Inclusive J/ψ production:
first results in p+p at 7 TeV at ALICE

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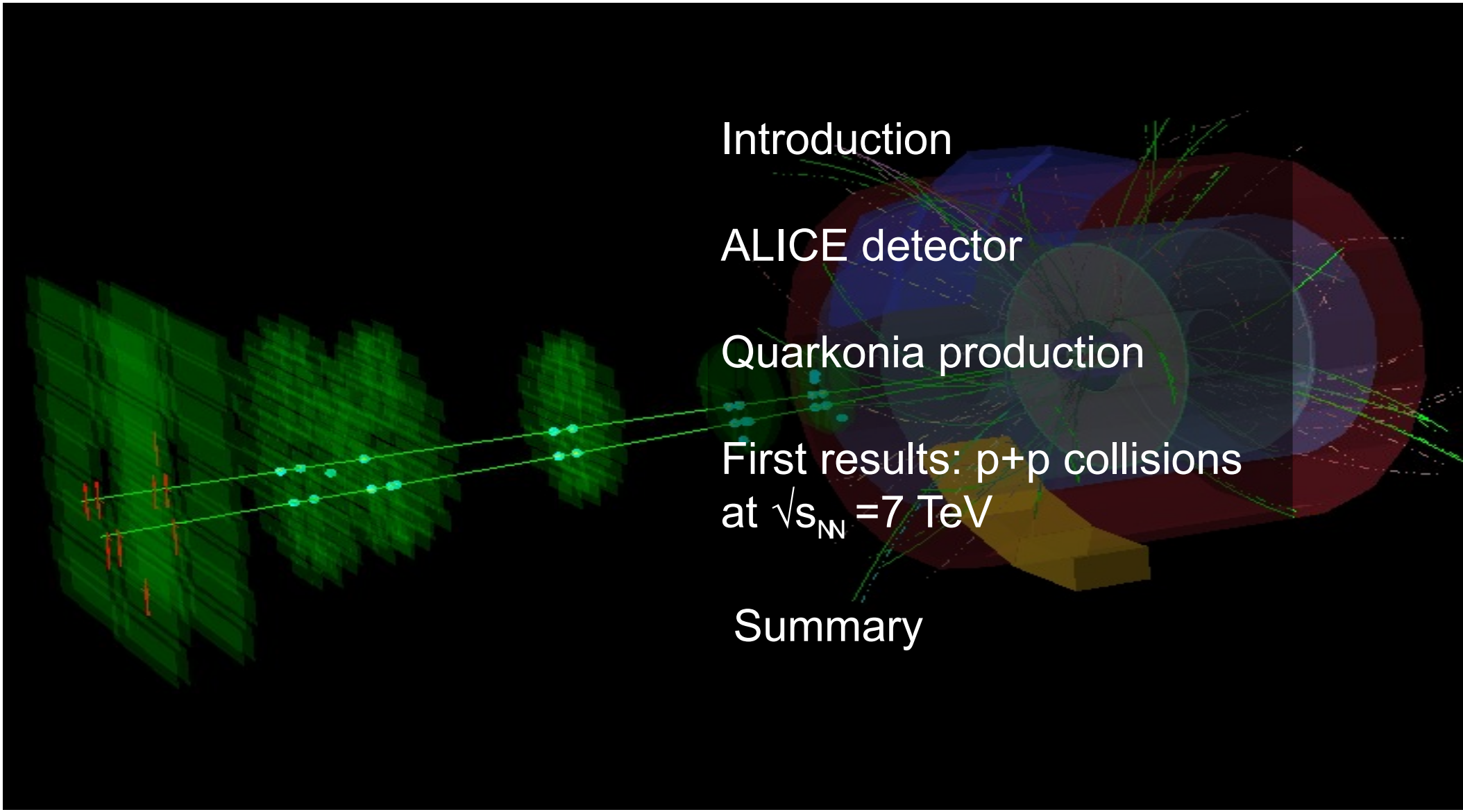
Nuclear modifications of the parton distribution functions
High-pT jet production in pp, pA and AA
High-pT jet propagation in matter
Nuclear modifications of the fragmentation functions Correlations of leading particles
Direct photon and heavy flavor tagging

HIGH ENERGY
Instituto de Ciencias Nucleares
MÉXICO, CITY
SEPTEMBER 27th- OCTOBER 1st

MÉXICO 2010
Bicentenario Independencia Centenario Revolución

CONACYT REDFAE UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO
https://www.nucleares.unam.mx/highpt2010 ICN

Plan of this talk



Introduction

ALICE detector

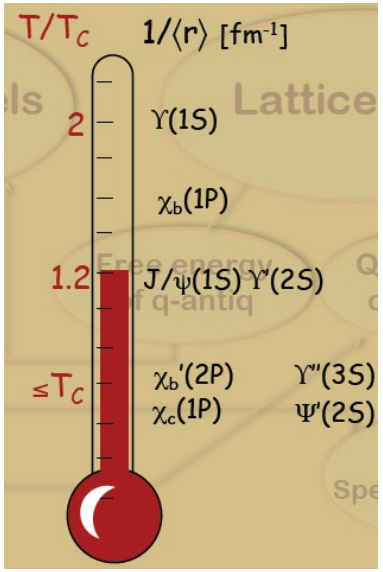
Quarkonia production

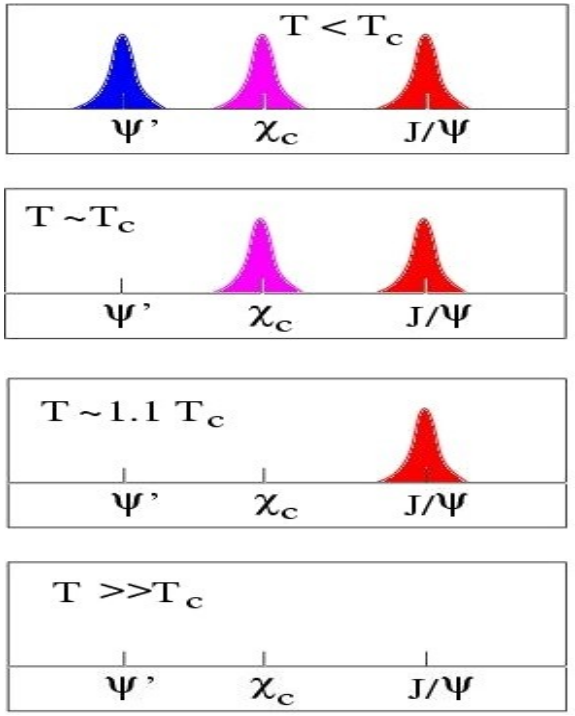
First results: p+p collisions at $\sqrt{s_{NN}}$ =7 TeV

Summary

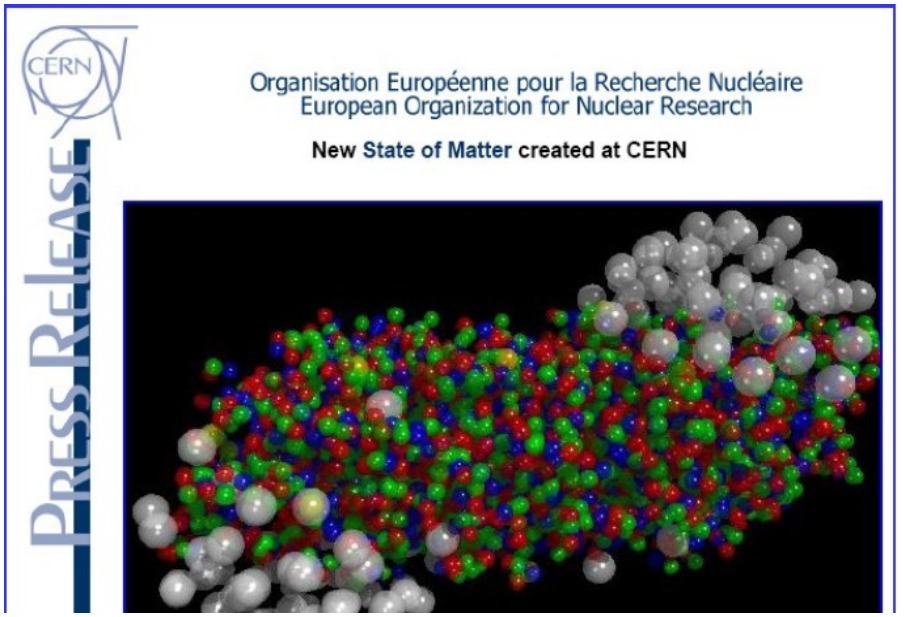
Quarkonia in heavy-ions

Quarkonia suppression was one of the main pieces of evidence for CERN's claim to have produced a QGP phase at SPS energies

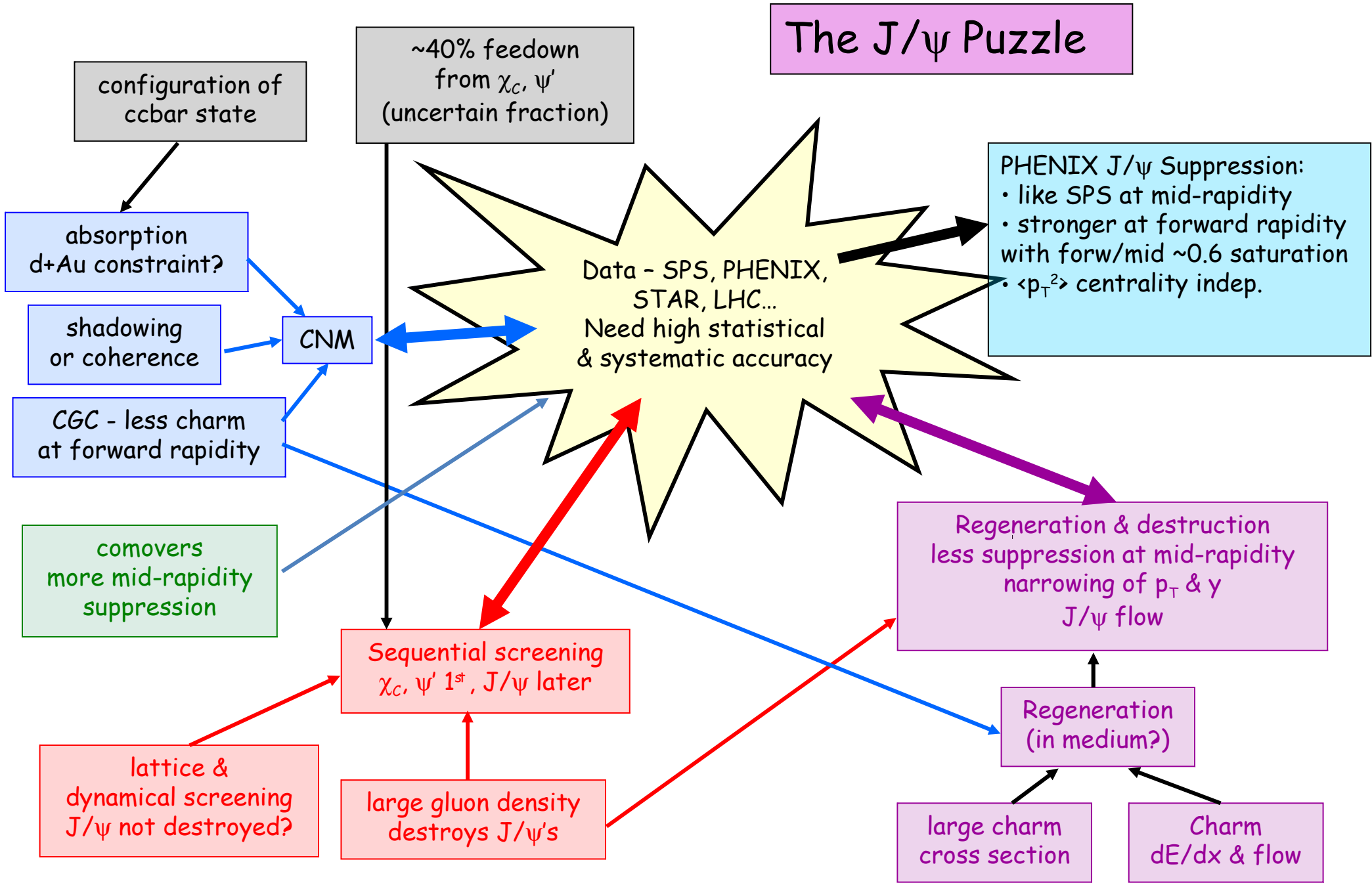




Different lattice calculations do not agree on whether the J/ψ is screened or not measurements will have to tell!



