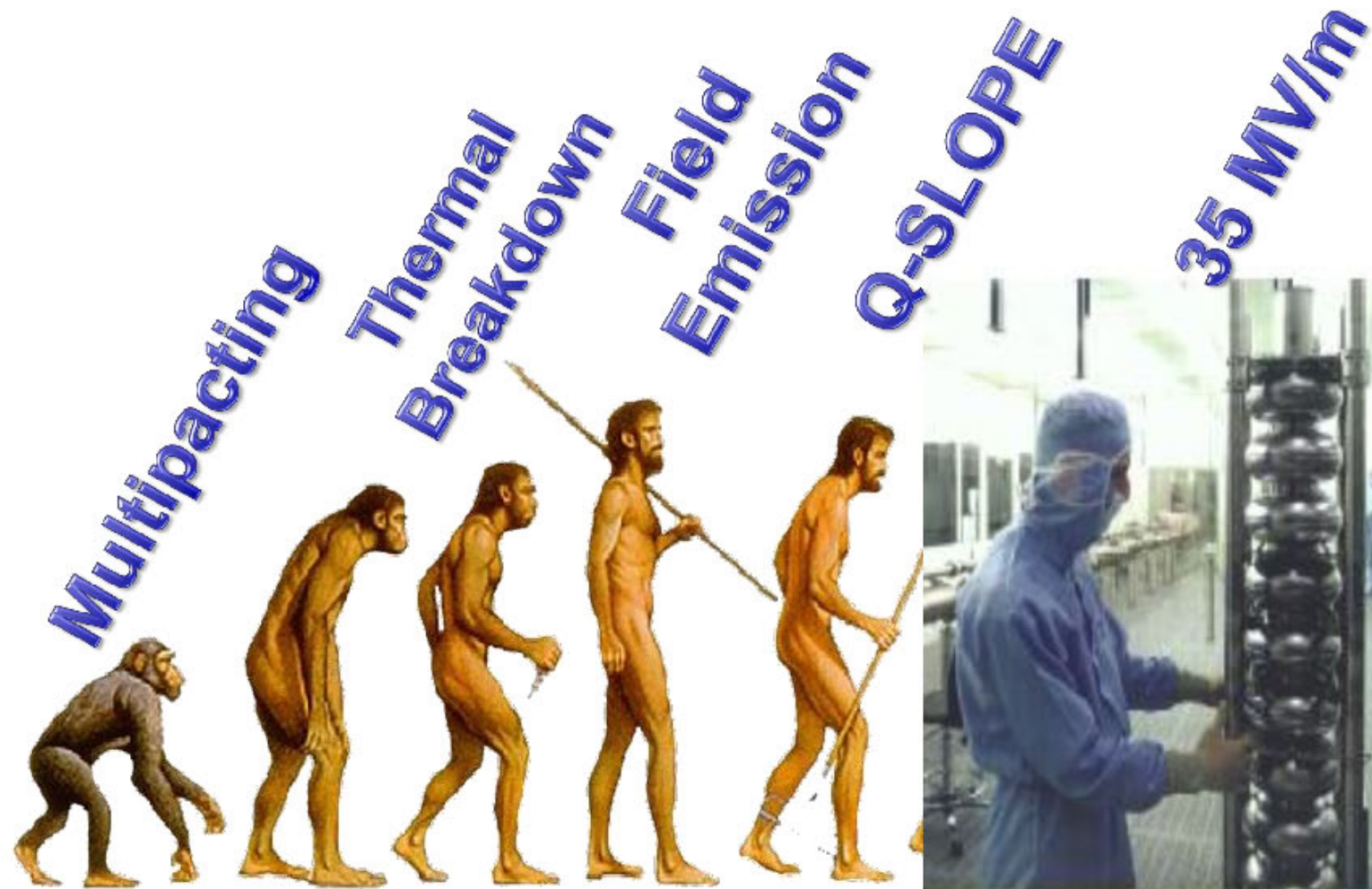


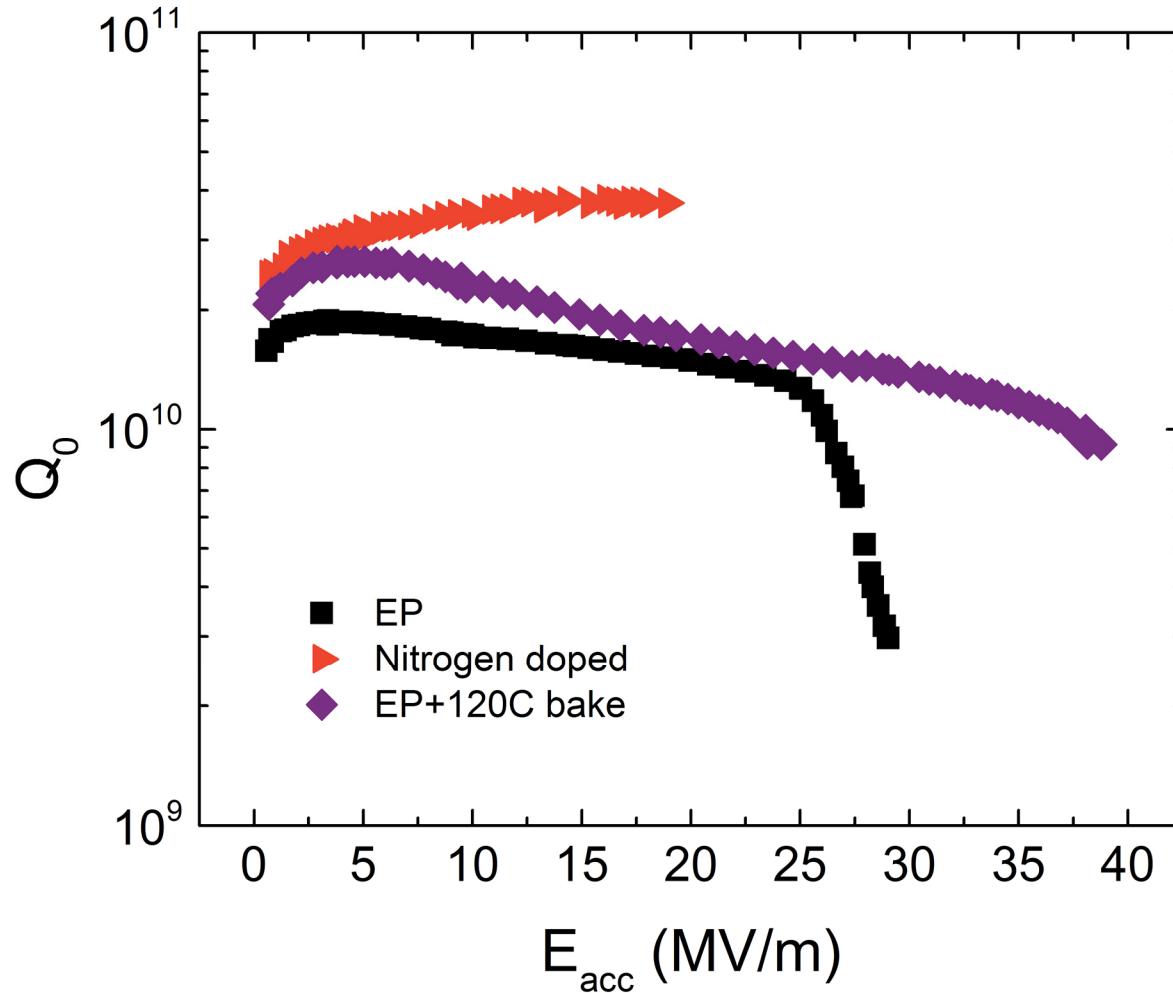
# Field dependent losses mechanisms in SRF Nb cavities probed via muon spin rotation

