



# Flux expulsion on small samples for LCLS-II HE

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TESLA Technology Collaboration 2020

February 5, 2020

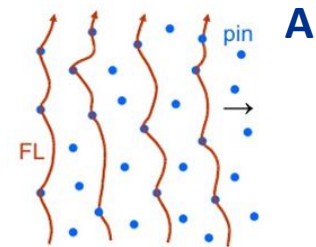
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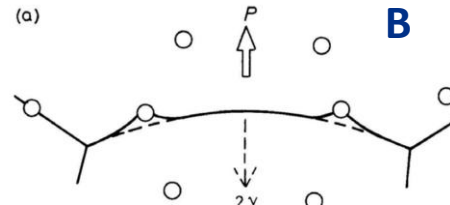
# Changes in grain size after heat treatment

- Painful to fabricate and measure flux expulsion in a series of single cell cavities to determine heat treatment temperatures for production material
- Avoid this for LCLS-II HE, inform purchasing new materials
- Came up with hypothesis that whatever pins flux during cooldown might be same thing that pins grain boundaries during heat treatment, and also determines grain size for given heat treatment process
- Dislocations are the key mechanism for flux pinning
  - This also pins grain growth
- Sort material for cavity vendor to direct heat treatment



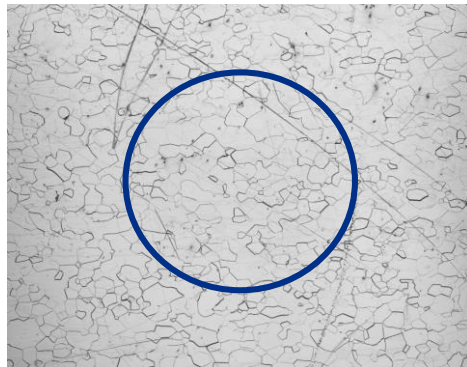
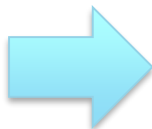
Lorentz force  $B \times j \rightarrow$

Mechanism that pins flux may also pin grain growth



## Niobium Vendor

- Performs grain size measurement after various heat treatments, sorts



To be baked at...



