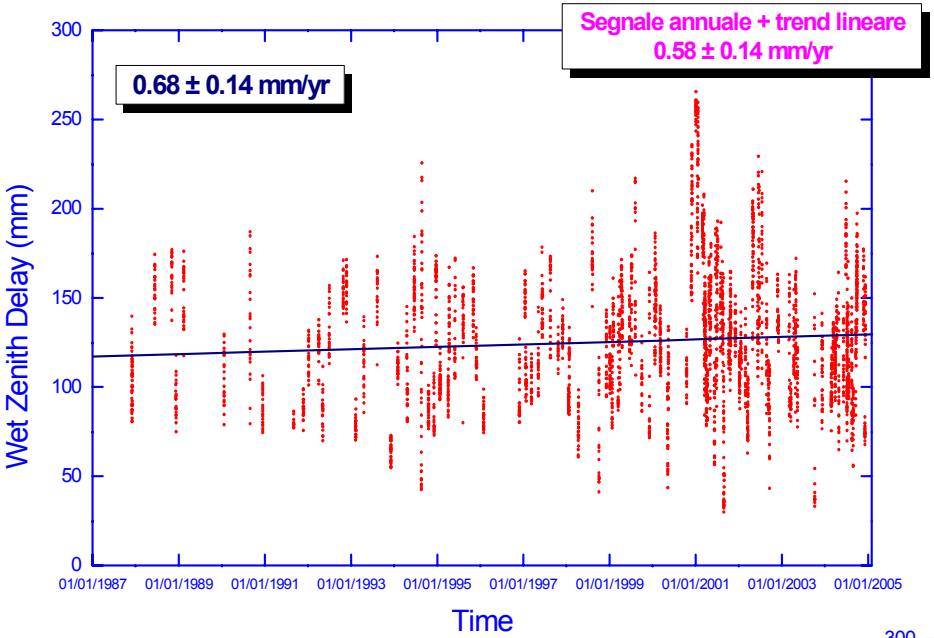
IS MEDICINA SITE SUITABLE FOR 90 GHz OBSERVATIONS?

A. ORFEI

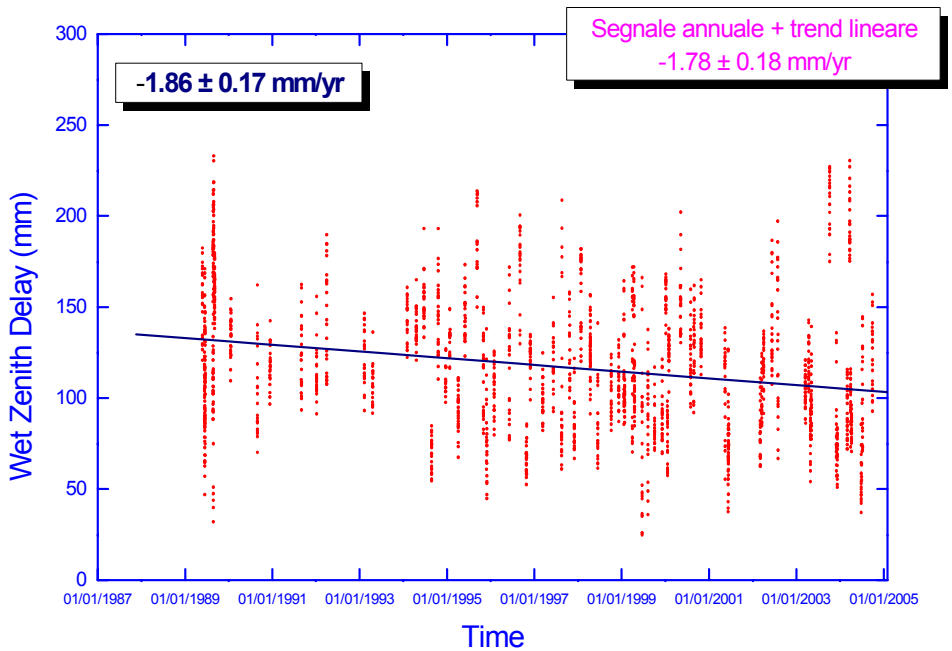
Medichat, 29 APRILE 2008



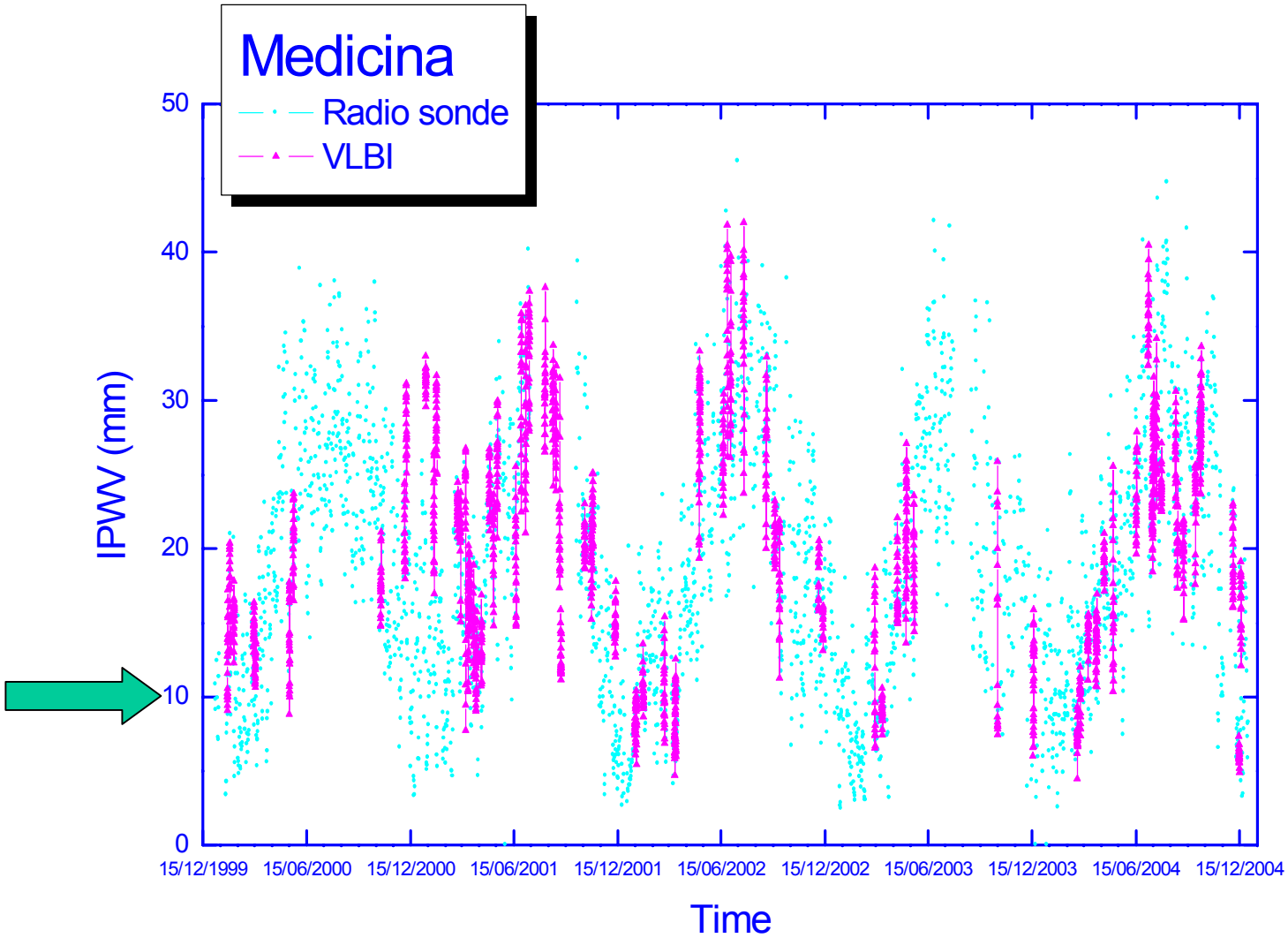
$$\frac{\mathrm{PWV(mm)}}{\mathrm{ZWD(mm)}} = 0.15 \pm 20\%$$

