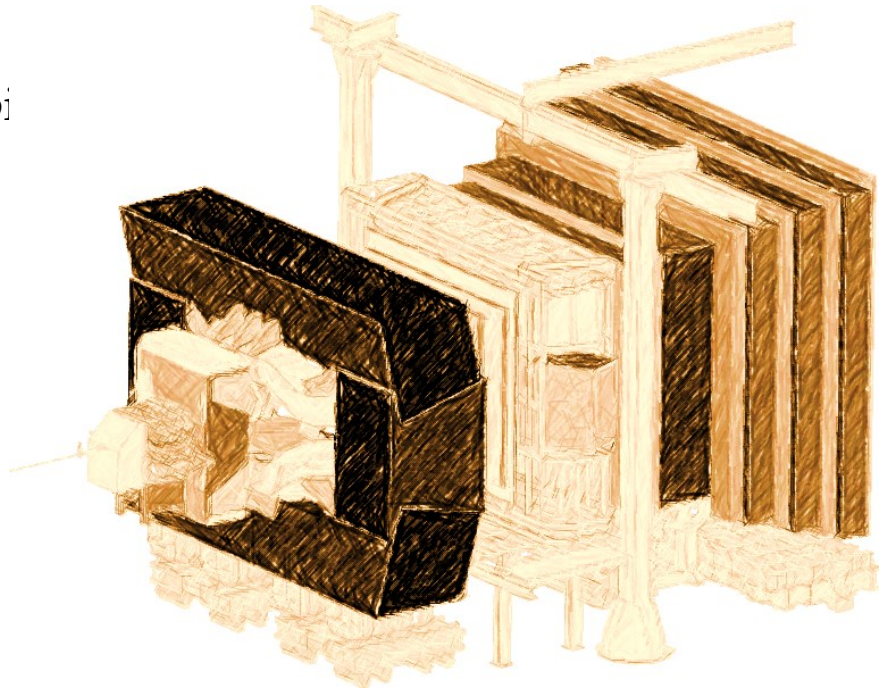
Results on LFV and on Dark Sector searches

Diego Martínez Santos

(Universidade de Santiago de Compostela & The European Research Council)
On behalf of LHCb

Introduction

Show LHCb results from two separate topi



- Lepton Flavour Violation:
  - Forbidden in SM
  - Ridiculously small in SM + ν mass

B→eμ, D→eμ, τ → μμμ, …

(Not to be confused with Lepton Universality Violation, eg., B→K*μμ/B→K*ee)

- Direct searches for BSM bosons (Dark photons, HV pions, NMSSM higgses…)

- The results I'm going to show correspond to the following datasets

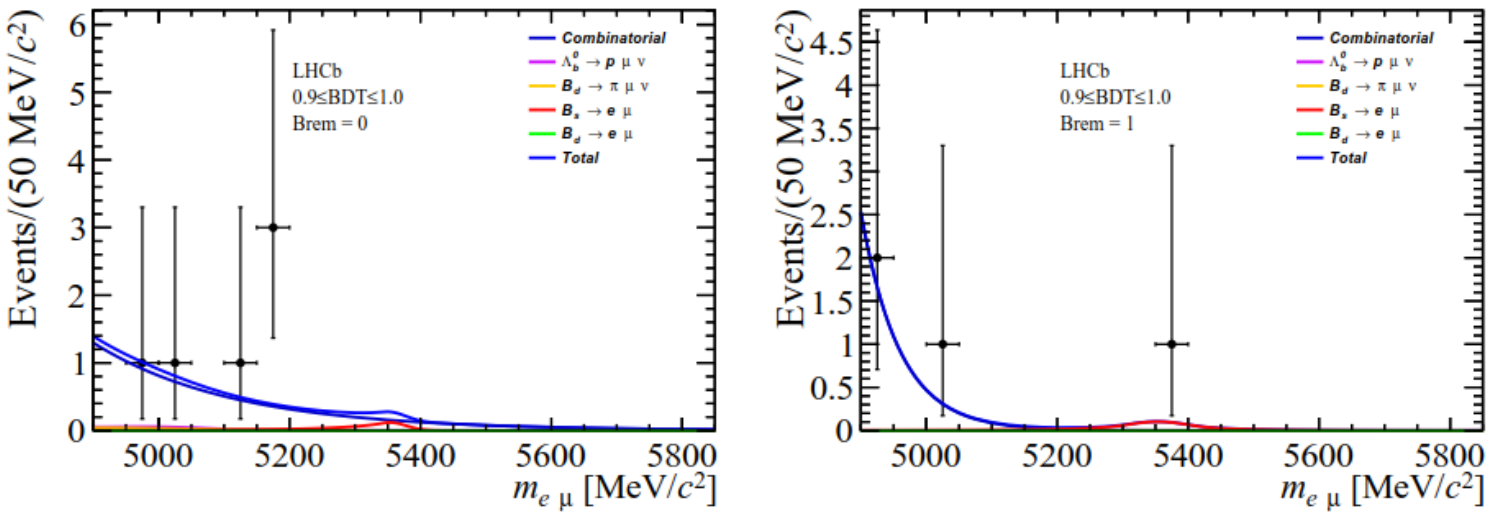
  - Run-I : 2011: 1fb^{-1} @ 7 TeV , 2012: 2fb^{-1} @ 8 TeV
  - Run-II: 1.6 fb^{-1} @ 13 TeV

