Performance of the b-jet tagging algorithm in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV at ALICE

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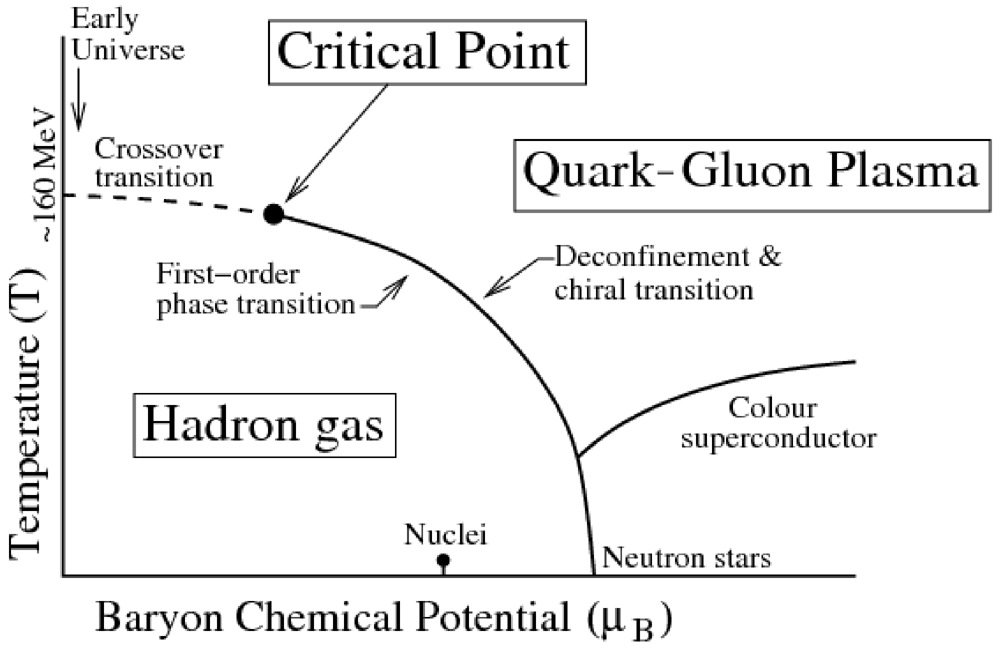
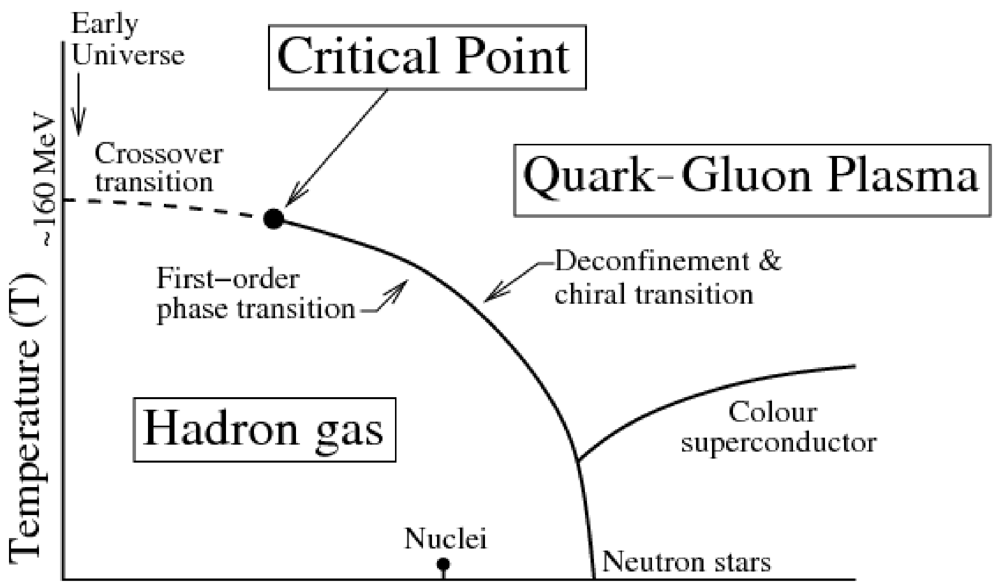
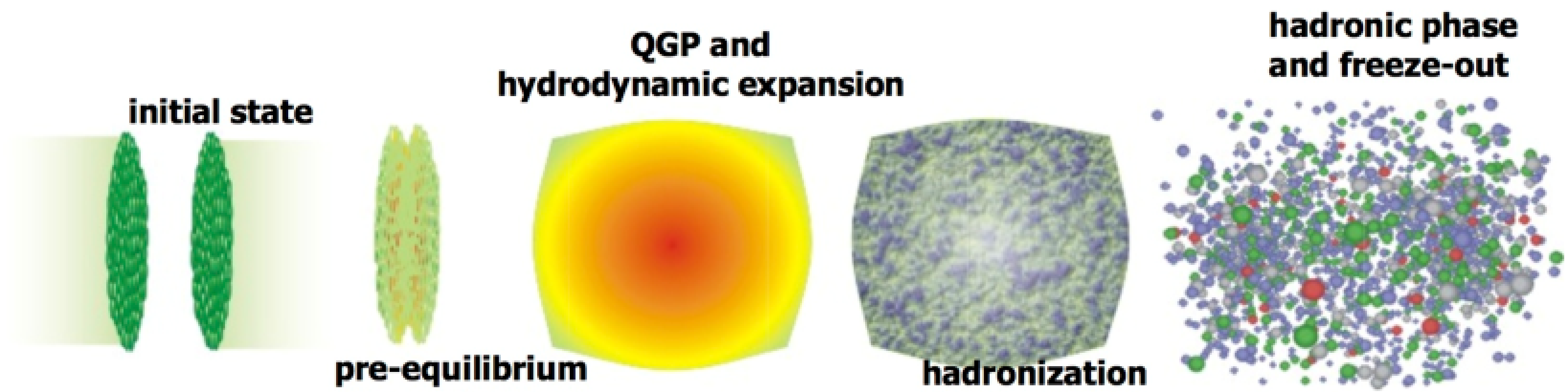
Introduction



