Tauonic B Decays and LFUV

Measurement at future ee colliders

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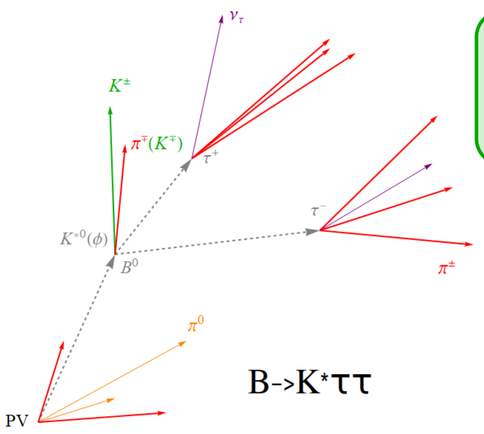
Based on arXiv: 2012.00665 and ongoing projects

TAU2021

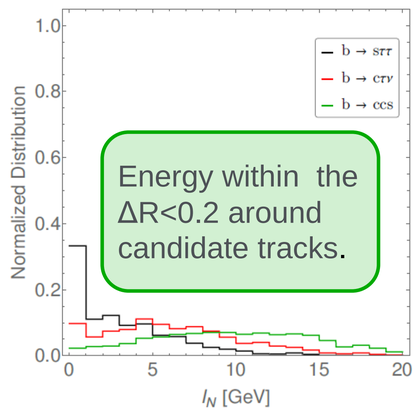
Introduction



B->K*ττ

In SM, large backgrounds from D mesons faking τ: 3π+X decays of D mesons is common!

Type	Channel	Color	$s\bar{s}$	τ	BR
$b \to c\bar{c}s$	$B^0 \to K^{*0} D^{(*)+} D^{(*)-}$				1.2×10^{-2}
	$B_s \to K^{*0} D_s^{(*)+} D^{(*)-}$				1.2×10^{-2}
	$B_s \to \bar{K}^{*0} D_s^{(*)+} D^{(*)-}$				1.2×10^{-2}
	$B^0 \to K^{*0} D_s^{(*)+} D_s^{(*)-}$		✓		1.6×10^{-3}
$b \to c\tau\nu$	$B^0 \to K^{*0} D_s^{(*)-} \tau^+ \nu$	✓		✓	3.0×10^{-5}
	$B_s \to \bar{K}^{*0} D^{(*)-} \tau^+ \nu$			✓	4.6×10^{-4}



Energy within the ΔR<0.2 around candidate tracks.

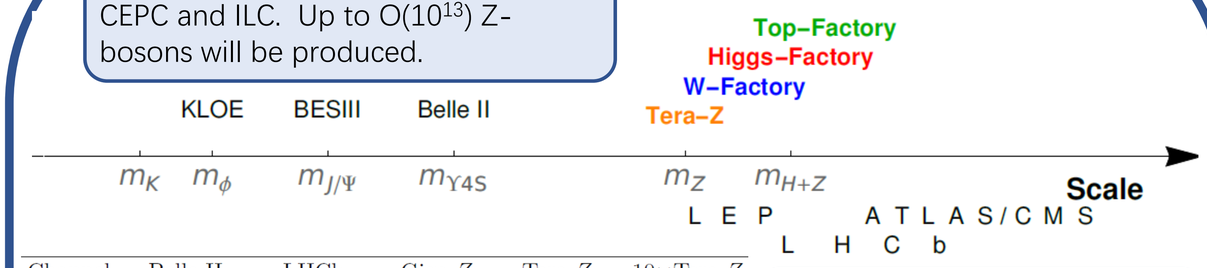
Quiet ee collider + boosted tracks: Large D meson veto.

The 3πν decay of τ provides information of each decay vertex, given the high boost and tracking precision at the Z pole. .

- 6 kinetic constraints + 2 mass-shell conditions,
- Fully reconstruct m_B

Simulation & Analysis

Z-Factory of ee-colliders, e.g. FCC-ee, CEPC and ILC. Up to O(10^{13}) Z-bosons will be produced.

