Strange physics at LHCb

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October 2nd, 2026

Why are we still doing kaons?

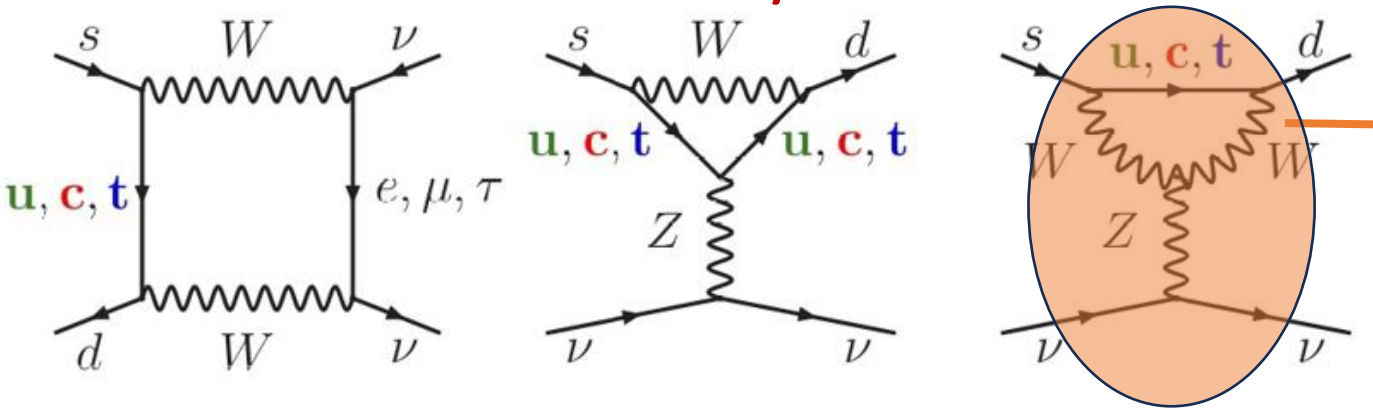
- Important questions we still haven't answered: What is origin of the SM flavour structure?
  - hierarchies of the fermion Yukawa couplings and mixing parameters, observed matter-antimatter asymmetry, etc…

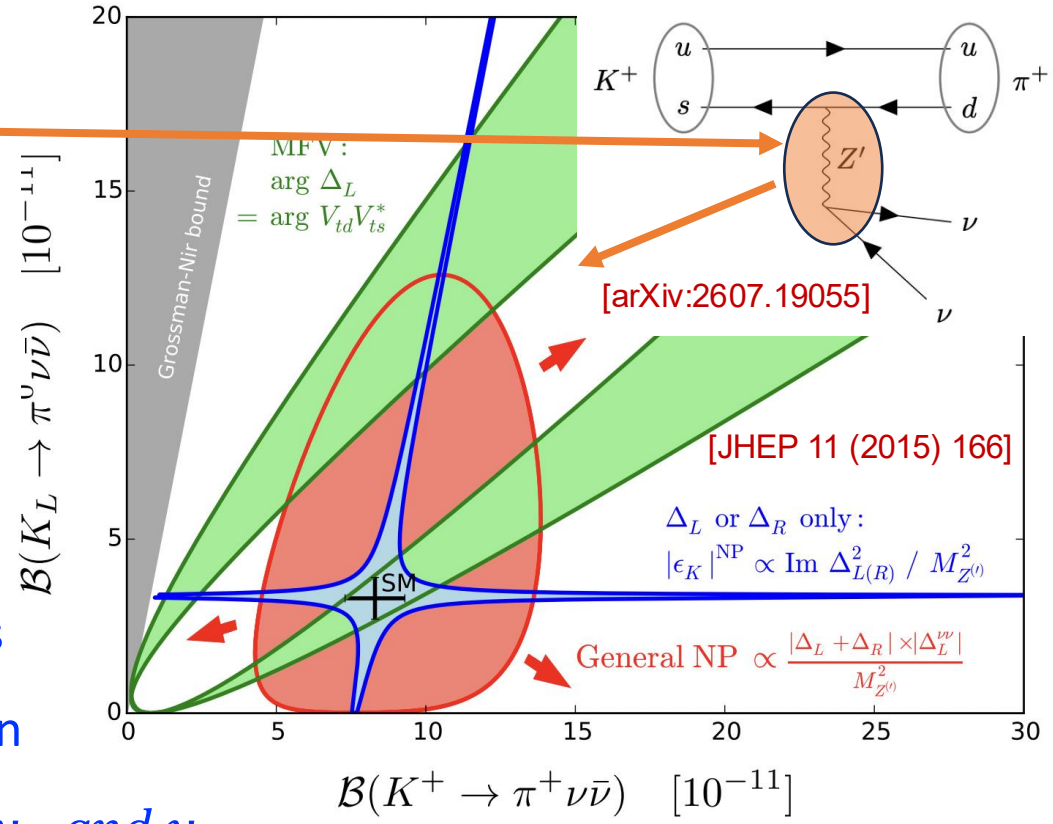
- Rare $s \to d\nu\bar{\nu}$ and $s \to d\ell^+\ell^-(\ell = e, \mu)$ transitions in the kaon sector offers insight into the SM flavour structure
  - Flavour Changing Neutral Currents (FCNCs) forbidden at tree level → **loop + CKM suppression**
  - several golden-plated observables: **dominated by Short Distance (SD) physics**
  - tests of low-energy hadronic theories and methods (lattice QCD, ChPT, dispersive analysis, etc…)
  - direct and indirect searches for NP through LFV and LNV processes
  - sensitive direct searches for Feebly Interacting Particles (FIPs) below the EW scale
  - typically, most of these processes have been studied at dedicated experiments (e.g. NA62, KOTO)

Precisely known theoretically
High NP sensitivity up to $\mathcal{O}(100\ \mathrm{TeV})$

LHCb will play an important role in the global kaon program with Run 3 and beyond!

Golden kaon decay modes: $K \to \pi\nu\bar{\nu}$





- $s \to d$ transition sensitive to the CKM structure of the SM:
  - **tree-level FCNCs forbidden → loop + CKM suppression**
- Theoretically clean process: dominated by short-distance physics
- $K - \pi$ Form Factor (FF) extracted from $K \to \pi l \nu_l$: sub-% precision
- Sensitive to new physics in the lepton sector as well: *involves $\nu_e, \nu_\mu, and\ \nu_\tau$*

Theory Status

$$\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})_{SM} \approx 8.5 \times 10^{-11} (\pm 5\%)$$

$$\mathcal{B}(K_L \to \pi^0\nu\bar{\nu})_{SM} \approx 3 \times 10^{-11} (\pm 6\%)$$

Recent SM calculations: [Buras et al. EPJC 82 (2022) 7, 615][Allwicher et al., PLB 861 (2025) 139295]
(differences in SM calculations from the choice of CKM parameters: see [Eur.Phys.J.C 84 (2024) 4, 377][arXiv:2607.19055])

Experimental Status

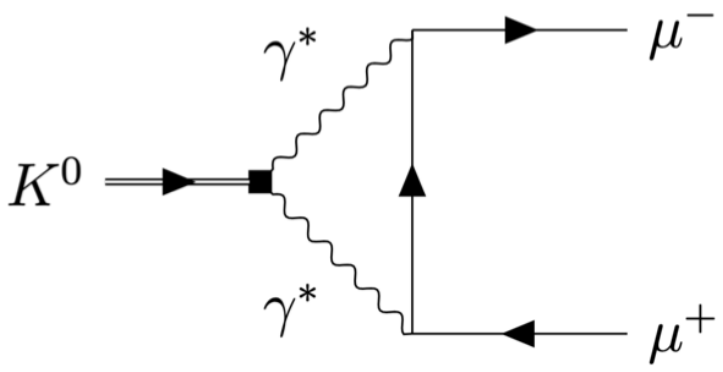
$$\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})^{NA62}_{2016-22} = (13.0^{+3.3}_{-3.0}) \times 10^{-11}$$

$$\mathcal{B}(K_L \to \pi^0\nu\bar{\nu})^{KOTO}_{2021} < 2 \times 10^{-9}$$

NA62: [JHEP 02 (2025) 191]
KOTO: [PRL 134 (2025)

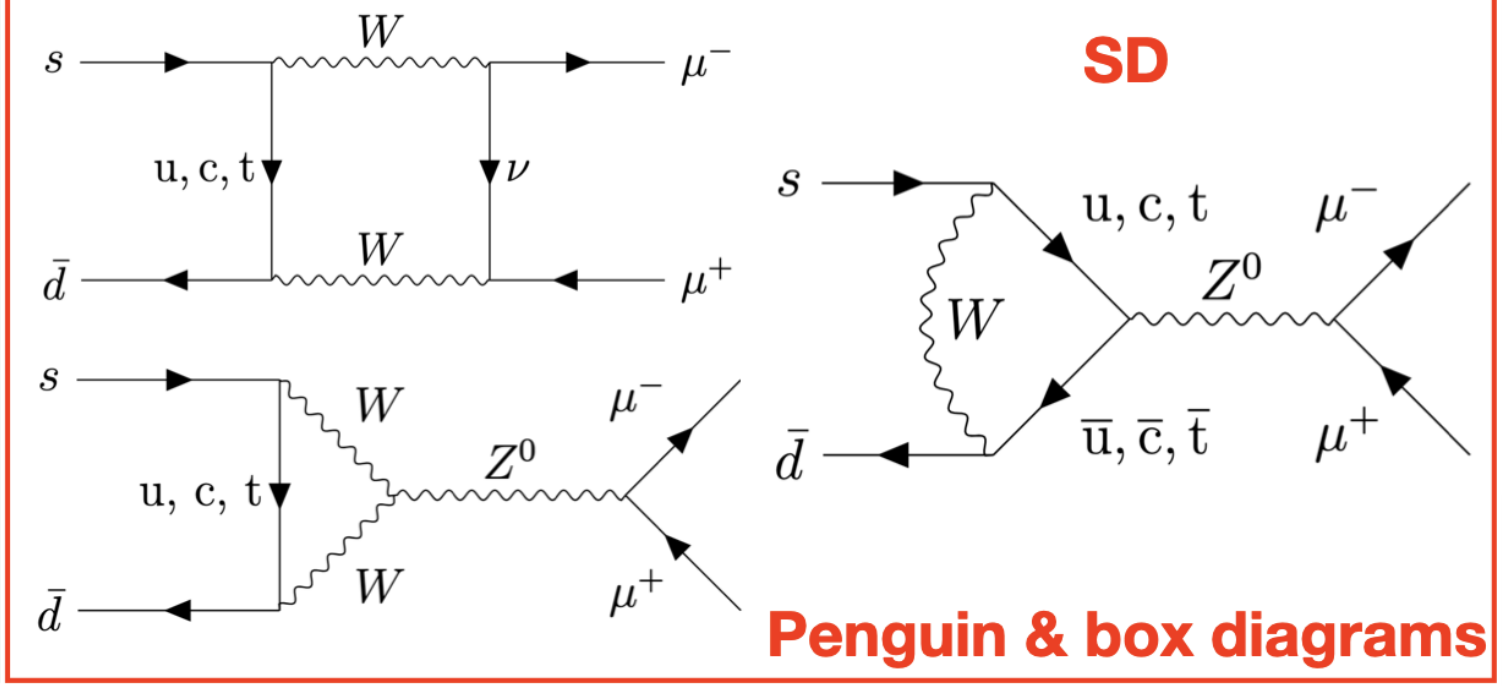
Adding $K \to \mu^+\mu^-$ to the picture

