

**Test der Einkoppelschleife
vom Alvarez 2.0 FOS am Alvarez A4-Tank**

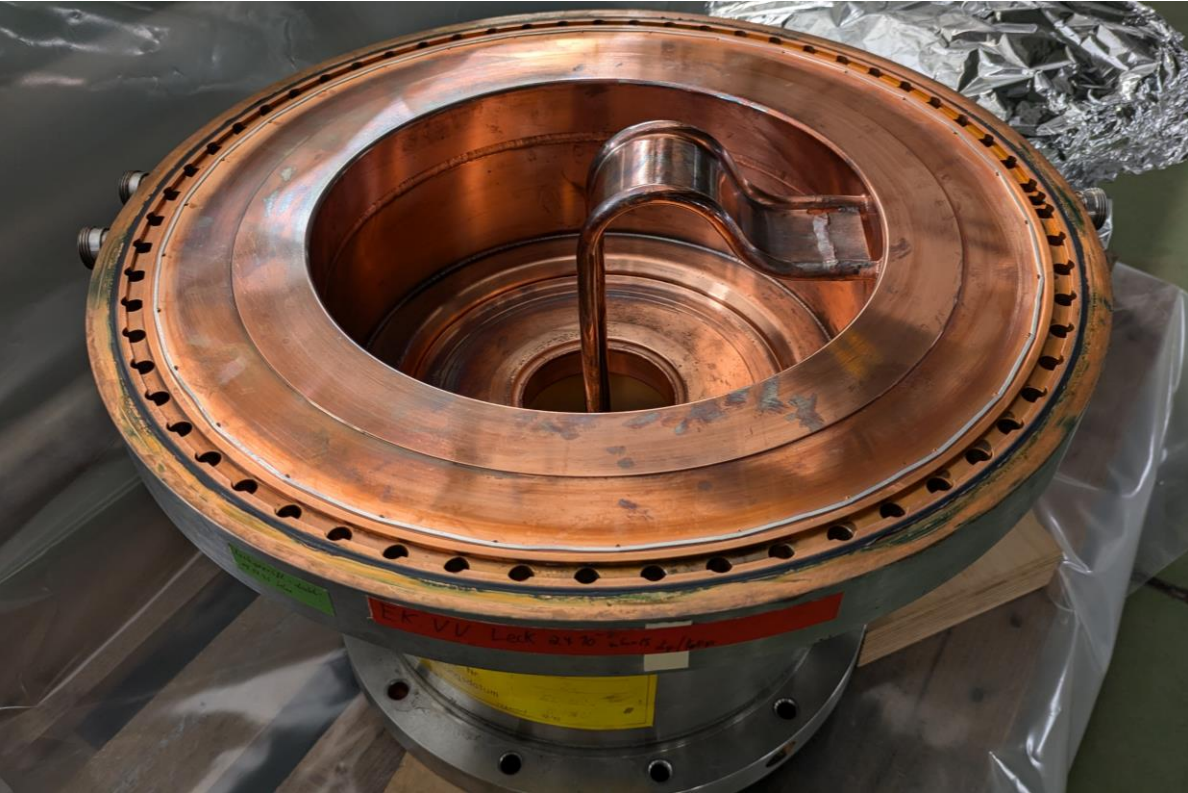
**B. Schlitt, G. Schreiber, C. Herr
(Linac RF)**

- Motivation
- Low level measurements @ coupling loop – coupling factor fluctuations
- High power RF tests
- Comparison to other systems
- Low level test of IH2 coupling loop @ A4 tank
- Measurement of transmission line resonances & high power tests of Thales HPA on dummy load
- Remarks & conclusions

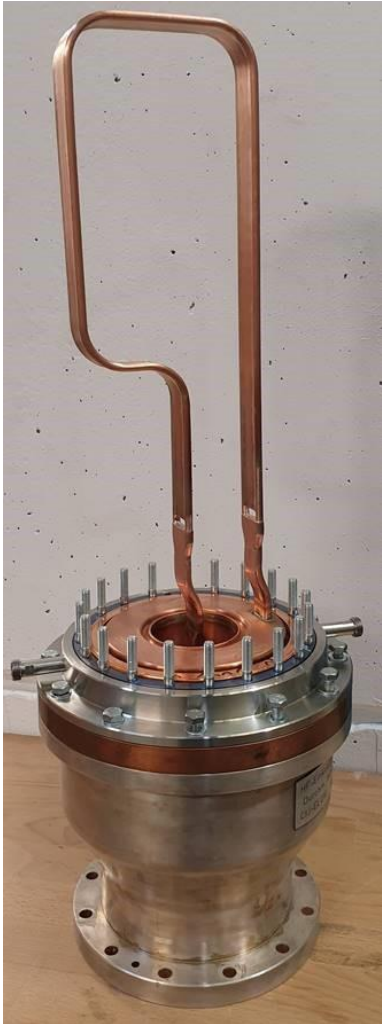
- **Alvarez 2.0 (PSU):**
HF Duty Cycle: 30 % (6 ms @ 50 Hz) → **2 %** (2 ms @ 10 Hz)
→ Verwendung einer **kompakteren Einkoppelschleife (EKS) für 6 1/8“ HF-Leitung** statt der großen EKS am bestehenden Alvarez Linac für HF-Leitung GSI-400
- **EKS für 6 1/8“ HF-Leitung** ebenfalls am HSI in Verwendung sowie an der pLinac Prototyp-CH-Struktur und weiteren Strukturen (alle Strukturen > 1 MW HF-Pulsleistung),
kommerziell von NTG lieferbar (Rahmenvertrag)
- **Alte Alvarez EKS für GSI-400 HF-Leitung:** keine ausreichende Dokumentation verfügbar, Neukonstruktion erforderlich, sehr unhandliche, schwere EKS,
HF-Leitungsteile für Umbau auf Alvarez 2.0 erfordern Sonderlösungen
- **Alte EKS vom A4** → **Ersatzteilsicherung für Restbetrieb des bestehenden Alvarez** bis zur Inbetriebnahme des neuen post strippers (PSU)

Input coupling loops

Original input coupling loop @ A4



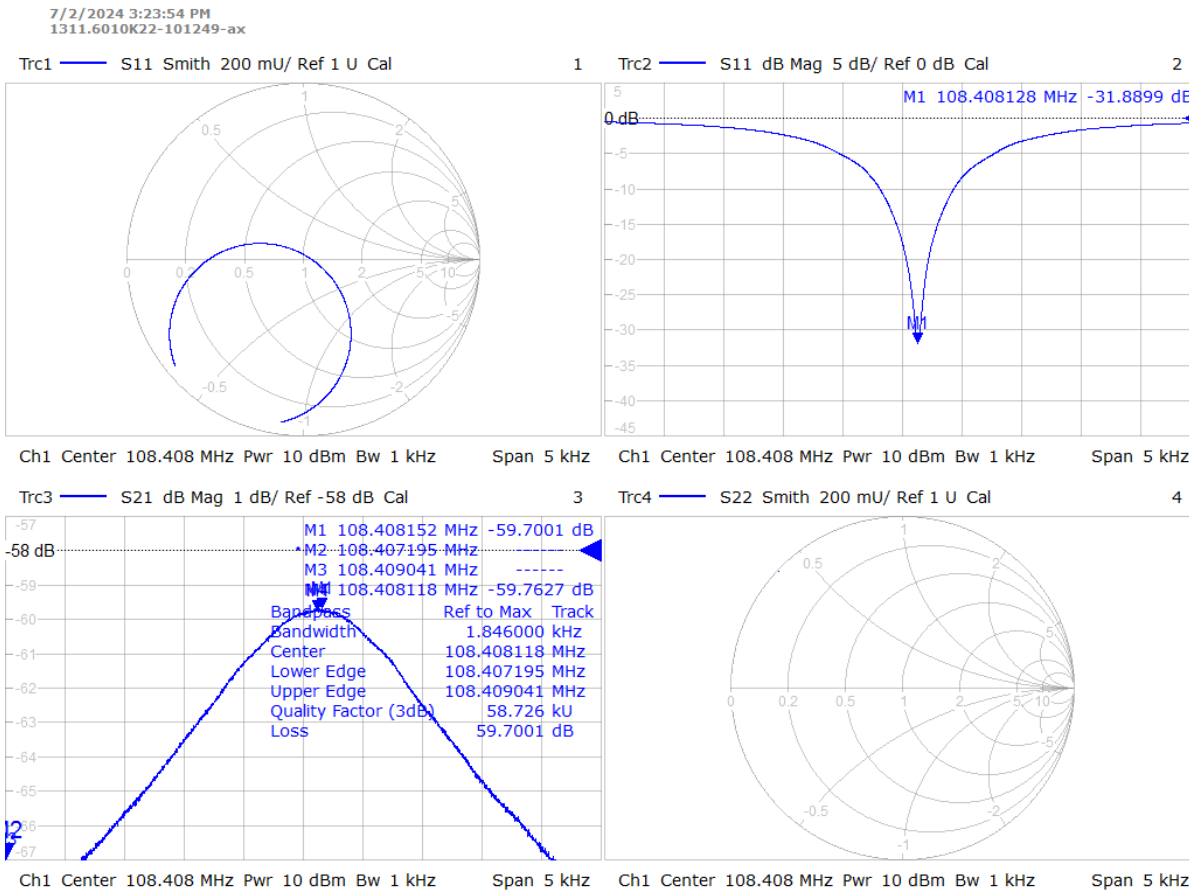
New input coupling loop / Alvarez 2.0 FOS



