

Prospects $B_c^+/B^+ \rightarrow \tau^+\nu_\tau$ at FCC-ee

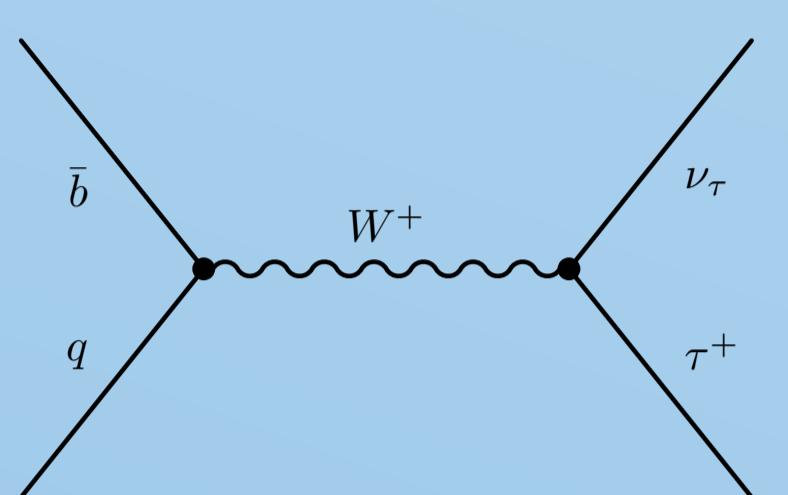
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1. Motivation - independent probe of $b \rightarrow q\ell\nu$

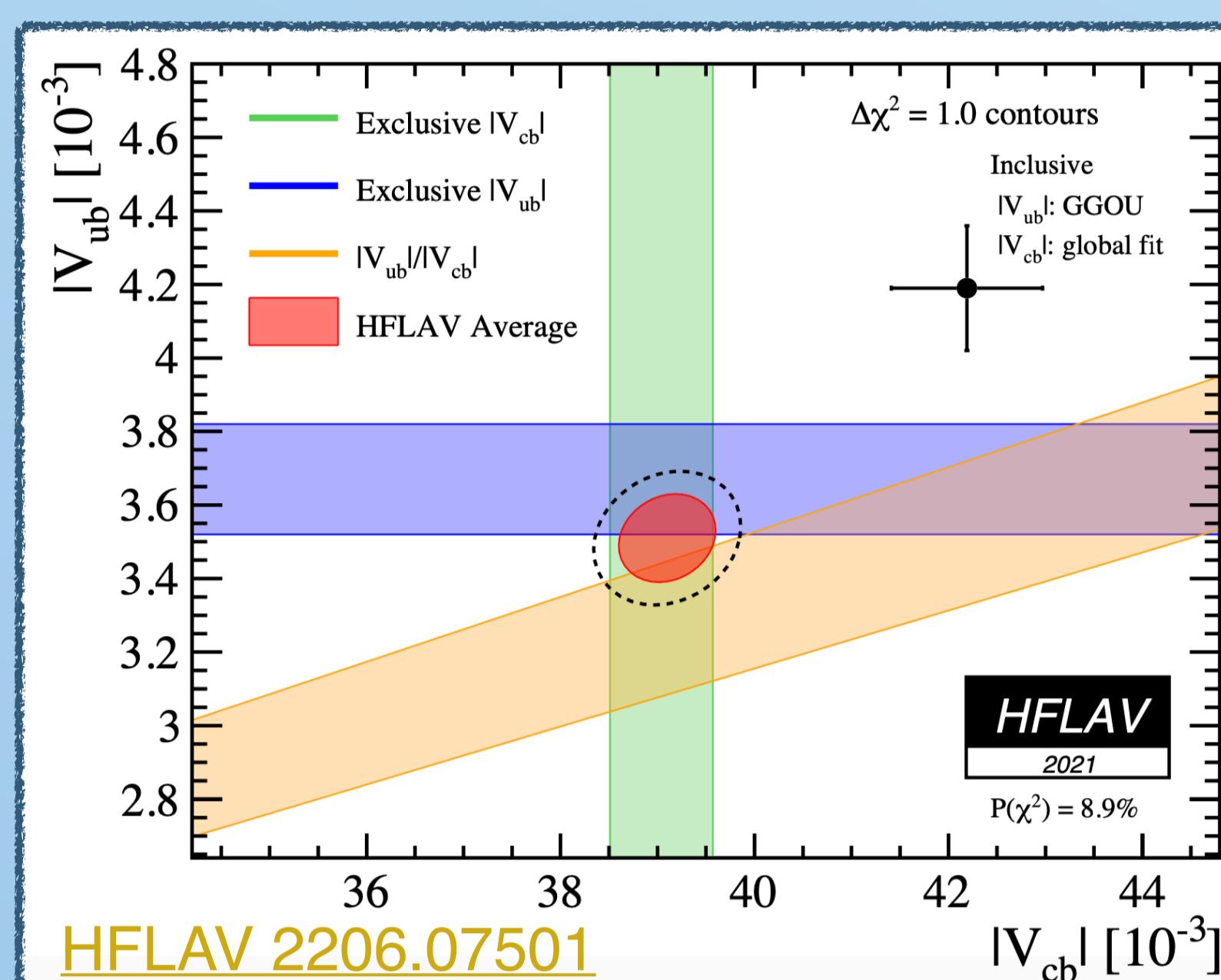
- **6×10^{12} Z bosons** expected at FCC-ee
 - About 1M $B_c^+ \rightarrow \tau^+\nu_\tau (\pi^+\pi^+\pi^-\bar{\nu}_\tau)$
 - About 7M $B^+ \rightarrow \tau^+\nu_\tau (\pi^+\pi^+\pi^-\bar{\nu}_\tau)$
 - B_c decay somewhat unique at FCC-ee

