WBSPF – AIP
Band B feed test results

Miroslav Pantaleev

On behalf of the Band B team

SKA SQUARE KILOMETRE ARRAY
WIDE BAND SINGLE PIXEL FEEDS

Outline

- Introduction
- Feed design
- Beam pattern measurements
- Y-factor tests
- Performance analysis in SKA dish

Band B work package

Feed design, performance analysis and system tests

- Electrical – Jian Yang (Chalmers, Antenna Group) and Bin Dong (visiting researcher from NAOC)
- Mechanical – Jens Dahlström (OSO)
- Performance analysis – Jonas Flygare (OSO)
- System tests – Magnus Dahlgren and Leif Helldner (OSO)

Low Noise Amplifiers - InP

- Low Noise Factory – LNA prototyping

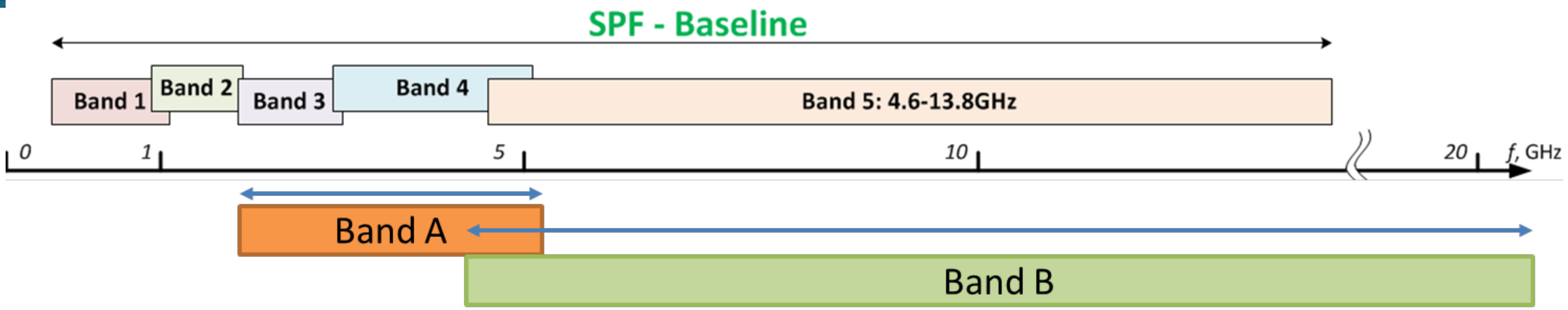
Low Noise Amplifiers - mHEMT

- IAF – MMIC processing
- MPIfR – LNA design and testing

Beam Pattern Measurements

- Yebes Observatory, Jose Antonio Lopes Perez
- Chalmers, S2, Antenna Group – Jian Yang and Bin Dong

Requirements



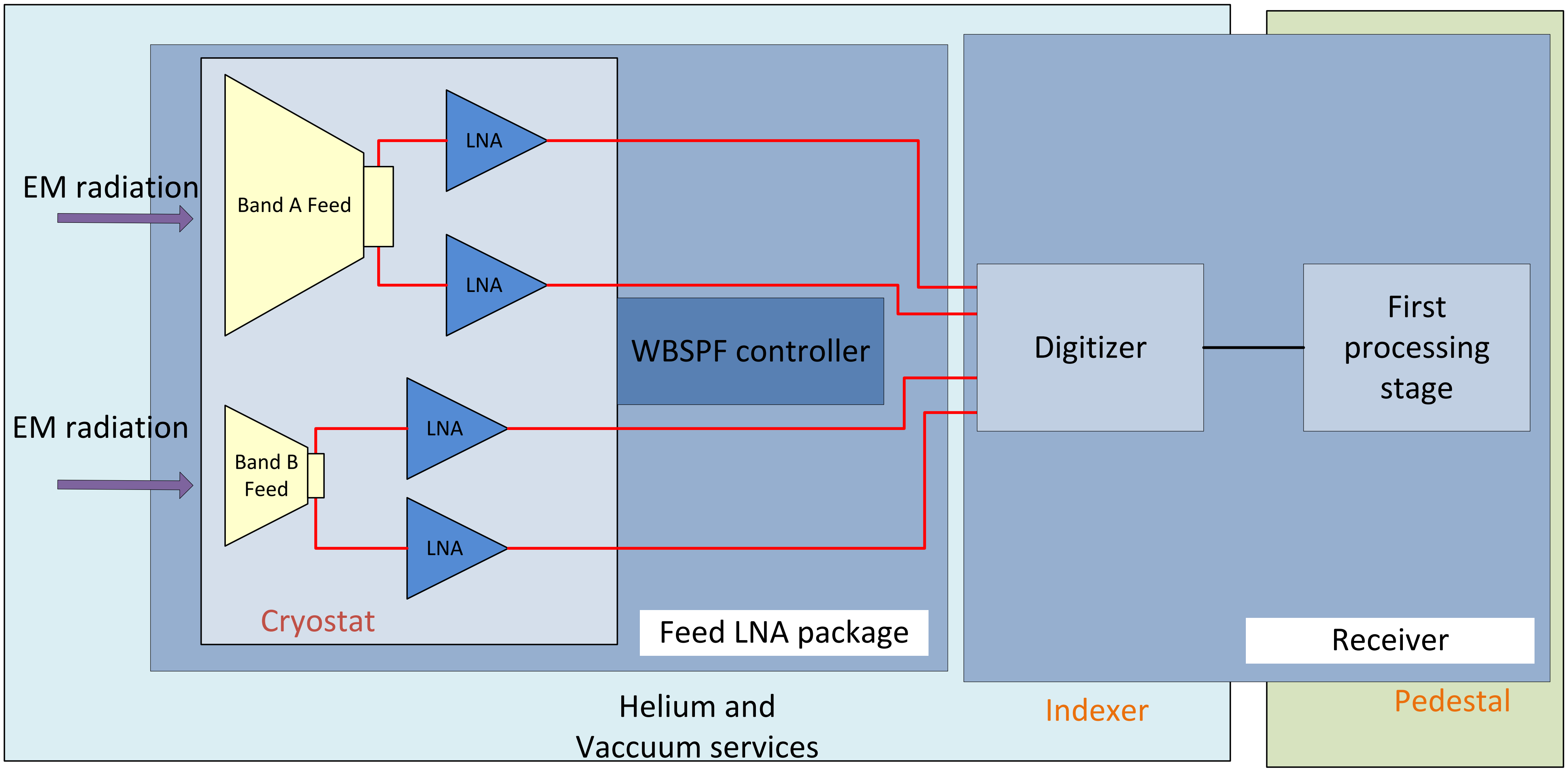
- Sensitivity requirement (Goal)
  - Band A (1.6 – 5.2 GHz) : 6.5 m^2/K (η ≈ 78%)
  - Band B (4.6 – 24 GHz):

    6.1 m^2/K from 4.6 – 13.8 GHz (η≈70%)

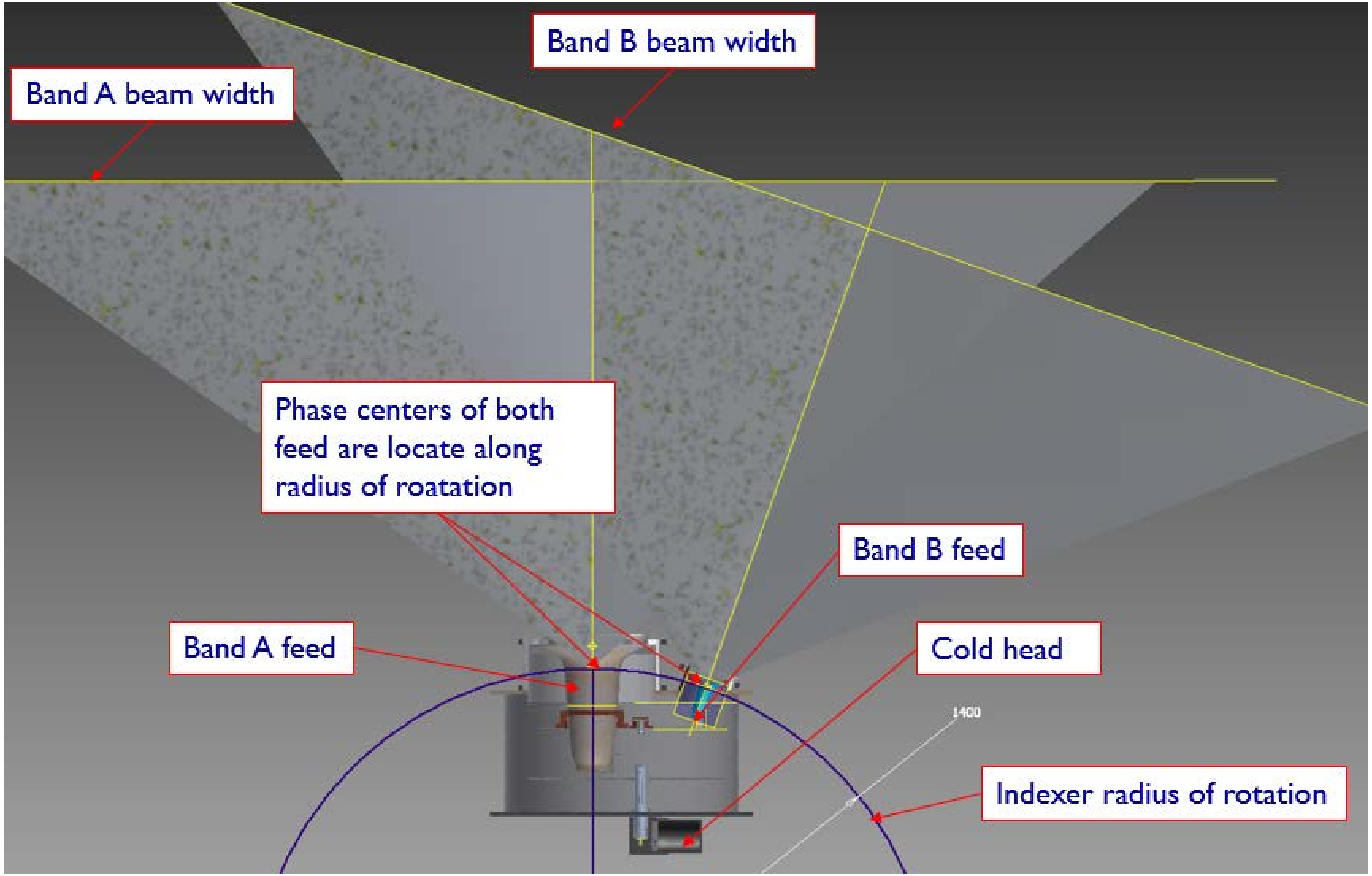
    4.7 TBC m^2/K from 13.8 – 20 GHz (η ≈ 65%)

