Higgs couplings to hadrons in the Z→νν channel @ FCCee

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FCCee Higgs kick-off meeting
Mar 23, 2022

Introduction

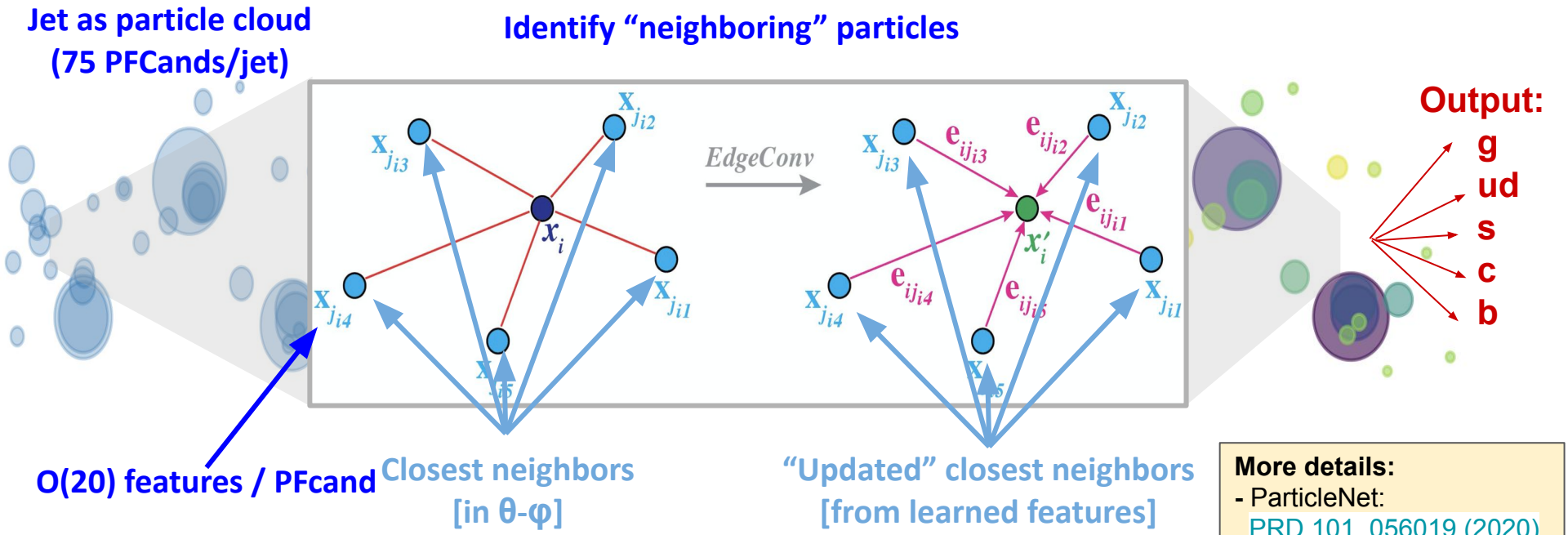
- **Big priority of FCCee: measurement of Higgs couplings**
  - Higgs-bottom: <1% precision at FCCee
  - Higgs-charm: extremely challenging/ [probably] impossible at the LHC
    - Aim ~% precision at FCCee
  - Higgs-strange: Can we probe SM couplings at FCC-ee?
  - Interaction with gluons?

- **How?**
  - Detectors with excellent tracking & vertexing capabilities, timing information
  - Powerful jet flavour tagging algorithms

- **Focus of last year:**
  - (a) study different detector concepts
  - (b) develop a jet tagging algorithm using state-of-the-art techniques
  - Summary of results: ArXiv:2202.03285 (submitted to EPJ C)

