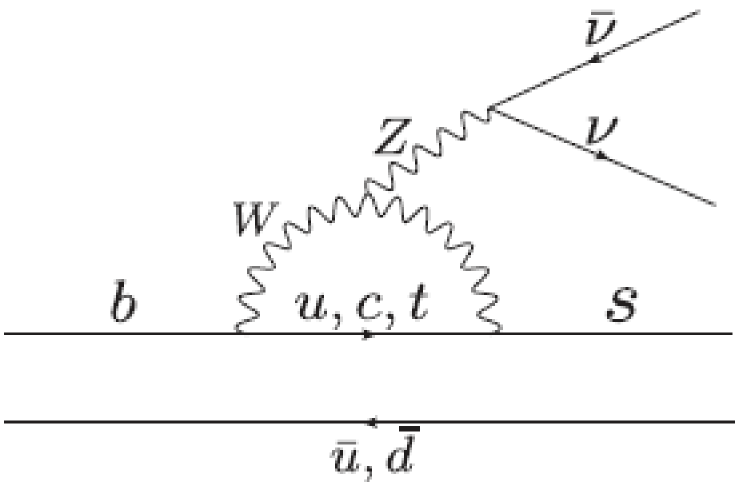
$B(B^0 \rightarrow \tau\tau) < 1.0(1.3)\ 10^{-3}$ at 90 (95)% CL

First experimental limit!

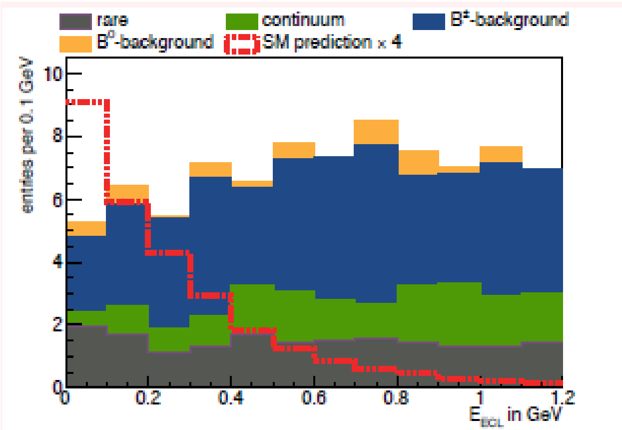
Improve Babar result by factor~4

b → (s,d)$\nu\bar{\nu}$

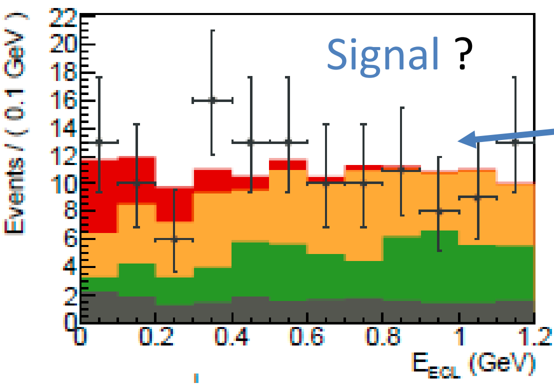


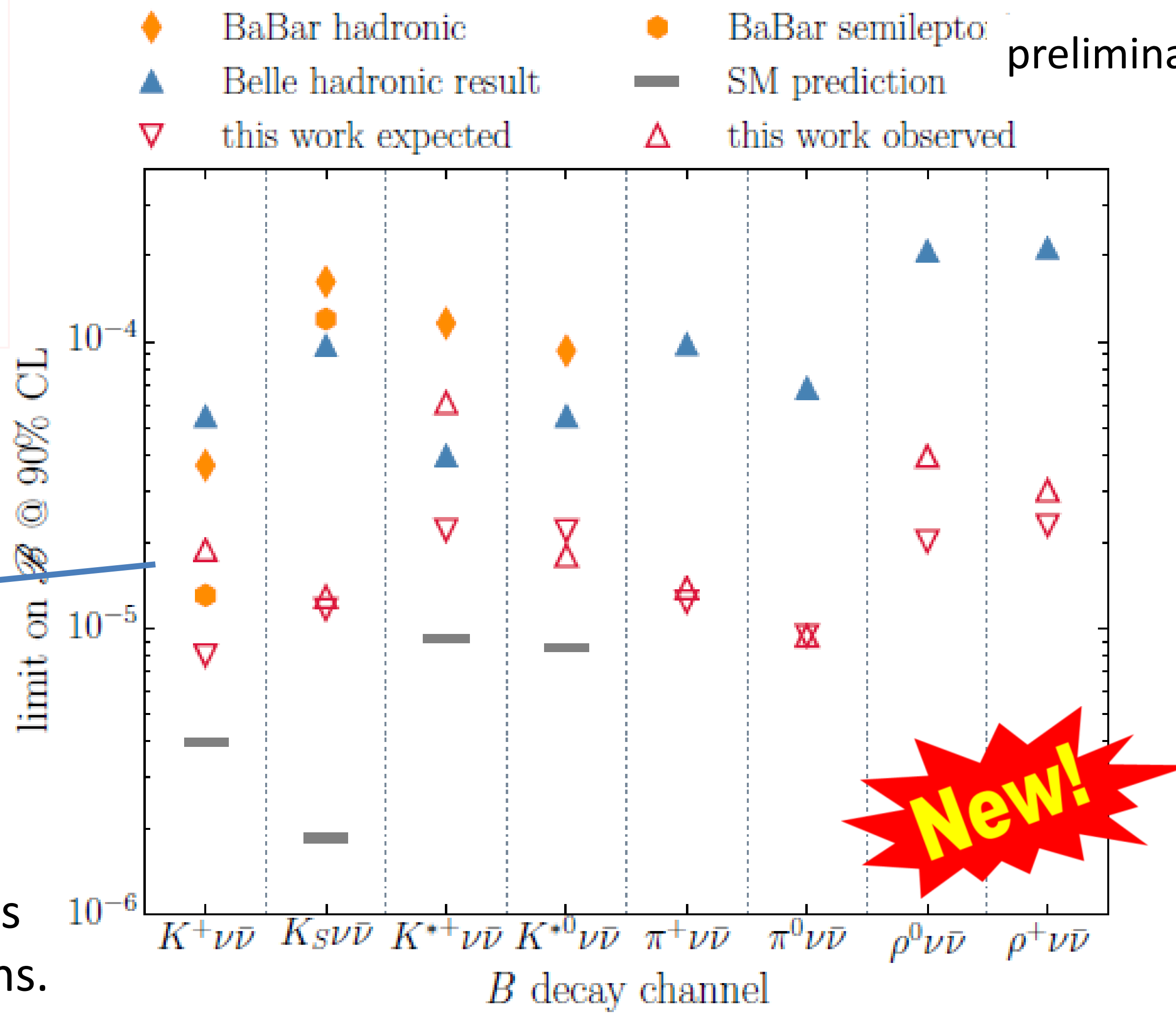


New Belle limits using semileptonic tags, fitting extra energy in the calorimeter



$K^+\nu\bar{\nu}$





preliminary

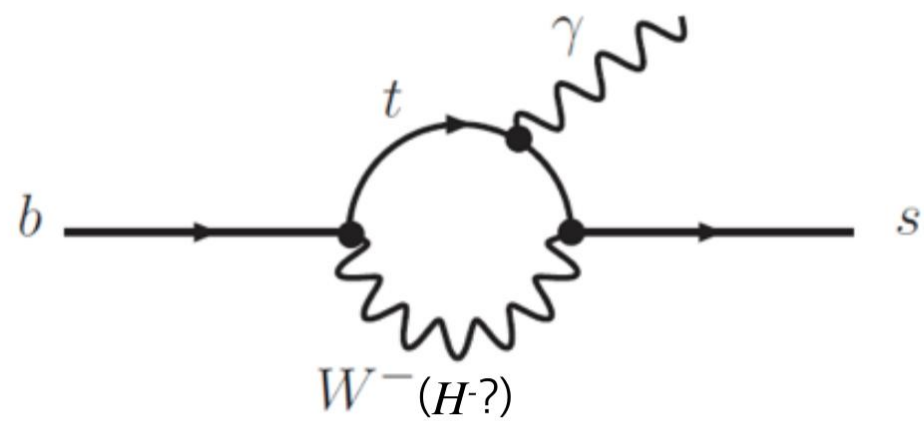
Pablo Goldenzweig

Kaon modes about ~4 times larger than theory predictions.

Worlds most stringent limits obtained for:

$B^0 \to K_S^0\nu\bar{\nu},\ B^0 \to K^{*0}\nu\bar{\nu},\ B^{+/0} \to \pi^{+/0}\nu\bar{\nu},\ B^{+/0} \to \rho^{+/}$

b → sγ

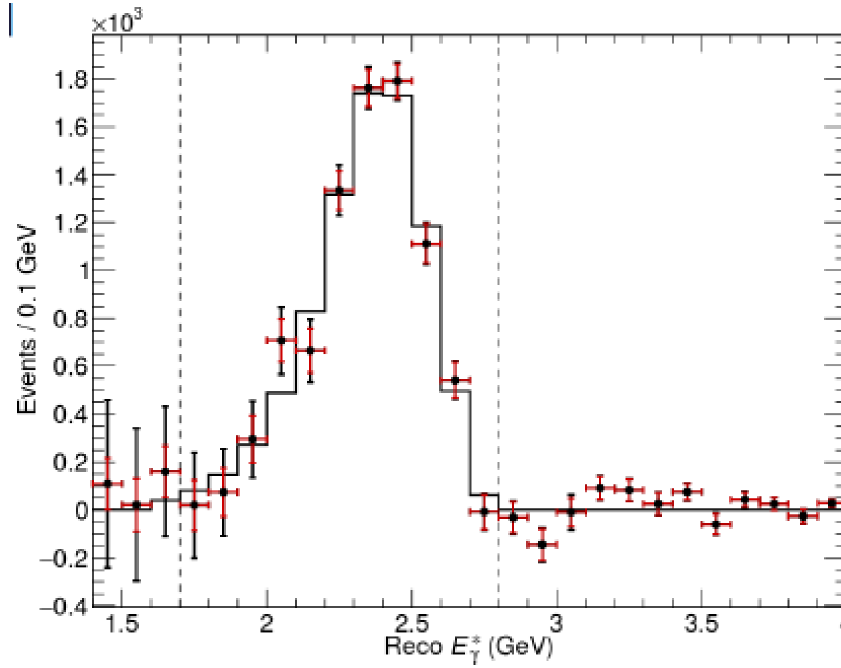


$B \to X_{(s+d)}\gamma$

- Measured photon energy spectrum can be used to constrain HQE parameter e.g. m_b

