Prospects for beauty-jet measurements with ALICE

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Introduction

Determine beauty quark production rate via the measurement of beauty-flavoured jets. Quantify mass and colour charge dependence of parton energy loss in a Quark-Gluon Plasma (QGP).

Tag jets coming from fragmentation of beauty quarks - unbiased selection on the kinematics of the hard scattering, even in the presence of an (underlying) heavy-ion collision

Three main analysis steps:
1. Jet-finding algorithms - reconstruct full jet starting from charged tracks and neutral energy
2. Beauty (b)-tagging algorithms - exploit long lifetime (τ ~ 500 μm) and large mass (~ 5 GeV/c²) of B mesons
3. Corrections - unfold jet energy resolution and correct for b-tagging efficiency and charm/light flavour contamination

MC studies of b-jet properties

Track counting method

Benefit from the relatively long lifetime of B mesons. Calculate the impact parameter (d0) in āp for each track within the reconstructed charged jet and project along the jet axis. PHSV-200117

The third most displaced (d0,v) value used as discriminator (N=3)
• Jet flavour defined via the leading (highest pT) parton in the jet cone,
• The pT of is taken from the MC truth to account for neutral particles

Selection criteria:
FastJet Anti-kₜ, R=0.4
pT,min > 1 GeV/c
pT,c > 10 GeV/c
|d0,v| < 0.2 cm
decay length < 10 cm
DCA(jet,track) < 7 μm
ΔR(jet,track) < 0.3

3-prong vertex
Select jet flavour using leading parton in the jet

Vertex selections:
• |L_{v} - L_{m}| ≥ |L_{m}|(0.7pT,μ)
• 3-track invariant mass
• Impact point mass for track mass hypothesis

Prospects with LHC/ALICE upgrades

ALICE read-out and LHC upgrades (2018)
Higher integrated luminosity (10 fb⁻¹ in pp and 10 nb⁻¹ in Pb-Pb) collisions at a L ≈ 35.5 TeV required by the ALICE upgrade program
High-precision heavy-flavour results, possibility to study on-line b-jet tagging

Upgrade of the Inner Tracking System (2018)
• (3.5%) improvement of the track impact parameter resolution in the transverse (longitudinal) direction 
• Improved light-flavour rejection in b-tagging analyses

Expected yield of raw b-jets per pb⁻¹ in minimum bias pp collisions at √s=5.5 TeV assuming a constant b-tagging efficiency of 10% for jet pT > 20 GeV/c

Reduced statistical uncertainty on the raw b-jet yield allows measurements over a larger momentum range

Achievable purity with improved light-flavour rejection being studied

Operating point: Taking the DCA for charged tracks as the impact parameter (Δr = 0)

Benefits of the ITS Upgrade

1. Improved tracking resolution by a factor of 10
2. Increased event rate to 20 kHz in pp and 10 kHz in Pb-Pb
3. Increased trigger rate to 5 kHz

Beauty-tagging algorithms

Beauty-jet tagging algorithms

Secondary vertexing method

Benefit from the relatively long lifetime and large mass of B mesons. High multiplicity of charged particles produced in the decay.

3-prong vertex
Select jet flavour using leading parton in the jet

What’s next?
Cut optimization studies
• Strong criteria => favouring a pure sample
• Loose criteria => favouring more statistics, b-jet yield extraction via MC mass template fits

Ongoing studies

• Estimation of the purity of the b-tagged sample with current detector setup and with ALICE ITS upgrade
• Correction for b-tagging efficiency and unfolding of the jet spectrum for the jet energy scale and background fluctuations
• Electron identification to enhance the purity, take advantage of the highly efficient EMCal event trigger
• Tagging algorithm based on the probability of in-jet tracks to be secondary
• Vertex finding algorithm based on vertex clustering and/or N-track vertices
• Comparison of the results obtained using the different algorithms

GOALS:
b-jet pT differential cross section in pp, p-Pb, and Pb-Pb collisions down to low pT (~20 GeV/c), complement high-pT measurements from CMS

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