    3.5 TBC m^2/K from 20.0 – 24 GHz (η ≈ 60%)
  - Polarization (IXR) better than 15 dB over HPBW
- Sampled Bandwidth
  - Band A: 1 x 3.6 GHz @ 12 GSPS for each pol., 6 bit
  - Band B: 2 x 2.5 GHz @ 50 GSPS for each pol., 3 bit

WBSPF block diagram diagram

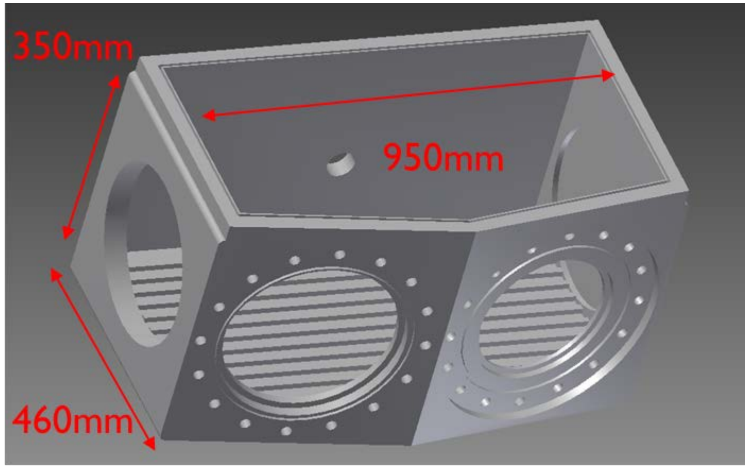


Cryostat

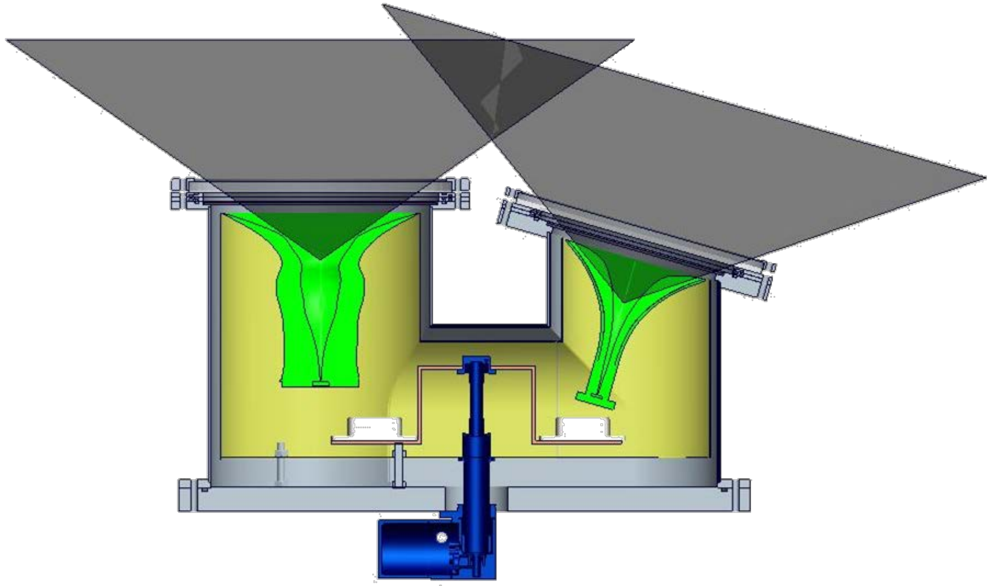


Band B beam width
Band A beam width
Phase centers of both feed are locate along radius of roatation
Band B feed
Band A feed
Cold head
1400
Indexer radius of rotation

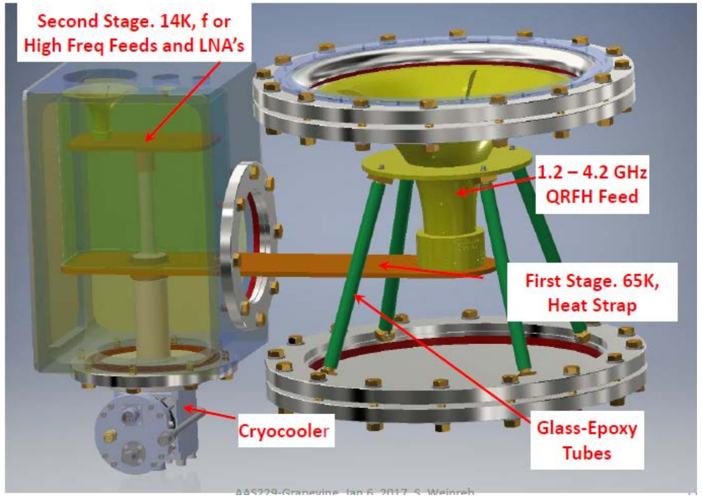
Cryostat design alternatives



Original “single-body” concept



The Current Concept of the Cryostat for SKA WBSPF

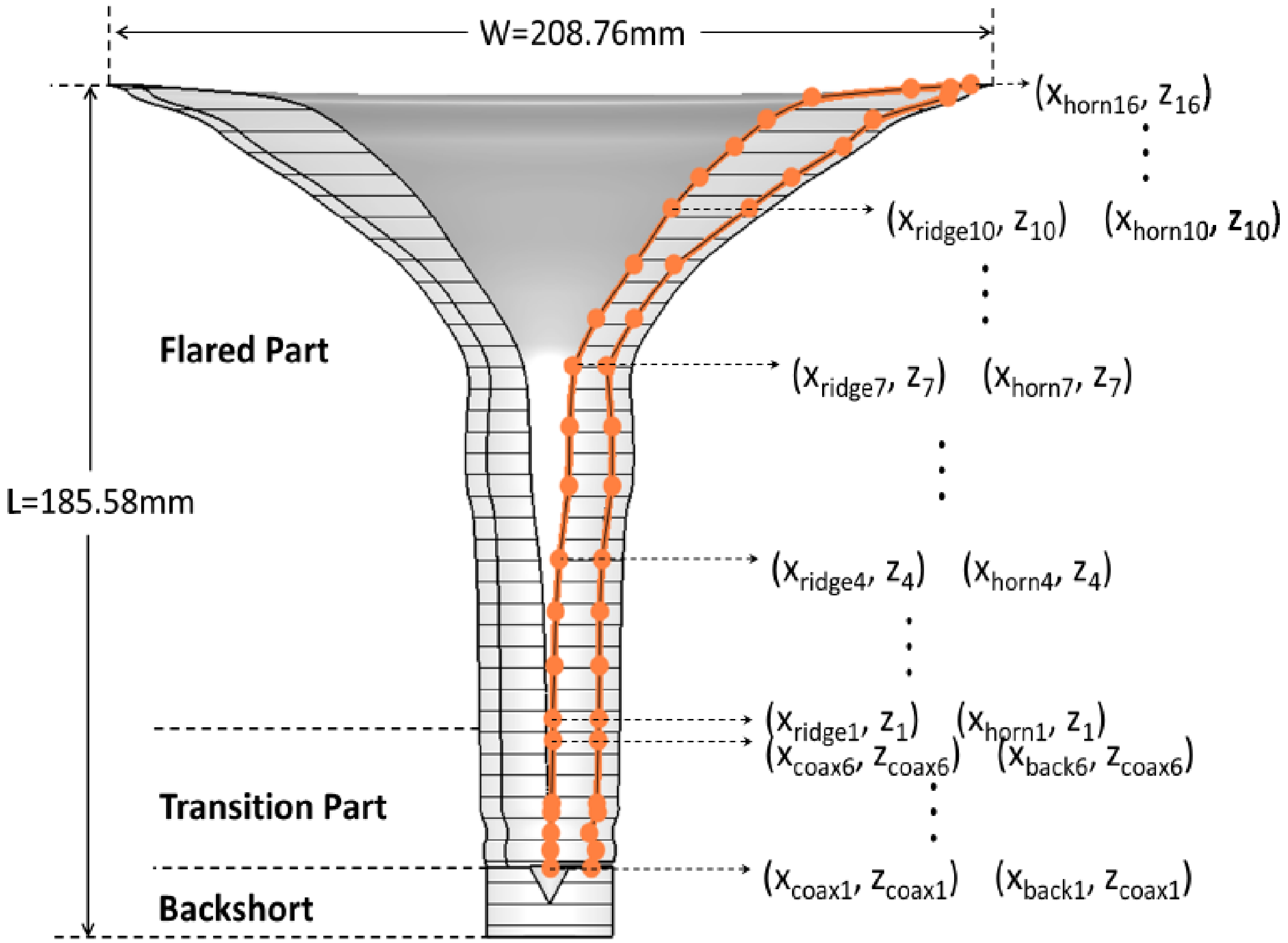


Sandy’s concept for NgVLA

The two feed are put in one cryostat
T_feed and T_LNA is 20K
Vacuum window: multi-layer Mylar
The feeds, thermal shielding, LNA and other parts are mounted from the bottom of the dewar, in order to ease the installation procedure.
Thermal load optimization / minimization is still challenging to maintain 20 K with 2 W of cooling power.

