Physics Plan for J/Ψ
How much p-p and p+A data do we need?
Background and Efficiency issues
Discussion

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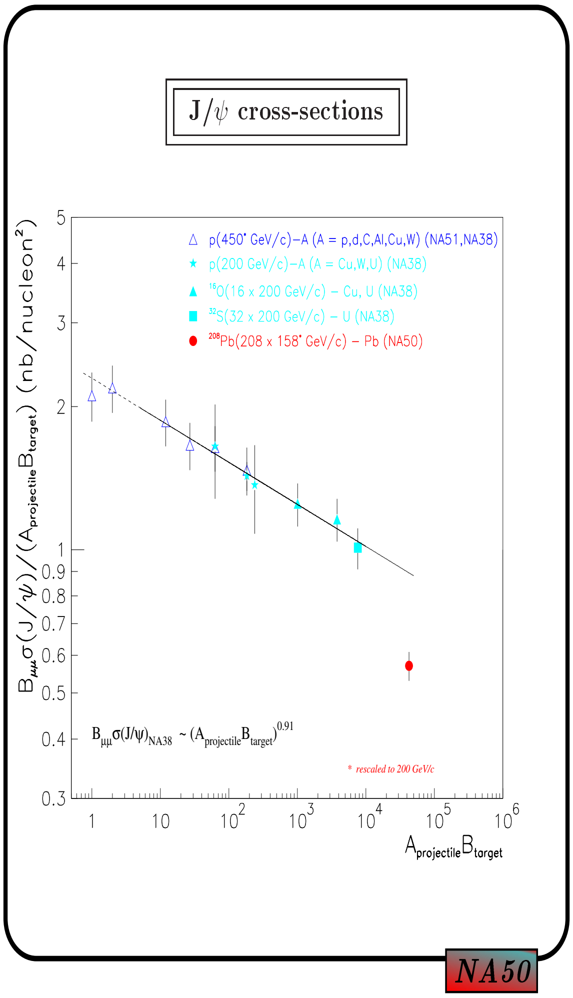
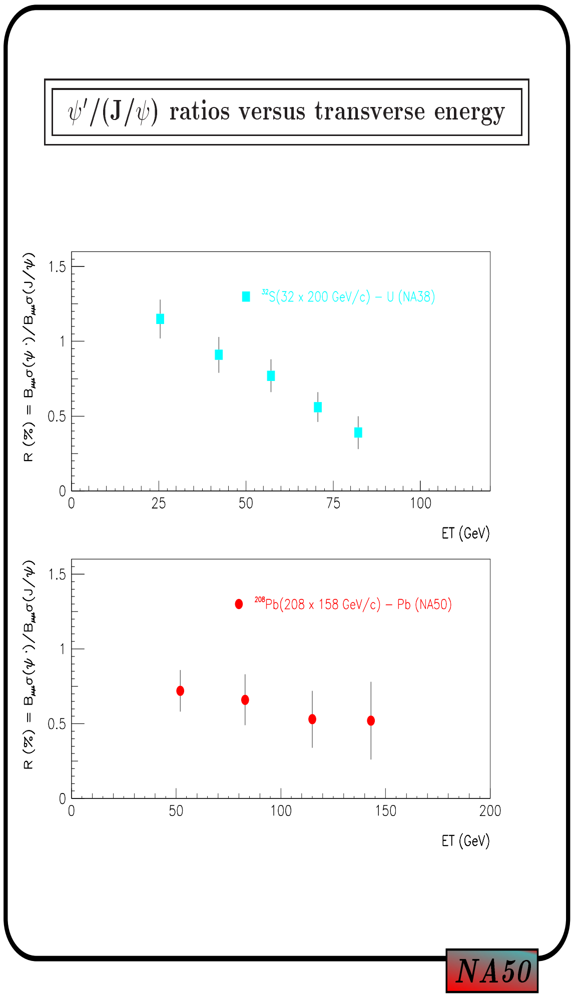
OUTLINE

