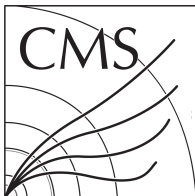# Adding Tau Leptons to TTTT X-Section Measurement

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# INTRODUCTION

- **Goal:** Investigate how the TTTT cross-section measurement could be improved by adding taus to the lepton selection.
- To avoid the work of modifying the existing analysis looper to include taus, a simple "mock"[1] analysis was implemented from scratch which attempts to replicate the main features of the real analysis.
- Runs on same `CMS4` nTuples as existing analysis.

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[1]`https://github.com/cfangmeier/FTAnalysis/tree/tau_studies/studies/tau`

Mock Analysis 2016 Yields

- Attempt to replicate AN yields with mock analysis using only electrons and muons
- Generally overestimate yield (wrt analysis note)by 10-30%. (However this doesn't include any scale factors)
- But shapes tend to match, so go ahead and add taus to make a comparison.
- All data normalized to 35.9 fb^{-1}.
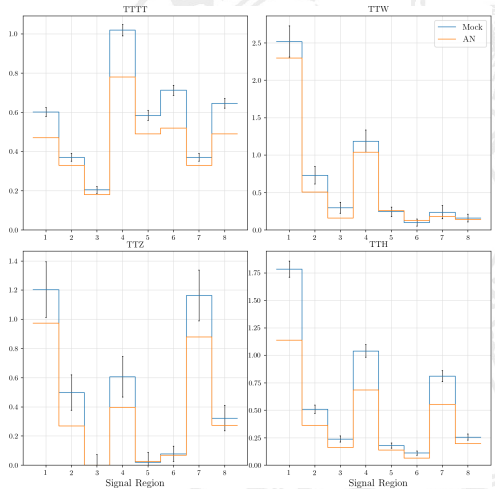
Tau Selection

- Taus to be considered in the SS pair must pass the following requirements
    - Pass the ID: `byTightIsolationMVArun2v1DBdRO3oldDMwLT`
    - Have $P_T > 20$GeV
    - Isolated ($dR > 0.4$) from any electrons or muons that pass their respective selection criteria
- Generator-Level taus used in truth-matching must:
    - Be flagged as prompt (ie. `tas::genps_fromHardProcessDecayed()==1`)
    - Decay hadronically ($\tau^{\pm} \to \pi^{\pm}\{\pi_0\}$, $\tau^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}\{\pi_0\}$)
- A reconstructed tau is considered truth-matched if it is within $dR < 0.3$ of a generator-level tau
- Otherwise taus are treated exactly the same as electrons and muons in the SS-pair construction/Z-Veto/Jet-Cleaning.

Yields/Truth Matching
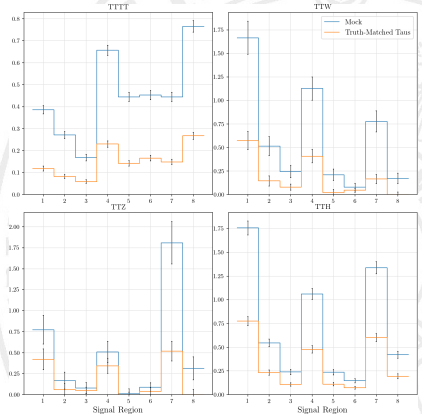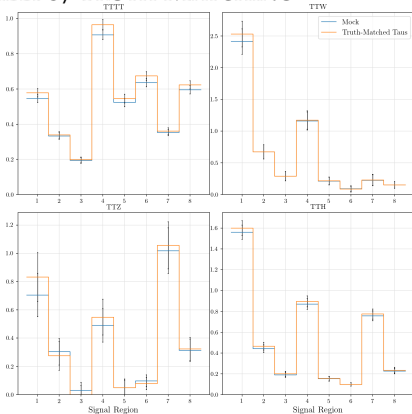
- ▶ Above figures show yields when there are zero selected taus(left) or one selected tau(right).
- ▶ Orange Lines show yields when the tau is required to be truth-matched.
- ▶ About 60% of taus are fakes!
- ▶ Adding taus is clearly not helpful at all in SS regions(1-6), but maybe helpful in multi-lepton regions(7-8)

