WG3 – Summary

Rare B, D and K decays, radiative and penguin decays, including constraints on V_{td}/V_{ts} and ϵ'/ϵ

S. Schacht, P. Naik, M. Gorbahn, E.-H. Chao, R. Hill, M. Koval, K. Shiomi, W. Altmannshofer, A. Mauri, M. Borsato, J. Serrano / R. Tiwary, U. Egede, M. Rehoud, S. Stefkova, J. Libby / G. Mohanty, G. Fedi, M. Bauer, Z. Li, L. Leskovec, C. Bouchard

Conveners

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Similar questions – different approaches

- **9 theory contributions**

  S. Schacht, M. Gorbahn, M. Rehoud, — **SM**

  E.-H. Chao, R. Hill, L. Leskovec, C. Bouchard, — **lattice**

  W. Altmannshofer, M. Bauer — **NP**

- **12 experimental contributions**

  P. Naik, M. Koval, K. Shiomi, A. Mauri, M. Borsato, J. Serrano / R. Tiwary, U. Egede, S. Stefkova, J. Libby / G. Mohanty, G. Fedi, Z. Li, J. Serrano

- ✘ no clear sign of NP
- ✘ generic TeV-scale BSM (Hierarchy Problem) under pressure

➜Unclear which NP scale accessible by current experiments

[talk by Altmannshofer]

Aim for a broad experimental program

WG3 @ CKM23

- **B physics**
  $B \to K^{(*)}\ell\ell$, R_K and LFU, LFV ($B \to \ell\tau$),
  $b \to s/d\gamma$ (inclusive & exclusive), $B \to K^{(*)}\nu\nu$, $\Lambda_b \to \Lambda\mu\mu, \ldots$

- **D physics**
  $D^{(*)} \to \mu\mu$, $D \to hh\mu\mu$ (angular analysis), $D \to h(h')ee$,
  $D^0 \to \pi^0\nu\nu$, $\Lambda_c \to p\mu\mu$, $\Lambda_c \to p+$dark-photon,
  large number of searches for rare/forbidden decays:
  LNV ($D^0 \to hhe^+e^+\ldots$), BNV ($D^0 \to pe\ldots$), charged-LFV
  ($J/\psi \to e\mu\ldots$)

- **K physics**
  $K \to \pi\nu\nu$, $K^+ \to \pi^+\mu\mu$, $K \to \mu\mu$, $K \to \mu\mu\mu\mu$,
  $K^+ \to \pi^0e^+\nu\gamma$, $K^+\pi^+\gamma\gamma$, ϵ_K

Cannot provide a full summary (apologies). Highlight some results and their synergies (B↔D↔K and experiment↔theory)

B physics *"golden observables"*

- $B_{s/d} \to \mu\mu$ at ATLAS/CMS/LHCb
  [talks by G. Fedi (exp) and M. Gorbahn (theory)]

- Tests of LFU in $b \to s\ell\ell$ after 2022
  [talk by M. Borsato]

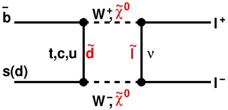
- Radiative inclusive/exclusive $b \to s\gamma$ at Belle/Belle2
  [talk by J. Seranno/R. Tiwary]

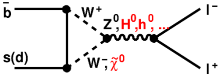
- $B \to K\nu\nu$ at Belle2
  [talk by S. Stefkova]

➜ Results are important input for NP-fits and constraining the allowed patterns for deviating from SM

$B_{s/d} \to \mu\mu$

[talks by G. Fedi (exp) and M. Gorbahn (theory)]





High-precision SM FCNC+loop, CKM, helicity suppressed with single hadronic input f_B

- $\overline{\mathcal{B}}_{s\mu} = (3.65 \pm 0.06) \times (1.008) \times R_{t\alpha} R_s \times 10^{-9}$ [1311.0903] including QED 0.8% effect [1908.07011]

- Input f_{B_s} (Lattice), CKM, $m_t^{\overline{MS}}$ and α_s:

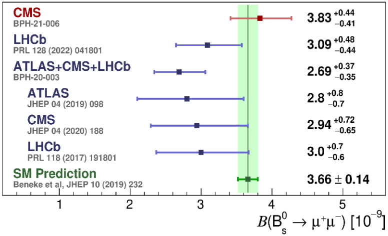
$$R_s = \left(\frac{f_{B_s}[\mathrm{MeV}]}{227.7}\right)^2 \left(\frac{|V_{cb}|}{0.0424}\right)^2 \left(\frac{|V_{tb}^\star V_{ts}/V_{cb}|}{0.980}\right)^2 \frac{\tau_H^s\,[\mathrm{ps}]}{1.615}$$

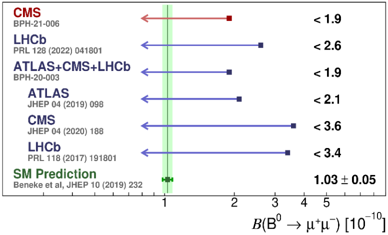
$$R_{t\alpha} = (m_t/(163.5\,\mathrm{GeV}))^{3.02}\ (\alpha_s(M_Z)/0.1184)\,\alpha^{0.032}$$

$B_{s/d} \to \mu\mu$

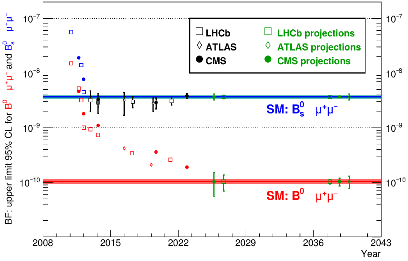
[talks by G. Fedi (exp) and M. Gorbahn (theory)]

ATLAS – CMS – LHCb





Projections



Also first measurement of $B_s \to \mu\mu\gamma$ (LHCb), effective lifetime, and first studies of $B_{s,d} \to \mu\mu\mu\mu, B_{s,d} \to \tau\tau$.

More is coming!

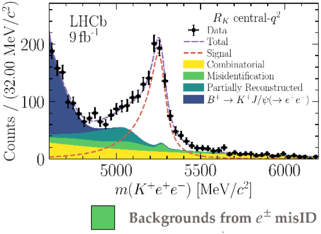
LFU in $b \to s\ell\ell$ / $R_K^{(*)}$

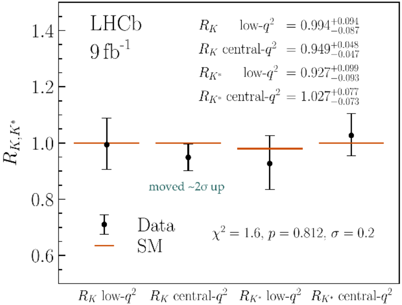
[talk by M. Borsato]

$$R_K = \frac{\frac{\mathcal{N}}{\varepsilon}(B \to K\mu\mu)}{\frac{\mathcal{N}}{\varepsilon}(B \to Kee)} \times \frac{\frac{\mathcal{N}}{\varepsilon}(B \to K\, J/\psi(ee))}{\frac{\mathcal{N}}{\varepsilon}(B \to K\, J/\psi(\mu\mu))}$$

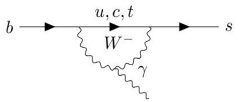
- Among the most involved analyses of LHCb!

➜ multiple improvements in particular successfully pinned down bkg from electron misID ✓





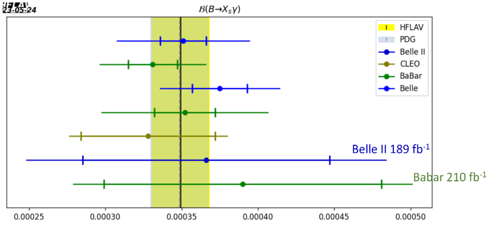
$B \to X_s\gamma$ and $B \to \rho\gamma$ at Belle(2)



$b \to s\gamma$ loop

- sensitive to NP, C_7 also relevant for $b \to s\ell\ell$
- inclusive $B \to X_s\gamma$ difficult at LHCb
- Inclusive Belle2 measurement with 210 fb^{-1}
- Most precise measurements for exclusive mode $B \to \rho\gamma$ (Belle 711fb^{-1} and Belle2 362fb^{-1})

$B \to X_s\gamma$



$B \to \rho\gamma$

(Belle+Belle2)