Debye screening predicted to destroy J/ψ's in a QGP with other states "melting" at different temperatures due to different sizes or binding energies


The J/ψ Puzzle
configuration of ccbar state
~40% feedown from χc, ψ' (uncertain fraction)
absorption d+Au constraint?
shadowing or coherence
CNM
CGC - less charm at forward rapidity
comovers more mid-rapidity suppression
Data – SPS, PHENIX, STAR, LHC… Need high statistical & systematic accuracy
PHENIX J/ψ Suppression:
• like SPS at mid-rapidity
• stronger at forward rapidity with forw/mid ~0.6 saturation
• <pT2> centrality indep.
Regeneration & destruction
less suppression at mid-rapidity
narrowing of pT & y
J/ψ flow
Sequential screening
χc, ψ' 1st , J/ψ later
Regeneration (in medium?)
lattice & dynamical screening J/ψ not destroyed?
large gluon density destroys J/ψ's
large charm cross section
Charm dE/dx & flow

Central to Peripheral Modification Factor (R_{CP})

$$R_{CP}(p_T) = \frac{\langle N_{coll} \rangle_P}{\langle N_{coll} \rangle_C} \times \frac{d^2 N_C / dp_T dy}{d^2 N_P / dp_T dy}$$

C and P are two centrality classes, Central and Peripheral

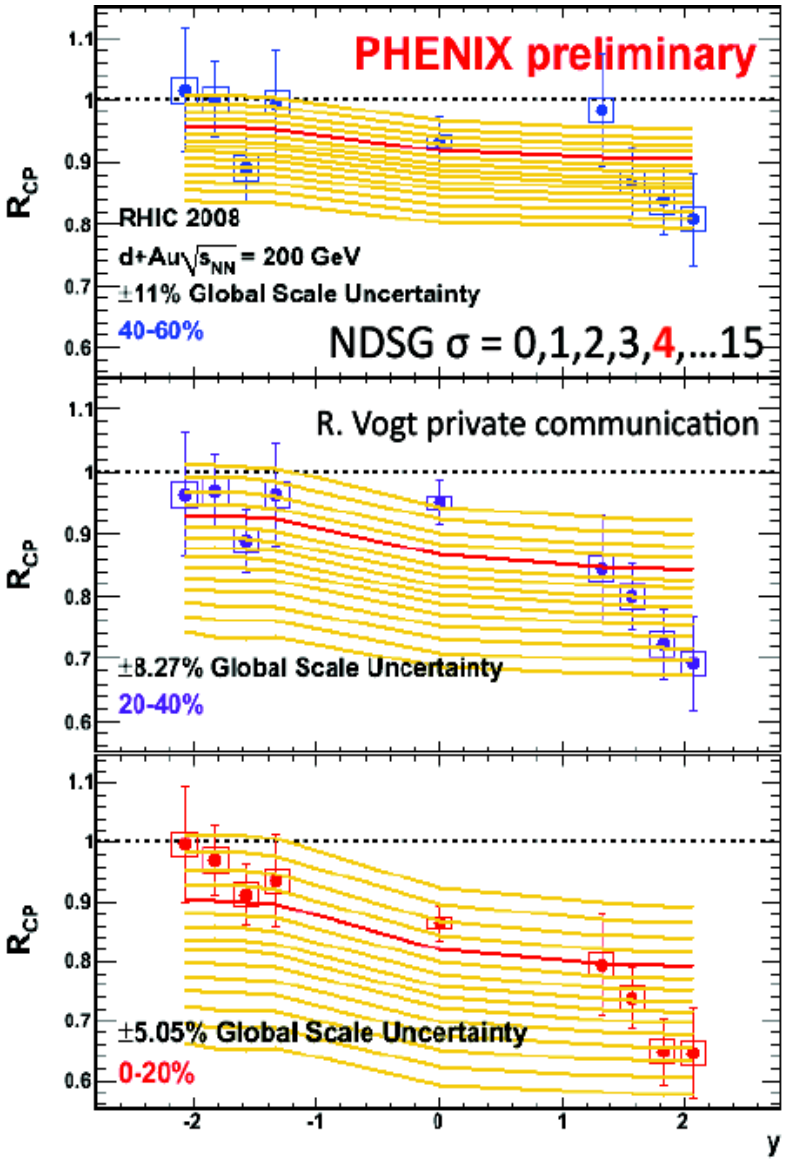
N_{coll} are the average number of nucleon-nucleon (N-N) collisions for nucleus-nucleus (A-A) collisions in a given centrality class

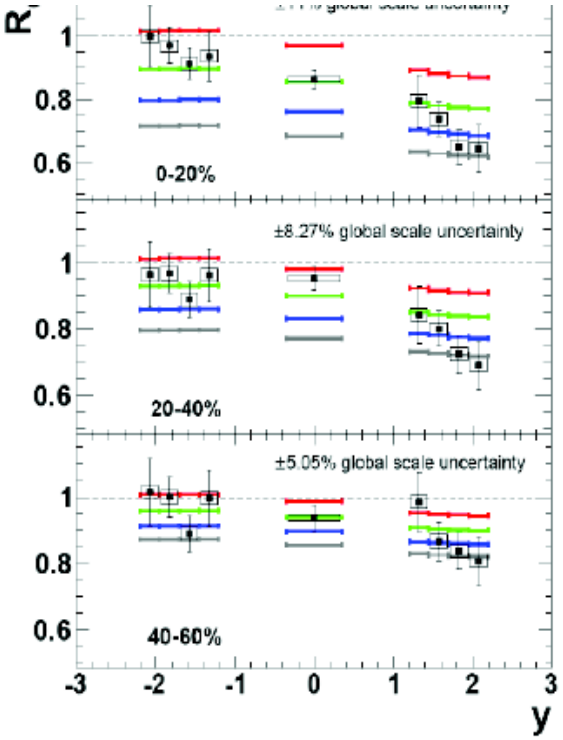
- Expect $R_{CP} = 1$ if the A-A collision were merely a superposition of N_{coll} independent N-N collisions

Ref: F Antinori *et al.* (NA57 Collaboration), **Phys. Lett. B 623** (2005) 17

J/ψ CNM effects

pA might be crucial to understand the AA data at LHC energies

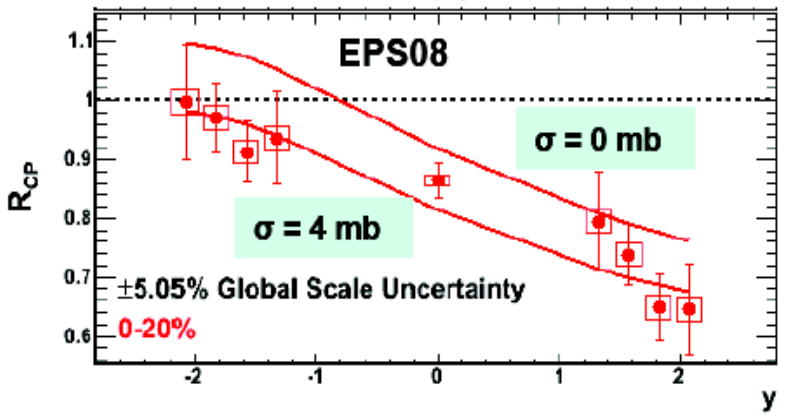




arXiv:0912.4498

At PHENIX, CNM effects (EKS shadowing + dissociation from fits to d+Au data, with R. Vogt calculations) give large fraction of observed Au+Au suppression, especially at mid-rapidity

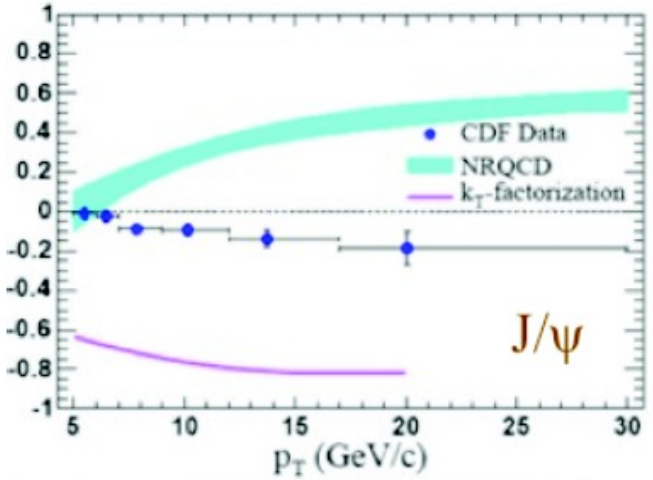
Bottom line:
CNM could explain the mid-forward rapidity difference

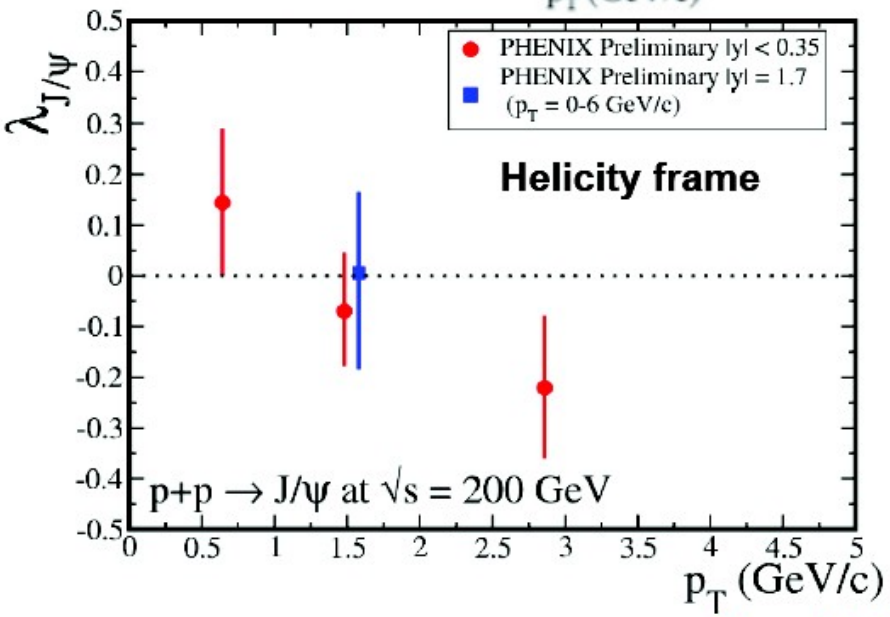


High statistics data provides a strong test of CNM models

J/ψ polarisation

λ>0 transverse
λ<0 longitudinal





- no model explains cross section and polarization simultaneously
- many models on the market
  - Color Singlet Model: LO, NLO, NNLO
  - Color Octet Mechanism: NRQCD...

many more

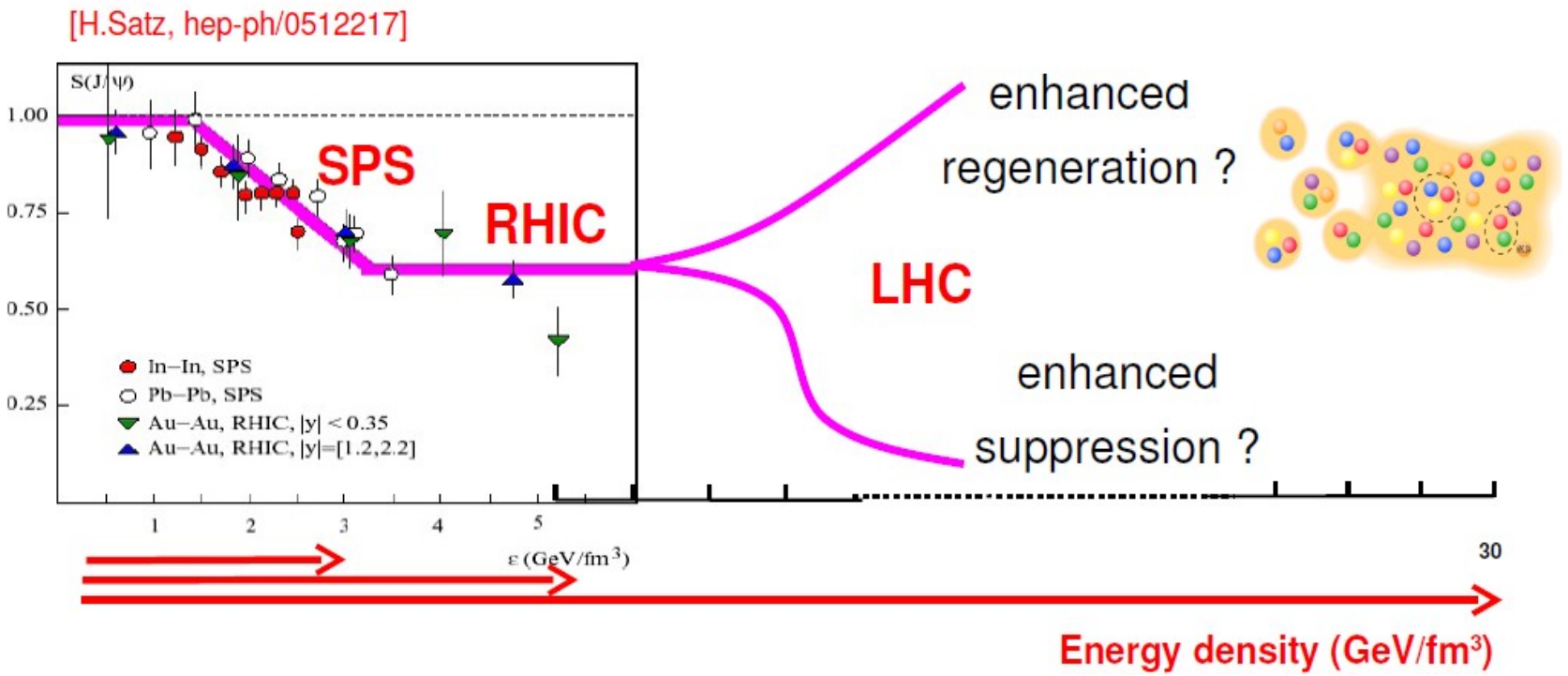
$$\frac{dN}{d\cos\theta} = A(1+\lambda\cos^2\theta)$$

λ>0 transverse
λ<0
longitudinal

L. Levy @ ICHEP 2010

Should help constrain production models

Quarkonia in heavy-ions



The long standing unambiguous signature of deconfined quark matter has somehow become ambiguous :Suppression pattern "anomalously" comparable at SPS and RHIC.

