Beauty-decay electron cross section measurements in pp collisions with ALICE

Tomas Aronsson
for the ALICE Collaboration
Yale University

Outline

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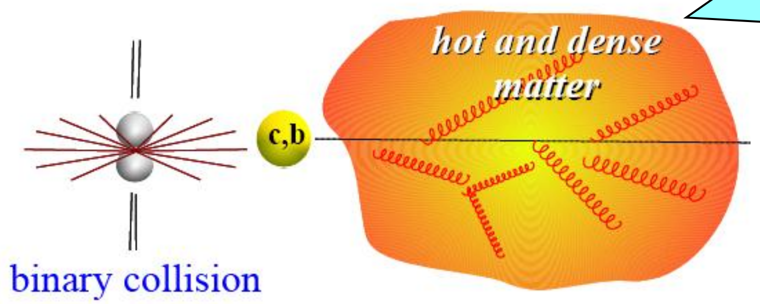
Summary

Introduction



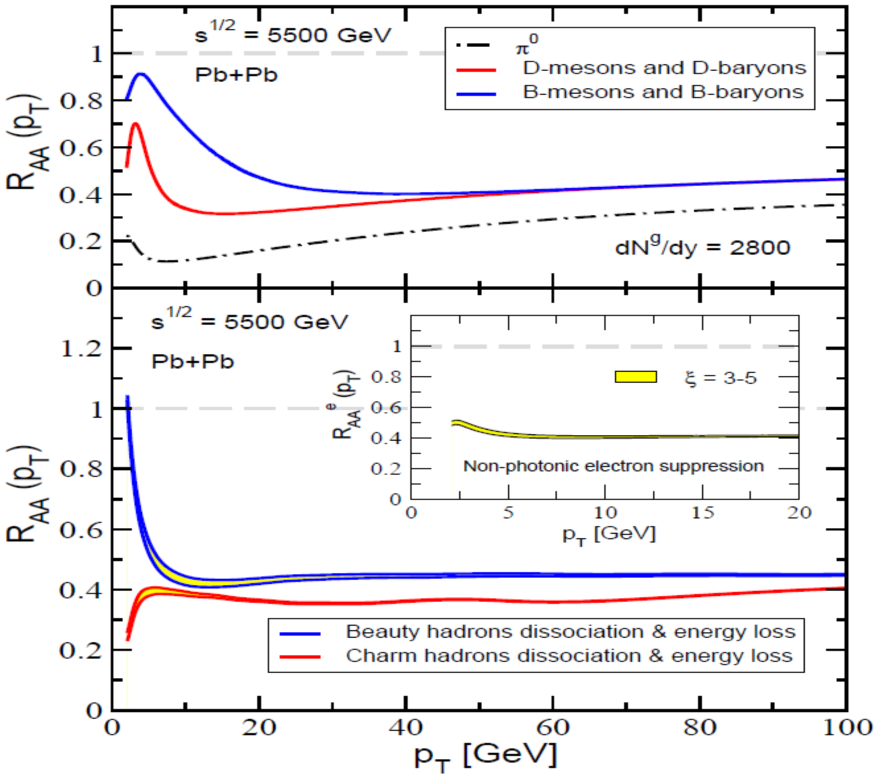
- collective flow
- parton energy loss

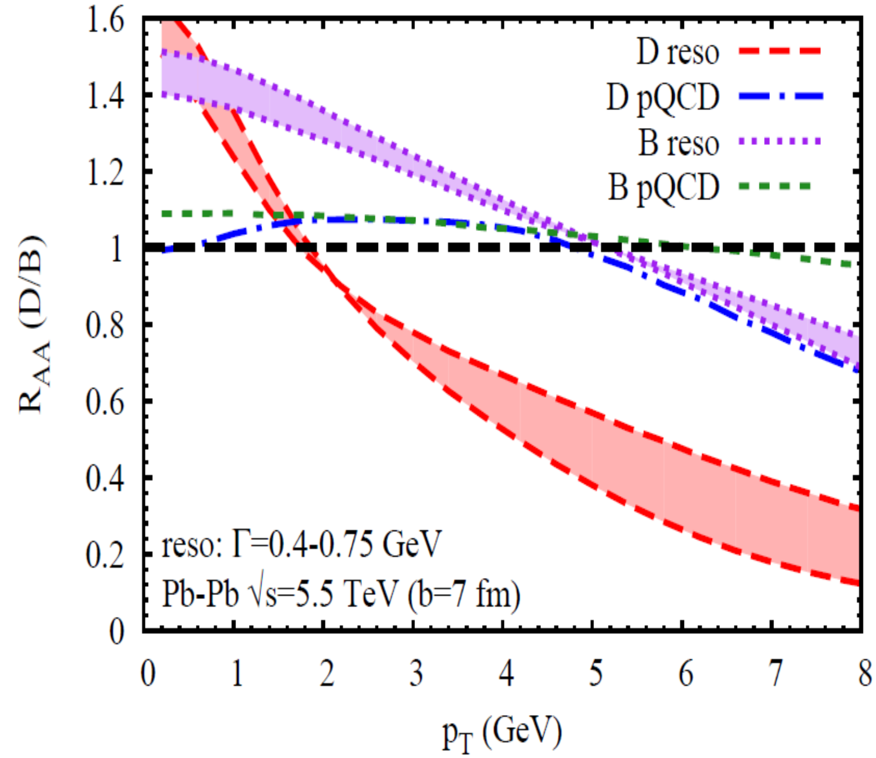
=> measurements of transport properties of the medium

Heavy quarks are excellent probes of QGP:
- Created in initial hard scattering processes
- Interact with the medium $\rightarrow$ carry information about QGP

Can study the medium through R_{AA} (energy loss, mass dependence) or azimuthal anisotropies (v_2) in peripheral collisions (parton-QCD matter interactions and thermalization)

