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ADDENDUM TO THE SPSC PROPOSAL $P_5$

# MEASUREMENT OF BACKWARD 2-BODY AND QUASI-2-BODY REACTIONS INDUCED ON UNPOLARIZED AND POLARIZED PROTONS BY $\pi^{\pm}$, $K^{\pm}$, $\bar{p}$ RANGING FROM 25 TO 120 GeV/c.

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The purpose of the present addendum is :

A) - To illustrate more clearly the possibilities of the proposed apparatus to measure the S dependence at large momentum transfer ( $|u| \simeq 1$ to 2 $(GeV/c)^2$) of $\pi$-N elastic cross sections.

B) - To show the capabilities of the set-up to perform measurements at higher u , if physics interest requires it.

C) - To give further details on the polarization measurements (2nd part of the proposal).

A) - The proposal $P_5$ gives, in a tabulated form, the total yields of events for $|u| < 1.3\ (GeV/c)^2$. They are obtained during a total running time of 800 hours (including a security factor of 0.5) with a total flux of $10^7$/second.

This running time is equally shared between 4 momenta (25, 40, 75, 120 GeV/c) and both polarities of the beam.

Figures 1 and 2 show extrapolated cross-sections from Regge-pole models [1] , [2] . The spread of the different predictions at each momentum is indicated by the hatched zone.

In order to show the repartition as a function of u of the expected events we have simulated the measurement of the most pessimistic cross-sections. The results are the points with their statistical errors. A balance of the errors at different momenta can be achieved by altering the equal sharing of the total time.

Figure 3 shows at fixed u $(0, -1., -2.(GeV/c)^2)$ S dependences of cross-sections. They have been extrapolated ($S^{-3}$ to $S^{-5}$) from measurements below 20 GeV/c. The points with error bars are the predicted values for measurements in u bins of $\Delta u = \pm 0.125\ (GeV/c)^2$. This different way of arranging the results shows the ability of the set-up to furnish the good power of the S dependence.

Non peripheral amplitudes associated with hypothetical constituents of the proton which could be present above 50 GeV/c [3] should affect the power law of S, at large u .

To see if such effects are detectable with our apparatus, we show on figure 3 some arbitrary examples of breaks ($S^{-3}$, $^{-4}$, $^{-5}$ to $S^{-2}$).

B) - Our set-up is able to perform measurements at values higher than those of proposal $P_5$.

A simple change of the incoming beam angle ( $\simeq$ 15 mrad) allows :

- to cover the range $0.5 < u \lesssim 4.$
- to get the unscattered beam out of the foward spectrometer thus permitting higher beam fluxes.

The price to pay for this is to drop out the tagging of the beam. We have performed Monte-Carlo calculations with :

$\frac{\Delta p}{p}$ beam = $\pm$ 1.% , $\Delta\theta_H$= 0.9 mrad and $\Delta\theta_v$ = 0.6 mrad.

They give :

- the global geometical efficiency (Fig. 4).
- the amount of background given by the reaction $\pi\ p \rightarrow (\pi\pi^{\circ})\ p$ which simulates most likely the elastic channel.

We found a contamination of **10 %** which can be compared with the previous set-up.

Using a total flux of $10^8$/second improves the statistics by a <u>factor 5</u> in the whole range assuming the same total running time of 800 hours.

C ) Polarization measurements : we give here detailed results of a Monte-Carlo simulation performed for $\pi$-N elastic scattering at 50 GeV/c. The elastic events can be simply selected by using the two following criteria :

- the coplanarity of the three measured particles defined as :

$$\varepsilon = \left[\hat{p}_{inc} \cdot (\hat{p}_p \wedge \hat{p}_\pi)\right]$$

where the $\hat{p}$ are unitary vectors,

- the angular correlation

$$\delta = \theta_p^{lab}\,(\text{measured}) - \theta_p^{lab}\,(\text{computed})$$

$\theta_p^{lab}$ (measured) is the angle of the forward scattered proton in the laboratory,

$\theta_p^{lab}$ (computed) is the value of the proton angle deduced from the measured angle of the backward scattered pion, assuming the events obey elastic kinematics.

Fig. 4a and 4b show the Monte-Carlo distributions for $\varepsilon$ computed for elastic events, respectively on free and bound protons.

Fig. 5c and 5d show the similar distributions for $\delta$.

Fig. 6 shows the correlation of $\varepsilon$ versus $\delta$ in the same conditions as previously.

Equal number of events have been generated for scattering on free and bound protons.

Owing to the good separation obtained, we plan to perform specific checks on $\varepsilon$ and $\delta$ both in the trigger and in fast off-line analysis.

Then, the $\rho$ parameter ( $\rho = \frac{\text{events produced on free protons}}{\text{events on free + bound protons}}$ ) increases from $\simeq$ 0.25 to 0.92.

