

Exploring flavour violation with modern taggers at FCC-ee

FCC-EWP roundtable 06.05.2026
Kyle Cormier

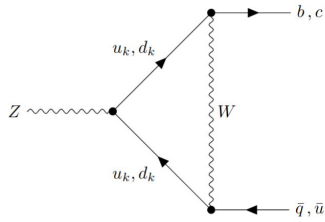
For more details, see:

<https://indico.cern.ch/event/1674070/#14-limits-on-flavour-violating>

Flavour violating boson decays: Overview

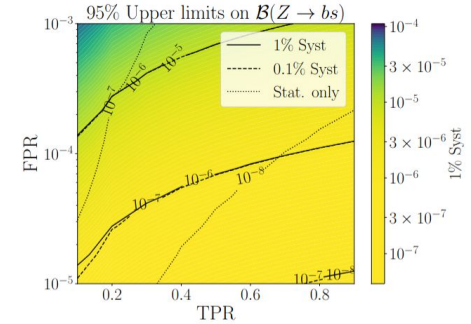
Previous work: Kamenik et. al.

<https://arxiv.org/pdf/2306.17520>



Decay	SM prediction	exp. bound	indir. constr.
$\mathcal{B}(h \rightarrow bs)$	$(8.9 \pm 1.5) \cdot 10^{-8}$	0.16	2×10^{-3}
$\mathcal{B}(h \rightarrow bd)$	$(3.8 \pm 0.6) \cdot 10^{-9}$	0.16	10^{-3}
$\mathcal{B}(h \rightarrow cu)$	$(2.7 \pm 0.5) \cdot 10^{-20}$	0.16	2×10^{-2}
$\mathcal{B}(Z \rightarrow bs)$	$(4.2 \pm 0.7) \cdot 10^{-8}$	2.9×10^{-3}	6×10^{-8}
$\mathcal{B}(Z \rightarrow bd)$	$(1.8 \pm 0.3) \cdot 10^{-9}$	2.9×10^{-3}	6×10^{-8}
$\mathcal{B}(Z \rightarrow cu)$	$(1.4 \pm 0.2) \cdot 10^{-18}$	2.9×10^{-3}	4×10^{-7}

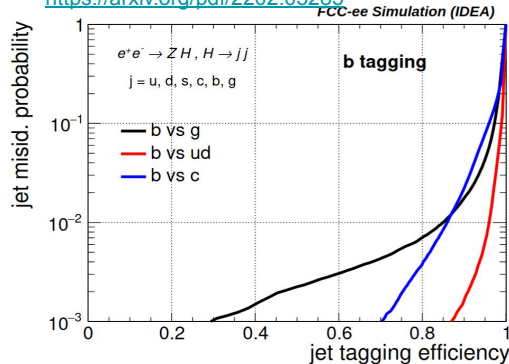
*general higgs width constraints



Estimated limits/discovery potential with simple model using simple tag/no-tag efficiency model

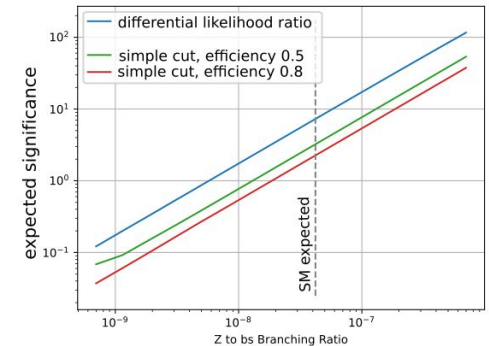
Bedeschi et. al.:

<https://arxiv.org/pdf/2202.03285>

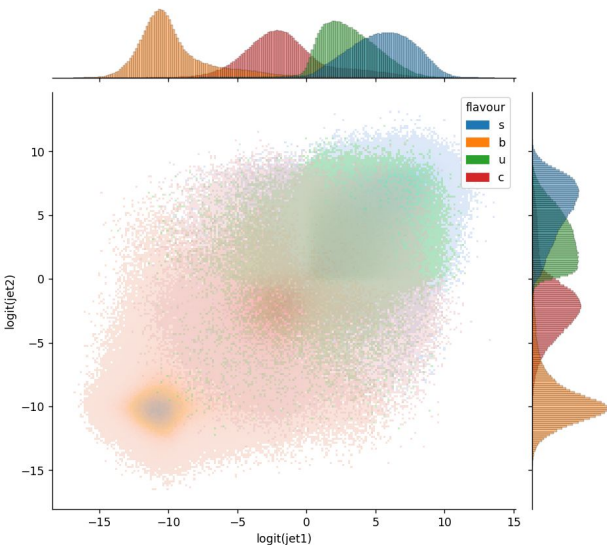


Current work

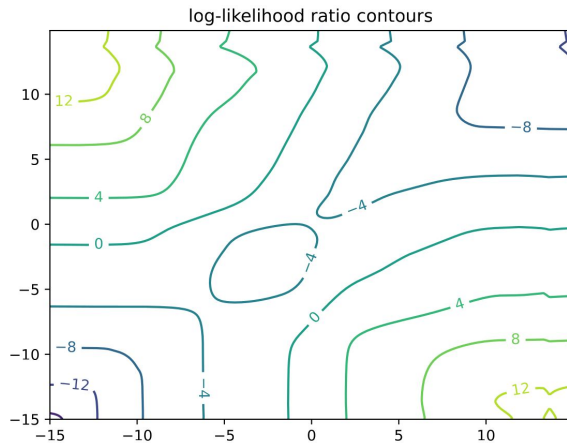
- Use ParticleNet Idea with fast simulation
- Estimate likelihood ratio in tagger-score space for better performance
- **Potential "discovery" ($>5\sigma$) for $Z \rightarrow bs$ SM**
- **Calibration of taggers will be key!**



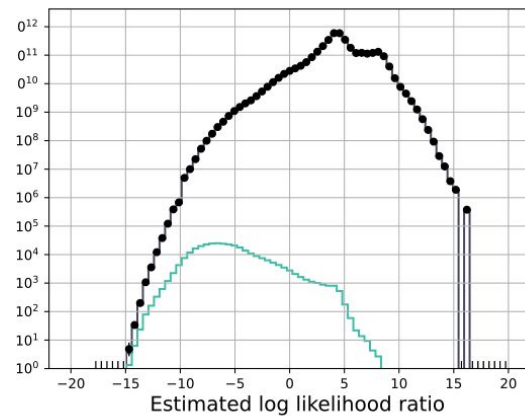
Need for Calibration



Start from tagger space of both 2D tagger scores



Divide space into estimated S/B likelihood ratio



Signal "peak" is still hidden under much larger, falling background → Requires good calibrations of background

Example calibration with lots of data

If Jet 1 and Jet 2 tag scores are independent

“ABCD”-like but extended to multiple independent sources

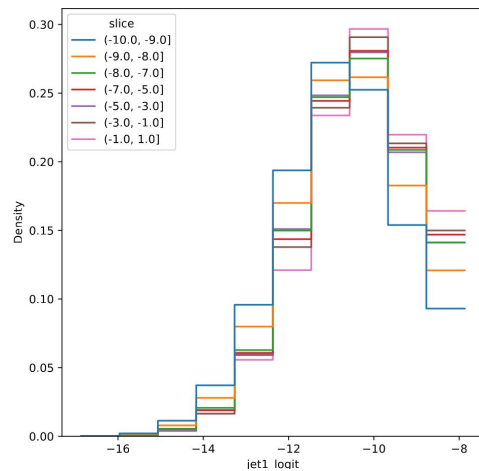
For N independent sources (e.g. 4 qq flavour pairs) in a 2-dimensional space

$$\text{Data} \cong u d_1 \otimes u d_2 + s_1 \otimes s_2 + c_1 \otimes c_2 + b_1 \otimes b_2$$

→ **system is overconstrained for a sum of independent sources if N_{bins} is large even for multiple independent background sources**

Plenty of data to do an shape-agnostic sum of independent sources calibration

Including Correlations Between Jet 1 and Jet 2



Some correlation does exist between jet scores

- Fit the data to a sum of N quasi-independent sources
- Parameterize independence of each source by parameter α_i
- Constrain fit to minimize α_i along with data-model agreement

Summary + Status

- Some preliminary work has been done showing potential improvement on old results
- Calibration will be critical
- New ideas on Calibration in data

Next Steps:

- Test Calibration Method(s) in Simulation, and refine, estimate uncertainties etc...
- Try Calibration on existing LEP data