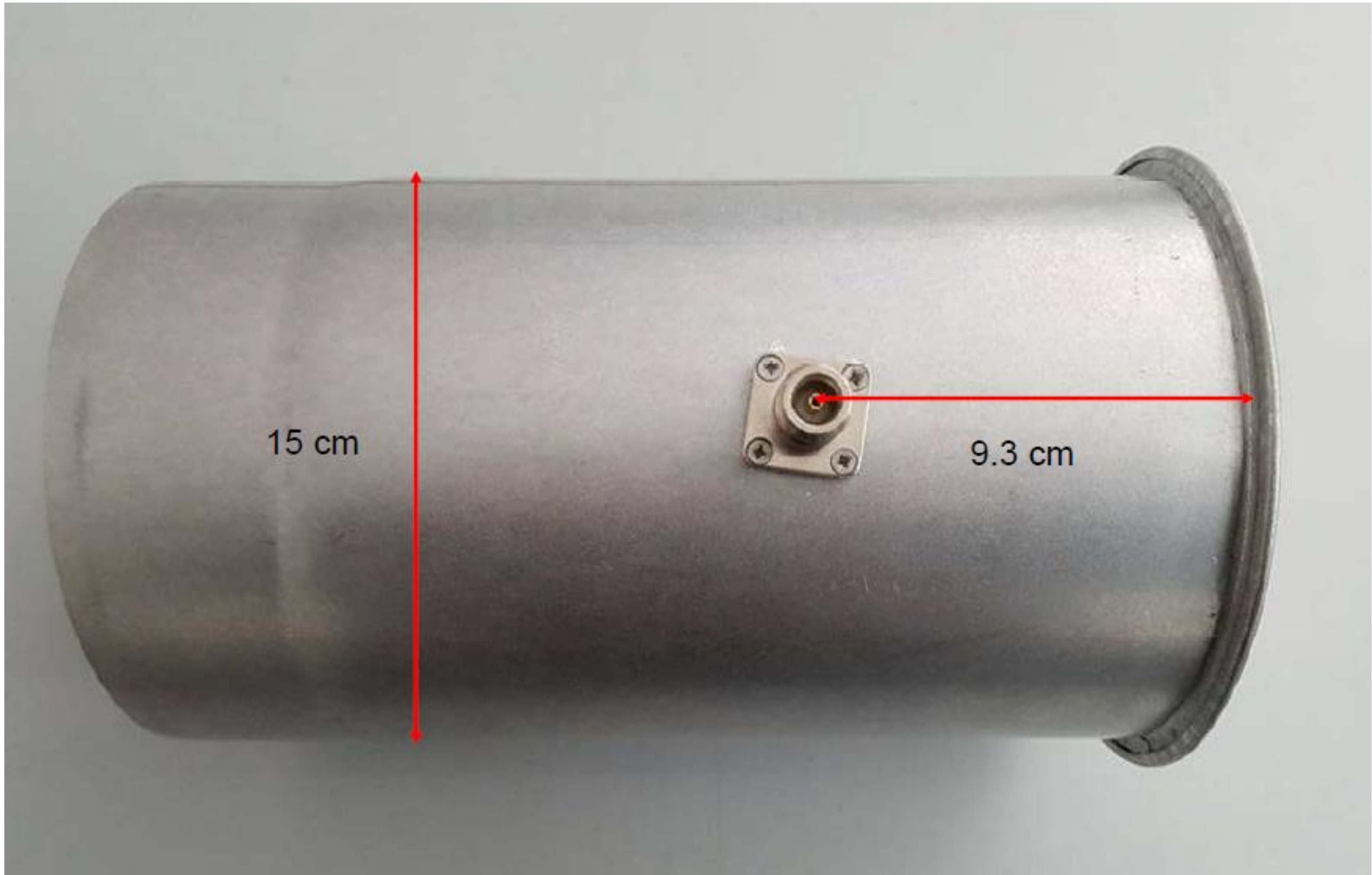
Calculating Cantenna Dimensions for H-Line

Astropeiler Stove-Pipe Cantenna Design



Waveguide wavelength (λg) & probe placement — practical starting points

- Waveguide wavelength $\lambda g = \lambda_0 / \mathrm{sqrt}(1-(fc/f)^2)$. Using the TE11 fc above:
- 145 mm dia → **λg ≈ 404 mm** → place probe **≈ 0.25–0.40·λg ≈ 100–162 mm** from back wall as a tuning range to try.
- 165 mm dia → **λg ≈ 319 mm** → place probe **≈ 0.25–0.40·λg ≈ 80–128 mm** from back wall.
  Many builders report good starting probe positions around 3–3.5 in (≈75–89 mm) for the ~154 mm cans; so use the ranges above and fine-tune while measuring return loss.