Medicina
1987-2005

Noto
1989-2005

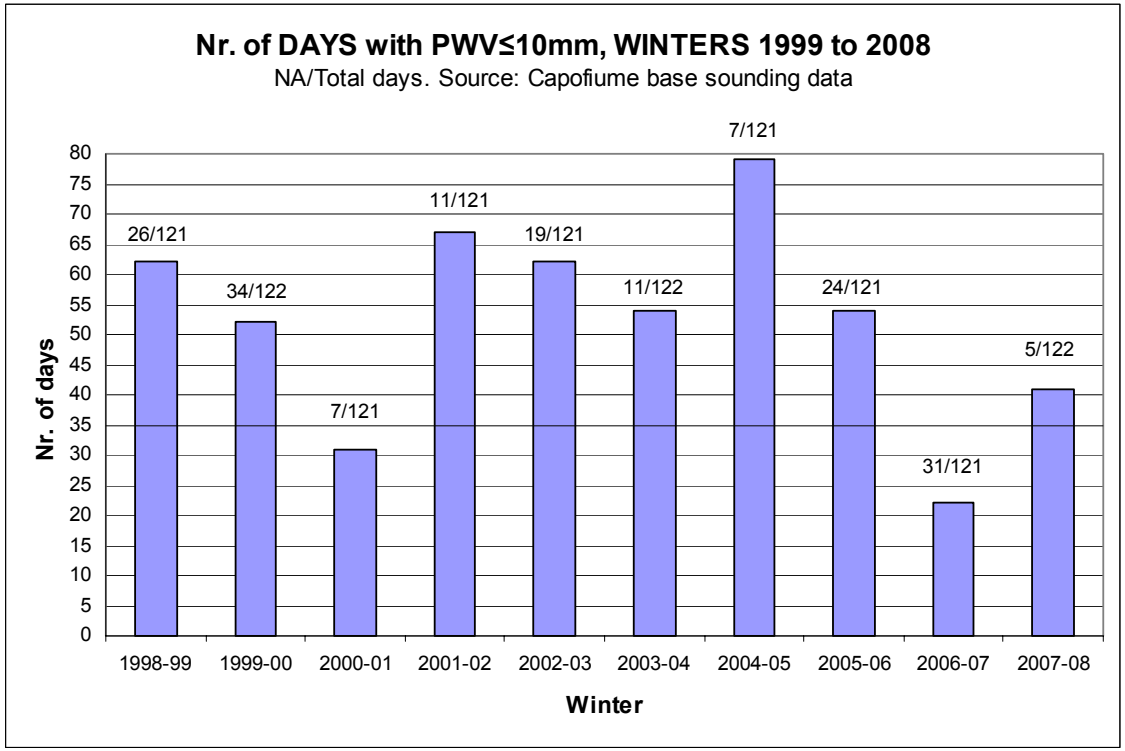


M. Negusini ; “Uso della tecnica VLBI nello studio del contenuto di vapore d'acqua in atmosfera e della sua variazione a medio e lungo termine.” Dottorato di Ricerca in Geofisica (XVI CICLO), Marzo 2005

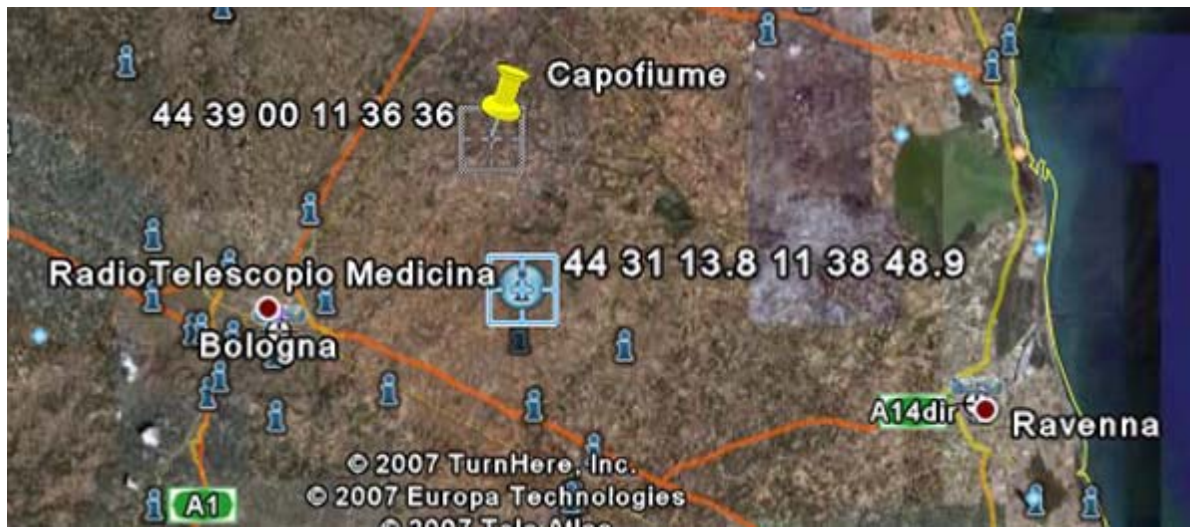


Medicina: periodo 1999-2004

M. Negusini ; "Uso della tecnica VLBI nello studio del contenuto di vapore d'acqua in atmosfera e della sua variazione a medio e lungo termine." Dottorato di Ricerca in Geofisica (XVI CICLO), Marzo 2005



Winters=1dec to 31march



FOR SITE EVALUATION, VARIOUS ALTERNATIVES

1º) radiometer

(costly ☹ ; takes years ☹ ; precise ☺ ; on site ☺)

2º) direct measures of τ_o (skydip)

(steals observing time ☹ ; precise ☺; on site ☺)

