
HOM feedthroughs (and more) at DESY

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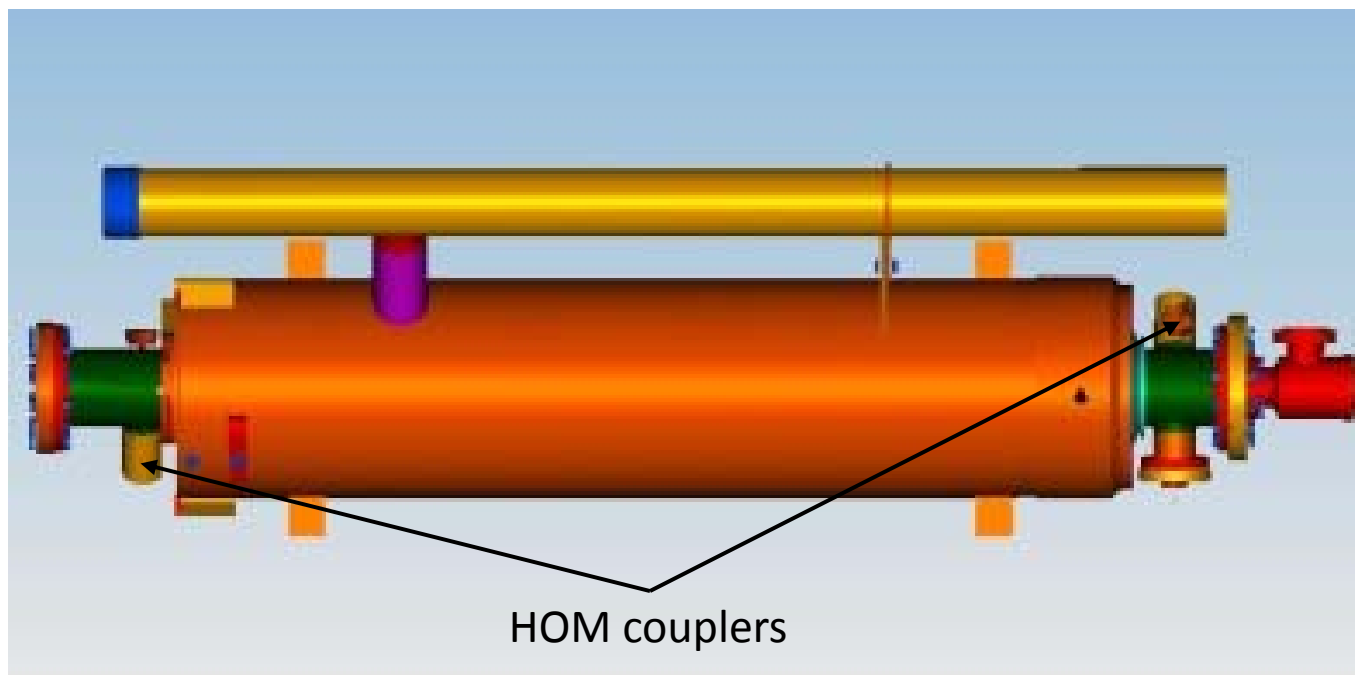
- Introduction and Motivation for Higher Heat-conduction Feedthroughs.
- Modeling
- New Feedthroughs
- Final Remarks

Introduction: History of the TESLA cavity design

TESLA cavity and its auxiliaries:

- LHe vessel
- HOM couplers
- FM coupler
-

were designed in **1992** for short pulse operation at 25 MV/m and **DF of ~1%**. Cost of the TESLA cavity was one of the criteria (22000 cavities for the collider), that is why HOM couplers have been located outside the LHe vessel (other than for HERA cavities)



