Electron fake rates and trigger efficiency

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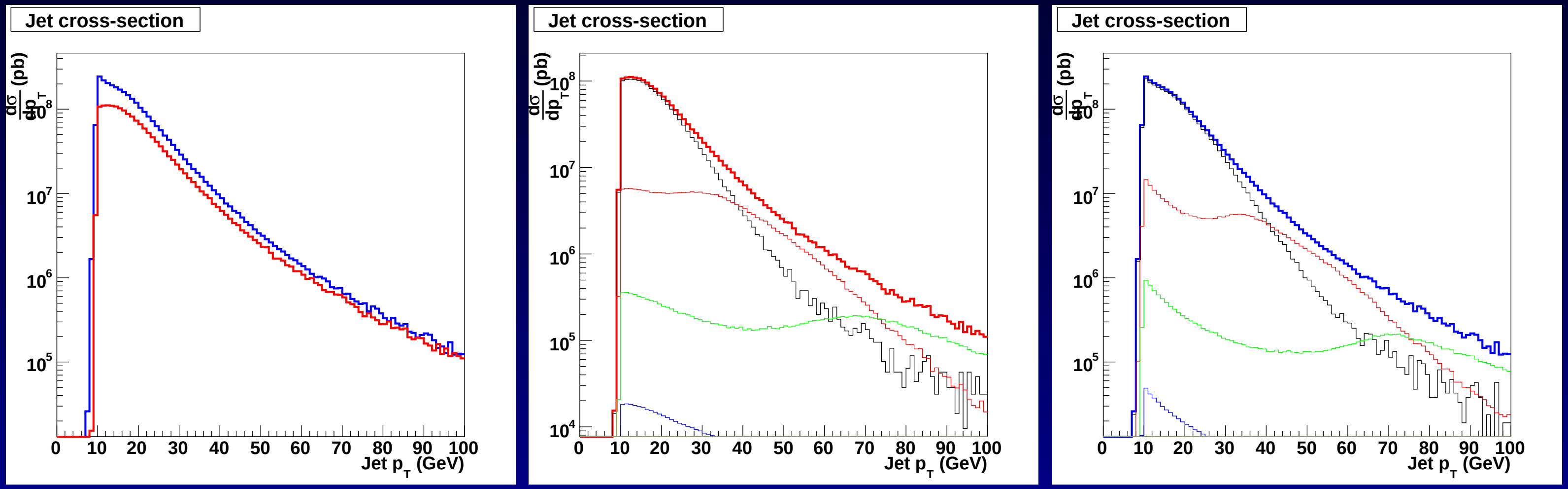
Outline

- QCD background in the $Z \longrightarrow ee$ channel
    - Jet cross-section
    - Electron isolation in jets
    - Rates of electron reconstruction in jet events
    - QCD background in the $Z \longrightarrow ee$ channel
- Determining trigger efficiencies from data using $Z \longrightarrow ee$
    - ‘Tag and Probe’ or ‘Double Object’ method
    - Z reconstruction in the ATLAS trigger
    - Global e25i trigger efficiency
    - Differential efficiency with and without charge separation
- Outlook and next steps

