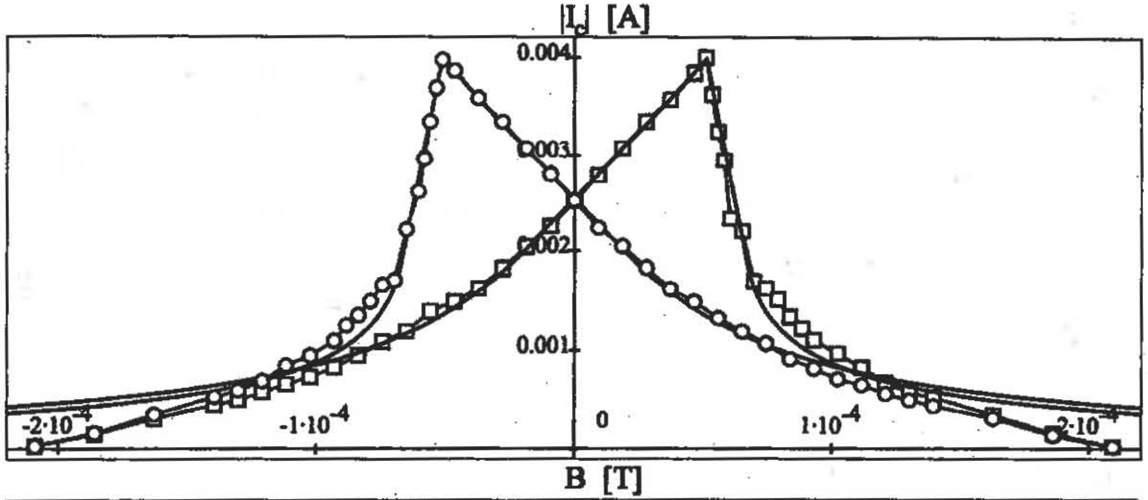
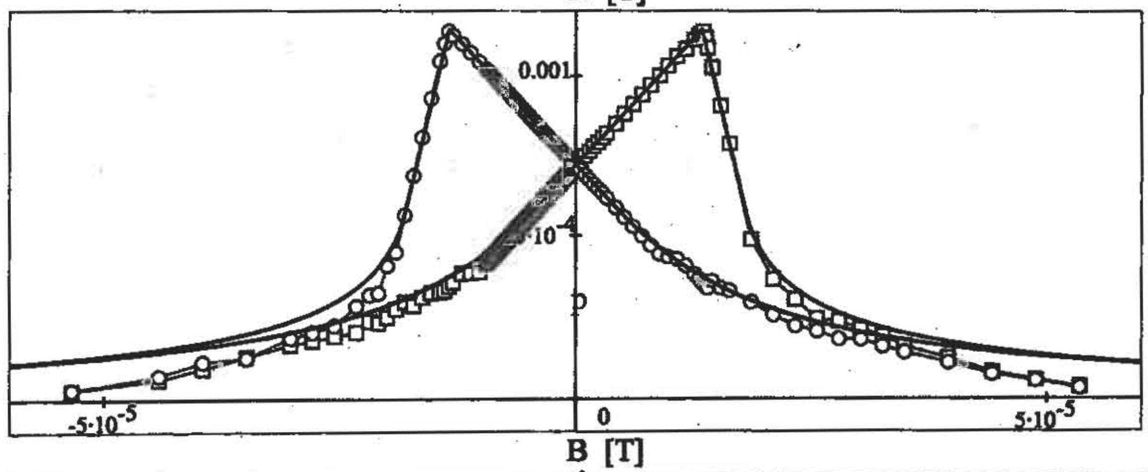
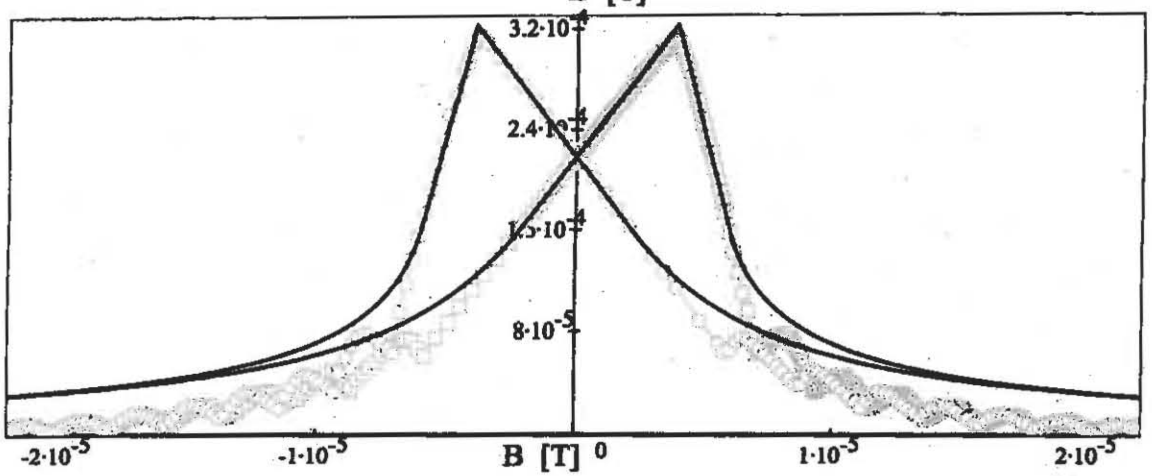
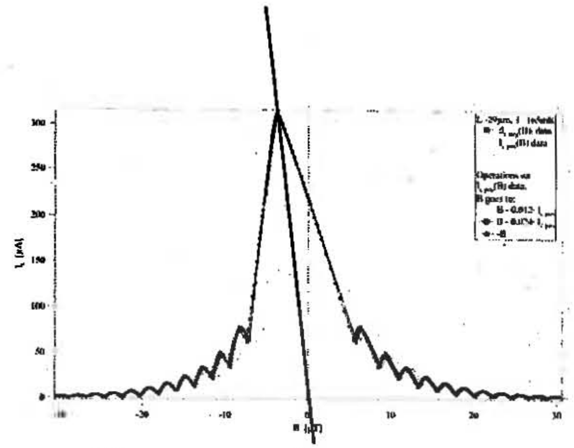
Magnetic field dependance of the critical current in S/N bilayer thin films