If the remaining events are fitted (4C-fit), the $\rho$ parameter jump to 0.98. Figure 7 shows the $\chi^2$ distributions of elastic events on free and bound protons, respectively.

As an example of the statistical accuracy which can be reached we give on figure 8 a simulated measurement with the following conditions :

- 500 hours of running time with a security factor of 0.5,
- a total flux of $10^7$/second,
- a butanol target, 20cm long, polarized at 70% with a filling factor of 0.7.

The predictions for the polarization parameter given on figure 7 come from Regge models extrapolations [1].

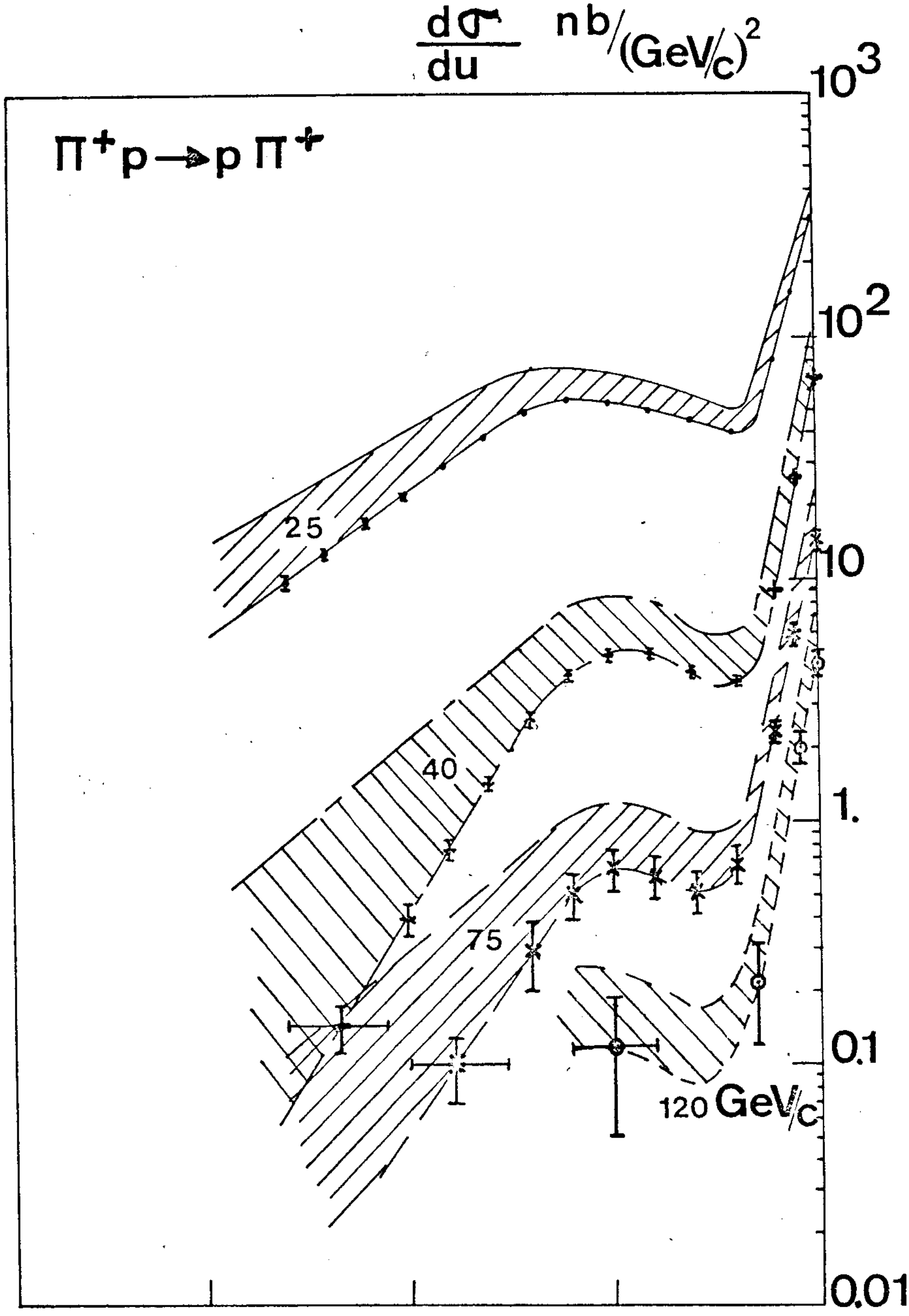
Figure 9 shows computed shapes of the shims located in the Goliath gap and the expected magnetic field homogeneity.

