Quark jets vs. gluon jets
with different IHCAL configuration

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Setup

- Same as John's setup

  - Revised G4 simulation geometry from Chris P. (9/29/2017)
    - Main effect is SS310 IHCAL is ~0.15 interaction lengths thinner
  - Used an analysis code that was originally developed to study jets with forward instrumentation:
    - /sphenix/user/lajoie/sPHENIX/jet_simulations/FastTrackingEval
  - Start with the same Pythia8 HepMC files as Dennis:
    - /sphenix/user/dvp/gen/QCD35/
    - Jets >50 GeV, R=0.4 jet in $|\eta|$<0.6, 10k events
  - Reconstructed jets three ways, R=0.4:
    - Primary Particle Jets
      - No muons, neutrinos
    - Track Jets
      - Tracks require ndf>60, χ^2/ndf<1.5, DCA2D<0.1cm
    - Calorimeter Tower Jets
      - Require tower energy > 100 MeV
  - Conditions – SS310, SS310 w/o readout, Al, and Al w/o readout, and SS310 frame (steel cylinder)
  - "Matched" jets require track and tower jets match the primary jet within ΔR<0.4: (note was ΔR<0.3 from previous studies)
   - Primary jet must have $|\eta|$<0.6, E>50 GeV consistent with trigger

Motivation

- Gluon radiation proportional to color factor
  - C_F: strength of gluon coupling to quarks
  - C_A: strength of gluon coupling

$$\left| q \underset{}{\diagup} \begin{matrix} g \\ q \end{matrix} \right|^2 \sim C_F = 4/3$$

$$\left| g \underset{}{\diagup} \begin{matrix} g \\ g \end{matrix} \right|^2 \sim C_A = 3$$

- Jet shapes are sensitive to whether they are originating from quark or gluon -> allow separation of quark and gluon jets!
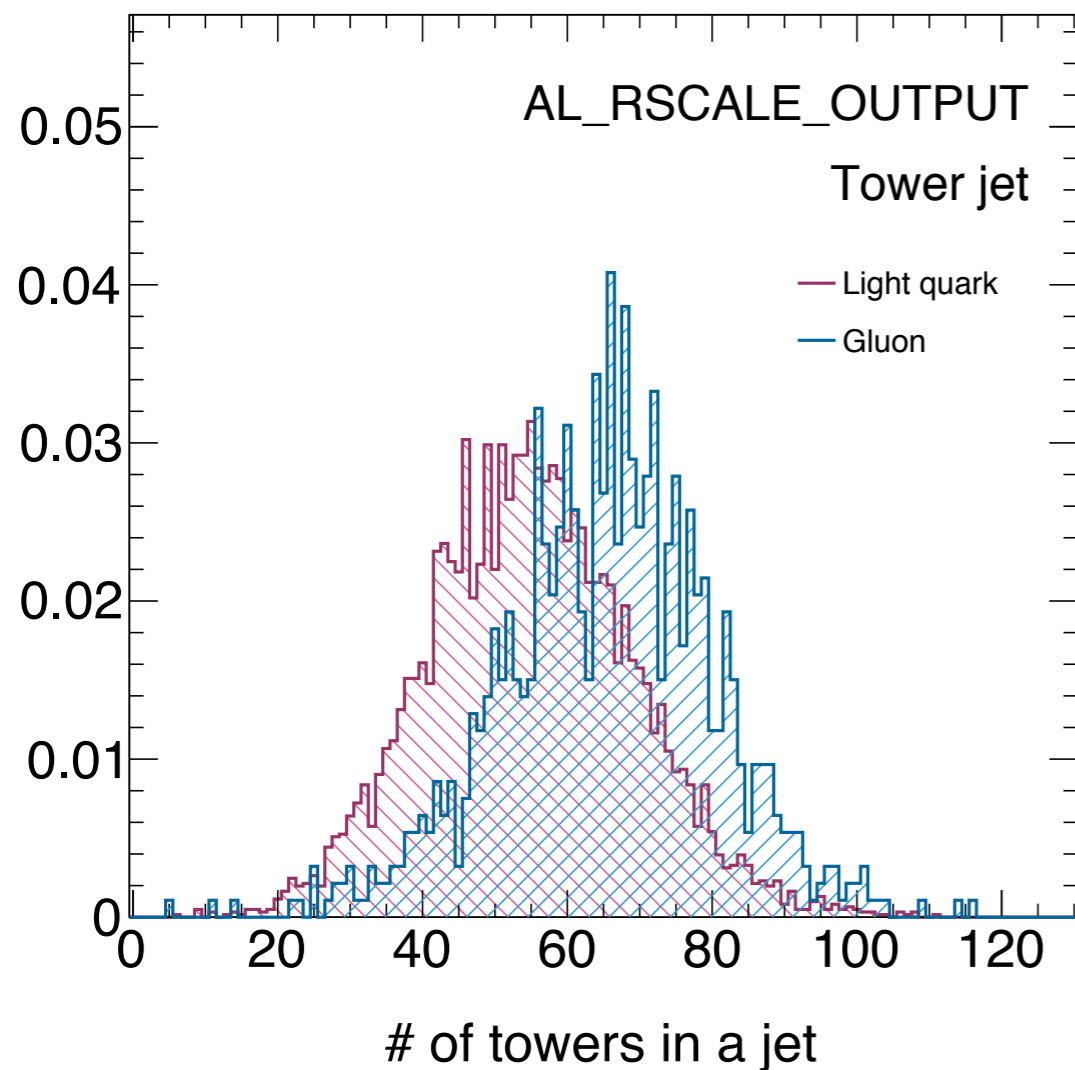
- Gluon jet, compared to light-quark jet,
  - has higher multiplicity
  - fragments softer
  - is less collimated
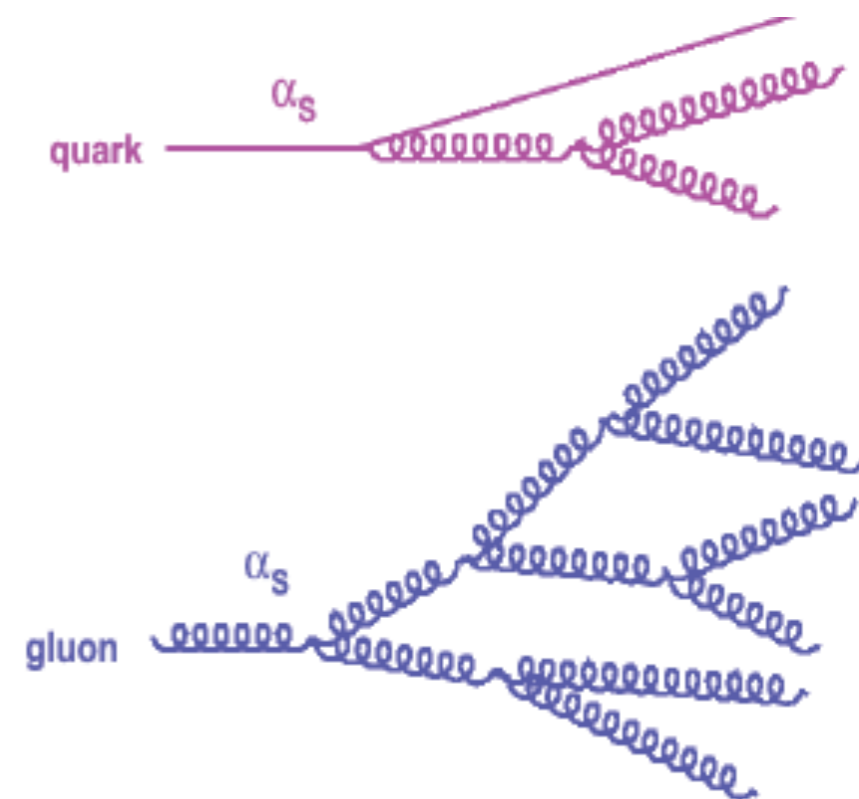
Discrimination variables

- ## Multiplicity

  - Number of jet constituent
    (em and hcal towers in tower jets)