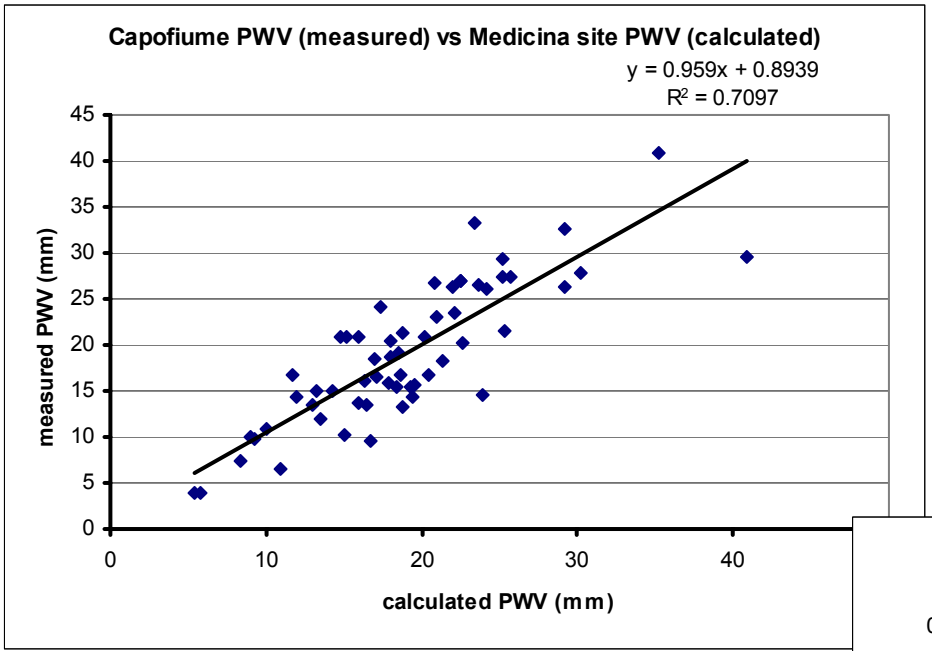
3º) PWV measures by sounding

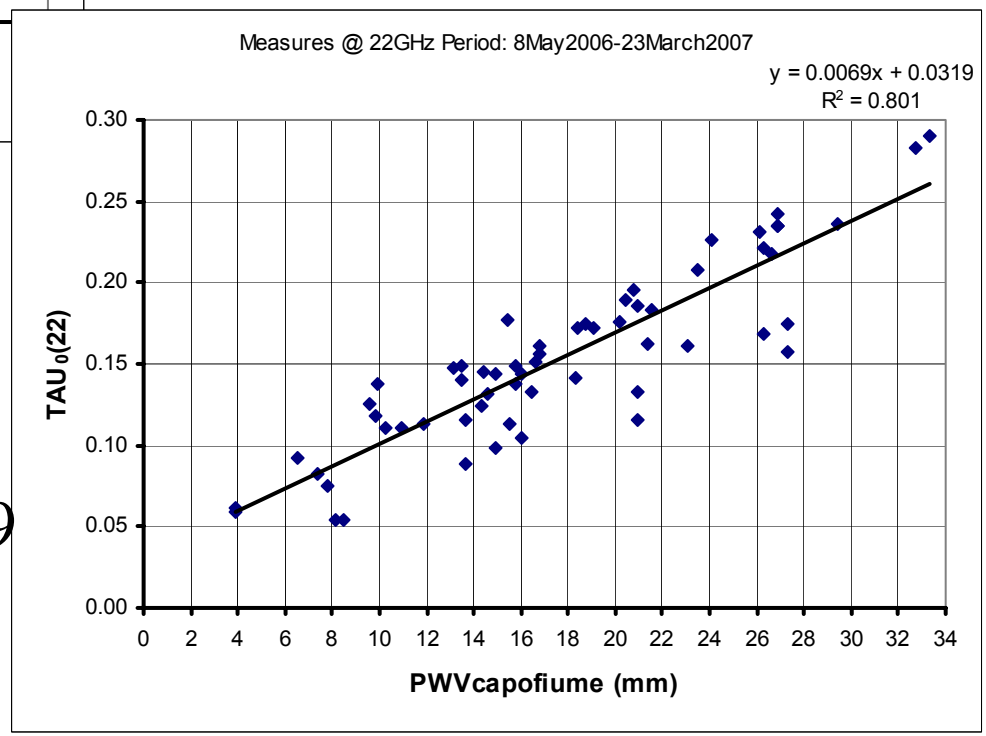
(precise ☺ ; off site ☹ ; indeterminate ☹)

4º) PWV calculation from (P,T,RH) values at ground

(inaccurate ☹ ; on site ☺)

SITE EVALUATION AT 90GHz: step1, measures at 22GHz



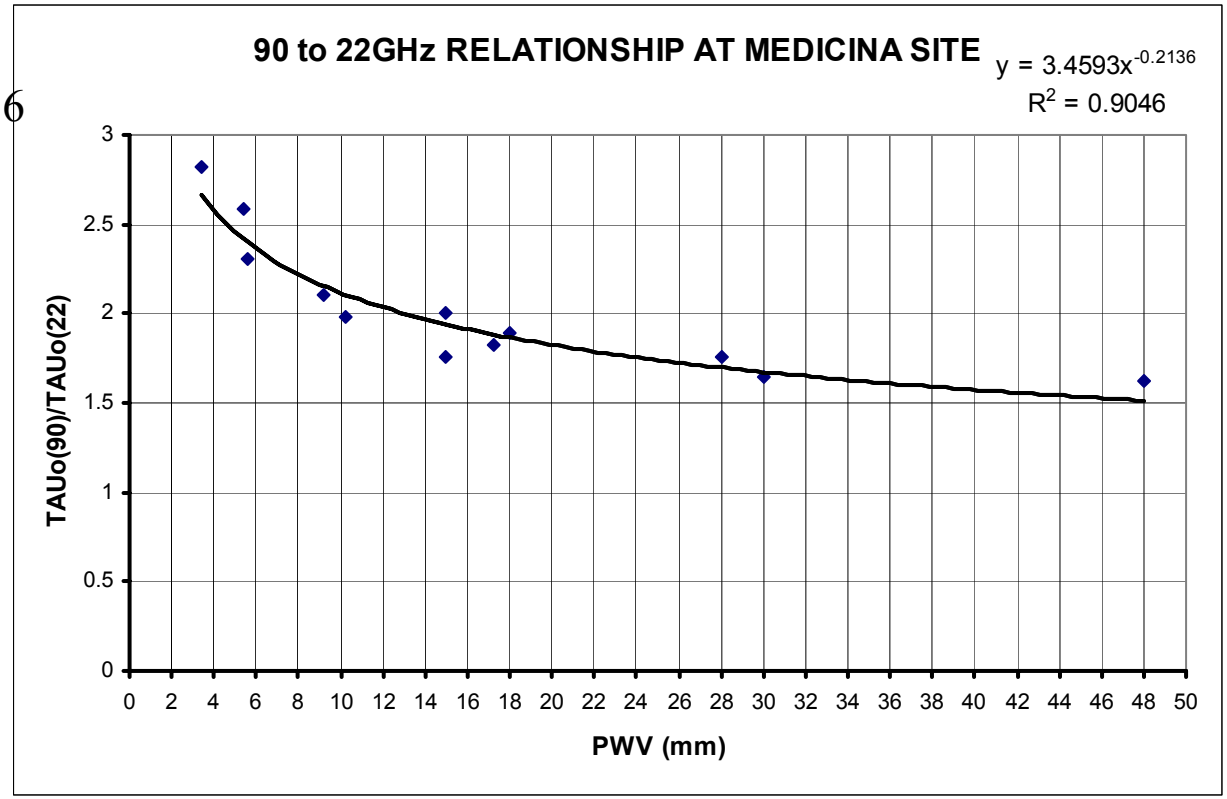


$$\tau_o(22) = 0.0069 * PWV + 0.0319$$

SITE EVALUATION AT 90GHz: step2, 90:22GHz ratio

USING "ATM" (Atmospheric Transmission at Microwave)

