# Feedhorn Analysis for Parabolic Dish G/T

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Analysis and optimization of parabolic dish antennas and feeds has largely been aimed at maximizing efficiency, to realize as much gain as possible for a given reflector diameter. Several of my previous papers[1,2] have analyzed various feedhorns to determine resulting dish efficiency. In this paper I will add **G/T** calculations to the feedhorn analysis

At popular microwave EME frequencies, between 1.2 and 10.4 GHz, sky noise is very low. Modern preamplifiers have very low noise figures, so the noise contribution is also small. The remaining limitation on receiver sensitivity is the noise contributed by the antenna, which includes all sources, not just sky noise. Thus, it is important to minimize the noise of the antenna expressed as a temperature, **T**, as well as maximizing the gain, **G**. A useful metric is **G/T**, the ratio of gain to noise temperature. Ultimate signal-to-noise ratio is set by the antenna **G/T** – the rest of the system can only make it worse. An increase in **G/T** improves the receive capability, while only the gain affects the transmit signal

A 1984 paper by Peter Riml, OE9PMJ, apparently unpublished but provided to me by SM6FHZ, shows calculations accounting for spillover to derive "reception performance" for a W2IMU dual-mode feed. The paper is included as Appendix A. In 1992, Hannes Fasching, OE5JFL, published a paper[3] on computer simulation of dishes and feeds, including **G/T** calculations with some simplifying approximations. He emphasized that **G/T** is most important for EME. More recently, OM6AA[4] and RA3AQ[5] have examined **G/T** of dish antennas. RA3AQ did a full EM simulation analysis of several feedhorns and dish sizes, and used **ANTC** software[6] from OM6AA to calculate **G/T**.

Ideally, we would perform a full EM analysis of each feedhorn with dishes of all sizes and ***f*/D**, but this would require a huge amount of computer resources and human interpretation of the results. I no longer have regular access to EM software to perform the simulations, but I do have simulation results for many feed antennas which I used to calculate dish efficiency for these feeds with my **PHASEPAT** program. While **G/T** may be inferred from spillover curves in the calculated efficiency plots, a numerical comparison is more useful. I added noise calculations to the program to see if **G/T** could be quickly calculated as well. Comparison with RA3AQ data showed agreement within about one dB, so it seems that the approximations are reasonably accurate.

## Examples – Popular Feeds

For two popular high-efficiency feeds, the Super-VE4MA feedhorn[1] and the W2IMU dual-mode horn[7], the calculated **G/T** curves are overlayed on dish efficiency plots in Figures 1 and 2, respectively, for a 20λ dish. Sky noise at 23cm is estimated as 5.7K by RW3BP[5]. The **G/T** curves are shown for dish elevations of 20, 45, and 70 degrees, covering the useful elevations for most EME stations. The curves are not significantly different over this range of elevations; at very low elevations, ground noise becomes a much larger factor and **G/T** deteriorates. These **G/T** curves are for prime-focus dishes only.

Curves for both feeds show the dish ***f*/D** for best **G/T** is smaller than the ***f*/D** for best efficiency. This is not surprising, since spillover is less for smaller ***f*/D**. What is interesting is that, without considering the receiver noise contribution, the W2IMU feed shows better **G/T** than the VE4MA for deep dishes, with ***f*/D** in the range of 0.3 to 0.4, even though the efficiency falls off significantly in this range.

These two feeds, among the best for efficiency, are also among the best for **G/T**. Curves for some other popular feeds are included below.

## G/T Calculation

**G/T** is simply the ratio of gain to noise temperature, usually expressed in dB.

The gain is calculated by multiplying the potential gain of the geometric area of the dish reflector by the calculated efficiency of the dish and feed. The efficiency (η) is calculated by integrating with the full feed radiation pattern $\boldsymbol{U(\theta,\phi)}$ from EM simulations:

$$\eta = \frac{\iint_{reflector} U_{CP}(\theta,\phi) sin\theta \, d\theta d\phi}{\iint_{sphere} U_{all}(\theta,\phi) sin\theta \, d\theta d\phi}$$

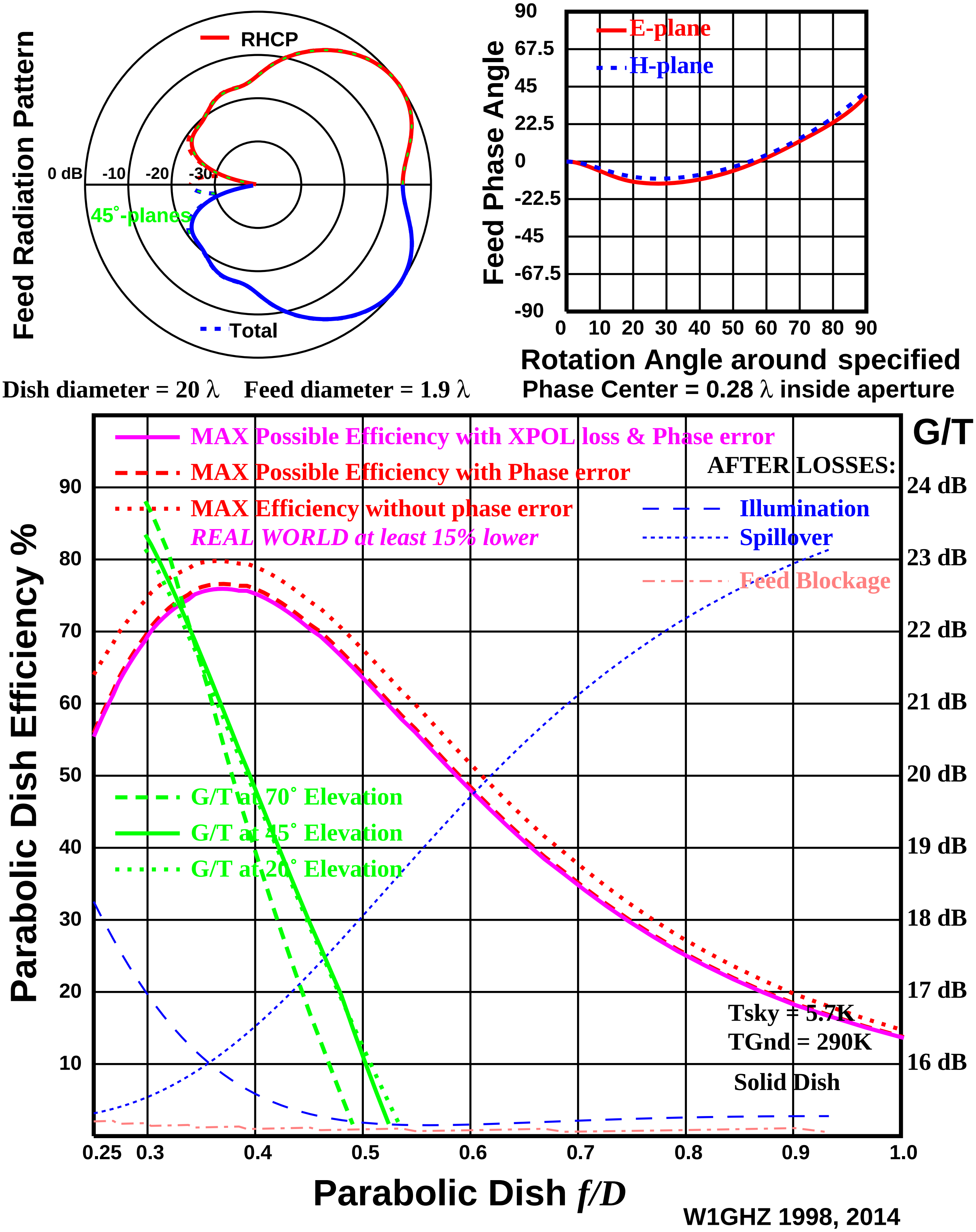
The numerator is the integration of the feed pattern for the desired polarization over the dish surface, while the denominator is the integration of the feed pattern for all polarizations (total power) over the full radiation sphere. Since phase and polarization are included in the calculation, the calculated efficiency includes phase and XPOL errors, but not other factors that typically reduce efficiency in the real world by 15% or more.

The efficiency is calculated for each ***f*/D** by integrating over the corresponding reflector illumination angle.

Noise temperature may be calculated by multiplying the feed pattern by the noise pattern and integrating over the full radiation sphere; noise has no polarization so the feed patterns are total power including all polarizations. Noise patterns for offset dishes are different than the noise

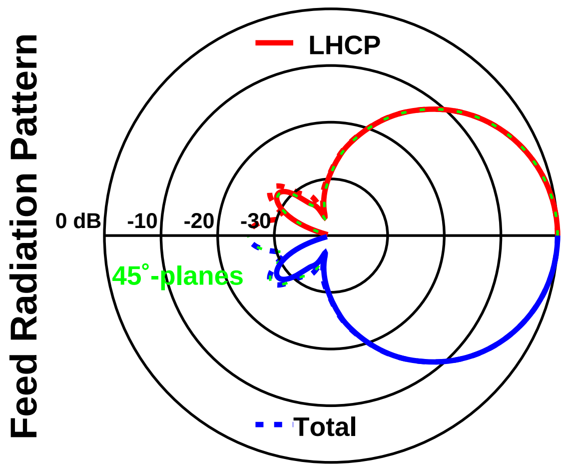
# Super VE4MA, choke 0.6λ wide x 0.45λ deep, back 0.15λ, RHCP

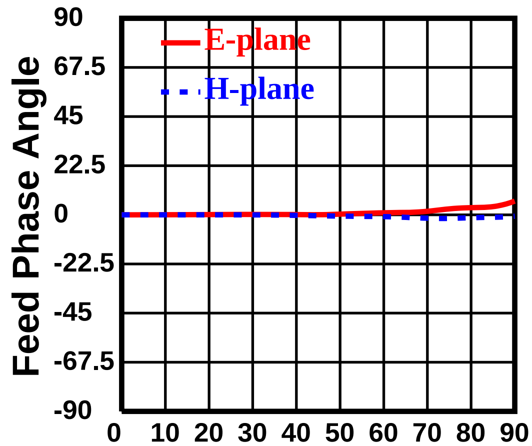
## Figure 1



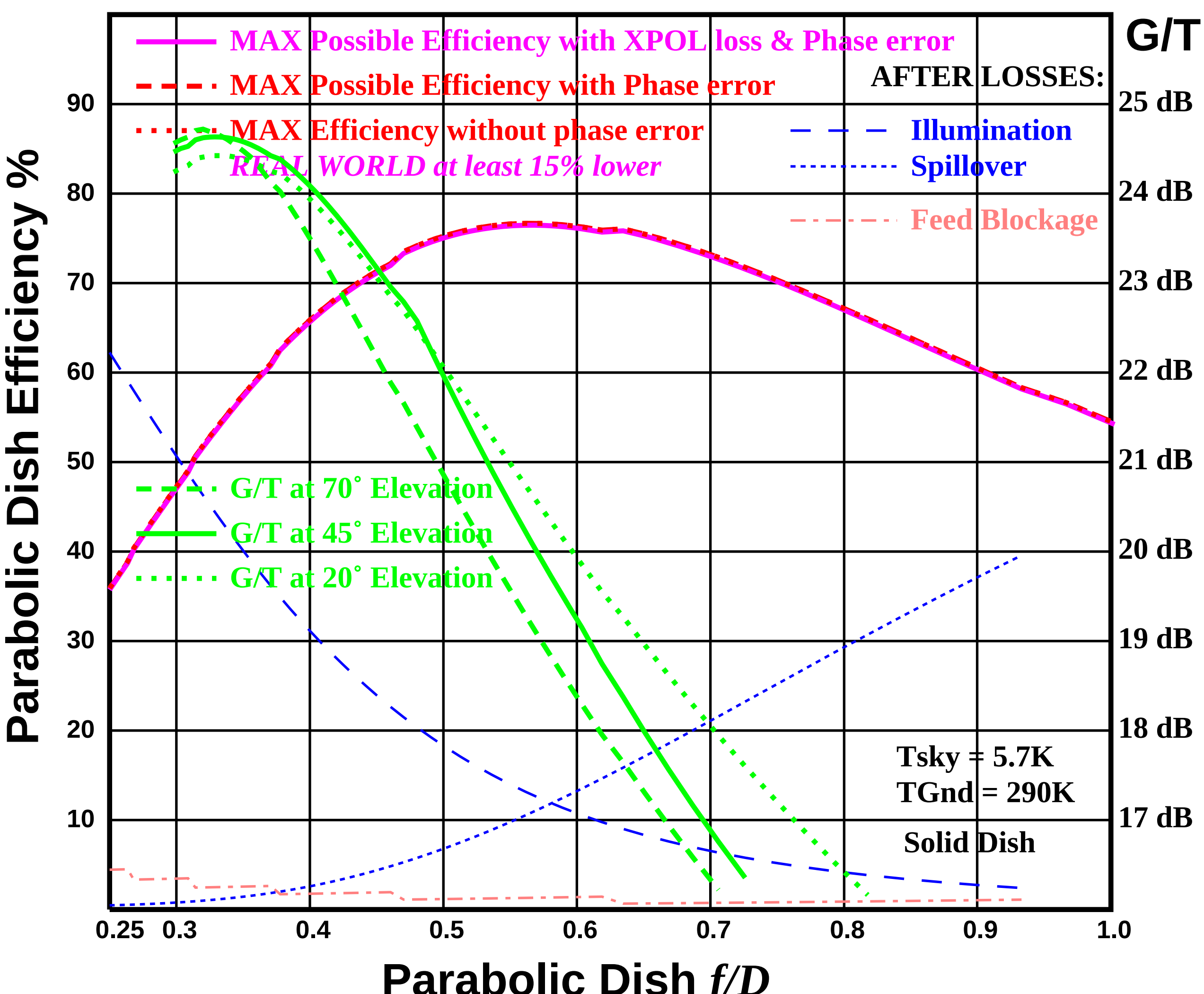
# W2IMU Dual-mode feed, 1.31λ diameter, LHCP

## Figure 2




Dish diameter = 20 λ  Feed diameter = 1.31 λ  Phase Center = 0 λ beyond aperture

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patterns for prime-focus dishes due to the geometry of the offset dish, so only prime-focus dishes are considered in this paper.

## Approximations

To make the calculations more manageable, several approximations are made:

1. For well-behaved feeds with circular polarization, the feed patterns are quite axisymmetric, so the E-plane and H-plane cuts are adequate for the $\phi$ integration. However, some feeds with square cross section, like the OK1DFC septum, have some difference in the diagonal planes, so 45-degree cuts are also included.
2. The calculations do not include diffraction at the edge of the reflector. Anyone who has used a small dish for portable operation has probably noticed significant sidelobes at 90 and 180 degrees – these are the result of edge diffraction. In very deep dishes, the feed is completely shielded from ground noise by the reflector, so the noise temperature (and **G/T**) is very optimistic unless edge diffraction is included. The diffraction calculation is exceedingly difficult[8], so I chose not to plot **G/T** for ***f*/D** < 0.3, following the example of RA3AQ.
3. Sky noise is assumed to be uniform. This is probably reasonable at higher elevations, but not at very low elevations.
4. Interaction between feed and reflector, called mirror reaction by RA3AQ, is ignored. This interaction is small for larger dishes, so calculations are for 20λ and larger.

## Measurements by WD5AGO

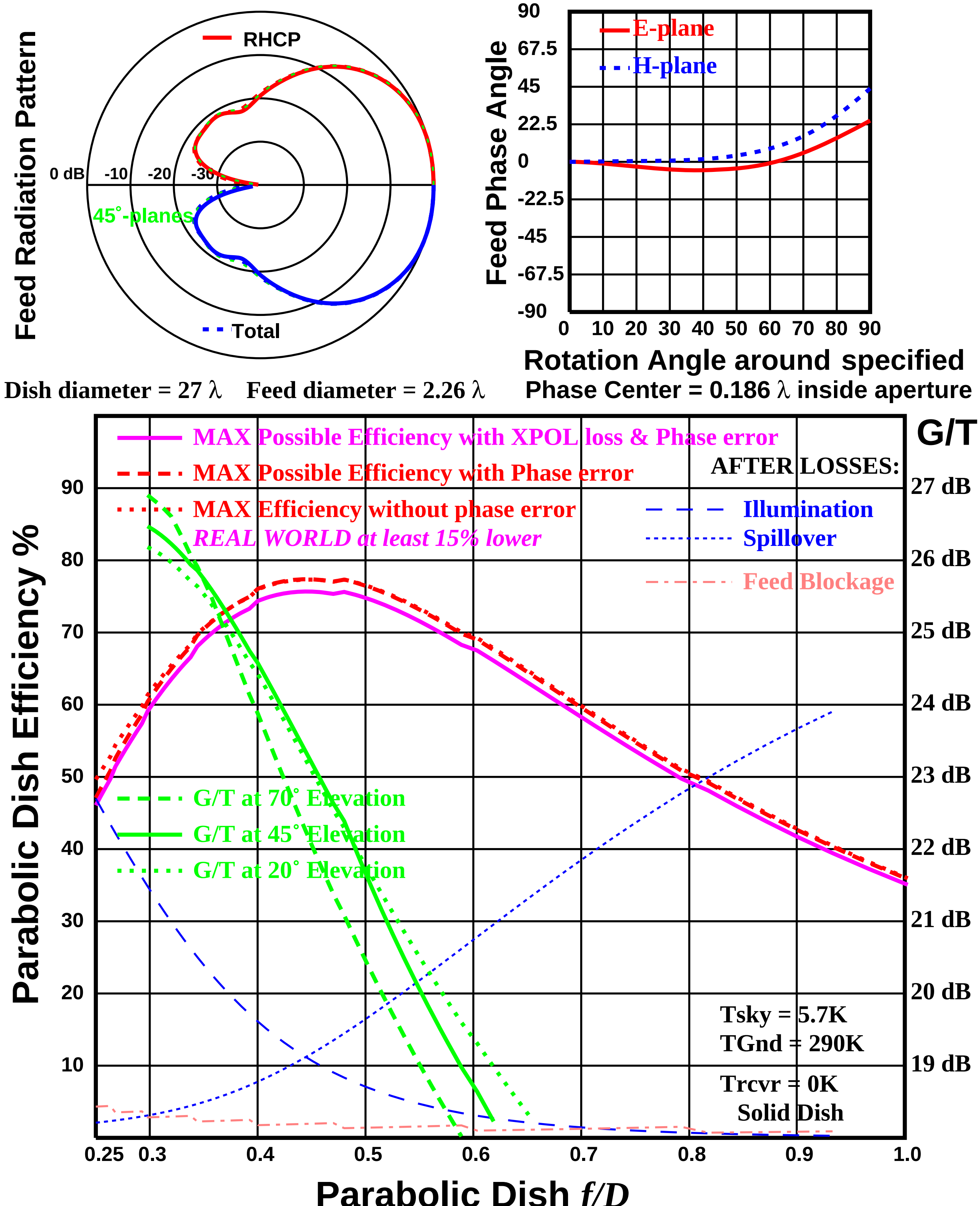
Tommy Henderson, WD5AGO, has collaborated with me to verify efficiency calculations with sun noise measurements[1]. I asked him to measure two feeds similar to those in Figures 1 and 2, one for deep dishes and one for smaller ***f*/D**. He had one available, a Chaparral-style horn with three rings, each ring 0.25λ wide and 0.2λ deep, with the rings 0.25λ behind the aperture. The curves for this horn, in Figure 3, show best efficiency for an ***f*/D** ≈ 0.45 and best **G/T** for very deep dishes, ***f*/D** ≤ 0.3, on Tommy's 27λ dish.

