Eaton 2075a versus HP 8970a gain / noise analyser hint & kinks

Eaton 275a and HP/ Agilent 8970a noise/gain analyser

The 4 parts described

- Part 1 : measurements without external mixer
- Part 2 : measures from 2 to 26 GHz with external extensions - - - and « low-cost » ham solution
- Part 3 : 1.8 – 26 GHz Eaton MT7552b extension analysis (reverse engineering)
- Part 4 : 2 – 18 GHz Agilent / HP 8971b NF test-set extension (to be done)

Parts 1 - 2 - 3 are already on the site de F6KMX site at the following page:

http://f8buu.free.fr/index.php?option=com_wrapper&Itemid=51

PART 1

MEASURES done WITHOUT OUTSIDE MIXER

Overview

- Before year 2004, all gain and noise measurements in the industry world were principally done with these 2 noise/gain analysers models
- It is now more easy to find them on the refurbished marked.
- This Powerpoint is illustrating hits and kinks about both Eaton 2075a and HP or Agilent 8970a analysers.

Abstract

1- Eaton 2075a memory backup repairing

2- Specs differences

3- Warm-up time effect and Nf precision measures

4- +28V noise source drive aspect

5- ENR source transformation down to 5 dB : 3 examples

6- Unknown noise source calibration

7- Cautions to take with Nf measurement accuraty with scale <1 dB

8- 144 to 1296 MHz masthead preamps measures

9- Conclusions

1- Eaton 2075a memory backup repairing

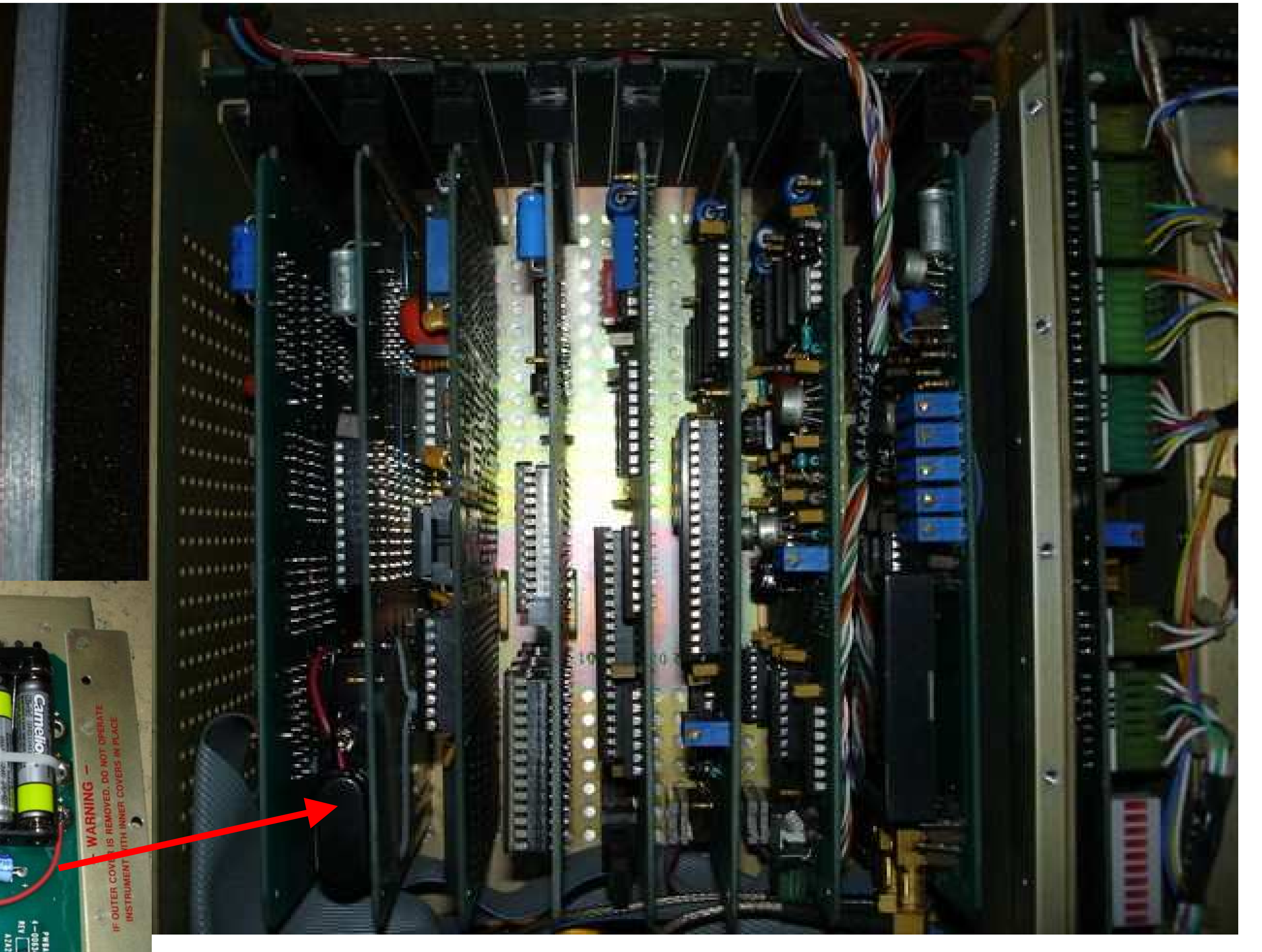
Eaton 2075a memory backup repairing

After upside cover removing

Memory backup printboard
Eaton version with 3 x 1.2V NiCd cells (dead)

Eaton 2075a memory backup repairing

Replacement of the 3 NiCd cells



Firmware SU-6 (obtained with SP 8.1)

2- Rapid differences overview

Rapid specs differences

Measure frequencies

	Eaton 2075a	HP 8970a
Band (MHz)	10 - 1900	10 - 1500
ENR mem table	1 fixed and 3 custom	1 custom only
ENR values	Up to 25 dB	<16 dB

- Only the HP 8970b is able to do measures at frequencies >1500 MHz with the HP 8971b or c NF test-set and an HP 8350b sweep with adequate RF plugin
- The Eaton 2075 has up to 4 different ENR memories, plus an « ENR all table » for rapid measurements (also adjustable)
- For Nf measures <1 dB, the dedicated ENR of the noise diode must be manually entered at every frequency

3- The warm-up time effect

Warm-up time and precision of measurement

Warm-up time for getting good stability of 0.00 +-0.1 dB Gain/Nf after calibration

	Eaton 2075a	**Eaton 2075b**	**HP 8970a**
<1000 MHz	¼ hour to 20 minutes	<5 minutes	10 minutes to ¼ hour
1100 to 1500 MHz	½ to 3/4 hour	<5 minutes	20 minutes to ½ hour
1600 to 1800 MHz	>1 hour	10 minutes	
1900 MHz	1 ½ hour	1/4 hour	
2050 MHz		½ hour	

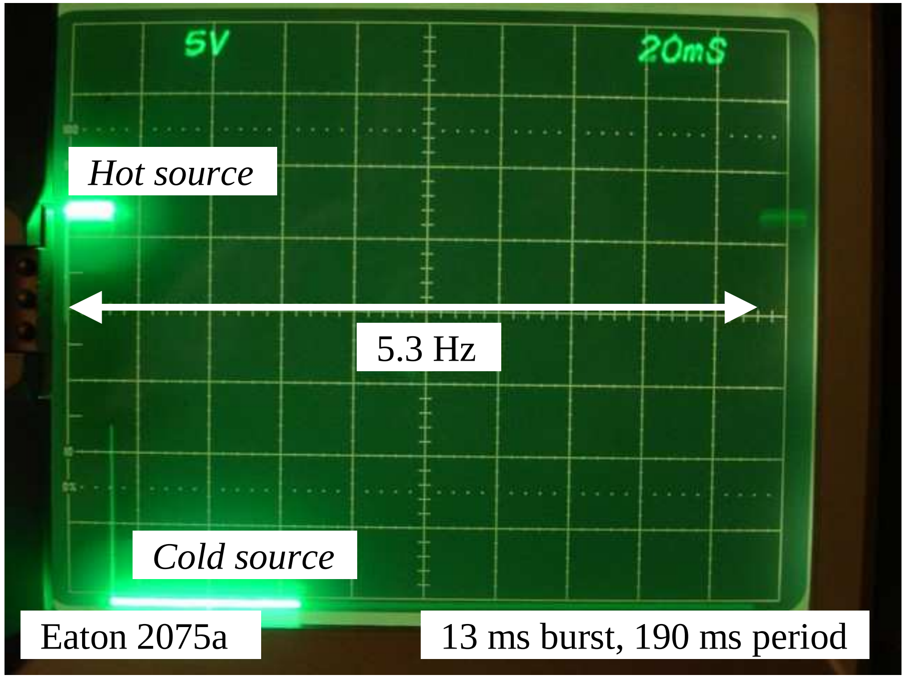
- Eaton 2075A : the gain (principally Nf) calibration zero stability at frequencies over 1600 MHz takes often more than and hour !!!!
NF calibration at 1.9 GHz highest point doesn't remain stable with the time.

