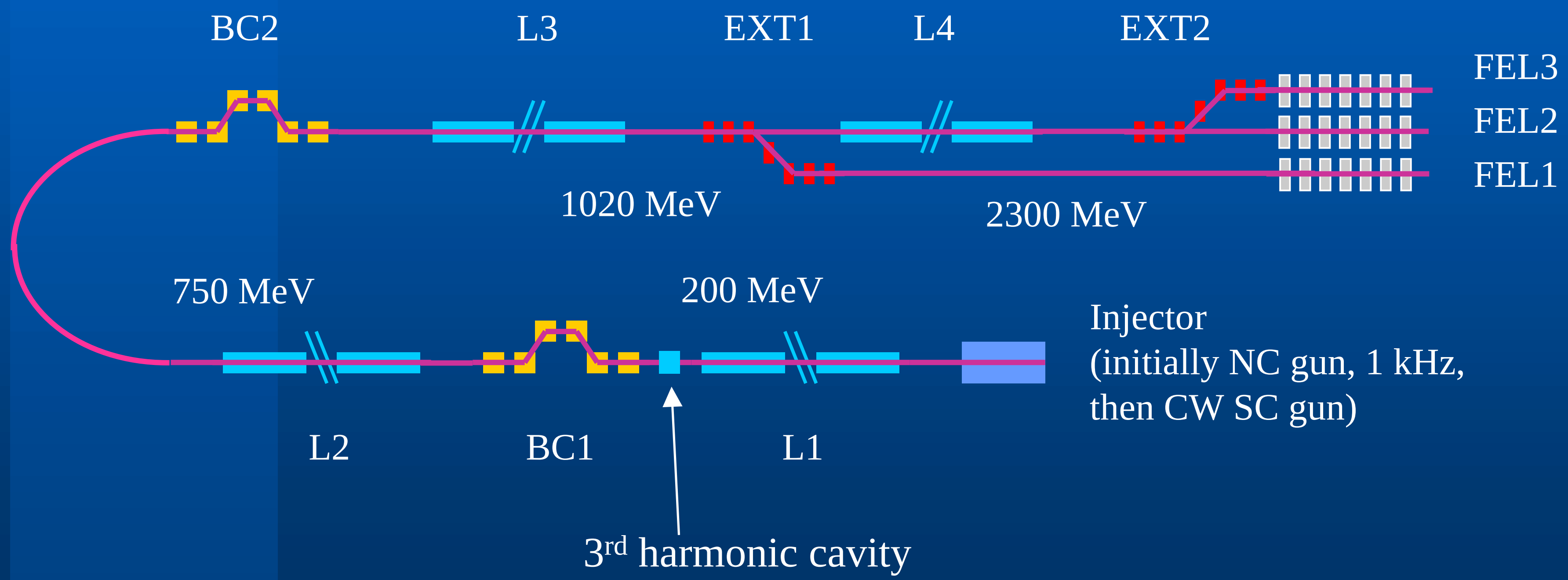
The Superconducting Linac for the BESSY FEL and the HOBICAT SC Cavity Testfacility

J. Knobloch, W.Anders
BESSY, Berlin

Linac Layout



Main Linac Technology: TESLA

- Mature and successfully operated at TTF
- Adopt this to reduce development time and cost
- R & D work and design changes only where necessary to adapt pulsed TESLA technology for CW operation