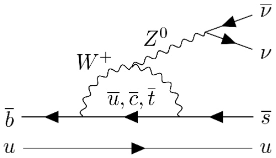
$$\mathcal{B}\left(B^+ \to \rho^+\gamma\right) = \left(12.9^{+2.0+1.3}_{-1.9-1.2}\right) \times 10^{-7},$$
$$\mathcal{B}\left(B^0 \to \rho^0\gamma\right) = \left(7.5^{+1.3+1.0}_{-1.3-0.8}\right) \times 10^{-7},$$
$$A_{\rm CP}\left(B^+ \to \rho^+\gamma\right) = \left(-8.4^{+15.2+1.3}_{-15.3-1.4}\right)\%,$$
$$A_{\rm I}\left(B \to \rho\gamma\right) = \left(11.0^{+11.2+7.1+3.8}_{-11.7-6.3-3.9}\right)\%,$$

Uncertainty: stat. + sys. + f_{+-}/f_{00} (for A_I)

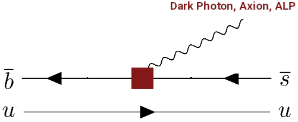
$B^+ \to K^+\nu\nu$

[talk by S. Stefkova and see also talk by M. Bauer]

SM (3body decay)

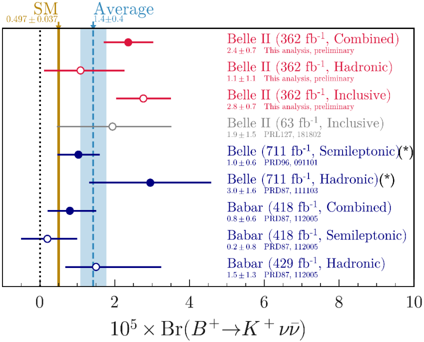


Light NP (2body decay)



not done presently – requires recast

First evidence at Belle2



- **3.6 σ significance w.r.t background-only hypothesis**
- **2.8 σ significance w.r.t SM signal hypothesis**

evidence for the $B^+ \to K^+\nu\bar{\nu}$ decay, with

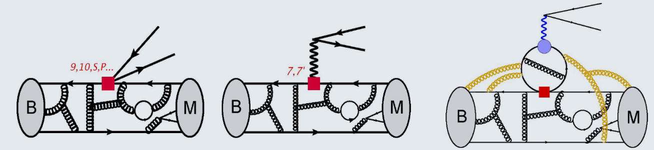
$$\mathscr{B}(B^+ \to K^+\nu\bar{\nu}) = [2.4 \pm 0.5(\mathrm{stat})^{+0.5}_{-0.4}(\mathrm{syst})] \times 10^{-5}$$

Future directions:

$B^0 \to K^0_s\nu\nu$, $B^+ \to K^{*+}\nu\nu$,

$B^0 \to K^*\nu\nu$, $B \to K$+lightNP

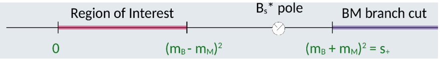
$b \to s(d)\ell\ell$

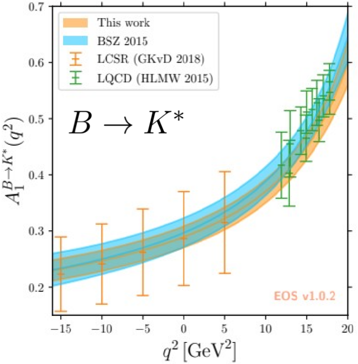


Multi-disciplinary and collaborative efforts to further our understanding of data and their (in)compatibility with SM

- Form-factors from lattice: $B \to K^*\ell\ell$ [talk by L. Leskovec] and $B \to \pi\ell\ell$ and $B \to K\ell\ell$ [talk by C. Bouchard]
- Dispersive analysis of local form-factors for a controlled combination of LCSRs and lattice results [talk by M. Reboud]
- Data driven determination of charms loops [talk by A. Mauri]

- lattice progress in and $B \to \pi$ and $B \to K$
  e.g., HPQCD 2023 , first using fully relativistic b quark $\to 3\times$ more precise at $q^2 = 0$
- combination of LCSR (small q^2) and lattice (large q^2) evaluations using analyticity





➜ good fit, progress in Lattice will gradually replace LCSR for local FFs

➜ systematically improvable approach

[talk by M. Reboud]
non-local charm FFs more difficult $\to$ data driven methods

[talk by A. Mauri]