Can length, probe tip and other tips

- Can length: many practical designs use **~0.75–1.0·λg** (experimentally people report ~0.75·λg works well for 6" cans). A short choke / flange at the mouth helps control pattern and improve matching.
- Probe (pin) length: start near a quarter-wave in free space (~52–53 mm) and trim for best return loss inside the can. Use an LNA at the probe and an analyzer/SWR meter or NWA to tune.
- Mechanical: 165 mm cans (or buckets) are a bit heavier/larger — make sure mounts and supports are solid. Add a choke/flange or taper if you use the cantenna as a feed for a dish.

Mode behaviour for a 160 mm diameter cantenna

If D = 160 mm, c = 3e8 m/s, f = 1420.4058 MHz, λ0 ≈ 211 mm (free-space wavelength)

TE11 cutoff frequency

Formula (circular waveguide): fc_TE11 = (1.841 * c) / (pi * D)

Insert numbers (convert D = 0.160 m): fc_TE11 ≈ (1.841 * 3e8) / (3.1416 * 0.160)

fc_TE11 ≈ 1.10 GHz

TE21 cutoff frequency

fc_TE21 = (3.054 * c) / (pi * D)

Numerically:

fc_TE21 ≈ (3.054 * 3e8) / (3.1416 * 0.160)

fc_TE21 ≈ 1.82 GHz

Since: fc_TE11 < 1420 MHz < fc_TE21 the can operates **single-mode** at 1420 MHz (ideal).

Waveguide wavelength (λg)

Formula:

$$\lambda g = \lambda 0 / \text{sqrt}(1 - (fc\_TE11 / f)^2)$$

Compute ratio:

$(fc\_TE11 / f) \approx (1.10 / 1.420) \approx 0.775$

$(fc\_TE11 / f)^2 \approx 0.6006$

Then:

$1 - 0.6006 = 0.3994$

$\text{sqrt}(0.3994) \approx 0.632$

➔ $\lambda g = 211$ mm / $0.632 \approx 336$ mm

Probe distance from back of can

Use 0.25–0.40 of λg:

0.25 * λg ≈ 0.25 * 336 ≈ 84 mm

0.35 * λg ≈ 0.35 * 336 ≈ 118 mm

Recommended starting value:

Probe distance = 90–100 mm from the back plate

Probe (feed pin) length

Start with quarter-wave in free space:

L_probe ≈ λ0 / 4

L_probe ≈ 211 / 4

L_probe ≈ 52–53 mm

Trim by a few mm during tuning.

Summary Values

D = 150-160 mm

Height = 165 mm (good)