- ## Fragmentation

$$p_{\mathrm{T}}D = \frac{\sqrt{\sum_i p_{\mathrm{T},i}^2}}{\sum_i p_{\mathrm{T},i}} \quad (i : \text{jet constituents})$$
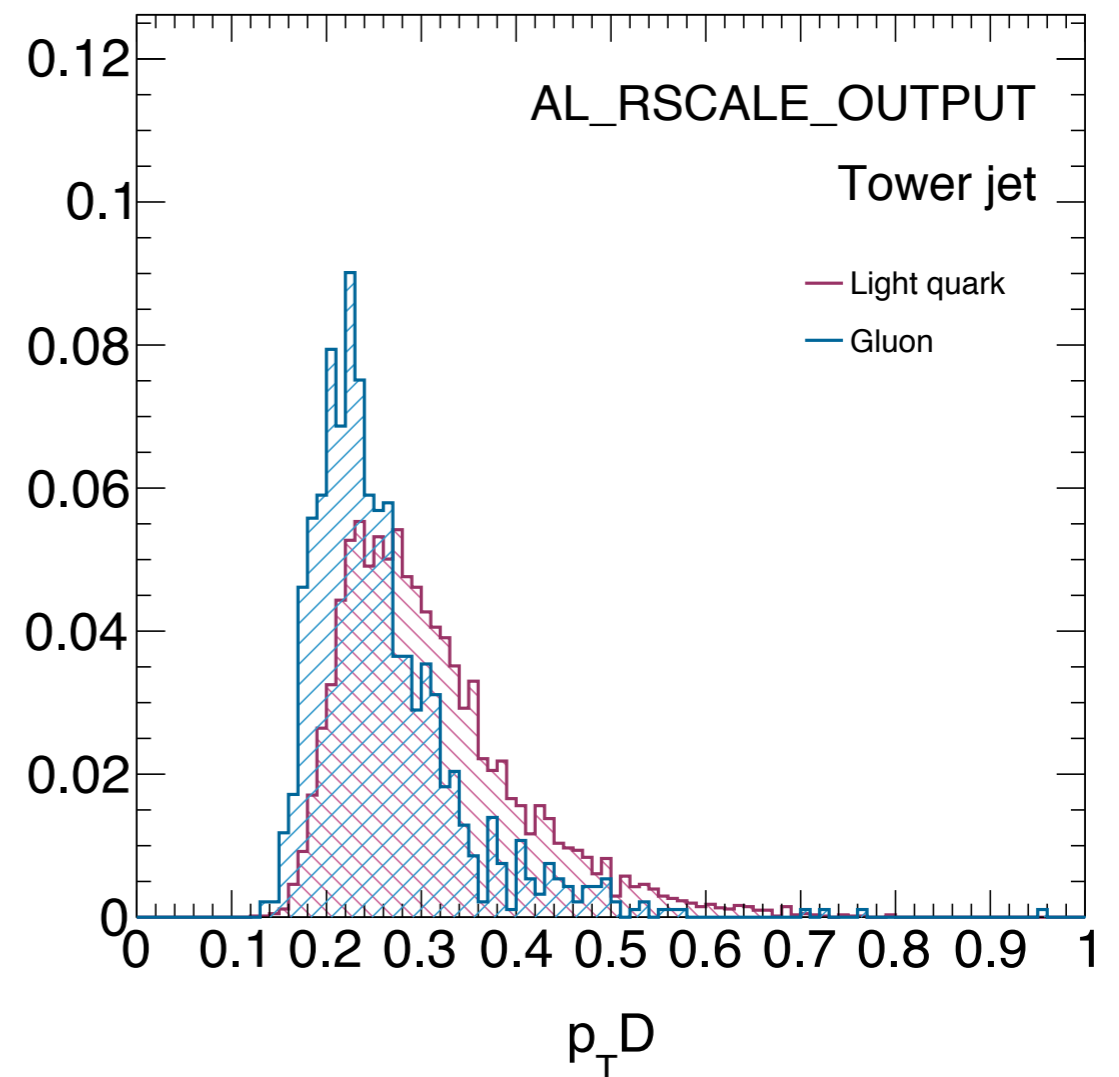
ROC curves
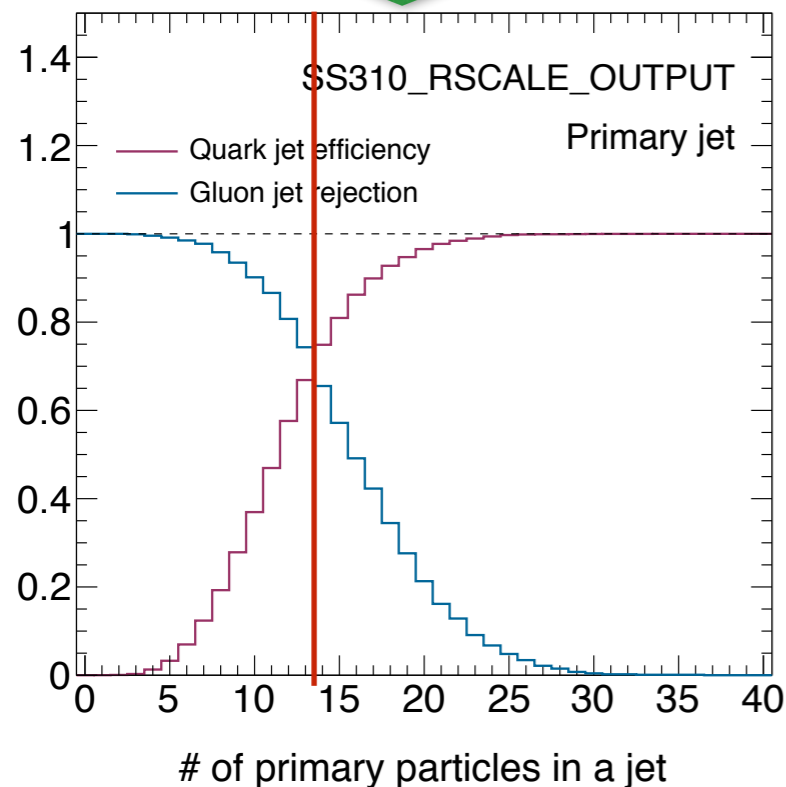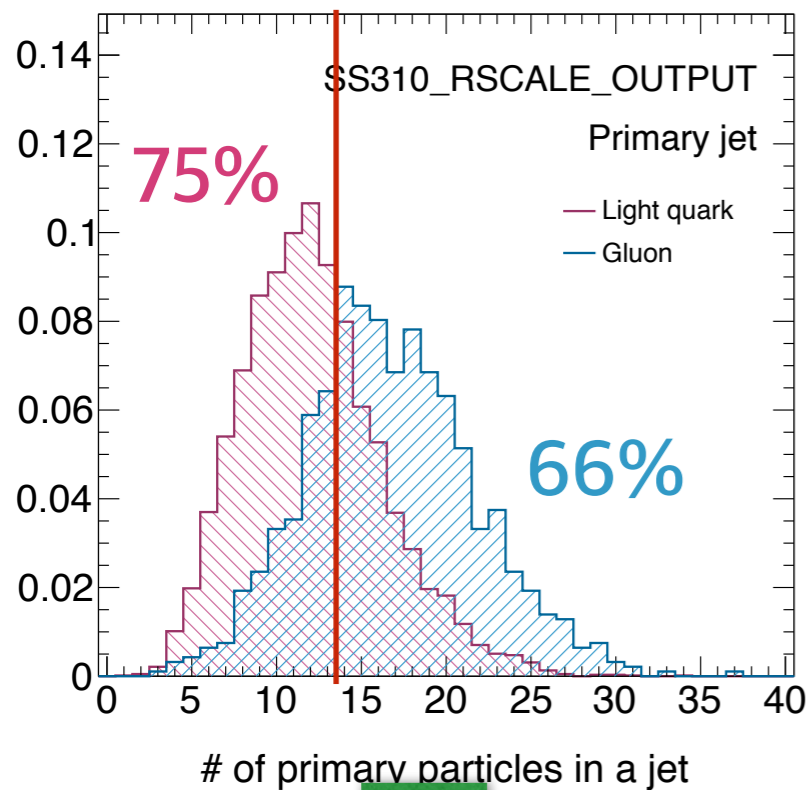
- e.g.) If we set WP as <u>Multiplicity < 14</u>
  - 75% of quark jets are accepted
  - 66% of gluon jets are rejected
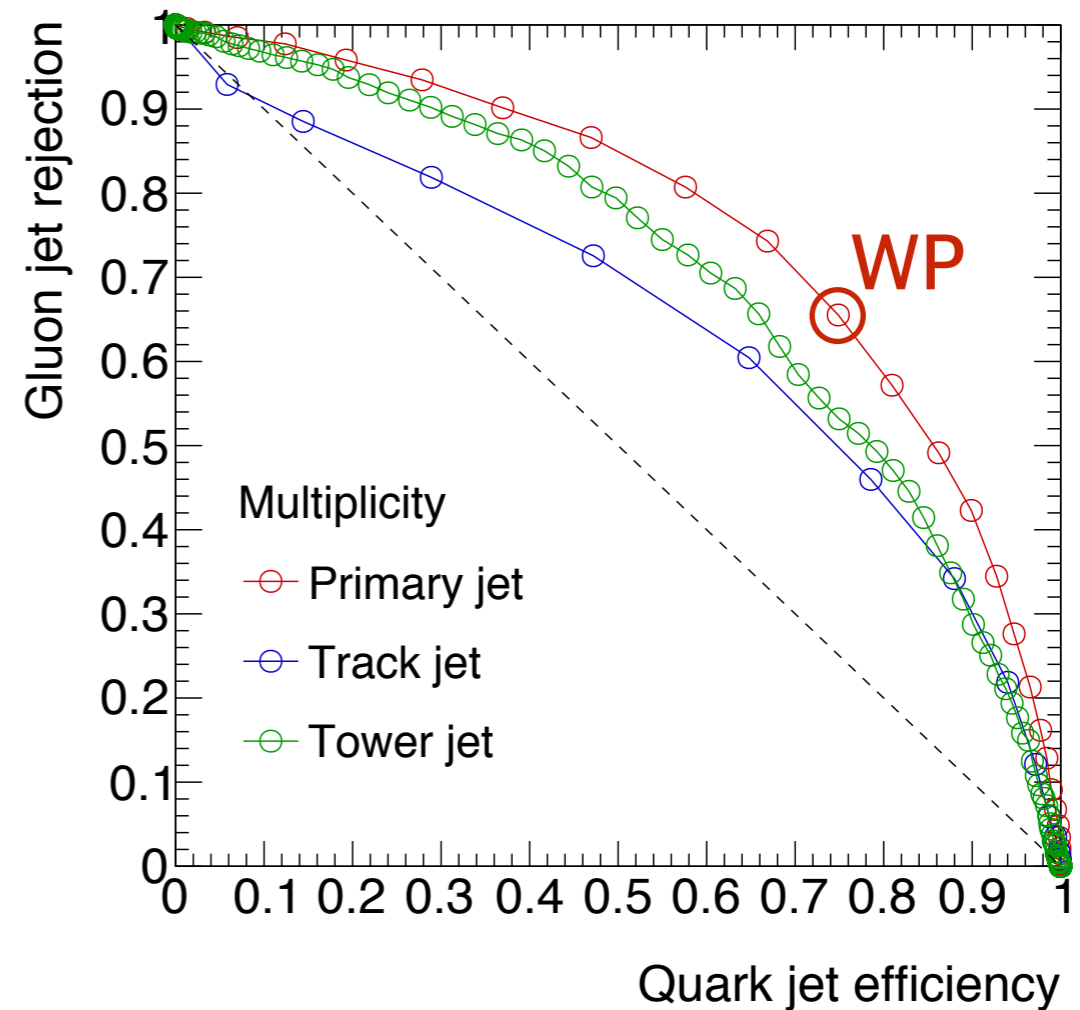
- Better performance with tower jets compared to track jets

