Comparison studies for b tagging variables in data and simulation

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"LHCP2018: Sixth Annual Conference on Large Hadron Collider Physics"

Introduction

The **identification of jets originated from b quarks** is crucial for a broad range of physics analyses. Various b tagging algorithms exist at CMS and are further developed with the use of the machine learning techniques. **Constant monitoring** of the basic quantities provided to the high-level taggers is fundamental to ensure a good tagging performance and to spot potential issues in the data taking. We present a comparison between the **proton-proton collision data** collected by **the CMS detector in 2016** and **simulation**. The comparison is between **input variables** used by the heavy flavour tagging algorithms and the **taggers distributions** in several event topologies.

Event Topologies

- **Inclusive multijet sample:** enriched in light jets
- **Muon-enriched jet sample:** dominated by jets containing heavy-flavor hadrons
- **Dilepton ttbar sample:** enriched in b jets from top quark decays
- **Single-lepton ttbar sample:** higher fraction of c jets

Heavy Flavour Jet Discriminating variables

Heavy-flavour jet identification algorithms use **variables associated with the properties of heavy-flavour hadrons** that are present in jets.

- The lifetime of hadrons containing b quarks is of the order of 1.5ps. This results in a **displacement of the tracks** from which a **secondary vertex** (SV) may be reconstructed.
- **Impact Parameter (IP):** the distance between the primary vertex and the tracks at their points of closest approach.
- Exploits the large (~15%) **semileptonic branching ratio of heavy hadrons**. The presence of a muon or electron permits the selection of a pure sample of heavy-flavour jets

