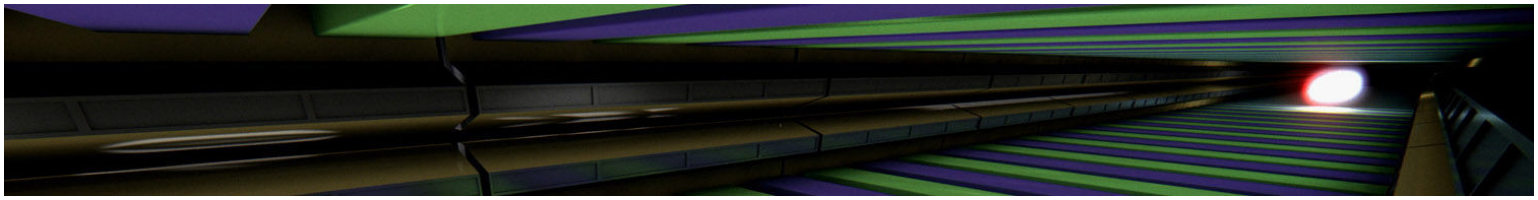


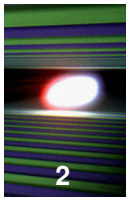
Power Couplers, HOM Couplers and Tuners for the XFEL

Wolf-Dietrich Möller, DESY, MHF-SL

DESY-XFEL – CERN-SPL Meeting, 08 to 09 September 2009

European XFEL

1. Power Coupler Specification

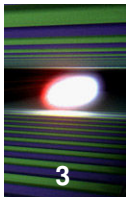


Frequency	1.3 GHz
Peak power (incl. control margin)	150 kW
Repetition rate	10 Hz
Pulsed mode	500 µsec risetime, 800 µsec flat top with beam
Average power	1.9 kW
High Power Processing (only on module test stand)	1 MW at reduced pulse length (≤500 µsec and repetition rate 1 Hz)

Coupling	$Q_{ext} = 10^6 – 10^7$ (± 10 mm)
2 K heat load	0.06 W
4 K heat load	0.5 W
70 K heat load	6 W
Lateral displacement	± 2 mm
diagnostic	sufficient for safe operation and monitoring

European XFEL

2. Power Coupler Design Criteria



- coax is easy for: - variable coupling
  - fabrication
  - assembly
- two windows for: - clean assembly of the cavity
  - save operation
- cold coax: - at 70 Ohm, 40 mm diameter
- warm coax: - at 50 Ohm, 60 mm diameter
- bias on inner conductor: - suppress multipacting
- flexibility: - bellows in the warm and cold coax
- ceramics: - Al_2O_3 with TiN coating
- copper plating: - 10/30 µm outer/inner coax
  - high thermal/electric conductivity (RRR ≥ 30)
  - high purity, Hydrogen free

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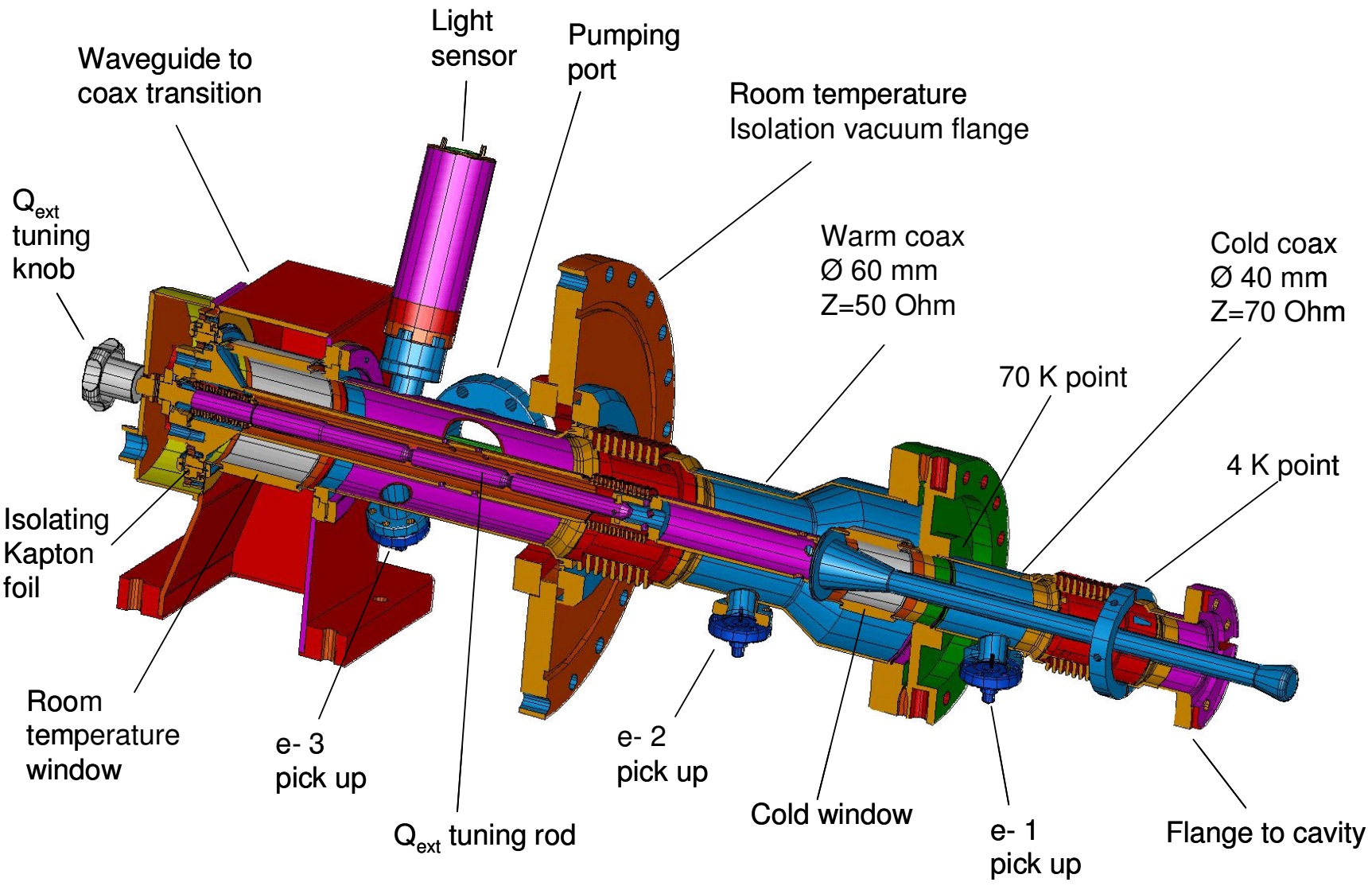
3. Power Coupler Design



