CCDTL module 2
low power RF measurements

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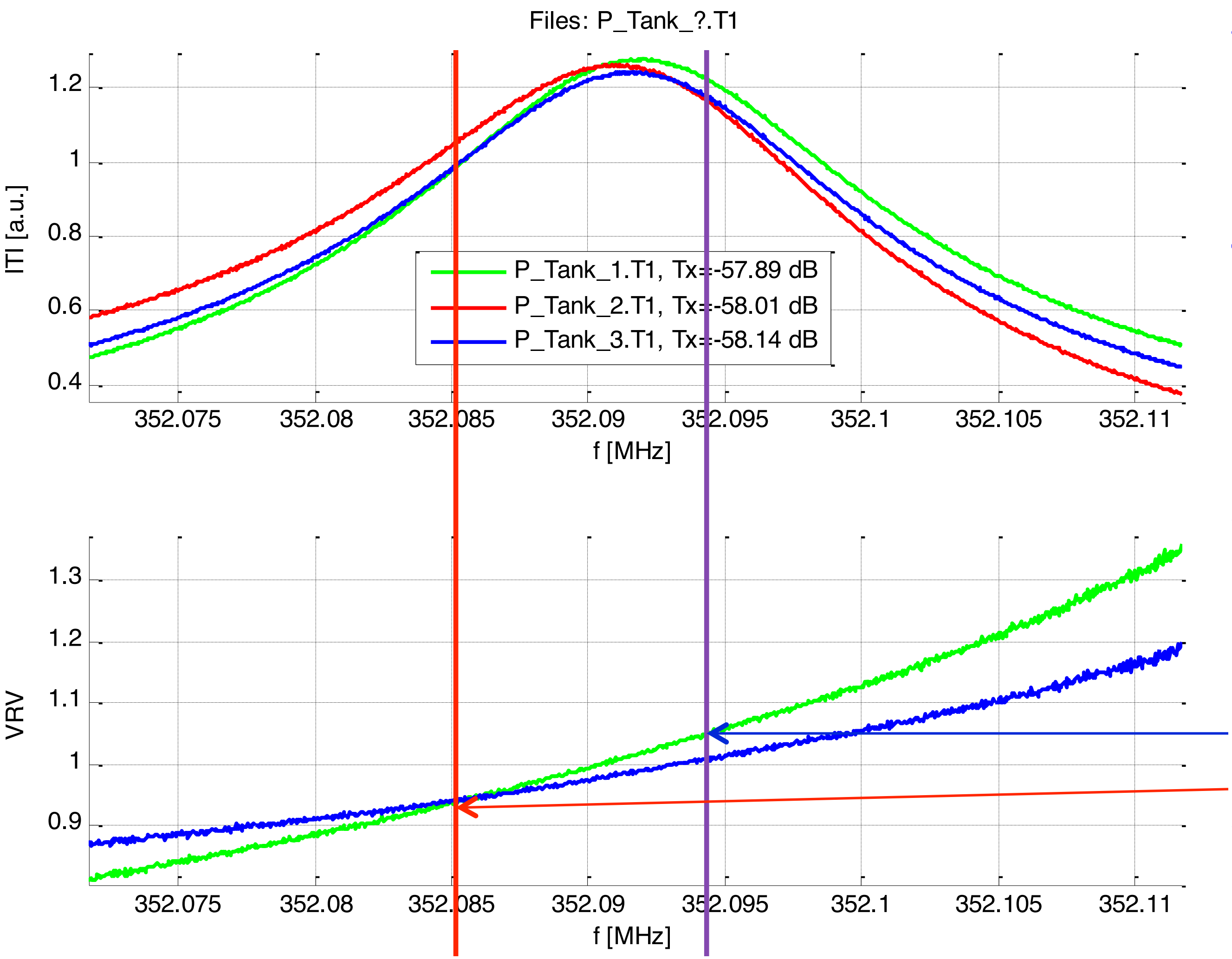
Motivation

- After observing **field distribution changes with frequency** in the order of several %/kHz during the high power test, low power measurements have been done to investigate the reason.
  * Can this effect be seen also in low power measurements, what is the **source of the effect**?
  * How **stable is the field distribution** over frequency?
  * How much is the field distribution **disturbed** when a **tuner in tank 2** (central tank) changes the frequency of the operational pi/2 mode by ~80 kHz (ΔT ~ 10K) ?
  * How does the **cavity-to-waveguide coupling** influence the field distribution (operation @ β~1.3 & 1.0 without & with beam)

Transmission WG => Pickups, air

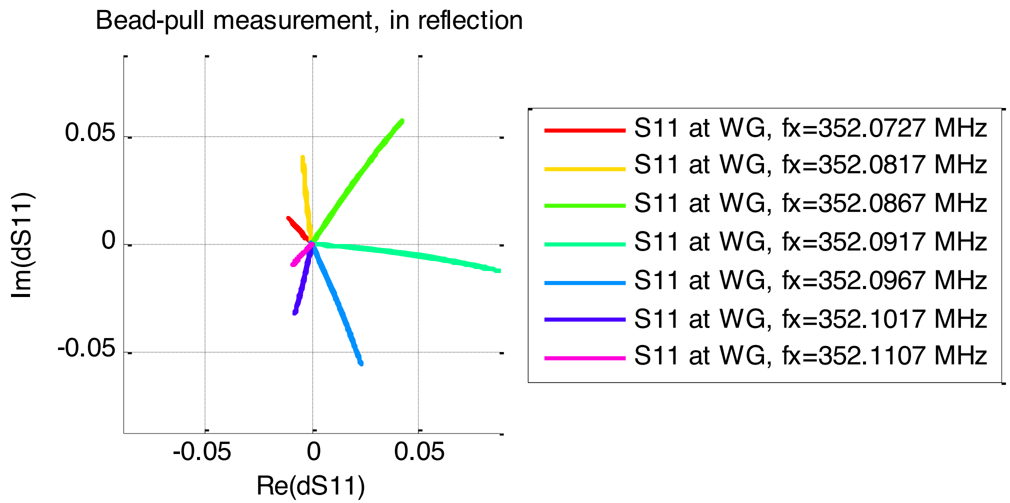


T=22.2°C, pressure 954 hPa, humidity 46%

Transmission WG to pickups has clear frequency dependence => **reason** for power readings during high power test @ different frequencies

