Open heavy flavour production in p-p collisions at 7 TeV with the ALICE experiment

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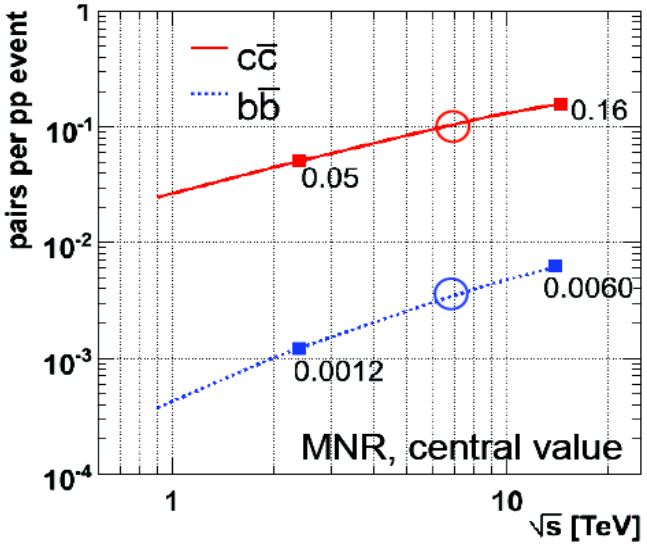
Outline

1. Introduction on Heavy Flavour physics
2. ALICE detector and performance
3. HF at midrapidity
   - D mesons in hadrons
   - c/b in electrons
4. HF→ single-μ at forward rapidity
5. Conclusions and outlook for PbPb collisions

Heavy flavour production at LHC in p-p collisions

p-p

- Test pQCD in a new energy domain ($3.5 - 7 \times \sqrt{s_{Tevatron}}$)
  - * Factor 2 uncertainty in NLO predictions
- c and b factory
- Normalization for Pb-Pb HF yield

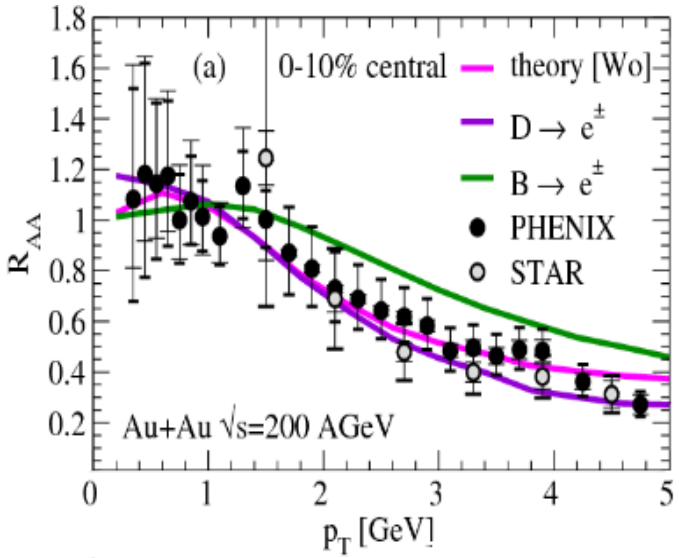


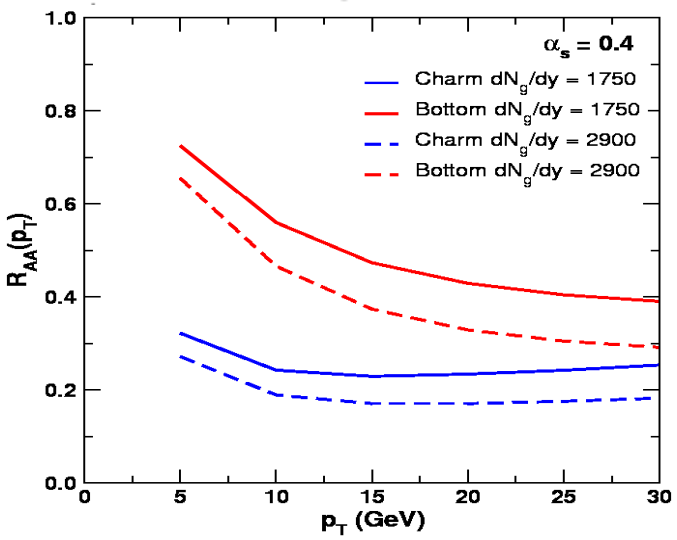
Mangano, Nason, Ridolfi, NPB373 (1992) 295.

Heavy flavour production at LHC in PbPb collisions

Pb-Pb

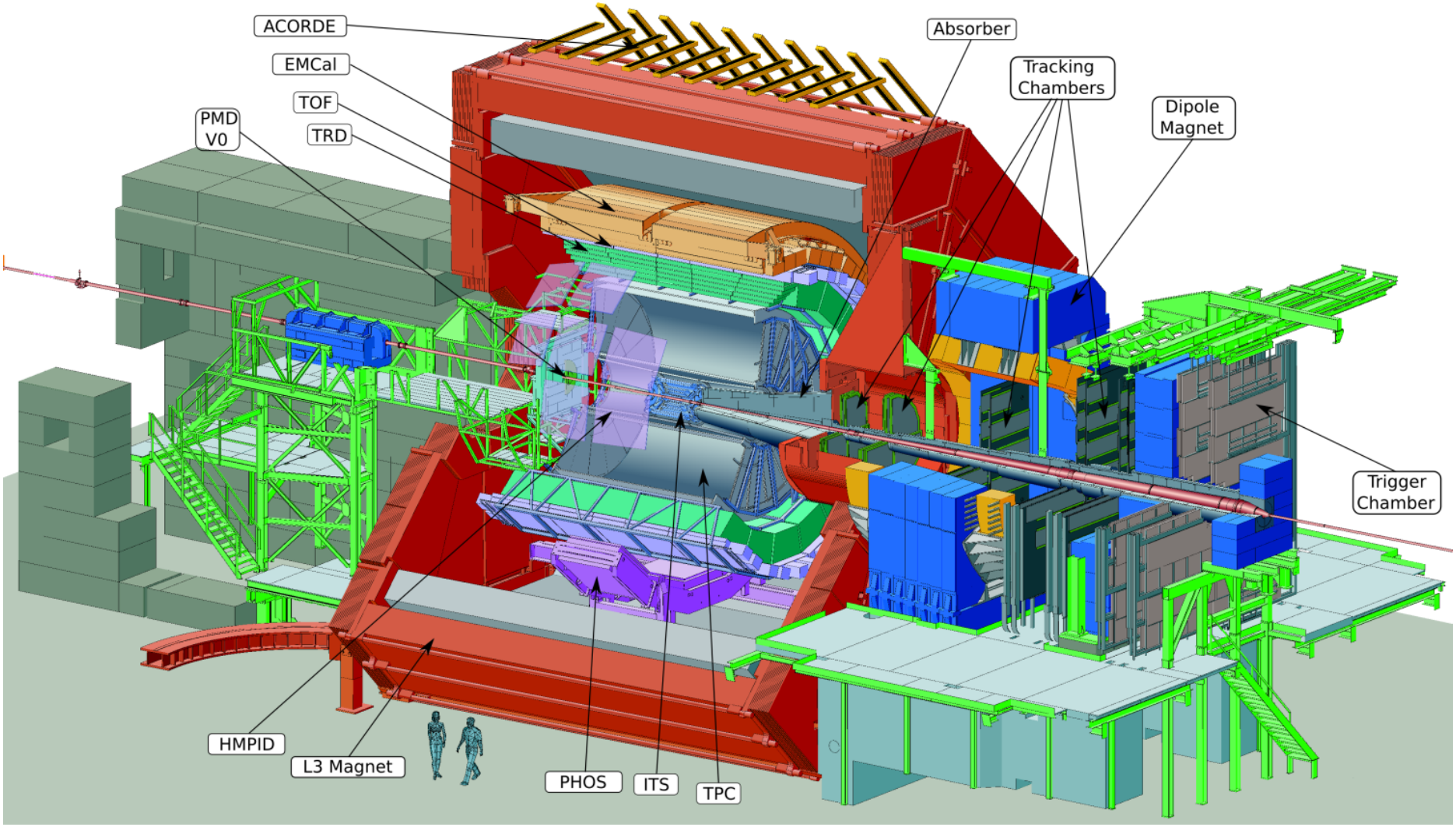
- ALICE ↭ Heavy Ion experiment!
- Non-photonic electrons suppressed at RHIC
  - * but not possible to separate c and b
- In a Quark Gluon Plasma p_t distribution of quark soften due to energy loss
- Energy loss predicted to depend on quark mass
  - * factor 5 suppression for charm
  - * Smaller suppression for beauty ⇝ heavy-to-light ratio enhanced



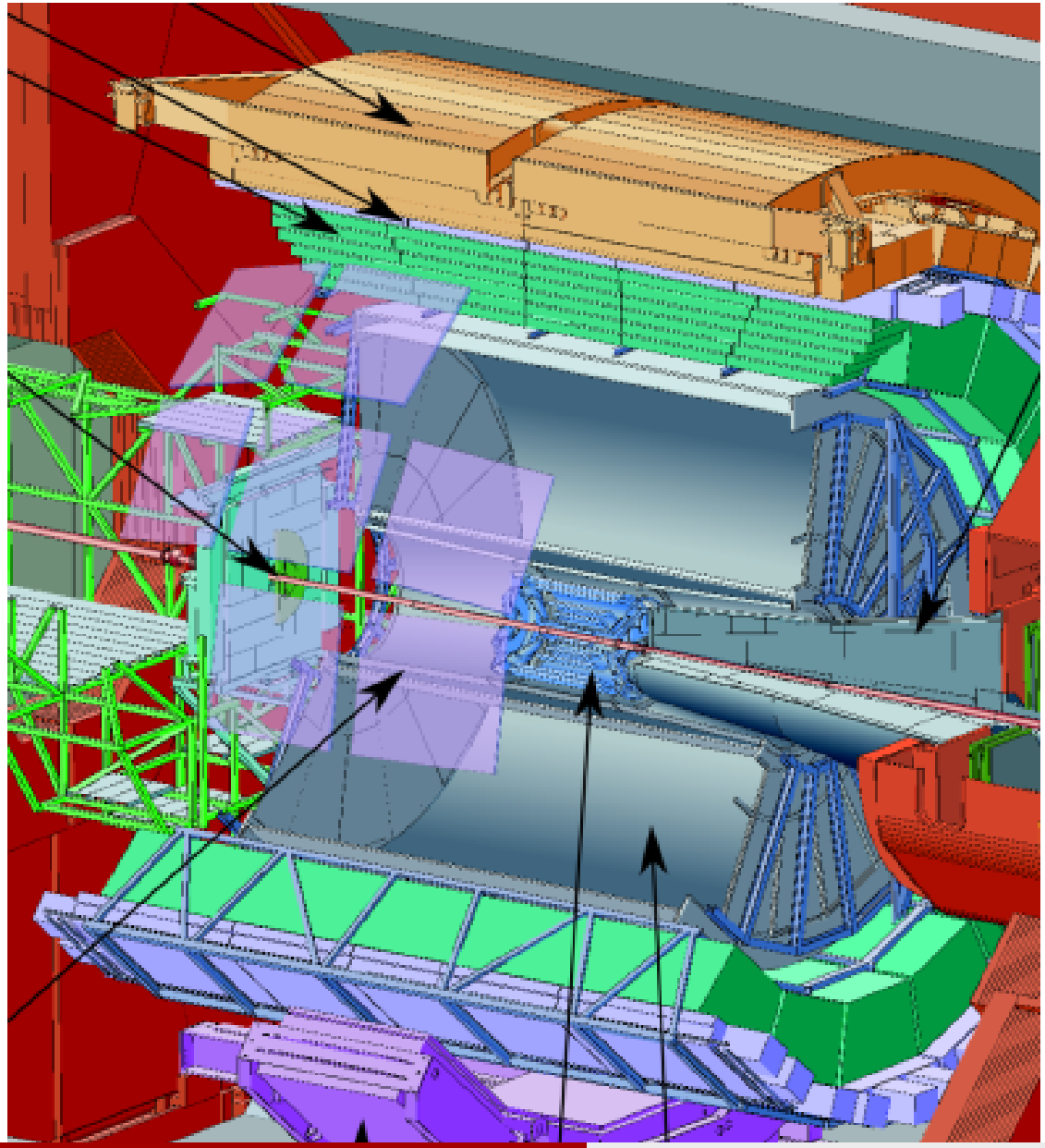


Wicks, Gyulassy, "Last Call for LHC Predictions" workshop

A Large Ion Collider Experiment



Heavy Flavour at midrapidity (I)



