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AMICSA 2010

**LOCAL OSCILLATOR RADIATION TEST RESULTS OF THE SiGe
TECHNOLOGY SGB25 TM1TM2 OF IHP**

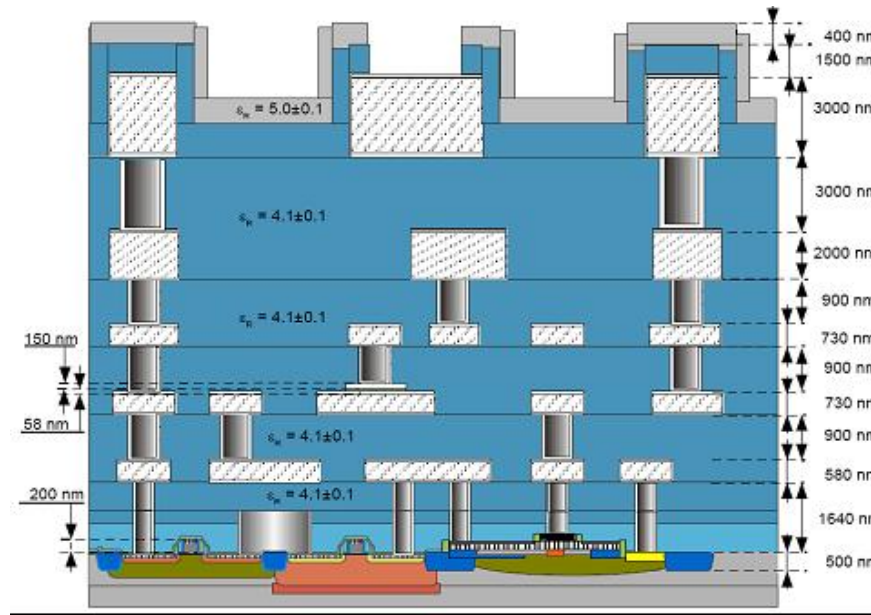
September 7th, 2010 – 16:30

Kayser-Threde GmbH, Munich / Heinz-Volker Heyer

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- Overview of the technology
- Overview of the local oscillator
- TID verification test environment
- TID test results
- SEE verification test environment
- SEE test results
- Conclusion.

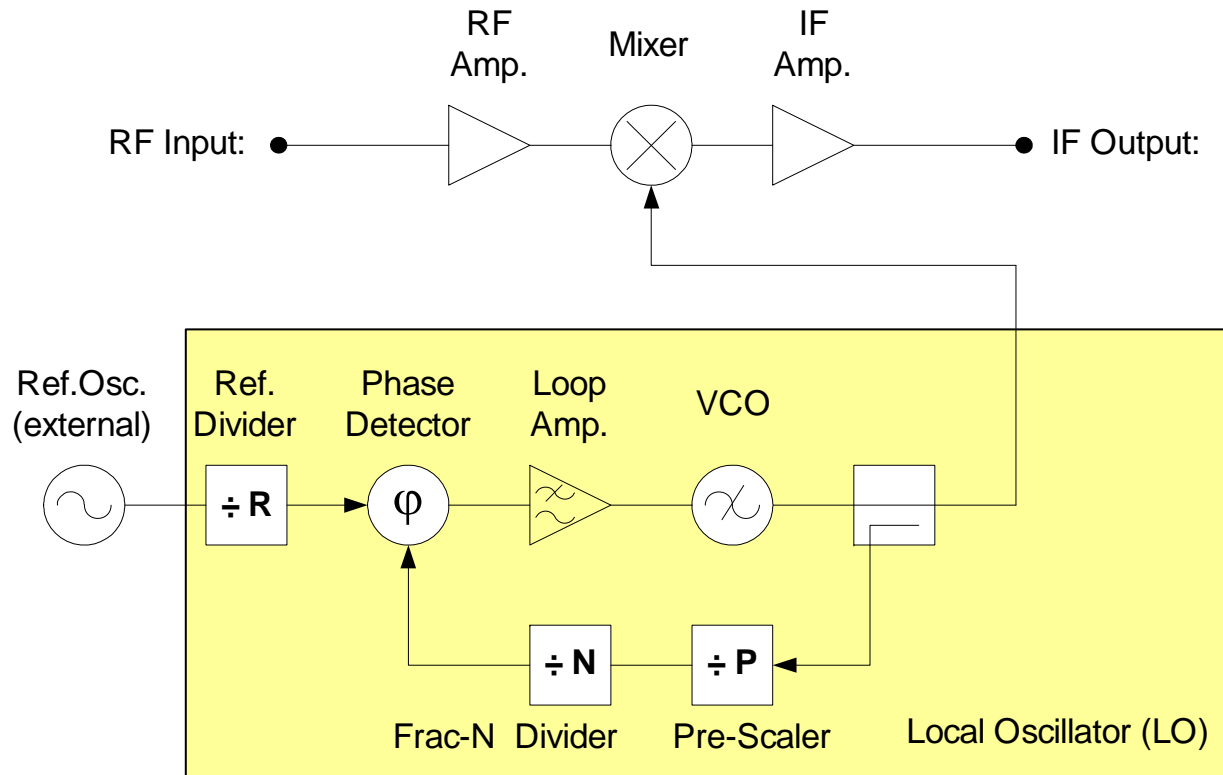
Overview SGB25V TM1TM2 technology



Parameter	High Performance	Standard	High Voltage
Bipolar Section			
A_E	$0.42 \times 0.84 \mu\text{m}^2$		
Peak f_{max}	95 GHz	90 GHz	70 GHz
Peak f_T	75 GHz	45 GHz	25 GHz
BV_{CE0}	2.4 V	4 V	7 V
BV_{CB0}	>7 V	>15 V	>20 V
V_A	>50 V	>80 V	>100 V
β	190		

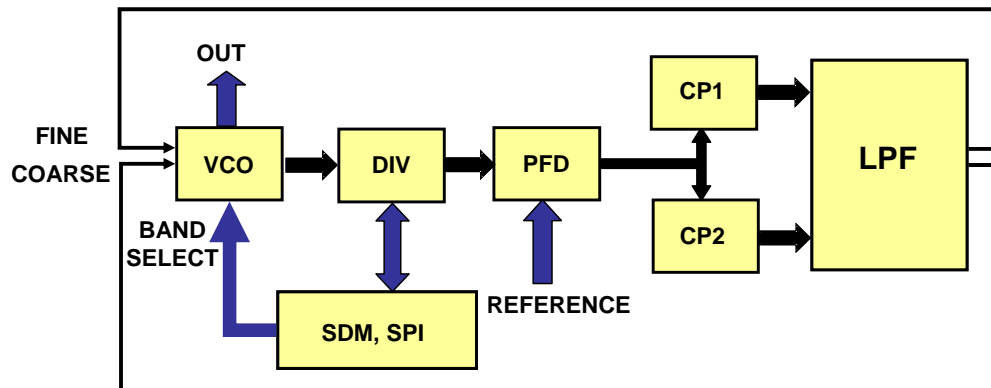
Parameter	SGB25VD
CMOS Section (0.25 μm)	
Core Supply Voltage	2.5 V
nMOS V_{th}	0.6 V
nMOS I_{Dsat}	570 $\mu\text{A}/\mu\text{m}$
nMOS I_{off}	3 pA/ μm
pMOS V_{th}	-0.51 V
pMOS I_{Dsat}	290 $\mu\text{A}/\mu\text{m}$
pMOS I_{off}	3 pA/ μm

Overview of the local oscillator (1)



Block diagram of downconverter

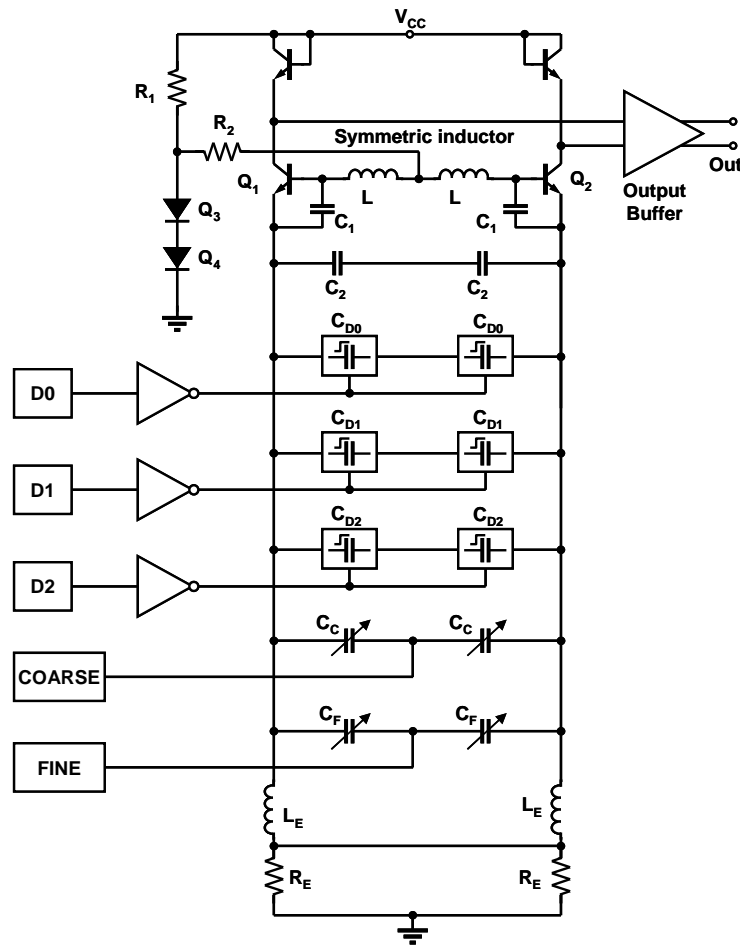
Overview of the local oscillator (2)