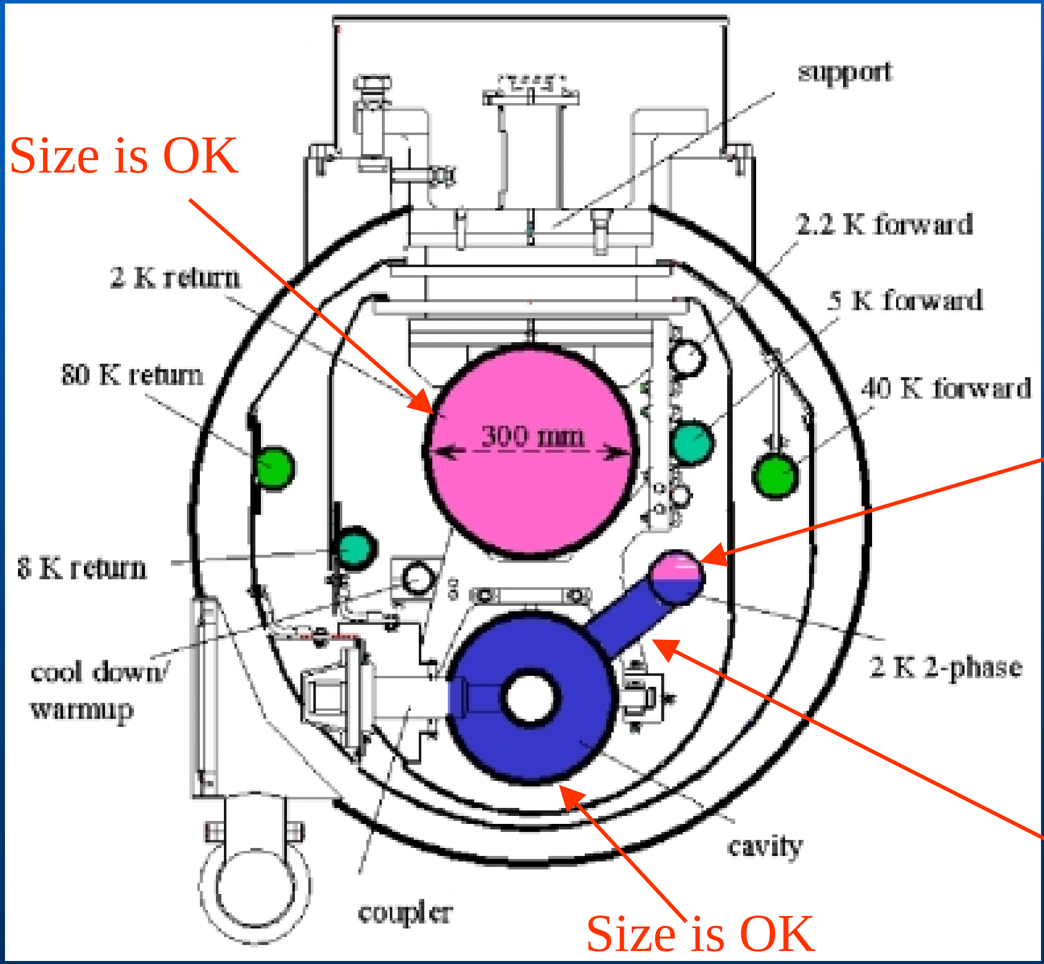
CW Operation

	TESLA	BESSY-FEL
Duty factor	1%	100%
Gradient	23.4 MV/m	15.6 MV/m
Dyn. Load	< 1 W/cavity	~25 W/cavity
Beam current	9 mA (peak)	< 75 µA
Peak RF Power	230 kW	< 15 kW
Average RF Power	~2 kW	< 5 kW
Bandwidth	400 Hz	< 40 Hz
Microphonic detun.	25 Hz	25 Hz