f_{c_TE11} ≈ 1.10 GHz

f_{c_TE21} ≈ 1.82 GHz

Operates single-mode at 1420 MHz

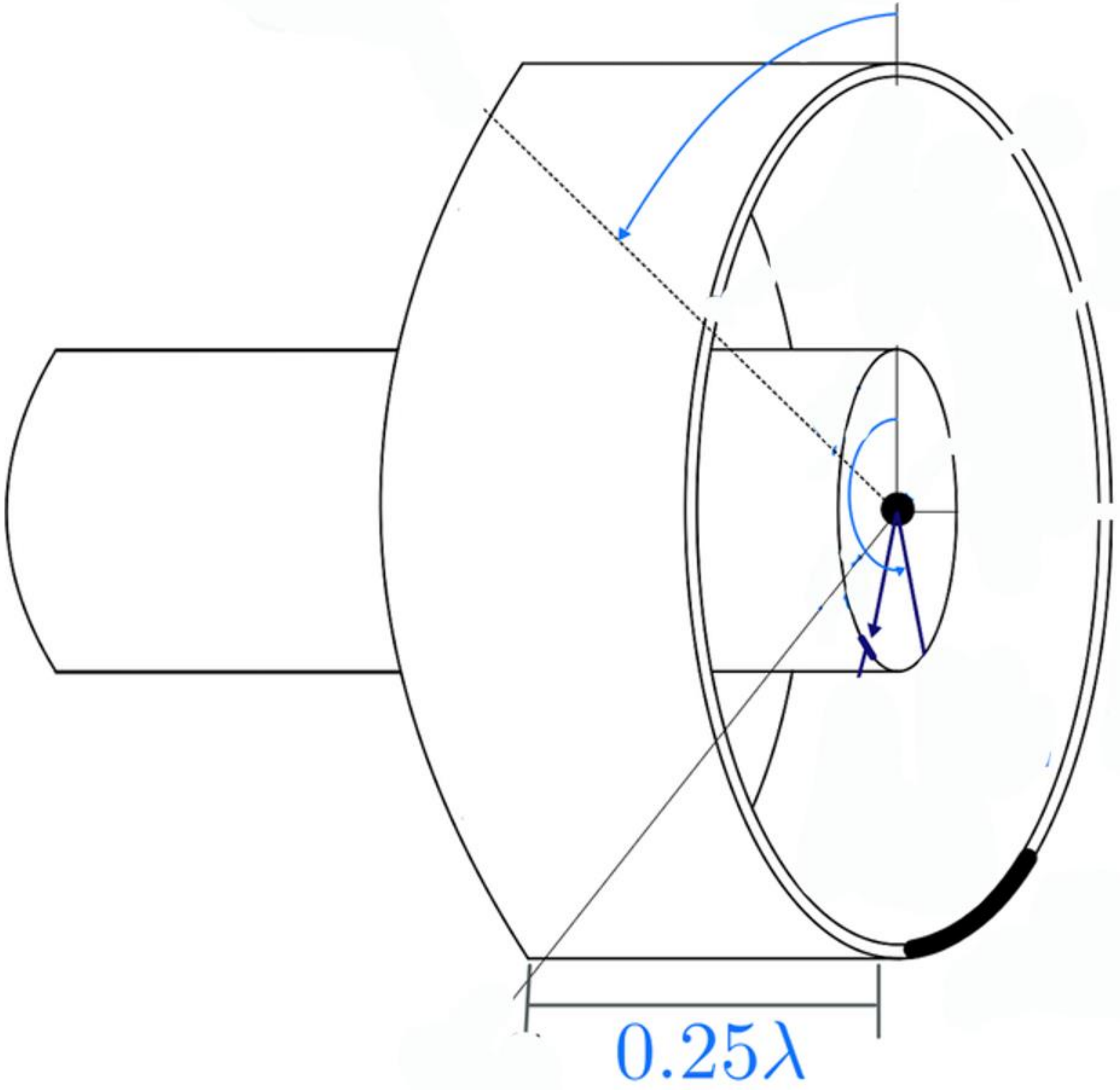
λ_g ≈ 336 mm

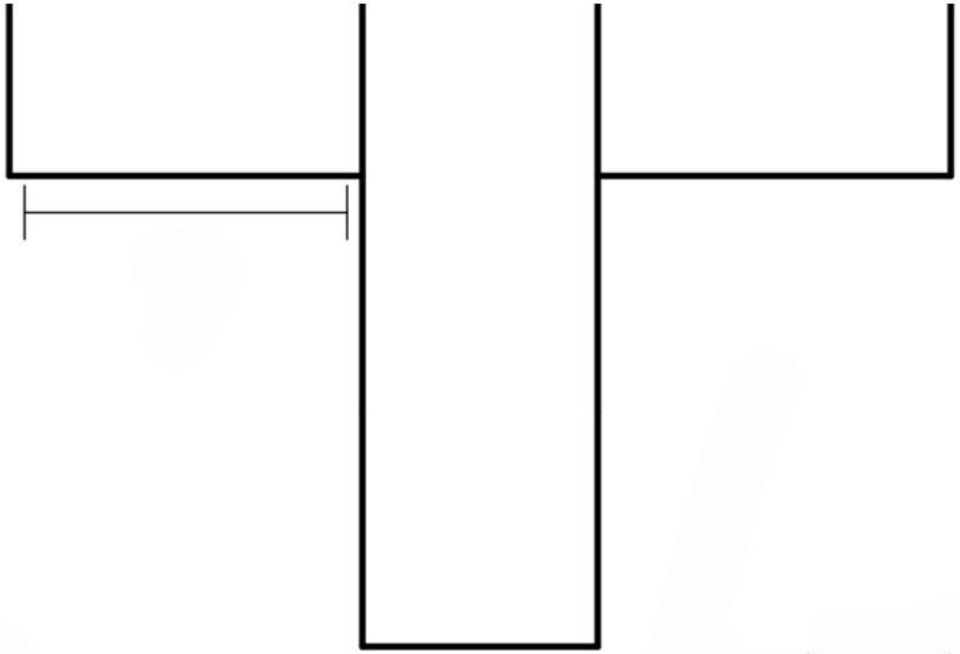
Probe distance = 90–100 mm, Astropeiler 93mm with D=150mm

