A COLD TUNER SYSTEM WITH MOBILE PLUNGER

ESS-BILBAO, IFMIF, MYRRHA AND SPIRAL2
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
- Isac2 tuner, Triumf
- ESS- Bilbao tuner
- ReA3 tuner
- ESS Spoke tuner
- MYRRHA CH cavity tuner

By insertion
- Spiral2 tuner

Variable reactance
- ATLAS upgrade

29/01/2014 – Longuevergne David
# PROS AND CONS

<table>
<thead>
<tr>
<th>Pros</th>
<th>By deformation</th>
<th>By insertion</th>
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<td>- No risks of plastic deformation</td>
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**Complementary solution:** good where the other fail

- 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
- 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
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.
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.
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.
- 2 Niobium bellow tuners
- Sensitivity $\sim 125$ kHz/mm
- Fast tuner $\Delta F=130$Hz, slow tuner $\Delta F=130$kHz
- Optimized to limit multipacting in bellow
- Cavity and tuners have been built
- To be tested at 4K
- 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
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 only if Surface treatment of plunger = Surface treatment of cavity
<table>
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<tr>
<th>Diameter</th>
<th>Static detuning (kHz)</th>
<th>Dynamic detuning (Hz)</th>
<th>Additional losses (%) @ 6.5 MV/m</th>
<th>Magnetic field at flange (mT)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Min (10mm)</td>
<td>Max (50 mm)</td>
<td>+/- (4 mm)</td>
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<tr>
<td>Φ = 20 mm</td>
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<tr>
<td></td>
<td>5</td>
<td>25</td>
<td>1900</td>
<td>0.05</td>
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<td>Φ = 25 mm</td>
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<td>8</td>
<td>39</td>
<td>3000</td>
<td>0.11</td>
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<td>Φ = 30 mm</td>
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<td>11</td>
<td>50</td>
<td>4300</td>
<td>0.25</td>
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Quench problematic:

Cavity is strongly overcoupled
⇒ Quenched cavity has a $Q_o$ close to $Q_{ext}$
⇒ Significant RF power dissipated $\sim 500W$
⇒ If plunger is quenched, temperature increases very quickly.
⇒ Can be destructive if power not stopped within seconds.
Mechanical problem observed:
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!
⇒ Trick: force swing motion along field lines to avoid frequency change (Slater Th.)
⇒ Reduce hyperstatism.
⇒ Overshoot < 5 Hz.
⇒ Hysteresis < 20 Hz.
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
Thank you for your attention

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