Millimeter HEMT amplifier measurements at cryogenic temperatures

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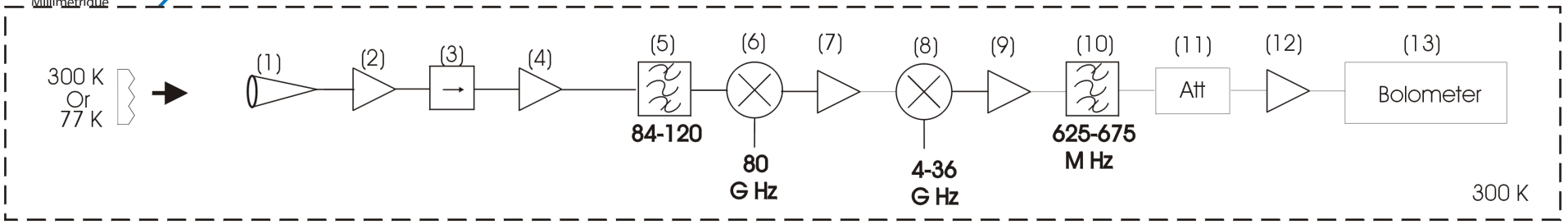
OUTLINE

- MOTIVATION:

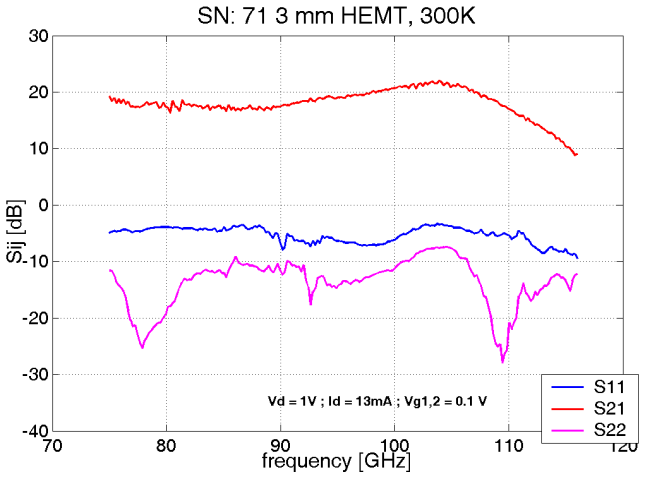
  Cryogenic mm HEMT amplifier measurements to build a 3 mm PV frontend

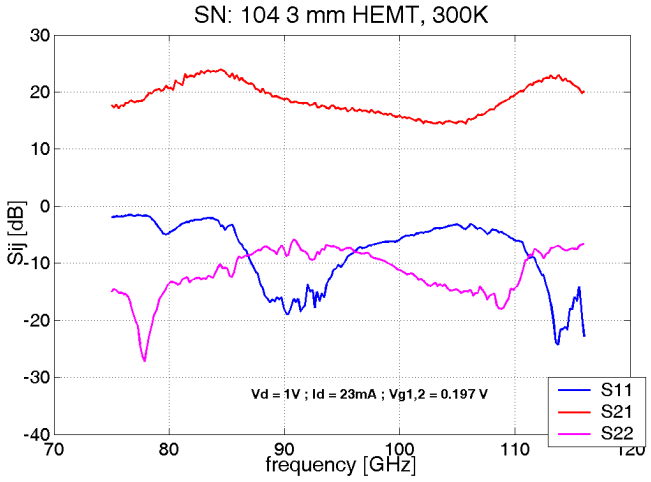
- UMass HEMT amplifiers tested in a 84-116 GHz receiver built with 32 GHz IF band [4-36 GHz]
  - HEMT $|Sij|^2$, Receiver gain and noise temperature at 300K and at 4K
  - Receiver stability & saturation
- UMass HEMT amplifiers tested in a 84-116 GHz receiver built with 8 GHz IF band [4-12 GHz]
  - Measurement setup (HPF, coupler and mixer responses at 300K)
  - Receiver noise temperature at 4 K and noise in the 4-12 GHz IF band
  - Receiver stability
- CONCLUSION