Introduction

Quark Gluon Plasma (QGP) is created in heavy-ion collisions





CGC "Glasma" Hydrodynamics Hadronic gas

Introduction

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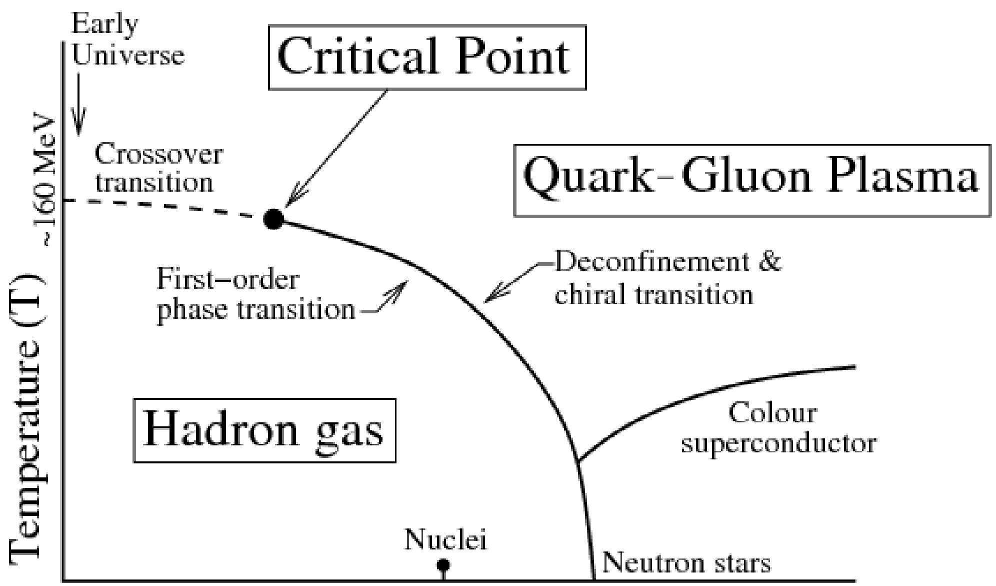
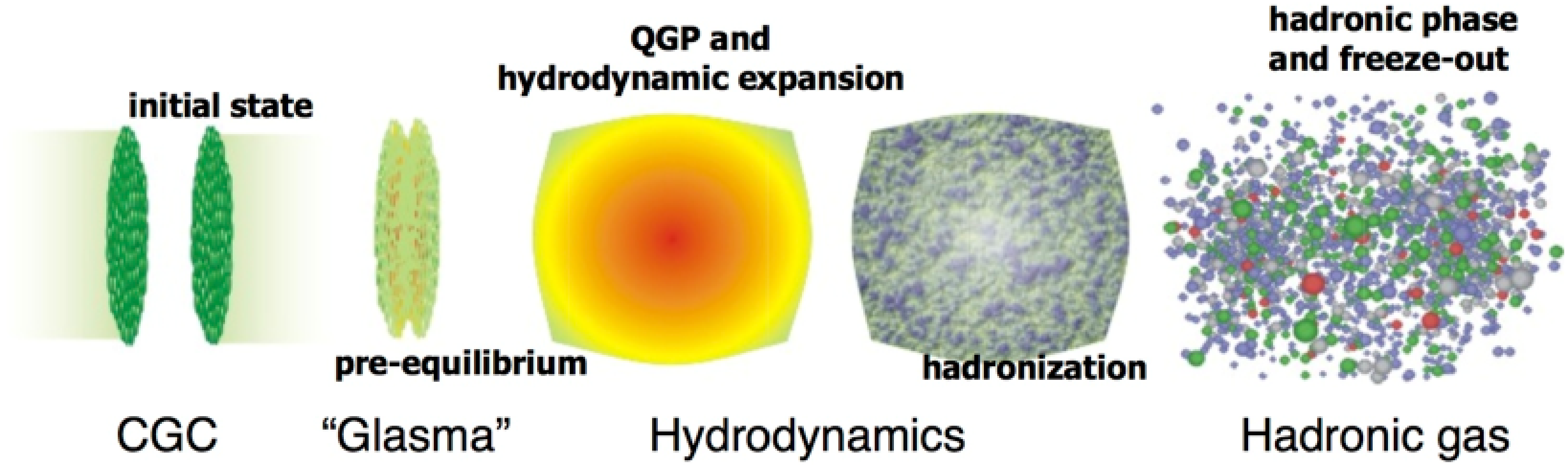