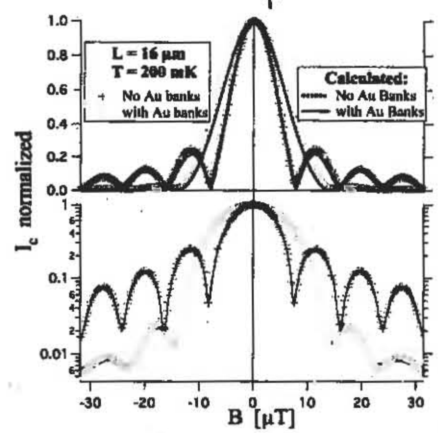
Jack Sadleir

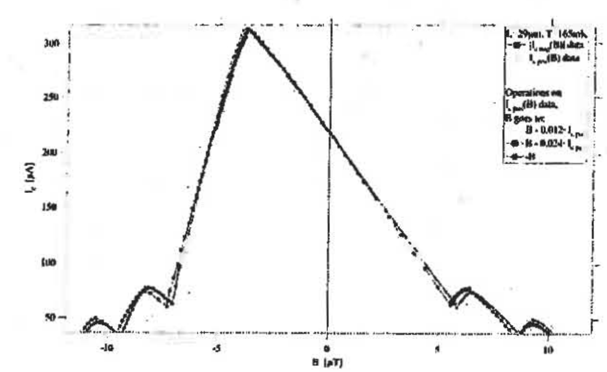

|I_c| [A]
0.004
0.003
0.002
0.001
-2·10^-4
-1·10^-4
0
1·10^-4
2·10^-4
B [T]

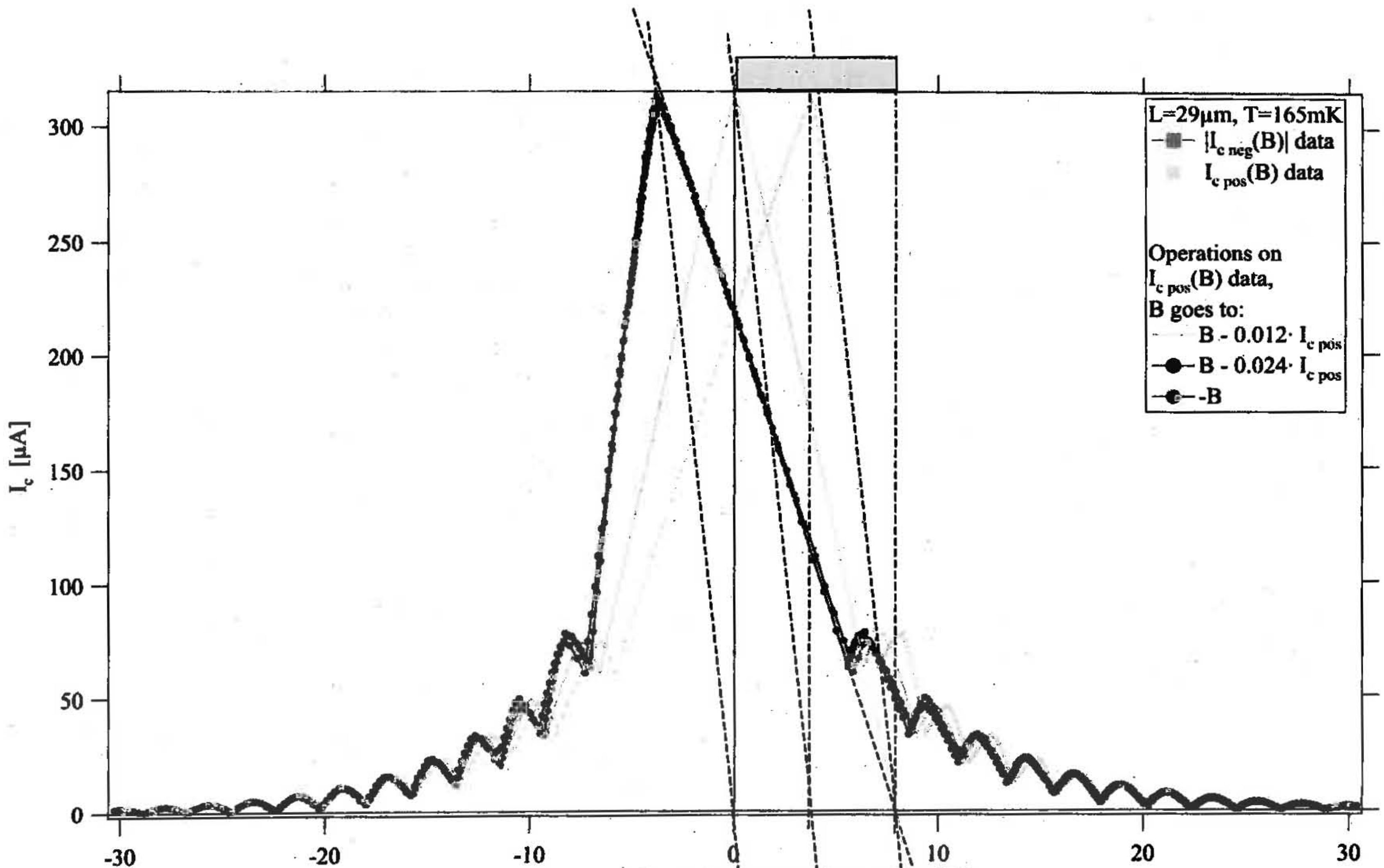

0.001
0
-5·10^-5
5·10^-5
B [T]


