System Considerations

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Considerations

- Cost effectiveness
  - trade-off between specifications and cost
  - minimize operations cost
- Reliability
  - minimize mechanical devices
  - component lifetime calculations
  - extensive monitoring (and automatic diagnostics)
  - maintainability

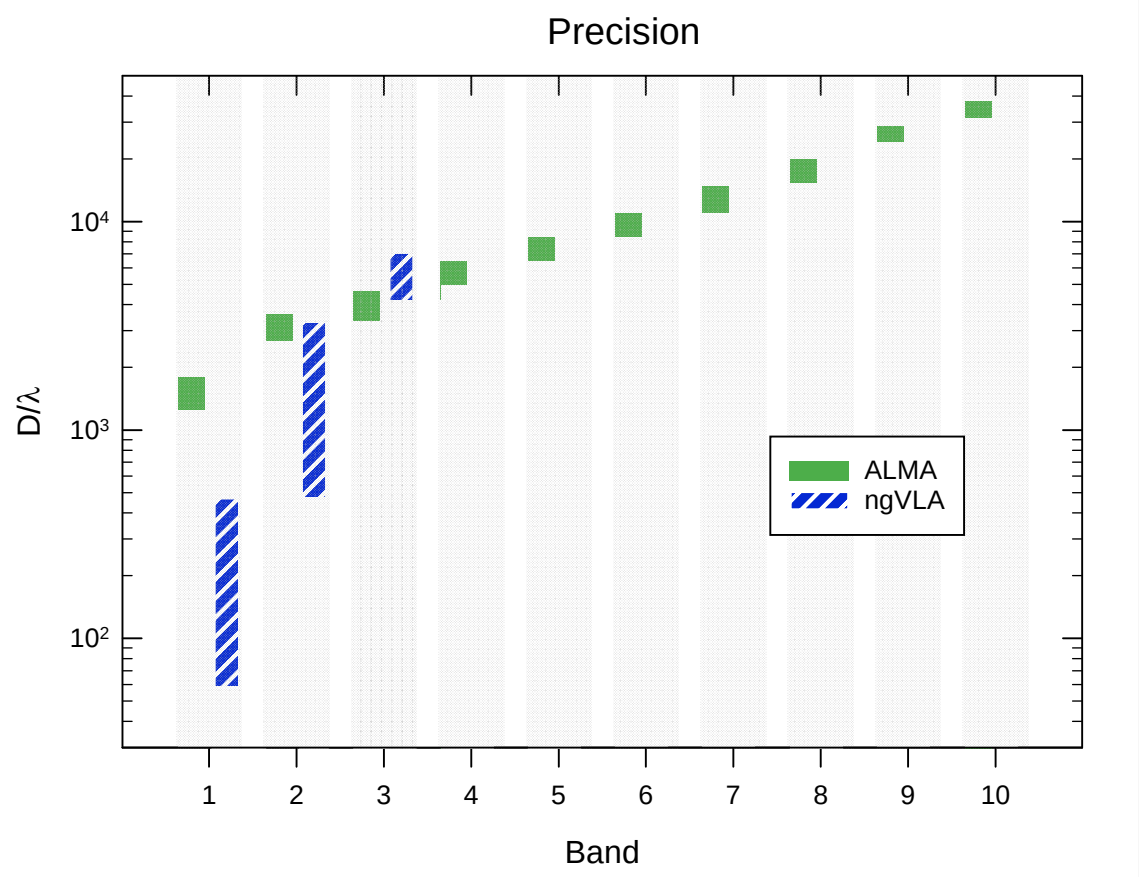
Precedents

- JVLA
  - similar frequency range
  - older technology
- ALMA
  - overlap in frequency
  - new technology
  - similar cost

