New Tuners
for ILC Cavity Application

Shuichi Noguchi
KEK

Outline

- Brief Introduction
- New Tuners for ILC Application
  - Elliptical Cavity
  - Pulsed Operation
  - High Gradient
  - Lorentz Detuning Compensation
  - (Cavity Deformation by Maxwell Stress)

Frequency Tuner

- RF Accelerating Cavities usually have Tuners.
- They are used to tune the Cavity Resonance Frequency, in order to minimize the reflected RF power, usually.
- Tuning Accuracy << Resonant Band Width
- They must cover the Wide Range of the Fabrication Error.
- Feed-back can be used in CW operation.

Possible Error Sources

Error Sources	Magnitude / Bandwidth	Speed
Fabrication Error	Very Large	Static
Drift (Temperature, Pressure)	Comparable	Slow
Micro-Phonics (Vibration)	Small	Slow
Beam Loading (if ϕ is not 0)	Comparable	Slow
De-tuning Offset	Comparable	Offset
Lorentz De-tuning	Comparable	Fast in Transient

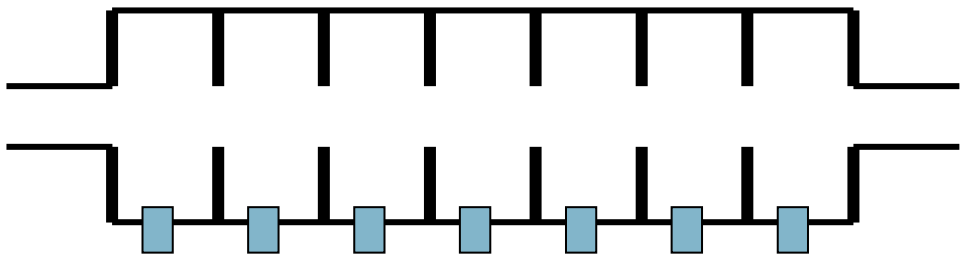
Tuning Principle : by Slater

Volume Change of ΔV → Frequency Change of Δf

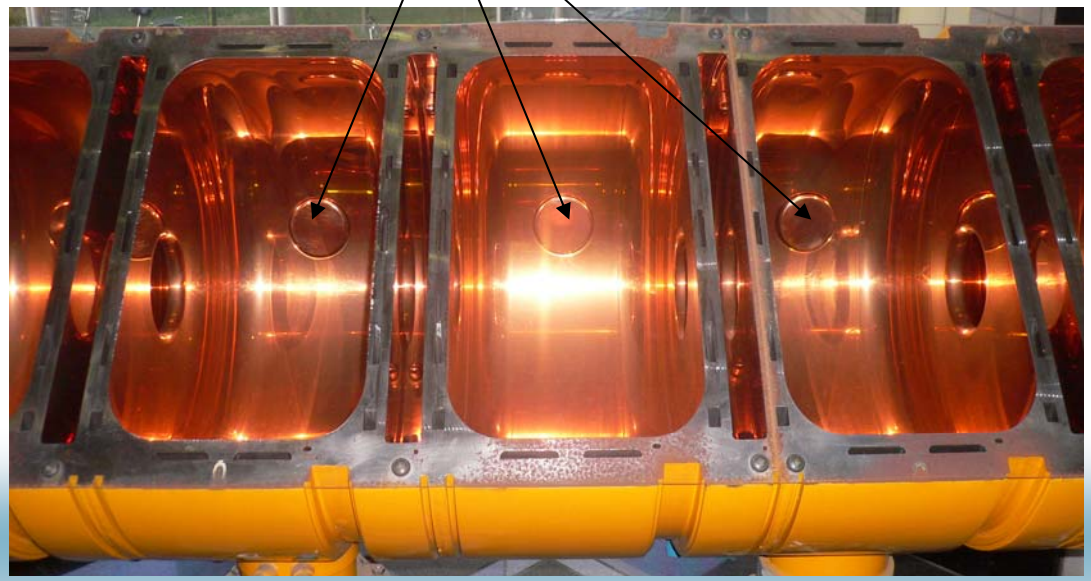
$$\frac{\omega^2}{\omega_0^2} = 1 + \frac{\int_{\Delta V} \left(\varepsilon E^2 - \mu H^2 \right) dV}{2W}$$

$$\frac{\delta f}{f_0} \approx \frac{1}{4W} \int_{\Delta V} \left(\varepsilon E^2 - \mu H^2 \right) dV$$

Normal Conducting



Piston Tuners

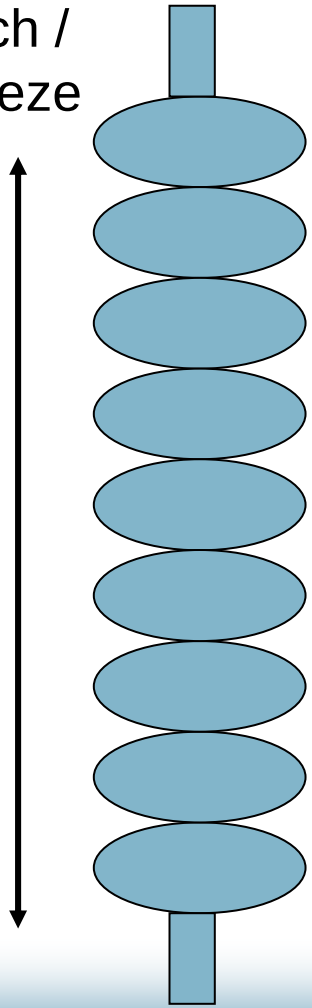


Superconducting

Stretch / Squeeze

$\beta \sim 1$

3000N/mm



New Tuners

Several Candidates for the ILC Cavity

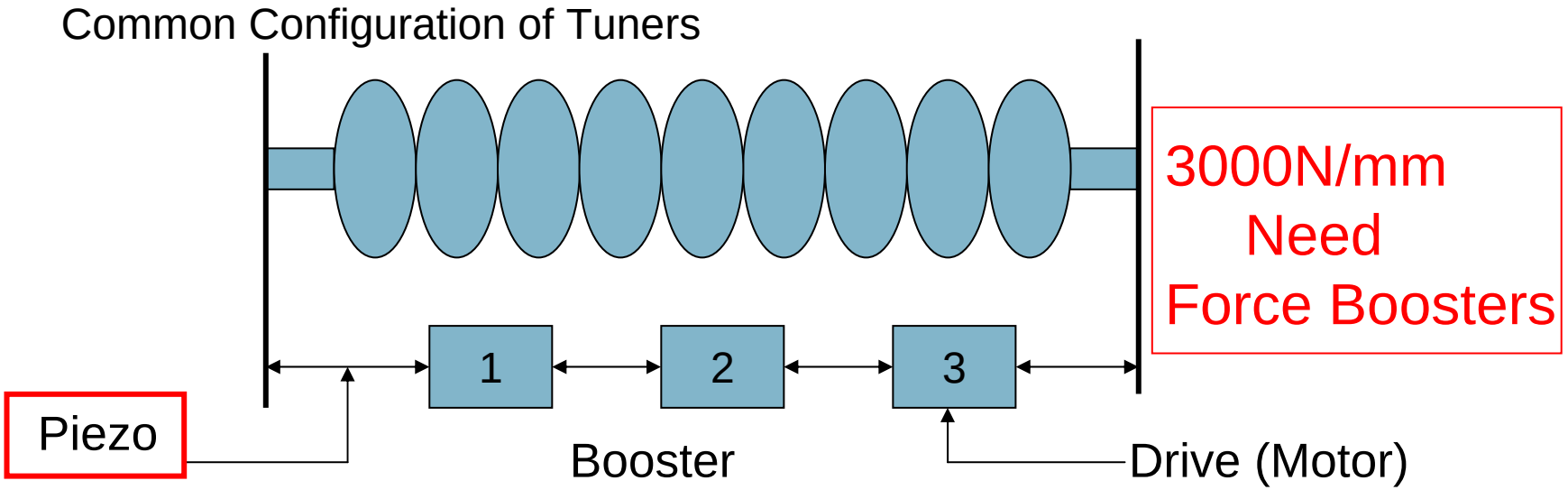
Requirement

Stroke > 2mm, Axial Force > 6000N

It must not move the Beam Axis.