Tower jets performance

Multiplicity

$p_T D$
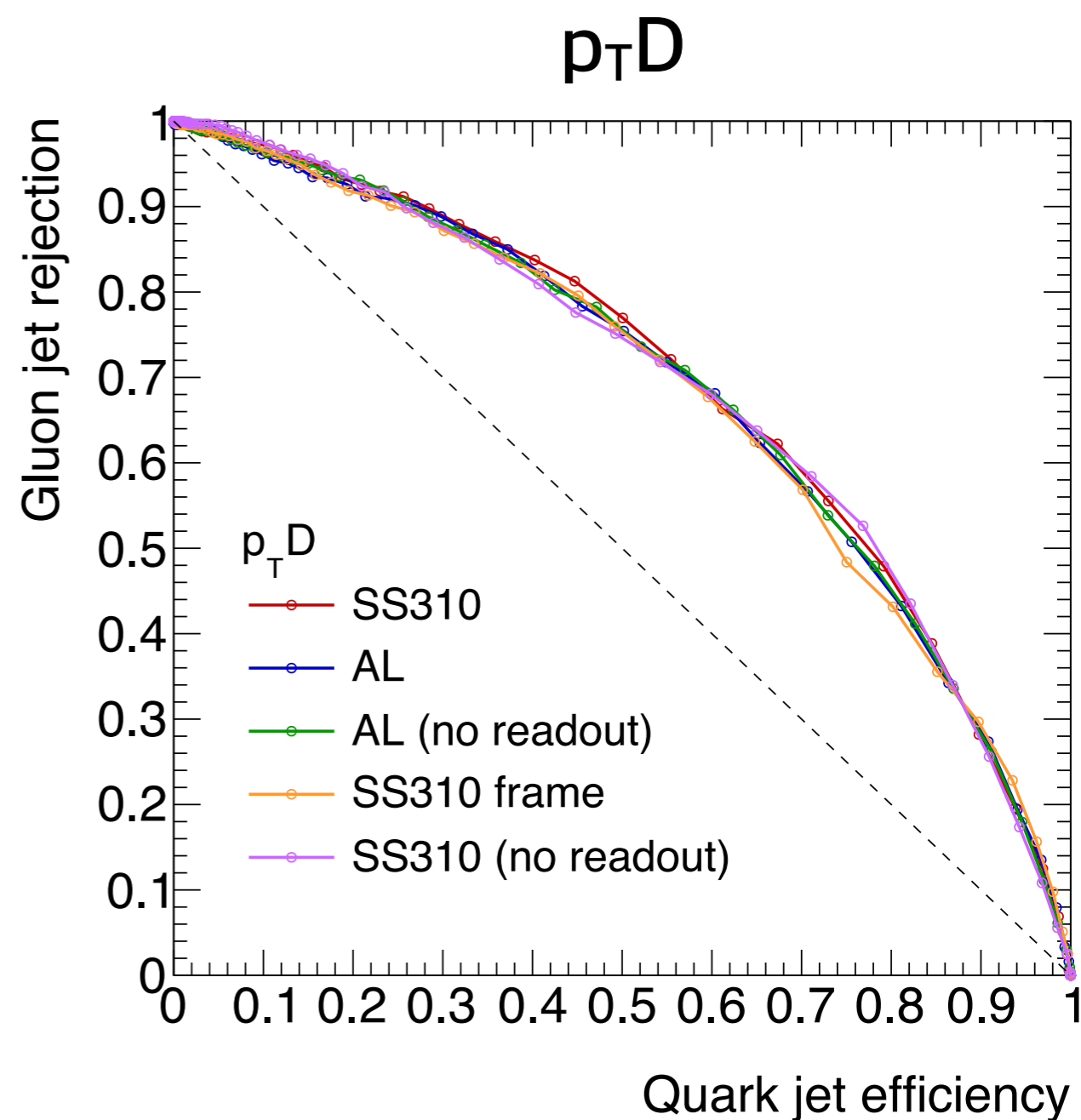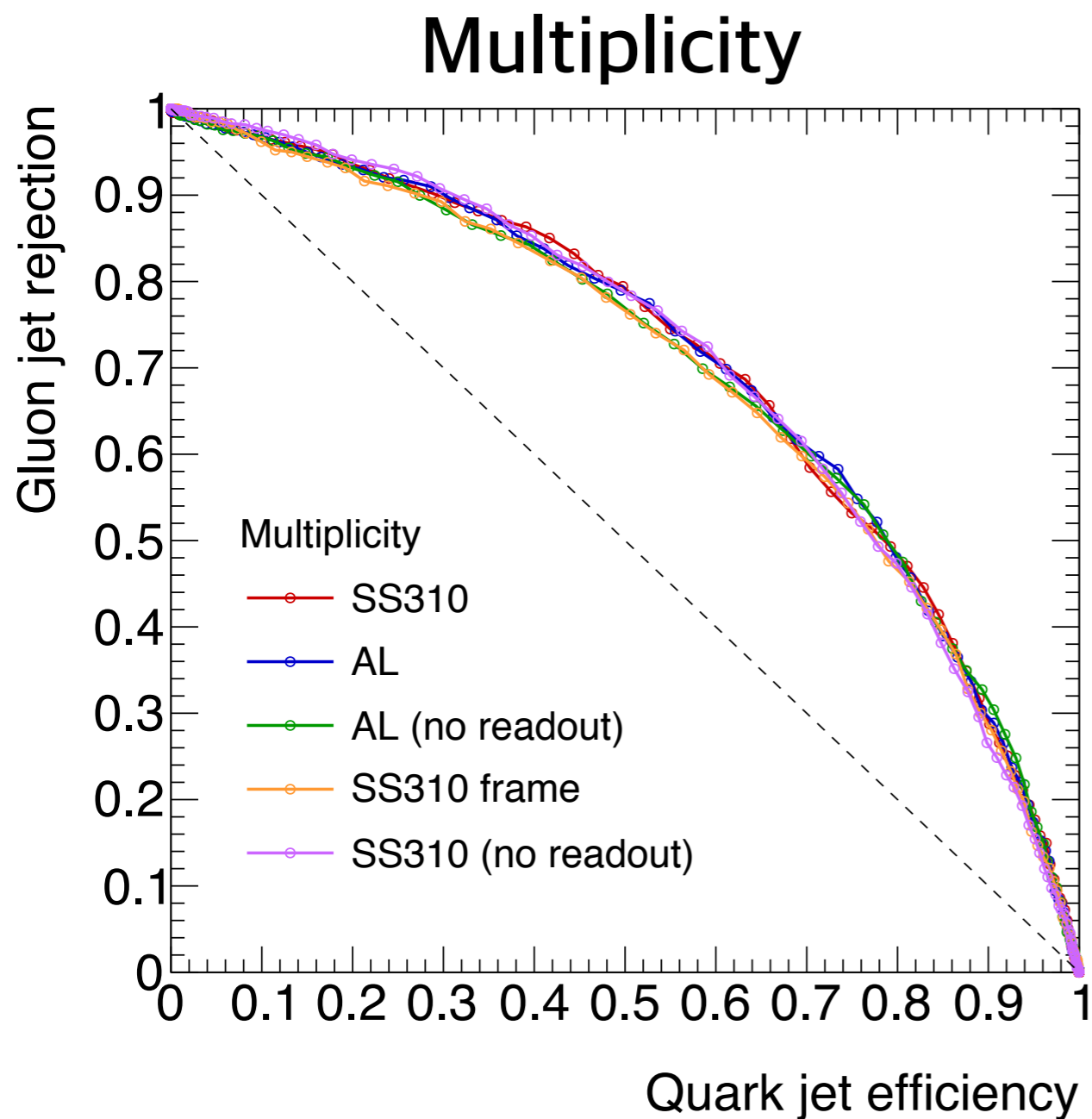
- No big differences between different IHCAL configurations

Summary

- Separation between quark and gluon jets are feasible!

- No big differences between different IHCAL configurations

  - More detailed study will be done later (e.g., with more statistics, building discriminator, etc)

  - For the current descoping decision, this is enough to confirm that the change in IHCAL configuration would not tremendously affect the quark vs. gluon jet study

Backup

Correlations b/w multiplicity var.

- e.g.) SS310_RSCALE_OUTPUT
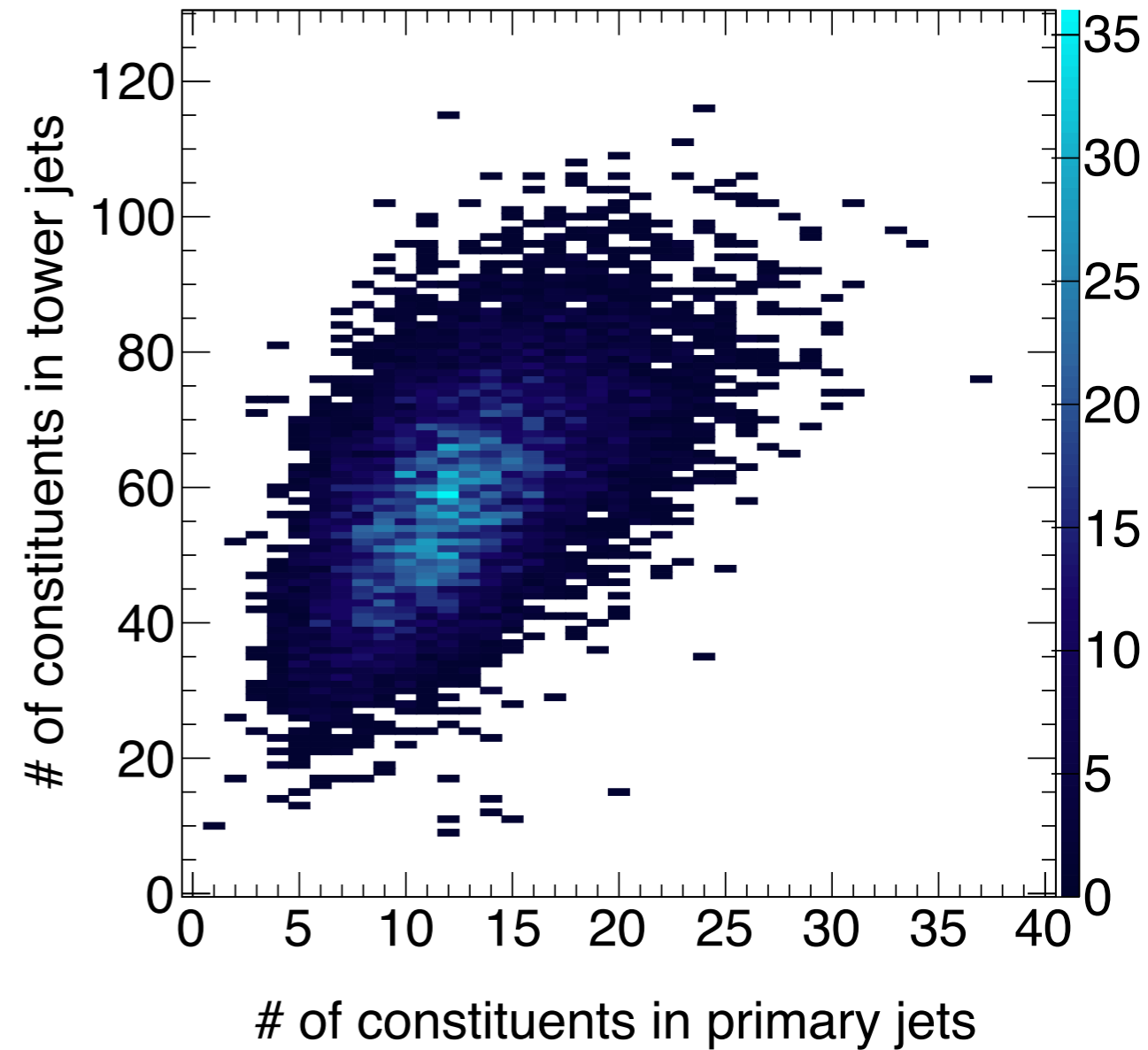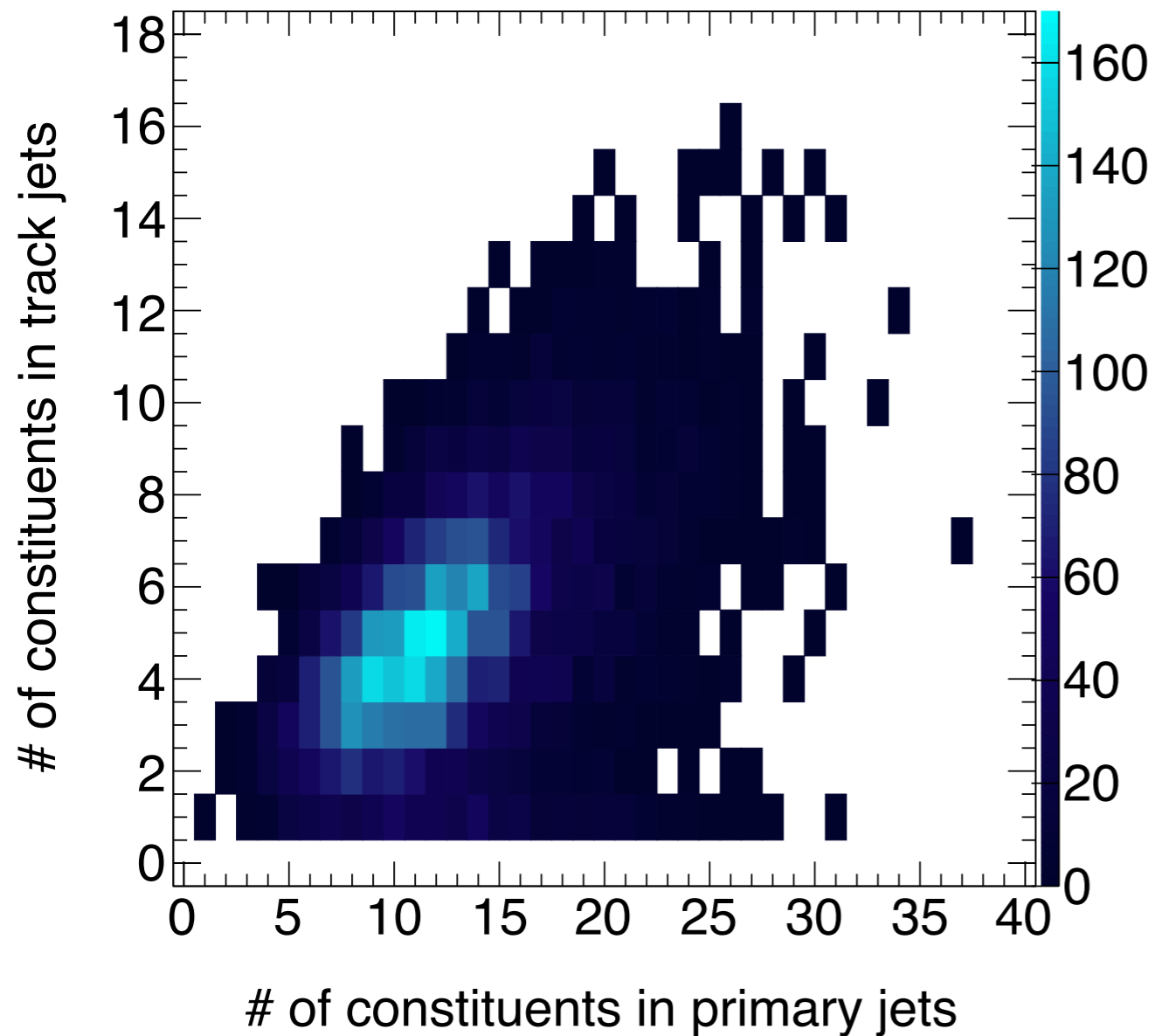
Multiplicity