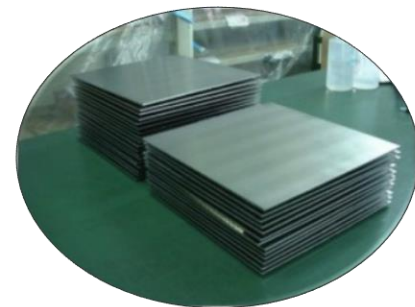
900 C



950 C



975 C

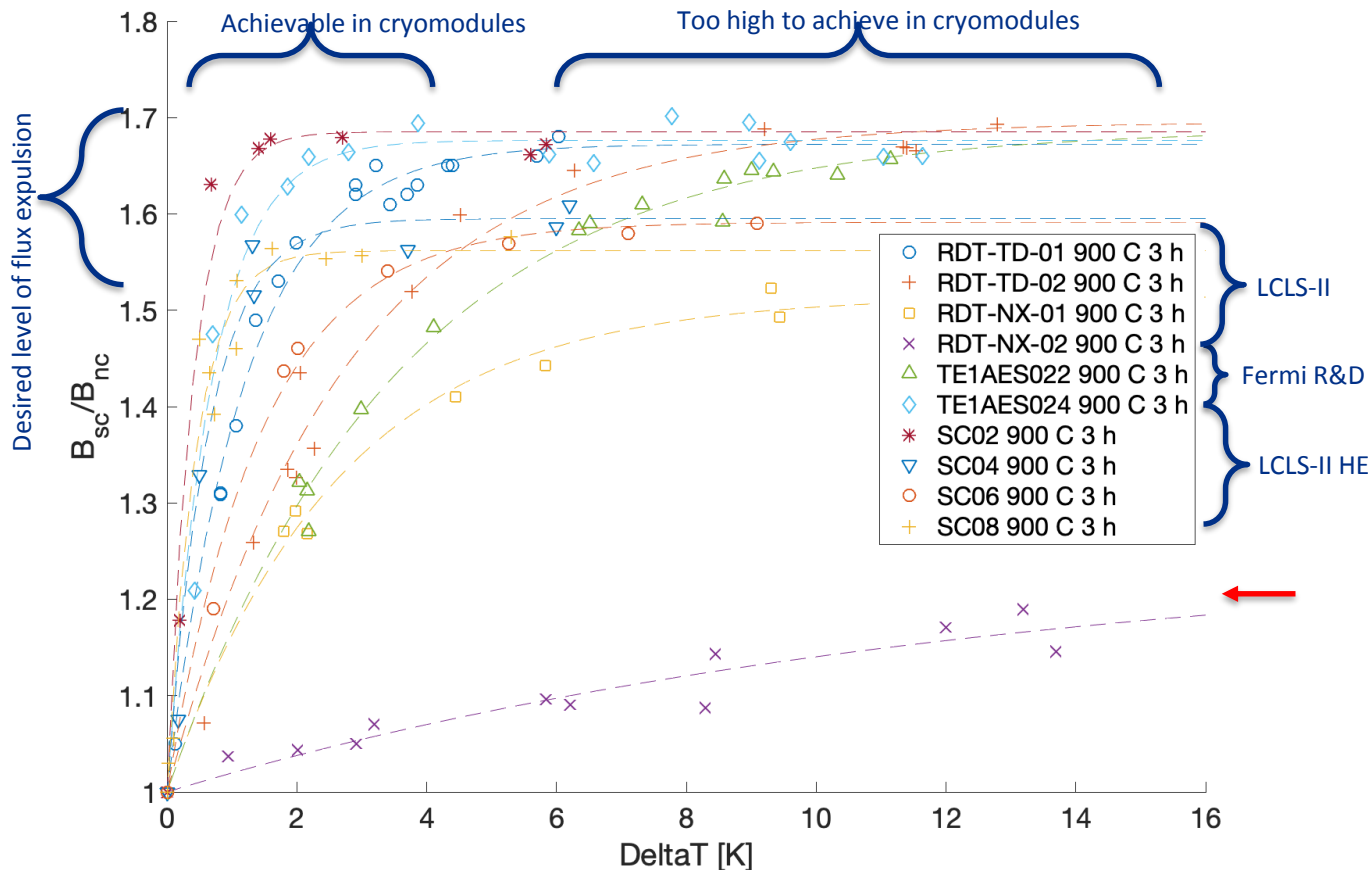


## Cavity Vendor

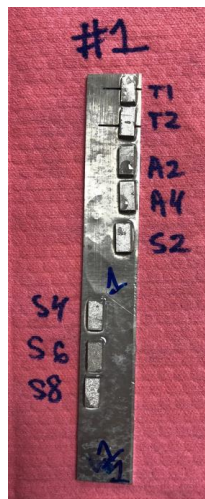
- Builds cavities with sorted material, has better idea of bake temp

We have seen a lot of variation in flux expulsion in the niobium material purchased from cavity vendors. All vendors seem to have variability from batch to batch.

# Why did we choose these cavities?



We studied extra material (corners) from sheets used to fabricate 10 single cell cavities. Flux expulsion of these cavities is well documented, now studying the material directly



Samples taken from corners, heat treated at temperatures of interest, and then cross-cut to study the inner grain size.



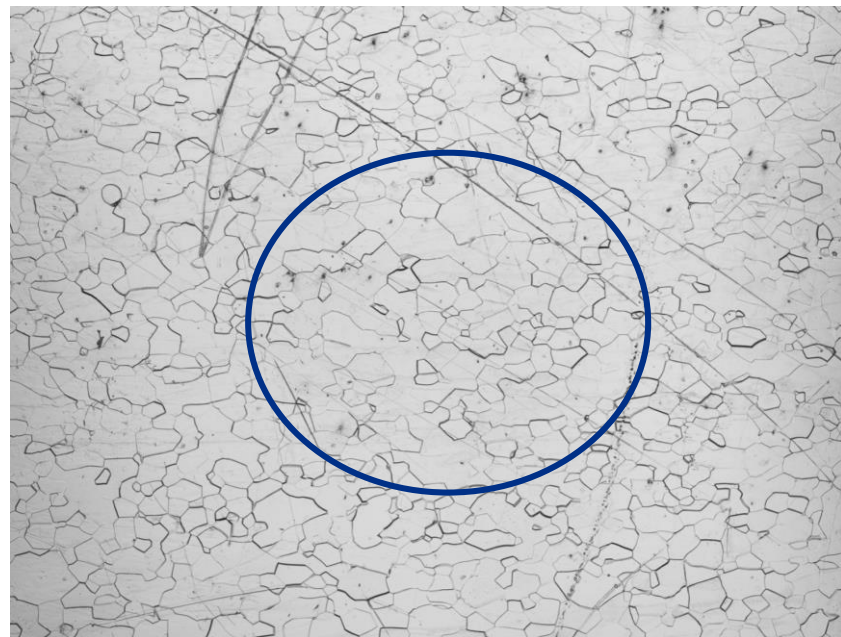
After cutting, samples were imbedded into thermoplastic, then mechanically polished to 0.05um and BCP'd.

Samples then studied in LCSM, an instrument accessible to vendors.

