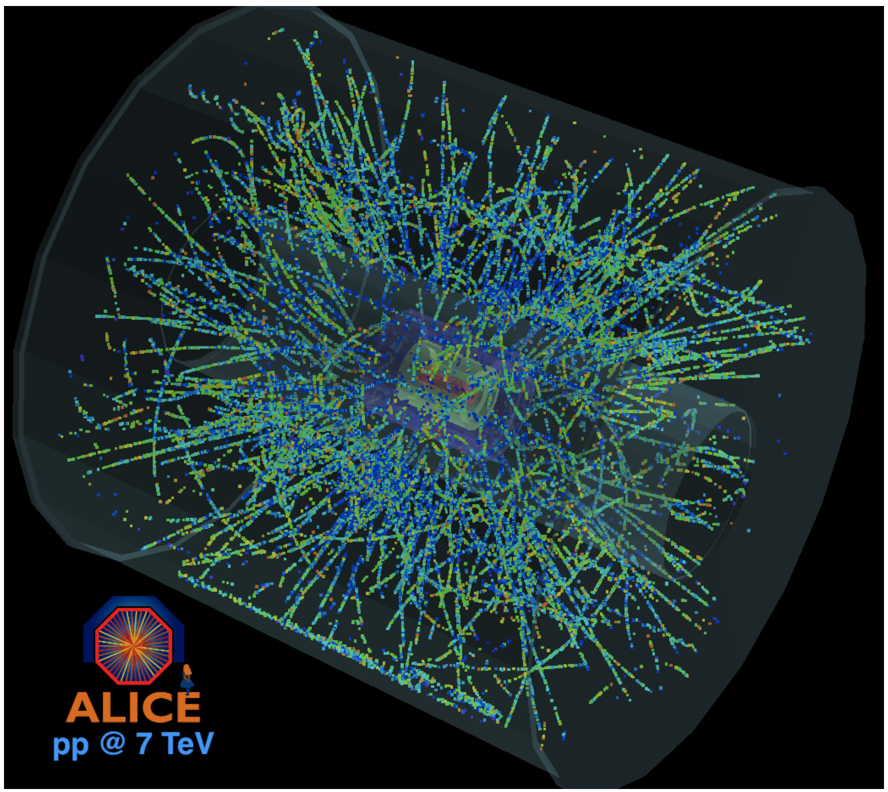
J/Ψ measurement in 7 TeV pp collisions at mid-rapidity in the e^+e^- channel with ALICE



Ionut Arsene
for the ALICE Collaboration

GSI
FIAS Frankfurt Institute for Advanced Studies
EMMI

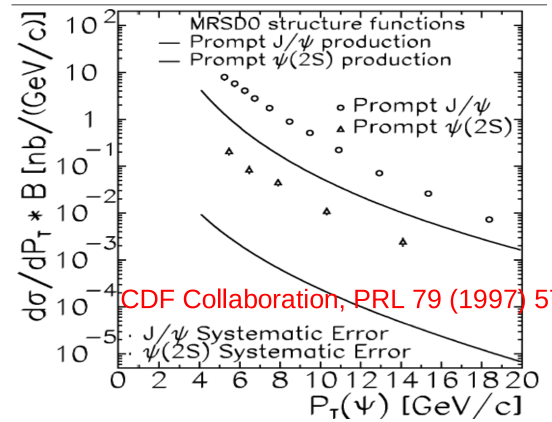
Contents

Introduction

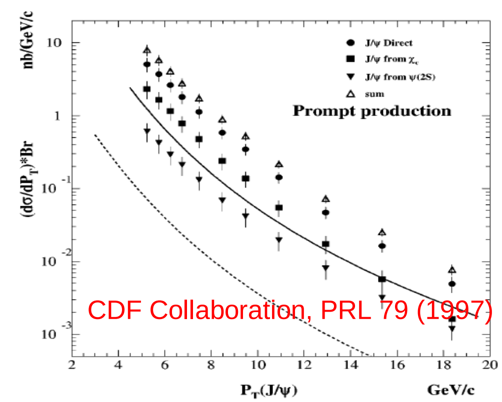
J/Ψ production mechanisms:

- Direct production via the interaction of initial partons
- Feed-down from charmonium states, mainly Ψ(2S) and χ_c (~35% of prompt production rate)
- B-hadron decays (10% of the inclusive J/Ψ cross-section at Tevatron at Pt=1.5 GeV/c)

