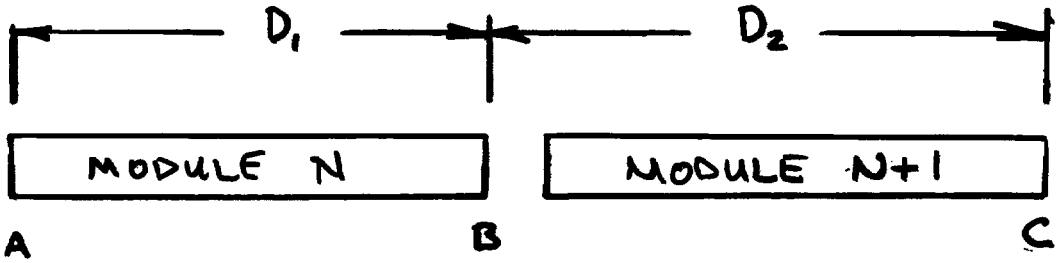
# BASIC THEORY BEHIND THE ΔT PROCEDURE

## I. GEOMETRY




$$\Delta t_{AB} = t_{AB}^{off} - t_{AB}^{ON}$$

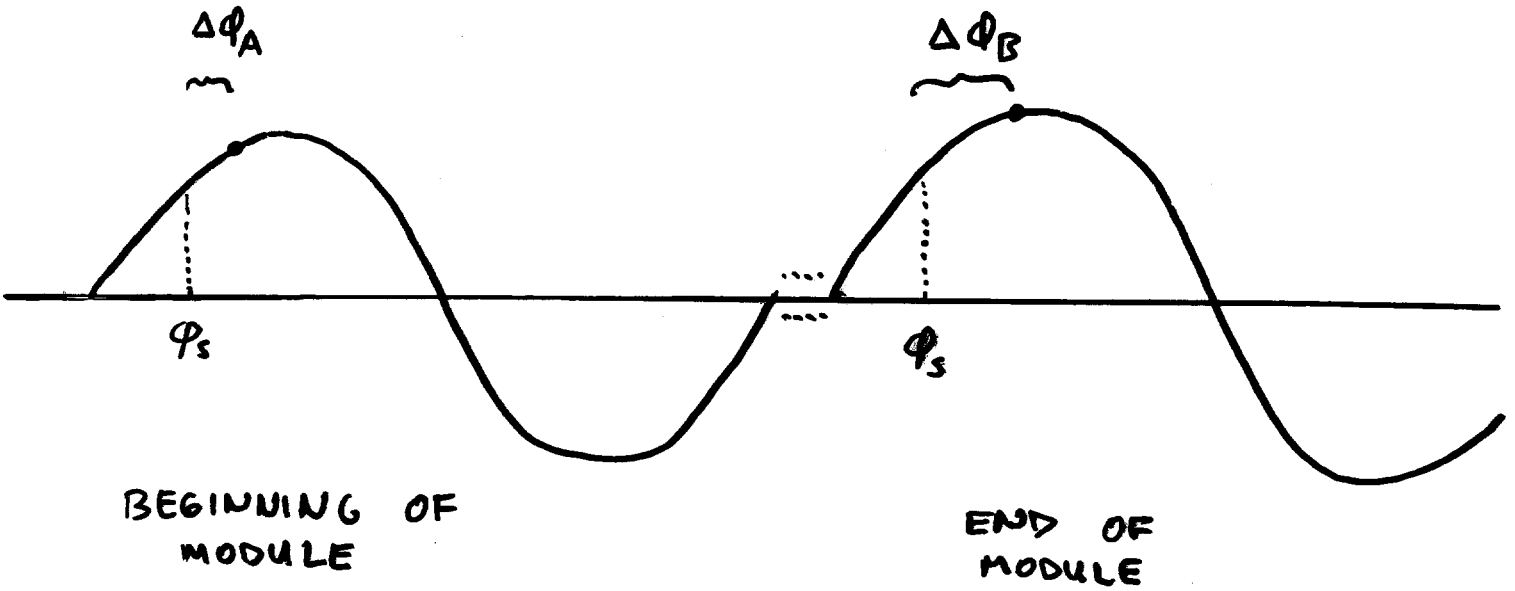
$$\Delta t_{AC} = t_{AC}^{off} - t_{AB}^{on}$$