- Full inclusive method with lepton tagging
- Detector resolution effects unfolded

- HQE parameter fit result
  - $m_b = 4.626 \pm 0.028\ \mathrm{GeV}/c^2$
  - $\mu_\pi^2 = 0.301 \pm 0.063\ \mathrm{GeV}/c^2$
  - correlation $\rho = -0.701$



Simon Wehle

Subtracting $b \to d\gamma$ using $|V_{td}/V_{ts}|^2 \sim 4\%$

Belle** preliminary* ***Results

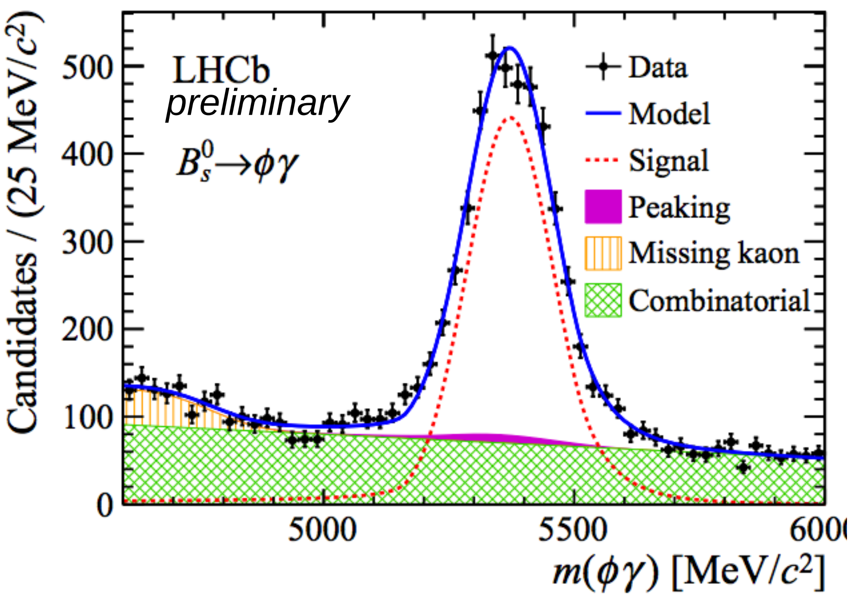
$$\mathcal{B}(\overline{B} \to X_s\gamma)_{E_\gamma > 1.6 GeV} = (3.12 \pm 0.10_{\mathrm{stat}} \pm 0.19_{\mathrm{syst}} \pm 0.08_{\mathrm{model}}) \times 10^{-4}$$

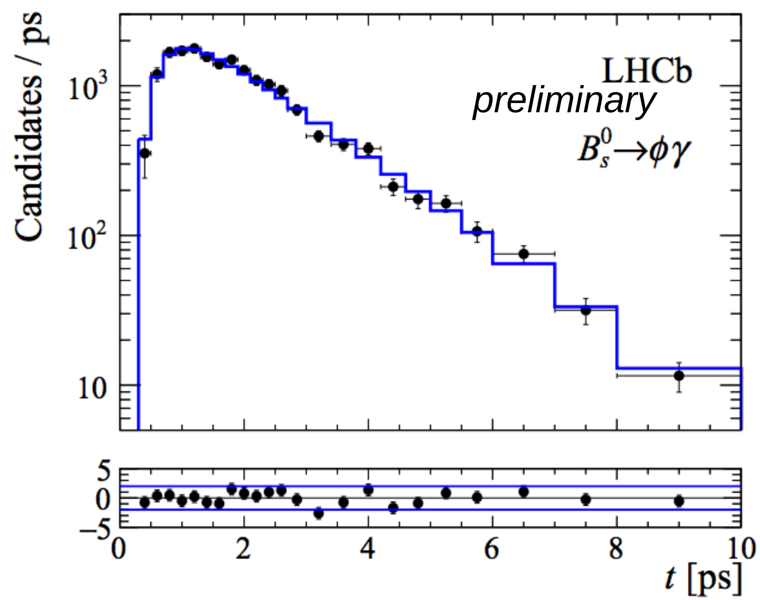
$B_s \to \phi\gamma$

- First measurement of photon polarization in radiative B_s decays
- Untagged measurement of the time dependent decay rate of $B_s \to \phi\gamma$

$$\Gamma(B_s+\overline{B}_s)(t) \propto e^{-\Gamma_s t}\left[\cosh\left(\frac{\Delta\Gamma_s}{2}t\right) - A^{\Delta\Gamma}\sinh\left(\frac{\Delta\Gamma_s}{2}t\right)\right]$$

$$A^{\Delta\Gamma} \sim \frac{|\mathcal{A}(B_s\to\phi\gamma_L)|}{|\mathcal{A}(B_s\to\phi\gamma_R)|}\cos\phi_s$$





Francesco Polci

- Consistent with SM within 2σ:

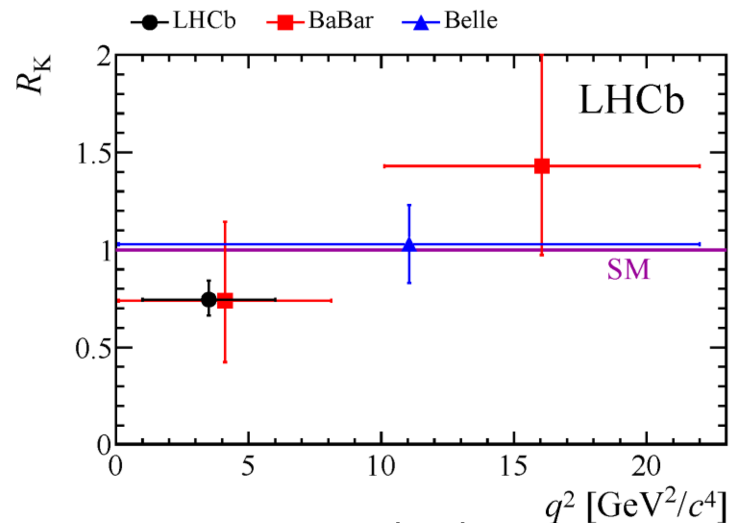
$$\mathcal{A}^{\Delta} = -0.98\,^{+0.46}_{-0.52}\,^{+0.23}_{-0.20}$$

$$A^{\Delta\Gamma}(SM) = 0.047^{+0.029}_{-0.025}$$ Muheim et al. [PLB664(08)174]

LFV/LNV/LUV

Lepton Universality in $B \to K l^+ l^-$

$$R_X = \frac{\int_{q^2_{\min}}^{q^2_{\max}} \frac{d\Gamma(B \to X\mu^+\mu^-)}{dq^2} dq^2}{\int_{q^2_{\min}}^{q^2_{\max}} \frac{d\Gamma(B \to Xe^+e^-)}{dq^2} dq^2}$$



- SM prediction $R_K \approx 1.0 \pm$ ~0.01
- LHCb measurement at 2.6σ
- More precise evaluation of QED

correction (see M. Bordone's talk) $\Rightarrow R_K = 1.0 \pm 0.01$, PHOTOS looks correct

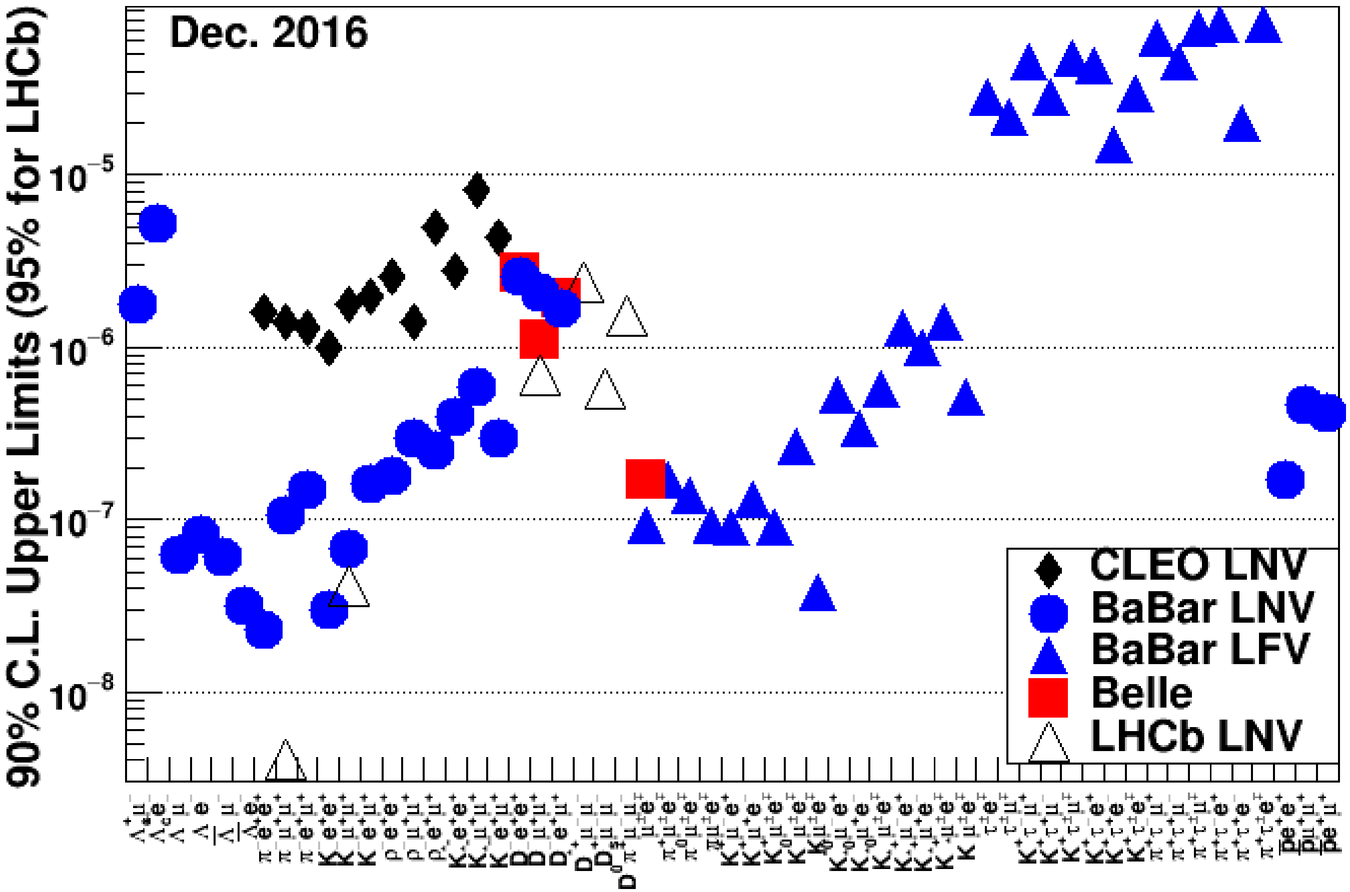
Ratio	Value	Range	Publication	Exp
$R_{K^{(+,*)}}$	$0.64^{+0.39}_{-0.30} \pm 0.06$	$1.0-6.0$	To be submitted	BaBar
R_{K^+}	$1.03 \pm 0.19 \pm 0.06$	$1.0-6.0$	PRL 103, 171801(2009)	Belle
R_{K^*}	$0.83 \pm 0.17 \pm 0.08$	$1.0-6.0$	PRL 103, 171801(2009)	Belle
R_K	$0.74^{+0.40}_{-0.31} \pm 0.06$	$0.1-8.1$	PRD 86, 032012 (2012)	BaBar
R_{K^+}	$0.745^{+0.090}_{-0.074} \pm 0.036$	$1.0-6.0$	PRL 113,151601(2014)	LHCb