LD



Via intermediate virtual γ^*

SD



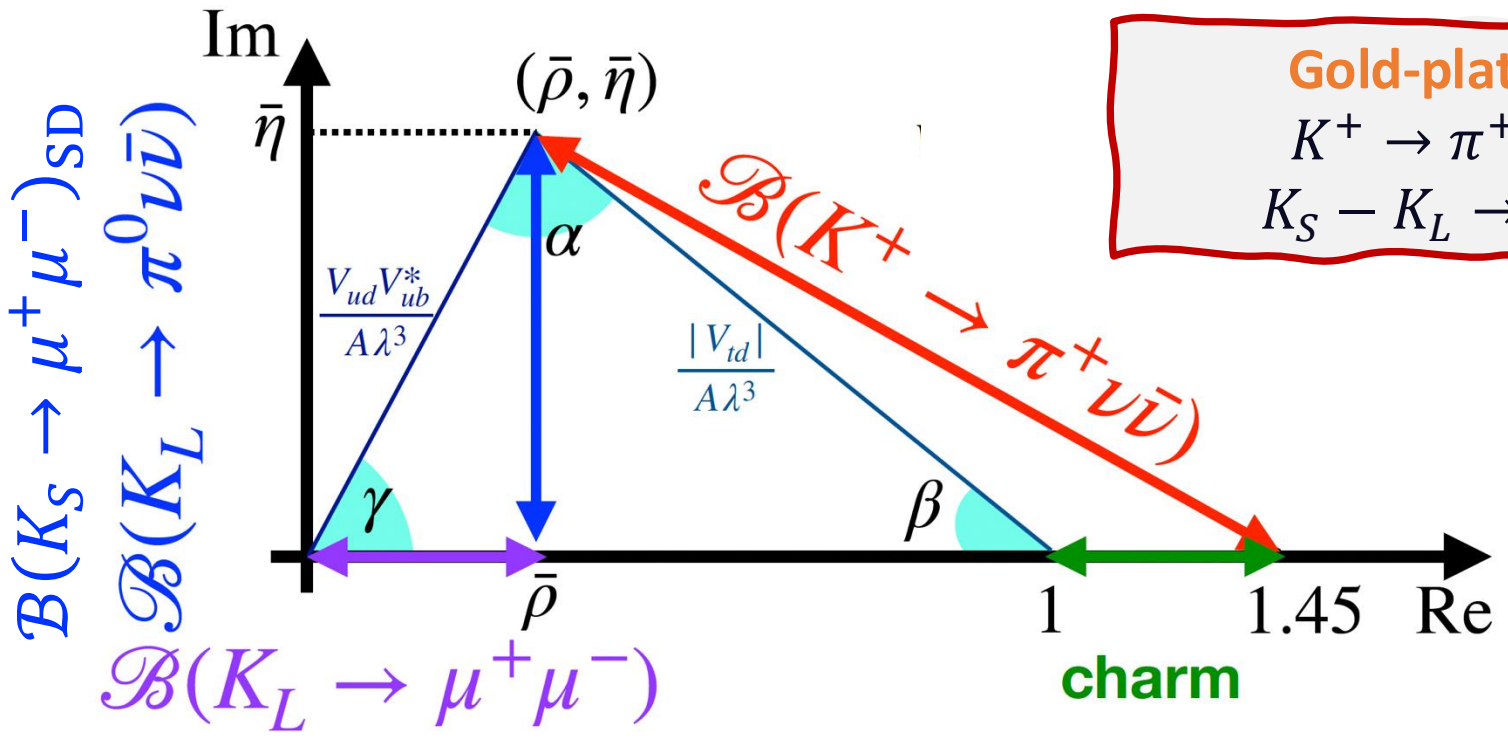
Penguin & box diagrams

$\mathcal{B}(K_S \to \mu^+\mu^-)_{SM} = (5.18 \pm 1.50) \times 10^{-12}$ [PRL 119 201802 (2017)]

$\mathcal{B}(K_S \to \mu^+\mu^-)_{SD} = (1.6 \pm 0.1) \times 10^{-13}$ [JHEP 07 (2021) 103]

Access via time-dependent decay rates
$K^0 - \bar{K}^0$ ***interference effect***
[PRL 119 201802 (2017),
JHEP 07 (2021) 103]

Adding $K \to \mu^+\mu^-$ to the picture



Gold-plated observables

$K^+ \to \pi^+\nu\bar{\nu}, K_L \to \pi^0\nu\bar{\nu}$

$K_S - K_L \to \mu\mu$ interference

$\mathcal{B}(K_S \to \mu^+\mu^-)_{SM} = (5.18 \pm 1.50)\times 10^{-12}$ [PRL 119 201802 (2017)]

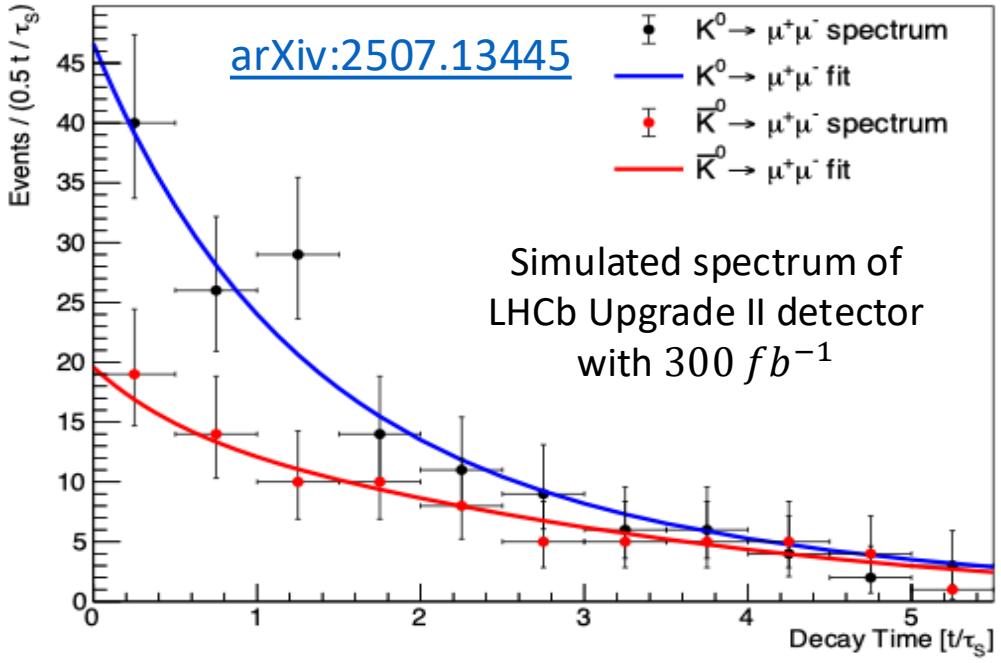
$\mathcal{B}(K_S \to \mu^+\mu^-)_{SD} = (1.6 \pm 0.1)\times 10^{-13}$ [JHEP 07 (2021) 103]

Access via time-dependent decay rates

$K^0 - \bar{K}^0$ ***interference effect***

[PRL 119 201802 (2017),
JHEP 07 (2021) 103]

Kaon physics observables: $K \to \mu^+\mu^-$



Time-dependent rate

$$\frac{1}{\mathcal{N}}\frac{d\Gamma(\overline{(K)}^0 \to \mu^+\mu^-)}{dt} = C_L\, e^{-\Gamma_L t} + C_S\, e^{-\Gamma_S t} \pm 2\, C_{\text{Int.}} \cos(\Delta M_K t - \varphi_0) e^{-\Gamma t}$$

Short-distance CPV contribution

$$C_L = |A(K_L)_{\ell=0}|^2,$$

$$C_S = |A(K_S)_{\ell=0}|^2 + \beta_\mu^2 |A(K_S)_{\ell=1}|^2,$$

$$C_{\text{Int.}} = |A(K_S)_{\ell=0}|\,|A(K_L)_{\ell=0}|, \Rightarrow C_{\text{Int.}} = C_L \sqrt{\frac{\tau_L}{\tau_S}\frac{\mathcal{B}(K_S \to \mu^+\mu^-)_{l=0}}{\mathcal{B}(K_L \to \mu^+\mu^-)}}$$

$$\varphi_0 = \arg\left[A(K_S)^*_{\ell=0}\, A(K_L)_{\ell=0}\right].$$

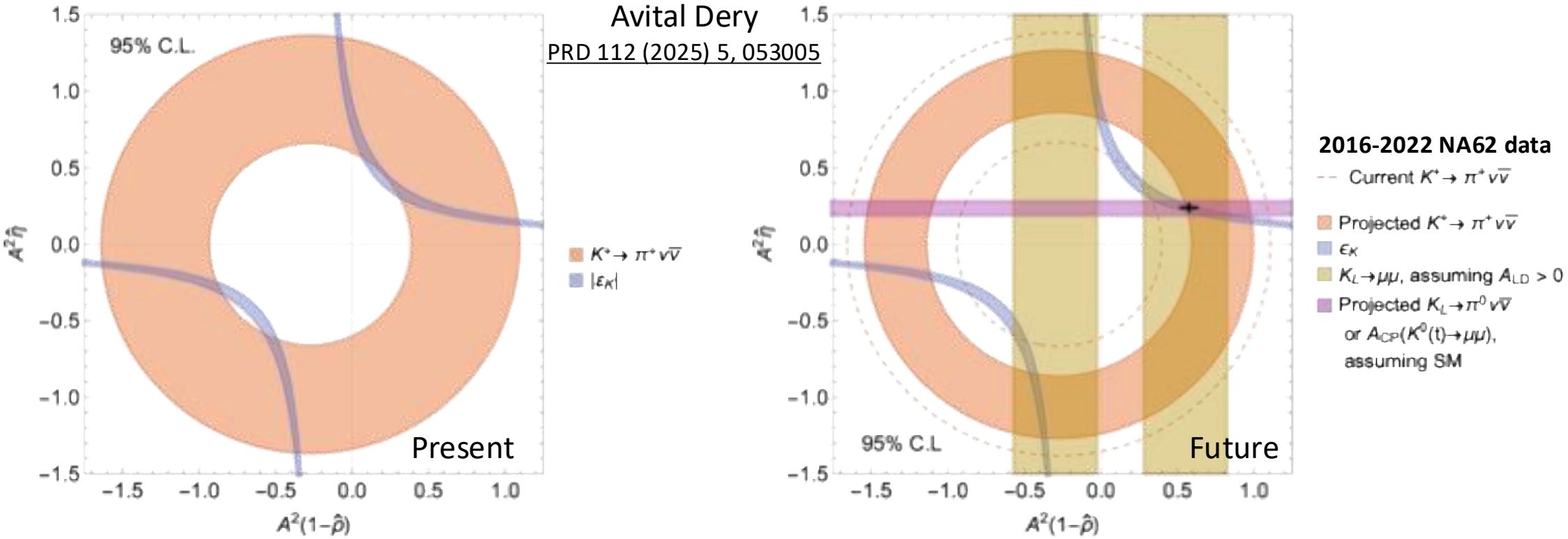
$$\mathcal{B}(K_S)_{\ell=0} = \frac{\beta_\mu \tau_S}{16\pi m_K}\left|\frac{2\, G_F^2 m_W^2}{\pi^2} f_K m_K m_\mu Y_t\right|^2 \cdot (\lambda^5 A^2 \bar{\eta})^2$$

- Measuring $K \to \mu^+\mu^-$ interference can give direct access to the short-distance component of $K_S \to \mu^+\mu^-$
- The strong phase φ_0 can be obtained from the measured rates of $K_L \to \gamma\gamma$ and $K_L \to \mu^+\mu^-$ [JHEP03(2023)014]
- Two unknown parameters: $\boldsymbol{C_S, C_{\text{Int.}}}$
- **Measurement of $\boldsymbol{C_{\text{Int.}}}(|A(K_S)_{\ell=0}|)$ is a direct measurement of η**

Needs kaon tagging

Testing the SM with FCNC: CKM tests

Avital Dery
PRD 112 (2025) 5, 053005



- Presenting kaon information in the $(\hat{\rho}, \hat{\eta})$ plane → artificial error inflation due to $|V_{cb}|$ dependence
- More natural to present the kaon CKM information in the $(A^2(1-\hat{\rho}), A^2\hat{\eta})$ plane → avoid B physics input
- Test of the CKM picture exclusively with loop observables in the kaon sector!

