

3rd Heavy Flavour Meet 2019

Electrons from beauty-hadron decays in different collision systems with
ALICE at the LHC

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on behalf of ALICE Collaboration

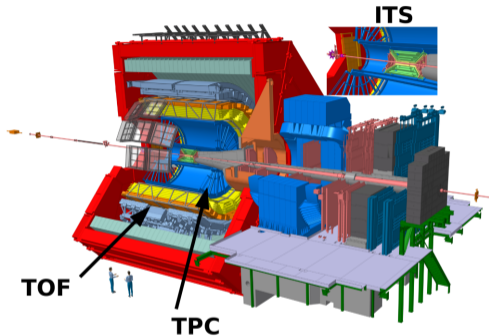
Indian Institute of Technology Indore, India

March 18, 2019

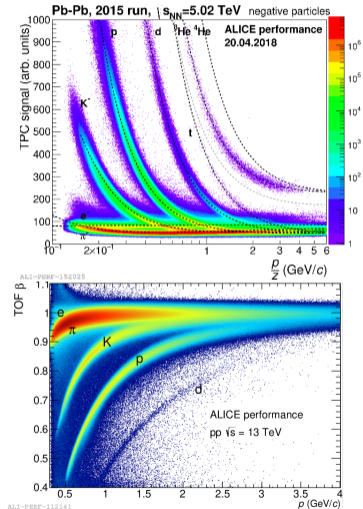
- Physics motivation
- Analysis strategy
- Results and discussion
- Summary and outlook

- Charm and beauty quarks are produced in the initial hard scattering processes at the early stages of the collision.
- $m_{c,b} \gg$ Quantum ChromoDynamics scale parameter ($\Lambda_{\text{QCD}} \approx 200 \text{ MeV}$).
- $\text{BR}(B, D \rightarrow e\nu X) \approx 10\%$.
- **pp collisions**
 - Measure the cross section of electrons from beauty-hadron decays in pp collisions and provide the required reference for corresponding studies in large systems.
 - Test of perturbative Quantum ChromoDynamics.
- **Pb-Pb collisions**
 - Study the mass dependent energy loss of quarks in hot QCD medium and participation of heavy quarks the collective expansion of the system.
- **p-Pb collisions**
 - Study the cold nuclear matter effects.

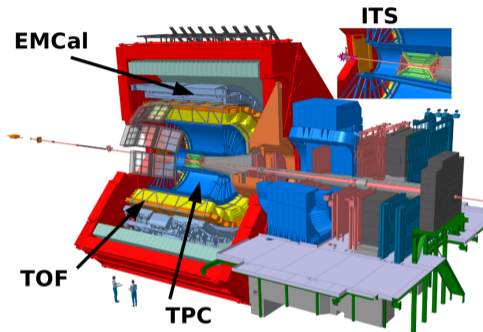
ALICE Detector: Identification of electrons at low p_T



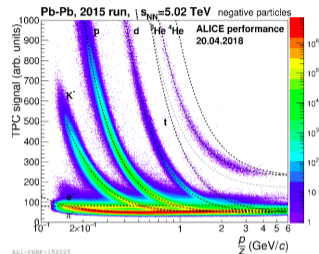
- Hits in both SPD layers to minimize the number of tracks from photon conversions.
- Cut on deviation from the expected electron dE/dx .
- $|t_{TOF} - t_{TOF}^e| < 3\sigma_{\text{electron}}$



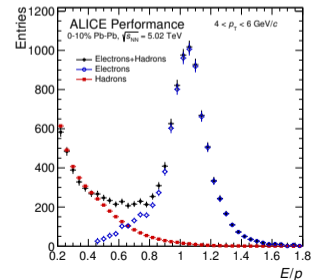
ALICE Detector: Identification of electrons at high p_T



- Hits in both SPD layers to minimize the number of tracks from photon conversions
- Cut on deviation from the expected electron dE/dx .
- E/p : energy deposited in the EMCal / track momentum ($0.9 < E/p < 1.2$)



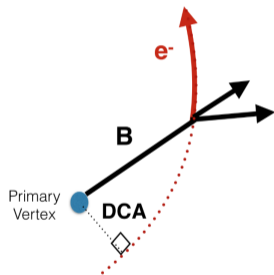
ALICE-PHOS-152025



ALICE-PHOS-119871

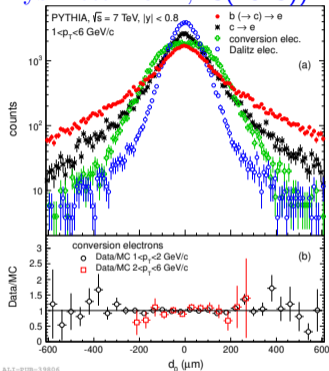
Analysis strategy: pp 7 TeV and p-Pb 5.02 TeV

