# RA3AQ Septum Feed Simulations

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Dmitri, RA3AQ developed a feed in 2007 with a square septum and a round aperture, and updated it in late 2008. I received this drawing in early 2007 from OK1DFC along with supporting data:

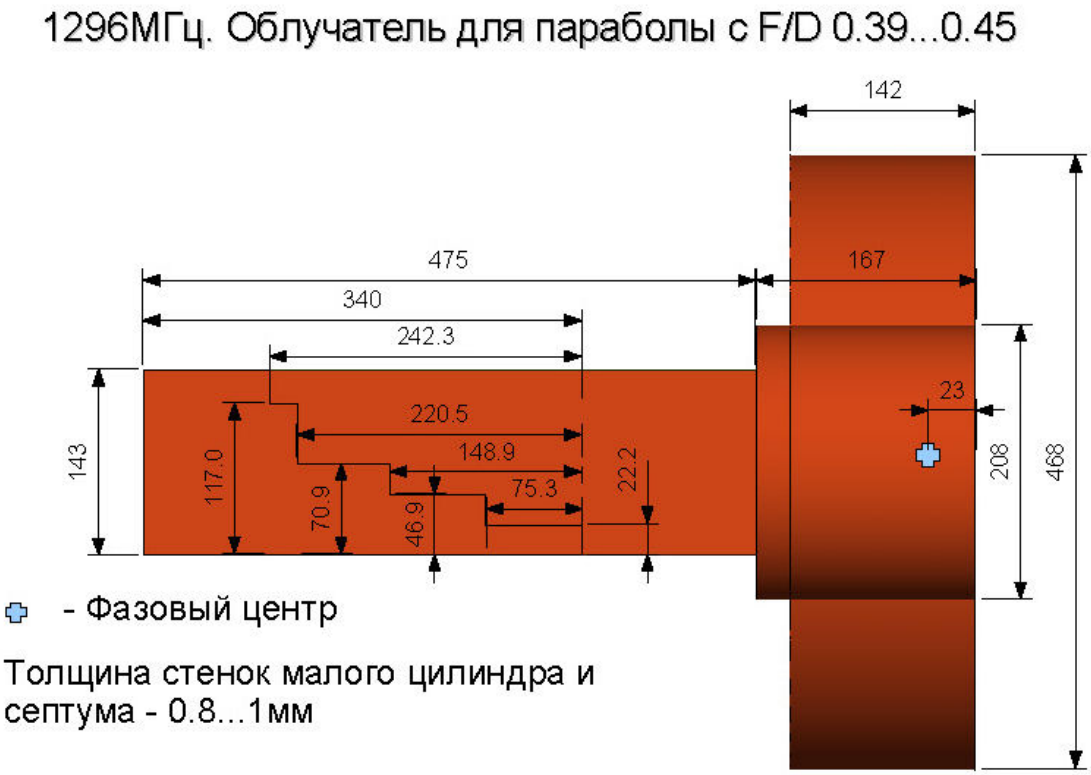


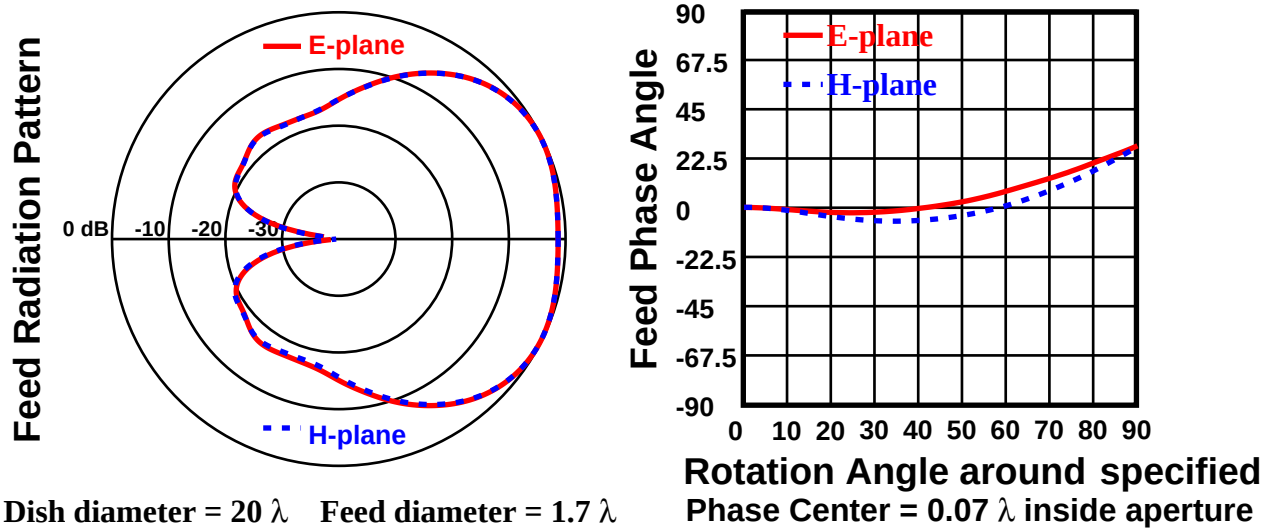

**Figure 1 - RA3AQ Septum Feed Dimensions**

With help from a Russian-speaking colleague, I was able to translate the text.

