Quarkonia Measurements with ALICE

Frederick Kramer

IKF, Goethe-Universität Frankfurt

WWND, Ocho Rios, Jan 8, 2010

Outline

Physics Goals

Quarkonia:

- Bound states of heavy quark pairs, created in early stage of collision

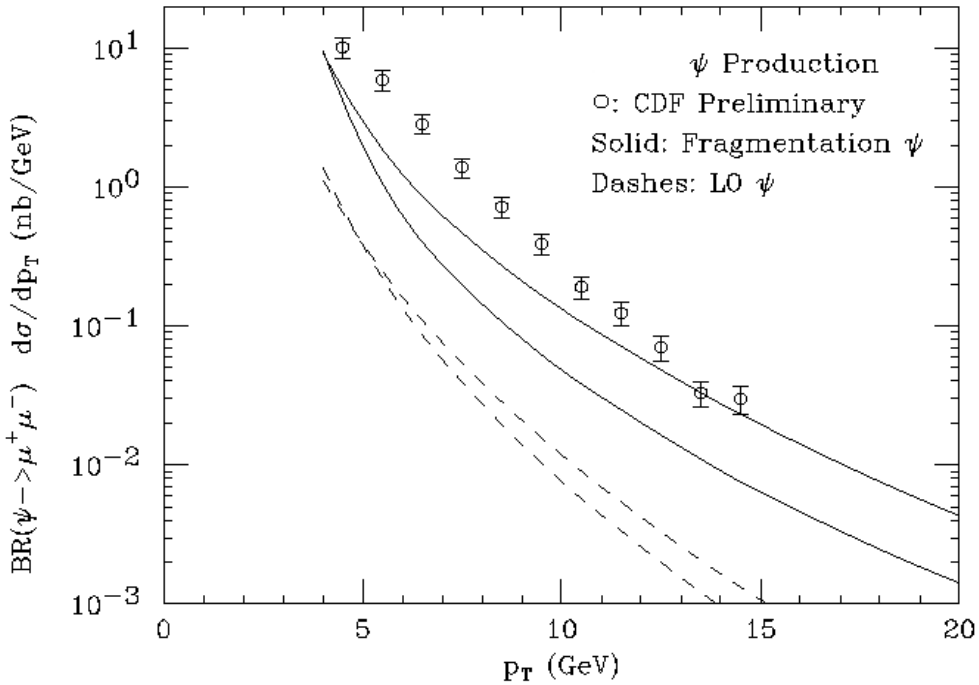
Primary physics goals:

- Study elementary production mechanism (p+p)
- Probe properties of the QGP (A+A)

Elementary Reactions

Quarkonia production:

- Colour Singlet Model
- Colour Octet Model
- Colour Evaporation Model



[Phys. Lett. B333 (1994) 548-554]

Elementary Reactions

Quarkonia production:

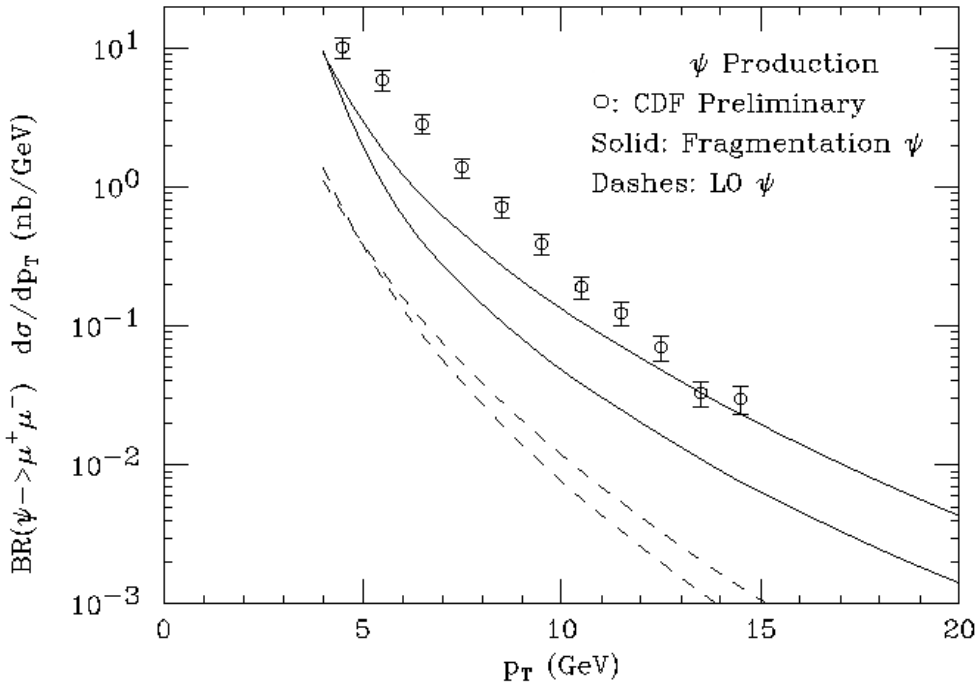
- Colour Singlet Model
- Colour Octet Model
- Colour Evaporation Model

Contribution from feed-down:

- $\chi_c \rightarrow J/\psi + \gamma$
- $\mathrm{B} \rightarrow \mathrm{J}/\psi + \mathrm{X}$ or $\psi' + X$

Measure $\frac{\mathrm{d}^2\sigma}{\mathrm{d}y\mathrm{d}p_\mathrm{t}}$ to distinguish between:

- Production models
- PDFs

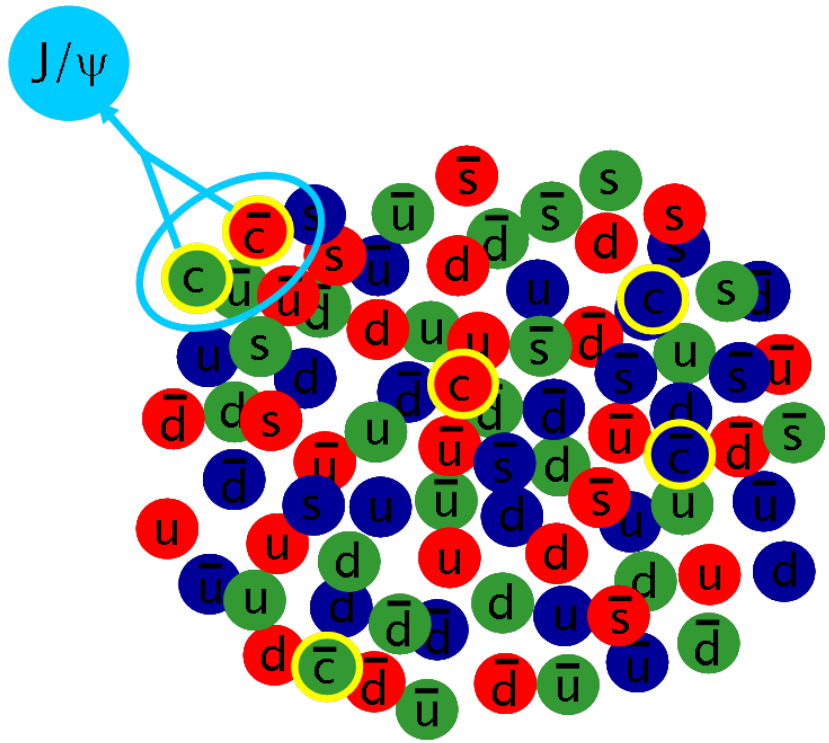


[Phys. Lett. B333 (1994) 548-554]

