Development of Integrated Receiver for Radio Astronomy

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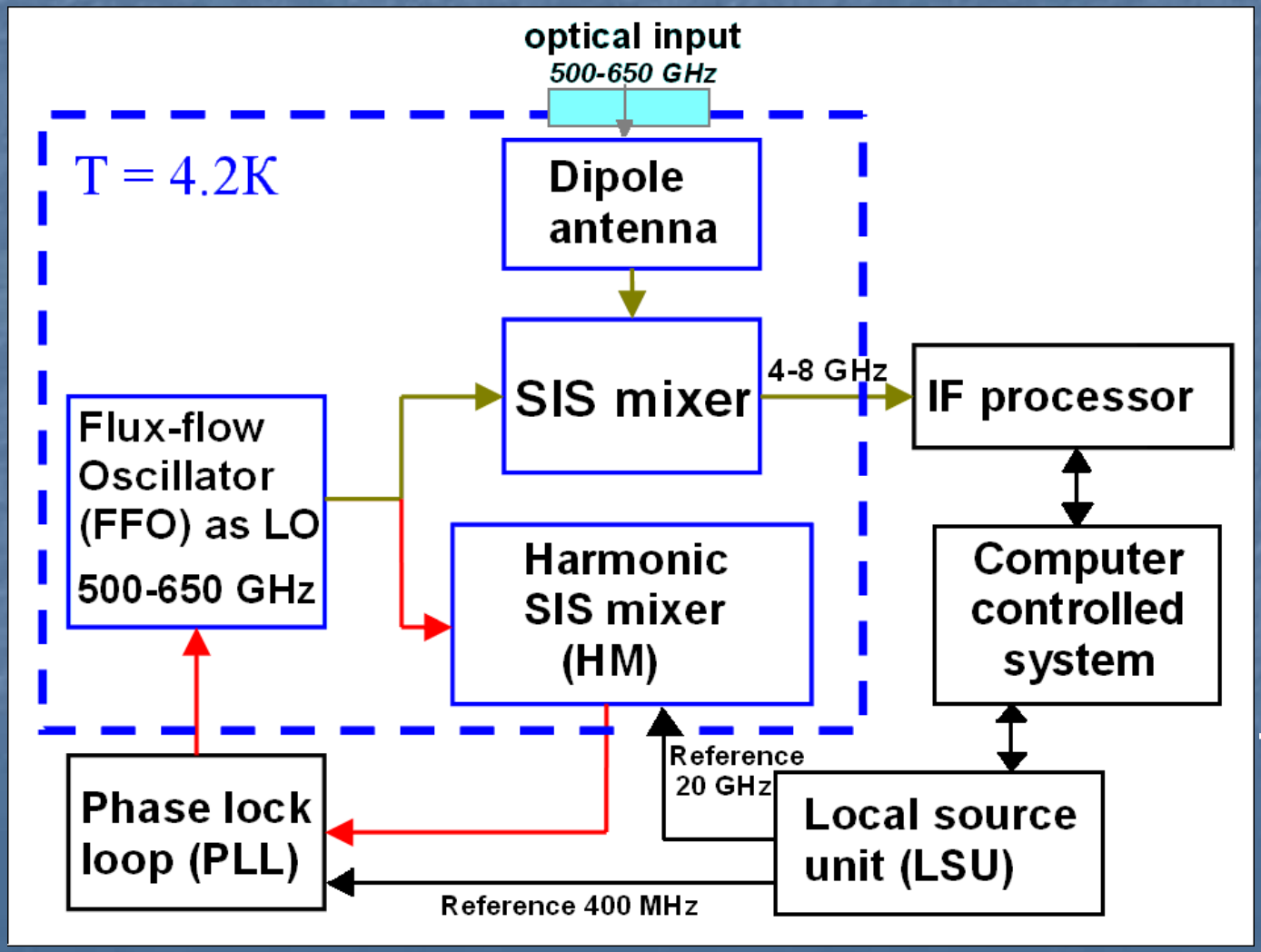
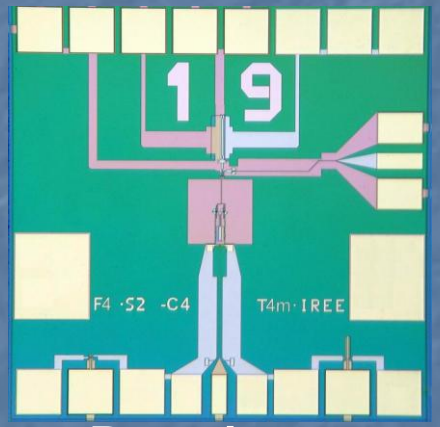
Development of Integrated Receiver for Radio Astronomy

- Superconducting Integrated Receiver of 500-650 GHz
- New applications of Integrated Receiver
- Development of flux-flow oscillator (FFO) for 250-400 GHz
- Development and testing circuit including FFO, SIS and Harmonic Mixers.
- Calculation and experimental results
- Summary