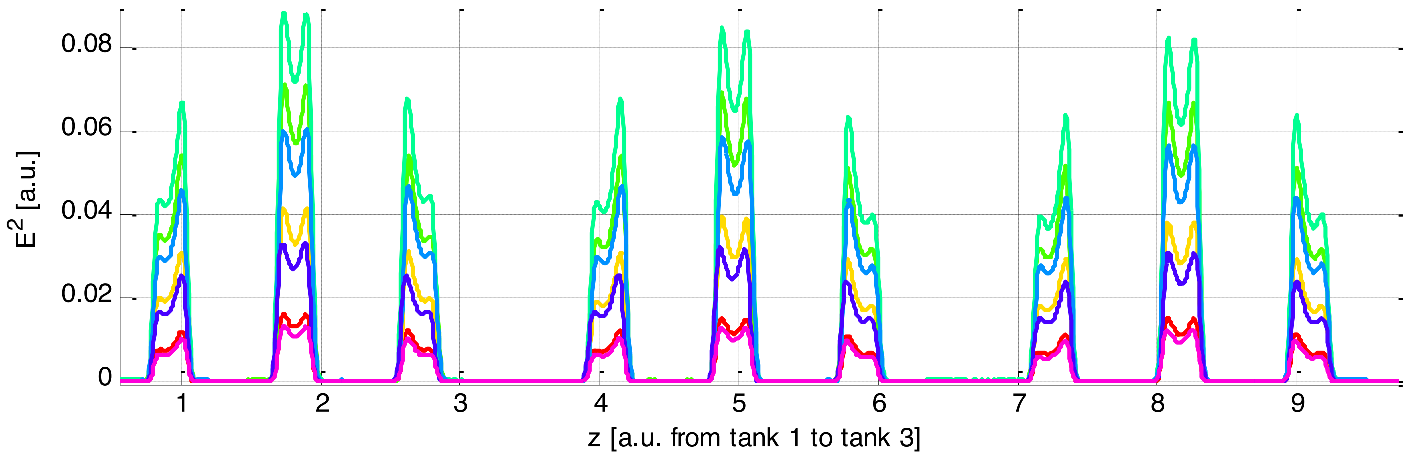
example:
purple: P(T2 & T3) ~ 90% P(T1)
red: P(T1 & T3) ~ 90% P(T2)
for a frequency change of <10 kHz