(Some) Issues for a CW Module

- **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

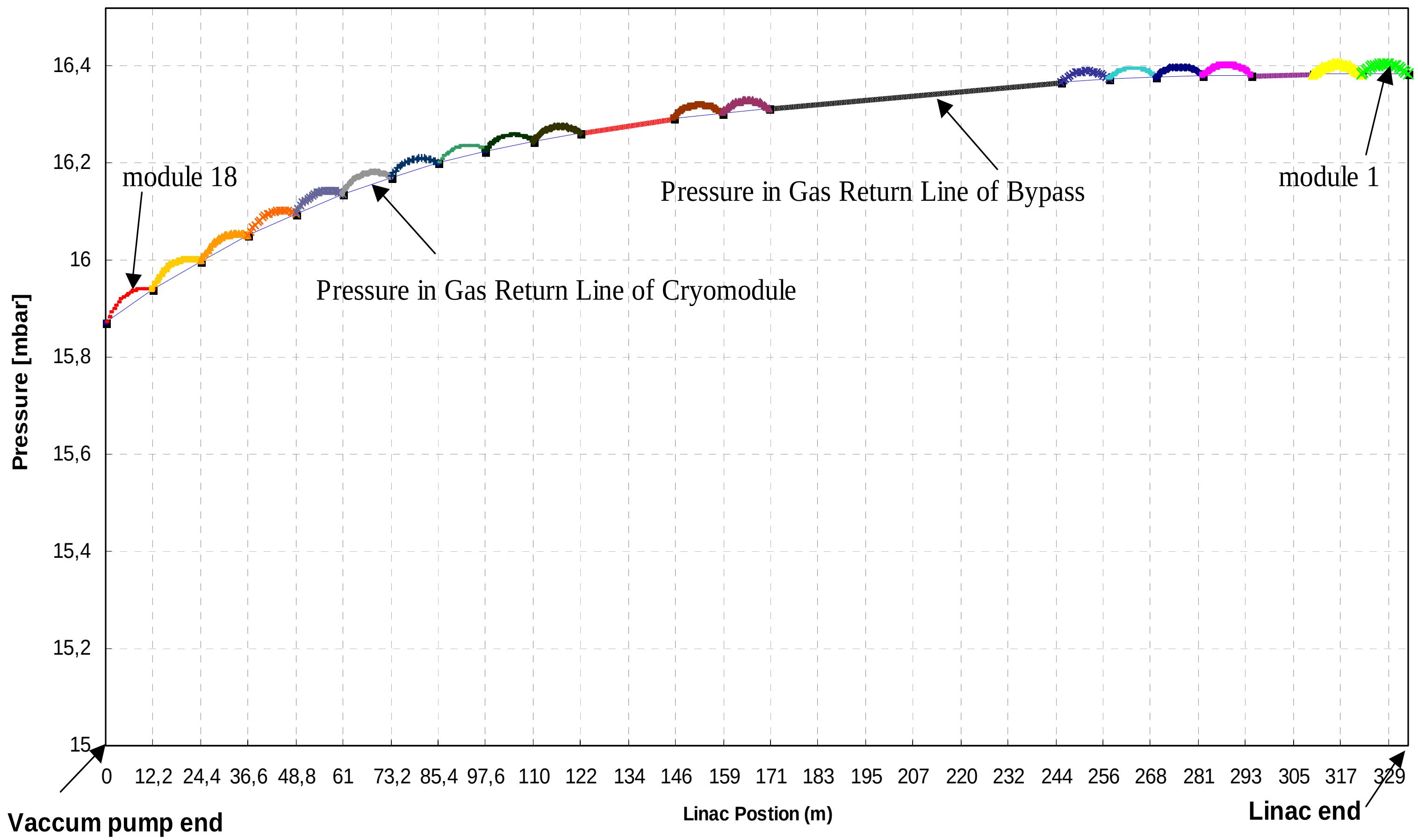
TESLA Module Redesign



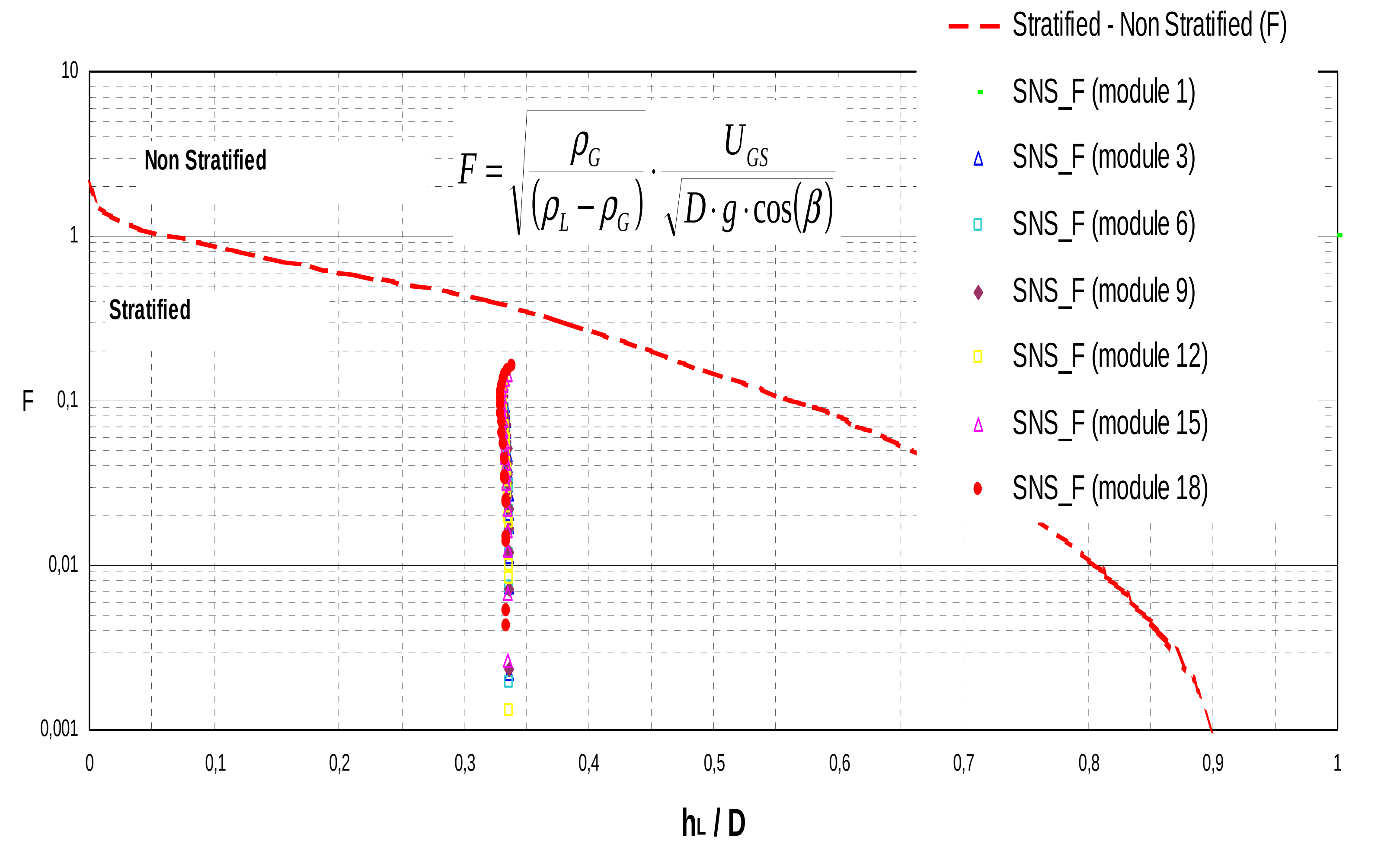
Increase size of 2-phase line (76 → 96 mm)

Increase chimney size (54 → 90 mm)