Anna Grassellino  
SRF Development Department, Fermilab

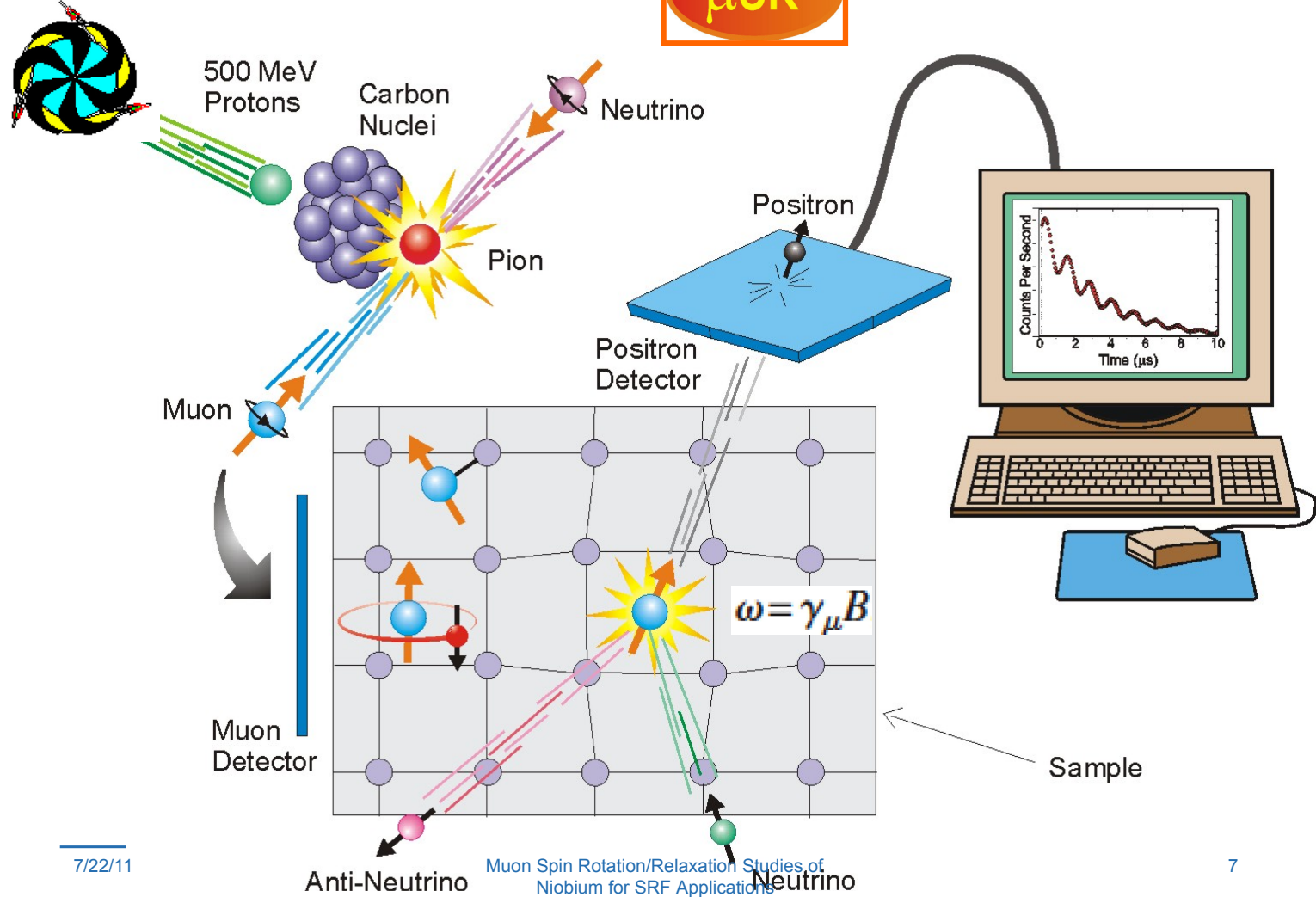
NAPAC 2013  
Pasadena, California

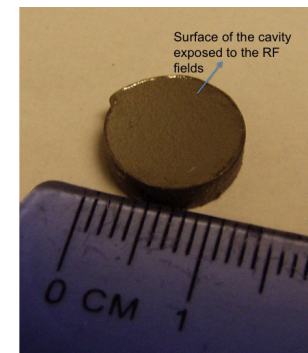
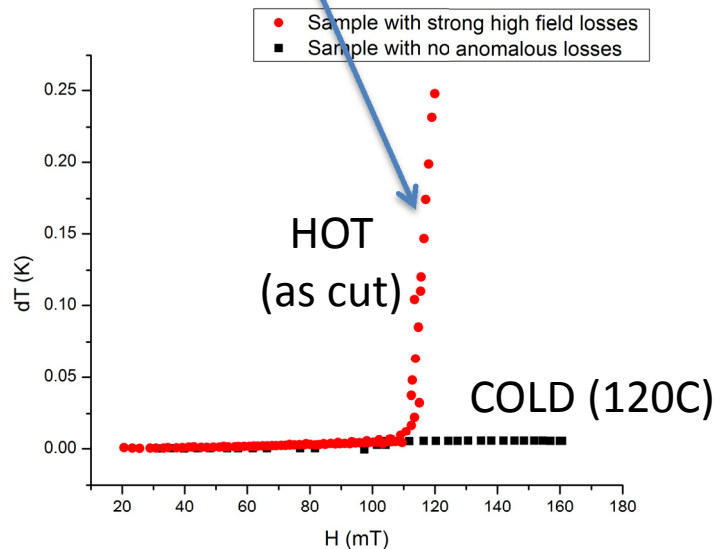
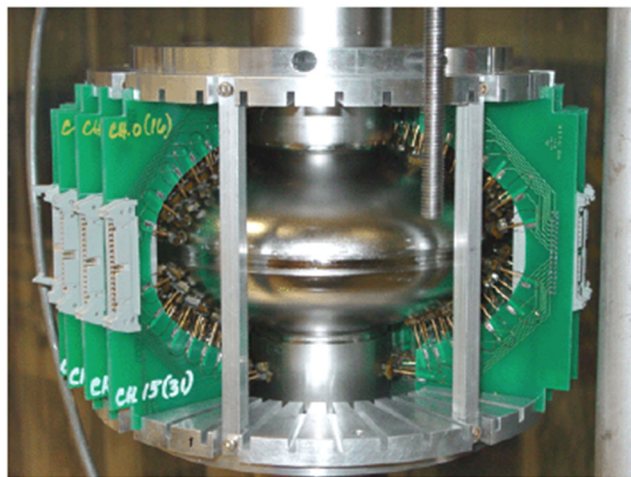
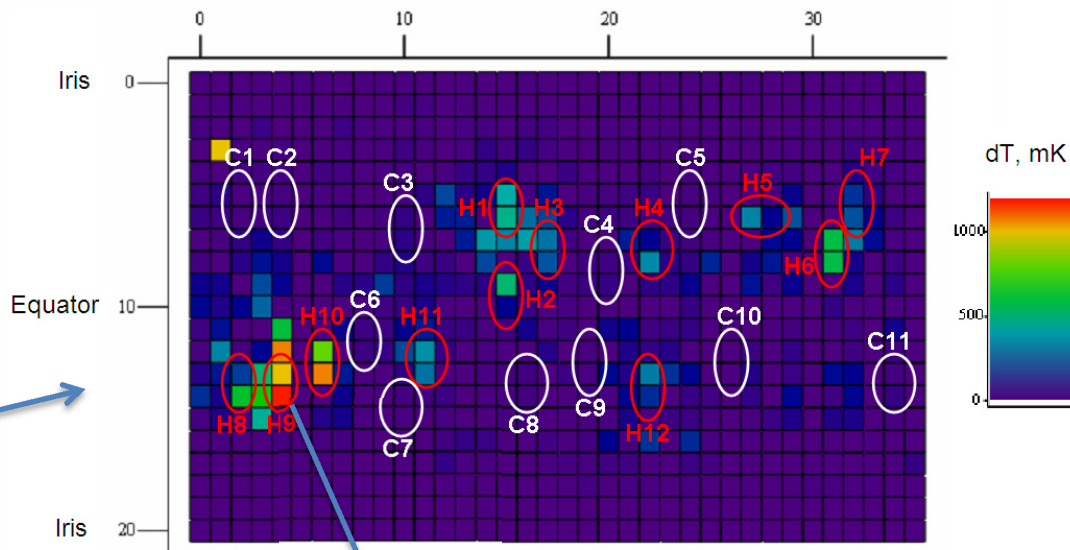
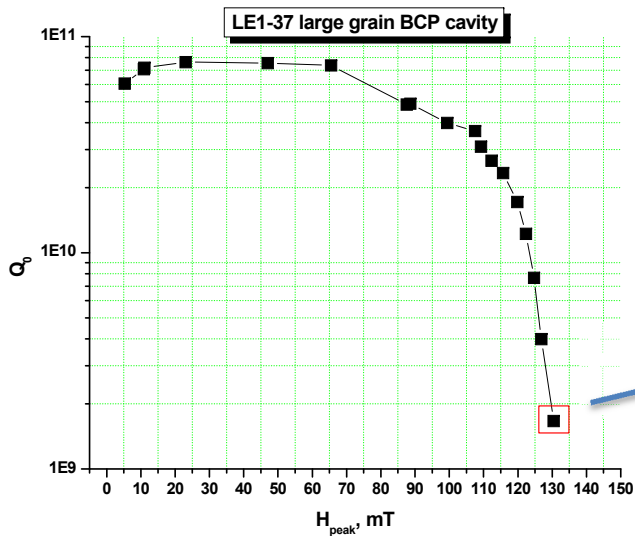


