SRF2013 PARIS
16th International conference on RF Superconductivity

A COLD TUNER SYSTEM WITH MOBILE PLUNGER

ESS-BILBAO, IFMIF, MYRRHA AND SPIRAL2

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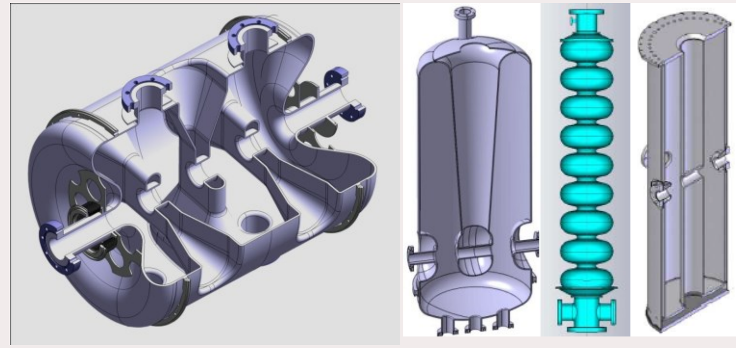
26/09/2013 - Longuevergne David

OUTLINE

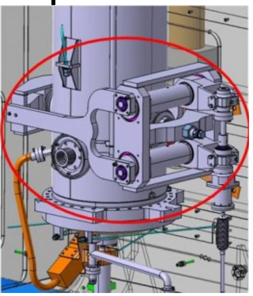
- Mobile plunger System presentation
- ESS-Bilbao System
- IFMIF System
- MYRRHA 325MHz CH Cavity
- SPIRAL2 System
- CONCLUSION

EXAMPLES OF TUNING SYSTEMS

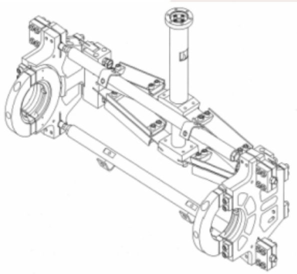


By deformation (most used)

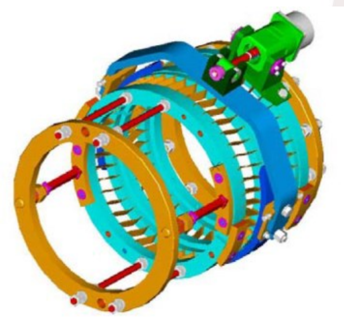
Spiral2 tuner.



Scissors Jack tuner

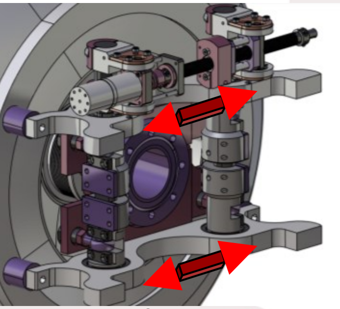


Blade tuner.



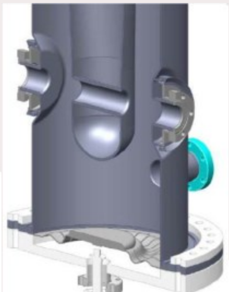
ESS Spoke tuner

By insertion

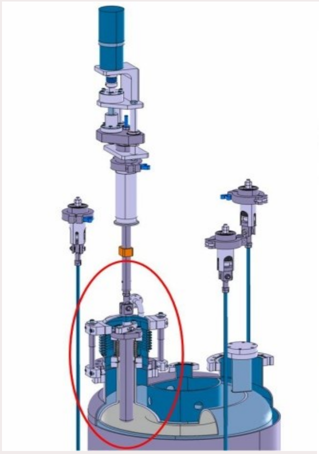


Isac2 tuner, Triumf.

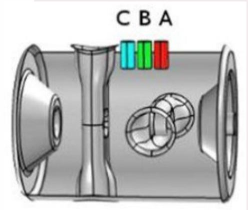
ReA3 tuner



Spiral2 tuner.

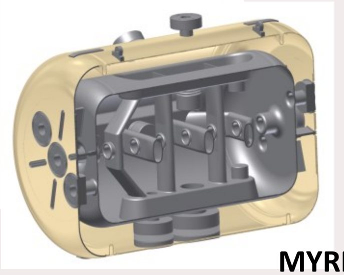


ESS- Bilbao tuner

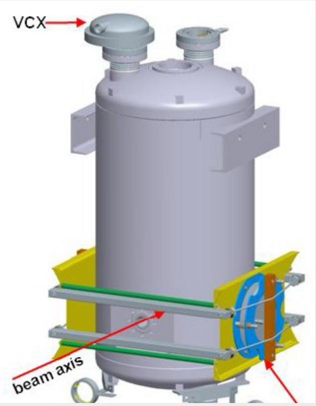


MYRRHA CH cavity tuner.

