medium temperature heat treatments of SRF cavities @ DESY

observations and starting points for analyses

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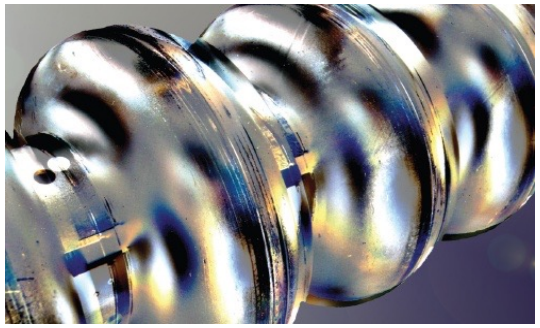
cavity meeting, 3rd May 2023



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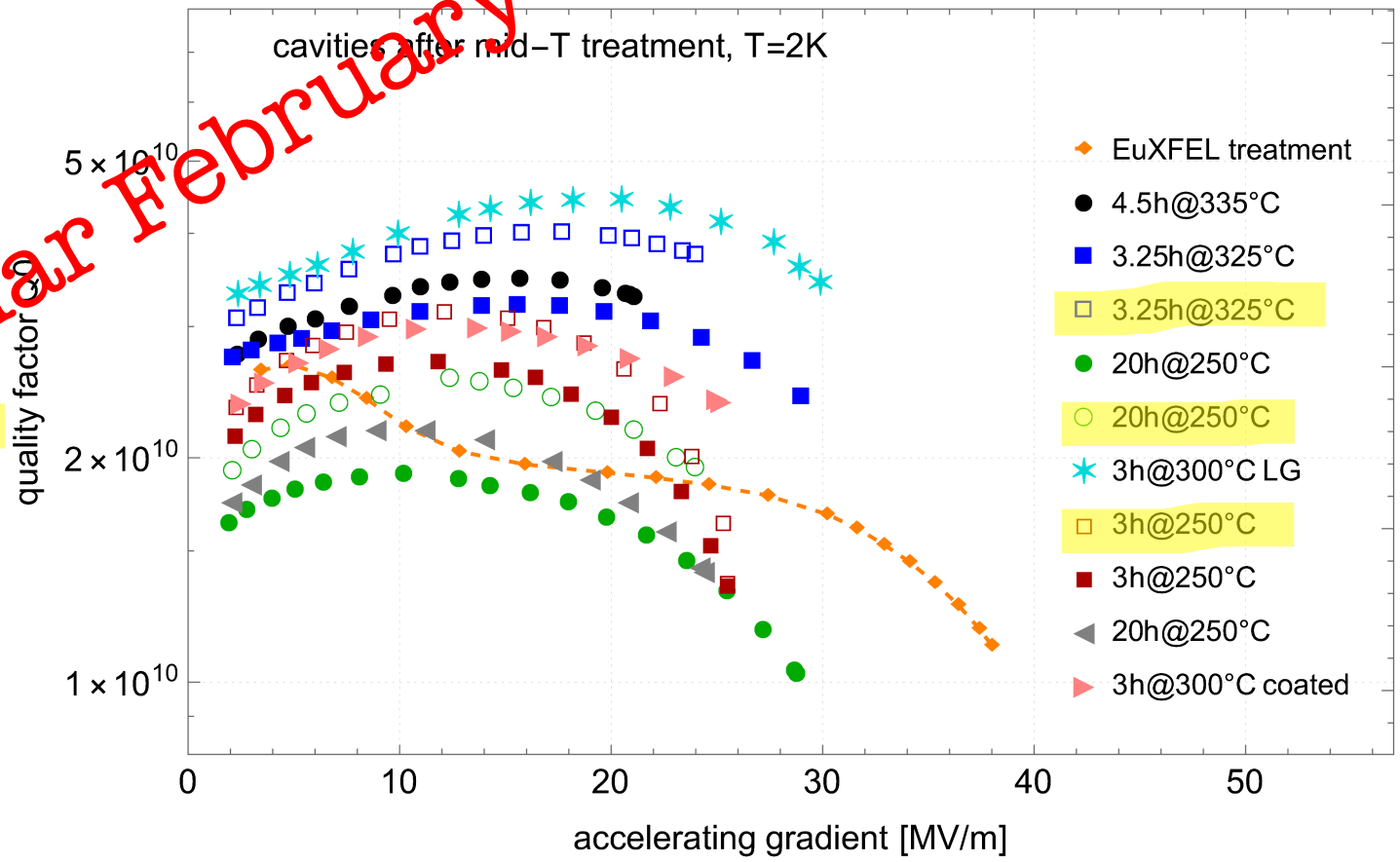
DESY.

Zusammenfassung DESY mid-T Kampagne

sehr guter Ofen am DESY – erst Startpunkt ausführlicher Studien

- 7 Cavities im Niob-Ofen am DESY
- alle Cavities zeigen ähnliches Verhalten
  - (stark) **verbesserte Güte**
  - **anti-Q-slope** Verhalten
  - verringerte Gradienten
- **manche** Cavities frieren magn. Fluss ein
- ausstehende Messungen
  - 1DE17: 20h bei 300°C
  - 1RI03: N-Infusion Versuch
  - 1DE12: 3h bei 250°C wird folgen

