Hot Topic #2

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Is Niobium at the end of the road?

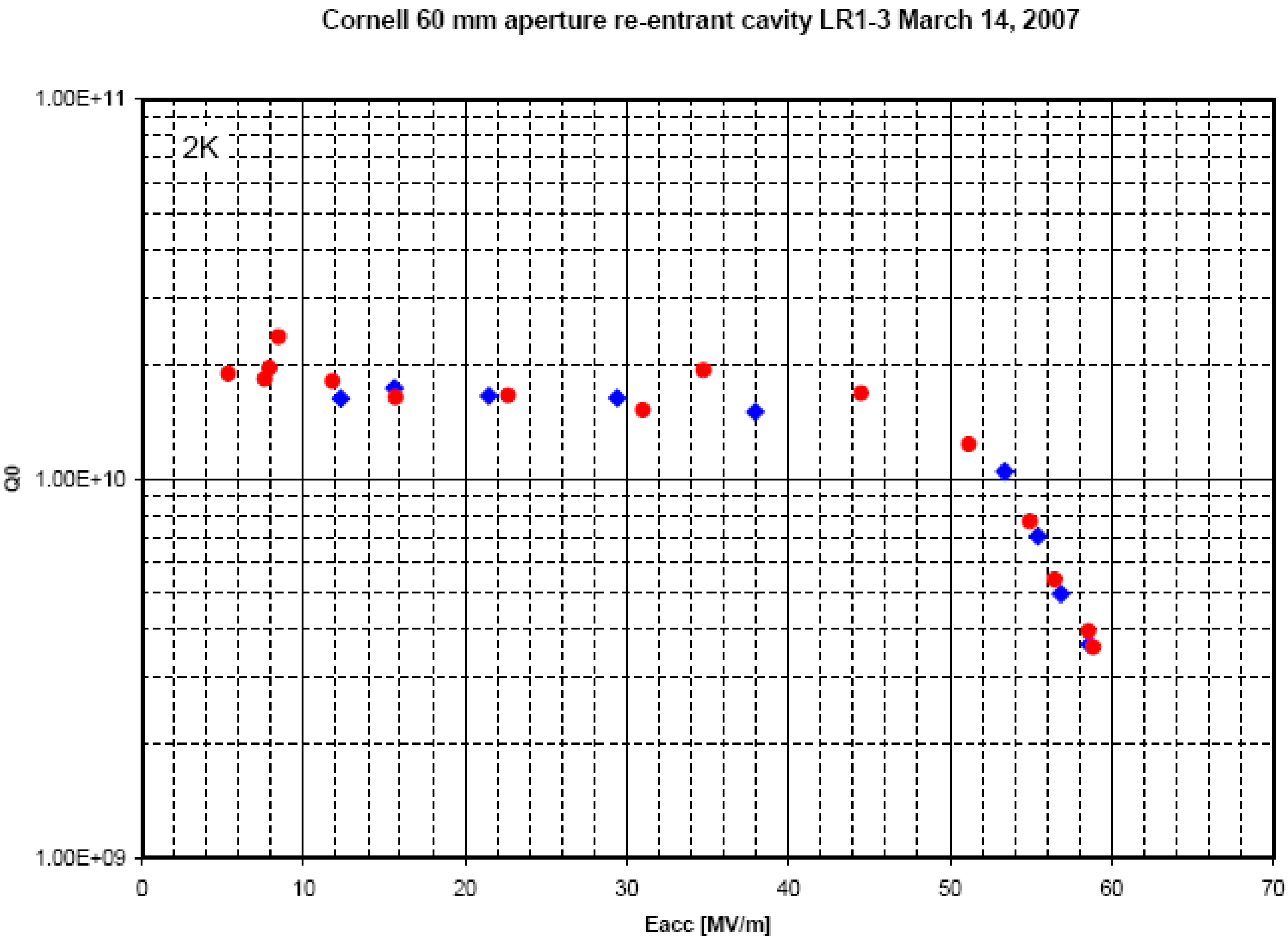
At what front should we do battle?

Is Nb at the end of the road? Absolutely not

- Critical field has been reached in a few cases, but:
- Technology far away from routinely reaching the limit, especially in multi-cell cavities
- Surface treatment (EP) and fabrication (EBW) are less than reproducible: still large spread in data
- FE is still the major problem
- For cw application Q-values (residual resistance) needs to be improved and reproducibly achieved
- The fact, that work is going on to improve surface

  - ALD, EP of various flavors, fabrication (seamless, LG,EBW), furnace treatments, baking in argon, Nb thin films.. – speaks for itself
- Major goal for large projects such as e.g.ILC should be reduction of costs

End of the road? [R.Geng etal]



At what front should we do battle?

