Performance of the HIE-ISOLDE seamless cavity compared with welded series productions

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- Review of the last talk in 2016: seamless cavity
- Measured performance
- Comparison with series production
  - Cooldown effect
  - Magnetic field effect
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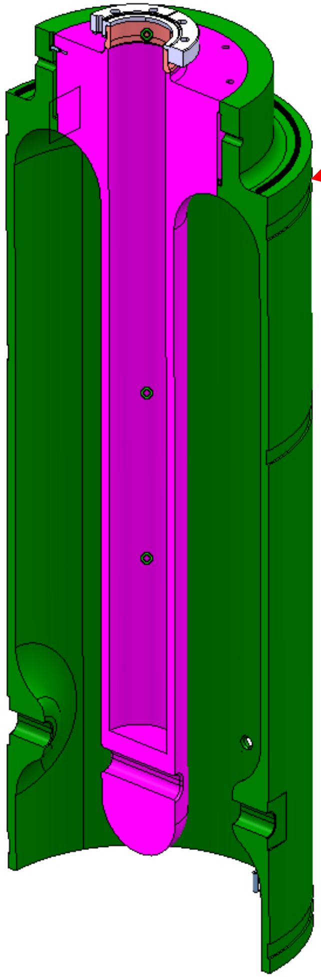
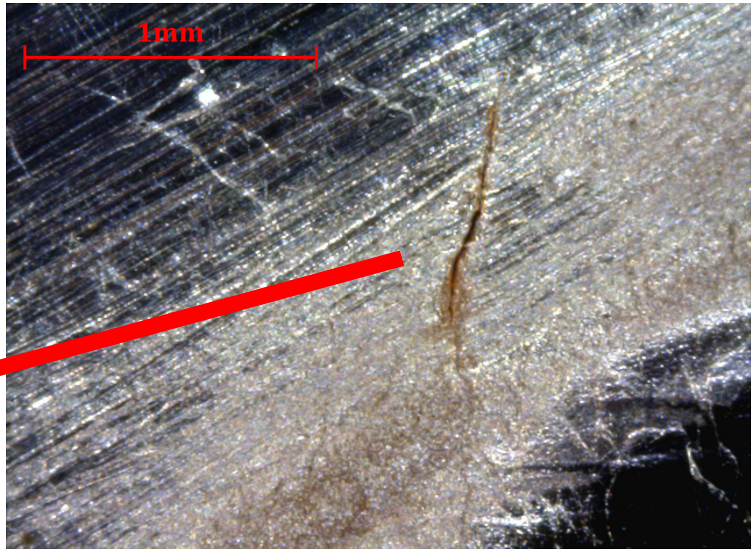
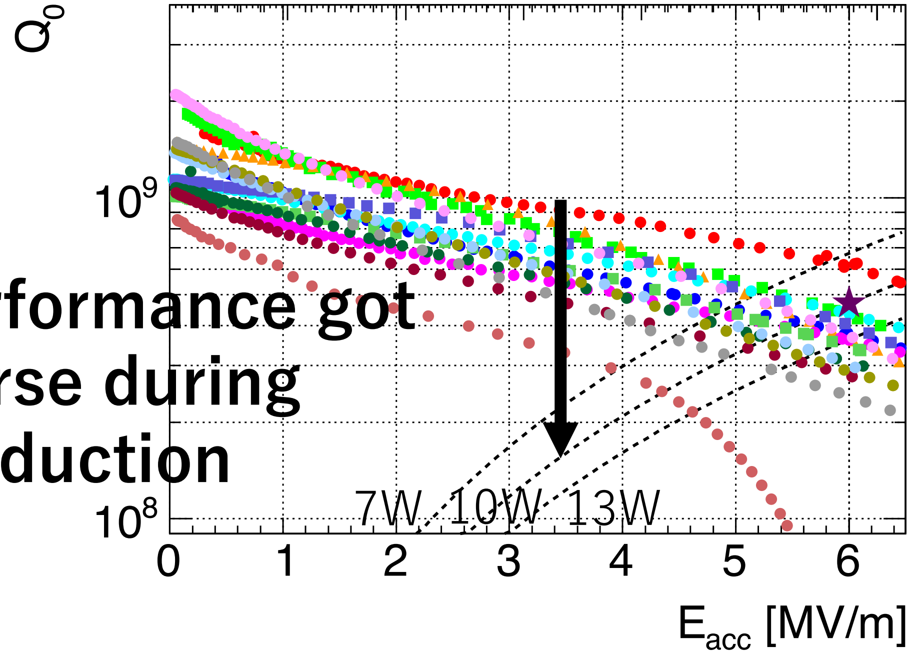
Review of the last talk in December 2016

Cracks were found near the weld of series production

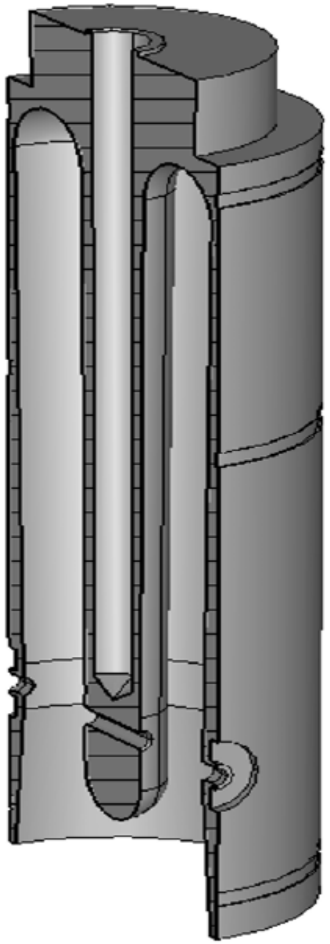






Performance got worse during production

Seamless cavity machined from a Cu billet was designed



A dummy cavity to benchmark the mechanical process showed *defect-free surface* ☺

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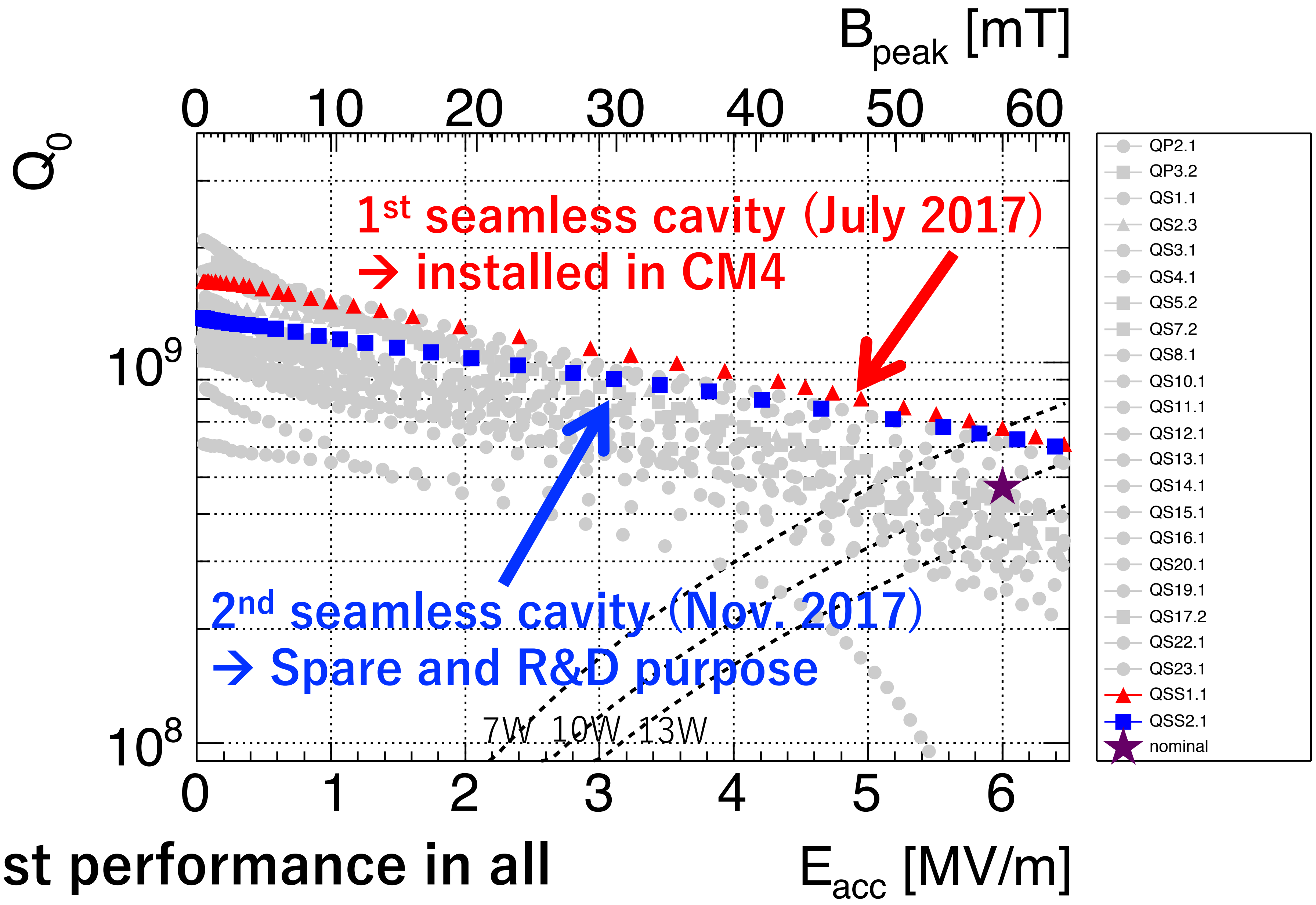
Measurement in a testing cryostat