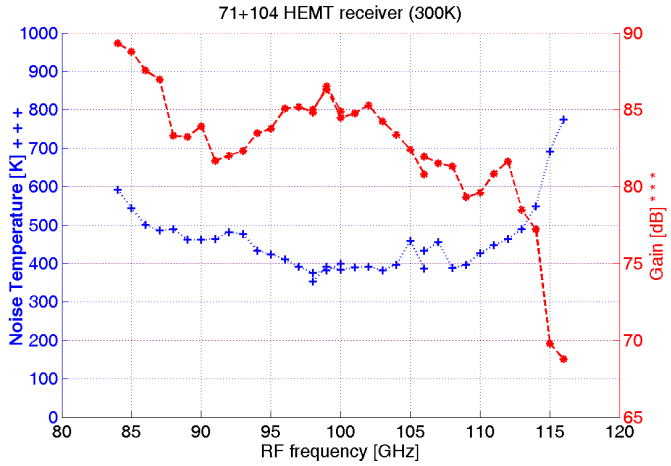
84-116 GHz Receiver-32 GHz IF band [4-36 GHz]at 300K



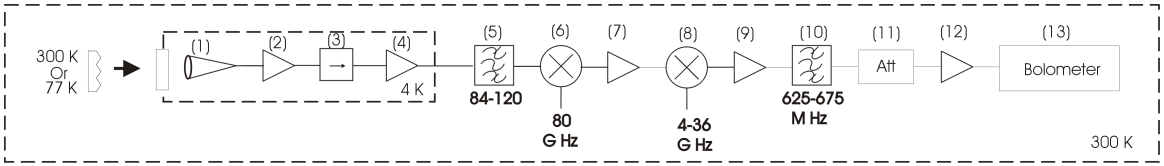
(1) : (ref 71, IRAM) Corrugated horn
(2) : (ref 71, Umass) 3 mm HEMT amplifier
(3) : (ref 213, millitech) cryogenic isolator
(4) : (ref 104, Umass) 3 mm HEMT amplifier
(5) : (ref 486, IRAM) 84-120 Band pass filter
(6) : (ref 6654, Farran) 80-116 GHz DSB mixer
(7) : (ref 2,IRAM)16 dB 2-40 G Hz IF amplifier.
(8) : (ref TBL0440LW1R,miteq) 4-40 G Hz DSB mixer.
(9) : (ref15542,minicircuit) 1GHz 25 dB IF amplifier.
(10) : (ref 16A62-01,FILTEX) 667 M Hz band-pass filter.
(11) :SMA 10 dB attenuator.
(12) : (ref15542,minicircuit) 1GHz 25 dB IF amplifier.
(13) : (ref E9300A, Agilent) bolometer.







84-116 GHz Receiver-32 GHz IF band [4-36 GHz] at 4K



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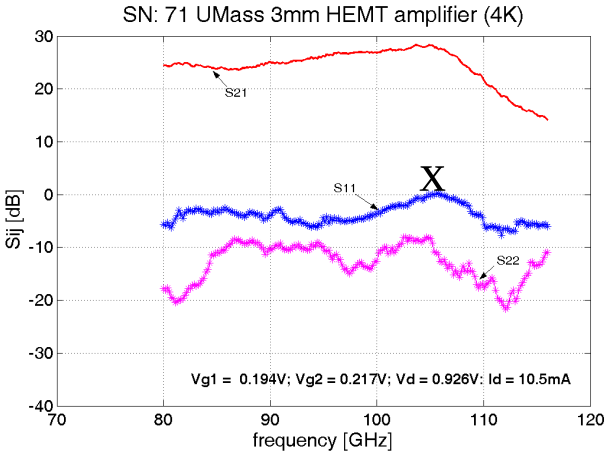
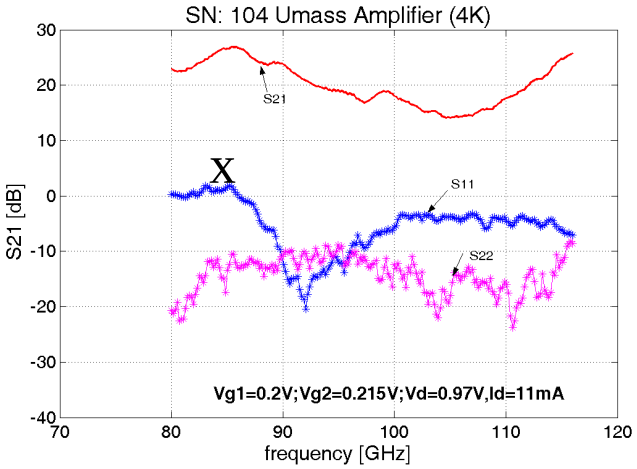
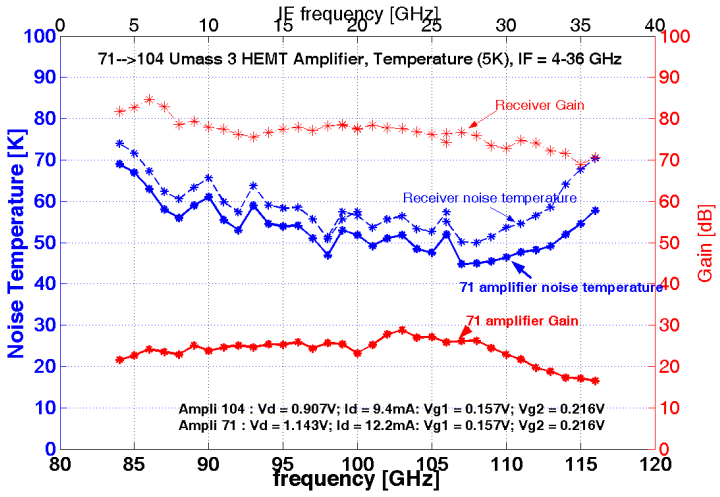
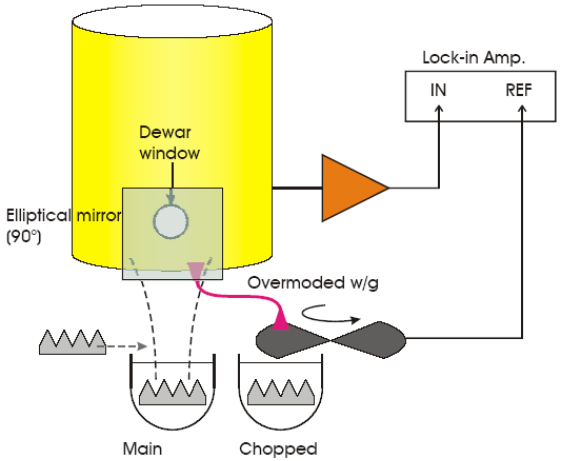






