Search of new scalars with top quark at FCC-ee

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EXtt focus topic Group Meeting

Motivation

- **FCNC interactions** are forbidden at tree level in the SM
- **Significantly suppressed in higher orders**, especially in the case of the top quark
- Ideal to look for **new physics** effects
- Studied in detail with the LHC data
- The goal of this work is to explore the **top-scalar FCNC connection in FCCee**

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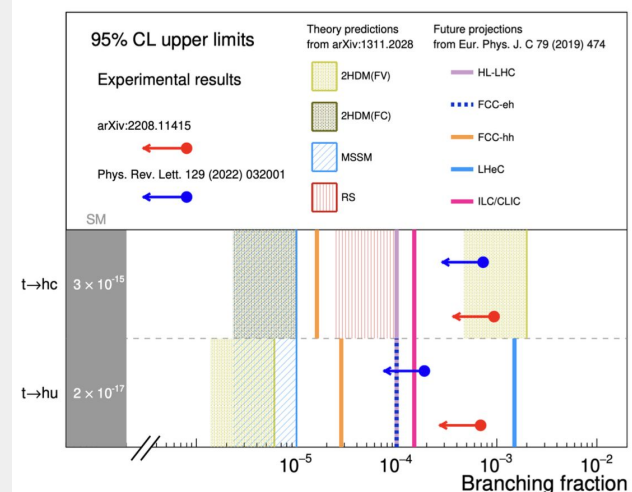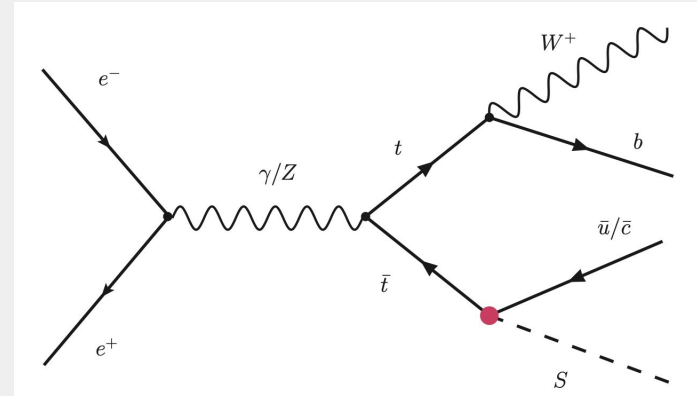
Samples

Generated signal events in MG using **TopFCNC model**

- Focus on single lepton + jets final states
- Consider only the **h → bb** decay mode
- **hct coupling**: RCtcphi = 1, ICtcphi = 1, RCctphi = 1, ICctphi = 1
- **Ecm = 365 GeV**
- Samples with scalar mass = [15, 20, 50, 125] GeV

Main background considered:

- **ttbar+jets production (NLO)**
- Cross section ≈ 0.5 pb
- Target integrated luminosity = 1.5 ab-1
- All samples use key4hep event production chain (DELPHES output, IDEA detector concept)
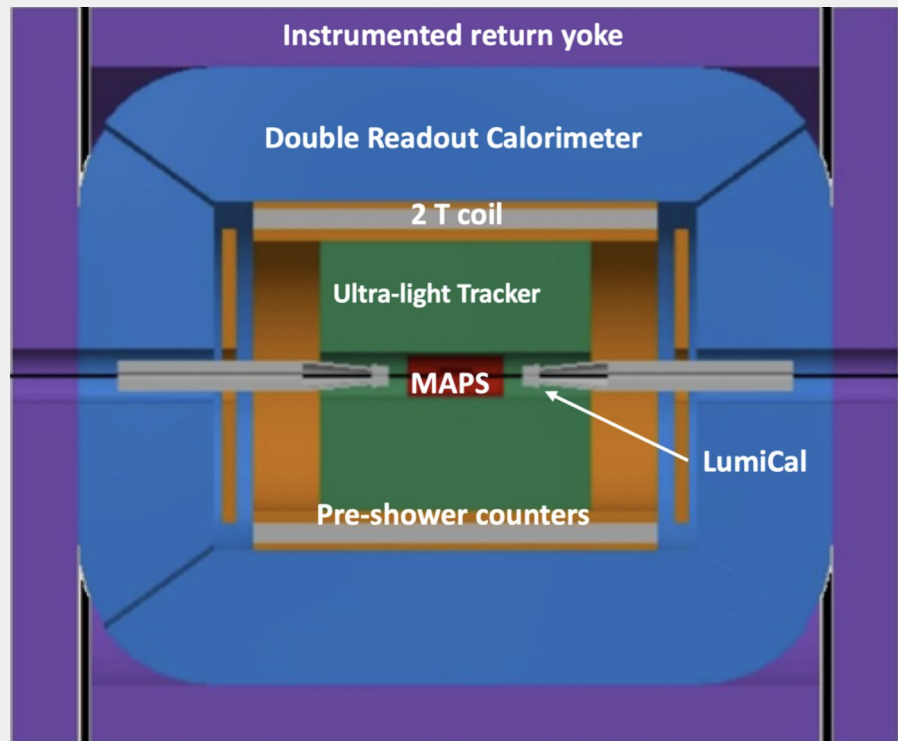
Selection

