Study of nuclear modification factor of the beauty decay electrons in Pb-Pb collisions in ALICE

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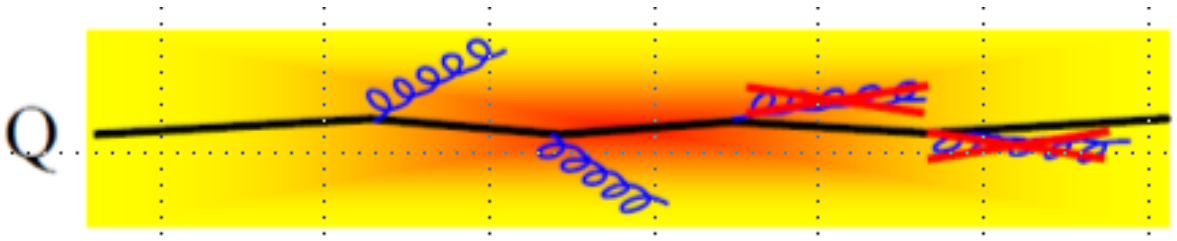
Heavy Quark Energy Loss in Medium

Dead Cone Effect

In vacuum, suppression of the small-angle gluon radiation for heavy quark



✓ Gluonsstrahlung Probability

$$\propto \frac{1}{[\theta^2 + (\frac{M}{E})^2]^2}$$

In medium, dead cone implies lower energy loss for heavy quark

Color Charge Dependence of Energy Loss

Gluon radiation spectrum by the parton propagation in the medium

$$\omega \frac{dI}{d\omega} \propto \alpha_s C_R f(\omega)$$

$$where \quad C_R = 3 \ for\ g, \ \frac{4}{3} \ for\ q$$

Nuclear Modification Factor (R_{AA})

$$R_{AA}(p_T) = \frac{1}{\langle N_{coll} \rangle} \frac{dN_{AA}/dp_T}{dN_{pp}/dp_T}$$

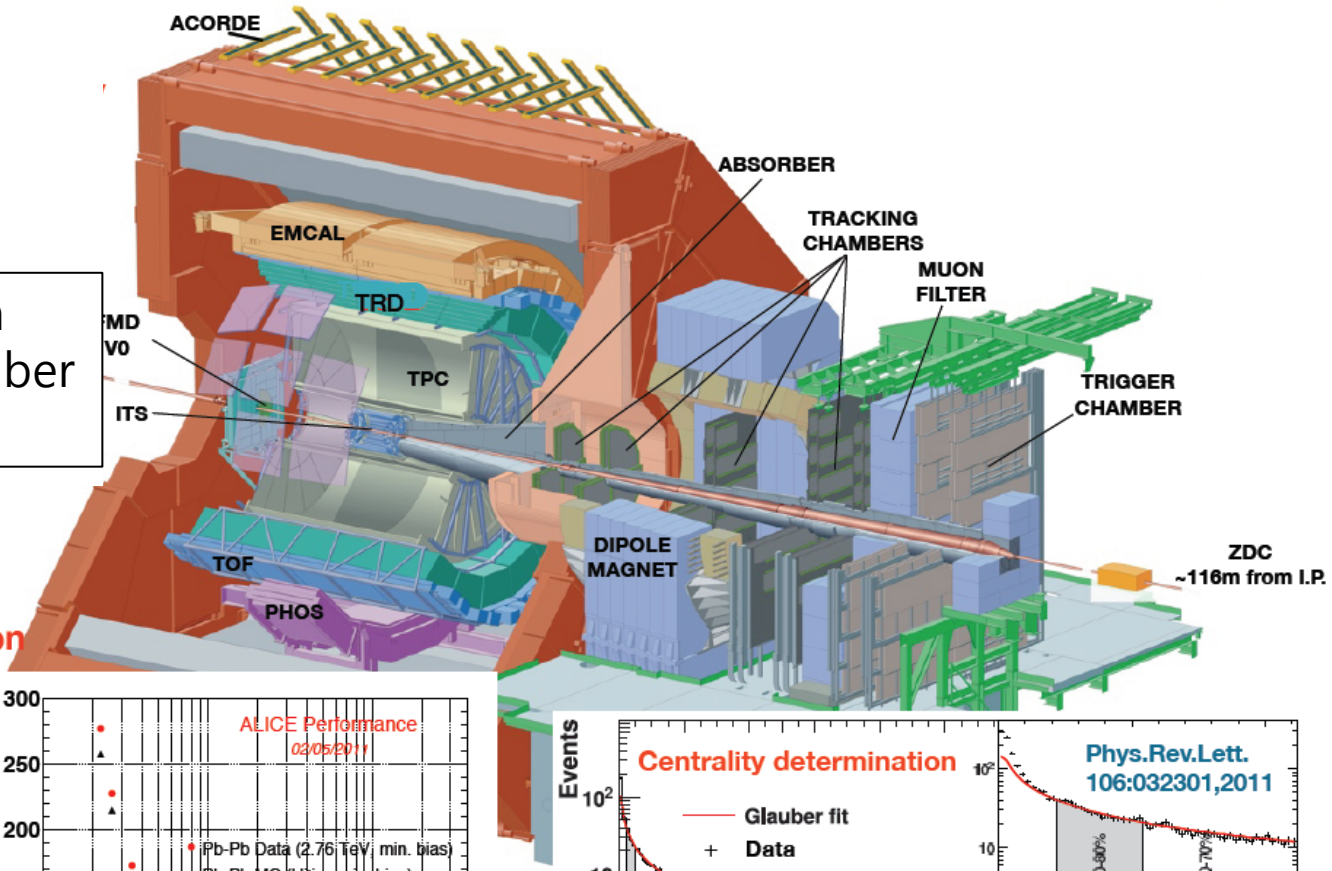
$$R_{AA}^{\pi} < R_{AA}^{D} < R_{AA}^{B}$$