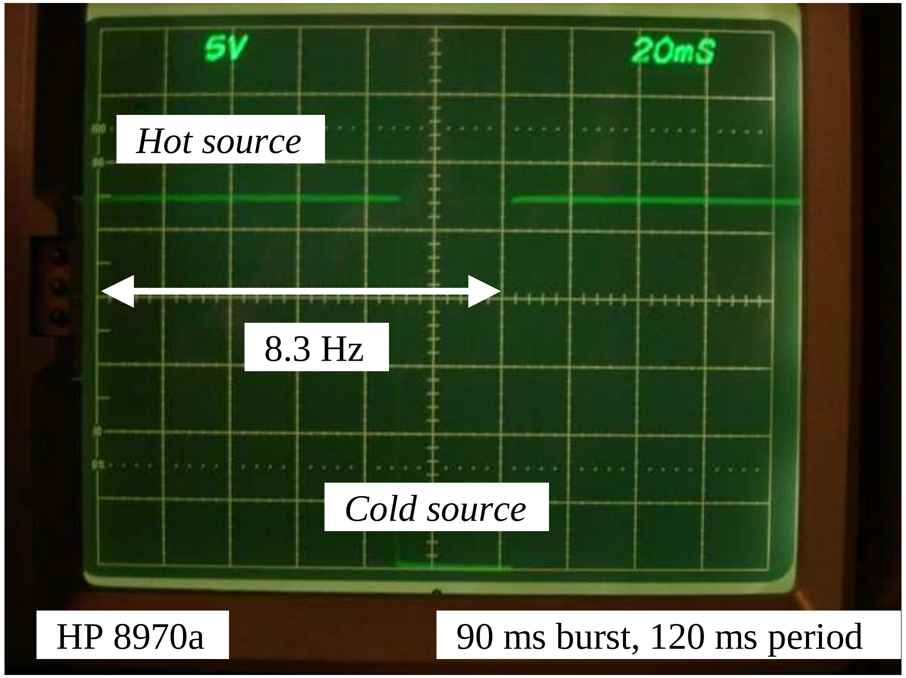
- **Eaton 2075B** : great improve in stability over 1.6 GHz and far less warm-up time.
But again same zero NF stablity problem at 2 GHz than on the A version above 1.8 GHz (with less errors)

- Up to 1500 MHz the HP warm-up time is slower
- Models HP 8970b or Eaton 2075b and up have far better warm-up times.
- I really insist : the **precision meas** at highest frequencies with NF<1 dB really **depends** of the **warm-up time**

4- The +28V noise source feeding

+28V noise source drive output aspect





5- ENR transformation down to 5 dB

15 to 5 dB ENR noise source transformation

Target :

- getting a 5 dB ENR diode with an original 15 dB one

- internal noise source attenuator repairing after a letal DC overload

Adding a 10 dB attenuator between ENR source and device under test gives far better isolation between noise source and device under test and so, far better Nf meas precision.

Operation mode :

- Take a 10 dB (N) attenuator with same bandpassing
- Measure its exact attenuation value at every wanted frequency corresponding to the initial ENR table with a scalar analyser.
- Finally substract every value to the original ENR table one at each frequency and write a new one.

These given examples are given as illustrating way:

- An original 25 dB ENR diode can be slowed down to 15 or even 5 dB ENR (with 10 or 20 dB attenuator)
- Every 15 dB ENR source can be transformed to a 5 dB ENR one
- After a DC overload on its RF output, the internal attenuator can directly be substituted by a higher one, in order getting directly a 10 dB lower ENR than the original value

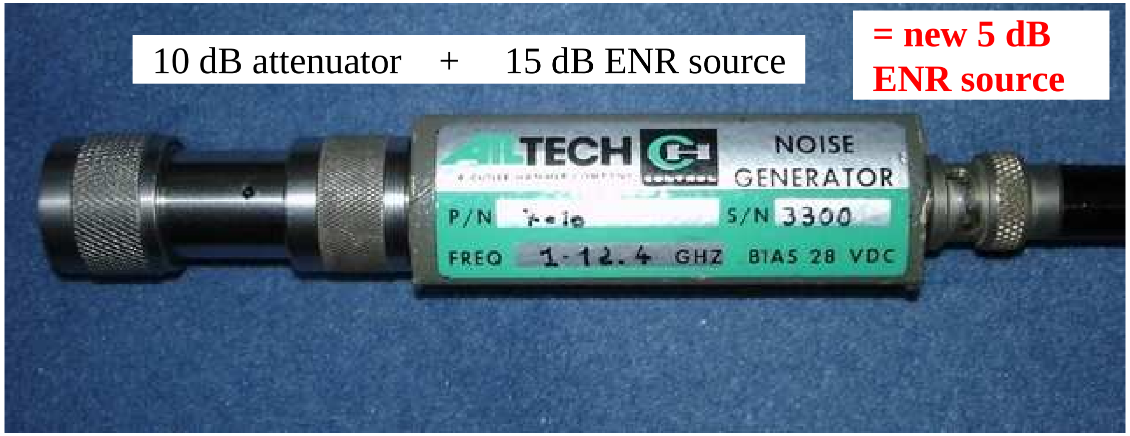
This procedure avoids the buying of an expansive 6 dB ENR source like the HP-346a and gives exactly the same results !

15 to 5 dB ENR noise source transformation

Example 1

10 dB attenuator + 15 dB ENR source

= new 5 dB ENR source

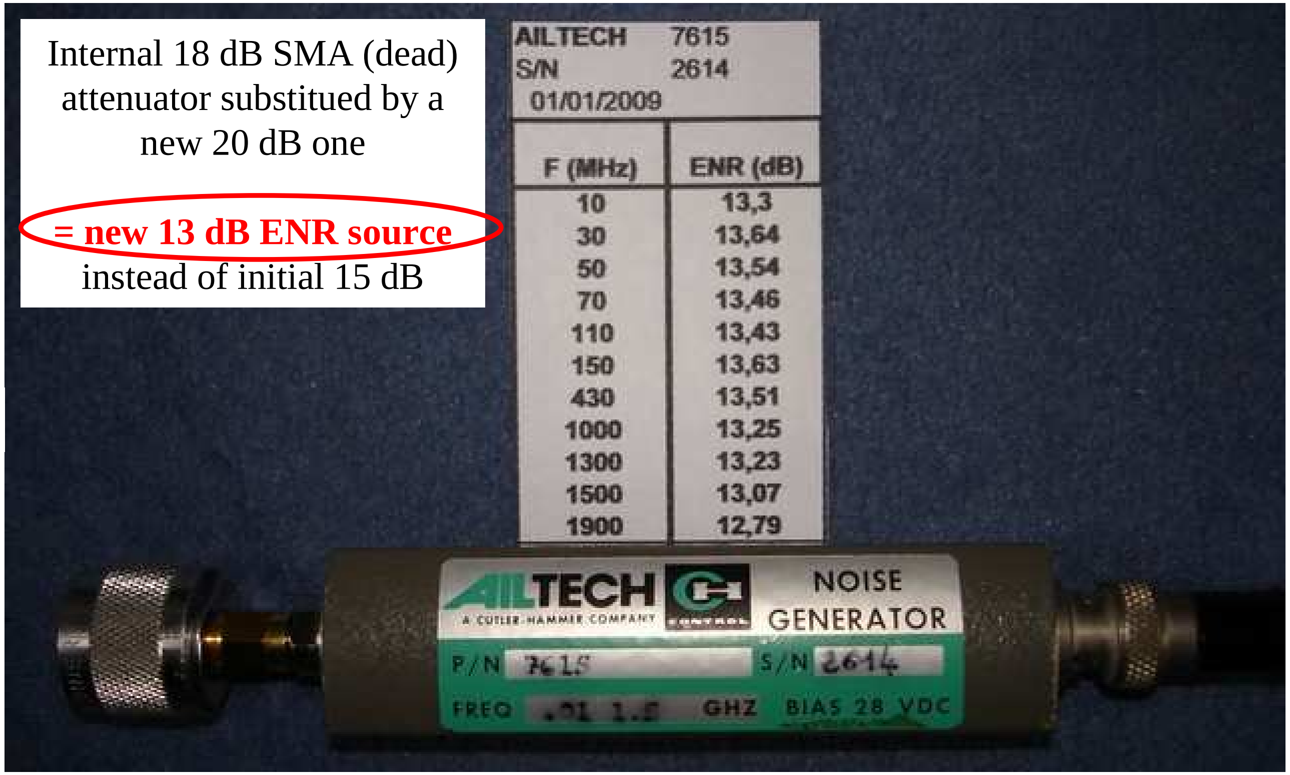


Example 2

Internal 18 dB SMA (dead) attenuator substitued by a new 20 dB one

= new 13 dB ENR source

instead of initial 15 dB



15 to 5 dB ENR noise source transformation

Example 3 : MSC noise source ENR = roughly 25 dB with no dedicated ENR table !

a/ Adding a 10 dB attenuator'll roughly give a 15 dB ENR ensemble.
So its exact ENR can be easy calculated from the ENR of a reference noise source at same frequencies.
But the exact attenuator value must be measured precisely at every ENR frequency point (scalar analyser)

15 to 5 dB ENR noise source transformation

b/ At every frequency, a comparaison with a well known noise source gives the error to add

	HP 346b		MS 65230		
	2614A07146		S/N 4173		
F (MHz)	ENR HP	Attén 10 dB HQM Radiall	Nf lu (dB)	ENR corr (dB)	ENR corr + 10 dB (dB)
10	15,15	9,74	0,7	24,19	14,45
30	15,14	9,74	-0,5	25,38	15,64
50	15,14	9,74	0,05	24,83	15,09
70	15,14	9,74	-0,1	24,98	15,24
110	15,13	9,75	-0,2	25,08	15,33
150	15,13	9,76	-0,4	25,29	15,53
430	15,13	9,78	-0,6	25,51	15,73
1000	15,13	9,79	-0,6	25,52	15,73
1300	15,08	9,81	-0,5	25,39	15,58
1500	15,04	9,83	-0,43	25,3	15,47
1900	14,94	9,74	2,6	22,08	12,34
			avec atten	diode	diode+ atten
			10 dB	seule	10 dB

	MS 65230	
	S/N 4173	
Attén 20 dB Yoann	Nf lu (dB)	ENR corr + 20 dB (dB)
19,88	10,7	4,45
19,88	8,25	6,89
19,88	10,15	4,99
19,9	10,02	5,12
19,9	9,9	5,23
19,92	9,6	5,53
19,97	9,5	5,63
20	9,55	5,58
20,01	9,5	5,58
20,03	9,5	5,54
19,92	9,4	5,54
diode+ atten	diode+ atten	diode+ atten
20 dB	20 dB	20 dB