- Identify inclusive electrons using Time Projection Chamber (TPC) and Time of Flight (TOF) detectors with ALICE.
- The electrons from beauty-hadron decays have larger impact parameter or distance of closest approach (DCA) to the primary vertex compared to the electron background from other sources.
- Limit on the minimum DCA of the electron candidate tracks is applied to increase the signal to background ratio.
- The remaining electron background is estimated in the MC and then subtracted, based on other ALICE measurements by re-weighting the background sources in PYTHIA to match with the measured ones.

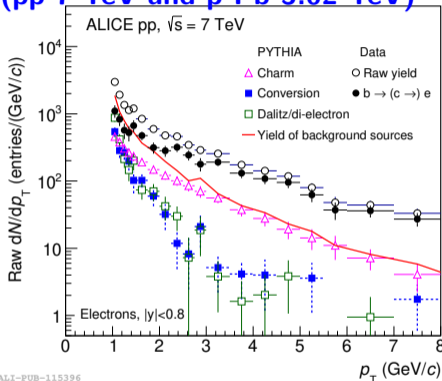


Analysis Strategy: Electrons from beauty decays via DCA cut method

(Phys. Lett. B721, 13(2013))



(pp 7 TeV and p-Pb 5.02 TeV)



- The $b \rightarrow e$ have larger DCA compared to their background \Rightarrow cut on the minimum DCA to increase the S/B ratio.
- Background sources are estimated, based on other ALICE measurements by re-weighting the relevant background sources in PYTHIA to match the measured ones.

Analysis strategy: Pb-Pb 2.76 and 5.02 TeV analyses at low and high p_T

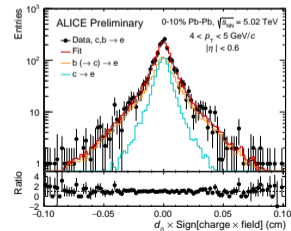
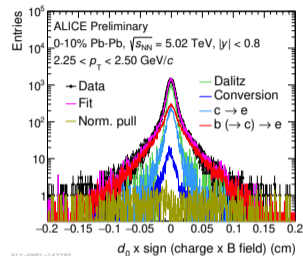


Steps	low p_T	high p_T
Identify inclusive electron yield	TPC-TOF	TPC-EMCal (Electromagnetic Calorimeter)
Remove hadron contamination		Subtract hadron DCA distribution scaled to match the estimated hadron contamination
Remove conversion and non-HF electrons		Subtract the main background from photonic sources using data-driven photonic electron tagging method
	Fit four MC templates (Dalitz, conversion electrons, $c \rightarrow e$, and $b \rightarrow e$) to inclusive electron DCA	
Remove $c \rightarrow e$		Fit two MC templates ($c \rightarrow e$ and $b \rightarrow e$) to non-photonic electron DCA

Analysis Strategy: Electrons from beauty decays via DCA fits

(Pb-Pb 2.76 and 5.02 TeV)

- Low- p_T analysis, DCA templates like Dalitz, conversion electrons, $c \rightarrow e$, and $b \rightarrow e$ obtained using MC and fit to data using a log-likelihood fitting routine.
- High- p_T analysis, \Rightarrow just two templates for $c \rightarrow e$ and $b \rightarrow e$ since, Dalitz, conversion electrons and hadron contamination are removed using data-driven method.
- DCA templates are further corrected to better match to the data since they are not well reproduced in the Monte Carlo sample.
 - Shift DCA mean and correct resolution using Improver task.
 - Reweight the $D + B$ meson p_T spectra.
 - Correct Λ_c/D^0 , D^+/D^0 , and D_s^+/D^0 ratios in the charm template based on ALICE measurements.

