Tagger on Z -> qq events

Tagger from Michele, Loukas et al, version wc_pt_13_01_2022
- ParticleTransformer
- trained over Higgs samples (winter2023, Whizard + Pythia6)

Used out-of-the-box over Pythia8 events of Z -> qq events at $\sqrt{s}$ = 91 GeV
- exclusive samples, about 10M events each
   Z -> bb,
   Z -> cc,
   Z -> ss,
   Z -> uu & dd

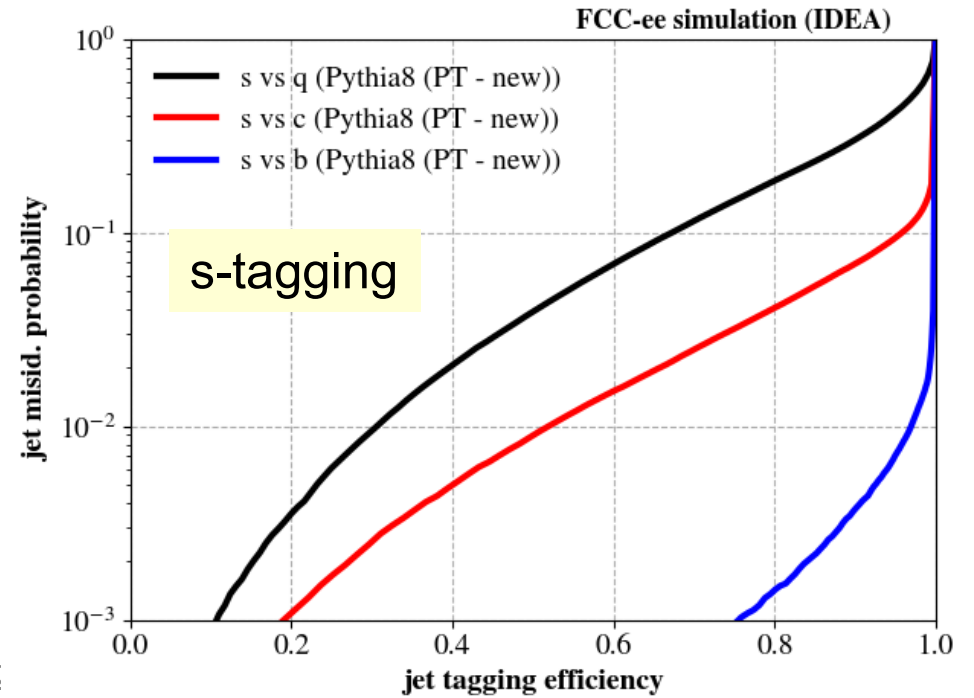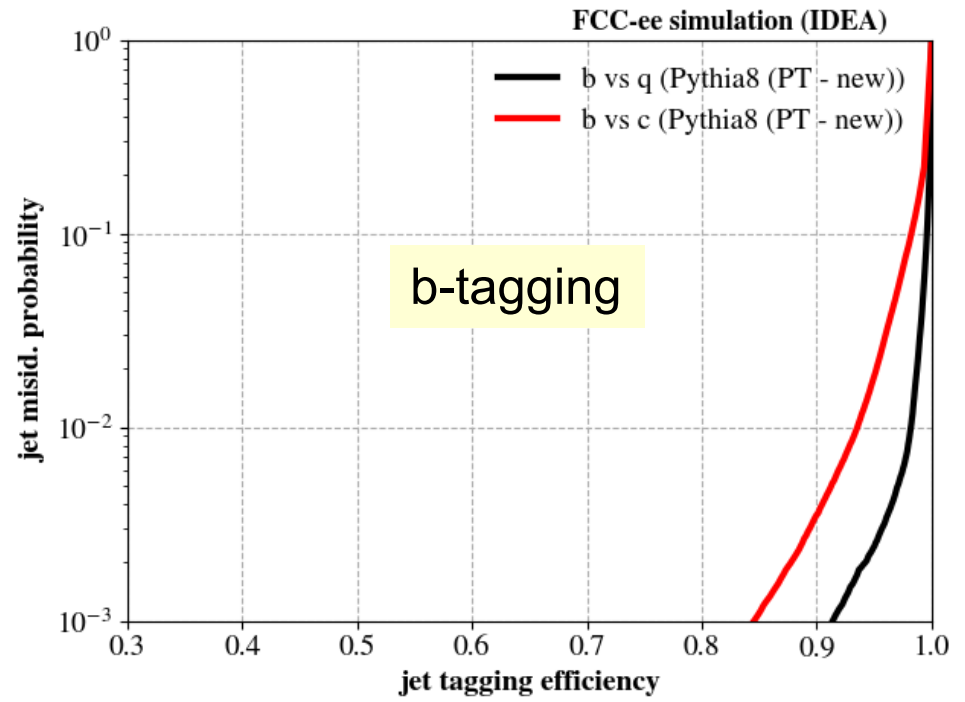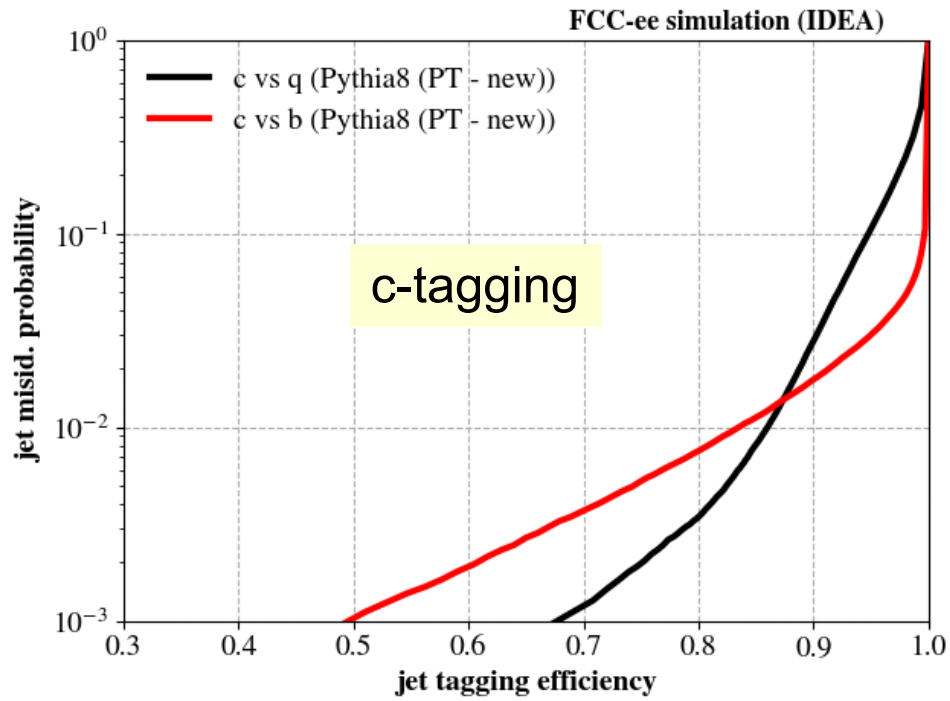Jets = exclusive Durham, N = 2 jets, E-scheme

See https://github.com/HEP-FCC/FCCAnalyses/tree/master/examples/FCCee/weaver
- very well documented and easy to use !

ROC curves from plots_roc.py in the examples/FCCee/weaver directory
- see next slide
- very similar to the performances seen over the Higgs samples

ROC curves, Z -> qq

b-tagging

c-tagging

s-tagging

Tagging efficiencies (b-tagging)

B-tag criterium used in the following:
isB > cut or
isB / (isB + isC) > cut

Looked at tagging efficiencies versus several variables

And at correlations, i.e. tagging efficiency of one leg when the other leg is tagged.