Best performance in all

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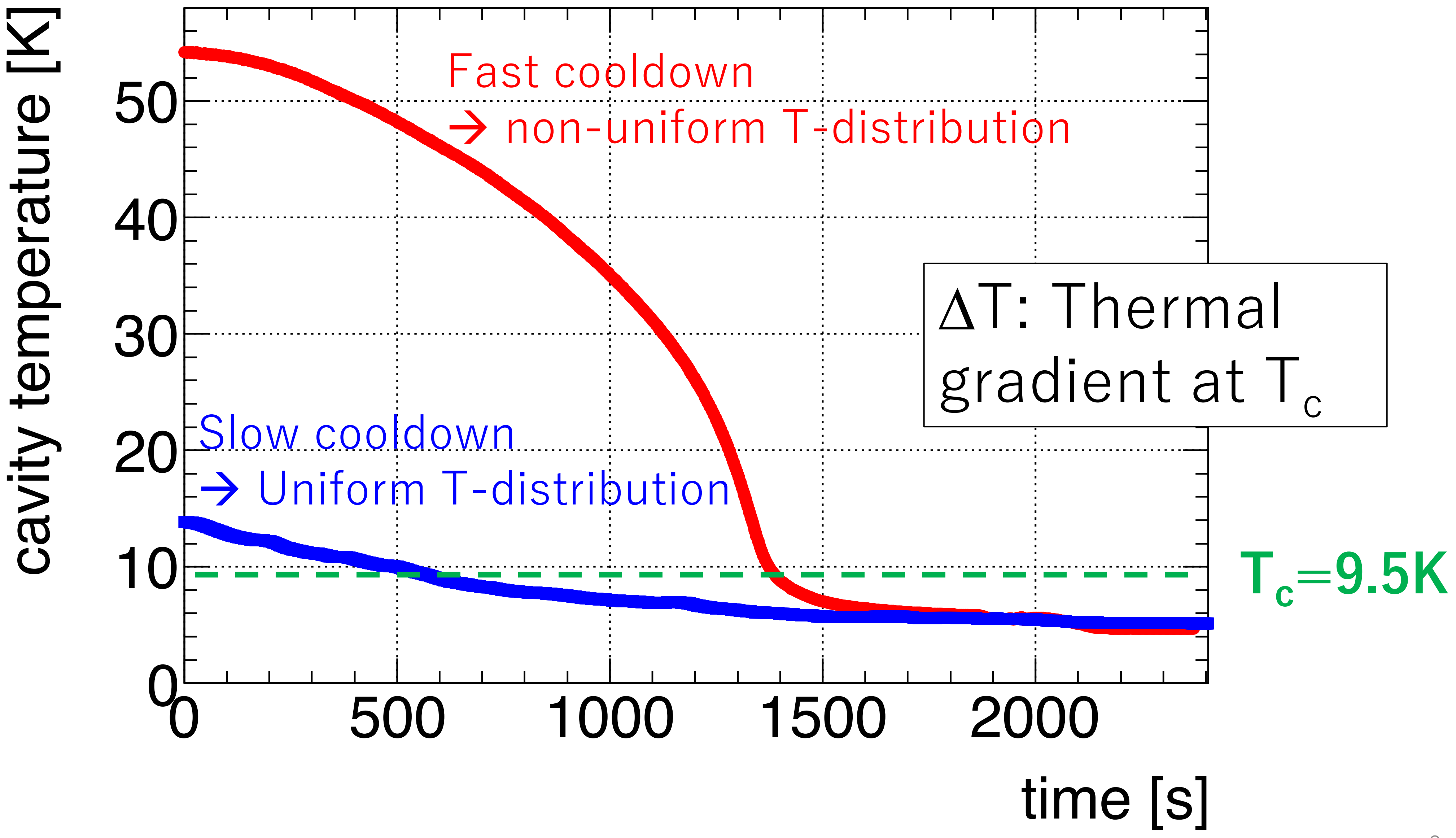
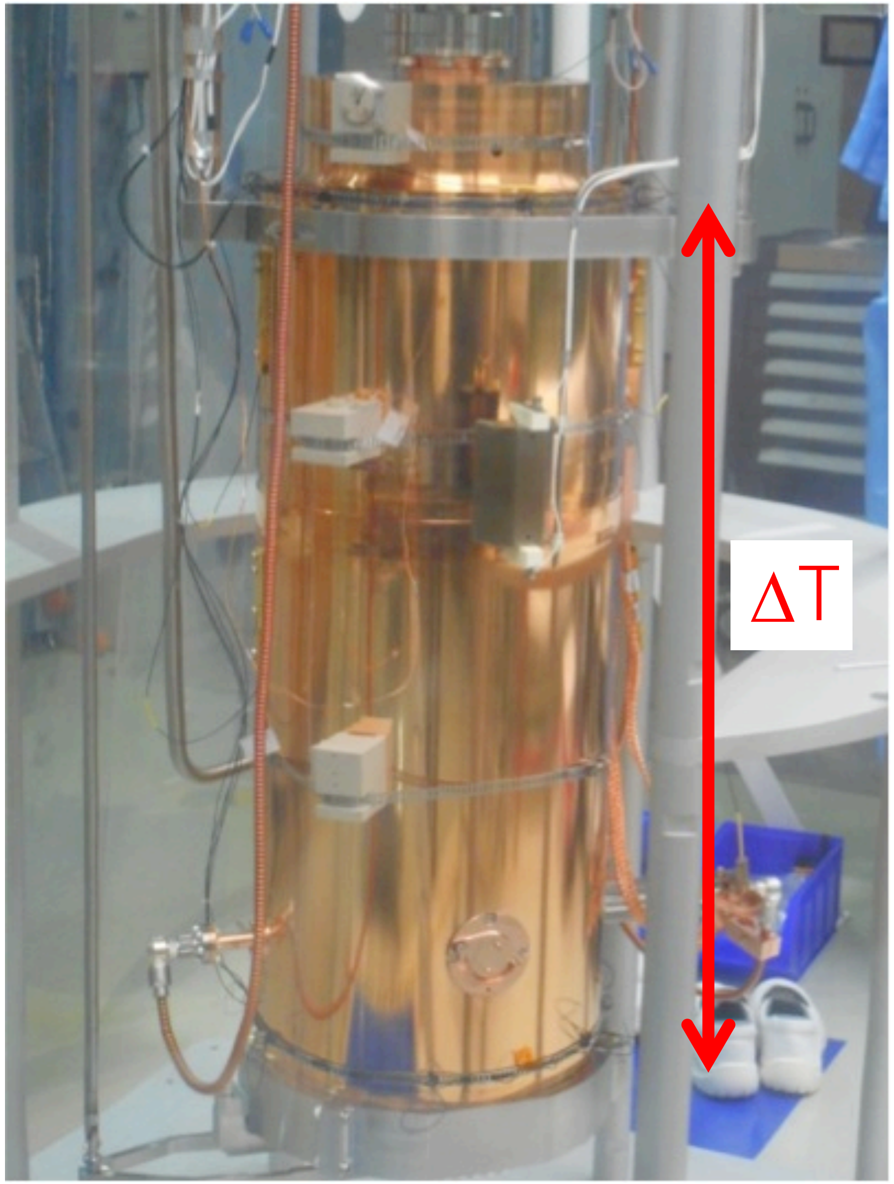
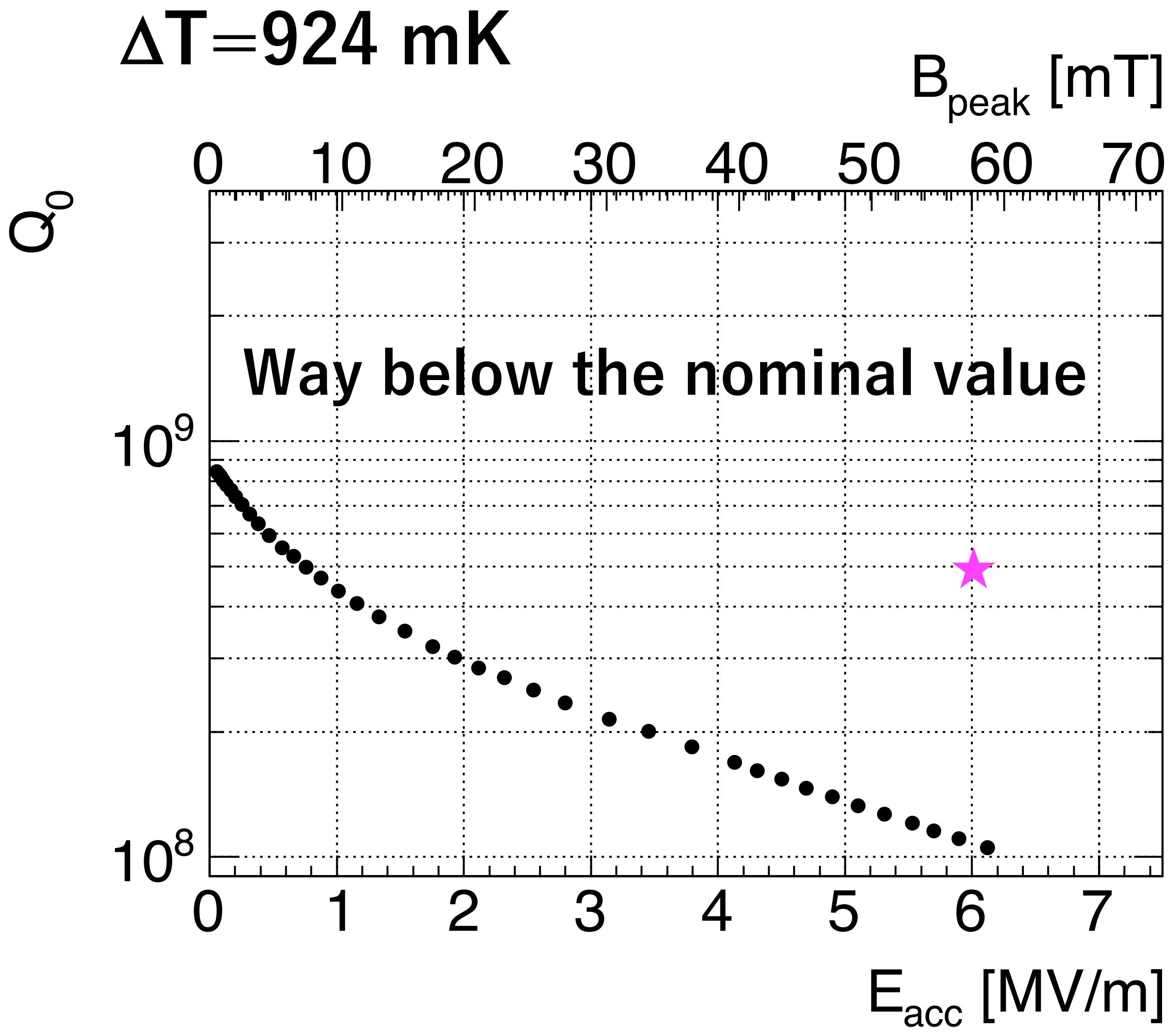
Cooldown processes → uniformity of temperature