Variable reactance



ATLAS upgrade

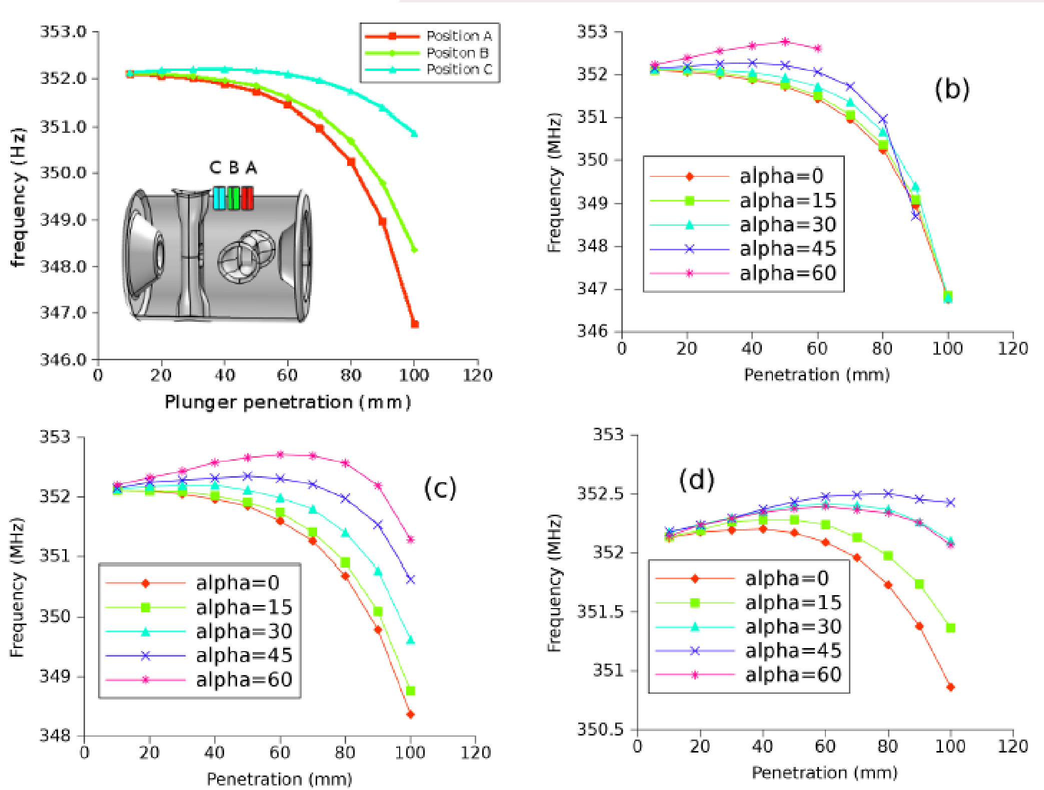


PROS AND CONS

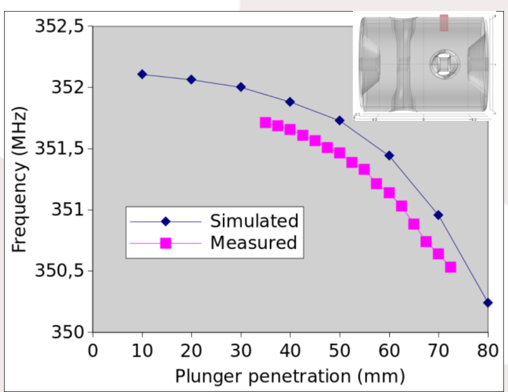
	By deformation	By insertion
Pros	- Reliable - A lot of experience - No direct interactions in cavity RF space - Ea	- Low force needed - No risks of plastic deformation - Tuning range not limited by Niobium - Several tuners in parallel. mpact
Cons	- Possible irreversible damages (plastic deformation) - Massive (difficult to cool down) - High forces involved - Tuning range limited by limit of elasticity of Niobium - Only one tuner per cavity	- Lack of experience - Inserted in cavity volume (problems of cleanliness, possible RF limitations) - Has to be integrated in LHe loop - Complexity of cleaning procedure and maintenance (dust generation?) - Quench problems

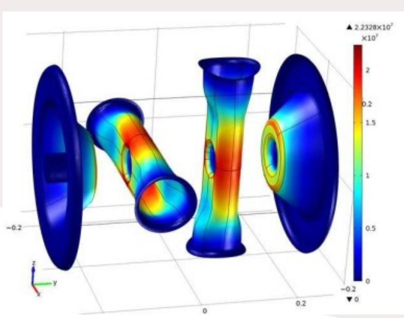
Complementary solution : good where the other fail

ESS-BILBAO TUNER (1)

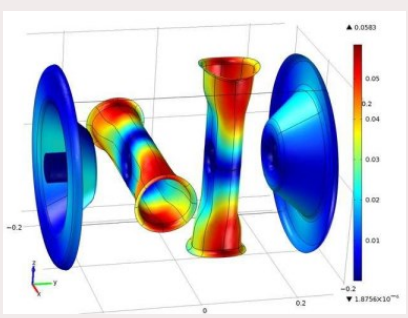


- RF simulations done for different plunger position and orientation (diameter of 35mm)
- Most favorable is perpendicular and aligned with spoke.
- Aluminium prototype built to validate simulations
- Good agreements between simulations and prototype measurements

