Optical Design Aspects

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Importance of "Good" Optics

- Accuracy is often limited by baseline artifacts which are related to optical problems:
  - Standing waves or other multipath effects
  - Beam truncation
  - Frequency dependent FOV
- Pathlength modulator only randomizes these baseline, but does not remove it completely
- Ideally the optics should be designed to be free of these artifacts, but this requires detailed optical models from the feed to the last reflector

Optical Design Tools

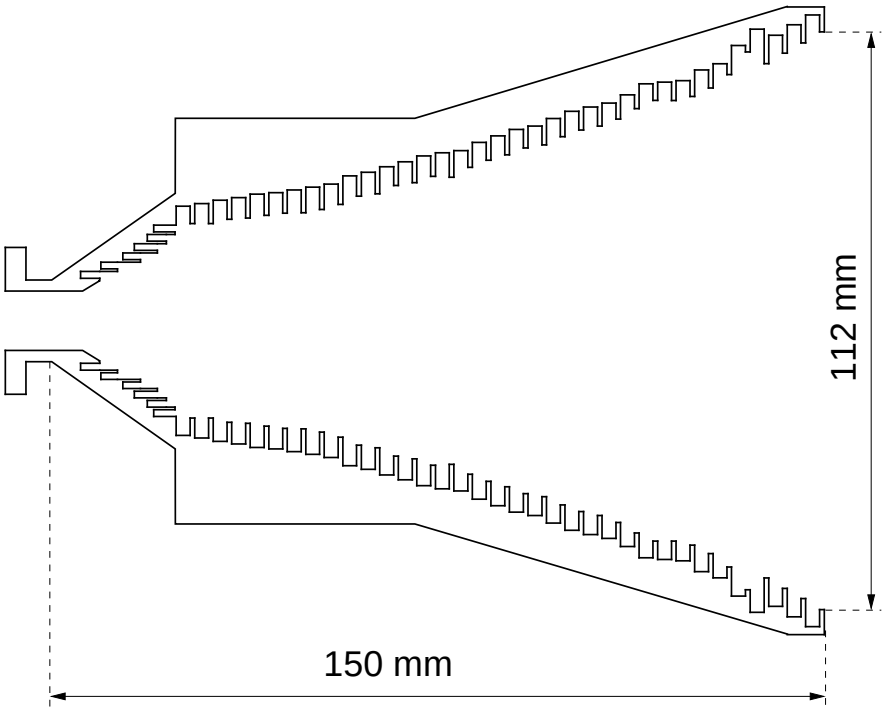
- **Fundamental Gaussian Beam Analysis**
  Simple analytical approximation
  Neglects feed side lobes, beam aberrations, polarization, ...
  Not sufficient for accurate simulations
  $\Rightarrow$ You will most likely underestimate your spillover, etc...
- **Higher Order Gaussian Beam Analysis**
  Better than the above, but still not the truth...
- **Physical Optics (PO) Analysis**
  GRASP Software Package from www.ticra.com
  Quite expensive, but good and respected industry standard
  Free student version with limited capabilities (max. 2 reflectors)