Heavy flavour energy loss





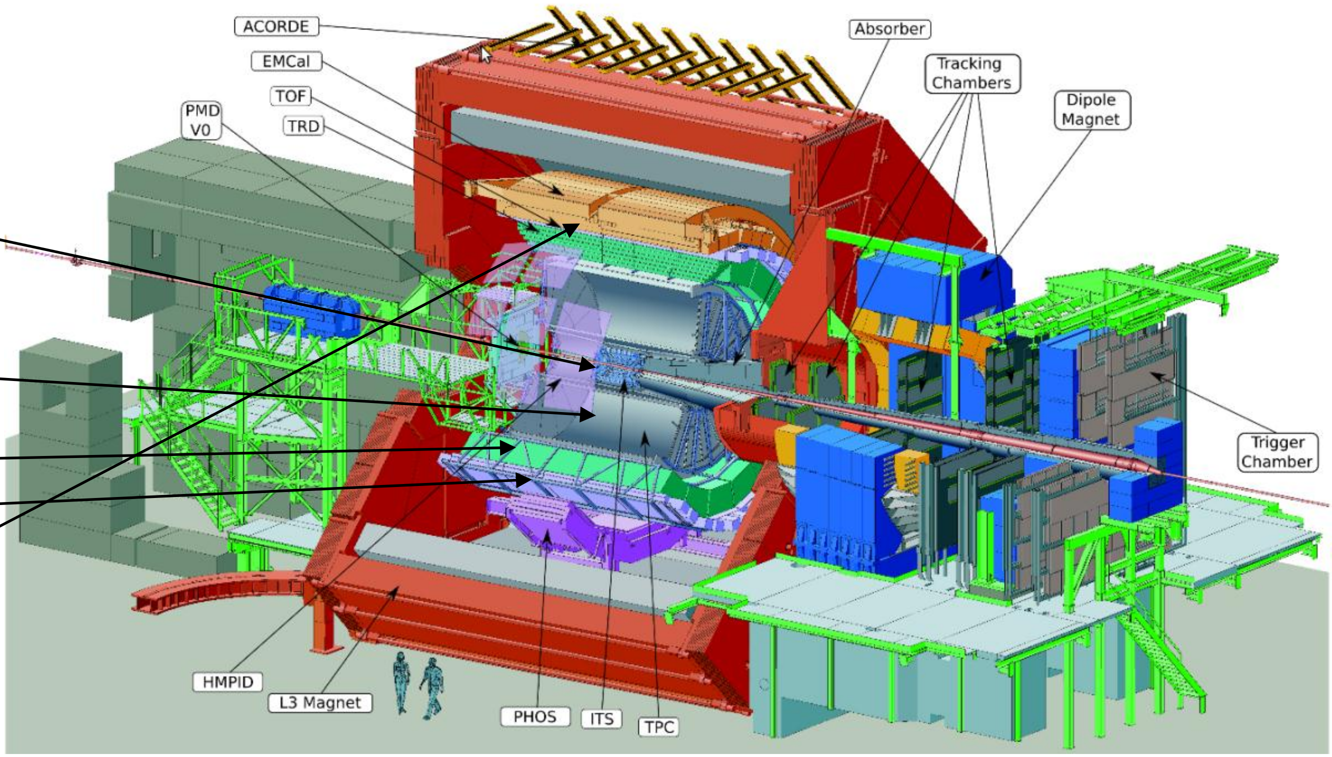
Theoretical prediction : $R_{AA}^{charm} < R_{AA}^{beauty}$

(J.Phys.G35 (2008) 054001)

- Need to separate b and c
- Need pp as baseline measurement for the study of R_{AA}

The ALICE detector

Main detectors used for b-electron analyses are:
Inner Tracking System (ITS)
Time Projection Chamber (TPC)
Transition Radiation Detector (TRD)
Time of Flight (TOF)
Electromagnetic Calorimeter (EMCal)



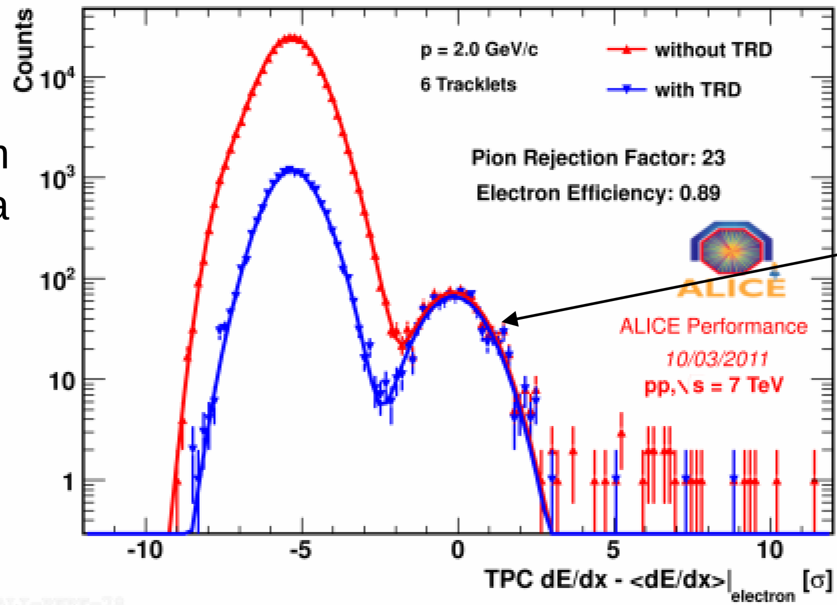
Electron identification capability from 100 MeV/c to 50 GeV/c ($|\eta| < 0.8$)

EMCal extends kinematic reach with trigger capability

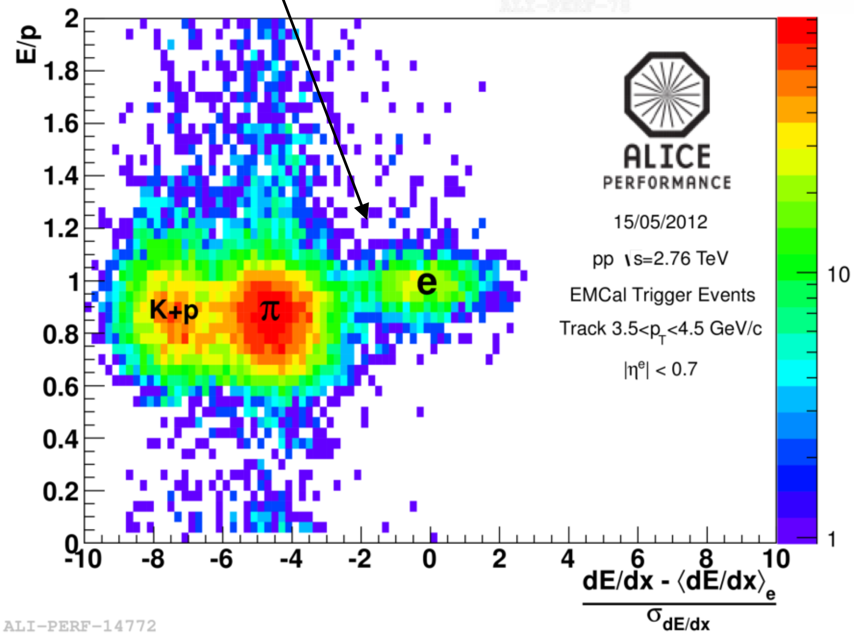
The ITS is a 6-layer silicon detector which provides accurate track reconstruction & vertex resolution

