Search for $K^0_{S(L)} \to 4\mu$ at LHCb

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Analysis Overview

- Highly constrained by phase space (very low background)
- K^0_L escapes the detector acceptance
- No existing measurements
- Follows the scheme of $K^0_S \to \mu^+\mu^-$ [1]

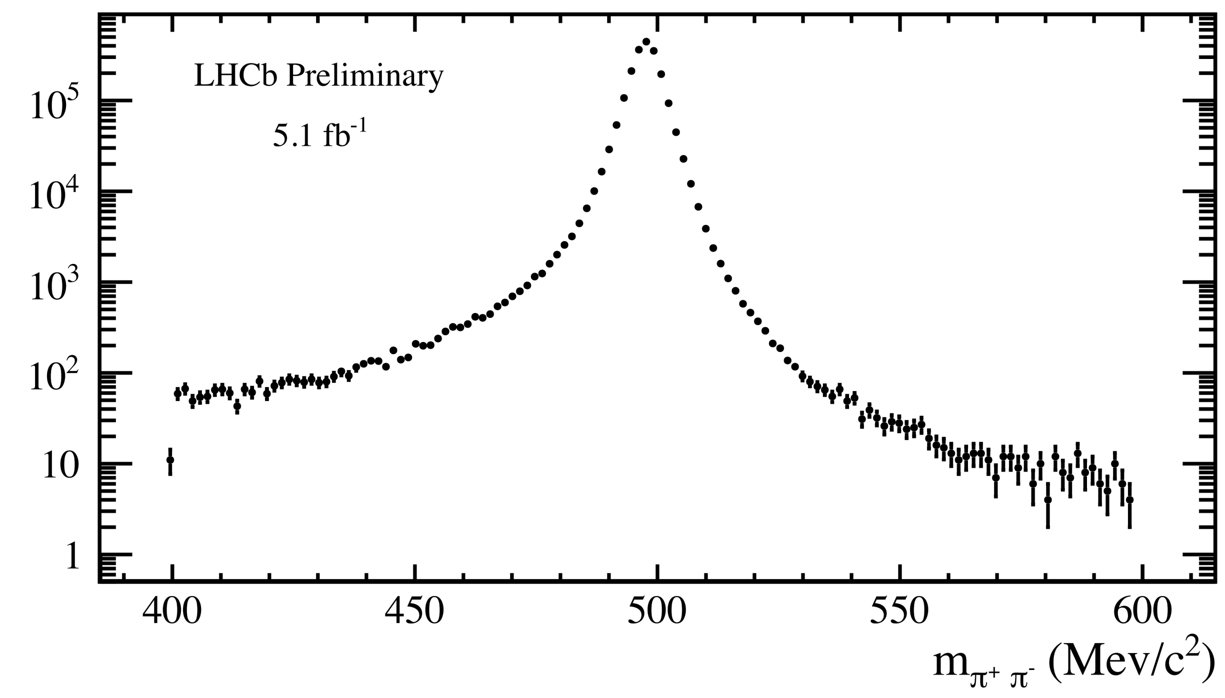
Prediction/ Channel	$K^0_S \to 4\mu$	$K^0_L \to 4\mu$
SM [2]	$\mathcal{O}(10^{-14})$	$\mathcal{O}(10^{-13})$
$U(1)_d + S$ [3]	2×10^{-12}	2.3×10^{-9}

Analysis Strategy

- 2016-2018 LHCb data
- $K^0_{S(L)}$ coming from PV
- Blind analysis
- Control mode: $K^0_S \to \pi^+\pi^-$

$$\mathscr{B}(K_{S(L)} \to 4\mu) = \alpha N_{sig}\ , \quad \alpha \sim \frac{\mathscr{B}(K^0_S \to \pi^+\pi^-)}{N_{norm}} \times \frac{\varepsilon_{norm}}{\varepsilon_{sig}} \simeq 2 \times 10^{-12}$$

