The measurement of the Boosted ttZ process

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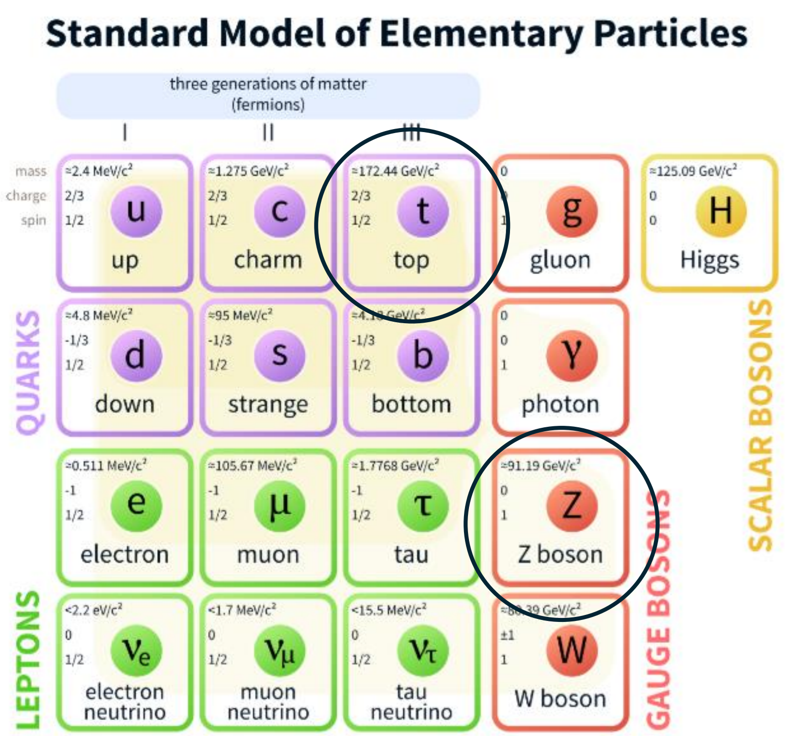
The Top Quark in the Standard model

- Heaviest elementary particle, with a mass of 173 GeV/c^2
- With charge **+2/3** .
- Discovered in **1995** by the CDF and DØ experiments at Fermilab's Tevatron collider.
- The **LHC** is a top quark factory and produces a large number of top quarks
  - This enables detailed and precise studies of the top quark's properties and interactions

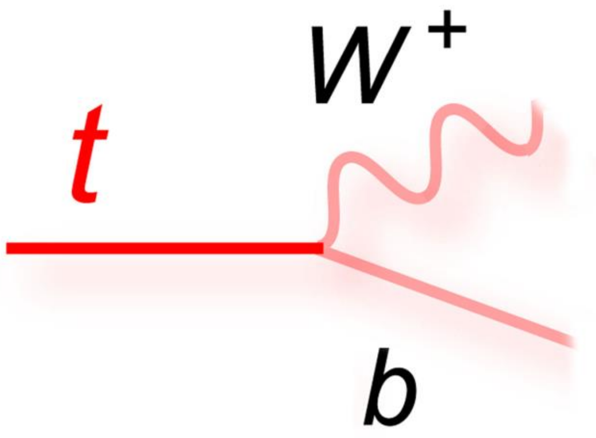


Yukawa Coupling

- is proportional to the top mass, so it has the largest Yukawa coupling.

Lifetime of the Top Quark

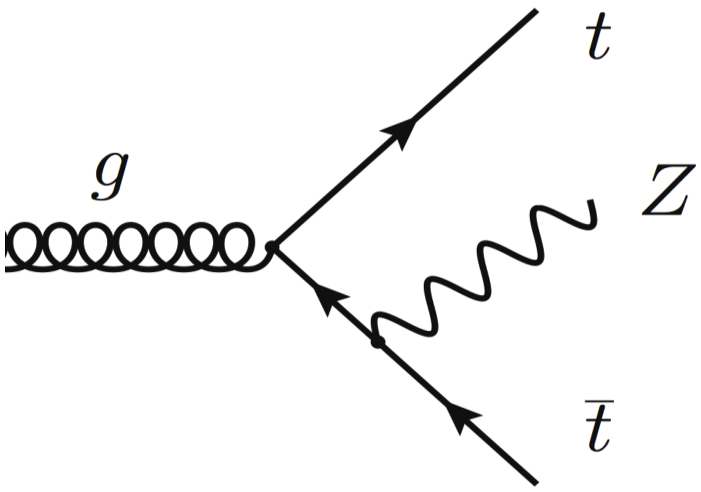
- Top quark has a very short lifetime. It decays before it can hadronize.



