Phase-locked Local Oscillator for Superconducting Integrated Receiver

Valery Koshelets, Andrey Ermakov, Pavel Dmitriev, Lyudmila Filippenko, Andrey Khudchenko, Nickolay Kinev, Oleg Kiselev, Alexander Sobolev, and Mikhail Torgashin

Institute of Radio Engineering and Electronics (IREE), Moscow, Russia

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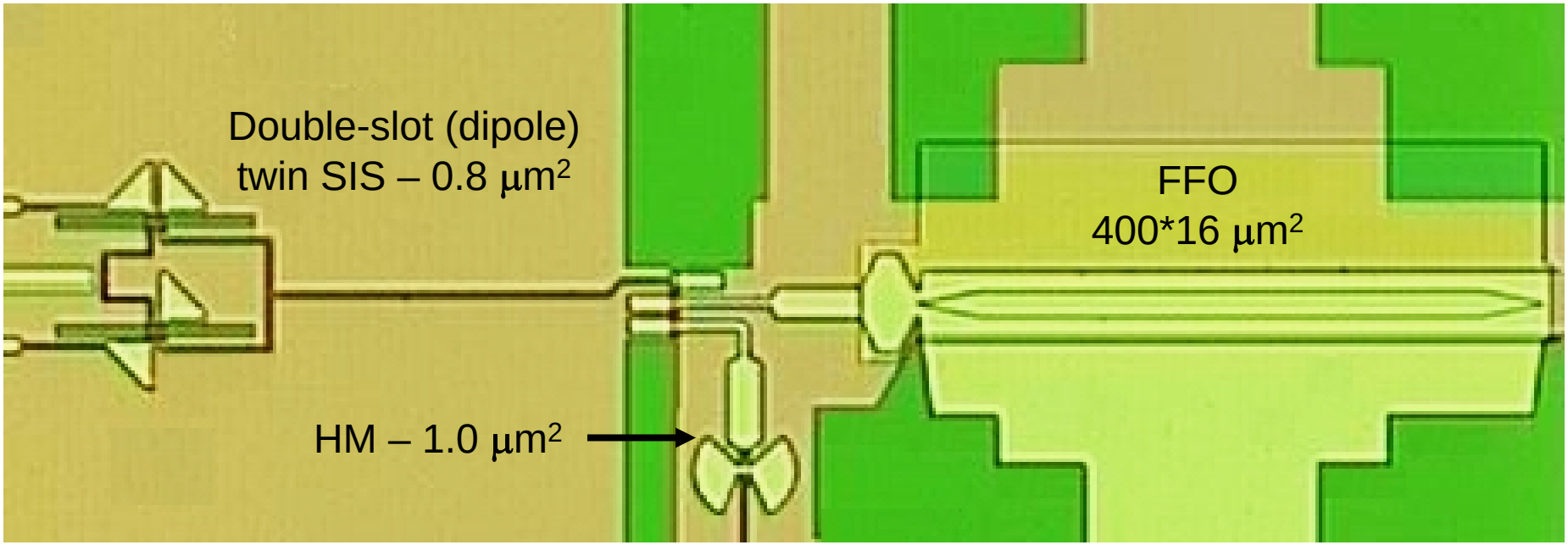
Phase-locked Local Oscillator for Superconducting Integrated Receiver

Outline

- Superconducting Integrated Receiver (SIR)
- Flux Flow Oscillator (FFO) for the TErahertz LImb Sounder (TELIS) project
- NbN FFO for TELIS – new features: continuous frequency and power tuning; FFO linewidth
- Remote optimization of the FFO/SIR operation
- PL FFO phase noise & spectral ratio
- New approaches and future FFO applications
- Conclusion

Internal part of the SIR Microcircuit



Nb-AlOx-Nb or Nb-AlN-NbN; Jc = 5 - 10 kA/cm²

Optionally: SIS – Jc = 8 kA/cm²; FFO + HM = 4 kA/cm²

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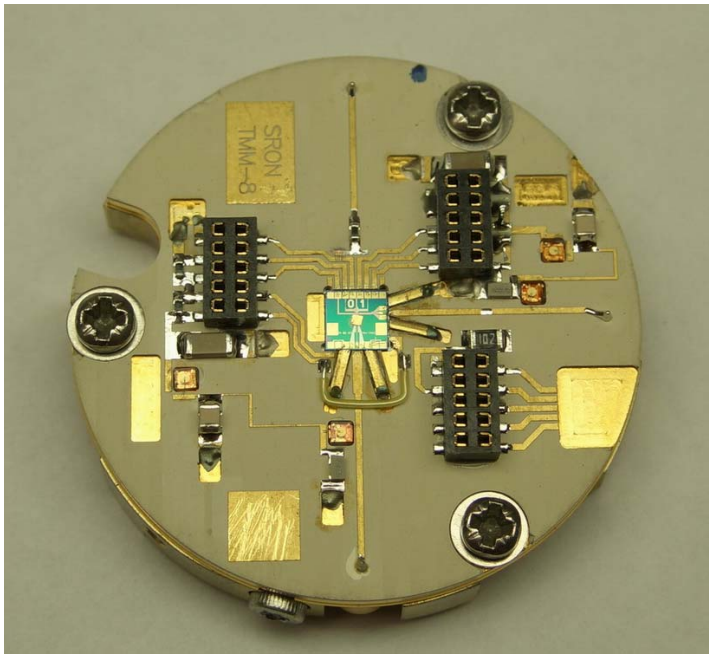
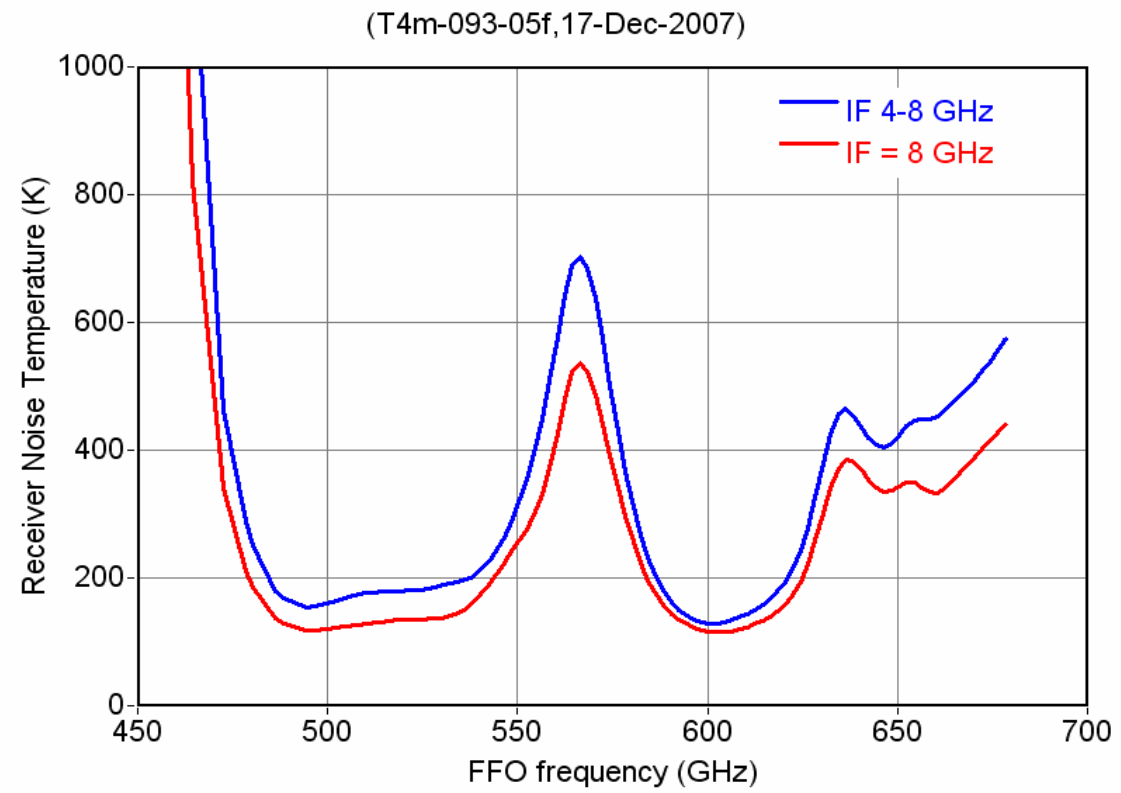
Superconducting Integrated Receiver for TELIS - TErahertz LImb Sounder