Kaon physics observables: $K \to \pi^0 l^+ l^-$

$$BR(K_L^0 \to \pi^0 l^+ l^-)_{SM} = \left(C_{dir}^l \pm C_{int}^l \times |a_S| + C_{mix}^l \times |a_S|^2 + C_{\gamma\gamma}^l\right) \times 10^{-12}$$

Both decays not measured yet, KOTO II might be able to measure them

NA48 results

$a_S = -1.6^{+2.1}_{-1.8}$, $b_S = +10.8^{+5.4}_{-7.7}$ PLB 576 (2003) 43-54

$a_S = +1.9^{+1.6}_{-2.4}$, $b_S = -11.3^{+8.8}_{-4.5}$ PLB 599 (2004) 197-201

$$BR(K_L^0 \to \pi^0 \mu^+ \mu^-)_{SM} = \{1.4 \pm 0.3, 1.0 \pm 0.2\} \times 10^{-11}$$

JHEP 08 (2006) 088

Theory

$|a_S| = 1.3 \pm 3.2$

$|b_S| = 18.0 \pm 11$

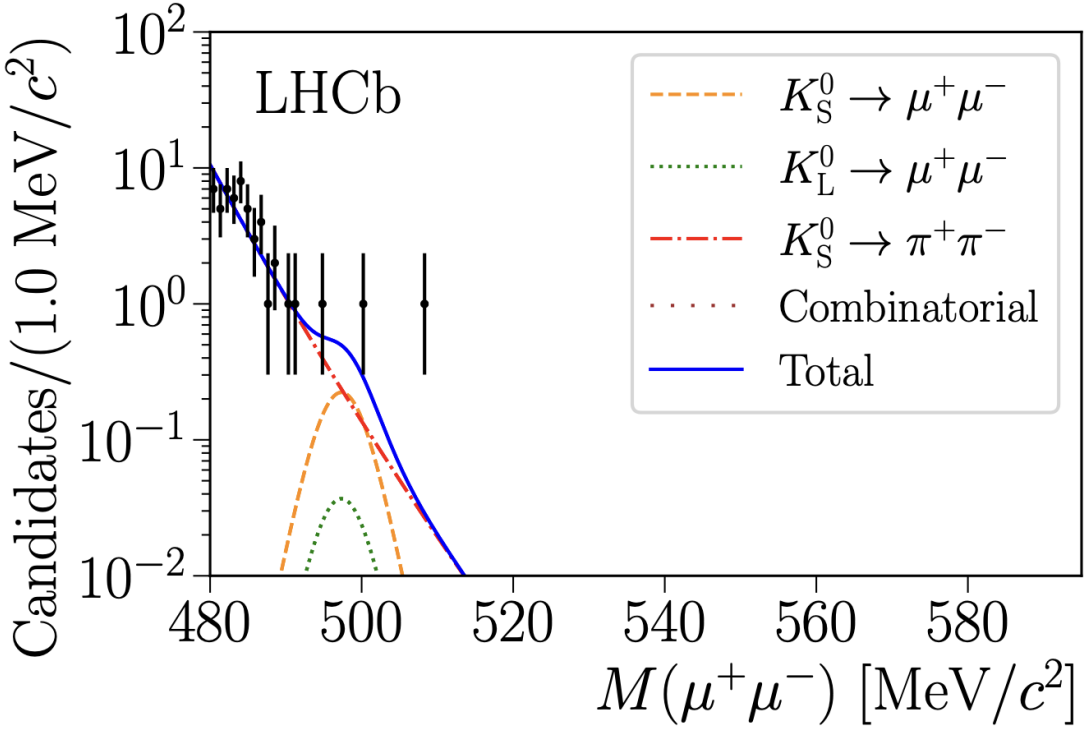
PLB 797 (2019) 134891

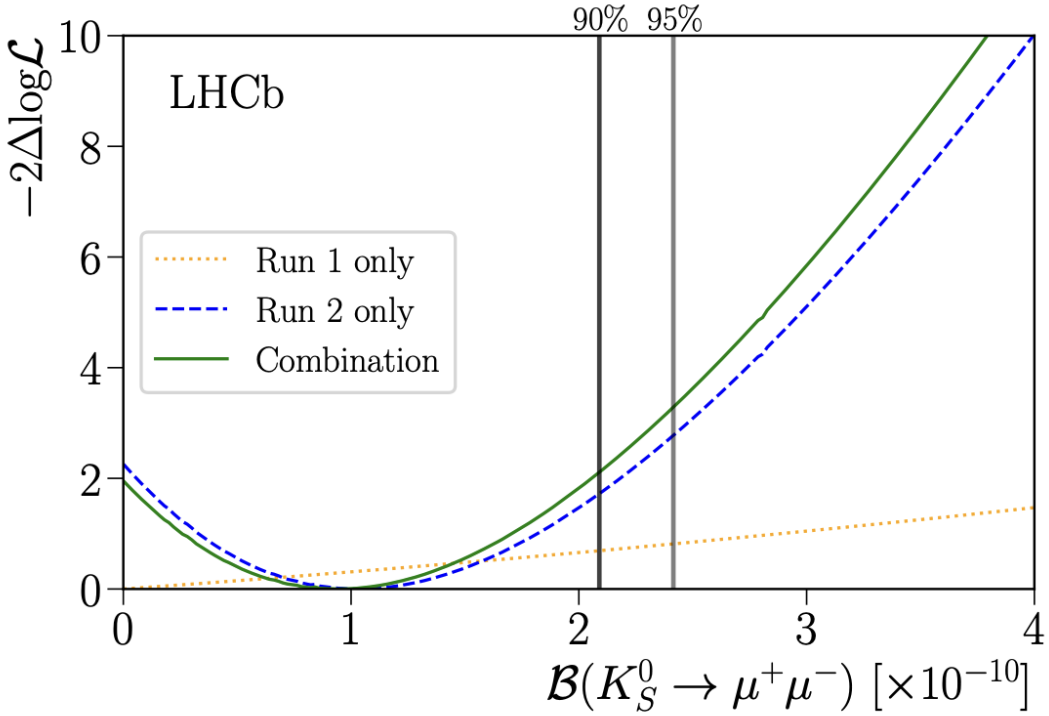
- $C_{dir}^e = (4.62 \pm 0.24) \times \left(w_{7V}^2 + w_{7A}^2\right)$
- $C_{int}^e = (11.3 \pm 0.3) \times w_{7V}$
- $C_{mix}^e = 14.5 \pm 0.5$
- $C_{mix}^e \approx 0$

- $C_{dir}^\mu = (1.09 \pm 0.05) \times \left(w_{7V}^2 + 2.32 \times w_{7A}^2\right)$
- $C_{int}^\mu = (2.63 \pm 0.06) \times w_{7V}$
- $C_{mix}^\mu = 3.36 \pm 0.20$
- $C_{mix}^\mu \approx 5.2 \pm 1.6$

- $w_{7A,7V} = \frac{\mathrm{Im}(\lambda_t \times y_{7A,7V})}{\mathrm{Im}\lambda_t}$, $y_{7V}(\mu \approx 1\mathrm{GeV}) = 0.73 \pm 0.04$, $y_{7A}(M_W) = -0.68 \pm 0.03$
- $\mathrm{Im}\lambda_t = (1.407 \pm 0.098) \times 10^{-4}$

First attemts to do kaons: $K_S \to \mu^+\mu^-$ in Run 1+2





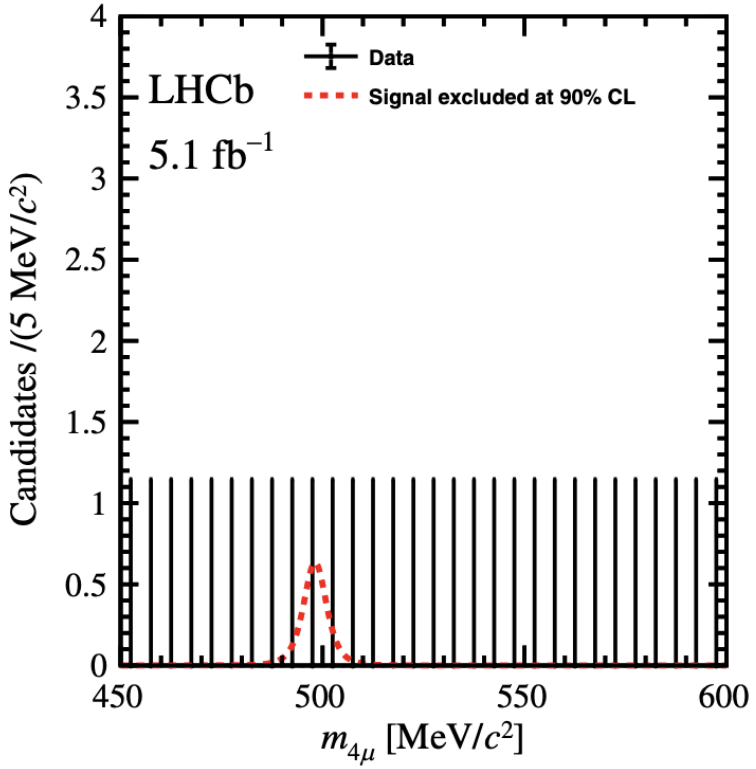
- Full Run 1 +2 dataset (9 fb^{-1})
- No evidence of signal

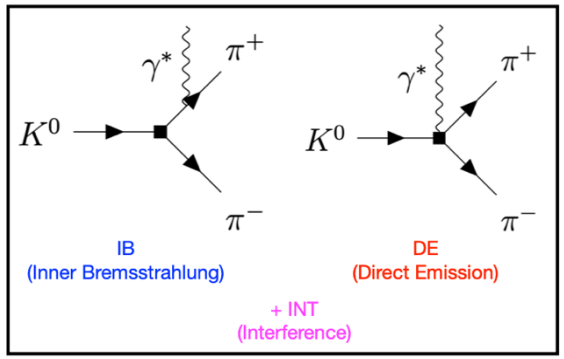
$$BR(K_S^0 \to \mu^+\mu^-) < 2.1\times10^{-10} \text{ @ } 90\% \text{ CL}$$

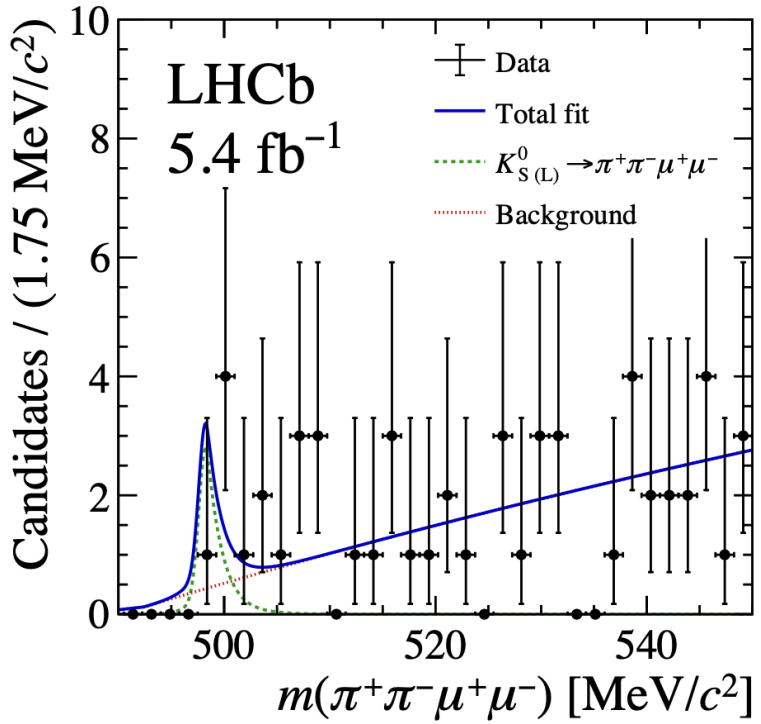
PRL 125, 231801 (2020)

- Search perform in bins of the BDT output for different trigger categories
- Factor 40 above the SM value

$K_S \to \mu^+\mu^-\mu^+\mu^-$ and $K_S \to \pi^+\pi^-\mu^+\mu^-$ in Run 1+2







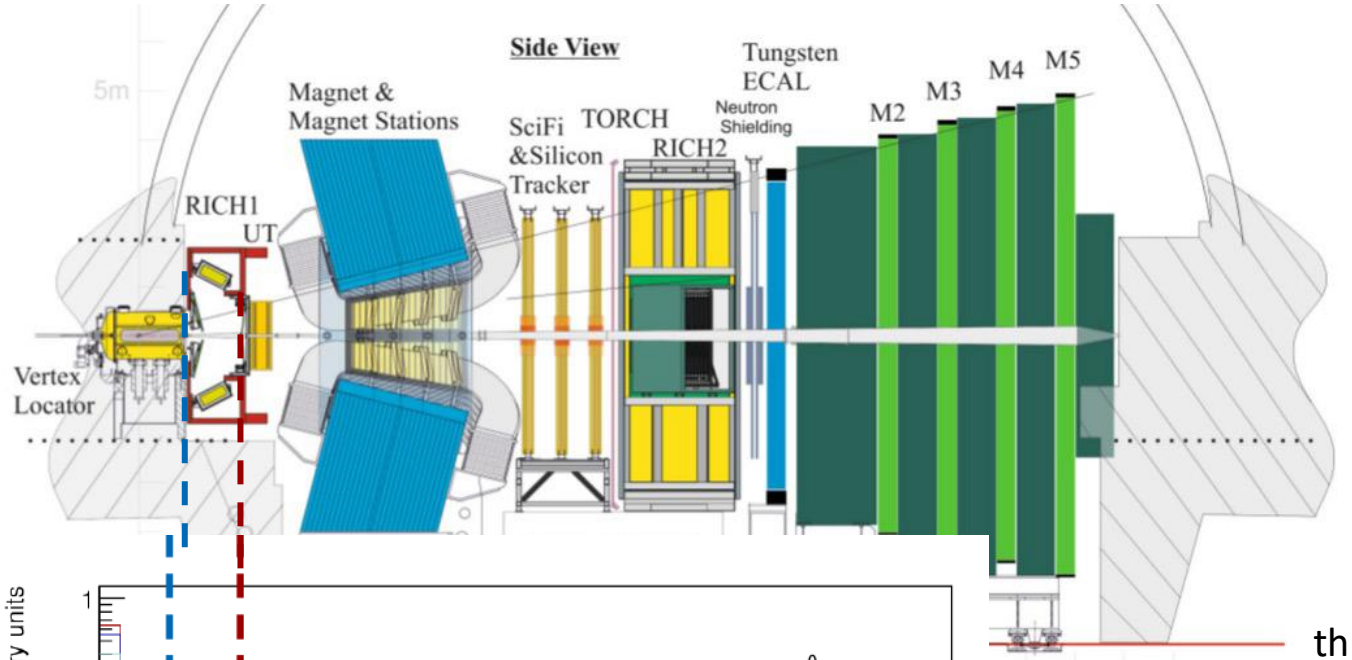
$BR(K_S^0 \to \mu^+\mu^-\mu^+\mu^-) < 5.1\times10^{-12}$ @ 90% CL
$BR(K_L^0 \to \mu^+\mu^-\mu^+\mu^-) < 2.3\times10^{-9}$ @ 90% CL

