WP2 in PRIN 2017 - I

OBJECTIVES

Improve the flavour tagging classification and its impact on the measurements.

STATE OF THE ART

Flavour tagging is the ability to retain jets stemming from the hadronisation of b-quarks while discarding jets originating from lighter quarks or gluons. The discrimination relies on a number of physical properties of B-hadrons: the lifetime, the large mass, the decay multiplicity and the presence of muons from semi-leptonic decays. The current flavour tagging algorithm in ATLAS (MV2) is a Boosted Decision Tree combining the discriminant information related to the impact parameters of the tracks associated to the jet and to the presence of secondary vertices.

And now?

- MV2 and DL1 are now both supported
- DL1r is also partially supported (calibrated only on b-jets)

WP2 in PRIN 2017 - II

ADVANCEMENT AND METHODOLOGY

The challenges in flavour tagging are well suited for Machine Learning algorithms, recently examined in details in ATLAS for this purpose. As a result, a new approach based on deep learning (DL1) from the open-source neural network Keras library with a Theano backend, is being proposed. This WP aims at having the DL1 algorithm fully commissioned and usable in the physics analyses. Calibration studies for extracting tagging rate correction factors to be applied in simulation will be carried out for DL1 with the full Run-2 dataset. Improvements on the calibration strategies will be considered with the aim of reducing the flavor tagging systematic uncertainties, whose impact on the Higgs cross-section measurement in the bb final state are sizable. The work will be then expanded to explore adversarial techniques for reducing the impact of pile-up on the discrimination power and to define the best composition, in terms of kinematic properties, of the training sample to target the best performance of the flavour tagging on data.

And now?

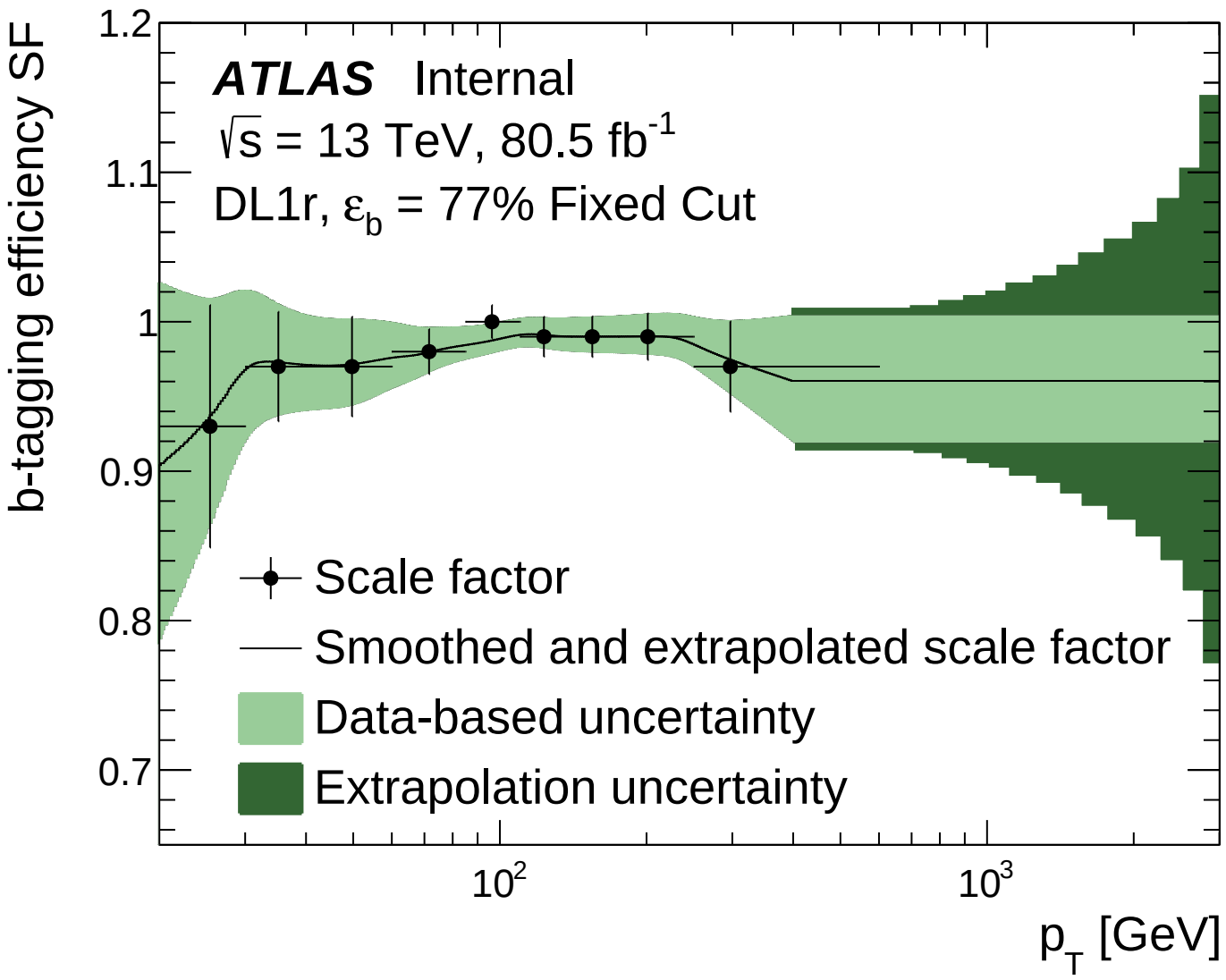
- DL1 is fully calibrated and documented (an incredibly nice paper is now out, 1907.05120
- several improvements has been incorporated in the likelihood calibration method
- no attempts in exploring adversarial techniques and no attempts in having dedicated trainings in boosted environments