## II DESIGN PARTICLE (SYNCHRONOUS PARTICLE) THROUGH MODULE N,

$$t_{AB}^{off} = T_d^{off} \qquad t_{AB}^{ON} = T_d^{on}$$

$$\Delta t_{AB} = t_d^{off} - T_d^{on}$$

III. CONSIDER PARTICLE WHICH DEVIATES FROM DESIGN.




$$\tau_s = \tau_{ds} + \frac{\Delta\phi_A}{2\pi}\tau_0 \quad ; \quad \tau_f = \tau_{df} + \frac{\Delta\phi_B}{2\pi}\tau_0$$

$$t_{AB}^{on} = (\tau_f - \tau_s) = -(\tau_{ds} - \tau_{df}) + (\Delta\phi_B - \Delta\phi_A)/\omega_0$$

$$t_{AB}^{on} = t_d^{on} + \frac{(\Delta\phi_B - \Delta\phi_A)}{\omega_0}$$

$$t_{AB}^{off} = \frac{D_1}{V_A + \Delta V_A} \simeq \frac{D_1}{V_A}\left(1 - \frac{\Delta V_A}{V_A}\right) \simeq t_d^{off} - D_1 \frac{\Delta V_A}{V_A^2}$$

$$\rightarrow \Delta t_{AB} = \left(t_d^{off} - D_1 \frac{\Delta V_A}{V_A^2}\right) - \left(t_d^{on} + \frac{\Delta\phi_B - \Delta\phi_A}{2\pi} \tau_0\right)$$

$$= \left(t_d^{off} - t_d^{on}\right) - \left(D_1 \frac{\Delta V_A}{V_A^2} + \frac{\Delta\phi_B - \Delta\phi_A}{\omega}\right)$$

$$= \Delta t_{AB}\Big|_{design} - \left(D_1 \frac{\Delta V_A}{V_A^2} + \frac{\Delta\phi_B - \Delta\phi_A}{\omega}\right)$$

DEVIATIONS IN THE CHANGE IN TIME OF FLIGHT WITH RF OFF THEN ON IS GIVEN BY,

$$\delta(\Delta t_{AB}) = -\left(D_1 \frac{\Delta V_A}{V_A^2} + \frac{\Delta\phi_B - \Delta\phi_A}{\omega}\right)$$

$$\delta(\Delta t_{AB}) = (a)\,\Delta W_A + (b)\,\Delta\phi_A + (c)\,\Delta\phi_B$$

USING $\quad \dfrac{\Delta V_A}{V_A} = \dfrac{1}{\gamma(\gamma+1)} \dfrac{\Delta W_A}{W_A}$

SIMILARLY,

$$\delta(\Delta t_{AC}) = (d)\,\Delta W_A + (e)\,\Delta\varphi_A + (f)\,\Delta W_B + (g)\,\Delta\varphi_B$$

III. USING THE TRANSFORMATION MATRIX

$$\begin{pmatrix} \Delta\varphi_B \\ \Delta W_B \end{pmatrix} = T \begin{pmatrix} \Delta\varphi_A \\ \Delta W_A \end{pmatrix}$$

$$\Rightarrow \begin{pmatrix} \delta(\Delta t_{AB}) \\ \delta(\Delta t_{AC}) \end{pmatrix} = Q \begin{pmatrix} \Delta\varphi_A \\ \Delta W_A \end{pmatrix}$$

$$\Rightarrow \boxed{\begin{pmatrix} \Delta\varphi_A \\ \Delta W_A \end{pmatrix} = A \begin{pmatrix} \delta(\Delta t_{AB}) \\ \delta(\Delta t_{AC}) \end{pmatrix}}$$

<u>WHERE A IS A FUNCTION OF E</u>

# APPROXIMATIONS FOR THE $m_{21}$ ELEMENT OF THE TRANSFORMATION MATRIX

I. FOR SMALL DISPLACEMENTS IN PHASE & ENERGY ABOUT SYNCHRONOUS VALUES:

A. $$\frac{d\Delta\varphi}{ds} = -\frac{2\pi}{\lambda}\,\frac{\Delta W}{\beta_s^3\,\gamma_s^3\,m_0c^2}$$

B. $$\frac{d^2\Delta\varphi}{ds^2} = \frac{2\pi e E T\cos(\varphi_s)}{\lambda\,\beta_s^3\,\gamma_s^3\,m_0c^2}\,\Delta\varphi$$

