Study of semileptonic B decays with the Central Barrel

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for ALICE Padova

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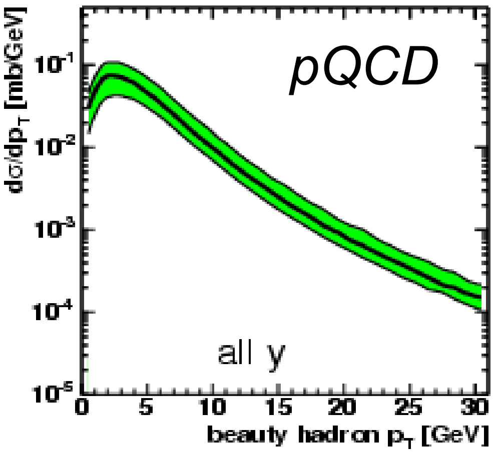
- **Outline of a possible analysis**
- **Results**
- **Extra:** ***a topological approach*** **(by J. Faivre)**
- **Conclusions**

Why beauty?

Important test of pQCD in a new energy domain

Theoretical uncertainty on beauty cross section of a factor ~2

HERA-LHC Workshop Proceedings using: Mangano, Nason, Ridolfi, NPB373 (1992) 295



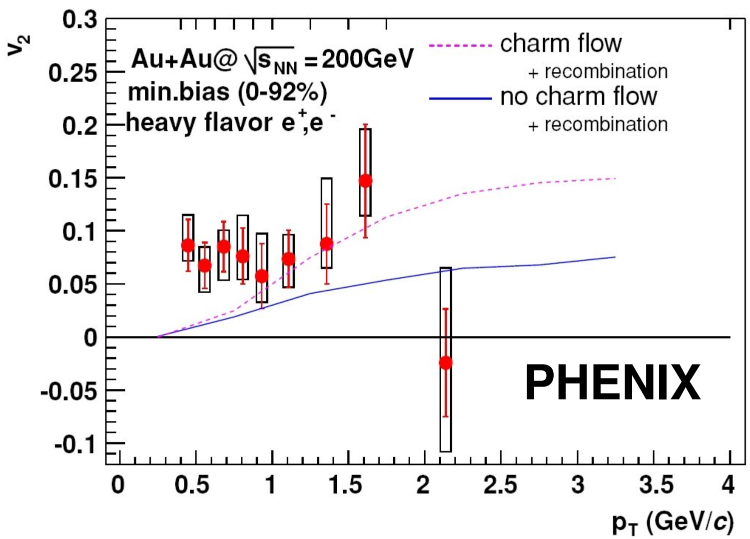
Beauty as a probe for the medium

- Interacts through parton energy loss
- Energy loss depends on: flavour charge, mass and a medium transport coeficient

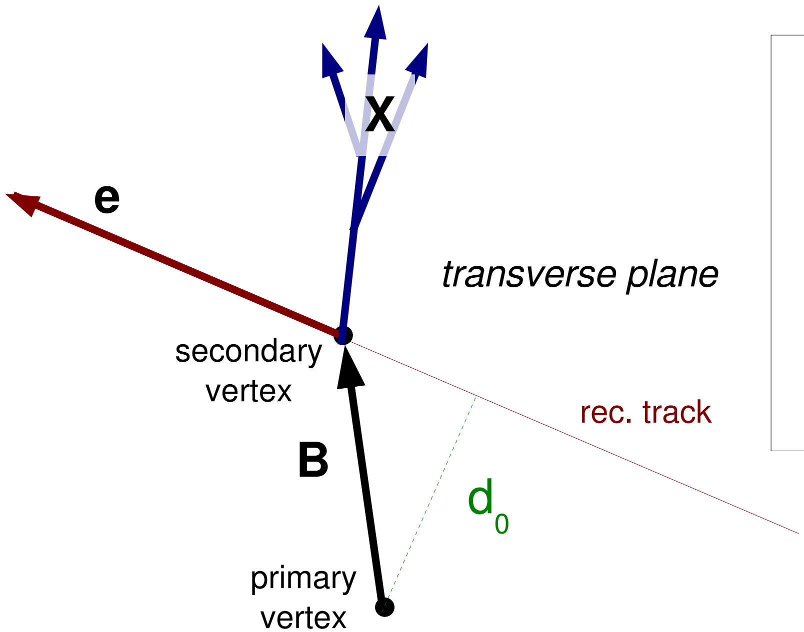
$$R_{AA}^{D,B}(p_t) = \frac{1}{N_{coll}} \times \frac{dN_{AA}^{D,B}/dp_t}{dN_{pp}^{D,B}/dp_t}$$

Elliptic flow for beauty:

- At low-medium p_t: it's a test for the initial thermalization
- At high p_t: it's a test for the medium density (again through energy loss)



Beauty in the Central Barrel



Semi-electronic channel

$B \rightarrow e + X$

Branching Ratio

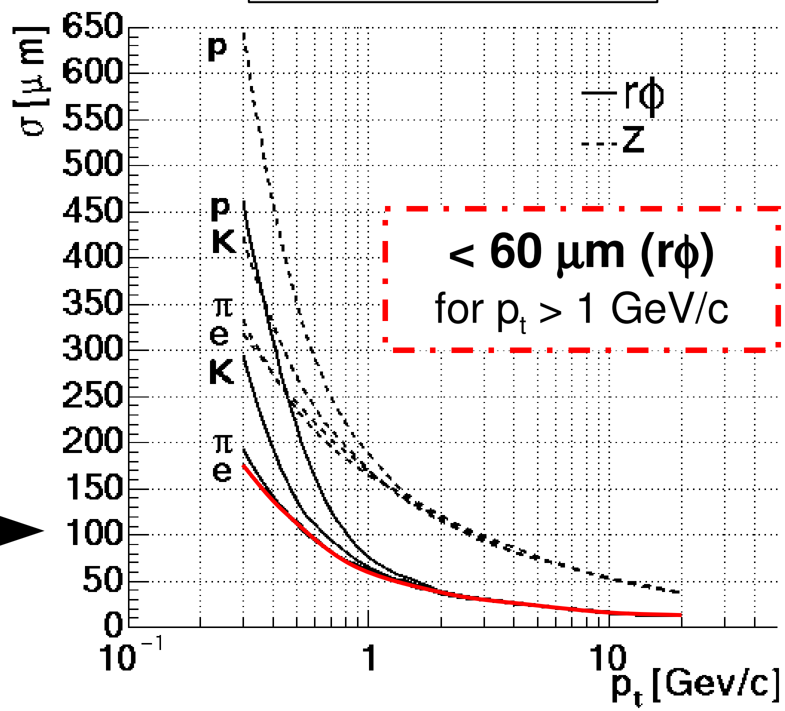
11% from $b \rightarrow B \rightarrow e+X$

+10% from $b \rightarrow B \rightarrow D \rightarrow e+X$

$c\tau$ D^0 123 μm

$c\tau$ B ~500 μm

Resolution for d_0



Collision	pp (14 TeV)		PbPb (5.5 TeV)	
Product	b-bbar pairs	B-mesons with an electron in acceptance	b-bbar pairs	B-mesons with an electron in acceptance
Yield	0.0072	0.00076	4.56	0.48

ITS: for vertexing

TPC: for tracking and PID

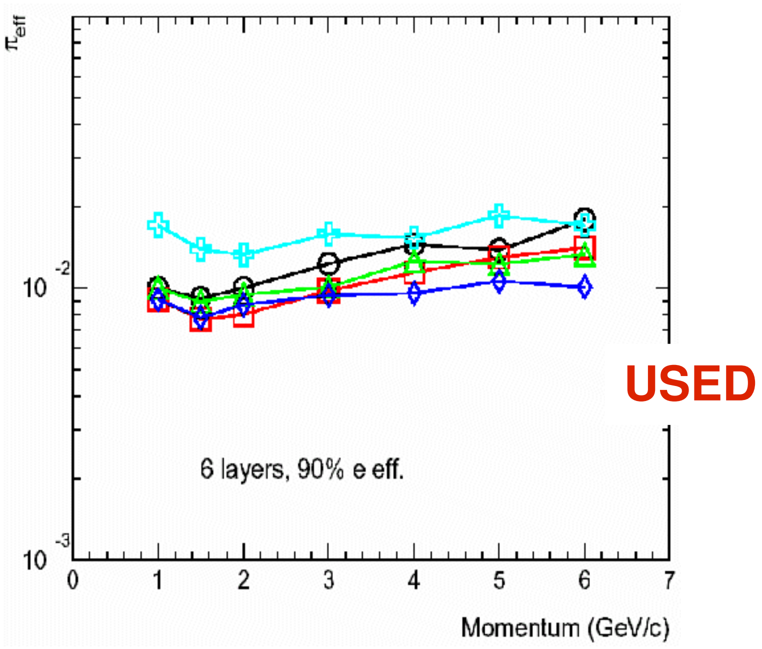
TRD: for π/e separation

Technicalities

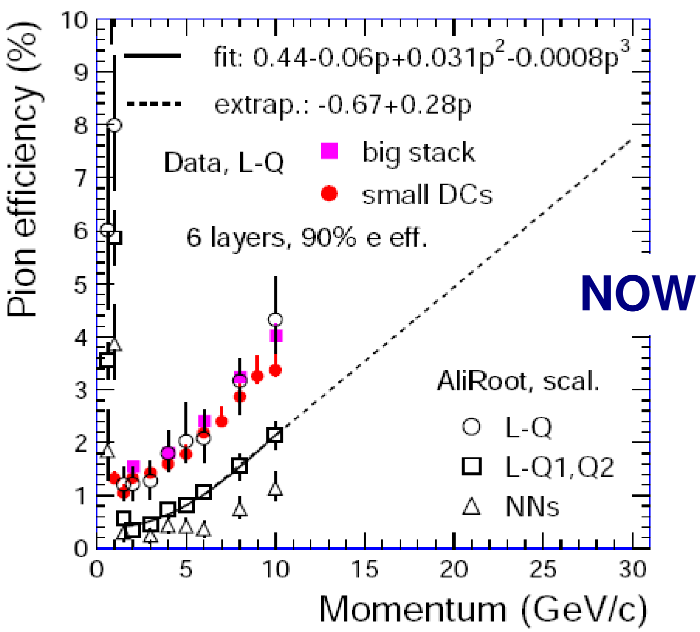
- Simulations based on Pythia + Heavy Flavours tuned on MNR* calculations
- ITS: assumed perfect alignment
- TPC: old track reco. algo. (now it is more efficent)
- TRD: old pion rejection

*MNR code: Mangano, Nason, Ridolfi, NPB373 (1992) 295.