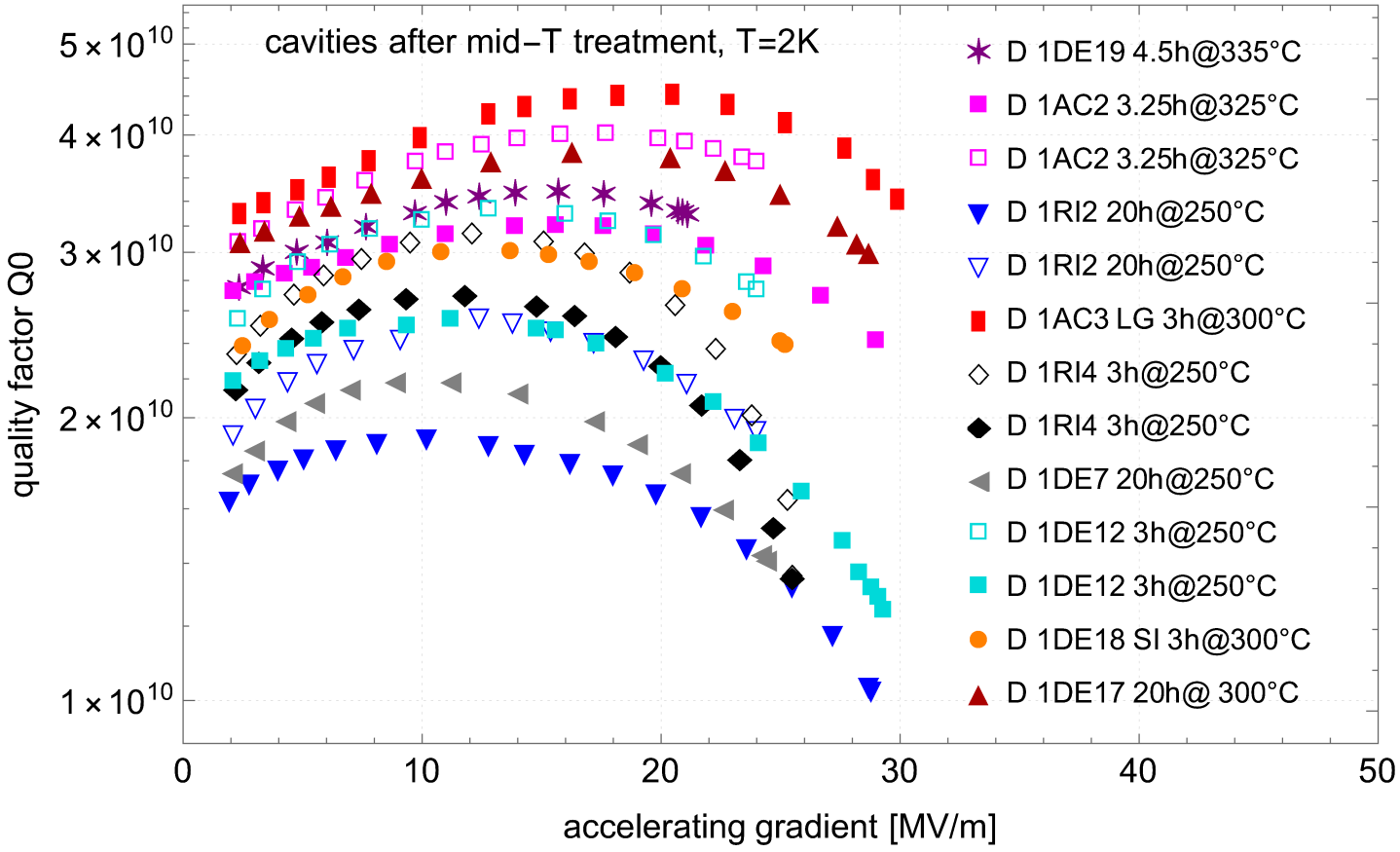
MSL seminar February 2023



complete mid-T heat treatment campaign @ DESY

crowded plot… difficult interpretation

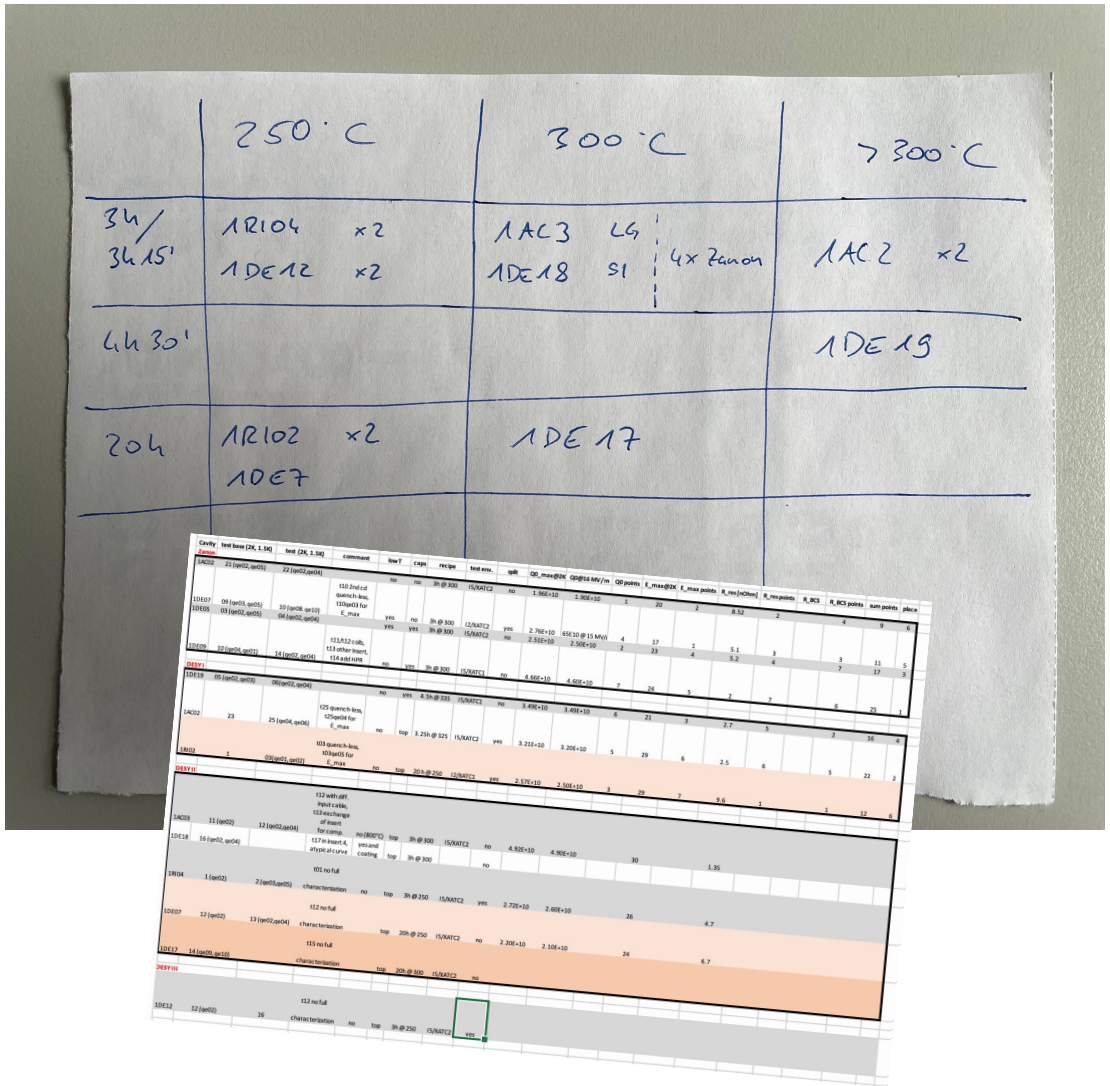
- 9 cavities in Nb retort furnace @ DESY
- all cavities show characteristic behavior
  - **enhanced quality factor**
  - **anti-Q-slope**
  - **lower gradients** up to 30 MV/m
  - **Q_0 degradation** due to frozen flux:
    - 4 out of 9
