# THE UA4/2 $\rho^{\bar{p}p}$ SEMI-THEORETICAL PARAMETER AND THE MAXIMAL ODDERON

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ABSTRACT

We study the dependence of the value of the semi-theoretical parameter ρ given by the UA4/2 Collaboration on different nuclear theoretical models. The value of ρ is shown to be extremely dependent on the models. The Maximal Odderon model is compatible with the UA4/2 dN/dt data.

In 1993 the UA4/2 Collaboration published the result of its "measurement" of the parameter $\rho$[1] (the ratio of the real to the imaginary part of the nuclear $\bar{p}p$ amplitude at $t = 0$). This result is obtained in two steps :

1) the measurement of the true (raw) experimental data, the t-distribution of elastic scattering dN/dt, over the interval $0.00075 \leq |t| \leq 0.12$ GeV$^2$. The elastic differential cross-section is defined such that $d\sigma/dt = (1/L)\cdot dN/dt$ where L is the normalization factor.

2) the extraction of $\rho$ from the experimental distribution dN/dt using a *theoretical* model (the exponential form of the nuclear scattering amplitude) :

$$F(s,t) = (\sigma_T / 4\pi)\,(i + \rho)\, e^{bt/2} \; , \qquad (1)$$

where $\sigma_T$ is the total cross-section and b is the slope of the diffraction peak ($\rho$ and b are taken as constant).

The determination of $\rho$ is obviously model dependent and therefore $\rho$ is a semi-theoretical parameter.

While extracting $\rho$ we have to be cautious not to take too simple a model with not enough freedom, which could spoil[2] the determination of $\rho$. We have to check the dependence of the result on different models, pay attention to the normalisation which is, in principle, linked to all the other data at all energies and more generally verify the compatibility of the result with the previous overall set of data at different energies.

We will illustrate all these problems with the UA4/2 measurement.

The UA4/2 model[1] depends on 4 parameters : $\rho$, b, $\sigma_T$ and L. But in practice the UA4/2 Collaboration reduced the number of parameters to 3 by adding one more constraint

$$(1 + \rho^2)\sigma_T = 63.3 \text{ mb} \; , \qquad (2)$$

i.e. the central value of $(1 + \rho^2)\sigma_T$ from an older UA4 luminosity independent measurement[3]

$$(1 + \rho^2)\sigma_T = 63.3 \pm 1.5 \text{ mb} .^* \qquad (3)$$

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* After the publication of the $\rho$ value, the UA4/2 Collaboration published a luminosity dependent measurement of $\sigma_T$ using the present dN/dt distribution, $\sigma_T = 63.0 \pm 2.1$ mb.[4]

We first relax the constraint (2) by using (3). Then we generalize the UA4/2 form (1) just by allowing a t-dependence of b and/or ρ. Namely we take,

$$F(s,t) = (\sigma_T /4\pi)\, [i + \rho(t)]\, e^{b(t)t} \tag{4}$$

with $$b(t) = b_0 + b_1 t + b_2 t^2 \quad \text{and} \quad \rho(t) = \rho + dt\,, \tag{5}$$

still keeping the condition (3). The results are summarized in Table 1.

Table 1
Parameters of the different models and related quantities

| Model | PARAMETERS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $(1+\rho^2)\sigma_T$ mb | $b_0$ $GeV^{-2}$ | $b_1$ $GeV^{-4}$ | $b_2$ $GeV^{-6}$ | $\rho$ | d $GeV^{-2}$ | 1/L mb | $\chi^2$; /pt | $\chi^2{}_{;8}$ /pt | $\sigma_T$ mb |
| 1 | 63.3 | 15.56 | 0 | 0 | 0.132 | 0 | 0.092 | 1.103 | 1.63 | 62.2 |
| 2 | 64.8 | 15.49 | 0 | 0 | 0.153 | 0 | 0.096 | 1.077 | 1.26 | 63.3 |
| 3 | 64.8 | 15.06 | - 4.13 | 0 | 0.165 | 0 | 0.0967 | 1.029 | 1.29 | 63.07 |
| 4 | 64.8 | 14.88 | -16.58 | -74.82 | 0.175 | 0 | 0.0970 | 1.015 | 1.36 | 62.88 |
| 5 | 64.8 | 13.86 | -19.39 | -69.03 | 0.172 | 2.0 | 0.0967 | 1.019 | 1.39 | 62.94 |