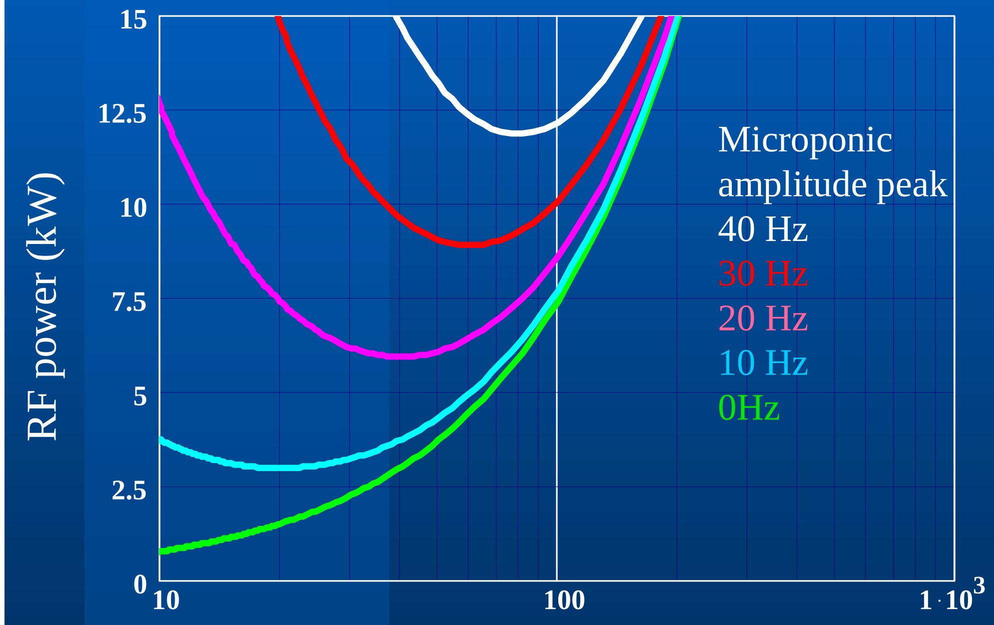
Superfluid 2-Phase Flow Simulations



Simulations of two phase flow (Yu Xiang)