## References.

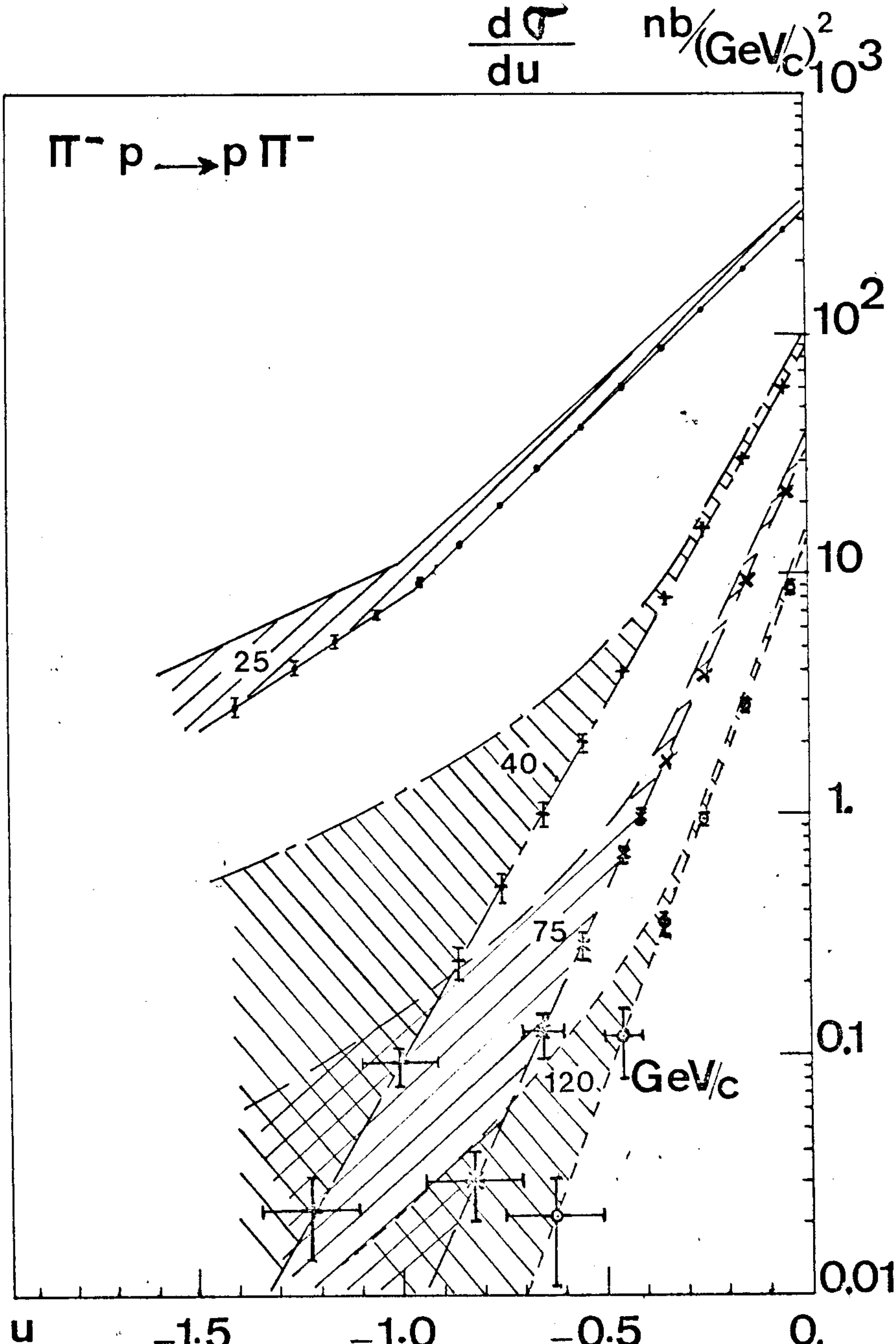

[1] E.L. BERGER and G.C. FOX, Nuclear Physics B26, 1 (1971).

[2] F. HAYOT, A.MOREL, Private Communication.

