Fake-background estimation for the search for supersymmetry in multileptonic final states with the ATLAS detector

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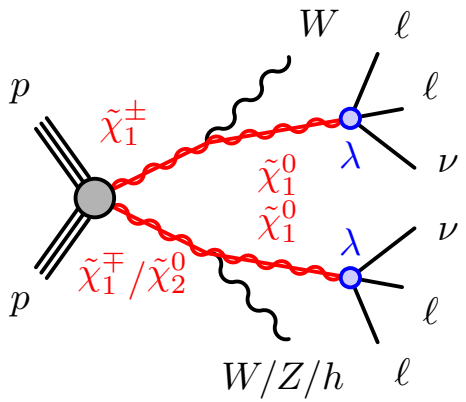
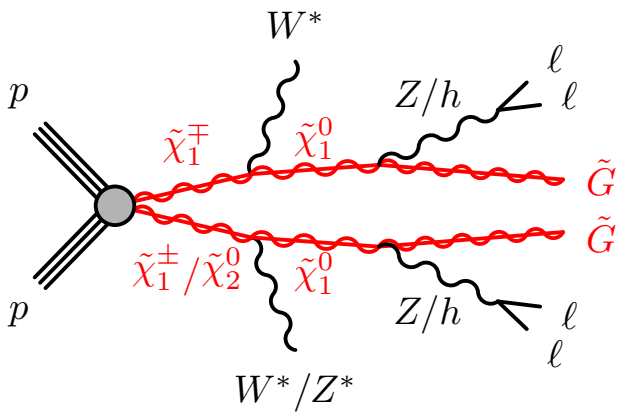
Introduction

Search for Supersymmetry in Final states with four leptons





R-parity violating (RPV) SUSY

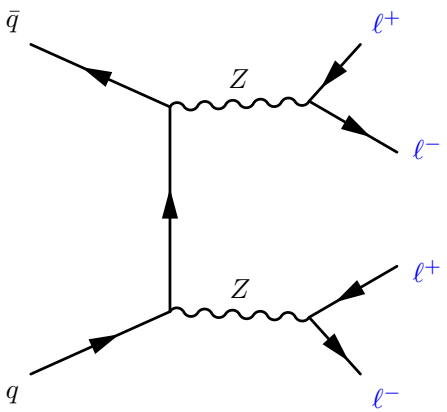
General Gauge Mediated (GGM) SUSY

Final states distinguished by hadronic τ multiplicity and the presence or absence of a Z boson

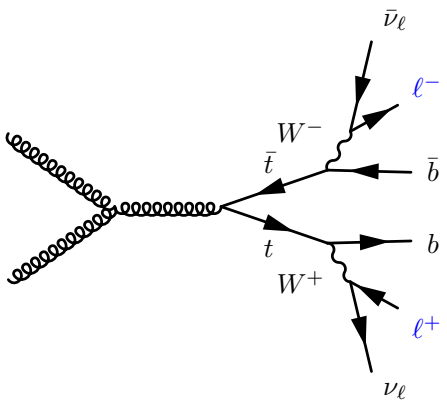
Background

Two types of background:

- Irreducible background:
  - Processes with four or more leptons in the final state
  - e.g. ZZ, $t\bar{t}Z$, VVZ ($V = Z, W$)
  - Estimated from Monte Carlo simulation



- Reducible background:
  - Processes with at least one fake lepton
  - Estimated with data-driven fake-factor method
  - e.g. $t\bar{t}$, Z+jets
  - dominating background in regions with τs



The Fake factor method

Why not using Monte Carlo simulation for the fake lepton background?

- low statistics
- bad modeling of fake leptons

To increase statistic:
Use control regions with one or two loose leptons (lepton failing a signal selection criteria).

$$N_{SR}^{SM,reducible} = (N_{CR1}^{data} - N_{CR1}^{SM,irreducible})F - (N_{CR2}^{data} - N_{CR2}^{SM,irreducible})F_1F_2$$

- Fakefactor: $F \approx \frac{N_{signal}}{N_{loose}}$
- CR1: Region with 1 loose lepton (most likely a fake lepton)
- CR2: Region with 2 loose leptons

Fake factor F depends on process ($t\bar{t}$, Z+jets) and fake type

The Fake factor method

$N_{SR}^{SM,reducible} = (N_{CR1}^{data} - N_{CR1}^{SM,irreducible})F - (N_{CR2}^{data} - N_{CR2}^{SM,irreducible})F_1F_2$

The final Fake factor is the weighted average over all fake types and processes

$F^{\ell} = \sum_{i,j}(f^{ij} \times sf^{i} \times F^{ij})$

$F^{ij} = \frac{N_{signal}}{N_{loose}}$: Fake factor

- estimated from MC
- independent from the region (no need for four leptons)

$sf^{i} = \frac{F_{data}}{F_{MC}}$: Scale factor

- Correct data to MC
- measured in a region enriched with a certain fake type

f^{ij}: Process fraction

- Fraction of each contributing fake type and process
- estimated from MC
- dependent on the contro lregion

Fake type

Fake leptons are distinguished by the fake origin

- light flavor (LF) jets
  - -- hadrons misidentified as leptons
- heavy flavor (HF) jets
  - -- leptons originating from leptonic decays of heavy hadrons
  - -- real leptons but not originating from the primary process
- Conversion
  - -- electrons only
  - -- originating from photons decaying into e^+e^- (one is not reconstructed)
- Gluon jets
  - -- τ only
  - -- Gluon jet reconstructed as τ