Rapidity dependence

Different CNM/shadowing effects

Sequential melting : ψ', χ_c only

Statistical hadronisation : a possible scenario motivated by the large production of charm in Pb+Pb collisions

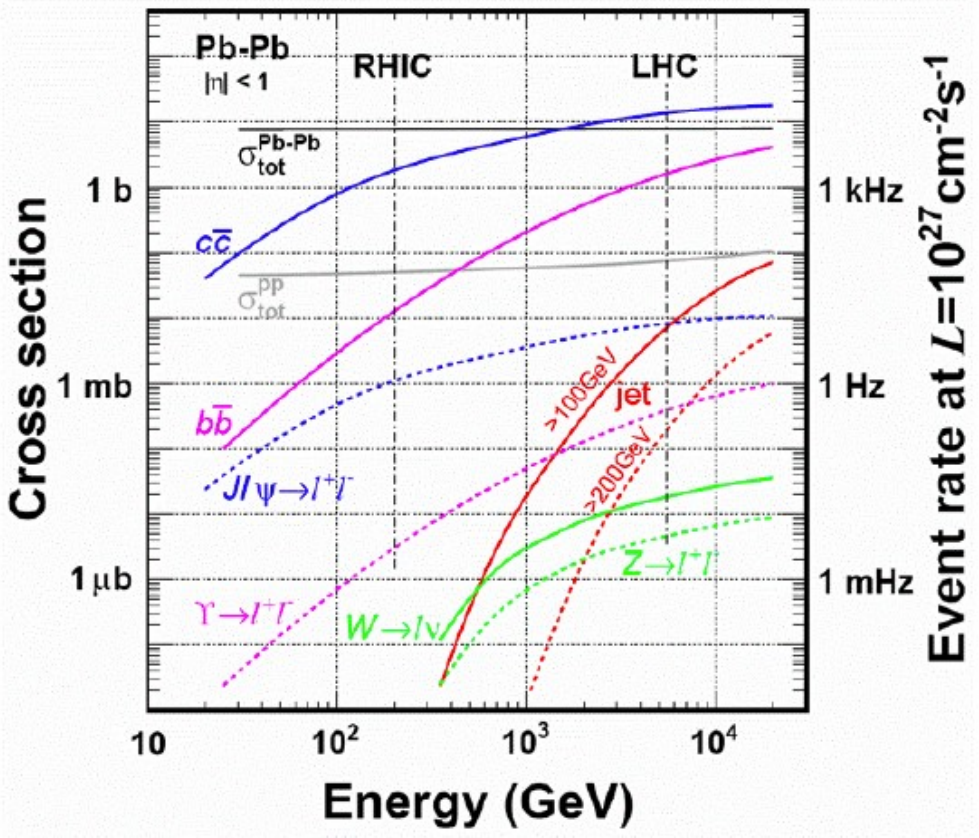
The ALICE experiment at the LHC

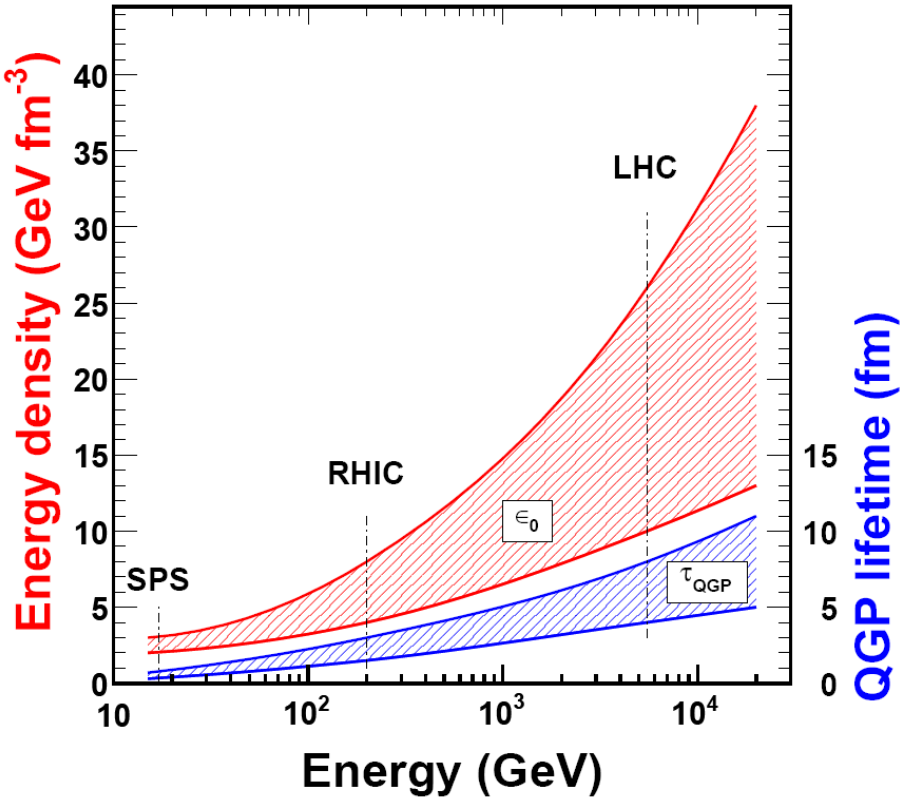
Physics motivation

- A big step in $\sqrt{s_{NN}}$
  - (SPS x 13 = RHIC) x 28 = LHC
  - Energy density well above the expected phase transition (hotter,bigger,longer)

  → Hard probes as new probes

For more details on Jet Physics at ALICE, see Andreas Morsch 's talk today





Heavy Quarks, abundantly produced in the first instant 0.03-0.1 fm/c, will probe QGP/medium over its whole lifetime (~ 10 fm/c)

