Nb sputtered Quarter Wave Resonators for HIE ISOLDE

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- HIE ISOLDE project
- Cavity design and technical choices
- Nb/Cu QWR for HIE ISOLDE
- New developments at LNL-INFN
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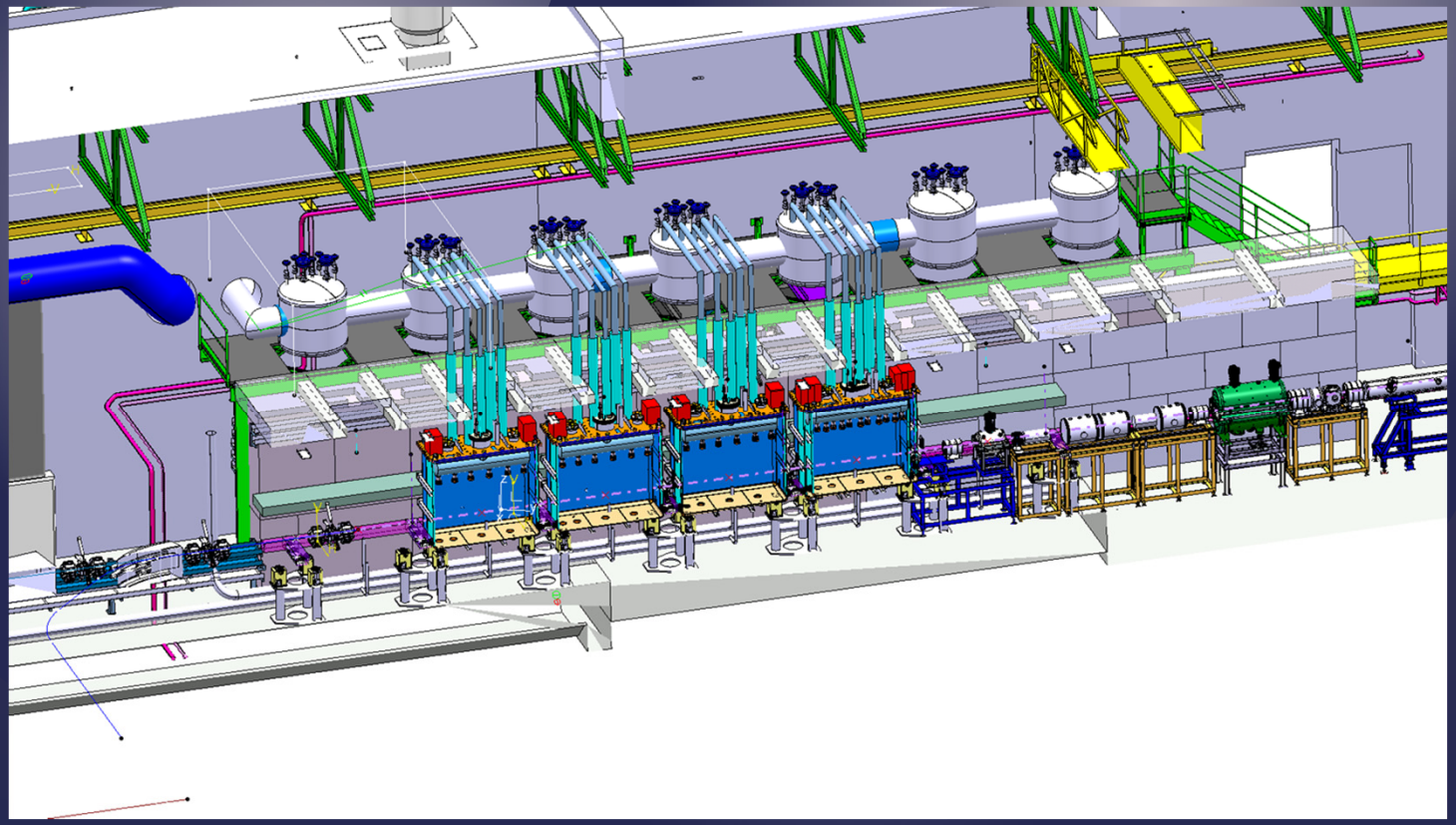
The HIE ISOLDE project at CERN

HIE-ISOLDE aims at boosting the energy of the Radioactive Ion Beams of REX-ISOLDE from 3 MeV/u up to 10 MeV/u (A/q < 4.5) by means of a SC linac



The HIE ISOLDE project at CERN

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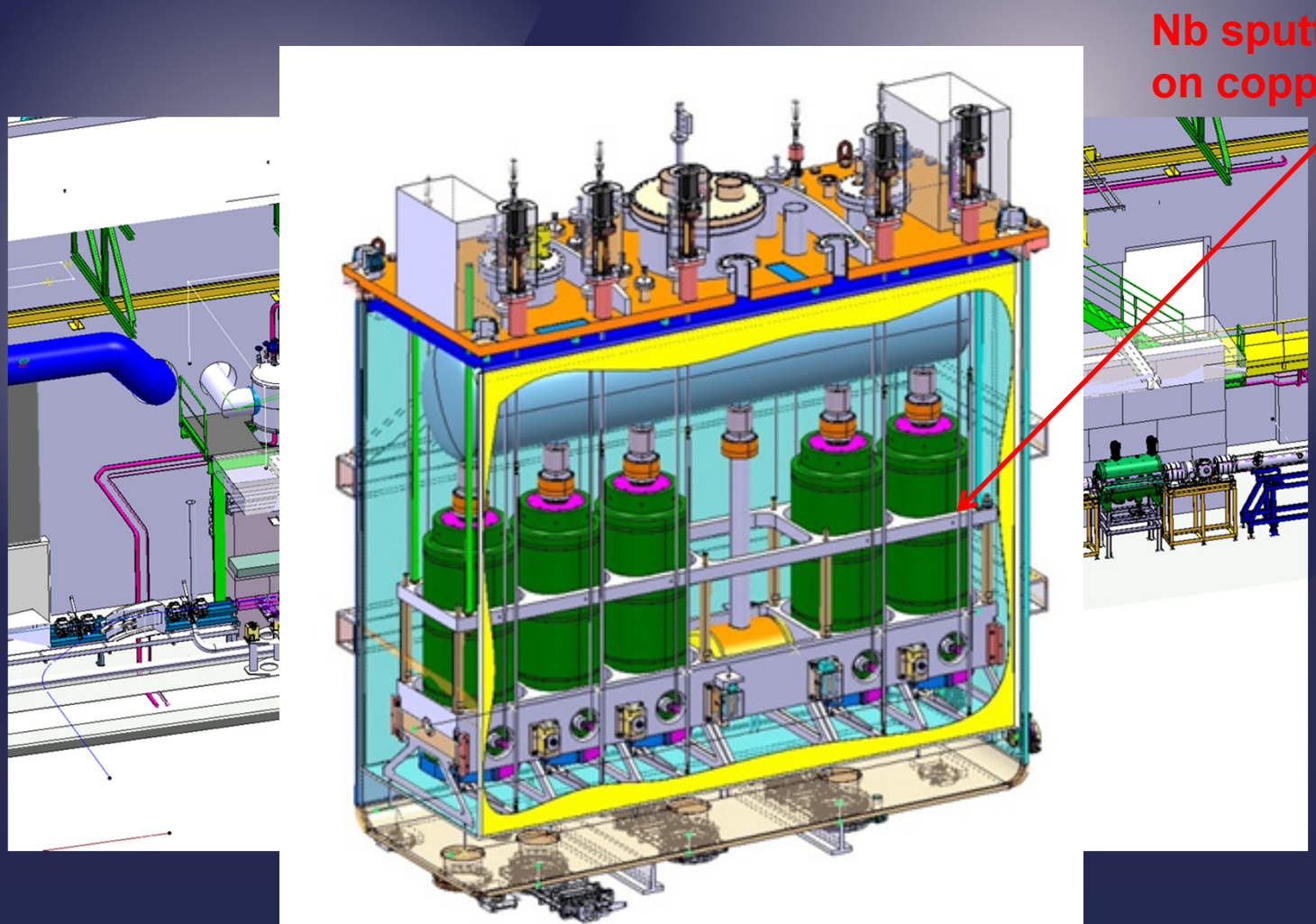
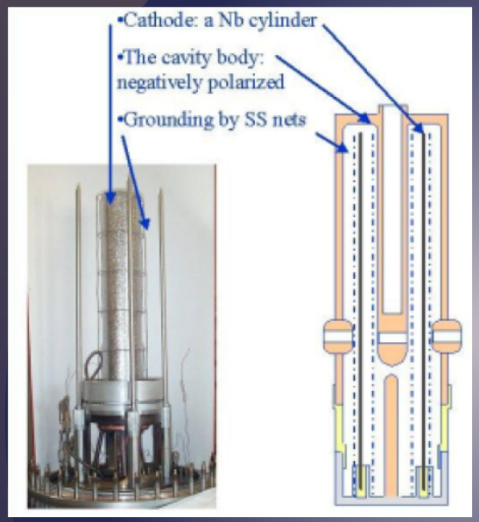
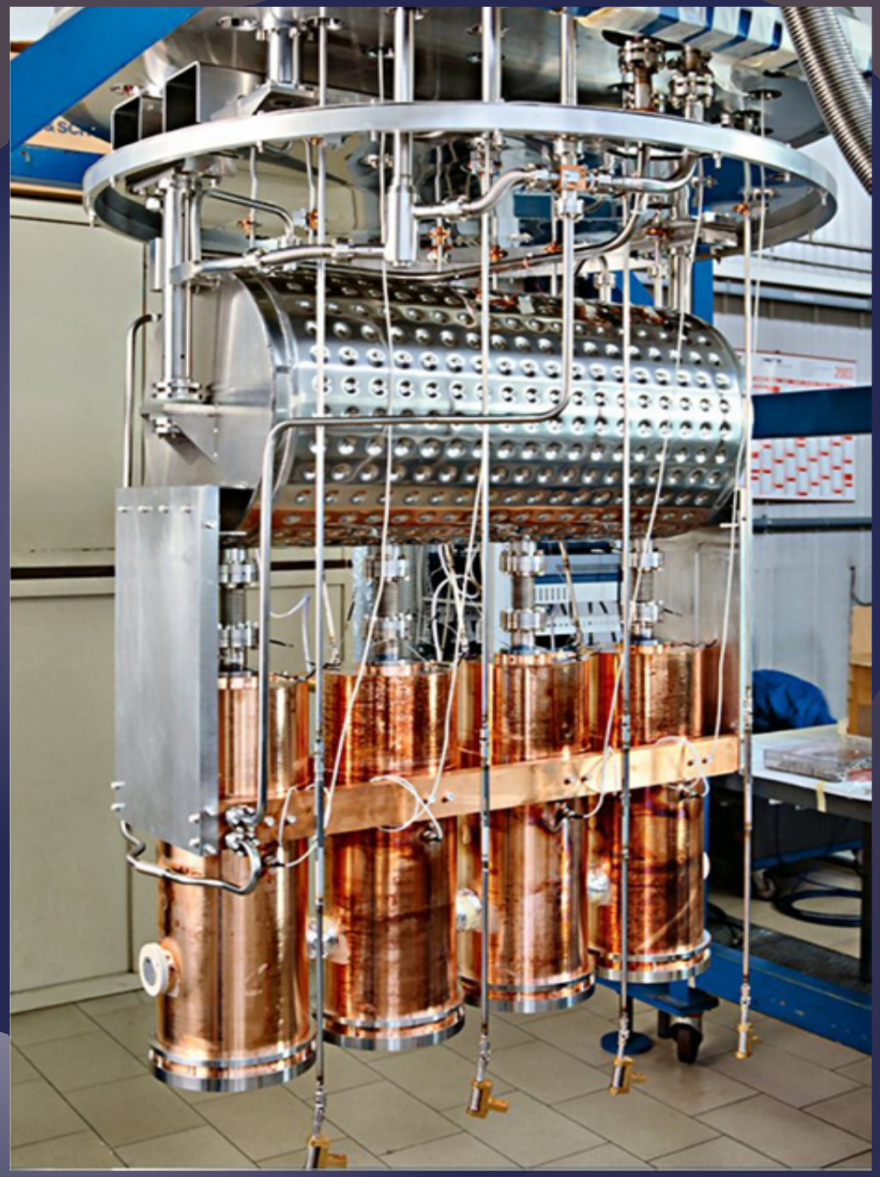