Input coupling factors & more (A4)



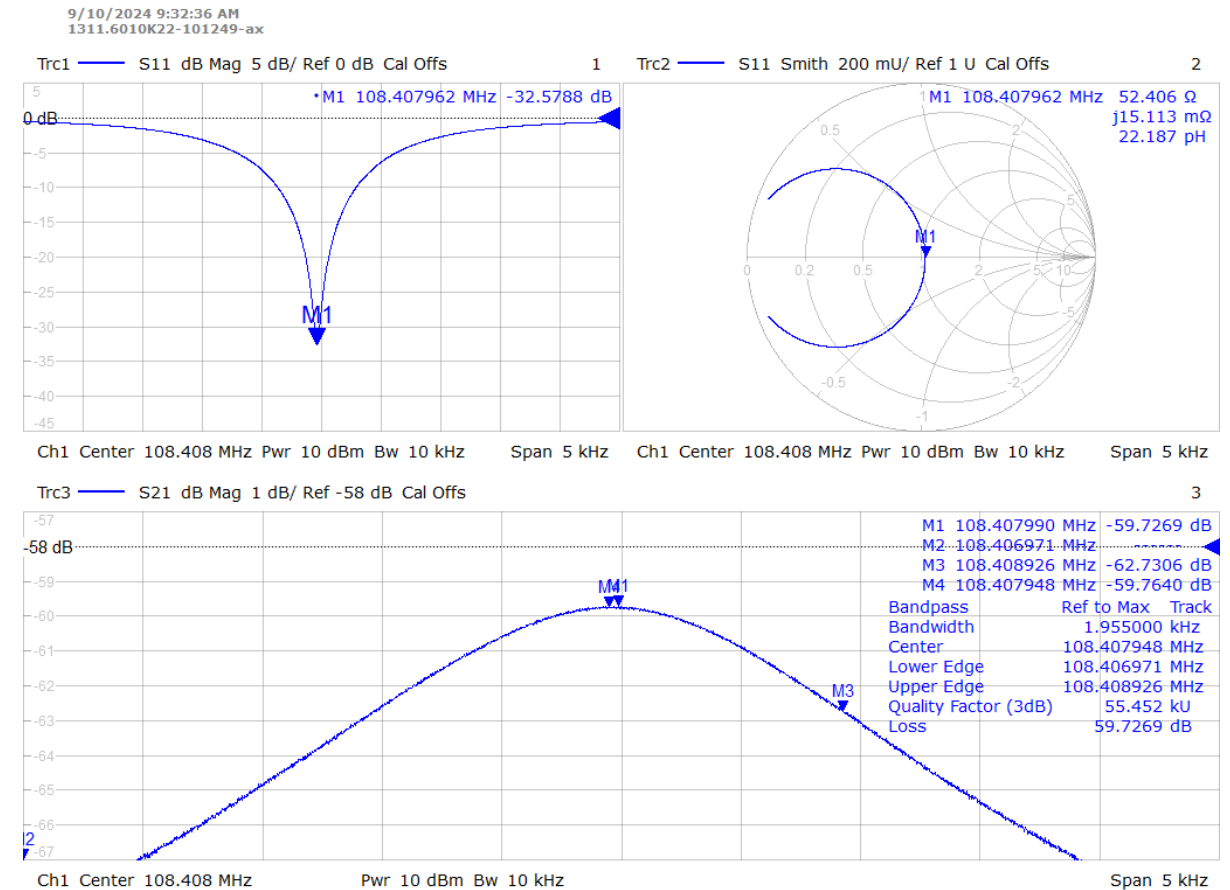
Original A4 input coupling loop (July 2024)



S11 ≈ -31,9 dB

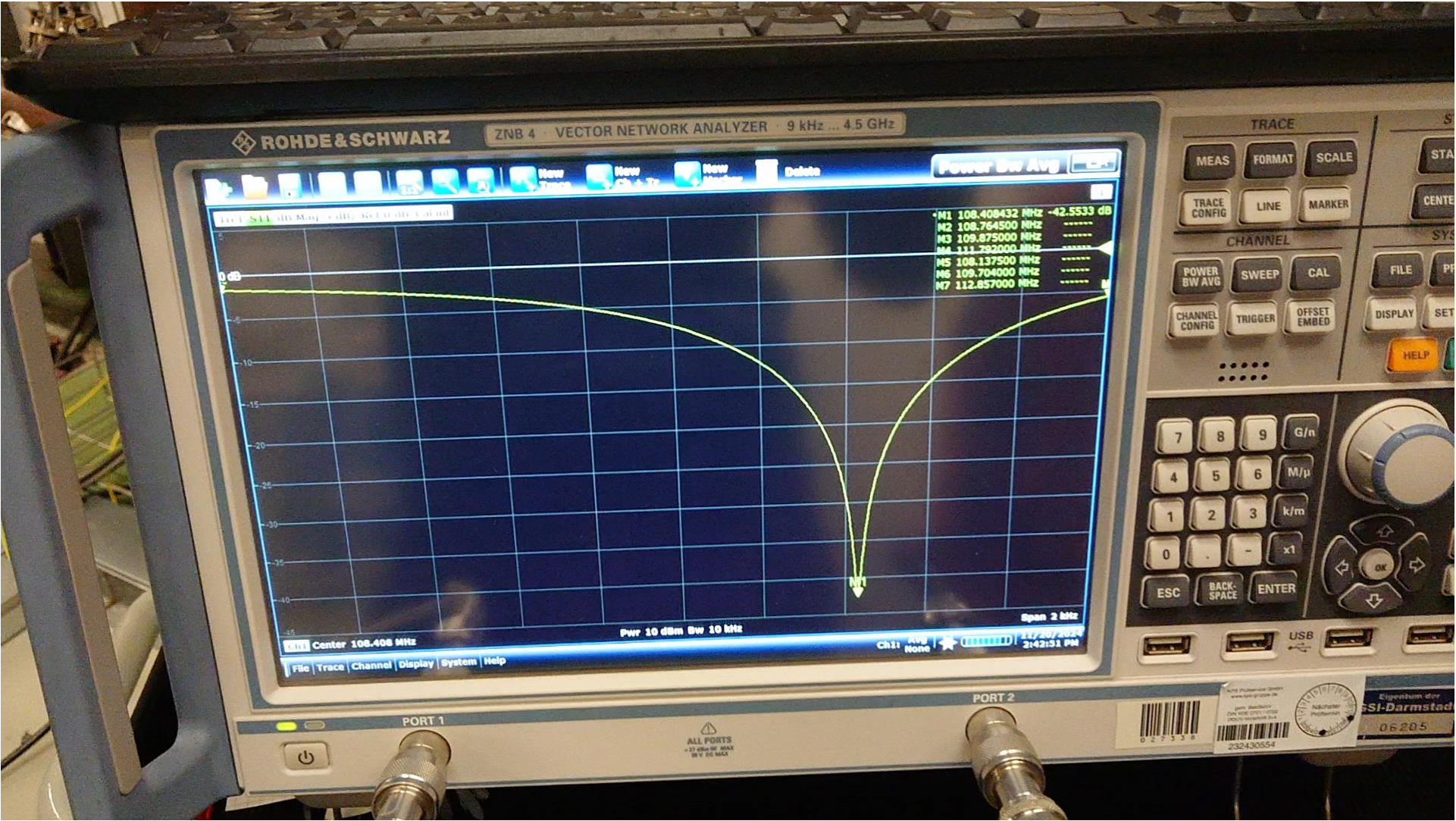
(Tank A4 under vacuum)

New input coupling loop from FOS @ A4 (Sept. 2024)



S11 ≈ -32,6 dB

Input coupling factor fluctuations (FOS input coupling loop @ A4 tank)

