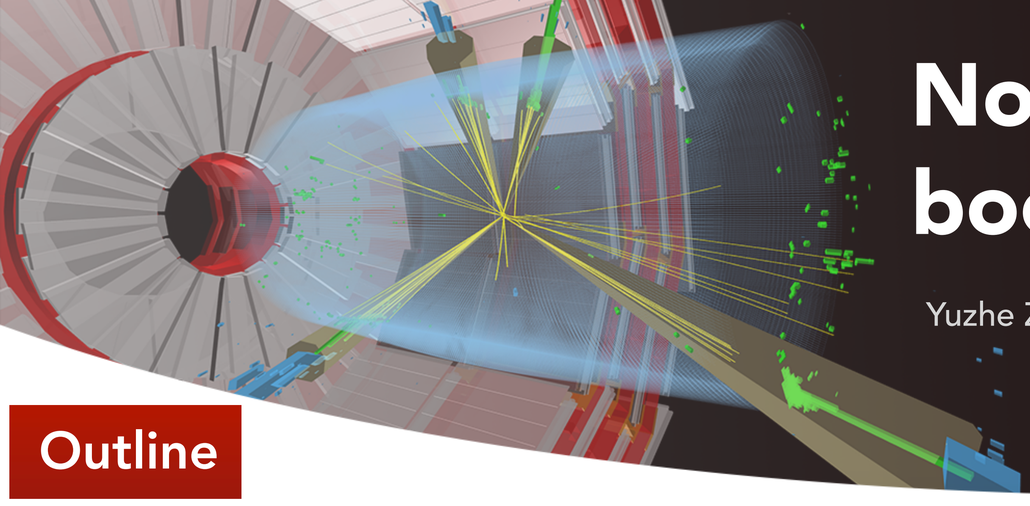


Novel $|V_{cb}|$ extraction via Lorentz-boosted *bc*-tagging at the LHC

Yuzhe Zhao, Congqiao Li†, Antonios Agapitos, Dawei Fu, Leyun Gao, Yajun Mao, Qiang Li

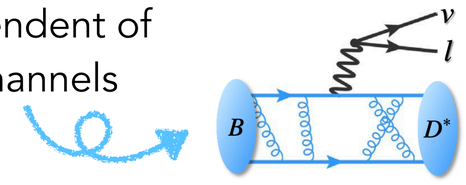
Peking University

yuzhe.zhao@cern.ch, congqiao.li@cern.ch

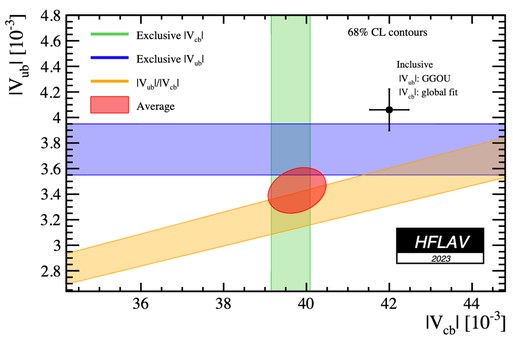
See more on arXiv:2503.00118

Outline

- **The decay of $W\to cb$** offers a clean, complementary handle on $|V_{cb}|$, independent of traditional B-physics channels



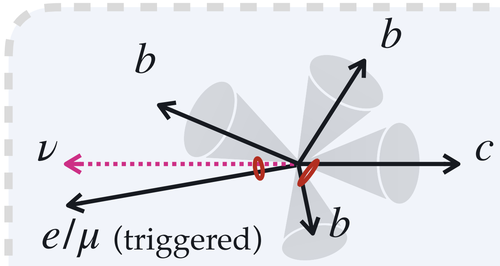
- May help address the discrepancy between inclusive and exclusive $|V_{cb}|$ measurements



- Boosted $W\to cb$ search allows **stronger background rejection**, hence better sensitivity to measure $|V_{cb}|$
- Expect to achieve ~10% level uncertainty on $|V_{cb}|$ based on Run 2+3, and ~5% uncertainty at HL-LHC

1. Method

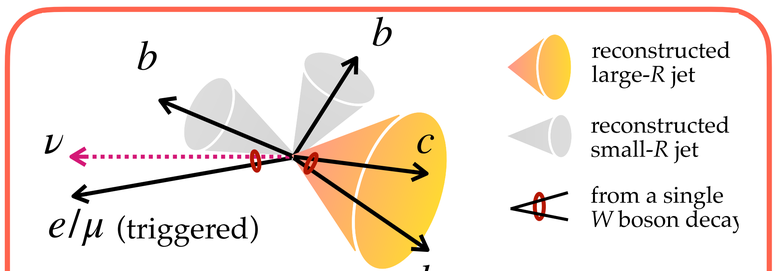
- Conventional LHC method: measuring $W\to cb$ decay from $t\bar{t}$ semi-leptonic (1ℓ) phase space



