Cryogenic results from IAF mHEMTs in CAY hybrid amplifiers

Juan Daniel Gallego
Ricardo Amils Samalot
Isaac López Fernández
Carmen Diez González

Centro Astronómico de Yebes
Observatorio Astronómico Nacional

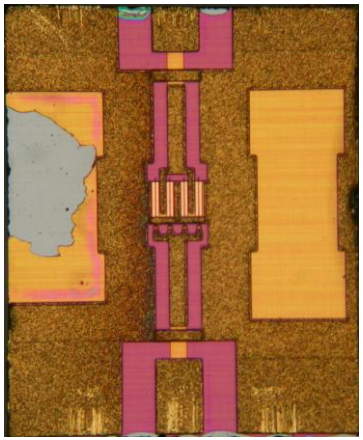
IAF devices

Different gate dimensions and wafers measured in two different test amplifiers:

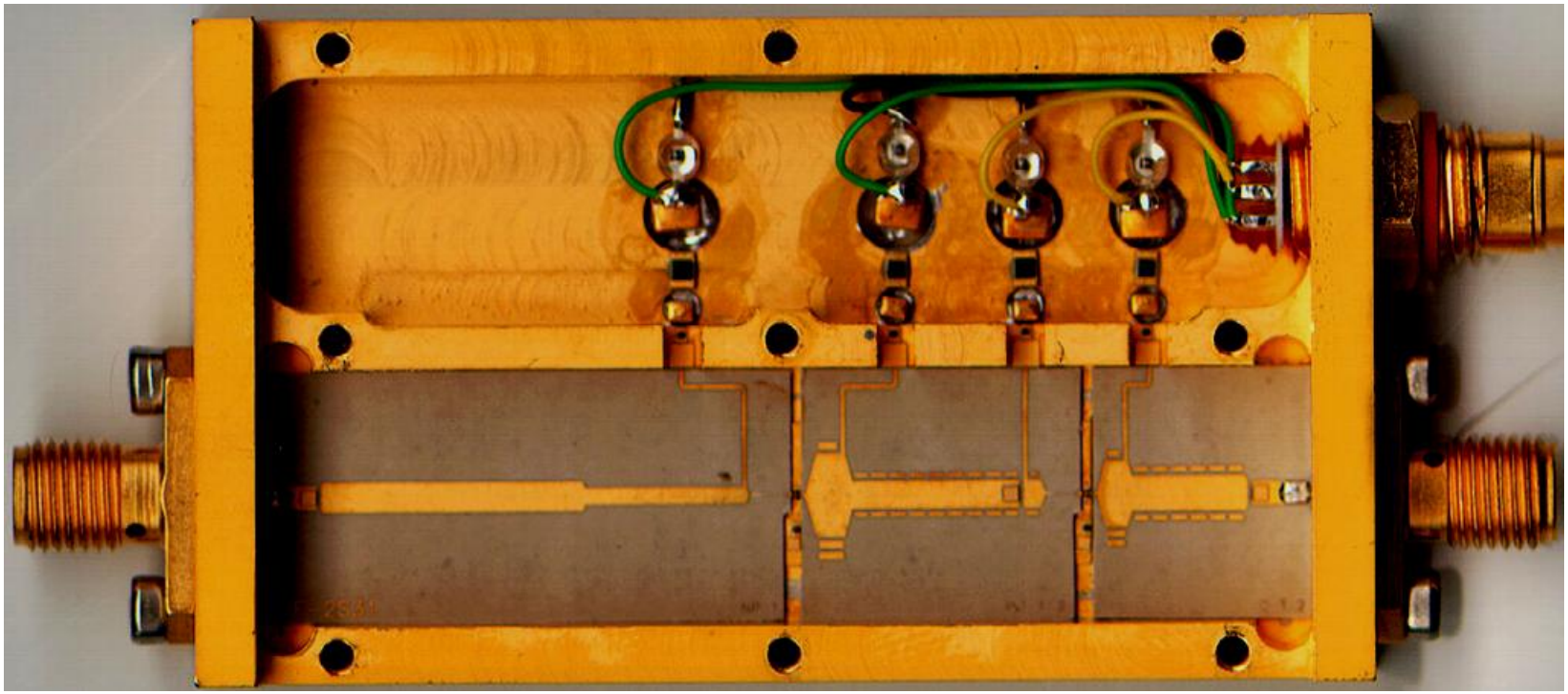
CAY Code	Wafer	Gate dimensions	N. Samples	Amplifier
T-62	R703d W210 (14/04/03)	0.07x180μm	2	YCF 2010 (4-8GHz)
T-89	L060406 W31 (11/12/07)	0.1x160μm	5	YCF 2010 (4-8GHz)
T-89	L060406 W31 (11/12/07)	0.1x160μm	2	YK22 004 (20.5-24.5GHz) GHz
T-91	RT12B, W. 25 (09/05/08)	0.05x160μm	1	YCF 2010 (4-8GHz)
T-91	RT12B, W. 25 (09/05/08)	0.05x160μm	3	YK22 004 (20.5-24.5GHz)
T-92	R723B, W7 (04-03-09)	0.1x120μm	1	YCF 2010 (4-8GHz)
T-93	R723B, W7 (04-03-09)	0.1x180μm	1	YCF 2010 (4-8GHz)

