# Regge description of high energy pion pion total cross sections

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**Abstract**

We have recently presented a Regge description of $\pi\pi$ total cross sections valid above 1.4 GeV, consistent with the few existing experiments, factorization and crossing symmetry. In this note we show how it also describes a further large data sample obtained from an analysis of experiments on $\pi^{\pm}p \to X\Delta^{++}$ and $\pi^{\pm}n \to Xp$.

## 1 Regge description of $\pi\pi$ total cross sections

In references [1, 2], we have shown how it was possible to obtain a precise Regge description of high energy total $\pi\pi$ scattering down to $E_{kin} \simeq 1.1$ GeV. Apart from the interest in itself, there has been a renewed interest in this high energy region because the imaginary part of the $\pi\pi \to \pi\pi$ amplitude is needed for dispersive studies aiming at a precise description of $\pi\pi$ data at low energies [3, 4, 1].

A relevant property of our description is that it respects *factorization*. This means that, for instance, the imaginary part of an amplitude $F_{A+B\to A+B}$ is:

$$\mathrm{Im}\, F_{A+B\to A+B}(s,t) \simeq f_A(t) f_B(t) (s/\hat{s})^{\alpha_R(t)}, \quad \hat{s} = (1\,\mathrm{GeV})^2. \tag{1}$$

The $(s/\hat{s})^{\alpha_R(t)}$ behavior comes from the so-called Regge pole $R$. All poles have $\alpha_R < 1$ and thus vanish for large $s$, except the Pomeron that scales like $s$ up to around 15 or 20 MeV, where it dominates all other pole contributions, giving a common prediction $\sigma^\infty$ for all $\pi\pi$ channels. For larger energies it increases logarithmically. As a matter of fact there could be many Regge poles exchanged in each channel, all them with their corresponding $f_i(t)$ factors depending on $R$ and the particles in the initial state. Using factorization, it is thus possible to obtain the $\pi\pi$ Regge amplitudes from those of $\pi N$ and $NN$. Total cross sections are then related to forward scattering amplitudes by: $\sigma_{AB} = 4\pi^2 \mathrm{Im}\, F_{A+B\to A+B}(s,0)/\lambda^{1/2}(s, m_A^2, m_B^2)$, with $\lambda(a,b,c) = a^2 + b^2 + c^2 - 2ab - 2ac - 2bc$. Thus we [2] fitted the large $\pi^\pm N$ and $NN$ data compilation of the COMPASS group as given in the Particle Data Tables [5], and the few $\pi\pi$ data [6] points known to us down to $E_{kin} \simeq 1.1$ imposing factorization. The fit parameters are largely dominated by the $\pi^\pm N$ and $NN$ experiments, but still we obtained a very precise description for $\pi\pi$ total cross sections, that was in remarkable agreement with the $\sigma_{tot}^{\pi\pi}$ data above 2 GeV. At lower energies these data are in conflict with the $\sigma_{tot}^{\pi\pi}$ reconstructed [2] from lower energy phase shifts analysis and our results fall somewhere in-between. We refer to our paper [2] for further details.

In addition, we have also checked that our high energy results together with fits [1] to the low energy satisfy two crossing symmetry sum rules. This is again of relevance because in the seventies [7] there was a suggestion that the predictions of factorization $\sigma^\infty \simeq 13\,$mb, together with the existing phase shifts analysis at that time, violated crossing symmetry, suggesting $\sigma^\infty = 6 \pm 5\,$mb. Of course this was tenable until the first high energy $\sigma_{tot}^{\pi\pi}$ were measured, and indeed the very same authors [7] pointed out somewhat later that the central value should be raised to $\sigma^\infty = 8.3\,$mb. The recent studies in [3, 4] used $\sigma^\infty = 5 \pm 3\,$mb, following [3]. Unfortunately, the $\sigma_{tot}^{\pi\pi}$ data went largely unnoticed to our days, including to ourselves, so that in [1] the use of factorization was only based on QCD considerations. In [2] we "rediscovered" four different experimental works [6] that we used in a reanalysis to find $\sigma_{tot}(20\mathrm{GeV}) = 13.4 \pm 0.6\,$mb, while simultaneously respecting crossing.