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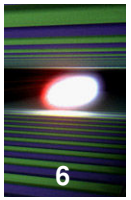
4. Power Coupler in FLASH on Module 5

5. Power Coupler Test and Operating Experience



- More than 50 TTF 3 couplers are tested on a coupler test stand at 1 MW, 2Hz, 1.3 ms, traveling wave, baked in situ, two at a time
- TTF 3 couplers are operated at the FLASH for more than 450 000 coupler-hours up to 400 kW, 2-10 Hz, 1.3 ms
- All couplers in the VUV FEL linac could be processed and operated up to the cavity performance limits

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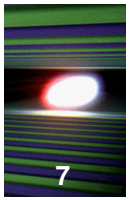
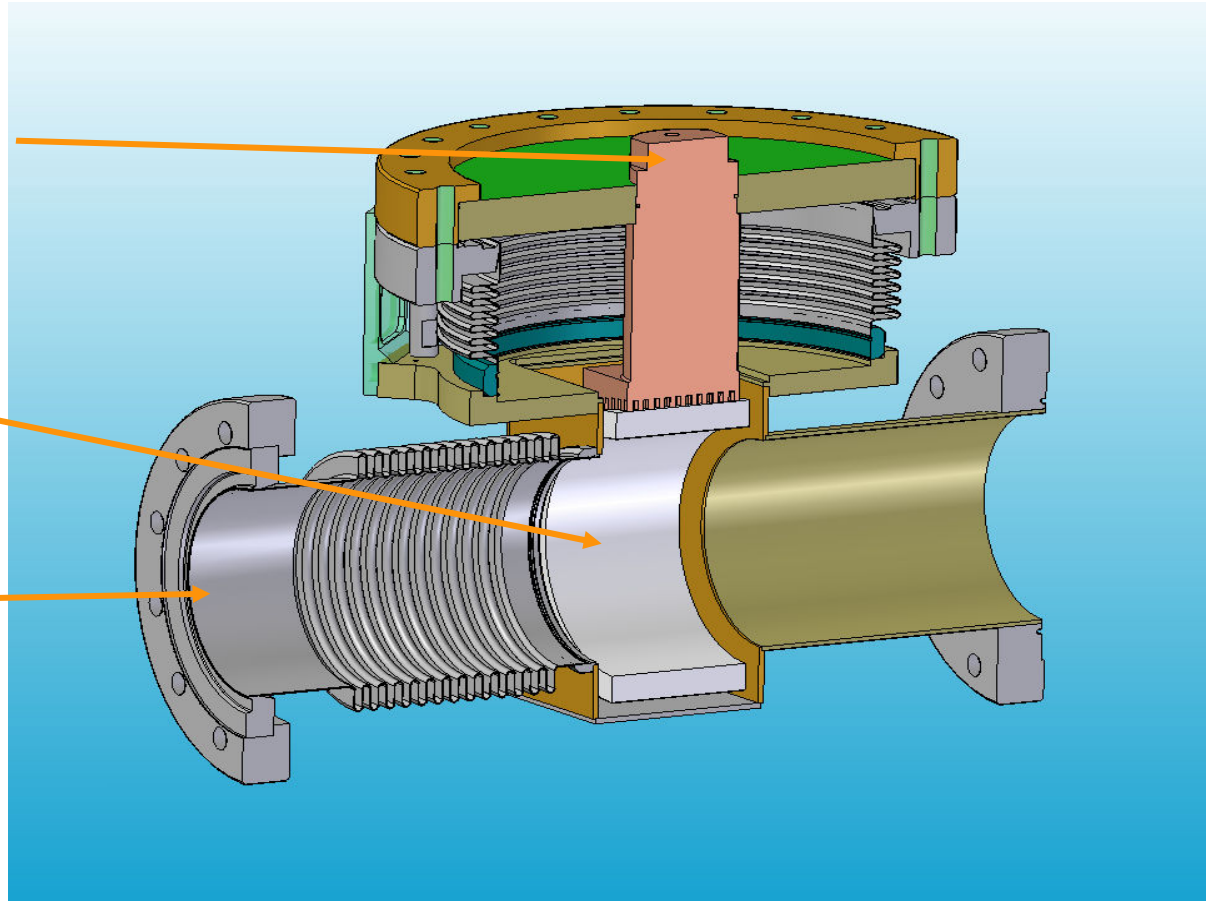
6. Power Coupler High Gradient Test