Probe length = 52–53 mm

Choke rings for cantennas in hydrogen line radio astronomy

A waveguide choke ring is a special conductive groove or structure around a waveguide opening, used to improve performance by suppressing unwanted modes, reducing reflections (improving impedance matching), or shaping radiation patterns, often seen in high-performance feeds for satellite dishes or specialized antennas to improve efficiency, bandwidth, and reduce cross-polarization. Essentially, it acts as a parasitic element or a broadband matching network to control how microwave energy radiates or couples between components, preventing signal leakage and improving directivity, especially in compact designs.


0.25λ



Choke Ring Design (Waveguide Choke)

- Choke ring = physical structure around mouth of cantenna/feed horn/antenna.
- **Purpose:** Improves beam efficiency & reduces side lobes (cutting down noise from unwanted directions).
- **Design Considerations:**
  - **Dimensions frequency-dependent:** Dimeter & depth of choke ring is critical and precisely calculated based on operating frequency (1420 MHz for h-line projects).
  - **Calculation Tools:** Specialized Excel sheets & software from sources like the SETI League or specific amateur radio operators (e.g., JA6XKQ) are used to determine these exact dimensions.
  - **Construction:** Prototypes can be built from sheet metal or even simple folded mesh to test effectiveness.
  - **Placement:** The choke ring is typically placed a short distance from the mouth of the feed element.

SETI League Choke Design
http://setileague.org/hardware/feedchok.htm

SETI League Photo

Design by Barry Malowanchuk VE4MA

Dimension	cm	inches
Inside Diameter of Waveguide	15.6	6.14
Total waveguide length	27.8	10.94
Inside Diameter of Choke Ring	36.0	14.17
Depth of Choke Ring	10.6	4.17
Length of Coax Probe	4.6	1.81
Placement of Coax Probe	8.8	3.46

The use of a single scalar-mode choke on a cylindrical feedhorn has been explored extensively by Barry Malowanchuk, VE4MA. He has presented a nicely optimized dish feed for the amateur 5 cm (5760 MHz) band. [3] By fortuitous coincidence, the frequency for which Barry designed his horn is almost precisely four times that of the neutral hydrogen line. Since dimensions for waveguide scale linearly with wavelength, if we desire to build a hydrogen line feed using Barry's design, all we need do is multiply all of his dimensions precisely by four. This scaling process gives us the working dimensions shown in **Table 1** below.

Table 1

Dimension	cm	inches
Inside Diameter of Waveguide	15.6	6.14
Total waveguide length	27.8	10.94
Inside Diameter of Choke Ring	36.0	14.17
Depth of Choke Ring	10.6	4.17
Length of Coax Probe	4.6	1.81
Placement of Coax Probe	8.8	3.46

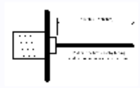
The final dimension above is measured with respect to the shorted end of the waveguide. See **Figure 2** for details of the quarter-wavelength monopole probe.

To download a Microsoft Excel ® spreadsheet for computing dimensions for feedhorns as a function of frequency and selected waveguide diameter, click here.

Figure 2

Construction details of the quarter-wavelength coaxial probe, which serves as the interface between the cylindrical waveguide feedhorn and the feedline (or antenna-mounted low-noise amplifier). The flange-type coaxial connector is mounted through the side of the cylindrical waveguide at the specified dimension, and receives a type N coaxial connector or adapter. For circular polarization, two such probes may be mounted 90 degrees apart on the feedhorn, and their outputs combined 90 degrees out of phase electrically by using a phase-quadrature hybrid coupler.

