AEC RESEARCH AND
DEVELOPMENT REPORT

MEASUREMENT OF TOTAL ν, $\bar{\nu}$ CROSS SECTIONS AT HIGH ENERGIES*

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Abstract

We propose that after the differential distributions for deep inelastic scattering are determined that accurate ($< 10\%$) measurements of σ_T for ν, $\bar{\nu}$ be made from ~ 30 - 300 GeV. This experiment will require about 400 hours of beam survey work with low intensity in the long spill and 1000 hours of ν data taking.

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The ideal way to measure ν cross sections is with the dichromatic beam. The fundamental importance of this normalized work for measuring linearity, checking sum rules, etc. are well known.

Table 1 shows the results of the first attempt to measure total cross sections in the present dichromatic beam and apparatus. Note that the limitations are purely systematic. The main sources are (1) the beam; normalization for fluxes and particle ratios (2) separation of ν_π and ν_k in apparatus (3) detection efficiency (determined primarily by x and y distributions) in the apparatus.

Fig. 1 shows the resulting cross sections with both statistical and systematic errors shown. Figure 2 shows $\sigma^\nu + \sigma^{\bar{\nu}}$ and $\sigma^{\bar{\nu}}/\sigma^\nu$ and Figure 3 shows a comparison with SLAC F_2^{ed} which implies a mean square fractional charge.

In the proposed experiment we believe the errors can be reduced to $\leqslant$ 10% and the cross section measured from ~ 30 - 300 GeV.

The requirements for making this measurement are the following.

1. Present target-detector.
2. New Toroidal Magnet Spectrometer for better efficiency in detecting the muon (see note on facility).
3. Results of deep inelastic distribution experiment to determine efficiency for detection.
4. Improved dichromatic train load capable of narrow momentum bite and high energy (see note on facility).
5. Beam survey of ~ 400 hours with low intensity in longspill to measure $\pi/k/p$ ratio in the new dichromatic beam.
6. Improved flux monitors, including monitors of muons from the decay pipe.

The proposed experiment would measure σ_T at 5 hadron energies (10 neutrino energies) and both signs of charge. 1000 hours of running will make systematic and statistical errors comparable.

Accurate total cross sections for ν interactions have been a prime goal since the construction of the Fermilab Accelerator. This experiment is aimed at yielding those accurate cross sections.

TABLE I.

Parent Particle	Mean E_ν (GeV)	ϵ	$\left(\frac{\Delta\epsilon}{\epsilon}\right)_{sys}$	T (events)	$\left(\frac{\Delta T}{T}\right)_{sys}$	$\left(\frac{\Delta T}{T}\right)_{stat}$	$F \times 10^{11}$ (neutrinos)	$\left(\frac{\Delta F}{F}\right)_{sys}$	σ_{tot} (10^{-38} cm^2)	$\Delta\sigma^{stat}$	$\Delta\sigma^{total}$
π^+	38	.326	.066	233.6	.073	.061	7.77	.13	29.9	1.8	5.2
K^+	107	.454	.052	102.8	.078	.092	.74	.16	98.6	9.1	20.4
π^-	38	.529	.164	97.6	.049	.097	5.02	.11	11.9	1.2	2.7
K^-	102	.647	.125	10.9	.181	.29	.24	.18	22.9	6.6	9.3