Eff: 1 (%)



Eff: -0.67 + 0.28p (%)



S. Masciocchi, PWG3 October 2007

Beauty signal

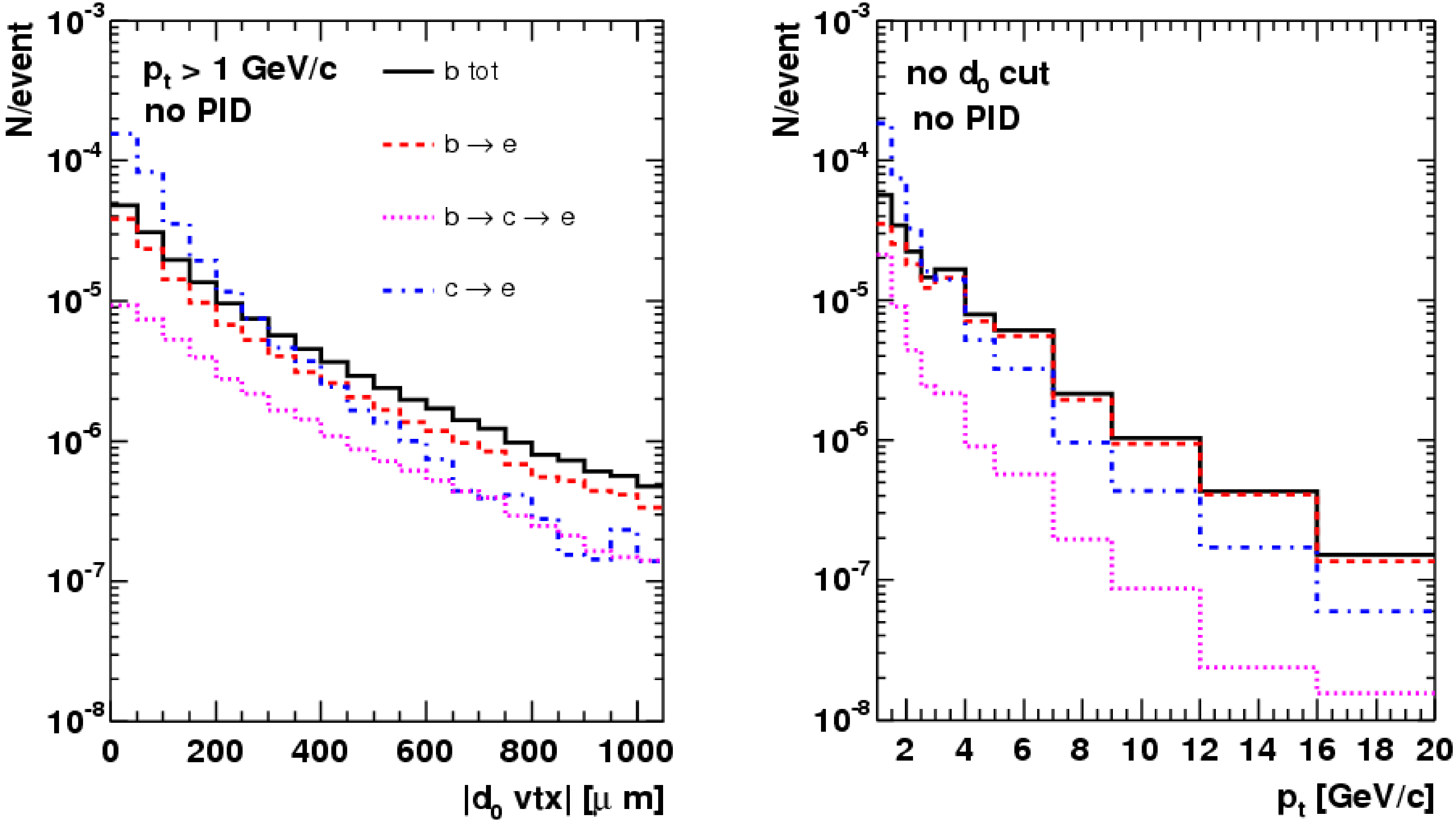
Heavy-quark decays:

- b→B→e
- b→B→D→e
- c→D→e

} **beauty**

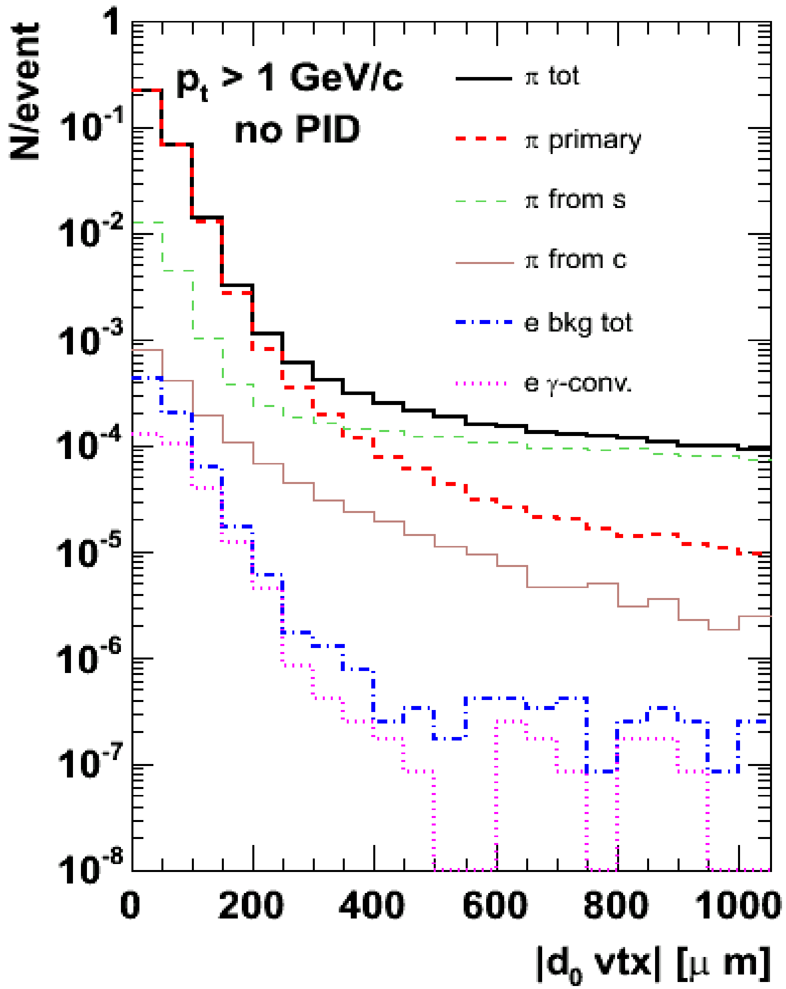
} **charm** (background)