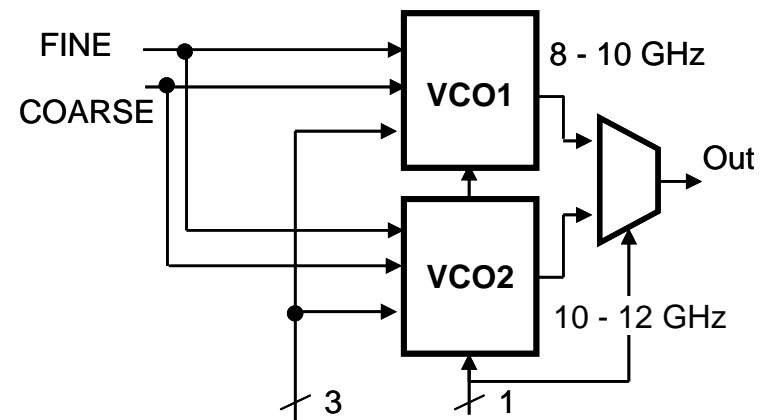
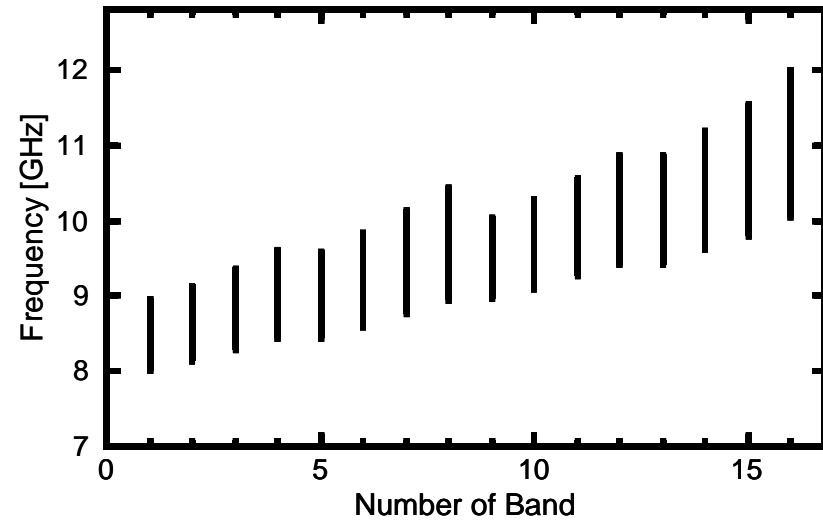
Block diagram of local oscillator

- A phase frequency detector with two charge pumps
 - a fixed coarse charge pump
 - and a programmable fine charge pump
- An integrated VCO bank
- Prescalers
- Dual modulus divider
- Main divider
- The fractional-N logic block (SDM)
- Interface to the periphery to command the whole LO unit.

Overview of the local oscillator (3)

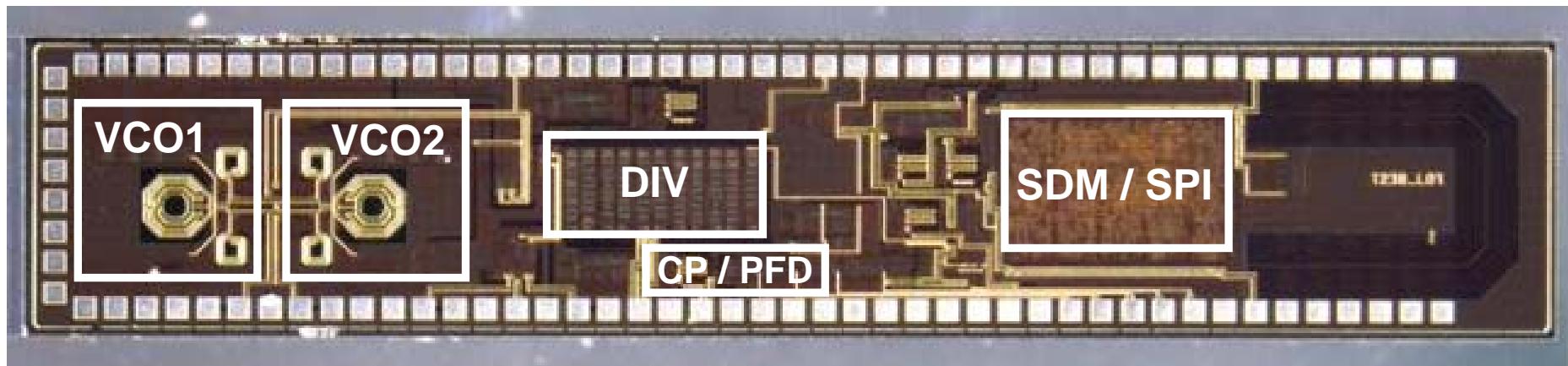


Block diagram of integrated VCOs



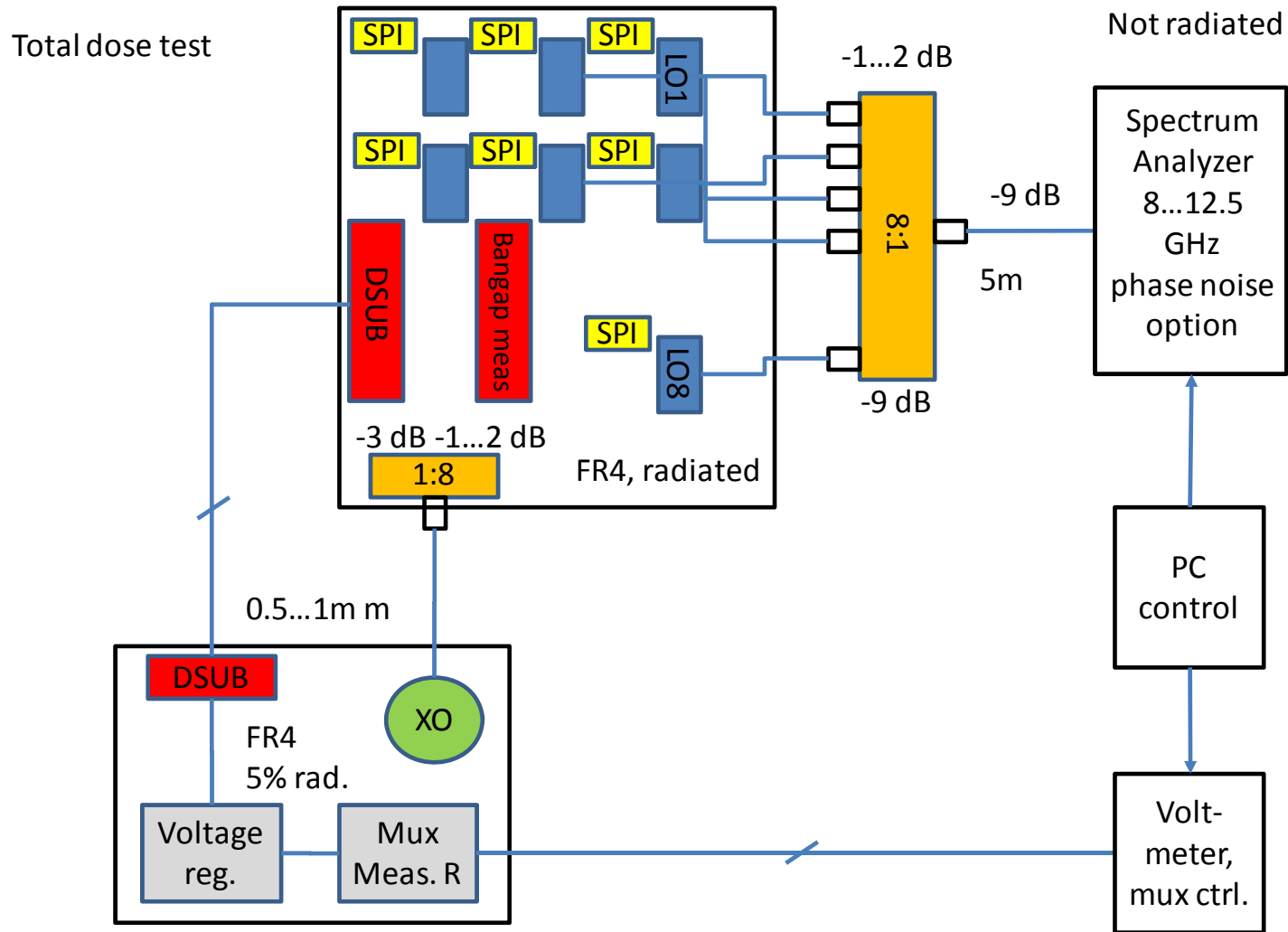
Digital tuning

Overview of the local oscillator (4)