Microphonic Detuning

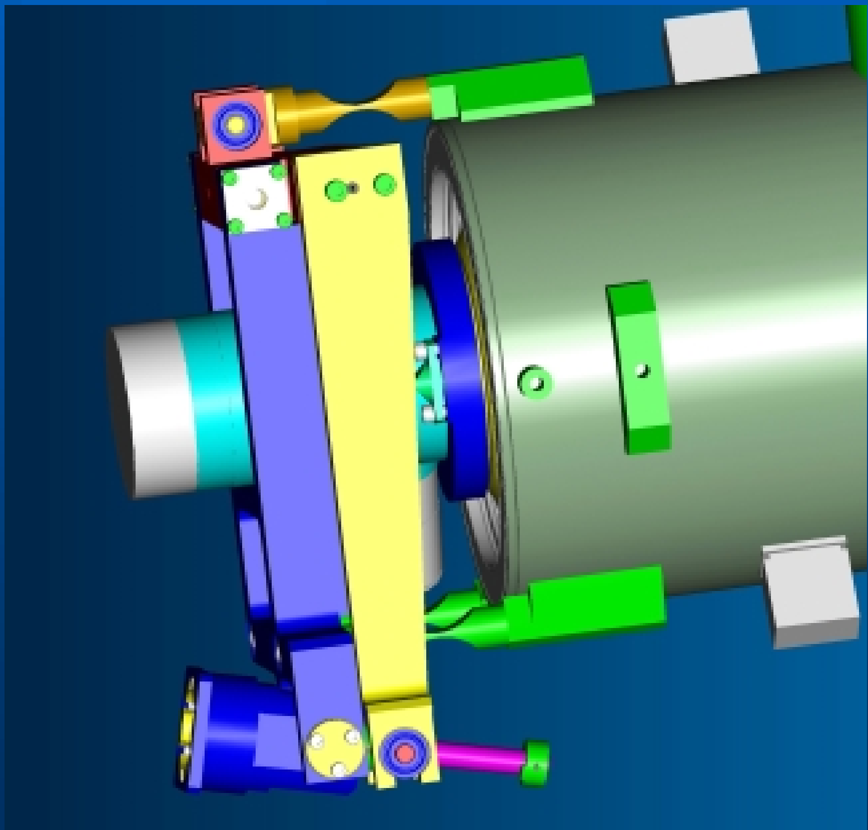


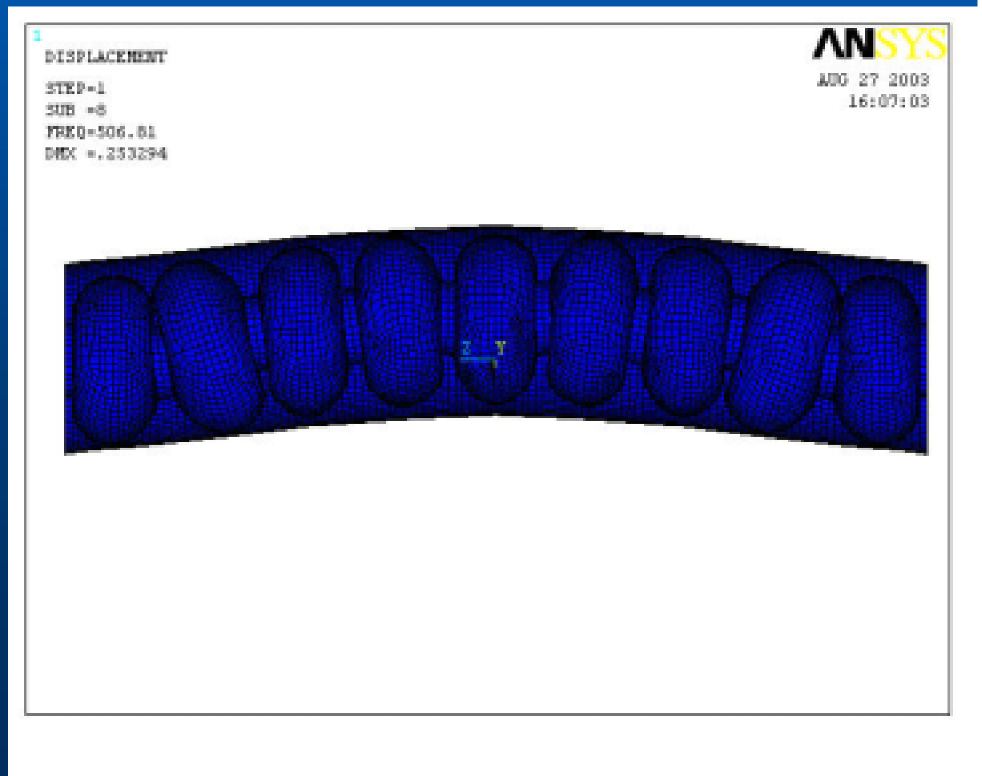
Cavity Bandwidth (Hz) controled by Q_{ext}

- **Mechanical detuning shifts cavity resonance → More power is required to maintain a constant voltage**
- **Narrow bandwidth → large power reserve needed**
- **Note:**
  - **BESSY FEL beam power at 75 µA is < 1.5 kW ← microphonics dominate**
  - **TESLA beam power = 230 kW ← beam dominates**
- **For linac trip rate < few/day need at least 10 kW peak power**

