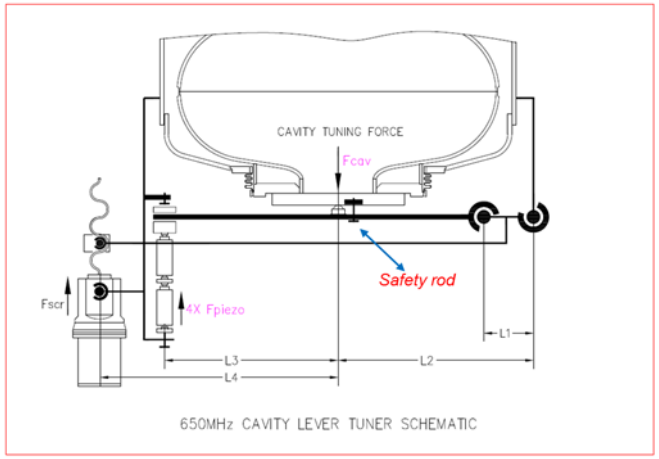
Lessons learned during R&D program in development of the 650MHz SRF cavity tuner for PIP II project.

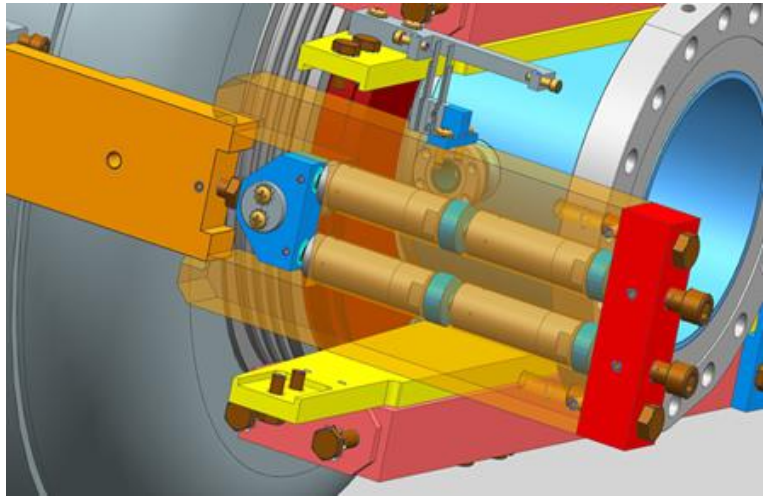
Yuriy Pischalnikov

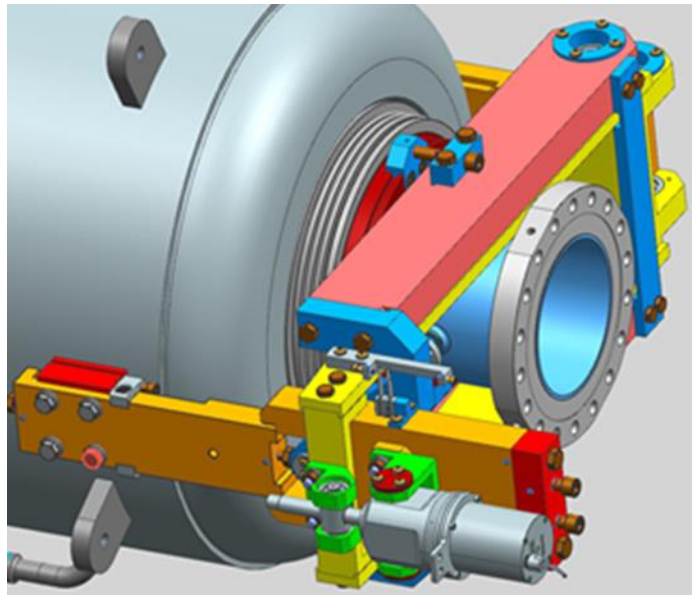
- Development of the 650MHz cavity Tuner took several years.
- We developed two version of the Tuner design
- Prototype tuner Version#1 was built in 2016-2017.
- Prototype V#1 was assembled on the test-stand (dummy cavity set-up)
- Details studies of the prototype V#1 revealed several deficiencies:
  - Tuner stiffens was below 30kN/mm
  - Piezo-stroke was 2-3 times less than expected
- Analysis (after testing) of the V#1 tuner model confirmed that
  - 1. Model used during ANSYS simulation didn't captured all specifics of the tuner design and as results simulation value of $K_{TUNER\_stiffenss}$ was significantly off from experimentally measured value
  - Value of the piezo-stroke was 2-3 times less than expected

