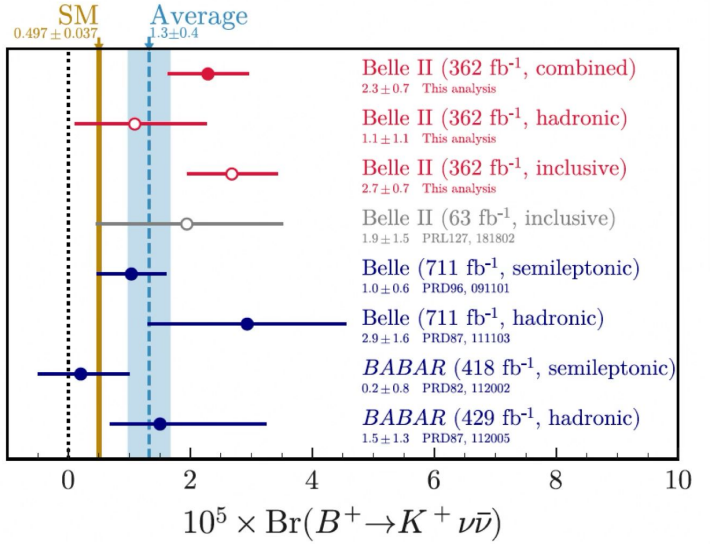
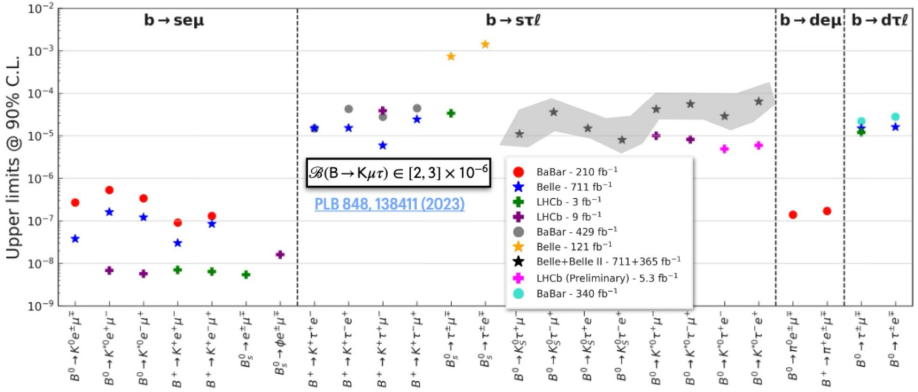
Opportunities for $b \to s$ missing energy for Belle II

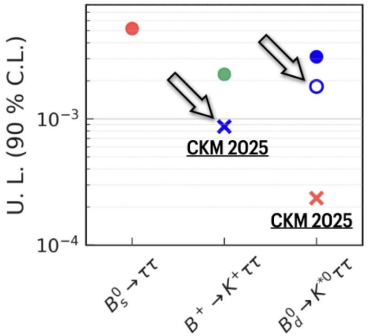
David, Elisa, Michael, Wolfgang

Panel discussion
2025 BelleII Physics week

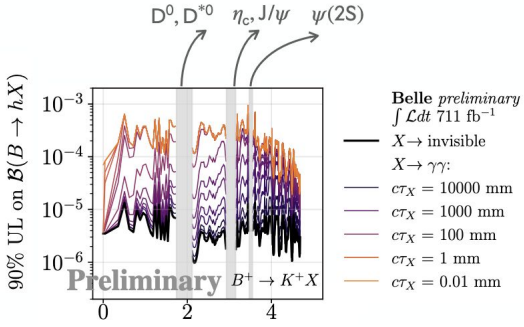
Status of Belle II analyses







M_{X_s} [GeV/c^2]	ϵ	N_{sig}	$\mathcal{B}$ [10^{-5}] Central value	UL$_{\mathrm{obs}}$	UL$_{\mathrm{exp}}$
$[0, 0.6]$ ✱	0.26%	10^{+18+18}_{-17-16}	$0.5^{+0.9+0.9}_{-0.8-0.8}$	2.5	2.4
$[0.6, 1.0]$	0.12%	37^{+27+31}_{-25-26}	$3.8^{+2.8+3.3}_{-2.6-2.7}$	10.1	7.3
$[1.0, m_B]$	0.06%	33^{+44+63}_{-42-53}	$7.3^{+9.6+13.8}_{-9.2-11.5}$	35.1	27.9