Why do we study ttZ ?

The process ttZ involves the production of a top-antitop quark pair in association with a Z boson

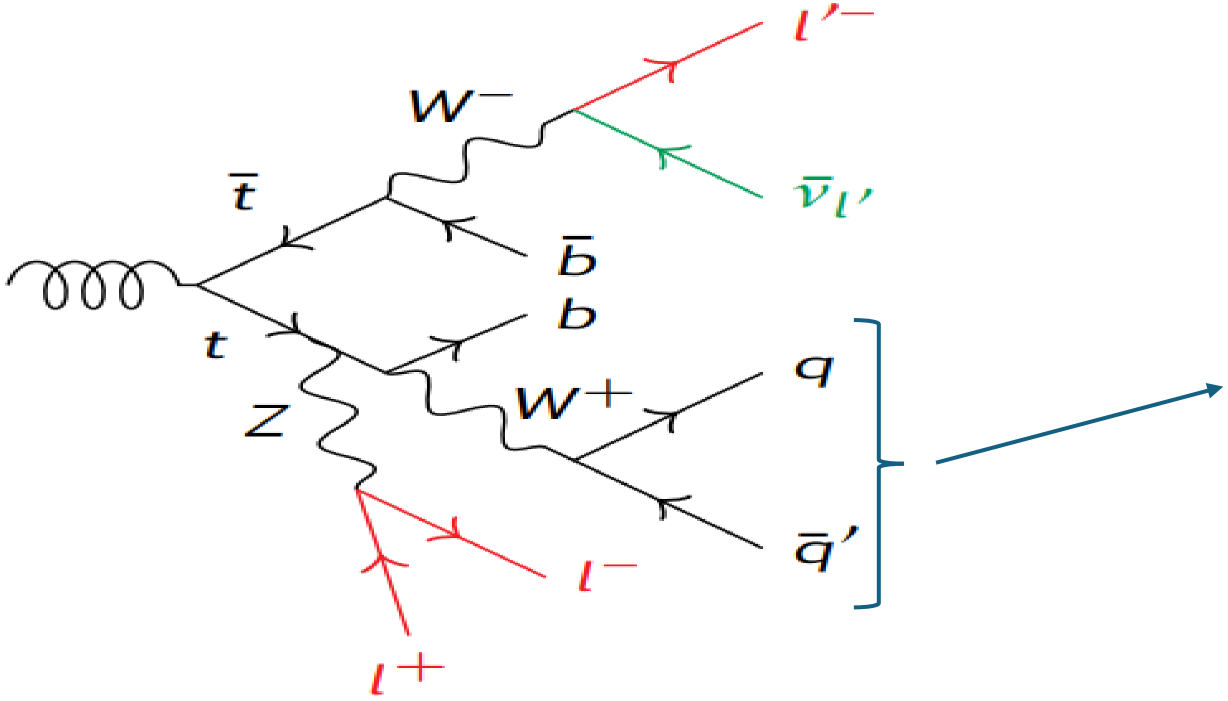
- Unique opportunity to study the electroweak interactions of the top quark.
- Precise measurements of the ttZ cross-section and kinematic distributions can test the Standard Model predictions and probe for potential anomalies or new physics.
- Allows direct measurement of the top quark's coupling to the Z boson.
- Sensitive to new physics effects parameterized within the Effective Field Theory (EFT) framework.