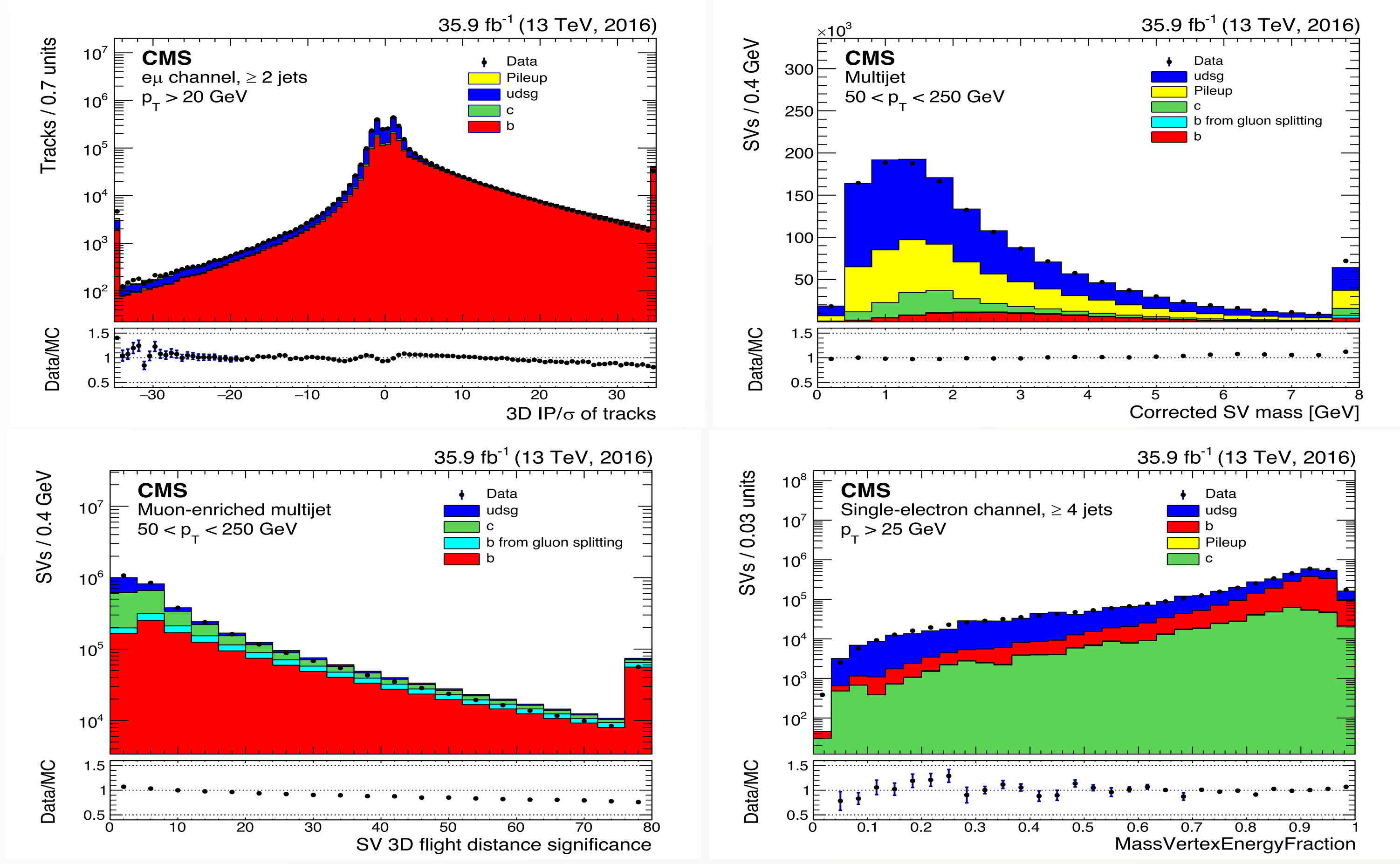


Fig I: **Data-MC comparison** for **input variables** used for heavy flavour tagging for several topologies. The total number of entries is normalized to the observed entries in data.

Heavy flavour jet identification algorithms

Jet Probability Taggers (JP) : combines the probabilities from all tracks to originate from the Primary Vertex (PV).

Combined Secondary Vertex Taggers

- **CSVv2 tagger :** combines the information of the displaced tracks with the information of the secondary vertices associated with the jet using multivariate techniques.
- **DeepCSV:** compared to CSVv2, uses a deep neural network with more hidden layers, more nodes per layer, and a simultaneous training in all vertex categories and for all jet flavours.

Soft Lepton (SL) Combined Taggers:

- rely on the presence of a muon or electron from semileptonic b-decays.
- can be used as input for a combined tagger.

Combined tagger cMVAv2: takes input from JP, SL and CSVv2 to perform a MVA training.