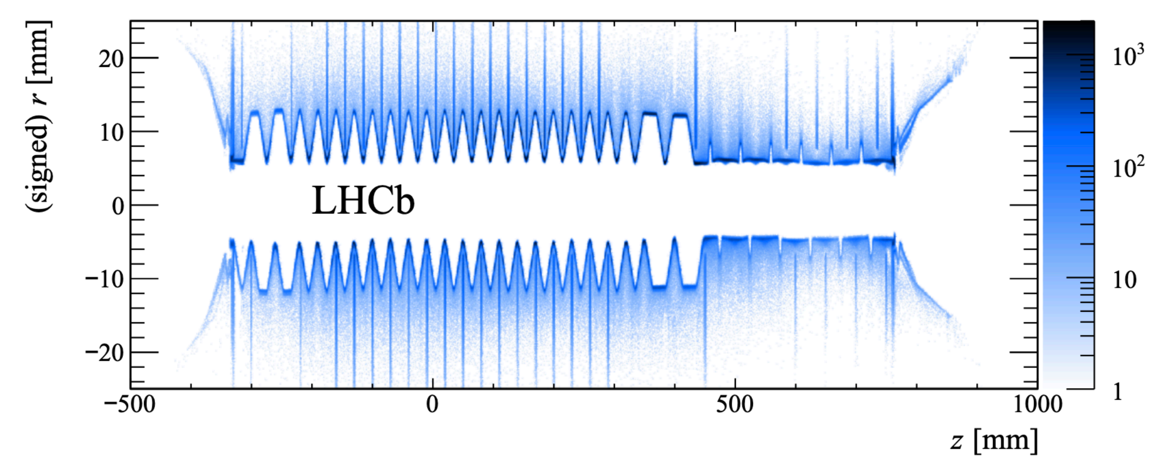
- $\mathscr{B}(K^0_S \to \pi^+\pi^-) \sim 70\,\%$
- N_{norm} is obtained after a soft selection
- $K^0_L \to 4\mu$ contributions are neglected when studying $K^0_S \to 4\mu$ and vice versa

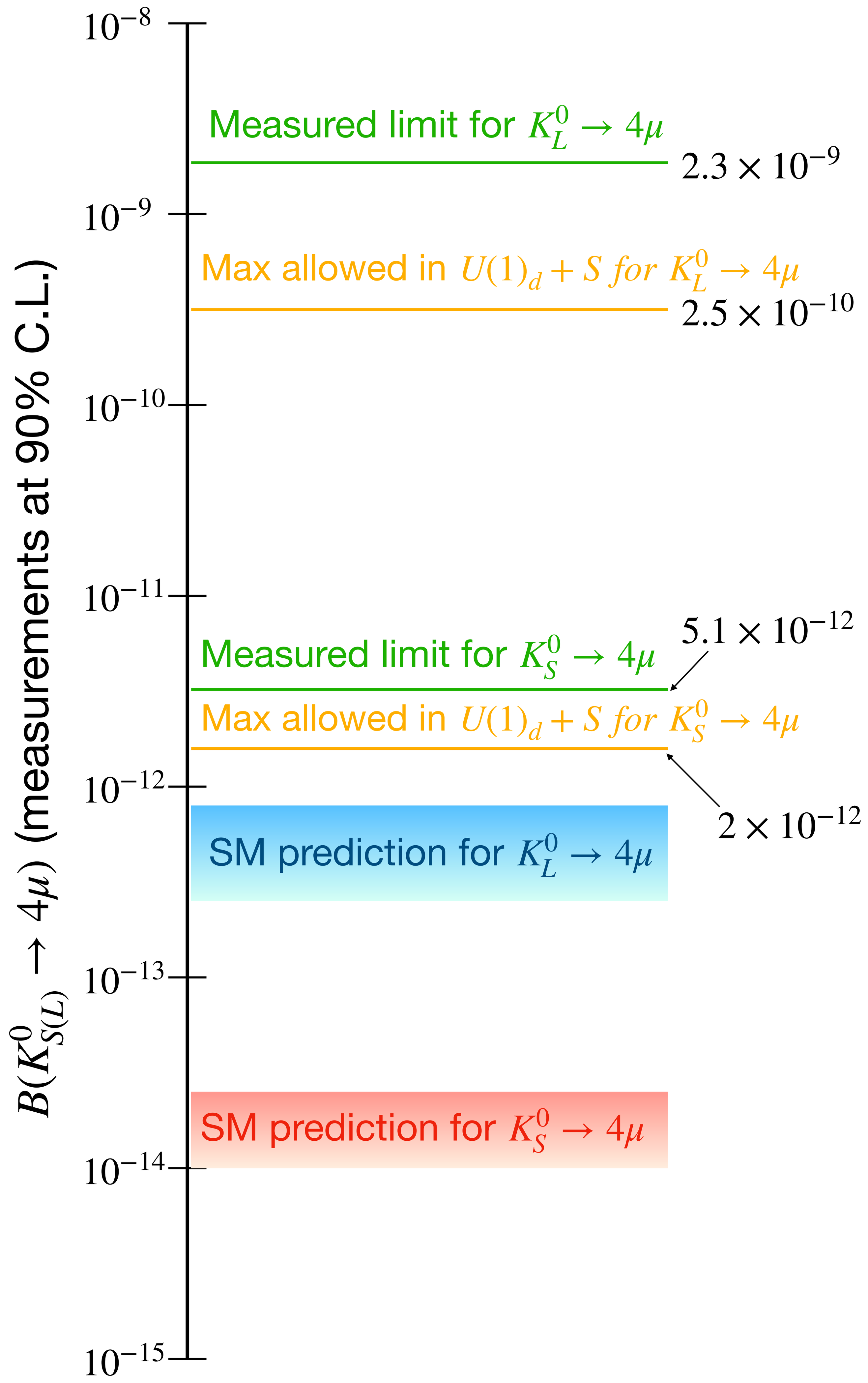


After a soft selection, background on the control channel can be neglected.