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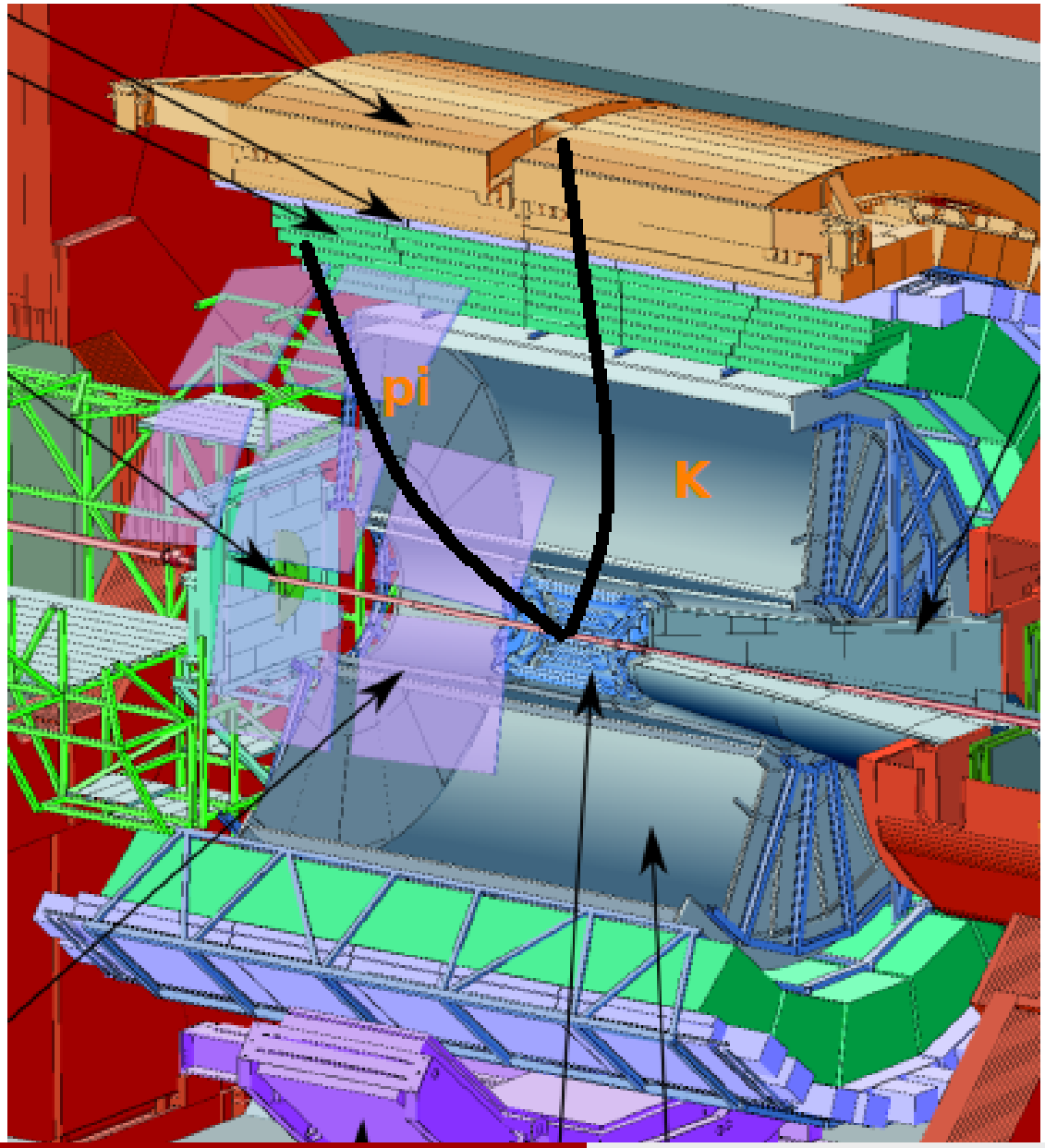
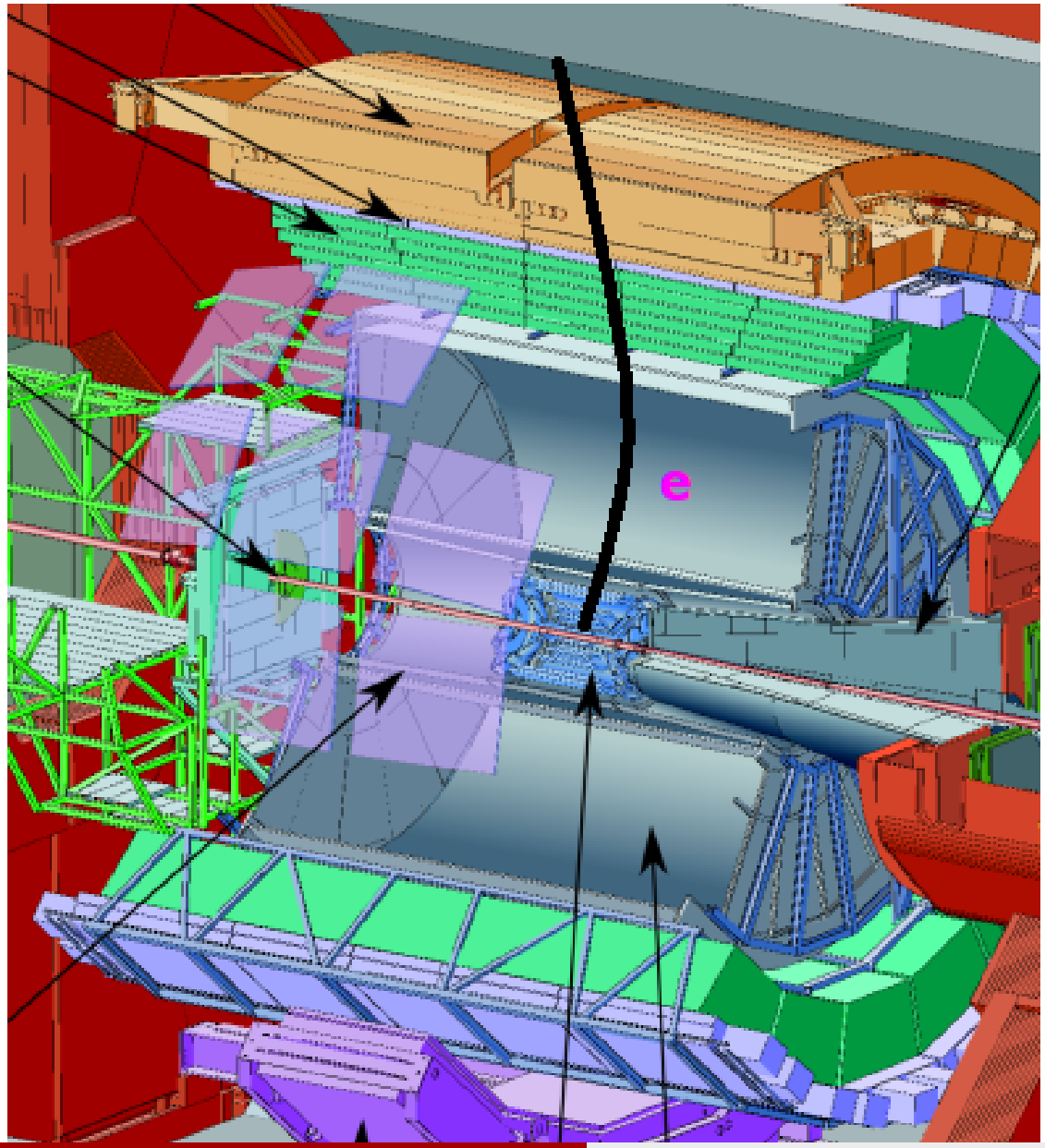


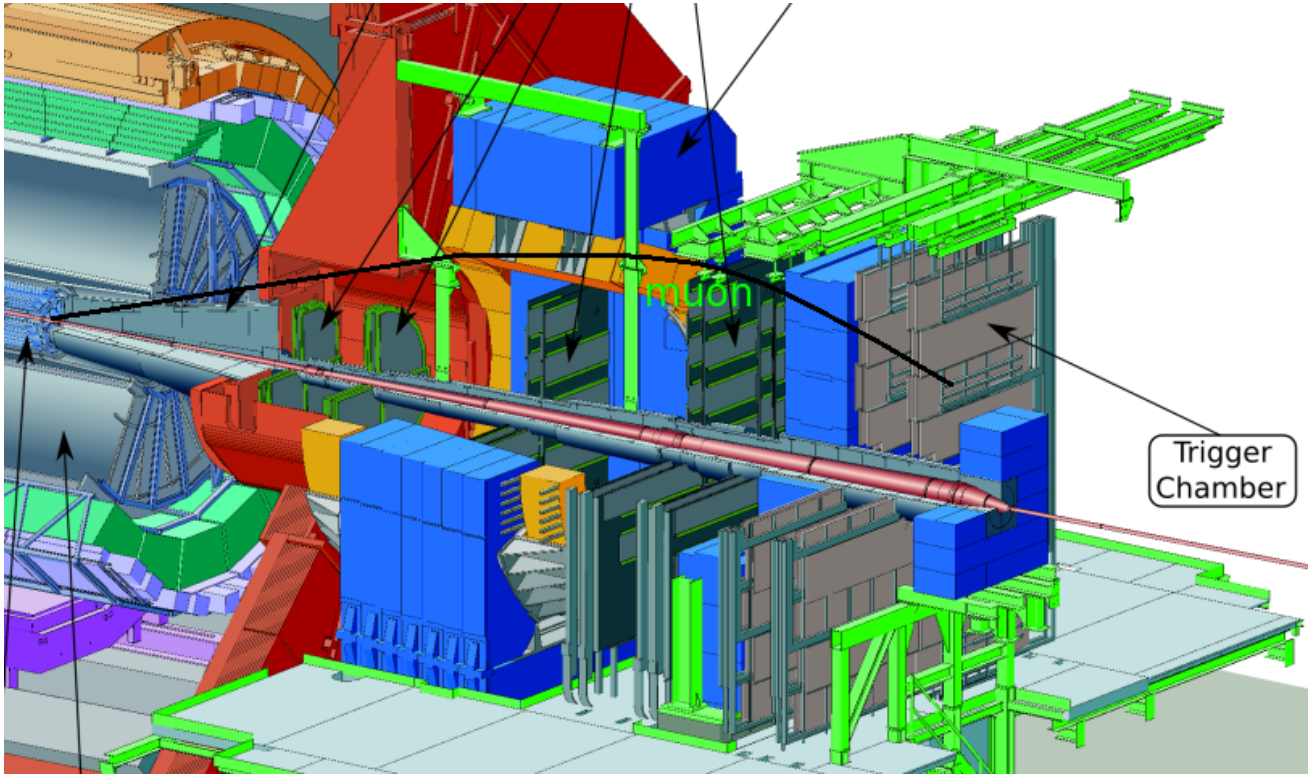
- $D \rightarrow hadrons$
  - ☑ $D^0 \rightarrow K^- \pi^+$
  - ☑ $D^+ \rightarrow K^- \pi^+ \pi^+$
  - ☑ $D^{*+} \rightarrow D^0 \pi^+_{soft}$
  - ☑ $D^+_s \rightarrow K^- K^+ \pi^+$
  - ☑ $D^0 \rightarrow K^- \pi^+ \pi^- \pi^+$
  - ☑ $\Lambda^+_c \rightarrow \mathrm{p} K^- \pi^+$
- Invariant mass analysis
- Displaced secondary vertex reconstruction

Heavy Flavour at midrapidity (II)



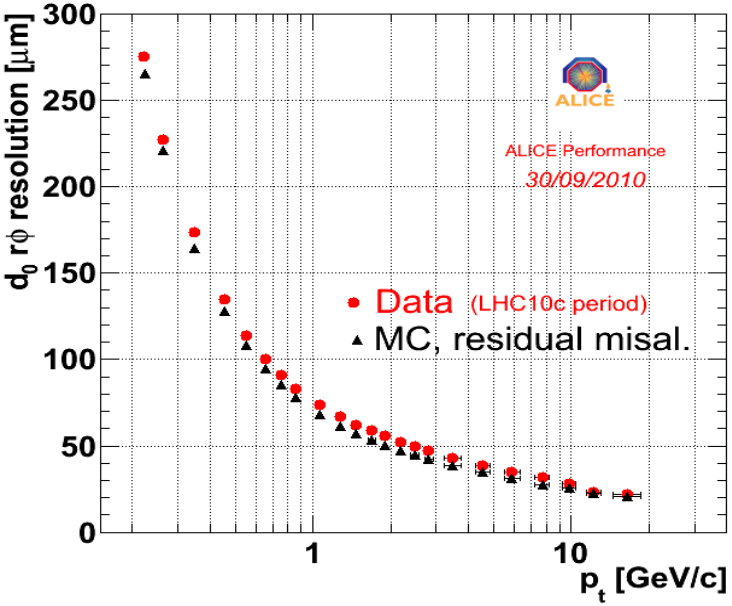
- $c/b \rightarrow electrons$
  - ☑ $c/b \rightarrow e + X$
  - ☑ $b \rightarrow c \rightarrow e + X$
- Background subtraction from inclusive e p_t spectrum

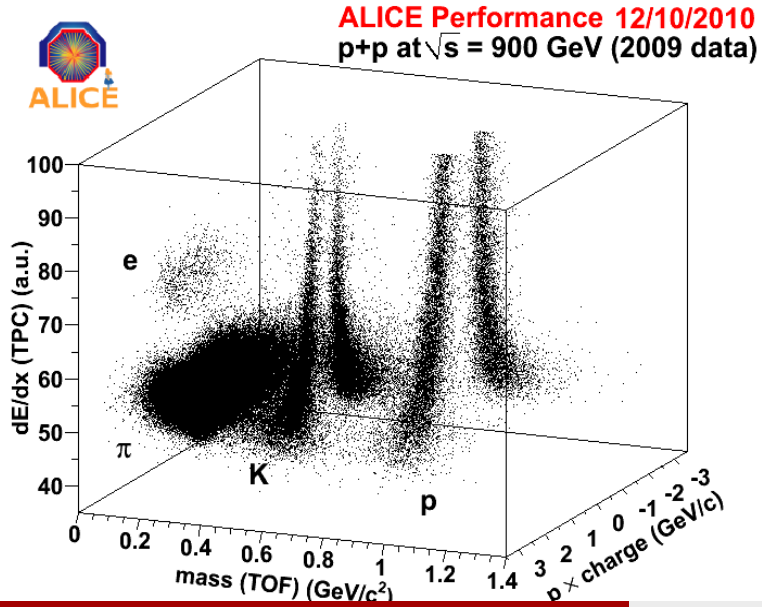
Heavy Flavour at forward rapidity

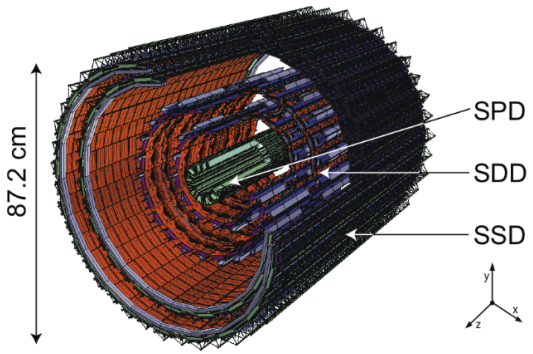


- $c/b \rightarrow$ single muon
  - ☑ $c/b \rightarrow \mu + X$
  - ☑ $b \rightarrow c \rightarrow \mu + X$
- Background subtraction from inclusive single-μ p_t spectrum