- What is the Physics program?
  - e.g. How do we reproduce the NA50 QM'96 plot—p-p, p+A, A+A (inclusive), A+A (vs. centrality)
- Descoping—My bottom line is a 2-arm measurement, starting latest in the Fall of 2000, with Luminosity $\geq$ 10% Blue Book (i.e. $\geq 2 \times 10^{25}$ cm^{-2} s^{-1}).
- Our main problem remains Background:
  - Real $e^{\pm}$ from conversion and Dalitz
  - Albedo from every surface—shielding study

  Background can be Eliminated with cuts, but at the expense of inefficiency. Where do we stand? and What is the previous experience?
- Discussion of Physics topics—volunteers for indivdual topics.

Suppose we get a measurement of the J/Ψ cross section in Au+Au in year 1 What other data do we need to compete with NA50?





On the left I show the NA50 transparency from QM'96 where they plot only measured quantities, $B_{\mu\mu}\sigma(J/\Psi)/AB$, as a function of $A \times B$ where A and B are the number of nucleons in the projectile and target. It is clear that if we would get a cross section measurement like the NA50 Pb+Pb point (in red) we would not be able to compare it to existing p-p and p+A data. Thus, We would need to make extensive comparison measurements. **Of course, we could plot $\sigma(J/\Psi)$ vs centrality or (J/Ψ)/Drell-Yan vs centrality (cf. M. Gonin at RHIC '97)**. Another important issue is $<p_T>$ of J/Ψ vs centrality and also the Ψ'/Ψ ratio vs centrality (NA50 result shown on right).

What does NA50 mean by $\sigma(J/\Psi)$?
M. Gonin gives the answer on the WWW.

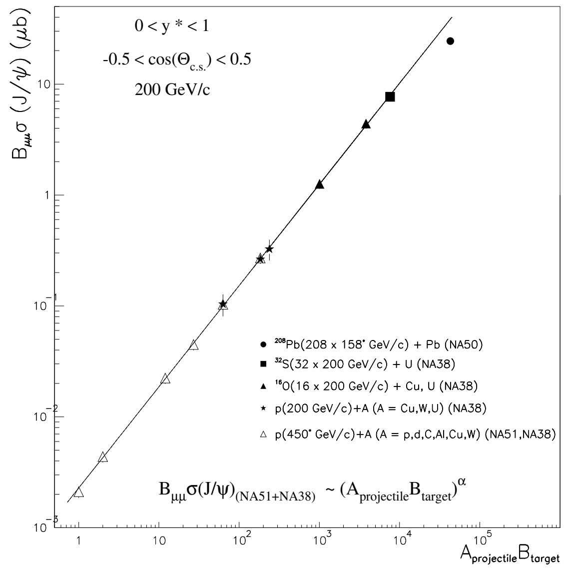


Figure 3. J/ψ cross sections measured in NA51, NA38 and NA50 experiments.

effects" was called "J/ψ suppression" by the NA38 collaboration. It should be pointed out that in contrast with previous experiments, this value is deduced for a wide range of projectile and target masses. Nonetheless this value is in very good agreement, better than systematic errors, with the value obtained at higher energy by E772 or by the NA3 experiment using proton beam.

As can be seen from Fig.3, the J/ψ cross section for Pb+Pb is smaller than the expected value obtained with the relation $(A_{projectile} \cdot B_{target})^{0.91}$ shown by the solid line. This result suggests an *anomalous* J/ψ suppression in Pb+Pb collisions in comparison with p+B_{target}, O+B_{target} and S+U collisions. All the data presented in Fig.3 are obtained after corrections presented in section 3 for the *same* kinematical domain.