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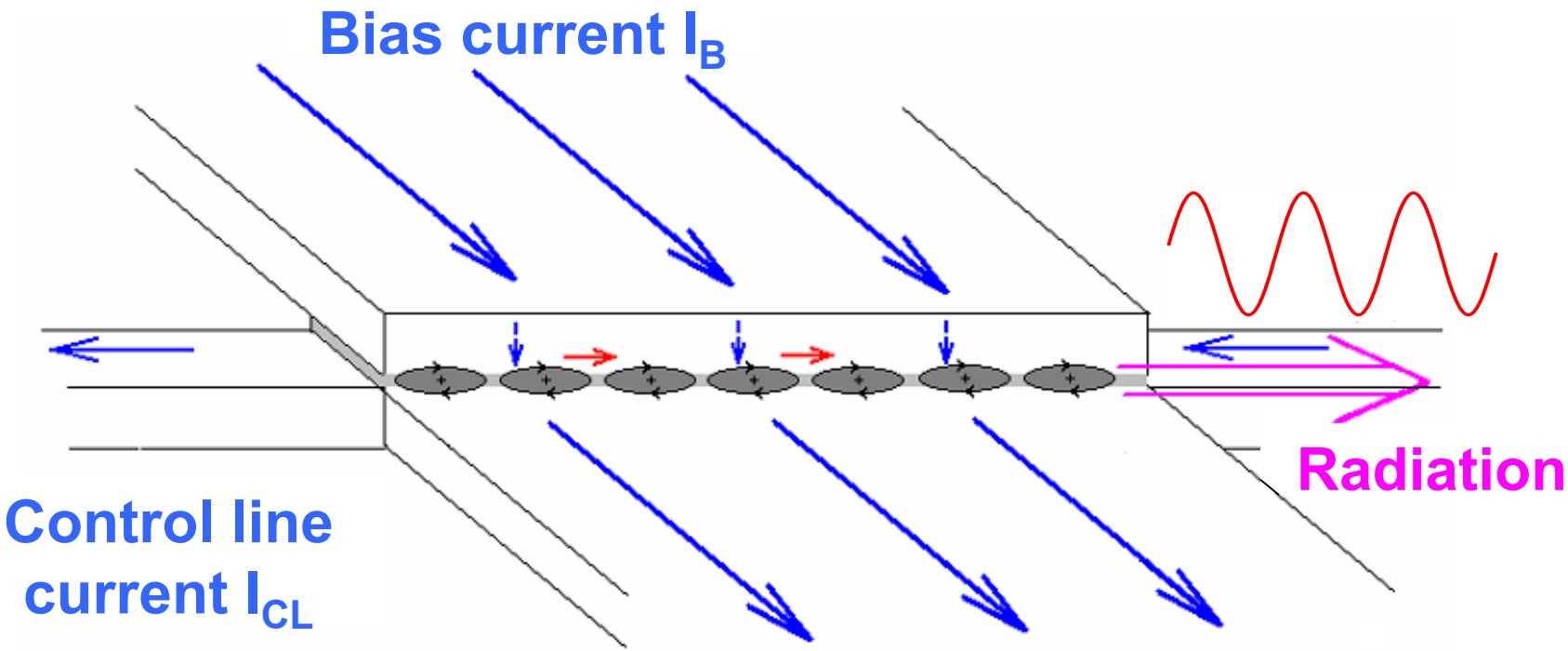
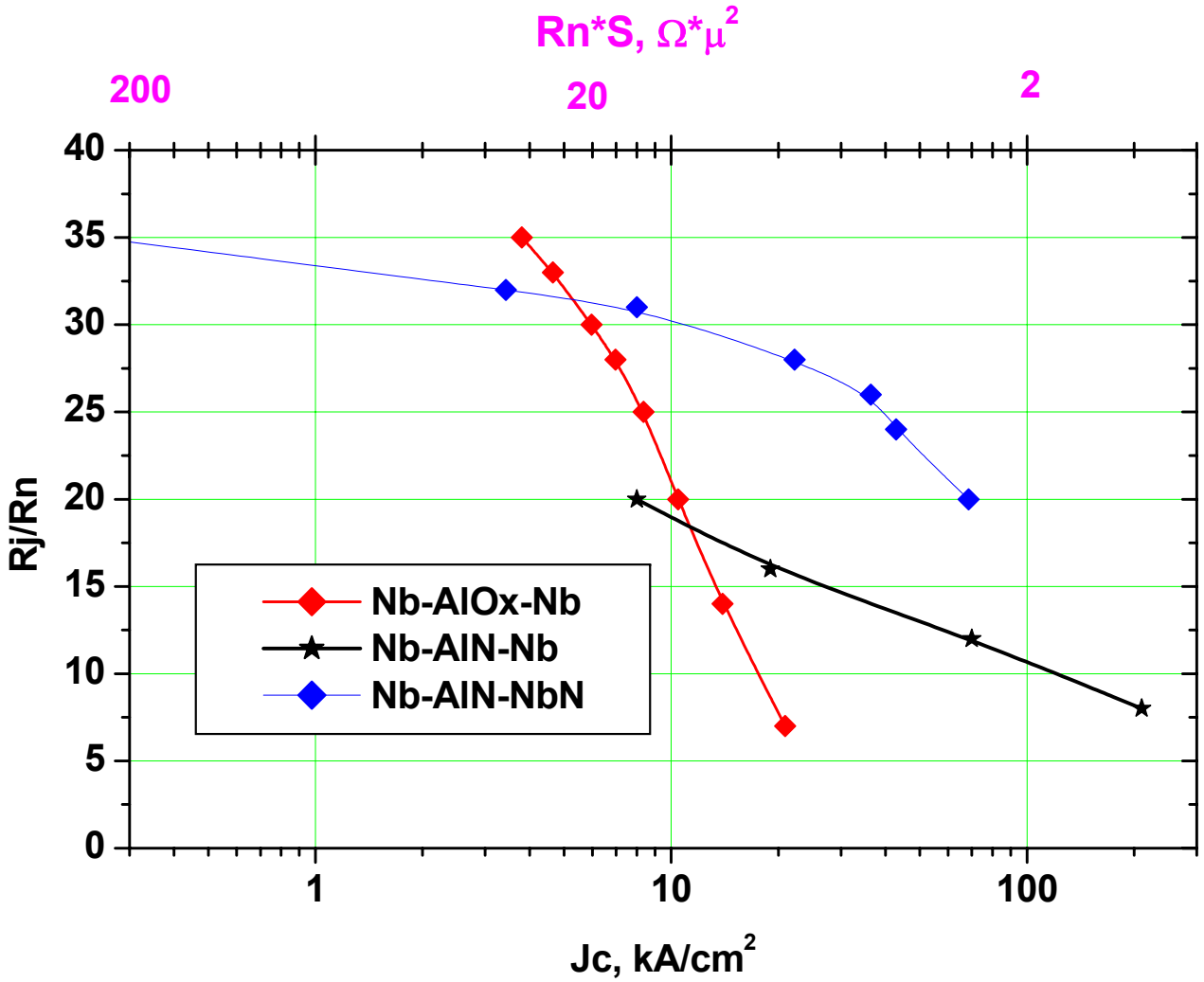
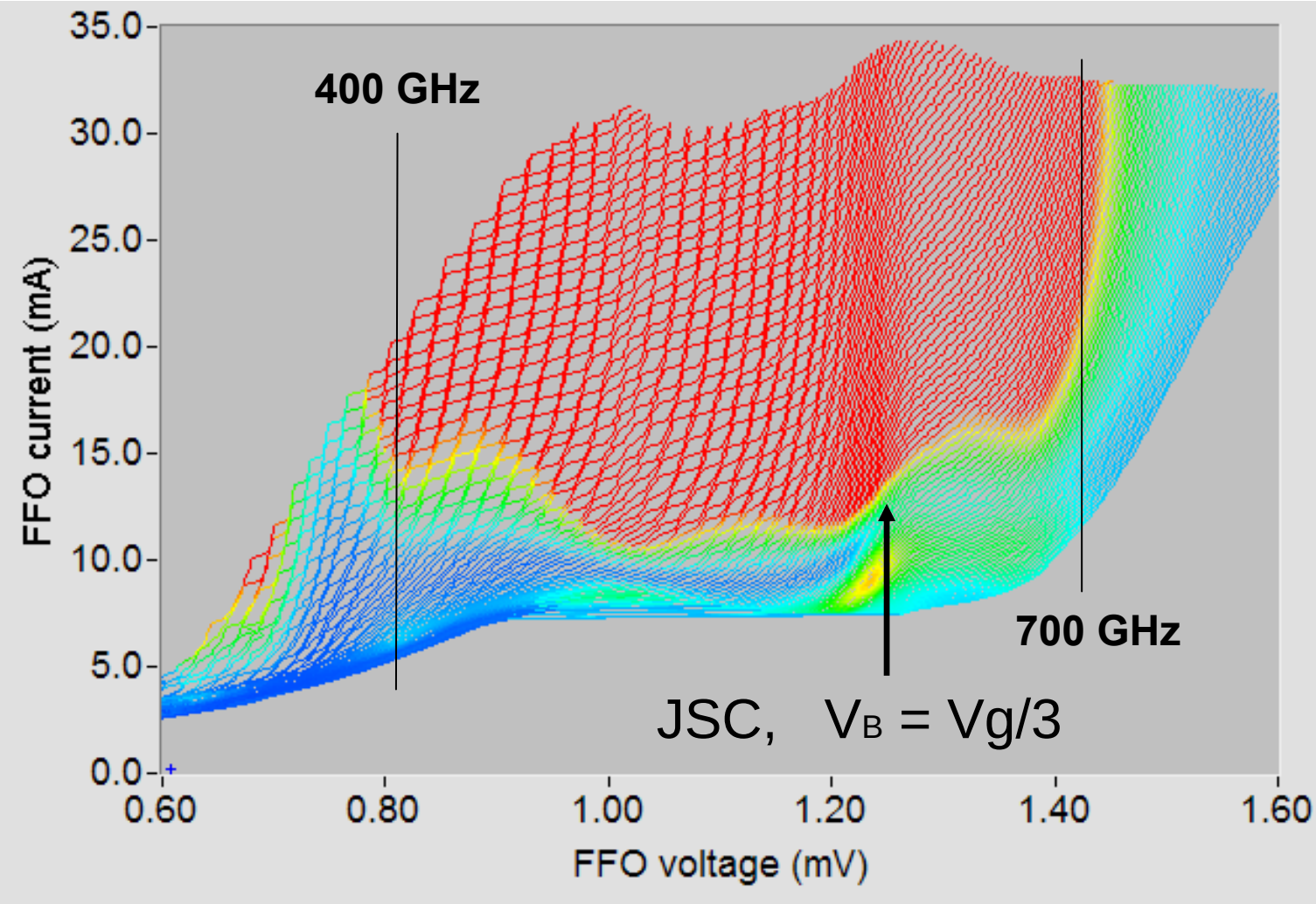
Flux Flow Oscillator
based on Long Josephson Junction