The ALPI experience: over 50 Nb/Cu QWR made at LNL and installed between 1999 and 2003





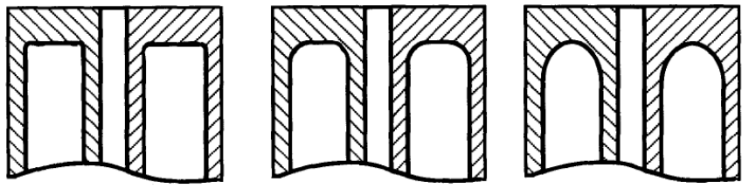
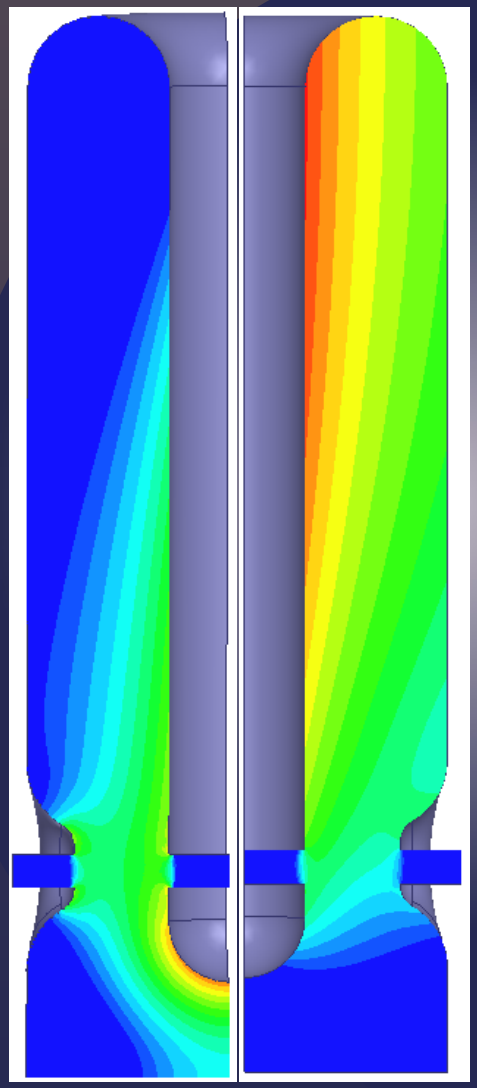


Fig. 6. Detail of resonator geometry: a) old model with curvature radius of 10 mm; b) modifyed model with curvature radius of 20 mm; c) definitive model with curvature radius of 30 mm.

Evolution of resonator geometry
(from *V. Palmieri, V. L. Ruzinov, S. Stark, et al; Proceedings of the 6th Workshop on RF superconductivity, 1993)*

High beta QWR design (electromagnetic)



HIE ISOLDE	Baseline†	New*
f_0 at 4.5K [MHz]	101.28	101.28
β_{opt} [%]	10.86	10.88
TTF at β_{opt}	0.9	0.9
R/Q [Ω] (incl. TTF)	554	556
E_p/E_{acc}	**5.5**	**5.0**
H_p/E_{acc} [G/(MV/m)]	95.4	95.3
U/E^2_{acc} [mJ/(MV/m)^2]	208	207
$G=R_sQ$ [Ω]	30.7	30.8
P_{diss} @ 6 MV/m [W]	**10**	**10**
P_{diss} on bottom plate [W]	**0.0035**	**0.0018**

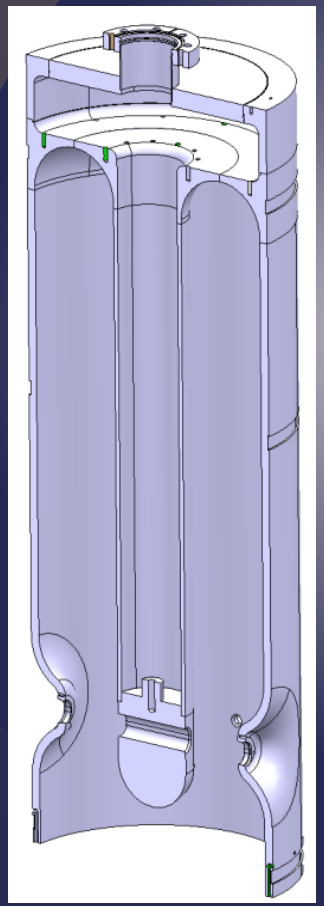
†Original tuning plate *Simplified tuning plate

Ref. Proceedings of SRF2009, p. 609

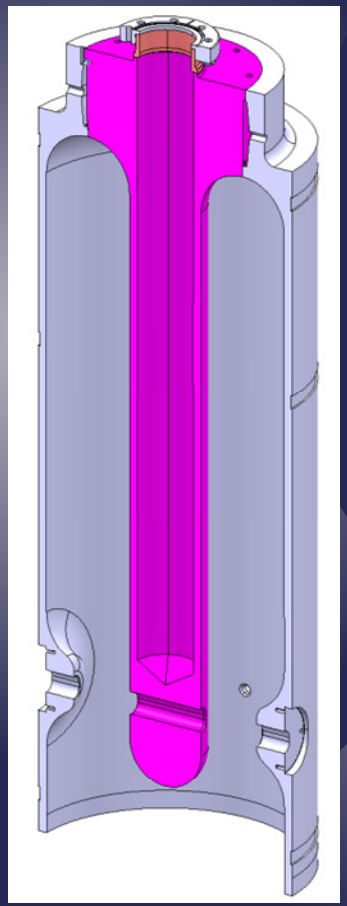
Visit the POSTER (THPO84) on the tuning system!

High beta QWR design (mechanical)

Version 1



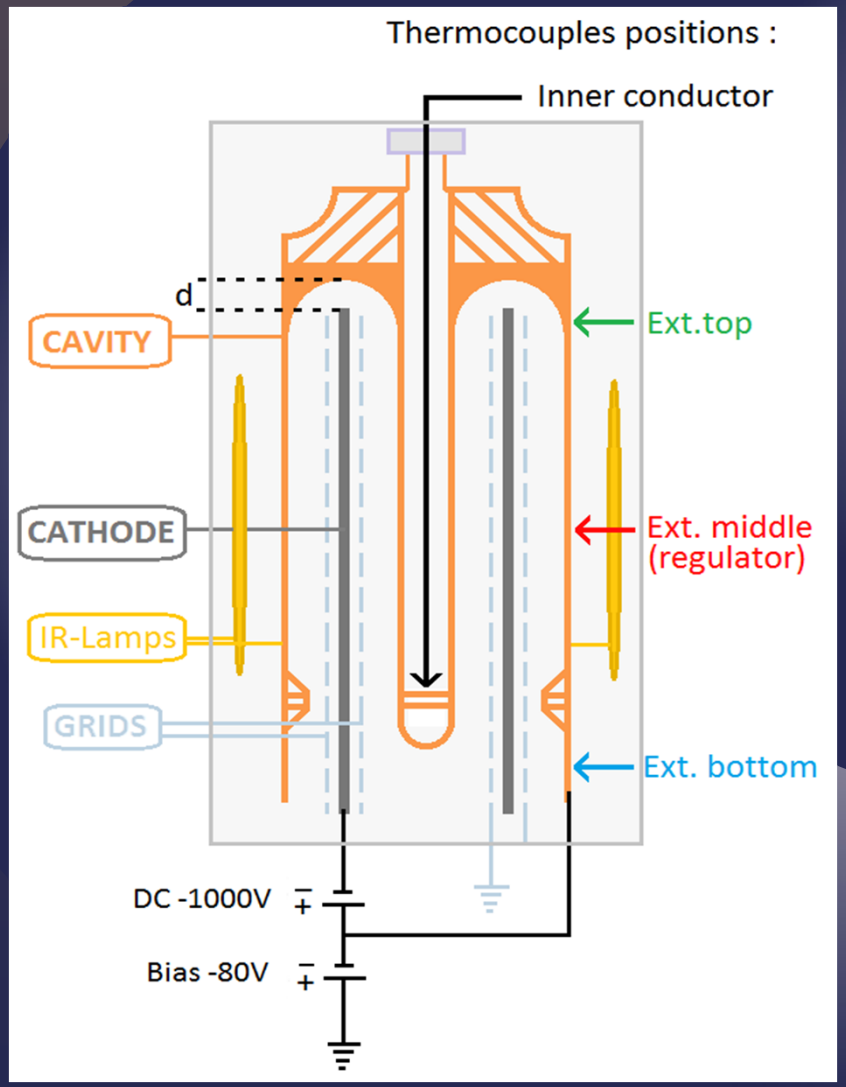
Version 2

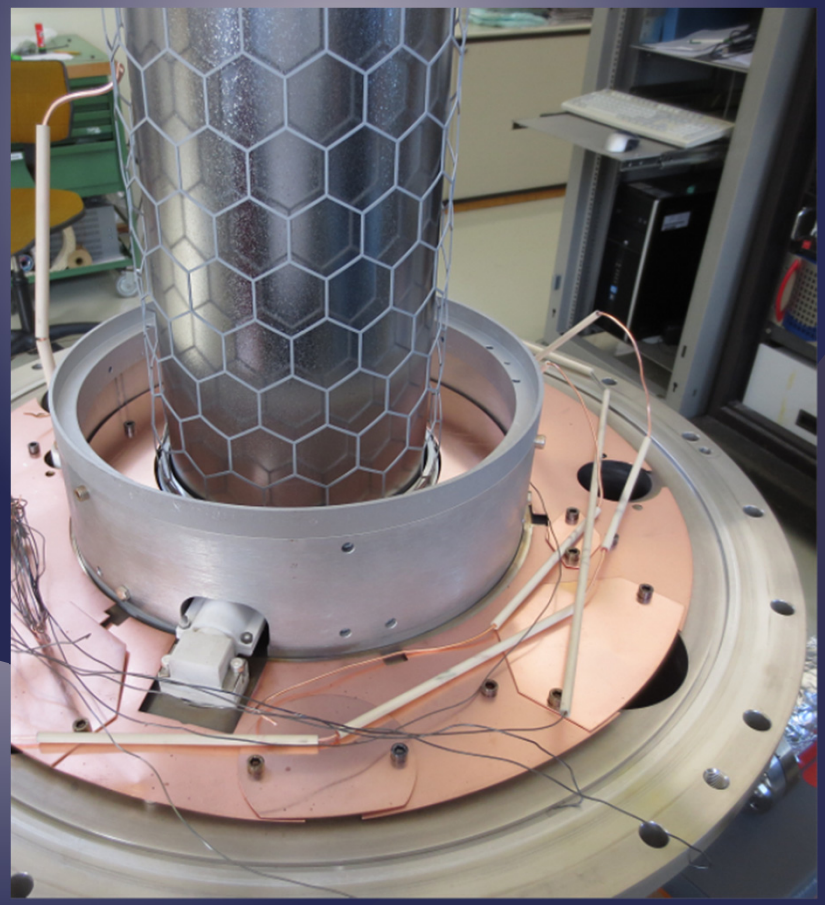


POSTER (TUPO69)