Tuner version #1

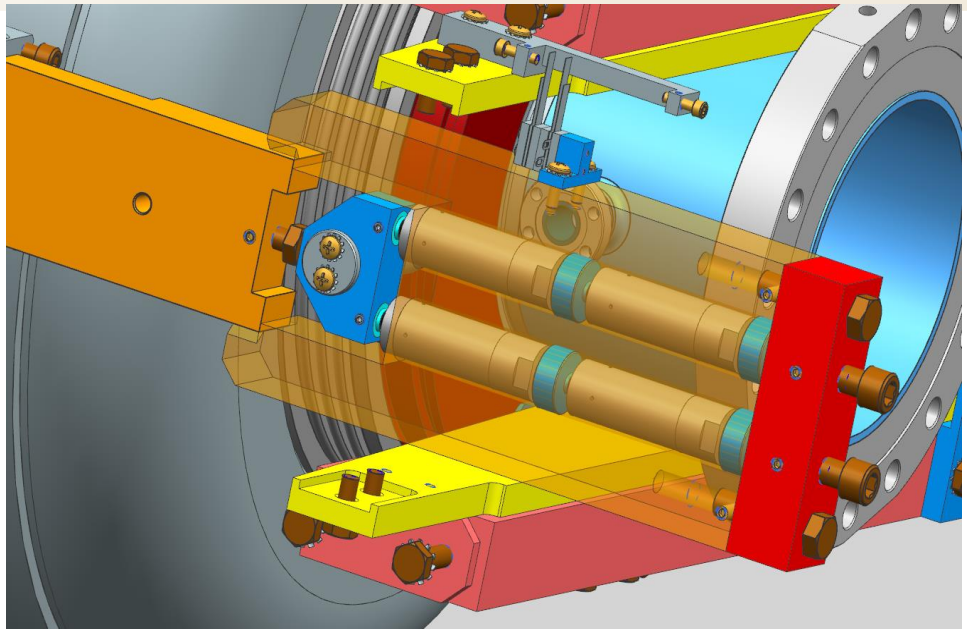
- First version of the tuner that designed as HB&LB 650MHz tuner presented bellow.
- Tuner V#1 has 4 piezo-actuators (installed inside special cartridge). This cartridge located on the side of the left side of the tuner. The goal was to decrease load (forces) on each of the piezo-actuator to keep range of the slow tuner for b=0.9 cavity 200KHz (the same as for b=0.92 & b=0.6).





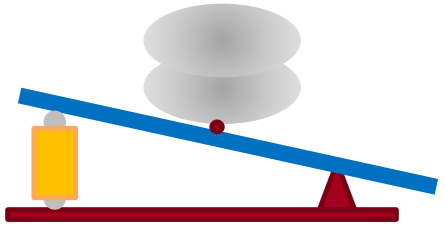


Design of the Fast/Fine Tuner



½ stroke of the the piezos will applied to the cavity.

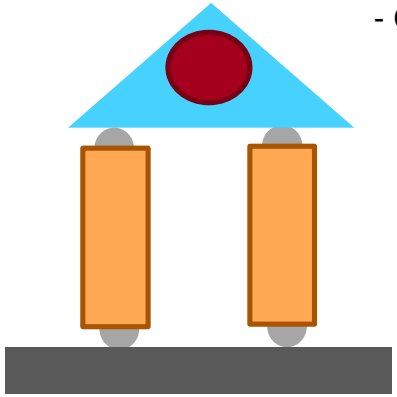
½ force generated by compressed cavity will applied to piezos