Primary jet
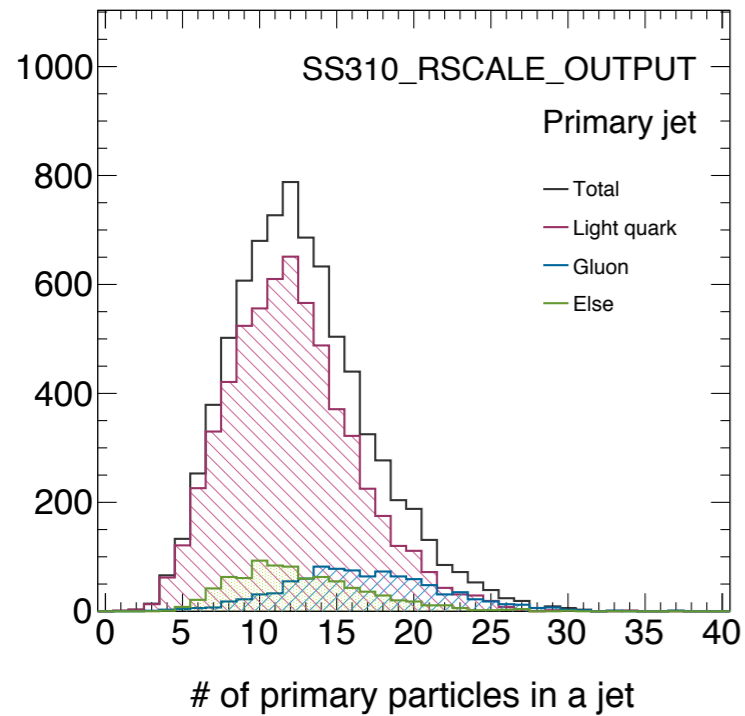
Track jet
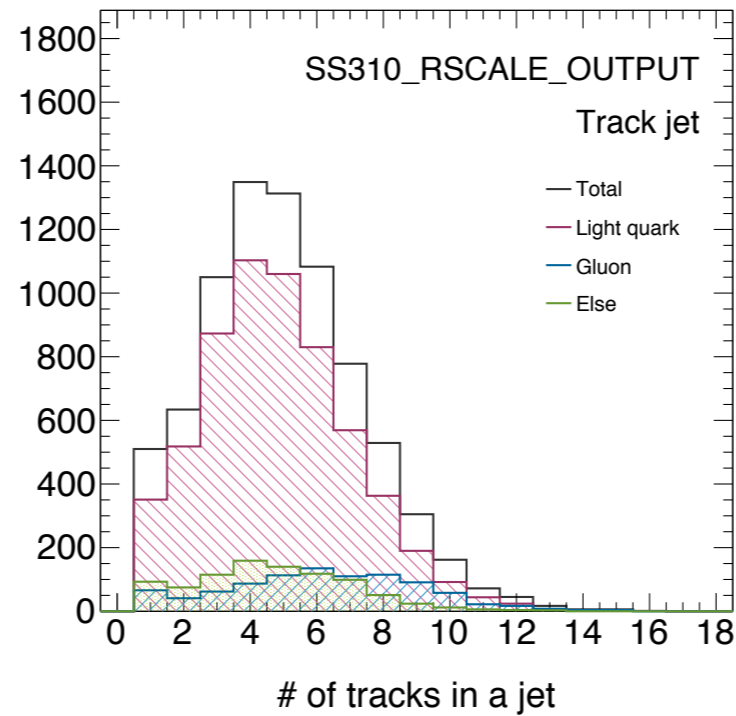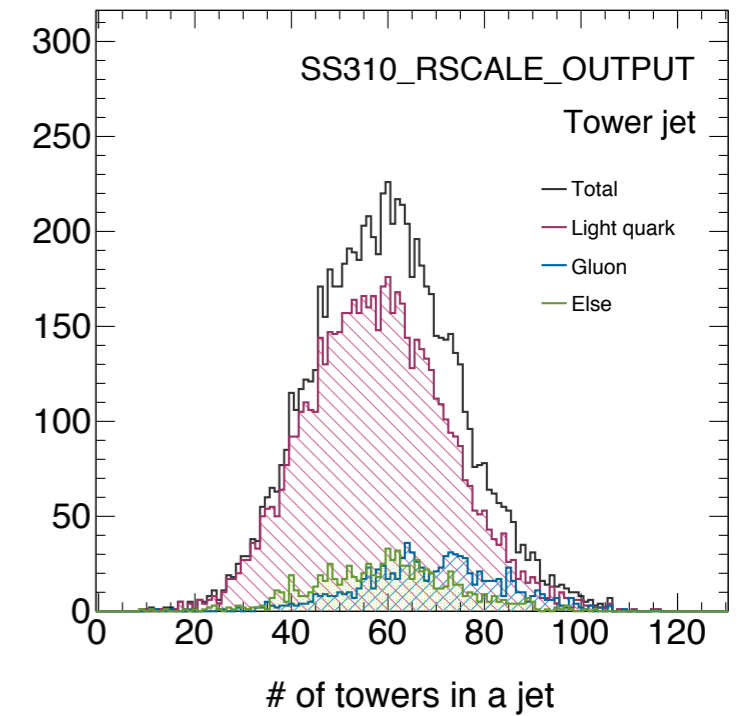
Tower jet

Normalized by integral
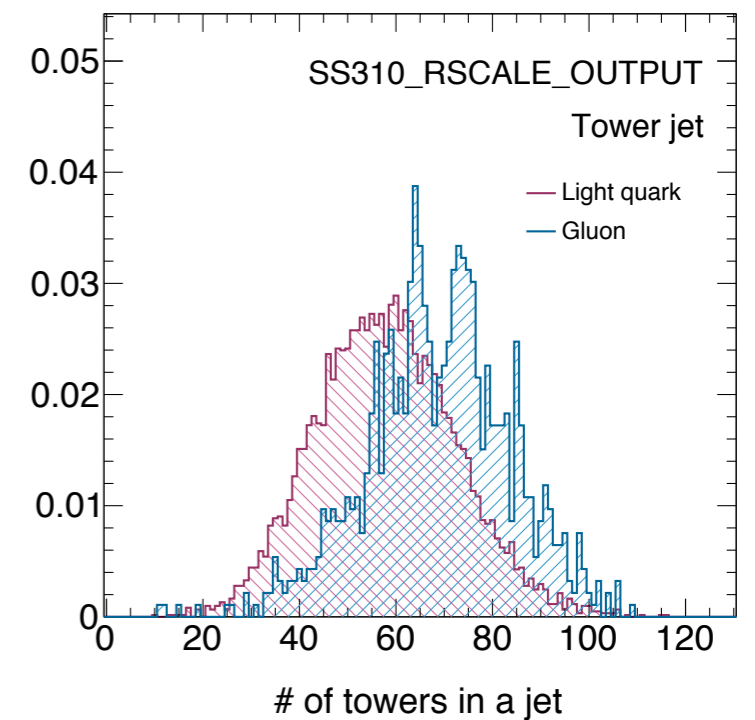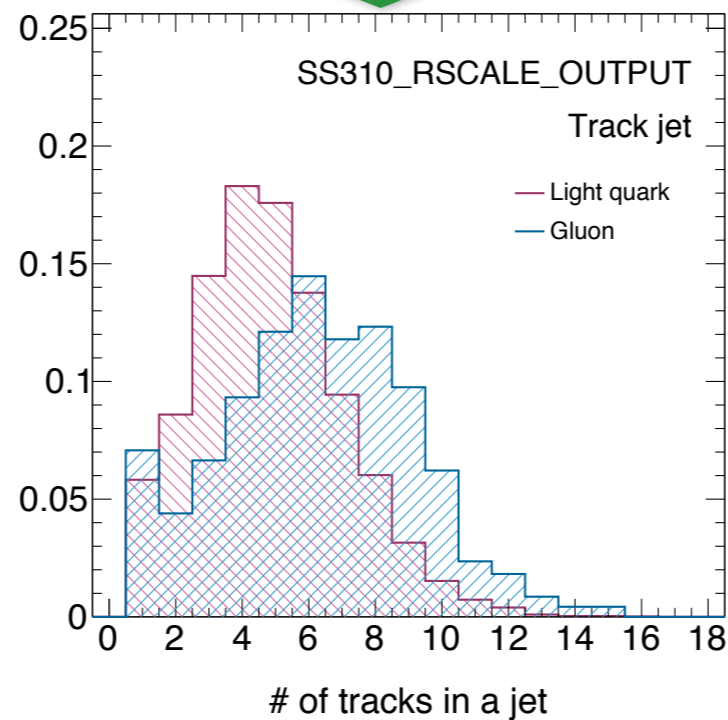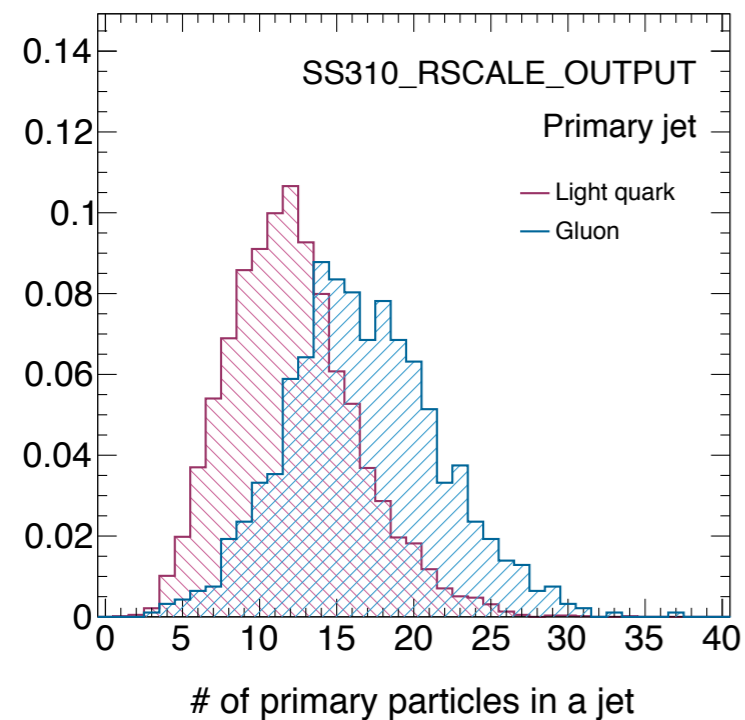
p_T D