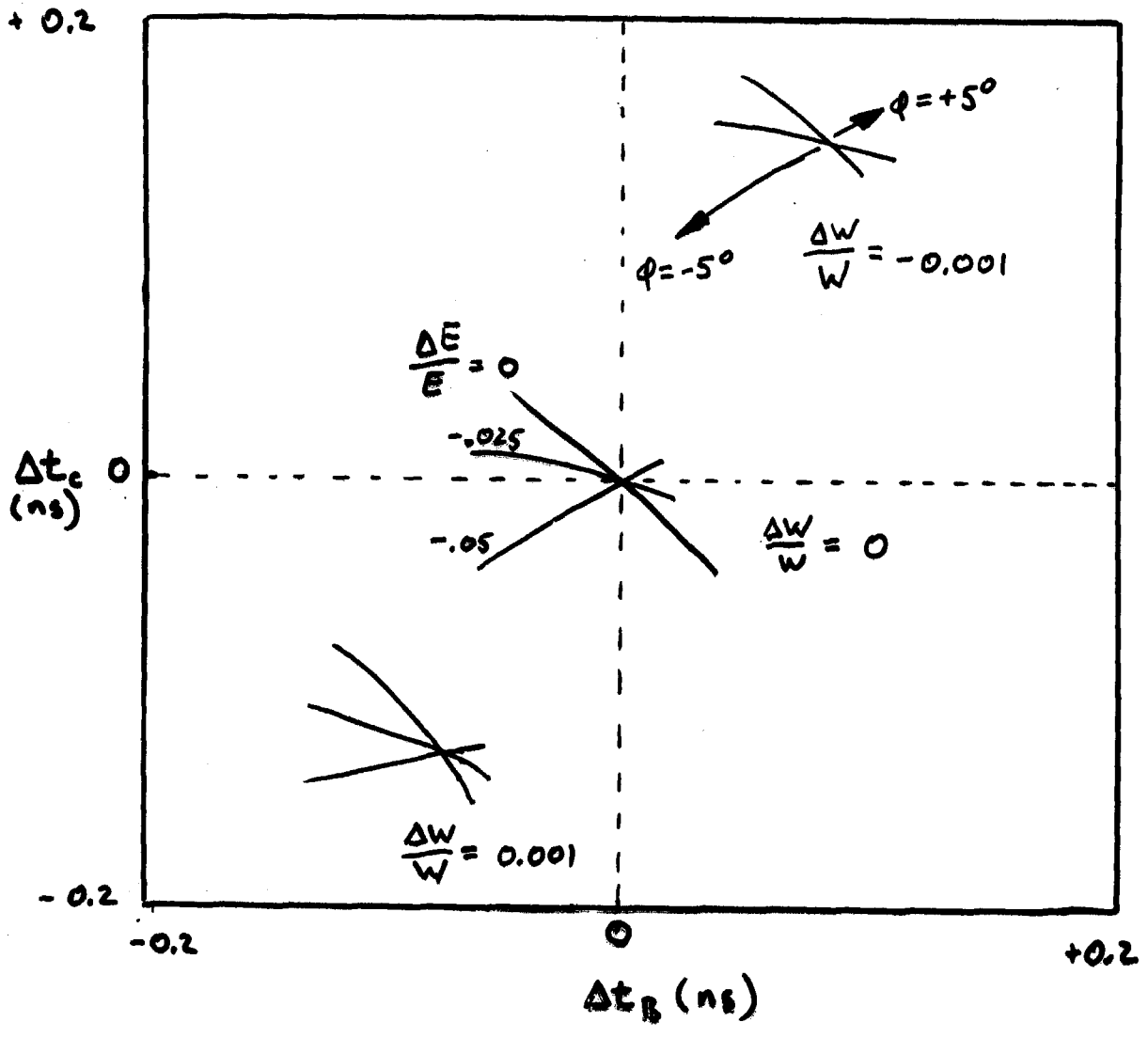
II. SOLUTIONS TO ABOVE YIELD,

$$\frac{\Delta W_B}{\Delta\varphi_A} = m_{21} \cong \left[\frac{eET\cos(\varphi_s)\,\lambda\,\beta_s^3\,\gamma_s^3\,m_0c^2}{2\pi}\right]^{1/2}\sin\Phi$$