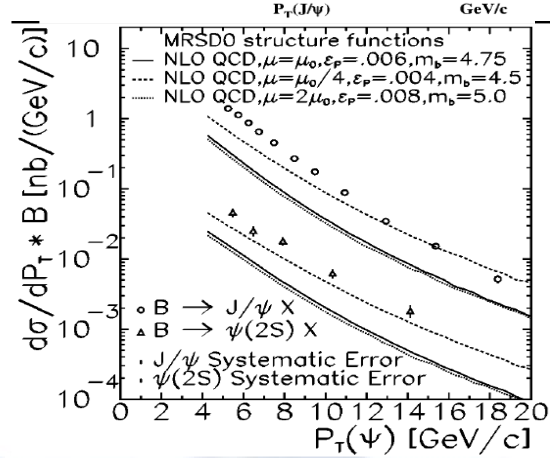
$p+\bar{p}@\sqrt{s}=$உகூTeV



CDF Collaboration, PRL 79 (1997) 572



CDF Collaboration, PRL 79 (1997) 578

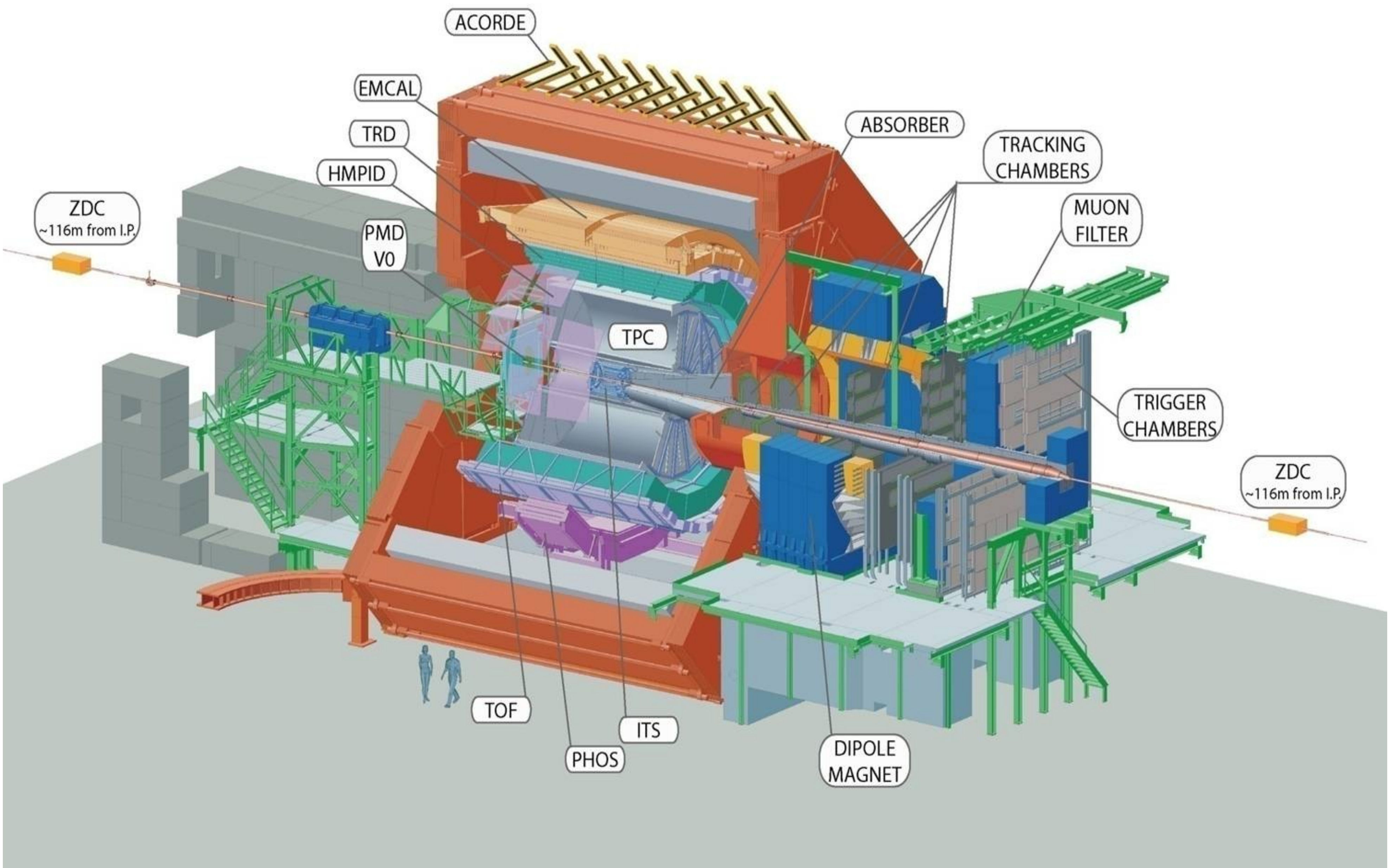


Introduction

Some of the most remarkable approaches to explain the quarkonium production:

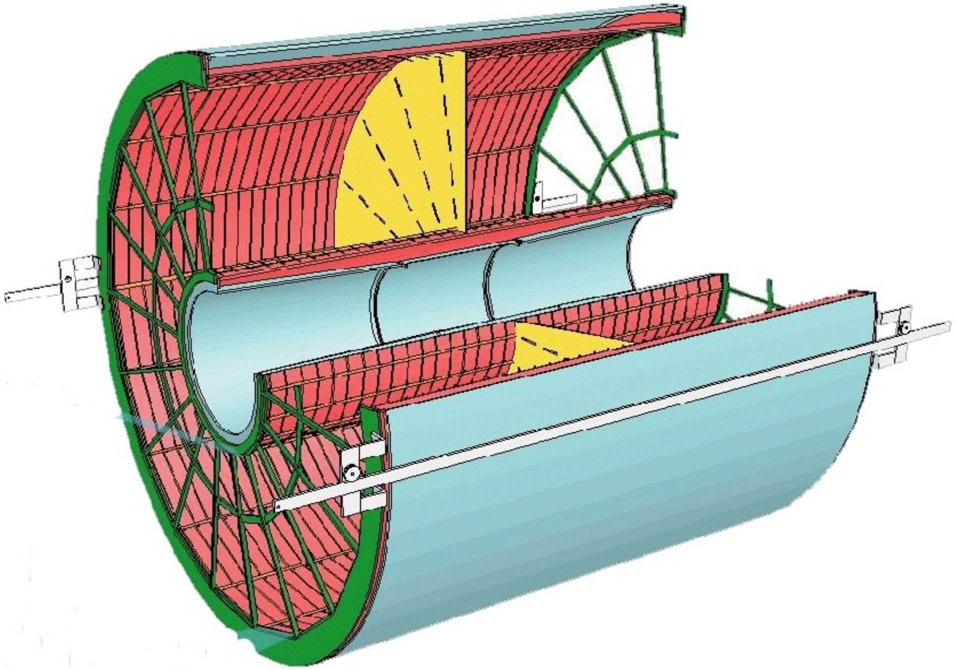
- Color Singlet Model (CSM) S.D.Ellis, M.B.Einhorn, C.Quigg, PRL 36 (1976) 1263
- Color Evaporation Model (CEM) H.Fritzsch, PLB 67 (1977) 217
- Non-relativistic QCD G.Bodwin, E.Braaten, G.Lepage, PRD51 (1995) 1125

The ALICE setup

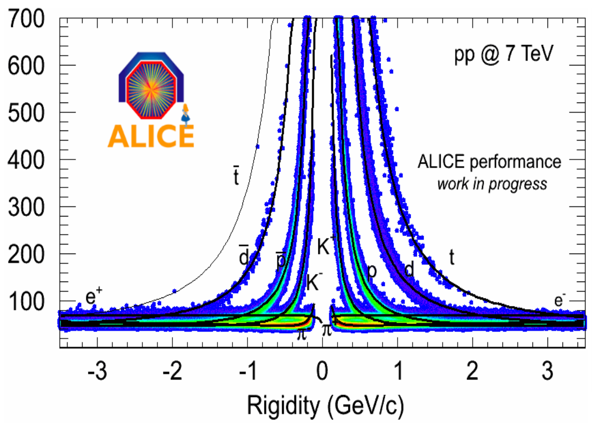


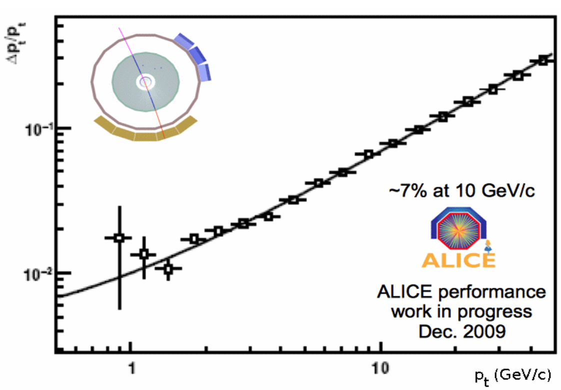
Time Projection Chamber

- 557,568 readout channels
- Central electrode at 100 kV
- 94 µs maximum drift time
- 90 m³ gas volume
- Ne - CO_2 – N_2 (85.7-9.5-4.8)



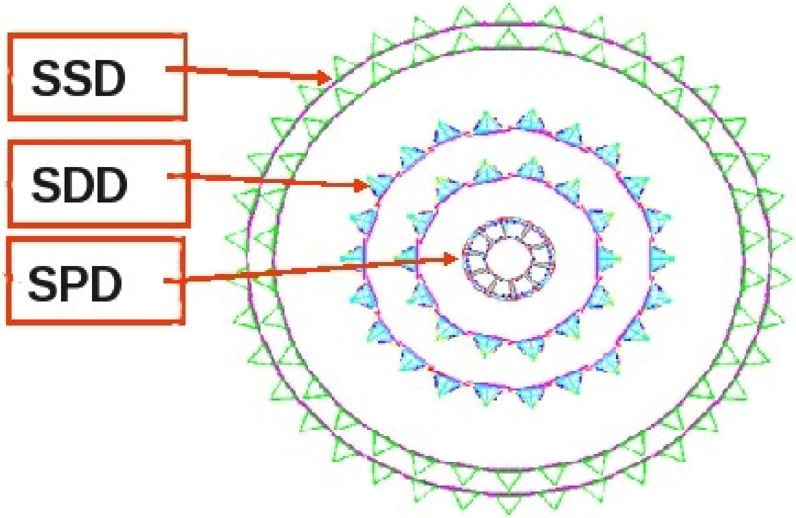
- Very good momentum resolution (~10% at 20 GeV/c)
- Particle identification via linear energy loss (dE/dx)



