Table 39.2: Total hadronic cross section. Analytic S-matrix and Regge theory suggest a variety of parameterizations of total cross sections at high energies with different areas of applicability and fits quality.

A ranking procedure, based on measures of different aspects of the quality of the fits to the current evaluated experimental database, allows one to single out the following parameterization of highest rank[1]

$$\sigma^{ab} = Z^{ab} + B\log^2(s/s_0) + Y_1^{ab}(s/s_1)^{-\eta_1} - Y_2^{ab}(s/s_1)^{-\eta_2}\ , \qquad \sigma^{\overline{a}b} = Z^{ab} + B\log^2(s/s_0) + Y_1^{ab}(s/s_1)^{-\eta_1} + Y_2^{ab}(s/s_1)^{-\eta_2}$$

where Z^{ab}, B, Y_i^{ab} are in mb, s, s_1, and s_0 are in GeV^2. The scales s_0, s_1, the rate of universal rise of the cross sections B, and exponents η_1 and η_2 are independent of the colliding particles. The scale s_1 is fixed at 1 GeV^2. Terms $Z^{ab} + B\log^2(s/s_0)$ represent the pomerons. The exponents η_1 and η_2 represent lower-lying C-even and C-odd exchanges, respectively. Requiring $\eta_1 = \eta_2$ results in somewhat poorer fits. In addition to total cross sections, the measured ratios of the real-to-imaginary parts of the forward-scattering amplitudes were included in the fits by using s to u crossing symmetry and differential dispersion relations. Global fits were made to the 2001-updated data for $(\overline{p})pp$, $\Sigma^-p, \pi^\pm p, K^\pm p, \gamma p$, and $\gamma\gamma$. Exact factorization hypothesis was used to extend the universal rise of the total hadronic cross sections to the $\gamma p \to hadrons$ and $\gamma\gamma \to hadrons$ collisions. The price of this universality is one extra "asymptotic" parameter $\delta = \sigma^{\gamma p}/\sigma^{pp}$ for $s \gg s_0$. The asymptotic parameters thus obtained were then fixed and used as inputs to a fit to a larger data sample that included cross sections on deuterons (d) and neutrons (n). All fits were produced to data above $\sqrt{s_{\rm min}} = 5$ GeV.

Fits to $\overline{p}(p)\,p$, Σ^-p, $\pi^\pm p$, $K^\pm p$, γp, $\gamma\gamma$			Beam/	Fits to groups				χ^2/dof
Z	Y_1	Y_2	Target	Z	Y_1	Y_2	B	by groups
35.49(47)	42.65(1.35)	33.36(1.04)	$\overline{p}(p)/p$	35.49(47)	42.65(23)	33.36(33)	0.307(10)	
			$\overline{p}(p)n$	35.83(16)	40.27(1.6)	30.01(96)	0.307(10)	1.03
35.22(1.45)	−206(106)	−271(129)	Σ^-/p	35.22(1.40)	−206(88)	−271(114)	0.307(10)	0.56
20.88(40)	19.25(1.22)	6.03(19)	$\pi^\pm/p$	20.88(3)	19.25(18)	6.03(9)	0.307(10)	0.96
17.93(36)	7.1(1.5)	13.46(40)	$K^\pm/p$	17.93(3)	7.10(25)	13.46(12)	0.307(10)	
			$K^\pm/n$	17.88(6)	5.12(50)	7.24(28)	0.307(10)	0.67
0.1075(16)	0.0410(81)		γ/p	0.1075(9)	0.0410(64)		0.307(10)	
2.83(18)E−4	0.32(13)E−3		γ/γ	2.83(17)E−4	0.32(14)E−3		0.307(10)	0.67
$\chi^2/dof = 0.968$,	$b = 0.307(10)$ mb,		$\overline{p}(p)/d$	64.45(38)	130(3)	85.6(1.3)	0.534(31)	1.43
$\eta_1 = 0.460(17)$,	$\eta_2 = 0.545(7)$		$\pi^\pm/d$	38.66(21)	59.82(1.54)	1.60(41)	0.460(14)	0.73
$\delta = 0.0039(3)$,	$\sqrt{s_0} = 5.38(50)$ GeV		$K^\pm/d$	33.43(20)	23.72(1.45)	28.72(37)	0.449(15)	0.81

The fitted functions are shown in the following figures, along with one-standard-deviation error bands. When the reduced χ^2 is greater than one, a scale factor has been included to evaluate the parameter values, and to draw the error bands. Where appropriate, statistical and systematic errors were combined quadratically in constructing weights for all fits. On the plots, only statistical error bars are shown. Vertical arrows indicate lower limits on the $p_{\rm lab}$ or $E_{\rm cm}$ range used in the fits.

One can find the details of the global fits (all data on proton target and $\gamma\gamma$ fitted simultaneously) and ranking procedure as well as the exact parameterizations of the total cross sections and corresponding ratios of the real to imaginary parts of the forward-scattering amplitudes in the recent paper of COMPETE Collab[1]. The database used in the fits now includes the recent OPAL[2] and L3[3] (LEP) $\gamma\gamma$ data, new highest-energy data for π^-p and Σ^-p from SELEX (FNAL)[4] experiment, and cosmic-ray data from the Fly's Eye[5] and AKENO (Agasa)[6] experiments.

The parameterization of the previous edition can still produce acceptable fits to updated total cross sections database, but only for $\sqrt{s} > 10$ GeV.

The numerical experimental data were extracted from the PPDS accessible at `http://wwwppds.ihep.su:8001/ppds.html`

Computer-readable data files are also available at `http://pdg.lbl.gov`. (Courtesy of V.V.Ezhela, Yu.V.Kuyanov, S.B.Lugovsky, E.A.Razuvaev, N.P.Tkachenko, COMPAS group, IHEP, Protvino, Russia, August 2001.)

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