$B \to K^* \mu\mu$

data-driven determination of non-local charm effects *[talk by A. Mauri]*

- Perform q^2 unbinned amplitude analysis
  - model *local* vs *non-local* contributions

non-local hadronic matrix elements "charm-loop"

$$\mathcal{A}_\lambda^{L,R} = \mathcal{N}_\lambda \left\{ \left[(\mathcal{C}_9 \pm \mathcal{C}_9') \mp (\mathcal{C}_{10} \pm \mathcal{C}_{10}') \right] \mathcal{F}_\lambda(q^2) + \frac{2 m_b M_B}{q^2} \left[(\mathcal{C}_7 \pm \mathcal{C}_7') \mathcal{F}_\lambda^T(q^2) - 16\pi^2 \frac{M_B}{m_b} \mathcal{H}_\lambda(q^2) \right] \right\}$$

$\lambda = \perp, \parallel, 0$

Wilson coeff.   Form Factors   polynomial expansion

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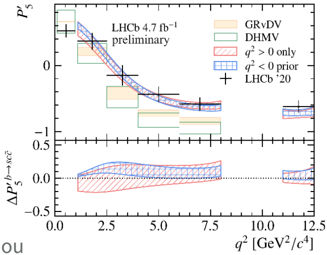
- perform fit to constrain charm-loop parameters
  - Global compatibility [4 d.o.f.] with SM $1.3\,(1.4)\,\sigma$



	Fit result	deviation from SM
	$q^2 > 0$ only	
$\mathcal{C}_9$	$-0.93^{+0.53}_{-0.57}$	$1.9\ \sigma$
$\mathcal{C}_{10}$	$0.48^{+0.29}_{-0.31}$	$1.5\ \sigma$
$\mathcal{C}_9'$	$0.48^{+0.49}_{-0.55}$	$0.9\ \sigma$
$\mathcal{C}_{10}'$	$0.38^{+0.28}_{-0.25}$	$1.5\ \sigma$
	$q^2 < 0$ prior	
$\mathcal{C}_9$	$-0.68^{+0.33}_{-0.46}$	$1.8\ \sigma$
$\mathcal{C}_{10}$	$0.24^{+0.27}_{-0.28}$	$0.9\ \sigma$
$\mathcal{C}_9'$	$0.26^{+0.40}_{-0.48}$	$0.5\ \sigma$
$\mathcal{C}_{10}'$	$0.27^{+0.25}_{-0.27}$	$1.0\ \sigma$

$B^0 \to K^*\tau\tau$ at Belle with 711fb^{-1}

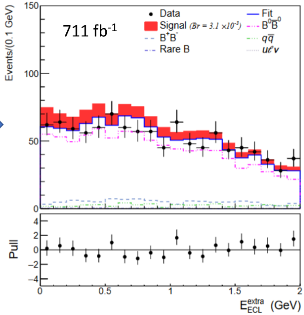
[talk by J. Seranno]

Decays	SM prediction	Best 90% CL UL
$B^0 \to \tau\tau$	$(2.22\pm0.19)\ 10^{-8}$ [1]	$1.6\ 10^{-3}$ [3] LHCb
$B_s \to \tau\tau$	$(7.73\pm0.49)\ 10^{-7}$ [1]	$5.2\ 10^{-3}$ [3] LHCb
B0 → K*0ττ	$(0.98\pm0.10)\ 10^{-7}$ [2]	This result Belle
B+ → K+ττ	$(1.20\pm0.12)\ 10^{-7}$ [2]	$2.25\ 10^{-3}$ [4] Babar

- B hadronic tagging based on neural network
- Select event with 4 remaining tracks
- Reconstruct one prong τ decays τ →e/μ/π
- Signal yield obtain by fitting the extra ECL energy (clusters not associated with B_{sig} or B_{tag})

$$N_{\text{sig}} = -4.9 \pm 6.0$$

Background only fit with signal superimposed



- Fit procedure validated on B→Dlv decays

Upper limit is set at 3.1×10^{-3} @90% C.L.

Improvements foreseen at Belle II: FEI, τ → ρ mode, multivariate analysis. Stay tuned!