Tommy then fabricated a comparison horn, a W2IMU-style dual-mode horn with the smallest aperture that will support two modes, 1.22λ. The curves for this horn, shown in Figure 4, show best efficiency for an ***f*/D** ≈ 0.55 and best **G/T** for ***f*/D** ≈ 0.35, a good match for Tommy's 3.55 meter dish with ***f*/D** = 0.33. The calculated **G/T** for this feed on the dish is about one dB better than the feed in Figure 3. Note that these curves are for Tommy's 27λ dish, so the gain and **G/T** are higher, as would be expected.

When sun noise for the two feeds was measured at 13 cm, the dish with the W2IMU-style feed measured 14.7 dB while the Chaparral-style measured 15.5 dB (SFU = 117), the opposite of the **G/T** prediction for the antenna alone.

# Chaparral 3 rings 0.25λ wide x 0.20λ deep, back 0.25λ

## Figure 3

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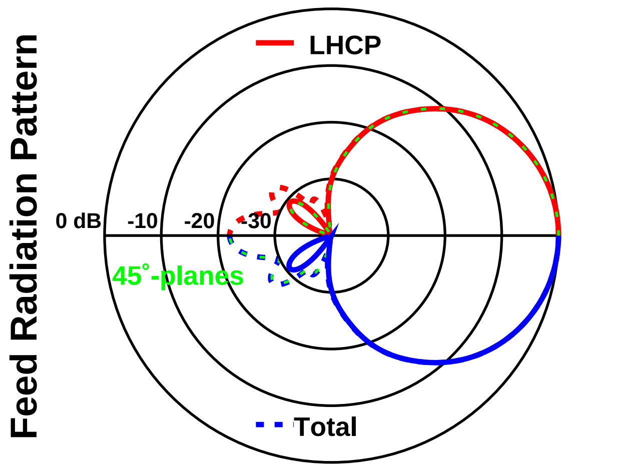
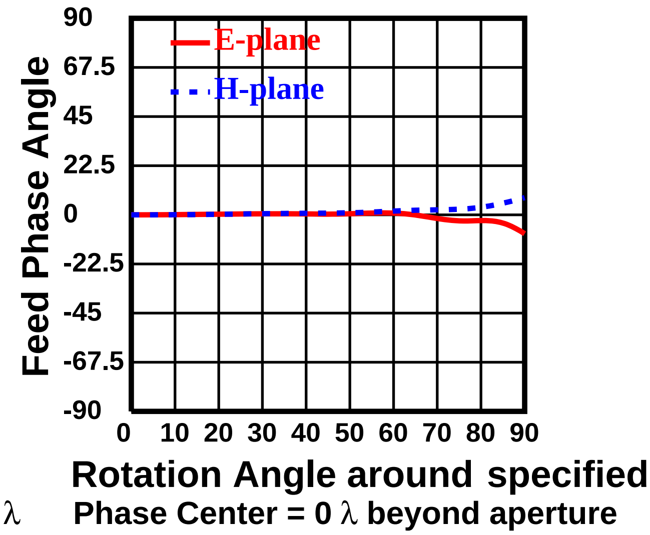
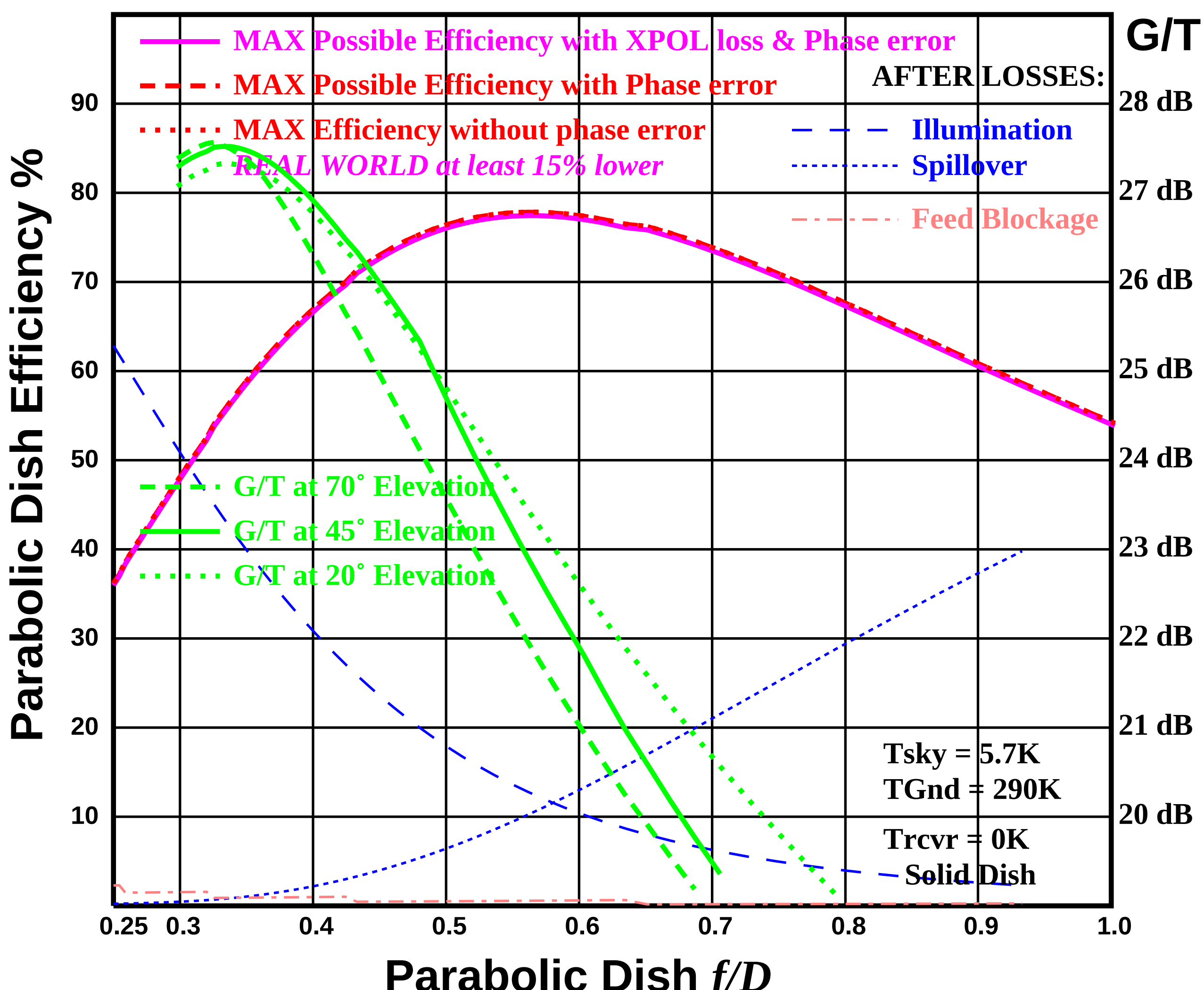
# W2IMU Dual-mode feed 1.22λ diameter by WD5AGO

## Figure 4




Dish diameter = 27 λ     Feed diameter = 1.22 λ

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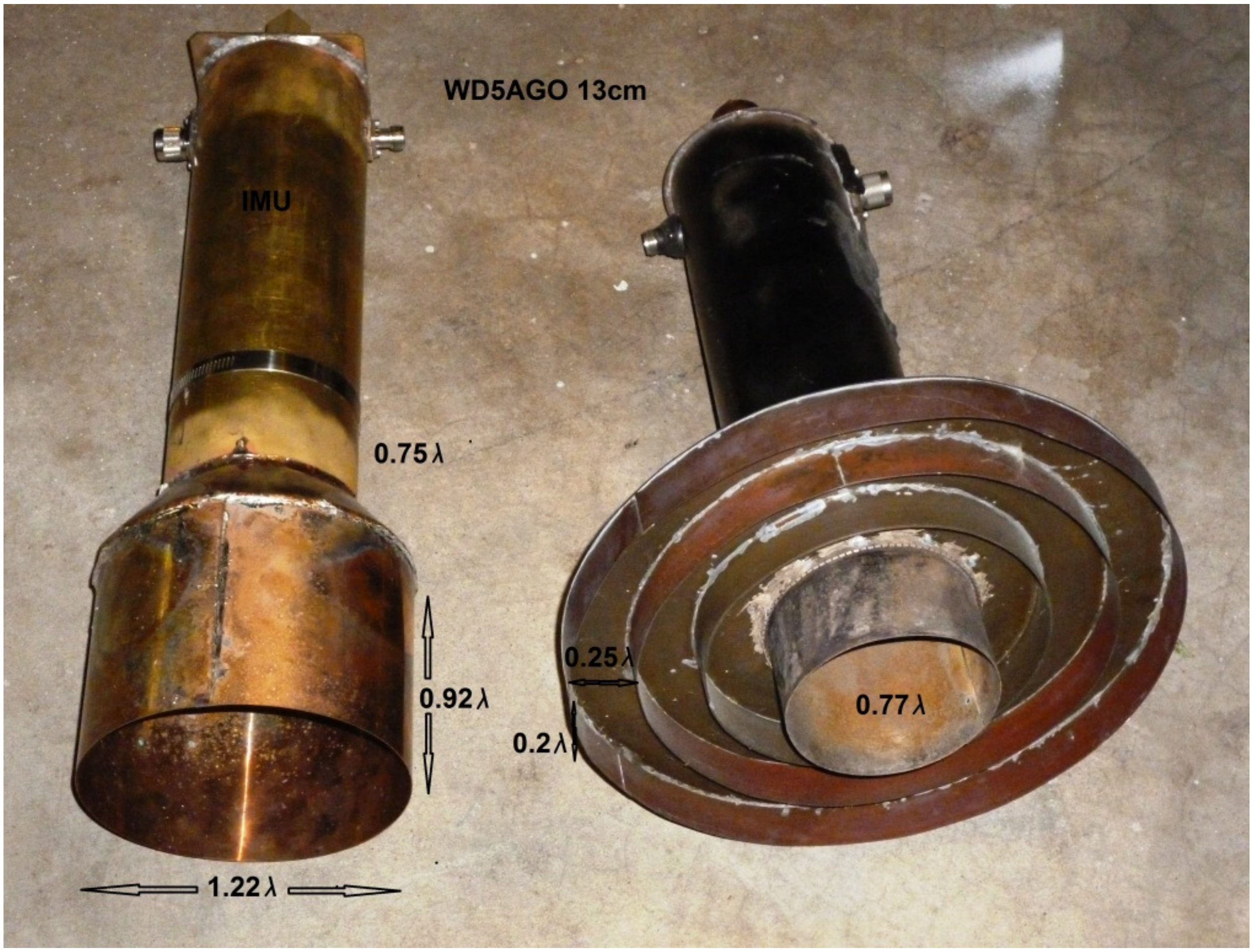



**Figure 9 – Feedhorns for 13 cm fabricated and measured by WD5AGO**

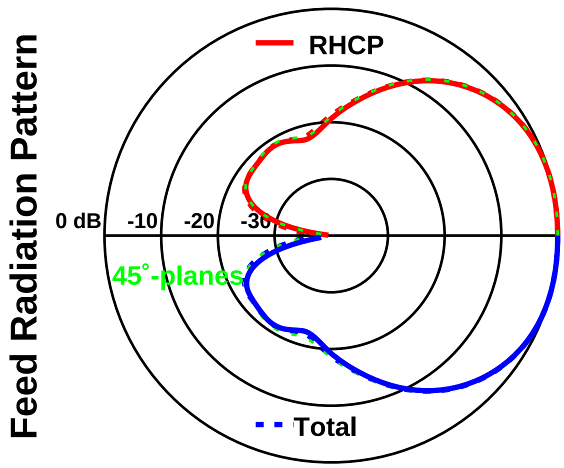
The curves in Figures 1 through 4 are for the antenna alone, with no receiver noise contribution. Curves including the receiver noise temperature, estimated by Tommy as 34.5K, reduce the calculated **G/T** and shift the peak to larger ***f*/D**, so that the Chaparral-style feed now has the better **G/T**, as seen in Figures 5 and 6.

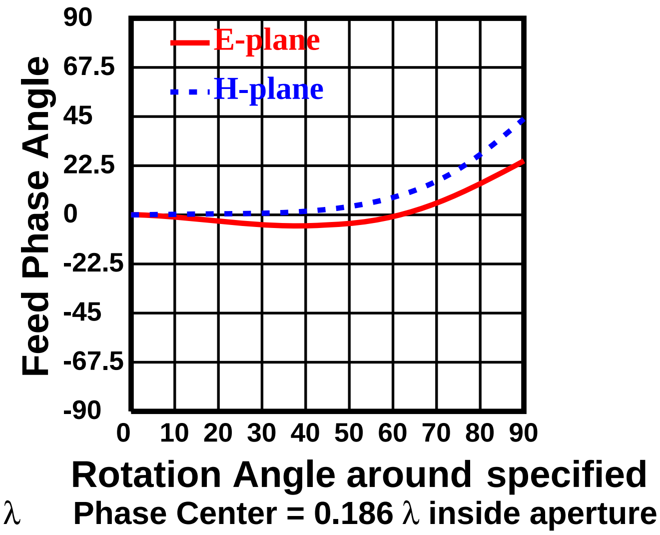
Further reading[9] suggests that the difference in received noise from a source is proportional to the difference in efficiency, plus the difference in antenna noise. Since the received sun noise is greater than 1000K, the calculated difference in antenna temperature of about 5K is not going to show up in an amateur measurement. The calculated difference in efficiency is 0.76 dB, very close to the measured 0.8 dB. A bit more calculation suggests that the actual receiver noise temperature is about 44K rather than 34.5K, a noise figure difference of perhaps 0.1 dB.

After removing a relay to reduce the receiver noise temperature by perhaps 10K, Tommy measured noise from the sun, moon, and Cygnus A. For the Chaparral-style horn, results were 16 dB, 0.4 dB, and 0.12 dB respectively, while for the small 1.22λ diameter W2IMU-style horn, the results were 15.6 dB, 0.35 dB, and 0.10 dB.

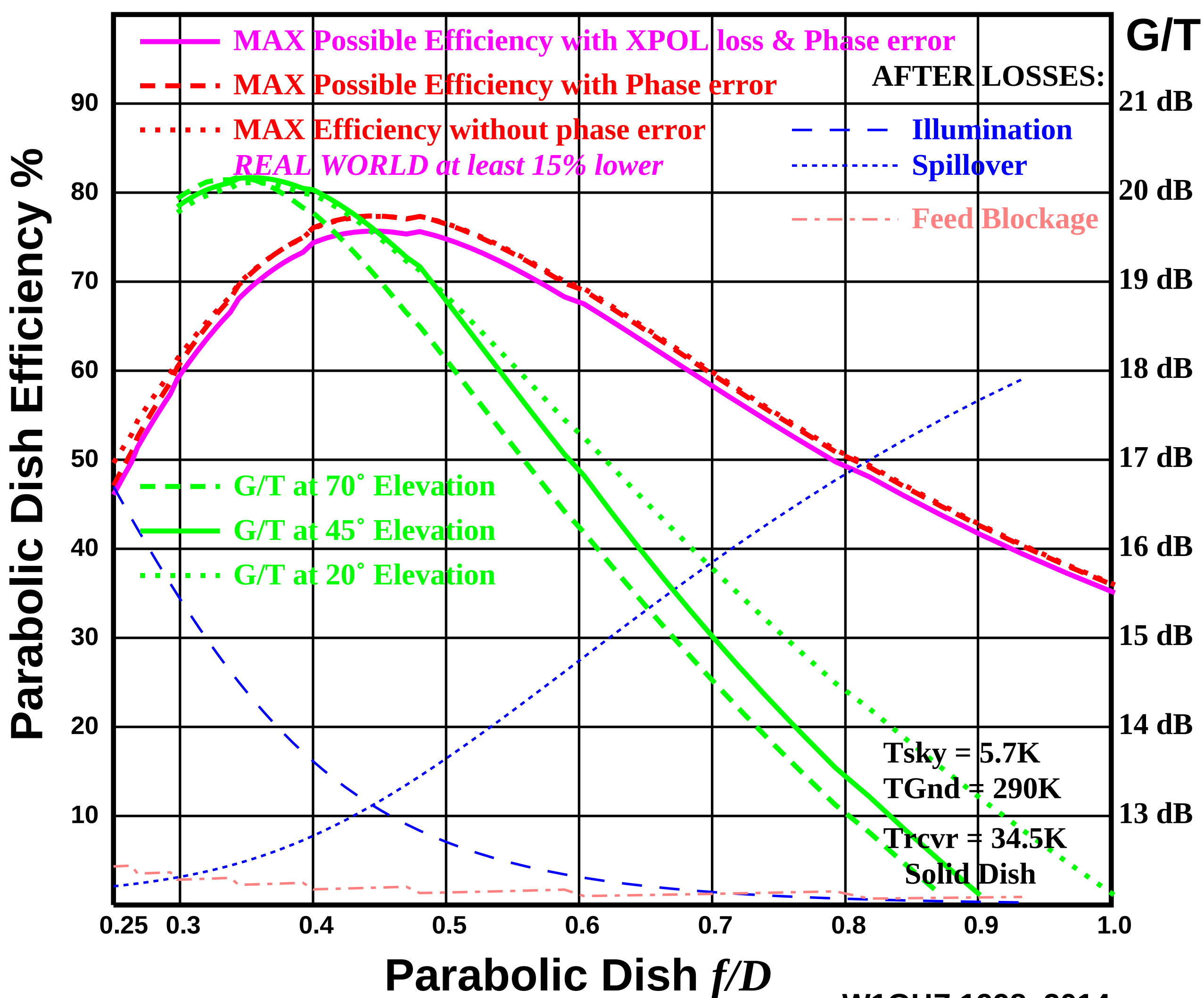
## Chaparral 3 rings 0.25λ wide x 0.20λ deep, back 0.25λ