Py8, Z → bb, √s = 91 GeV

- b discr.
- c discr.
- s discr.
- q discr.
- g discr.

a.u.

discriminant

Motivations:
- Data-driven calibration of the tagger on Z events ("tag and probe")
- Rb, inclusive measurement from double-tag method
    - From the ROC curves, expect superb precision. But correlations must be minimised / understood
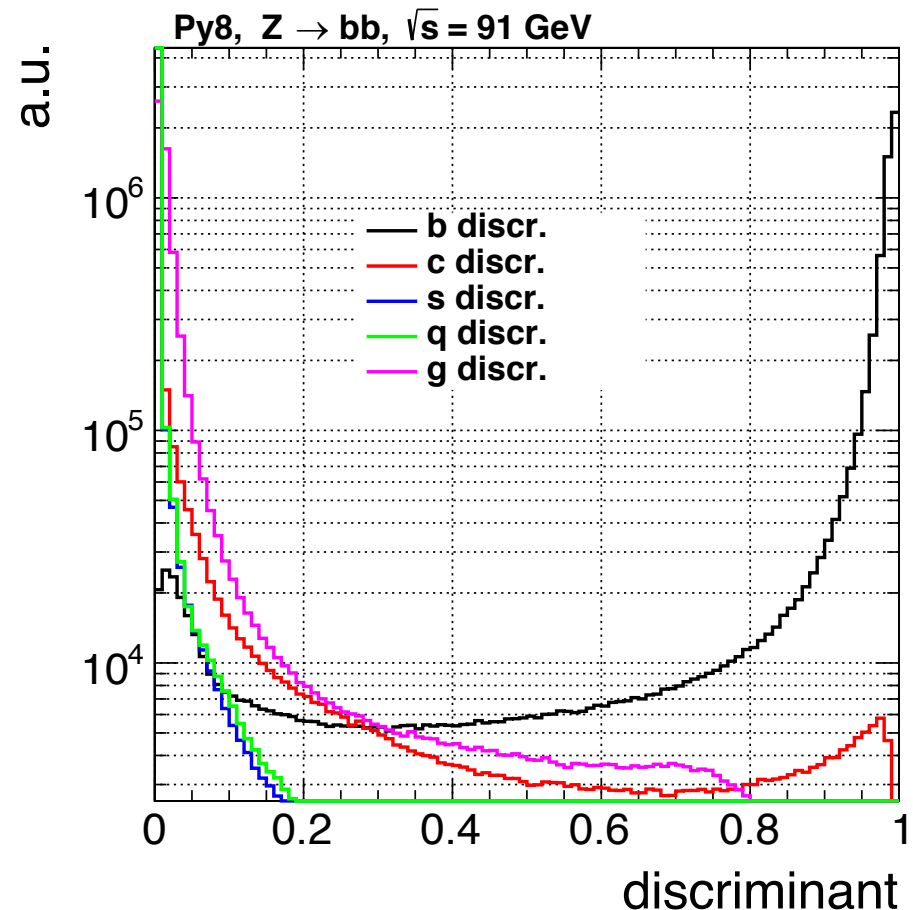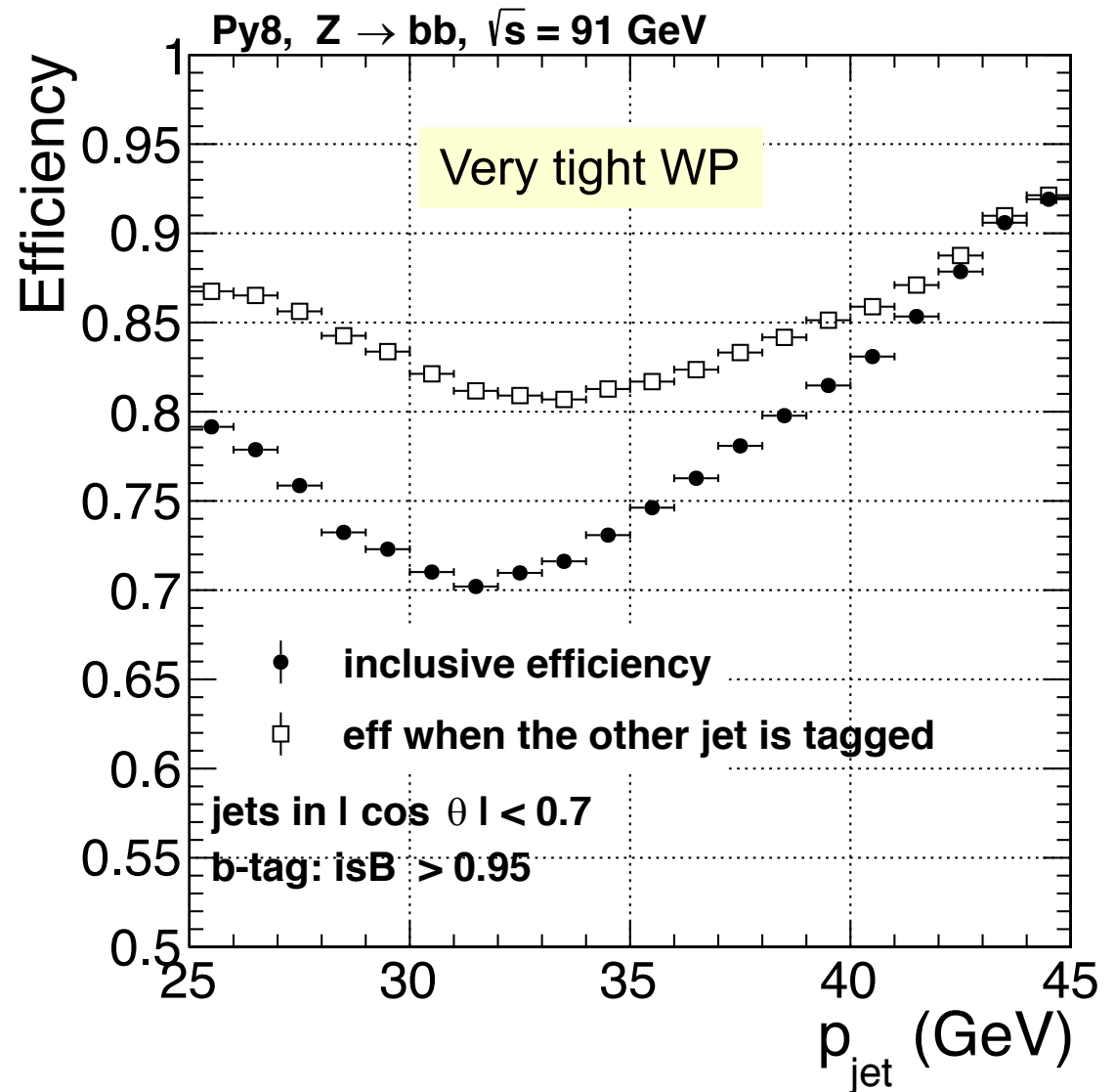
Tagging efficiencies vs theta