Beadpull at different frequencies

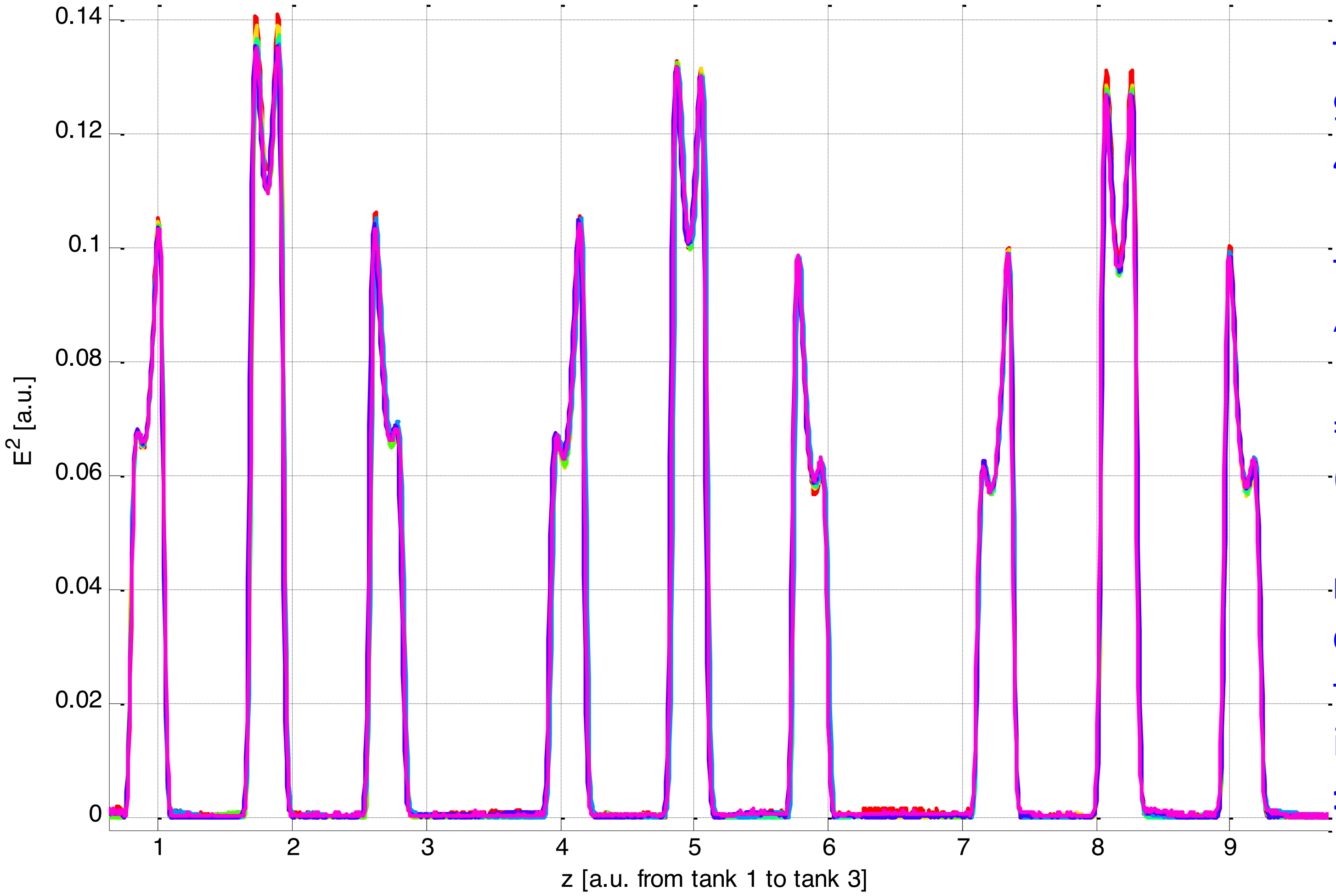


T=22.2°C, pressure 954 hPa, humidity 46%

$f_{\pi/2}$=352.0917 MHz
Δf= ±0, 5, 10, 19 kHz



Beadpull at different frequencies



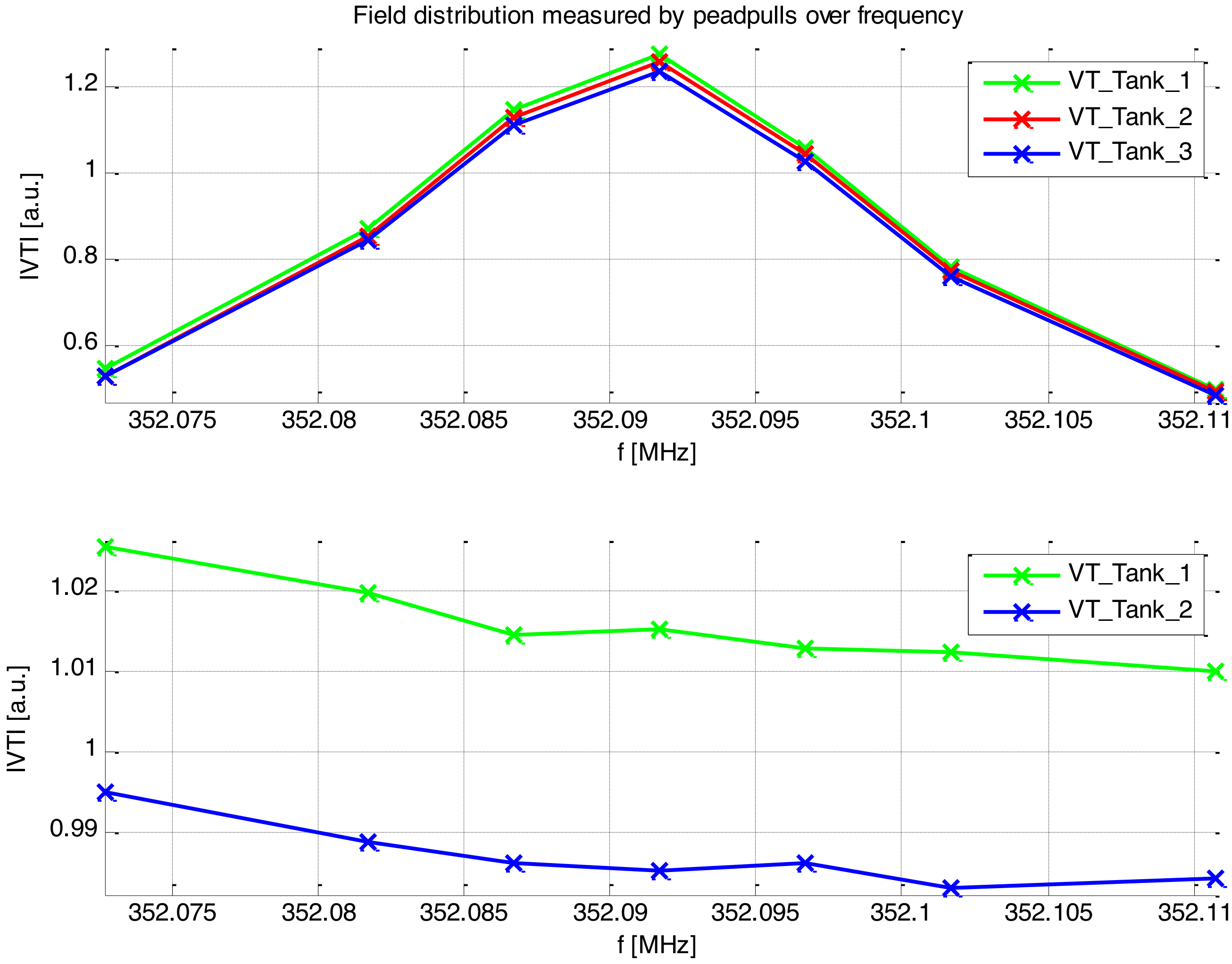
T=22.2°C, pressure 954 hPa, humidity 46%

$f_{\pi/2}$=352.0917 MHz
Δf= ±0, 5, 10, 19 kHz

=> normalised fields (for comparison)

nearly identical field distribution for all frequency variations in the range of **±20 kHz**