Primary jet
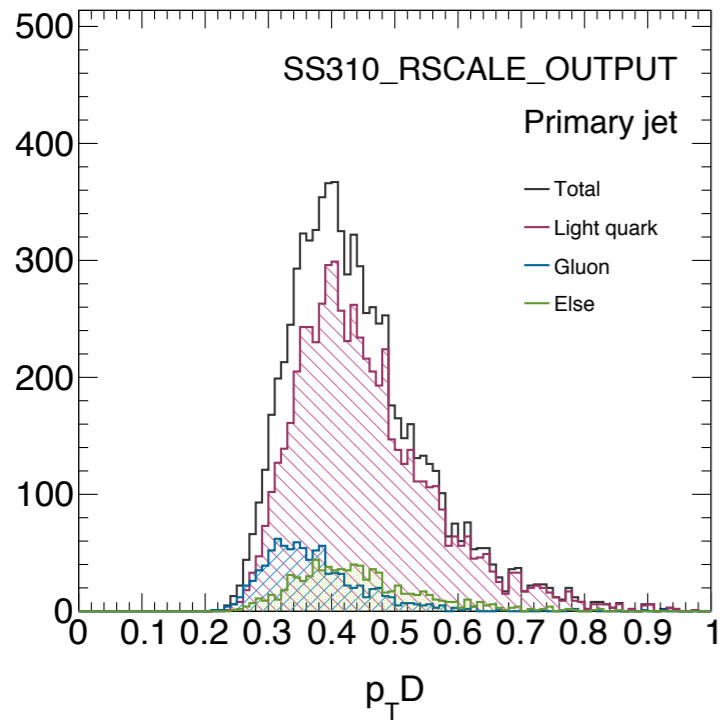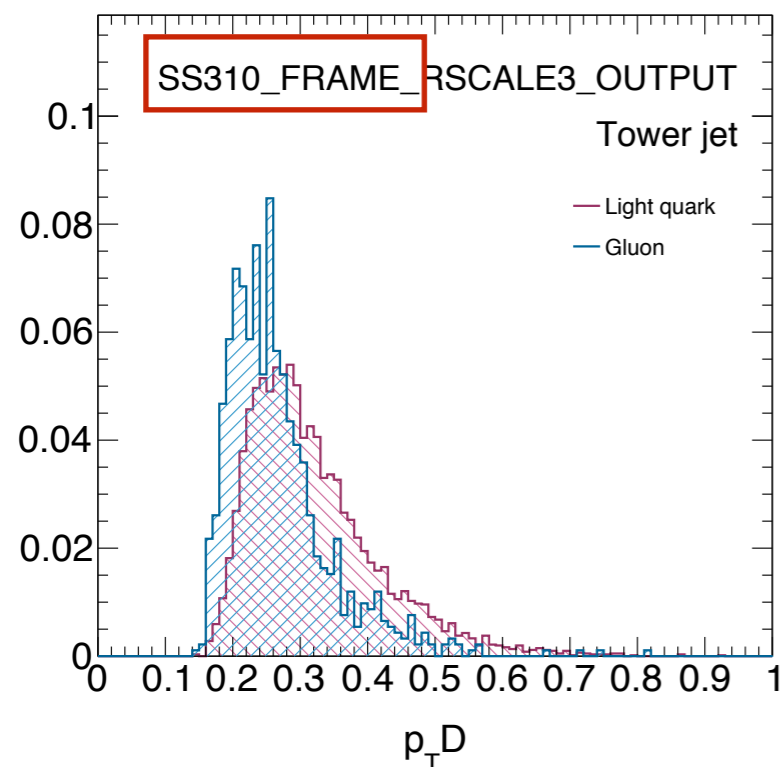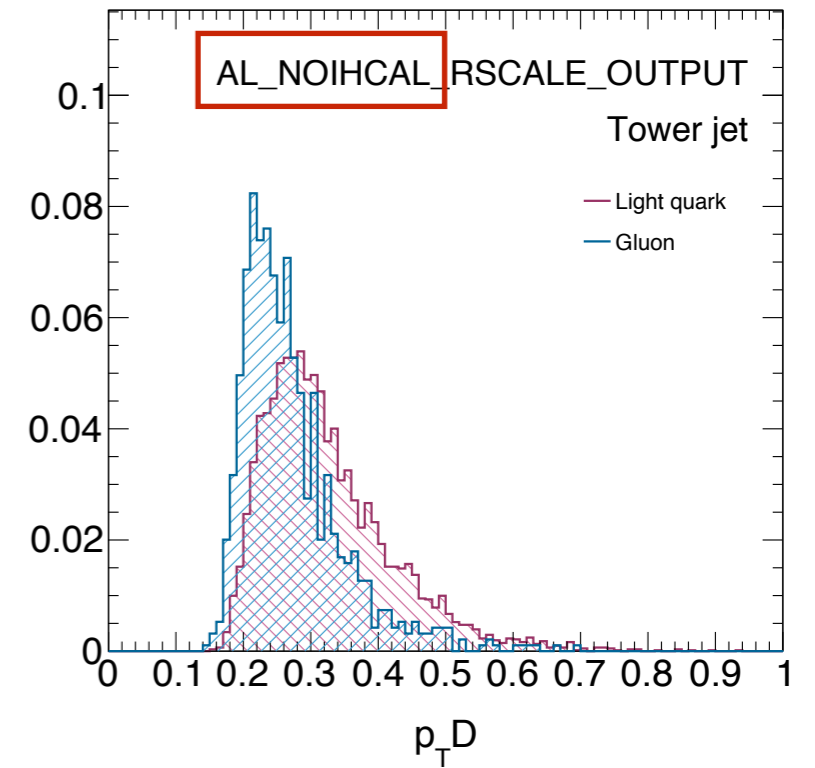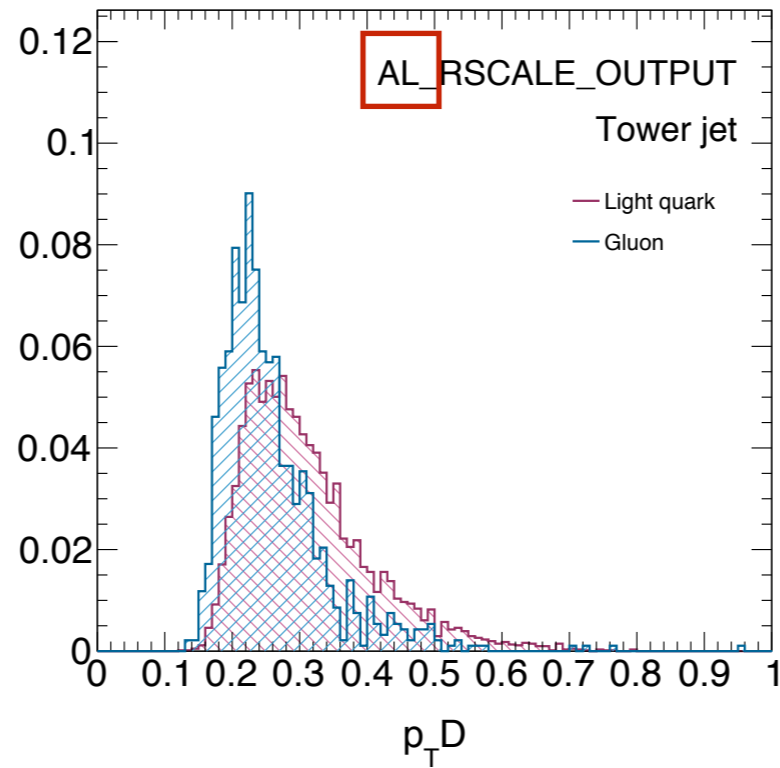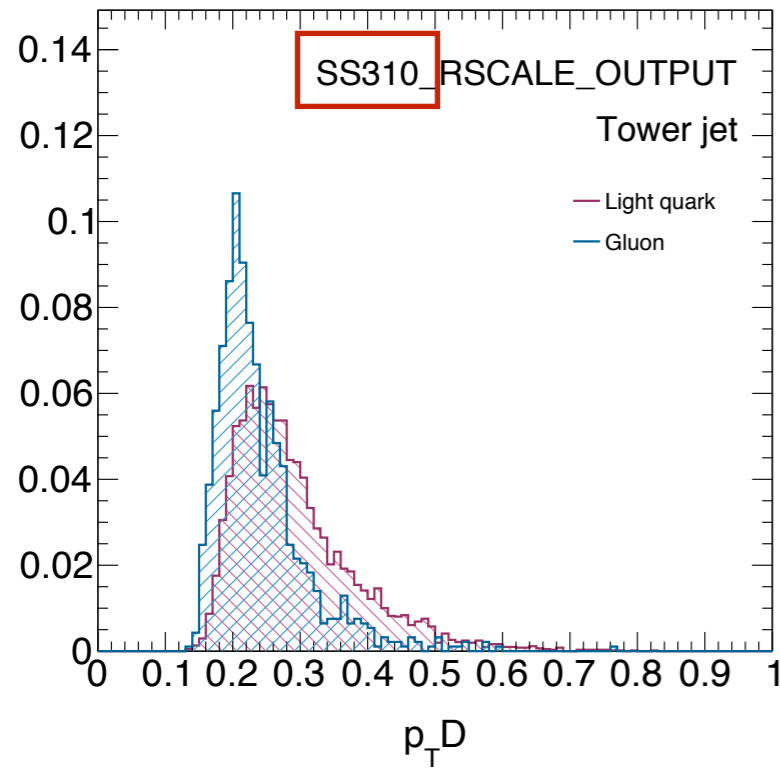
Track jet
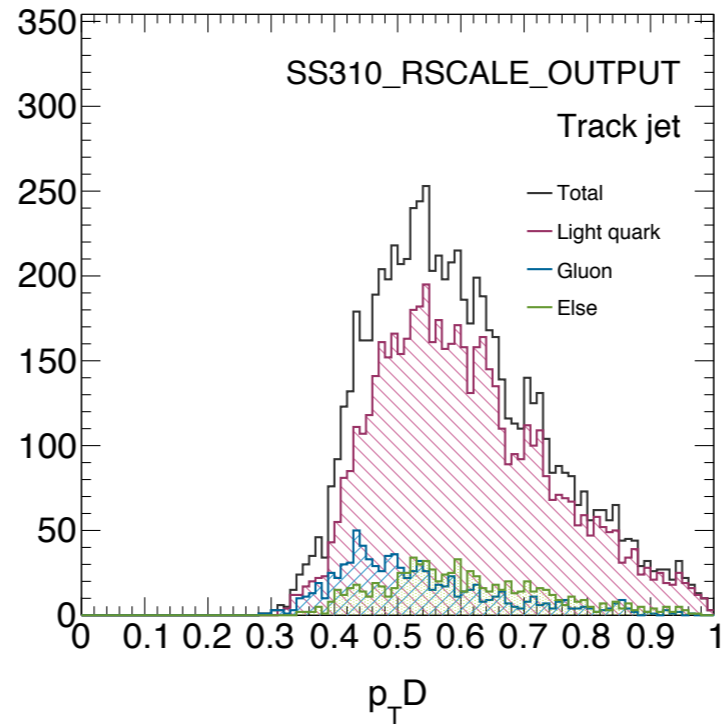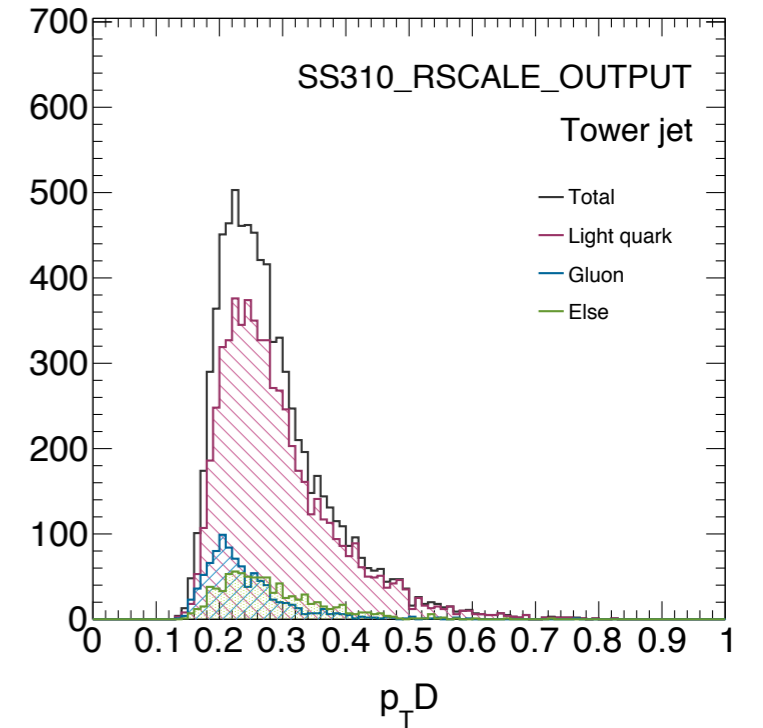
Tower jet