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## 2 Comparison with further data

Following the discussions of my talk on this MESON2004 conference I came to know that there was another analysis [8] of $\pi\pi$ total cross sections. In that work, a triple reggeon model is used to analyze several sets of experimental data on $pp \to X\Delta^{++}$ and $pn(p) \to Xp(n)$, and obtain Regge parameters with whom to extract total $\pi^\pm\pi^-$ cross sections from $\pi^\pm p \to X\Delta^{++}$ and $\pi^\pm n \to Xp$. The most relevant contribution of this paper is the inclusion of absorptive corrections in the last two reactions, which seems to decrease the results by about 10 to 15%. In Fig.1, we show how our Regge description, and in particular, our value $\sigma_{tot}(20\text{GeV}) = 13.4 \pm 0.6\,\text{mb}$ indeed provides a good description of this data, which strongly disfavors a value more than two times smaller. Following the authors we display only the statistical errors. Systematic errors were estimated at the $7-10\%$ level.


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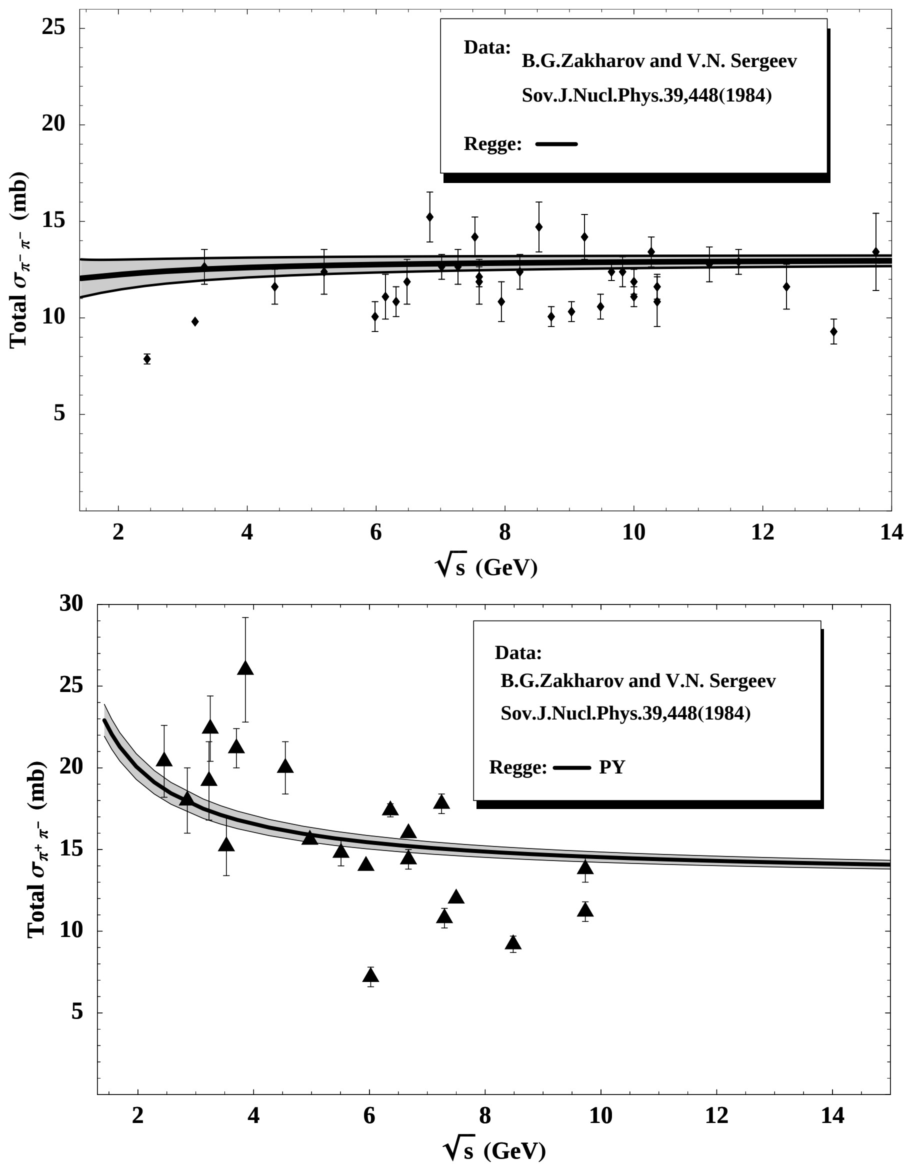


Figure 1: The continuous line stands for our Regge representation and the gray band for the associated uncertainty. Data are from [8] and the error bars are just statistical, however, the authors pointed out a "possible systematic error of $\simeq 7-10\%$".