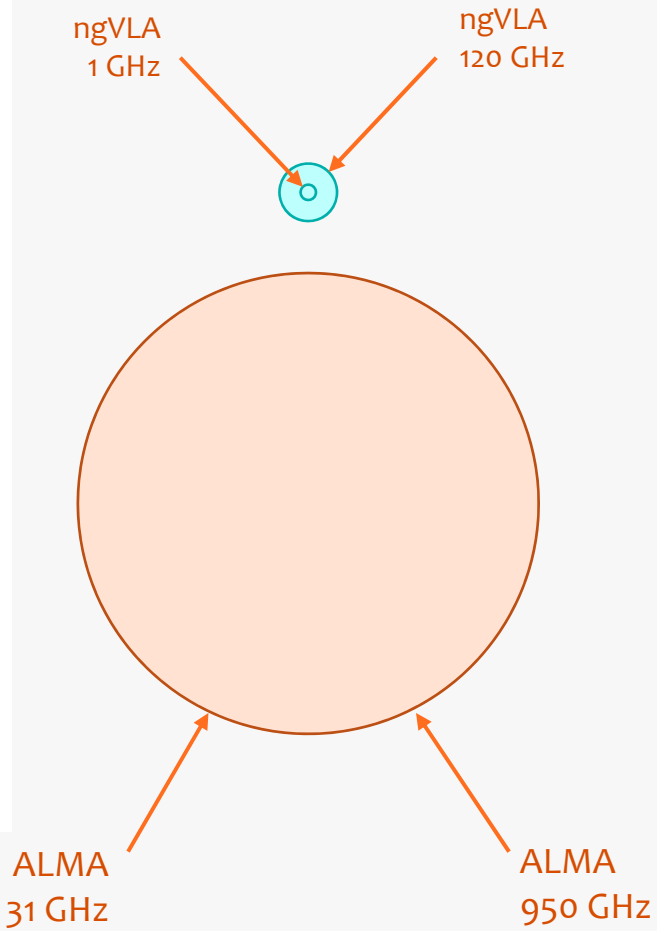
Image courtesy of NRAO/AUI

Image courtesy of NRAO/AUI and ALMA/ESO/NRAO/NAOJ

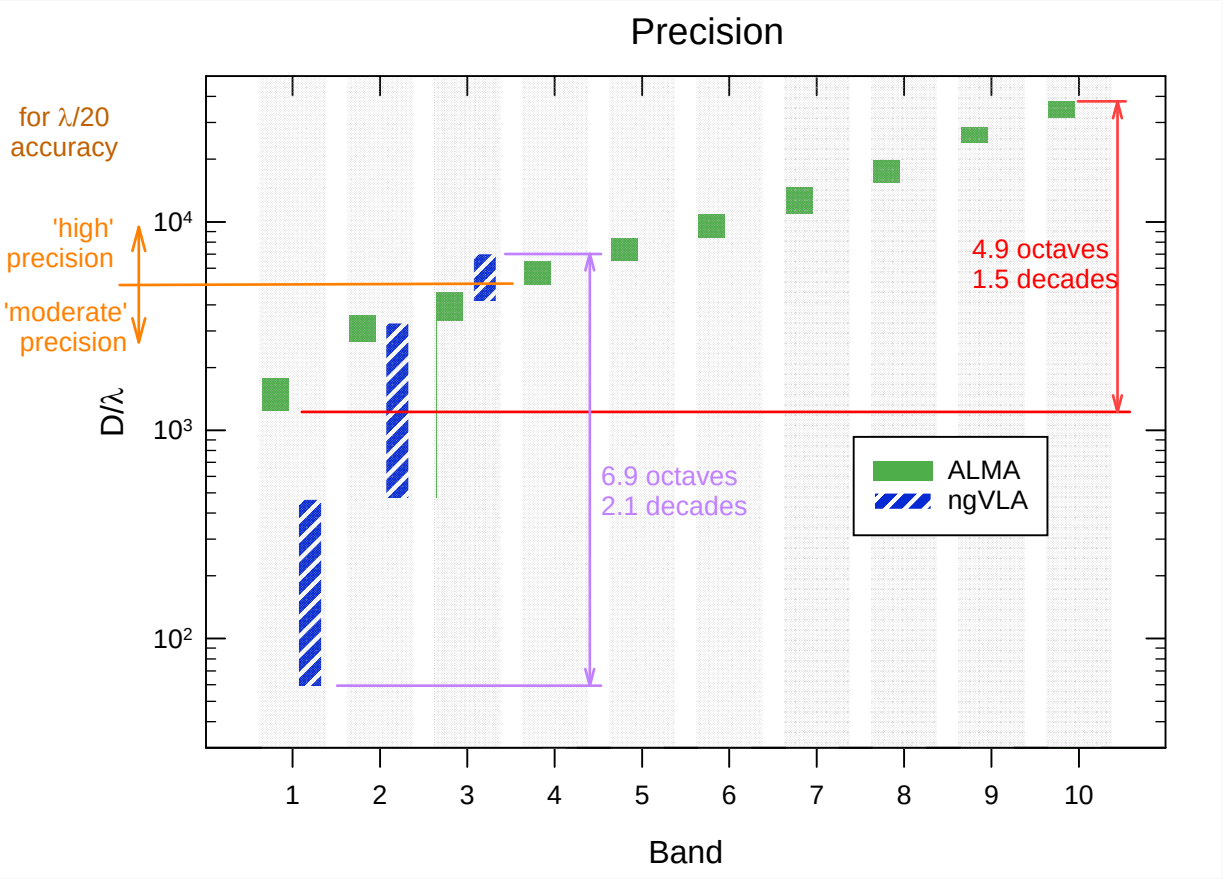
Comparison of ALMA and ngVLA



antenna size in wavelengths



Some observations



- Considerable overlap
- Mostly, ngVLA is does not have high precision requirements
- Range of resolution is >100
- Keck: 1.2 decades, 4.1 octaves

System design issues

- offset *or* symmetric
- prime focus *or* Cassegrain/Gregorian
- phase correction (λ 3-mm, long baselines)
- analog vs digital transmission
- fiber links
- thermal control
- maintenance
- …

Mechanical

- Motors
  - antenna drive motors
  - cryogenic refrigerator
  - air conditioning
  - fans
  - focus (x, y, z)
  - receiver select

Metrics?

- G/T is a common metric for antennas
- for ALMA
  - assumed this was ≈ aperture efficiency
  - for electrically small antennas need G *and* T