**Steady progress due to basic understanding of limiting phenomena and invention of effective cures**



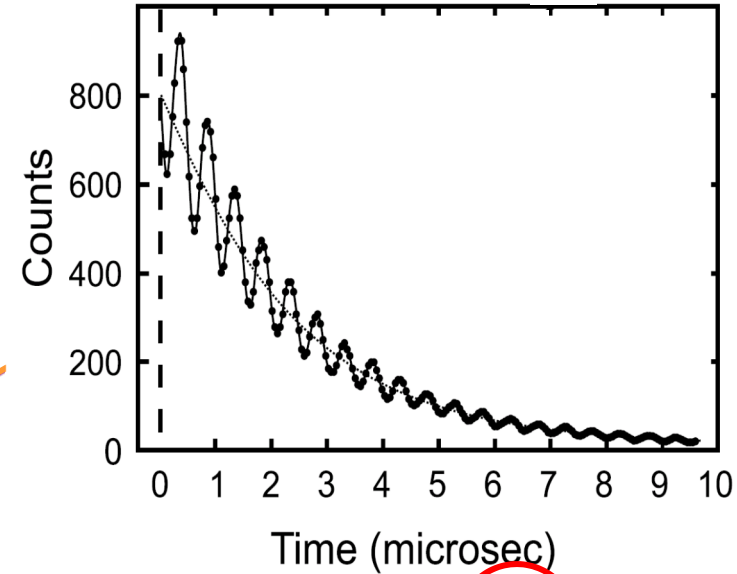
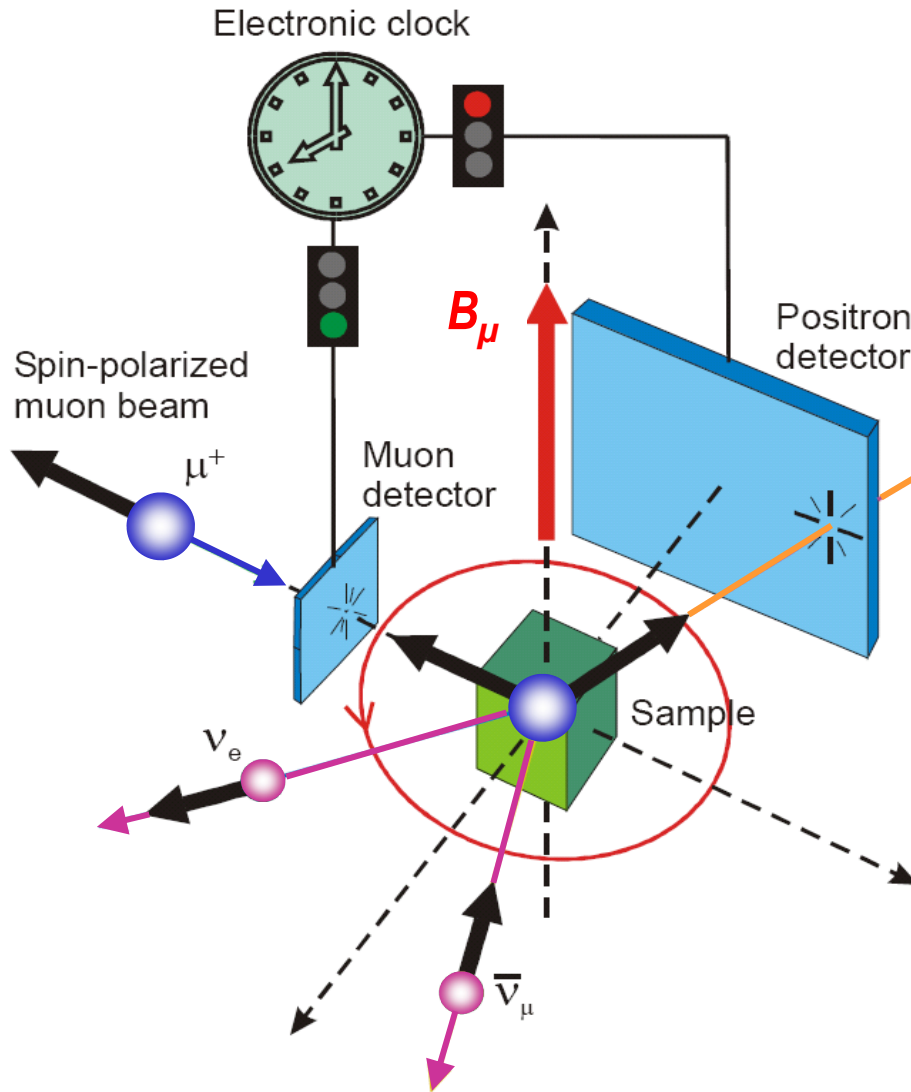
- Why do EP and BCP surfaces produce losses at high field (HFQS)?
- Why does the 120C bake allow to push cavities to higher gradients?
- Why does nitrogen doping lead to a reverse field dependence and higher Q?





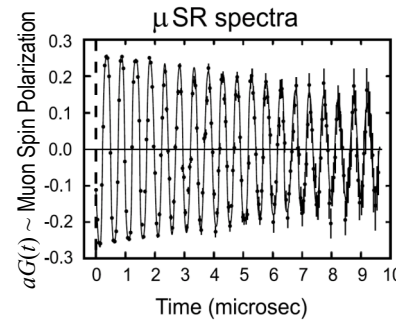
Is HFQS related to magnetic flux penetration or flux depinning?