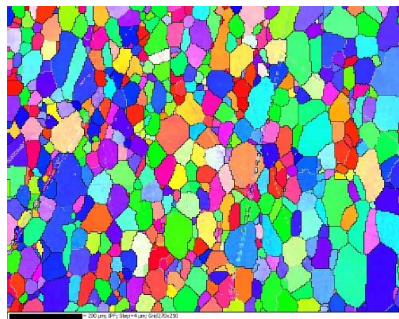


## First measurement of grain size

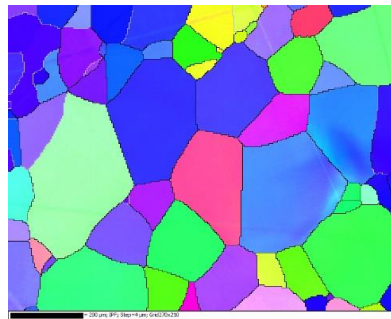
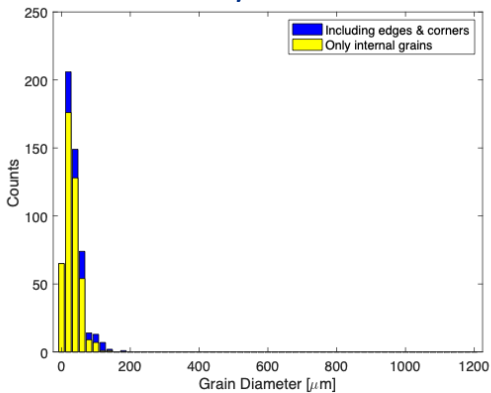
- Images taken by PLM, LCSM
- Manually counted intercepts, ASTM



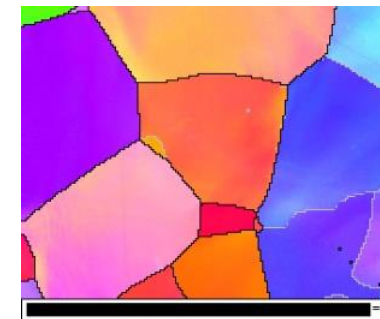
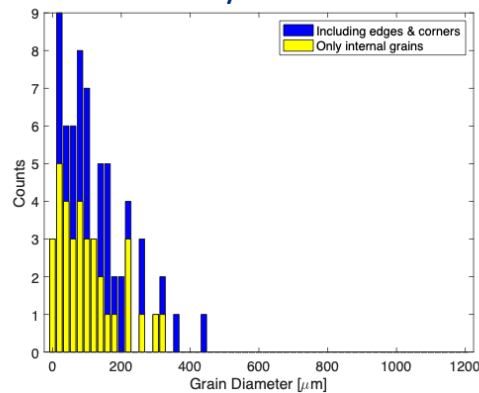
# EBSD- Zuhawn Sung