↑ Mass effect

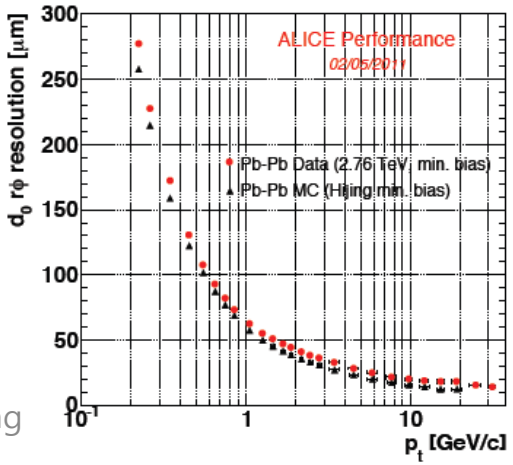
Pions mainly come from gluon

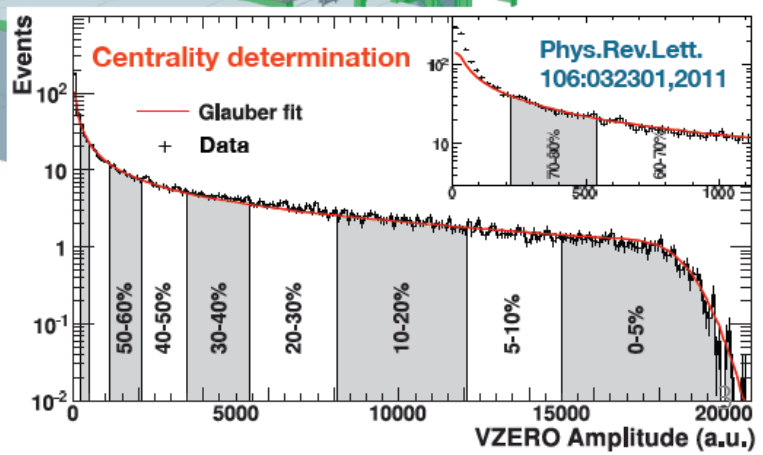
Electron Analysis in ALICE

Inner **T**racking **S**ystem
Time **P**rojection **C**hamber
Time **O**f **F**light



Excellent vertex resolution



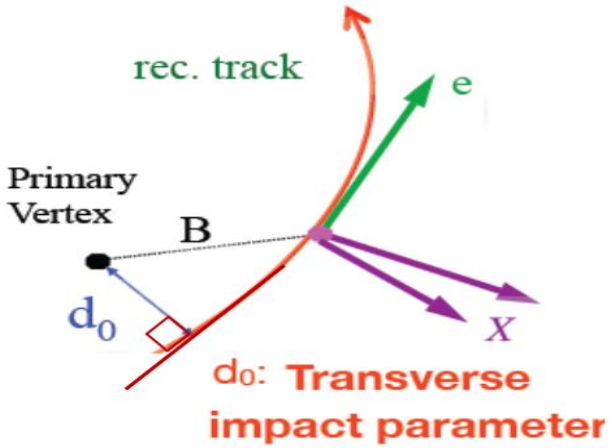


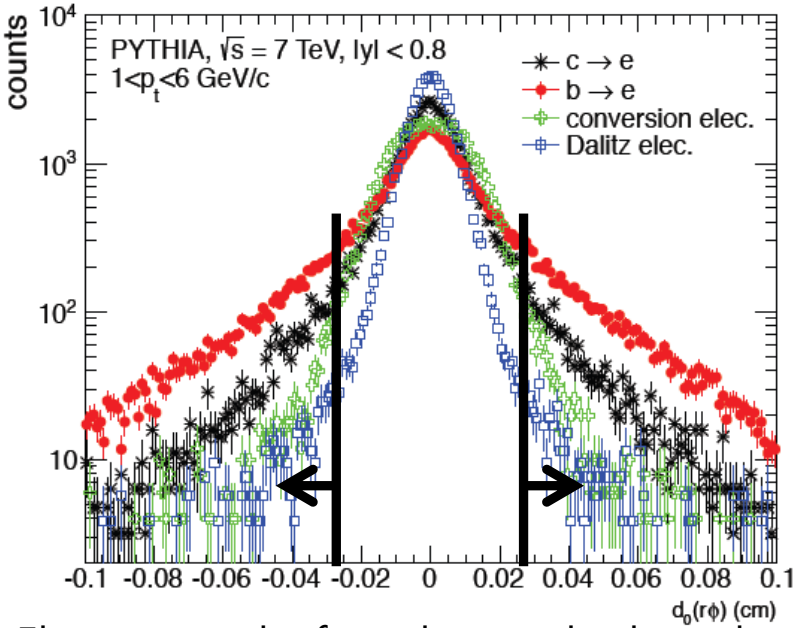
Analysis Approach for Electron from B Hadron Decay

-Branching ratios of semileptonic decays of beauty hadron:

- ✓ b→e+X(~11%)
- ✓ b→c→e+X(~10%)

-Beauty hadron has cτ ≃ 500 μm and hard momentum spectrum, which leads to **larger impact parameter** of decay electrons than those from background





-Electron tracks from beauty hadron decays features **broader IP distribution** compared to that from background

Apply **IP cut → Increasing S/B**

Then Subtract remaining backgrounds:

Charm/Light meson decay electrons

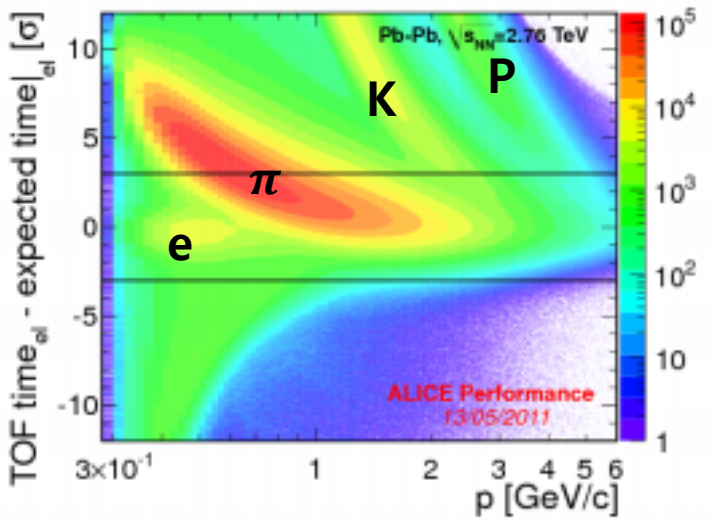
Electron Identification : TOF+TPC

- **TOF(Time Of Flight) PID :**

-With a 3σ electron hypothesis compatibility cut:

✓ Reject kaons for p<1.5 GeV/c

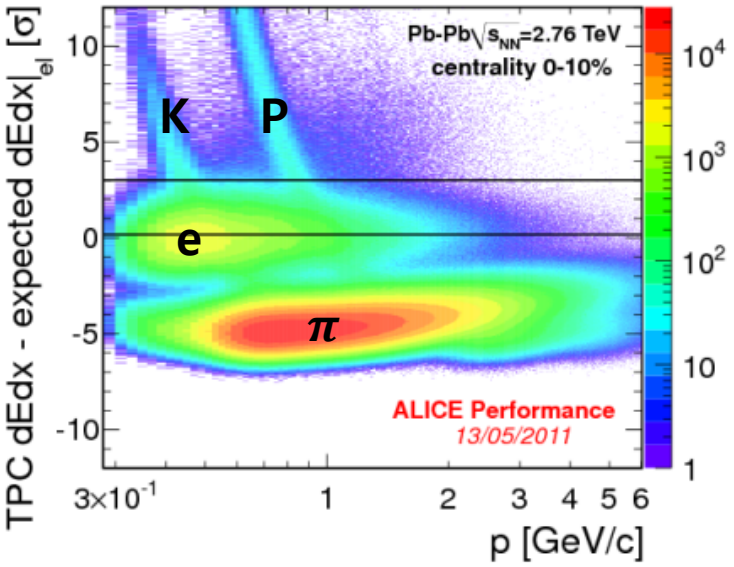
✓ Reject protons for p<3 GeV/c



- **TPC(Time Projection Chamber) PID :**

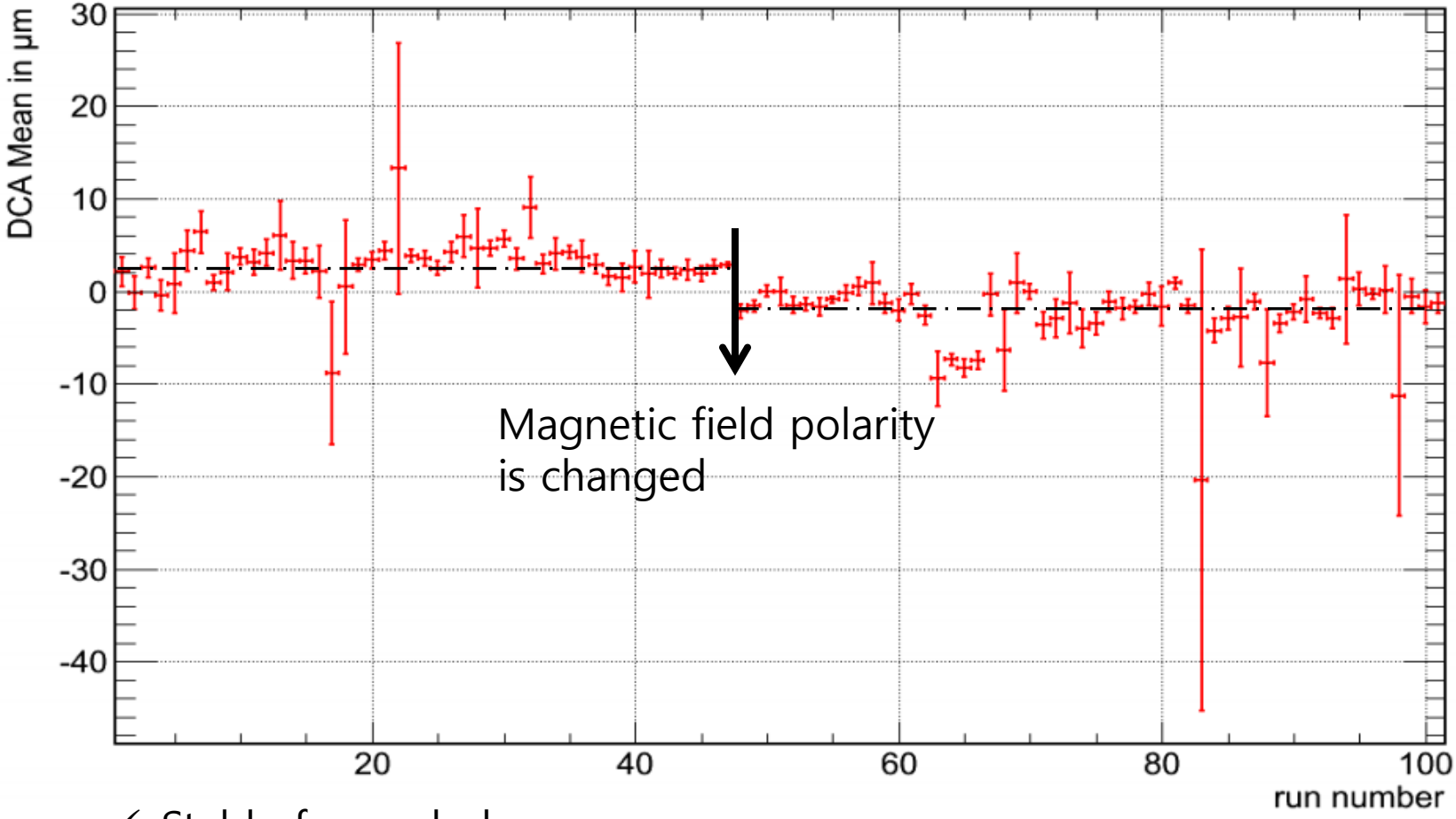
-Upper cut: ≤ 3σ

-Lower cut: mean position of the electron contribution



IP Quality Assurance

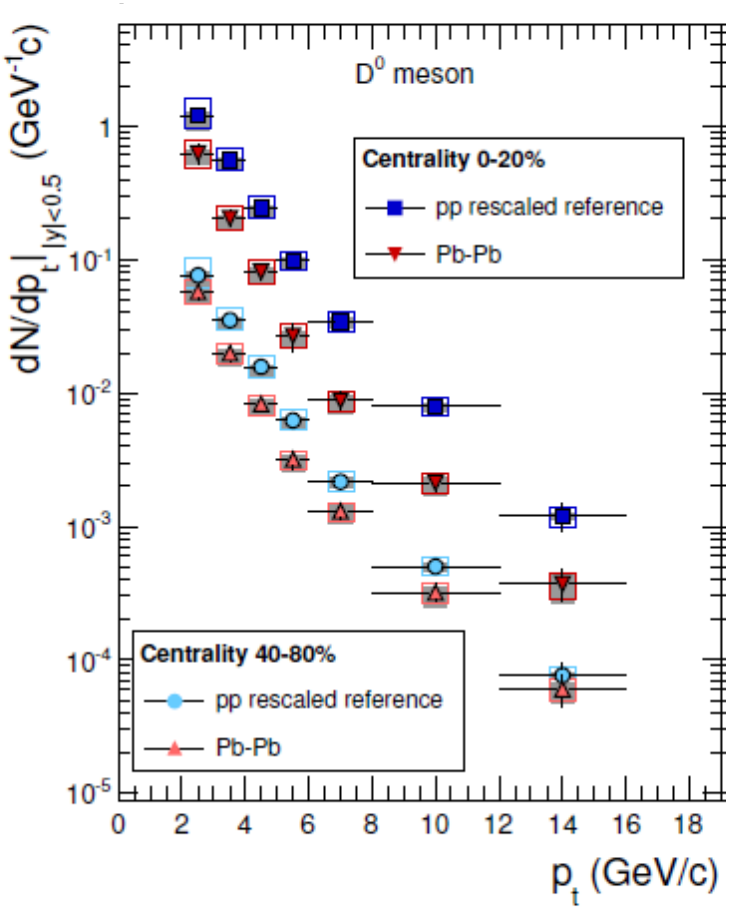
- run-by-run mean values of the impact parameter distributions



✓ Stable for a whole run

Background Estimate : From Charm Hadron Decay

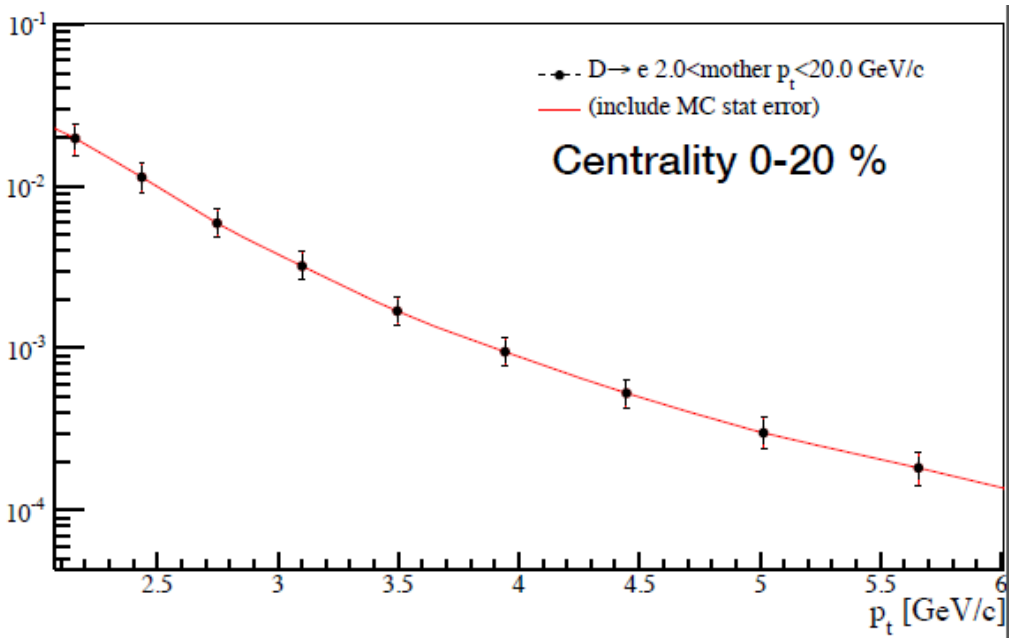
- Based on the charm hadron spectra measured by the ALICE
- Estimate decayed electron P_T spectra using PHYTHIA decay kinematics