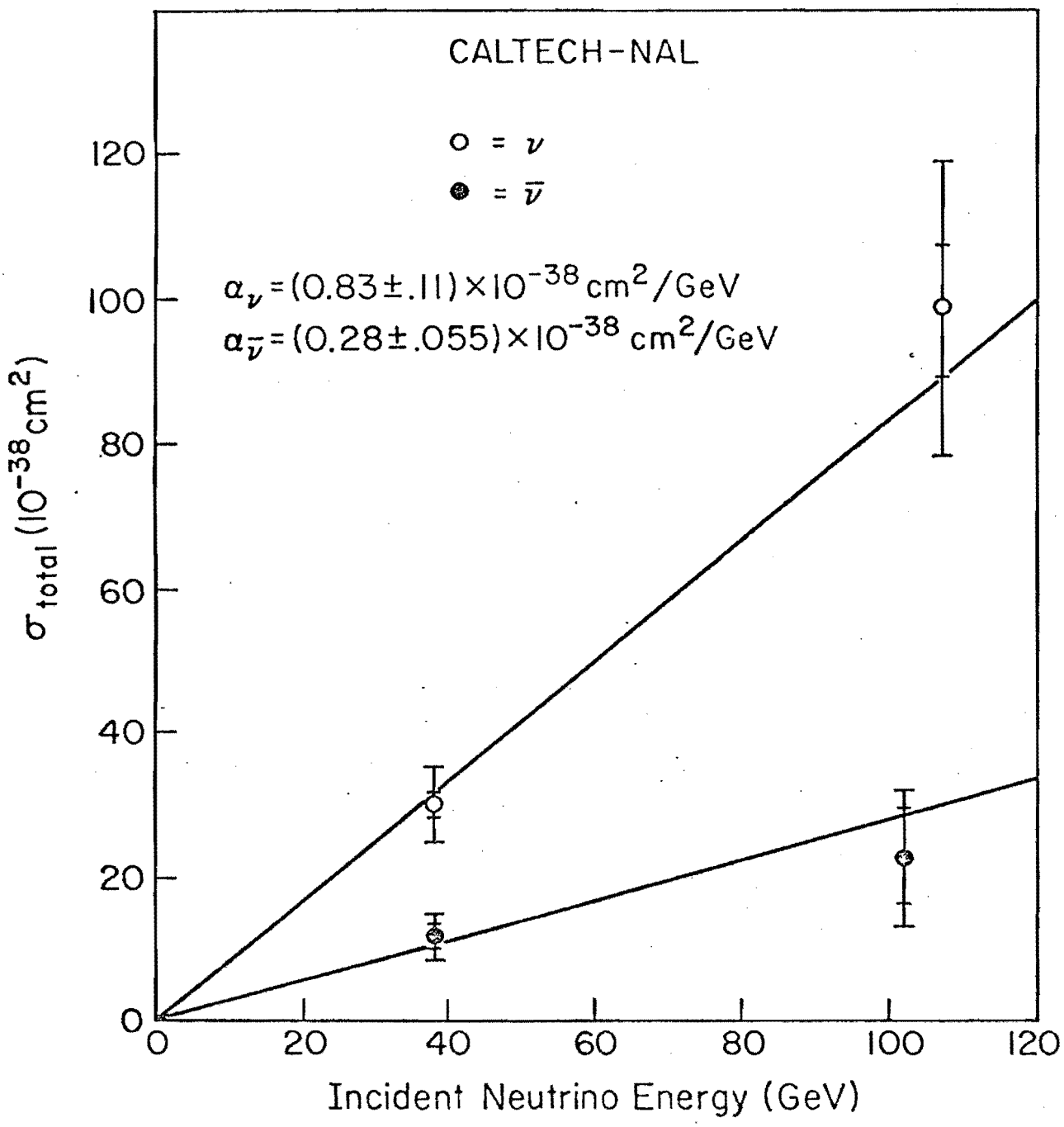
CALTECH-NAL
○ = ν
● = ν̄
$\alpha_\nu = (0.83 \pm .11) \times 10^{-38}\ cm^2/GeV$
$\alpha_{\bar{\nu}} = (0.28 \pm .055) \times 10^{-38}\ cm^2/GeV$
$\sigma_{total}\ (10^{-38} cm^2)$
0
20
40
60
80
100
120
Incident Neutrino Energy (GeV)