- Clean description in SM
 - Free from semileptonic form factors

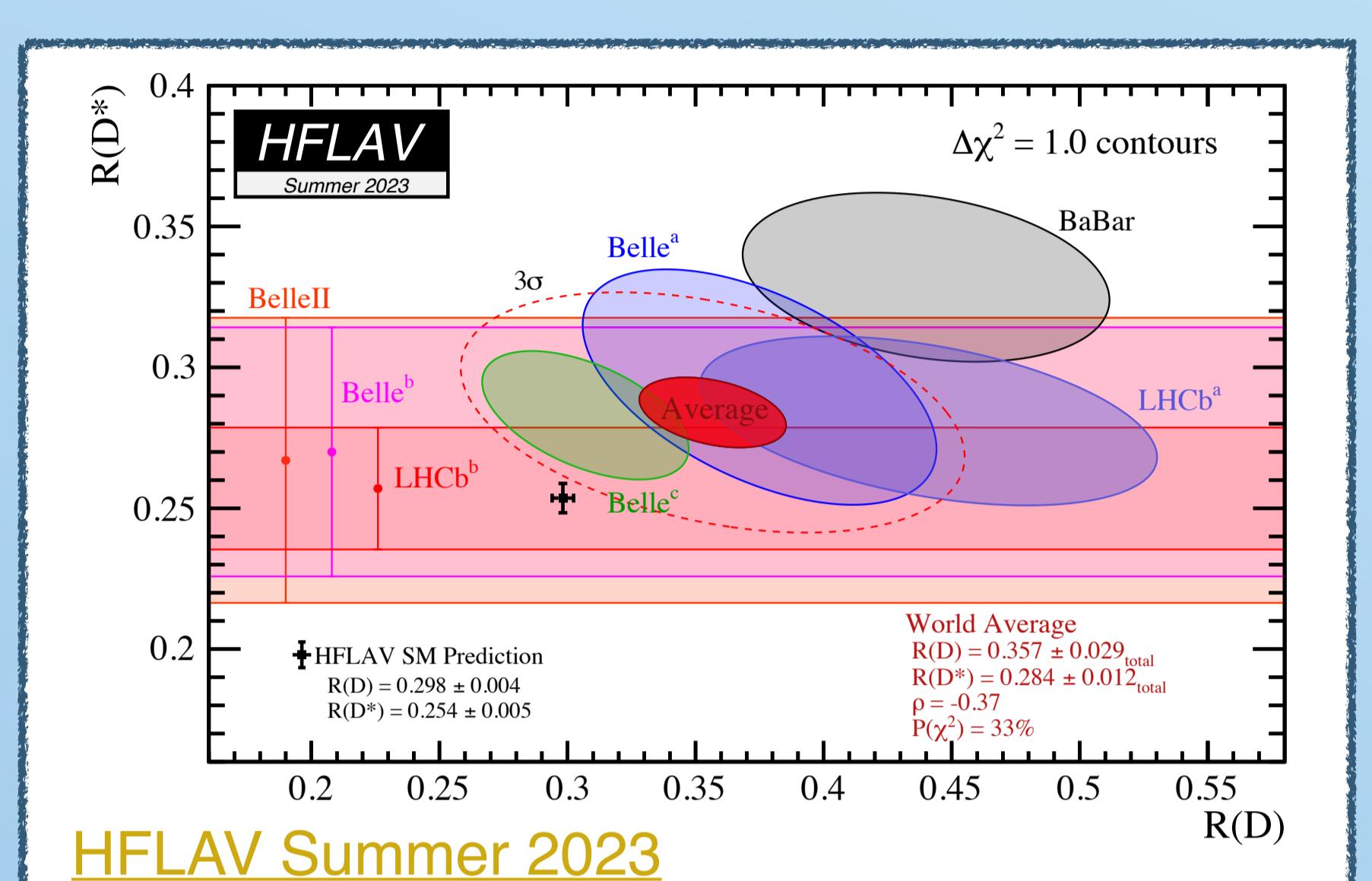


$$\mathcal{B}(B_q^+ \rightarrow \tau^+\nu_\tau)^{\text{SM}} = \tau_{B_q^+} \frac{G_F^2 |V_{qb}|^2 f_{B_q^+}^2 m_{B_q^+} m_\tau^2}{8\pi} (1 - \frac{m_\tau^2}{m_{B_q^+}^2})^2$$

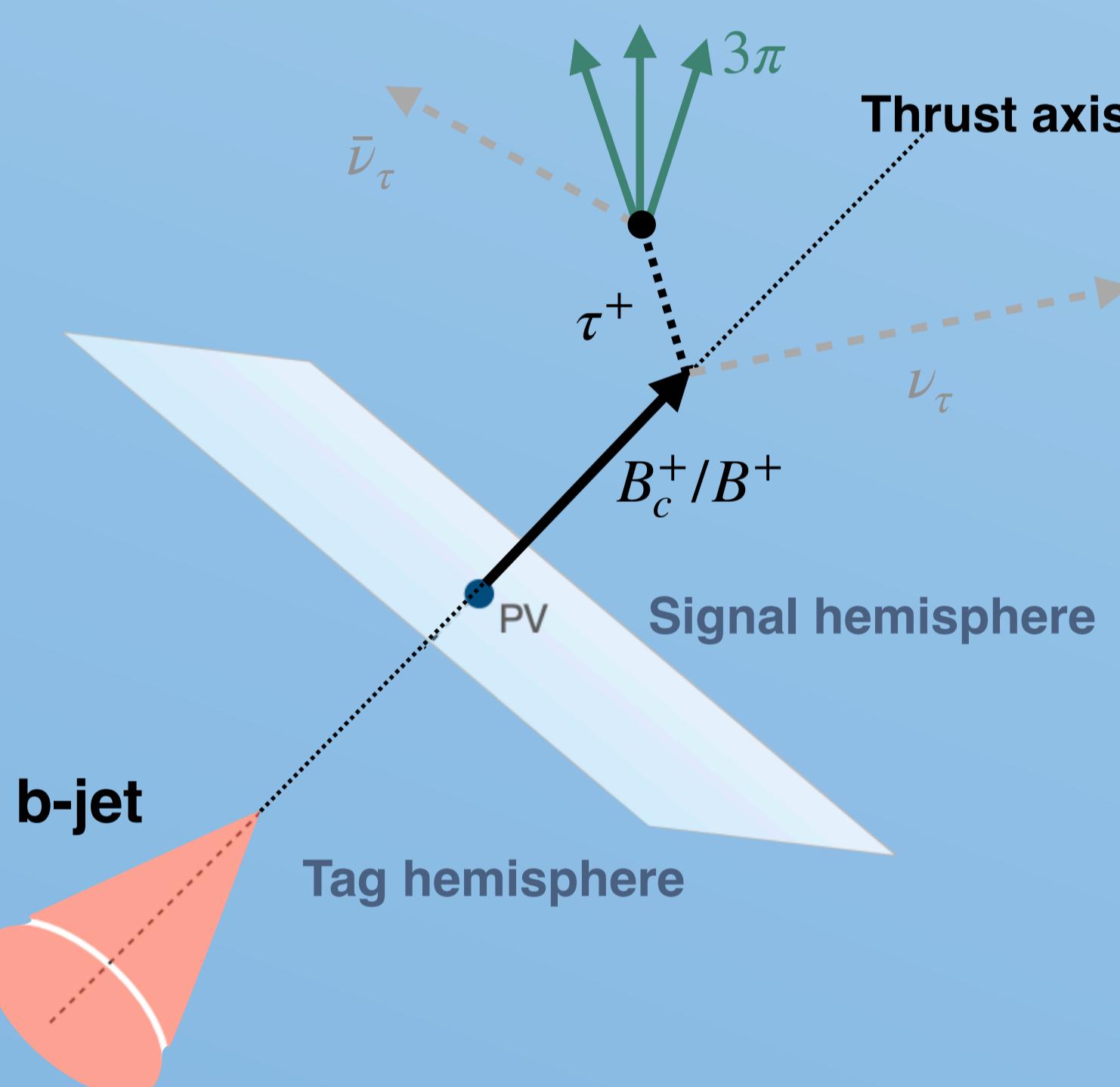
- Resolve **inclus. vs excl. puzzle** in $|V_{ub}|$ and $|V_{cb}|$