Heavy Ions

Competing mechanisms:

1. Quarkonia production
2. Feed down from higher mass quarkonia $\Uparrow$
3. QGP induced effects:
   - Melting (Debye screening) $\Downarrow$
   - Recombination (uncorr. $Q\bar{Q}$) $\Uparrow$
4. Cold nuclear matter effects:
   - Nuclear absorption $\Downarrow$
   - Shadowing $\Downarrow\Uparrow$



Need to disentangle!

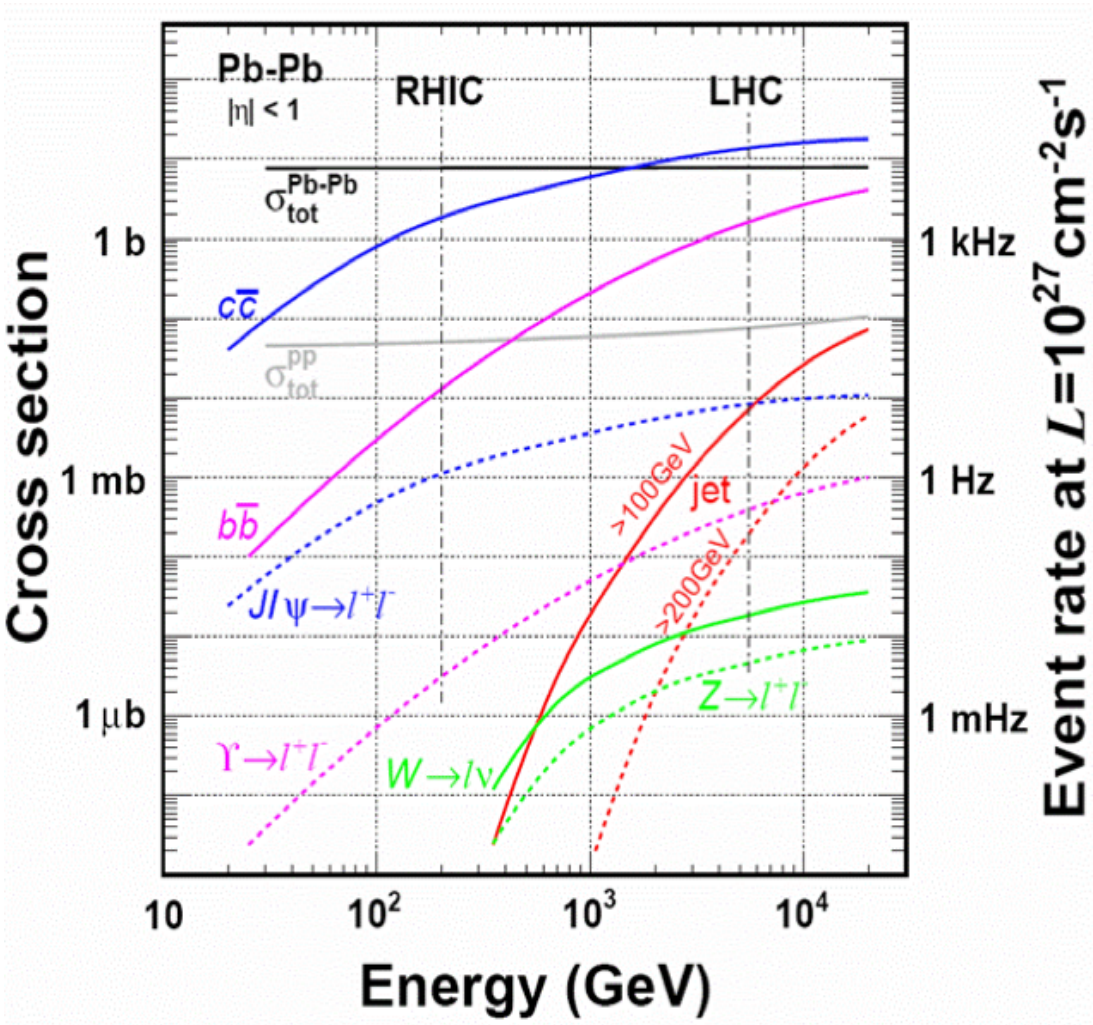
Necessary Measurements

Measure quarkonia in different systems:

- **p+p**: elementary processes, baseline for A+A
- **p+A**: cold medium effects, baseline for A+A
- **A+A**: interaction with hot medium

