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A DIRECT COMPATIBILITY CHECK OF THE CEA AND CORNELL ELECTROPRODUCTION PION FORM FACTOR DATA WITH e^+e^- ONES

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1. INTRODUCTION

The electromagnetic pion form factor (ff) $F_\pi(t)$ is in principle measurable for all values of four-momentum transfer squared $t = -Q^2$. In the time-like region, numerous electron-positron annihilation experiments have accumulated a large amount of accurate data. The cross section is in this case directly proportional to $|F_\pi|^2$ much like for the elastic pion scattering on atomic electrons — a reaction which gave the precise information on pion ff in the space-like region up to -0.253 GeV^2. On the other hand, the only process which can yield the pion ff data in the deeper space-like region is the electroproduction of pions from nucleons

$$\begin{aligned} e^- p &\to e^- \pi^+ n \\ e^- n &\to e^- \pi^- p . \end{aligned} \tag{1}$$

These reactions have been measured in a series of experiments at the Cambridge Electron Accelerator (CEA)[1] and at the Cornell University Synchrotron[2,3,4]. Though the measurements have been performed more than ten years ago, they remain up to now to be the only source of valuable experimental information on the $F_\pi(Q^2)$ behaviour in the region $0.29\ GeV^2 \le Q^2 \le 9.77\ GeV^2$. However, the presence of a nucleon and its structure complicates the analysis of measured cross sections. None of the used theoretical models is sufficiently refined to give total confidence in the determined 22 values of $F_\pi(Q^2)$ which become model-dependent.

More precisely, the reactions (1) were analysed[4] in terms of the virtual photoproduction

$$\gamma^* p \longrightarrow \pi^+ n , \quad \gamma^* n \longrightarrow \pi^- p , \tag{2}$$

the differential cross section of which has the general form

$$\frac{d\sigma}{d\Omega} = A + \epsilon C + \epsilon (\cos 2\phi) B + \left[\frac{\epsilon(\epsilon + 1)}{2}\right]^{1/2} (\cos\phi) D . \tag{3}$$

Terms A, B, C and D are functions of CMS variables W (total energy), θ (angle between photon and pion) and Q^2 (photon four-momentum squared). A and C represent the cross sections for transverse and longitudinal photons, respectively. The interference terms B and D vanish as $\theta \to 0$ while terms C and D vanish as $Q^2 \to 0$. The parameter ϵ describes the virtual photon polarization and ϕ is the azimuth.

In the final analysis [4] of the measured cross sections, where five new data points on $F_\pi(Q^2)$ were determined and all previous results were reanalyzed, the following procedure was applied:

i) The use of data with $\theta < 3^\circ$ to eliminate the interference terms B and D in (3).

ii) The assumption that the amplitude due to longitudinal photons is given by the t-channel one-pion-exchange Born term.

iii) The assumption that for $\theta \simeq 0$ the Q^2-dependence of the transverse cross section A is the same as that for the total virtual photoproduction cross section.

The purpose of the first assumption is evident. The second assumption is based on the results of theoretical models for the electroproduction cross section of pions emitted along the virtual-photon direction. However, the assumed dominance of t-channel pion-exchange term in the longitudinal cross section had not been confirmed by previous measurements [1] of the authors.

While the longitudinal amplitude is directly proportional to the pion ff, the transverse amplitude is the absolute prediction of the models and is subject to large theoretical uncertainties. The dispersion-theory model [5] used by the authors before the final analysis [4] predicts the θ-behaviour of the transverse cross section in conflict with the measured curves and the discrepancy grows with the enhancement of Q^2. The assumption (iii) is therefore an attempt to avoid this problem by using the previously discovered experimental fact of approximately equal Q^2-dependence of the forward transverse cross section and the total one at low Q^2. However, for values of Q^2 greater than 4 GeV^2 the transverse cross section was determined from extrapolation of the relatively low-precision measurements of only three (W, Q^2) points.

Taking into account the uncertainties connected with the assumptions (ii) and (iii), the authors conclude that the reliability of their data on $F_\pi(Q^2)$ above 4 GeV^2 decreases with the enhancement of Q^2.

In this paper, we propose a direct compatibility check of the electroproduction pion ff data [4] with the most reliable ones obtained from $e^+e^- \to \pi^+\pi^-$. We have not revealed increased unreliability of space-like $F_\pi(Q^2)$ data with the increased values of Q^2 and our result is that they are globally correct. However, some doubtful isolated data points (see partial χ^2 in Table II) are almost uniformly spread over the whole measured region of momenta 0.18 $GeV^2 \le Q^2 \le 9.77$ GeV^2.

