NEW MUON COLLABORATION

NA37 - CERN

J/ψ PRODUCTION IN DEEP INELASTIC SCATTERING AT 280 GeV AND THE GLUON DISTRIBUTION

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17-22 SETTEMBRE

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- THE NMC EXPERIMENT
- J/ψ EVENTS SELECTION

H_2 AND D_2

- THE RATIO $\sigma(D_2)/\sigma(H_2)$
- INELASTIC J/ψ :

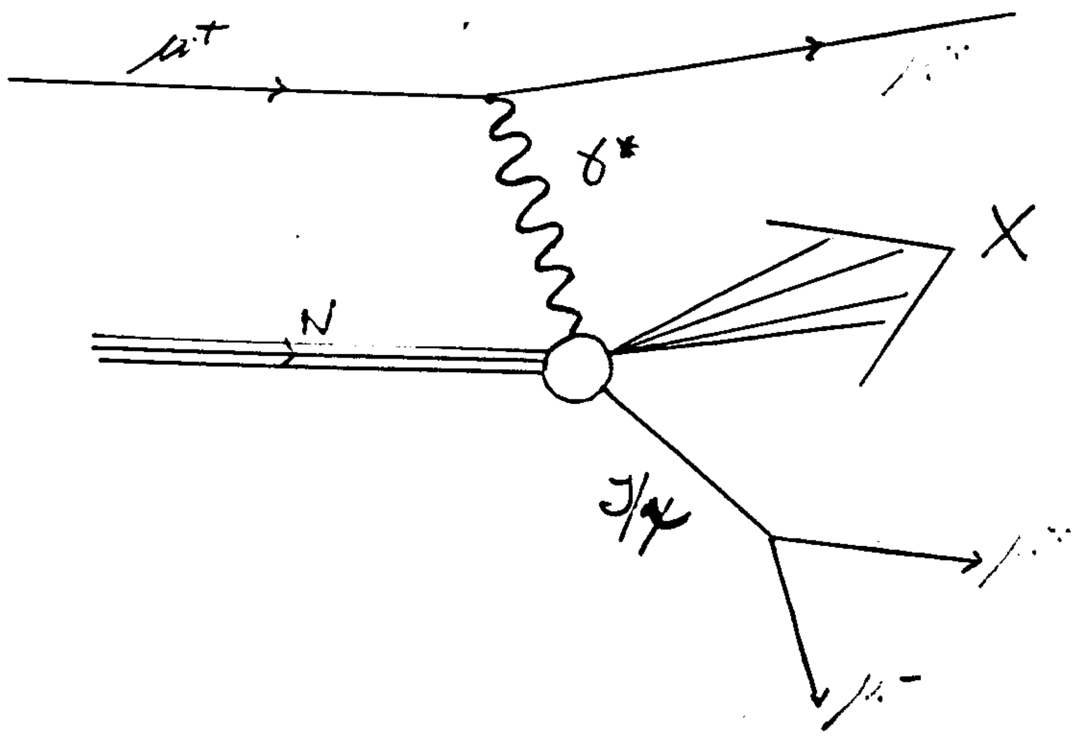
  RESULTS
  COMPARISON WITH MODEL PREDICTIONS

- THE GLUON DISTRIBUTION

Sn AND C

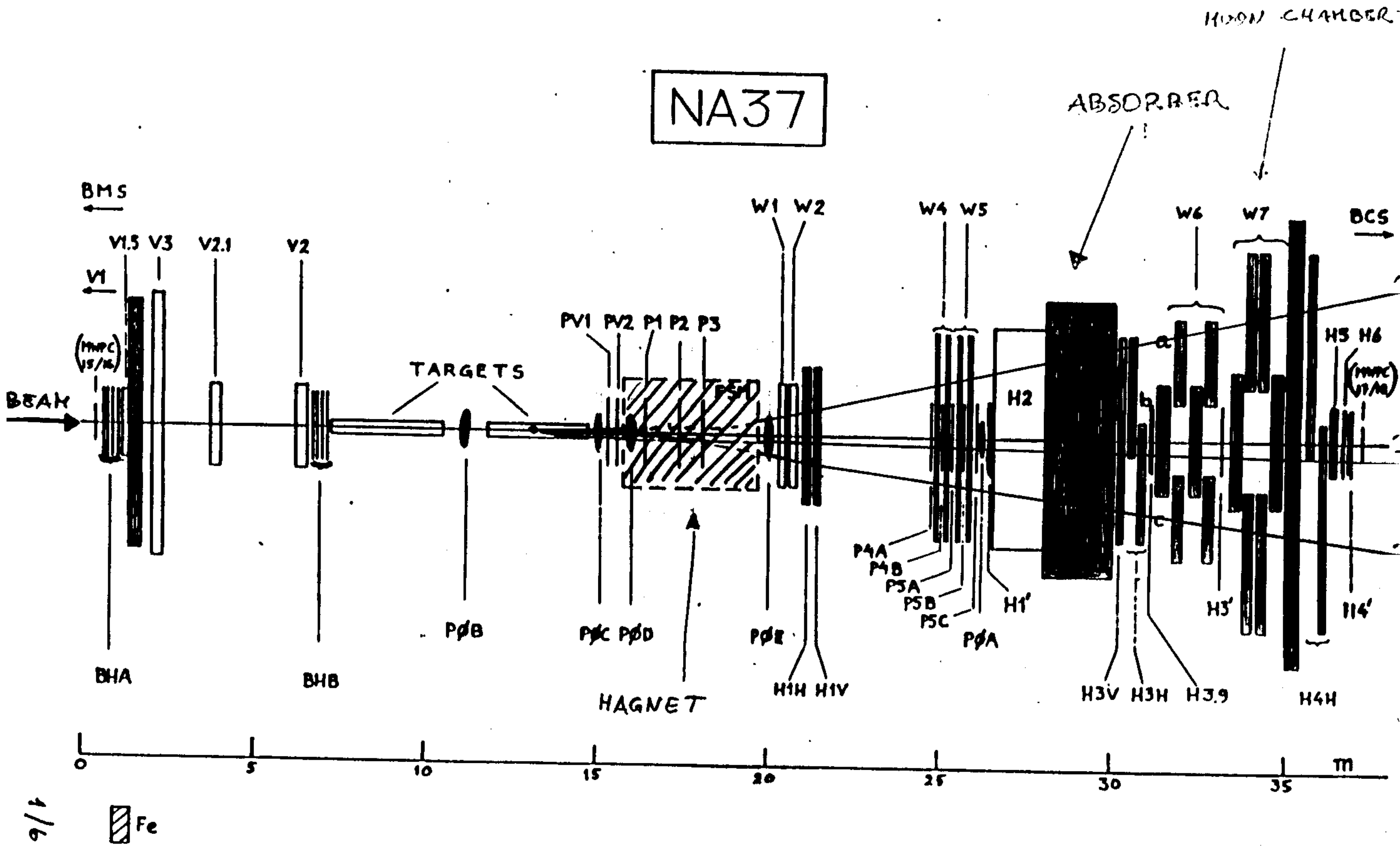
- J/ψ FROM HEAVY NUCLEI
- THE RATIO $\sigma(Sn)/\sigma(C)$
- THE z AND P_t^2 DEPENDENCE
- OPEN PROBLEMS
- SUMMARY

$$\mu^+ N \to \mu^+ J/\psi\ X$$
$$J/\psi \to \mu^+\mu^-$$



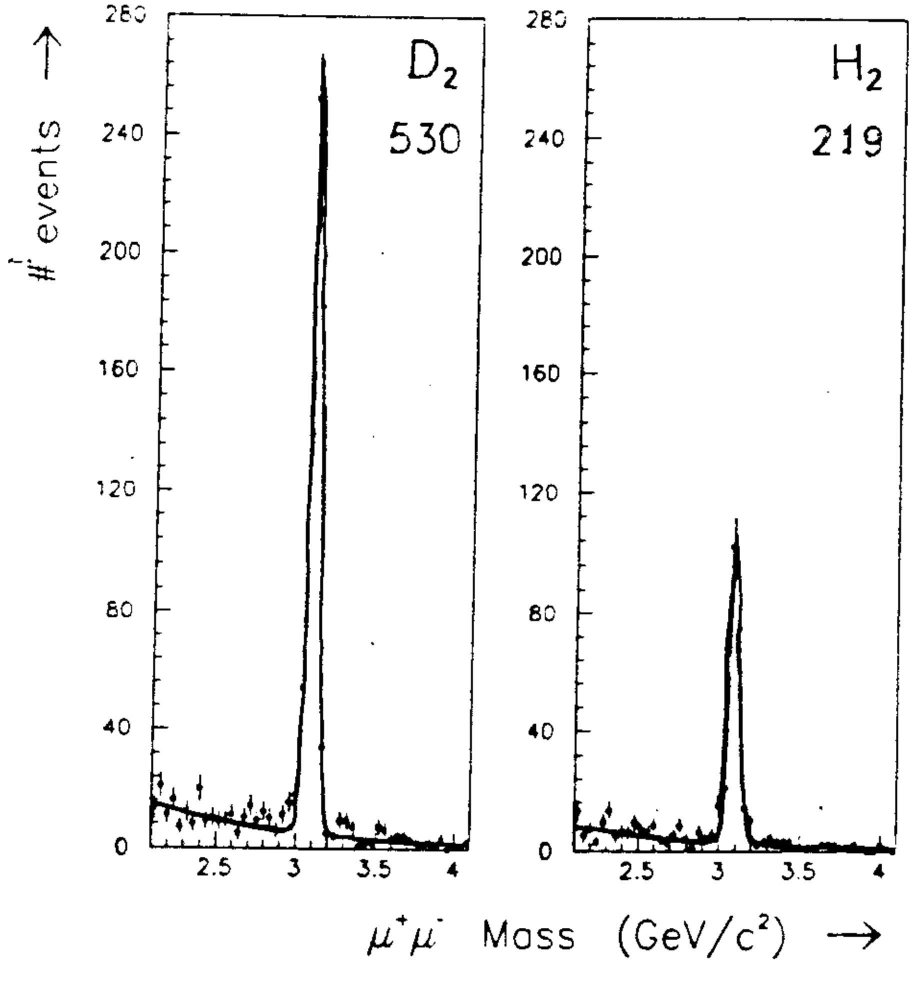
KINEMATIC VARIABLES

- [illegible] — $(\text{INV. MASS})^2$ OF VIRTUAL PHOTON
- [illegible] — ENERGY OF VIRTUAL PHOTON
- $W^2 =$ [illegible] — $(\text{CENTER OF MASS ENERGY})^2_{\gamma^* N}$
- $z = E_{J/\psi}/\nu$ — FRACTIONAL ENERGY OF THE J/ψ
- [illegible] — $(\text{TRANSVERSE MOMENTUM})^2$ OF J/ψ /
- $y = \frac{1}{2}\ln\left(\frac{E_{J/\psi}+p_\parallel}{E_{J/\psi}-p_\parallel}\right)$ — J/ψ RAPIDITY



NA37
MUON CHAMBER
ABSORBER
BMS
V1
V1.5 V3
V2.1
V2
(MWPC 15/16)
BEAM
TARGETS
PV1 PV2 P1 P2 P3
W1 W2
W4 W5
W6
W7
BCS
H5 H6
(MWPC 17/18)
H2
BHA
BHB
PØB
PØC PØD
MAGNET
PØE
H1H H1V
P4A
P4B
P5A
P5B
P5C
PØA
H1'
H3V H3H H3.9
H3'
H4H
H4'
0
5
10
15
20
25
30
35
m
Fe

1/6/86



KINEMATIC CUTS

$10 < E(\mu \text{ DECAY}) < 240$ GeV

$15 < E(\mu \text{ SCATT}) < 270$ GeV

$60 < \nu < 240.$ GeV

$0 < Q^2 < 18.$ GeV^2

J/ψ EVENT $\rightarrow$ $2.9 < M_{\mu^+\mu^-} < 3.3$ GeV

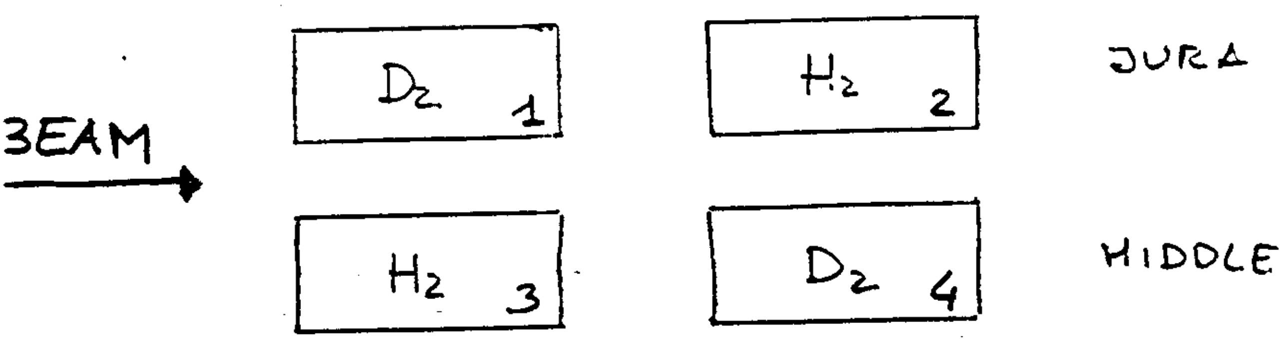
+

SCATTERED MUON

$$\frac{\sigma_{D_2}}{\sigma_{H_2}}$$

CROSS SECTION : $\sigma = \frac{N_{EVENTS}}{\Phi * L * \rho * A}$

Φ = FLUX L = TARGET LENGTH ρ = TARGET DENSITY A = ACCEPTANCE



$$\frac{N_1 * N_4}{N_2 * N_3} = \frac{(\sigma_{D_2} * \Phi_1 * L * \rho_{D_2} * A_1) * (\sigma_{D_2} * \Phi_4 * L * \rho_{D_2} * A_4)}{(\sigma_{H_2} * \Phi_2 * L * \rho_{H_2} * A_2) * (\sigma_{H_2} * \Phi_3 * L * \rho_{H_2} * A_3)}$$