$$\frac{\tau_o(90)}{\tau_o(22)} = 3.4593 * \mathrm{PWV}^{-0.2136}$$

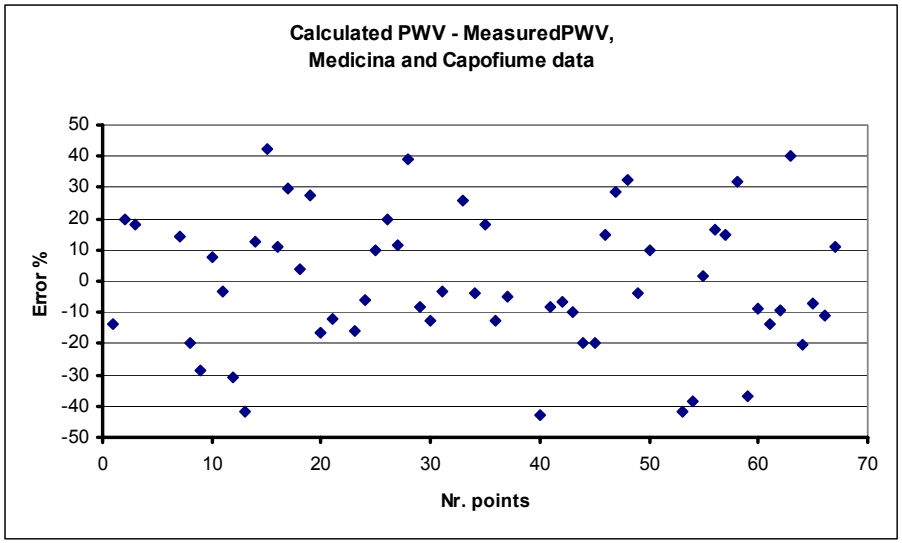


PWV(mm)	2	3.4	5.4	5.6	9.2	10.2	15	15	17.2	28	30	48
$\tau_o(90)/\tau_o(22)$	3.13	2.82	2.59	2.31	2.1	1.98	2	1.76	1.82	1.76	1.64	1.62

“EXCESS FACTORS” ON EVALUATION OF THE SITE

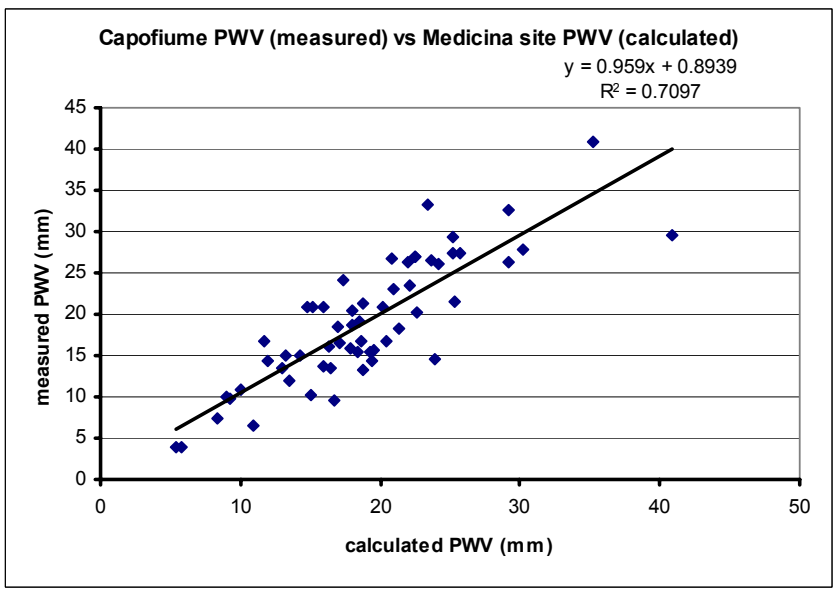
Excess factor 1: ON NOMINAL PWV VALUE

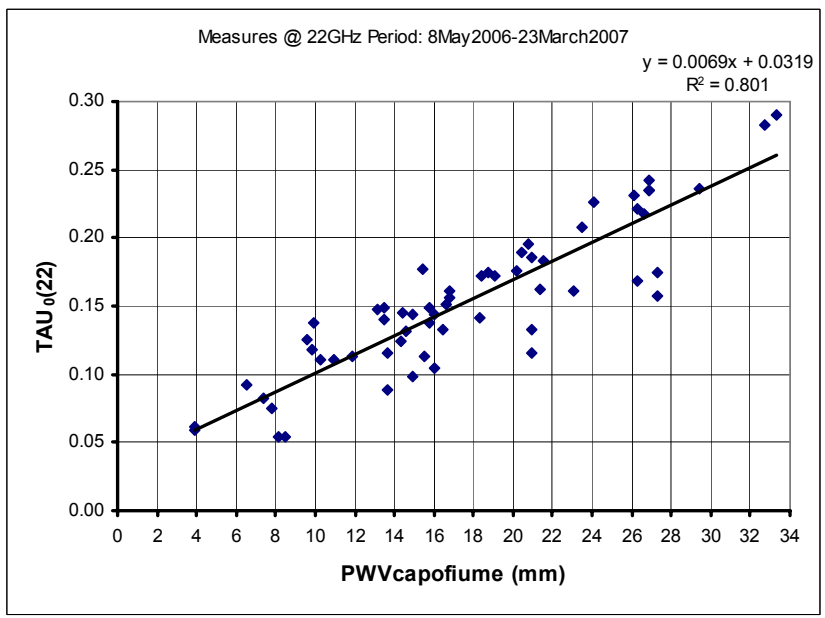
Excess factor 2: DAILY FLUCTUATIONS OF PWV