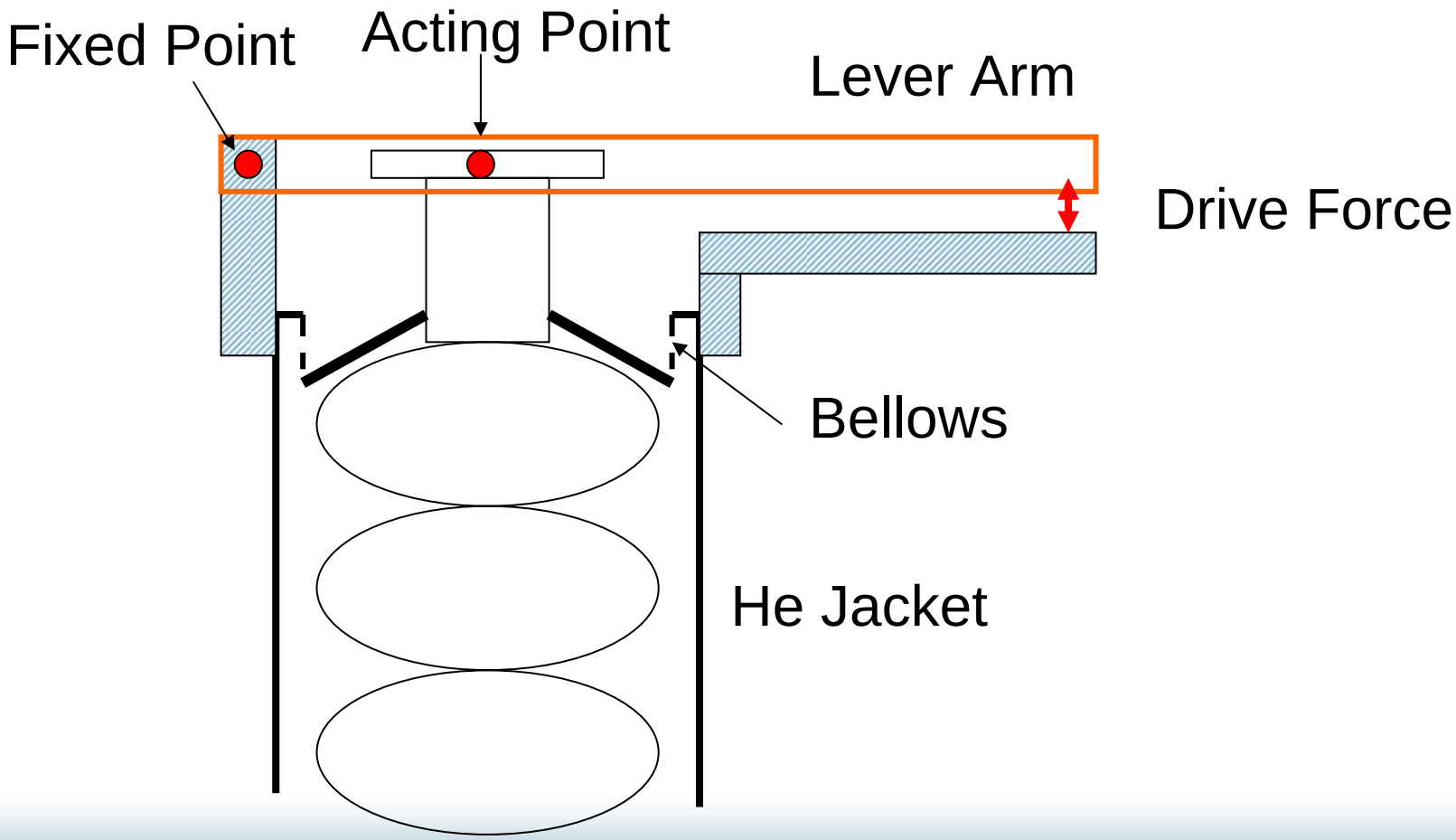
Compact and Reliable

Fast Response → Piezo

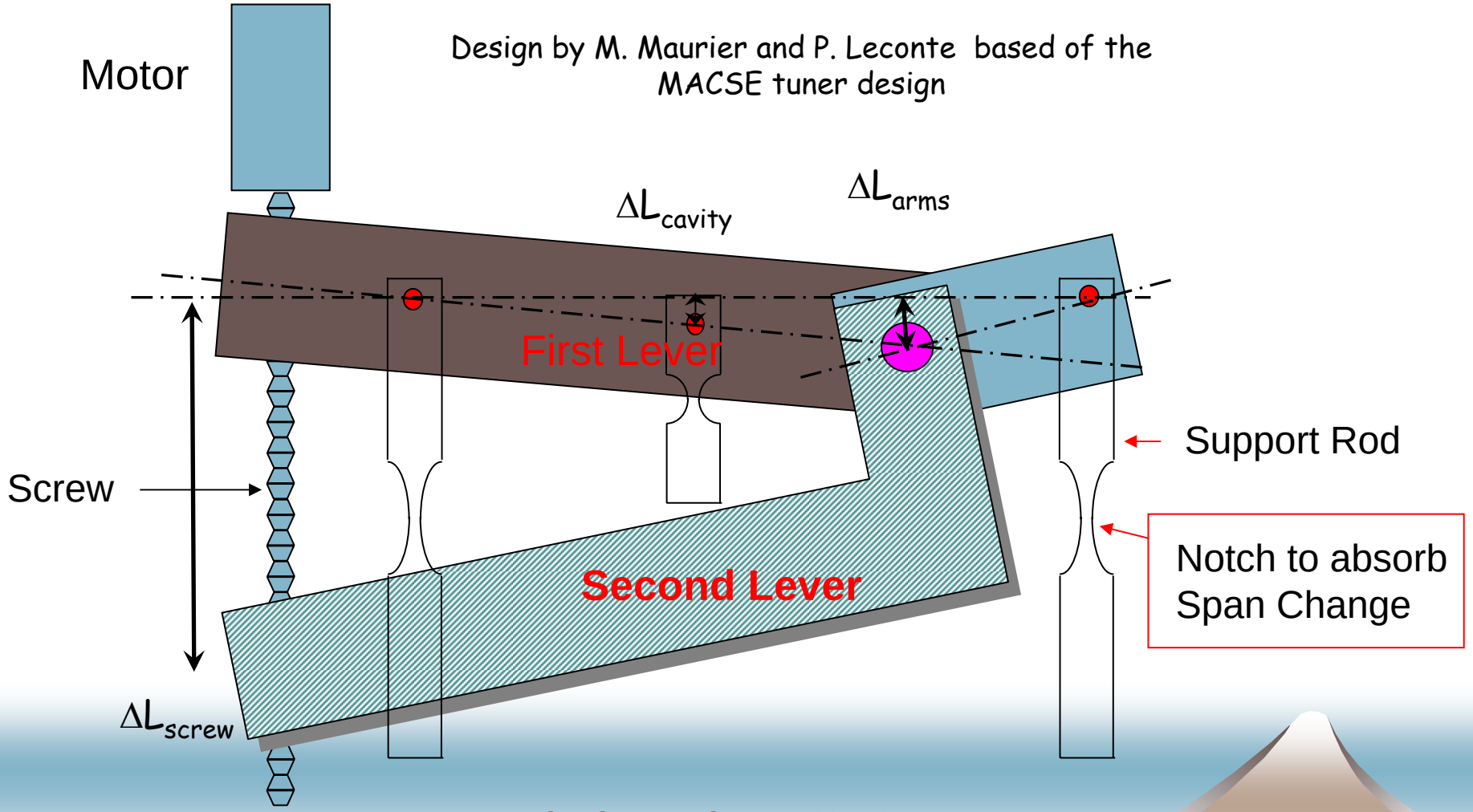


Tuner	Booster-1	Booster-2	Booster-3	Experience
Saclay-1	Lever	Lever	Screw	TTF
Saclay-2	Cam & Lever	Screw		Under Test
Blade	Blade	Lever	Screw	Under Test
Ball-Screw	Large Screw	Worm Gear	Worm Gear	Under Test
Slide Jack	Wedge	Screw	Gear	Under Test