$\Phi_1 = \Phi_2$ $\Phi_3 = \Phi_4$

$A_1 = A_3$ $A_2 = A_4$

$$\frac{\sigma_{D_2}}{\sigma_{H_2}} = \sqrt{\frac{N_1 * N_4}{N_2 * N_3}} * \frac{\rho_{H_2}}{\rho_{D_2}}$$

$$\frac{\sigma_{D_2}}{\sigma_{H_2}} = 1.10 \pm 0.09$$

Q^2 DEPENDENCE

TO EXTRAPOLATE AT $Q^2=0$ AND HAVE PHOTON CROSS SECTIONS

$$\frac{d^2\sigma}{dQ^2 d\nu} = \Gamma_t \sigma_t + \Gamma_\ell \sigma_\ell$$

σ_ℓ σ_T → LONGITUDINAL AND TRANSVERSE POLARIZED CROSS SECTION

Γ_t Γ_ℓ → LONG. AND TRANS. PHOTON FLUXES

$$= \Gamma_t \sigma_t \left(1 + \varepsilon R\right) \qquad R = \frac{\sigma_L}{\sigma_T}$$

$$\varepsilon = \left(1 + 2\,\frac{Q^2+\nu}{Q^2}\tan^2\frac{\theta}{2}\right)^{-1} = \frac{\Gamma_\ell}{\Gamma_t}$$

$$\Gamma_t = \frac{\alpha_{em}}{4\pi M} \cdot \frac{2M\nu - Q^2}{Q^2 E^2} \cdot \frac{1}{1-\varepsilon} \Rightarrow \frac{\#\ \text{PHOTONS}}{\Delta Q^2 \Delta\nu}$$

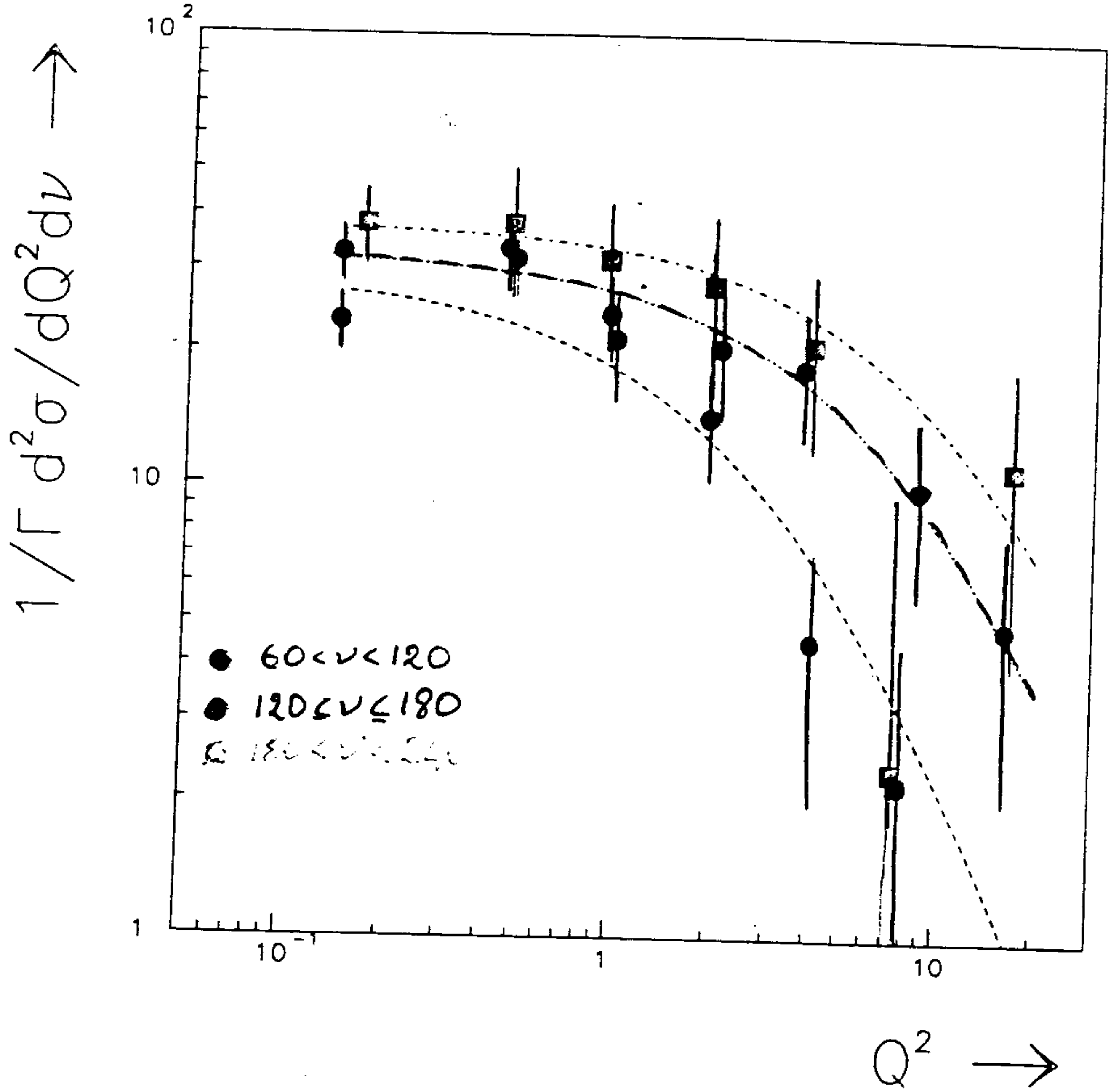
IF R IS SMALL :

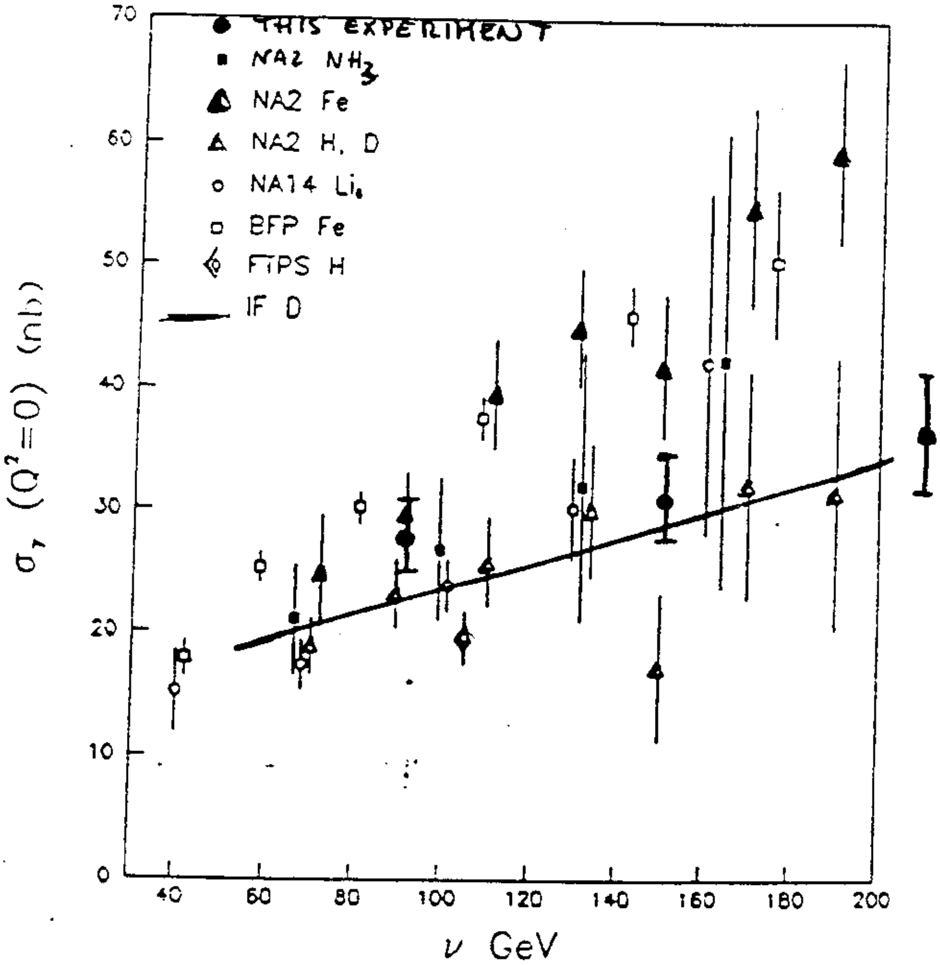
$$\frac{1}{\Gamma_t} \cdot \frac{d^2\sigma}{dQ^2 d\nu} = \sigma(Q^2=0, \nu) * \frac{1}{\left(1+\frac{Q^2}{M^2}\right)^2}$$

⇒ $\sigma(Q^2=0, \nu)$ REAL PHOTON CROSS SECTION

$$\frac{1}{\Gamma}\frac{d^2\sigma}{dQ^2 d\nu} = \sigma(Q^2=0,\nu)\cdot\left(1+\frac{Q^2}{M^2}\right)^{-2}$$

ν	$\sigma(Q^2=0)$	M
60 - 120	28.7 ± 3.4	2.0 ± 0.3
120 - 180	32.4 ± 3.9	3.2 ± 0.6
[illegible]	[illegible]	[illegible]



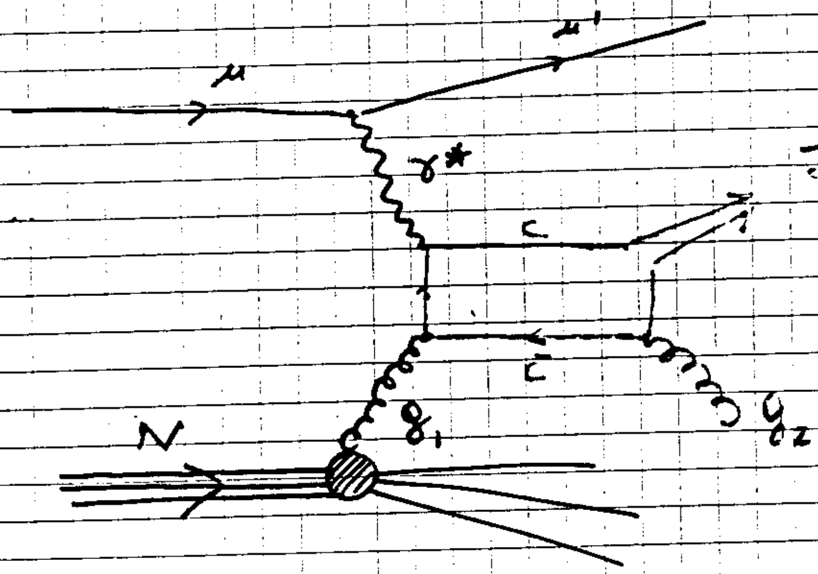


THIS EXPERIMENT
NA2 NH3
NA2 Fe
NA2 H, D
NA14 Li6
BFP Fe
FTPS H
IF D
σγ (Q²=0) (nb)
ν GeV
0
10
20
30
40
50
60
70
40
60
80
100
120
140
160
180
200

Phys. Rev. D

COLOUR SINGLET MODEL

$\gamma g \to J/\psi\, g$



$c\bar{c}$ STATE ⟶ COLOUR SINGLET STATE

$J^{PC} = 1^{--}$

2 * SPIN $\frac{1}{2}$ WAVE FUNCTION

$$\Gamma_{ee} = \frac{e_q^2 e^2}{2\pi M_{J/\psi}} |\psi(0)|^2$$

$$\Gamma_h / \Gamma_{ee} = \frac{5}{18} \frac{\pi^2 - 9}{\pi} \frac{\alpha_s^3}{\alpha}$$