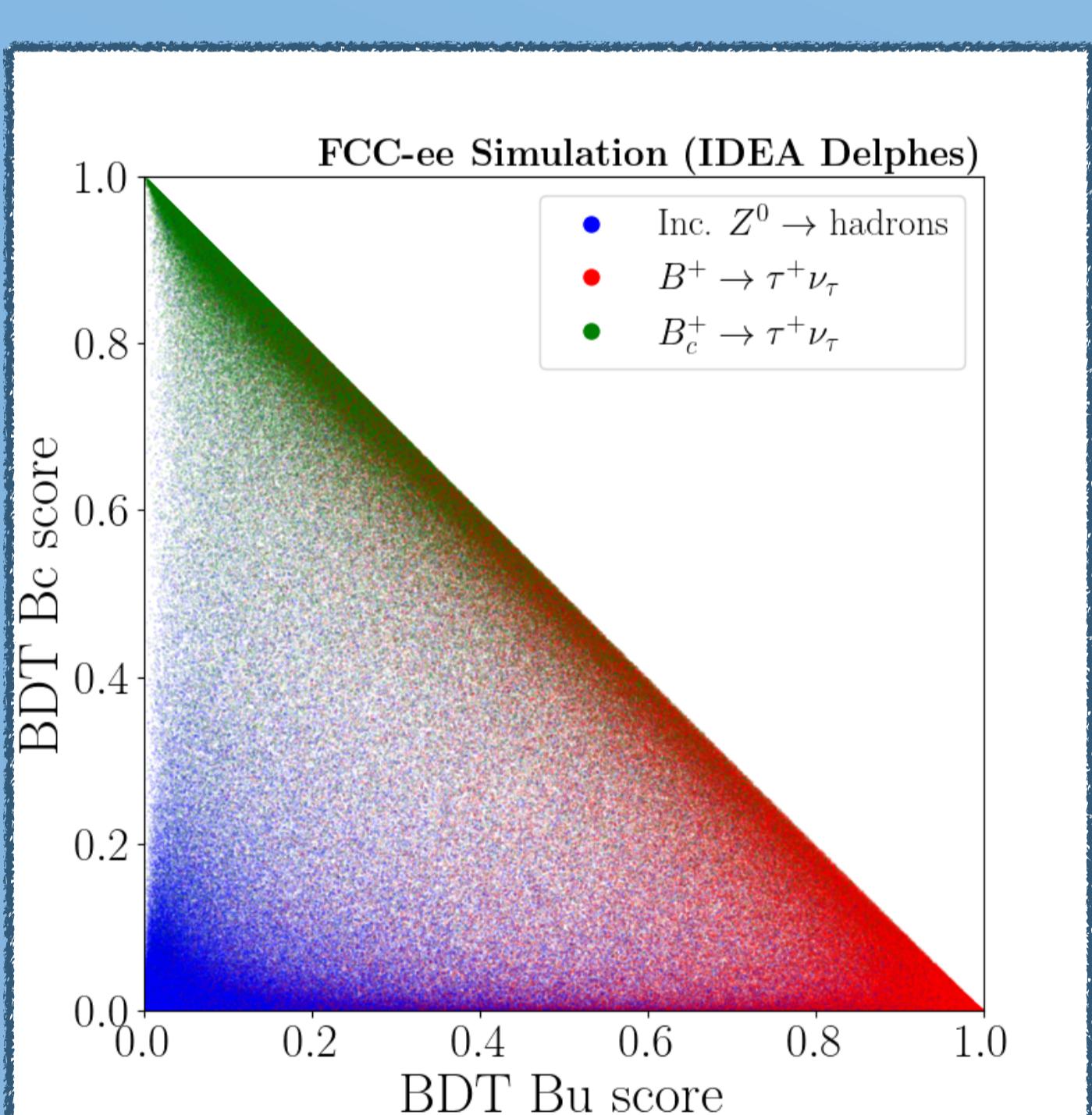
- Complementary test to $R(D)$ and $R(D^*)$ anomalies (3.3σ from SM)