LHC - New Perspectives

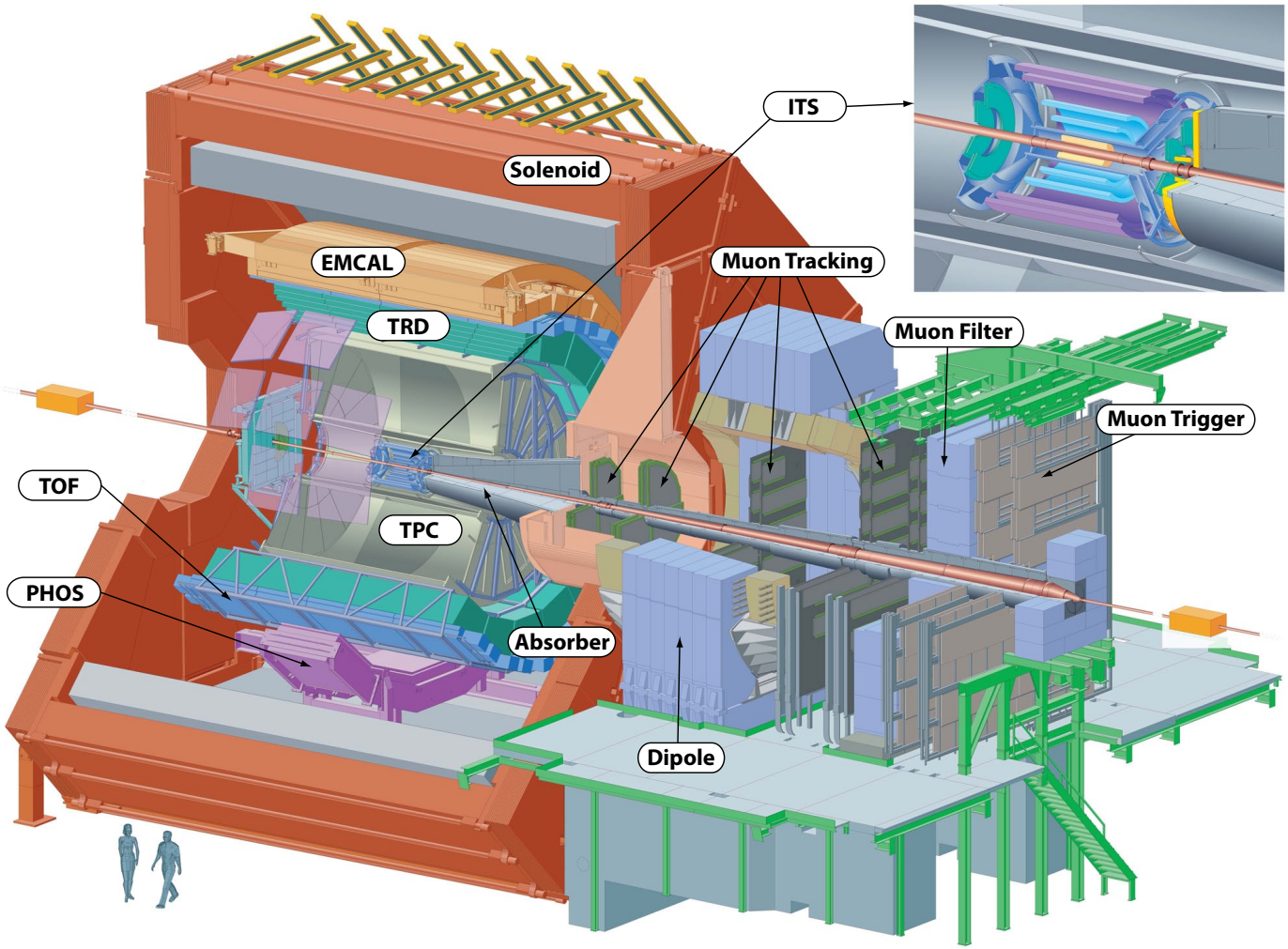
	$\sqrt{s_{NN}}$ (GeV)	$N_{c\bar{c}}$/ev. cent. AA
SPS	17.3	0.2
RHIC	200	10
LHC	5500	115



LHC will deliver excellent statistics for quarkonia measurements!

ALICE

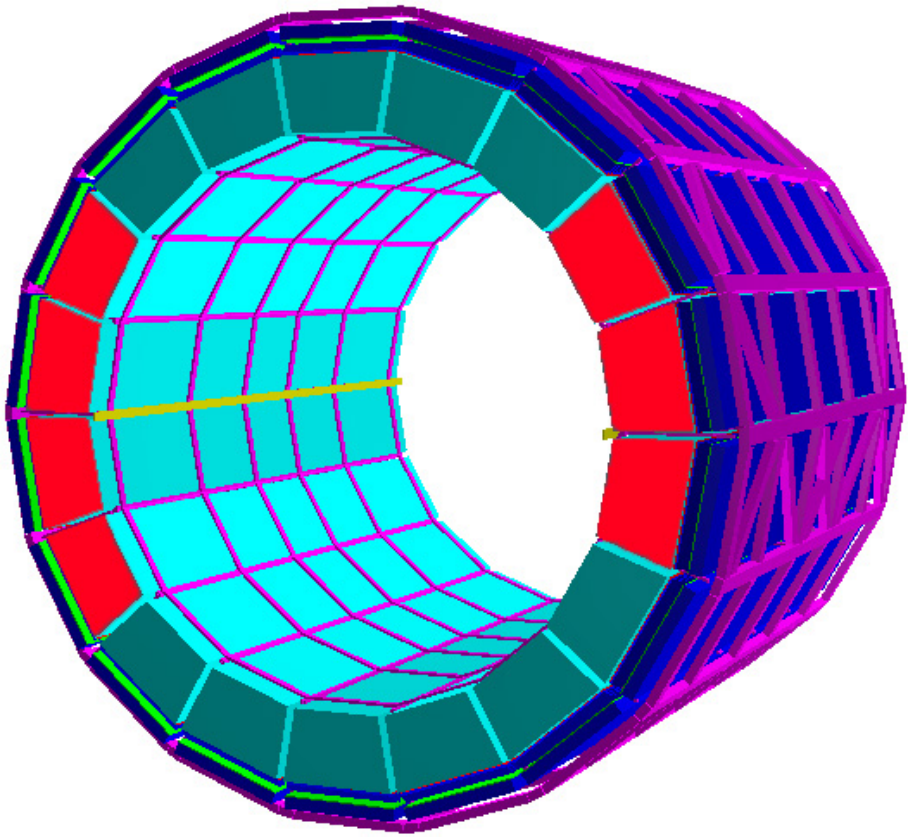
$\sim$ 1000 members from 111 institutes from 31 countries

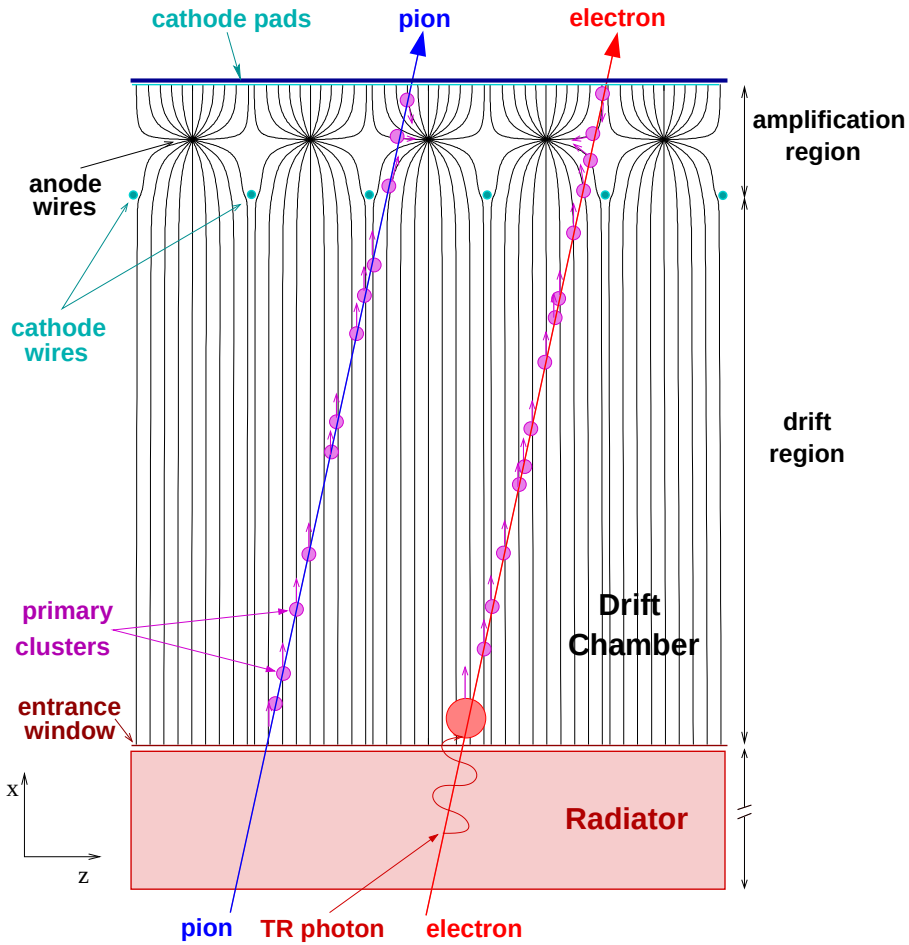


ITS: Inner Tracking System, TPC: Time Projection Chamber, TRD: Transition Radiation Detector