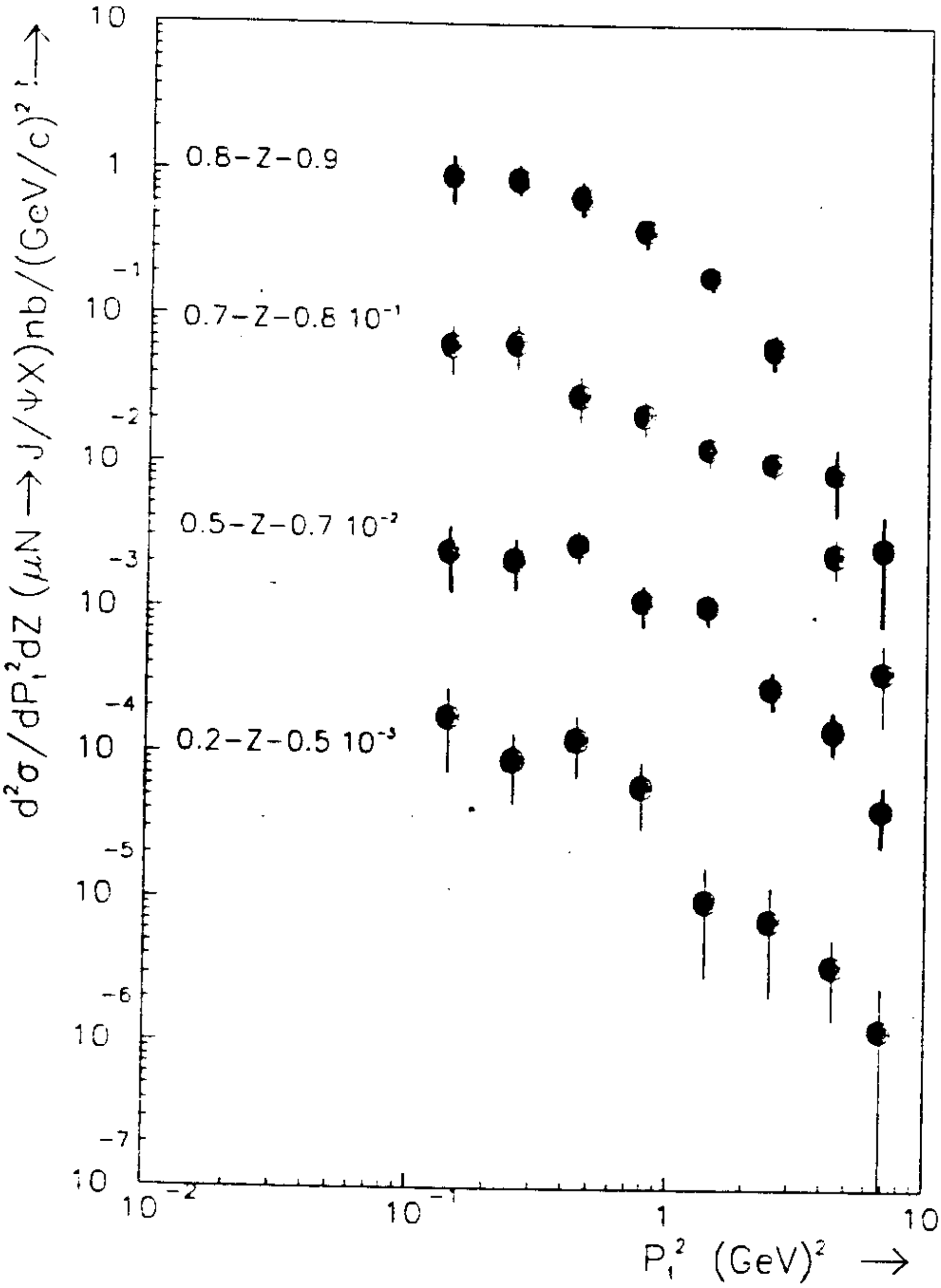
g_1 g_2 ARE HARD → INELASTIC REGION

$z < 0.9$

$P_t^2 > 0.1$ GeV^2

$$z = \frac{E_{J/\psi}}{\nu}$$

$$\frac{d^2\sigma}{dz\, dP_t^2} (\mu N \rightarrow \mu\ J/\psi\ X)$$

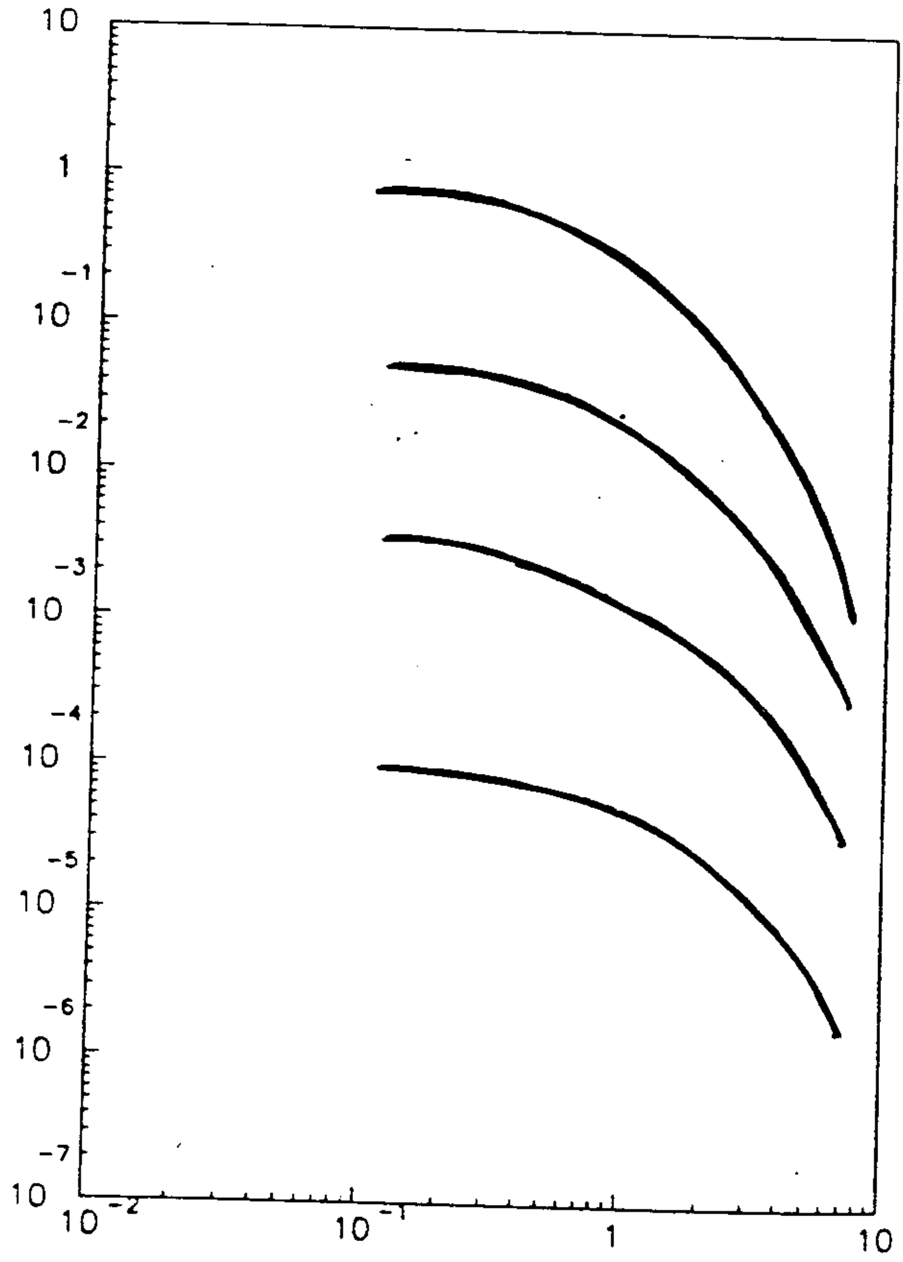


— COLOUR SINGLET MODEL (* 2.5)

$\alpha_s = 0.3$

$2\, m_{c,\bar{c}} = M_{J/\psi}$

$x G(x) = 3(1-x)^5$



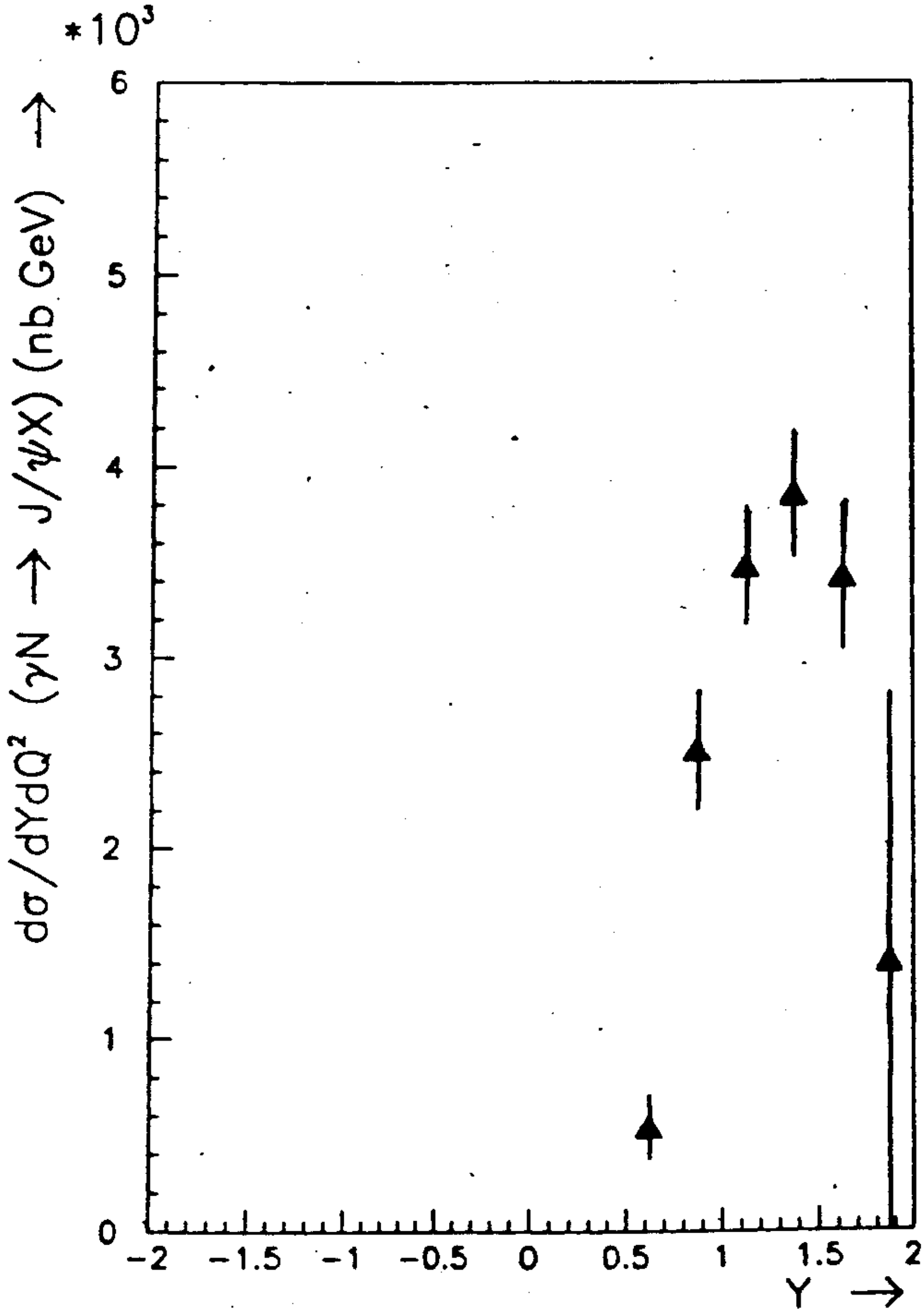
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-2}
10^{-1}
1
10