6. (J/ψ)/(Drell-Yan) cross section ratios

As already mentioned, the Drell-Yan cross section scale as $(A_{projectile} \cdot B_{target})$ implying that the measurement of the ratio $\sigma^{J/\psi}/(A_{projectile}B_{target})$ can be replaced by the mea-

From this plot, we see that $\sigma(J/\Psi)$ does **NOT** mean the cross section integrated over all rapidity (the theorists cross-section). The NA50 value for $B_{\mu\mu}\sigma(J/\Psi)$ is the cross section for muon pairs produced in 1 unit of rapidity and for the angular interval indicated on the plot. Apart from the issue of the angular correction (i.e what is the $\cos\theta^*$ distribution vs p_T for $J/\Psi \rightarrow l^+l^-$ in central Au+Au collisions with or without a QGP?), this cross section is similar in spirit to $Bd\sigma/dy|_{y=0}$.

Descoping—my bottom line
See Marzia Rosati's Talk for J/Ψ acceptance

M. J. Tannenbaum, PHENIX EC/DC Video Conf, June 18,1997

PHENIX MUST MEASURE e^+e^- pairs (J/Ψ)
BY THE START OF YEAR-2

This leads to 3 acceptable configurations:

- [**Two Halves**] Scenario 2f: **Trigger, FEE, DAQ** from 1/2 of West Arm moved to East Arm in a back-to-back in azimuth configuration.
- [**Three Quarters**] Scenario 3 (non-recoverable), Scenario 2b: 3/4 solid angle with **ALL** Systems (includes **Trigger**).
- [**Full PHENIX**] Scenario 2a: As above, but 4/4.

A If we adopt scenario 3, we get 3/4 in the baseline, *no* risk (?)

B If we adopt scenario 2, the risk is that we get insufficient additional money during FY2000 to achieve 3/4 by the beginning of year 2.

- If we take this risk, there must be an official policy statement **NOW** that the minimum configuration of PHENIX at the beginning of year 2 is one of the above, i.e **Two Halves or better**.
- (In DOE-speak) The PERFORMANCE MEASURE for PM will be to achieve as much of PHENIX operating at the start of Year-2 under scenario 2 as would have been achieved with scenario-3.

I now think that we must also insist on a reasonable Luminosity:

- This run should have $\mathcal{L} \geq 10\%$ Blue Book, preferably $\sim 50\%$ blue book, i.e. $\sim 10^{26}$ cm^{-2} s^{-1}, *a performance measure of achievement for the RHIC accelerator group.*

BACKGROUND

A plot of the unlike-sign and like-sign pairs for the CERES experiment:

I can't show their unpublished figure, so I give the WWW address:

`http://ceres6.physi.uni-heidelberg.de/`
`ceres/publications/cph-phd.ps.gz`, page 78.

Interestingly, the CERES background outside the π^0 dalitz region does, in fact, have a very similar shape to their net signal. A key issue is what evidence they have that their background estimate is correct. On the positive side, Axel Drees, in a presentation to RHIC'97, mentioned that CERES was making a run with converter added to increase their background. This should provide another point for the background determination and allow them to extrapolate to the 'Dalitz point'—e.g. see MJT, 'Charm in PHENIX', section 3.1, Fig.3, from Santa Fe meeting July 1996.

Efficiency for Background Elimination
Ancient Experience from the ISR, circa 1981

Exercise on Real Rates in Real Experiments

In 1981, I tried to compare 3 ISR experiments on Υ production, CCOR, ABCSY (Willis), and CHFMITNP (Ting) for an ISABELLE/CBA study. I tried to tabulate $\sqrt{s}$, $\int \mathcal{L}dt$, Geometrical Acceptance, Detection Efficiency, Mass Resolution at 10 GeV, Υ events (in mass bin 8.5-11 GeV), background in this bin, Υ/continuum, Υ cross section. Other interesting information would have been Instantaneous Luminosity and total elapsed calendar time. *This would be an excellent exercise for a young person to repeat again with all the published experiments.* I found it very difficult to extract Luminosity, geometrical acceptance and Detection efficiency for ABCSY. At the time I didn't find Ting's data on $Bd\sigma/dy|_{y=0}$, but it is given in an article by Ulrich Becker in 1979 EPS meeting in Geneva (CERN, 1979) as $(1.0 \pm 0.35) \times 10^{-35}$ cm^2 which compares nicely with CCOR value $(0.9 \pm 0.2) \times 10^{-35}$ cm^2 given in the same proceedings. I got Ting's data for the following tables from U. Becker's article in Proceedings 1981 Summer ISABELLE workshop BNL-51443, pp 124-177. I found that the most convenient single number to represent the experiments turned out to be:

$$\epsilon \equiv \frac{\text{Events Observed}}{\int \mathcal{L}dt \times B\sigma(\Upsilon)} \tag{1}$$

where I took

$$B\sigma(\Upsilon) \equiv 1.5 \times B\frac{d\sigma}{dy}\bigg|_{y=0} \tag{2}$$

which I got from Ting's data. Alternately, it is simpler to use

$$\epsilon' = \frac{\text{Events Observed}}{\int \mathcal{L}dt \times Bd\sigma(\Upsilon)/dy|_{y=0}} \tag{3}$$

I sumed all the 3 Υ's and corrected for the continuum, i.e. Υ's only. **My conclusion is that the electron pair detection efficiency (beyond Acceptance) was $\sim$ 10-50%.**

	CCOR	**ABCSY**	**Ting**	**Phenix** (est.)
ϵ	3.5%	3.5%	17%	
ϵ'	5.2%	5.2%	25%	4.0% $\times$ 0.25

MJT Physics topics using electrons cf. 11/96

Topic	Method	Comment
Soft γ QGP e^+e^-		Hugely Background Limited
π^0	external conversions (+Dalitz) $m_{e^+e^-} \leq m_{\pi^0}$	Inclusive γ
η	$140 \leq m_{e^+e^-} \leq 400$ MeV/c^2	Dalitz decay
Direct γ	$400 \leq m_{e^+e^-} \leq 600$ MeV/c^2	Internal Conversion
ρ^0	$600 \leq m_{e^+e^-} \leq 900$ MeV/c^2	Lose money on every sale...
ω^0	$m_{e^+e^-} \simeq 782 \pm 8$ MeV/c^2	Should work (?)
ϕ	$m_{e^+e^-} \simeq 1019 \pm 4$ MeV/c^2	compare K^+K^-
Charm	$e^\pm$ inclusive $p_T \geq 1.1$ GeV/c	No combinatoric bkg.
$c - \bar{c}$	$1.6 \leq m_{e^+e^-} \leq 5$ GeV/c^2	Jet Quenching
$c - \bar{c}$	$1.6 \leq m_{e^\pm\mu^\mp} \leq 5$ GeV/c^2	Jet Quenching Msmt. Charm bkg for D-Yan
$b - \bar{b}$	$e^\pm$ inclusive $p_T \geq 4.0$ GeV/c $5 \leq m_{e^\pm\mu^\mp, e^+e^-} \leq 9$ GeV/c^2	Jet Quenching Msmt. bkg for D-Yan Rate Limit ?
Drell-Yan	$4.0 \leq m_{e^+e^-}$ GeV/c^2	QCD Sanity check
J/Ψ	$m_{e^+e^-} \simeq 3097 \pm 0.09$ MeV/c^2	QGP or Bust Inclusive, Central $(AB)^\alpha$ p_T dependence
Ψ'	$m_{e^+e^-} \simeq 3686 \pm 0.3$ MeV/c^2	Rate Limit ?
Υ	$9.6 \leq m_{e^+e^-} \leq 10.6$ GeV/c^2	*Rate Limit*

Volunteers:
More people welcome on all topics

ω, ρ: R. Seto

ϕ: B. Jacak

Single $e^{\pm}$: Y. Akiba

J/Ψ, Ψ': M. Rosati

Drell-Yan vs Centrality: A. Petridis

$b - \bar{b}$: R. Seto

π^0, γ via Dalitz: MJT

Tracking: J. Mitchell

Electron Id: Y. Akiba

Shielding: K. Shigaki

Electron Trigger: Y. He, A. Petridis, G. David

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