3.2·10^-4
2.4·10^-4
1.5·10^-4
8·10^-5
-2·10^-5
-1·10^-5
0
1·10^-5
2·10^-5
B [T]




L = 16 μm
T = 200 mK
No Au banks
with Au banks
Calculated:
No Au Banks
with Au Banks
I_c normalized
B [μT]





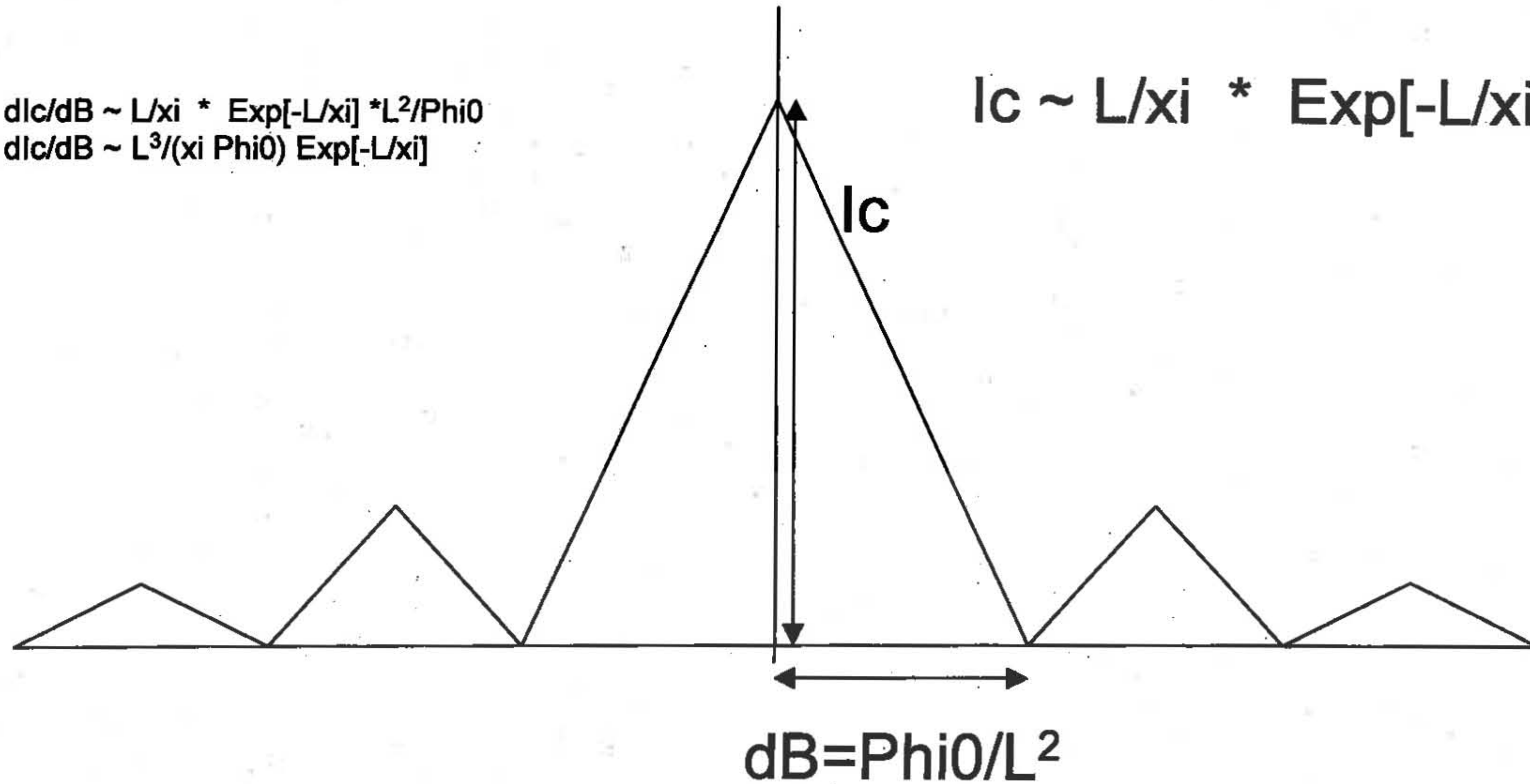
It would follow the minimum value of the intersection of Ic(B) with B = Btot= Ba+gI line with the line B=Ba=gI

smaller thermal G less bias current less self-fielding should be able to take a larger g before becoming double valued.