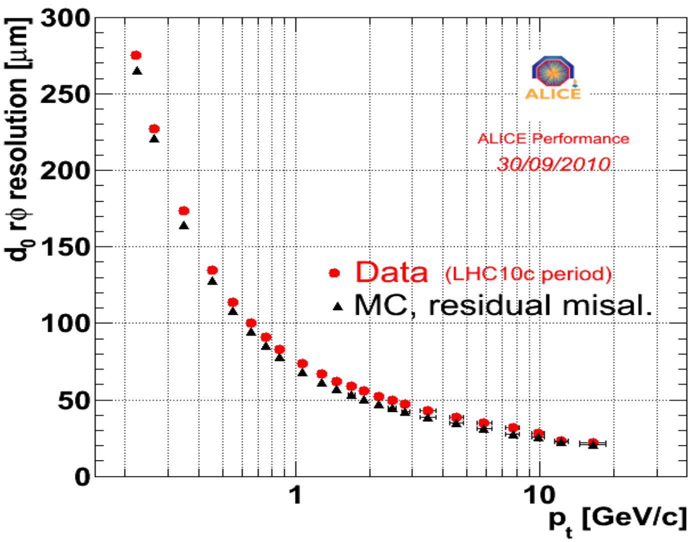


Inner Tracking System

6 layers, three technologies:
- Silicon pixels (0.2 m^2, 9.8M channels)
- Silicon drift (1.3 m^2, 133k channels)
- Silicon strip (4.75 m^2, 2.6M channels)
- Material budget ~1% X/X_0 per layer



- Rejection of electrons from conversions by requiring a hit in the two innermost layers
- The extraction of the fraction of J/Ψ's from b-hadron decays is posible via the reconstruction of secondary vertices. This analysis requires high statistics and is in progress.

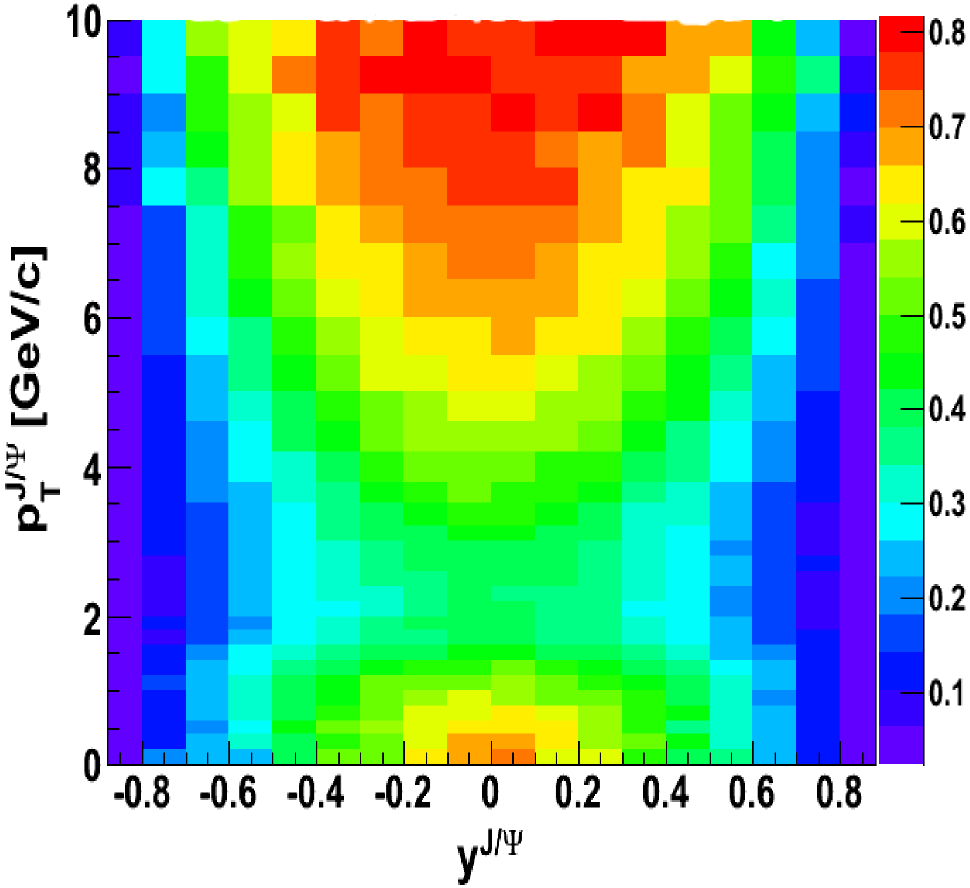


Analysis

- Cuts
  - Kinematics
  - Track selection
  - Particle identification
- Signal extraction
- Efficiencies
- Systematics

Kinematic cuts

Monte-Carlo: Single unpolarized J/Ψ



- Fiducial rapidity cut to avoid detector edge effects

$$|y^{J/\Psi}| < 0.88, |\eta_{legs}| < 0.88$$

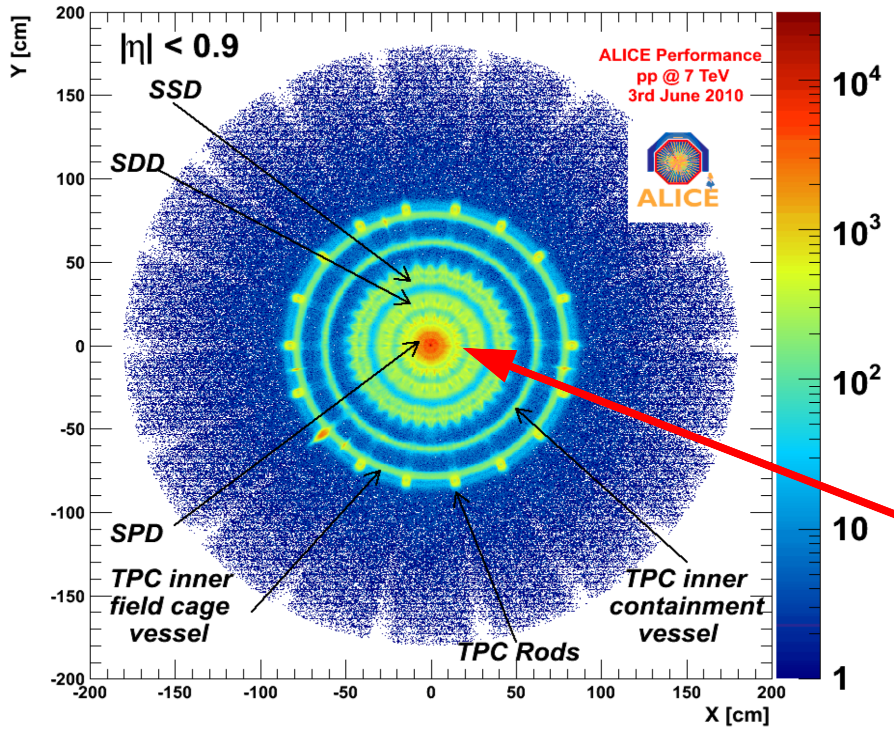
- Pt cut on the electrons to reject background without loosing too much in efficiency

$$p_T^e > 1.0\, GeV/c$$

ALICE can measure J/Ψ's down to P_t=0 at mid-rapidity

Track selection

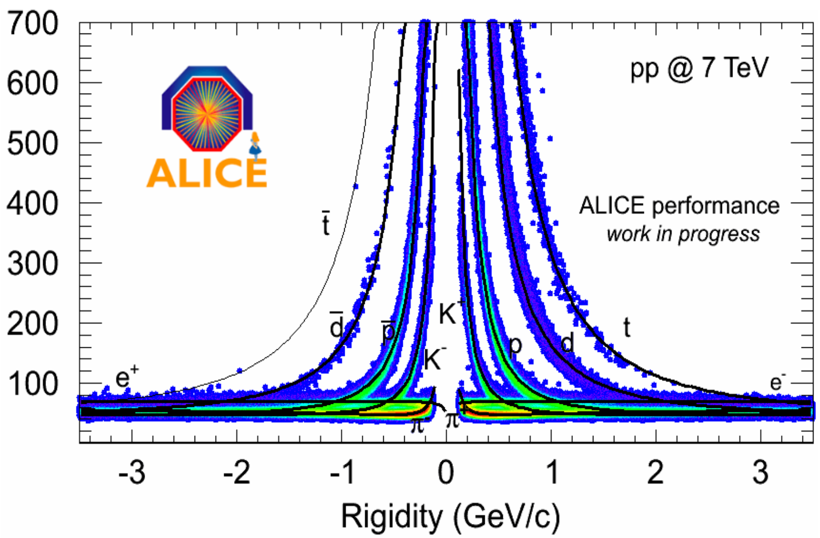
Spatial distribution of photon conversion points