IAF devices

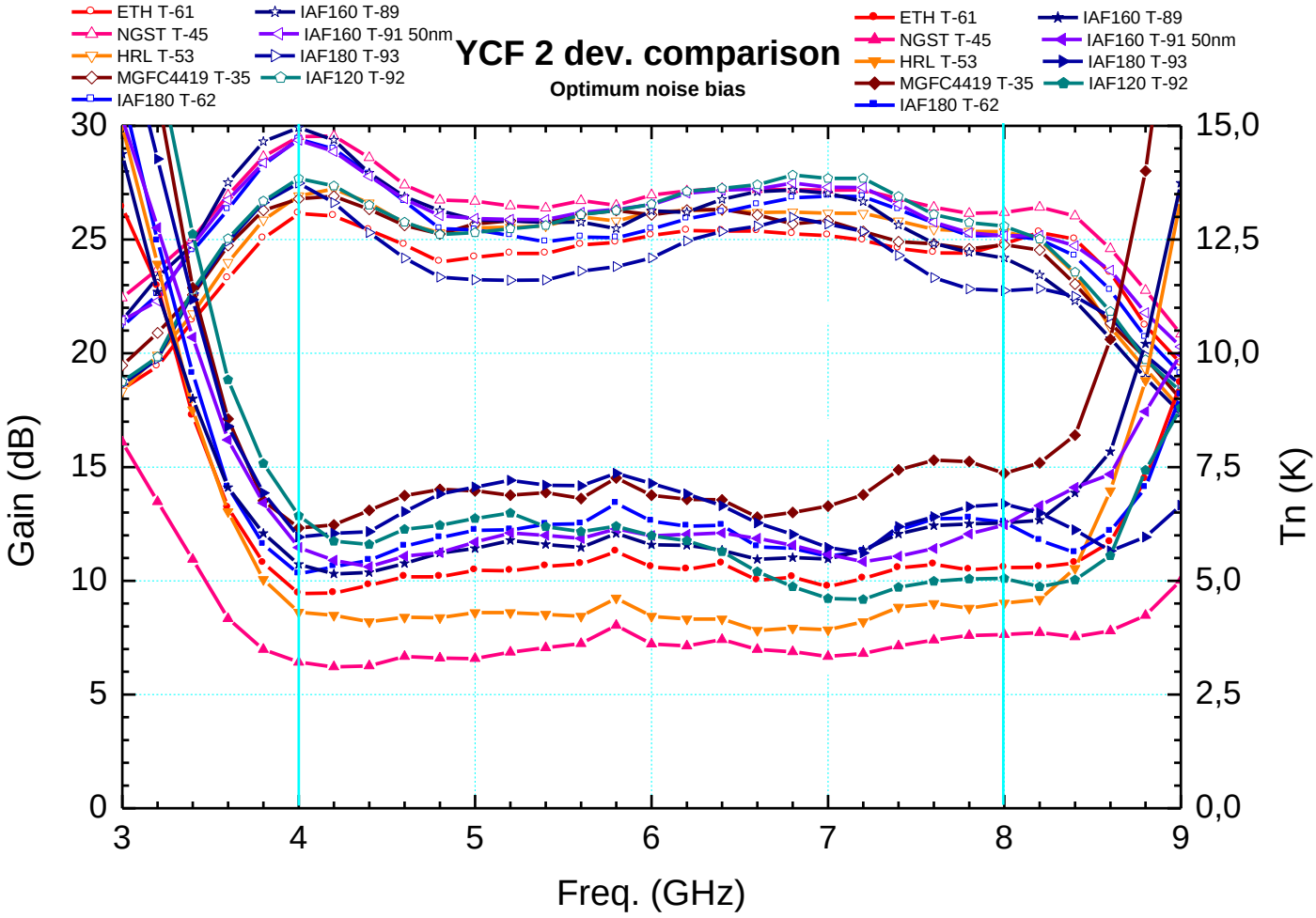
Tested for noise at 15 K in a 4-8 GHz and 18-26 GHz amplifiers