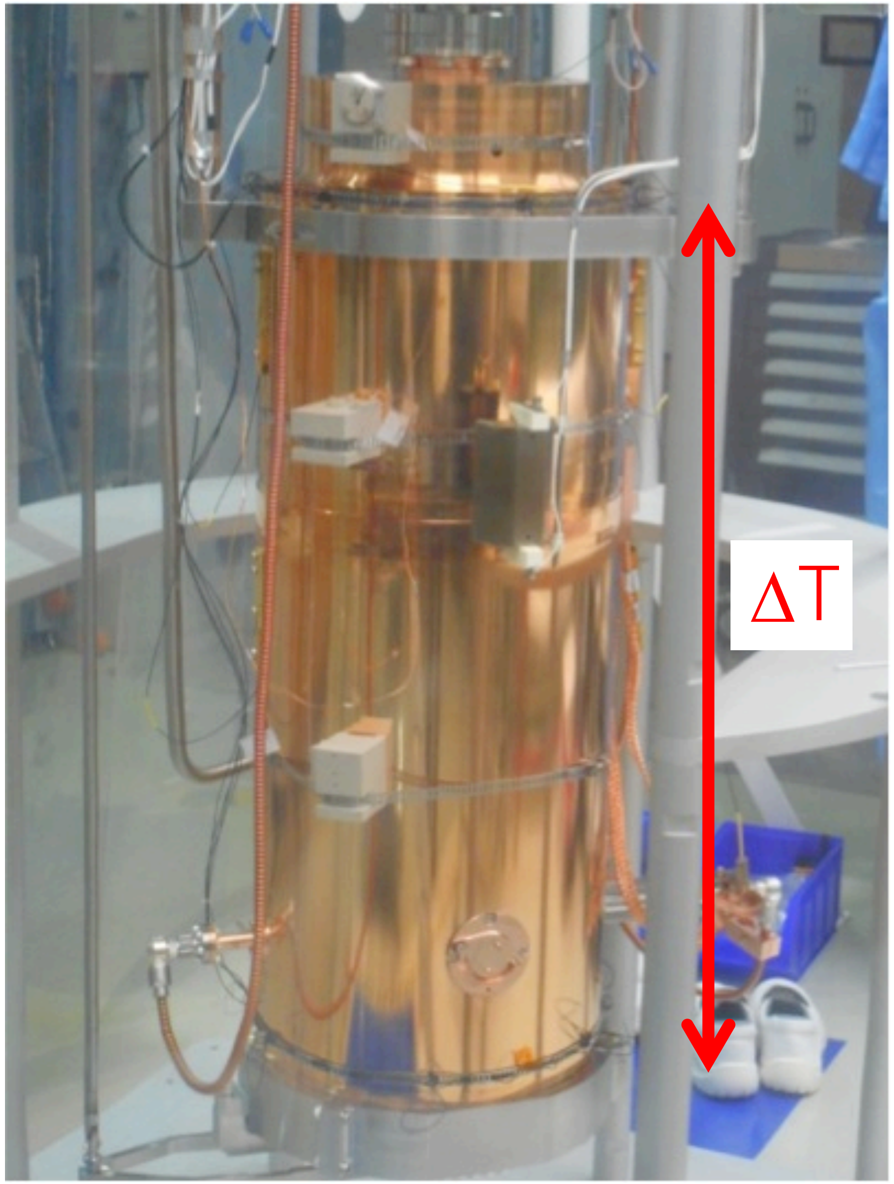


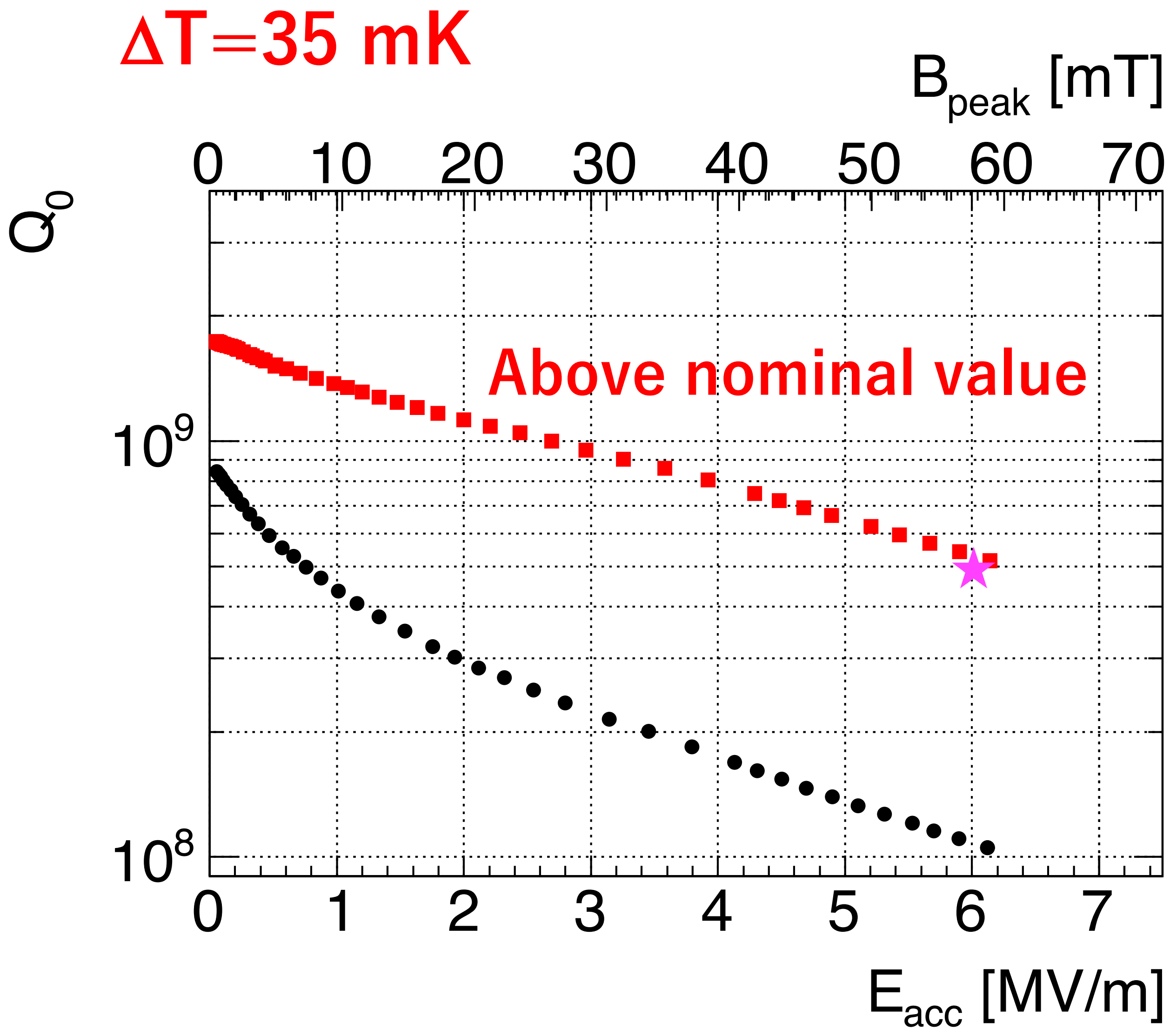
Cooldown effect of the **welded** cavities





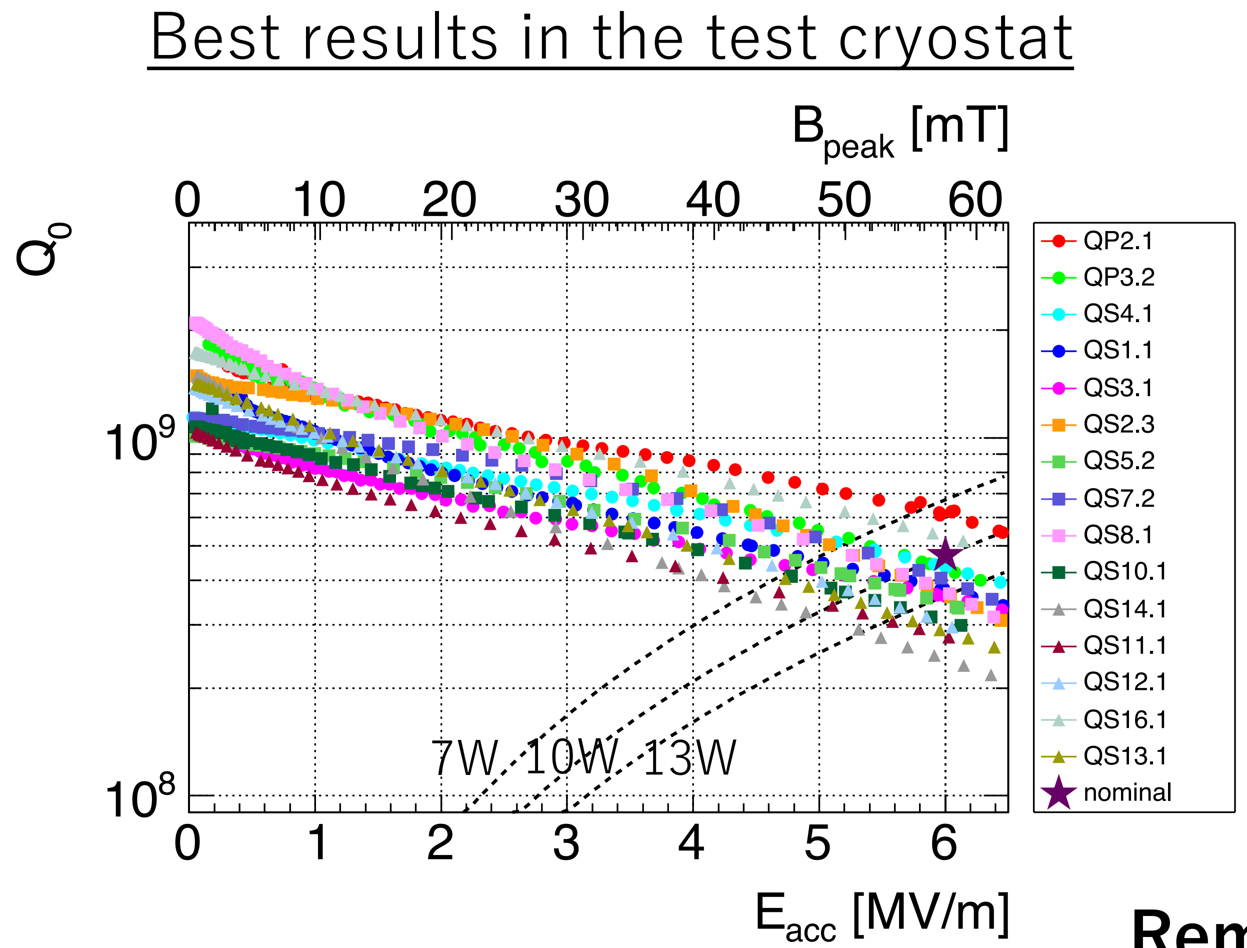
Cooldown effect of the **welded** cavities

