Proton Calibrations of the IMP H and J CPME Package in the 50 to 500 MeV Energy Range

1. Scope

The purpose of this document is to list the procedures required for the proton beam calibration of the CPME detectors.

2. Background Information

2.1 The Proton-Electron Telescope (PET)

PET makes use of E and ΔE signals from the 40μ, 1000μ and 3000μ detectors to define passbands for response to incident protons, electrons, alphas, and heavier nuclei. Correct interpretation of the flight data will depend on the availability of reliable $E_{incident}$ vs. ΔE data for the telescope. The expected energy loss has been calculated from nominal values of the detector thickness using the range energy tables. There are several known sources of uncertainty which complicate the calculated response and which must be calibrated for:

2.1.1 Detector nonuniformity of thickness - probably contributes $\sim$ 5 to 10% width to the ΔE signal. Uncertainty of the average thickness contributes about 1%.

2.1.2 Dispersion of ΔE signals owing to path straggling and statistical fluctuations in the energy loss. Small deviations of the protons from straight line motion cause a small dispersion of ΔE. The statistical uncertainty in the energy loss resulting from a finite number of interactions, known as the Landaw spread, also contributes. The dispersion of ΔE arising from these two sources is probably in the range of 5% in the 100 MeV range. The Landaw effect is most pronounced when the fractional energy loss is small ($\frac{\Delta E}{E} \ll 1$) as is sometimes the case in this experiment.

2.1.3 Intrinsic detector noise contributes an additive uncertainty in the ΔE signal of about ~~47~~ keV for the 40µ detector and 18 keV for the 1000µ and 3000µ. (14 keV)

2.1.4 Electronic noise from preamps and amplifiers contributes about 44 for the 40µ channel and 18 for the 1000µ and 3000µ (14 keV channels.

2.1.5 Inelastic nuclear interactions. The probability for an inelastic nuclear interaction of a 100 MeV proton in the 40µ detector is about 1%; in the 1000µ, 25%; in the 3000µ, 75%. Such an interaction usually gives rise to multiple products, some charged, some uncharged. To accurately calculate the effective ΔE for such processes is extraordinarily difficult. Hence, one must rely on calibrations to yield the necessary data.

2.1.6 Variation of projected thicknesses of detectors and shielding with incidence angle. The 22 to 23° opening angle of the telescope causes about an 8% increase in the effective thickness of the detectors and tungsten absorber. Although the effect of off-axis incidence can be easily calculated, several runs at oblique incidence should be made to verify the calculations.

2.2 The G.M. Tubes

2.2.1 The upper thresholds for foreground protons are unknown and should be calibrated.

2.2.2 The effectiveness of the anticoincidence shield should be measured.

4. Summary of Accelerator Time Required

4.1 Proton-Electron Telescope

Energy (MeV)	Current (particles/cm^2sec)	Time (sec)
650	5×10^3	10^2
600	5×10^3	10^2
550	5×10^3	10^2
525	5×10^3	10^2
500	5×10^3	10^2
475	5×10^3	10^2
450	5×10^3	10^2
425	5×10^3	10^2
400	5×10^3	10^2
350	5×10^3	10^2
300	5×10^3	10^2
275	5×10^3	10^2
250	5×10^3	10^2
225	5×10^3	10^2
200	5×10^3	10^2
190	5×10^3	10^2
180	5×10^3	10^2
170	5×10^3	10^2
160	5×10^3	10^2
150	5×10^3	10^2
140	5×10^3	10^2
130	5×10^3	10^2

Energy (MeV)	Current (particles/cm^{2}sec)	Time (sec)
120	5×10^3	10^2
110	5×10^3	10^2
100	5×10^3	10^2
90	5×10^3	10^2
80	5×10^3	10^2
70	5×10^3	10^2
60	5×10^3	10^2
50	5×10^3	10^2
120	10^4	10^3
120	10^5	10^3
120	10^6	10^2
300	10^4	10^3
300	10^5	10^3
300	10^6	10^2

4.2 GM Tubes

Energy	Current	Time
30	5×10^3	10^2
40	5×10^3	10^2
50	5×10^3	10^2
60	5×10^3	10^2
70	5×10^3	10^2
80	5×10^3	10^2
90	5×10^3	10^2
100	5×10^3	10^2
150	5×10^3	10^2

Energy	Current	Time
200	5×10^3	10^2
300	5×10^3	10^2
400	5×10^3	10^2
500	5×10^3	10^2

5. <u>Summary of Equipment Required</u>

5.1 Experiment Package

5.2 GSE, including buffers where necessary.

5.3 Pulse height analyzers (2) 512 or 1024 channel variety.

5.4 Biased Amplifier

5.5 Logic Modules, two input OR.

5.6 Scalars (16) plus timer

5.7 Vacuum Feedthroughs

5.8 Mounting fixture for experiment

5.9 Oscilloscope

3. Calibration Procedures and Data to be Obtained

3.1 Proton foreground passbands P8, P9, P10, P11.

3.1.1 Set up and align experiment with proton beam. Connect to accumulate data from channels:

Channels		Continuous Monitor	Spot Check
P6	o		x
P7	o		x
P8	*	x	
P9	*	x	
P10	*	x	
P11	*	x	
A1	●	x	
A2	●	x	
A3	●	x	
A4	+	x	
A5	+	x	
A6	Δ	x	
A7	◒	x	
Z1	●	x	
Z2	●	x	
M	▭	x	

* Primary foreground channels to be recorded over entire energy range 50 to 500 Mev.

● These channels should respond to a part of the inelastic events in A. The rates should be between $10^{-4 \text{ or } 5}$ to 10^{-2} of P10.

\+ These channels should respond to a part of the inelastic events in B. The rates should be $10^{-4 \text{ or } 5}$ to 10^{-2} of P10.

△ This channel requires an inelastic event in both A and B. The rate should be extremely small.

◒ This channel should respond to part of the inelastic events in C with a rate $\sim 10^{-3}$ of P10.

▭ This channel will respond to direct penetrations of the scintillator by the 50 to 500 Mev protons as well as to inelastic events.

○ The rates here should be very small at > 50 Mev - hopefully less than .001 or .0001 of P10.

3.1.2 Connect external logic circuitry to get beam intensity monitor.

3.1.3 Connect pulse height analyzer channels to detectors B and C.

3.1.4 Request beam intensity in the range 10^4 to $10^3/cm^2 sec$ at maximum available energy, $\sim E_p > 500$ Mev. Verify small counting rates in foreground channels. Step down in energy as follows, accumulating at least 10^5 counts in the beam monitor at each step:

650 Mev
600
550
525
500
475
450
425
400
350
300
275
250
225
200

190
180
170
160
150
140
130
120
110
100
90
80
70
60
50

3.2 Alpha and $Z \geq 3$ channels.

Disconnect analyzers from B and C. Choose energy of 120 Mev and vary beam intensity from about 10^4 to about 10^6. Accumulate 10^8 counts in beam monitor. Repeat at 300 Mev.

3.3 G-M tube data.

Orient experiment package so that the axis of G-M 2A is co-linear with the proton beam. Connect scalars to E1, E2A, E2B, E2C, E3, S. Put cover on PET and connect scalars to M, Z1, P1, P2, P6, P9. Disconnect pulse height analyzer from PET channels B and C.

3.3.1 Choose beam energy $\sim$ 30 or 40 Mev or lowest available and increment in 10 Mev steps to 100 Mev then in 50 Mev steps to 500 Mev. Beam current $\sim 10^3$ or 10^4 cm^2sec. Accumulate about 10^4 counts in G-M 2A or in S at each energy.