QCD Background Estimation From Data for Supersymmetry Searches at ATLAS

The University Of Sheffield.

ATLAS EXPERIMENT

Abstract

A major challenge in the search for Supersymmetry (SUSY) with no leptons at ATLAS is the measurement of the background from QCD multi-jet production. A data-driven estimation is very important for this background; it is difficult to accurately estimate **jet response tails** using Monte Carlo (MC) simulation and furthermore it is impossible to generate sufficient MC simulated QCD events, given the high QCD cross section.

The jet smearing method is a fully data-driven technique which uses a measurement of the **jet response function** to estimate the QCD background to SUSY through the 'smearing' of **seed events**. The technique has been validated using MC simulation and is now being used on ATLAS data.

QCD as a SUSY Background

SUSY searches with no leptons at ATLAS require:

(1) A number of high transverse momenta (p_T) jets.

(2) A certain amount of missing transverse energy (MET).

The high QCD cross-section means many events satisfy (1) despite the steeply falling jet p_T spectrum. (2) is satisfied if one or more jets are severely mismeasured (**fake MET**) or contain neutrinos from heavy flavour quark decay (**real MET**).

Jet Smearing Overview

(1) Construct the jet response function by using special control samples to measure the amount of fluctuation in the measurement of a jet's energy. This is done in two stages:

(a) Parametrise the Gaussian component by applying Gaussian jet smearing on **dijet events** as described in the '**Gaussian Response**' section.

(b) Measure the non-Gaussian component by looking at three jet **'Mercedes' events** where there is a large amount of MET co-directional with one of the jets (see Fig. 1).