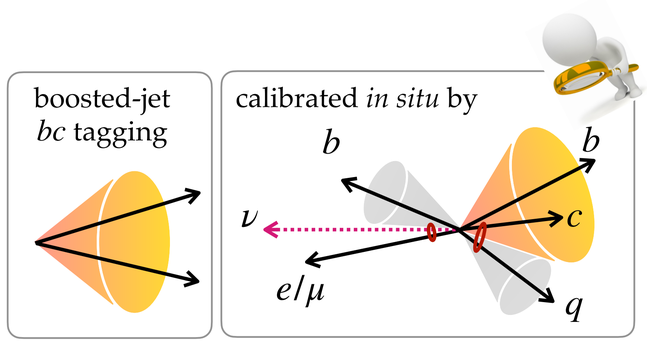
Resolved topology

vs.

- **New method:** measuring highly Lorentz-boosted $W\to cb$ decay from $t\bar{t}$ (1ℓ)



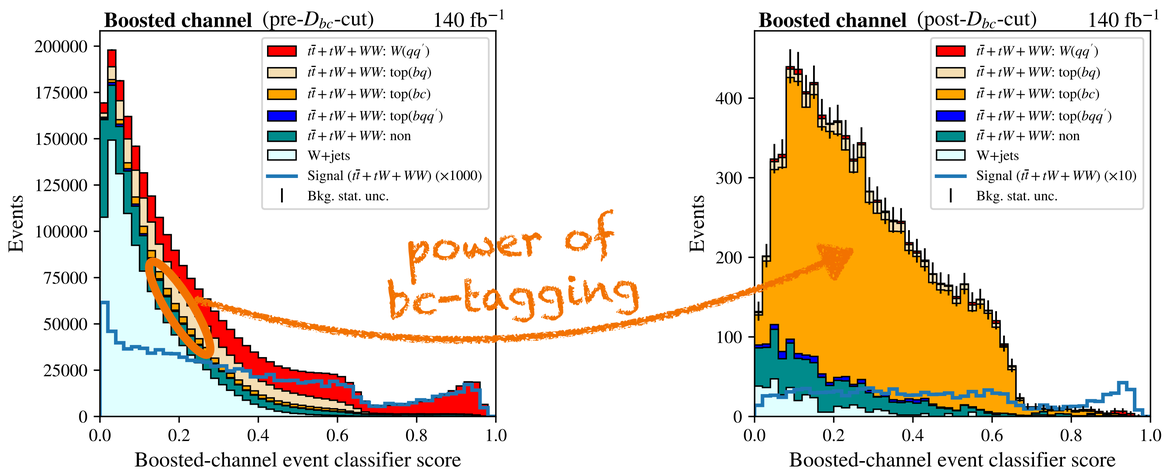
Boosted topology

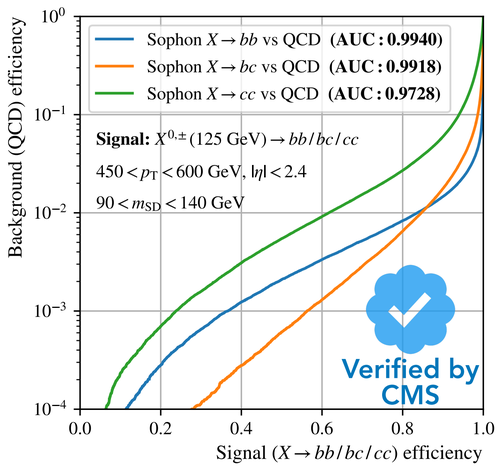


- **Benefits of boosted channel:**
  - ✓ Significant background veto powered by "boosted bc-tagging"
  - ✓ Better control of systematic uncertainties via an *in-situ* calibration

A new V_{cb} handle at the LHC —here's how...

