Summary of WG1: high-Q/high-G

A. Miyazaki, D. Bafia, J. Chen, D. Reschke

Remote WG: high-Q / high-G

- Between in-person TTC meetings
- Promote very fresh results, students, follow-up VISA issues
- Next meeting: 2024 spring (TBD)

Conveners

Kensei Umemori (kensei.umemori@kek.jp)
Martina Martinello (martinam@slac.stanford.edu)
Akira Miyazaki (Akira.Miyazaki@cern.ch / Akira.Miyazaki@ijclab.in2p3.fr)

Overview of Sessions: 24 talks

Tuesday

Introduction and short summary of remote WG high-Q/hig...
Akira Miyazaki (CNRS/IN2P3/...
11:00 - 11:15

LCLS-II-HE Cavity and CM Results
James Maniscalco (SLAC)
11:15 - 11:30

Performance of first mid-T 1.3 GHz cryomodules
Jiyuan Zhai (IHEP)

Recent results of SHINE High-Q cavities and cryomodules
Jinfang Chen (SARI, CAS)

The first horizontal test results of TESLA-type large grain ...
Tomohiro Yamada (KEK)

Exploring mode mixing in PIP-II LB650 Cavities: Impact of 350C furnace baking on reduction post HPR and vertical tests
Genfa Wu (FNAL)

In-situ baking of SRF cavities
Oliver Kugeler (Helmholtz-Zentrum-Berlin)

Cooldown dependencies of mid-T treated cavity performa...
Christopher Bate (DESY)

80.5 MHz QWR 4K Q curves with various surface treatments
Jacob Brown (MSU)

RF and Material Studies on Interstitial Impurities in Bulk Nb Cavities
Hannah Hu (UChicago)
14:45 - 15:00

Study of interstitial oxygen as a result of various surface t...
Marc Wenskat (University of ...

Exploring the Effect of Various parameters in the HFQS P...
Katrina Howard (UChicago)

Recent Beta-NMR Studies at TRIUMF
Edward Thoeng (TRIUMF)

Electromagnetic Response of Disordered Superconductin...
Mehdi Zarea (Louisiana State...

Anomalous frequency shift within Dynes superconductor ...
František Herman (Comenius...

EP parameter investigation for low and high beta 650 MHz niobium cavities
Vijay Chouhan (FNAL)
16:45 - 17:00

Plasma Electrolytic Polishing *Cristian Pira (INFN LNL)*
17:00 - 17:15

Topographic Evolution of Heat-Treated Nb Upon Electrop...
Eric Lechner (JLab)

Wednesday

Suppression of field emission for the SRF cavities at KEK
Tomohiro Yamada (KEK)

Update on Traveling Wave Cavity Progress at FNAL
Fumio Furuta (FNAL)

Development and Application of Nb3Sn Thin Film SRF Ca...
Ziqing Yang (IMP)

ALD surface engineering for SRF cavities
Yasmine Kalboussi (CEA Saclay)

SRF multi-layer thin film R&D at KEK *Ryo Katayama (KEK)*
12:00 - 12:15

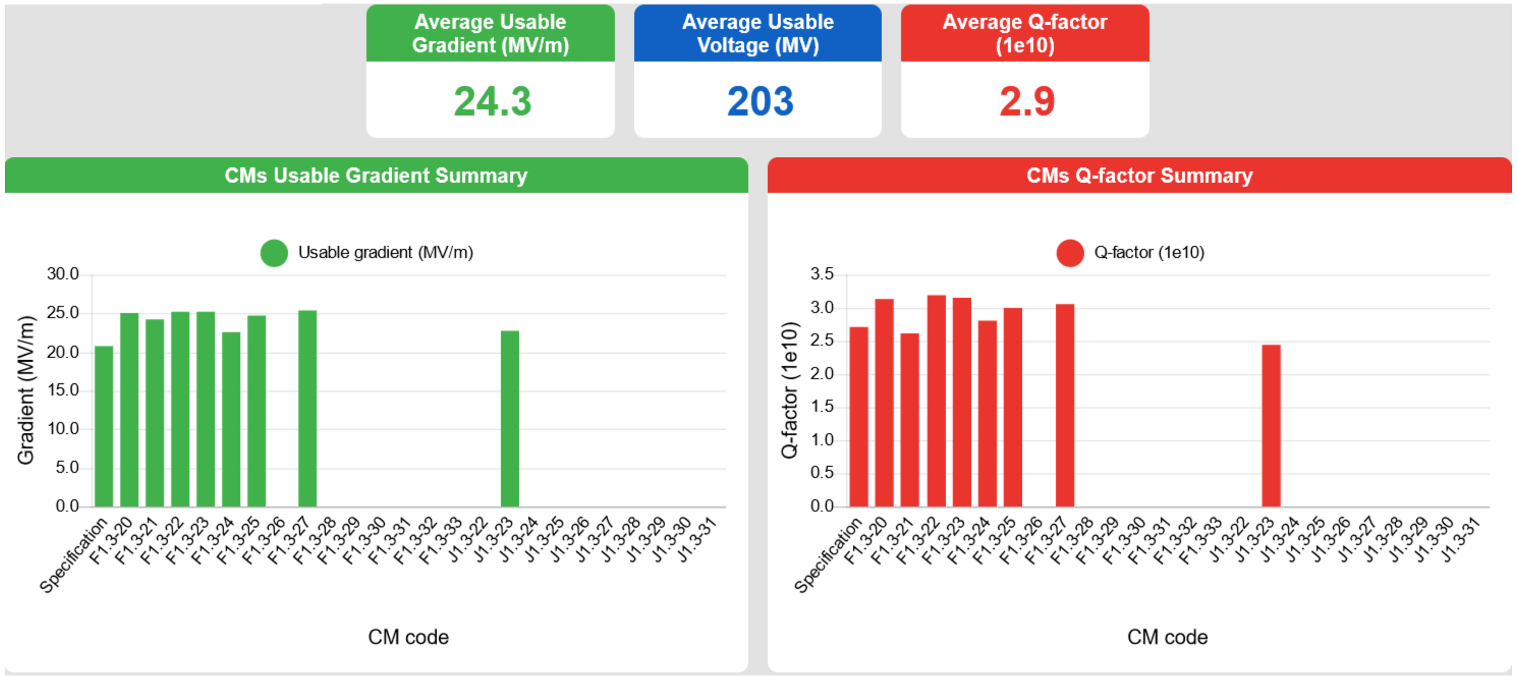
Comparison of Nb, Nb3Sn, MgB2, cuprate, and pnictide for future SRF cavities
Akira Miyazaki (CNRS/IN2P3/IJCLb)

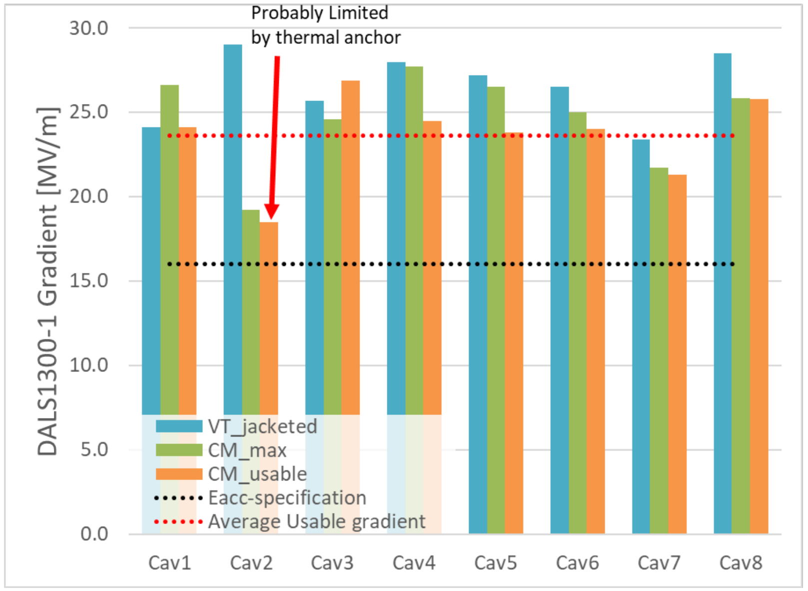
Exciting discussions!