Click on thumbnail to view full image



SETI League drawing

Design b
VE4MA

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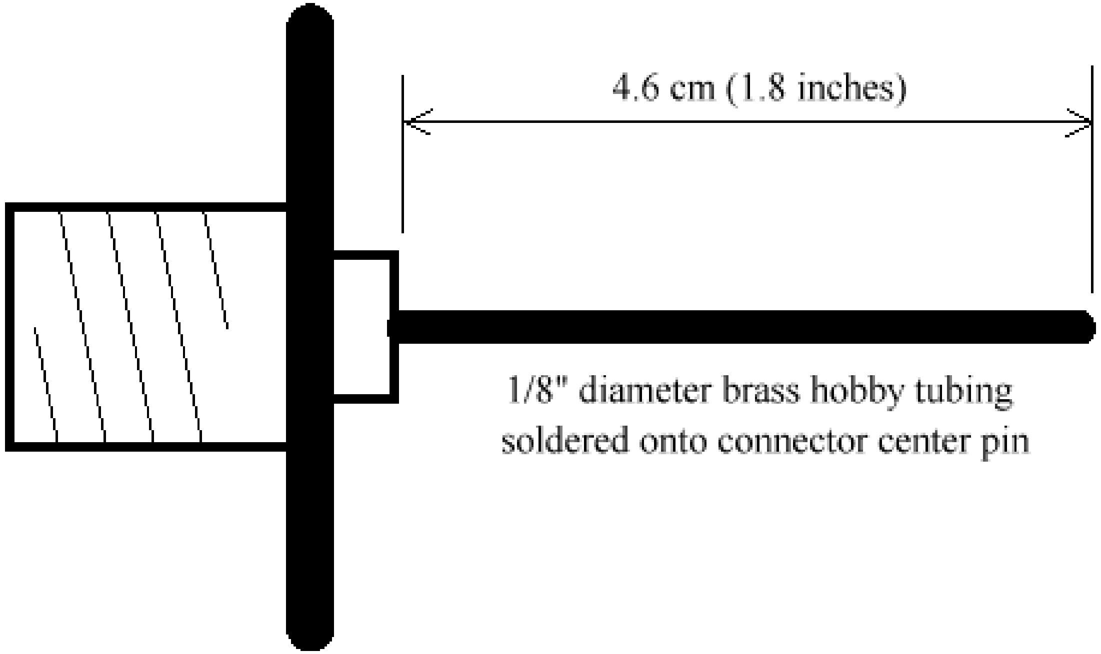
Detail of Monopole Probe for Cylindrical Waveguide Feedhorn

Insert through side of feed horn
8.8 cm (3.5 inches) ahead of shorted end



Type N Female Flange Mount Coaxial Connector
Amphenol P/N 82-368 or equivalent

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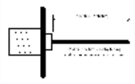
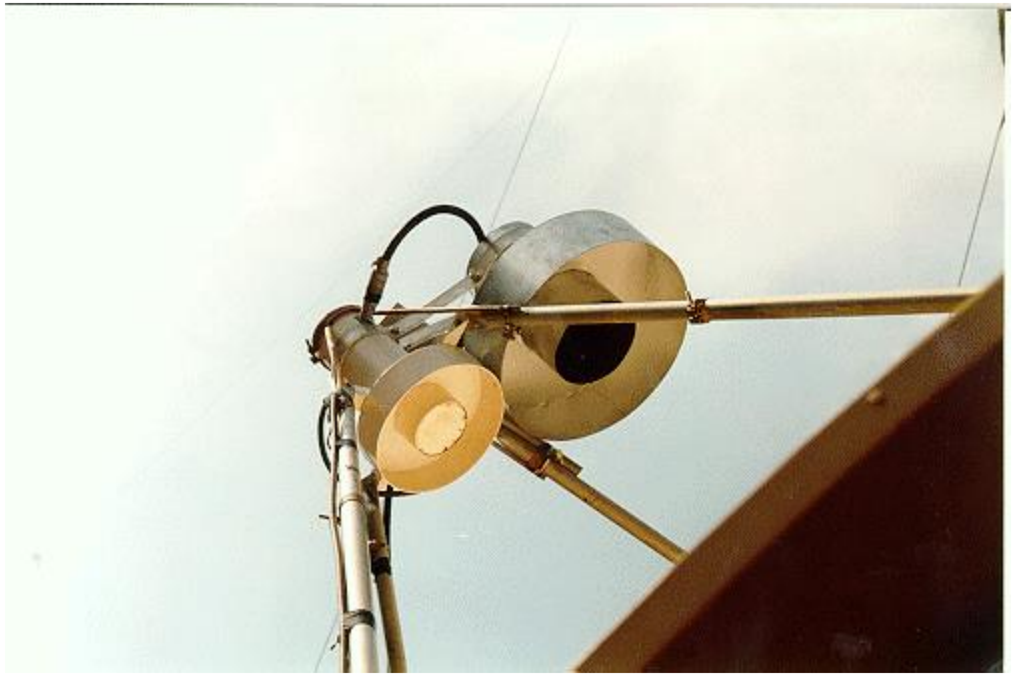