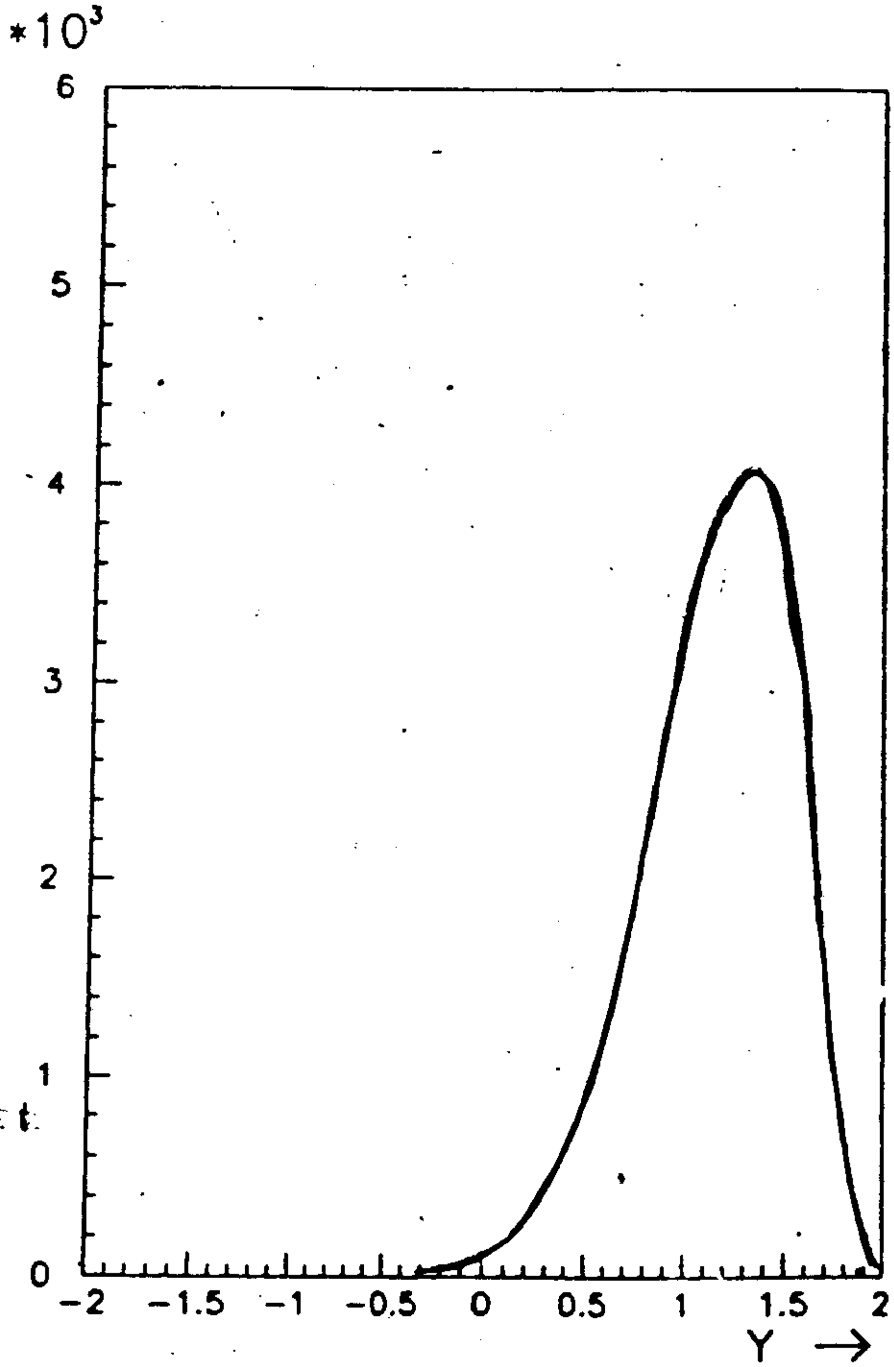
RAPIDITY IN THE

γN CENTER OF MASS SYSTEM

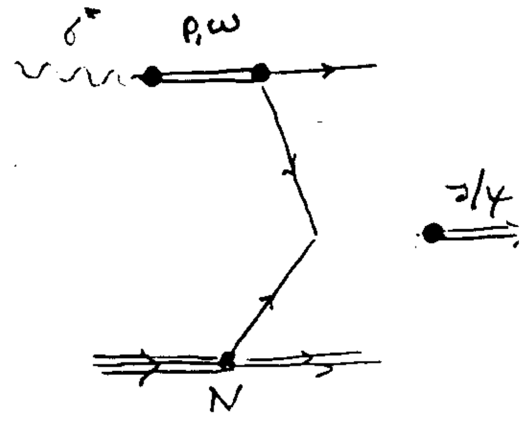
$$Y = \frac{1}{2} \ln \left(\frac{E_{J/\psi} + P_{\parallel J/\psi}}{E_{J/\psi} - P_{\parallel J/\psi}} \right)$$

EXTRAPOLATED AT $Q^2=0$

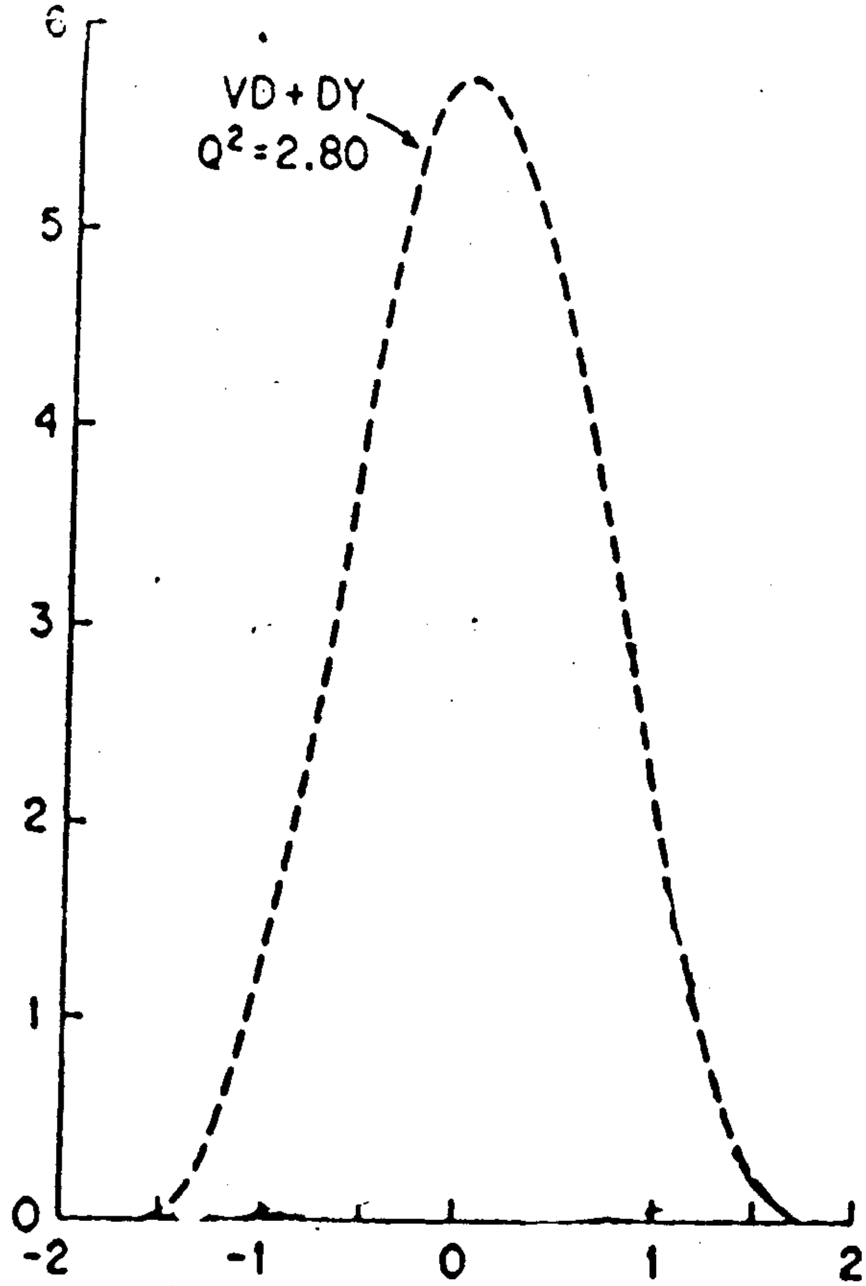




*10^3
6
5
4
3
2
1
0
−2
−1.5
−1
−0.5
0
0.5
1
1.5
2
Y →



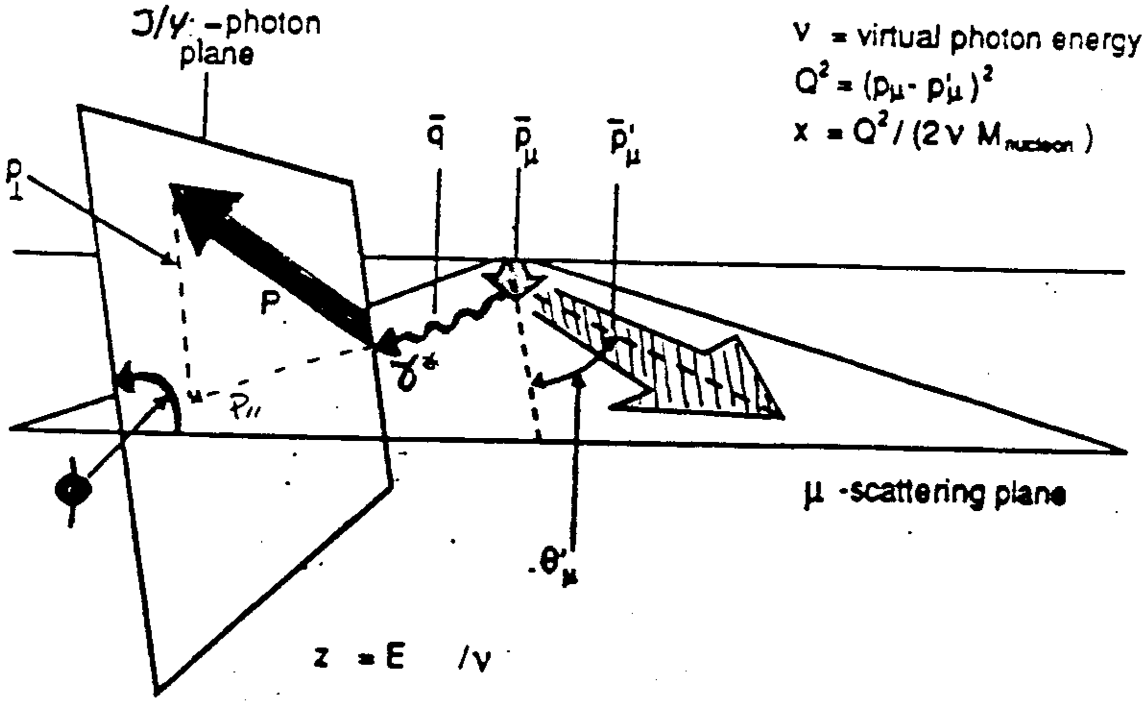
ρ,ω
N



VD + DY
Q² = 2.80

THE PRODUCTION PLANE

ϕ



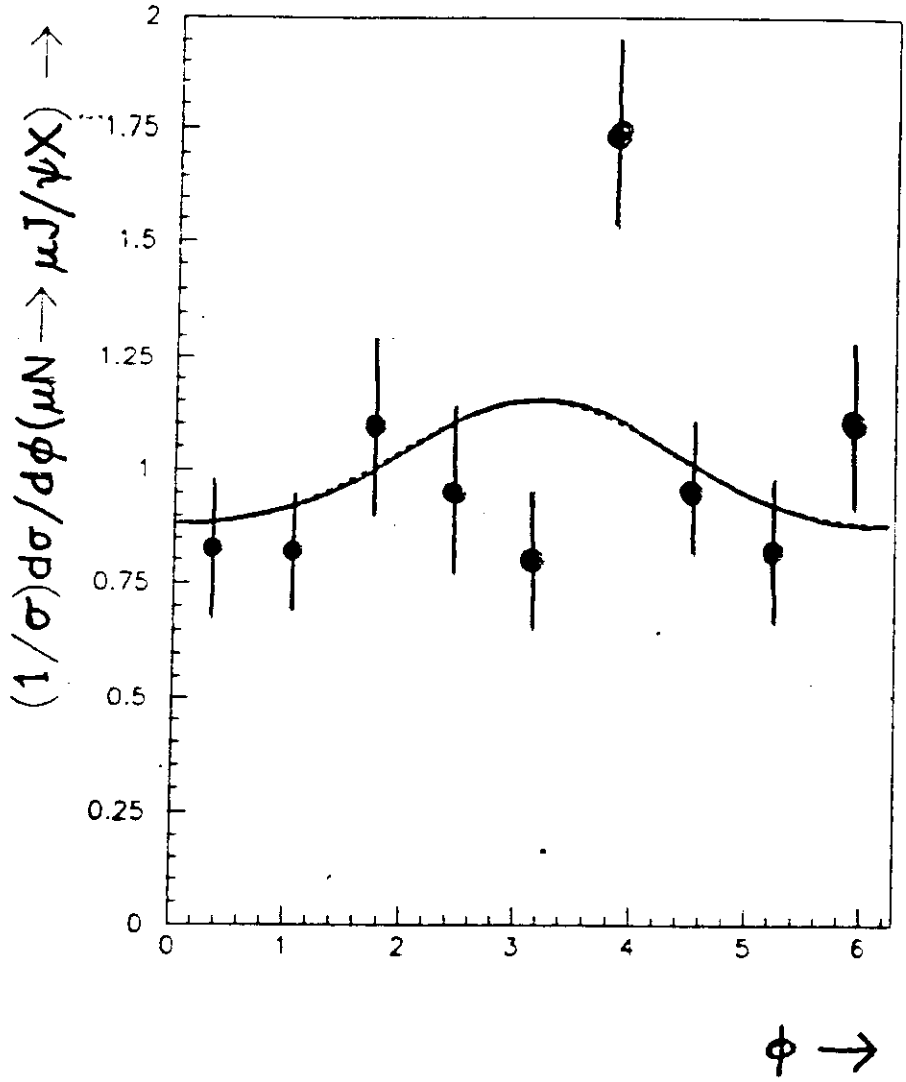
$$2\pi \frac{d\sigma}{d\phi_r}(\epsilon^2, \nu, P_\perp, \phi_r) = (\sigma_T + \epsilon\sigma_L) \times (1 + B\cos\phi_r + C\cos 2\phi_r)$$

TRANSVERSE MOMENTUM OF THE PARTON (q or g) PRODUCES THE AZIMUTHAL ASYMMETRIES UNDER THE SPIN CORRELATIONS

FROM B AND C VALUES IT IS POSSIBLE TO DISCRIMINATE BETWEEN MODELS.