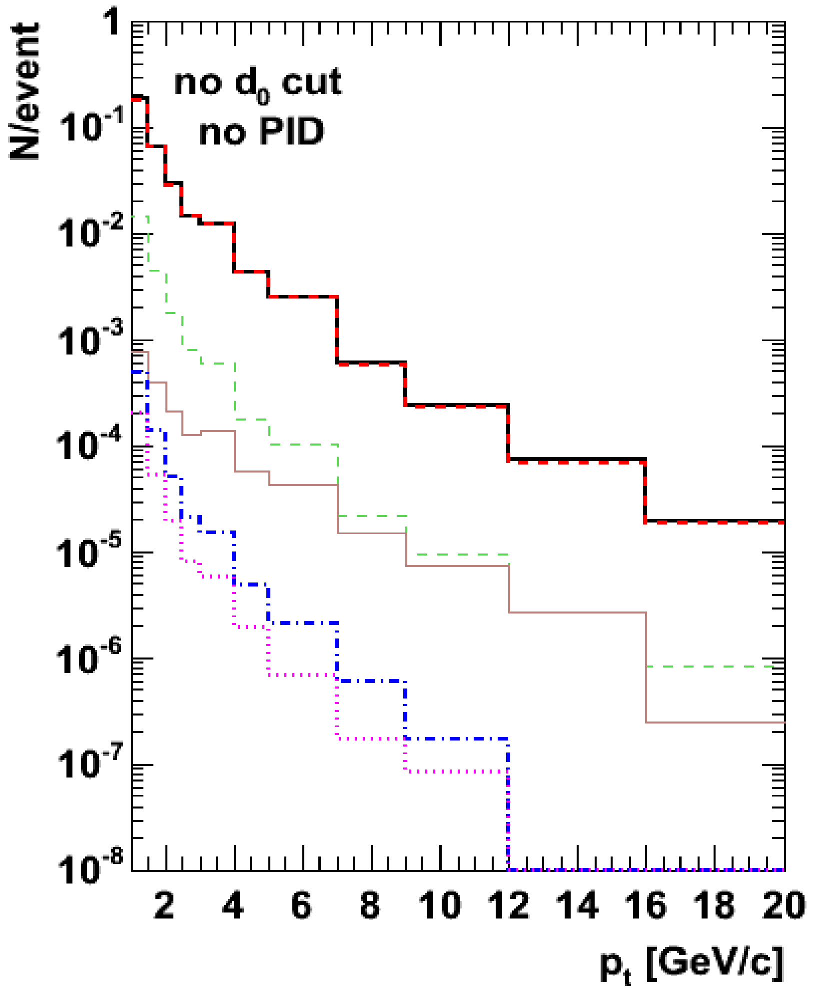
p-p at 14 TeV



Background sources

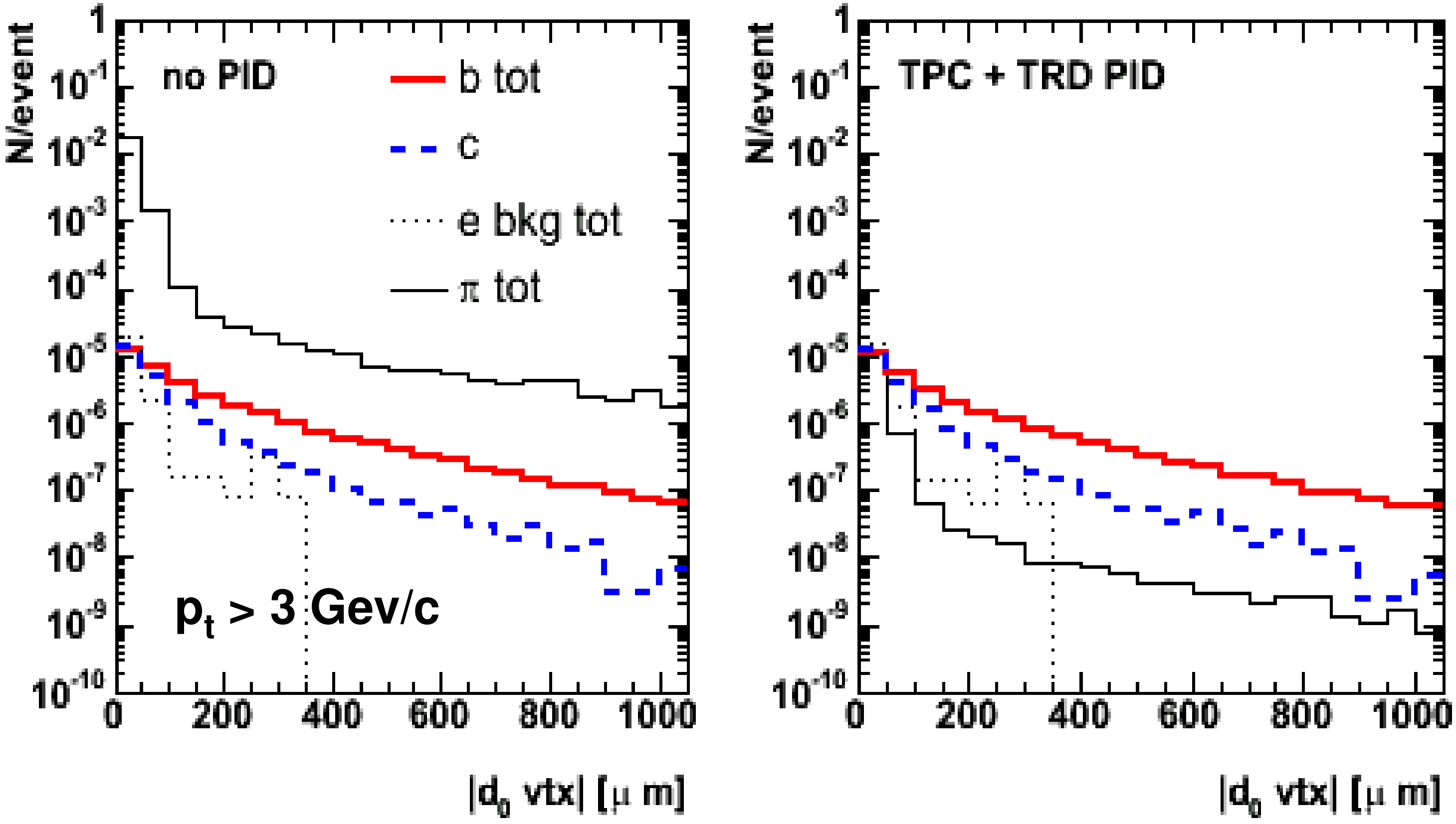
1. **Charged Pions** mis-identified as electrons
2. Photon conversions ($\gamma \rightarrow e^+e^-$) in the beam pipe and inner layers
3. Decays of light mesons and Dalitz decays (mostly π^0)





Selection strategy

Electron Identification (TPC+TRD)
(separation between e/π)



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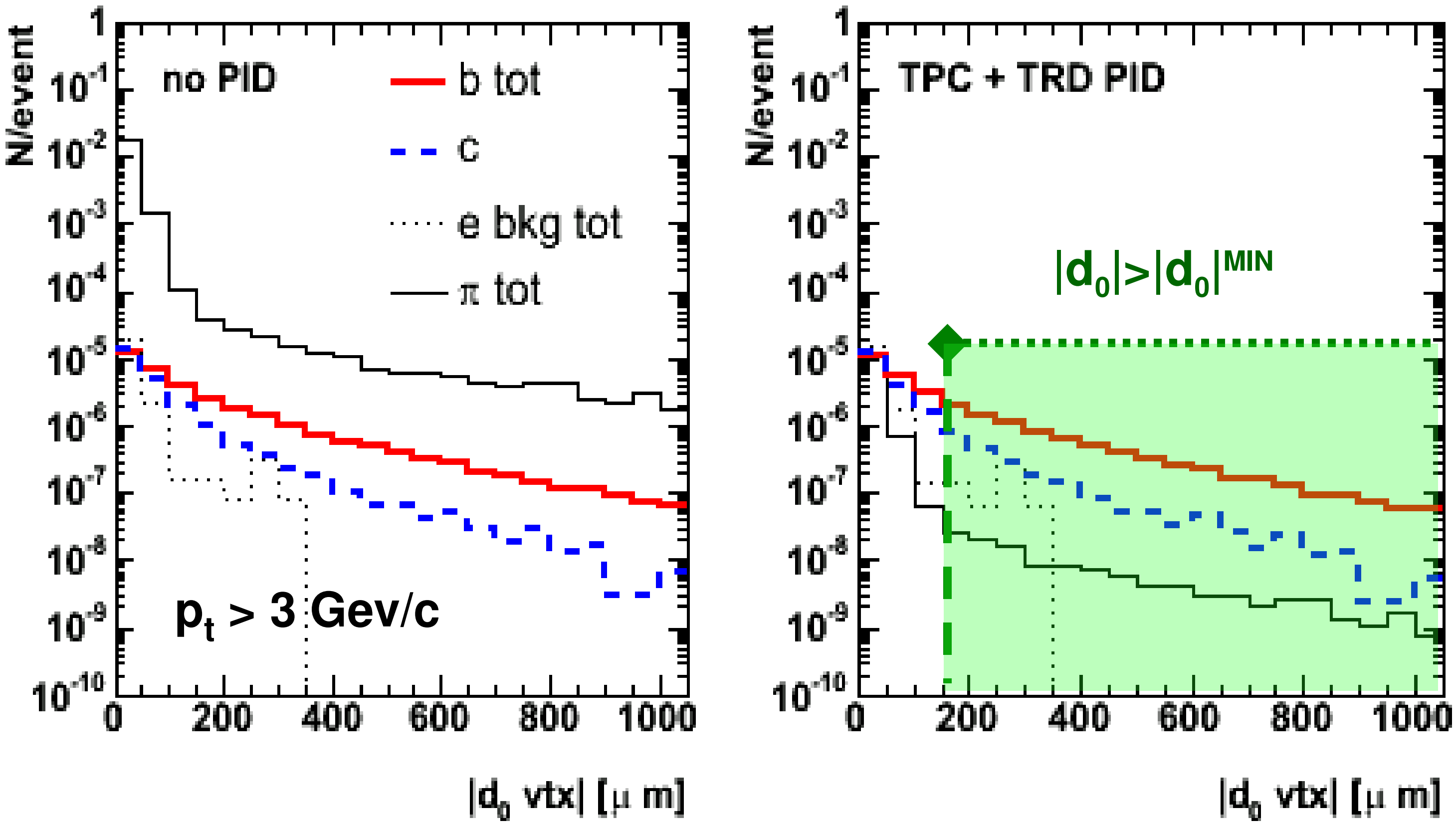

Kinematical Cuts
(in d_0 according to the p_t bin)