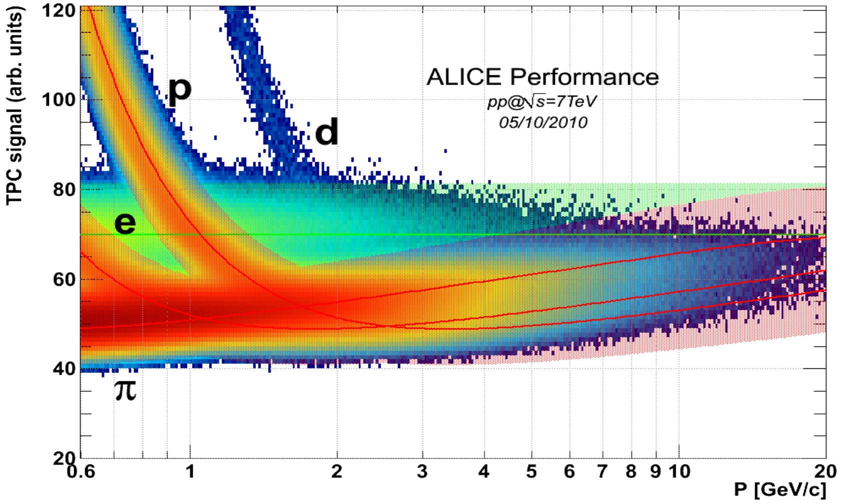


- Select only well defined TPC tracks:
  - # TPC clusters > 90/159
  - χ2 / cluster < 4
- Rejection of kink daughters
- Rejection of secondaries
  - DCA to event vertex cut
- Rejection of electrons from conversions:
  - At least one hit in the first 2 ITS layers (SPD)

Particle identification

TPC dE/dx





Particle identification uses the Bethe-Bloch parameterization of the linear energy loss (dE/dx) in the TPC

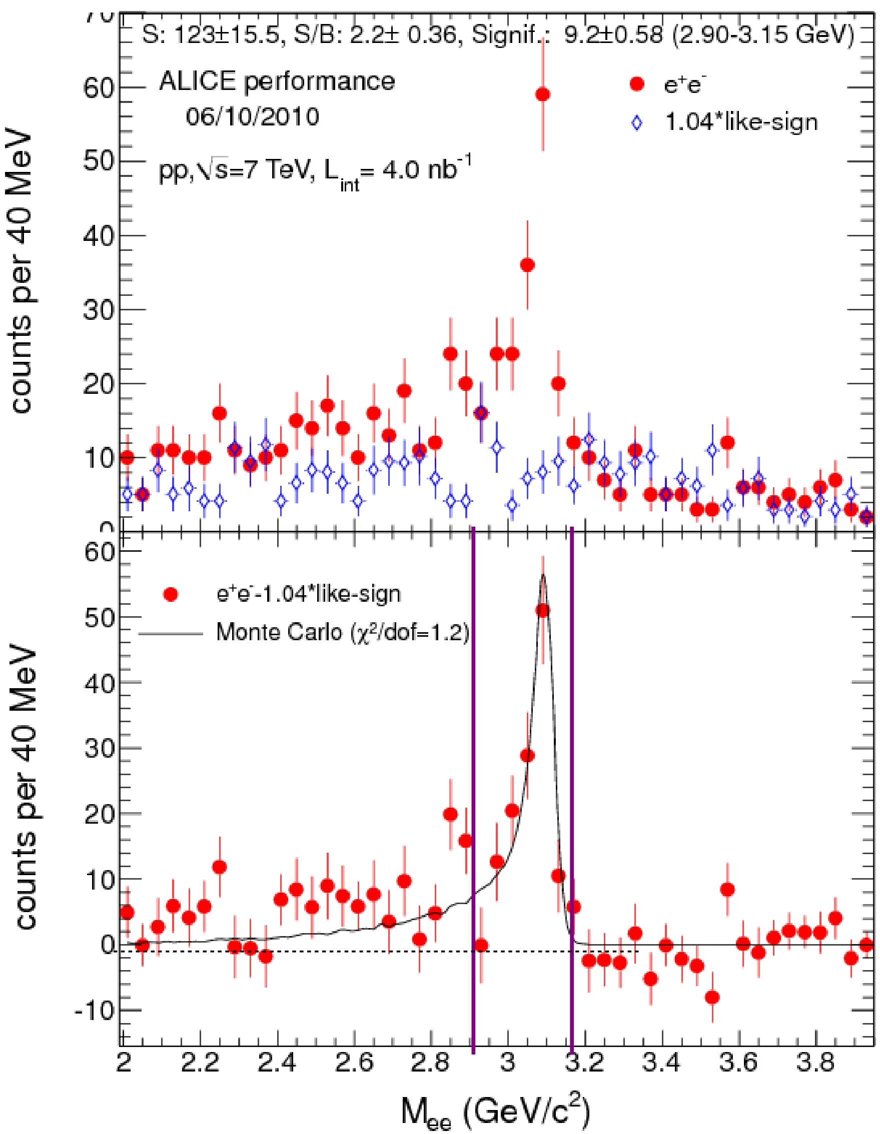
- Electron selection is made in a ±3σ band around the Bethe-Bloch curve.
- Pions and protons are rejected in ±3σ bands around their Bethe-Bloch curves.

Signal extraction

- Like sign substraction method :

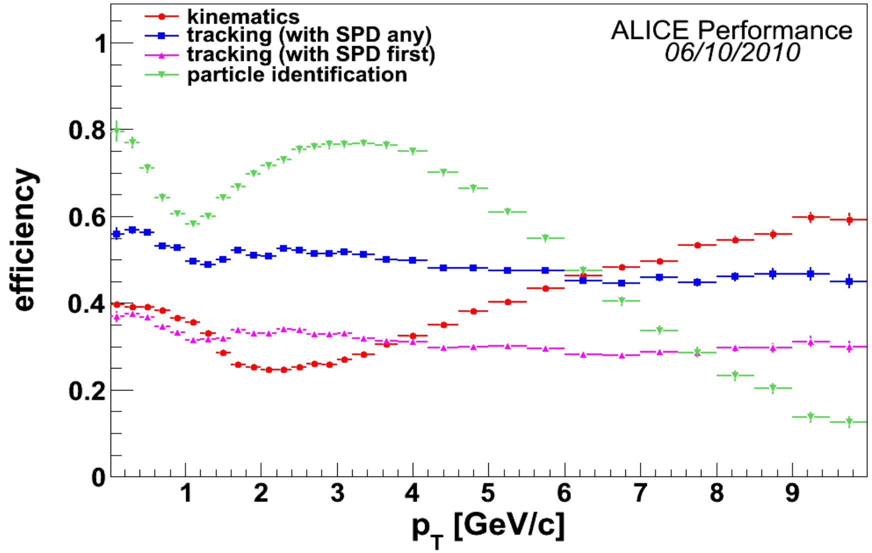
$$S = N_{PM} - 2R\sqrt{N_{PP} \times N_{MM}}$$