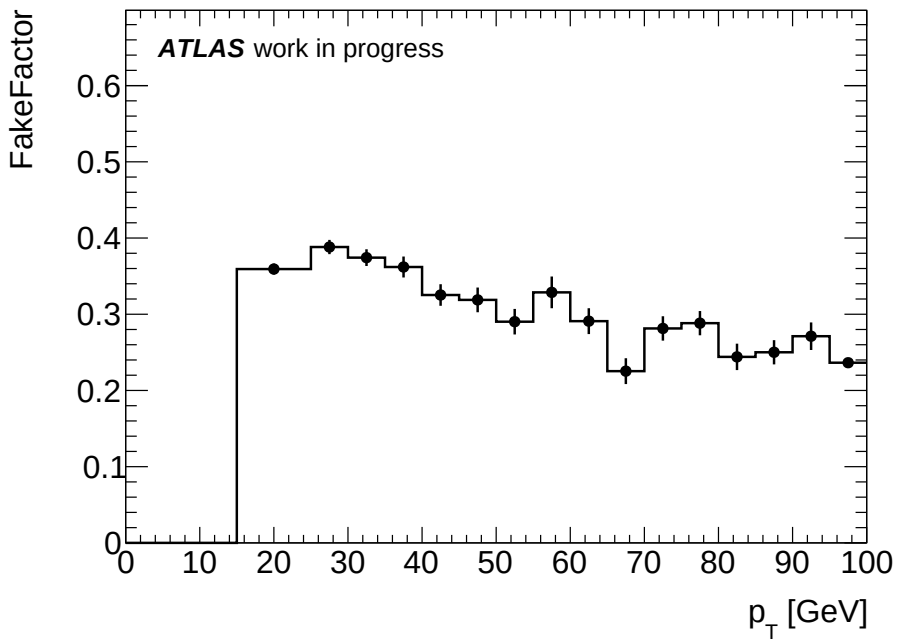
Concentrating on τs for this talk

Fake factor

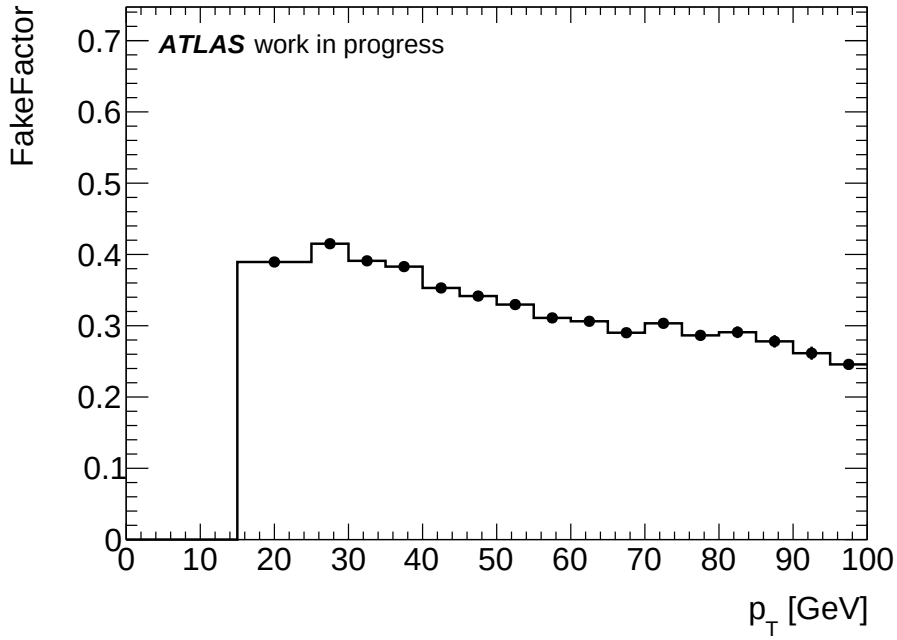
Fake τ from light flavor jets.

1-prong τ

Process: Z+jets



Process: $t\bar{t}$



$$F = \frac{N_{signal}}{N_{loose}}$$

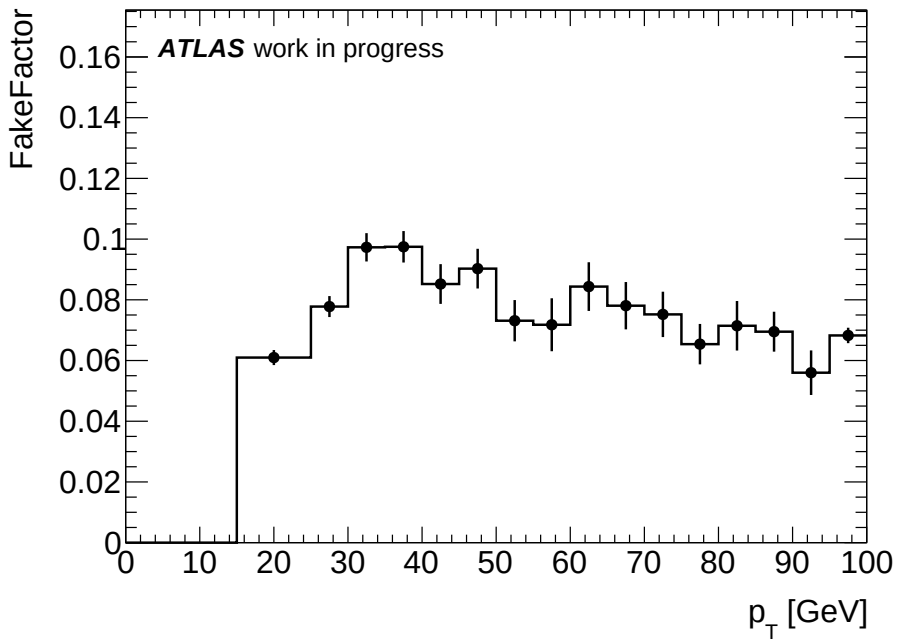
- similar behavior for fake τ from $t\bar{t}$ and Z+jets