AND TEST THE SPIN AND THE PARITY OF THE GLUON.

$$\frac{d\sigma}{d\phi} \propto \left(1 + B \cos\phi + C \cos 2\phi \right)$$

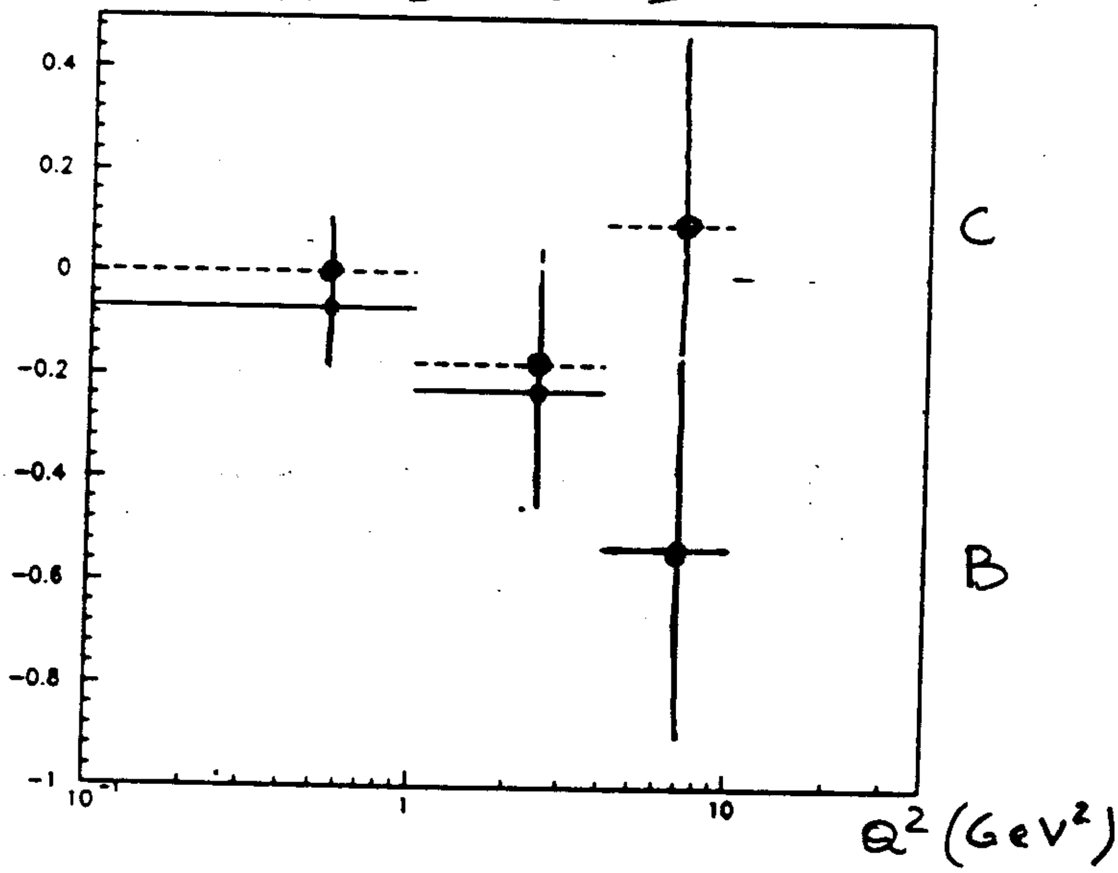


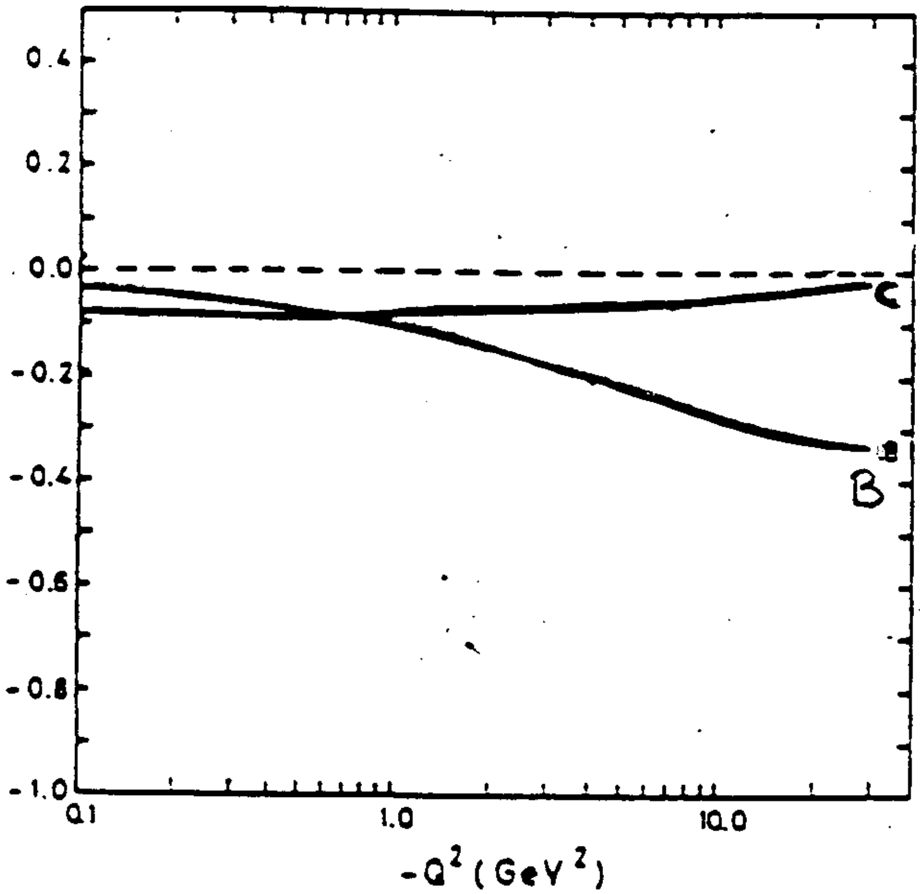
	FITTED VALUE	COLOUR SINGLET MODEL EXPECTATION
B =	−0.13 ± 0.08	−0.12
C =	0.01 ± 0.08	−0.08

Q^2 DEPENDENCE OF THE ϕ_p DISTRIBUTION

$$\frac{d\sigma}{d\phi_p} \propto 1 + B\cos\phi_p + C\cos 2\phi_p$$

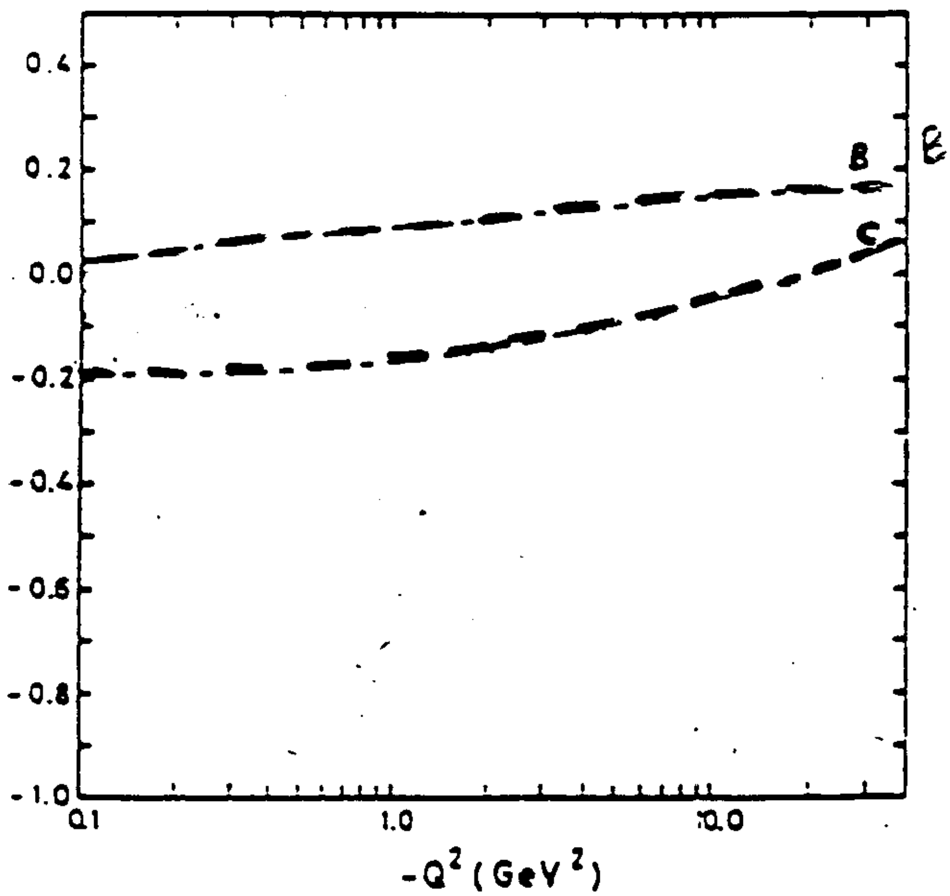
FITTED VALUES





MODEL EXPECTATION

↳ GLUON $J^P = 1^-$



MODEL EXPECTATION

↳ GLUON. $J^P = 0^+$

THE GLUON DISTRIBUTION

$$x\,G(x)$$

IN THE FRAMEWORK OF THE COLOUR SINGLET MODEL WITH INELASTIC J/ψ

$$0.2 < z < 0.9$$
$$P_t^2 > 0.1\ \mathrm{GeV}^2$$

$$\sigma_{CS} = \sigma\left(x\,G(x),\, z,\, P_t^2\right)$$

$$x = \frac{1}{W^2}\left[\frac{M_{J/\psi}^2}{z} + \frac{P_t^2}{z\cdot(1-z)}\right]$$

$$\frac{d\sigma}{dz\,dP_t^2} = x\,G(x)\, f(z, P_t^2, x)$$

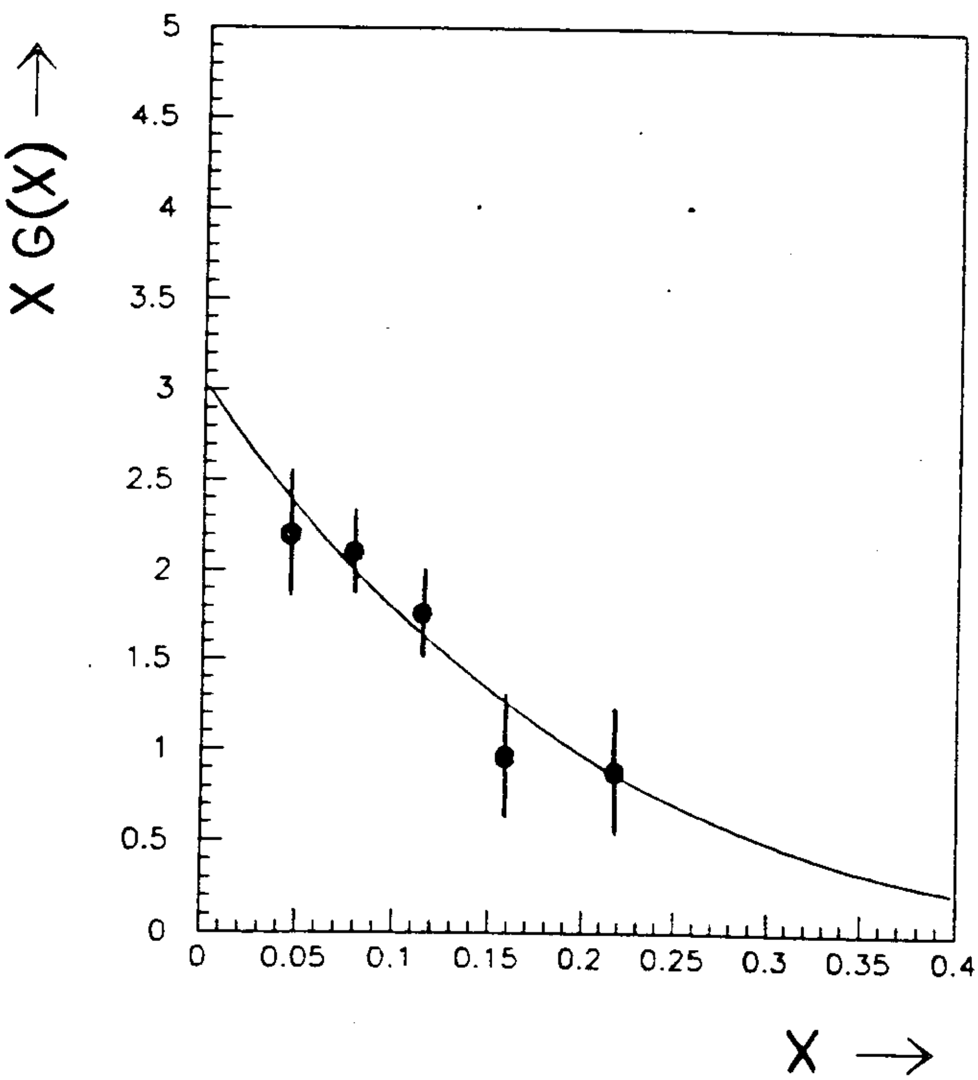
$$\sigma = \bar{x}\,G(\bar{x}) \underbrace{\int_{x_1}^{x_2} f(x, z, P_t^2)\, dP_t^2\, dz\, dx}_{F}$$

