Blade Tuner

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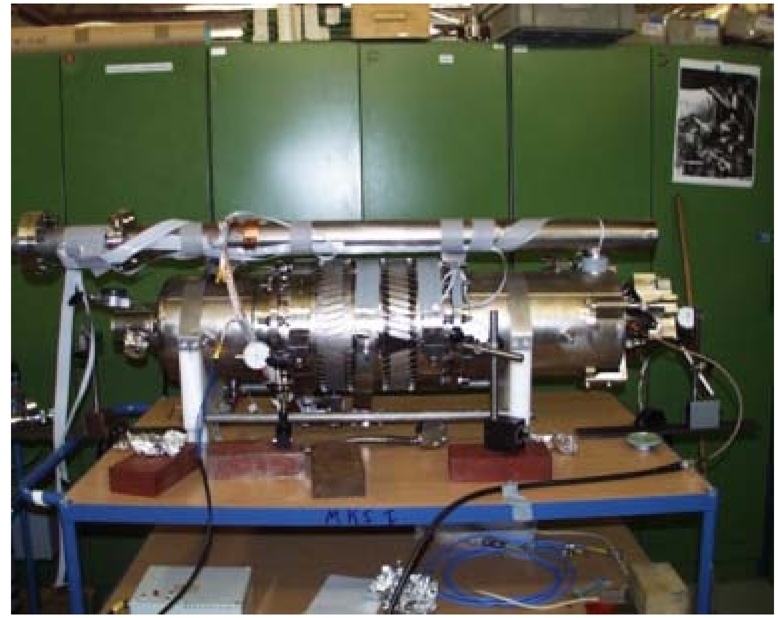
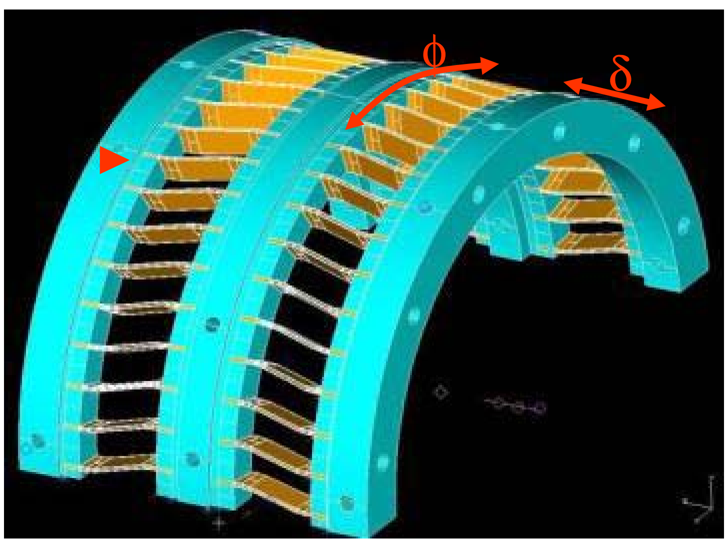
for the INFN colleagues

Disclaimer

- The slides were prepared by R. Paparella and N. Panzeri for Carlo Pagani who could not attend.
  - All from INFN Milano
- The Blade tuner was developed as a lower cost design from the original idea of a coaxial tuner by Kaiser et al. (DESY)

The coaxial Blade Tuner for superstructures





INFN Milano
H.B. Peters – R. Lange

Transforms azimuthal rotation in a longitudinal motion and allows changing the length of a cavity coaxial with it.