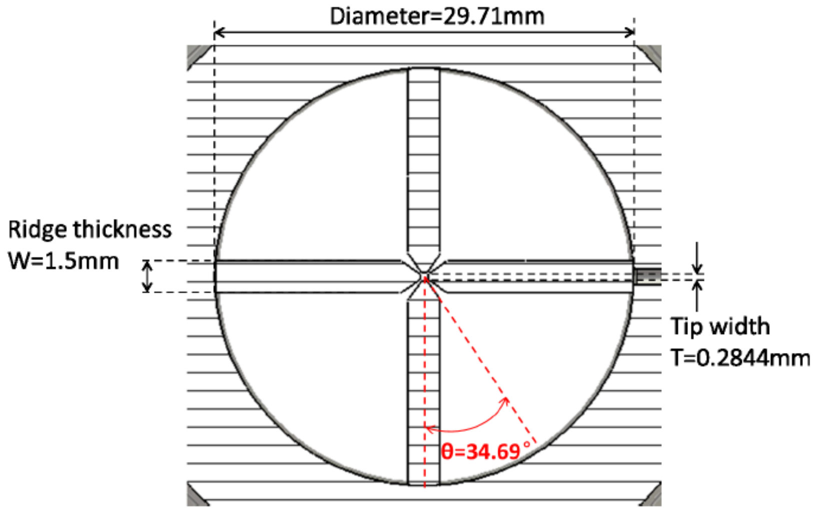
Feed design

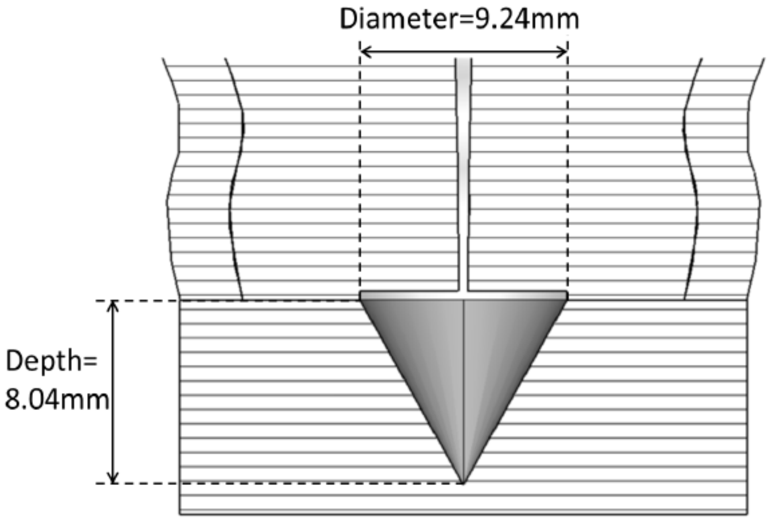
Feed design



- Spline-defined profiles using discrete points in CST
- Flared part – 47 parameters
- Transition part – 18 parameters
- Back short – 10 parameters
- Genetic Algorithm used for the optimisation
- 5000 different sets of parameters evaluated

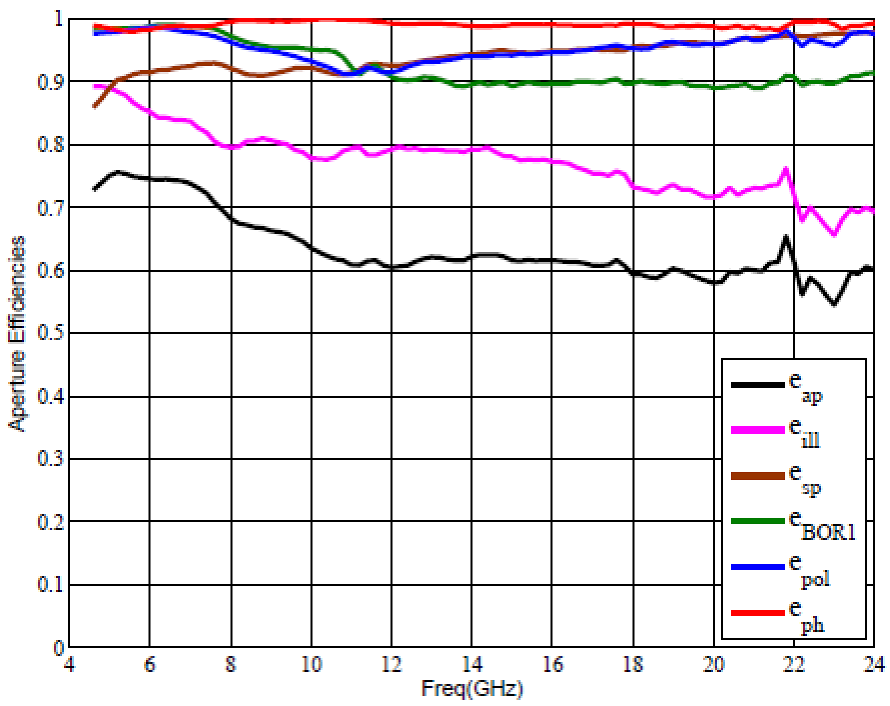
Feed back short design





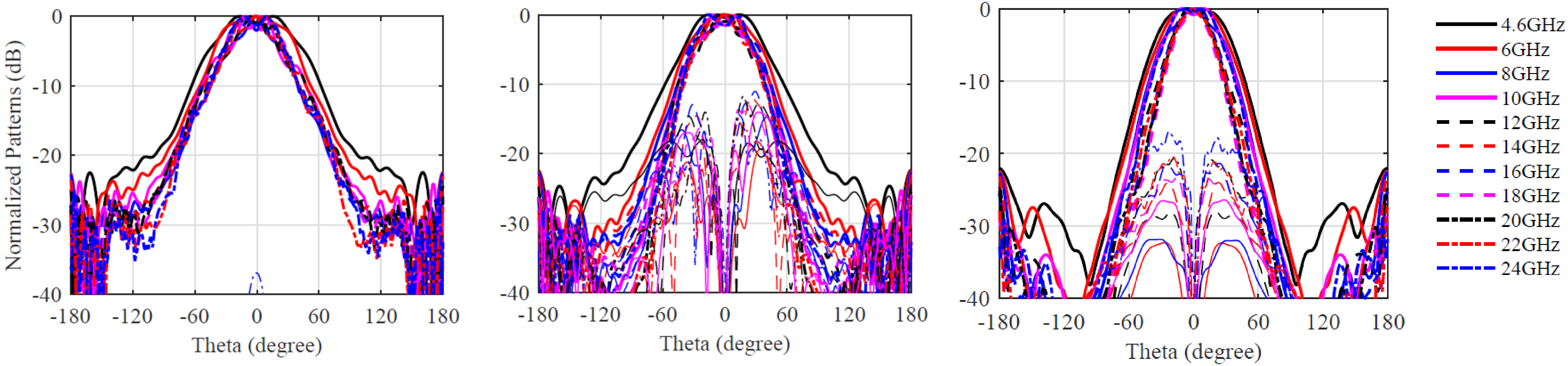
- Four ridges with thickness of 1.5 mm
- Optimisation of the feed pin location
- Maintain small gap between ridges with large chamfering angle of 55.31 degrees
- Conical-shaped back short cavity to improve the wide bandwidth performance

