Fixed target charmonium production with proton and lead beams at LHC

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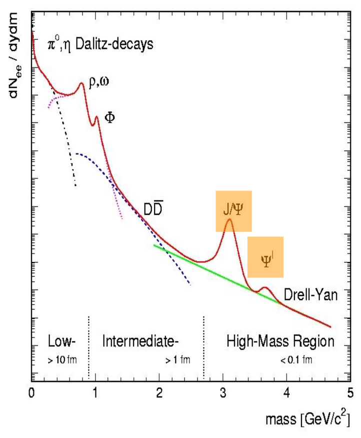
Charmonium

37 years ago: discovery of J/ψ, 25 years ago: Matsui & Satz
colour screening in deconfined matter → J/ψ suppression
→ possible signature of QGP formation



Experimental and theoretical progress since then
→ situation is much more complicated
- cold nuclear matter / initial state effects
  "normal" absorption in cold matter
  (anti)shadowing
  saturation, color glass condensate
- suppression via comovers
- feed down from Xc, ψ'
- sequential screening
  (first: Xc, ψ', J/ψ only well above Tc)
-regeneration via statistical hadronization
  or charm coalescence

important for "large" charm yield, i.e. RHIC and LHC

Fixed-target data (SPS, FNAL, HERA)

AA collisions SU, PbPb, InIn	SPS: NA38, √s(GeV) 19.4	NA50, NA60 17.3
pA collisions	HERA-B, √s(GeV) 41.6	E866, 38.8; NA50/51, 29.1/27.4; NA38/3, 19.4; NA60 27.4/17.3

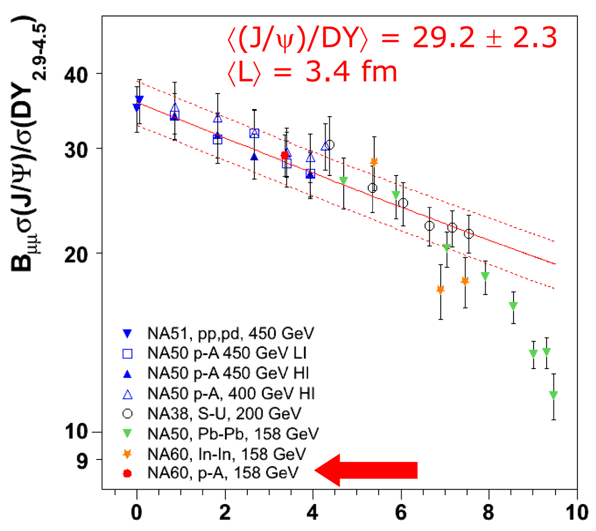
Colliders (RHIC,LHC)

AA collisions	RHIC CuCu, AuAu √s =130 GeV, 200 GeV LHC PbPb √s = (5.5), 2.76 TeV
pA collisions	RHIC pp, dAu √s =130 GeV, 200 GeV LHC pp, pA √s = (14), 7 TeV

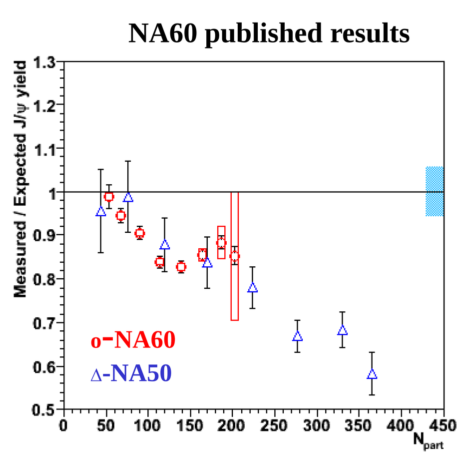
Fixed-target (LHC) – new opportunity – energy between SPS and RHIC

AA collisions	Pb-Pb 2750 GeV/nucleon, √s = 71.8 GeV
pA collisions	p-A 7000 GeV , √s = 114.6 GeV (5000 GeV, √s = 96.9 GeV)

Comparison of J/ψ/DY (NA38, NA50, NA60)