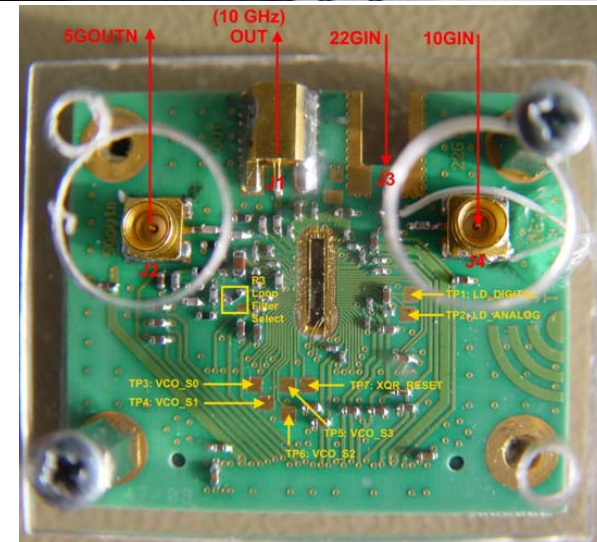
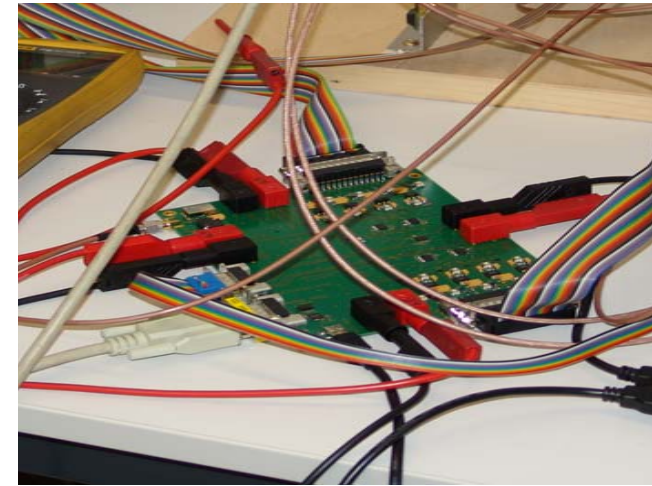
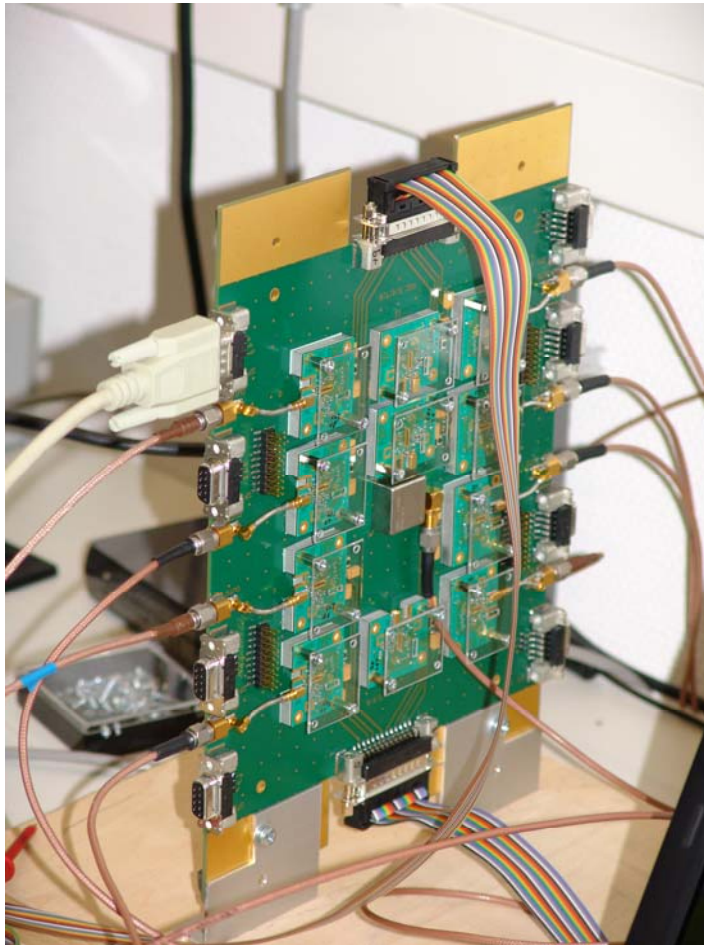


Layout of the local oscillator

TID test circuit block diagram



TID test circuit test boards



TID tests automated test messages per SMS

Automated 20/30 Radiation Measurement									
!	Start Time:	Thu 12/Nov/2007	Duration:	00:03:10					
!	DUT	DUT 0	DUT 1	DUT 2	DUT 3	DUT 4	DUT 5	DUT 6	DUT 7
I3.3V [mA]	233.75	235.84	238.55	241.34	224.98	234.02	234.08	232.35	
I5.0V [mA]	66.22	65.49	69.64	64.68	66.25	64.13	65.44	106.60	
Freq [Hz]	8,20E+09	8,60E+09	9,00E+09	9,40E+09	9,80E+09	10199996883	10599996588	10999996418	
Amp [dBm]	-19.52	-20.34	-21.33	-20.49	-20.58	-30.01	-23.61	-29.26	
Fref [Hz]	1,00E+08	1,00E+08	1,00E+08	1,00E+08	1,00E+08	1,00E+08	1,00E+08	1,00E+08	
!	Phase Noise [dBc/Hz]								
10000	-99	-95	-96	-96	-96	-93	-95	-95	
30000	-100	-95	-99	-96	-98	-97	-96	-96	
50000	-99	-97	-97	-97	-94	-93	-95	-94	
100000	-99	-96	-98	-97	-96	-95	-96	-95	
300000	-103	-102	-100	-101	-99	-98	-99	-98	
500000	-105	-104	-102	-102	-100	-99	-100	-98	
1000000	-109	-107	-106	-104	-102	-100	-102	-99	
3000000	-114	-112	-111	-111	-110	-102	-109	-102	
5000000	-114	-114	-113	-113	-112	-104	-110	-105	

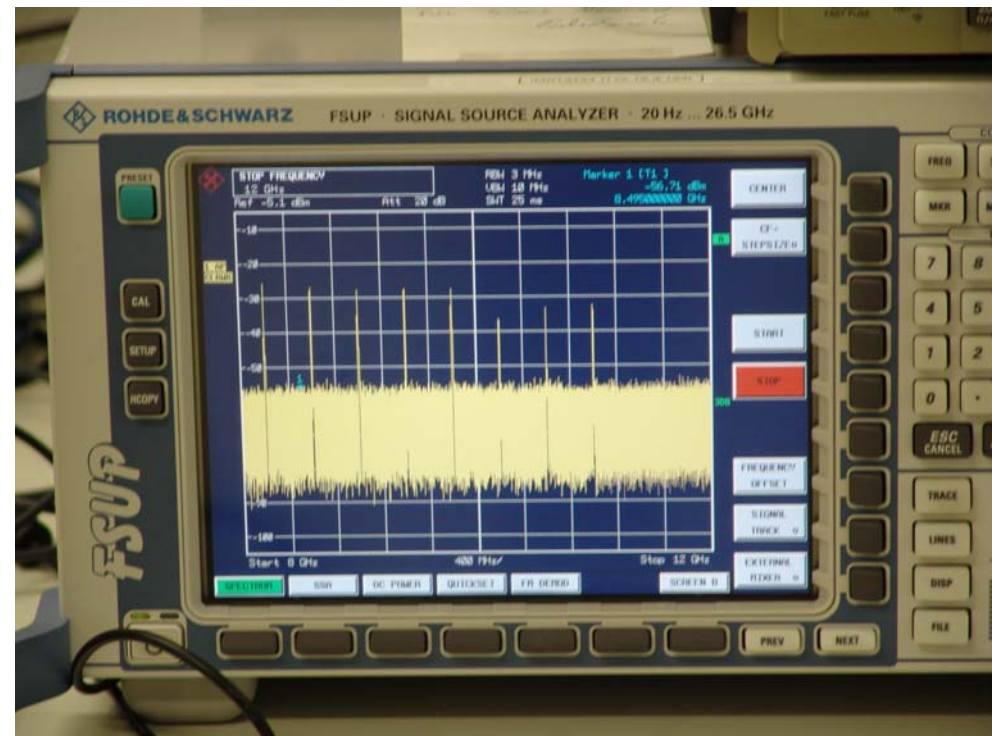


Tested frequency ranges

The 8 operating synthesizers were programmed to the following frequencies:

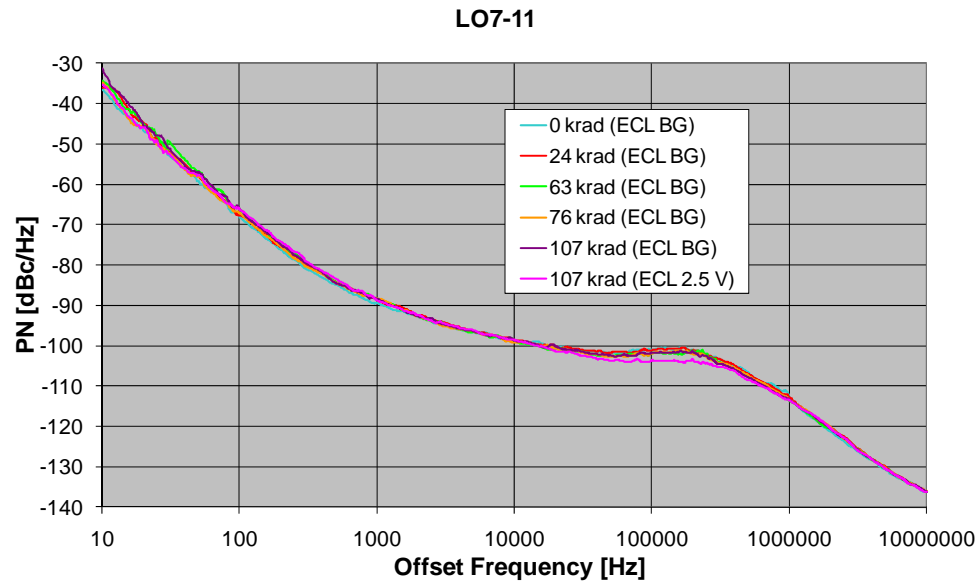
- 8.2 GHz (integer mode)
- 8.6002 GHz (fractional mode)
- 9 GHz (integer mode)
- 9.4002 GHz (fractional mode)
- 9.8 GHz (integer mode)
- 10.2002 GHz (fractional mode)
- 10.6 GHz (integer mode) and
- 11.0002 GHz (fractional mode).

Spectrum of the 8 frequencies



Low dose rate tests

Integer-N performance at 8.2 GHz at different total dose levels
Phase noise of the local oscillators up to 107 krad
(dose rate 0.1 rad/s)



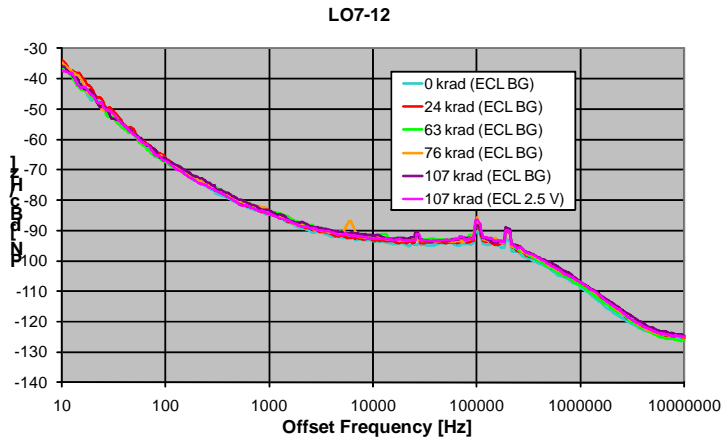
Test results for the radiated synthesizers up to 107 krad.

This includes:

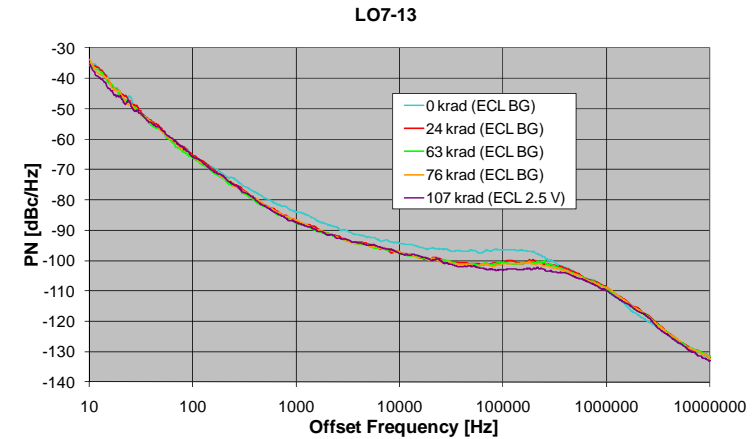
- Phase noise measurements
- Current consumption measurements
- Output power level
- Frequency stability
- Spur level
- Bandgap voltages.

Phase noise of the local oscillators up to 107 krad (dose rate 0.1 rad/s)

