Study of the production of B mesons in pp and Pb-Pb collisions using displaced electrons in ALICE

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Heavy Quark Energy Loss in Medium

Radiative energy loss via gluon radiation

Color charge dependence of energy loss

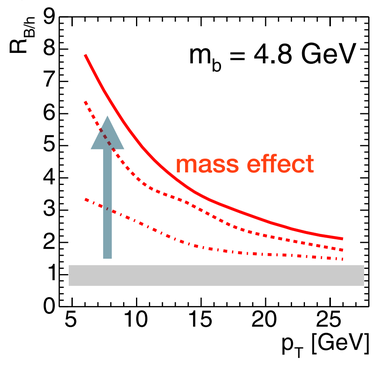
Dead Cone Effect

- In vacuum, gluon radiation is suppressed at angles smaller than M_Q/E_Q (ratio of the quark mass to its energy)
- In medium, this implies lower energy loss for massive partons Dokshitzer and Kharzeev, PLB 519 (2001) 199

$$R_{AA}^{\pi} < R_{AA}^{D} < R_{AA}^{B}$$

$$R_{AA}(p_T) = \frac{1}{< T_{AA} >} \times \frac{dN_{AA}/dp_T}{d\sigma_{pp}/dp_T}$$

$R_{B/h}$: R^{B}_{AA}/R^{h}_{AA}
(ratio of nuclear modification factors)



Armesto, Dainese, Salgado, Wiedemann, PRD 71 (2005) 054027

Elastic energy loss is not negligible?
Simon Wicks, William Horowitz, Magdalena Djordjevic, Miklos Gyulassy, Nucl.Phys.A784 (2007) 426-442

Collisional dissociation probability of heavy mesons in the QGP?
I Vitev, A Adil and H van Hees, J. Phys. G: Nucl. Part. Phys. 34 (2007) 769–773

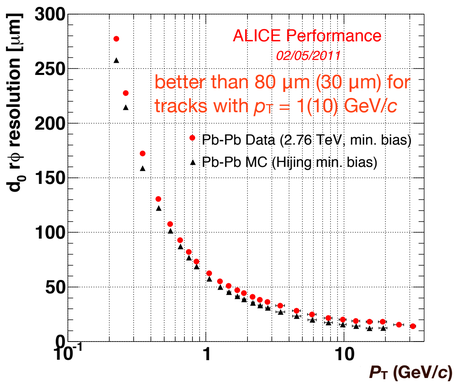
Baryon enhencement?
Sorensen, Dong, PRC 74 (2006) 024902

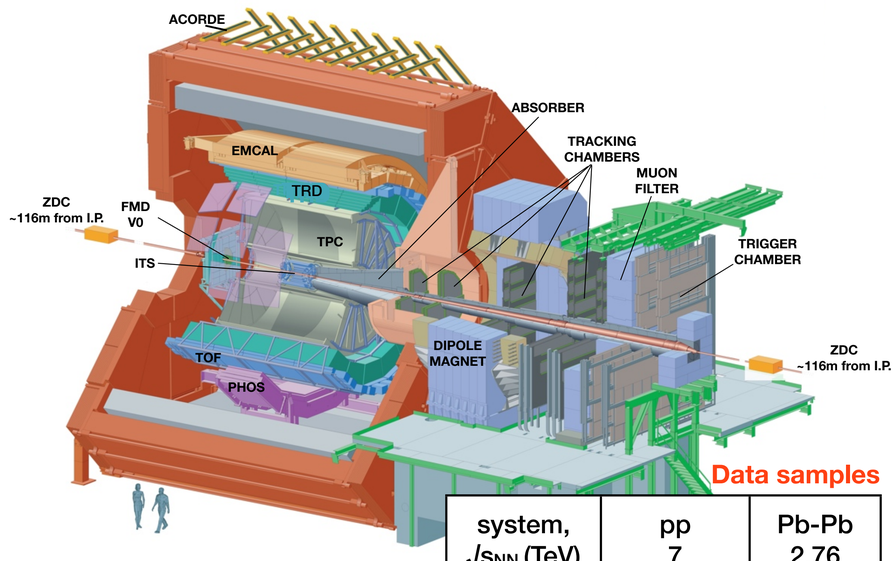
Proton-proton collisions: provide important test of pQCD in a new energy domain and heavy ion reference

Electron Analysis in A Large Ion Collider Experiment

Electron identification capability
from ~100 MeV/*c* to above 50 GeV/*c* at mid rapidity (|η|<0.8)