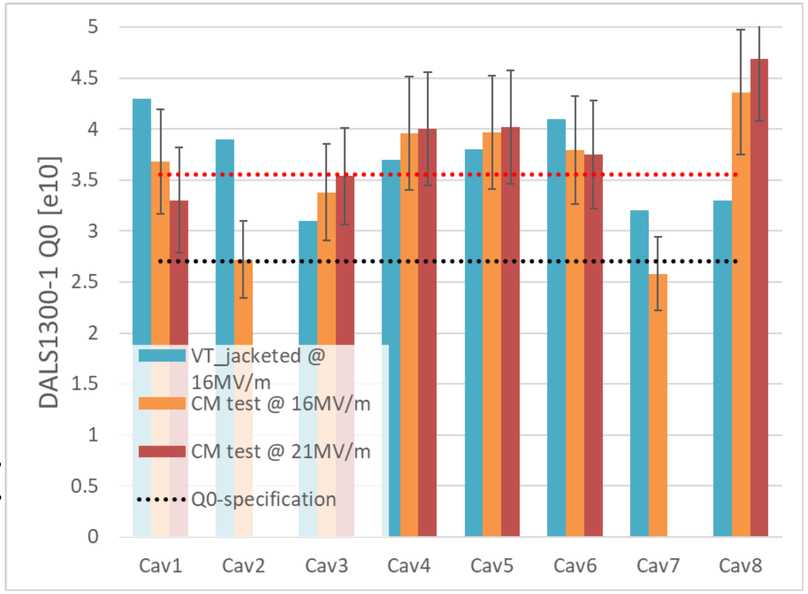
Han Li on behalf of Jiyuan Zhai

High Q/high G Cryomodules

James Maniscalco



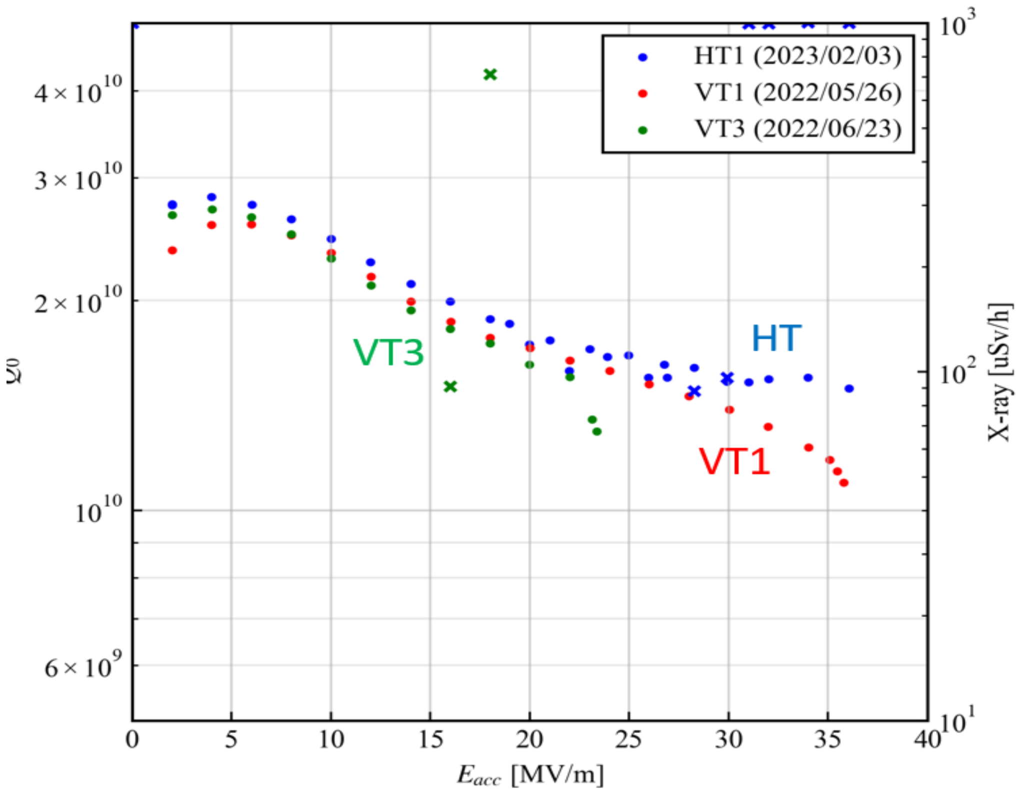




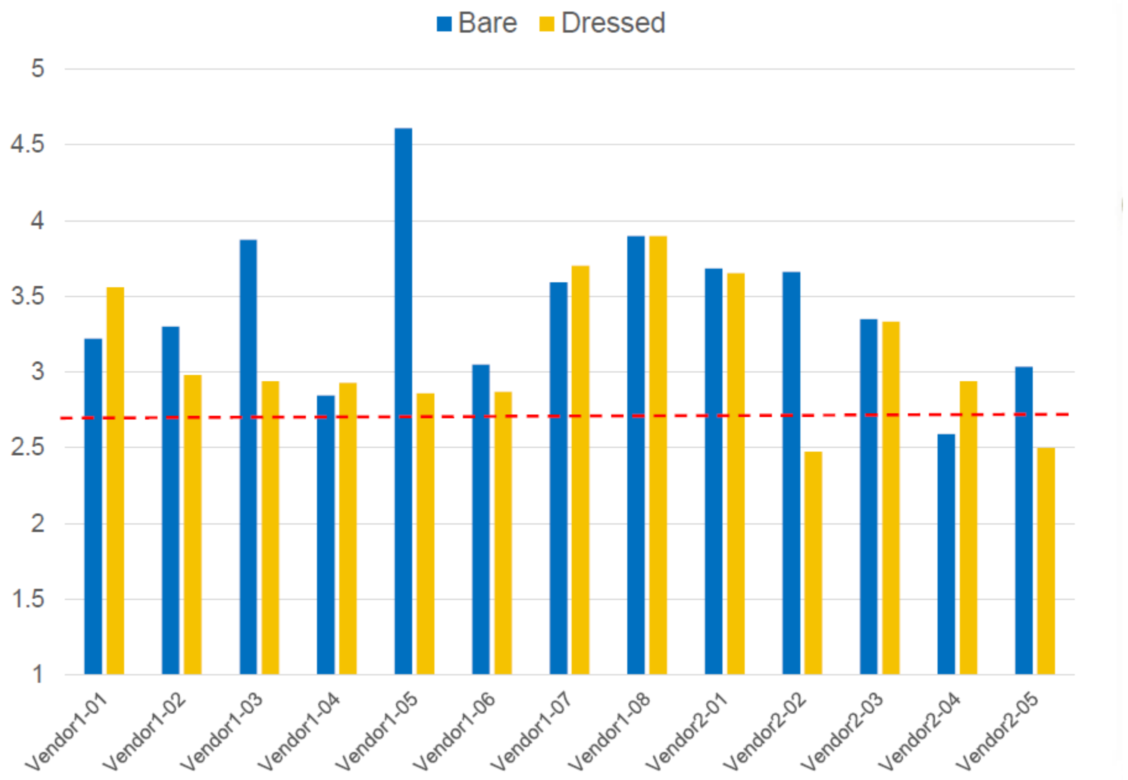
- Consistent excellent performance in LCLSII-HE
  - $E_{acc,avg}$ = 24.3 MV/m, $Q_{0,avg}$ = 2.9e10
- Successful transfer of mid-T baking by IHEP for DALS / S3FEL / SHINE
  - $E_{acc,avg}$ = 23.1 MV/m, $Q_{0,avg}$ = 3.6e10

High Q/high G Cavities for Cryomodules

Tomohiro Yamada



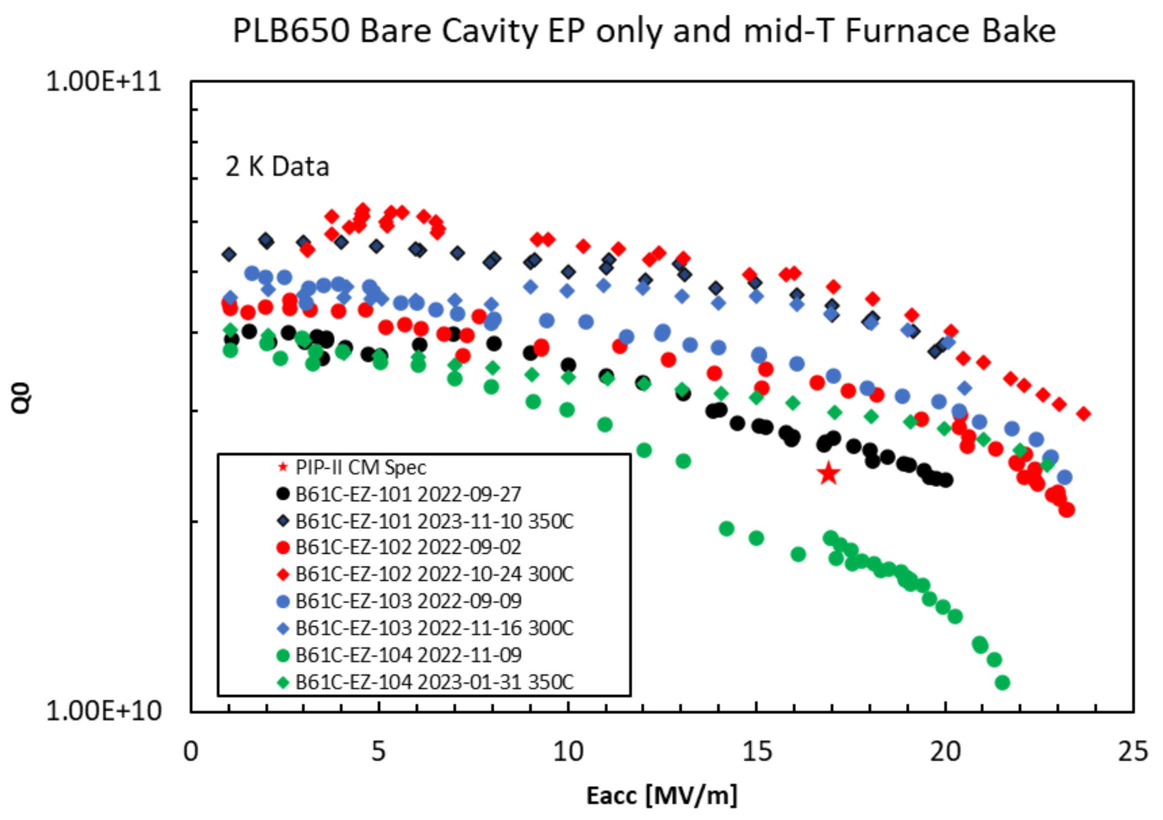
Zhenyu Ma on behalf of Jinfang Chen



- EP+LTB Jacketed large grain showed encouraging HT results compared to VT
- VT of Mid-T baking 9-cell cavities before and after jacketing show promising first steps toward CM assembly for SHINE

Mid-T baking for Improved 650 MHz cavities & Mode Mixing

Genfa Wu



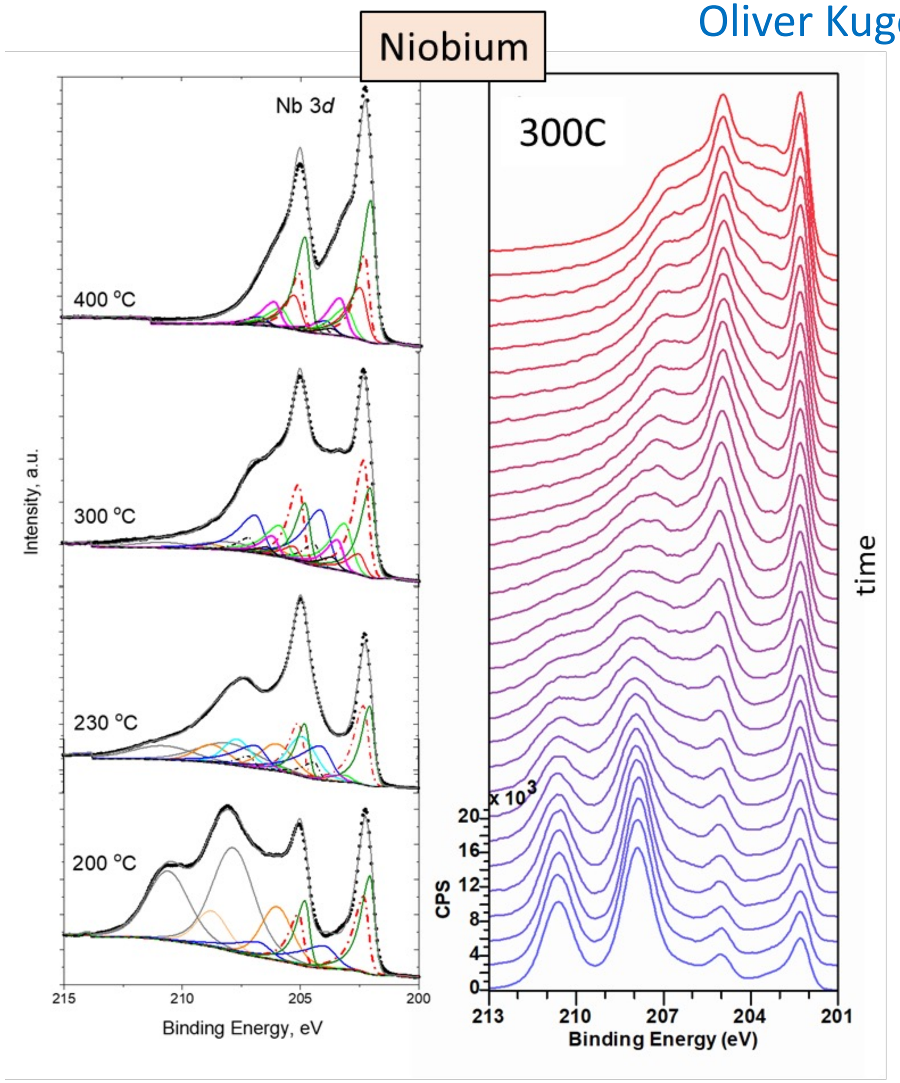
Cavity	Major processing	Mode mixing
B61C-EZ-101	800°C, 350°C	No
B61C-EZ-104	800°C, 350°C	No
B61C-EZ-104	900°C, 350°C	No
B61C-EZ-101	900°C, 350°C	Yes*