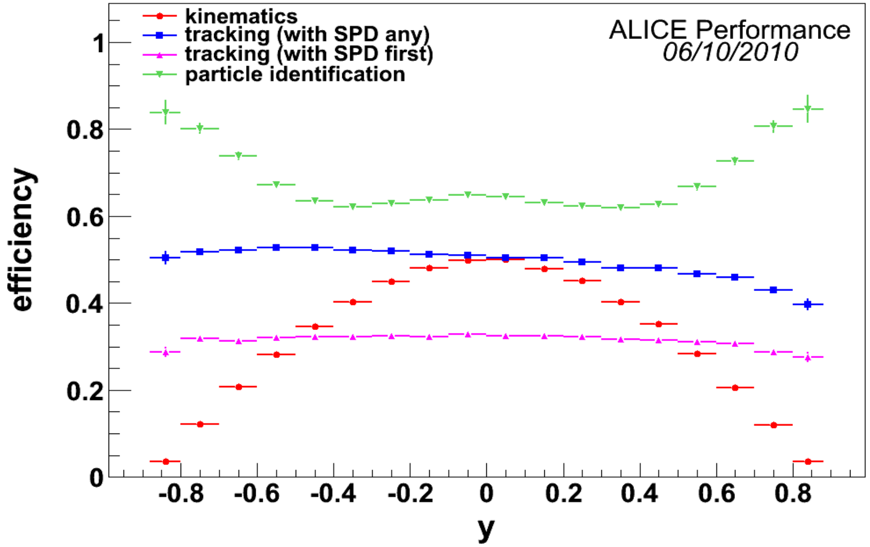
- Some residual background still remains after the like-sign subtraction (R~1.04)
- The signal shape is in agreement with the Monte-Carlo simulation
- 69% of the total yield is in the integration range 2.90-3.15 GeV/c^2



Efficiencies

Monte-Carlo: Pythia + 1 J/Ψ per event





- Efficiencies are calculated using Monte-Carlo simulations matching the exact setup of ALICE at the moment the data were taken.
- Differential J/Ψ efficiencies are factorized in 3 different contributions:
  - Kinematics
  - Tracking
  - Particle identification

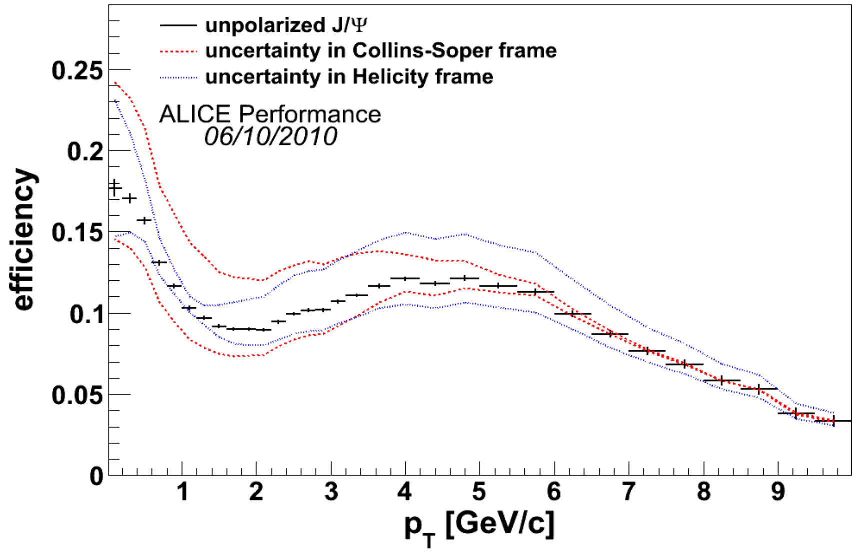
Systematic errors

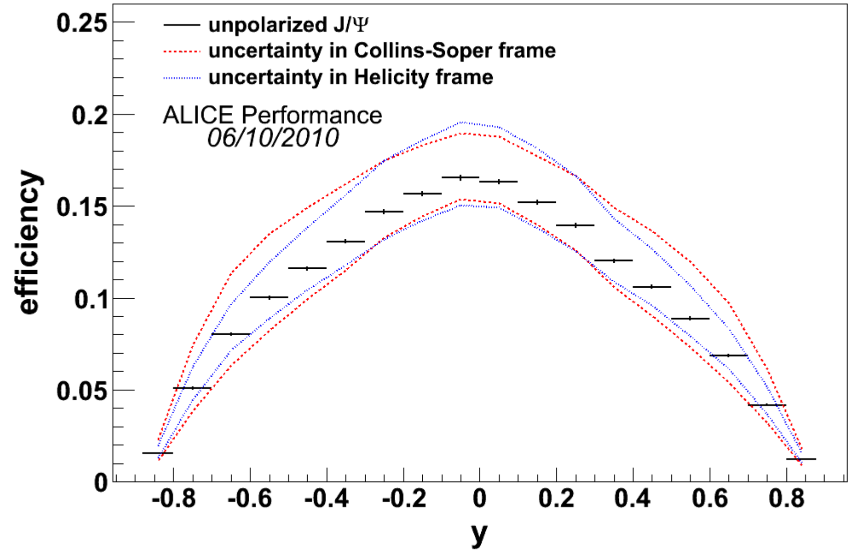
Mismatch between data and Monte-Carlo	10%
Particle identification cuts	10%
Normalization (mainly due to uncertainty on the LHC beam intensity)	10%
Signal extraction range	4%
J/Ψ Pt spectrum assumption	1%

We are still working on decreasing our systematics

Systematics from J/Ψ polarization

Monte-Carlo: Pythia + 1 J/Ψ per event



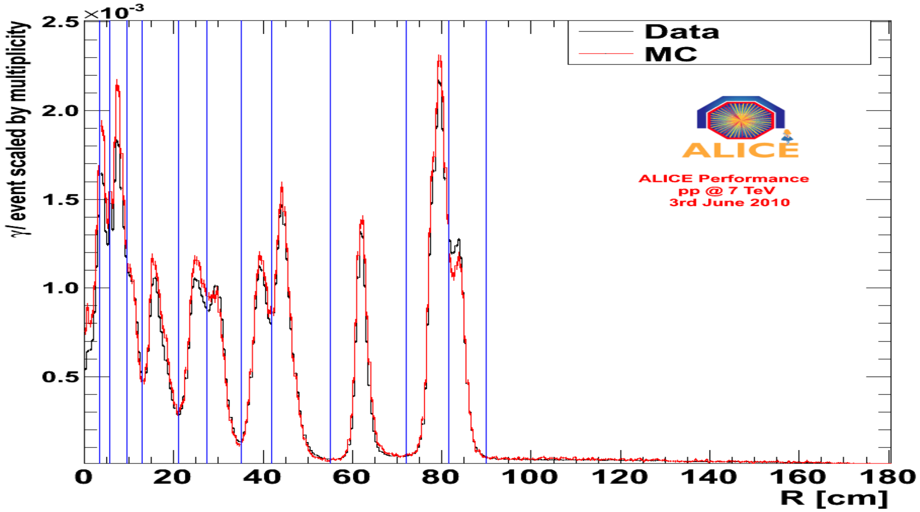


$$\frac{dN}{d\cos(\theta)} \sim 1 + \alpha \times \cos^2(\theta)$$

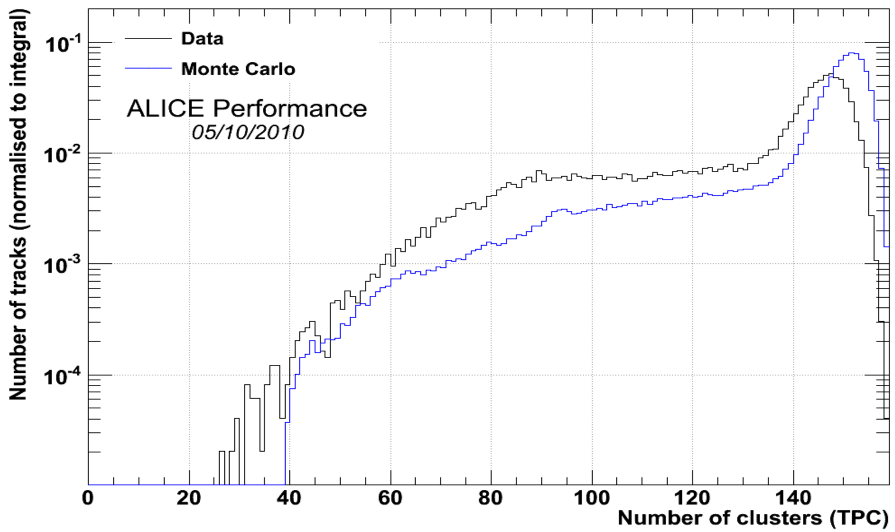
Uncertainty considering the extreme cases:

Reference frame	α = -1	α = +1
Collins-Soper	+24.8%	-11.9%
Helicity	+19.7%	-9.7%

Systematics (MC vs. data)

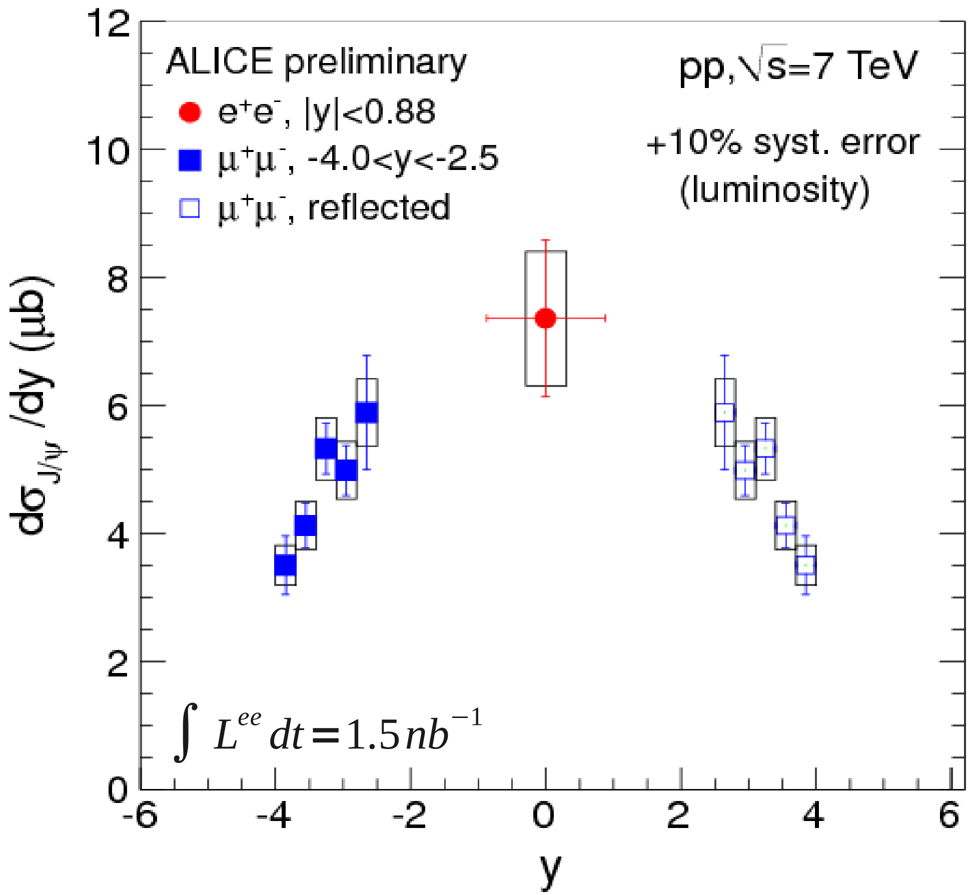


- The material budget is very well understood in our simulations.



- We observe a disagreement between data and Monte-Carlo for the distribution of the number of TPC clusters.
- We apply a correction for this (~3%)

J/Ψ production cross-section



$$\left(\frac{d\sigma_{J/\Psi}}{dy}\right)_{y=0} = \frac{1}{L_{int}} \times \frac{N_{J/\Psi}}{(eff) \times \Delta y \times (B.R.)}$$

(eff.) = (kinematics) x (track quality) x (PID) x (Minv integration range)

(B.R.) = (J/Ψ → e+e-) branching ratio

$$\frac{1}{L_{int}} = \frac{1}{N_{CINT1B}} \times \left(\frac{N_{CINT1B}}{N_{V0and}}\right)_{reference} \times \sigma_{V0and}$$

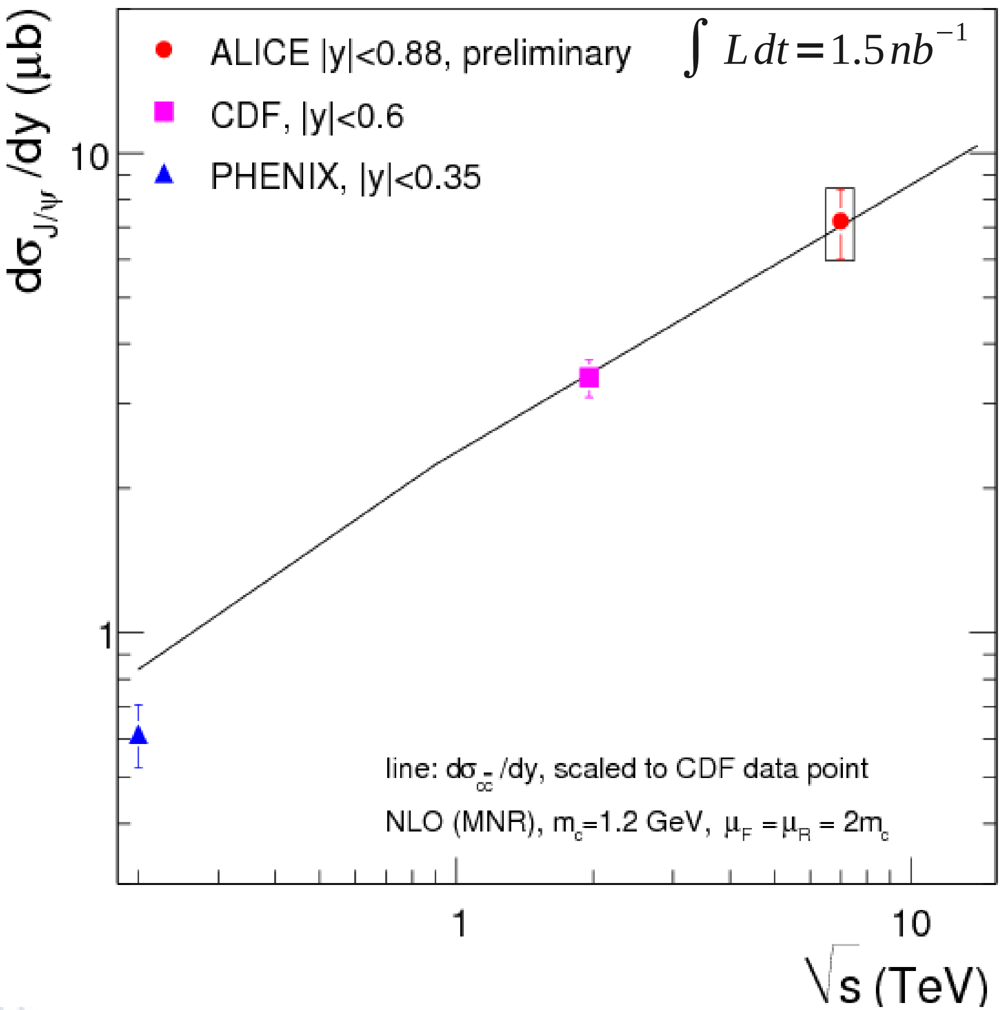
CINT1B – inelastic trigger used in the analysis