4-8 GHz “Test” amplifier



IAF devices (4-8 GHz) (I)



IAF devices (4-8 GHz) (II)

- Good results at room temperature for both 50nm and 100nm gate length devices.
- Noise temperature at cryogenic temperature slightly worse than best tested InP devices (from other manufacturers).
- Significant differences among all the samples tested at cryogenic temperature:
  - In general the optimum bias for minimum noise is very critical. The best results are obtained in a very narrow range of Vds, Ids (Vds values around 0.2V). However, in some cases, the best noise results are obtained in a wider range of Vds, Ids.
  - Anomalous behavior in noise are found in some devices (100nm gate length transistors from more than one batch) for a quite wide range of Vds values coinciding with anomalous effect around the same values of Vds in the I-V plots. This effect is not found in the 50nm gate length devices.

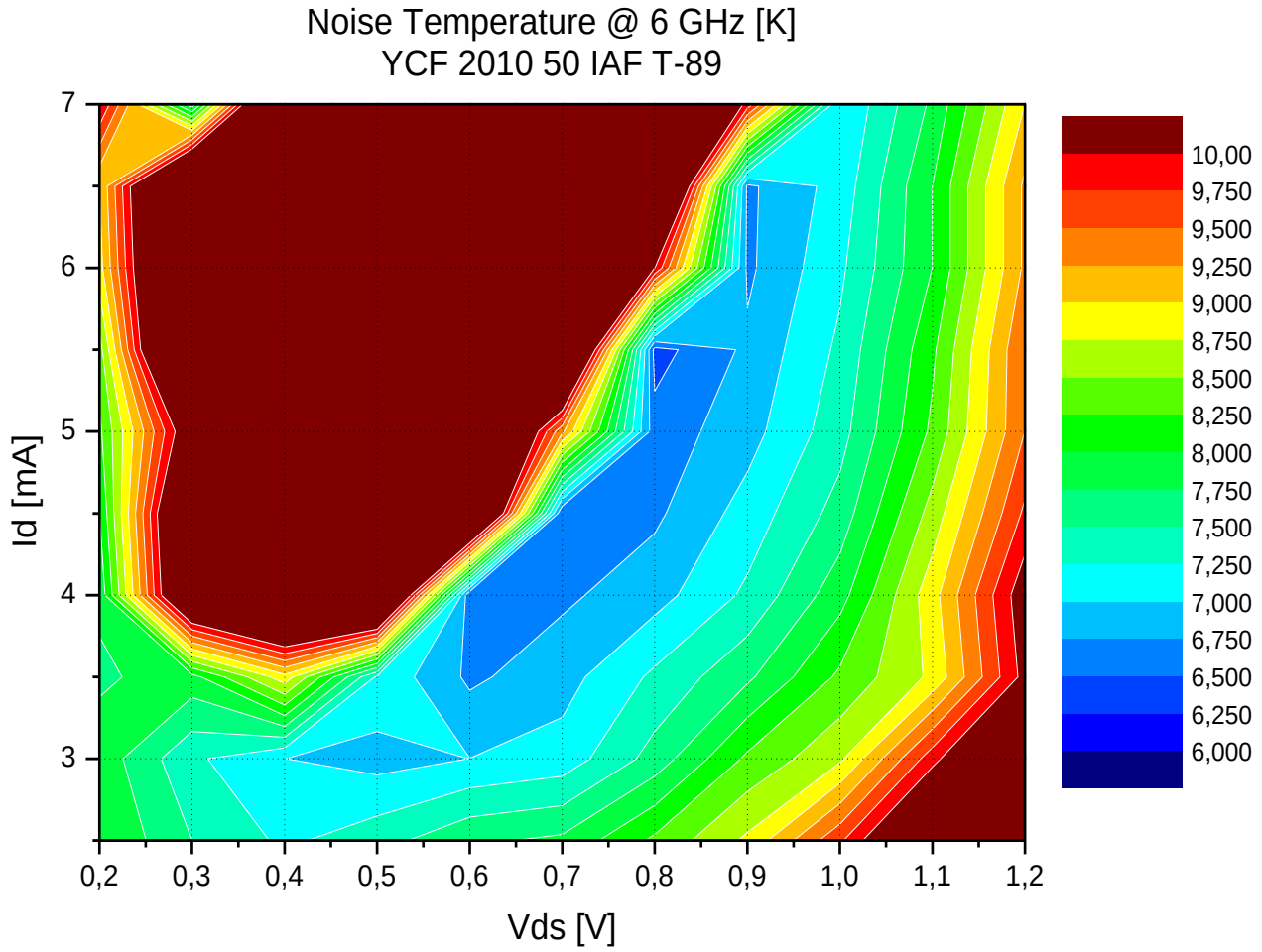
IAF devices (4-8 GHz) (III)

- The sensitivity to the illumination varies significantly between samples; variations from 0.3K to 4K have been observed when the red LED is ON. A sample (T-89) where the noise improves slightly when illuminated was found (very unusual!!!).
- In some cases, the best noise results are obtained by first illuminating the device and then switching off the illumination. However, there are devices where this procedure does not work and the results remain the same after switching off the illumination.
- There are samples where it is impossible to go back to the same situation changing the bias back to the initial point once the bias point is changed in darkness (Hysteresis). This does not happen when illuminated. Nevertheless, other similar samples does not present important hysteresis phenomenon.