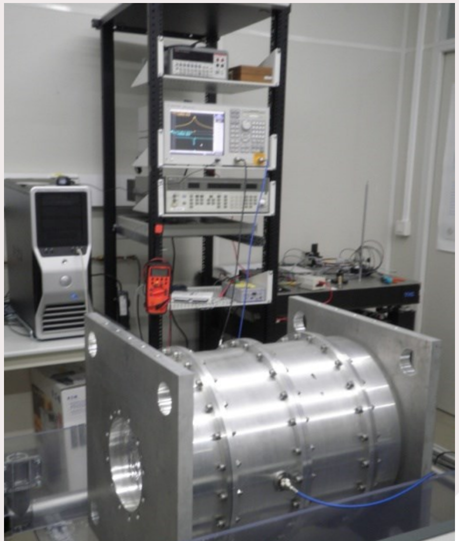




Electric field



Magnetic field

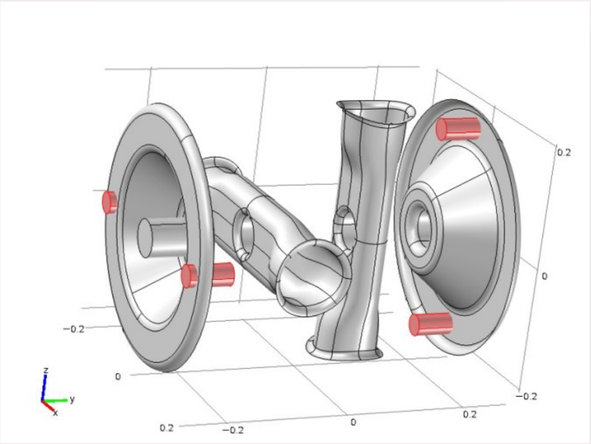


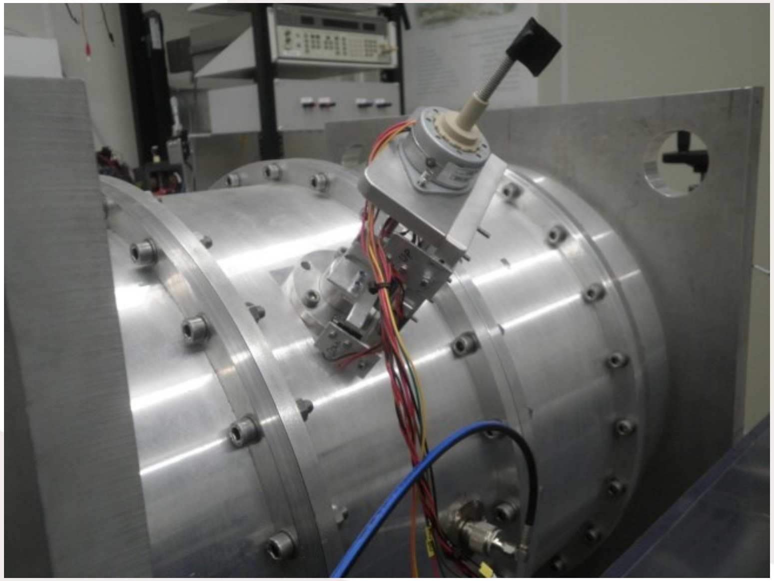
β = 0.39 Double Spoke

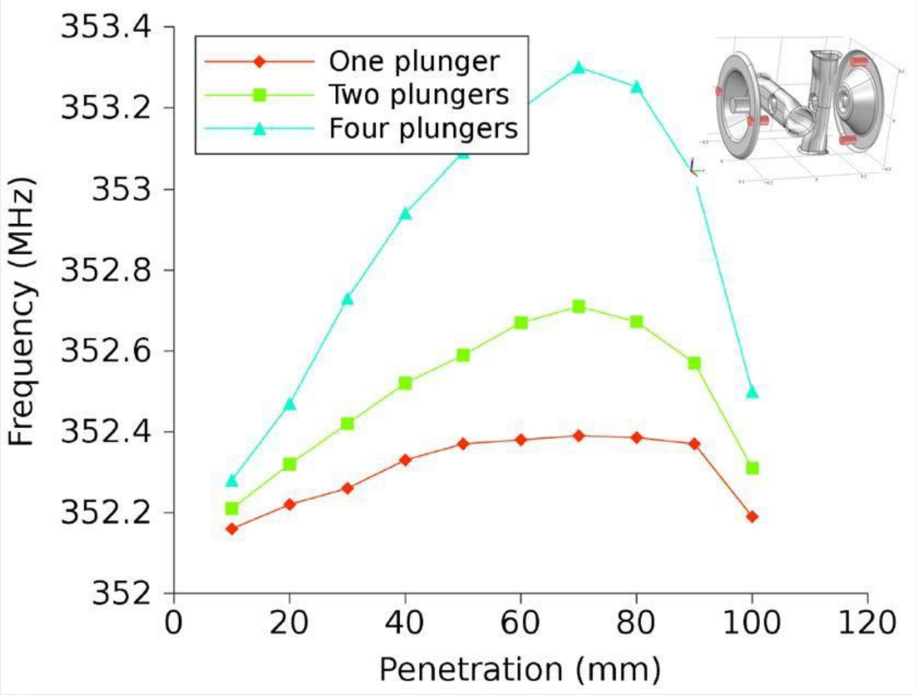
ESS-BILBAO TUNER (1)

- Alternative position studied through end covers (positive shift).

- To be done :
  - Mechanical design
  - LHe loop design
  - Additional RF analyses : perturbation of electric field on beam axis.

