



LCLS-II CM Flux Expulsion Analysis

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CERN

Acknowledgements

- LCLS-II cryomodule production in partnership with teams at FNAL, JLab, and SLAC
- All cryomodule measurements shown here are by FNAL LCLS-II team
- Major thanks to Genfa Wu, Anna Grassellino, Elvin Harms, Nikolay Solyak

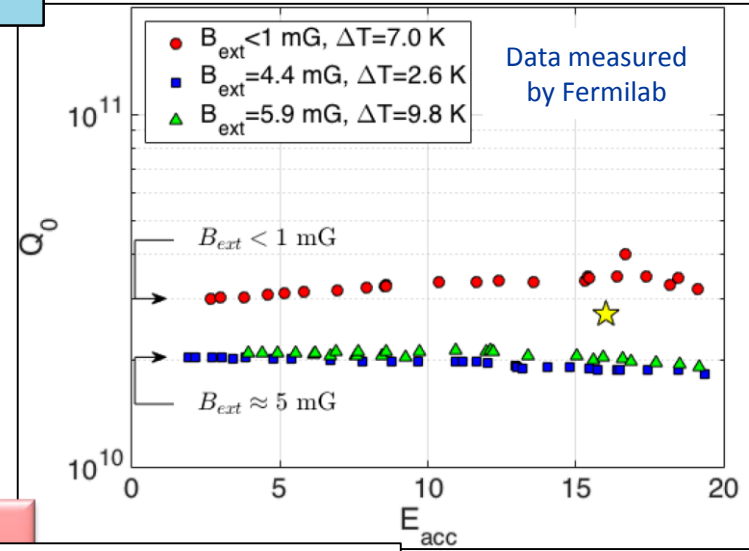
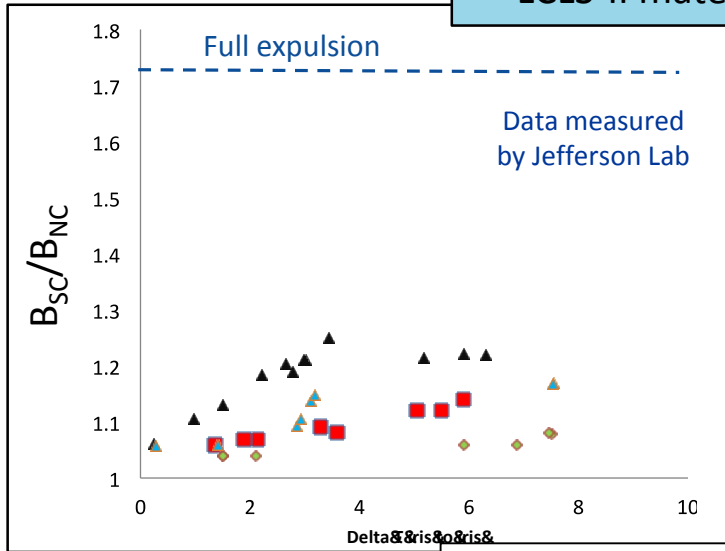