(2) Jet smearing is applied by using the full response function to scale the four-momenta of jets in events with low MET. The new set of **'smeared' events** can now have sufficient MET to enter the SUSY signal region and hence provide an estimation of the QCD background in this region (see Fig. 2).
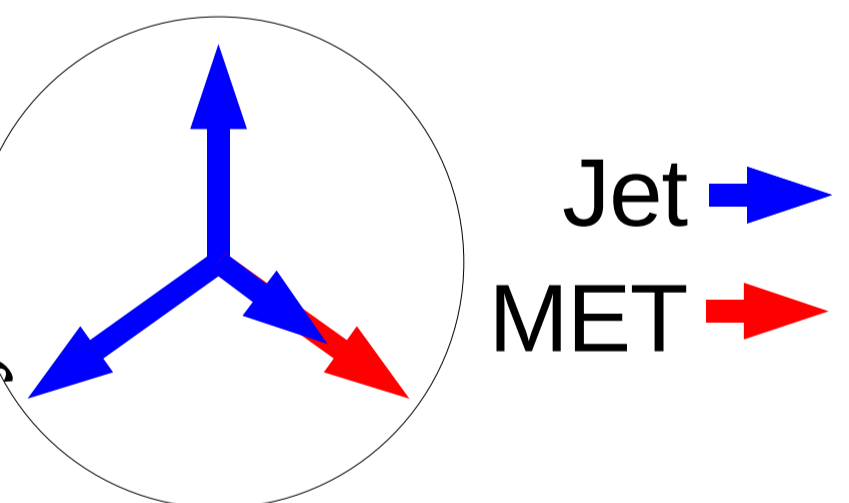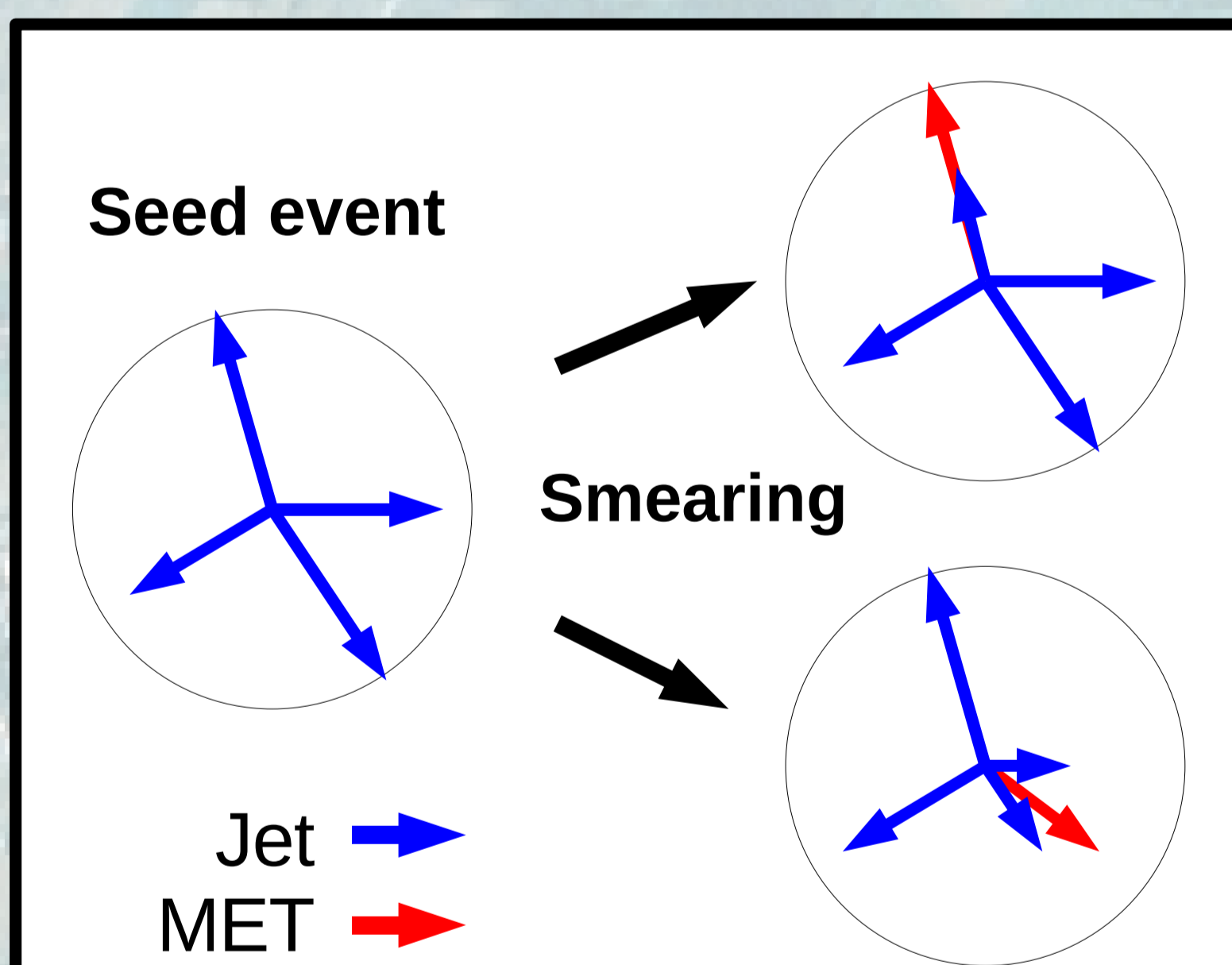

Figure 1: Mercedes jet event

Jet →
MET →

Seed event

Smearing

Jet →
MET →

Figure 2: Jet smearing depiction

Δφ Trigger for Measuring non-Gaussian Jet Response

A major systematic to the final QCD background measurement comes from the finite statistics of 'Mercedes' events. Many of these events are not recorded by the ATLAS trigger system due to **prescaling** of single jet triggers.

A solution being developed is to trigger on Δφ between jets, thereby vetoing back-to-back jet events and reducing the trigger rate. This allows the application of a lower prescale than standard single jet triggers and therefore greater statistics for the non-Gaussian jet response measurement.

Jet Response Function

Gaussian Response

The Gaussian fit to the jet response is constrained in the following way:

• Apply jet smearing with the Gaussian jet response on low MET, well measured, dijet seed events. This produces a set of smeared events.

• Compare the MET distribution of the smeared events with the MET distribution of data in the low MET region.

• Vary the Gaussian parametrisation and repeat the above two steps to find the closest match and therefore the optimal Gaussian fit.

