Recent Results of High Gradient Studies (at Argonne)

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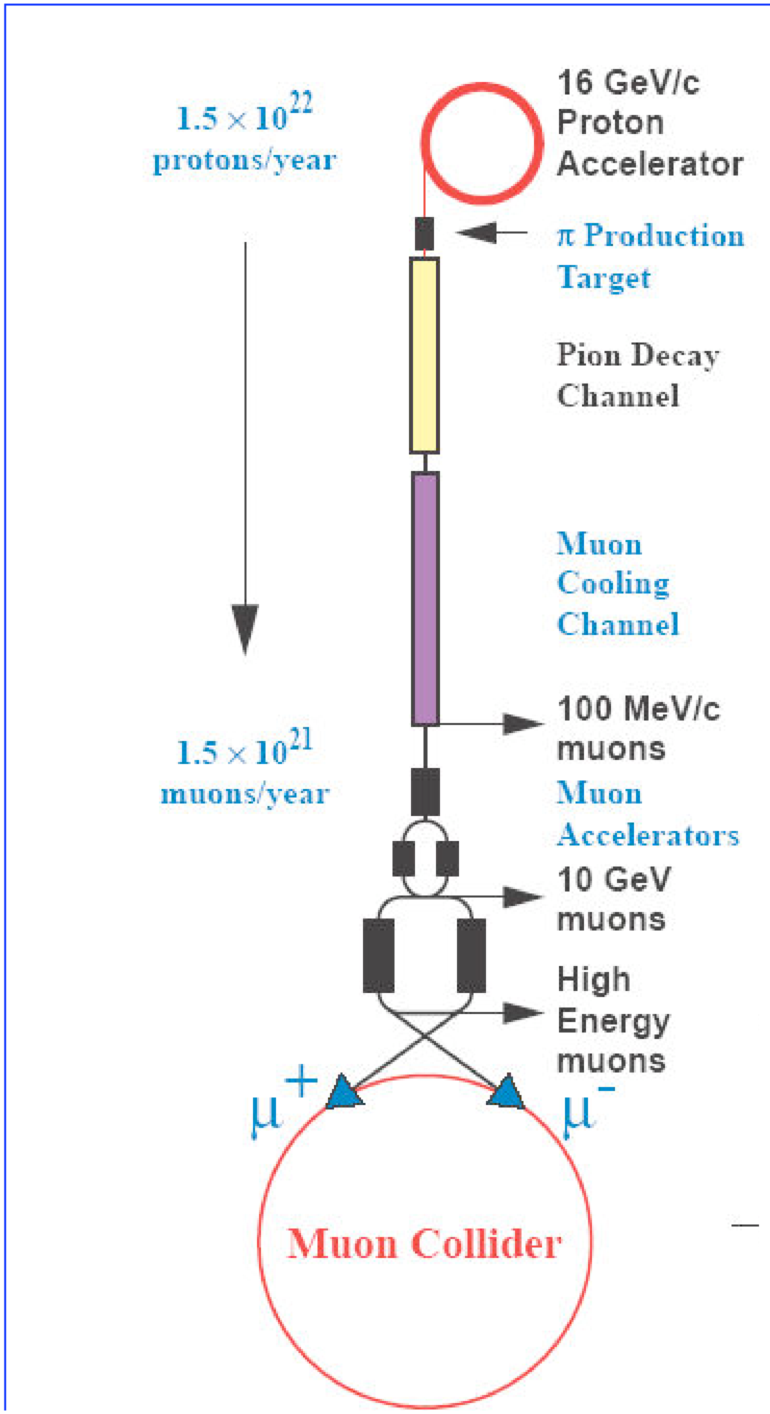
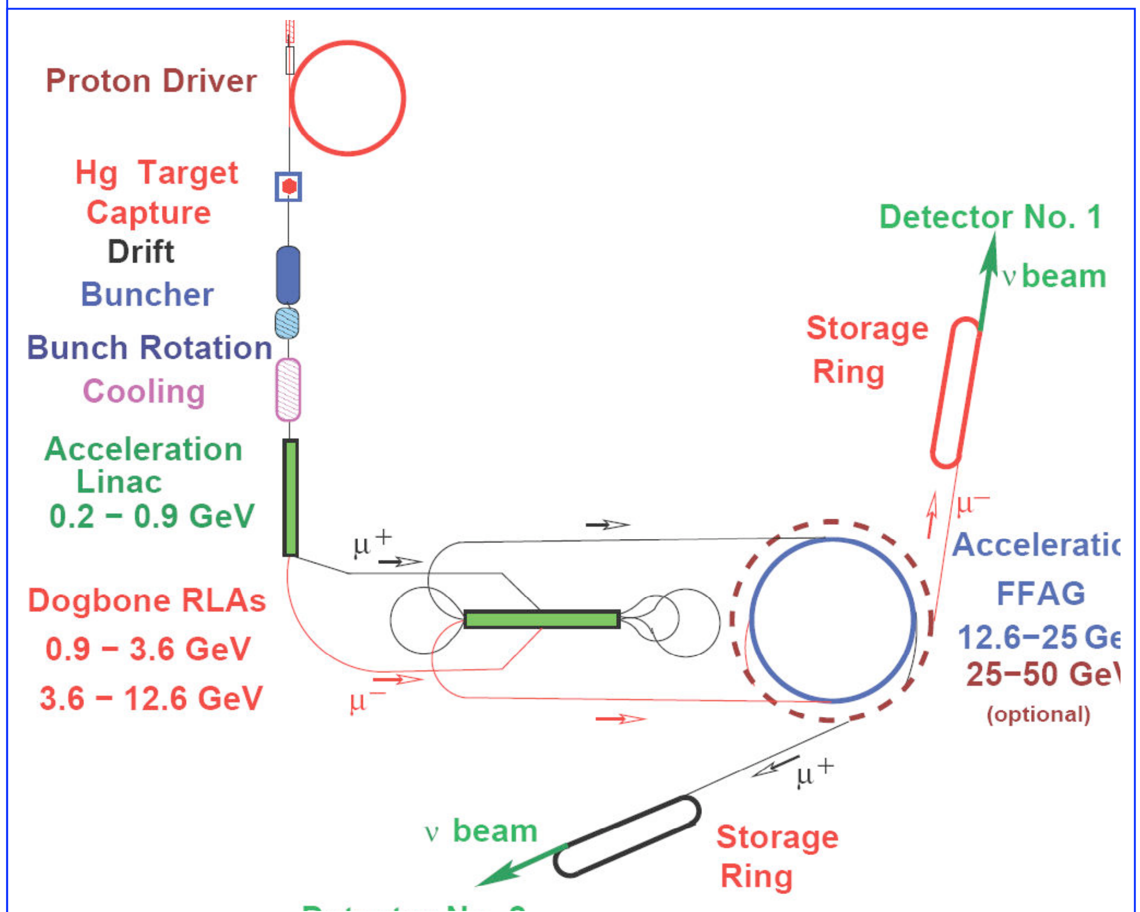
NFMCC Mtg.
Fermilab, 1/11/8