The ILC optimized Blade Tuner prototype

Lighter

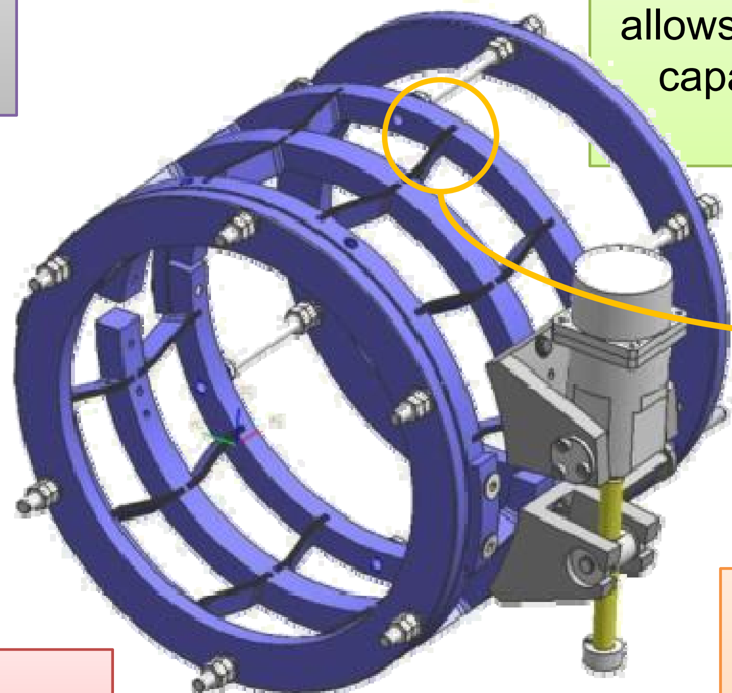
The redesign of rings allowed an important **weight reduction** (about 40%) maintaining the full symmetry with collinear blades.

Cheaper

The new geometry and mechanism lead to an **important reduction of costs**.

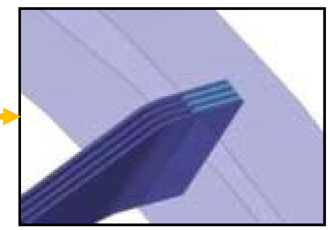
New driving mechanism

The new driving mechanism is simpler, cheaper and more compact, simplifying the installation of an external magnetic shield.



Ready for future steel tank

The tuner can be **built both with titanium or stainless steel rings**. The use of an high strength alloy for blades allows to exploit the full tuning capabilities without plastic strains.



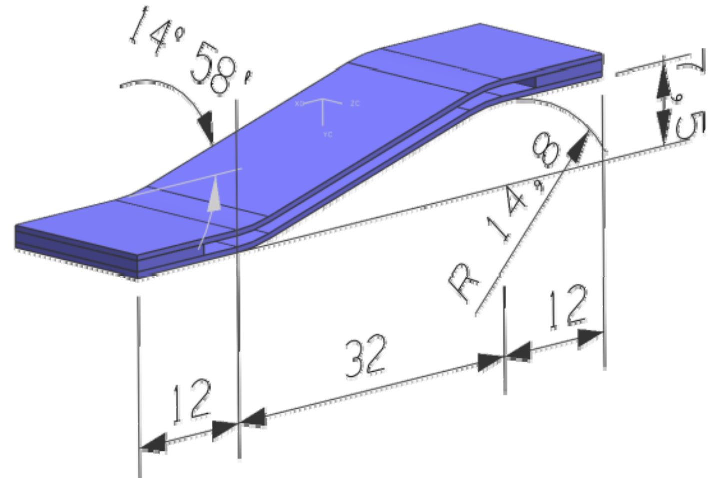
Higher tuning range

The different blade geometry adopted **improve the slow tuning capabilities** to more than 1.5 mm at the cavity level.