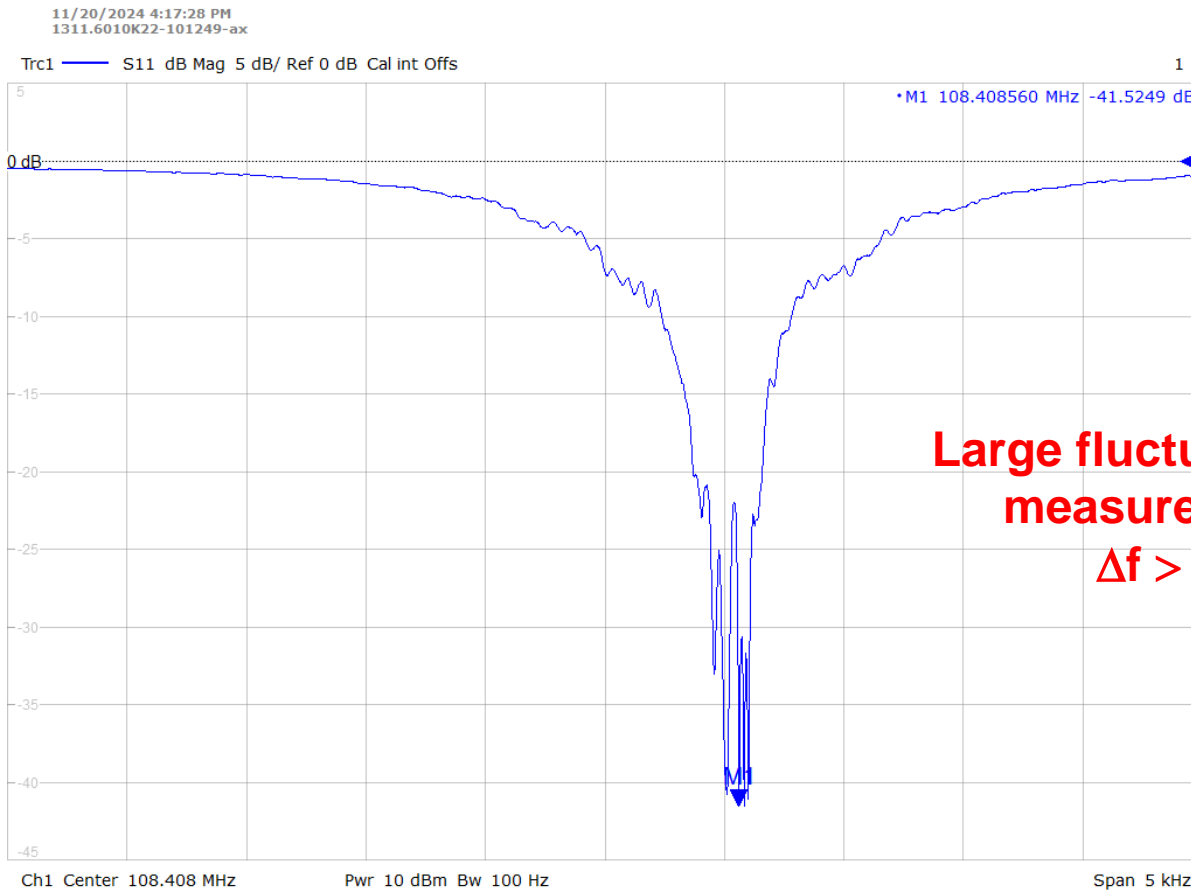


(→ Video 1)

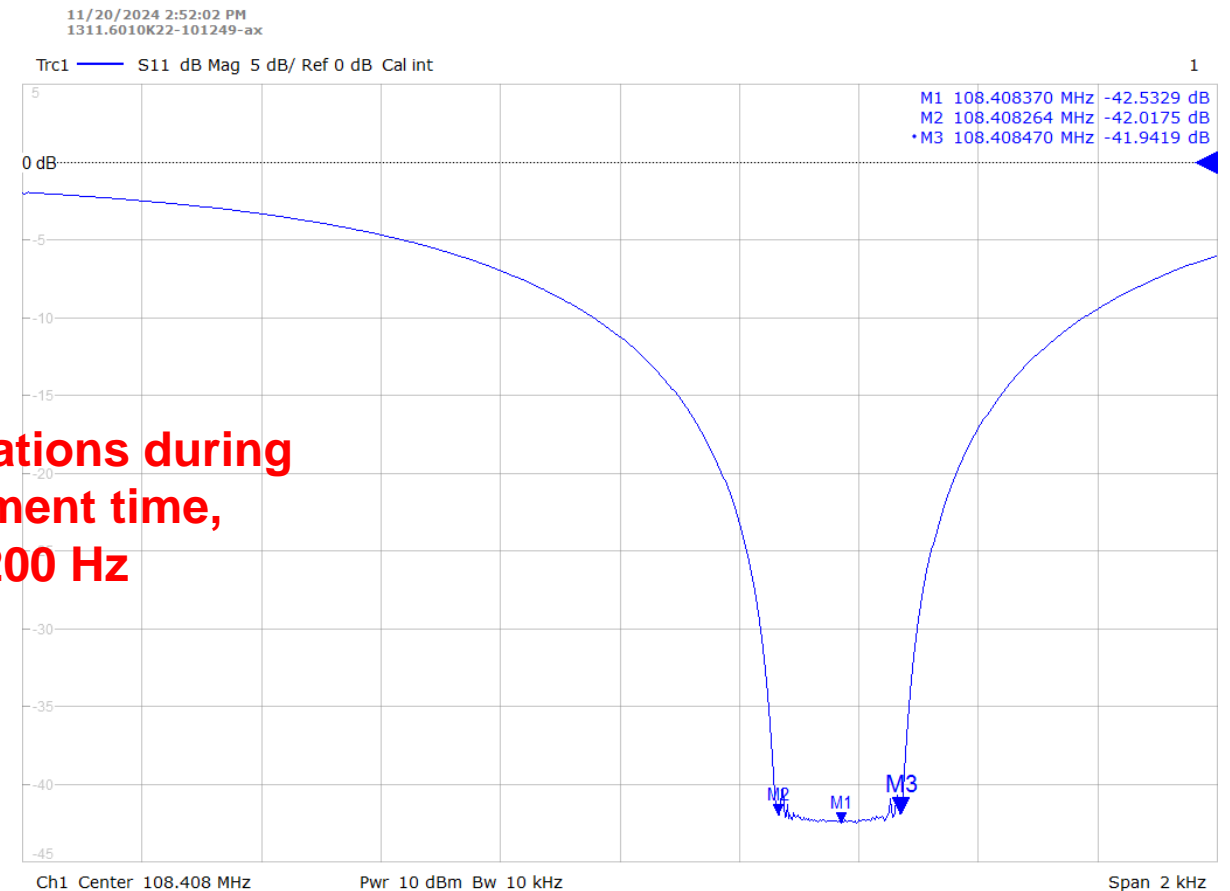
Input coupling factor fluctuations – Frequency domain (FOS input coupling loop @ A4 tank)



(Measurements from RF gallery, Nov. 2024)