New Babar analysis (same data) on the q^2 range [1,6]GeV^2

Naive average Babar-LHCb : $0.739^{+0.094}_{-0.081}$

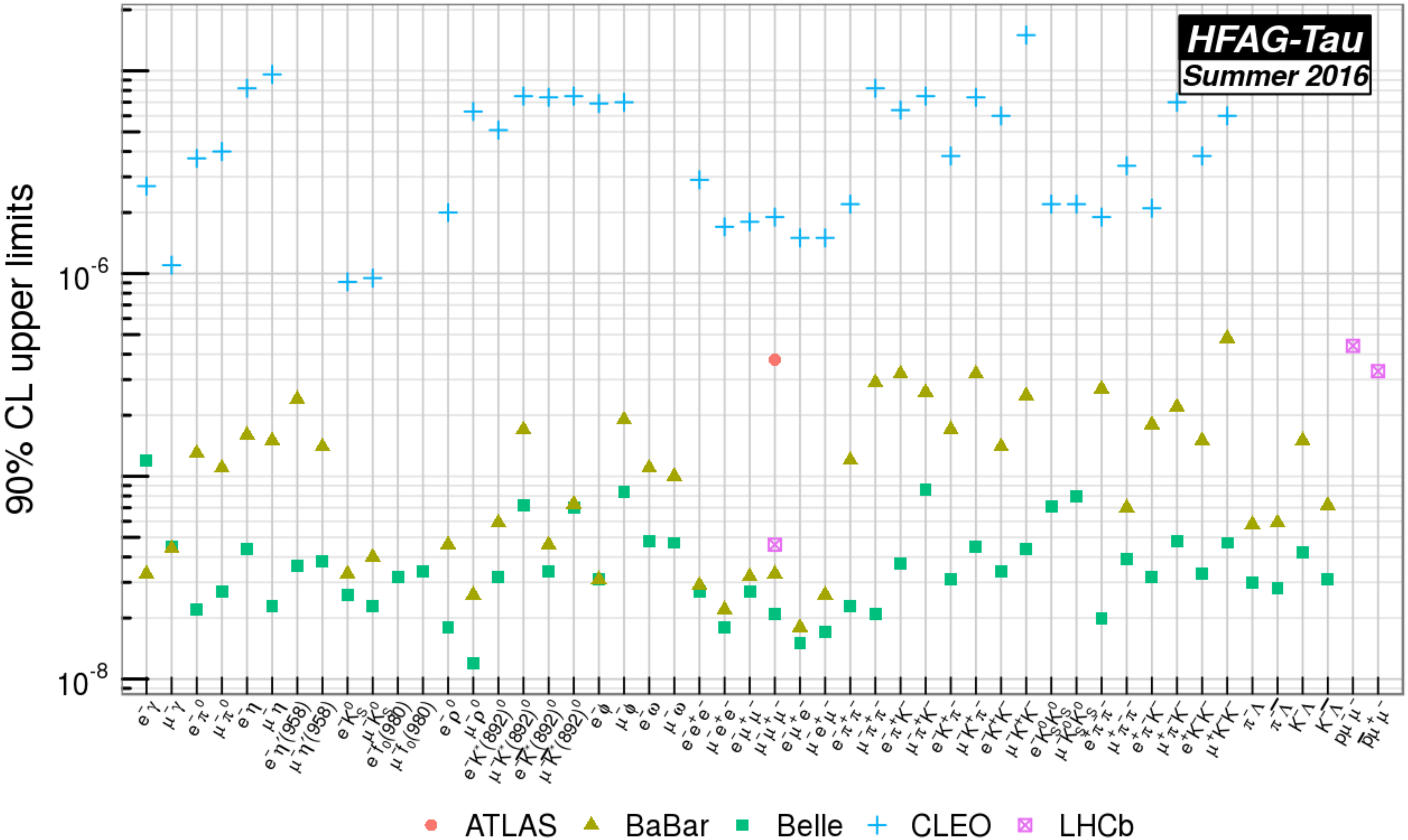
Paula Alvarez Cartelle, Fergus Wilson, Marzia Bordone

B-meson LFV and LNV Summary



Fergus Wilson

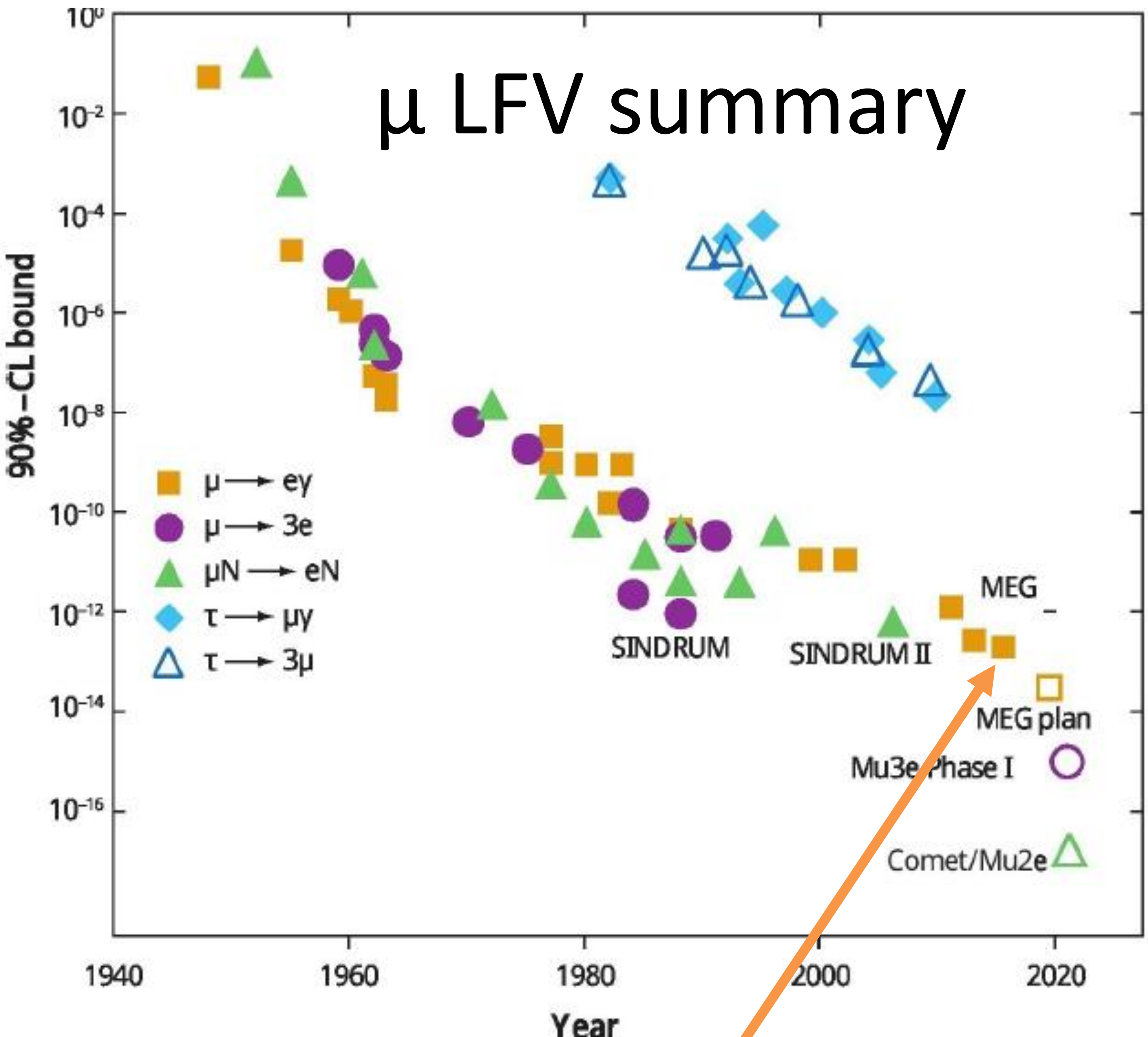
τ LFV summary



Fergus Wilson

No LFV observed. Limits in the range 10^{-8} to $2x10^{-7}$

μ LFV summary



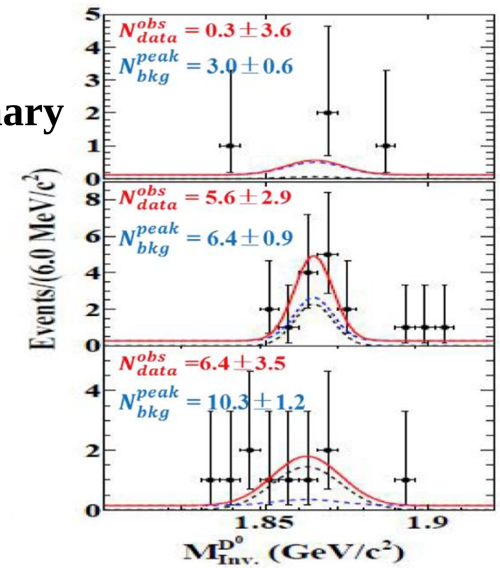
Final MEG upper limit $B(\mu \to e\gamma) < 4.2\ 10^{-13}$ @90% CL

Paolo Cattaneo

Rare charm decays

Rare D decay experiments

BES-III preliminary



Vindhyawasini Prasad

$D^+ \to D^0 e^+ \nu_e$

BR_{SM} = 2.78 ×10^{-13}

New preliminary from BES-III, this conference:

- Search using double-tag technique, 2.92 fb^{-1} at ψ(3770)
- Reconstruct 3 signal channels: $K\pi$, $K\pi\pi^0$, $K\pi\pi\pi$

No signal found: **BR < 8.7 × 10^{-5} 90%CL**

$D^+ \to h^\pm e^+ e^\mp$

New!