Evolution of the design - 1

Evolution of the blade design

First prototype

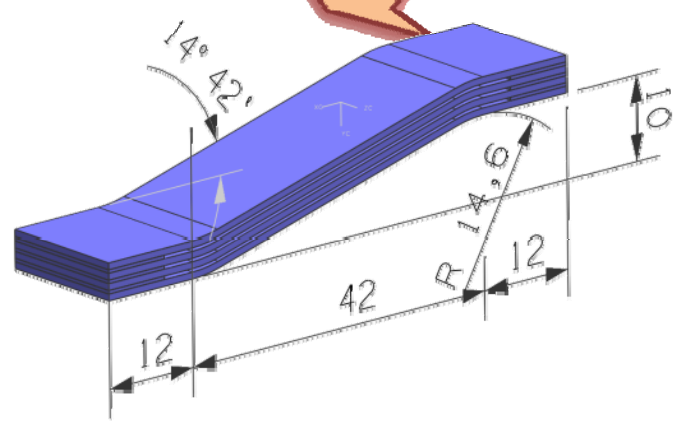


Blade pack for the blade tuner

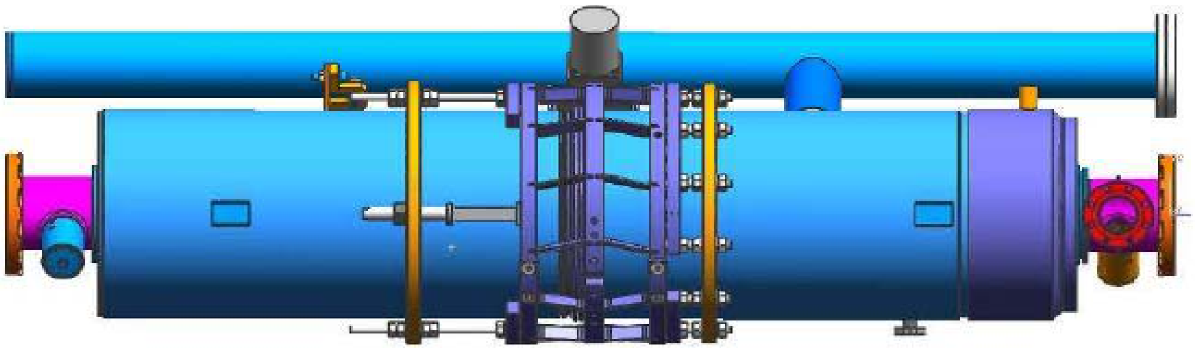
- 2 blades per pack
- Cheaper
- Tuning range = 1.3 mm

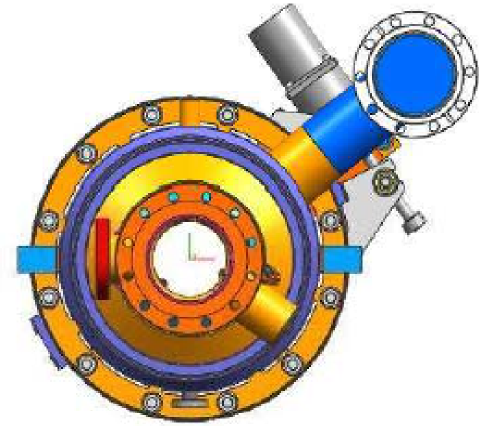
Blade pack for the slim blade tuner

- 3 or 4 blades per pack
- Lower number of eb welds
- Tuning range = 1.9 mm
- Thicker = higher strength
- Welded according to the piezo position
- Inconel and titanium version: different thickness -> same strength