LFV: $B_{(s)} \rightarrow e\mu$

JHEP 1803 (2018) 078

- Run-I dataset
- Used BDT to discriminate from background
- Invariant mass fit in different bremsstrahlung categories

BDT most signal-like



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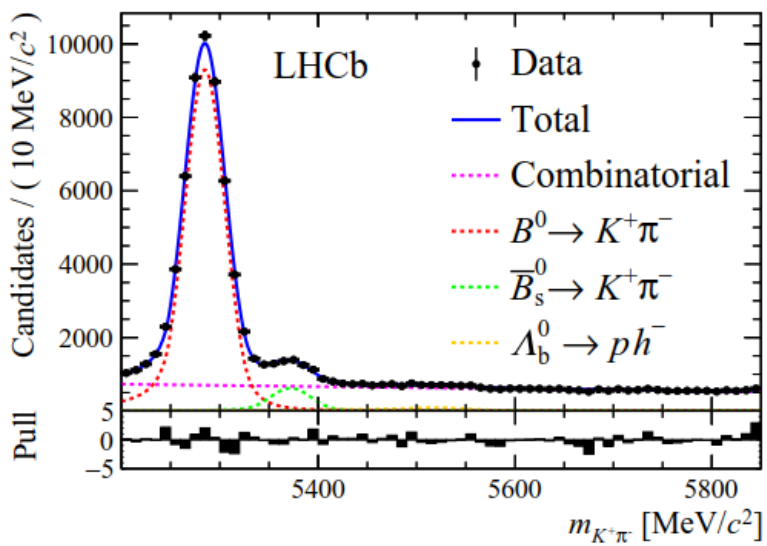

