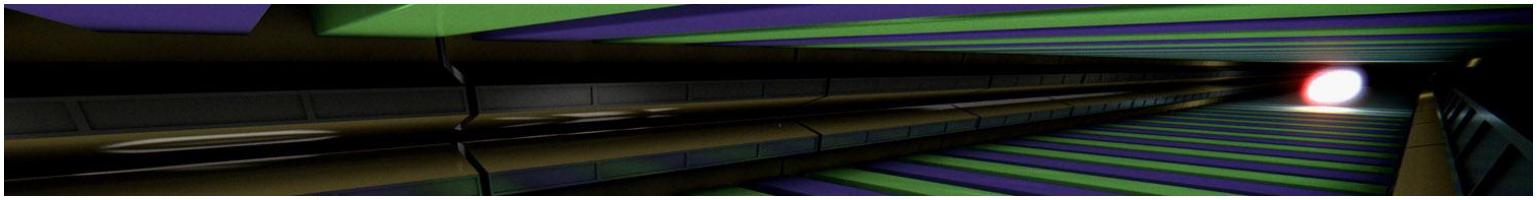
European XFEL



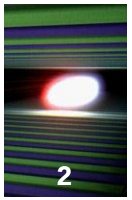
Beam Line Absorbers at DESY

J. Sekutowicz

DESY

HELMHOLTZ ASSOCIATION

Outline



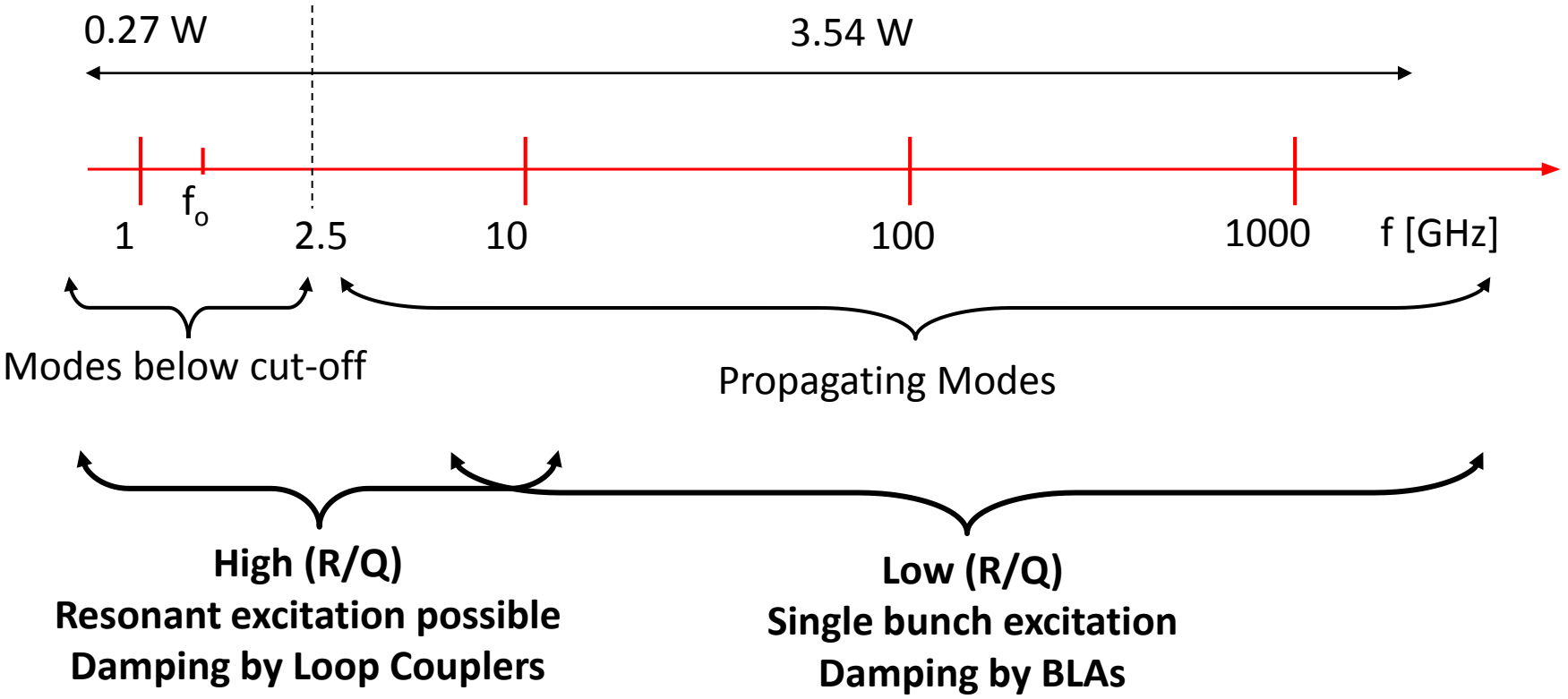
- Beam Line Absorber (BLA)
  - Motivation
  - Design of the BLA
  - Tests in 2008 and 2009
  - Thermal Connection to 40 (70) K and Mechanical Support
- Final Remarks

Motivation

Nominal beam of the European XFEL:

2700 bunches/rf pulse, σ_z = 25 µm, 1 nC, t_b =220 ns. RF-pulse rep. rate 10 Hz.