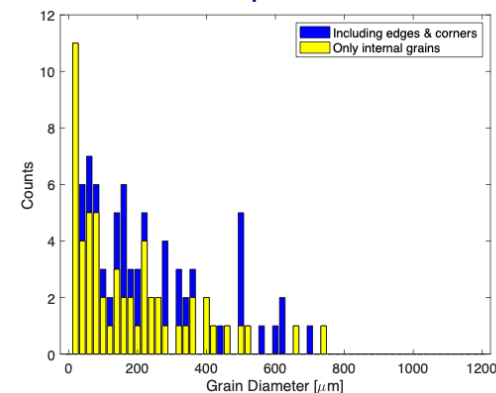
Vacuum Heating  
800 C / 3 hours



Vacuum Heating  
900 C / 3 hours

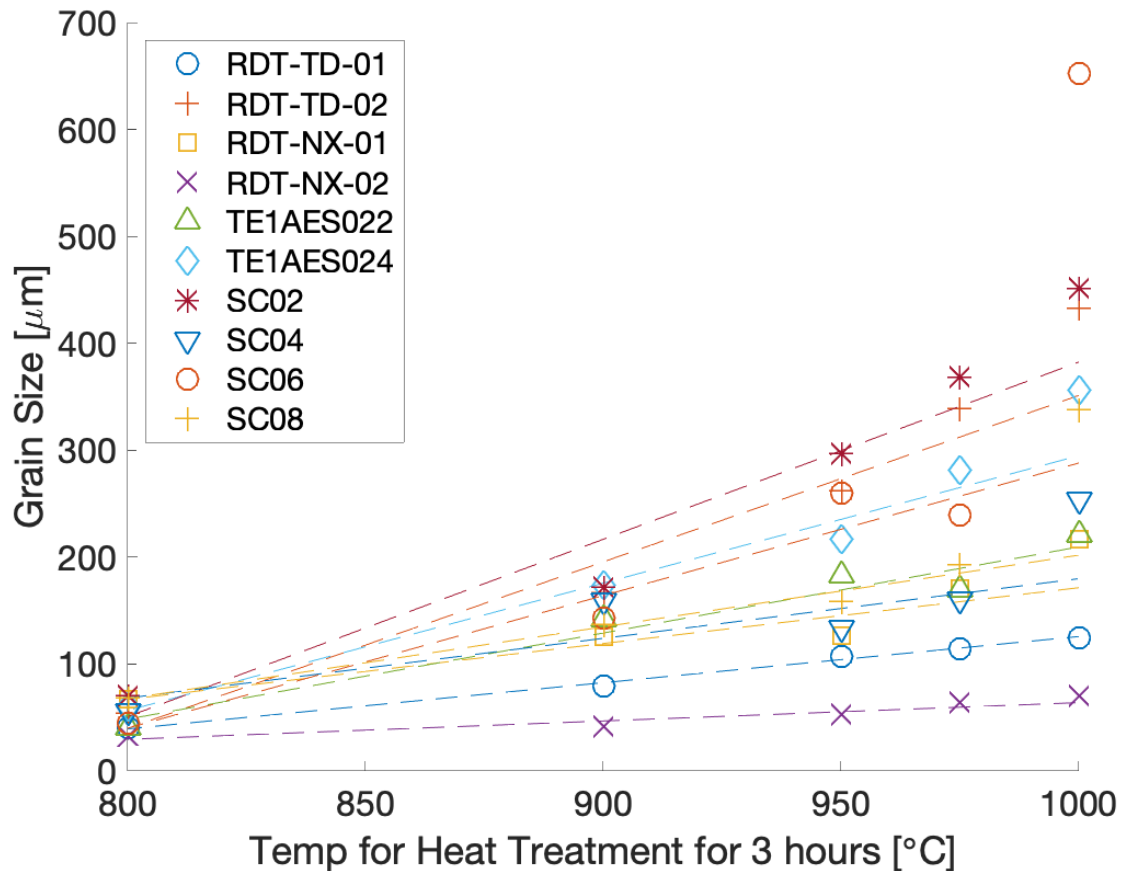


Vacuum Heating  
1000 C / 3 hours



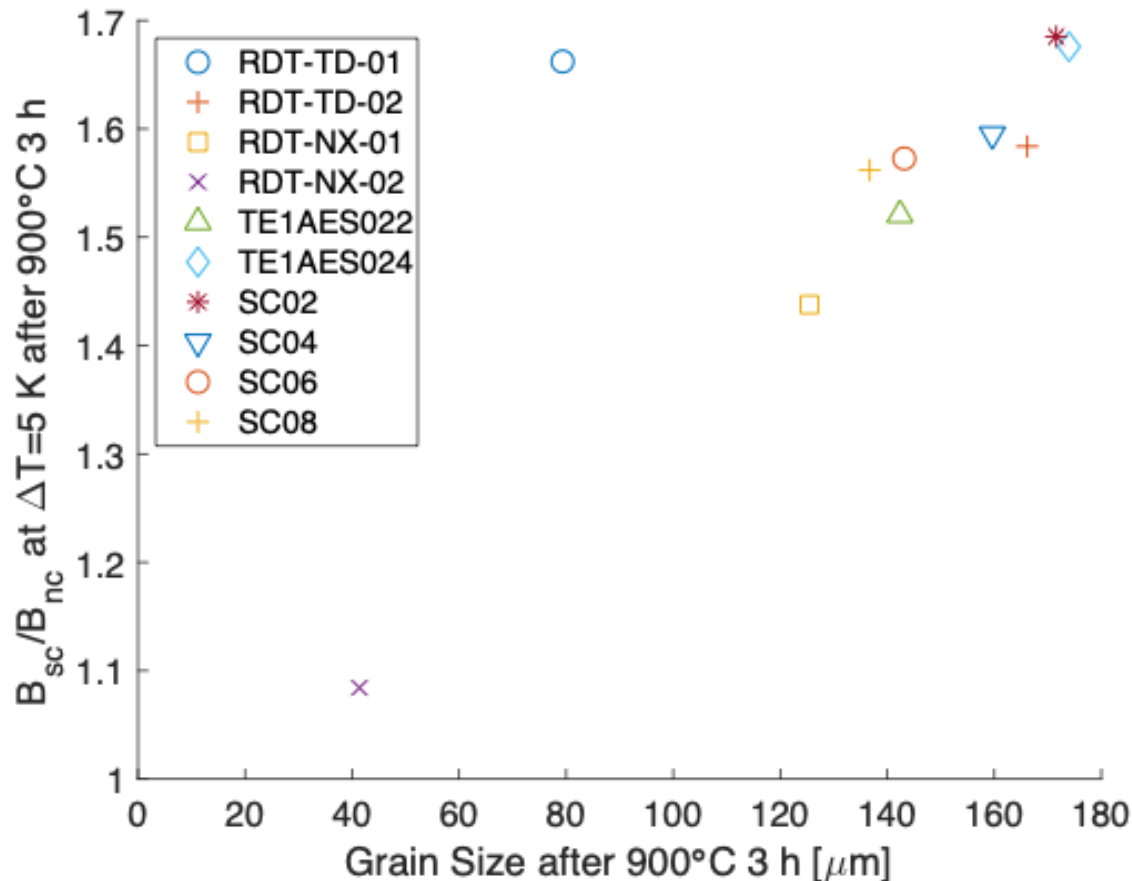