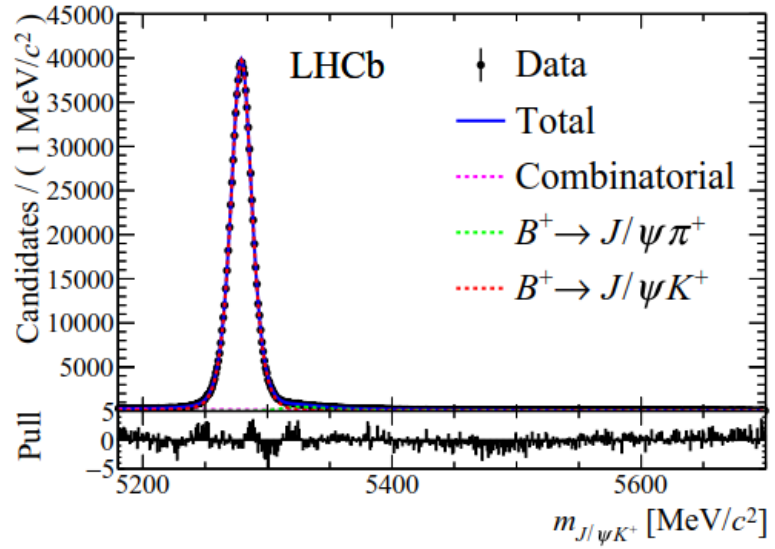

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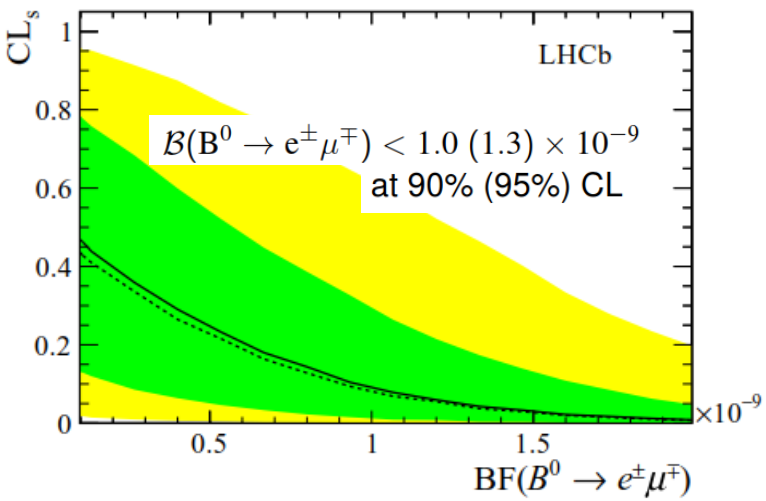
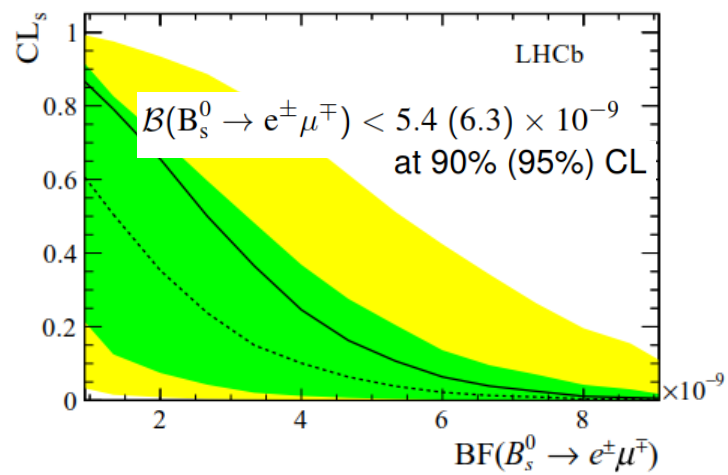
- Upper limit set with CLs

World best upper limits:

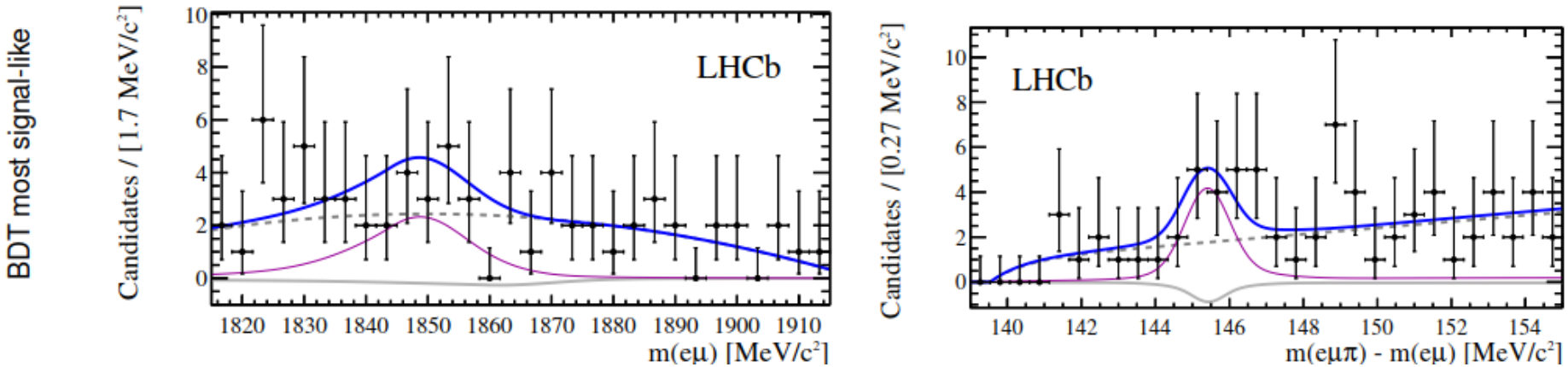




LFV: $D^0 \rightarrow e\mu$

PLB 754(2016)167

- Run-I dataset
- Used BDT to discriminate from background
- D^0's are tagged from $D^{*\pm} \rightarrow D^0\pi^\pm$ decays
- Invariant mass fit in different BDT categories, two mass variables: help discriminating against ~irreducible background from $D^0 \rightarrow \pi\pi$
- Normalization of the signal yield to $D^0 \rightarrow K\pi$



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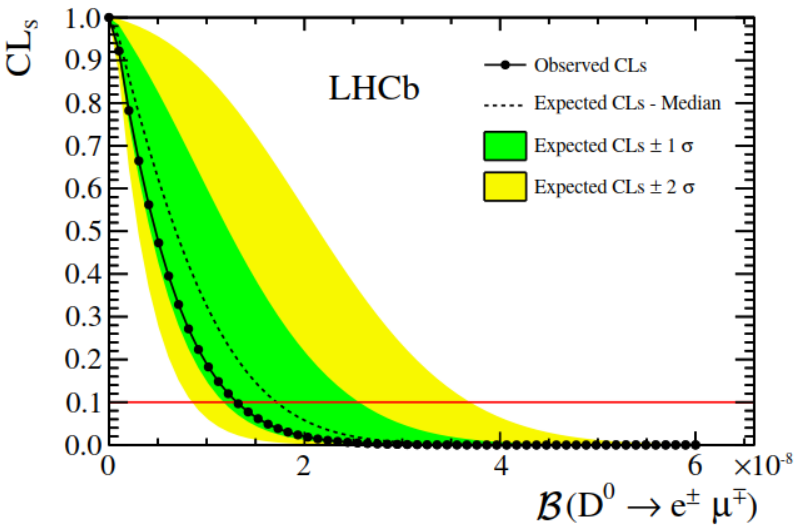
- Limit set with CLs