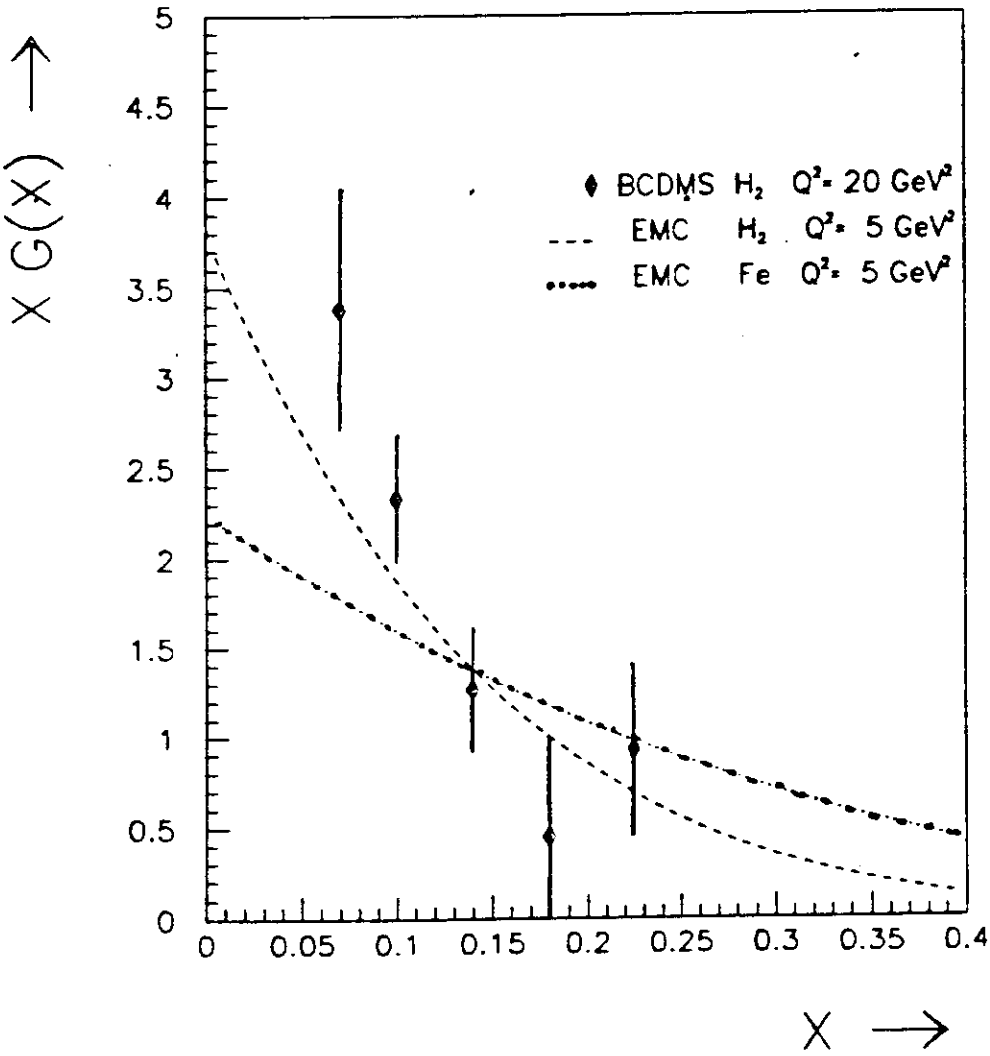
$$x\,G(x) = \frac{\sigma}{F}$$

$$xG(x) = C_0 \cdot \frac{\alpha+1}{2} \cdot (1-x)^{\alpha}$$

$$C_0 = 2.4 \pm 0.4$$

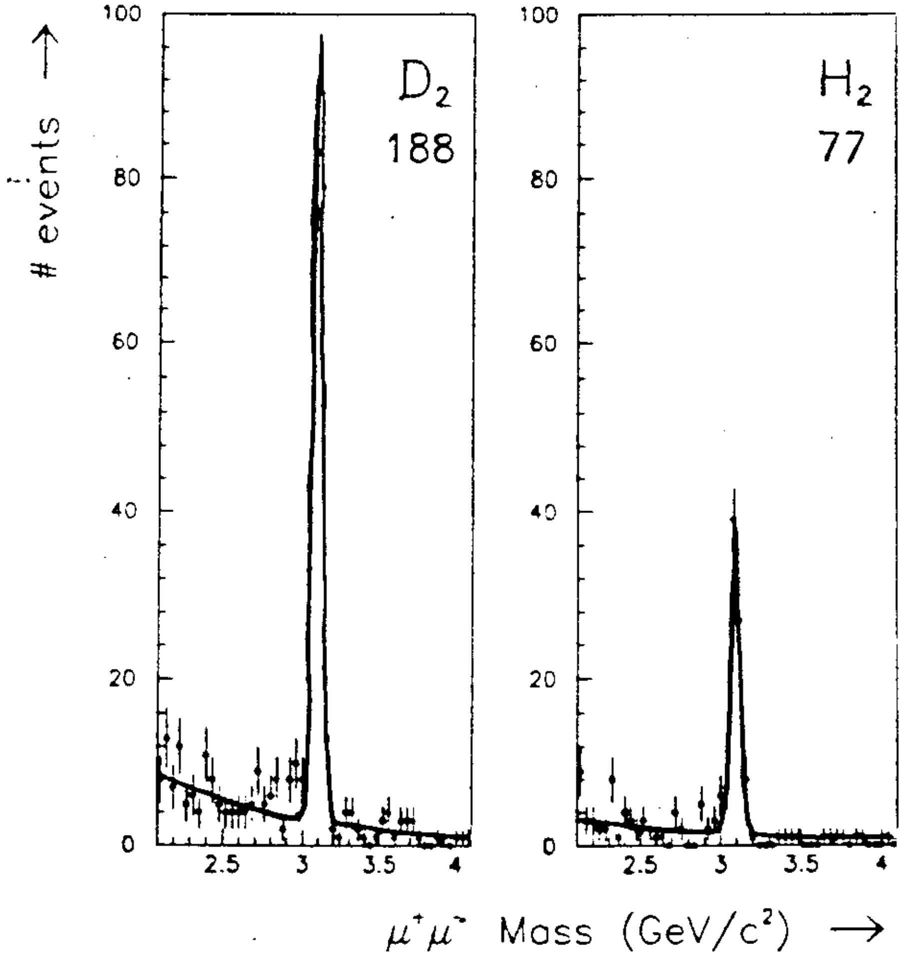
$$\alpha = 5.1 \pm 0.9$$





BCDMS H2 Q²= 20 GeV²
EMC H2 Q²= 5 GeV²
EMC Fe Q²= 5 GeV²
X G(X) →
X →
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4

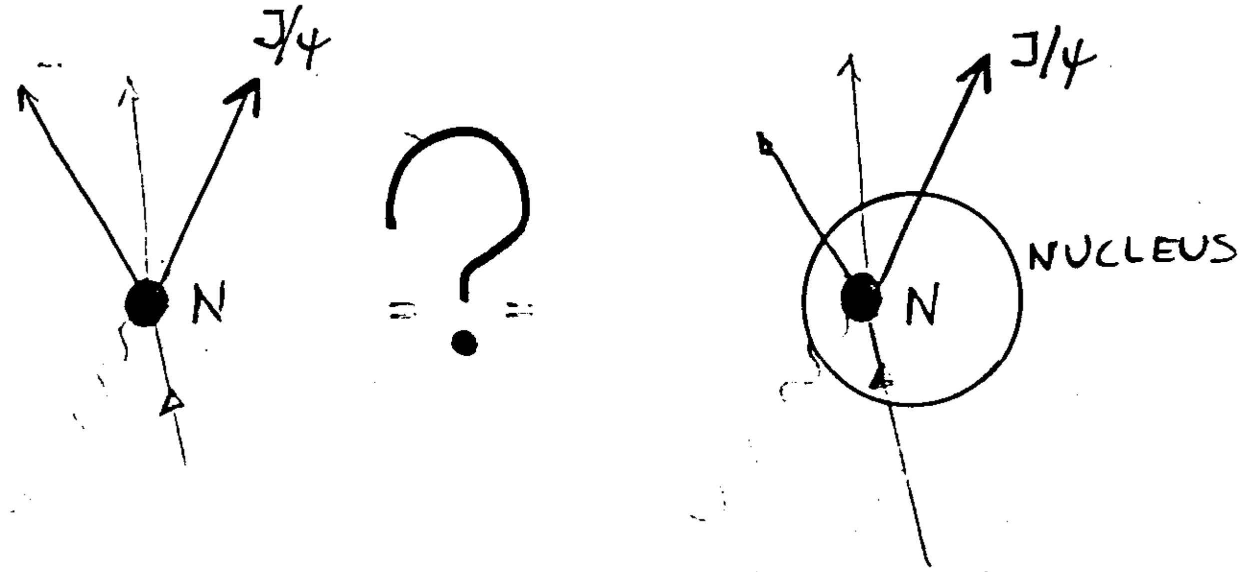
INELASTIC events : $Z<0.9$ – $P_t^2>0.1$

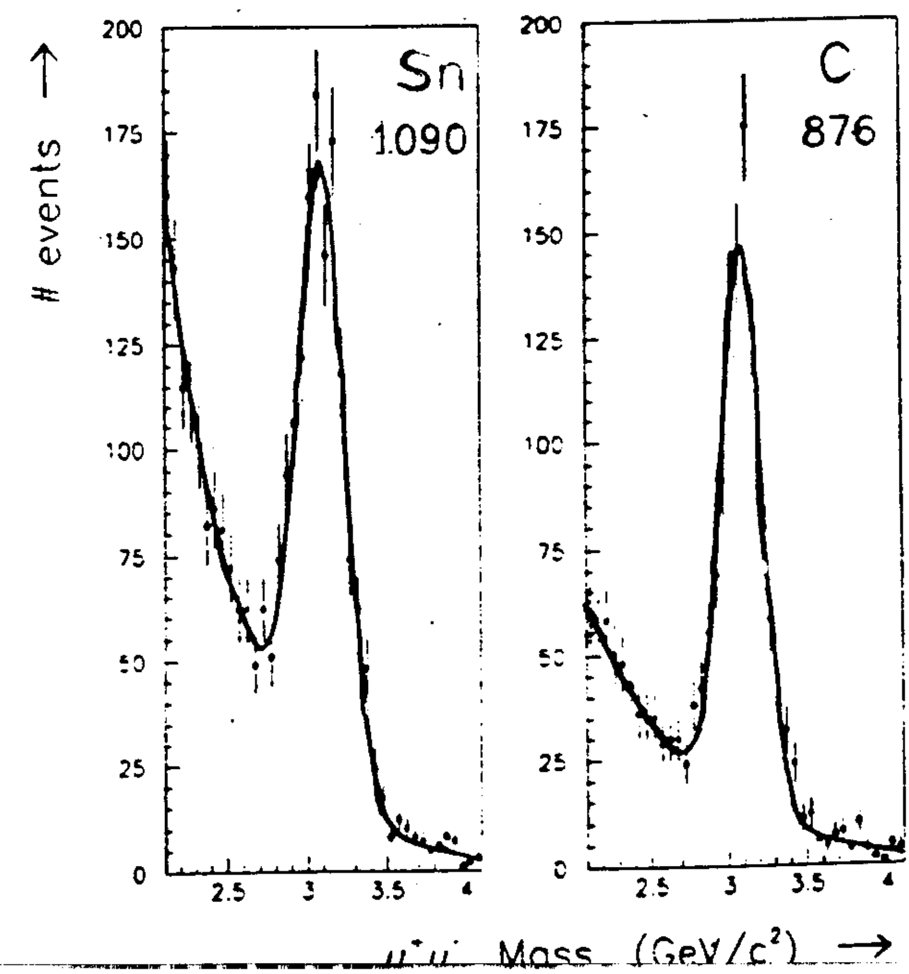


INELASTIC J/ψ ~ 30% OF THE TOTAL SAMPLE

[illegible] (inelastic) $= \dfrac{xG(x)_{D_2}}{xG(x)_{H_2}} = 1.11 \pm 0.2$ [illegible]

J/ψ PRODUCTION FROM Sn AND C





PREVIOUS EXPERIMENTS MEASURED

$$\sigma_{J/\psi}(A) \,/\, \sigma_{J/\psi}(H)$$

EMC [CERN]

$\mu\,(Fe, H) \rightarrow \mu\, J/\psi\, X$ at $E_\mu = 200$ GeV
$= 280$ GeV

NO CUTS ON z

NO CUTS ON P_t

COHERENCE CORRECTION FOR $z > 0.95$
$P_t^2 < 0.18$ GeV

$$R(Fe/H) = 1.45 \pm 0.12 \pm 0.22$$

E691 [FNAL]