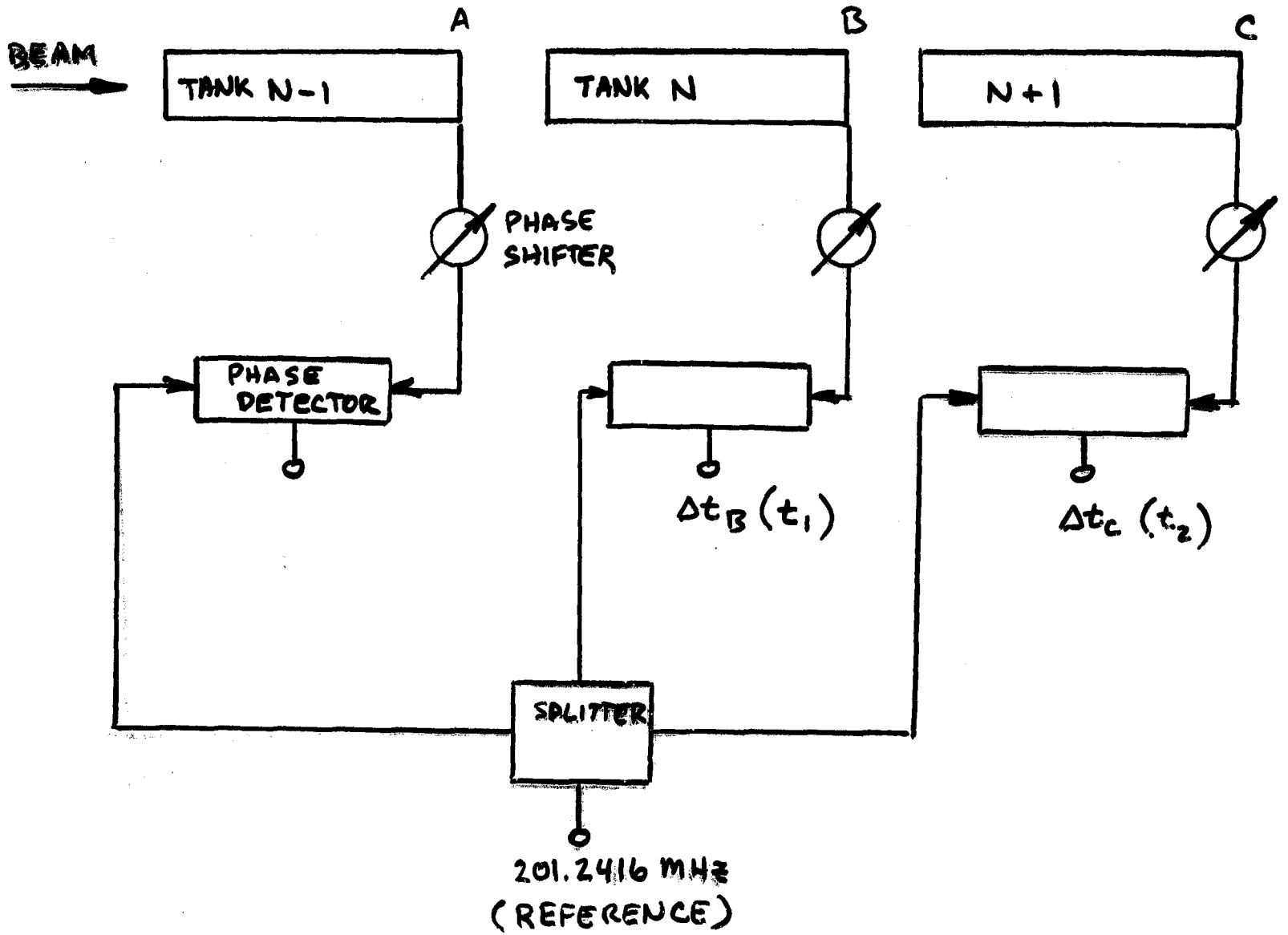
III. FOR SMALL PHASE ADVANCE:

$$\boxed{m_{21} \simeq s\cdot e\cdot E\cdot T\cdot\cos(\varphi_s)} \rightarrow m_{21} \text{ dependent upon } E.$$