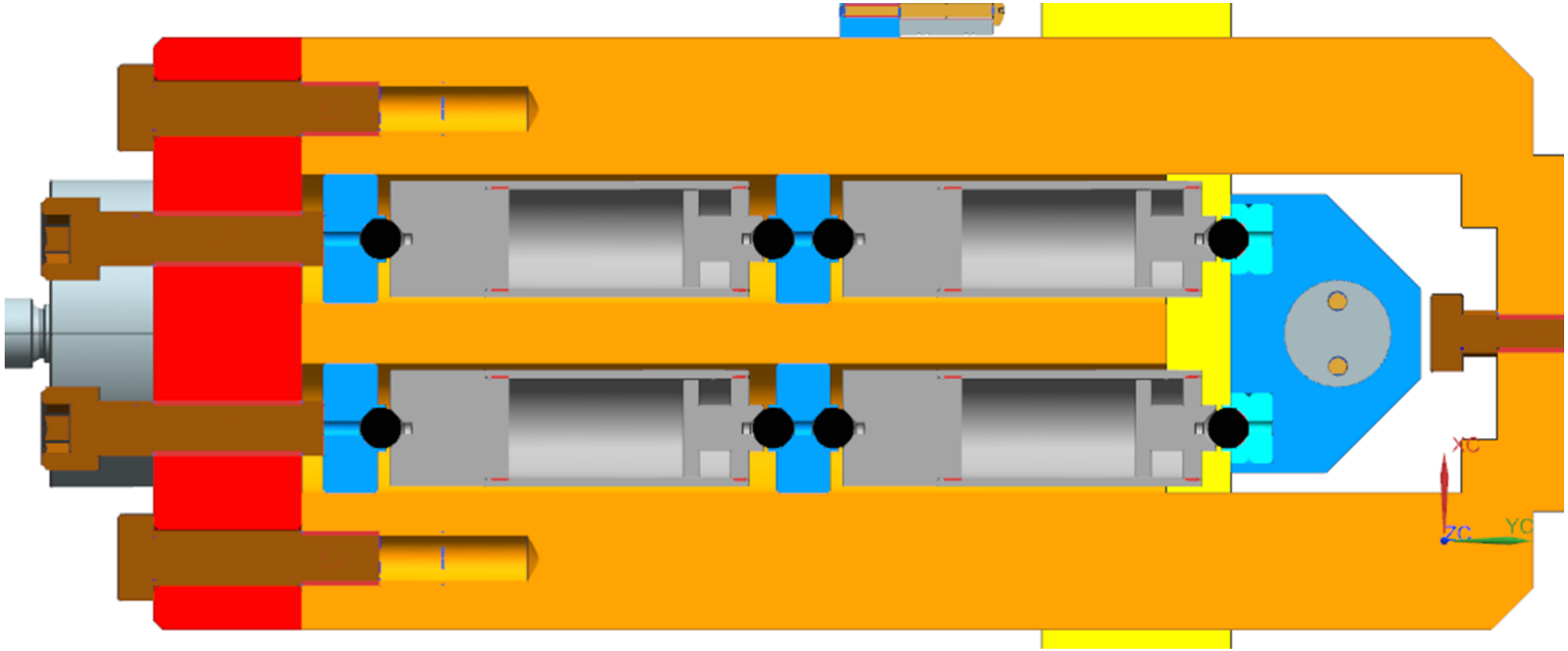
Maximal forces on the piezos ~ 3kN…
Each piezo-capsule will be loaded on max. ~1.5kN.
Internal preload of the piezo-stack inside each Capsule ~ 800N.

Blocking forces for each capsule ~4kN.

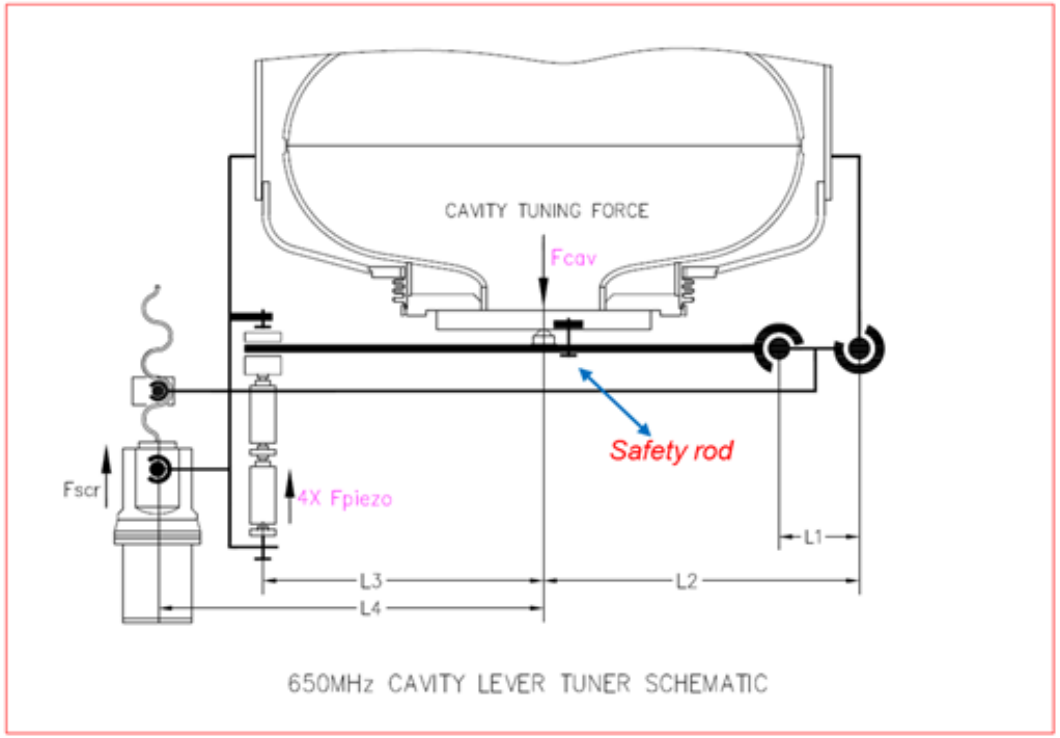
Rocking motion:
- Piezo from both side working
- One piezo can fail..