- but is this the best metric?
  - yes, for point sources ($\theta_{source} < \theta_{FWHM}$)
  - for extended sources?
    - beam efficiency?
    - photons on sky?
- Other metrics
  - polarization purity
  - …

Aberrations for offset feed

- Reduction in peak gain

Astigmatism: $$\Delta\eta_{ast} = \left(\frac{\pi D^3}{16Mfd\lambda}\right)^2 \alpha^4 \qquad (1)$$

Coma: $$\Delta\eta_{com} = \frac{1}{2}\left(\frac{\pi D^3}{96M^2 f^2 \lambda}\right)^2 \alpha^2 \qquad (2)$$

Curvature: $$\Delta\eta_{cur} = \frac{1}{3}\left(\frac{\pi D^3}{16 fd\lambda}\right)^2 \alpha^4 \qquad (3)$$

Prime focus vs Cassegrain/Gregorian

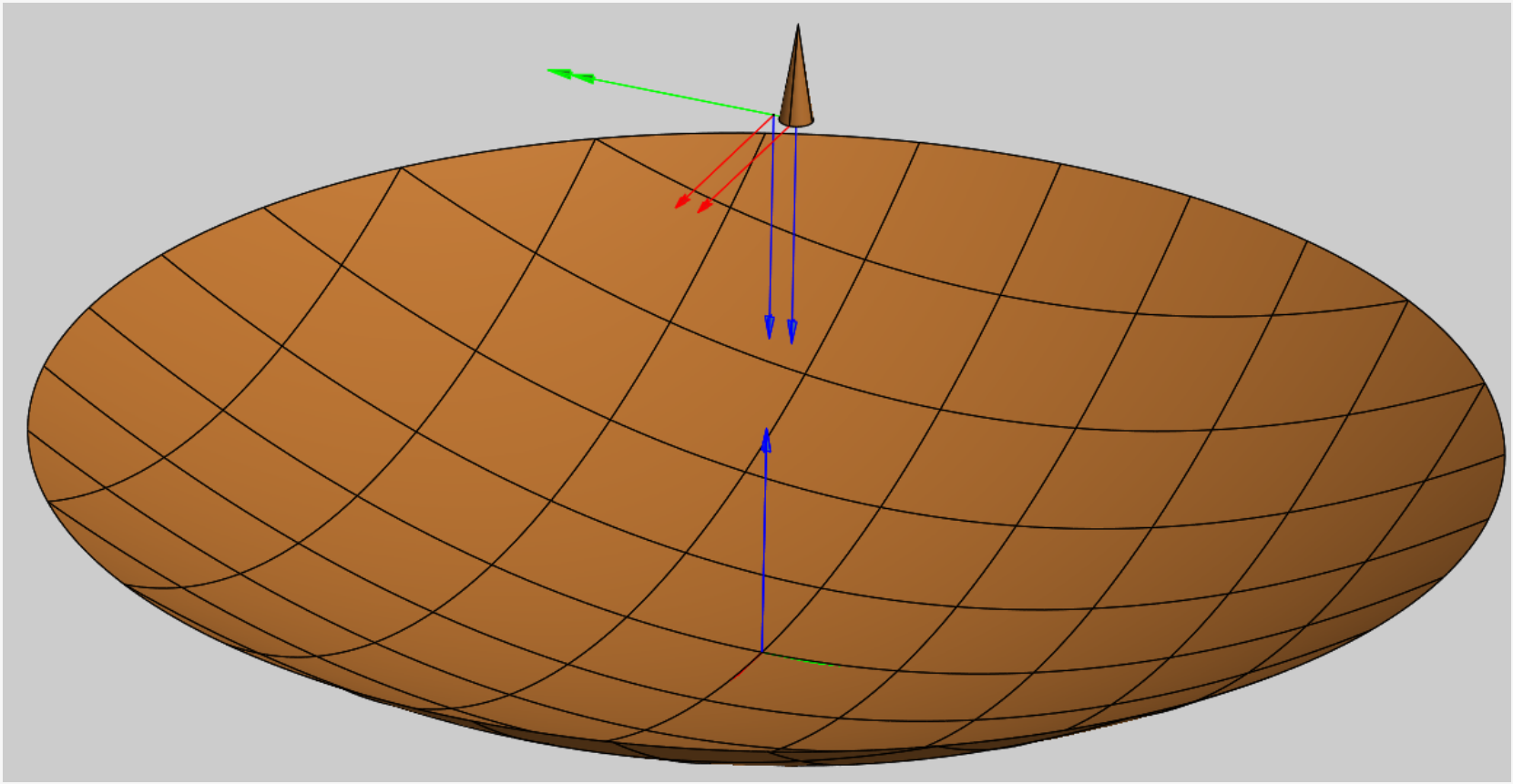
	prime focus	secondary focus
focal length	limited choice 0.25—0.8	free parameter 0.5—20
feed spillover	on ground	on sky
rx location	at prime focus	at secondary focus
field of view	small	large