- An electro polished cavity & TTF3 coupler have been operated at 35 MV/m for more than 1100 hours in the horizontal test stand and also in FLASH with beam
- Forward power was above 600 kW
  (due to the not compensated Lorentz Force detuning)
- No degradation in the performance of cavity or coupler
  (During setup of LLRF system breakdowns in coupler and quenches in cavity were caused by unexpected high power pulses)

1. Beam Line HOM Absorber Design

- thermal connection to 70 K
- ceramic absorber
- beam line



J. Sekutowicz, DESY, Hamburg

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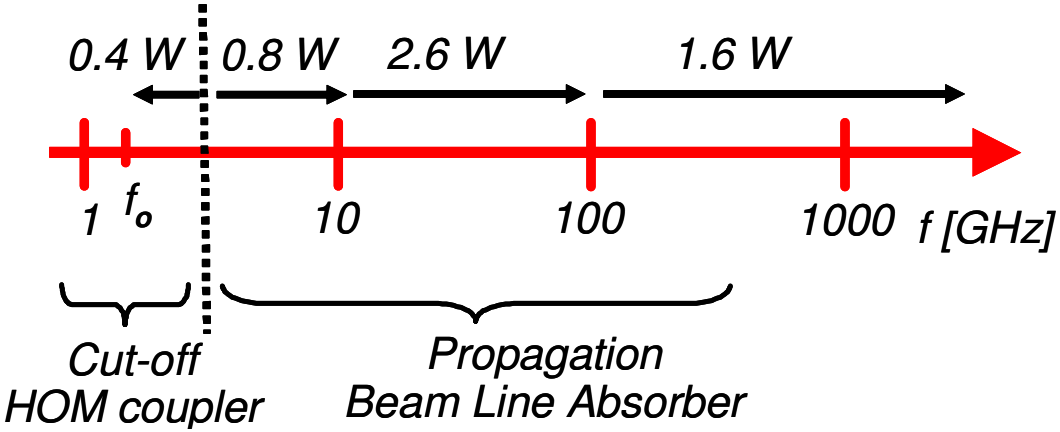
2. Beam Line HOM Absorber in Module