NFMCC systems require superconducting linacs, which need R&D.





ANL is starting a program to extend SCRF and NC gradients.

- This effort will involve Argonne Materials Scientists (+ local Universities) in accelerator problems. Argonne effort is based around Atomic Layer Deposition. So far, this is supported by internal Argonne funds.

- We have had great success with our initial efforts:

  1 A new, and persuasive, model of high field Q-Slope in SCRF systems (IIT).

  2 A new way to control SCRF surface chemistry.

  3 Practical ways to simultaneously attack all the SCRF limits.

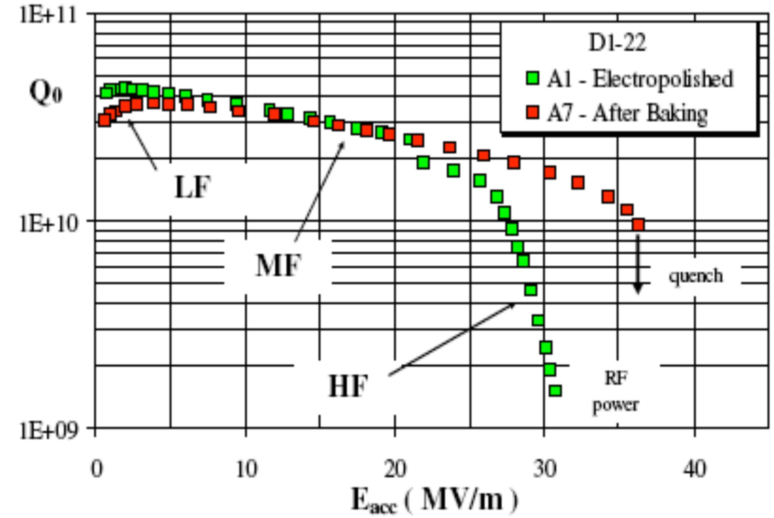
  4 Ideas on improving normal conducting structures.

