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Cross Sections for Reaction $\gamma p \to p\pi^+\pi^-$ Between 0.3 and 5.8 GeV

Data of the
Aachen-Berlin-Bonn-Hamburg-Heidelberg-München Collaboration

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Abstract

We give total cross sections for the reaction $\gamma p \to p\pi^+\pi^-$ as measured by the Aachen-Berlin-Bonn-Hamburg-Heidelberg-München Collaboration. The cross sections are renormalized (by $\leq 1.4\%$) using a new calculation of the pair production cross section in hydrogen. The errors of the cross section determination are discussed. The cross sections are known to 3-4% below 2 GeV and to 5-8% between 2 and 5 GeV.

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Among all photoproduction reactions accessible to a hydrogen bubble chamber experiment the reaction $\gamma p \rightarrow p\pi^+\pi^-$ can be measured with the highest accuracy. The reaction is therefore best suited for comparison of different experiments. The measurement of $\sigma(\gamma p \rightarrow p\pi^+\pi^-)$ by the Aachen-Berlin-Bonn-Hamburg-Heidelberg-München Collaboration has been published in Figure 4 of Ref. 1. It is the purpose of this note to give more detailed information on this measurement.

The cross sections were obtained by relating the number of events to the number of e^+e^- pairs observed using the known cross section for pair production(for details of the experimental procedure see Refs. 1 and 2). The pair production cross section derived and used in Refs. 1 and 2 is accurate to about $\pm$ 1%. The resulting cross sections for $\gamma p \rightarrow p\pi^+\pi^-$ are listed in column I of the table. Recently T.M. Knasel[3] has calculated more accurate values of the pair cross section which differ from the cross sections used in Ref. 1 by up to 1.4% and are accurate to $\pm$ 0.5%. The pair cross sections of Ref. 1 and the new values by Knasel are given in columns II and III of the table. The values of col. II and III were used to renormalize $\sigma(\gamma p \rightarrow p\pi^+\pi^-)$ of col. I. Results are in col. IV and V for two different sets of E_γ bins.

The errors of the published cross sections (col. I) are statistical only. The main source of systematical errors is the flux normalization i.e. the uncertainty of the pair counting and of the photon energy spectrum shape . This uncertainty is estimated to be 2%, 3%, 5% and 10% for the E_γ intervals < 2.5 GeV, 2.5-3.5 GeV, 3.5-5.0 GeV and 5.0-5.8 GeV respectively.

Other systematic errors (event identification($\leq$ 1%), uncertainties of the scanning correction(1-2.5% between 2.5 and 5.8 GeV)) are small compared to the normalization uncertainty and can be neglected. The errors given in cols. IV and V were calculated by adding quadratically the statistical errors and the normalization uncertainty. Total errors are 3-4% below 2 GeV and 5-8% between 2 and 5 GeV.

The cross sections given in cols. IV and V should be used for further reference and comparison with other experiments.

References

1. Aachen-Berlin-Bonn-Hamburg-Heidelberg-München Collaboration, Phys. Rev. 175, 1669 (1968)
2. H. Spitzer, Internal Report DESY F 1/4 (1967) (unpublished).
3. T.M. Knasel, DESY Report 70/3 (1970) (unpublished).

Summary of cross section calculation as described in the text. Cols. IV and V give the renormalized cross sections for $\gamma p \rightarrow p\pi^+\pi^-$ which should be used for further reference.