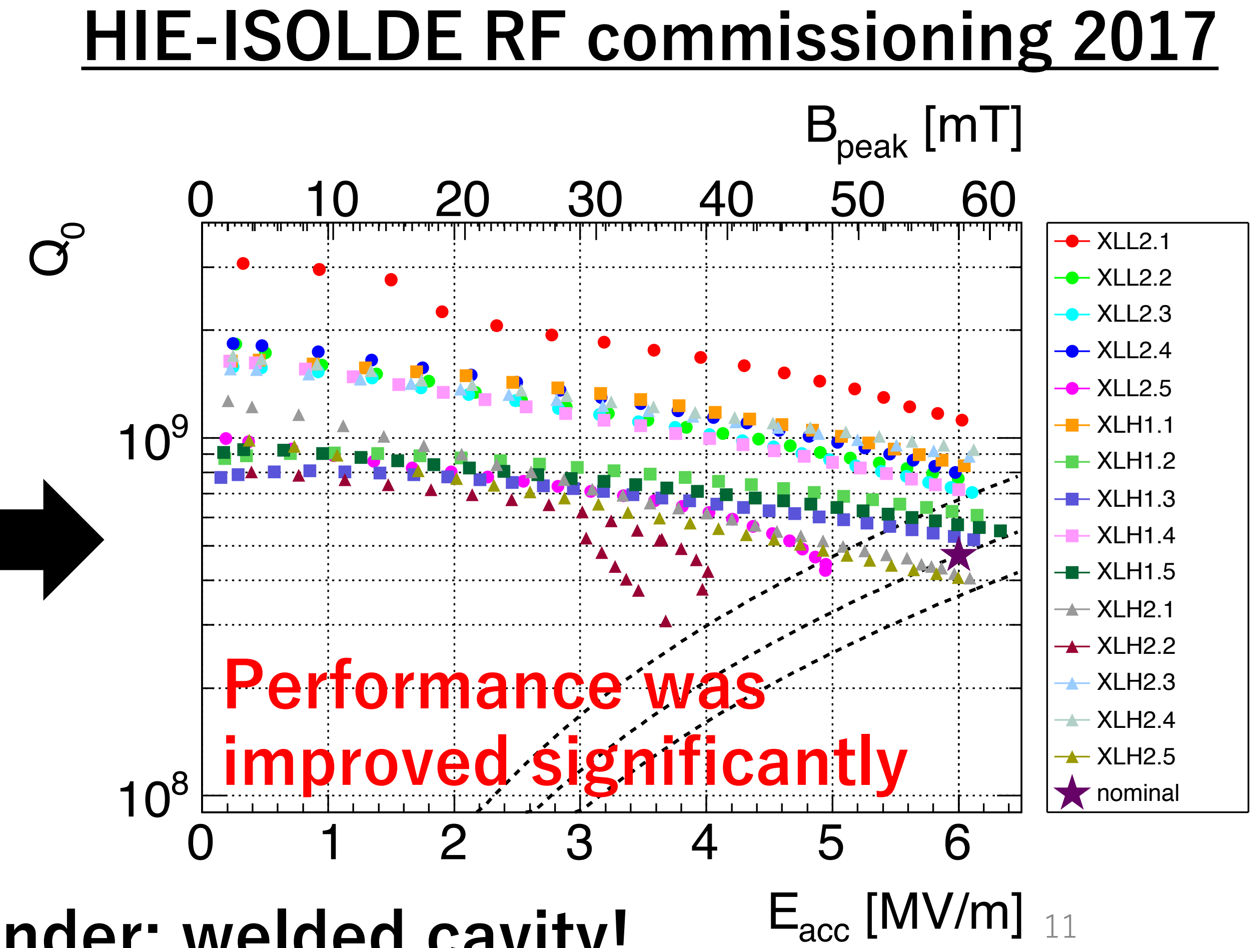




Cooldown process was optimized in the machine

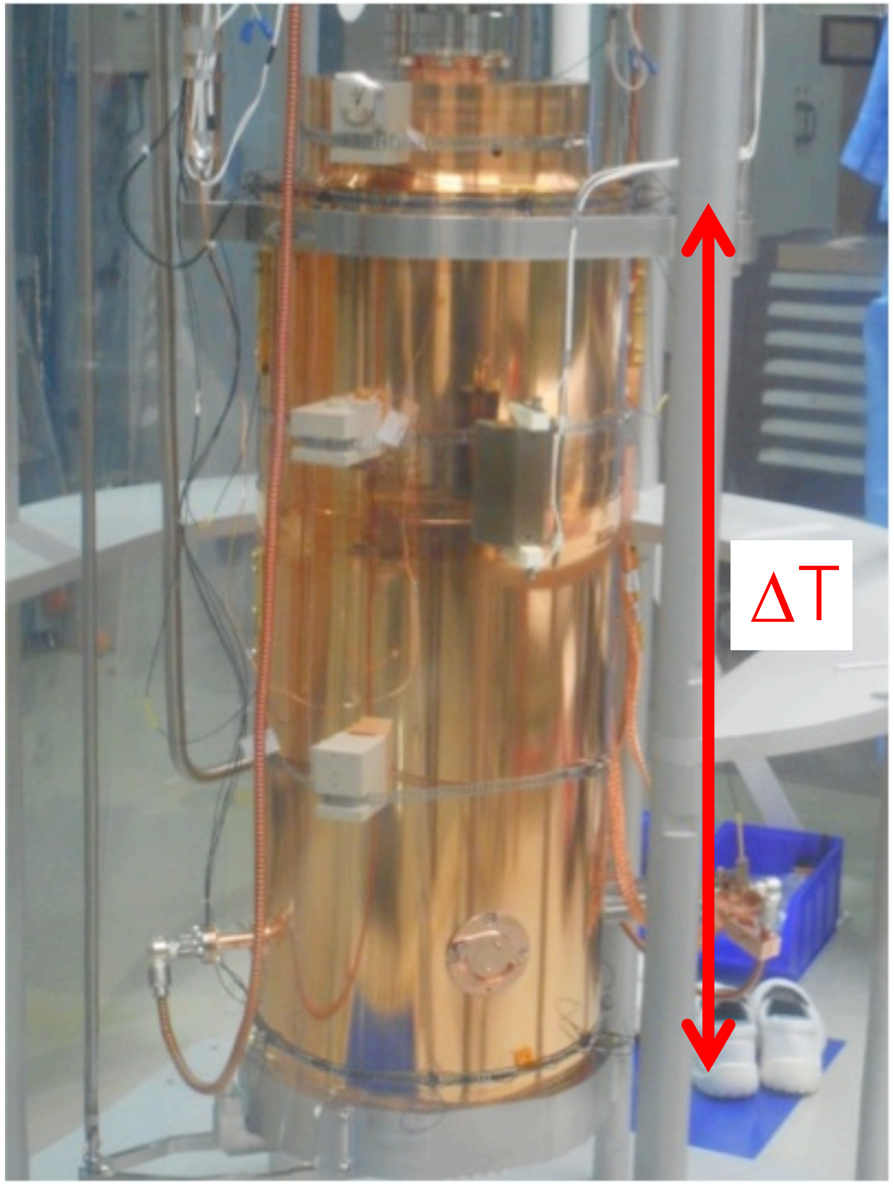
- The cavity was actively cooled down also from the bottom
- The temperature was kept at just above T_c for long time for uniform transition

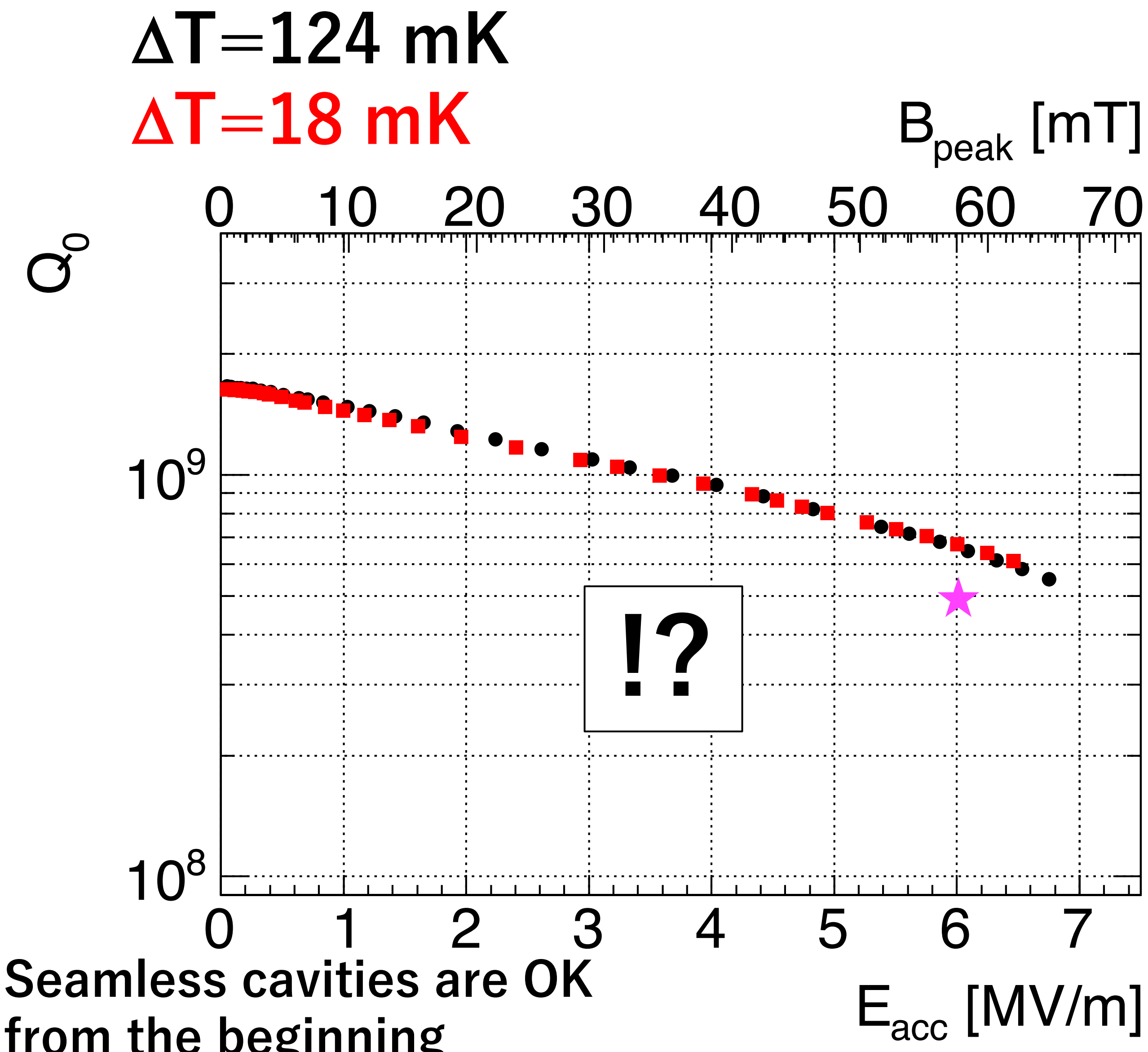




Reminder: welded cavity!