Superconducting Integrated Receiver

Superconducting Integrated Receiver with phase-locked FFO





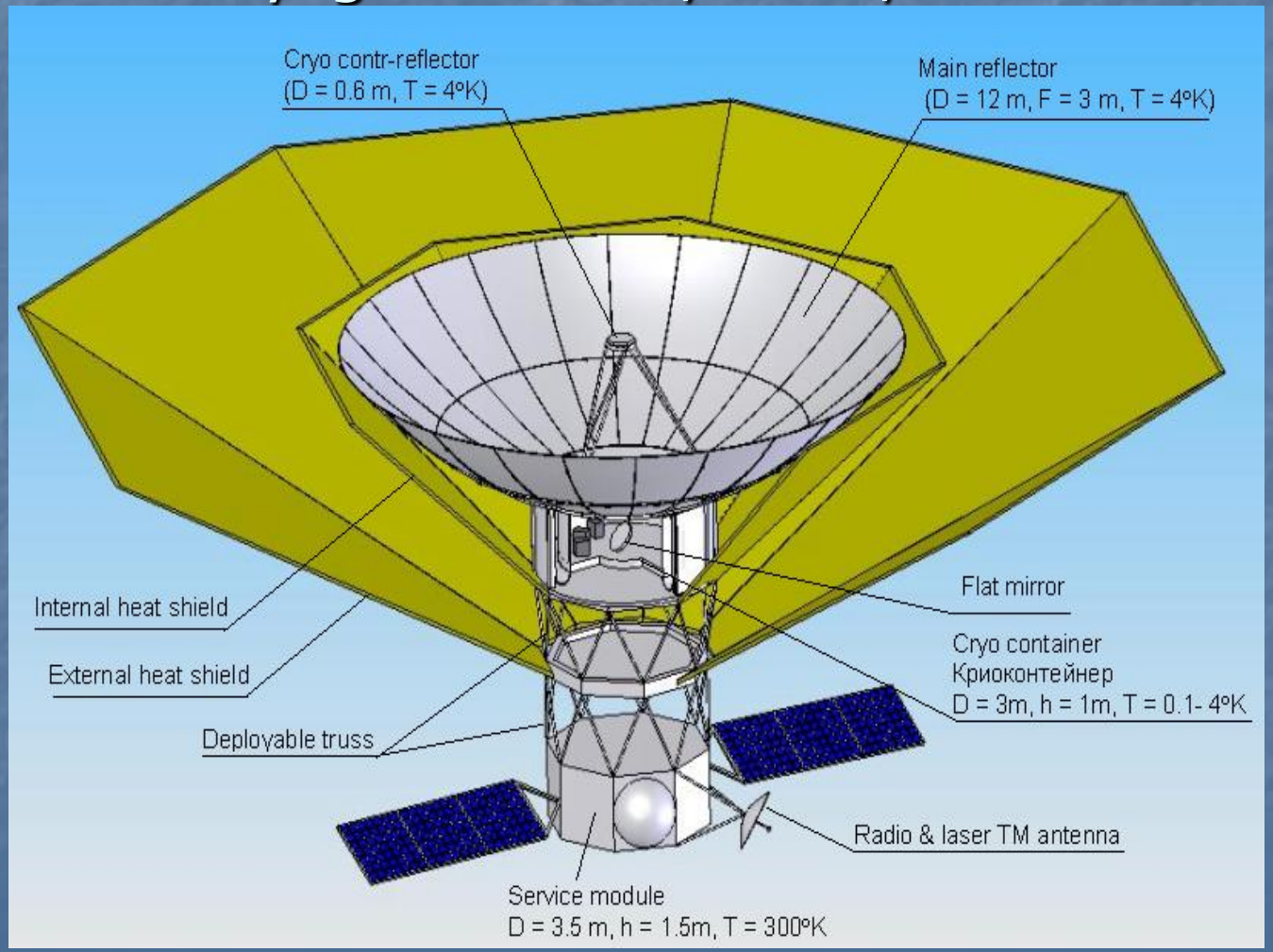
Receiver Microcircuit 4x4 mm

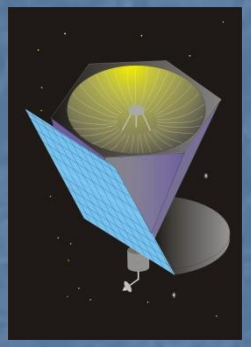
Success in TELIS project: 500-650 GHz

New applications of Integrated Receiver

New applications of Integrated Receiver (1)

"Millimetron" – Russian Space Agency (> 2017)
12 m cryogenic mirror; λ = 0,01- 20 mm.

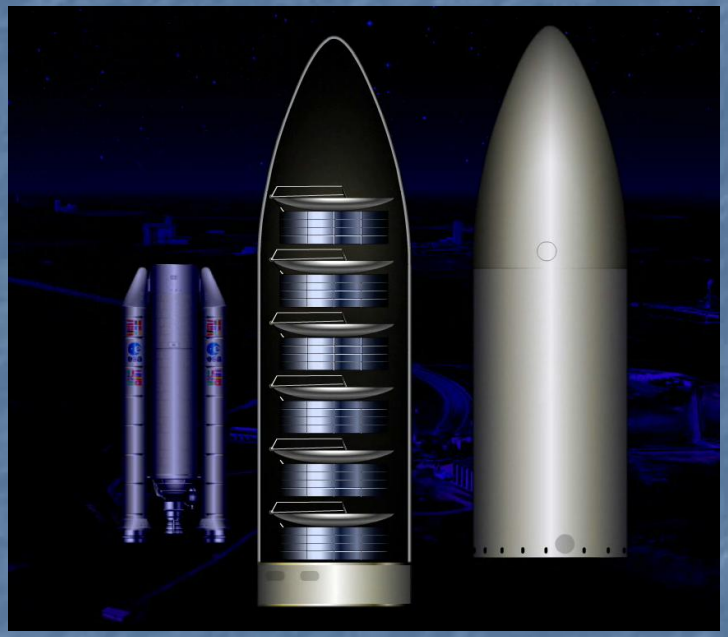




Ground-space interferometer

New applications of Integrated Receiver (2)

ESPRIT – Exploratory Submm Space Radio-Interferometric Telescope



The six elements of ESPRIT in an Ariane 5

- Telescope sizes ~ 3.5 meter ; off-axis
- Number of elements N = 6 (15 baselines)
- Projected baselines 200 - 1000 meter
- Frequencies:
  Spots in the range 0.5 – 6 THz
- Front Ends - (0.5 – 1.5 THz): SIS mixers, multiplier LO / SIR = FFO + SIS + HM
  (1.5 – 6 THz) HEB mixers, QCL as LO
- System temperature < 1000 K
- IF bandwidth > 4 GHz (goal 8 GHz)

New applications of Integrated Receiver (3)

Submillimeter Telescope (SMT)
Arizona Radio Observatory (ARO)

Main reflector: paraboloid D=10 m; F/D=0.35. Subreflector: d=0.69 m;
SIS-490: The SORAL 490 GHz single-channel receiver;
T(DSB) = 110-150 K across its 425 to 500 GHz tuning range.