Initial HP 346b ENR table

Attenuator precisely measured

Error measured on Nf

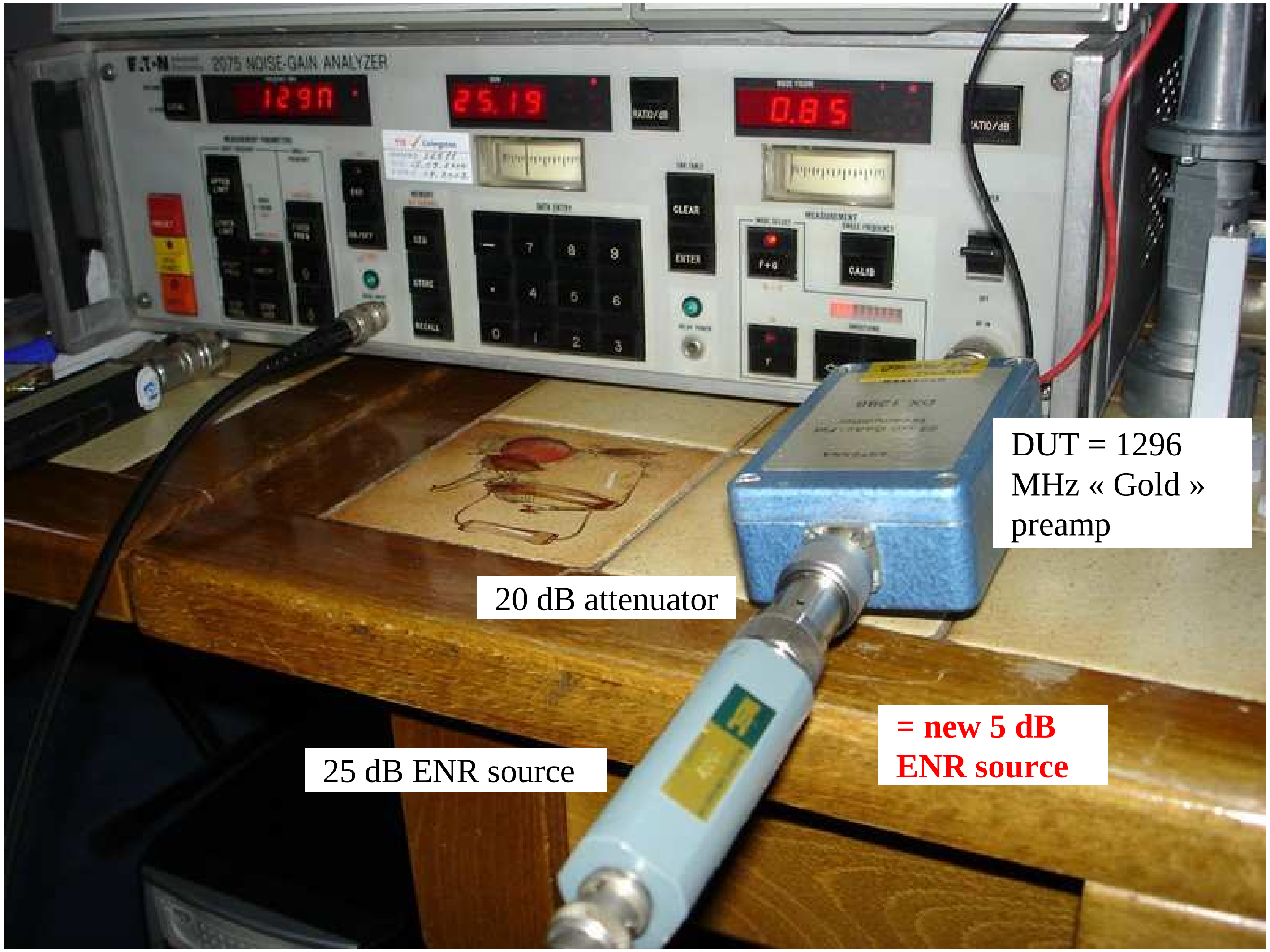
Original 25 dB ENR table of alone MSC noise source restituted

15 dB ENR table of MSC noise source + dedicated 10 dB attenuator

5 dB ENR table of MSC noise source + other dedicated 20 dB attenuator

15 to 5 dB ENR noise source transformation

c/ Gain/Nf test proofs on a « gold » DUT, after new ENR table memory entering + calibrating



6- Calibration of an unknown ENR noise source

Unknown noise source calibration

Target :

- ENR calibration at YOUR dedicated frequencies for best noise meas precision

- Best precision achieved with both sources of roughly same ENR value

Operation mode :

Take absolutely care of the followings:

- Enter carefully in the analyser the « gold » source ENR table
- respect a warm-up time as **long as possible** (one hour) - - the key to precision key lays there !!!!!!!
- Calibrate the reference « Gold » ENR source at your dedicated frequencies
- Get **0.00 dB** on gain & Nf calibration as **stable as possible** !
- **Verify your zeroiing gain / Nf calibration** by waiting up to 5 or 10 subsidial minutes !

- Substitute the « gold » source by your new ENR source of same ENR range
- At every dedicated frequency, substract the noise measured value from the ENR « gold » original table value - - a simple way is to do this in an Excel table at every wanted frequency.
- (With a negative noise measure, addt it)

- Now you have written a **new ENR dedicated table at your favourite frequencies**.

Unknown noise source calibration

Example :

a/ « Gold » noise source : good and stable calibration stability after min 1/2 hour

- Enter the « Gold » ENR in its inside analyser ENR table memory
- Assume a value of 15.2 ENR at 1000 and 1500 MHz as example
- verify by waiting 5 minutes more stand-by !!!

b/ Unknown noise source at same frequency:

- Substract (0.27+0.1)/2 = 0.18 to the « gold » ENR
- That gives 15.2 – (0.18 algebric value) =**15.02** dB - new ENR value at 1200 MHz

NB:
- If absolute values of gain and Nf at one frequency aren't exactly the same (as far as 0.5 to 0.8 dB), calculate the rapid « proportional middle » between both values, then substract it from the original « Gold » ENR table value
- If the « Gold » ENR is 15.0 à 1000 MHz and 15.3 à 1500 MHz, take the middle value of 15.15 at 1300 MHz
- The SP 13.1 function of the Eaton gives the middle ENR value between 2 ENR values in memory

Unknown noise source calibration

c/ Measures reported on an Excel table:

Sources de bruit : calibration par comparaison d'ENR

01/01/2009

Analyseur gain/bruit EATON 2075a Fmax =1900 MHz

SP 13,1 moyennage d'ENR entre 2 fréquences

Gold source

	F6DPH REF diode HP 346b 2614A07146	Eaton 7616 S/N 3710		Eaton 7616 courte S/N 3300		Eaton 7615 S/N 2614		F6AJW Ailtech 7615 courte S/N 1933		F6AJW Ailtech 7616 S/N 8167	
F (MHz)	**ENR HP**	**Nf lu (dB)**	**ENR corr (dB)**	**Nf lu (dB)**	**ENR corr (dB)**	**Nf lu (dB)**	**ENR corr (dB)**	**Nf lu (dB)**	**ENR corr (dB)**	**Nf lu (dB)**	**ENR corr (dB)**
10	**15,15**	8,3	**6,85**	0,45	**14,7**	1,85	**13,3**	0,45	**14,7**	8,8	**6,35**
30	**15,14**	-4,1	**19,24**	-1	**16,14**	1,5	**13,64**	0	**15,14**	2,65	**12,49**
50	**15,14**	1,2	**13,94**	-0,45	**15,59**	1,6	**13,54**	0,5	**14,64**	1,1	**14,04**
70	**15,14**	0,67	**14,47**	-0,55	**15,69**	1,68	**13,46**	-0,1	**15,24**	0,6	**14,54**
110	**15,13**	0,35	**14,78**	-0,7	**15,83**	1,7	**13,43**	-0,24	**15,37**	0,18	**14,95**
150	**15,13**	-0,2	**15,33**	-1	**16,13**	1,5	**13,63**	-0,3	**15,43**	0	**15,13**
430	**15,13**	0	**15,13**	-1	**16,13**	1,62	**13,51**	-0,2	**15,33**	-0,26	**15,39**
1000	**15,13**	-0,15	**15,28**	-1,05	**16,18**	1,88	**13,25**	-0,25	**15,38**	-0,46	**15,59**
1300	**15,08**	-0,24	**15,32**	-1,15	**16,23**	1,85	**13,23**	-0,27	**15,35**	-0,58	**15,66**
1500	**15,04**	-0,3	**15,34**	-1,1	**16,14**	1,97	**13,07**	-0,3	**15,34**	-0,69	**15,73**
1900	**14,94**	-0,55	**15,49**	-0,9	**15,84**	2,15	**12,79**	-0,15	**15,09**	-0,8	**15,74**
3950	**14,82**		**15,3**		**15,6**				**15,6**		
8200	**15,1**		**15,1**		**15,6**				**15,6**		
12400	**15,56**		**15,7**		**15,3**				**15,3**		

Unknown noise source calibration

d/ Copy/paste of only interesting values giving the new ENR table:

1/1/09 après comparaison avec la HP 346b de F6DPH								
AILTECH	7616		**AILTECH**	7615		**AILTECH**	7616 courte	
S/N	3710		S/N	2614		S/N	3300	
01/01/2009			01/01/2009			01/01/2009		
F (MHz)	**ENR (dB)**		**F (MHz)**	**ENR (dB)**		**F (MHz)**	**ENR (dB)**	
10	**6,85**		**10**	**13,3**		**10**	**14,7**	
30	**19,24**		**30**	**13,64**		**30**	**16,14**	
50	**13,94**		**50**	**13,54**		**50**	**15,59**	
70	**14,47**		**70**	**13,46**		**70**	**15,69**	
110	**14,78**		**110**	**13,43**		**110**	**15,83**	
150	**15,33**		**150**	**13,63**		**150**	**16,13**	
430	**15,13**		**430**	**13,51**		**430**	**16,13**	
1000	**15,28**		**1000**	**13,25**		**1000**	**16,18**	
1300	**15,32**		**1300**	**13,23**		**1300**	**16,23**	
1500	**15,34**		**1500**	**13,07**		**1500**	**16,14**	
1900	**15,49**		**1900**	**12,79**		**1900**	**15,84**	
3950	**15,3**		**3950**	___		**3950**	**15,6**	
8200	**15,1**		**8200**	___		**8200**	**15,6**	
12400	**15,7**		**12400**	___		**12400**	**15,3**	

New calculated ENR table (rows 10 to 1900 MHz)

Original ENR table (rows 3950 to 12400 MHz)

7- Cautions to take with NF measurement accuraty (<1 dB)

Cautions to take with Nf measurement accuraty

Target : taking maximum cautions for the noise measures, especially under 1 dB Nf scale

Affecting factors (exactly in this order):

- The noice source ENR calibration
- The analyser internal IF calibration
- The noise source absolutely good behaviour
- The minimum losses between ENR source and DUT

Cautions to take with Nf measurement accuraty

Operating mode after gain/Nf zeroiing calibration :

1/ Be sure of the noise source last ENR sheet calibration date

Example 1 : if last cal date marked on the noise source is january 2009, it signifies only that its correct behaviour was tested on this date - - - so all measurements done after are subject to uncertainity !!!