Tracking and PID performance







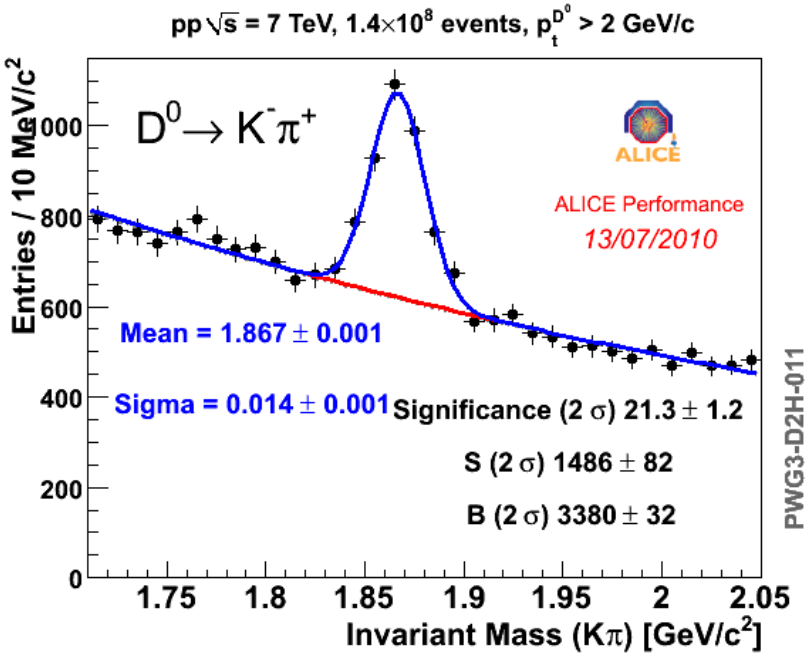
- Impact parameter resolution provided by Inner Tracking System (pixel radii = 3.9 and 7.6 cm):
  - → ~ 70μm at 1 GeV/c
- Many detectors with complementary PID capabilities:
  - → *D → hadrons*: Kaons identification with TPC & TOF ⇝ rejecting bkg at low p_t
  - → *c/b → e + X*: Hadron rejection and *e* identification (TPC+TOF)

D mesons in p-p collisions at LHC

- ~ 800 million minimum bias triggers collected, ~ 100 million (~ 1.4 nb^{-1}) minimum bias used in the analysis presented (optimal calibration)

Analysis strategy

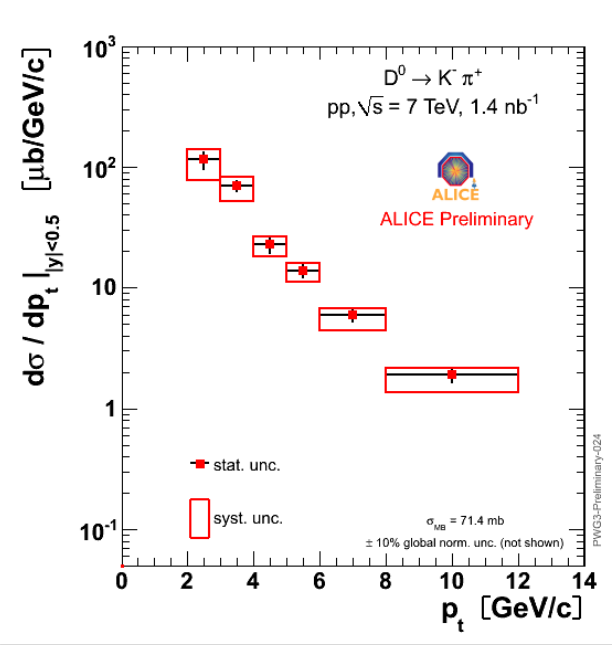
- Invariant mass analysis of the fully reconstructed decay vertices
- Feed-down from B decay
  - Using pQCD (FONLL) so far
  - Data-driven method (impact parameter) when all the stat will be available

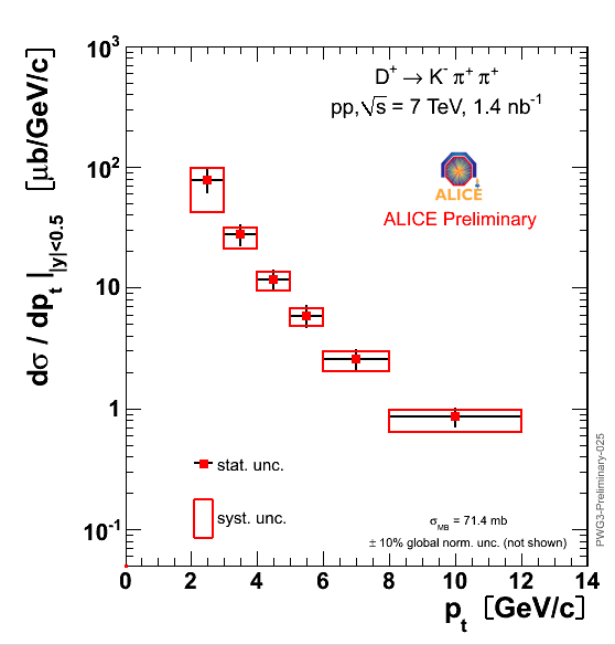


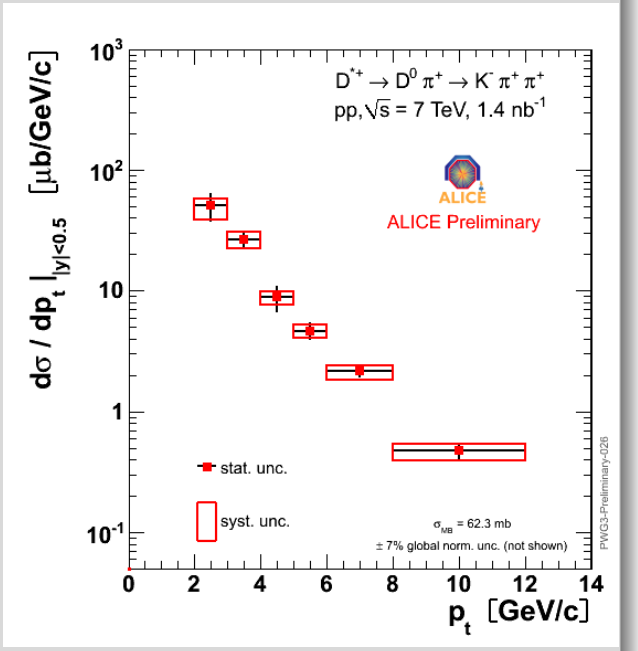
- Correction for efficiency (reco, acceptance, analysis cuts, pid. . .)
- Normalization of the corrected yield to the cross section

D meson cross section

D^0, D^+ and D^* cross section in p-p at $\sqrt{s}$ = 7 TeV







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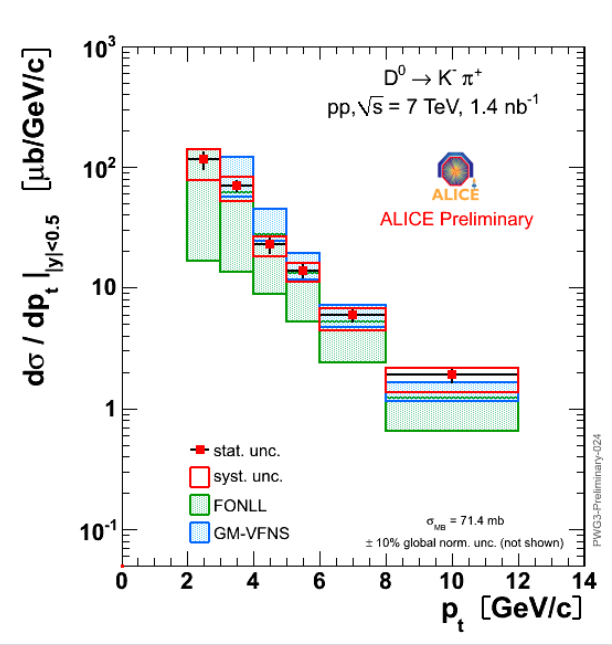
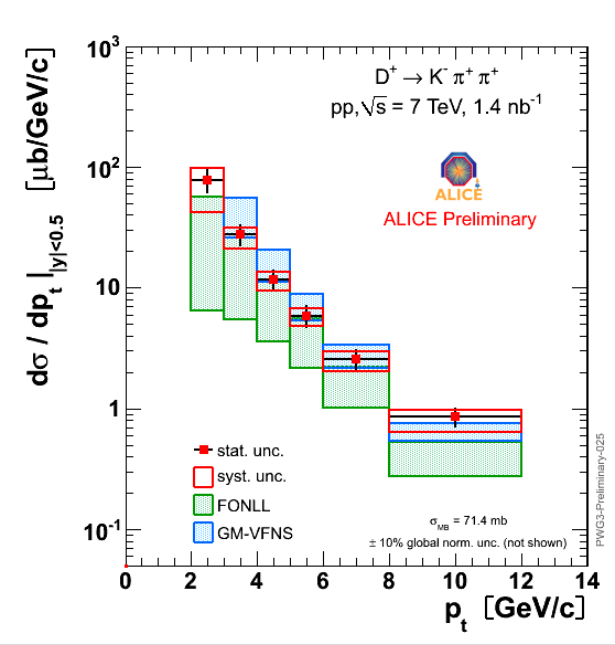
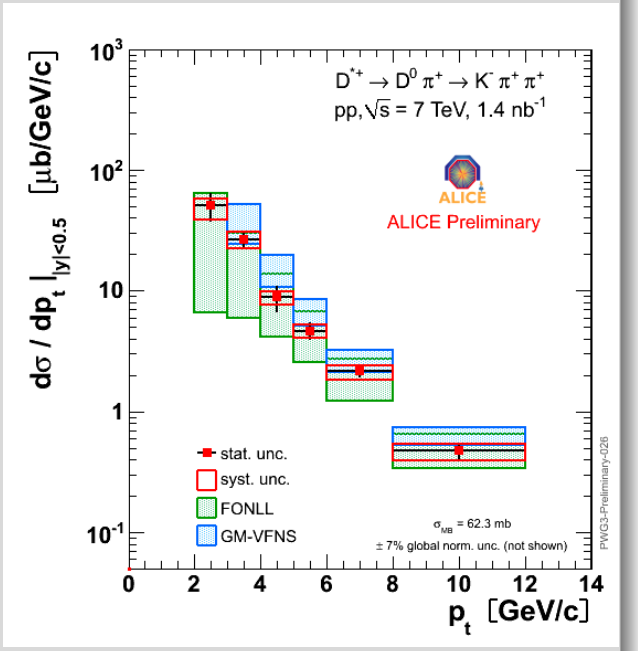




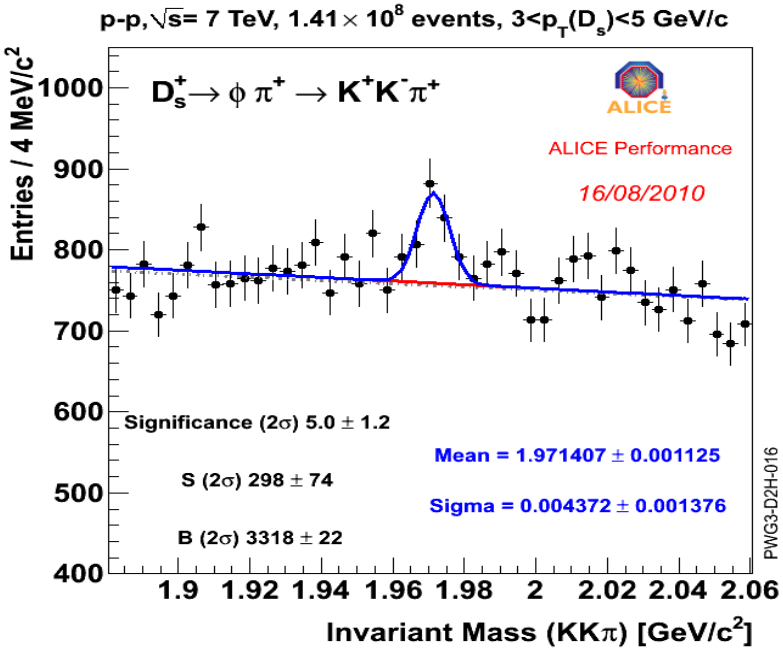


- The measurements are well described by pQCD predictions FONLL (Cacciari et al.) and GM-VFNS (Kramer et al)
- Extension at lower and higher p_t expected with increased statistics