Electron identification in ALICE

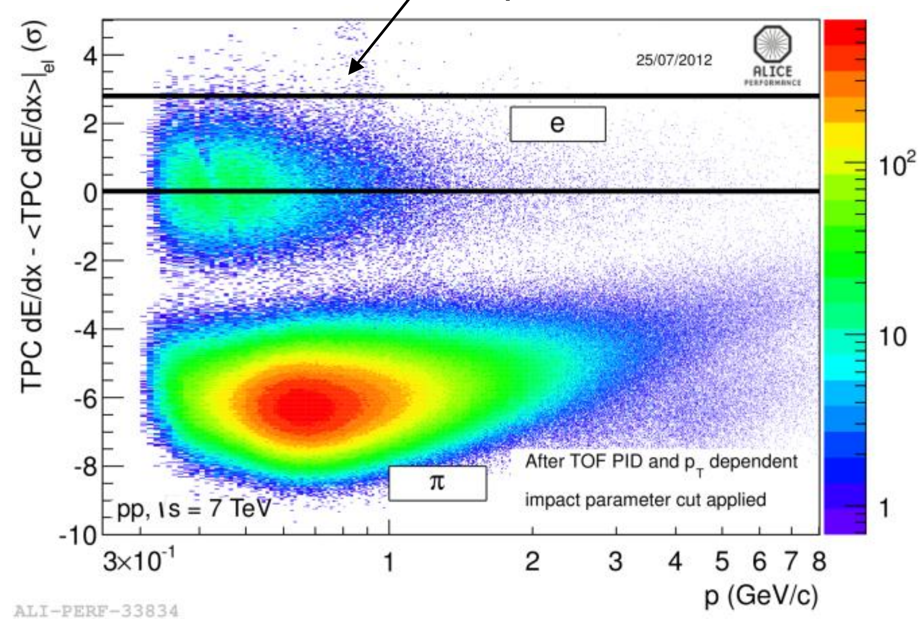
TPC + EMCal provides electron identification from 2 <p_T<15 GeV/c through a combination of track energy loss (TPC dE/dx) and an EMCal cluster energy (E) over track momentum (p) ratio



TRD provides electron identification (rejects pions) 0.5 < p_T < 8.0 GeV/c while keeping 80% electron efficiency

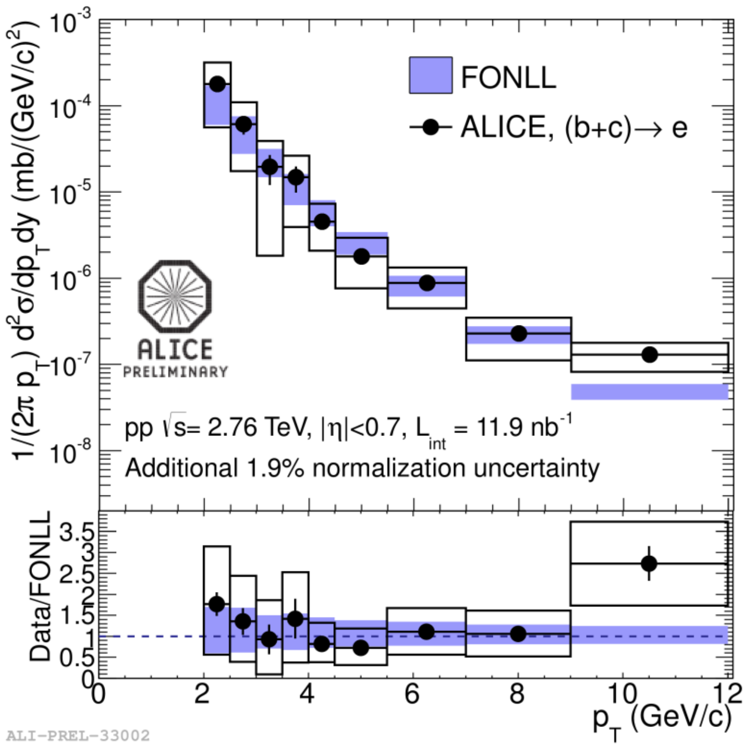


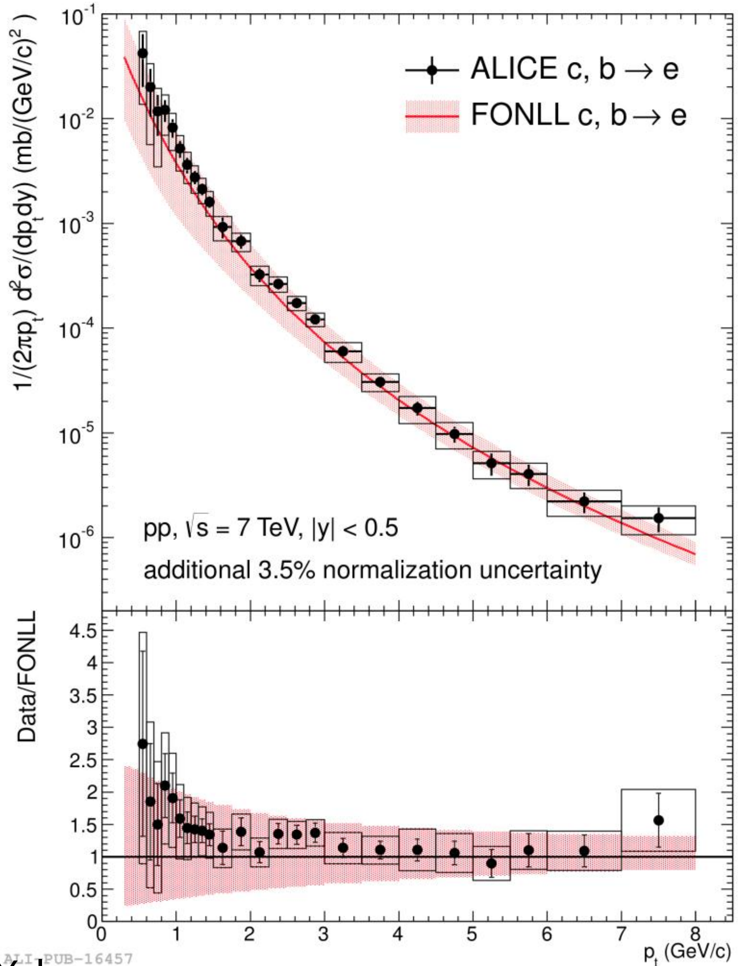
TOF+TPC rejects hadronic contamination (pions) up to 5.0 GeV/c



Heavy flavour electron production cross section in pp collisions at √s = 2.76 and 7 TeV

arXiv : 1205.5423 (accepted by PRD)





- Heavy flavour decay electron (b + c) → e cross section is well described by pQCD FONLL at both energies (see talk by T. Rascanu)
- Need to separate b from c!