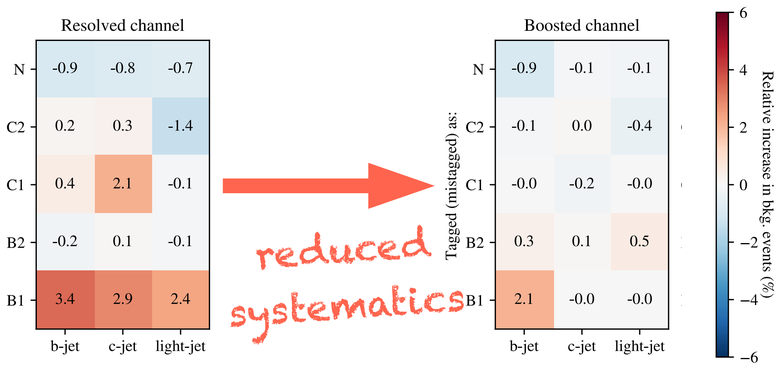
2.A Boosted bc tagging





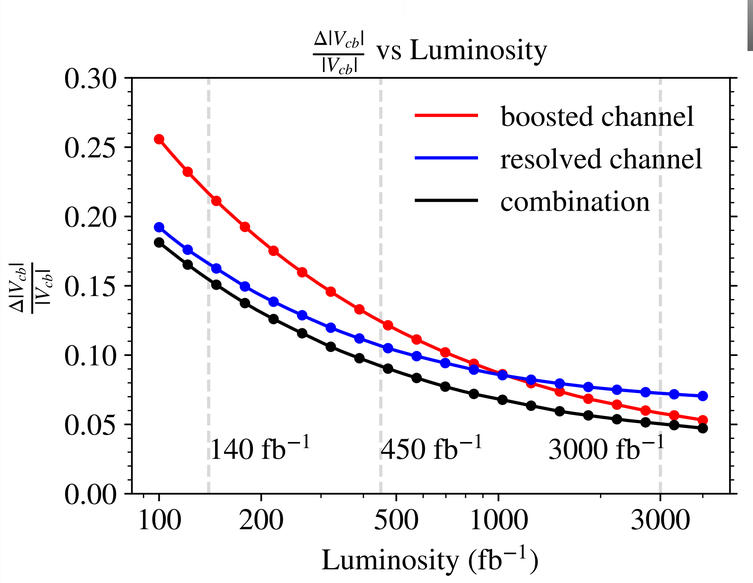
- **Superior background suppression power in the boosted regime!**
  - Retain **40% of signal** while **pushing QCD background to 0.02% level!**
  - Why so powerful? —thanks to the state-of-the-art DNN-based boosted-jet taggers in CMS/ATLAS
  - Already demonstrated in recent bb or cc-tagging analyses

2.B Flavour tagging uncertainties



- Improved flavour tagging uncertainties (traditionally the key challenge) thanks to *in-situ* calibration

3. Results

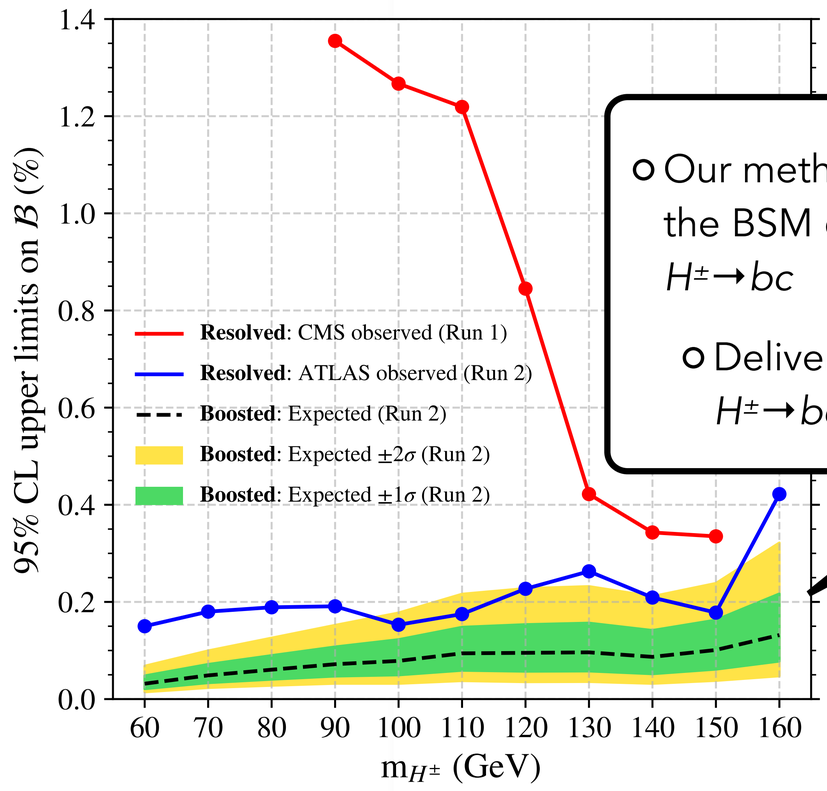


- Under Run-2 data, the conventional approach yields:

$$\Delta|V_{cb}|/|V_{cb}| = 0.065\ (\text{flavor tag. syst.}) \oplus 0.154\ (\text{stat.})$$

cross-checked with ATLAS preliminary results

- HL-LHC (3 ab^{-1}) reaches 0.05 relative uncertainty on $|V_{cb}|$
  - ATLAS–CMS combination: **0.036 relative uncertainty**. Enable to offer critical insights to $|V_{cb}|$ puzzle



- Our method also constrains the BSM charged Higgs decay $H^\pm\to bc$
  - Delivers the most stringent $H^\pm\to bc$ limit to date!