BR_{SM} ~ 10^{-8}-10^{-6} (SD part)

BES-III preliminary results

- Search using single-tag technique, 2.92 fb^{-1} at ψ(3770)
- Improvements for $D^+ \to h^\pm e^+ e^\mp$ and $D^+ \to h^\pm e^+ e^\mp$

$D^+ \to h^\pm e^+ e^\mp$: BES-III preliminary

	N^{data}_{inside}	$N^{data}_{outside}$	$\mathcal{B}[\times 10^{-6}]$
$D^+ \to K^+ e^+ e^-$	5	69	< 1.2
$D^+ \to K^- e^+ e^+$	3	55	< 0.6
$D^+ \to \pi^+ e^+ e^-$	3	65	< 0.3
$D^+ \to \pi^- e^+ e^+$	5	68	< 1.2

$D^0 \to \gamma\gamma$

BR_{SM} ~ 3 × 10^{-11} (SD part)

Strongly suppressed by GIM mechanism

BR could be ~ **10^{-6}** in MSSM

BR($D^0 \to \gamma\gamma$)

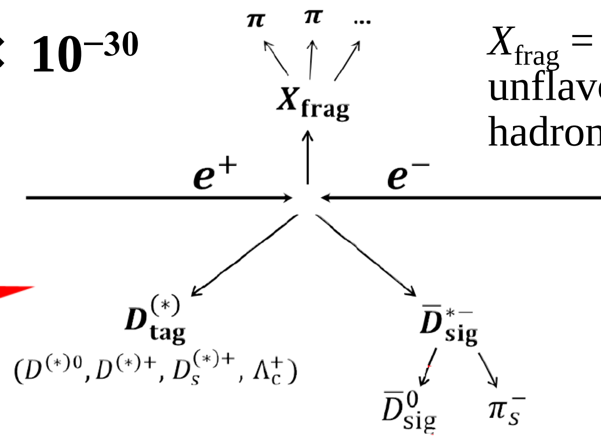
BES-III 2015 Double tag method	**3.8 ×10^{-6}**
Belle 2016 $D^{*+} \to D^0(\to \gamma\gamma)\pi^+$	**8.5 ×10^{-7}**

$D^0 \to e\mu$

LHCb: B($D^0 \to e\mu$) < 1.3 x 10^{-8} at 90%CL

$D^0 \to$ invisible

$D^0 \to \nu\nu$ helicity suppressed, predicted BR = 1.1 × 10^{-30}
NP models may enhance BR to ~10^{-15}



X_{frag} = few unflavored hadrons

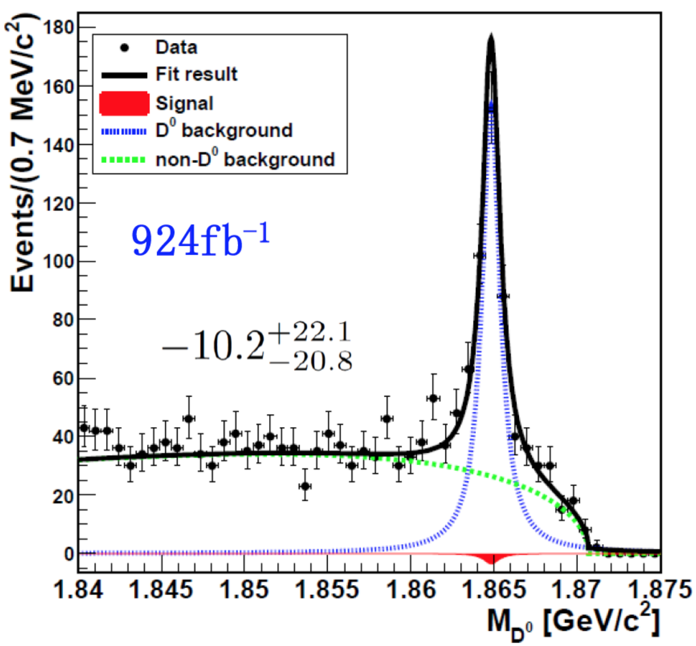
New result from Belle: First ever limit on BR($D^0 \to$ invisible)

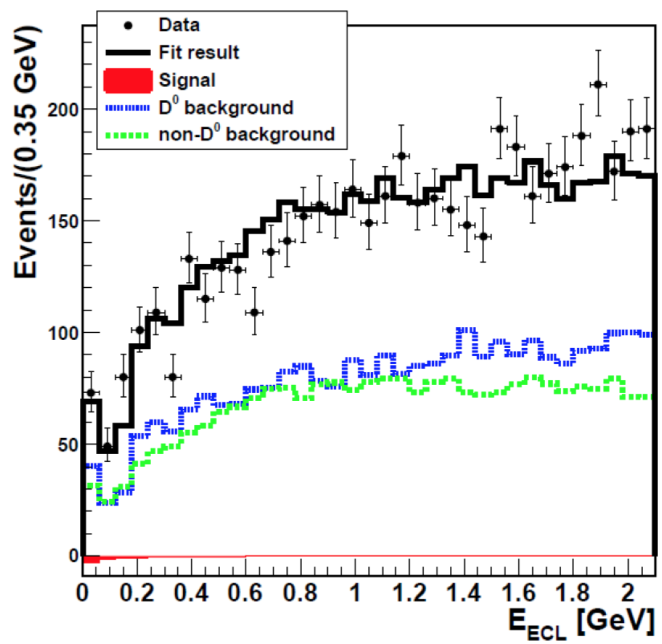
New!

BELLE

924 fb^{-1}
Charm tag for D^0 selection

$M(D^0)$: $M_{miss}(D_{tag}, X_{frag}, \pi_S)$





Reconstruct X_{frag}

Reconstruct $D^{(*)}_{tag}$

- 4 types of D_{tag} in 23 modes
- D^* tag in 5 modes

2D fit: $M(D^0)$, E_{ECL} for signal extraction

Vindhyawasini Prasad

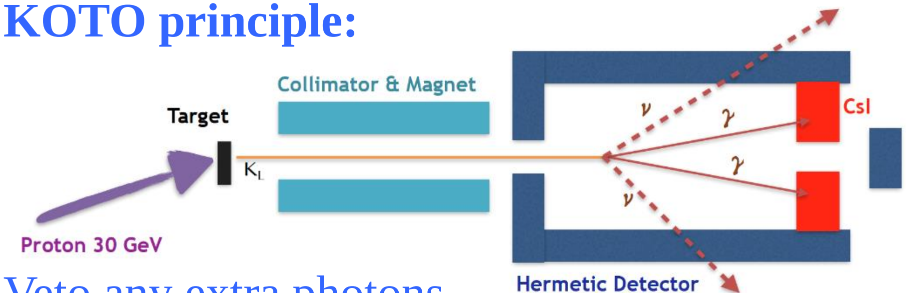
No signal found: BR($D^0 \to$ invisible) < 8.8 x 10-5 @ 90%C.L.

Rare strange decays

$K_L \to \pi^0 \nu\nu$

Y.-C. Tung

KOTO principle:

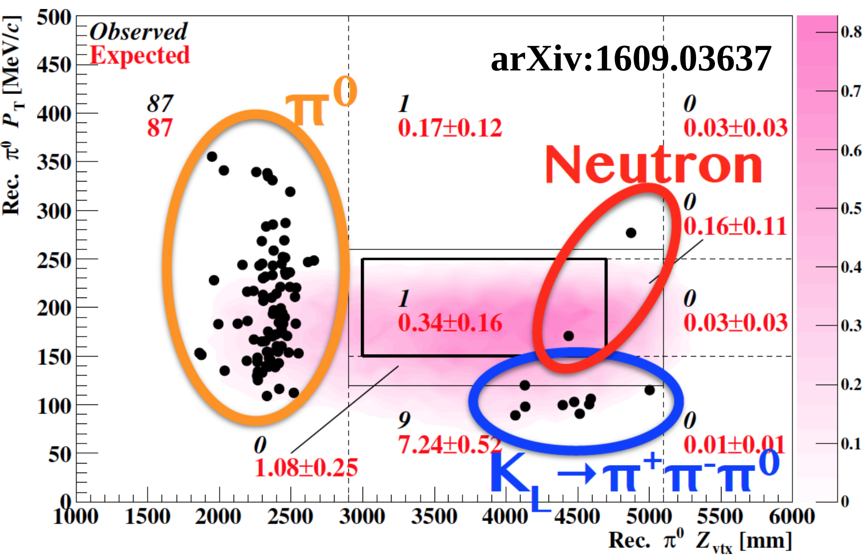


Veto any extra photons

Reconstruct z by imposing $M_{\gamma\gamma} = m_{\pi 0}$

Previous result (100 hrs in 2013)

BR < 5.1 × 10^{-8} (90%CL)

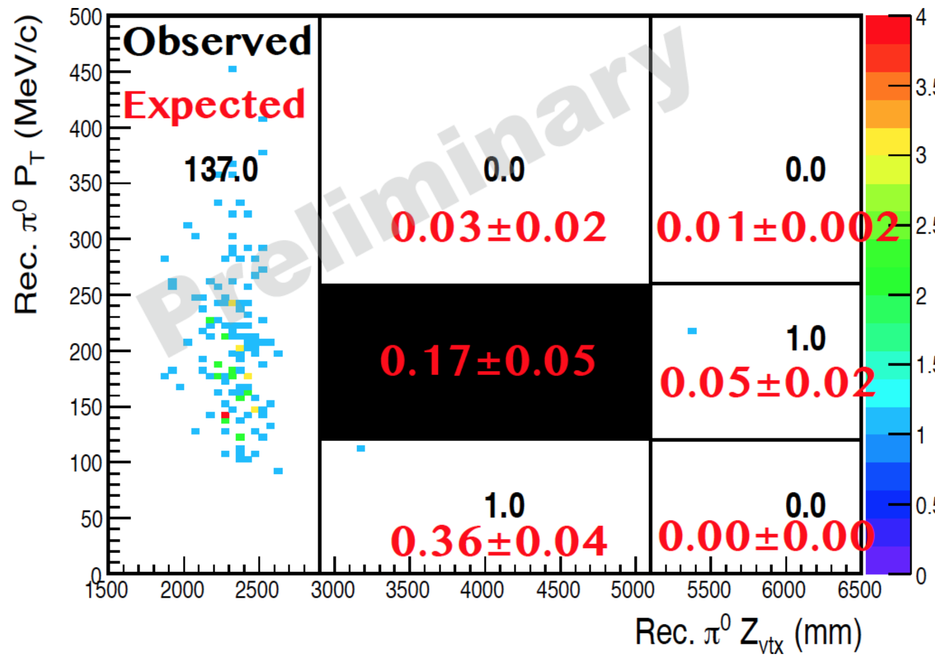


- Various improvements to reduce background before 2015-2016 run

Current status from Run 62 (2015):