Fake factor

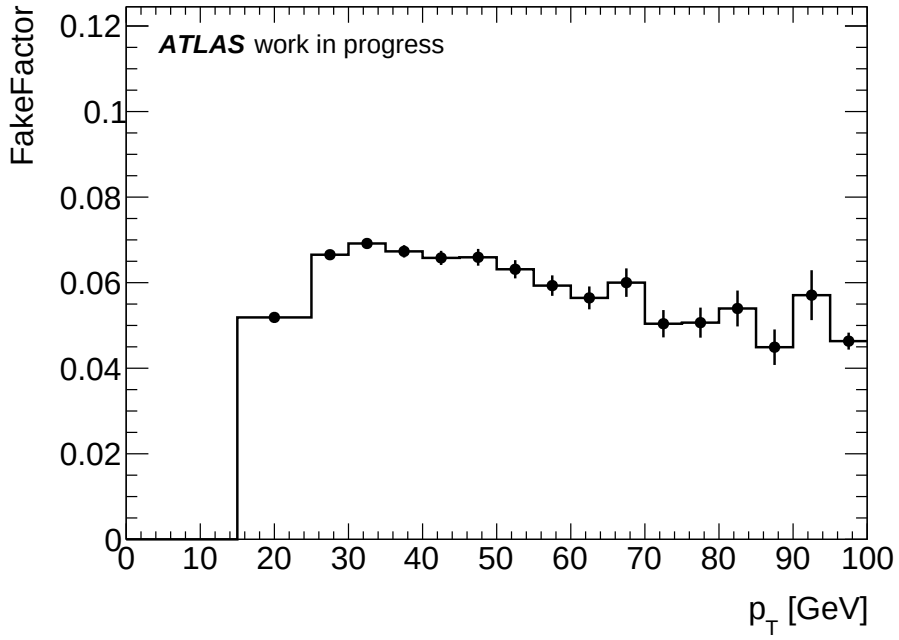
Fake τ from light flavor jets.

3-prong τ

Process: Z+jets



Process: $t\bar{t}$



$$F = \frac{N_{signal}}{N_{loose}}$$

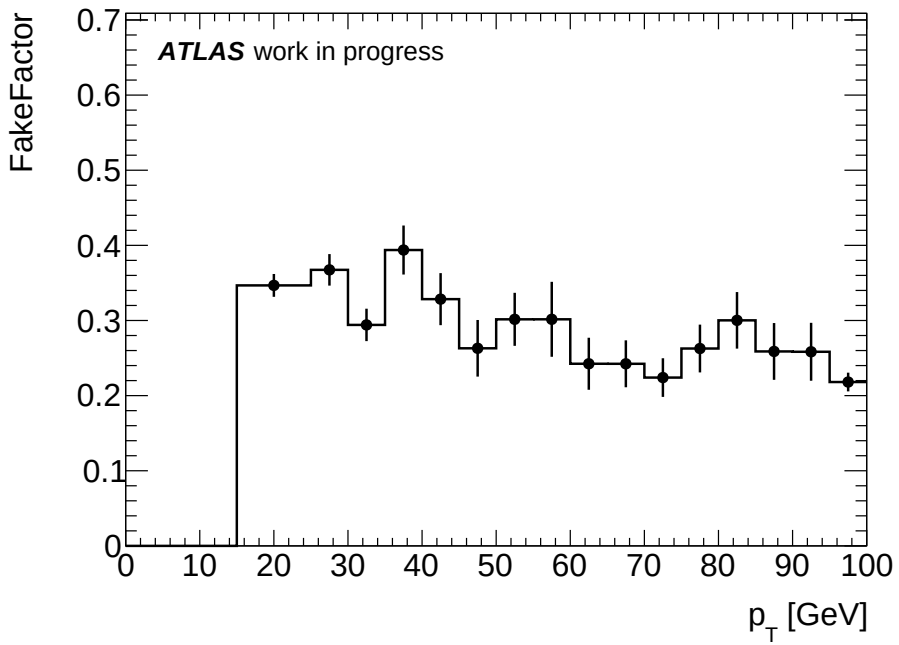
- lower fake factor for 3-prong τ

Fake factor

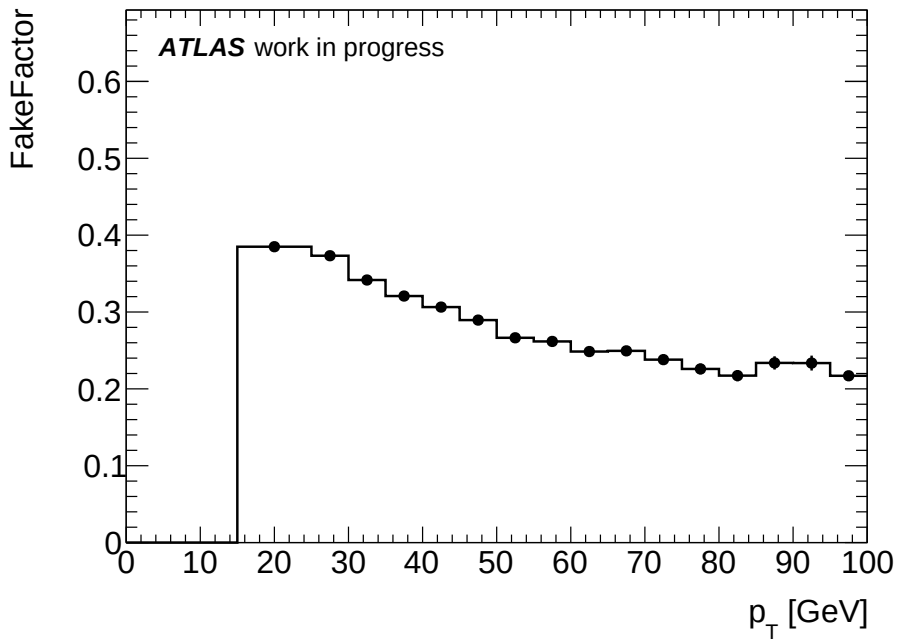
Fake τ from heavy flavor jets.