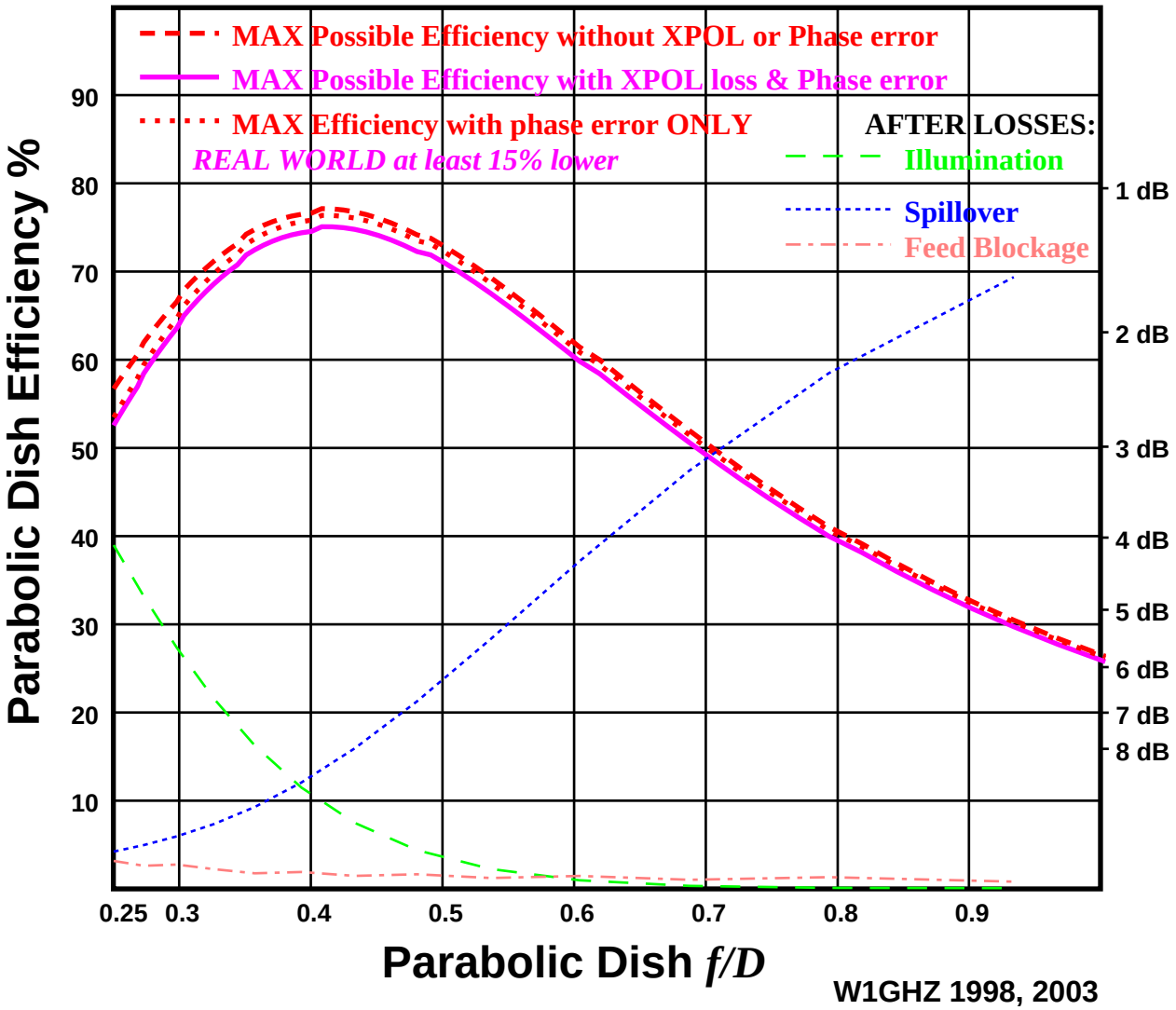
Of course, I had to simulate this antenna. The calculated dish efficiency is shown in Figure 2 – 74.7% efficiency at the best ***f*/D** = 0.42. The data from Dmitri used my old FEEDPATT program which only considers amplitude, not phase or XPOL, so the calculated efficiency was more optimistic. Still, the data in Figure 2 is as good as the best septum feed to date. Other choke positions were investigated; the best was 0.05λ behind the aperture, with efficiency of 75.0%. Other positions were not as good, and made little difference in ***f*/D**.

# Fig 2. RA3AQ square septum with round aperture

## Round choke ring 2.0λ dia x 0.6λ deep, flush




**Dish diameter = 20 λ  Feed diameter = 1.7 λ**

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More interesting was the purity of circular polarization produced by this septum. The axial ratio in Figure 3 is very good, < 0.2 dB, on boresight and pretty good over the whole illumination angle. The polarization ratio, in Figure 4, is also very good over the illumination angle. These two parameters are good indicators of circularity.