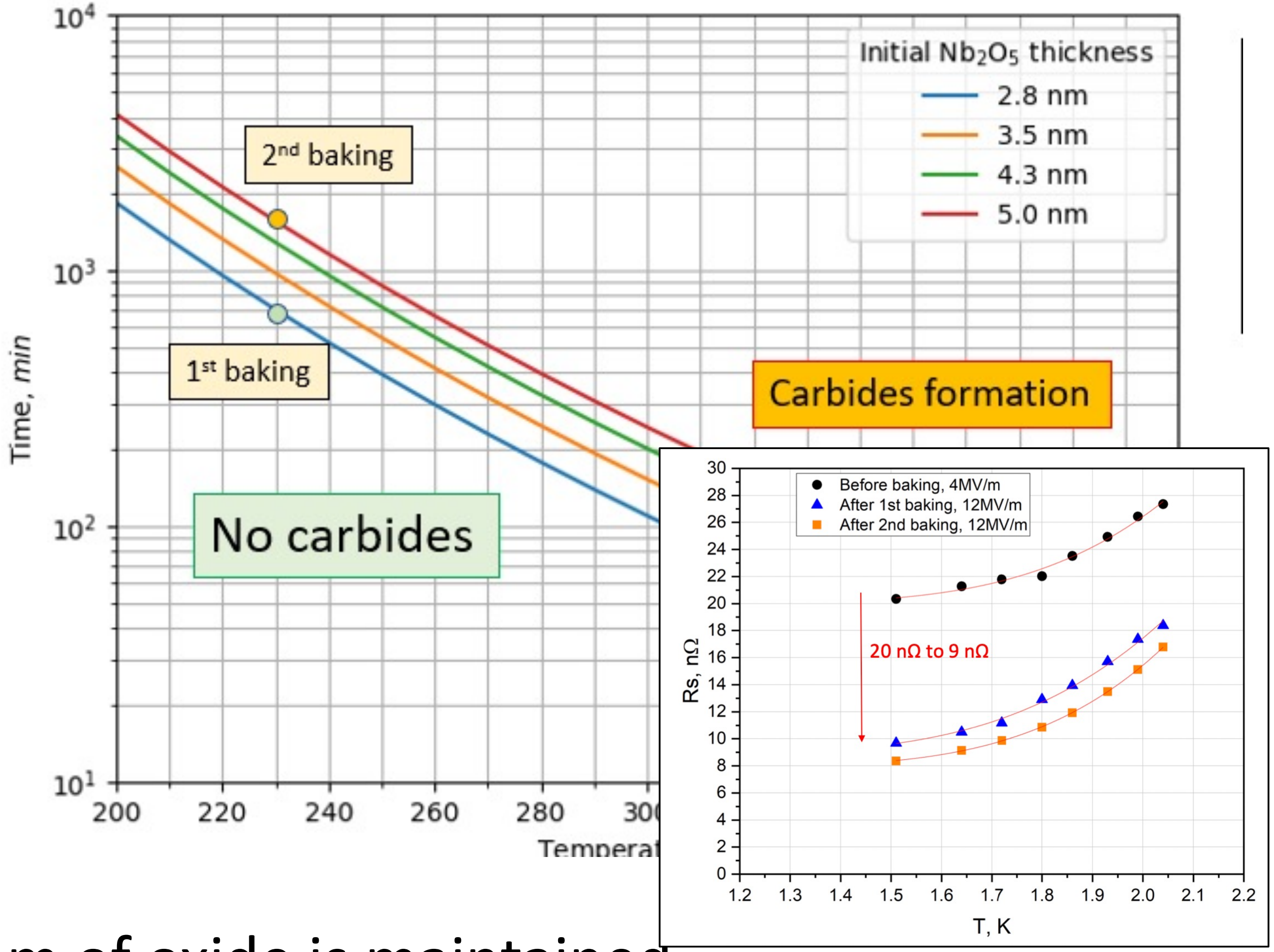
*cavity was shelved for four weeks, compared to routine test 1-week after evacuation

- Mid-T Baking shows improved 650 MHz performance for PIP-II
- Mode Mixing remains a topic of further study: is 350C critical to mitigate?

In situ Mid-T Baking XPS Study on Nb Samples

Oliver Kugeler on behalf of Alena Prudnikava





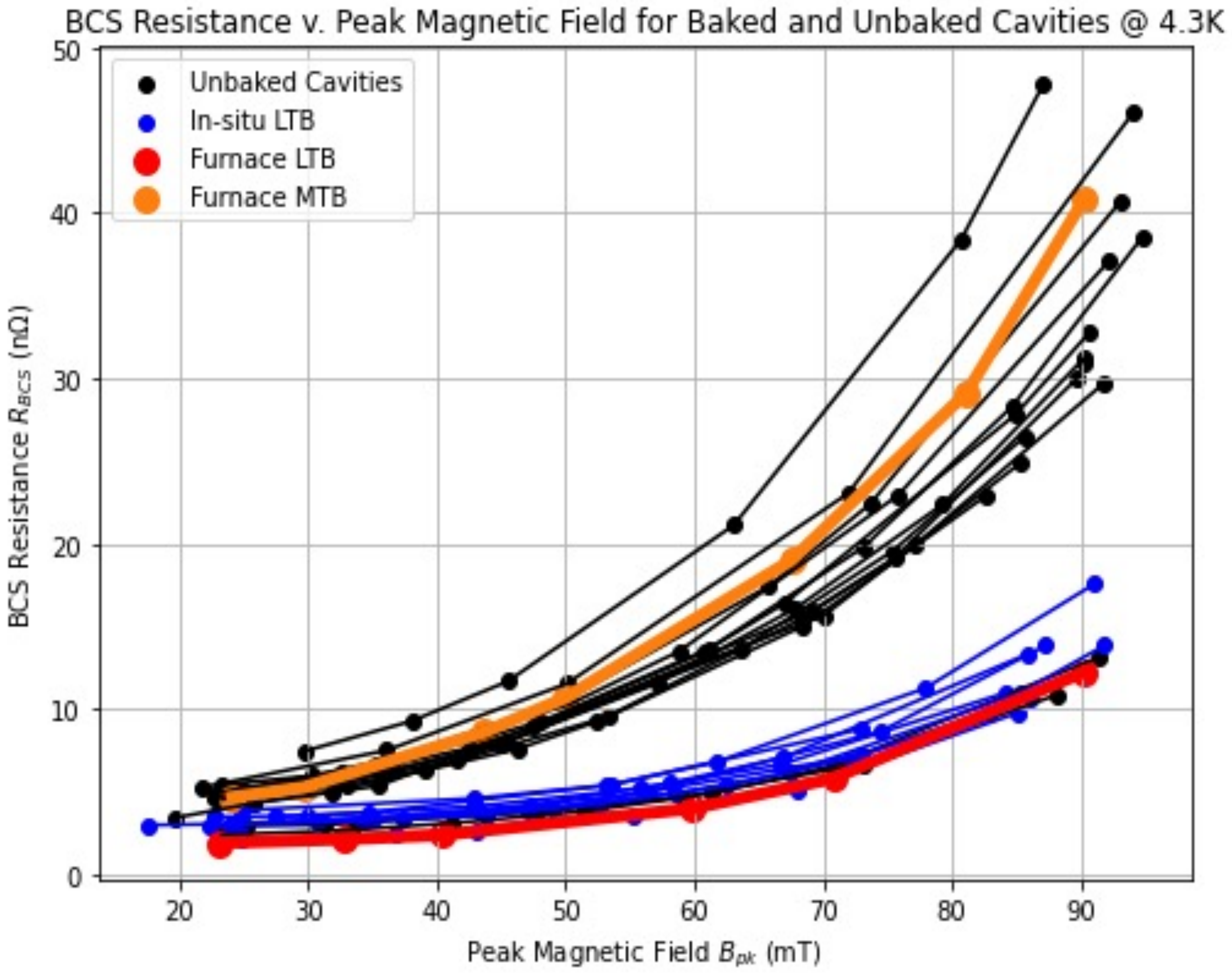
- No carbides form as long as >1 nm of oxide is maintained

Vacuum Baking Low Beta Cavities

Jacob Brown

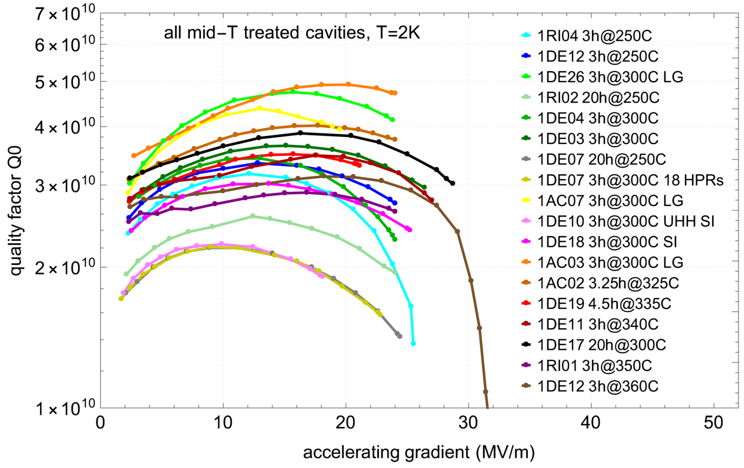
- Confirmed result of TRIUMF on the impact of vacuum baking (mid-T/low-T)
- LTB shown to be superior to Mid-T baking for QWR

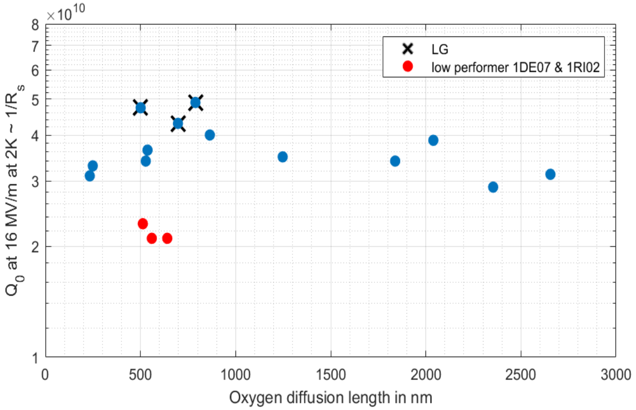
→ Standardization of the baking recipe for low-beta cavities?