measure

$\mathbf{D^0 \rightarrow e}$

decay kinematics



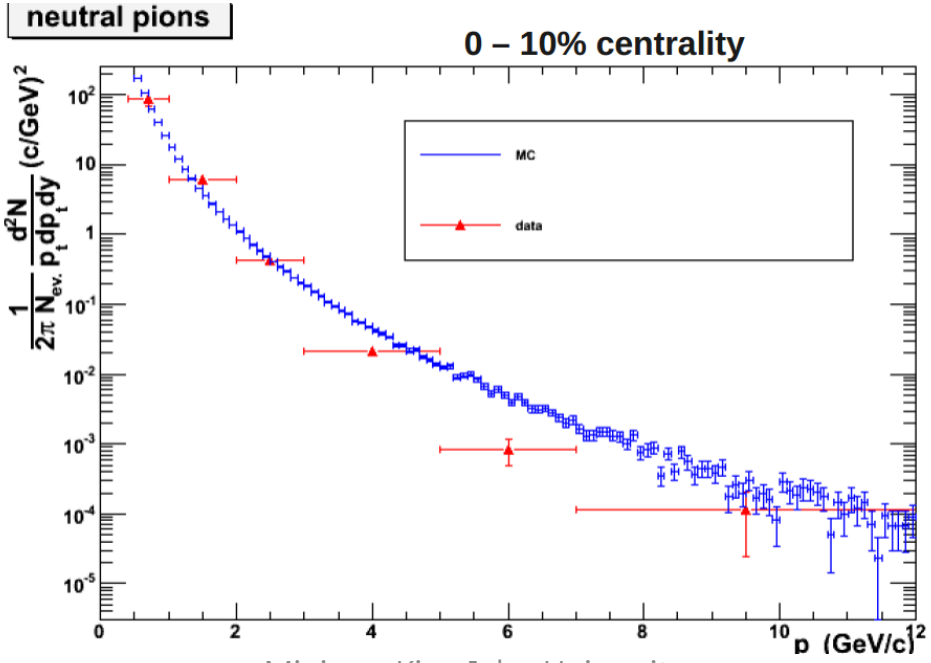
Background Estimate : From Light Meson Decay

- The contributions of neutral meson decays :

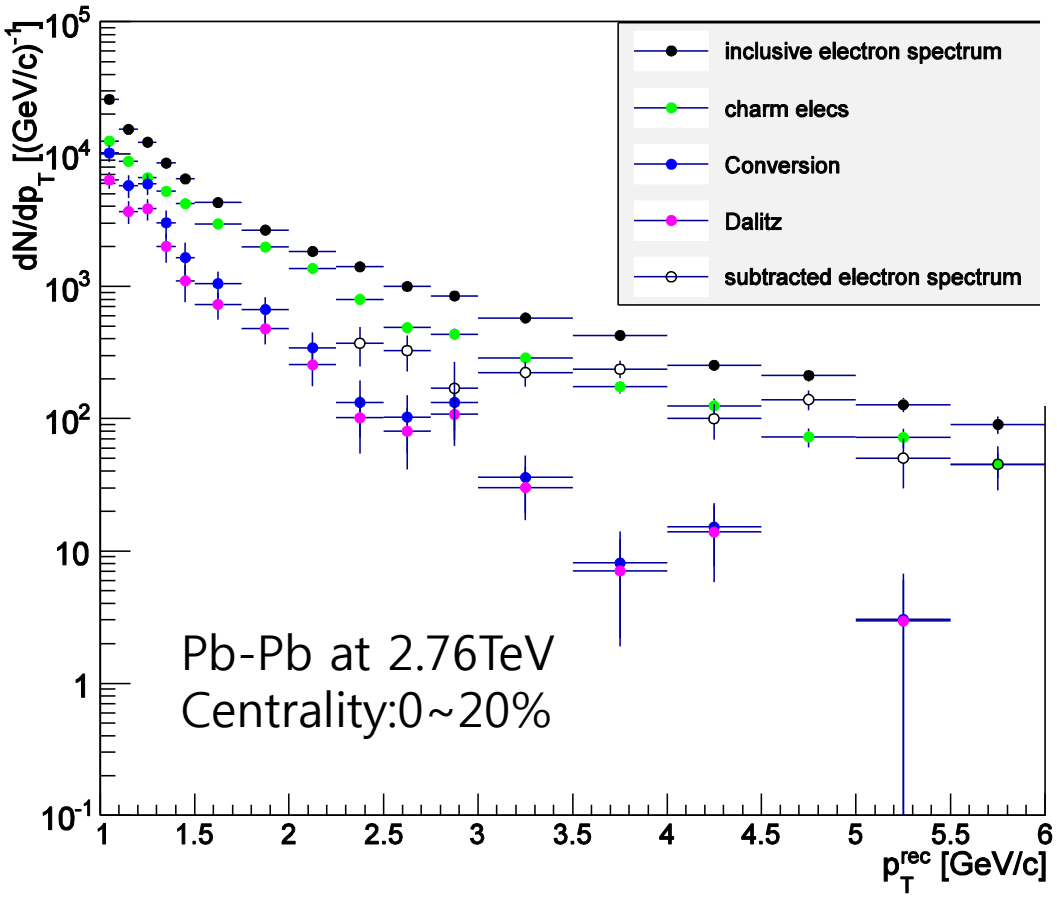
  ex) Pion Dalitz decay ($\pi^0 \rightarrow e^+e^-\gamma$)

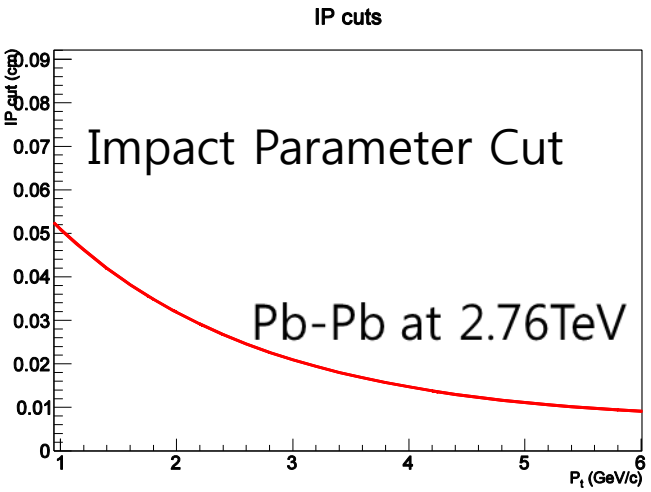
  Conversion electrons: $\pi^0 \rightarrow \gamma\gamma$(BR∽98%), $\gamma + X \rightarrow e^+e^-$)

- Based on measured in ALICE light meson spectra, estimate light meson decay electron backgrounds with PYTHIA decay kinematics as we've done for charm background.