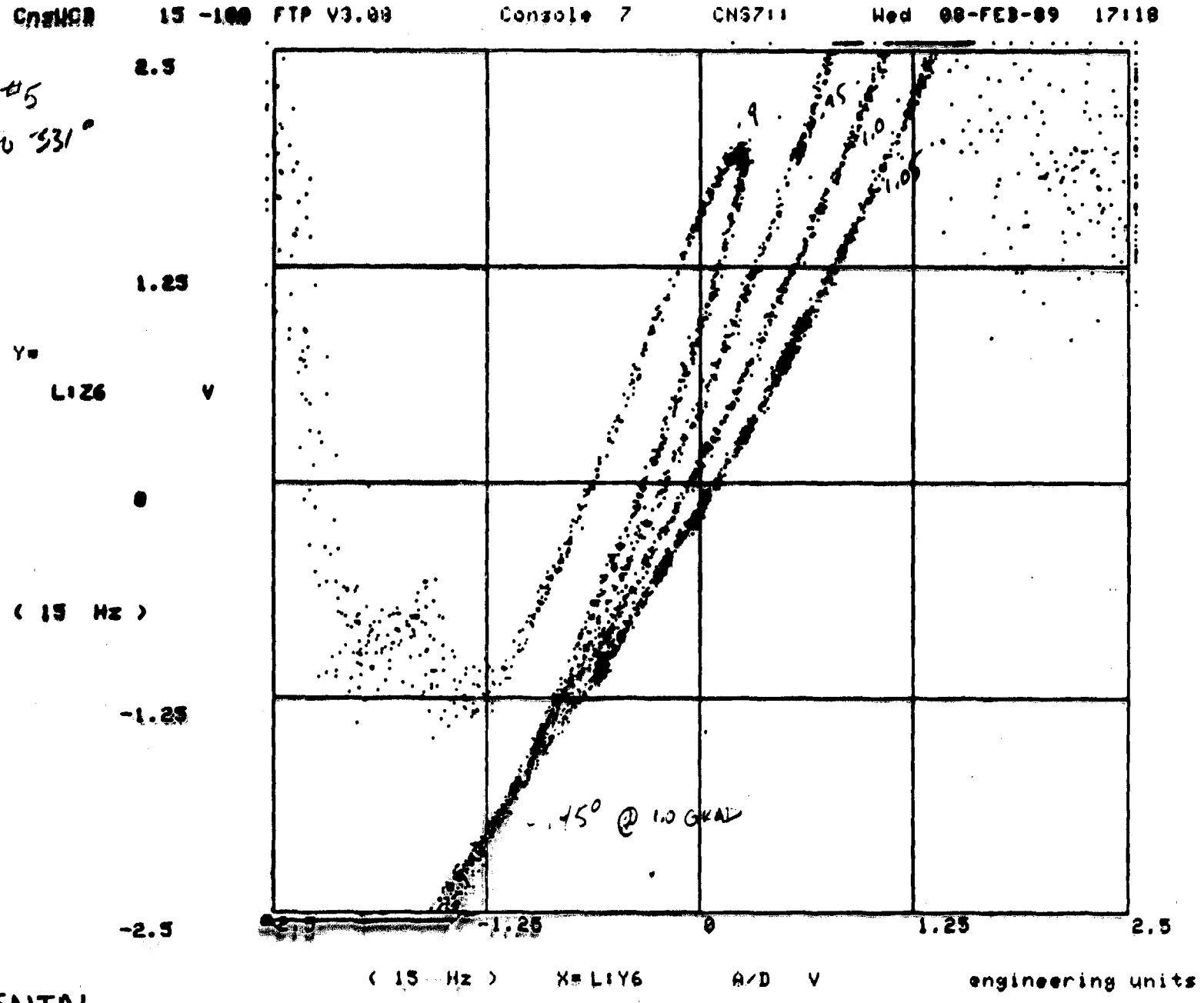
# CURVES OF CONSTANT ELECTRIC FIELD AMPLITUDE