Slow measurement @ 100 Hz BW

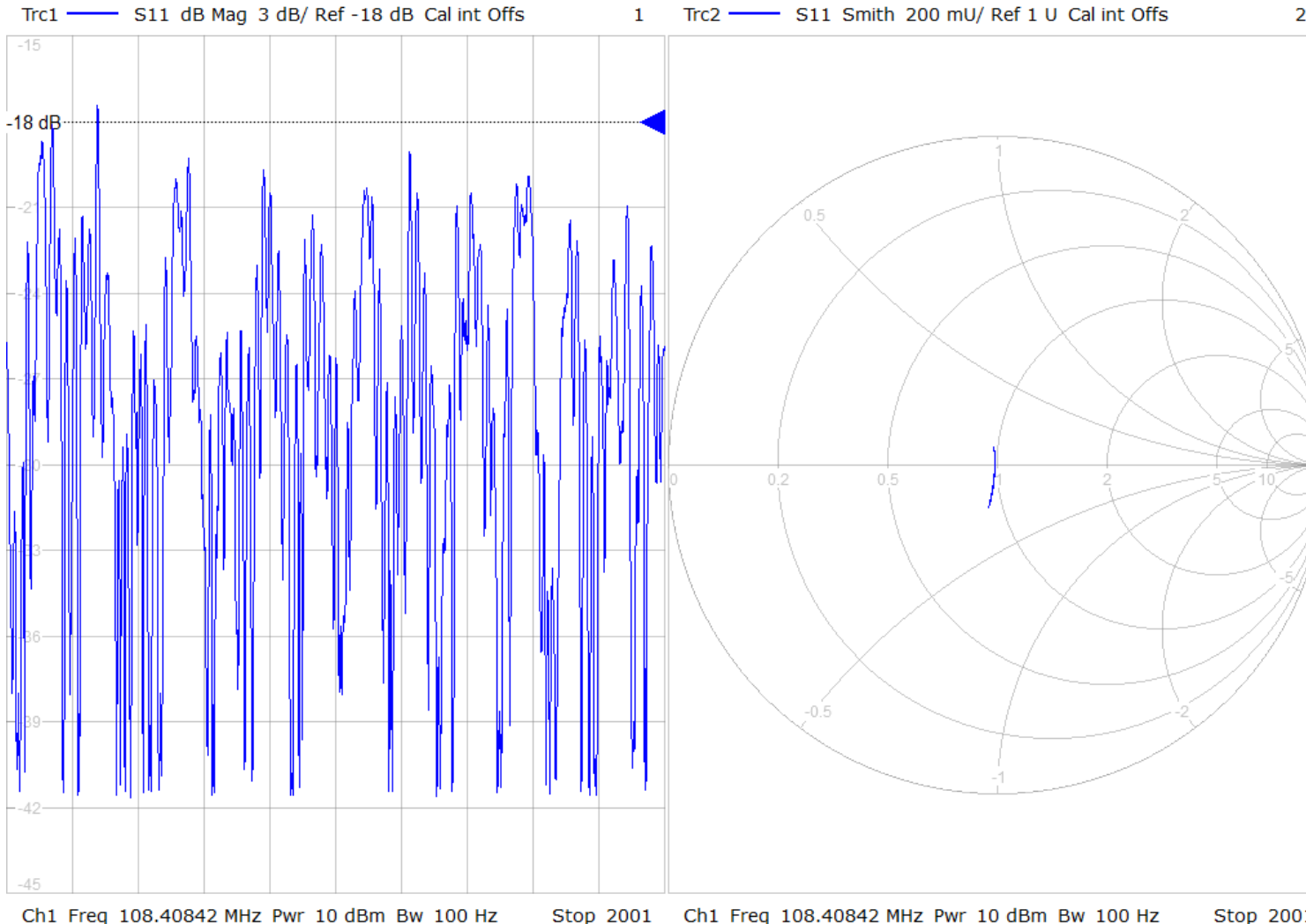


Analyzer @ Min Hold, measurement @ 10 kHz BW

Large fluctuations during
measurement time,
 $\Delta f > 200$ Hz

Input coupling factor fluctuations – Time domain (FOS input coupling loop @ A4 tank)

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S11 Time domain measurement
(left plot, from RF gallery, Nov. 2024)

**Input coupling factor fluctuations
up to ~ 24 dB !**

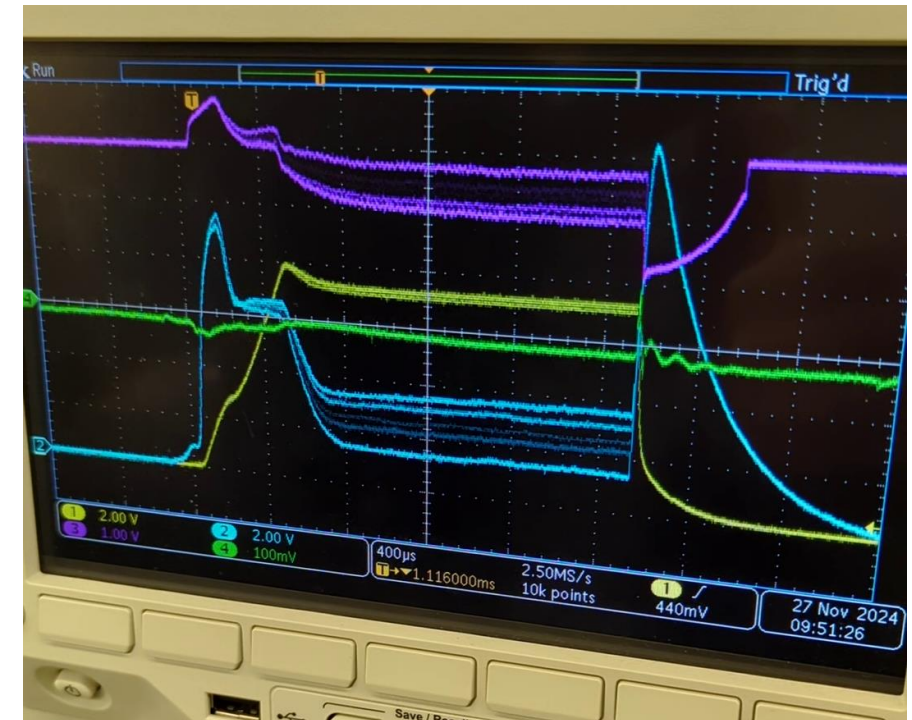
Two major fluctuation periods:

~ 170 ms

~ 1.2 s

Impact on RF operation – High power RF tests (FOS input coupling loop @ A4 tank)

- As expected from low level measurements:
Large pulse to pulse fluctuations of reverse RF power as well as corresponding fluctuations of forward RF power to keep field in cavity stable
- **Resonance frequency control: no stable operation in automatic mode at high RF power** (switched to manual mode to test operation at high power)
- **Highest RF powers as required for beam time 2025 could not be reached during test operation with FOS coupling loop**

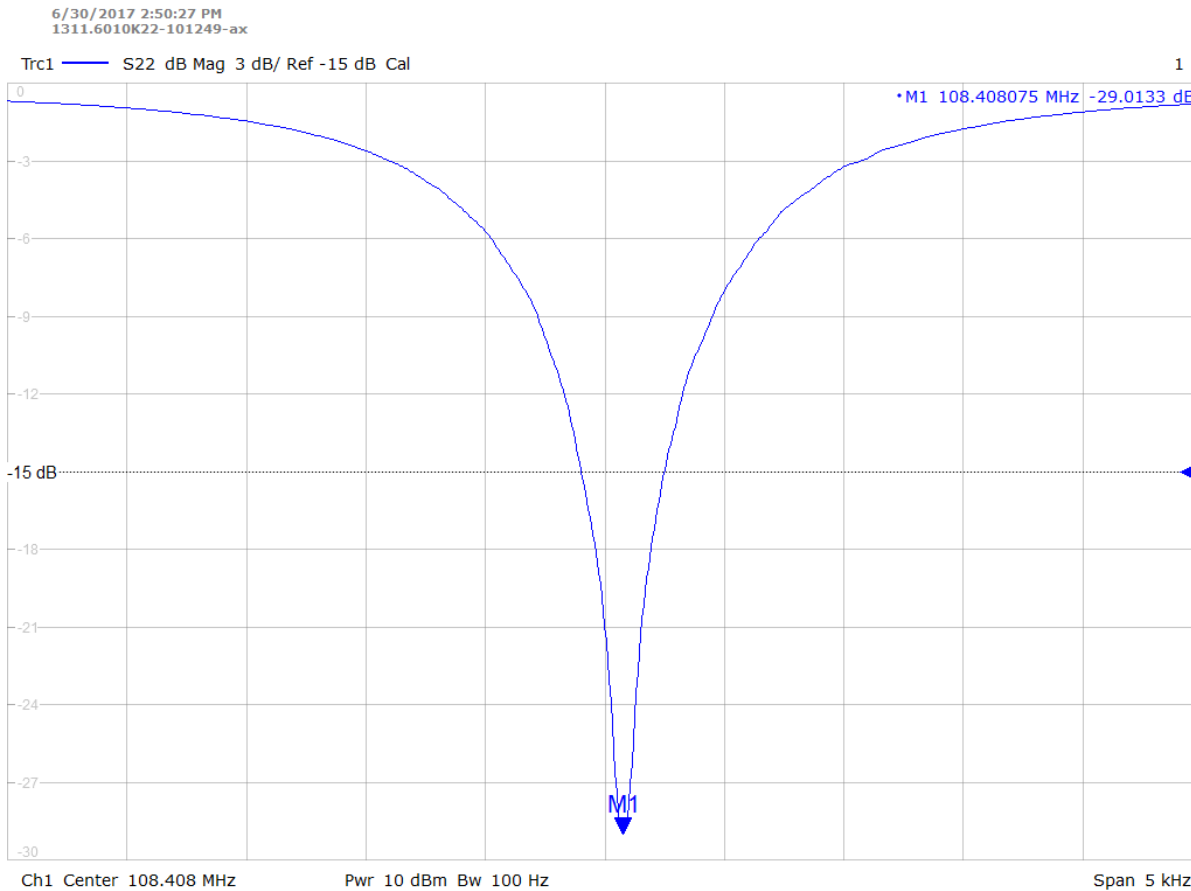


(→ Video 2)