Selection strategy

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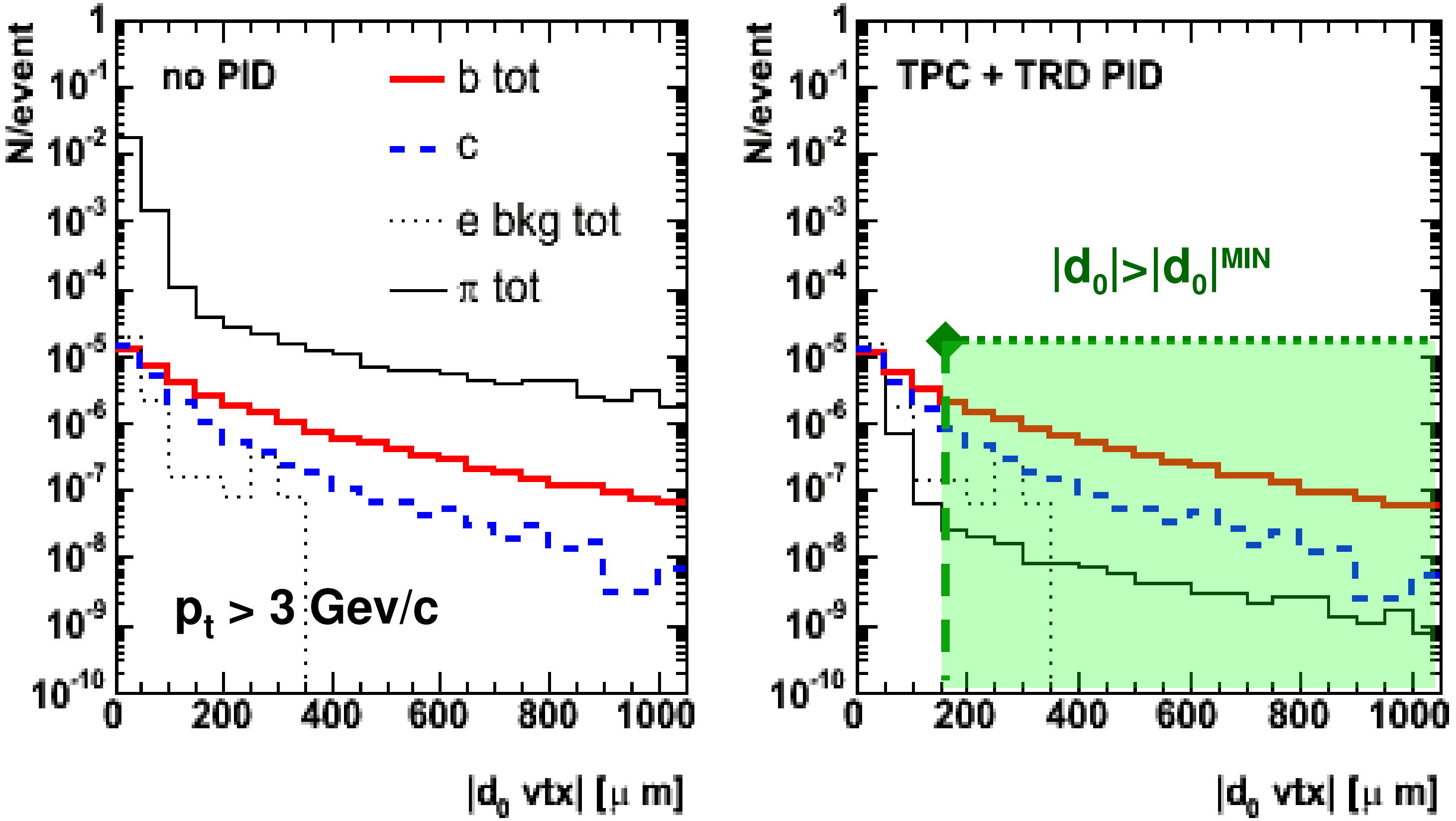


Kinematical Cuts
(in d_0 according to the p_t bin)

Subtraction of residual background
(small)

Recipe

In a given p_t-bin we get N "electrons": $N = N_b + N_c + N_{bkg}$

1. We subtract the contribution from charm: $N - N_c$

Charm calculated from D^0 measurement

2. We subtract the contribution from background: $N_b = (N - N_c) - N_{bkg}$

Estimated from measured pions dN/dp_t plus MC (including conversions)

3. We correct for acceptance/efficiency: $dN_b^{corr}/dy = (N_b / \varepsilon)$

Calculated with MC techniques

4. We multiply by the inelastic pp cross section: $d\sigma_e/dy = \sigma_{pp} \cdot dN_b^{corr}/dy$

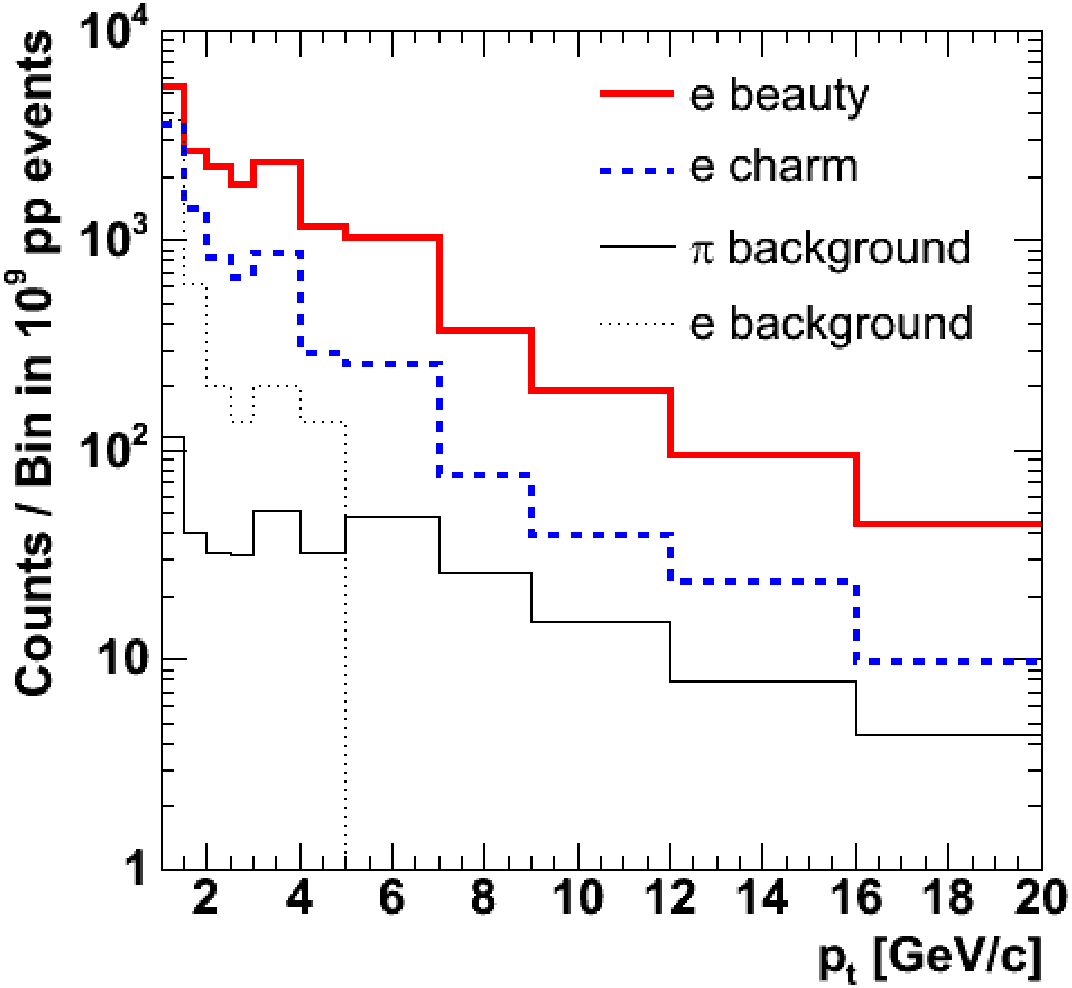
Cross section measured at LHC

Statistics (p-p)

p_t bin [GeV/c]	$\lvert d_0 \rvert$ cut [μm]
1.0 – 1.5	400
1.5 – 2.0	400
2.0 – 2.5	300
2.5 – 3.0	200
3.0 – 4.0	150
4.0 – 5.0	150
5.0 – 7.0	100
7.0 – 9.0	100
9.0 – 12.0	100
12.0 – 16.0	50
16.0 – 20.0	50

10^9 pp events

(1 year of nominal ALICE luminosity)