2. Experimental projection



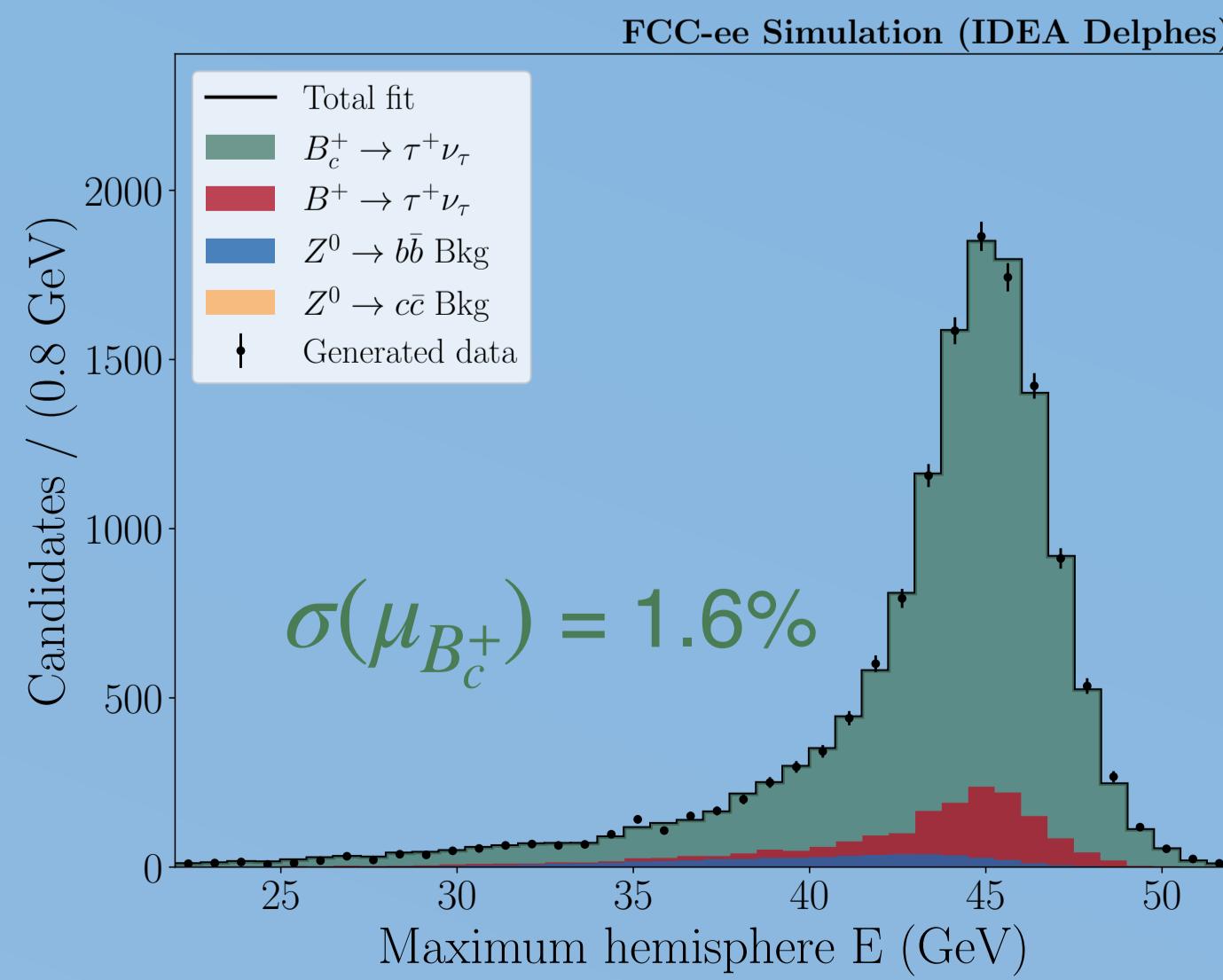
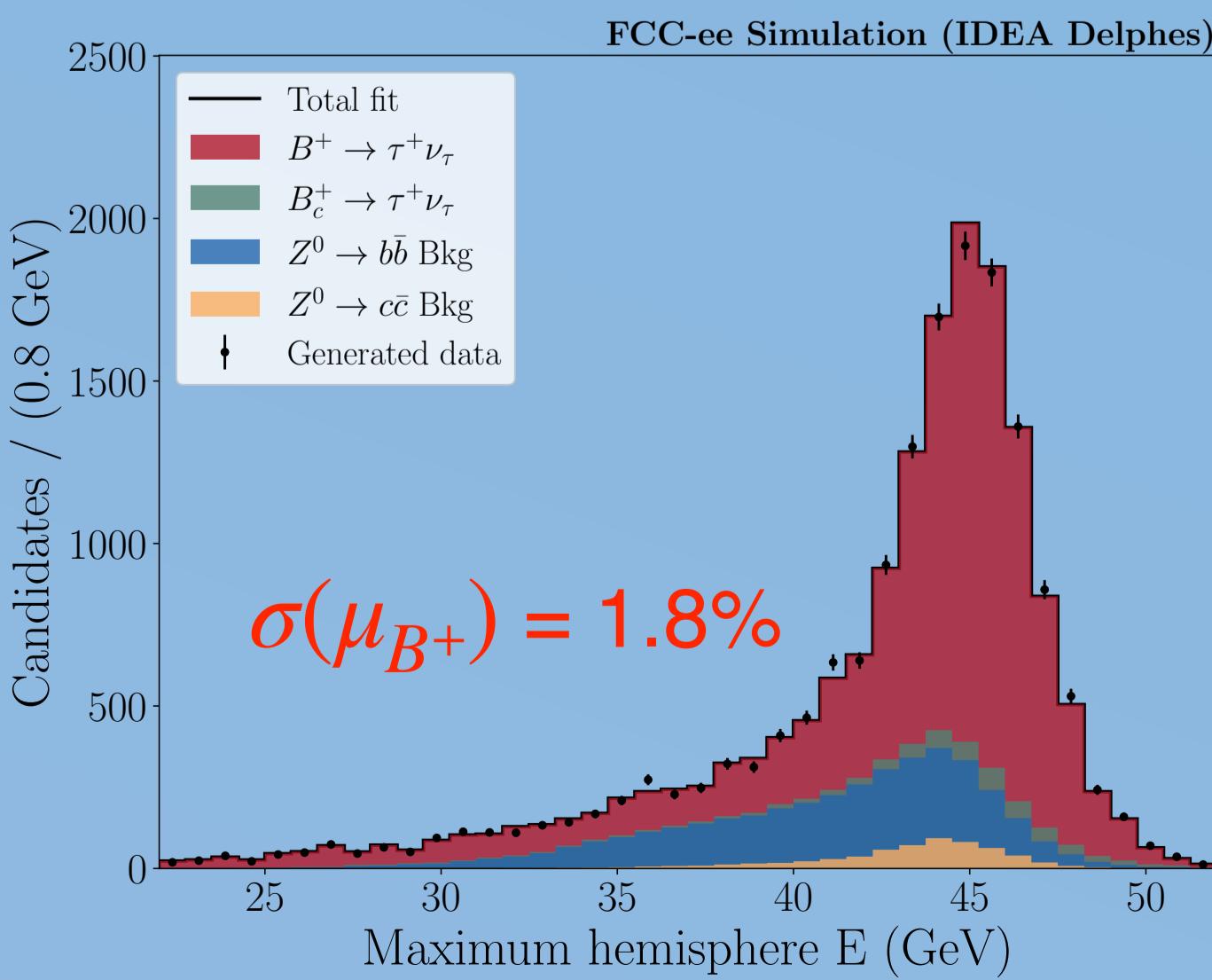
- Reconstruct tertiary $\tau^+ \rightarrow \pi^+\pi^+\pi^-\bar{\nu}_\tau$ vertex
- Compatible with $a_1^+ \rightarrow (\rho^0 \rightarrow \pi^+\pi^-)\pi^+$
- Significant E^{miss} in signal hemisphere
- More SV in B_c^+ events, due to hadronization