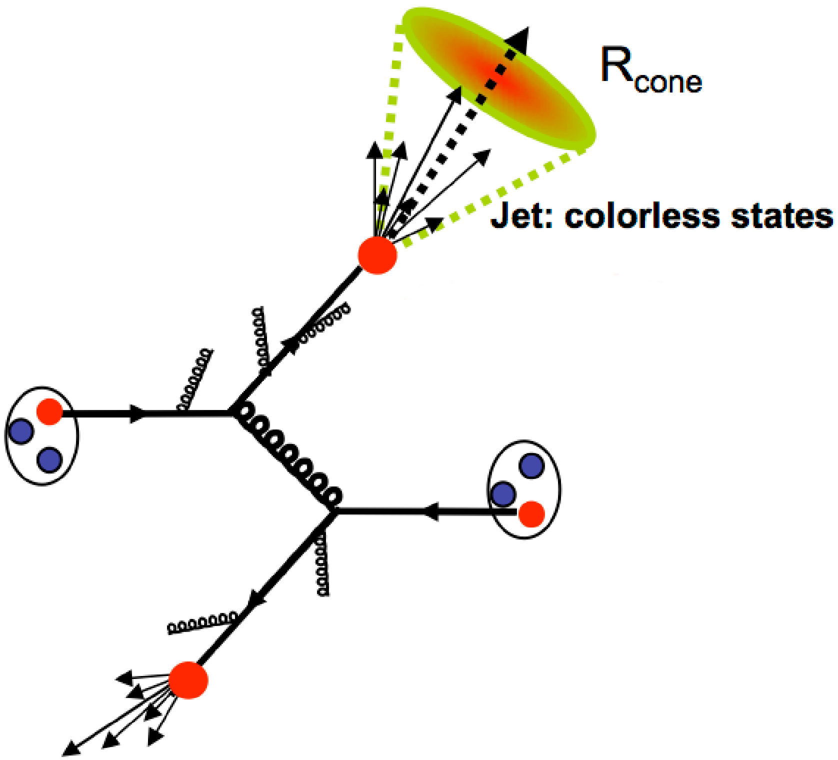
Signatures of QGP:

- **Collective flow** → QGP behaves like nearly-perfect liquid
- ***Jet quenching*** → QGP slows penetrating patrons



The study of the Jets

Jet – a collimated spray of hadrons, created during hadronization of quark or gluon after hard scattering, defined via algorithm



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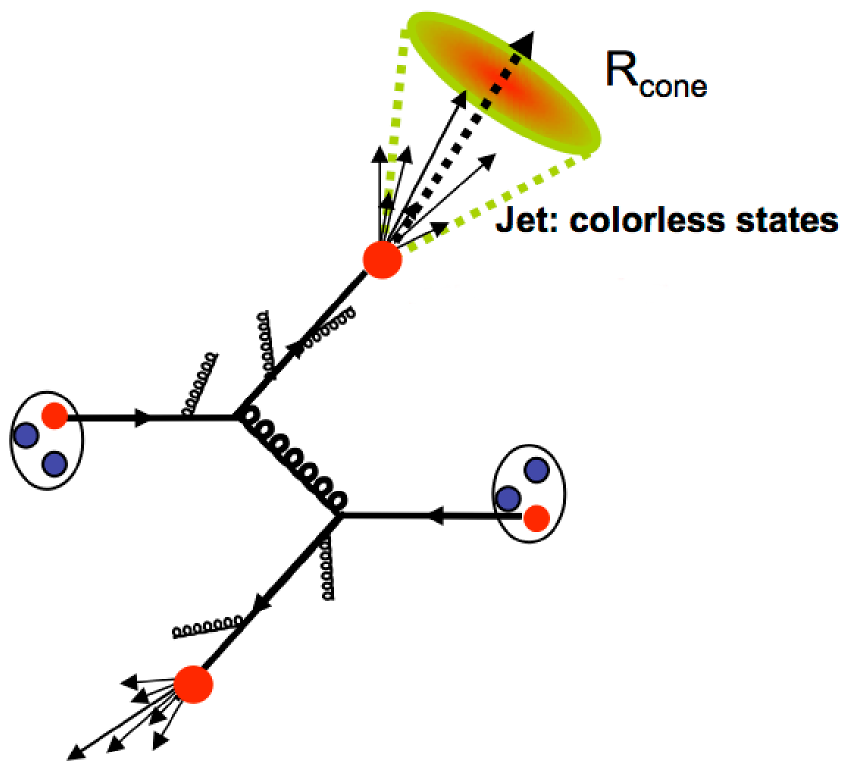


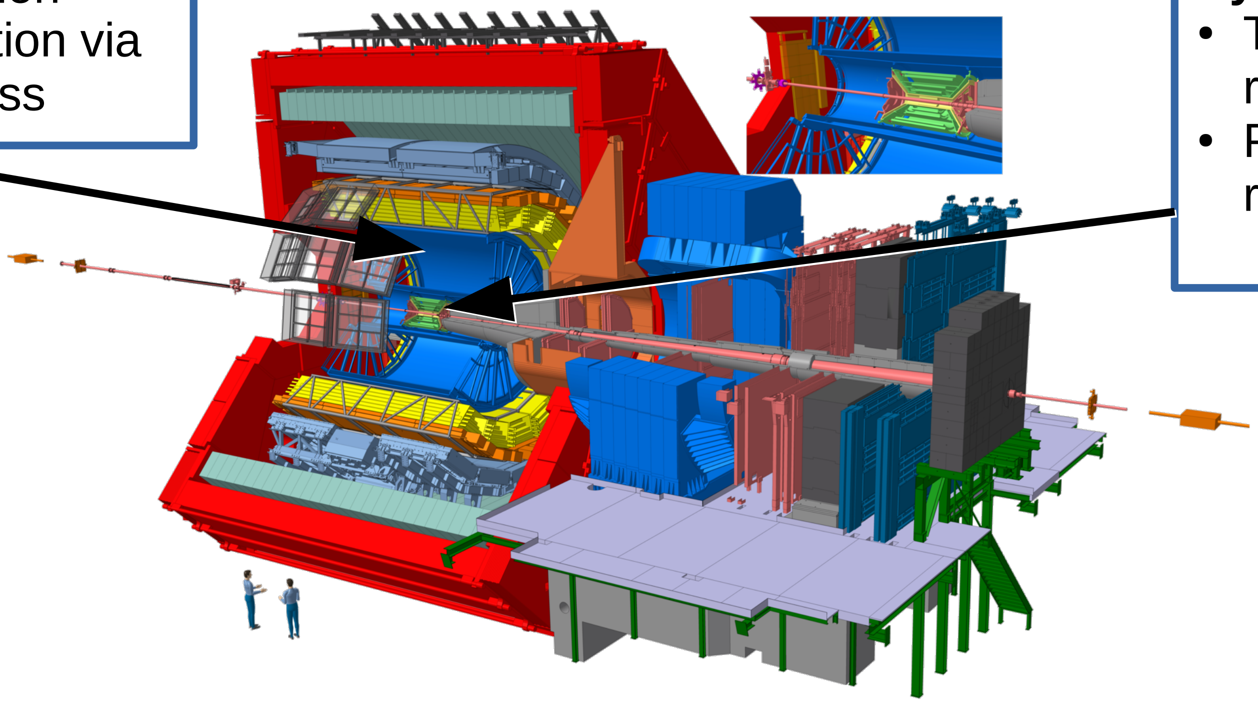
- b-quark has large mass (4.62 GeV/c^2), so it can be created only in initial hard scatterings. Its production rate can be calculated from pQCD
- b-quark has long lifetime so it survives through the whole evolution of QGP