Quality of the AlOx and AlN tunnel barriers on the current density

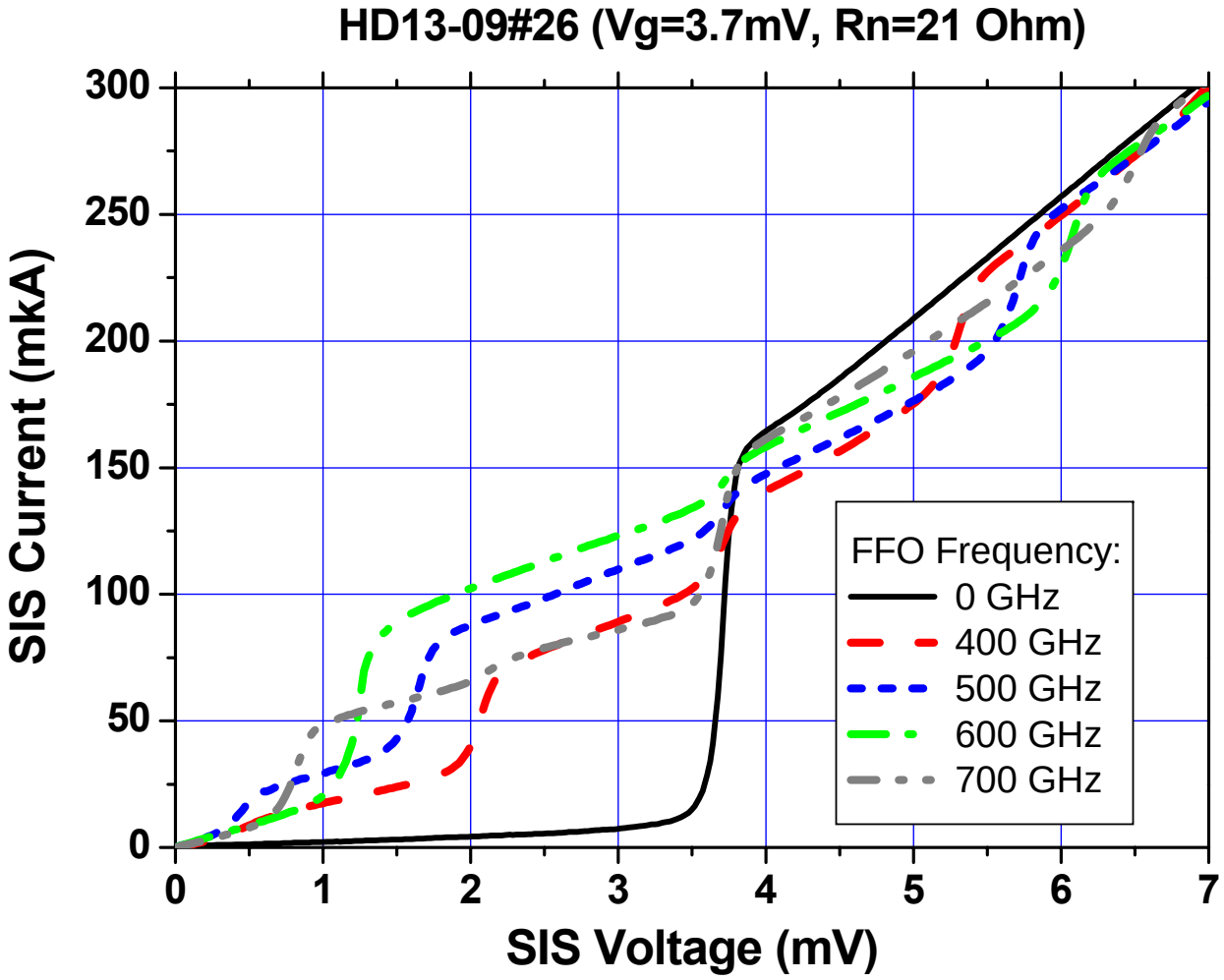


Nb-AlN-NbN FFO for SIR; new features

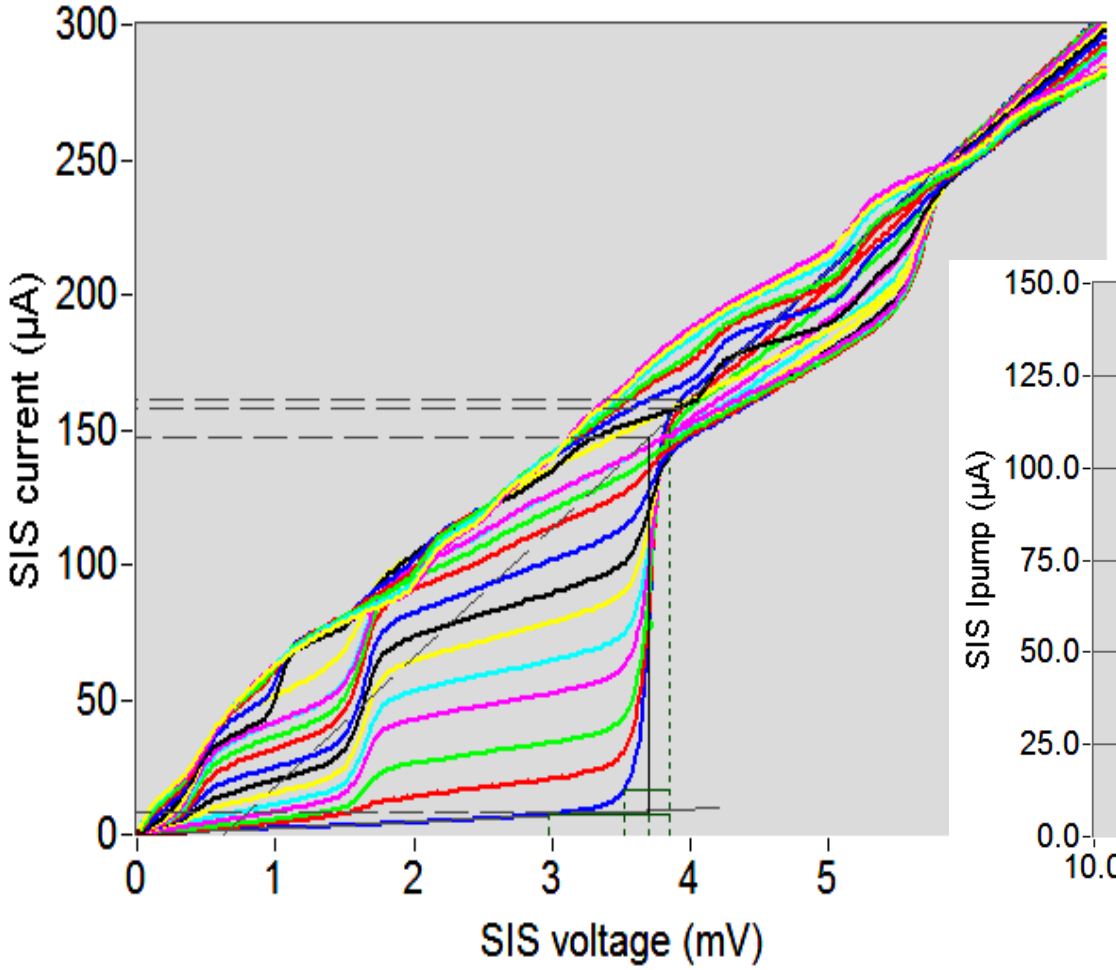


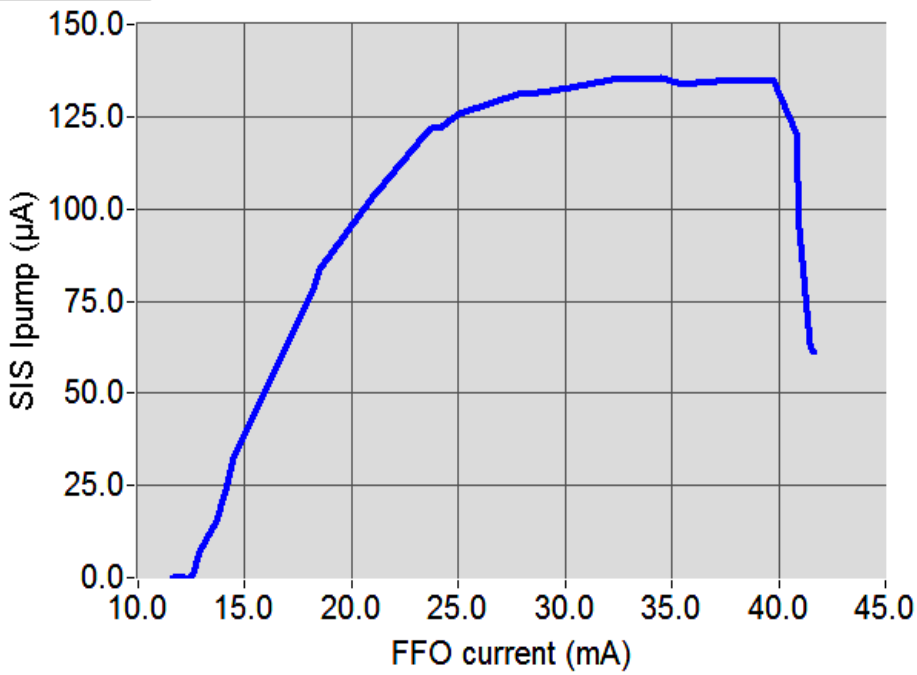
V.P. Koshelets, et al, Phys. Rev. B, vol. **56**, pp 5572-5577, (1997)