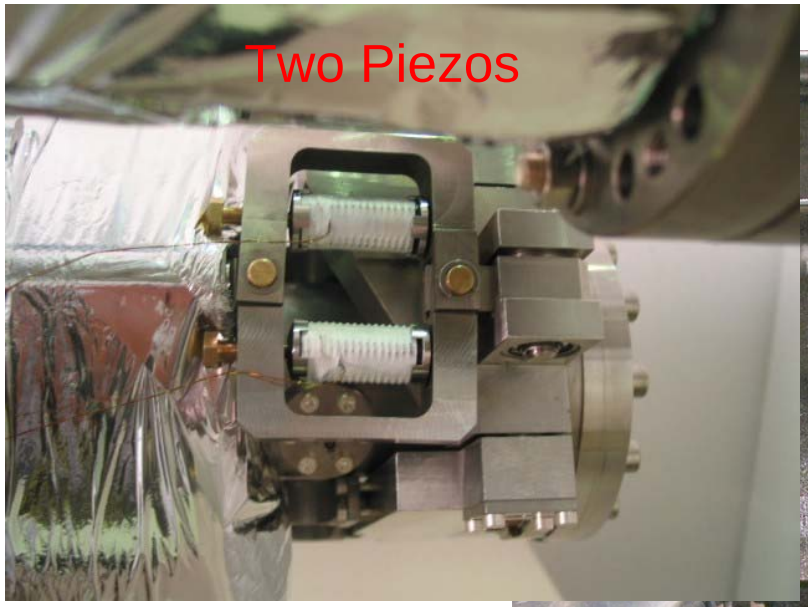
Lever

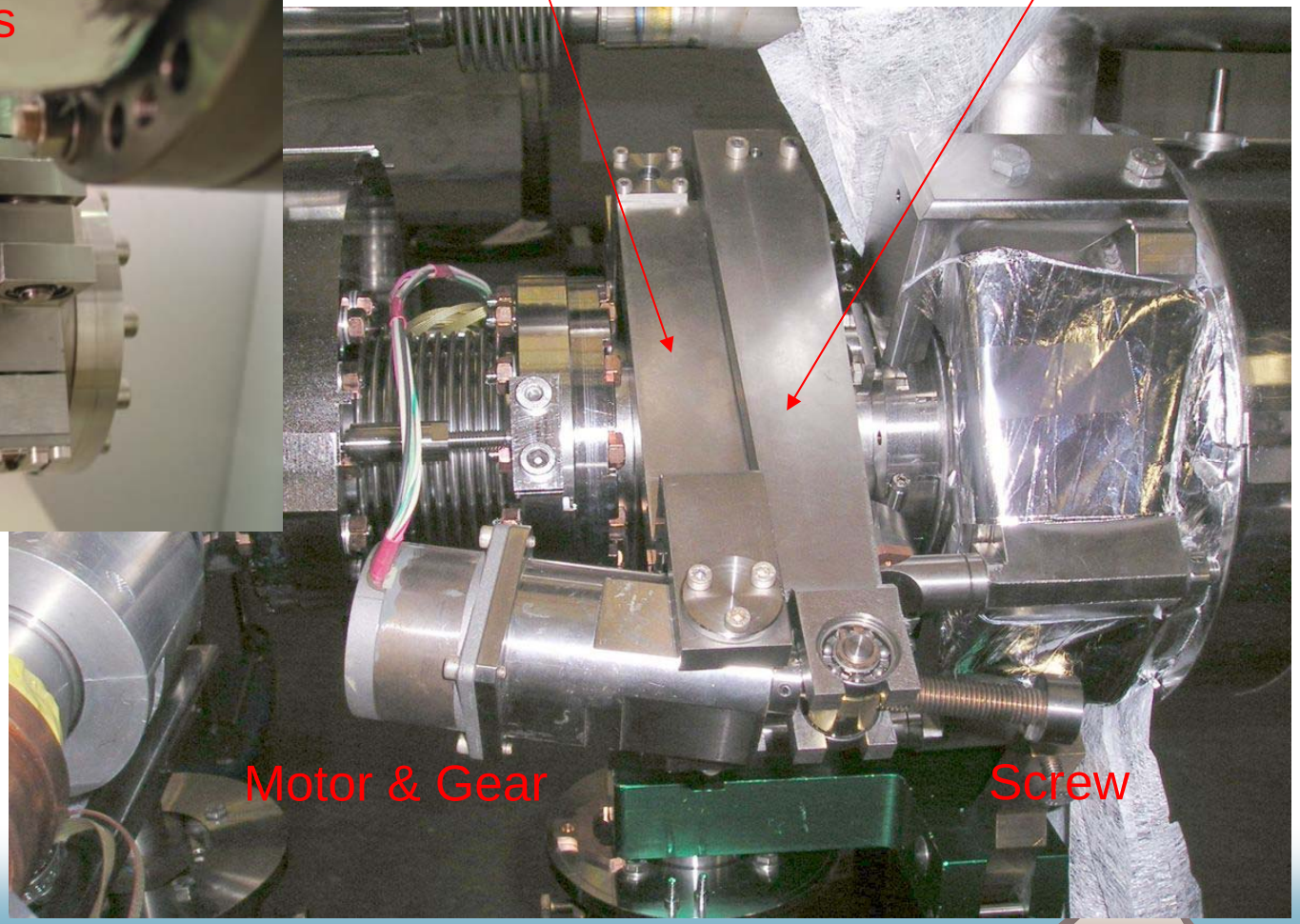

Fixed Point
Acting Point
Lever Arm
Drive Force
Bellows
He Jacket

Saclay -1 : Operation Principle



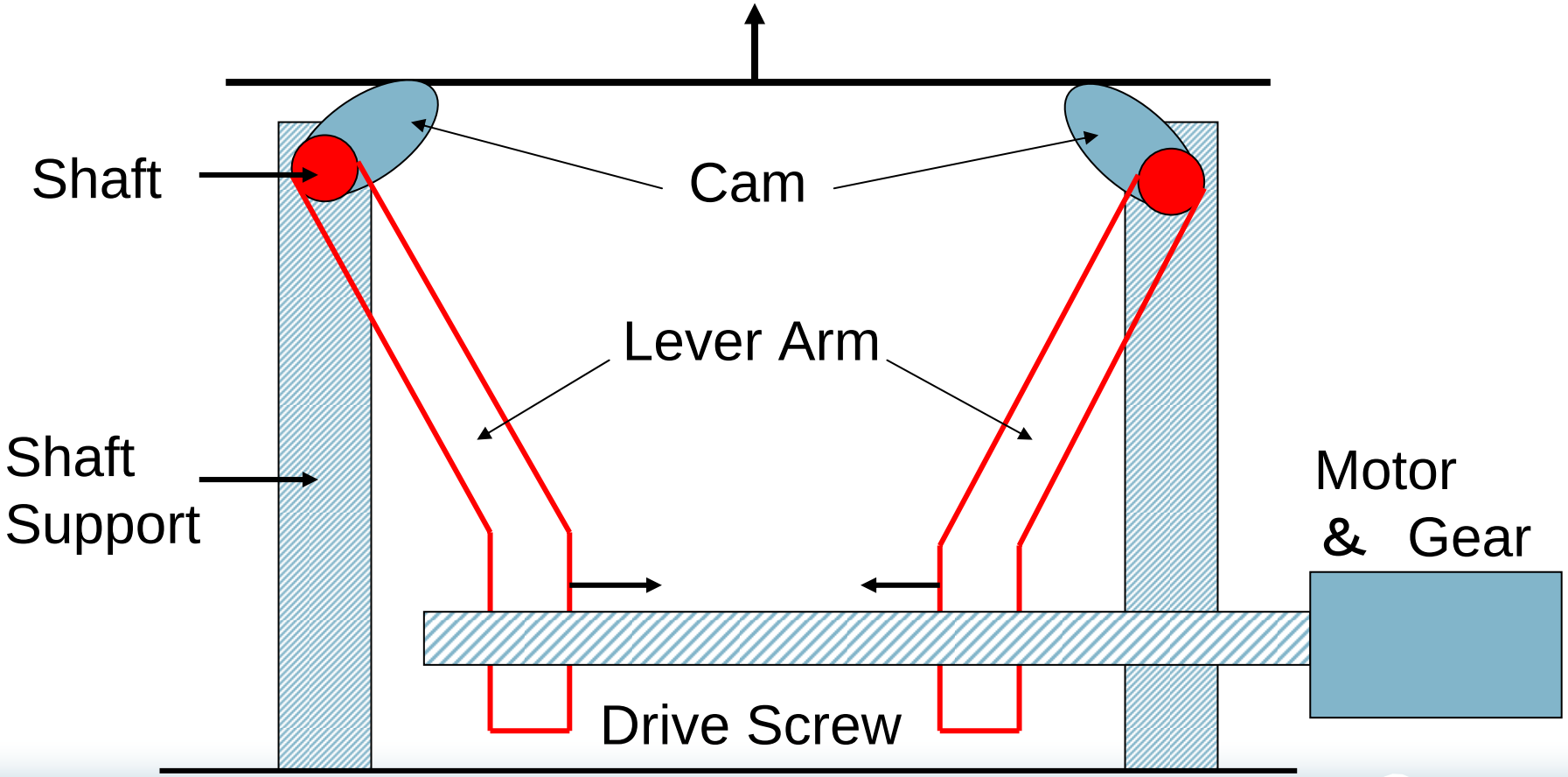
Saclay-1 on a TTF Cavity