## Figure 5




Dish diameter = 27 λ  Feed diameter = 2.26 λ

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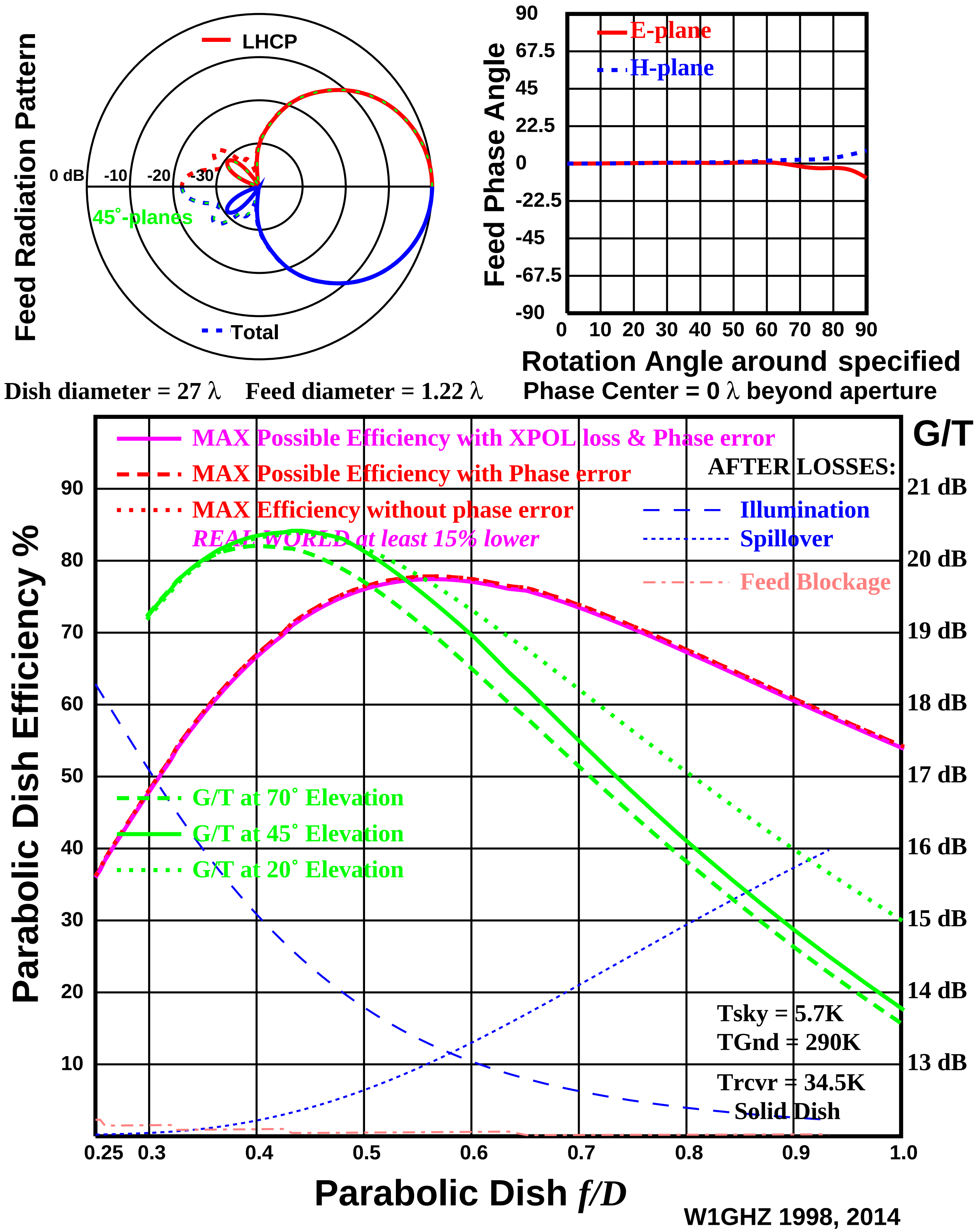
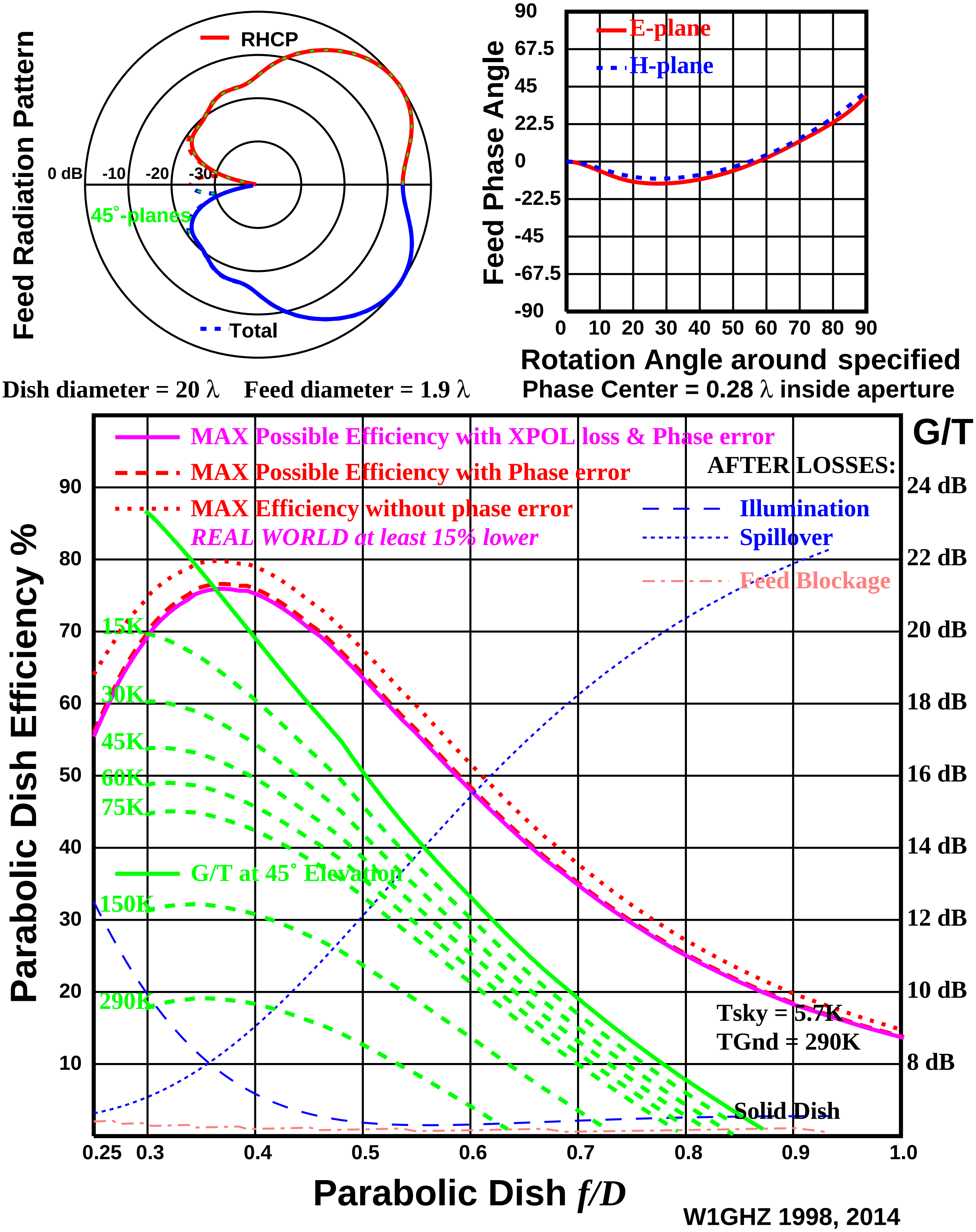
# W2IMU Dual-mode feed 1.22λ diameter by WD5AGO

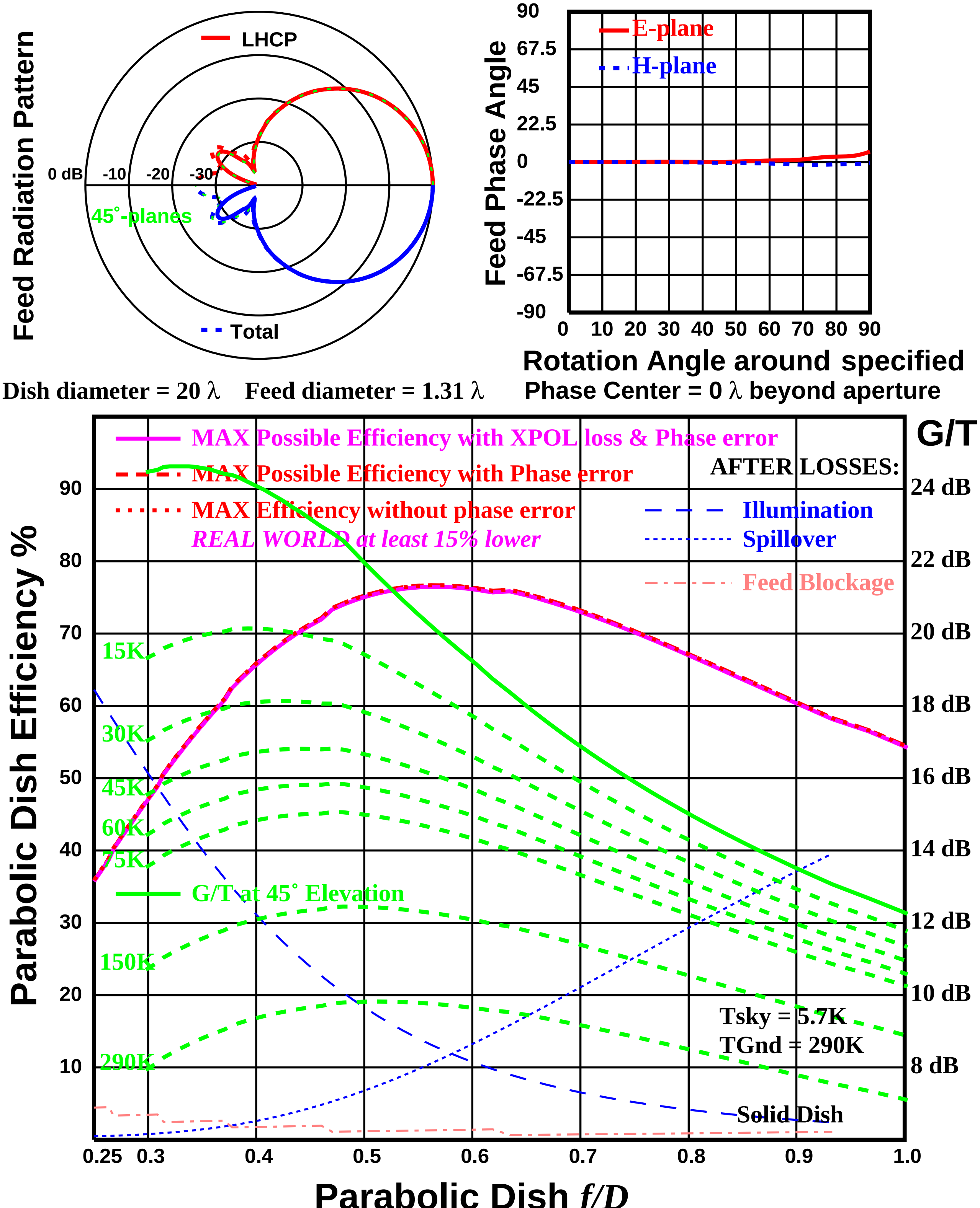
## Figure 6



# Super VE4MA, choke 0.6λ wide x 0.45λ deep, back 0.15λ
# Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
# Figure 7



# W2IMU Dual-mode Feed, 1.31λ diameter, LHCP
# Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
## Figure 8

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## Summary

From the experience of our experimental results, it does not seem meaningful to calculate **G/T** of the antenna alone – the receiver noise temperature must also be considered to estimate system **G/T** and real life performance. Figures 7 and 8 are plots of the same feeds as Figure 1 and 2, but with **G/T** curves for a range of receiver noise temperatures. Only the 45 degree elevation curves are shown, but the curves at different elevations move close together as the receiver noise temperature increases. These curves also emphasize the critical importance of low receiver noise temperature – a change of 0.1 dB in noise figure may not seem significant, but it can reduce **G/T** by as much as one dB. Of course, all EME operators know that each 0.1 dB of loss between the antenna and preamp increases the noise figure by 0.1 dB.

If we choose to optimize for **G/T**, there may be a tradeoff of slightly lower antenna gain. For transmitting, this could be compensated by increased transmitter power. But there is no way to compensate for noise in the receiver, except to prevent it from reaching the receiver as much as possible**.**

The first impression of someone seeing these **G/T** curves is that there is only a small difference between feeds. That is correct – the difference between 60% and 75% efficiency is only one dB, and a few degrees of noise temperature is a small difference unless the receiver noise temperature is low. But successful EME requires attention to every dB and tenth of dB.

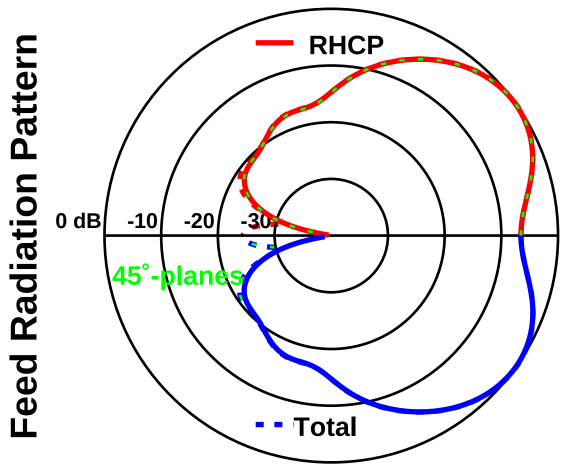
## Mesh Dishes

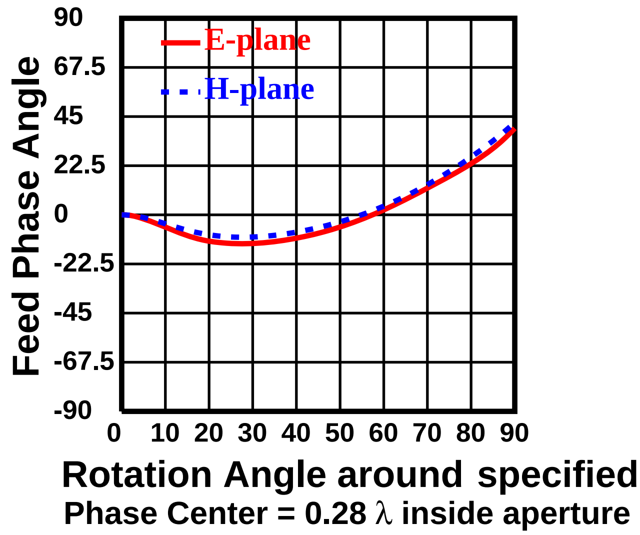
Most amateurs do not purchase new dishes, but use whatever is available. Many of these dishes have a mesh or screen surface rather than a solid surface. Advantages include lower weight and possibly lower wind resistance in climates without ice and snow.

Loss due to leakage through the holes in the mesh is usually small, so the reduction in gain is not significant. However, the leakage also allows ground noise from behind the reflector to reach the feed. Since the ground noise (290K) is much larger than the sky noise (<10K), leakage of even a small fraction of the ground noise can result in a large increase in antenna noise temperature. This is illustrated in the plots of Figures 10 and 11, showing a range of mesh leakage added to the **G/T** curves of Figure 1 and 2. Mesh leakage of 20%, about 1 dB, results in 1 dB less gain but perhaps 8 dB lower **G/T**. Mesh leakage has traditionally been estimated from curves generated by the RADLAB[10]; for more accurate calculations, Otoshi[11] has equations for wire mesh and for round holes. I put the Otoshi mesh equations into a spreadsheet, **mesh_calculator.xlsx**.

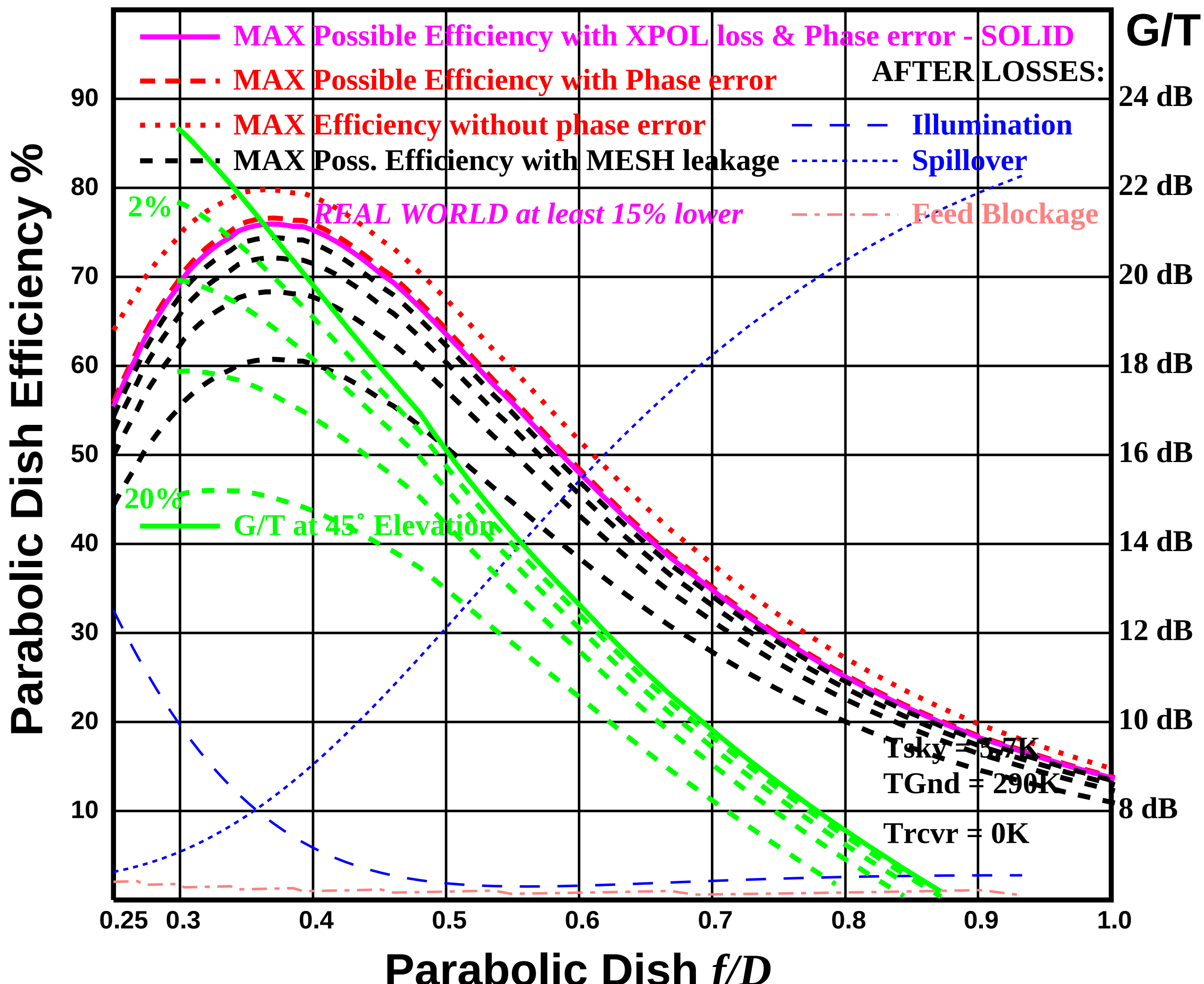
Equations and spreadsheets rarely provide an intuitive view of relationships. Figure 12 may provide more insight for mesh leakage, plotting leakage through a square mesh of fine wires (1mm diameter at 1296 MHz). The curves suggest that leakage increases quickly for wire spacing greater than about 5% of the wavelength.