- try to organize results a little….



organizing the chaos

overview about different treatments

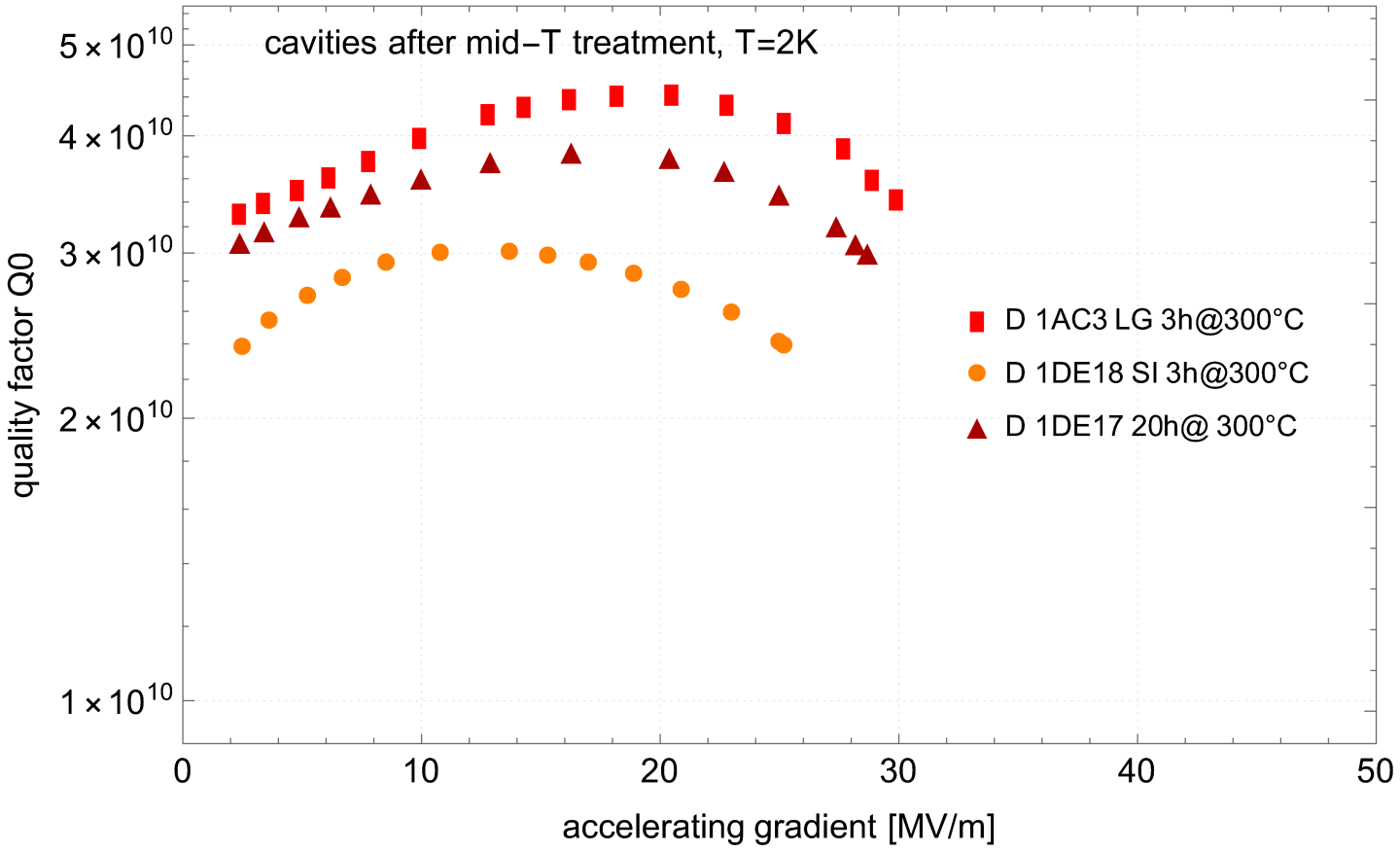
- 9 cavities in Nb retort furnace @ DESY
- cavities have different histories, materials, grain sizes, coatings, testing environments…
- sortable by
  - temperature T (marker color)
  - duration t (marker style)
- missing:
  - more statistics for 3h@300°C
  - 20h @ temperatures above 300°C
  - at least intermediate t @ 300°C