Receiver stability & saturation

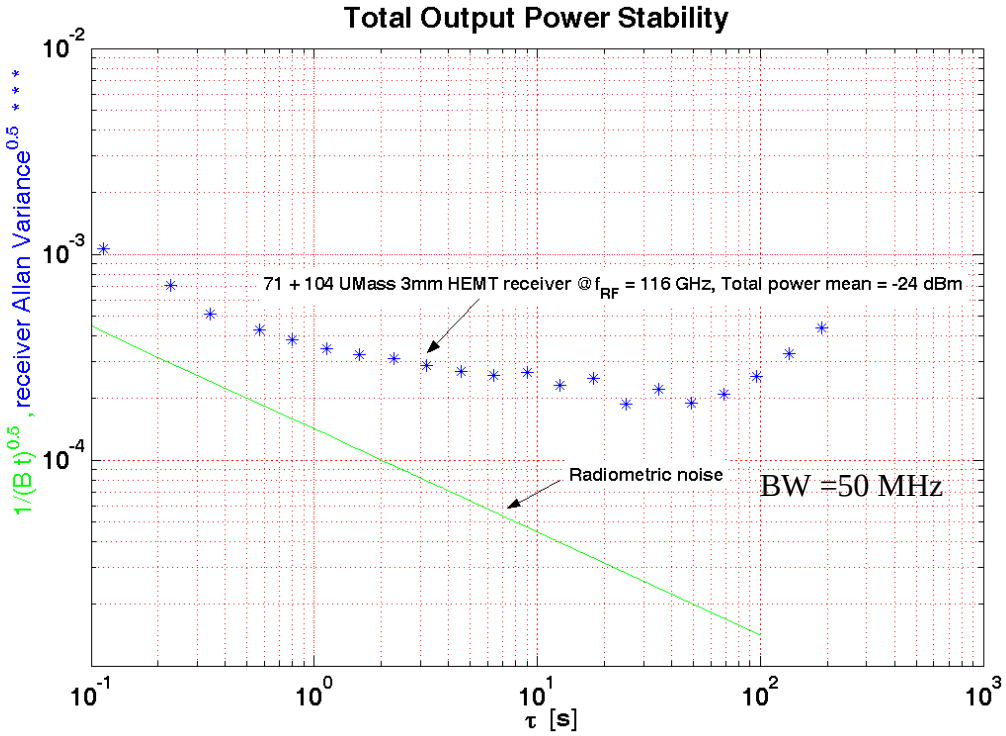


$$gc_{ls} = \frac{1}{2} gc_{diff} = \frac{1}{2} \frac{V_C - V_H}{V_C} \frac{P_H - P_C}{P_H - P'_C}$$