4 piezo-actuators cartridge (Tuner Version#1)



Kinematic Model of the Tuner V#1



MOTOR

MOTOR SHAFT

MOTOR ARM

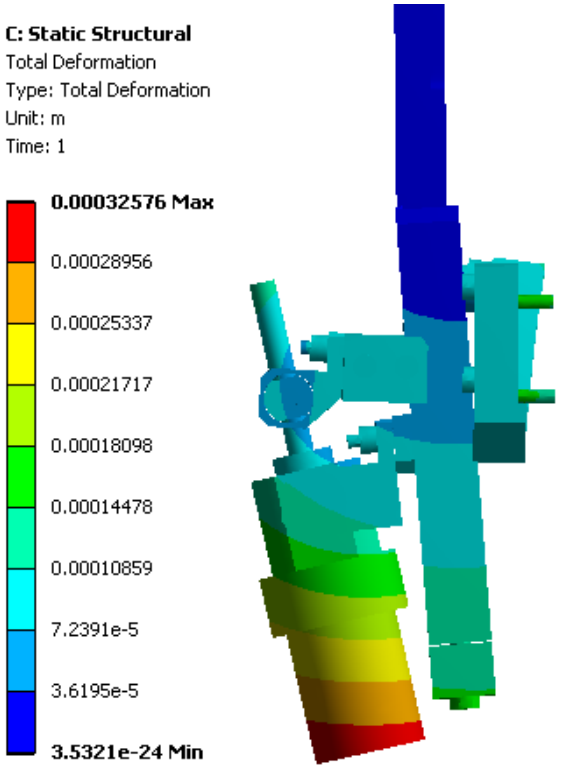
MAIN LEVER

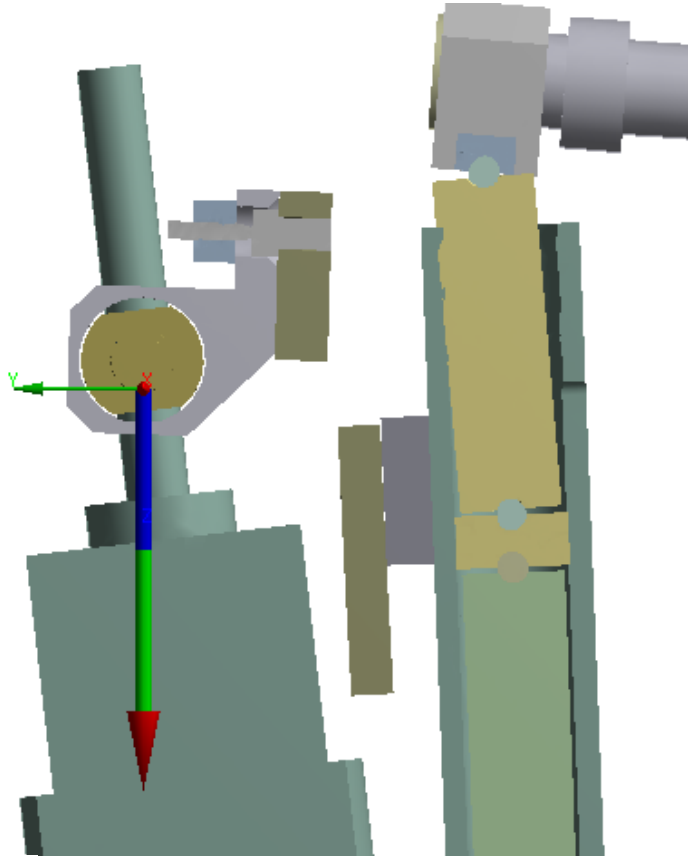
PIEZO

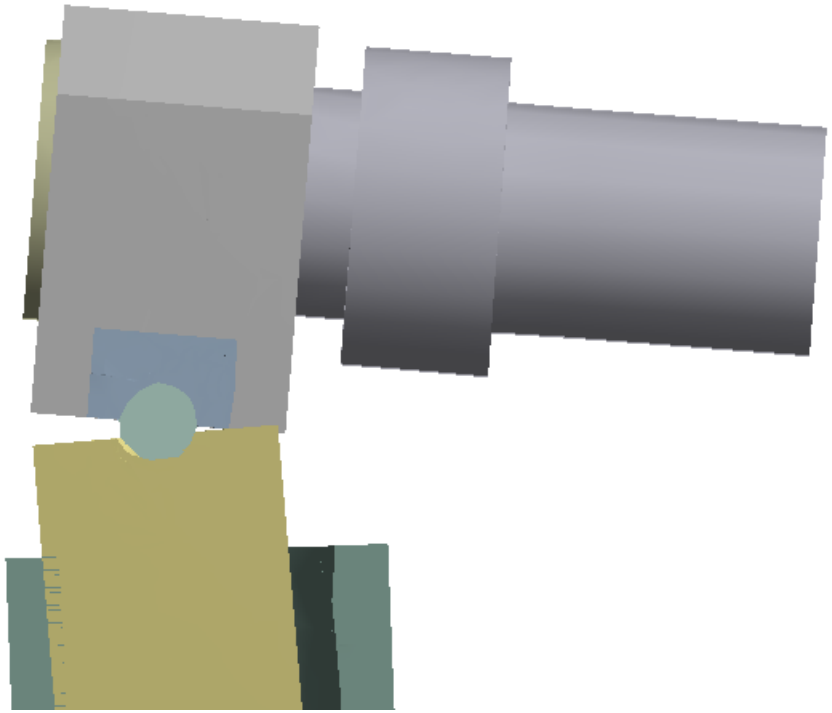
ELECTRICAL, MOTOR

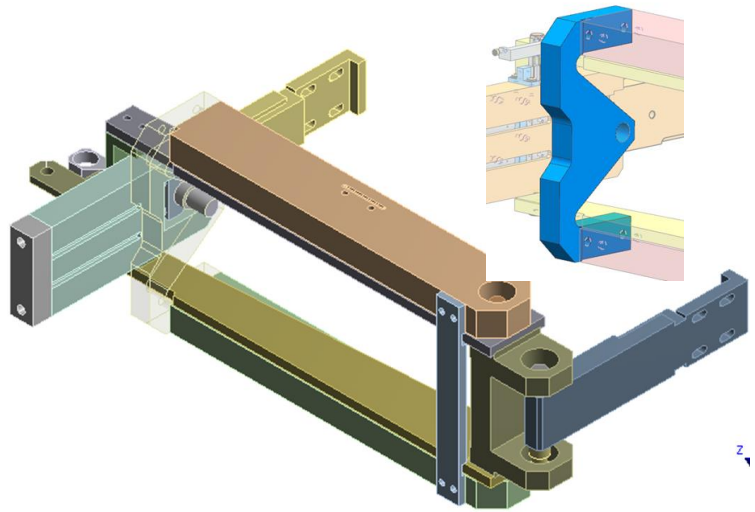