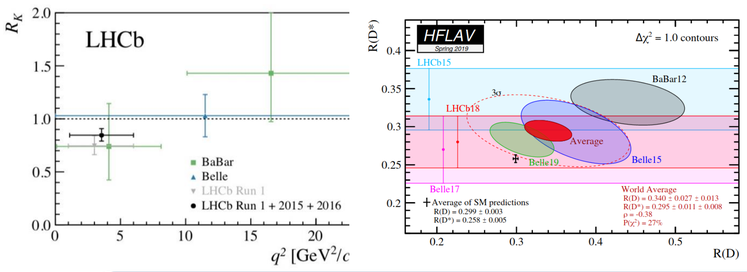


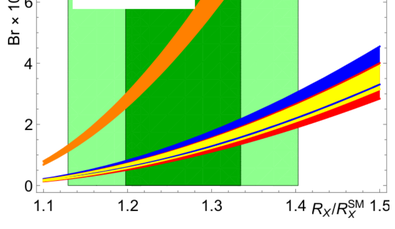
Channel	Belle II	LHCb	Giga-Z	Tera-Z	10×Tera-Z
B^0, $\bar{B}^0$	5.3×10^{10}	$\sim 6 \times 10^{13}$	1.2×10^8	1.2×10^{11}	1.2×10^{12}
$B^\pm$	5.6×10^{10}	$\sim 6 \times 10^{13}$	1.2×10^8	1.2×10^{11}	1.2×10^{12}
B_s, $\bar{B}_s$	5.7×10^8	$\sim 2 \times 10^{13}$	3.2×10^7	3.2×10^{10}	3.2×10^{11}
$B_c^\pm$	-	$\sim 4 \times 10^{11}$	2.2×10^5	2.2×10^8	2.2×10^9
Λ_b, $\bar{\Lambda}_b$	-	$\sim 2 \times 10^{13}$	1.0×10^7	1.0×10^{10}	1.0×10^{11}

Producing all kinds of b-hadrons. Sufficient energy stems from m_Z ~91 GeV, allowing production with sufficiently boosted tracks.

Recent hints of Lepton flavor universality (LFU) violation:

- Charged current anomalies (τ vs. μ/e): R_D, R_{D*}, $R_{J/\Psi}$.
- Neutral current anomalies (μ vs. e): R_K, R_{K*}.

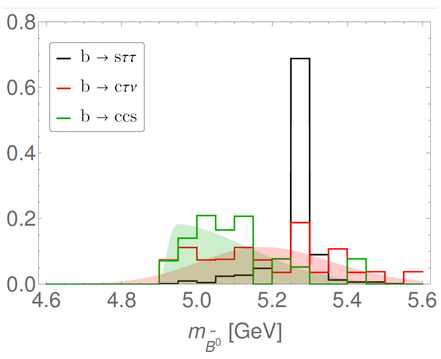




Many new physics scenarios plausible: (leptoquarks, new bosons, SUSY…)

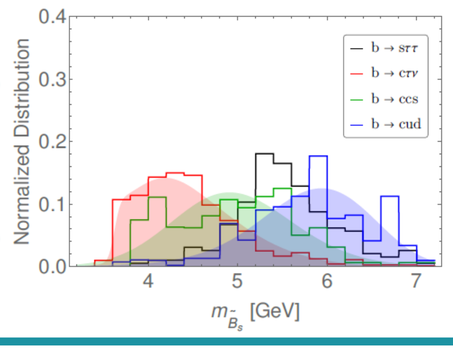
- Models resolving the FCCC b ⟶ cτν anomaly introduce O(0.1) correction to SM coupling at tree level.
- Enhancing b ⟶ sττ rates by ~3 orders: more than a smoking gun!
- Still compatible with stringent FCNC b ⟶ sνν limits (O(10^{-5}))