G. de Marino

Few words on the perspectives

- $b \to s\nu\nu$: unique to Belle II, corroborate evidence improving precision with
  - ITA with additional $K^{(*)}$ channels
  - additional tagging techniques (STA to improve precision, HTA to study q2 spectrum with better resolution)
  - use of Run2 dataset (and what will come next)

- $b \to s\tau\tau$:
  - most stringent limit from $B^0 \to K^{*0}\tau\tau$ LHCb measurement (Abhijit's talk)
  - many handles to improve Belle II $B^+ \to K^+\tau\tau$ measurement: additional τ channels, semileptonic and inclusive tag, further optimisation of analysis strategy when adding less pure modes

Systematics evolution

We foreseen improvements on systematics related to:

- background normalisations →generally, statistical in origin
- specific background modelling
- detectors performances (improvements in particle reconstruction and identification algorithms, usage of MCrd)
- simulated sample size → larger MC samples can be produced in a smart way (save to disk only skimmed events)

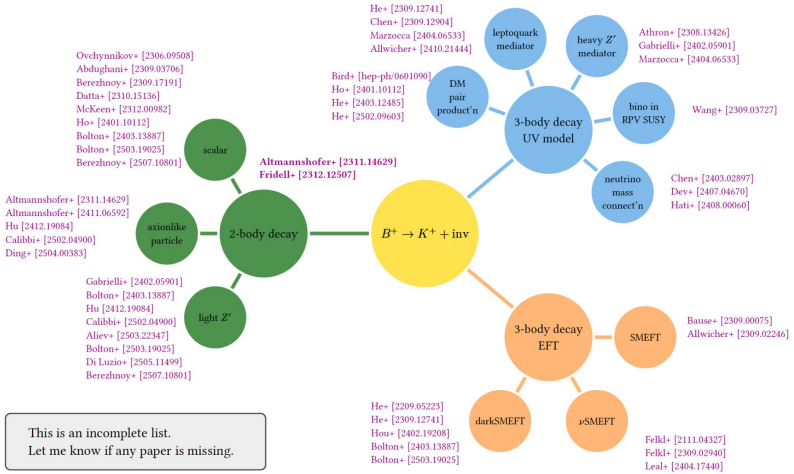
ITA

	Source	Impact on σ_μ
1	Normalization of $B\bar{B}$ background	0.90
	Normalization of continuum background	0.10
	Leading B-decay branching fractions	0.22
3	Branching fraction for $B^+ \to K^+ K_L^0 K_L^0$	0.49
	p-wave component for $B^+ \to K^+ K_S^0 K_L^0$	0.02
4	Branching fraction for $B \to D^{**}$	0.42
	Branching fraction for $B^+ \to K^+ n\bar{n}$	0.20
	Branching fraction for $D \to K_L^0 X$	0.14
	Continuum-background modeling, BDT_c	0.01
	Integrated luminosity	<0.01
	Number of $B\bar{B}$	0.02
	Off-resonance sample normalization	0.05
	Track-finding efficiency	0.20
	Signal-kaon PID	0.07
	Photon energy	0.08
	Hadronic energy	0.37
	K_L^0 efficiency in ECL	0.22
	Signal SM form-factors	0.02
	Global signal efficiency	0.03
2	Simulated-sample size	0.52

Suggested discussion points

B → K $\nu\nu$ reinterpretation

M. Schmidt



Dream scenario:

assume that the B → K $\nu\nu$ excess is confirmed with 5sigma.

What do we learn about new physics?

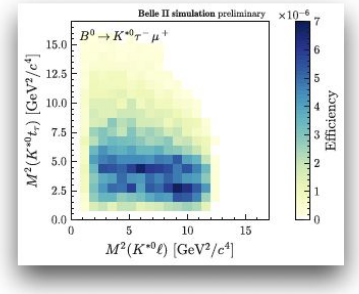
What are the most important model independent and model dependent implications?