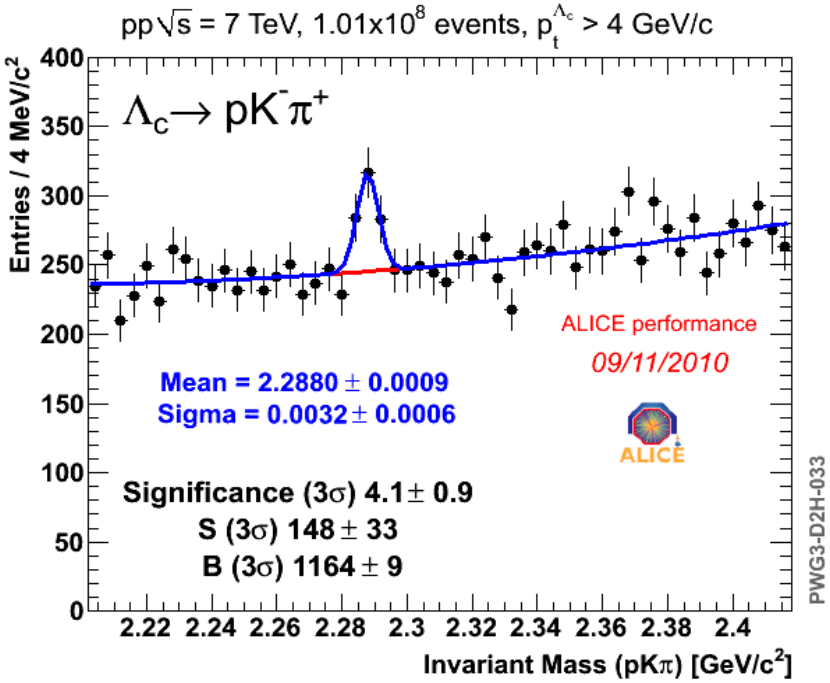
Outlook for D mesons analyses

Analyses ongoing, need more statistics

D_s



Λ_c

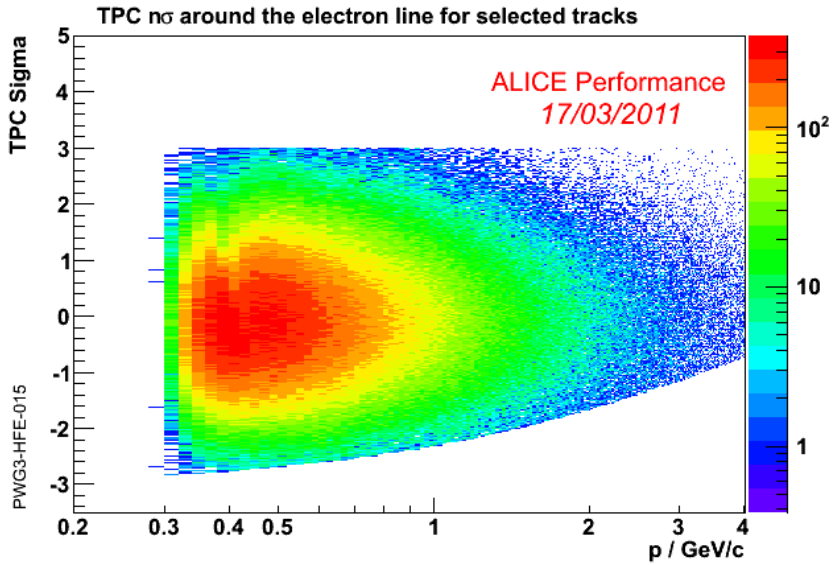


Electrons from c/b decay in p-p collisions at LHC

- About 1.25×10^8 events selected for this analysis (2.6 nb^{-1})

Analysis strategy:

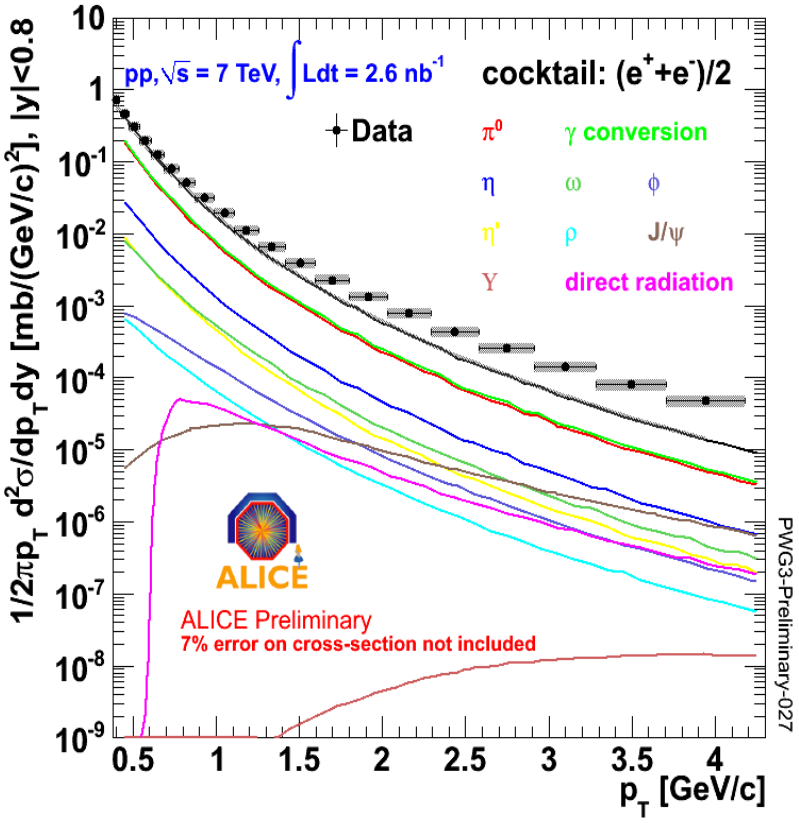
- *e* identification:
  - K and p rejection with TOF
  - *e* identification with TPC
- Correction for efficiency
  - tracking and acceptance via MC
  - *e* identification $\leftrightarrow$ conversion *e* used



Electrons cocktail

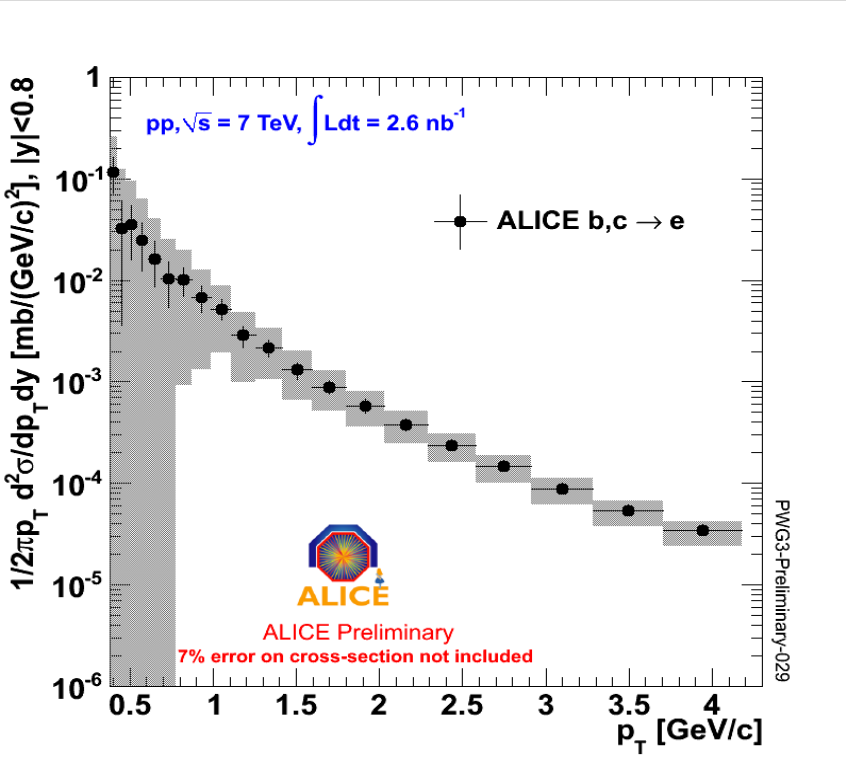
- Subtraction of the background via data-tuned MC cocktail
  - Photonic background from Dalitz decays of light neutral mesons (π^0 measured by ALICE, m_T scaling) and photon conversion
  - Non-photonic background from $K \to e\pi\nu$, dielectrons decays of light vector mesons and heavy quarkonia (J/ψ, Υ)

Inclusive e cross section and cocktail



Electrons from c/b decay cross section

Electrons from c/b decay x-section



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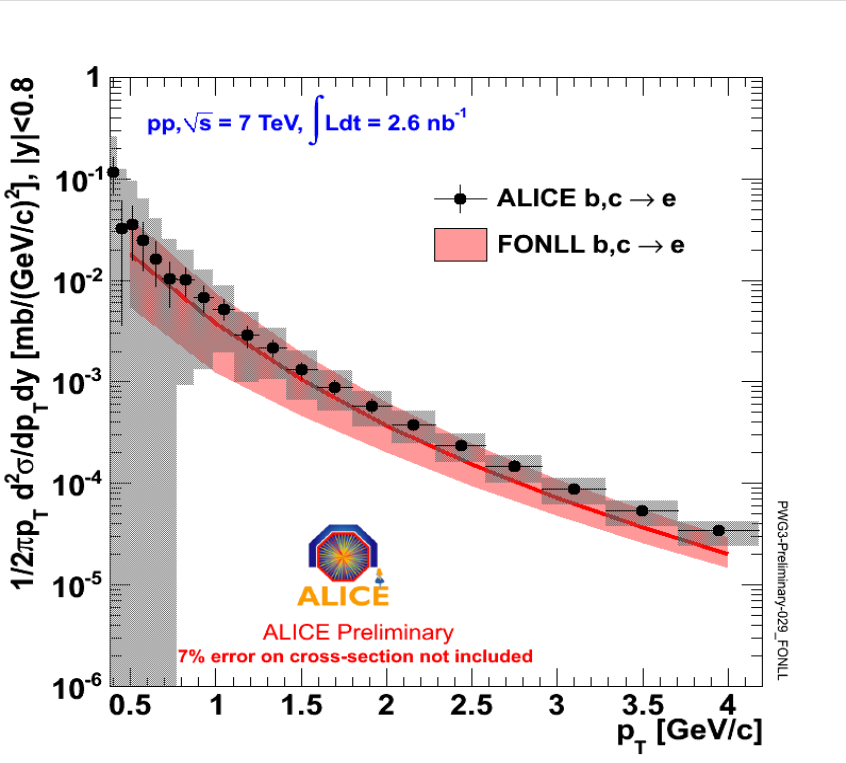

- FONLL calculation in agreement with measured cross section

Electrons from c/b decay cross section

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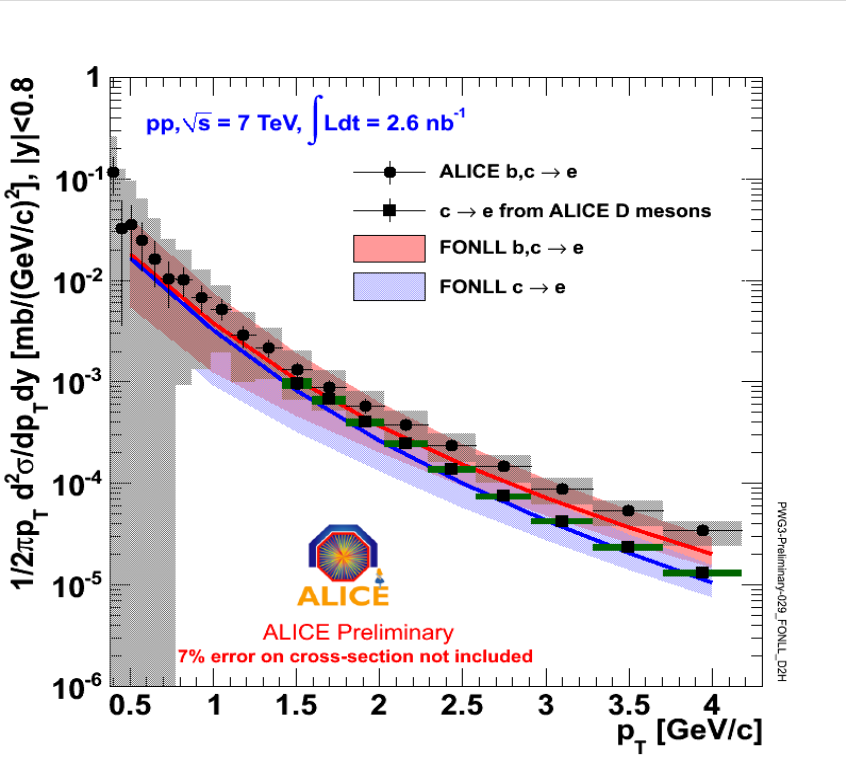
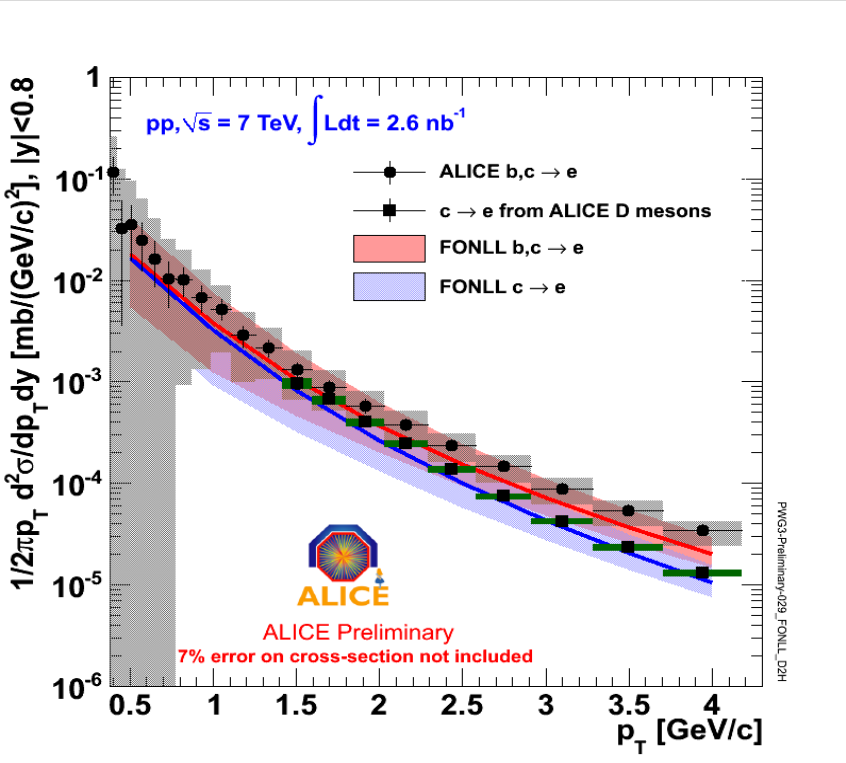