Introduction: Motivation

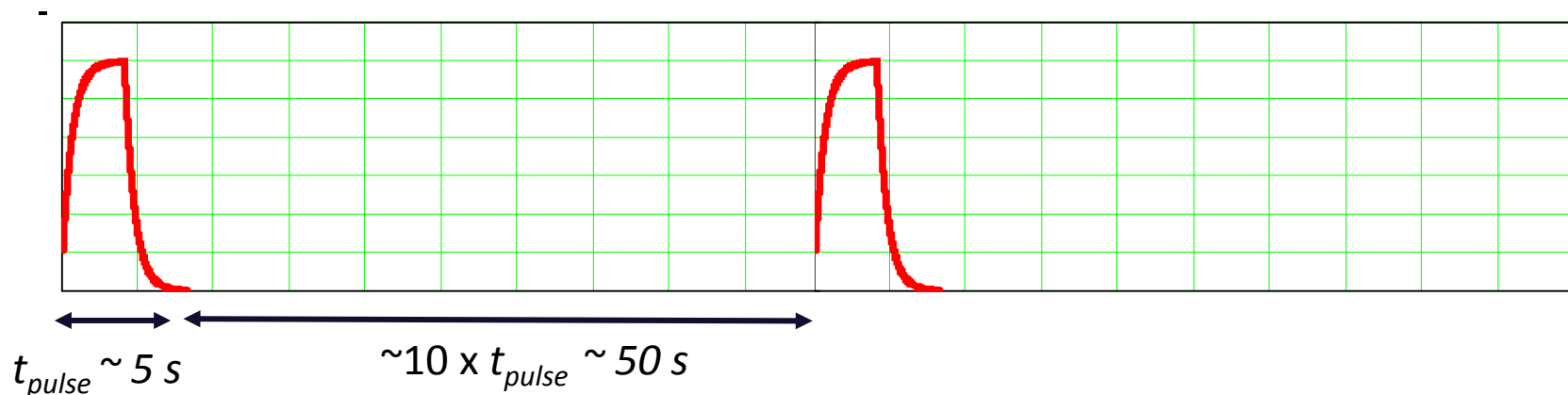
We want to equip all 808 XFEL TESLA cavities with the HOM feedthroughs having high heat conduction.

Because:

1. The acceptance “vertical” test of cavities will be performed for cavities equipped with the HOM feedthroughs (this lowers the production cost).
2. Future possible operations of XFEL are cw- and so called “long pulse” modes (e.g. ~ 100 ms pulses with 1 Hz repetition rate). The new operation modes will cause higher heating of HOM and FM couplers. What is the limit?

Ad 1.) Since March 2010, we test cavities in 10% DF mode, if they are equipped with HOM feedthroughs. In that test, the heat load is 10x bigger then heat load during the nominal operation (for cw-test it is 100x).

In the time from March 2010 till now, no cavity demonstrated HOM problem due to the feedthroughs.