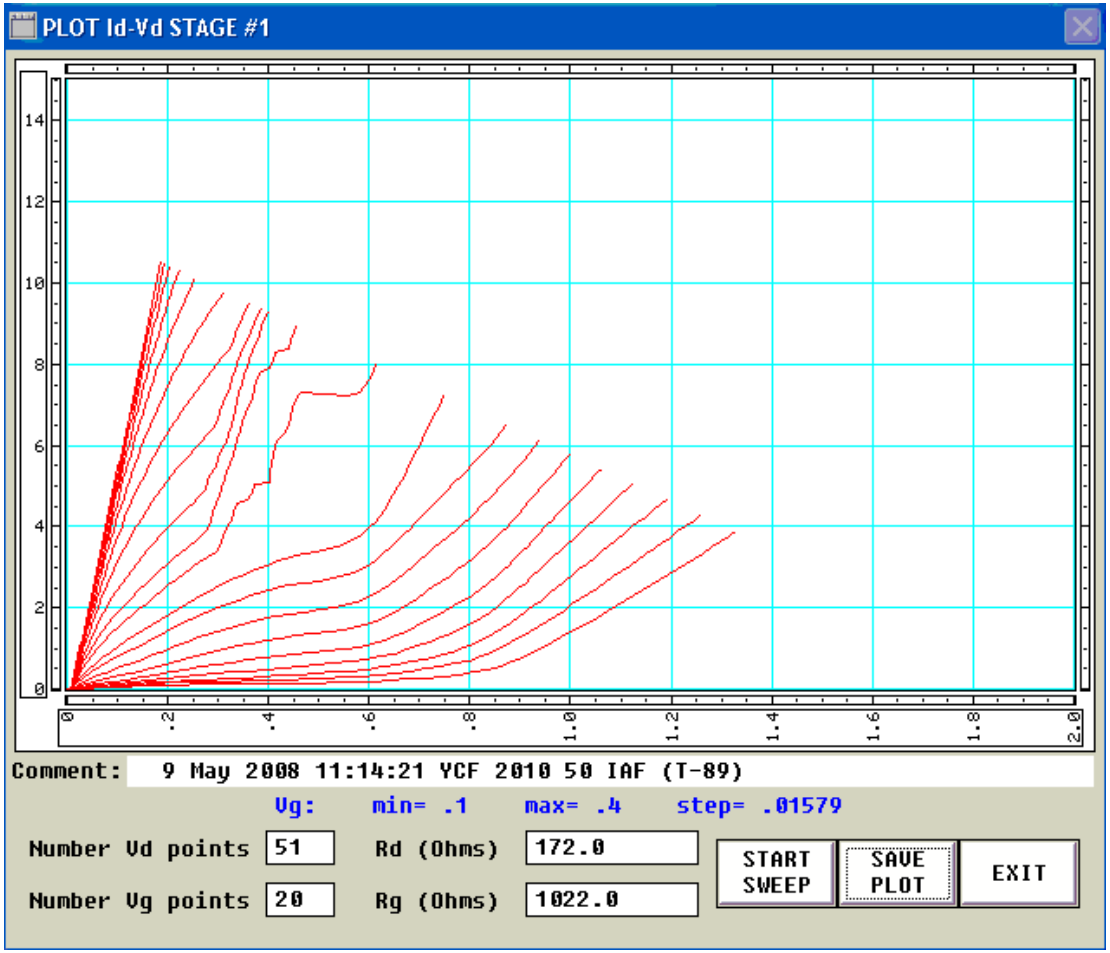
IAF devices (4-8 GHz) (IV)

- In the most of the 100nm gate length samples, oscillations for high Vds-Ids values appear at low frequency as wide band noise in the spectrum analyzer (100 MHz- 2GHz). Do not appear to be related with input or output loading impedances. However, no oscillations are detected for the 50nm gate length devices.
- Good Gain Stability results are obtained with 160x0.1μm and 160x0.05μm devices comparable to other good InP devices. The results for the 50nm gate length transistors are better than those for the 100nm devices.
- Possible power dissipation between 2 and 4 mW for low noise.