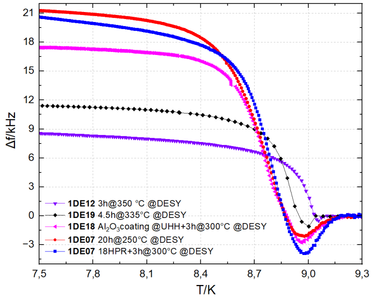


Optimization of mid-T baking

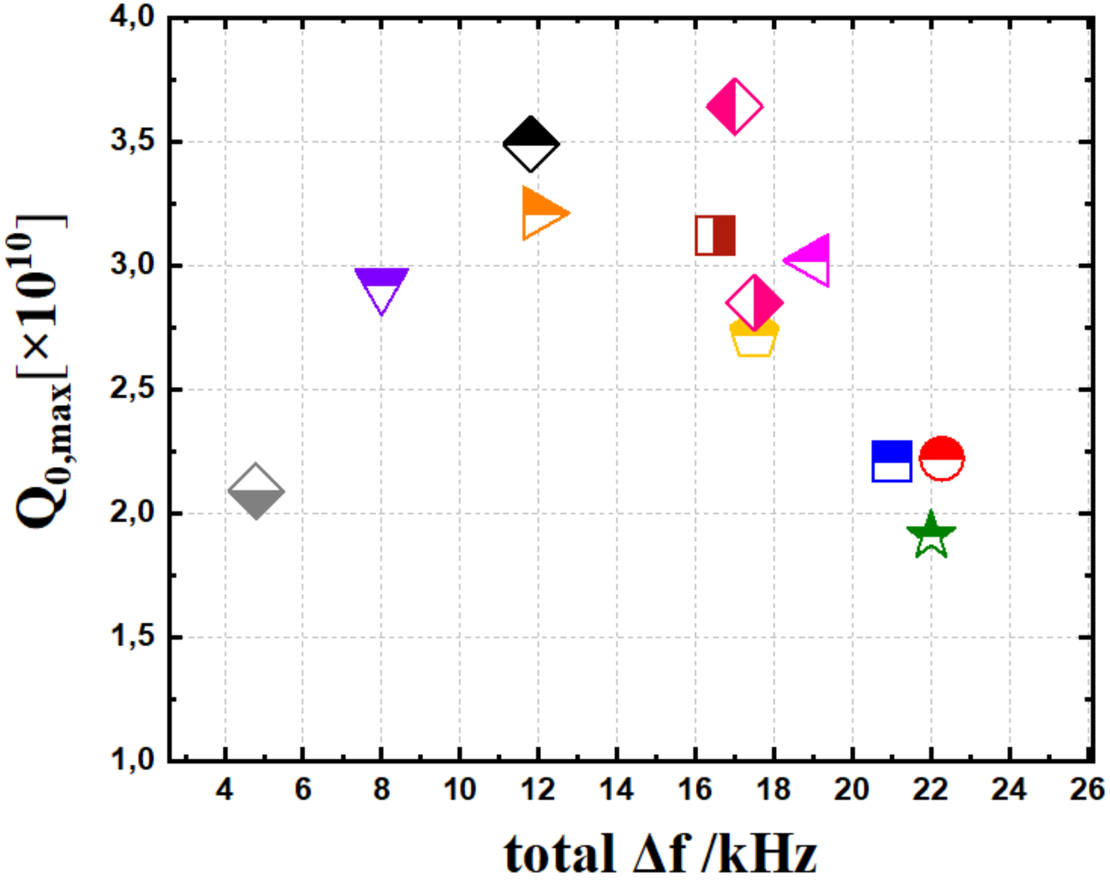
Christopher Bate







Marc Wenskat on behalf of Rezvan Ghanbari

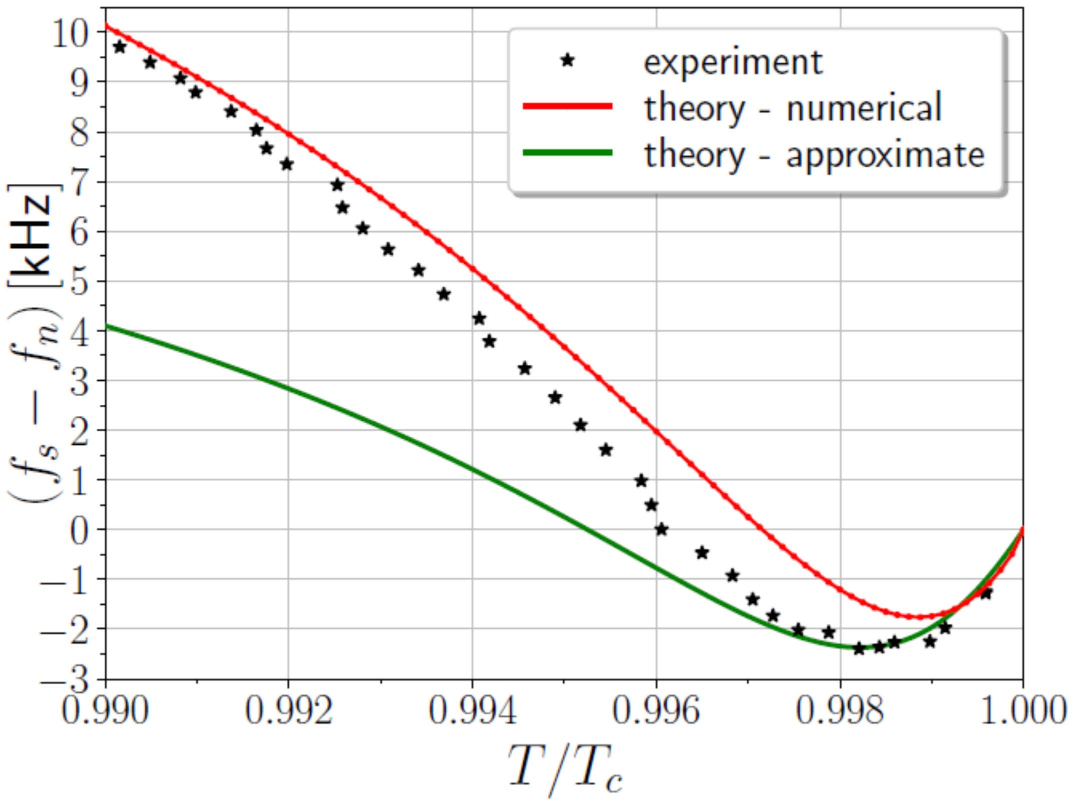


- Parameter sweep of mid-T baking surface treatments showed no obvious trend in Q or gradient with oxygen diffusion length >500 nm

- Rezvan confirmed positive correlation of Q_0 with frequency dip magnitude, but show non-monotonic behavior for large magnitudes

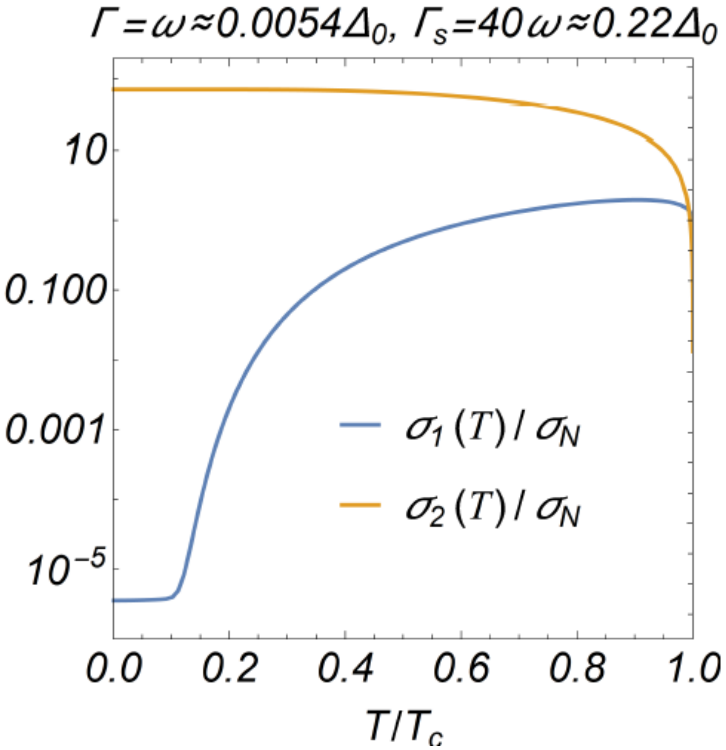
Understanding the F vs T Dip

Mehdi Zarea

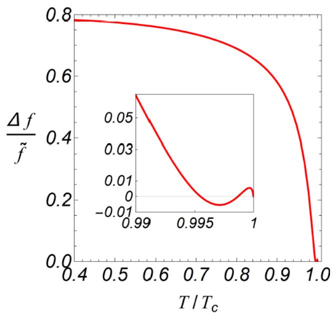


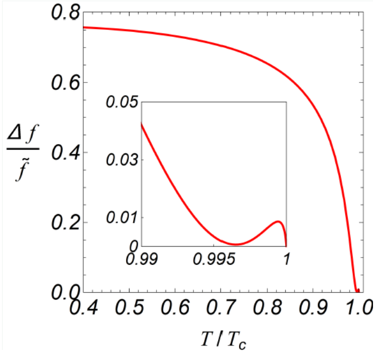
- Extended numerical theory to create approximate, analytical version
  - Captures salient features

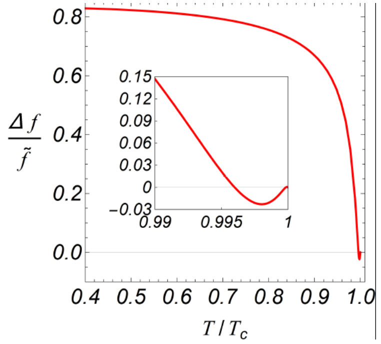
František Herman

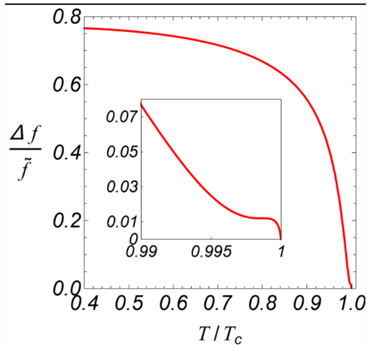


- Correctly calculated all frequency features near T_c
  - Simple interplay of Re vs Im conductivity





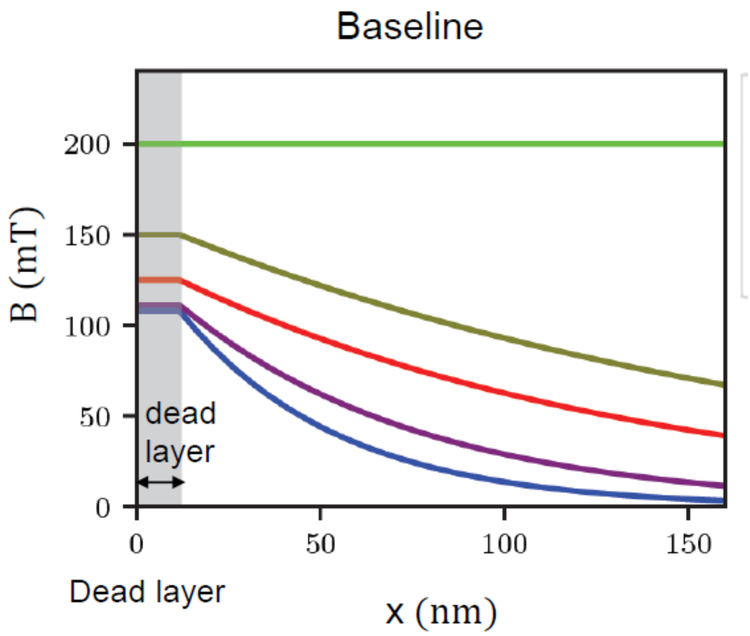


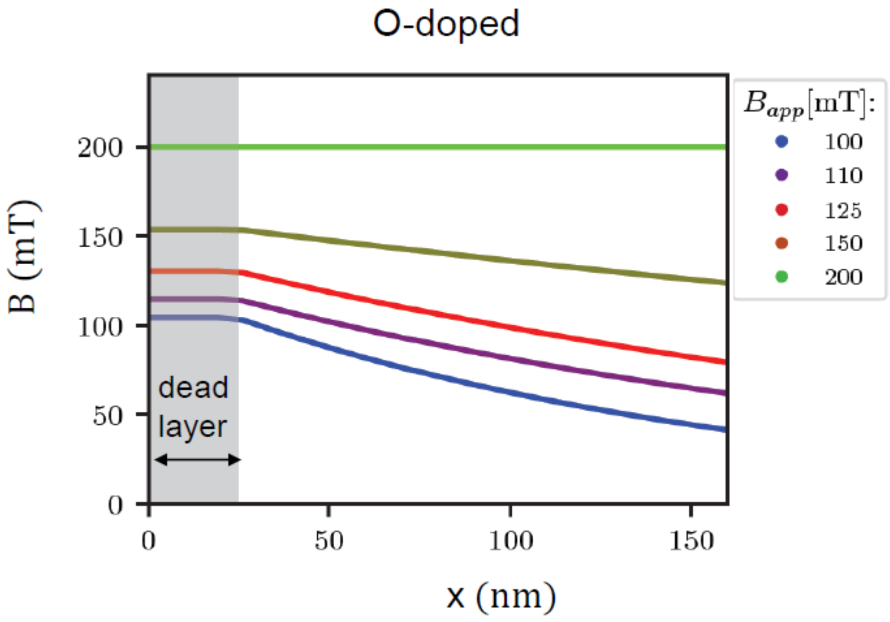


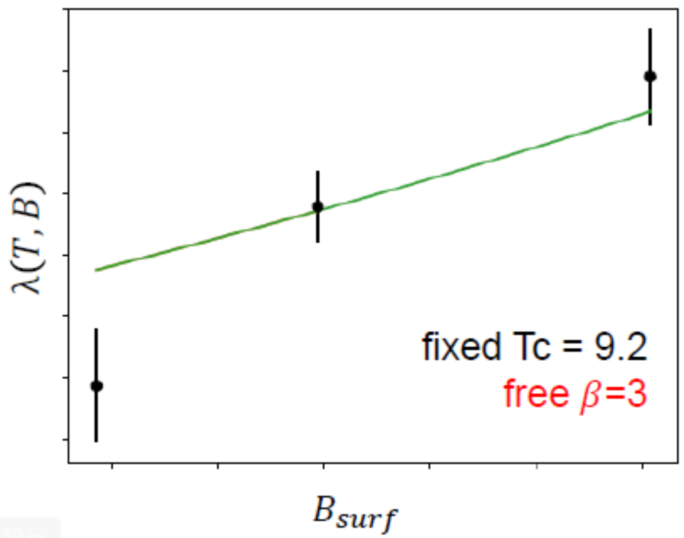
Beta NMR

- Upgraded to 200 mT applied field
- Comparison of BCP and O-Doped samples showed extended B field: Nonlinear Meissner Effect (?)