low statistics @ 300°C

one LG, one coated, one long treated

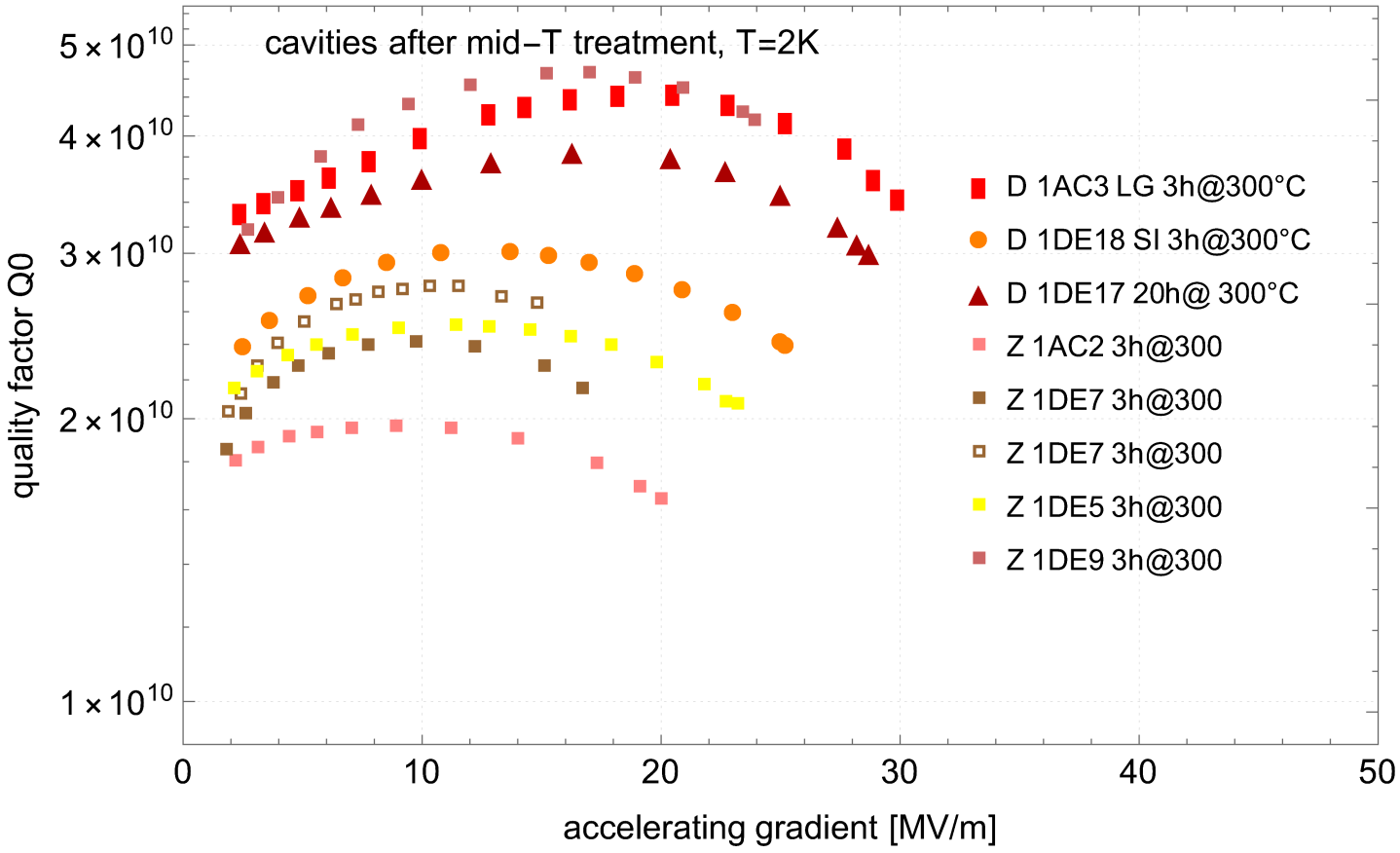
- very good results
  - 1AC3 best performance overall, but LG cavity
  - 1DE26 (also LG) will be treated next
  - 1DE18 tested several times, here: best results
  - no effect of frozen flux
- treat standard cavities with this recipe
  - first tandem run planned: 3h@300°C



better statistics @ 300°C

added four cavities treated at Zanon

- very good and worse results
  - large spread
  - 1AC2 and 1DE7 in one run
  - 1DE5 and 1DE9 in one run
  - 1DE7 and 1DE5 with low T bake before
  - once effect of frozen flux