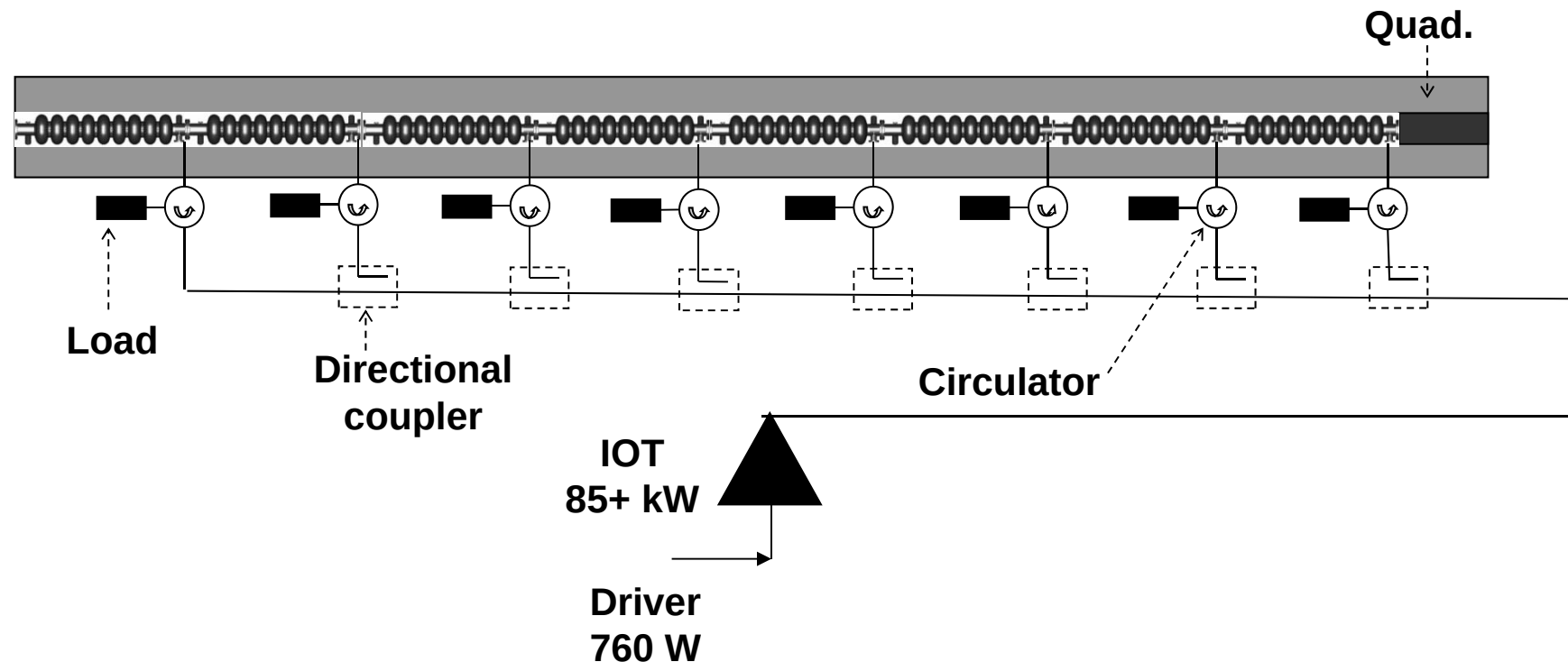
Introduction: Motivation

Ad 2.) We performed in June this year the first test of the cw and long pulse (lp) operation of the XFEL-like cryomodule with IOT amplifier.

In that test:

- 6 cavities had $Q=1.6E7$, one $0.8E7$ and one $0.4E7$
- achieved gradients: in cw up to $<5.5 \text{ MV/m}>$ in lp $\sim 11 \text{ MV/m}$ ($t_p = 300 \text{ ms}$)
- vector sum stabilization: rms $1E-3$ with no “dedicated” LLRF system.