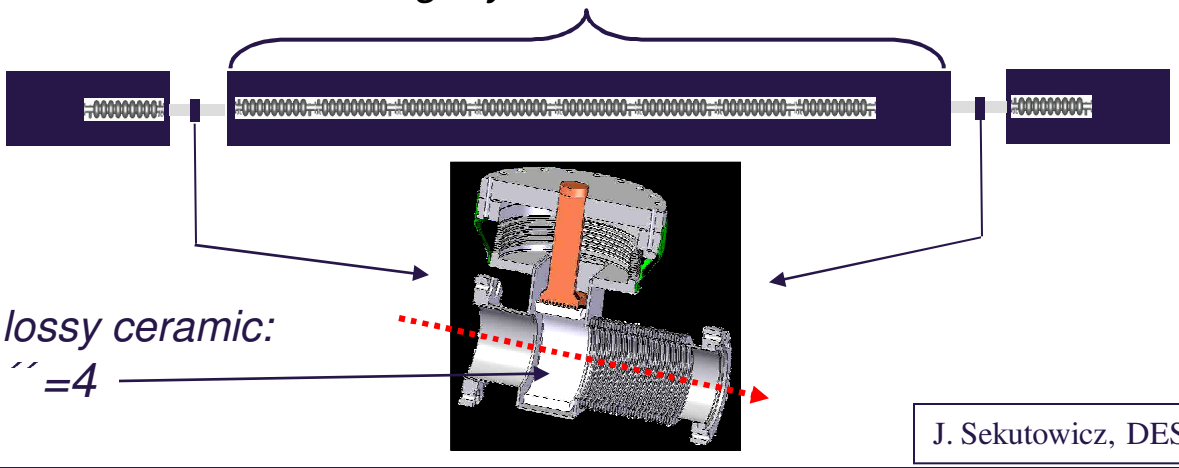
HOM power deposited by the nominal beam

5.4 W/(8-cavity cryomodule, $k_{||}$ =135 V/pC)



- first test in FLASH sucessfull

12 m long cryomodule: 8 cavities



Absorbing ring made of lossy ceramic:
ε´=15 and ε´´=4

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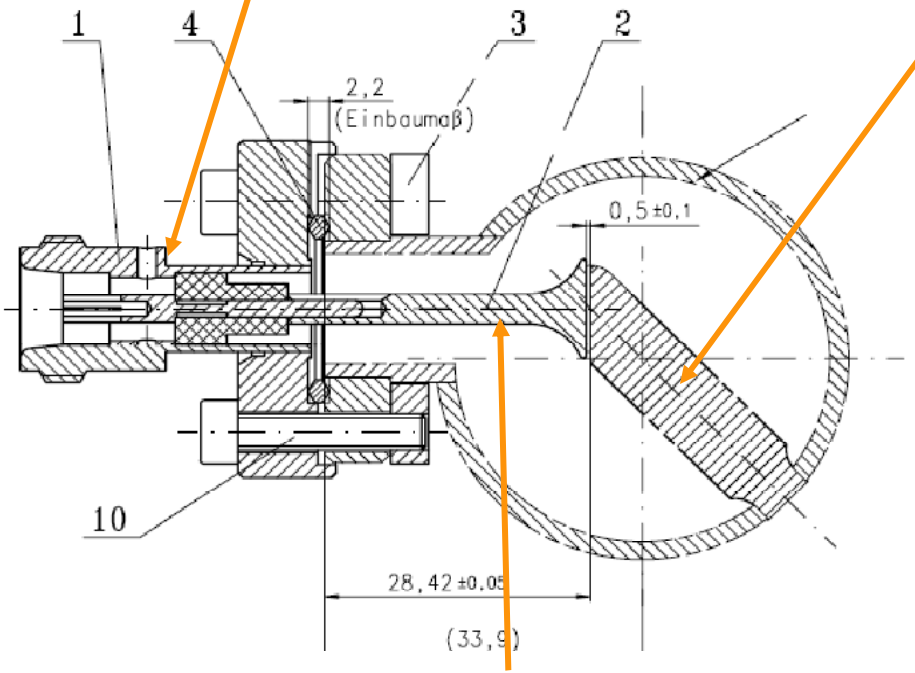
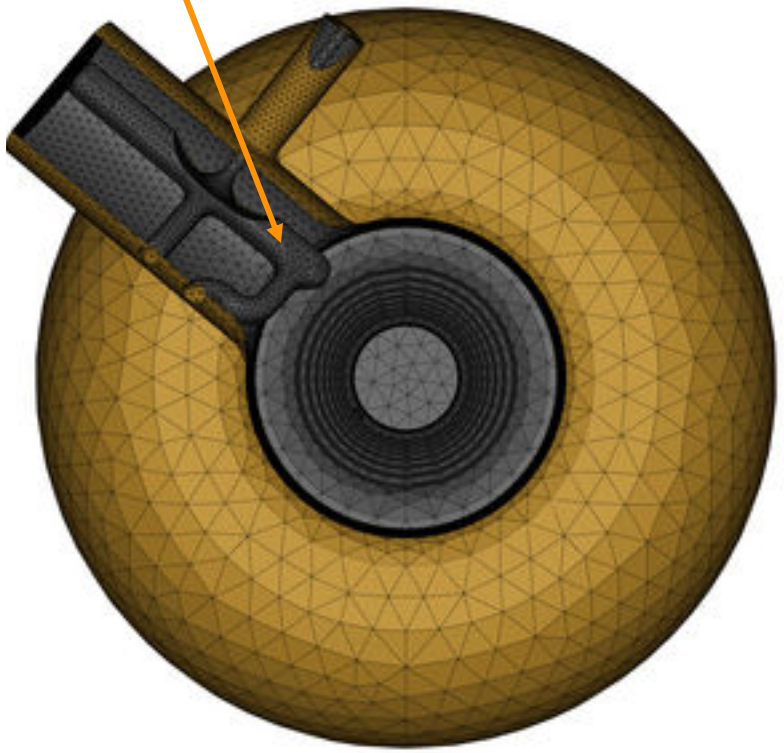
1. HOM Coupler