Normalized by integral
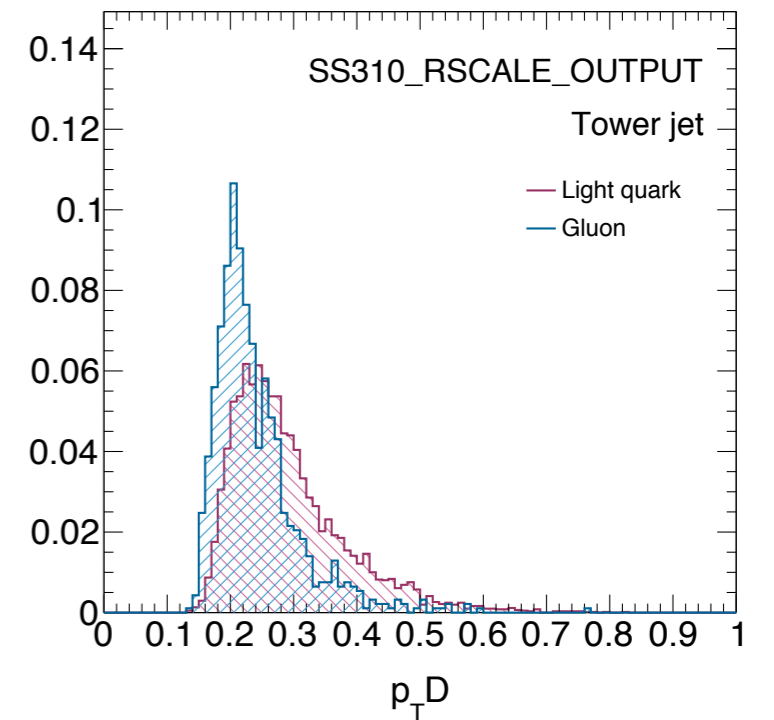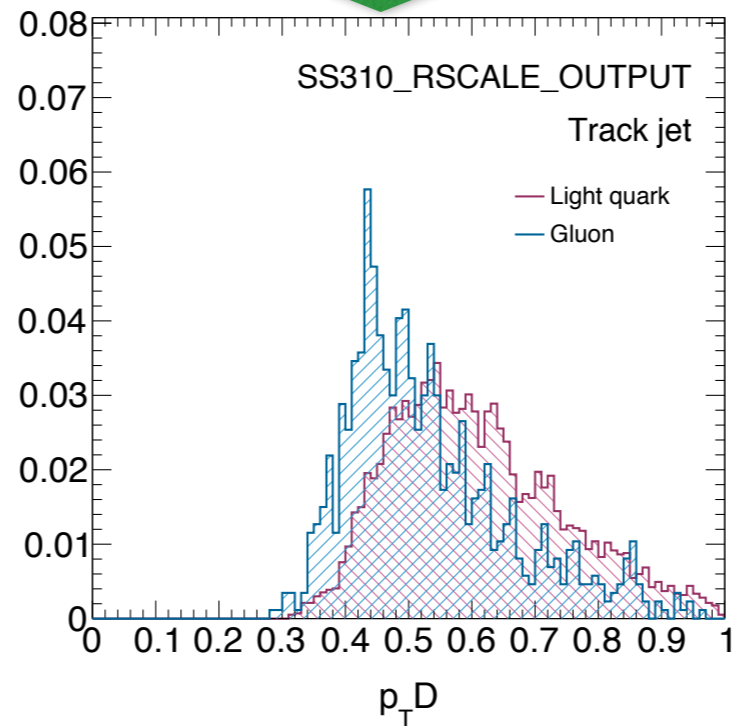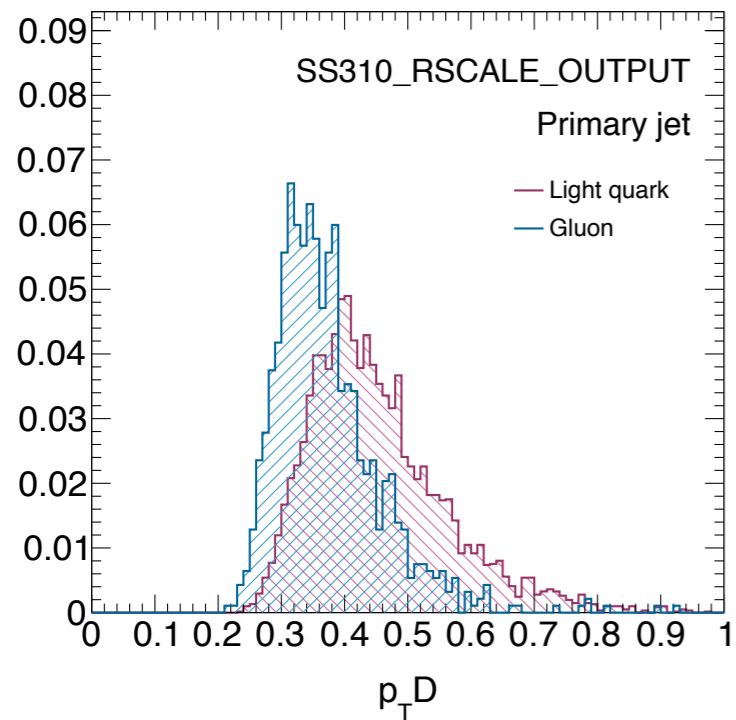
Tower jet: multiplicity