WP2 in PRIN 2017 - III

DELIVERABLES
The first deliverable for WP2 is the commissioning and characterisation of a flavour tagging algorithm based on a modern deep-learning approach. The success of this deliverable will depend on the financing of a GPU cluster (15k€) to be installed in the INFN Genova Data Center. The second deliverable is the understanding of its performance in data and the evaluation of its impact, both in terms of sensitivity and associated systematic uncertainties, at the physics-analysis level. These two deliverables are denoted WP2a and WP2b in Figure 2 on the PRIN timeline. A public document summarising the work is foreseen in the second deliverable.

And now?

- If DL1 has to be considered as the modern deep-learning approach, then deliverables are done
- in reality more deep-learning approaches are possible
  - DL1 is just a NN with the same inputs of MV2
  - RNNIP is a RNN which greatly improves the performance at high-p_T
  - some attempts in using graph networks are emerging
  - some thoughts in having RNN and DL1 in one go and in having ML in low-level taggers (images for finding SV?)


ATLAS Internal
√s = 13 TeV, 80.5 fb-1
DL1r, εb = 77% Fixed Cut
b-tagging efficiency SF
1.2
1.1
1
0.9
0.8
0.7
Scale factor
Smoothed and extrapolated scale factor
Data-based uncertainty
Extrapolation uncertainty
10^2
10^3
pT [GeV]

Thoughts for WP2 in PRIN 202X - I

GPU cluster

- GPUs are now available at CERN
- comment by referee: need of a dedicated GPU cluster is questionable, better would be to leverage resources in national or regional data centres

Algorithms

- still many ML-related ideas to explore but baseline ML-based approach is now a reality
- some high-p_T improvements are now in place but no change in the performance in boosted environments

Calibrations

- many improvements in the calibrations and also much more documentation available
- improvements also at high-p_T but still with an approach that adds systematics without modifying the central value of the scale factor as measured in data in $t\bar{t}$ events
- some cross-checks in boosted environments but real calibration only starting now

Thoughts for WP2 in PRIN 202X - II

Various ideas could be coherently framed in relation with boosted Higgs decays

- training and calibration of the algorithms always been done with isolated jets
- low-level algorithms could also be restructured keeping boosted environments in mind
- ML can of course also enter

Some current and future commitments in Genoa which could be considered for PRIN 202X

- *b*-jet triggers and their evolution with FTK/HTT
- calibration on charm jets (actually phasing out)
- JetFitter rewriting considering both software aspects (multi-thread) and injection of new physics ideas (not only jet direction as a proxy for *b*-hadron direction, exclusive decays, double *b*-tagging, ..)

Genoa and WP2

In PRIN 2017

- Andrea (convener in 2016-2018)

In PRIN 202X

- Andrea, Carlo (convener in 2019-2021), Fabrizio, Federico
- :-)