For a **SETI-style "Horn of Plenty" horn antenna tuned to the neutral hydrogen line (1420.4058 MHz)**, you're essentially building a **pyramidal or exponential horn** fed by a rectangular waveguide. Below are **practical, proven dimensions** that balance gain, beamwidth, and buildability (very similar in spirit to the original Big Ear / Project SERENDIP horns).

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1. Fundamental numbers (1420 MHz)

- Wavelength, λ ≈ **0.211 m**
- Free-space half-wavelength ≈ **10.5 cm**

These drive everything else.

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2. Recommended feed waveguide

Use **WR-650 waveguide** (very appropriate for 1420 MHz):

- Internal dimensions:
  - **a = 165.1 mm**
  - **b = 82.55 mm**
- Dominant TE_{10} mode cutoff ≈ 908 MHz
- Excellent match at 1420 MHz

This is exactly what many hydrogen-line systems use.

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3. Horn type

For SETI work you want:

- **Low sidelobes**
- **Well-defined beam**
- **Stable phase centre**

Best choices:

- **Pyramidal horn** (simplest)
- **Smooth exponential flare** (better sidelobes, harder build)

Below assumes a **pyramidal horn**, which is entirely suitable.

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4. Aperture size (this sets gain & beamwidth)

A good SETI compromise:

Aperture dimensions

- **Width (H-plane): 1.4 m**
- **Height (E-plane): 1.0 m**

This gives:

- Gain ≈ **18–19 dBi**
- Beamwidth:
  - ~18° (H-plane)
  - ~25° (E-plane)

Large enough for sensitivity, wide enough for sky survey work.

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5. Horn length (flare length)

For good phase error (< λ/8 at edges):

$$L \approx \frac{A^2}{8\lambda}$$

Using the larger dimension (1.4 m):

$$L \approx \frac{(1.4)^2}{8 \times 0.211} \approx 1.16m$$

Recommended horn length:

- **1.1–1.2 m**

Shorter horns work, but sidelobes increase.

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6. Flare angles

From waveguide to aperture over ~1.15 m:

- H-plane flare ≈ **30° total**
- E-plane flare ≈ **22° total**

These are comfortably within good horn design practice.

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7. Feed transition

You want a **smooth transition** from WR-650 to horn throat:

- Start horn throat at **waveguide dimensions**
- Use **¼-λ (~53 mm) matching section** if possible
- Avoid abrupt steps

If feeding with coax:

- Use a **probe-fed waveguide launcher**
- Probe length ≈ **λ_g / 4** inside waveguide (~60 mm at 1420 MHz)

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8. Polarization

- TE_{10} mode → **linear polarization**
- Align polarization intentionally (e.g. E-field vertical)
- If doing drift scans, keep orientation fixed

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9. Expected performance

- System temperature dominated by:
  - Sky noise ≈ 3–10 K
  - LNA noise (use ≤ 0.6 dB if possible)
- Excellent for:
  - Galactic hydrogen mapping
  - Drift-scan SETI
  - Spectral line integration

This horn will outperform most small dishes at 1420 MHz for survey work.

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10. If you want smaller or larger

Aperture	**Gain**	**Length**
1.0 × 0.7 m	~16 dBi	~0.7 m
1.4 × 1.0 m	~18.5 dBi	~1.15 m

2.0 × 1.5 m ~21 dBi ~2.2 m

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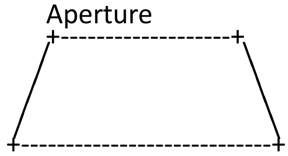
11. Construction tips (learned the hard way)

- Aluminium sheet ≥ 1 mm thick
- Electrically continuous seams (rivets + conductive tape)
- Interior must be **smooth**
- Matte black exterior, bare metal interior

Horn length (flare depth): ≈ 1.1 – 1.2 m
Operating frequency: 1420.4058 MHz (Hydrogen line)
Polarisation: Linear (set by waveguide orientation)
Gain: ~18–19 dBi
Beamwidth: ~18° (H-plane) / ~25° (E-plane)

Side view (showing flare angle)

Aperture



Horn length
≈ 1.15 m

Notes

- Horn walls expand smoothly from **WR-650 throat** to aperture
- No dish, no reflector — sensitivity comes from **aperture area**
- Ideal for **drift-scan SETI** and **HI mapping**
- Keep seams electrically continuous