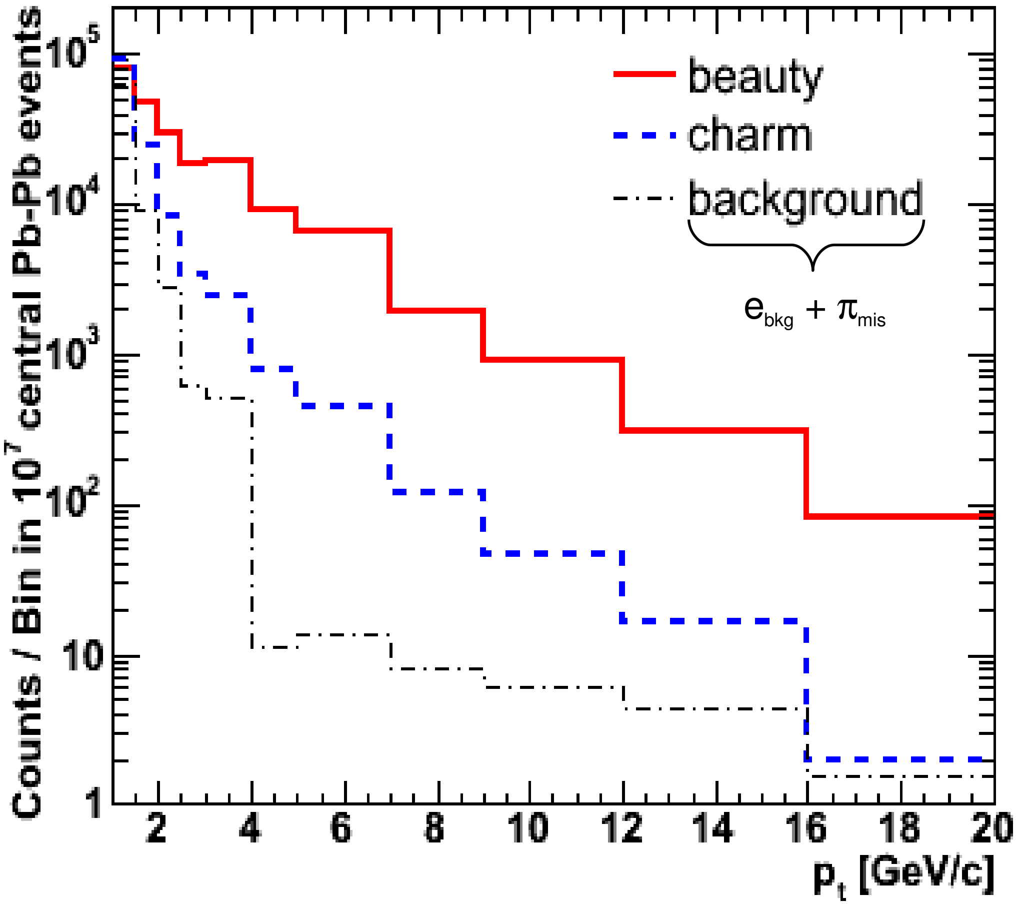


Statistics (Pb-Pb)

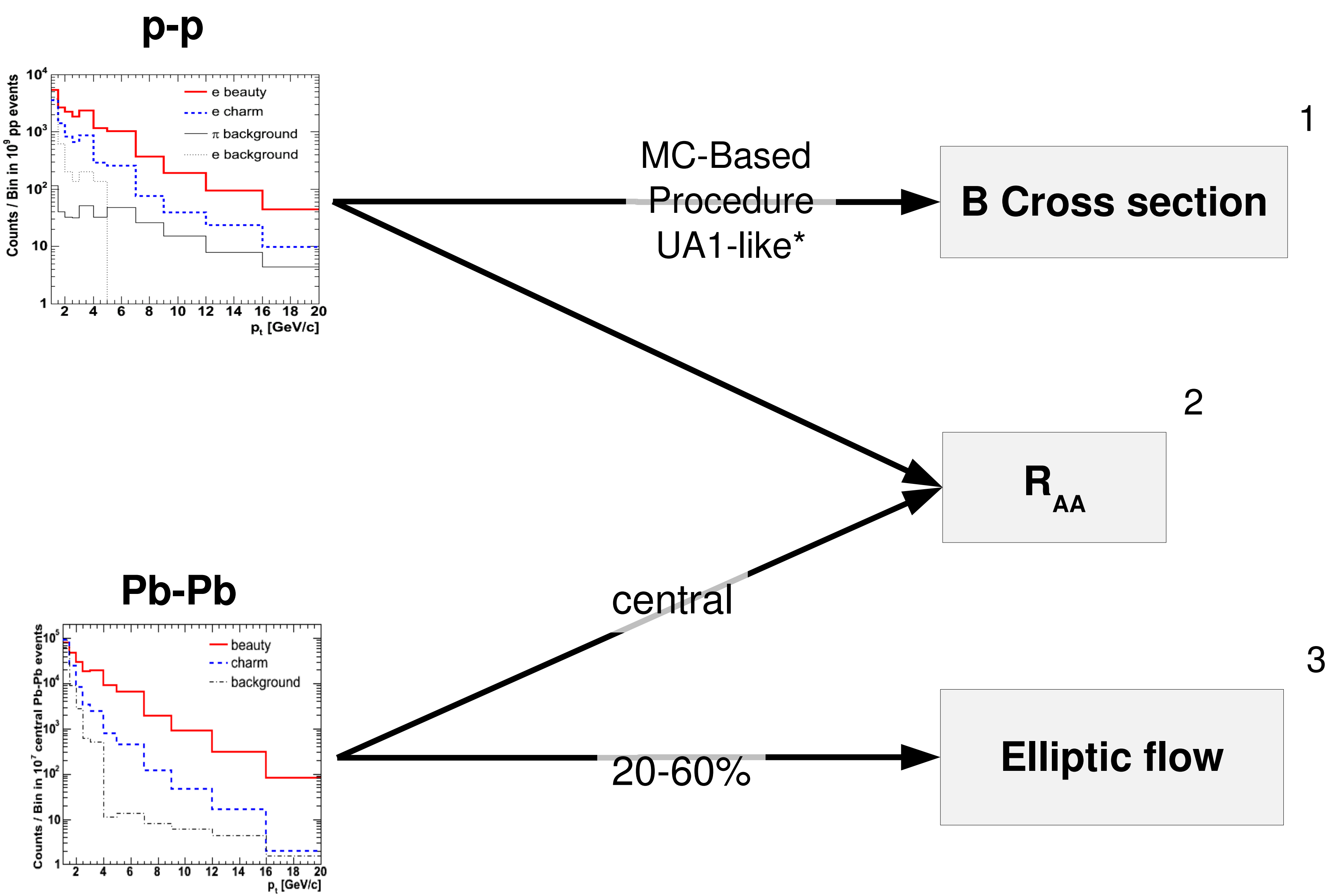
p_t bin [GeV/c]	$\|d_0\|$ cut [μm]
1.0 – 1.5	200
1.5 – 2.0	200
2.0 – 2.5	200
2.5 – 3.0	200
3.0 – 4.0	200
4.0 – 5.0	200
5.0 – 7.0	200
7.0 – 9.0	200
9.0 – 12.0	200
12.0 – 16.0	200
16.0 – 20.0	200

10^7 central (0-5%) Pb-Pb events

(1 year of nominal ALICE luminosity)

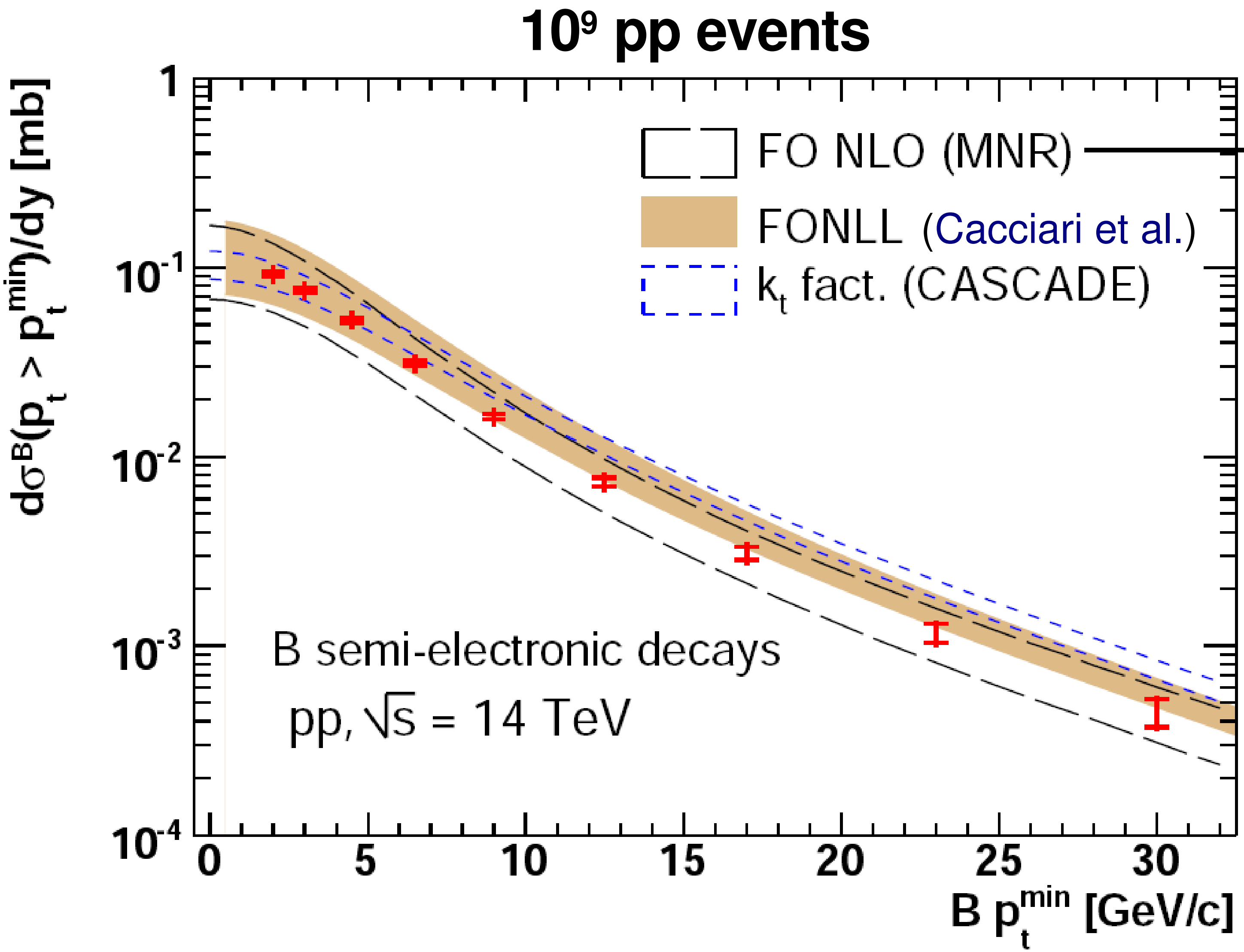


Results



*P. Crochet, R. Guernane, A. Morsch and E. Vercellin

Beauty cross section (1)