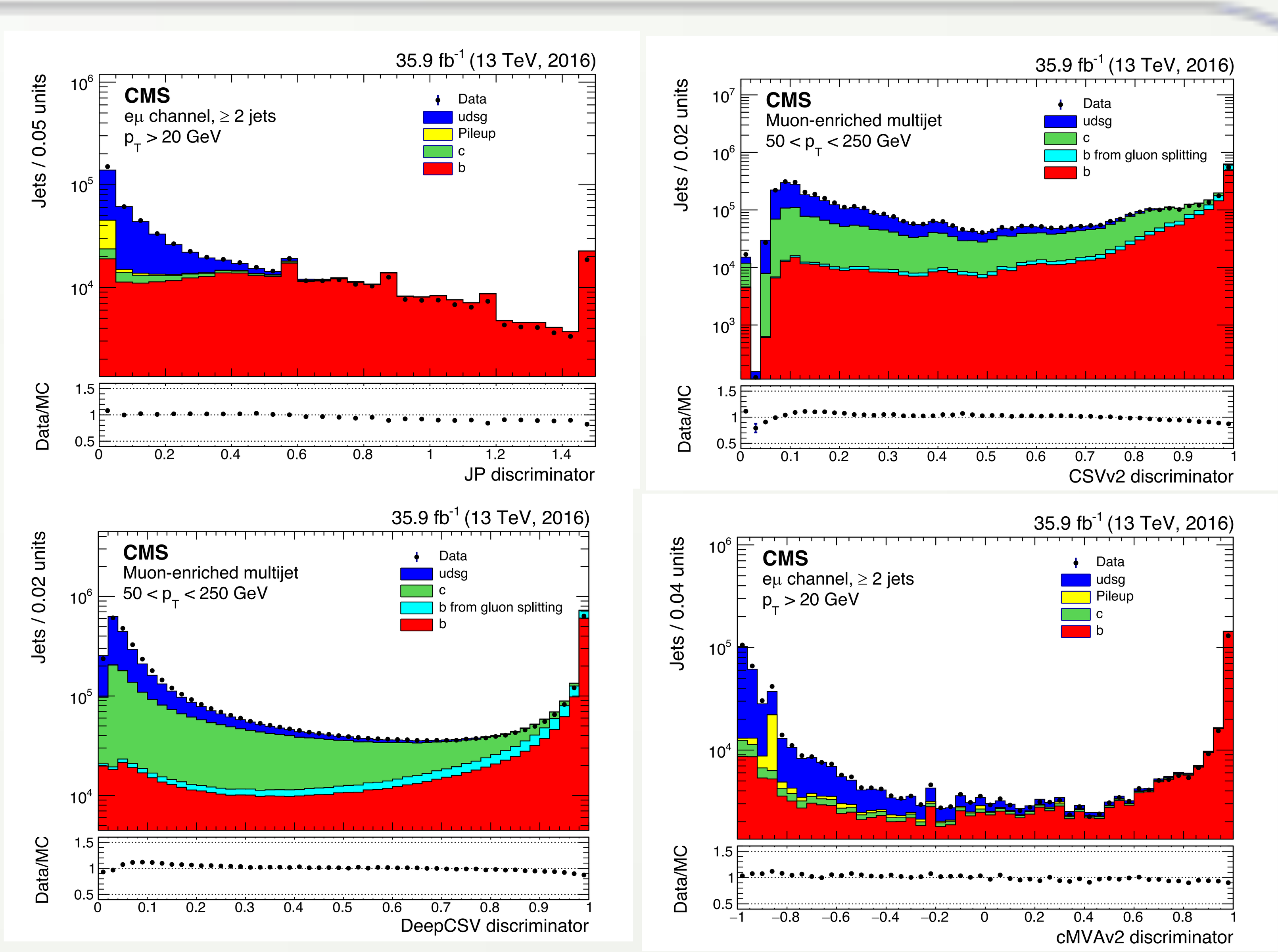


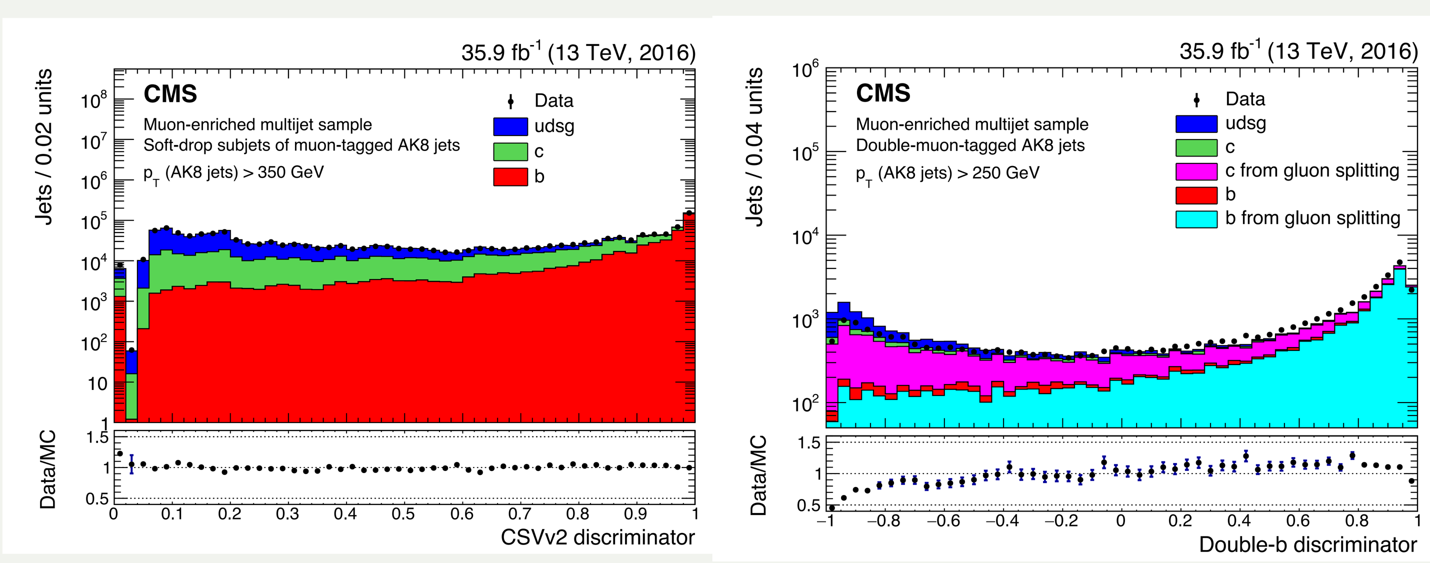
Fig II**: Data-MC comparison** of **discriminator distributions** for for several topologies. The total number of entries is normalized to the observed entries in data**.**

Identification of b jets in boosted topologies

- particles decaying to b quarks can be produced with large Lorentz boost
- jets are reconstructed with a cone of R=0.8 (AK8 jets)
- **CSVv2** applied either to an AK8 jet or its subjets
- dedicated **double-b tagger** for boosted jets with double b content

Two samples for validation purposes:

- muon-enriched boosted subjets sample
- double-muon tagged boosted sample



Reference:
1: Identification of heavy-flavour jets with the CMS detector in pp collisions at 13 TeV The CMS Collaboration JINST 13 (2018) no.05, P05011

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