Thermal & Statistical Models for Quench

Joshua Wiener and Hasan Padamsee

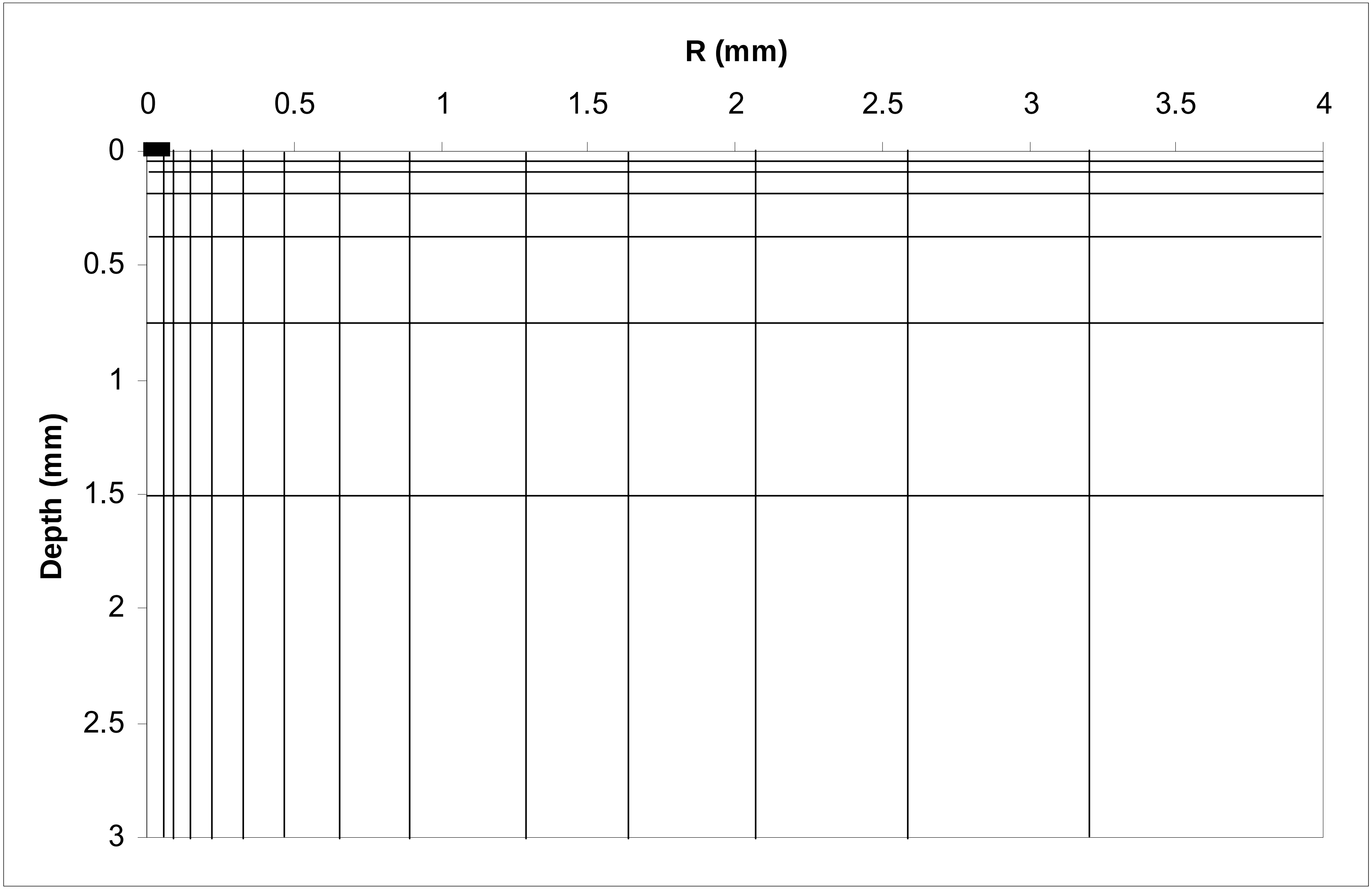
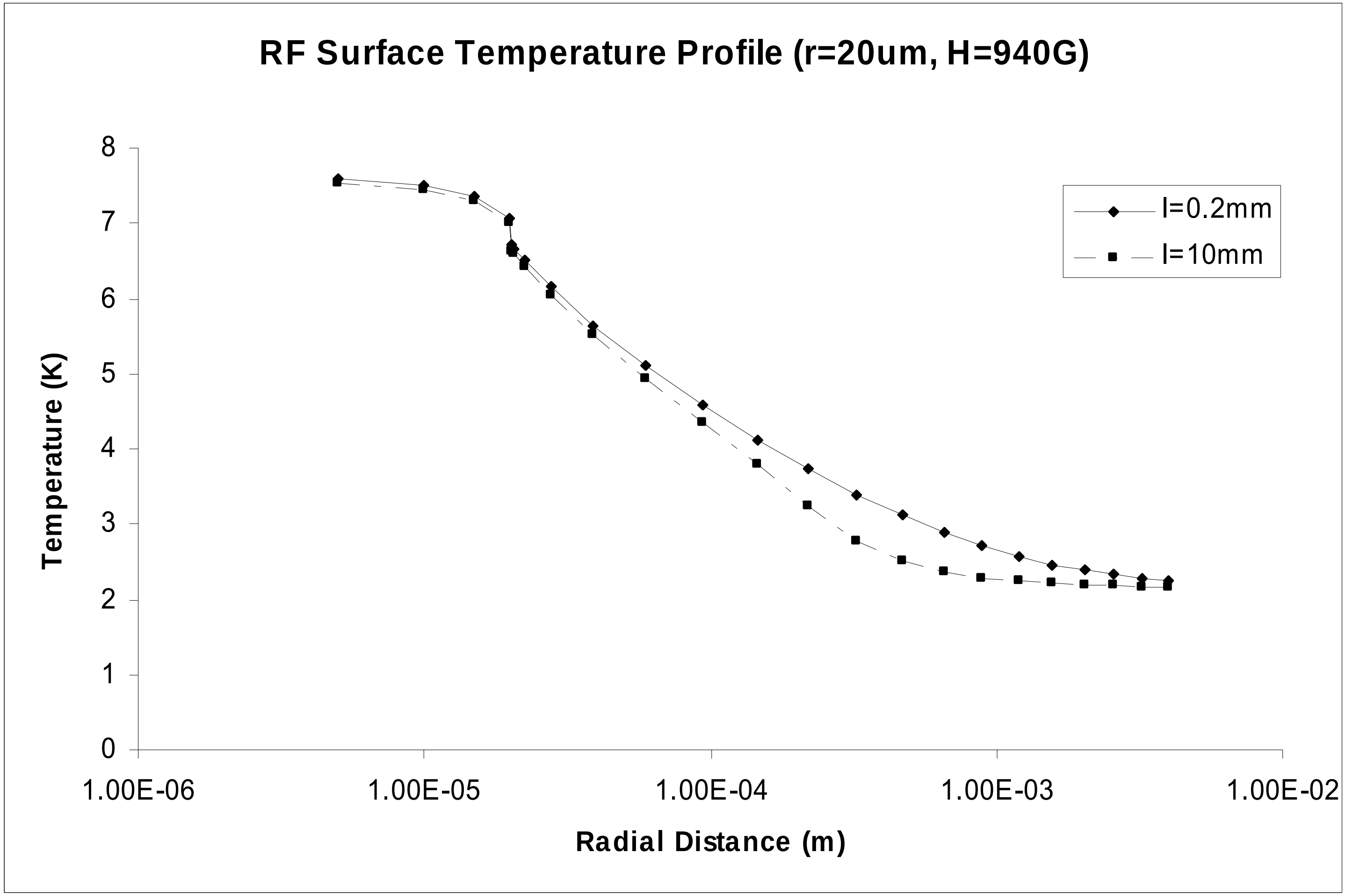
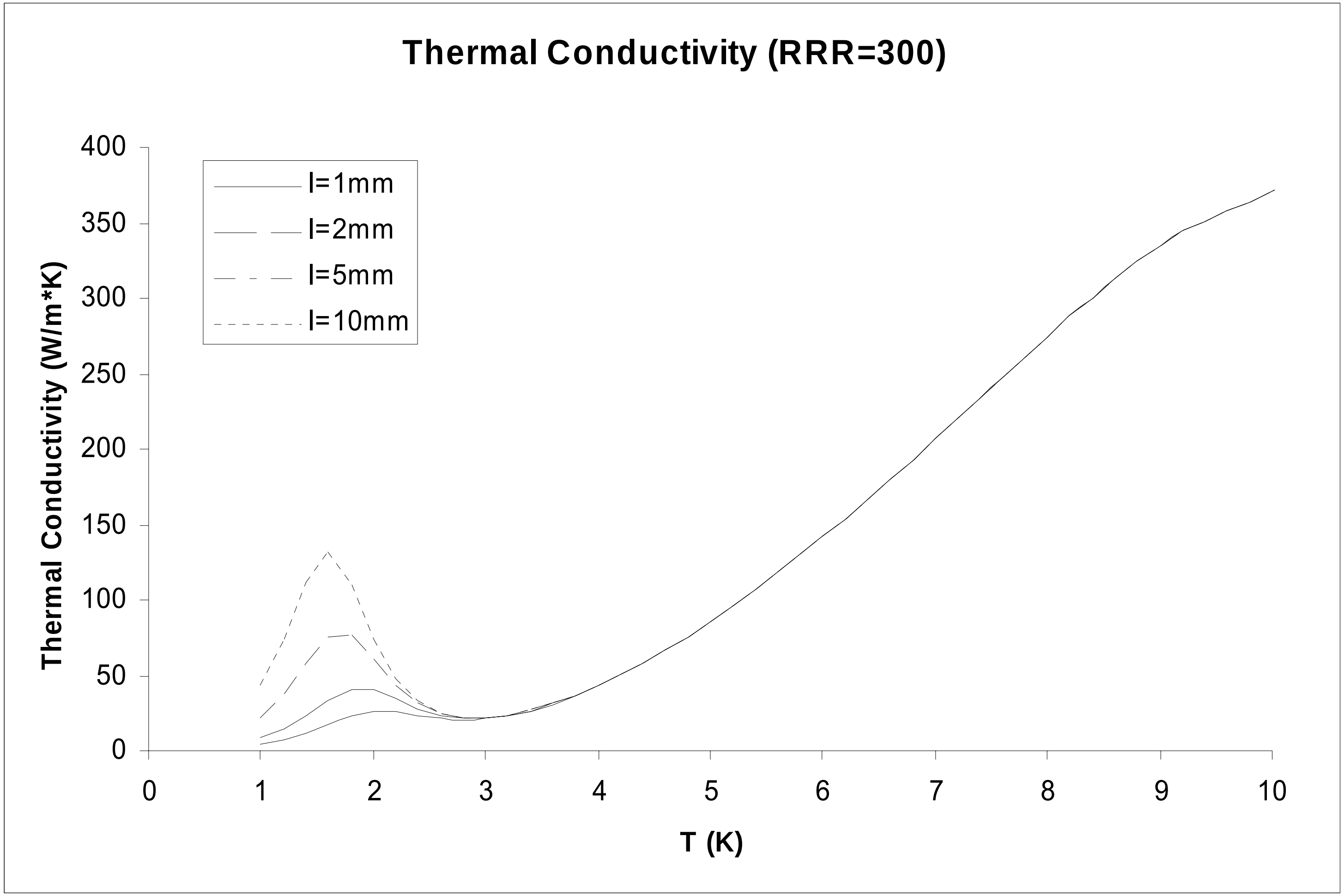