Top row: cut = LB > 0.95 / 0.8 / 0.5

Bottom row: cut = LB / (LB + LC) > 0.997 / 0.95 / 0.5
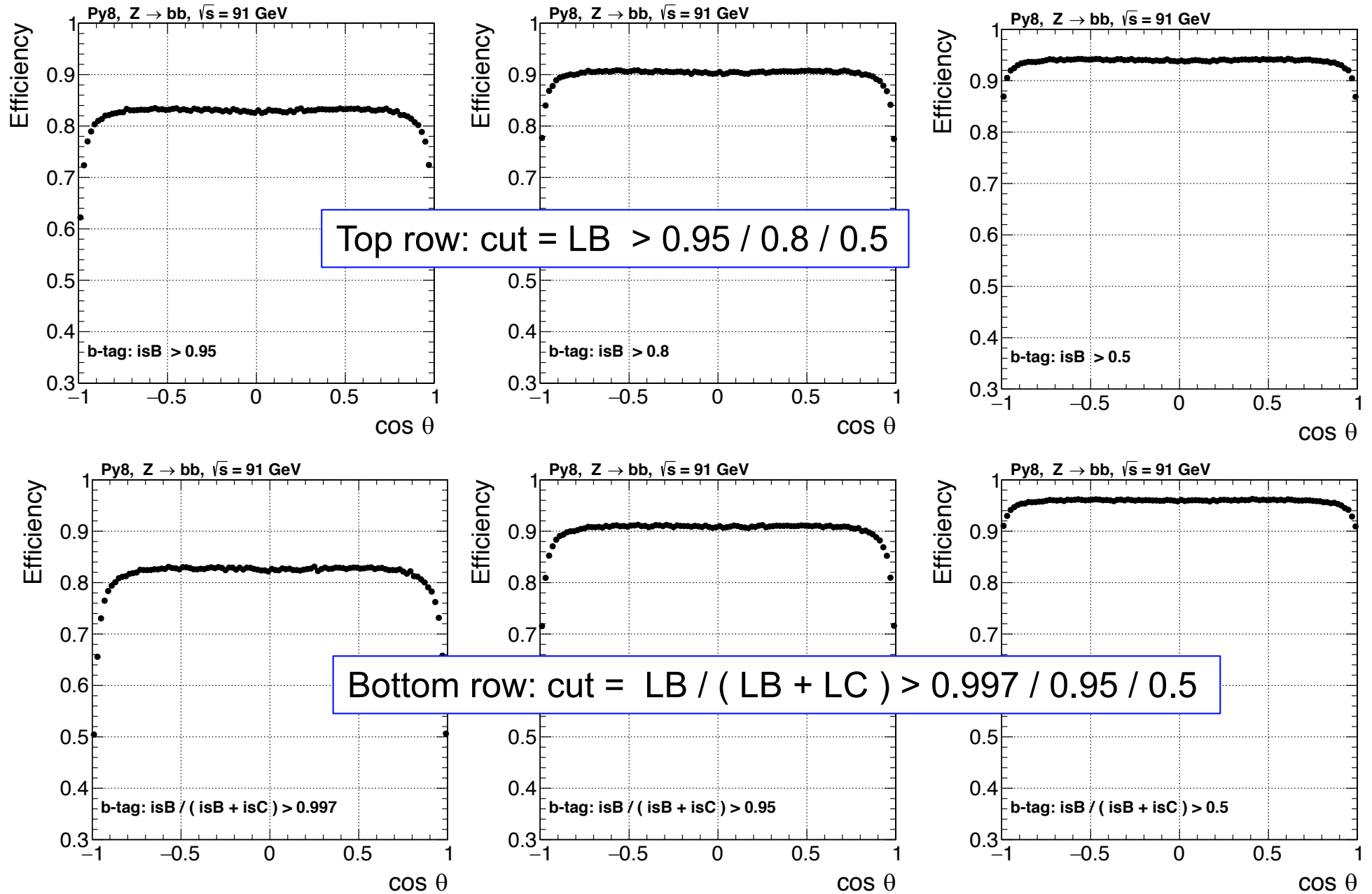
Correlations of tagging efficiencies

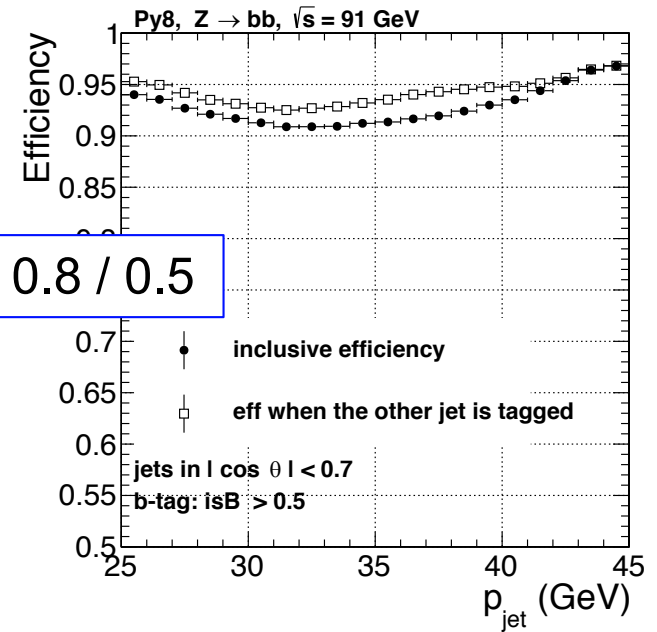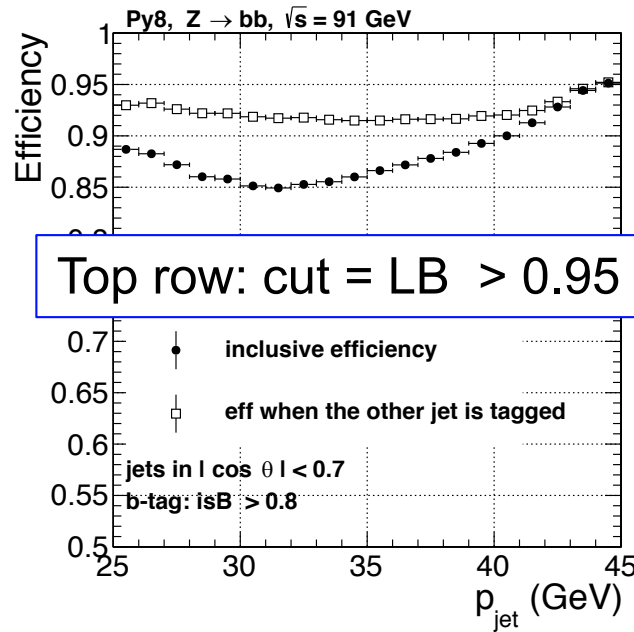Use only events where both jets are within |cos theta | < 0.7 (flat efficiency vs theta)
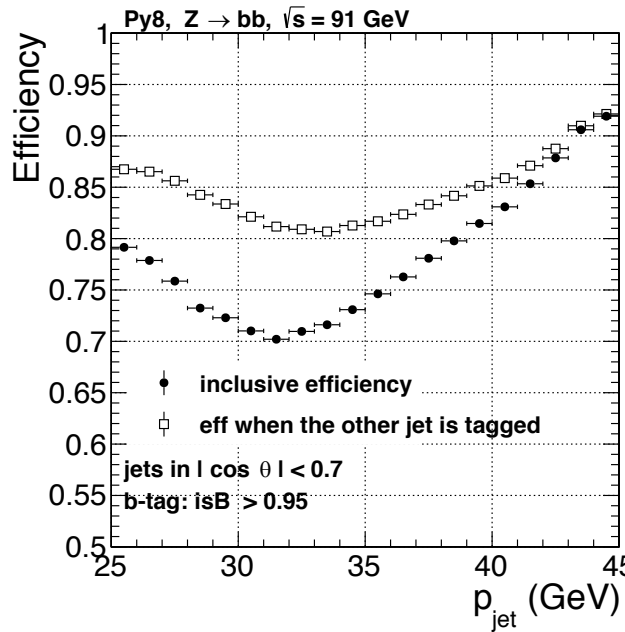
Inclusive efficiency (full black symbols) differs from efficiency determined from tag-and-probe (open black symbols).