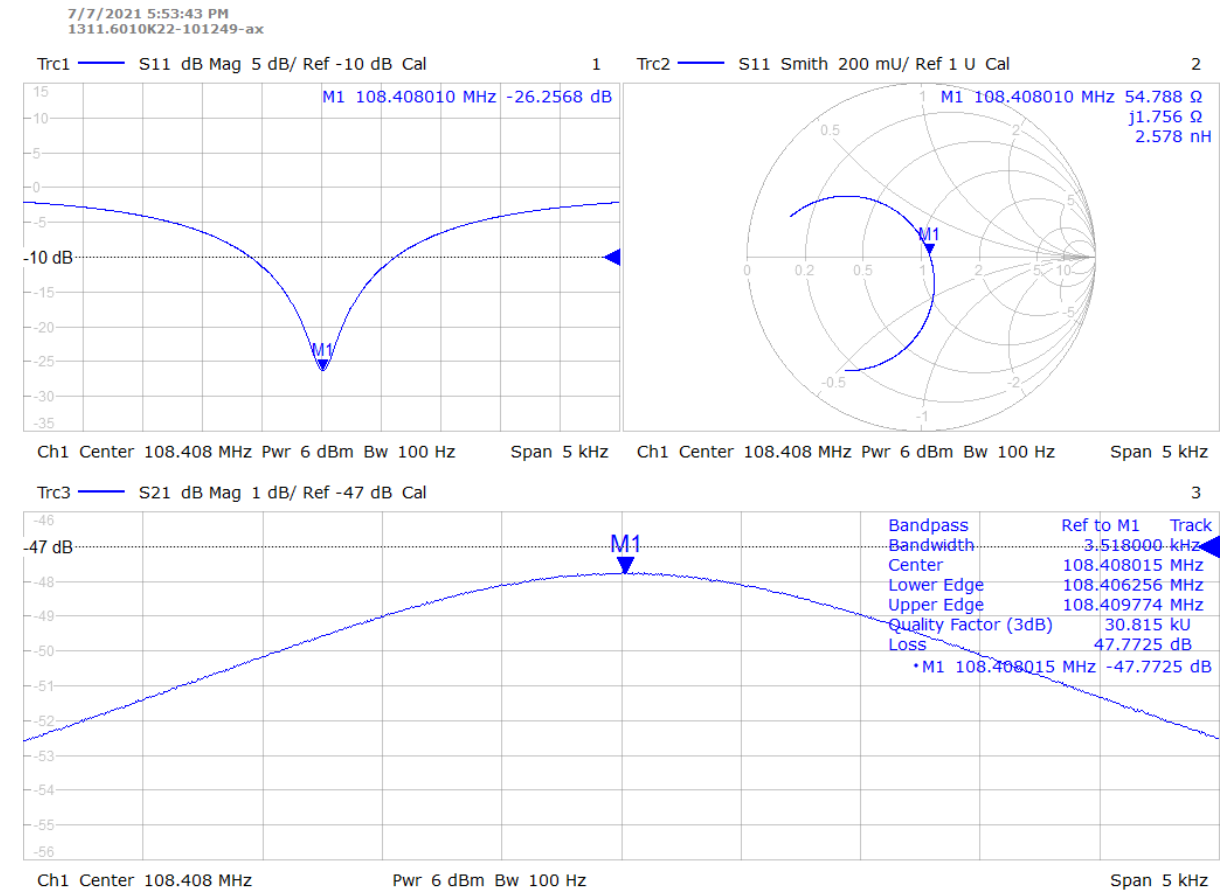
Input coupling factor stability – comparison to A4 (original loop) & FOS



Original coupling loop @ A4 (2017, from RF gallery)



New coupling loop @ FOS (2021)

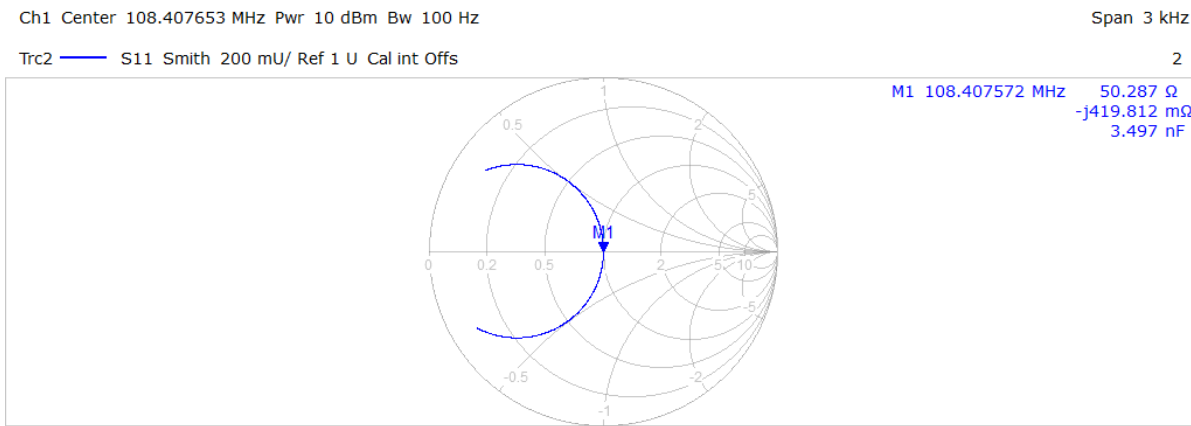
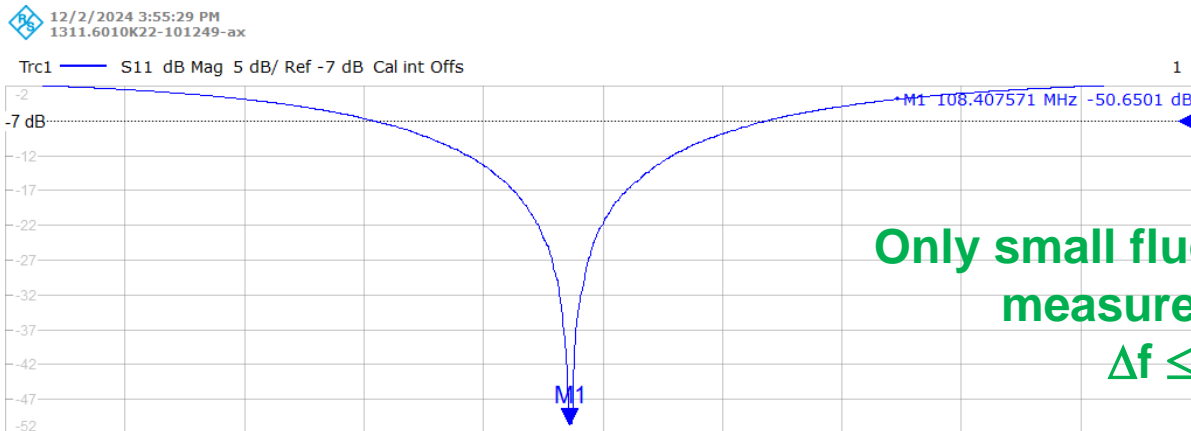


Slow measurements @ 100 Hz BW: stable conditions – compare to slide No. 6 for new loop @ A4

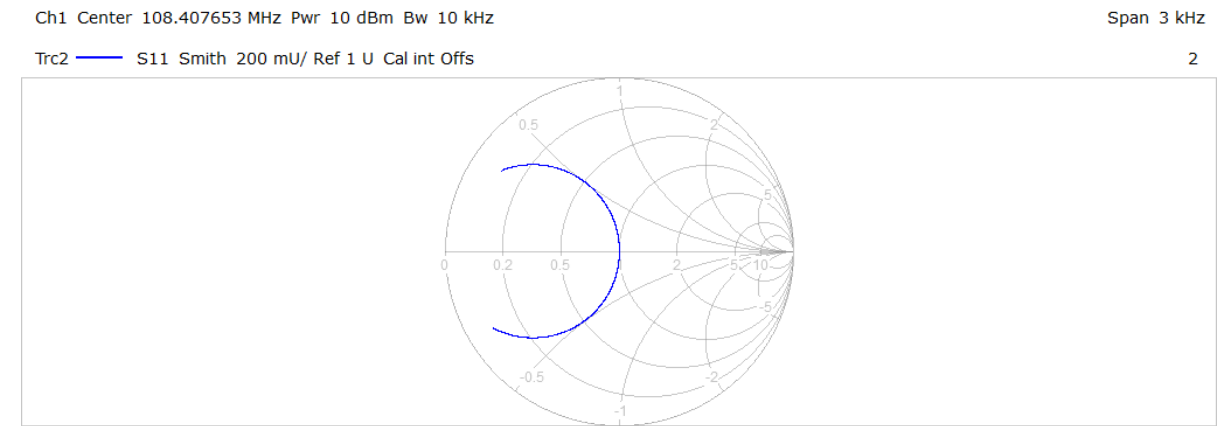
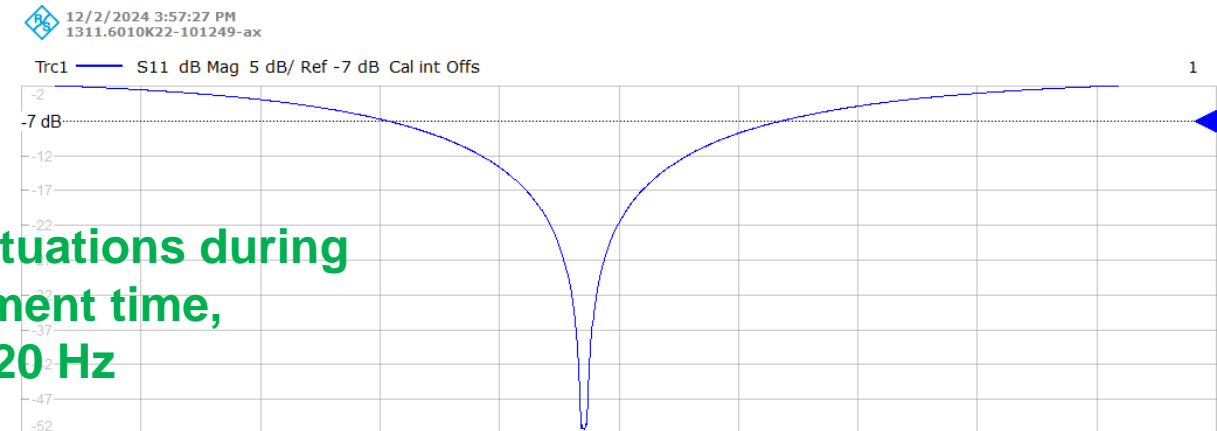
Input coupling factor stability – comparison to A1