Methods to measure b→e in ALICE

- Single displaced electrons: select tracks with large separation from primary vertex ($\sqrt{s}$ = 7 TeV)

Branching Ratios:

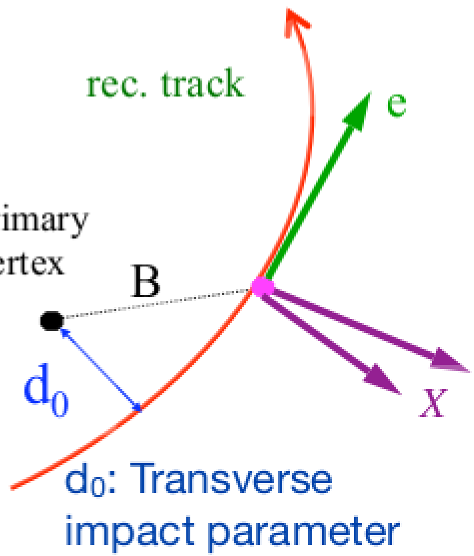
$c \rightarrow e + X$	$\mathcal{O}$ (9.6%)
$b \rightarrow e + X$	$\mathcal{O}$ (11%)
$b \rightarrow c \rightarrow e + X$	$\mathcal{O}$ (10%)

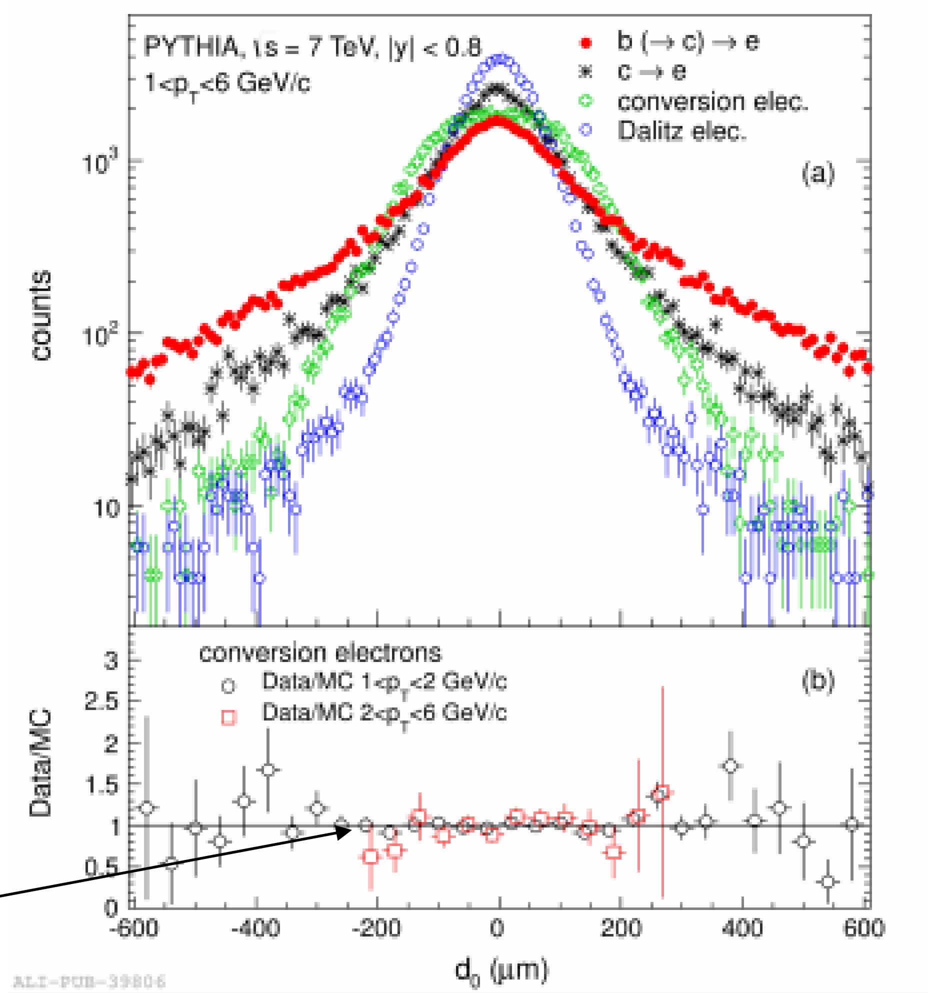
- Secondary vertexing: tagging of b-decay electrons using two-track displaced vertices ($\sqrt{s}$ = 7 TeV)

$c\tau_B \sim 500\ \mu m$

- HFE + electron-hadron (e-h) correlations:
obtain c+b-electron spectrum (heavy flavour electron spectrum, HFE), use e-h correlations to measure b-fraction ($\sqrt{s}$ = 2.76 TeV). See S. LaPointe's talk.

Impact parameter method





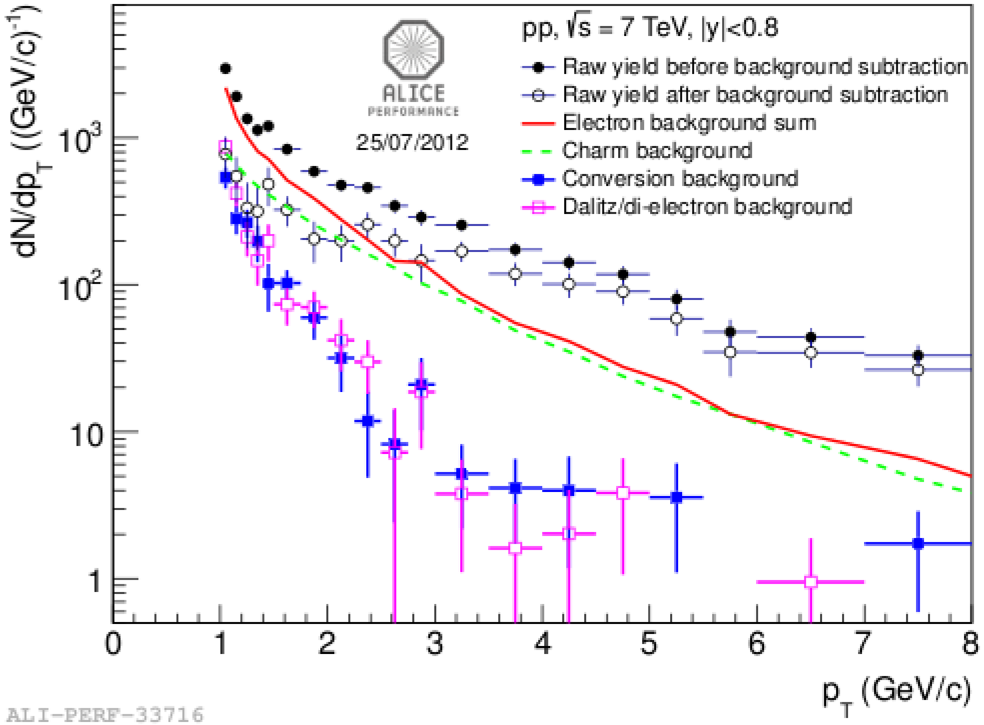
• Preferential selection of electrons from B decay via their large impact parameter (d_0)