Same correlations observed when the reco'ed primary vertex, or the MC-truth vertex, is used in the tagger.
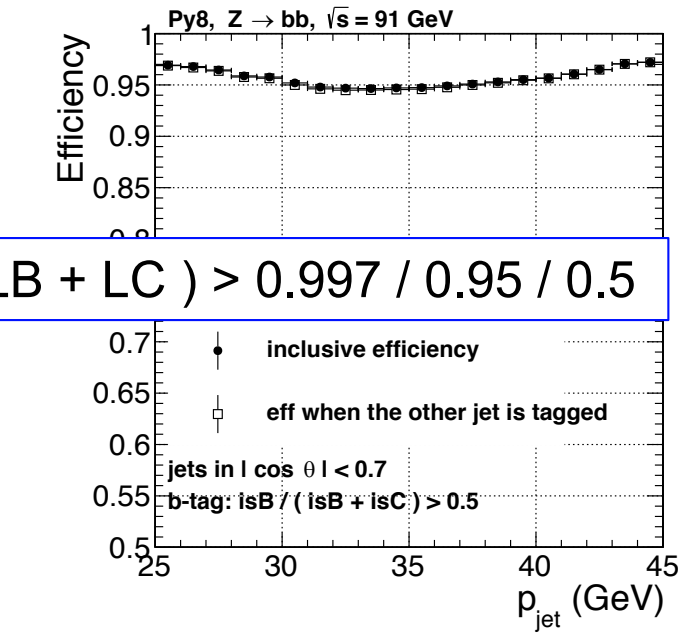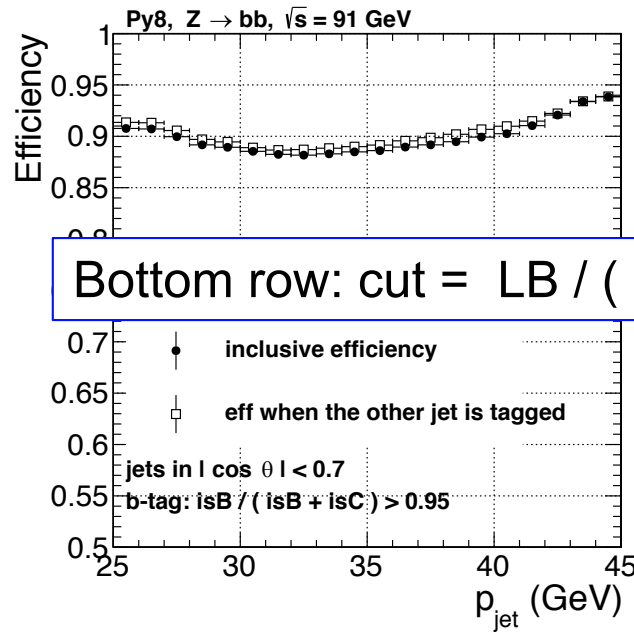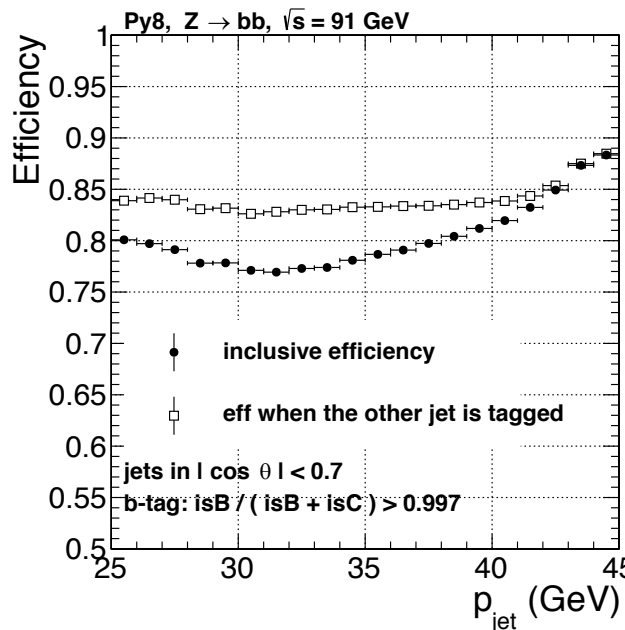Correlations can not be due to the reconstruction of the event vertex.

Py8, Z → bb, √s = 91 GeV

Very tight WP

- ● inclusive efficiency
- ☐ eff when the other jet is tagged

jets in I cos θ I < 0.7
b-tag: isB > 0.95

Efficiency

p_{jet} (GeV)