FLASH feedthrough

F-antenna for electric and magnetic coupling





Niobium antenna

European XFEL

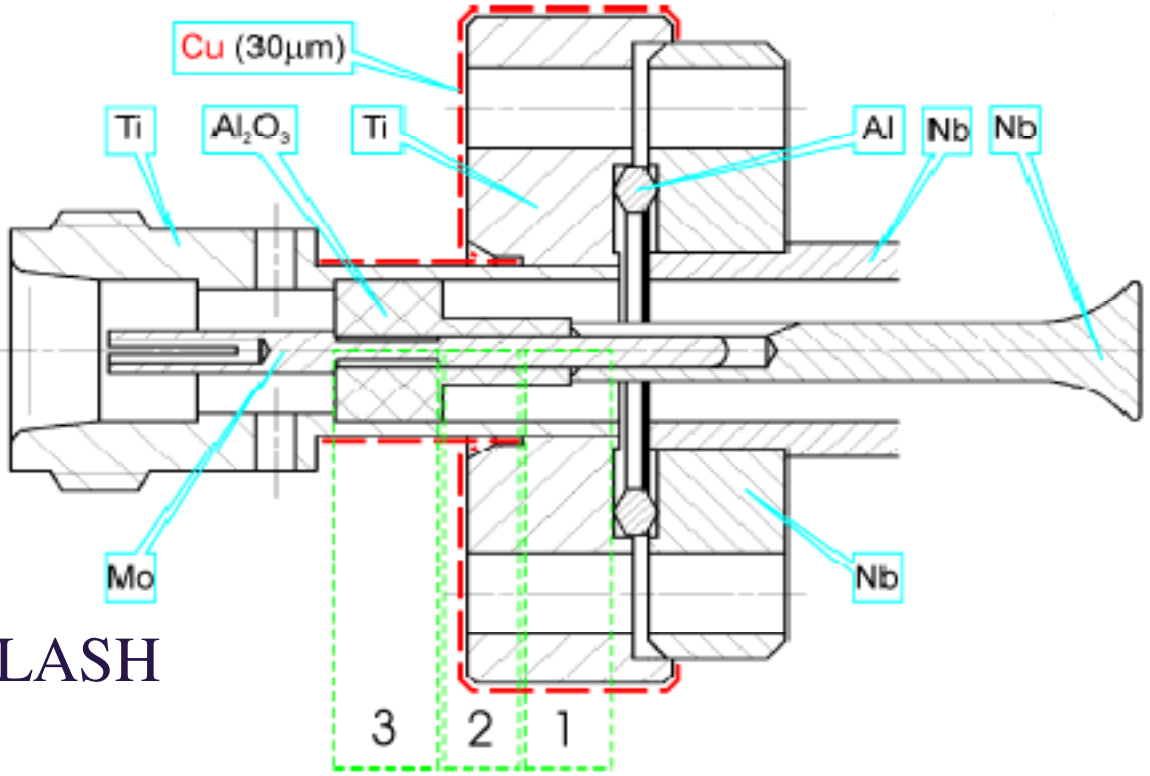
2. HOM Coupler Feedthrough

KYOCERA

SMA-R-Ti, but:

- N – connector
- copper plating

used for the
2nd cavity production in FLASH



DESY HELMHOLTZ ASSOCIATION

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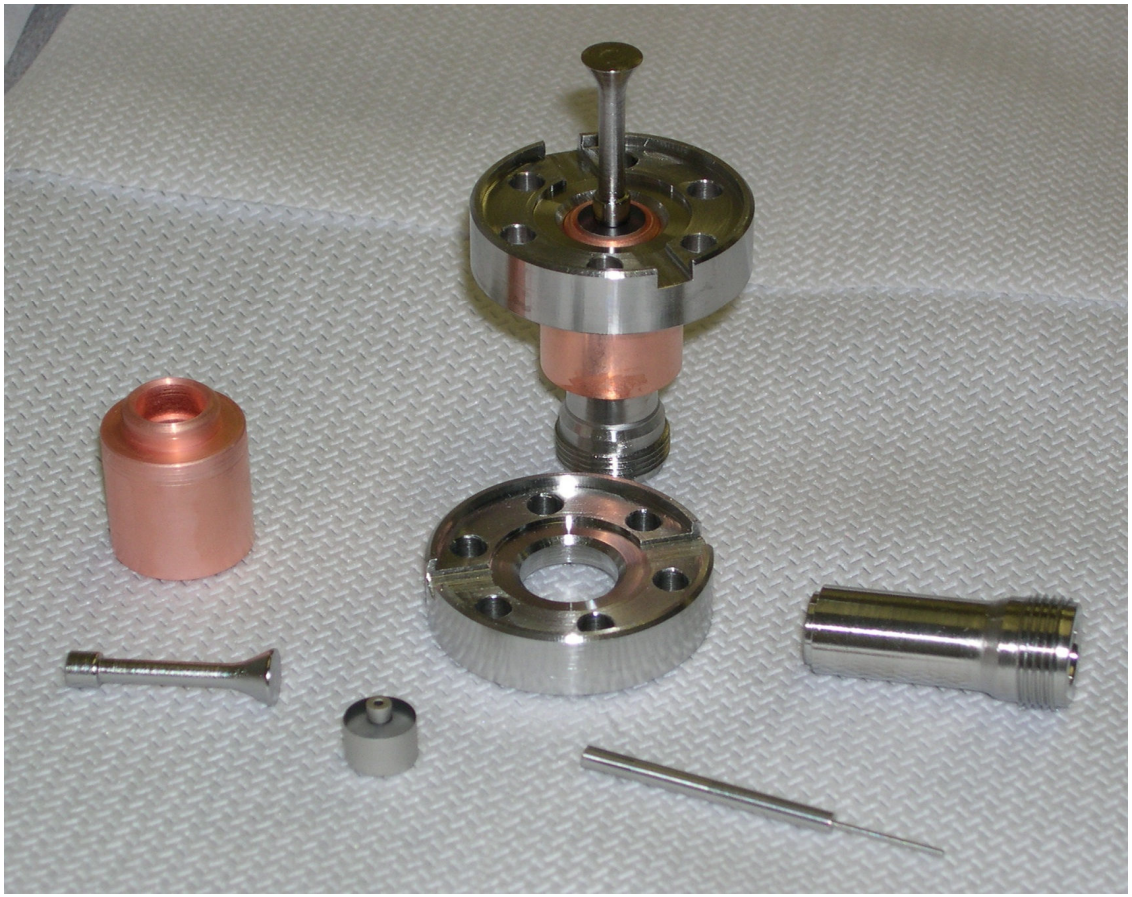
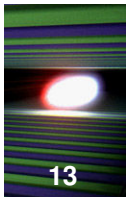
3. HOM Coupler Feedthrough