Spectra After P_T Dependent IP Cut Applied

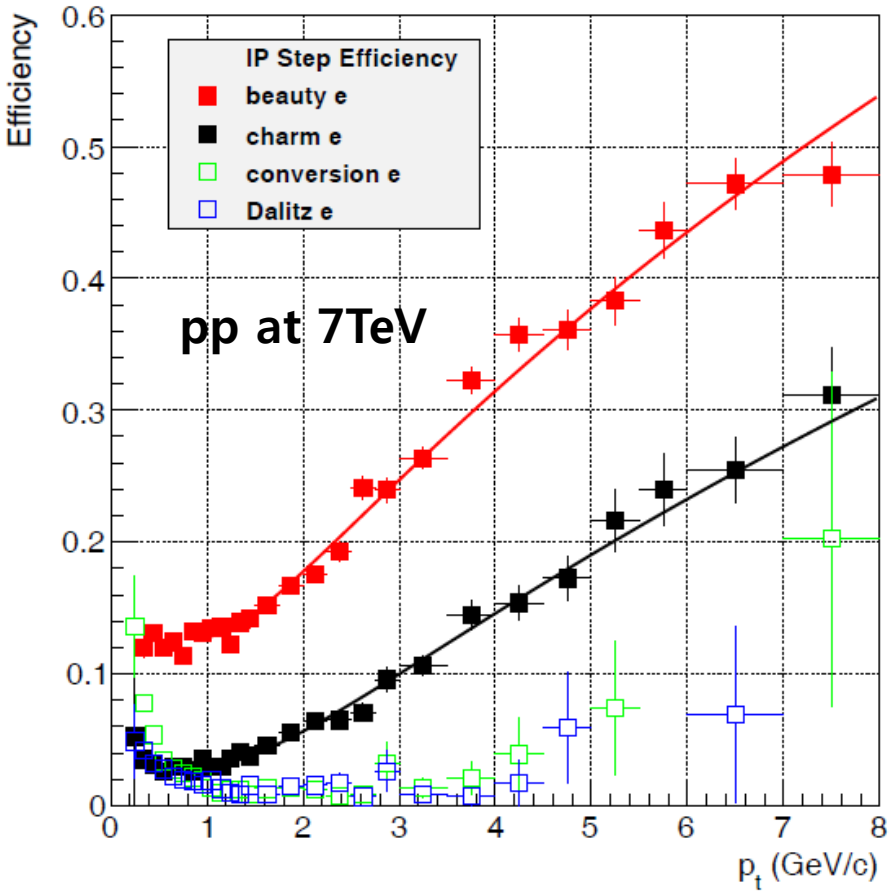




Work In Progress!

Background from light meson decays seems to be over estimated
→ Need to investigate (especially at low P_T)

Efficiency of Impact Parameter Cut



- Efficiency study is on going
- After correction, we can obtain final beauty decay electron spectrum
- With the spectrum of pp and Pb-Pb, we can calculate R_{AA}

Summary and Outlook

- With excellent electron identification and vertex resolution in ALICE, measurement of beauty production via the measurements of electrons from beauty hadron decay is available.

- We can understand the strong interaction in medium(medium effect) by the analysis of beauty hadron in Pb-Pb.

- Progress is on going for R_{AA} of beauty decay electron.

BACKUP SLIDES

Dead Cone Effect

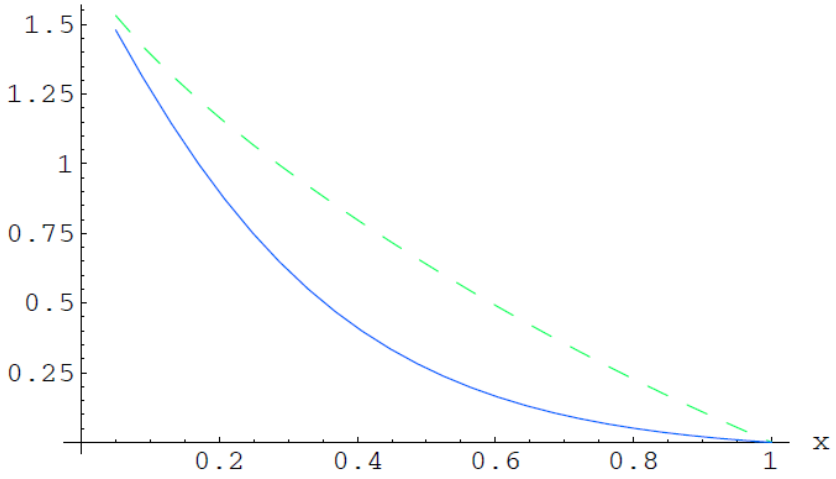
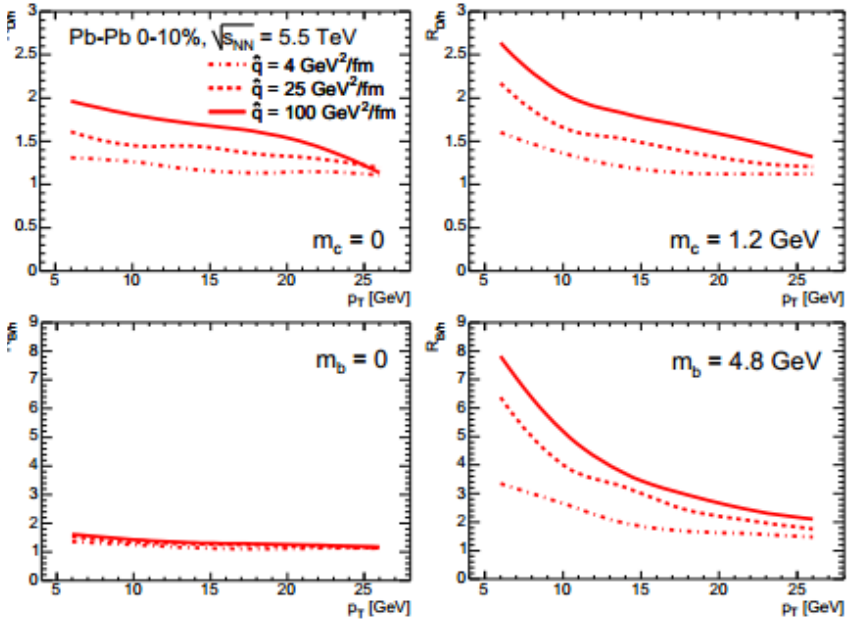