ALICE experiment

ALICE (A Large Ion Collider Experiment) – one of the experiments located at the LHC.

Time Projection Chamber
- Track reconstruction
- Particle identification via specific energy loss

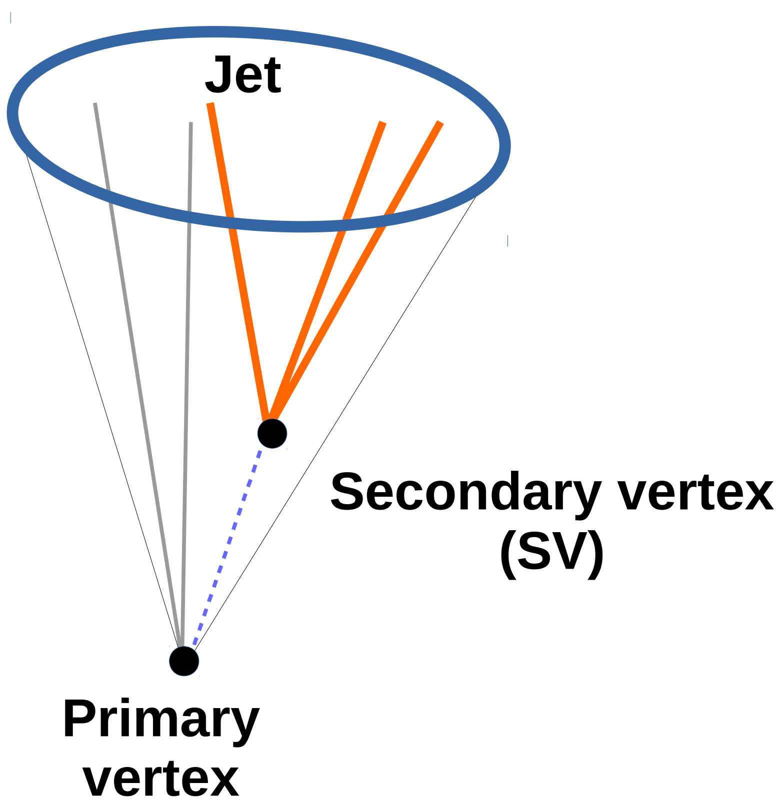
Inner Tracking System
- Track reconstruction
- Primary and SV reconstruction



V0
Scintillator array for triggering

- Impact param. < 75 μm
- $|\eta| < 0.9$
- Full azimuth
- 0.5 T solenoid

Jet selection



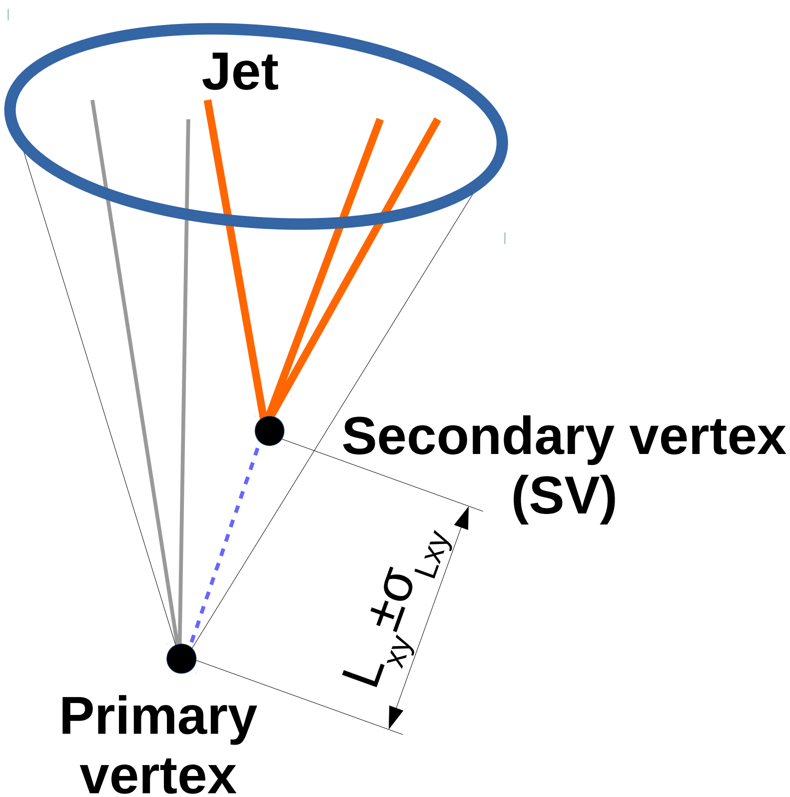
- Jets were reconstructed with the anti-k_T algorithm:

$$\begin{cases} d_{ij} = min\left(p_{ti}^{-2}, p_{tj}^{-2}\right)\frac{\Delta R_{ij}^2}{R^2} \\ \Delta R_{ij}^2 = (y_i - y_j)^2 + (\phi_i + \phi_i)^2 \\ d_{iB} = p_{ti}^2 \end{cases}$$