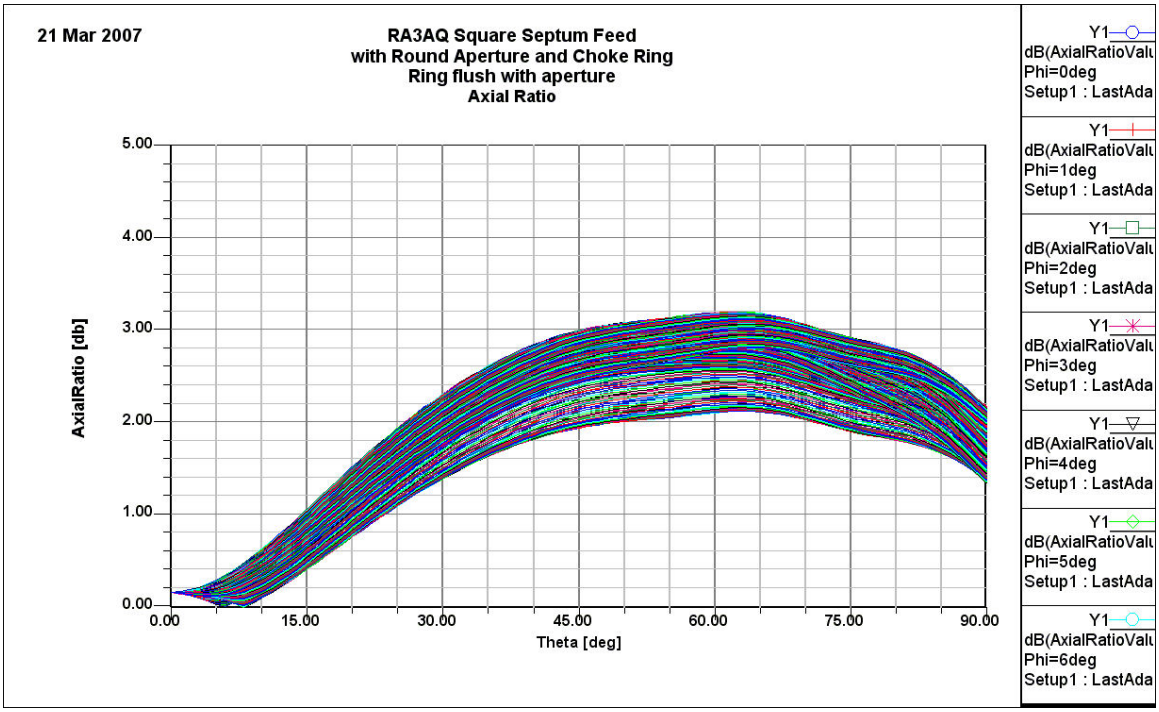



**Figure 3**

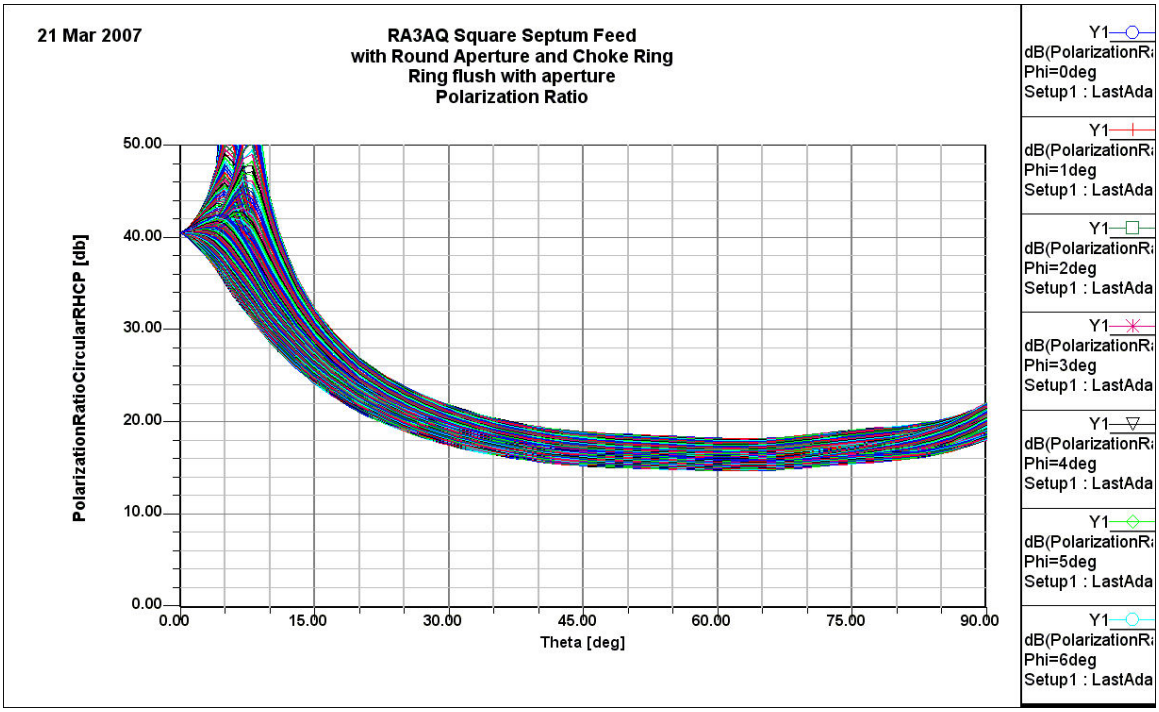



**Figure 4**

An even better indicator of circularity is the phase rotation of the polarity, the phase difference between orthogonal polarization vectors. If we were exciting circular polarization with orthogonal probes, we would excite them with 90° phase difference and expect the radiated field vectors to also have 90° phase difference. I don't believe that this can be measured, but software can do it easily. The polarization phase rotation for this feed is shown in Figure 5 – close to 90 degrees on boresight, falling off a small amount over Theta. This is better than some of the other septum feeds – I am working on a separate paper on this topic.