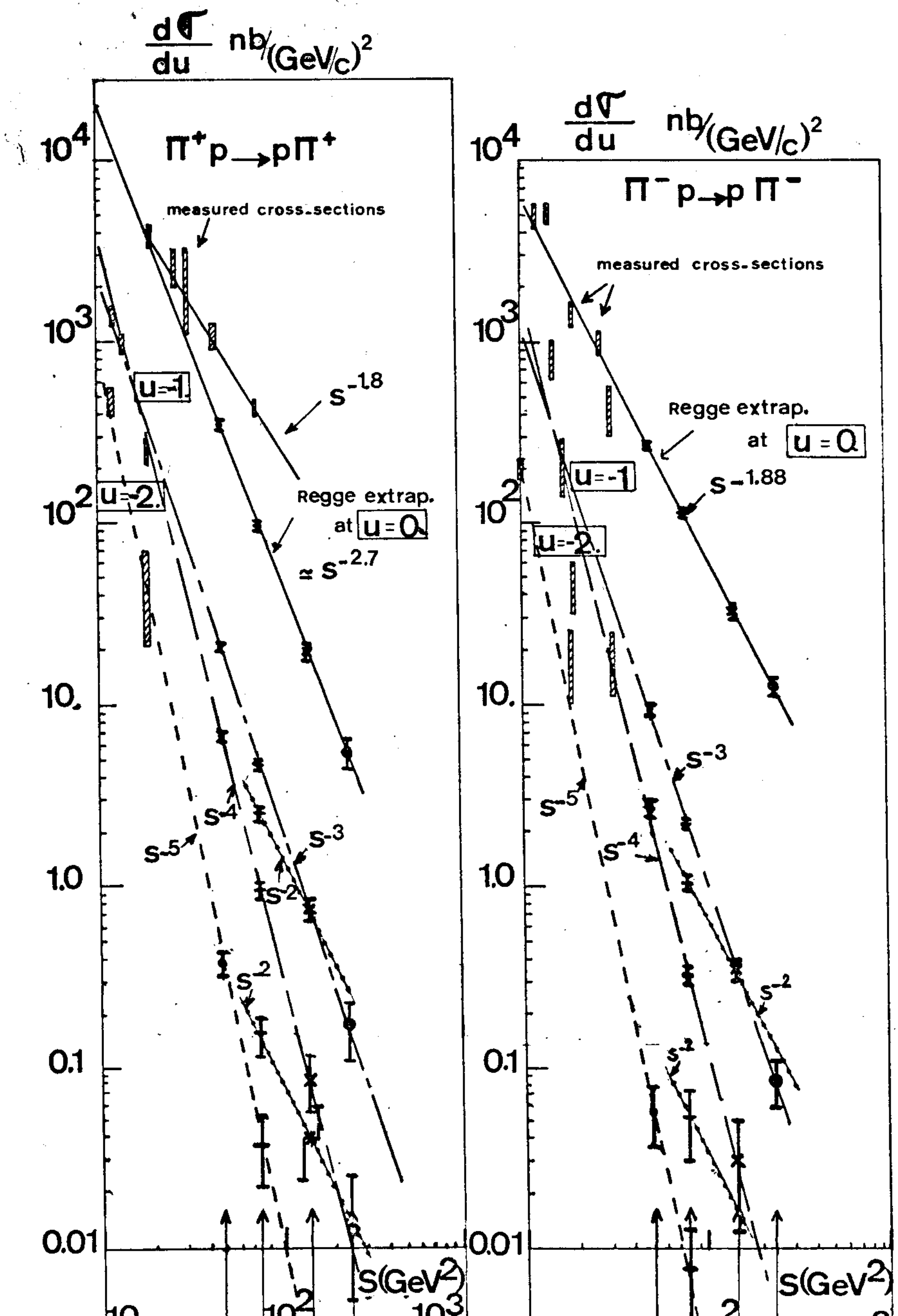
[3] D.C. CAREY et al, Phys. Rev. Letters 32, 24 (1974).



dσ/du nb/(GeV/c)^2
π⁺p → pπ⁺
25
40
75
120 GeV/c
10^3
10^2
10
1.
0.1
0.01



dσ/du nb/(GeV/c)²
10³
π⁻ p → p π⁻
10²
10
1.
0.1
0.01
25
40
75
120.
GeV/c
u
-1.5
-1.0
-0.5
0.



$\frac{d\sigma}{du}$ nb/(GeV/c)$^2$
$\pi^+ p \to p \pi^+$
measured cross-sections
u=-1.
u=-2.
$s^{-1.8}$
Regge extrap. at u=0.
$\simeq s^{-2.7}$
$s^{-4}$
$s^{-5}$
$s^{-3}$
$s^{-2}$
$s^{-2}$
S(GeV$^2$)
$\frac{d\sigma}{du}$ nb/(GeV/c)$^2$
$\pi^- p \to p \pi^-$
measured cross-sections
Regge extrap. at u=0.
u=-1
u=-2.
$s^{-1.88}$
$s^{-3}$
$s^{-5}$
$s^{-4}$
$s^{-2}$
$s^{-2}$
S(GeV$^2$)

