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A Specification on RF Amplitude and Phase Control for the Injector

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Some calculations using PARMELA were made for the purpose of optimizing the design of our injector stage by stage and determining the beam quality available from the injector. The layout of the injector under consideration is shown in Figure 1. The best results obtained at point A, with an initial 60° chopped bunch, were a 0.7° phase width and a 19 KeV energy spread at a final energy of 5.6 MeV. The graphs of longitudinal and transverse motion are shown in Figure 2.

Any variation of RF amplitude and phase in the buncher cavity, the capture section, and the first two superconducting cavities of the injector will introduce changes in the phase width and energy spread of the bunches and in the phase (or time) at which bunches arrive at point A. Among these the phase (time) is the most important factor, because it causes a correlated phase jitter of the input bunches to the main accelerator.

Estimating, by analytic formulae, the effects of error in field amplitude and phase on the phase stability of the output bunch from the injector is a difficult and inaccurate process, due to the complexity of dynamic motion of the electrons in the injector. The data calculated by PARMELA are given in Figures 3 and 4. For a 10^{-3} amplitude variation in the buncher, capture section, cecav 1, and cecav 2, the phase shifts of the bunch at point A are 0, 0.12°, 0.08°, and 0.05°, respectively. For a 0.2° phase variation in these components, the phase shifts are 0.04°, 0.04°, 0.1°, and 0.06°, respectively.

For example, if field amplitudes in all components of the injector are stabilized within 10^{-3} and phases are maintained within 0.2°, the phase jitter at point A, 15 m downstream from the gun, is 0.2°. Field amplitude errors in the capture section and in cecav 1 contribute more to the phase jitter of the output bunches from the injector than do errors in the other components, making tighter controls on them desirable.

The variations in phase width and energy spread of the bunches at point A, caused by errors of 10^{-3} amplitude and 0.2° phase in the buncher cavity, capture section, cecav 1, and cecav 2, are less than 0.04° and 0.8 KeV, respectively.

In order to measure the phase shift of the bunches at point A, an experimental arrangement is proposed and shown in Figure 5. A cavity resonated at 6 GHz is placed at point A to detect the fourth harmonic wave of the bunch-induced signal. The higher frequency provides a better sensitivity to the phase shift of the bunches. A vector meter is used to compare the phases of two signals from the cavity and reference line at 6 GHz.

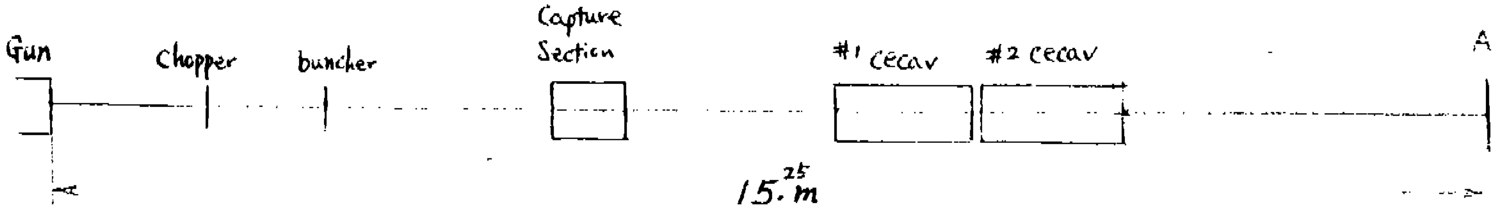

fig. 1 The layout of Injector.