V0and – non-single diffractive trigger with cross-section measured in a Van der Meer scan

$$\sigma_{V0and} = 62.3 \pm 6.2\,(syst.)\,mb$$

Total luminosity accumulated ~ 10.0 nb^{-1}, but final refinements from detectors are still ongoing

Energy dependence



PHENIX Collaboration, PRL 98 (2007) 232002

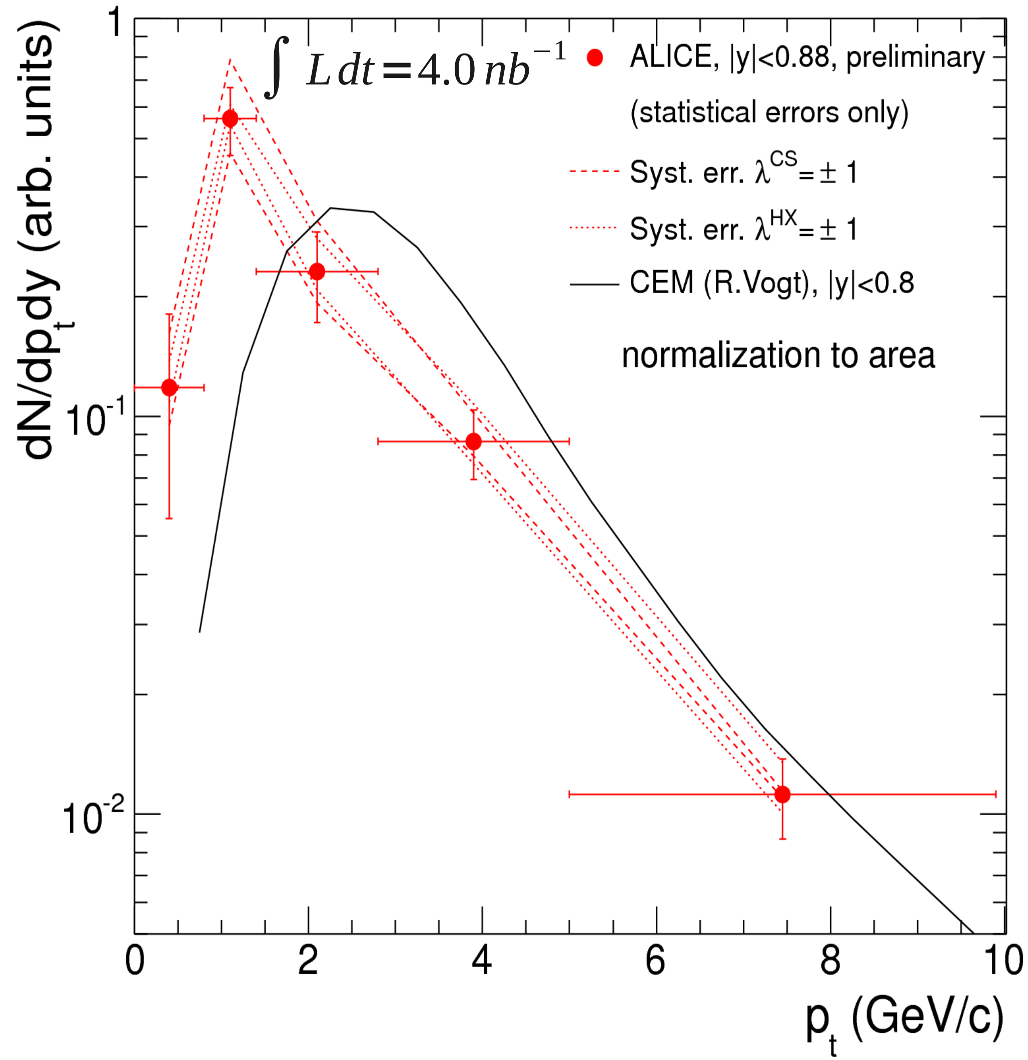
CDF Collaboration PRD71 (2005) 032001

- Solid line is a NLO calculation for the c-cbar cross-section scaled to the CDF data.
- Our data is consistent within errors with the lower energy experiments

Pt dependence

The Color Evaporation Model calculations underestimates the data at low transverse momentum.

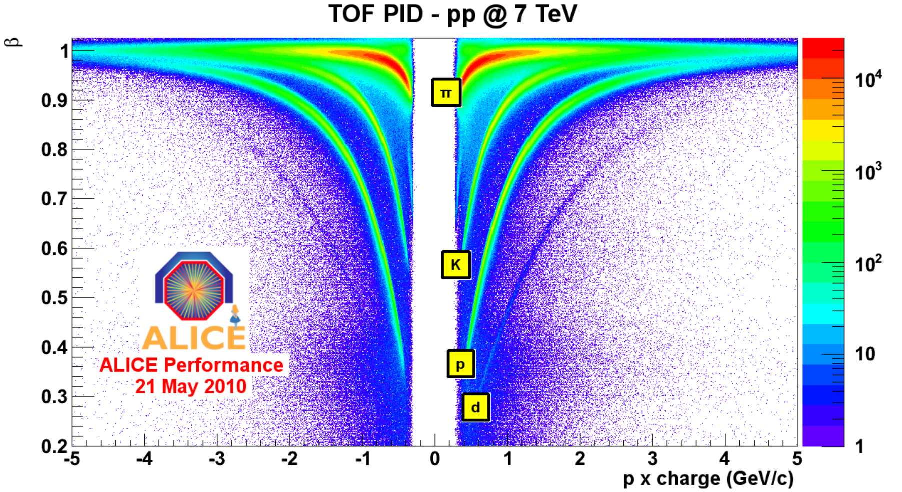
Data is from a larger sample with partial calibration and it is not fully normalized yet.