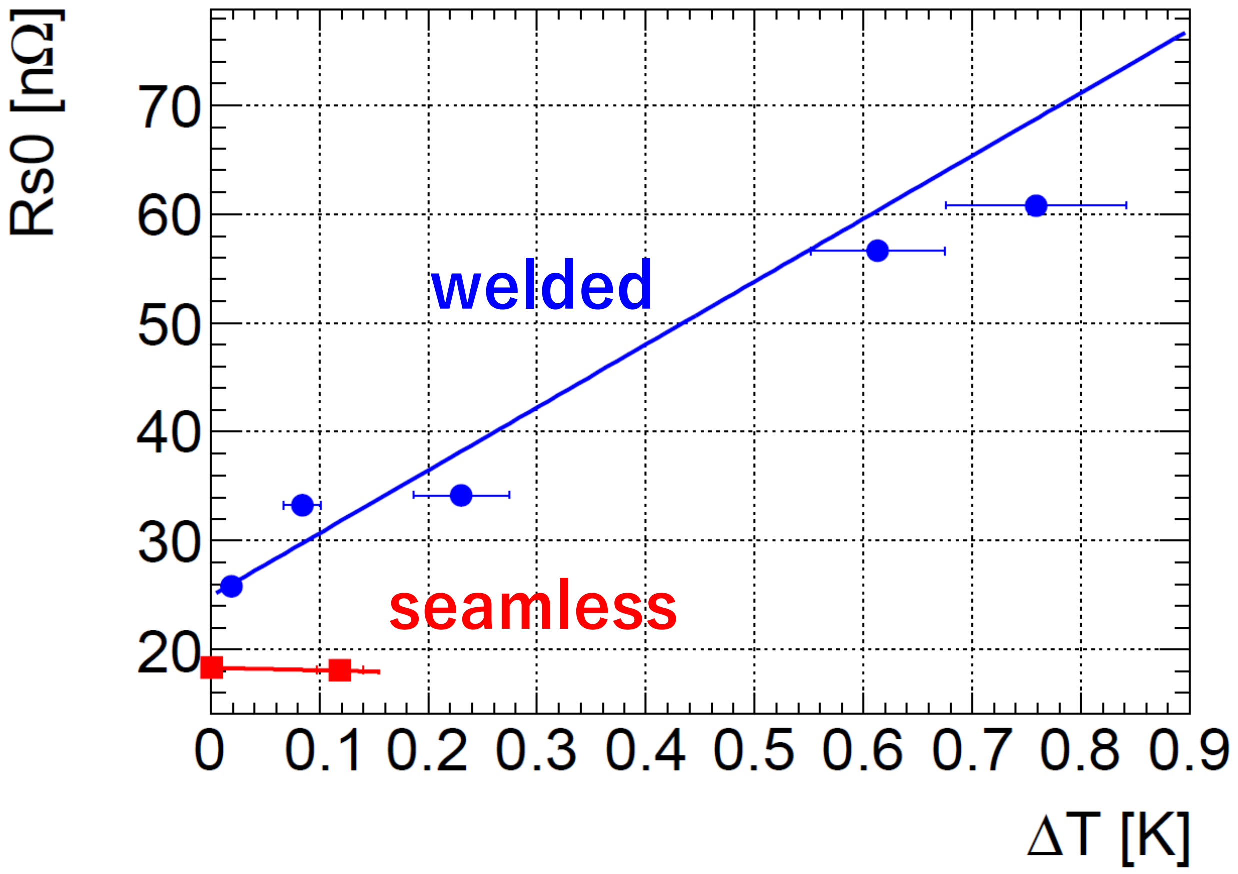
Cooldown effect of the **seamless** cavity

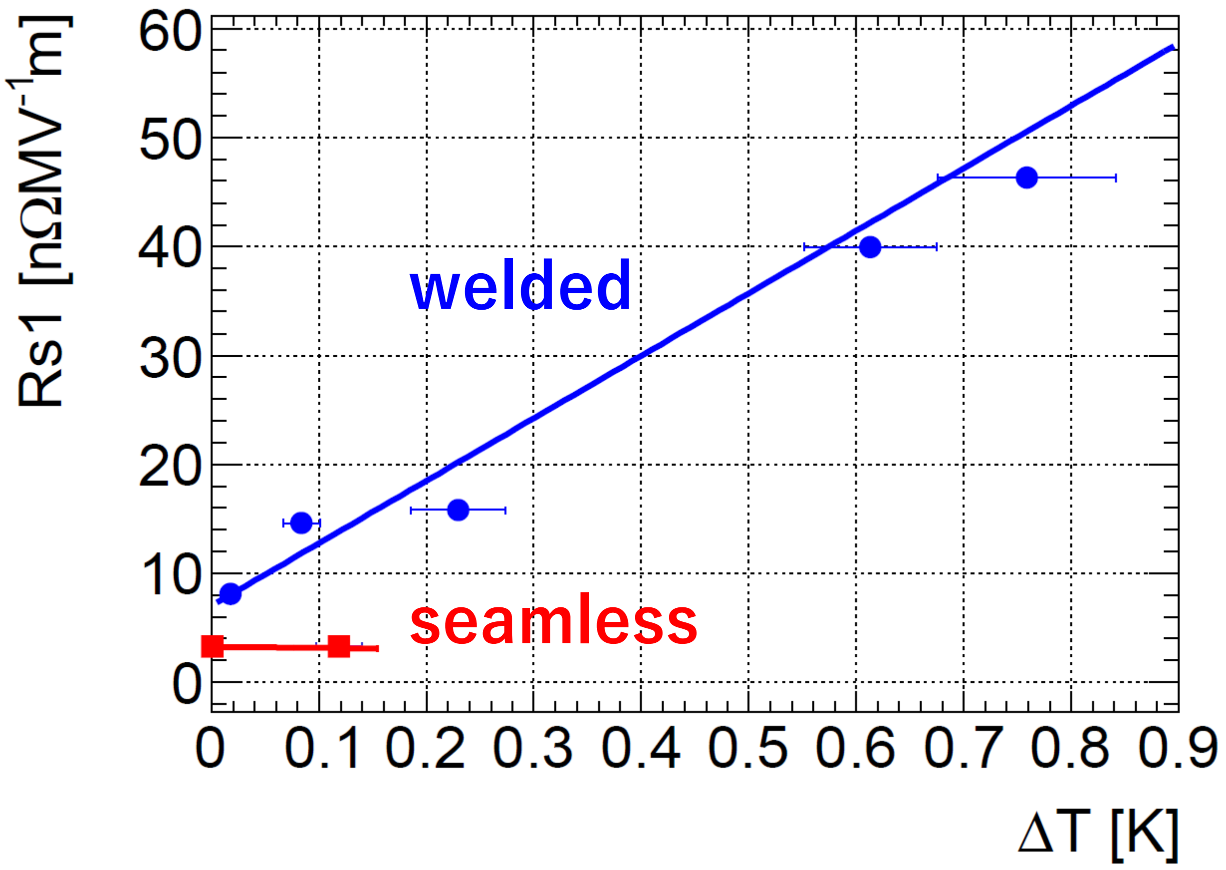




Seamless cavities are OK from the beginning

Sensitivity to the thermal gradient





No ΔT dependence was observed in the seamless cavity!

Optimized cooling down is not necessary for this cavity

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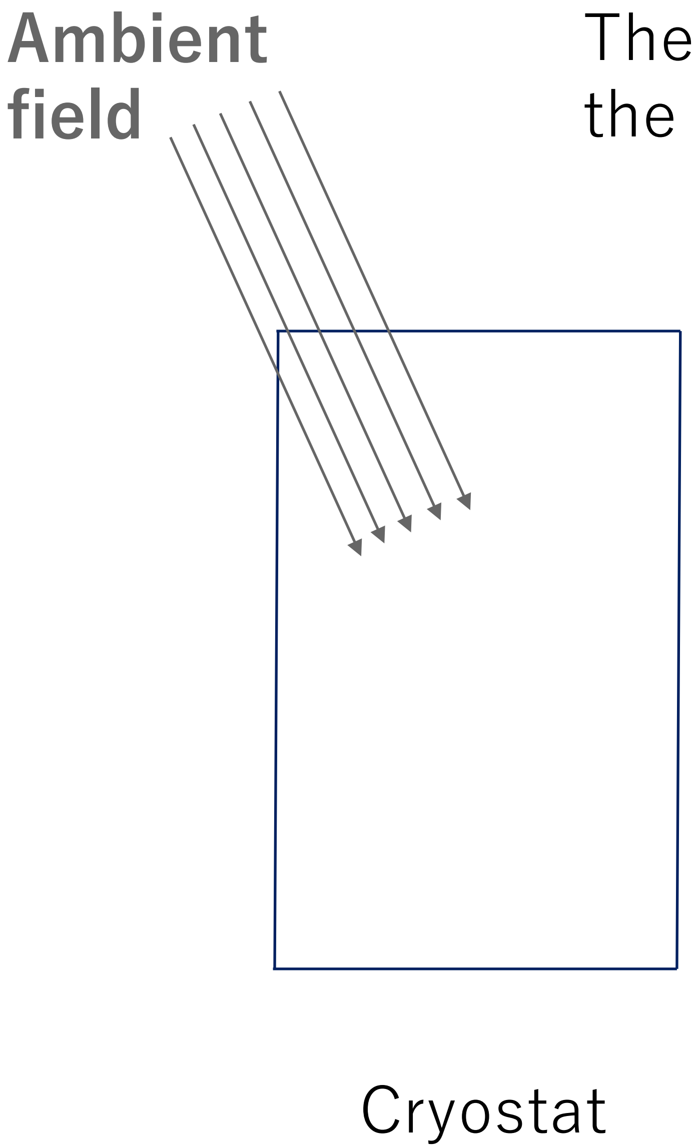
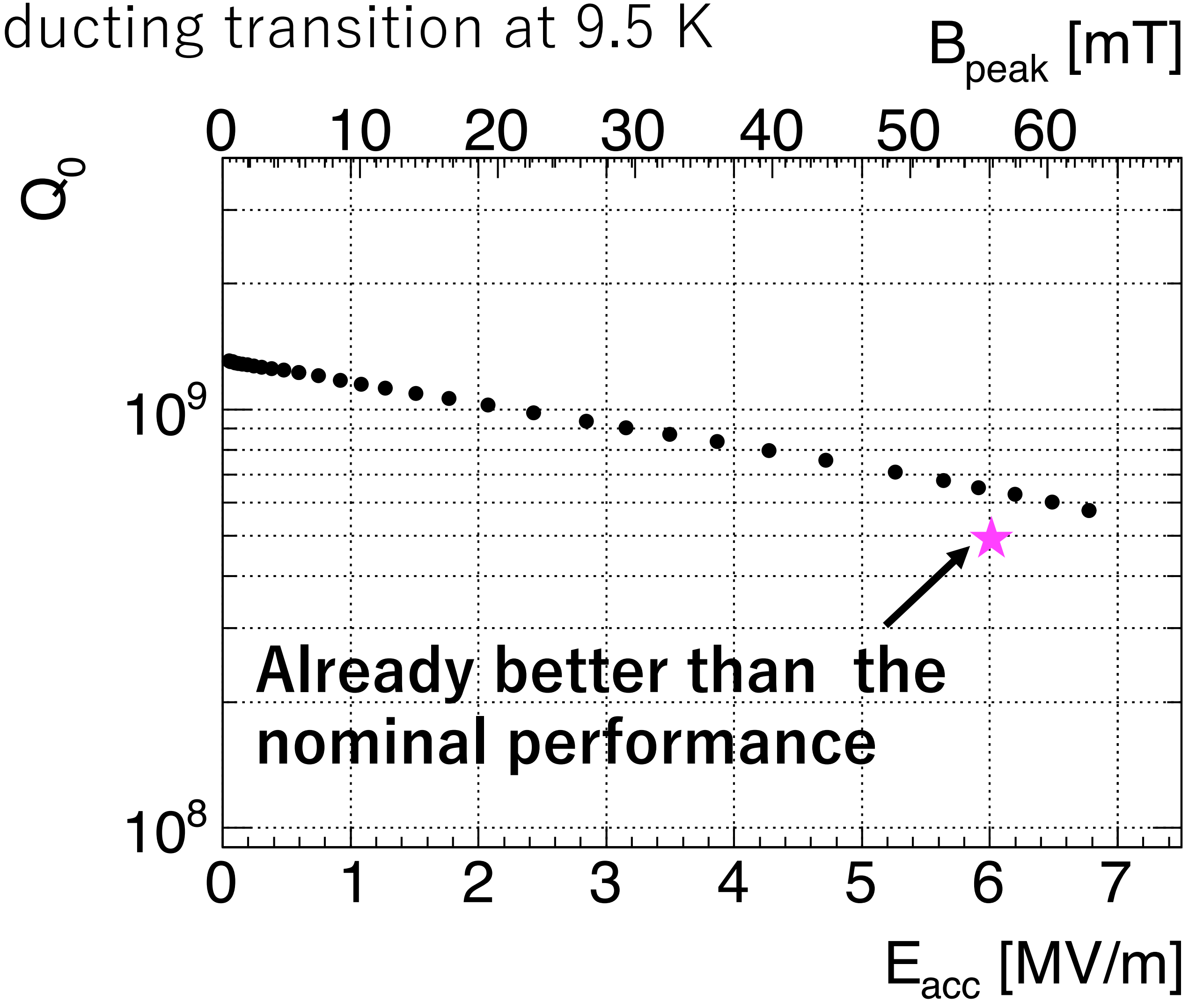
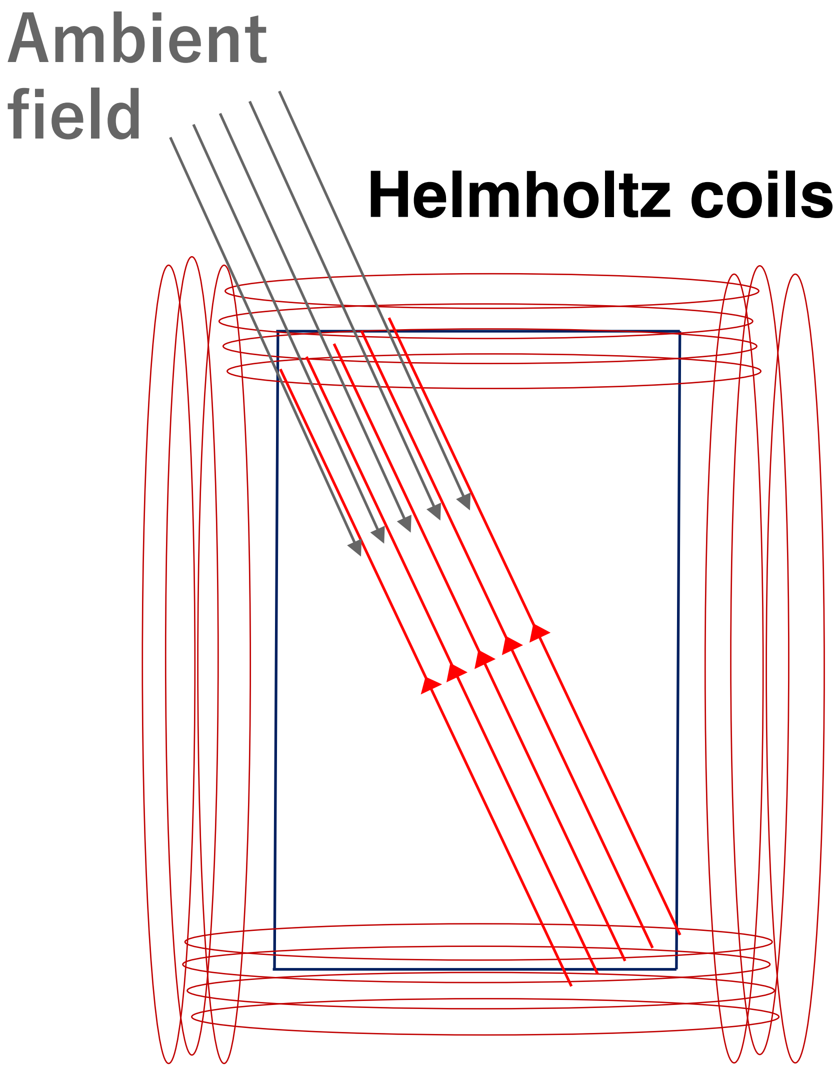
Effect of the trapped magnetic field