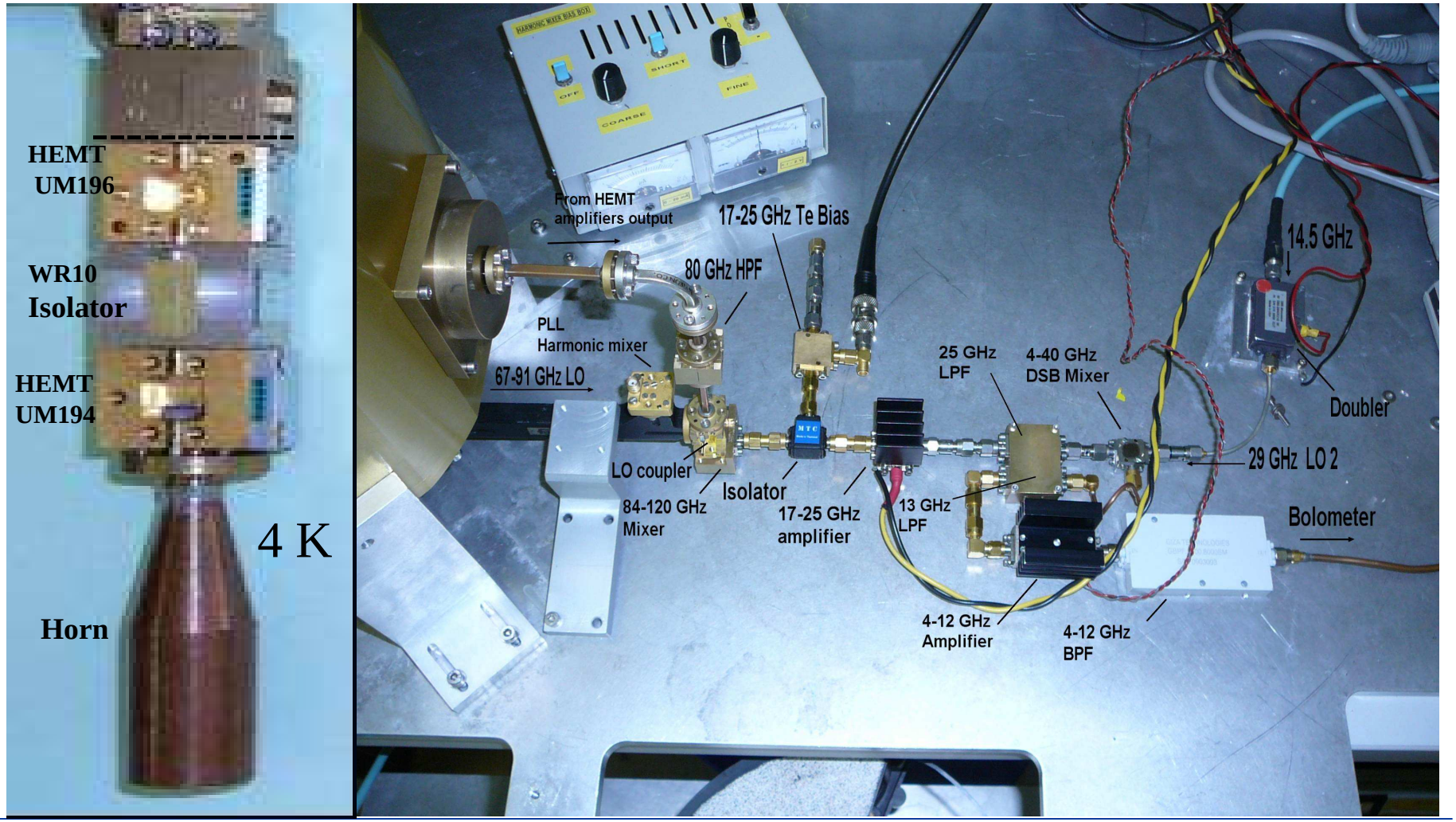
$$\mathrm{var}(\tau) = \frac{1}{2 \cdot (m-1)} \sum_{k=1}^{m-1} (y_{k+1} - y_k)^2 \qquad y_k = \frac{1}{\tau} \int_{t_k}^{t_k+\tau} y(t) \cdot dt$$