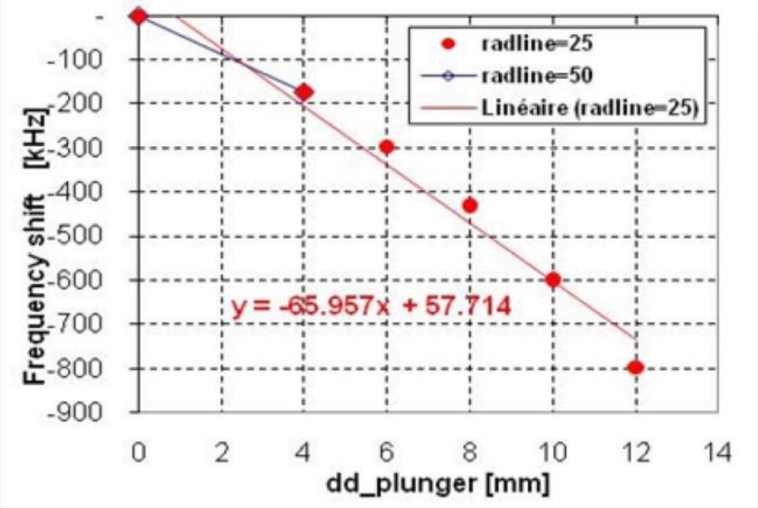


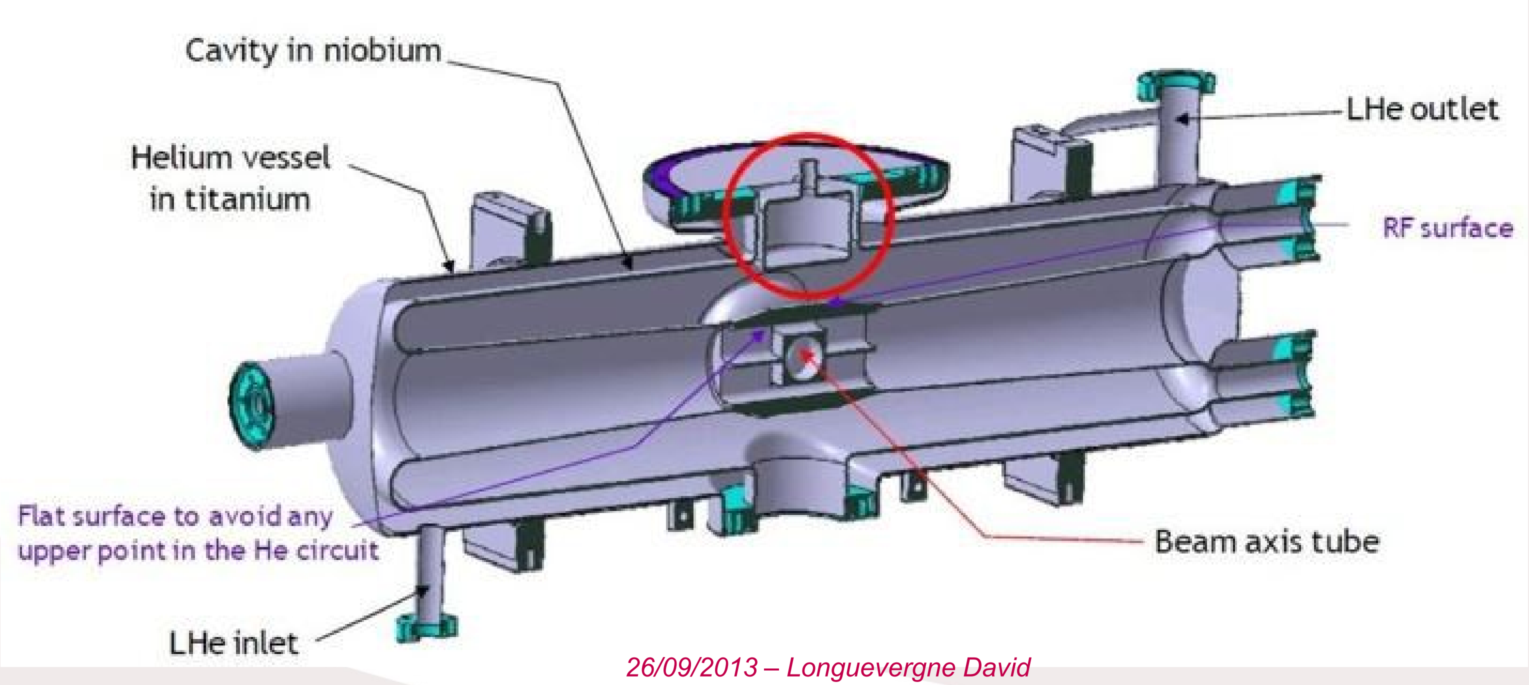




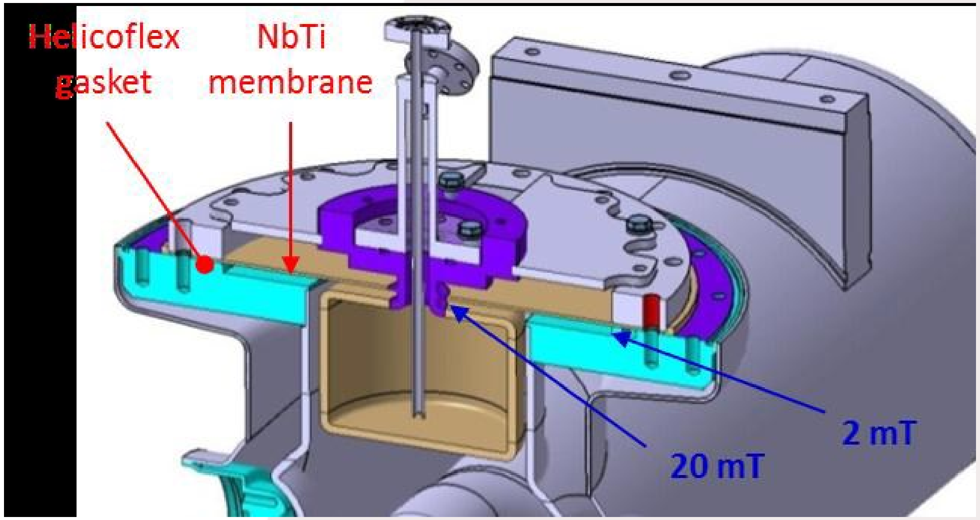
IFMIF TUNER (1)

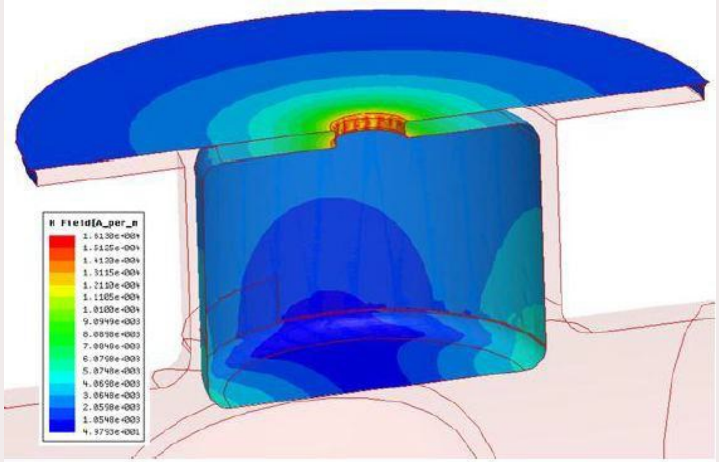
- Plunger solution envisaged for compactness and because of stiffness of cavity
- Ø = 100mm, bulk Nb.
- Membrane in NbTi : ± 1 mm => ± 50 kHz
- Design well advanced and prototyping done
- Cold test revealed premature quench at 1 MV/m and low Qo.

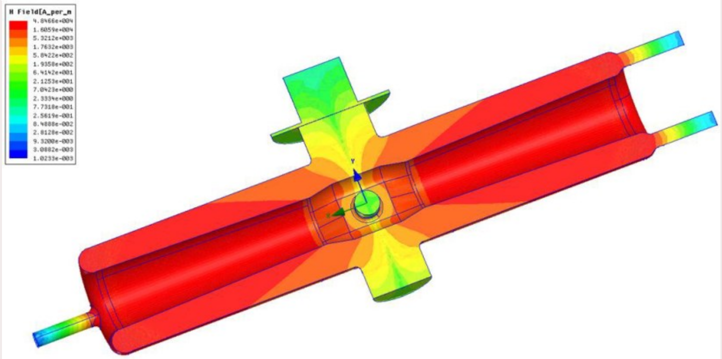


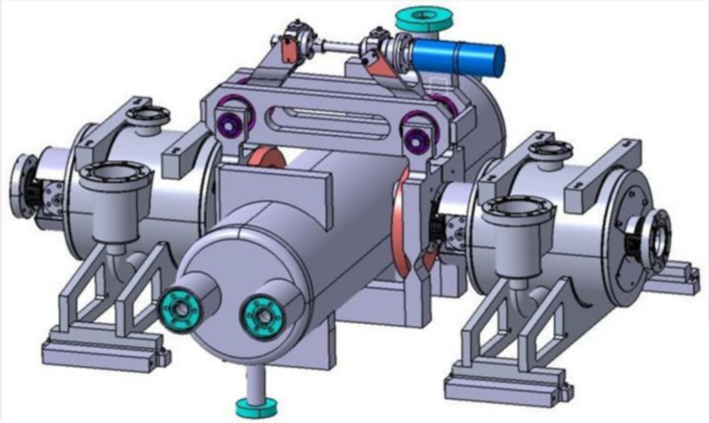


IFMIF TUNER (2)







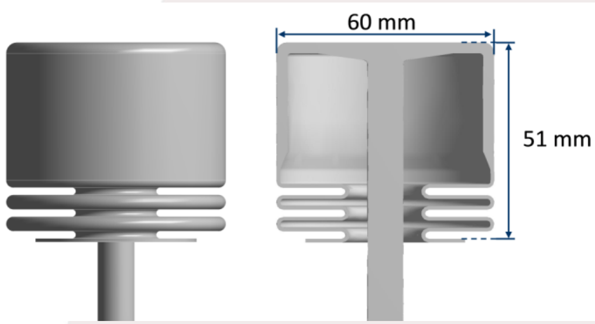


- Additional RF simulation showed a significant magnetic field on plunger neck (NbTi) and on Helicoflex gasket.
- Tests done to localize quench :
  - NbTi parts replaced by Nb parts

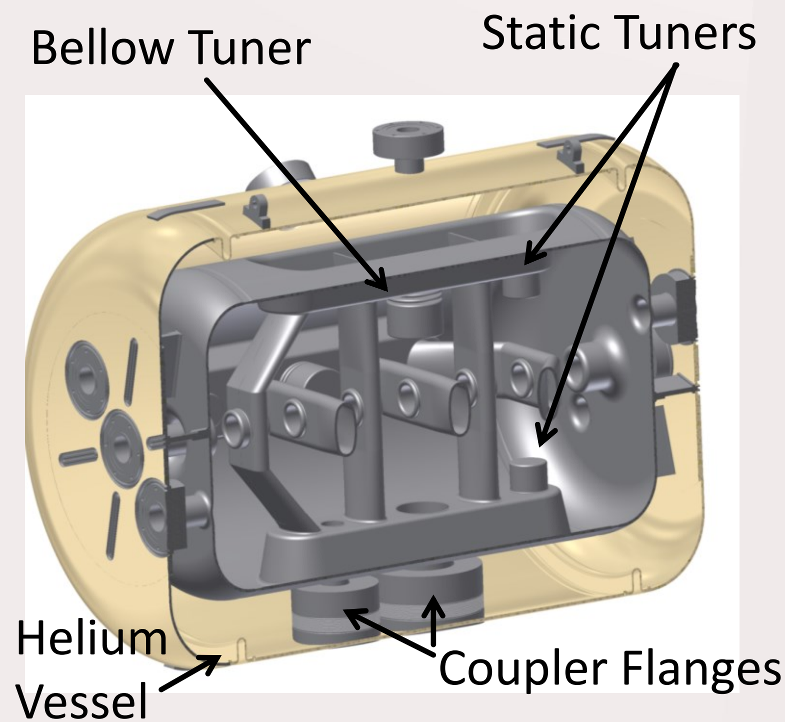
    ⇒ Quench field increased but Qo still low
  - Nb plunger inverted (field reduction on gasket)