- Jefferson Lab development
- higher thermal conductivity
- plan for XFEL: already assembled at vertical cw test (much higher power)
- vertical cw tests at 9-cell cavities under way



European XFEL

1. Tuner Specification



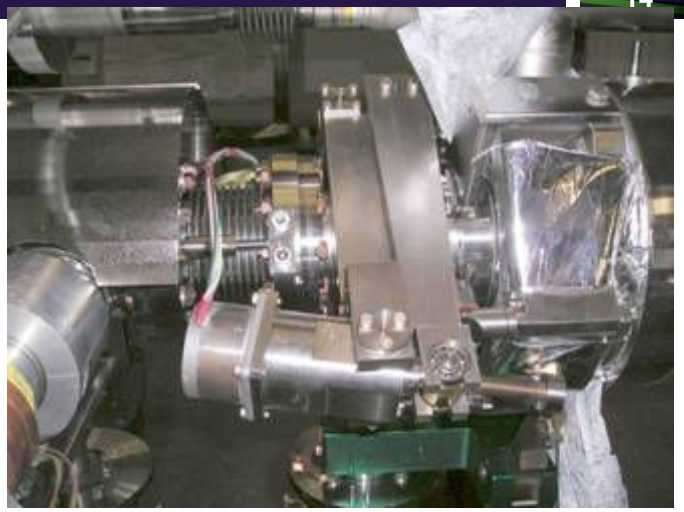
- Required tuning range:
  - Slow: 800 kHz ~ 2 mm
  - Fast: 1 kHz ~ 3um
  - Resolution: Better than 1Hz/step
- Operating conditions inside the cryostat
  - Isolation vacuum
  - Temperature ~2 K
- Stiffness of the mechanical part
  - Better than 20 um/kN
  - Hysteresis-free
- **Proposed solution**
  - Mechanical lever arm system with stepping motor (slow) and piezo elements (fast)