SES = 5.9 × 10^{-9} (90%CL)

- Grossman-Nir limit can be reached with 2015-2016 data (10x Run 62)



Continuing upgrades to reduce background

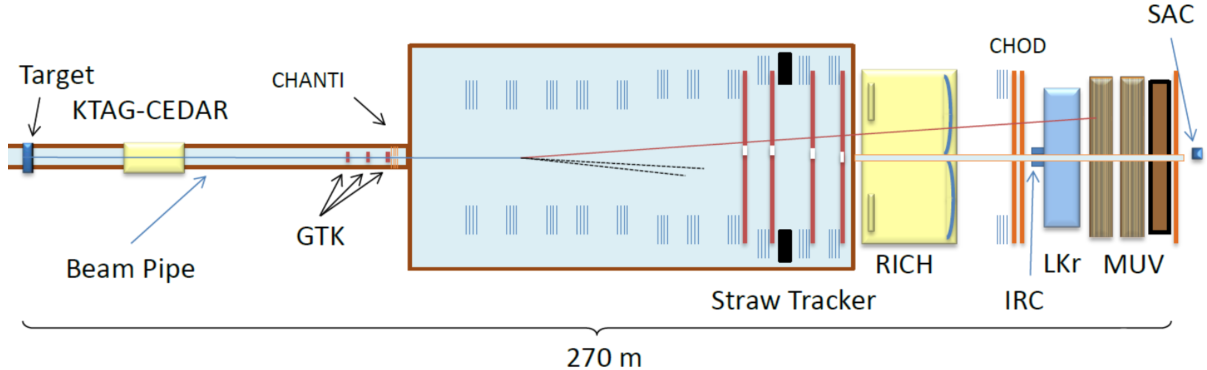
- New barrel veto
- Both-end readout for CsI crystals

Reach standard model sensitivity by 2021

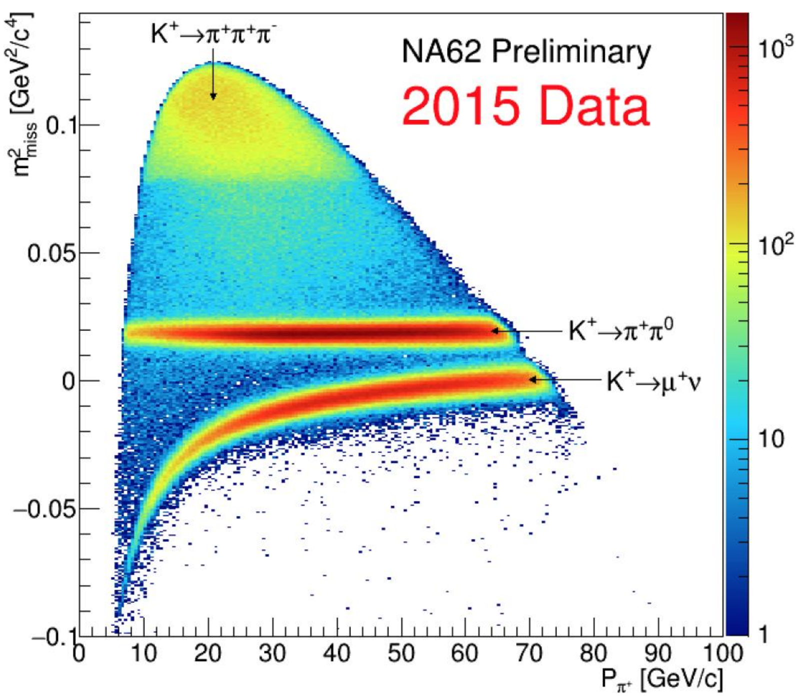
$K^+ \to \pi^+ \nu\nu$

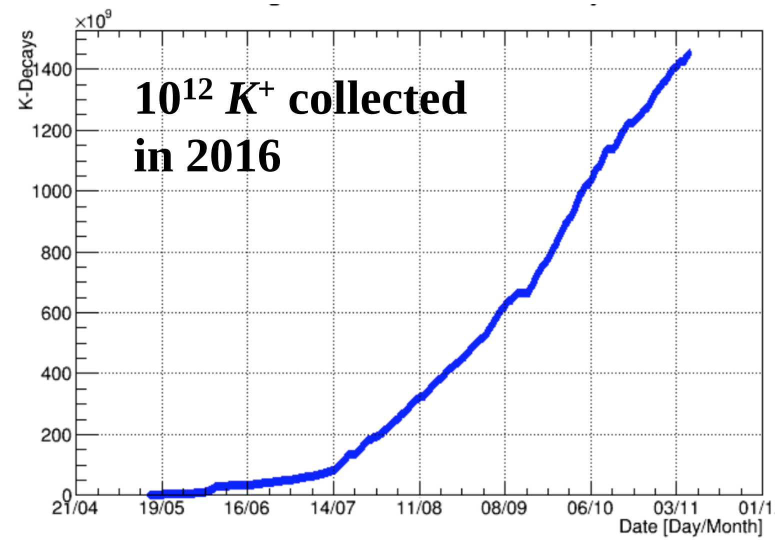
NA62 principles:

- ~100 ps timing for K^+-π^+ association
- EM calorimeters to veto γs
- Hadron calorimeters to veto μs
- Very light, high-rate trackers to reconstruct K^+ and π^+
- Full particle identification



1-track selection with K^+ beam ID



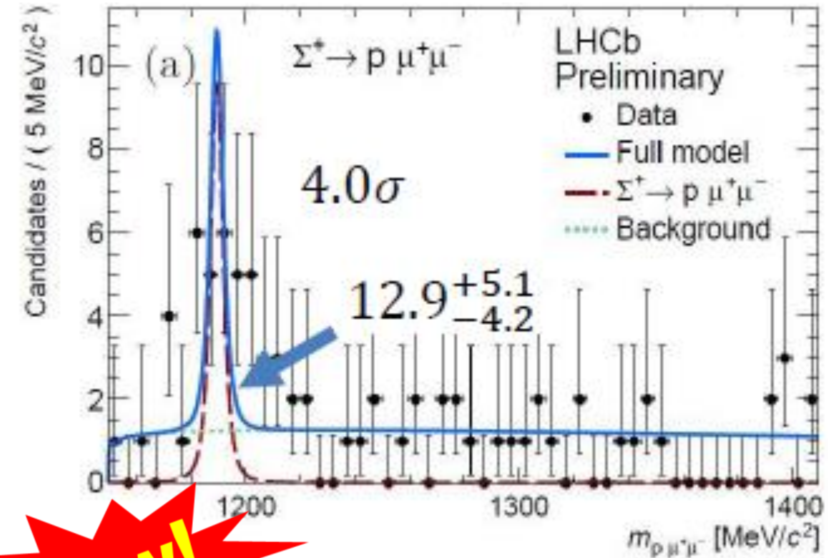


10^{12} K^+ collected in 2016

- **10^{13} K^+ will be collected before LS2**
- **~ 100 SM $K+ \to \pi+\nu\nu$**
- Several triggers collected simultaneously to address a broad physics portfolio
- NA62 plans to explore the dark sector after LS2

A. Ceccucci

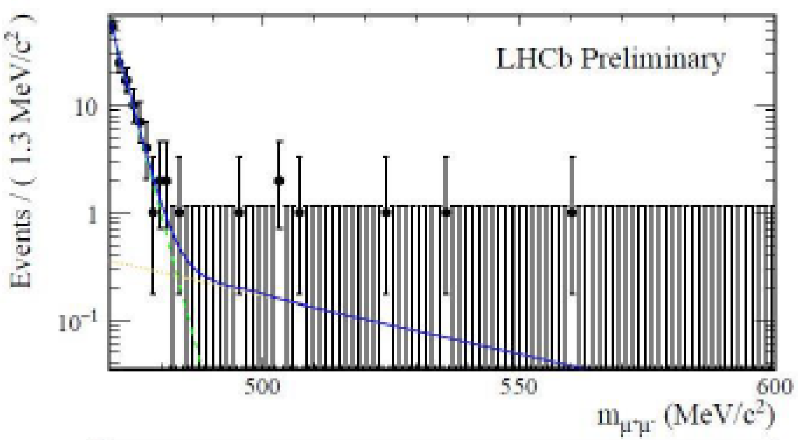
$\Sigma \rightarrow p\mu\mu$



- $\Sigma^+ \to p\mu^+\mu^-$ 4.0σ evidence with full selection
- No enhancement at $m(\mu^+\mu^-) = 214.3$ MeV
- No significant signal in TIS sample:

$$BF(\Sigma^+ \to p\mu^+\mu^-) < 6.3 \times 10^{-8} \quad @\ 95\%\ \text{CL}$$

$K_S \rightarrow \mu\mu$



No signal found, upper limit:

$$BF\left(K_S^0 \to \mu^+\mu^-\right) < 5.8(6.9) \times 10^{-9} \ @\ 90(95)\%\ \text{CL}$$