II. THE RELIABILITY TEST OF THE ELECTROPRODUCTION DATA

The idea of the compatibility check consists in the transfer of the reliable experimental information on the pion ff obtained from the reaction $e^+e^- \to \pi^+\pi^-$ into the space-like region by means of the integral representation

$$F_\pi(Q^2) = \frac{1}{\pi}\int_{4m_\pi^2}^{t_{\pi^0\omega}} \frac{\mathrm{Im}\,{}^{E}F_\pi(t)\,dt}{t+Q^2} + \frac{1}{\pi}\int_{t_{\pi^0\omega}}^{\infty} \frac{\mathrm{Im}\,{}^{A}F_\pi(t)\,dt}{t+Q^2}\,. \qquad (4)$$

The next step is the comparison of the predicted values with the electroproduction pion ff data by calculating partial χ^2 at each point.

In order to evaluate the contribution of the first integral in (4) to $F_\pi(Q^2)$ for 0 $GeV^2 \le Q^2 \le 9.77$ GeV^2, we describe a method of extracting $\mathrm{Im}\,{}^{E}F_\pi(t)$ in the elastic region $4m_\pi^2 \le t \le (m_{\pi^0} + m_\omega)^2$ from the measured cross section of the reaction $e^+e^- \to \pi^+\pi^-$. The latter can be written as

$$\sigma(t) = \frac{\pi\alpha^2\beta_\pi^3}{3t}\left|F_\pi(t) + \xi e^{i\phi}\frac{m_\omega^2}{m_\omega^2 - t - i m_\omega\Gamma_\omega}\right|^2, \qquad (5)$$

where α is the fine structure constant, $\beta_\pi = (1 - \frac{4m_\pi^2}{t})^{1/2}$ is the velocity of an outgoing pion in CMS and m_ω, Γ_ω are the mass and total width of the ω-meson. The second term in (5) represents the contribution of the ω-meson to the two-pion final state. This effect is induced by the well-known $\rho-\omega$ mixing due to G-parity nonconserving interactions with the strength of electromagnetism [6,7,8]. The parameter ξ can be related to the ratio of the differences of light quark masses [8,9] or is equivalently given in terms of measured widths according to

$$\xi = \frac{6}{\alpha m_\omega}\left(\frac{m_\omega^2}{m_\omega^2 - 4m_\pi^2}\right)^{3/2}\left[\Gamma(\omega \to e^+e^-)\,\Gamma(\omega \to \pi^+\pi^-)\right]^{1/2}. \qquad (6)$$

The angle ϕ is the $\rho-\omega$ interference phase

$$\phi = \mathrm{arc\,tg}\,\frac{m_\rho\Gamma_\rho}{m_\rho^2 - m_\omega^2}\,. \qquad (7)$$

Making use of the elastic unitarity condition, which guarantees the identity between the pion ff phase and the P-wave isovector phase shift $\delta_1^1(t)$ in the region $4m_\pi^2 \le t \le t_{\pi^0\omega}$:

$$F_\pi(t) = |F_\pi(t)| \exp[i\delta_1^1(t)] , \qquad (8)$$

one can rewrite the relation (5) into the quadratic equation [10]

$$|F_\pi(t)|^2 + 2Z'(t)|F_\pi(t)| + \{\frac{\xi^2 m_\omega^4}{(m_\omega^2 - t)^2 + m_\omega^2\Gamma_\omega^2} - [\frac{3t}{\pi\alpha^2\beta_\pi^3}\sigma(t)]^2\} = 0 . \qquad (9)$$

Its physical solution is

$$|F_\pi(t)| = -Z(t) + \{Z^2(t) + [\frac{3t}{\pi\alpha^2\beta_\pi^3}\sigma(t)]^2 - \frac{\xi^2 m_\omega^4}{(m_\omega^2 - t)^2 + m_\omega^2\Gamma_\omega^2}\}^{1/2}, \qquad (10)$$

where

$$Z(t) = \frac{\xi^2 m_\omega^2}{(m_\omega^2 - t)^2 + m_\omega^2\Gamma_\omega^2}\{(m_\omega^2 - t)\cos(\phi - \delta_1^1(t)) - m_\omega\Gamma_\omega\sin(\phi - \delta_1^1(t))\} .$$

The data on $\mathrm{Im}\, F_\pi(t)$ (see Table I) for $4m_\pi^2 \le t \le t_{\pi^0\omega}$ are determined from (10) and (8) by utilizing the experimental information on ξ, ϕ, m_ω, Γ_ω, $\sigma(t)$ and suitable parametrization of $\delta_1^1(t)$ [11].