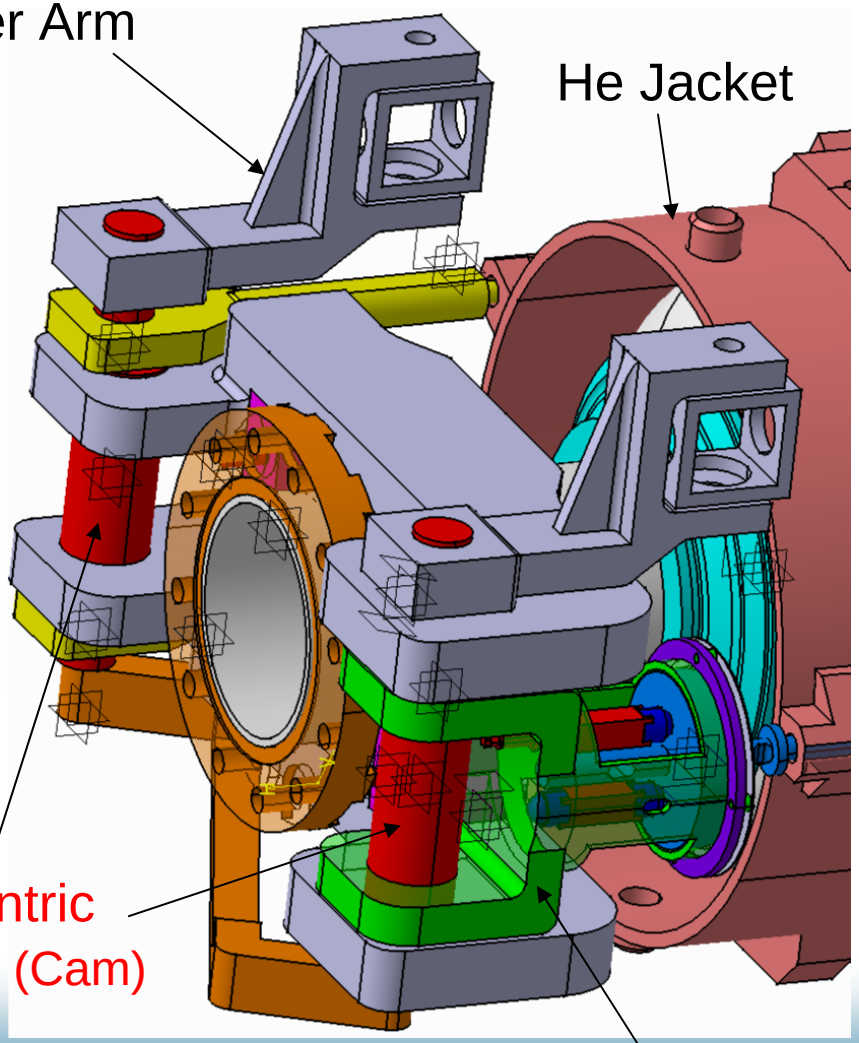


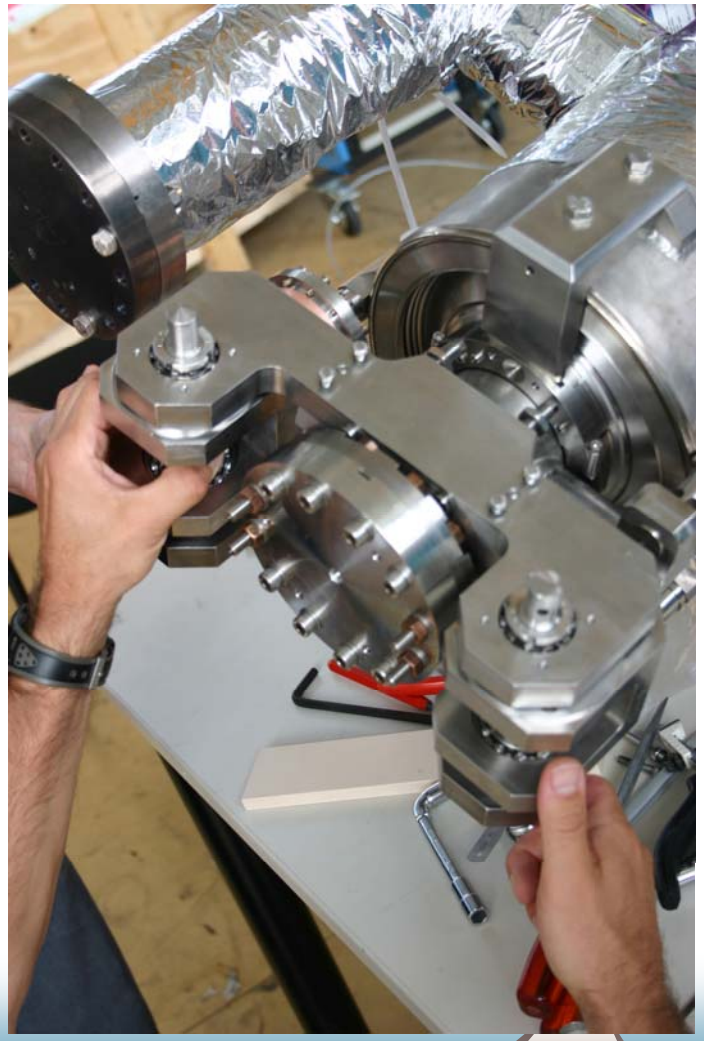
Double Lever
Tuner Stiffness
~ 100 N/μm

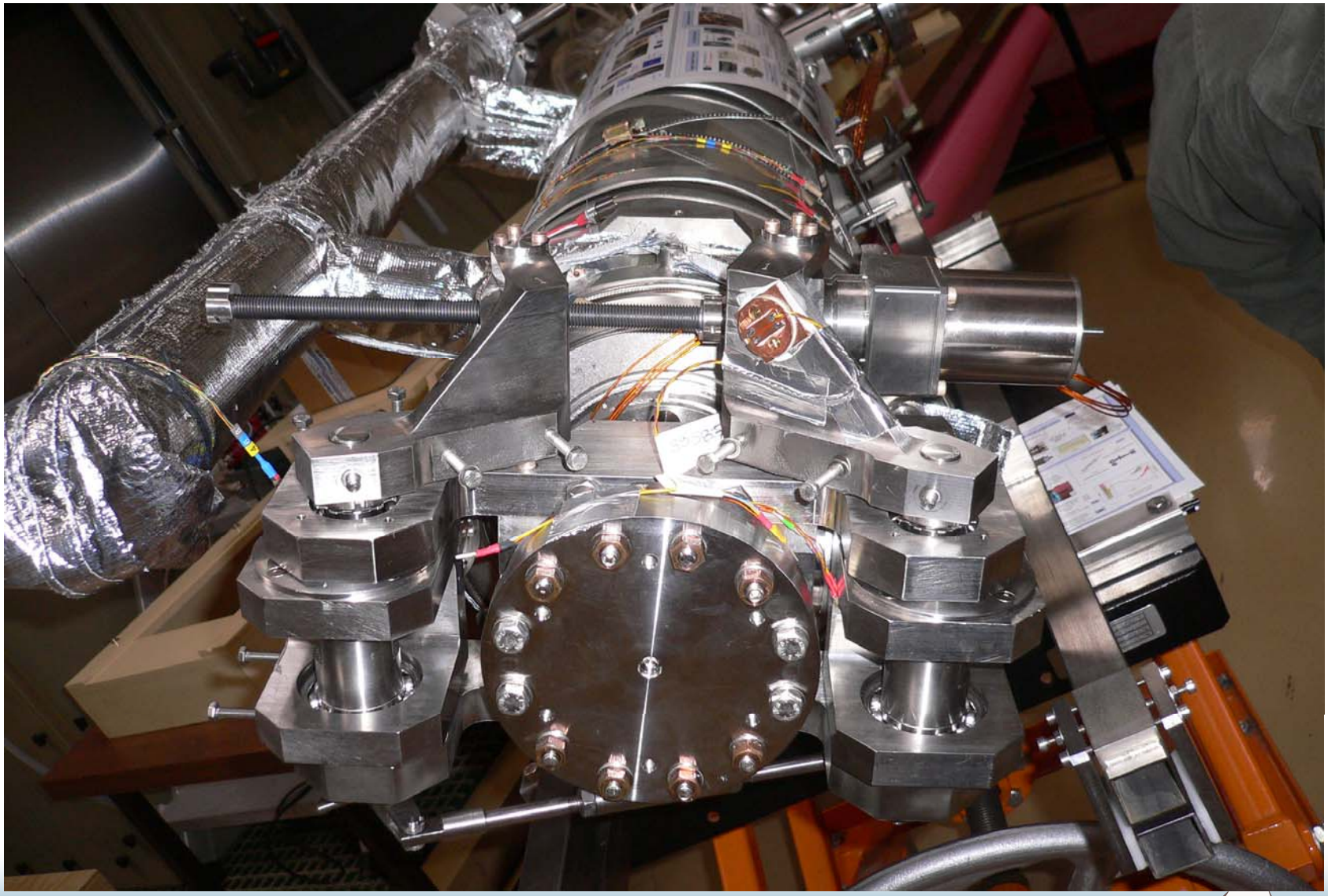
Saclay – 2 : Cam & Lever



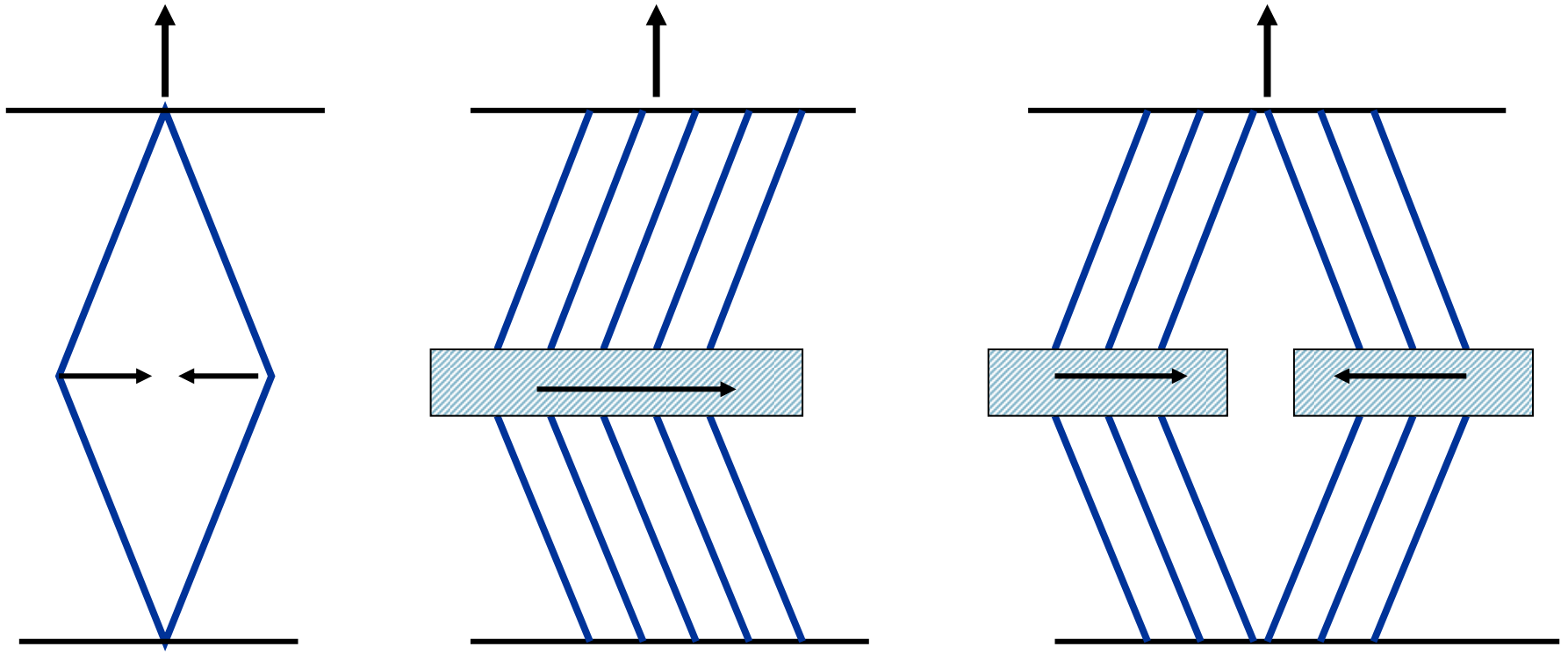
Saclay - 2 : Cam & Lever