$\sim$ 2 times improvement compared to previous limit

Matteo Rama

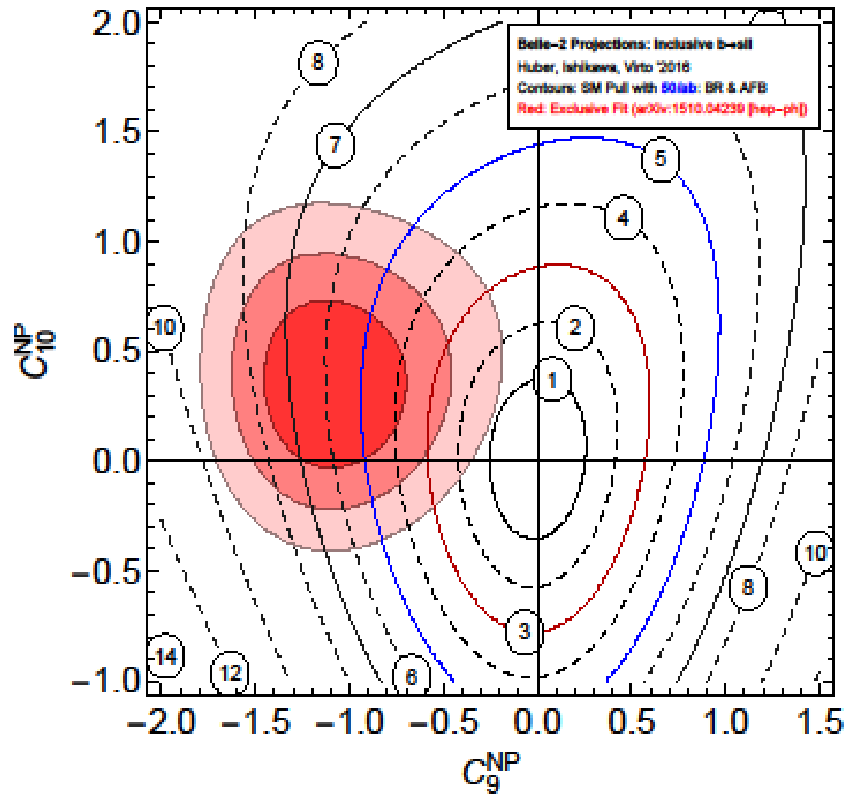
Summary of the summary

- Rich variety of results on $b \to s\ell\ell$ decays:
  - Tensions persist in angular observables : LHCb still see a deviation in P'_5 with full Run1 dataset, new analyses of Belle and Babar go in the ‘right’ direction. First Q_i measurement by Belle.
  - First results with τ in the final state are appearing. Still far from SM values but interesting to test LFU!
  - Plenty of other intersting results : of $B^+ \to \pi^+ \mu\mu$, $B_s \to \phi\, \mu\mu$,$\Lambda_b \to \Lambda\, \mu\mu$, $B^0 \to K^*ee$, $\Lambda_b \to p\pi\mu\mu$, $B^+ \to K^+\mu\mu$,...
- New result for $BR(B \to X_s\gamma)$ and first measurement of the photon polarization in $B_s \to \phi\gamma$
- New results on charm and kaons decays from BES-III, Belle and LHCb
- Limits improved in several very rare decay :
  - $B_{(s)} \to \mu\mu\mu\mu$, $b \to (s,d)\nu\nu$, $Ks \to \mu\mu$, ...

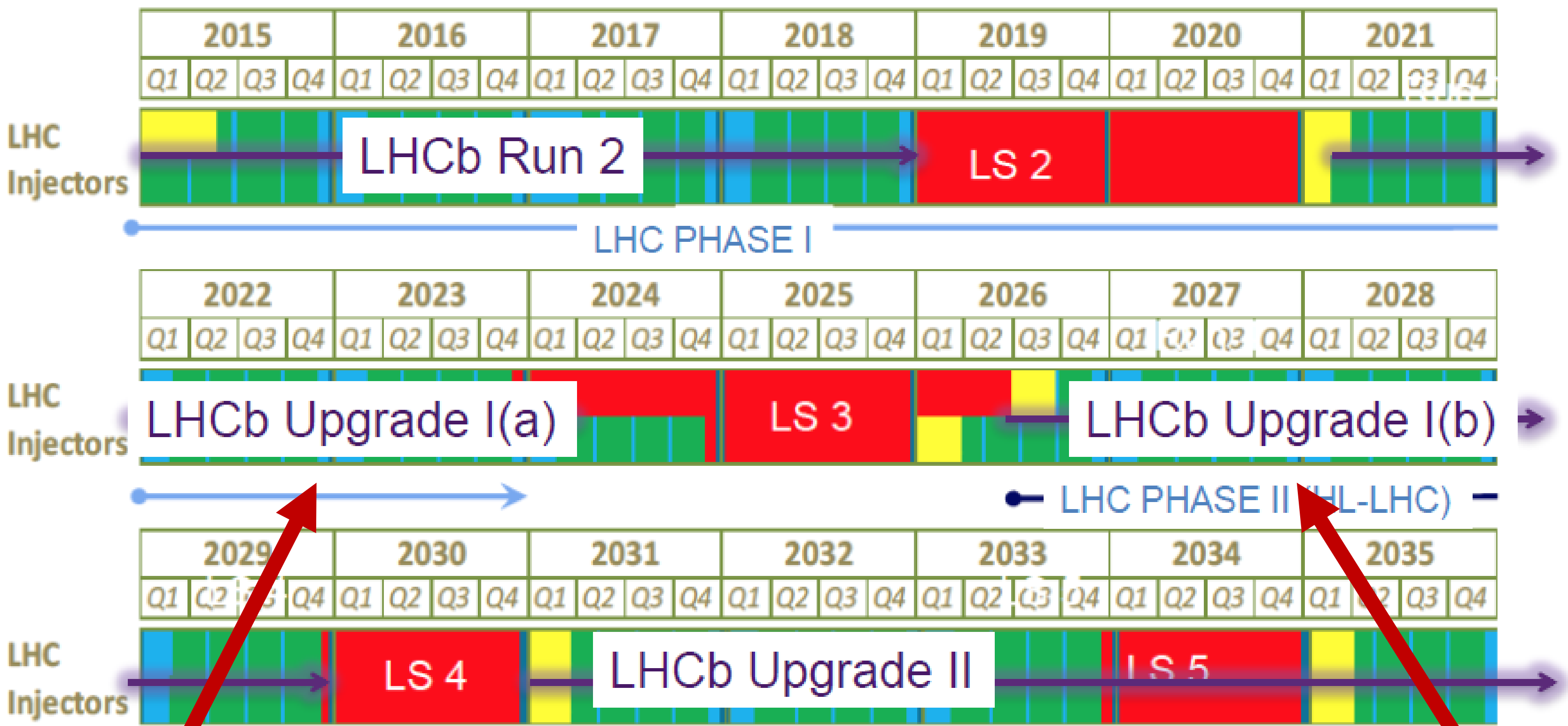
More to come

- New LHC Run 2 data still to be analyzed $\Rightarrow$ CKM18
- NA62 is fully operational $\Rightarrow$ CKM18
- KOTO has more data on tape $\Rightarrow$ CKM18
- Belle 2 is expected to start in 2018, prospects for rare decays (50 ab-1):
  - $b \rightarrow s\gamma$: CP violating measurement less than 1% precision
  - $S(K_s\pi^0\gamma)$ uncertainty ~ 0.03
  - $BR(B \rightarrow K^*\nu\nu)$ at 15%

  see more in talk of Saurabh SANDILYA



- Future LHCb upgrades under study



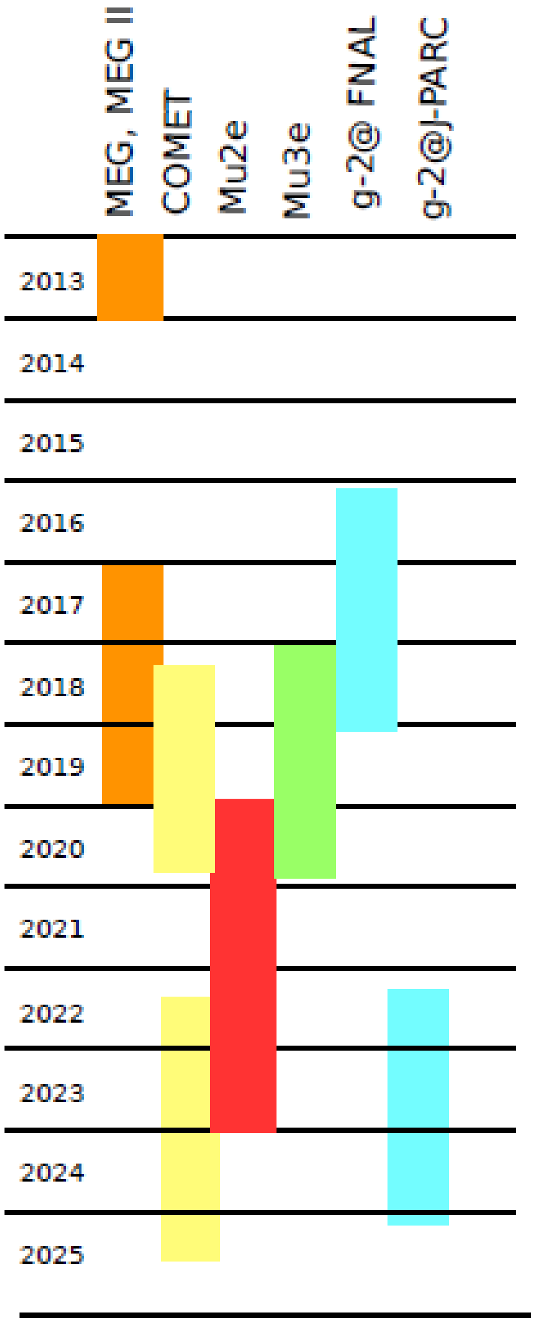
Chris Parkes

40MHz readout, software trigger only, acquire 5fb-1 per year

New detector to benefit from HL-LHC and record >50 fb-1 per year. Total > 300fb-1 ?????

Improve detector (add tracking station, improve ECAL,...) ?

- Several μ LFV experiments will start in 2017-2019 :
  - MEGII (PSI): improve resolution by a factor 2, engineering run foreseen in 2017
  - COMET (J-PARK): μ-e conversion in atoms, target ~10 $^{-17}$
  - Mu2e (FNAL): μ-e conversion in atoms, target ~10 $^{-17}$
  - Mu3e (PSI): previous result from 1988 at 10^{-12}, goal is to reach 10^{-15} in a first phase, then 10^{-16}



Paolo Cattaneo


SERIOUS
FUN
AHEAD

Observation of $B_c^+ \to J/\psi D^{(*)} K^{(*)}$ decays

New!

