Tag and Probe Methodology

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Contents

1 Introduction

The tag and probe method represents a way to select a pure sample of leptons in data. By defining the event selection requirements carefully, this sample can be used to measure the efficiency of lepton reconstruction and selection requirements. By applying the same method to measure efficiency in simulation, we are able to derive data-to-simulation scale factors.

The nature of these scale factors is, in general, analysis dependent. This document provides guidelines on the methodology that is most generally applicable to all analyses in Section 2. In Section 3 we discuss those specific cases where a common data-to-simulation scale factor may be applicable between multiple analyses.

2 Methodology

2.1 Triggers

Which trigger paths should be used for which run ranges?

- For 2011 data, I think the tag and probe trigger is easier because it's always existing while the single electron trigger fluctuated a lot sometimes disappearing altogether from the menu.
- For the 2012 data, it would be nice if we can get this proposed single ele unprescaled at 60Hz. Using this trigger is the obvious simplest choice.

Do we need to take into account prescaling?

- For 2011 data, there is no problem if using Ele32_SC17 because this trigger was always unprescaled (we think). This trigger should not require prescaling in the future if the tag leg is kept tight. There may be issues for the triggers with a lower p_T leg. If necessary the control dataset can be re-weighted to the analysis dataset according to the number of reconstructed vertices.
- In general if the prescale is constant accross the entire dataset to be analysed then no additional re-weighting is required. It is better to have a trigger with a constant prescale rather than an initially small but growing prescale.

Do we introduce special treatment of double L1-seeded signal triggers?

- If the L1 decision is required simultaneously on two legs then there is a correlation between the two legs and the tag must be picked a-priori to avoid bias. Reference somewhere what we did for muons. It is the same problem.

2.2 Binning

Set of variables in which we bin the probes
1D, 2D, multi-dimensional?
Bin boundaries

- These are all analysis dependent.

2.3 Tag and probe selection

The exact selection for the tag
Requirements for the probe (for efficiency demonimnator)
Require opposite sign for the tag-probe pair?
Invariant mass requirement

- Fix the overall window within which events are selected (including side-bands for background fitting/extraction) to 60-120 GeV. The low mass threshold is motivated by avoiding kinematic turn-on effects.
- Also there is the subtle issue of which window you use to make the efficiency measurement (as opposed to the window used to fit). That question is extremely delicate and is very analysis dependent.

How to choose between multiple tag-probe pairs (closest to mZ / random / use all)?

- As long as same procedure is used in data and simulation, in principle the effect on extracted scale factors should be small.

2.4 Measuring isolation efficiency at low p_T

When measuring the data-to-simulation scale factor at low p_T, the tag and probe sample in data can be contaminated with backgrounds from fake electrons from the mis-identification of jets. In general the background from fake electrons can be reduced by measuring the efficiency in data and simulation (same method must be applied to both) with respect to a tightened probe definition. Because isolation is one of the most stringent requirements to remove fakes, the measurement of the isolation efficiency itself is the most problematic.

If the electron footprint removal from the isolation sum is performed correctly, then we expect the p_T in a cone drawn around an electron to be independent of the p_T of that electron. This is illustrated in Figure 1 produced using simulation of electrons from Higgs boson decays in the $ZZ \to 4\ell$ channel. We thus propose the following strategy for the extraction of isolation data-to-simulation scale factors:

- Measure the expected absolute isolation sum using a pure sample of high p_T electrons. The efficiency of any isolation cut can be extracted from this measurement, scaling the threshold as appropriate for the definition of the cut.
- Measure the isolation efficiency for low p_T electrons in the usual way by estimating and subtracting backgrounds.
- The two methods should be compared. If they are consistent we recommend using the method with smaller systematic uncertainties.

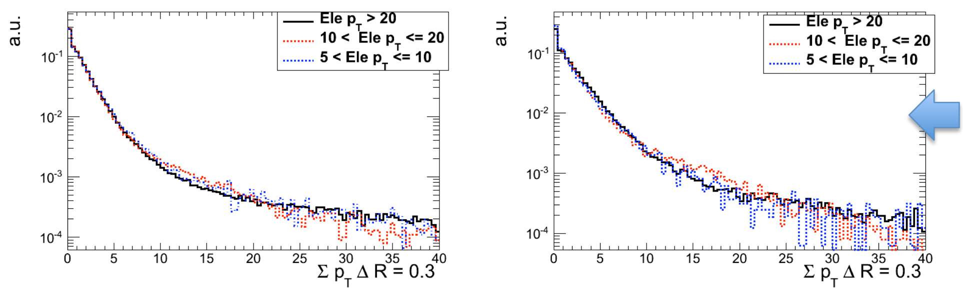

Figure 1: The distribution of the absolute isolation sum calculated with PF-candidates (charged, neutral and photons) in a cone dR < 0.3 for electrons. Endcap (right) vetoes of dR > 0.015 and > 0.08 for charged hadrons and photons respectively. Barrel (left) vetoes of dR > 0.015 for charged hadrons in the case the electron is not preselected by PF. Figure from D. Benedetti.

2.5 MC treatment

generator level matching requirements

- It is not clear the generator level matching is required. The fraction of probes in simulation from fake leptons from additional jets is likely to be small. If absolutely necessary, an anti-matching could be performed between partons and the reconstructed probe.

For efficiency not binned in PU, how is the difference in PU between data and MC is taken care of?

- Run on the same dataset you are using in your analysis if possible (see above point in case prescale of control triggers changes).

Which efficiencies are computed from counting and which from fits?

2.6 Fitting

Fit range

- Probably a common sense recommendation can be made.

Binned or unbinned

- It's a technical choice. As long as you apply the same fit in both data and simulation either is fine If speed is not an issue unbinned fit may be preferred.

simultaneous pass+fail or separate

- The simultaneous fit is probably better, since correlated uncertainties can be better handled, and the result (efficiency) can be constrained to be less than or equal to one.

The exact definition of signal PDF

- It is necessary to take into account the expected signal shape from simulation with an additional smearing term to take into account difference in resolution and energy scale between data and simulation.

The exact definition of background PDF

- It has been shown (citation?) that there is no significant difference to the result between exponential and exponential*linear models. Other models could be tested as part of systematics

2.7 Systematic uncertainties

Extrapolation of efficiencies from electrons to photons

- We have not considered this.

Dependence on tag selection

- Changing the tag will probably not have any effect, unless it is a proxy for a background normalisation/modelling uncertainty.

Dependence on choice of fit functions

- Probably should be investigated.

Background subtraction when counting is used instead of a fit

- This question is mis-phrased. if there is background it has to be subtracted using an appropriate method. if the background is negligible, then it's irrelvant. If there is background and you don't subtract it then it's clearly biased, and then you have to cover the bias with a systematic error.

Are the biases in measuring efficiency as a function of p_T from $Z \rightarrow ee$?

- We are not clear what this question is referring to? Isolation efficiency extraction at low p_T?

3 Central Measurements

- The only measurement it makes sense to do centrally with a standard definition is the one that is common to everyone - the reconstruction efficiency. In other cases the definition of tag and probe is motivated by the analysis selection used.