• Simulated impact parameter distributions are in good agreement with data

• Subtract remaining background

(arXiv:1208.1902)

Impact parameter method: background subtraction



Backgrounds are estimated by weighting relevant electron source yields in PYTHIA to match the measured ones

• Electrons from charm hadron decays via ALICE measured D meson cross section (JHEP 01 (2012) 128)

• Electrons from Dalitz/di-electron decays and γ-conversions through ALICE measured π^0/η spectra (Phys. Lett. B 717 (2012) 162)

Impact parameter method: results

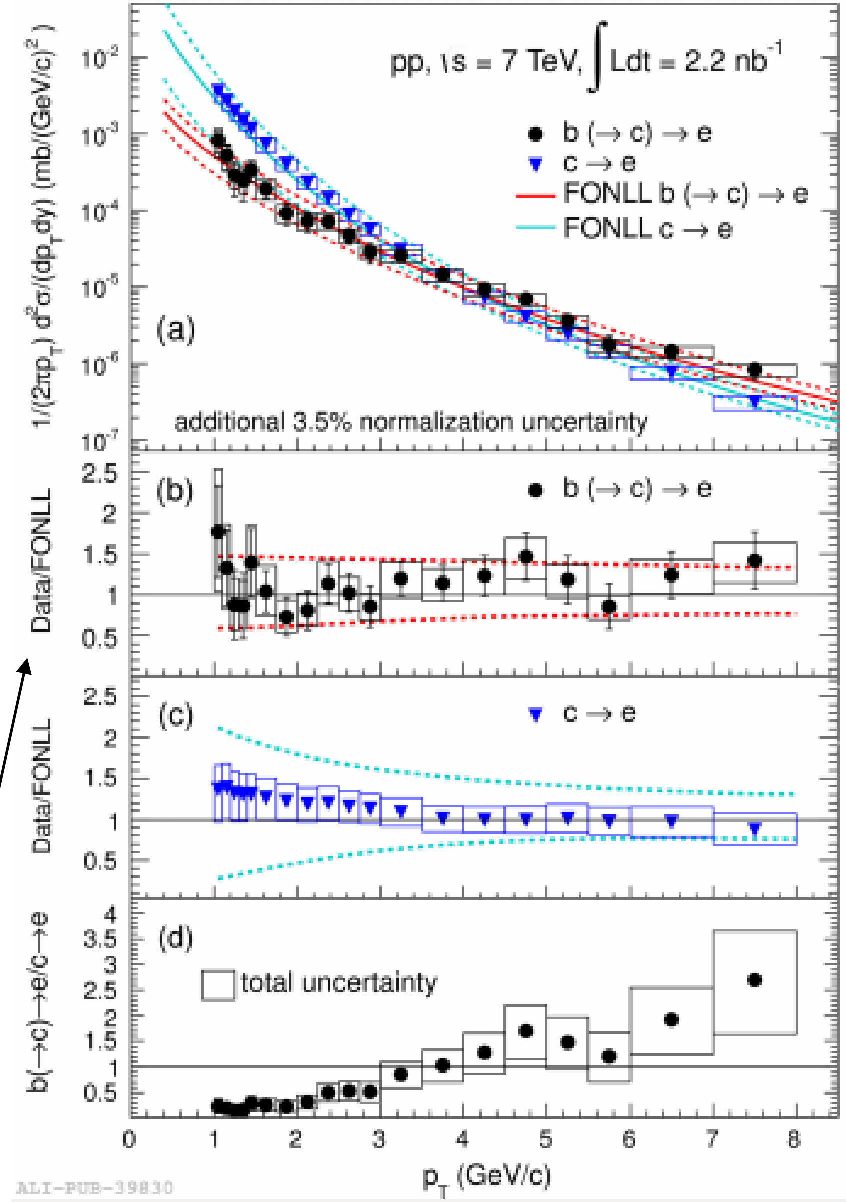
$$\frac{1}{2\pi p_{\mathrm{T}}}\frac{d^2\sigma}{dp_{\mathrm{T}}dy} = \frac{1}{2\pi p_{\mathrm{T}}^{\mathrm{c}}}\frac{N_e(p_{\mathrm{T}})}{\Delta y \Delta p_{\mathrm{T}}}\frac{1}{\varepsilon}\frac{\sigma_{\mathrm{MB}}}{N_{\mathrm{MB}}}$$

To get final cross section, scale with minimum bias cross section σ_{MB} and number of events (N_{MB}).

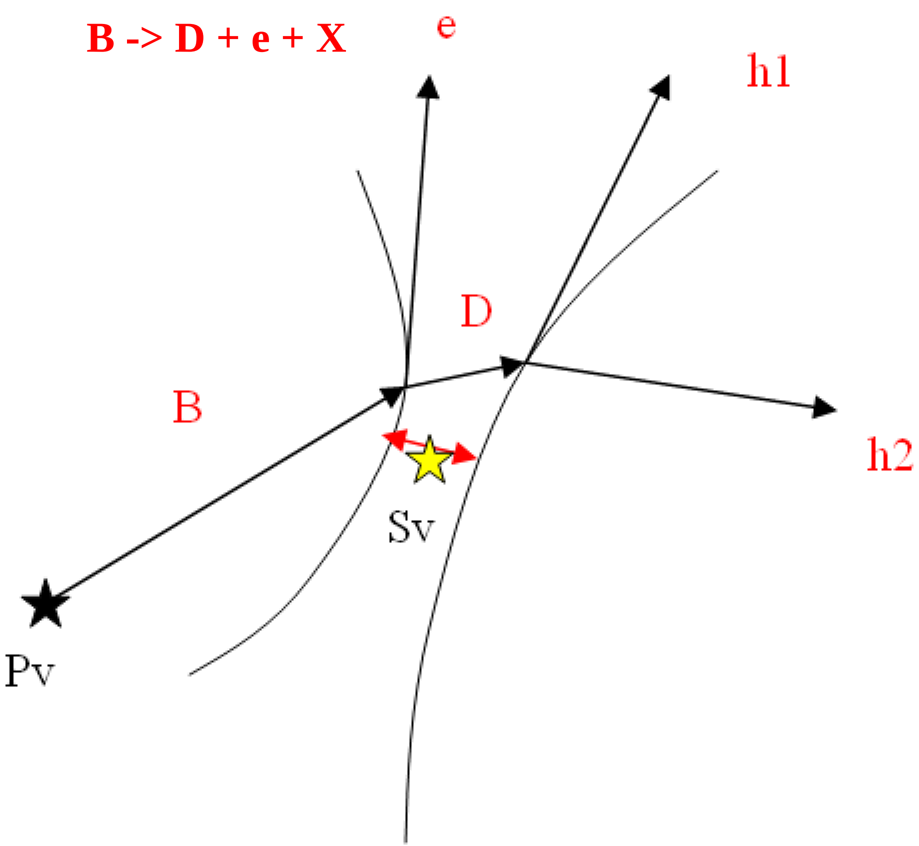
ε = efficiency of geometrical acceptance, track reconstruction and the d_0 cut.