New applications of Integrated Receiver (4)

30-cm **POrtable Submillimeter Telescope** (POST)
Purple Mountain Observatory (PMO); Nanjing.
Site: Delingha of Qinghai province *(altitude ~3200 m)*

Required parameters:

Frequency - 345 GHz
Tr (DSB) ≤ 100 K

IF range - 3.6-4.6 GHz
Spectral resolution ≤ 30 KHz

Output power ≥ 5 dBm
Output frequency - 0.01-1GHz

Dissipated power at 4.2K stage ≤ 100 mW

Integrated Receiver of 345 GHz for POST:

collaboration:

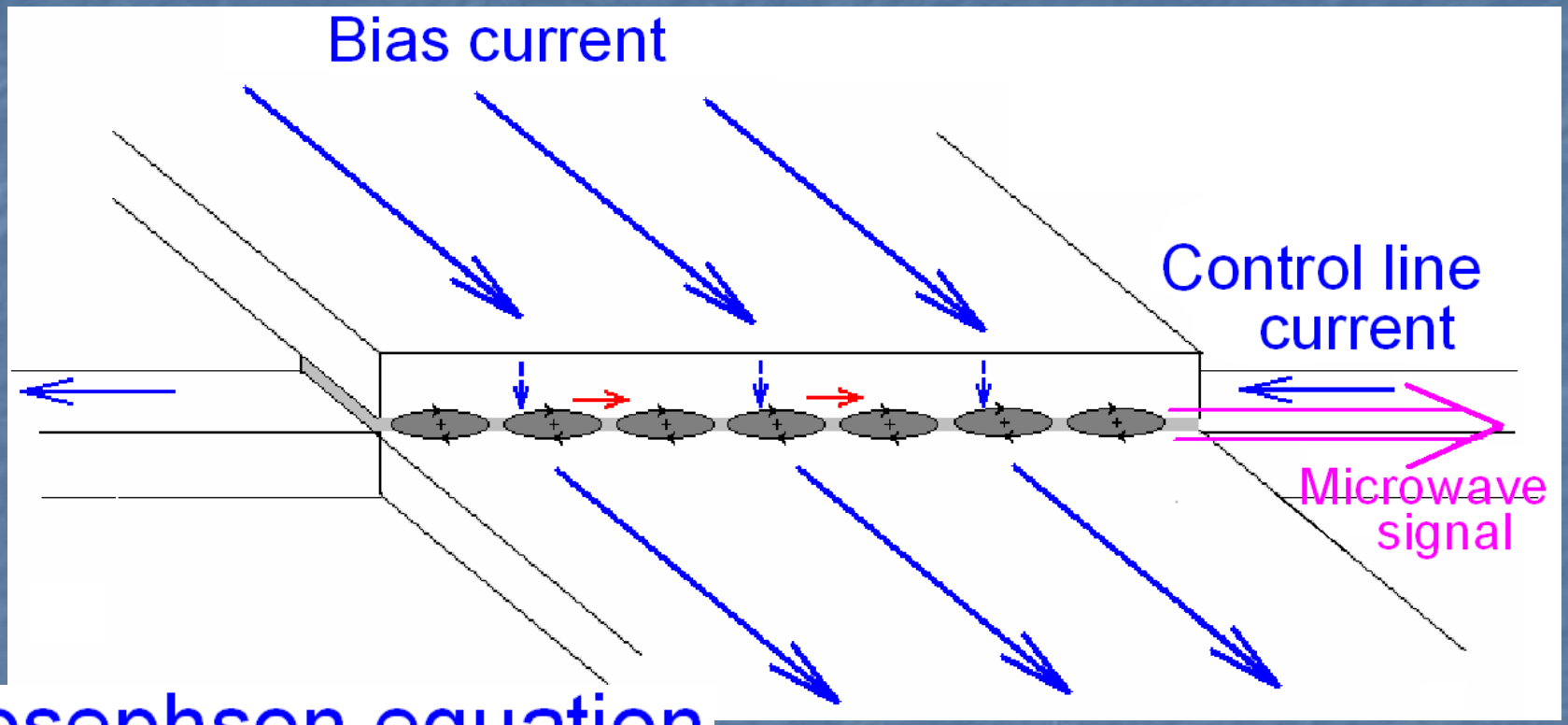
- *IREE, Moscow, Russia*
- *PMO, Nanjing*

Development of such Integrated Receiver for POST includes stages:

- New FFO design for 325-365 GHz
- Microcircuit design to pump SIS and Harmonic mixer with FFO power
- Integrated lens-antenna
- Mechanical design for mounting a new receiver at the telescope
- Related stuff and equipment (cables, amplifiers, controlling software, etc.)