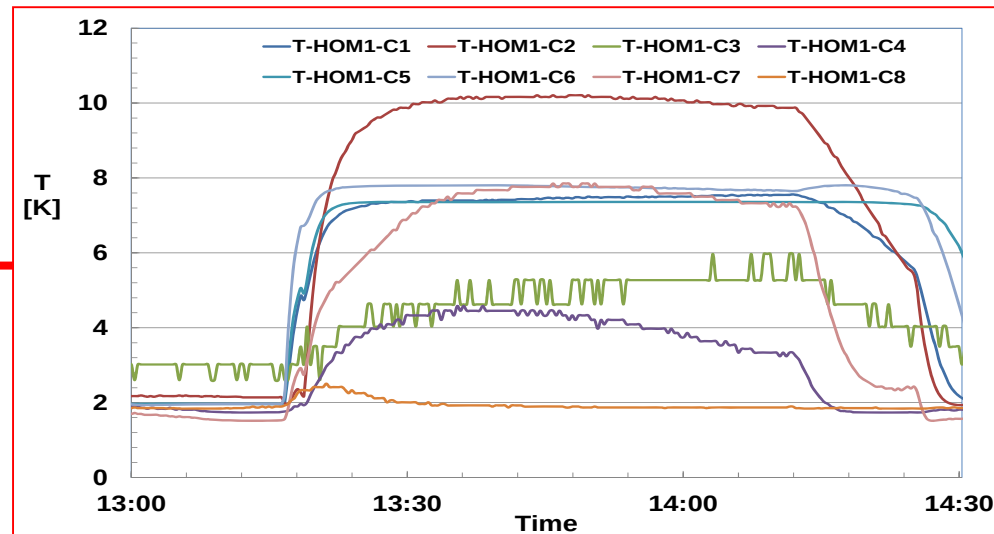
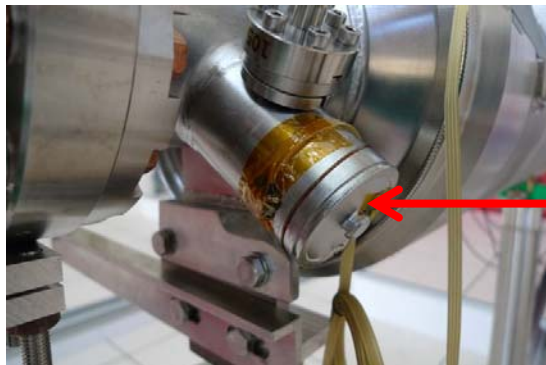
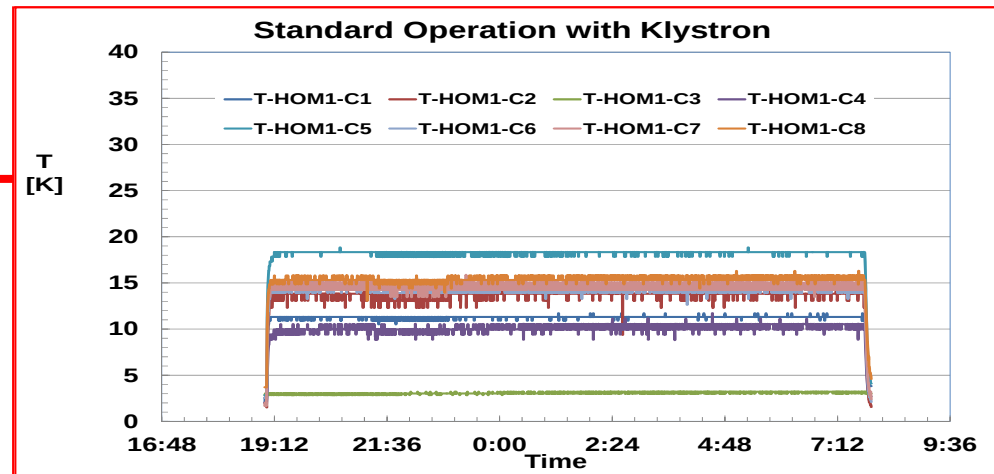
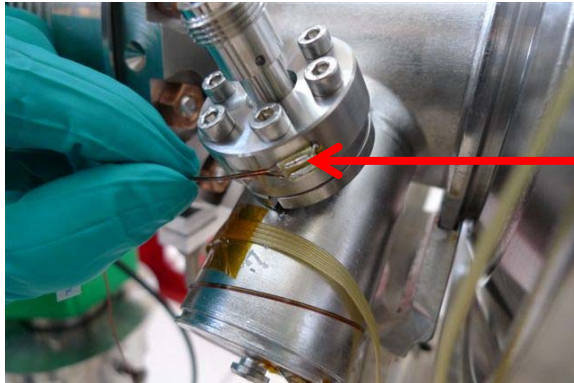
The result was encouraging and will perform second test in January 2012 with new LLRF, dedicated to cw/lp mode.



Introduction: Motivation

Ad 2.) cont.

During the test we observed temperature increase of HOM couplers for all three operation modes: short pulses (nominal) I_p and cw.



Introduction: Motivation

Ad 2.) cont.

- No observable T change of LHe bath (vessels) for all 8 cavities, **no quench**..
- 18% (5/27) of the total heat was very probably resulting from the heating of HOM antennae ($\sim 0.3\text{W}/\text{antenna}$):

<Gradient>	Total Heat at 2K	Dynamic Heat at 2K	Estimated ($Q_0=1.5\text{E}10$) Dynamic Heat at 2K	ΔDH
[MV/m]	[W]	[W]	[W]	[W]
5.5	27	20.8	16.0	~ 5