Fig. 1

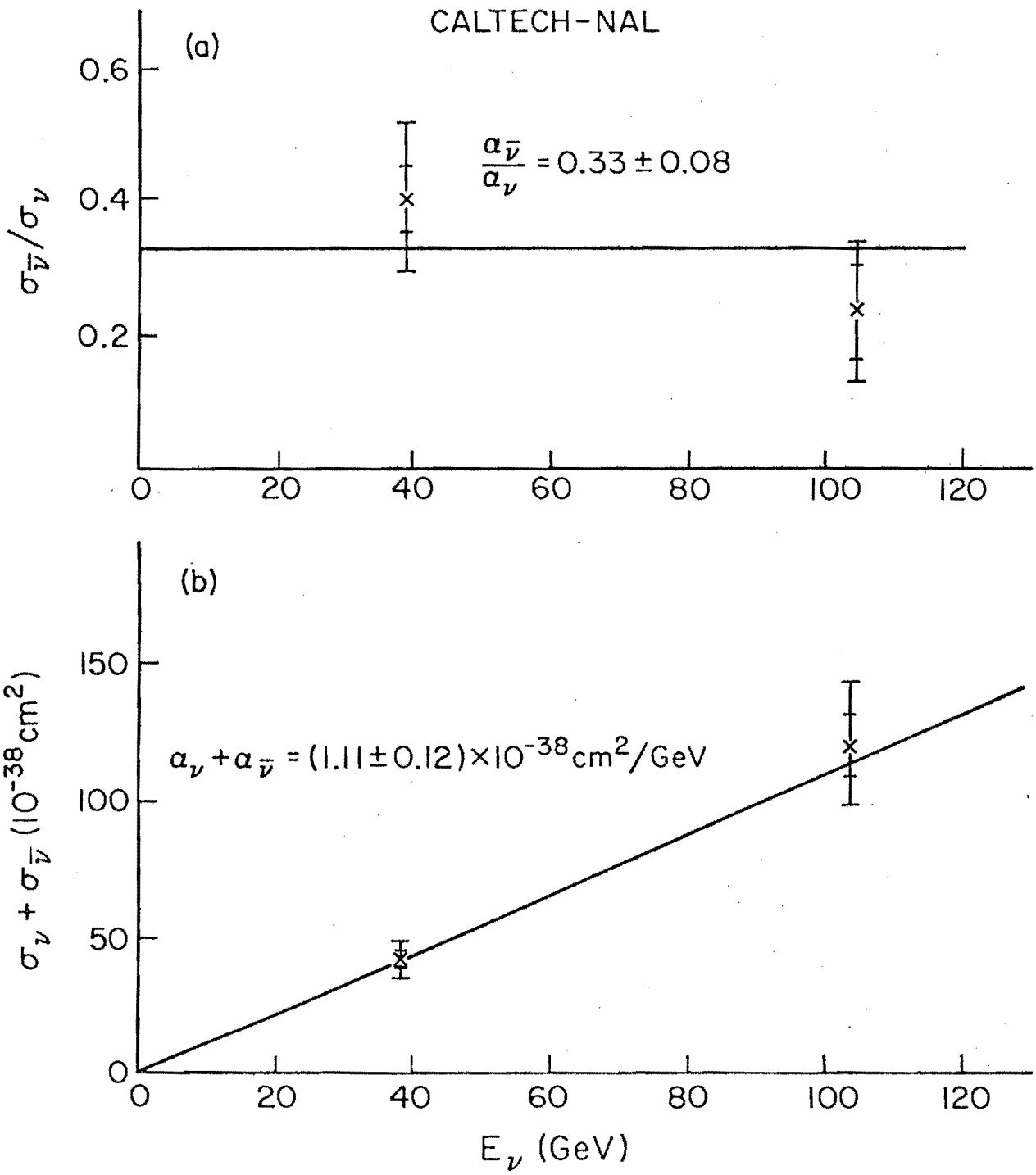
CALTECH-NAL
(a)
0.6
0.4
0.2
$\sigma_{\bar{\nu}}/\sigma_{\nu}$
$\frac{\alpha_{\bar{\nu}}}{\alpha_{\nu}} = 0.33 \pm 0.08$
0
20
40
60
80
100
120
(b)
150
100
50
0
$\sigma_{\nu} + \sigma_{\bar{\nu}}$ (10^{-38}cm^2)
$\alpha_{\nu} + \alpha_{\bar{\nu}} = (1.11 \pm 0.12) \times 10^{-38}$cm^2/GeV
0
20
40
60
80
100
120
E_{ν} (GeV)