Edward Thoeng



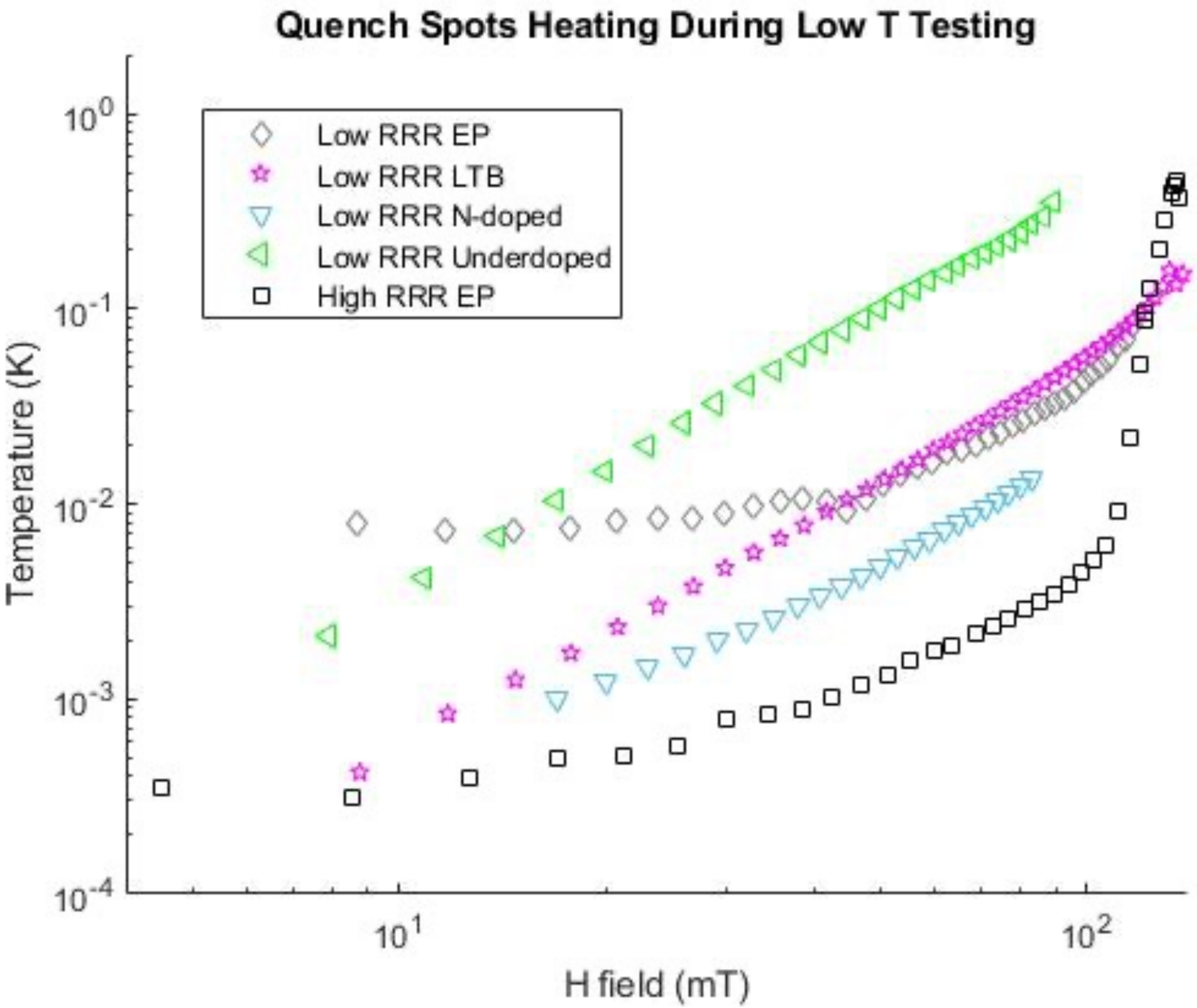




Further Insights on Role of Impurities in Cavities

Katrina Howard

- Impurities intrinsic to low RRR cavities seem to prevent onset of HFQS losses
  - Synergy between intrinsic and introduced impurities



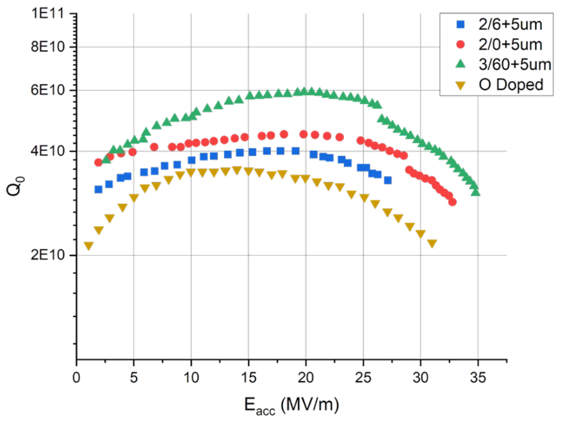
O vs N vs EP in Enabling High Gradients

Hannah Hu

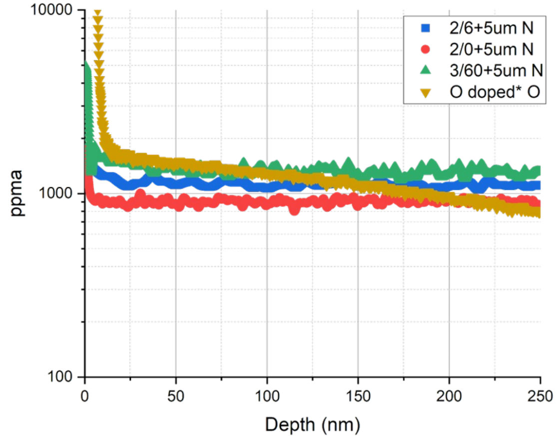
- O-doping and N-doping show similar concentrations of impurities and similar performance

→ O and N are performing similar roles in cavities
  - Is O less effective than N at capturing H?
  - Q: Does EP play a critical role in establishing high G?

Comparison of O vs N Doped Cavities



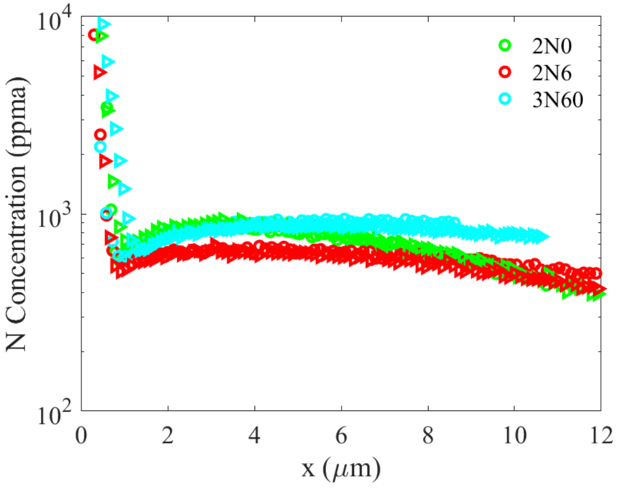
ToF-SIMS



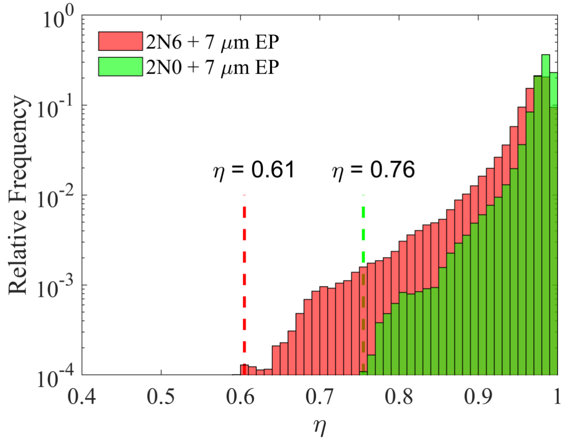
Eric Lechner

- AFM studies on variously N-doped samples post sequential EP reveal severity of surface roughness driven by pits scooped out by nitrides
- SIMS measurements confirm similar concentrations between 2/0, 2/6, and 3/60
  - A: EP DOES play a critical role in enabling high G: surface roughness decreases superheating suppression factor

SIMS



Superheating Suppression Factor Obtained from AFM Measurements

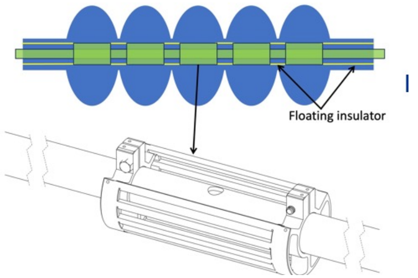


Optimizing EP for Low and High B 650 MHz

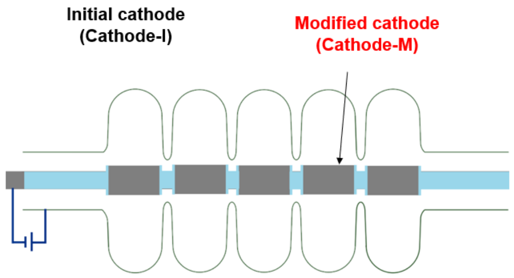
- EP with modified cathode and parameters showed good performance in baseline VT
- Next step: mid-T or N-doping!