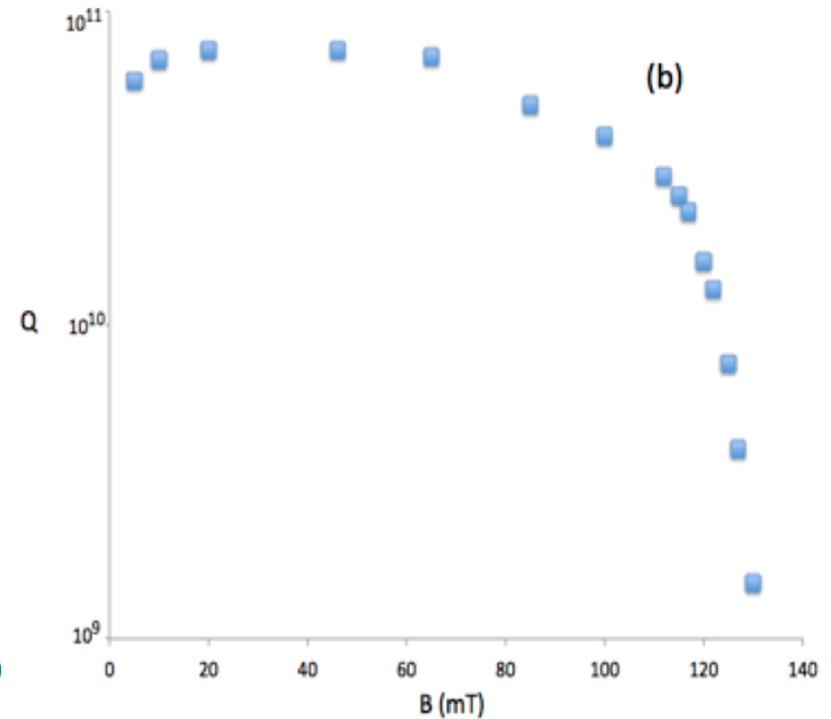
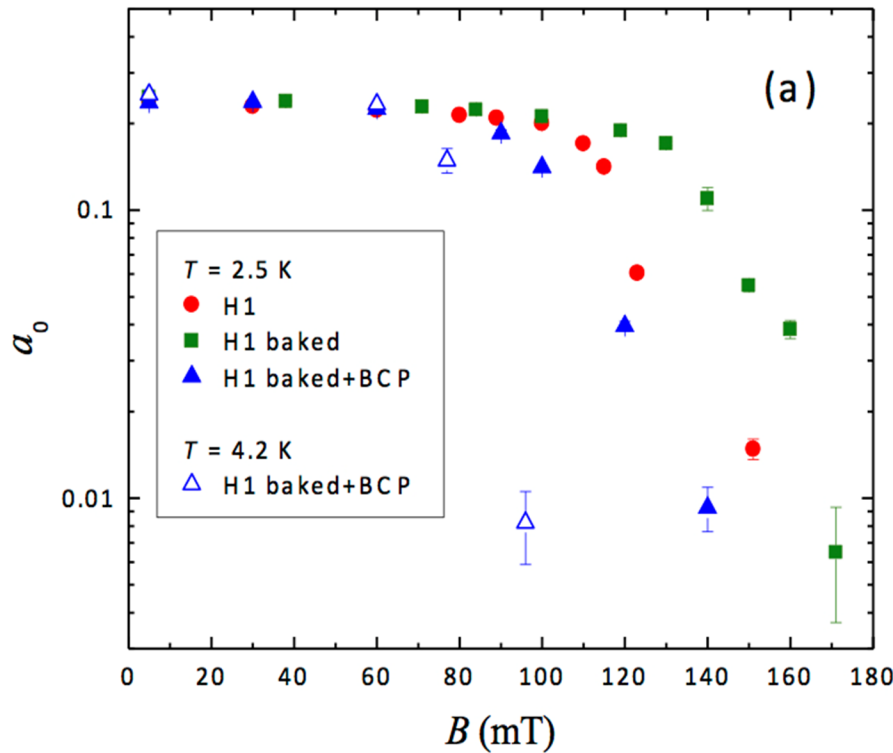
$$N(t) = N_0 \exp(-t/\tau_\mu) [1 + a G(t)] + \text{Bkg}$$

Contains physics ←

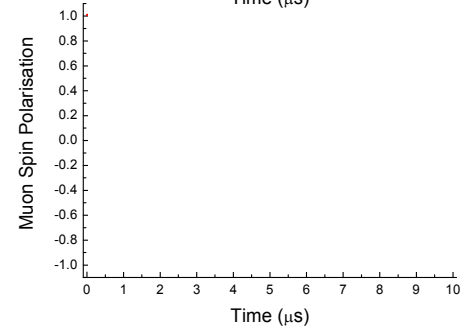
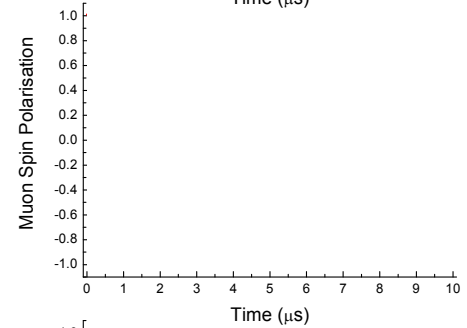
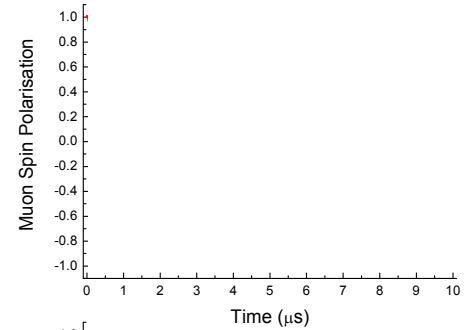
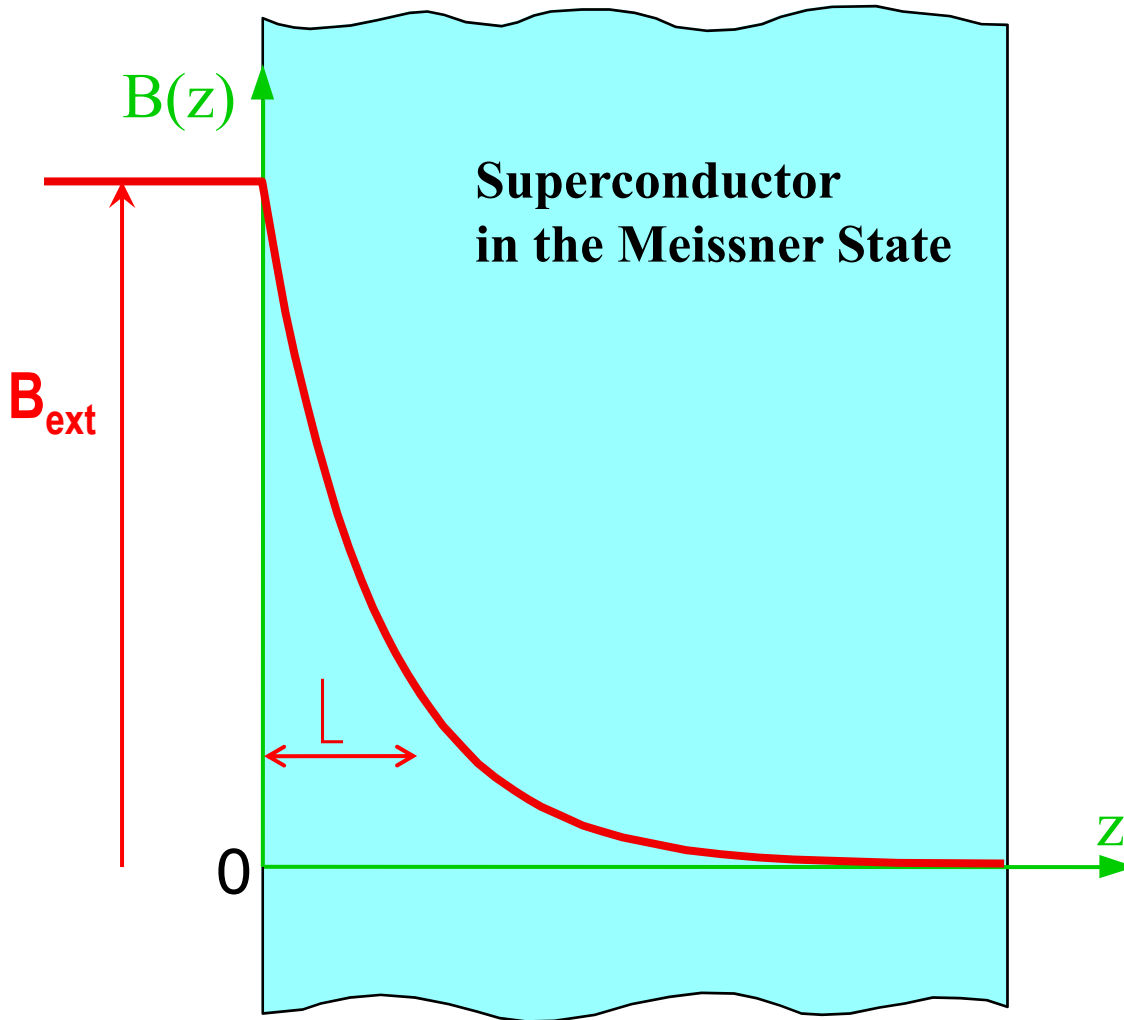