LCLS-II - Preproduction

1.3 GHz 1-cell cavities made with LCLS-II material

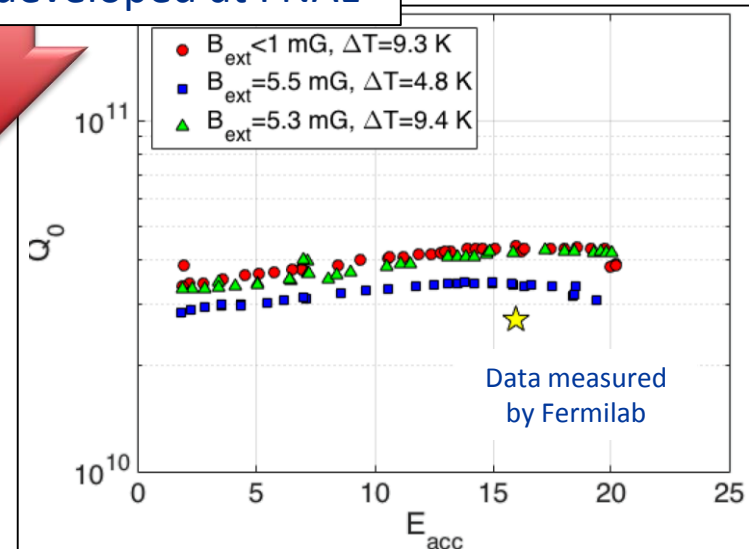
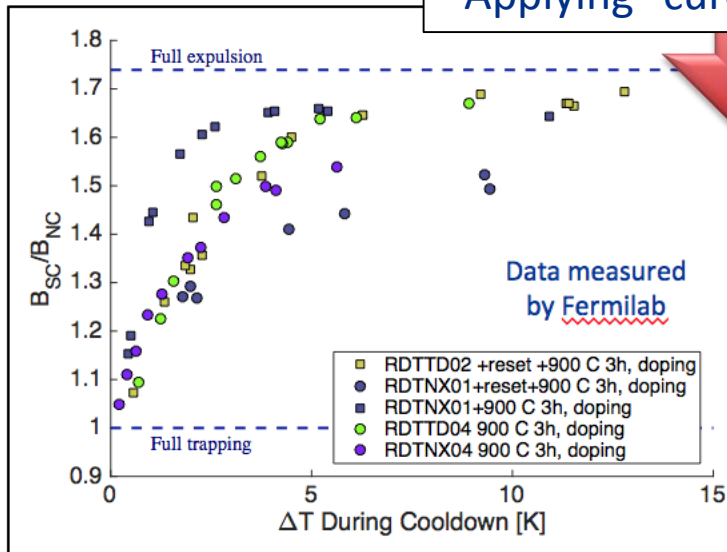
Cooling in 5 mG applied field (spec for background field in module)

As-received niobium material for LCLS-II production: very poor expulsion



Applying "cure" developed at FNAL

After 900°C treatment: TD material much improved, NX material required higher temperatures