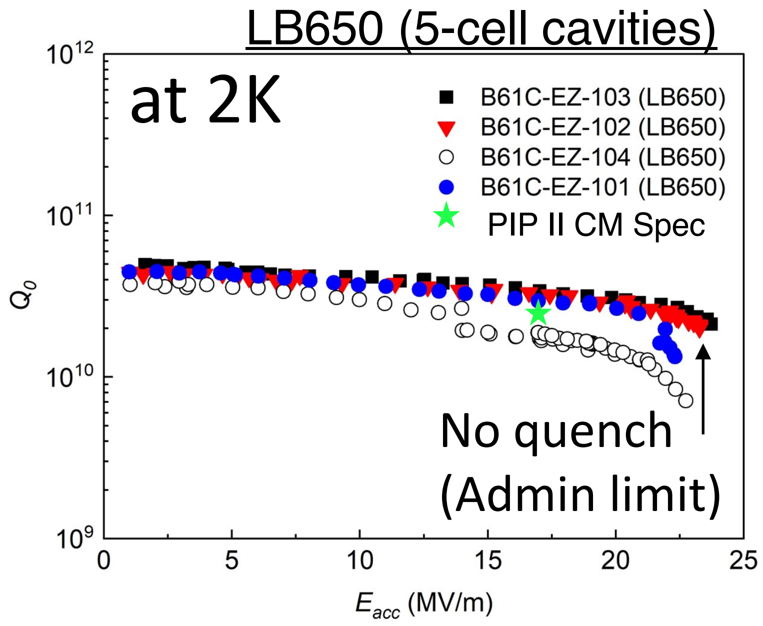
Vijay Chouhan

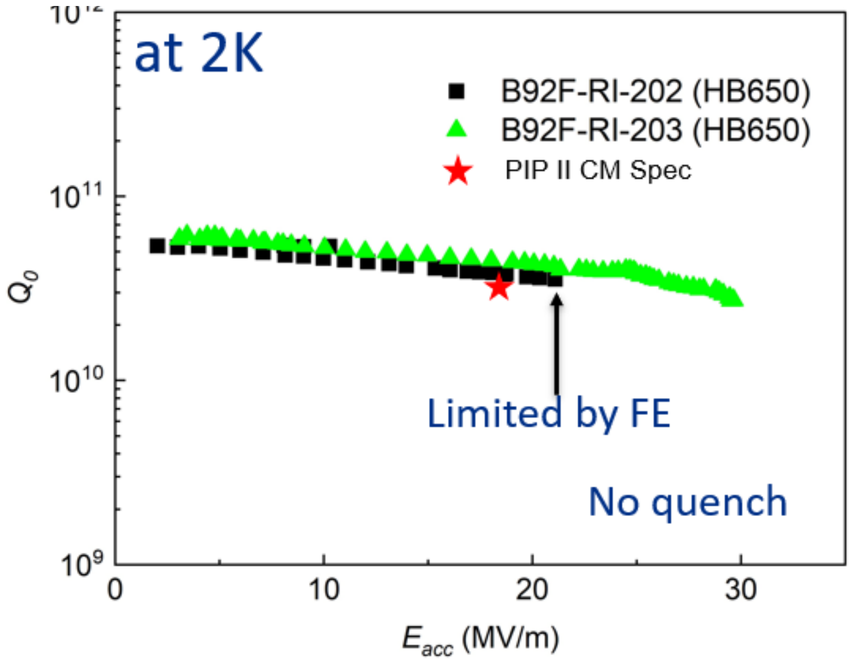
HB 650



LB 650



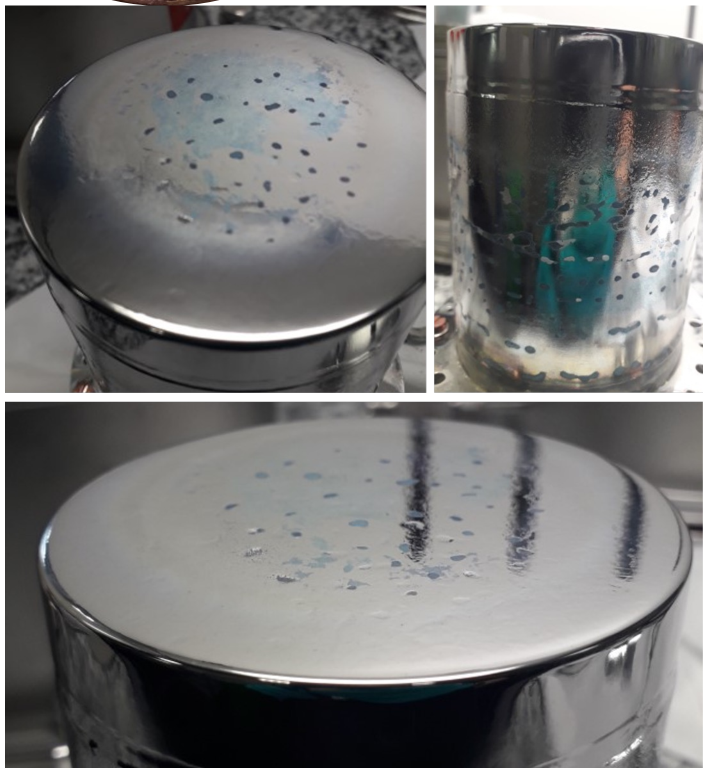




Plasma Electrolytic Polishing

Cristian Pira

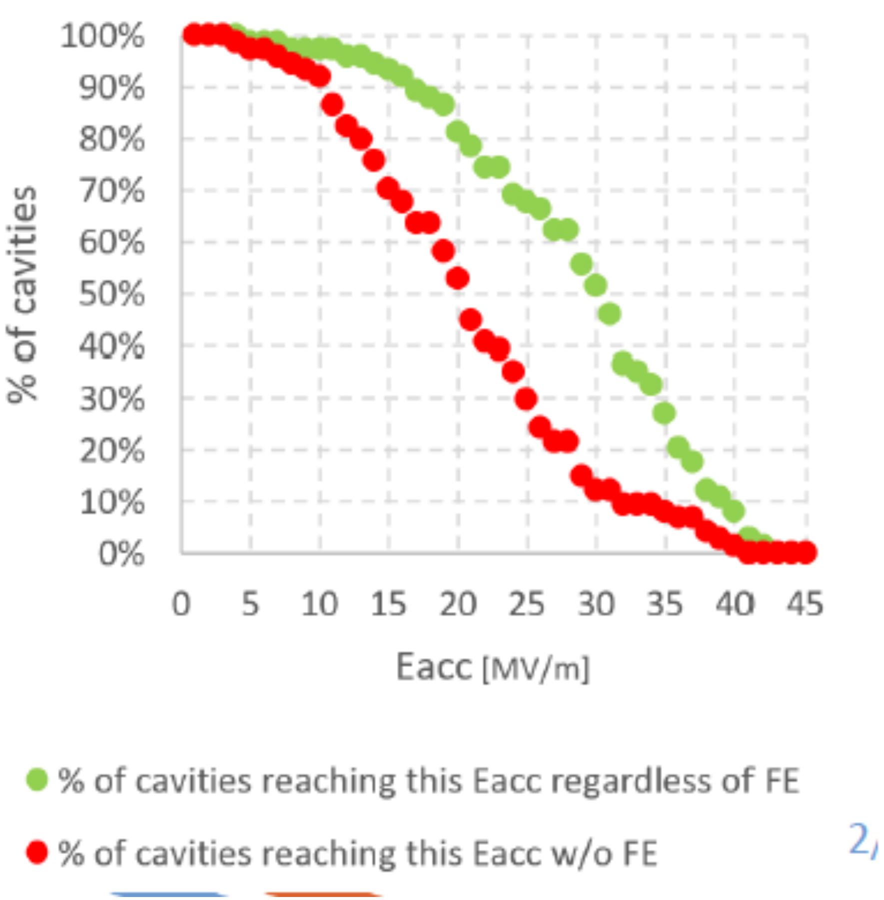
- Green, fast, efficient, and versatile alternative to traditional EP
- Easily applied to copper cavities (without an internal cathode!)
- Further development required for scaling to full niobium cavities

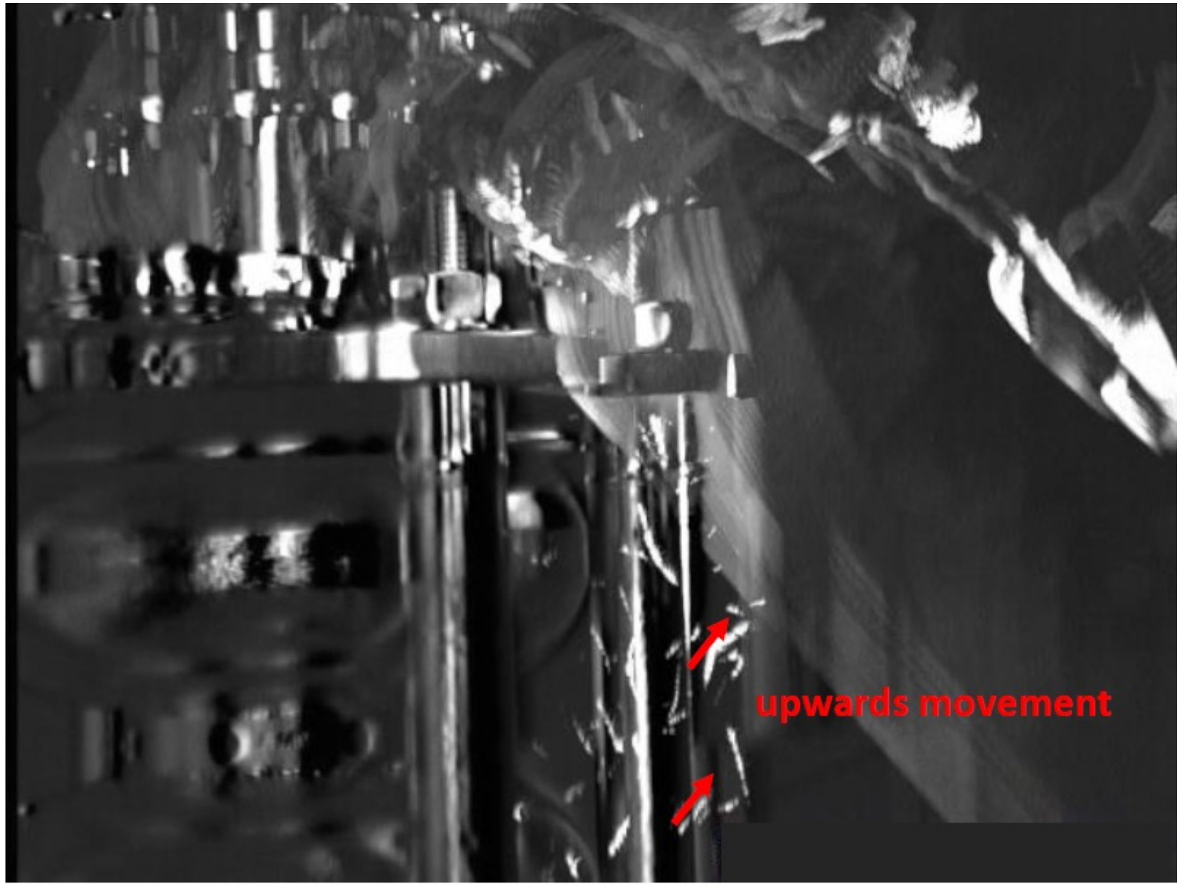


FE Suppression

Tomohiro Yamada

- Reachable Eacc w/ and w/o field emission shows statistically significant discrepancy
- Visualizing dusts in the clean room → documentation, qualification, know-hows,
- Dusts were visible even though particle counters did not react