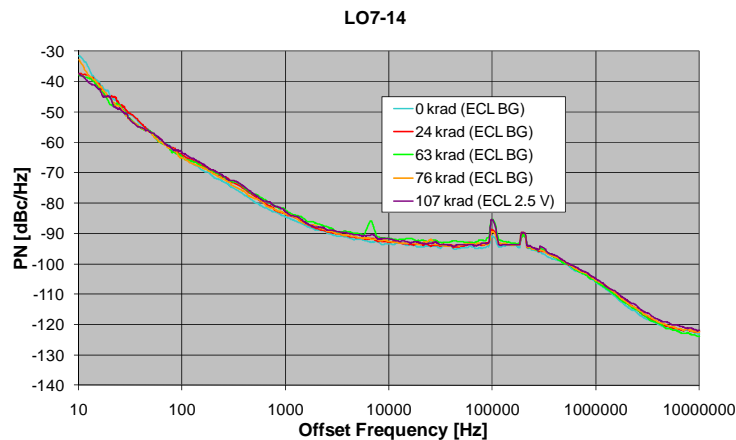
Fractional-N performance at 8.6002 GHz



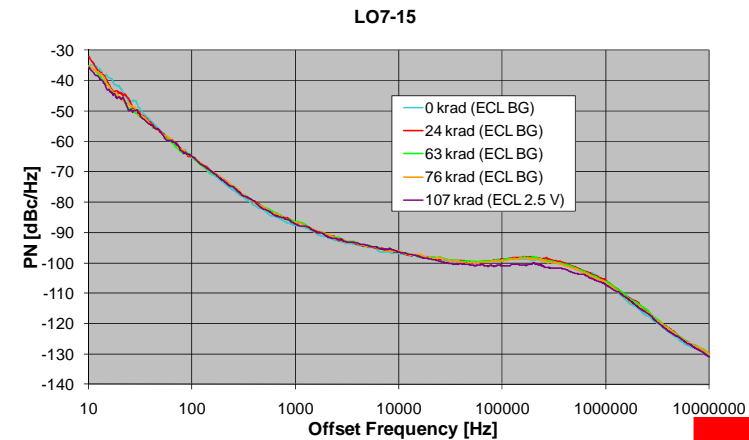
Integer-N performance at 9 GHz



Fractional-N performance at 9.4002 GHz



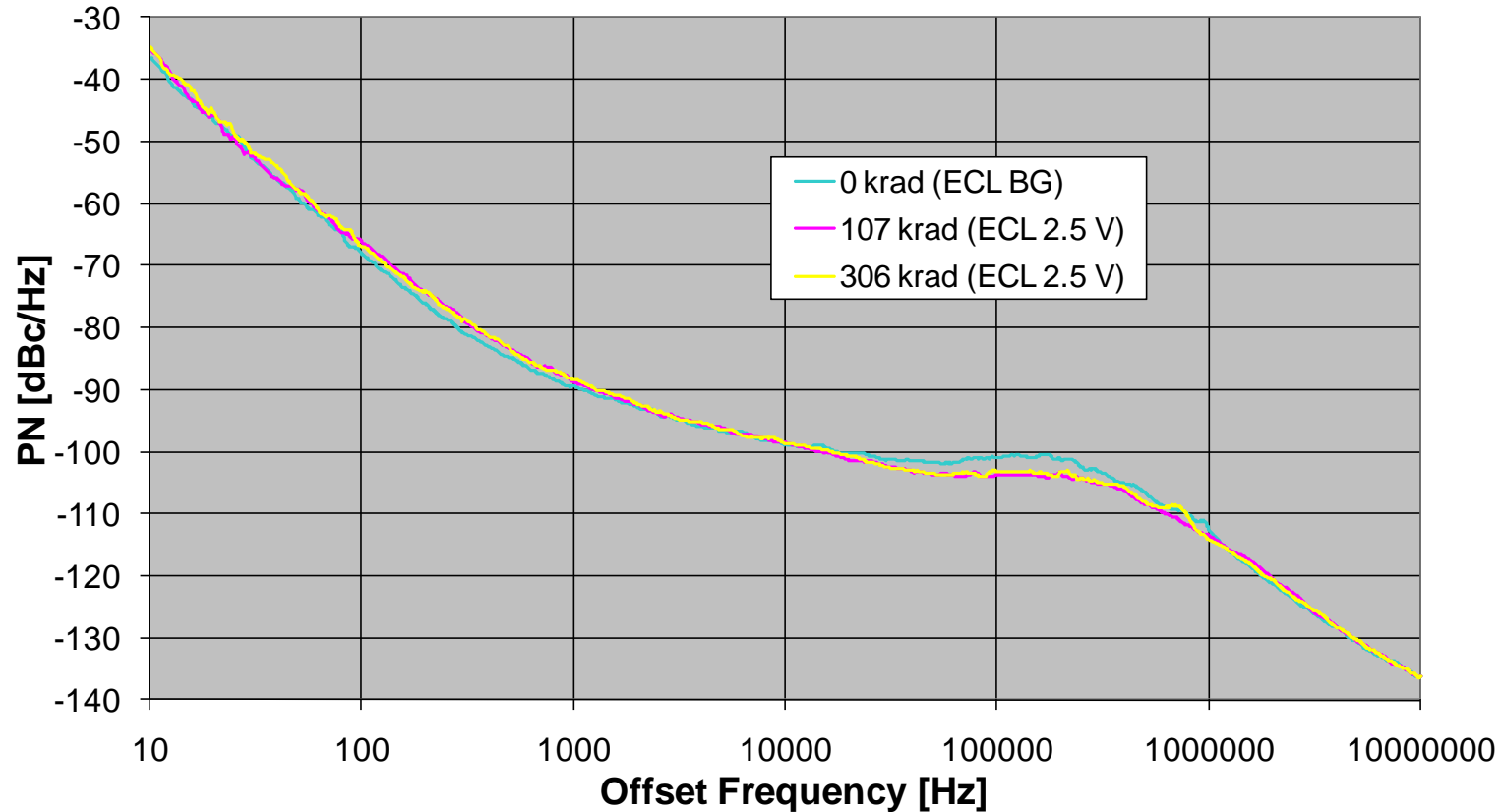
Integer-N performance at 9.8 GHz



Phase noise of the local oscillators up to 307 krad (dose rate 2 rad/s)

Integer-N performance measurement (8.2 GHz)

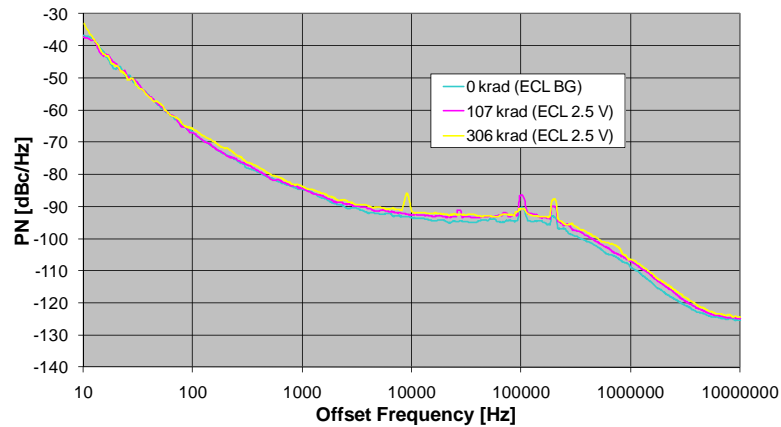
LO7-11



Phase noise of the local oscillators up to 307 krad (dose rate 2 rad/s)

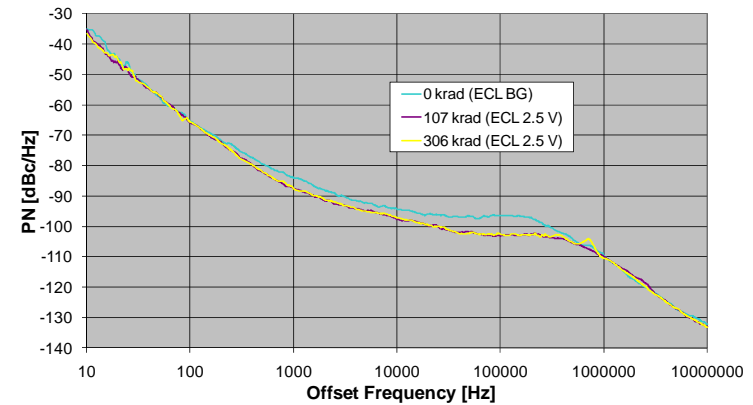
Fractional-N performance (8.6002 GHz)

L07-12



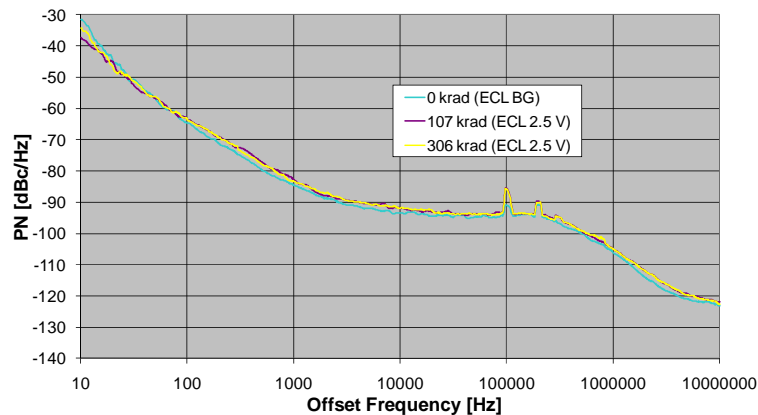
Integer-N performance (9 GHz)

L07-13



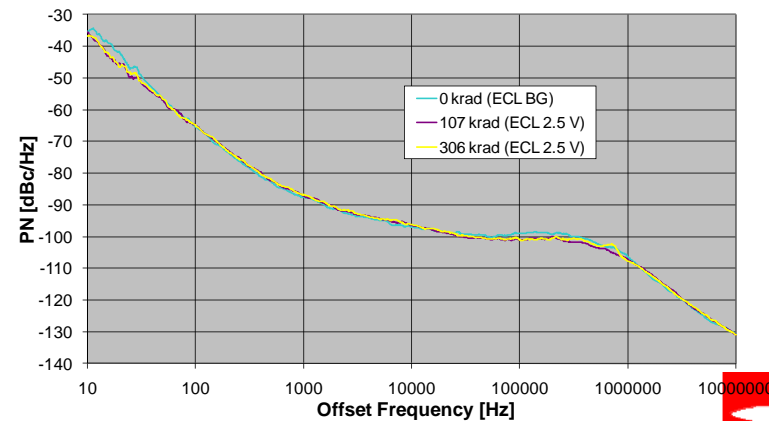
Fractional-N performance (9.4002 GHz)