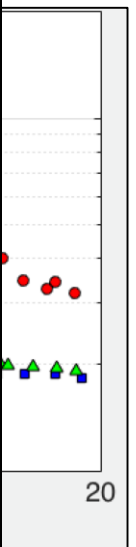
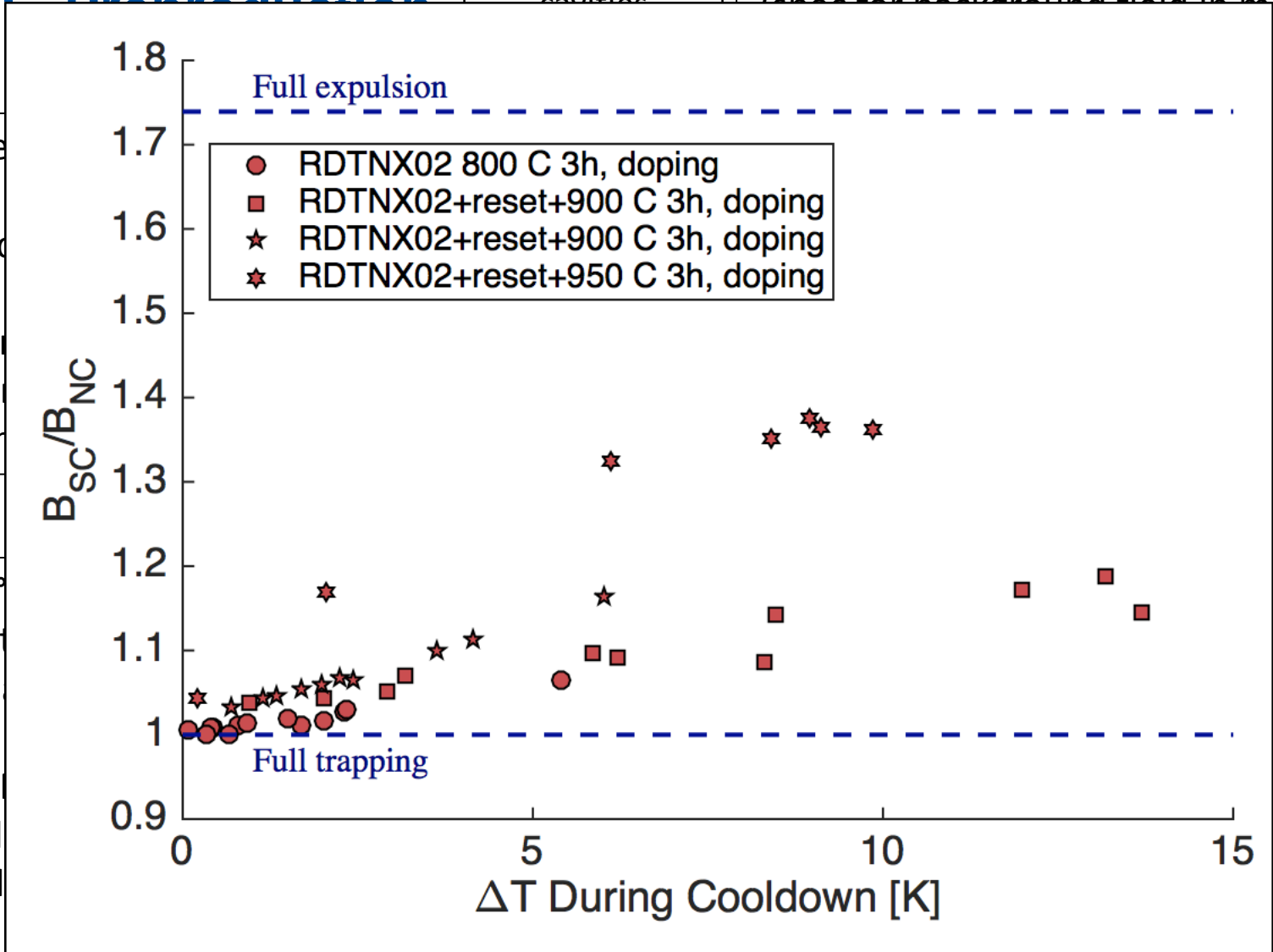
LCLS-II Production

1.3 GHz 1-cell

Cooling in 5 mG applied field
(less for background field in module)