## Super VE4MA, choke 0.6λ wide x 0.45λ deep, back 0.15λ
## Mesh Dish Comparison - 2, 5, 10, and 20% Mesh Leakage
## Figure 10




Dish diameter = 20 λ Feed diameter = 1.9 λ

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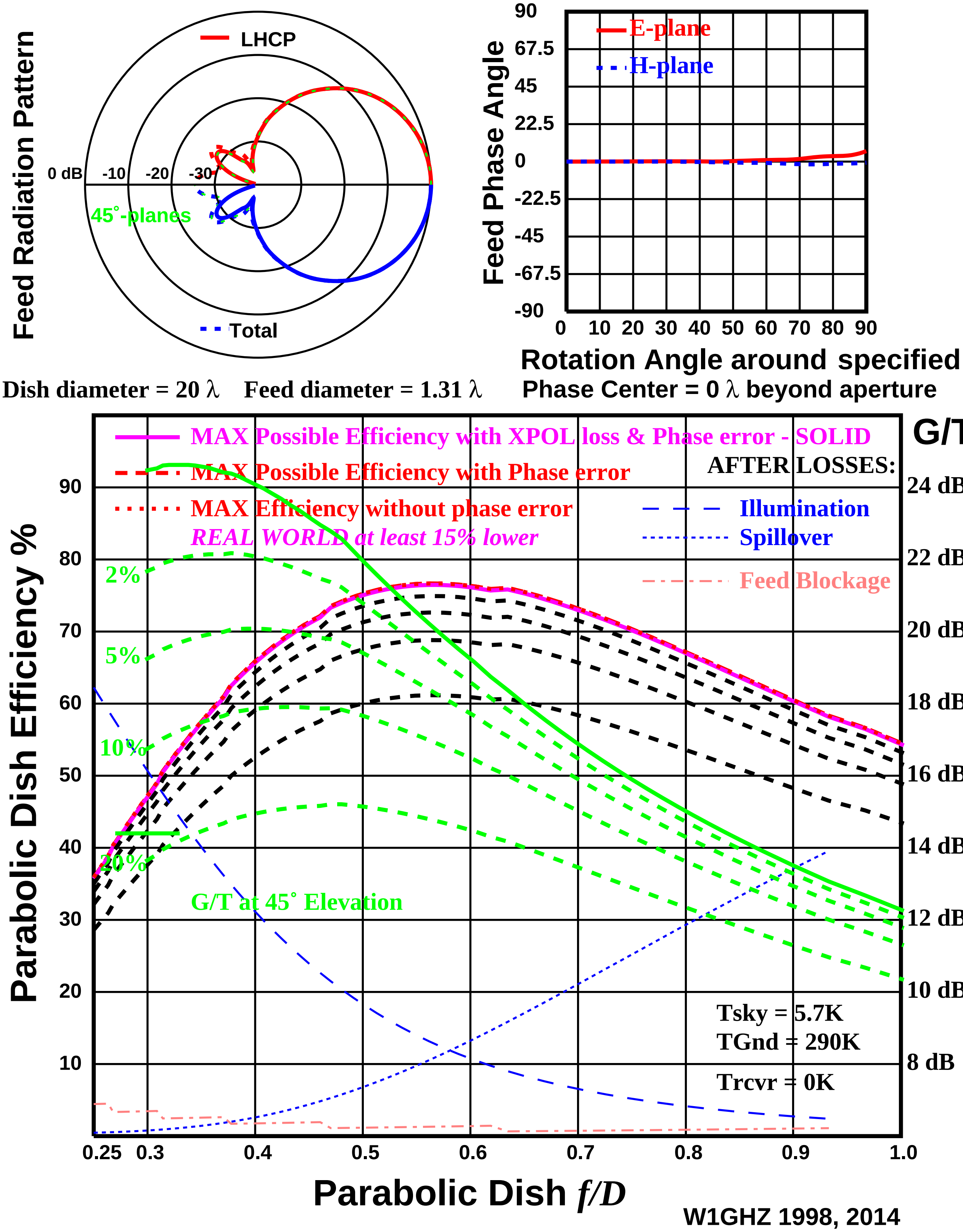
# W2IMU Dual-mode Feed, 1.31λ diameter, LHCP
## Mesh Dish Comparison - 2, 5, 10, and 20% Mesh Leakage
## Figure 11



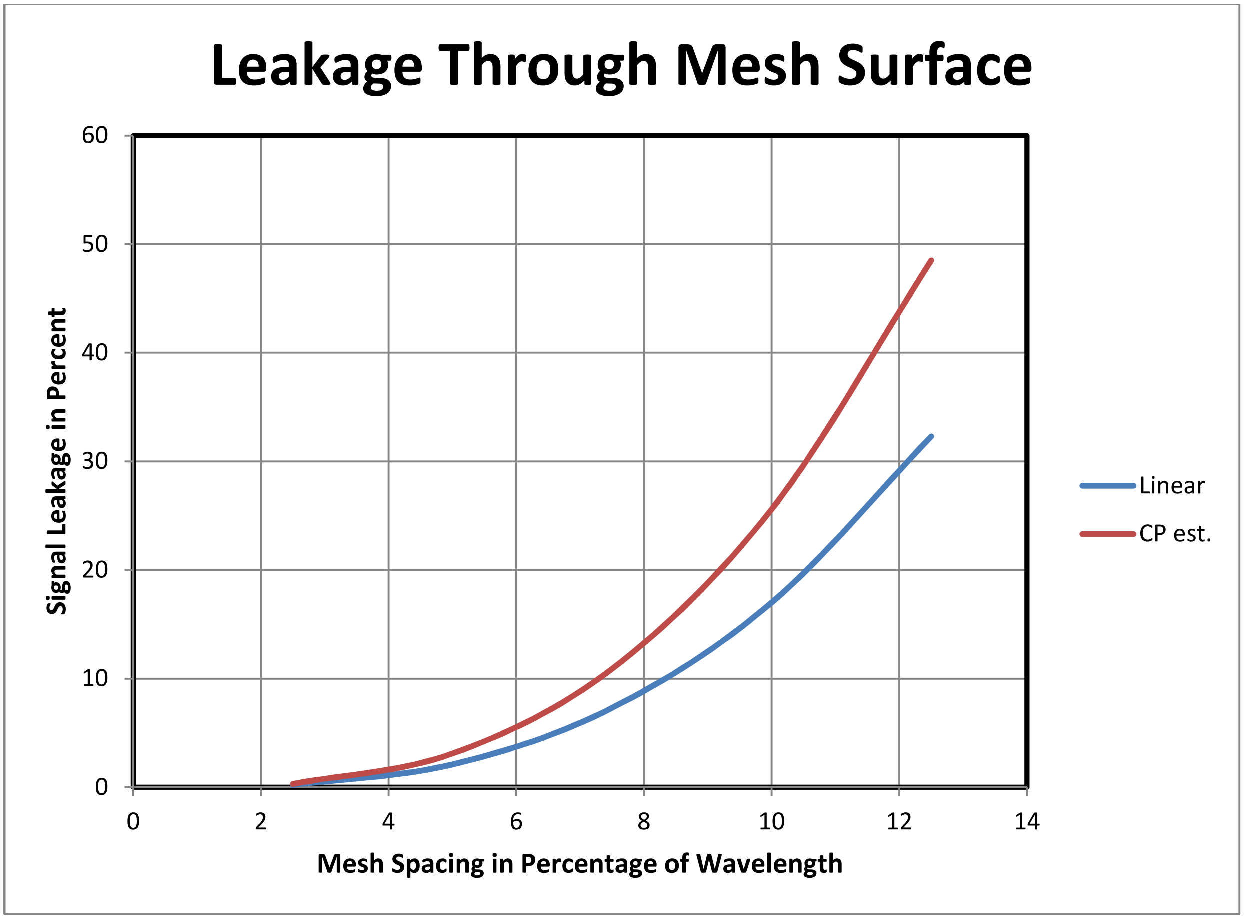


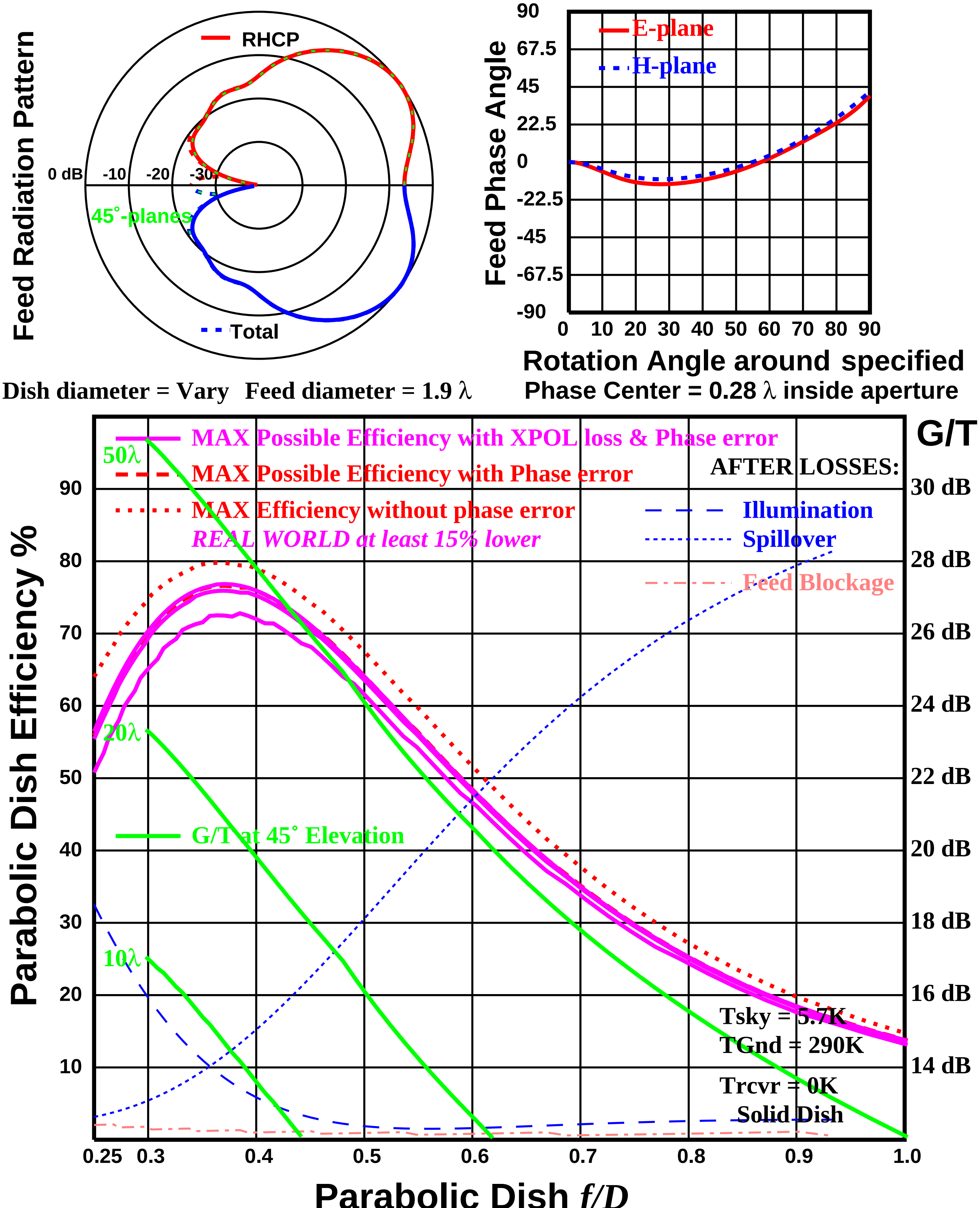

**Figure 12 – Leakage through wire mesh reflector based on Otoshi**

Some hams have added mesh at the perimeter of a dish to increase the size and thus the gain. This also reduces the ***f*/D**, usually requiring a different feed to maintain efficiency. An alternative approach with the added mesh would be to use the original feed, which now under-illuminates the expanded dish, for better **G/T**. Even if the added mesh has some leakage, the noise contribution for the mesh area is greatly reduced.

## Dish Size

Gain is proportional to aperture, while **T** is not. Thus, we can expect **G/T** to be proportional to reflector area. This is illustrated in Figure 13, showing **G/T** curves for dish diameters of 10, 20 and 50λ. There is a slight increase in efficiency and gain for larger dishes, as feed blockage becomes smaller, but the difference is minor. Small dishes also suffer from interaction between feed and reflector (mirror reaction), which may reduce gain further.

# Super VE4MA, choke 0.6λ wide x 0.45λ deep, back 0.15λ
# Dish Size Comparison - 10, 20, and 50λ Diameter
# Figure 13

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## Other Feeds

There are a number of feeds in use by EME stations. Curves for several more of the popular ones on a 20λ dish are included for comparisons – for instance, Figure 14 is for the original VE4MA feedhorn. These curves are like the ones in Figures 7 and 8, with **G/T** curves for a range of receiver noise temperatures. All are for circular polarization – it should not matter how the CP is produced, as long as the circularity is good (a septum is a polarizer, not an antenna).

List of feeds with **G/T** curves, all for a 20λ diameter dish:

- Super-VE4MA, choke back 0.15λ — Figure 7
- Super-VE4MA, choke back 0.05λ — Figure 15
- Original VE4MA, choke back 0.1λ — Figure 14
- W2IMU Dual-mode 1.31λ diameter — Figure 8
- W2IMU Dual-mode 1.22λ diameter — Figure 18
- W2IMU Large Dual-mode 1.71λ diameter — Figure 19
- Chaparral-style 3-rings 0.25λ wide and 0.2λ deep, back 0.25λ — Figure 16
- Chaparral-style 3-rings 0.20λ wide and 0.33λ deep, back 0.05λ — Figure 17
- RA3AQ-042 feed (2008 version) — Figure 20
- Skobelev Optimum Dual-mode 1.7λ diameter — Figure 21
- Skobelev Optimum Dual-mode 2.3λ diameter — Figure 22
- SM6FHZ CP Patch feed — Figure 23
- Coffee Can (Cylindrical waveguide) — Figure 24
- N2UO round septum, no choke — Figure 25
- WA9HUV round with 2λ diameter flange — Figure 26
- OK1DFC square septum, no choke — Figure 27
- OK1DFC square septum with 1.5λ diameter flange — Figure 28

The last few feeds are interesting. The WA9HUV feed[13] in Figure 26, simulated by F6DRO, adds a plain flange with no choke to a cylindrical waveguide (Figure 24). The result is lower efficiency for small ***f*/D**, but improved **G/T** since backlobes are reduced. Figure 25 demonstrates that a septum in cylindrical waveguide is identical to the same as cylindrical waveguide with pure CP – the septum is not part of the feed antenna.

In Figure 28, a plain flange with no choke is added to an OK1DFC square septum feed. The flange lowers efficiency for for small ***f*/D**, but again increases **G/T** since backlobes are reduced. The 1.5λ diameter flange is slightly better than 2λ diameter, but neither the size nor the position is necessarily optimum.

## Mirror Reaction

Interaction between feed and reflector, called mirror reaction by RA3AQ[5] and chromatism for radio telescopes by Morris[12], can be a problem for small prime-focus dishes. Power from the feed is reflected back into the feed by the center of the dish. The reflected power can be described[10] as a reflection coefficient, $\Gamma_m$:

$$\Gamma_m = \frac{G_0}{4\pi}\frac{\lambda}{f}$$

This feed mismatch interacts with the system mismatch **Γ** and can increase the antenna noise temperature **T**:

$$\frac{\Delta T}{T} = 4\Gamma_m\Gamma$$

Even in a matched system, $\Gamma = 0$, the feed mismatch increases system temperature. Since reflection coefficients are complex quantities, the feedhorn can be tuned to a $\Gamma$ which cancels $\Gamma_m$ and the increase in noise. However, low-noise preamplifiers rarely have $\Gamma = 0$; a HEMT device might have $\Gamma$ closer to 0.9, so the system noise temperature may be significantly different than predicted by a noise figure measurement in a matched environment.

When circular polarization is reflected from a plane surface, the polarization sense is reversed. The center of a parabola is a plane to a reasonable approximation. Transmitted power is reflected into the receive polarization sense; it can add or cancel the isolation leakage from the polarizer, depending on the phase of the reflection. Moving the feed in or out controls the reflection phase. Received signal mismatch is reflected into the transmit polarization sense, but noise has no polarization, so the mirror reaction can still increase the antenna noise temperature. In addition, any noise at the transmit port of a polarizer, either transmitter standby noise or noise from a termination at 290K, can also be reflected into the receiver.

## Moon Noise

For large dishes, the beamwidth is narrow enough so that the moon disc fills a significant portion of the beam. Moon noise, perhaps ~200K, is added to that portion of the beam and may become the limiting noise factor for very large dishes. At lower frequencies, the high gain of a large dish will probably more than compensate for the increased noise. However, at the higher microwave frequencies, a dish large enough for EME will have a narrow beamwidth and moon noise becomes more of a problem.

## Conclusions

These approximate calculations of **G/T** can be useful for feed comparisions, but receiver noise temperature must be included to estimate system performance. It appears that the ideal feed curve would show a best ***f*/D** slightly larger than the ***f*/D** of the dish, to under-illuminate the dish without a significant reduction in efficiency and gain.

Since these comparisons are multi-dimensional and difficult to show on a single graph, the program **Feed_GT** will be available at www.w1ghz.org along with pattern data for many popular feeds. It is hoped that hams with access to EM simulation software will make pattern data available for additional feeds.

It should be clear that the receiver noise temperature is the critical part of **G/T**. After selecting the feed and optimizing it, the most important thing is the preamp, and minimizing losses before the preamp. The final improvement is to increase TX power, if possible.

Actual measurements are more important than computer simulations. Careful measurements of sun noise, moon noise, and especially celestial sources will verify system performance and show the real effect of any improvements or changes to the whole system. But the final test is getting on the air and making contacts.

## Acknowledgements

Doug McArthur, VK3UM, has been asking me questions about edge taper for several years – what he really wanted was **G/T**, so I started thinking about it. Reading the work of Dmitry Dmitriev, RA3AQ, and Rastislav Galuscak, OM6AA, finally got me moving. Barry Malowanchuk, VE4MA, Ingolf Larsson, SM6FHZ, and Dom Dehays, F6DRO, all provided valuable suggestions for this paper. And the measurements by Tommy Henderson, WD5AGO, add reality to the computer calculations.