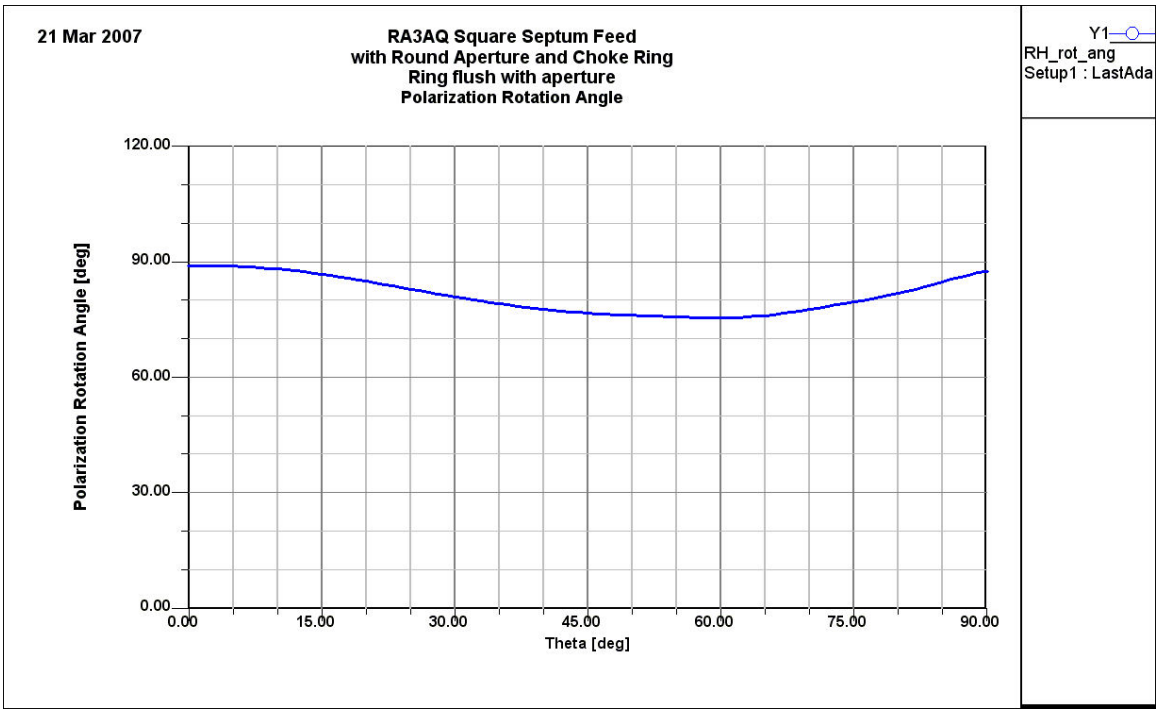
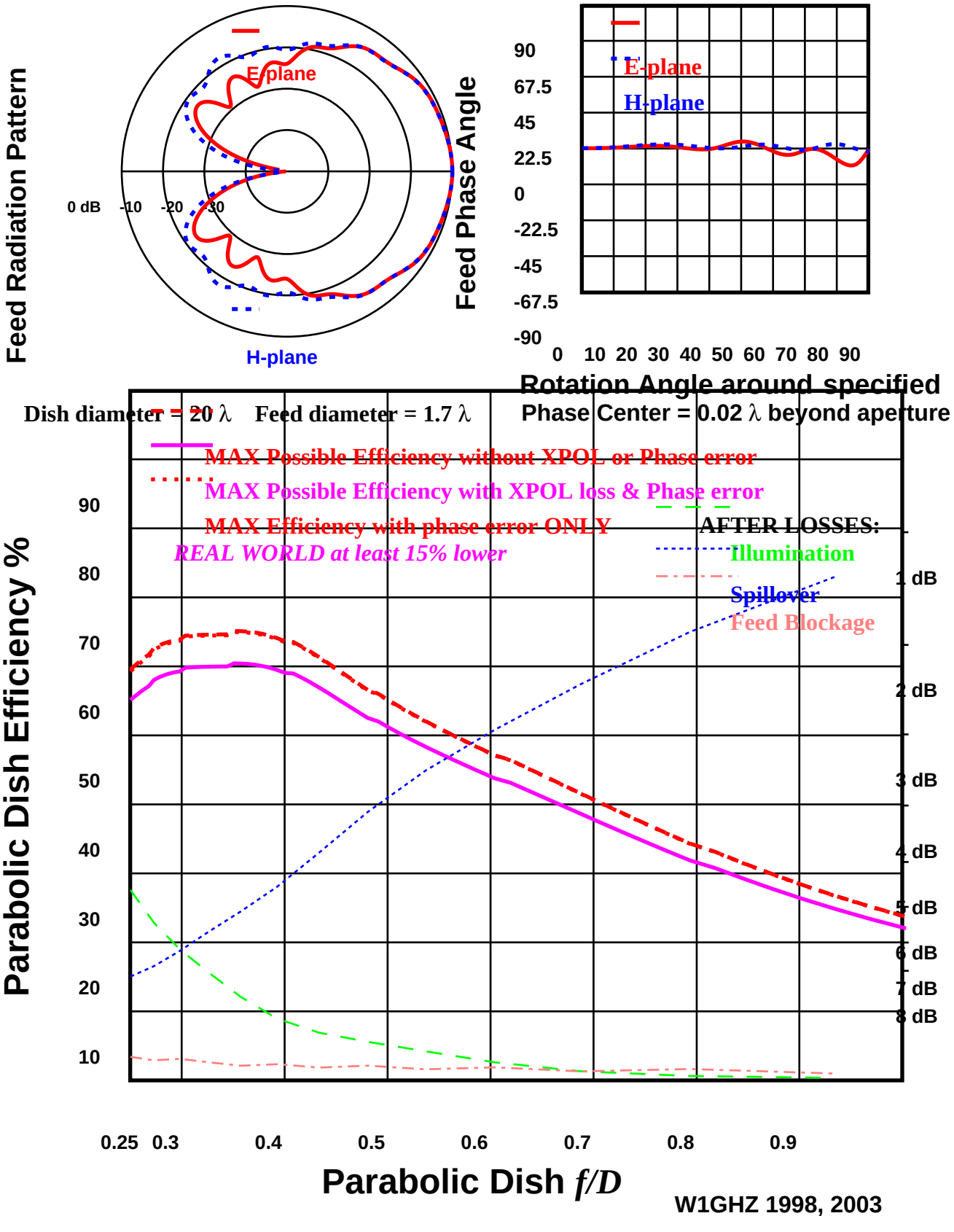



**Figure 5**

## RA3AQ Septum Alone

Since the RA3AQ feed seemed to have good circularity, I wanted to look at the septum alone and compare it with others. This is simply a matter of deleting the circular aperture and choke ring, leave a square septum feed. The feed performance, shown in Figure 6, is comparable to other septum feeds. This is to be expected – the antenna is simply a square horn, independent of septum dimensions, as long as the circularity is reasonably good. In fact, the polarization phase rotation is quite good, as shown in Figure 7, very close to 90 degrees over a wide illumination angle. The axial ratio, in Figure 8, and the polarization ratio, in Figure 9, are also very good, comparable to the complete RA3AQ feed above. Our conclusion is that the circular polarization is mainly controlled by the polarizer, while the radiation pattern is a function of the aperture section of the antenna.