- Dataset: Run 1 (3 fb^{-1})
- $D^0 \to K^- \pi^+$ ($D^0 \to K^- \pi\pi\pi$); $K^{*0} \to K^+ \pi^-$
- First observation of
  - $B_c^+ \to J/\psi D^0 K^+$ (6.3 σ)
  - $B_c^+ \to J/\psi D^{*0} K^+$ (10.3 σ, partial reconstruction)

- First evidence of
  - $B_c^+ \to J/\psi D^{*+} K^{*0}$

  (4.0 σ, partial reconstruction)
  - $B_c^+ \to J/\psi D^+ K^{*0}$ (4.4 σ)

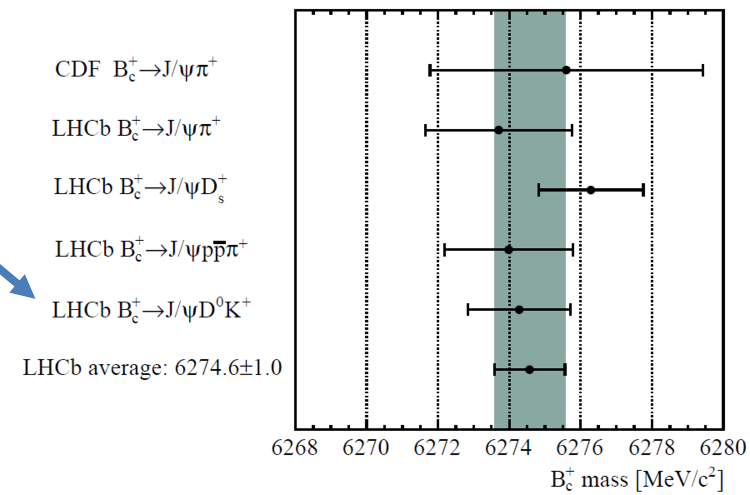
Matteo Rama

- Most precise B_c^+ mass measurement made using $B_c^+ \to J/\psi D^0 K^+$

$$M(B_c^+) = 6274.28 \pm 1.40 \pm 0.32 \ \text{MeV/c}^2$$

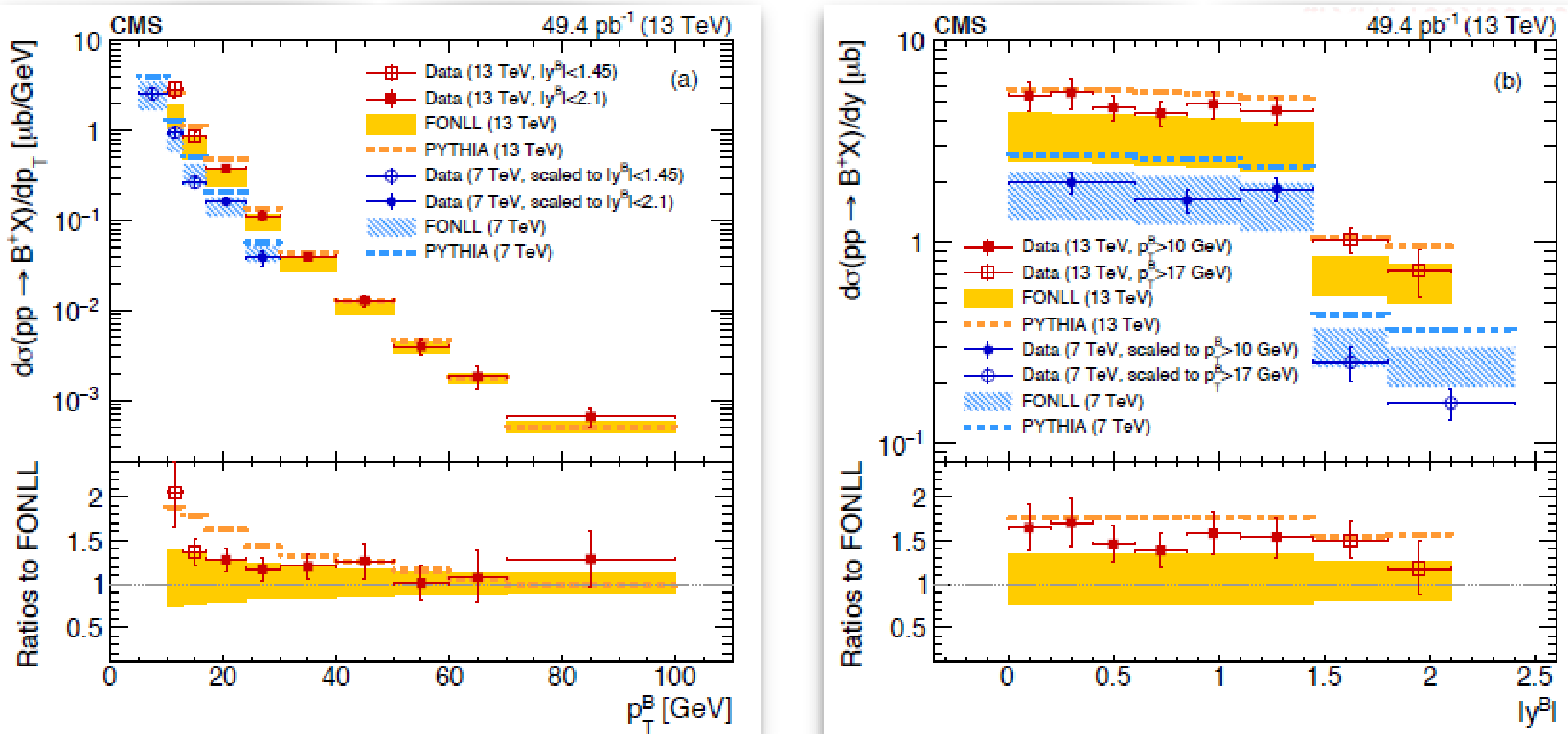
New LHCb average:

$$M(B_c^+) = 6274.6 \pm 1.0 \ \text{MeV/c}^2$$



B^+ production cross-section from CMS

arXiV: 1609.00873



Niladribihari SAHOO

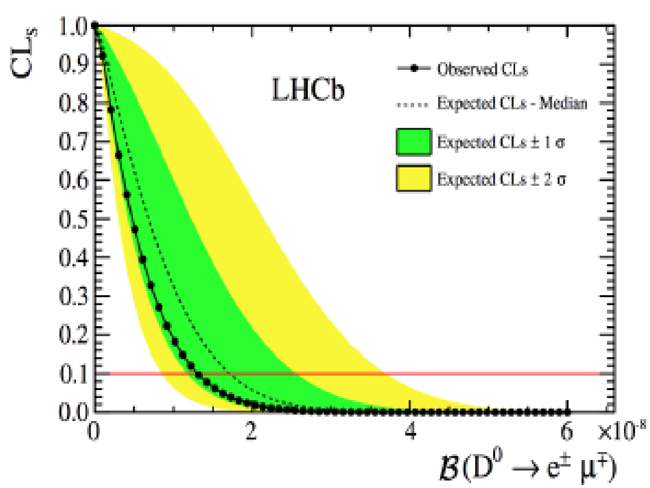
$D^0 \to e\mu$

Paula Alvarez Cartelle

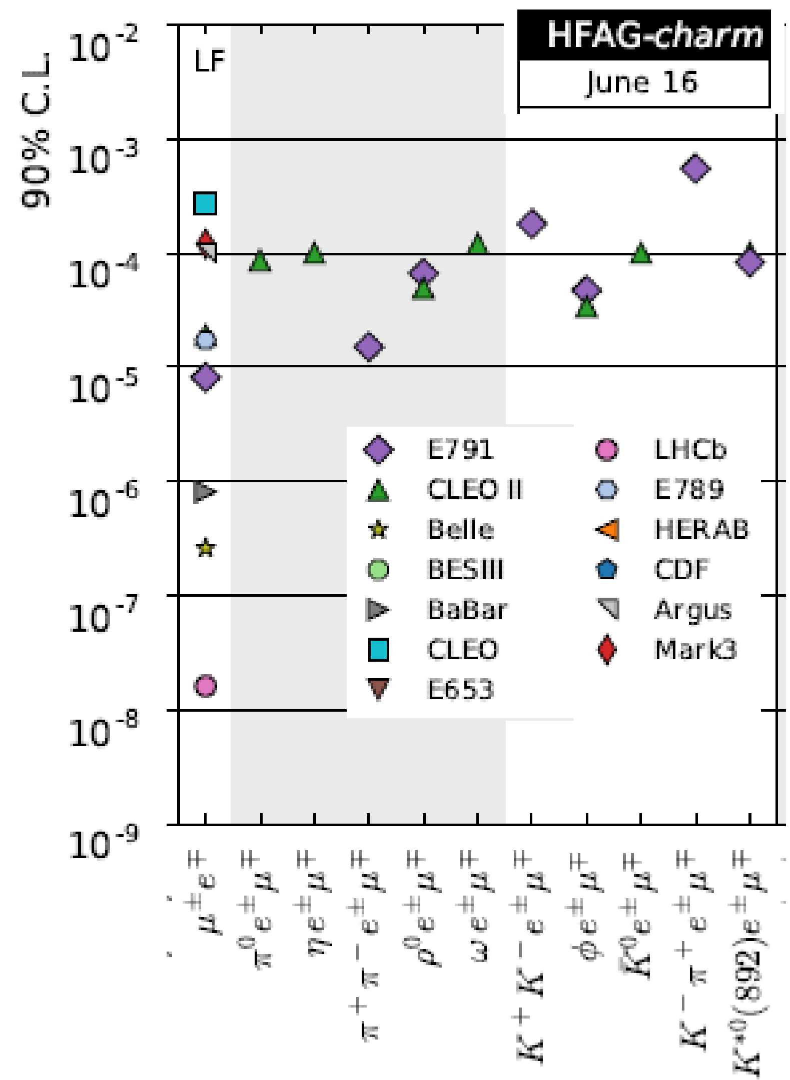
- Select D^0 from $D^{*+} \to D^0 \pi+$ decays
- Fit simultaneously $m(D^0)$ and $\Delta m = m(D^{*+})- m(D^0)$ in 3 bins of BDT
- Upper limit set from the CLs method using $D^0 \to K\pi$ as normalization channel