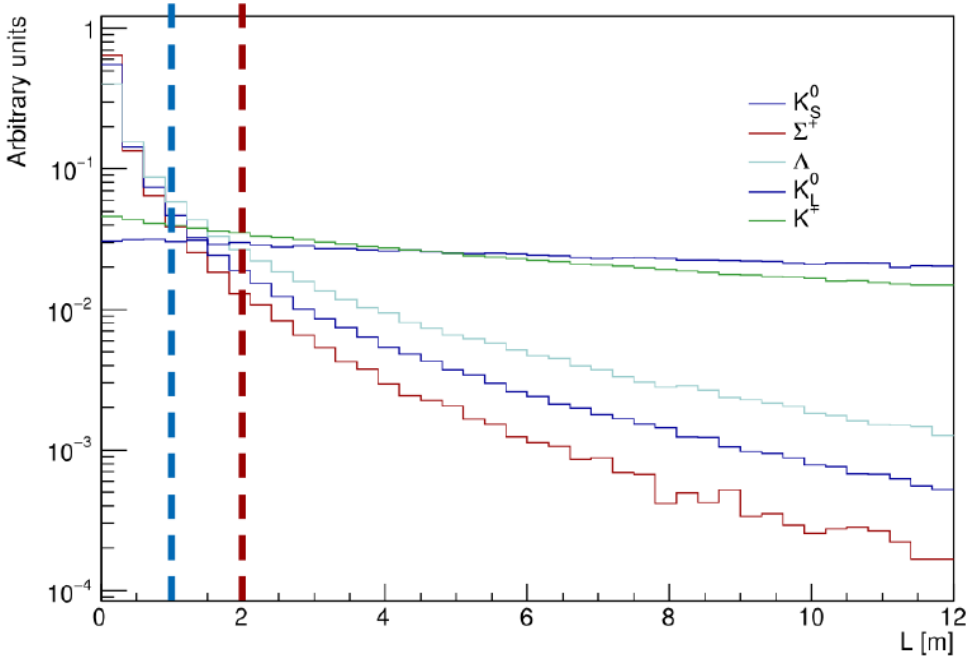
PRD 108 (2023) L031102

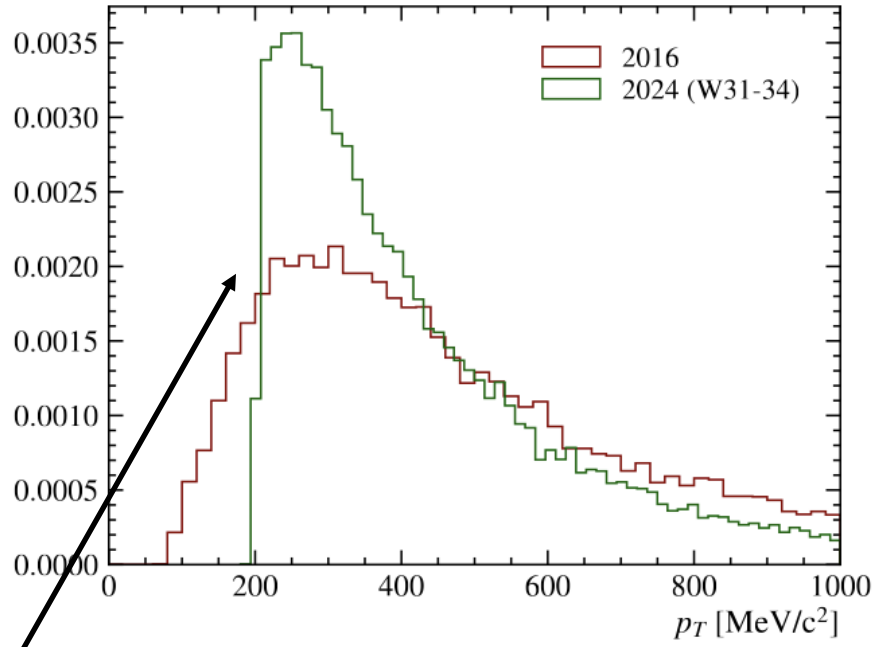
$BR(K_S^0 \to \pi^+\pi^-\mu^+\mu^-) < 1.4\times10^{-9}$ @ 90% CL
$BR(K_L^0 \to \pi^+\pi^-\mu^+\mu^-) < 6.6\times10^{-7}$ @ 90% CL

PRD 113 (2026) 7, 072001

Strange physics in Run 3







We were affected by the pT-threshold container at HLT1 in 2024 → Fixed in 2025 (even higher trigger efficiency gains)

- Enormous strange production cross section (~ 1 barn) + fully software trigger (allowing go to reach practically zero p_T) $\Longrightarrow$ ***great for kaons!***
- Total trigger efficiency for $K_S \to \mu^+\mu^-$ increased by a factor ~4 wrt Run 2
- Other decays also affected $K_S \to \pi^0\mu^+\mu^-, \mu^+\mu^- X, e^+e^-$, etc …
- Significant gains in sensitivity possible if bg-suppression at low-p_T is good

Strange physics in Run 3

- Long shopping list for studies of kaons and other strange particles
- $\mathcal{R}$ = production of hadron / production of K_S
- ε_L = acceptance for decay / acceptance for $K_S \to \mu^+\mu^-$ (using only long tracks)
- *A lot of potential physics analyses but are there people interested in the program?*

[JHEP 05 (2019) 048]

Channel	$\mathcal{R}$	ϵ_L
$K_S^0 \to \mu^+\mu^-$	1	1.0 (1.0)
$K_S^0 \to \pi^+\pi^-$	1	1.1 (0.30)
$K_S^0 \to \pi^0\mu^+\mu^-$	1	0.93 (0.93)
$K_S^0 \to \gamma\mu^+\mu^-$	1	0.85 (0.85)
$K_S^0 \to \mu^+\mu^-\mu^+\mu^-$	1	0.37 (0.37)
$K_L^0 \to \mu^+\mu^-$	~ 1	2.7 (2.7) $\times 10^{-3}$
$K^+ \to \pi^+\pi^+\pi^-$	~ 2	9.0 (0.75) $\times 10^{-3}$
$K^+ \to \pi^+\mu^+\mu^-$	~ 2	6.3 (2.3) $\times 10^{-3}$
$\Sigma^+ \to p\mu^+\mu^-$	~ 0.13	0.28 (0.28)
$\Lambda \to p\pi^-$	~ 0.45	0.41 (0.075)
$\Lambda \to p\mu^-\bar{\nu}_\mu$	~ 0.45	0.32 (0.31)
$\Xi^- \to \Lambda\mu^-\bar{\nu}_\mu$	~ 0.04	39 (5.7) $\times 10^{-3}$
$\Xi^- \to \Sigma^0\mu^-\bar{\nu}_\mu$	~ 0.03	24 (4.9) $\times 10^{-3}$
$\Xi^- \to p\pi^-\pi^-$	~ 0.03	0.41(0.05)
$\Xi^0 \to p\pi^-$	~ 0.03	1.0 (0.48)
$\Omega^- \to \Lambda\pi^-$	~ 0.001	95 (6.7) $\times 10^{-3}$

New RareAndStrange sub-WG of RD

LHCb analyses: private, preliminary and public

Filter analyses: RareAndStrange

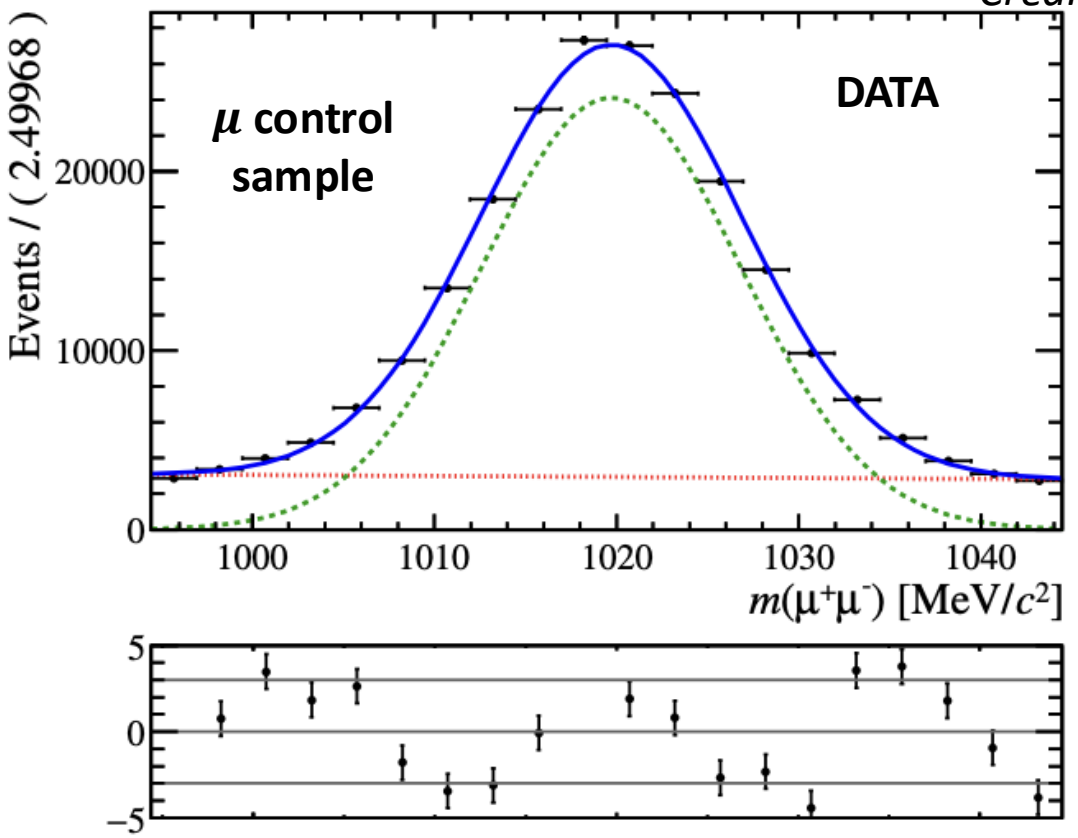
☑ Show only ongoing analyses ☐ Show suspended analyses