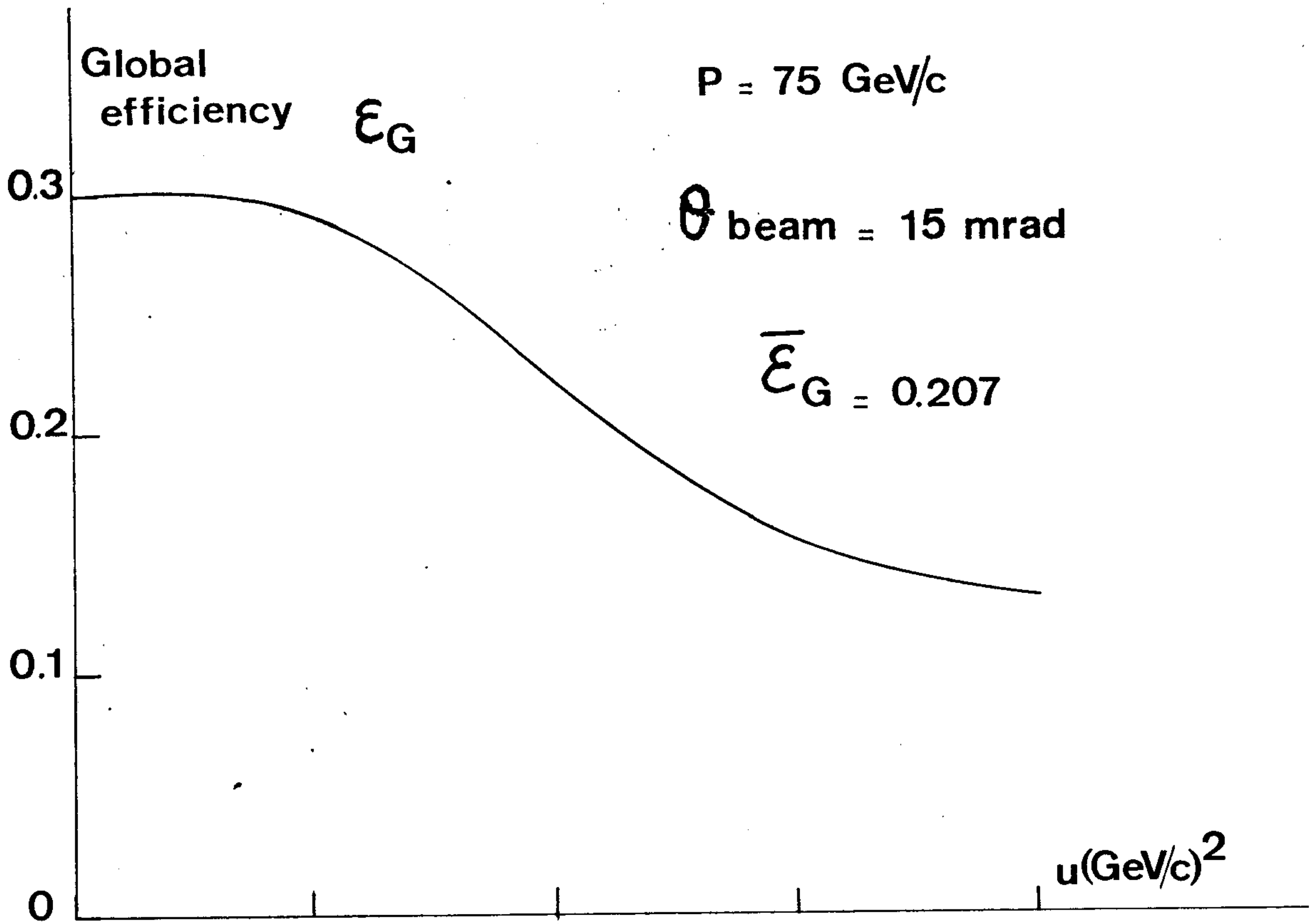

Global
efficiency
εG
P = 75 GeV/c
θ beam = 15 mrad
ε̄G = 0.207
0.3
0.2
0.1
0
0.
-1.
-2.
-3.
-4.
u(GeV/c)2