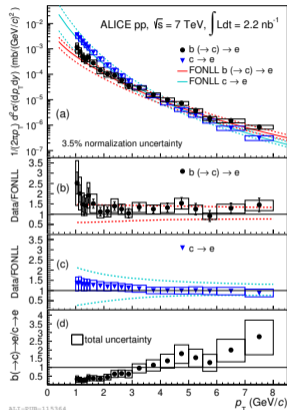


Results: Electrons from beauty decays in pp at 7 and p-Pb at 5.02 TeV

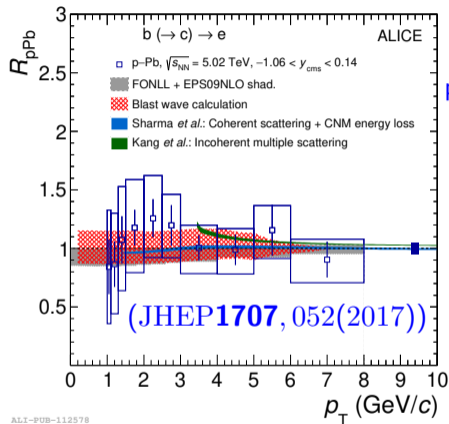


(Phys. Lett. B721, 13(2013))

pp 7 TeV



ALI-PUB-115364



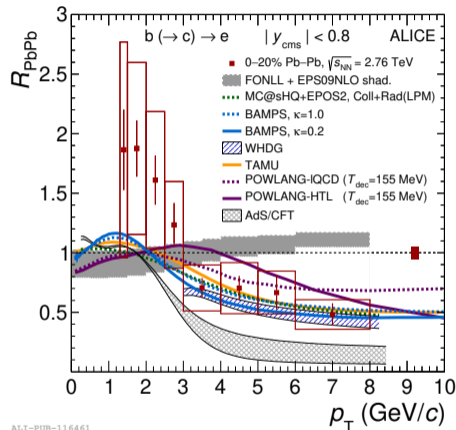
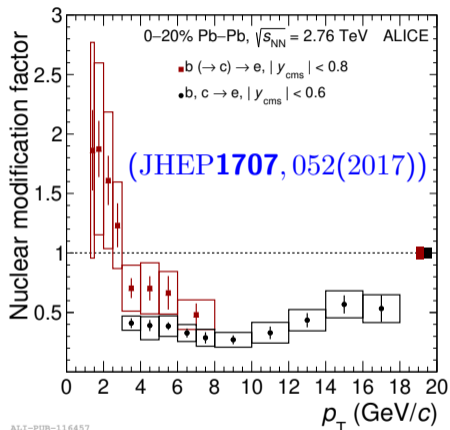
ALI-PUB-112578

p-Pb 5.02 TeV

(JHEP1707, 052(2017))

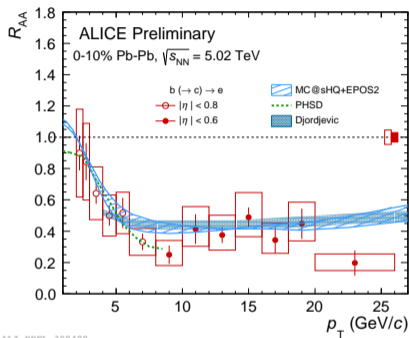
- Measured cross section is in agreement with the FONLL predictions.
- R_{pPb} of electrons from beauty hadron decays is consistent with unity in the measured p_T range.
- It is also in the agreement with the theoretical predictions in the p_T range under study.

Results: Electrons from beauty decays in Pb-Pb at 2.76 TeV

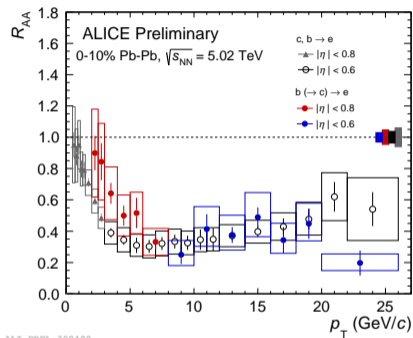


- Indication of smaller suppression of $b \rightarrow c \rightarrow e$ with respect to $b, c \rightarrow e$ at low/intermediate p_T .
- R_{AA} consistent with various theoretical models that consider mass-dependent radiative and collisional energy loss.