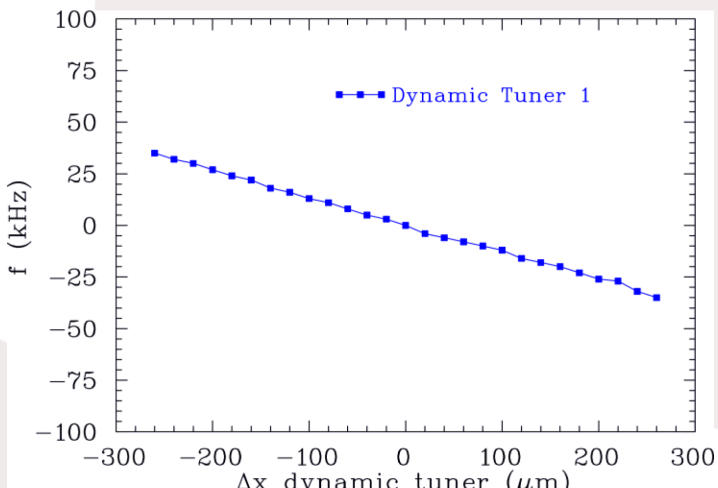
    ⇒ Qo and quench field increased
- Plunger solution abandoned for more conservative tuner system by deformation due to tight schedule.

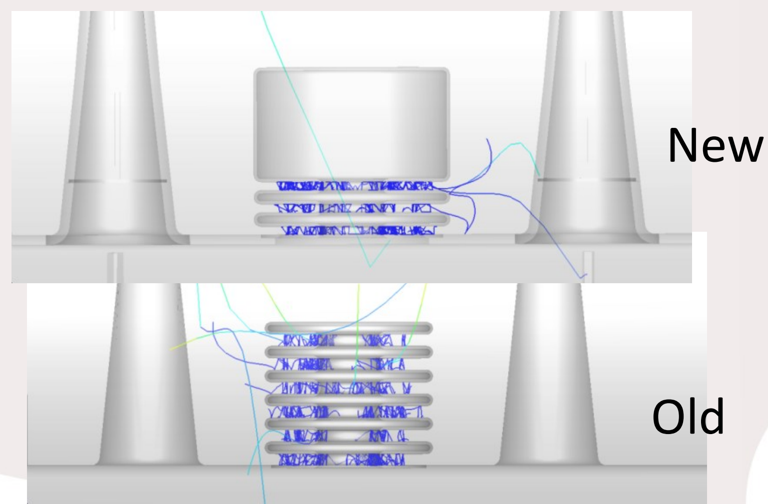
MYRRHA 325 MHZ CH CAVITY TUNER



- 2 Niobium bellow tuners
- Sensitivity ~ 125 kHz/mm
- Fast tuner ΔF=130Hz, slow tuner ΔF=130kHz
- Optimized to limit multipacting in bellow
- Cavity and tuners have been built
- To be tested at 4K



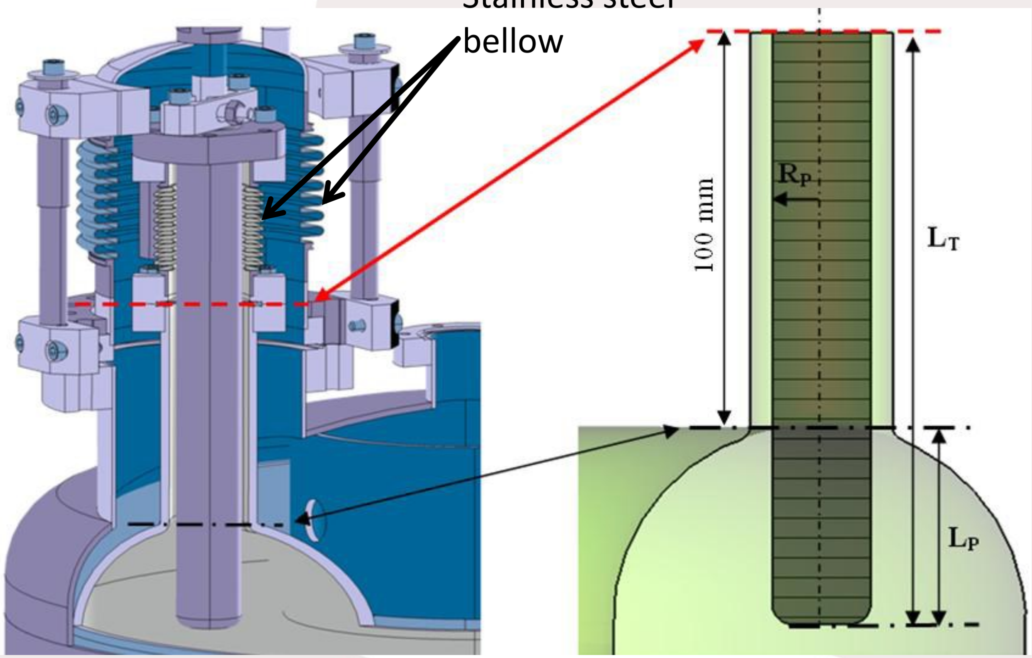


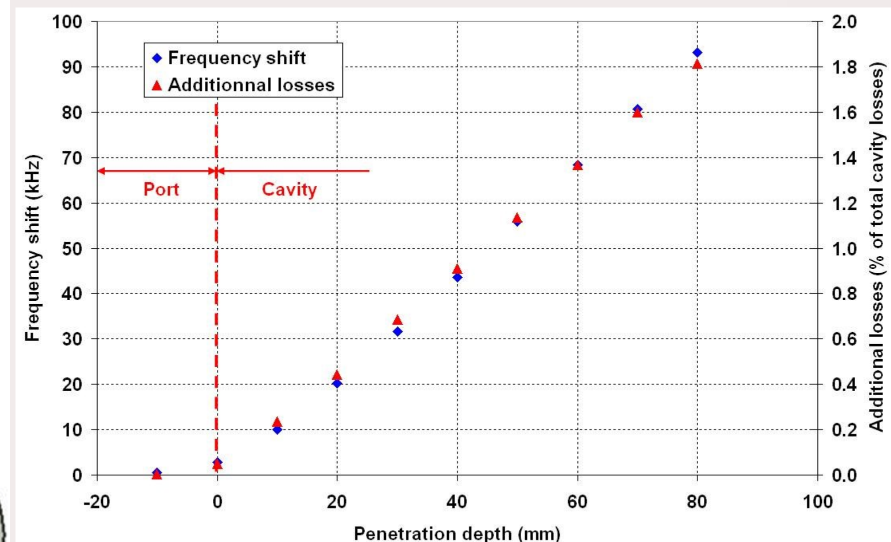


SPIRAL2 TUNER (1)