# REMINDER OF ΔT SETUP



CONSOLE LOCATION 07, MCR-W1 8-FEB-1989 17:26
Fast Time Plot

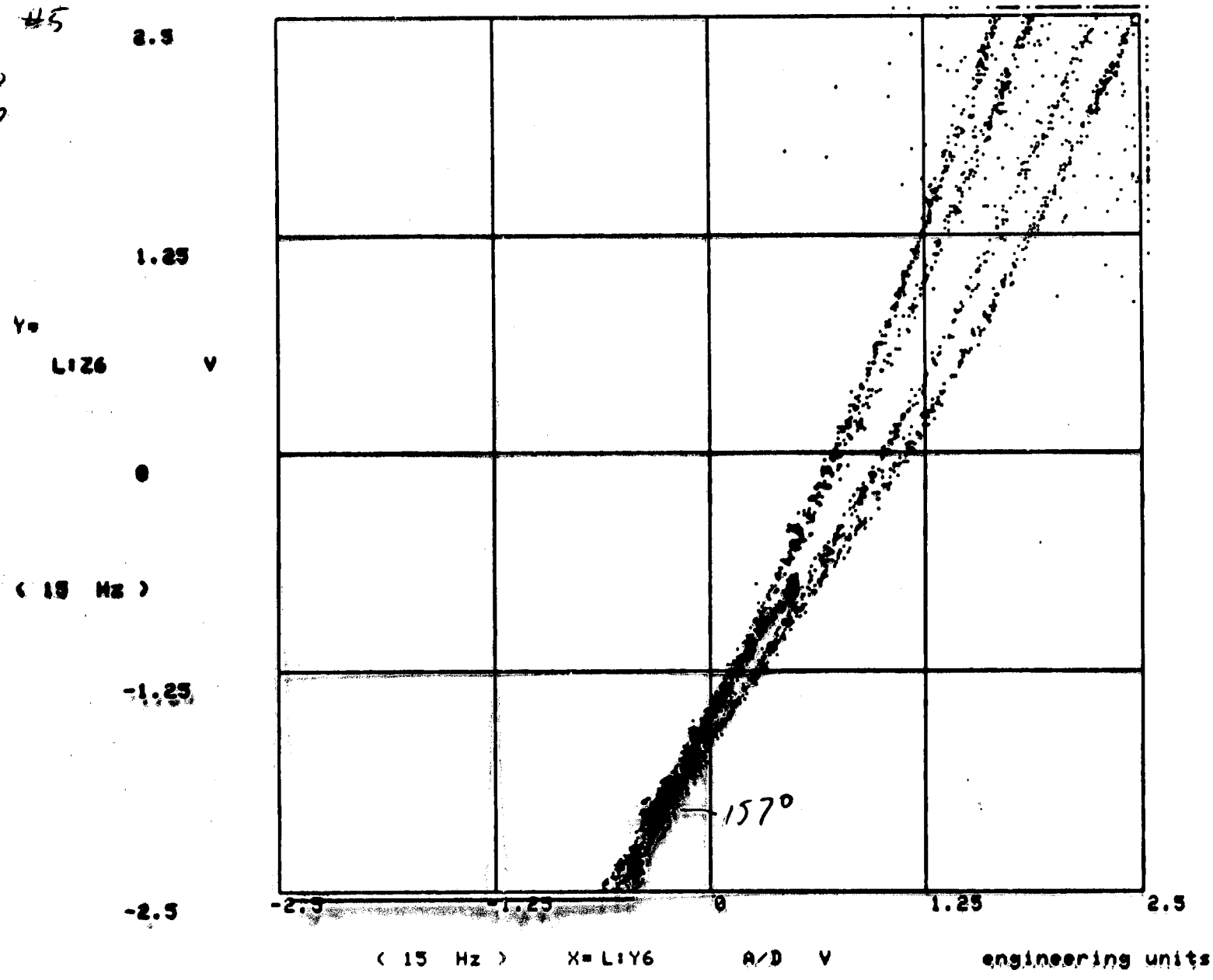



EXPERIMENTAL TEAM: ALLEN, CARLSON, McCORY, SCHMIDT, WAHL

CONSOLE LOCATION 02, MCR-W1 8-FEB-1989 17:38
Fast Time Plot

TANK #5
Set to
350°

FTP V3.08 Console 7 CNS711 Wed 08-FEB-89 17:3



# MEASUREMENT OF CHANGE IN ENERGY THROUGH TANK 6

I.

$$\frac{\Delta\beta}{\beta_i} = \left\{ \frac{1}{\left[1 - \left(\frac{\Delta t_2 - \Delta t_1}{D}\right) V_i\right]} - 1 \right\} ; \quad \frac{\Delta W}{W_i} = \gamma(\gamma+1)\frac{\Delta\beta}{\beta_i}$$

$$\frac{\Delta W}{W} \simeq \frac{(\beta\gamma)^3}{(\gamma-1)} c \left[\frac{\Delta t_2 - \Delta t_1}{D}\right]$$