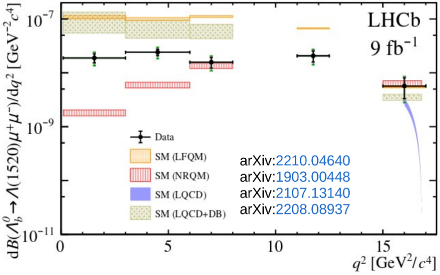
$\Lambda_b \to \Lambda(1520)\mu\mu$

[talk by U. Egede]

baryon decays sensitive to different linear combination of NP Ws

➜possible crosschecks for meson decays

- Branching fraction measurement at the end is dominated by statistical uncertainty
- Comparison to theoretical predictions are all over the place
- Some consolidation required on theory side to be conclusive



Lepton flavour violating decays [talk by J. Libby/G. Mohanty]

1) Search for $B_s^0 \to \ell\tau$ with the semi-leptonic tagging method at Belle JHEP 08, 178 (2023)
2) Search for the LFV decays $B^+ \to K^+\tau^\pm\ell^\mp$ at Belle PRL 130, 261802 (2023)
3) Search for the LFV decays $B^0 \to K^{*0}\tau^\pm\mu^\mp$ JHEP 06, 143 (2023)
4) Search for the LFV decays $B^0 \to K^{*0}\mu^\pm e^\mp$ and $B_s^0 \to \phi\mu^\pm e^\mp$ JHEP 06, 073 (2023)

Main results

- Limits in the range of 10^{-4}–10^{-5} for modes with τ's and 10^{-9} for modes with electrons and muons
- results statistically limited, Belle2 results will follow

D physics

rare decays

Large number of new results

- BESIII [talk by Z. Li]

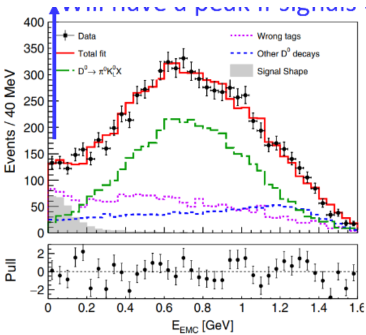
  Charmonium weak decays, FCNCs, BNV, LNV, and charged LFV

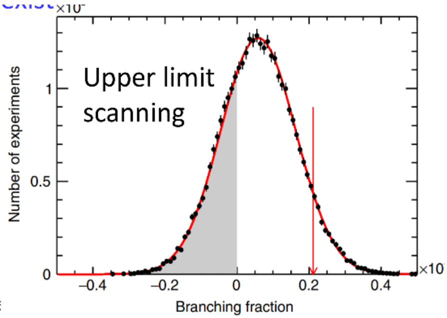
- LHCb [talk by P. Naik]

Below some highlights

$D^0 \to \pi^0 \nu\nu$ at BESIII with 2.93fb^{-1}

[talk by Z. Li]





- ✓ E_{EMC}: EMC energy not associated with π^0 and tag D decays
- ✓ **If has signals, it will have events exceeding zero in E_{EMC}**
- ✓ $\mathcal{B}(D^0 \to \pi^0 \nu\bar{\nu})$ $< \mathbf{2.1 \times 10^{-4}}$ @90% C. L.
- ✓ The first experimental results of search for $c \to u\nu\bar{\nu}$ processes

New data sample with 20fb^{-1} underway $\to$ further improvements

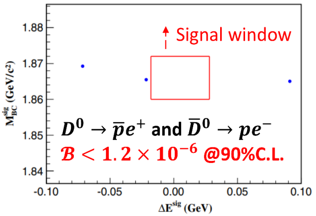
LNV and BNV at BESIII

[talk by Z. Li]

Lepton Number Violation

- $\mathcal{B}(D^0 \to K^- \pi^- e^+ e^+) < 2.8 \times 10^{-6}$ @90%C.L.
- $\mathcal{B}(D^+ \to K_S^0 \pi^- e^+ e^+) < 3.3 \times 10^{-6}$ @90%C.L.
- $\mathcal{B}(D^+ \to K^- \pi^0 e^+ e^+) < 8.5 \times 10^{-6}$ @90%C.L.