Figure 2: The 2D mesh. The defect is in the upper left corner. Gridlines closest to the edges are not shown.

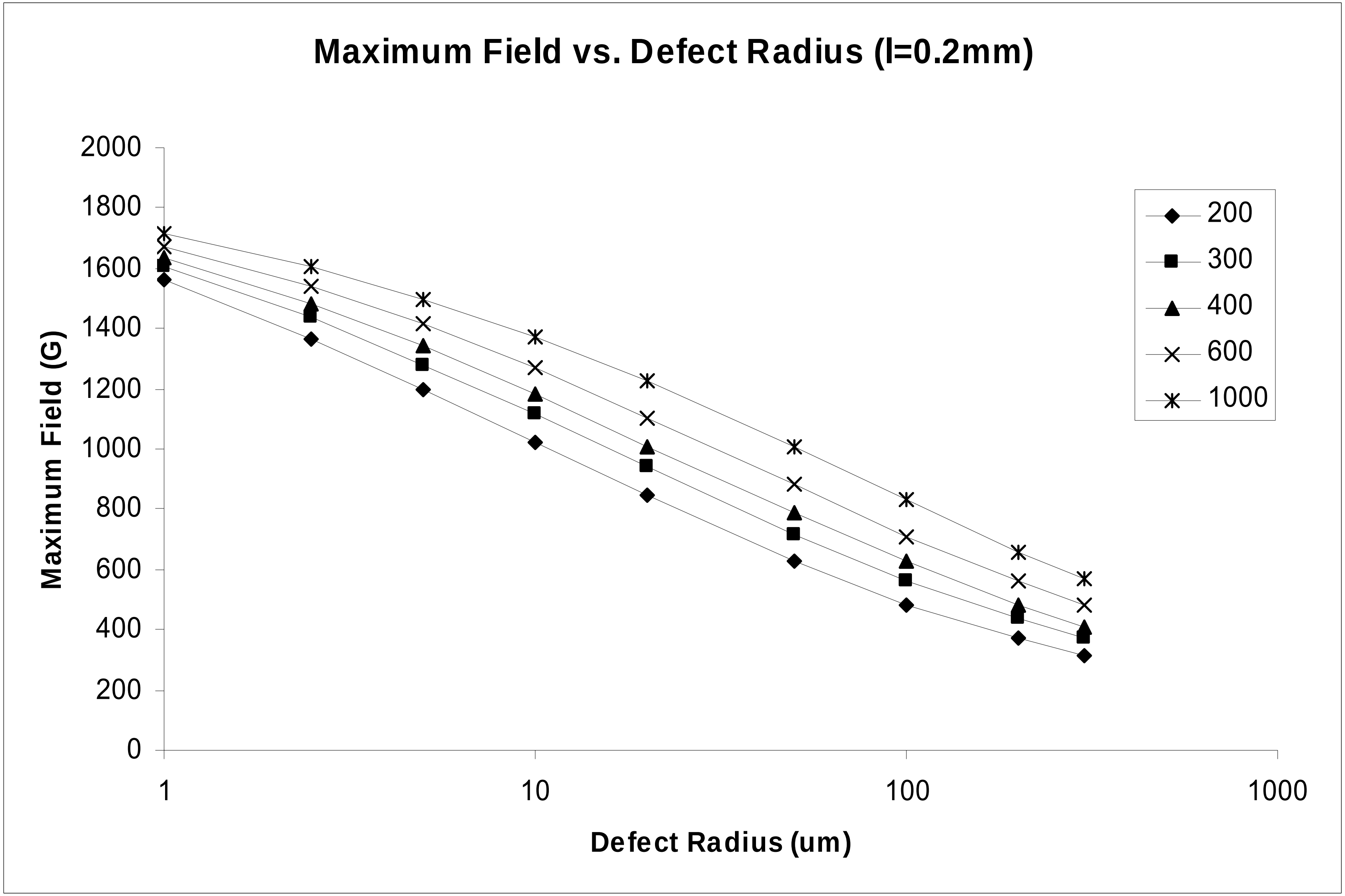
Temperature Profile Comparison For A 20 μm Radius Defect With Small And Large Phonon mfp.