- Most advanced system already validated at 4K on 14 cavities (RF validation).
- Validated on cryomodule (RF + mechanical validation)
- Ø = 30mm, bulk Nb, stainless steel bellow
- Sensitivity ~ 1kHz/mm, Range : ± 4mm
- Static penetration ~ 50mm in cavity

Stainless steel bellow





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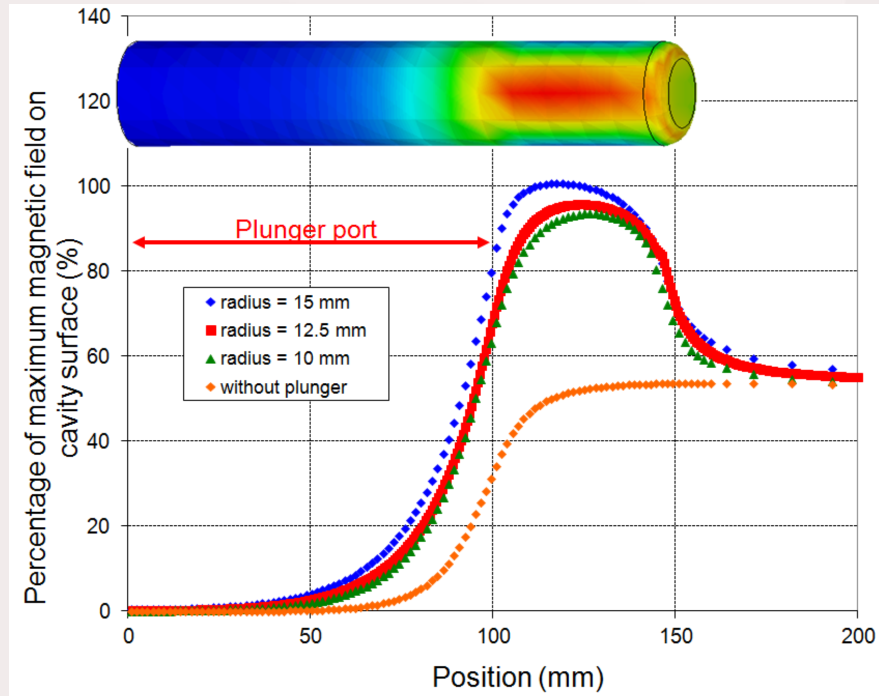
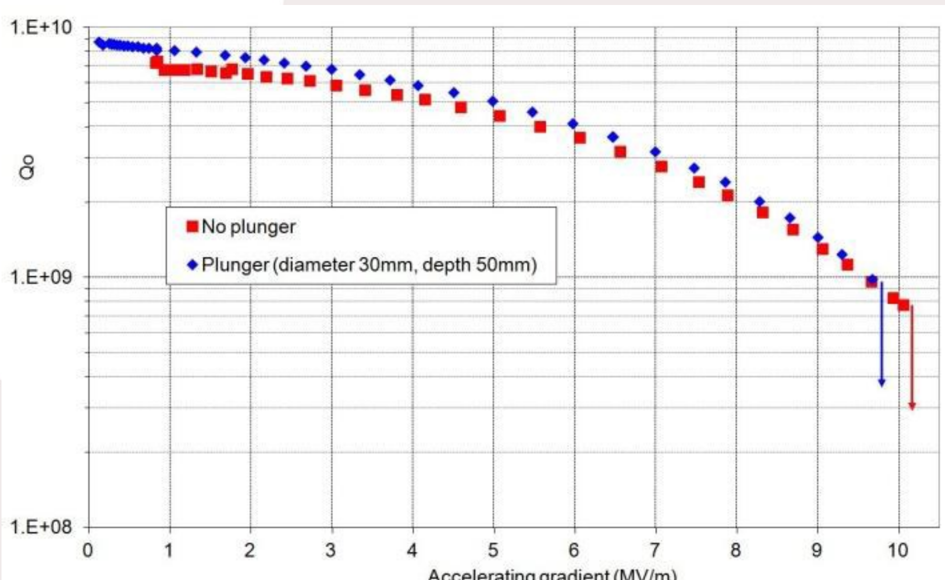
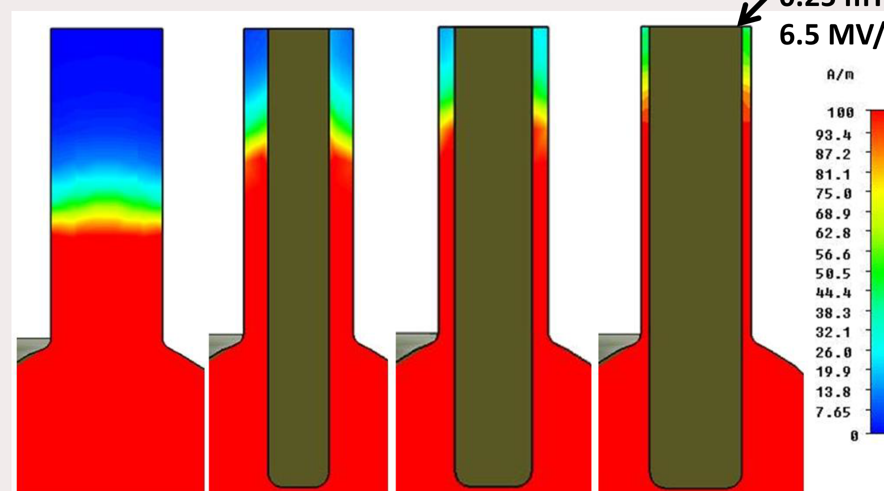
SPIRAL2 TUNER (2)

- RF simulations done to ensure :
  - Surface magnetic field on plunger not greater than in cavity
  - Residual magnetic field at cavity flange below 1 mT
  - Losses not above 1W.
- RF tests showed no limitations <u>only if</u>
  Surface treatment of plunger = Surface treatment of cavity







SPIRAL2 TUNER (3)

Diameter	Static detuning (kHz)		Dynamic detuning (Hz)	Additional losses (%) @ 6.5 MV/m	Magnetic field at flange (mT)
	Min (10mm)	Max (50 mm)	+/- (4 mm)	Max (50mm)	
Φ = 20 mm	5	25	1900	2.2	0.05
Φ = 25 mm	8	39	3000	4.7	0.11
Φ = 30 mm	11	50	4300	11	0.25

SPIRAL2 TUNER (4)

➢ Quench problematic :