Beadpull at different frequencies

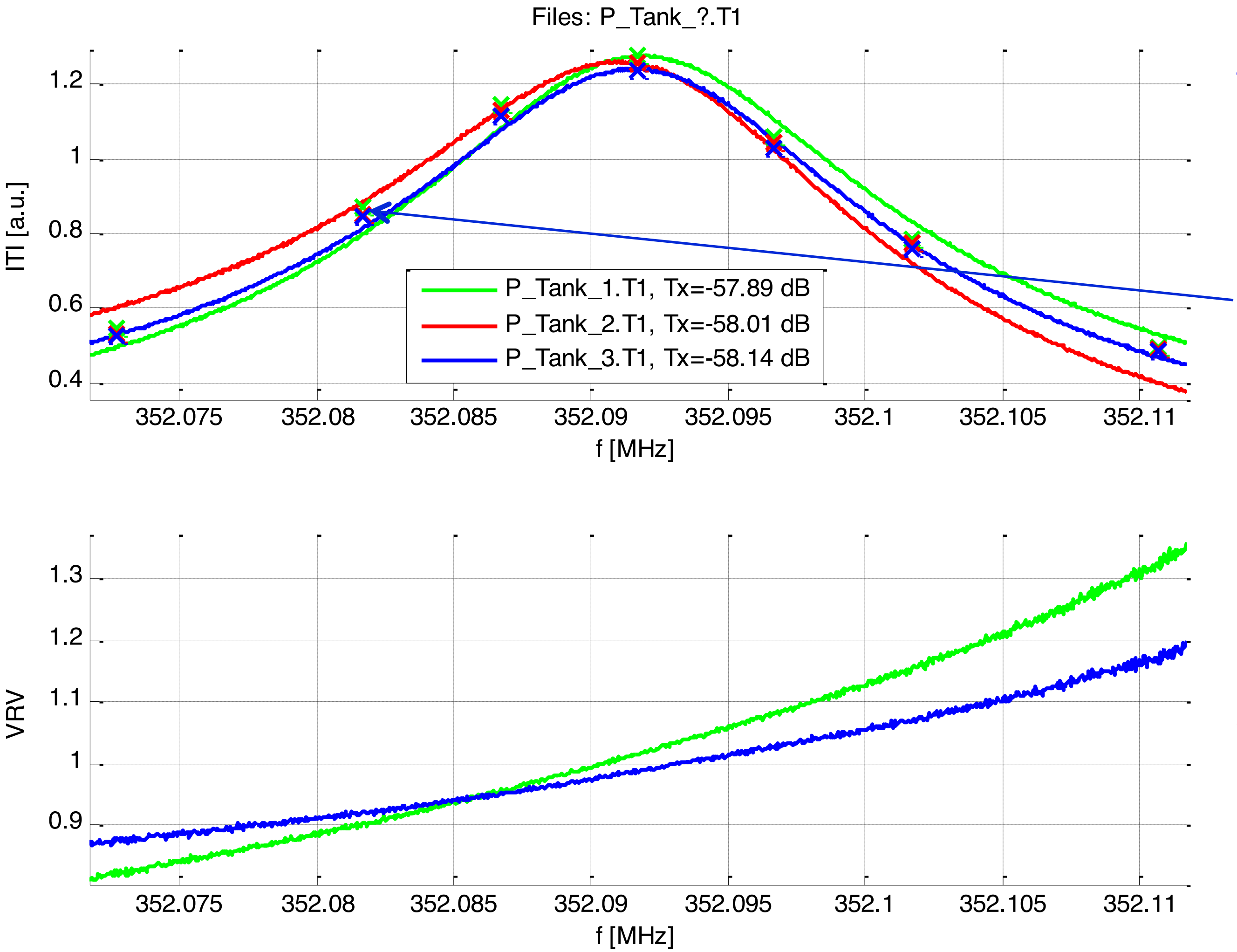


$f_{\pi/2}$=352.0917 MHz
Δf= ±0, 5, 10, 19 kHz

fields in the 3 tanks determined by beadpull measurements

nearly identical field distribution over frequency in the range of ±20 kHz [change <2% for 40 kHz]