1-prong τ

Process: Z+jets



Process: $t\bar{t}$



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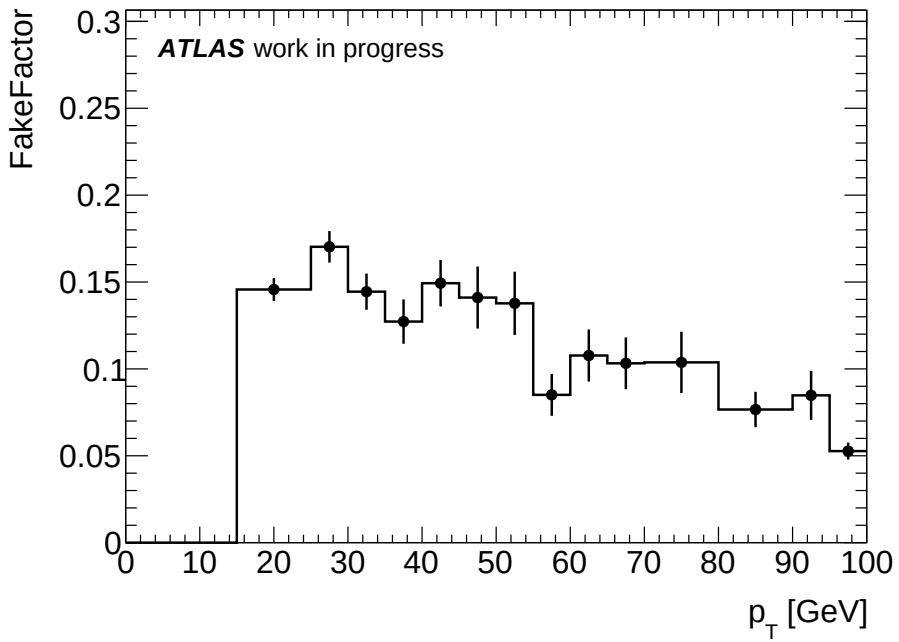
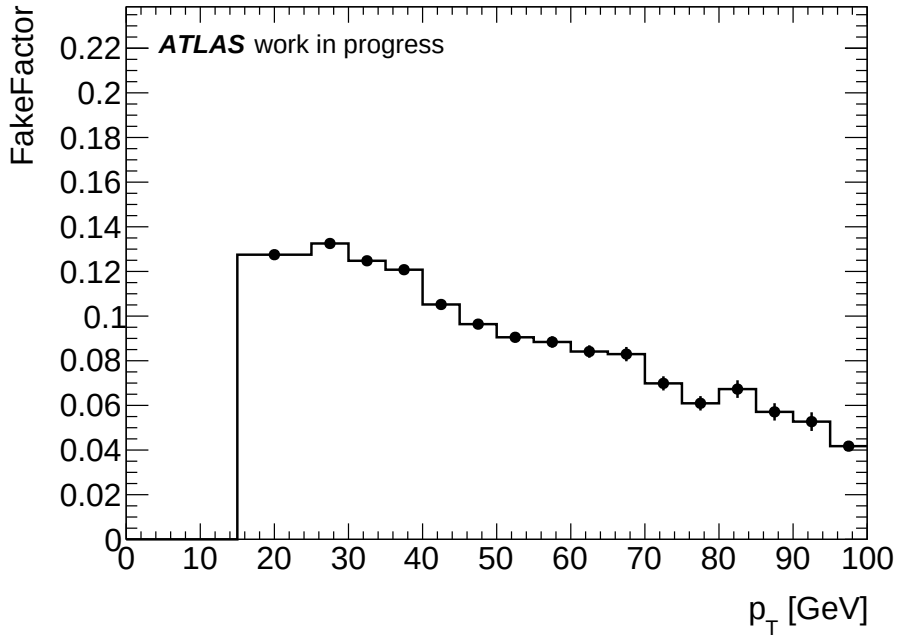


Process: $t\bar{t}$



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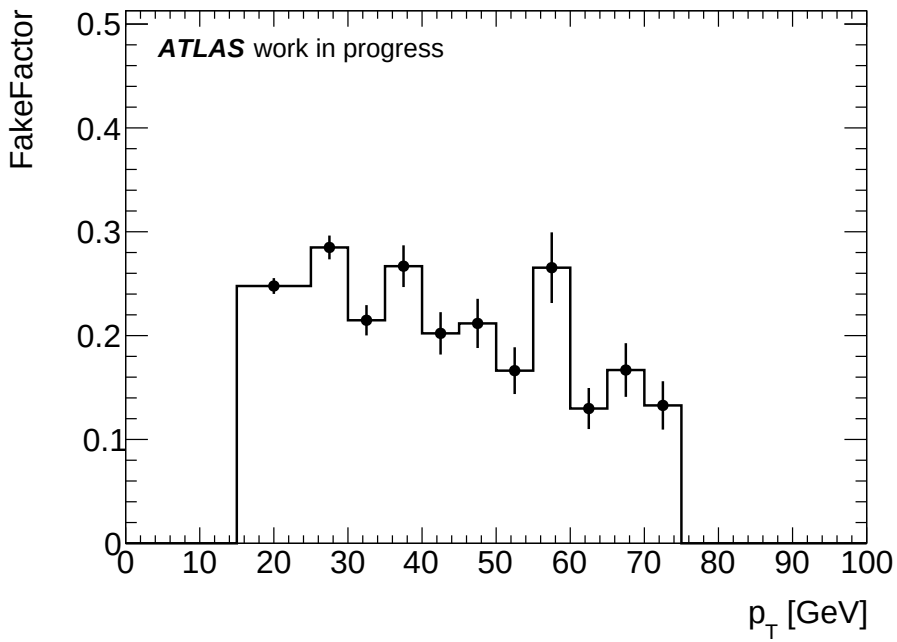
- lower fake factor for 3-prong τ

Fake factor

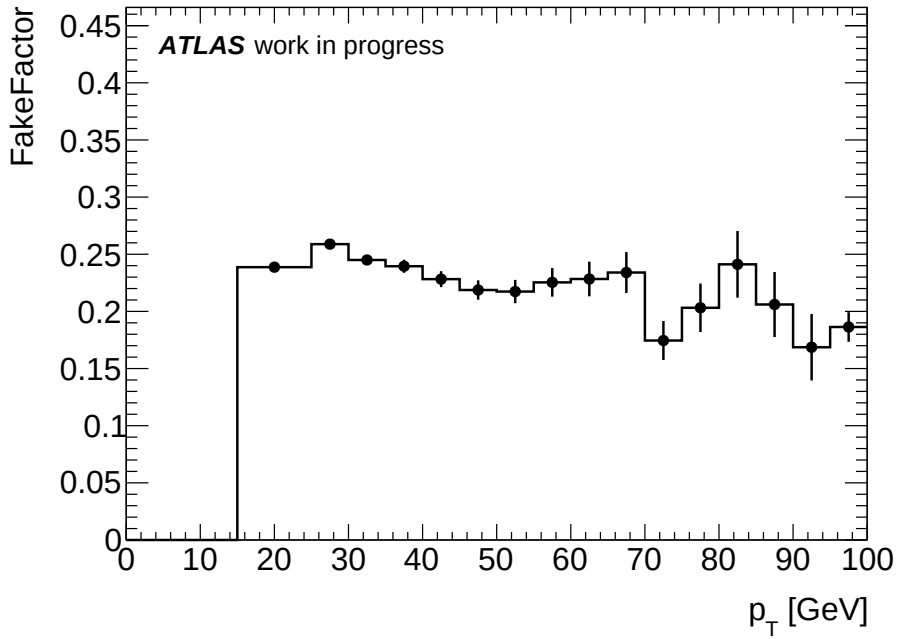
Fake τ from gluon jets.