# Square septum feed, no choke ring, RA3AQ septum, RHCP
# Figure 6

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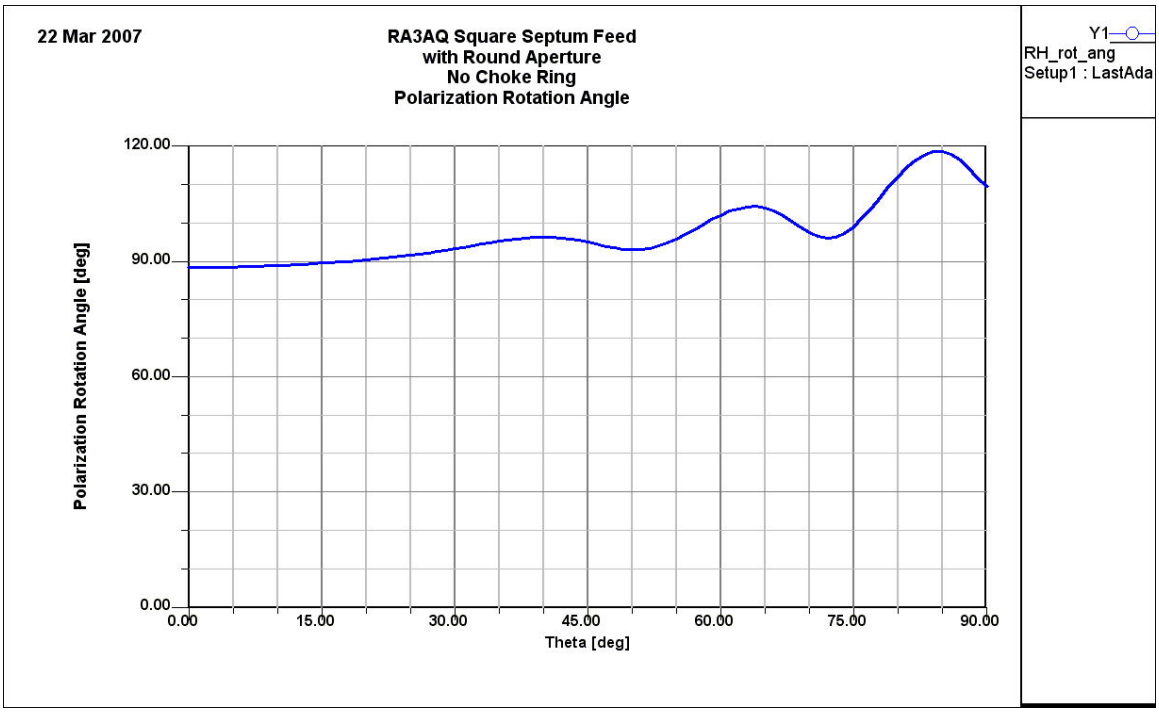