Different WPs: eff vs p, correlations – better with looser WPs

Top row: cut = LB > 0.95 / 0.8 / 0.5
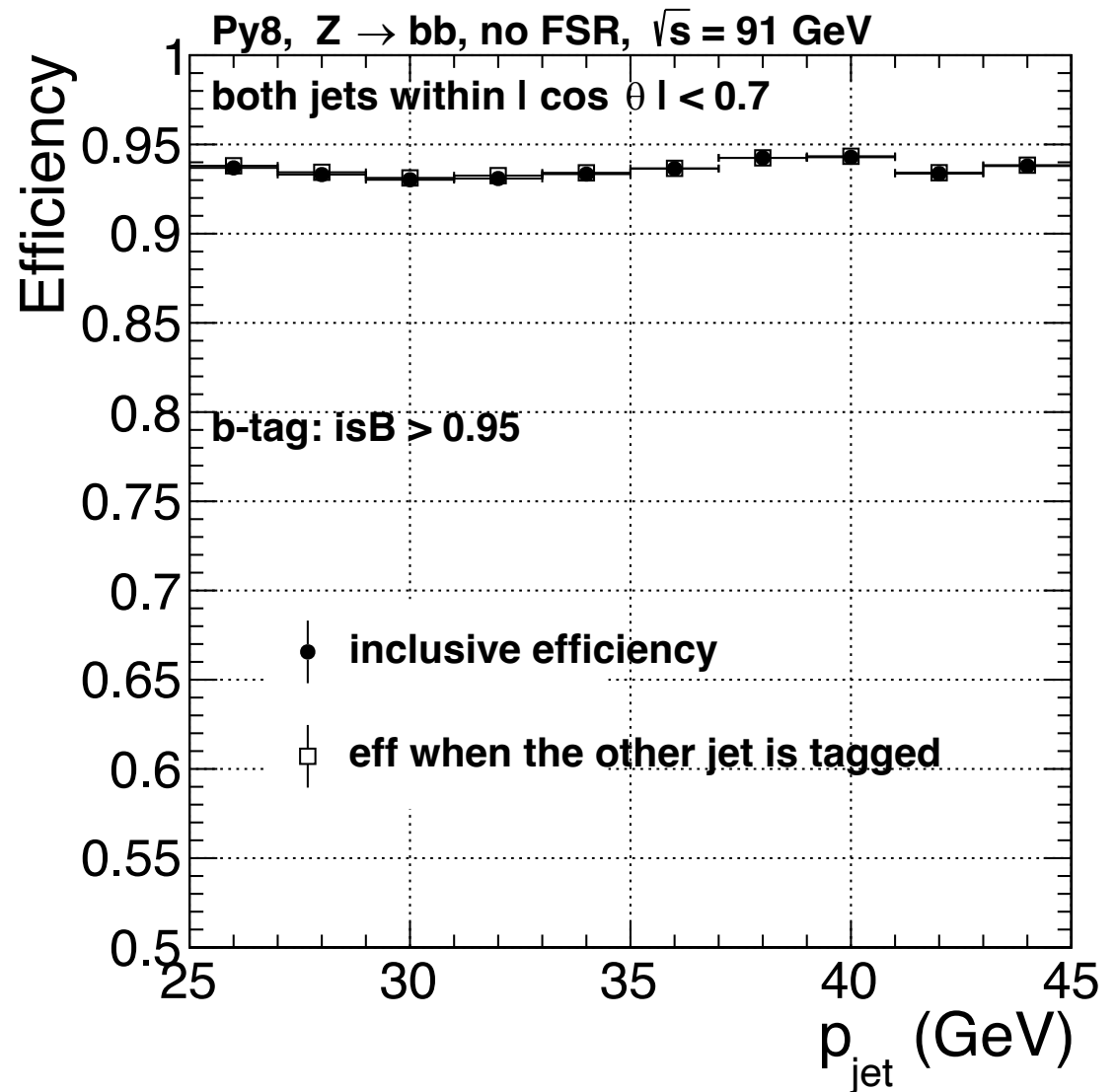
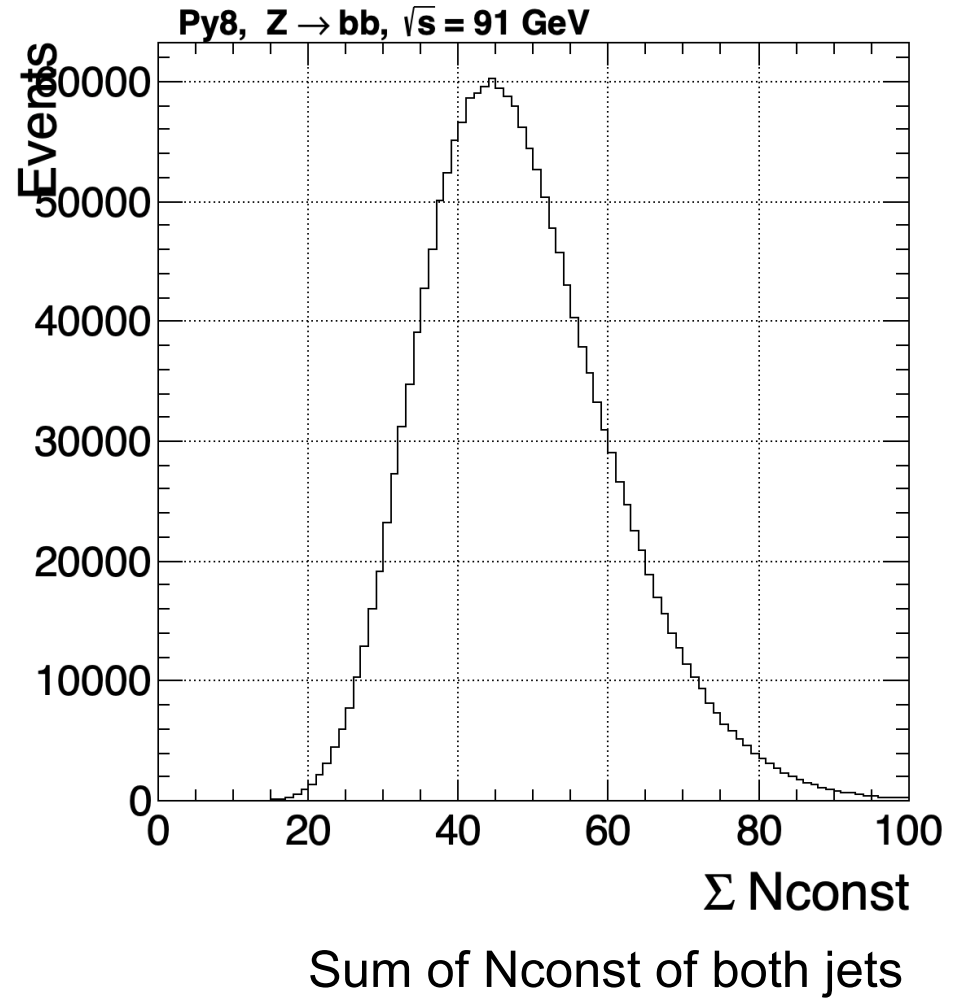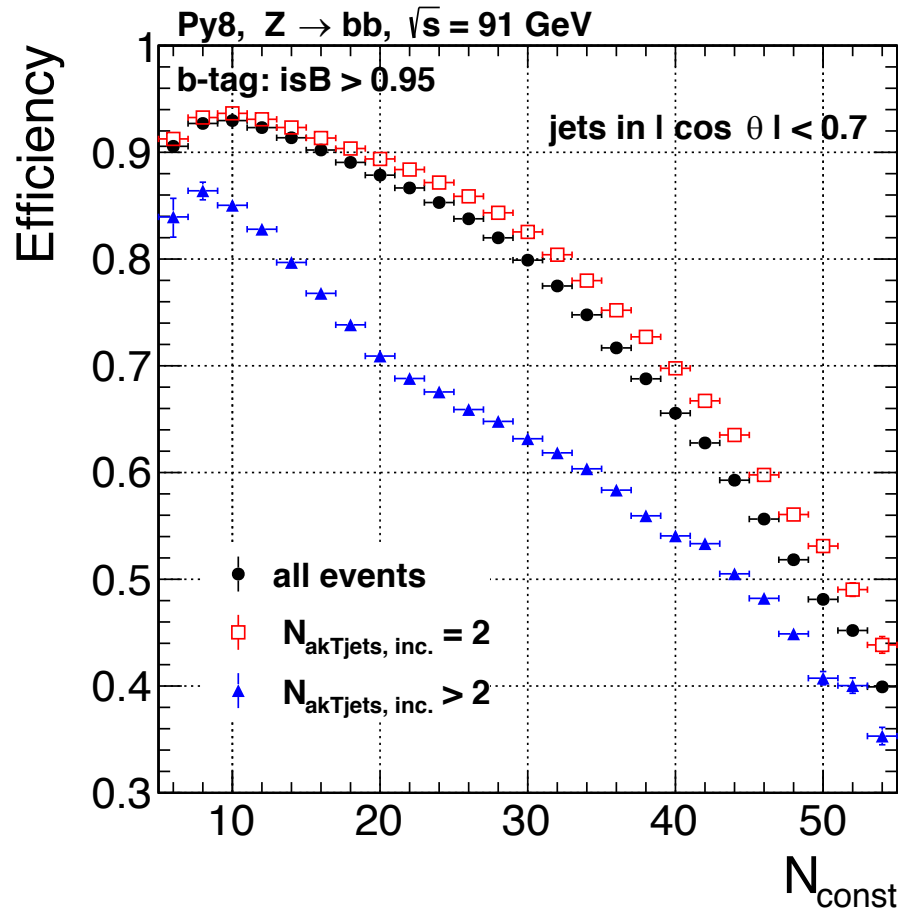Bottom row: cut = LB / (LB + LC) > 0.997 / 0.95 / 0.5