- At least one isolated lepton: p > 5 GeV, |η| < 2.9, relative isolation ΔR < 0.5
- 4-jets exclusive clustering with algo Durham, at least two of which are b-tagged (ParticleTransformer, trained on Higgs samples, training: wc_pt_13_01_2022, WP > 0.5) and at least one that is c-tagged (WP > 0.5)
- Flavour tagging performance is crucial for this analysis.
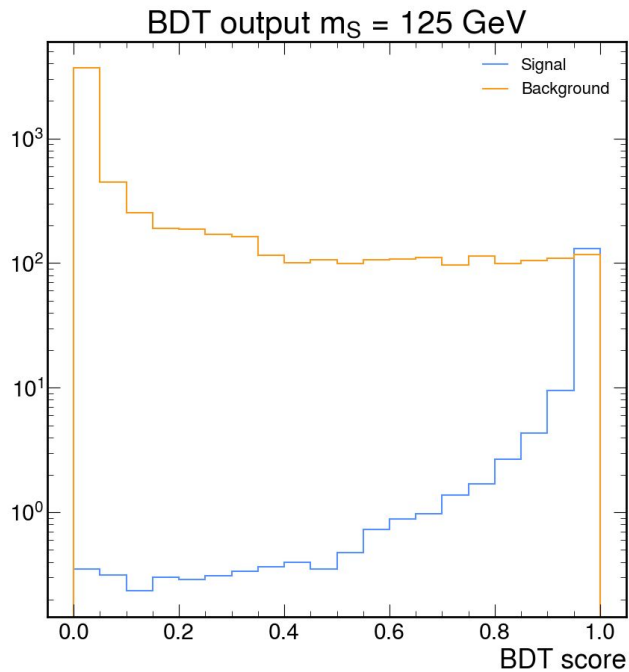- Jets are combined in order to get the best combination for the S -> bb and t -> cS

BDT to discriminate signal to background
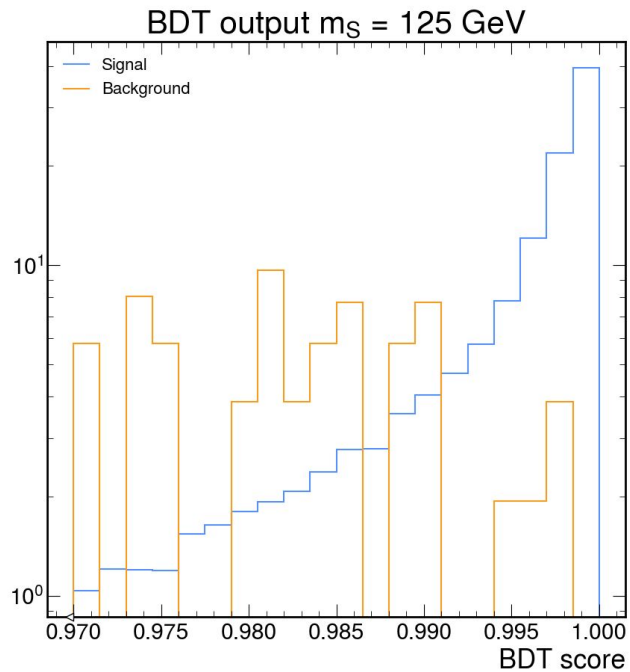- With good performance for high working point (0.97).