**Figure 7**

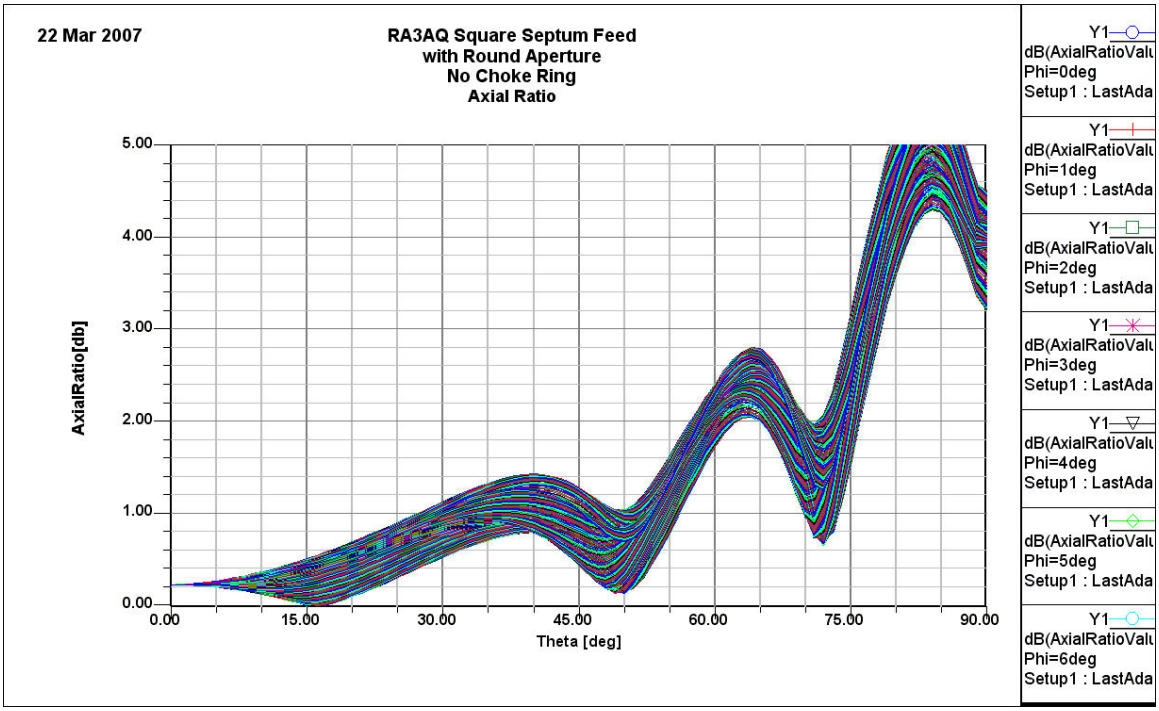



**Figure 8**

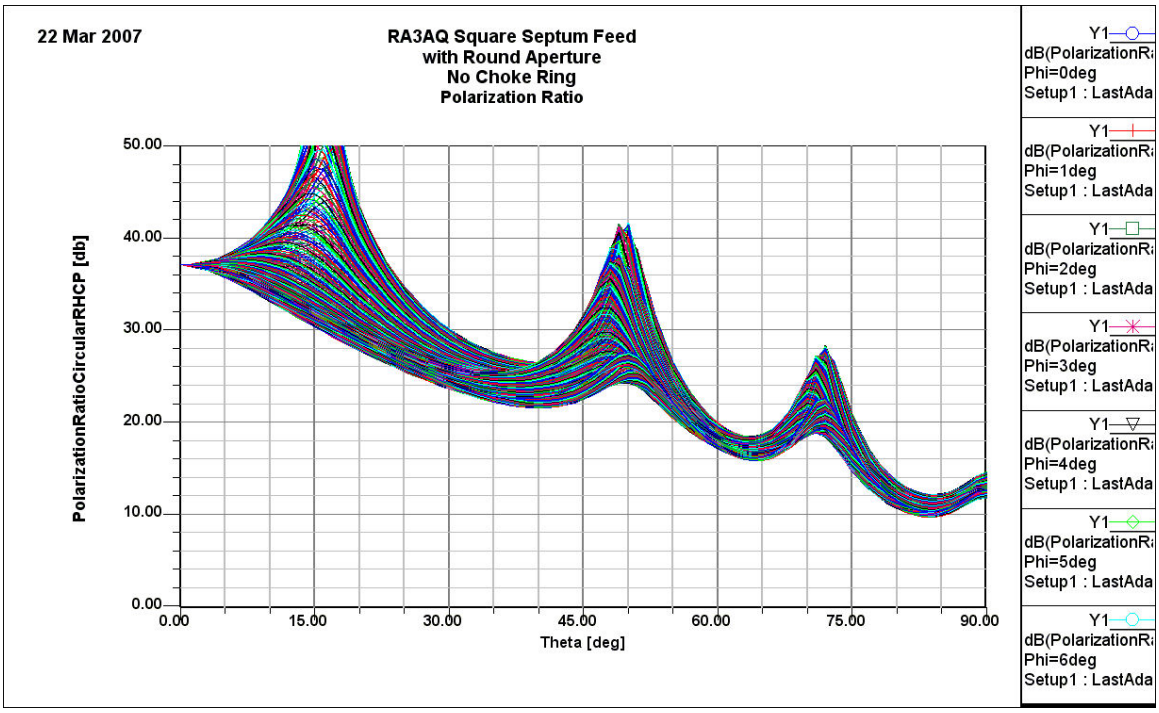



**Figure 9**

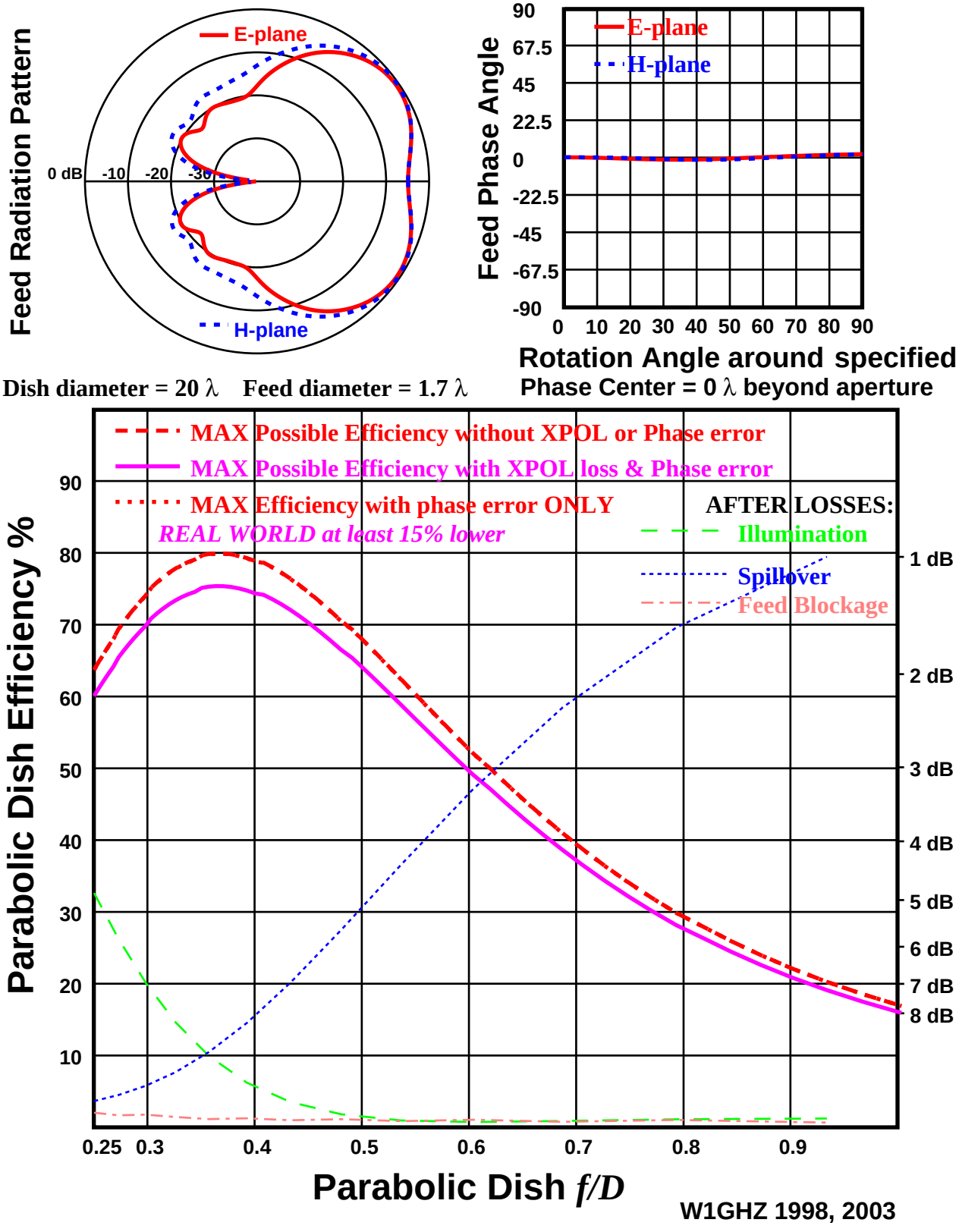
## Square aperture with Choke ring

For the OK1DFC septum feed, I determined an optimum set of choke ring dimensions, 2.0λ in diameter x 0.375λ deep, placed 0.175λ behind the aperture. Since the square aperture is the same with the RA3AQ septum, the same choke ring should work. As expected, it does – Figure 10 shows the dish performance. The calculated efficiency is 75.2% at the best ***f*/D** = 0.36. This is very slightly better than with the OK1DFC septum, perhaps attributable to the improved circularity of the RA3AQ septum.

## Summary – 2007 version

The RA3AQ septum provides good circular polarization, providing good dish efficiency for ***f*/D** ~ 0.42 with the round aperture plus choke ring configuration, and for ***f*/D** ~ 0.36 with a choke ring alone on the square aperture. In neither case does moving the choke ring affect the best ***f*/D**.