1-prong τ

Process: Z+jets



Process: $t\bar{t}$



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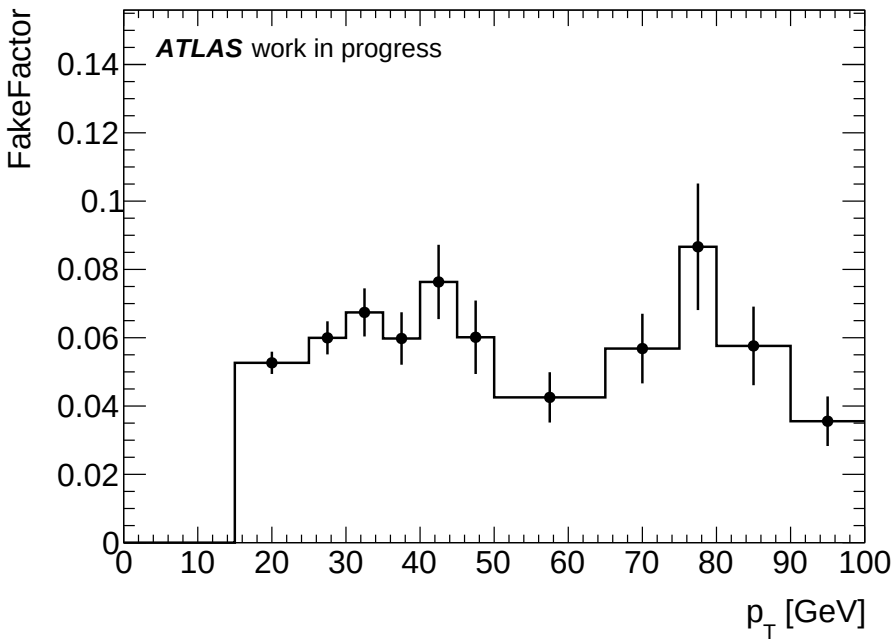
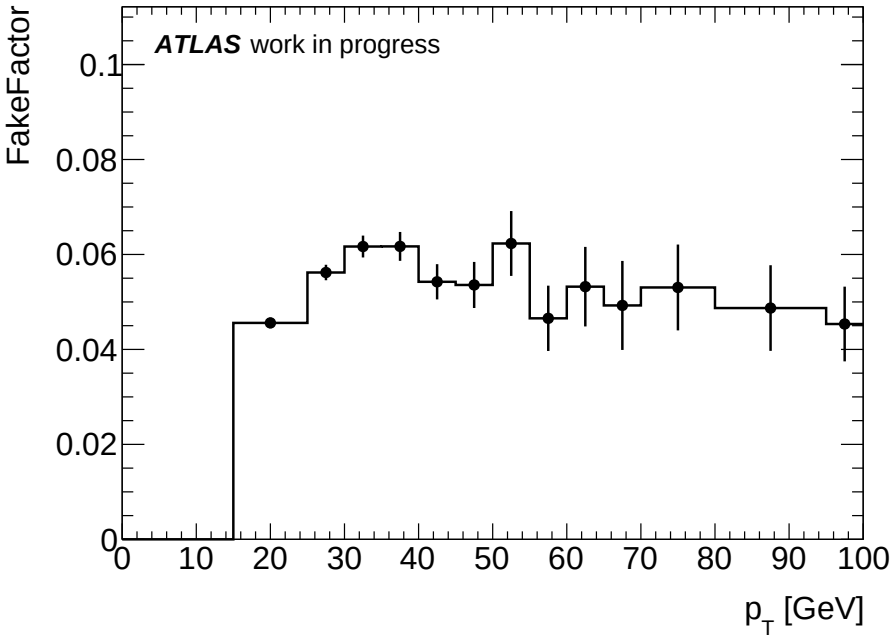


Process: $t\bar{t}$



$$F = \frac{N_{signal}}{N_{loose}}$$

- lower fake factor for 3-prong τ

Scale factor

Fake factors are corrected to data to account for mismodeling

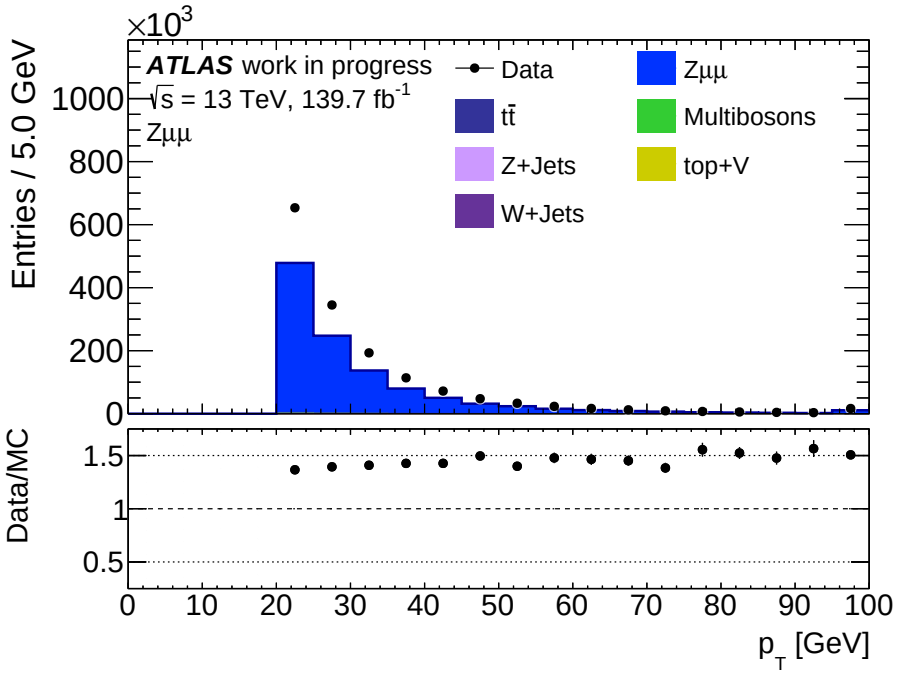
$F^{\ell} = \sum_{i,j}(f^{ij} \times sf^{i} \times F^{ij})$