Measurements @ A1 from RF gallery (Dez 2024) – compare to slide No. 6 for new loop @ A4



Slow measurements @ 100 Hz BW



Analyzer @ Min Hold

Only small fluctuations during measurement time,
 $\Delta f \leq 20$ Hz

Test of input coupling loop for HSI IH2 @ A4



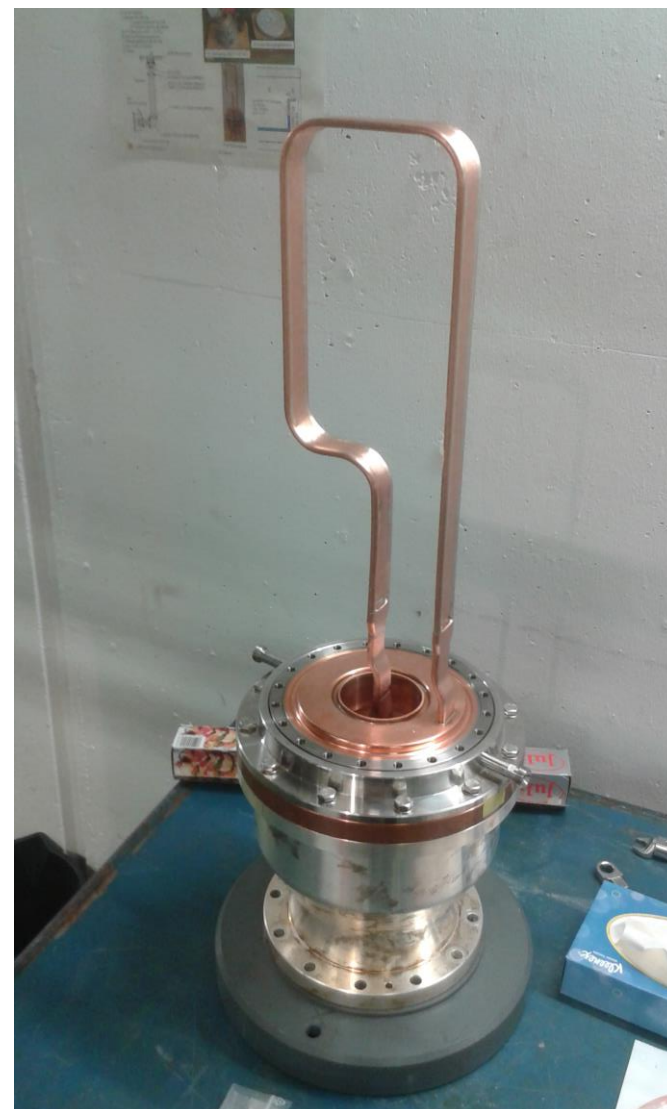
Coupling loop from HSI IH2 (spare)

Height \approx 310 mm



Coupling loop from Alvarez 2.0 FOS

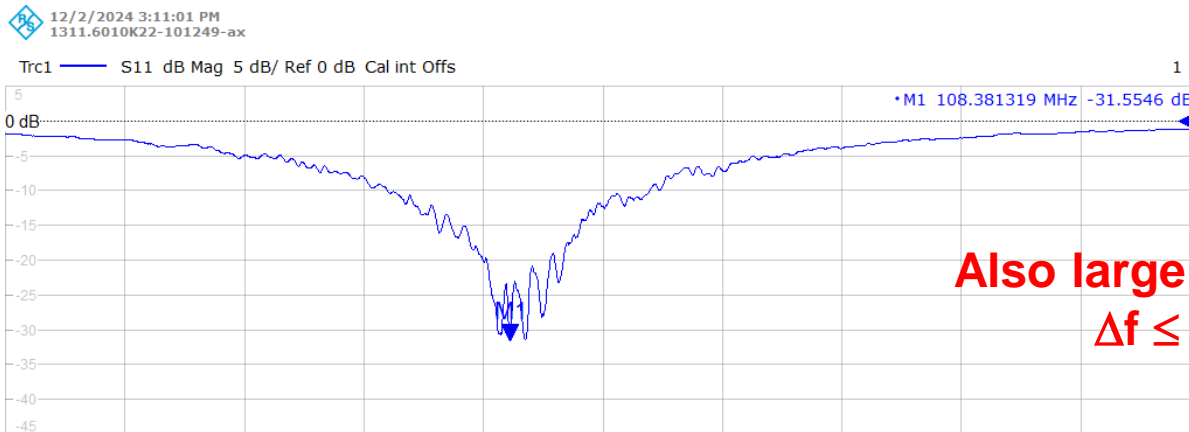
Height \approx 450 mm



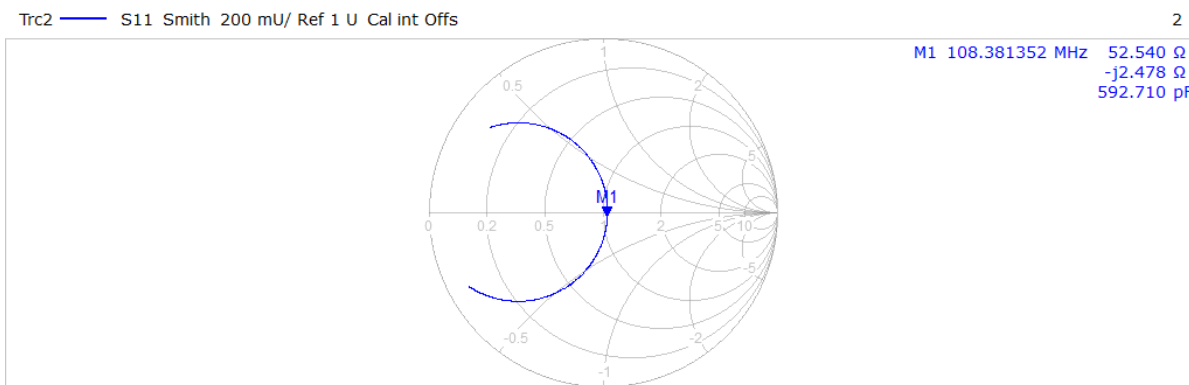
Test of input coupling loop for HSI IH2 @ A4: Input factor fluctuations