As-received niobium material for LCLS-II production very poor expulsion

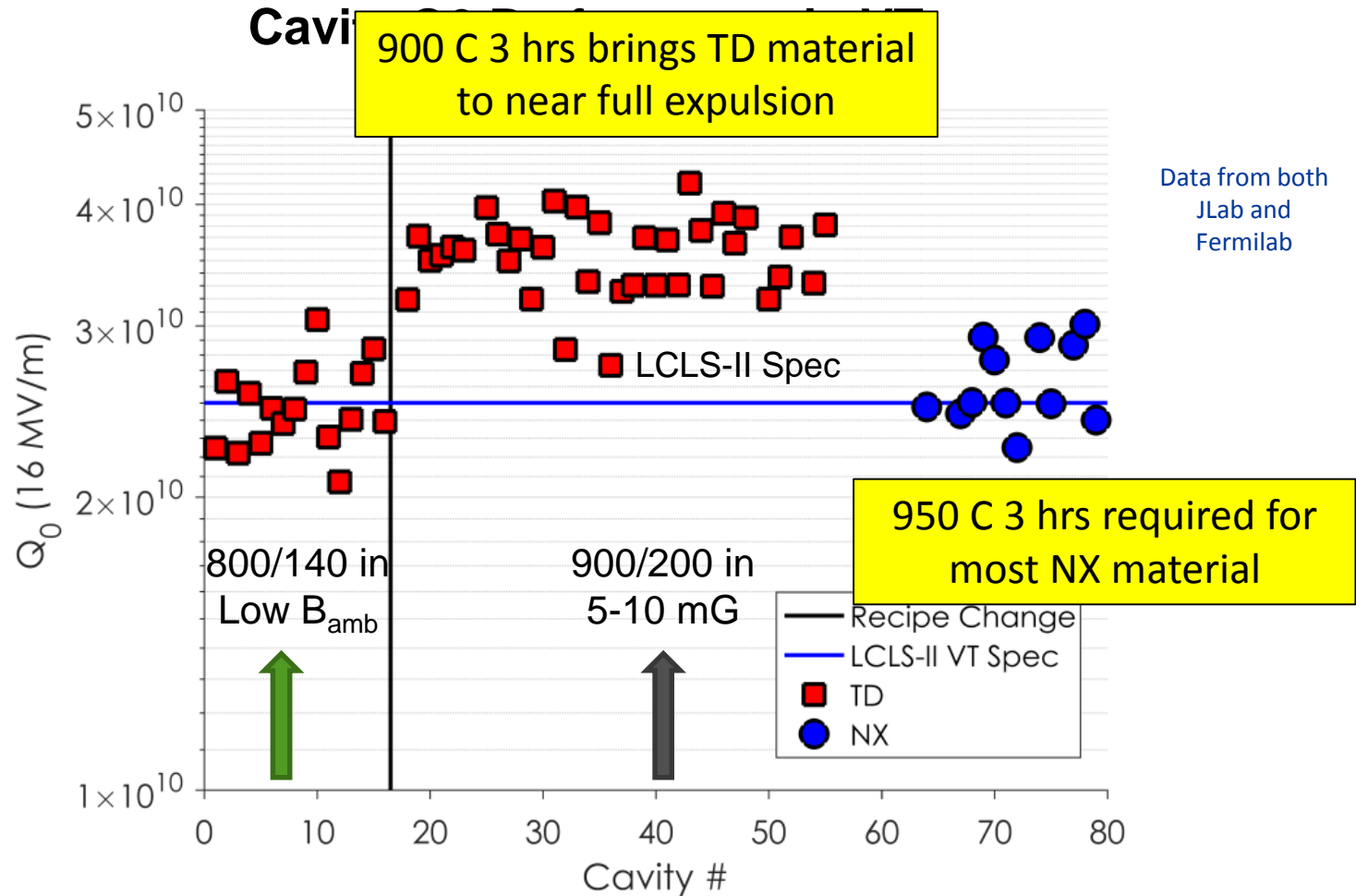
After 900° treatment TD material much improved, material required higher temperatures