Nb-AlN-NbN SIS pumped by FFO; FFO frequency tuning

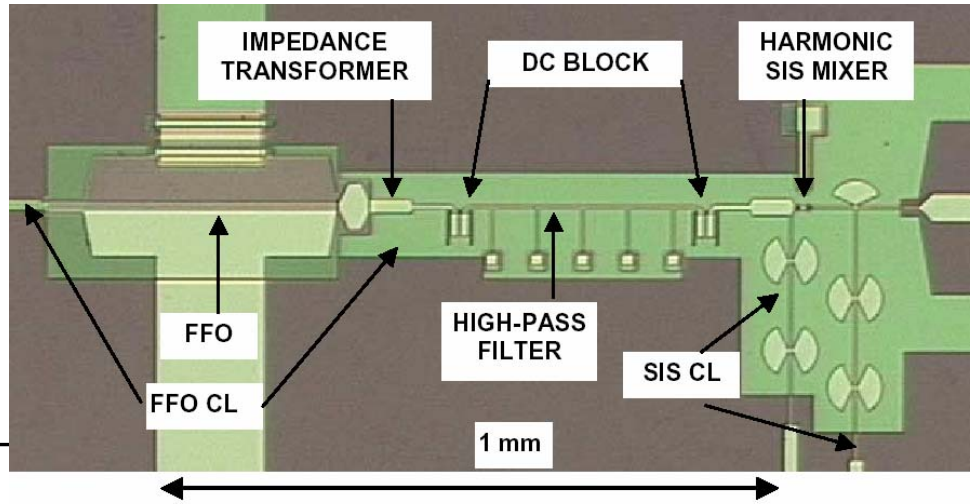


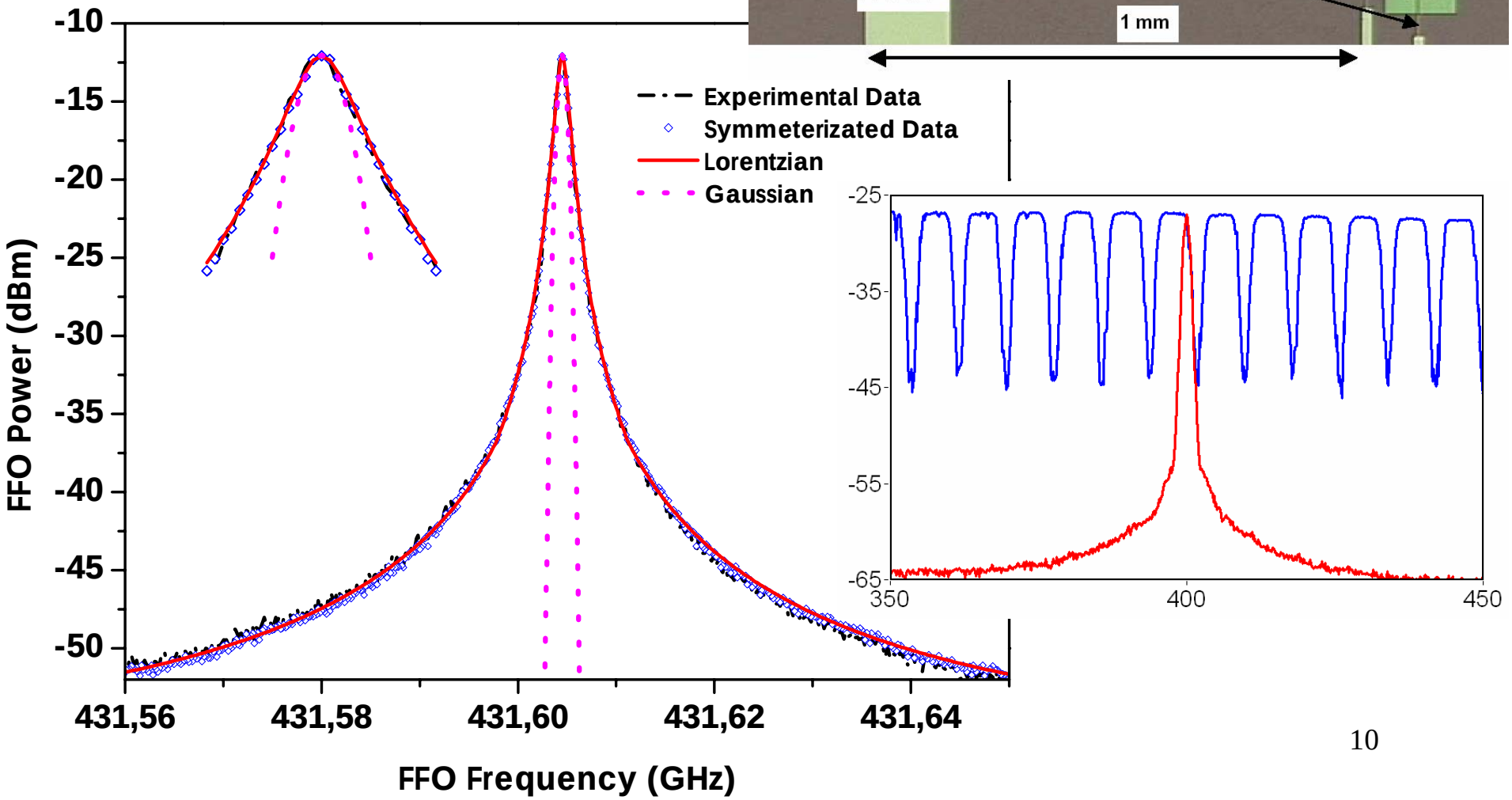
Nb-AlN-NbN SIS pumped by FFO; FFO power tuning (f = 500 GHz)