Full Jet Response

The full response function is constructed by appropriately normalising the Gaussian and non-Gaussian components. The normalisation is calculated by comparing the measured non-Gaussian response with the tail of the **dijet balance distribution** (R_3) as shown in Fig 3. The figure also shows the application of the smearing method can reproduce the dijet balance distribution and therefore this provides a **closure test** of the method.
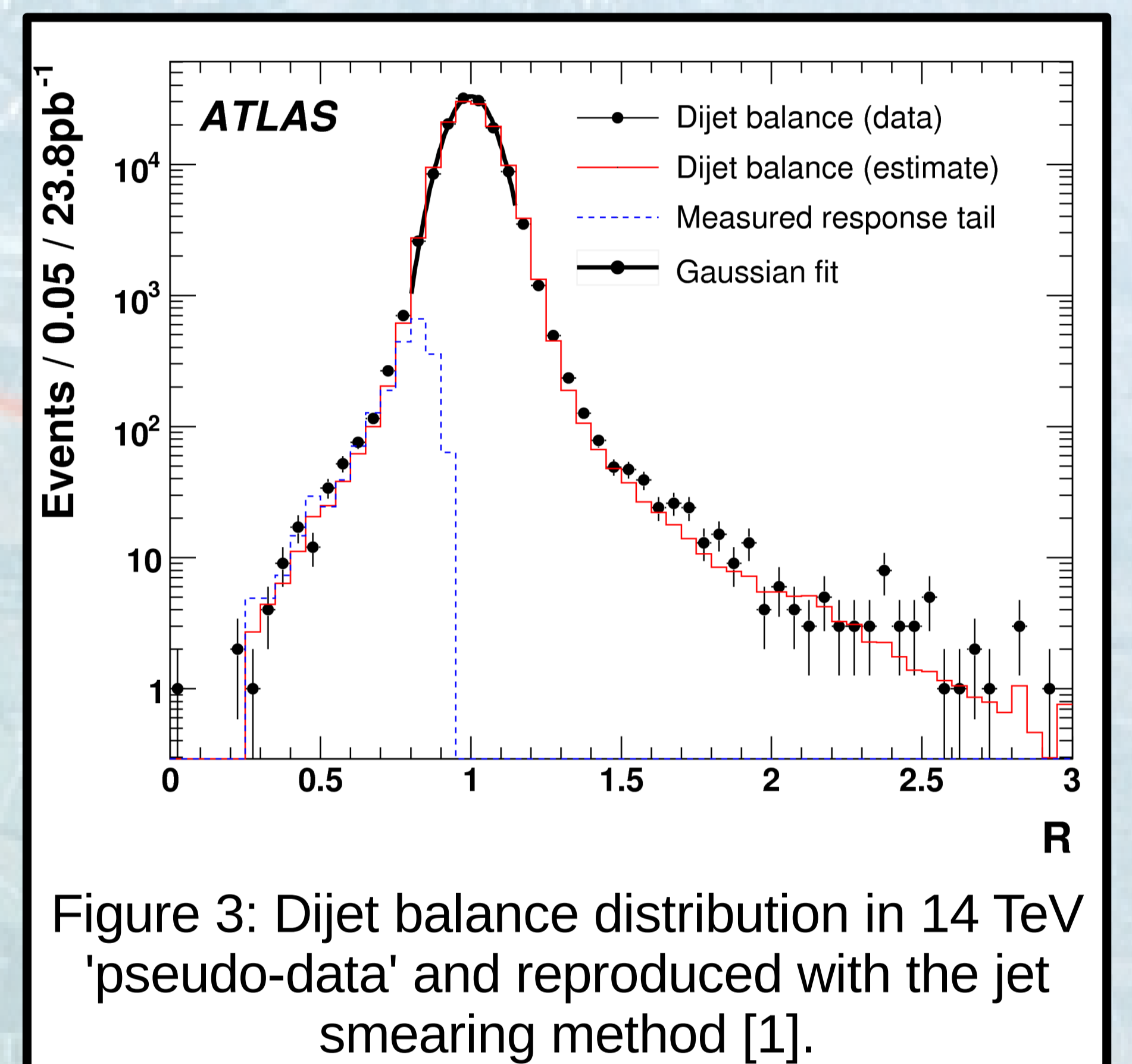

Figure 3: Dijet balance distribution in 14 TeV 'pseudo-data' and reproduced with the jet smearing method [1].