Fig. 3

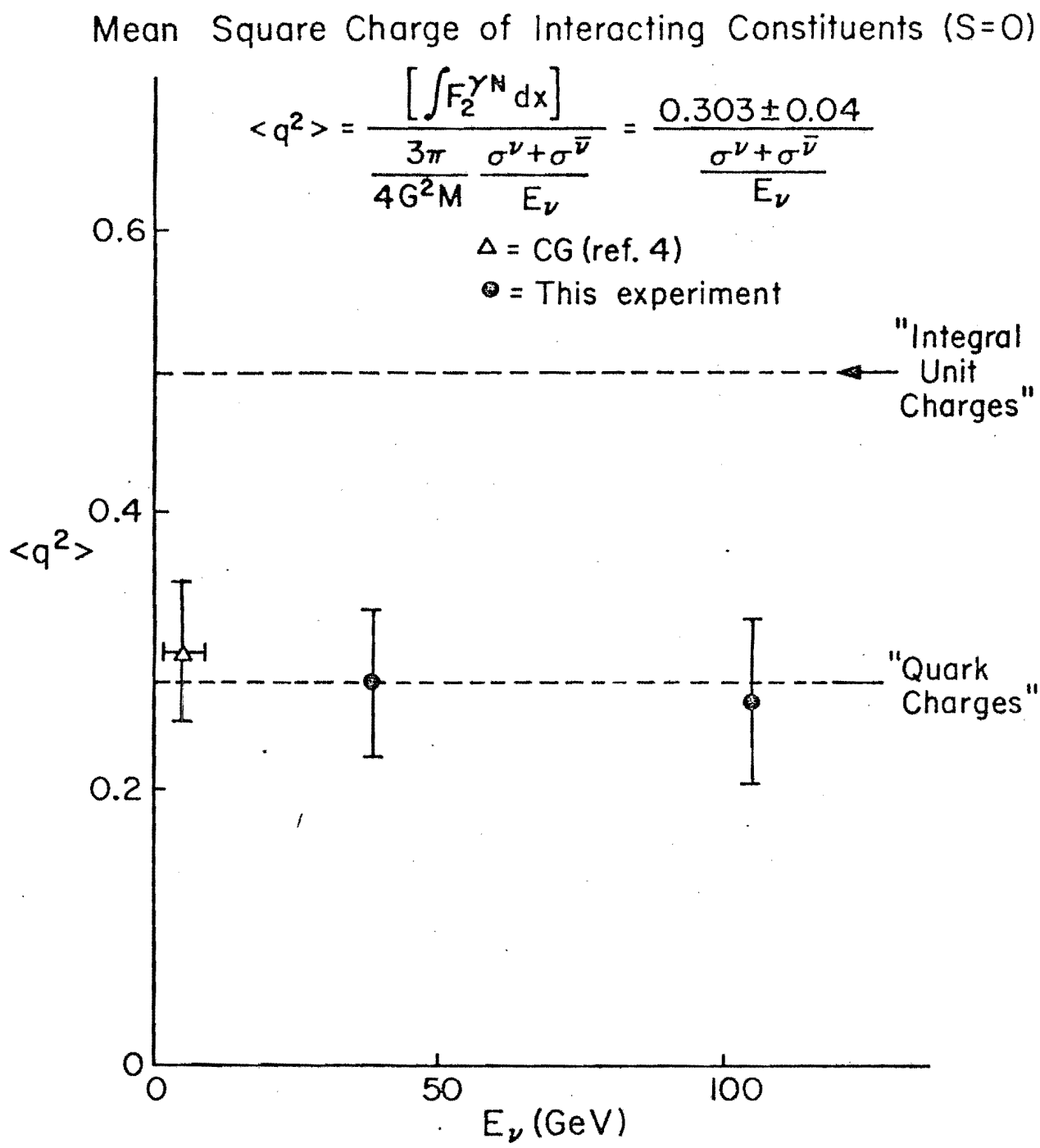
Mean Square Charge of Interacting Constituents (S=O)
$\langle q^2 \rangle = \frac{\left[\int F_2^{\gamma N} dx\right]}{\frac{3\pi}{4G^2M}\frac{\sigma^\nu+\sigma^{\bar{\nu}}}{E_\nu}} = \frac{0.303 \pm 0.04}{\frac{\sigma^\nu+\sigma^{\bar{\nu}}}{E_\nu}}$
Δ = CG (ref. 4)
● = This experiment
"Integral Unit Charges"
"Quark Charges"
$\langle q^2 \rangle$
0.6
0.4
0.2
0
0
50
100
E_ν (GeV)

Fig. 4