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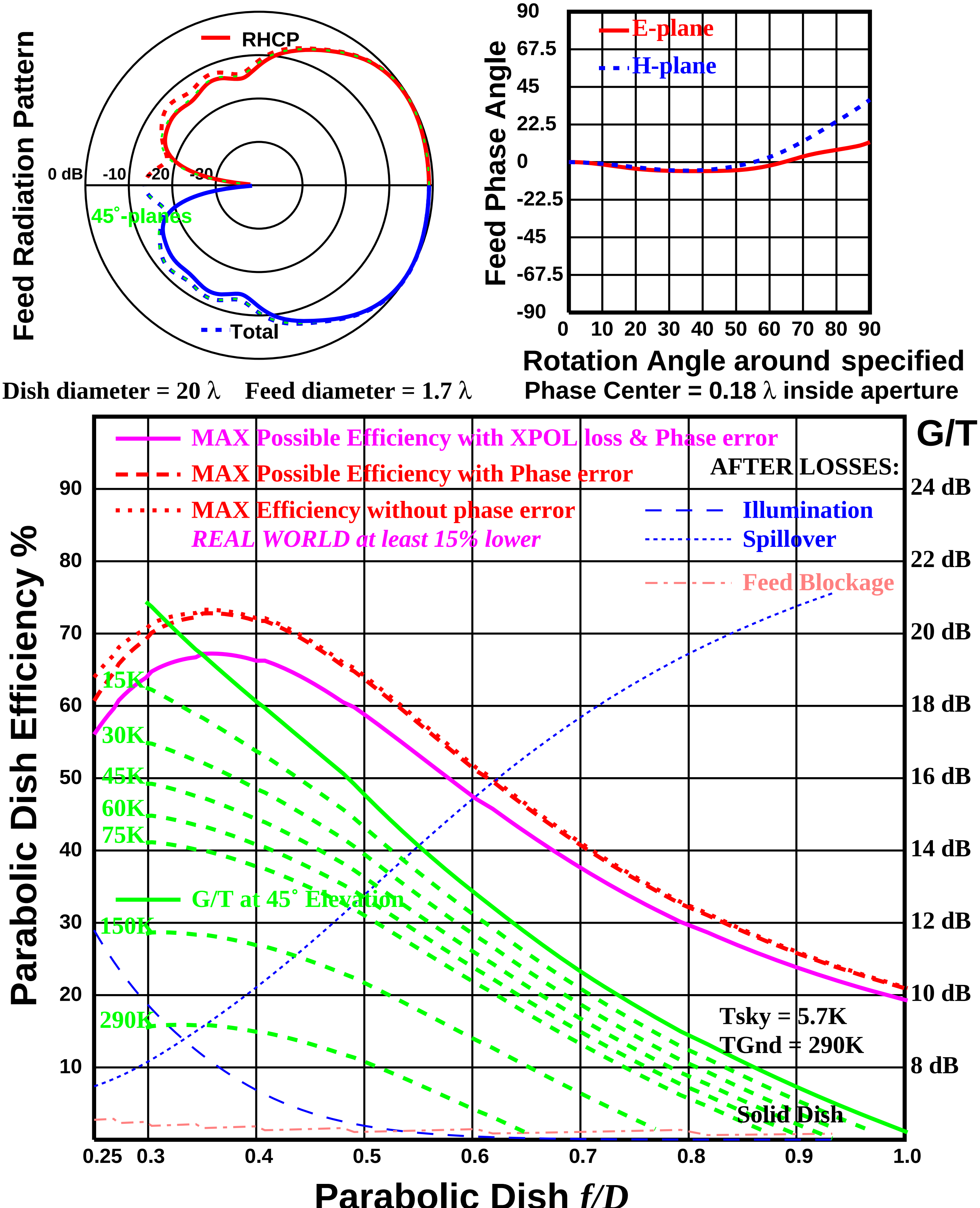
# Original VE4MA, choke 0.5λ wide x 0.5λ deep, back 0.1λ
# Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
# Figure 14

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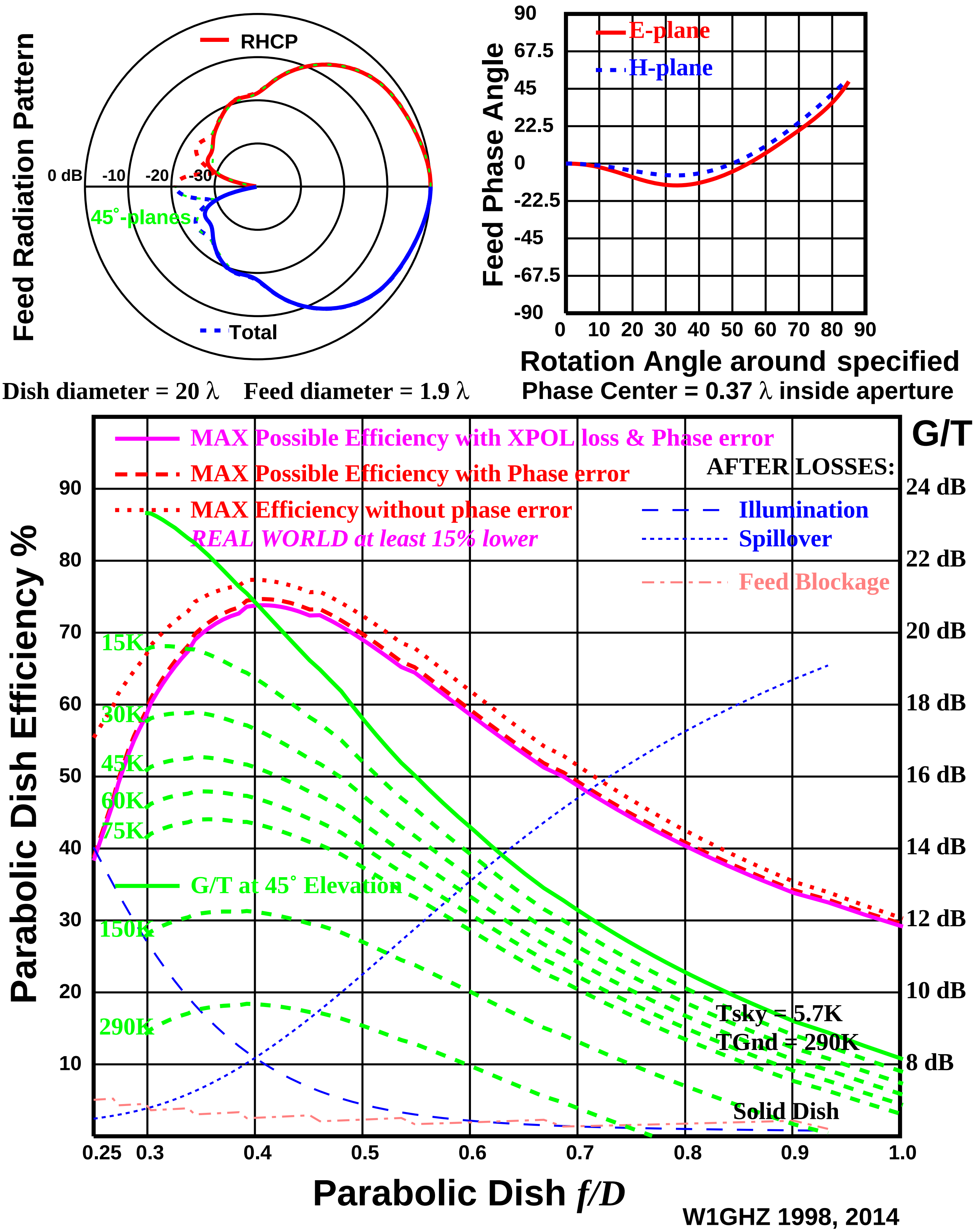
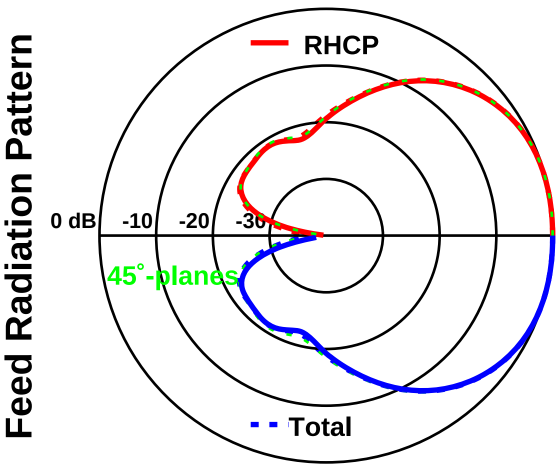
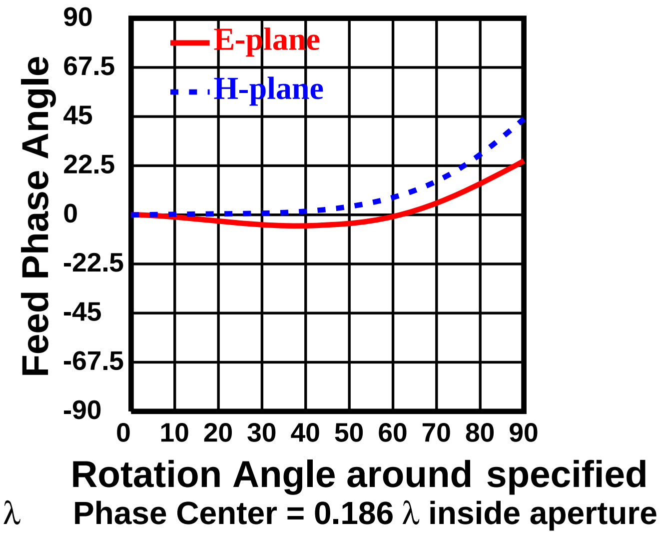
**Super VE4MA, choke 0.6λ wide x 0.45λ deep, back 0.05λ**
**Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K**
**Figure 15**



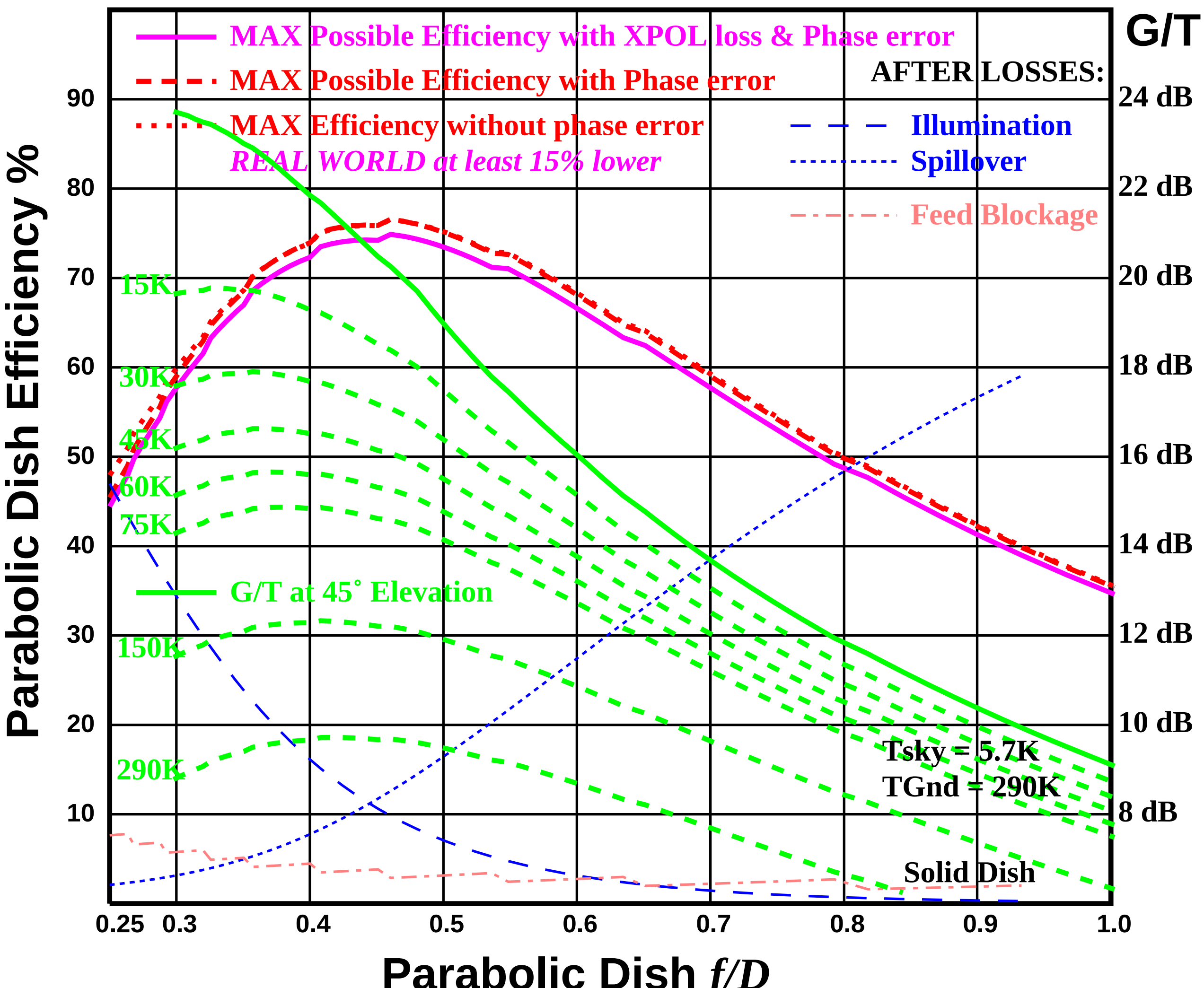

W1GHZ 1998, 2014

## Chaparral 3 rings 0.25λ wide x 0.20λ deep, back 0.25λ
## Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
## Figure 16