fig 4

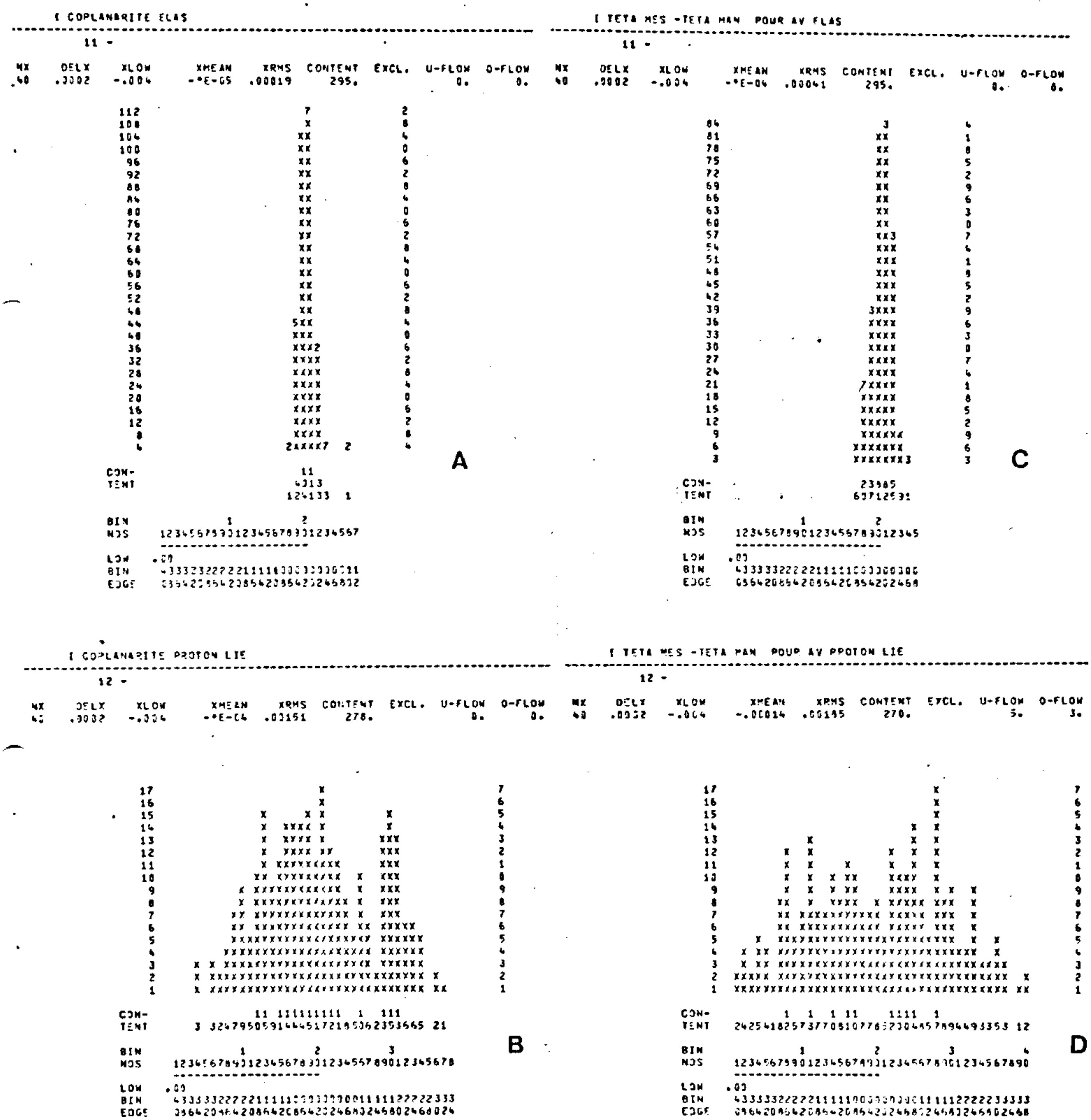
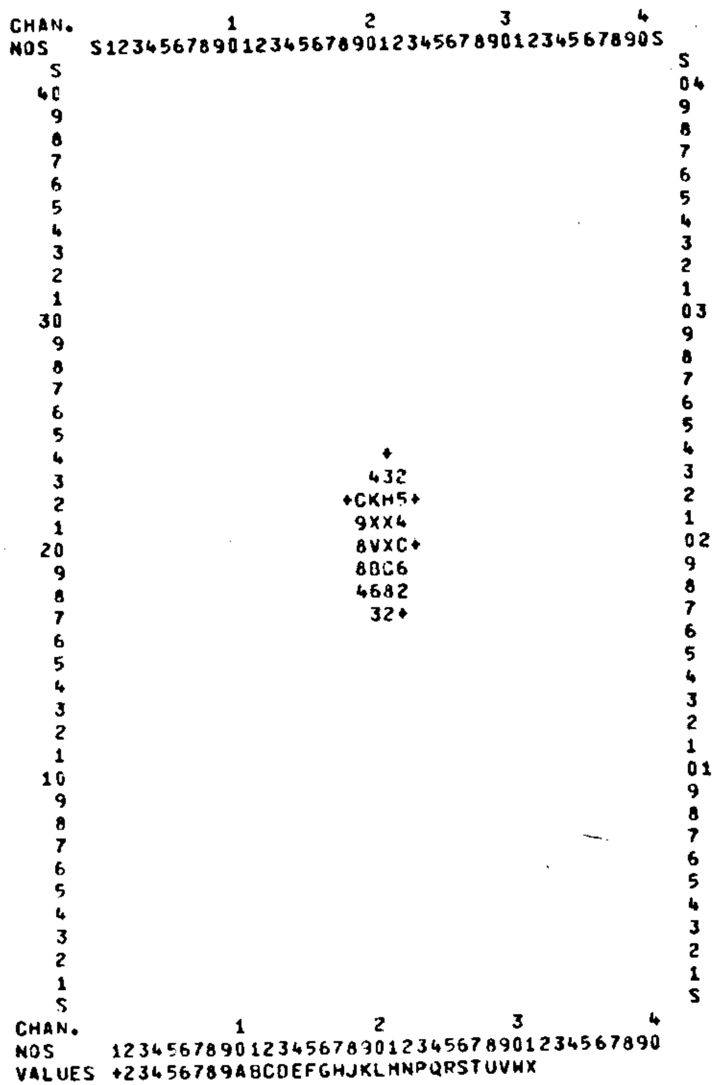