$\mathcal{B}(D^0 \to e\mu) < 1.3 \times 10^{-8}$ at 90%CL

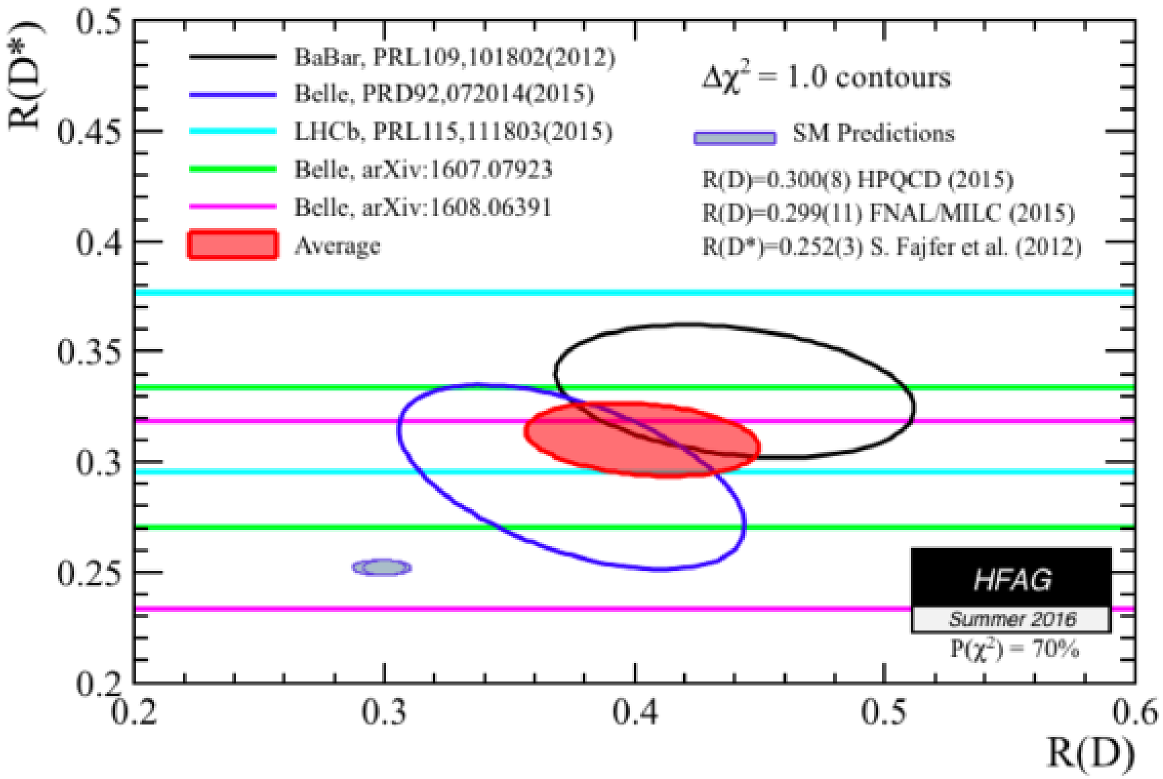
order of magnitude lower than previous limit



D⁰ LFV status:



$R(D^{(*)})$ status



→ Latest HFAG average: 3.9σ from SM expectation (includes new result from Belle with $\tau \to \pi^{+}(\pi^{0})\nu$)

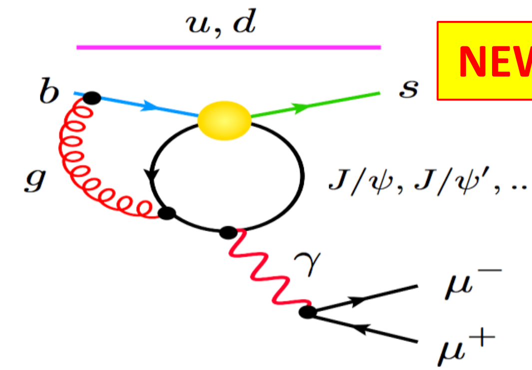
Paula Alvarez Cartelle

EVALUATING CHARM CONTRIBUTIONS IN $B^+ \to K^+\mu\mu$

NEW

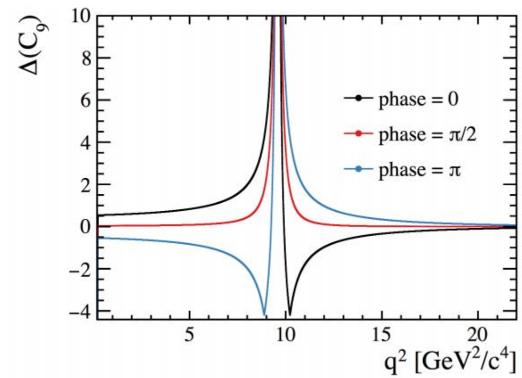
Purpose: measure the phase difference between short- (FCNC) and long-distance amplitudes

- Sizeble effect of the long-distance contributions far from the resonances could explain the observed tensions



Method: analize the dimuon mass spectrum

- long-distance modeled as sum of BW
- magnitudes, phases, C_9, C_{10} floated
- C_7 fixed to SM
- hadronic form factors f_+ constrained
- crucial control of the **resolution function**



$$\frac{d\Gamma}{dq^2} = \frac{G_F^2\alpha^2|V_{tb}V_{ts}^*|^2}{2^7\pi^5}|\boldsymbol{k}|\beta\left\{\frac{2}{3}|\boldsymbol{k}|^2\beta^2\left|C_{10}f_+(q^2)\right|^2 + \frac{4m_l^2(m_B^2-m_K^2)^2}{q^2}\left|C_{10}f_0(q^2)\right|^2 + |\boldsymbol{k}|^2\left[1-\frac{1}{3}\beta^2\right]\left|C_9^{\text{eff}}f_+(q^2) + 2C_7\frac{m_b+m_s}{m_B+m_K}f_T(q^2)\right|^2\right\},$$

$$C_9^{\text{eff}} = C_9 + \sum_j |\eta_j| e^{i\delta_j} A_j^{\text{res}}(q^2)$$

$$P_{\text{sig}}(m_{\mu\mu}^{\text{rec}}) \propto R(m_{\mu\mu}^{\text{rec}}, m_{\mu\mu}) \otimes \left(\varepsilon(m_{\mu\mu})\frac{\text{d}\Gamma}{\text{d}q^2}\frac{\text{d}q^2}{\text{d}m_{\mu\mu}}\right)$$

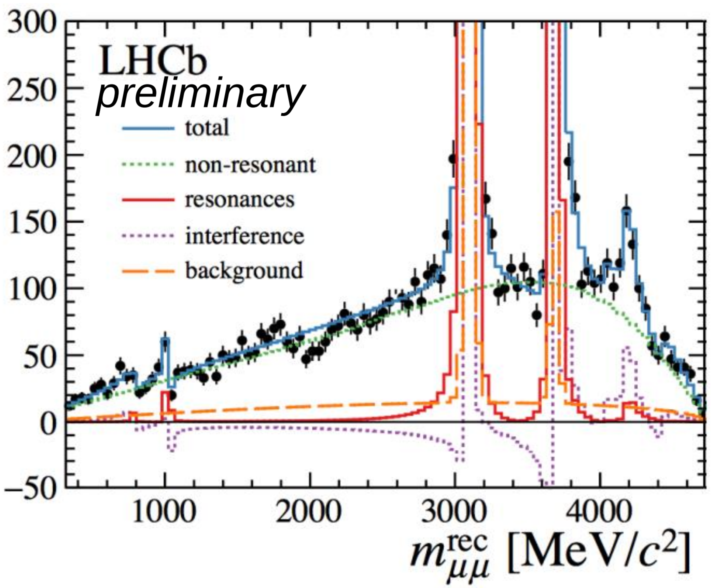
EVALUATING CHARM CONTRIBUTIONS IN $B^+ \to K^+\mu\mu$

- Four degenerate solutions, corresponding to the ambiguities of J/Psi and Psi(2s) phases being negative or positive
- J/Psi phase is compatible with +/-π/2 => is small away from the pole
- Preferred values: $|C_{10}|<|C_{10}^{SM}|$ and $|C_9|>|C_9^{SM}|$

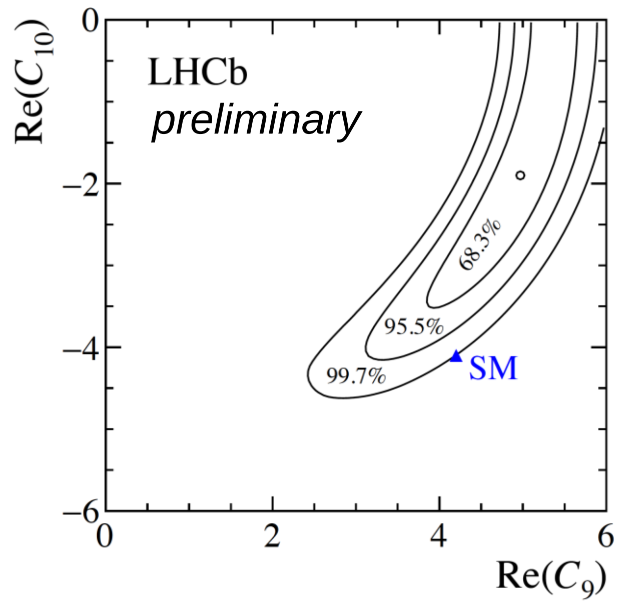
  If $C_{10} = C_{10}^{SM}$, $|C_9|<|C_9^{SM}|$

NEW

LHCb-PAPER-2016-045
COMING SOON



Resonance
$\rho(770)$
$\omega(780)$
$\phi(1020)$
J/ψ
$\psi(2S)$
$\psi(3770)$
$\psi(4040)$
$\psi(4160)$
$\psi(4415)$



- BF compatible with previous measurement and smaller than the SM:

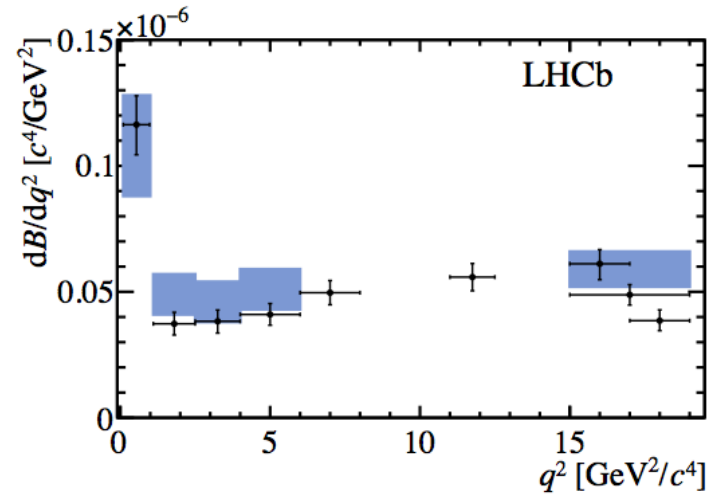
$$\mathcal{B}(B^+ \to K^+\mu^+\mu^-) = (4.37 \pm 0.15\,(\text{stat}) \pm 0.23\,(\text{syst})) \times 10^{-7}$$

For the future: improved *B->K* form factors and more data needed.
More difficult for the *K**: helicity states can have different relative phases

$B^0 \to K^{*0}\mu\mu$

Plenty of new results!

- Differential BR measurement of $B \to K^*(892)\mu\mu$ removing S-wave contribution
- $B \to K\pi\,\mu\mu$ BR and angular analysis in the $K_{0,2}{}^*(1430)$ region



Francesco Polci