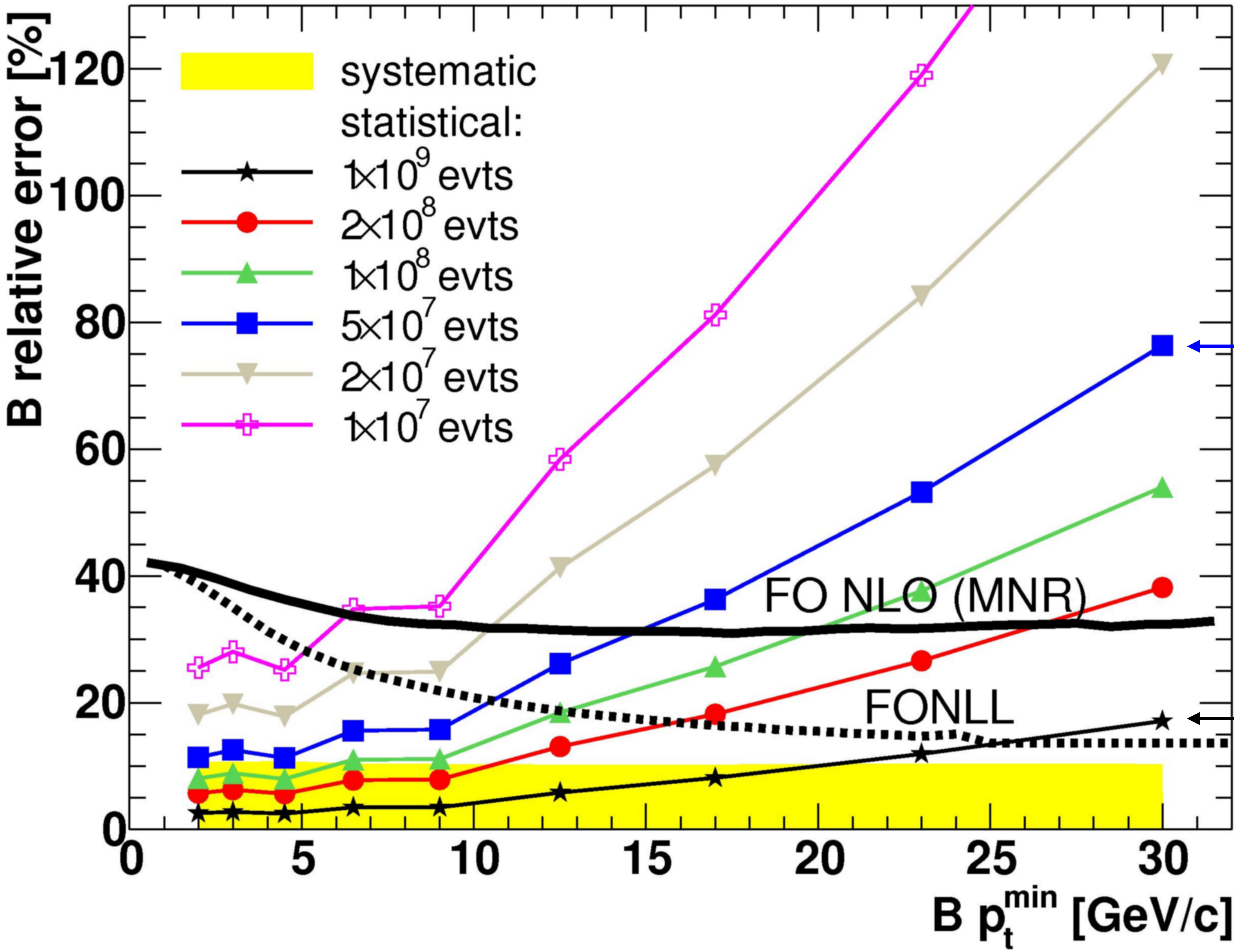
Baseline for this study

Red bars: results of this study

Theoretical predictions rescaled from |y|<2.5 to |y|<1

From electrons in $2 < p_t < 20$ GeV/c, B mesons in $2 < p_t^{min} < 30$ GeV/c

Perspectives for the initial runs



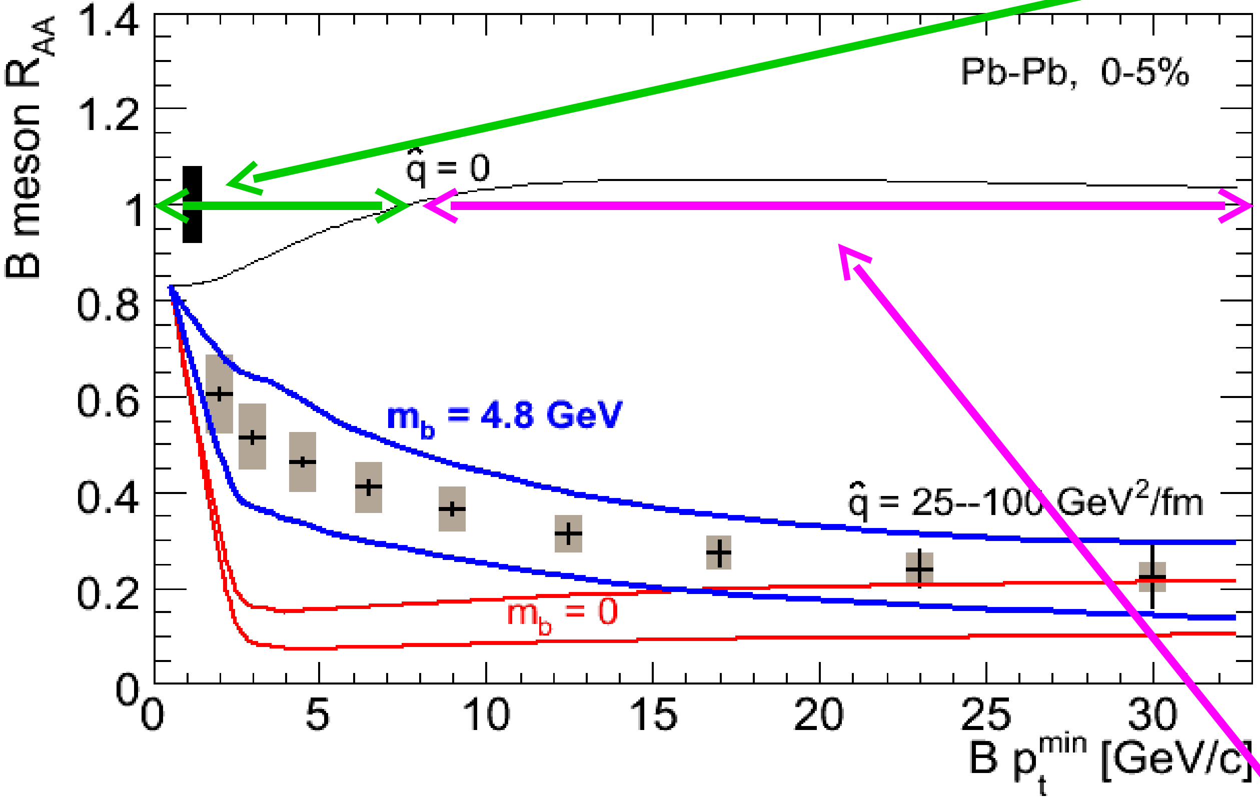
Full setup
(ITS+TPC+TRD)

~1 nominal ALICE-month

1 nominal ALICE-year

R_{AA} (2)

$$R_{AA}^{B}(p_t^{\min}) = \frac{1}{\langle N_{coll} \rangle} \frac{dN_{AA}^{B}(p_t > p_t^{\min})/dy}{dN_{pp}^{B}(p_t > p_t^{\min})/dy}$$



Low p_t (< 6–7 GeV/c)

Also nuclear shadowing & in medium hadronization

Black Bars: statistical error

Grey Area: systematic error

High p_t (> 6–7 GeV/c)

Only parton energy loss

1 year at nominal luminosity

(10^7 central Pb-Pb events, 10^9 pp events)