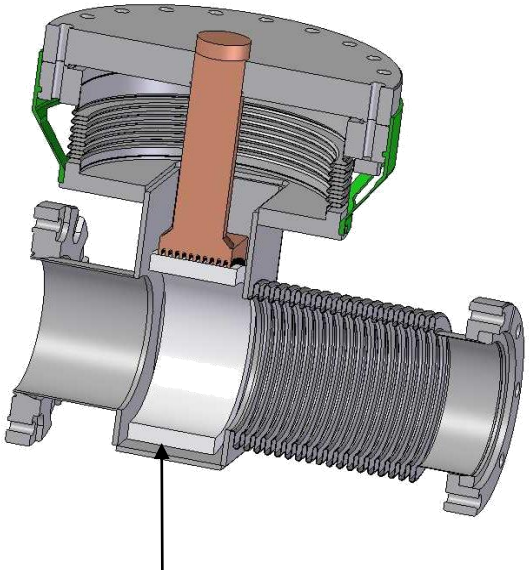
The longitudinal HOM loss factor of the XFEL cryomodule is 141 V/pC.



Design of the BLA

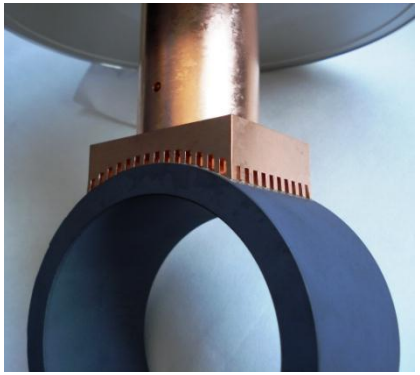
Assumptions for the design:

- low cost
- capacity ~ 100 W



Lossy ceramic (final choice CA137)

Mechanical design by Nils Mildner

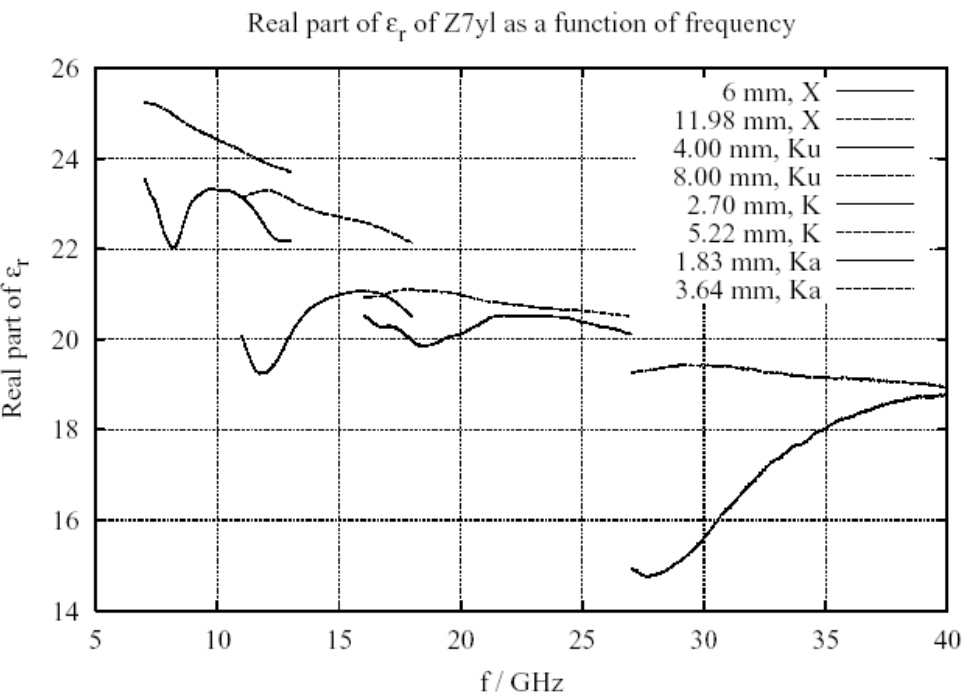


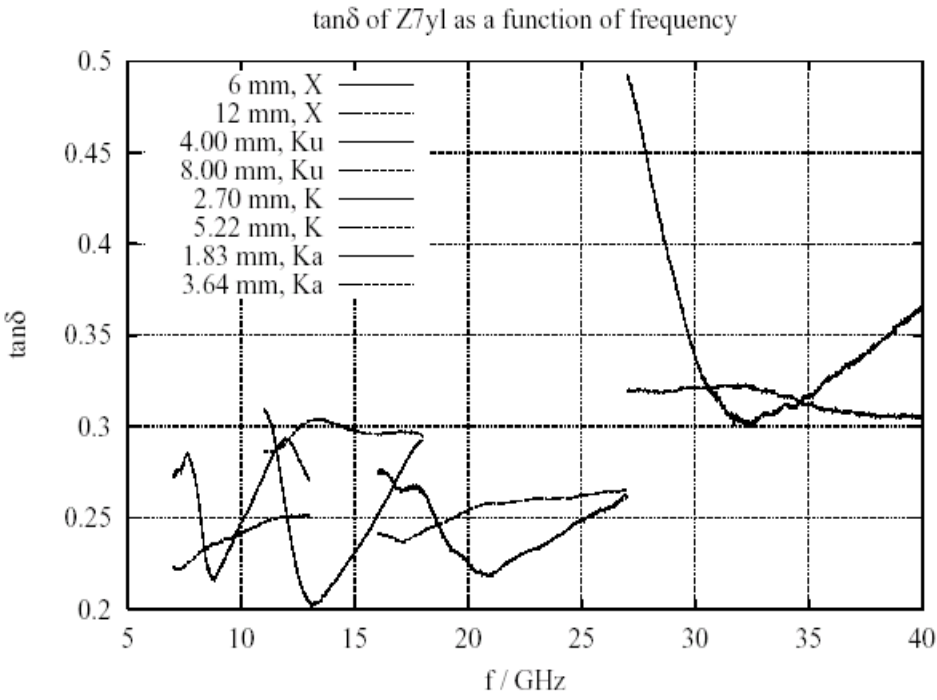
Absorbing ceramic ring brazed to the Cu stub