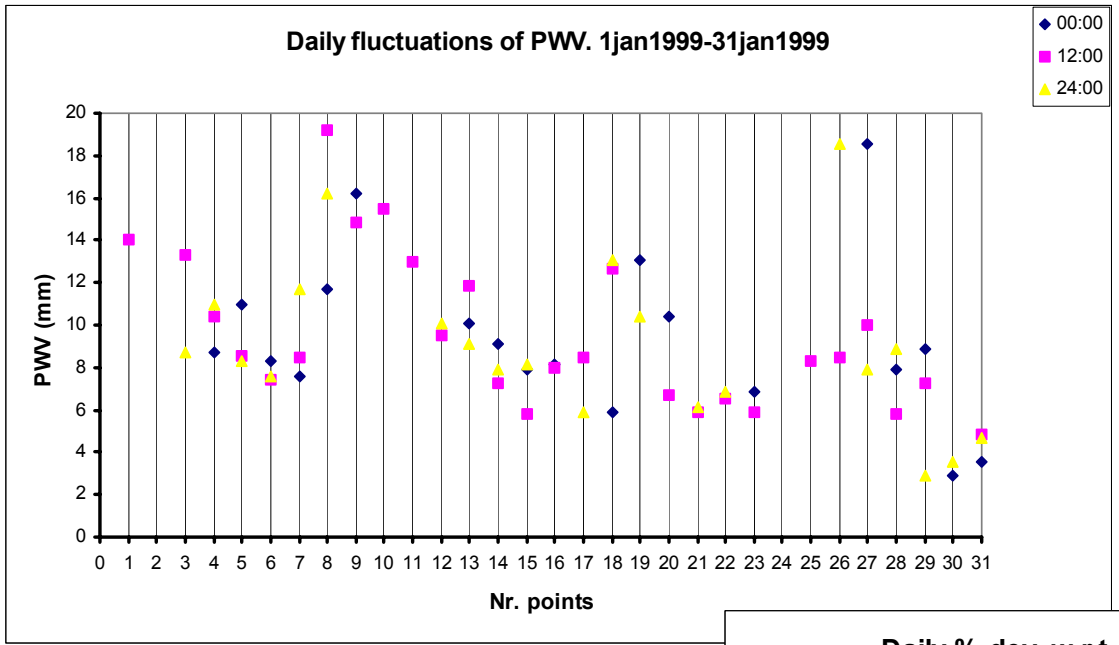
ON NOMINAL PWV VALUE

Excess factor 1 = 1.4



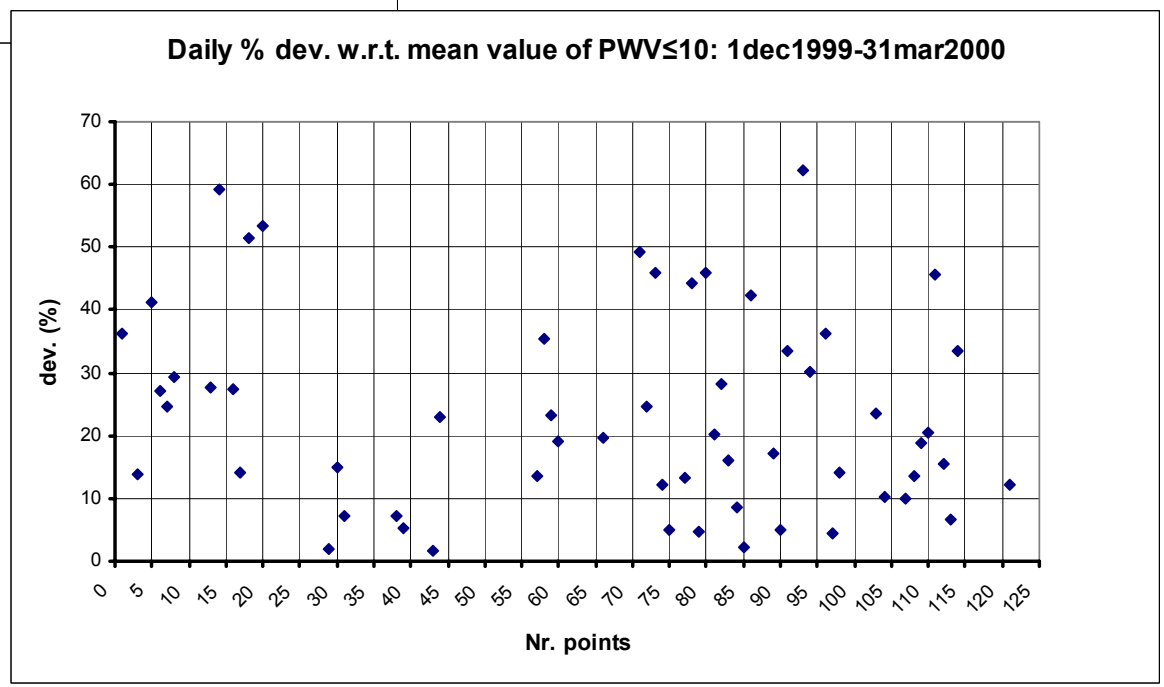


STATISTICS BASED ON WINTERS FROM 1999 TO 2007



ON DAILY FLUCTUATIONS OF PWV

Excess factor 2 = 1.25



FURTHER RESULTS FROM STATISTICS BASED ON WINTERS FROM 1999 TO 2008

a) Number of days where PWV < 8mm
b) Days with PWV≤10mm show absolute fluctuation ≤ 3mm
c) A lot of periods where PWV≤10mm lasts for consecutive days (Tab.1)

	December	January	February	March
1998-99	5;4;4	4;7;6;4	8;8;5	5
1999-00	3;3	2;2;4	6;8	3;6
2000-01	4	3	9;3	0
2001-02	22	19	0	4;9
2002-03	2	6;2;8	3;23	14
2003-04	3;4	4;5;4	2;9	5
2004-05	5;4;2	8;5;11	10;16	10
2005-06	3	14;8	6;6;3	2;3;3;3
2006-07	2;2;4	2;8	2;4	2
2007-08	2;5;4	2;2;2	13	2;4

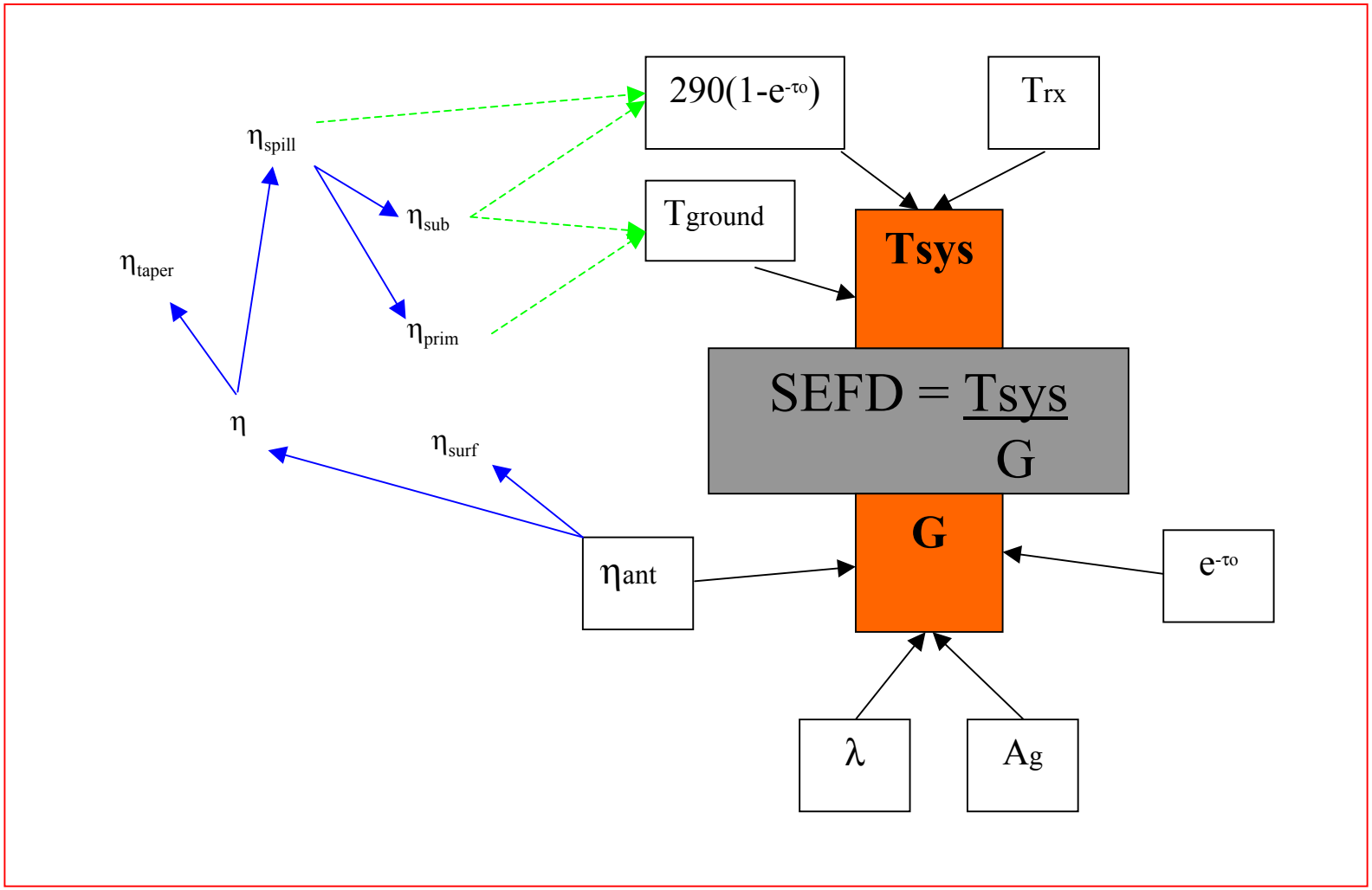
Tab.1 Consecutive days where PWV ≤ 10mm. Winters 1999-2008