PIEZO

Scale 1.3e2



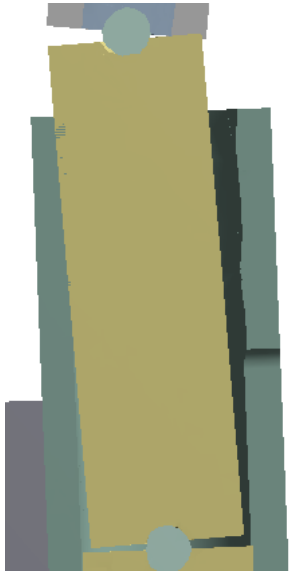


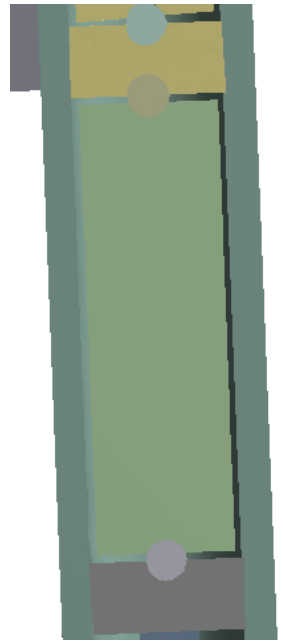




Details of the design of the joints piezo-actuator cartridge and Main Tuner arms

This picture demonstrated deficiency of the this interface and non-desirable extra shearing forces on the piezo