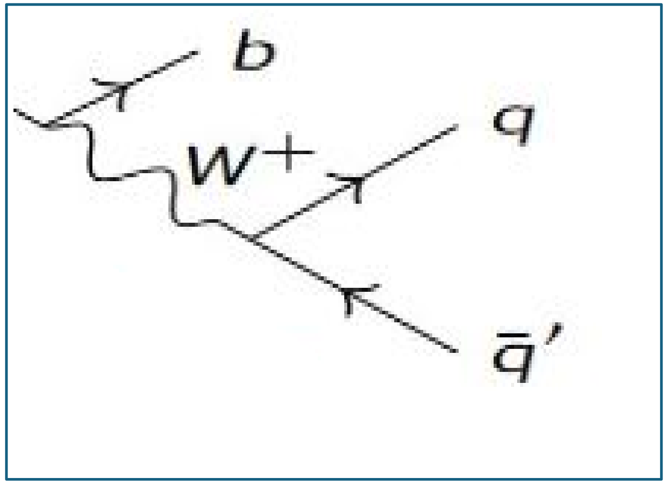


Overview of the Boosted ttZ Process 3l channel

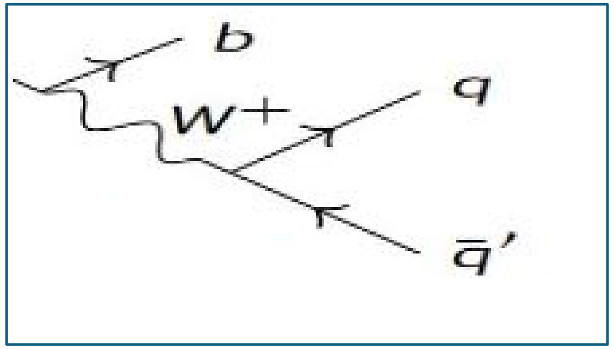
Event :

- ***3l***: Z→ ll (Same Flavor Opposite Sign) and W→ lν
- **2 b-jets:** from decays of the top quarks
- **2 light jets**





Overview of the Boosted ttZ Process 3l channel

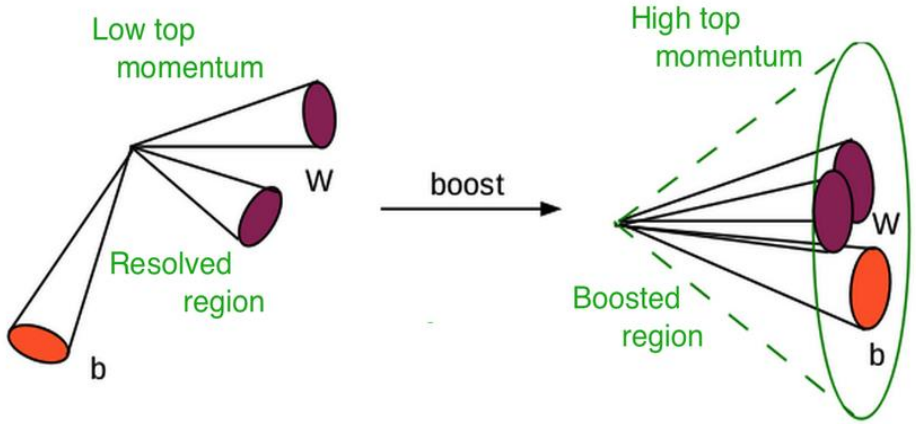


Boosting :

- high momentum
  - Decay products are not separated by large angles.
- Large Radius jets
  - Decay products are contained in a single large radius jet

RC jets:

- Using algorithm that re-combine small sub-jet into larger jets.
- Improve the identification and reconstruction of hadronically decaying boosted particles.



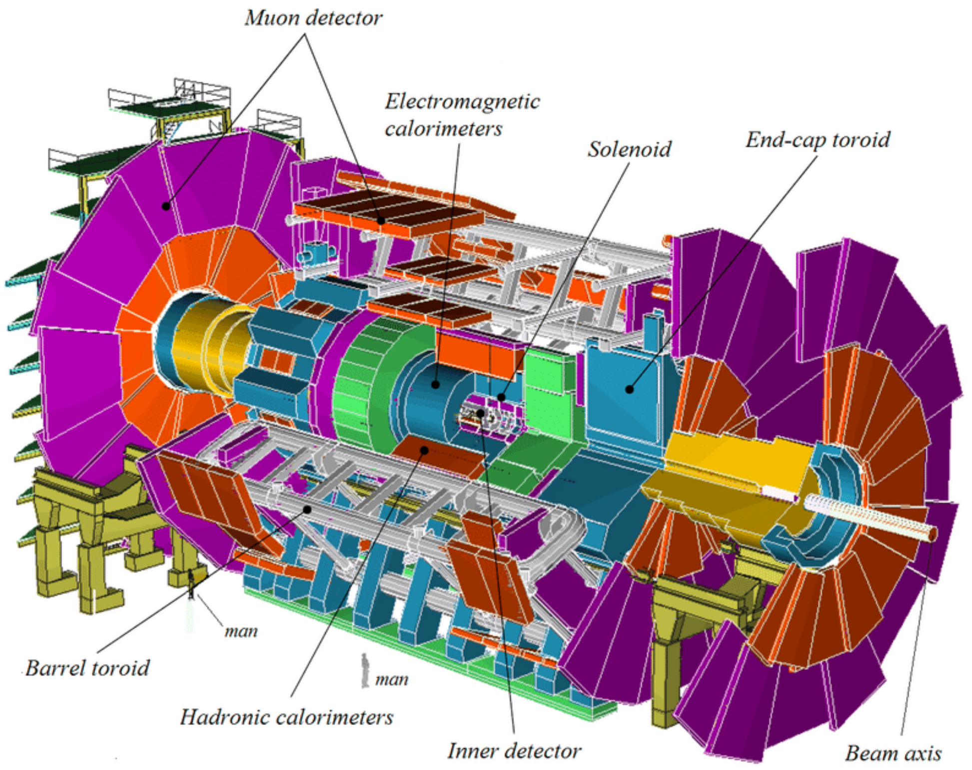
Full Simulation (FS) and Atlas Fast Simulation (AF3) in the ATLAS Detector