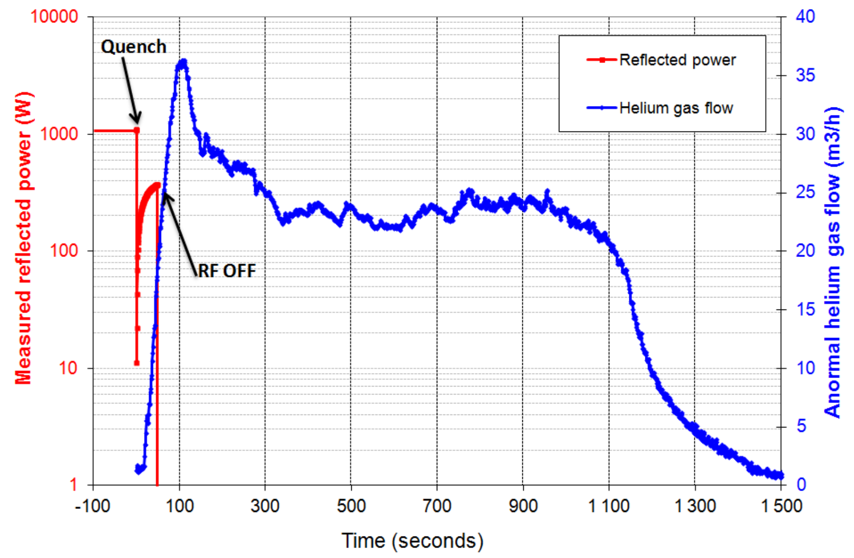
Cavity is strongly overcoupled

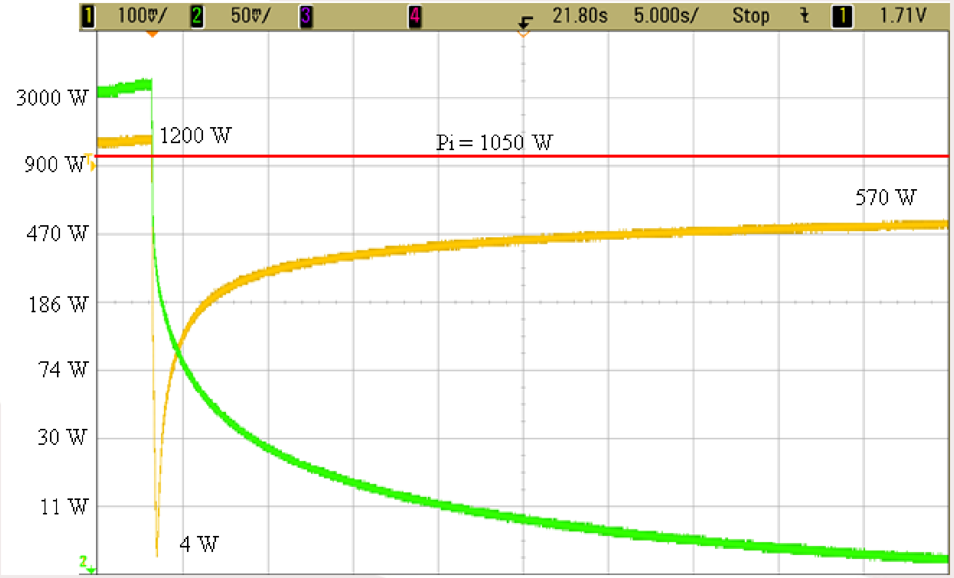
⇒ Quenched cavity has a Qo close to Qext

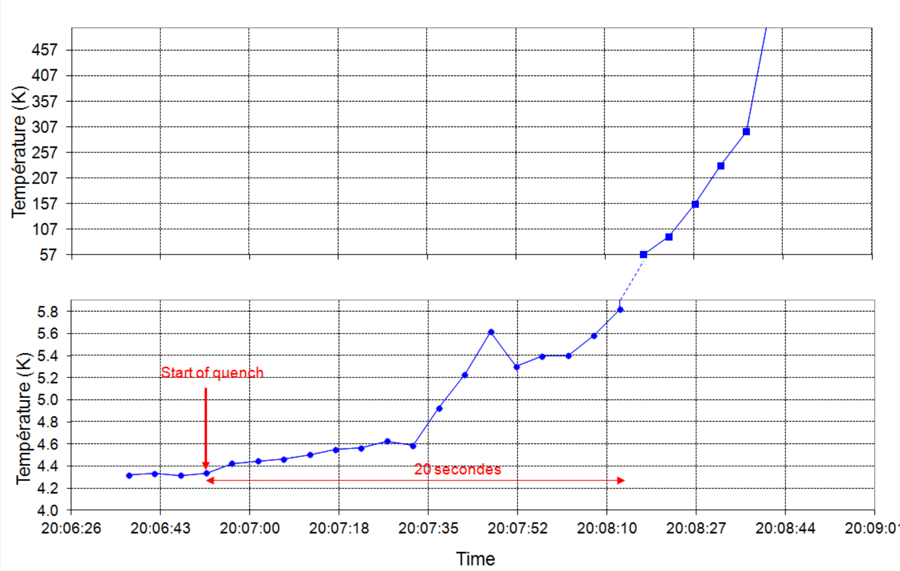
⇒ Significant RF power dissipated ~ 500W

⇒ If plunger is quenched, temperature increases very quickly.

⇒ Can be destructive if power not stopped within seconds.







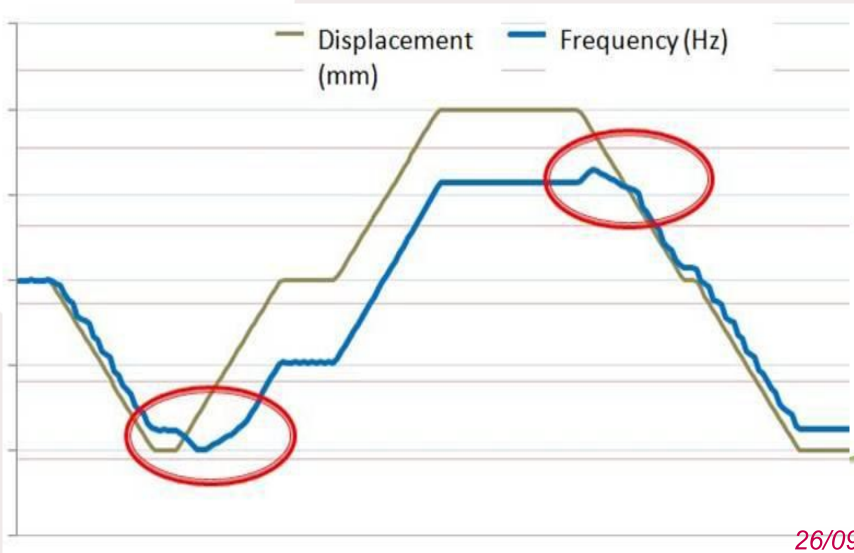
Temperature in plunger during a quench

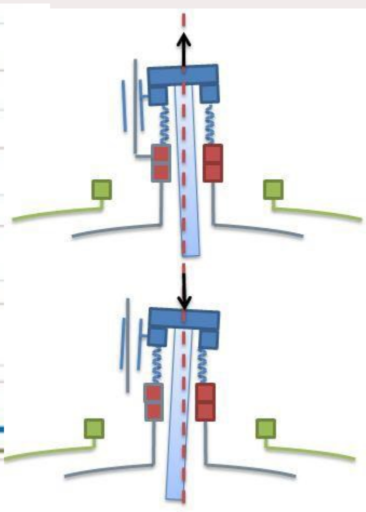
SPIRAL2 TUNER (3)

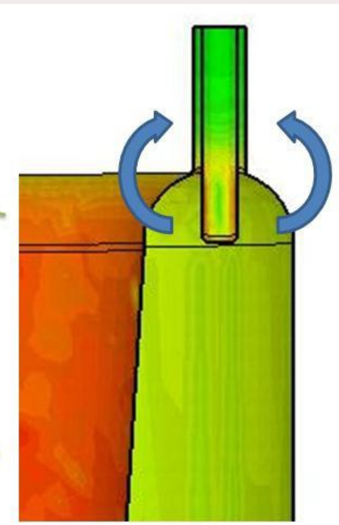
➢ **<u>Mechanical problem observed :</u>**
Significant overshoot (~ 100 Hz) and hysteresis (< 200 Hz) when direction of motion is changed
⇒ frequency regulation impossible as bandwidth ~ 88 Hz.