Transmi. WG => Pickups & Beadpulls

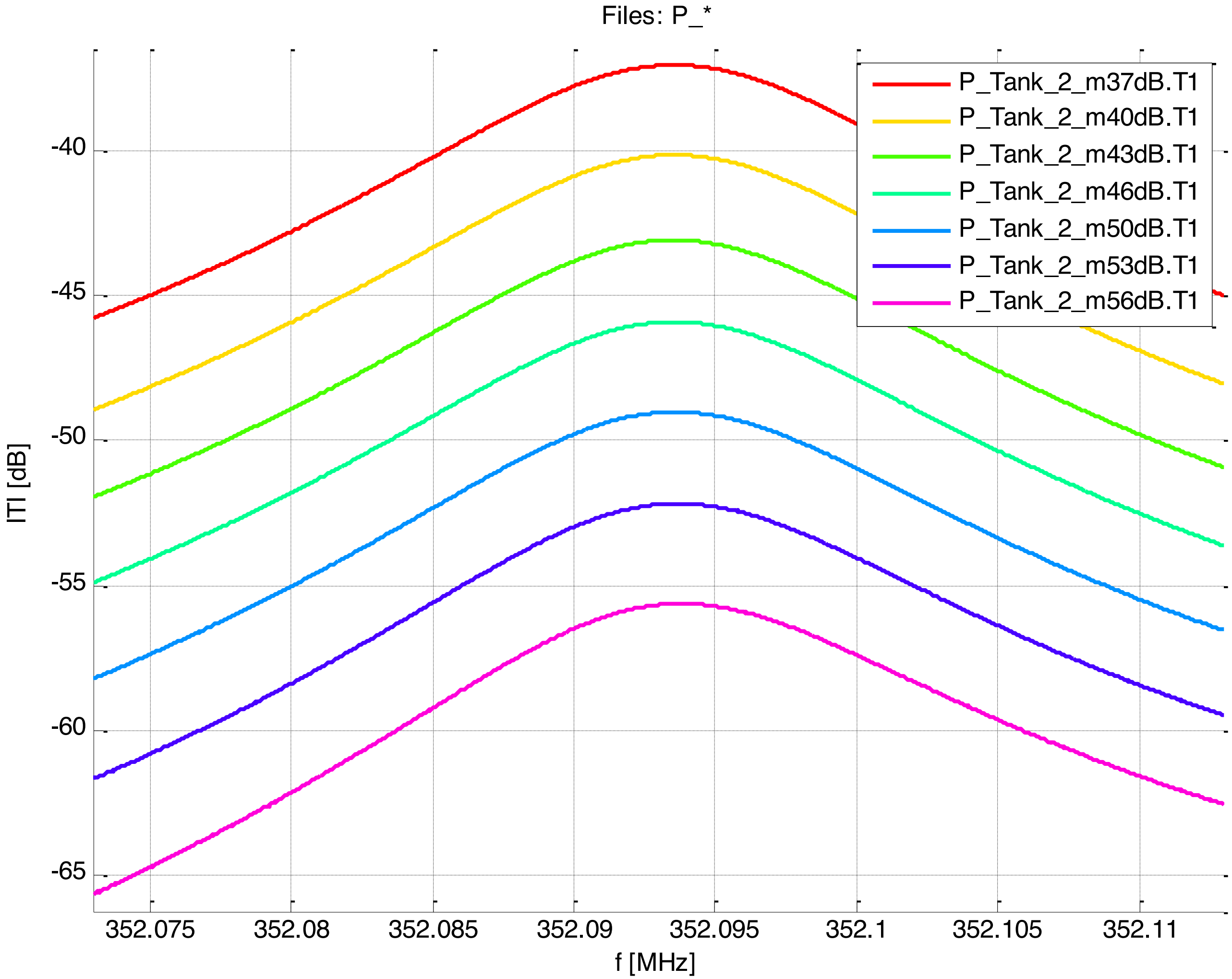


T=22.2°C, pressure 954 hPa, humidity 46%

Beadpull measurements

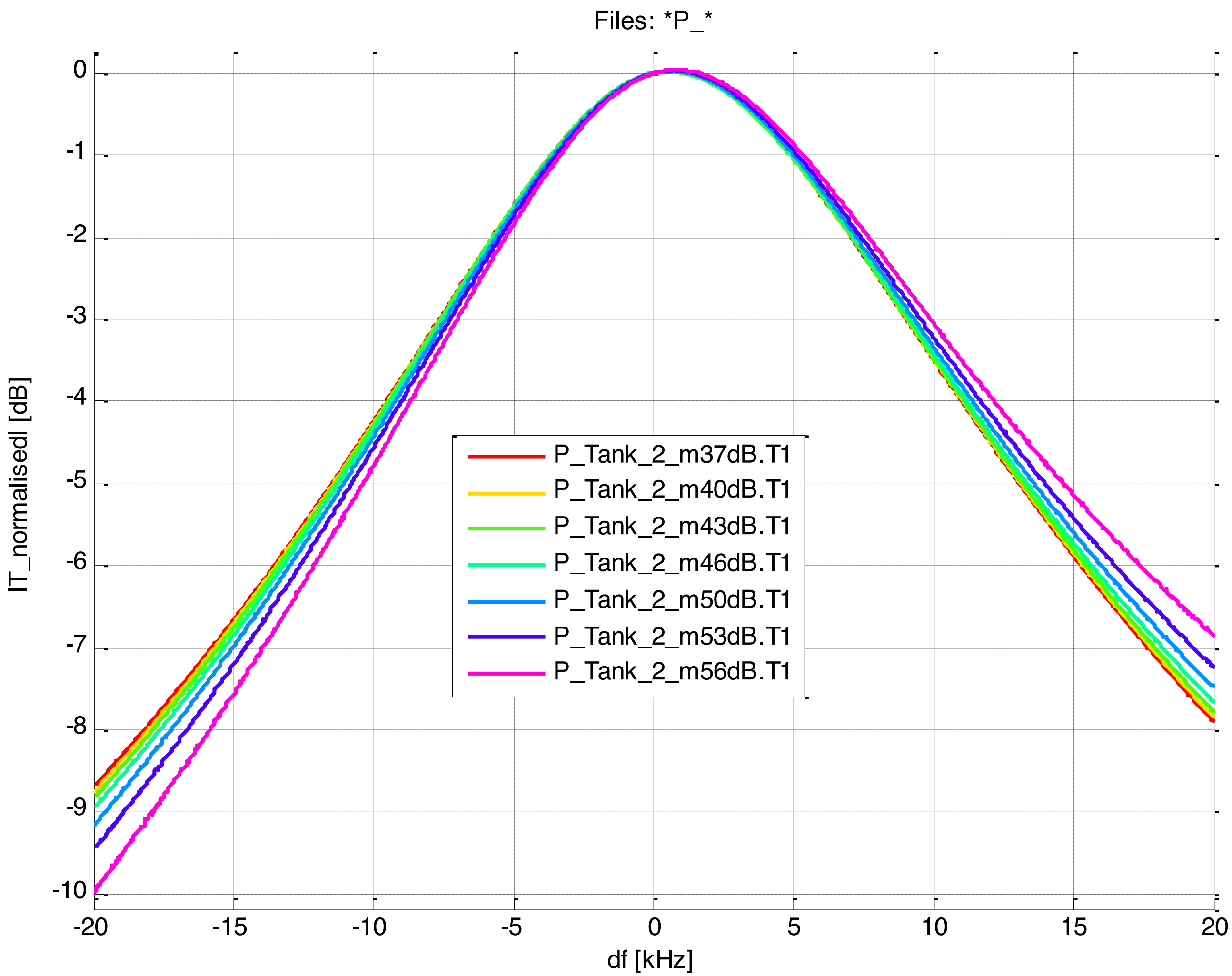
Pickups do not follow field distribution with frequency
=> do they have a frequency dependent transfer function ????

Investigation of Pickups



measuring transmission from WG to pickup of tank 2, changing the coupling of the pickup

Investigation of Pickups

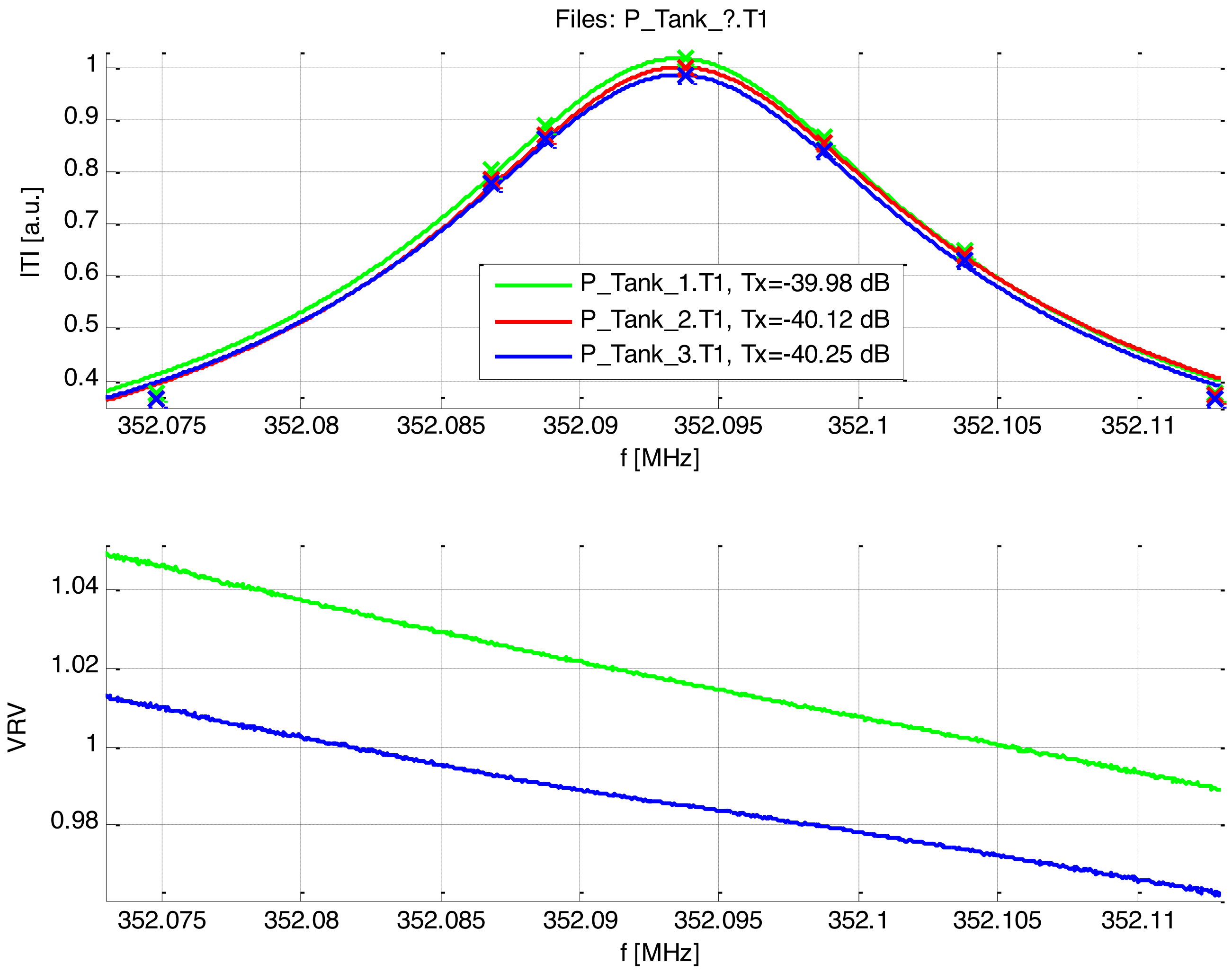


measuring transmission from WG to pickup of tank 2, changing the coupling of the pickup

=> the pickup system itself has a frequency dependent transfer function !
That's the source of our trouble

A quick & dirty solution is to couple stronger to reduce the frequency dependence, a better solution is to reduce the parasitic, frequency dependent coupling