- Obviously there is a tendency to explore other/better superconducting materials, because of lower costs,less sc material, cheaper structure (L.Phillips,3rd thin film workshop, Jlab 2008)
- The argument for doing this is often focussing on higher critical fields (multi-layers) and higher T_c (other sc materials), which implies higher Q-values??
- Is this true?

Choices among Superconducting Materials

- Nb compounds
- A15 compounds
- MgB2

Material	T_c (K)	ρ_n($\mu\Omega$cm)	$H_c(0)$ [T]	$H_{c1}(0)$ [T]	$H_{c2}(0)$ [T]	$\lambda(0)$ [nm]
Nb	9.2	2	0.2	0.17	0.4	40
NbN	16.2	70	0.23	0.02	15	200
NbTiN	17.5	35		0.03		151
Nb_3Sn	18	20	0.54	0.05	30	85
V_3Si	17					
Mo_3Re	15		0.43	0.03	3.5	140
MgB_2	40		0.43	0.03	3.5	140

Other Superconductors

Nb_3Sn:

Most explored alternative material; most successful process:

Vapor diffusion

Siemens : ~ 110 mT in TE cavity (X-band)

Uni Wuppertal (M.Peiniger, thesis): process improvement, multi cell cavities; E_{acc} ~ 10 MV/m

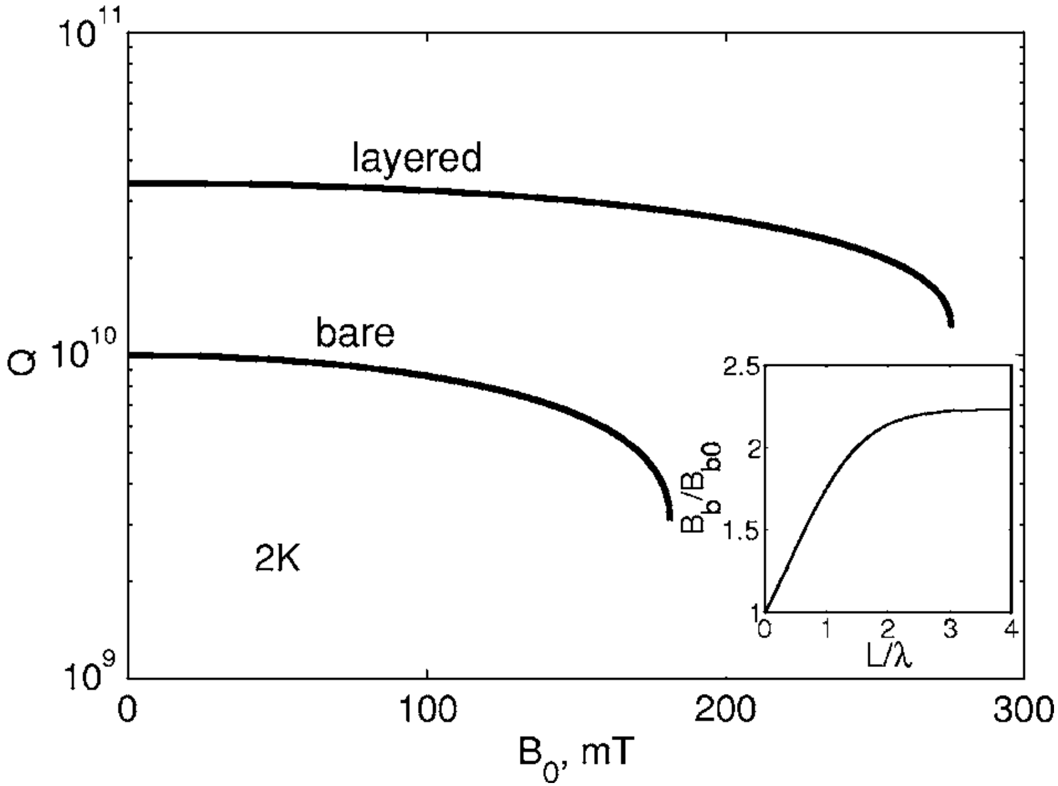
Uni Wuppeertal/SLAC: pulsed

Uni Wuppertal/Cornell: HPP

Wuppertal/Jlab(G.Mueller et al, Abano Terme): single cell and multi-cell 1.5 GHz cavities,High Q's at lower fields, strong dependence of Q on field, reason for stopping development

INFN: co-sputtering and reaction, dipping in liquid tin bath

Multi Layer [A. Gurevich, APL 88 (Jan.2006)]