Bias diode sputtering system at CERN

Schematics





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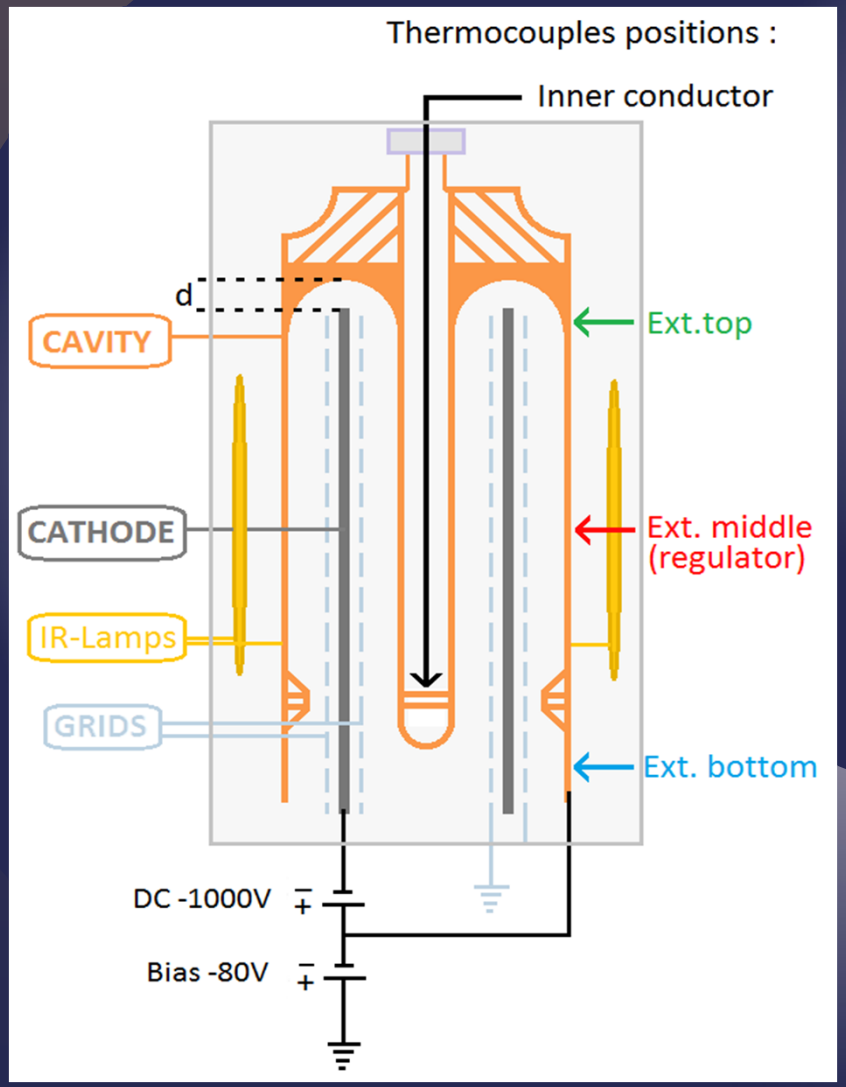
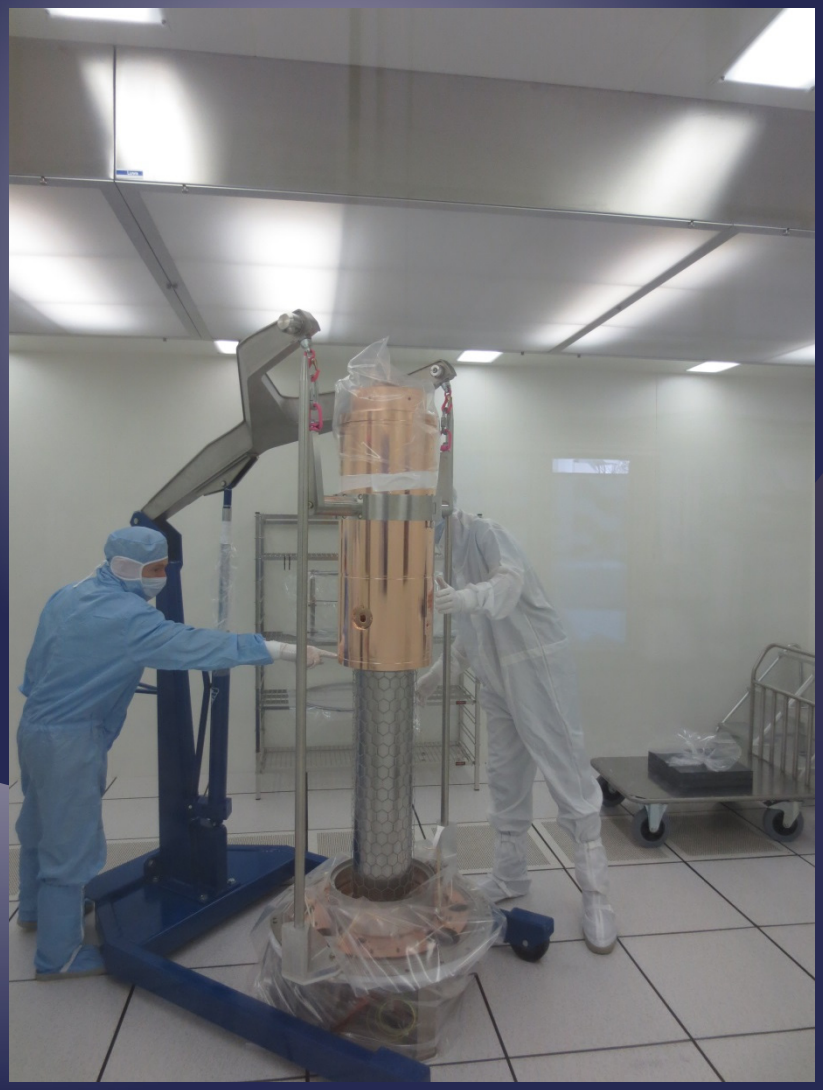


System assembly in clean room



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Roadmap of developments (2011-2013)

Strong development program focused on bias diode sputtering method. Main steps:

- Increasing baking and coating temperatures
- Increasing sputtering power (global deposition rate)
- Layered coatings
- Sputtering gas, venting gas
- Global film thickness
- Local film thickness

RF tests in vertical cryostats

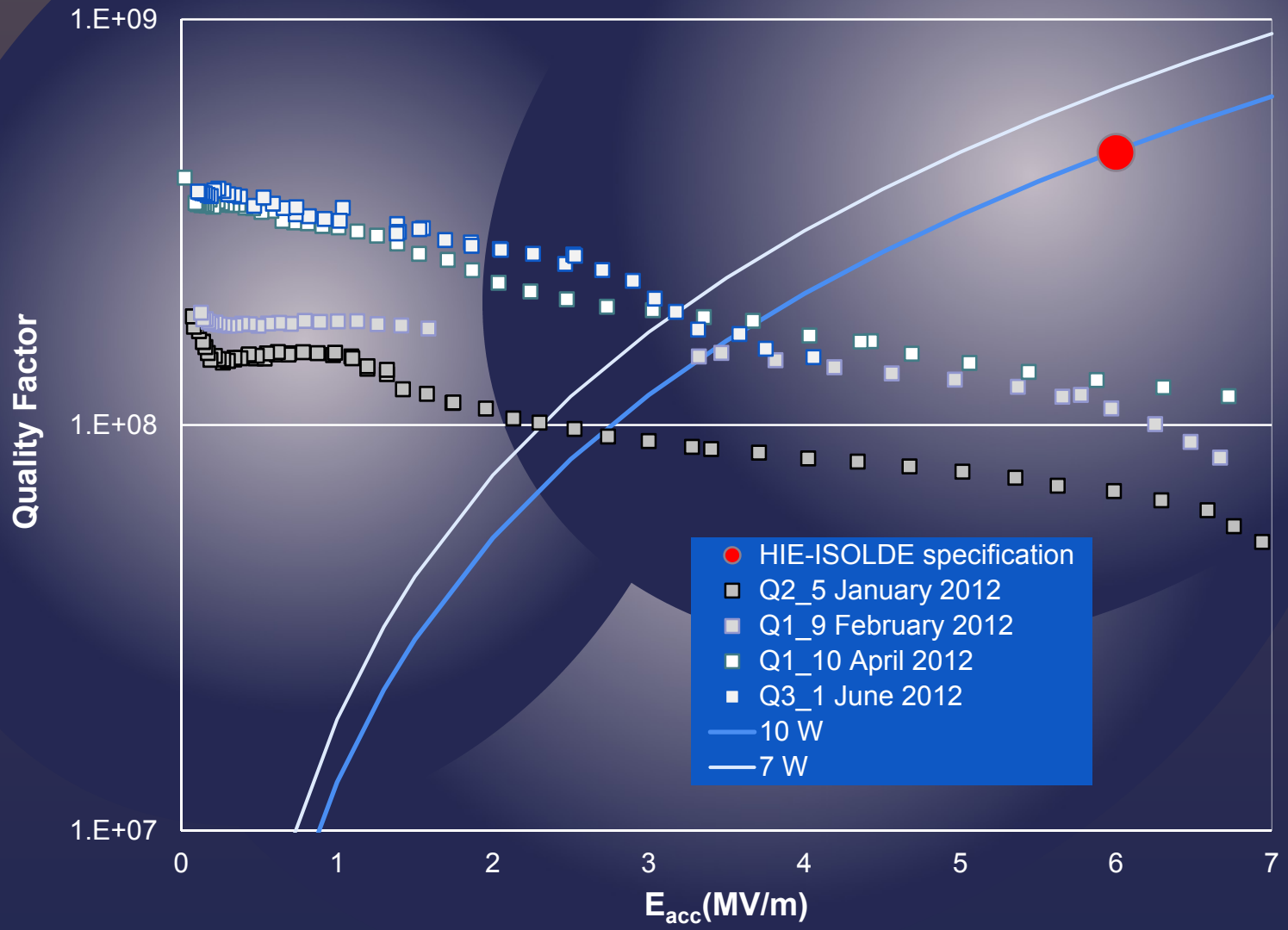
Quick turnaround (2 weeks) essential to feedback on coating