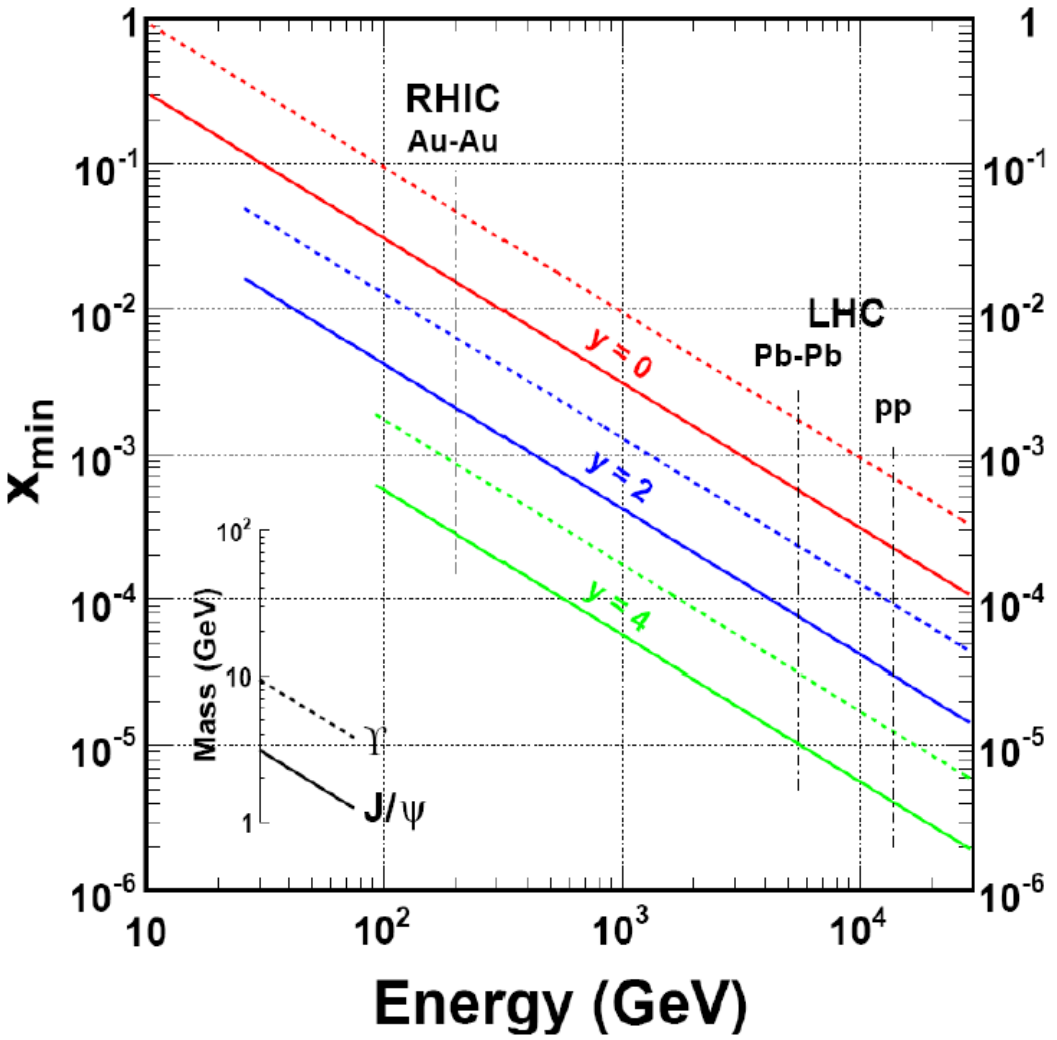
Open beauty and charm physics

J/ψ, ψ' and Υ,Υ',Υ'' as medium thermometer

Important B-hadron decays to charmonia yields

See talk by Serhiy Senyukov

The small-*x* regime



From RHIC to LHC

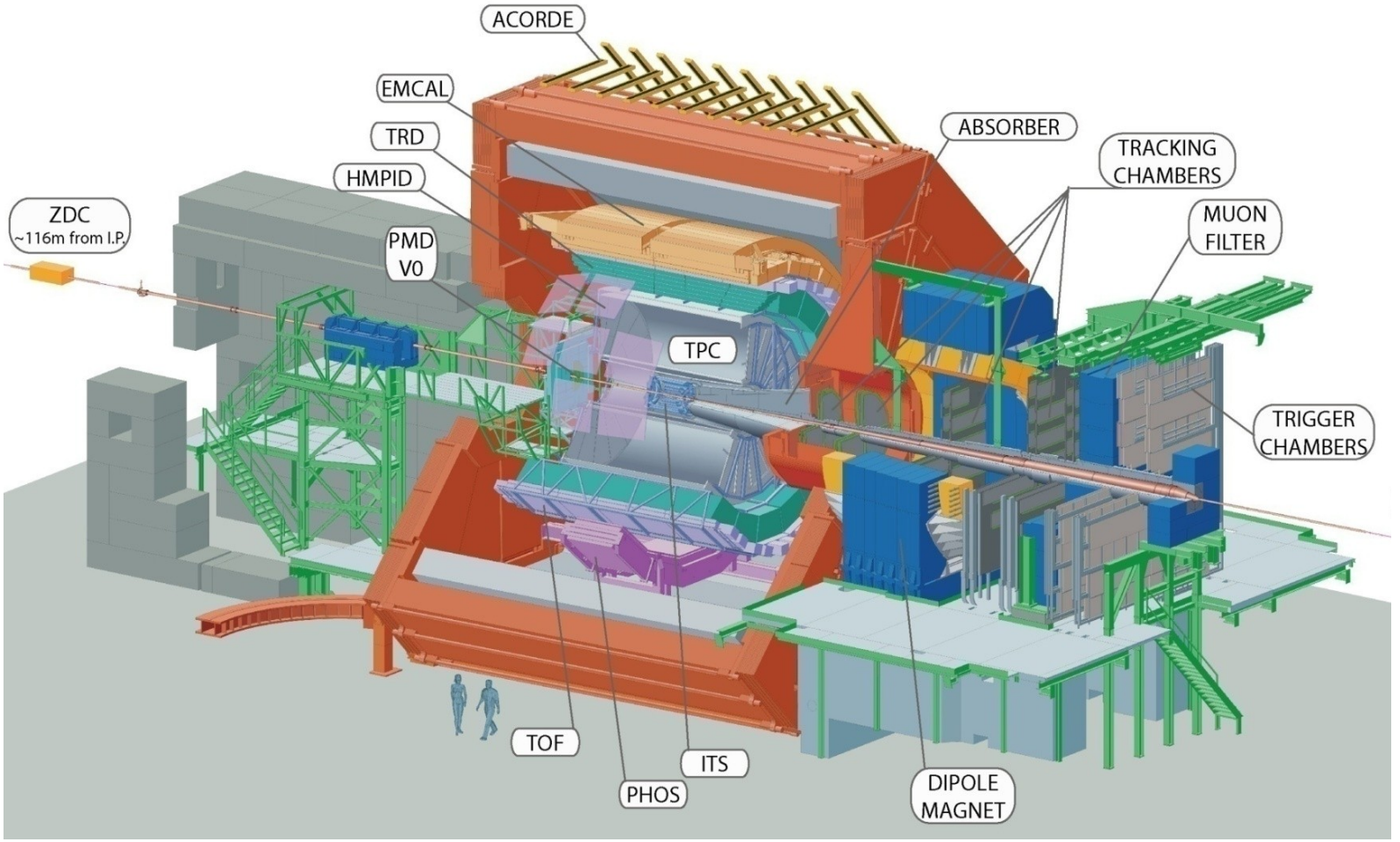
x_{min} ↘ ~ 10^{-2}

- factor 1/30 due to energy
- factor 1/3 larger rapidity

With J/ψ at rapidity 4

- Pb+Pb collisions x_{min} ~ 10^{-5}
- p+p collisions x_{min} ~ 3×10^{-6}

The ALICE experiment



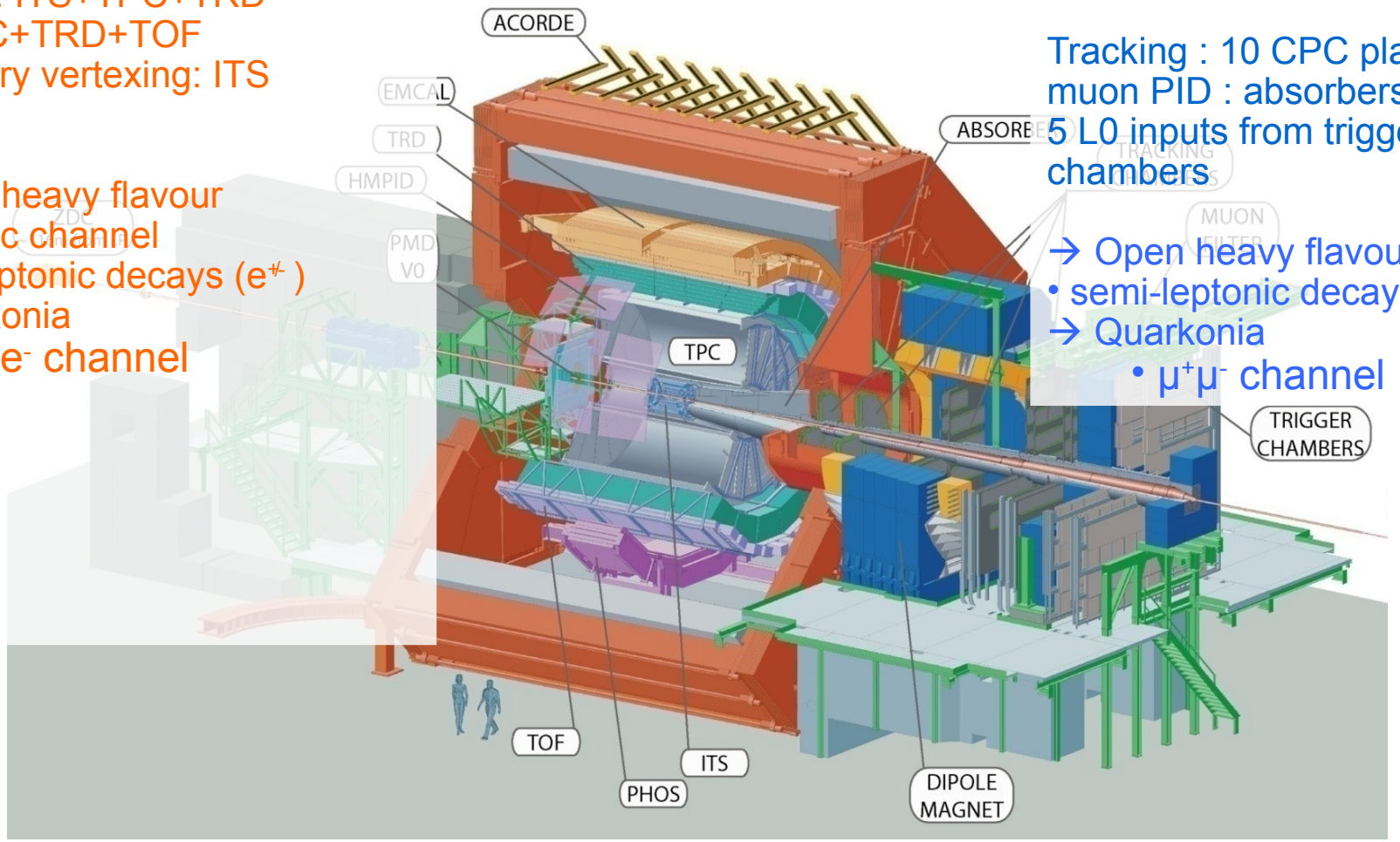
For more details on p+p physics at ALICE, see Jean-Pierre Revol's talk on Monday

The ALICE experiment

Central barrel (|η|<0.9)

Tracking: ITS+TPC+TRD
PID: TPC+TRD+TOF
Secondary vertexing: ITS

→ Open heavy flavour
• hadronic channel
• semi-leptonic decays ($e^{+/-}$)
→ Quarkonia
• e^+e^- channel



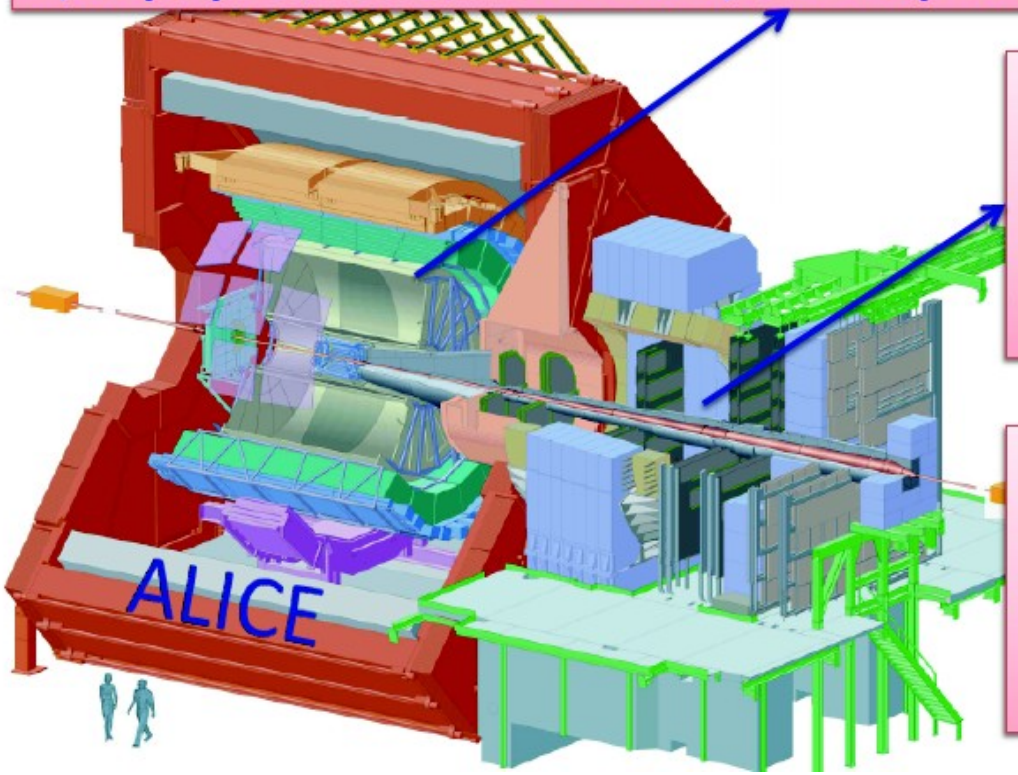
Muon spectrometer (-4.0<η<-2.5)

Tracking : 10 CPC planes
muon PID : absorbers
5 L0 inputs from trigger chambers

→ Open heavy flavour
• semi-leptonic decays ($\mu^{+/-}$)
→ Quarkonia
• $\mu^+\mu^-$ channel

Quarkonium Detection in ALICE

Central Barrel |y|<0.9; ITS+TPC+TRD+TOF; electron ID and μm vertex.
1) J/ψ, ψ', Υ, Υ', Υ'' -> e^+e^-; 2) B-> J/ψ+X->e^+e^-; 3) χ_c->γ+e^+e^- in pp;



Forward muon spectrometer 2.5<|y|<4.0; Muon trigger and tracking; J/ψ, ψ', Υ, Υ', Υ'' -> $\mu^+\mu^-$;

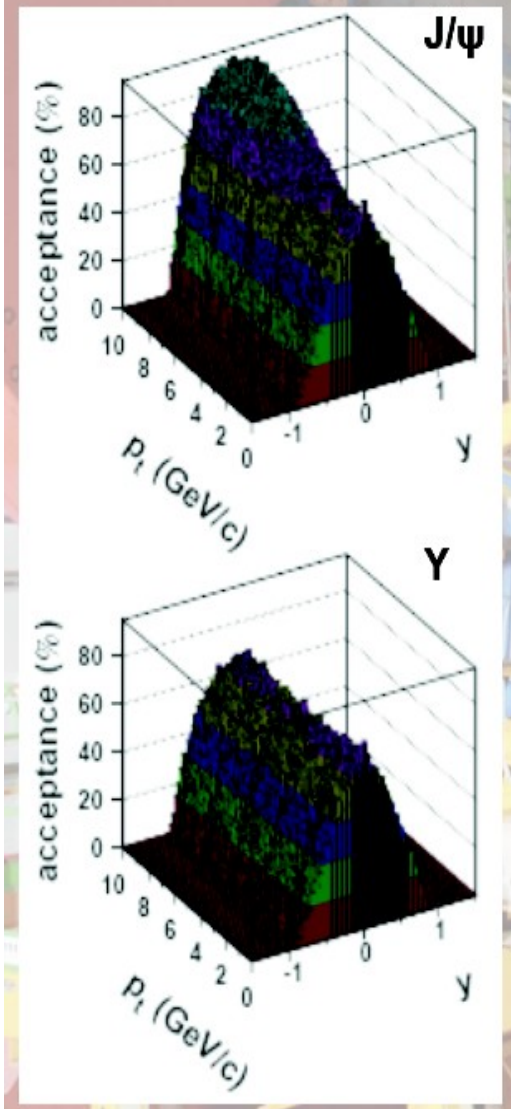
D-hadron & B-electron measurements in |y|<0.9; B-muon and B-dimuons in 2.5<|y|<4.0;

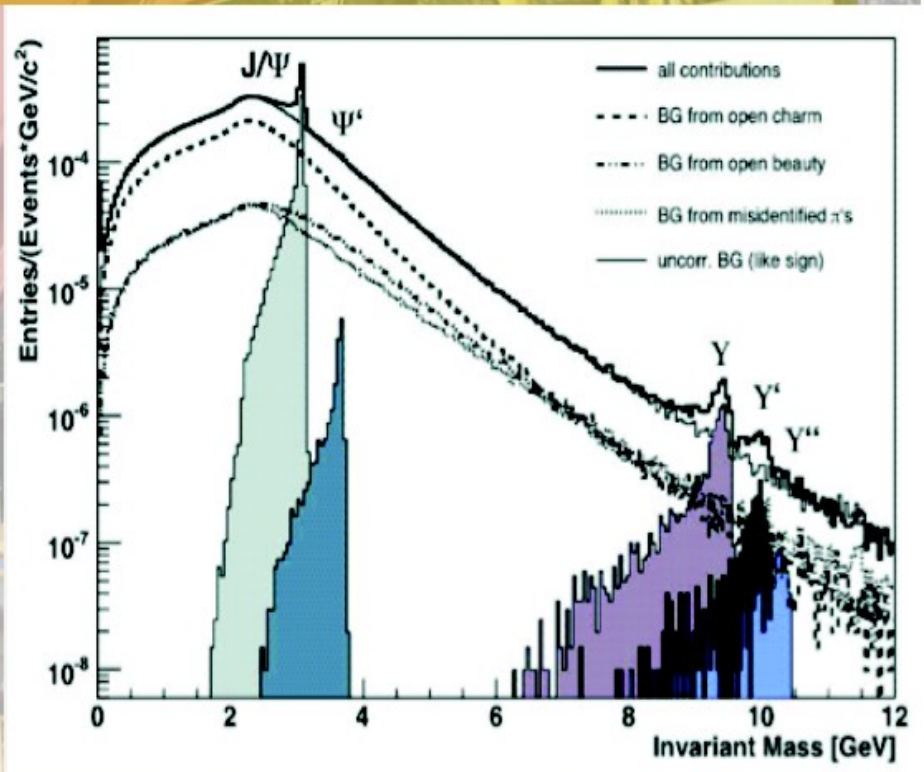
For more details on Heavy quark production at ALICE, see talk by Serhiy Senyukov