I COPLANARITE ELAS
I TETA MES -TETA MAN POUR AV ELAS
I COPLANARITE PROTON LIE
I TETA MES -TETA MAN POUR AV PROTON LIE
NX DELX XLOW XMEAN XRMS CONTENT EXCL. U-FLOW O-FLOW
A
B
C
D

fig.5

ORRELATION COPLANARITE -COR.TETA AV ELAS

11 -

| ITS | BINS | CAP. | LOST | NX | DX | XL | NY | DY | YL | ENTRIES |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 12 | 31 | 7 | 40 | .0002 | -.004 | 40 | .0002 | -.004 | 295 |




CORRELATION COPLANARITE -COR.TETA AV PROTON LIE

12 -

| BITS | BINS | CAP. | LOST | NX | DX | XL | NY | DY | YL | ENTR |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 12 | 31 | 0 | 40 | .0002 | -.004 | 40 | .0002 | -.004 | |

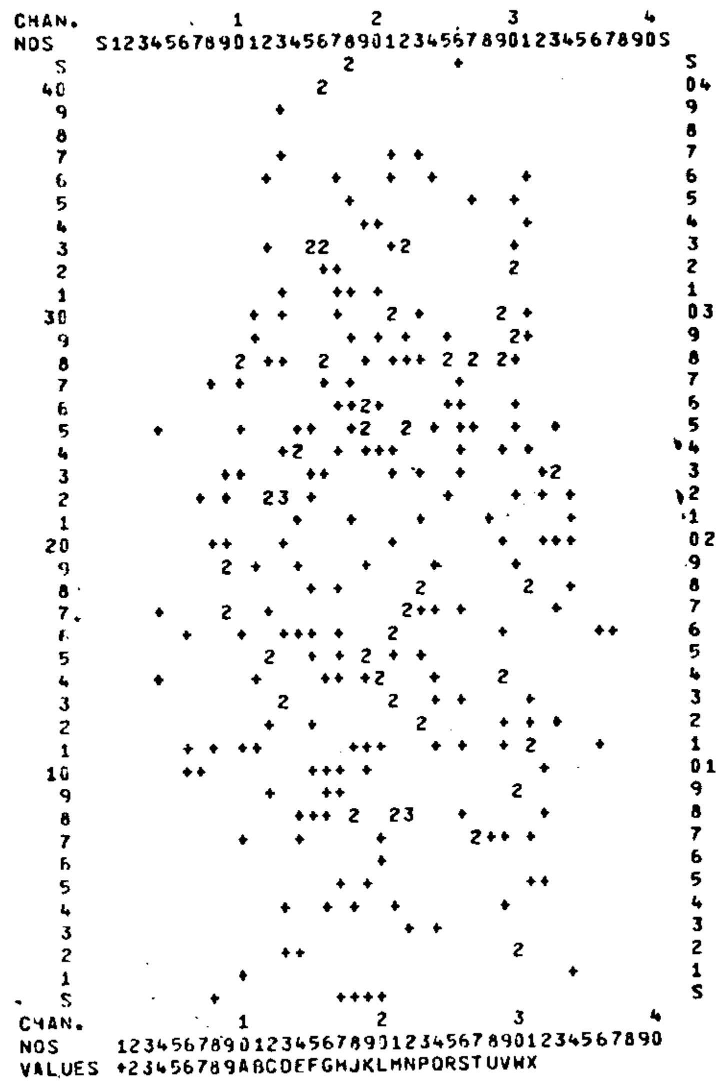



fig 6

```
     [CHI2 DU FIT ELAS
-----------------------------------------------------------------------
          11 -

NX     DELX      XLOW        XMEAN     XRMS  CONTENT  EXCL.  U-FLOW  O-FLOW
50      2.        0.        4.5373   4.1777     291.              0.      4.


           99  7                   9
           96  X                   6
           93  X                   3
           90  X                   0
           87  X                   7
           84  X                   4
           81  X                   1
           78  X                   8
           75  X                   5
           72  X                   2
           69  X7                  9
           66  XX                  6
           63  XX                  3
           60  XX                  0
           57  XX3                 7
           54  XXX                 4
           51  XXX                 1
           48  XXX                 8
           45  XXX                 5
           42  XXX                 2
           39  XXX                 9
           36  XXX                 6
