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Potentials for J/ψ from b decays measurement in ALICE

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Summary. — This paper is intended to discuss the ALICE potentials for the measurement of the fraction of J/ψ produced at central rapidity in beauty hadrons semi-inclusive decays, namely $B \to J/\psi X$. This measurement relies on the combined use of the Time Projection Chamber (TPC) for tracking and particle identification via $\mathrm{d}E/\mathrm{d}x$; the Inner Tracking System (ITS) for tracking and detection of displaced vertices; the Transition Radiation Detector (TRD) for particle identification.

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1. – Introduction

Measuring the fraction of J/ψ coming from beauty hadron decays (the so-called *secondary* J/ψ component) is an important issue to study in p-p as well as A-A collisions both open beauty production (has shown by recent measurements from CDF (Collider Detector at Fermilab) [1] in $p\overline{p}$ collisions at $\sqrt{s} = 1.96\,\mathrm{TeV}$) and charmonium production. On this regard, recent results from CDF and theoretical predictions at LHC energy suggest that $\sim 30\%$ of the totally produced J/ψ in p-p collisions should come from beauty hadron decays. As a consequence, an accurate knowledge of the J/ψ production mechanism in the vacuum and in heavy-ion collisions as well, requires the adequate measurement and subtraction of this component.

2. – Analysis and results

A detailed analysis description can be found here [2]. Dedicated Monte Carlo samples for prompt J/ψ, J/ψ from b-hadrons and minimum bias events have been used to tune the analysis. Inclusive J/ψ reconstruction is performed in the dielectron $J/\psi \to e^+e^-$ channel at central rapidity ($|\eta| < 0.9$). Main tracking is provided by the TPC, together with ITS at low momenta. Only tracks with high tracking quality (at least 5 points in ITS, 70 clusters in TPC) are selected. e/π discrimination is provided by the combined

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TABLE I. – *Log-likelihood fit algorithm results on the extracted fraction of J/ψ from B hadrons.*

$p_T(J/\psi)$ GeV	# J/ψ from B	True $f_B(p_T)$	Meas. $f_B(p_T)$	$\sigma(f_B)$	$\sigma(f_B)/f_B$
2–3	32	0.179	0.216	0.055	$\sim 26\%$
3–4	35	0.194	0.177	0.046	$\sim 26\%$
4–6	56	0.227	0.206	0.038	$\sim 18\%$
> 2	269	0.349	0.361	0.072	$\sim 20\%$

use the TPC (via $\mathrm{d}E/\mathrm{d}x$) and TRD signals. A pion rejection factor of 10^{-4} for momenta $p < 2\,\mathrm{GeV}$, and up to 10^{-2} at higher momenta, is achievable in this way. The invariant mass analysis is performed in the region $|m_{ee} - M(J/\psi)| < 250\,\mathrm{MeV}$ for selected di-electron candidates. The combinatorial background has been estimated using the like sign technique. J/ψ from inclusive $B \to J/\psi X$ decay can be separated from the prompt charmonium component since B hadrons ($c\tau \sim 500\,\mu\mathrm{m}$) can travel a sizable distance in the detector far from the interaction region. The signed projection of the J/ψ flight distance on its transverse momentum, named L_{xy}, is a good measurement of the displaced vertex and is used to separate J/ψ of the B hadrons from that of prompt production. The L_{xy} is defined as $L_{xy} = \vec{L} \cdot \vec{p}_T(J/\psi)/|\vec{p}_T(J/\psi)|$ where $\vec{L}$ is the vector from the primary vertex, where B hadrons are produced, to the J/ψ decay vertex in the r-ϕ plane, and $\vec{p}_T(J/\psi)$ is the transverse momentum vector. To reduce the dependence on the J/ψ transverse momentum bin size and placement, a new variable x, called *pseudoproper decay length* has been used instead of L_{xy}, namely $x = L_{xy} \cdot M(J/\psi)|\vec{p}_T(J/\psi)|$. In order to extract the fraction $f_{(B\to)J/\psi}(p_T^{J/\psi})$ of J/ψ coming from b-hadrons as a function of the charmonium transverse momentum, a simultaneous two-dimensional fit algorithm of the total dielectron invariant mass m_{ee} and the total pseudoproper decay length x distributions is used. The fit is performed in each p_T bin in which the sample is divided. The approach adopted is based on the unbinned maximum-likelihood (ML) fit technique. The probability distribution function that describes the frequency of occurrence of data at (m_{ee}, x) is $F(m_{ee}, x; \vec{a})$, where $\vec{a}$ is the set of parameters describing the true shape. $f_{(B\to)J/\psi}(p_T^{J/\psi})$ belongs to the parameters list. $F(m_{ee}, x; \vec{a})$ is written as the sum of two different terms for the signal J/ψ (prompt and secondary) and the background events. For each term, the distributions for m_{ee} and x are assumed independent and can be factorized. They are accurately determined by means of detailed Monte Carlo studies. Table I summarizes the likelihood method performance in the measurement of f_B, for a total J/ψ statistics corresponding to one year of ALICE data taking in p-p collisions at $\sqrt{s} = 7\,\mathrm{TeV}$.

Assuming 10^9 minimum bias events and the fully installed TRD, the fraction f_B of secondary J/ψ measurement, integrated over charmonium transverse momentum for $p_T(J/\psi) > 2\,\mathrm{GeV}$, is possible in one year of data taking, with a relative error $\sigma(f_B)/f_B \sim 30\%$. The p_T differential measurement of the secondary J/ψ fraction is possible up to $p_T(J/\psi) \sim 6\,\mathrm{GeV}$, with a relative error $\sigma(f_B)/f_B \sim 25\%$ at high momentum.

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