World best upper limit:

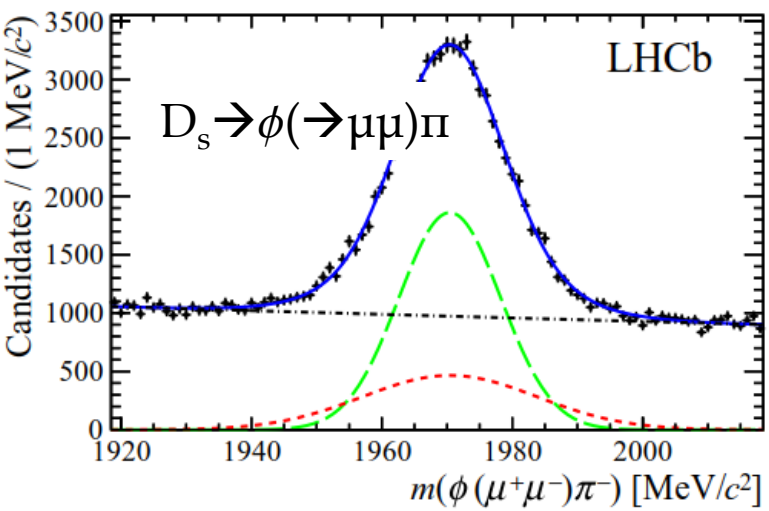
$BR(D \rightarrow e\mu) < 1.3\ (1.6) \times 10^{-8}$

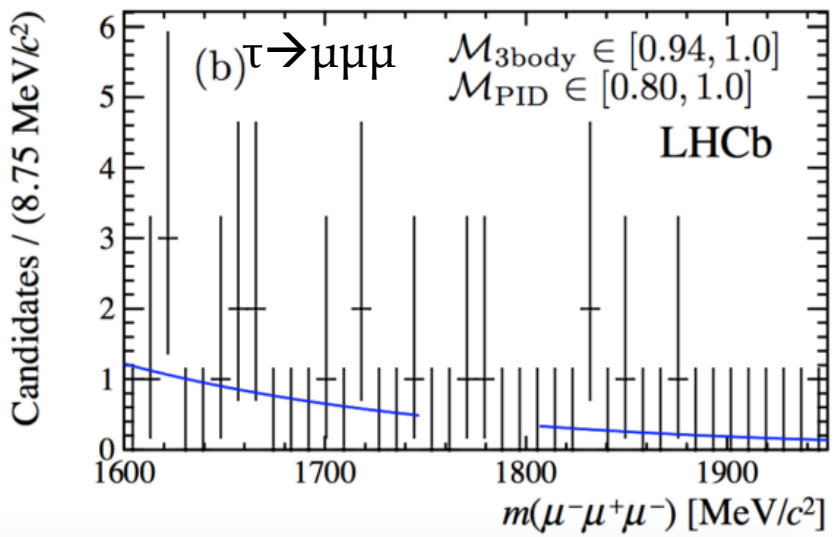
@90 (95)% CL

LFV: τ→μμμ

JHEP 02 (2015) 121

- Run-I dataset
- Used BDT to discriminate from background
- Classification of events in bins of 2 BDT's and μμμ mass
- Normalization of the signal yield to $D_s \to \phi(\to \mu\mu)\pi$
- Background estimate from sidebands





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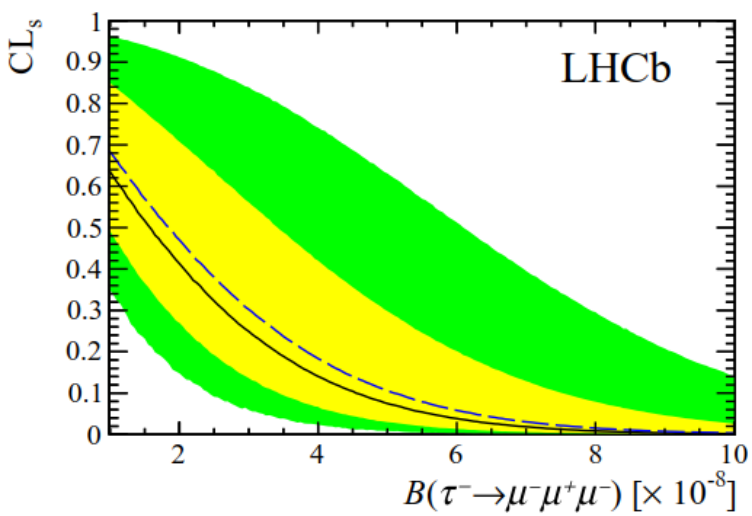