J/ψ in the electron decay channel

Pb+Pb physics performance

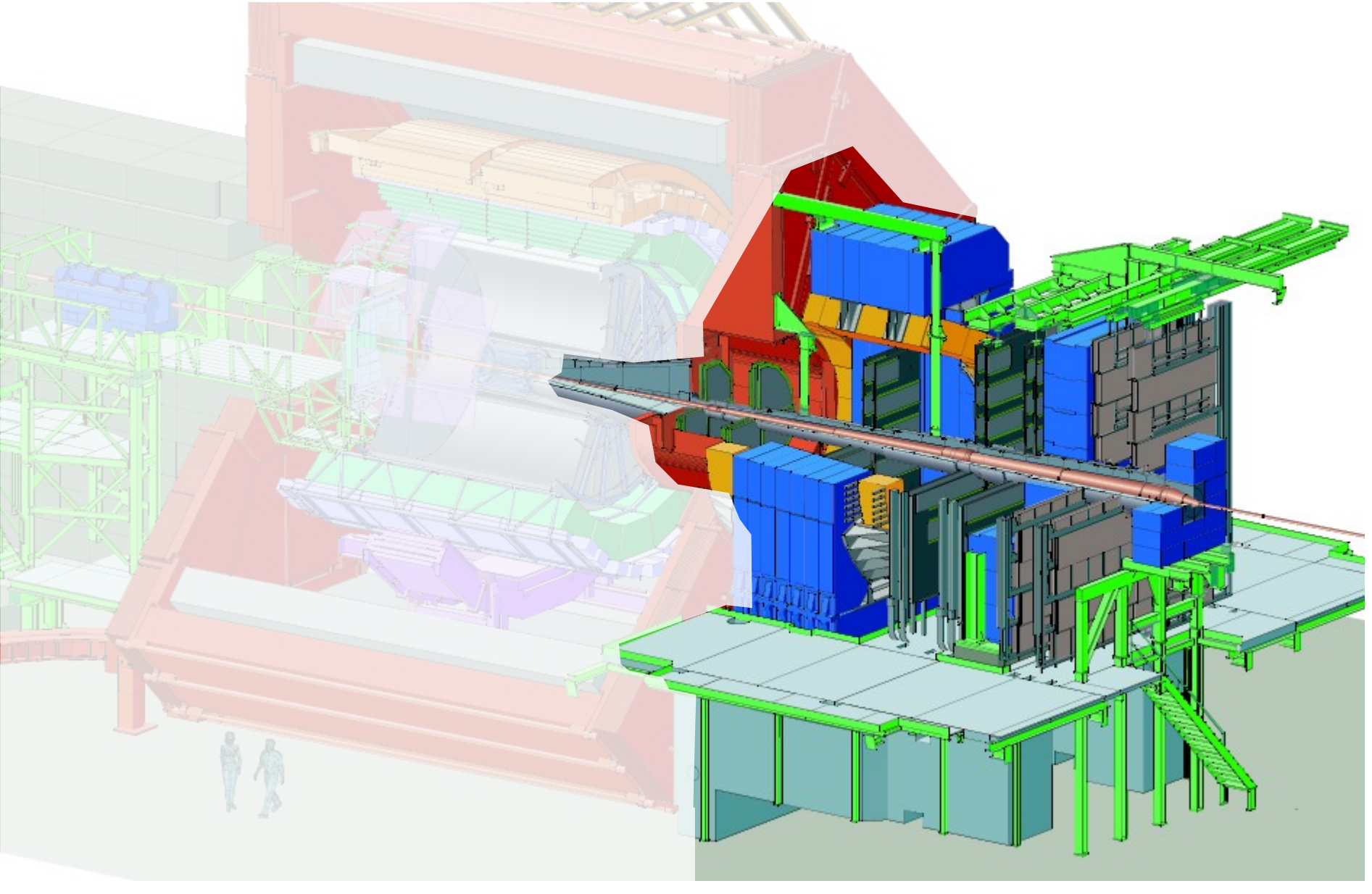
|y|<1 and pt>0



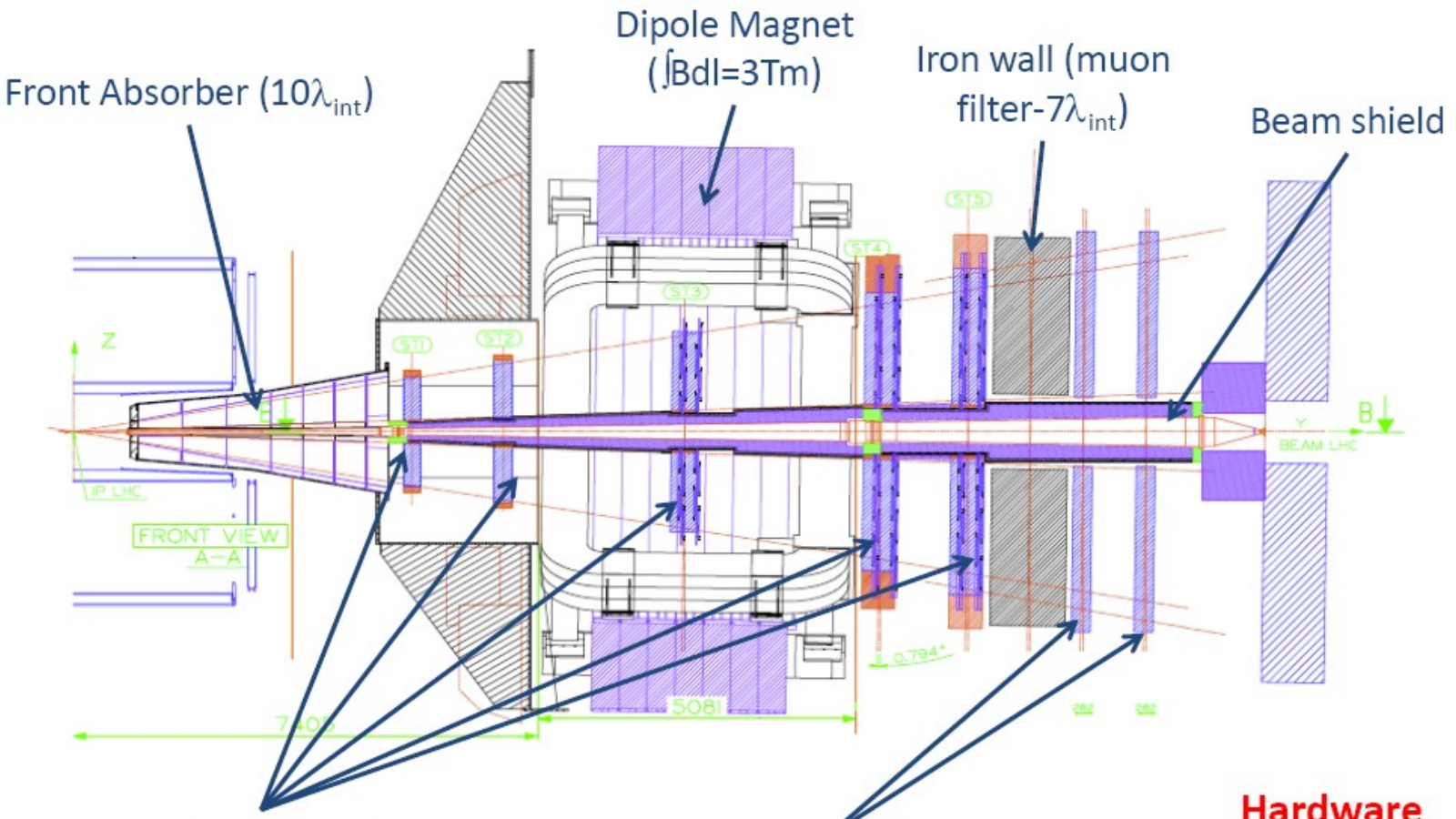


	J/ψ	Υ
Mass resolution	~30 MeV/c^2	~90 MeV/c^2
Signal/Noise	1.2	1.0
Counts (nominal PbPb year) 10%	120k	*900*

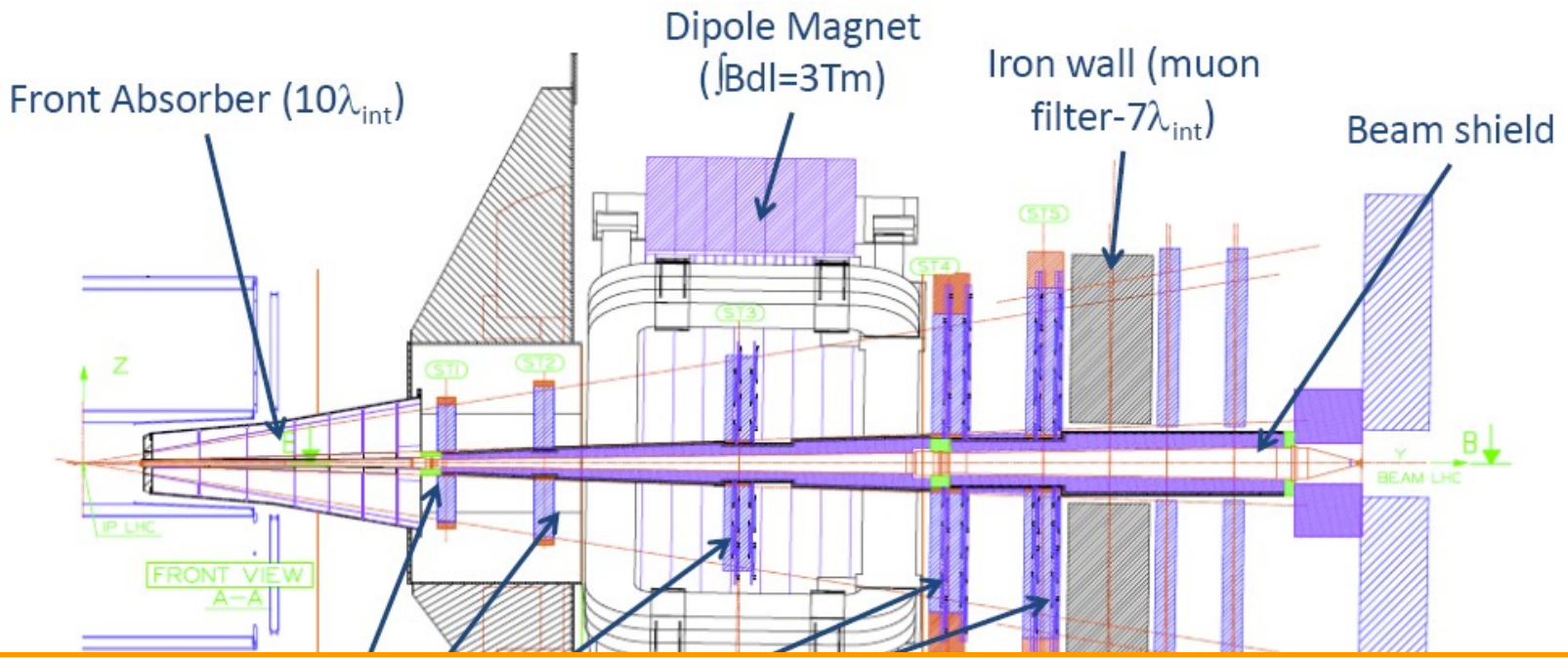
ALICE Muon Spectrometer



ALICE Muon Spectrometer



ALICE Muon Spectrometer



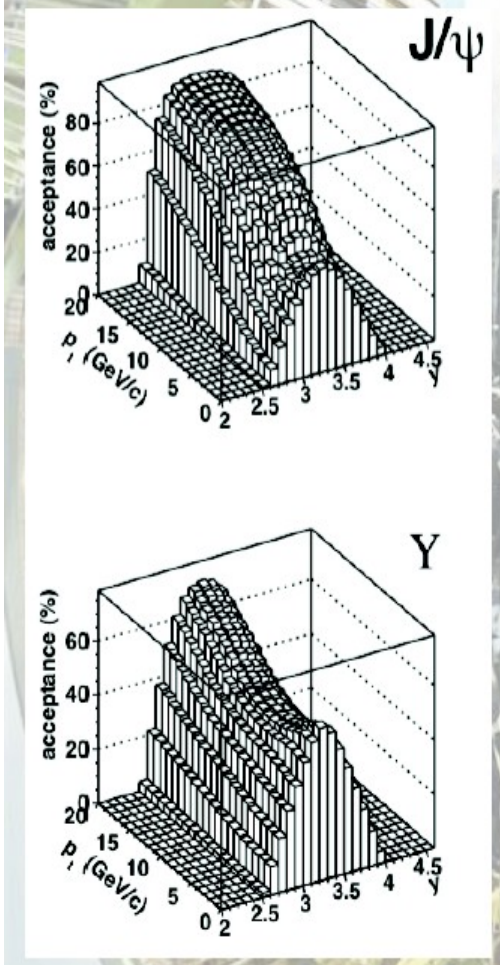
I. **Mass resolution for Υ < 100 MeV/c^2 → spatial resol. < 100 μm along y (bending direction)**

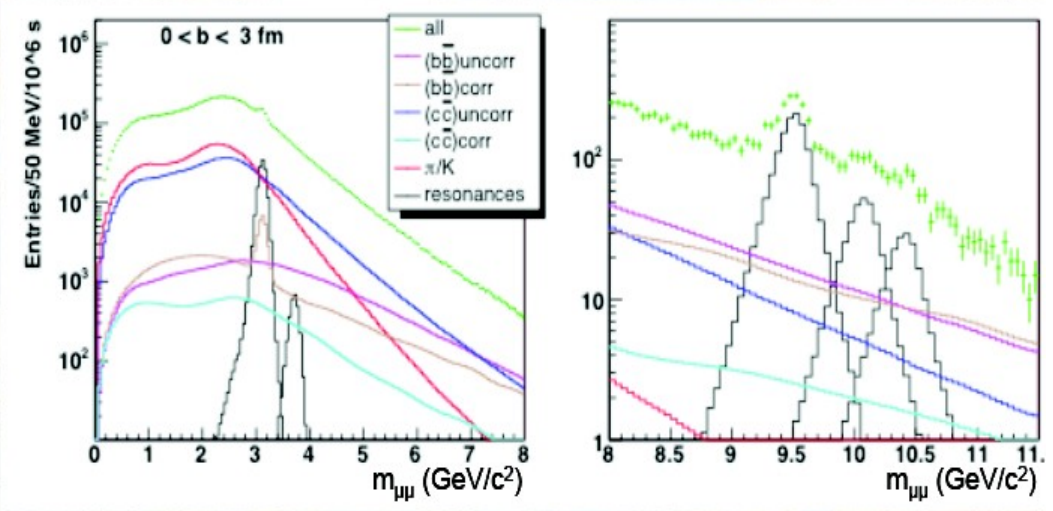
II. **Designed for up to 500 hits/central Pb-Pb collision on the 1rst station (assuming $dN_{ch}/dy|_{y=0}$ = 8000) Today, $dN_{ch}/dy|_{y=0}$ = 2000 would be a more realistic value**

III. **Trigger rate < ~1 kHz (DaQ bandwidth for muon)**
- **8 kHz Pb-Pb collisions with L = 10^{27} $cm^{-2}s^{-1}$**

J/ψ in the muon decay channel

Pb+Pb physics performance





	J/ψ	Υ
Mass resolution	~70 MeV/c^2	~100 MeV/c^2
Signal/Noise	0.3	2.5
Counts (nominal PbPb year) MB	680k	*6000*

J/ψ production in Pb+Pb

The suppression pattern is a thermometer of the QCD matter produced : clear advantage to have a measurement of J/ψ and Y.