Test sample: Z -> bb, no gluon radiation

When gluon radiation is switched off in Pythia:

- Flat efficiency vs p
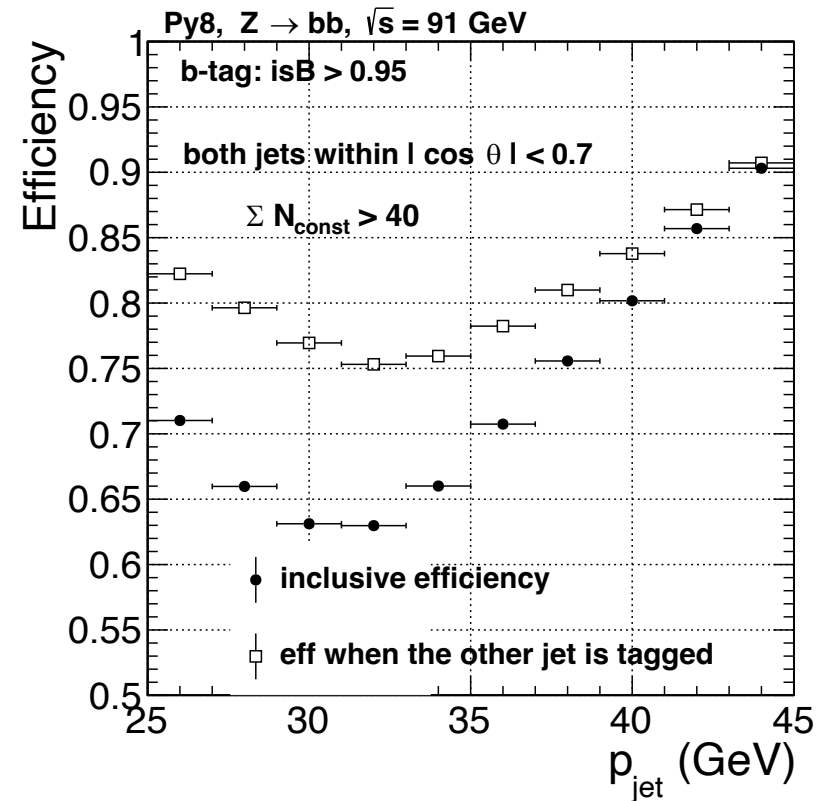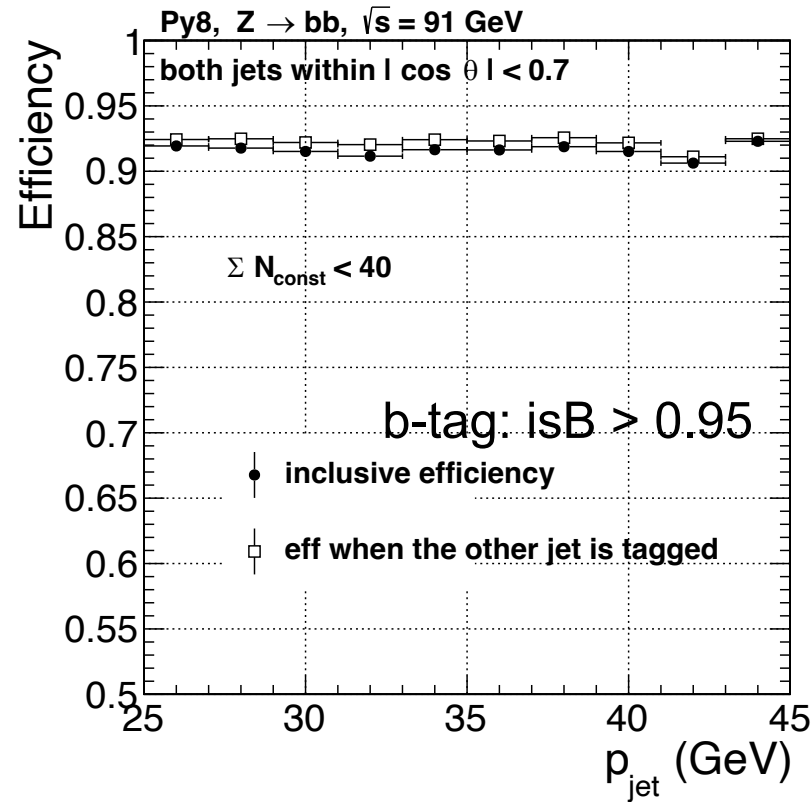- Tagging one leg does not bias the efficiency of the other leg