Results: Electrons from beauty decays in Pb-Pb at 5.02 TeV



ALI-PREL-308498



ALI-PREL-308490

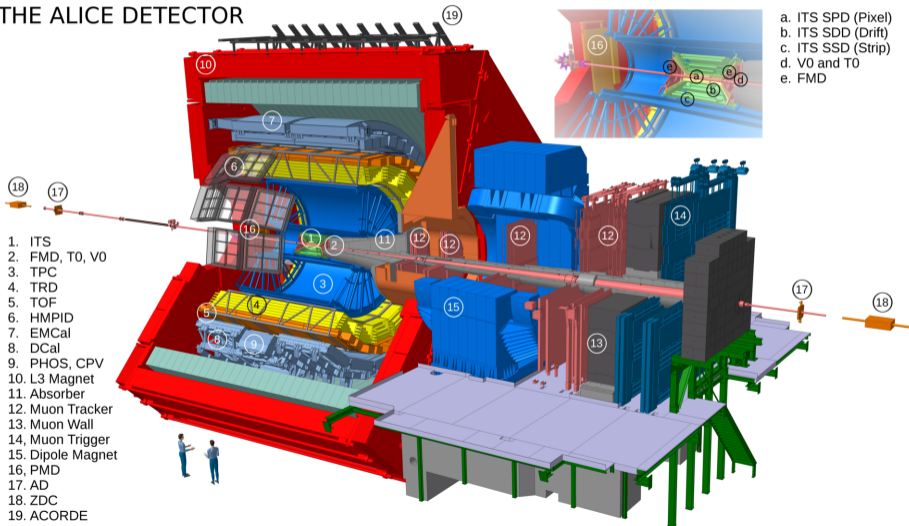
- R_{AA} shows good agreement with Run 1 measurement.
- Hint of smaller suppression of $b \rightarrow c \rightarrow e$ with respect to $b, c \rightarrow e$.
- R_{AA} consistent with models that consider mass-dependent radiative and collisional energy loss.
- Analysis of new pp reference at 5.02 TeV is ongoing which would reduce the systematic uncertainties in the R_{AA} measurement and can give more precise results.

- Electrons from beauty hadron decays are measured using the ALICE detector which offers excellent particle identification as well as excellent vertex and track position resolution.
- Measurements were done using two different approaches:
 - By subtracting the electrons from background sources using other ALICE measurements (pp 7 TeV and p-Pb at 5.02 TeV).
 - By using DCA template fit method where the DCA templates of the electrons from different sources are fitted to the inclusive electrons using the log-likelihood fit approach (Pb-Pb at 2.76 and 5.02 TeV).
- R_{AA} hints at smaller suppression of $b \rightarrow c \rightarrow e$ with respect to $b, c \rightarrow e$ at both 2.76 and 5.02 TeV at low/intermediate p_T .
- All the measurements are consistent with the theoretical predictions within uncertainties.

- Nuclear modification factor of beauty-hadron decay electrons in semi-central Pb-Pb collisions at 5.02 TeV.
- New pp reference at 5.02 TeV using the DCA template fit method will be available soon for improving the precision on R_{AA} in Pb-Pb collisions.
- The measurements of the beauty-hadron decay electrons will be improved with the upcoming ALICE detector upgrade.

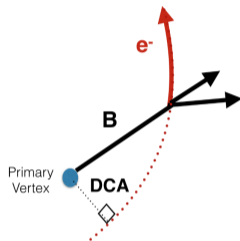
BACK-UP

THE ALICE DETECTOR

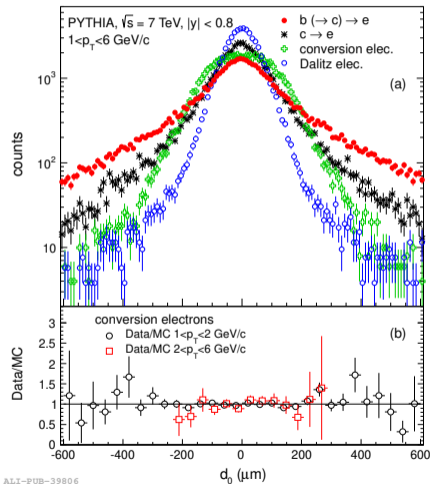


Analysis Strategy: Electrons from beauty quarks via DCA cut method

(pp 7 TeV and p-Pb 5.02 TeV)



- The $b \rightarrow e$ have larger DCA compared to the electron background \Rightarrow cut on the minimum DCA to increase the S/B ratio.
- In pp and p-Pb collisions, $|DCA| > [64 + 780 \times \exp(0.56 p_T)]$ (DCA in μm , p_T in GeV/c).