Transmi. WG => Pickups & Beadpulls



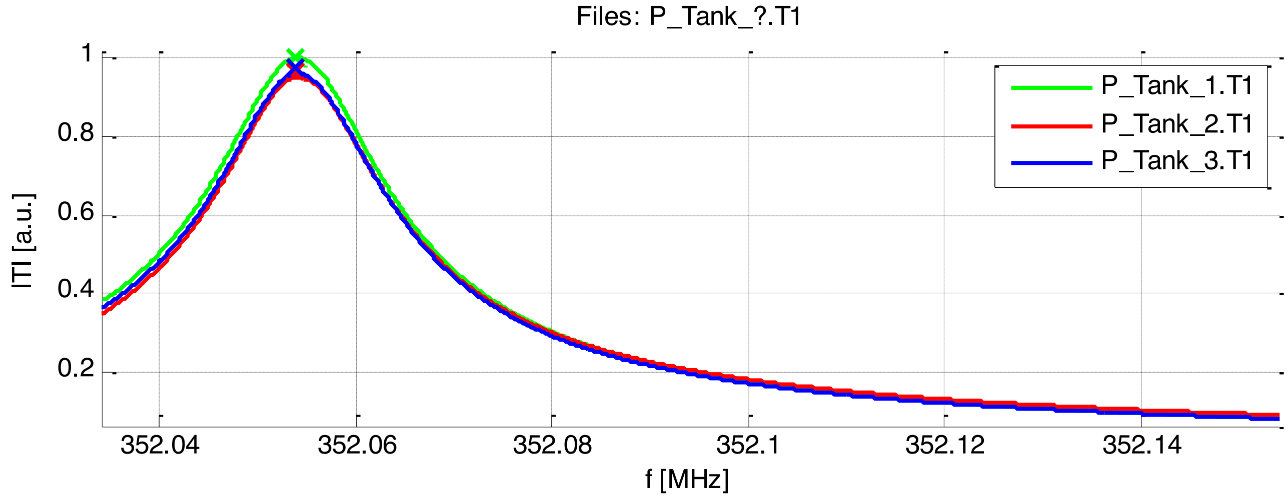
T=21.3°C, pressure 964 hPa, humidity 37%

Pickups coupled stronger (-40 dB)

Field distribution determined by Pickups follows beadpull measurements better than before but sill a clear deviation can be seen (~ ±3% error in power readings over ±10 kHz)

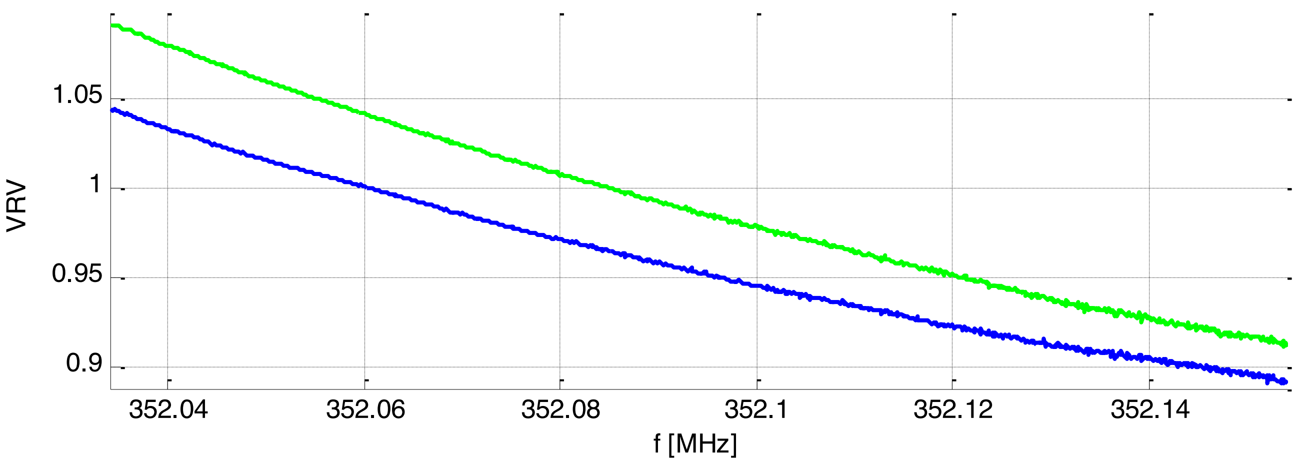
$VRV_{beadpull}$: [1.02, 0.99]