Estimating QCD backgrounds in $Z \rightarrow ee$

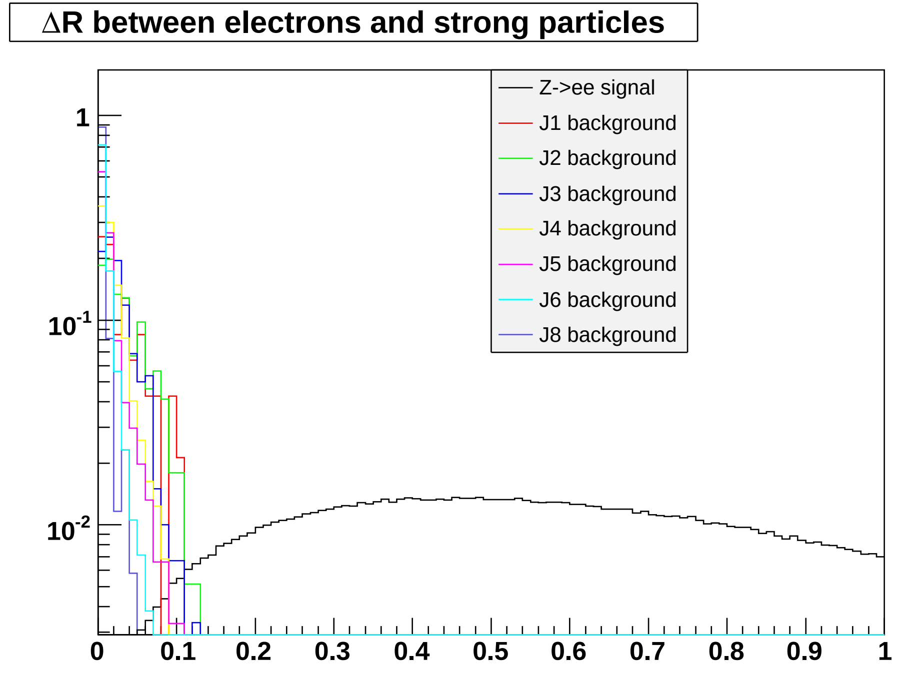
- *The Aim*: To accurately predict the ‘di-electron’ spectrum that will result from dijet events in ATLAS
- *A Problem*: The QCD cross-section is so huge ($\mathcal{O}$(0.1 barn) - TDR) that direct simulation is impossible
- *A Solution*: To parameterise the probability of a single jet to be reconstructed as an electron (*Jet Weight*), and use this to weight individual QCD events
    - The *Event Weight* is the product of the two *Jet Weights*
- This simply leaves the problem of how to estimate the Jet Weights with as few systematics as possible, and which variables to use as parameters
- Analysis done in v11.0.4, samples 5144 ($Z \rightarrow ee$ signal) and 5010-5017 (dijet backgrounds), all generated with Pythia
- NTuples were produced from official AODs available over the Grid

Jet cross-section: True and Reconstructed



- True cones (blue) and reconstructed cones (red) shown, with a breakdown by sample number
- Samples are classified by p_{T} range of lead jet, roughly doubling with each sample (first four are visible)
- Reconstructed cones from BJetCollection (size = 0.4) used, with easy access to flavour information
  - Despite the name, all jets are in this collection!
- Samples are very small, effective luminosity of 290k events in J2 is 3.1 nb^{-1}, or about 3 seconds’ worth at 10^{33} cm^{-2}s^{-1}