- Some results are published, others are coming:

- This talk will be an outline - details will come later.

A new model of losses in SCRF systems.

- Q-Slope is an anomalous loss that appears at high gradients in SCRF systems.



- Much theoretical and experimental effort has been inconclusive.

- John Zasadzinski will present a better argument.

	Q-Slope Fit	Q-Slope before baking (EP = BCP)	Q-Slope Improvem't after baking	Q-Slope after baking (EP < BCP)	No change after 4 y. air exposure	Exceptional Results (BCP)	Q-Slope unchanged after HF chemistry	TE_{011} Q-slope after baking	Quench EP > BCP	BCP Quench unchanged after baking	Argum't Validity	Fund'al Disagreem't Exper. ≠ Theory
Magnetic Field Enhancem't	Y simulat. code	~~N~~ $\beta_m \neq$ $B_{C2}^S \neq$	Y $B_{C2}^S \uparrow$	Y lower β_m	-	N high β_m	-	-	Y lower β_m	N $B_{C2}^S \uparrow$	Y	D_1
Interface Tunnel Exchange	Y E^8	N $\beta_* \neq$	Y $Nb_2O_{5-y} \downarrow$	Y lower β_*	N $Nb_2O_{5-y} \uparrow$	N high β_*	~~N~~ new Nb_2O_{5-y}	~~N~~ improv't	-	-	Y	D_2
Thermal Feedback	Y parabolic	Y = thermal properties	Y $R_{BCS}\downarrow$ $R_{res}\uparrow$	N = therm. propties	-	-	-	-	-	-	N C coeff.'t	-
Magnetic Field Dependence of Δ	Y expon'tial	N $B_{C2}^S \neq$	Y $B_{C2}^S \uparrow$	Y higher B_{C2}^S	-	-	-	-	-	-	~~N~~ thin film	D_1
Segregation of Impurities	?	N segregation ≠	N only O diffusion	Y surface ≠	-	Y good cleaning	N chemistry	-	-	-	Y	-
Bad S.C. Layer Interstitial Oxygen $Nb_{4-6}O$	?	Y NC layer	Y O diffusion	N	N interstitial re-appears	-	~~N~~ new bad layer	-	Y higher B_{C2}^S	N $B_{C2} \downarrow$	Y	D_1

We have demonstrated we can control the surface.

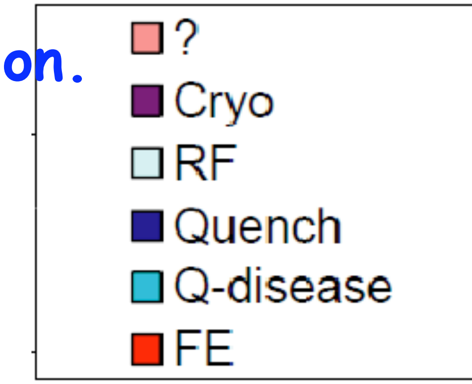
- Using Atomic Layer Deposition, Mike Pellin et. al. have shown that it is possible to control the oxide composition and density in the near surface region of niobium.