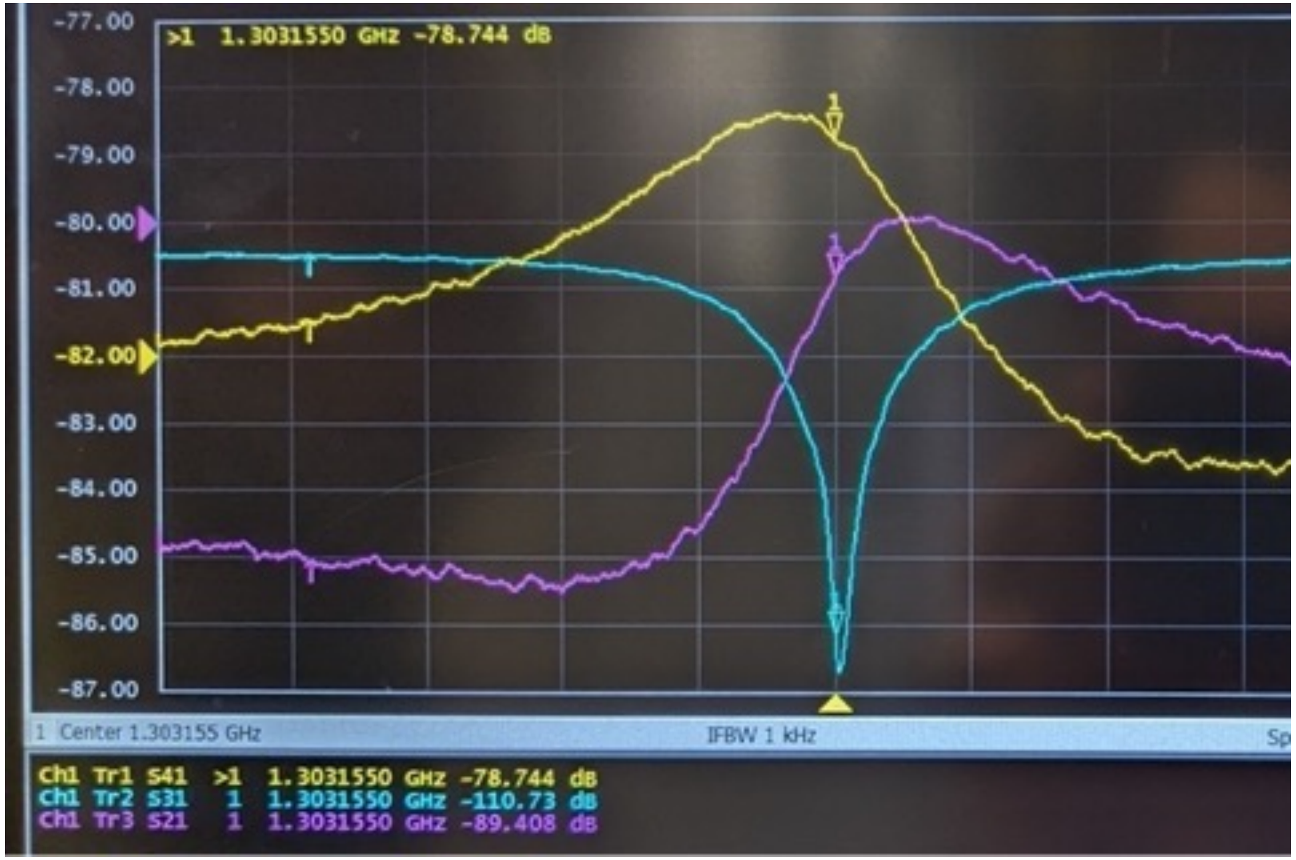


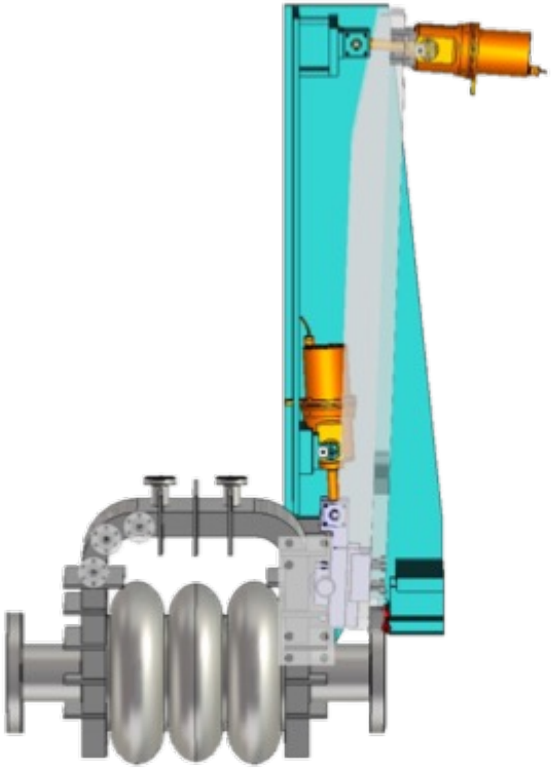


Travelling Wave Cavity Progress

Fumio Furuta

- Successfully demonstrated travelling wave operation in a 3 cell cavity at 2 K!





An example of TW at 1303.155 MHz being tuned at 2K

- Yellow; a forward wave signal
- Blue; a suppressed backward wave signal (>30dB less than forward)
- Magenta; a signal from the calibration pick up.

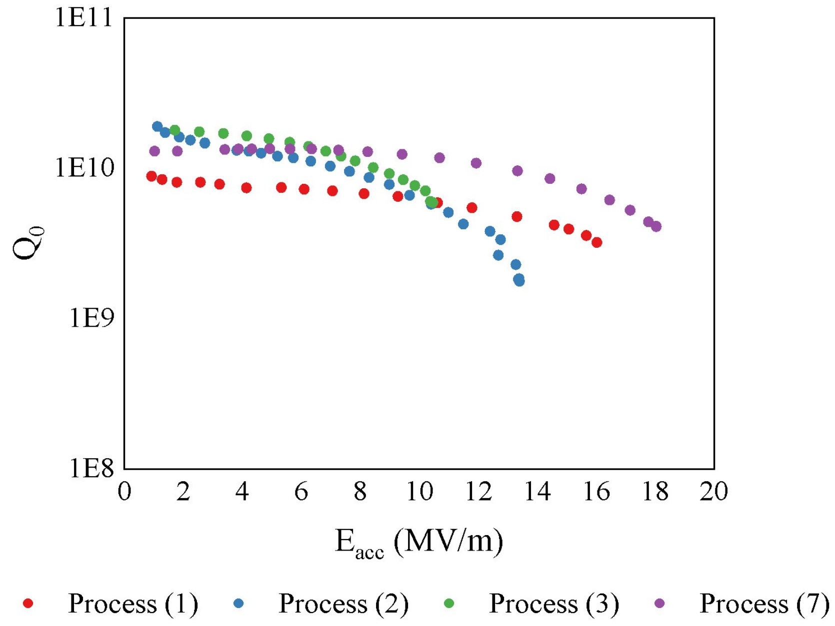
Critical questions on realization in a machine → demonstration first

Sn vapor diffused Nb3Sn Optimization at IMP

Jiankui Hao on behalf of Ziqin Yang

- Systematic studies on coating parameters → successful Q vs E result

Coating process	Sn source Temperature/℃	Growth stage time / Minute	Exploration of methods for adsorbing residual Sn vapor			
			Sn power[1]	Valves[2]	Mo belt[3]	Ceramics[4]
1	1310	180	On	Closed	On	Without
2	1200	180	On	Closed	On	Without
3	1200	180	Off	Closed	On	Without
4	1200	180	On	Opened	On	Without
5	1200	180	On	Closed	Bottom On	Without
6	1200	180	On	Closed	On	With
7	1233	120	Off	Closed	Bottom On	With

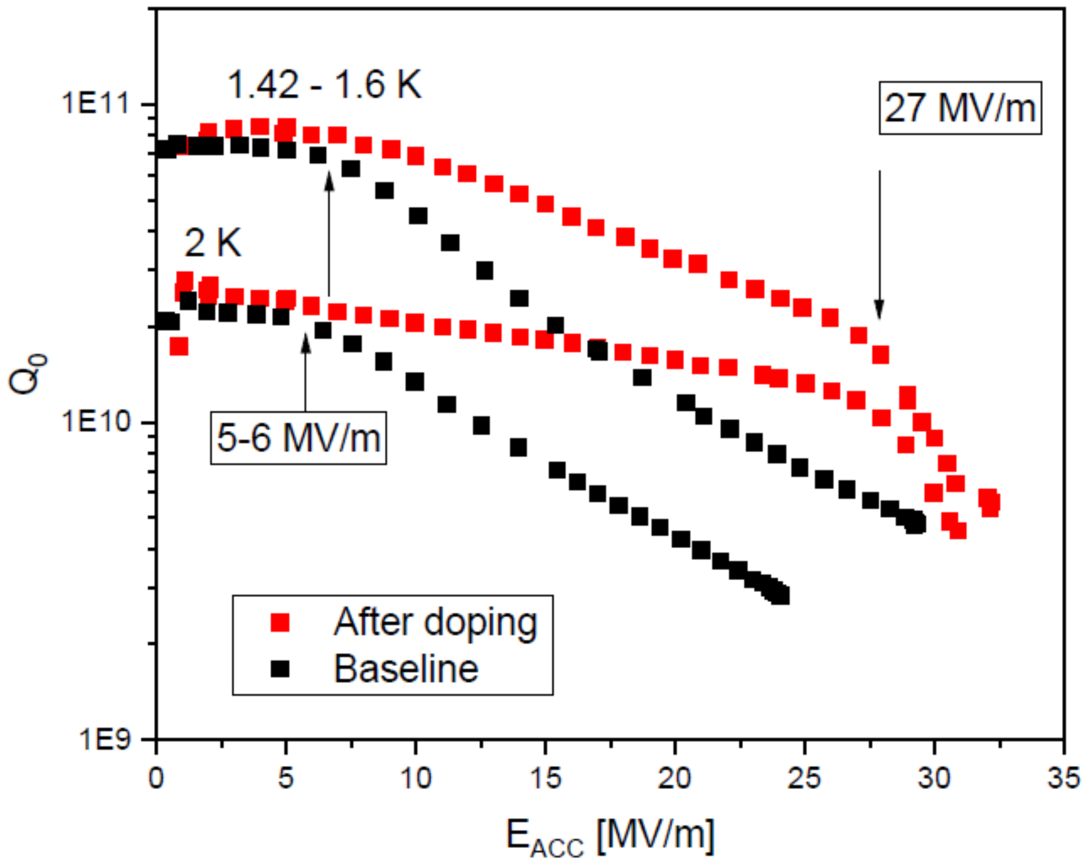


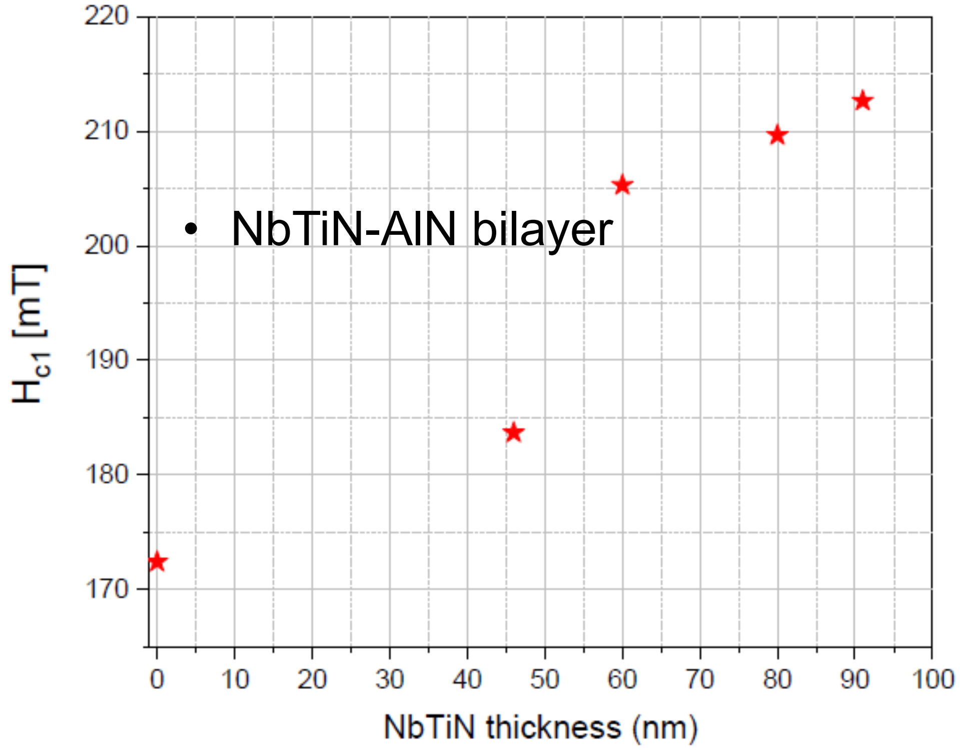
- The gradient exceeded 16 MV/m which was the first limitation of Cornell and Fermilab
  - They solved this by thinner layer to reach 22 MV/m
- How was the case in IMP recipe?

ALD

Yasmine Kalboussi

- The cavity was coated with 5nm of NbN + annealing at 900°C-3hours.
- No electro-polishing have been performed.