BDT output m_S = 125 GeV
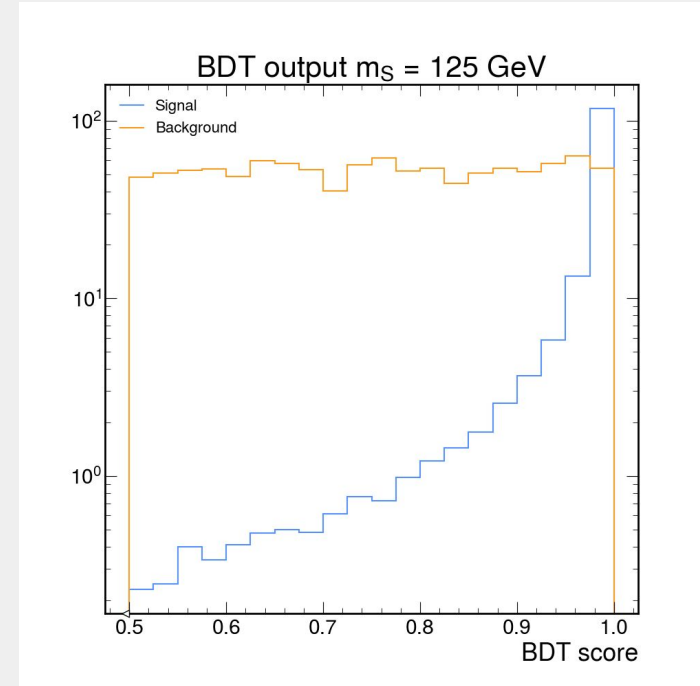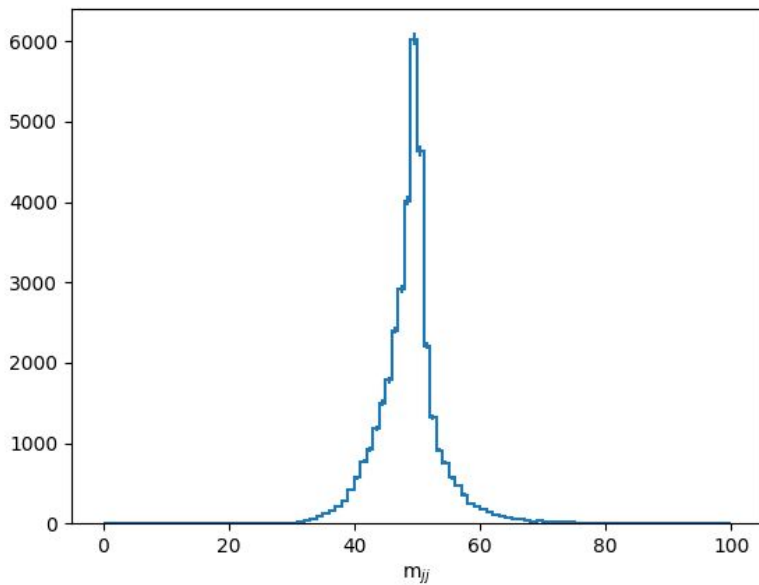
BDT output

no BDT selection

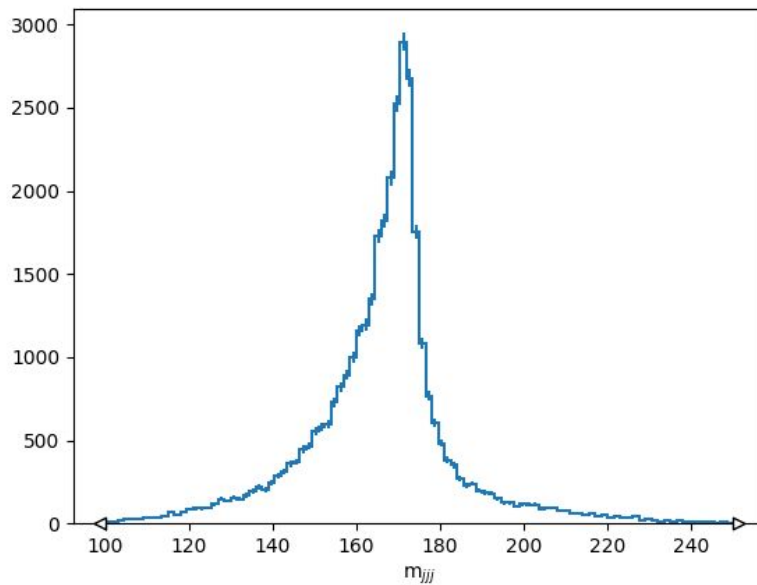**after the cut = used in the final fit**