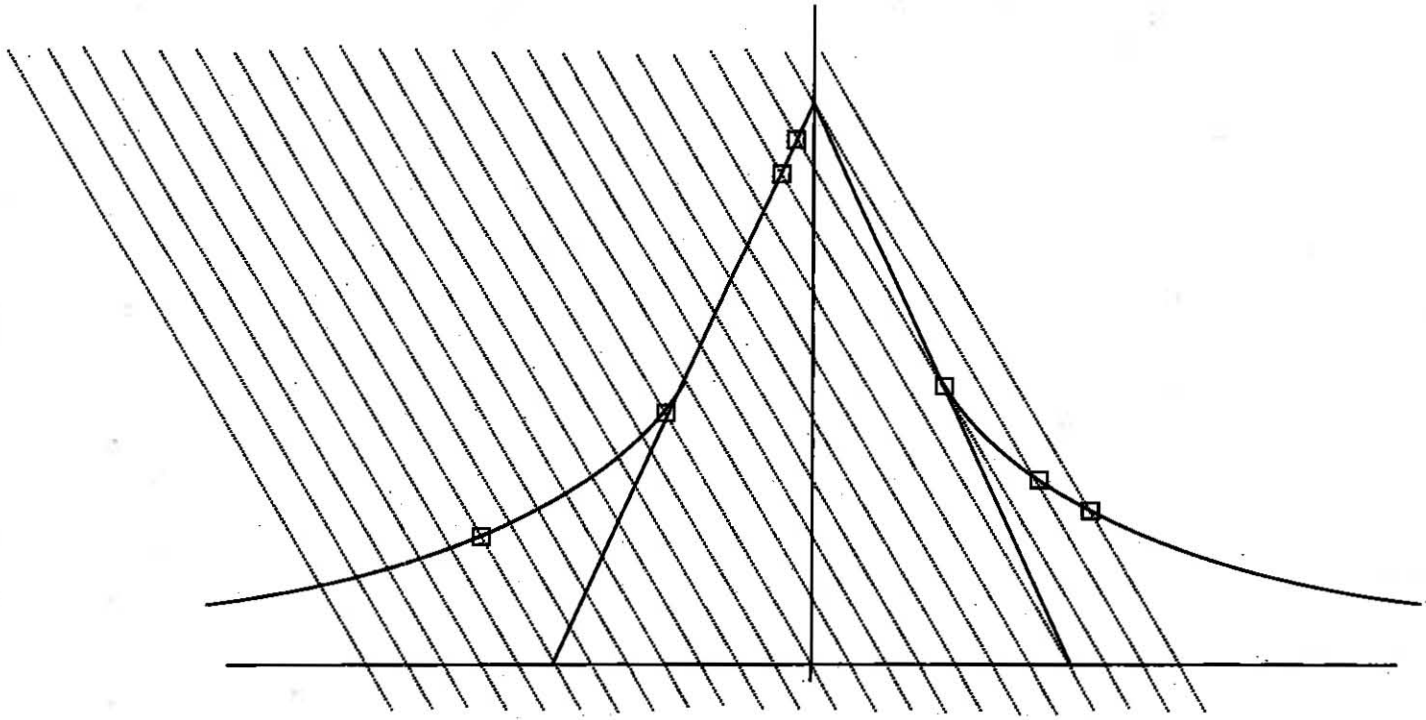
dIc/dB ~ L/xi * Exp[-L/xi] *L^2/Phi0

dIc/dB ~ L^3/(xi Phi0) Exp[-L/xi]

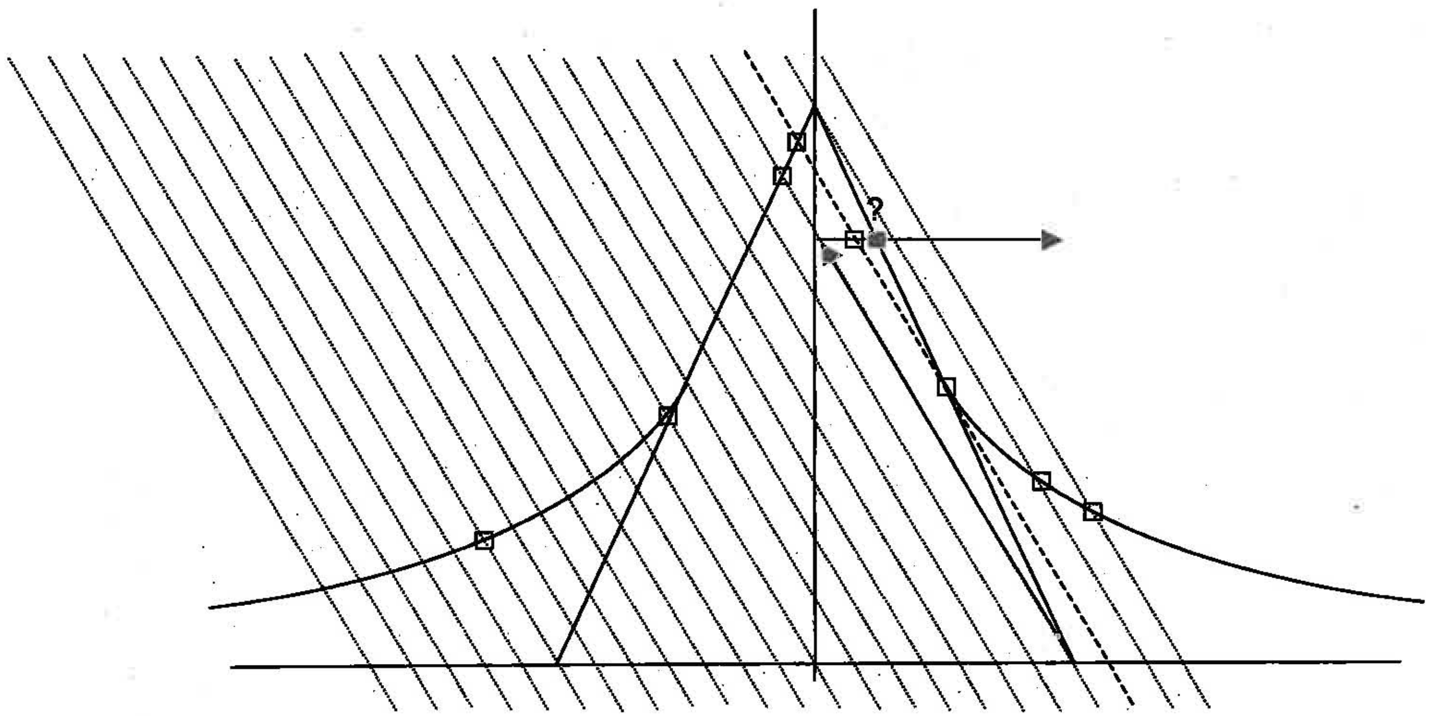
Ic ~ L/xi * Exp[-L/xi]