Results & Physical Interpretation



Up: Mass peak of $B^0 \to K^* \tau\tau$
Right: Mass peak of $B_s \to \tau\tau$

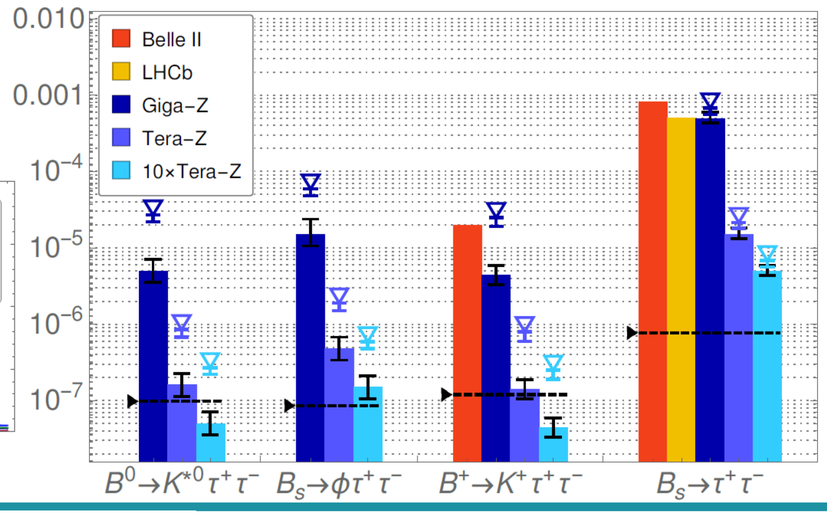
Sepratation between sig & bkg
Final S/B ratio ~1-10%

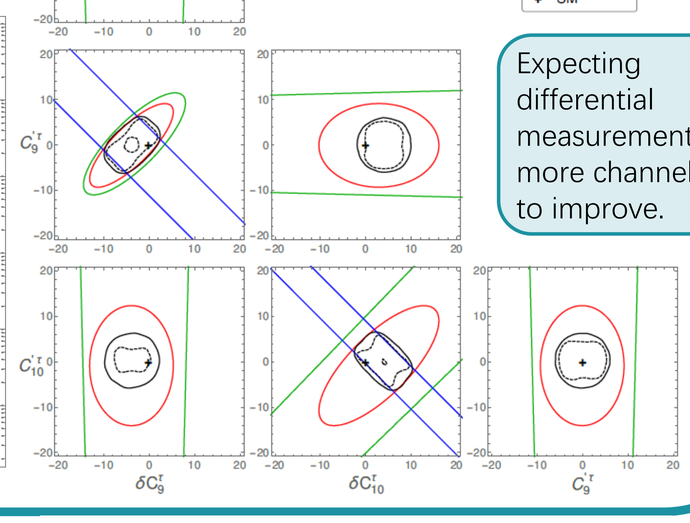


- At Tera-Z., able to see O(1) deviations..
- Precision/differential measurements available for lumin. upgrades.
- UNIQUE at the Z pole!

Constraints on the 4 Wilson coefficients of EFT:

- Vector and pseudoscalar modes both relevant.
- Current limit of O(10^3) ⟶ O(10).