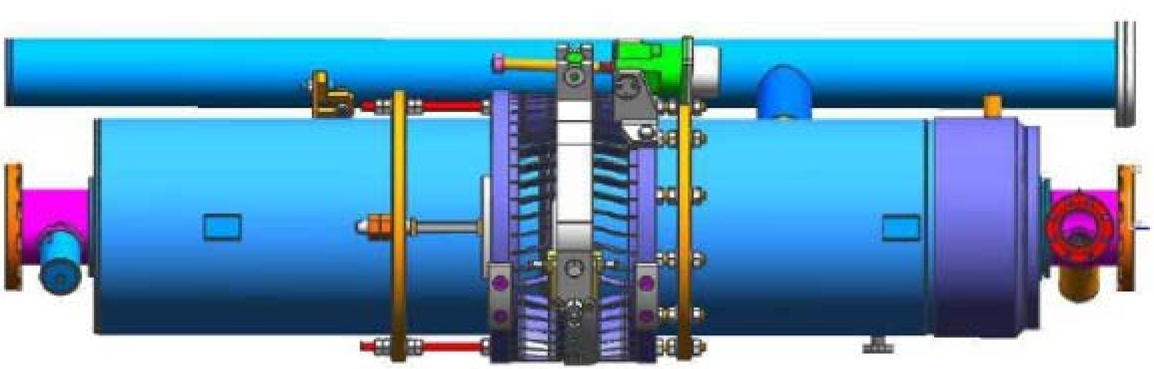


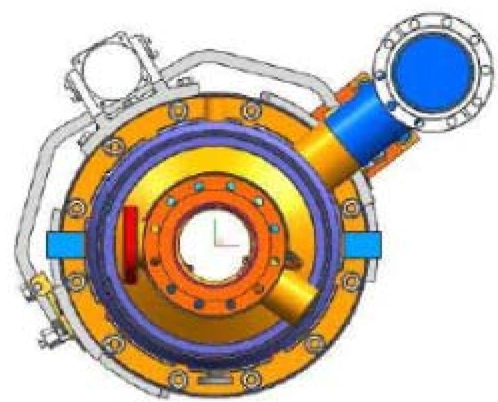
Evolution of the design - 2





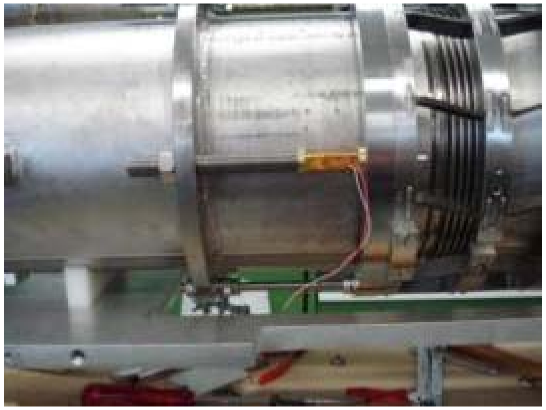
The new tuner installed on the old TTF helium tank.
Lateral and frontal views.

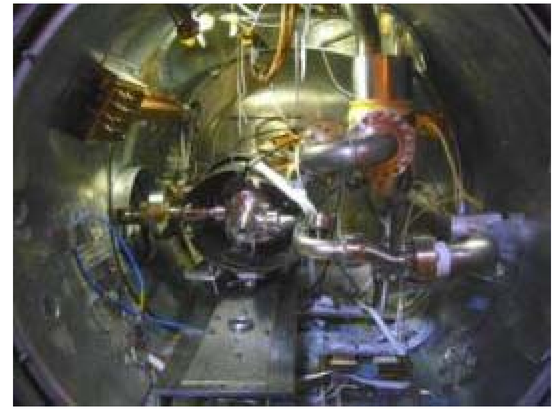


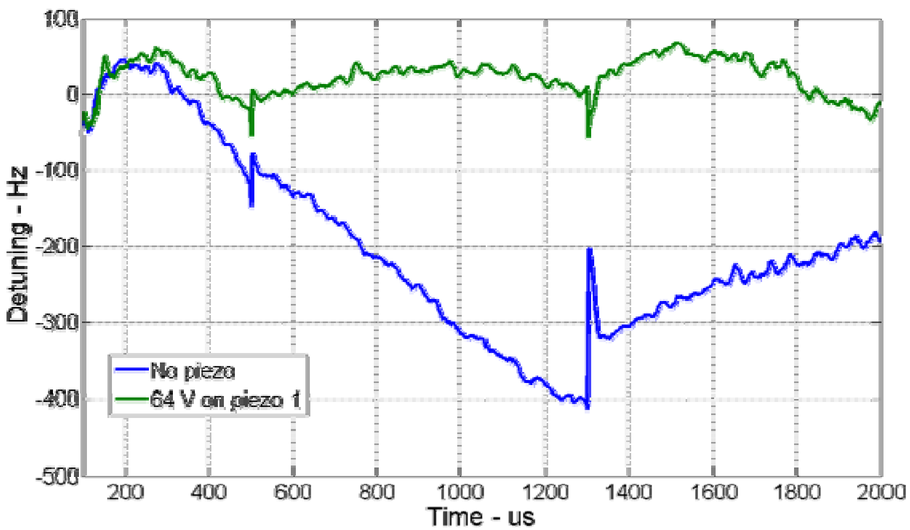


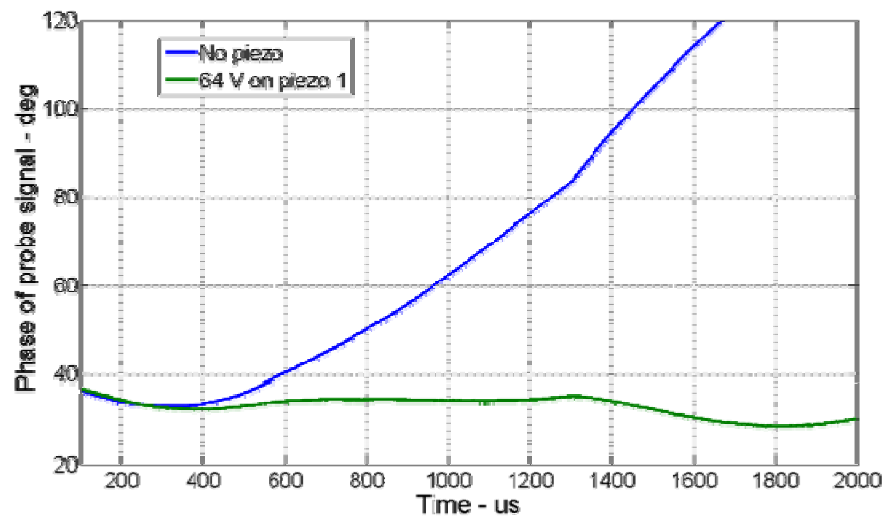
The old blade tuner installed on the TTF helium tank.
Lateral and frontal views.

