Multiple tags in Tag-and-Probe

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This note aims to summarize the logic behind the treatment when both electrons(muons) of Z pass the tag selection in Tag-and-Probe (TnP). In the EGM package, if there are more than one objects being able to pass the tag selections, all the choices of the tag object will be considered and counted. The following arguments are followed from the discussion with Fabrice (one of the EGM conveners) and Ming.

The point of adding the second lepton is to avoid a bias. (you are throwing away an event with high efficiency while keeping in your denominator all events with only one tag so low efficiency)

Let's assume one wants to measure the efficiency of whatever selection applied on the tag. Also, here I denote the efficiency of this selection as ϵ.

- Total number of events with 1 tag exactly : $2 \times \epsilon \times (1 - \epsilon)$
- Total number of events with 2 tags : $\epsilon \times \epsilon$
- The number of events with a passing probe is $\epsilon \times \epsilon$ (both objects pass the selection we are looking at).

So if one considers only a random tag, the measured efficiency is:

$$\epsilon_{measured} = \frac{N_{probe}^{pass}}{N_{probe}^{Total}} = \frac{\epsilon \times \epsilon}{2 \times \epsilon \times (1 - \epsilon) + \epsilon \times \epsilon} = \frac{\epsilon}{2 - \epsilon} \tag{1}$$

If now one considers both tags in the event, the measured efficiency becomes:

$$\epsilon_{measured} = \frac{N_{probe}^{pass}}{N_{probe}^{Total}} = \frac{2 \times \epsilon \times \epsilon}{2 \times \epsilon \times (1 - \epsilon) + 2 \times \epsilon \times \epsilon} = \epsilon \tag{2}$$

This is a very simple and naive example but generally if the tested selection of the probe is correlated to the selection of tag (which is, in practice, usually the case, if an event is very well identified it always passes looser cuts), then you will have a bias.