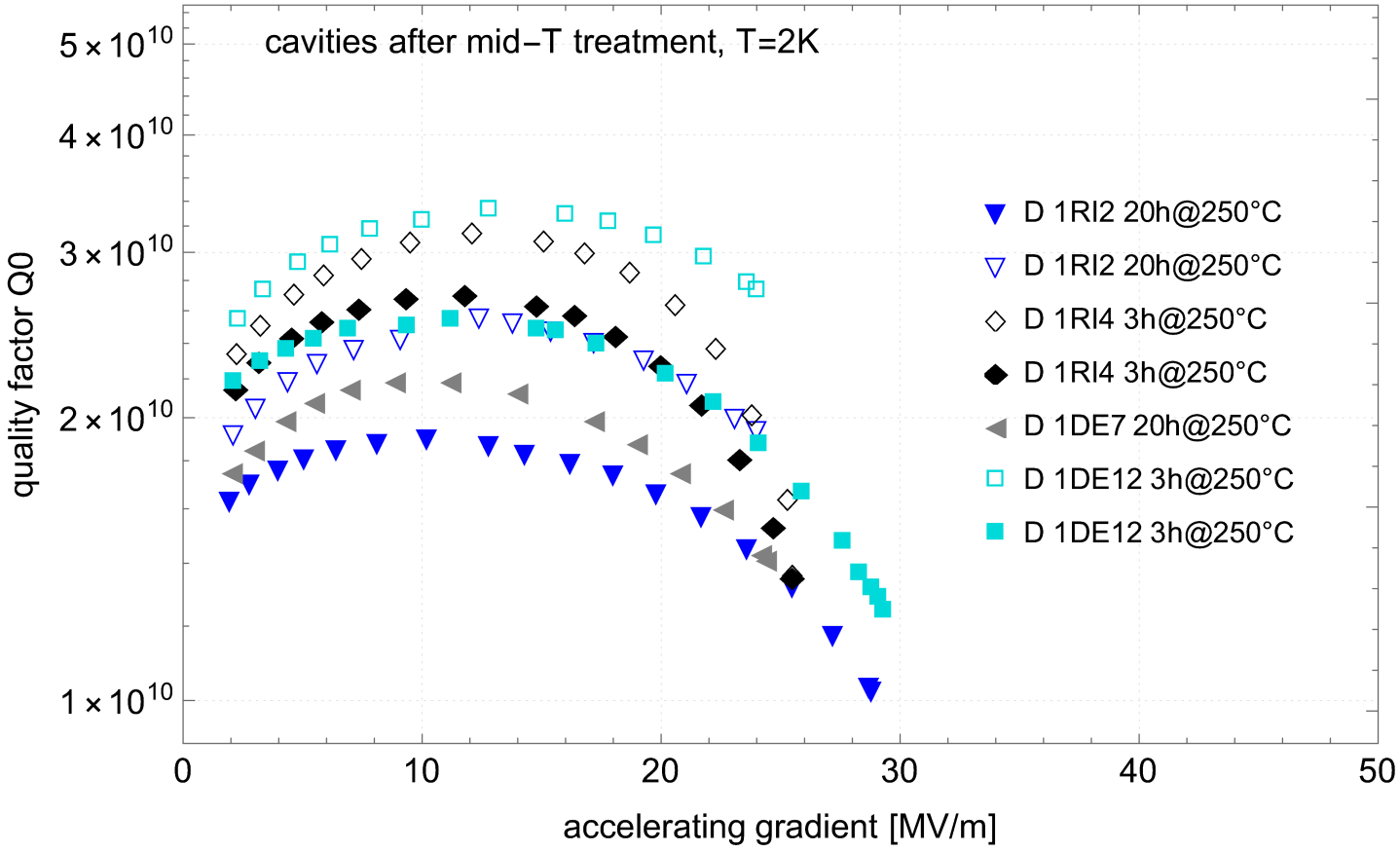


lower temperatures – worse results

250°C seems not to be the best temperature

- Q_0 lower in average
- 2 of 4 cavities: effect of frozen flux

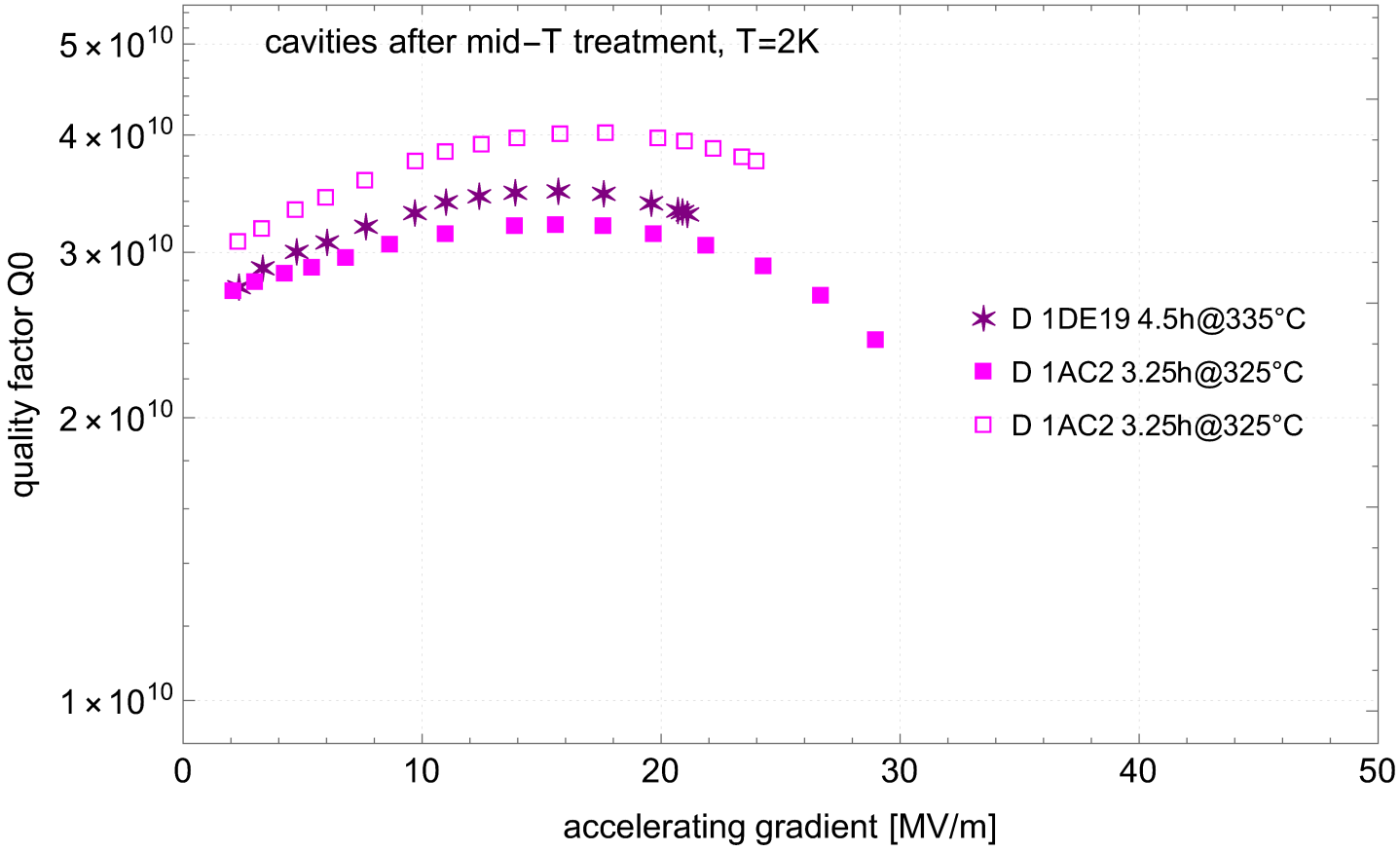
- in future: no more runs with temperatures below 300°C !?