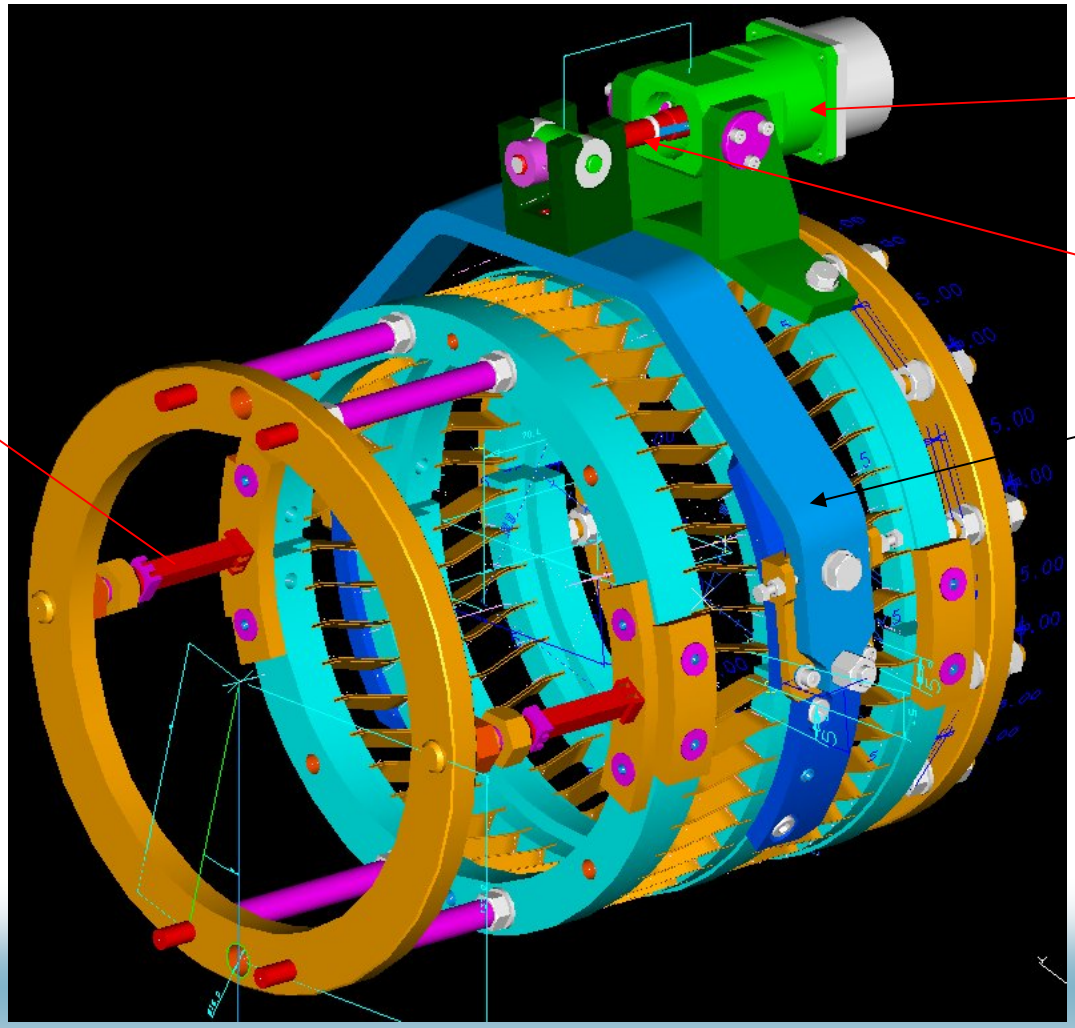




Blade : Jack System

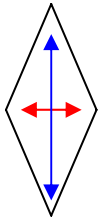


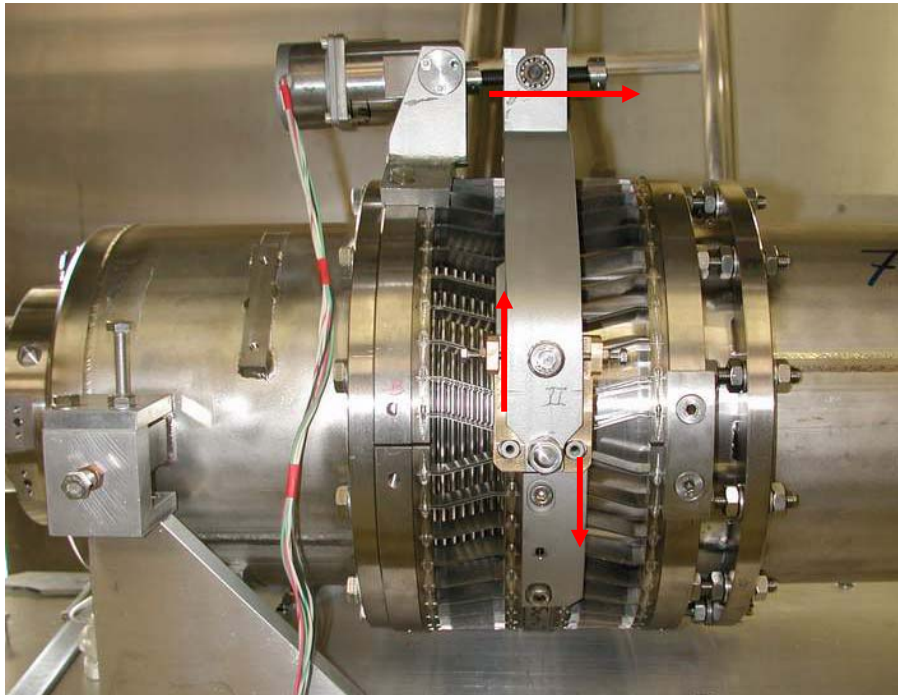
Blade : Jack, Lever & Screw



Blade Tuner 25 N/μm

Not Stiff, Fatigue of Blade, K_S=13N/μm

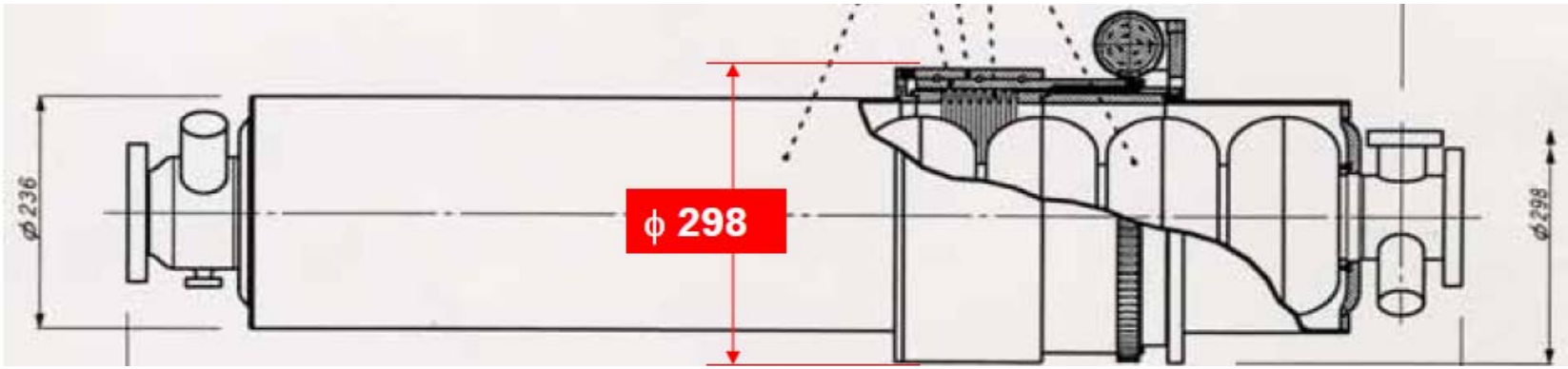