- FONLL calculation in agreement with measured cross section
- Comparison with $e \leftarrow c$ (using charm x-section measured by ALICE) in agreement where the c dominates the e spectrum, excess due to beauty at higher momentum

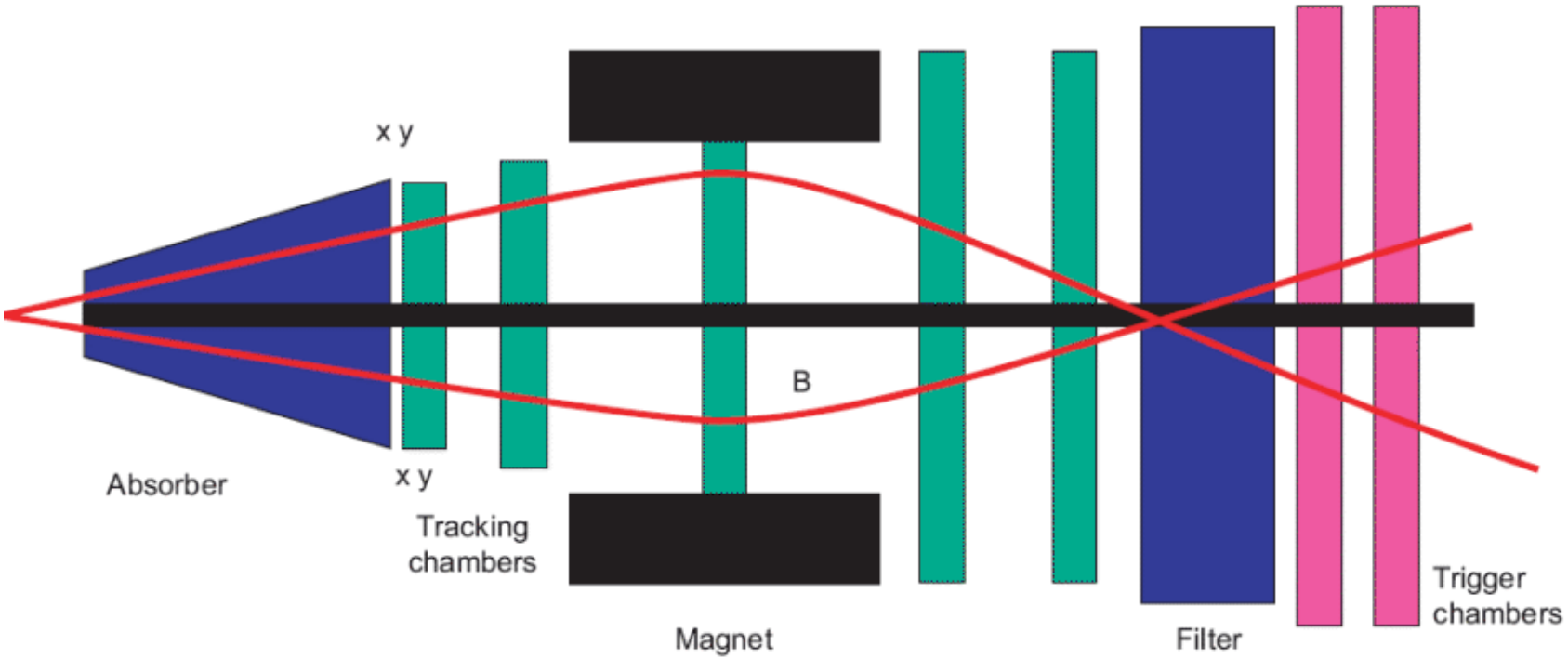
Electrons from c/b decay cross section

Electrons from c/b decay x-section



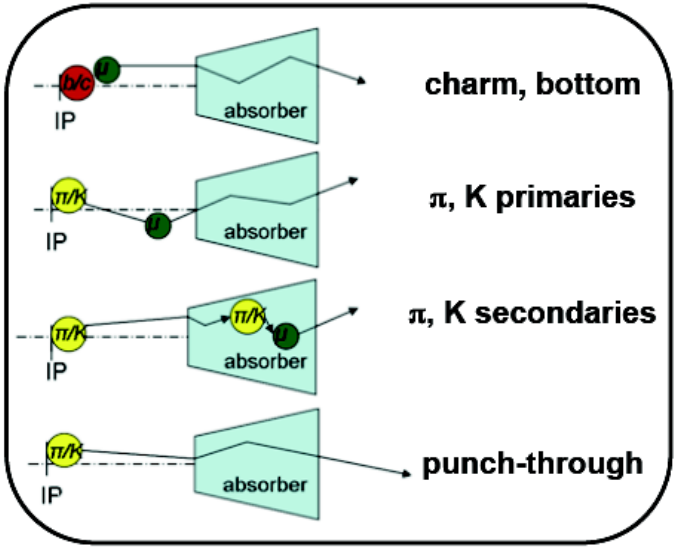
- FONLL calculation in agreement with measured cross section
- Comparison with $e \leftarrow$ c (using charm x-section measured by ALICE) in agreement where the c dominates the e spectrum, excess due to beauty at higher momentum
- Outlook: increase p_t reach with higher stat & TRD and EMCal for PID

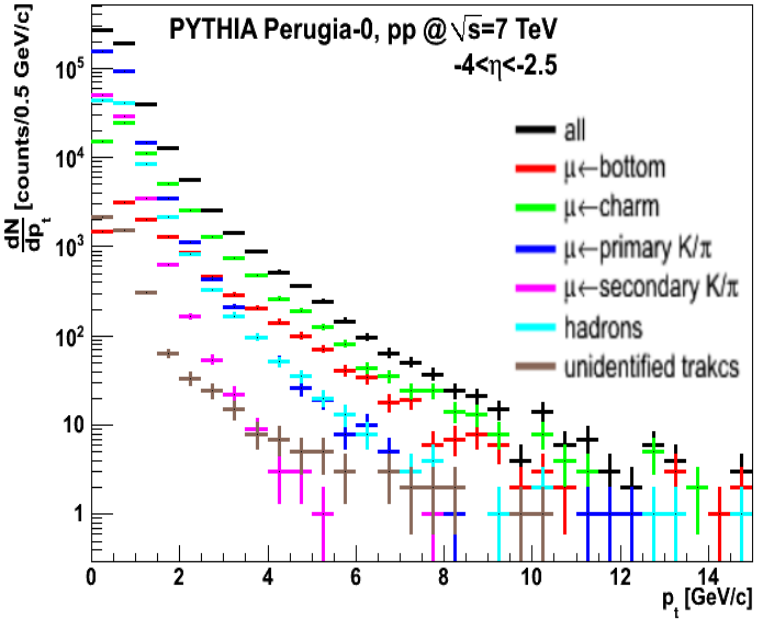
Heavy flavour in the ALICE muon spectrometer



- Rapidity coverage: $-4 < \eta < -2.5$
- Dataset:
  - $\sim 60 \times 10^6$ MB
  - $\sim 2 \times 10^6$ Muon trigger
  - integrated luminosity 3.49 nb^{-1}

Towards single-μ cross section

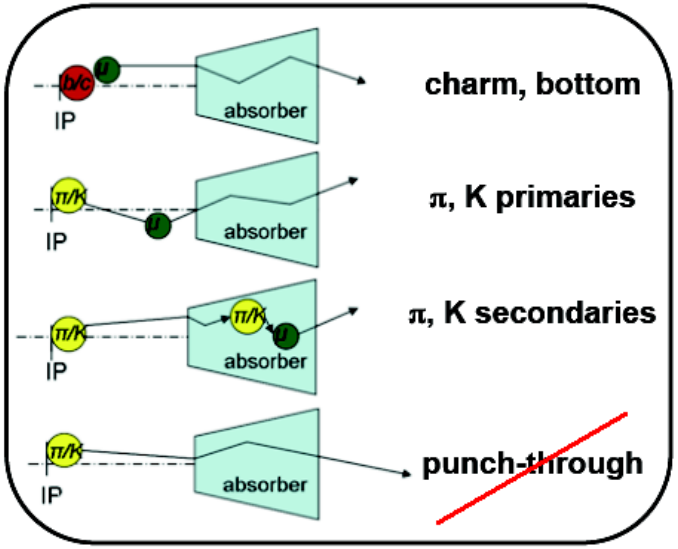


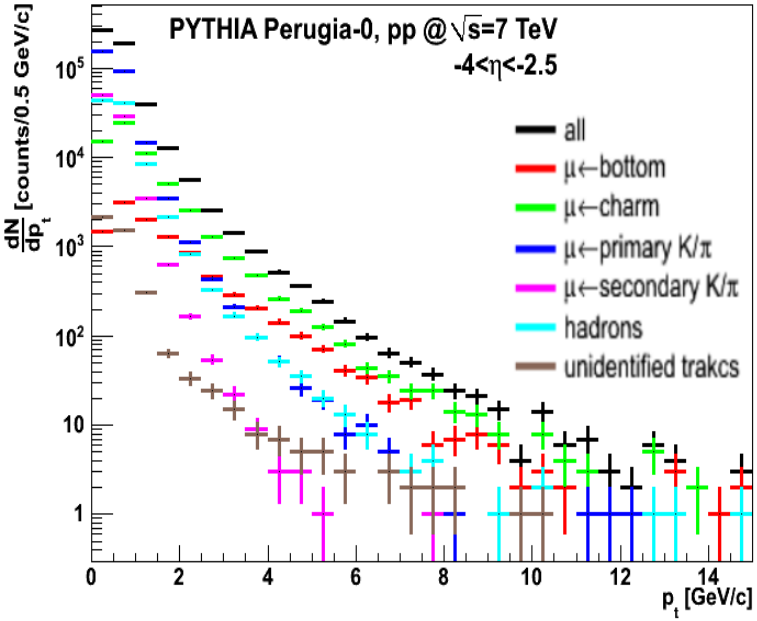


Background rejection:

- punch-through hadrons removed requiring match with trigger

Towards single-μ cross section





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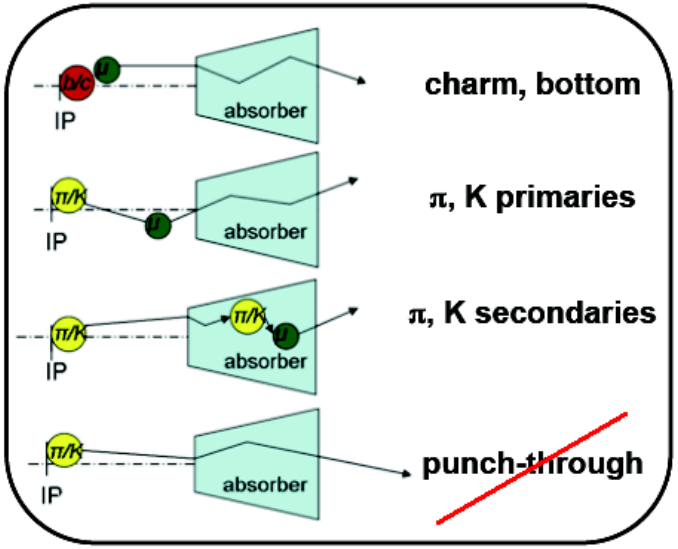