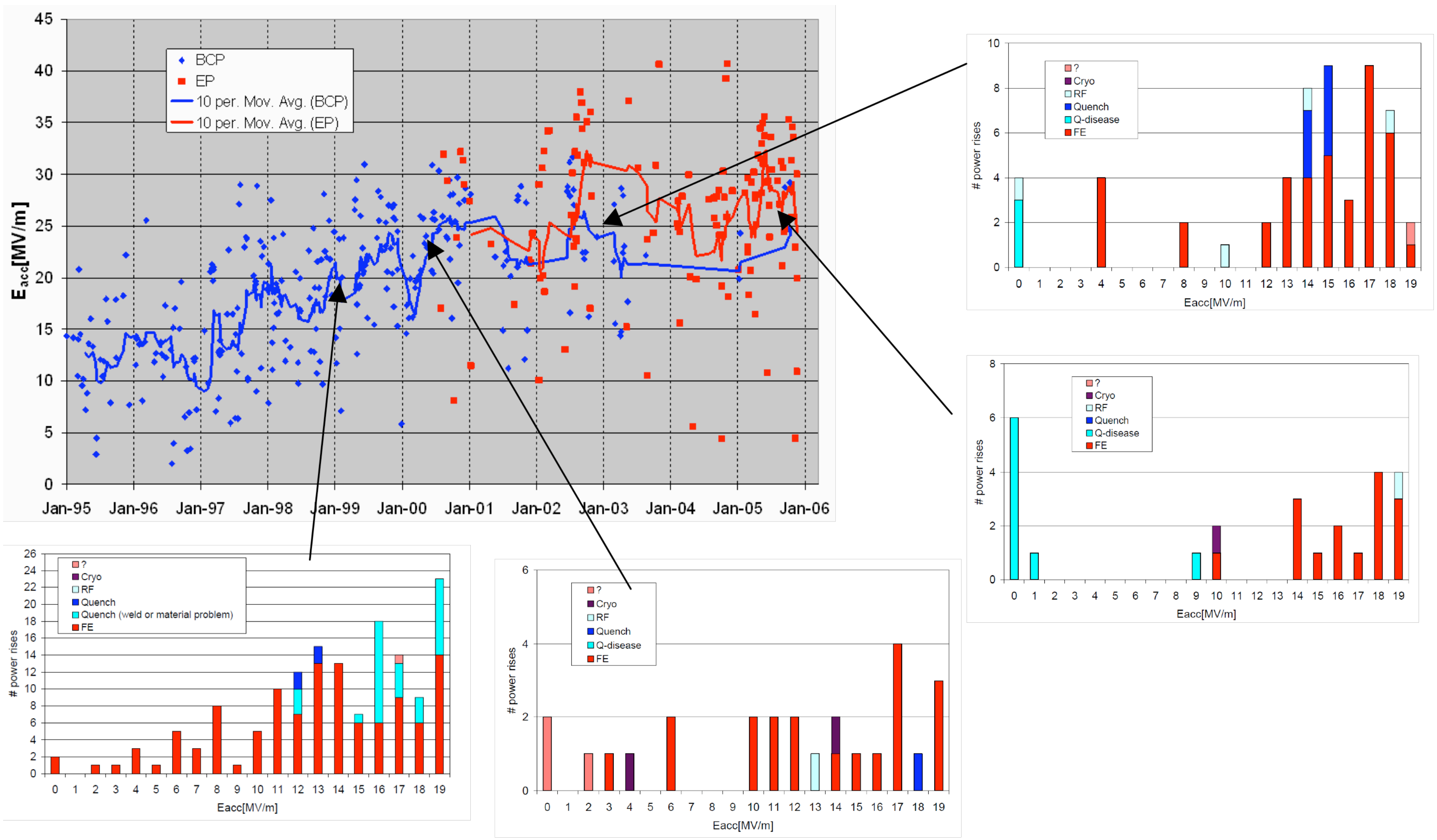
- We are trying to coat a JLab cavity to show that this technique will produce practical accelerator components.

  This is an iterative process, there are many variables.

  Mike Pellin should give a talk on this.

The main problem with SCRF is still Field Emission.





L. Lilje's summary of DESY cavity databank, DESY, 200

Can all SCRF problems can be solved with ~50nm ALD coatings?