Background contributions

- Main contributions are combinatorial
- Can be random tracks disguised as $K^0 \to 4\mu$ candidates
- Can also be tracks originated in inelastic collisions with the material
- BDT classifier removes most of the background



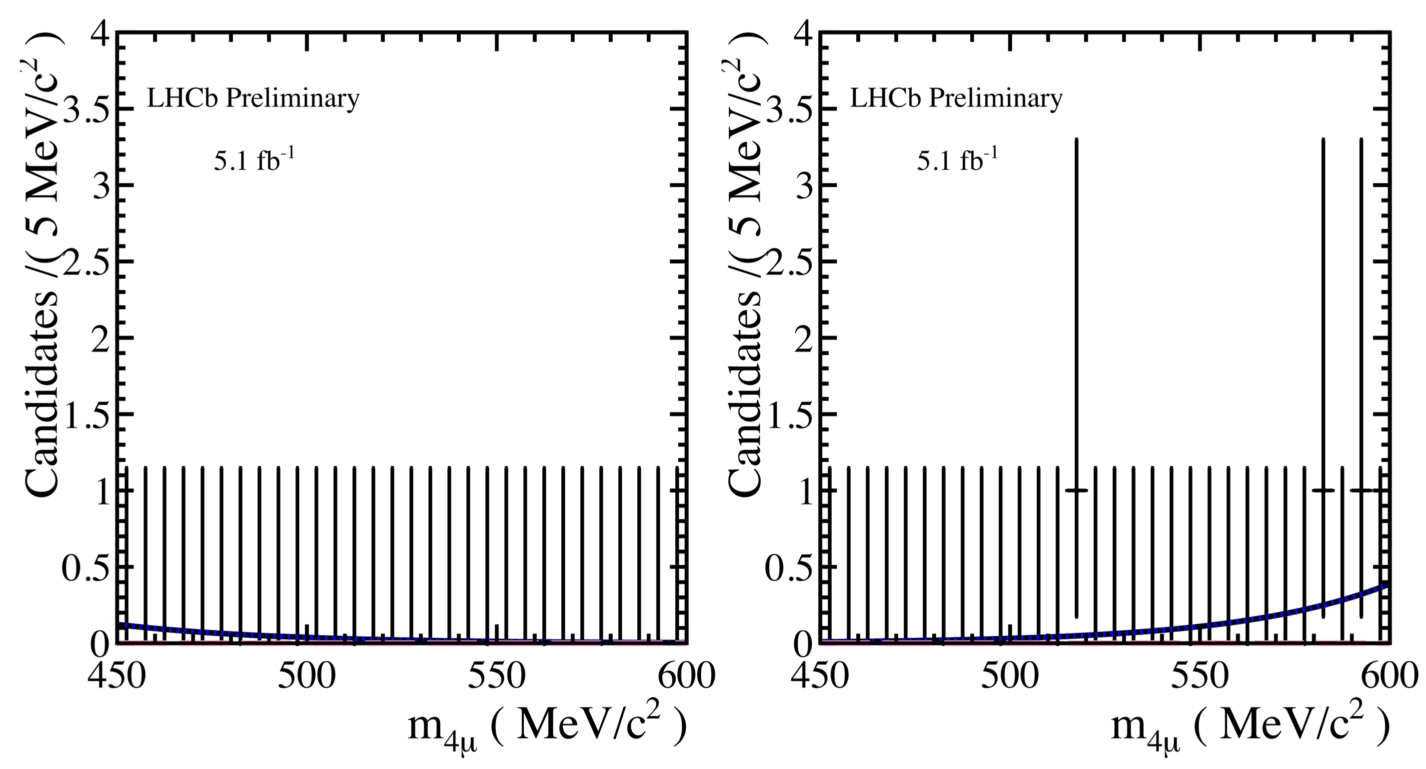


Results and prospects

- No significant signal observed
- First upper limits set for both decays (at 90% C.L.):

$$\mathscr{B}(K^0_S \to 4\mu) < 5.1 \times 10^{-12}\ , \quad \mathscr{B}(K^0_L \to 4\mu) < 2.3 \times 10^{-9}$$

- Most stringent limit at LHC so far
- Expect to gain an order of magnitude after LHCb Upgrade I



References

[1] LHCb collaboration, R. Aaij *et al.*, *Constraints on the $K^0_S \to \mu^+\mu^-$ branching fraction*, Phys. Rev. Lett. 125 (2020) 1231801, arXiv:2001.10354

[2] G. D'Ambrosio, D. Greynat, and G. Vulvert, *Standard model and new physics contributions to K^0_L and K^0_S into four leptons*, Eur. Phys. J. C 73 (2013) 2678, arXiv:1309.5736

[3] E. Goudzovski *et al.*, *New physics searches at kaon and hyperon Factories*, arXiv:2201.07805