p($\bar{p}$)p ELASTIC SCATTERING AND COSMIC RAY DATA

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ABSTRACT

It is shown that the total cross section σ_T for pp elastic scattering at cosmic ray energies, as well as the total cross section σ_T, the slope parameter b(s,t) and the differential cross section $d\sigma/dt$ for small momentum transfer at ISR and collider energies for p($\bar{p}$)p elastic scattering can be simultaneously fitted by using a simple Regge pole model.

1. Introduction. The total cross sections for proton-proton and proton-antiproton scattering for $20<\sqrt{s}<2\times10^5$ GeV have been measured at ISR and SPS collider and derived from the cosmic ray data[1,2]. The data show that the total cross section keeps on rising throughout the measured range. The results of these measurements are shown in Figs.1 and 2. The slope parameter b(s,t) for $pp\to pp$ at $\sqrt{s}=53$ GeV has been measured by various authors[3] and the results are shown in Fig.3. Accurate measurements of b(s,t) at collider energy $\sqrt{s}=546$ GeV were made by using luminosity independent technique[3] and are shown in Fig.4. It may be noted that the value of 15.3±0.3 $(GeV/c)^{-2}$ of slope parameter for $0.03<-t<0.1$ $(GeV/c)^2$ as measured by this group differs significantly from the earlier measurement of the slope parameter at $\sqrt{s}=540$ GeV which gives a value of 17.2±1.0 $(GeV/c)^{-2}$ in the range $0.05<-t<0.19$ $(GeV/c)^2$[4].

Simultaneous measurements of differential cross sections for $\bar{p}p$ and pp elastic scatterings at $\sqrt{s}=31$, 53 and 62 GeV in the interval $0.05<-t<0.85$ $(GeV/c)^2$ have been made by Breakstone et al[5] at the CERN ISR. At 53 and 62 GeV, for $0.17<-t<0.85$ $(GeV/c)^2$ both pp and $\bar{p}p$ data show simple exponential fall. At $\sqrt{s}=31$ GeV, the data in the interval $0.05<-t<0.85$ $(GeV/c)^2$ are consistent with a change in slope near $-t=0.15$ $(GeV/c)^2$. Results of these ISR measurements are plotted in Fig.5. Very recently, UA4 collaboration[6] has measured the differential cross section of proton-antiproton elastic scattering at $\sqrt{s}=546$ GeV. The $d\sigma/dt$ distribution shows a steep exponential decrease, with a change of slope around the same value of -t as at ISR energies. The data for this reaction for $-t<0.8$ $(GeV/c)^2$ are shown in Fig.6.

2. Calculations and Discussion. Following Refs.7 8, we find that for both the reactions a very good fit with the total cross section, the slope parameter and the differential cross section for small momentum transfers is obtained by choosing

the residue function as a sum of two exponentials. Thus the scattering amplitude may be written as

$$T(s,t)=\beta(t)\,\xi(t)\,s^{\alpha(t)} = (Ae^{Bt}+Ce^{Dt})\,\xi(t)\,s^{\alpha(t)}$$

The differential cross section is then given by

$$d\sigma/dt = \frac{1}{s^2}|T|^2 = (Ae^{Bt}+Ce^{Dt})^2\, s^{2\alpha(t)-2}$$

The expression for the slope parameter b(s,t) can be obtained by using the formula