Figure 2: Comparison of energy distributions $\sqrt{x}I(x)$ of gluons radiated off charm (solid line) and light (dashed line) quarks in hot matter with $\hat{q} = 0.2\,\mathrm{GeV}^3$ ($p_\perp = 10\,\mathrm{GeV}$, $L = 5\,\mathrm{fm}$).

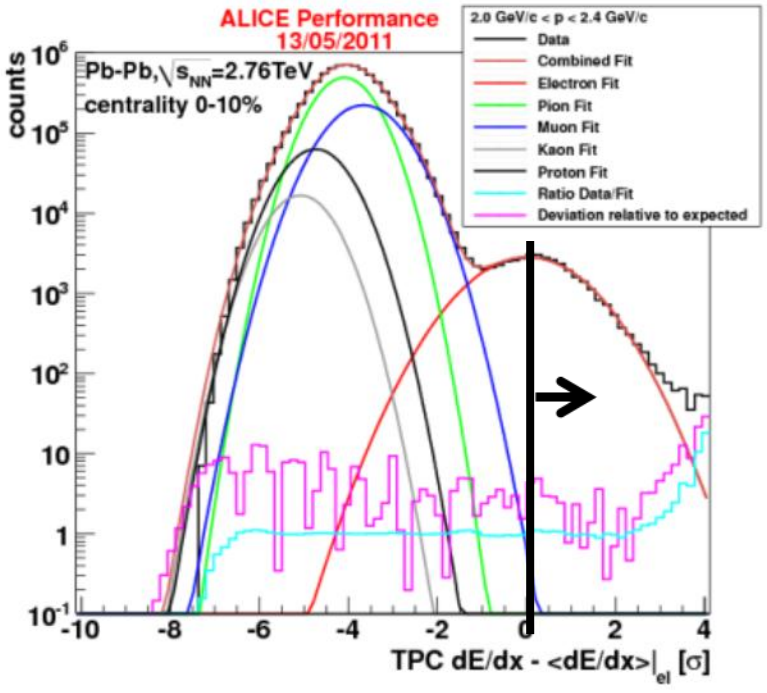
$$I(\omega) = \omega \frac{dW}{d\omega} = \frac{\alpha_s\, C_F}{\pi} \sqrt{\frac{\omega_1}{\omega}}\, \frac{1}{(1+(\ell\,\omega)^{3/2})^2},$$