Transition Radiation Detector

- 7/18 supermodules installed and operational
- 6 layers of drift chamber + radiator
- Factor 100 in π rejection ($p > 3$ GeV)

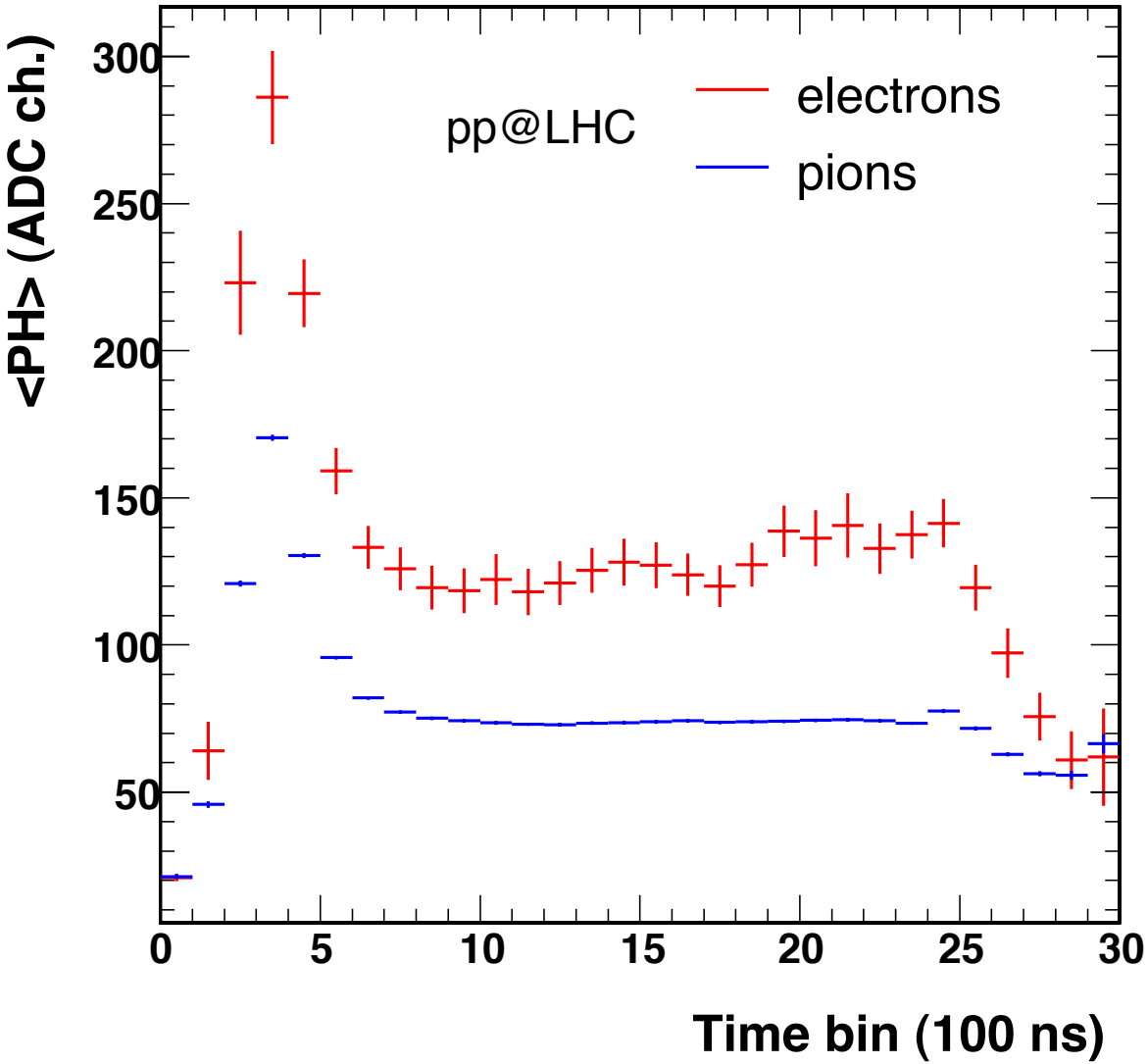




Transition Radiation Detector

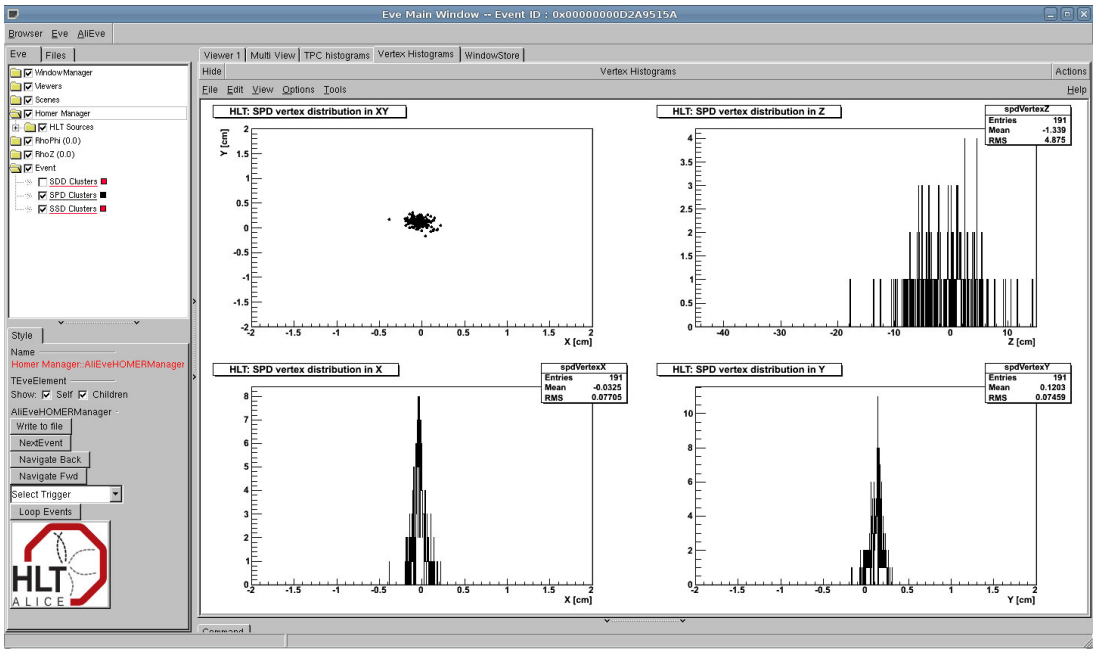
First analysis of real data! (p+p, 900 GeV)