           33  XXX                 3
           30  XXX                 0
           27  XXX                 7
           24  XXX                 4
           21  XXXX                1
           18  XXXX3               8
           15  XXXXX7              5
           12  XXXXXX              2
            9  XXXXXX7             9
            6  XXXXXXXX            6
            3  XXXXXXXX7 3 7       3

         CON-  965211
         TENT  885164862 1 2

         BIN            1
         NOS   12345678901234

         LOW        111112222
         BIN    2468024680246
         EDGE  .
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     [CHI2 DU FIT PROTON LIE
-----------------------------------------------------------------------
          12 -

NX     DELX      XLOW        XMEAN     XRMS  CONTENT  EXCL.  U-FLOW  O-FLOW
50      2.        0.        61.437   26.024      78.              0.    200.


           4                X    X      X             X       X        4
           3                X    X      XX  X         XXXX X XX        3
           2         X      X    X  X XXXX XXX  X X XXXXXX XXXXX       2
           1     X XXX  XXXXX XXXXXXX XXXX XXXX X X XXXXXX XXXXX       1

         CON-    1 112  11114 1114112 2243 2321 2 2 224333 32342
         TENT  .

         BIN            1         2         3         4         5
         NOS   12345678901234567890123456789012345678901234567890

         LOW        111112222233333444445555566666777778888899999
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         EDGE  .
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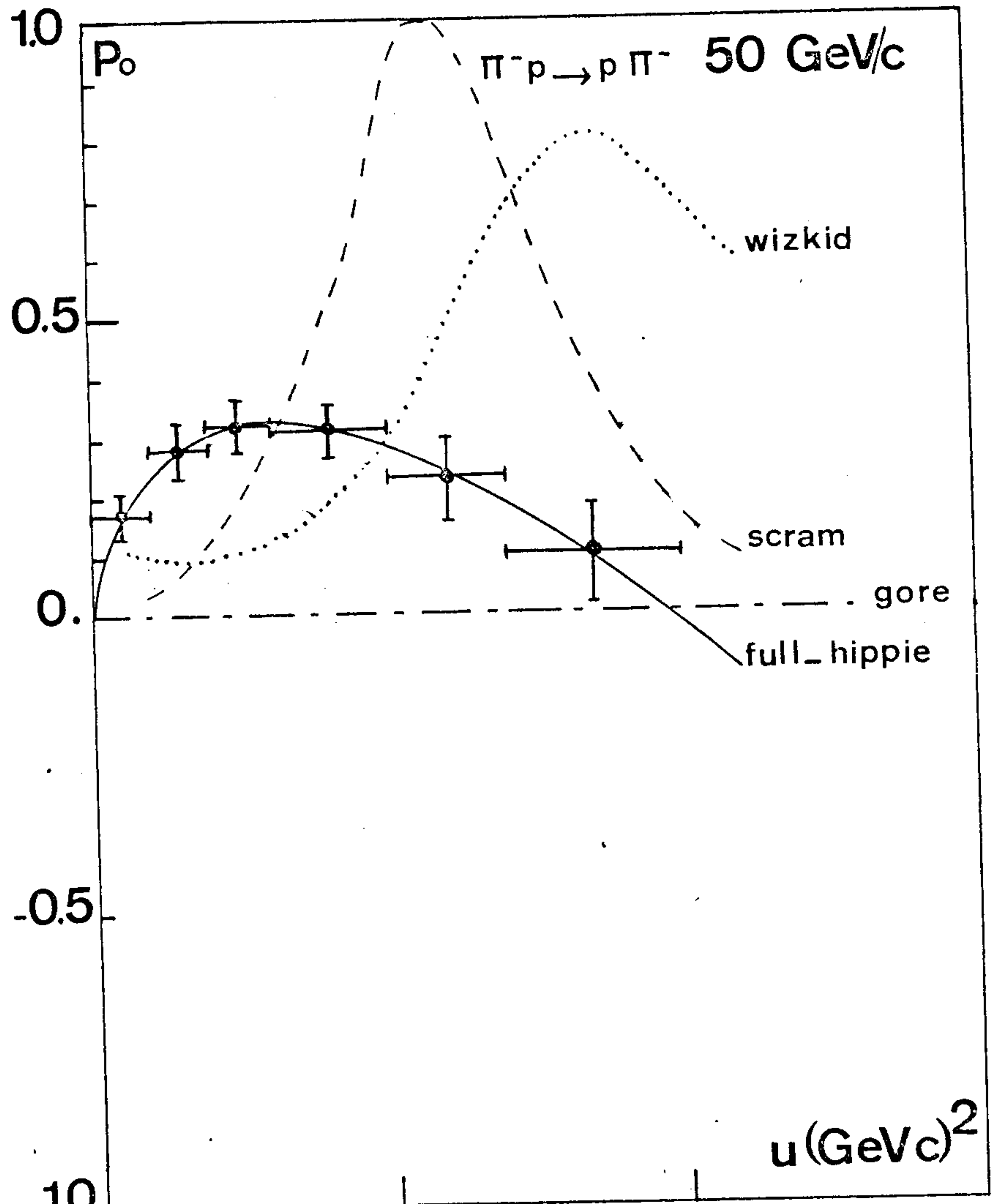

1.0
Po
π⁻p → p π⁻ 50 GeV/c
wizkid
0.5
scram
gore
0.
full_hippie
-0.5
u (GeV c)²

# Shims Goliath

$B_0 \simeq 18$ KGauss