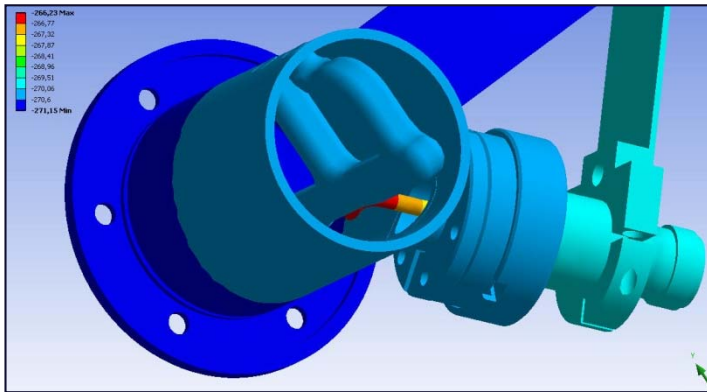
That was due to the bad thermal conditions in the tested cryomodule:

- low conductivity old feedthroughs (no-brazed antennae, alumina window..)
- big diameter antennae ($\varnothing$ 11 mm)
- no- thermal connection of feedthroughs to 2K tube.

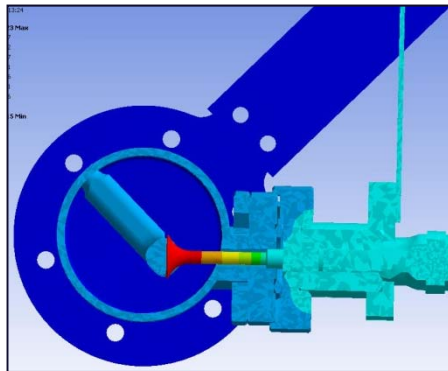
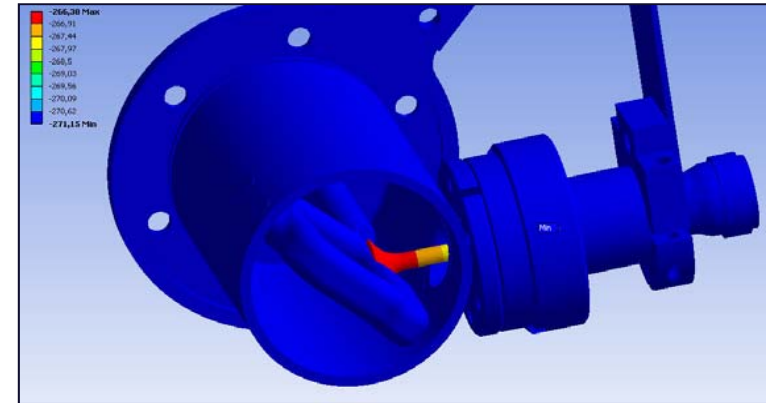
Both, higher conductivity feedthroughs with $\varnothing$ 7mm antennae and connections direct to the 2K tube will improve the thermal conditions of HOM couplers in the series XFEL cryomodules.

Modelling: T_{antenna} vs. Dissipated heat

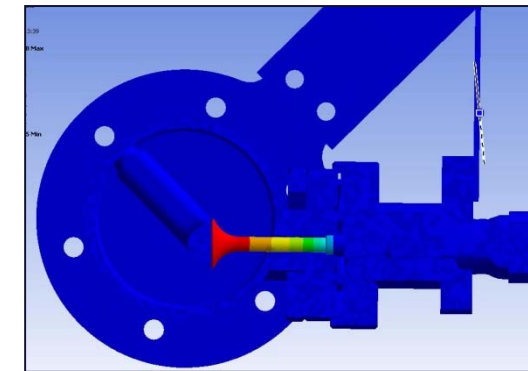
In cryomodule (vacuum)



In vertical cryostat (LHe)



Heat	T_{antenna} vacuum	T_{antenna} superfluid He
[mW]	[K]	[K]
20	7.0	6.8
5	4.6	4.5
4	4.2	4.2
3	4.0	3.9
2	3.6	3.5
1	3.1	3.0