SETI League drawing

SETI LEAGUE



Dual feedhorns installed on EA3UM 5m SETI dish. These cylindrical waveguide feedhorns utilize choke rings of VE4MA design.

H-line feed offset from centre, allowing parasitic SETI whilst dish still used for another purpose.

Argus Station Measurements

https://www.seti.net/indepth/calculators/calculators.php

Cylindrical Waveguide Feedhorn analysis					**Measured**
Freq =	1.42	GHz	21.1	cm	5.9 In
Waveguide Dia. =	6	in	15.2	cm	
Lower Cutoff =	1.14	GHz	26.4	cm	
Upper Cutoff =	1.49	GHz	20.1	cm	
Guide Wavelength =	13.87	in	35.2	cm	
Probe placement =	3.47	in	8.8	cm	3.562
Feedhorn Length =	10.41	in	26.4	cm	
Zo =	629	ohms	1.67	vswr	
Choke Ring Depth =	4.16	in	10.6	cm	
Choke Ring Diameter =	14.32	in	36.4	cm	
Dish F/D Ratio =	0.4				(Valid range: 0.25 to 0.50)
Feedhorn Placement:		1.46	in	3.7	focal point of reflector falls inside lip of feedhorn by this amount
		1.46	in	3.7	
Choke Ring Placement:					Distance from front of feed horn to back of choke ring
Max. Gain (10 dB taper)	4.59	in	11.7	cm	4.5in
Min. Noise (15 dB taper)	4.10	in	10.4	cm	

SETI Calculators https://www.setileague.org/software/spreadsh.htm

www.setileague.org/software/spreadsh.htm   Sign in

SETI League Technical Manual -- Software

SETI Spreadsheet Templates

This page provides SETI enthusiasts with a collection of downloadable Microsoft Excel ® spreadsheets for performing some of the more common radio astronomy and SETI computations. With most browsers operating under the more popular operating systems, you may run any spreadsheet by left-clicking on the title, or save to hard disk by right-clicking.

Like all SETI League software, we consider these spreadsheets shareware. That means you are encouraged to download, distribute, modify, and experiment, but you are *not* permitted to sell these templates, or to commercialize them in any way. Violators will be ostracized.

Many other spreadsheet programs will also import and run Excel ® templates. It shouldn't be necessary to have Excel on your computer to download these files. Try this: use the "save as" option of your Web browser to save the files to disk. They are *not* executables, so should save as straight ASCII. Then use the "import" option of your existing spreadsheet program to open them. I've done this successfully with Microsoft Works, and *presume* it will work with Lotus 123, Quattro Pro, SuperCalc, VisiCalc, etc.