Development of Flux-flow oscillator for 250-400 GHz

Flux-flow oscillator as LO



Josephson equation

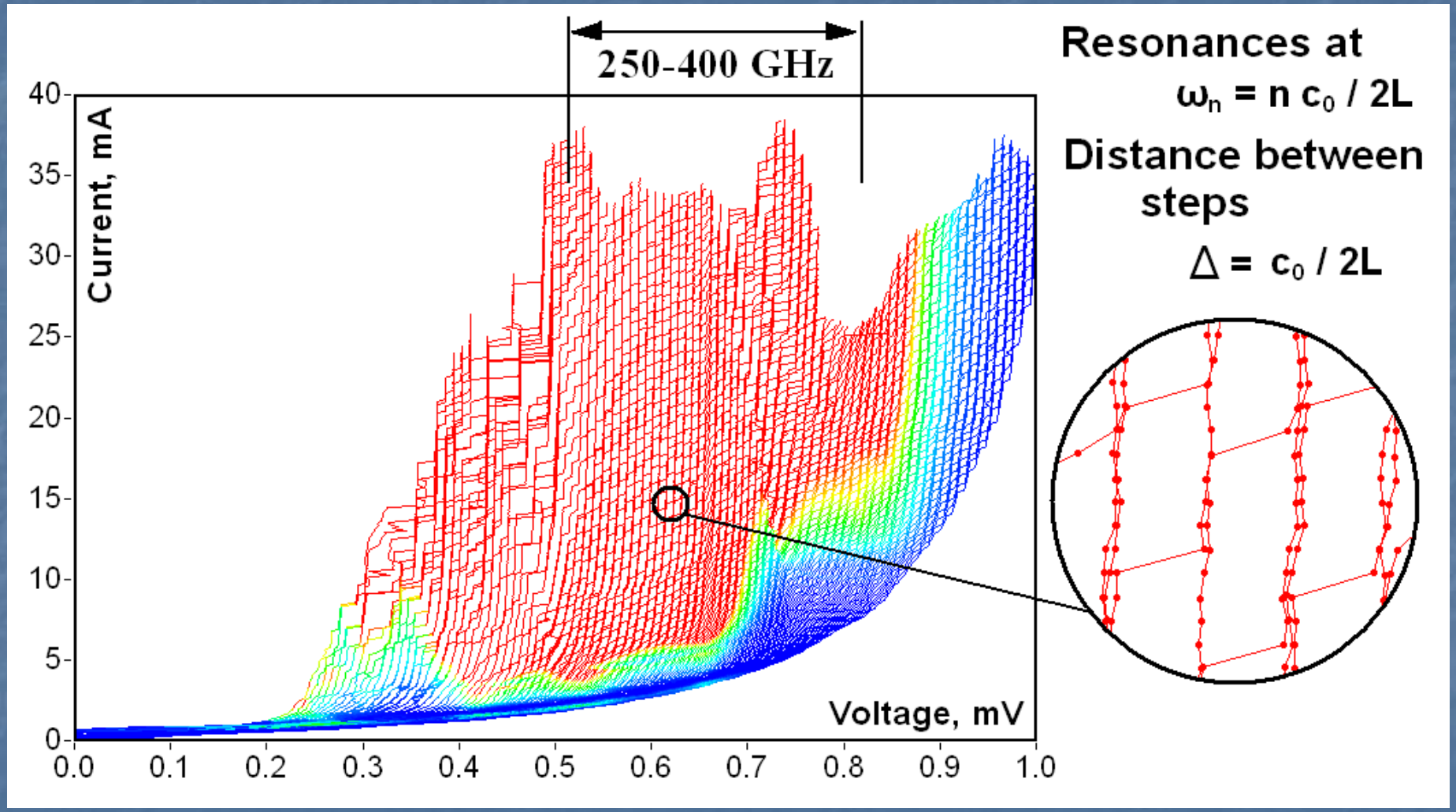
$$f_{FFO} = \frac{2eV_{FFO}}{hc}$$

(483.6 GHz/mV)

Working regimes:

- 400-650 GHz – Fiske steps and flux-flow regime
- 250-400 GHz – Fiske steps regime with low damping