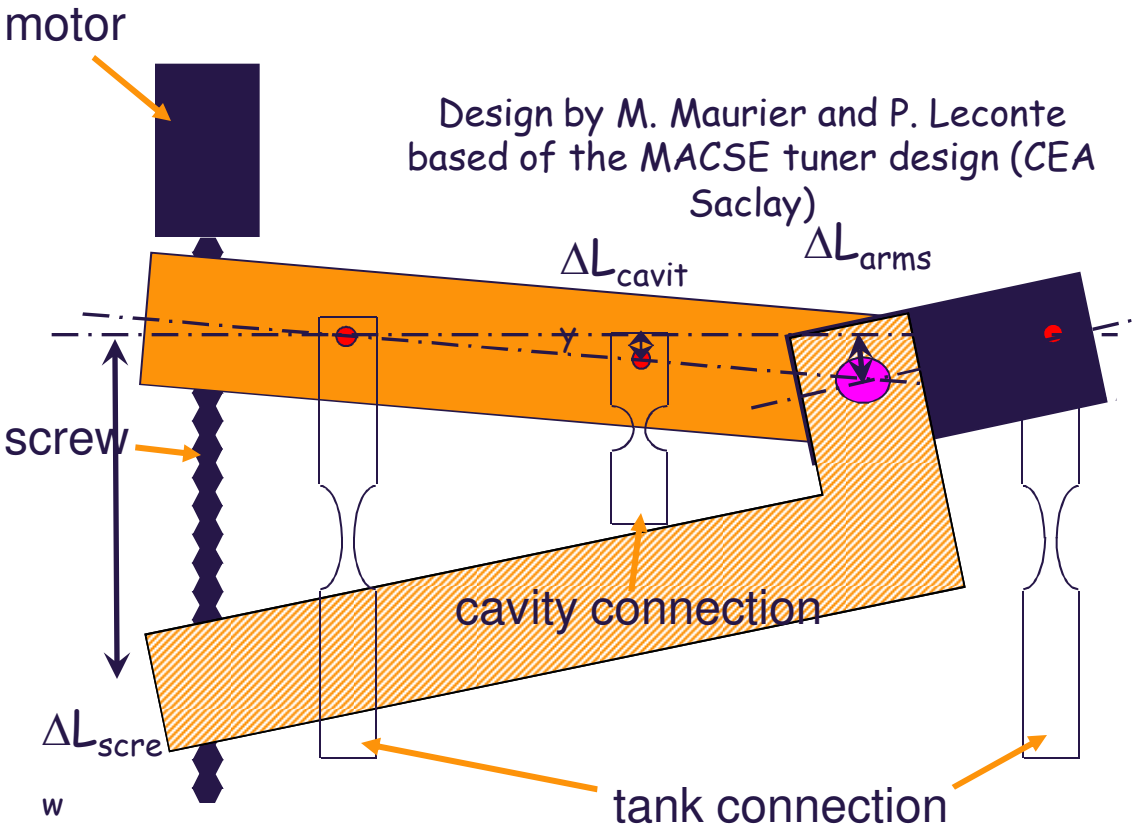
L. Lilje, DESY, Hamburg

2. Tuner Design

Current design in use at FLASH

- Design by CEA
- Fast piezo detuning introduced not from beginning





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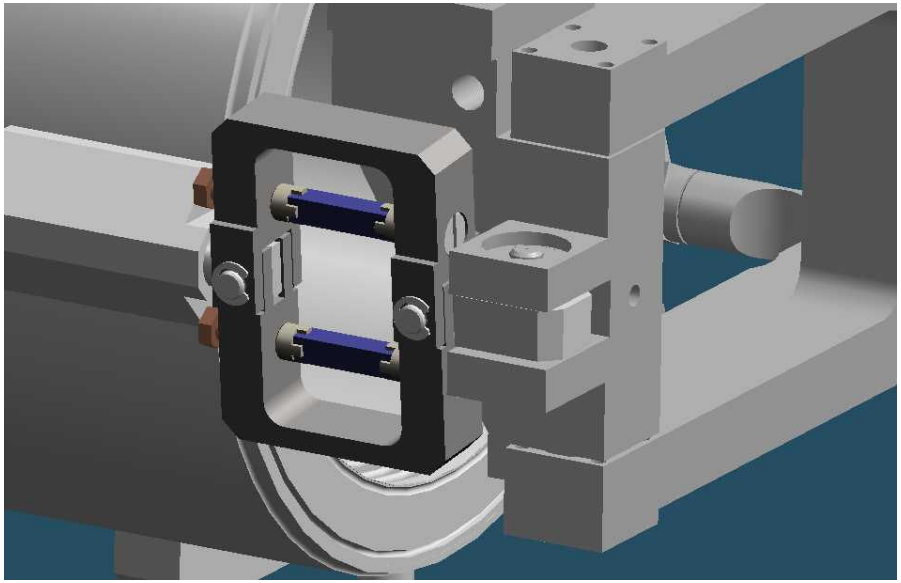
2. Fast Tuner with Piezos

- Maximal load:
  - <5 kN
- Operating temperature
  - 4 -10 K in isolation vacuum
  - Stroke (and capacity) reduced to about 10-20% of room temperature stroke
- Preload force
  - 0,8-1,2 kN/cm^2 for highest lifetime
- Sensor and actuator configuration
  - One active element
  - other element as sensor and for redundancy



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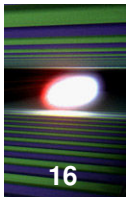
3. Tuner controls



- Control for stepping motor
  - Integrated in control system
  - Use os XFEL ‘standard’ motor controls (as for couplers etc.)
- Piezo Amplifier
  - Compact reliable prototyping underway
    - ➔ Possibly using ATCA standard crates
  - Specification available on request