$$\omega_\mu(z) = \gamma_\mu B_{\text{loc}}(z)$$

Frequency – field amplitude  
Damping – field non-uniformity

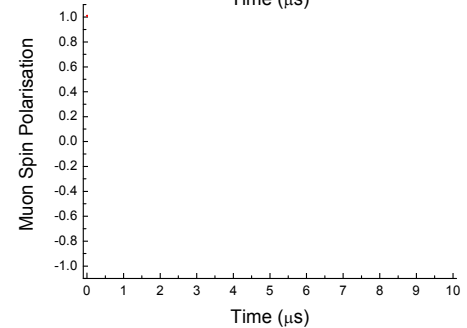
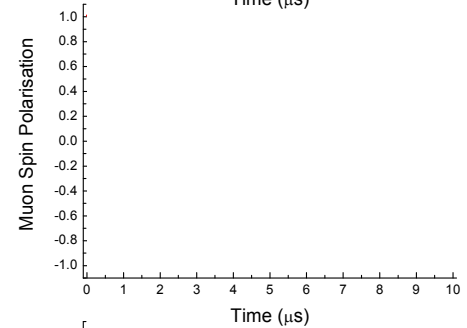
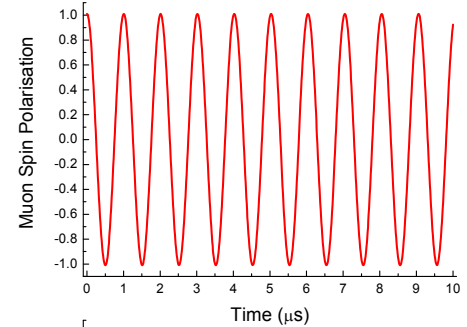
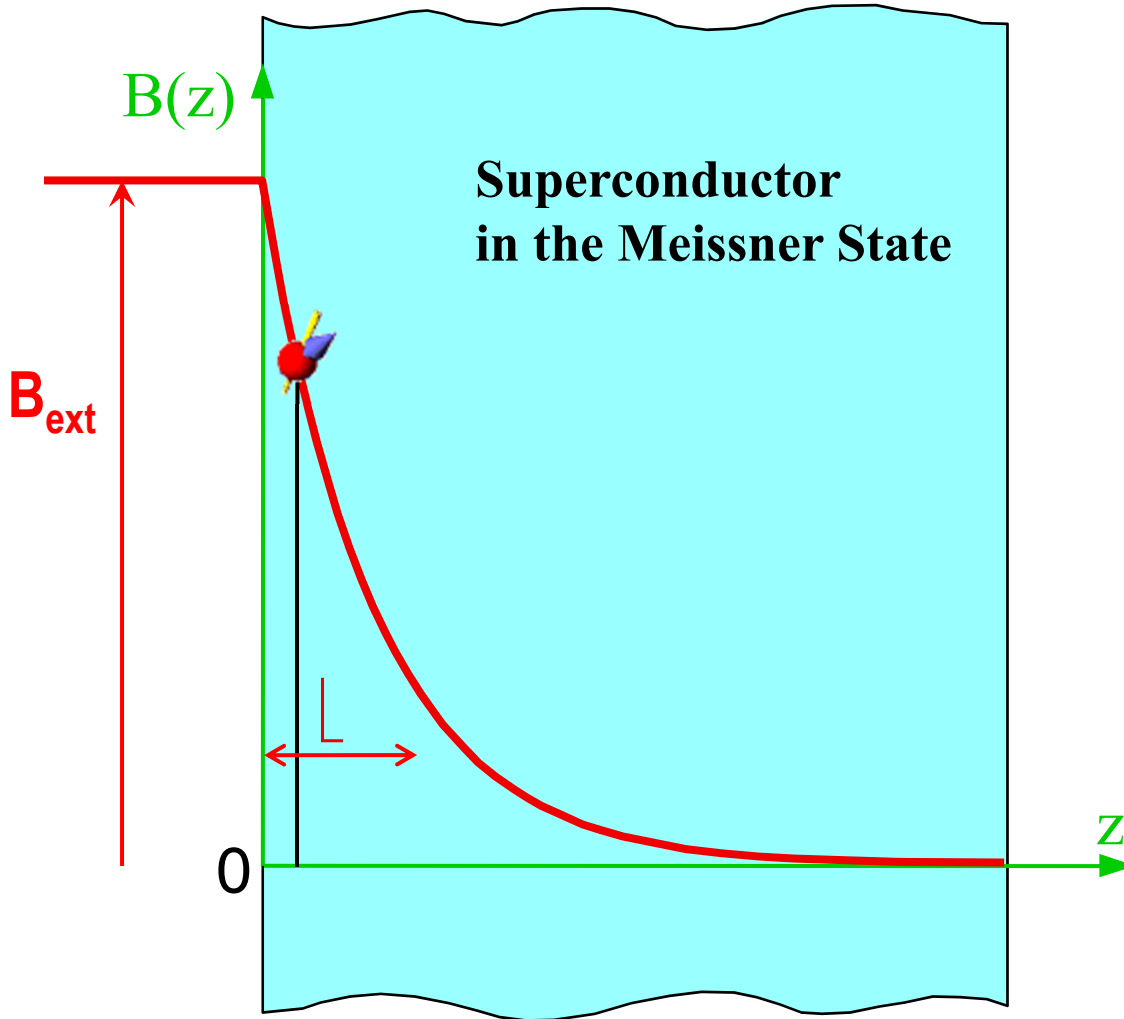


- Strong correlation between field at which magnetic flux starts being detected by muons and onset of HFQS
- Hinting towards mechanism behind the 120C bake being the increase in surface pinning, effectively delaying flux entry or flux depinning