L07-14

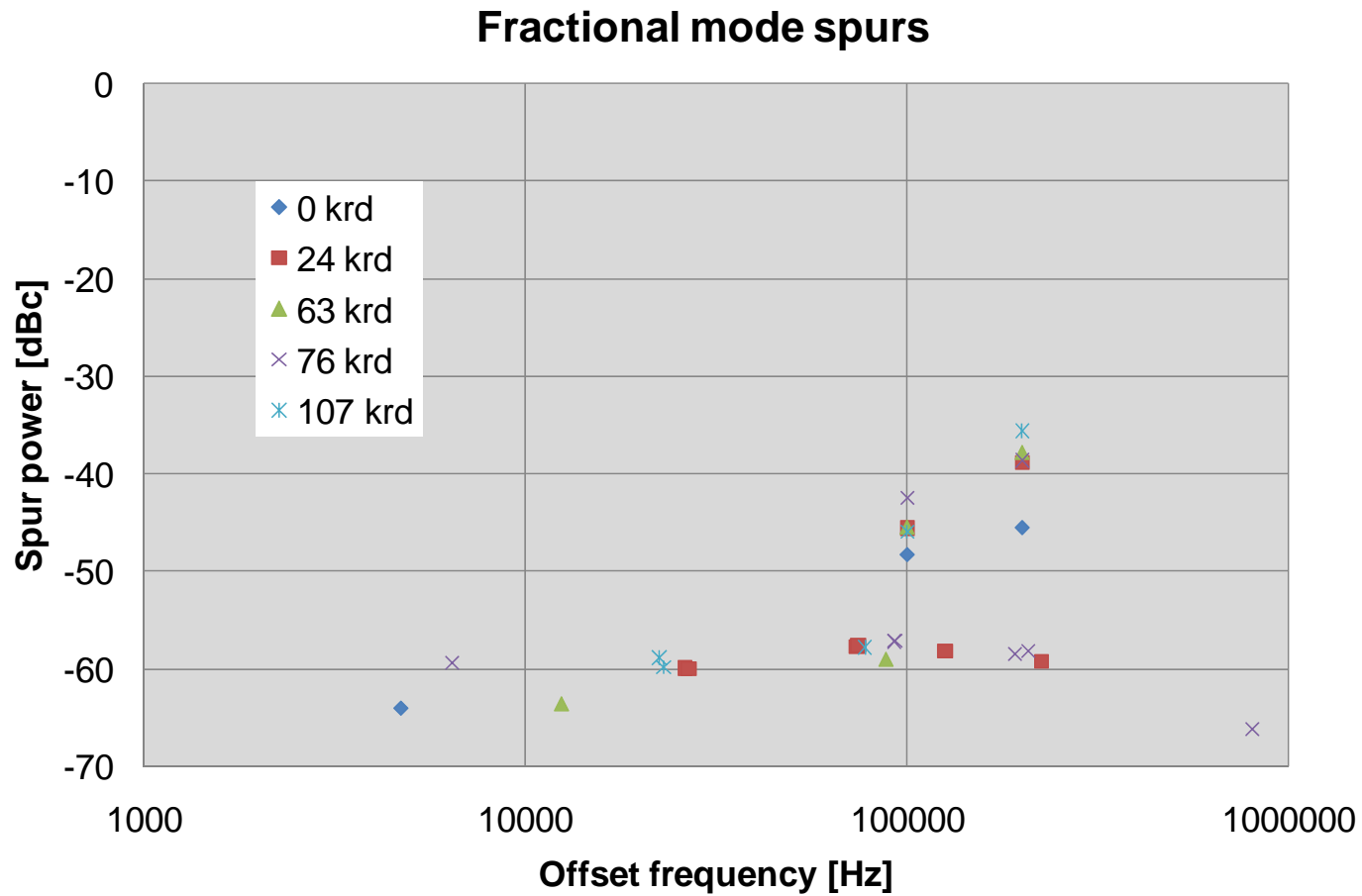


Integer-N performance (9.8 GHz)

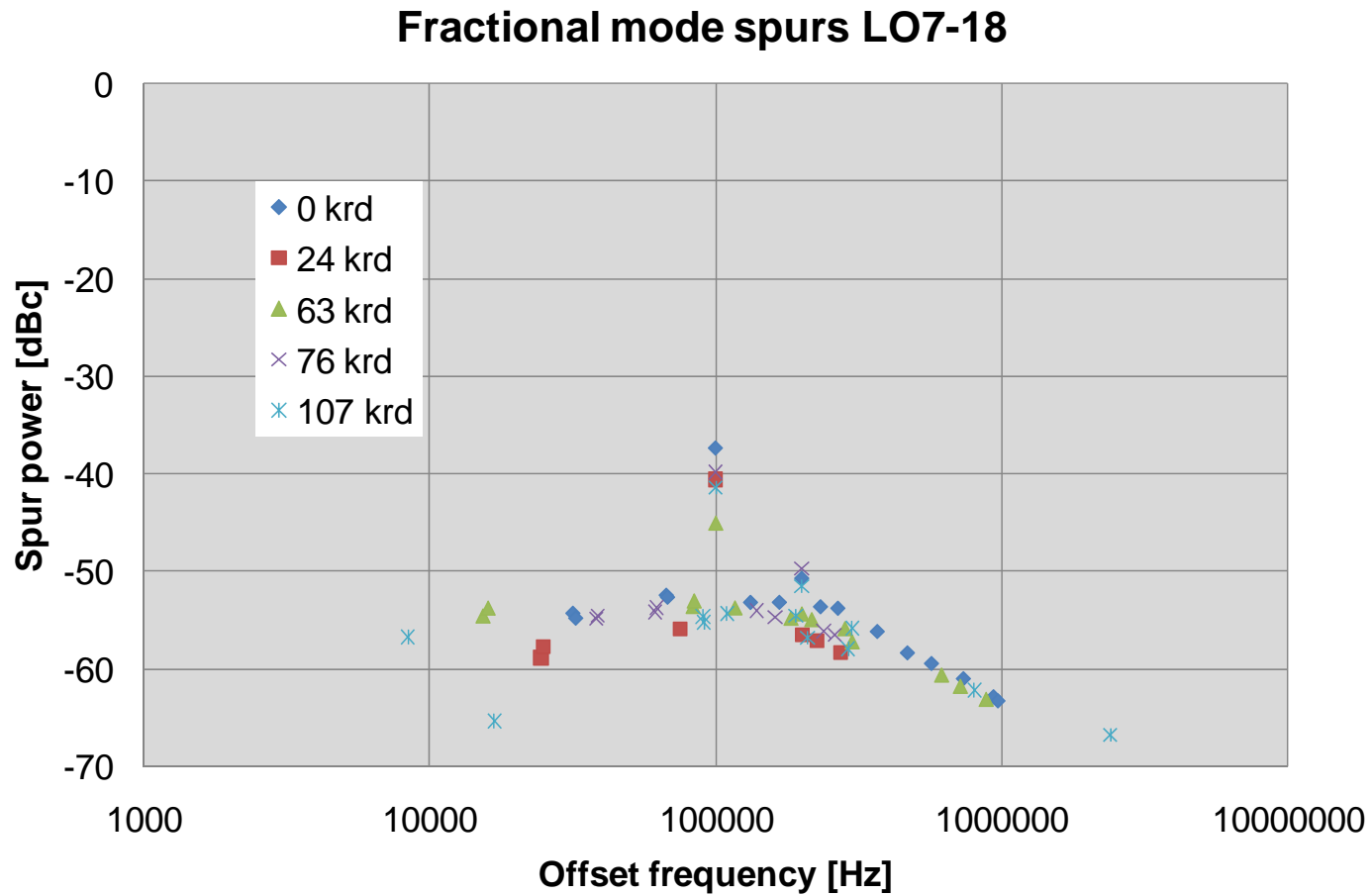
L07-15



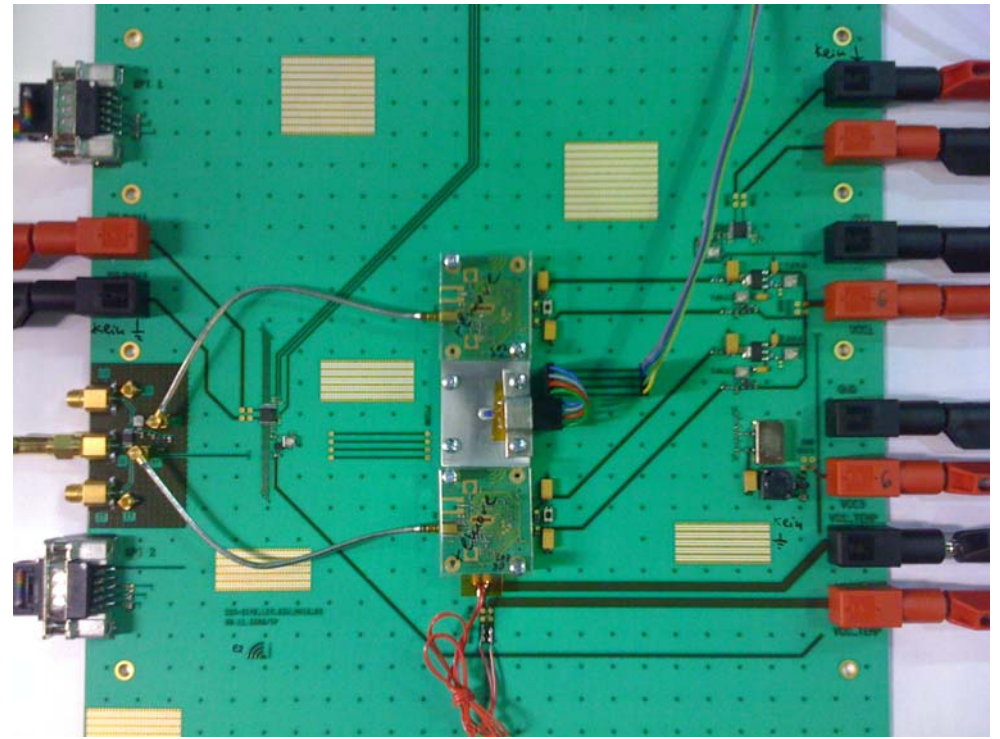
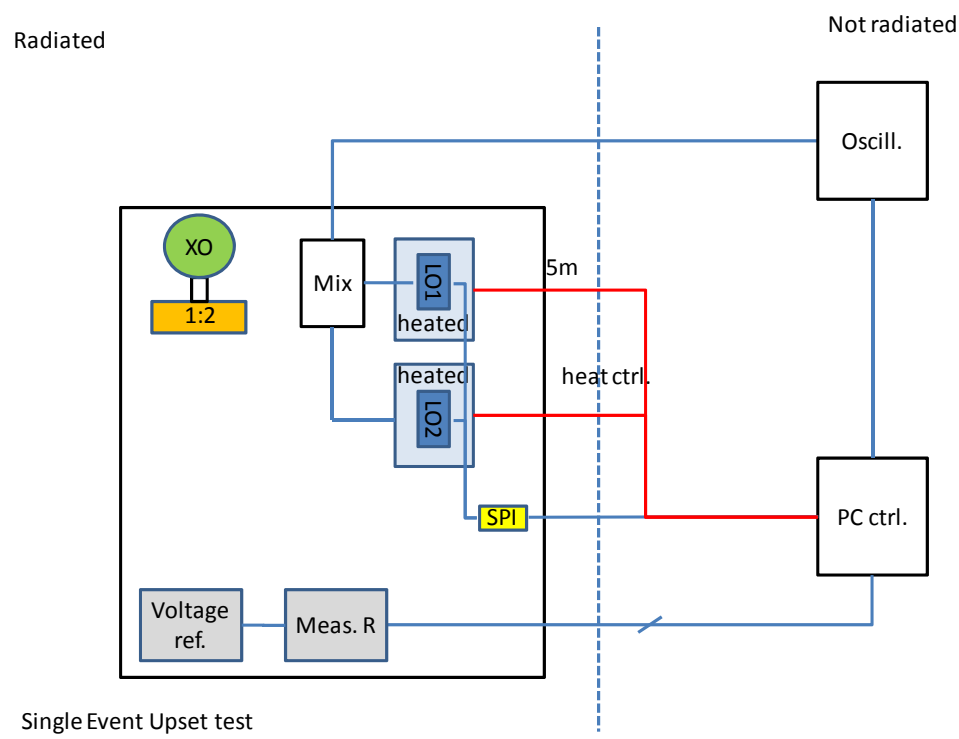
Spur level of the LOs depending on total dose (1)