$\sigma_{abs}(J/\psi) = 4.2\pm0.5$ mb

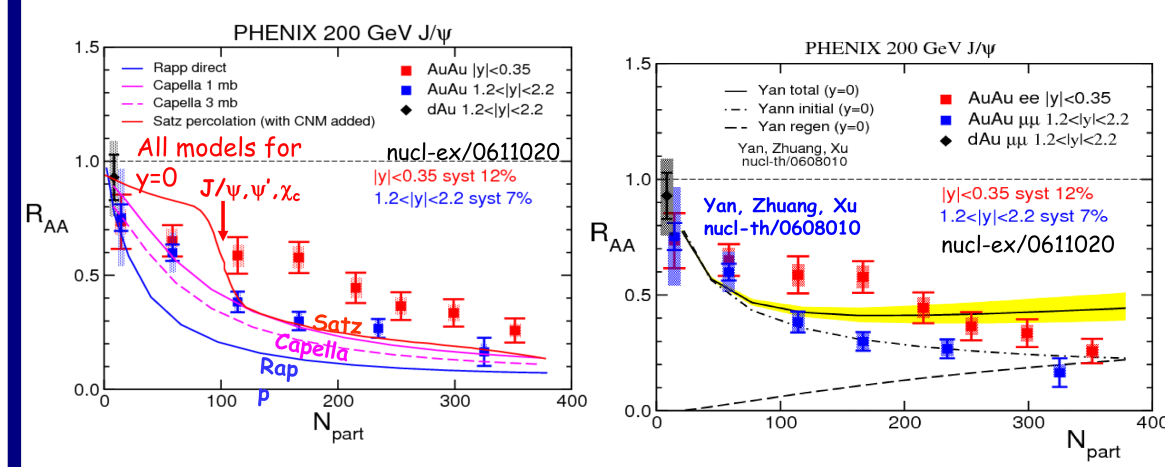


R. Arnaldi et al., PRL99 (2007) 132302

NA50 results- an "anomalous suppression" in PbPb.
Preliminary NA60- "anomalous suppression" presented already in In-In.
p-A at 158 GeV showed that rescaling from 400 and 450 GeV to 158 GeV is correct. σ_{abs} does not have strong energy dependence.

Suppression R_{AA} vs N_{part} at RHIC

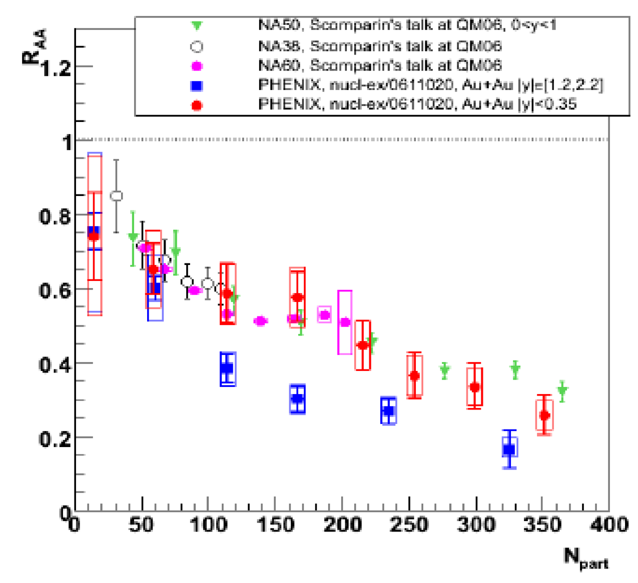
PHENIX Au-Au data



Models for mid-rapidity Au-Au data

Without regeneration With regeneration

Comparison SPS and RHIC data



No energy dependence, but rapidity dependence

Fixed target experiment

Pb-Pb, T=2750 GeV, √s=71.8 GeV.

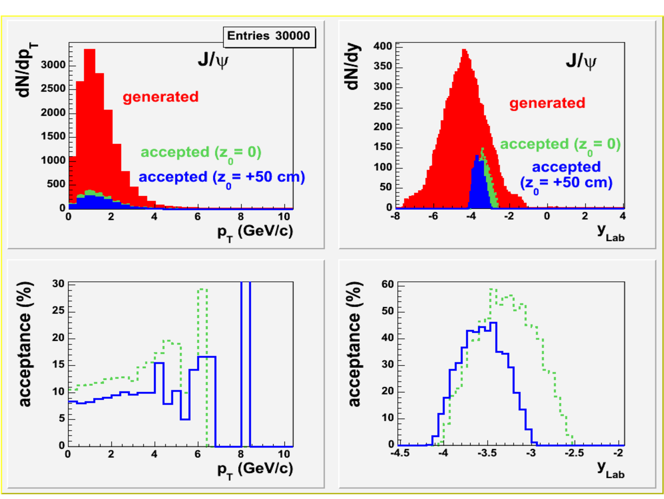
J/ψ are generated at z=0 and at z=+50 cm.