- Resolution parameter R = 0.4
- |η| < 0.9 - R
- Charged tracks with p_T > 0.15 GeV/c
- Jet momentum is corrected for the mean underlying event density

$$P_{jet,charged}^{corrected} = P_{jet,charged}^{RAW} - \rho \cdot A_{jet}$$

Jet selection



b-jet candidate selection:

- Significance of the distance between primary and secondary vertices $\mathbf{L_{XY}/\sigma_{Lxy}}$
- Choice of the most displaced SV
- 3 prong SV
- Dispersion of the SV $\boldsymbol{\sigma_{SV}}$:

$$\sigma_{SV} = \sqrt{\sum_{i=1}^{3} d_i^2}$$

Contribution of the work

- Selected sample of the b-jets candidates contains b-jets, c-jets and LF-jets.
- To get RAW transverse momentum spectra of b-jets, the spectrum of b-jets candidates needs to be corrected:

$$\frac{dN_{b\,jet}^{primary}}{dp_{T\,,\,jet\,ch}} = \frac{dN_{b\,jet\,candidates}^{raw}}{dp_{T\,,\,jet\,ch}} \times \frac{P_b}{\varepsilon_b}$$

P_b − purity of the b-jet candidates

ε_b − efficiency of the b-jet selection after applying cuts

Choice of the cut

- We need to optimize the cuts such, that they will significantly suppress the number of c and light-quark admixture (<1%) and keep the number b-jets as high as possible
- Efficiency of b-jet tagging:

$$\varepsilon_b = \frac{N_{b-jets}^{selected}}{N_{b-jets}^{all}}$$

N_{b-jets}^{all} − the number of b-jets without any constraint on presence and parameters of SV

$N_{b-jets}^{selected}$ − the number of b-jets that were reconstructed when applying cuts on b-jets candidates

- Efficiency is estimated on a base MC data (PYTHIA + EPOS)

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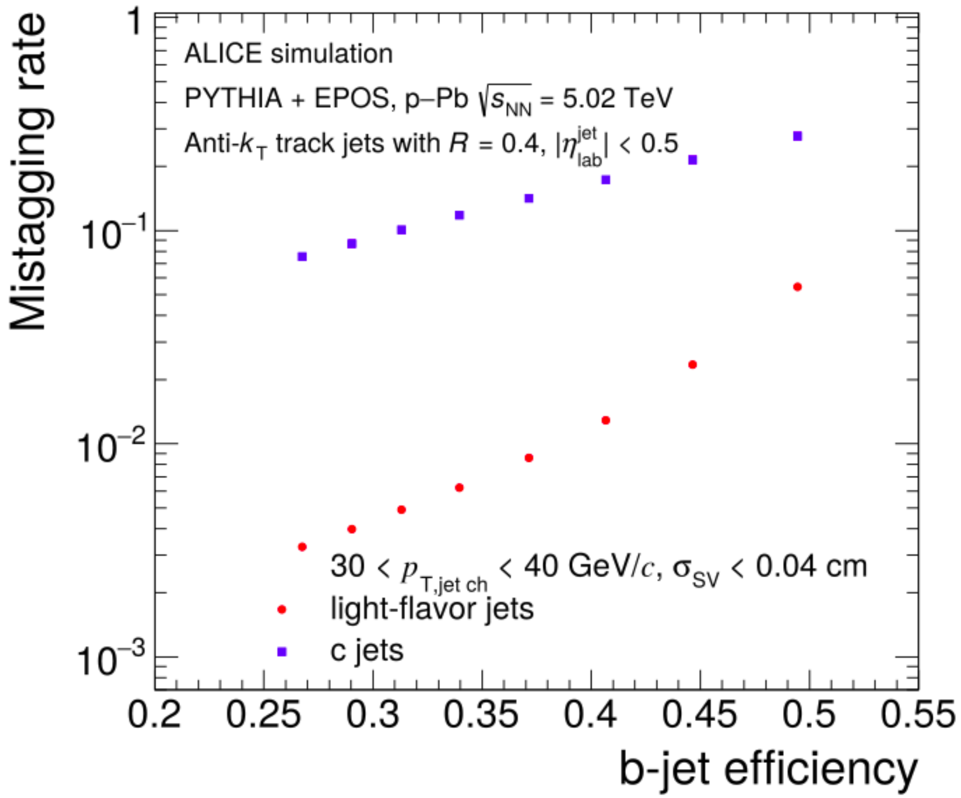