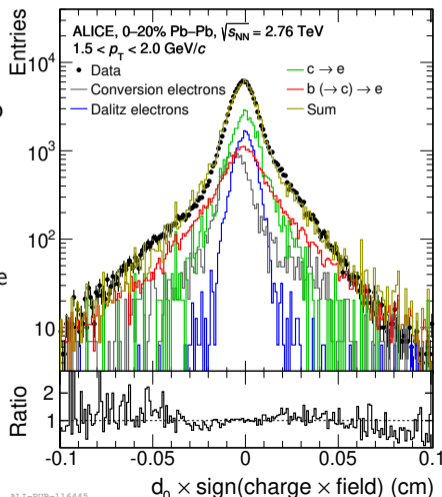


ALI-PUB-39806

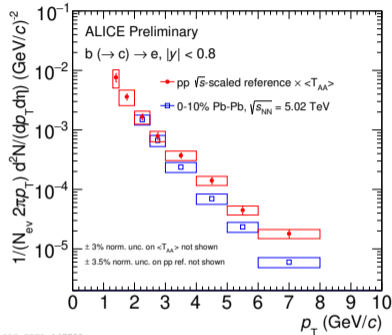
Analysis Strategy: Electrons from beauty quarks via DCA Template fits

(Pb-Pb 2.76 and 5.02 TeV)

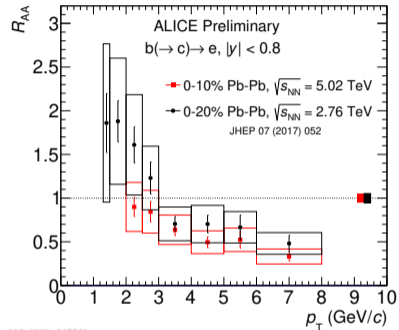
- Low- p_T analysis, DCA templates like Dalitz, conversion electrons, $c \rightarrow e$, and $b \rightarrow e$ obtained using MC and fit to data using a log-likelihood fitting routine.
- High- p_T analysis, \Rightarrow just two templates for $c \rightarrow e$ and $b \rightarrow e$ since, Dalitz and conversion electrons are removed using data-driven method along with the hadron contamination.
- DCA templates are further corrected to better match to the data since they are not well reproduced in the Monte Carlo sample.
 - Shift DCA mean and correct resolution using Improver task.
 - Reweight the D and B meson p_T spectra.
 - Correct Λ_c/D^0 , D^+/D^0 , and D_s^+/D^0 ratios in the charm template based on ALICE measurements.



Results: Electrons from beauty quarks in Pb-Pb at 5.02 TeV

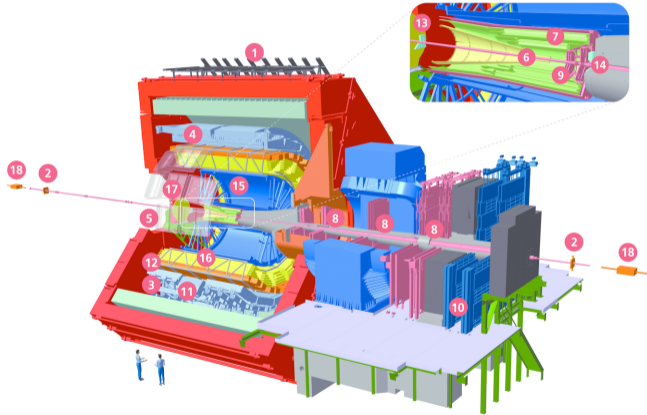


ALI-PREL-147782



ALI-PREL-147761

- R_{AA} shows good agreement with Run 1 measurement.
- Indication of smaller suppression of b (\rightarrow c) \rightarrow e with respect to b, c \rightarrow e at low/intermediate p_T .
- The scaled pp reference is used which is obtained from scaling it from 7 TeV using FONLL.
- Analysis of new pp reference is ongoing which would reduce the systematic uncertainties in the R_{AA} measurement and can give more precise results.



- 1 **ACORDE** | ALICE Cosmic Rays Detector
- 2 **AD** | ALICE Diffractive Detector
- 3 **DCal** | Di-jet Calorimeter
- 4 **EMCal** | Electromagnetic Calorimeter
- 5 **HMPID** | High Momentum Particle Identification Detector
- 6 **ITS-IB** | Inner Tracking System - Inner Barrel
- 7 **ITS-OB** | Inner Tracking System - Outer Barrel
- 8 **MCH** | Muon Tracking Chambers
- 9 **MFT** | Muon Forward Tracker
- 10 **MID** | Muon Identifier
- 11 **PHOS / CPV** | Photon Spectrometer
- 12 **TOF** | Time Of Flight
- 13 **T0+A** | Tzero + A
- 14 **T0+C** | Tzero + C
- 15 **TPC** | Time Projection Chamber
- 16 **TRD** | Transition Radiation Detector
- 17 **V0+** | Vzero + Detector
- 18 **ZDC** | Zero Degree Calorimeter

References

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