

# First Results of the SC Cavity Test Facility HoBiCaT

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# The BESSY FEL Project

Photon energy range	20 - 1000	eV
Electron energy	2.3	GeV
RF frequency	1.3	GHz
RF mode	CW	
Cavities/Cryomodules	TESLA type modified	
Bunch repetition rate	25 (1st stage: 1)	kHz

**FEL Project evaluated by Wissenschaftsrat in July 2005**



# HoBiCaT Cavity Test Facility

(Horizontal Bi Cavity Testfacility)

HoBiCaT is built as test bench to characterize the TESLA superconducting cavities in CW mode

- Gain practical experience to address the outstanding issues
- Gain operating experience of superconducting RF- technology
- Components should be operated under similar conditions as in the BESSY FEL

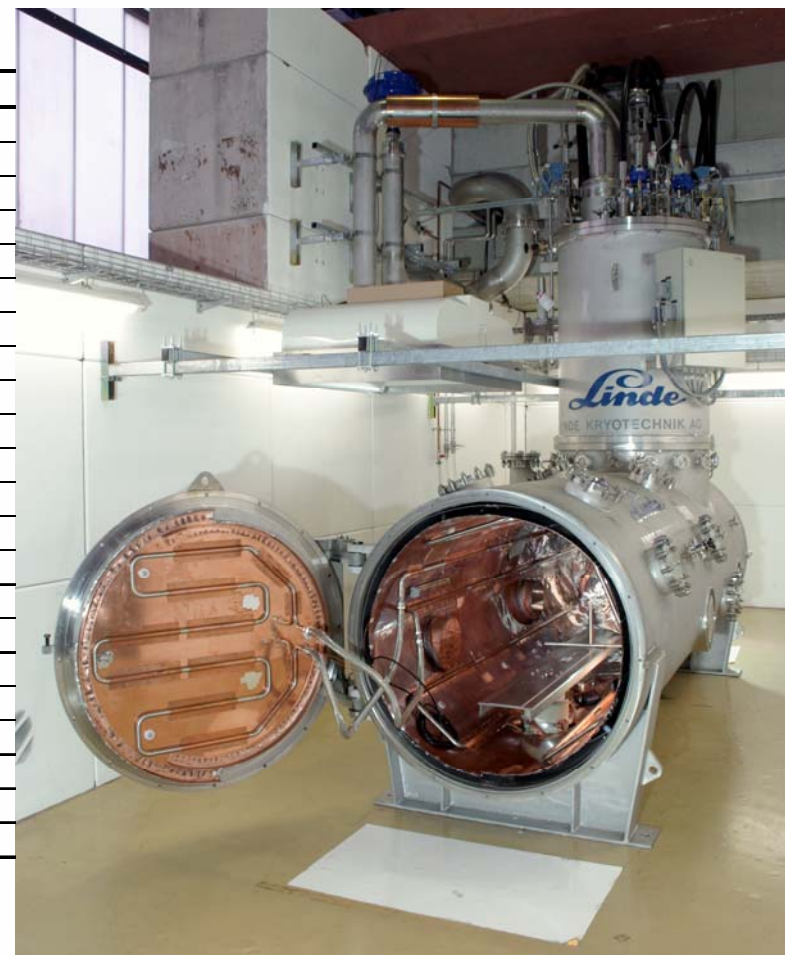
# HoBiCaT Test Program

- Gradient
- Bath temperature
  - Optimize bath temperature to reduce refrigeration cost
- Cryogenic load
  - Cryostat design changes for CW operation
  - Demonstrate stable operation
- Microphonics
  - Level and sources of microphonic detuning
  - Compensation of microphonics
- RF system
  - Power requirements and distribution
  - Control system (digital/analog, IQ/Amp-Phase ...?)
  - How accurately can we control the cavity voltage?
- Input coupler
  - CW and standing wave power limit