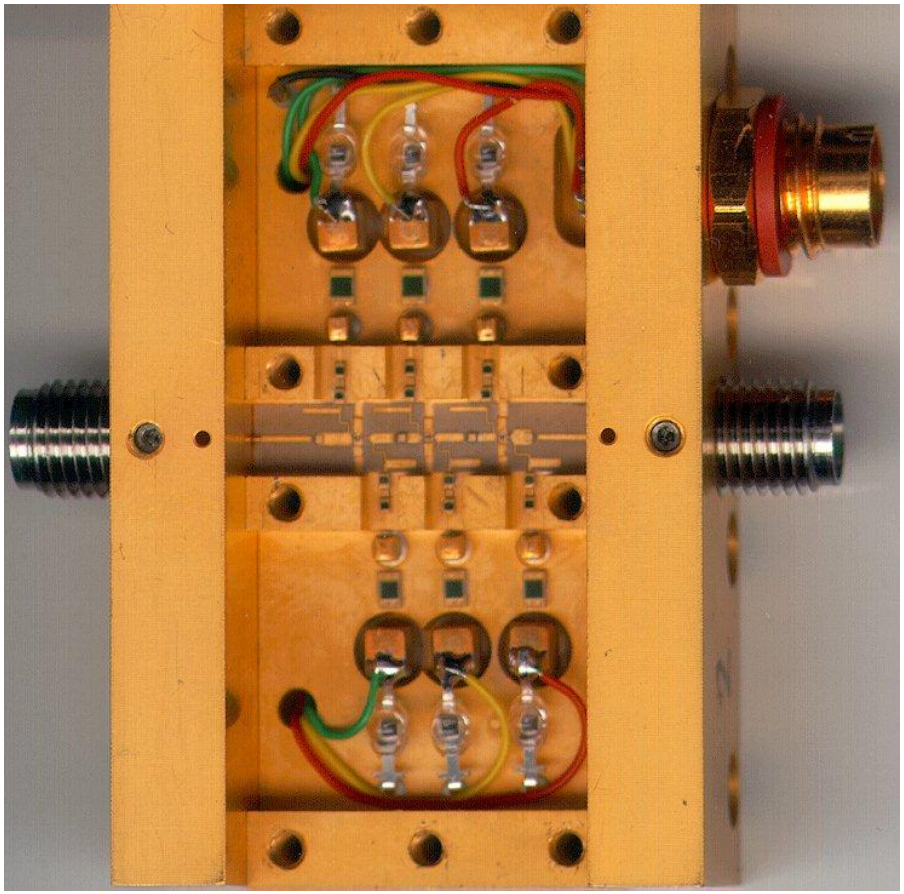
IAF devices (100nm)