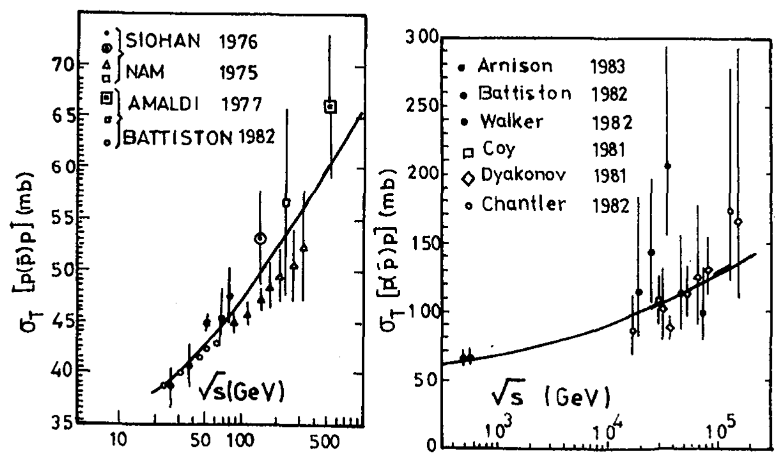
$$b(s,t)= d/dt\,(\ln d\sigma/dt)$$

It is found that a good fit with the experimental data, including the most recent results, is obtained by the following choice of residue function β(t):

$$\beta(t)= 4.35e^{2.72t} + 1.45e^{10.93t}$$

The equation of the Pomeron has been chosen as [9,10]

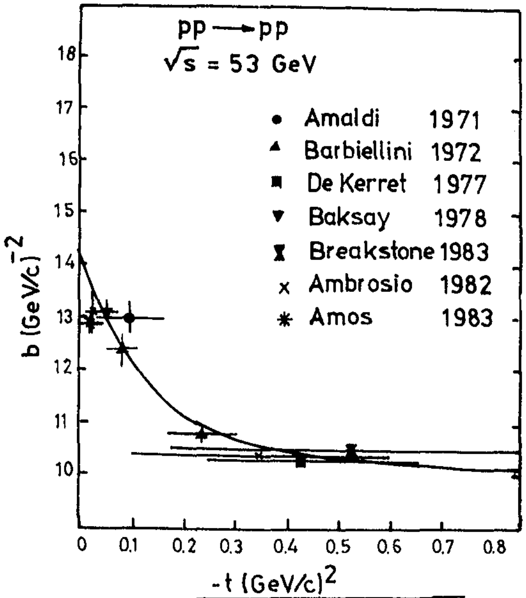
$$\beta(t)= 1.069+0.3t$$

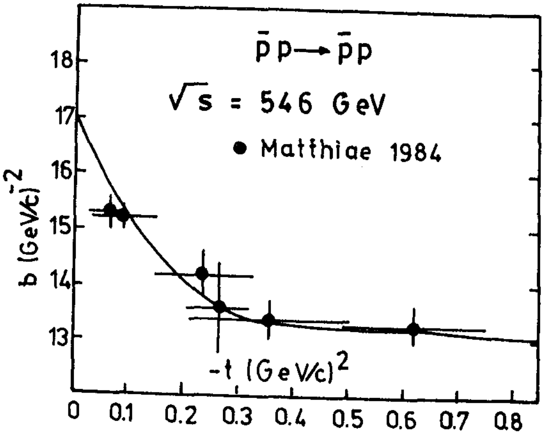


Figs.1 and 2. The total cross sections for $20<\sqrt{s}<2\times10^5$ GeV. Theoretical curves are the predictions of the model described in the text.

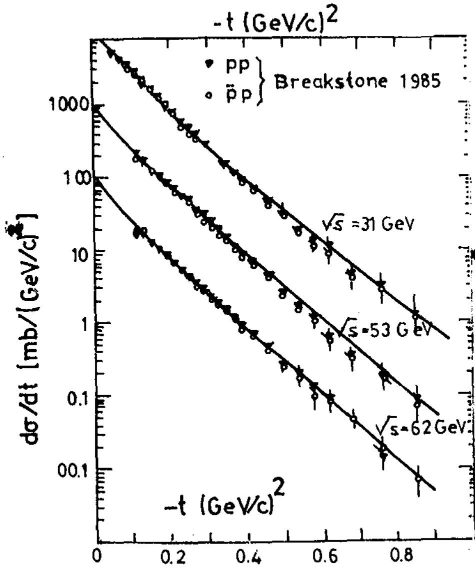
Figs.1 and 2 show the total cross sections for $20<\sqrt{s}<2\times10^5$ GeV. Theoretical curves are the predictions of simple Regge pole model. Figs.3 and 4 show the results of the slope parameter for $p(\bar{p})p$ elastic scattering at $\sqrt{s}$= 53 and 540 GeV respectively. The curves represent predictions of the model described in the text. In Figs.5 and 6 the measured differential cross sections for pp and $\bar{p}p$ elastic scatterings at ISR and collider energies have been plotted together with the predictions of the model described in the text.