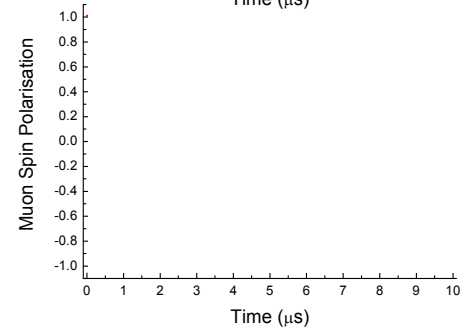
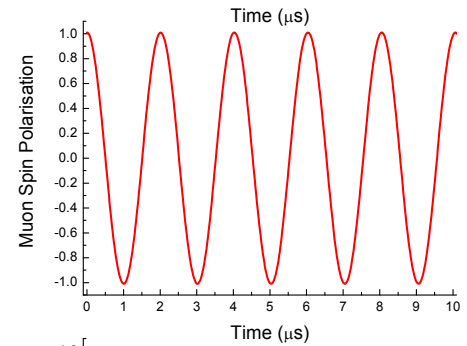
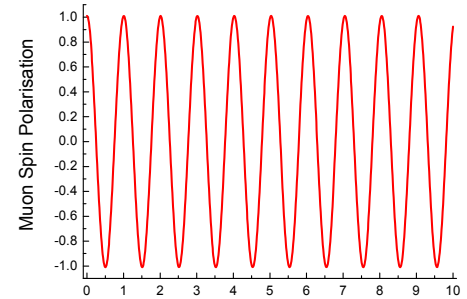
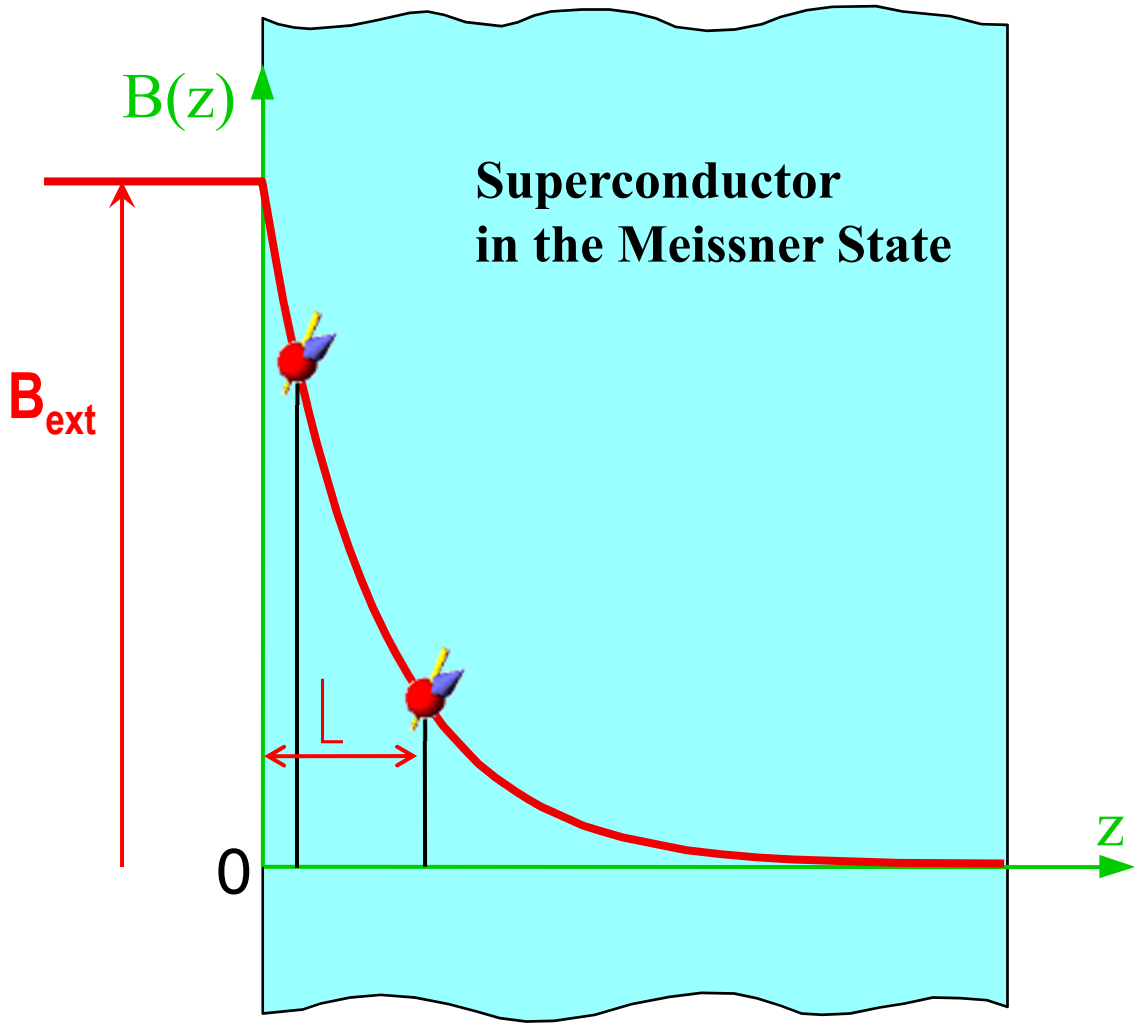


$$\omega_{\mu}(z) = \gamma_{\mu} B_{\text{loc}}(z)$$

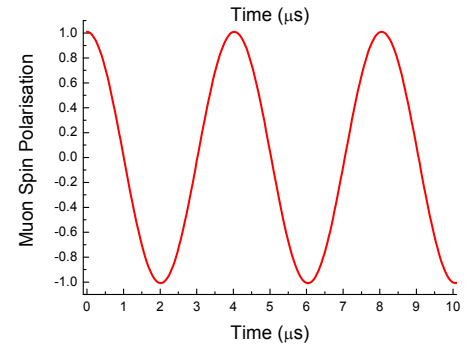
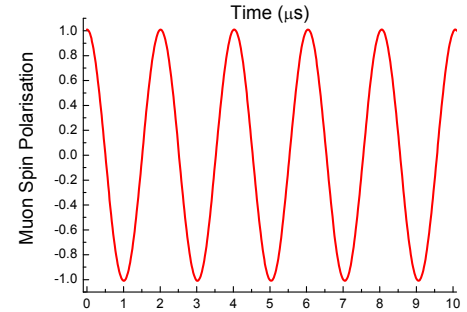
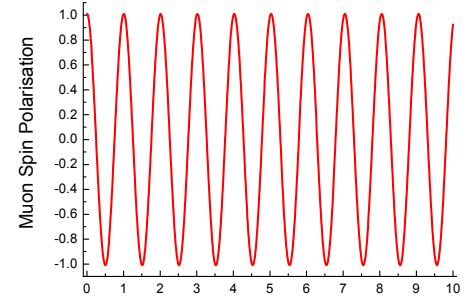
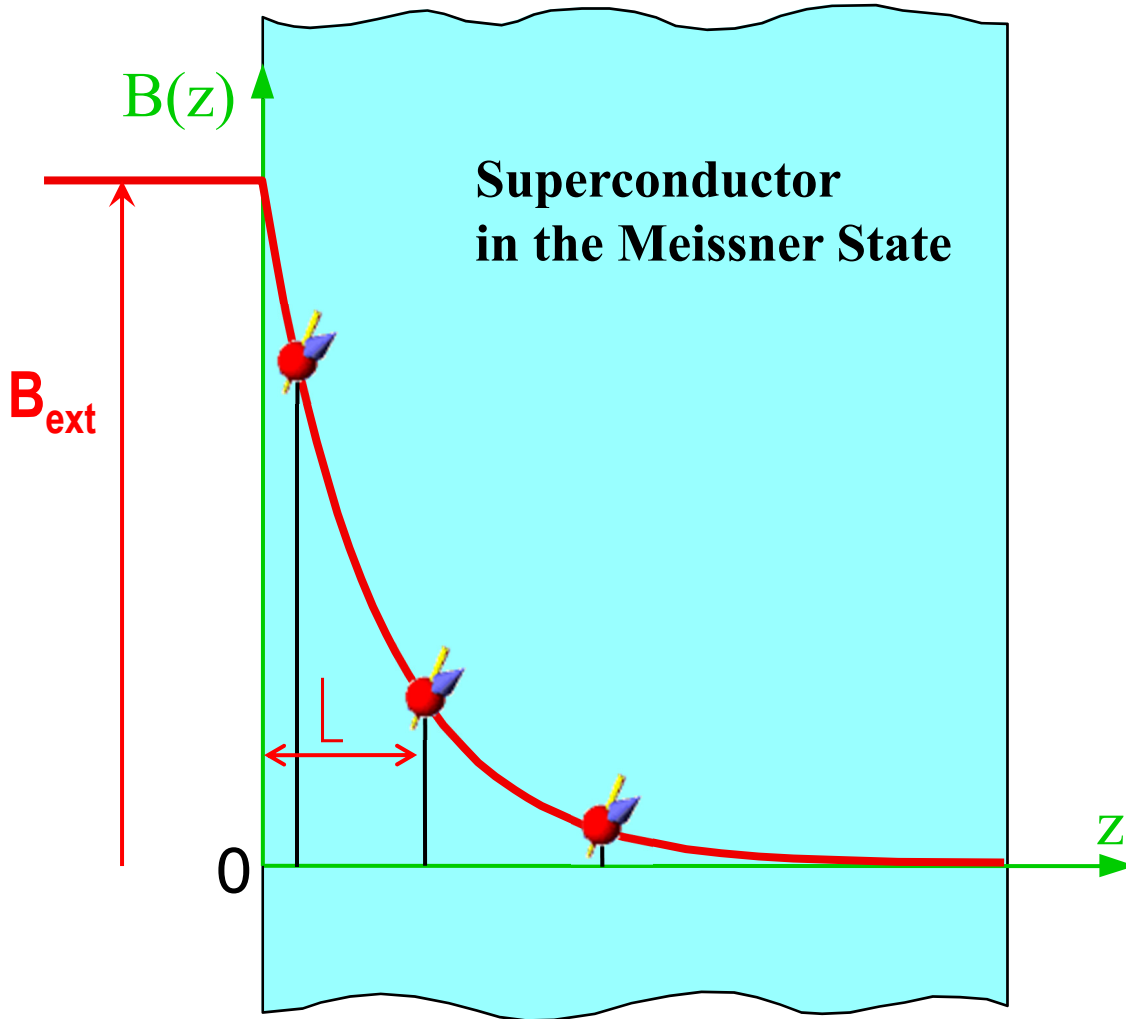