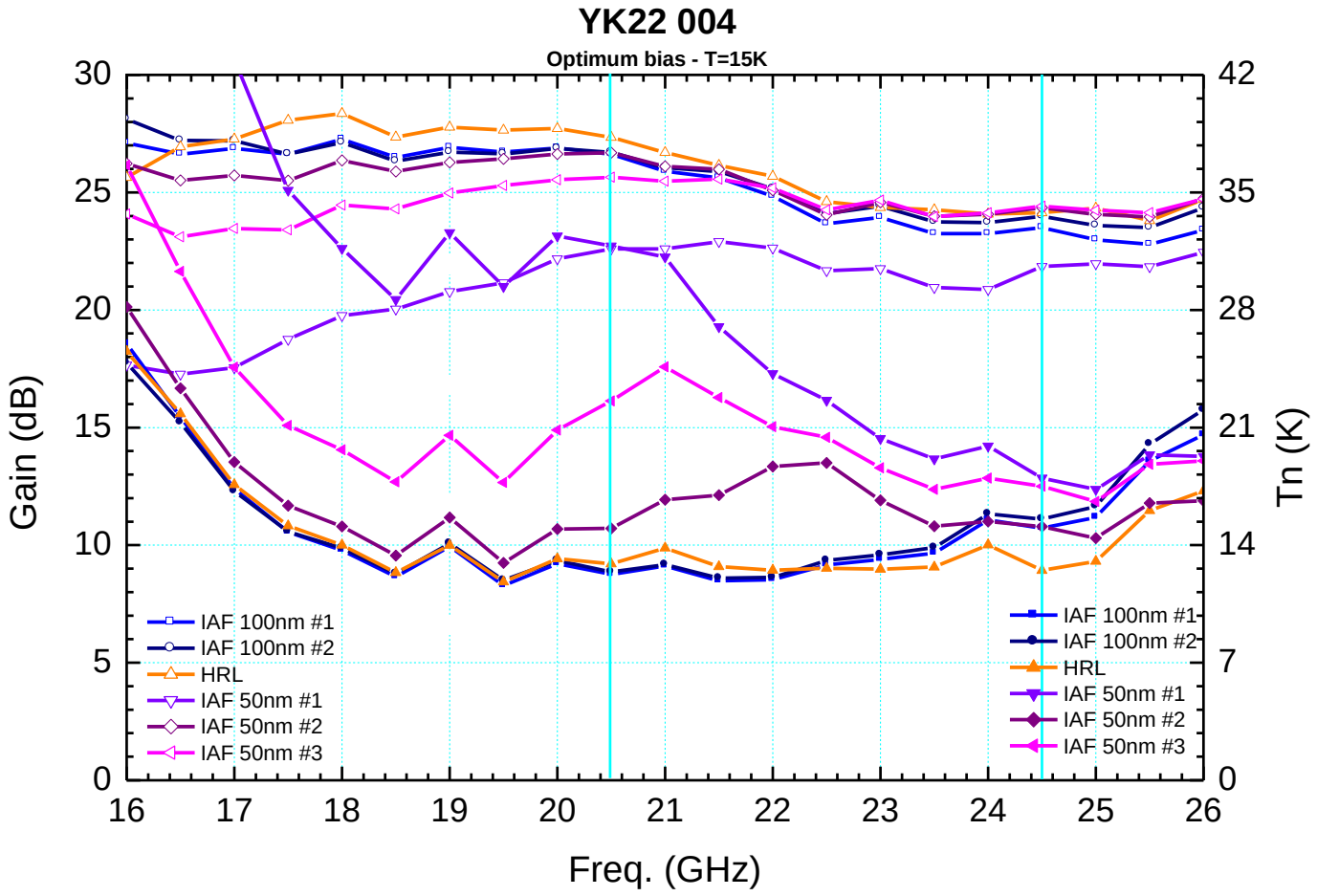
IAF devices (100nm)