Two cryogenics inserts

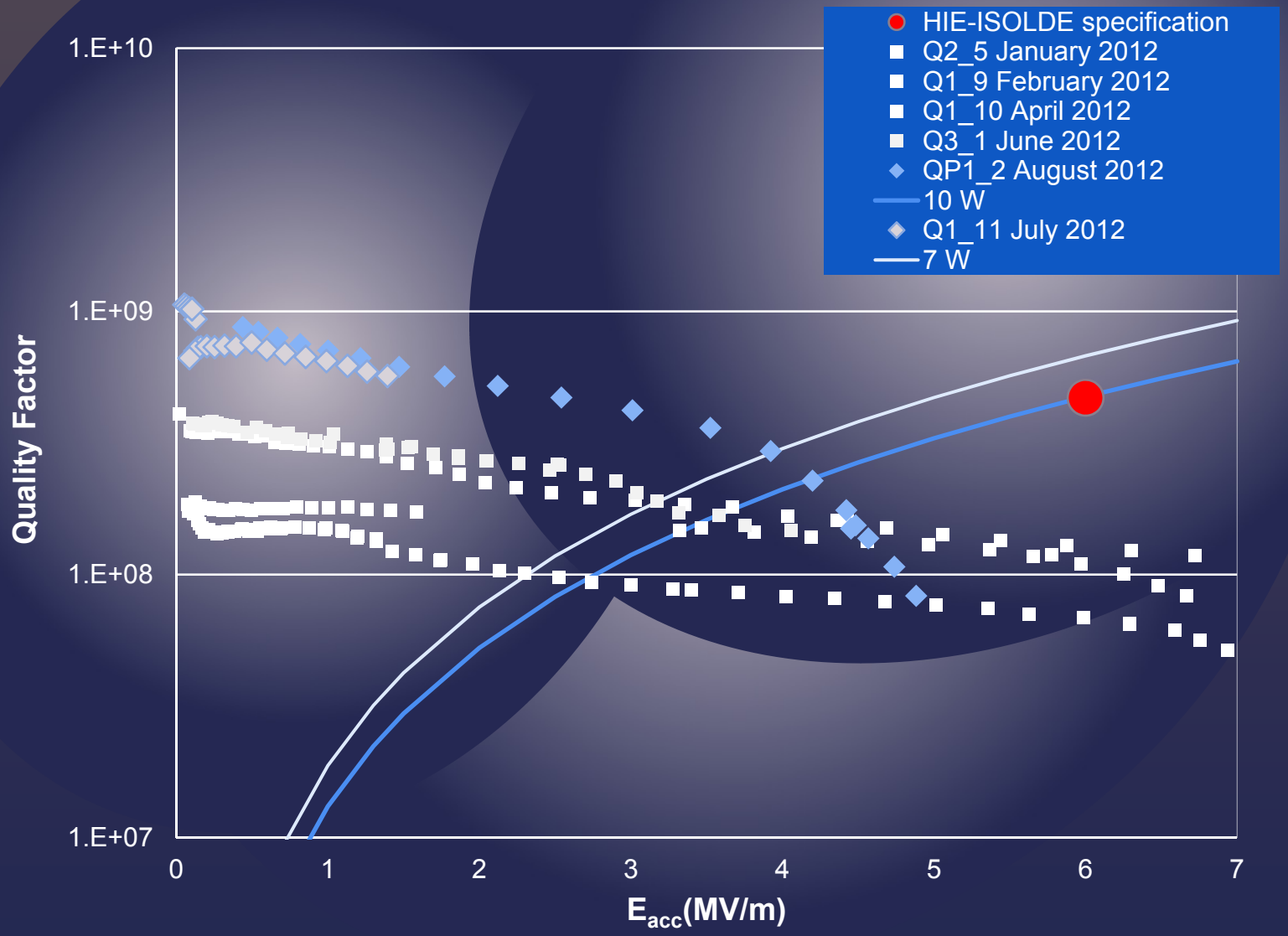
Thermal shield (50 K) and cavity circuit (4.5 K) cooled in parallel

Same cooling scheme as in the HIE-ISOLDE Linac

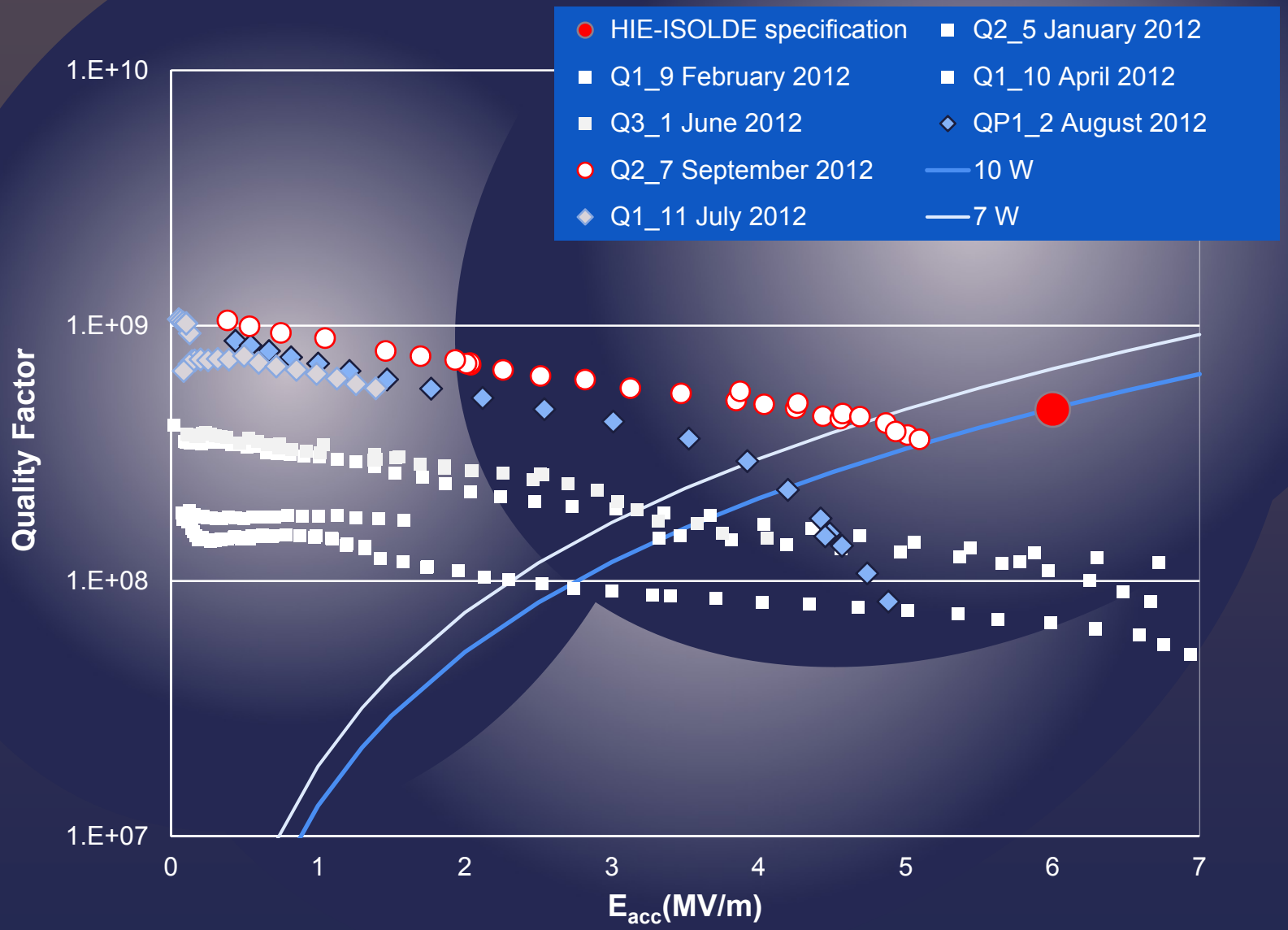
Increasing coating temperature, $T_{(bake\ out)} < T_{(coating)} \rightarrow 600\ °C$



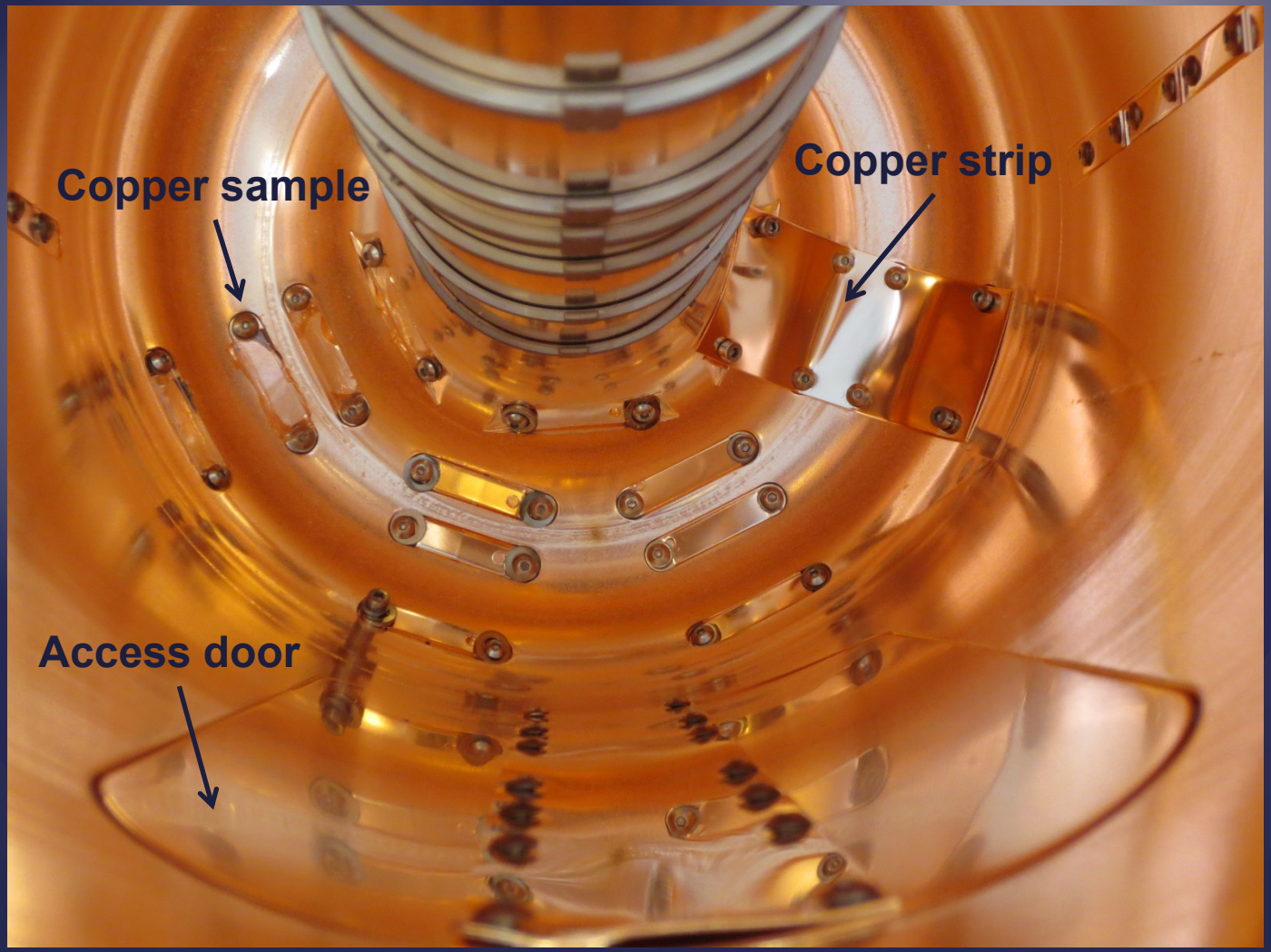
$T_{(bake\ out)} > T_{(coating)}$, higher sputtering power (layers), change of gases: Kr, dry air → Ar, N_2