Flavour tagging

- **Exploit low-level info (ie. PFcands) and Graph NN (ie. ParticleNet)**

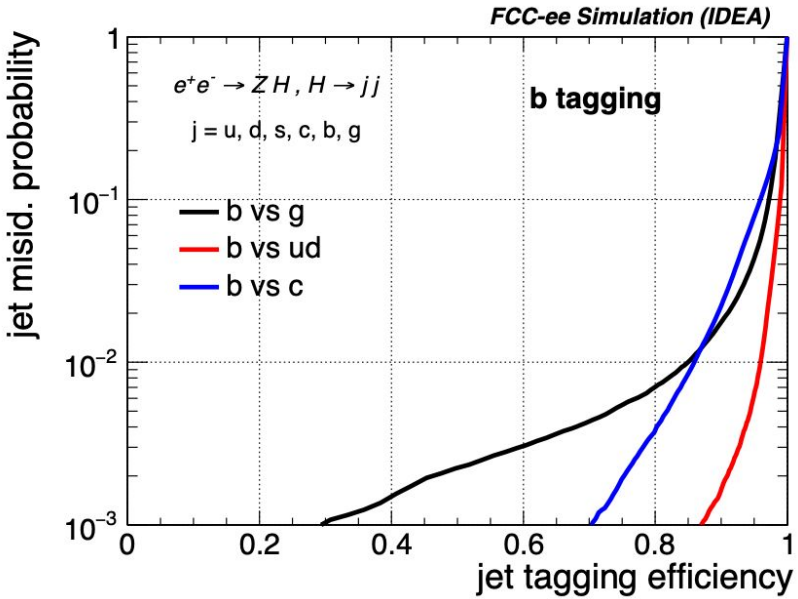


More details:
- ParticleNet: PRD 101, 056019 (2020)
- ParticleNetIDEA: arxiv

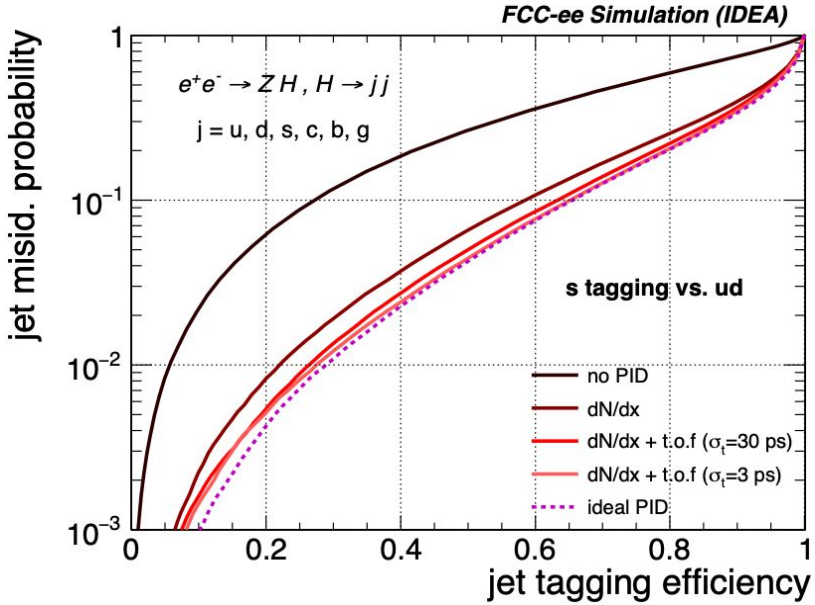
Flavour tagging (II)

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

Bottom tagging



Strange tagging



Powerful performance
(NB. using Delphes simulation)

Higgs coupling measurements

- **What precision aiming for (eg. H-charm coupling)**

FCCee: σ_{ZH}~200fb, L~5 ab^{-1} (2 IP): **~1M ZH**
[600k H→bb, 100k H→gg, **30k H→cc**]

- **Stat limit [i.e. no BKG]:**
  $\delta(\sigma_x BR)/\sigma_x BR$ (%) ~0.6%
- **No BKG rejection:**
  $\delta(\sigma_x BR)/\sigma_x BR$ (%) ~2.9%

Charm tagging WP:
[c-tag: 90%, b-mistag: 5%, g-mistag: 10%
- **Scenario 2:** Z(→νν)H
  $\delta(\sigma_x BR)/\sigma_x BR$ (%) ~ 1.5 [no systematics]
- **Scenario 1:** Z(→all)H
  $\delta(\sigma_x BR)/\sigma_x BR$ (%) ~ 0.7 [no systematics]

Looks promising!