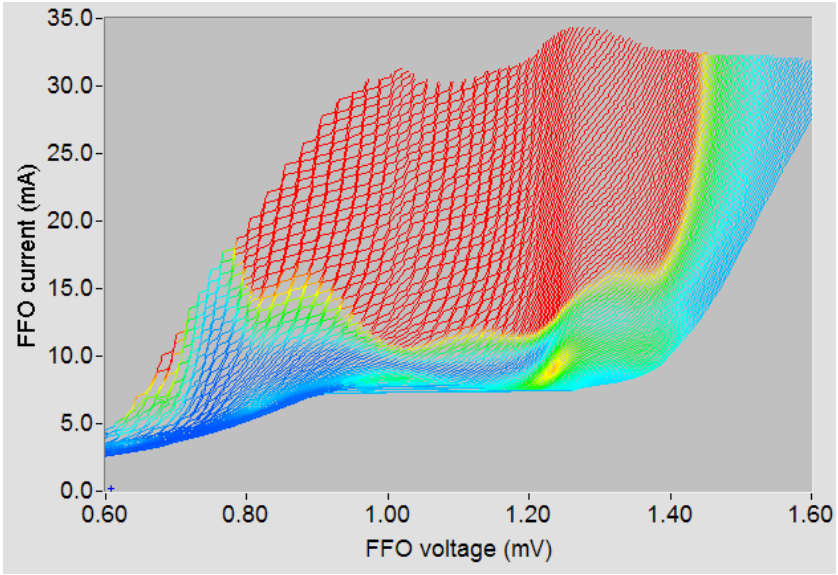


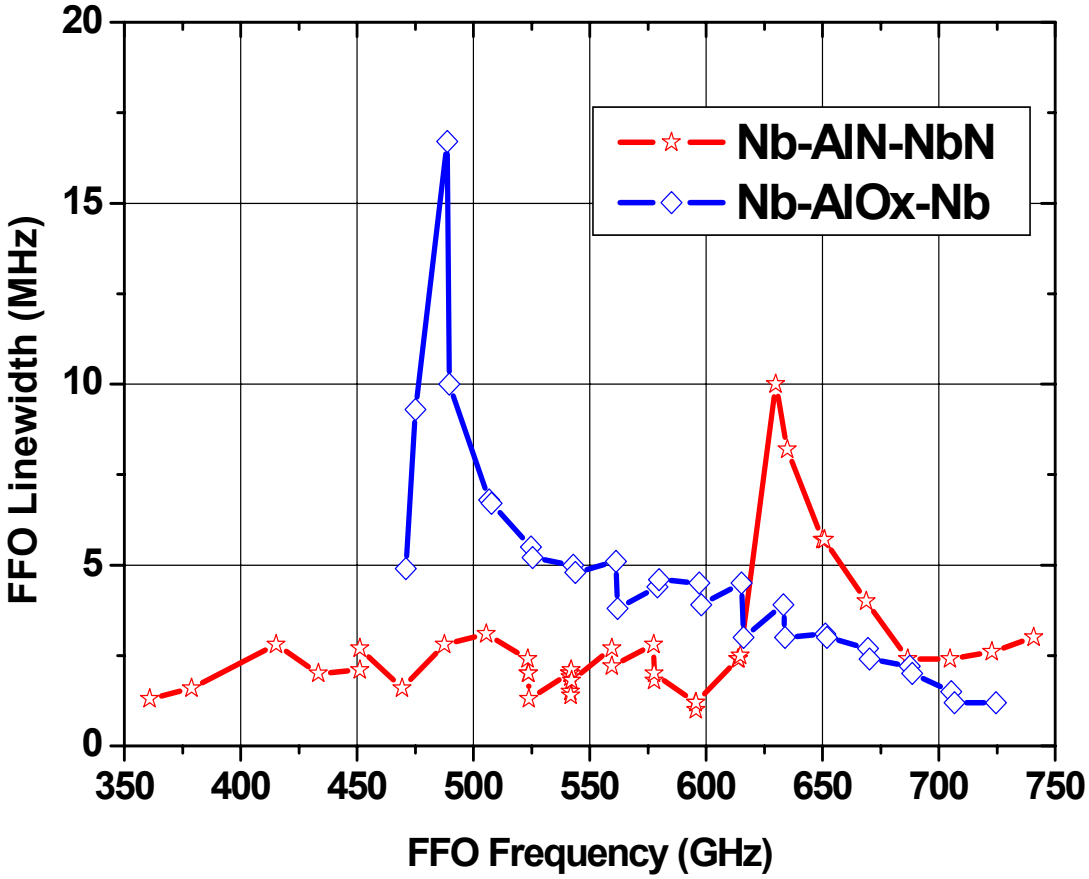
FFO Spectrum



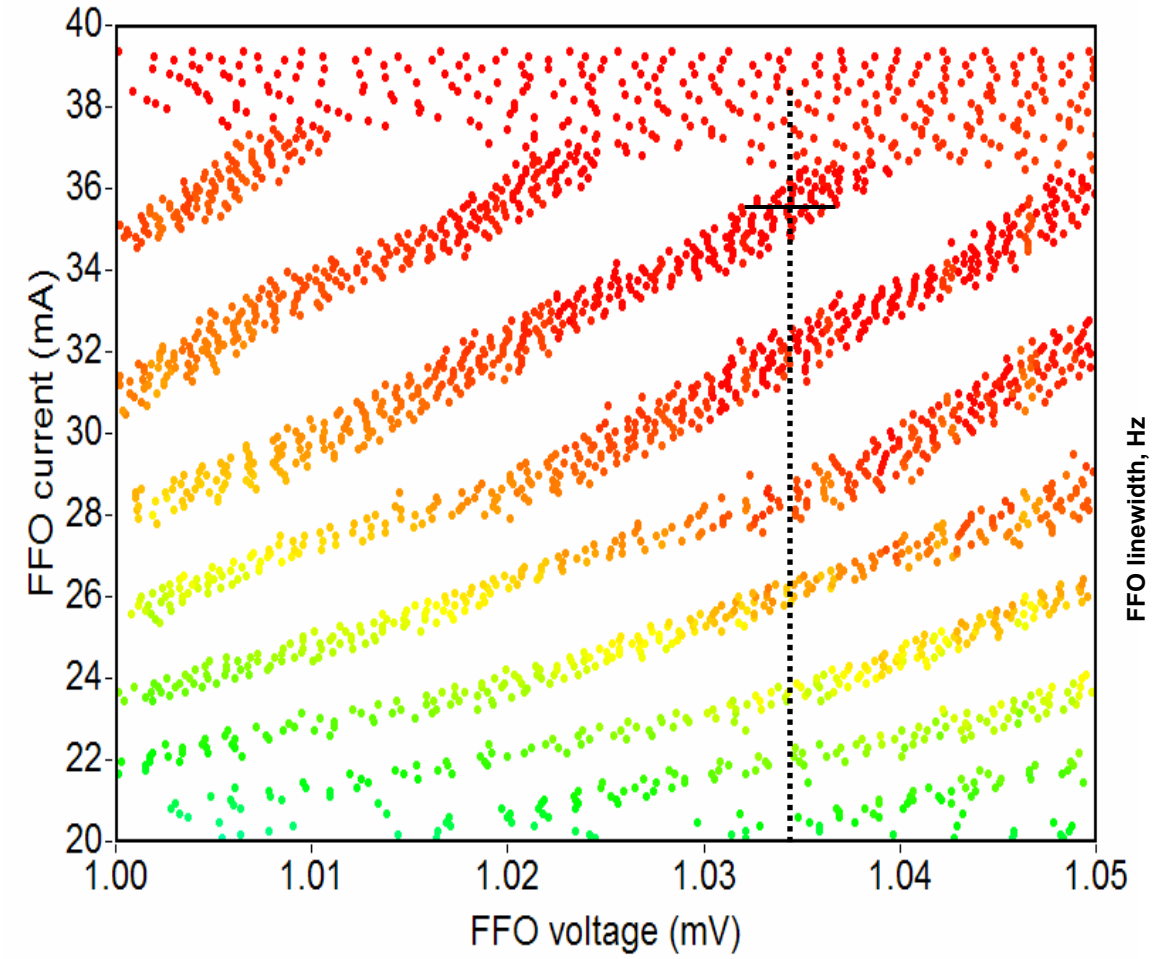


Frequency dependence of the FFO: Nb-AlOx-Nb and Nb-AlN-NbN circuits

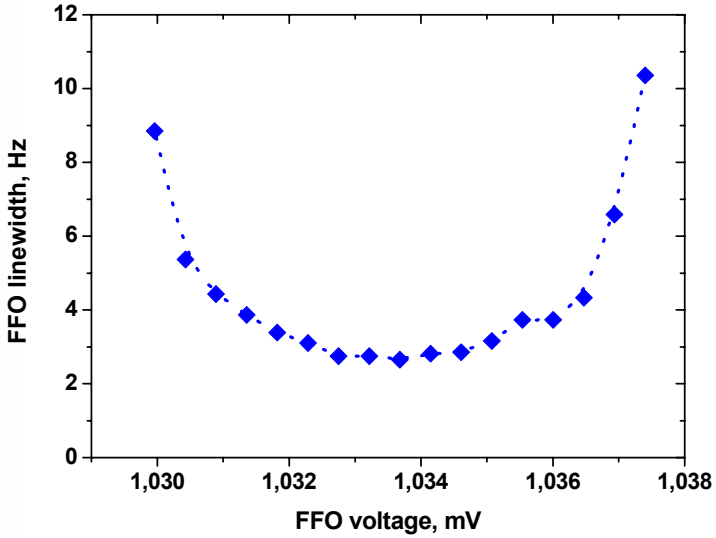




SIR for TELIS – remote operation on the Fiske steps



FFO frequency of about 500 GHz