Py8, Z → bb, no FSR, √s = 91 GeV
both jets within | cos θ | < 0.7
b-tag: isB > 0.95

• inclusive efficiency
□ eff when the other jet is tagged

Tagging efficiency versus number of jet constituents

Py8, Z → bb, √s = 91 GeV

b-tag: isB > 0.95

jets in | cos θ | < 0.7

- ● all events
- □ $N_{akTjets, inc.} = 2$
- ▲ $N_{akTjets, inc.} > 2$

Efficiency

N_{const}

Py8, Z → bb, √s = 91 GeV

Events

ΣN_{const}

Sum of Nconst of both jets

Correlations of tagging efficiencies: cut on sum(Nconst)

With this very tight WP: Tagging one leg biases the sample: favors events with no hard gluon radiation, hence efficiency for the probe is higher.

Some conclusions

- The tagger (trained on Higgs samples) shows very good performances out-of-the-box at the Z pole, even w/o retraining

- For a very tight working point, large correlations between the b tagging efficiency in the two hemispheres of a Z to bb event
  - Due to gluon radiation

- Correlations get smaller for looser WPs, and using a cut on LB / (LB + LC) instead of a cut on LB. To be quantified better, in view of
  - a precision at the level of the per-mil or better on ε(b tag)
  - a measurement of Rb from the double-tag method in inclusive bb events, as $\Delta Rb / Rb \sim \Delta \rho_b$

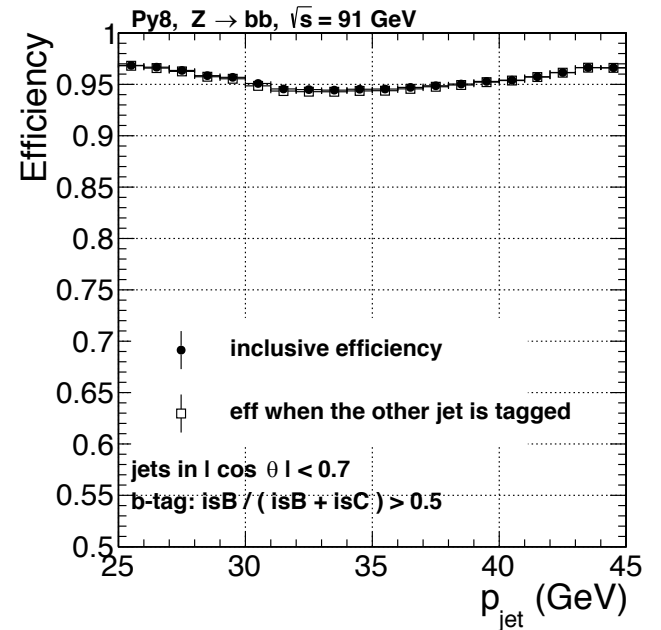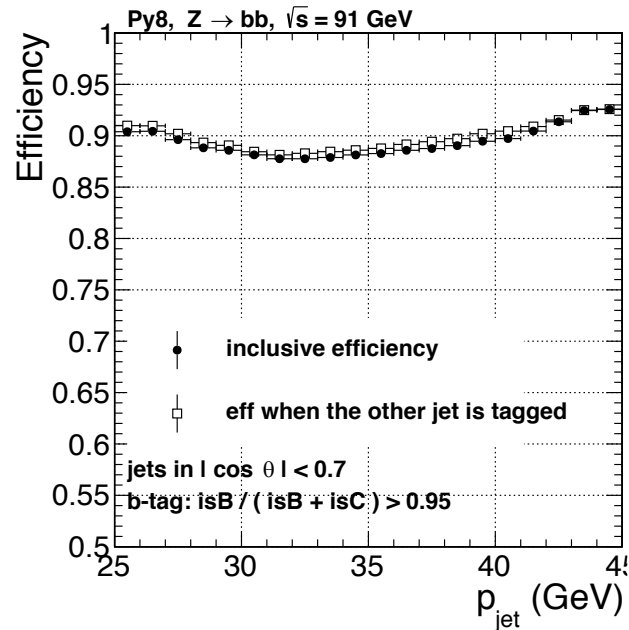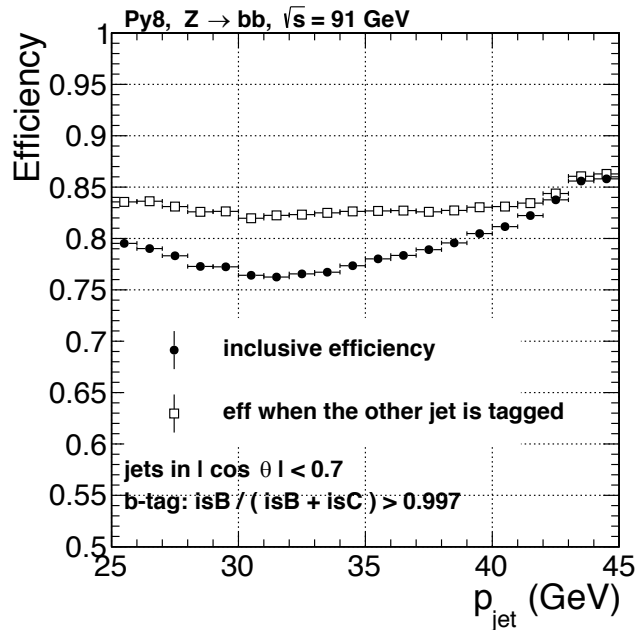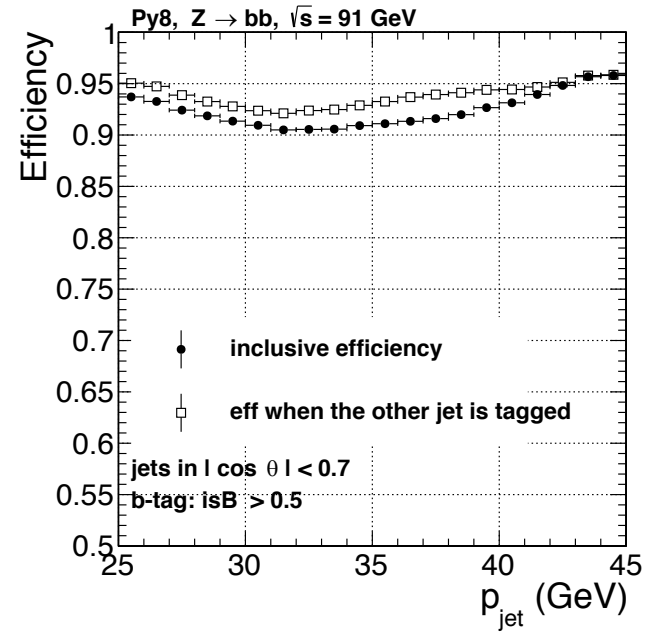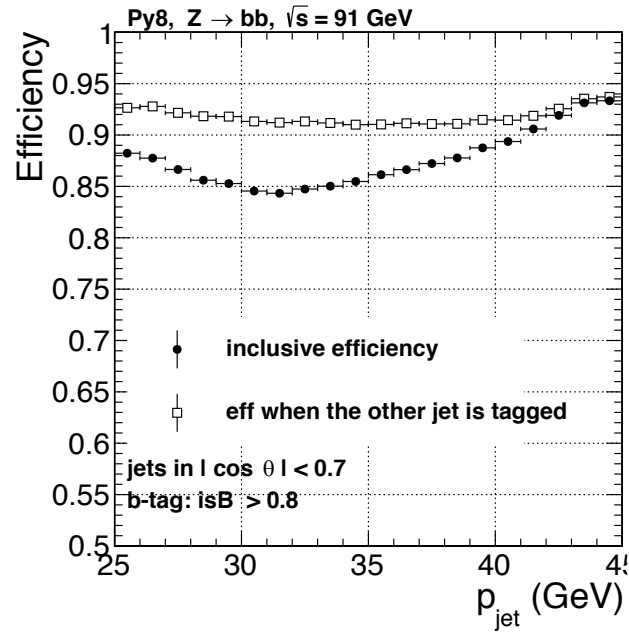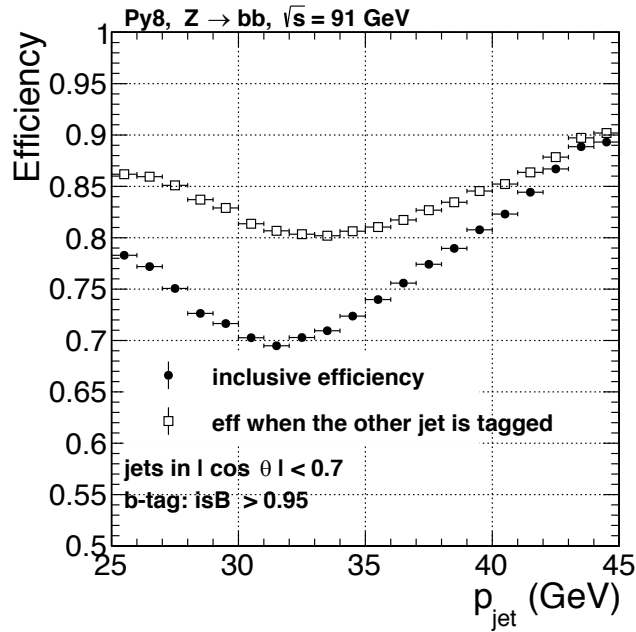# Backup