Baryon Number Violation



Mode (+c.c.)	$\mathcal{B}^{UL}$ @90%C.L.
$D^+ \to \bar{n}e^+$	$< 1.4 \times 10^{-5}$
$D^+ \to \bar{\Lambda}e^+$	$< 6.5 \times 10^{-7}$
$D^+ \to \bar{\Sigma}^0 e^+$	$< 1.3 \times 10^{-6}$
$D^+ \to ne^+$	$< 2.9 \times 10^{-5}$
$D^+ \to \Lambda e^+$	$< 1.1 \times 10^{-6}$
$D^+ \to \Sigma^0 e^+$	$< 1.7 \times 10^{-6}$

Rare charm at LHCb

[talk by P. Naik]

$D^0 \to \mu\mu$

(full Run 1+2 analysis)

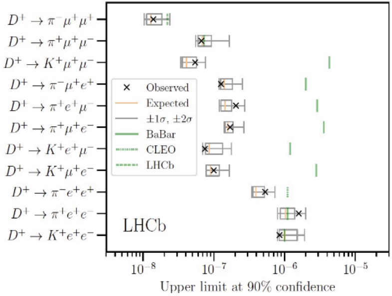
$\mathcal{B}(D^0 \to \mu^+\mu^-) < 3.1(3.5) \times 10^{-9}$ at 90(95)%C.L.

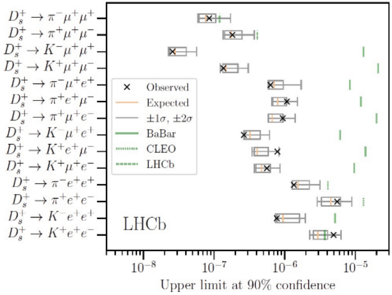
$D^{*0} \to \mu\mu$

(**new** - full Run 1+2 analysis)

$\mathcal{B}(D^{*0} \to \mu^+\mu^-) < 2.6 \times 10^{-8}$ at 90% CL

25 searches for forbidden decays of $D^+_{(s)}$





Complementary information to BESIII

K physics

rare decays

- less modes than in B/D physics due to phase-space
- among most constraining probes of NP
  ➜new results in precision SM predictions for $K \to \pi\nu\nu$ and $K_S \to (\mu\mu)_{\ell=0}$ [talk by M. Gorbahn]
- some modes long-distance dominated $K_L \to \mu\mu$, $K \to \pi\ell\ell$, $K \to \gamma\gamma$ ➜lattice efforts [talks by E.-H. Chao, R. Hill]
- rich ongoing and **future-planned** experimental programm with new possibilities (NA62,KOTO,LHCb,…,HIKE)
  [talks by K. Shiomi, M. Koval, P. Naik, and S. Schacht]

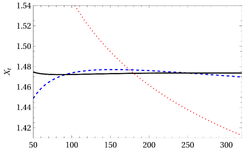
Below some highlights

The $K \to \pi\nu\nu$ golden modes in the SM

[talk by M. Gorbahn]

- 2105.02868 Standard Model Prediction
  $\mathrm{BR}(K^+ \to \pi^+\nu\bar{\nu}) = 7.73(16)_{SD}(25)_{LD}(54)_{para.} \times 10^{-11}$,
  $\mathrm{BR}(K_L \to \pi^0\nu\bar{\nu}) = 2.59(6)_{SD}(2)_{LD}(28)_{para.} \times 10^{-11}$.
- Using 2022 PDG CKM fitter values
  $\mathrm{BR}(K^+ \to \pi^+\nu\bar{\nu}) = 8.25(11)_{SD}(25)_{LD}(57)_{para.} \times 10^{-11}$,
  $\mathrm{BR}(K_L \to \pi^0\nu\bar{\nu}) = 2.83(1)_{SD}(2)_{LD}(30)_{para.} \times 10^{-11}$.
- V_{cb} dominates uncertainty: ϵ_K has similar V_{cb} dependence

X_t@NNLO



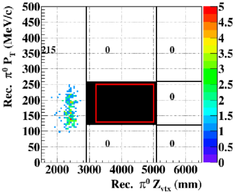
(new)
$1\% \to 0.1\%$

Small hadronic uncertainties in K^+ mode ➜lattice in future?

$K_L \to \pi^0 \nu \bar{\nu}$ at KOTO

[talk by K. Shiomi]

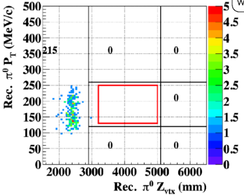
- very difficult signature, only neutrals in final state
  2γ+nothing+ missing p_T
- preliminary analysis of 2021 data



- No signal candidate observed
- BR<2.0x10^-9@90% C.L.