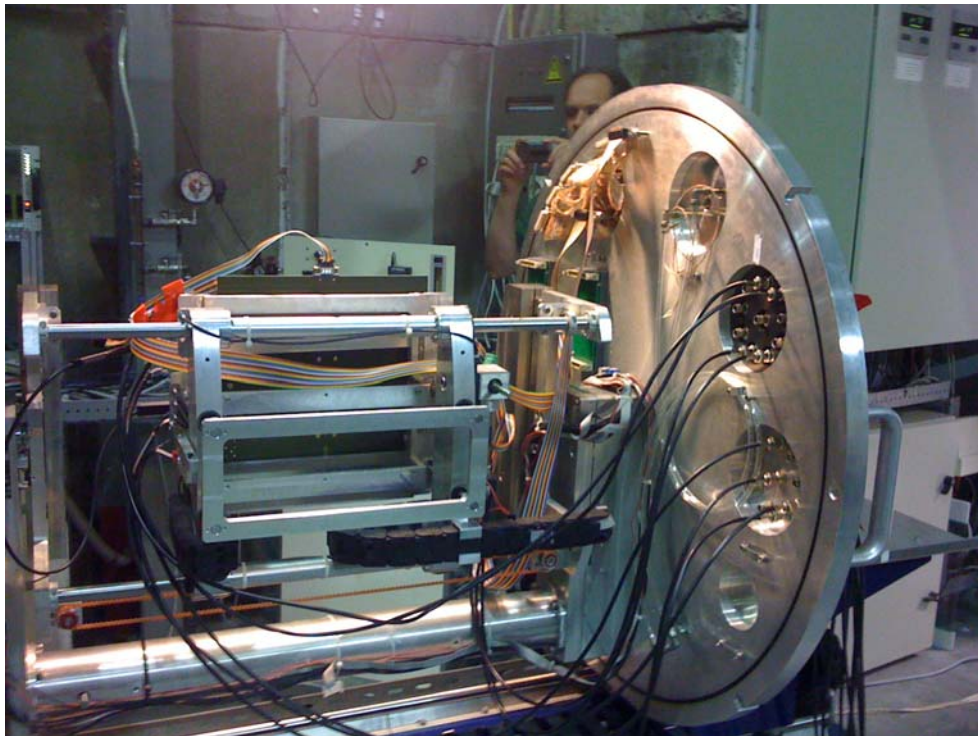
Spur level of the LOs depending on total dose (2)



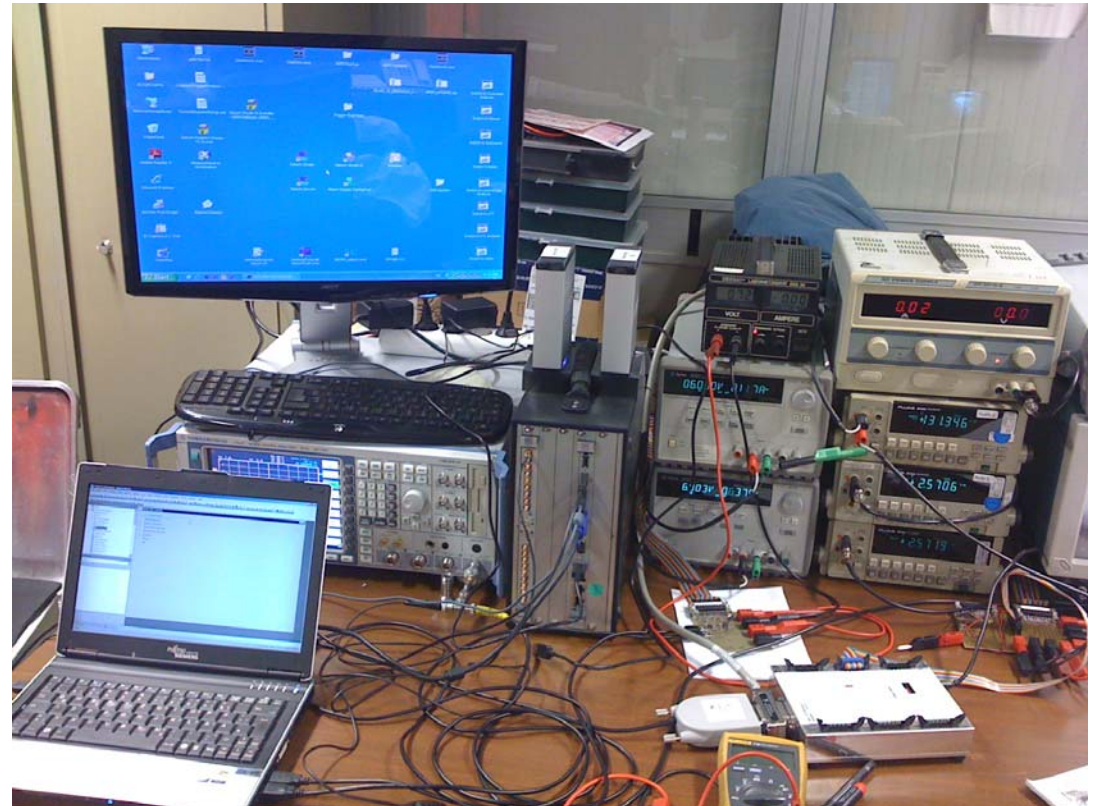
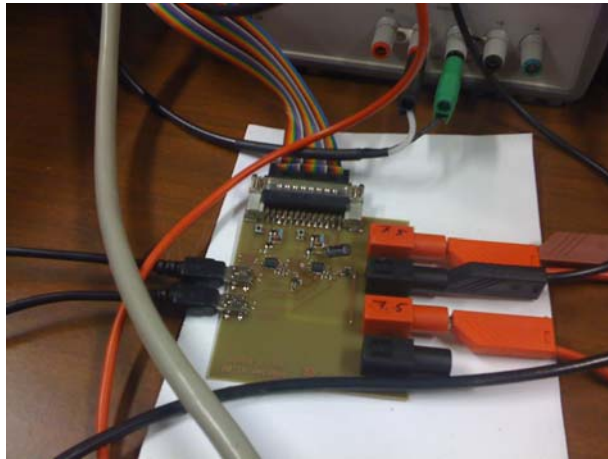
SEE test circuit block diagram and test board