Example 2 : take a « suspected » noise source with an internal attenuator suspected problem (10 dB instead of 18 dB (that you formerly don't know)!!!!!
- Its gain/Nf zeroiing will be correct (even in the 20 dB range)
- Then, the gain measurement (passive or active device) will always be correct
- **But Nf measurement'll be totally wrong - - the Nf measure could also be NEGATIVE !!**

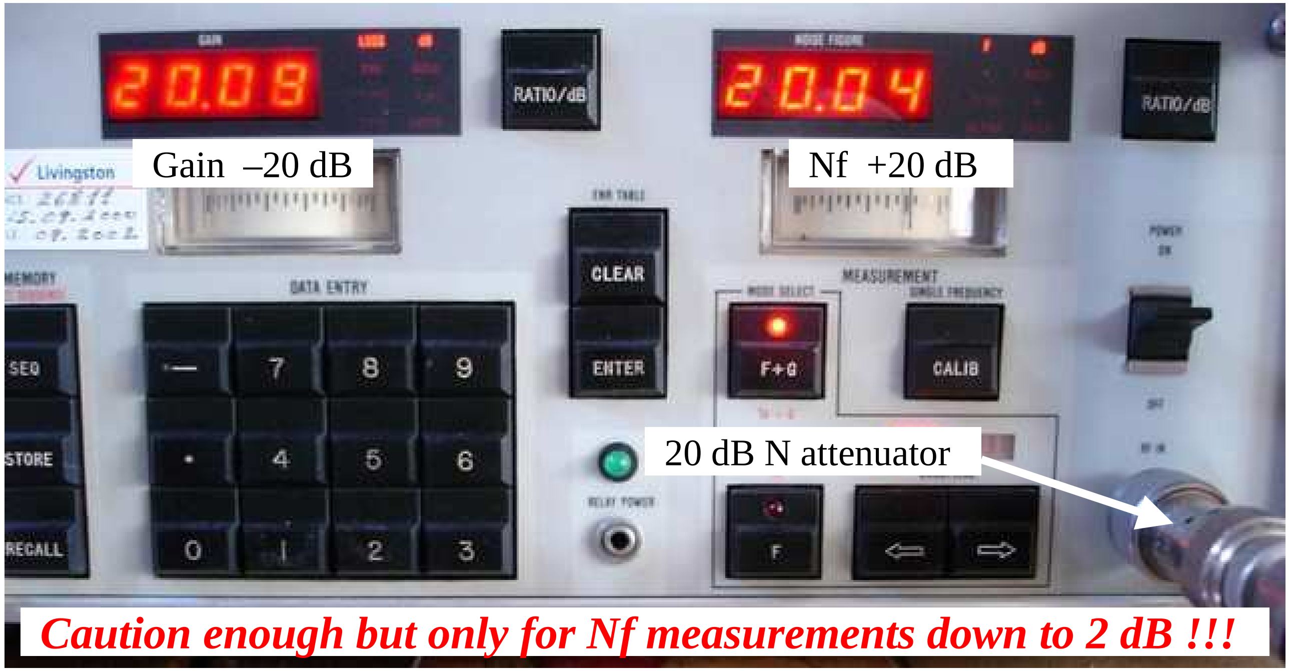
2/ Dedicated ENR table of noise source MUST BE ENTERED

The Eaton 2075 has the « ENR all 15.5 dB » table choice. It does only give a noise idea, but not serious Nf measures under 1 dB !

Cautions to take with Nf measurement accuraty

3/ Measurement of a passive well known <u>attenuator</u> as first DUT (device under test)

Be sure of its good adaptation at the meas frequency (S11>=20 dB)
That's the 1st minimal measure and caution - - but not the only one to take!!!



4/ <u>IF calibration</u> must be done every 2 weeks

Without anything connected to the analyser IF input
- *Eaton 2075* → *SP 15.1 ENTER*
- *HP / Agilent 8970* → *33.0 SP*

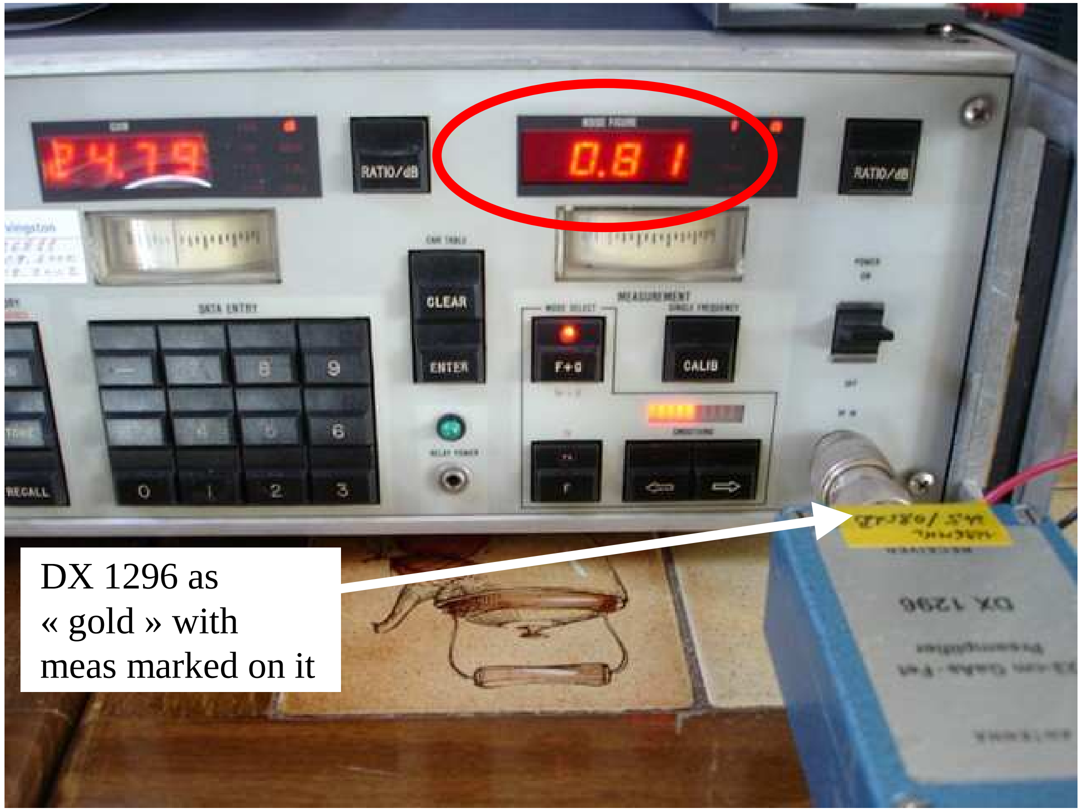
Cautions to take with Nf measurement accuraty

5/ Comparaisons with a narrowband « Gold » preamp taken as reference measure(s)

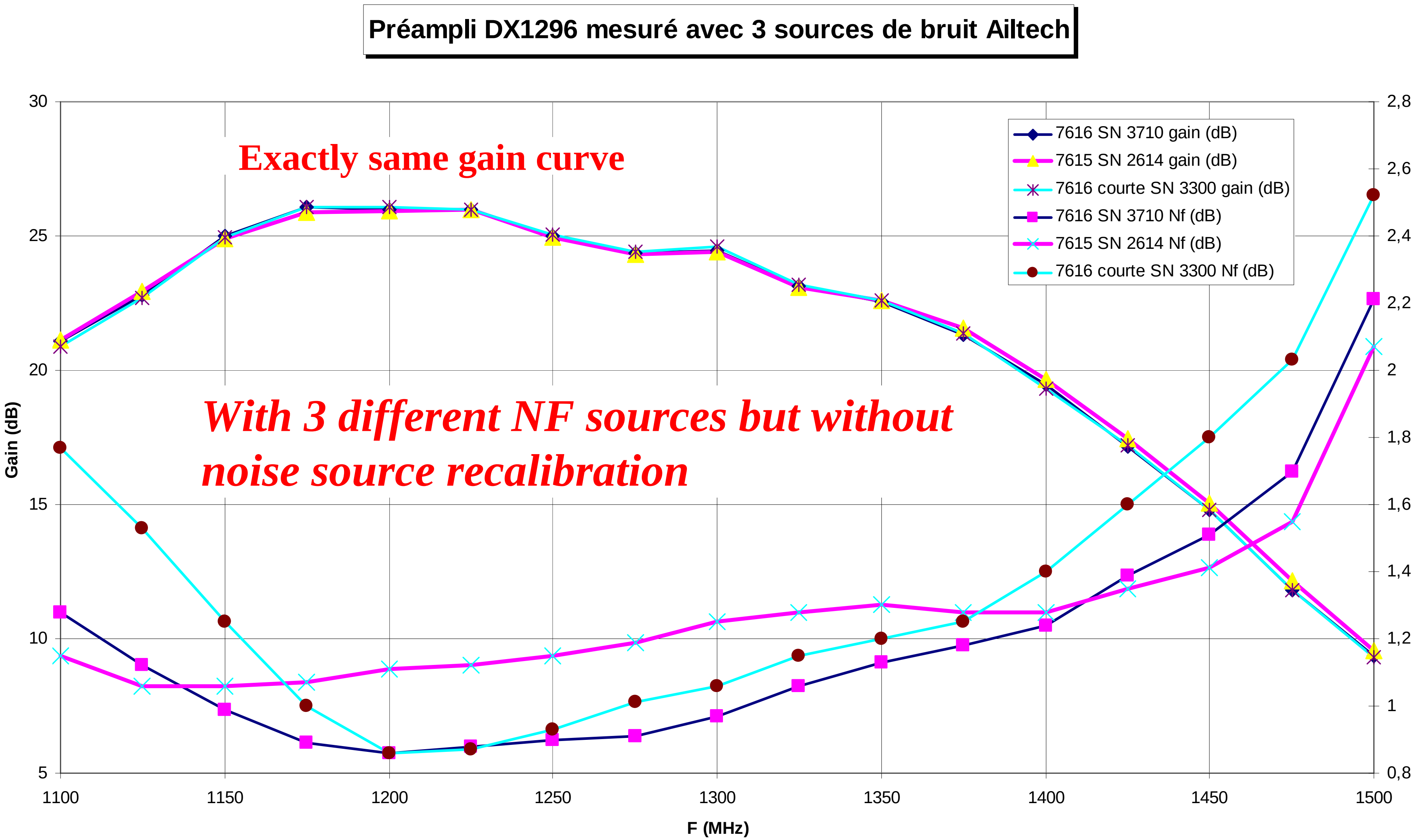
The Nf precision described before is enough with preamplifiers of 2 to 3 dB Nf.
But with Nf scales <1 dB, the only way to get a good Nf precision is to get a comparaison with the measurement of a previously « Gold » preamp with same Nf scales