Quarkonia production in Pb+Pb in the Muon Spectrometer

$\sqrt{s_{NN}}$ =5.5 TeV [2.76 TeV → 40 to 55 % in σ]

no recombination

central Pb-Pb (0 < b < 3 fm), (MB)

no nuclear effects, $p_\perp$ > 1 GeV/c

Running time : 10^6 s with a Pb-Pb [~90%]

luminosity of 5×10^{26} $cm^{-2}s^{-1}$ [10^{25} $cm^{-2}s^{-1}$]

→ Good statistics for ϒ(1S)

→ ϒ(2S), ϒ(3S) will requires a few runs

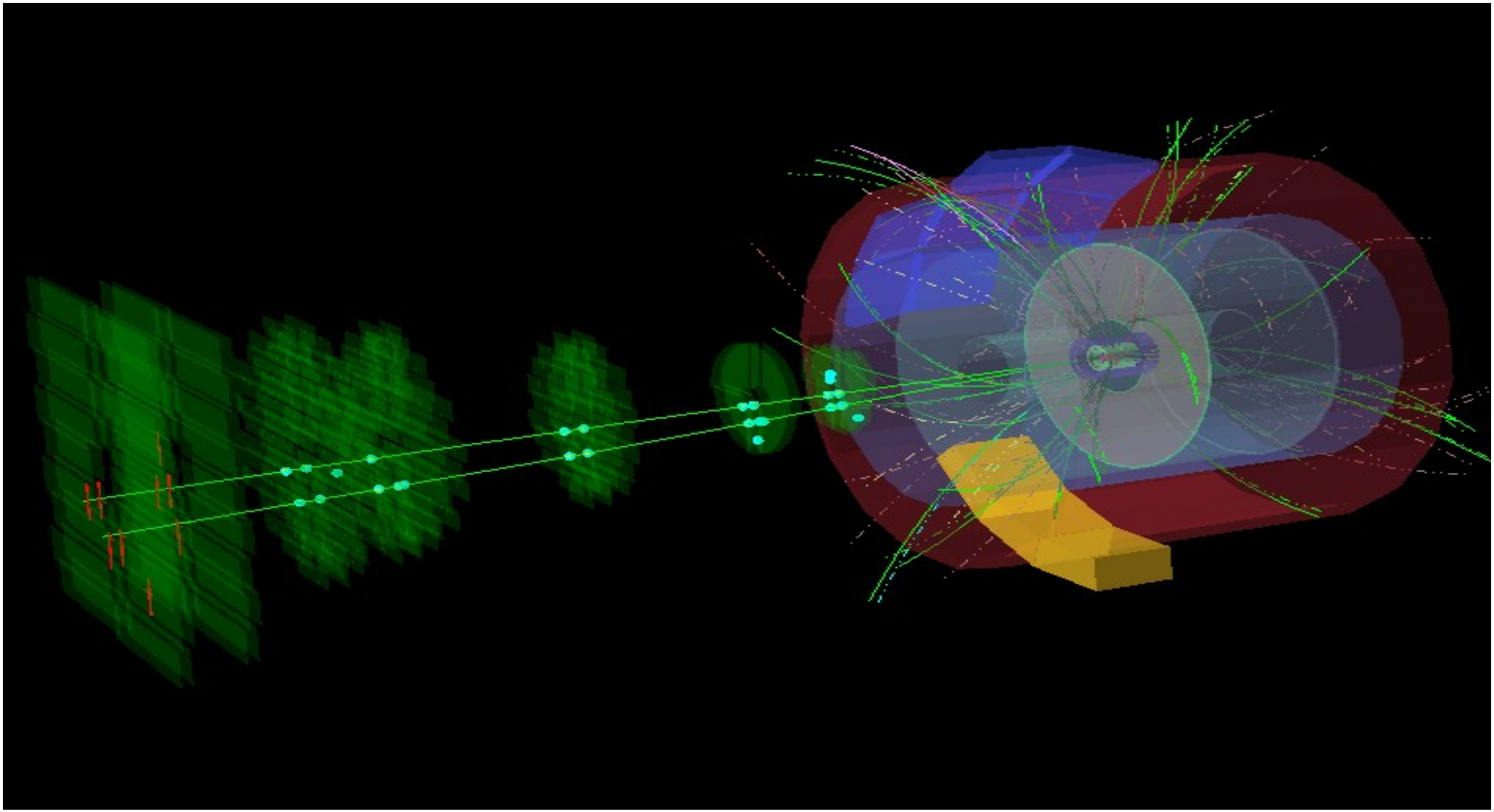
J/ψ statistics allows polarization studies

⇒ In fact for the first PbPb run > 1/100

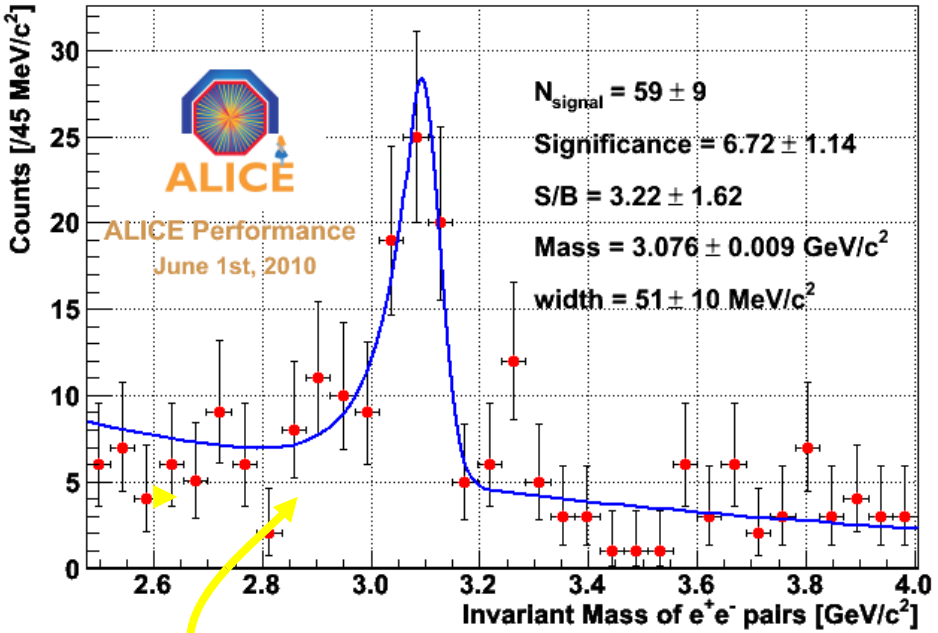
State	S[10^3]	B[10^3]	S/B	S/(S+B)$^{1/2}$
J/ψ	130 (700)	680	0.20	150
ψ'	3.7 (20)	300	0.01	6.7
ϒ(1S)	1.3 (7)	0.8	1.7	29
ϒ(2S)	0.35 (1.8)	0.54	0.65	12
ϒ(3S)	0.20 (1.0)	0.42	0.48	8.1

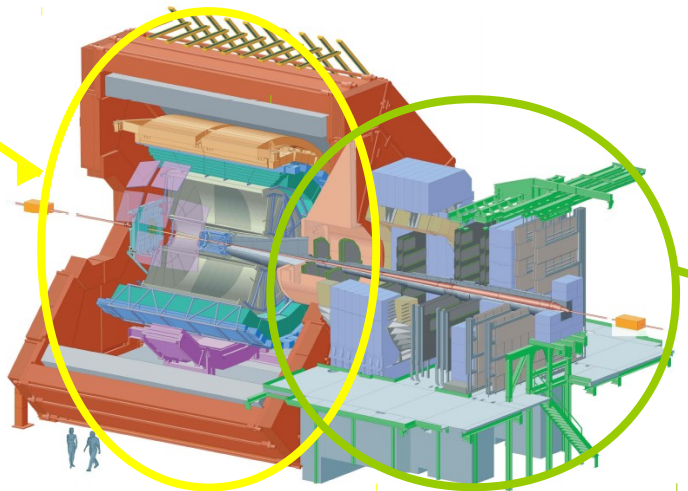
For Heavy-Ion physics at ALICE see Paolo Giubellino's talk on Thursday

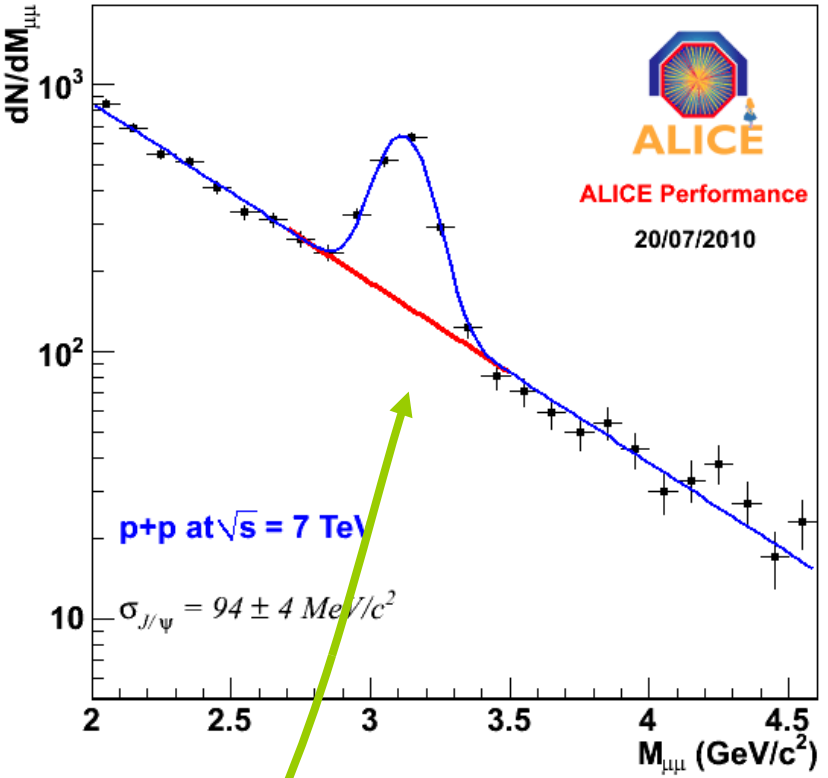
First results in p+p at 7 TeV



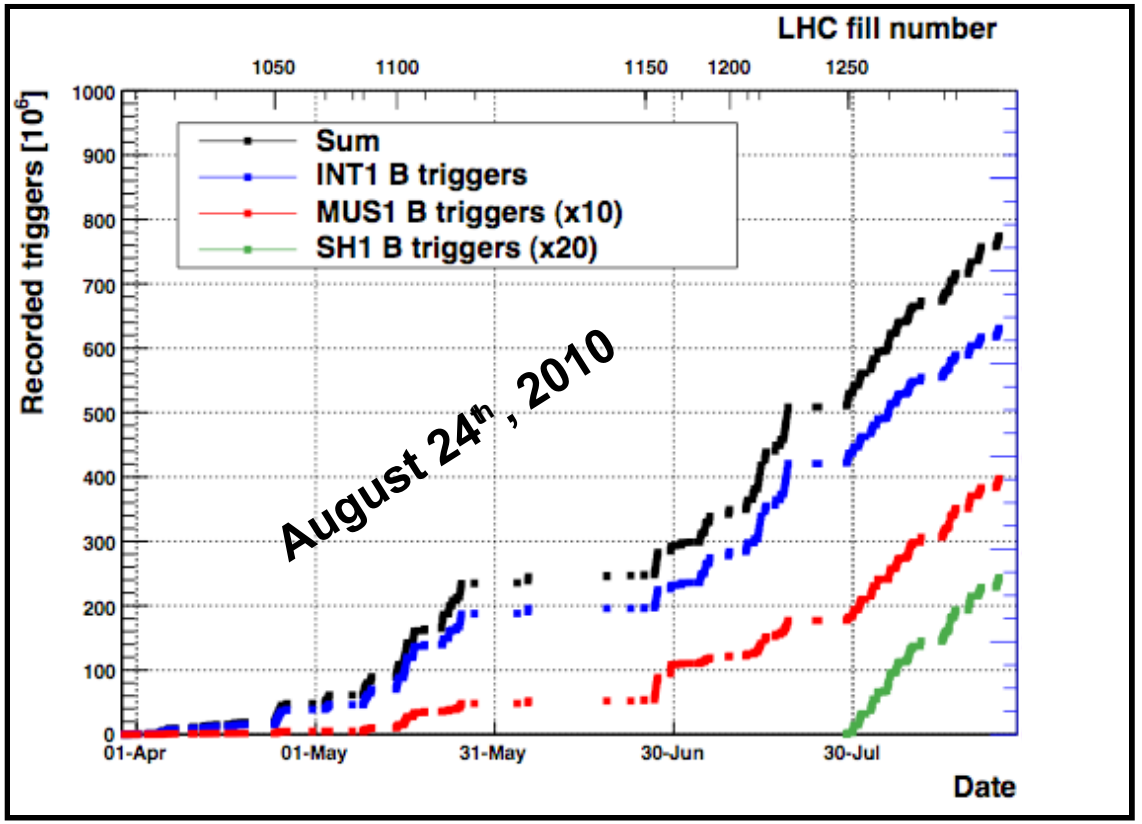
Preliminary results on J/ψ







Integrated luminosity at ALICE



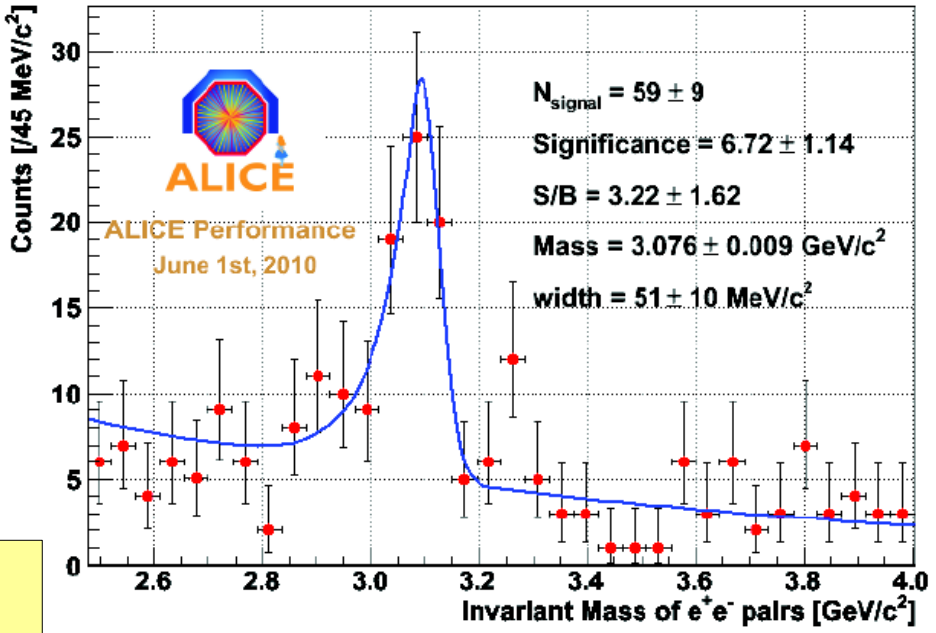
- **INT1-B: minimum bias interaction trigger**
  - at least one charged particle in 8 η units
- **MUS1-B: single-muon trigger**
  - forward muon in coincidence with MB trigger
- **SH1-B: high multiplicity trigger**

For all these classes, mask (≡ gate) to trigger on the crossing of the colliding bunches.