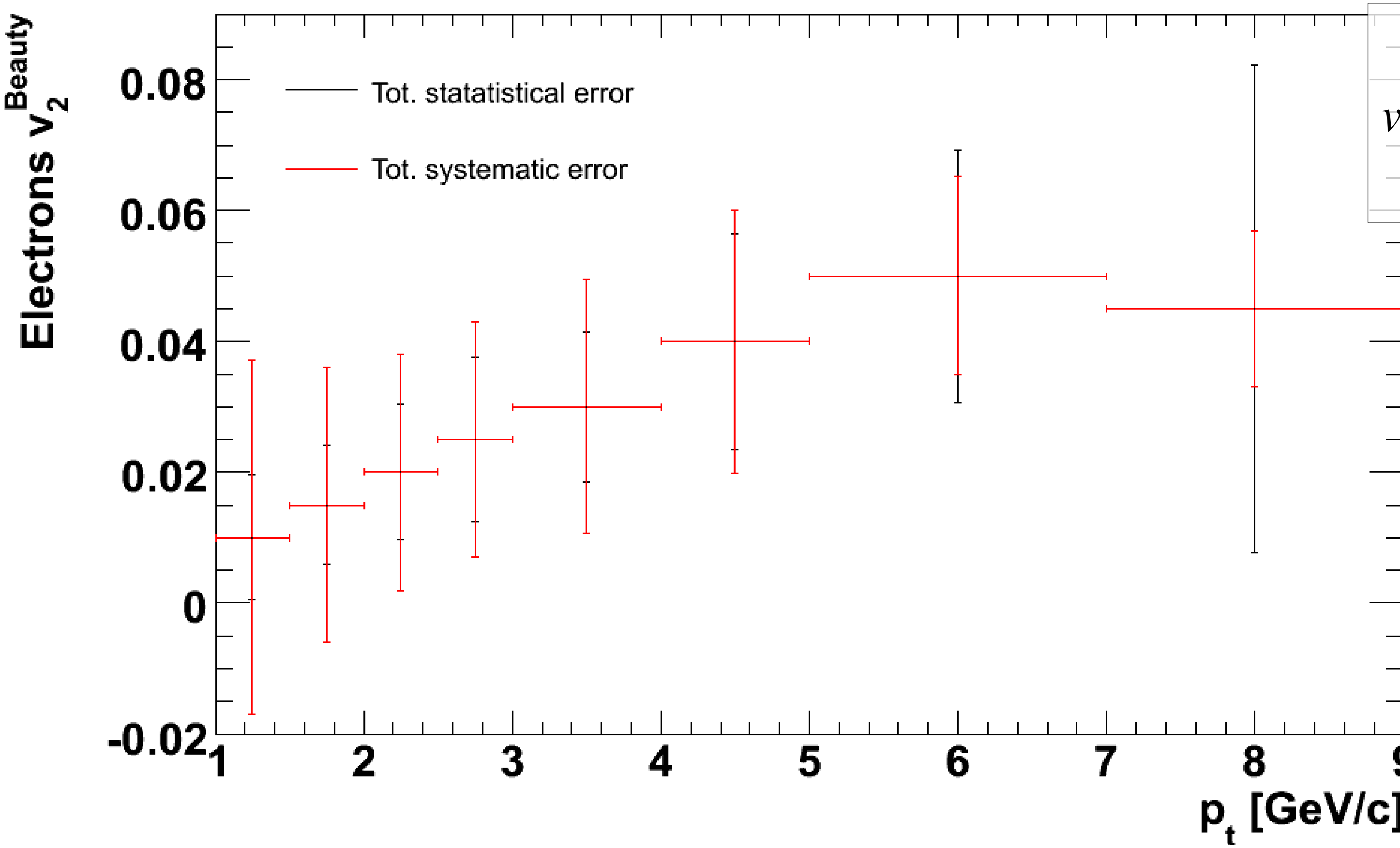
Beauty electrons elliptic flow (3)

$$v_2 = \frac{1}{2}\frac{N_{in} - N_{out}}{N_{in} + N_{out}}$$

- **in-plane** (-45<Δφ<45 & 135<Δφ<225)
- **out-of-plane** (45<Δφ<135 & 225<Δφ<315)

1 year at nominal luminosity

(8x10^6 20-60% Pb-Pb events, 10^9 p-p events)

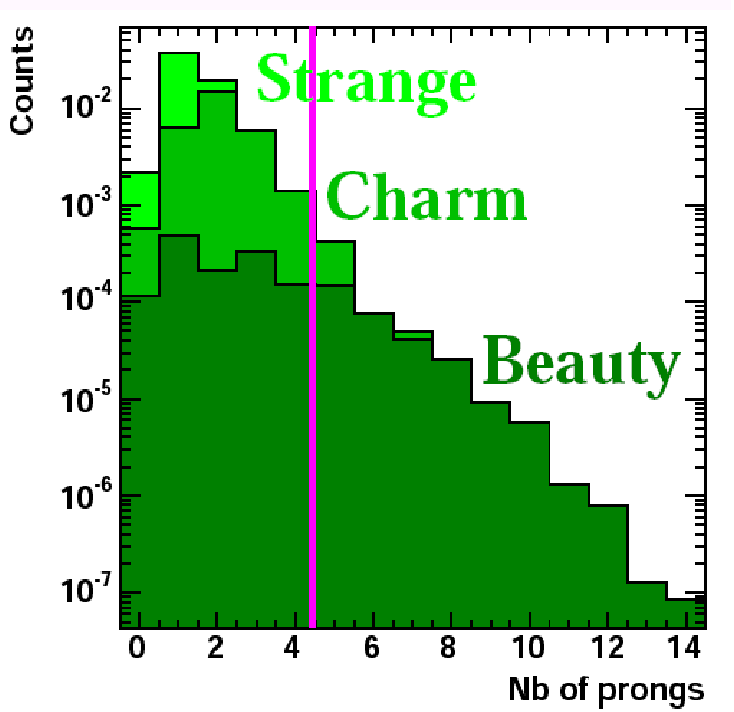


$$v_2^b = \frac{N_{tot} \cdot v_2^{meas} - N_c \cdot v_2^c - N_{bkg} \cdot v_2^{bkg}}{N_{tot} - N_c - N_{bkg}}$$

Theoretical predictions from:

- H. van Hees, V. Greco, R. Rapp
- C. A. Salgado, N. Armesto, M. Cacciari, A. Dainese and U. A. Wiedemann

J. Faivre: Beauty to "many prongs"



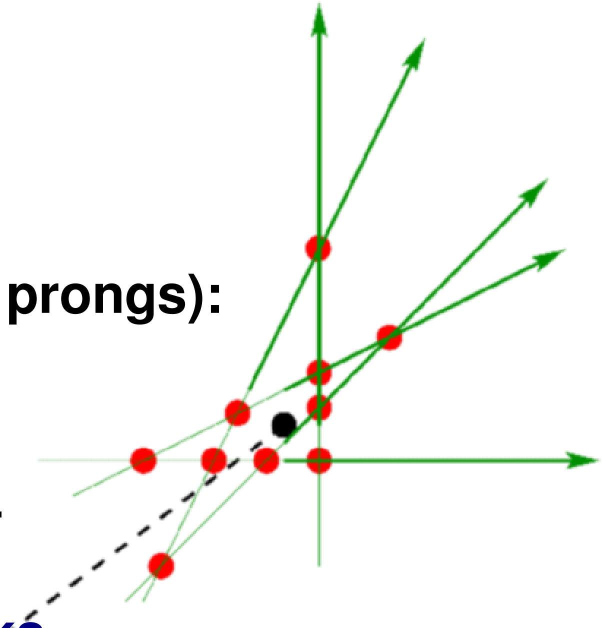
Characteristic of B decays:

→Many prongs (charged tracks : π, K, p, e, μ)

→Large cτ's

⇒Decays of B hadrons can be **reconstructed topologically**

Example in 2D (5 prongs):



Vertexer mechanism :

→Decay vertex characterized by small DCA's track-vertex...
...but also by small DCA's track-track

→So **points of closest approach between daughter tracks are in a small region of the space**

→ **We can bin the space and locate spikes in the number of DCA points**

J. Faivre: Results

Method: search zones where "many track pairs cross"

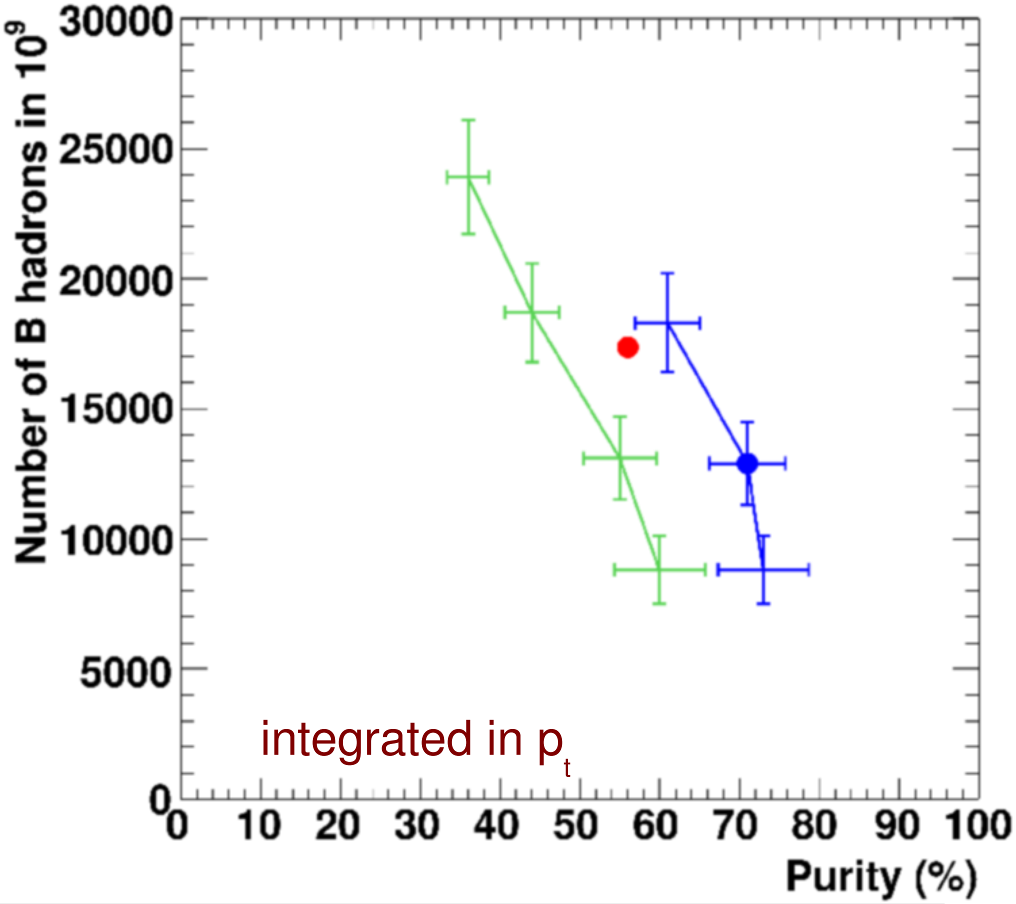
- Tracks' PID not used
- Plot of the reachable zone :

→ **Vertexer "as is"**

→ **With cut $1 < m_{inv} < 4.5$ GeV**

→ **Results from previous slides**

- No p_t-dependance yet



B-to-electron and "many prongs" methods are in the same playground

- Year-1 measurement (10^9 p-p minbias events)
- Purity is 70 % (NB : background is all due to primary tracks)

→Try to use that working-point + estimate background contribution

→Try to go to higher purities (geometrical cuts, under study)

- Will have to estimate the vertexer efficiency (hard work ahead !)