Prototype tuner tested in CHECHIA









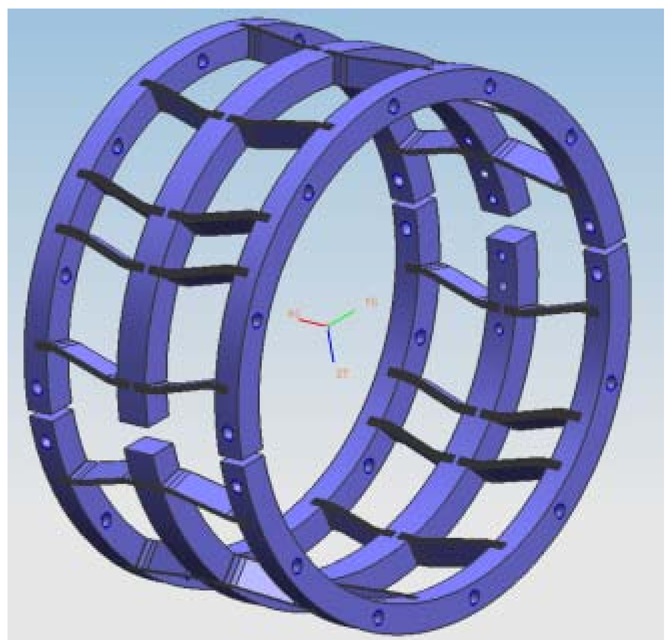
300 Hz of LFD, during the RF pulse flat top, have been compensated at the maximum Z86 gradient of E_{acc} = 23 MV/m, driving only one of two installed piezo actuators with 64 V, that corresponds to less than 1/3 of the nominal maximum driving voltage (200 V @ RT).

Lessons from the CHECHIA tests

- **What we learned**:
  - Tuning range and tuning sensitivity confirmed expectation
  - The mechanical weakness does not affect piezo compensation
  - The mechanical weakness only demands a 20-30% extra stroke to the piezo to compensate for a 20-30% larger detuning
  - The piezo stroke has large performance margin. At 23 MV/m 64 V were required on a single piezo of 40 mm length. The system is designed for up to 70 mm piezos, driven to up to 200 V. If the two piezos are operated in parallel the effect is almost twice. The safety factor at 31.5 MV/m is > 3 or > 5 (40 or 70 mm).
  - The mechanical hysteresis that was observed over the full tuning range has been further investigated. Preliminary results from on-going tests at BESSY confirm that hysteresis is significantly reduced with successive load cycles.
- **What we decided to improve**:
  - Mechanical stiffness of the whole assembly to fulfill the pressure vessel certifications according to ASME regulations: 4 bar absolute.
  - Effective stiffness of the tuner on the piezo position, this will also further increase the already large compensation margin.
  - Mechanical details for safe assembly and safe operation in the extreme conditions that could be expected during the cool-down

Improved tuner design - 1

- The experience gained with cold tests has been used to improve the design of the tuner
- 8 improved piezo Blade-Tuners have been ordered to be delivered by April this year.
- After tests they will be delivered to Fermilab for their integration in the 2° ILCTA cryomodule (to be delivered by INFN by September)
- They should represent the baseline design for the 24 complete cavities funded by EU in the framework of the FP7 contract: ILC Hi-Grade, to be delivered by end 2010.