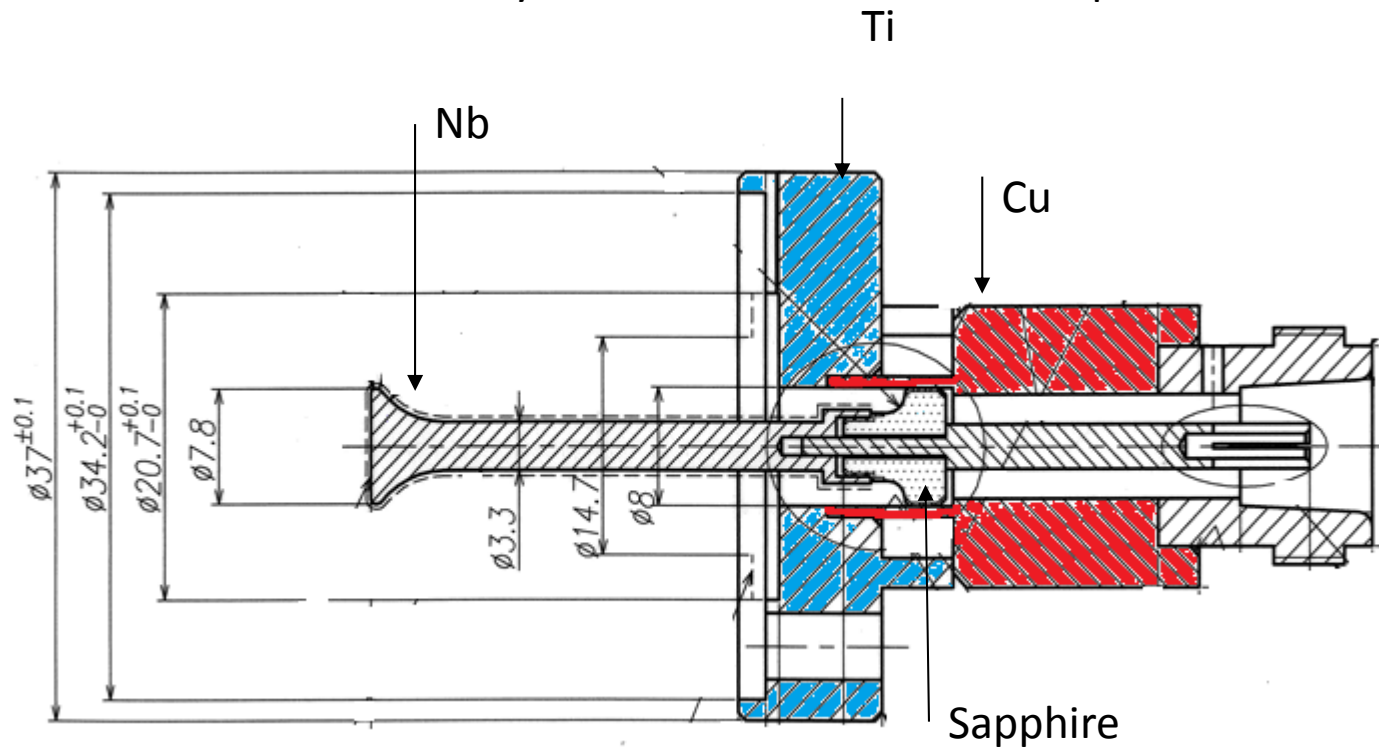


Conclusion from the modeling was that T of antenna is almost the same for either condition

New Feedthroughs

In general, all manufacturer we asked to develop a higher conductivity feedthrough use the sapphire window (JLab design).