FS:

- Refers to a detailed simulation approach with high precision.
- Provides accurate data but requires significant computational resources.

AF3 :

- A parametrized detector response model.
- Significantly speeds up the simulation process by simplifying the modeling of detector responses.



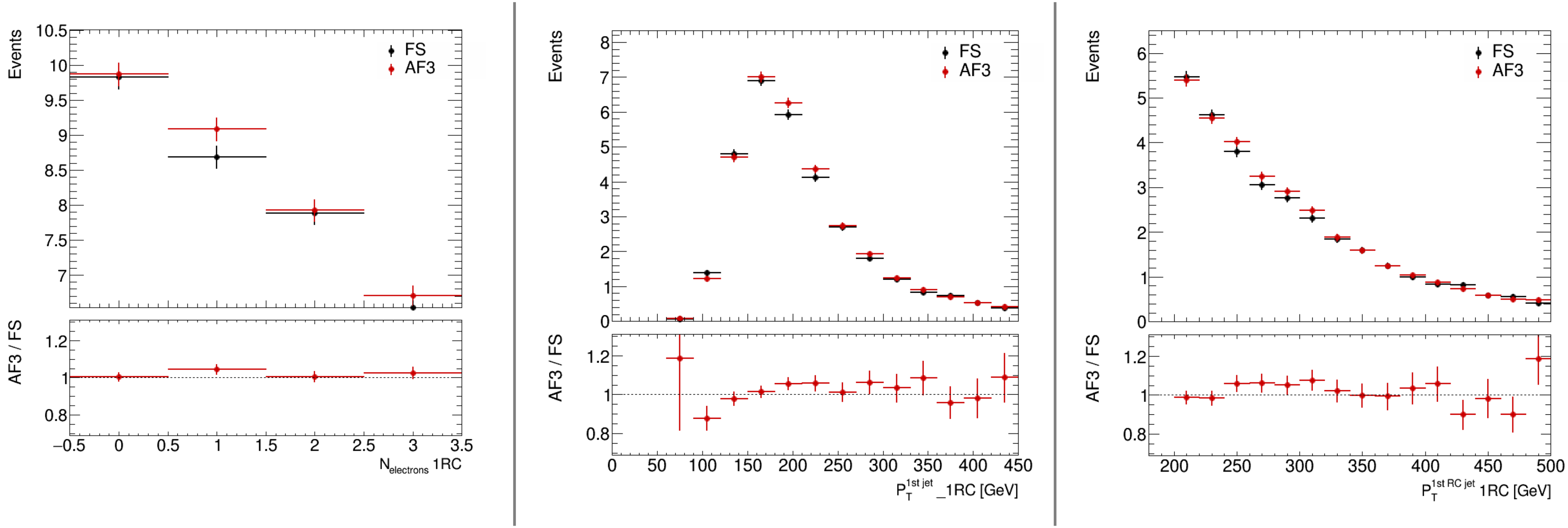
Comparison of Two Simulations Using PyROOT