BR(τ→3μ) < 4.6 (5.6) x 10^{-8}
@ 90 (95)% CL

Competitive with Belle (2.1 x 10^{-8} @ 90%CL)

PLB 687 (2010) 139

LHCb Upgrade (s) will explore the 10^{-9} region

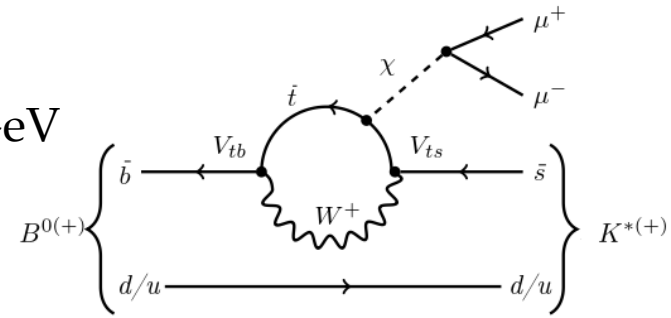
Dark Sector searches

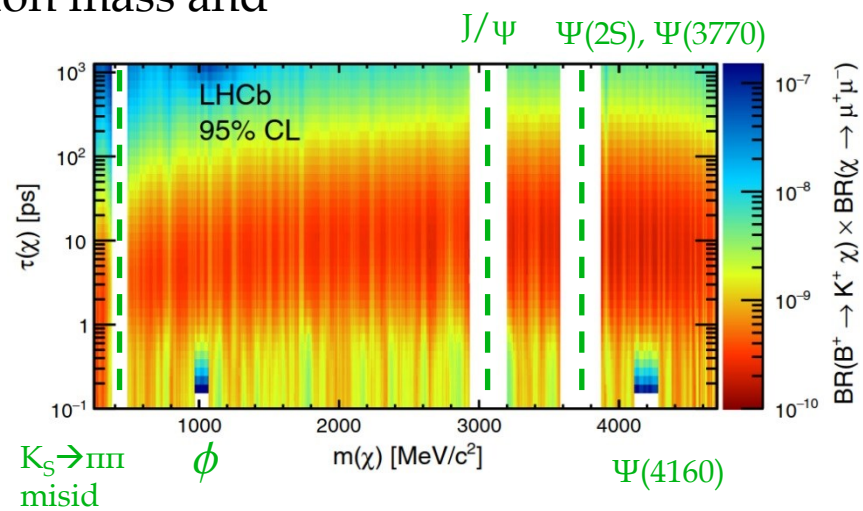
(Direct Searches for BSM bosons)

Hidden sector bosons from flavour decays

PRL 115 161802 (2015)
PRD 95, 071101(R) (2017)

- Searches for BSM bosons (χ) in b→sμμ transitions performed in full Run-I data
- Provide sensitivity in the region ~$2m_\mu$ < mχ < ~4.7 GeV
- Lifetimes up to 1000 ps
- Upper limits for B→Kχ(μμ) and B→K*χ(μμ) are in the 10^{-10} – 10^{-7} range, depending on the dimuon mass and the χ lifetime (analysis reoptimized)
- See talk by Preema Pais
- Similar searches possible in s→dμμ, eg, Σ→pμμ

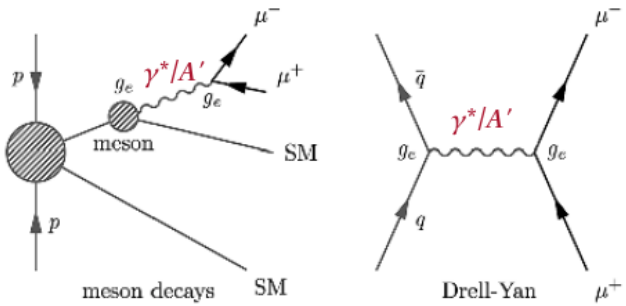




Dark photons

PRL 120 (2018) no.6, 061801

- Search for dark photons, that mix to off-shell photons → shared production mechanism→ normalization to DY
- Uses dedicated "turbo" trigger: writes on tape only the relevant part of the event



Turbo trigger: Write on tape the relevant information of the event as measured online:

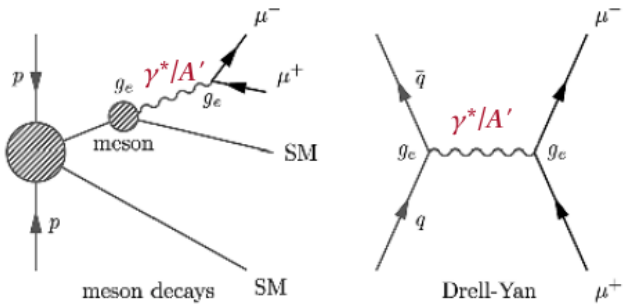
+ Advantage: Little event size → afford higher output rate and hence efficiency

+ Disadvantage: Give up offline reconstruction quality, analysis reoptimizations

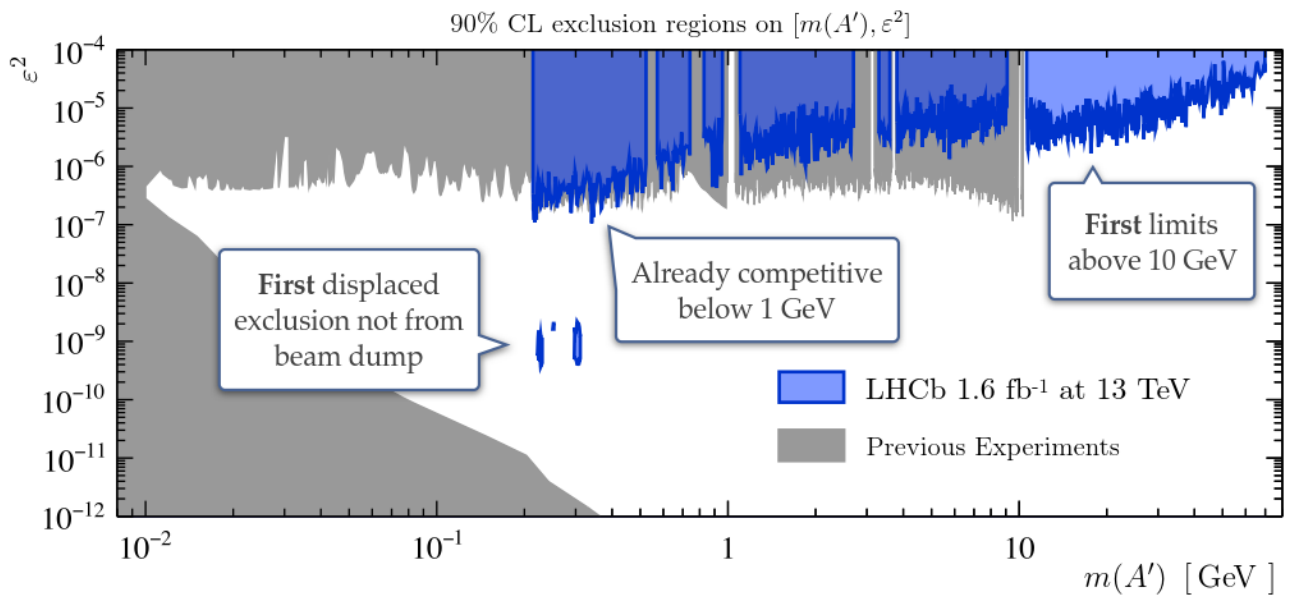
Dark photons

PRL 120 (2018) no.6, 061801

- Search for dark photons, that mix to off-shell photons → shared production mechanism→ normalization to DY
- Uses dedicated "turbo" trigger: writes on tape only the relevant part of the event
- 1.6 fb^{-1} of Run-II (13 TeV) data