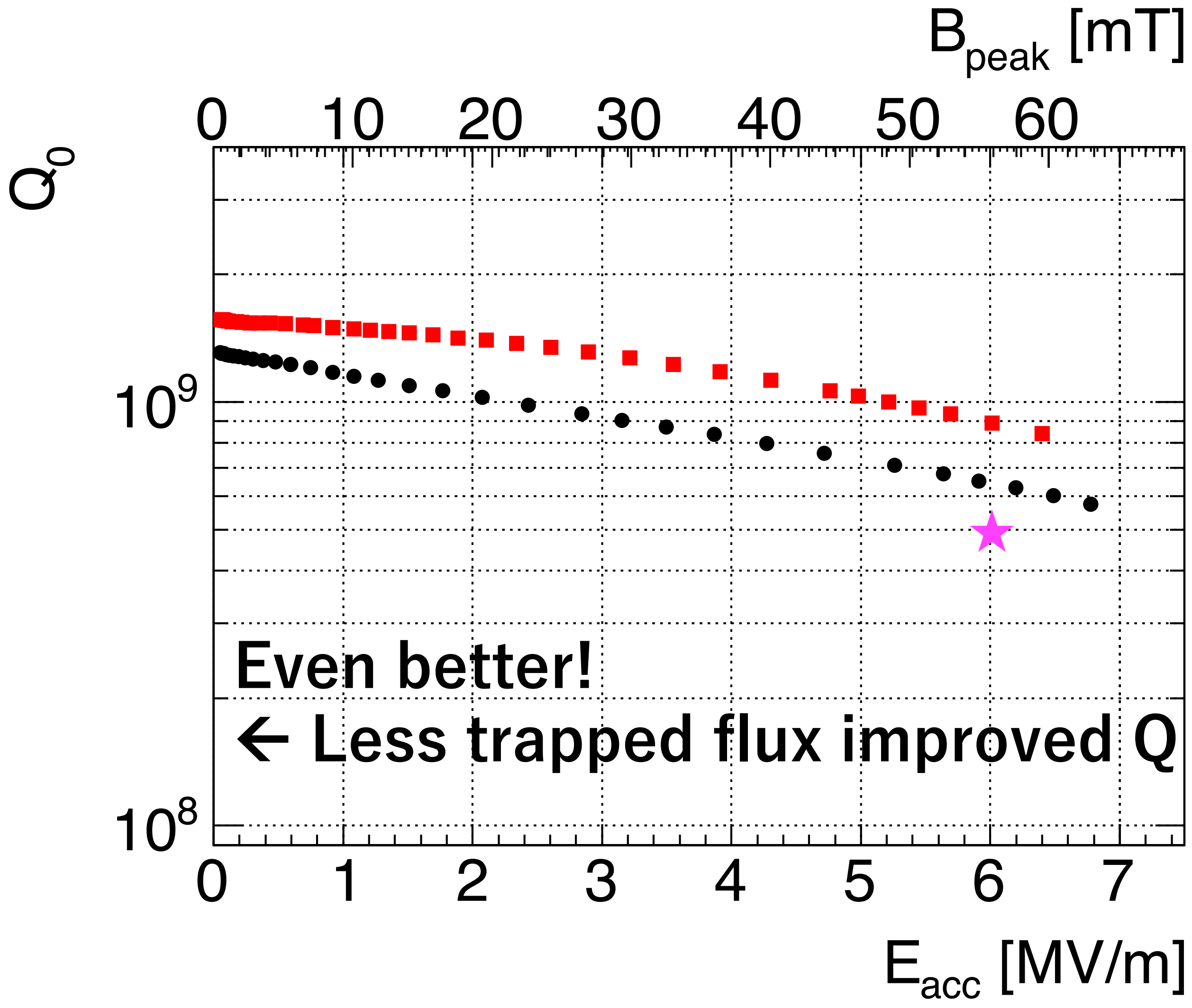
The cavity traps the ambient field during the superconducting transition at 9.5 K