Average Pulse Height



The TRD as Trigger Detector

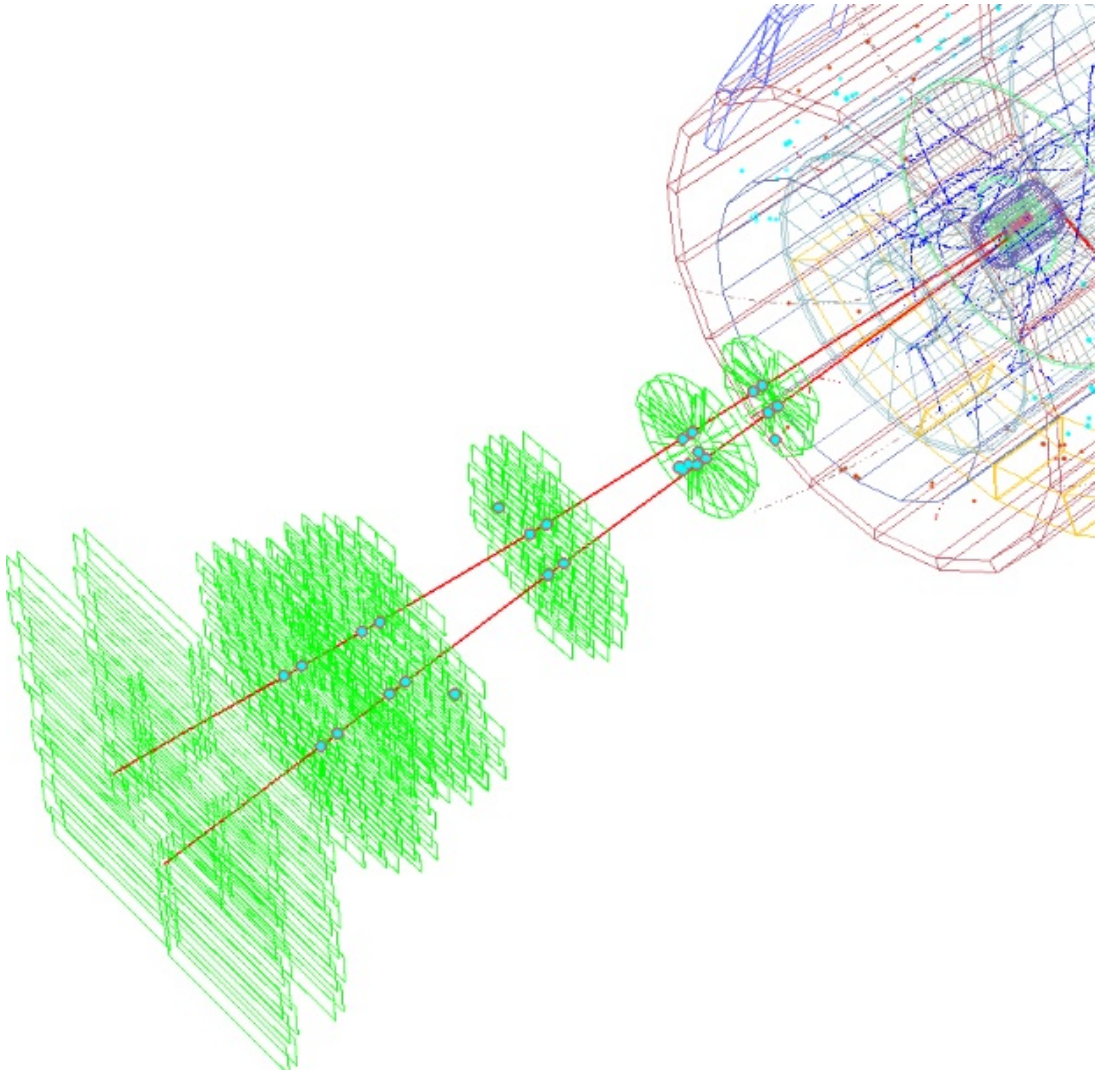
- **L1**: trigger on high momentum single electron/electron pair
- **HLT**: full online data analysis ($\rightarrow$ trigger on e^+e^- inv. mass), event selection and compression



Online display of the vertex positions reconstructed by the ALICE HLT

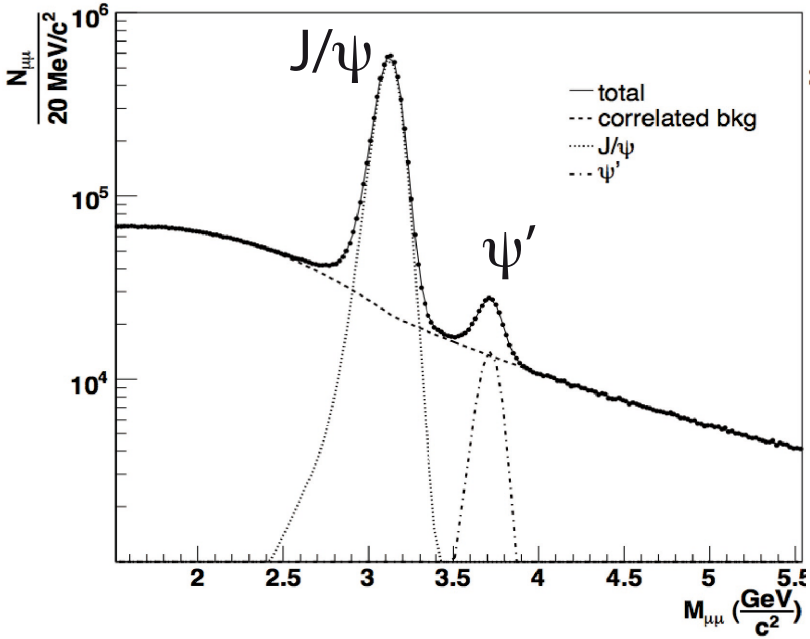
First collisions (p+p, 900 GeV) Nov/Dec 2009 **[EPJC, Vol. 65 (2010) pp. 111-125]**