	number of events		I	II	III	IV	V
E_γ (GeV)	found	scanning loss correction	σ (μb) Ref. 1	σ_{pair} (mb) Ref.1,2	σ_{pair} (mb) Ref.3	σ (μb)	σ (μb)
0.35 - 0.40	6	-	0.22 ± 0.09	16.2	16.1	0.22 ± 0.09	
0.40 - 0.45	97	-	4.13 ± 0.42	16.50	16.44	4.11 ± 0.42	
0.45 - 0.50	319	-	15.2 ± 0.86	16.76	16.72	15.2 ± 0.9	
0.50 - 0.55	670	-	36.0 ± 1.4	16.99	16.96	35.9 ± 1.6	
0.55 - 0.60	945	-	55.9 ± 1.8	17.18	17.18	55.9 ± 2.1	
0.60 - 0.65	1111	-	72.0 ± 2.2	17.35	17.37	72.1 ± 2.6	
0.65 - 0.70	1074	-	76.1 ± 2.4	17.50	17.54	76.3 ± 2.8	} 74.2 ± 2.2
0.70 - 0.75	933	-	71.5 ± 2.4	17.64	17.69	71.7 ± 2.7	
0.75 - 0.80	852	-	70.5 ± 2.4	17.76	17.82	70.7 ± 2.8	} 71.2 ± 2.2
0.80 - 0.85	845	-	74.8 ± 2.6	17.87	17.94	75.1 ± 3.0	
0.85 - 0.90	812	-	76.8 ± 2.7	17.97	18.05	77.1 ± 3.1	} 76.1 ± 2.4
0.90 - 0.95	722	-	73.3 ± 2.8	18.07	18.15	73.6 ± 3.1	
0.95 - 1.00	682	-	73.4 ± 2.8	18.16	18.25	73.8 ± 3.2	} 73.7 ± 2.5
1.00 - 1.05	582	-	66.4 ± 2.7	18.24	18.34	66.8 ± 3.1	
1.05 - 1.10	571	-	69.1 ± 2.9	18.30	18.42	69.6 ± 3.2	} 68.2 ± 2.4
1.10 - 1.15	502	-	64.2 ± 2.8	18.36	18.49	64.7 ± 3.2	
1.15 - 1.20	427	-	57.6 ± 2.8	18.42	18.55	58.0 ± 3.0	} 61.5 ± 2.4
1.20 - 1.25	392	-	55.5 ± 2.8	18.48	18.61	55.9 ± 3.0	
1.25 - 1.30	358	-	53.3 ± 2.8	18.53	18.67	53.7 ± 3.0	} 54.8 ± 2.3
1.30 - 1.35	358	-	55.8 ± 3.0	18.59	18.73	56.2 ± 3.2	
1.35 - 1.40	345	-	56.6 ± 3.1	18.64	18.79	57.1 ± 3.3	} 56.6 ± 2.4
1.40 - 1.45	307	-	52.3 ± 3.1	18.70	18.84	52.7 ± 3.2	
1.45 - 1.50	298	-	53.0 ± 3.1	18.75	18.89	53.4 ± 3.3	} 53.1 ± 2.5
1.50 - 1.55	276	-	51.3 ± 3.2	18.79	18.93	51.7 ± 3.3	
1.55 - 1.60	266	-	51.5 ± 3.1	18.83	18.97	51.9 ± 3.3	} 51.8 ± 2.4
1.6 - 1.7	454	-	46.6 ± 2.2	18.88	19.05	47.0 ± 2.4	
1.7 - 1.8	415	-	46.1 ± 2.3	18.94	19.11	46.5 ± 2.5	} 46.8 ± 1.8
1.8 - 1.9	357	-	42.6 ± 2.3	19.01	19.17	43.0 ± 2.4	
1.9 - 2.0	301	-	38.4 ± 2.2	19.06	19.23	38.7 ± 2.4	} 40.8 ± 1.8
2.0 - 2.1	273	-	37.3 ± 2.3	19.10	19.28	37.7 ± 2.4	
2.1 - 2.2	272	-	39.4 ± 2.4	19.15	19.32	39.7 ± 2.6	} 38.7 ± 1.8
2.2 - 2.3	209	-	32.0 ± 2.2	19.19	19.37	32.3 ± 2.3	
2.3 - 2.4	190	-	31.0 ± 2.3	19.23	19.41	31.3 ± 2.4	} 31.8 ± 1.7
2.4 - 2.5	198	1.2	34.0 ± 2.4	19.26	19.45	34.3 ± 2.5	
2.5 - 2.6	164	2.2	30.2 ± 2.4	19.29	19.49	30.5 ± 2.6	} 32.4 ± 1.8
2.6 - 2.8	310	7.1	30.9 ± 1.8	19.34	19.55	31.2 ± 2.0	
2.8 - 3.0	252	8.3	28.0 ± 1.8	19.40	19.61	28.3 ± 2.0	
3.0 - 3.25	260	13.8	25.8 ± 1.6	19.45	19.68	26.1 ± 1.8	
3.25 - 3.50	221	15.3	24.7 ± 1.7	19.50	19.74	25.0 ± 1.8	
3.50 - 3.75	185	15.5	23.3 ± 1.7	19.54	19.80	23.6 ± 2.1	
3.75 - 4.00	179	17.4	24.8 ± 1.9	19.58	19.85	25.1 ± 2.3	
4.0 - 4.5	263	35.0	21.3 ± 1.3	19.63	19.91	21.6 ± 1.7	
4.5 - 5.0	238	30.3	22.2 ± 1.4	19.69	19.97	22.5 ± 1.8	
5.0 - 5.8	247	33.4	21.0 ± 1.4	19.75	20.04	21.3 ± 2.5	