SITE EVALUATION USING PWV IS NOT ENOUGH!

IS SEFD (**System Equivalent Flux Density**) at 90GHz SUFFICIENTLY LOW?

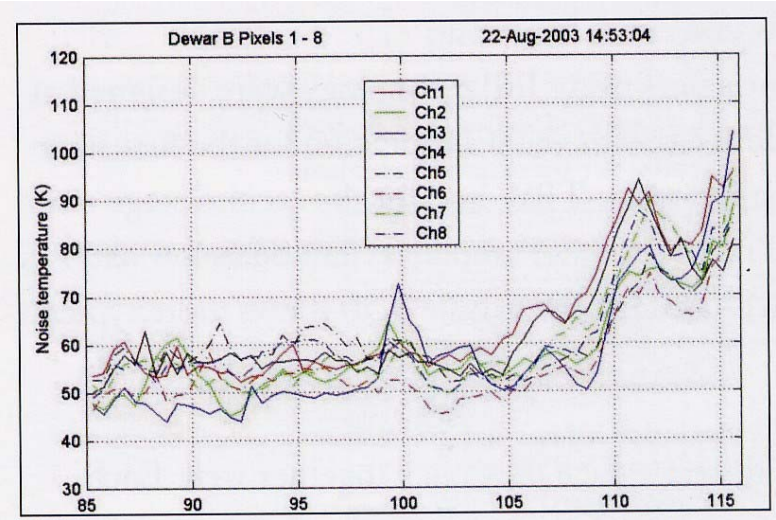
IN ORDER TO KNOW IT IS NECESSARY TO EVALUATE,

1º) which receiver performance we are able to obtain (T_{RX})
2º) which surface upgrade we are able to obtain (σ_{rms})
3º) the relationship among τ_o, T_{RX}, σ_{rms}, and the antenna illumination


290(1-e^-τo)
Trx
ηspill
ηsub
Tground
Tsys
ηtaper
ηprim
SEFD = Tsys / G
η
ηsurf
G
ηant
e^-τo
λ
Ag

ESTIMATION OF T_{RX} AT 90GHz

MULTIFEED "SEQUOIA", THE BEST KNOWN.



$T_{RX} = 60K$

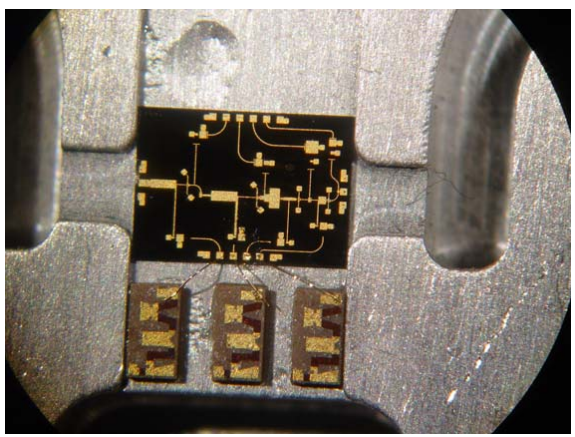
WE ?

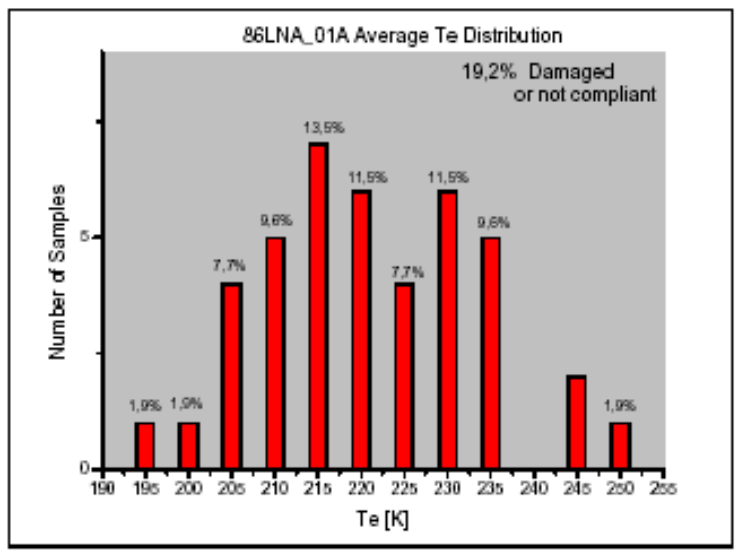
-same MMIC (70÷90GHz)

-$T_{LNA} \approx 300K$ not cooled, thus…

-…..$T_{LNA} \leq 75K$ cooled….

-…..$T_{RX} \leq 100K$





ESTIMATION OF ANTENNA GAIN DEGRADATION AT 90GHz

$$\eta_{surf} = e^{-(4\pi\sigma_{rms}/\lambda)^2}$$

σ_{rms} components (micron)		
Subreflector, wind	negligible	negligible
Subreflector, thermal	negligible	negligible
Subreflector, gravity	negligible	negligible
Subreflector, meas. error	15	15
Panel, wind	4	4
Panel, thermal	11	11
Panel, gravity	29	29
Panel, meas. error	25	25
Panel, manufacturing	65	65
Subreflector, manufacturing	50	50
Alignment	150	50
TOTAL σ_{rms} (RSS)	*176*	*105*