Thermal conductivity with different values of phonon mean free path *l*.

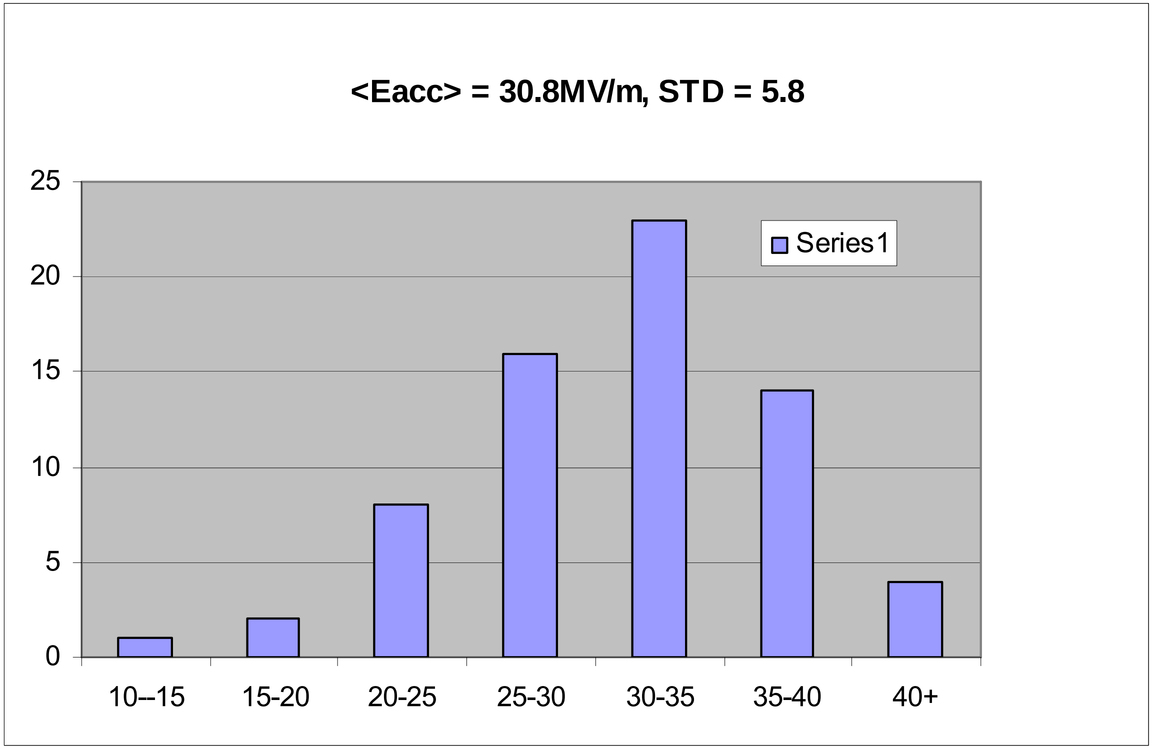


- Hcrit (T= 0 K)= 2000 Gauss



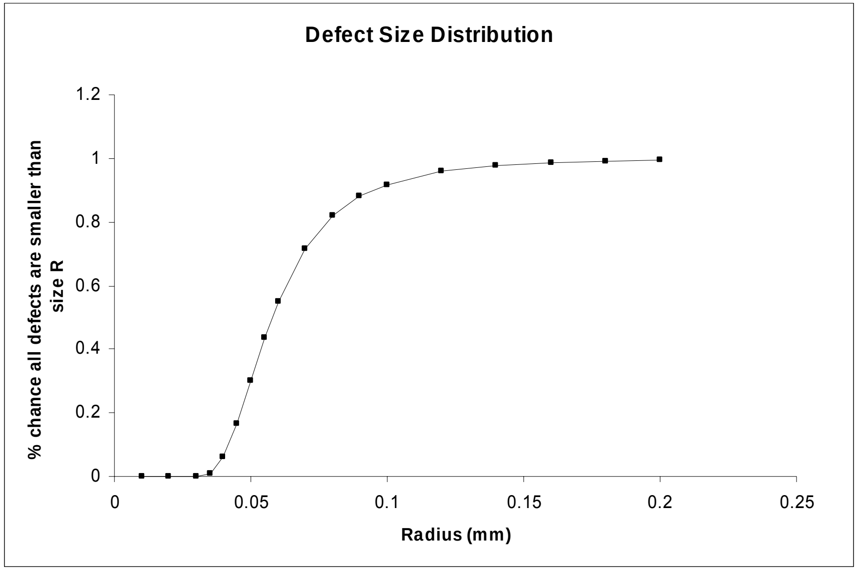
What Is The Distribution Of Defect Sizes That Gives Rise To an Observed Quench Distribution?

- Consder DESY cavities prepared by EP, HPR and bake that show quench
- 66 Tests On 51 Cavities
- From DESY Cavity Data Base



Statistical Model

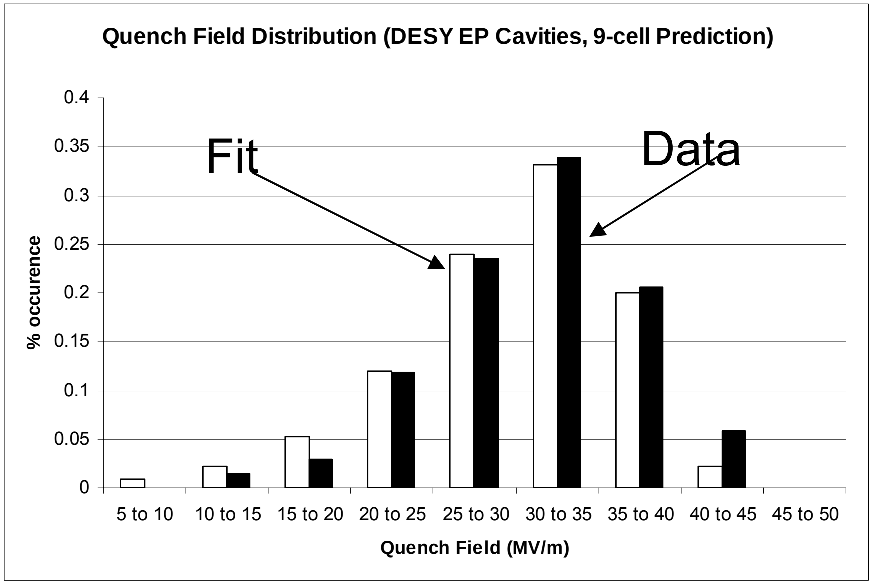
(adapted from H. Safa)