J/ψ in the electron decay channel

First p+p results at 7 TeV

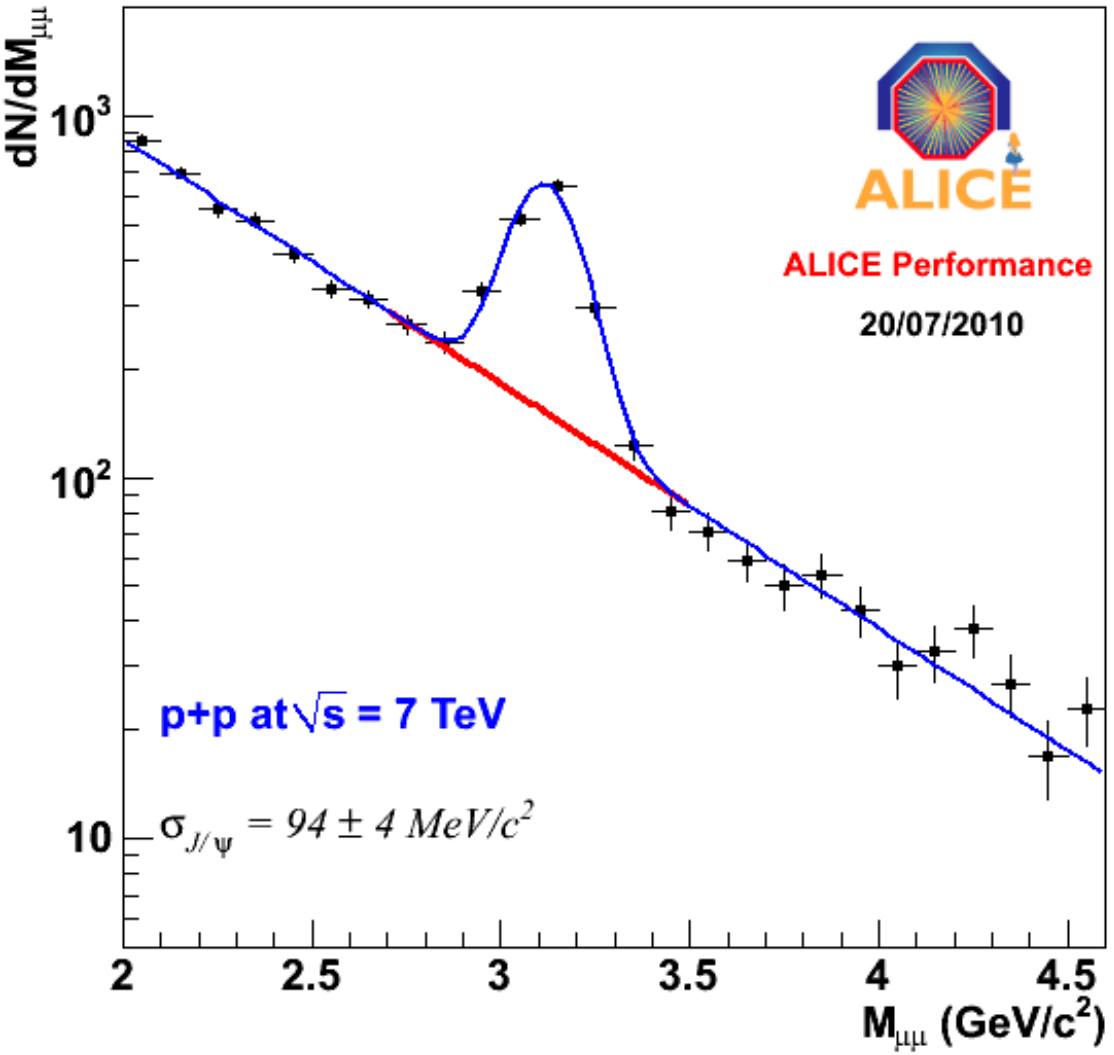
- 110M p-p events at 7 TeV
  - 1/3 of available statistics
- Track reconstruction
  - TPC + ITS
- Electron identification (and pion rejection)
  - TPC
  - TRD could be included later
- Fit with a Cristal Ball function
- $|\eta|<0.9$



110 M events

For Particle ID performance, see Jean-Pierre Revol's talk on Monday

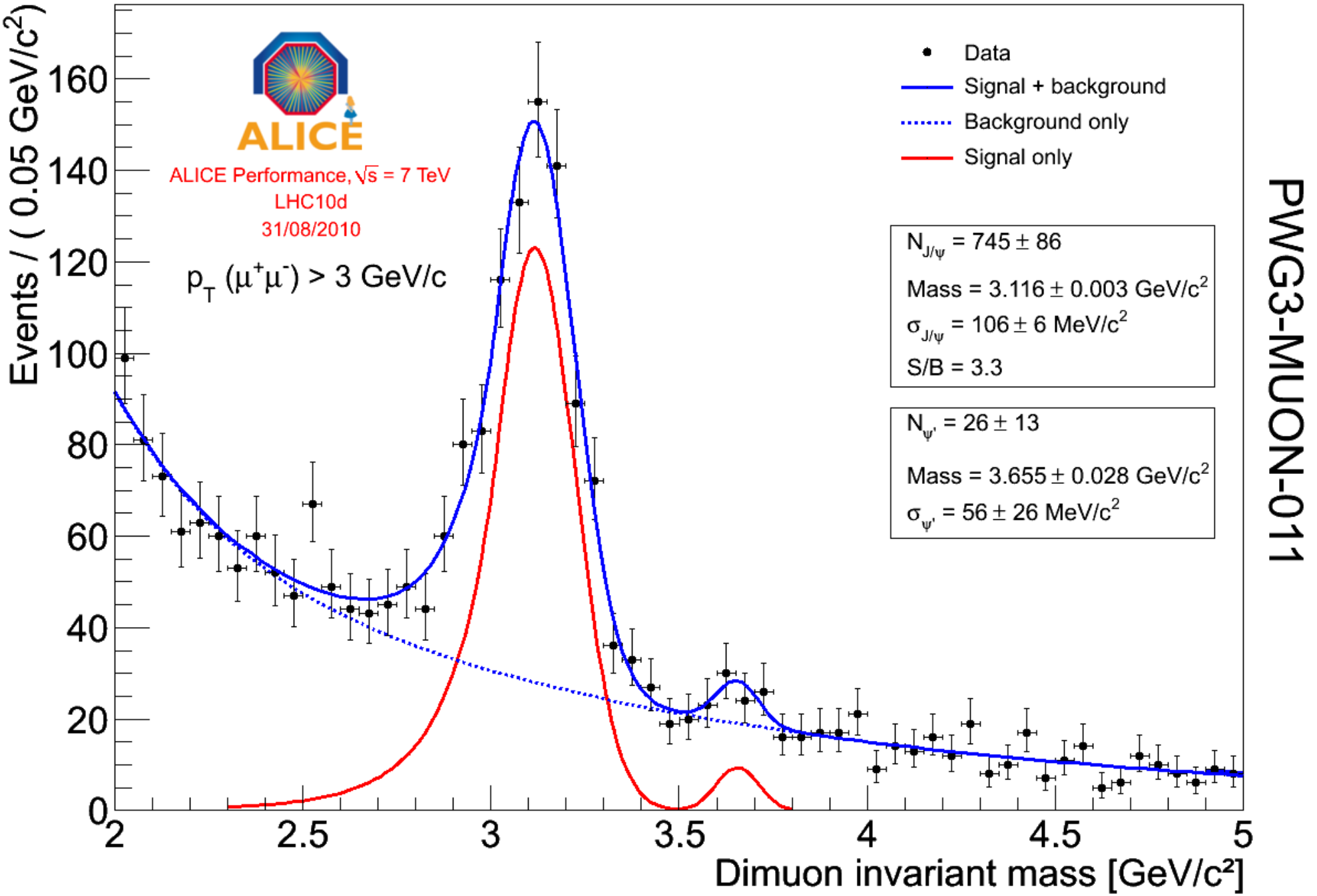
J/ψ in the muon decay channel



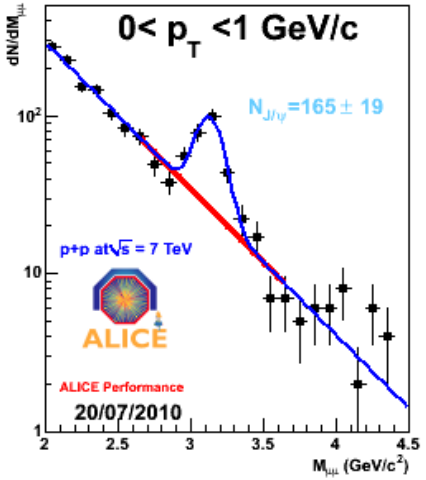
- detector performance close to nominal
  - efficiency
  - mass resolution 94 MeV/c^2 (target is 70 MeV/c^2)
- data/analysis flow works well
- recent changes in trigger strategy allows to accumulate more statistic

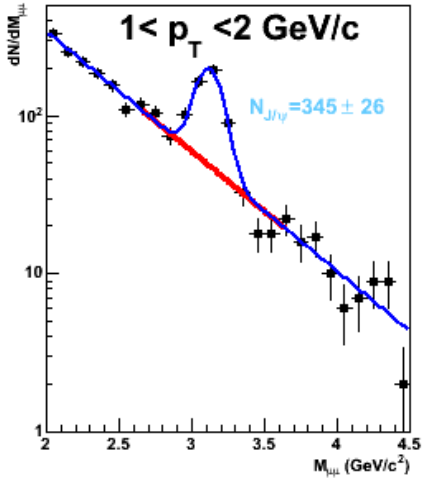
So far ~ 6000 J/ψ recorded.

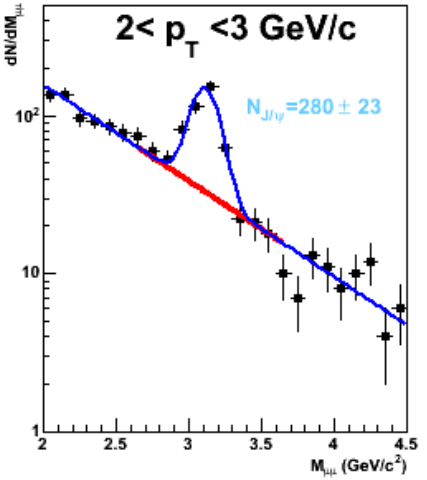
ψ' shows up

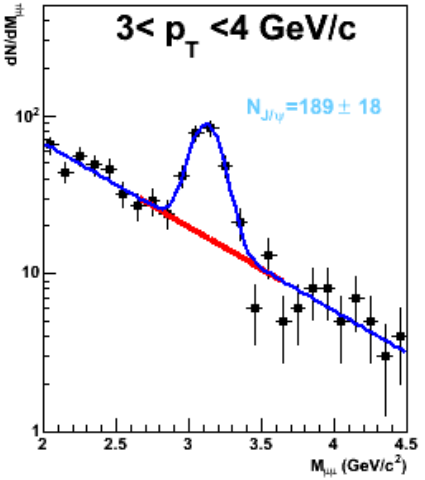

ALICE
ALICE Performance, √s = 7 TeV
LHC10d
31/08/2010
p_T (μ⁺μ⁻) > 3 GeV/c
Data
Signal + background
Background only
Signal only
N_J/ψ = 745 ± 86
Mass = 3.116 ± 0.003 GeV/c²
σ_J/ψ = 106 ± 6 MeV/c²
S/B = 3.3
N_ψ' = 26 ± 13
Mass = 3.655 ± 0.028 GeV/c²
σ_ψ' = 56 ± 26 MeV/c²
PWG3-MUON-011
Events / (0.05 GeV/c²)
Dimuon invariant mass [GeV/c²]
0
20
40
60
80
100
120
140
160
2
2.5
3
3.5
4
4.5
5