Shown in Fig. 3 is an example of *QB0 calculated from* Eqs. 11–14 for bare and 50 nm Nb3Sn clad Nb cavities at 2 K for =2, *Rb=20 n, R0=2 n at 2 K, s=0.215, D*=3 mm, *h=5 kW/m2 K, =10 W/mK, and* $Q_0^{Nb}=10^{10}$. In this case a 50 nm Nb3Sn overlayer more than triples *Q at* low field and increases *Bb from 180 mT to 280 mT,*
while a 100 nm multilayer more than doubles *Bb to* 340 mT, as shown in Fig. 3. For a 100 nm multilayer, *Bb is* twice of *Bc* Nb, but still lower than *Bc=540 mT of Nb3Sn.*

Other considerations

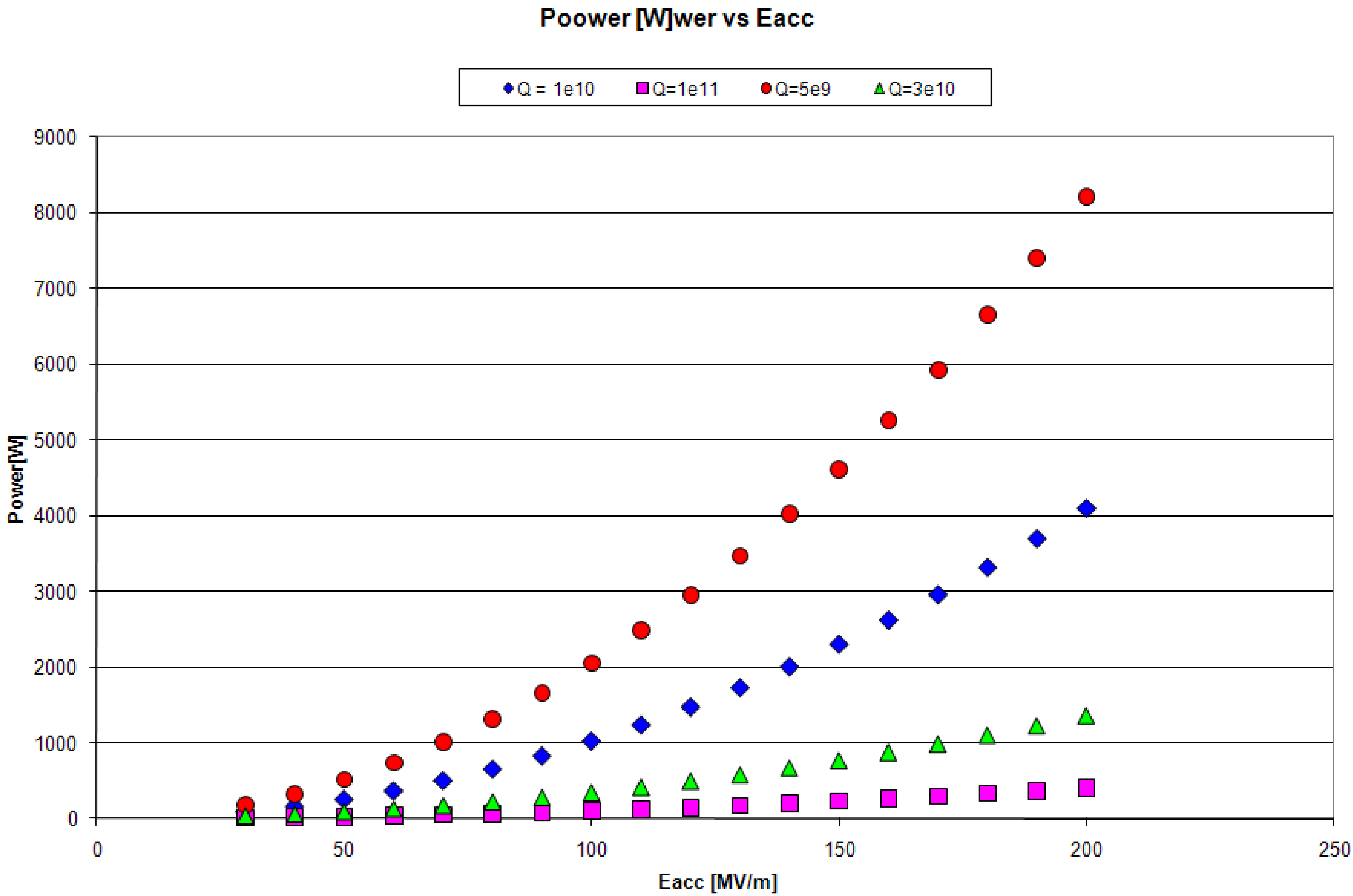
- Residual resistance
- Field dependence of Q
- Surface electric fields : field emission
- Thermal stability: substrate material
- Frozen-in flux due to e.g. MP
- Lorentz force detuning: typically – 2 Hz/(MV/m)^2