# Fig 10. Square septum feed, RA3AQ septum dimensions with choke ring 2.0λ dia x 0.375λ deep, back 0.175λ, RHCP



## 2008 Version of RA3AQ-042

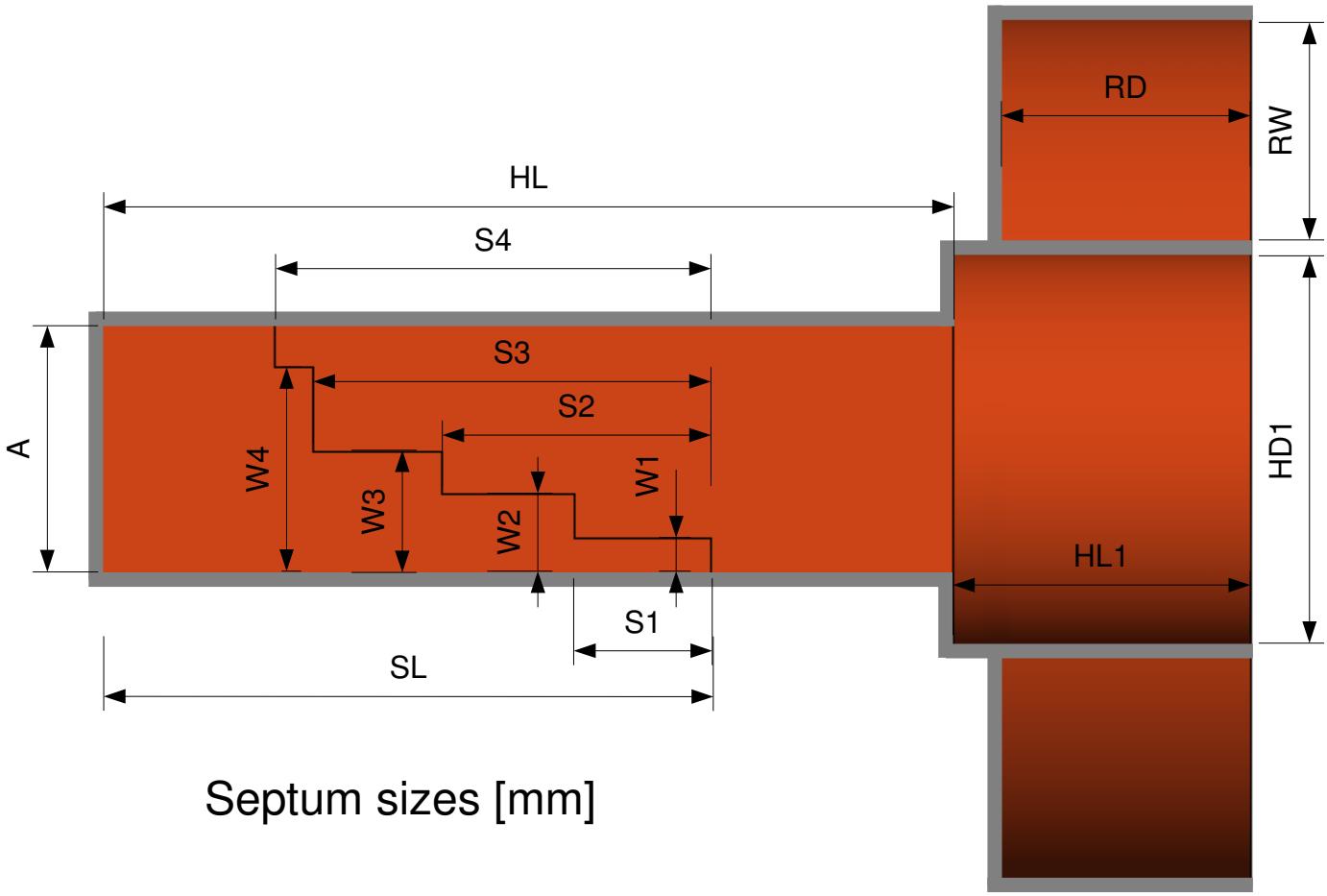
Dmitry recently posted a new version, RA3AQ-042, on the website http://www.vhfdx.ru/faylyi/start-download/shemyi-i-opisaniya/ra3aq-feed-with-square-septum. This version is shown in Figure 11.

Since it was very similar to the previous one, with only slight changes in the septum and horn dimensions, I expected that this one might be a slight improvement. The calculated efficiency curve Figure 12 shows this to be the case, with calculated efficiency as high as 76.5% for an ***f*/D** of 0.43, and nearly as good for ***f*/D** from about 0.38 to about 0.47. Calculated isolation looks good, but reflections from the dish surface can reduce isolation significantly. Circular polarization also looks excellent, even better than the earlier version.

## Conclusion

Excellent! While the feed as a whole looks very good for an ***f*/D** around 0.42, as specified, the square septum polarizer is usable with other horns for other ***f*/D** as well. The polarizer generates good circular polarization, and may be mated with other horns as needed – for instance, a Chaparral-style horn or Super-VE4MA ring for deeper dishes. For shallower dishes or offset-fed ones, a dual-mode horn would be good – the circular transition section would also be needed.

# RA3AQ feed for dishes with F/D 0.37...0.45




## Septum sizes [mm]

| F[MHz] | A | HL | SL | W1 | W2 | W3 | W4 | S1 | S2 | S3 | S4 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1296 | 143,0 | 475,0 | 340,0 | 22,2 | 46,9 | 70,9 | 117,7 | 75,6 | 148,6 | 220,5 | 242,3 |
| 2320 | 79,9 | 265,3 | 189,9 | 12,4 | 26,2 | 39,6 | 65,7 | 42,2 | 83,0 | 123,2 | 135,4 |
| 3420 | 54,2 | 180,0 | 128,8 | 8,4 | 17,8 | 26,9 | 44,6 | 28,6 | 56,3 | 83,6 | 91,8 |