Conclusions

- **Beauty production at collider energies**
- Test of pQCD theory (Large uncertainities for prediction at LHC)
- Probe for QGP (mass dependence of in-medium Energy Loss)
- Test for thermalization (elliptic flow)

- **ALICE is equipped for heavy-flavour studies**
- Using single electrons is just the first/simplest approach
- *Cross section for B mesons*: sensitive to QCD predictions
- R_{AA} *for B mesons*: measure of q-hat and mass dependence of energy loss
- *Elliptic flow for B electrons*: possible measurement between p_t ~2.0-7.0 GeV/c
- Promising alternative method: *topological approach*

Backup

Selecting the cuts (for pp)

Cut: $|d_0|>|d_0|^{MIN}$

<u>Systematic error:</u>

prefers tight cut (high signal purity)

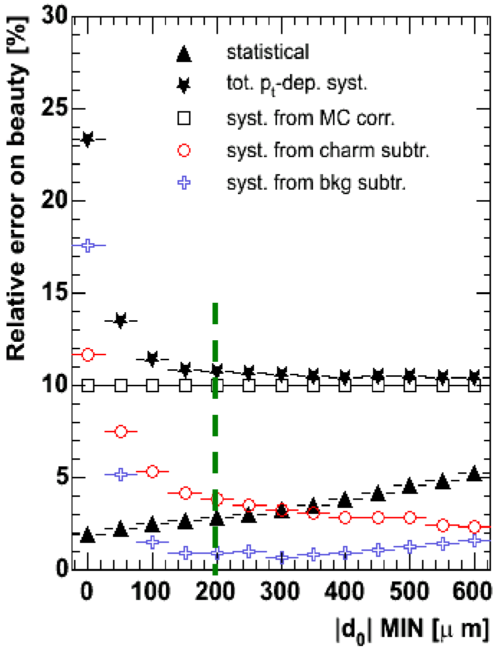
dominates at low p_t

<u>Statistical error</u>:

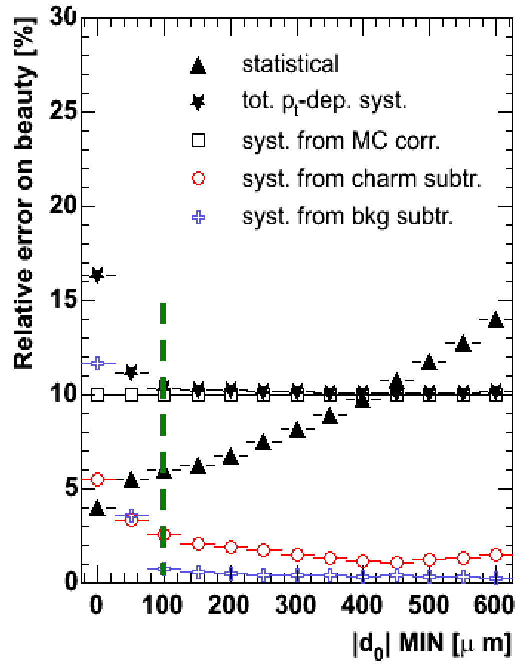
prefers loose cut (small d_0 MIN)

dominates only at high p_t

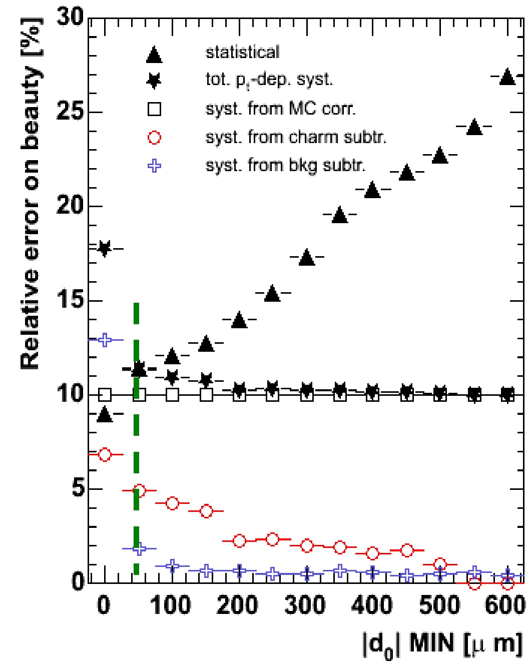
$2.5 < p_t < 3$ GeV/c



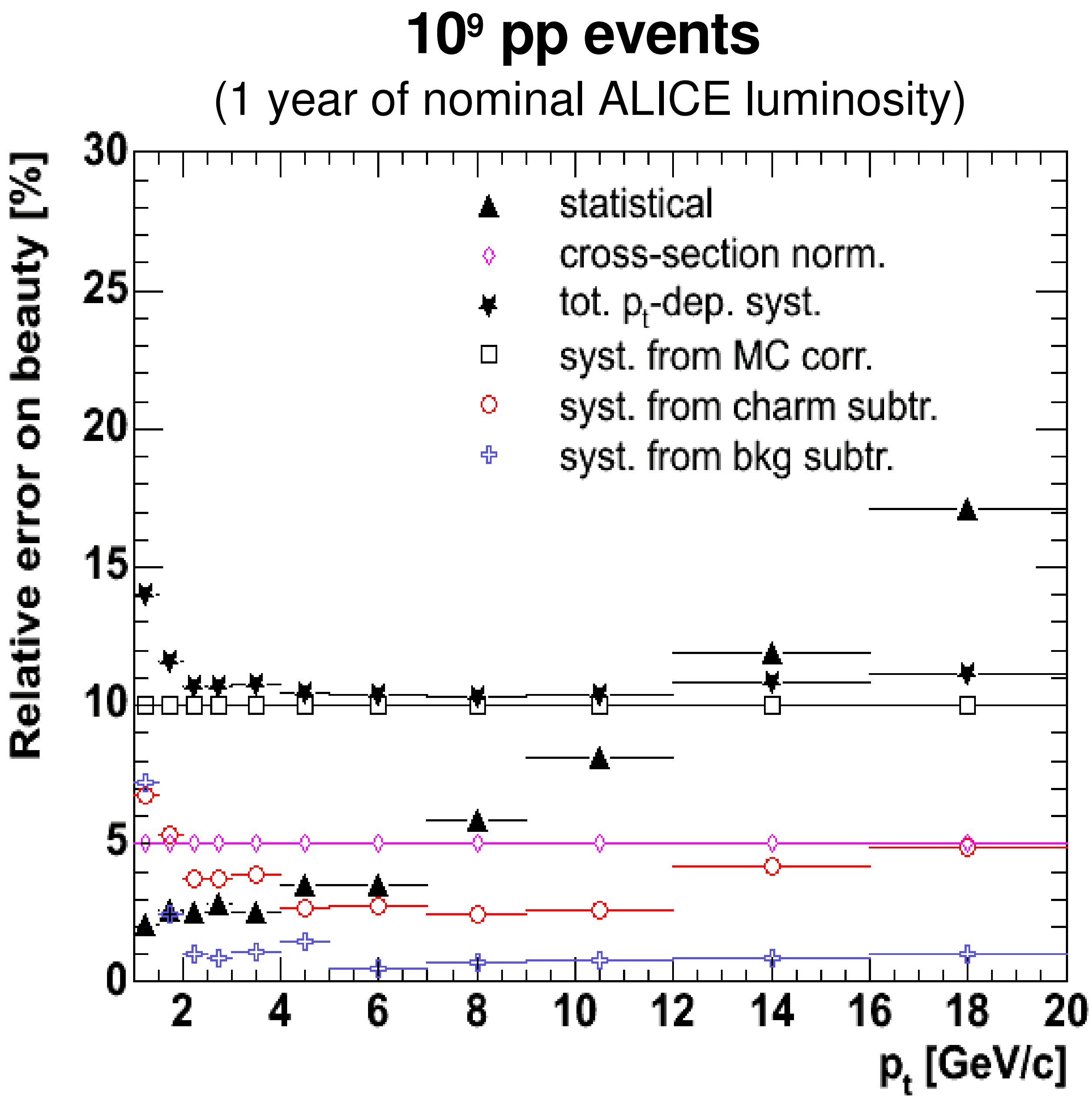
$7 < p_t < 9$ GeV/c



$12 < p_t < 16$ GeV/c



Errors summary (for pp)



Recipe for elliptic flow

Goal: an estimate of the error on v_2 for beauty electrons

To achieve this we use:

- Our results (electrons from beauty) for Pb-Pb rescaled for 20-60% centrality
- Our error estimates for the charm and background subtraction
- Van Hees and Salgado predictions for beauty/charm v2 presented at the “Heavy Ion Collisions at LHC” (2007)

Assumptions:

- v2(bkg) = v2(charm)
- err[v2(charm)] = 25%
- err[v2(bkg)] = 15%

• H. van Hees, V. Greco, R. Rapp
• C. A. Salgado, N. Armesto, M. Cacciari, A. Dainese and U. A. Wiedemann