Tuner taken partly out, $\Delta f_{\pi/2}$=-40 kHz

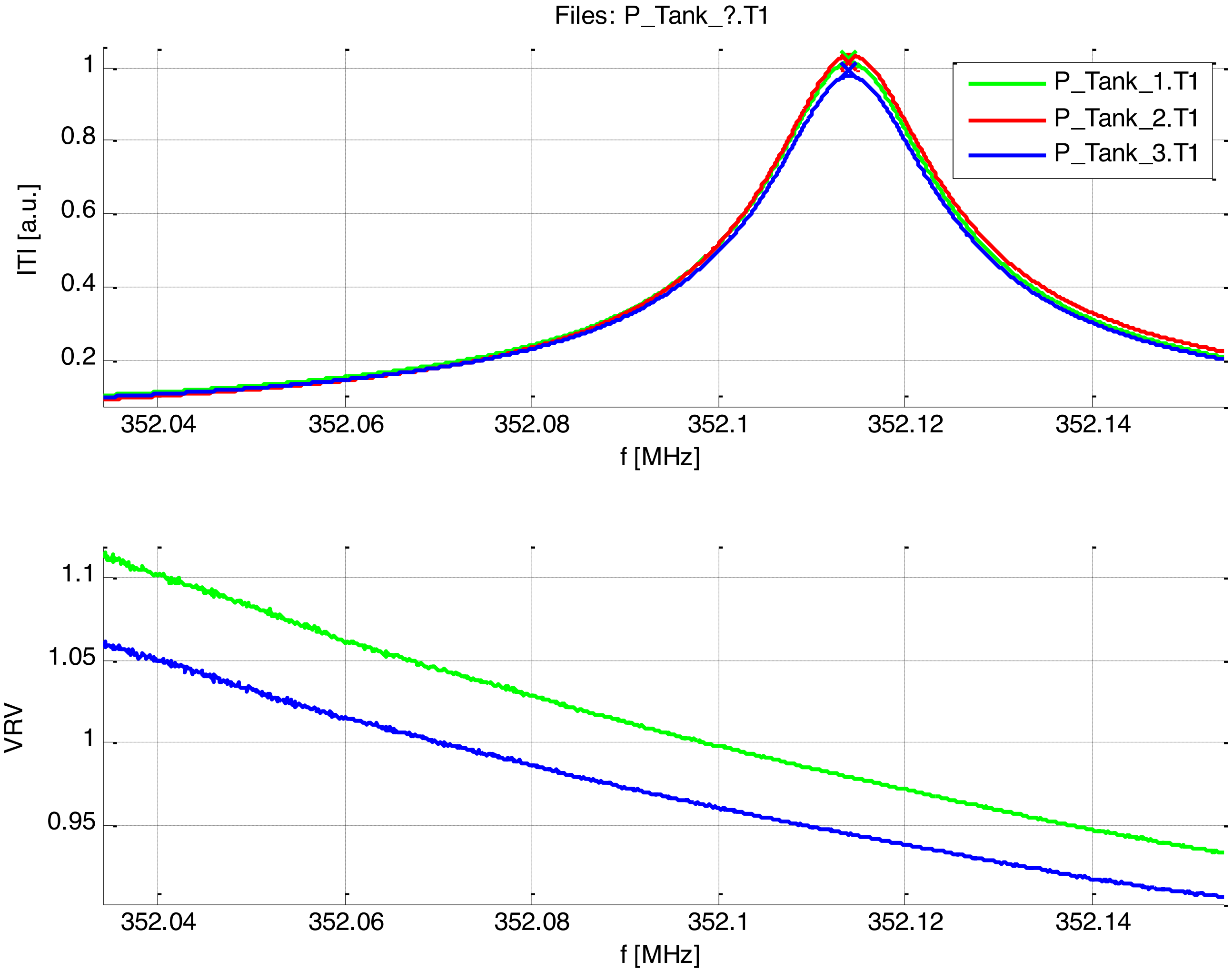


T=21.5°C,
pressure 964 hPa,
humidity 36%
Pickups coupled ~-40 dB

tuner: $\Delta f_{\pi/2}$=-40 kHz
$VRV_{beadpull}$: [1.04, 1.01]
$VRV_{pickups}$: [1.05, 1.01]



Tuner deeper penetrated, $\Delta f_{\pi/2}$=+40 kHz

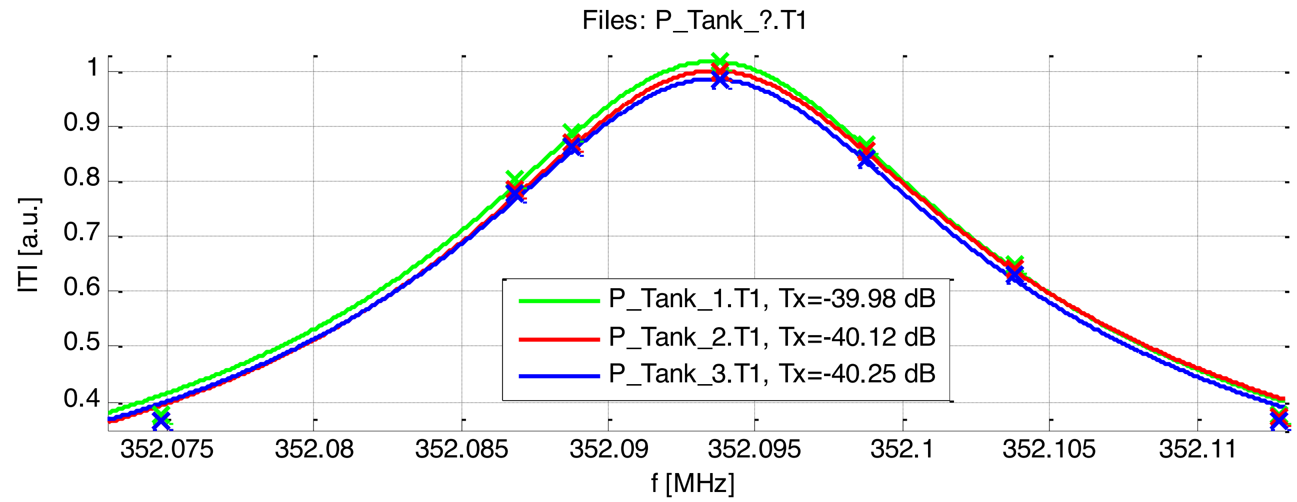


T=21.6°C,
pressure 964 hPa,
humidity 36%
Pickups coupled ~-40 dB

tuner: $\Delta f_{\pi/2}$=+40 kHz
$VRV_{beadpull}$: [1.01, 0.98]
$VRV_{pickups}$: [0.98, 0.94]

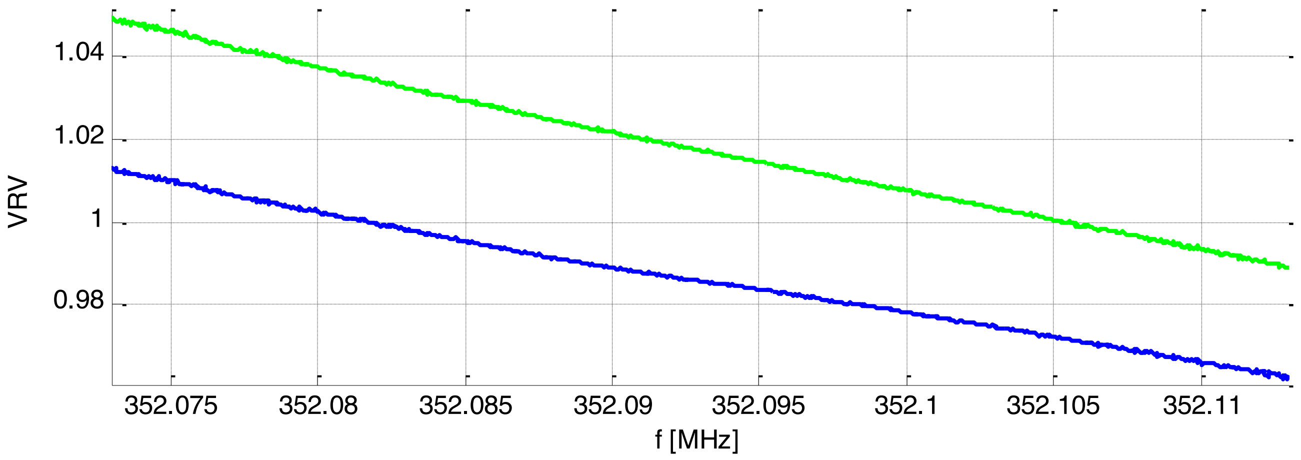
=> CCDTL field level changes ≤ ±1.5% for tuning of ±40 kHz of the π/2-mode => very stable!