Housing

Design of the BLA

Permittivity of sample CA137(or C7Y1) hot pressed (measured at Univ. of Magdeburg).



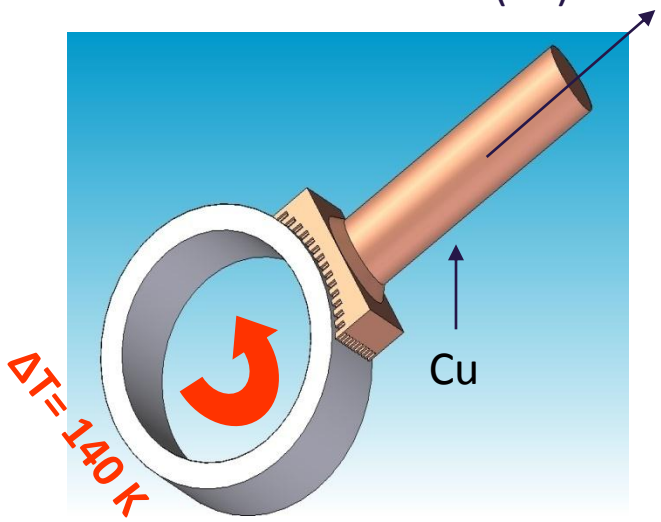


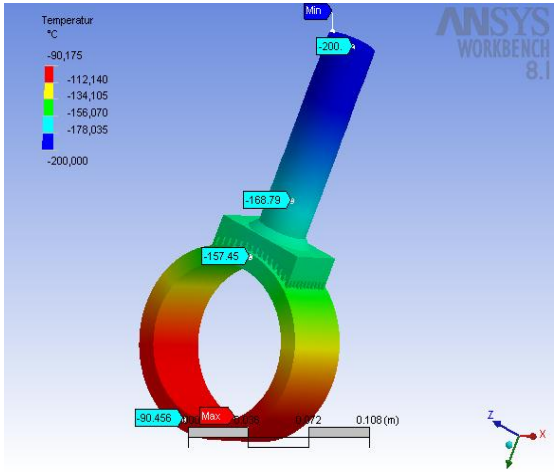
Permittivity: $\varepsilon' = <18, 25>$

$\tan\delta = <0.2, 0.3>$

Design of the BLA

Modeling:



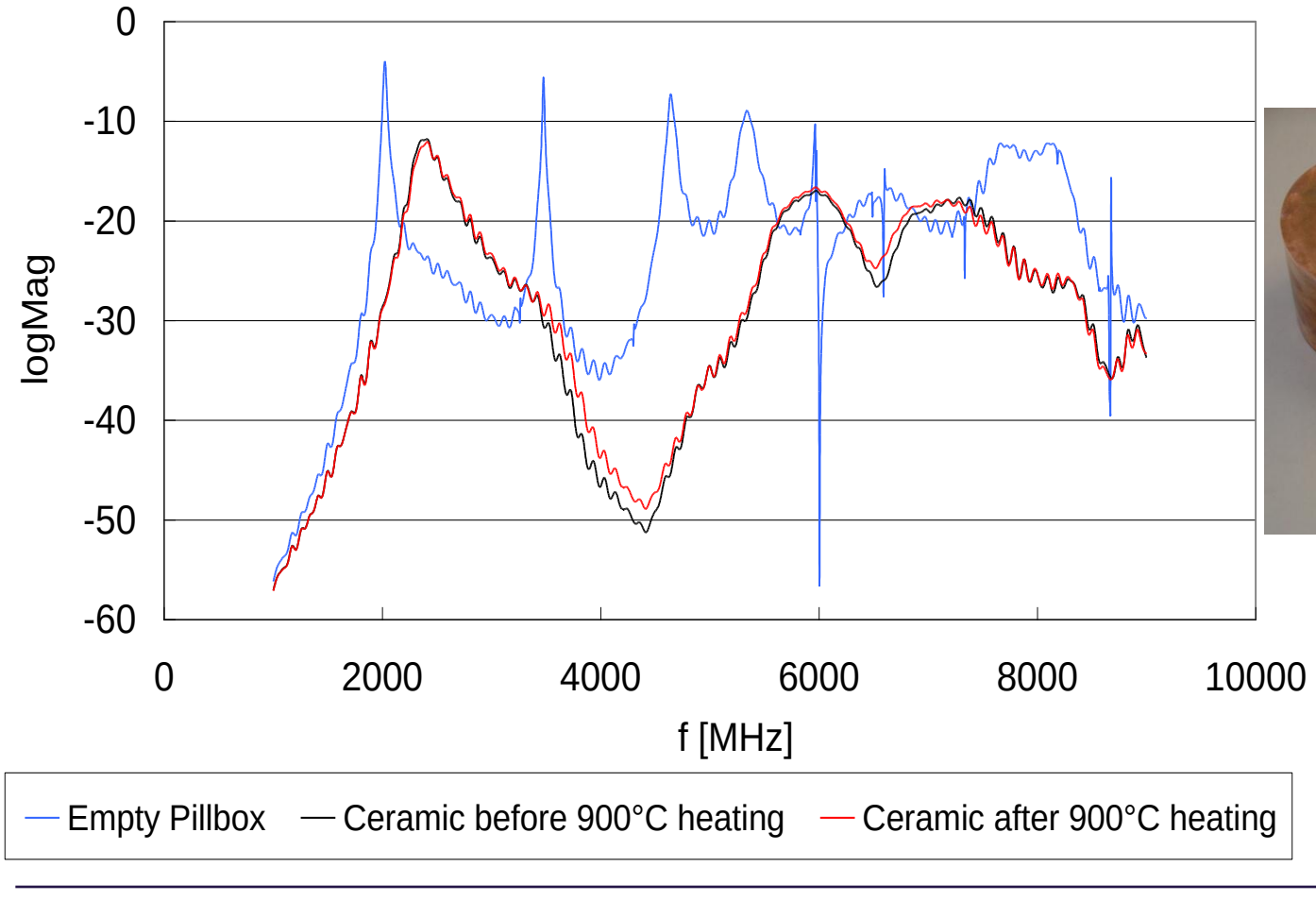


Tests:

- 10 x fast cool-down to 70 K
- 140 K ΔT across the ceramic and stub
- Several times cool-down to 4K

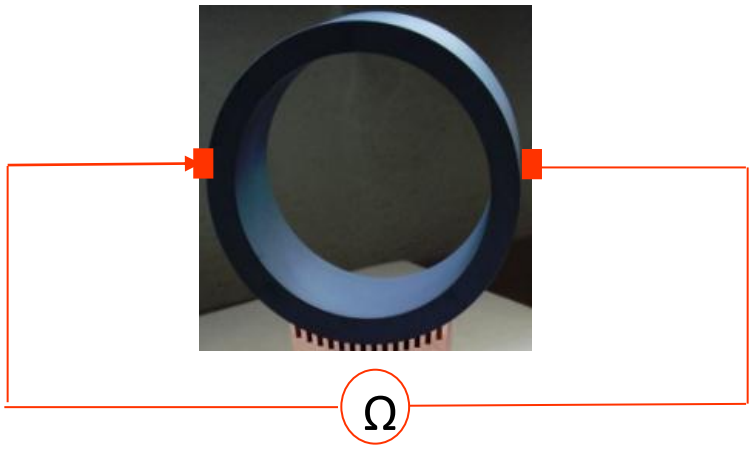
Design of the BLA

The damping properties of ceramic rings were tested before and after heating at 900° C (brazing temperature). No change was observed.



Design of the BLA

DC-resistivity of the ceramic CA 137 was recently measured at 300K and 70 K.