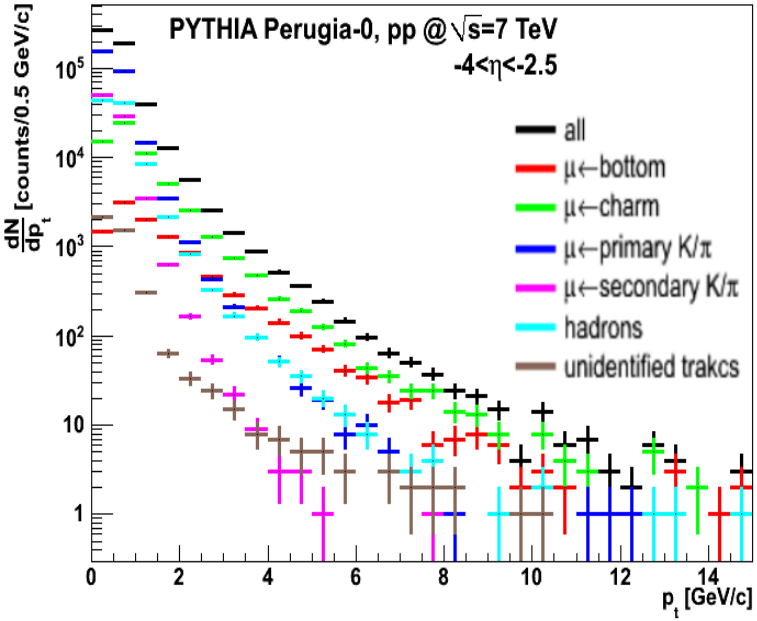

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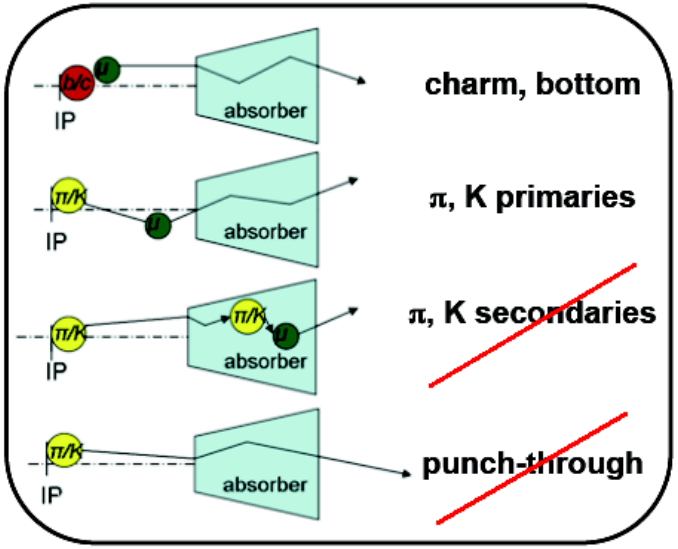
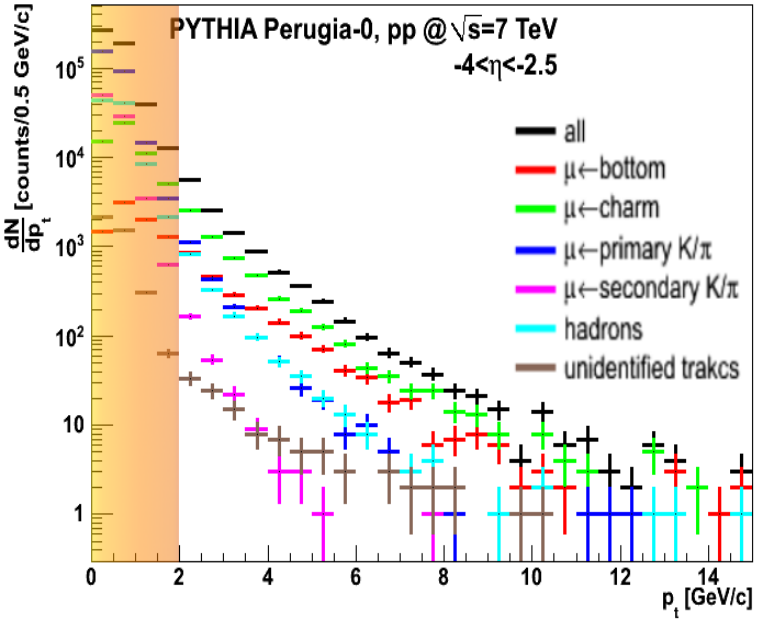
Towards single-μ cross section





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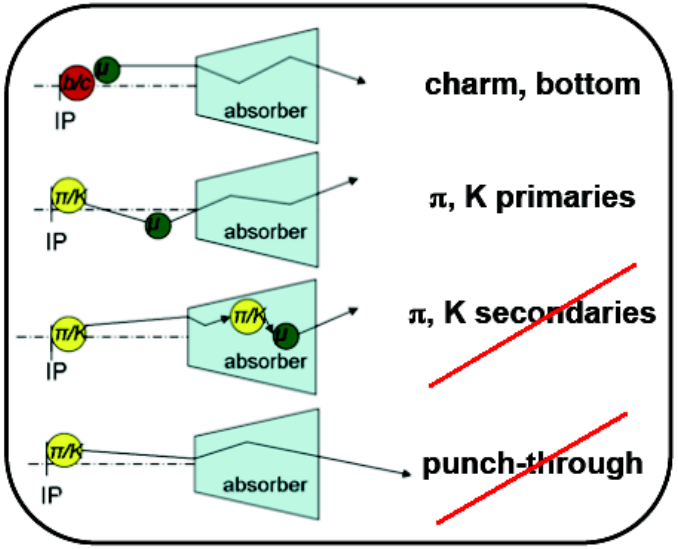

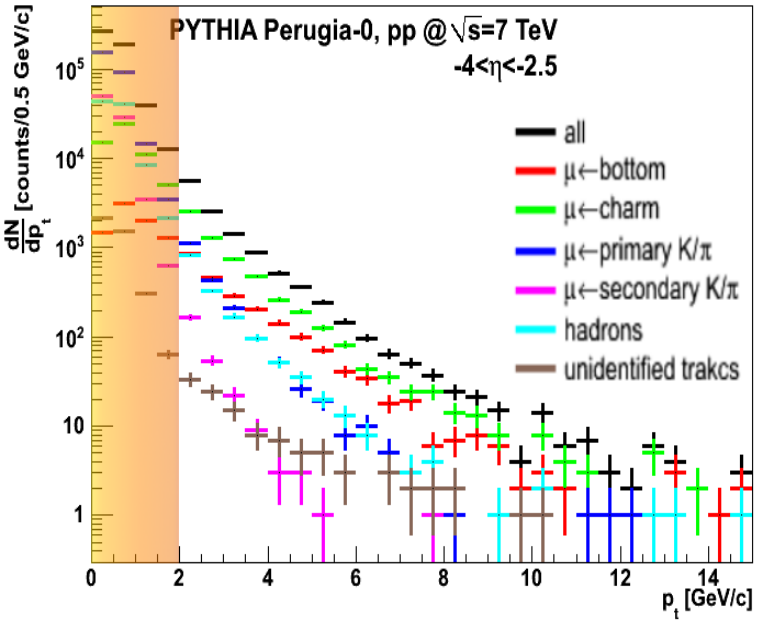

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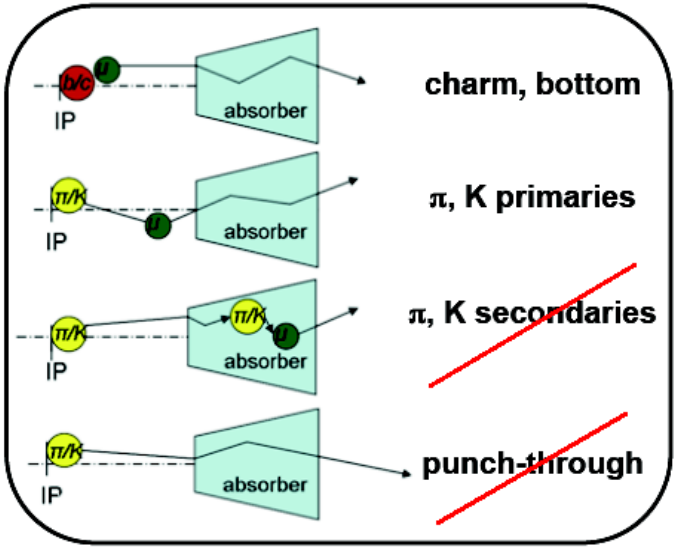
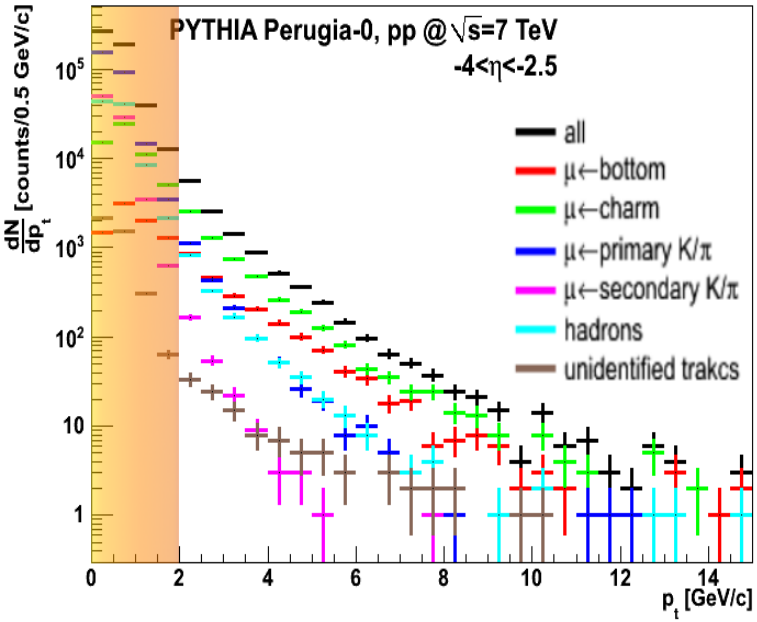
- primary μ: main source of bkg, subtracted using MC:
  - $\rightsquigarrow$ $R^{MC}(\eta) = N^{\mu}_{primary}/N^{\mu}_{total}$ at low p_t (were primaries dominate)

Towards single-μ cross section





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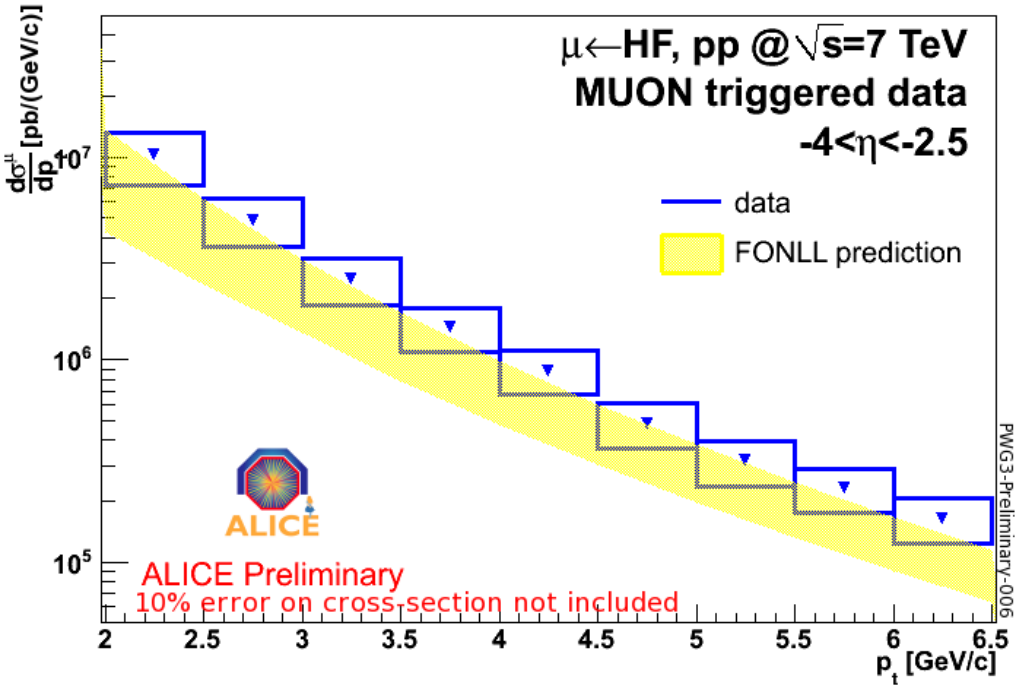
Correction for

- efficiency, acceptance (80%), pileup rejection

$c/b \rightarrow$ single-μ cross section in p-p



- $c/b \rightarrow \mu + X$ cross section measured in the $2 < p_t < 6.5$ GeV/c and $-4 < \eta < -2.5$
- FONLL prediction in agreement with data

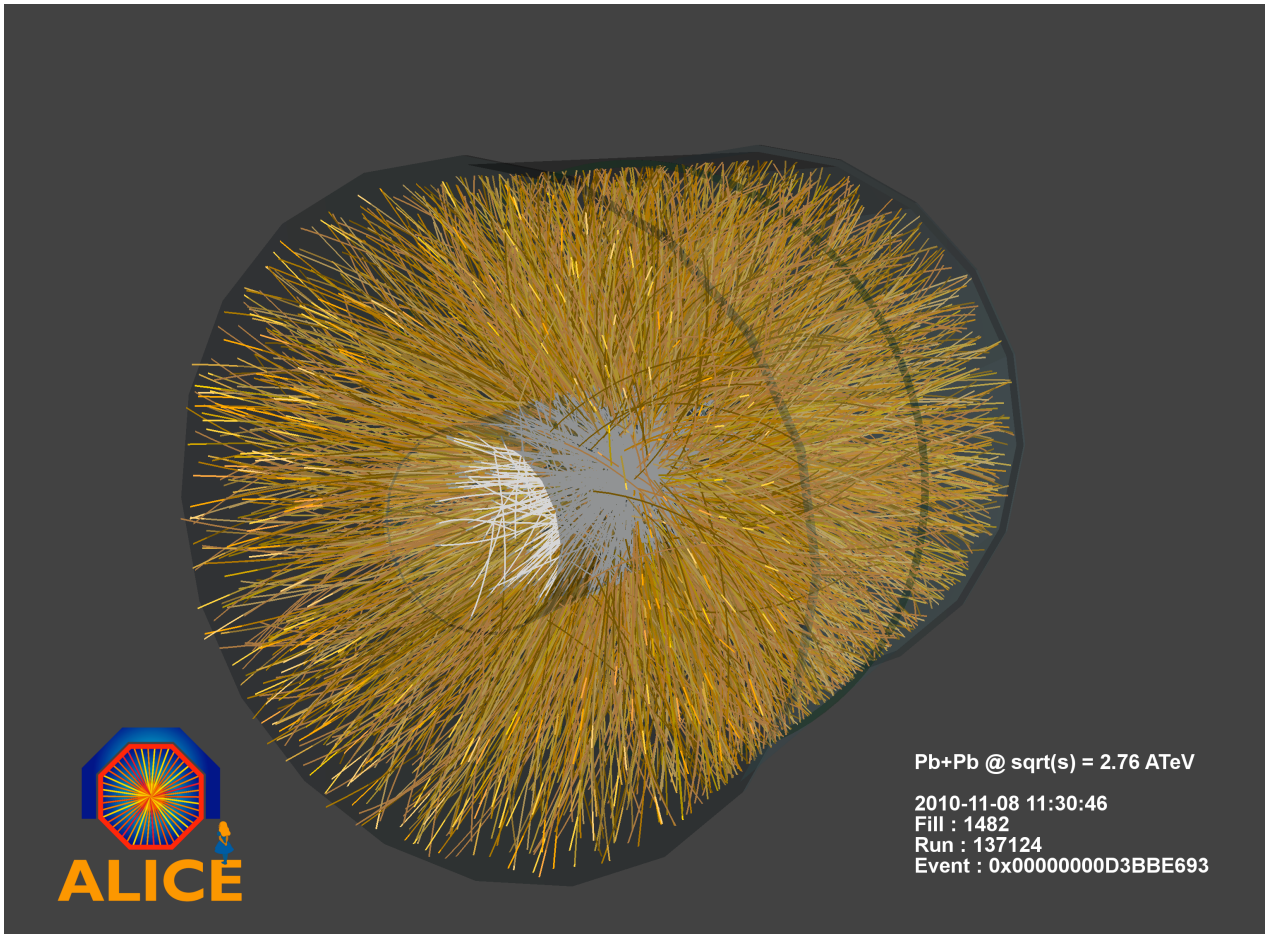
- Extension to $p_t \sim 15$ GeV/c and rapidity distribution very soon!