Narrowband amps can have noise figure <0.5 dB.
So a 1300 MHz or 23 cm narrowband preamp is a good « Gold » reference

*Don't forget also that the frequency of Nf min value is **never corresponding** to the max gain*



Cautions to take with Nf measurement accuraty



Eaton 275a and HP/ Agilent 8970a noise/gain analyser

Cautions to take with Nf measurement accuraty

6/ Comparaisons with a broadband « Gold » preamp taken as reference measure(s)

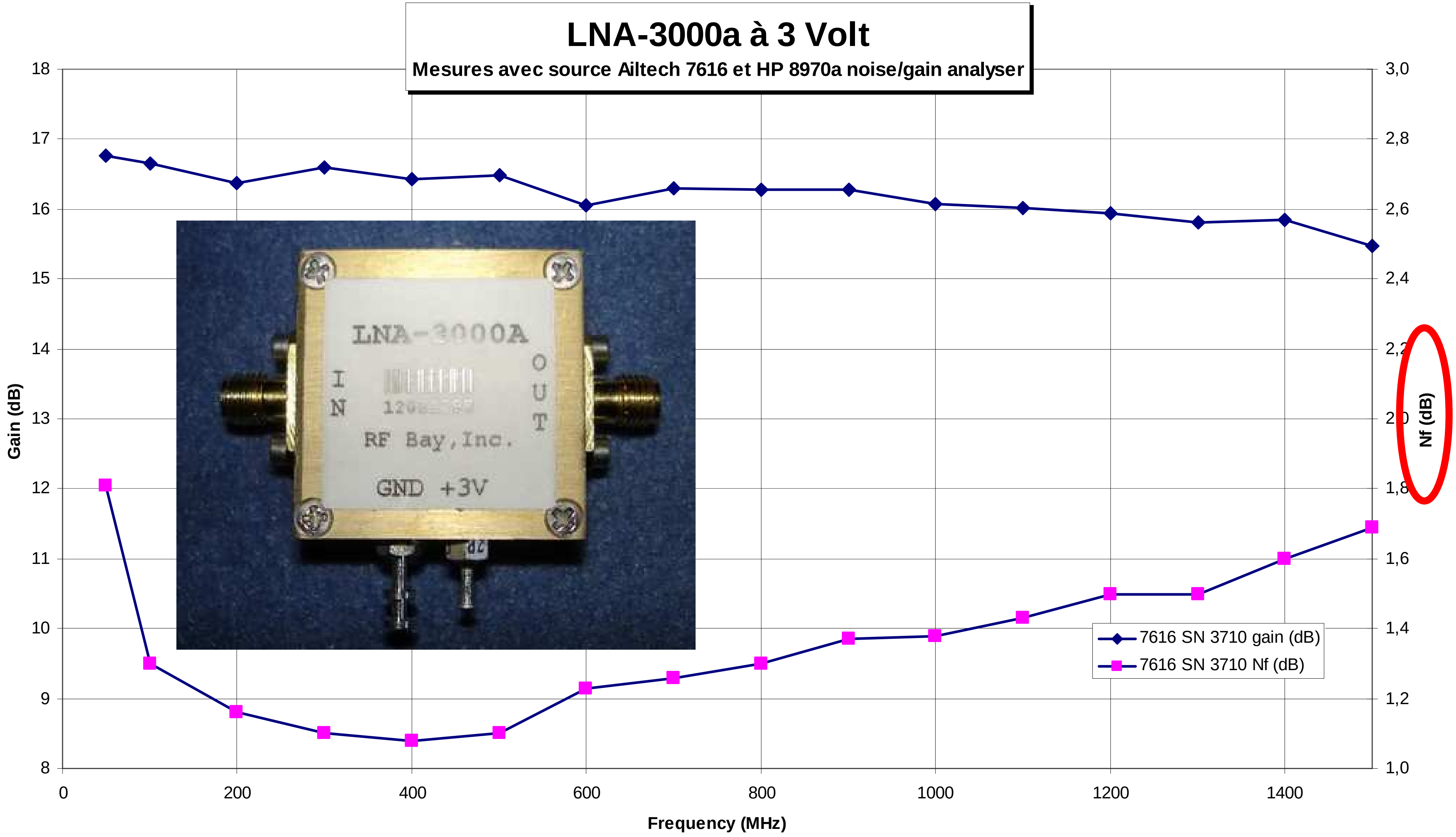
Broadband amps have noise figure >1dB but the noise of a 10 – 2000 MHz GaAs amp can be as low as 1.2 dB on the whole band

This LNA-3000A broadband from RF Bay Inc as « Gold » is a good compromise because :

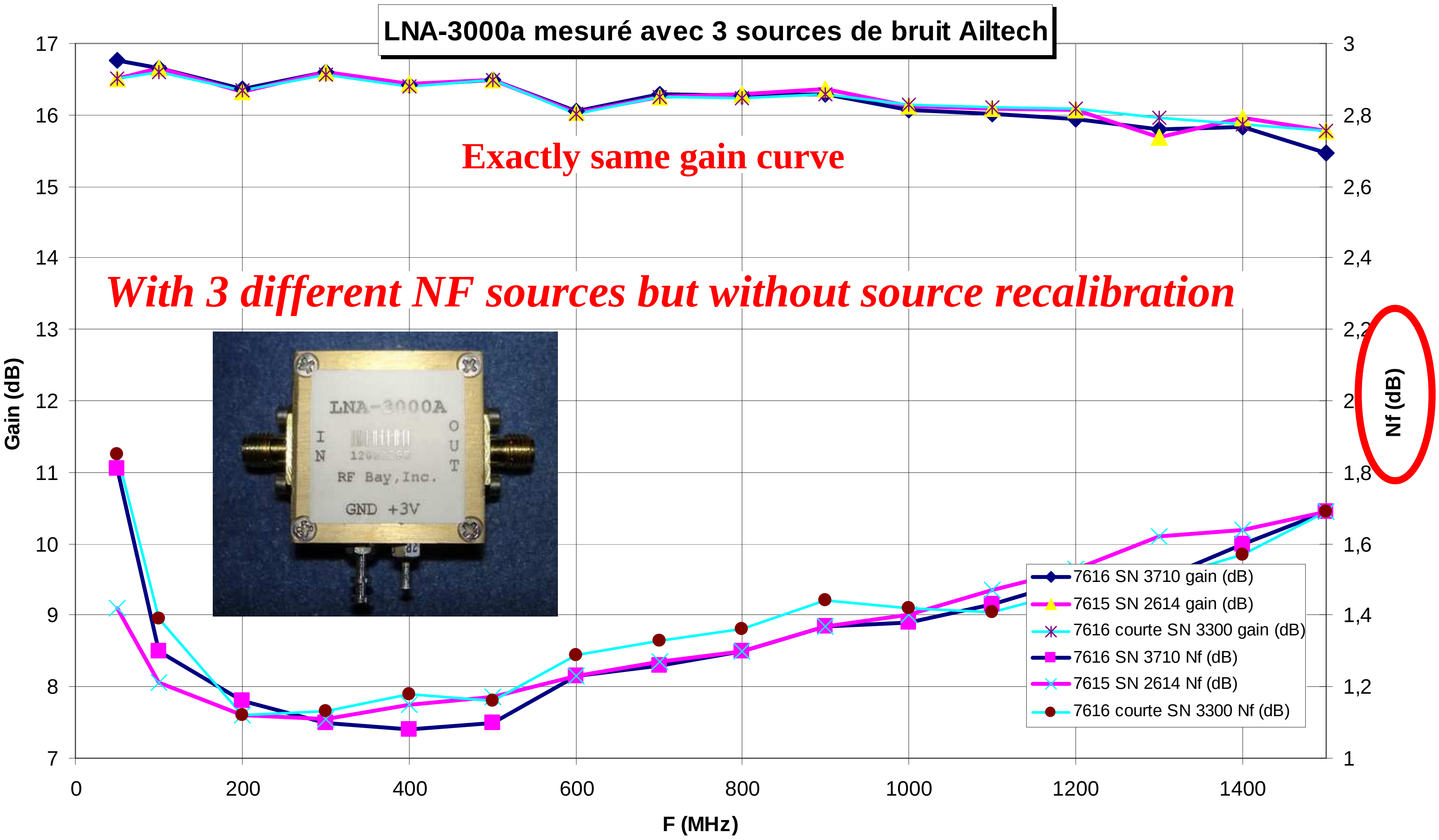
- Band from 10 MHz to more than 3 GHz
- Good gain compromise (15 dB) compatible with our 15 to 25 dB gain measurements
- Good Nf compromise with Nfmin of 1.2 dB near 1.3 GHz
- Power only 15 mA under 3V - - no heating problem after 5 or 10 minutes !!

For our ham bands, do gain/Nf measures at 50, 144, 432,1300 and 2300 MHz and write them !