The values of the first integral in (4) for the momentum transfer squared $0\ \mathrm{GeV}^2 \le Q^2 \le 9.77\ \mathrm{GeV}^2$ were evaluated numerically by the trapezoidal rule using the program TRAPER from the CERN computer program library. For $Q^2 = 0$ we have

$$\frac{1}{\pi}\int_{4m_\pi^2}^{t_{\pi^0\omega}} \frac{\mathrm{Im}^E F_\pi(t)\, dt}{t} = 0.9302 , \qquad (11)$$

i.e. more than 90% contribution to $F_\pi(0) = 1$. In fact, not too much is known about the behaviour of $\mathrm{Im}\,^A F_\pi(t)$ under the second integral of (4). However, from the general QCD restriction obtained recently [12] for the second integral of (4) it follows that $\mathrm{Im}\,^A F_\pi(t)$ has at least one zero (generally odd number of zeros) and it vanishes from negative values as $t \to +\infty$. Really, the pion ff behaviour predicted by QCD to leading logarithmic accuracy is [13, 14, 15]

Table I

The data on $\mathrm{Im}\,^E F_\pi(t)$ for $4m_\pi^2 < t < t_{\pi^0\omega}$

t [GeV^2]	$\mathrm{Im}\,^E F_\pi(t)$	$\Delta \mathrm{Im}\,^E F_\pi(t)$	t [GeV^2]	$\mathrm{Im}\,^E F_\pi(t)$	$\Delta \mathrm{Im}\,^E F_\pi(t)$
0.0800	0.00010	0.00002	0.4390	1.81960	0.19750
0.0880	0.00200	0.00010	0.4591	2.26070	0.22240
0.0900	0.00250	0.00020	0.4728	2.73170	0.28710
0.1010	0.00720	0.00030	0.4866	3.13680	0.32500
0.1060	0.00930	0.00080	0.4900	3.29680	0.37980
0.1160	0.01680	0.00100	0.4900	3.19260	0.45740
0.1220	0.02020	0.00140	0.4970	3.38640	0.38850
0.1270	0.02280	0.00100	0.5007	3.56010	0.36780
0.1296	0.02760	0.00140	0.5149	4.10270	0.41660
0.1414	0.03970	0.00220	0.5294	4.73480	0.46620
0.1520	0.04540	0.00190	0.5441	5.36690	0.46290
0.1600	0.05640	0.00390	0.5476	5.96520	0.55340
0.1600	0.05190	0.00550	0.5589	5.88150	0.40910
0.1681	0.06960	0.00330	0.5628	5.57060	0.40100
0.1764	0.07280	0.00570	0.5740	6.19290	0.30150
0.1780	0.07530	0.00340	0.5746	5.87010	0.41000
0.1849	0.09060	0.00540	0.5776	6.10300	0.33170
0.1918	0.10570	0.00570	0.5892	6.34580	0.17320
0.1936	0.12780	0.01660	0.5929	6.35270	0.16350
0.2116	0.12400	0.01040	0.5951	6.00940	0.30640
0.2209	0.14800	0.00740	0.5978	6.31910	0.22940
0.2333	0.17590	0.01470	0.5985	6.35140	0.19710
0.2340	0.18580	0.01510	0.5991	6.26240	0.15600
0.2916	0.35270	0.02080	0.6016	6.31990	0.15790
0.3364	0.55370	0.03710	0.6047	6.19300	0.17810
0.3629	0.79860	0.06350	0.6048	6.20400	0.32320
0.3844	0.95650	0.07320	0.6053	6.48870	0.18710
0.4096	1.21380	0.10150	0.6056	6.29920	0.26460
0.4130	1.38320	0.13090	0.6078	6.04810	0.23640
0.4356	1.63220	0.15410	0.6084	6.41170	0.31310