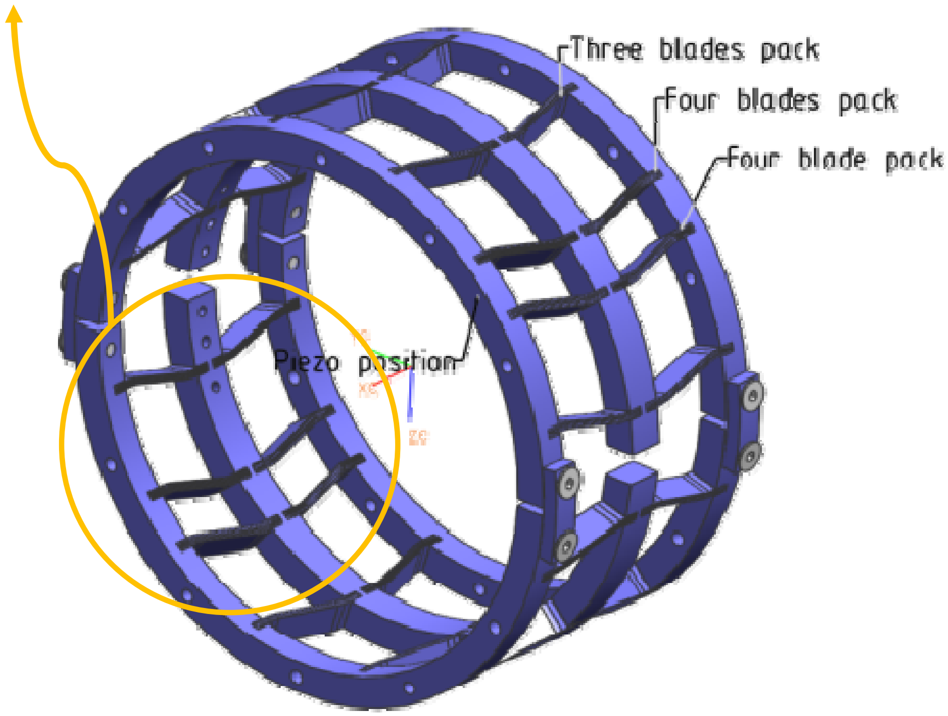


Improved tuner design - 2

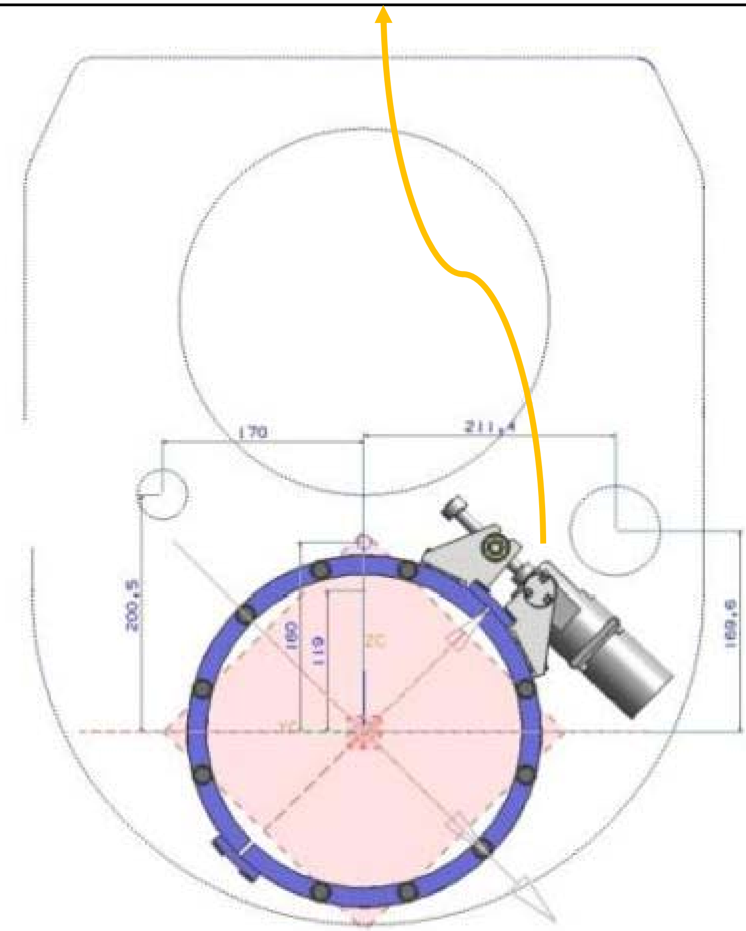
With the introduction of the piezo elements the load is not symmetric:

→ different distribution of blades: higher density where the force is transferred

→ different piezo: closer to the center of the half ring



Different assembly angle to increase the clearance with the GRP



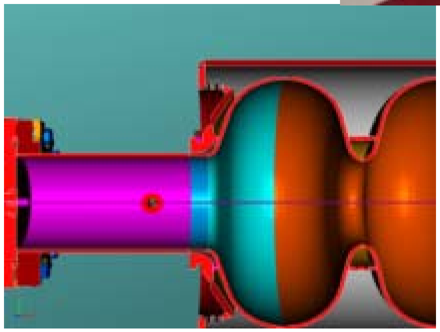
Mechanical performances

- Confirmed tuning range
  - 550 kHz full range
- Higher longitudinal stiffness
  - 35 kN/mm , ready to operate with new design end dishes
- Higher compressive load limits
  - blades buckling load > 17 kN total
  - limit compressive load > 12 kN total
- No mechanical stress on the cavity
  - titanium material for the tuner nulls differential thermal contractions
  - stainless steel and Inconel kept as an option in view of an eventual steel He vessel
- It satisfies the ASME code compliance as required for XFEL/ILC

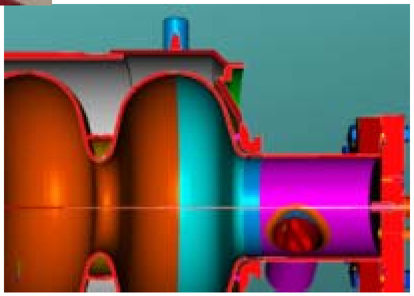
Status	**Pressure Beam pipe** mbar	**Pressure He tank** mbar	**Pressure isovac** mbar	**Temp. cavity** K
Normal operation	0	30	0	1.9
Emergency 1	0	2000	0	300
Emergency 2.1	1000	4000	0	1.9
Emergency 2.2	0	4000	1000	1.9
Leak test	0	0	1000	300

Worst conditions in traction due to the pressure difference. (→ Emergency 2.1)