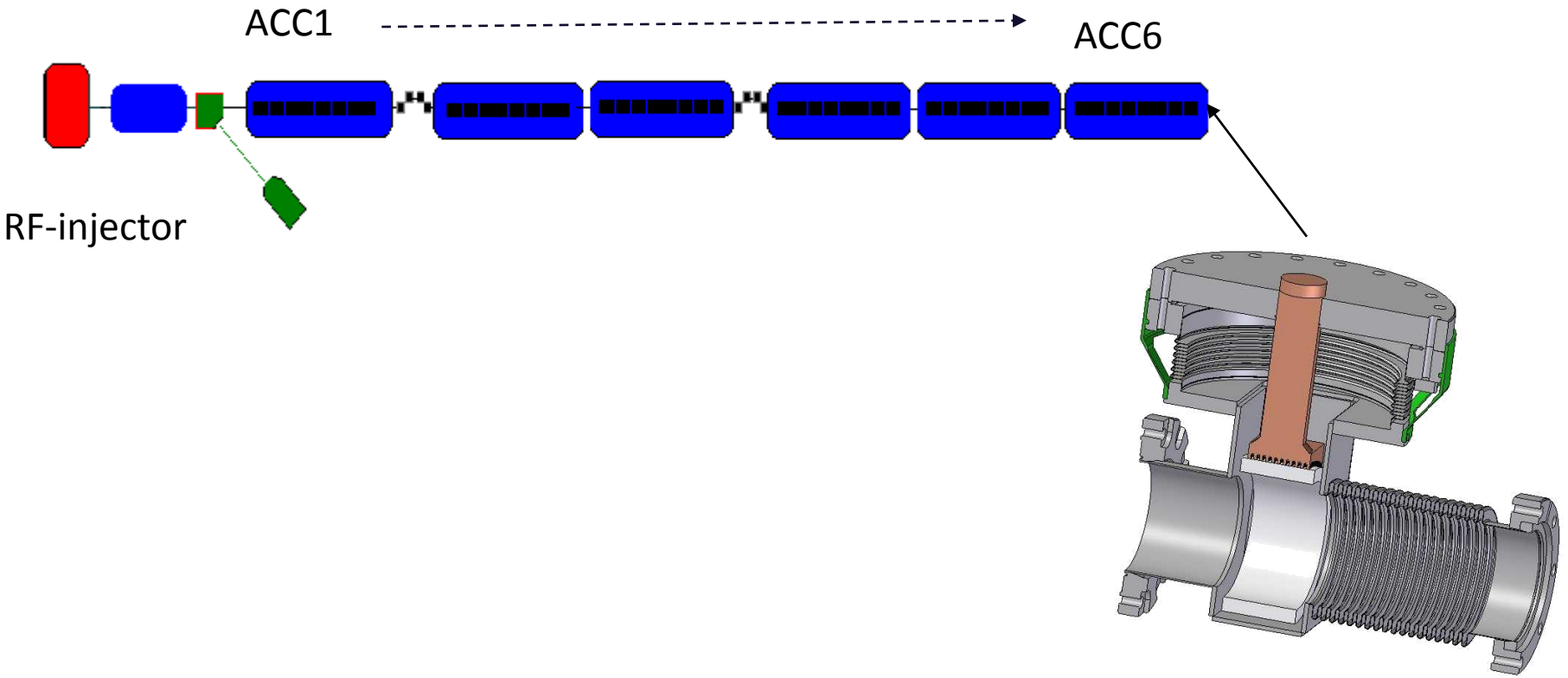


$R_{dc} < 1\ k\Omega$ at 70 K

Courtesy E. Plawski

Beam tests in 2008 and 2009

Beam Tests in September 2008 and 2009: High current runs at FLASH



Beam tests in 2008 and 2009

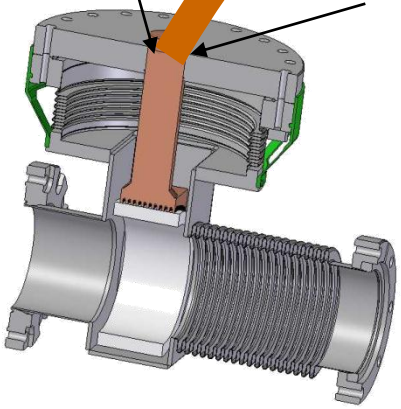
Thermal connection to 42 K tube

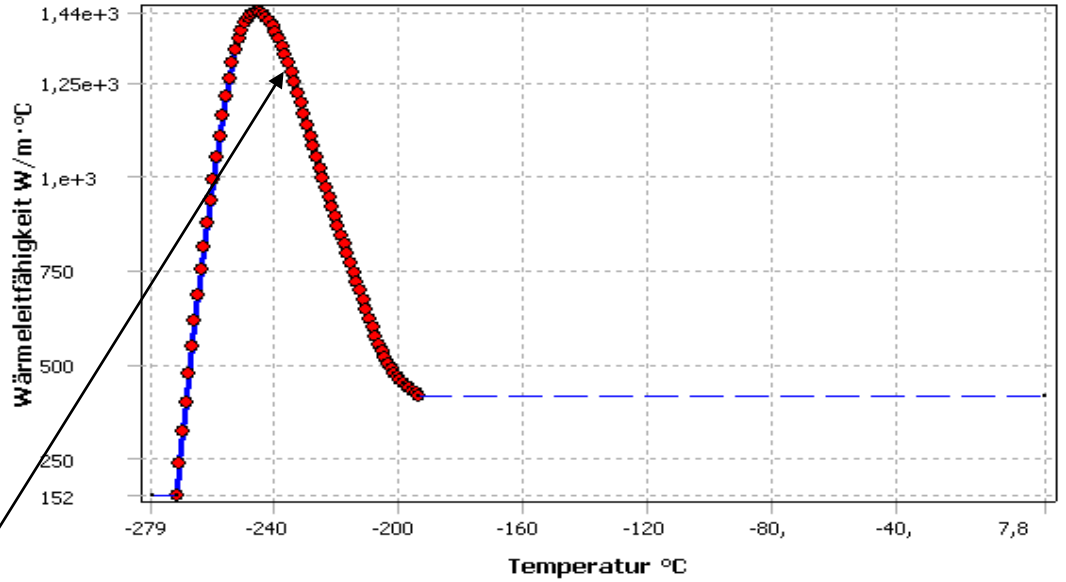
Sensor T0 attached to two-phase tube (42K)

Cu braid 700 mm long, cross-section 74.4 mm^2

Sensor T2

Sensor T1

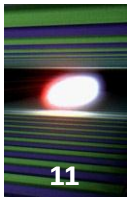




Heat conductance of the braid :

$$\kappa = 1250 \frac{W}{m \cdot K} \cdot \frac{74.4 \cdot 10^{-6} m^2}{0.7 m} = 0.13 \frac{W}{K}$$

Beam tests in 2008 and 2009



1st Test in September 2008

- Charge/bunch was up to 3 nC
- Number of bunch/pulse was up to 500
- The nominal bunch length σ_z was 1.5 mm ($k_{||}$ = 54 V/pC)
- Run was not very stable, we did not observe the steady state in the absorption process
- The beam induced HOM power and the temperature of two thermometers on the stub increase and decrease synchronously.