Ic~L/xi * Exp[-L/xi]



Plot I_{TES} vs B_{tot}



Self-field trajectories. Larger self-fielding factor g means more sloped lines. Offset of lines comes from different field coild values. You see that your |g| can be so large that the Ic is double valued (for some values of the applied field coil). Therefore it is possible to have “too much” self-field such that the range of positive magnetic feedback operating region is too small or doesn’t exist.

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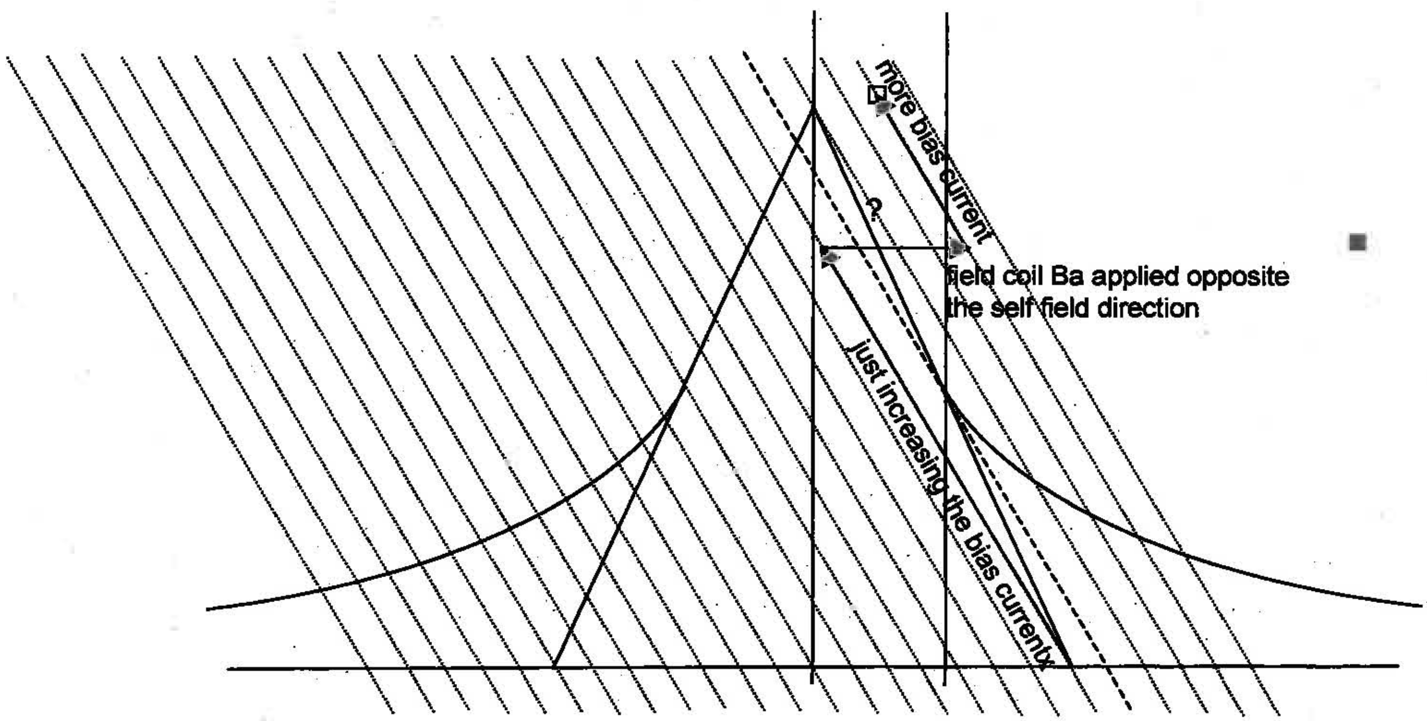