Inner Tracking System
Time Projection Chamber
Transition Radiation Detector
Time Of Flight
ElectroMagnetic Calorimeter





impact parameter d_0 resolution
(**ITS** with 6 Si layers)

Data samples

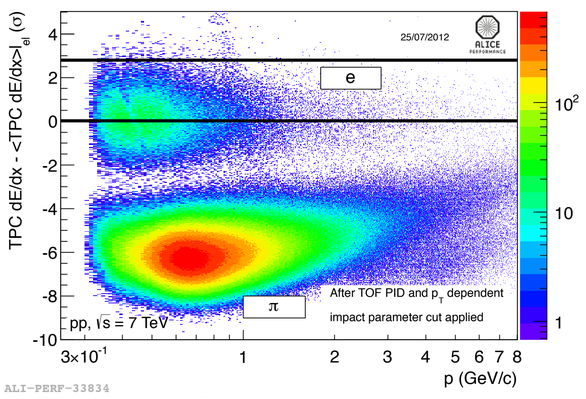
system, $\sqrt{s_{NN}}$ (TeV)	pp 7	Pb-Pb 2.76
when	2010	2010
N_{events}(MB)	180 x 10^6	17 x 10^6

Analysis Method: Beauty Measurement via Impact Parameter

Analysis approach is based on:

- High rate of electron production via semi-leptonic decay (~11%[b→e] + ~10%[b→c→e])
- Beauty hadron has cτ ≃ 500 μm and a hard momentum spectrum, which leads to larger impact parameter of decay electrons than those from backgrounds

Electron identification

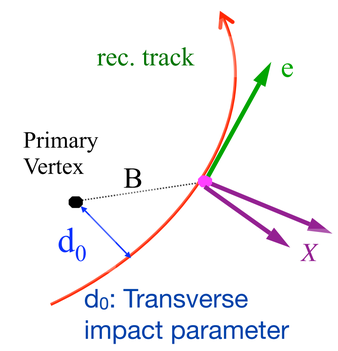


- **Time Of Flight:** Kaon & Proton Rejection with time of flight for electron hypothesis (3 σ from the expectation)
- Cut on minimum impact parameter d_0 (defined on the right) removes hadrons originating from primary vertices

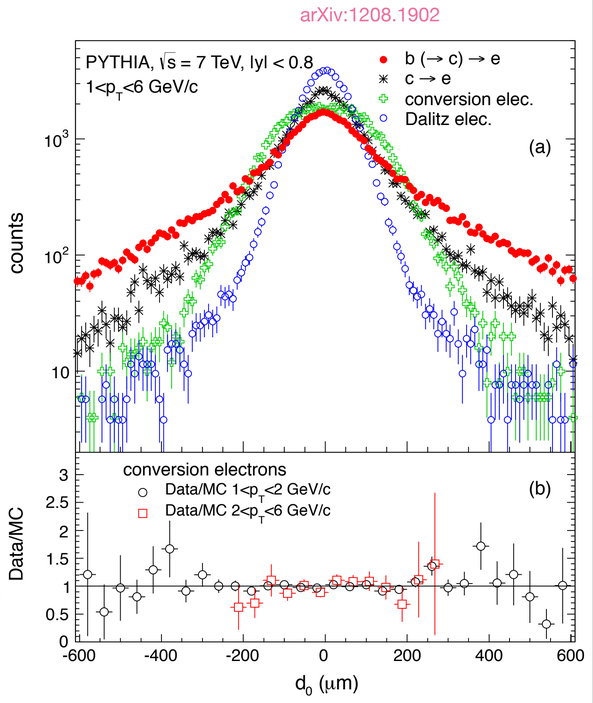
- **Time Projection Chamber:** Further hadron rejection (select tracks in the upper half of the electron Bethe-Bloch band (0-3σ))

Resulting hadron contamination at p = 8 GeV/c ~ 3 %

Impact parameter



arXiv:1208.1902



- Electron tracks from semi-leptonic beauty hadron decays feature a broader d_0 distribution compared to that from background
- Ratios of the measured d_0 distribution of conversion electrons to the one from simulation show good agreement