“Lot C” material – lower RRR, smaller grains

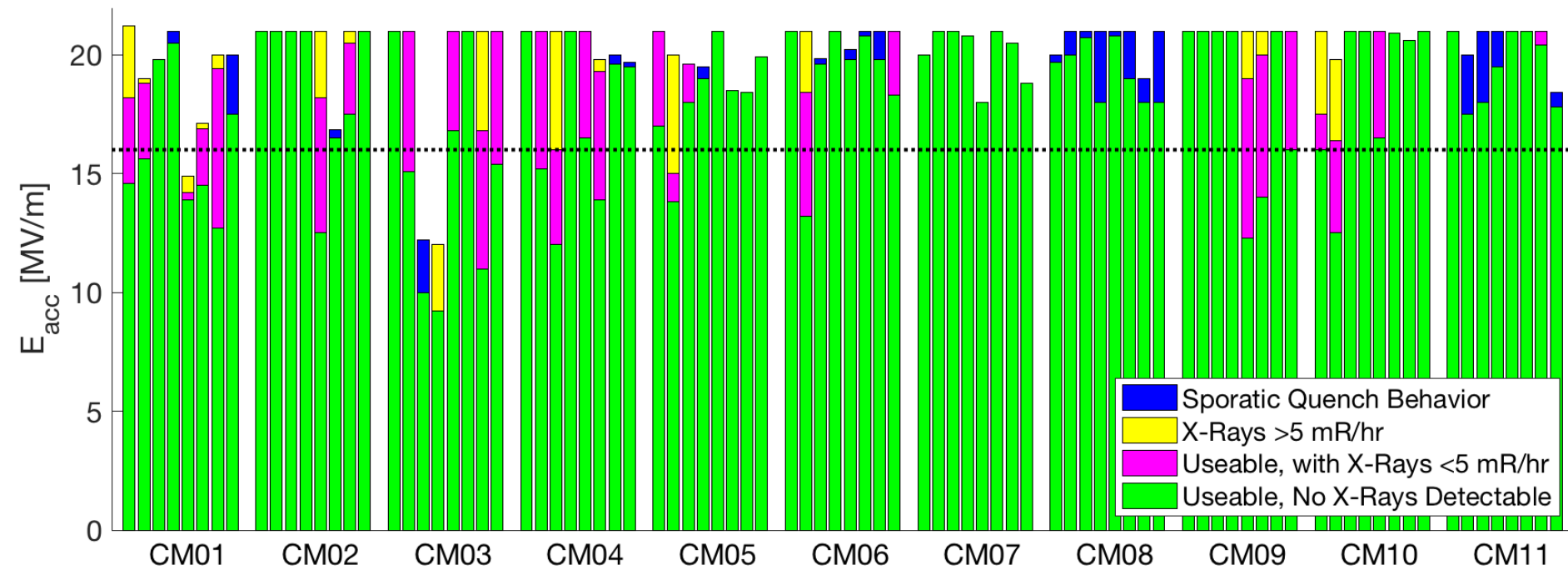
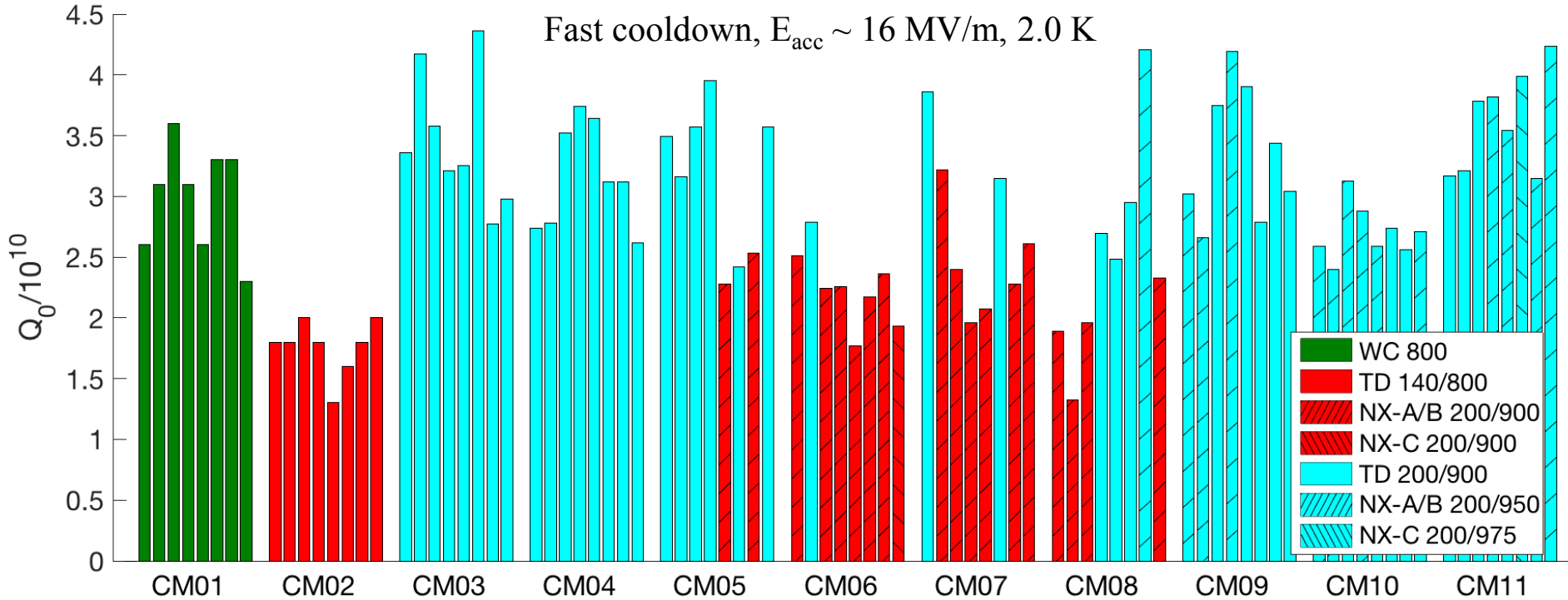