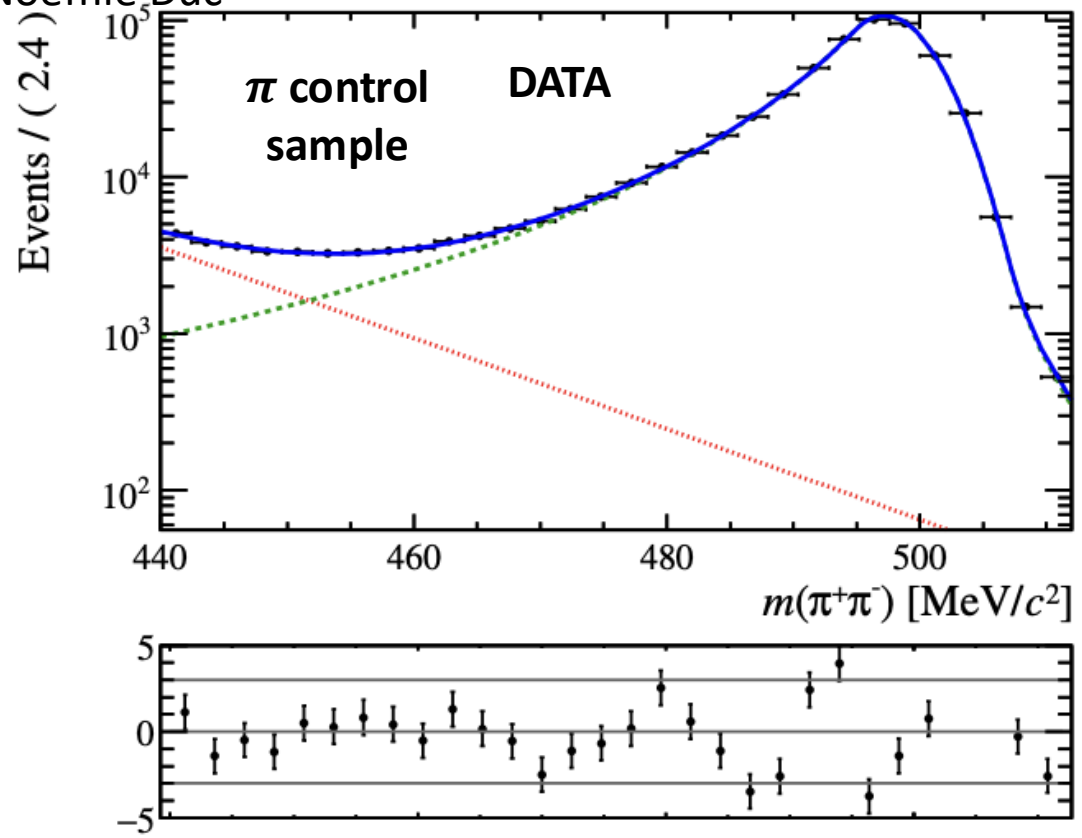
Custom identifier	Paper identifier	Stage	Title	Working Groups
$\Xi^-\to p\pi^-\pi^-\ (\Delta S=2)$ Run 3 search Summary	-	Started	$\Xi^-\to p\pi^-\pi^-\ (\Delta S=2)$ Run 3 search	Rare decays, Very rare decays
$\Xi^-\to\Lambda\pi^-$ Run 2+3 CPV Summary	-	Started	$\Xi^-\to\Lambda\pi^-$ Run 2+3 CPV	Rare decays, Very rare decays
$\Omega^-\to\Lambda K^-$ Run 2+3 CPV Summary	-	Started	$\Omega^-\to\Lambda K^-$ Run 2+3 CPV	Rare decays, Very rare decays
$\Omega^-\to\Lambda\pi^-$ Run 3 search Summary	-	Started	$\Omega^-\to\Lambda\pi^-$ Run 3 search	Rare decays, Very rare decays
$\Sigma^+\to p\mu^+\mu^-$ Run 3 BF measurement Summary	-	Started	$\Sigma^+\to p\mu^+\mu^-$ Run 3 BF measurement	Rare decays, Very rare decays
$\Sigma^+\to p\mu^+\mu^-$ Run 2 CPV and differential BF Summary	-	Started	$\Sigma^+\to p\mu^+\mu^-$ Run 2 CPV and differential BF	Rare decays, Very rare decays
$\Sigma^+\to p\nu\bar{\nu}$ Run 3 search Summary	-	Started	$\Sigma^+\to p\nu\bar{\nu}$ Run 3 search	Rare decays, Very rare decays
$K_s^0\to\mu^+\mu^-X$ Run 3 search Summary	-	Started	$K_s^0\to\mu^+\mu^-X$ Run 3 search	Rare decays, Very rare decays
$K_s^0\to\mu^+\mu^-\mu^+\mu^-$ Run 3 search Summary	-	Started	$K_s^0\to\mu^+\mu^-\mu^+\mu^-$ Run 3 search	Rare decays, Very rare decays
$\Sigma^+\to pe^+e^-$ Run 2+3 search Summary	-	Started	$\Sigma^+\to pe^+e^-$ Run 2+3 search	Rare decays, Very rare decays
$\Xi^0\to p\pi^-\ (\Delta S=2)$ Run 3 search Summary	-	Started	$\Xi^0\to p\pi^-\ (\Delta S=2)$ Run 3 search	Rare decays, Very rare decays
$\Omega^-\to\Xi^-\pi^+\pi^-$ Run 2+3 BF measurement Summary	-	Started	$\Omega^-\to\Xi^-\pi^+\pi^-$ Run 2+3 BF measurement	Rare decays, Very rare decays

- Significantly enhanced interest in strange physics ⟹ new subWG to coordinate the activities!
- Call for sub-WG conveners open until October 9th

$K_S \to \mu^+\mu^-$ in Run 3: low-pT PID

Credit: Noemie Duc

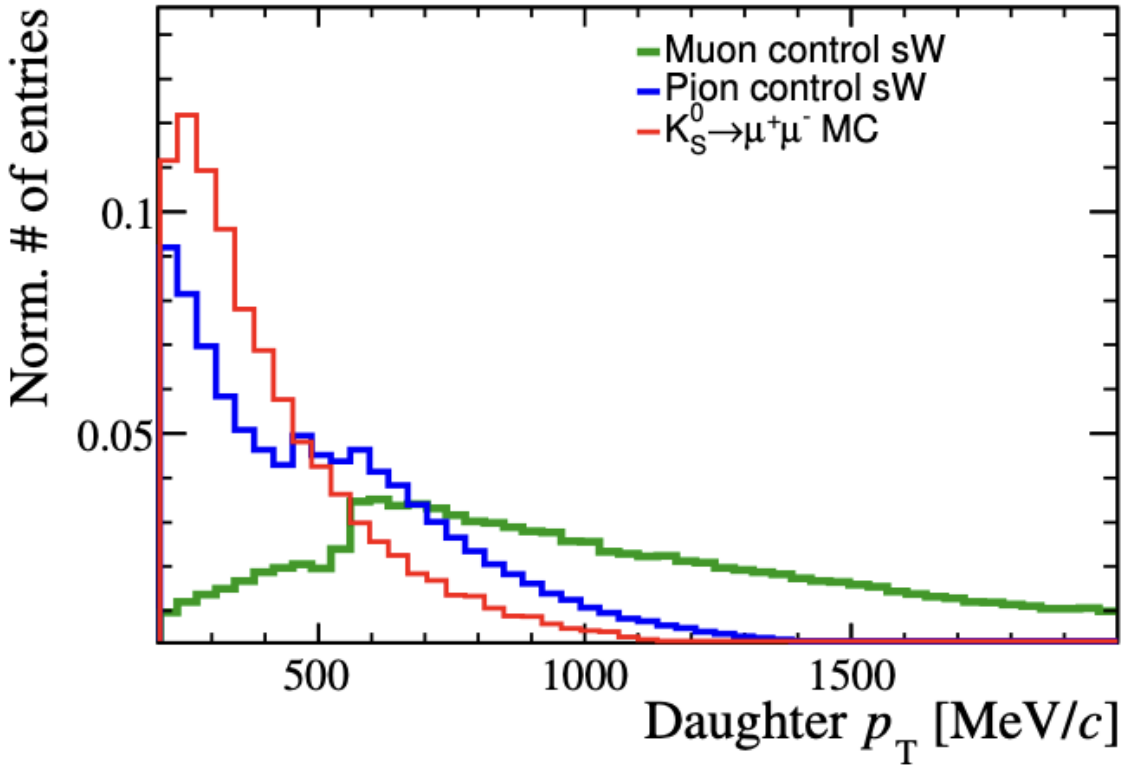


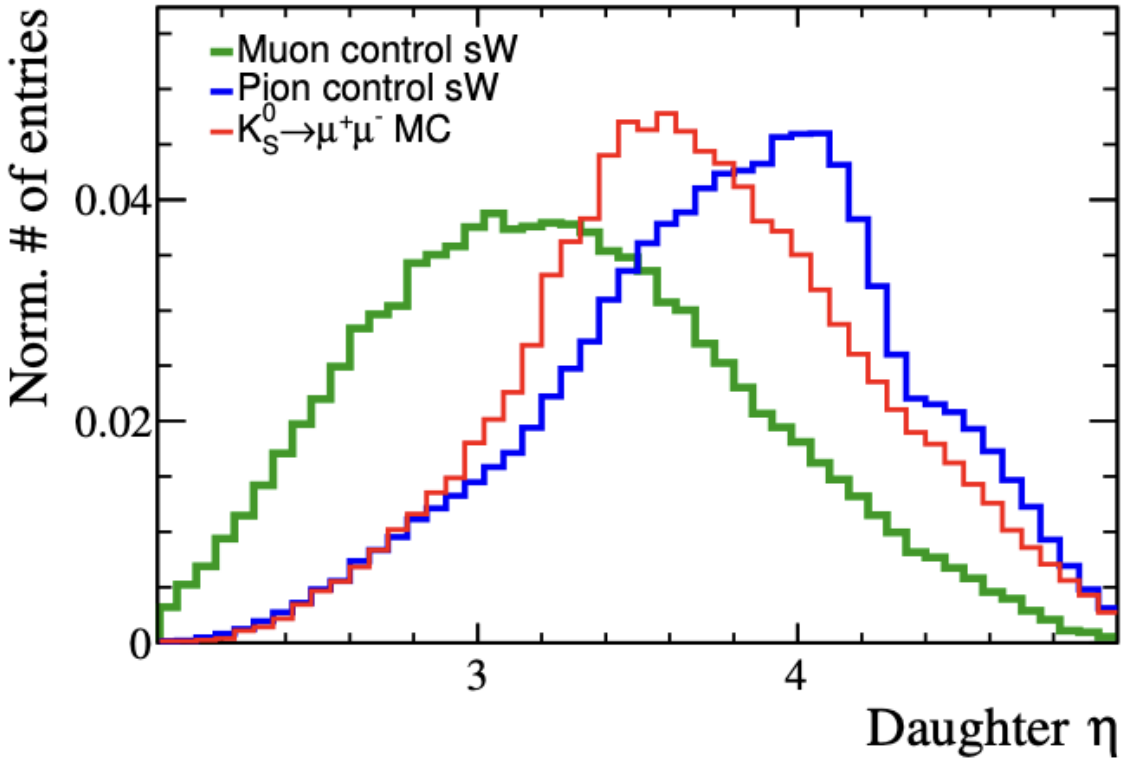


- Performance of the standard PROBNN is not ideal, need a better algorithm for low pT
- Developed an algorithm targeting low-pT tracks (using muons from $D_s^+ \to \phi(\to \mu^+\mu^-)\pi^+$)
- Pions from the tail of the $\pi^+\pi^-$ mass distribution (main background to $K_S \to \mu^+\mu^-$)

$K_S \to \mu^+\mu^-$ in Run 3: low-pT PID

Credit: Noemie Duc



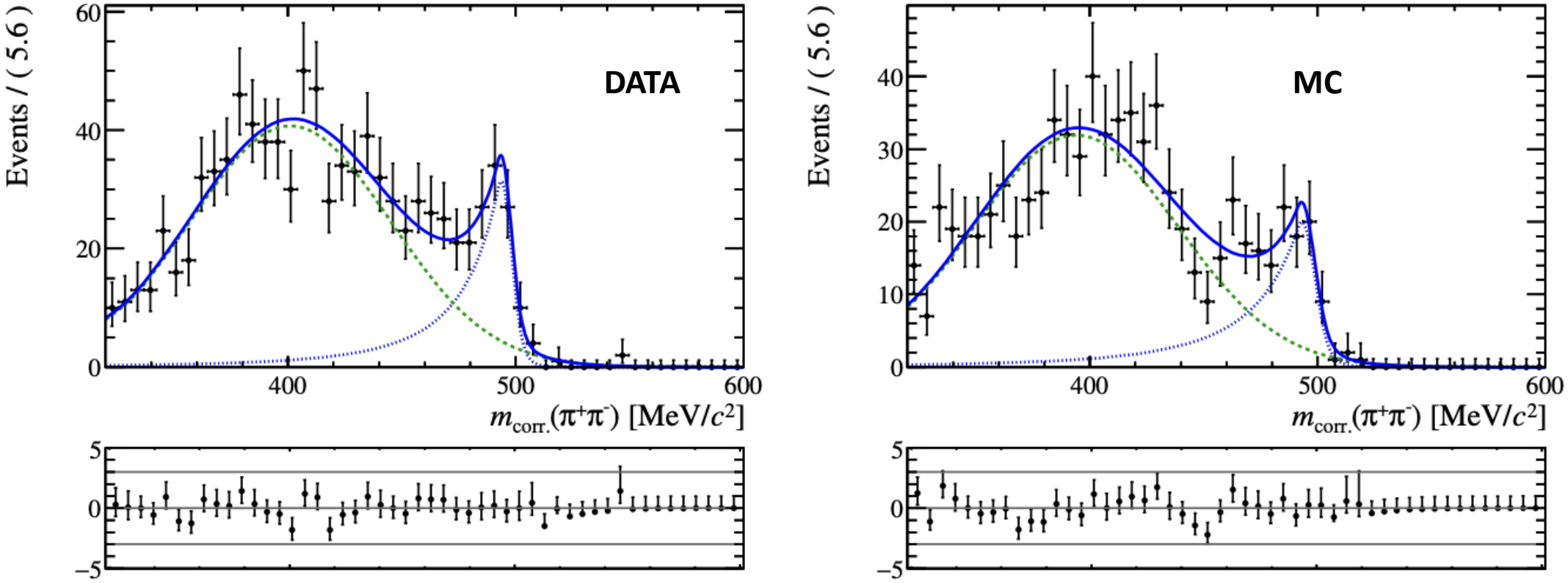


- Good amount of statistics present in the full p_T range so we can cover the signal range
- Reweight the p_T, η distributions between (μ and π) before training
  - otherwise the neural network start using p_T, η to separate them
- We use as inputs 11 features as inputs (PROBNN_mu, muon chi2, RICH and ECAL variables, etc…)