$$R_3(j) = 1 + \frac{\vec{E_T^{Miss}} \cdot \vec{p}_T(j')}{|\vec{p}_T(j')|^2}$$

Final QCD Background Estimate

Jet smearing is applied on low MET, well measured, **multi-jet seed events** with the full jet response function. This produces a set of smeared events. Fig. 4 shows the MET distribution of these events compared with 'pseudo-data' after application of the standard SUSY jet cuts; reasonable agreement is found between the datasets.
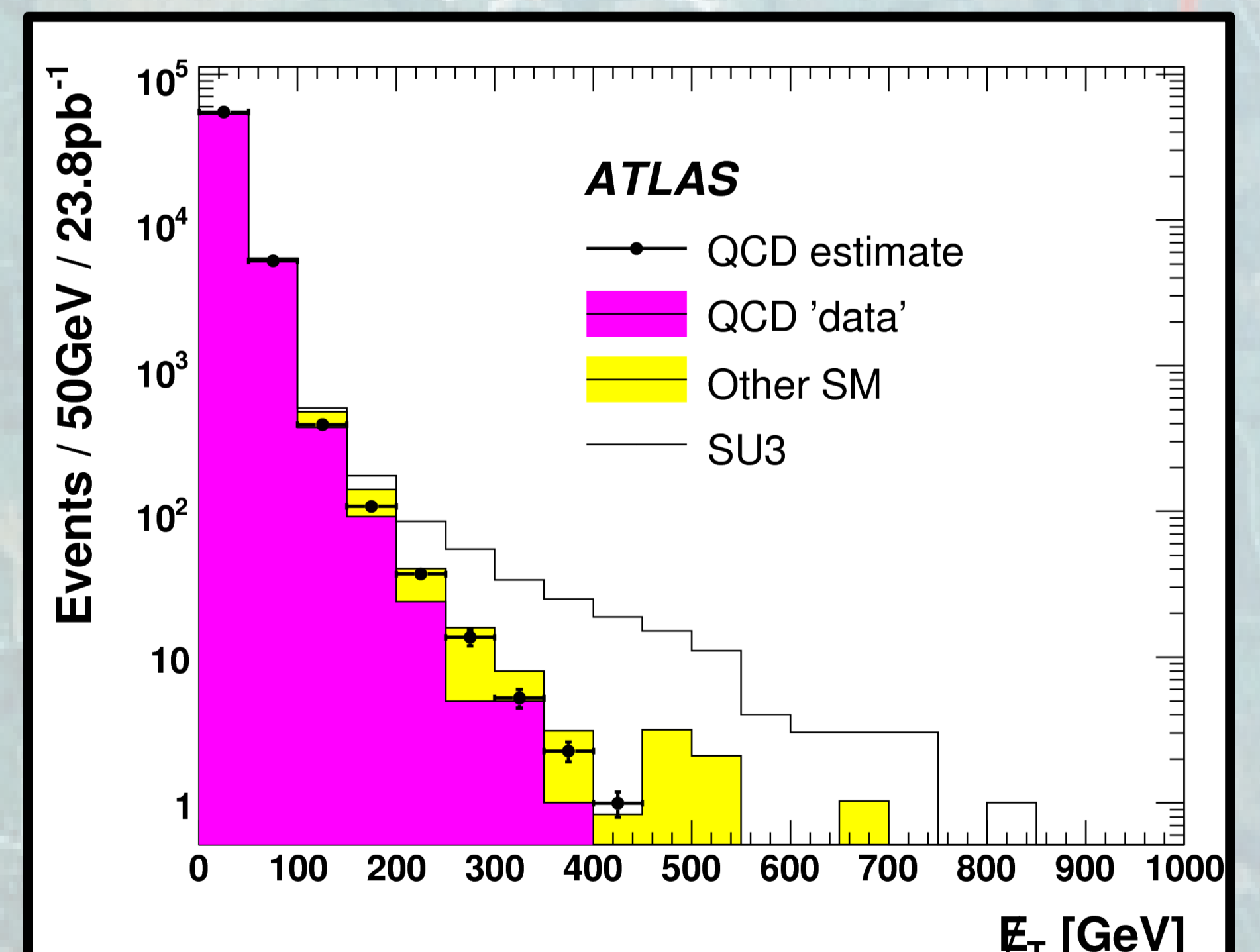

Figure 4: MET distribution of smeared events (QCD estimate) and 14 TeV 'pseudo-data' (QCD 'data') [1].

Simon Owen, University of Sheffield 05/2010

References and Acknowledgements

[1] ATLAS Collaboration, "Expected Performance of the ATLAS Experiment: Detector, Trigger and Physics", 2008, arXiv:0901.0512