Results from the 2010 7 TeV pp data, L_{int}= 2.2 nb^{-1}, see arXiv:1208:1902

Described well by pQCD FONLL calculations (JHEP 9805 (1998) 007)



B-tagging – Secondary vertex method

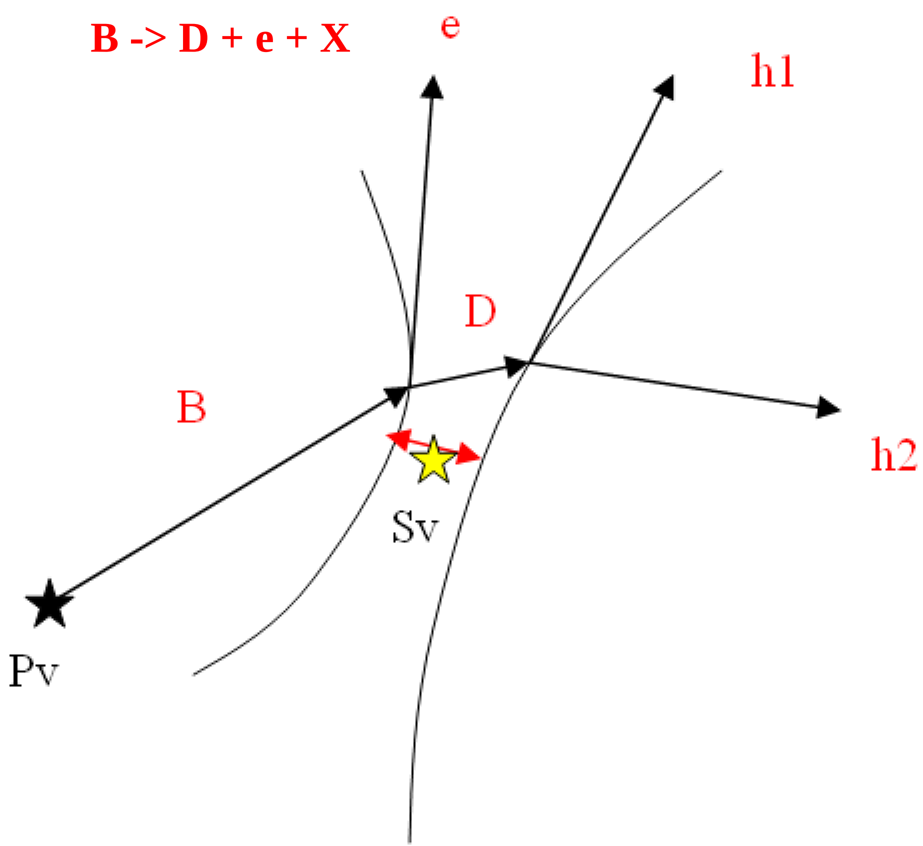


- Exploit large cτ of B decay (~0.5 mm)

- Use electron candidate track as seed

- Identify secondary vertex: identify if other tracks originate from “close to electron track” (with certain criteria)

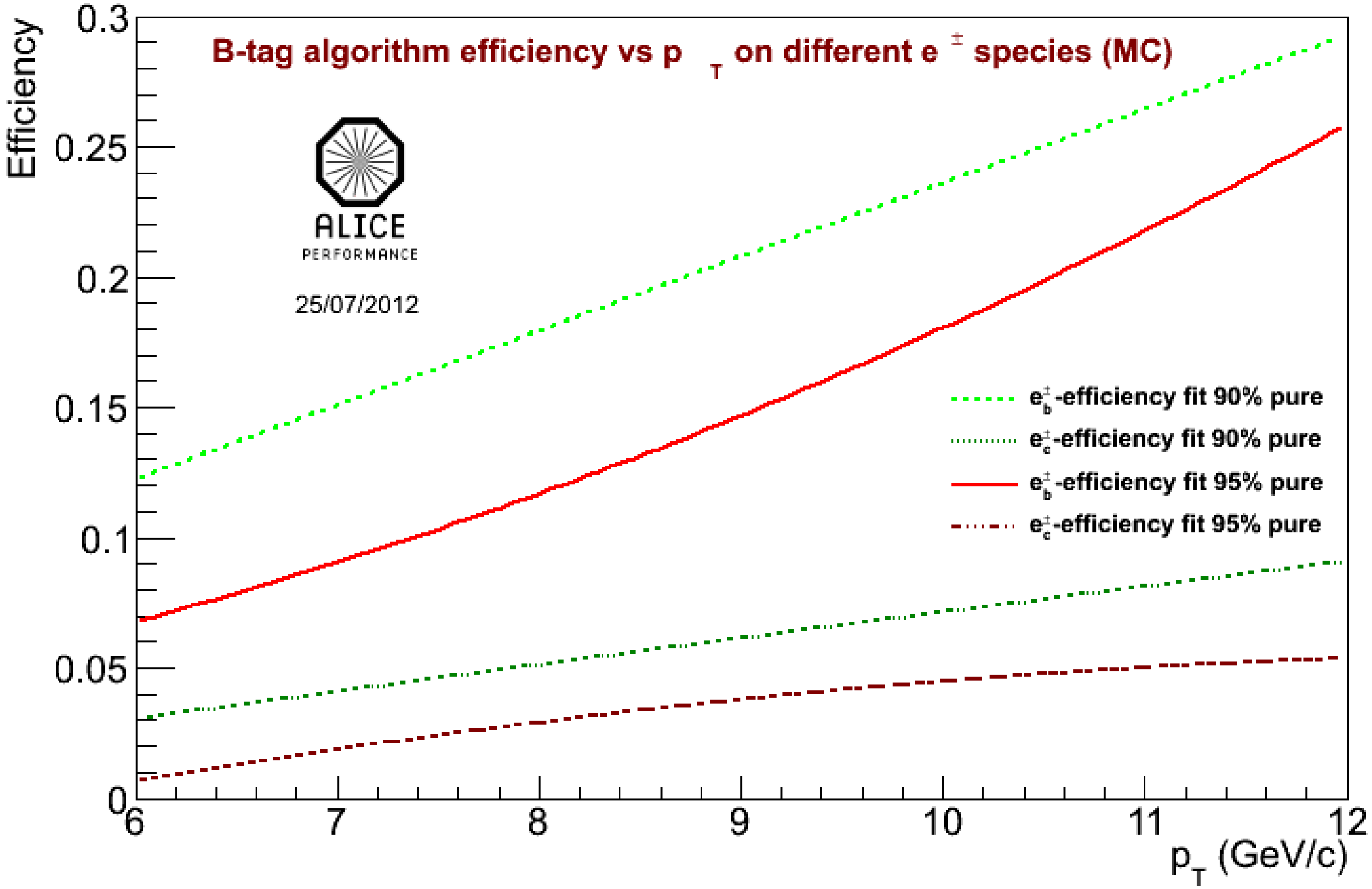
B-tagging – Secondary vertex method



Selections applied on electron-hadron secondary vertices:

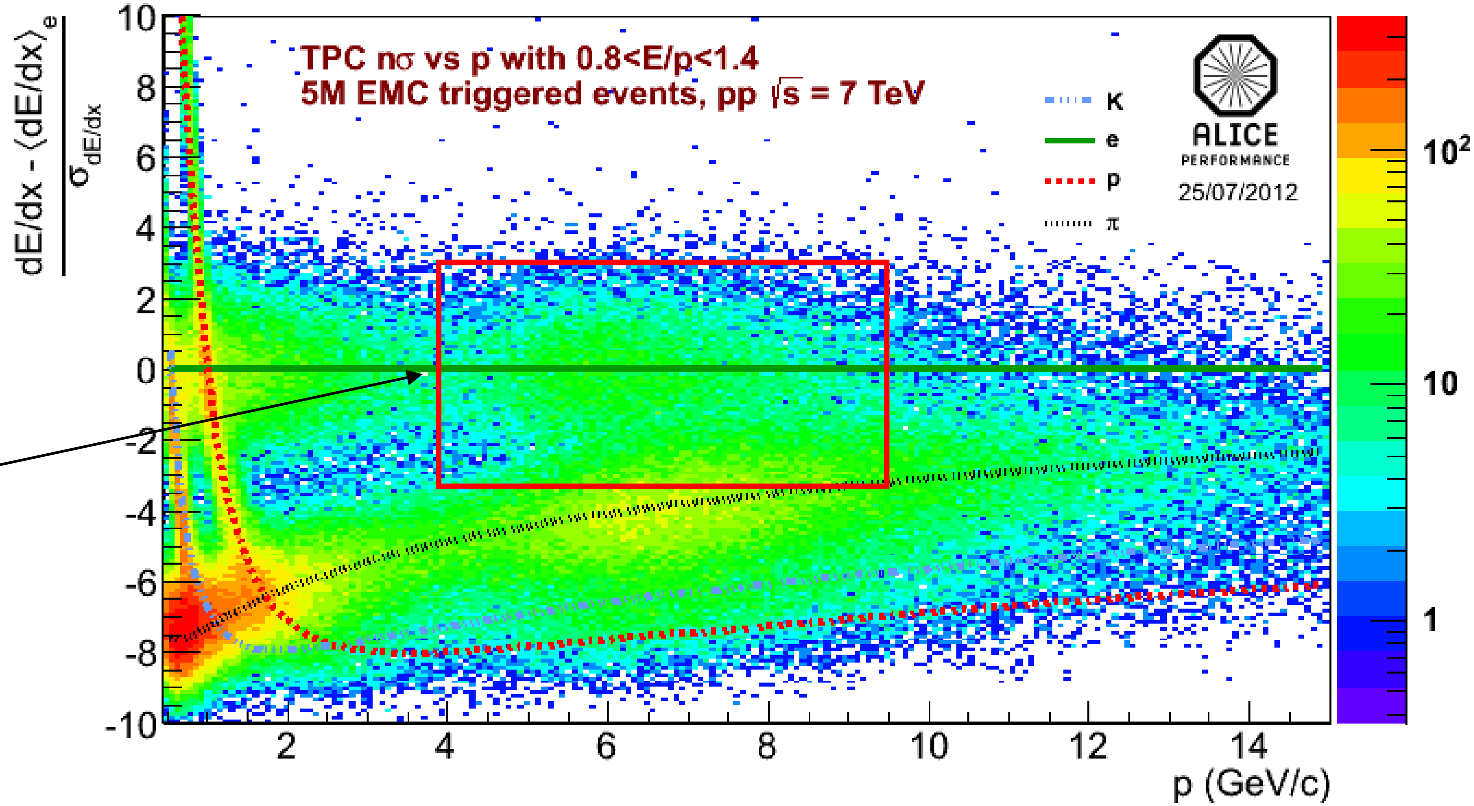
- Cone radius : hadron should be in a certain cone size from e^-
- Pair DCA : close enough to electron candidate
- SignDCA : secondary vertex has a certain “sign distance” from the primary vertex
- Invariant mass : B mass larger than background mass (D, π^0 etc)

B-tagging performance



- Efficiencies on different electron sources have been studied through simulations
- Shown here are the tagging efficiencies of beauty and charm electrons for two different cuts
- Can tune cuts for higher efficiency or better purity

2011 EMCal triggered data



High p_T electrons enhanced by trigger

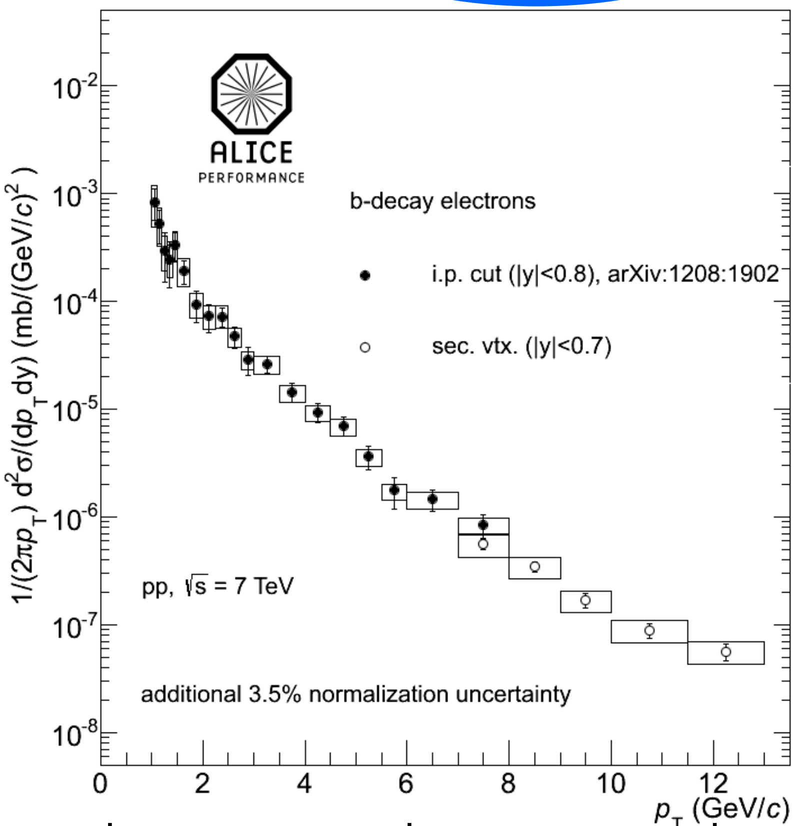
- 2011 data taking introduced triggering by calorimeters, (L_{int}~ 210 nb^{-1}). EMCal $|\eta|<0.7$ and ~ 100° in azimuth (φ)
- Analyzed 5 M EMCal triggered events, with trigger threshold at 4.8 GeV
- Extend high-p_T reach for electrons