$sf = \frac{F_{data}}{F_{MC}}$

The scale factor (*sf*) for LF fake τ estimated in a $Z\mu\mu$ region:

- $N_{\mu} = 2$
- $q_{\mu\mu} = 0$
- $61 < m_{\mu\mu} < 121$ GeV
- $N_{\tau} = 1$ (loose or signal)

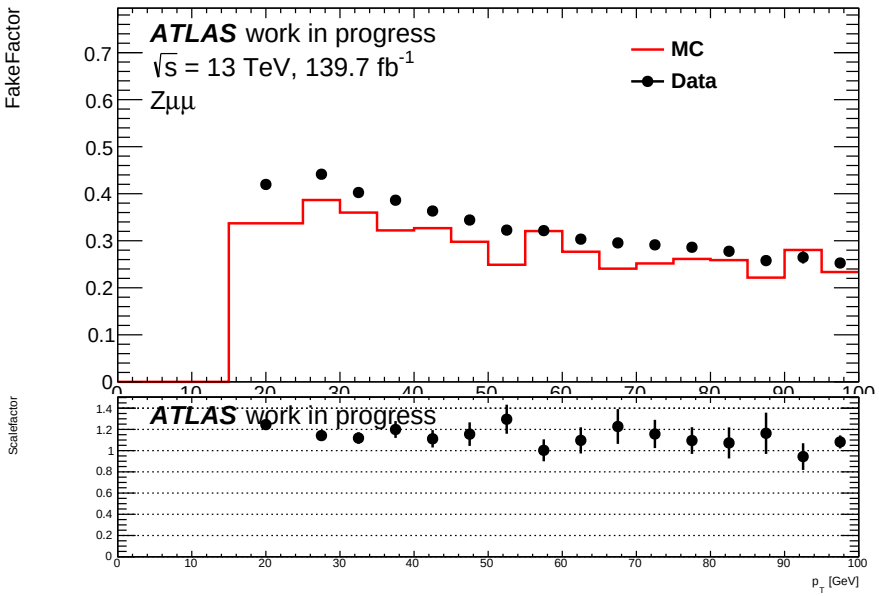
- high purity in Z+jets events
- bad modeling of fake τ p_{T}