Fluctuations similar to FOS loop – compare to slide No. 6 for new loop @ A4

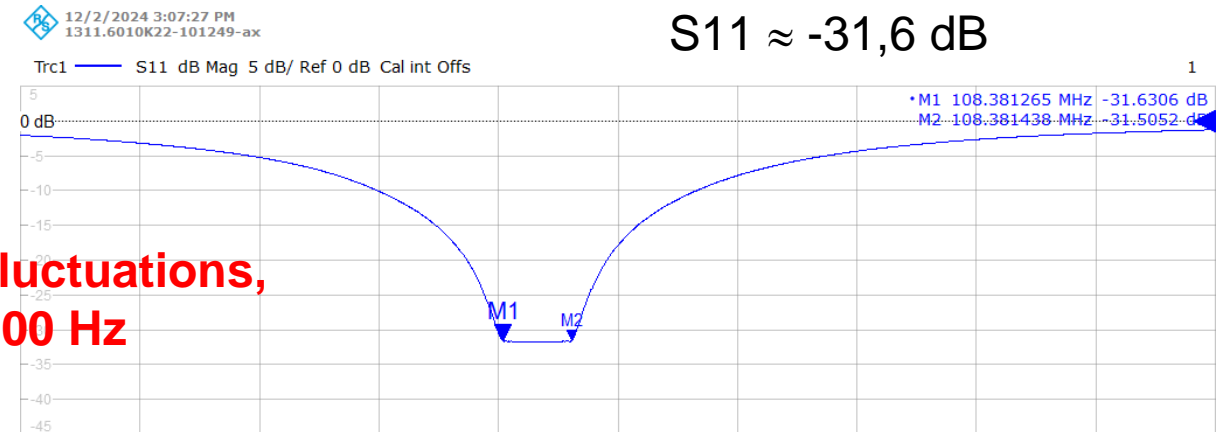


Ch1 Center 108.381553 MHz Pwr 10 dBm Bw 100 Hz Span 3 kHz



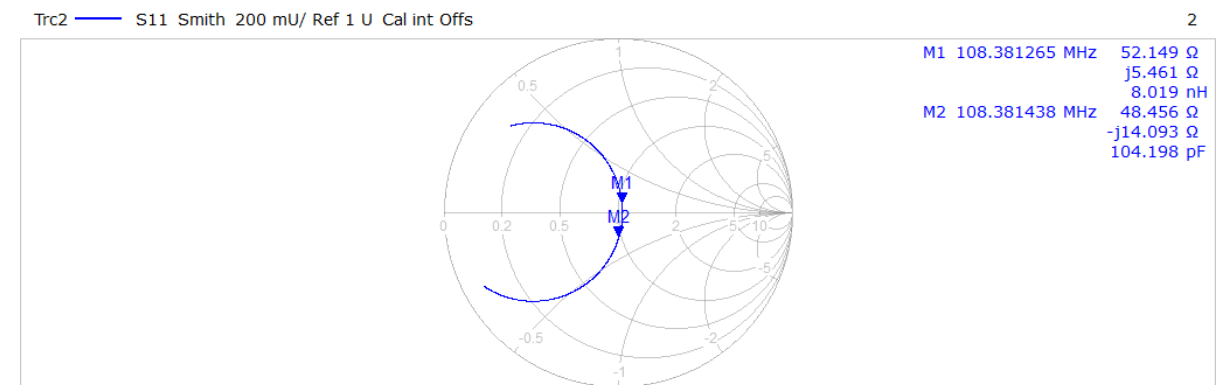
Ch1 Center 108.381553 MHz Pwr 10 dBm Bw 100 Hz Span 3 kHz

Slow measurements @ 100 Hz BW



S11 ≈ -31,6 dB

Ch1 Center 108.381553 MHz Pwr 10 dBm Bw 10 kHz Span 3 kHz



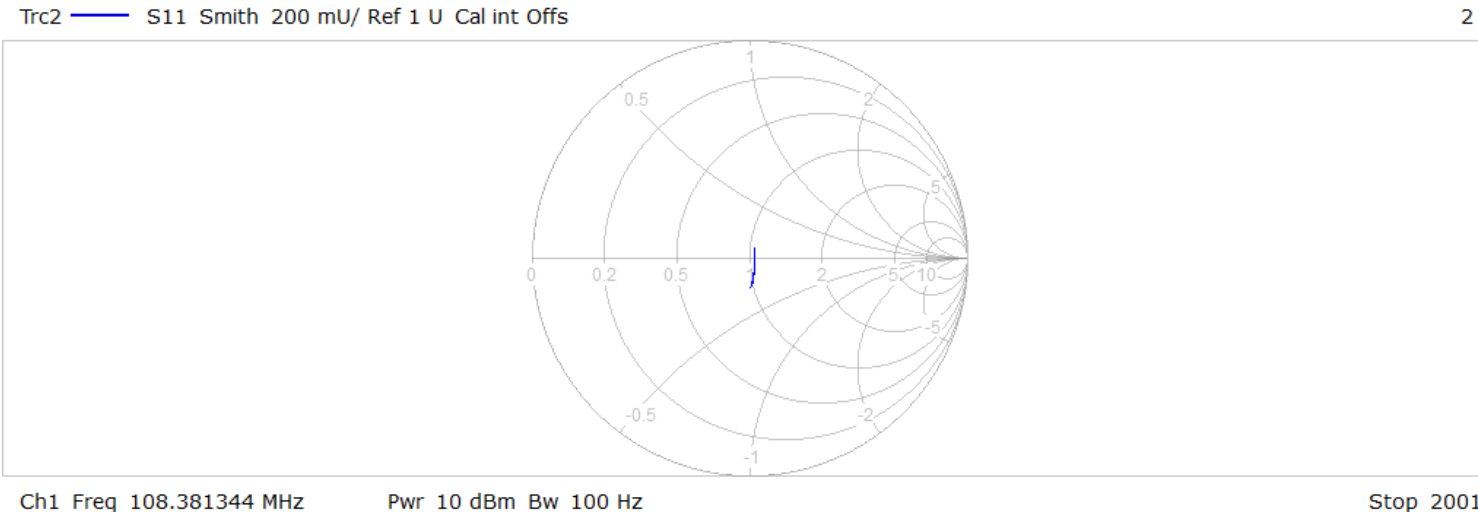
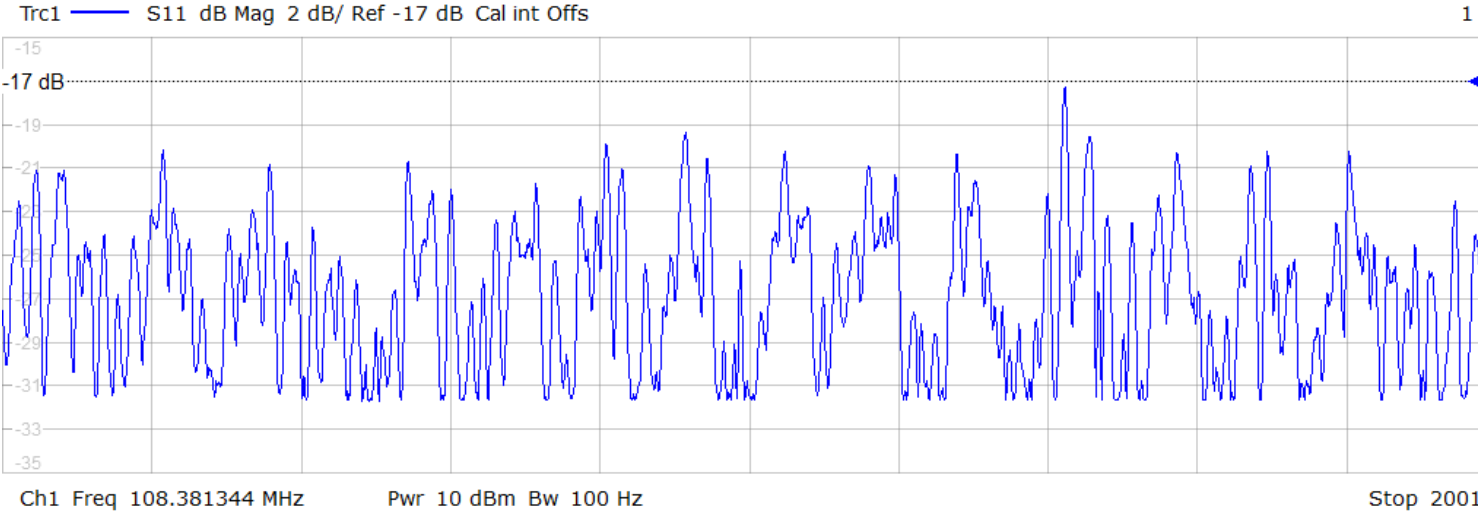
Ch1 Center 108.381553 MHz Pwr 10 dBm Bw 10 kHz Span 3 kHz

Analyzer @ Min Hold

Test of input coupling loop for HSI IH2 @ A4: Input factor fluctuations – Time domain



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S11 Time domain measurement
(measurement directly at A4 cavity in
tunnel, cavity at air pressure)