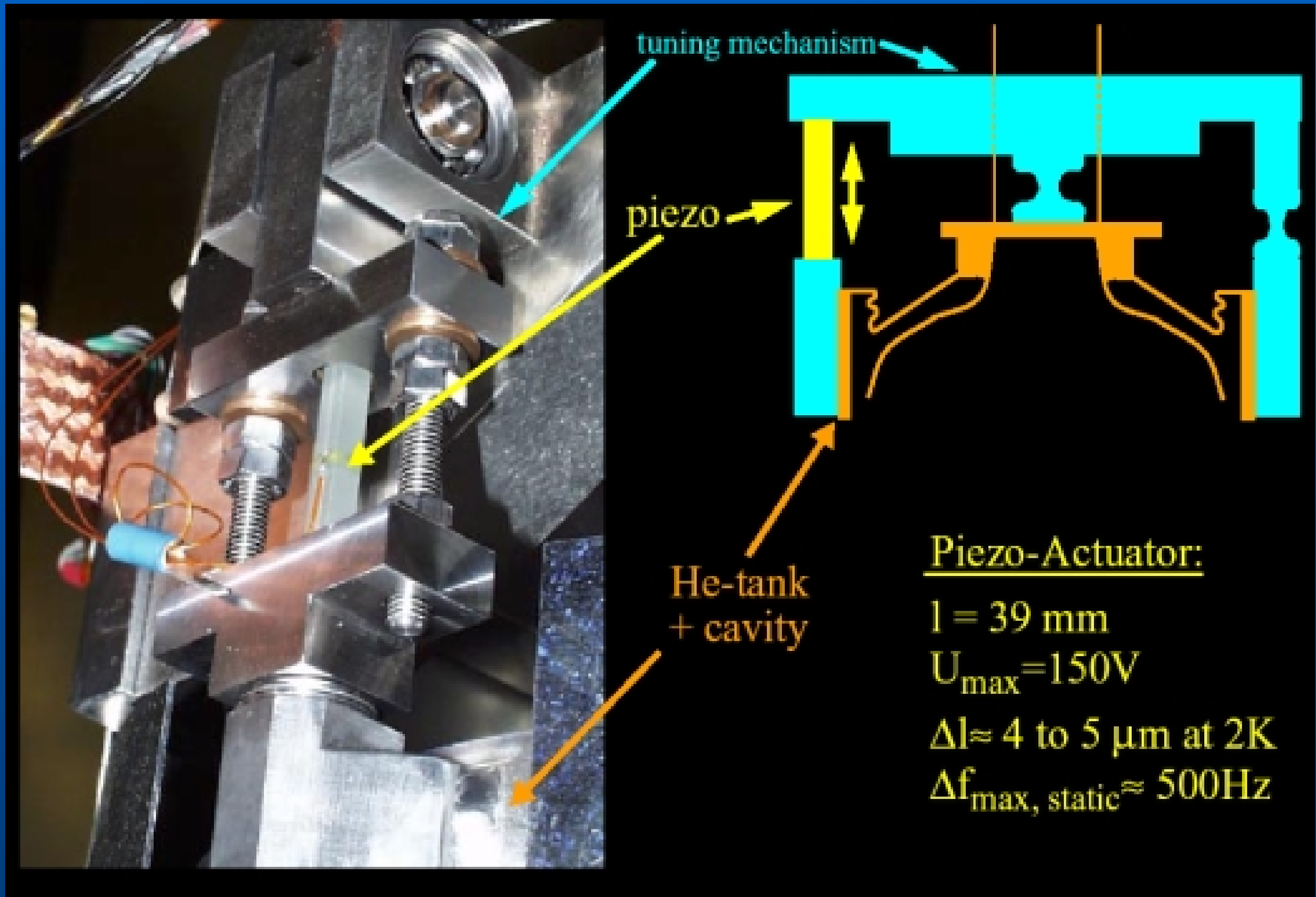
Passive Control of Microphonics

- **Damping system?**
- **Type of tuner system?**
- **Additional cavity stiffeners?**