K-Band (20.5-24.5 GHz) VLBI



IAF devices (20.5-24.5 GHz) (I)



IAF devices (20.5-24.5 GHz) (II)

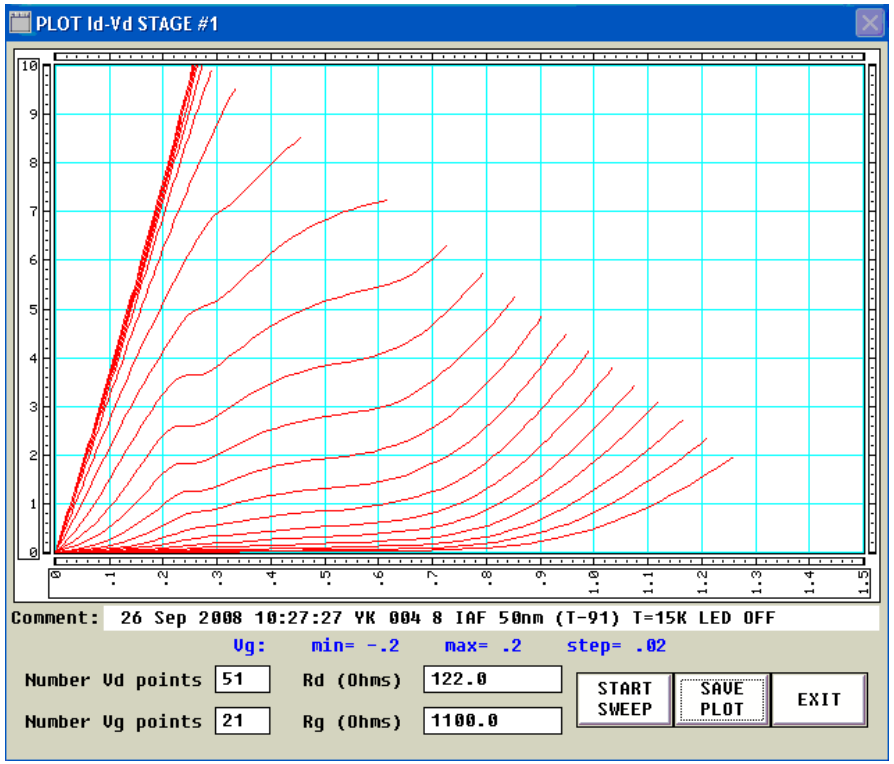
- 100 nm gate length devices:
  - Good noise results at room and cryogenic temperature comparable with results got with good InP devices (HRL). This was not the case at lower frequency (4-8 GHz).
  - No anomalies in the behavior of the transistors. No sharp discontinuities in the noise behavior with DC bias point.
  - No oscillations detected with a spectrum analyzer (0-50 GHz) at any reasonable bias.
  - The I-V plots do not present anomalous effects around the Vds and Ids values for optimum noise temperature (other than the relative frequent “kink effect”).