Feed sizes

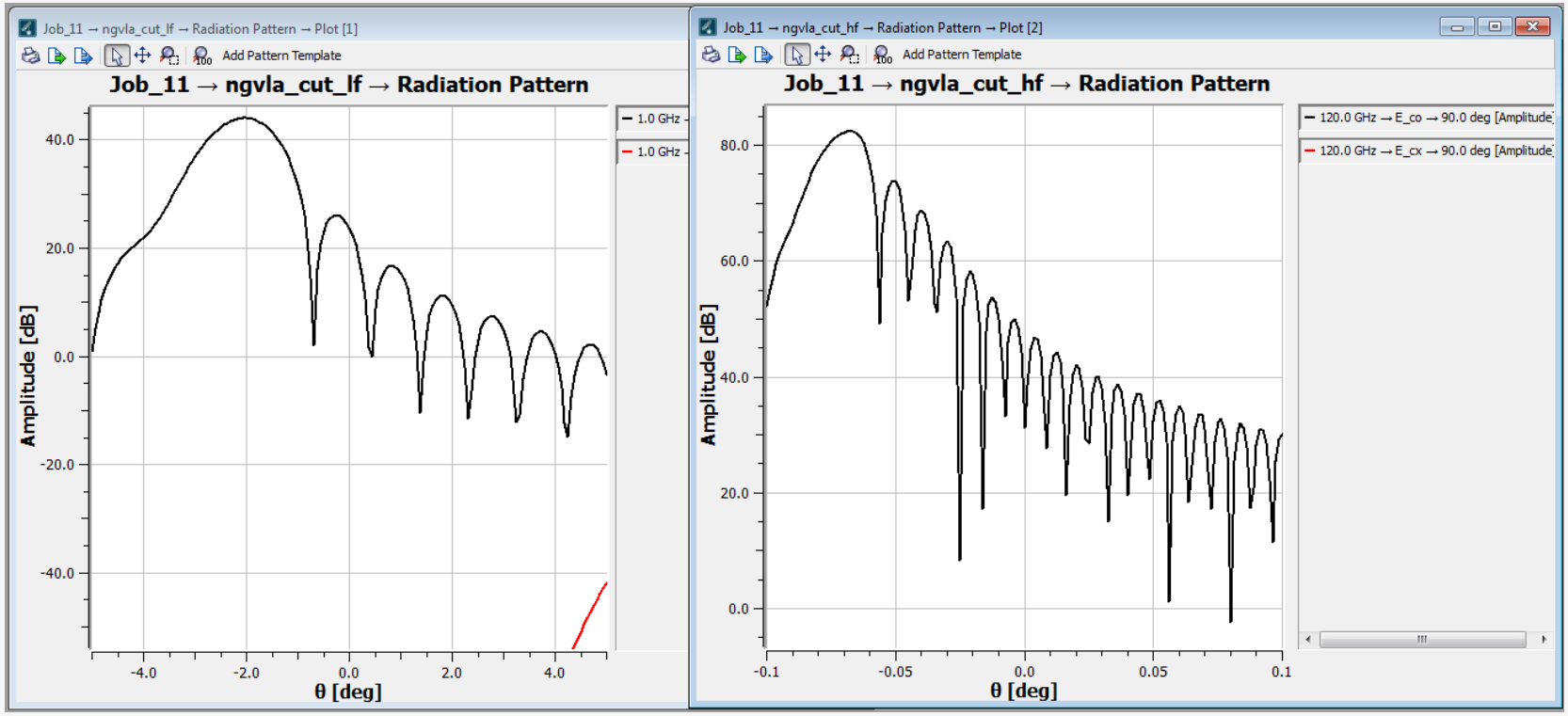
feed diameter: $d_f \approx 2.4\ \lambda\ f/D$