CROSS-CHECKING TRUTH MATCHING

- Previous slide indicates $\approx 60 - 70\%$ of taus are fakes.
- Figure shows the yields for events in any SR broken down by # of generator-level taus and # of selected taus.
- The figure on the right corroborates the previous slide; In TTTT, for example, only about 40% of events with 1 selected tau have 1 or more real taus.
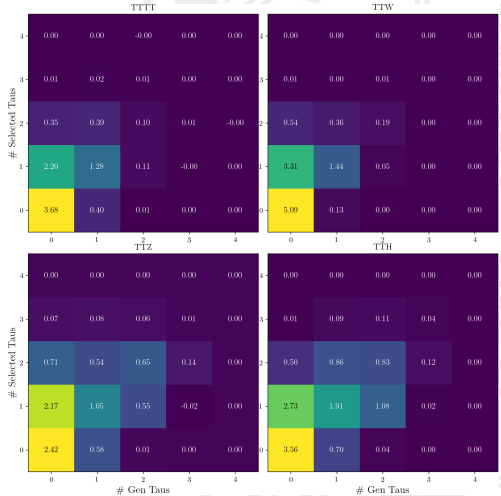
Results with Expanded Binning
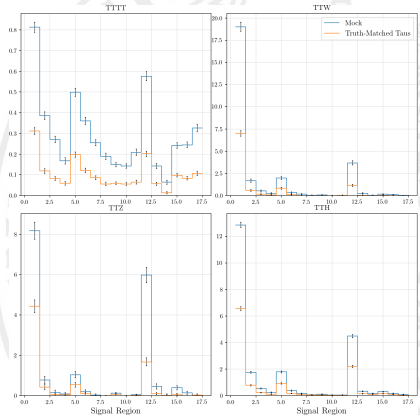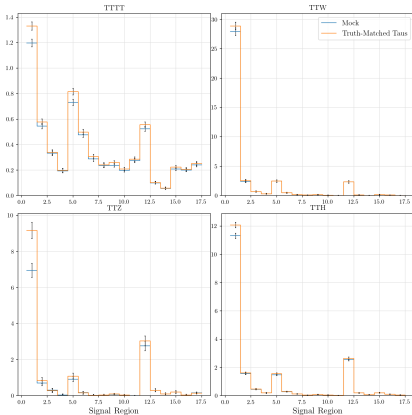
- ▶ Ongoing investigation of more fine binning[2].
- ▶ Same conclusions: SS show no gain, and multilepton may give marginal improvements

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[2] https://github.com/cfangmeier/FTAnalysis/blob/tau_studies/studies/tau/Yield.C#L261

Conclusions

- Investigated any benefit to including taus in measurement.
- With current tau selection no gain in SS
- Possibly very small (few percent) gain in multilepton categories
- Large amount of work needed to create data-driven estimate of fake-tau background
- Propose to document this and shelve it for now
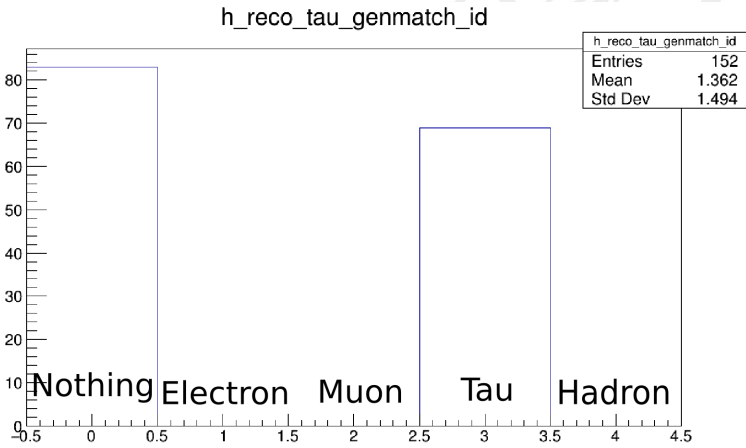
BACKUP - TAU RECO PERFORMANCE
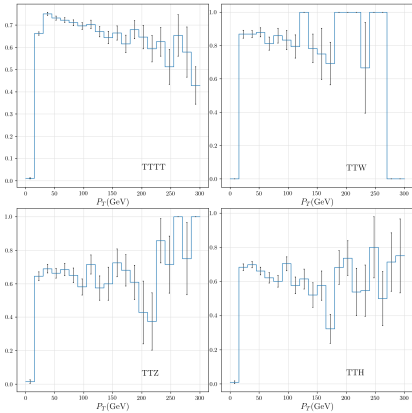
Tau Selection Efficiency (reco + id + $P_T > 20$GeV)
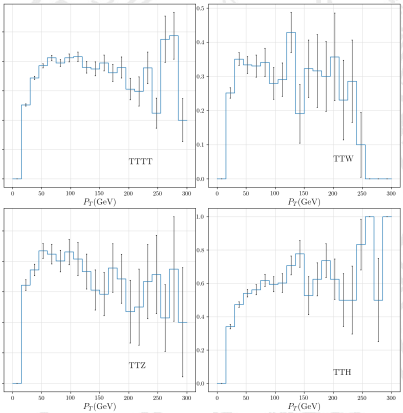
Tau Purity (matched w/ generator-level tau at $\delta R < 0.3$)

Backup - Truth Matching Identity

Tau Selection Efficiency (reco + id + $P_T > 20$GeV)

► **Note:** The flag for picking generator final state particles doesn't actually include the hadronic particles so it's likely that many of the "Nothing" taus really belong in the "Hadron" category. (Will be fixed in future)