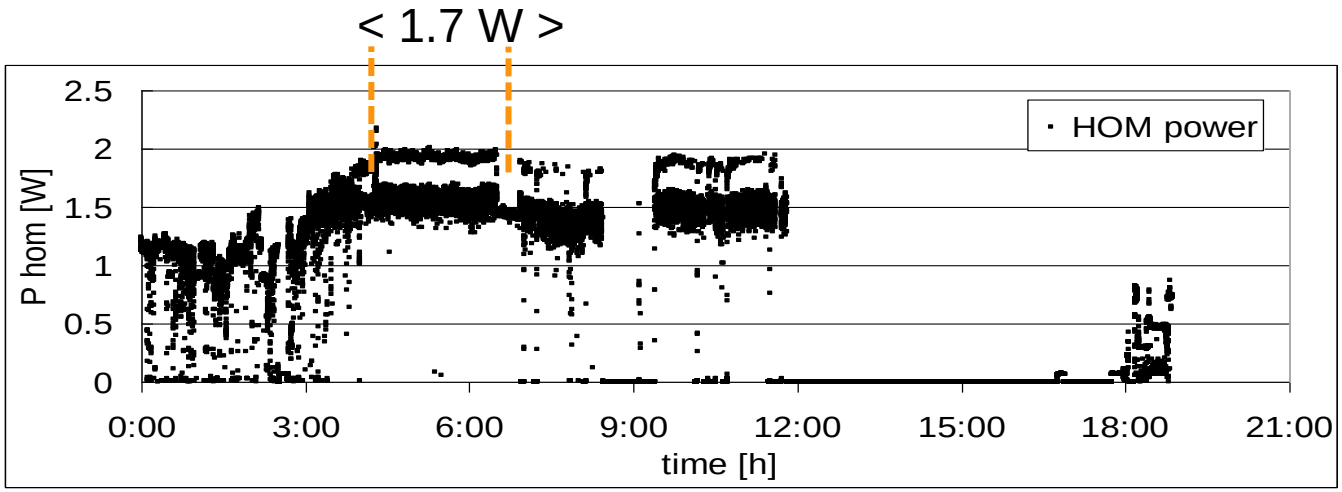
2nd Test in September 2009

- Charge/bunch was up to 3.2 nC
- Number of bunches/pulse was 800 (2400 with lower charge)
- The nominal bunch length σ_z was 1.5 mm ($k_{||}$ = 54 V/pC)
- This time we observed steady state in the absorption process
- The beam induced HOM power and the temperature of two thermometers on the stub increase and decrease synchronously.

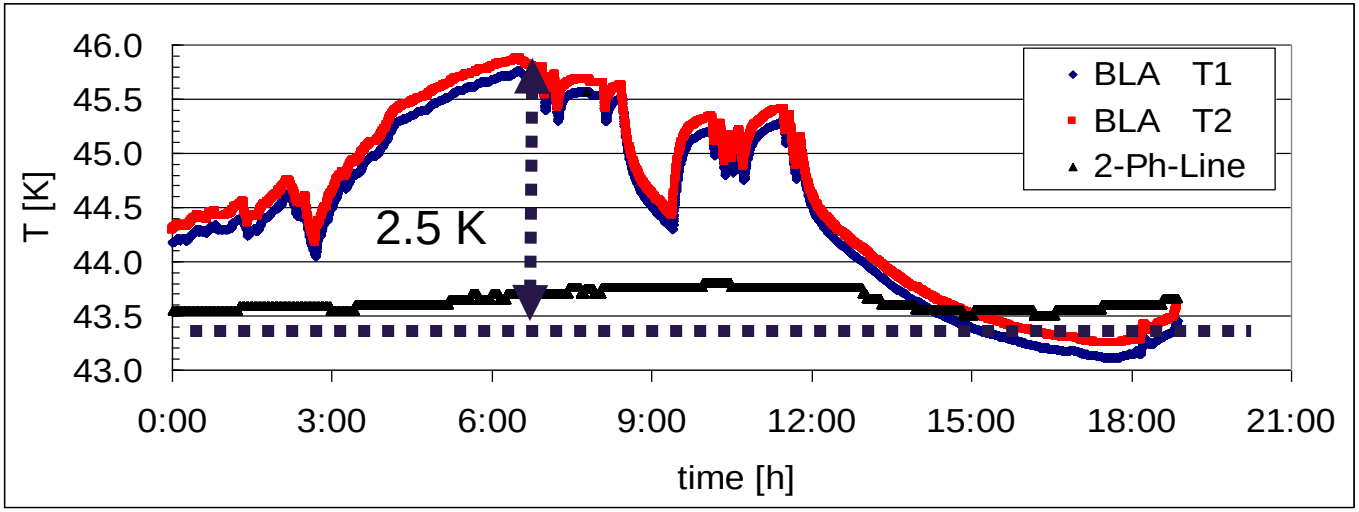
Beam tests in 2008 and 2009

Example: 2nd Test in September 2009

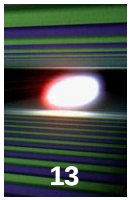
HOM Power in Cryomodule ACC6



Monitored BLA Temperatures



Beam tests in 2008 and 2009



Example: 2nd Test in September 2009, cont.