$\gamma\,(Fe, Be .. H) \rightarrow J/\psi\, X$ at $E_\gamma = 80 \div 190$ GeV

NO MEASUREMENT OF z

COHERENCE CORRECTION FOR $P_t^2 < 0.15$ GeV

$$R = 0.79 \pm 0.09$$

$P_t^2 < 0.15\ GeV^2$ WITH COHERENT CONTRIBUTION

$$R_{COHER}(Fe/Be) = 1.93 \pm 0.16$$

IN THE PROCESS OF J/ψ PRODUCTION

FROM HEAVY NUCLEI

IN ORDER TO UNDERSTAND THE

GLUON DISTRIBUTION

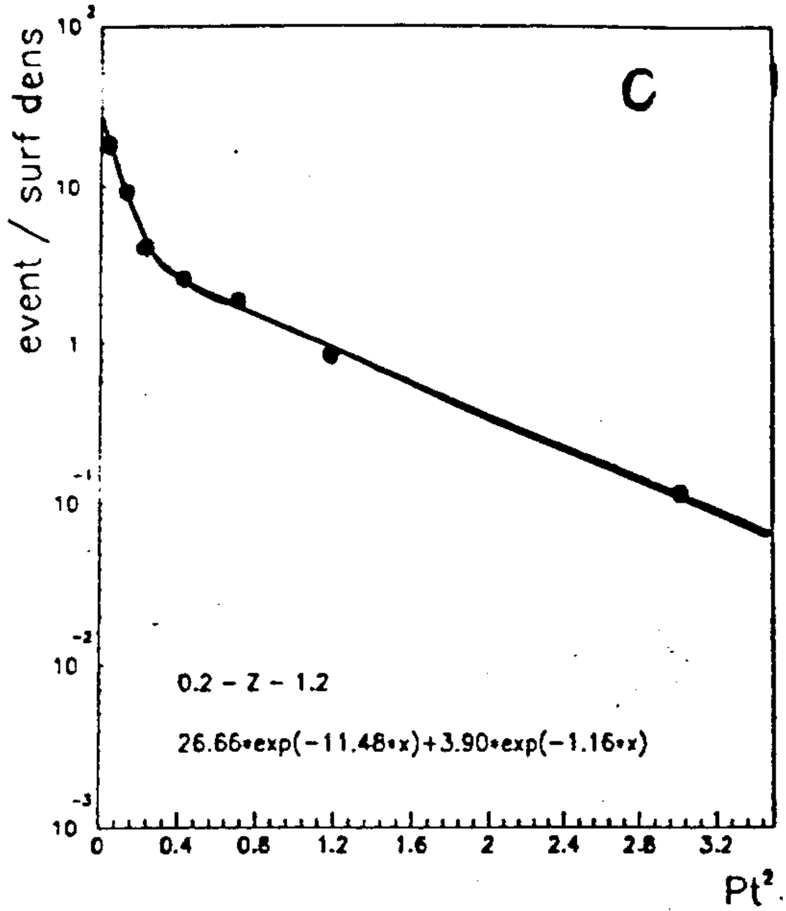
IT IS IMPORTANT TO STUDY

* COHERENCE CONTRIBUTIONS

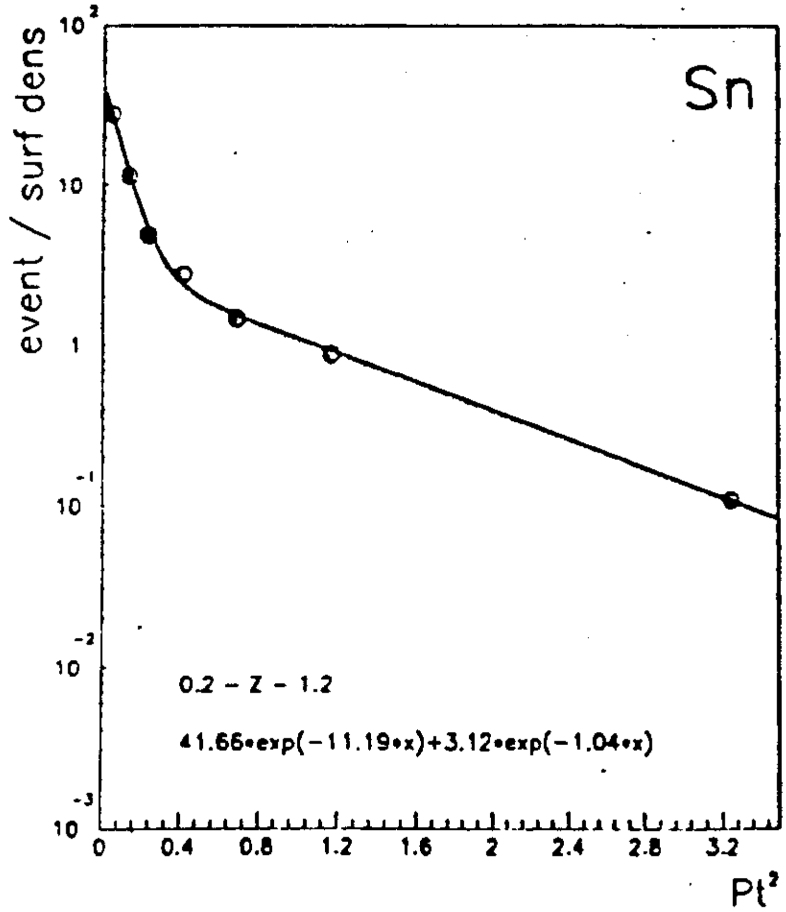
* RADIATIVE CORRECTIONS

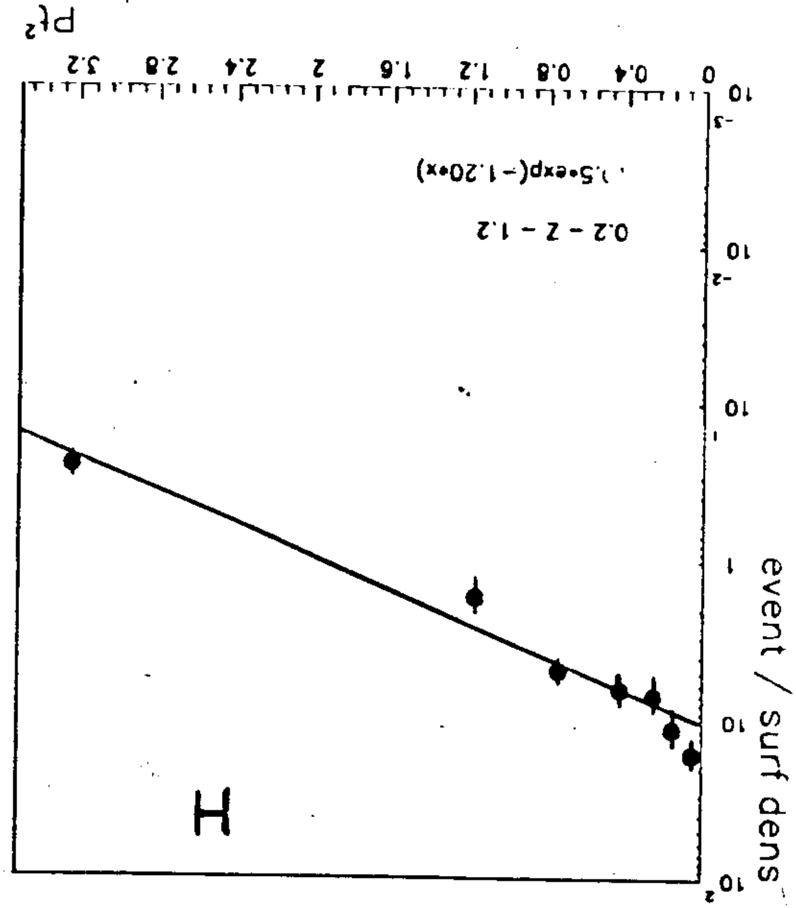
* ψ' CONTRIBUTION

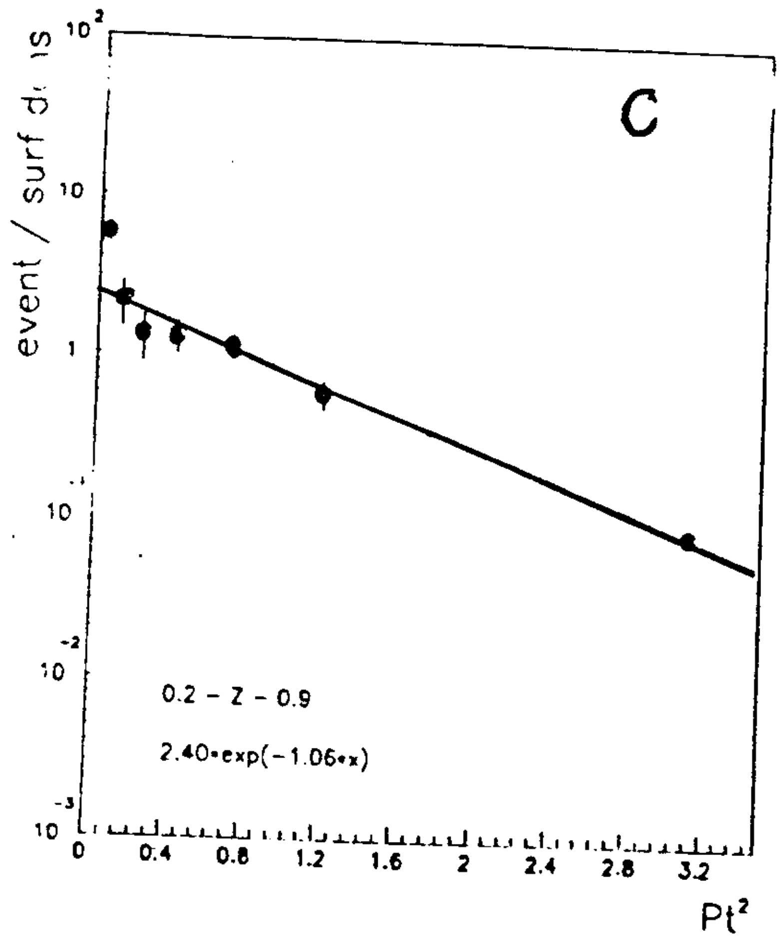
$\Rightarrow$ $< P_t^2$ DEPENDENCE


C
event / surf dens
0.2 - Z - 1.2
26.66*exp(-11.48*x)+3.90*exp(-1.16*x)
Pt²

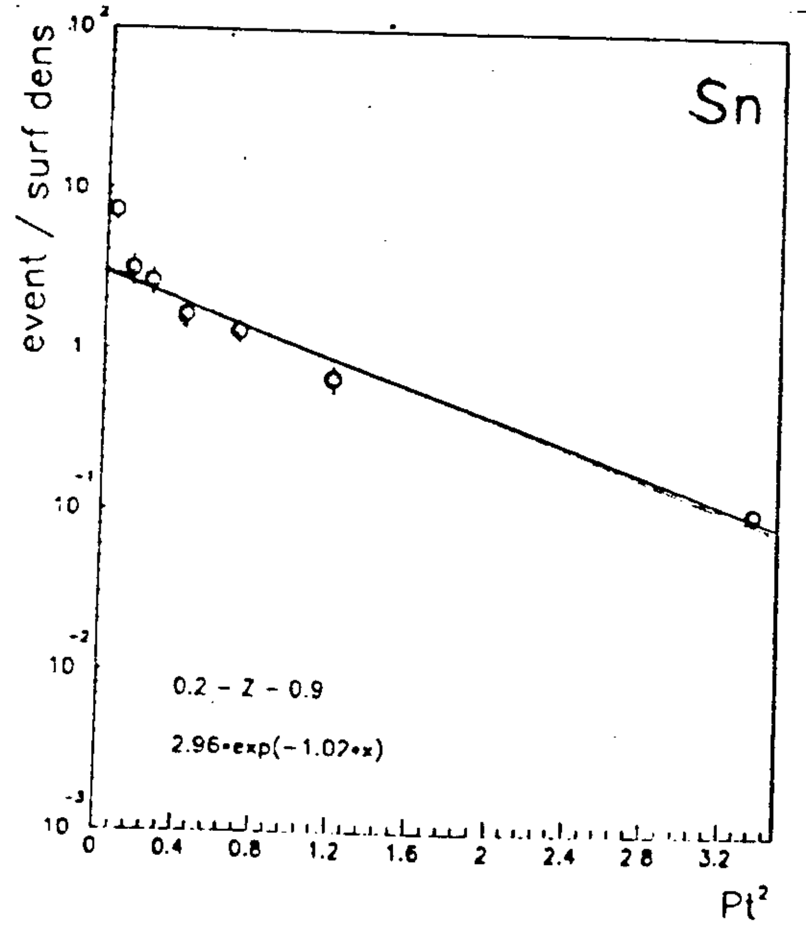
0.2 < Z < 1.2

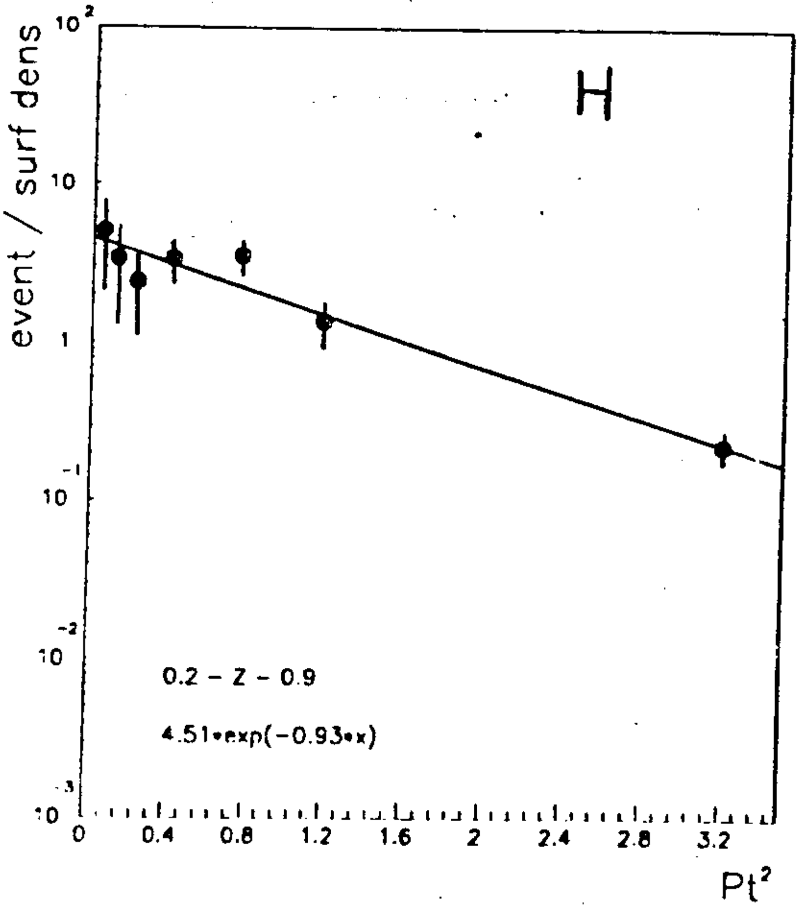

Sn
event / surf dens
0.2 - Z - 1.2
41.66*exp(-11.19*x)+3.12*exp(-1.04*x)
Pt²


event / surf dens
Pt²
0.2 - Z - 1.2
.5•exp(-1.20•x)
H

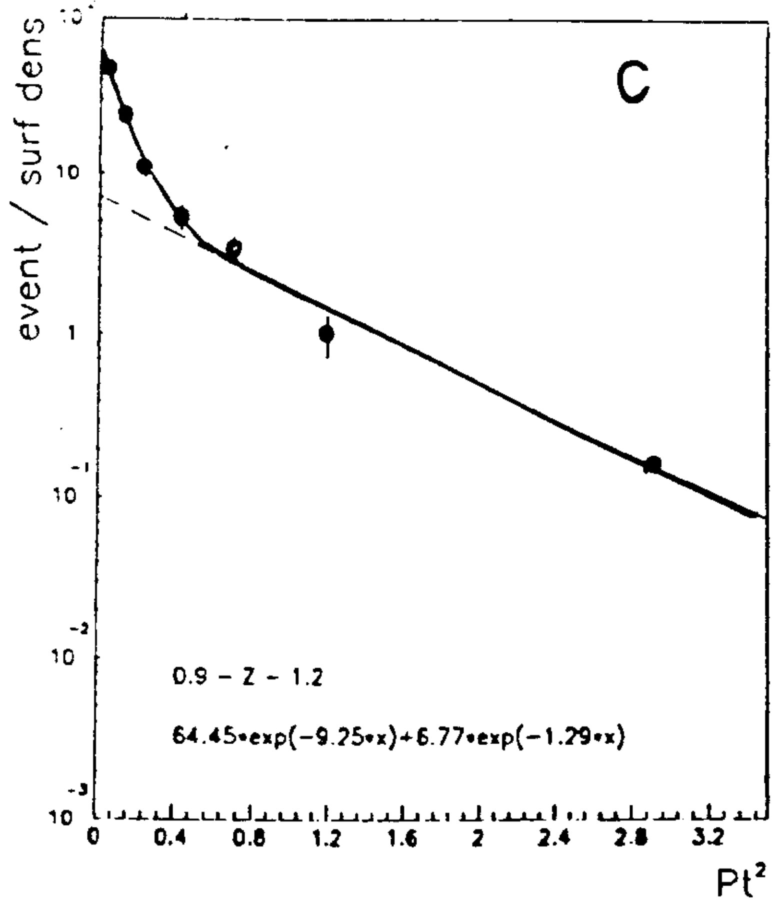

C
event / surf dens
0.2 - Z - 0.9
2.40•exp(-1.06•x)
Pt²

LOW Z $0.2 < Z < 0.9$


Sn
event / surf dens
0.2 - Z - 0.9
2.96•exp(-1.07•x)
Pt²

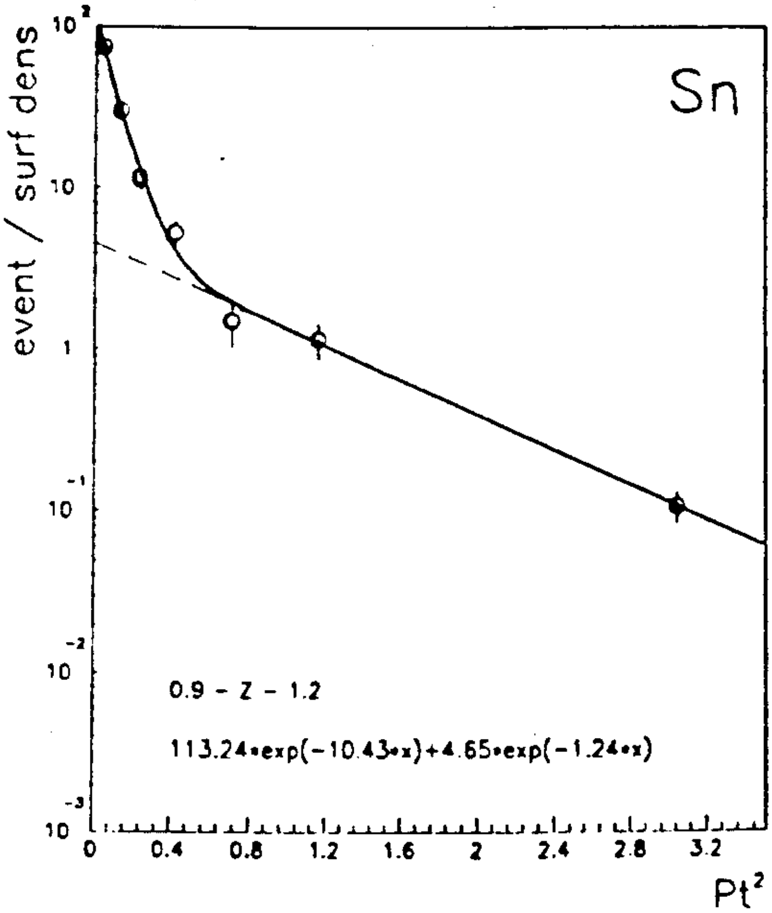


H
event / surf dens
10²
10
1
10⁻¹
10⁻²
10⁻³
0.2 - Z - 0.9
4.51*exp(-0.93*x)
0
0.4
0.8
1.2
1.6
2
2.4
2.8
3.2
Pt²

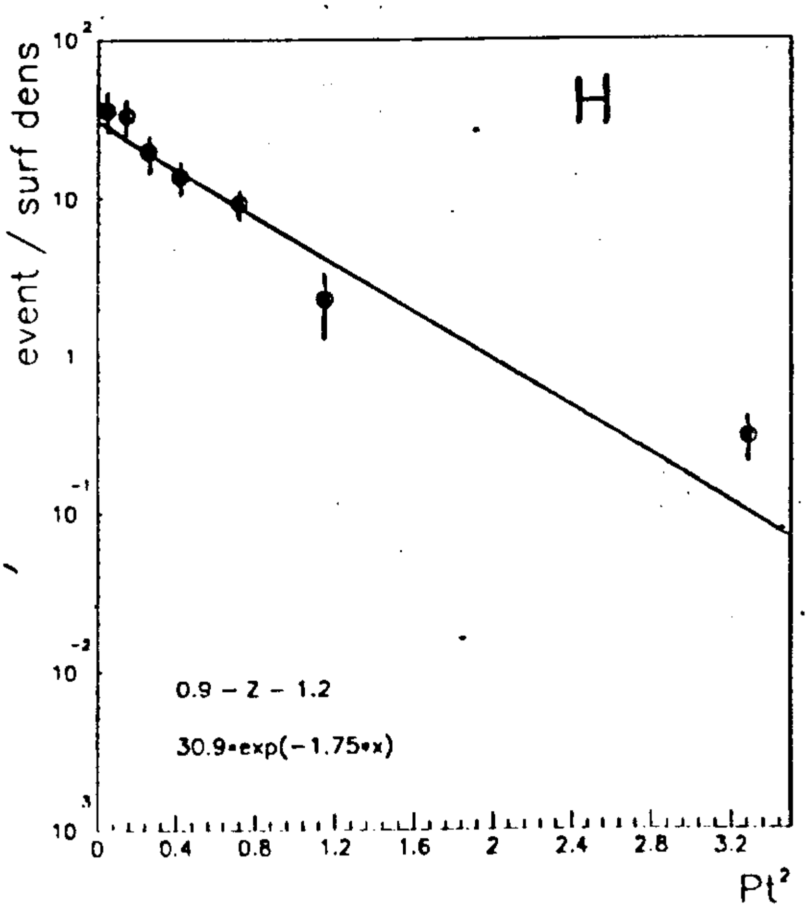


C
event / surf dens
0.9 - Z - 1.2
64.45•exp(-9.25•x)+6.77•exp(-1.29•x)
Pt²

HIGH Z 0.9< Z <1.2



Sn
event / surf dens
0.9 - Z - 1.2
113.24•exp(-10.43•x)+4.65•exp(-1.24•x)
Pt²



H
event / surf dens