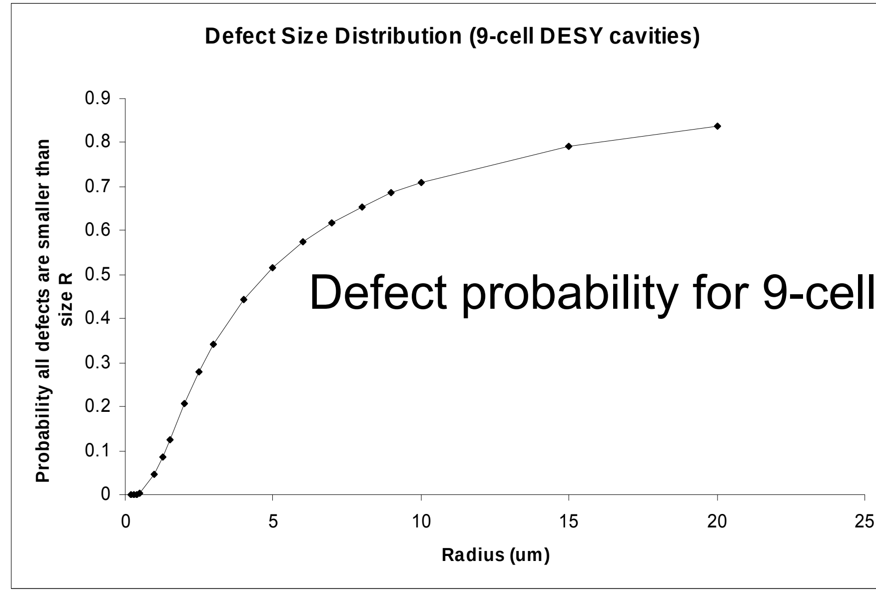


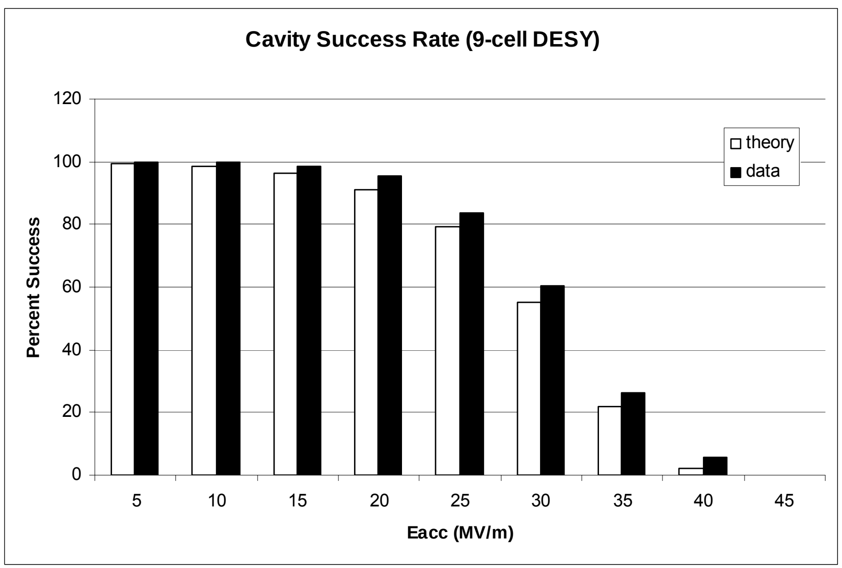
- Let $p(r, S)$ be the probability that all defects on an area S of niobium have radius less than r.
- $p(r, 2S) = [p(r, S)]^2$ since an area of $2S$ can be split up into two areas with area S.
- => $p(r, S)$ is exponential in S.
- $p(r, S)$ must increasing with r, approaching 1 as r gets larger
- and 0 as r nears 0.
- From these features, Safa assumes a general form of
- $\mathbf{p(r, S) = \exp[-(S/S_0)(r_0/r)^m]}$.
- The value of S_0 is arbitrary and normalizes the cavity area.
- S_0 is set to the area of a single-cell 1.3 GHz cavity.
- The values of r_0 and m determine the shape of the defect dist. curve

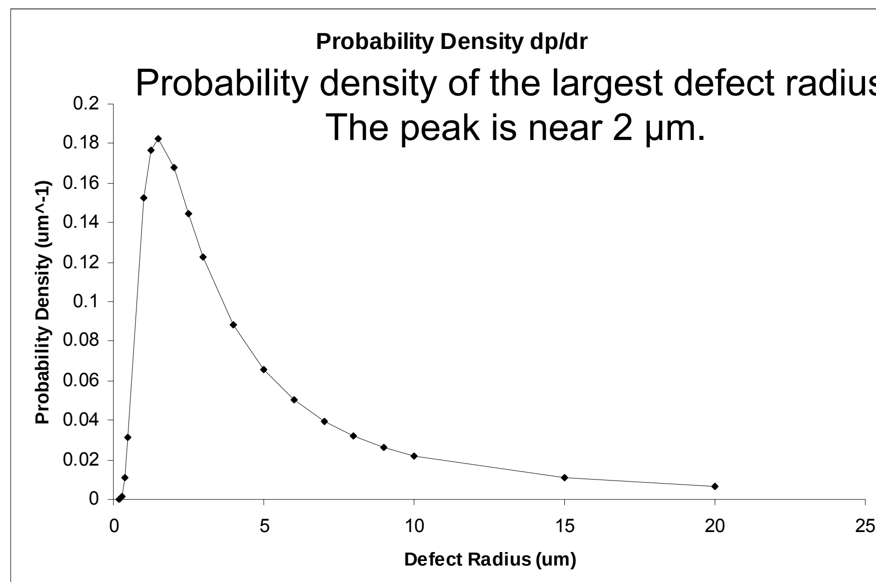
Results: 66 Tests On 51 Cavities: DESY EP Cavities limited by Quench

Preparation: EP, 800C, EP HPR bake (a few cases of flash BCP included)