	prime focus	secondary focus	
f/D	0.4	0.6	5
1 GHz	290 mm	430 mm	3600 mm
8 GHz	36 mm	54 mm	450 mm
70 GHz	4 mm	6 mm	51 mm

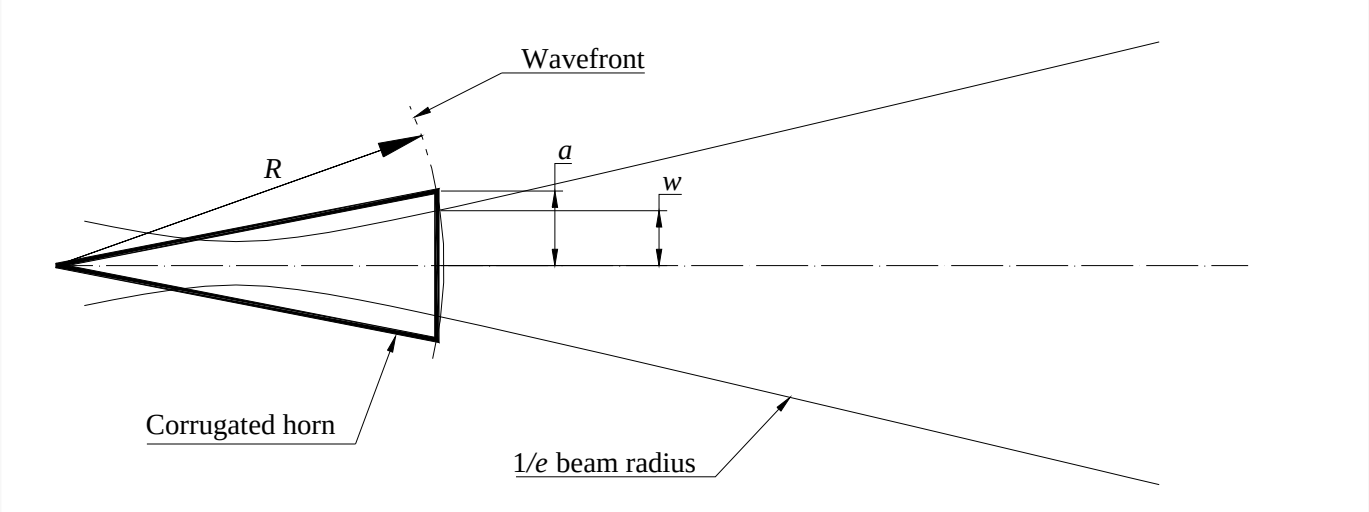
Offset feeds



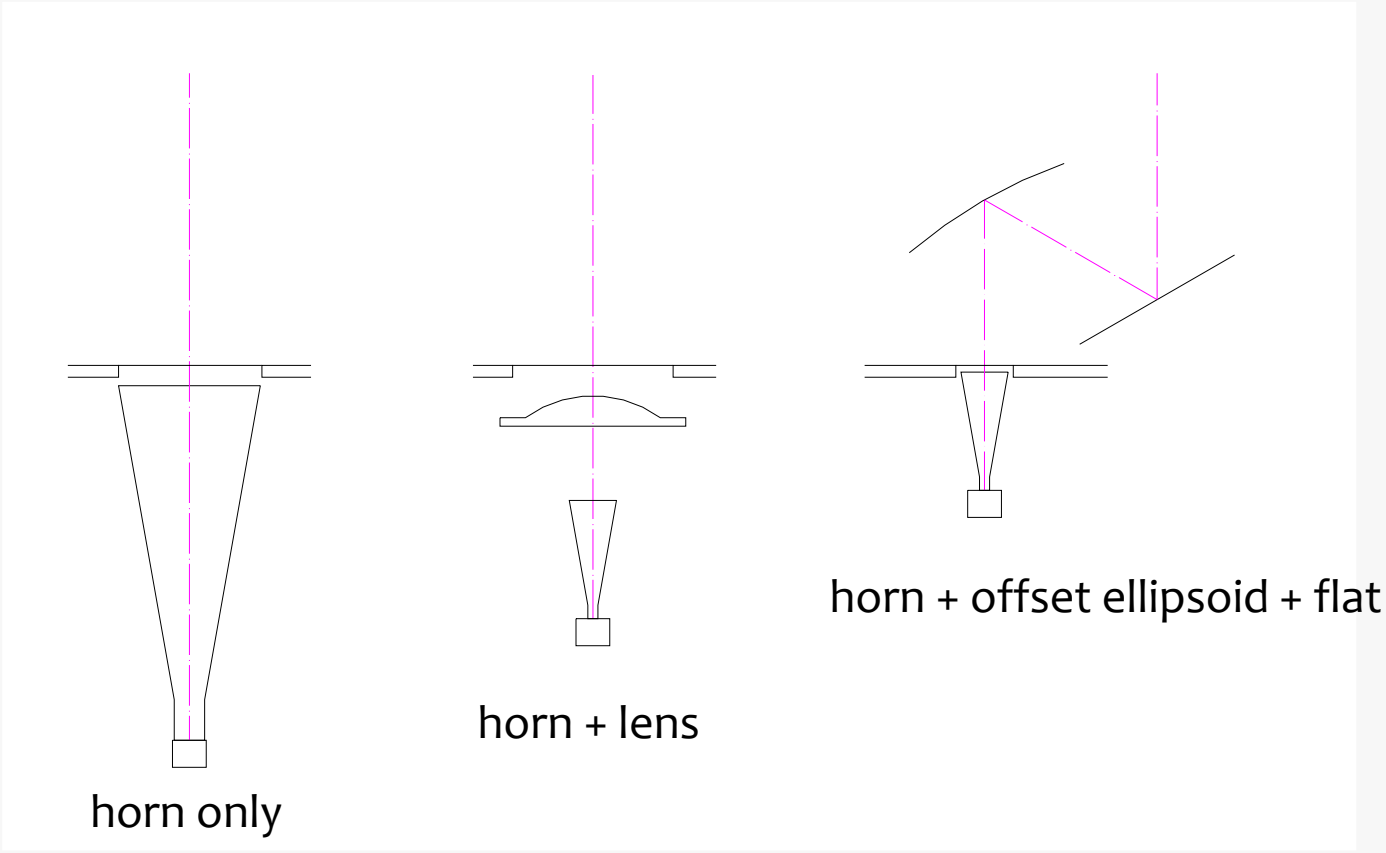
Beam patterns