→ Cryogenic Phase Locking Loop System for Flux-Flow Oscillator

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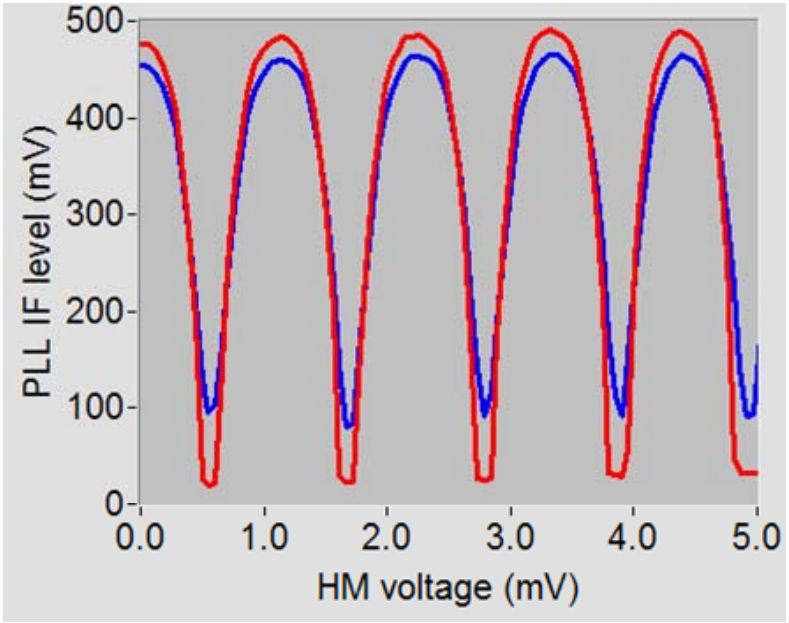
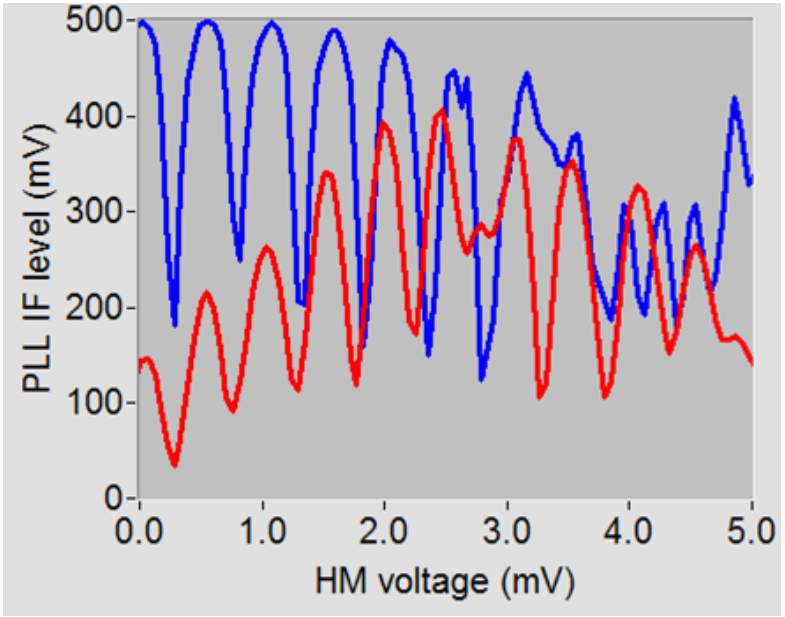
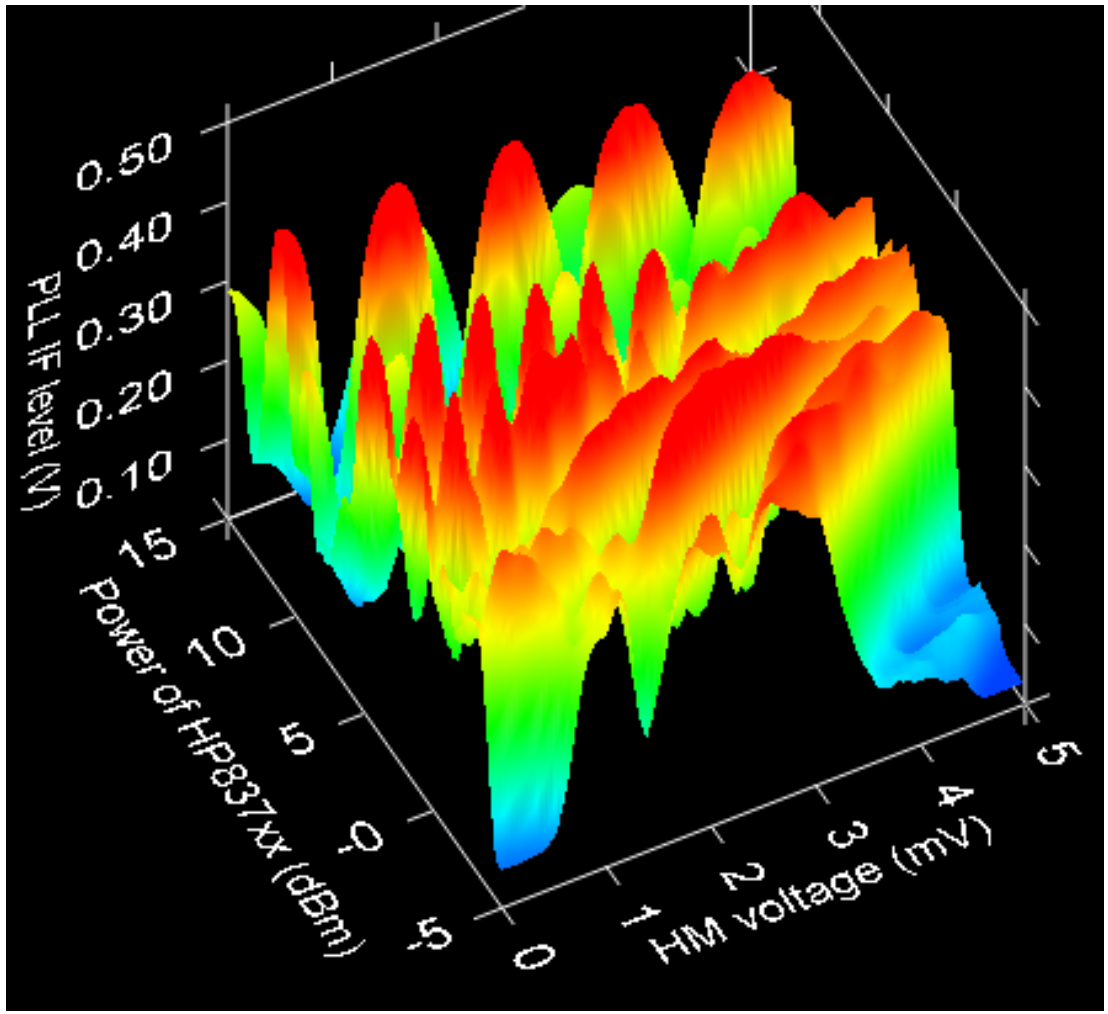
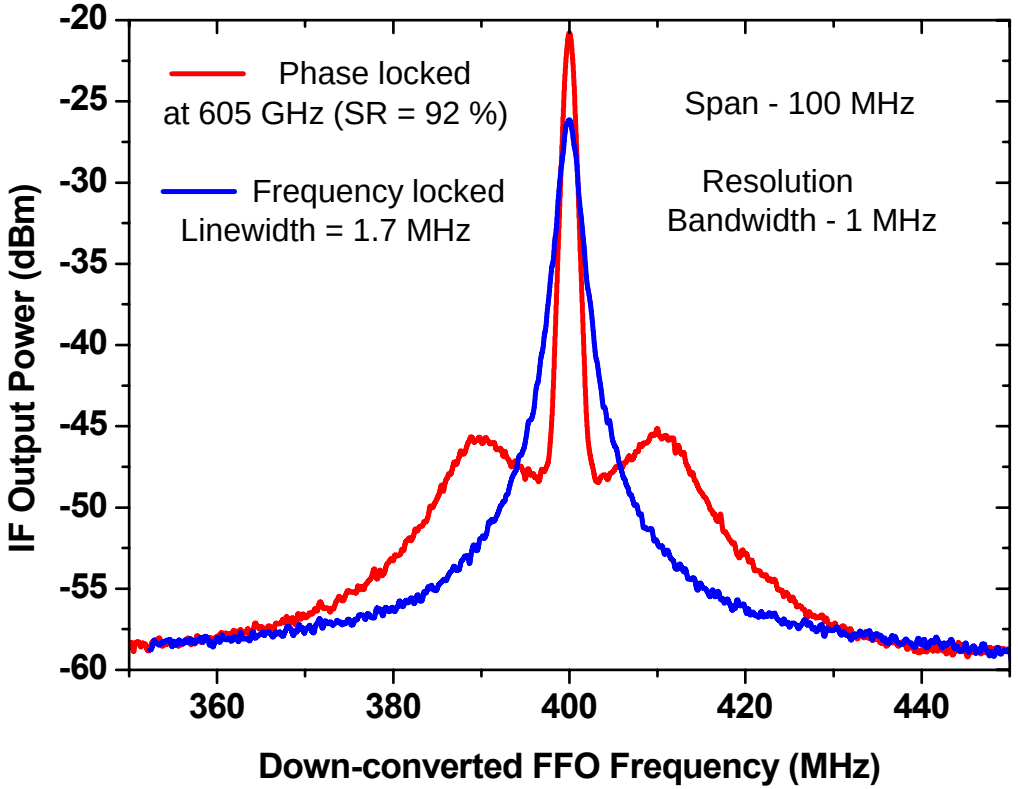
SIR for TELIS – remote operation: QP vs Josephson