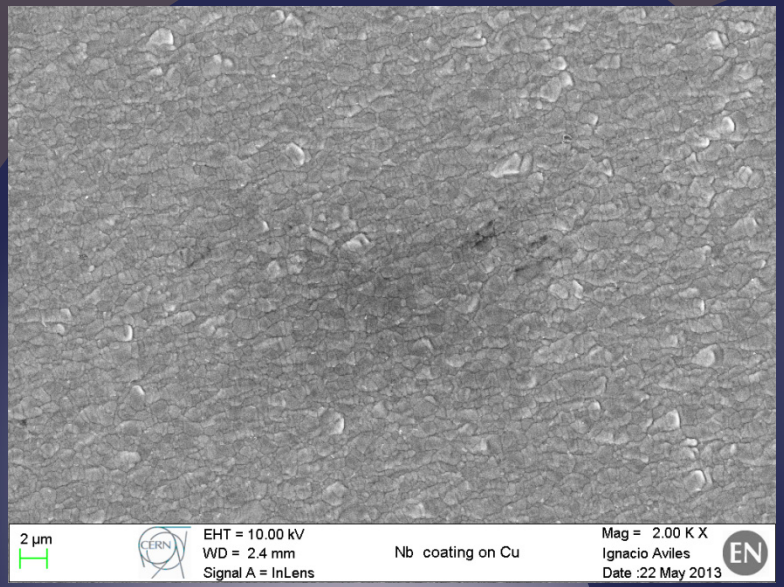
Increasing global Nb thickness by 25%

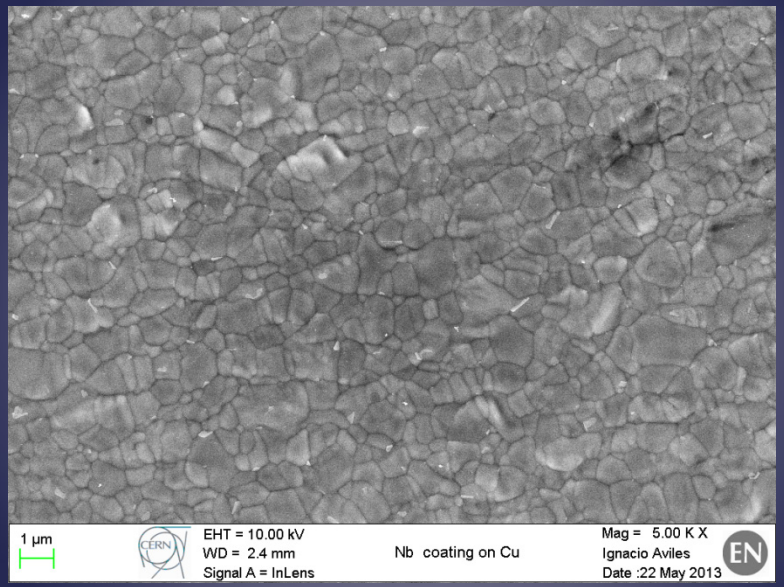


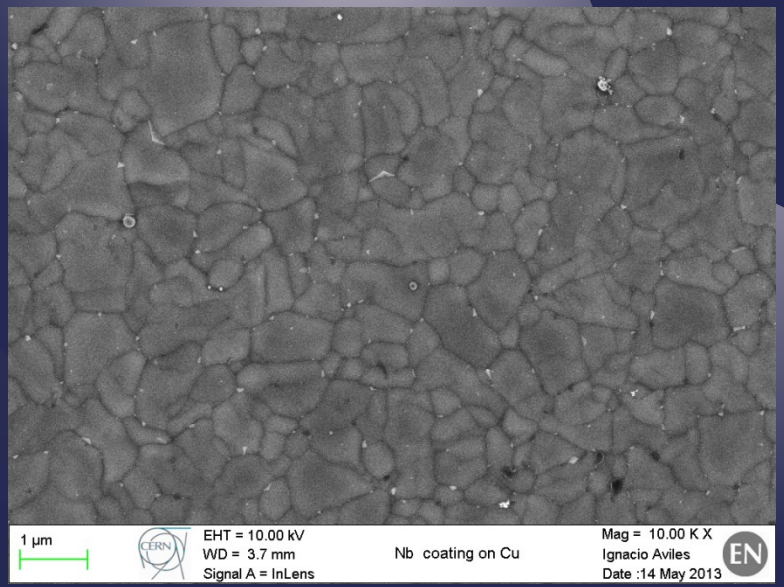
Full scale copper cavity used for sample studies