ELEMENTS TO CALCULATE THE SEFD

$$A = e^{-\tau_o / \cos(90-El)}$$

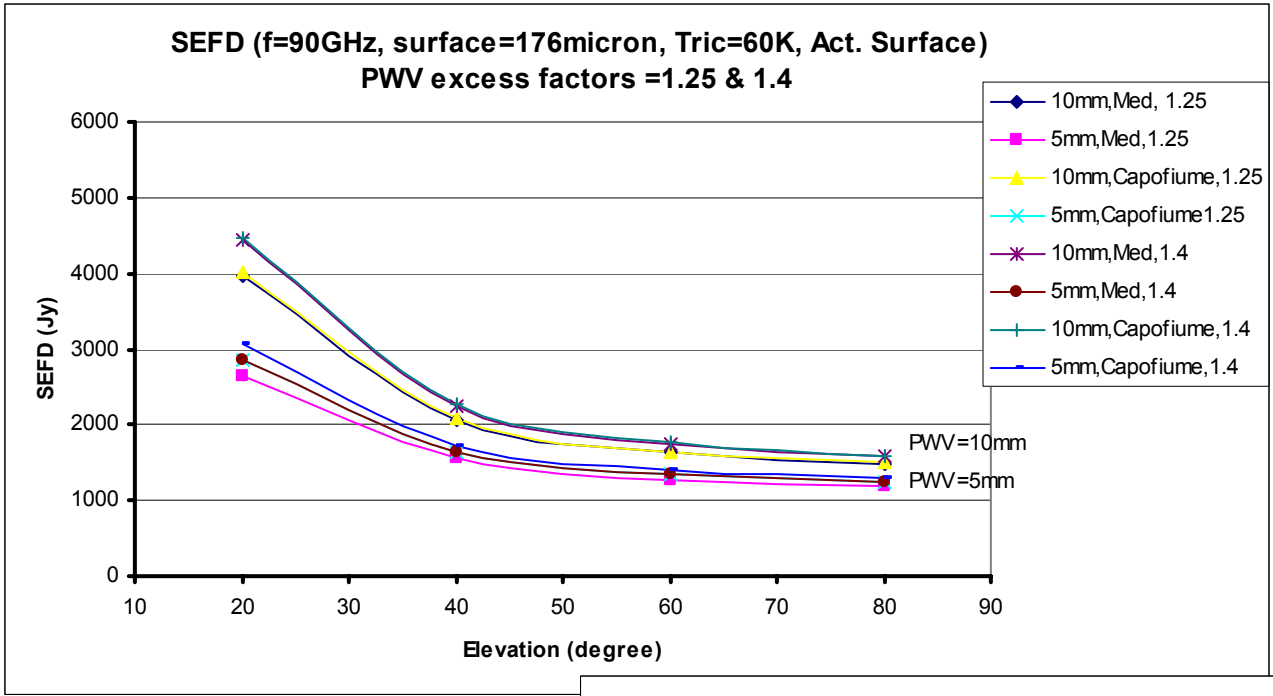
$$\eta_{ant} = \eta_{surf} * \eta_{spill} * \eta_{taper} * \eta_{ph} * \eta_{block} * \eta_{cross} * \eta_{diff}$$

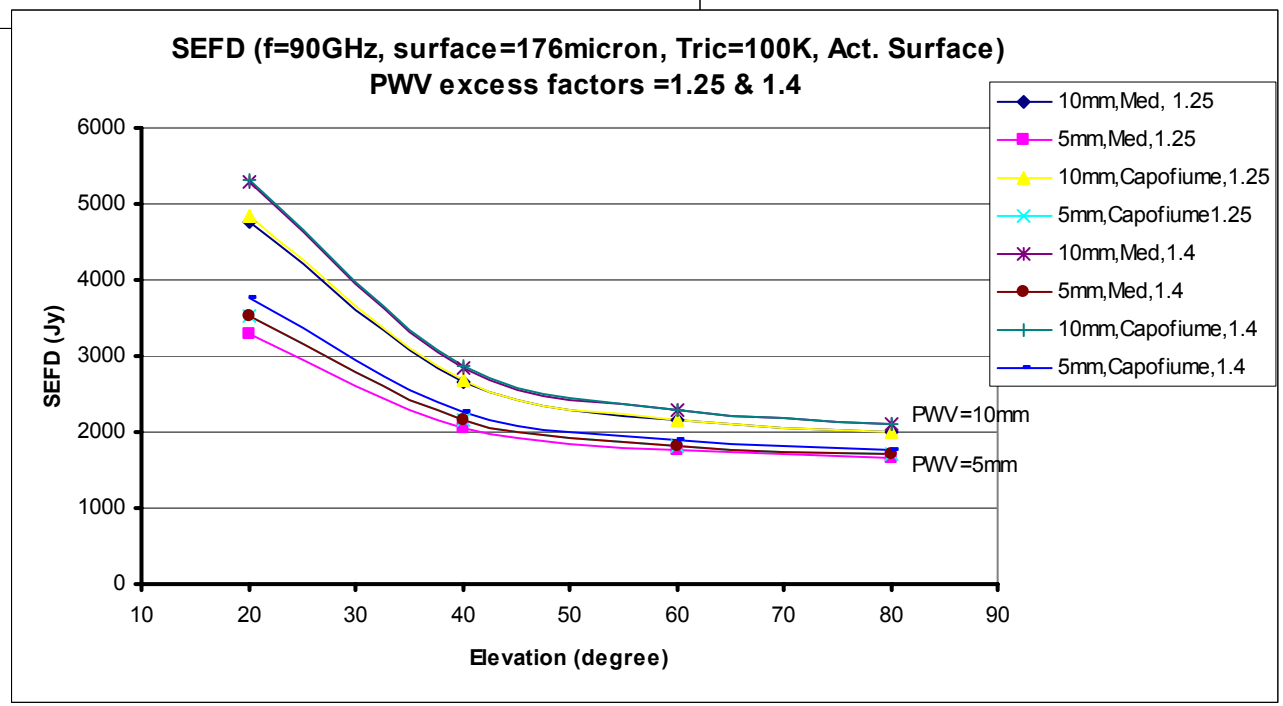
$$T_{spill} = \left((1-\eta_{sub})+\eta_{spill}\right) * [270 * (1-A) + 2.7 * A] + T_{ground} * \eta_{sub} * (1-\eta_{prim})$$