- No big differences between different IHCAL configurations
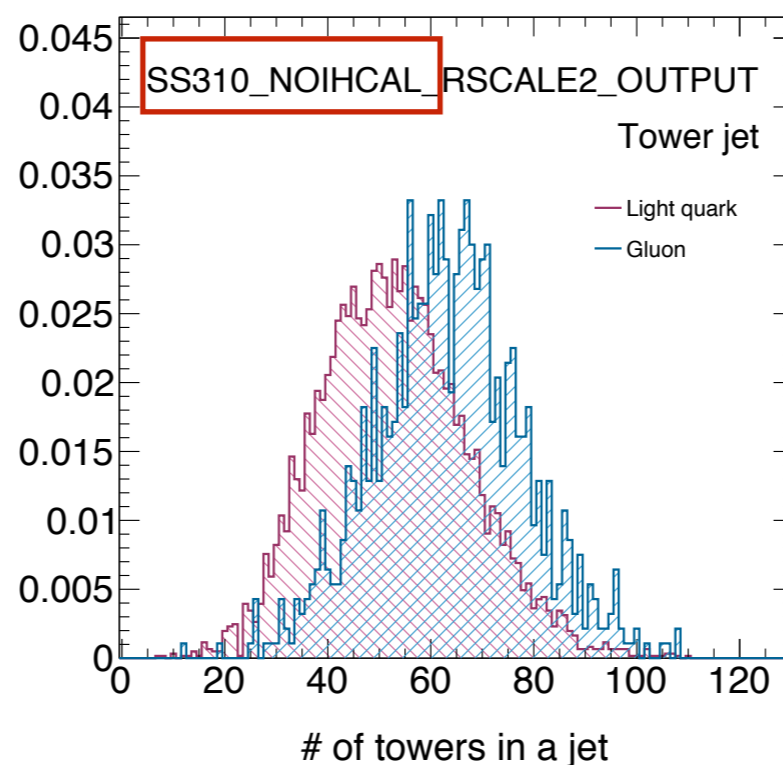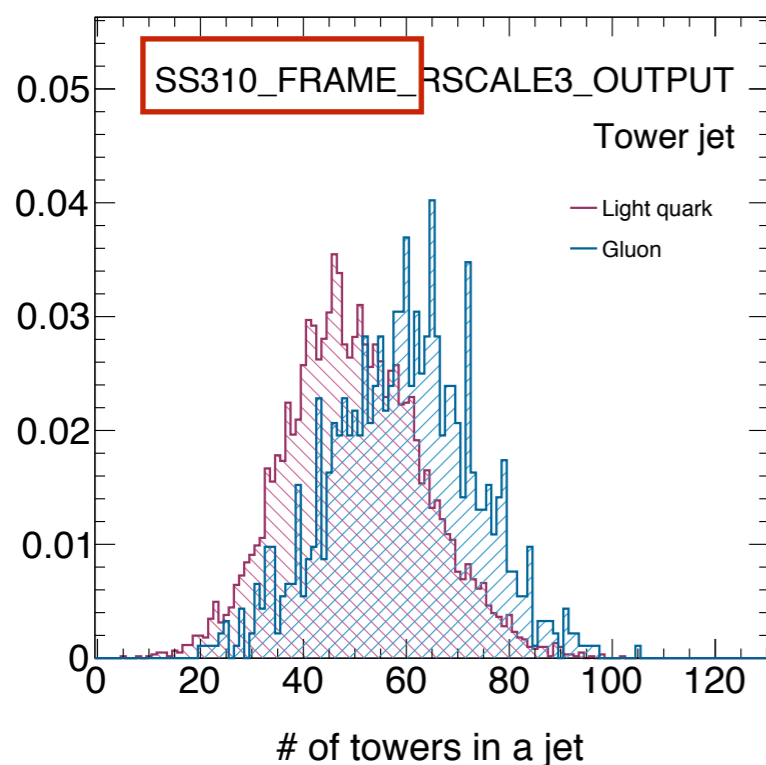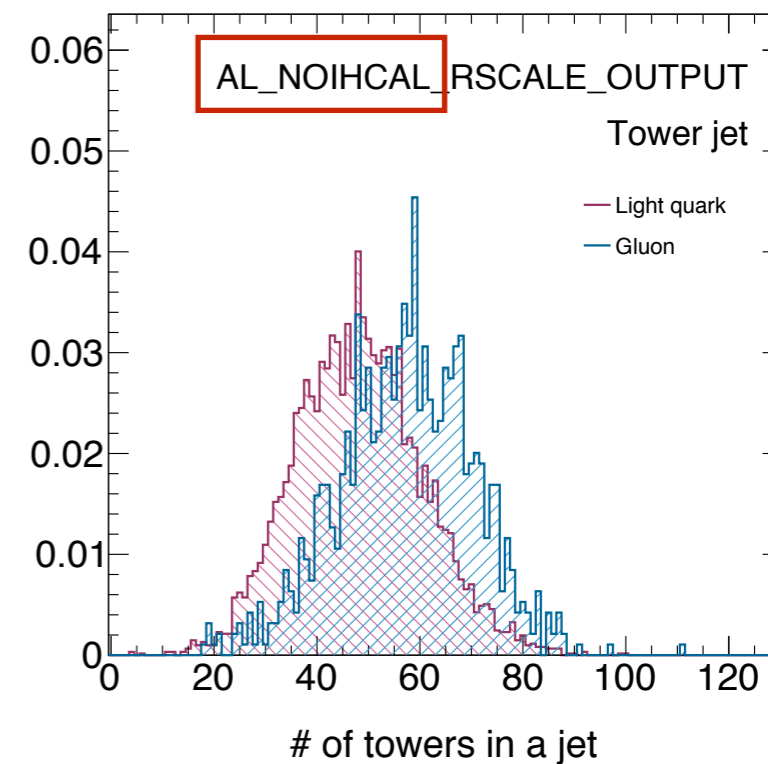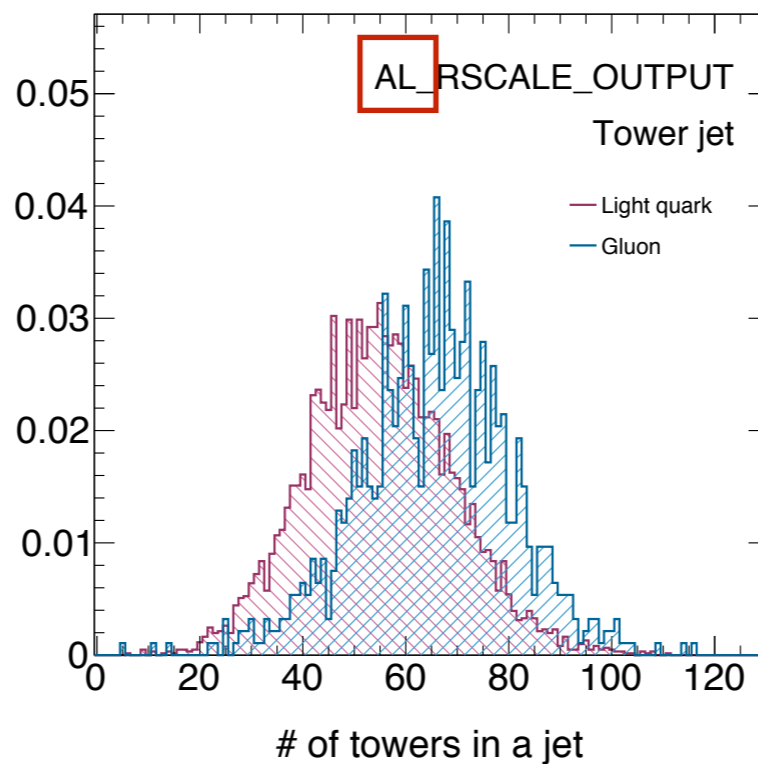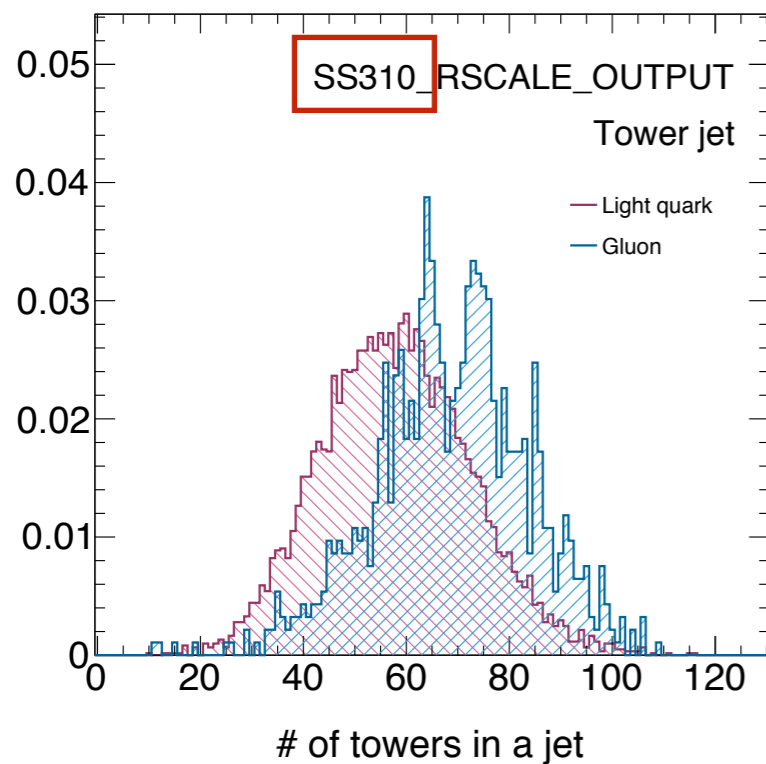
- No big differences between different IHCAL configurations
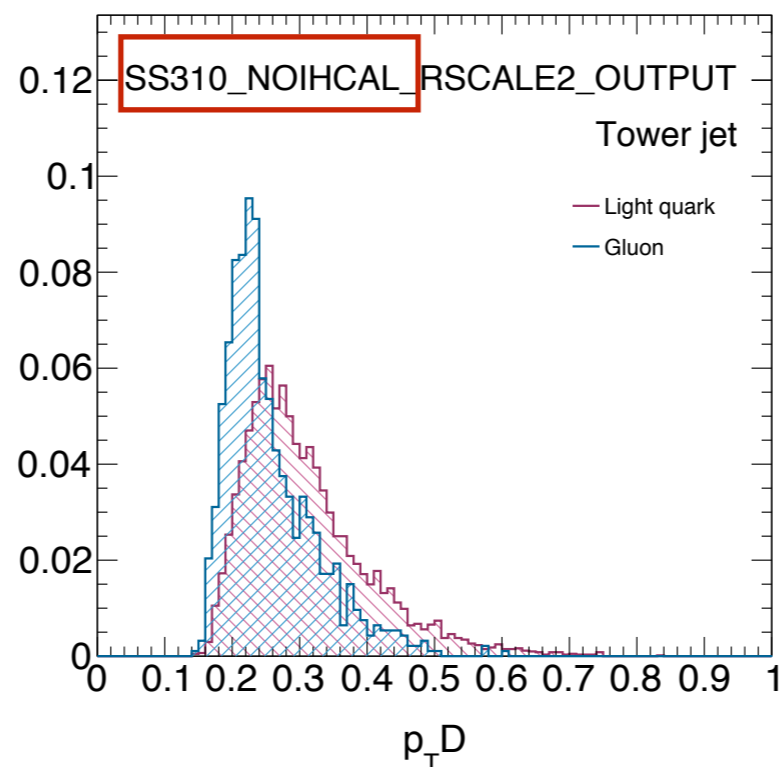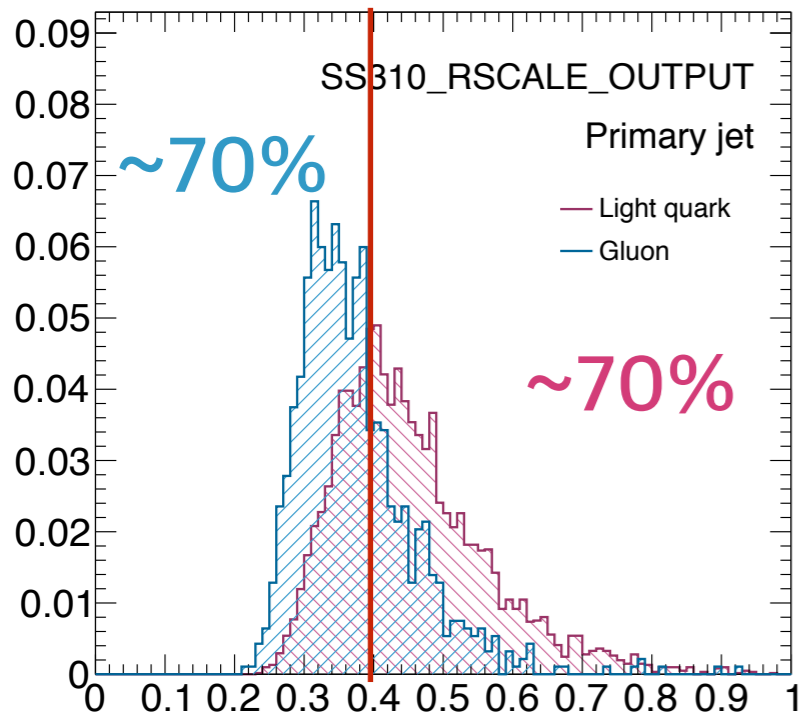