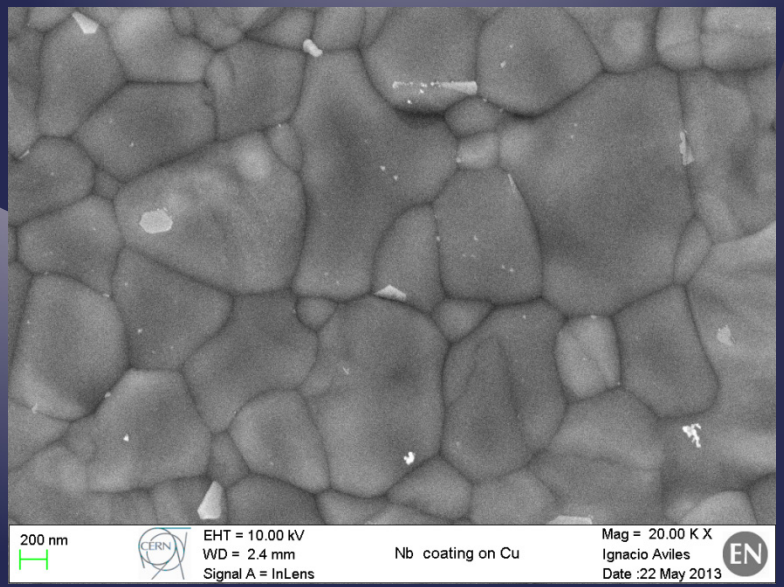


SEM images at inner conductor tip

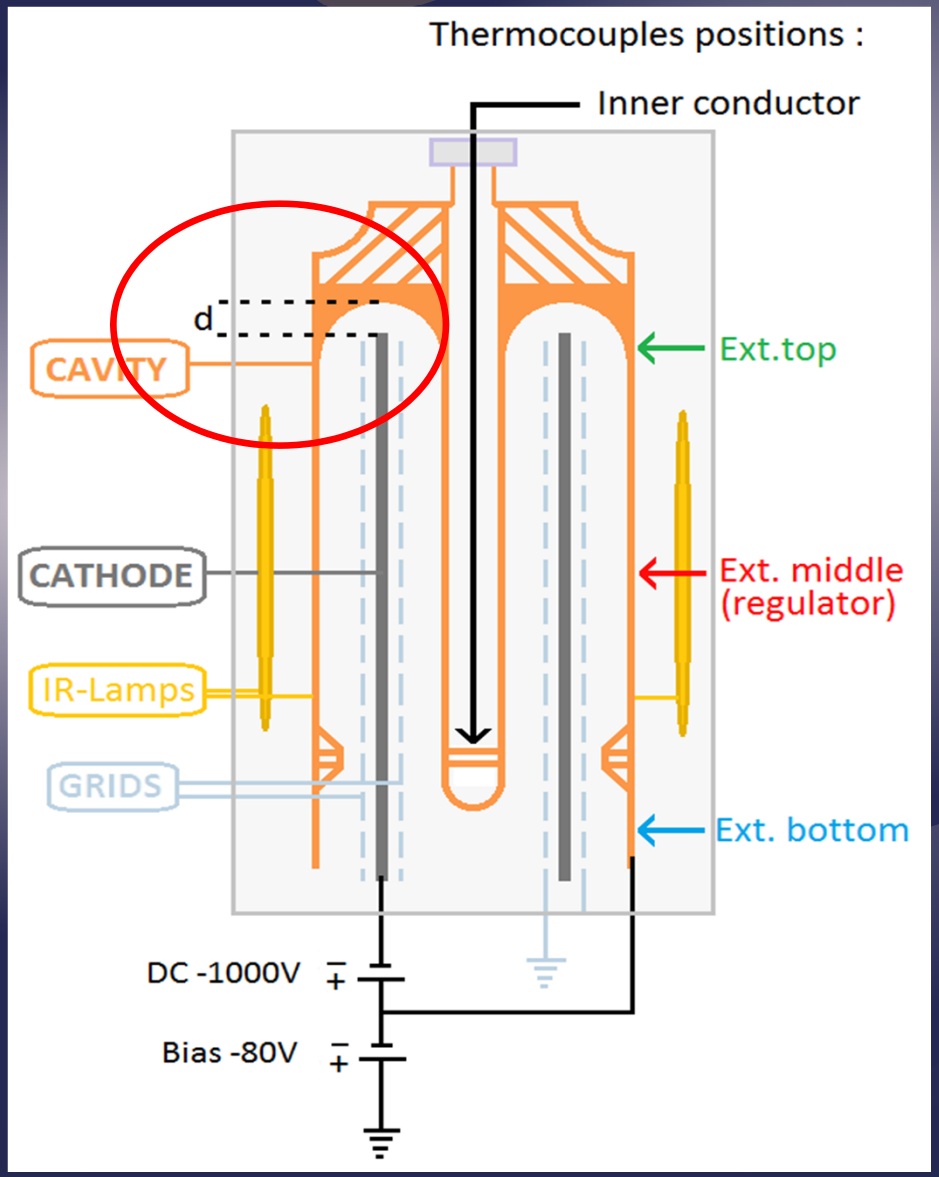




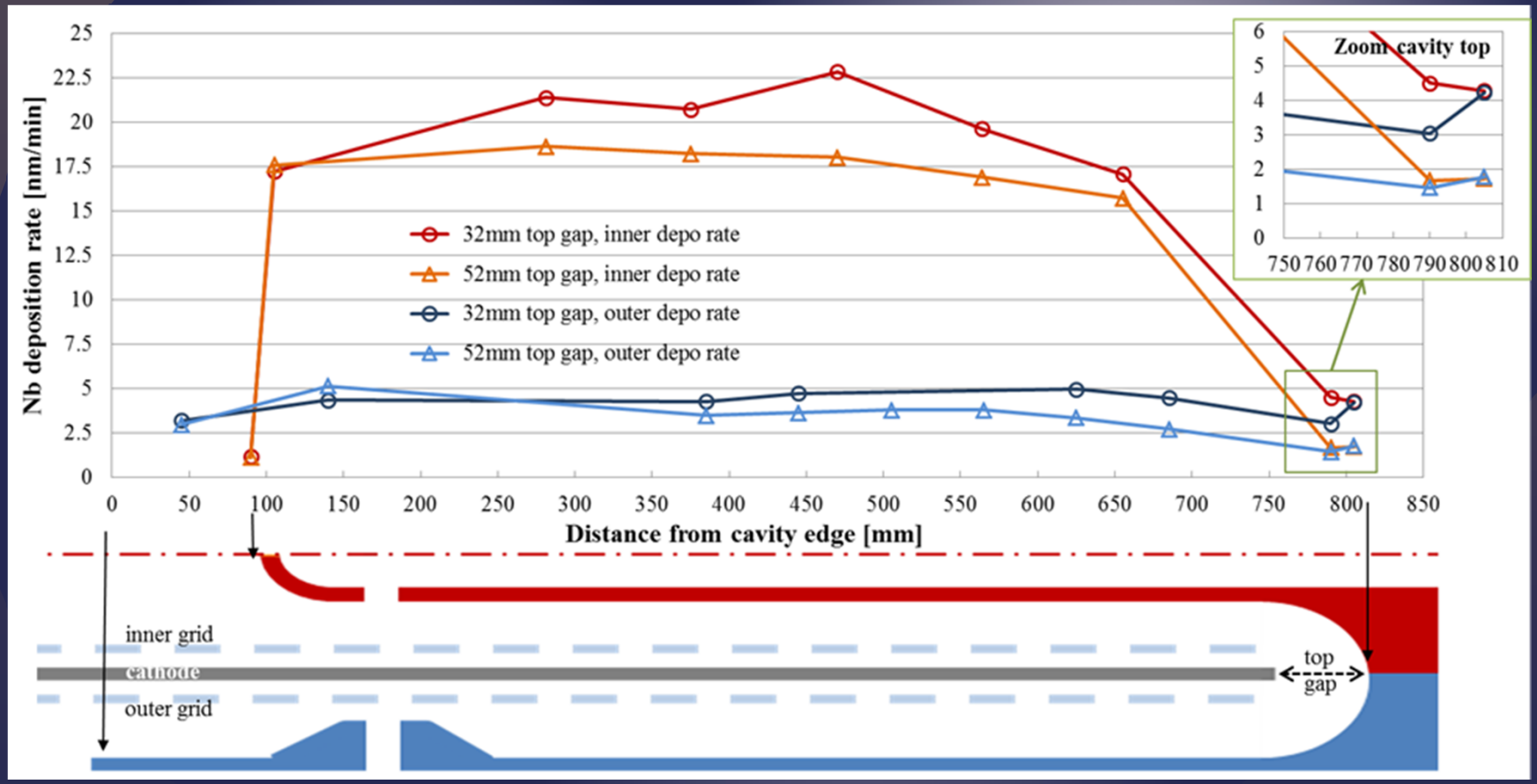




Scaling the “top-gap” length



Thickness profile study on samples: effect of reducing the top gap distance



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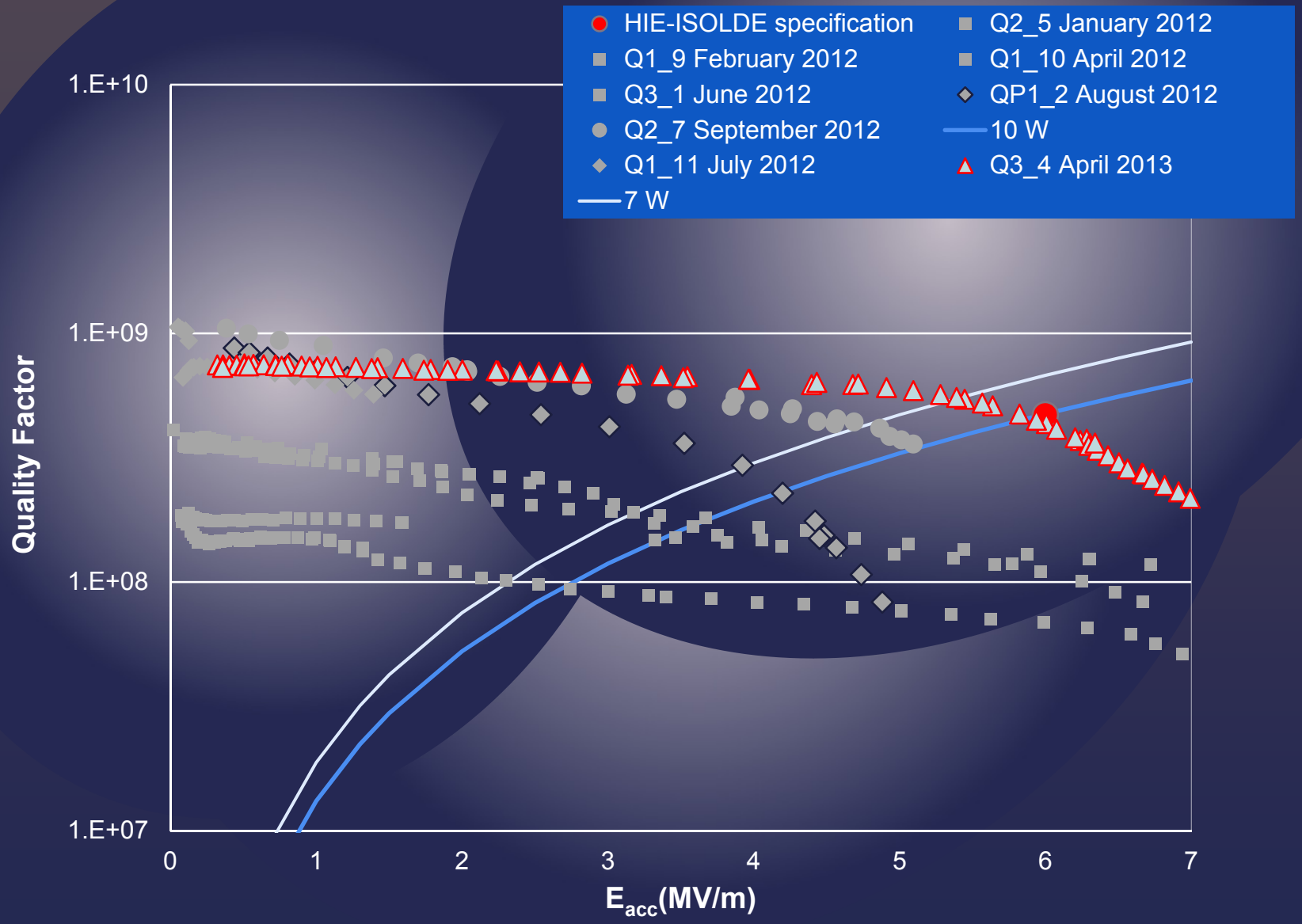
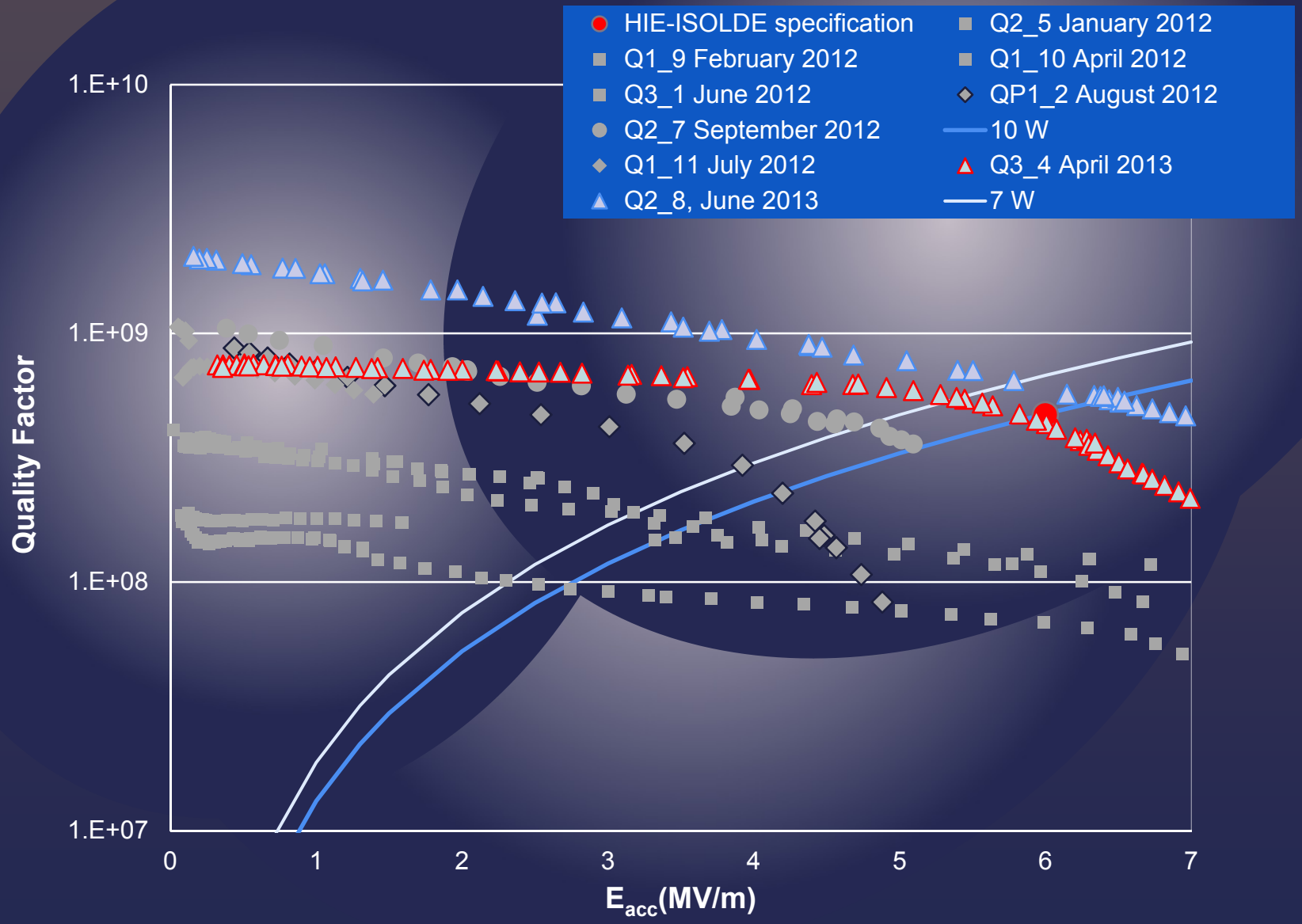
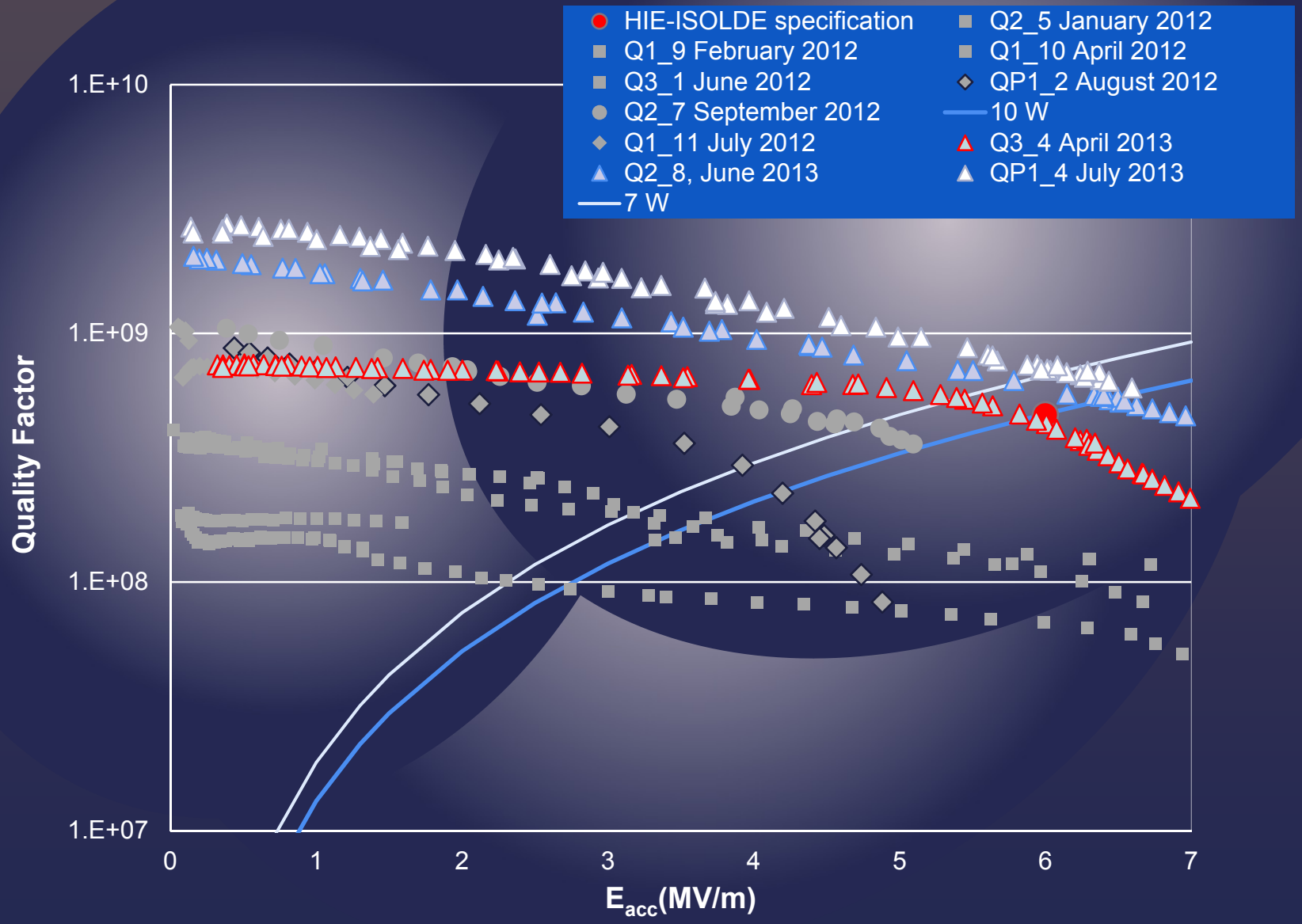
Reduced “top gap” length from 52 mm down to 32 mm