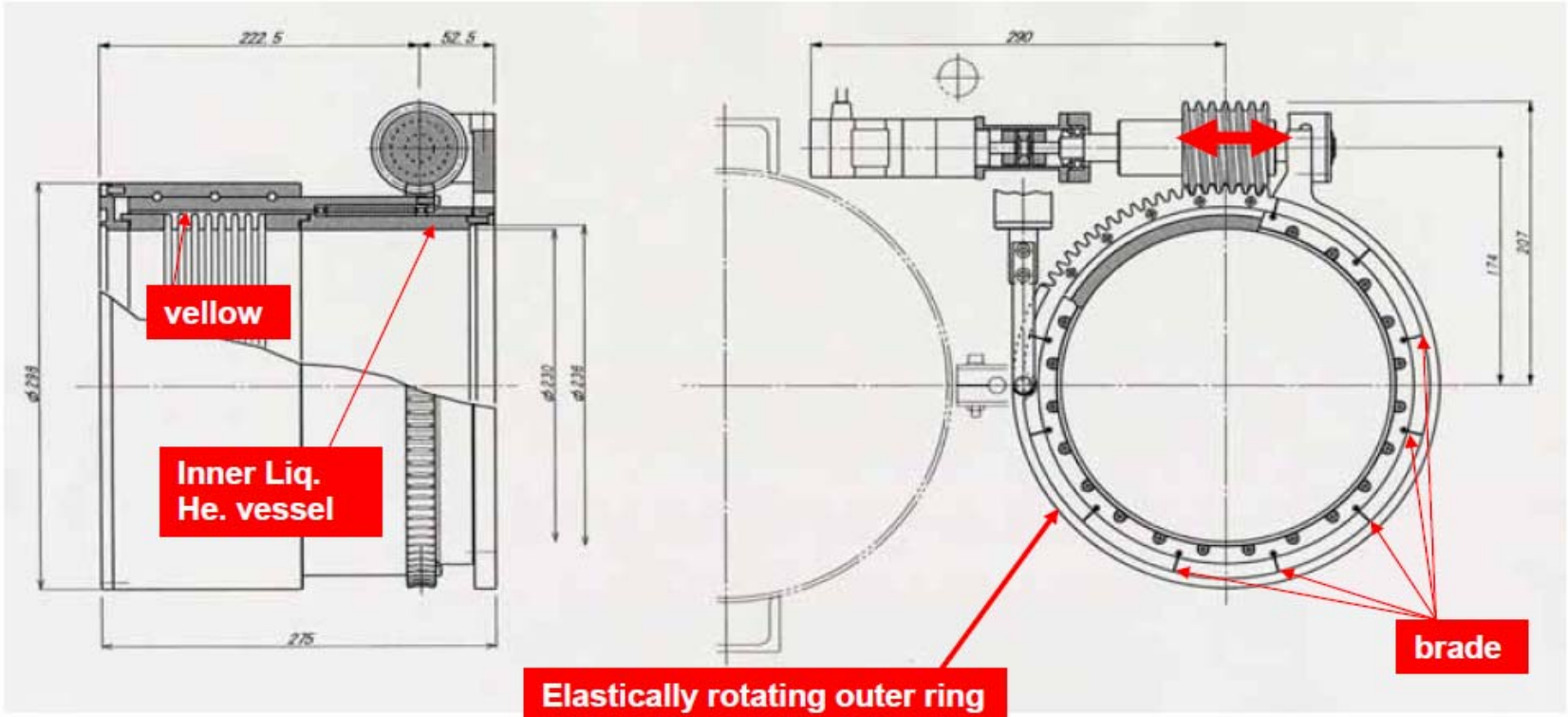


Original DESY

Revised INFN

Ball Screw : Large Ball Screw

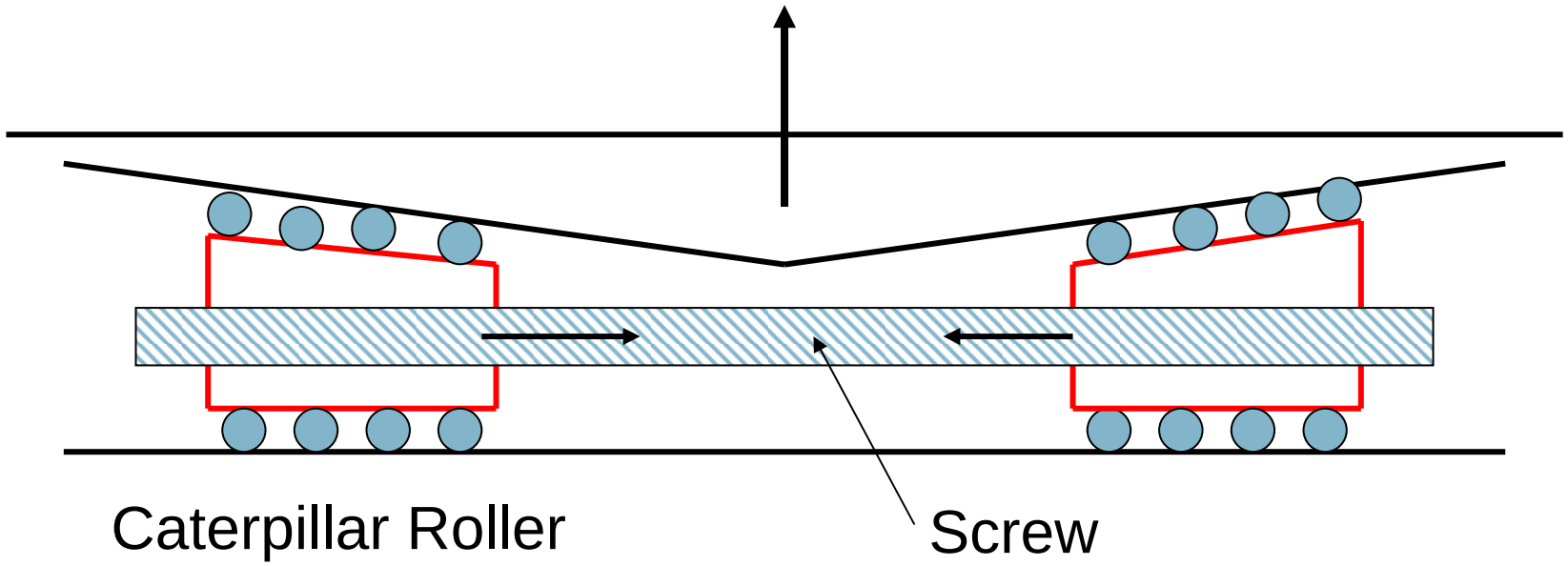




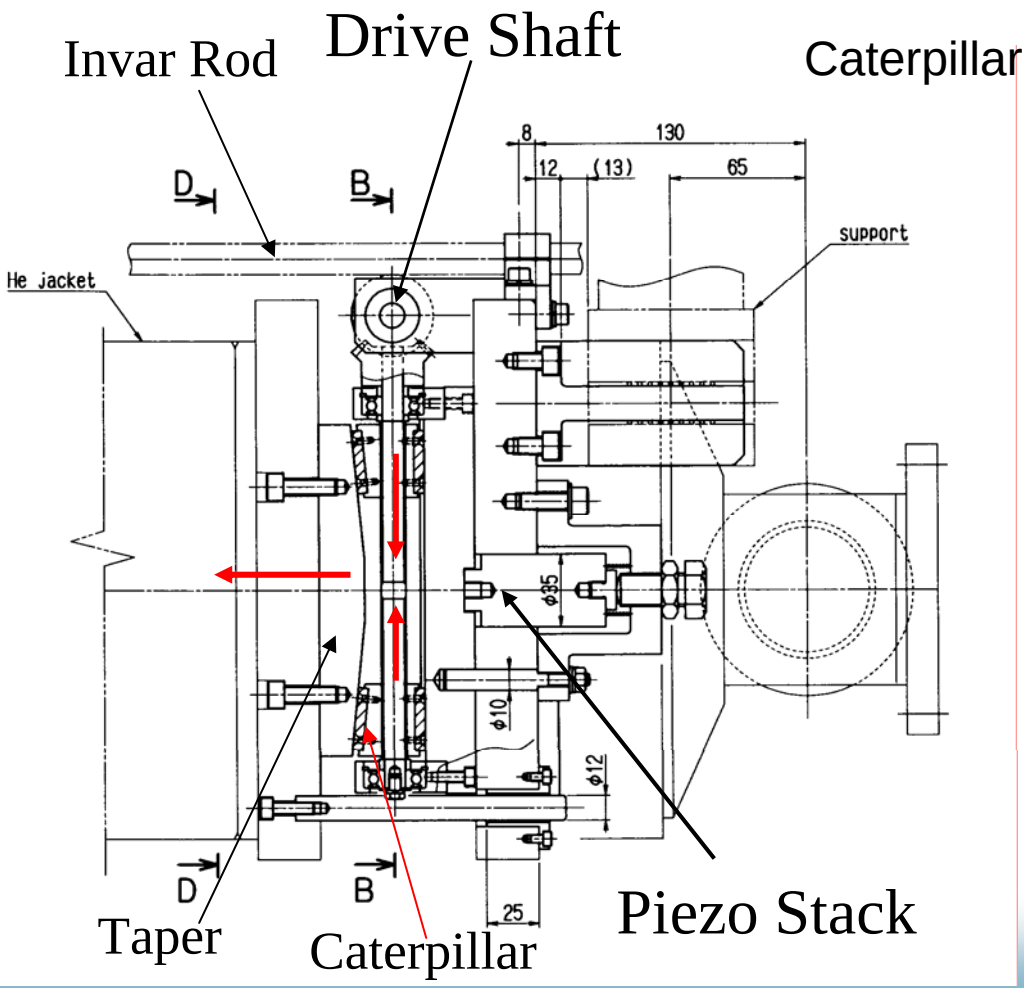
Coaxial Ball Screw 500N/μm

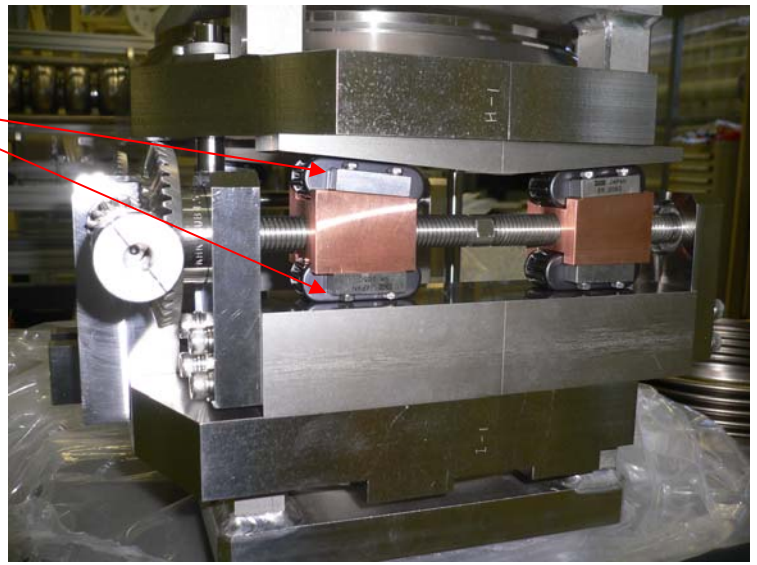