0.9 – Z – 1.2
30.9*exp(–1.75*x)
Pt²

FROM THE FIT TO THE DISTRIBUTIONS

$$R\left(Sn/C\right)$$

$0.2 < z < 0.8$ ALL P_t^2 - COHERENCE CORRECTED

$R = 1.23 \pm .13$

$0.8 < z < 1.2$ ALL P_t^2 - COHERENCE CORRECTED

$R = 0.69 \pm .19$

LOW P_t^2 - NON COH. COR.

$R = 1.76 \pm .11$

$0.2 < z < 1.2$ ALL P_t^2 - COHERENCE CORRECTED

$R = 0.80 \pm .18$

LOW P_t^2 - NON COH. COR.

$R = 1.56 \pm .18$

THESE RESULTS SUGGEST THAT

* THE DISCREPANCY BETWEEN THE EMC AND E691 RESULTS MAY BE UNDERSTOOD IN TERMS OF THE STRONG z AND p_t^2 DEPENDENCE OF $\sigma_{J/\psi}(A)/\sigma_{J/\psi}(N)$

** HOWEVER THE ACCURACY OF THE DATA PRESENTED HERE IS STILL AT THE 20% LEVEL AND

THE SYSTEMATIC ERRORS ARE NOT YET FULLY EXTIMATED (of ψ' CONTRIBUTION)

⇓

$$\sigma_{J/\psi}(Sn)/\sigma_{J/\psi}(C) = ?$$

THE CONCLUSIONS ABOVE ARE <u>QUALITATIVE</u> AND <u>PRELIMINARY</u>

SUMMARY

- **H_2 AND D_2**

  - 4760 J/ψ ANALYSED FROM DATA TAKEN IN '86 - '87 BY THE NMC EXPERIMENT AT CERN
  - THE STATISTICS WILL BE DOUBLED WITH DATA FROM 1988 RUNS
  - PREDICTIONS OF COLOUR SINGLET MODEL ARE IN AGREEMENT WITH NMC DATA
  - $x G(x) = \frac{\alpha+1}{2} \cdot (1-x)^{\alpha}$ $\alpha = 5.1 \pm 0.6$
  - $\frac{\sigma_{J/\psi}(D_2)}{\sigma_{J/\psi}(H_2)} = \frac{x G(x)_{D_2}}{x G(x)_{H_2}} = 1.1 \pm 0.1$

- **Sn AND C**

  - ~ 2000 J/ψ AT $E_\mu = 280$ GeV
  - ~2000 MORE EXPECTED AT $E_\mu = 200$ GeV, ANALYSIS IN PROGRESS.
  - STRONG z AND P_t^2 DEPENDENCE OF THE RATIO $\sigma_{J/\psi}(Sn) / \sigma_{J/\psi}(C)$
  - $\sigma_{J/\psi}(Sn) / \sigma_{J/\psi}(C) = ?$