II. FROM MEASUREMENTS OF $\Delta t_2 - \Delta t_1$ :

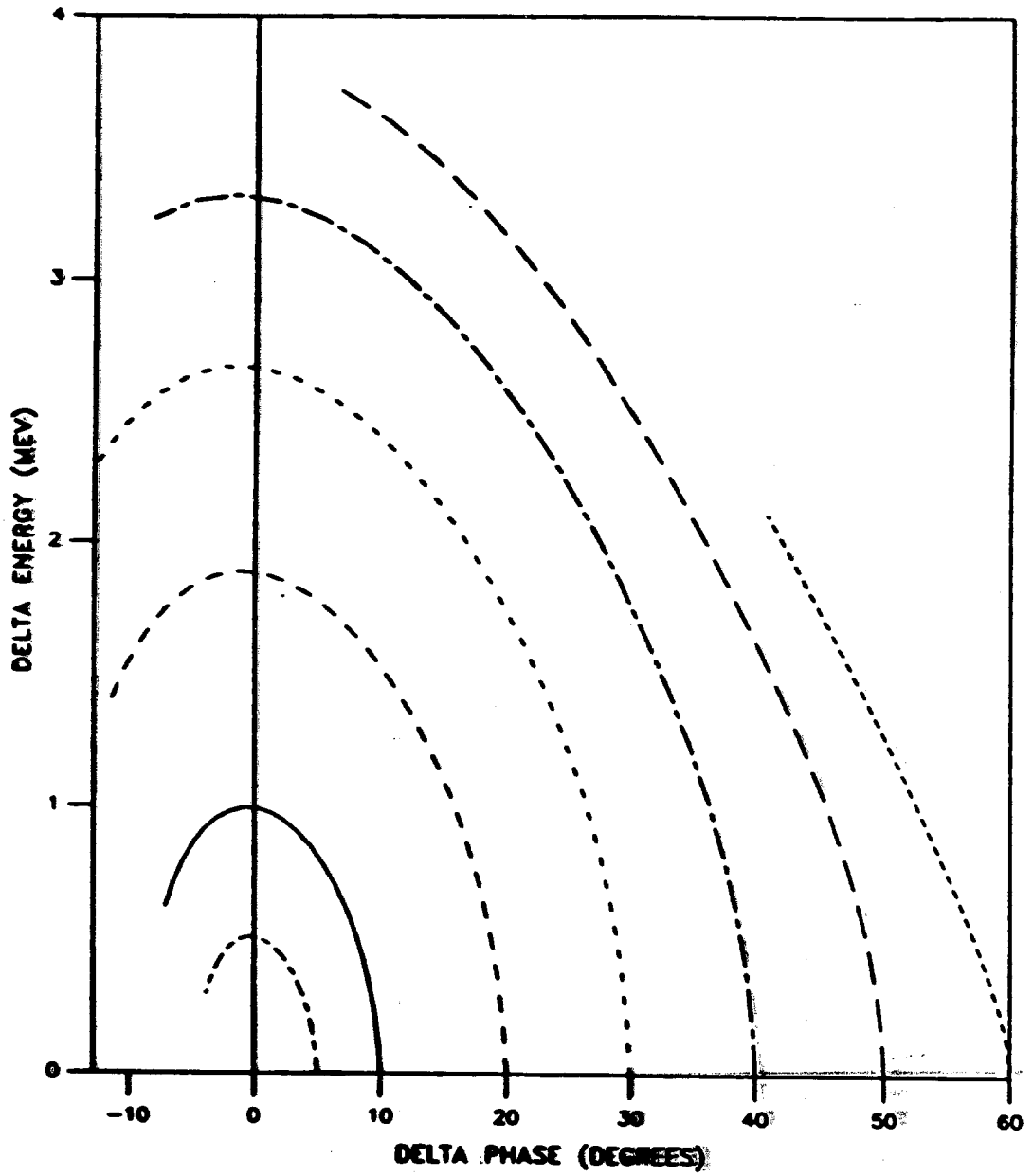
INPUT BEAM – $\frac{\Delta W}{W} = 0.3\%$ OVER 30 μs BEAM PULSE & MOST VARIATION OCCURS OVER FIRST 10 μs.