Need Long Stroke Piezo, Fatigue of Blade

Slide Jack : Roller Wedge & Screw

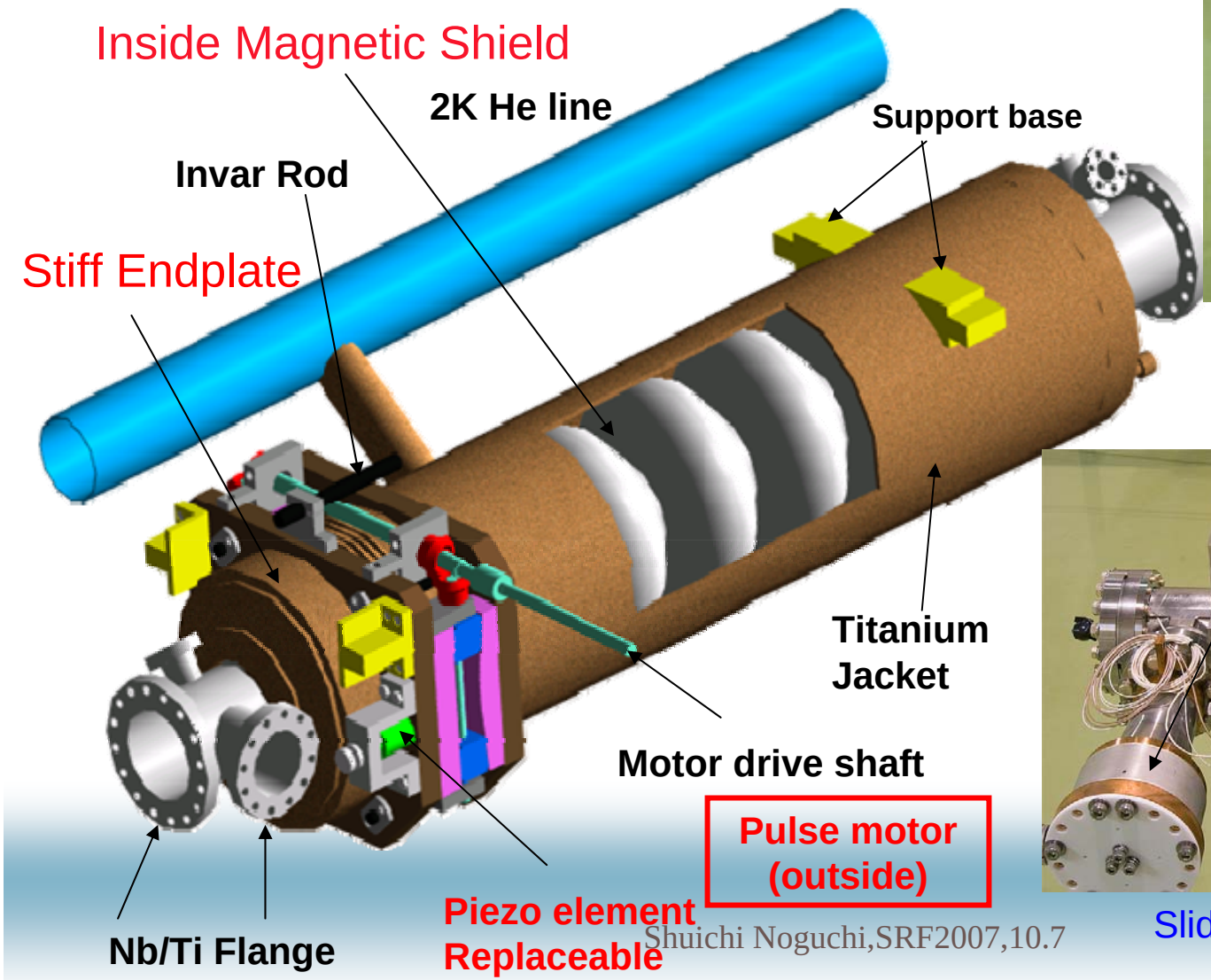


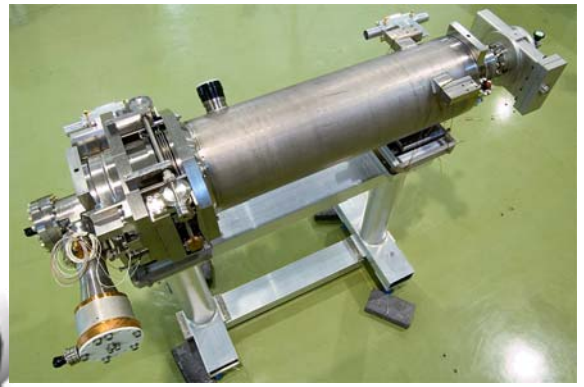
Slide Jack Tuner 290N/μm

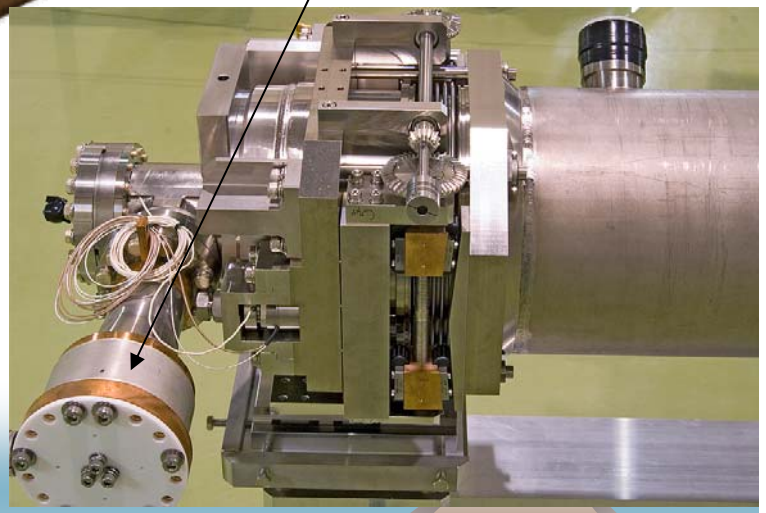




Tesla-like STF Baseline Cavity Package







Summary

- Several Candidates for ILC Application
- After Experimental Demonstration of Performances and Comparison from many Aspects, Decision will be done.
- Some of these Tuners can be used for other Application, with Simplified Design.