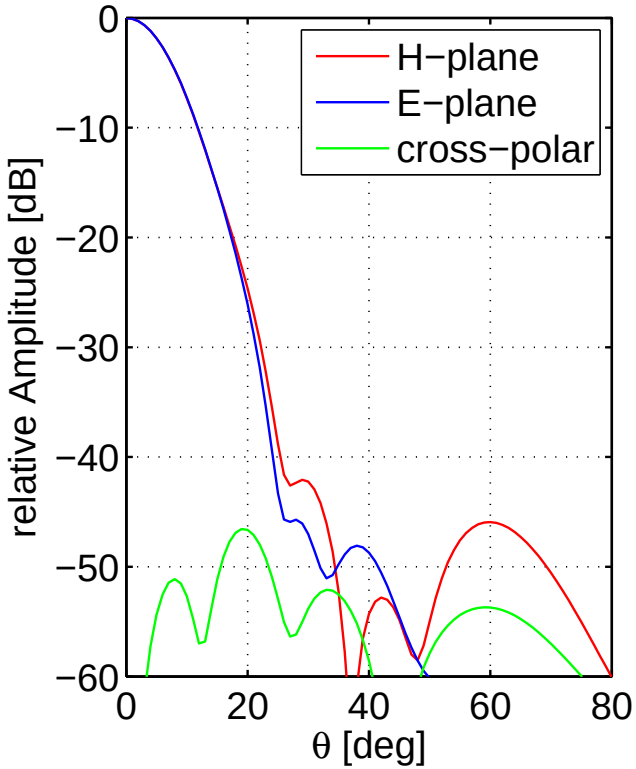
Importance of the Feed

- Feed determines the mode composition of the quasi-optical beam
  100% Gaussian would be ideal in most cases (but not all)
- Standard corrugated feed is $\sim$98% Gaussian. This sound quite high, but it leaves 2% of the power in side lobes
- Ultra-Gaussian Feeds are highly preferred

MIAWARA-C Feed

- Compact Choked-Gaussian feed horn with -40dB sidelobes
- Designed by J. Teniente, Univ. Publica de Navarra
- Similar designs now used by NRL, KIT, INGV





C. Straub et al, "Optical design for a compact 22 GHz radiometer for middle atmospheric water vapor", EUCAP (2007)
C. Straub et al, "MIAWARA-C, a new ground based water vapor radiometer for measurement campaigns", Atm.Meas.Tech. 2010