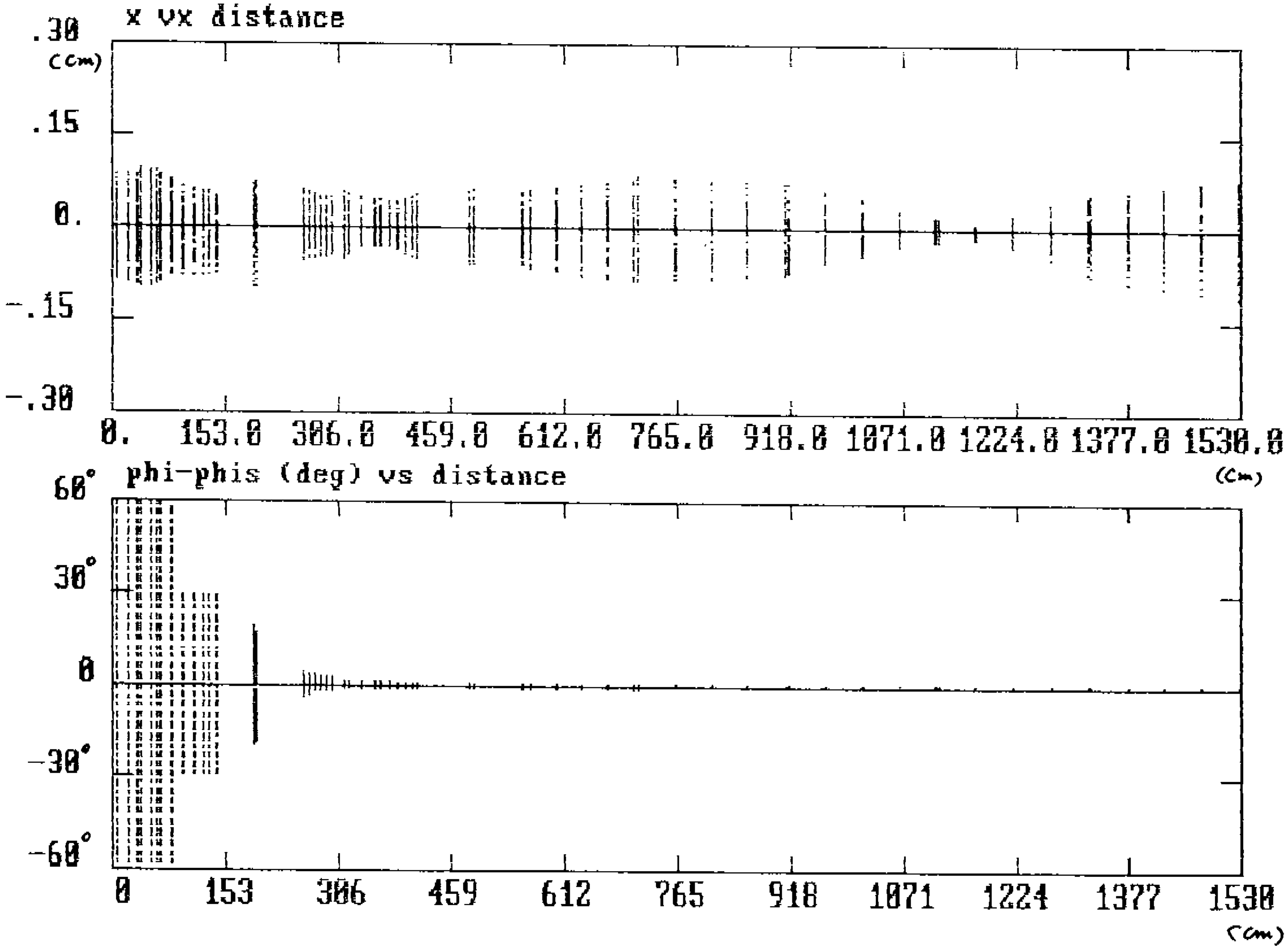

fig. 2. The graphs of longitudinal and transverse motion in Injector.