IV-curves of FFO

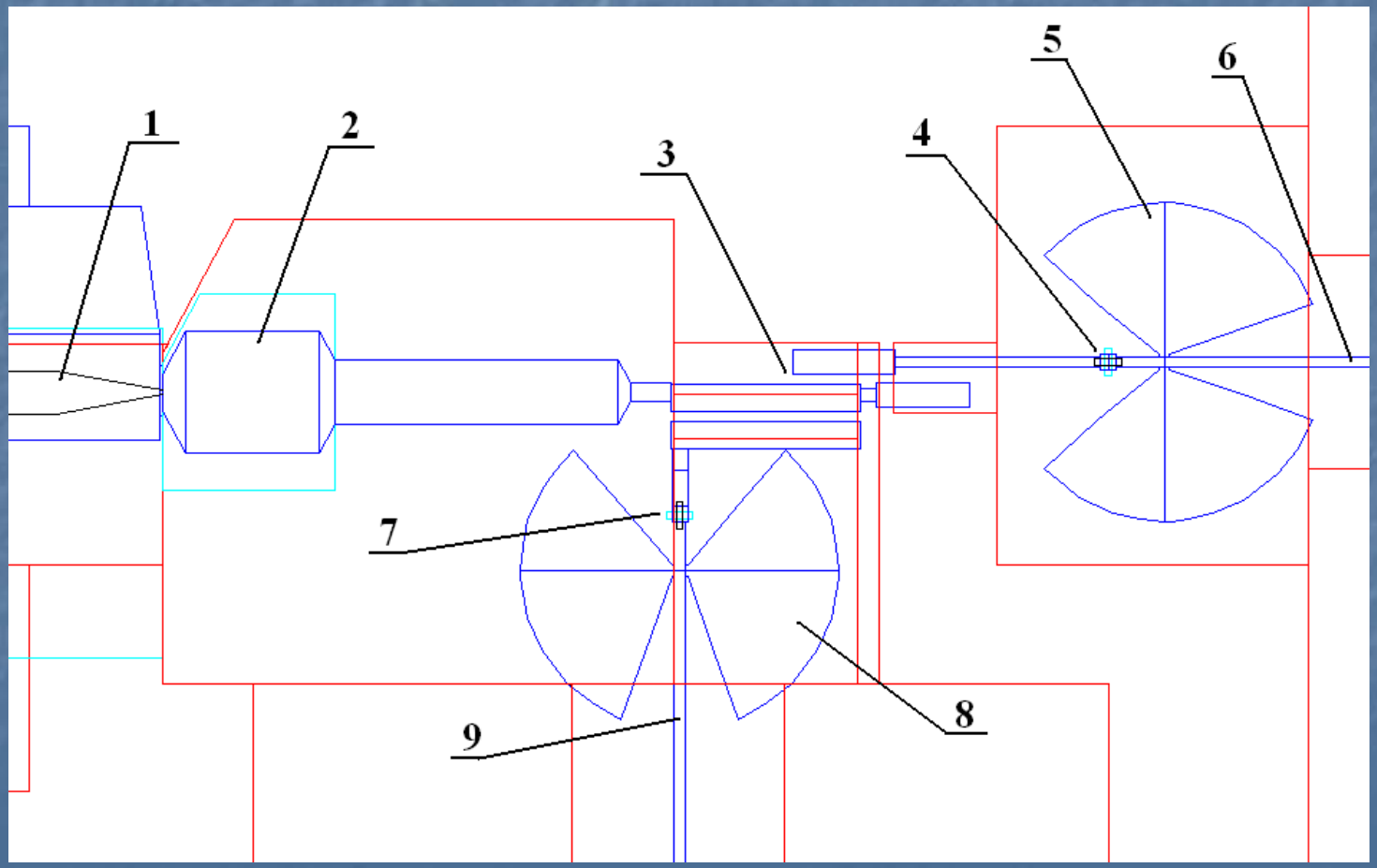


FFO Length 700 μm was taken

Development and testing of integrated circuit

Development of testing microcircuit

- FFO + SIS mixer + Harmonic mixer
- Power matching of FFO with mixers is required