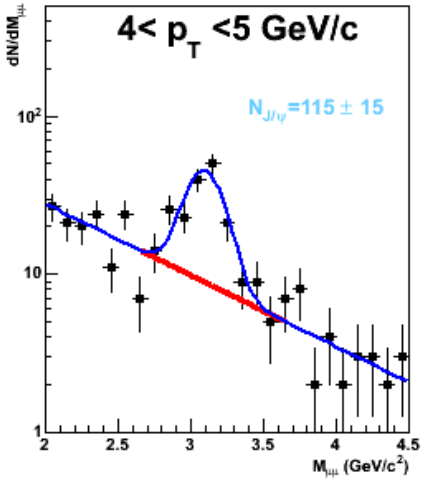
J/ψ's transverse momenta

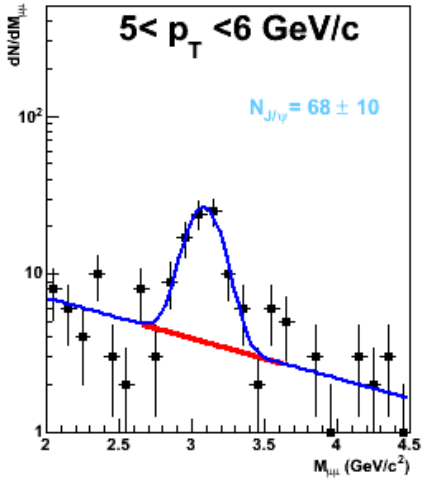


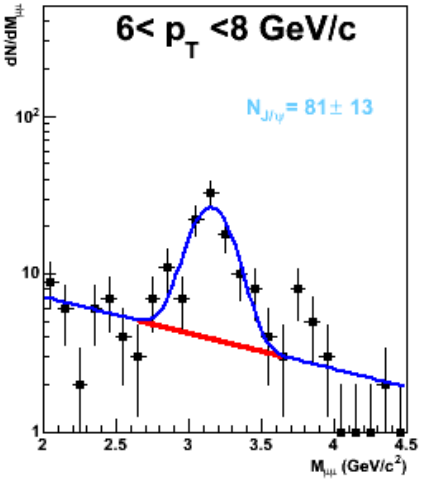


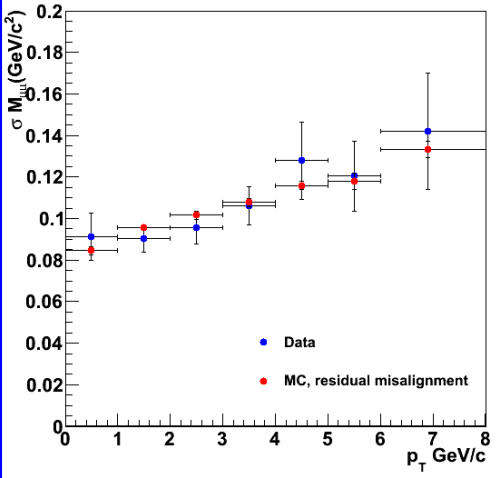






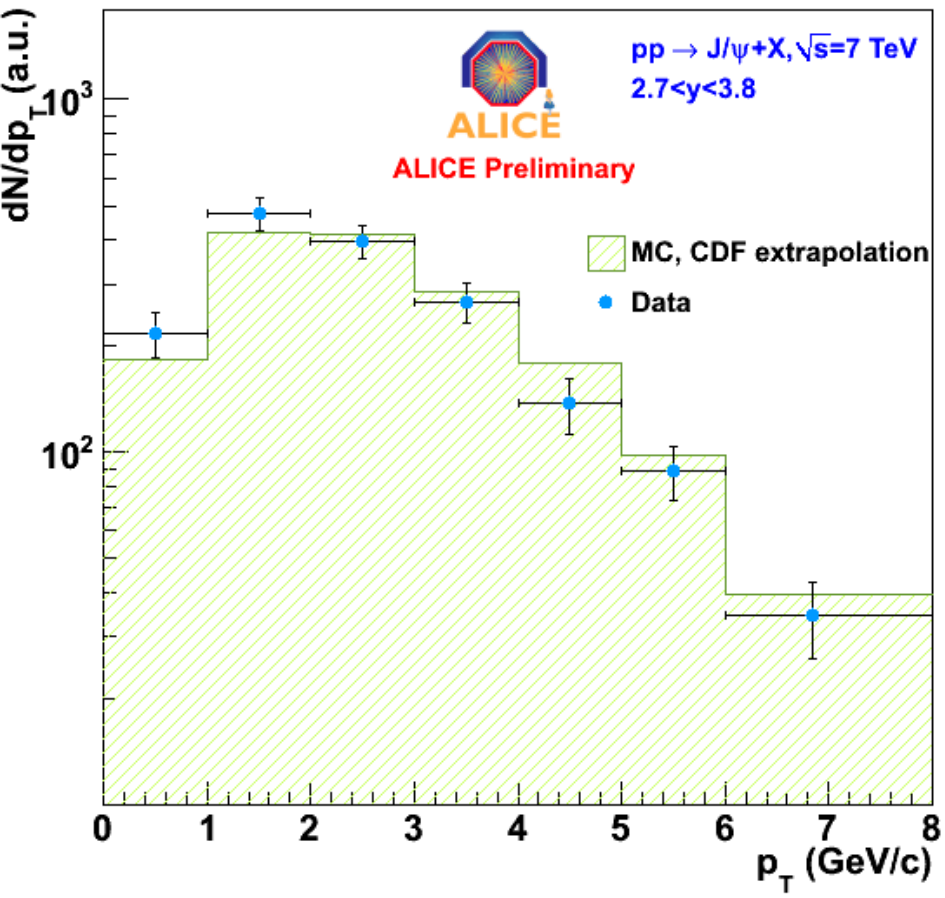


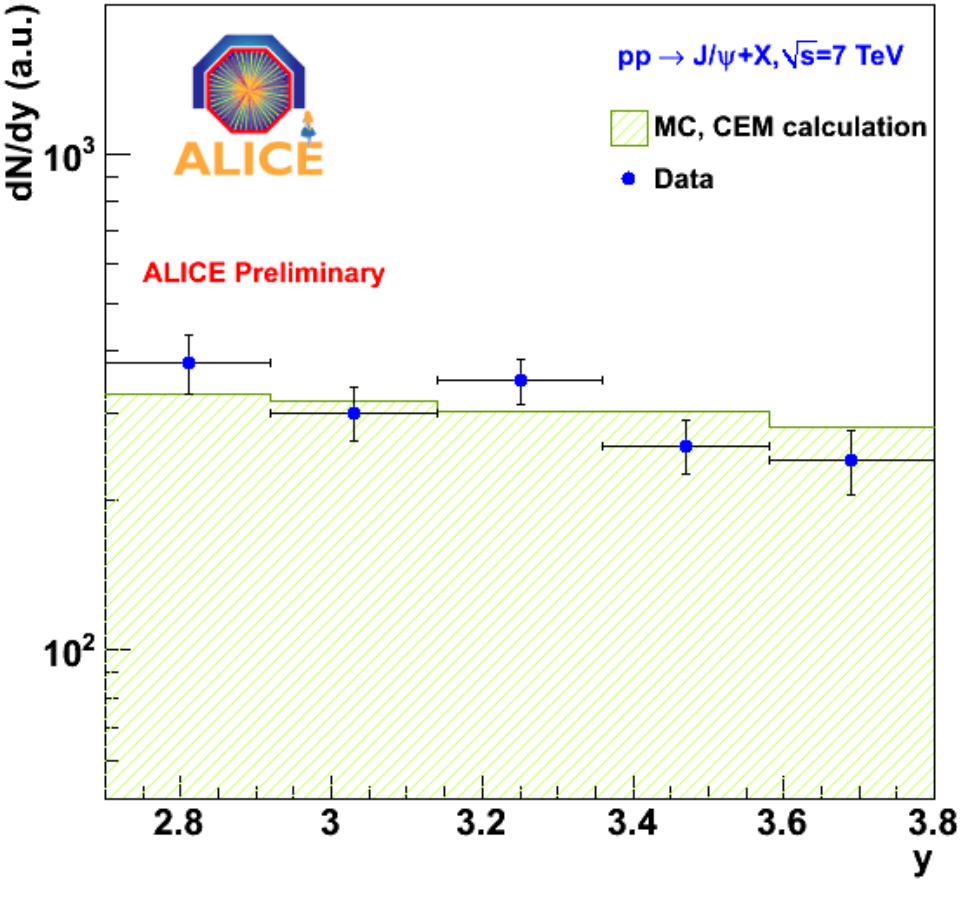




J/ψ peak width well reproduced by the MC

Comparing results to the MC





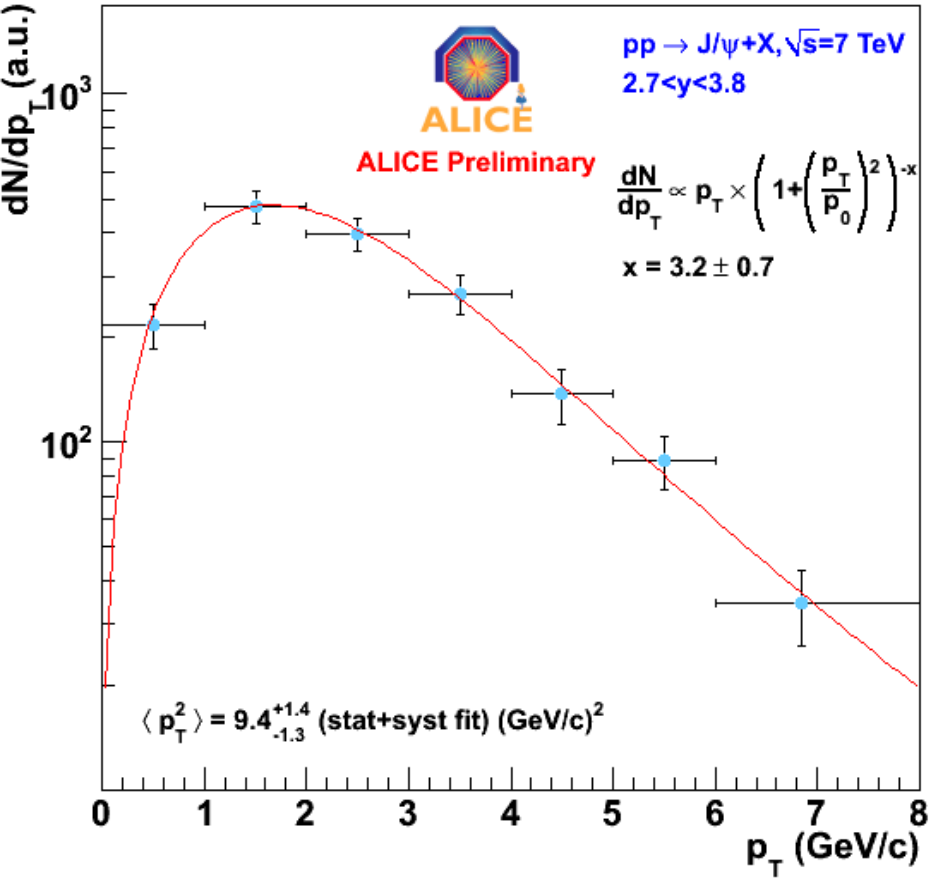
Data corrected for acceptance and efficiency

- data slightly softer than MC

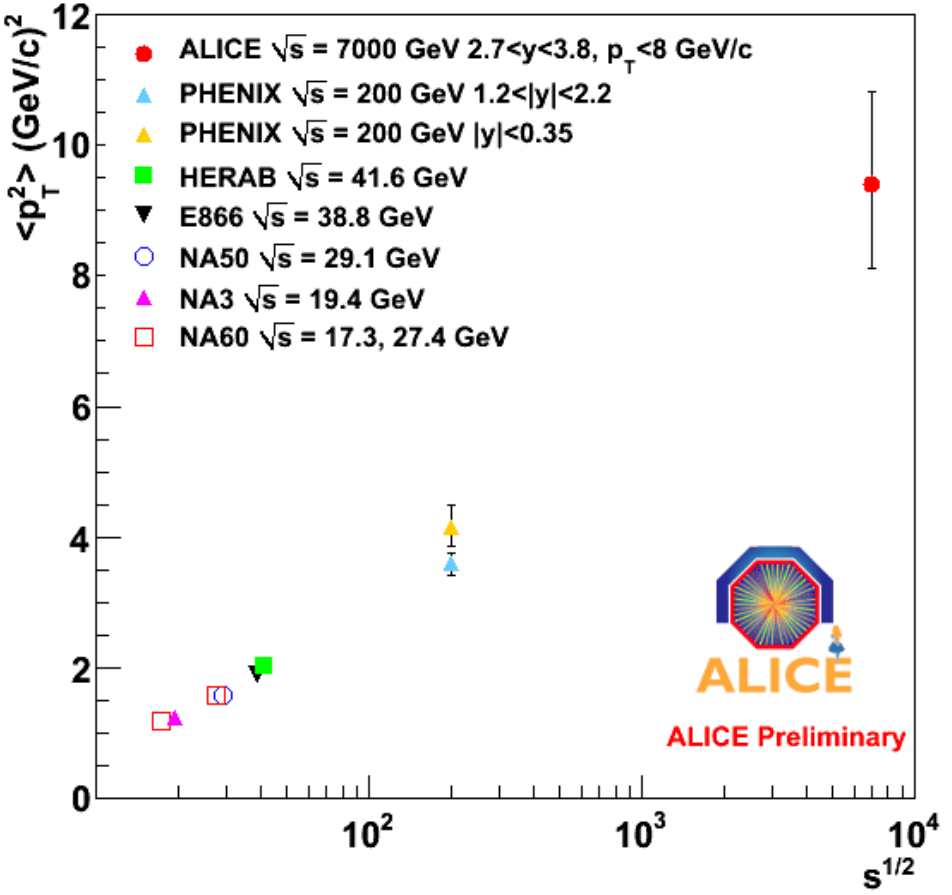
Generated MC distribution “CDF pp 7TeV”

- p_T extrapolated from CDF results, y obtained from CEM calculations, no polarisation

J/ψ's transverse momenta



<p_T^2> is extracted with the fit function first proposed by Yoh et al., PRL 41 (1978) 684 (also used by previous experiments)



Quoted uncertainties include systematics from the fit function. Full systematic uncertainties are being evaluated

Summary

The ALICE experiment has successfully started the study of
Inclusive quarkonia production in p+p interactions at $\sqrt{s_{NN}}$ = 7 TeV

- J/ψ's rapidity and transverse momentum distribution were presented

- Next: J/ψ's production cross section
  → Top priority : J/ψ analysis to be used as a reference for Pb+Pb

This is only the very beginning...
High luminosity p+p, Pb+Pb, p+A collisions .....