$$y(t) = \frac{\delta V}{Vmean}$$

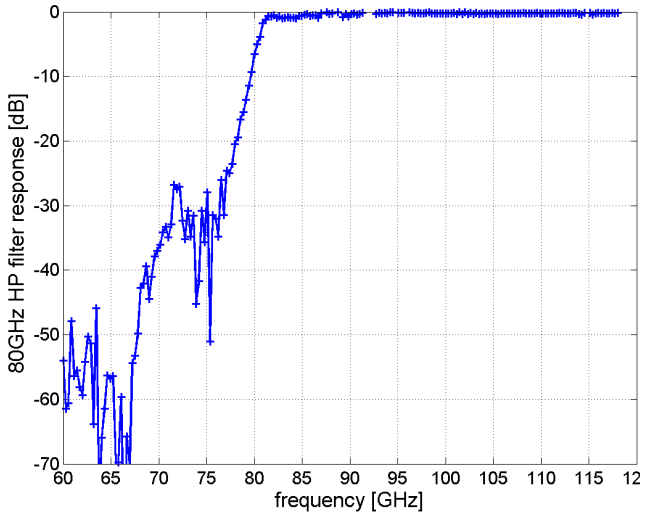
Fequency	Saturation
85 GHz	1 %
86 GHz	2.5 %
87 GHz	1 %
100 GHz	< 0.5 %
116 GHz	< 0.5 %

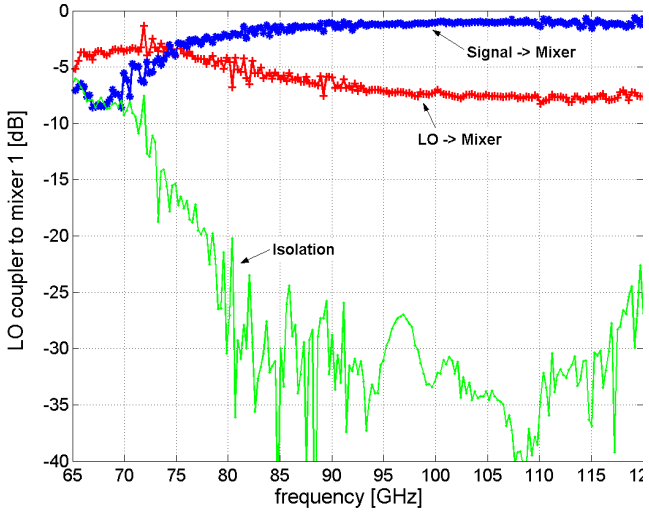


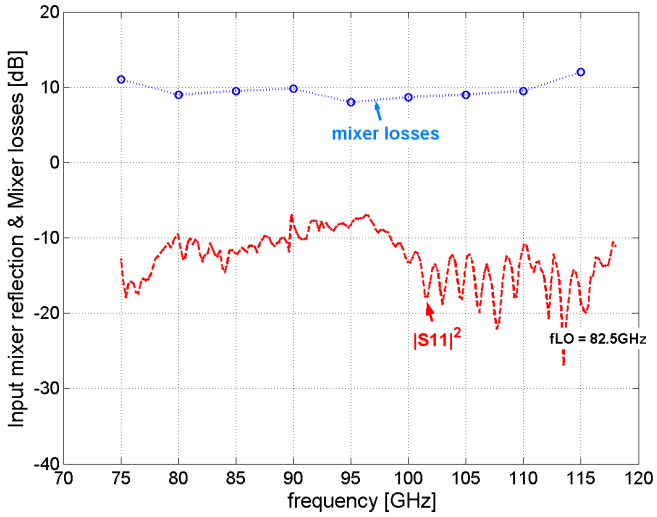
84-116 GHz receiver- 8 GHz IF band [4-12 GHz] setup at 4 K