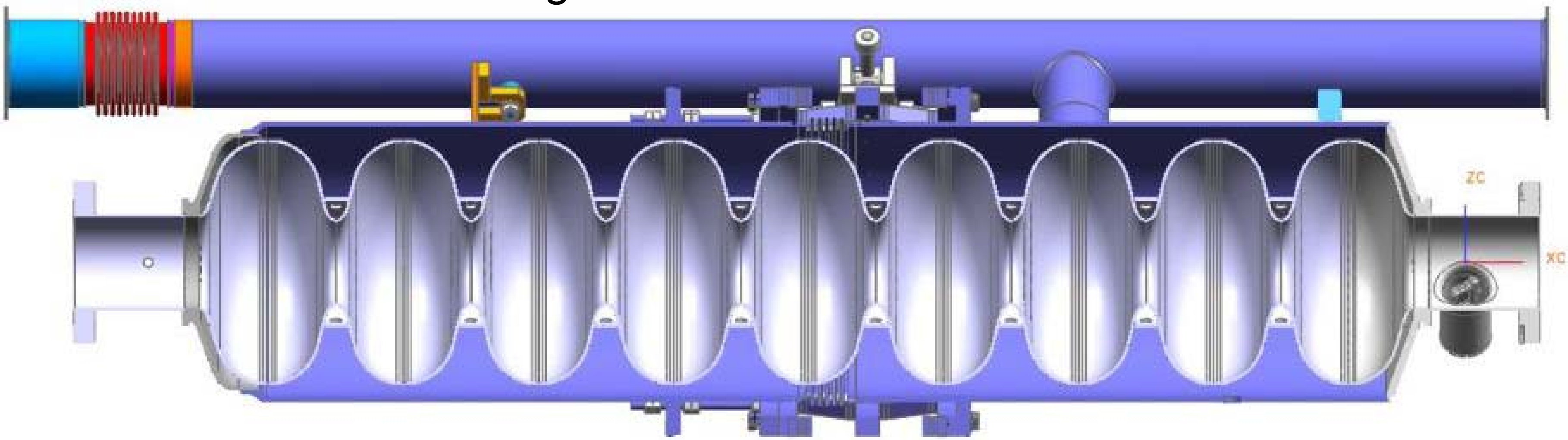
Improved and simplified Helium Tank



Present TTF dressed cavity



Design reviewed for Blade Tuner



Coaxial Blade tuner used for different cavities

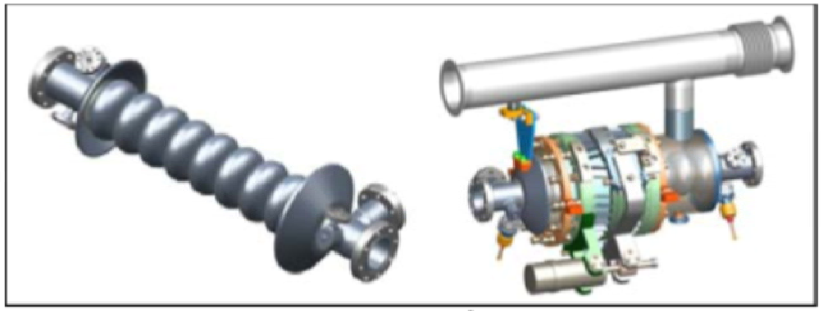
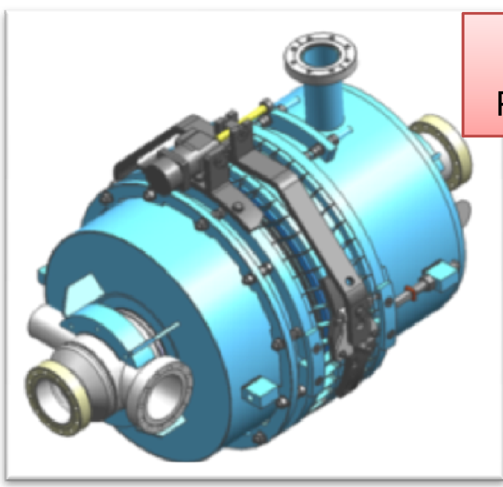
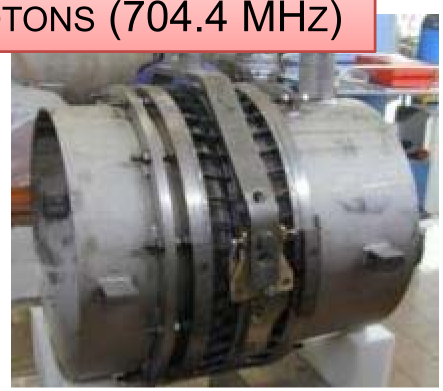


Fig.2. Naked and dressed 3rd harmonic cavity.

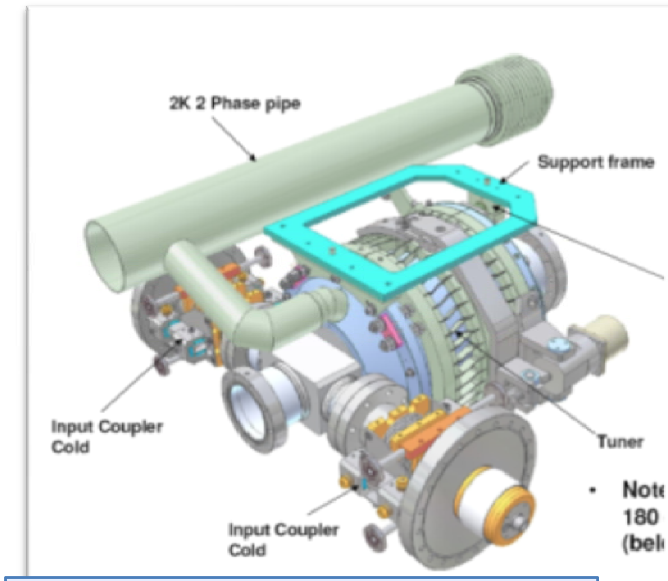
FERMILAB THIRD HARMONIC ACCELERATING (3.9 GHZ) SC CAVITY FOR NEW GENERATION HIGH BRIGHTNESS PHOTO-INJECTOR

UPENN PIEZO BLADE TUNER (ILC COLLABORATION)





LOW β CAVITY FOR PROTONS (704.4 MHz)



THE CORNELL ERL SUPERCONDUCTING 2-CELL INJECTOR CAVITY