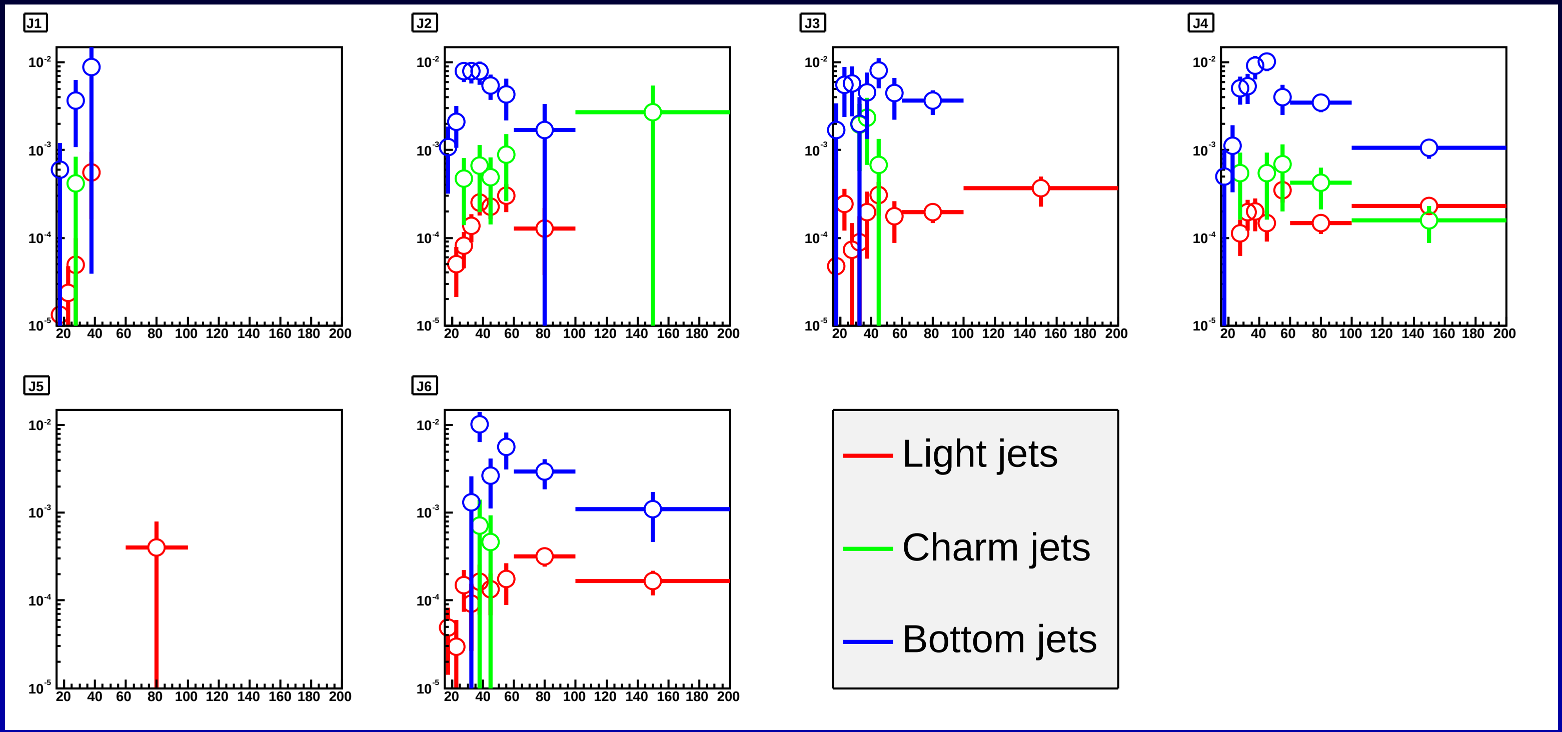
True electrons in jet events



- True electrons exist within the background samples, but are never isolated. The plot shows the separation ΔR between each true electron and the nearest strongly interacting particle

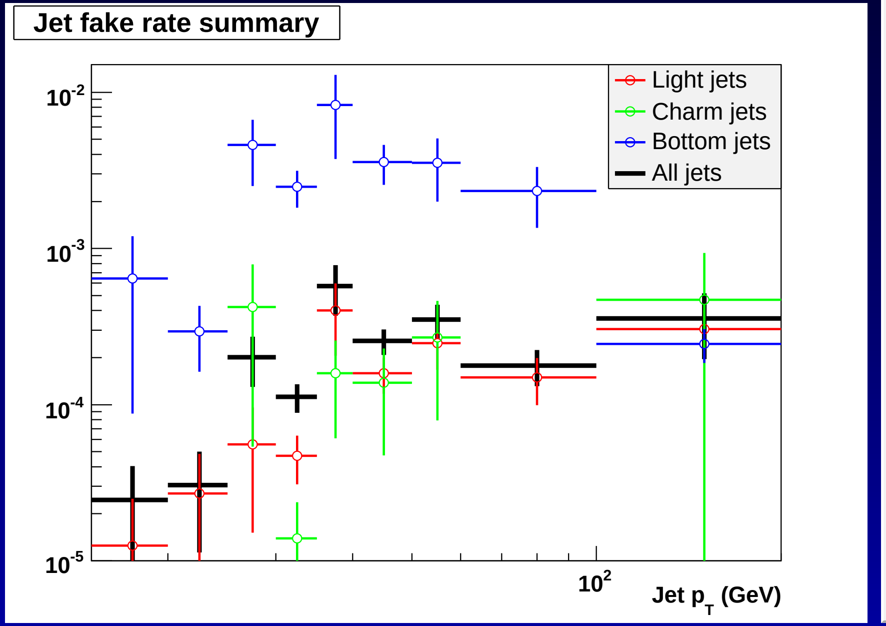
- These electrons need to be dealt with, and could be excluded from background samples
- But these electrons will predominantly come from heavy quark decays, and for the $Z \longrightarrow ee$ channel form an important background
- Can use flavour information as an extra parameter in the Jet Weight
  - Any increase in Jet Weight for b-jets will be squared in the Event Weight