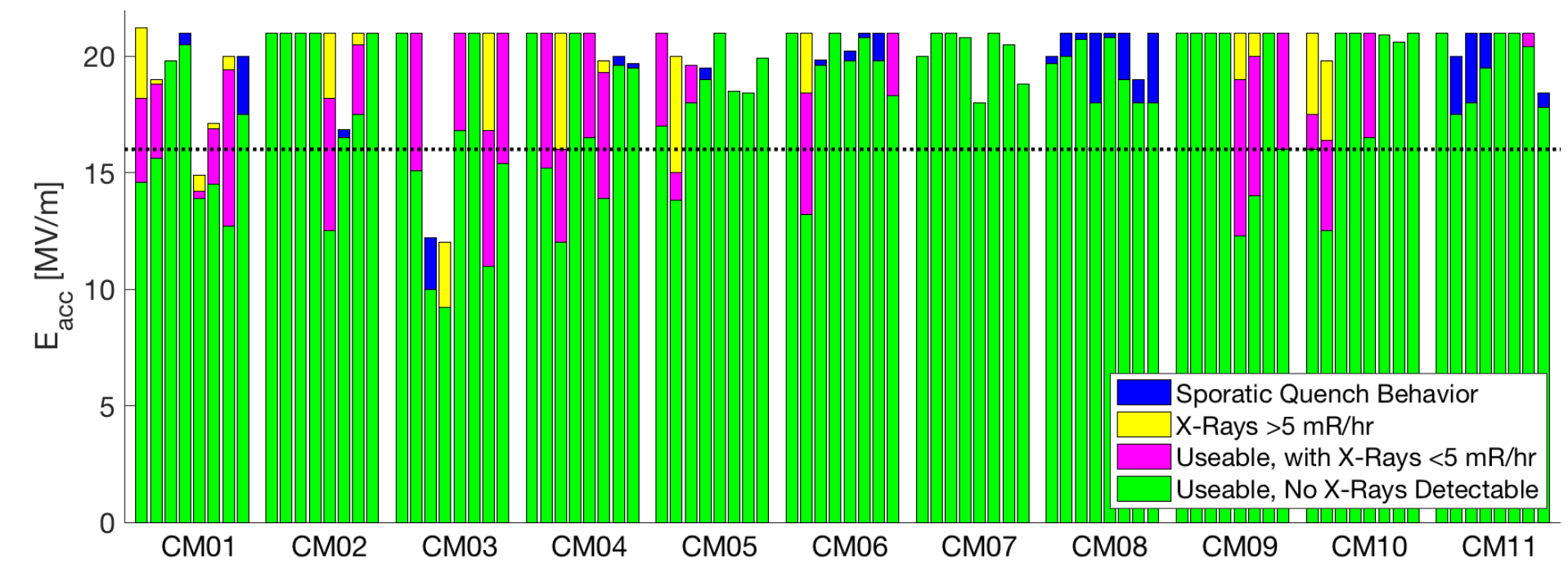
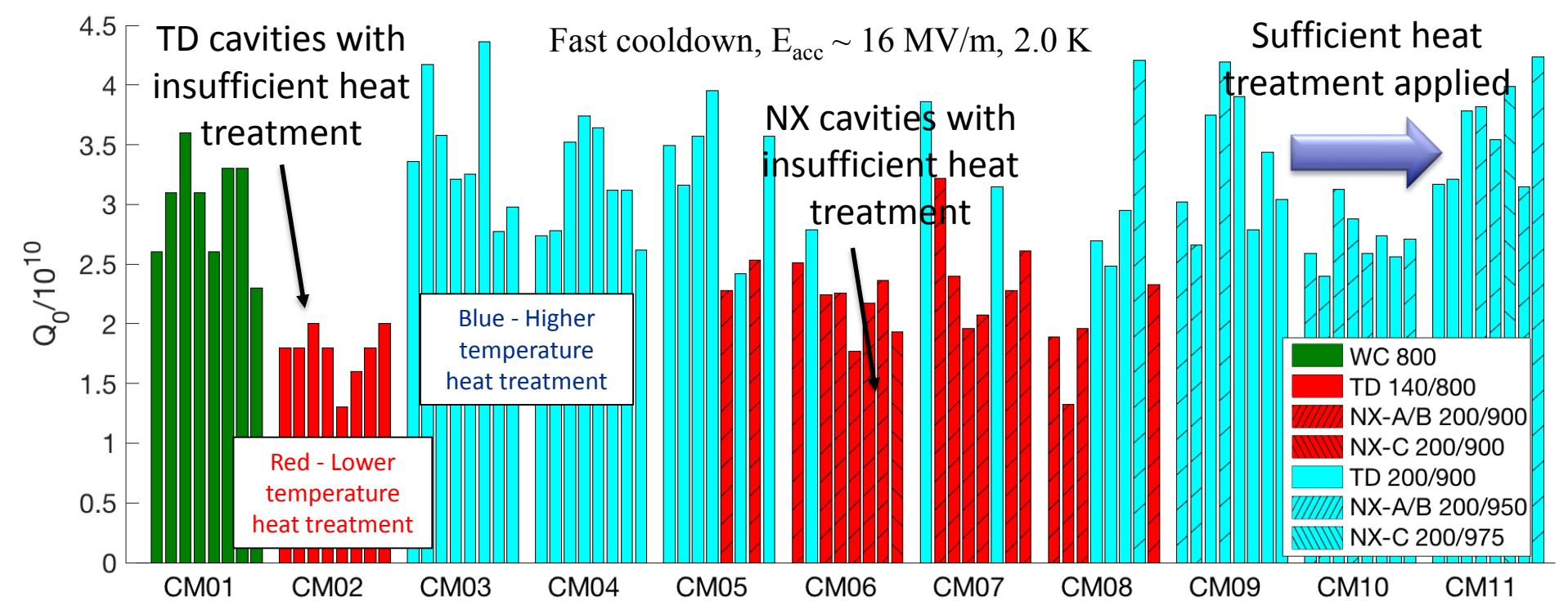
LCLS-II Production Cavity Q_0 Before/After Recipe Change