Cautions to take with Nf measurement accuraty



Cautions to take with Nf measurement accuraty



Eaton 275a and HP/ Agilent 8970a noise/gain analyser

Cautions to take with Nf measurement accuraty

7/ Effect on adding losses on purpose BEFORE DUT

Example : with same ENR table, put a 2 dB SMA attenuator between noise source and DUT

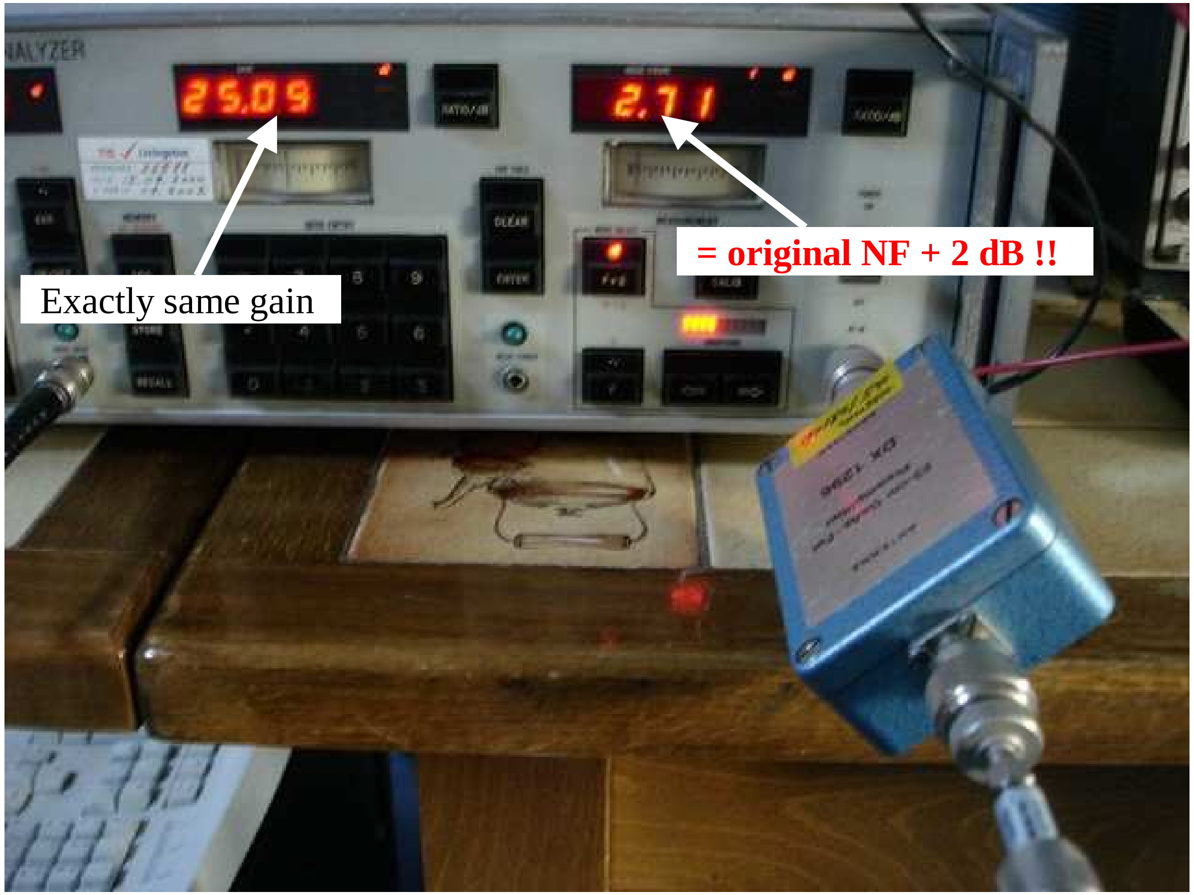
a/ Do the zeroiing calibration @ 1290 MHz with the attenuator

2 dB Narda SMA pre attenuator

Normal calibration

Cautions to take with Nf measurement accuraty

b/ Measurement of the same MDX 1296 narrowband preamp as DUT



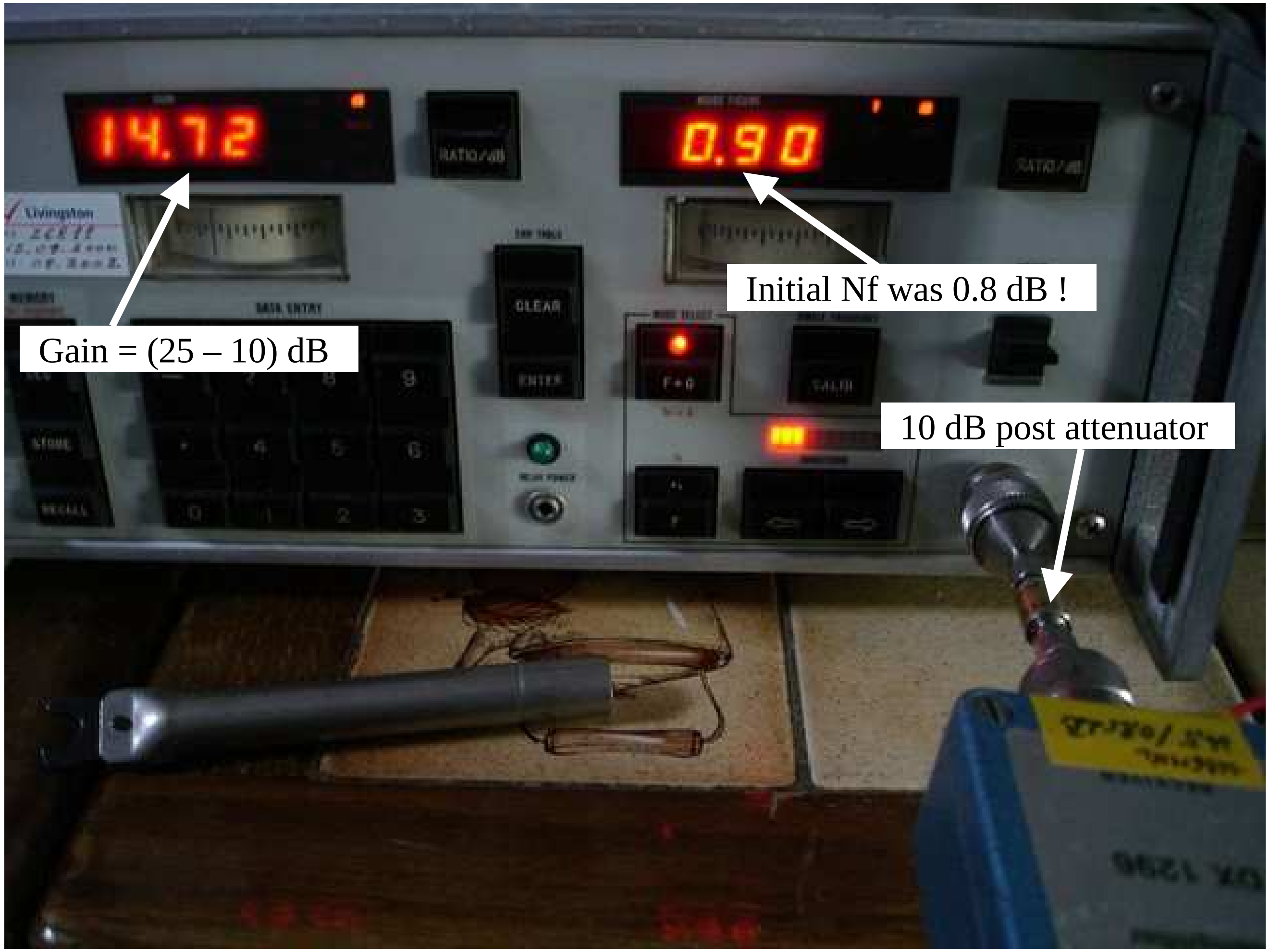
c/ conclusion

- Extra losses are drastically affecting the noise figure but NOT the gain (Poisson law)
- Extra care must be taken no minimise noise source to DUT path (for a circulator, its serial loss must be taken)

Cautions to take with Nf measurement accuraty

8/ Effect on adding losses on purpose AFTER DUT

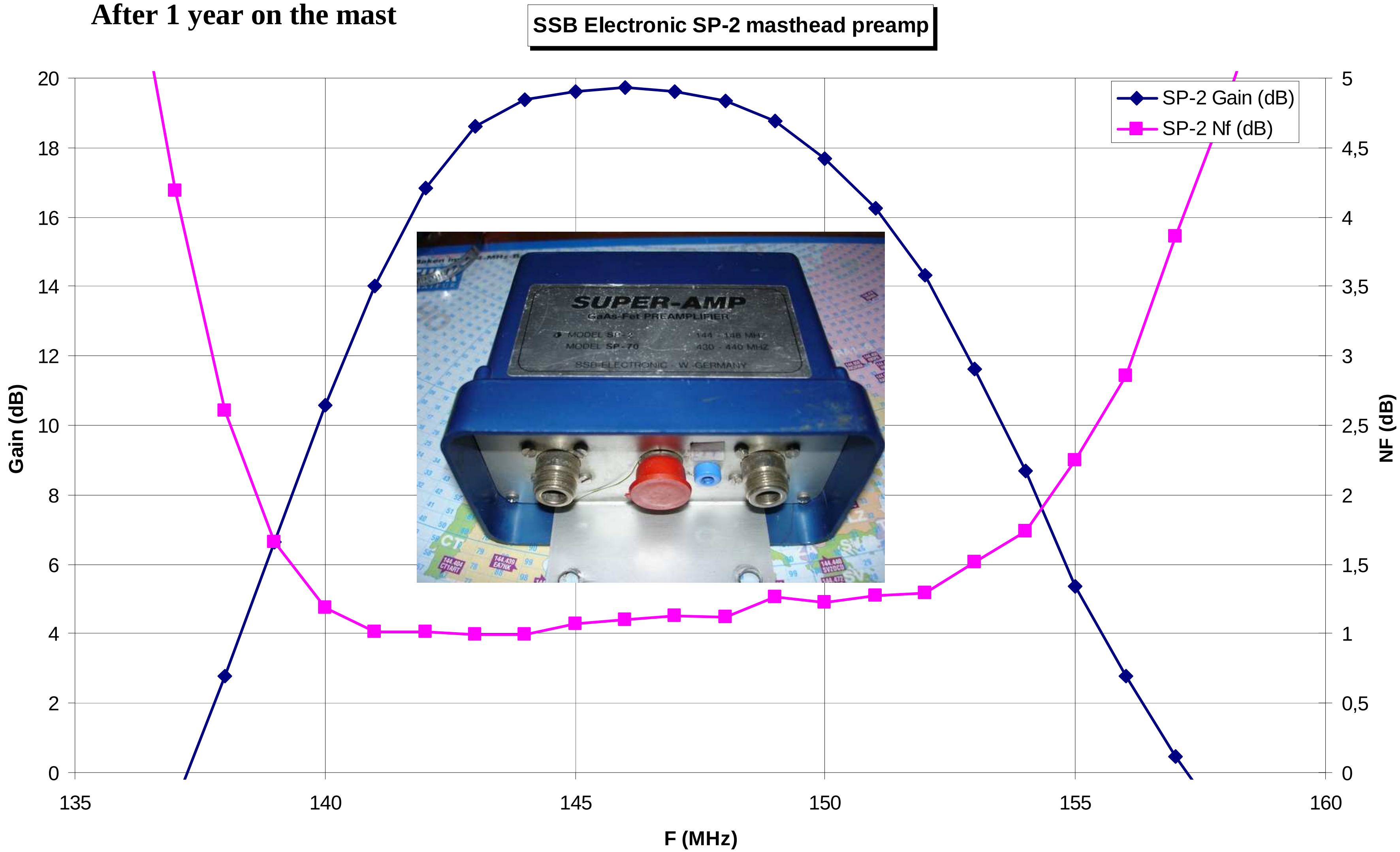
It doesn’t affect the overall gain, but only ITS NOISE FIGURE (with post attenuation <13 dB)