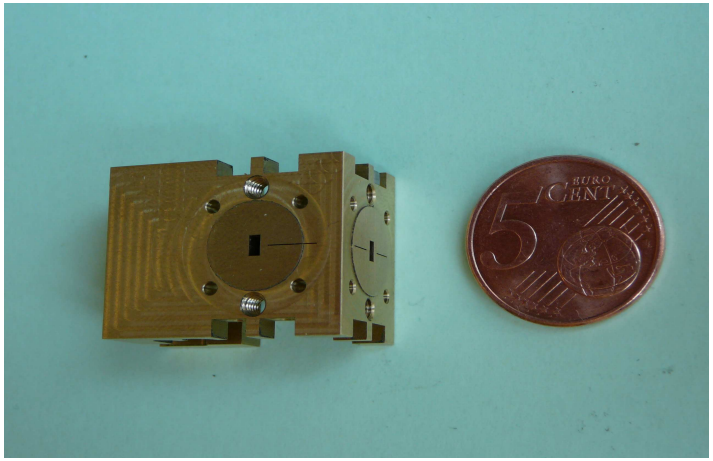


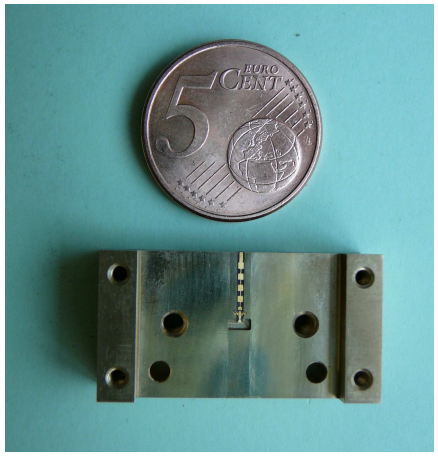
Filter, coupler and mixer responses at 300K