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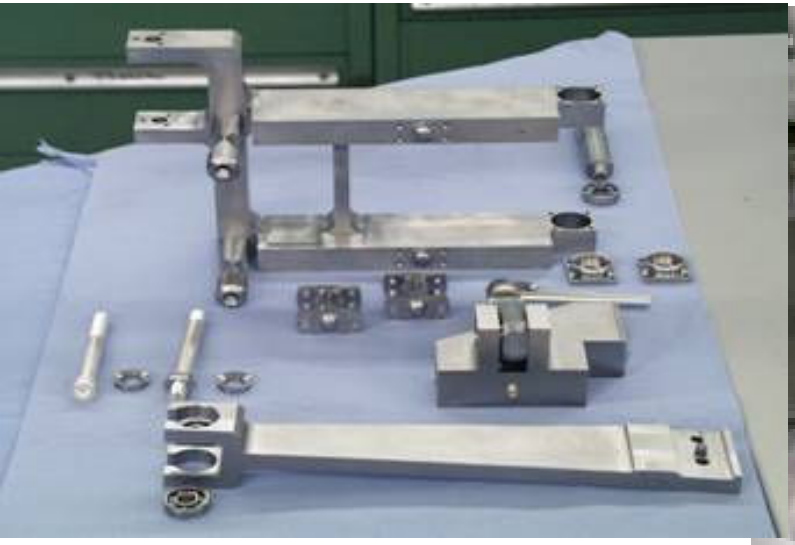
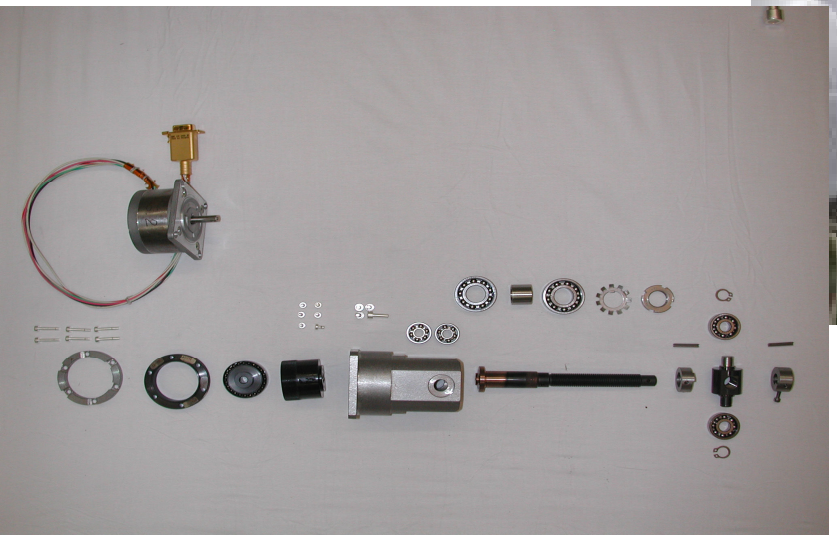
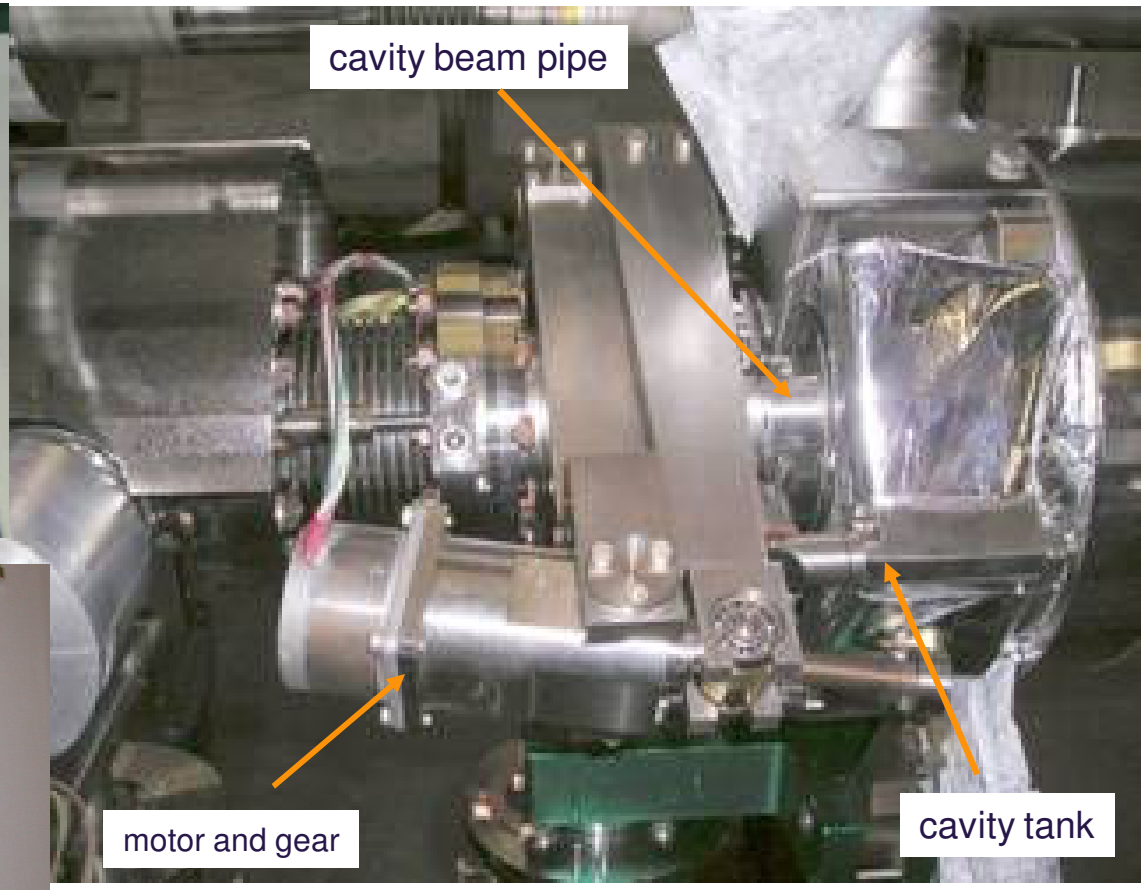
3. Tuner components







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