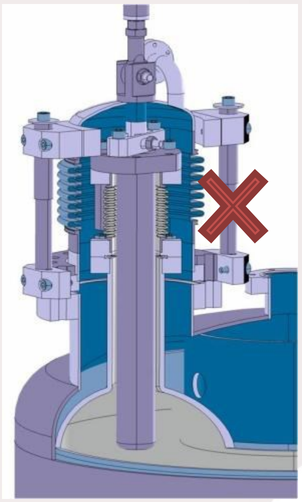
Difficulty to identify and localize the problem.
⇒ Need to develop a technique to measure small frequency deviation at room temperature to ease troubleshooting

➢ Swing motion of plunger because of plays
➢ Impossible to redesign the whole mechanism and annulate plays !
➢ <u>Trick</u> : force swing motion along field lines to avoid frequency change (Slater Th.)
➢ Reduce hyperstatism.
⇒ Overshoot < 5 Hz.
⇒ Hysteresis < 20 Hz.





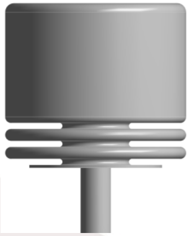




CONCLUSION

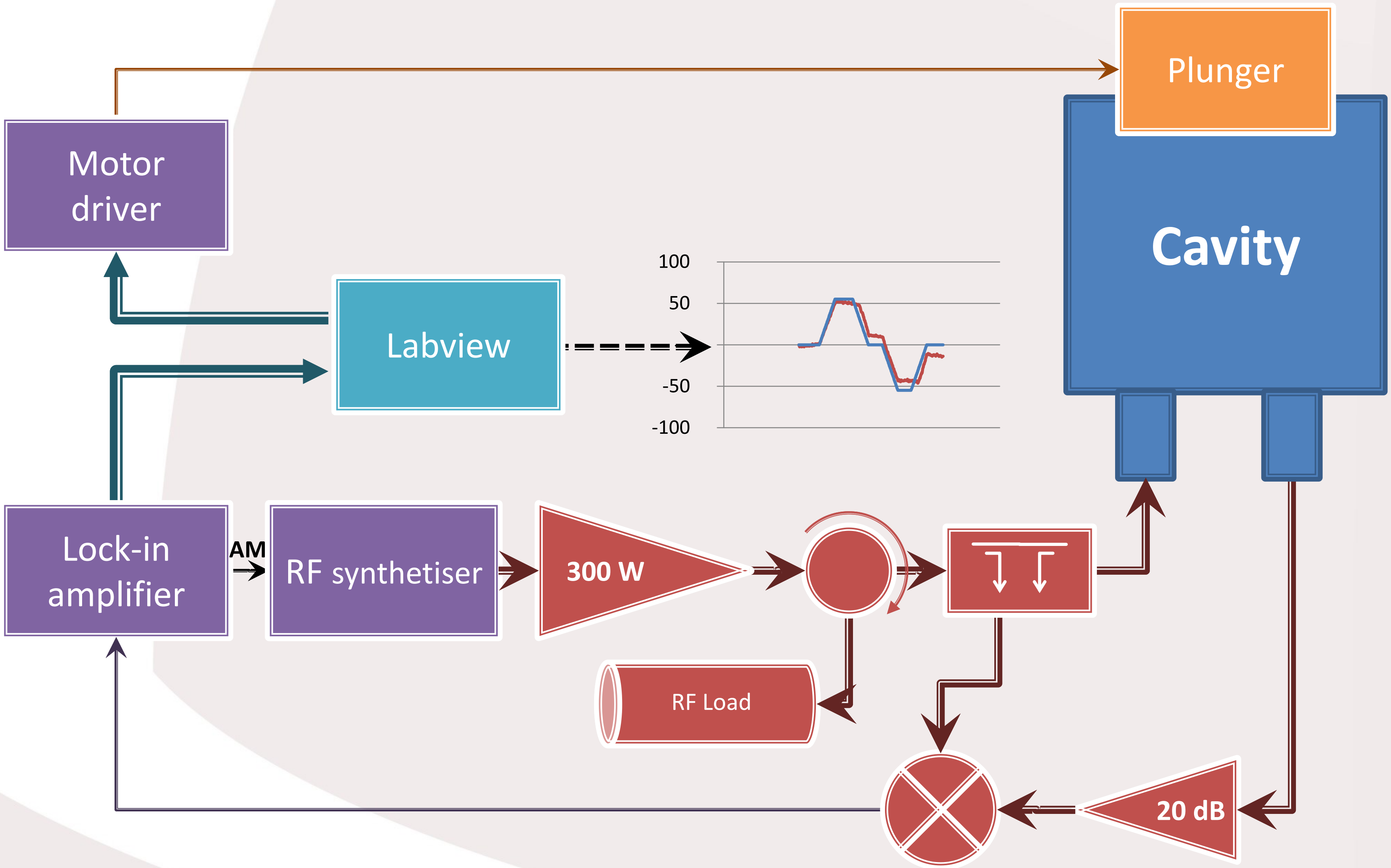
- ESS-Bilbao system offers many alternative
- IFMIF system abandoned but unfortunately lack of time
- MYRRHA system to be validated at 4K
- SPIRAL2 system is now successful !

- Moving plunger is a good alternative solution when
  - ⇒ Cavity is too stiff (QWR, HWR, Spoke, …)
  - ⇒ Compactness is required
  - ⇒ Flexibility is needed (capacitive or inductive, multiplicity)
- **BUT :**
  - ⇒ Lack of experience (dust generation ?)
  - ⇒ Require additional RF simulation (maximum field, residual field, losses, …)
  - ⇒ Require surface conditioning at the same standards as the cavity
  - ⇒ Maintenance more complicated (clean room required)
  - ⇒ Translation mechanism has to be well adjusted and very reliable



Many Thanks to J.L Munoz (ESS-Bilbao), Guillaume Devanz (CEA-IRFU) and H. Podlech (IAP) for the material.

Thank you for your attention


Plunger
Motor driver
Cavity
100
50
-50
-100
Labview
Lock-in amplifier
AM
RF synthetiser
300 W
RF Load
20 dB