8- 144 to 1296 MHz masthead preamps measures

144 MHz masthead preamplifier

After 1 year on the mast



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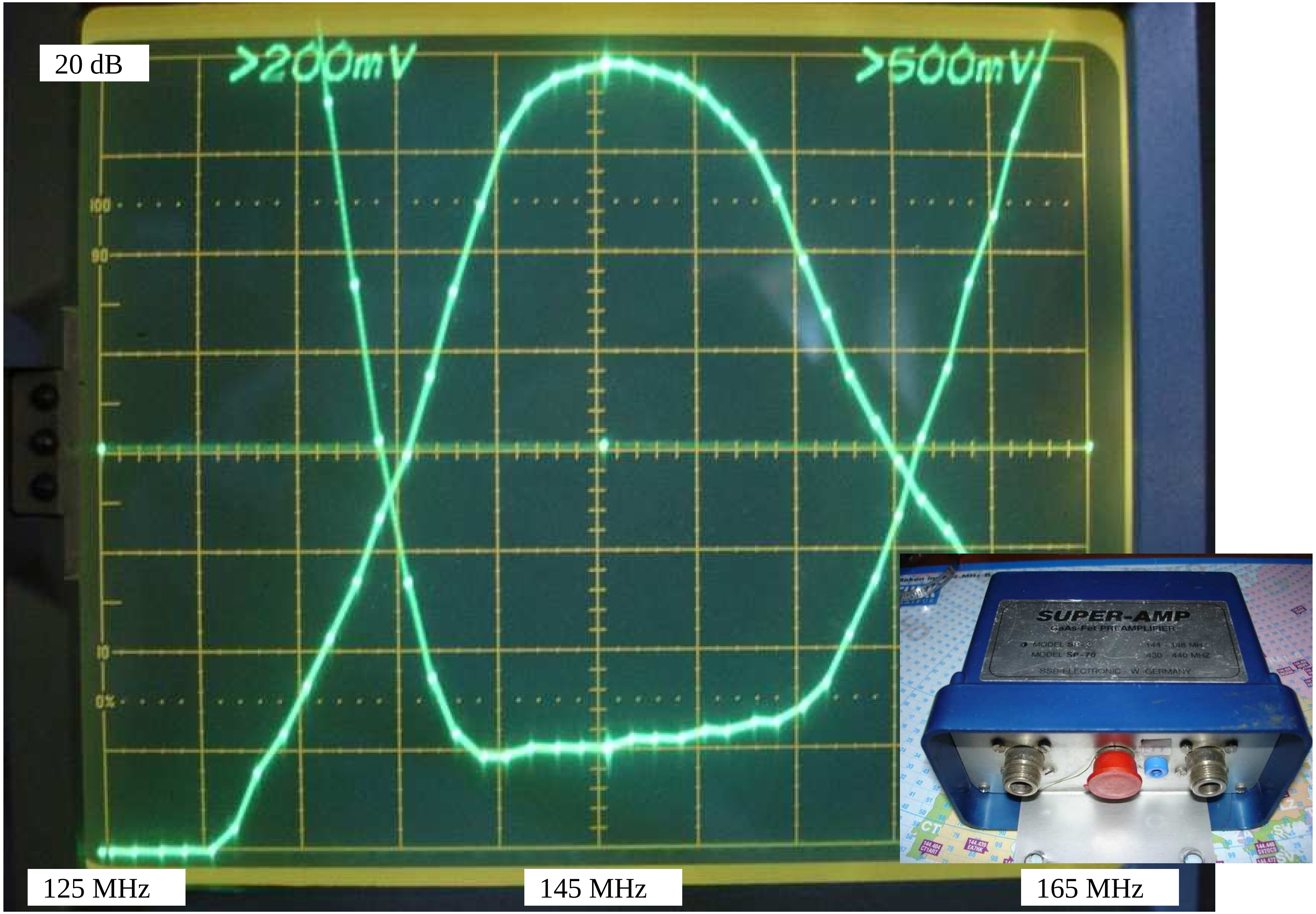
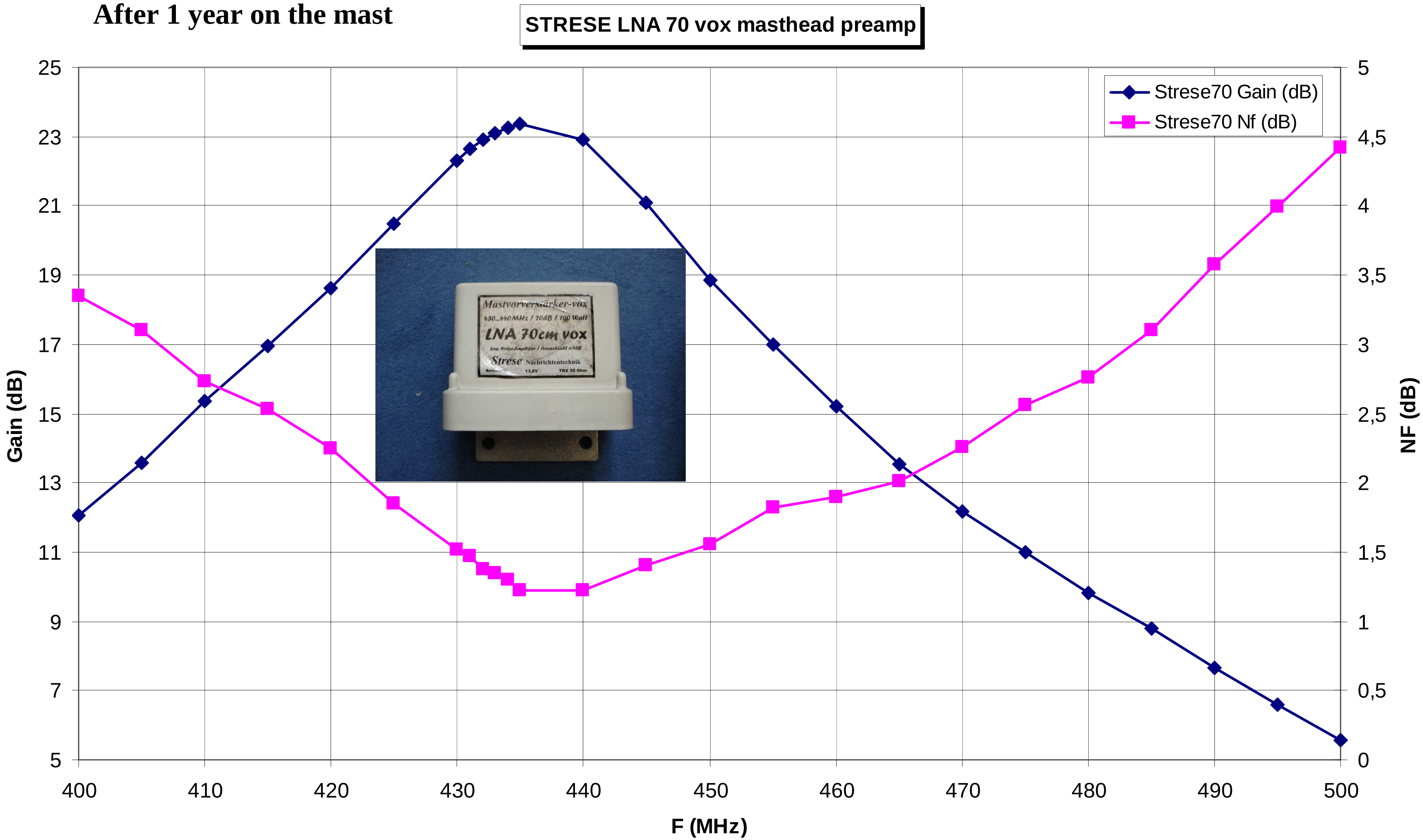
144 MHz masthead preamplifier