$K_S \to \mu^+\mu^-$ in Run 3: low-pT PID

$K_S \to \pi\mu\nu$ used for validation of the performance

Credit: Noemie Duc

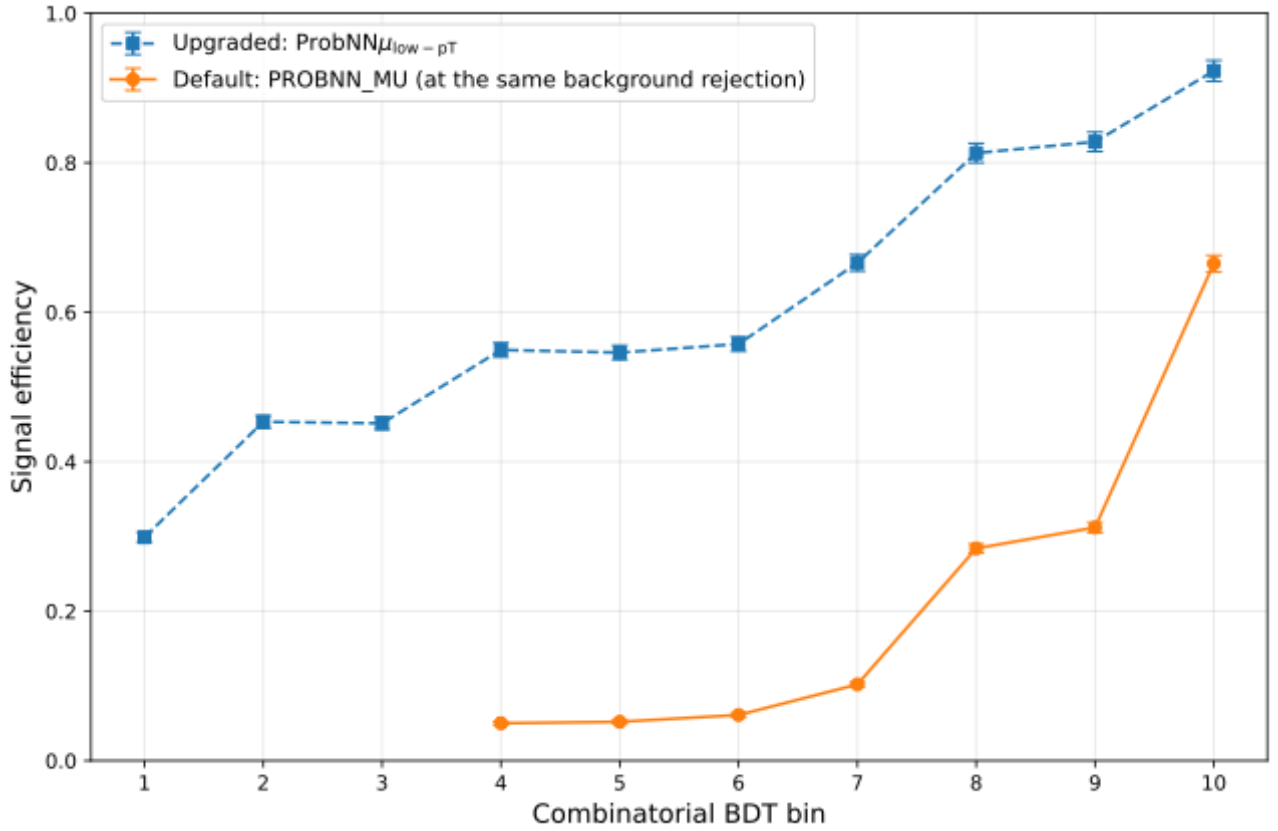


- We need to make sure that our performance is not affected by the lifetime of the particle producing the muon
- Test the performance on $K_S \to \pi\mu\nu$ decays: performance and p_T, η corrections maps transferable from the ϕ

$K_S \to \mu^+\mu^-$ in Run 3: low-pT PID

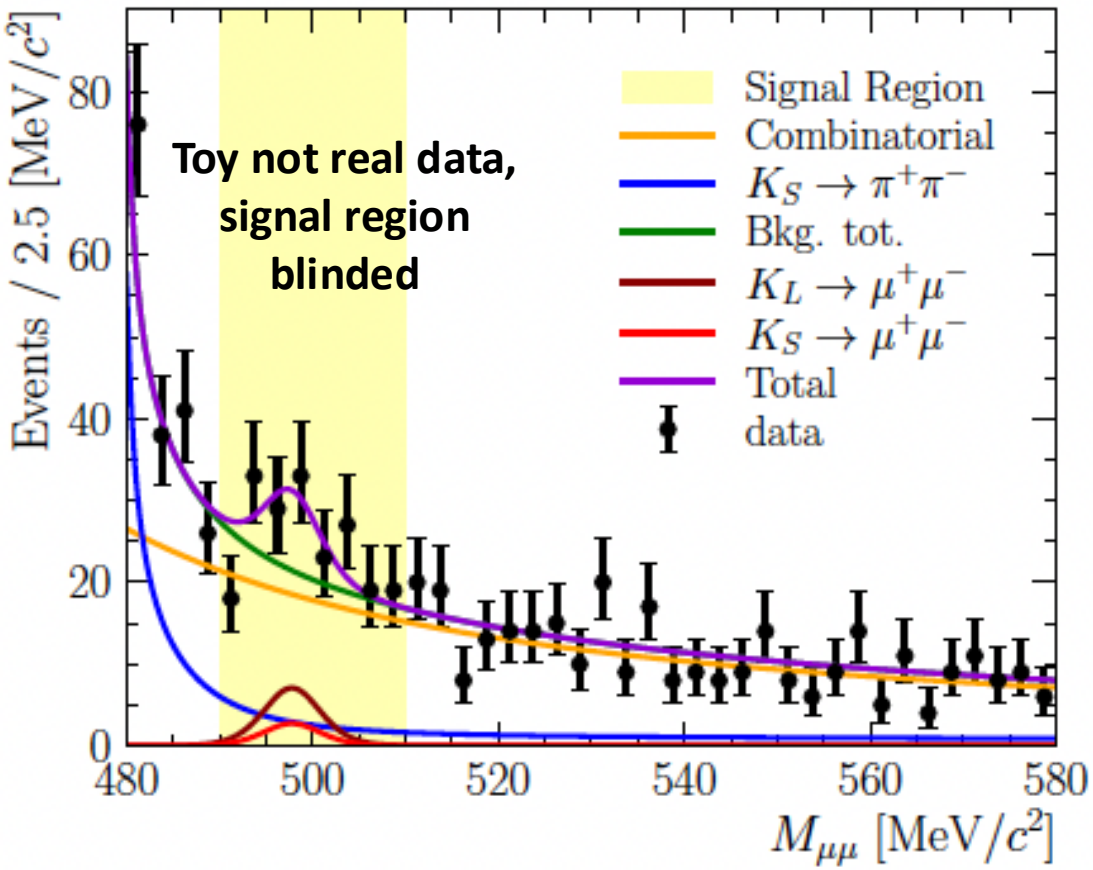
Credit: Noemie Duc

$K_S \to \mu\mu$ efficiency



- We need to make sure that our performance is not affected by the lifetime of the particle producing the muon
- Test the performance on $K_S \to \pi\mu\nu$ decays: performance and p_T, η corrections maps transferable from the ϕ
- Generalizable to other low-pT analyses we are interested in developing a tool for wider LHCb use

$K_S \to \mu^+\mu^-$ in Run 3: sensitivity

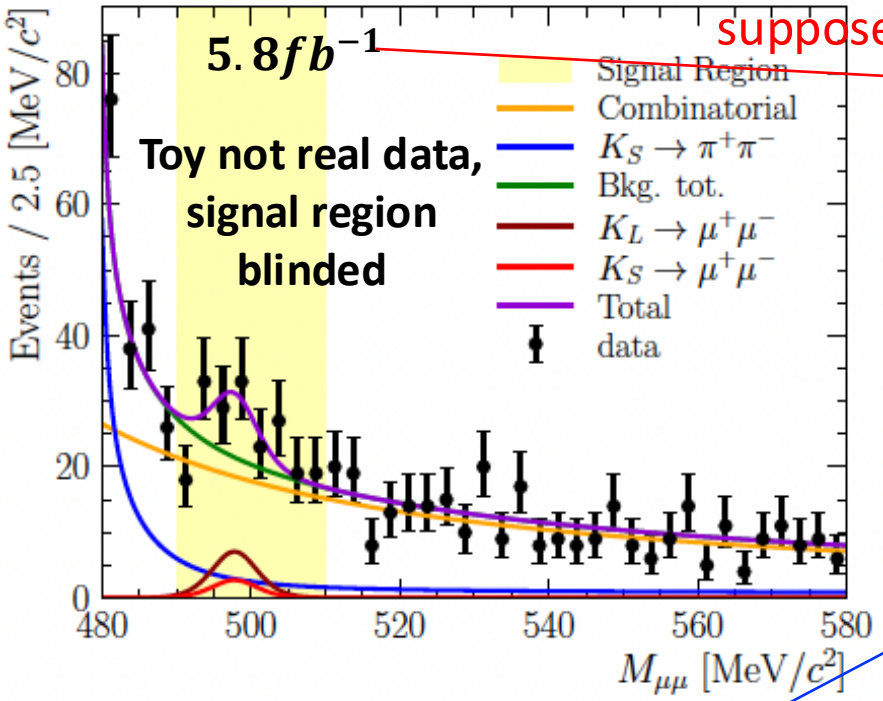


Credit: Joel Swallow

- $K_S \to \mu^+\mu^-$ analysis of 2024 data $(5.8 fb^{-1})$ very advanced (to be expected for implications)
- Significant boost of sensitivity wrt Run 2 (better detector, better trigger, performant low-pT PID $\Longrightarrow$ lower bg)
- $\alpha = (7.3 \pm 0.5)\times 10^{-13}$ (4 times better than Run 2)
- We expect to observe $K^0 \to \mu^+\mu^-$ (mostly $K_L \to \mu^+\mu^-$)
- Expected upper limit about $< 2.6\times 10^{-11}$ (about an order of magnitude better than Run 2)

Run 3 detector very well suited for strange physics!