- $L_{xy}/\ \sigma_{Lxy}$ was varied form 3 to 10 while keeping σ_{SV} fixed

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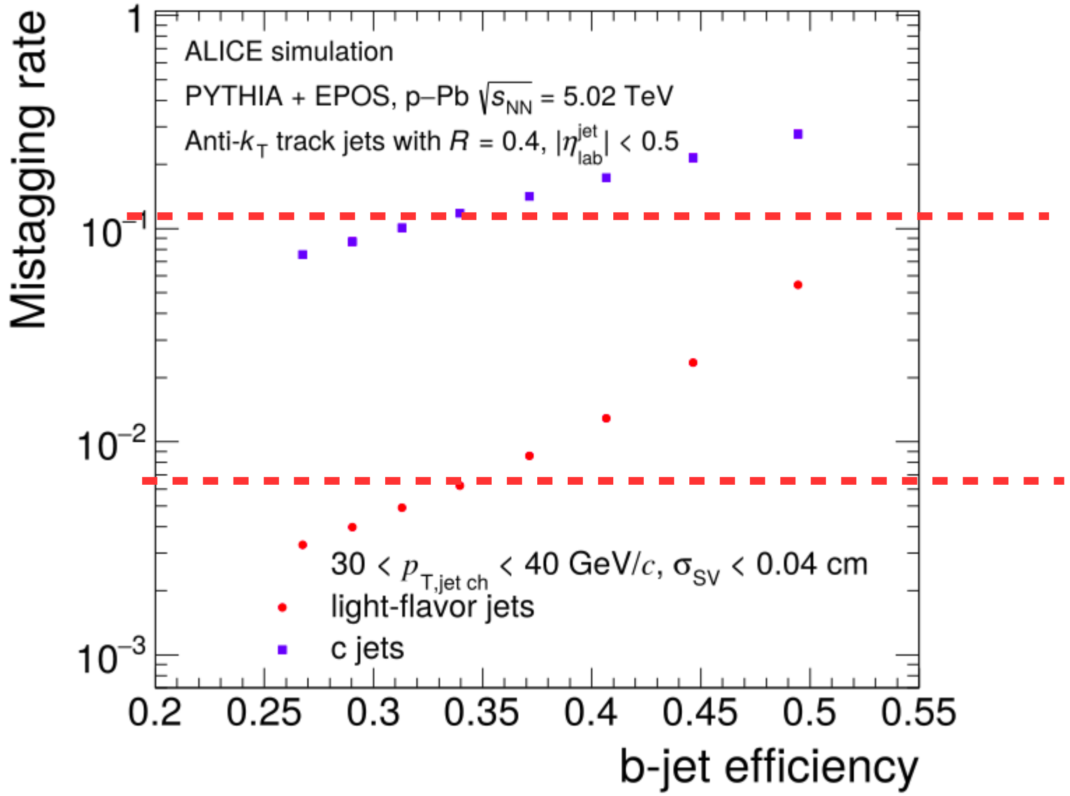
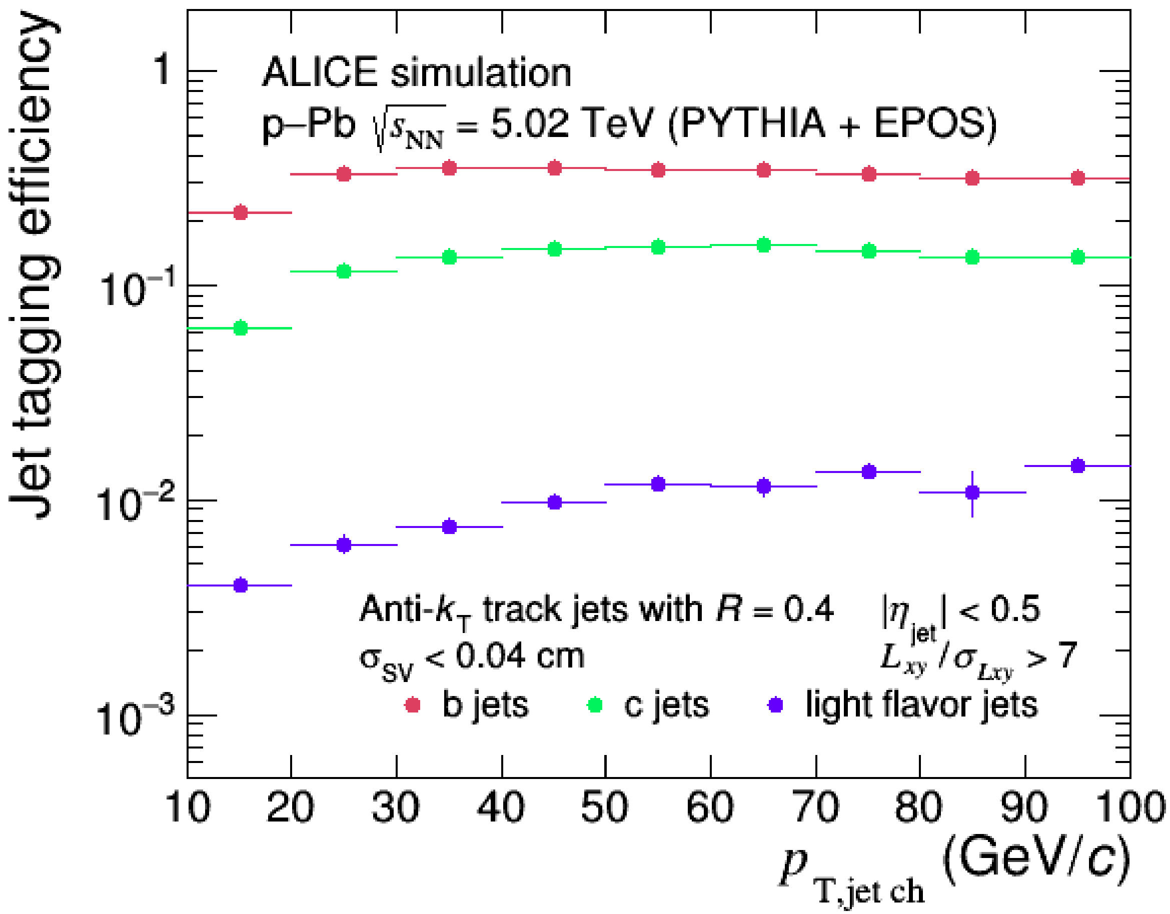