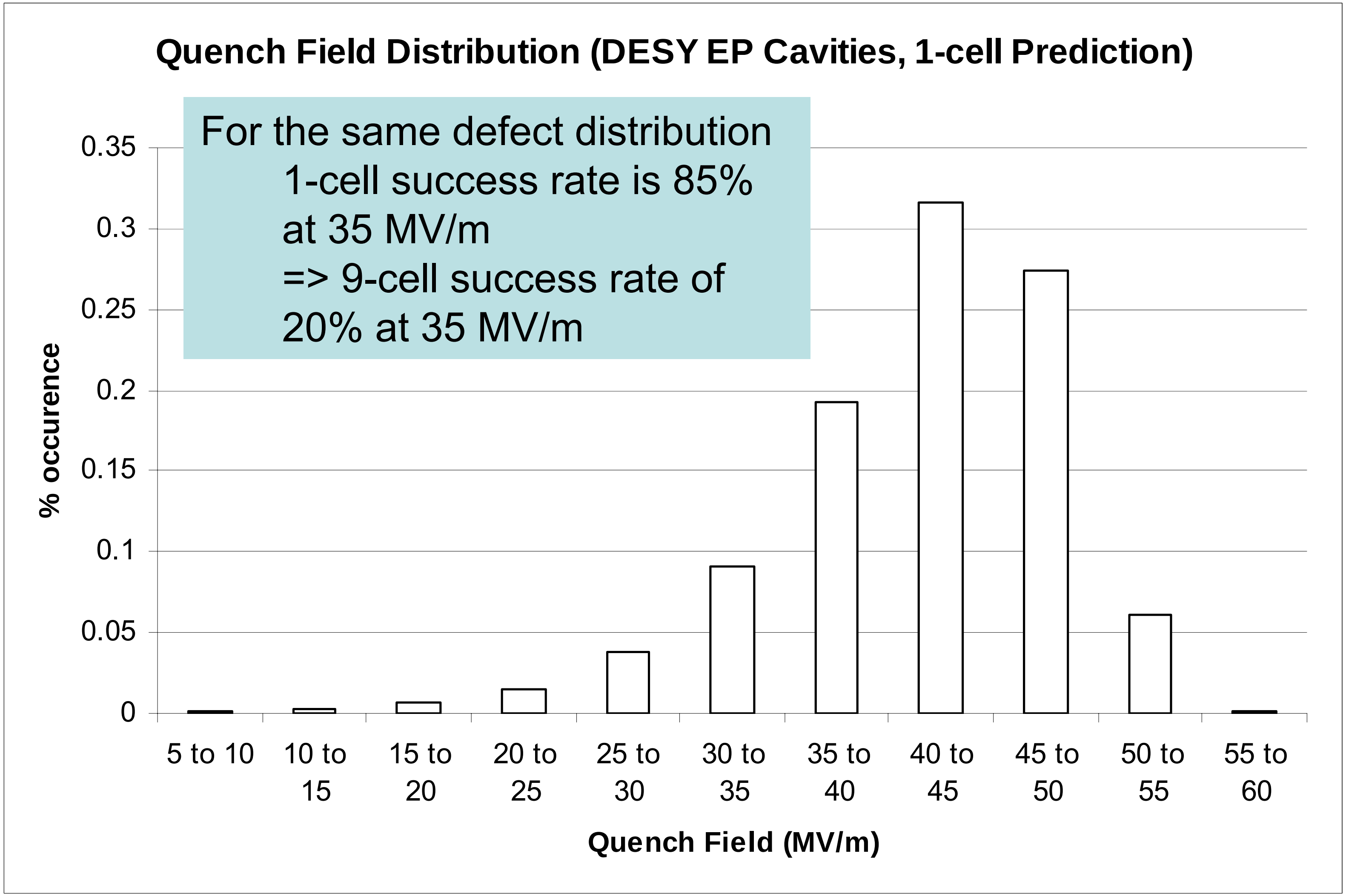








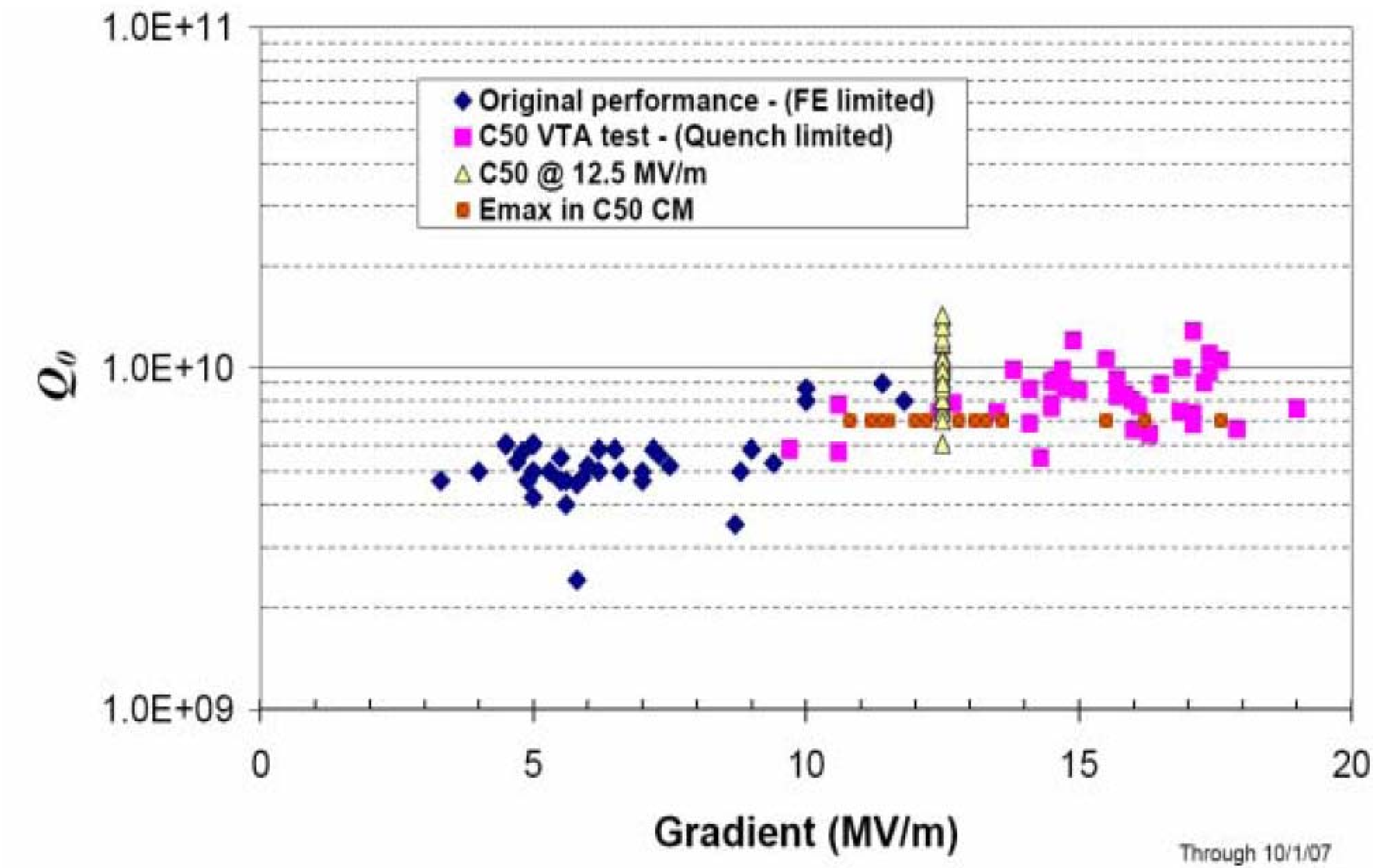
Area Effect: Expected 1-cell Gradient Distribution for the Same Defect Distribution