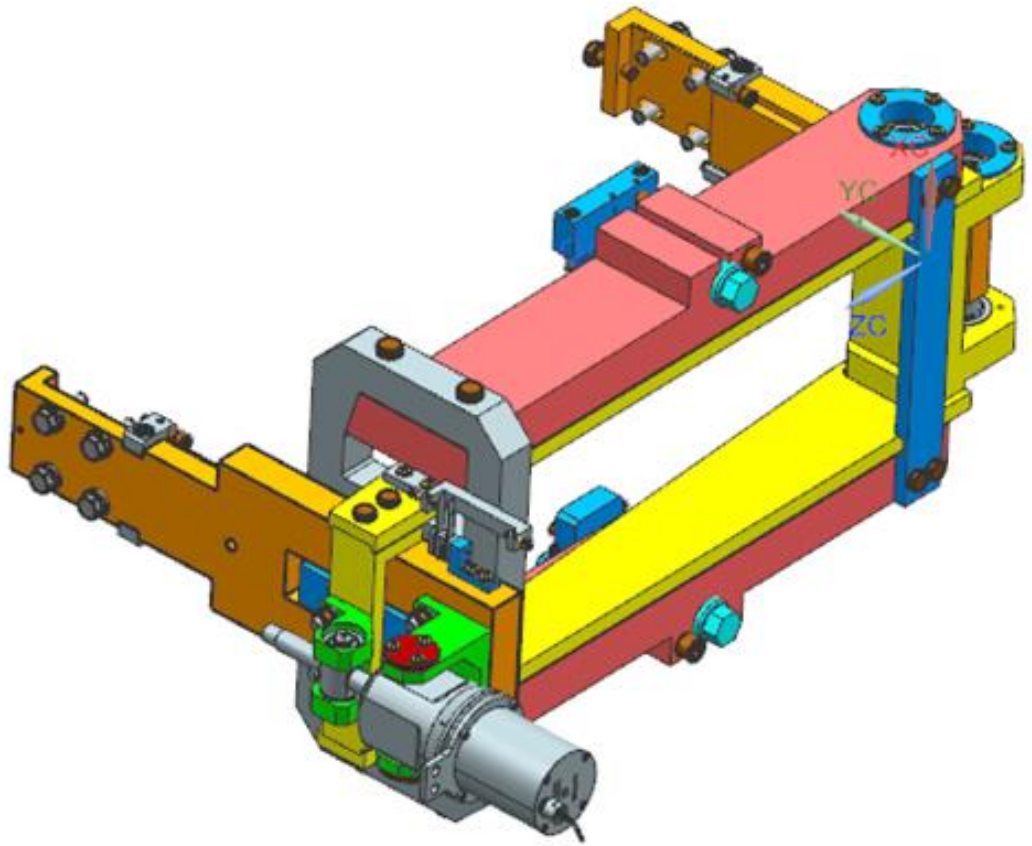


What we learned from our experience with prototype tuner *& Path forward*

- We got quite sophisticated design of the fast tuner (that need to translate to the cavity just several um of stroke)
  - cartridge with 4 piezo-capsules on the side of the tuner
  - stroke from piezo transfer to rocking triangle sliding on the shaft
  - shaft welded to quite weak Σ part, linking top & bottom main lever
  - gravitation forces sagging heavy Σ & levers … piezo's through balls interface will experience these side forces (??)
  - our LCLS II production experience told us that computer model and real assembly on the production floor sometimes not match… dressed cavity is not a built on the milling machine… you need to assume/take into account quite significant tolerance in cavity's dimensions …

- *We decided to review options to simplify design of the tuner with idea to simplify fast tuner and increase stiffness of the tuner/cavity system.*
- *Sergey and Valeri take as model LCLS II tuner and developed (draft) of the new 650MHz tuner design with goal to preserve with out modification as much as possible part from existing prototype…*

Tuner V#2 – 650MHz cavity TUNER



Lessons learned from prototype tuner design V#1 successfully applied during process of designing next generation of the tuner (Version#2)

Built tuner prototype V#2 has stiffens (measured) ~40kN/mm that is consistent with out ANSYS simulations.

Piezo-tuner capable to deliver 2.4kHz cavity detuning that is 2 times larger than specs.