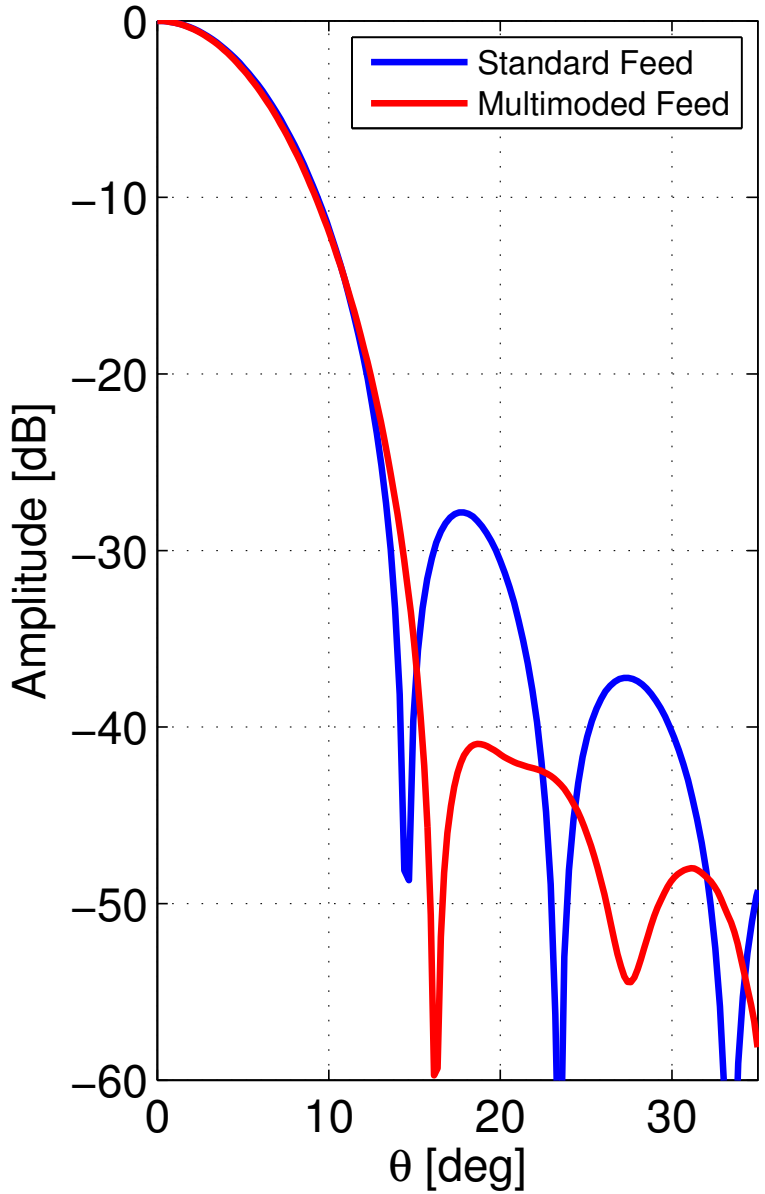
STEAMR Feed

Standard Corrugated Feed

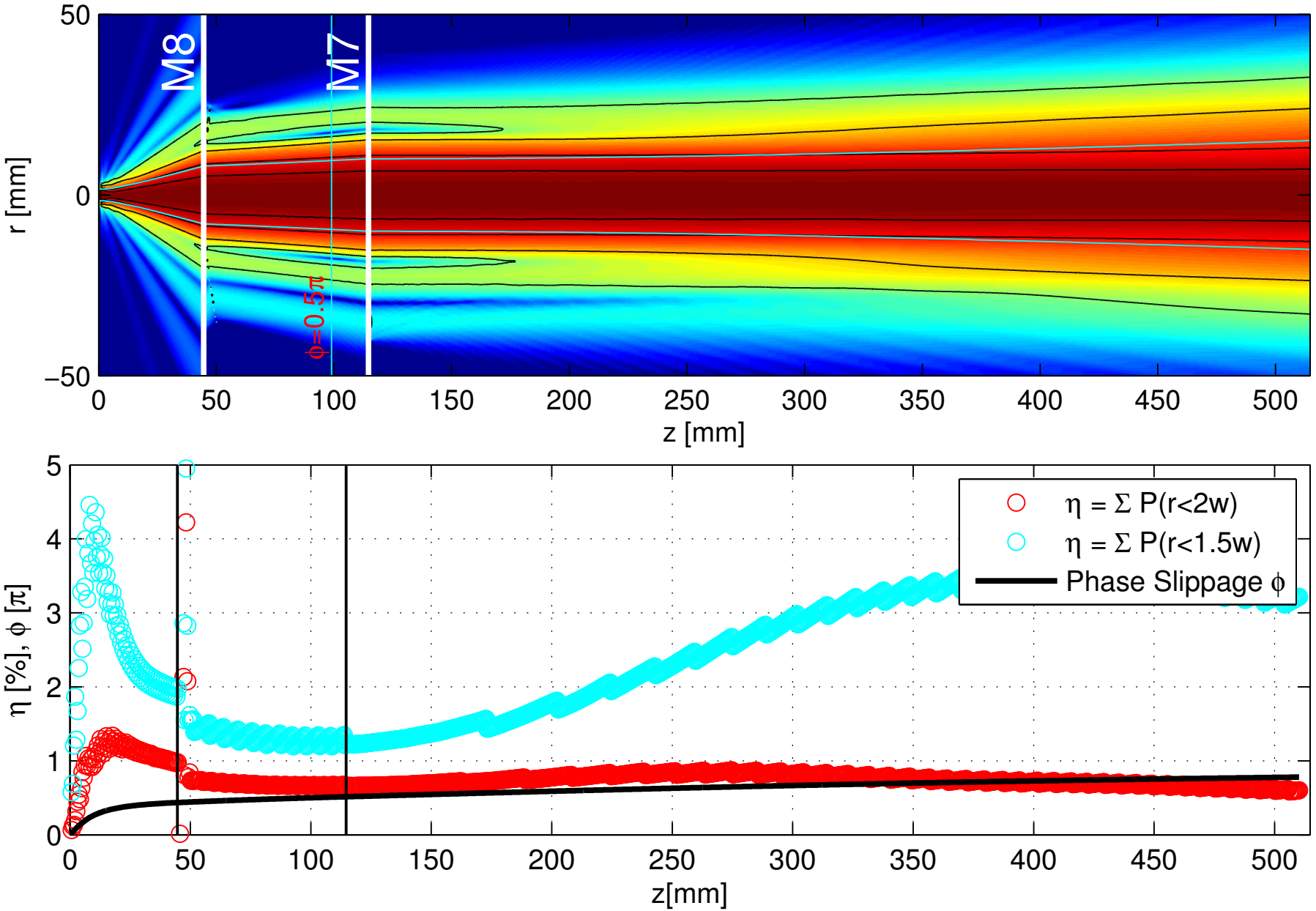
- Fundamental HE_{11} hybrid mode
- Truncated Bessel at aperture
- Farfield sidelobes -25dB
- 98% coupling to Gaussian