Table I. Continuation

$t\,[\mathrm{GeV}^2]$	$\mathrm{Im}^E F_\pi(t)$	$\Delta \mathrm{Im}^E F_\pi(t)$	$t\,[\mathrm{GeV}^2]$	$\mathrm{Im}^E F_\pi(t)$	$\Delta \mathrm{Im}^E F_\pi(t)$
0.6109	6.07890	0.28110	0.6685	4.36630	0.35730
0.6115	5.64360	0.30310	0.6724	3.97440	0.36330
0.6134	5.78140	0.34550	0.6724	4.06450	0.41720
0.6140	5.88560	0.33060	0.6849	3.88250	0.35590
0.6147	6.14360	0.35820	0.6989	3.12540	0.38010
0.6172	5.76650	0.31860	0.7016	3.45360	0.33570
0.6178	5.64150	0.31950	0.7056	3.01480	0.32480
0.6203	5.85430	0.31130	0.7110	3.14640	0.34440
0.6213	5.77030	0.33660	0.7184	3.02890	0.31410
0.6235	5.67910	0.29130	0.7355	2.70360	0.28310
0.6241	5.83060	0.30030	0.7396	2.43940	0.28210
0.6246	5.32990	0.30240	0.7527	2.41730	0.25460
0.6266	5.78470	0.30310	0.7702	2.13430	0.22410
0.6292	5.20240	0.32080	0.7744	2.00690	0.23910
0.6304	5.53690	0.30380	0.7878	1.89400	0.20150
0.6347	5.01460	0.42520	0.7978	1.83150	0.20900
0.6362	5.33760	0.29700	0.8057	1.69530	0.17670
0.6400	5.19000	0.37300	0.8100	1.55010	0.16940
0.6522	4.90340	0.34360	0.8237	1.57340	0.16250
0.6559	4.45940	0.41280	0.8372	1.48330	0.15140

$$F_\pi(Q^2) \underset{Q^2 \to \infty}{\simeq} \frac{64\pi^2 f_\pi^2}{(11 - \frac{2}{3} n_f) Q^2 \ln Q^2/\Lambda^2}, \tag{12}$$

where $f_\pi = 93$ MeV is the pion decay constant, n_f is the number of quark flavours and $\Lambda \simeq 100$ MeV is the QCD scale parameter.

Let Q^2_{QCD} be the value of a squared momentum transfer from which (12) starts to be dominant in comparison with higher order contributions to the pion ff behaviour. Then for $Q^2 > Q^2_{QCD}$ eq.(4) can be rewritten in the following form:

$$\frac{64\pi^2 f_\pi^2}{(11 - \frac{2}{3} n_f) Q^2 \ln Q^2/\Lambda^2} = \frac{1}{\pi} \int_{4m_\pi^2}^{t_{\pi^0\omega}} \frac{\mathrm{Im}^E F_\pi(t)\,dt}{t + Q^2} + \frac{1}{\pi} \int_{t_{\pi^0\omega}}^{\infty} \frac{\mathrm{Im}^A F_\pi(t)\,dt}{t + Q^2}, \tag{13}$$

$Q^2 > Q^2_{QCD}$.

It is transparent to see that t under the first integral on the right-hand side of (13) can be neglected due to the choice $Q^2 > Q^2_{QCD}$. As a result, one gets the relation

$$\frac{64\pi^2 f_\pi^2}{(11 - \frac{2}{3} n_f) Q^2 \ln Q^2/\Lambda^2} - \frac{1}{\pi Q^2} \int_{4m_\pi^2}^{t_{\pi^0\omega}} \mathrm{Im}^E F_\pi(t)\,dt = \frac{1}{\pi} \int_{t_{\pi^0\omega}}^{\infty} \frac{\mathrm{Im}^A F_\pi(t)\,dt}{t + Q^2}, \tag{14}$$

from which one sees that there is such $Q^2_C \geq Q^2_{QCD}$ that for all $Q^2 > Q^2_C$

$$\frac{1}{\pi} \int_{4m_\pi^2}^{t_{\pi^0\omega}} \frac{\mathrm{Im}^E F_\pi(t)\,dt}{t + Q^2} > \frac{64\pi^2 f_\pi^2}{(11 - \frac{2}{3} n_f) Q^2 \ln Q^2/\Lambda^2}, \tag{15}$$

since the QCD term has steeper falling and consequently

$$\frac{1}{\pi} \int_{t_{\pi^0\omega}}^{\infty} \frac{\mathrm{Im}^A F_\pi(t)\,dt}{t + Q^2} < 0. \tag{16}$$