$\chi^2{}_{;8}$/pt is the $\chi^2$/pt for the eight points with the lowest | t | - values, and the definition of the models 1-5 is obvious from Table 1.

Model 1 is just the UA4/2 model with $(1 + \rho^2)\sigma_T$ fixed at 63.3 mb. It leads to a low value $\rho = 0.132$, in agreement with the result of Ref. 1. As soon as we relax condition (2) (model 2), the value of $(1 + \rho^2)\sigma_T$ jumps up to 64.8 mb, the maximal value allowed by condition (3). At the same time the normalization parameter 1/L increases from 1/L = 0.092 up to 1/L = 0.096. This corresponds to the increase of $\sigma_T$ from $\sigma_T$ = 62.2 mb up to $\sigma_T \simeq$ 63.3 mb. We will come back to this normalization problem later. Finally the $\chi^2$/pt decreases from 1.1 in model 1 down to 1.08 in model 2. It is also interesting to note the decrease of the $\chi^2$/pt over the eight lowest - | t | points.

The models 3-5, which have a t-dependence of b and/or ρ, lead to the same properties as model 2. The parameter $(1 + \rho^2)\sigma_T$ is at its maximal value 64.8 mb, the factor L practically does not change and the $\chi^2$/pt are equivalently good. However the value of ρ changes considerably with the models. It can vary from $\rho = 0.165$ (model 3) up to as high a value as $\rho = 0.175$ (model 4). Obviously one could also consider more complex models, such as that of Ref. 5.

Our first comment on these results concerns the big variation of $\rho$. The $\rho$-value is strongly dependent on the model used and can reach as high values as $\rho = 0.175$ or even higher. These high values of $\rho$ ($\rho \gtrsim 0.155$) are striking. As they are obtained by using only an even-under-crossing amplitude $F_+$, they violate the analyticity in the s-channel : from dispersion relations with $F_+$ only, it is impossible to get $\rho \gtrsim 0.155$. Something else is needed : a non-vanishing odd-under-crossing amplitude $F_-$ at high energies.

The second question which arises is how to distinguish among the different models ? A way is to use a more general and complex model for F(s,t) which allows us to fit the distribution dN/dt together with all the previously existing data at different energies and t-values. This self-consistency of the experimental data themselves is a severe and fruitful theoretical constraint, in particular for correlating the normalization factors L at different energies.

We performed such a fit of the UA4/2 dN/dt data together with all the previous data using the Maximal Odderon (GLN) model[5], which includes a non-vanishing odd-under-crossing amplitude $F_-$ at high energies and is based on the assumption that the amplitudes increase as fast as allowed by general principles and asymptotic theorems. The UA4/2 distribution dN/dt matches very easily with all the other data. We get the following values of $\rho$ and $\sigma_T$ corresponding to $\chi^2/pt = 1.04$ and $1/L = 0.097$ :

$$\rho = 0.177 \qquad \text{and} \qquad \sigma_T = 63.1 \text{ mb}^* . \qquad (6)$$

So the Maximal Odderon model is compatible with the UA4/2 measurement, contrary to the statement of Ref. 1. This conclusion is in agreement with the analysis presented by other authors at this conference[6,7].

The results sketched in the present talk will be published soon[8].

## References


1) UA4/2 Collab., C. Augier et al., Phys. Lett. B316 (1993) 448 ; B315 (1993) 503.
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* As compared with the recent experimental result of Ref. 4, 63.0 ± 2.1 mb.