Reminder of where we thought we are going to be



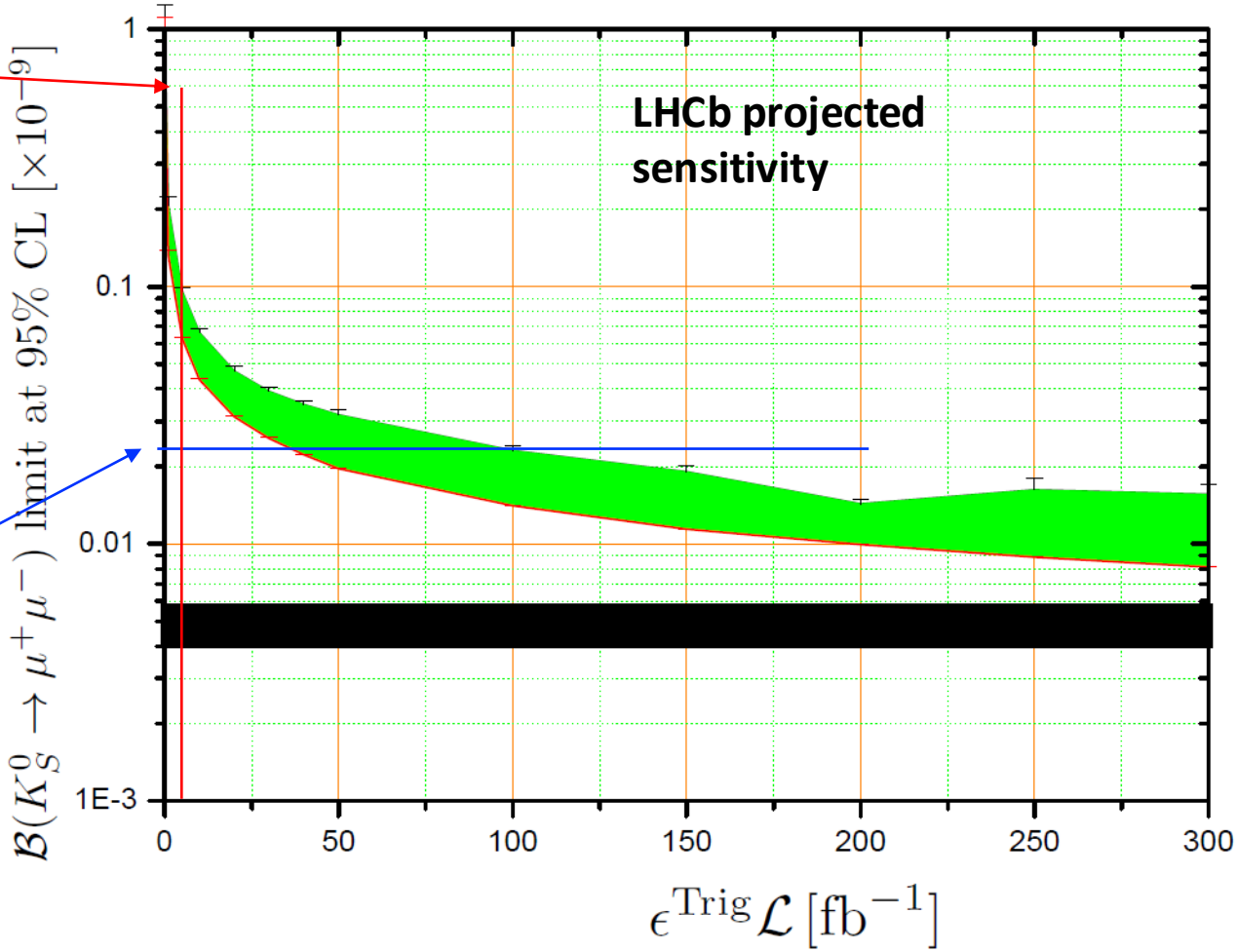
Credit: Joel Swallow

Where we are supposed to be

Where we are

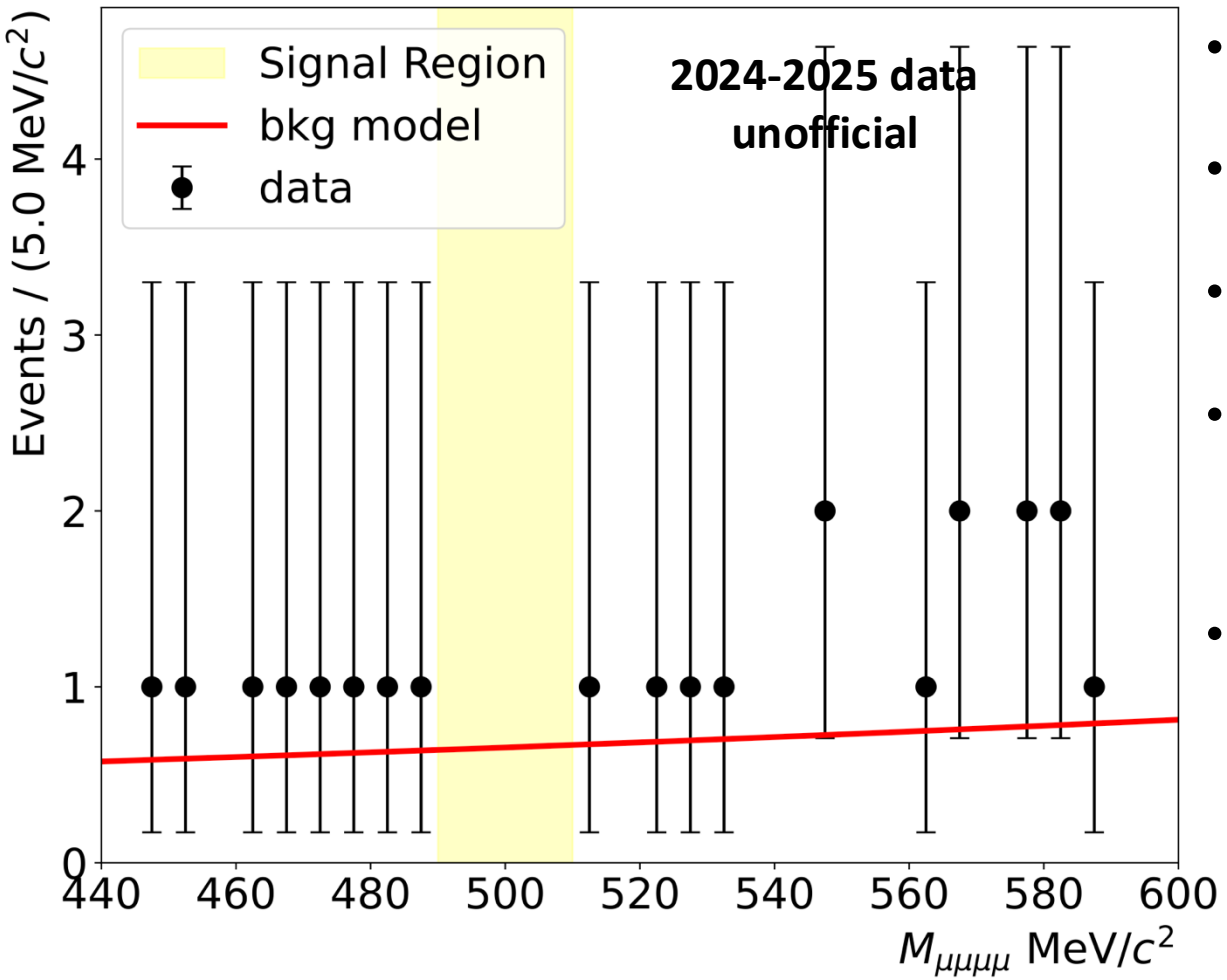
Expected upper limit about $< 2.6\times10^{-11}$

arXiv: 1808.03477
JHEP 05 (2019) 048



We've come a long way since 2019

$K_S \to \mu^+\mu^-\mu^+\mu^-$ in Run 3

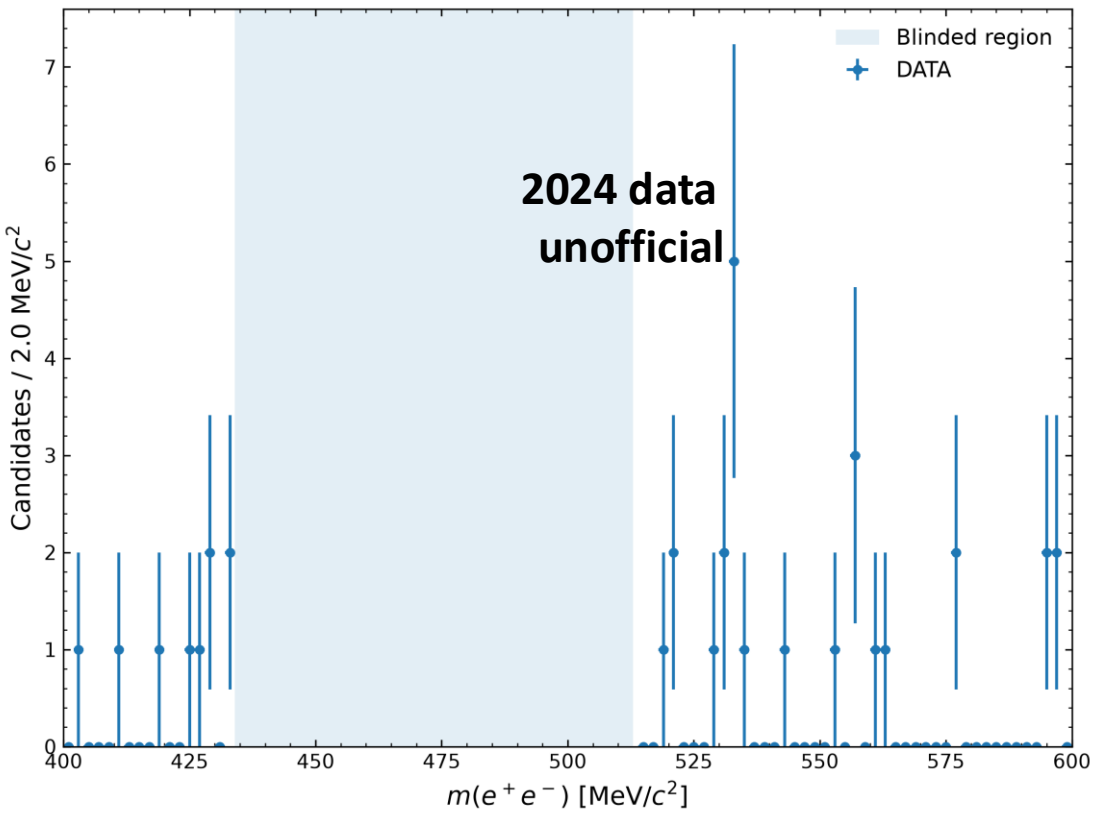


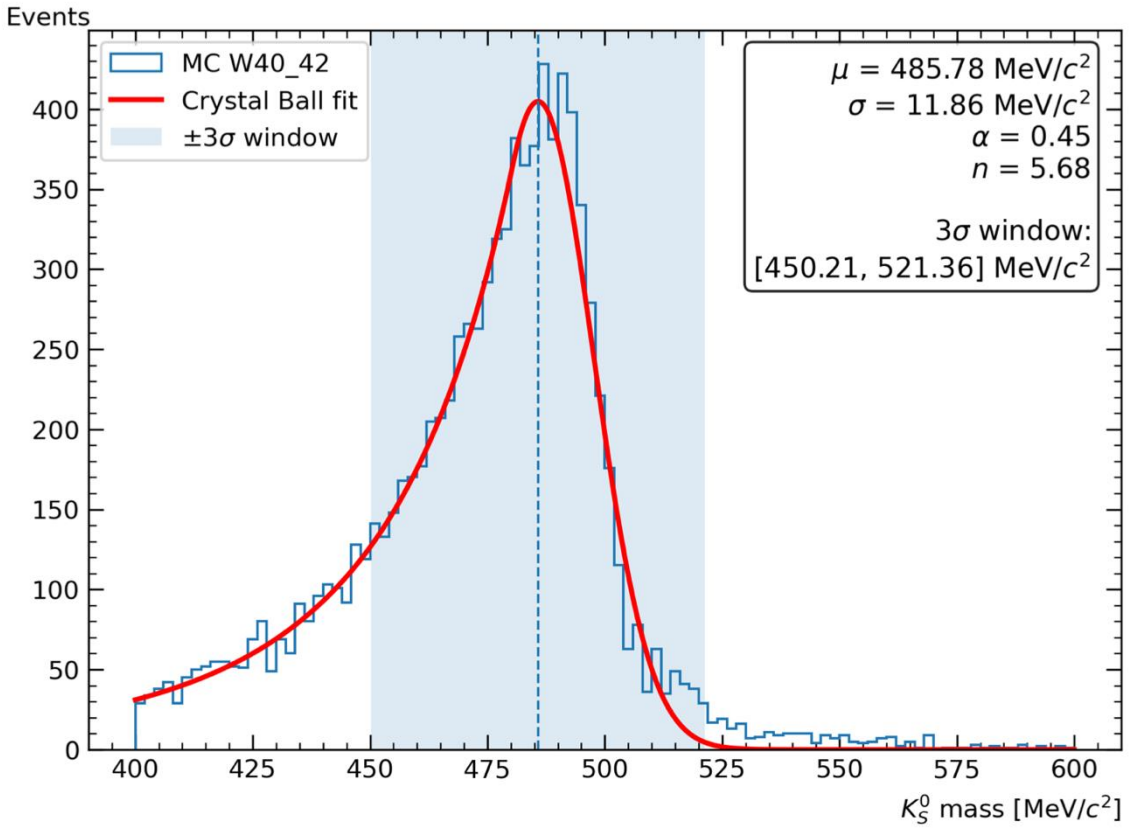
Credit: Sergio Arguedas and Joel Swallow