Active Control of Microphonics

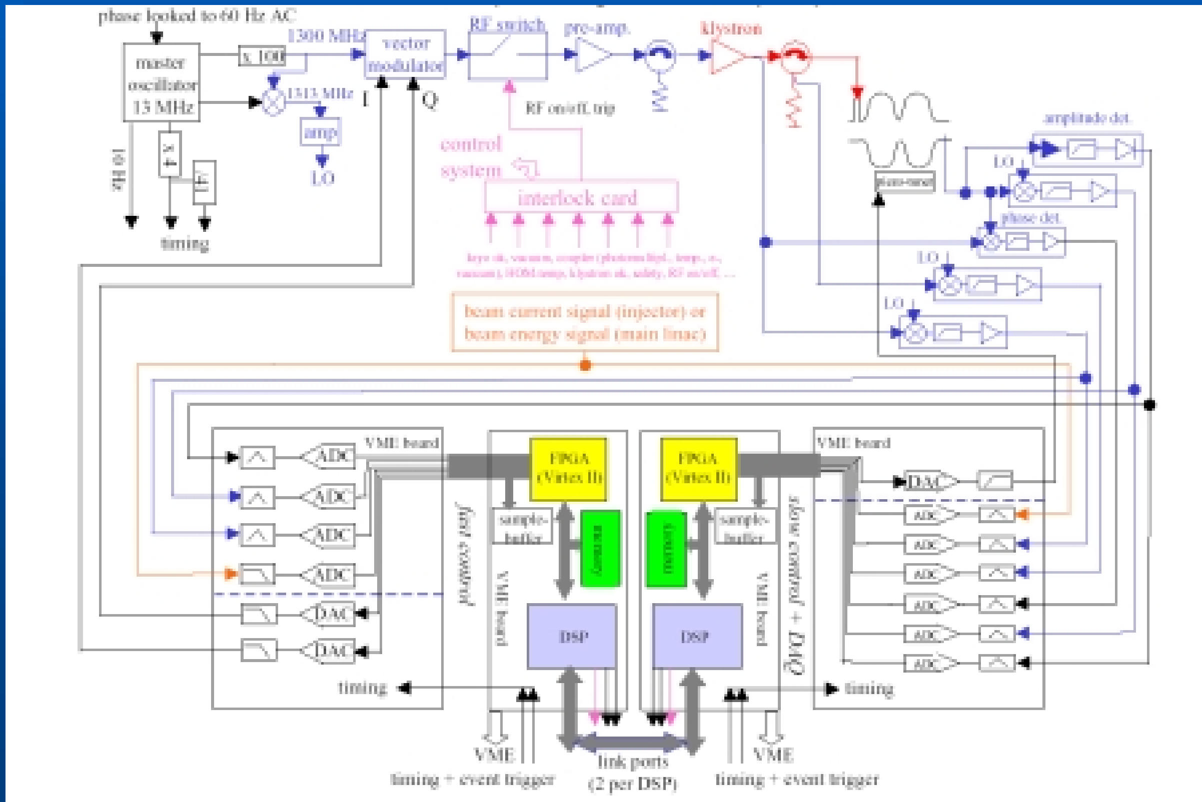


RF System Layout

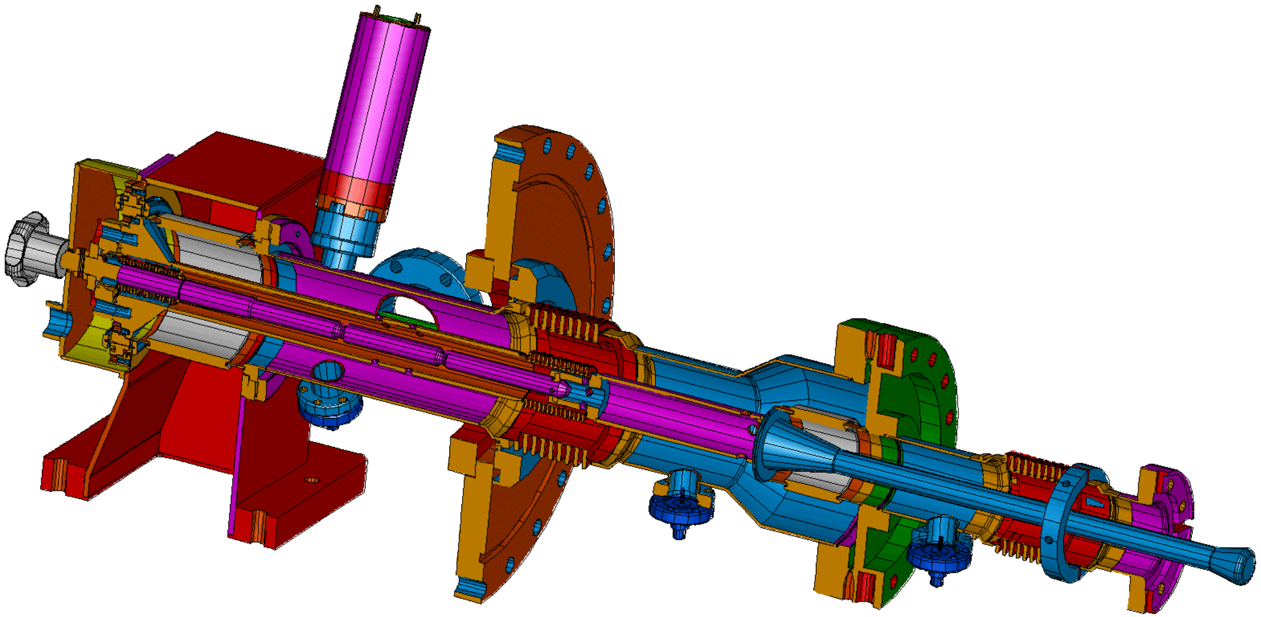
- Being developed in collaboration with Cornell
- Use 1 klystron for each cavity
  - Vector-sum control of narrow-bandwidth cavities difficult because of large fluctuations of V_{cav} due to microphonics
  - Independent, flexible operation of each cavity
- 15 kW of RF power per cavity
- Digital feedback for low level RF
  - Flexible
  - Programmed start up of linac
  - Easy implementation of feed forward

RF Control System

- **System being developed in collaboration with Cornell**



Input Coupler



- CW (SW) power limit to be tested in collaboration with KFZ Rossendorf, Cornell & ACCEL
- ANSYS simulations at BESSY

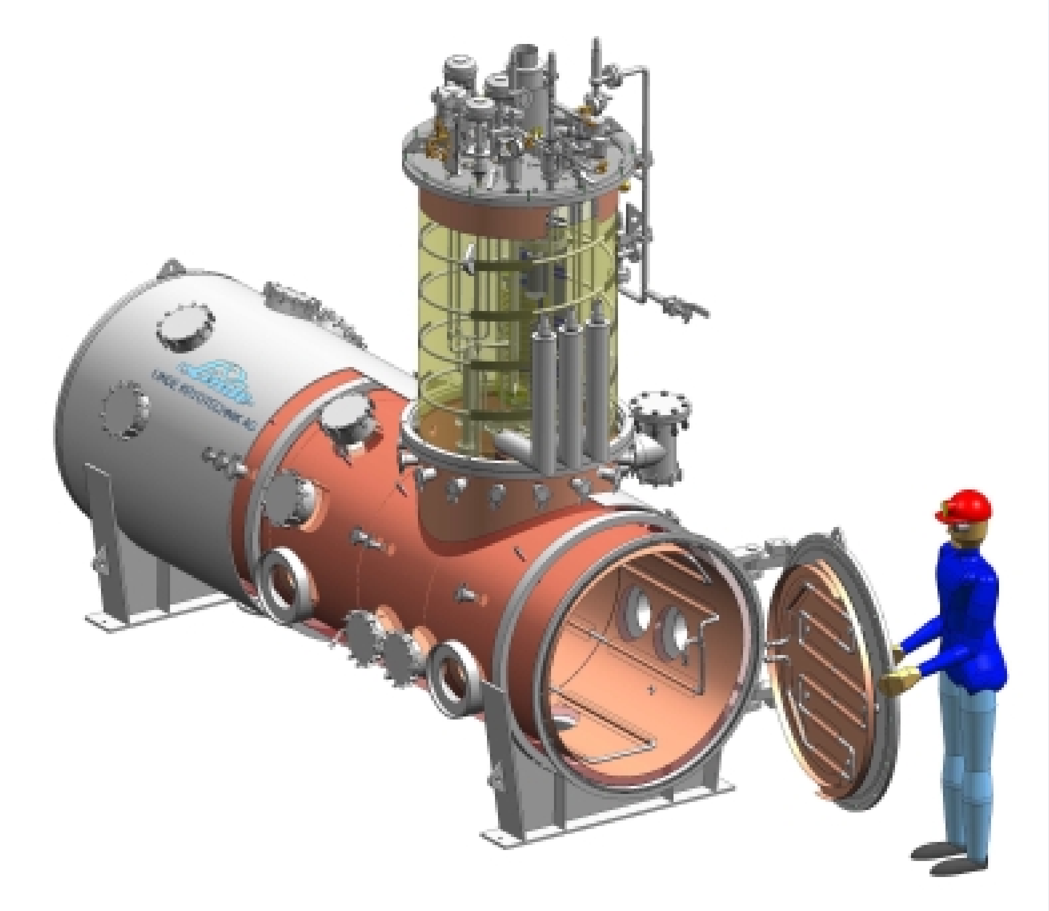
BESSY Test Facility

- Need test facility to
  - Gain practical experience to address the outstanding issues
  - Gain operating experience of srf technology
- Components should be operated under similar conditions as in BESSY FEL
- Maintain easy access to components to permit modifications