- $L_{xy}/\ \sigma_{Lxy}$ was varied form 3 to 10 while keeping σ_{SV} fixed
- **Optimal $L_{xy}/\ \sigma_{Lxy}$ > 6**

Efficiency of jet tagging

Jet tagging efficiency for jets with different flavors as a function of $P_{T,\text{ jet ch}}$



$\varepsilon_b \approx 35\ \%$

$\varepsilon_c \approx 11\ \%$

$\varepsilon_{LF} \approx 1\ \%$

Purity of b-jets

- Purity represents part of real b-jets in spectra of b-jets candidates
- Purity of b-jets can be represented by formula:

$$P_b = \frac{N_{b-jets,cut}^{true}}{N_{b-jets,cut}^{candidates}}$$

$N_{b-jets,cut}^{true}$ – the true number of b-jets after cut

$N_{b-jets,cut}^{candidates}$ – the total number of jets in reconstructed spectra

- Purity estimation based on MC data (PYTHIA + EPOS)

Data driven method

- The data driven method is based on representation of the distribution of invariant mass of SV as a linear combination of MC templates:

$$\begin{cases} n_{SV} = P_b \cdot T_b + P_c \cdot T_c + P_{LF} \cdot T_{LF} \\ 1 = P_b + P_c + P_{LF} \end{cases}$$

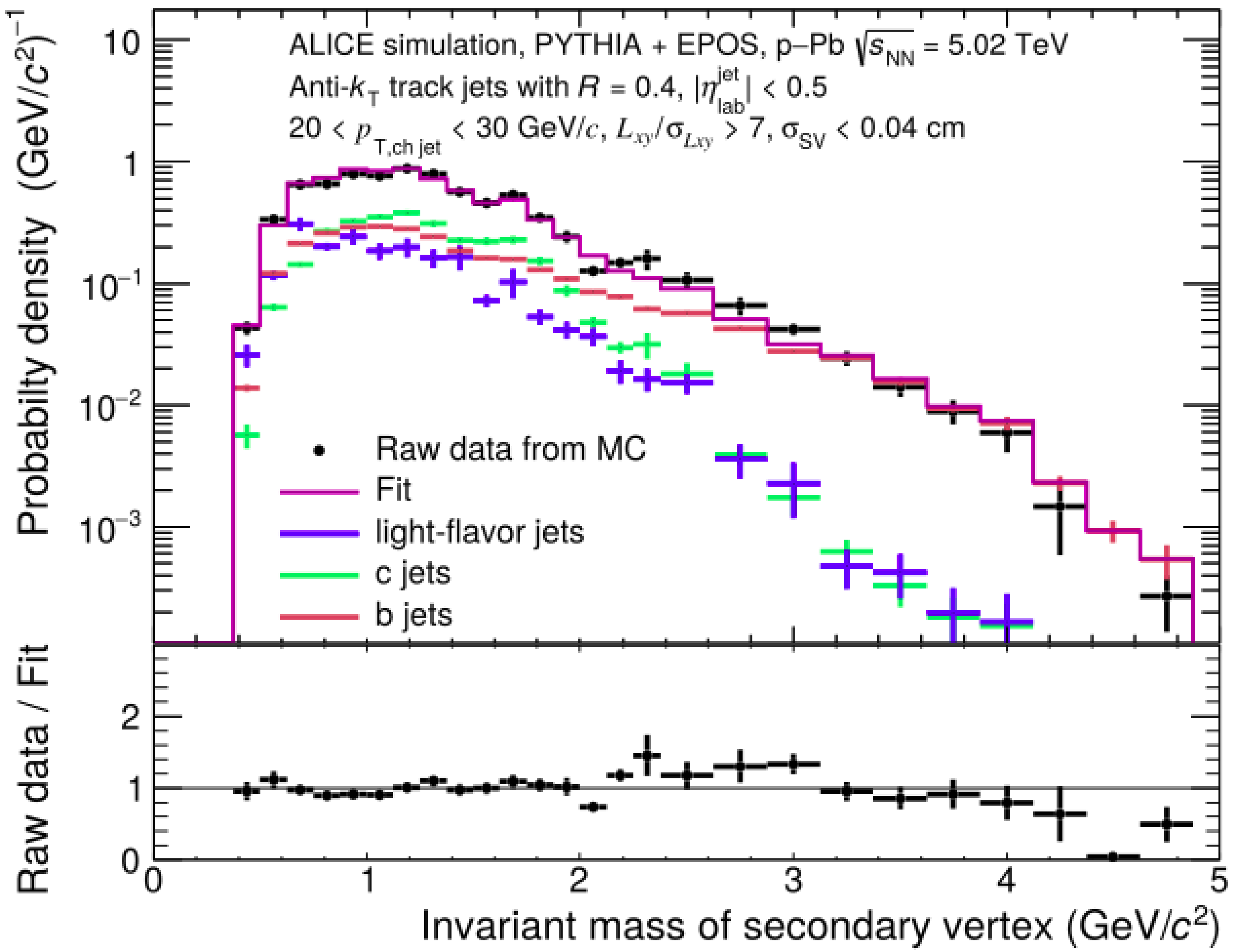
n_{SV} − SV invariant mass reconstructed distribution in given jet-p_T bin