1 – FFO

2 – impedance transformer

3 – DC-break

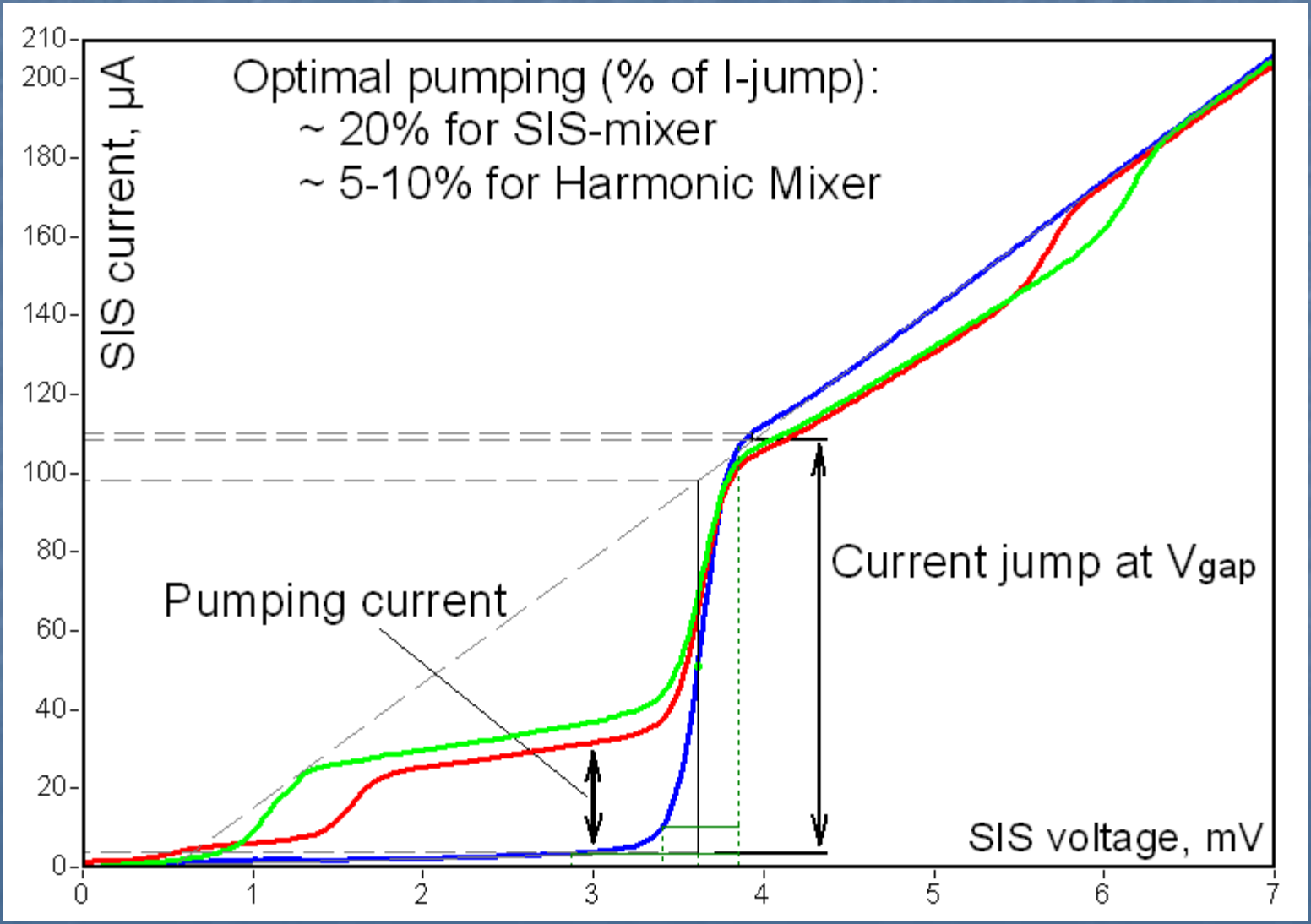
4 – SIS mixer

5,8 – radial stubs

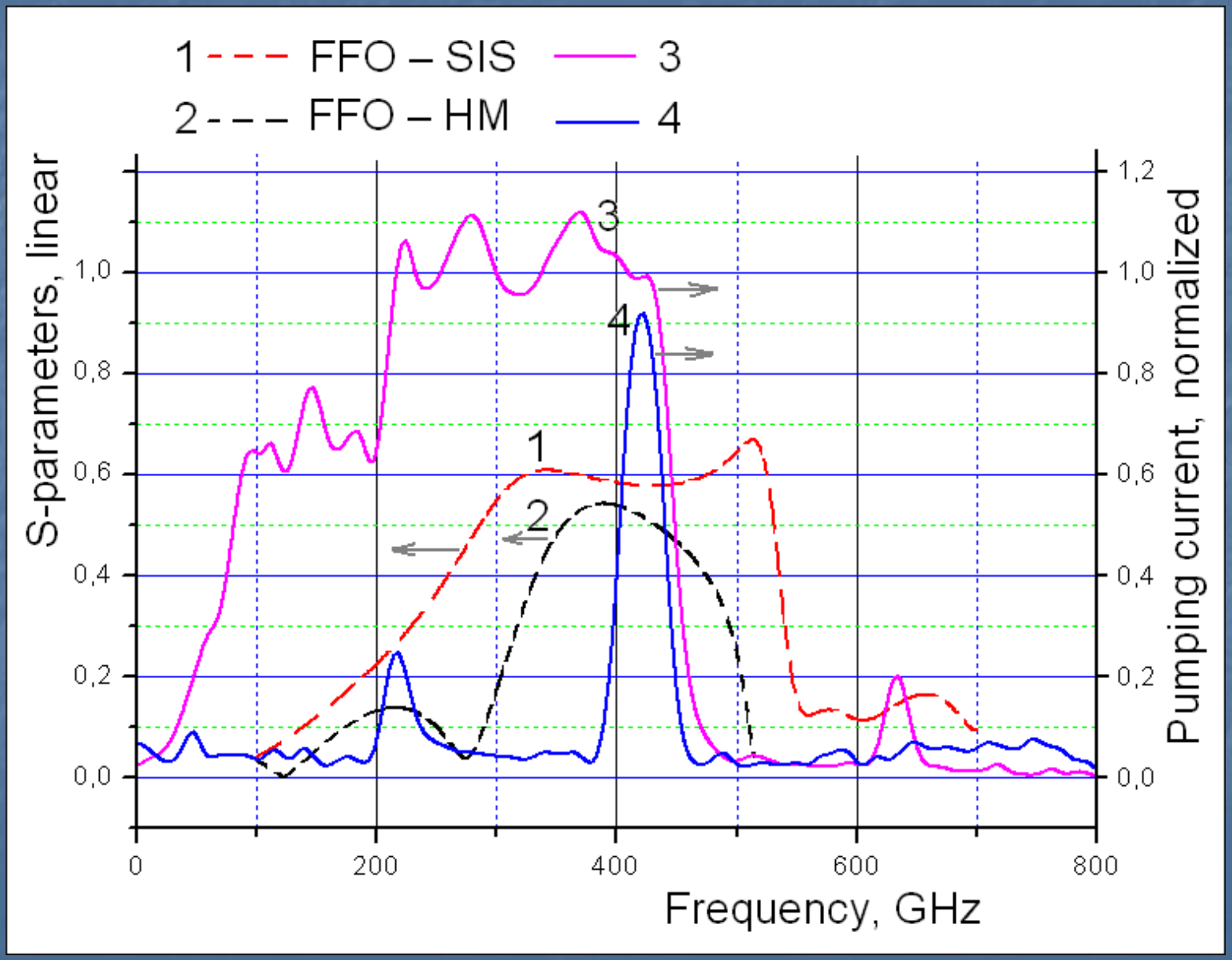