Conclusions and outlook

- ☑ The ALICE experiment provided measurements of open heavy flavour differential cross section in p-p collisions at $\sqrt{s} = 7$ TeV in the following channels:
  - ✓ D mesons at mid-rapidity
  - ✓ $c/b \rightarrow e + X$ at mid-rapidity
  - ✓ $c/b \rightarrow \mu + X$ at forward rapidity
- ☐ The analysis of the full 2010 sample is being completed, improvements expected!
  - ☐ More p_t bins for D_s and Λ_c
  - ☐ Wider momentum ranges for all the analyses
  - ☐ Higher statistics

Outlook for PbPb

- ☑ PbPb collisions at $\sqrt{s}$ = 2.76 TeV
  - ⋆ dNch/dy=1600 in central collisions



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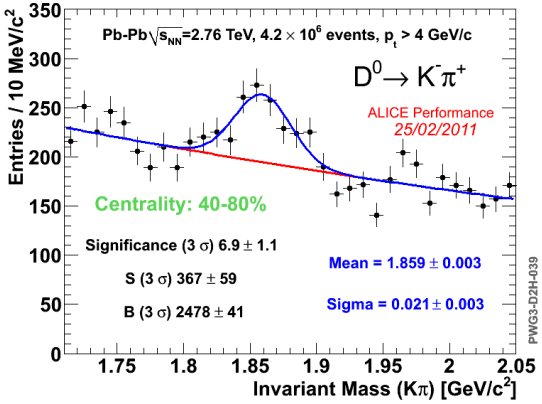
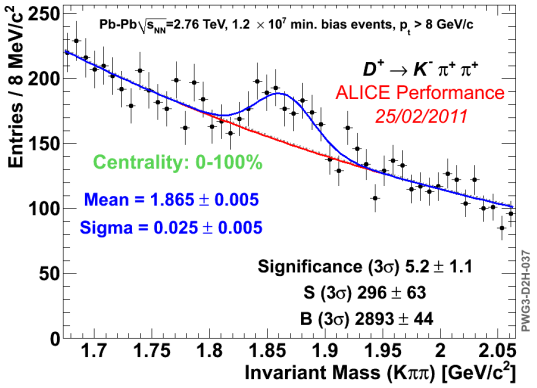
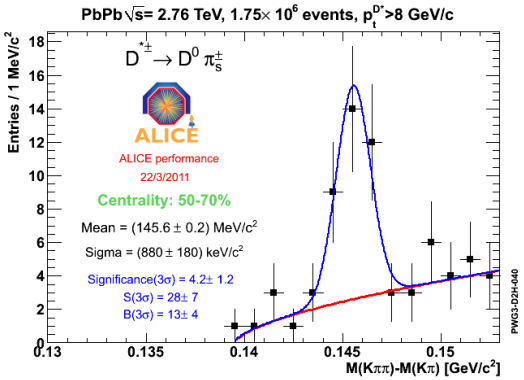


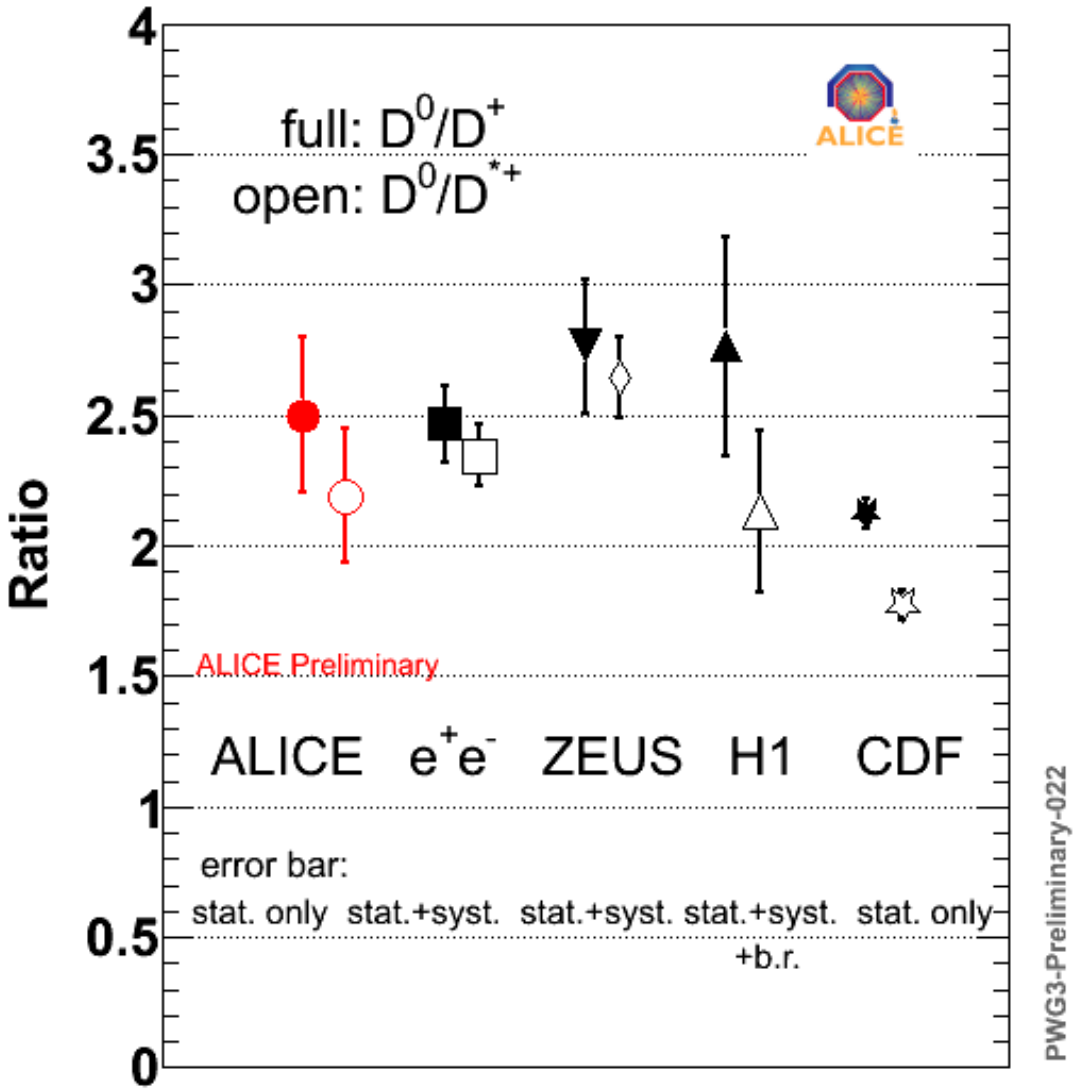




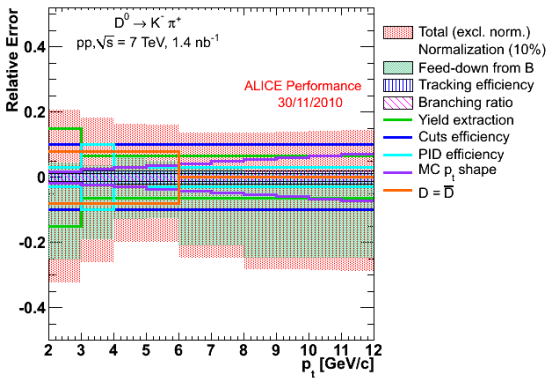
- ☑ Observed signals of D, analysis in progress
- ☑ single-μ and e from c and b analyses well advanced
- ☐ Looking forward for R_{AA} and v_2 studies with HF!

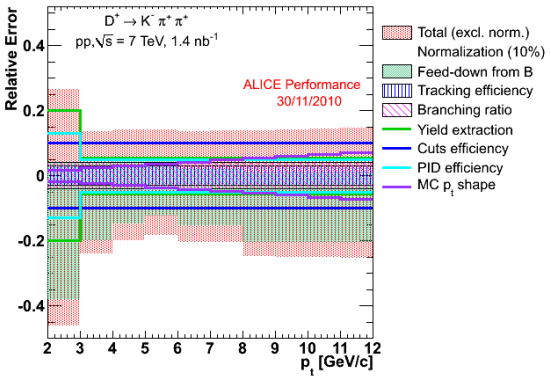
Thanks!

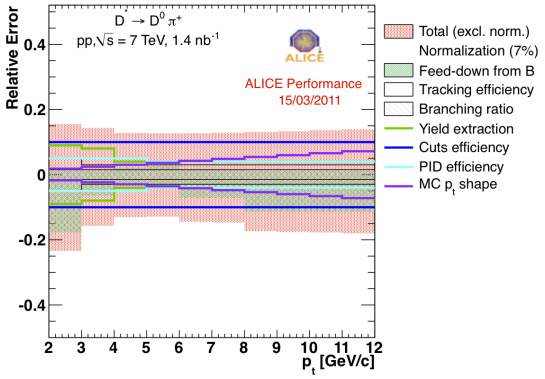
D mesons ratio

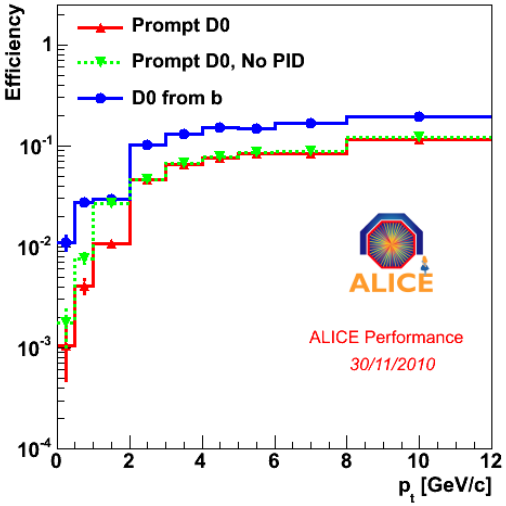


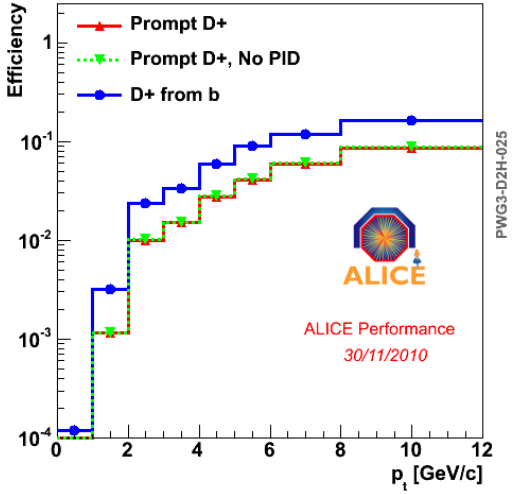
D mesons: systematic error and efficiency