Optimisation routine and optimisation strategy



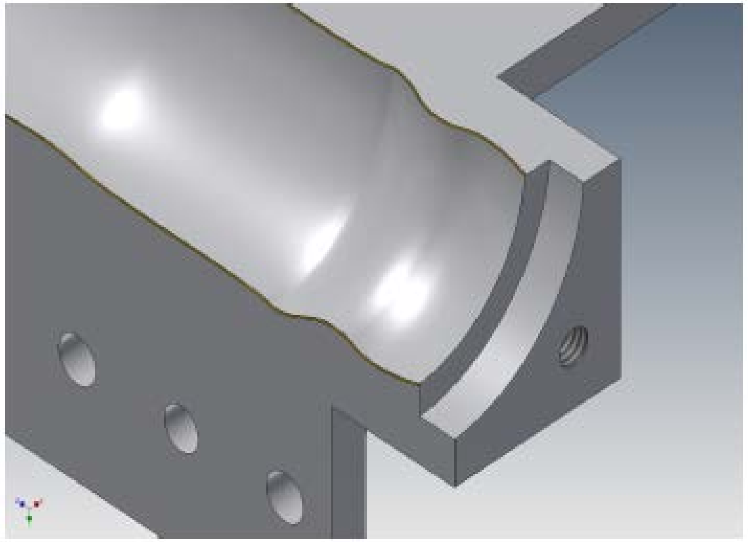
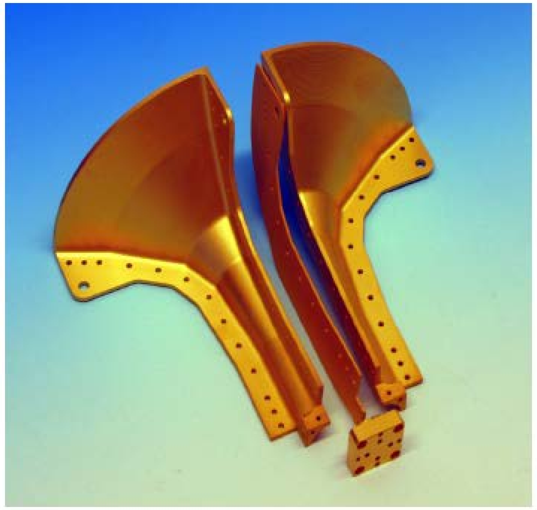
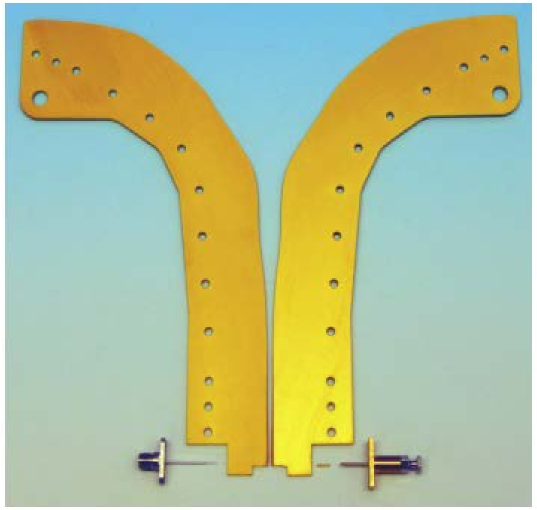
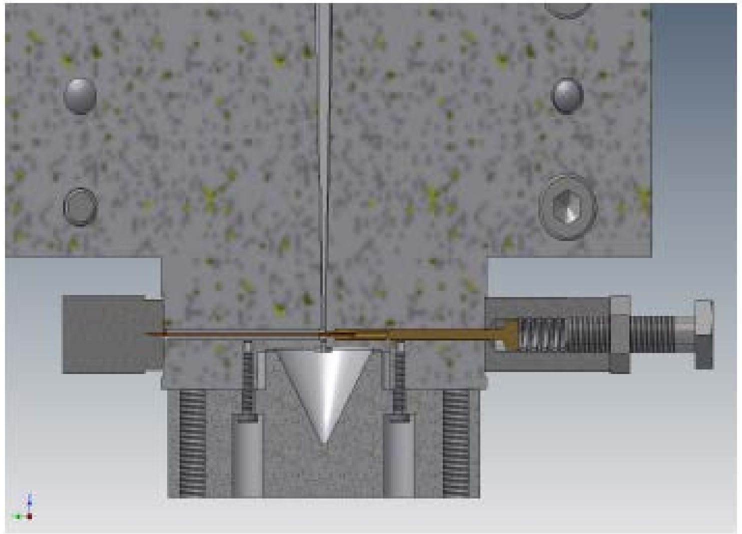
- Linked Matlab and CST to quick evaluate the performance
- Intermediate evaluation in MATLAB in primary fed axial-symmetric dish with half subtended angle of 51 degrees.
- Optimization goal is e_{ill} * e_{spill} followed by further optimization for improving spillover efficiency

Simulated beam patterns

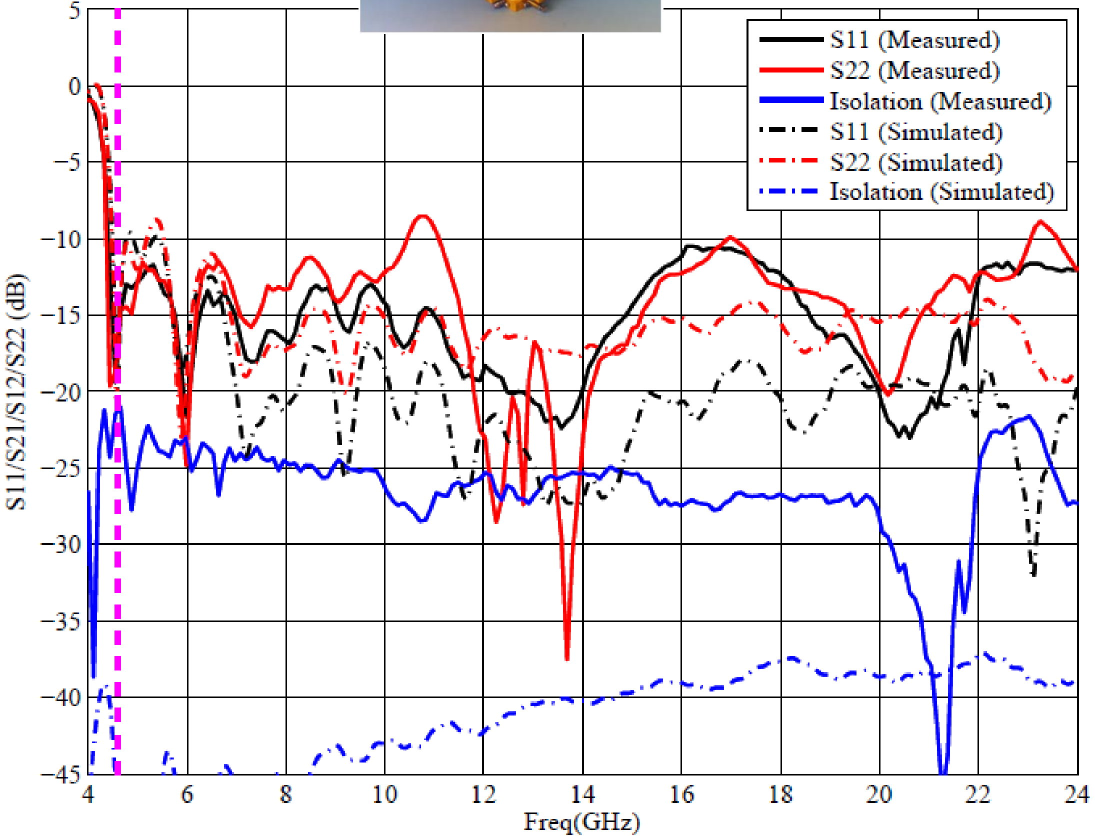


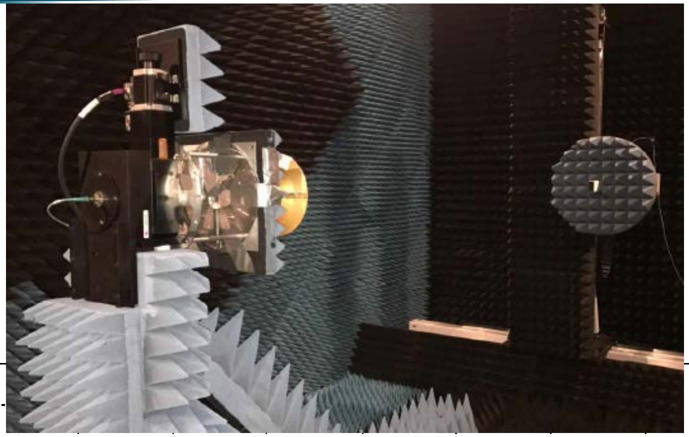
- E, D and H plane cuts
- Co- and cross pol components are shown
- Improved mode content that results in better efficiency at the high end of the band