Higgs coupling measurements (II)

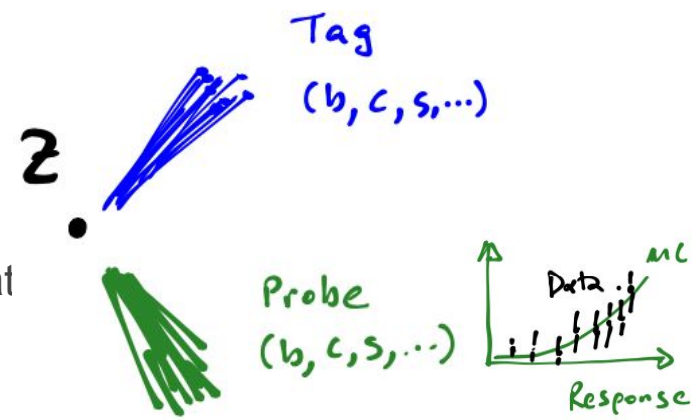
- **Target Z(→νν)H(→qq)**
  - And exploit the potential of multi-classification to measure Higgs-quark couplings
    - Focus on bb/cc/ss decay modes
  - Main BKGs: Z(→νν)Z(→qq), WW

- **Possible avenues:**
  - **Event categorization:** Select the jet with the largest sum of “s”+”c”+”b” scores
    - If “b” > max(“c”, “s”): H→bb event; If “c” > max(“b”, “s”): H→cc event , etc..
  - **Event-level separation:**
    - **Simpler-one:**
      - Multiple [orthogonal] categories using the cc, bb, ss scores
      - Extract signal by fitting m(dijet)
    - **More aggressive-ones:**
      - All event-level variables + tagger scores as input in a NN [ala LHC]
        - Very critical, full shape calibration of the tagger’s scores
      - Process full event [ie. PFcands] using ML

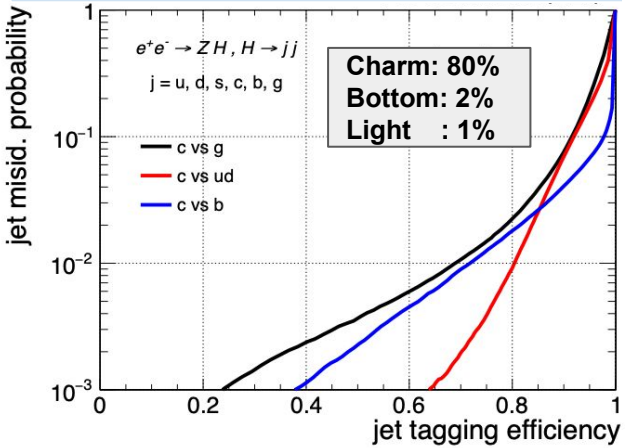
Start with the simpler one

Calibration strategy [/jet calibration]

- **Use a Tag-&-Probe method @ Z-pole**
  - **Tag:** one of the two jets with high purity
  - **Then:** use the 2nd jet to calibrate signal and mistag rat
  - **Extrapolate** measurement to jets from Higgs decay
- **Important: Tagging performance**
  ~similar b/w Z & Higgs



E.g.: charm tagging calibration



Back of the envelope.

Z → hadrons ~ 70%

⇒ bb ~ 15%

→ cc ~ 12%

Expected Z events (after Tag selection)

Incl. Z	Z→cc (30%)	Z→bb (2%)	Z→ll (1%)
10^{12}	10^{11}	3×10^9	4×10^9

For the 80% charm WP:
rel. unc. (stats-only) ~ $10^{-4} - 10^{-5}$

Overview and next steps

- **Target Z(→νν)H(→qq) mode and measure Higgs-quark couplings**
  - First focus on H-b, H-b, H-c; then target other flavours
  - Exploit potential of PaticleNetIDEA
  - Use official FCCSW
- **Short-term plan**
  - Incorporate ParticleNetIDEA in FCCSW
    - Possibly useful for other analyses
    - Bonus: prepare the infrastructure for other such tools
  - First results in time for FCC Week [June]
  - ParticleNetIDEA calibration;
    - access realistic uncertainties for the measurement
    - Provide a strategy to calibrate all jet flavours [but gluons]