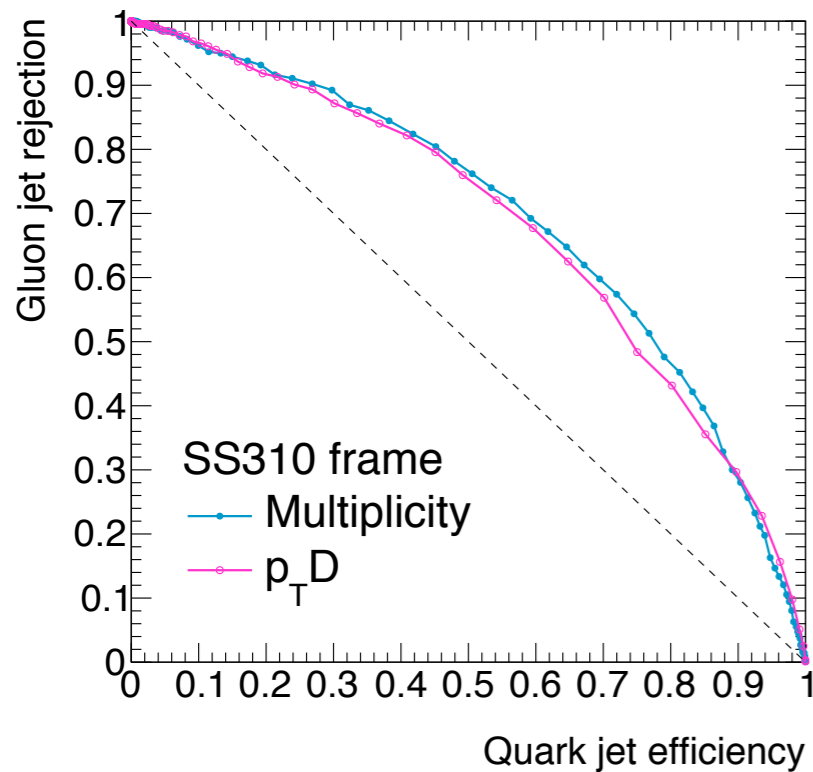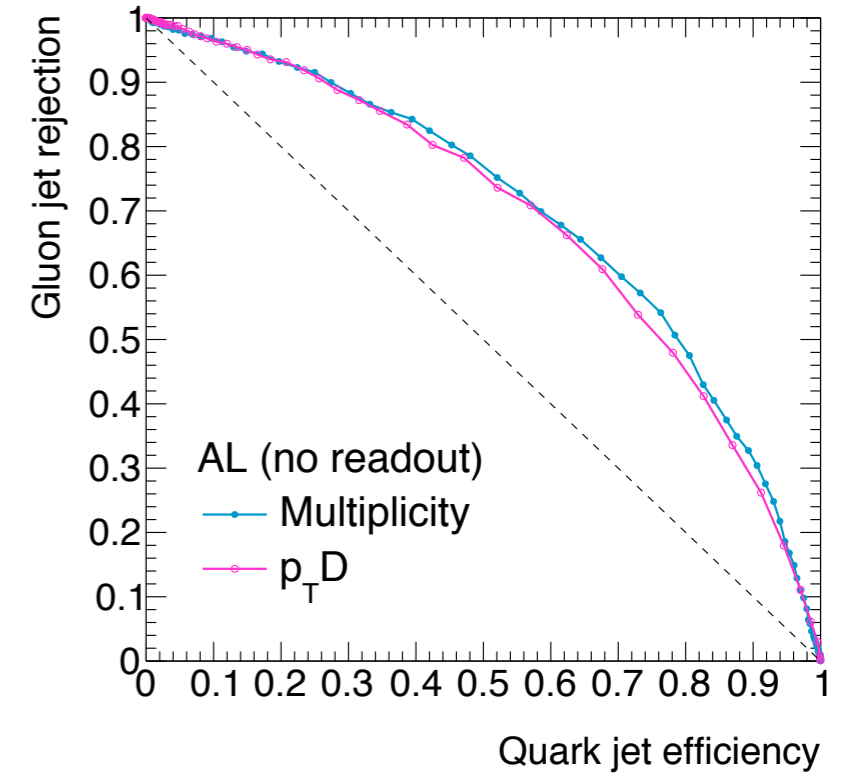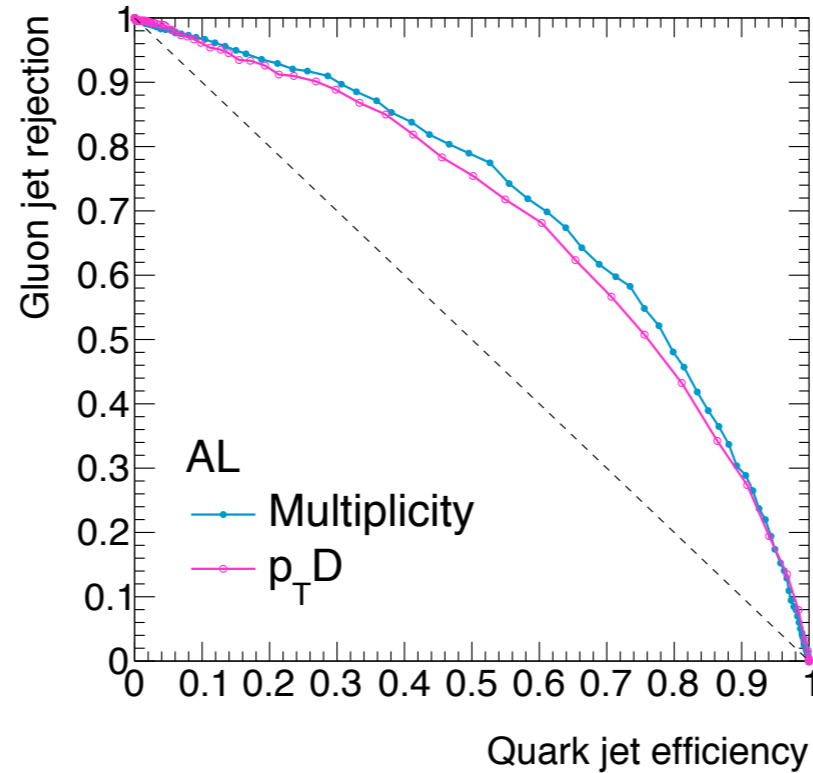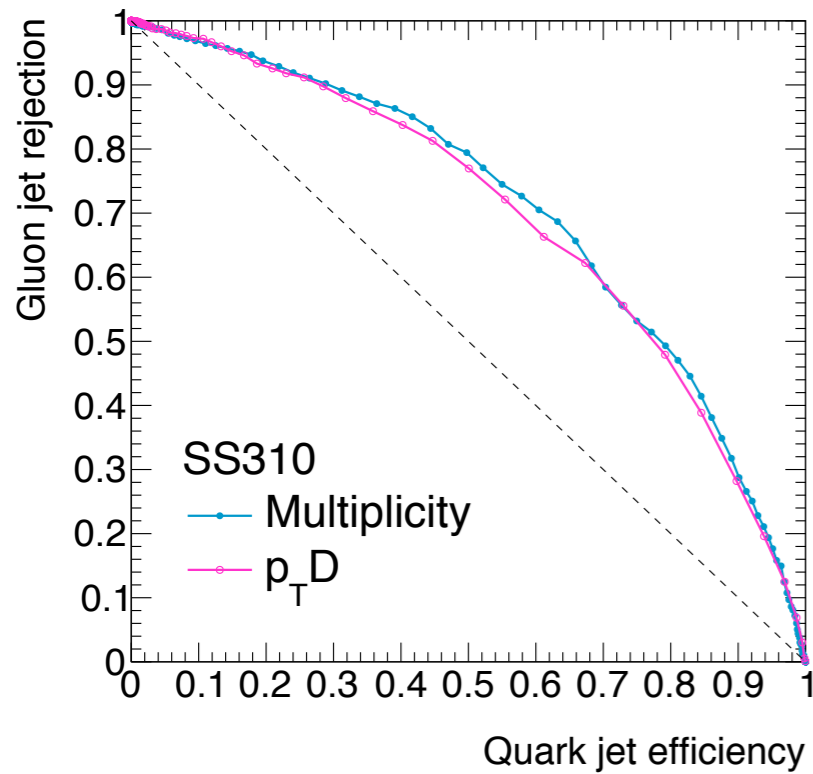
ROC curves (p_TD)
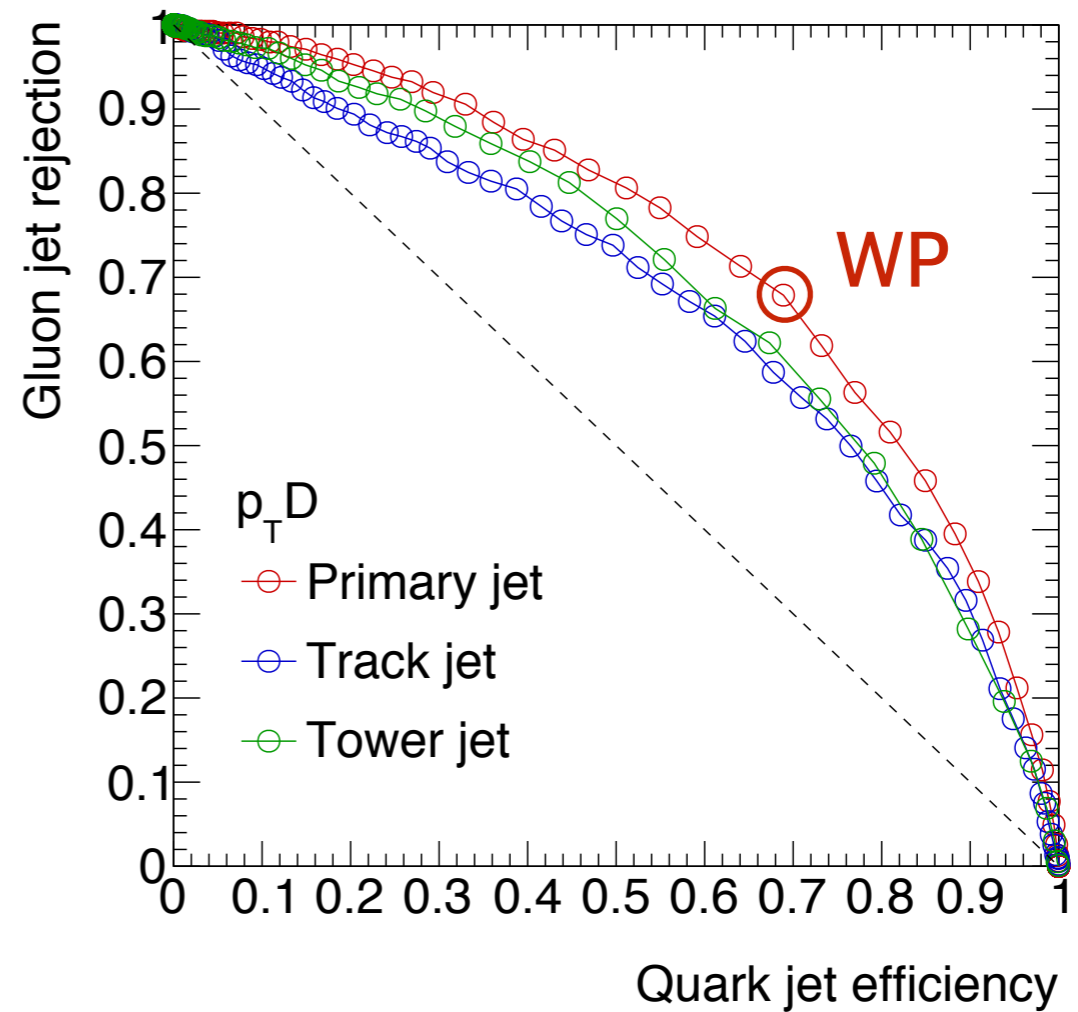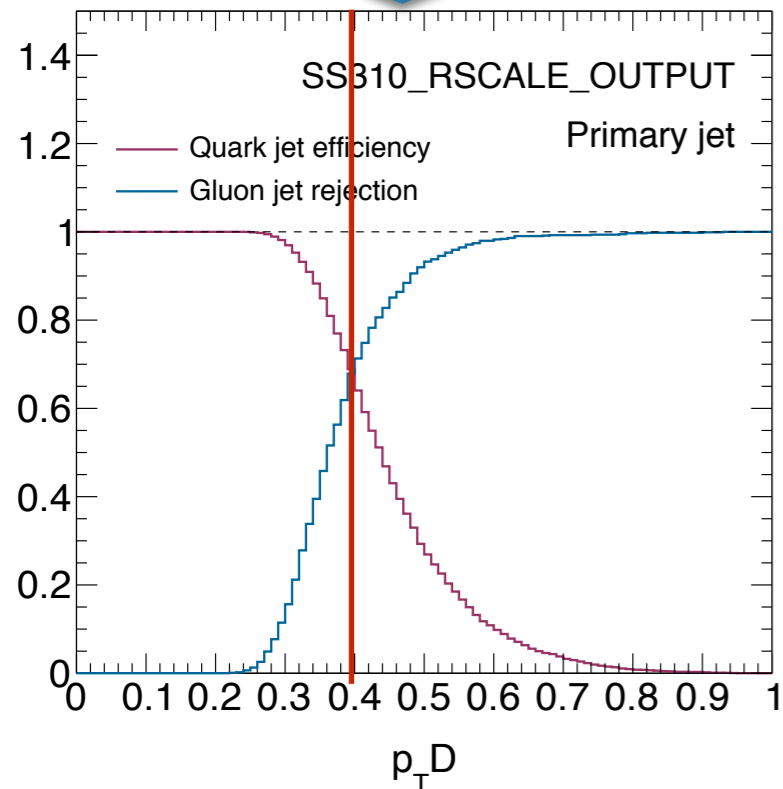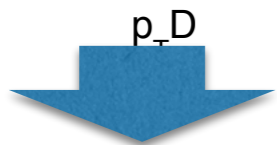
Multiplicity vs. p$_T$D
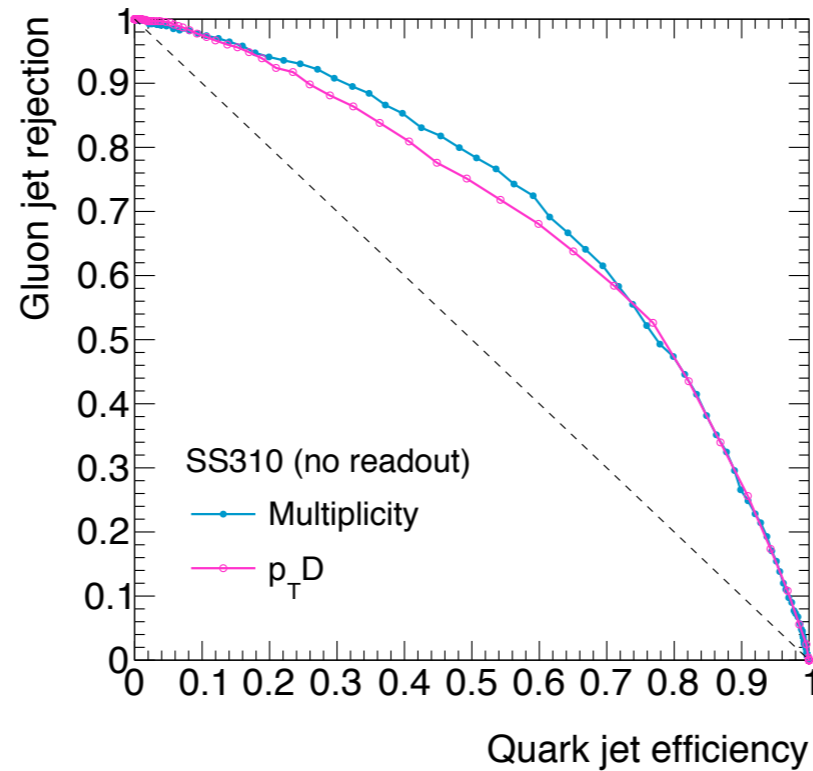
- Multiplicity slightly better, but no big difference