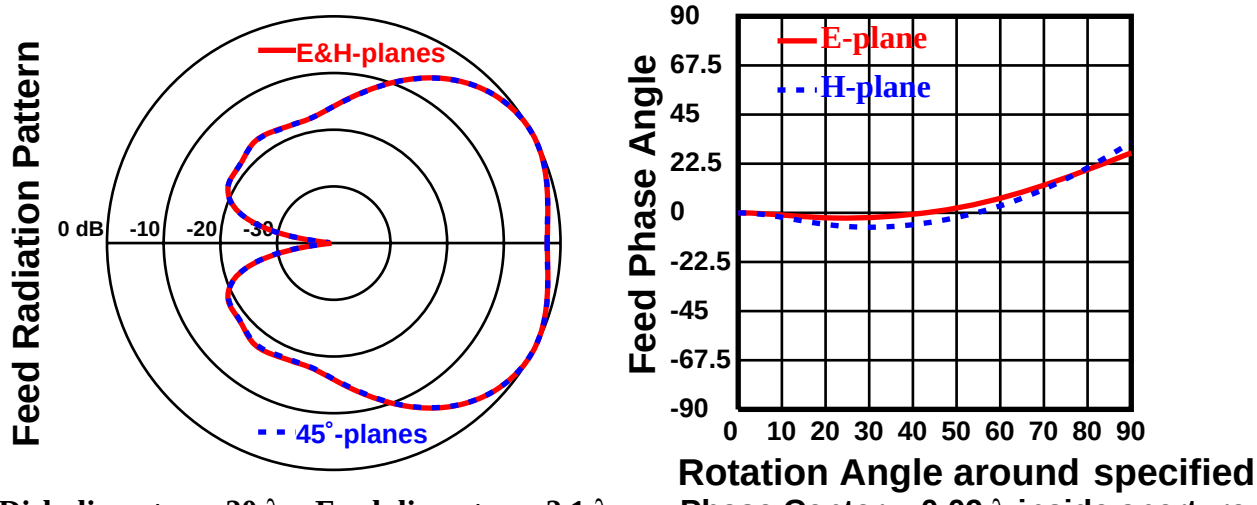
## Output section [mm]

| F[MHz] | HD1 | HL1 | RW | RD |
|---|---|---|---|---|
| 1296 | 214,0 | 173,0 | 135,0 | 142,0 |
| 2320 | 119,5 | 96,6 | 75,4 | 79,3 |
| 3420 | 81,1 | 65,6 | 51,2 | 53,8 |

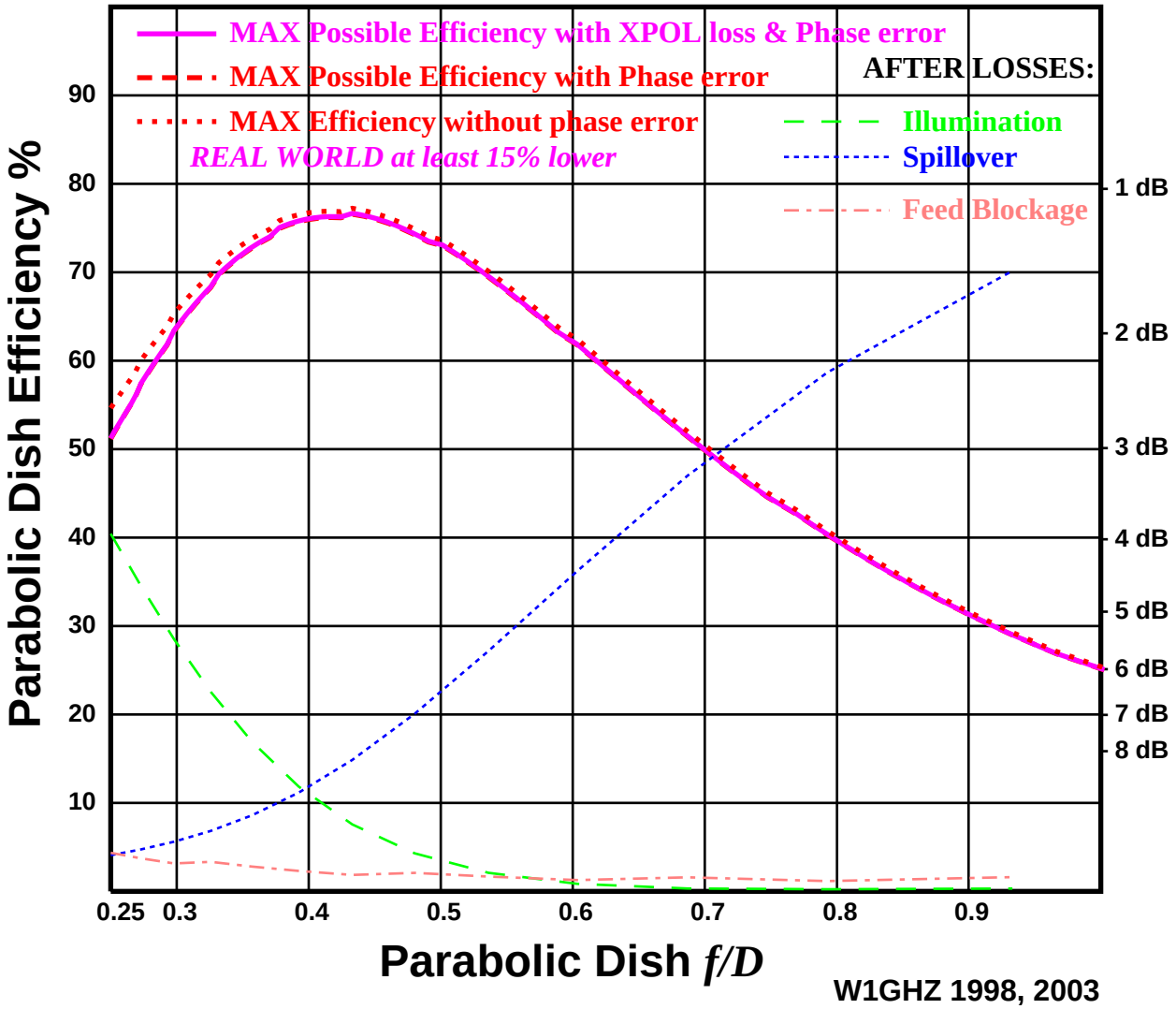
Septum plate thickness - 0.8...1мм

# RA3AQ-042 Feed - November 2008 version

## Figure 12




**Dish diameter = 20 λ  Feed diameter = 2.1 λ**

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