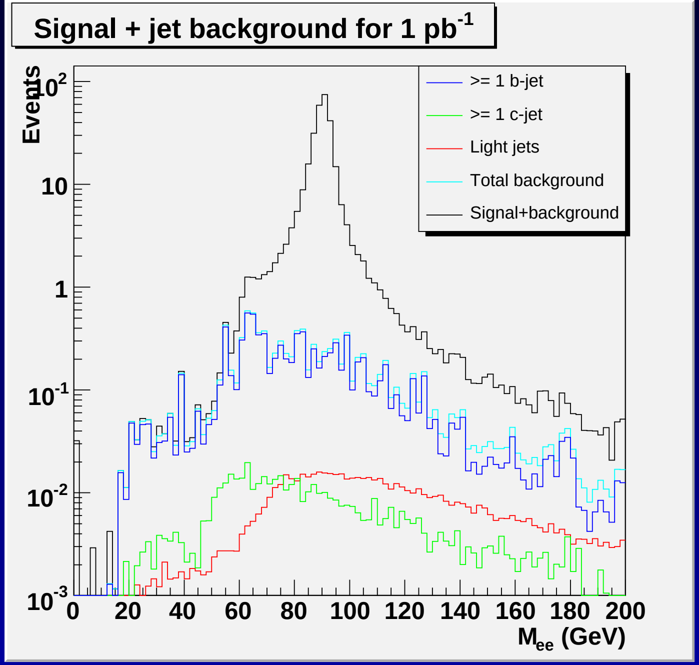
Jet weighting factors



- Jet Weights are the ratio of reconstructed electrons (isEM==0) matched to a specific jet type
  - ‘Matched’ means $\Delta R_{e,jet} < 0.4$
- Weights are largely consistent between samples, where statistics are available
  - b-jet weight can be up to $\sim 10^{-2}\ldots$

The weighted dijet spectrum





Despite smaller cross-section, events with b-quarks dominate the $Z \to ee$ background from dijets

- Significant contribution from charm too

In 1 pb^{-1}, prediction is 289 signal events with 10.6 events from jets

- Statistical errors are $\gtrsim 50\%$ on background estimate
- Without accounting for flavour, only ~ 5 background events are predicted