larger temperatures – good results

above 300°C larger quality factors

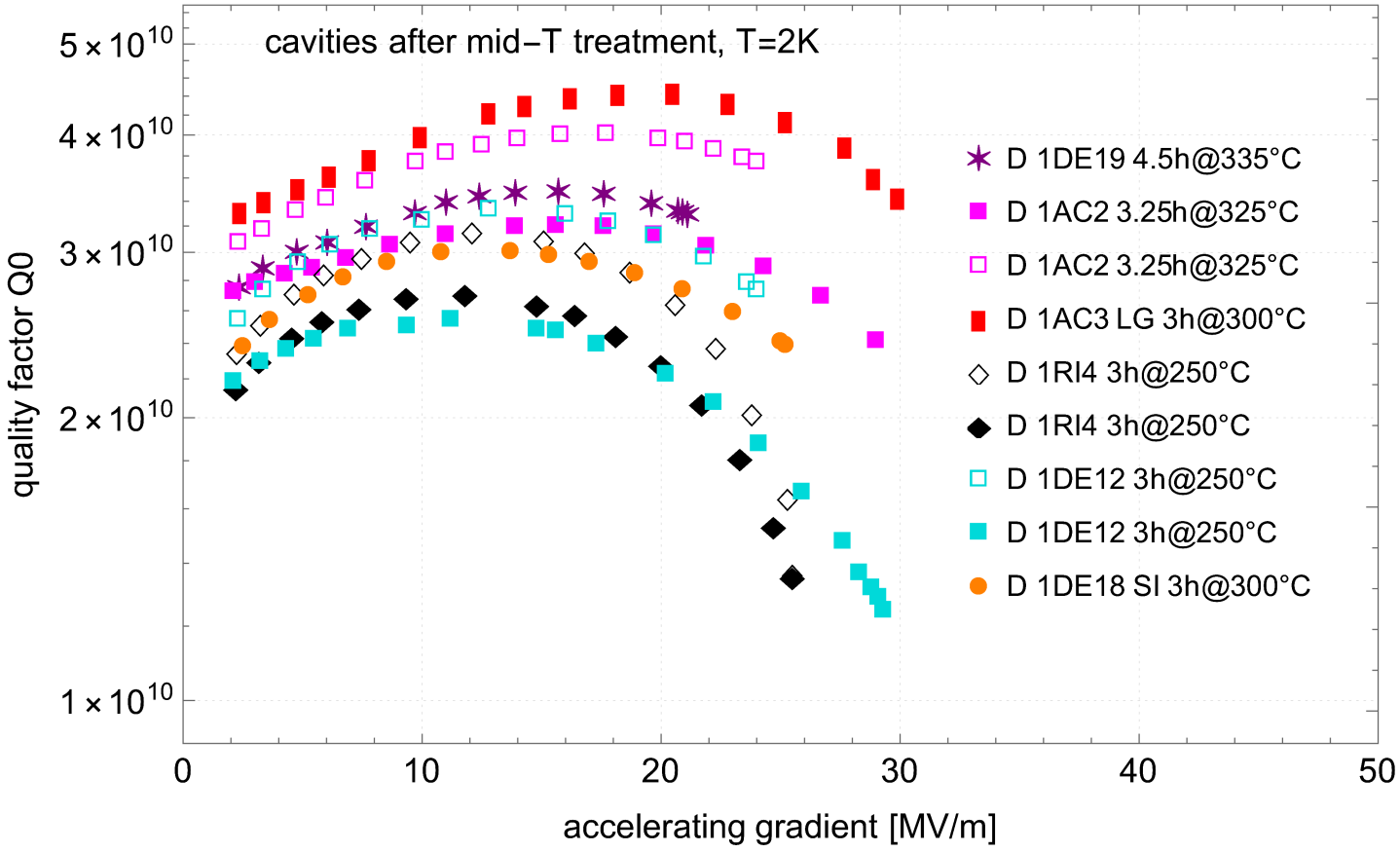
- temperatures not chosen, but due to furnace commissioning
- 1 of 2 cavities: effect of frozen flux
- more tests with temperatures above 300°C – especially large grain?