Vacuum chamber for the SEE test board

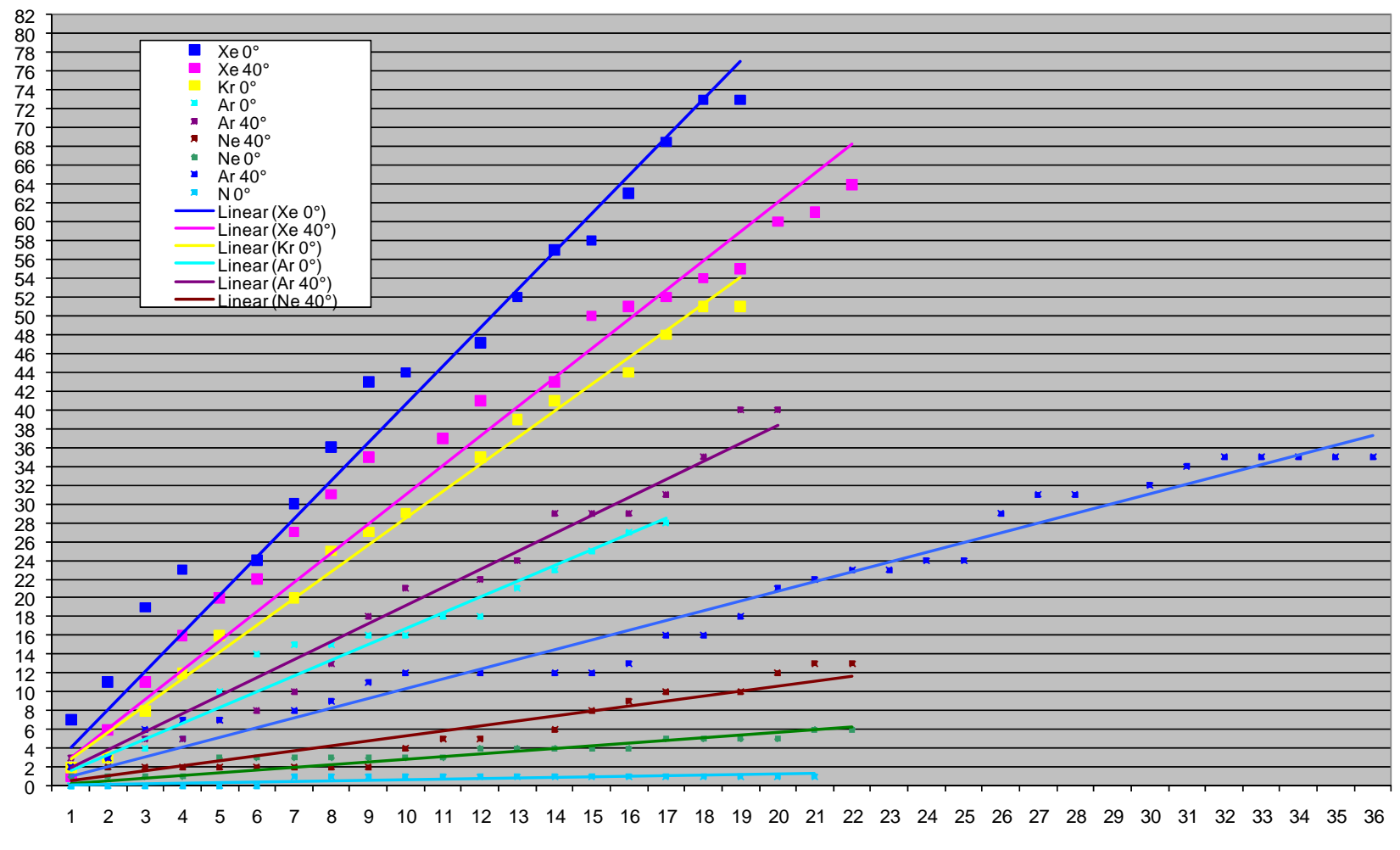


SPI board, Mux board, and measurement setup in control room for SEE test



Triple mode redundancy error counts vs. measurement time together with linear regression

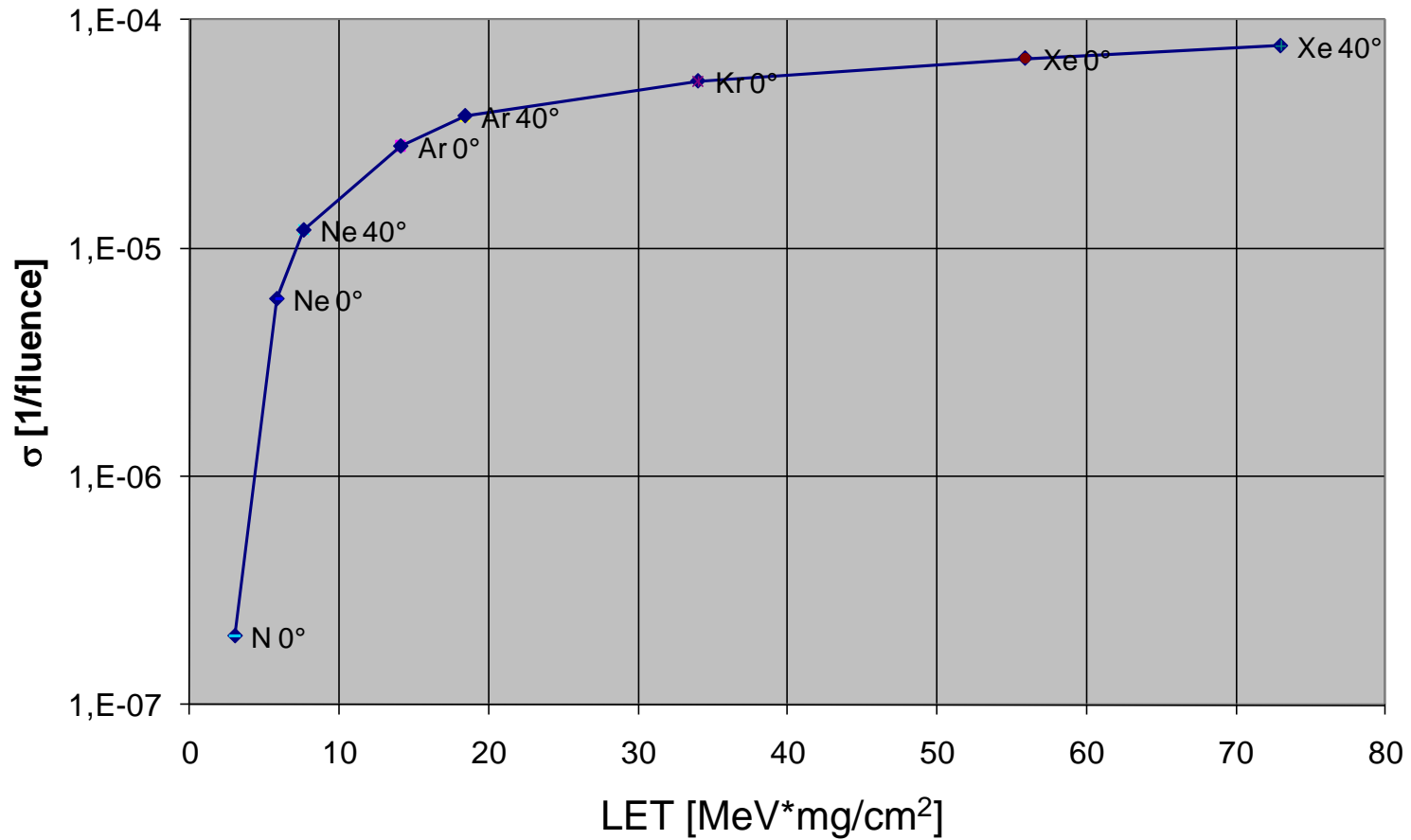
Error counter
[counts]



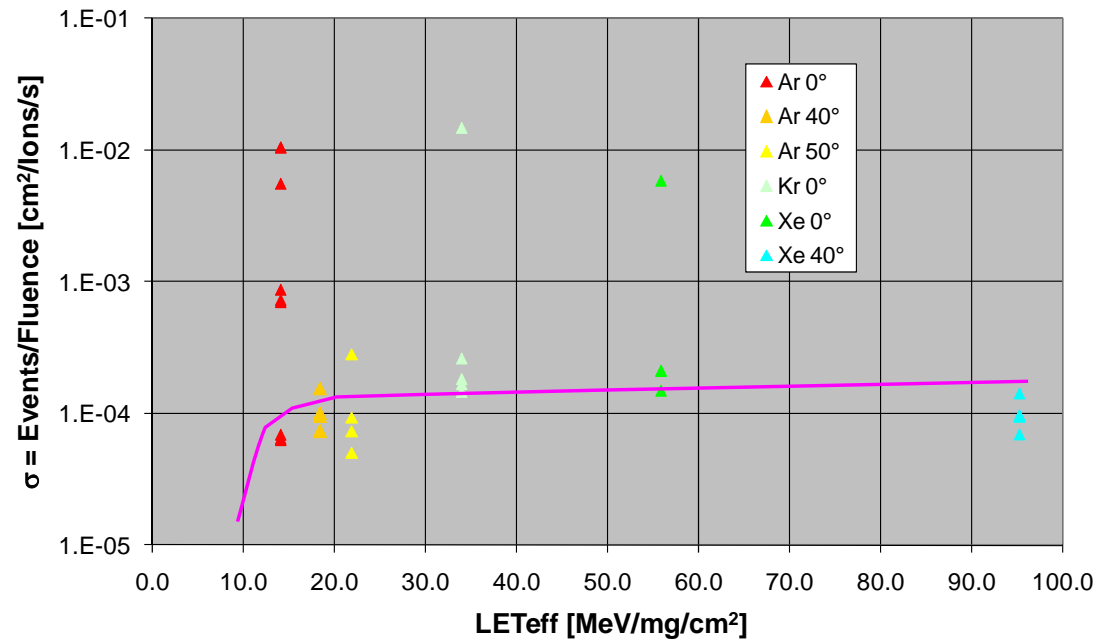
Time [s]



CMOS sensitivity to radiation



ECL sensitivity to radiation



Conclusion

- A single MMIC synthesizer (LO) with frequency range from 8.5 (8.2) to 11.7 (12.5) GHz has been demonstrated with acceptable phase noise
- Total dose up to 307 krad without degradation (internal bandgap will be replaced by external tested one) (low and high dose rate)
- MMIC LO is latch-up free
- SEU of the CMOS part behaved as expected (identical to the SGB25V structure tests)
- The threshold (non-corrected, excluding the triple mode redundancy) is at 3 MeV*mg / cm² (LET)
- SET behavior was difficult to measure in the UCL vacuum chamber environment due to EMI interference already without irradiation
- Sensibility testing with laser and circuit improvement is anticipated for SET.