ROOT
Data Analysis Framework

Part of my code

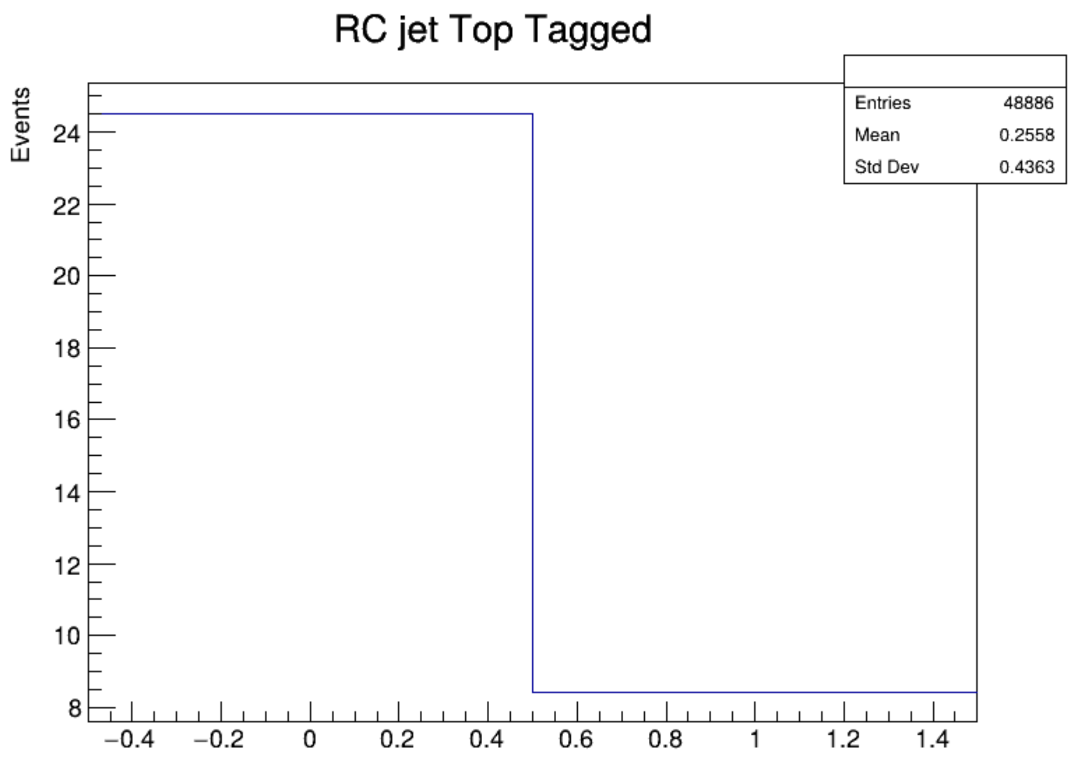
```python
# Get the histograms from the files
hist1 = file1.Get(f"{folder_name}/subjet_3_pt_region_3L_1RC")
hist2 = file2.Get(f"{folder_name}/subjet_3_pt_region_3L_1RC")

# Draw the histograms on these axes
hist2.SetMarkerColor(root.kRed+1)
hist2.SetLineColor(root.kRed+1)
ax1.plot(hist1, "EP" , linecolor= root.kBlack , label="FS", labelfmt="EP ")
ax1.plot(hist2, "EP", label="AF3", labelfmt="EP")



# Calculate and draw the ratio
ratio_hist = hist2.Clone("ratio_hist")
ratio_hist.Divide(hist1)
ratio_hist.SetMarkerColor(root.kRed+1)
ratio_hist.SetLineColor(root.kRed+1)
ax2.plot(ratio_hist, "EP" )


# Draw line at y=1 in ratio panel
line = root.TLine(ax2.get_xlim()[0], 1, ax2.get_xlim()[1], 1)
ax2.plot(line, linecolor=root.kBlack , linestyle=2)
line.SetLineStyle(2)
ax2.plot(line)
```

Some of the results



- Both simulations produce almost similar event counts for the given bins.
- The ratios are very close to 1, indicating that AF3 provides a similar response to FS.
- AF3 should therefore be calibrated.

Work in progress: add variables like RC Jet is top tagged or not ?




```cpp
ROOT::RDF::RNode ttZBoostedFrame::is_RCjetToptagged(ROOT::RDF::RNode mainNode) {
    auto isRCjetToptaggedLambda = [](const std::vector<RCJet>& rc_jets) {

        // loop through each RC jet in the vector
        for (const auto& rc_jet : rc_jets) {
            //check if the RC jet has at least 3 subjets
            if (rc_jet.n_subjets()>= 3) {
                //check if the RC jet mass and pt criteria
                if (rc_jet.M()> 20'000 && rc_jet.Pt()> 200'000){
                    //loop through each subjet in the RC jet
                    for (const auto& subjet:rc_jet.subjets()){
                        // check if the subjet is b-tagged
                        if (subjet->is_btagged()){
                            return true;
                        }
                    }
                }
            }
        }
        return false;
    };


    mainNode = systematicDefine(mainNode, "isRCjetToptagged_NOSYS", isRCjetToptaggedLambda, {"rc_jets_NOSYS"});

    return mainNode;
}
```

Thank you
For listening

Scan me