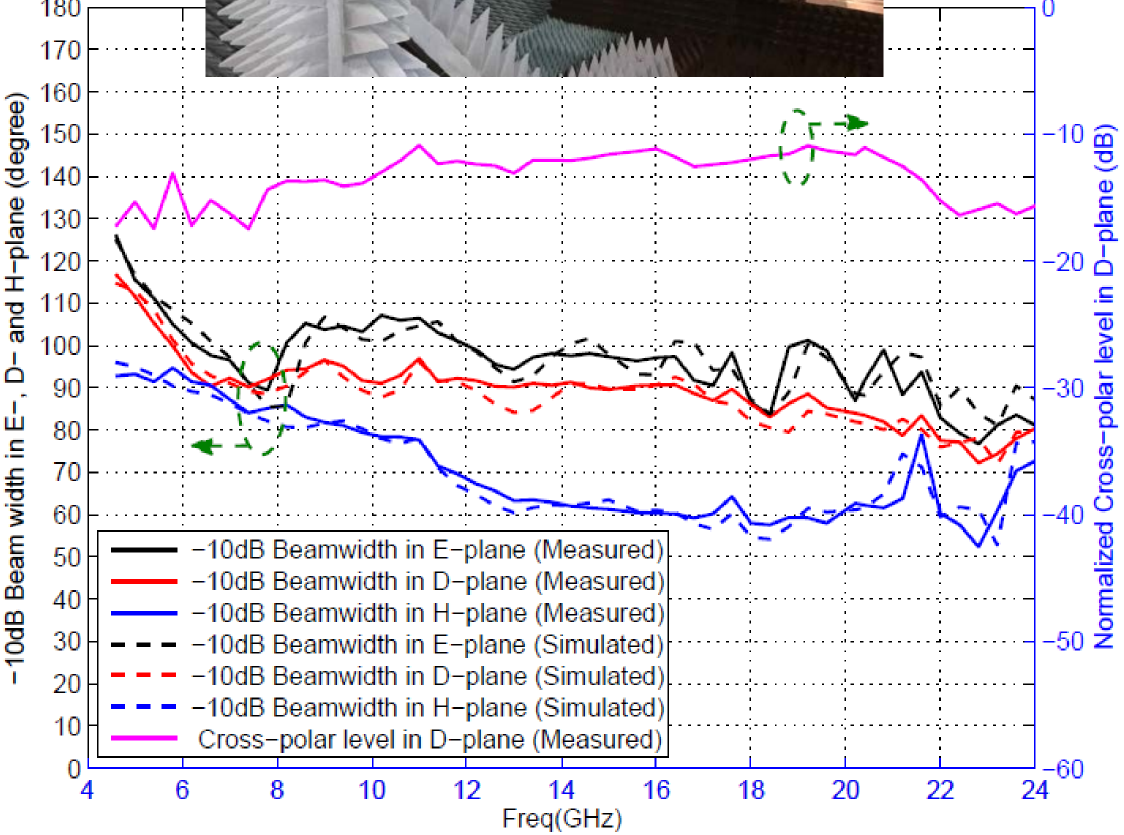
Feed prototype

Feed performance – measurement results

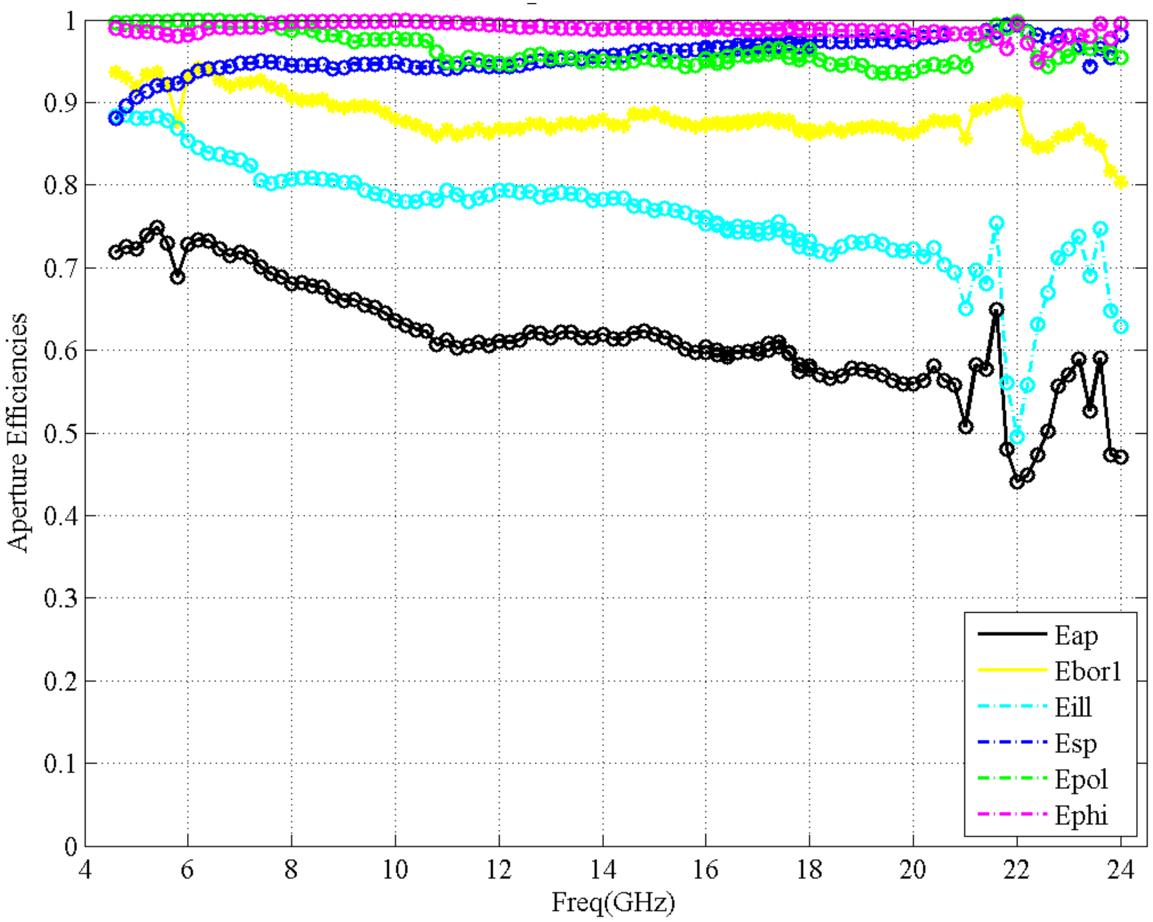




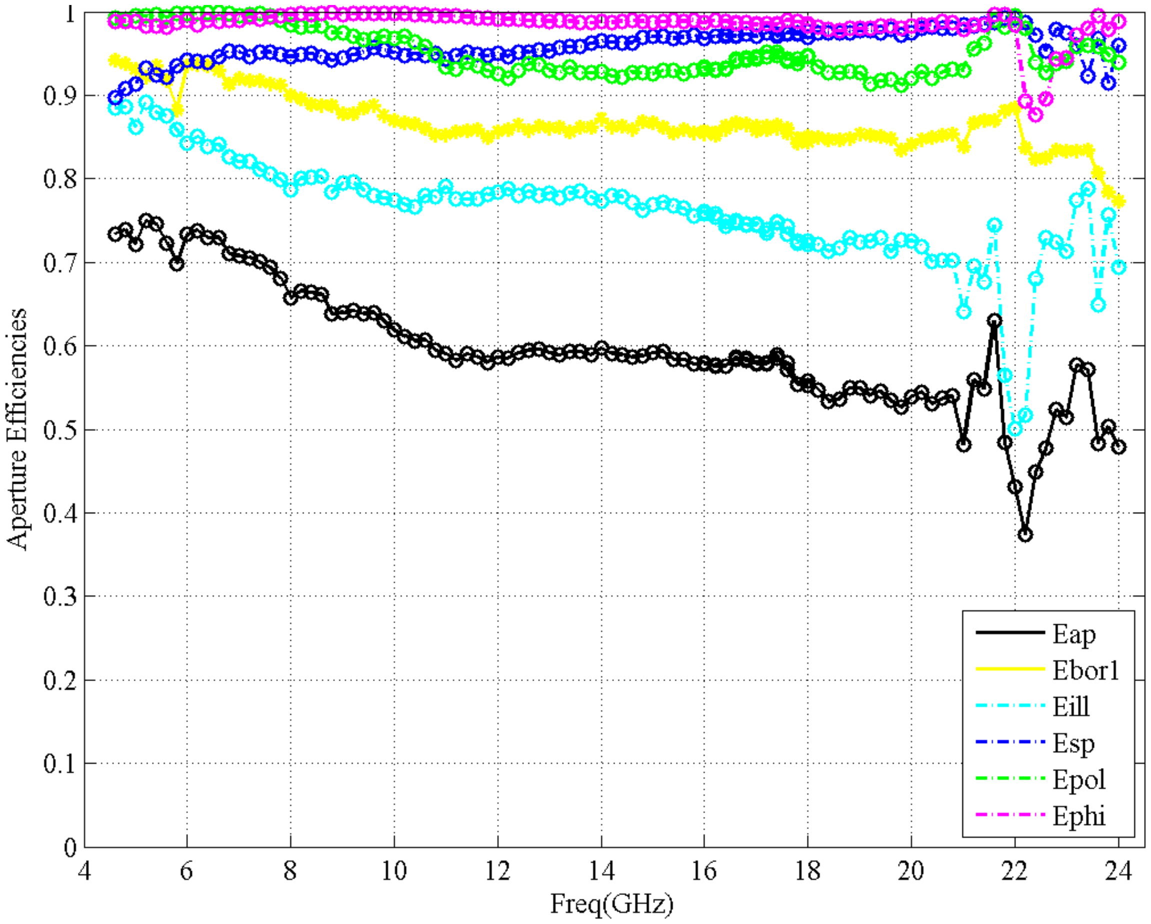