- Prompt search up to m_Z
- Displaced search up to 350 MeV

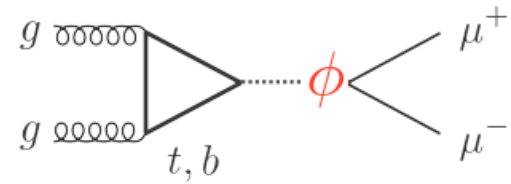


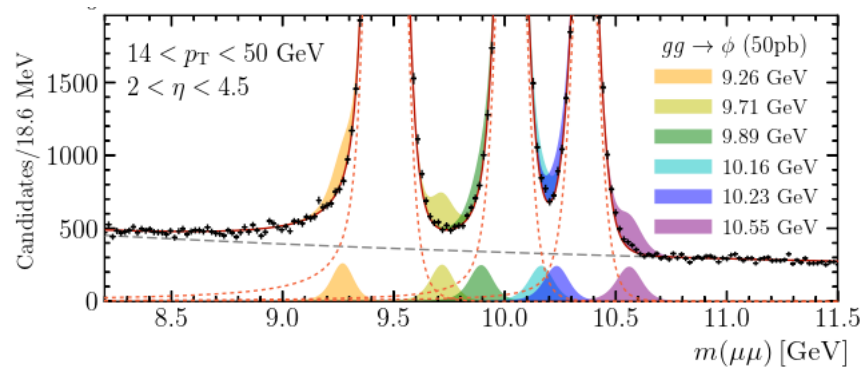
BSM bosons from gg→μμ

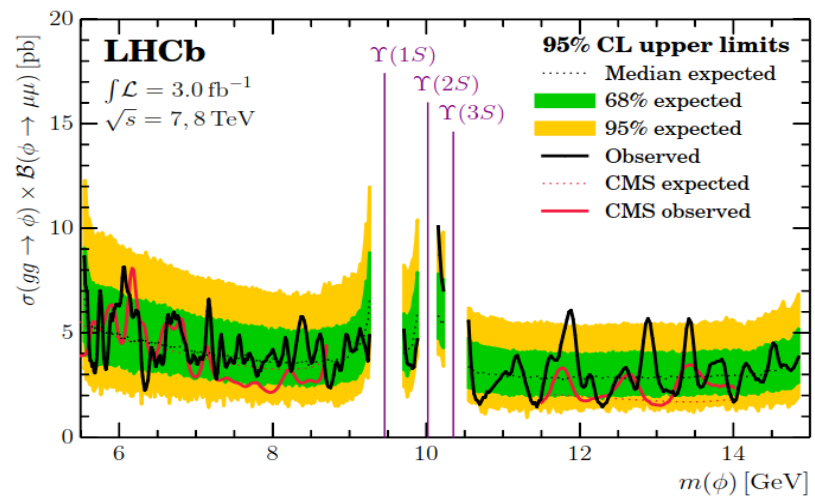
New

LHCb-PAPER-2018-008
arXiv: 1805.09820

- Search for a prompt dimuon resonance in the full Run-I data (supersedes preliminary result of Moriond EW)
- Statistically independent from the Dark Photon search → can be combined by recast searches)
- Search inspired in NMSSM, but done in bins of η, pt to easy interpretations in different models
- Good mass resolution of LHCb allows to explore closely the Υ region
- No signal found, upper limits in σ x BR set (CLs). ~ 5 pb level



