Terahertz-driven dielectric-lined waveguides (DLWs) have uses in electron manipulation; in particular, deflection, acceleration, and focussing. A rectangular DLW has been optimised for deflection of 100 keV electrons using a THz pulse with a centre frequency 0.5 THz. A narrowband THz pulse is generated using a lithium niobate crystal and chirped pulse beating. Electron-THz interaction and the effect of electron bunch injection timing on maximising deflection is presented, with a focus on beam dynamics. Structure design, including coupling from free-space into the DLW, has been completed and the practical aspects of operation are discussed. Finally DLWs and corrugated waveguides are compared to discuss relative advantages and disadvantages.

**Terahertz-driven dielectric-lined waveguides**

DLW accelerators are considered as an alternative to rf accelerating structures due to:
- Potential for high accelerating gradients
- Wave can propagate with phase velocity \( v_p \leq c \)
- Simple designs in the THz-driven regime

Fig. 1 shows a rectangular DLW. Short THz pulses are preferential over radio frequencies to improve accelerating gradients as field \( E_z \propto f^{-1/2}t^{-1/4} \).

**Corrugated waveguides**

Corrugated waveguides are another design option, shown in Fig. 2.

Corrugations allow \( v_p \leq c \). Comparisons of \( v_p \) and \( v_g \) for 100keV electron interaction are shown in Fig. 3 for a deflecting waveguide operating at 0.5 THz.

**THz-electron interaction**

The DLW can be driven by a THz pulse of any chosen length. The most easily generated pulse is single-cycle (wideband). The resultant y-momentum at a given time is shown in Fig. 6. This is compared with a ten-cycle pulse in Fig. 8. Interaction with the THz is not linear, but in the case of a single-cycle pulse the interaction is not constant – electrons do not appear to co-propagate with the THz pulse at the same phase velocity.

**Figures 3,4: Phase and group velocity of corrugated waveguide and DLW.**

Corrugated waveguides are preferable for higher transverse voltage at the operating frequency, but low \( v_p \) means short interaction length. Transit time factor is included in \( V_z \) calculations, shown in Fig. 5.

A coupler is required to guide a THz pulse with a transverse 5x10 mm spot size into the 0.2x1 mm waveguide. The coupler is metallic with no dielectric. Dispersion caused by the coupler is noticeable for 10-cycle pulses but the overall pulse shape is preserved. Figs. 9 and 10 show the coupler dispersion for single- and ten-cycle THz pulses.

**Figures 6,8: Grey y-momentum of particles in a bunch taken as a snapshot along the propagation axis.**

**Figures 5,9,10: THz pulse dispersion at the end of the coupler for single- and ten-cycle THz pulses.**

**Conclusions and future outlook**

A dielectric-lined waveguide has been designed and manufactured for deflection of 100 keV electrons. The effect of THz input pulse length on electron interaction has been studied to choose the optimal pulse for maximised deflection. An analogous corrugated waveguide has been shown to be favourable for ultra narrowband pulses, however manufacturing requires more precise tooling which is not as readily available.

**References:** [1] Lowe, G.A. et al., SLAC-PUB-4647, 1988

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