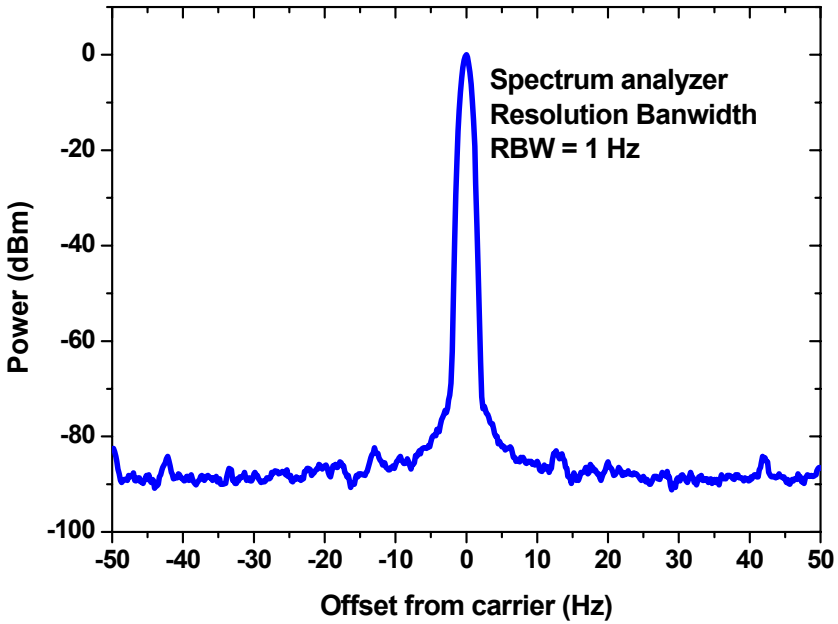




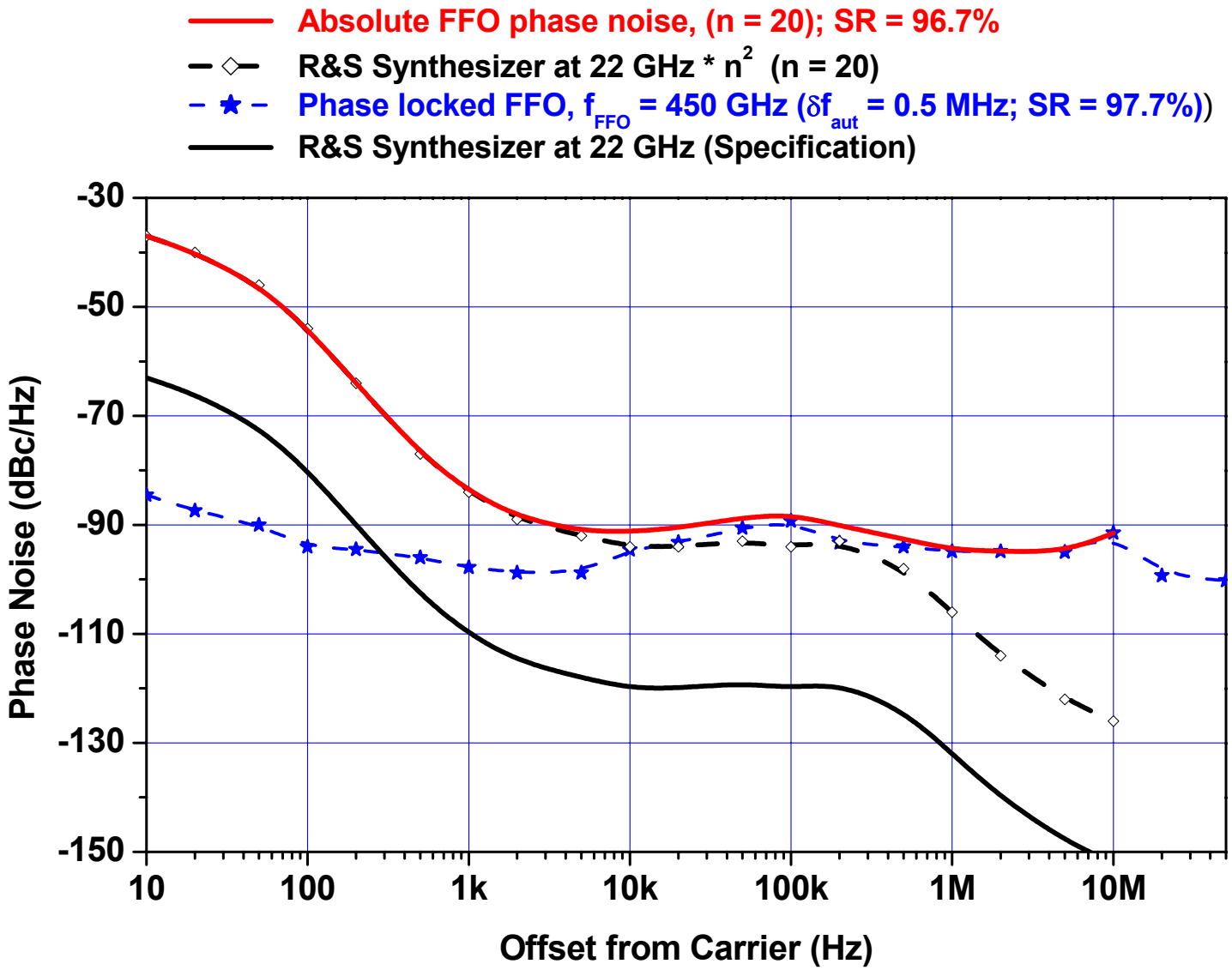


Frequency and Phase Locked spectra of the Nb-AlN-NbN FFO

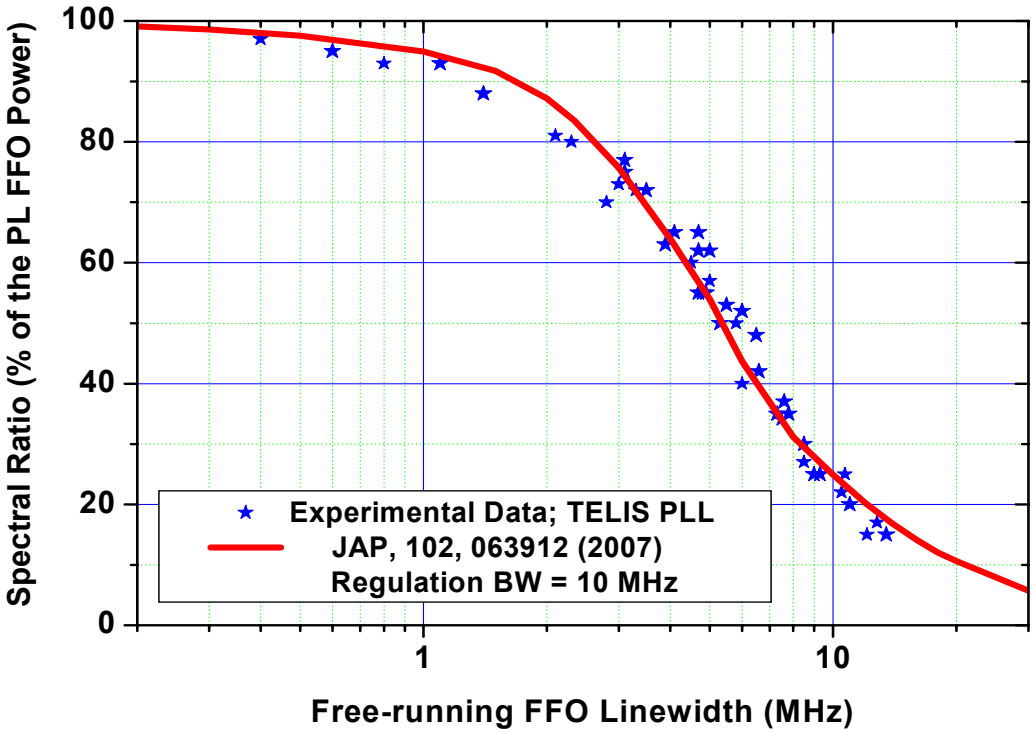


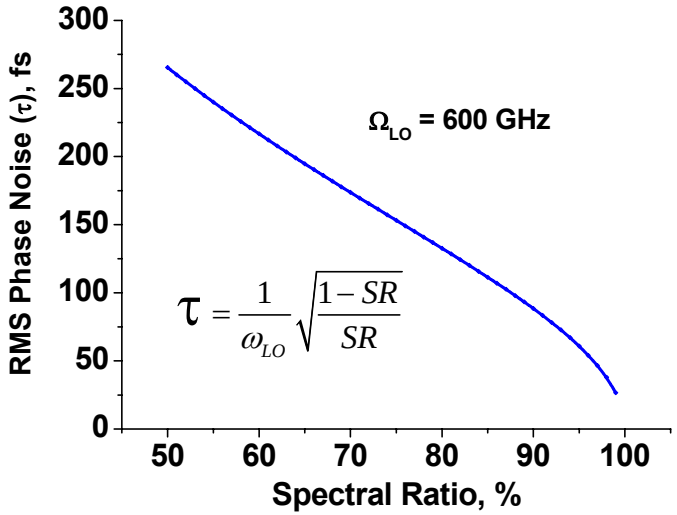


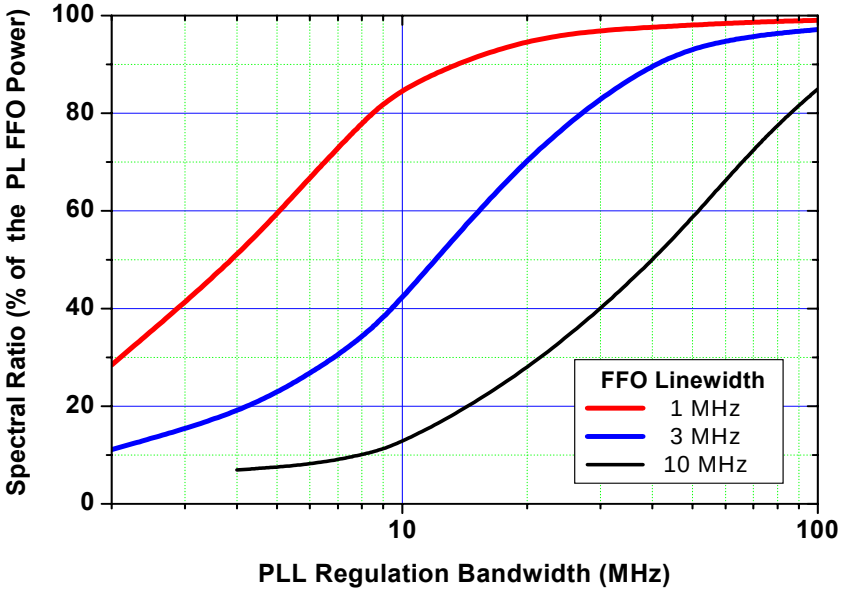
Phase Noise of the PL FFO



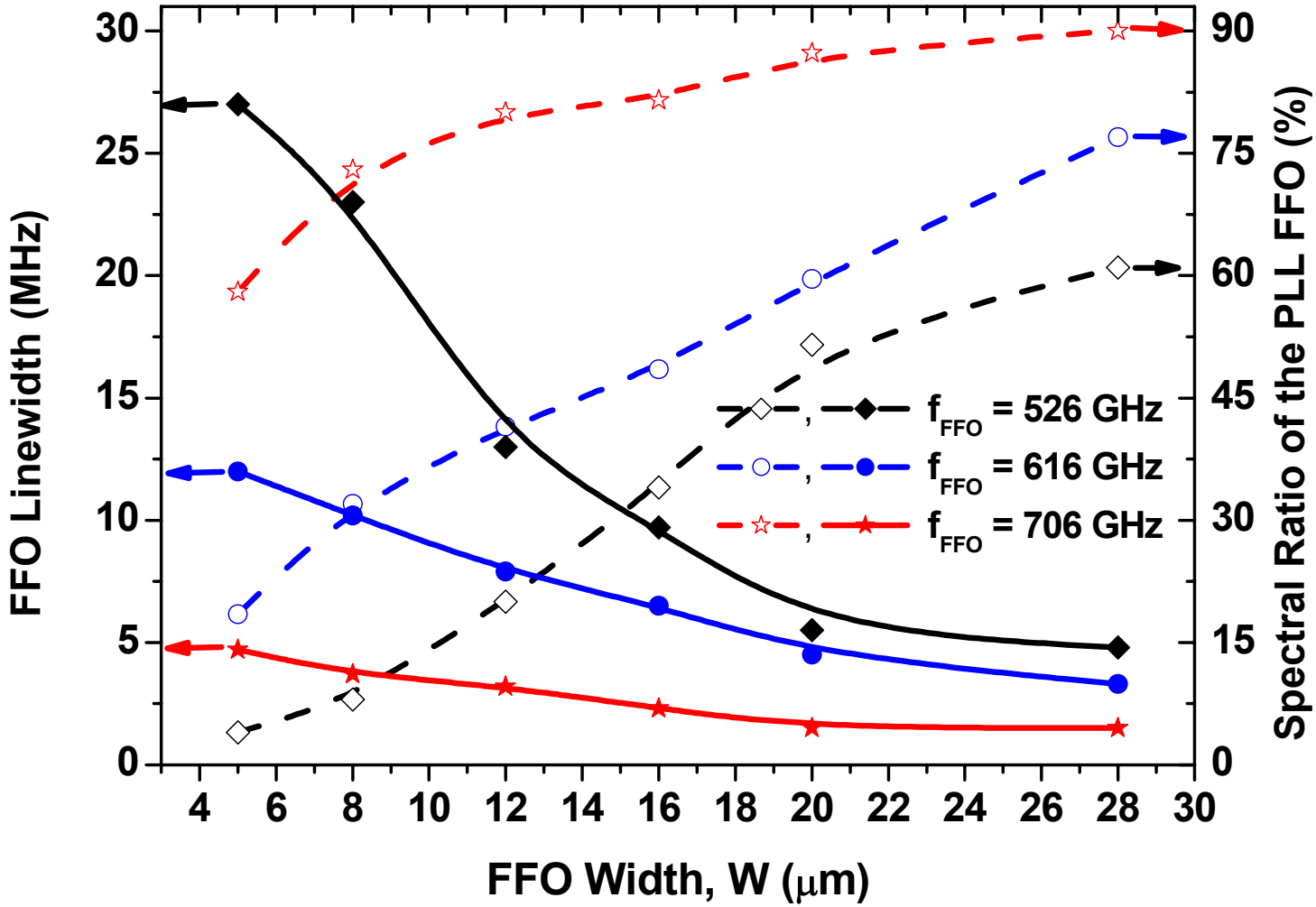
PL FFO Phase Noise and Spectral Ratio







Linewidth of free-running FFOs and SR for the PL FFO as a function of FFO width (RnS =30 Ω*μm²)

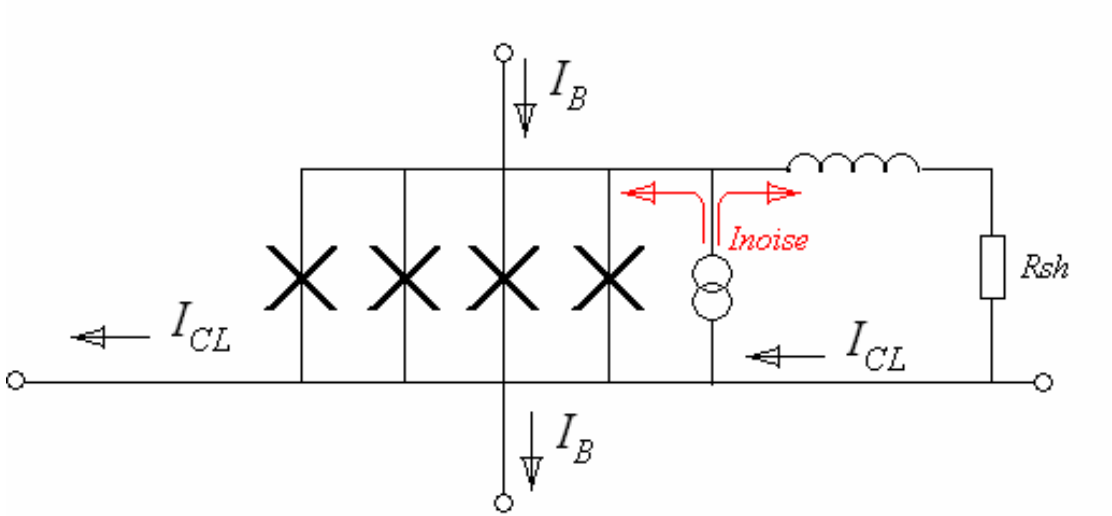


Suppression of the FFO voltage noise

The FFO voltage is independently controlled by the two currents I_B and I_{CL}

noisy!