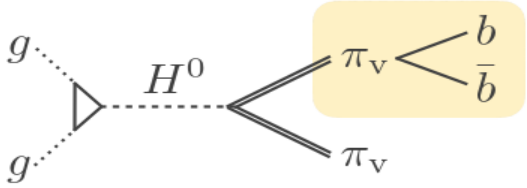


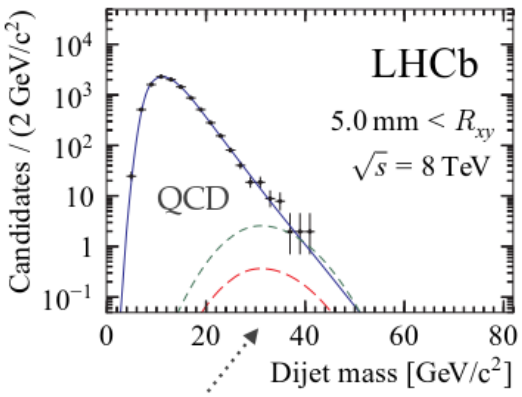


HV pions decaying to di-jets

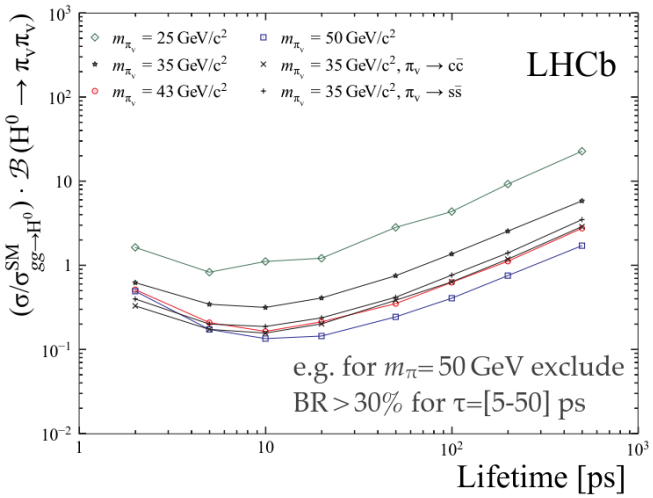
EPJC 77 (2017) 812

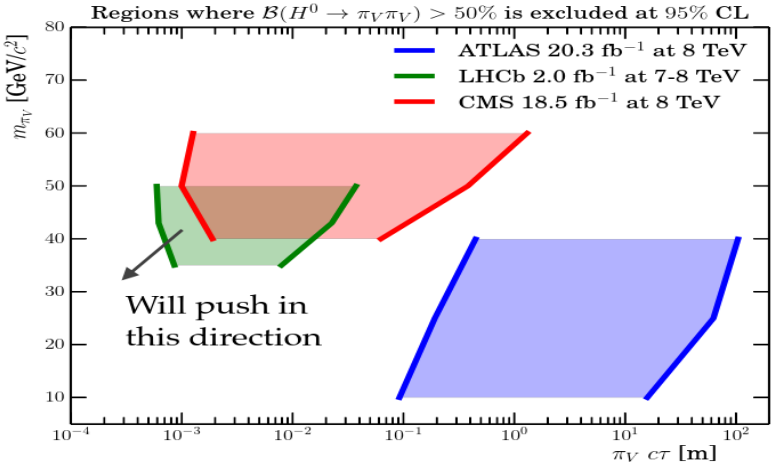
- Signature: search for a displaced vertex with two b-jets (low efficiency to search for all 4)
- This signature is possible in Hidden Valley pions from SM Higgs decay
- Di-jet mass fit in bins of transverse displacement
- 2 fb^{-1} of Run-I data, @7 and 8 TeV.





π_V (35 GeV, 10 ps)
best fit, BR=1





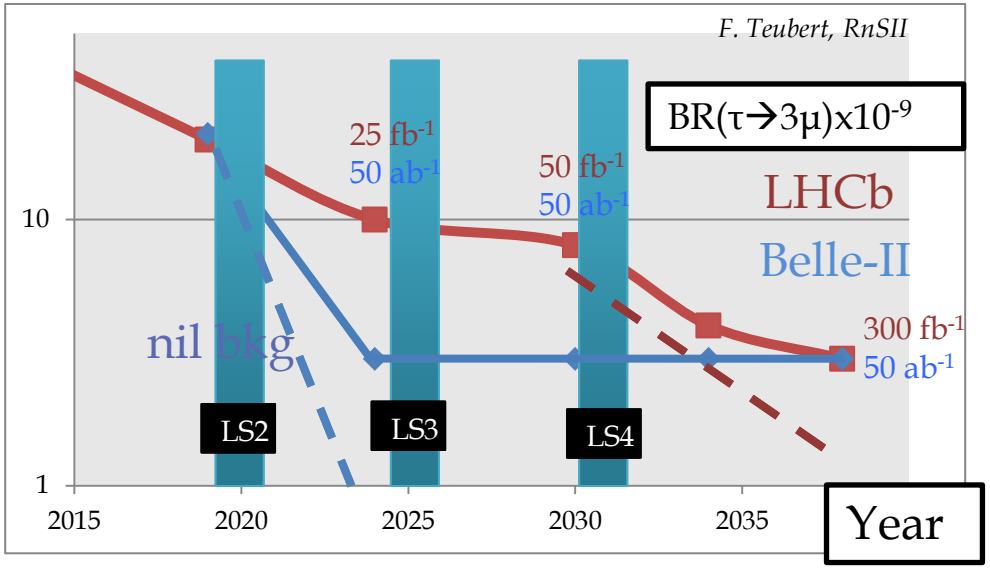
Conclusions

- Presented upper limits for LFV processes: $B_{s,d} \rightarrow e\mu$, $D^0 \rightarrow e\mu$, $\tau \rightarrow \mu\mu\mu$
- Didn't cover ongoing/planned searches : $B_{s,d} \rightarrow \tau\mu$, $B_{s,d} \rightarrow K^{(*)}\tau\mu$, $B_{s,d} \rightarrow K^{(*)}e\mu$, as well as Λ_b decays…
- Several direct searches performed in LHCb:
  - Hidden sector light bosons produced in HF decays
  - Dark photons → dimuon (13 TeV)
  - Prompt dimuons near the Y (Run-I)
  - Hidden Valley pions

Lepton Flavour Violation

- LFV forbidden in SM, but allowed in BSM

  →positive signal is compelling NP discovery



- LHCb searches for LFV

Several world best results in hadron decays

	1fb^{-1} (Phys. Rev. Lett. 111 (2013) 141801)	3fb^{-1} (exp)	300fb^{-1} (exp)
$B_s \to e^\pm \mu^\mp$	< 1.4x10^{-8} @ 90% CL	~3.8x10^{-9}	~3x10^{-10}
$B \to e^\pm \mu^\mp$	< 3.7x10^{-9} @ 90% CL	~1.2x10^{-9}	~1x10^{-10}

τ→3μ Phase-II competitive w/ Belle II

B→Keμ → expected O(10^{-9}) for Phase - II