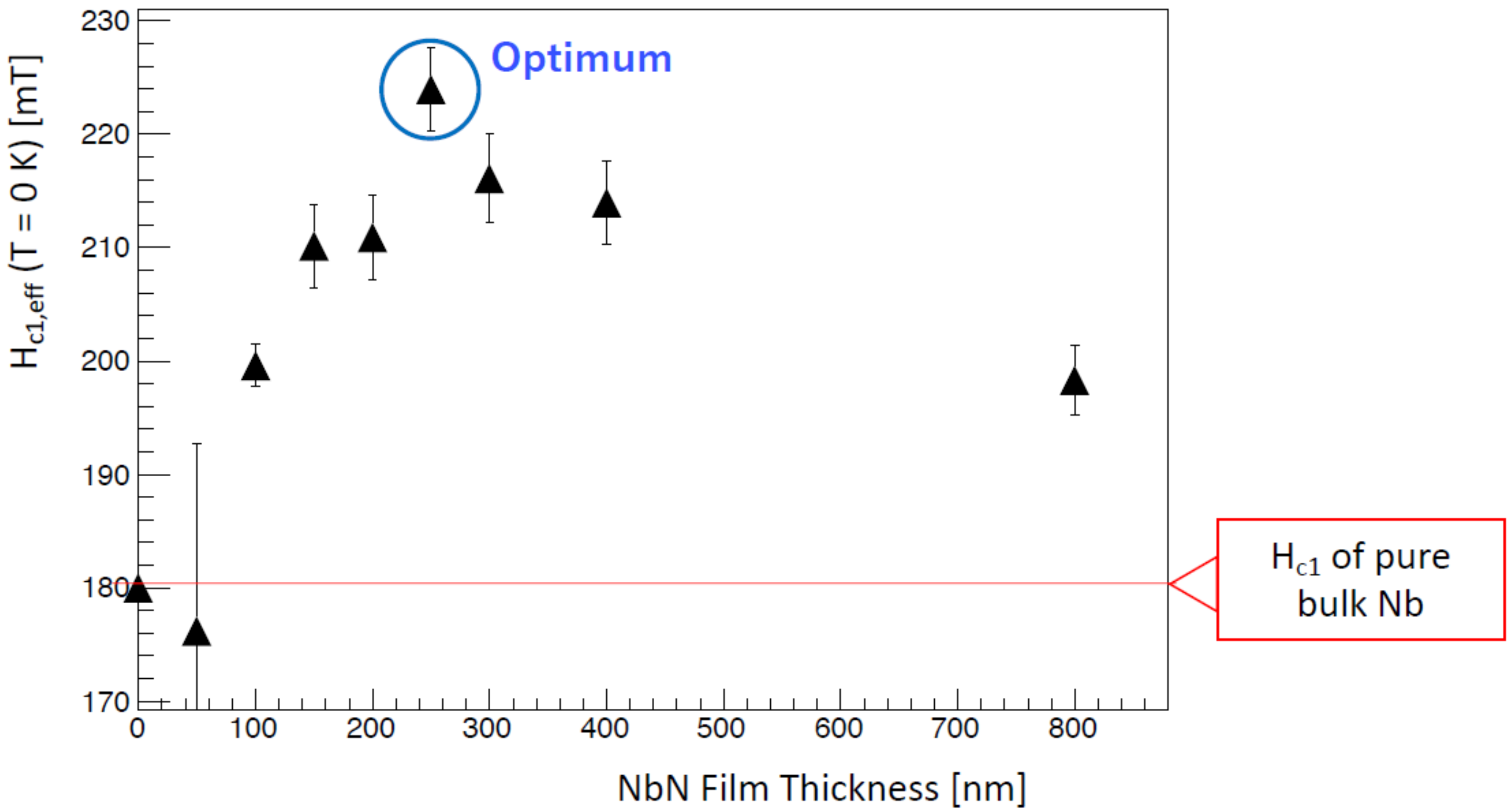


Enhancement in Hc1

Thin Films at KEK

Ryo Katayama

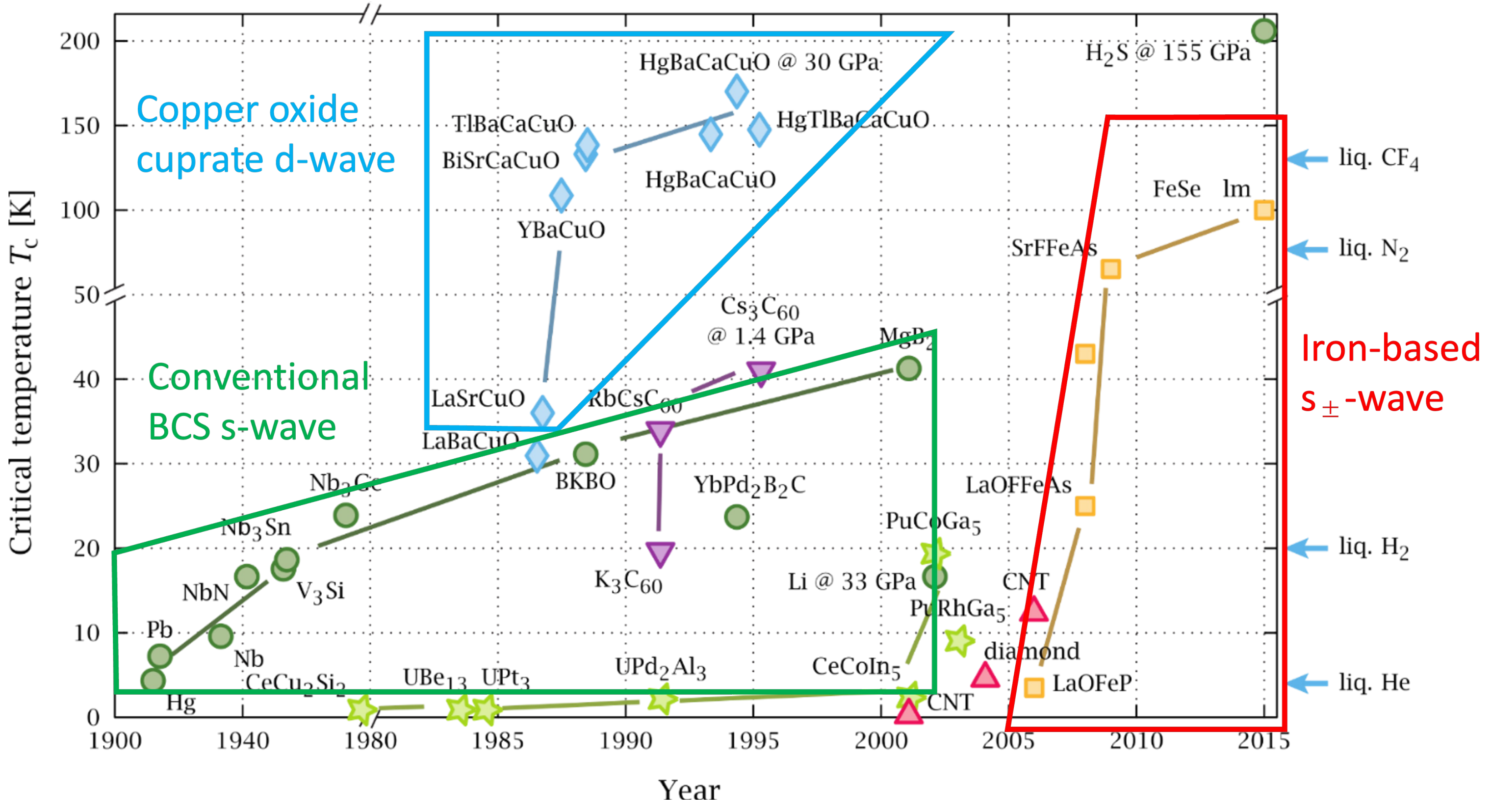
Effective Hc1 of S'IS sample as a function of NbN film thickness is shown below

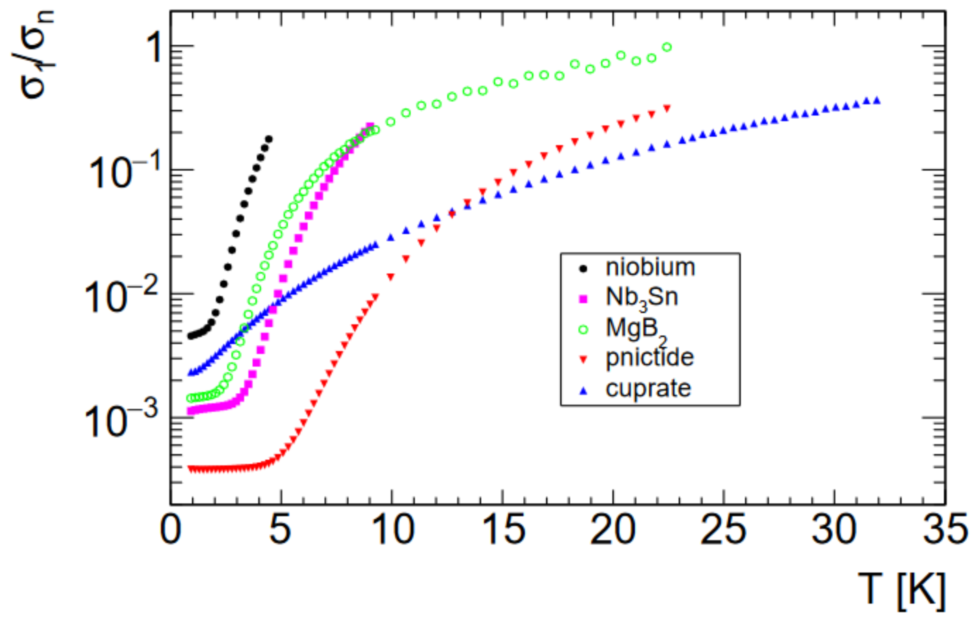


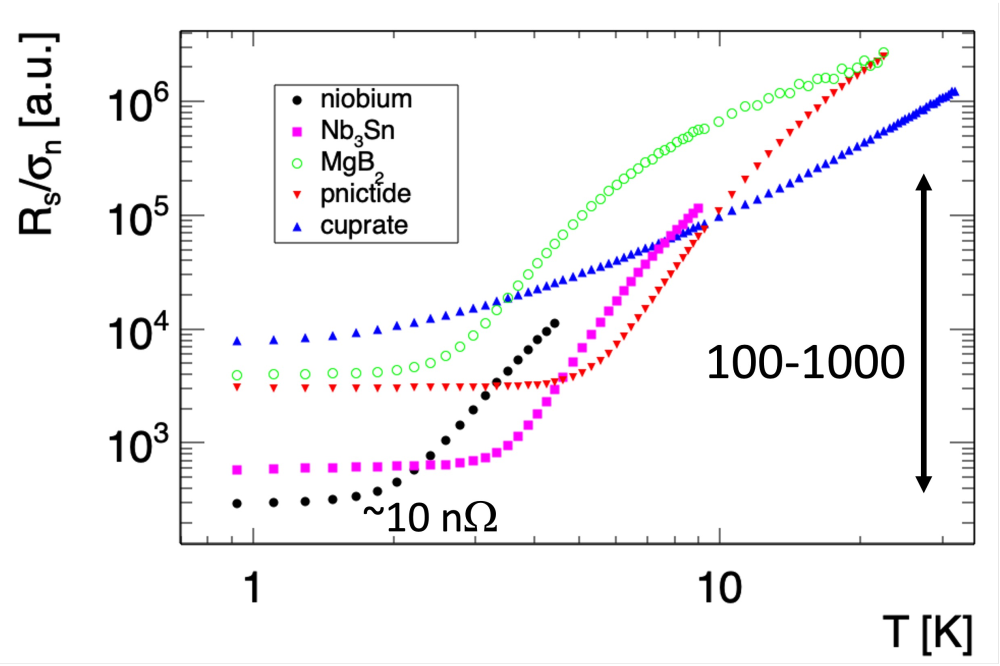
- Successful results in NbN multilayer measured with 3rd harmonics
- New projects in Nb_3Sn funded: Kiban-A

Other Superconductors

Akira Miyazaki







- 0th order calculation of different superconducting materials
- Penetration depth can be a problem of HTS → multilayer
- Pulse operation of HTS cavities

Our mission

WG-1: Progress on High Q and High Gradient activities

Conveners: Jinfang Chen (SARI), Daniel Bafia (FNAL), Akira Miziyaki (IJCLab)

The scope of this working group is to discuss the most recent results related to pushing niobium towards higher Q and higher gradient. Advances in understanding material evolution under established but also newly developed heat treatments, such as N-doping, N-infusion, Mid-T bake, Two-step Low-T bake with low-temperature EP, and current results on flux-expulsion studies should be discussed. The working group should also focus on operational experiences in existing high-Q/high-G cryomodules. Topics should discuss the activities on large and medium grain niobium materials including results from cavity fabrication, cavity performances and RF requirements. Results from cavity studies with different cavity types and frequencies, which could help to establish a core understanding, should be included.

Mission complete