Dish diameter = 20 λ Feed diameter = 2.26 λ

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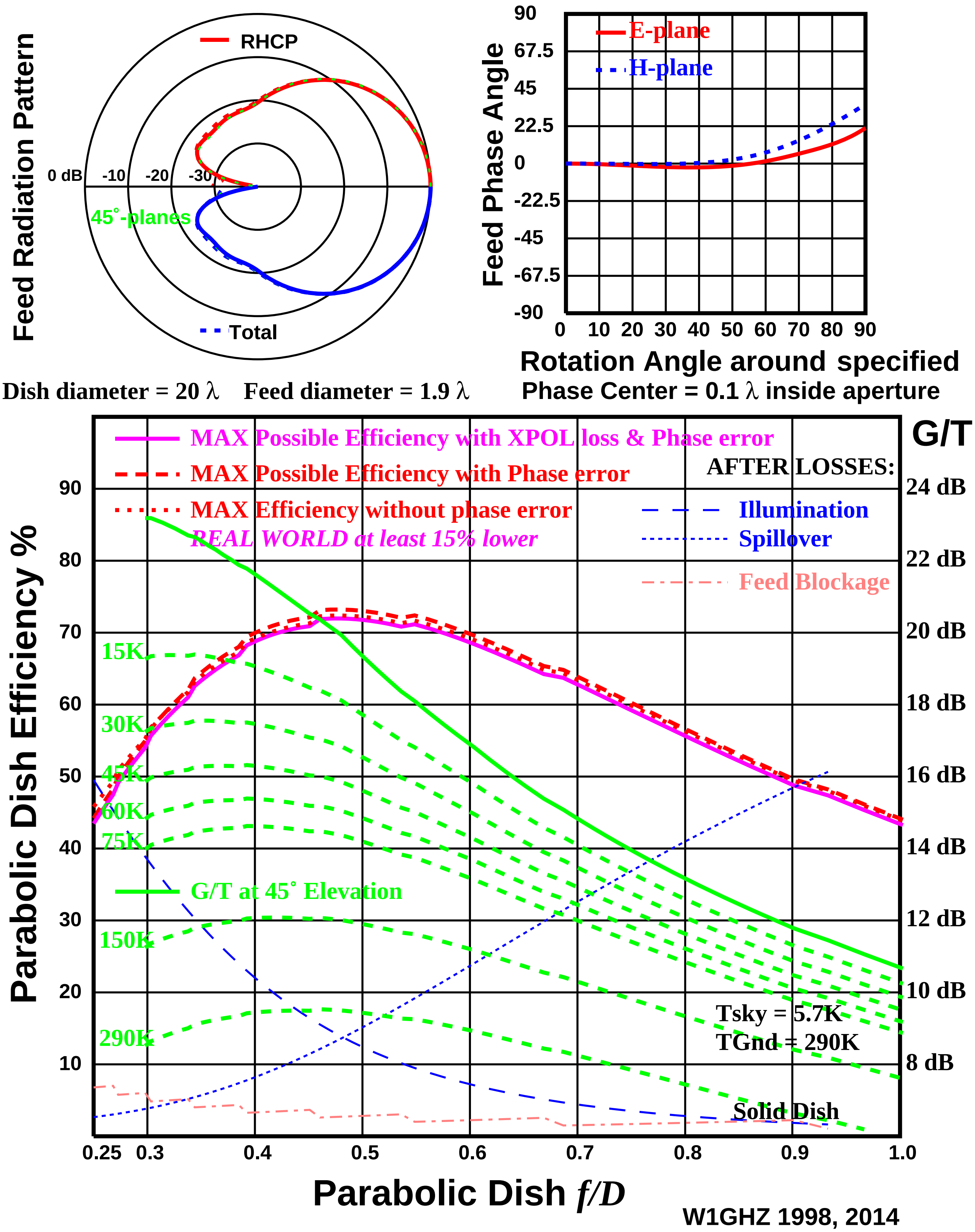
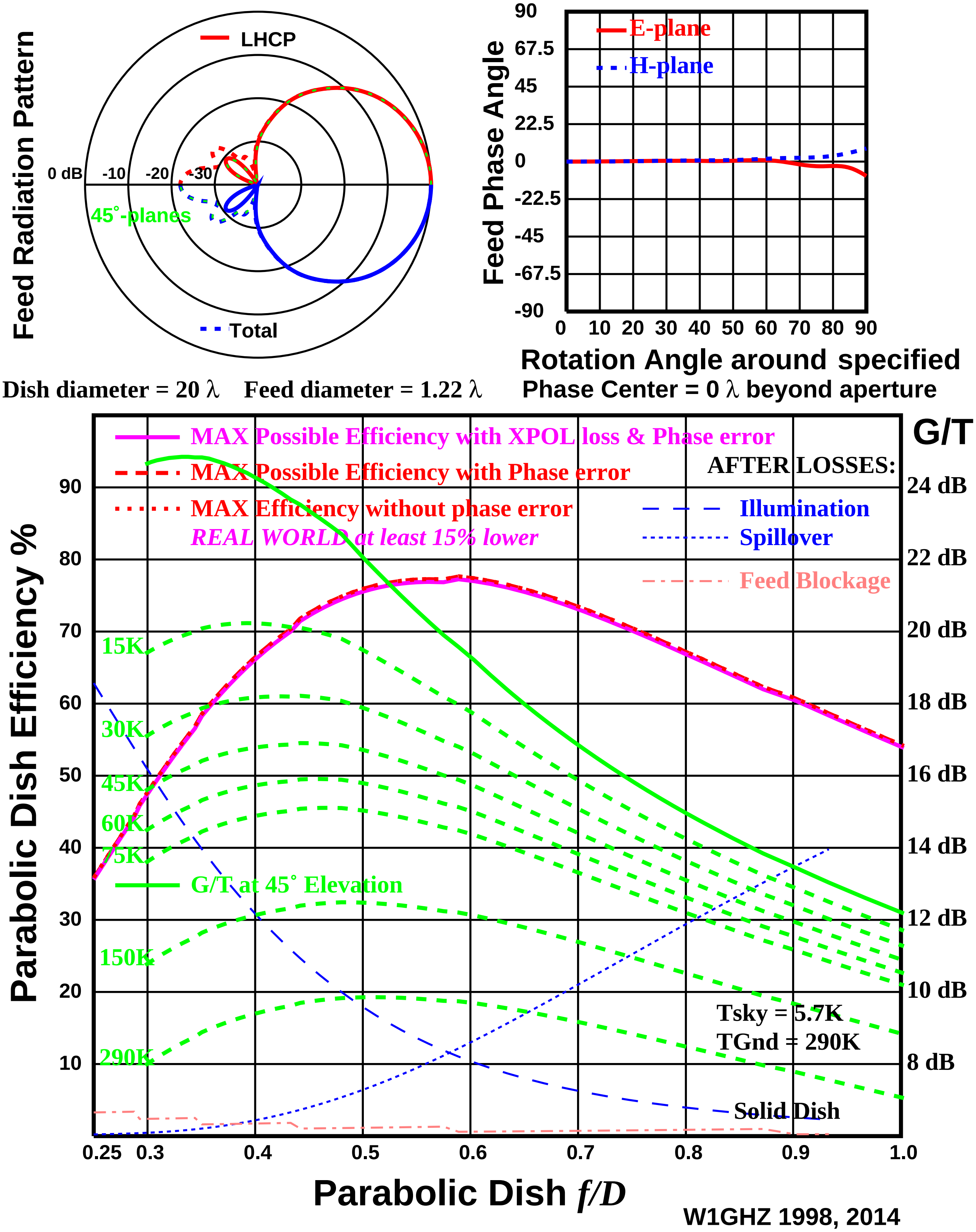
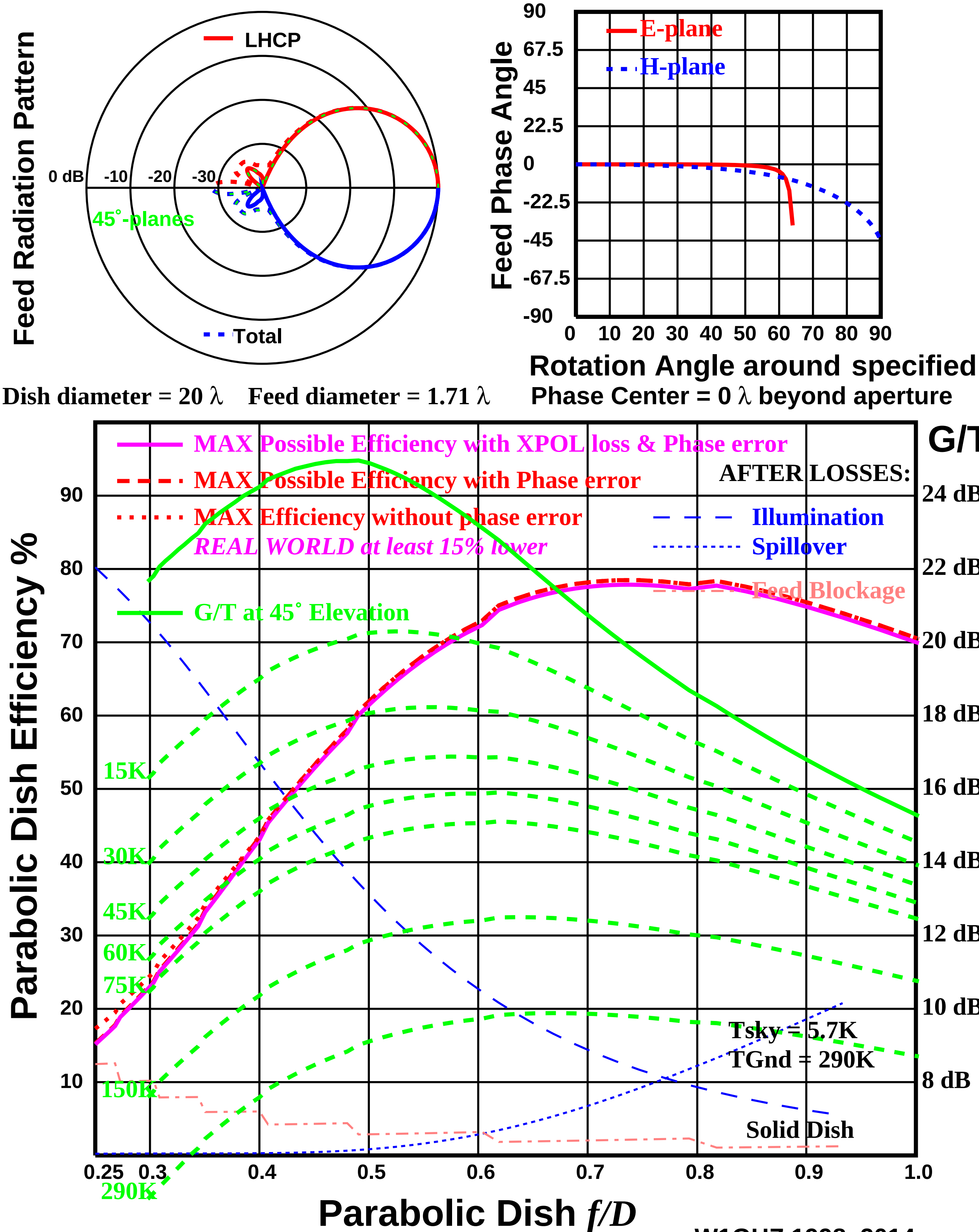
## Chaparral 3 rings 0.20λ wide x 0.33λ deep, back 0.05λ
## Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
## Figure 17



# W2IMU Dual-mode feed 1.22λ diameter by WD5AGO
## Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
## Figure 18

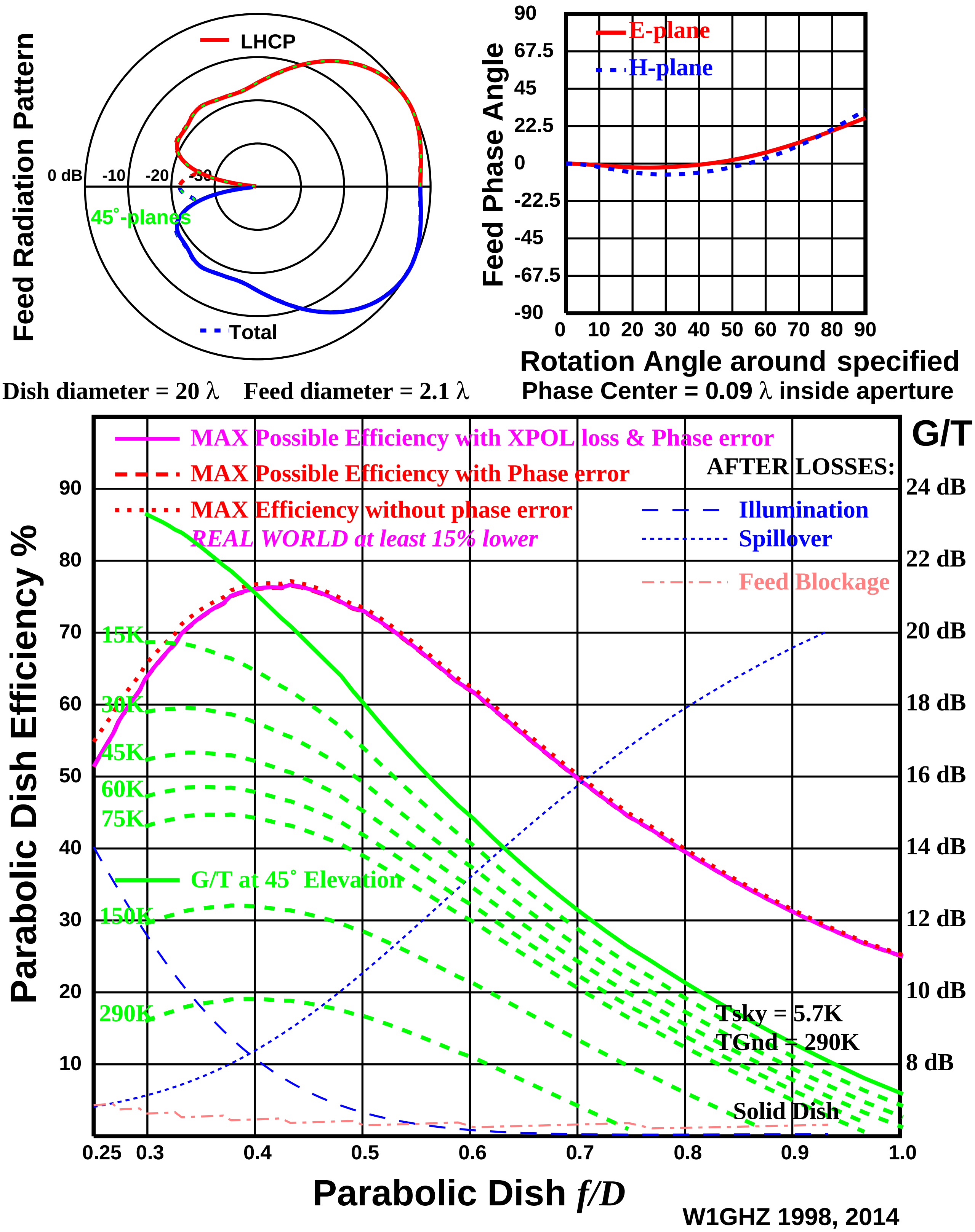


# W2IMU Large Dual-mode feed 1.71λ diameter
# Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
# Figure 19

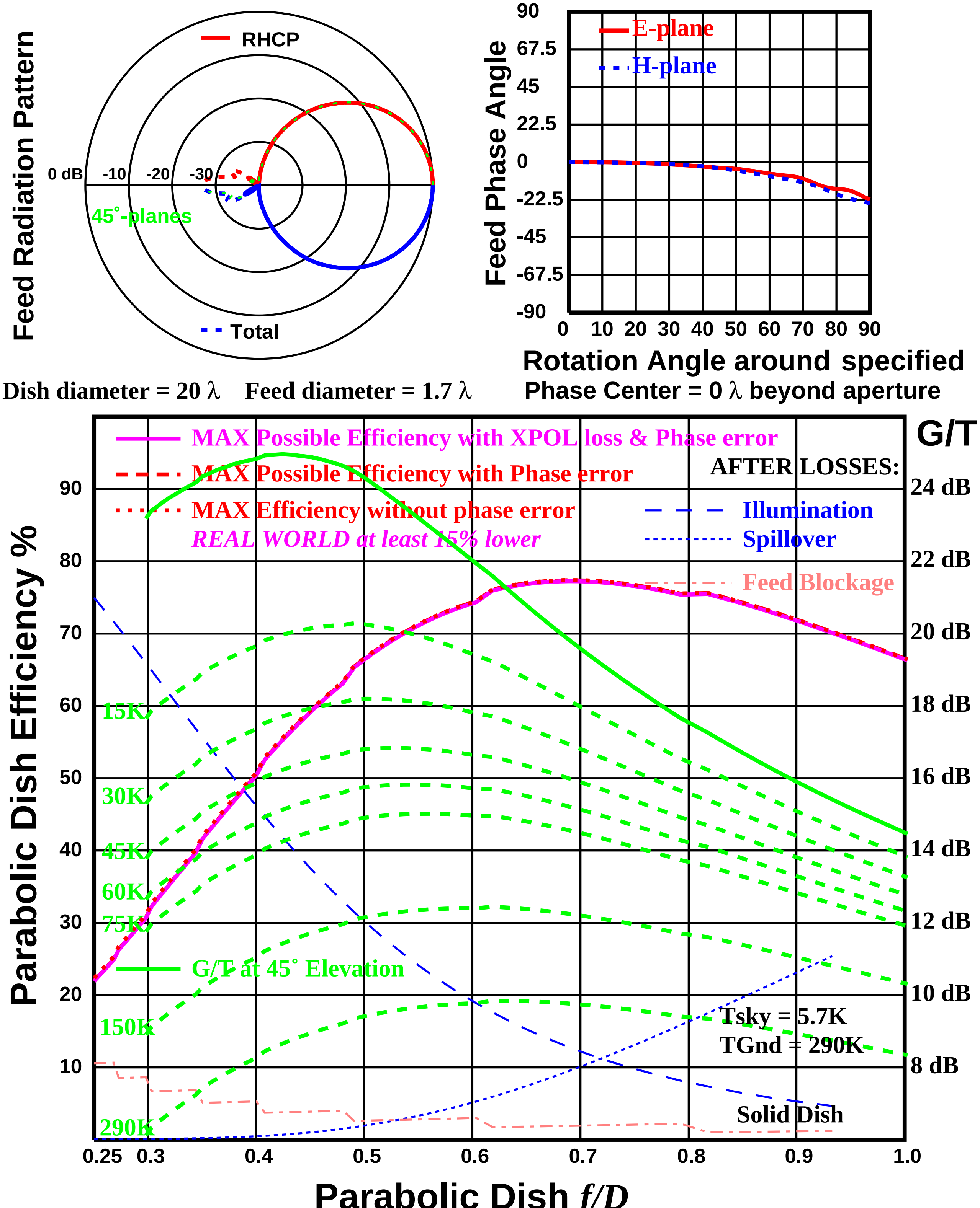



W1GHZ 1998, 2014

# RA3AQ-042 Feed - November 2008 version, LHCP
# Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
# Figure 20

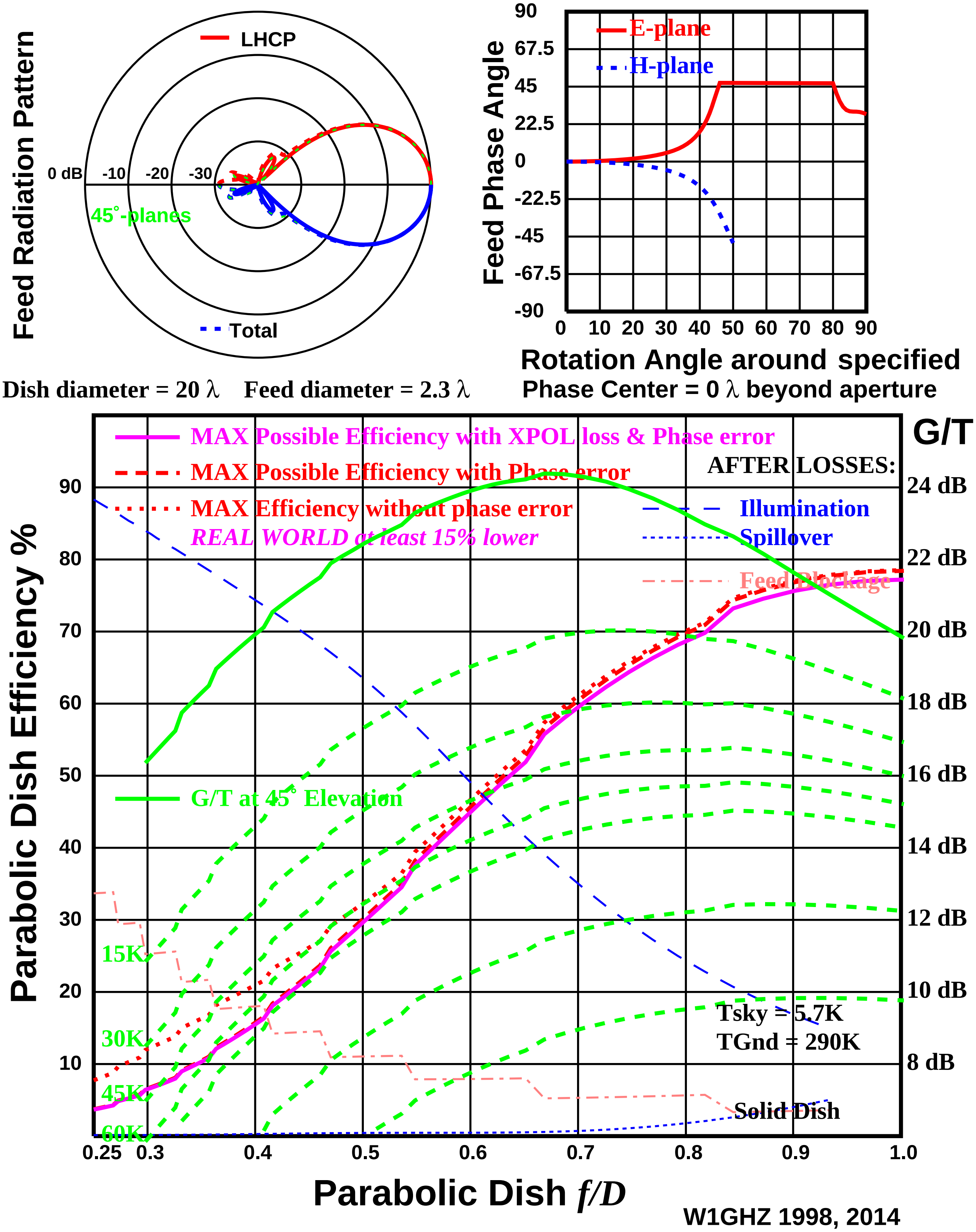


# Skobelev Optimum Dual-mode Feed, 1.7λ diameter, 2.4λ long
# Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
# Figure 21

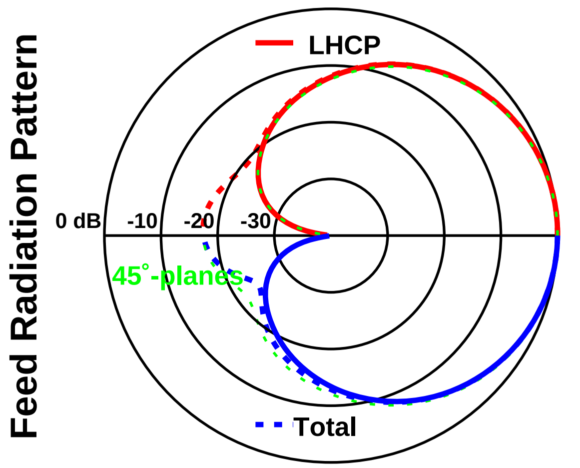


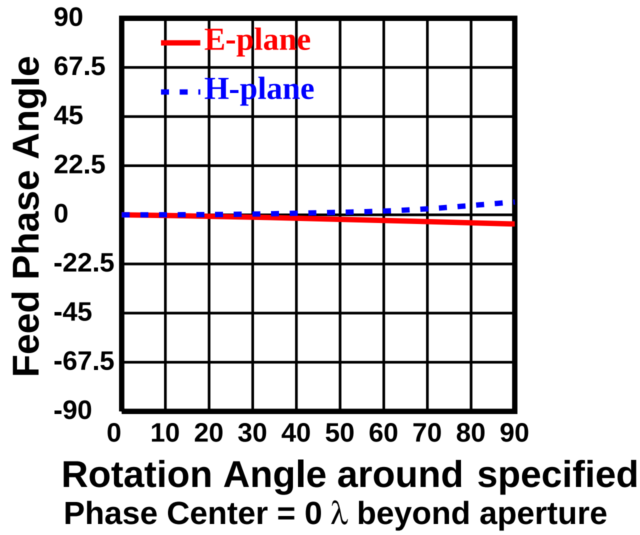

W1GHZ 1998, 2014

# Skobelev Optimum Dual-mode Feed, 2.3λ diameter, 3.26λ long
## Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
## Figure 22