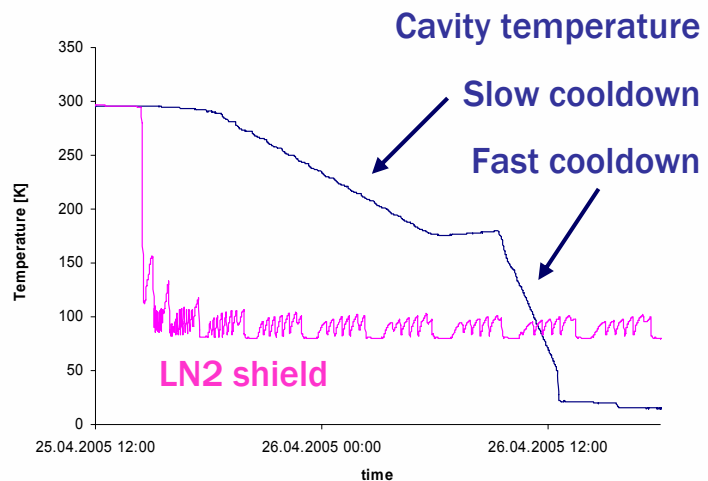


# HoBiCaT Parameters

Parameter	Value	Unit
<b>Mechanical parameters</b>		
Useable interior length	3,50	m
Number of TESLA cavities	2	
Useable interior diameter	1,10	m
Total height	3,2	m
<b>Main cooling loop</b>		
Temperature	1,8	K
Cooling capacity	80	W
Mass flow	4	g/s
<b>Temperatures of the secondary loops</b>		
Table cooling loop	4,5	K
Cavity fill loop	4,5	K
Coupler cooling	20	K
Heat shield LN2	77	K
<b>Vacuum pumps</b>		
Suction pressure	14	mbar
Pumping speed	6400	m <sup>3</sup> /h
Mains power	110	kW
<b>RF Power Source</b>		
Frequency	1300	MHz
Power	10	kW
Operating mode	cw	



# Automatic Cavity Cooldown at HoBiCaT

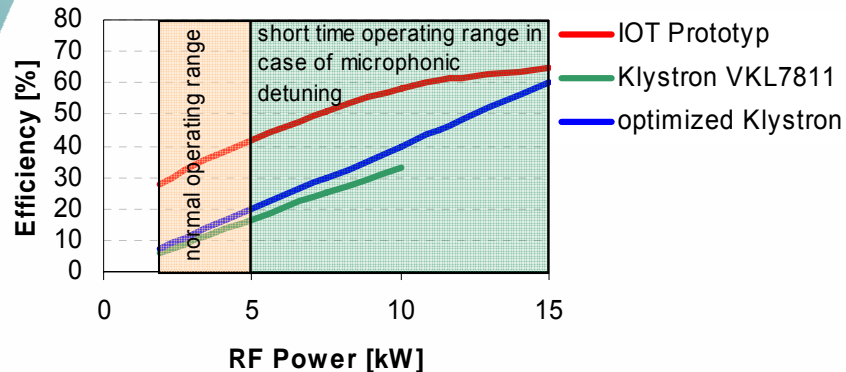


- First isolation vacuum:  
27.2.2004
- First cooldown LN2:  
15.3.2004
- First liquid helium:  
25.3.2004
- First 1.8 K helium:  
27.3.2004



# RF Transmitter development at HoBiCaT

Efficiency of Klystron and IOT



The Efficiency of a klystron and IOT at peak power is comparable, but in the typical operating range of an cw FEL the IOT has much better efficiency due to the class B operation mode.



HoBiCaT transmitter: in the middle the power supply, right side the 10 kW klystron and left side the IOT prototype

## Development steps

- 10 kW klystron transmitter
- Stability tests of power supply with IOT prototype at reduced power level
- Optimized IOT transmitter at full power
- High precision low level electronics using FPGA micro processor technique