# Grain Size vs. HT Temp

- Note NX-02 experiences least amount of grain growth

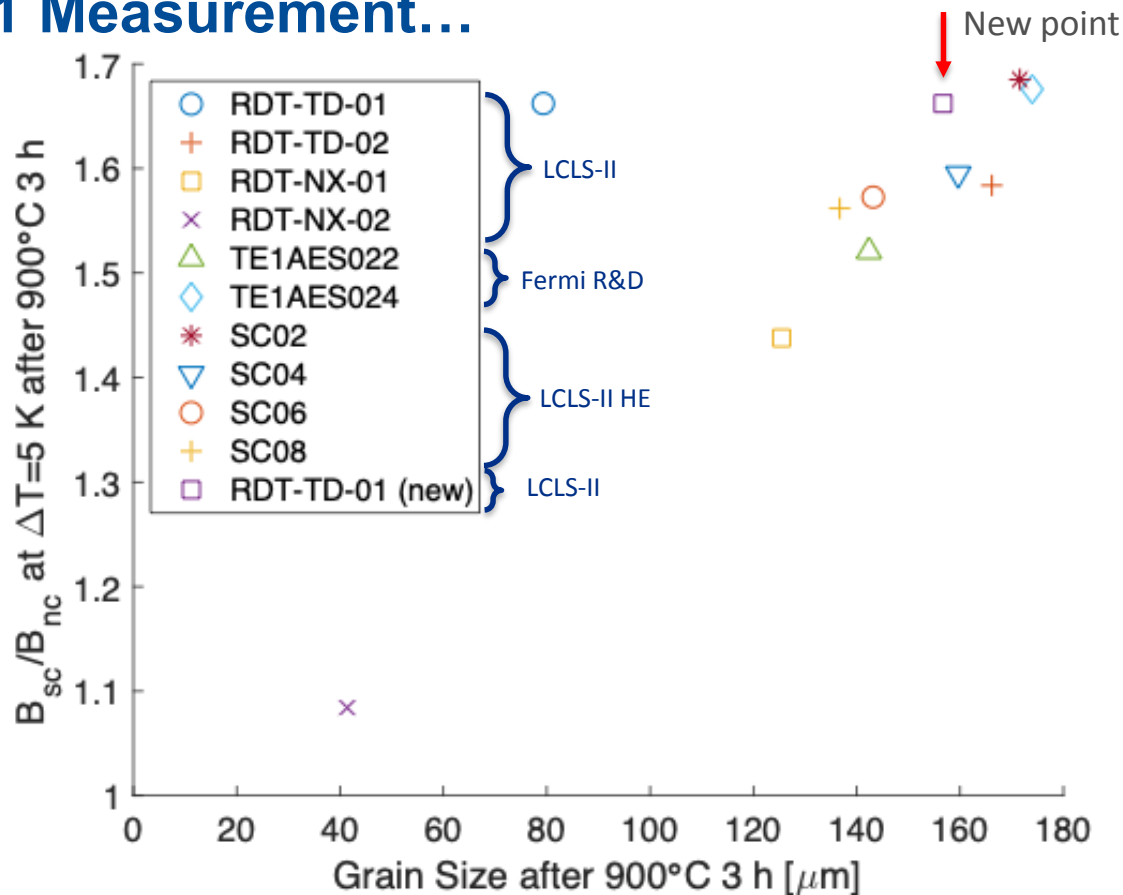




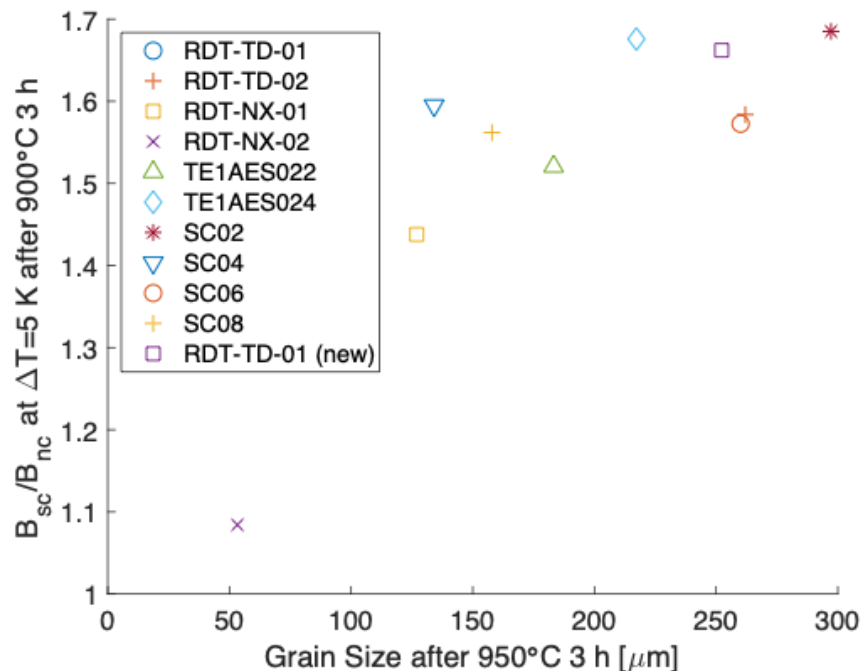
# Grain Size 900C vs. Flux expulsion 900C