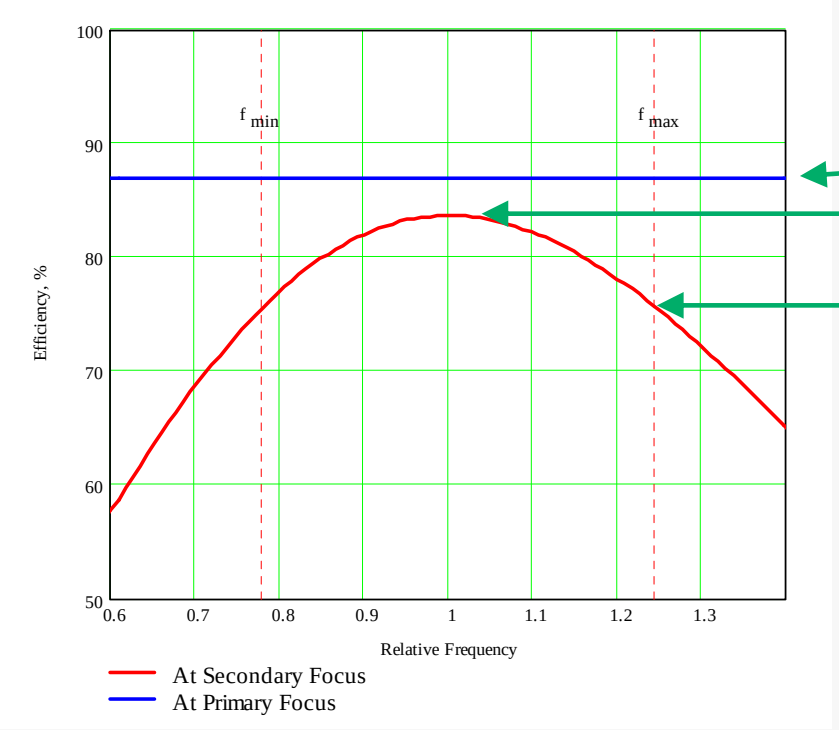
Feed bandwidth



Feed options



Corrugated horn (gold standard)



86.9%

83.7%

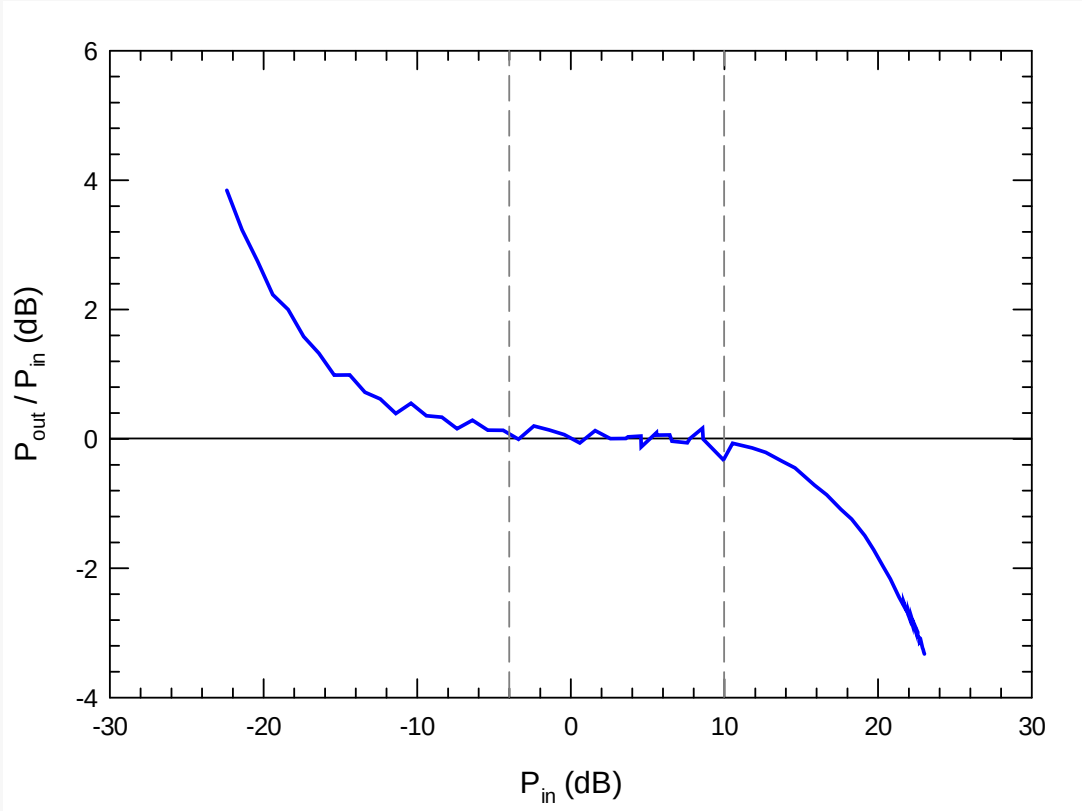
75.5%

40% BW

(need ~55% for ngVLA)

Analog fiber link dynamic range

Optilab fiber link



- input BW ~18 GHz
- DR ~ 14 dB
- pre-emphasized for uniform SNR
- DR scales ~ 1/BW
- DR ~ $P_{optical}$

Conclusions

- To early for conclusions
- Science drivers have to be clearly articulated
- Need a clear view on how much we want to trade off performance for cost