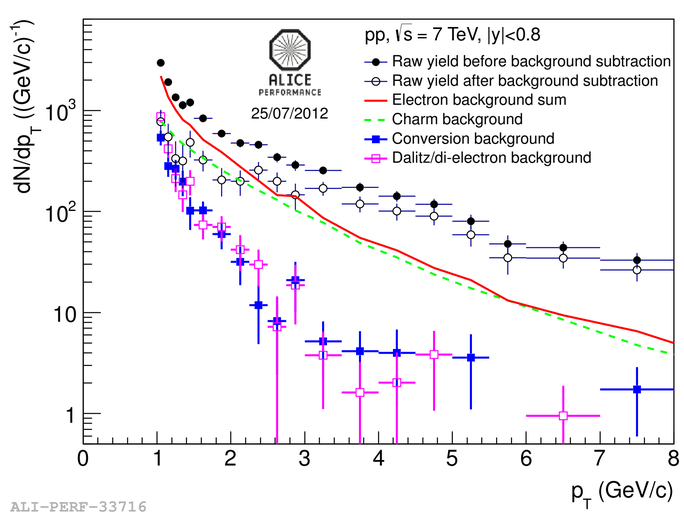
Minimum Impact parameter cut ($|d_0|>64+780\times\exp(-0.56p_T)$ (d_0 in μm, p_T in GeV/*c*)) is applied to reject misidentified $\pi^{\pm}$, $e^{\pm}$ from Dalitz decays, γ conversions and charm meson decays

note: d_0 cut was optimized to maximize *S/B* based on simulation

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 via ALICE measured π^0/η meson cross section arXiv:1205.5724



Signal and background yields after impact parameter cut.
At p_T = 1 GeV/*c*, *S/B* ~ 1/3, at p_T = 8 GeV/*c*, *S/B* ~ 5

Results in pp

Correction

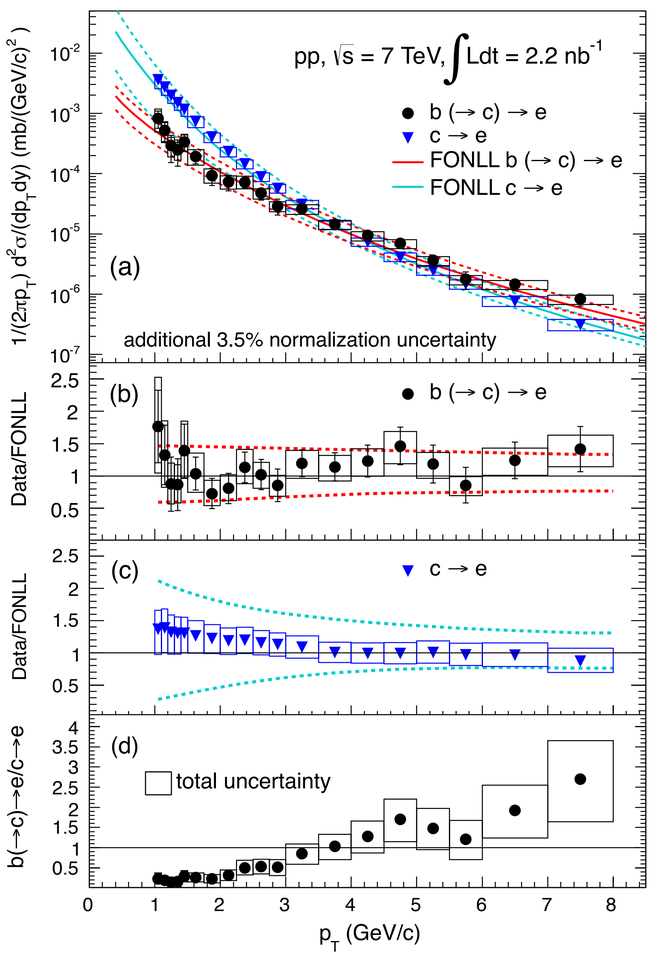
$$\frac{1}{2\pi p_T}\frac{d^2\sigma}{dp_T dy} = \frac{1}{2\pi p_T^c}\frac{N_e(p_T)}{\Delta y \Delta p_T}\frac{1}{\varepsilon}\frac{\sigma_{MB}}{N_{MB}}$$

Electron yield from beauty hadron decays ($N_e(p_T)$) was corrected for efficiency (ε) and number of minimum bias pp collisions (N_{MB}) and cross section (σ_{MB}).
(ε = geometrical acceptance × track reconstruction efficiency × electron identification efficiency × efficiency of the d_0 cut)

Systematic uncertainties are detailed in arXiv:

p_T-differential invariant cross section

arXiv:1208.1902



(a) p_T-differential invariant cross sections of electrons from beauty and charm hadron decays. The curves indicate the corresponding FONLL* predictions.
Ratios of the data and the FONLL calculations are shown in (b) and (c) for electrons from beauty and charm hadron decays, respectively, where the bands indicate the FONLL uncertainties.
(d) Measured ratio of electrons from beauty and charm hadron decays.
Over the explored p_t range the FONLL predictions are in good agreement with the data.