Measured Absorbed Power:

0.13 W/K * 2.5K= 0.325 W

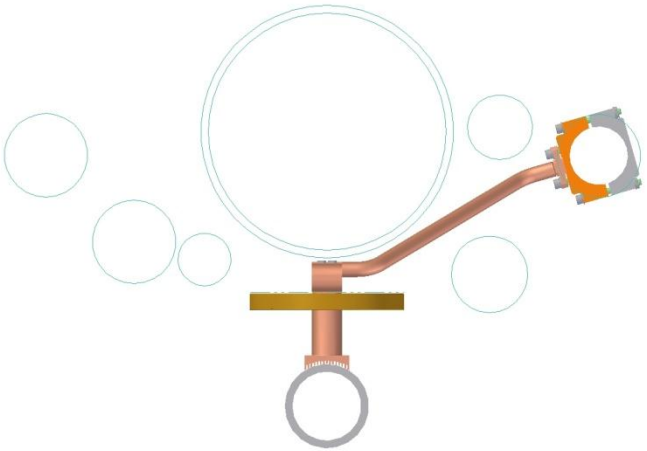
Computer modeling (*M. Dohlus*): 15% of the HOM power should be absorbed in the BLA.

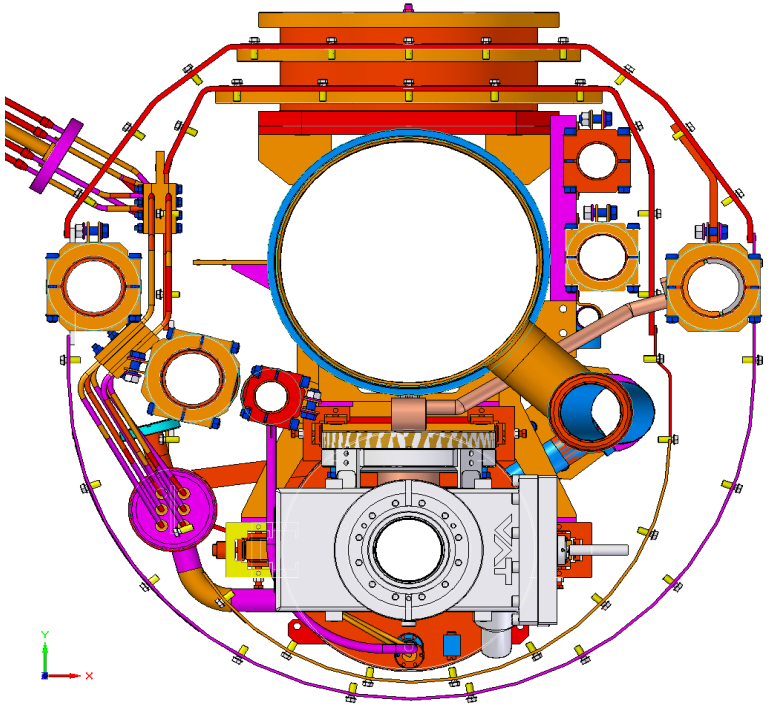
Results of two tests at FLASH

	September 08	September 09
Computed Absorbed Power [W]	0.180	0.255
Measured Absorbed Power [W]	0.143 (-21%)	0.325 (+27%)

Thermal Connection to 40 (70) K and Support

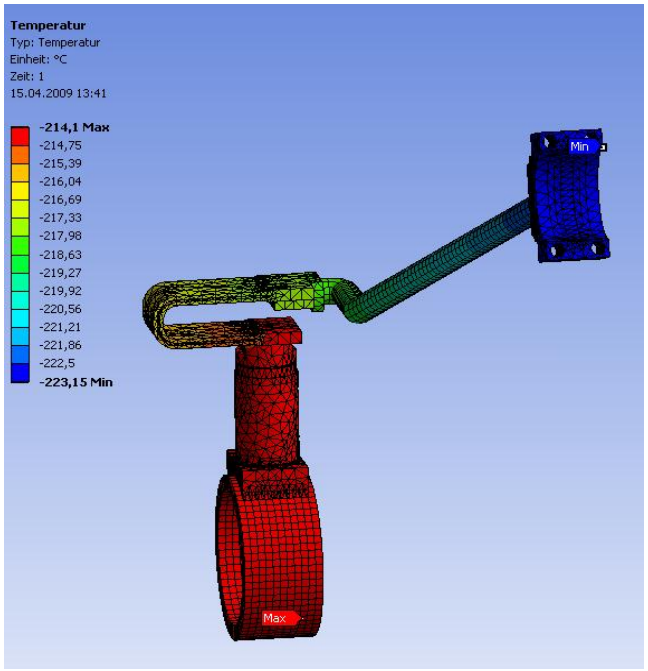
Modeling showed that thermal connection is not a trivial part of the BLA.





It is rather complicated due to very little space between cryomodules.