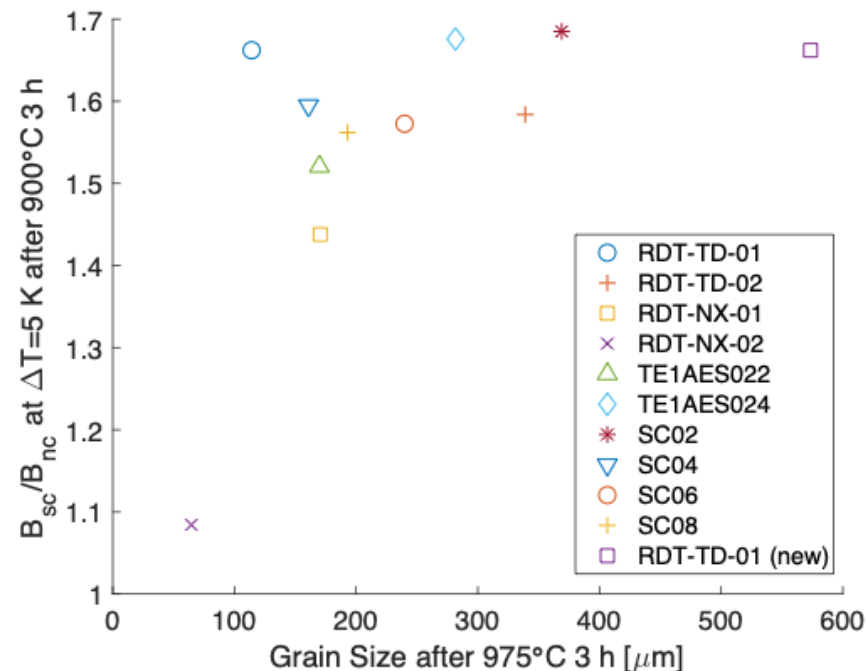
# Redid TD-01 Measurement...