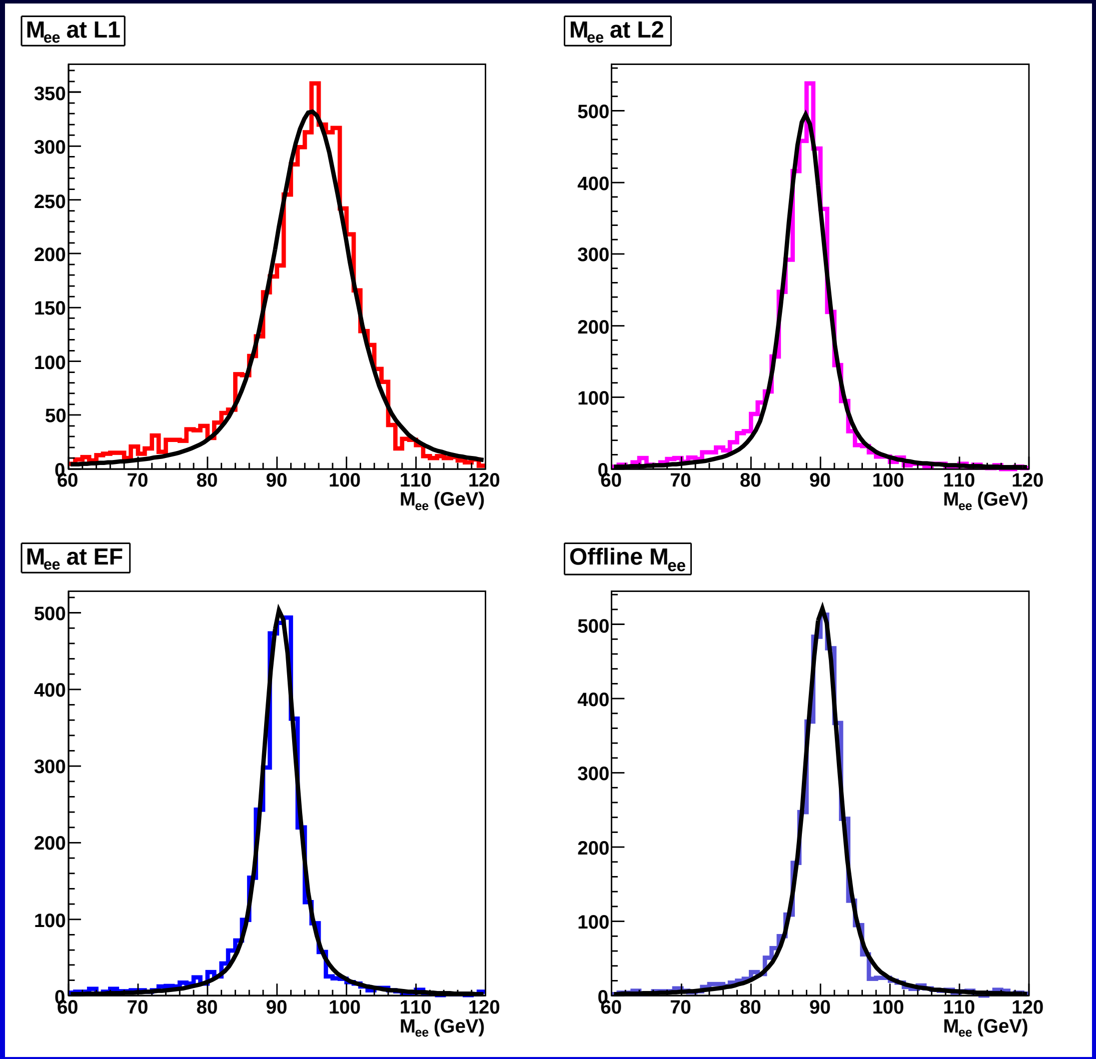
Conclusions: QCD background

- Dijet background may be small, but it can be better understood
    - Weighting MC events gives better understanding of MC and helps improve the statistics problem
    - Can be compared with real data, for improved understanding of electron ID
- Tightening isolation will change background composition
- W+jet background still to be investigated
- Systematics are still to be investigated:
    - Effect of leading (hard) jet on electron ID
    - Effect of changing cone size
    - Quark jets vs gluon jets
- Corrections are needed for difference in jet and EM energy measurements
- Stats will still be a problem in v12.0.6
    - Compare with sample 5802 (filtered dijets)
    - Is there a suitable $b\bar{b}$ sample?
- How will presence of real electrons (W, Z) affect measurement of Jet Weights with data?

Obtaining trigger efficiencies from data

- Based on work by the CERN trigger group. See, for example Teresa Fonseca Martin's talk in T&P week May 2006
- Work carried out in conjunction with Ellie Dobson and Tony Weidberg (Oxford), with initial studies of v11 NTuples provided by Teresa
- Preliminary results are presented, from a private production of $Z \rightarrow ee$ events in 12.0.4
- In v12, full trigger information is on ESD and AOD, transferred to NTuple
- Use 'tag and probe' or 'double object' method
  - Use offline preselection to give clean di-electron sample
  - Control Sample: Events where 2e25i trigger is satisfied (N_2 events)
  - Diagnostic Sample: Events where e25i trigger is satisfied (N_1 events)
- Good diagnostic of early data - few % error on global efficiency in a matter of days

Trigger reconstruction of Z bosons



Mass peaks at each level are fitted with convolution of Breit-Wigner and Gaussian curves

	Γ	M_Z	σ_M
L1	5.7(3)	94.9(1)	3.9(2)
L2	3.2(2)	87.9(1)	2.0(1)
EF	3.2(2)	90.41(5)	1.5(1)
OL	3.4(2)	90.27(1)	1.5(1)