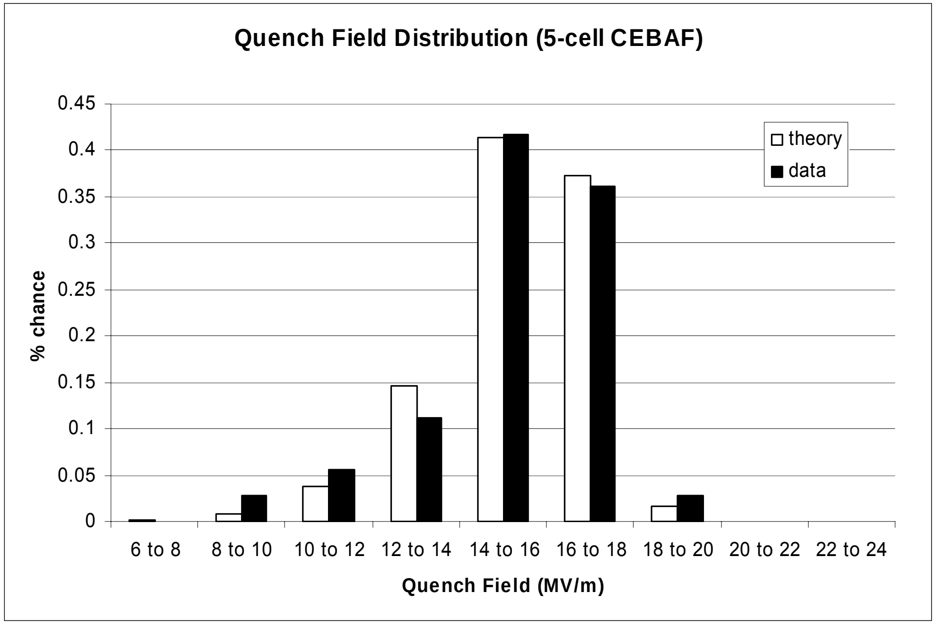
Compare with BCP Treated Cavities

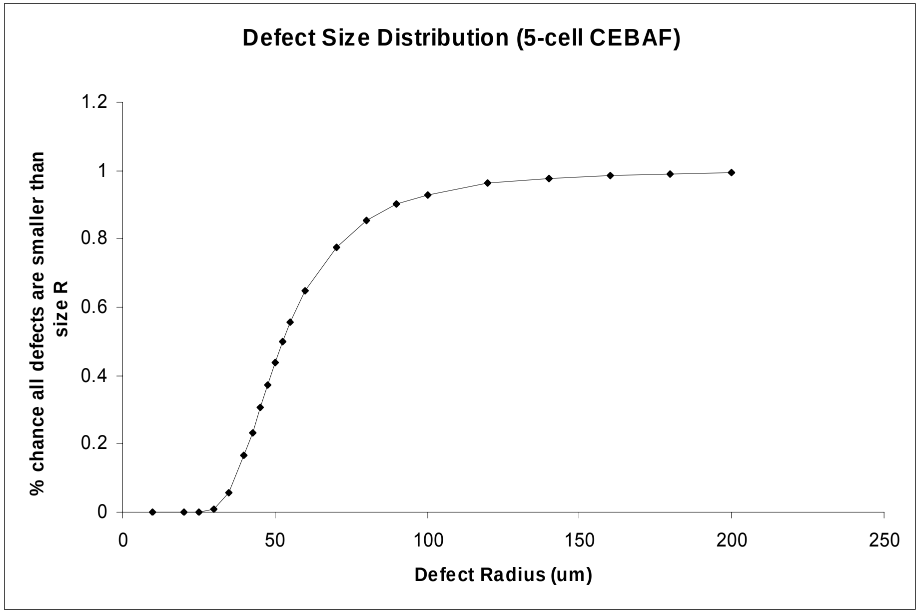
- From Jlab and DESY

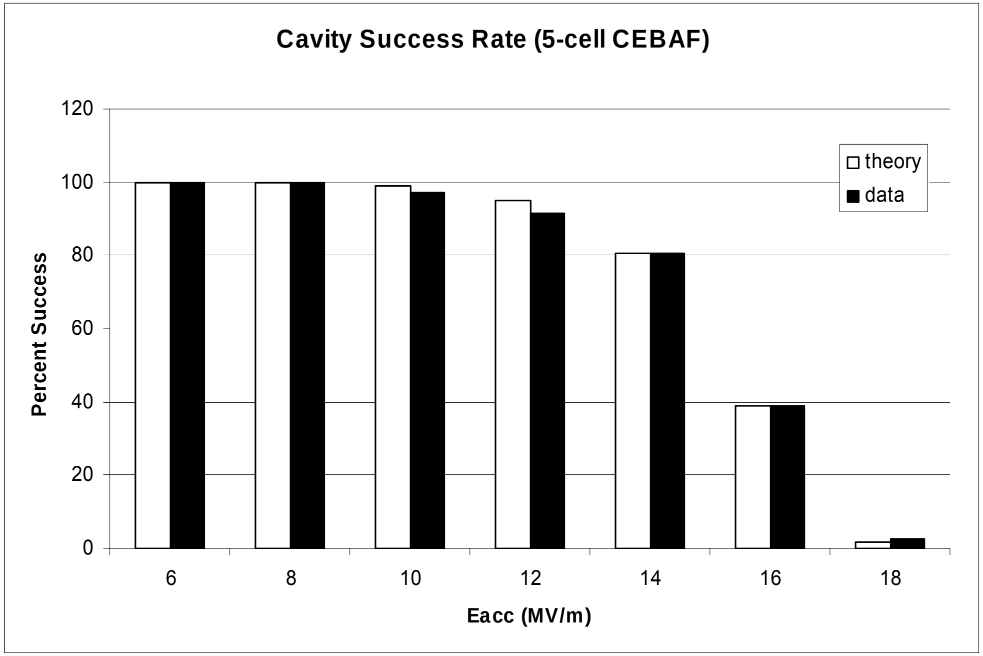
CEBAF cavity test quench data,
Fabricated in 1990's, RRR = 250 material, BCP, NO HPR
Re-processed in 2007, Re-BCP, 600 C HT, and HPR, 35 tests.