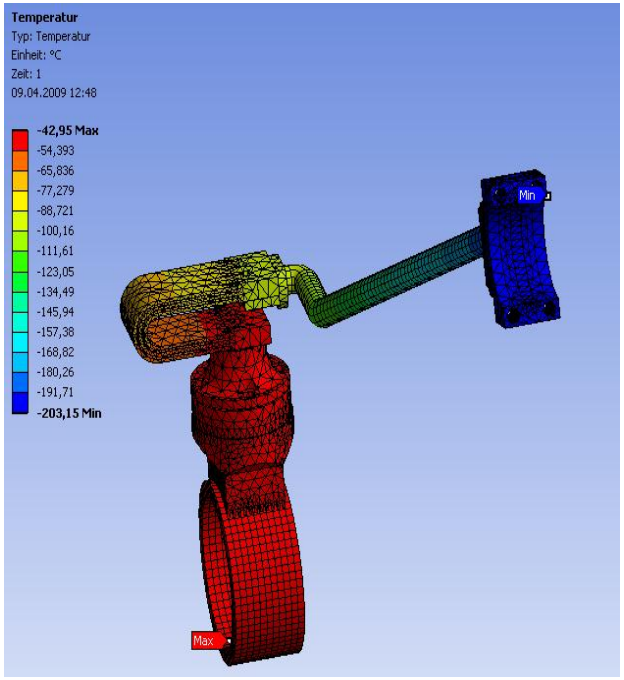
Thermal Connection to 40 (70) K and Support



50K

Nominal Pulse Operation
Absorbed Power: 3W
Temperature at the ceramic
-214° C (=59K)

This is OK



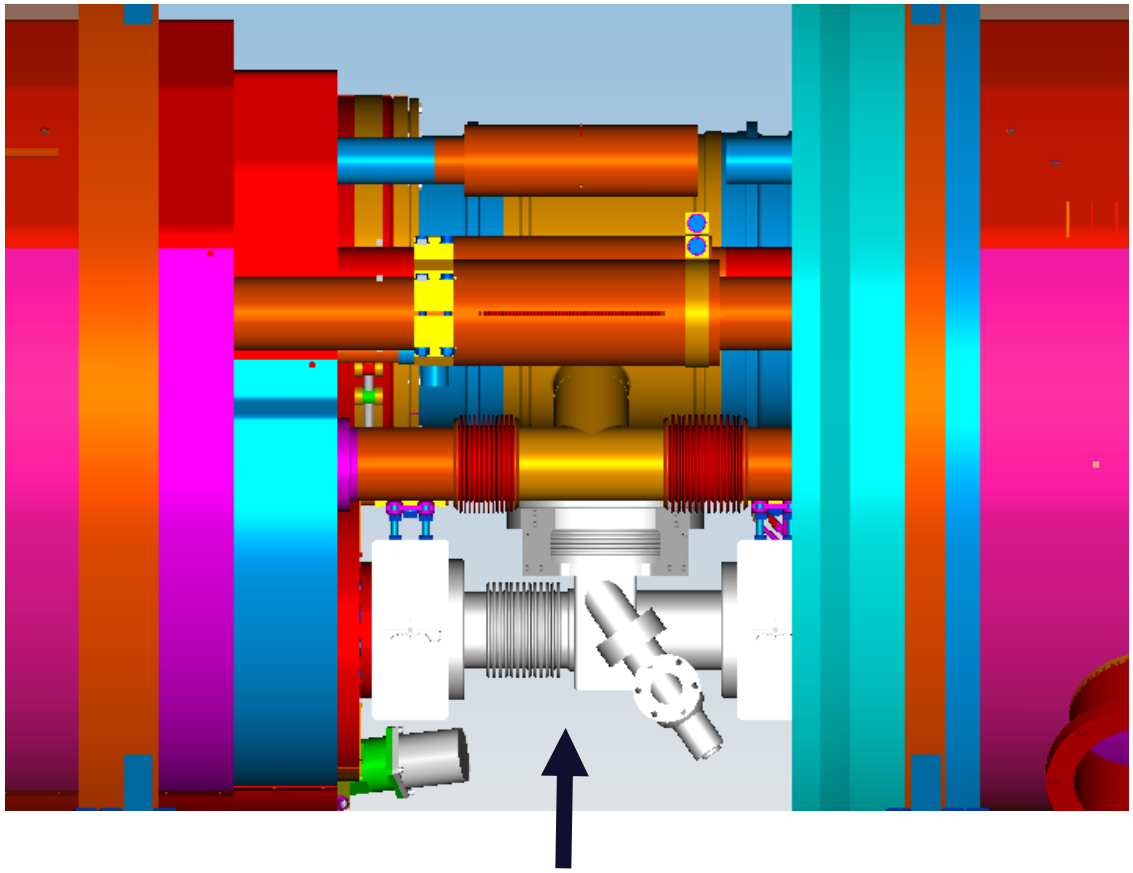
70K

CW Operation
Absorbed Power: 30 W
Temperature at the ceramic
-43° C (=230K) ???

More expensive connection with better heat conduction must be implemented

Thermal Connection to 40 (70) K and Support

The BLA weights 21 kg. The device should be held by a support to avoid mechanical deformations of the beam line.

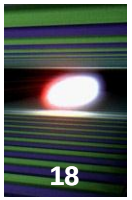


The support is not designed yet. We are working on it.

Final Remarks

- The performed beam tests at FLASH proved the concept of BLA design.
- The only one ceramic-to-copper brazing made the BLA cost acceptable.
- We are preparing production of ~ 100 BLAs for the XFEL linac.
- We think, that 100 W heat capacity of the existing design can be extended.

Acknowledgements



DESY

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- E. Pławski
- H. Wojnarowski

Thank you