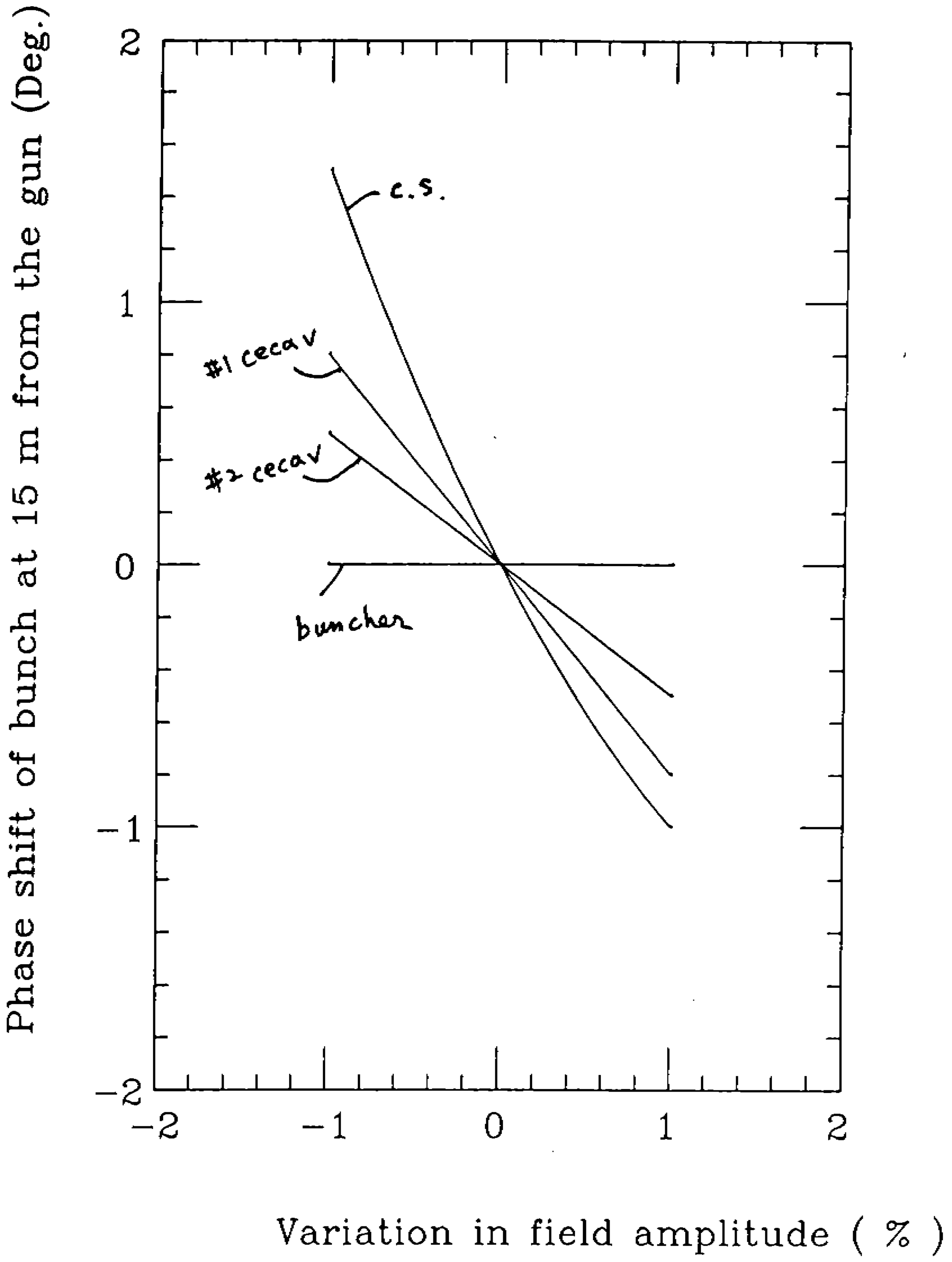
Phase shift of bunch at 15 m from the gun (Deg.)
2
1
0
−1
−2
−2
−1
0
1
2
c.s.
#1 cecav
#2 cecav
buncher
Variation in field amplitude (%)

fig. 3

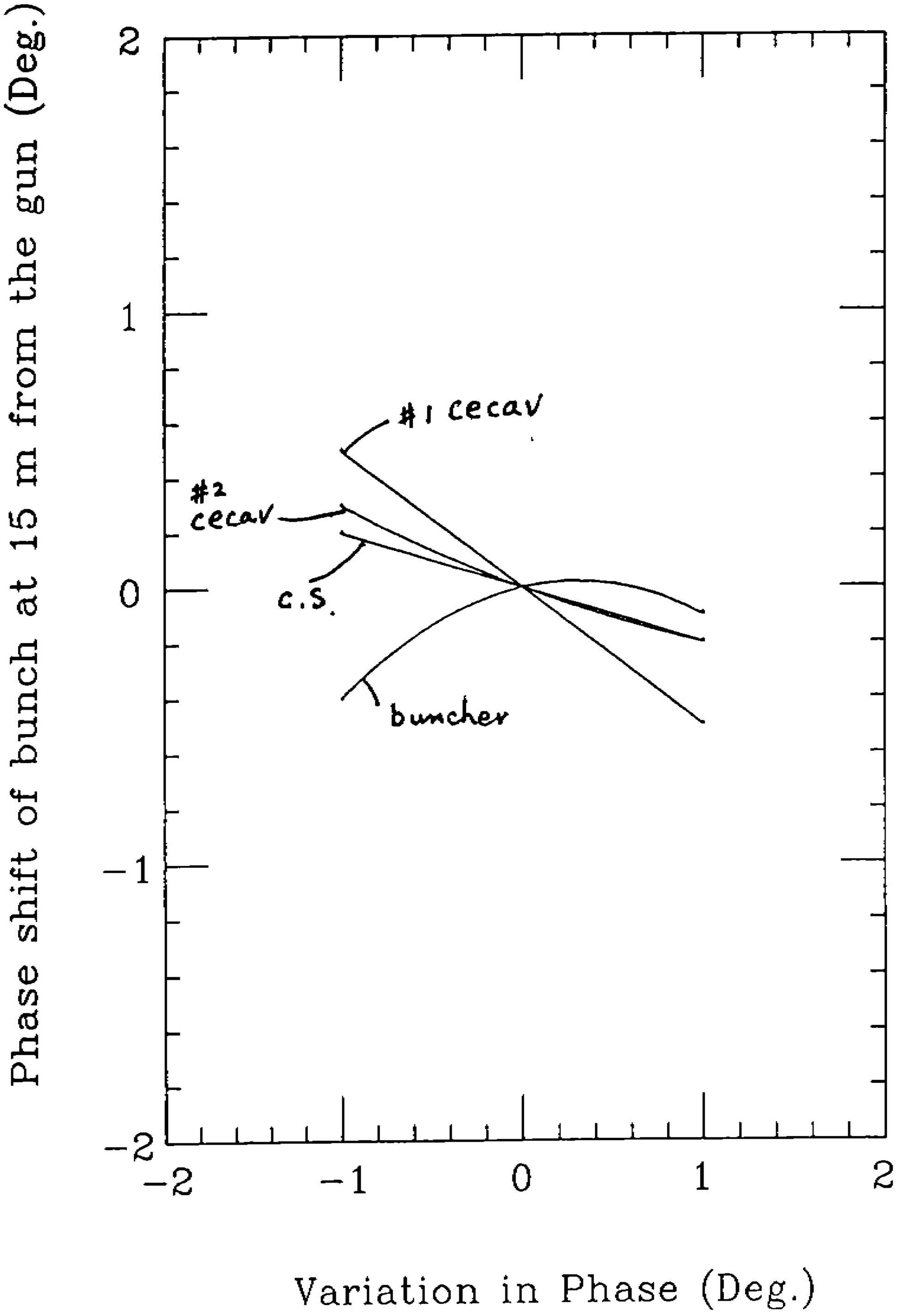
Phase shift of bunch at 15 m from the gun (Deg.)
Variation in Phase (Deg.)
2
1
0
−1
−2
−2
−1
0
1
2
#1 cecav
#2 cecav
c.s.
buncher