Preliminary

S.E.Sx 2.3
with Poisson statistics



Future targets:

- 10 times more POT in next $3-4$ years
- reach 10^{-10} sensitivity

$K^+ \to \pi^+\nu\nu$ and beyond at NA62

[talk by M. Koval, see also plenary by K. Massri]

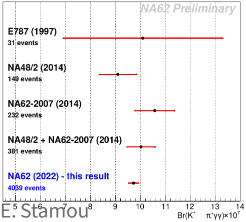
- NA62 Run 1 = 2016 – 2018 data:
  20 signal candidates, expected background: 7.0 events [JHEP 06 (2021) 093]

$$\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})_{\text{NA62}} = (10.6^{+4.0}_{-3.4}|_{\text{stat}} \pm 0.9_{\text{syst}}) \times 10^{-11}$$

Run 2 targets 15% precision

Broad experimental program beyond $K \to \pi\nu\nu$, news:

→	$K^+ \to \pi^+\mu^+\mu^-$ decay	[JHEP 11 (2022) 011]
→	$K^+ \to \pi^0 e^+\nu\gamma$ decay	[JHEP 09 (2023) 040]
→	$K^+ \to \pi^+\gamma\gamma$ decay	(preliminary results)



$$\mathcal{B}(K^+ \to \pi^+\gamma\gamma) = (9.73 \pm 0.19) \times 10^{-7}$$

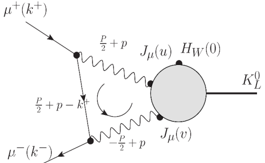
use such modes to extract FF information

Can lattice help?

Rare Kaons on the lattice

[talks by R. Hill and E.-H. Chao]

First ideas for $K_L \to \mu\mu$



- A coordinate-space based lattice-QCD formalism for the $K_L \to \mu^+\mu^-$ decay is proposed, enabling the determination of the phenomenologically inaccessible real part of the decay amplitude.

[talk by E.-H. Chao]

Lattice for $K^+ \to \pi^+\mu\mu$

$$\mathcal{A}_\mu(q^2) = \int d^4x \langle \pi(\mathrm{p})| T\left[J_\mu(0) H_W(x)\right] |K(\mathrm{k})\rangle$$

- Re-expressed using EM gauge invariance[1 2]:

$$\mathcal{A}_\mu(q^2) = -i\frac{G_F}{(4\pi)^2}\left[q^2(k+p)_\mu - \left(M_K^2 - M_\pi^2\right) q_\mu\right] V(z)$$

$$q_\mu = k_\mu - p_\mu,$$
$$z = q^2/M_K^2,$$
$$V(z) = a + bz + V^{\pi\pi}(z)$$

- Goal is to compute a, b
- Simulating rare kaon decays $K \to \pi\ell^+\ell^-$ using domain wall lattice QCD with physical light quark masses
  RBC-UKQCD (2023)
  Phys. Rev. D 107, 114512 (2023) [arXiv:2202.08795]

Demonstrated viability of method but FF not yet resolved

[talk by R. Hill]

$K \to \mu\mu$

[talks by S. Schacht and P. Naik (LHCb measurements)]

K physics at LHCb (reach SM sensitivity with Upgrade)

$\mathscr{B}(K_S \to \mu^+\mu^-) < 2.1 \times 10^{-10}$ (90% CL)

$\mathcal{B}(K^0_S \to \mu^+\mu^-\mu^+\mu^-) < 5.1 \times 10^{-12}$

$\mathcal{B}(K^0_L \to \mu^+\mu^-\mu^+\mu^-) < 2.3 \times 10^{-9}$

Can we disentangle the short-distance from the long-distance contributions?

➜decompose into angular-momentum states of dimuon

Short-distance (SD) and long-distance (LD) physics

- CP-conserving decays: SD and LD

K_L	$\to$	$(\mu\mu)_{l=0}$	K_S	$\to$	$(\mu\mu)_{l=1}$
CP-odd		CP-odd	CP-even		CP-even

- CP-violating decays: Only SD

K_S	$\to$	$(\mu\mu)_{l=0}$	K_L	$\to$	$(\mu\mu)_{l=1}$
CP-even		CP-odd	CP-odd		CP-even

$K_S \to (\mu\mu)_{\ell=0}$ CP violating and SD dominated!