Influence of cavity-to-WG coupling

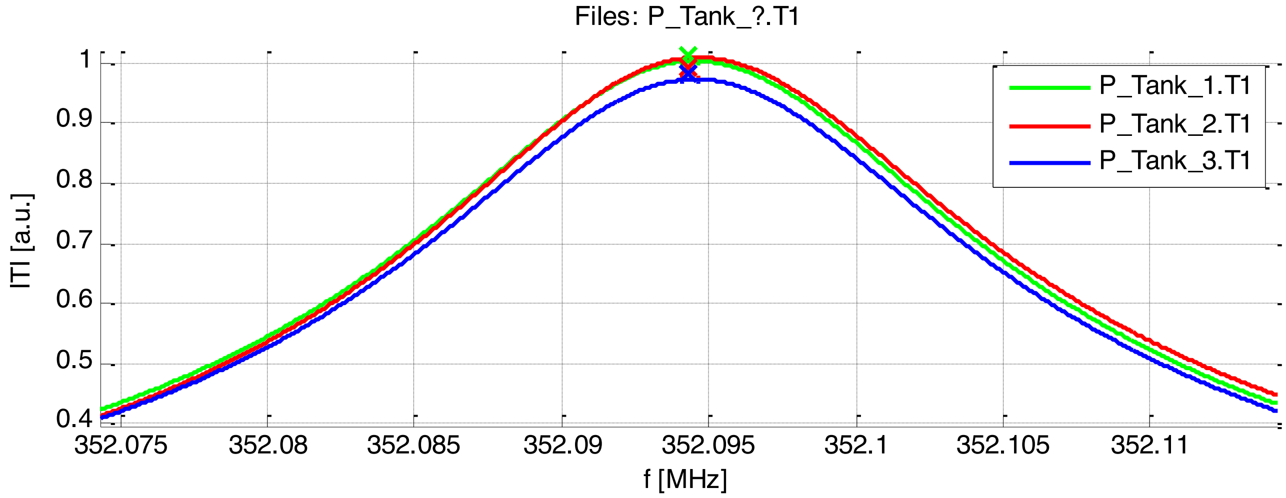


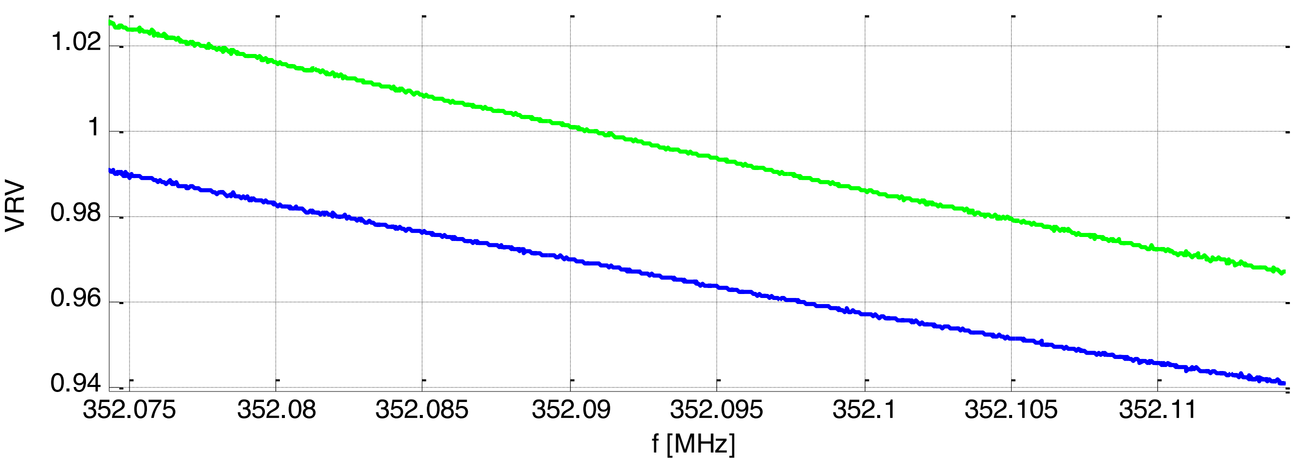
T=21.3°C,
pressure 964 hPa,
humidity 37%
Pickups coupled ~-40 dB

WG coupling: β=1.05
$VRV_{beadpull}$: [1.01, 0.98]
$VRV_{pickups}$: [1.01, 0.98]



Influence of cavity-to-WG coupling





T=21.3°C,
pressure 964 hPa,
humidity 37%
Pickups coupled ~-40 dB

WG coupling: β=1.32
$VRV_{beadpull}$: [1.02, 0.99]
$VRV_{pickups}$: [0.99, 0.96]

=> CCDTL field level changes ≤ ±0.5% for change of cavity-to-waveguide coupling from 1 to 1.3 => very stable, cavity can be tuned for either coupling

Summary I

- **CCDTL module 2 is well tuned !**
- The **problems experienced** come only from a frequency dependency of the 3 **pickup loops**. Solutions are being investigated.
- The CCDTL module 2 **can be tuned with a single tuner** in the central tank without perturbing the fields much (≤±1.5% field change for a detuning of ±40 kHz of $\pi/2$ mode).
- A change of the **cavity-to-waveguide coupling does not perturbe the fields** much (<0.5% field change between β=1.0 and β=1.3) => RF tuning is less difficult as it can be done either at β=1.0 or β=1.3 to include beam loading.

Summary II

- A **quantity to characterise the field stability** is the frequency dependent **Voltage Ratio Vector** (voltages in cell 1/5 in reference to the one in cell 3): VRV(f)=[V_1(f)/V_3(f), V_5(f)/V_3(f)].
  If VRV(f_{op})=[1, 1], the cavity has a flat field for the operating frequency f_{op}. For field stability, VRV'(f_{op})=[0, 0] is desired.
  The Voltage Ratio Vector VRV(f) is time consuming to measure and evaluate (transmission WG -> cells 1,3,5) => suited for validation, less for tuning.
- The **Voltage Ratio Vector** can be evaluated for both, **beadpull measurements** and **pickup readings.**

Summary III

- Considerable changes in the mode spectrum have been seen when going from **air to vacuum**. The voltage ratio vector VRV(f) can be evaluated under both conditions.
- **Pickups** shall be **calibrated in air** for the **frequency of the Bead-Pull measurement.** For the pickup calibration, the real field distribution ratio measured shall be taken as reference (not 1 for all cells). Beadpull measurements and calibration shall be done the same **temperature** (or temperature compensation needs to be applied). A **small bead perturbation** is desired for beadpull measurements to avoid frequency dependencies.