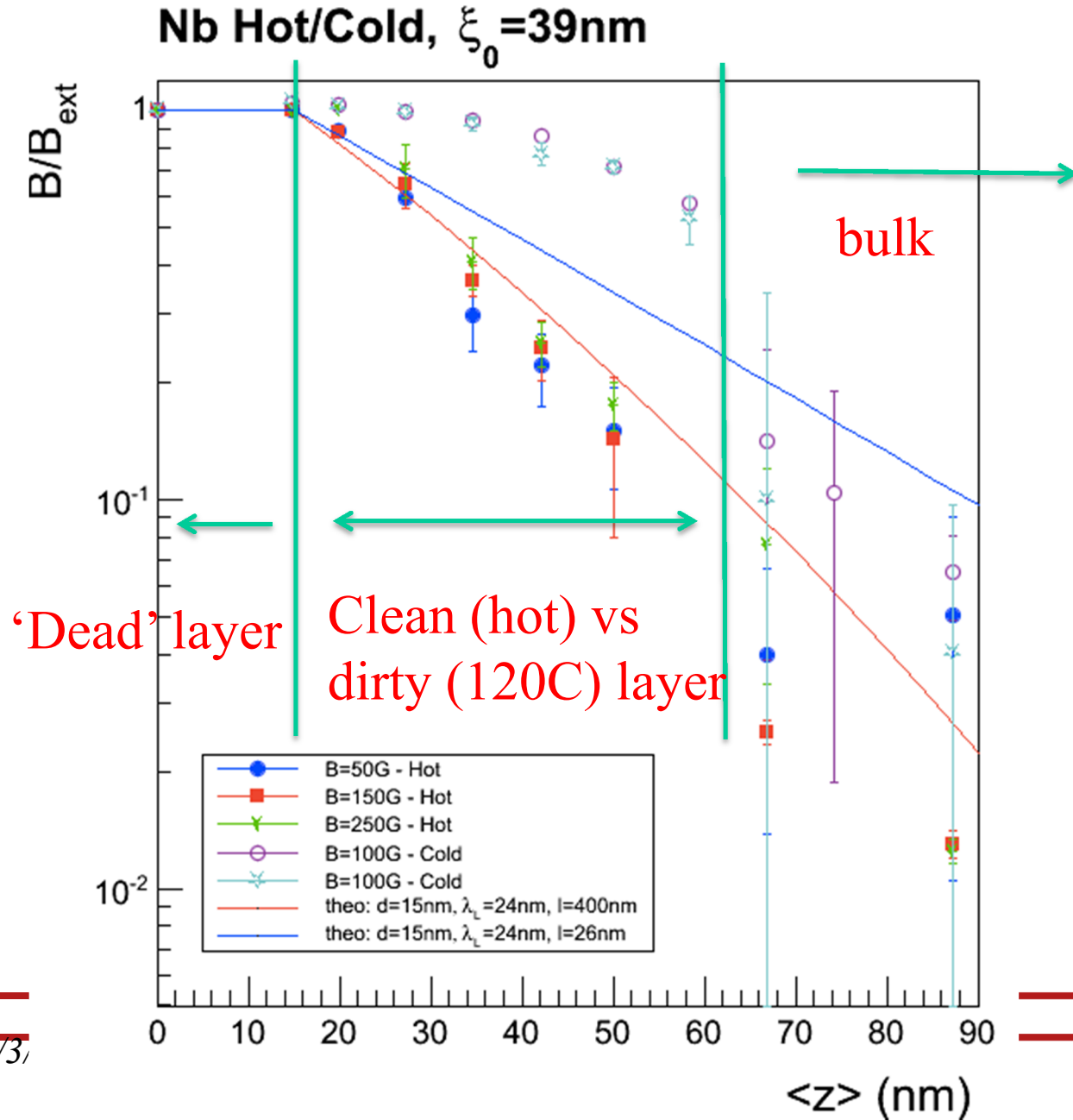
$$\omega_{\mu}(z) = \gamma_{\mu} B_{loc}(z)$$



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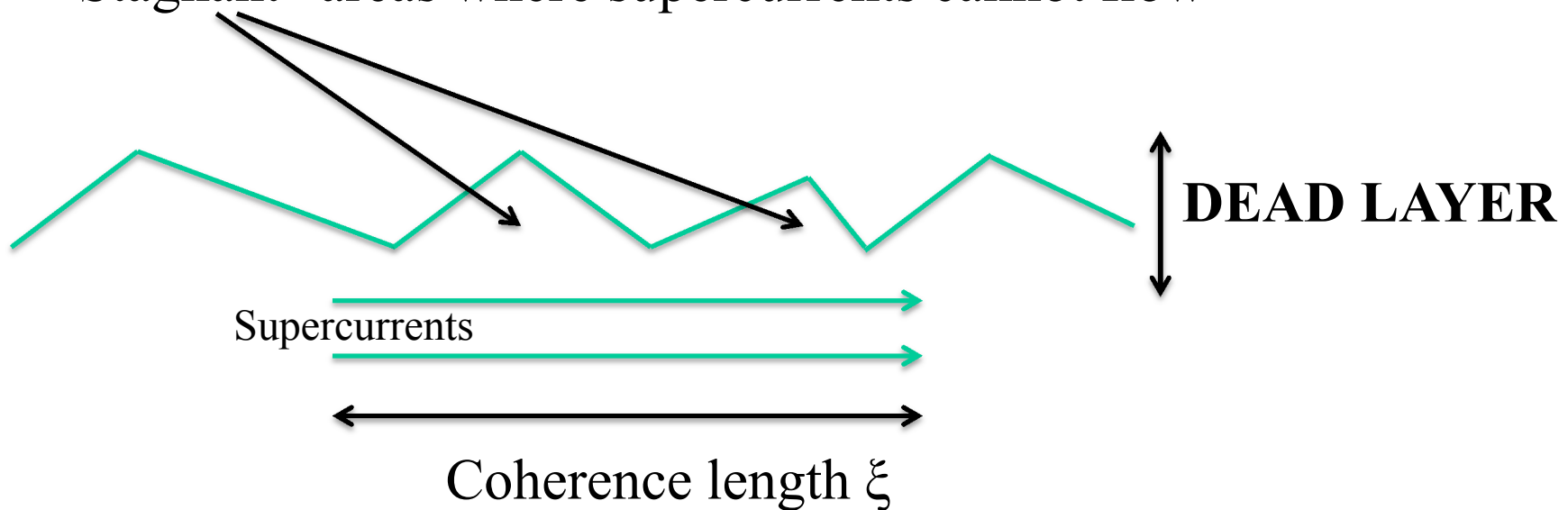