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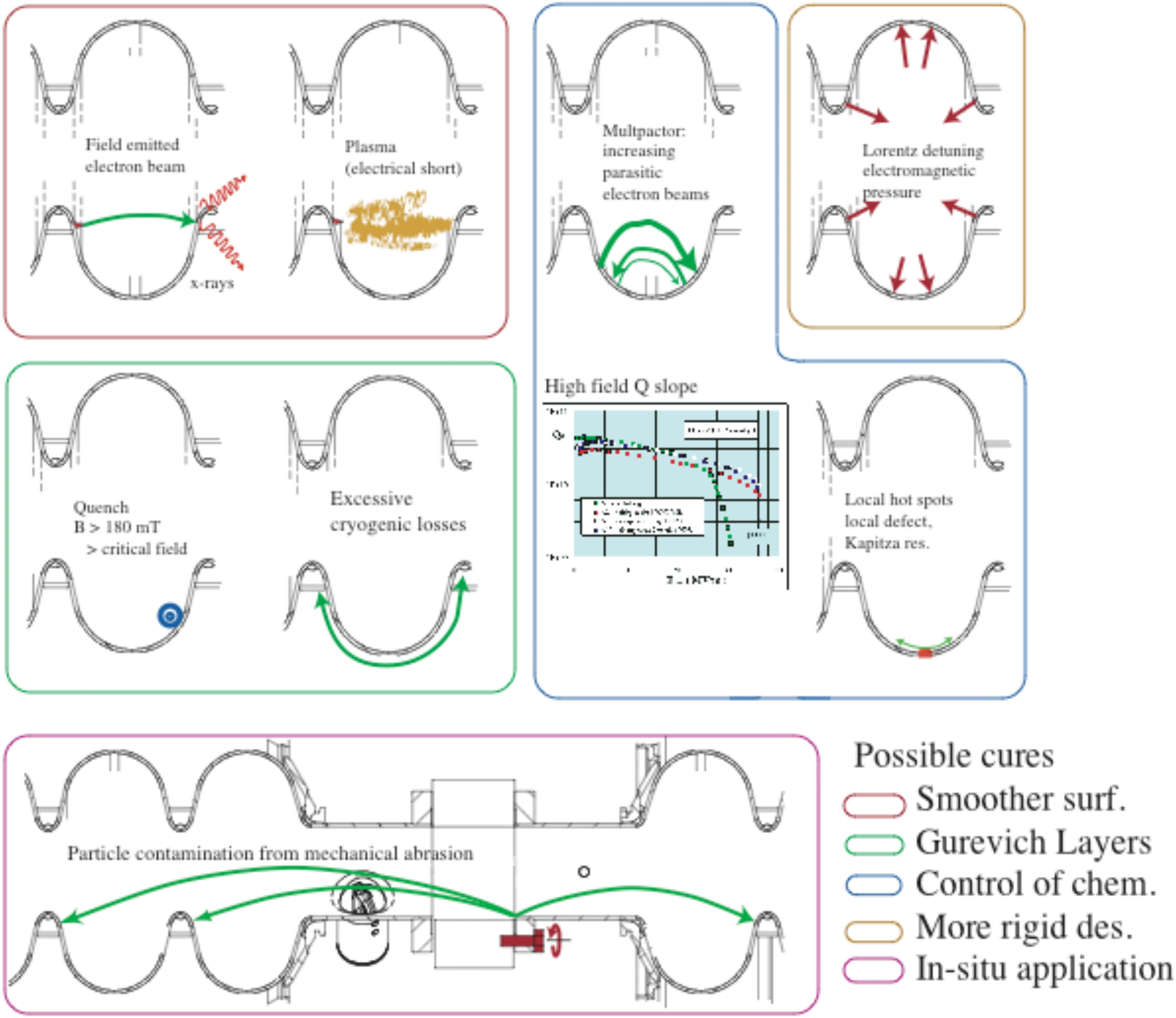

Normal conducting systems (μ cooling, CLIC) can also benefit.

- ~50 nm smooth coatings should also eliminate breakdown sites in NCRF.

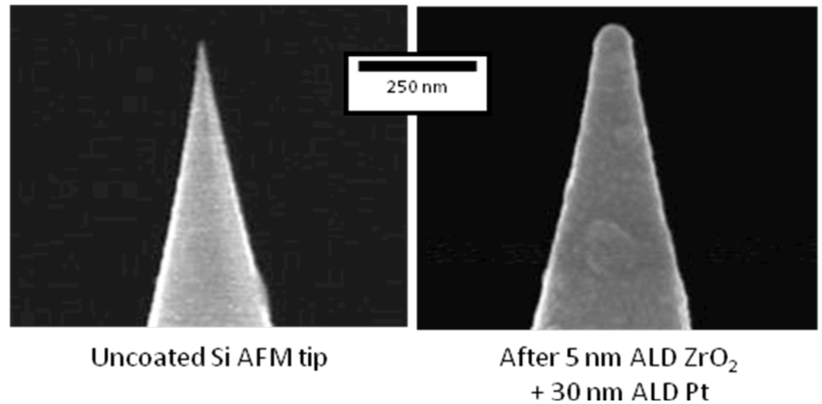

Figure 3: Scanning Electron Microscope images of nearly atomically-sharp tips, before and after coating with a total of 35nm of material by ALD. The tip, initially about 4 nm, has been rounded to 35nm radius of curvature by growth of an ALD film. Rough surfaces are inherently smoothed by the process of conformal coating.

- Copper, however, is a hard material to deposit, and it may be necessary to study other materials and alloys. Some R&D is required. This is underway.