On the other hand, the integral representation (4) for $Q^2 = 0$ provides the sum rule

$$1 = \frac{1}{\pi} \int_{4m_\pi^2}^{t_{\pi^0\omega}} \frac{\mathrm{Im}^E F_\pi(t)\,dt}{t} + \frac{1}{\pi} \int_{t_{\pi^0\omega}}^{\infty} \frac{\mathrm{Im}^A F_\pi(t)\,dt}{t}, \tag{17}$$

which together with the relation (11) gives

$$\frac{1}{\pi} \int_{t_{\pi^0\omega}}^{\infty} \frac{\mathrm{Im}^A F_\pi(t)\,dt}{t} = 0.0698 > 0, \tag{18}$$

i.e. another restriction on the behaviour of $\mathrm{Im}^A F_\pi(t)$ for $t_{\pi^0\omega} < t < +\infty$. The inequalities (16) and (18) can be fulfilled simultaneously only in the case if $\mathrm{Im}^A F_\pi(t)$ for $t > t_{\pi^0\omega}$ acquires at least one zero value and vanishes asymptotically from the negative values as $t \to +\infty$. The simplest parametrization, which reflects the latter property, is

$$\mathrm{Im}^A F_\pi(t) = a \frac{(t - t_0)}{(t - b)^M}, \tag{19}$$

where the parameters a, t_0, b and M are determined from the following requirements:

$$\operatorname{Im} {}^E F_\pi(t)\big|_{t=t_{\pi^0\omega}} = a\frac{(t-t_0)}{(t-b)^M}\Big|_{t=t_{\pi^0\omega}} \qquad (20)$$

$$\frac{d}{dt}\operatorname{Im} {}^E F_\pi(t)\big|_{t=t_{\pi^0\omega}} = \frac{d}{dt}\, a\frac{(t-t_0)}{(t-b)^M}\Big|_{t=t_{\pi^0\omega}} \qquad (21)$$

$$1-\frac{1}{\pi}\int_{4m_\pi^2}^{t_{\pi^0\omega}} \frac{\operatorname{Im} {}^E F_\pi(t)\,dt}{t} = \frac{1}{\pi}\int_{t_{\pi^0\omega}}^{\infty} \frac{a(t-t_0)\,dt}{t(t-b)^M} \qquad (22)$$

$$\int_{4m_\pi^2}^{t_{\pi^0\omega}} \operatorname{Im} {}^E F_\pi(t)\,dt = -a\int_{t_{\pi^0\omega}}^{\infty}\frac{(t-t_0)\,dt}{(t-b)^M}\,. \qquad (23)$$

The latter condition represents the superconvergence sum rule

$$\int_{4m_\pi^2}^{\infty} \operatorname{Im} F_\pi(t)\,dt = 0\,, \qquad (24)$$

which follows from (12) and the Cauchy theorem applied to $F_\pi(t)$ in the whole complex cut t-plane.

In order to evaluate the left-hand sides of (20) and (21), one must know the analytic expression instead of discrete data on $\operatorname{Im} {}^E F_\pi(t)$ in the vicinity of $t_{\pi^0\omega}$. For this purpose we use a Padé-type approximation of the pion ff /11/, respecting analyticity, reality, normalization and threshold conditions, the imaginary part of which has the form

$$\operatorname{Im} {}^E F_\pi(t) = \frac{\sum_{k=1}^{N} a_{2k+1}\, q^{2k+1}}{1+\sum_{k=1}^{N} a_{2k}\, q^{2k}}\,, \qquad (25)$$

where $q=[(t-4m_\pi^2)/4]^{1/2}$ and all the coefficients are real. Indeed, this functional form gives an excellent fit to our extracted data on $\operatorname{Im} {}^E F_\pi(t)$ with $N=3$ (χ^2/ndf = 0.44). The values of the first integral in (4) using eq.(25) agree with the TRAPER-integration for all values of Q^2 within one per cent.