duration in regime below 5 hours indifferent

very large result spread

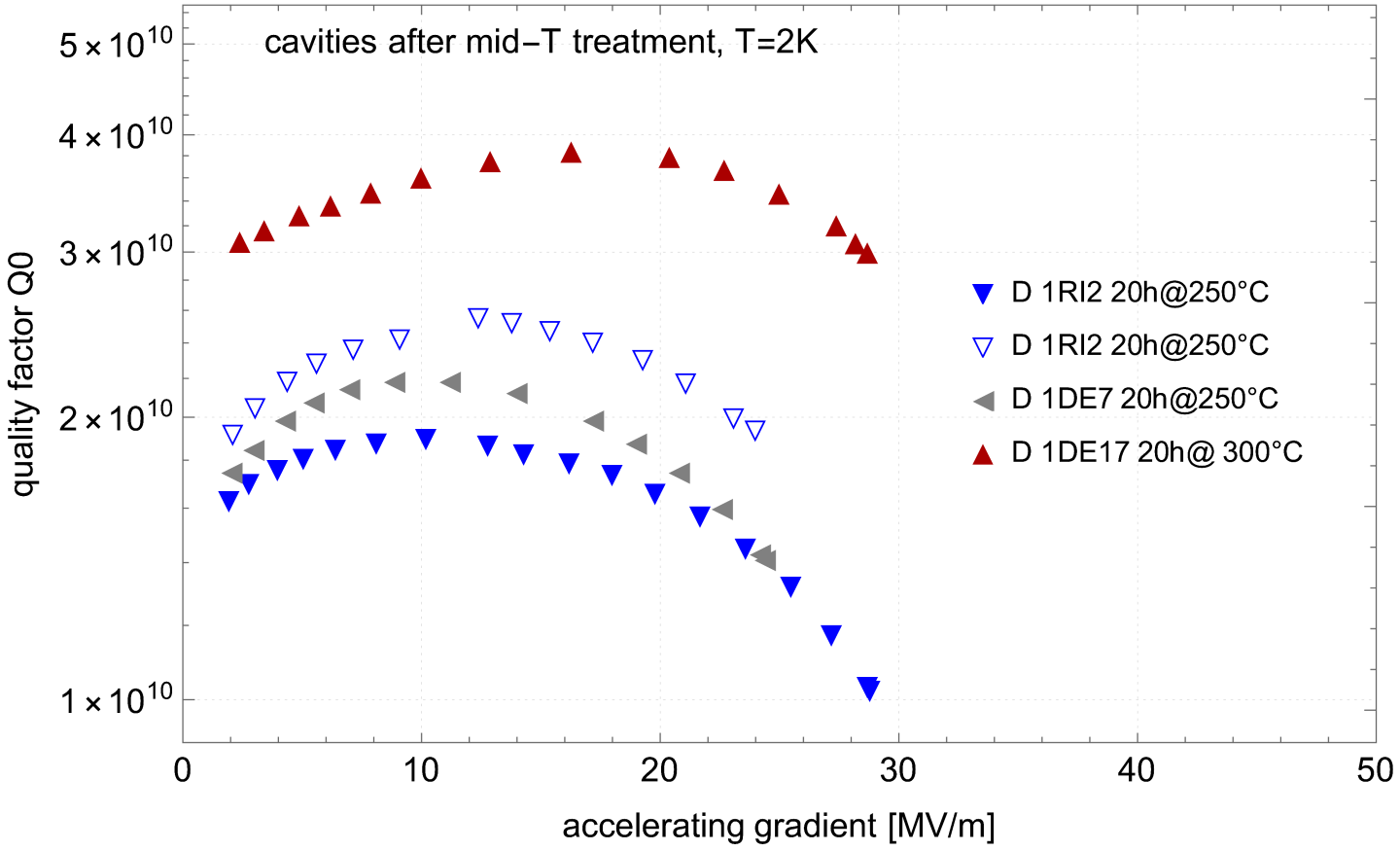
- no real correlation visible
- 50% of cavities: effect of frozen flux