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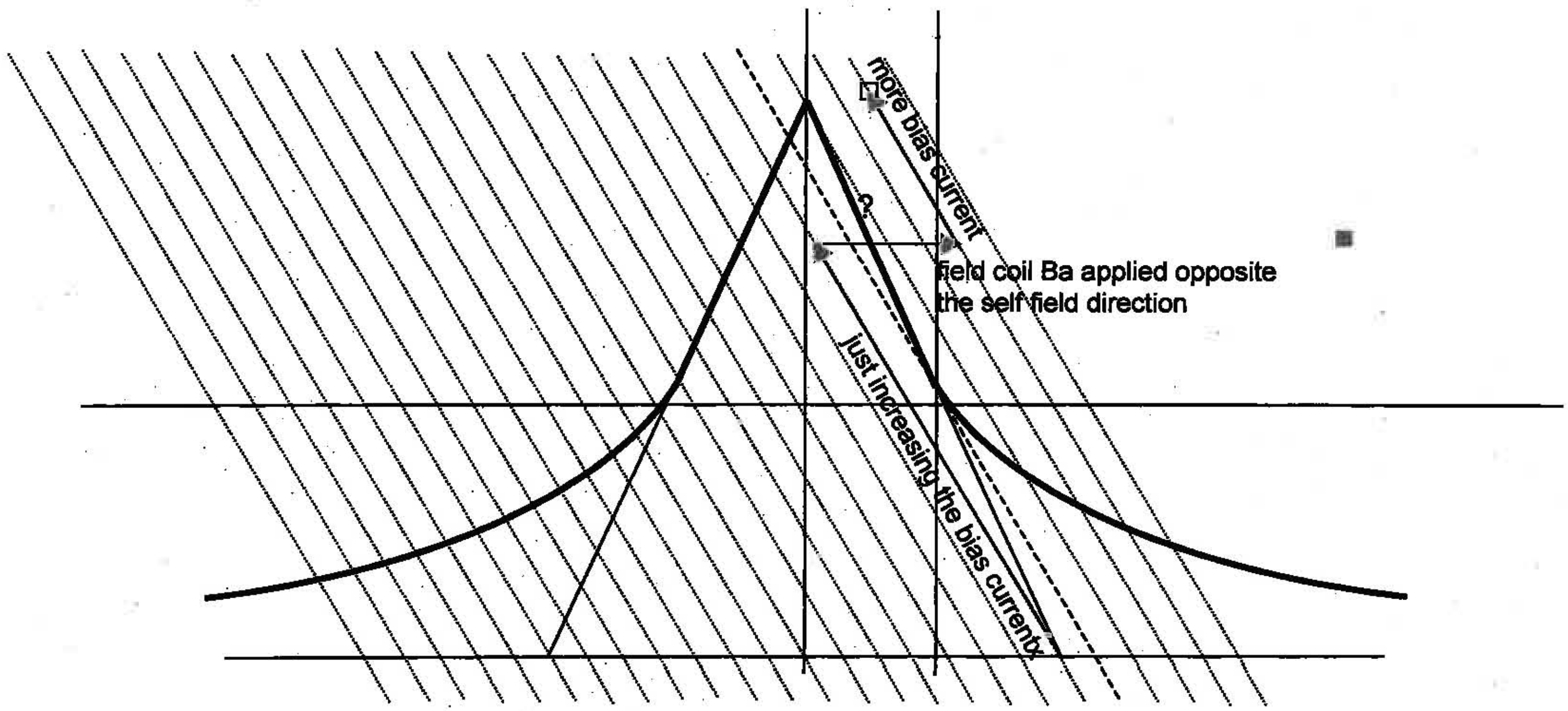

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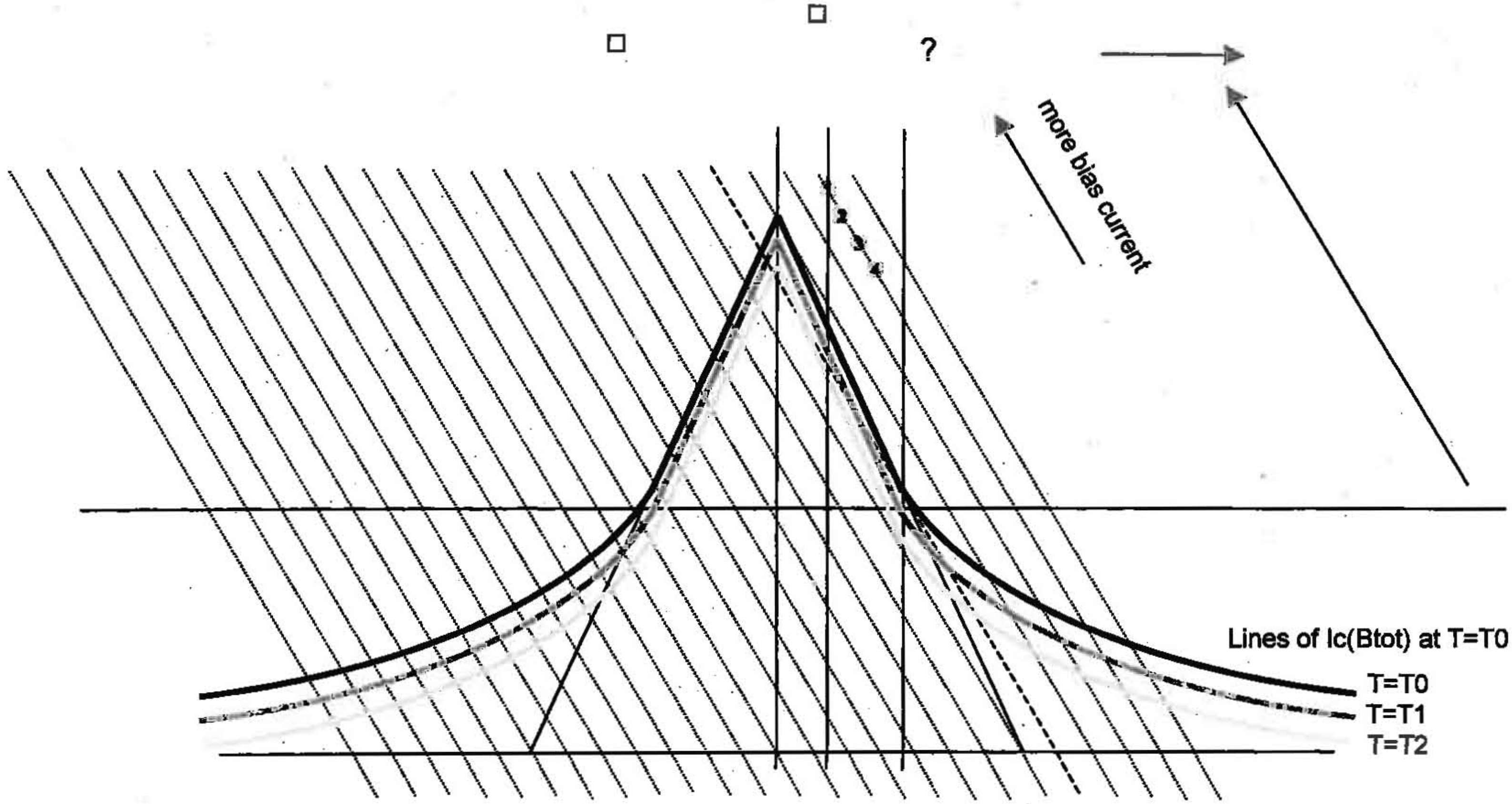