If we denote the left-hand sides of (20) and (21) by D_0 and D_1, respectively, then the parameters a and b of (19) can be expressed through t_0 and M as follows:

$$b = t_{\pi^0\omega} + \frac{M(t_0 - t_{\pi^0\omega})}{\frac{D_1}{D_0}(t_0 - t_{\pi^0\omega}) + 1}\,, \qquad (26)$$

$$a = \frac{D_0(t_{\pi^0\omega} - b)^M}{t_{\pi^0\omega} - t_0}\,. \qquad (27)$$

The numerical solution of two integral constraints (22) and (23) with a and b given by (26) and (27) yields

$$M = 2.129\,, \quad t_0 = 98.350\, m_\pi^2 \qquad (28)$$

and from (26) and (27) we have

$$a = -25.525\, m_\pi^{2M-2}\,, \quad b = 16.417\, m_\pi^2\,. \qquad (29)$$

Now it is straightforward to calculate the integrals in (4) at all space-like region points Q^2 at which electroproduction pion ff data were determined. The first integral in (4) is computed by trapeziodal rule. The second integral in (4) is evaluated by the standard routine GQUAD from the CERN computer library using the parametrization (25) with the values of parameters (28) and (29). However, before that, the integration interval $(t_{\pi^0\omega}, \infty)$ is transformed into the finite limits by substituting $t = t_{\pi^0\omega}/x$ as follows:

$$\frac{1}{\pi}\int_{t_{\pi^0\omega}}^{\infty}\frac{a(t-t_0)\,dt}{(t+Q^2)(t-b)^M} = \frac{a\,t_{\pi^0\omega}}{\pi}\int_0^1 \frac{(t_{\pi^0\omega} - t_0 x)\,x^{M-2}dx}{(t_{\pi^0\omega} + Q^2x)(t_{\pi^0\omega} - bx)^M}\,. \qquad (30)$$

The final results and their comparison with 22 CEA and Cornell space-like region pion ff data are presented in Table II. Discarding the experimental point at $Q^2 = 3.99$ GeV^2, which due to its small value and big error contains no information, all other electroproduction data are globally consistent with the data on $e^+e^- \to \pi^+\pi^-$. We have not revealed any enhanced unreliability of the electroproduction pion ff data with increased values of Q^2 as conjectured in /4/. However, some doubtful isolated data (the values of χ^2 indicate that there are seven such points) are spread almost uniformly over the whole measured region of momenta 0.18 GeV$^2 \le Q^2 \le$ 9.77 GeV^2.

Table II

The result of the analysis of CEA and Cornell electroproduction pion ff data

Q^2 [GeV^2]	Ref.	$F_\pi^{exp}(Q^2)$	$\Delta F_\pi^{exp}(Q^2)$	I_2	I_2	$F_\pi^{predict}(Q^2)$	$\chi^2_{partial}$
0.18	1	0.8500	0.0440	0.6962	0.0575	0.7537	4.93
0.29	1	0.6340	0.0290	0.6053	0.0513	0.6566	0.44
0.40	1	0.5700	0.0160	0.5359	0.0461	0.5620	0.30
0.62	2	0.4450	0.0160	0.4363	0.0380	0.4743	2.63
0.79	1	0.3840	0.0140	0.3818	0.0331	0.4149	3.92
1.07	2	0.3090	0.0190	0.3167	0.0270	0.3437	2.95
1.18	4	0.2560	0.0260	0.2970	0.0250	0.3220	6.05
1.19	1	0.2380	0.0170	0.2952	0.0249	0.3201	21.62
1.20	2	0.2690	0.0120	0.2935	0.0247	0.3183	16.86
1.20	2	0.2620	0.0140	0.2935	0.0247	0.3183	16.17
1.20	3	0.2940	0.0190	0.2935	0.0247	0.3183	1.64
1.22	3	0.2900	0.0300	0.2903	0.0244	0.3147	0.60
1.31	2	0.2420	0.0150	0.2765	0.0230	0.2995	13.37
1.71	3	0.2380	0.0200	0.2282	0.0180	0.2462	0.12
1.94	4	0.1930	0.0250	0.2073	0.0158	0.2231	1.35
1.99	3	0.1790	0.0210	0.2034	0.0153	0.2187	3.36
2.01	2	0.1540	0.0140	0.2017	0.0152	0.2169	19.05
3.30	3	0.1020	0.0230	0.1347	0.0080	0.1427	3.02
3.33	4	0.0860	0.0330	0.1338	0.0076	0.1416	2.77
3.99	3	0.0040	0.6780	0.1145	0.0058	0.1203	0.02
6.30	4	0.0590	0.0300	0.0761	0.0020	0.0761	0.39
9.77	4	0.0700	0.0190	0.0506	-.0002	0.0504	1.09

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