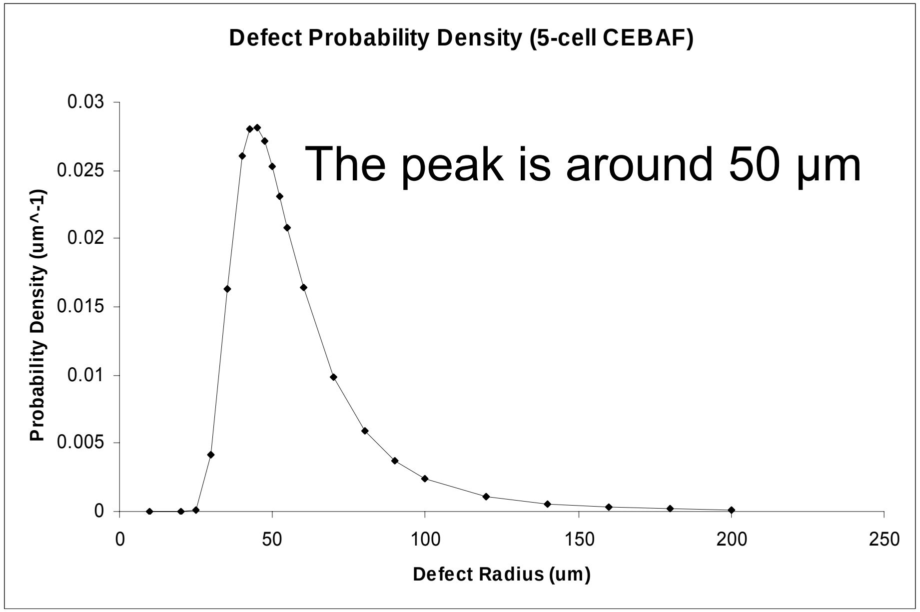


CEBAF BCP Cavities, Quench Limited

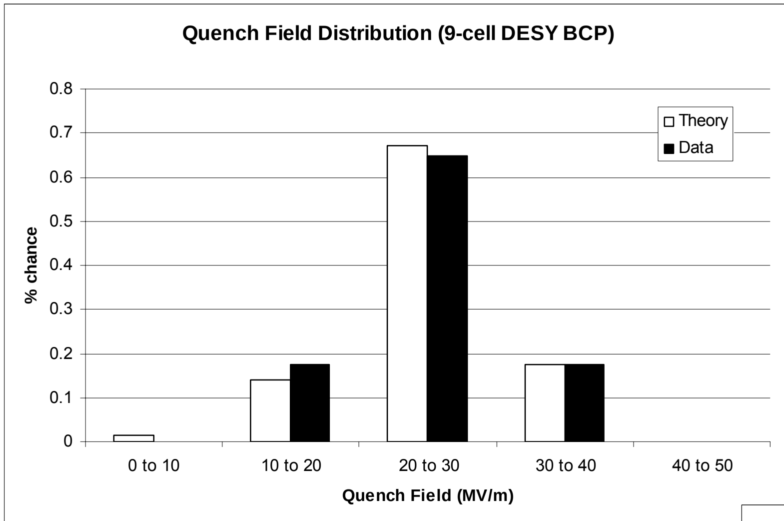




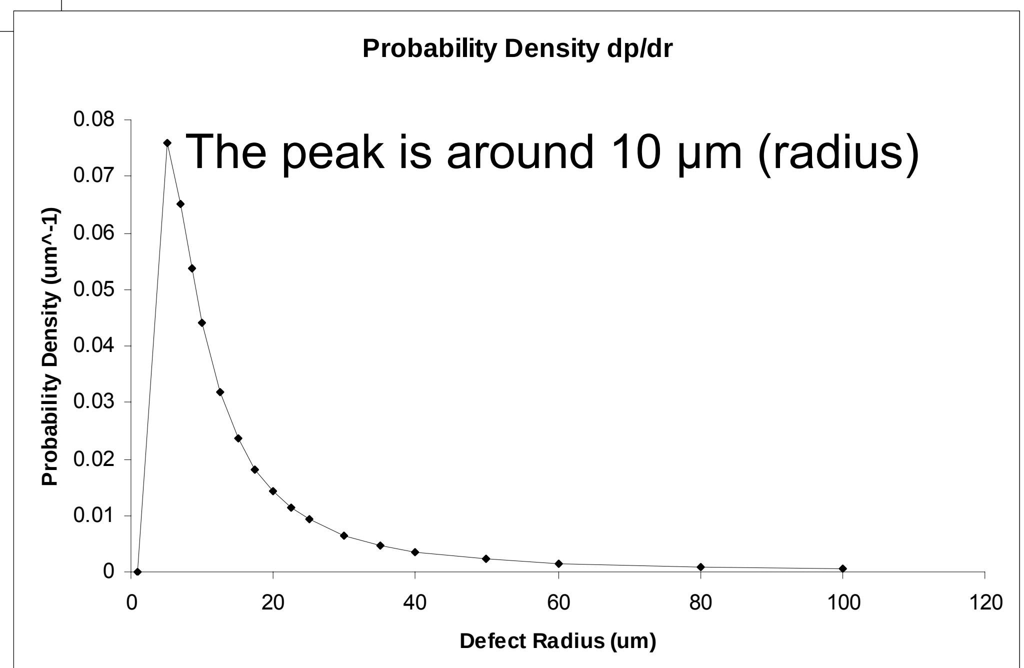




DESY BCP Treated Cavities (including 800 C HT)

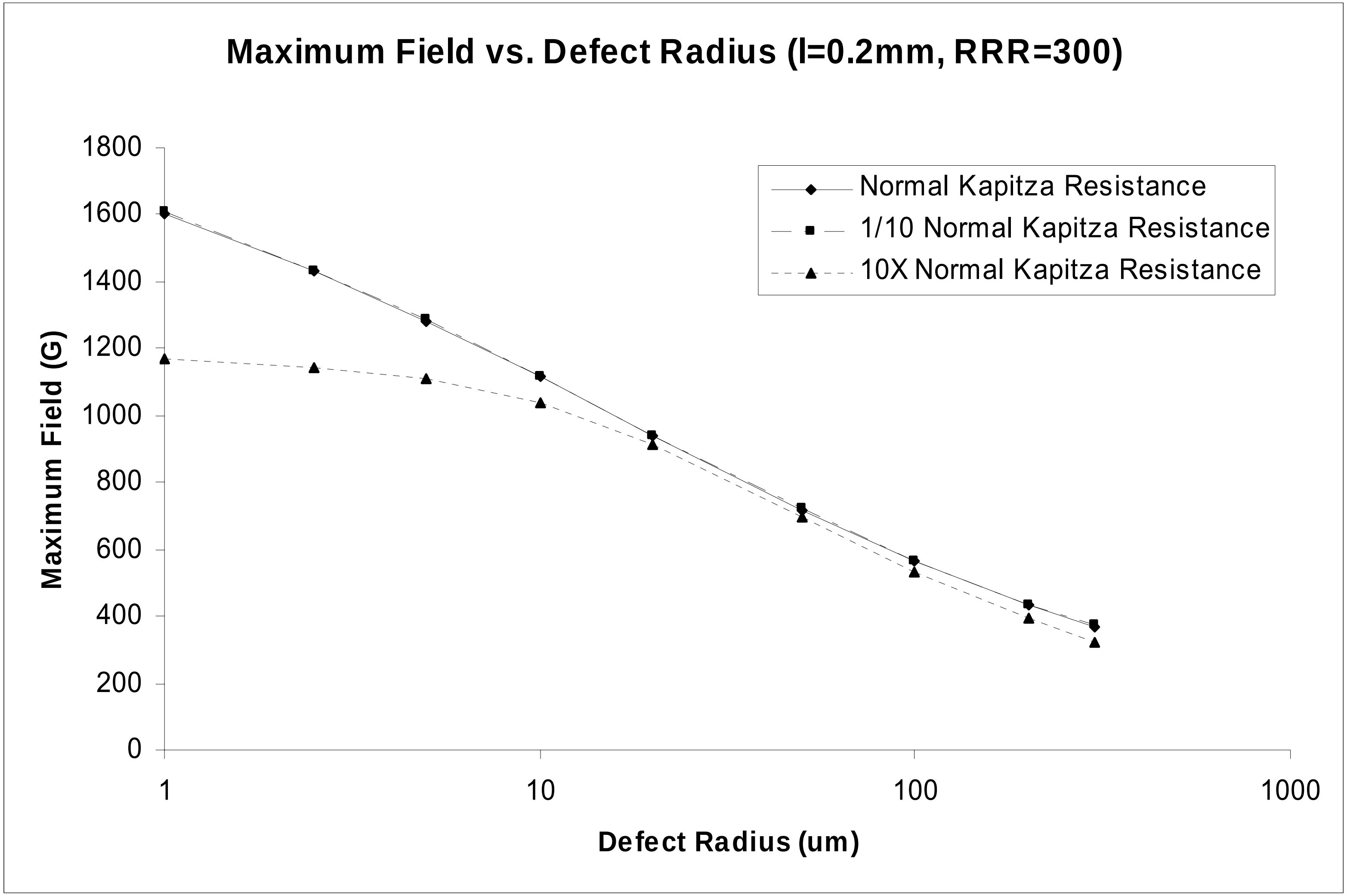


- Possible reasons for improved quench field for same BCP treatment
- Better material
- Screening by eddy current
- Better welding