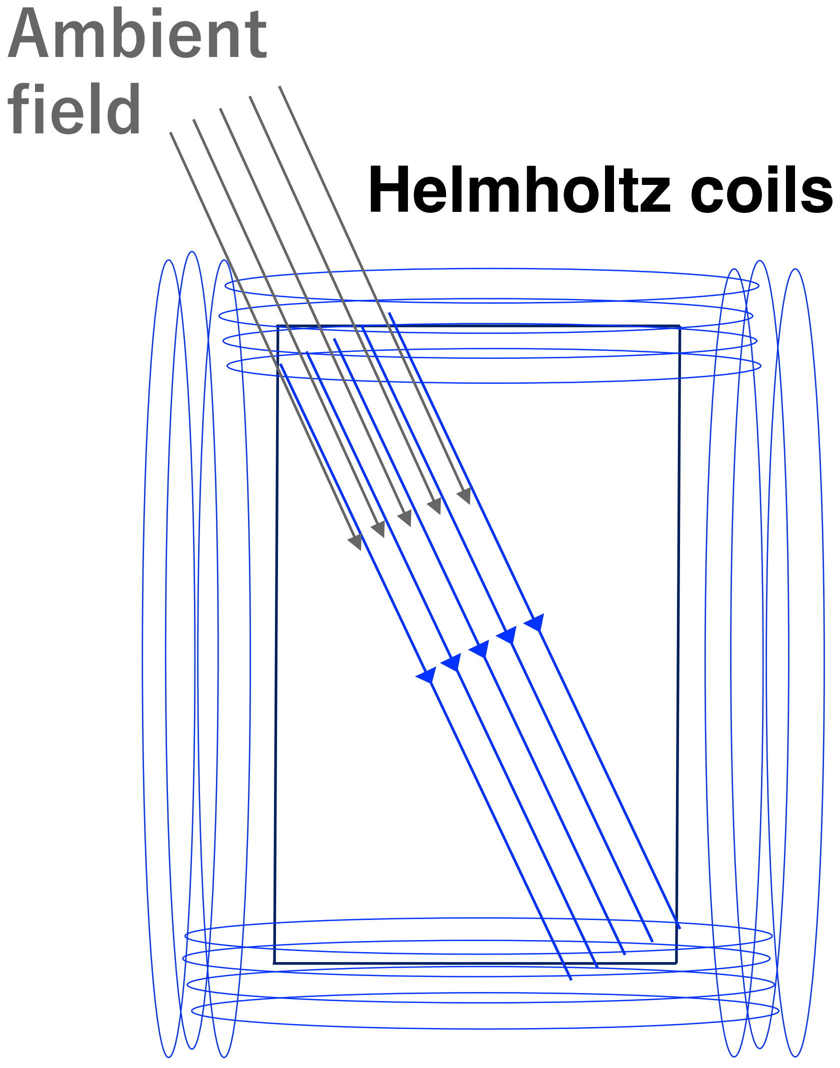


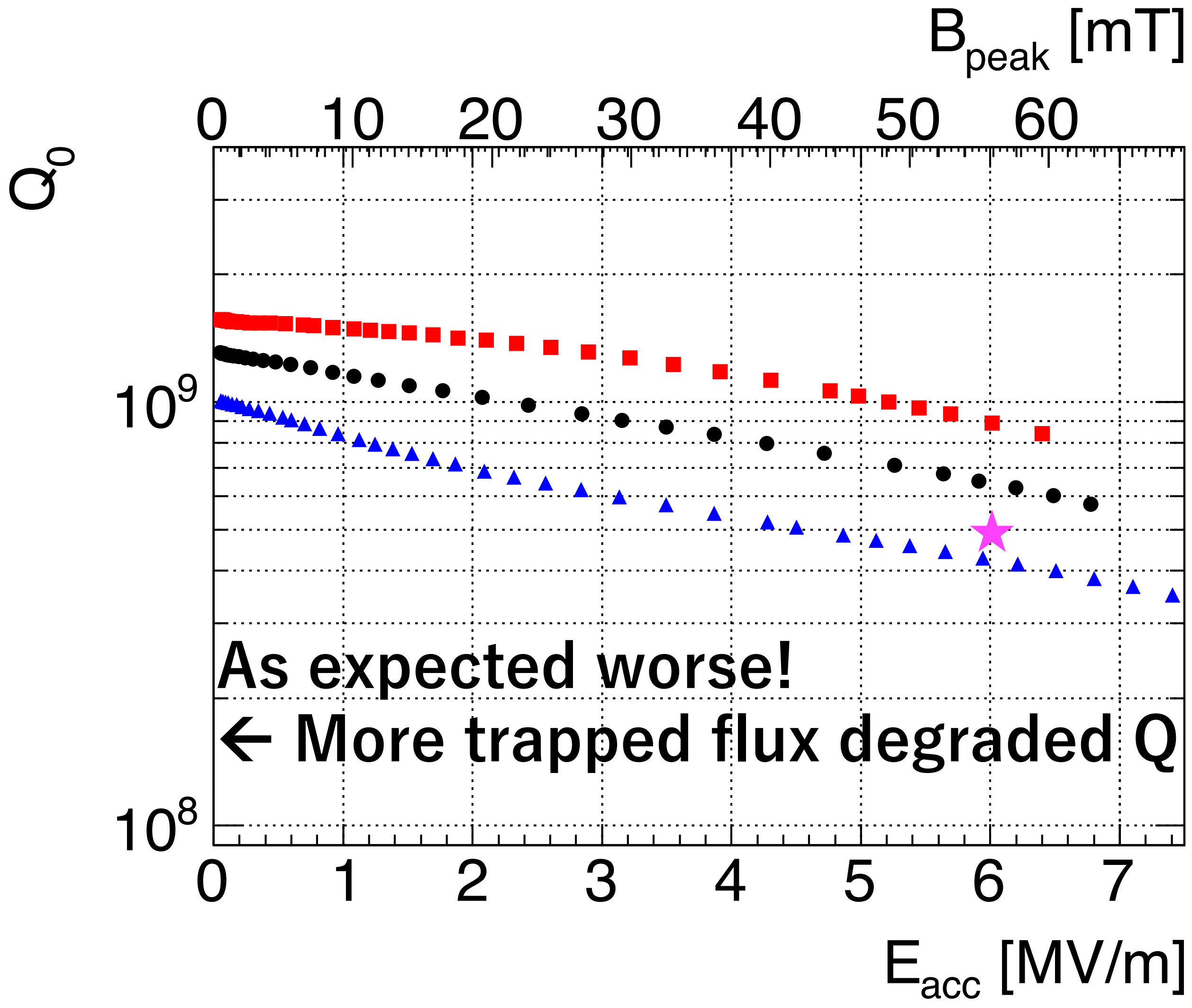
Performance under the **compensated** field



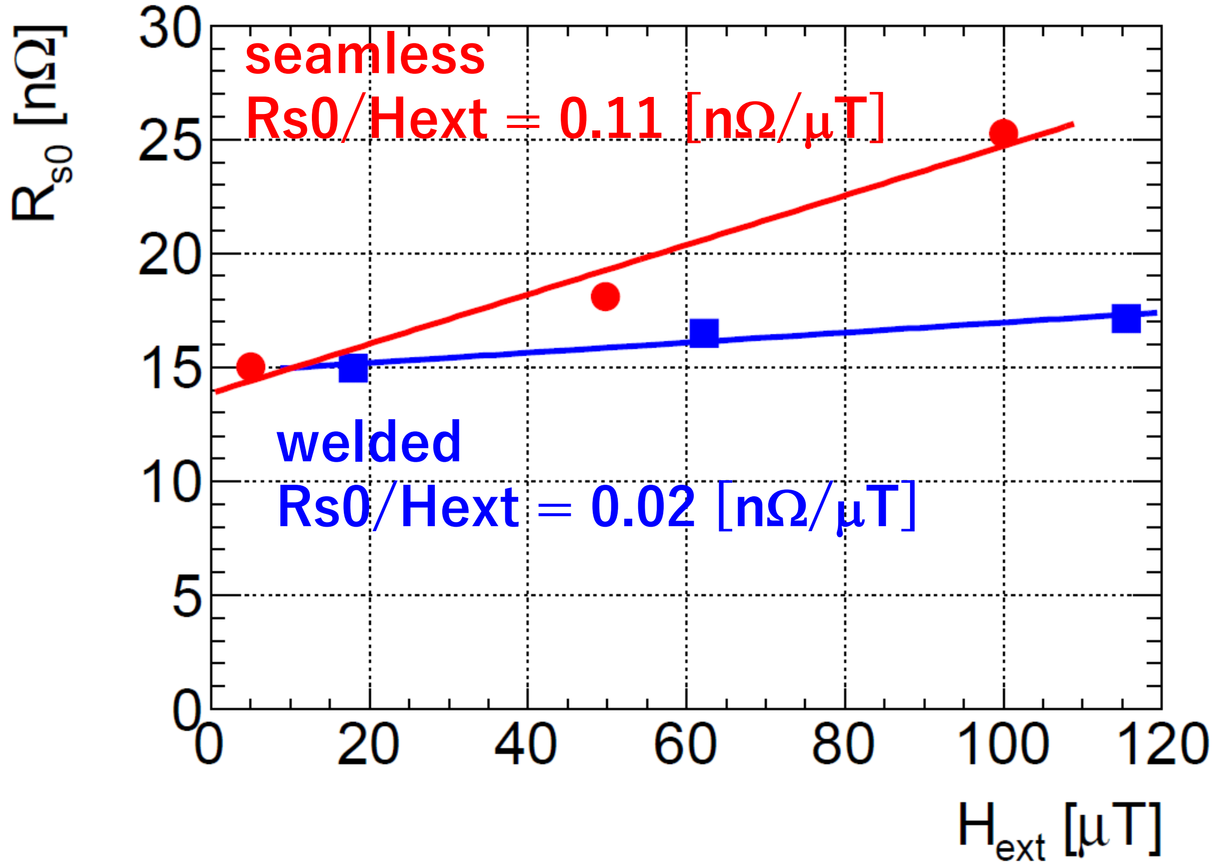


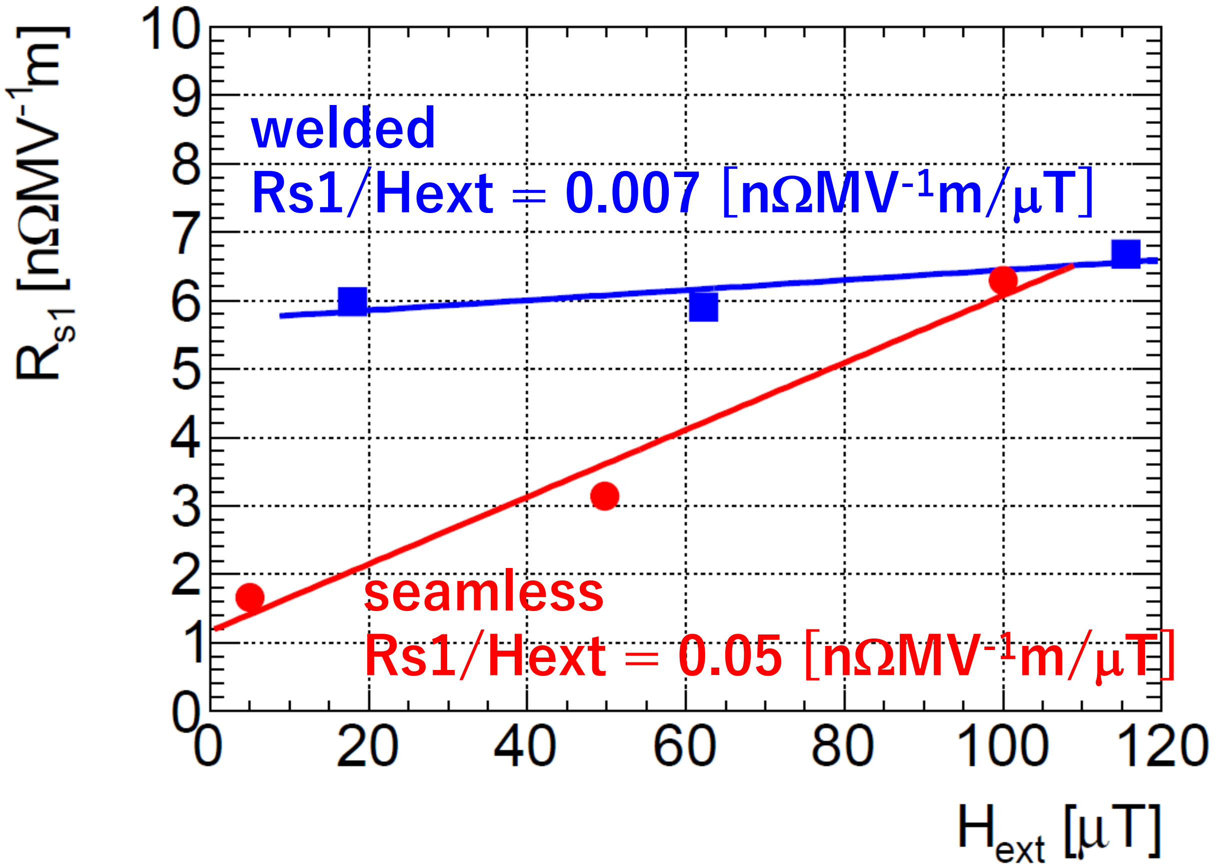
Performance under the **enhanced** field





Sensitivity to the ambient field





Seamless cavity is 1 order of magnitude more sensitive to the external magnetic field than series production

In any case much more insensitive than bulk Nb: O(1) [nΩ/μT]