  at E_{acc} ~ 100 MV/m : detuning 20 kHz

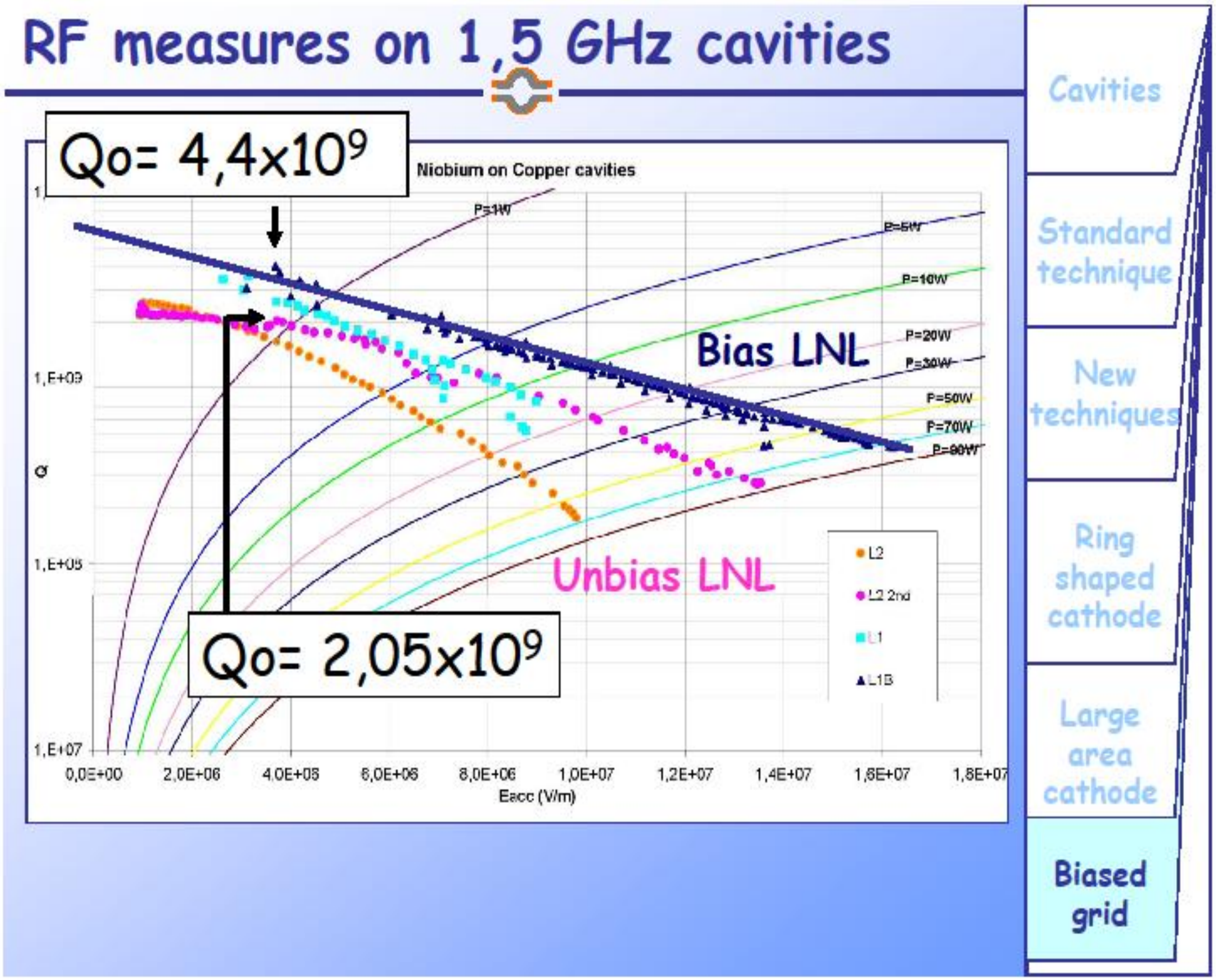
  at Eacc ~ 200 MV/m: detuning 80 kHz at BW of ~ 100 Hz
- What duty cycle is reasonable?
- High Power Input couplers, coarse and fine tuners?
- High T_c : How valid is the claim to operate at 4.2K?

  Thermal stability, heating,

Power Dissipation



G.Lanza, 3rd Thin film workshop



Final Remark

- There is plenty of development work necessary for the application of bulk Niobium
- Most important: reproducibility, cost reduction
- Alternative materials:

  Okay to learn more about physics – good for PhD's, ethically questionable to "sell" these materials for accelerator application in the near future
- Nb technology development started 1963 and hundreds of mill. of $ have been spent until now