6,9 – mixers output lines

7 – Harmonic mixer

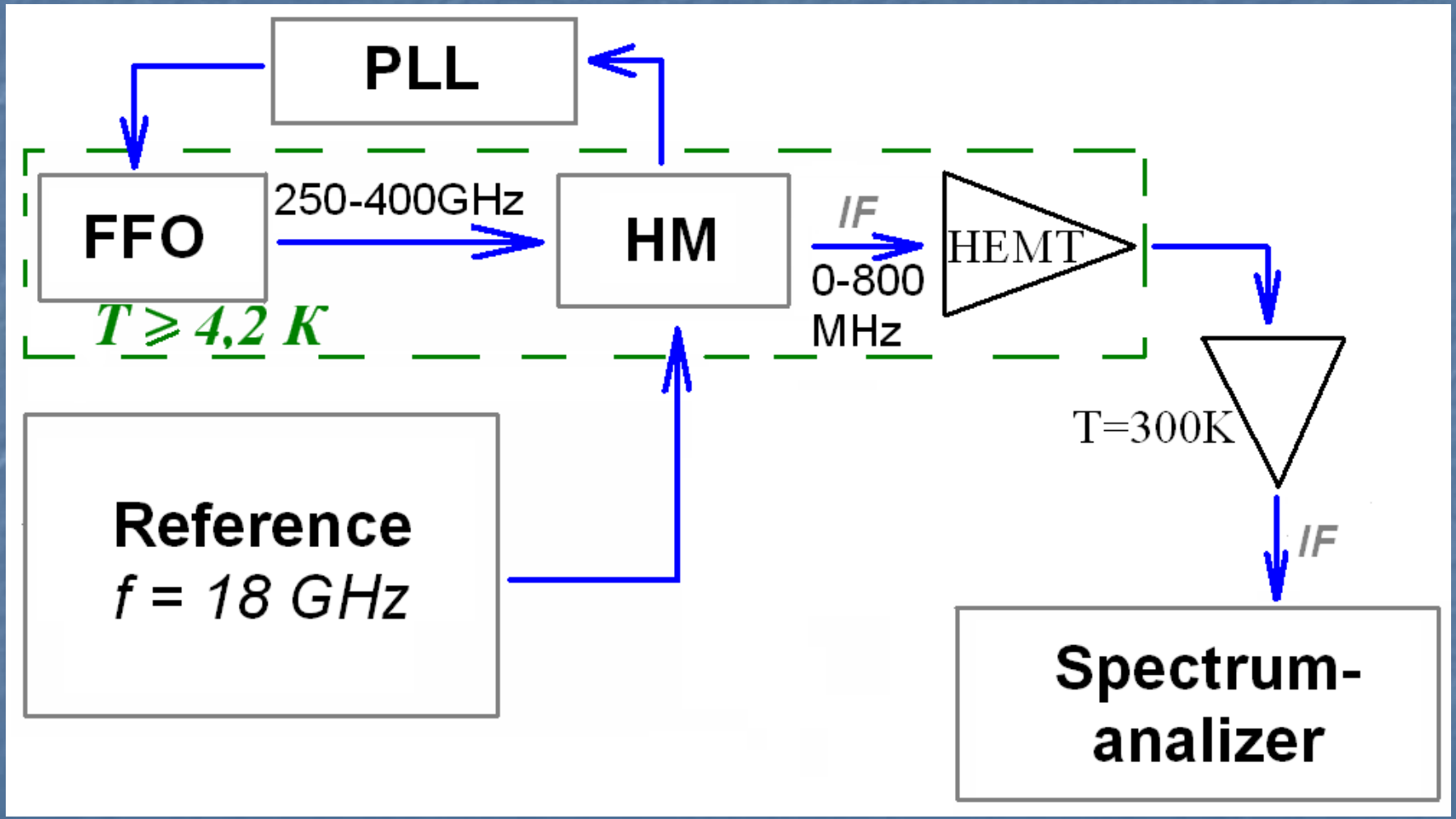
IV-curves of SIS mixer showing pumping by FFO power