$$\ell \equiv \hat{q}^{-1/3} \left(\frac{M}{E}\right)^{4/3}.$$

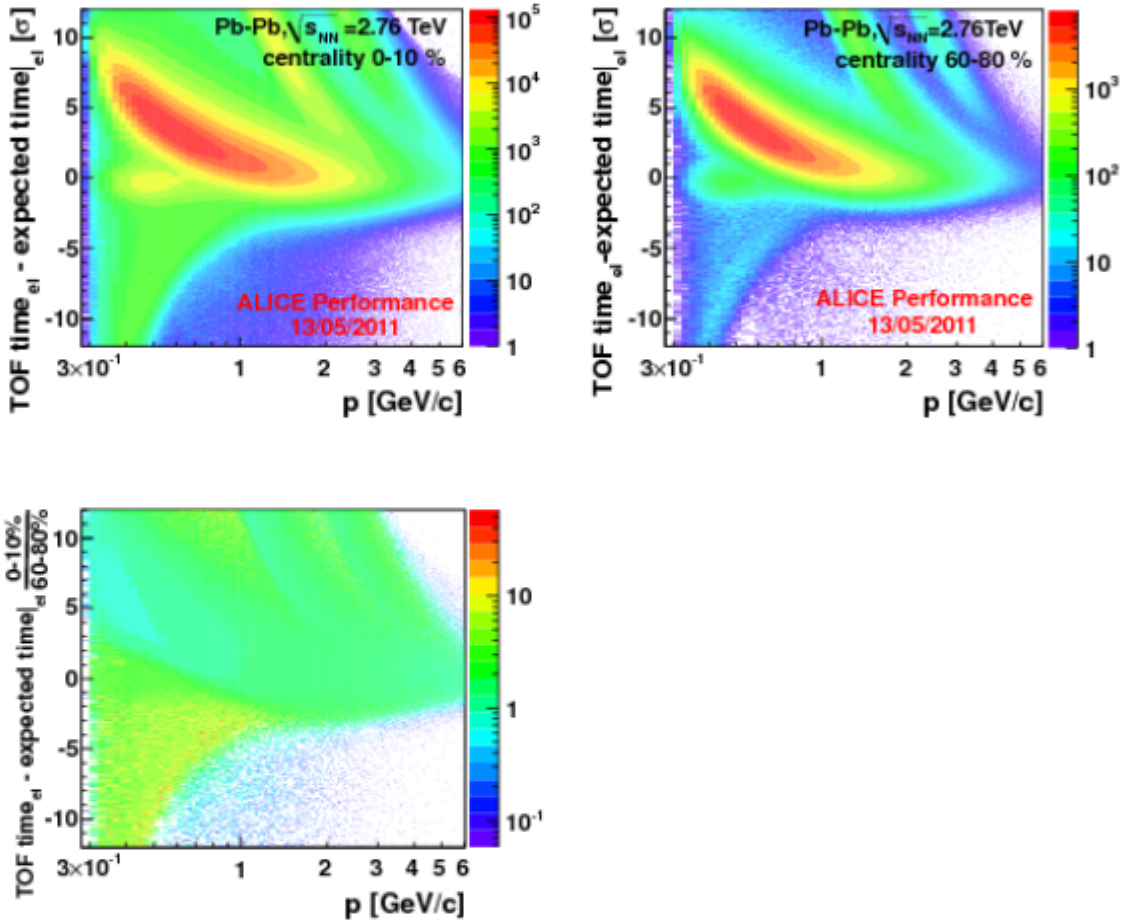


. 5. Heavy-to-light ratios for D mesons (upper plots) and B mesons (lower for the case of a realistic heavy quark mass (plots on the right) and for a case in which the quark mass dependence of parton energy loss is neglected (plots e left).

TPC dE/dx projection on pt



TOF PID for Different Centrality Ranges



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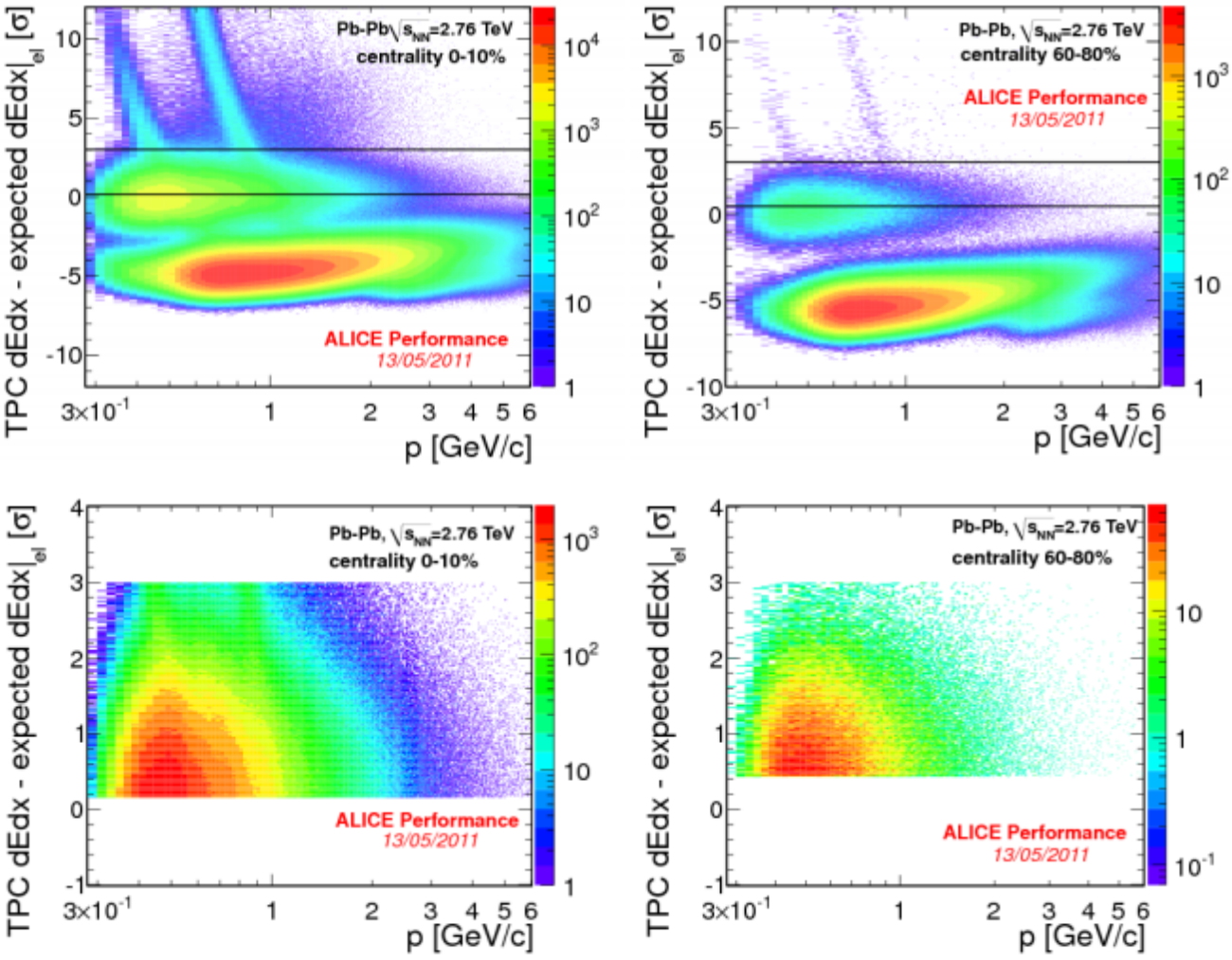

(a) central events (0-10%)

(b) peripheral events (60-80%)