Measurements with cryostat dummy

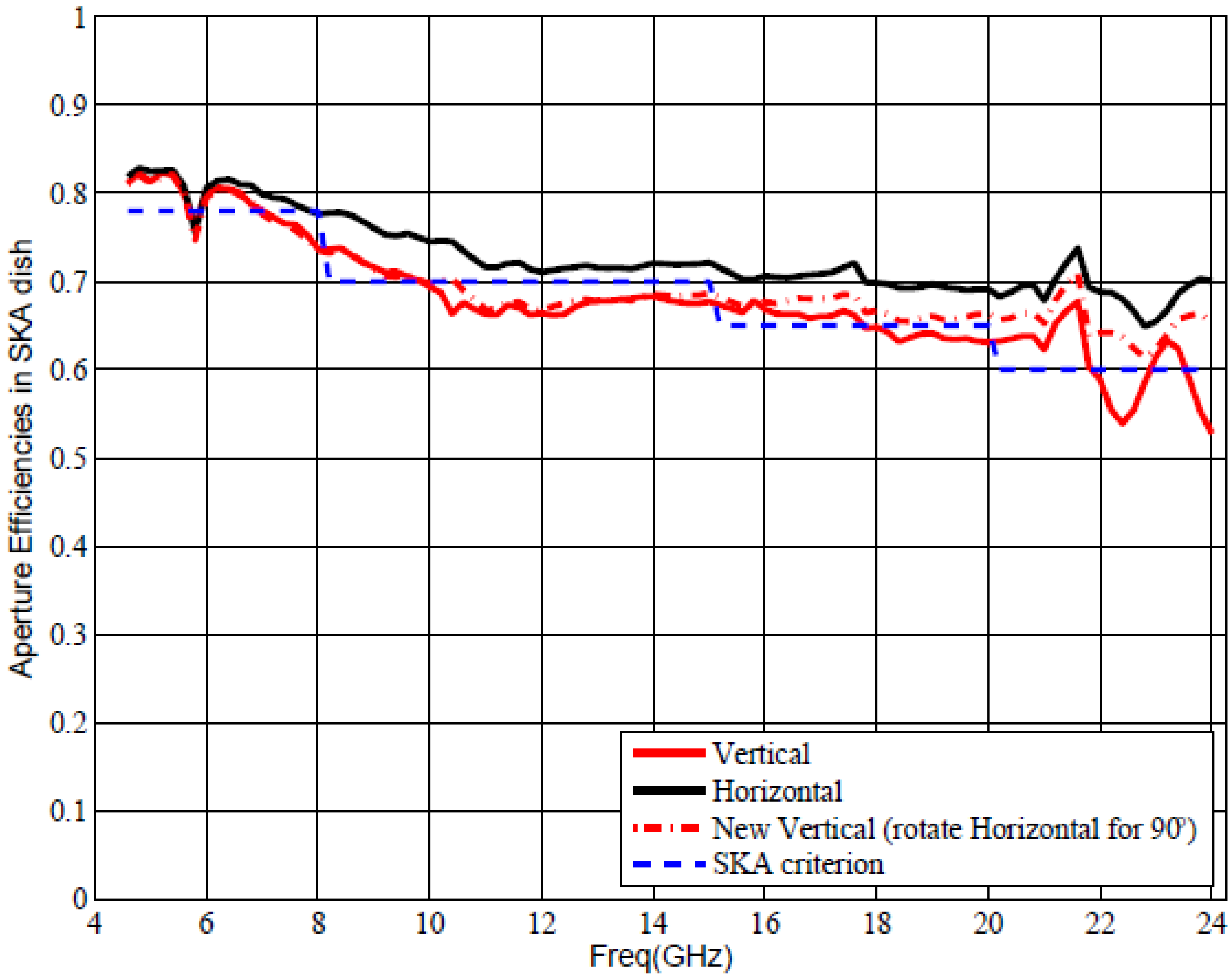
Chalmers Port 1

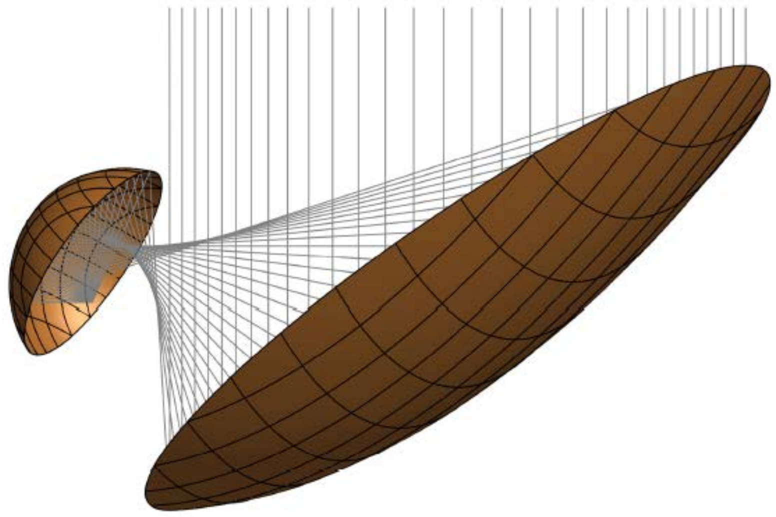


Chalmers Port 1 (with Cryostat Dummy)