→ Build the HoBiCaT facility for a two cavity „module“

HoBiCaT Cryostat

- **HoBiCaT Cryostat being built by Linde**
- **Delivery 11/2003**



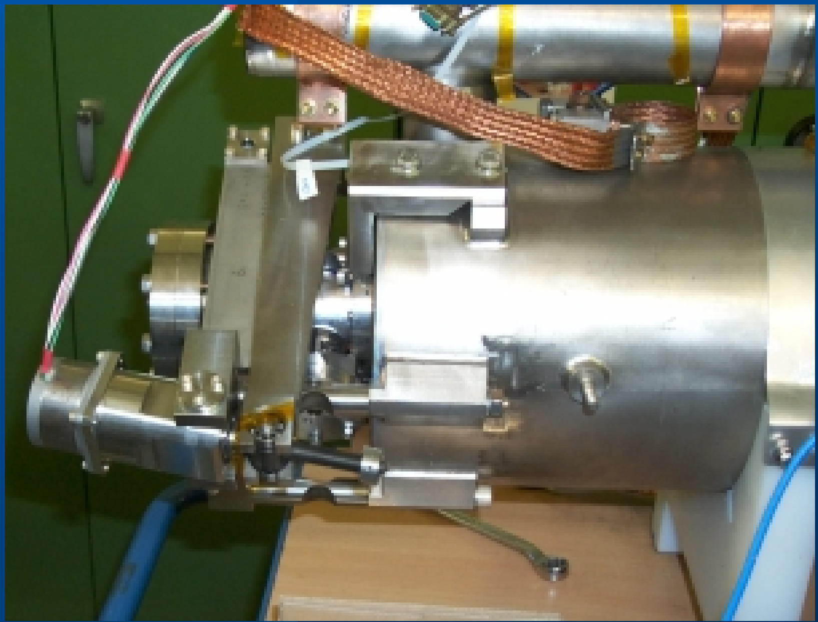
Cavities

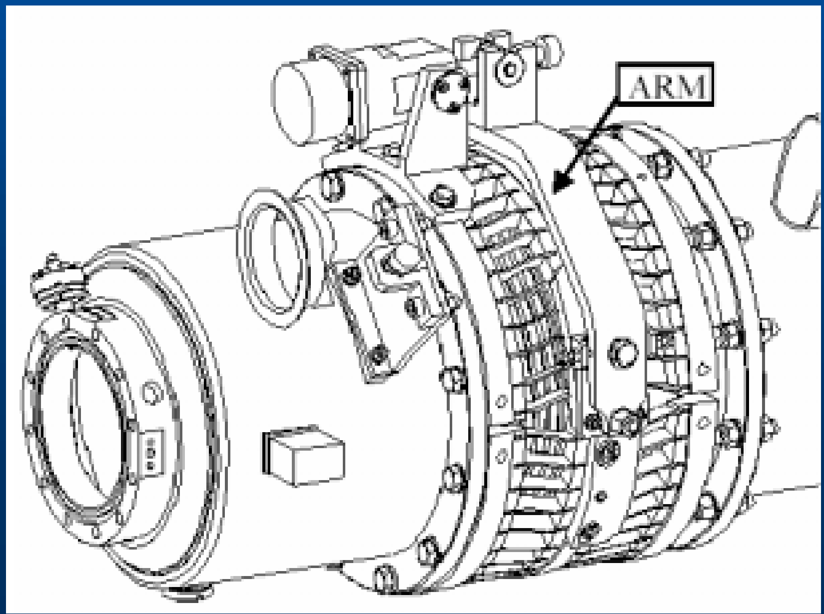
- **2 Cavities complete in 12/2003**

First BESSY TESLA cavity

Tuner

- 2 Tuners to be delivered this month
- Second design will be loaned by TESLA





Refrigeration

- **Linde refrigeration coldbox TCF50 for 4.2 K LHe in operation**
- **Pumps for 1.8 K operation delivered**
- **HoBiCaT radiation shielding in assembling phase**

TCF50 cryoplant

Vacuum pumps

HoBiCaT radiation shielding

RF Power

- 10 kW Klystron to be delivered by CPI in 10/2003
- 20 kW IOT planned for 2004
- Transmitter power supply by FUG in 1/2004
- 1 kW solid state amplifier in operation

HoBiCaT Test Program

- **First Tests expected early 2004**

- **RF control at of narrow-bandwidth cavities**
- **Causes and impact of microphonics**
- **Tuner characterization**
- **Fast piezo tuning**
- **Pressure stability and cryogenic operation**
- **CW operation of input coupler**
- **Cavity Q measurements as fn(*T*) and fn(*V*)**
- **Experience with IOT transmitter**