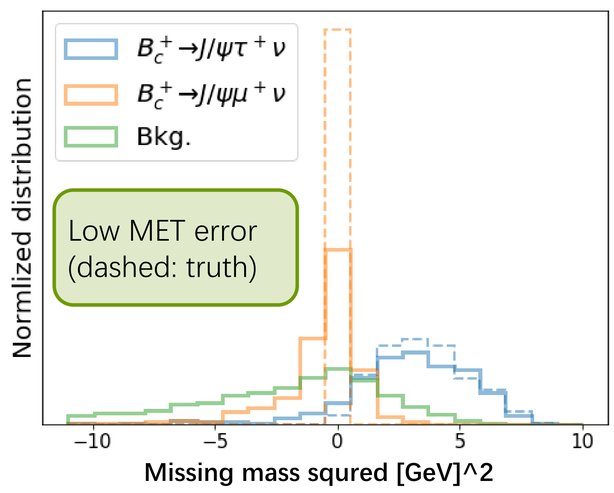


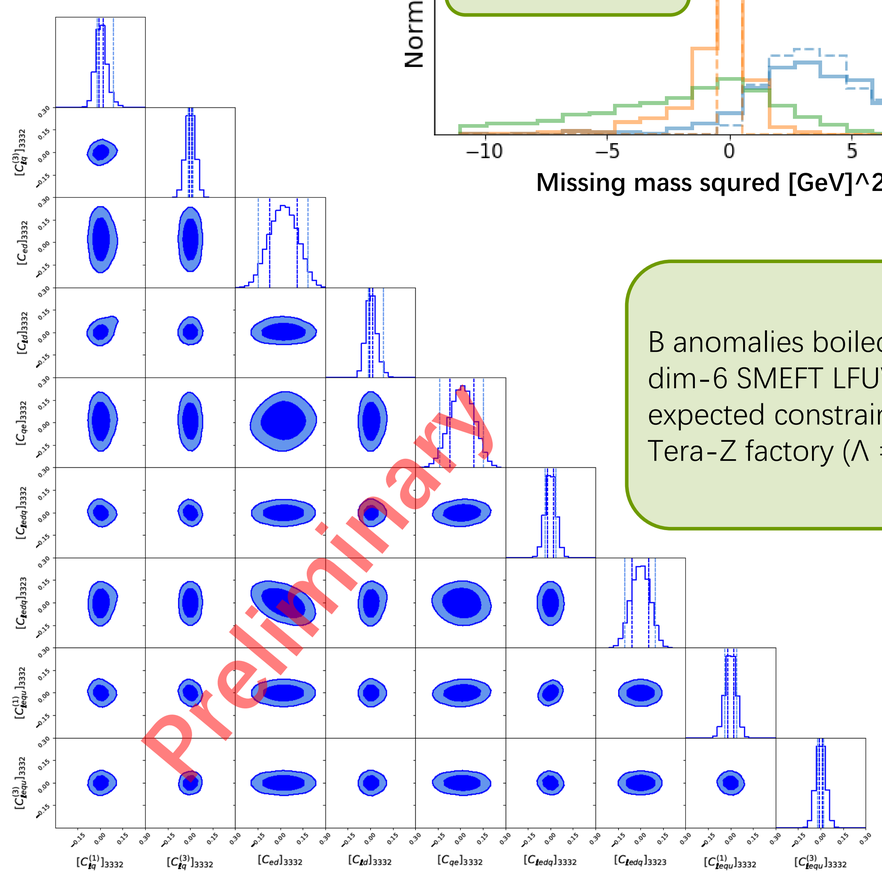
Expecting differential measurements/ more channels to improve.

Semi-Tauonic Decays and EFT

Ongoing ProjectMultiple searches using FCCC b ⟶ cτν decays are in preparation

- $R_{J/\Psi}$, R_{Ds}, R_{Ds*},and $R_{\Lambda c}$!
- Good reconstruction quality ensuring S/B~1.

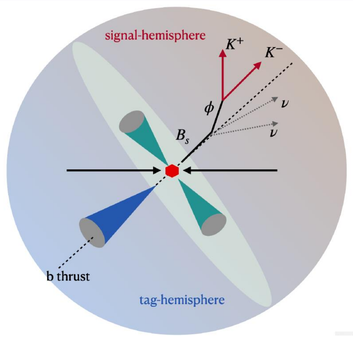


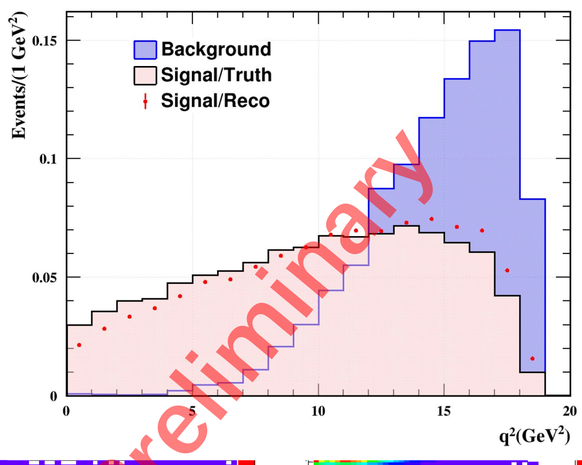


B anomalies boiled down to 9 dim-6 SMEFT LFUV opeartors, expected constraints from a Tera-Z factory (Λ = 3 TeV)

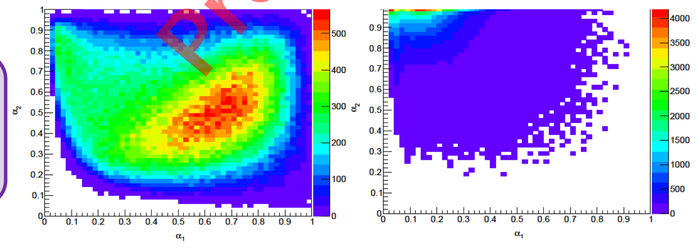
FCNC to Neutrinos

Projection of $B_s \to \phi\nu\nu$ process, using full simulation data from the CEPC group.





Kinematic differences that allows separate our signal (left) from semileptonic backgrounds (right)



References

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[2] J. F. Kamenik, S. Monteil, A. Semkiv, and L. V. Silva Eur. Phys. J. C77 (2017), no. 10 701,[arXiv:1705.11106].
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