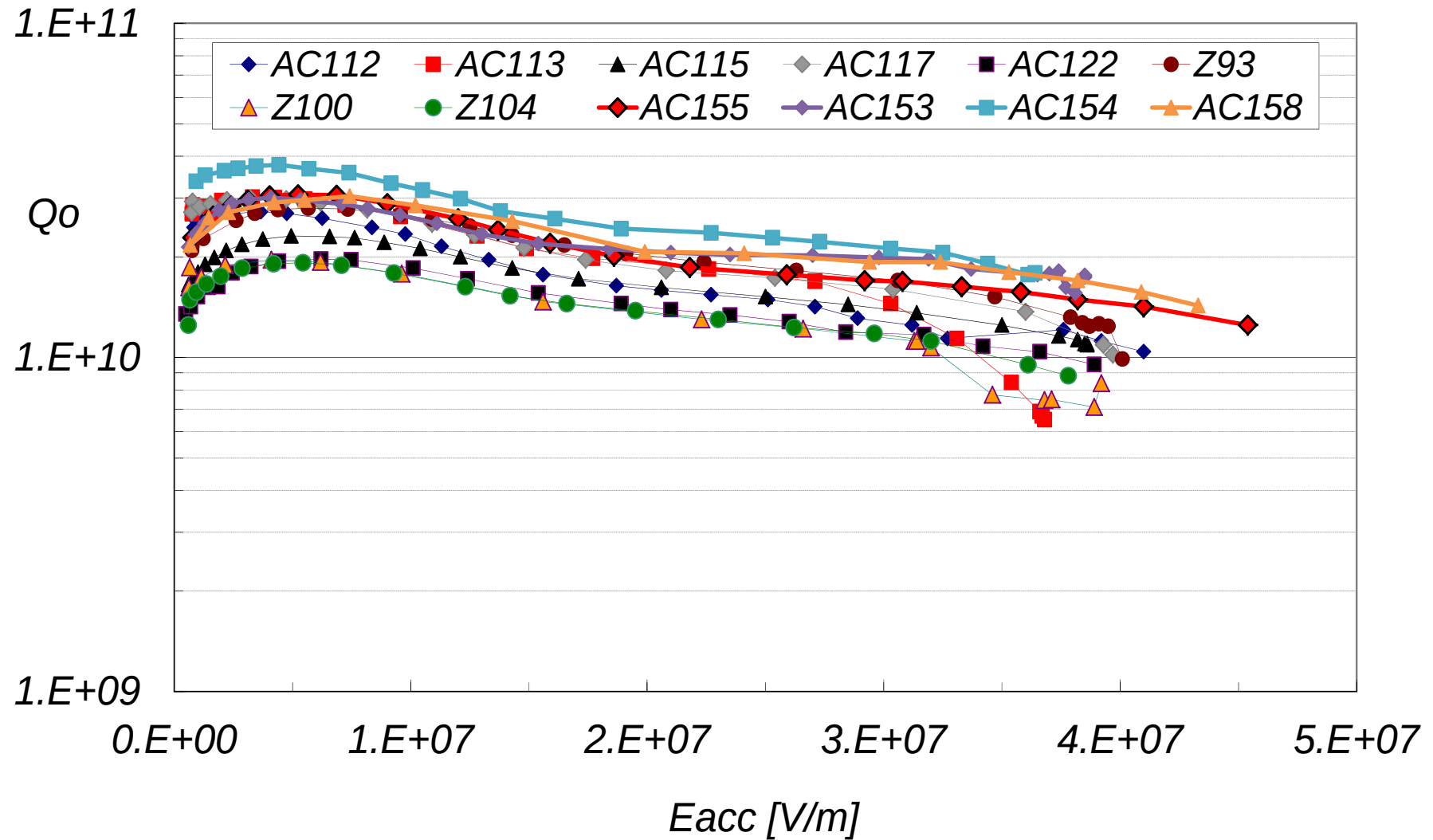
Finally the contract was awarded to Kyocera because of the lowest price:



Final Remarks

- Better thermal conditions, feedthroughs and thermal connections, will allow for operation of the linac (808 cavities) with lower dynamic heat load, making possible both higher gradient for the cw - and longer pulses for lp operation.
- The experiment in January 2012 will help us to find (partially) limits in these new operation modes. The cryomodule to be tested in January 2012 has 5 cavities equipped with new feedthroughs and 3 with the old ones. All will have thermal connections to 2K tube.
- The XFEL pre-series cryomodule will be tested by the end of July 2012.

Results at DESY (status July 2011) for 12 electropolished TESLA cavities tested at 2K:



Large Grain Nb + proper cleaning + operation at 1.8K :