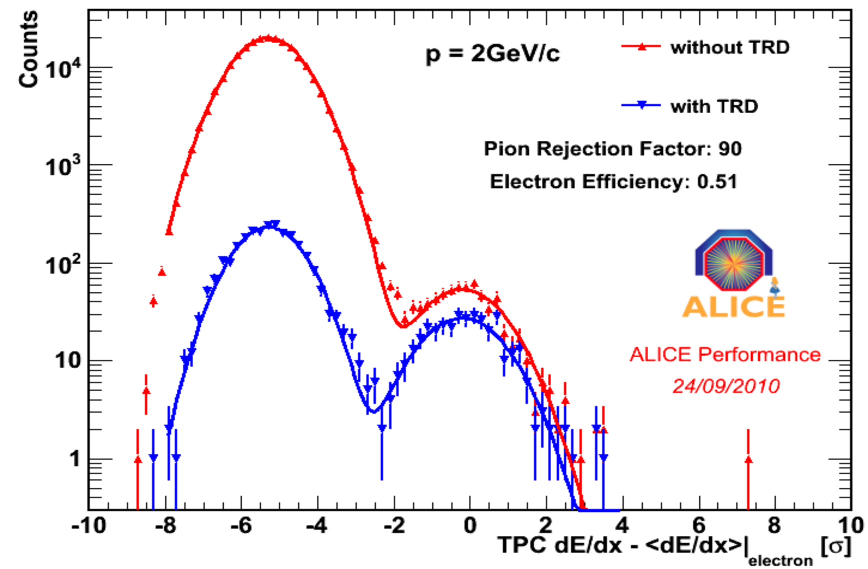


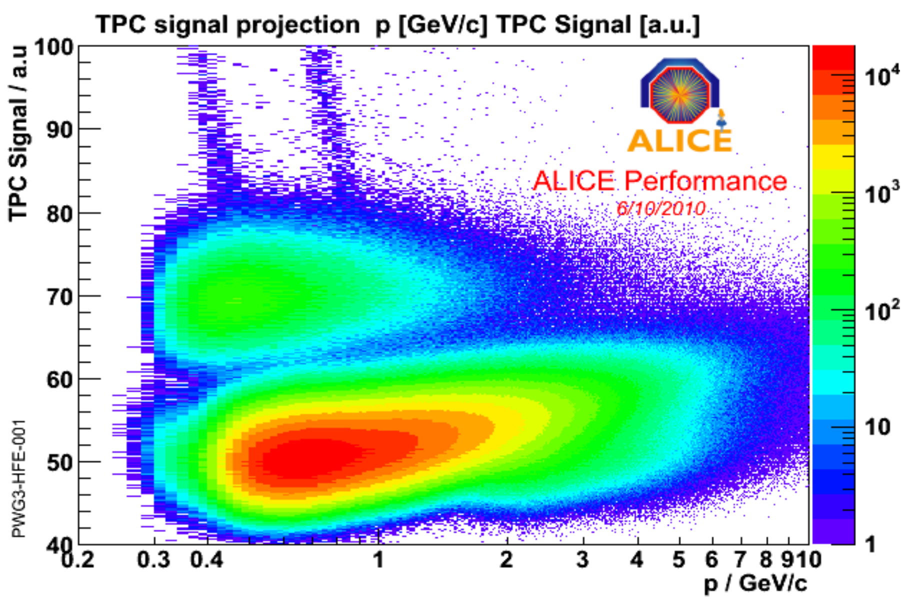
Outlook

- Extending of the particle identification with TOF and TRD detectors
- Measure J/Ψ polarization
- Trigger on events with at least one or two tracks above 1 GeV/c. This will significantly increase the number of measured J/Ψ's in the high event rate provided by LHC.
- Analyze the fraction of J/Ψ's originating from beauty decays.

Using PID with TOF and TRD

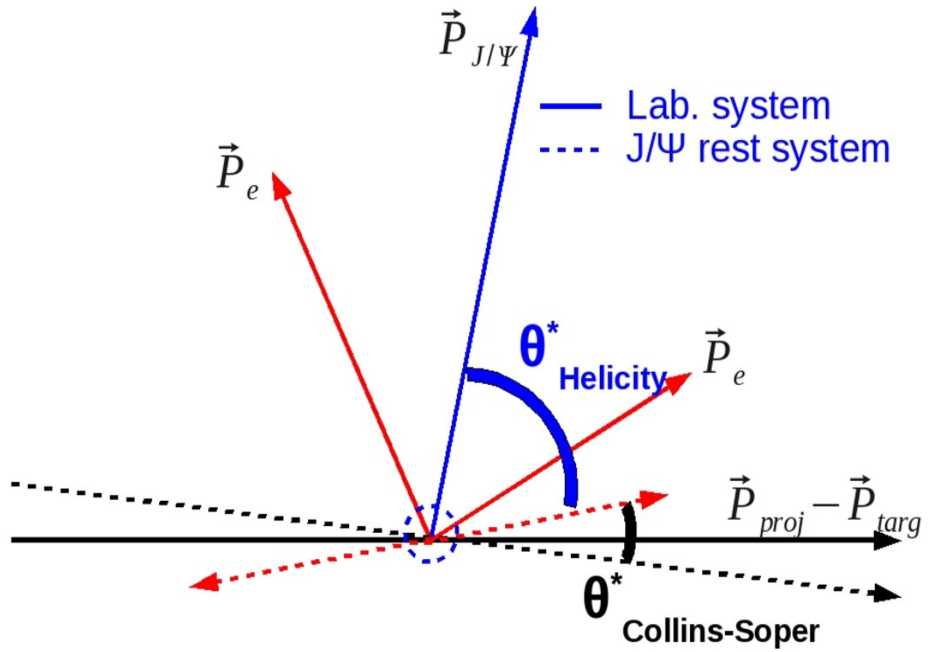


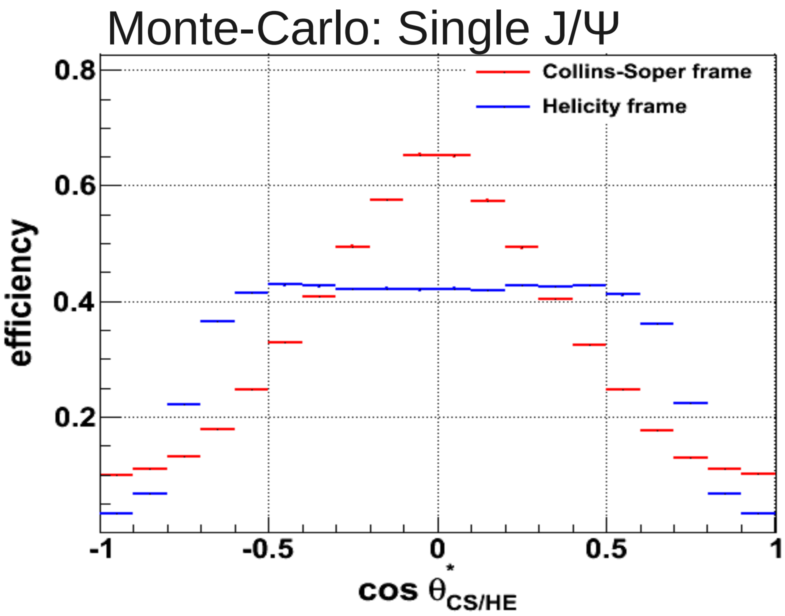


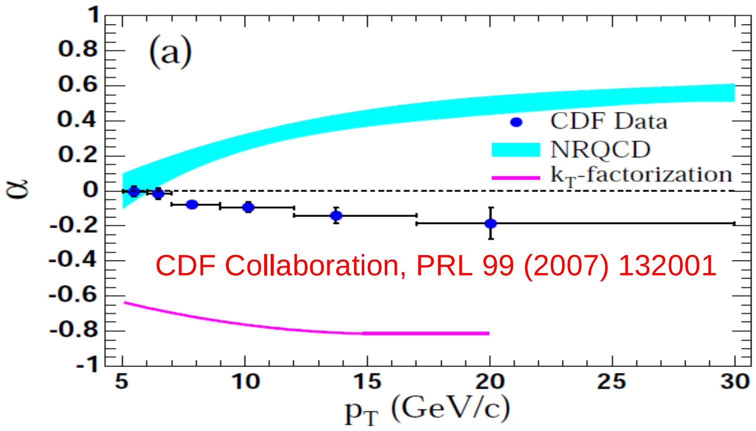


- TOF improves the background rejection at low momentum (p<3 GeV/c)
- TRD improves electron identification at high momentum

Future J/Ψ Polarization measurement







- Will significantly reduce the systematic error due to polarization
- Very interesting observable by itself and provides information on the production mechanisms
- ALICE has a very good acceptance for polarization measurements
- J/Ψ polarization is not well understood by theory

Summary

- We presented the mid-rapidity J/Ψ production cross section in non-single diffractive p+p collisions at 7 TeV extracted via the di-electron channel with the ALICE barrel detectors.
- The measured cross-section at mid-rapidity is consistent with the c-cbar cross section from an NLO calculation scaled to the J/Ψ yield from CDF data.
- The Pt dependence at low transverse momenta does not follow the CEM calculations
- With more statistics from future running the polarization measurements will be posible. This will decrease our systematics and provide a valuable observable.
- We are looking forward to the heavy ion collisions run from LHC!