- Multi-classifier MVA for B^+ vs. B_c^+ vs. bkg
- Little cross-contamination between signals
- Select orthogonal corners for B^+ and B_c^+ categories
- Final selections rejects $Z \rightarrow b\bar{b}$ bkg at 10^{-10} level

Simultaneous binned maximum likelihood fit

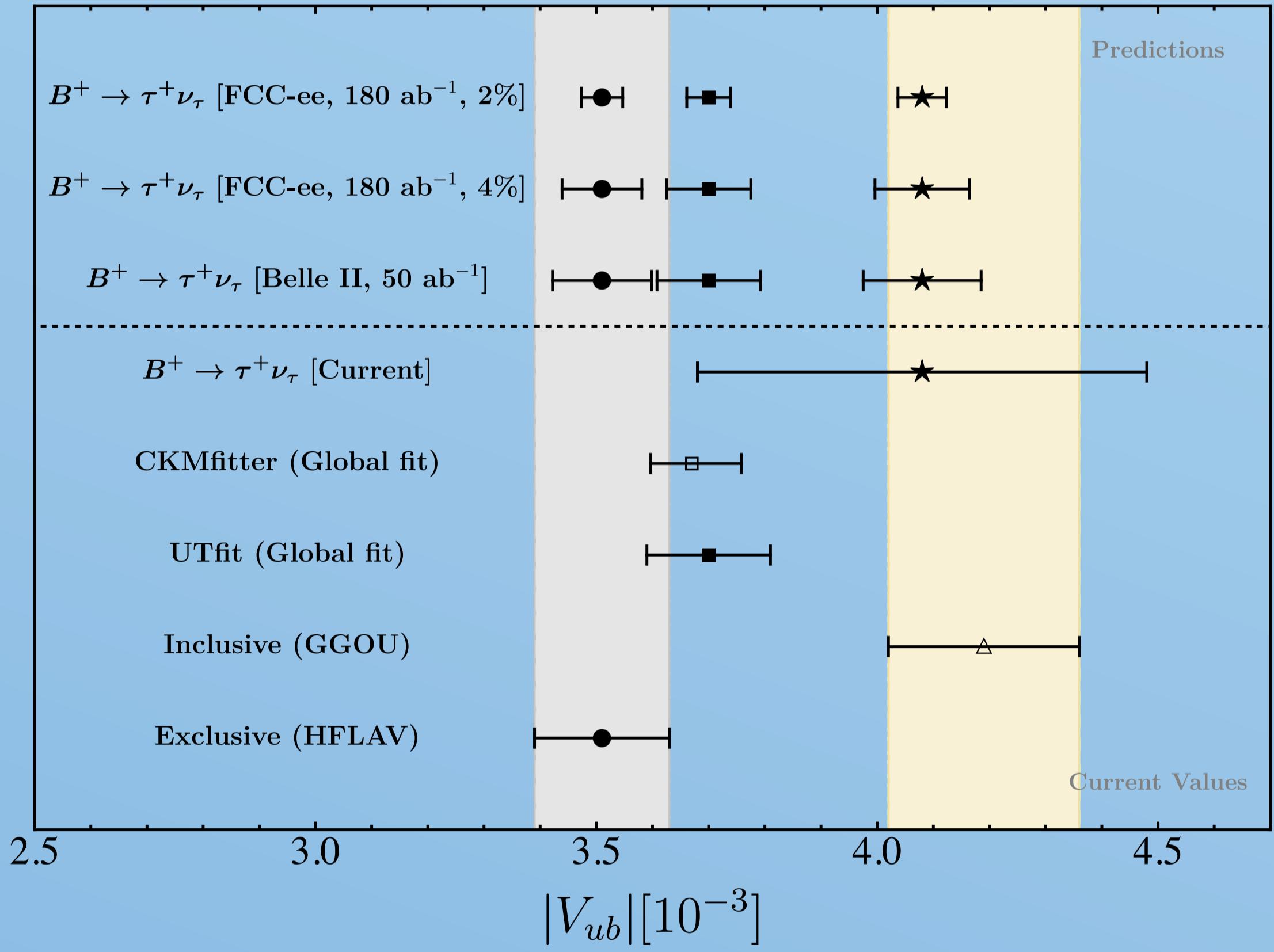
- All background unconstrained in fits
- Precisions evaluated with optimistic to pessimistic bkg yields