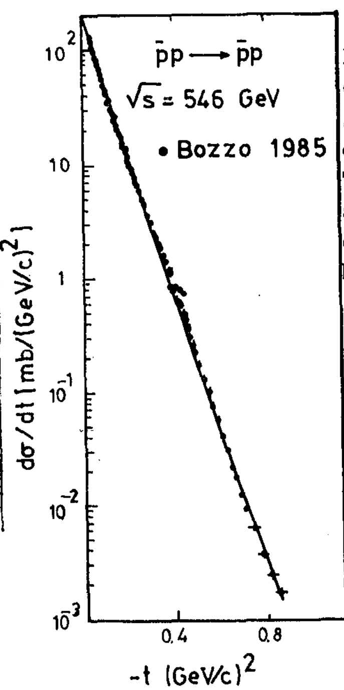
The CERN SPS proton-antiproton collider, after modifications which have enhanced the peak energy it can achieve, is back in action again. This time the collider is providing 630 GeV collision energy compared to the 546 GeV in previous runs. The results are expected to be available shortly. We predict the slope parameter at $\sqrt{s}$=630 GeV for $-t<1$ $(GeV/c)^2$. The curve in Fig.7 shows the predicted values.





Figs.3 and 4. The slope parameter at $\sqrt{s}$=53 and 540 GeV. Theoretical curves are the predictions of the model described in the text.





Figs.5 and 6. The differential cross sections at ISR and collider energies. Theoretical curves are the predictions of the model described in the text.

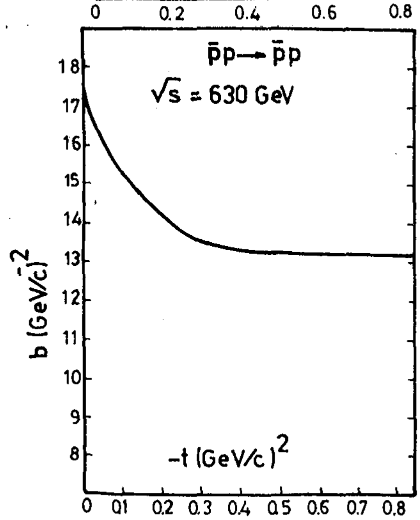


Fig.7. Predictions of the model described in the text for the slope parameter at $\sqrt{s}$=630 GeV.

3. Conclusions. We conclude that at high energies where pomeron is believed to dominate the behaviour of elastic scattering, a simple Regge pole model can be used to explain the total cross section for proton-proton elastic scattering at cosmic ray energies together with the total cross section, the slope parameter and the differential cross section for small momentum transfers at ISR and collider energies for $p(\bar{p})p$ elastic scattering.

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References.

1. G.B.yodh et al., Phys.Rev.(1983) 27D, 1183 (Also see references quoted therein).
2. J.Linsley, UNML-5/4/84-2 (Also see references quoted therein).
3. G.Matthiae, CERN/EP 84-119, 11 September 1984 (Also see references quoted therein).
4. R.Battiston et al., Phys.Lett.(1982) 115B, 333; Phys.Lett. (1982) 117B, 126.
5. A.Breakstone et al., Nucl.Phys.(1984) 248B, 253.
6. M.Bozzo et al., CERN/EP 85-31, 7 March 1985.
7. M.Saleem and Fazal-e-Aleem, Pramana (1985) 24, 429.
8. Fazal-e-Aleem, Hadronic J. (In press).
9. P.D.B.Collins et al., Phys.Lett.(1973) 43B, 171; Nucl. Phys.(1974) B80, 135.
10. S.Y.Chu et al., Phys.Rev.(1975) 13D, 2985.