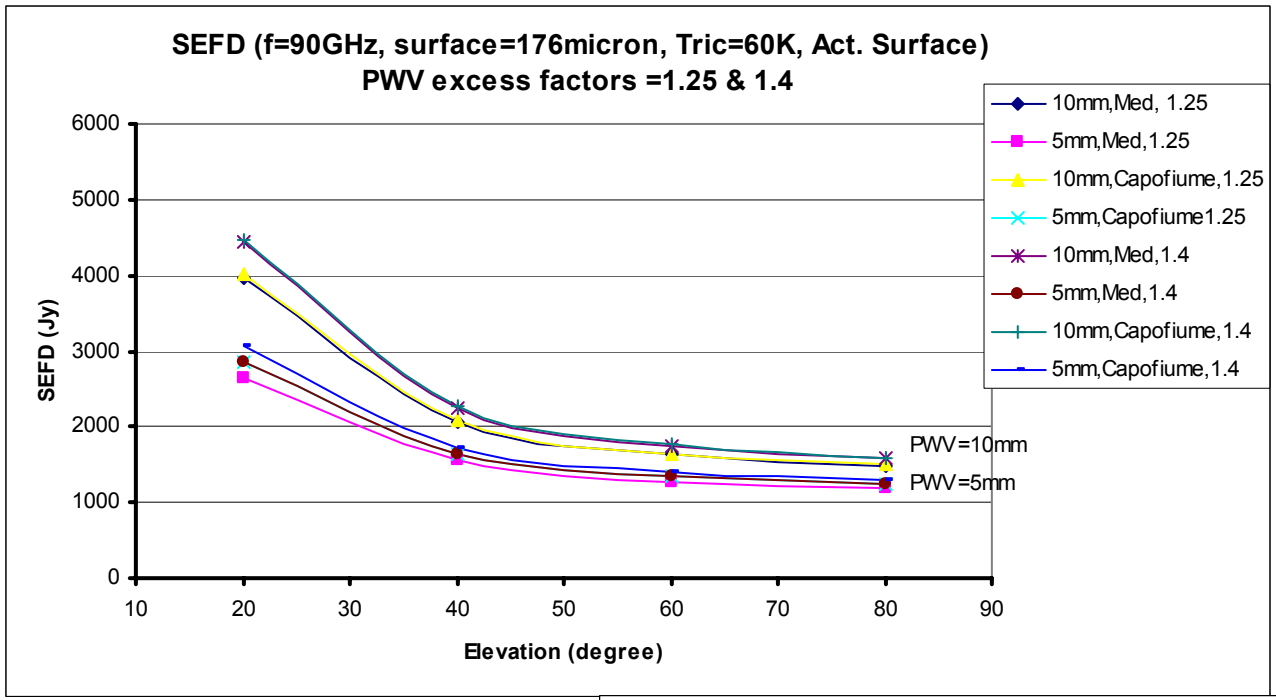
$$T_{sys} = T_{RX} + T_{spill}$$

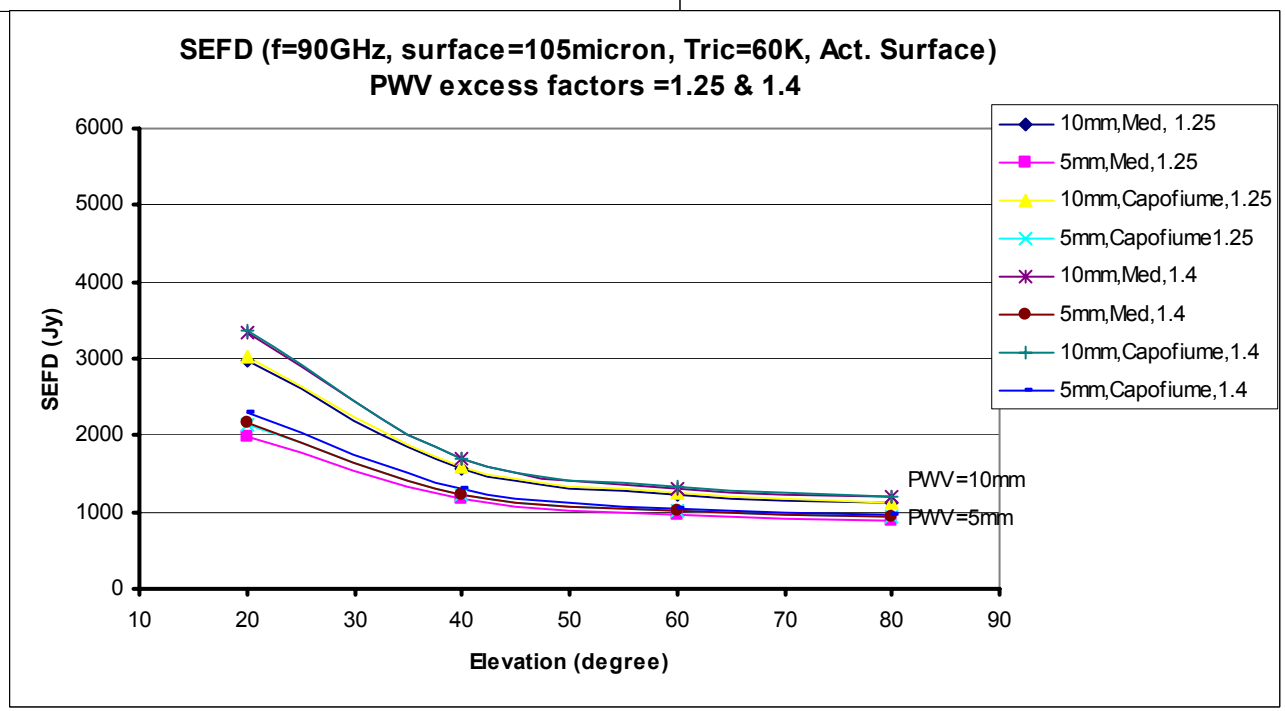
SEFD vs ELEVATION at 90 GHz FOR DIFFERENT PARAMETERS:

-2 vaues dof T_{RX} (60 and 100K)
-2 values of "excess factor" (1.4 and 1.25)
-2 values of σ_{rms} (176 and 105 micron)
-2 values of PWV≤ 10mm (5 and 10mm)
-2 sources for PWV (site and Capofiume)


SEFD (f=90GHz, surface=176micron, Tric=60K, Act. Surface)
PWV excess factors =1.25 & 1.4
SEFD (Jy)
Elevation (degree)
10mm,Med, 1.25
5mm,Med,1.25
10mm,Capofiume,1.25
5mm,Capofiume1.25
10mm,Med,1.4
5mm,Med,1.4
10mm,Capofiume,1.4
5mm,Capofiume,1.4
PWV=10mm
PWV=5mm


SEFD (f=90GHz, surface=176micron, Tric=100K, Act. Surface)
PWV excess factors =1.25 & 1.4
SEFD (Jy)
Elevation (degree)
10mm,Med, 1.25
5mm,Med,1.25
10mm,Capofiume,1.25
5mm,Capofiume1.25
10mm,Med,1.4
5mm,Med,1.4
10mm,Capofiume,1.4
5mm,Capofiume,1.4
PWV=10mm
PWV=5mm


SEFD (f=90GHz, surface=176micron, Tric=60K, Act. Surface)
PWV excess factors =1.25 & 1.4
SEFD (Jy)
Elevation (degree)
10mm,Med, 1.25
5mm,Med,1.25
10mm,Capofiume,1.25
5mm,Capofiume1.25
10mm,Med,1.4
5mm,Med,1.4
10mm,Capofiume,1.4
5mm,Capofiume,1.4
PWV=10mm
PWV=5mm


SEFD (f=90GHz, surface=105micron, Tric=60K, Act. Surface)
PWV excess factors =1.25 & 1.4
SEFD (Jy)
Elevation (degree)
10mm,Med, 1.25
5mm,Med,1.25
10mm,Capofiume,1.25
5mm,Capofiume1.25
10mm,Med,1.4
5mm,Med,1.4
10mm,Capofiume,1.4
5mm,Capofiume,1.4
PWV=10mm
PWV=5mm

CONCLUSIONS:

-MEDICINA, AND PRESUMABLY NOTO, ARE SUITED FOR 90 GHz OBSERVATIONS

-IN WINTER, IN A NOT NEGLIGIBLE QUANTITY OF DAYS

-A SUITABLE ANTENNA UPGRADE MAKES ACHIEVABLE GOOD PERFORMANCES AT 90 GHz FOR A SEA LEVEL ANTENNA!

DETAILED INFO IN TECHNICAL REPORT
IRA 418/08

FINE