Band B Feed Efficiency in SKA dish calculated from measured beam pattrens

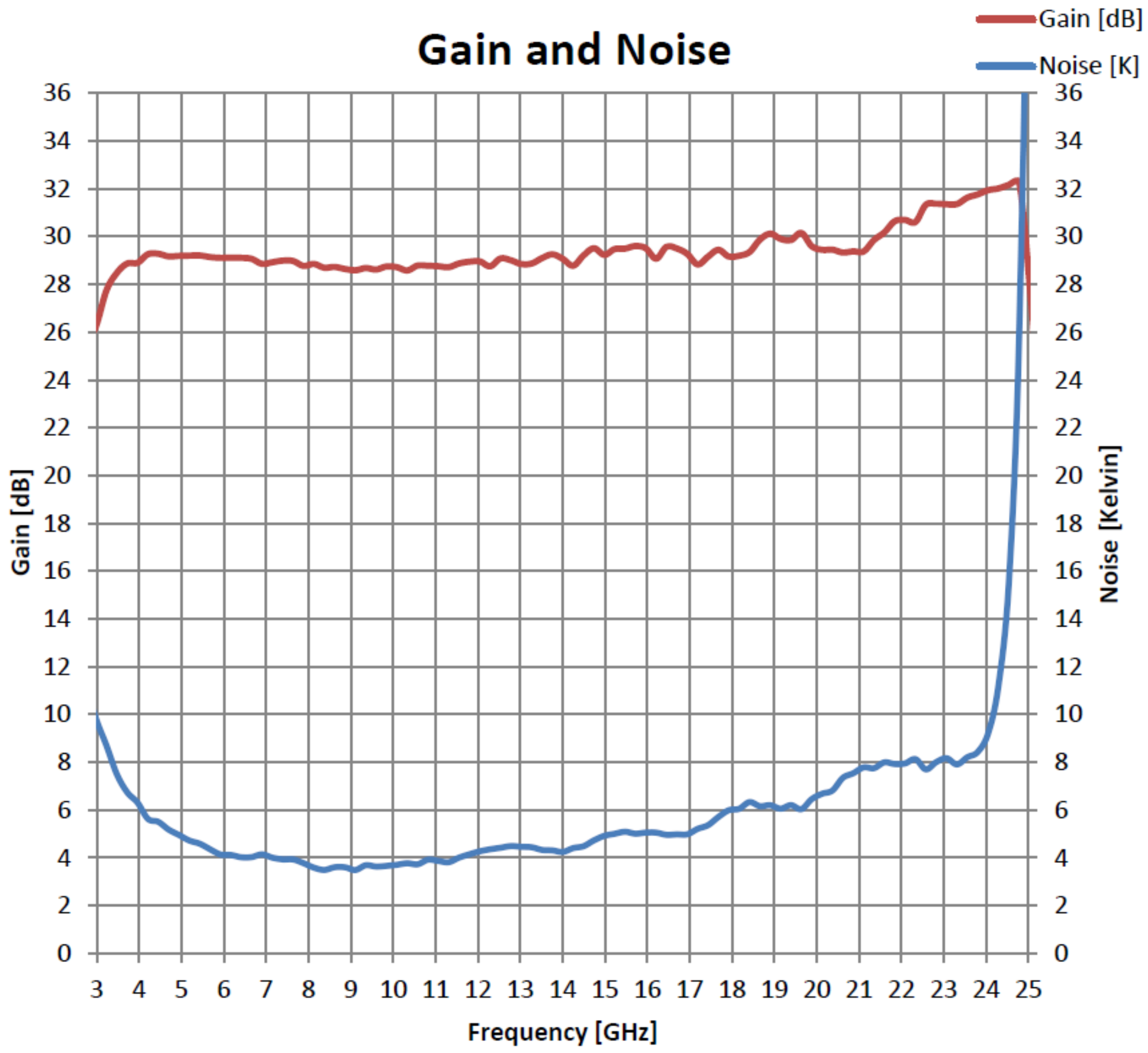


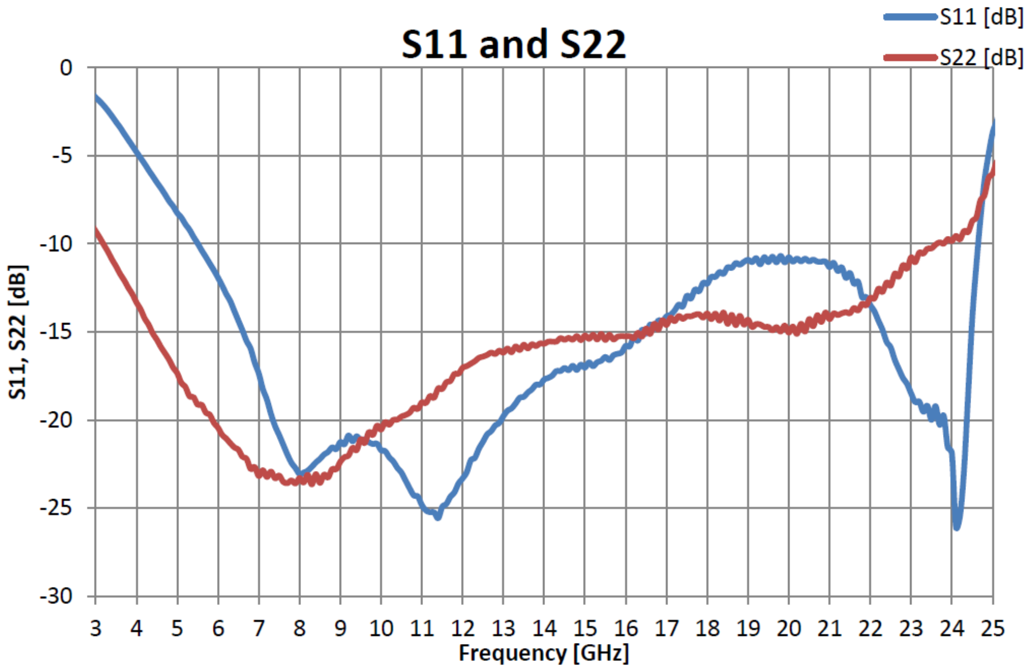


Band B
InP LNA

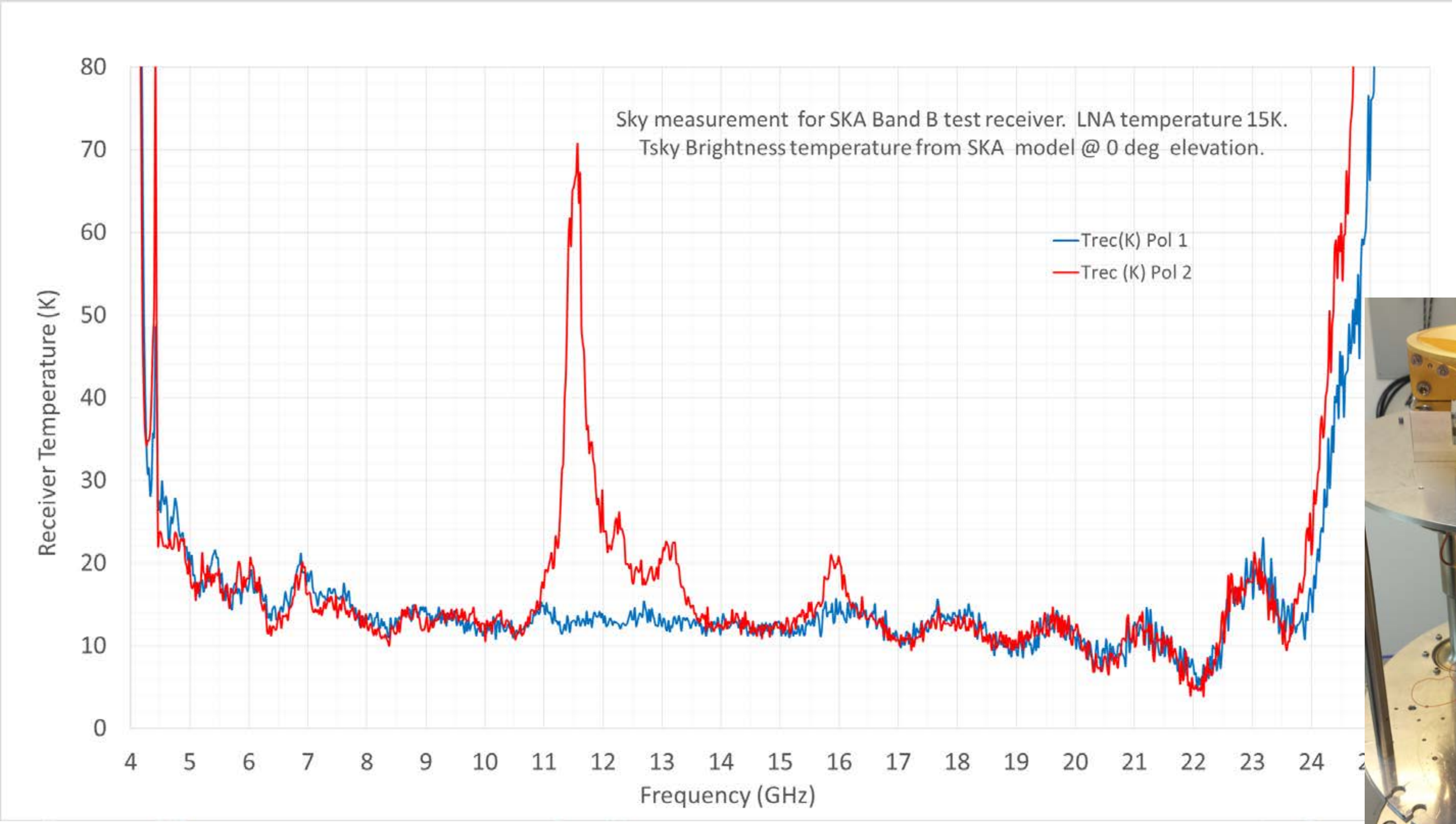
LOW NOISE FACTORY
www.lownoisefactory.com

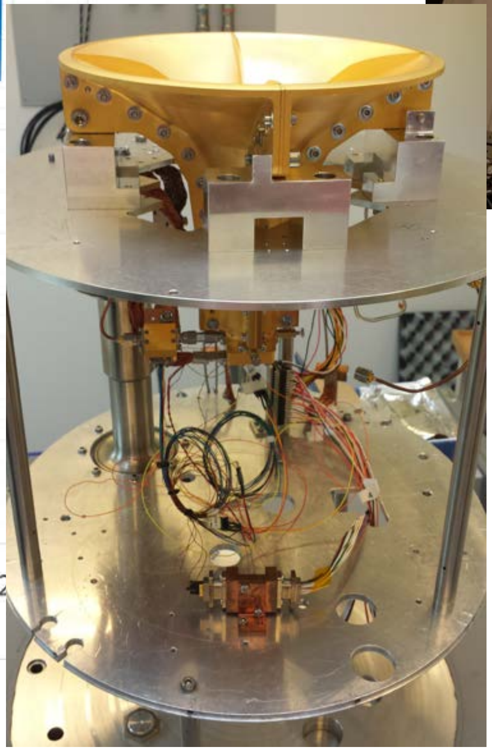
SKA SQUARE KILOMETRE ARRAY
WIDE BAND SINGLE PIXEL FEEDS