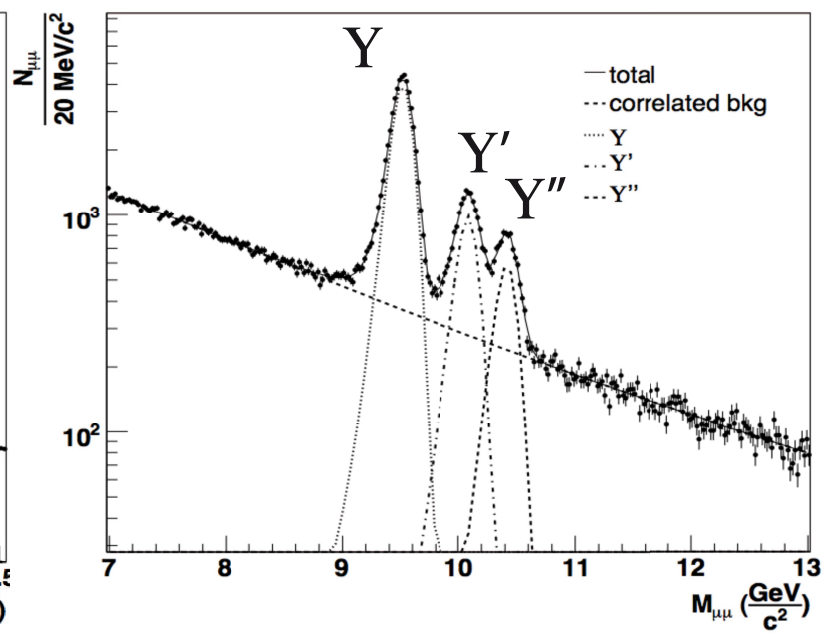
$J/\psi \rightarrow \mu^+\mu^-$



Event display from first collisions!

$J/\psi \rightarrow \mu^+\mu^-$

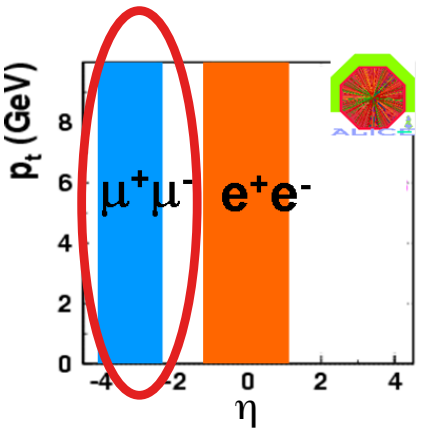




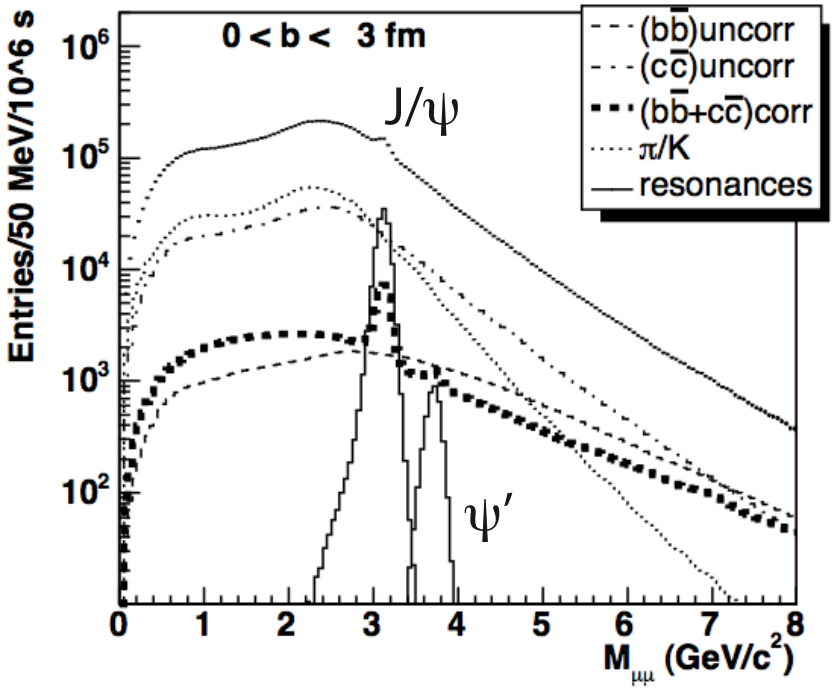
1 nominal LHC year (w/ trigger)		
	J/ψ	Υ
S	4.7M	44.7k
S/B	12.6	5.8
$S/\sqrt{S+B}$	2081	195

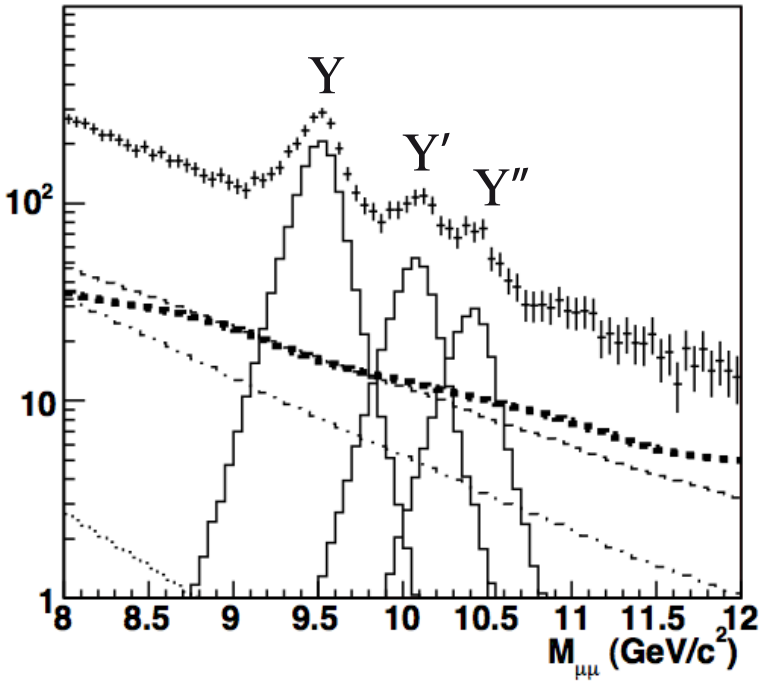
p+p simulation 14 TeV

[ALICE PPR v2 CERN/LHCC 2005-030]



$J/\psi \rightarrow \mu^+\mu^-$



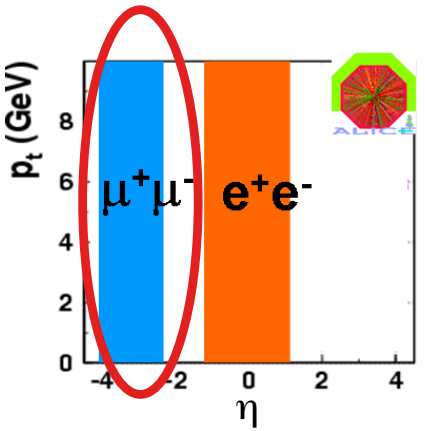


1 nominal LHC year (w/ trigger)