**Input coupling factor fluctuations
up to ~ 14 dB**

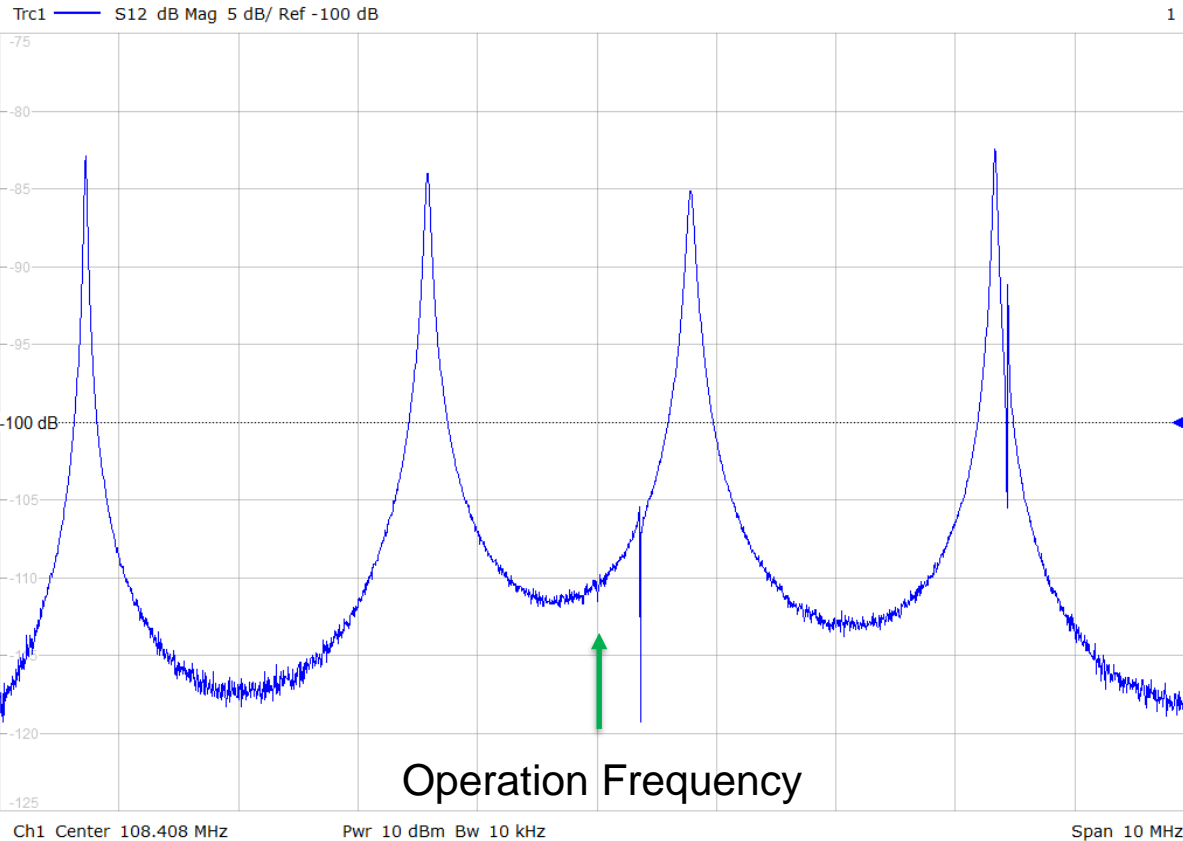
(similar to FOS coupling loop)

Thales – A4 RF Transmission Line Resonances



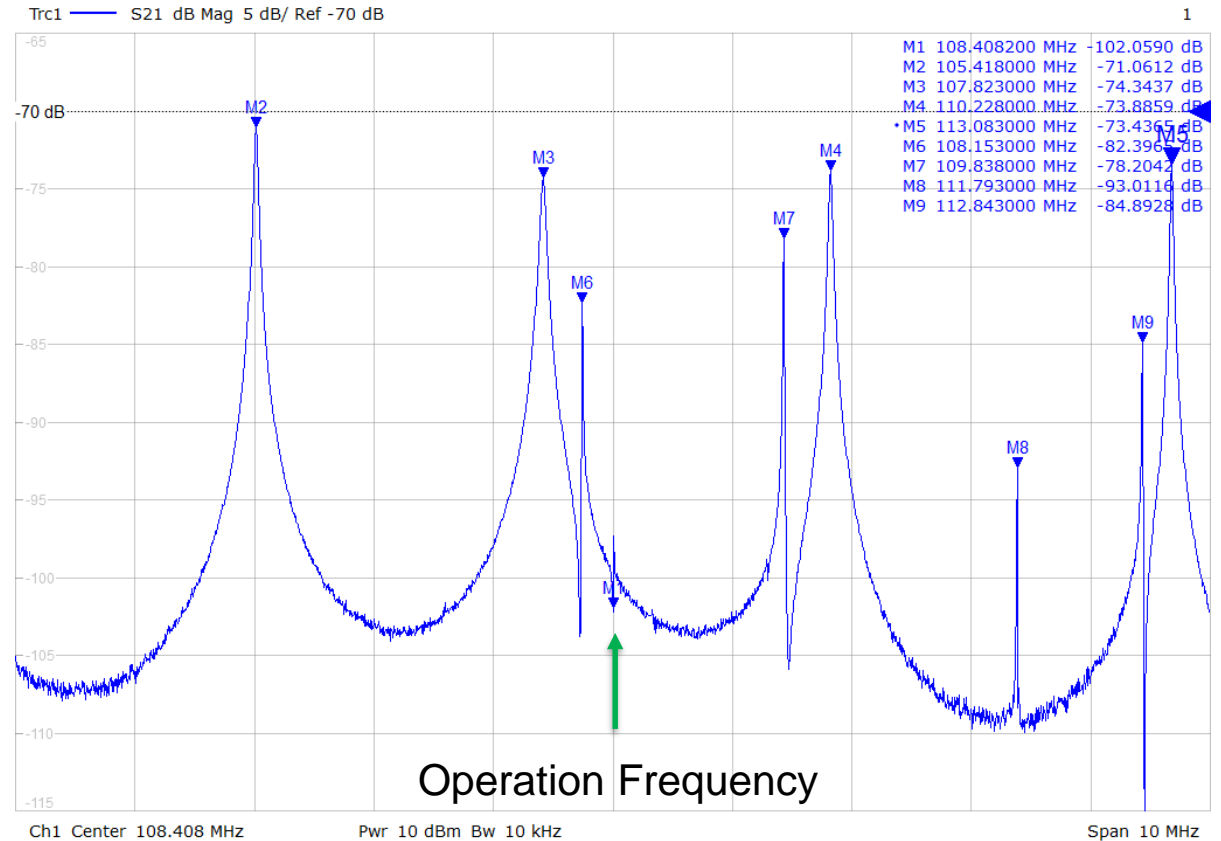
July 2017 (Thales HPA SAT – original coupling loop)

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Nov 2024 (new input coupling loop)

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Position of transmission line resonances depending on setting of HPA output circuit. Measurement: Output circuit @ 60 % (~ working point).

Thales HPA – Test on dummy load successful



≥ 1.95 MW reached on water dummy load, HPA works correctly, reproduction of SAT result
(S. Hermann, C. Herr, et al., 03.12.2024)

- **Mit neuem Schleifendesign vom FOS keinen stabilen HF-Betrieb erreicht**
⇒ **Rückbau auf Original-EKS vom A4**
- **Mechanische Schwingungen der Schleife oder der Driftröhren?**
Falls Driftröhren: geringerer Einfluss bei original Alvarez-EKS?
- **EKS vom Alvarez 2.0 FOS zu groß**, steht sehr schräg im Feld ($< 45^\circ$ zum H-Feld),
Einstellung / Tuning sehr positionsempfindlich,
kein stabiler HF-Betrieb möglich
- **EKS von HSI IH-Tanks gut angepasste Schleifengröße**,
gute Winkelstellung zum H-Feld, Einstellung gut durchführbar,
sehr gute Anpassung erreichbar,
leider ebenfalls zu große Schwankungen von Anpassung und Resonanzfrequenz
- Aktuelle Probleme **mit alter Alvarez-EKS bisher nicht beobachtet**,
stabiler HF-Betrieb, alte Alvarez-EKS mechanisch sehr robuster Aufbau

- **Am HSI bisher keine Probleme mit diesem Schleifentyp beobachtet**
(aber: deutlich geringere Güte der IH-Tanks im Vergleich zu Alvarez-Tanks)
- **Am Alvarez 2.0 FOS mit der neuen EKS ebenfalls keine derartigen Probleme beobachtet,**
keine spürbaren Schwankungen von Anpassung und Resonanzfrequenz,
stabiler HF-Betrieb (2021)
- **Resonanzverschiebung durch veränderte EKS ca. +2,8 kHz**
(Kompensation durch fahrbare Tuner unproblematisch)
- **HF-Leitungslänge** sollte für neue EKS (geringfügig) angepasst werden,
Betrieb mit der aktuellen Leitungslänge aber unproblematisch
- **Betrieb der Thales-Stufe gegenüber Testblock KW 43 – 45 optimiert**
(Heiz-Spannung Röhre, Tuning Thales-Stufe und Treiber)

Thank you!