Try again on a 20 mm shorter substrate

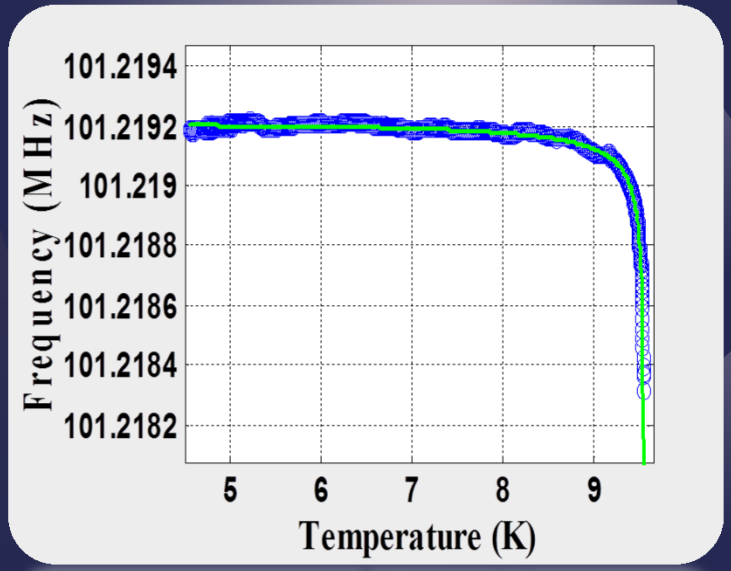


Top gap distance reduced to 22 mm



Average RRR extracted from $f_{res}(T)$ measurements

lambda0 =51±3 nm
Tc=9.55817±4e-5 K
Freq=101219201±3.5 Hz
mfp =64±14 nm
pho = (0.6±0.1) μΩ*cm
RRR =26±5.5



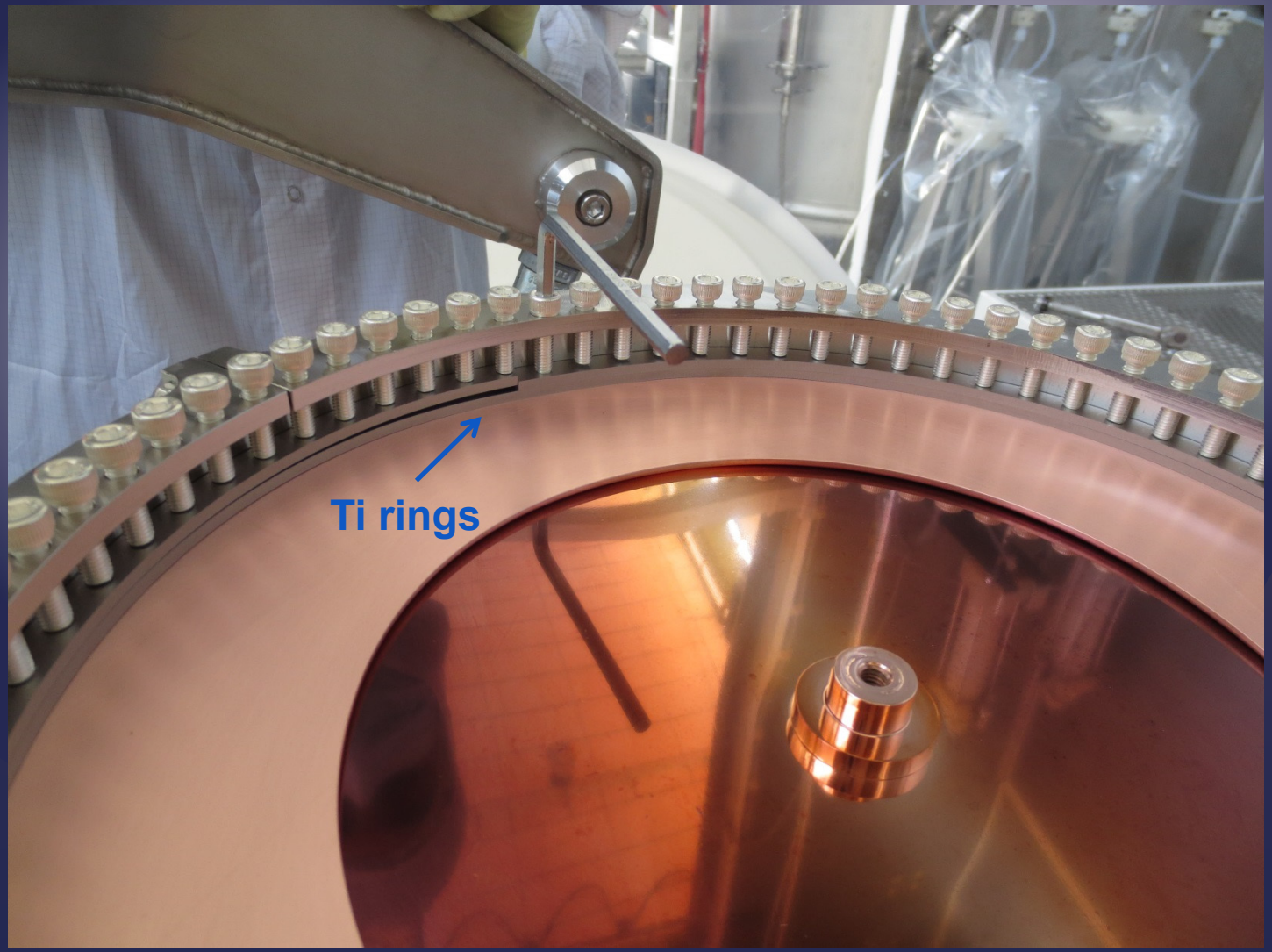
Coating test	λ_0 (nm)	RRR
Q2_3 April 2011	188	1.9
Q1_5 June 2011	83	6.8
Q1_10 Feb. 2012	62.3	13.5
Q2_8 April 2013	50.7	26.4
Q3_4 March 2013	45.7	41. 8

Surface quality of the inner conductor tip → source of field emission

Central electrode: 20 mm diameter, at earth potential

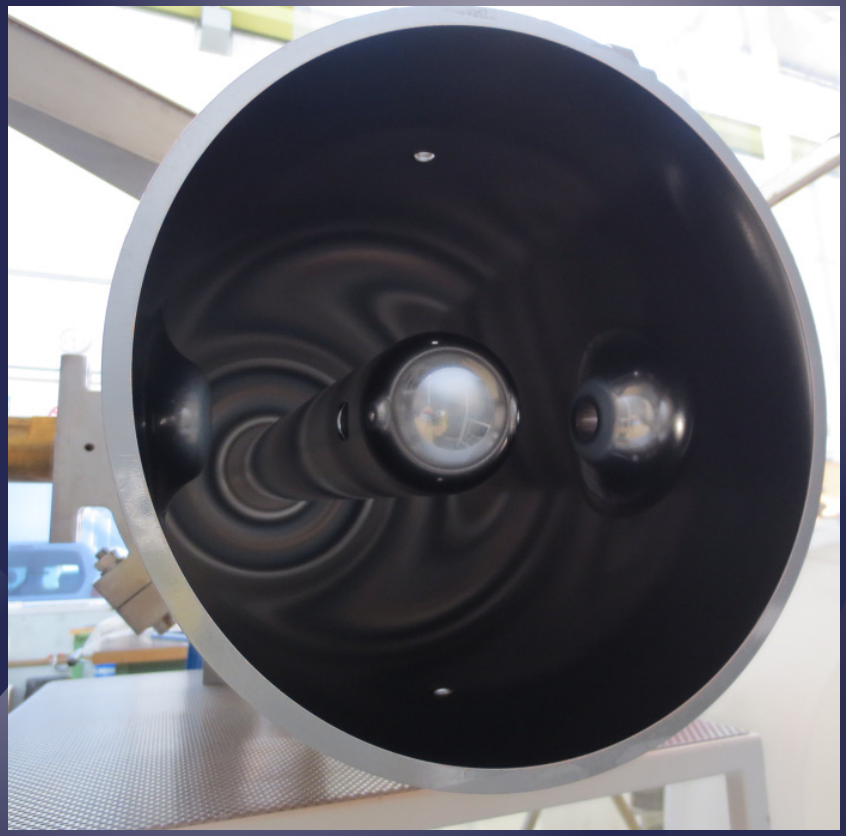
No counter electrode

Tuning plate is fixed with 72 M6 screws closed at 5 Nm and acting on Ti rings



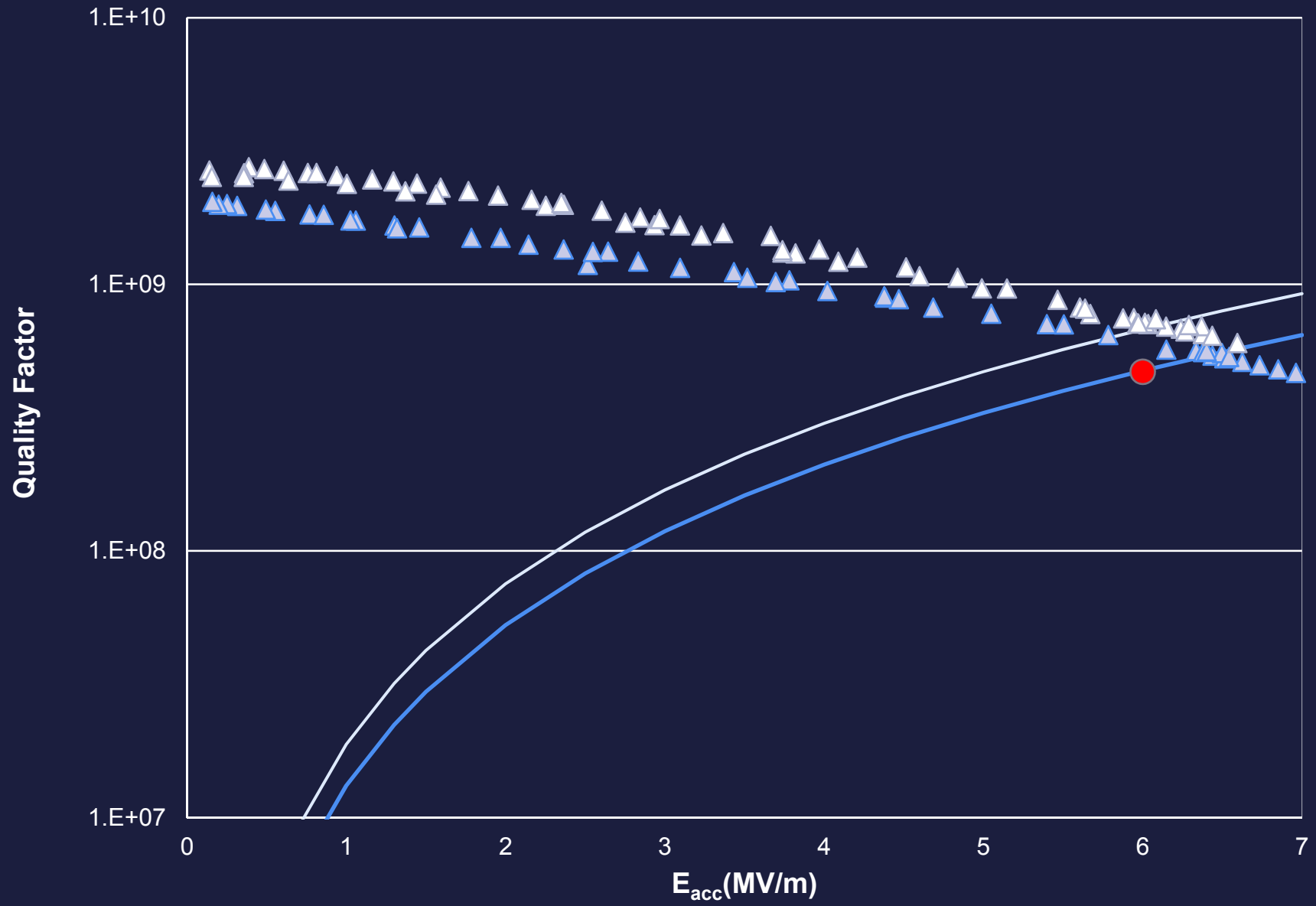
Adhesion on the lower edge (RF contact) was improved using a longer cathode