## 950 vs 900 flux expulsion

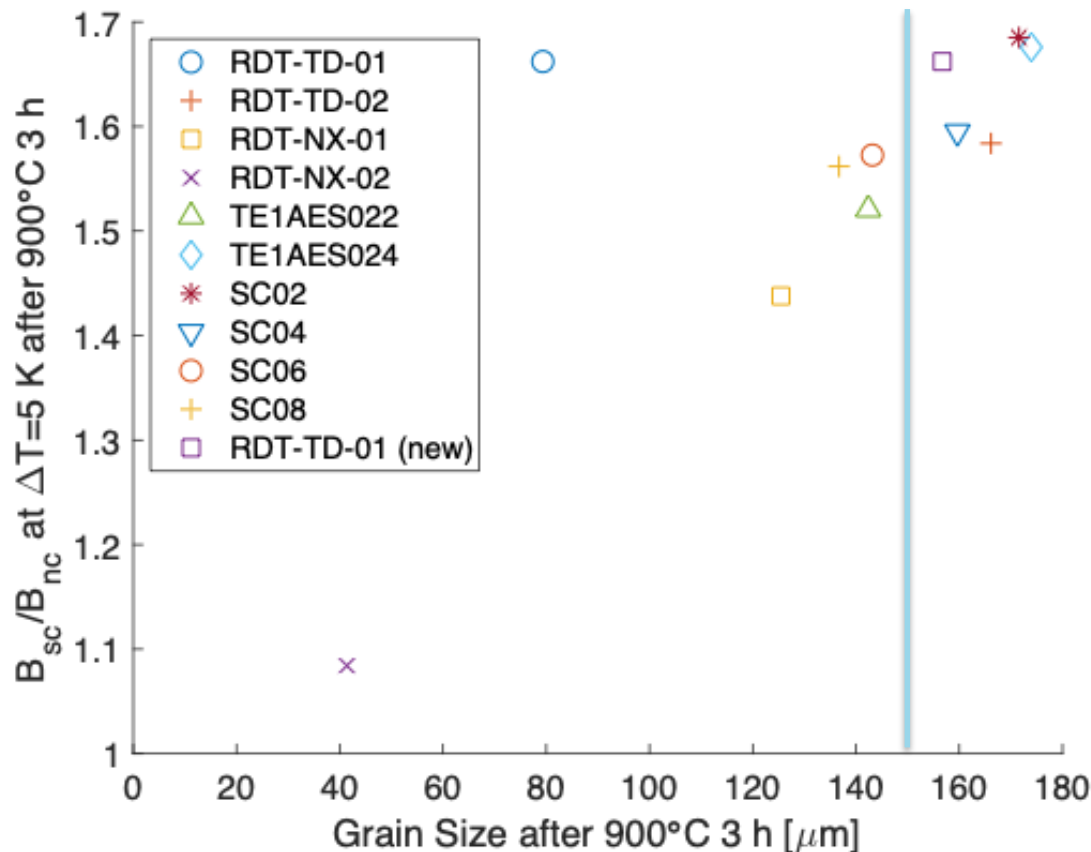


## 975 vs. 900 flux expulsion



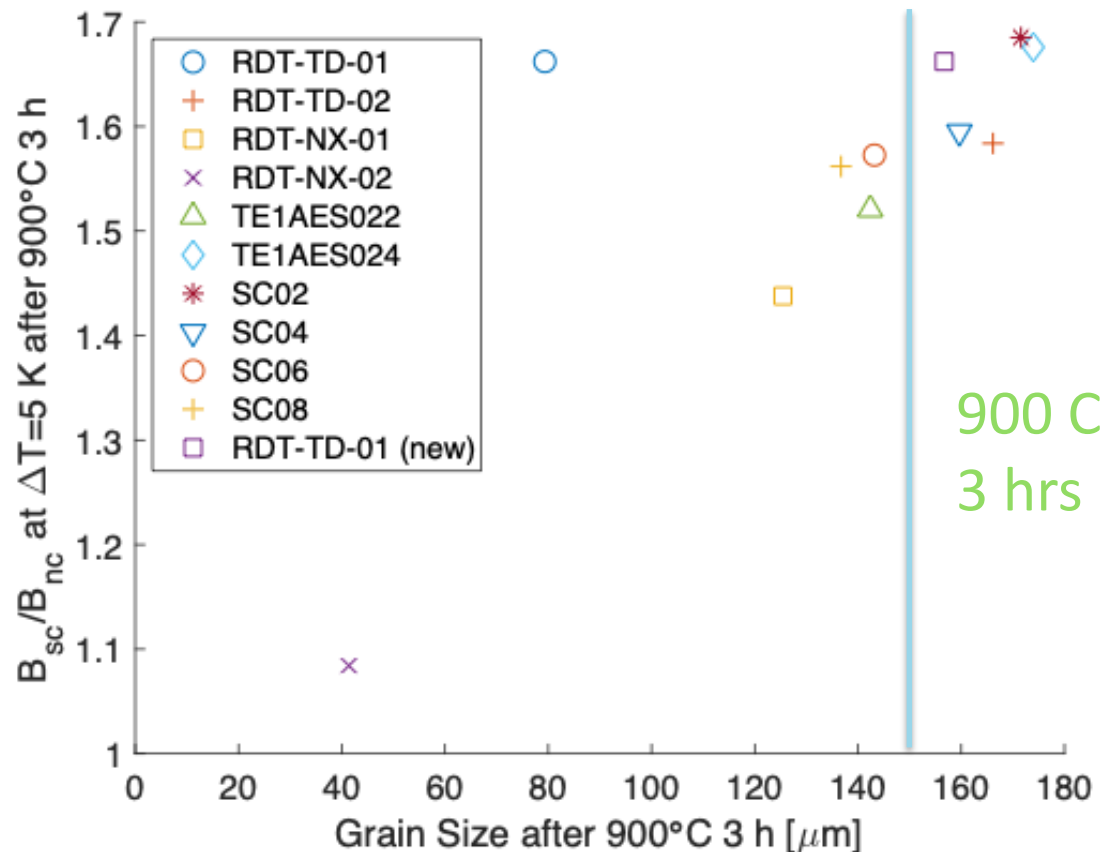
# Let's imagine a new spec...

- The flux you desire, informed by grain size



# Let's imagine a new spec...

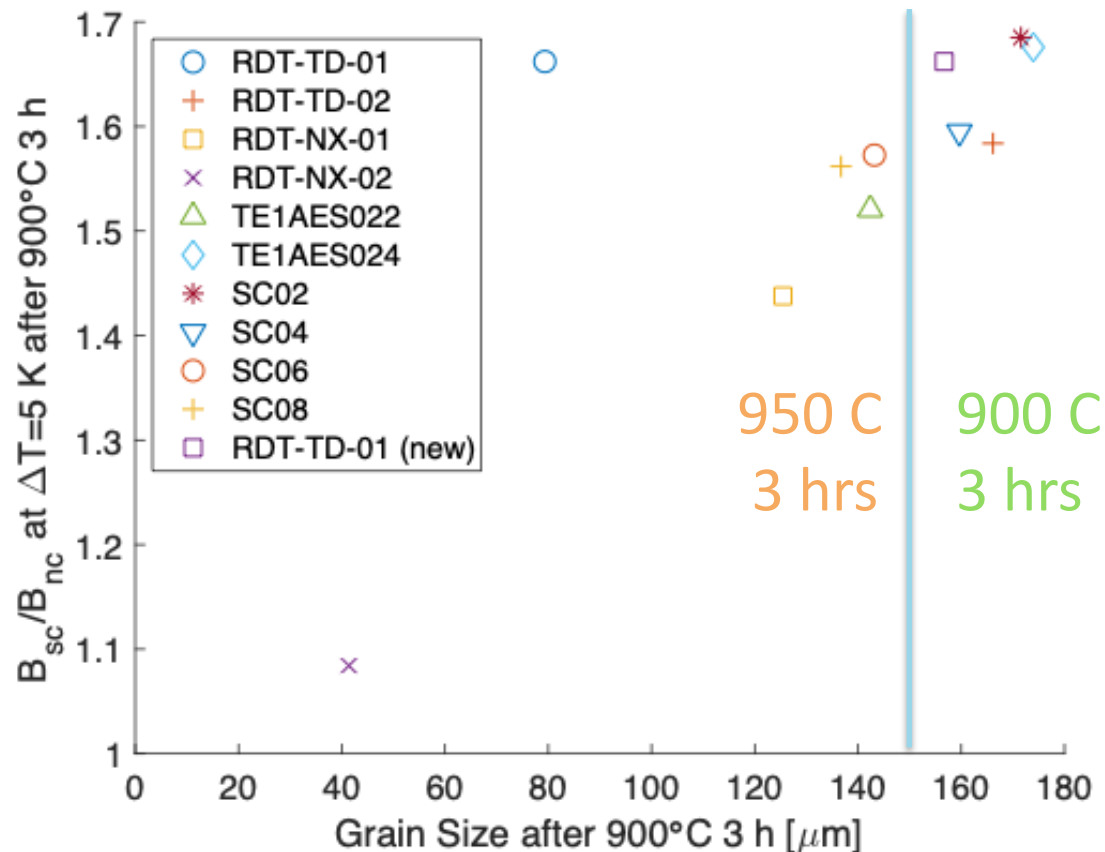
- The flux you desire, informed by grain size