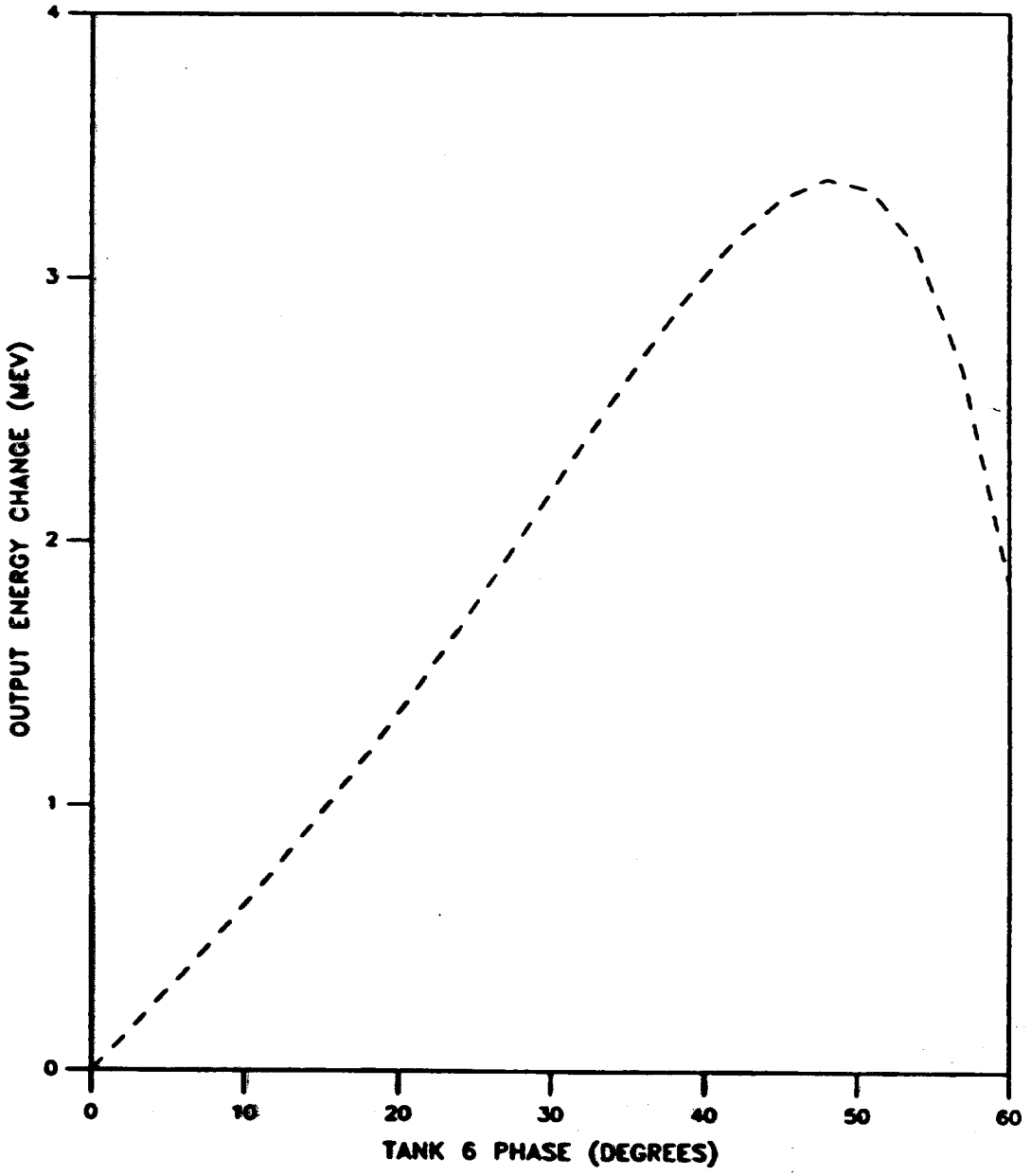
OUTPUT BEAM – $\frac{\Delta\beta}{\beta}$ (MEASURED) $= 9.5\%$

$\frac{\Delta\beta}{\beta}$ (DESIGN) $= 7.5\%$

# TANK 6 PHASE/ENERGY DIAGRAM

E0=3.0



# CHANGE IN ENERGY OUT VERSUS TANK 6 PHASE

( E0=2.56 , DELTA INPUT ENERGY=0.0)