10/2004

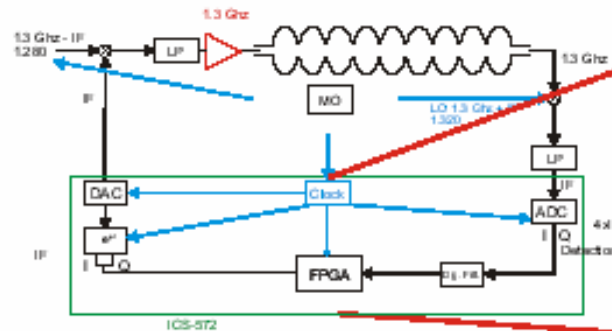
04/2005

02/2006

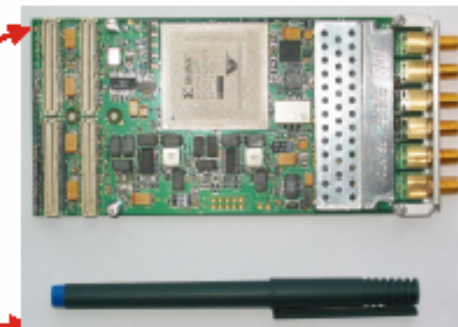
in test phase



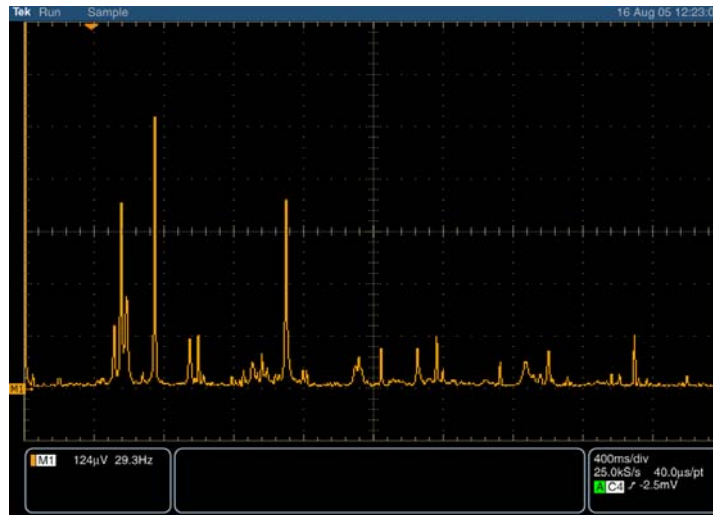
# Microphonics



**RF CONTROL SCHEME**



**ICS-572 ADC/DAC Board with Xilinx FPGA**



- Instrumentation in house.
- Commissioning the measuring instruments.
- First microphonics measurement, trying to identify the lines.



# Cavity Quality Measurements

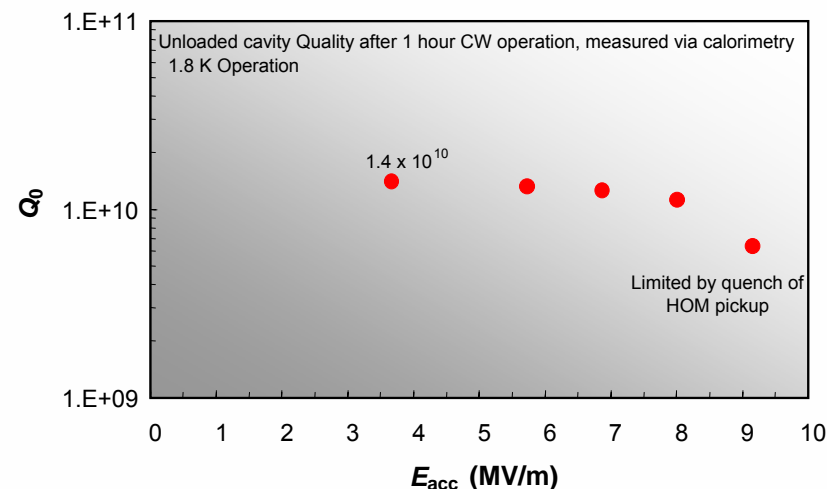
## Measurement of cavity quality of TESLA cavity produced and assembled by industry

Complete cavity unit installed in HoBiCaT:

- 9-Cell cavity
- TTF-III input coupler
- Magnetic shield
- Helium tank
- Tuner

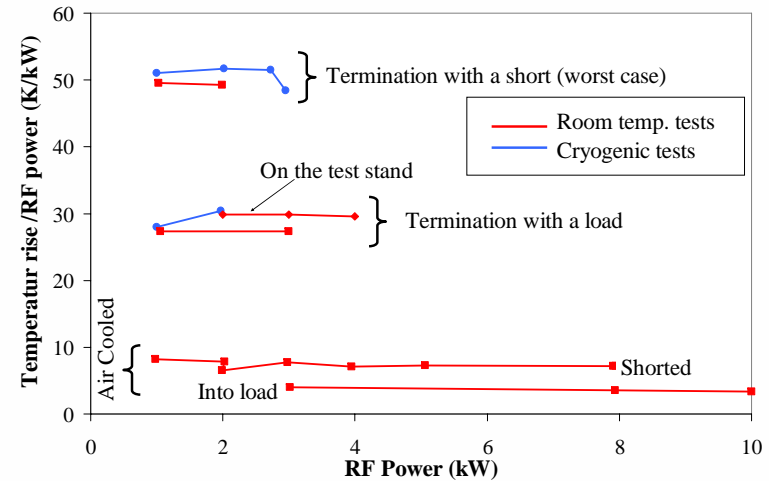
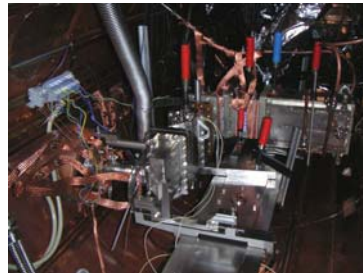
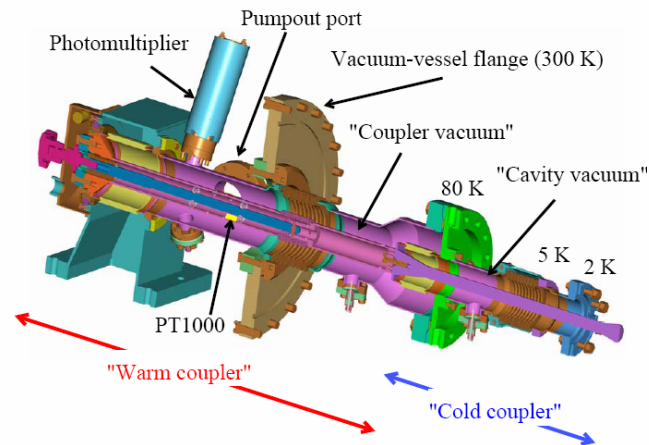


Installed cavity in HoBiCaT



- **Target  $Q$ -value achieved ( $1.3 \times 10^{10}$ )**
- Field-emission onset at moderate field  $\rightarrow$  cavity will be re-cleaned next month to improve field
- HOM pickup tip quenches  $\rightarrow$  installation of new feedthrough for improved cooling properties.