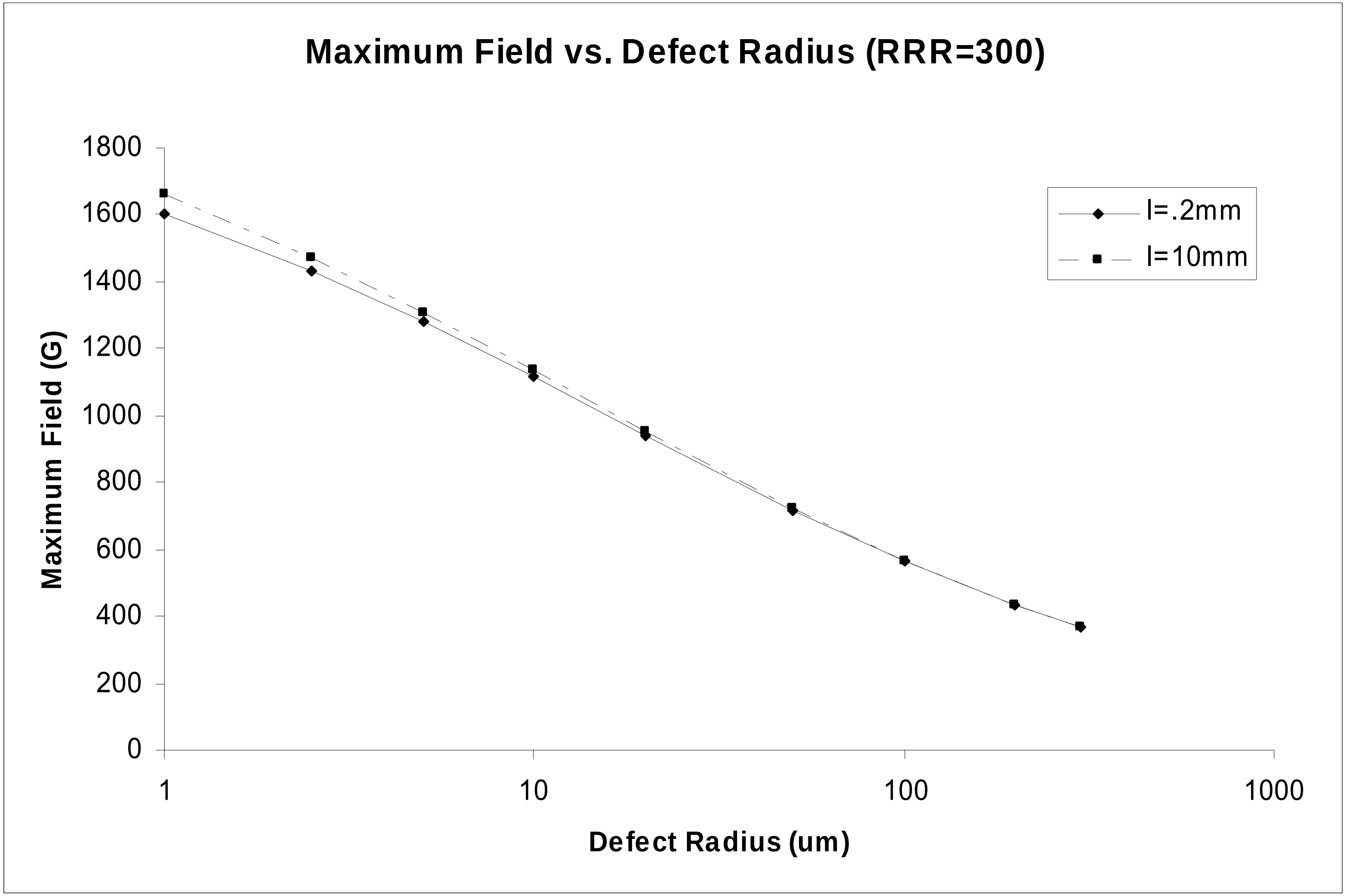
Other Useful Predictions of Thermal Model

- Quench field for good cavities can decrease if Kapitza resistance increases significantly
  - E.g.Poor outside surface quality
- Phonon peak can raise quench field by 12%
  - if bath temperature is lowered to 1.6 K

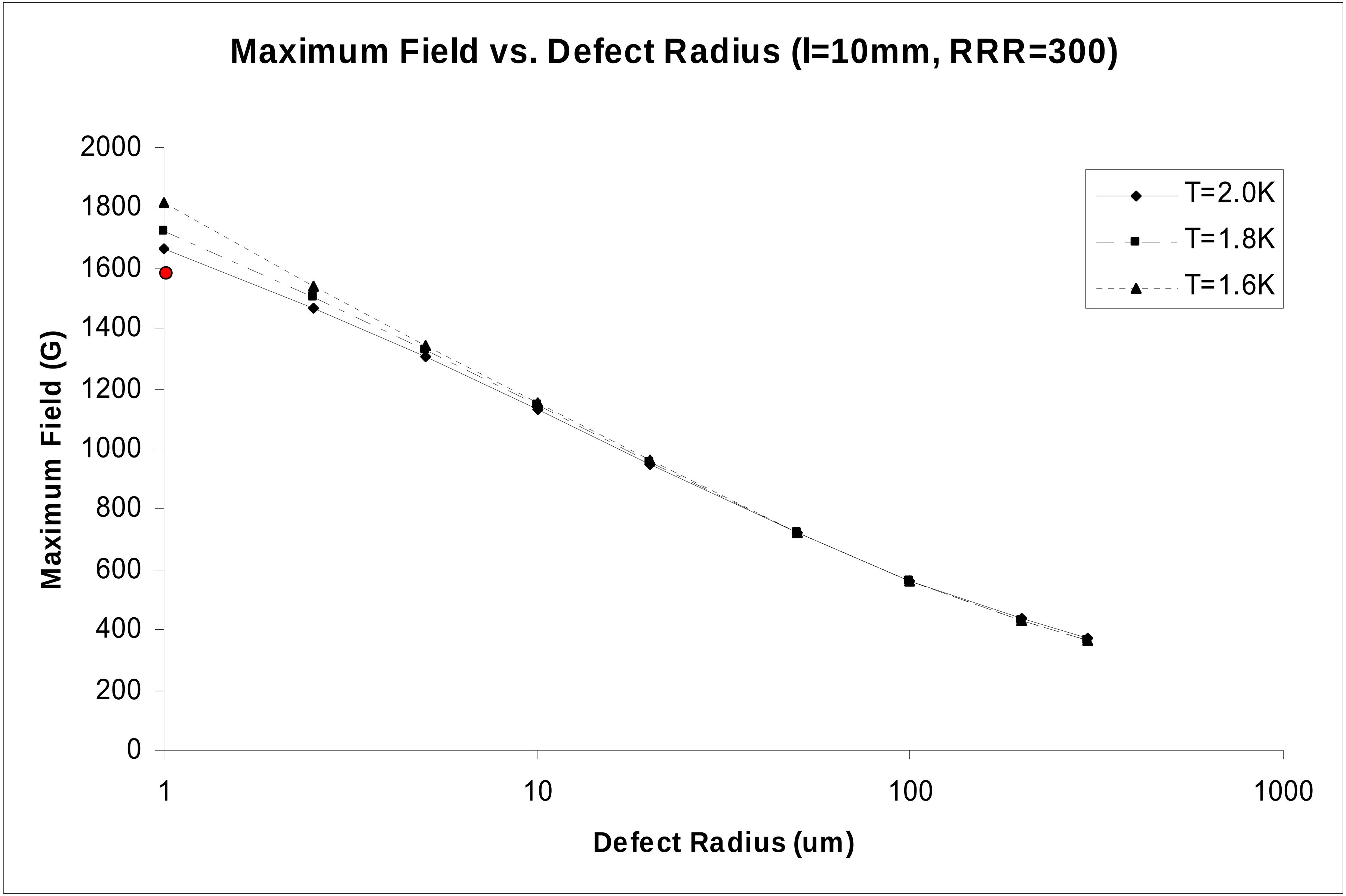


Maximum Field vs. Defect Radius (l=0.2mm, RRR=300)
Normal Kapitza Resistance
1/10 Normal Kapitza Resistance
10X Normal Kapitza Resistance
Maximum Field (G)
1800
1600
1400
1200
1000
800
600
400
200
0
1
10
100
1000
Defect Radius (um)

2 K operation



1.6 K operation



End