Usage of the Reco'ed primary vertex

Reco'ed primary vertex for (x, y, z).
Vertex time from the MC vertex.

Very little effect.

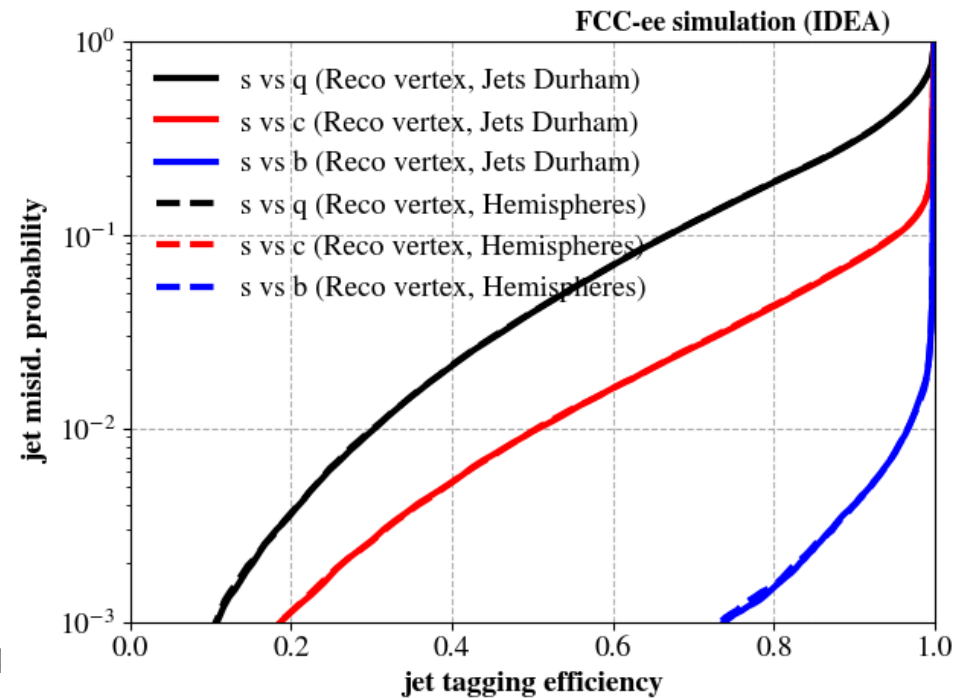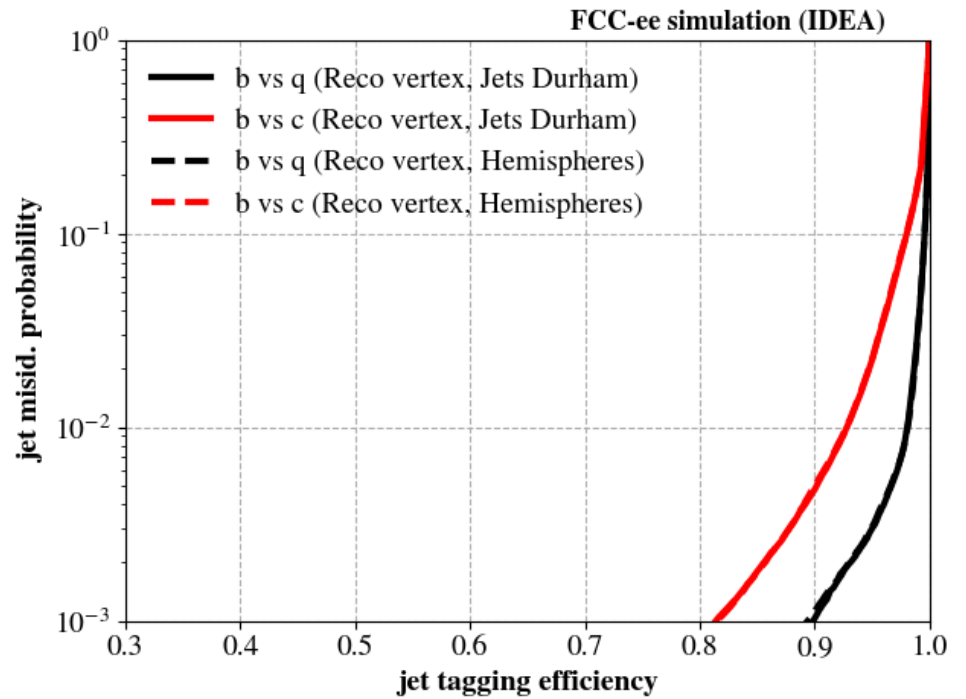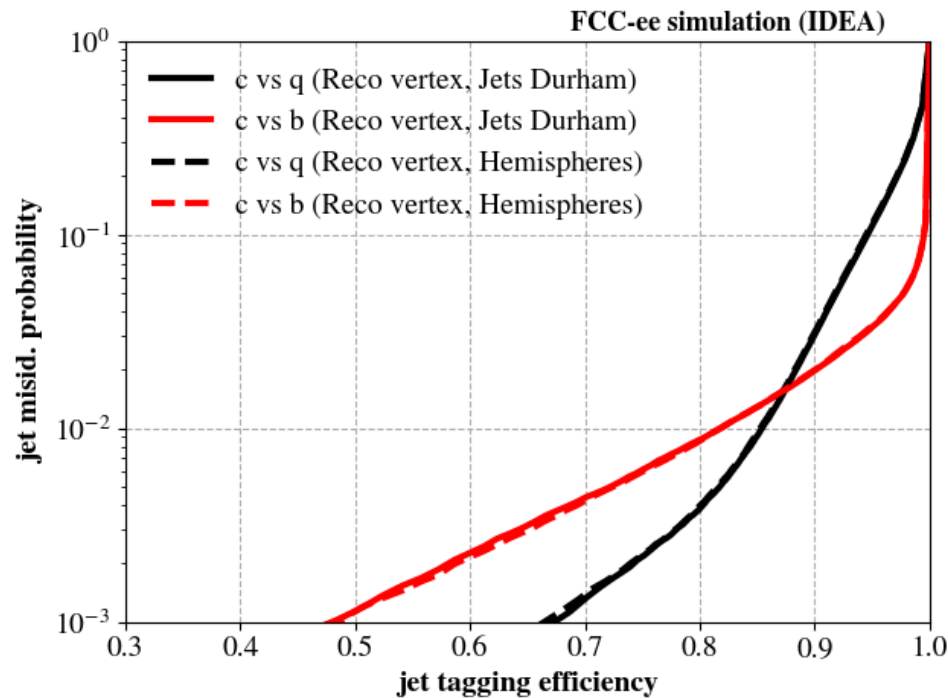Little effect as well on correlations
(next slide)
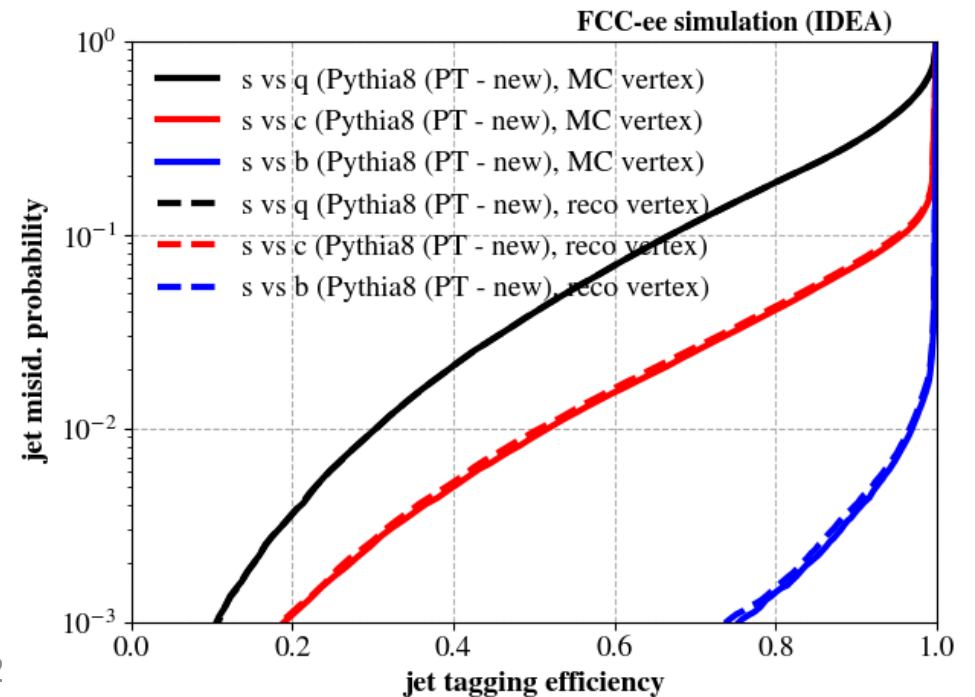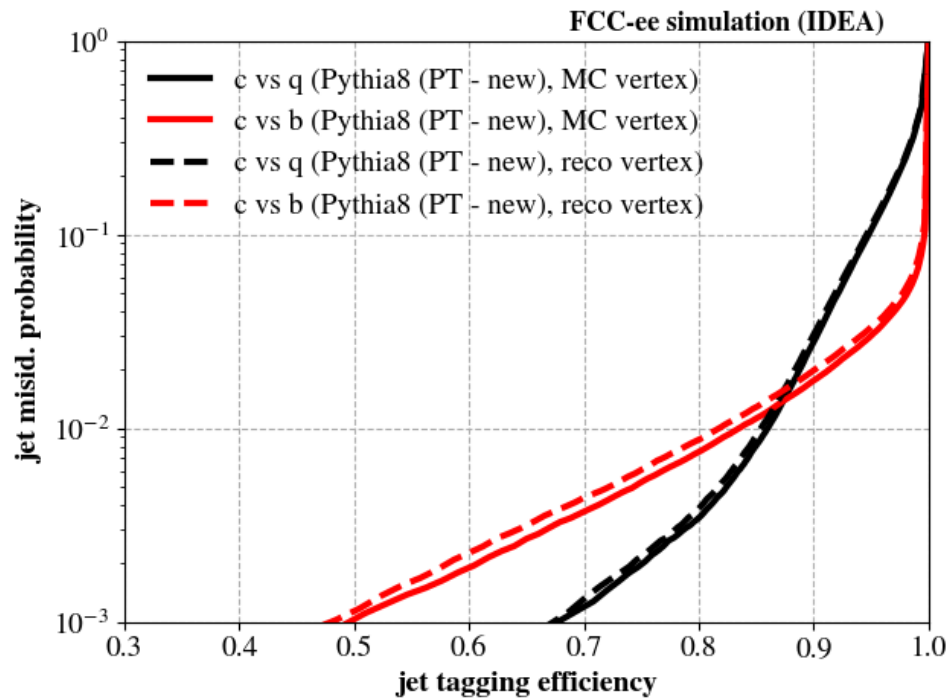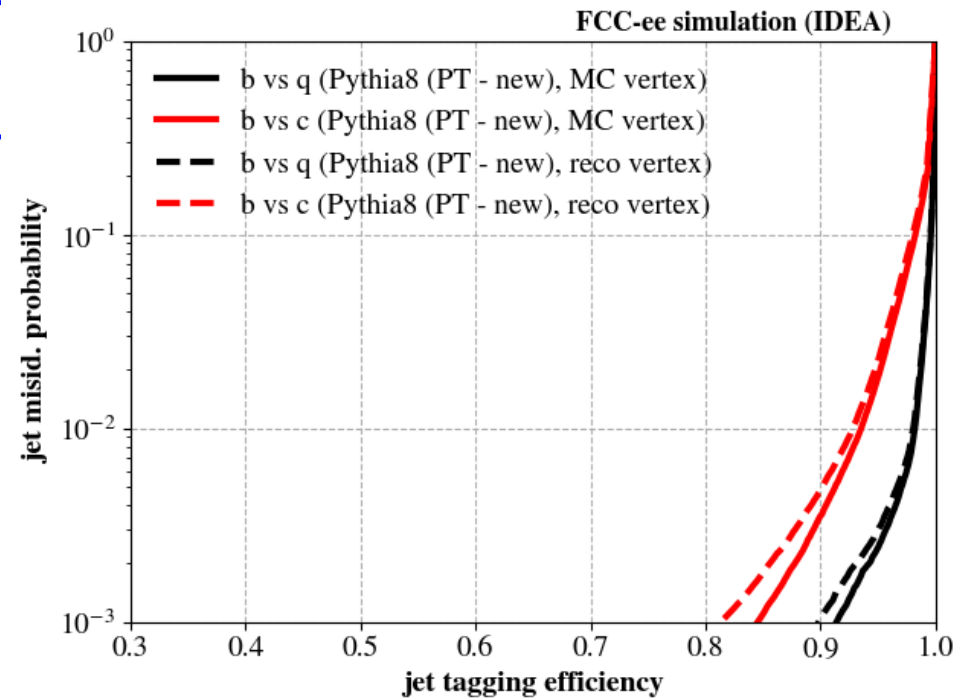
Correlations, using Reco'ed vertex.

"Hemisphere jets" instead of Durham

No difference, as expected

Kinem distributions

Black = leading jet
Red = subleading