All numbers are in GeV

OL = offline

Global electron trigger efficiency

- Global efficiency is process-dependent, but easy to calculate (cf Bellomo *et al* “Muon trigger efficiency from real data”, June 2006):

$$\epsilon = \frac{2N_2}{N_1 + N_2}, \quad \sigma_\epsilon = \sqrt{\frac{\epsilon(1-\epsilon)(2-\epsilon)^2}{2N_1}}$$

- Values N_1 and N_2 are obtained from counting Z candidates between 81 and 101 GeV. With data, background subtraction will be necessary!
- Offline preselection applied to clean up sample, but higher trigger levels than the one under consideration are not required
- Comparison with truth still to be done

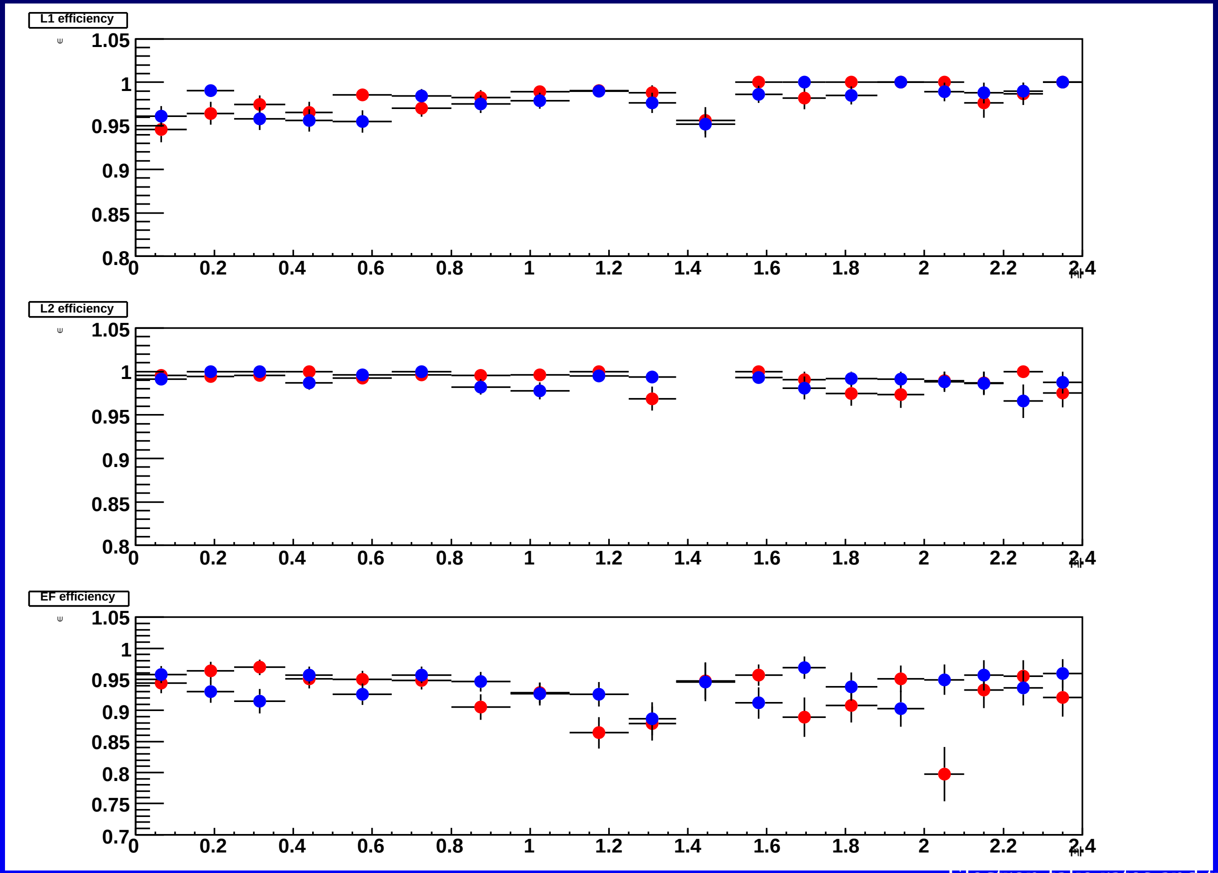
	Level efficiency	Cumulative efficiency	Version 11 result
L1	98.2(2)%	–	98.3(2)%
L2	95.6(3)%	93.9%	94.1(4)%
EF	93.3(3)%	87.6%	–