- 2024 and 2025 data used to search for $K_S \to \mu^+\mu^-\mu^+\mu^-$
- Suffer from large reco inefficiency (4 soft muons)
- Analysis still in its early stages
- SES at present $(\alpha \approx 3\times10^{-13})$ is about an order of magnitude smaller than the Run 2 result
- A lot more optimisations to come but promising results so far

$K_S \to e^+e^-$ in Run 3

Credit: Sergio Arguedas and Diego Garcia

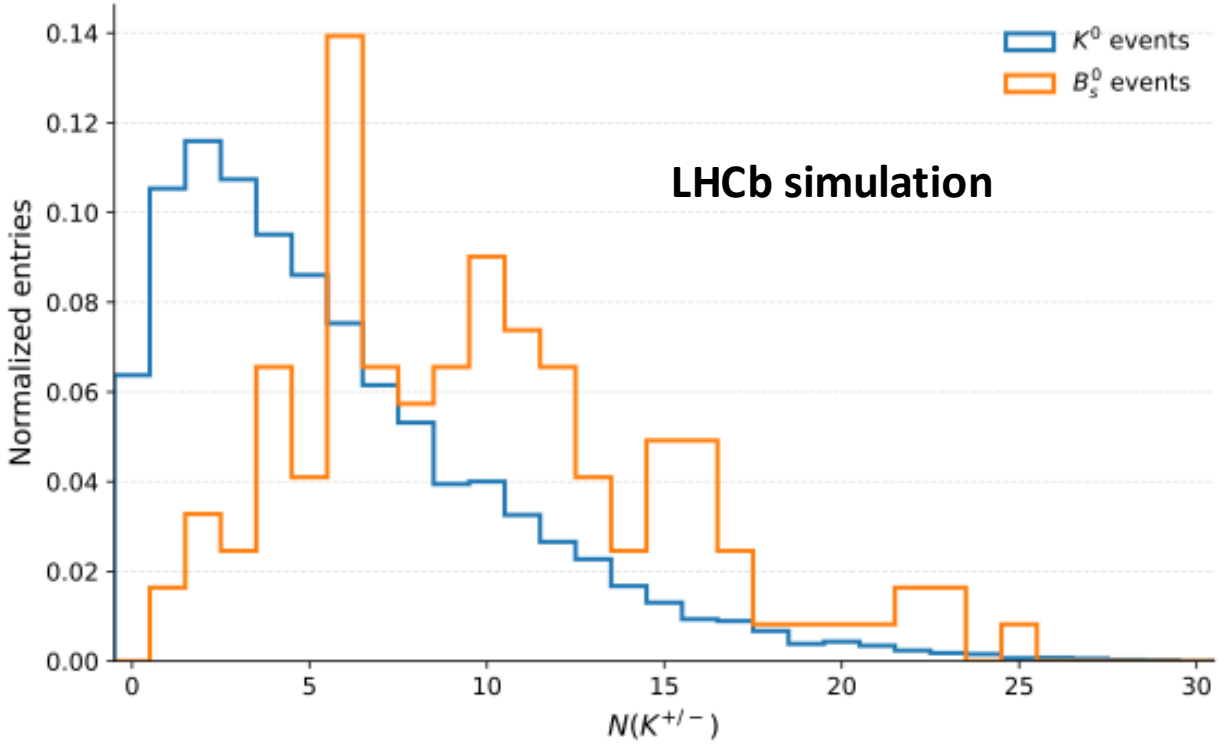


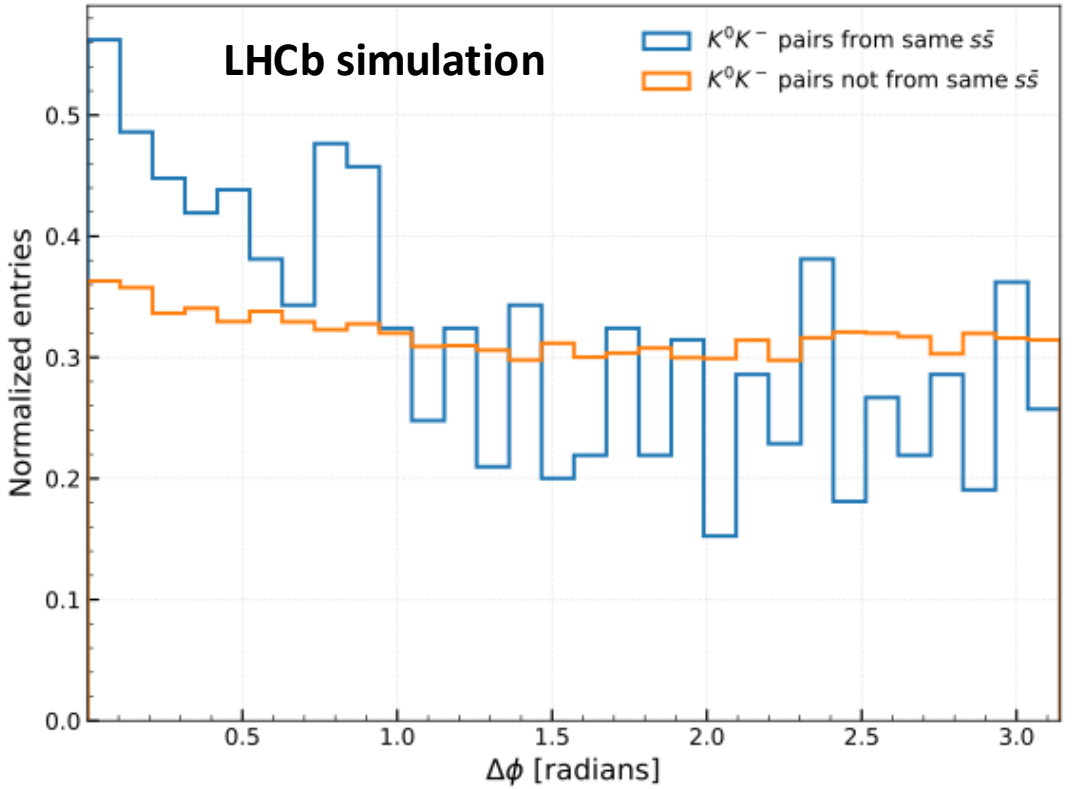


- Very challenging decay mode, low pT electrons ⟹ much worse resolution (about 4 times worse than $\mu\mu$)
- $\alpha \approx 2\times10^{-10}$ with 2024 data only but more background
- Plenty of room for improvement, still very preliminary selection
- Full Run 3 should be competitive with KLOE ($< 9\times10^{-9}$)

Kaon tagging

Credit: Noemie Duc





- We are starting to work on kaon tagging but still in its very early stages
- Some discriminatory power using charge kaon multiplicity angular distance between the kaon pair could also help to distinguish kaons coming from the same $s\bar{s}$
- A lot of work needed to understand feasibility but plenty of room for improvement

Conclusion

- Run 3 detector and trigger allowed for big gains on the trigger side boosting significantly LHCb's sensitivity to strange decays $\Longrightarrow$ ***strange program is developing with quick pace***
  - several ongoing analyses and more foreseen in the kaon sector ($K_S \to \pi^0\mu^+\mu^-, \mu^+\mu^- X, \mu^+\mu^-\gamma$)
  - many more in the baryon sector (e.g. see Gabriele's talk later for $\Sigma^+ \to p\mu^+\mu^-$)
- New RareAndStrange sub-WG has been created, call for conveners open until October 9th
- **Highlight:** $K_S \to \mu^+\mu^-$ is progressing very quickly with very big boost in sensitivity (results expected for implications)

LHCb will play an important role in the global kaon program with Run 3 and beyond!

Backup

Adding $K \to \mu^+\mu^-$ to the picture

Gold-plated observables

$K^+ \to \pi^+\nu\bar{\nu}, K_L \to \pi^0\nu\bar{\nu}$

$K_S - K_L \to \mu\mu$ interference

Approximations — All fulfilled in the SM to $\mathcal{O}(10^{-3})$

- Neglect CPV in mixing $\mathcal{O}(\varepsilon_K) \sim 10^{-3}$
- Leptonic current is vectorial, in SM good to $\mathcal{O}(m_K^2/m_W^2)$
- CPV in the LD physics can be neglected, of $\mathcal{O}(\lambda^4) \sim 10^{-3}$

$$\left(\frac{d\Gamma}{dt}\right) = N_f\, f(t)$$

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$$f(t) = C_L\, e^{-\Gamma_L t} + C_S\, e^{-\Gamma_S t} + 2\, C_{Int.}\, \cos(\Delta m t - \varphi_0) e^{-\Gamma t}$$

CP analysis

Kaon has $J = 0$:
$S = 0, \ell = 0$ or $S = 1, \ell = 1$

Initial state: K_L (CP-odd) K_S (CP-even)

Final state: $(\mu^+\mu^-)_{\ell=0}$ $(\mu^+\mu^-)_{\ell=1}$

$$C_L = |A(K_L)_0|^2$$

$$C_S = |A(K_S)_0|^2 + \beta_\mu^2 |A(K_S)_1|^2$$

$$C_{Int.} = D\,|A(K_S)_0 A(K_L)_0|$$

$$\varphi_0 = \arg\left(A(K_S)_0 A(K_L)_0\right)$$

Experimental parameters $\{C_L, C_S, C_{\rm Int}, \varphi_0\}$ ⟺ **Theoretical parameters** $\{|A(K_S)_0|, |A(K_L)_0|, |A(K_S)_1|, \arg(|A(K_S)_0^* A(K_L)_0|)\}$

$$D = \frac{N_{K^0} - N_{\overline{K}^0}}{N_{K^0} + N_{\overline{K}^0}}$$

$$|A(K_S)_0|^2 = \left| \frac{G_F}{2} \frac{2\alpha_{em} m_K m_\mu Y(x_t)}{\pi \sin^2\theta_W} \times f_K \times V_{cs}V_{cd}\,\mathrm{Im}\left(\frac{V_{ts}^* V_{td}}{V_{cs}^* V_{cd}}\right) \right|^2$$

Short Distance

Comparison with PROBNN_MU

Table 40: Raw and corrected efficiencies using the default $\texttt{ProbNN}_{\mu}$ with the official PIDCalib tool for same background efficiency as in Table 8 for the model without PID_MU.

BDT bin	$\texttt{ProbNN}_{\mu}^{\text{low-}p_{\text{T}}} >$	Bkg rate	PROBNN_MU >	Raw Eff.	Corr. Eff.
4	0.8	0.00553(10)	0.9926	0.0501(23)	0.0170(4)
5	0.8	0.00553(10)	0.9926	0.0520(24)	0.0185(4)
6	0.8	0.00553(10)	0.9926	0.0611(26)	0.0199(4)
7	0.75	0.00997(13)	0.9898	0.102(3)	0.0377(6)
8	0.65	0.02637(22)	0.9740	0.284(6)	0.1302(13)
9	0.65	0.02637(22)	0.9740	0.312(7)	0.1313(14)
10	0.5	0.0722(4)	0.8936	0.665(11)	0.3570(29)

Calibration on $K \to \pi\mu\nu$

Table 39: Closure test of the PID calibration algorithm on $K^0_S \to \pi^+\mu^-\bar{\nu}_\mu$. Eff. stands for efficiency and RD for relative difference.

Cut	Eff. MC	Eff. MC corr.	Eff. data	RD corr.-data	RD MC-data
0.6	0.87(5)	0.75(5)	0.79(4)	0.05(8)	0.10(9)
0.639	0.86(5)	0.73(5)	0.78(4)	0.07(8)	0.10(9)
0.678	0.85(5)	0.70(4)	0.75(4)	0.06(8)	0.14(9)
0.717	0.82(5)	0.66(4)	0.72(4)	0.08(8)	0.14(9)
0.756	0.80(5)	0.63(4)	0.67(4)	0.07(8)	0.18(10)
0.794	0.77(5)	0.58(4)	0.63(4)	0.07(8)	0.22(10)
0.833	0.72(5)	0.52(4)	0.57(3)	0.08(8)	0.26(11)
0.872	0.64(4)	0.44(3)	0.48(3)	0.09(9)	0.32(12)
0.911	0.50(4)	0.323(27)	0.373(26)	0.13(9)	0.34(13)
0.95	0.244(22)	0.150(17)	0.166(16)	0.10(13)	0.47(19)