Revised	Title	Description
06 Jun 1998	cooling.xls	This spreadsheet helps you to determine system performance improvements achieved by lowering the physical temperature of your low-noise preamplifier. The example values come from this article.
29 Jun 2003	g-t.xls	A method for quantifying SETI receive system performance, this spreadsheet computes G/T Ratio, a common figure of merit for space communications systems. G/T is the ratio of antenna gain to system noise temperature, typically converted to dB: the higher, the better. Contributed by Ed Cole, AL7EB, SETI League volunteer coordinator for Alaska, based upon equations collected by R.S. Flagg, AH6NM, of Hawaii. See Ed's paper in *Proceedings of SETICon01*.
19 May 2001	cascade.xls	Calculates the overall gain and noise figure of any receiver system, given the characteristics of the individual stages being cascaded. Allows the user to explore the performance of various system configurations. Contributed by Ed Cole, AL7EB, SETI League volunteer coordinator for Alaska. See Ed's paper in *Proceedings of SETICon01*.
12 Feb 2000	Tcalc.xlt	Another approach to analyzing receiver systems consisting of cascaded stages. Contributed by Roger Blackwell, G4PMK. Computes overall station gain and noise figure from the pertinent parameters of the individual stages. Click the "help" button to get started.
13 Dec 1997	ra_dec.xls	An astronomical calculator for determining Right Ascension and Declination, given user's location, time, and antenna aiming coordinates (azimuth and elevation). Contributed by Ian Drummond, VE6IXD, based upon equations collected by Dan Fox, KF9ET. The example values depict the conditions which prevailed during the detection of the Ohio State University "Wow!" signal.
13 Dec 1997	doppler.xls	For a specified frequency, observer's latitude, source hour angle and declination, computes instantaneous Doppler shift in Hertz, as well as rate of change of Doppler shift (df/dt) in Hertz per minute and Hertz per second, which an extra-terrestrial signal will undergo as a function of the Earth's rotation. Also determines how long a truly extra-terrestrial signal will remain within your antenna pattern, given the antenna diameter, right ascension and declination (it may be necessary to first run ra_decl.xls, above, to determine these values). Doppler rate and transit time are good checks for whether a given source is indeed exhibiting sidereal motion.
6 Aug 2016	stars.xls	Calculates the number of stars within a given distance from Earth, and provides a rough estimate of the number of stars within the beamwidth of a specified antenna at any given time. Assumes uniform stellar density, and (depending upon the direction in which the antenna is aimed) is probably valid only out to about 1000 light-years.
13 Dec 1997	sensitiv.xls	Determines the sensitivity (in Janskys for continuum measurements, and Watts per square meter for narrow-band signal detection) of any radio telescope, given its pertinent receiver and antenna parameters. Also shows the flux density of any received signal as a function of observed Signal-to-Noise Ratio (SNR). The sample caclulations seen in this spreadsheet show the sensitivity of the Ohio State University "Big Ear" radio telescope at the time the "Wow!" signal was detected. See this article for an example of sensitivity analysis.
13 Dec 1997	linkanal.xls	Determines the Signal-to-Noise Ratio (SNR) for any communications system, given the operating characteristics of the transmitter, receiver, and the intervening free-space propagation path. The sample spreadsheet calcuations show that the typical *Project Argus* station could easily receive a 1 MW hydrogen-line signal into a 100 meter dish, at a range of 1 parsec (3.26 LY), with just 10 seconds of integration. These normalized values may be used for comparison of various systems. See this article for more examples of link analysis.
13 Dec 1997	ranganal.xls	Performs range analysis of an electromagnetic communications system, assuming identical antennas at both ends. The example shows that the range over which a 1 MW hydrogen-line signal can be detected with existing receivers, assuming 100 meter dishes at both ends of the path, is on the order of 9 parsecs (28 LY). This spreadsheet may be used for range comparison of various systems.
15 Jun 2004	feedhorn.xls	Determines dimensions for cylindrical waveguide feedhorns with choke rings, and feedhorn placement with respect to focal point of the parabolic reflector. You specify a waveguide diameter, an operating frequency, and the F/D ratio of the parabolic reflector you wish to illuminate. The sample caclulations seen here are for the SETI League Hydrogen Line Feedhorn, as discussed in this article.
13 Dec 1997	parabola.xls	Calculates the electrical performance of a parabolic reflector antenna from specified physical dimensions. Also enables the user to determine focal length, F/D ratio and required feed illumination angle from dish diameter and depth.
21 Aug 1999	feedblok.xls	This spreadsheet, contributed by Edward R. Cole, estimates the gain of a parabolic antenna, taking into account aperture blockage by the feedhorn and its support arms. Assumes simple shadowing, and doesn't take into consideration diffraction effects. It assumes a circular feed structure and straight support arms from the edge of the dish.
26 Sep		A collaboration between Don Latham, Ed Larsen (KI7WB), Dr. John Marcus (KE3SW), and others on the SETI email discussion list, this "work in progress" helps you to design and evaluate end-fire helix antennas. Short helices make attractive dish feeds