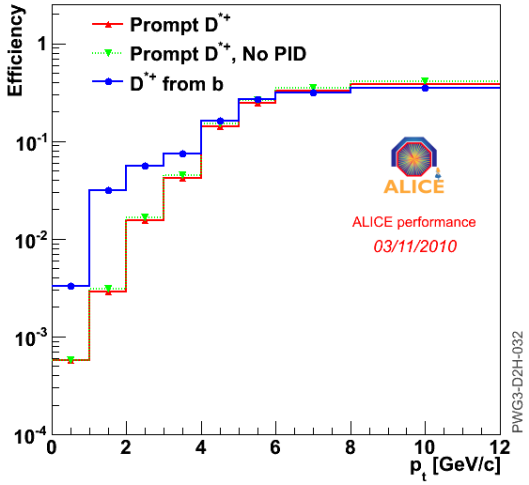






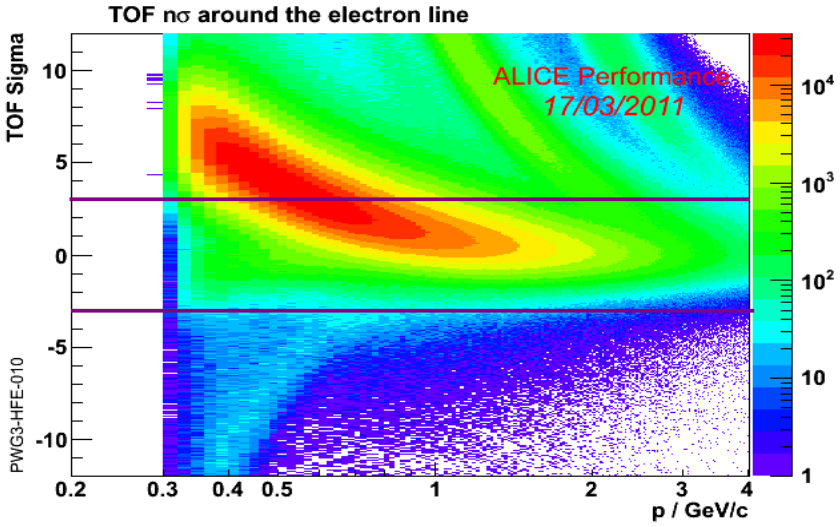




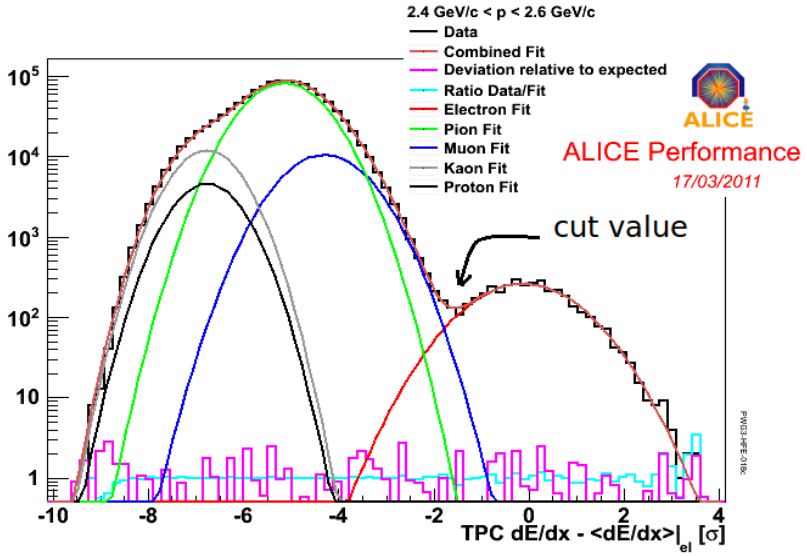


Electron identification

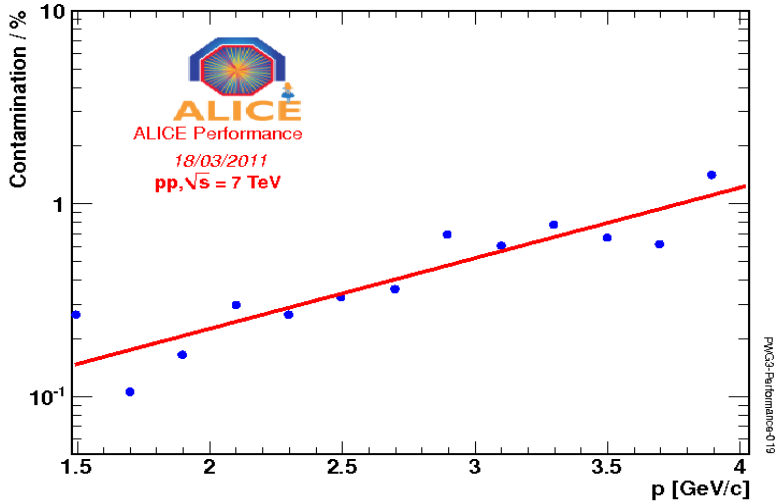
Cut around the e band for TOF



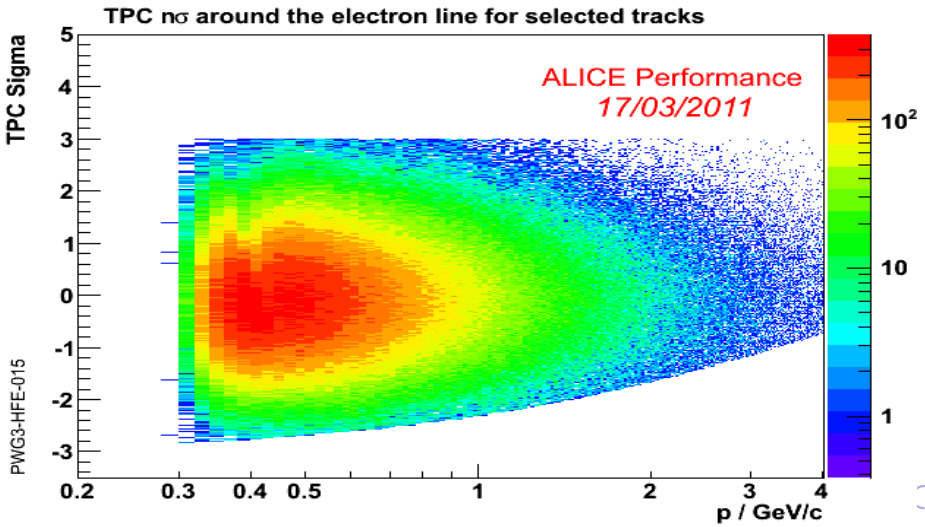
TPC dE/dx slice and fit



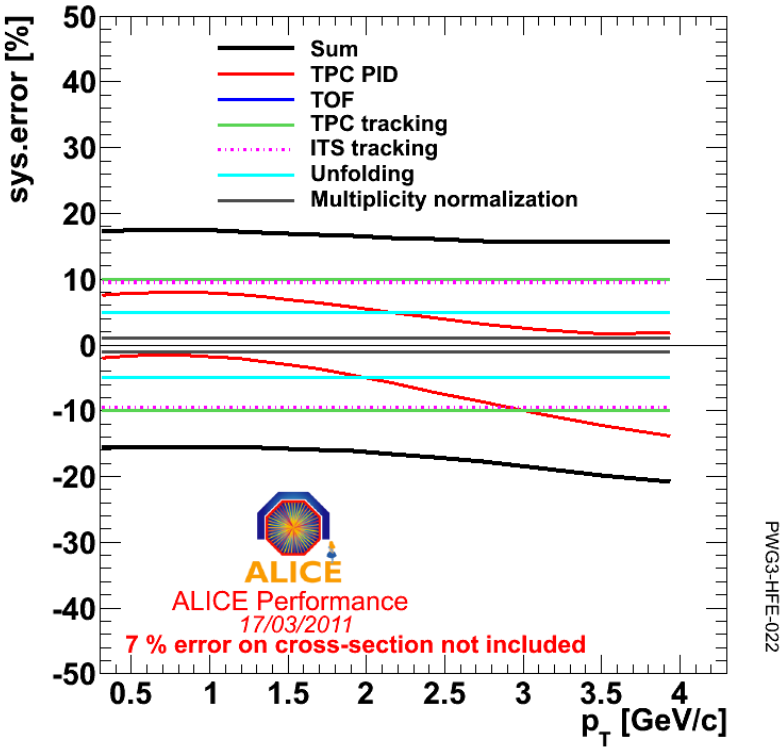
Residual hadron contamination

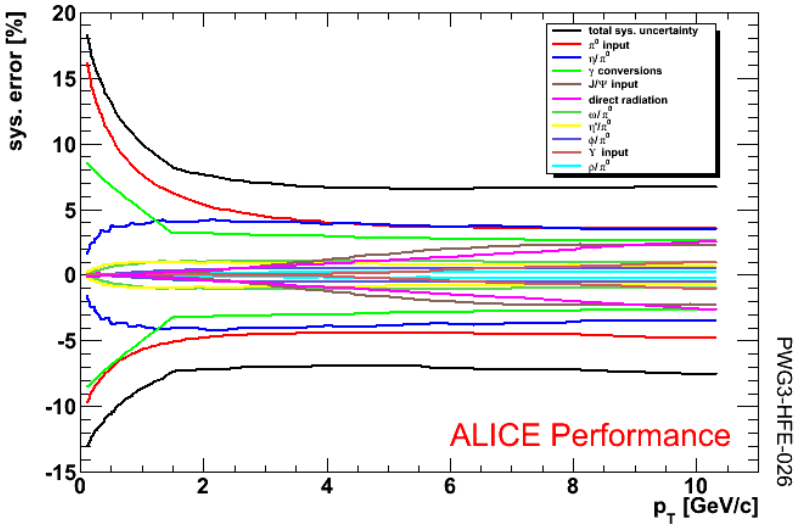


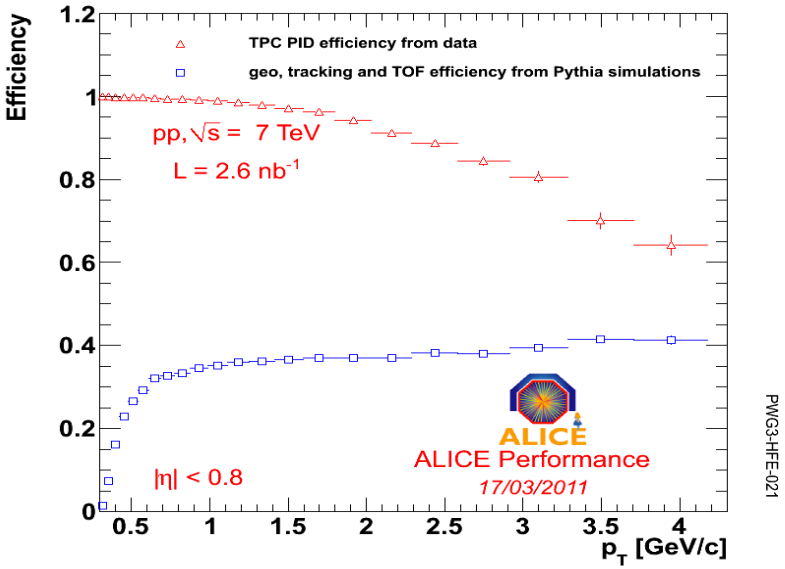
Selected electrons

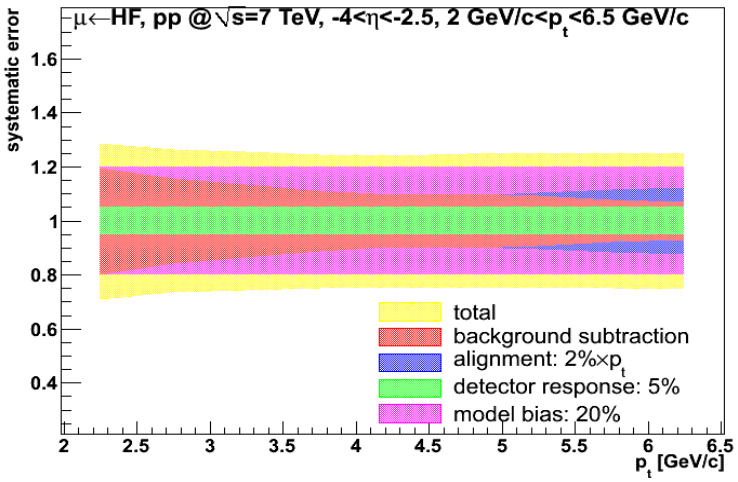
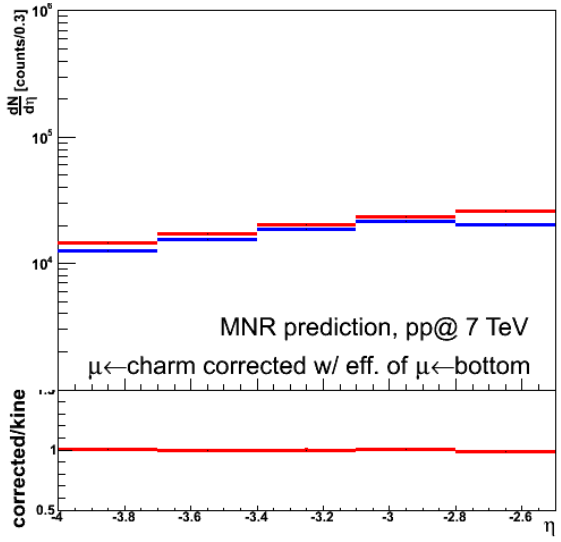
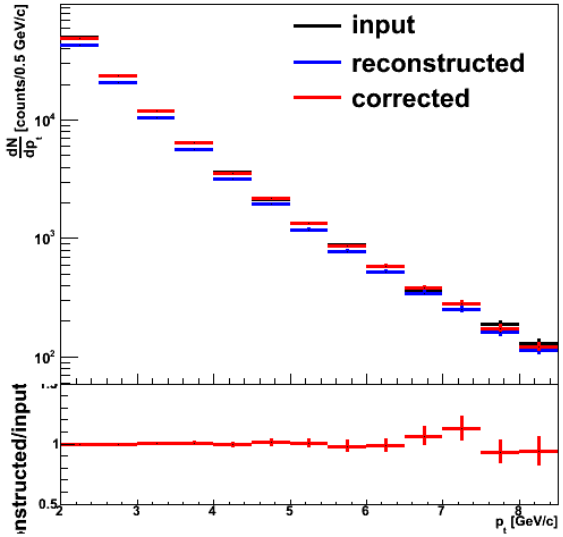


Electrons: systematic error and efficiency







Muons: systematic error and efficiency

$$\frac{d^2\sigma^{\mu\leftarrow HF}}{dp_t d\eta} = \frac{1}{N_{ev}} \times \frac{N_{MB}^{total\mu}}{N_{MU}^{total\mu}} \times \frac{1}{\epsilon \cdot pileup} \times \frac{d^2 N_{MU}^{\mu\leftarrow HF}}{dp_t d\eta} \times \sigma^{MB}$$