with 840 mm cathode



length increased to 870 mm

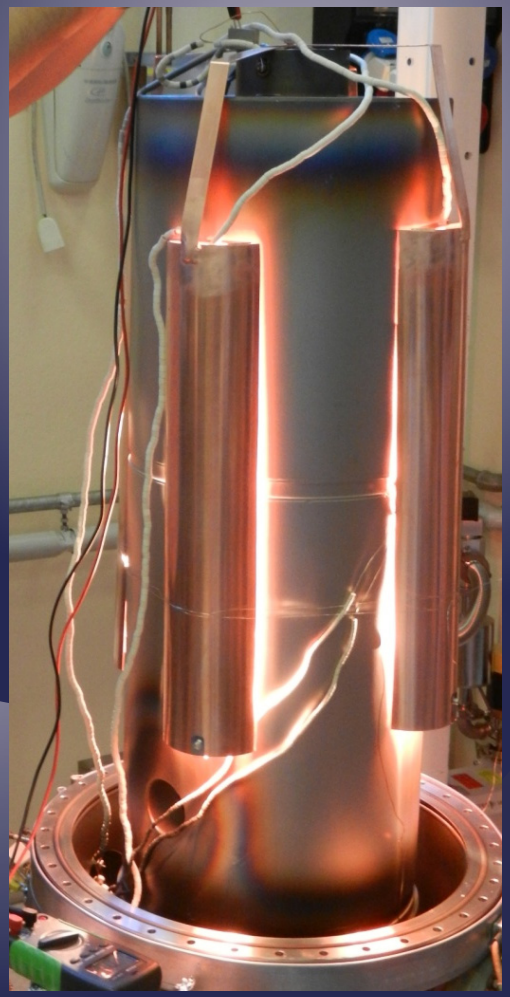
Ready for production…



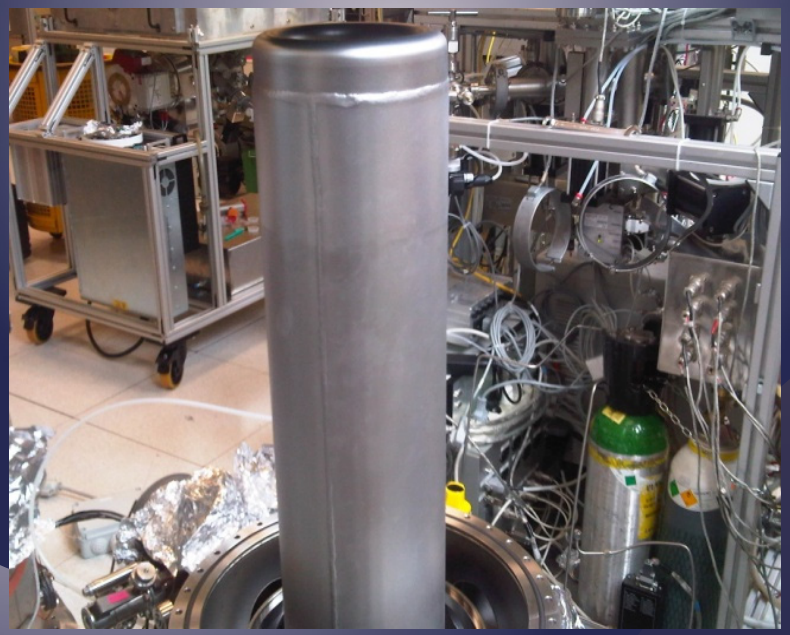
Yes…

But not abandoning R&D

System for magnetron sputtering HIE-ISOLDE cavities at INFN-LNL



Double diameter Nb cathode

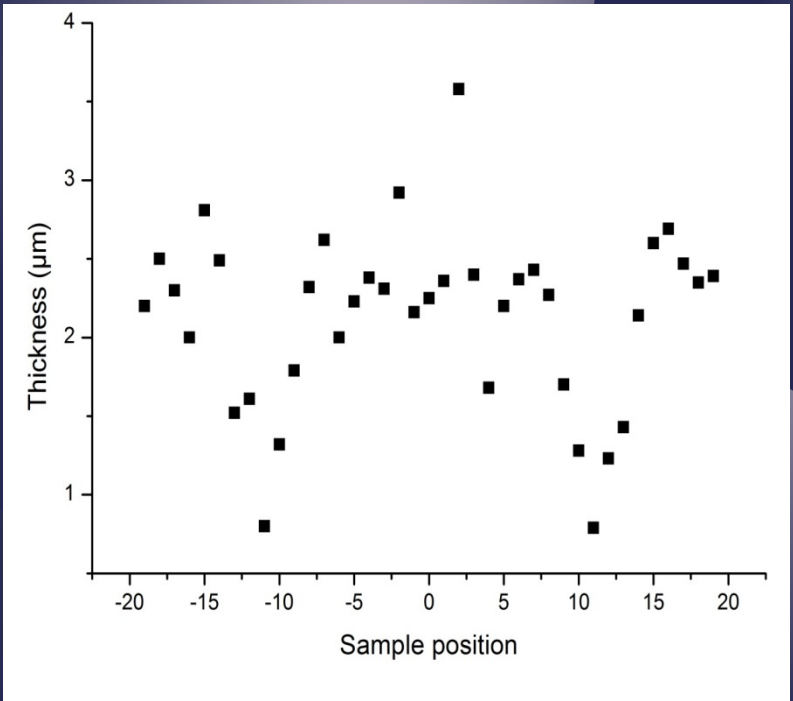


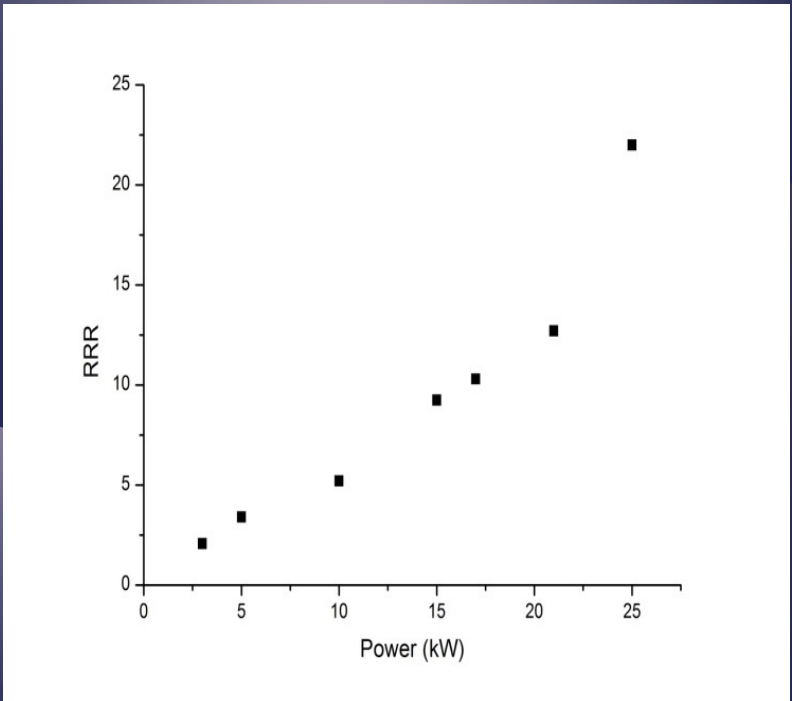
Results of sample study INFN-LNL

Deposition rates > 10 Å/s

Thickness homogeneity: 2±1μm thanks to double diameter cathode

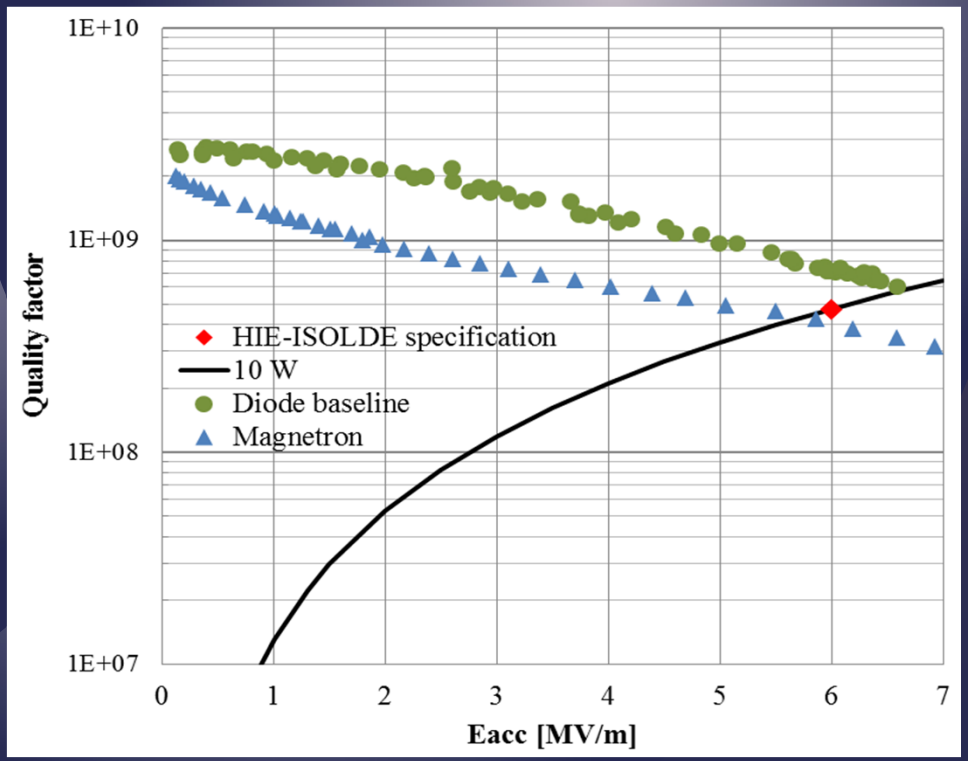
RRR vs. sputtering power





R&D on magnetron sputtering at CERN

- Coating time can be reduced from 4 days to 1 day
- Thickness profile matching the RF current distribution



POSTER (TUPO76)

Conclusions

HIE-ISOLDE needs 39.6 MV from 32 independently phased QWR, project schedules are always tight and physicists are waiting for the beam

Project oriented R&D, several parameters changed at a time

HIE ISOLDE specifications recently met, (with 30% margin in power)

We are on track to start series production for the first phase up to 5 MeV/u

R&D at INFN-LNL and at CERN continues with encouraging results, which could benefit phase II and phase III (low beta), and future machines

Acknowledgments

All the HIE ISOLDE Accelerating Structures Working Group at CERN, in particular

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E. Siesling

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G. Bisoffi, A. M. Porcellato, R. Laxdal

S. Bousson and the IPN Orsay team

The HIE ISOLDE International Advisory Panel

The CERN management

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