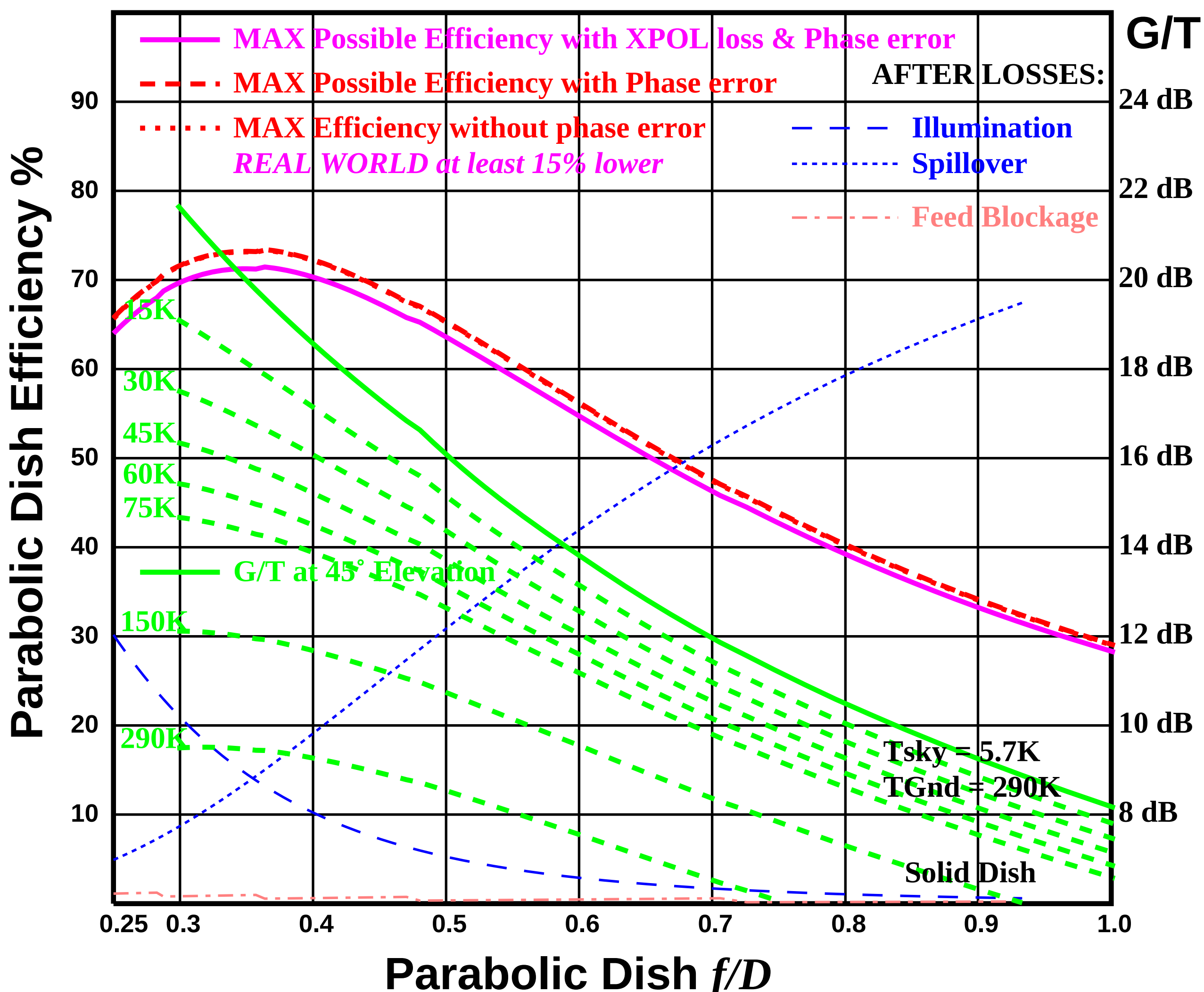


# SM6FHZ Patch Feed, LHCP
# Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
# Figure 23



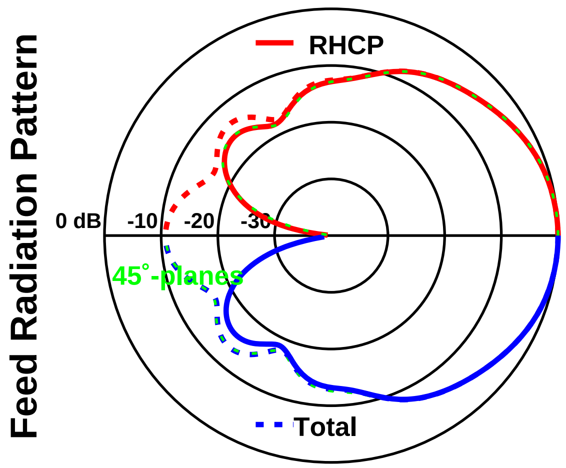



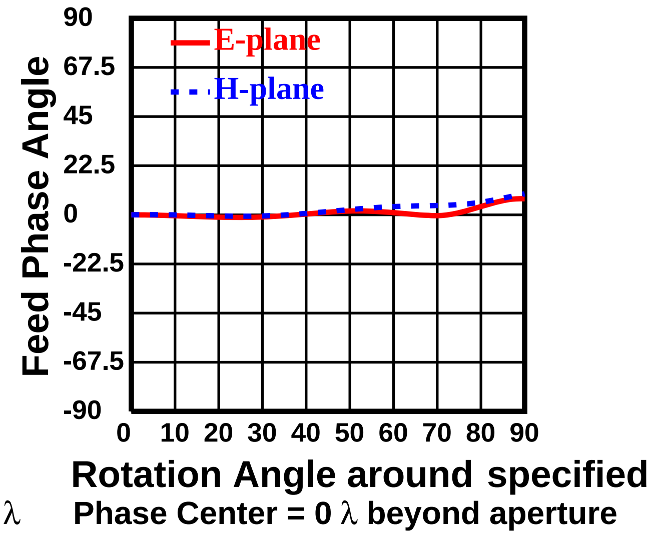

Dish diameter = 20 λ    Feed diameter = 1 λ



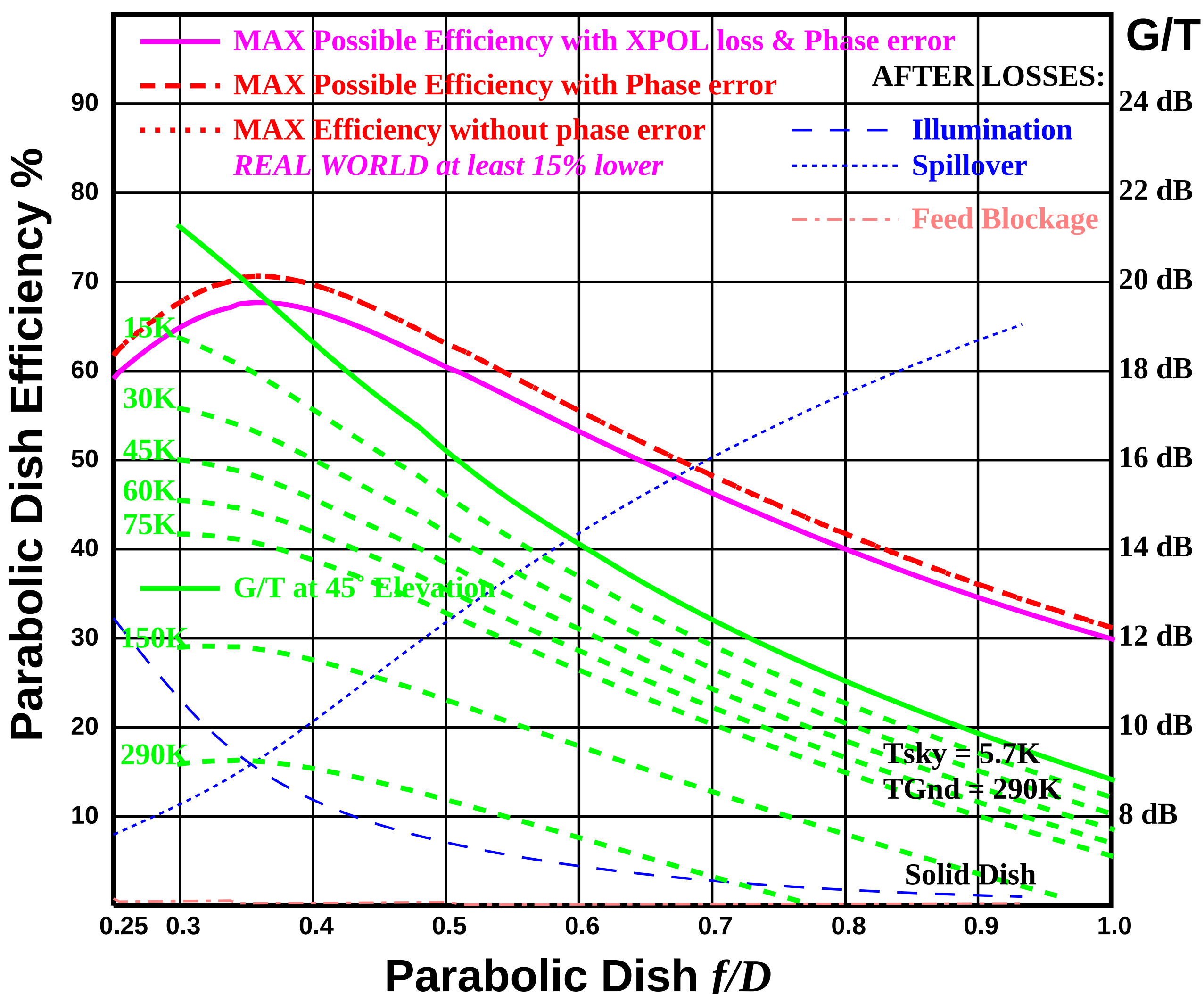

W1GHZ 1998, 2014

# Coffee Can Feed - Cylindrical Waveguide 0.71λ dia, RHCP
# Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
## Figure 24



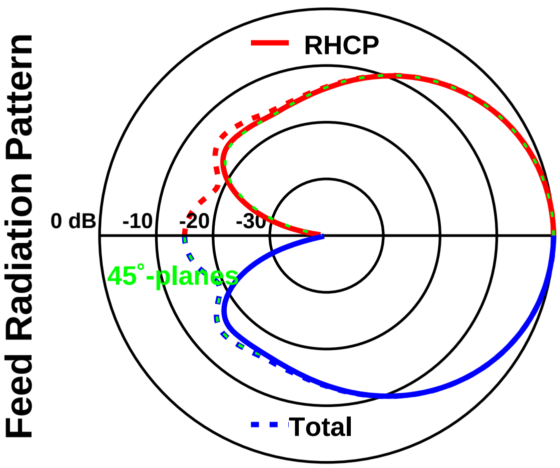



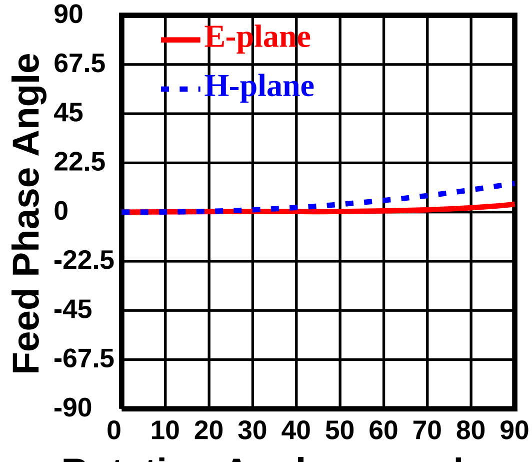

Dish diameter = 20 λ    Feed diameter = 0.71 λ




W1GHZ 1998, 2014

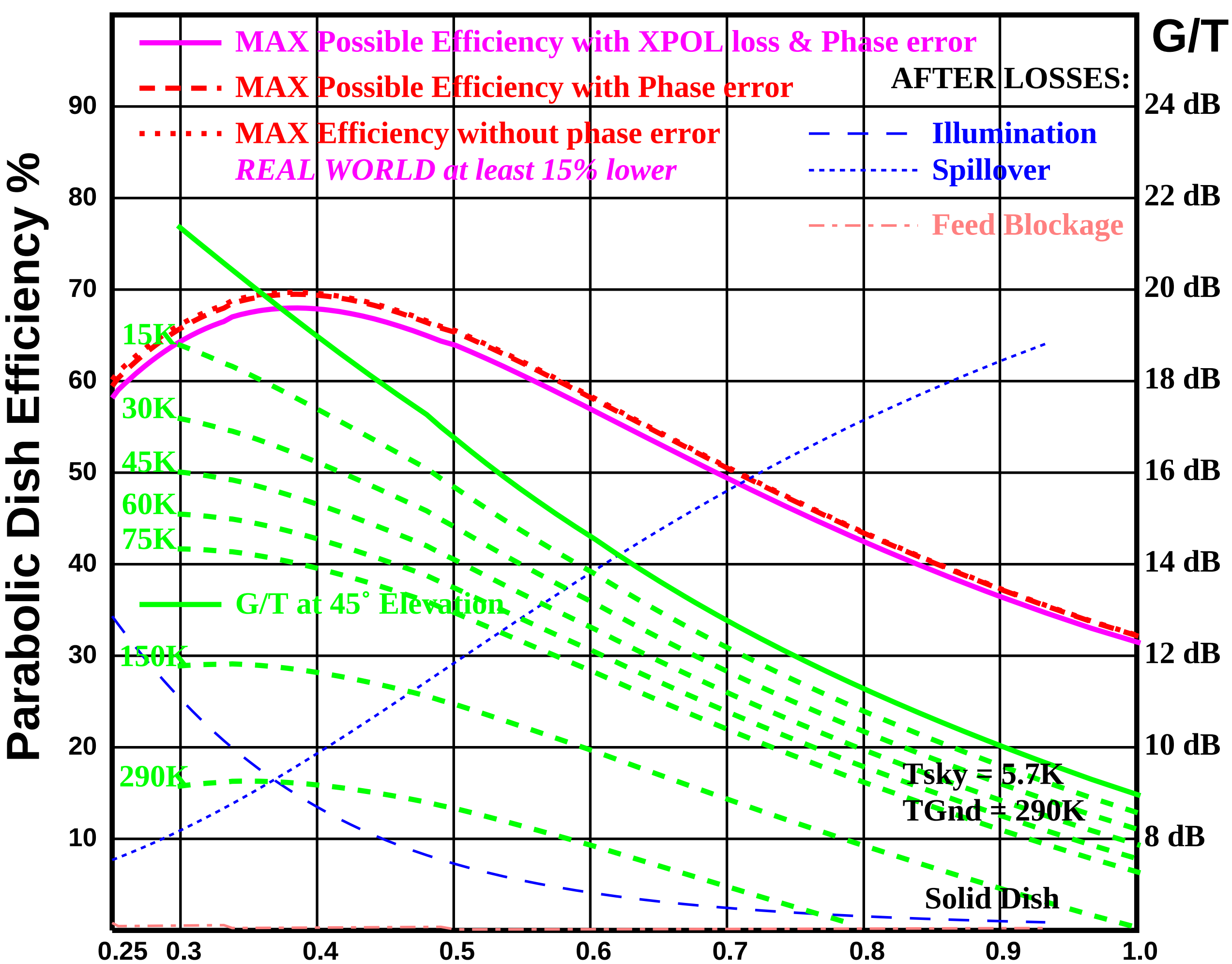
# N2UO Round Septum Feed, no choke, RHCP
# Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
# Figure 25