'Super-Gaussian' Feeds

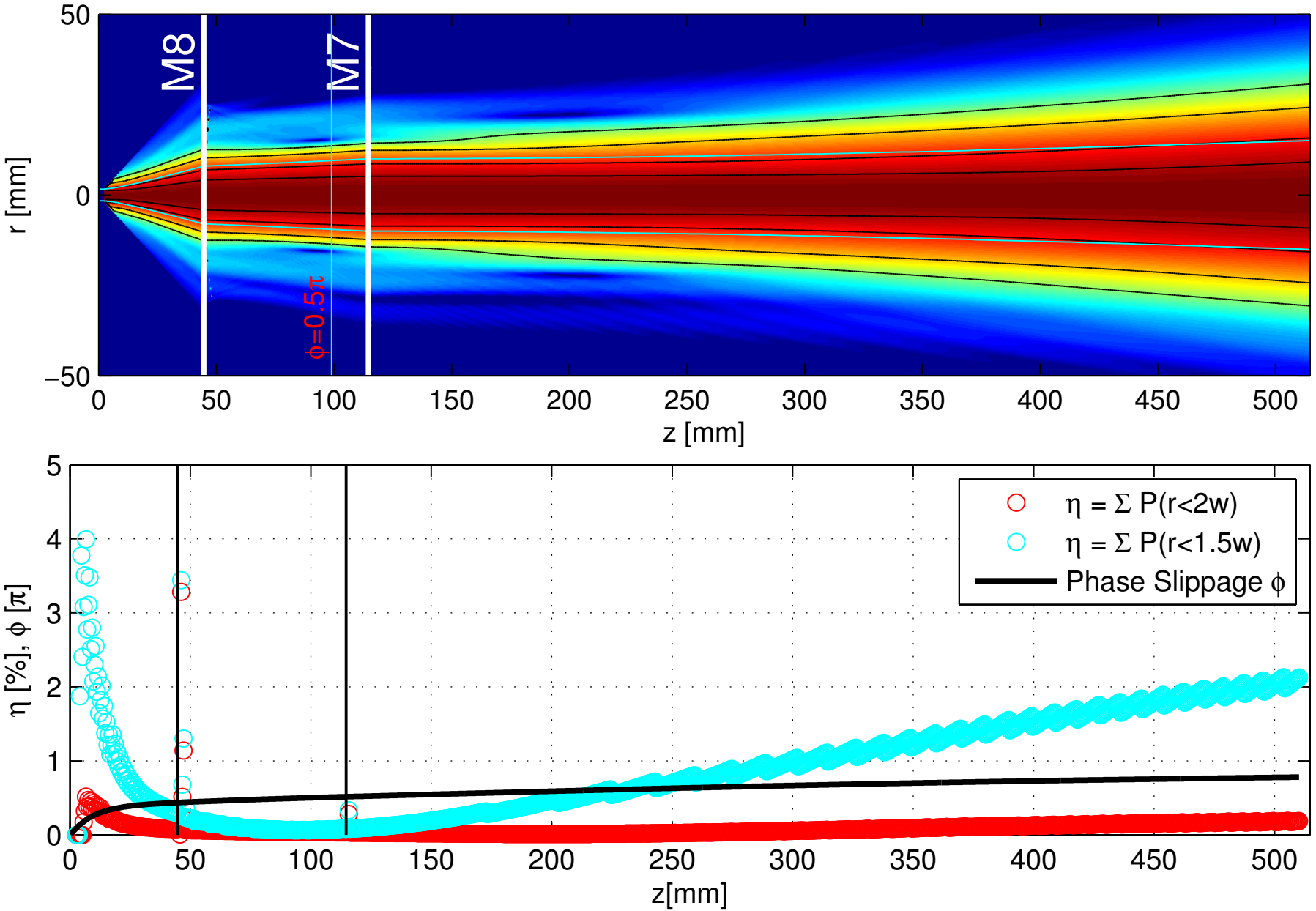
- Add HE_{12} mode with correct phase [P. Cruickshank et al, IRMMW 2007]
- Farfield sidelobes $\leq$-35dB
- 99.8% coupling to Gaussian



STEAMR FPA Beam Propagation: Standard Feed



STEAMR FPA Beam Propagation: Gaussian Feed



Recommendations

- If there is a baseline problem, try to find the origin and fix it instead of trying to wobble it away.
- Beam-pattern measurements and PO simulations can help to identify problems
- Ultra-Gaussian feeds will reduce spillover and standing waves
- MPI sideband filters or diplexers can introduce significant standing waves