Differential trigger efficiency I

Blue: electron probe, Red: positron probe. Charge separation allows for easier calculation as electrons are now non-identical

$$\epsilon = \frac{N_2}{N_1}, \quad \sigma_\epsilon = \sqrt{\frac{\epsilon(1-\epsilon)}{N_1}}$$

Discrepancies may show up material effects

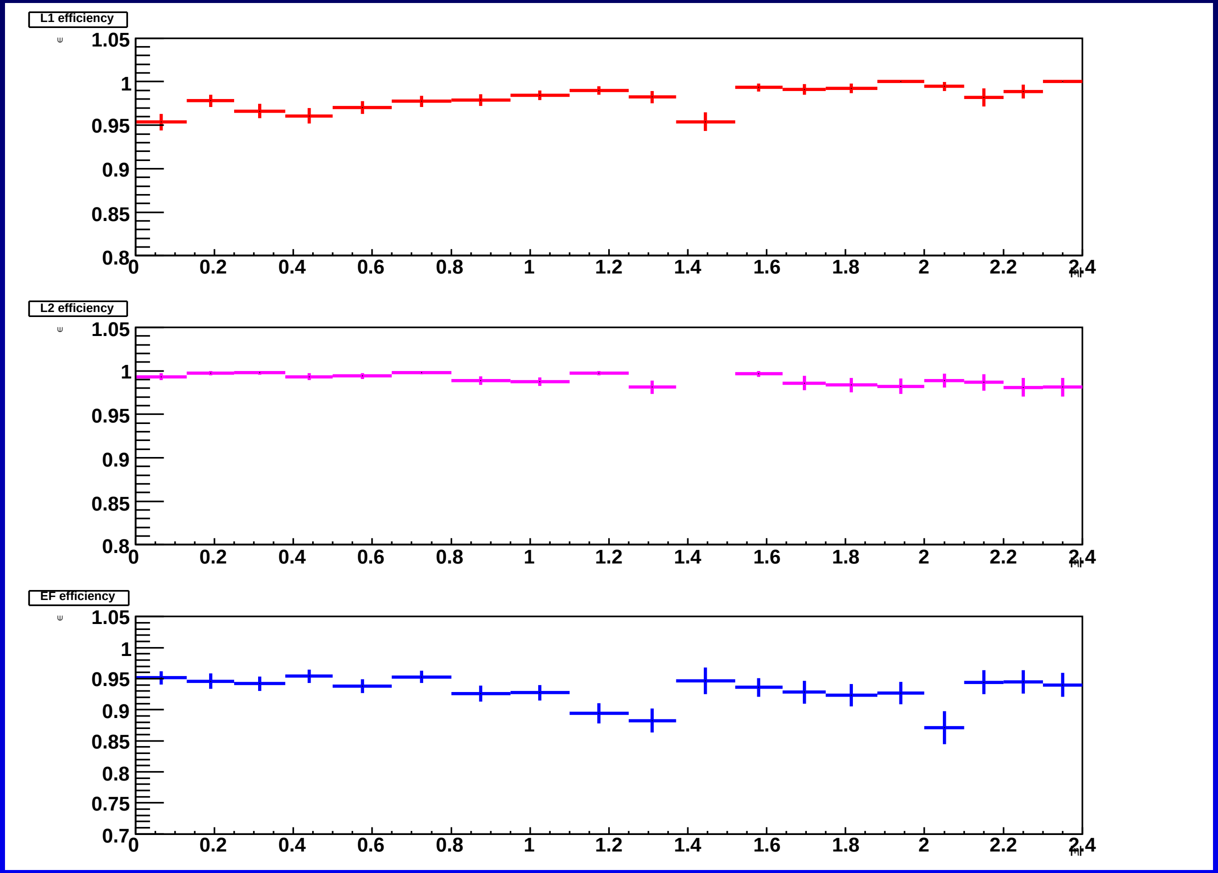


Differential trigger efficiency II

To gain statistics, we can properly account for the effect of binning:

$$\epsilon = \frac{N_2^A + 2N_2^B}{N_1^A + N_1^B + N_2^B}, \quad \sigma_\epsilon = \sqrt{\frac{(1-\epsilon)}{N_T}\left[\epsilon + \frac{2N_2^B}{N_1^A + N_1^B + N_2^B}(1-\epsilon)\right]}$$