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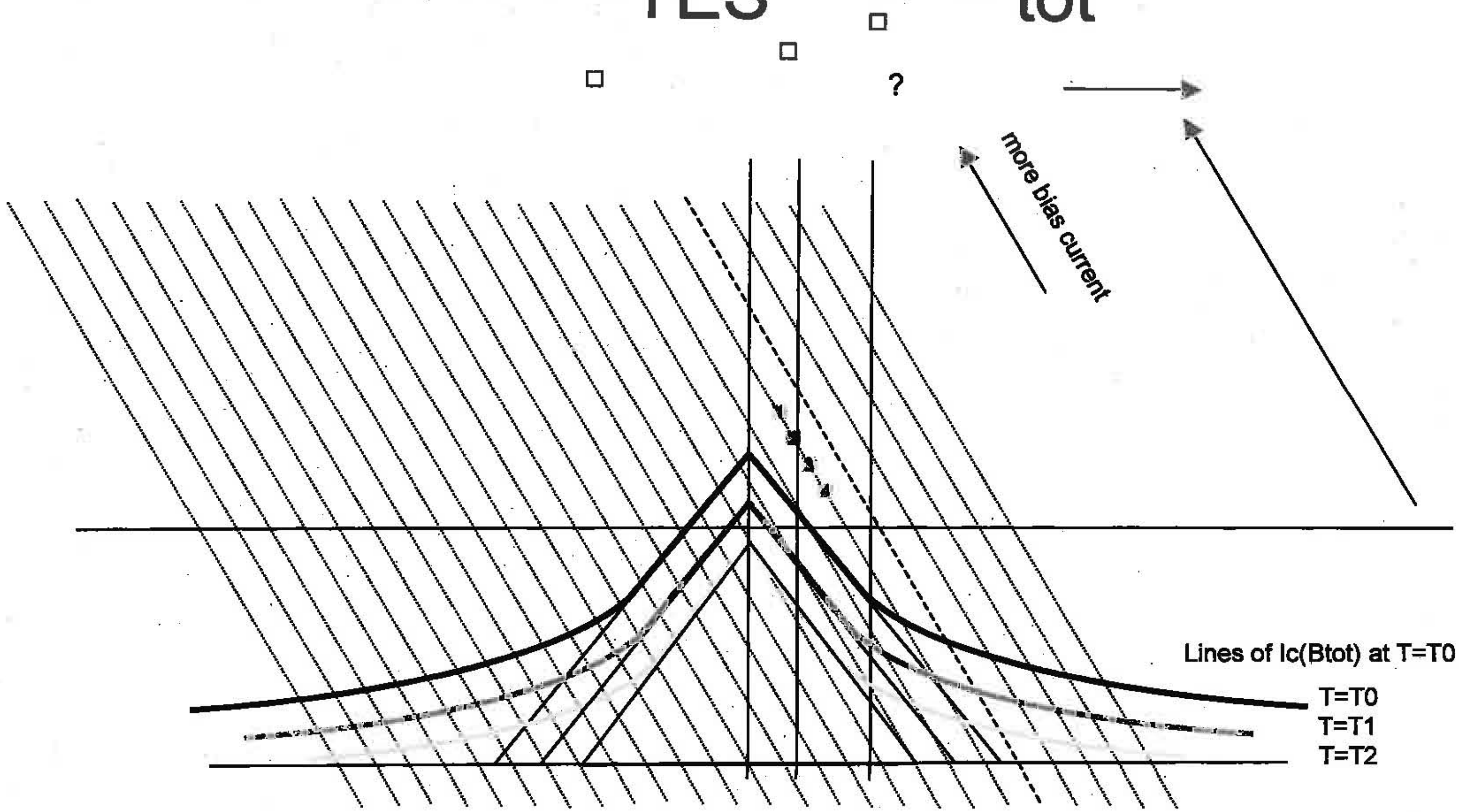

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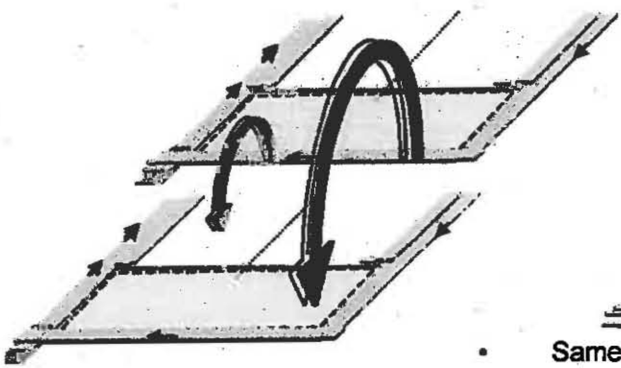
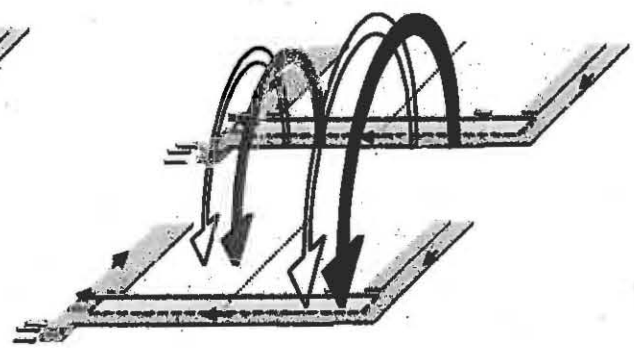
Designs to Reduce Magnetic Cross Talk and potentially improve performance

