(1)

HIFAN 1363 LBNL-56863

Comments on Time-Dependent Lenses (TDLs)

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- TDLs compensate the chromatic effect of tilt in final focus

- TDLs upstream from target
 $\approx 20\text{ m}$ for Fusion

$$\Delta\theta(t) \approx 10 - 30\text{ mrad}$$

- TDLs close to target
for HEDP

$$\Delta\theta(t) \approx 100 - 300\text{ mrad}$$

where $\Delta\theta(t) = a'/a$ of envelope

(2)

Fusion — Simple Solenoid — for TDL

$$\Delta\theta = \left[\frac{B_z}{2(B\rho)} \right]^2 l \quad \begin{array}{c} \uparrow \\ \text{magnet} \\ \text{length} \end{array} \quad \begin{array}{c} \uparrow \\ a \\ \text{beam} \\ \text{radius} \end{array}$$

Want $l \leq l_{\text{pulse}} \approx 0.5 - 1.0 \text{ m}$

Example $\left\{ \begin{array}{l} (B\rho) = 1.0 \text{ T-m} \\ (\sim 250 \text{ MeV Ne}^{+10}) \end{array} \right. \quad \begin{array}{l} \Delta\theta = 10 \text{ mrad} \\ a = 0.2 \text{ m} \\ l = 1.0 \text{ m} \end{array}$

$$\rightarrow B_z = 2(B\rho) \sqrt{\frac{\Delta\theta}{l a}} = 2 \times 1 \times \sqrt{\frac{.01}{1 \times .2}} \\ = \underline{\underline{1.45 \text{ T}}}$$

Single Turn
Solenoid
(Low
Impedance)

(3)

$$\text{Solenoid Current } I = \frac{l B_z}{\mu_0} = \frac{1 \times 0.45}{4\pi \times 10^{-7}} = \underline{\underline{358 \text{ kA}}}$$

$$\text{Stored Energy } W = \frac{B_z^2 \pi R^2 l}{2 \mu_0} = \frac{(0.45)^2 \pi (0.3)^2 (1)}{2 \times 4\pi \times 10^{-7}}$$

$$= \underline{\underline{23 \text{ kJ}}}$$

$$\text{Inductance } L = \frac{2W}{I^2}$$

$$= \frac{2 \times (23 \times 10^3)}{(358000)^2} = \underline{\underline{3.6 \times 10^{-7} \text{ Henry}}}$$

$$\text{Voltage } V = L \dot{I} = \frac{LI}{t_{\text{rise}}}$$

$$\text{Take } t_{\text{rise}} = 20 \text{ ns}$$

$$\rightarrow V = \frac{3.6 \times 10^{-7} \times (358 \times 10^3)}{20 \times 10^{-9}}$$

$$= \underline{\underline{6.4 \text{ Megavolts}}}$$

— Trouble —

(4)

Various Ideas To Reduce V

(1) Annular Solenoid with beams at edge

Highly Non Linear — fringe field gives distorted v_0 —

— Strong Deflection for Low B_0 but Somewhat Non Linear —

(5)

(3) Time Dependent Dipoles At Merge Point

$$\Delta\theta = \frac{B \cdot l}{(R_0)}$$

$$\Delta\theta = 10 \text{ mrad}$$

$$l = 1.0 \text{ m}$$

$$(R_0) = 1.0 \text{ T-m}$$

$$\rightarrow B = \underline{\underline{0.01 \text{ T}}} \quad (\text{Good})$$

This Seems The Best
Yet So Far

[Voltage Reduced 10-100]

⑥

Diamagnetic Effect (Rogers' Problem)

$$\frac{\partial B}{\partial t} \rightarrow E \rightarrow J$$

→ Reversed Component of B

→ Shielding

→ We can't Rise Quenchly

This is True for Metal
And A Collisional Plasma

Situation Not Clear yet
For Collisionless Plasma

Very Low Electron Drift
Velocities 1 to 10
Allowed

(7)

Example

Merged Main Pulse (to One Side of Target)

$$\left\{ \begin{array}{l} 2.5 \text{ MJ} \\ 250 \text{ MeV } - \text{Ne}^{+10} \\ l_p = .5 \text{ m} \\ a_p = .2 \text{ m} \end{array} \right. \quad \left(\begin{array}{l} Z = 10 \\ A = 20 \end{array} \right)$$

$$\left(\text{Number of Beam Ions} \right) = \frac{2.5 \times 10^6}{1.6 \times 10^{-19}} \frac{1}{250 \times 10^6} = 6.2 \times 10^{16}$$

$$n_p = \frac{6.2 \times 10^{16}}{\pi \times (.2)^2 \times .5} = \underline{\underline{1.0 \times 10^{18} \text{ m}^{-3}}}$$

$$\text{Take } n_e = 10 \text{ gH}_2 = \underline{\underline{1.0 \times 10^{20} \text{ m}^{-3}}}$$

$$\frac{\partial B}{\partial x} \sim \mu_0 n_e e v_{e\perp}$$

$$\therefore \text{Want } v_{e\perp} \ll \frac{B/a}{\mu_0 n_e e}$$

$$\approx \frac{(0.01)/(0.2)}{(4\pi \times 10^{-7})(10^{20})(1.6 \times 10^{-19})} = \underline{\underline{2500 \frac{\text{m}}{\text{s}}}}$$