noiseless



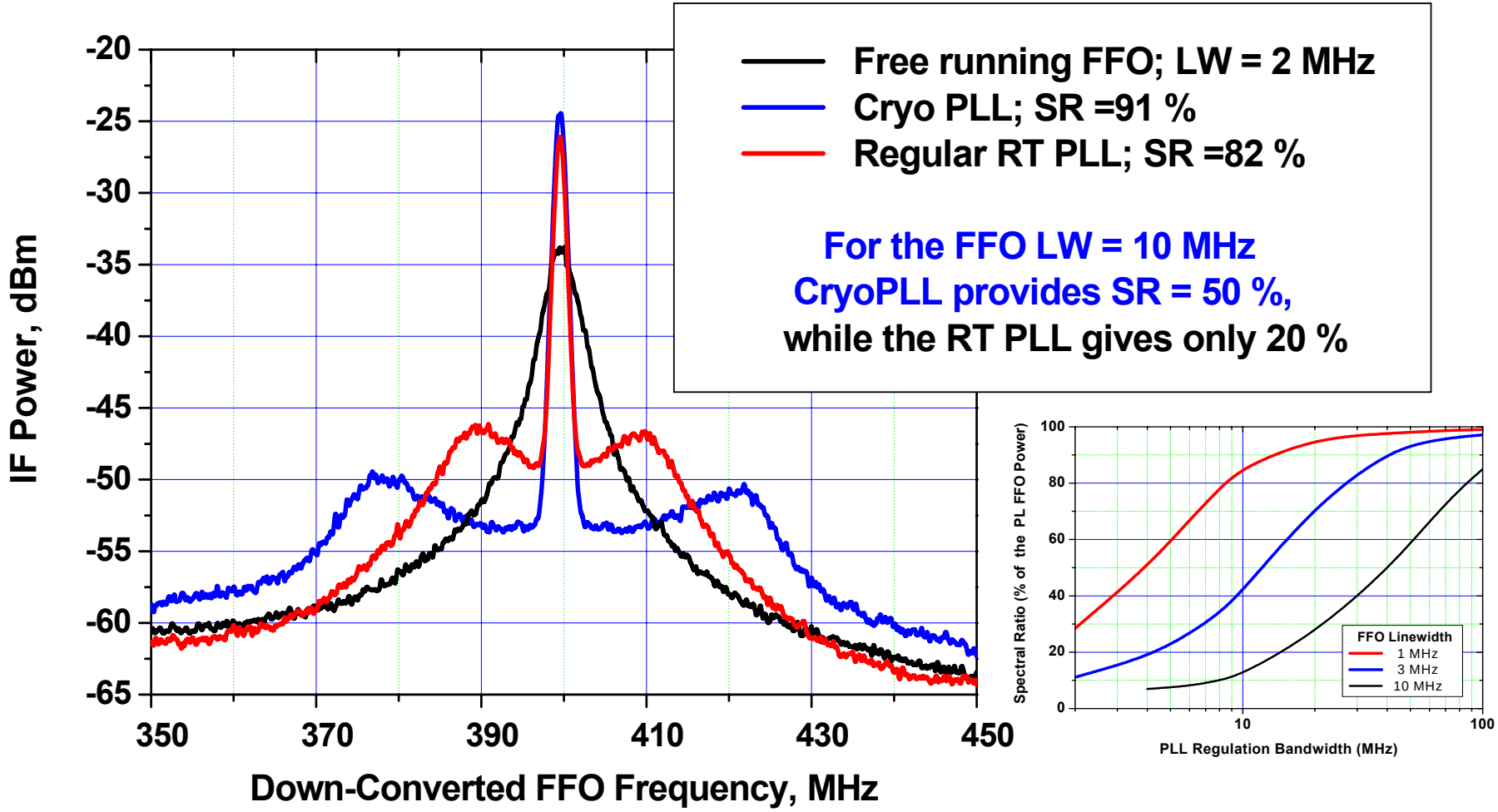
Correlated convey of the FFO bias current noise into the magnetic field (I_{CL})

Relation between the amplitude of the FFO noise current and voltage noise

$$Vnoise(\omega) = \left(Rd \cdot X_1(\omega) - \frac{A\alpha_{sh} X_2(\omega)}{A\alpha_1 + \alpha_2} Rd^{CL} \right) Inoise$$

$Rd^{CL} = \partial V / \partial I_{CL}$ $\quad$ $Rd = \partial V / \partial I_B$

Cryogenic PLL System



→ Cryogenic Phase Locking Loop System for Flux-Flow Oscillator

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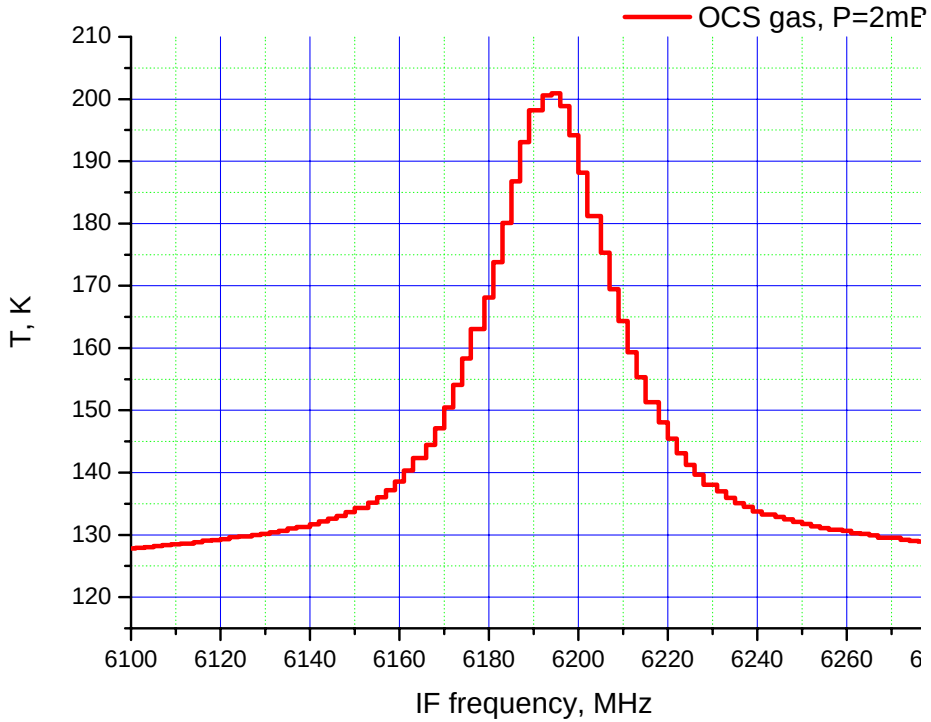
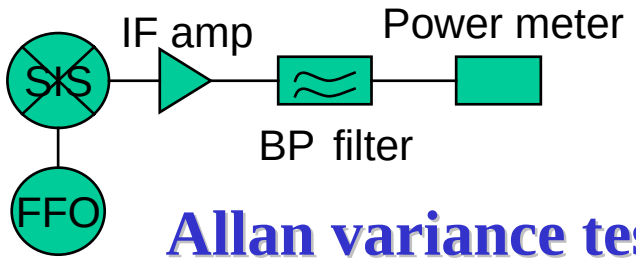
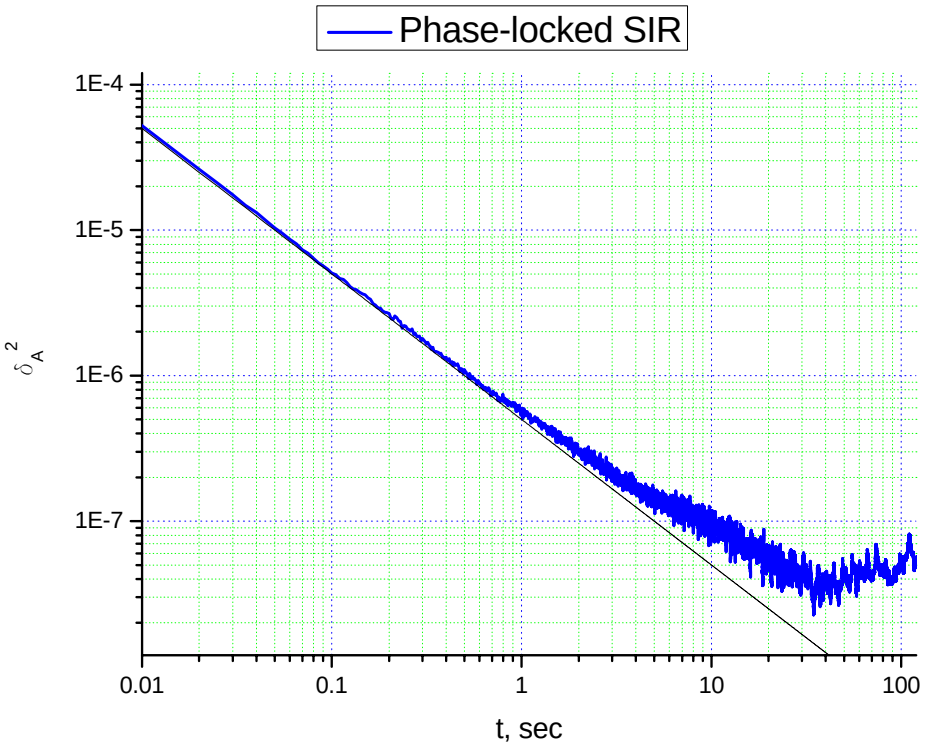
SIR Resolution & Stability

Gas cell measurements; resolution determined by DAC





Allan variance test



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Conclusion

- Concept of the Phase-locked SIR is developed and tested.
- Nb-AlN-NbN FFOs and SIRs have been successfully implemented.
- Improved design of the FFO for TELIS has been developed and optimized; free-running linewidth from 0.5 to 10 MHz recorded in the frequency range 350 – 740 GHz that allows to phase lock from 35 up to 97 % of the FFO power.
- 3-rd generation of the SIR with PL FFO for TELIS has been developed showing a possibility to realize TELIS requirements: Frequency range 500 – 650 ГГц; Noise Temperature < 150 К; IF bandwidth 4 - 8 ГГц; Spectral resolution better 1 МГц.
- Procedure for remote optimization of the PL SIR operation has been developed and experimentally proven.
- First TELIS flight is scheduled on May - June, 2008 (Terezina, Brazil).
- Approaches to increase SR of the PL FFO proposed and tested.
- Future space missions are under consideration.