How can the implications be checked?

Interpretation of experimental results, more in general

Belle II is going into the direction of making likelihoods, data tables, .. available on HEP data.

E.g.:



Selection efficiency as a function of dof (q^2,...) for the phase space model allow to reinterpret the results in specific BSM models

$\Delta\mathcal{C}_9^{\tau\ell} = -\Delta\mathcal{C}_{10}^{\tau\ell} \neq 0, \quad \Delta\mathcal{C}_S^{\tau\ell} \neq 0$ HEPData

G. de Marino, L Gärtner

- Data tables, likelihoods, . . .
- 10.6k publications
- >4 million page views / year
- 43 Belle, 9 Belle II entries
- $B^+ \to K^+\nu\bar{\nu}$ entry (coming soon): likelihood & joint number densities

HistFactory **Search for $B^0 \to K^{*0}\tau^+\tau^-$ decays at the Belle II experiment**

The Belle-II collaboration Adachi, I. ; Adamczyk, K. ; Aggarwal, L. ; *et al.*

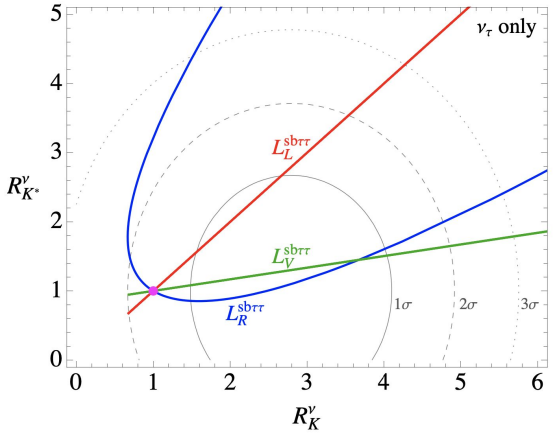
Suggestions for specific information/format that can help reinterpretation?

Examples of desiderata from future B → K$^{(*)}$ $\nu\nu$ measurements

O. Sumensari

Comparing B → K $\nu\nu$ and B → K(*) $\nu\nu$

integrated BF's: $R^{\nu}_{K^{(*)}} = \dfrac{\mathcal{B}(B \to K^{(*)}\nu\bar{\nu})}{\mathcal{B}(B \to K^{(*)}\nu\bar{\nu})_{\rm SM}}$

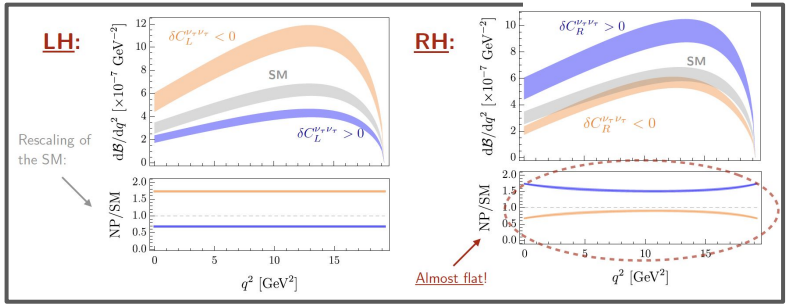


D. Marzocca

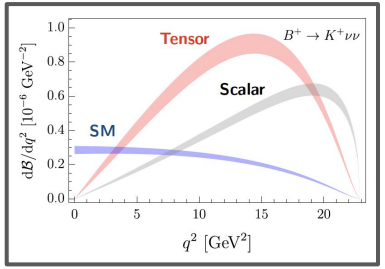
Comparing B → K $\nu\nu$ and B → K(*) $\nu\nu$

integrated BF's:

B⁺→K*$\nu\nu$



B⁺→K⁺$\nu\nu$



Impact of Belle II measurements depend on the needed precision and q^2 resolution, can we do something in the with the next round of measurements?

Additional questions from the audience?