Dish diameter = 20 λ Feed diameter = 0.7 λ

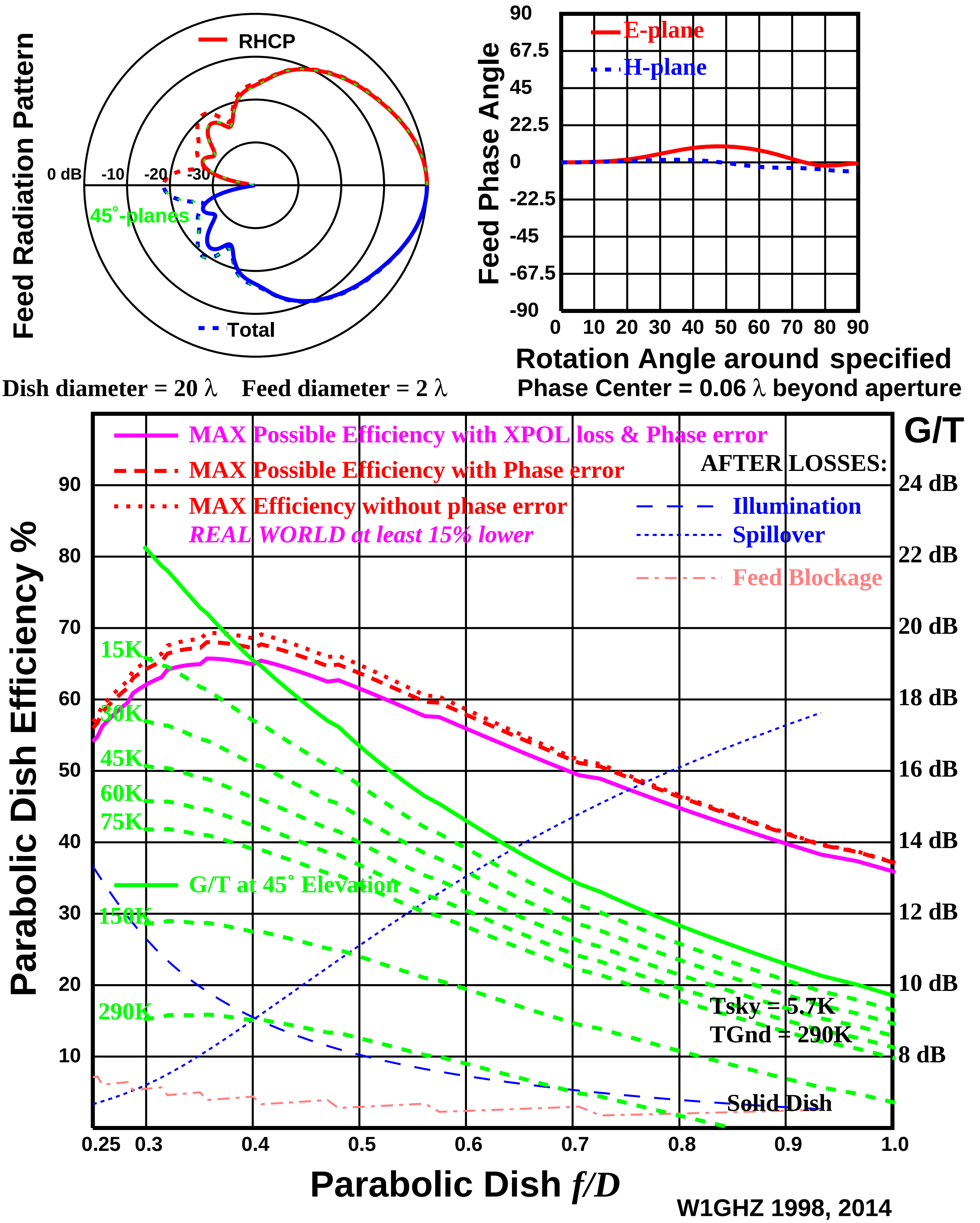
Phase Center = 0 λ beyond aperture



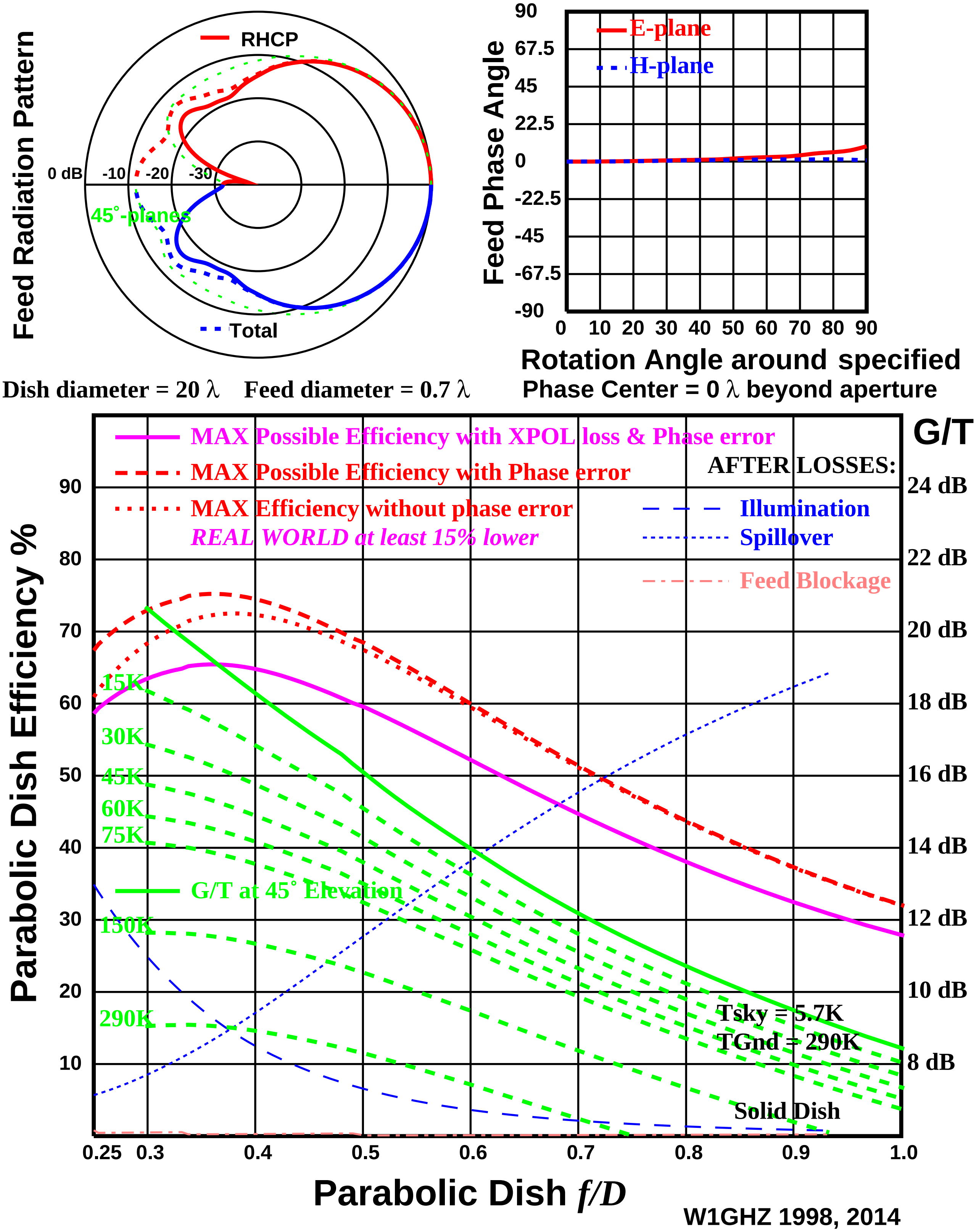

Parabolic Dish *f/D*

W1GHZ 1998, 2014

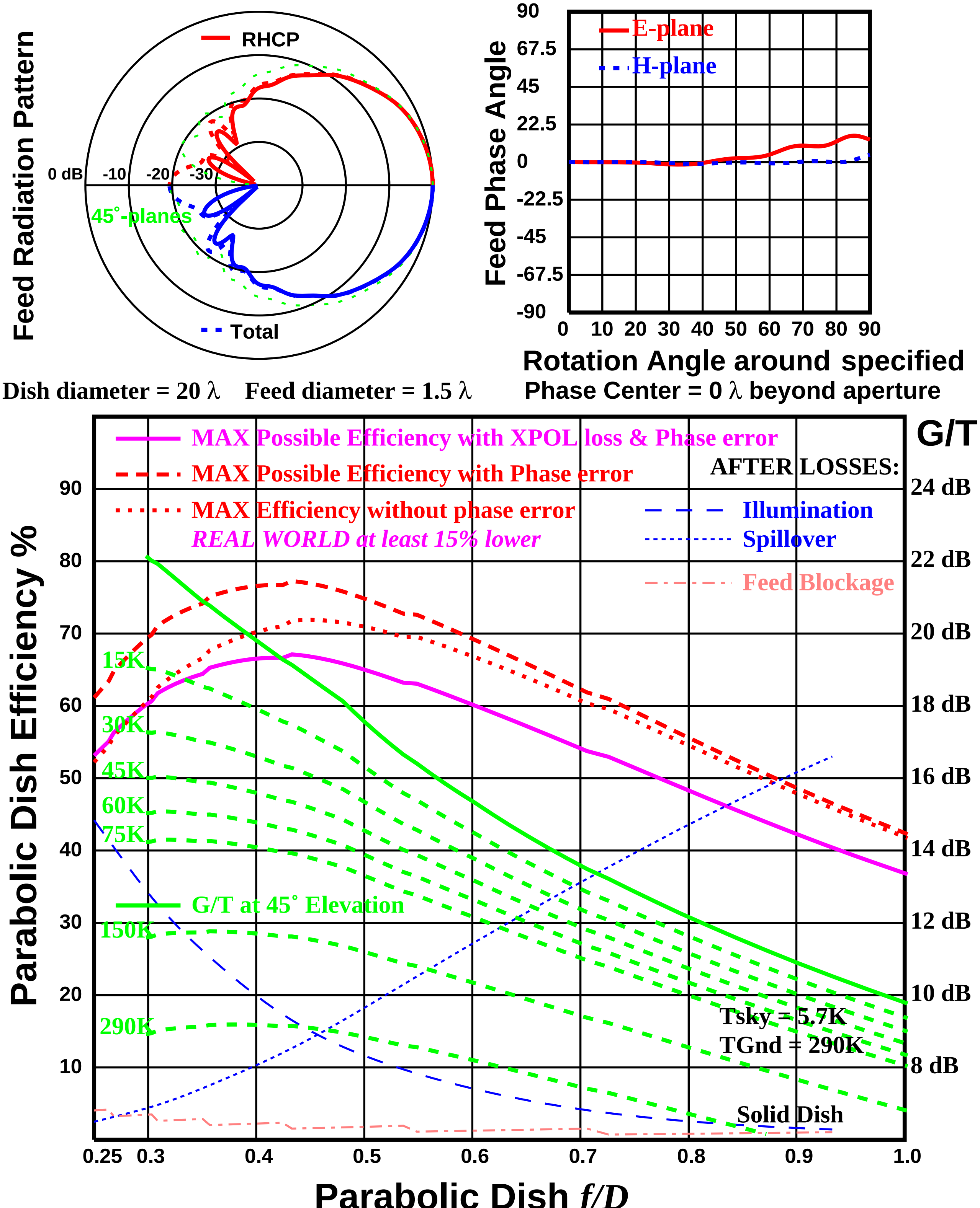
# WA9HUV Cylindrical Horn with 2λdiameter flange
# Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
# Figure 26



# OK1DFC Square Septum Feed, no choke, RHCP
## Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
## Figure 27



# OK1DFC Septum with flange 1.5λ diameter, back 0.35λ
# Receiver Noise Temp Comparison - 15,30,45,60,75,150 & 290K
# Figure 28




W1GHZ 1998, 2014

## Comments to the diagrams

The diagram of "reception performance" shows the signal-to-noise ratio of extra terrestrial signal reception (sun noise) dependent on f/D ratio.

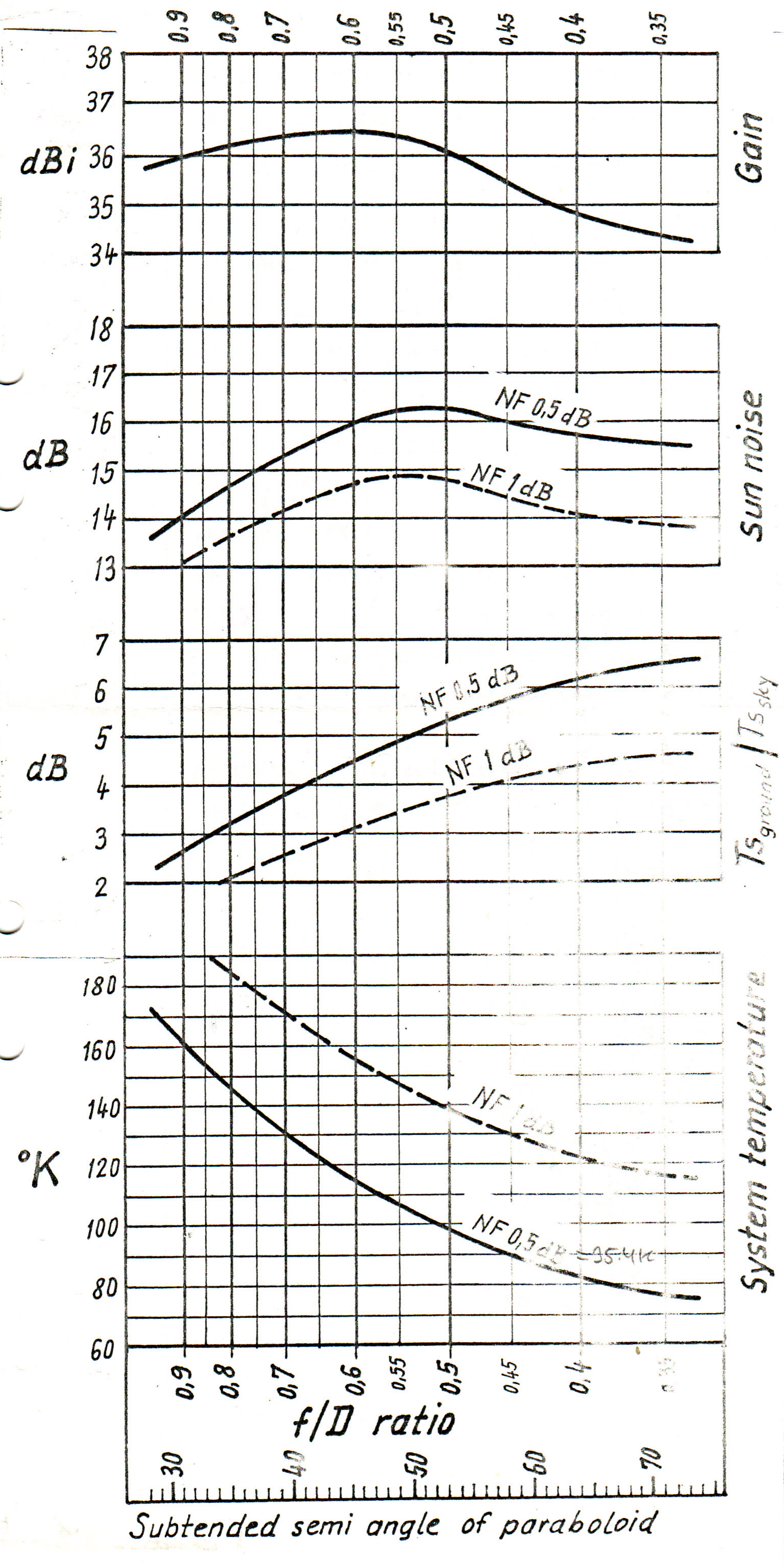
Using a 0,5dB NF front end, the best performance of the receiving system looks at 0,52 f/D (correspon-ding to −12,6dB dish edge illumination). The maximum gain is achieved at 0,59 f/D (corresponds to −9,9 dB dish edge illumination).

The best over all performance requires a compromise. In this case, compromise means an f/D ratio which gives equalized loss of transmission- and reception-performance. A closer look at the diagram shows this compromise at 0,55 f/D (both losses approx 0,2 dB) which corresponds to 11,3 dB apertur taper.

However, small movements in the 0,5 -0,6 f/D range archieves no significant effects on performance.

June 84, OE9PMJ

*Performance of a dish antenna in relation to f/D ratio, illuminated by a dual mode horn (W2IMU design) on 1296 Mc*




TRANSMISSION PERFORMANCE

Gain of 2oft dish dia

On o,59 f/D maximum aperture efficiency $\eta^f = 0{,}645$ , where spill-over $\eta^s = 0{,}831$ and illumination $\eta^i = 0{,}776$

RECEPTION PERFORMANCE

maximum at o,52 (o,54) f/D ratio

Calculated sun noise (Flux 65) for a 2oft dish and o.5(1.o)dB noise figure preamp.

Ratio of thermal earth noise (antenna aimed [illegible] elevation) on [illegible] sky reception.

It is a measure of receiver system temperature independent of antenna gain.

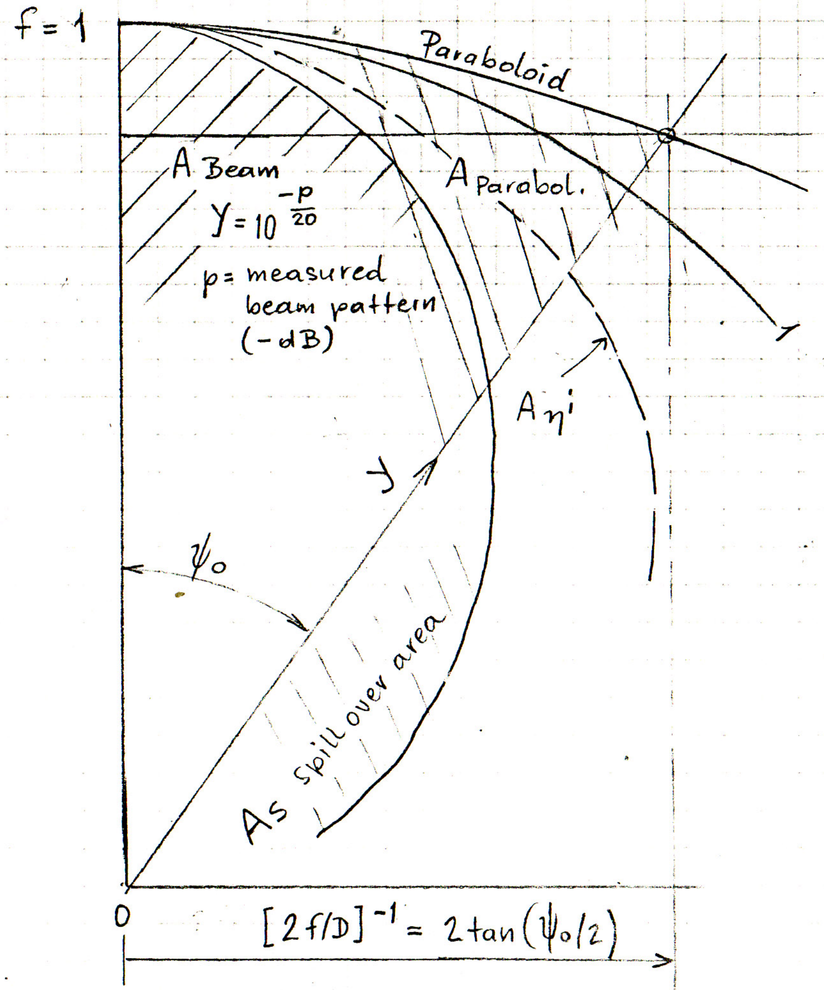
Noise temperature of receiving system with o.5(1.o)dB NF front end, antenna aimed at zenith.

All values are calculated based on a measured beam pattern diagram of the feed horn.
Reflector-, phase- and polarization efficiencies are $\eta$ = 1.

June 1984, OE 9 PMJ

# SCHEME FOR CALCULATION

of illumination efficiency $\eta^i$ and spill over effeciency $\eta^s$ of a paraboloid antenna illuminated by a radiator with equal E- and H-plan beam pattern (W2IMU-horn)




$$A_P = (4f/D)^{-1} + \left[192(f/D^3)\right]^{-1} = \tan(\psi_0/2) + \frac{[\tan(\psi_0/2)]^3}{3}$$

* Simpson's appoximation

$$\frac{h}{3} = \frac{\pi \cdot \psi_0}{3 \cdot 360 \cdot n} \; ; \; n = 2k$$

$$A_B = \int_0^{\psi_0} f(\psi)\,d\psi \overset{*}{\approx} \frac{h}{3}\left(Y_0 + 4Y_1 + 2Y_2 + 4Y_3 + 2Y_4 + \ldots \right.$$
$$\left. \ldots + 2Y_{2k-2} + 4Y_{2k-1} + Y_{2k}\right)$$

$$A_{\eta^i} = \sqrt[3]{A_B \cdot A_P^2} \; ; \quad \eta^i = \frac{A_{\eta^i}}{A_P} = \sqrt[1,5]{\frac{A_B}{A_P}}$$

$$A_S = \int_{\psi_0}^{180^\circ} f(\psi)\,d\psi \; ; \quad \eta^s = \frac{A_B + A_S}{A_P}$$

Apertur efficiency $\eta^f = \eta^i \cdot \eta^s \cdot \eta^\phi \cdot \eta^p \cdot \eta^R$ ; $\eta^\phi$ (phase) $\approx 1$, $\eta^p$ (polarization) $\approx 1$, $\eta^R$ (reflector performance) $\approx 0,85 \ldots 0,995$

June 1984, OE9PMJ