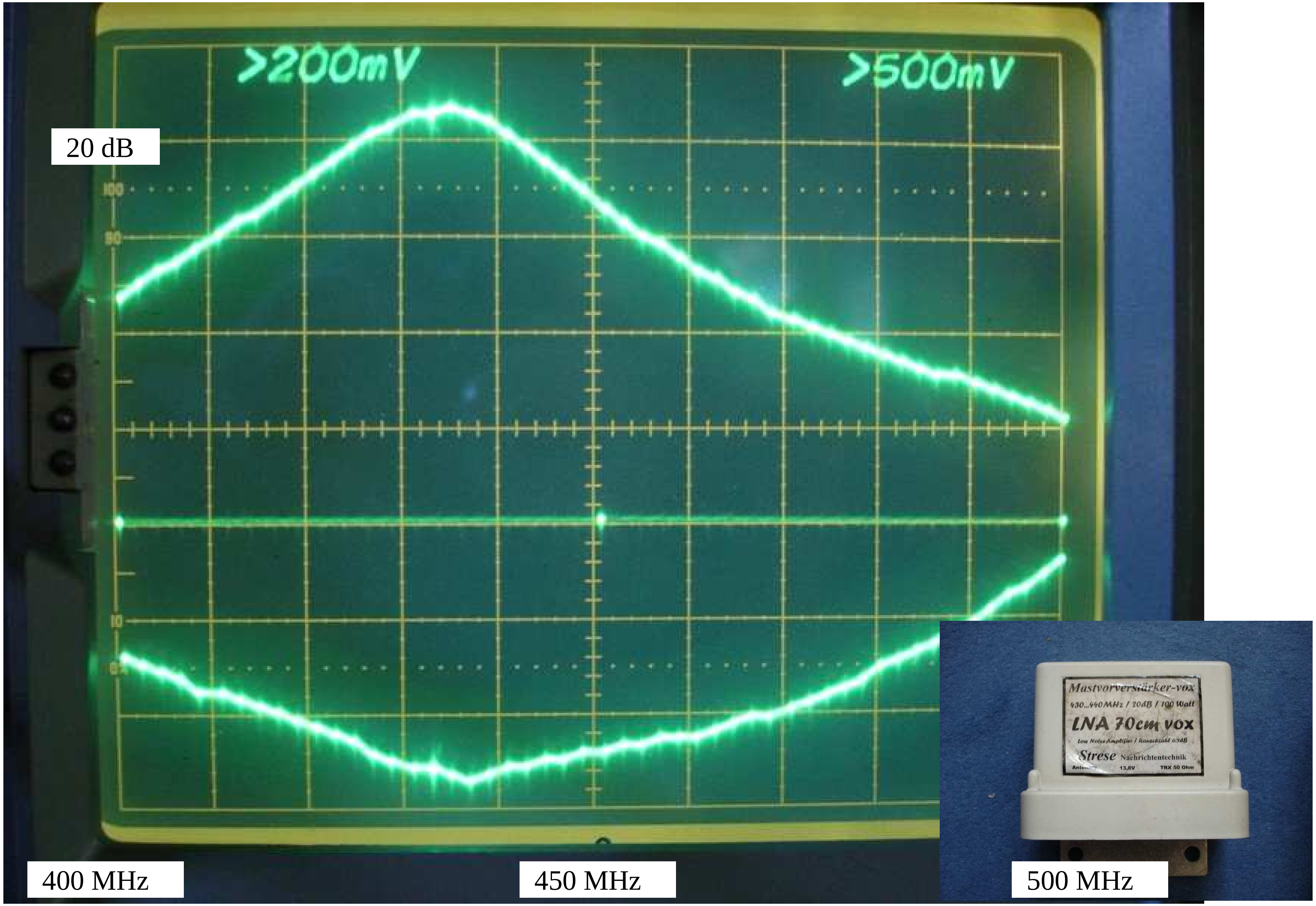
432 MHz masthead preamplifier

After 1 year on the mast



Eaton 275a and HP/ Agilent 8970a noise/gain analyser

432 MHz masthead preamplifier



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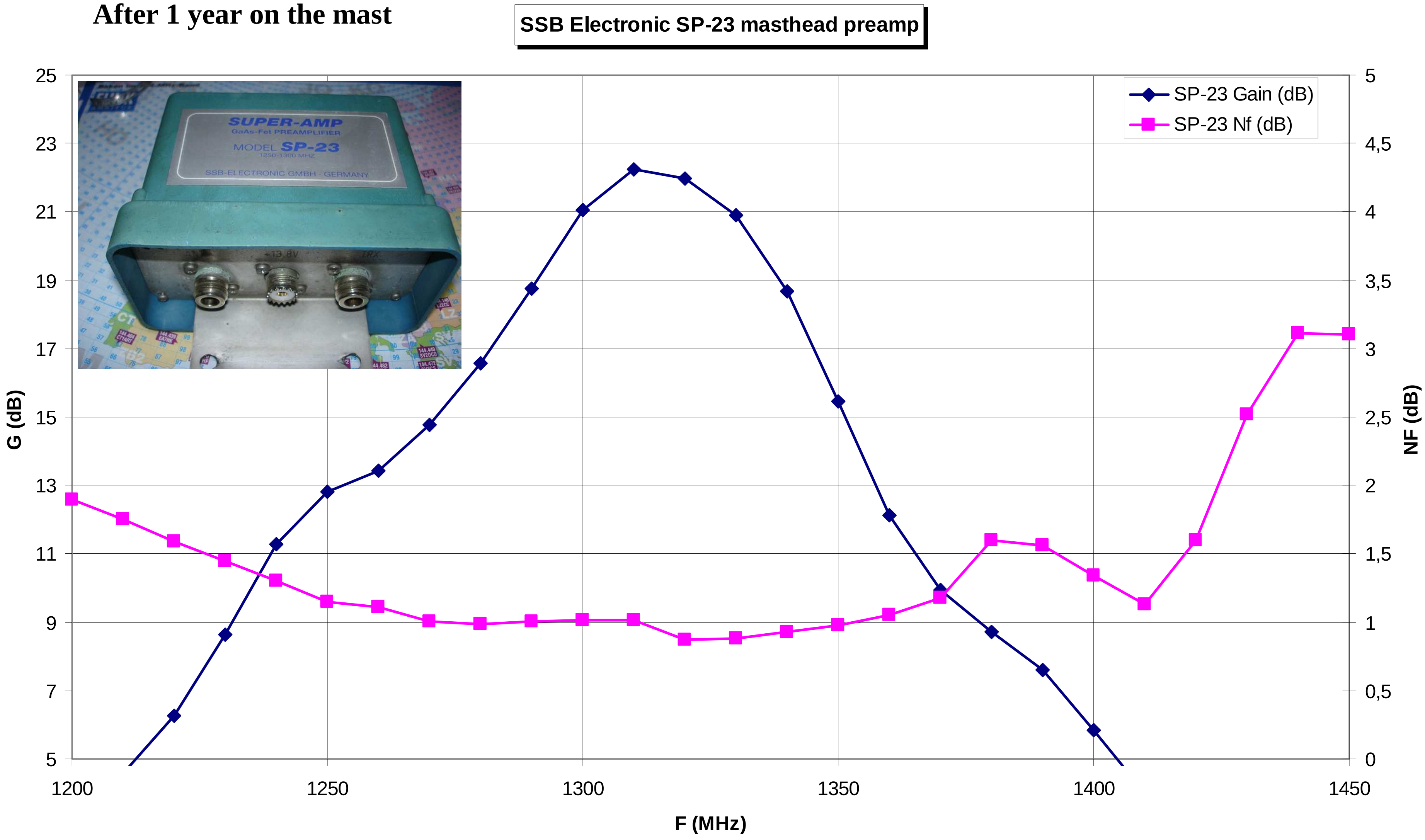
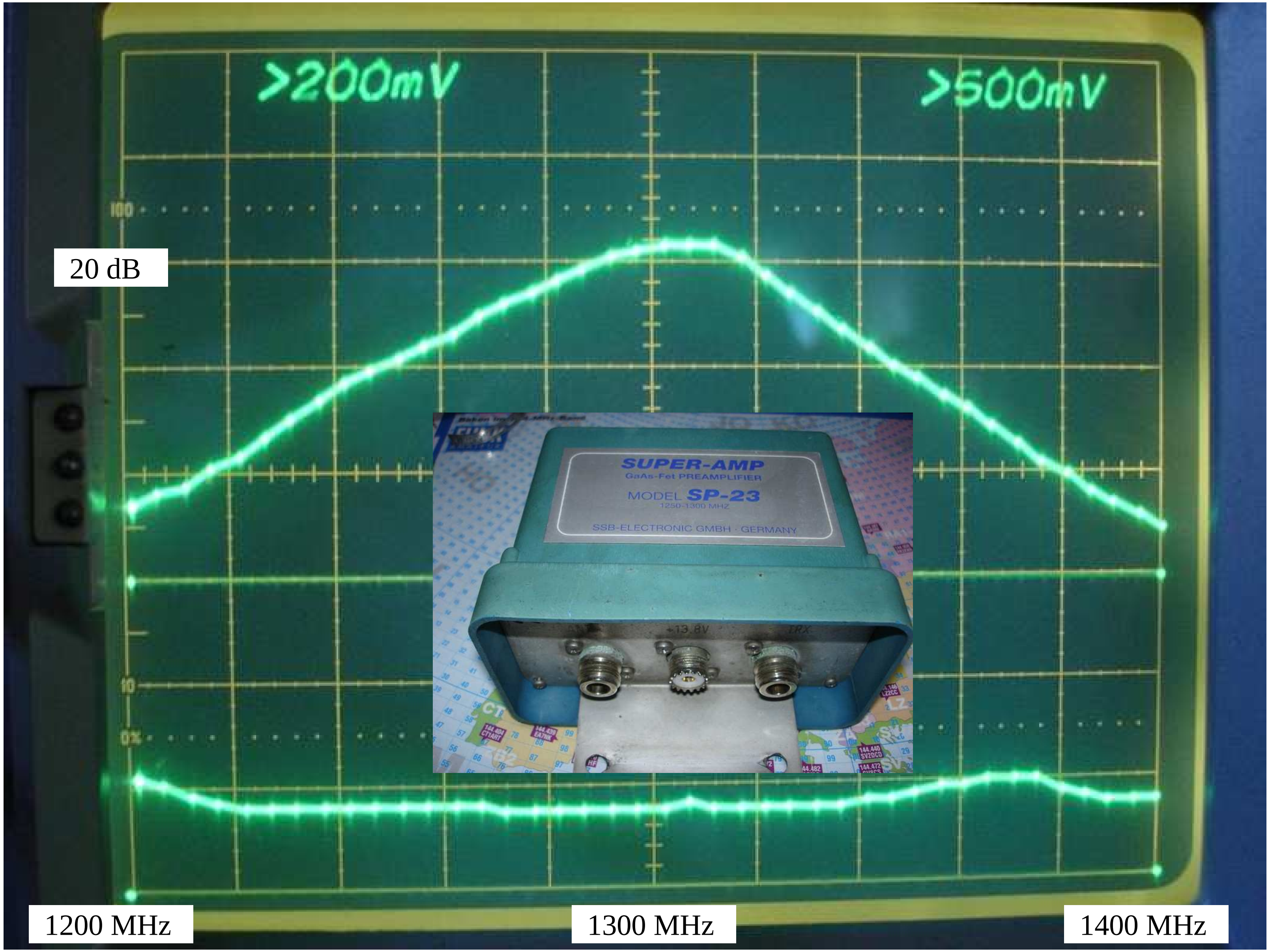
1296 MHz masthead preamplifier

After 1 year on the mast



Eaton 275a and HP/ Agilent 8970a noise/gain analyser

1296 MHz masthead preamplifier



Eaton 275a and HP/ Agilent 8970a noise/gain analyser

9- Conclusions

Conclusions

- The HP 8970a (only up to 1.5 GHz) has a largely quicker warm-up time than the Eaton 2075
- At 1.6 GHz and above, the Eaton 2075 warm-up time has a GREAT INFLUENCE

- Obtaining a 5db ENR noise source (better accuraty) is very easy to do
- Calibration of an unknown source is also easy to do
- Every « suspect » noise source is able to give a good gain value but **NOT a good Nf measure**

- Nf measurements especially under 1 dB must be made with great cautions as largely described just before !

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