A/B ⇒ electrons in different/same bin



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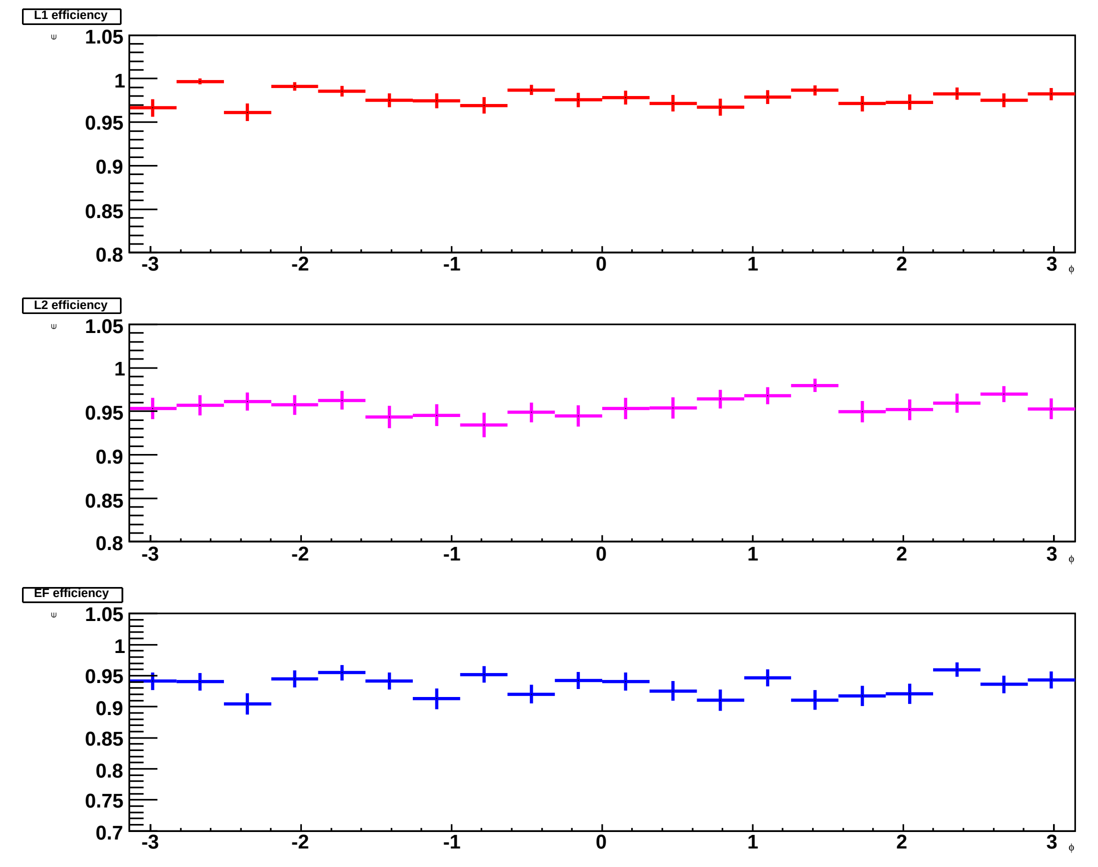

Conclusions: Trigger measurement

- Trigger efficiencies can be measured from data, along with dependencies on kinematics, cuts and so on
- Still to do in v12:
  - Validate technique with truth information
  - Investigate systematics - material, offline selection, e^+e^- correlations
  - Background modelling, subtraction and it's effect on the efficiencies measured
    - Includes irreducible Drell-Yan continuum
- Extension to other event topologies (Oxford and CERN)
  - Z+jets and efficiency degredation with hadronic activity
  - $W \rightarrow e\nu$ - can the missing E_T trigger be studied in a similar way?
  - Offline electron ID efficiency using $Z \rightarrow ee$
- Update in March T&P week