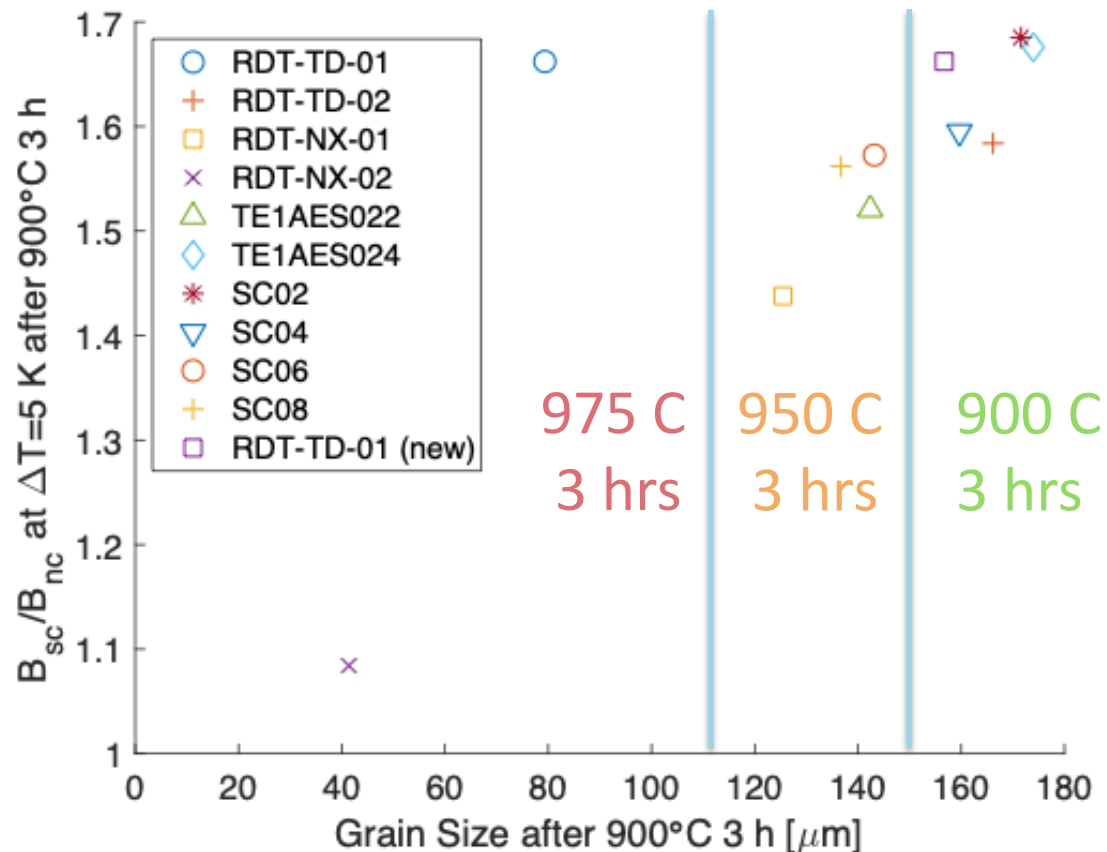
# Let's imagine a new spec...

- The flux you desire, informed by grain size



# Let's imagine a new spec...

- The flux you desire, informed by grain size



# Summary

- Fabricating and measuring flux expulsion in series of single cells is intensive
- Perhaps grain growth (easy to measure) can inform flux expulsion
- Nb corner samples heat treated, cut, and grain growth measured
- **We see a trend at 900C that correlated grain size and measured flux expulsion**
- Seeing this correlation may help us understand the mechanism behind flux pinning

## Outlook:

- See if grain size is good indicator
- Understand outliers better
- Possible method for sorting material at Nb vendor

**Thank you to LCLS-II HE for supporting this research!**