See D. Gonnella,
SRF 2017

Fast cooldown, $E_{\text{acc}} \sim 16$ MV/m, 2.0 K



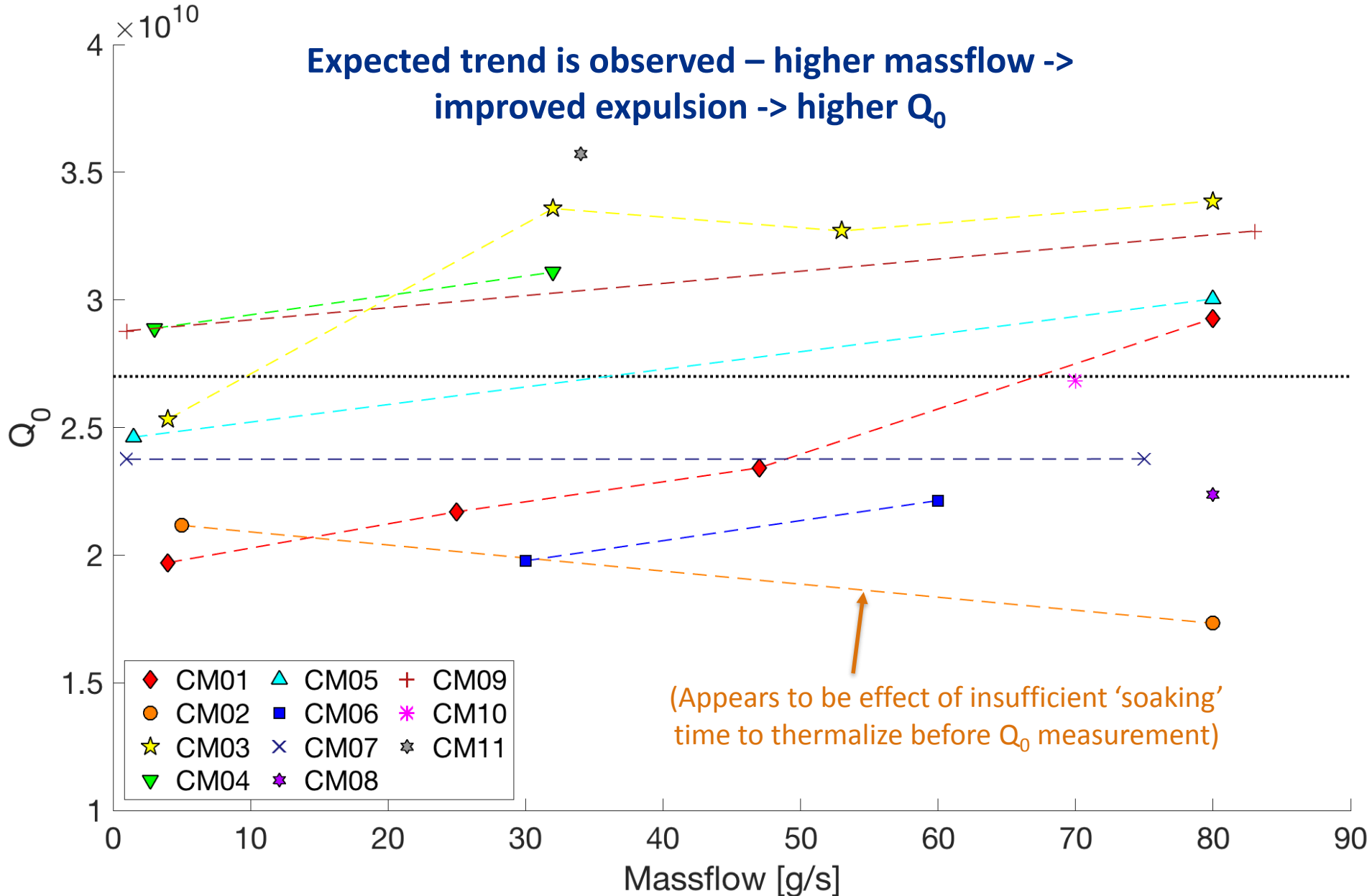


Example of Optimizing for Dynamic Load – CM07

Cavity	Q_0 /10 ¹⁰	Naïve [MV/m]	Simple [MV/m]	Optimized [MV/m]
1	3.86	16	18	20 (quench limit)
2	3.22	16	18	18.8
3	2.40	16	14	14.0
4	1.96	16	14	11.4
5	2.07	16	14	12.1
6	3.15	16	18	18.4
7	2.28	16	14	13.3
8	2.61	16	18	15.2
Dynamic Load [W]		83.0	80.5	73.5

***Note: Q_0 is expected to change with field, and this is not taken into account here, but the effect is second order

Effect of Massflow on Q_0



Summary

- N-doping enables Q_0 far exceeding what was possible with previous traditional treatments, but achieving the highest Q_0 requires trapped flux to be minimized
- To improve flux expulsion, heat treatment temperature was increased for LCLS-II cavities
- Temperature required was found to depend on niobium production run, but material from both vendors was made to satisfy the stringent requirements of LCLS-II
- $Q_0 \sim 3 \times 10^{10}$ regularly being achieved in LCLS-II cryomodules
- Production continues with increased heat treatment temperature