T_b, T_c, T_{LF} − MC template spectra for each jet flavor

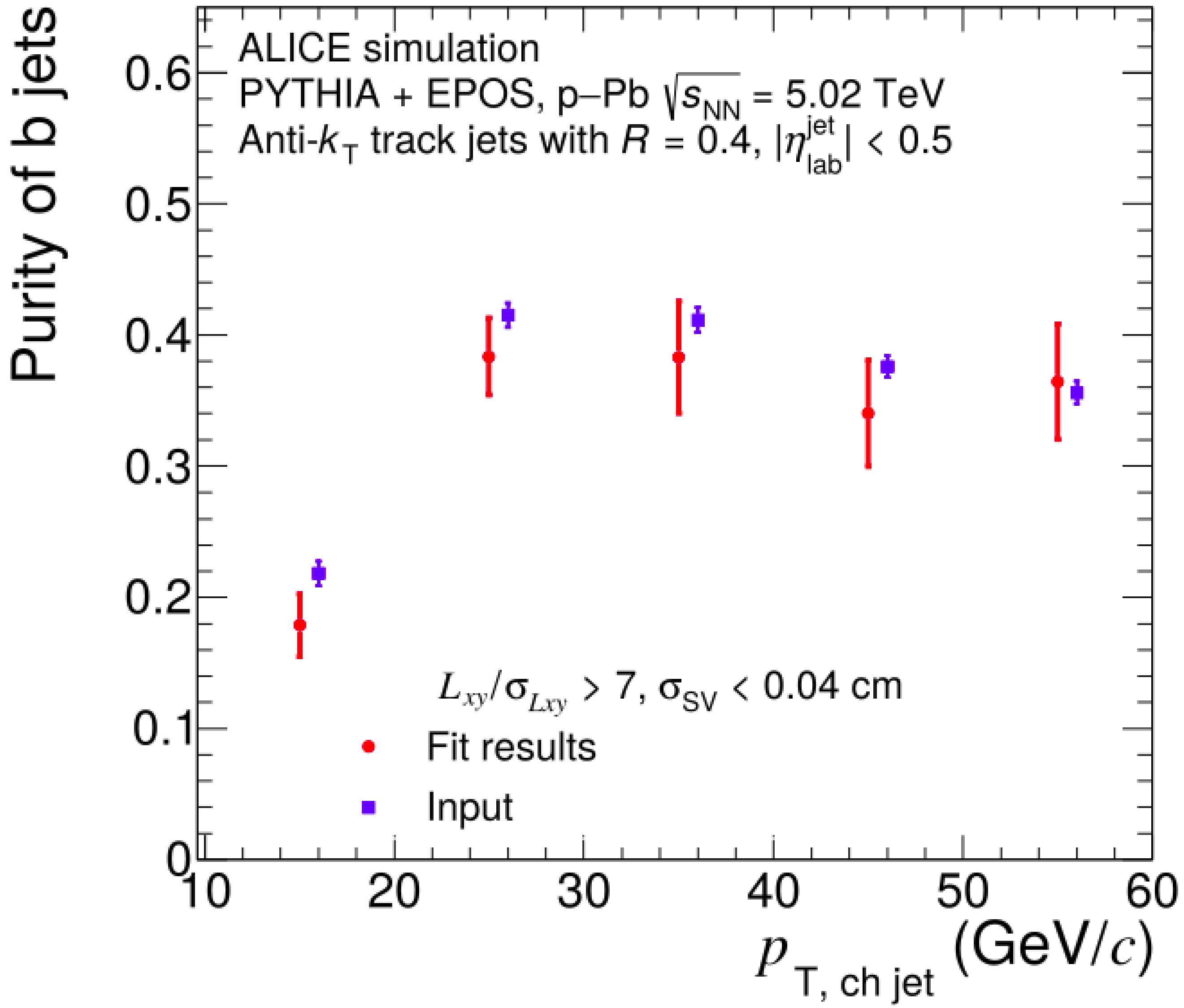
P_b, P_c, P_{LF} − purity for each jet flavor

- Purity is evaluated in following p_T bins = {10, 20, 30, 40, 50, 60} GeV/c
- TMinuit library was used for fitting reconstructed distribution to MC templates
- Template-fit method was tested on MC simulation (PYTHIA + EPOS)

Results of fitting



Closure test



Summary

- Performance of b-jet tagging algorithm done for $L_{xy}/\ \sigma_{Lx} > 7$ and $\sigma_{SV} < 0.04$ µm.
- Efficiency of b-jet tagging is $\boldsymbol{\varepsilon_b \approx 35\ \%}$
- Purity of b-jets is ~ 40%
- Closure test of data-driven algorithm for calculation of purity of b-jets was done

Further steps:

- Compare results of calculation purity with POWHEG simulation
- Try out purity calculation on real data

Backup

Fitting procedure

To perform fitting and calculate purity was used **TMinuit** library

This package allows to minimize multi parameter user function

In this work was used function:

$$\chi^2=\sum_{i=1}^{nbis}\frac{\left(n_{SV,i}-P_b\cdot T_{b,i}-P_c\cdot T_{c,i}-P_{LF}\cdot T_{LF,i}\right)^2}{\sigma_{n_{SV,i}}^2+\left(\sigma_{T_{b,i}}\cdot P_b\right)^2+\left(\sigma_{T_{c,i}}\cdot P_c\right)^2+\left(\sigma_{T_{LF,i}}\cdot P_{LF}\right)^2}$$

Where is

$n_{SV,i}$ – Invariant mass distribution of SV, **non-enhanced** MC

$T_{b,i}$, $T_{c,i}$, $T_{LF,i}$ – Invariant mass distribution of SV **for each flavor** MC

P_b, P_c, P_{LF} – purity for each jet flavor

σ_{nsv} , σ_{Tb} , σ_{Tc}, σ_{TLF} , – *statistical error* for each jet flavor