B-tagging corrections

$$\frac{1}{2\pi p_T}\frac{d^2\sigma_{b\rightarrow e^\pm}}{dp_T dy} = \frac{1}{2\pi p_T}\frac{1}{N\Delta p_T \Delta y}\frac{1}{\epsilon}\left[\frac{\rho_h N_{b-tags}}{\epsilon_{b-tag}}\right]\sigma_{MB-pp} - \frac{\epsilon_{c-tag}}{\epsilon_{b-tag}}\frac{1}{2\pi p_T}\frac{d^2\sigma_{charm}}{dp_T dy}$$

B-tagged sample consists mainly of b-electrons, but need to correct for hadronic and charm contamination

•Hadrons can be removed through data-driven measurement techniques (hadron versus electron purity, ρ_h)
•Charm background is estimated via a mis-tagging efficiency and a charm electron cross section (FONLL, JHEP 9805 (1998) 007) and subtracted
•Other sources contribute only a few percent (relatively small mis-tagging efficiency in simulations)



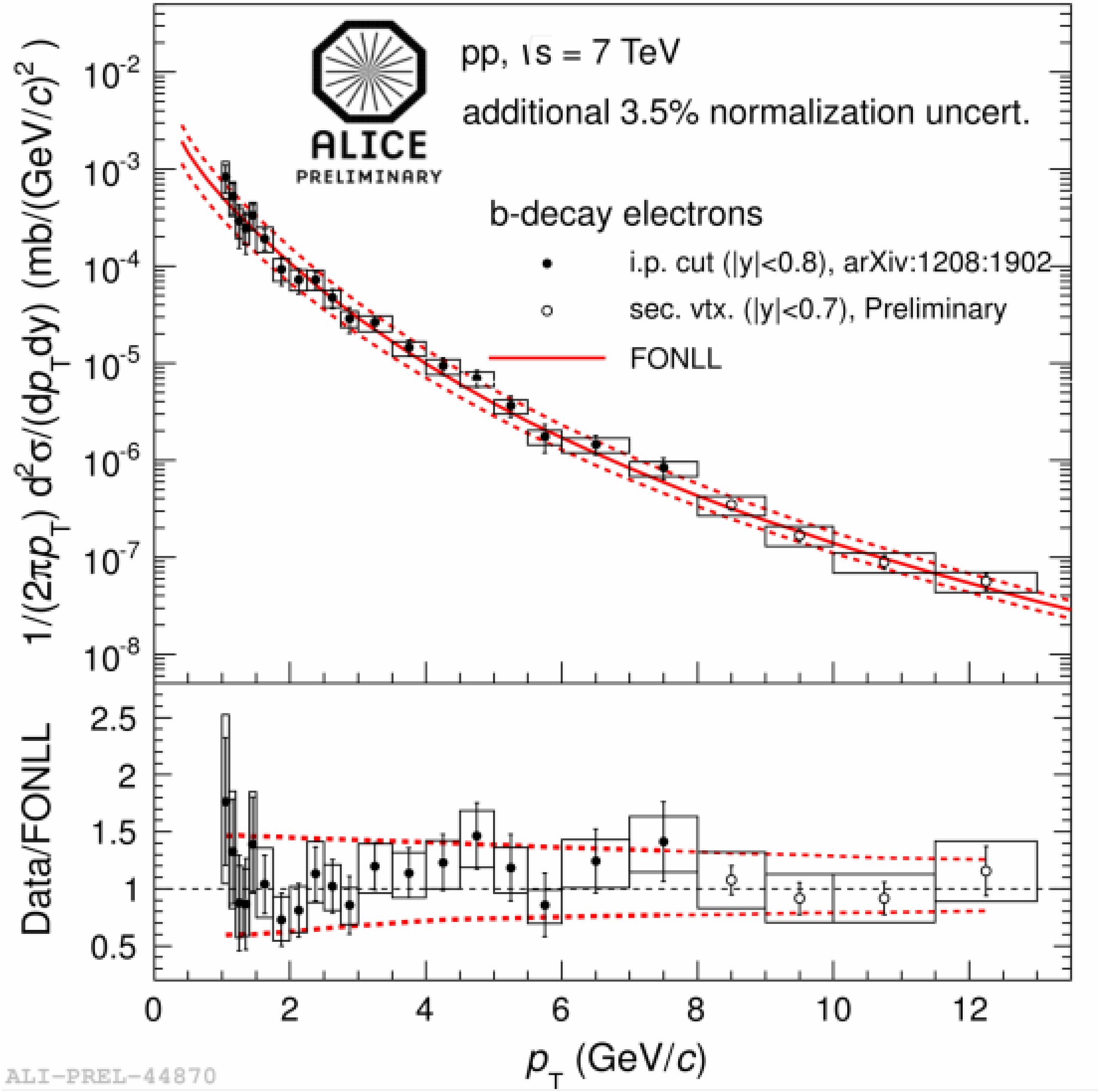
b→e cross section as measured from EMCal triggered pp data at √s = 7 TeV (7-13 GeV/c data points from b-tagging)

I.P cut + B-tagging combined cross section in pp at 7 TeV

Combined cross section at 7 TeV pp, as measured by ALICE

Well described by FONLL calculation (JHEP 9805 (1998) 007)

Serves as a baseline for Pb-Pb measurements (scale to 2.76 TeV; statistics are better than for 2.76 TeV pp data)



Summary/Future outlook

- ALICE detectors provide for excellent vertex reconstruction and electron identification. This makes it possible to measure beauty production via electrons from hadron decays, thus separating charm and beauty.

- In 2.76 (see S. LaPointe's talk) and 7 TeV pp the b->e cross section is measured with different detectors and methods, and is well described by pQCD calculations (FONLL)

- The next step is to look at beauty production in Pb-Pb data to measure the nuclear modification factor.