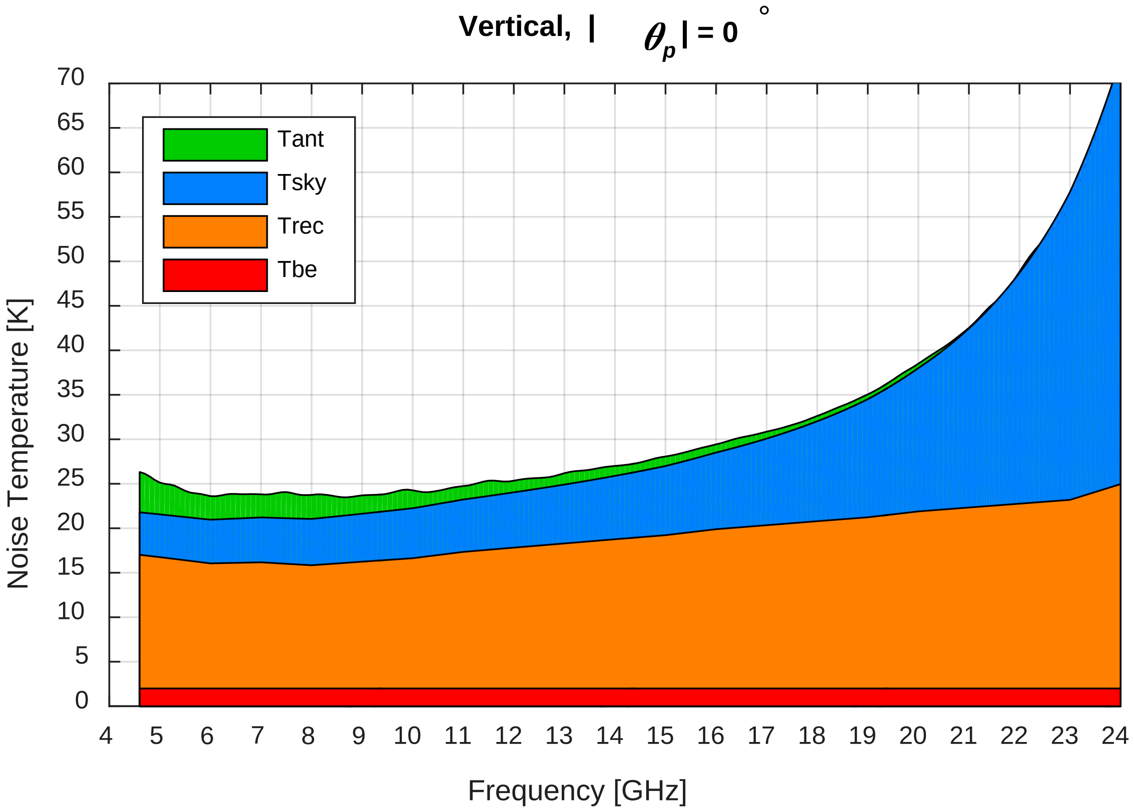


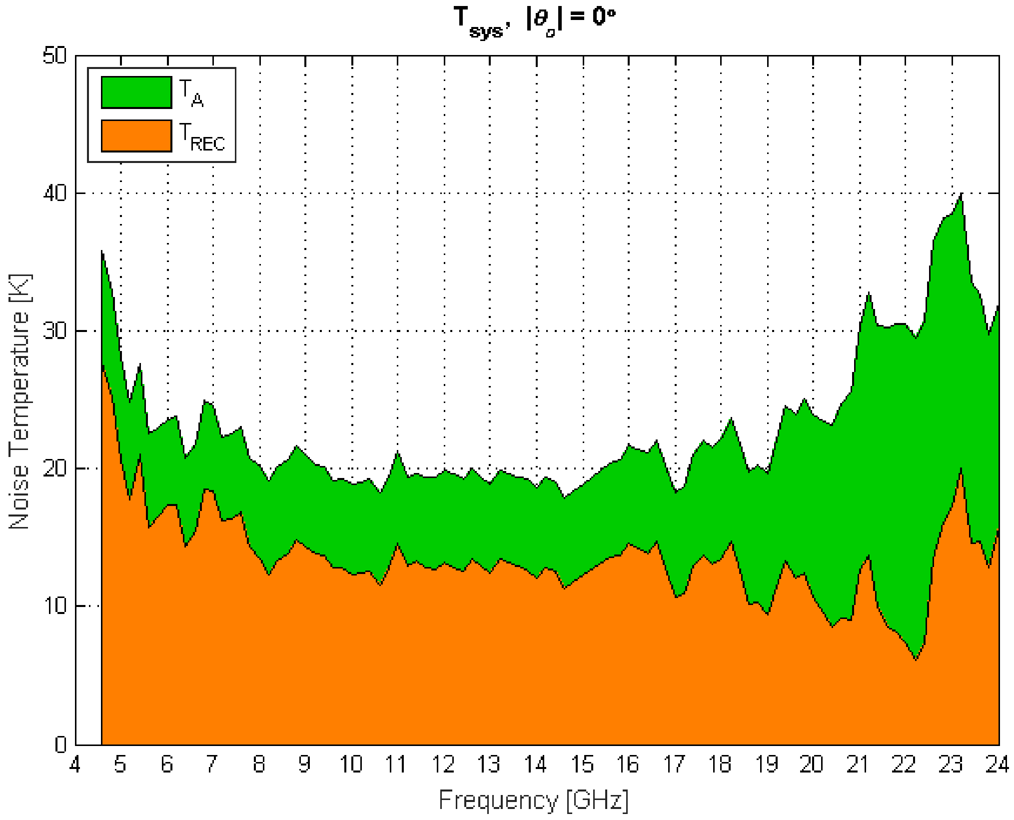
Measured Y – factor with Band B feed and LNA



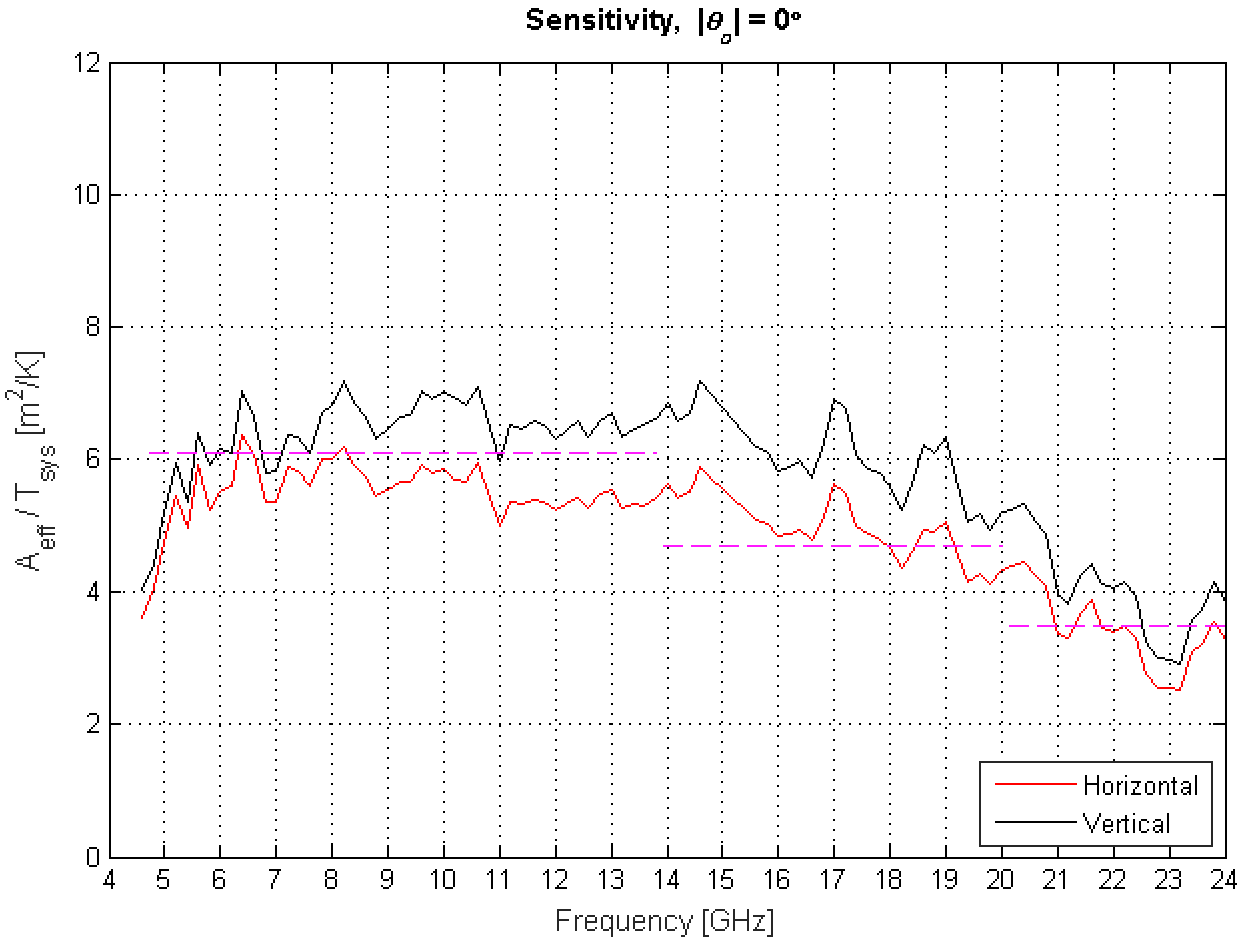


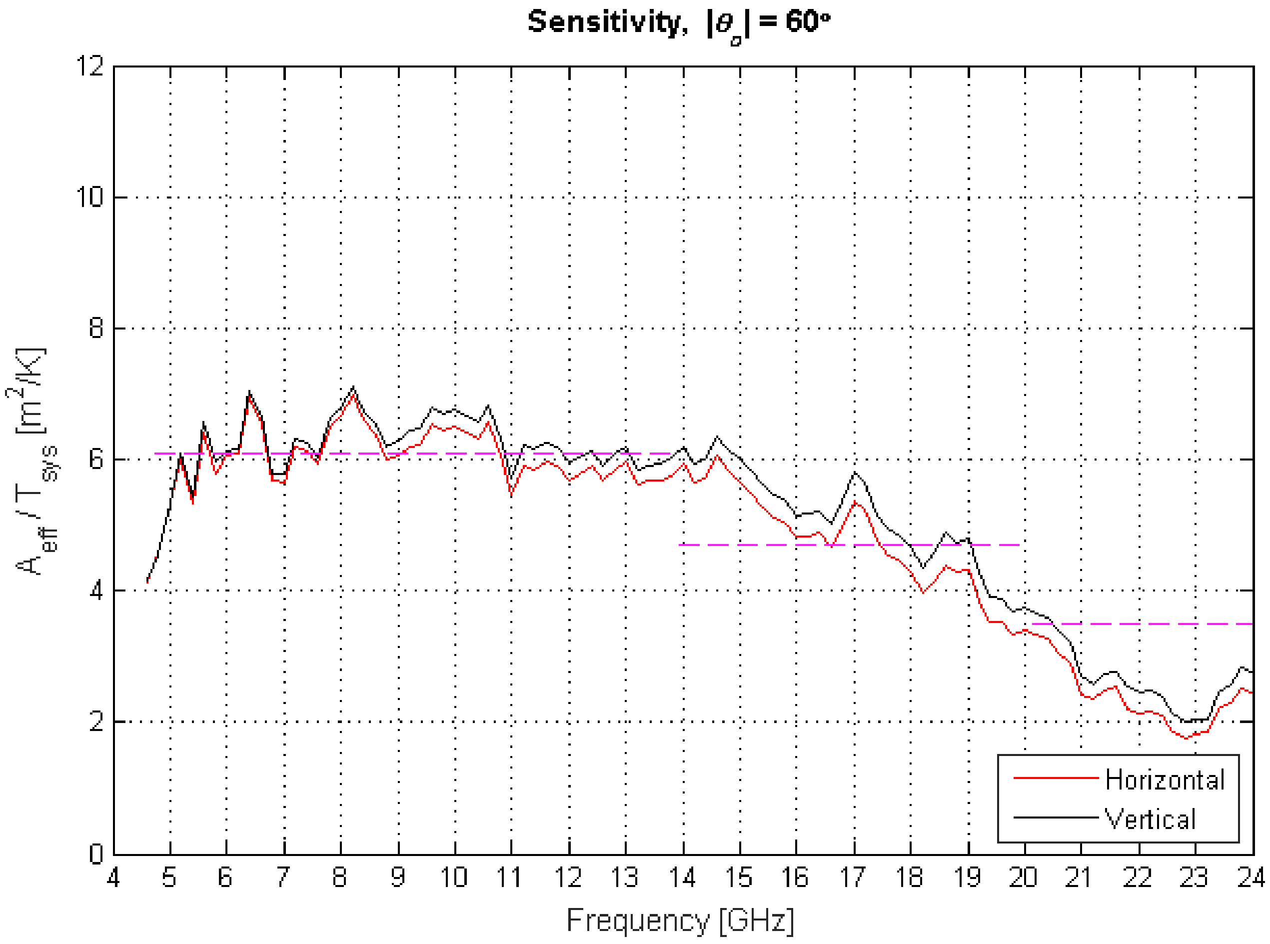
Band B noise model and test results





Sensitivity calculated with measured beam paterns and measured T_rec





Thank you
Questions?