J/ψ are generated using p_T-spectra with HERA and PHENIX form, consistent with COM model, but parameters are energy scaled: $dN/dp_T \sim p_T[1+(35\pi \cdot p_T/256 \cdot \langle p_T\rangle)^2]^{-6}$ with $\langle p_T\rangle$= 1.4, and using y-spectra as Gaussian with mean value y_{cm}=0 and σ=1.1

J/ψ are accepted in the rapidity range -2.5<η<-4.0 (-2.98<η<-4.14), and each of 2 muons in the degree range $171^0<\theta<178^0$ ($174.2^0<\theta<178.2^0$) for generation J/ψ at z=0 (z=+50 cm).

z=0
I_{acc} = 12.0%

z=+50 cm
I_{acc} = 7.97%

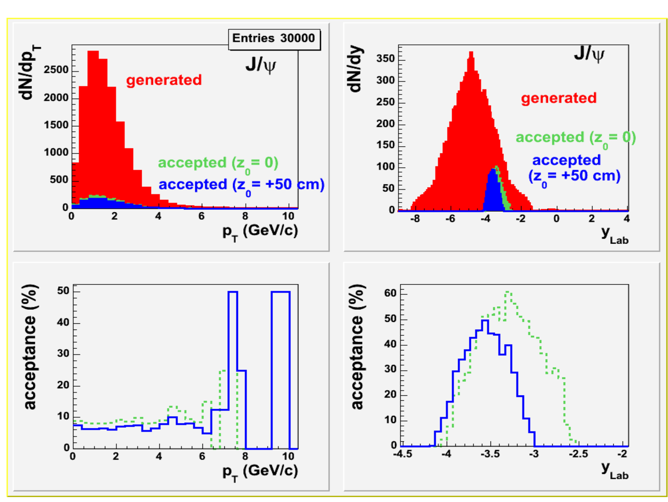


Fixed target experiment

pA, T=7000 GeV, √s=114.6 GeV.

J/ψ are generated at z=0 and at z=+50 cm.

J/ψ are generated using p_T-spectra with the same parametrization with energy scaled parameter: $dN/dp_T \sim p_T[1+(35\pi \cdot p_T/256 \cdot \langle p_T\rangle)^2]^{-6}$ where $\langle p_T\rangle$= 1.6 and using y- spectra as Gaussian with mean value y_{cm}=0 and σ=1.25.



z=0
I_{acc} = 8.54%

z=+50 cm
I_{acc} = 5.98%

As it was already used for the experiment on collider with a fixed target at HERA-B K.Ehret, Nucl. Instr. Meth. A 446 (2000) 190, the target in the form of thin ribbon could be placed around the main orbit of LHC. The life time of the beam is determined by the beam-beam and beam-gas interactions. Therefore after some time the particles will leave the main orbit and interact with the target ribbon. So for fixed target measurements only halo of the beam will be used. Therefore no deterioration of the main beam will be introduced. The experiments at different interaction points will not feel any presence of the fixed target.

Luminosity, cross sections(x_F>0) , counting rates

System	√s (TeV)	σ_{nn} (μb)	$\sigma_{pA}=\sigma_{nn}\cdot A^{0.92}$ (μb)	ε (%)	$\varepsilon\cdot B\cdot\sigma_{pA}$ (μb)	L ($cm^{-2}s^{-1}$)	Rate ($hour^{-1}$)
pp	14	32.9	32.9	4.7	0.091	$5\cdot10^{30}$	1635
pp_{RHIC}	0.200	2.7	2.7	3.59	0.0057	$2\cdot10^{31}$	410
pPb_{fixed}	0.1146	0.65	88.2	5.98	0.310	$1.\cdot10^{29}$(*)	112
pPb_{fixed}	0.0718	0.55	74.6	7.97	0.349	$1.\cdot10^{29}$	126
pPb_{NA50}	0.0274	0.19	25.8	14.0	0.212	$7.\cdot10^{29}$	535
$PbPb_{fixed}$	0.0718	0.65	11970	7.97	47.9	$2.2\cdot10^{27}$(**)	378

(*) pPb_{fixed}, 500 μ wire, 3.2 10^{11} protons/60 min, z=+50 cm
(**) PbPbfixed, 500 μ wire, 6.8 10^9 ions/60 min , z=+50 cm

For fixed target charmonium measurement the geometrical acceptances are : 12% (at z=0) and 7.97% (at z=+50 cm) for √s=71.8 GeV Pb-Pb and 8.54% (at z=0) and 5.98% (z=+50 cm) for √s=114.6 GeV pA.
The acceptances are compartible with the acceptances from other experiments.
The counting rates show that the J/ψ production on fixed target at LHC could be measured with rather high statistics collected in several days of data taking.