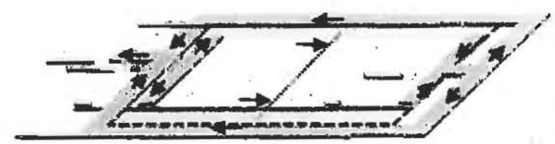
Electromagnetic Cross Talk

- When the current in pixel #2 changes from absorbing an X-ray there are two types of EM cross talk at pixel #1.
  - Change in local DC field value at TES #1.
    - We want this change in DC magnetic field B value at pixel #1 to be very small relative to the Josephson oscillation period of pixel #1.
    - We can reduce this cross talk by having the current flowing in #2 cancel approximately cancel out better making the field like a higher order pole which will have B decay much faster with distance. E.g. isolated wire lead $B \sim r^{-1}$, versus microstrip $B \sim r^{-2}$
  - Induced EMF in the circuit loop connected to #1.
    - Reduce the geometric area of the leads connecting TES #1.

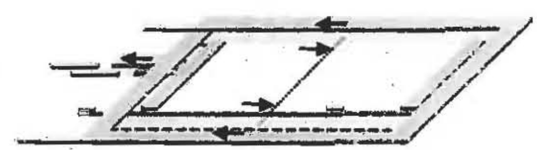




- Same array pitch
- Reduced loop area (light blue) reduced EMF cross talk
- Larger neighboring dipole lead separation and slightly better current cancelation both leading to reduced DC B cross talk
- Increased lead self field that is large and asymmetric
  - Reduced critical current at zero applied field
  - Increased critical current asymmetry



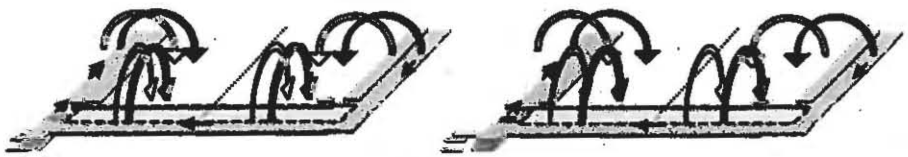
•What loop matters for EMF's?
•Better current cancelation but larger footprint



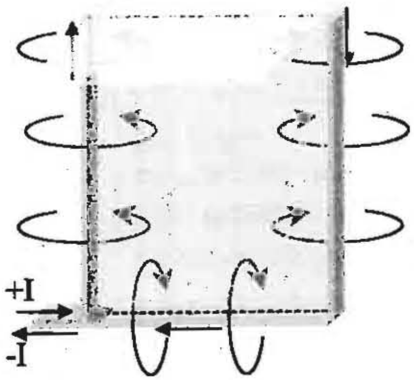
- Opposite ends different but has slighly smaller footprint

Design Considerations

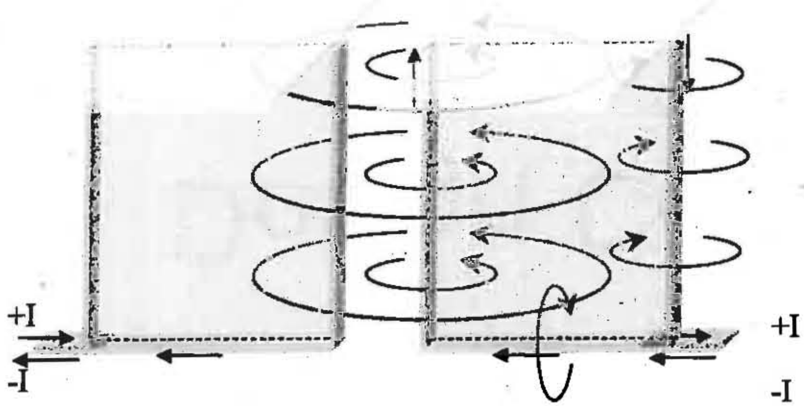
- Small TES footprint: so we can fit many pixels into the densest possible array.
- What is the TES current distribution
  - uniform or concentrated at the edges?
  - Meandering around fingers/stems or not?
  - Depends upon T, R/Rn, and design.
  - This impacts whether the current injection and removal geometry will decrease increase a leave unchanged the critical current of the device and with it determine the Ic asymmetry with bias direction.
- Well canceled TES + Lead current distribution
  - So small DC B crosstalk.
- Small loop
  - (so small EMF crosstalk)
- When the current splits want each arm as uniform as possible
  - E.g. we may not want a mircovia on each arm because if nonuniform may split current differently.
- Is a continuous superconducting loop of lead material ok or will it produce undesired effects?



Existing microstrip 2D lead design. Lead self field can be approximated as uniform over a certain range of high T. As loop (blue) becomes smaller self field is larger, Ic asymmetry is larger and Ic at Ba=0 is reduced.



Potential issue with simpliest "3D lead" concept.
(+) still increases space to pull out leaves
(+) can reduce DC B cross talk.
(-) concept drawn below shows increased induced EMF cross talk because larger loop area and potential stronger coupling between neighboring pixels.



All have:
1. small loop pick-up area.
2. small B on neighboring pixels

2D, self-field reduces Ic at Ba=0 and even Ba maximized Ic

3D. Self-field increases Ic. Fingers.

3D. Self-field increases Ic.

3D, self-field reduces Ic