note: for charm decays, p_T-differential invariant cross section was calculated for charm hadrons as measured with ALICE JHEP 01 (2012) 128

* : Cacciari, Greco, Nason, JHEP05(1998)007 and M. Cacciari private communication

Total cross section

arXiv:1208.1902

Total cross section determined by extrapolation procedure based on FONLL:

$$\sigma_{b\bar{b}} = 280 \pm 23(stat)^{+81}_{-79}(sys)^{+7}_{-8}(extr) \pm 10(BR)\ \mu b$$

Weighted average with the result of a previous measurement based on *J*/ψ mesons from beauty hadron decay: arXiv:1205.5880

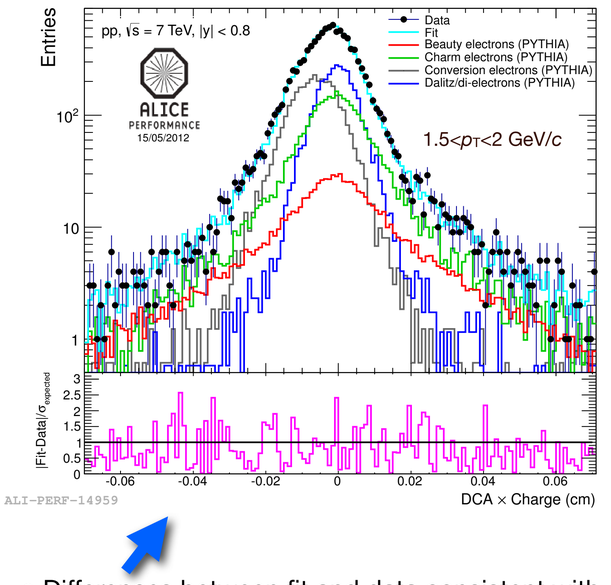
$$\sigma_{b\bar{b}} = 262 \pm 34(stat)^{+48}_{-49}(sys) \pm 7(extr)\ \mu b$$

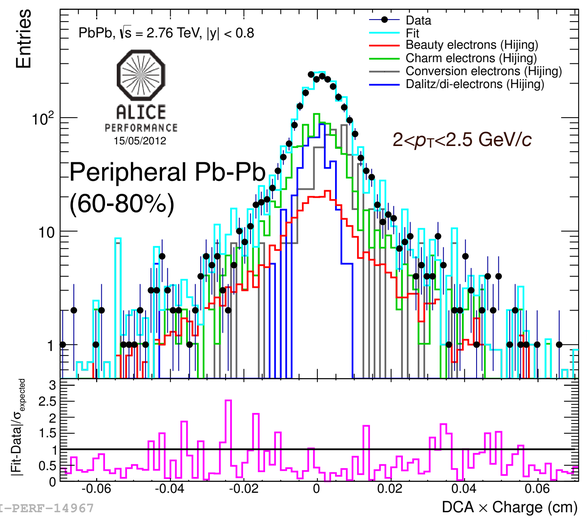
FONLL prediction $\sigma_{b\bar{b}} = 259^{+120}_{-96}\ \mu b$ is consistent within uncertainties with our measurement.

Outlook: Analysis on Pb-Pb Data

Two complementary approaches ongoing
- Impact parameter ($d_0(r\varphi)$) cut, as shown for pp
- Impact parameter fit with Monte Carlo templates

Fitting procedure
- Global fit of the inclusive electron distribution
- Distributions of individual sources taken from Monte Carlo (PYTHIA+GEANT3)
- Modified χ^2 method to take into account Poissonian fluctuations in templates as well as in data





- Differences between fit and data consistent with statistical variations
- In pp collisions, cross section of electrons from beauty hadron decays obtained via fit is consistent with result from cut method

- Peripheral Pb-Pb data described by fit within statistical variation
- Pb-Pb fits suffer from lower MC statistics
- Higher statistics being analyzed for both peripheral and central collisions

Summary and Outlook

- The ALICE electron identification and vertexing capability allow one to measure charm and beauty production via electrons from heavy flavour hadron decays.
- In √s = 7 TeV pp data, electron transverse momentum spectrum from charm and beauty hadron decays has been measured and is well described by pQCD calculations
- The analysis to study the suppression of beauty hadrons via decay electrons in Pb-Pb collisions is ongoing, so STAY TUNED!

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