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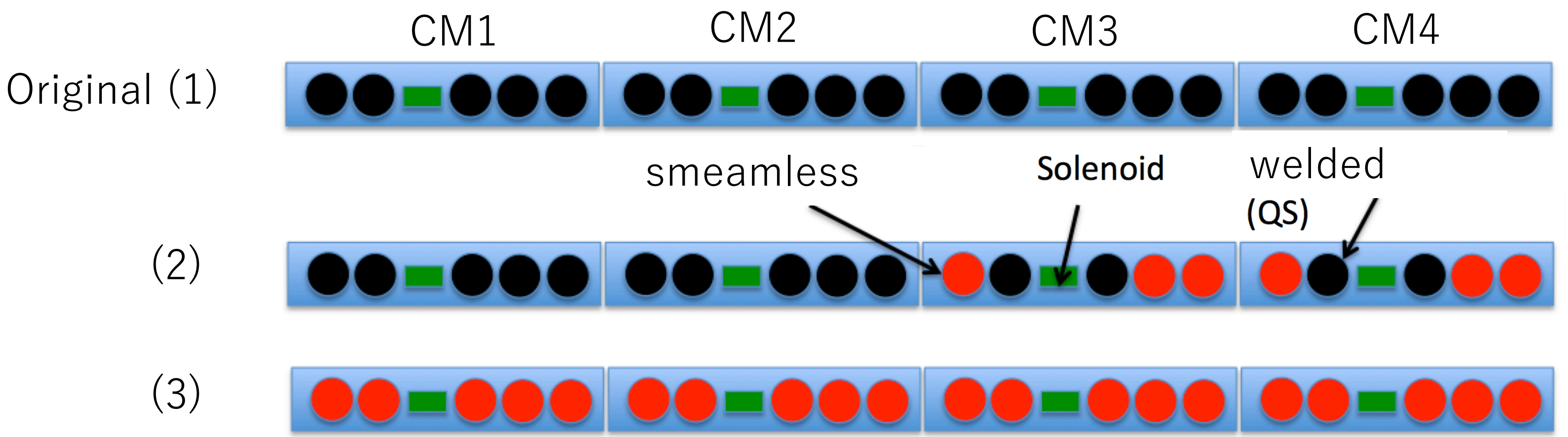
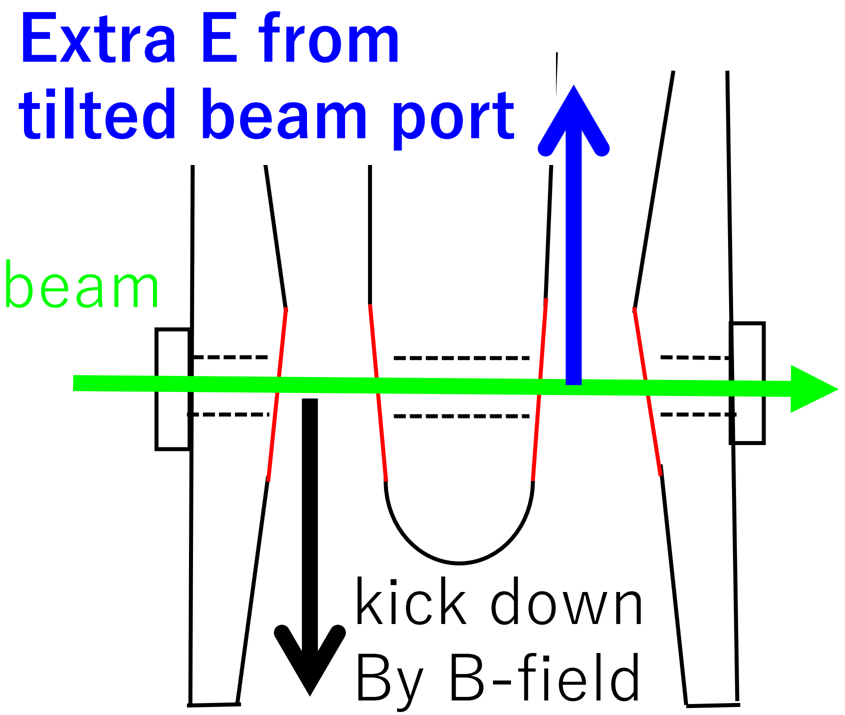
Can we use the present seamless cavities in CM1&2?

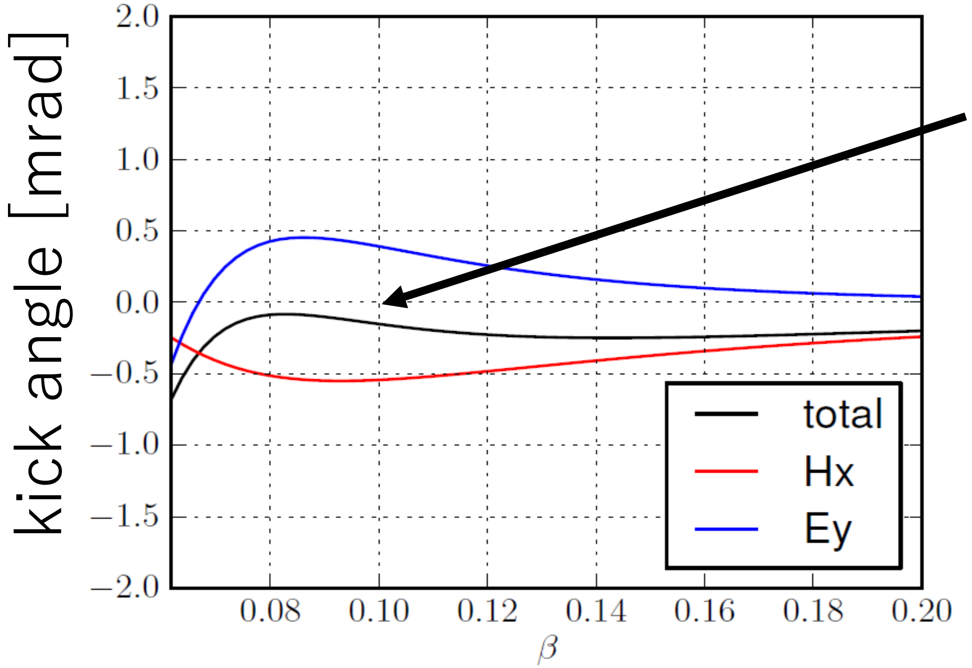


Cavity	Output Energy [MeV/u]	Transmission [%]	Transverse RMS Emittance Growth [%]
Original (1)	14.17	100	0
high β CM (2)	14.2	100	-0.3
All CM (3)	13.86	**85**	**21.2**

→ Beam steering effects are non-negligible in the low-β sections

Correction of beam steering was proposed





The beam steering in the Low-β section is properly corrected according to the simulation

Cavity	Output Energy [MeV/u]	Transmission [%]	Transverse RMS Emittance Growth [%]
Original	14.17	100	0
All seamless	13.86	**85**	**21.2**
All new correction	13.81	✓ **100**	✓ **4.6**

This was feasible but was not adopted as the first batch of production

→ Next production is on management decision ☺

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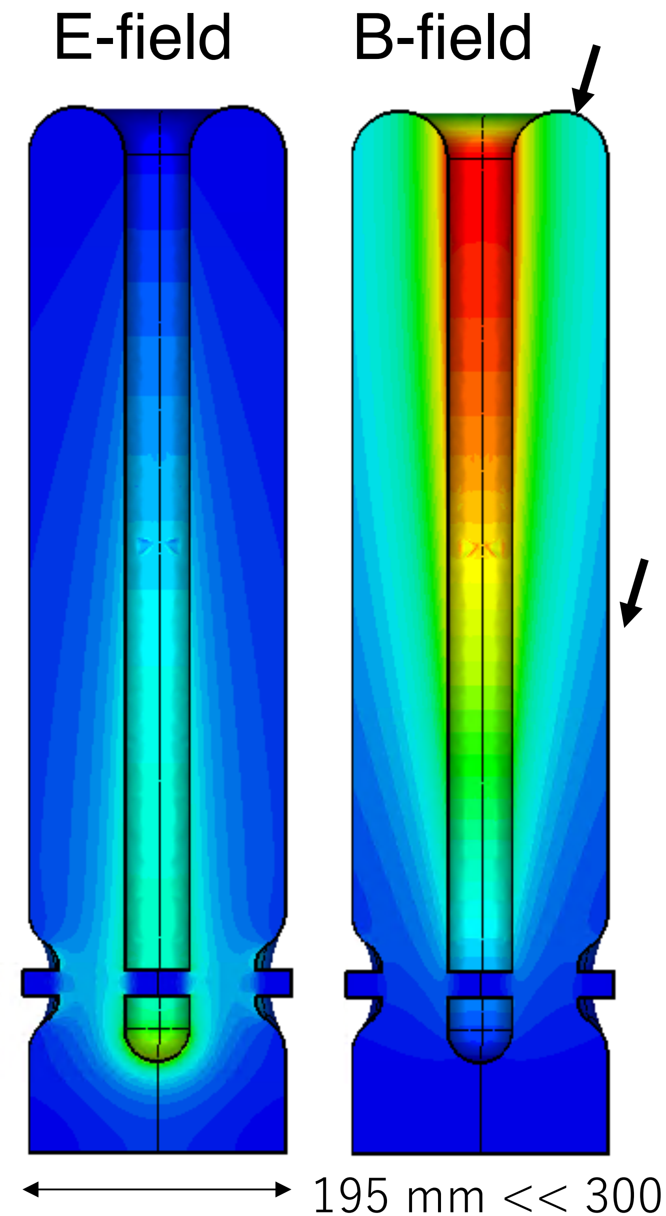
Application for the Low-β cavities in Phase 3?



195 mm << 300mm (high-β cavities)

Parameters	Low Beta	High Beta
β_{opt}	**0.07**	**0.11**
R/Q [Ω]	600	553
E_{peak}/E_{acc}	5.0	5.0
B_{peak}/E_{acc}	94	96
G	20	30.3
E_{acc}	6	6
U/E_{acc}^2	0.176	0.206

✓ RF design is ready

- Narrow gaps

→ Machining from a billet is not straight forward even if the beam-port cone is removed

- Very low β

→ Beam steering correction is even more critical

<u>Realistic proposal for mechanical design</u>

1. Move the weld from the highest B-field region
2. Optimize welding process for good thermal conductivity
3. Tolerance study is necessary

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Summary

- The newly developed seamless cavities constantly showed the best performance ever in the production phase
  - One of them was installed in CM4 to be operated from 2018
- The different behavior than original cavities were found
  - Less sensitive to the thermal gradient during cooling down
  - More sensitive to the trapped flux
  - Scientific studies are on going
- The present seamless cavities cannot be installed in CM1 and CM2 as a spare
  - The alternative design was studied and seems promising
- Application of the seamless cavity for phase 3 seems not straight forward
  - Changing the welding position was proposed

backup

Correction of the beam steering effect

The beam is kicked down mainly by the RF magnetic field of QWR

→ A **racetrack-shape beam port** in welded cavity