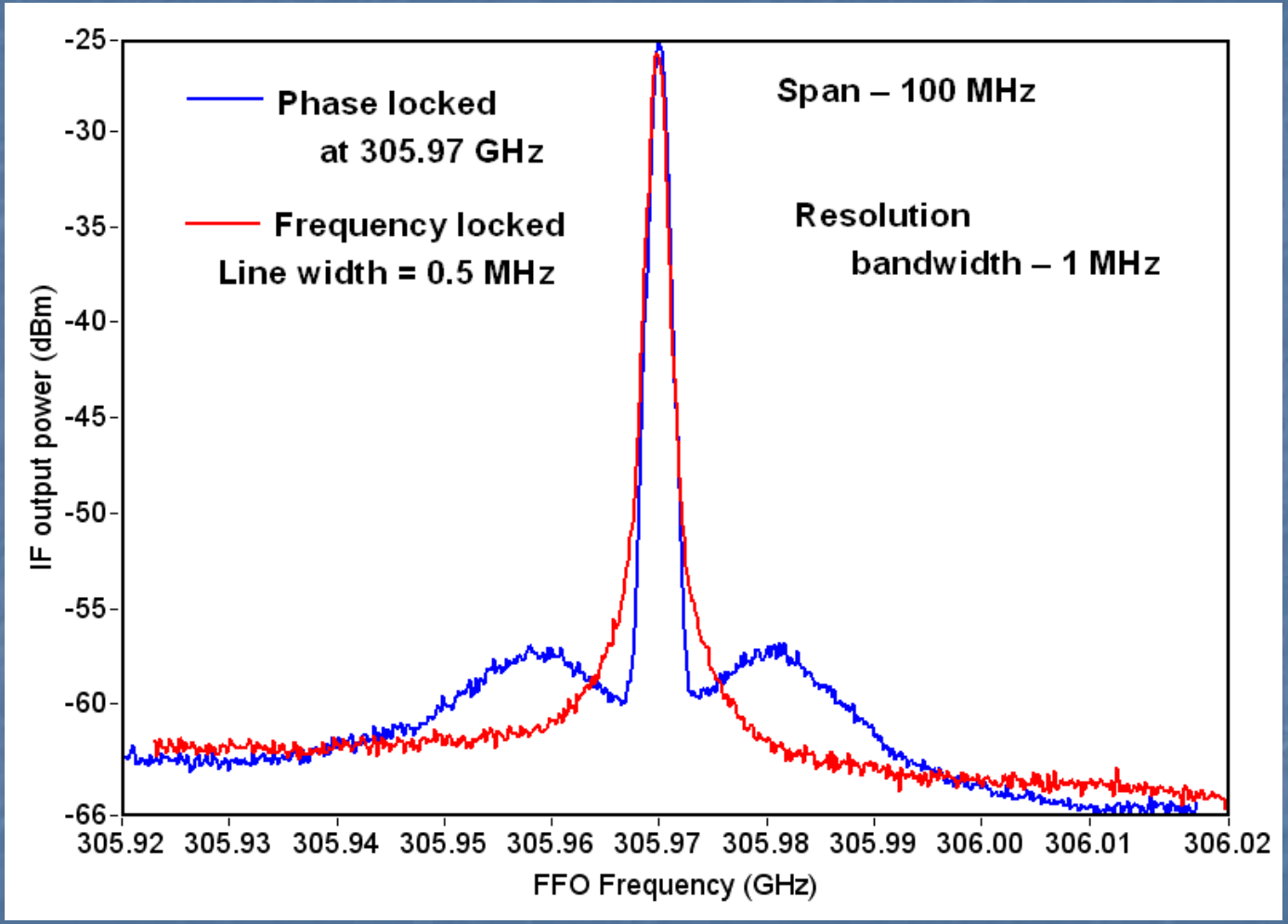
FFO and mixers power coupling



FFO Linewidth measurements

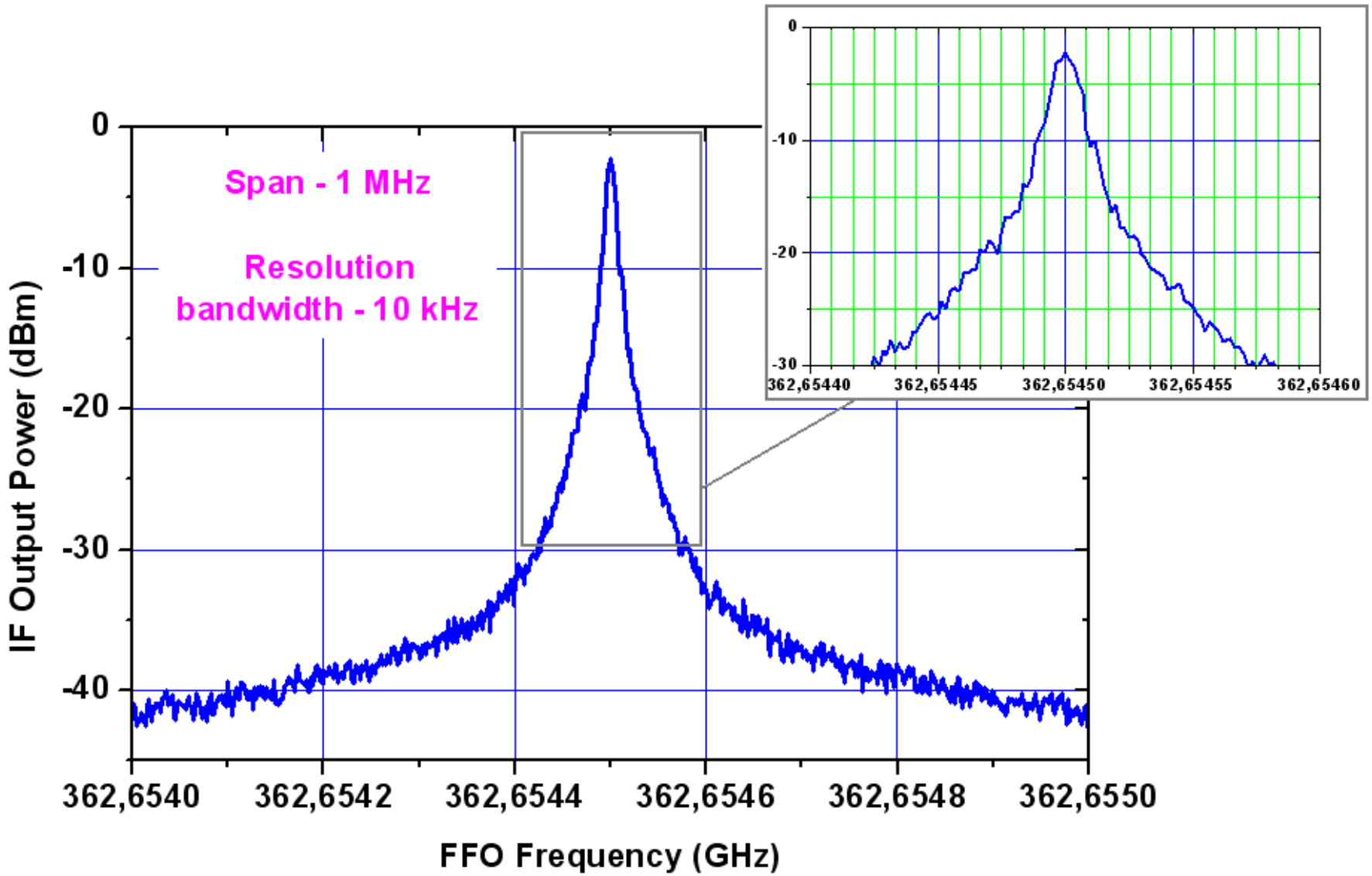


FFO radiation spectrum



Linewidth at best points below 1 MHz in the range 325-365 GHz was obtained.

Measured by integrated receiver a signal of external multiplier (driven by synthesizer)



Summary

- FFO linewidth below 1 MHz was demonstrated in range 325-365 GHz
- Sufficient power matching between FFO and both mixers (SIS and HM) was obtained

What has to be done:

- Integrated lens-antenna to be developed
- Circuit design with antenna to be retreated
- FFO design to be improved
- Mechanical construction for mounting receiver into telescope to be realized

Thanx for your attention :)

Phase Noise of the PL FFO