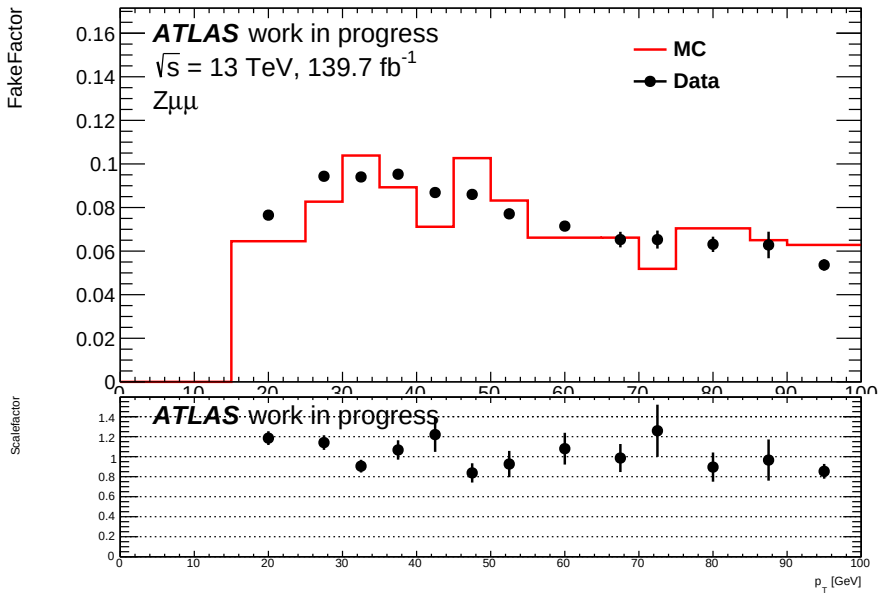
Scale factor

Fake factor calculated for Data and MC in the $Z\mu\mu$ region

1-prong τ



3-prong τ

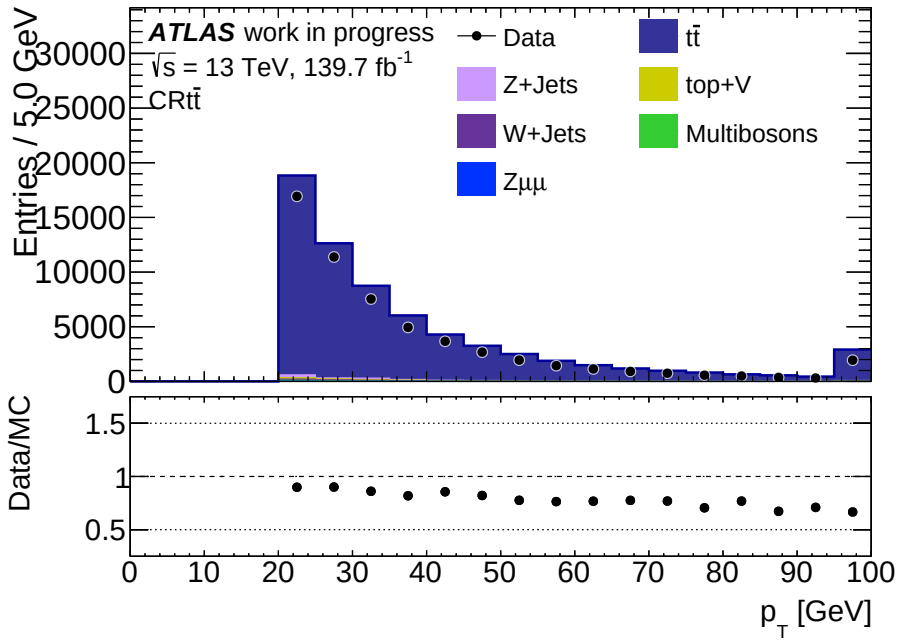


Scale factor

The scale factor (*sf*) for HF fake τ estimated in a $t\bar{t}$ region:

- $N_e = 1$
- $N_\mu = 1$
- $q_{e\mu} = 0$
- $N_{bjet} \geq 1$
- $N_\tau = 1$ (loose or signal)

- high purity in $t\bar{t}$ events
- bad modeling of fake τ p_T



Scale factor

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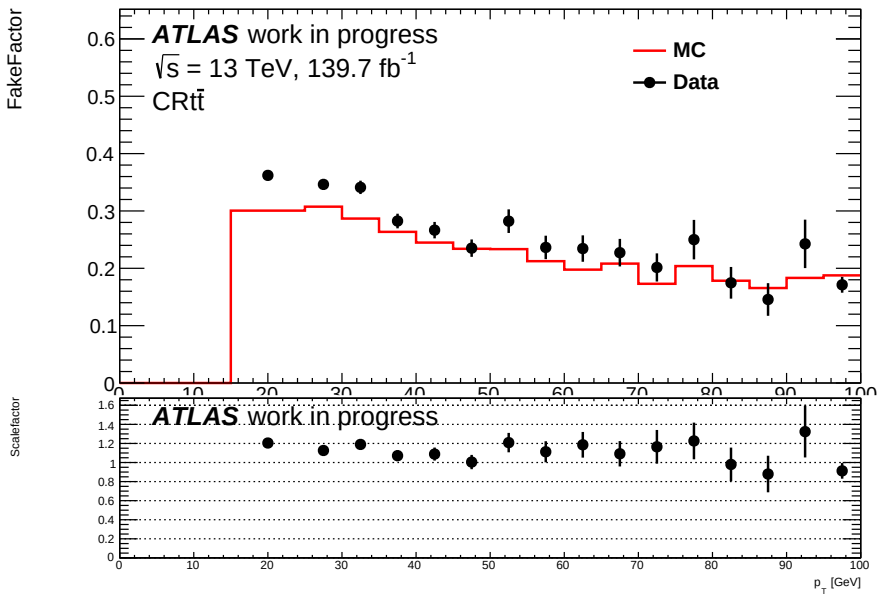
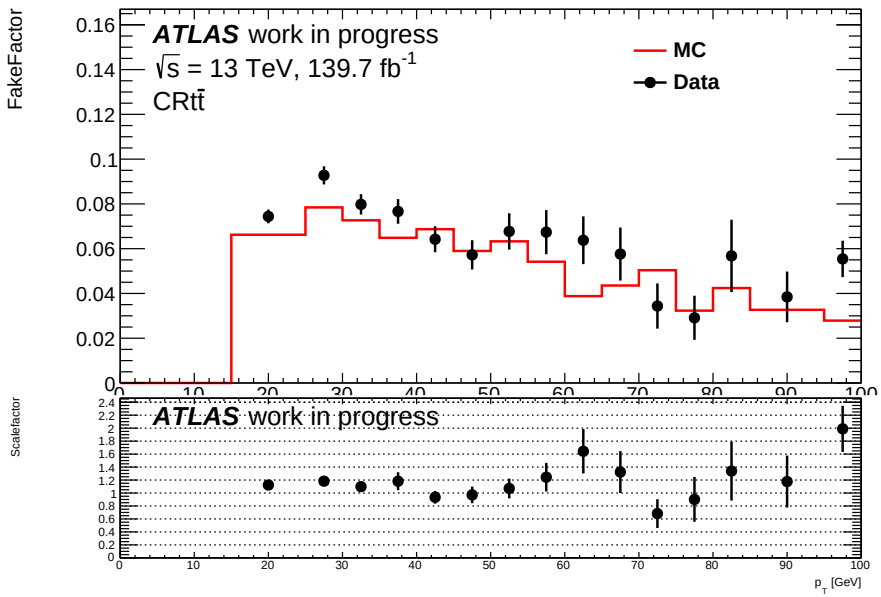
1-prong τ



3-prong τ



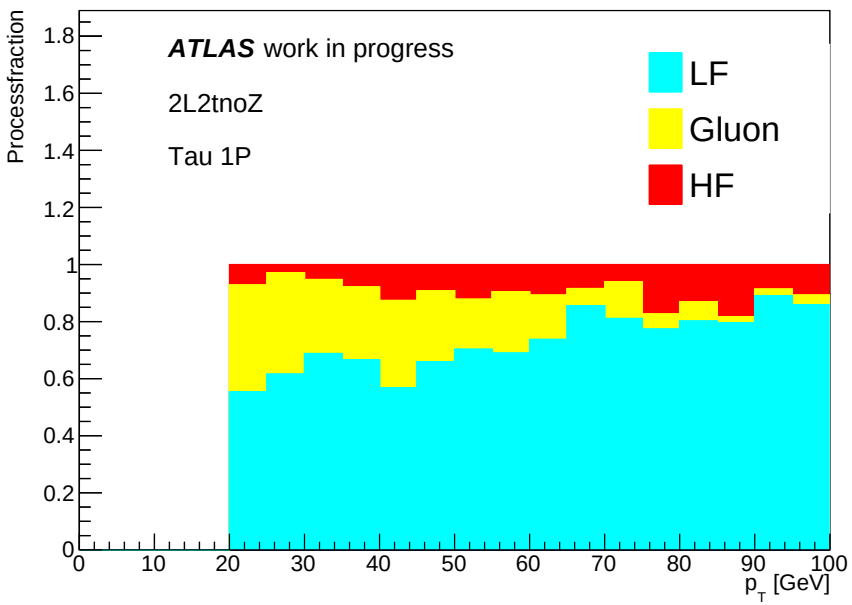
Process fraction

The fake factor for the different fake types have to be weighted with the fraction of each fake type in the Control regions:

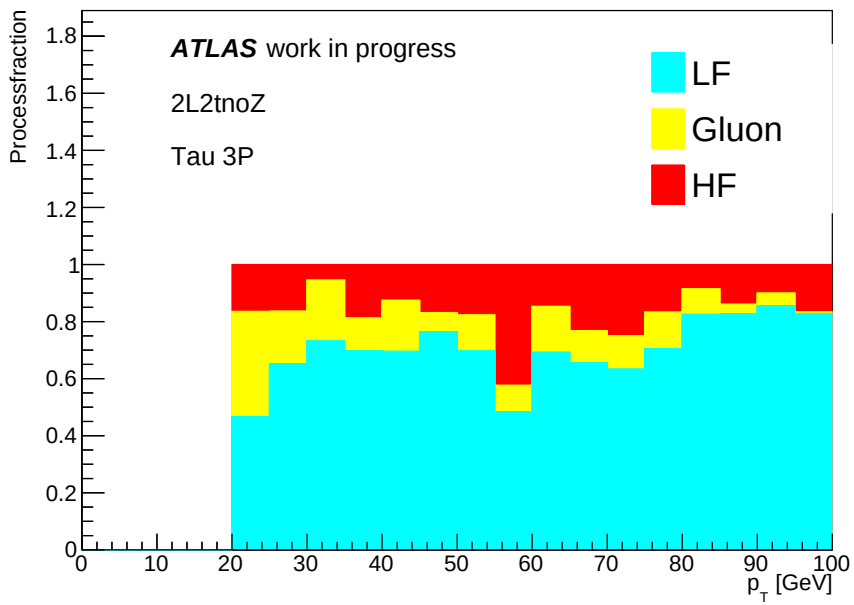
$F^{\ell} = \sum_{i,j} (f^{ij} \times sf^{i} \times F^{ij})$

Process: Z+jets

1-prong τ



3-prong τ



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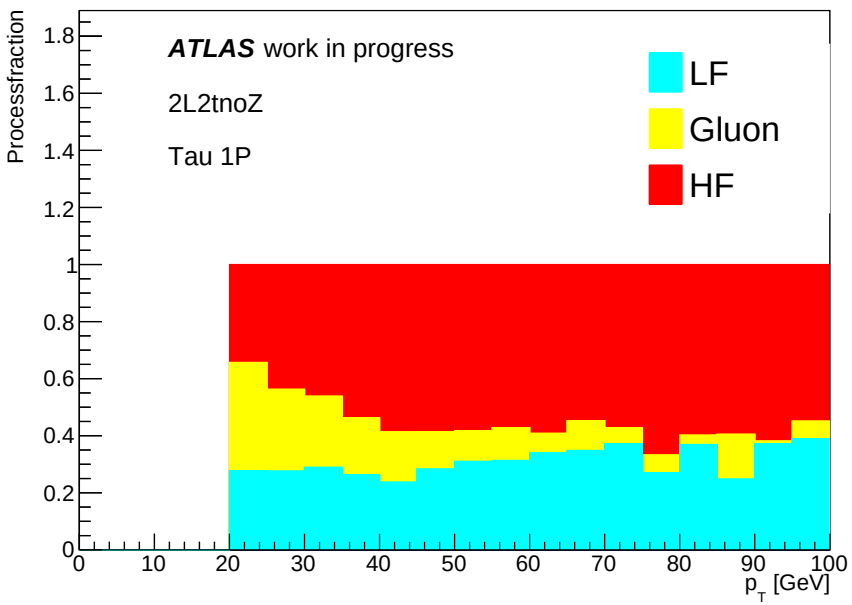
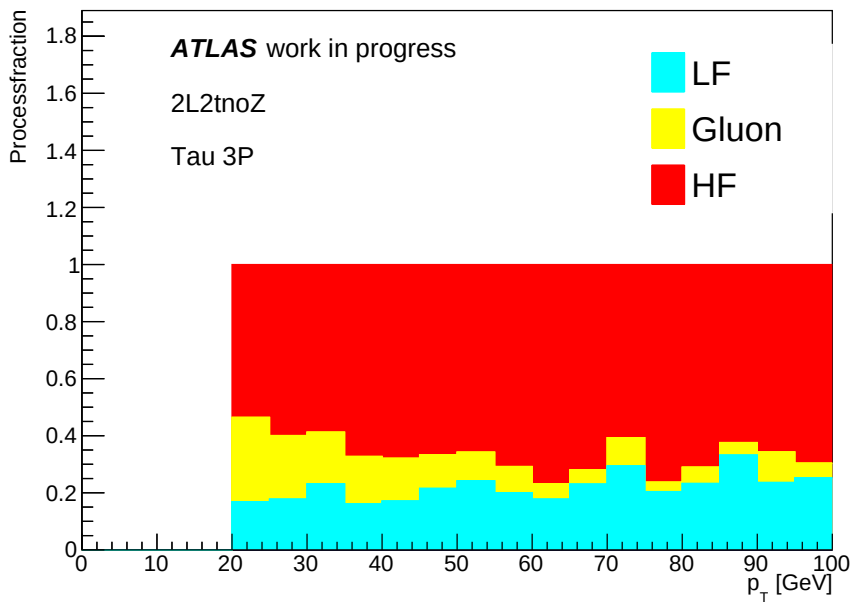
Process: $t\bar{t}$

1-prong τ



3-prong τ



Summary

- fake leptons are an important background contribution for the search for SUSY in four lepton final states
- Due to low statistics and bad modeling the analysis can not rely on Monte Carlo
- Data-driven fake factor method used to estimate fake lepton background
- different fake types and processes has to be considered