long mid-T heat treatment yield low Q_0, but…

…1DE17 shows very good performance

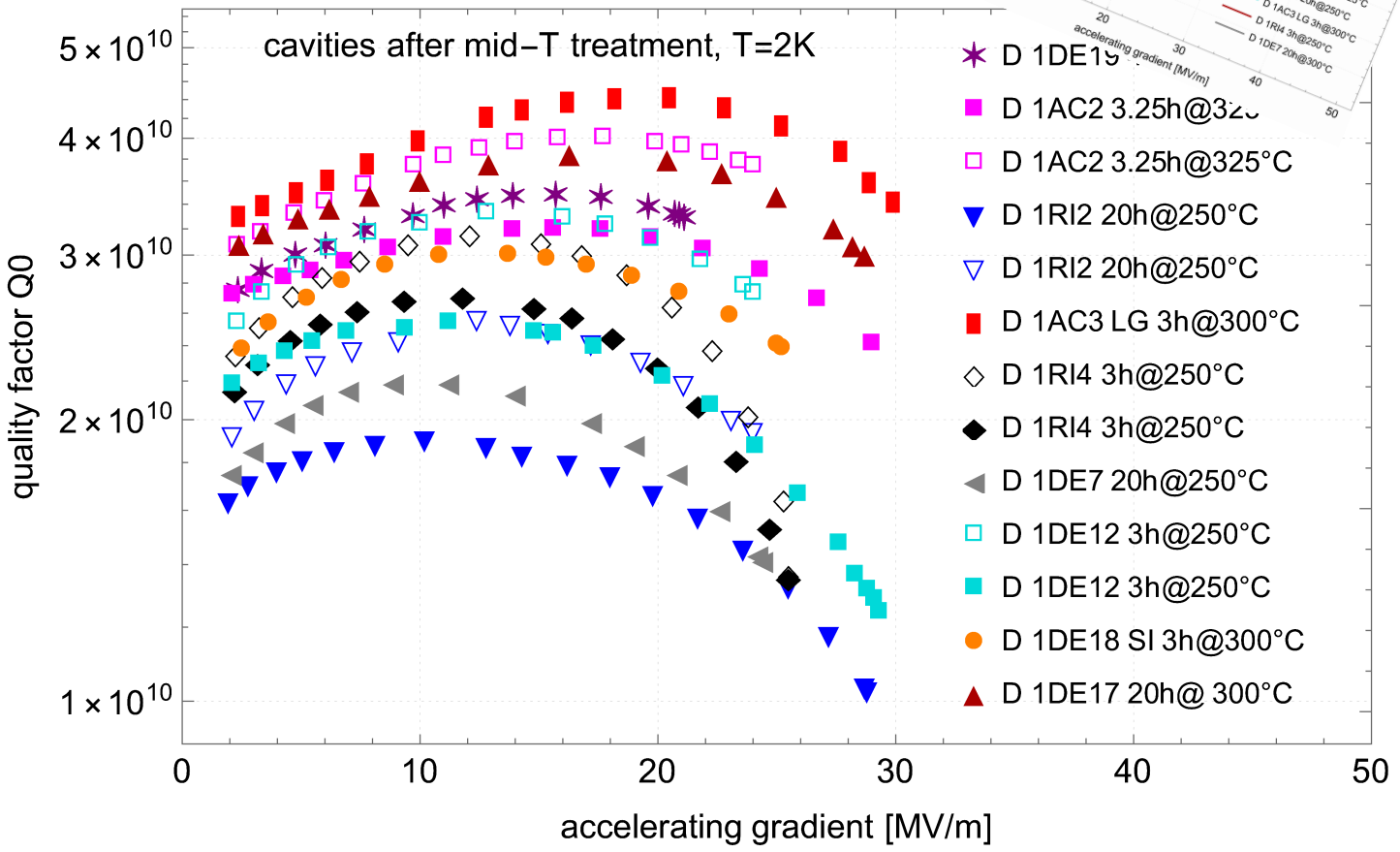
- 20 hrs seemed to be unfavorable, besides the 1DE17 result
- 1 of 3 of cavities: effect of frozen flux
- do we want more tests with 20 hours, or some with medium duration?



open points for analyses

again the complete picture

- R_{BCS} analysis
- frozen flux analysis
  - checked already insert/cryostat
- other parameters
  - T > 300°C
  - 3h < t < 20h
- combination recipes like
  - 3h @ 800°C + 3h @ 300°C
- comparison with sample results



RRR Sample results before and after treatment:

Treatment	RRR Before Err 1.5%	RRR After Err 1.5%		ΔRRR	Err
Probe 1 1DE7 20h@250°C	337,6	355,5		17,9	7
Probe 2 1DE17 20h@300°C	355,2	343,3		-11,9	7
Probe 3 1RI04 3h@250°C	357,7	372,7		15	8
Probe 4 1DE18 3h@300°C	346,7	355,3		8,6	7
Probe 5 1DE18 3h@300°C together with Probe 4	339,1	339,6		0,5	7
Probe 7 1DE12 3h @ 250°C	343	355,3		12,3	7
Probe 6 1RI03 „Infusion“	382	418,5		36,5	8
Singlecell furnace 800°C	312,24	347,44		35,2	7

- Sample 4 and Sample 5 were treated together, and within the margin of error, no significant change was observed in either sample.
- With the exception of Sample 2, the RRR either improved slightly or remained within the margin of error.
- Interestingly, the treatment at 250°C appeared to produce greater changes in RRR compared to 300°C. It is possible that at 300°C, oxides break down and have less diffusion into the bulk.
- The greatest improvement in RRR was achieved by the "Infusion" treatment, which involved little to no nitrogen exchange due to MFC failure, and by baking at 800°C in the new single-cell furnace. The MFC failure does not appear to have caused any contamination.
- Next steps: Since the Niobium foils could not maintain a high RRR due to excessive mechanical stress, samples with a thickness of 400-500 µm will be tested. However, the milling process may reduce the RRR once again. High-temperature treatment at 1100°C may be a potential solution to this issue.