3. Phenomenological interpretation

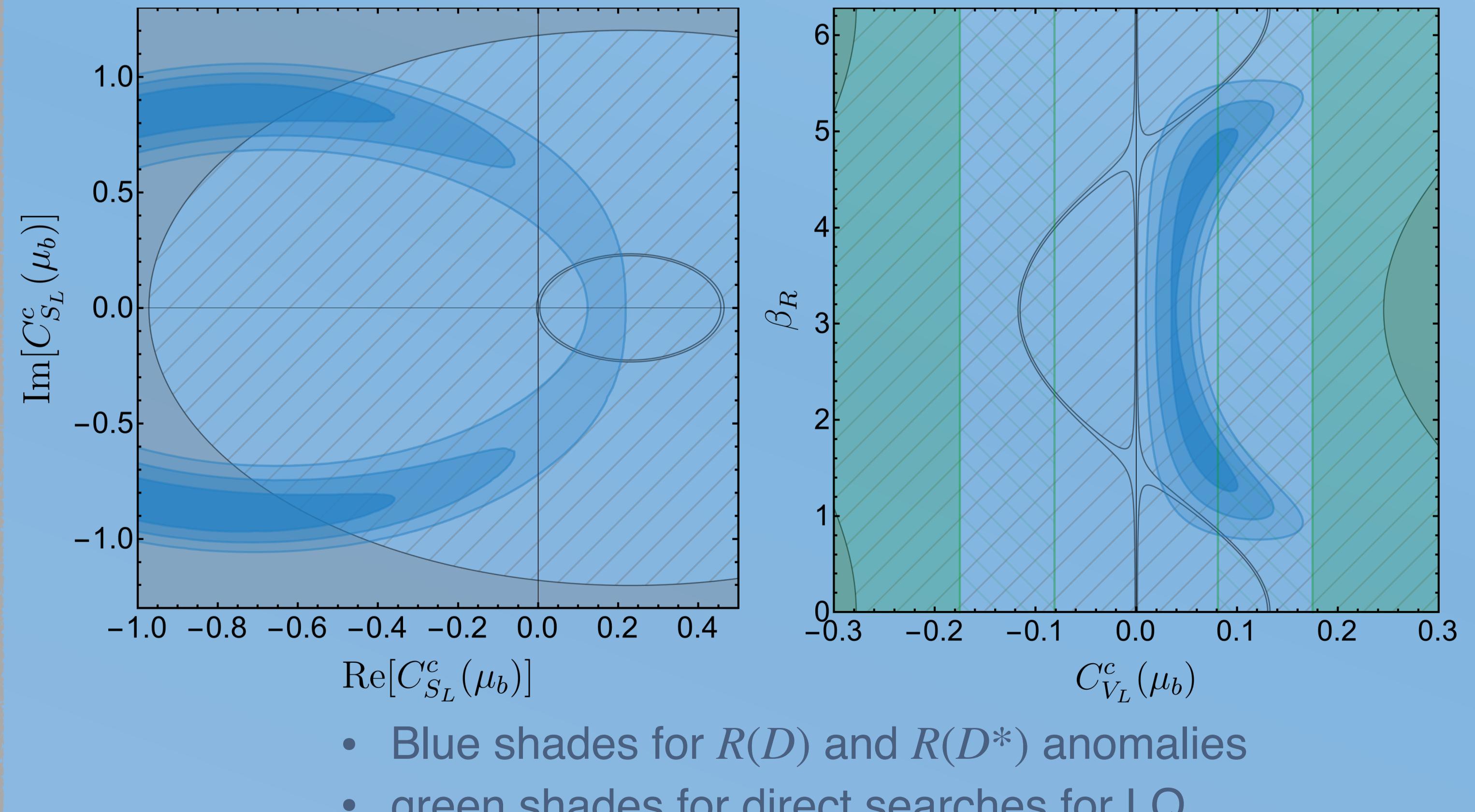
$|V_{ub}|$ extracted from $\mathcal{B}(B^+ \rightarrow \tau^+\nu_\tau)$ result

- Other theory inputs have negligible uncertainties



BSM constraints from $B_c^+ \rightarrow \tau^+\nu_\tau$ result

- Normalized to $B_c^+ \rightarrow J/\psi\mu^+\nu_\mu$ to factor out SM inputs
- Consider **Generic 2HDM** model and **leptoquark** models



- Blue shades for $R(D)$ and $R(D^*)$ anomalies
- green shades for direct searches for LQ