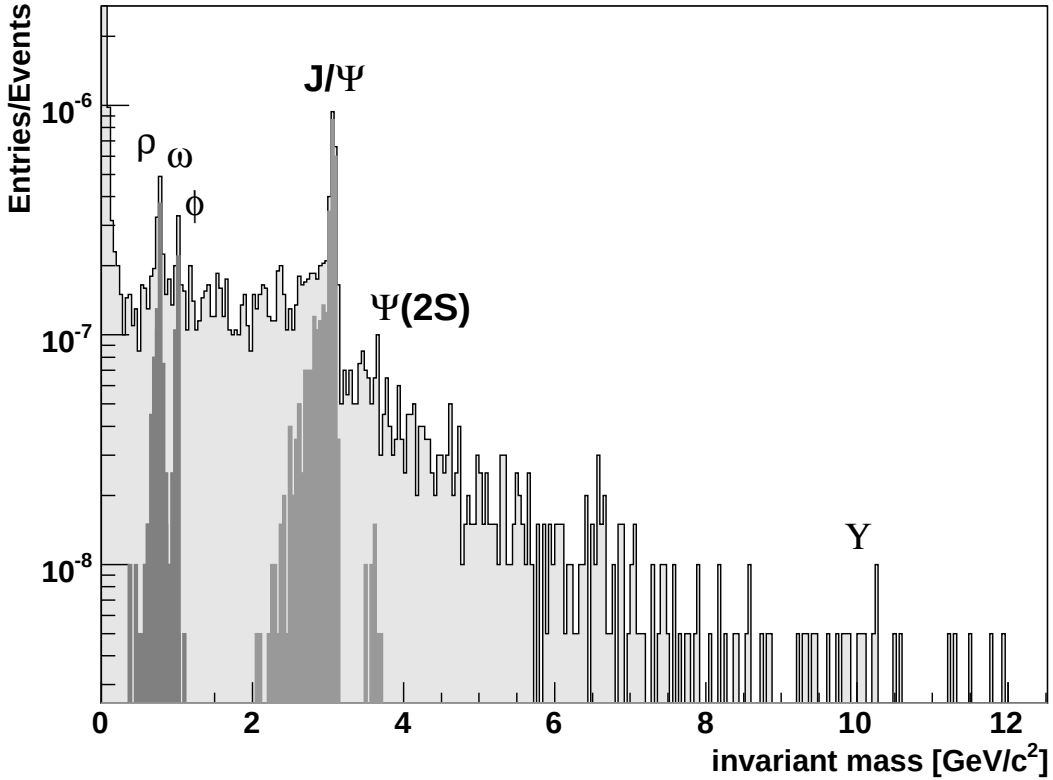
	J/ψ	Υ
S	130k	1300
S/B	0.2	1.7
$S/\sqrt{S+B}$	150	29
Resolution (MeV/c^2)	~70	~100

Pb+Pb simulation 5.5 TeV

[ALICE PPR v2 CERN/LHCC 2005-030]



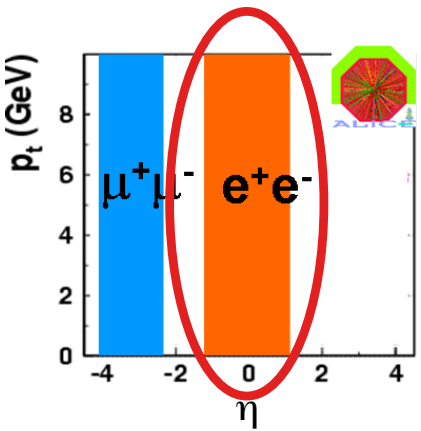
$J/\psi \rightarrow e^+e^-$



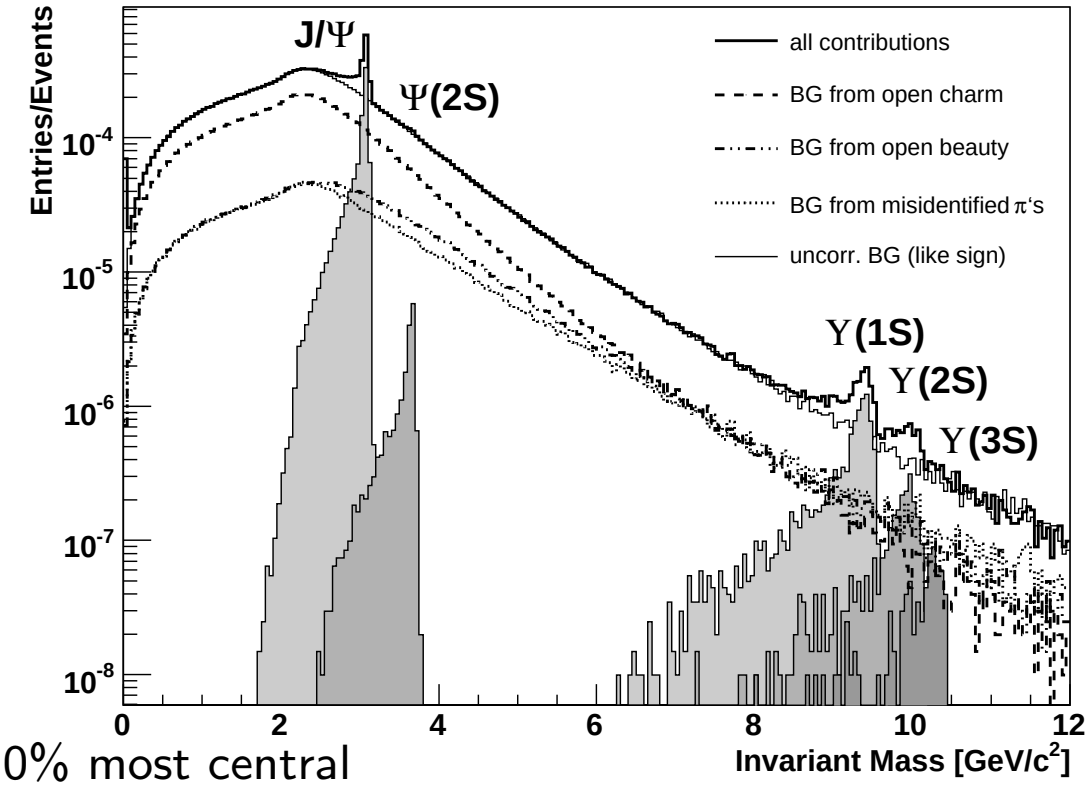
0.2 nominal LHC year (min bias)	
	J/ψ
S	360
S/B	9
$S/\sqrt{S+B}$	18
Resolution (MeV/c^2)	~30

p+p simulation 14 TeV

[arXiv:nucl-ex/0702045v1]



$J/\psi \rightarrow e^+e^-$



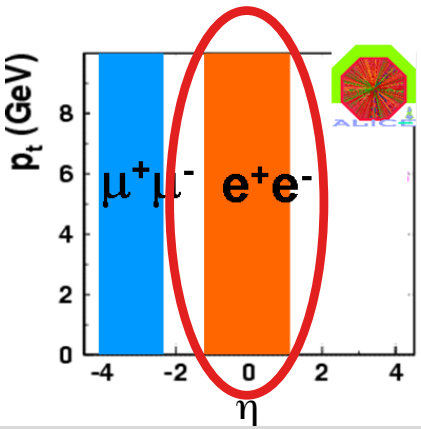
10% most central

1 nominal LHC year (min bias)