fig. 4.

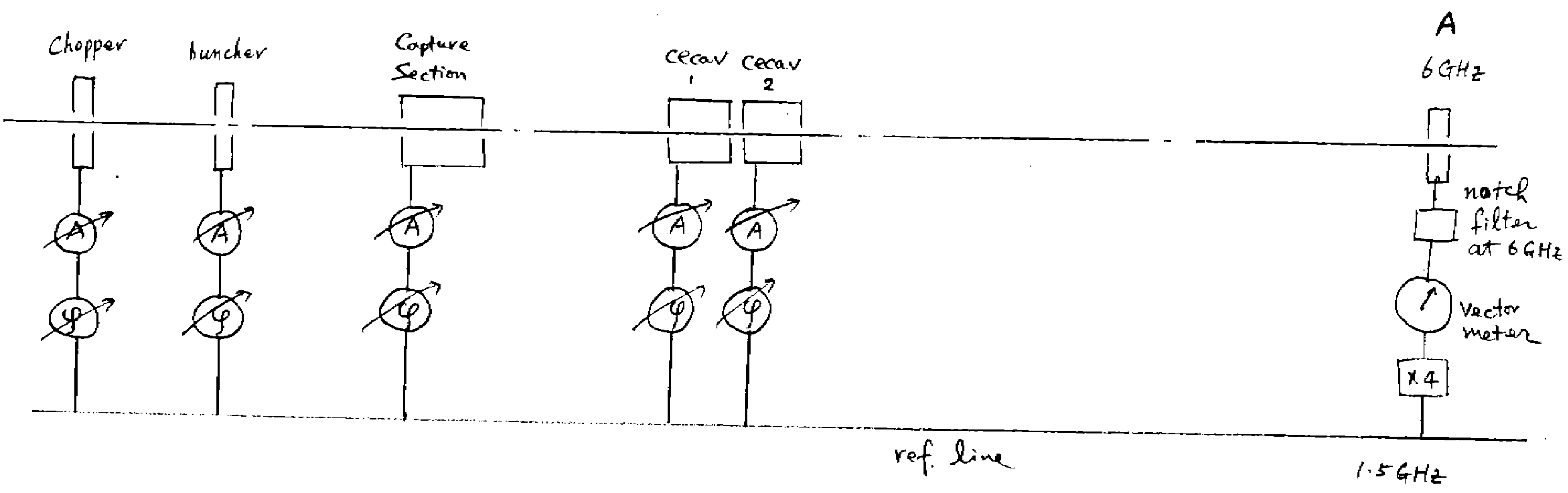

figure 5. An experimental arrangement for measurement of phase shift of the bunches at point A.