IAF devices (20.5-24.5 GHz) (III)

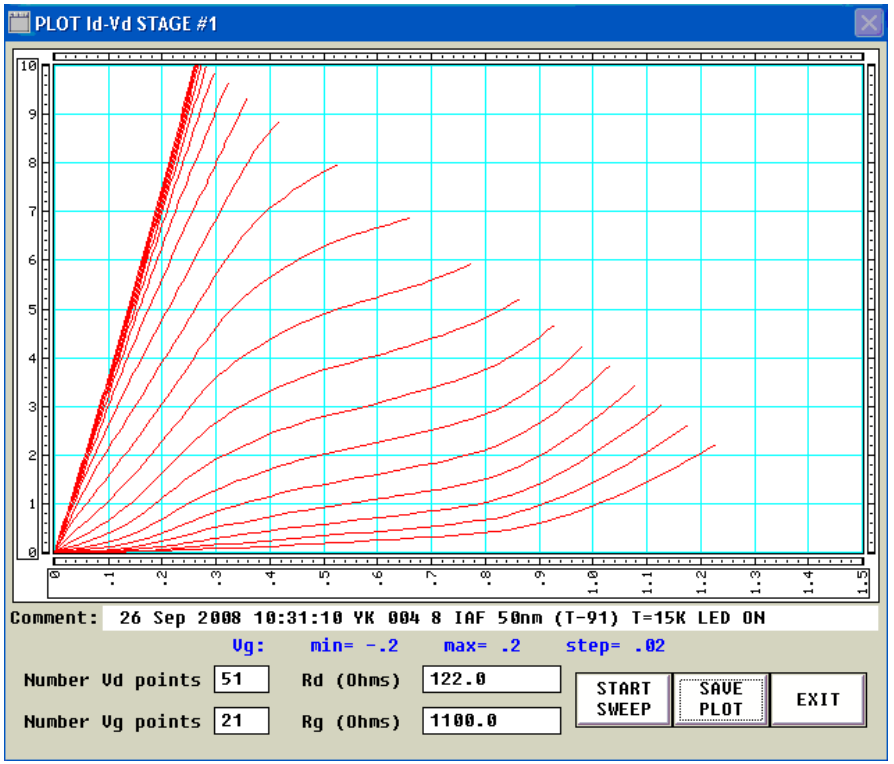
- 50 nm gate length devices:
  - Noise results at room and cryogenic temperature pretty worse than those got with the IAF 100nm gate length devices and with 150μm HRL devices.
  - No anomalies in the behavior of the transistors. No sharp discontinuities in the noise behavior with DC bias point.
  - No oscillations detected with a spectrum analyzer (0-50 GHz) at any reasonable bias.
  - The I-V plots taken without illumination of the transistors presented some “kink effect” that disappeared when the devices are illuminated.

IAF devices (20.5-24.5 GHz) (IV)

Without Illumination



With Illumination



Agreement UC-CAY-IAF

- 4 years, (mid 2008 - mid 2012)
- Investment (own funds): 260 + 120? = 380 K€

- Main goals:
  - Funding one post-doc level position for a person working at IAF
  - Improvement of Metamorphic technology for cryogenic LNAs competitive with InP
    - Discrete
    - MMIC
  - MMIC development in the 25.5-34 GHz band (ESOC K-Ka)
  - MMIC development for 4-12 GHz (ALMA-IRAM IF)
  - Other projects of interest for RA if time and funding is available