Observables

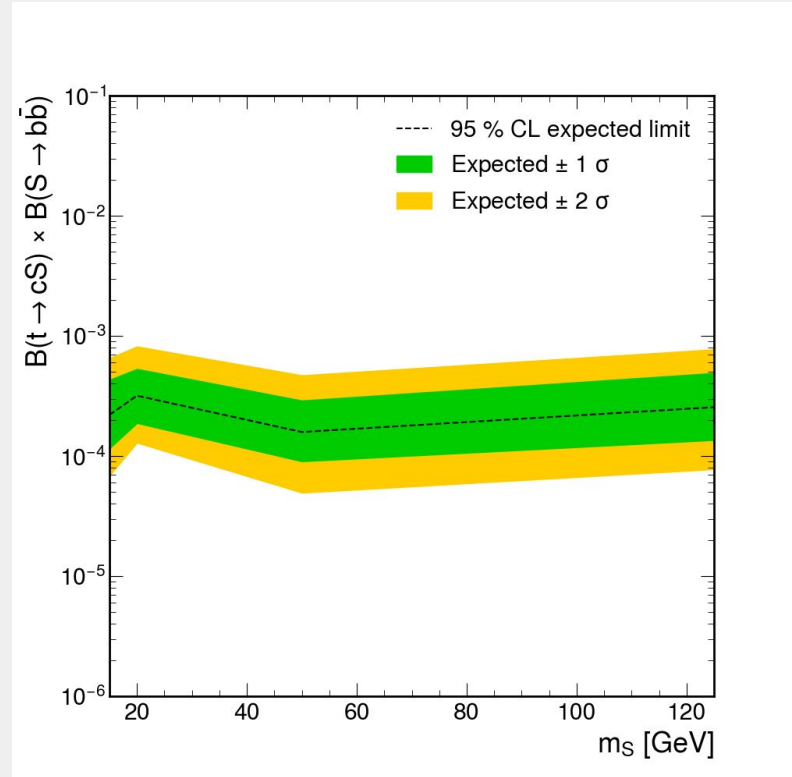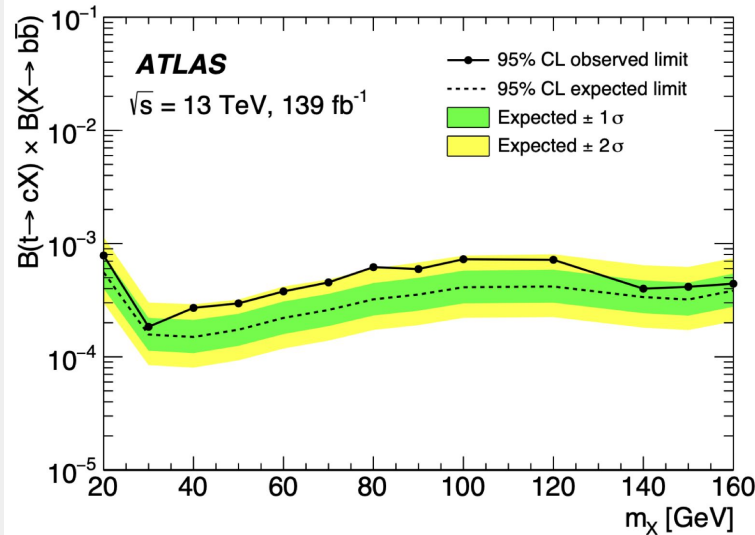**Invariant mass of the two jets bb**

Invariant mass of the three jets cbb

Limits

- Limits computed for scalars with the masses 15, 20, 50 and 125 GeV
- Sensitivity comparable with the current LHC light scalar searches
- CLIC sensibility is not far (8.8 x 10^{-5}, arXiv:1807.02441)

arXiv:2301.03902

Summary

- A very significant improvement in the sensitivity is obtained after the analysis strategy optimization (as expected)
- Currently excluding the top FCNC decay branching fractions down to the order of 10^{-4} (comparable to the CLIC projections)
- A unique sensitivity to very low scalar masses below 20 GeV (not reachable at the LHC)
- Still enough room for further improvement:
  - Add the analysis of the fully hadronic channel (currently, only the lepton+jets channel is included)
  - Add a BDT to pick the best jet permutation in the top quark reconstruction
  - Evaluate the analysis sensitivity in a finer binning at low scalar masses
  - Extend the studied scalar mass range up to the top quark mass
  - Add any remaining subdominant background processes for the final result