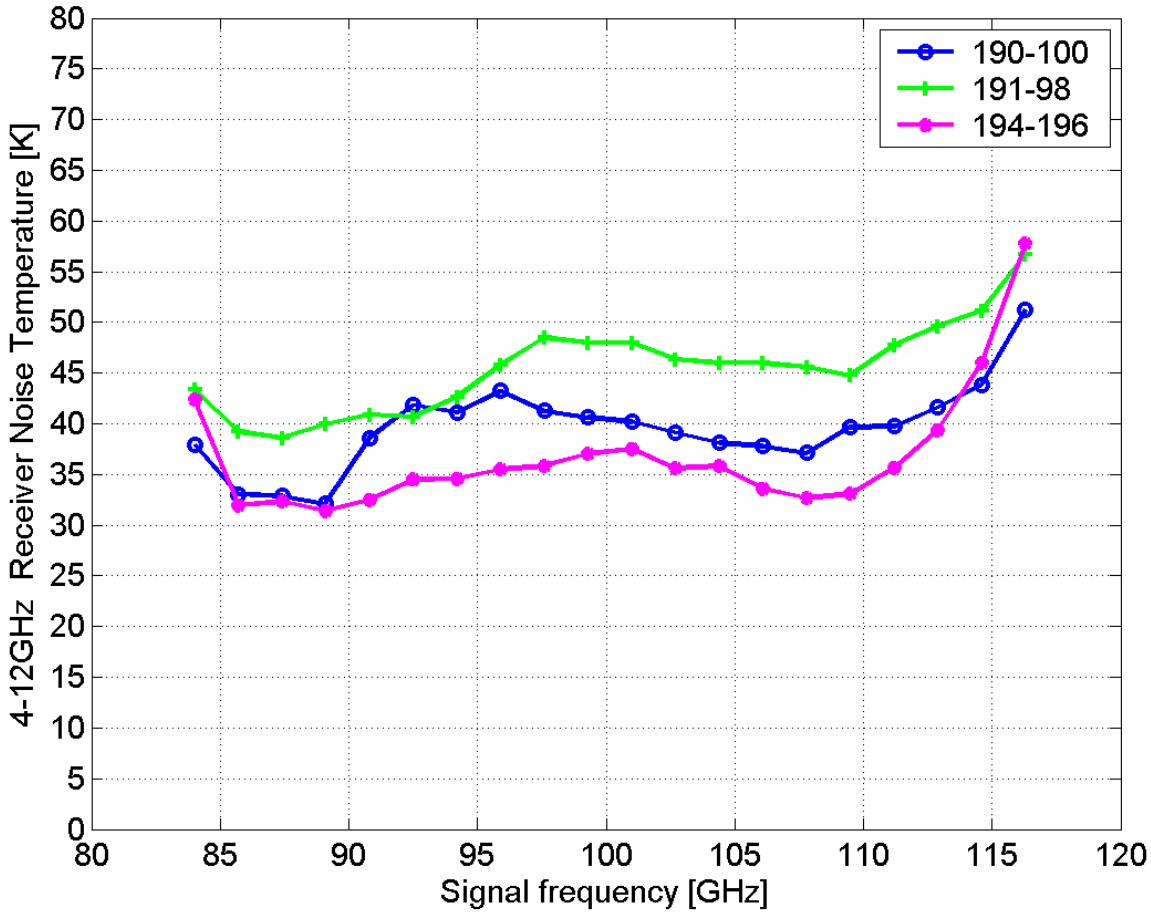




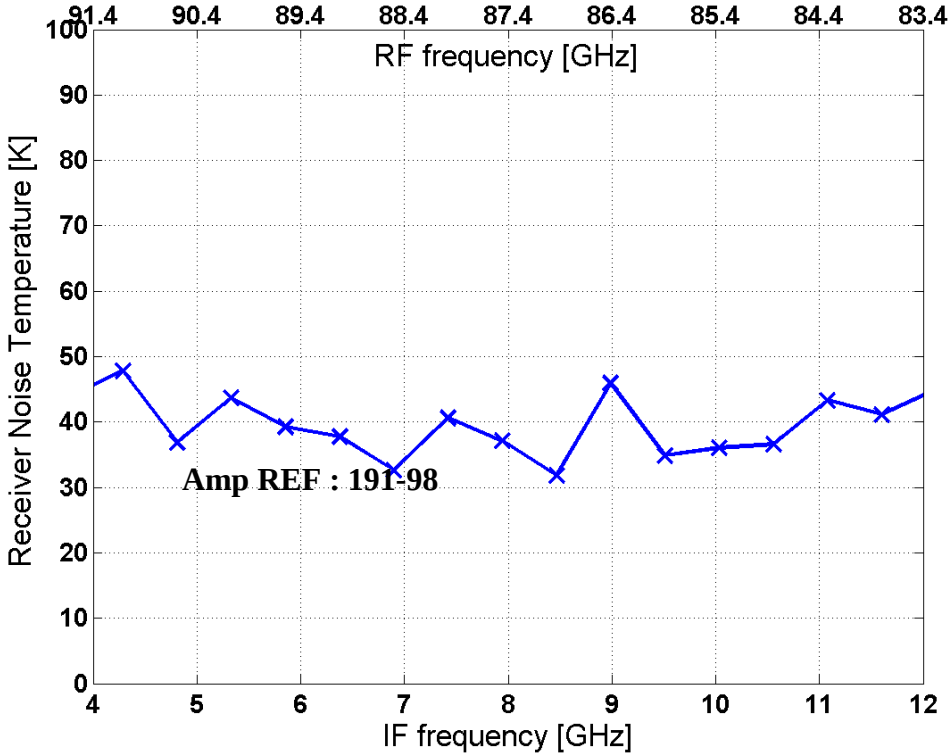


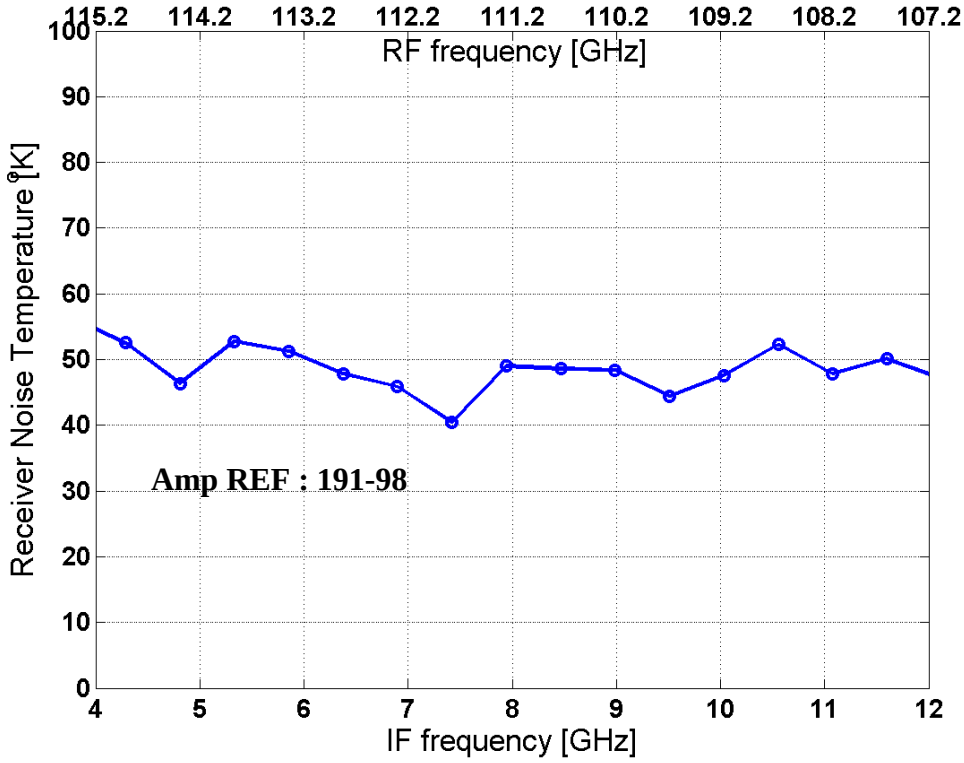


Receiver noise temperature at 4K



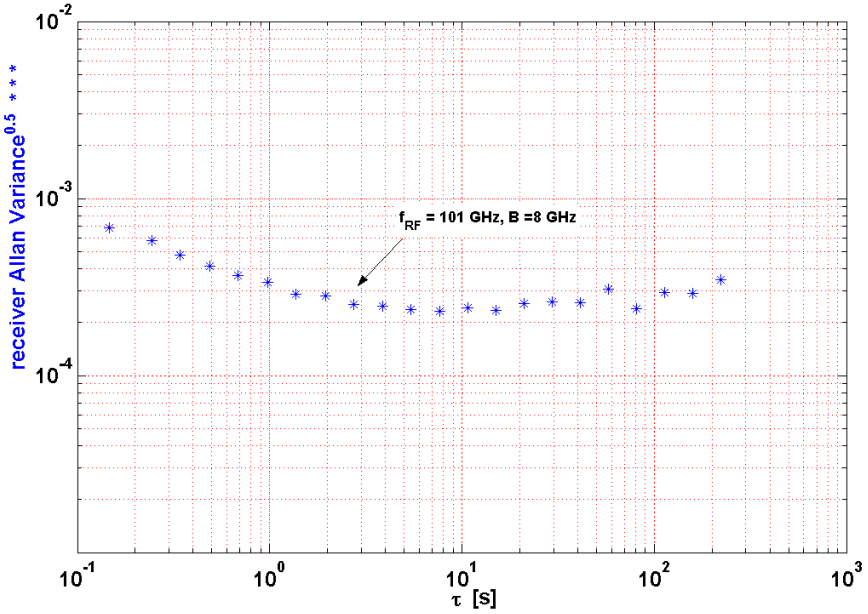
4-12 GHz IF band noise temperatures



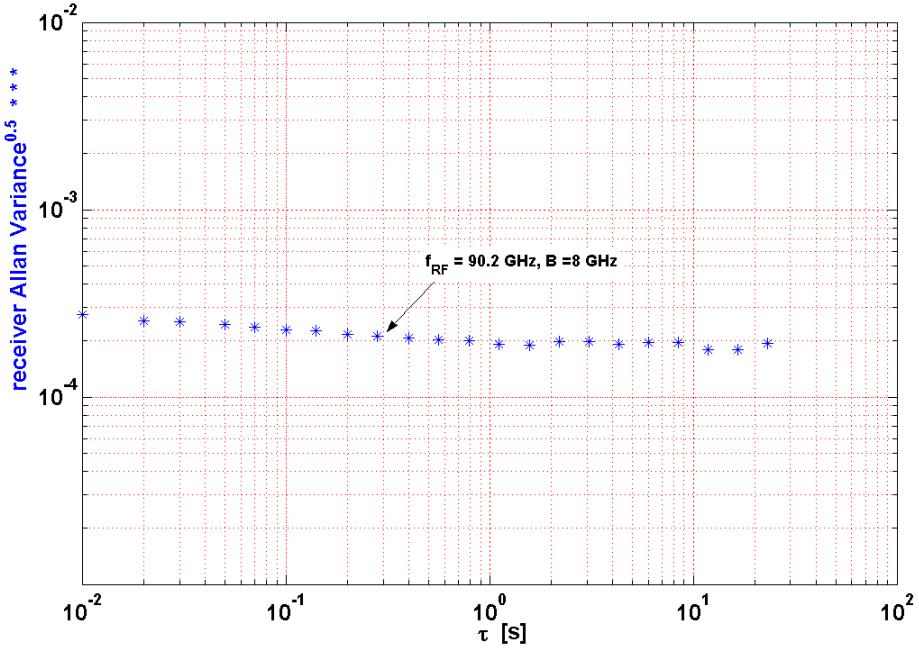


Total power stability measurements

Noisy bias power supply



Low noise bias power supply



Conclusions

- Receiver performances:

  - SSB receiver noise < 50K, 84-116 RF, 4-12 IF.
  - Amplitude stability < $3x10^{-4}$ ($1s<\tau<100s$).
  - Gain compression < 2.5 % (32 GHz IF Band)
  - UMass [190-100;194-196] amplifier pairs will be used in the 3mm PV receiver prototype for both polarisations
  - Test set compatibility for other millimeter MMIC technologies