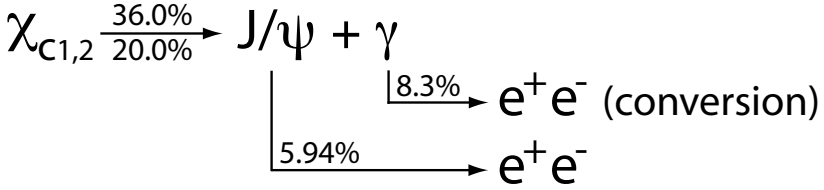
	J/ψ	Υ
S	120k	900
S/B	1.2	1.1
$S/\sqrt{S+B}$	245	21
Resolution (MeV/c^2)	~30	~90

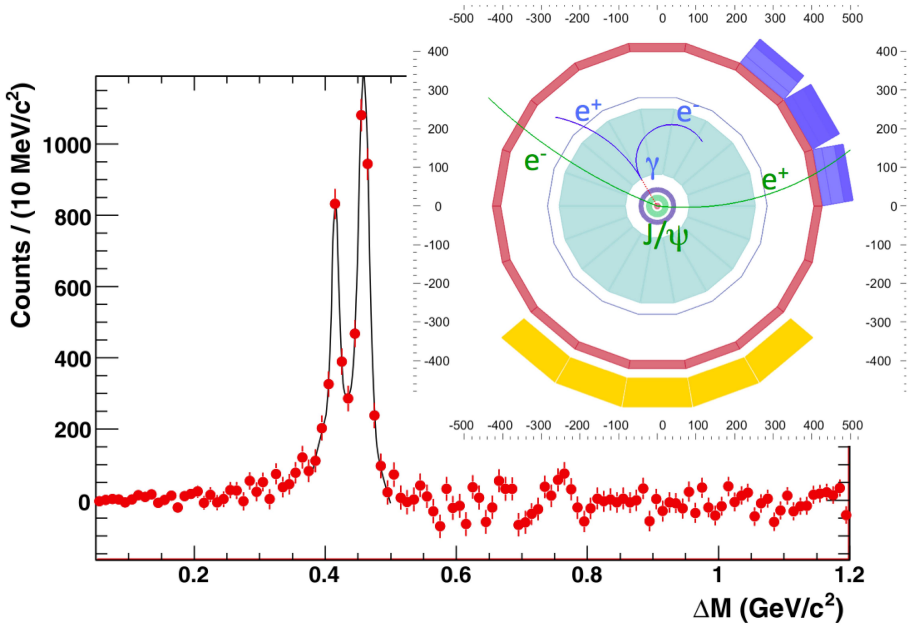
Pb+Pb simulation 5.5 TeV

[arXiv:nucl-ex/0702045v1]



Secondary J/ψ





Identify in $M(e^+e^-\gamma)$ spectrum

$\sim$ 30% contribution to yield

$\Delta M = M(e^+e^-\gamma) - M(e^+e^-)$

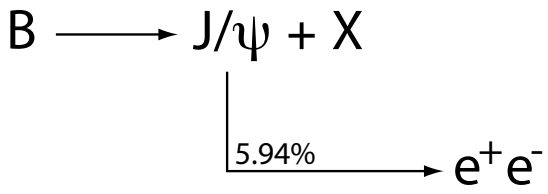
p+p 14 TeV,

1 nominal LHC year

$\sim 12,000$ χ_c (perfect trigger)

[EPJC 10.1140/epjc/s10052-009-0895-4]

Secondary J/ψ



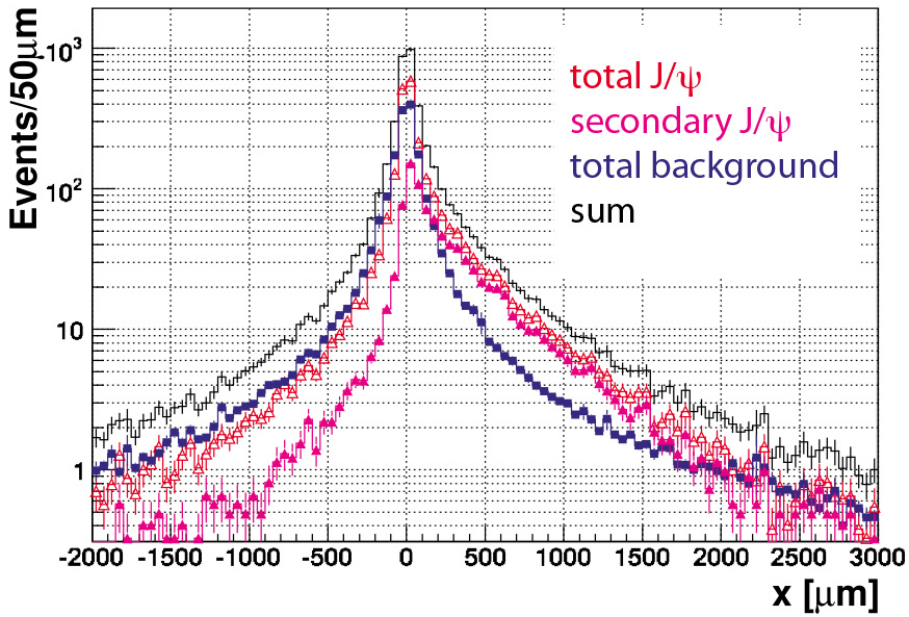
$c\tau \sim 500\mu\mathrm{m} \rightarrow$ likely to have a displaced vertex

B fraction: Simultaneous fit of inv. mass + pseudo proper decay time (CDF approach)

$$x = L_{\mathrm{xy}} \frac{M_{J/\psi}}{p_{\mathrm{t}}}$$

$L_{\mathrm{xy}} = \vec{L} \frac{\vec{p_{\mathrm{t}}}}{|p_{\mathrm{t}}|}$ and $\vec{L} = r_{\mathrm{vtx}}^{\vec{\mathrm{sec}}} - r_{\mathrm{vtx}}^{\vec{\mathrm{prim}}}$

$\sim$ 20-30% contribution to yield



p+p 14 TeV,
1 nominal LHC year

[J.Phys.G:Nucl.Part.Phys 36 (2009) 064053]

[PRD 71 032001 (2005)]

Summary

- LHC provides a very good environment for quarkonia measurements
- ALICE will measure quarkonia
  - Dielectron (midrapidity) and dimuon channel (forward)
  - Secondary J/ψ reconstruction
  - Dedicated triggers
  - Acceptance down to $p_t = 0$
- Clear signals are expected
  - in triggered samples
  - in 1st year's min. bias samples for J/ψ (Pb+Pb: also Υ)
- Very good mass resolution to separate between $Q\bar{Q}$ states
- LHC start end of 2009 very successful, so far 0.36 M p+p events $\sqrt{s} = 0.9$ TeV with all detectors