$K_S \to (\mu\mu)_{\ell=0}$ from interference in time-dependent decay

[talk by S. Schacht]

- The amplitudes that enter the decay, enter also the time-evolution

- Generic time dependence of K decay:

$$\left(\frac{d\Gamma}{dt}\right) \propto C_L e^{-\Gamma_L t} + C_S e^{-\Gamma_S t} + 2\left(C_{sin}\sin(\Delta m t) + C_{cos}\cos(\Delta m t)\right) e^{-\Gamma t}$$

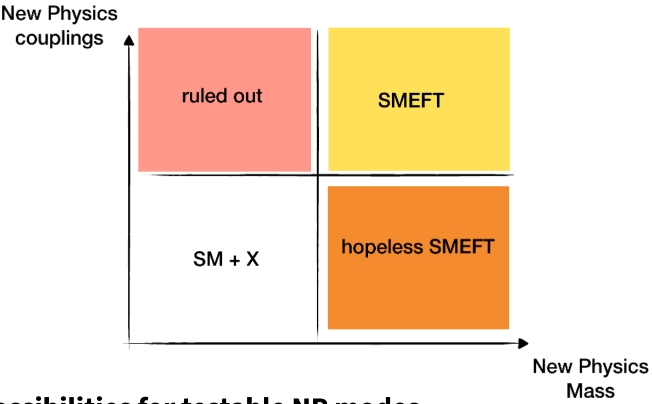
- The 4 Cs are the observables:
  - C_L is related to K_L decay rate.
  - C_S is related to K_S decay rate.
  - C_{sin} and C_{cos} are due to interference.

$$\mathcal{B}(K_S \to (\mu^+\mu^-)_{l=0}) = \mathcal{B}(K_L \to \mu^+\mu^-) \times \frac{\tau_S}{\tau_L} \times \frac{C_{cos}^2 + C_{sin}^2}{C_L^2}$$

IF we could measure the interference $(C_{\cos}, C_{\sin})$, we would have access to the SD physics and an independent determination of η

New Physics

[talks by W. Altmannshofer and M. Bauer]



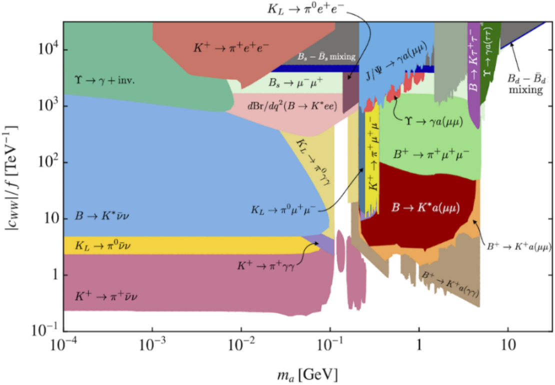
Two possibilities for testable NP modes

- Heavy NP – more traditional / contact interactions = higher-dim. operators
- Light NP – must be very weakly interacting (QCD axion, Dark Photons, ALPS, sterile ν)

Light NP and flavour

[talk by M. Bauer]

- Precision Flavour provides valuable input to probe light NP
- One example: **ALP with single interaction** $\propto c_{WW}\,\frac{a}{f}\tilde{W}W$ coupling



- in general: model-depedent competition between flavour-diagonal and flavour-off-diagonal constraints

Conclusions for WG3

- Topics covered representative of the **ongoing, broad research program in flavour physics**

- **Compementarity**
  Rare decays: B $\leftrightarrow$ D $\leftrightarrow$ K
  Experiment $\leftrightarrow$ Theory (SD vs LD efforts)
  Observables: CP conserving/violating $\leftrightarrow$ LFU$\leftrightarrow$ LFV$\leftrightarrow$ LNV $\leftrightarrow$ LNV

- Could summarise only a small portion of all new results
  ➜see original contributions

- No guaranteed discoveries anymore.
- We are in exploratory mode $\rightarrow$ "Leave no stone unturned"
- Anomalies need to be followed up in every way possible.
- Beyond anomalies, one can expect qualitatively new insights into flavored new physics from a number of processes in the near future.