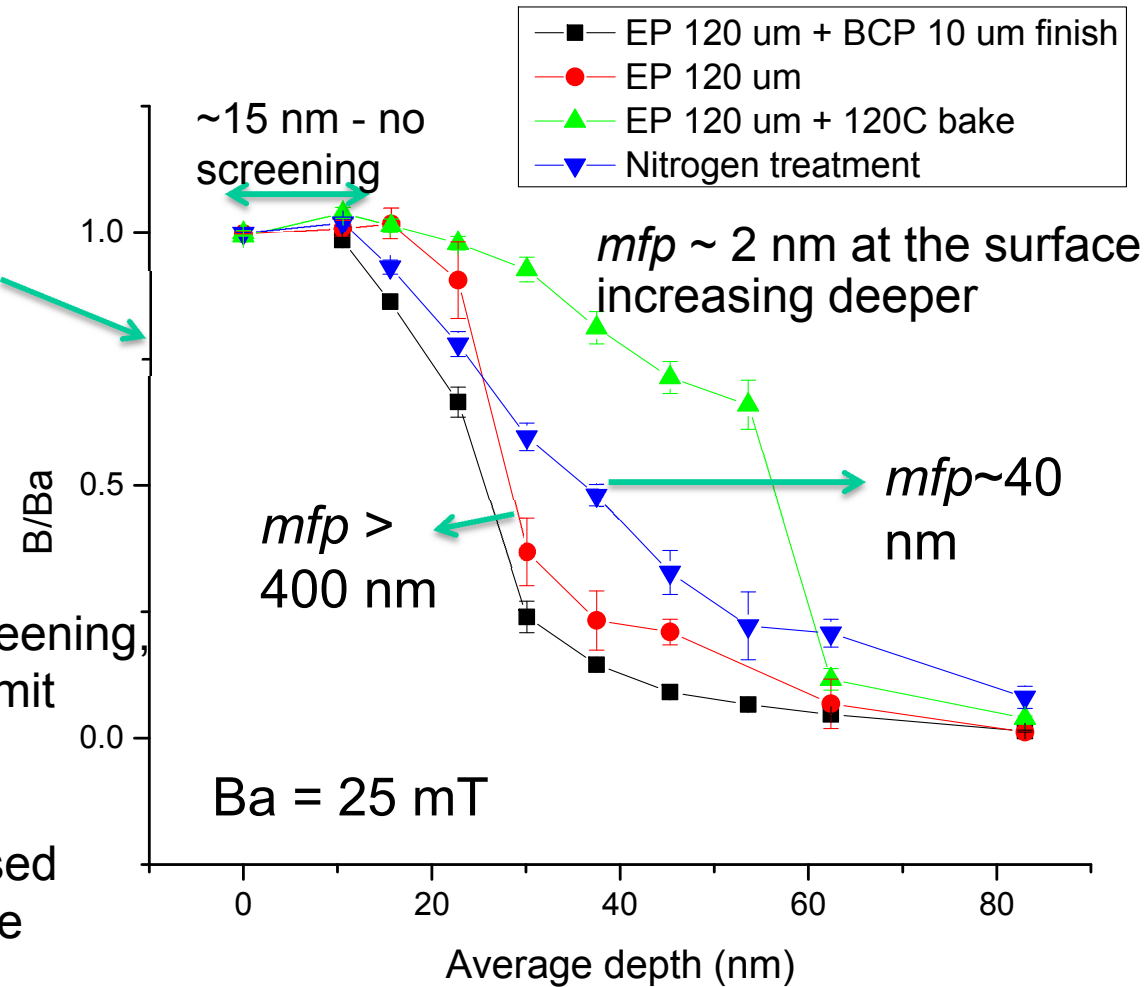
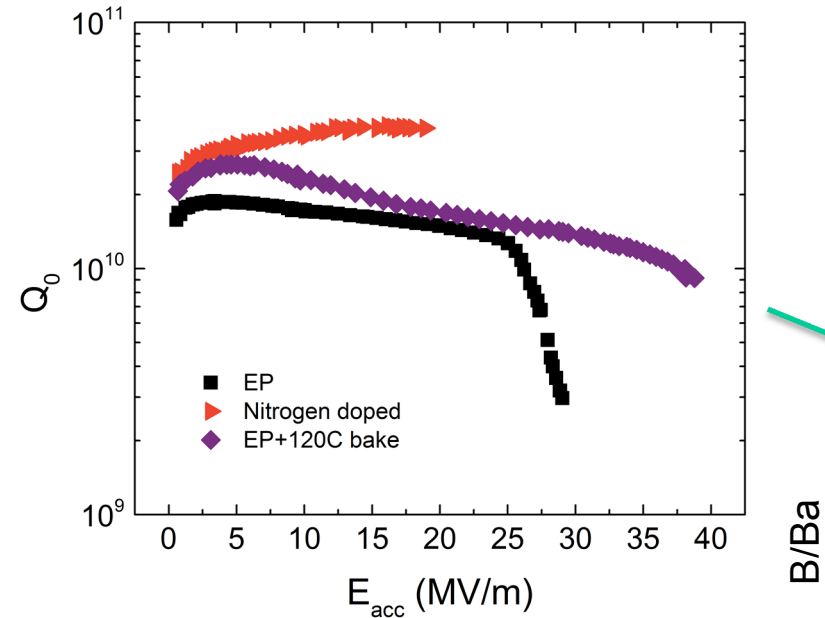
$$\omega_{\mu}(z) = \gamma_{\mu} B_{loc}(z)$$



# NANOROUGHNESS: roughness of the order or smaller than the coherence length

“Stagnant” areas where supercurrents cannot flow





BCP and EP unbaked -> strong screening, excellent fit provided by the clean limit Pippard/BCS model

EP+120C bake-> strongly suppressed m.f.p., gradient of the m.f.p. from the surface, dirty limit

N-doped -> intermediate purity!

Fit by Gaussian model for the field at the muon site – approximate, qualitative comparison



- Muon Spin Rotation experiments on SRF cavities cutouts have brought new insights on the physics of niobium RF surface resistance
  - Learned that enhancing surface pinning might be a pathway to increase achievable gradients and that doping with the right amount of impurities lowers the mfp just to the right value to increase cavity efficiency
  - Fundamental understanding is key to further advance technology
-

- Thesis Advisor: Prof Nigel Lockyer
  - Lia Meringa, for nominating me for this award and for her supervision of my PhD thesis at TRIUMF
  - Bob Laxdal, supervisor during thesis at TRIUMF
  - A. Romanenko, co-author on muSR experiments
  - IEEE PAST Award committee, Ilan Ben-Zvi , Jean Delayen, Patric Muggli
-