# TTF-III Coupler Performance Measured in HoBiCaT

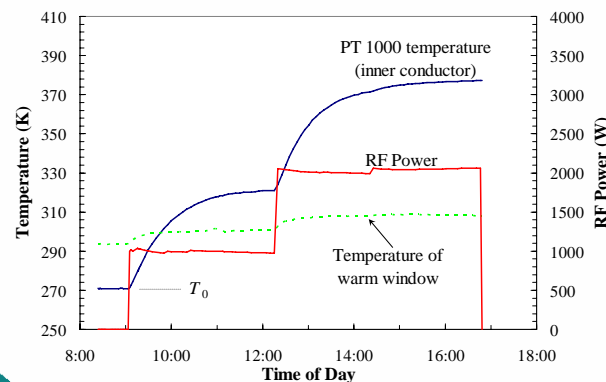


## Measurement of heating during CW operation

➤ *Coupler can withstand target power (5 kW CW standing wave)*

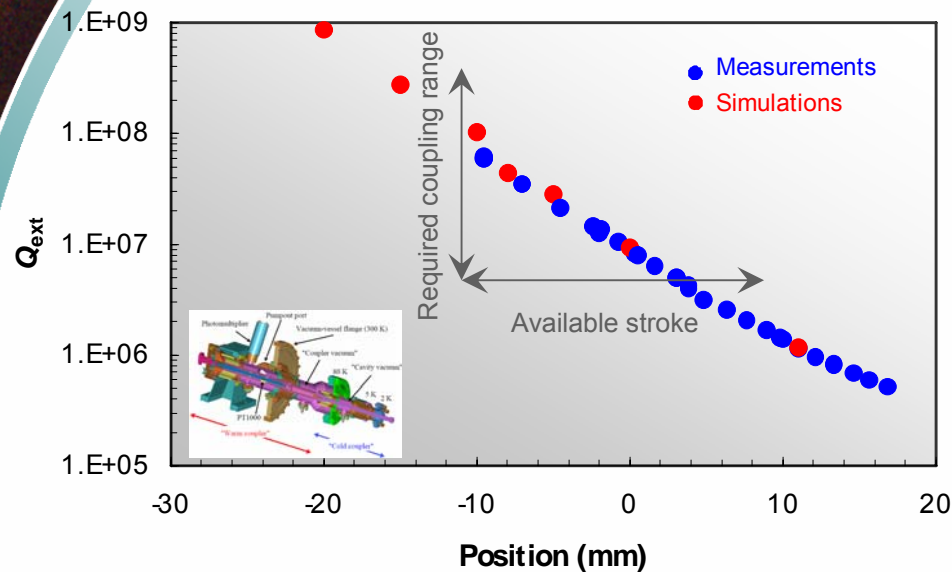
➤ *Critical components identified*

➤ *With additional air cooling of inner conductor 25 kW CW standing wave power should be possible*



# Variable Input Coupling for the BESSY FEL

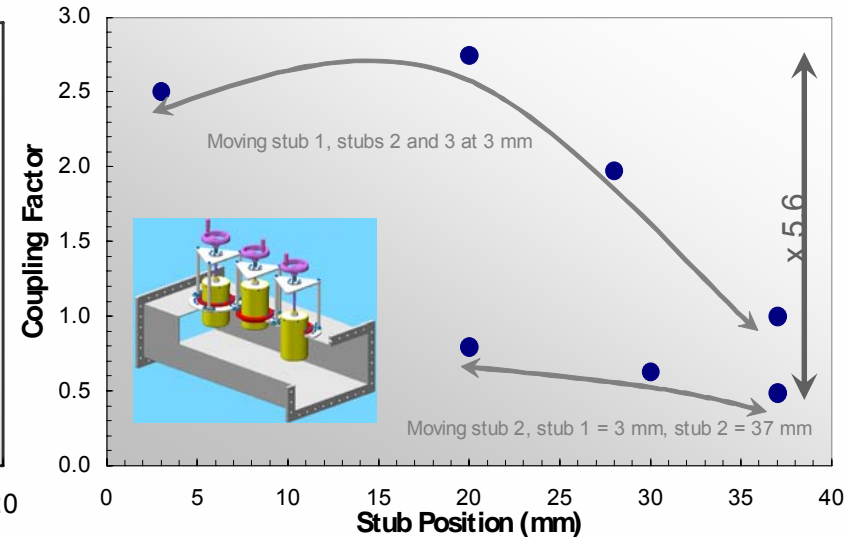
Measured coupling factor of TTF-III coupler



## Variability of coupling needed for

- Optimization of cavity performance, given level of microphonics
- High-power processing
- Coupling range from about  $2 \times 10^6$  to  $2 \times 10^8$  required.
- Stroke of coupler measured, nearly covers the range.

Measured coupling factor with 3-stub tuner



## 3-stub tuner for extended coupling range

- 3 Stub tuner provides another factor 6 in coupling factor
- **TTF-III coupler in conjunction with 3-stub tuner provides required coupling range for BESSY-FEL**

# Outlook

## Next steps:

- Cleaning cavity, etching and high pressure rinsing in clean room
- Disable HOM until sapphire feed through are available
- Mounting tuning mechanism including piezo
- Commissioning RF control
- Adjusting range of coupler
- Ordering IOT optimized transmitter
- ...

To achieve  
required  
gradient