Gradient and Wavelength Today 5/30/97

D. Whittum

This short note is intended to clarify the very popular gradient versus wavelength plot. All previous editions have had an error of one kind or another relating to the value of wavelength used for the two plasma accelerator schemes. The present version corrects this. I have appended a detailed explanation of the plot below.

⇒Depicted are gradients achieved to-date, versus wavelength of the *accelerating bucket*. In the case of the plasma accelerators, this means the plasma wavelength, not the electromagnetic signal wavelength.

⇒ Overlaid are the trapping condition, an extrapolation of known breakdown scalings, and curves of constant pulsed temperature rise (40°C, 80°C, and 120 °C), in one fill-time, in a constant gradient structure with attenuation parameter τ=1.

⇒ The breakdown scaling is Perry Wilson's fit to results of studies at S and X Band, extending only over the solid portion of the curve.

⇒ Also shown are results of Laser Wakefield Accelerator (LWFA) work at Rutherford Appleton Lab, and Plasma Beat-Wave Accelerator (PBWA) work at UCLA.

⇒The RAL LWFA work made use of a 25TW, 0.8ps laser pulse with peak intensity 10^{19}W/cm^2, producing an inferred plasma density of 10^{19}cm^{-3}, and 10^7 44MeV electrons of ˜5mm-mrad normalized emittance. The inferred gradient was 100GV/m.

⇒The UCLA PBWA work made use of a 0.2TW, 1ns laser pulse with peak intensity of 10^{14}W/cm^2, in a 10^{16}cm^{-3} plasma. It produced up to 28MeV electrons for an inferred gradient of 2.8GV/m.

⇒Points corresponding to the 0.5TeV collider concepts are also depicted. Shown but not labelled are DESY S-Band, NLC II, VLEPP, KEK C-Band. (Source: International Linear Collider Technical Review Committee Report, G. A. Loew and T. Weiland, eds, (July 1995) SLAC-R-95-471.)

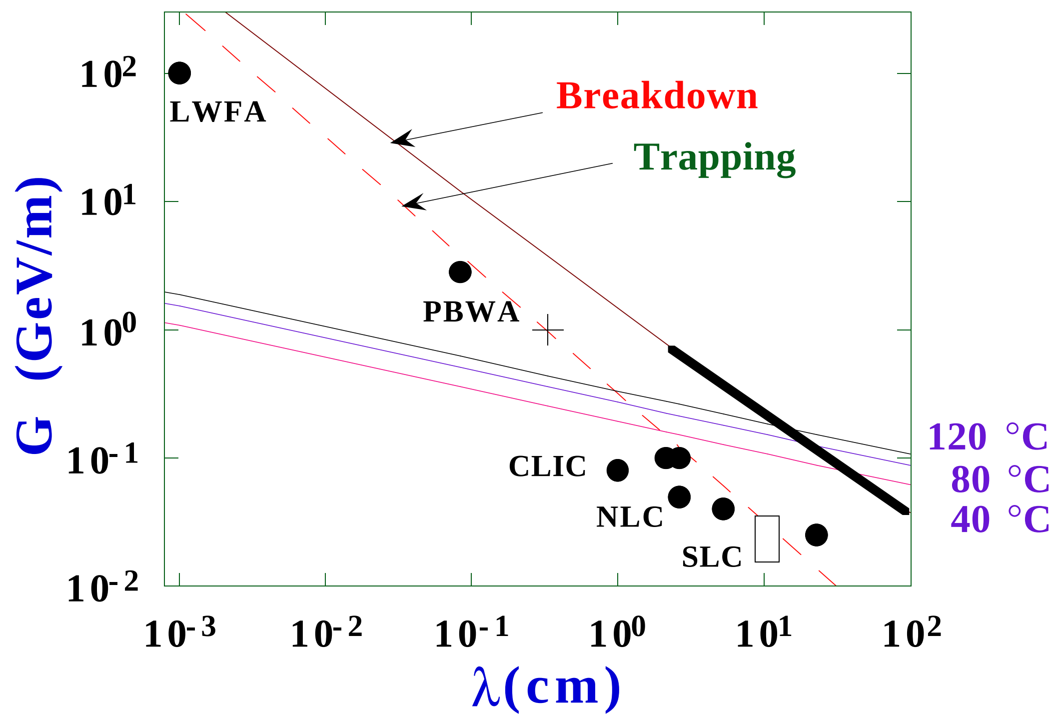
⇒The block marked "SLC" extends from 20MV/m as for a typical structure, to 40MV/m as for the capture section (1.5m section powered by one sledded klystron #20-3c)

⇒Actual Scalings Used are

$$G\left(\frac{GeV}{m}\right) = 0.25\left(\frac{\Delta T}{40°K}\right)^{1/2}\left(\frac{f}{91.4GHz}\right)^{1/4}$$ (ideal *[R/Q]*=221Ω)

$$E_{br} \approx 25\frac{MV}{m}f^{1/2}\left(1+2.7f^{3/8}\right)$$ (P. Wilson)

$G\lambda$=3.2MV (50% trapping fraction)



Breakdown
Trapping
LWFA
PBWA
CLIC
NLC
SLC
120 °C
80 °C
40 °C
G (GeV/m)
λ(cm)
10^2
10^1
10^0
10^-1
10^-2
10^-3