Multi-frequency mm-wave radio telescopes
& other software controlled operations

Introduction to conceptual design of compact triple bands(22/43/86GHz)

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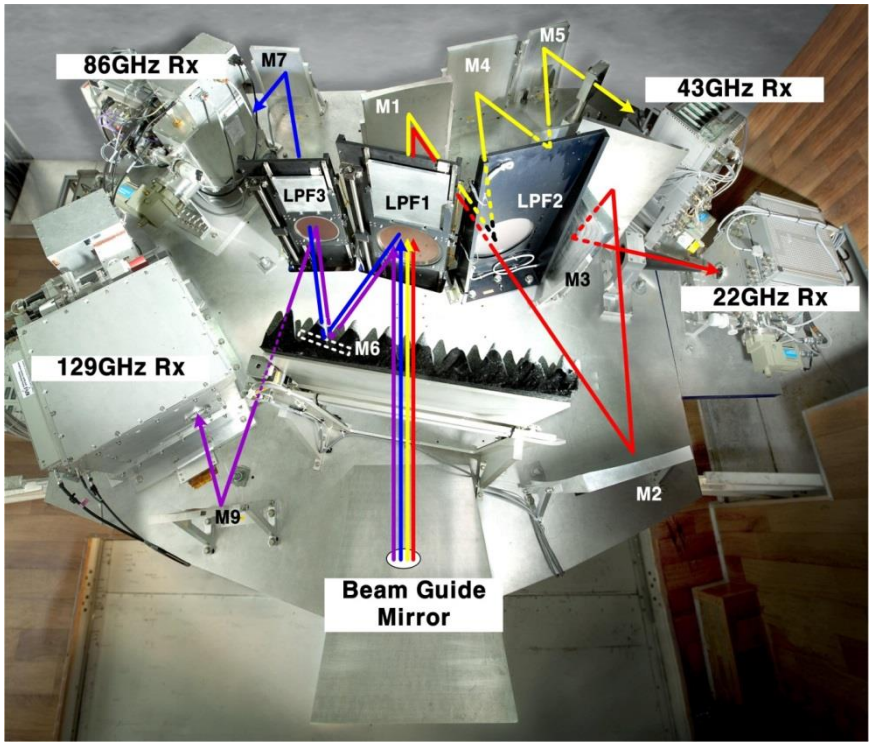
Outline

- Motivation
- What key components are needed
- Strategy
- Summary

I. Motivation



- Compact optical circuit
  to install on limited space of receiver cabin
- More easy beam axis alignment
- Easy transportation to site and installation
- Reduce the cost (?)

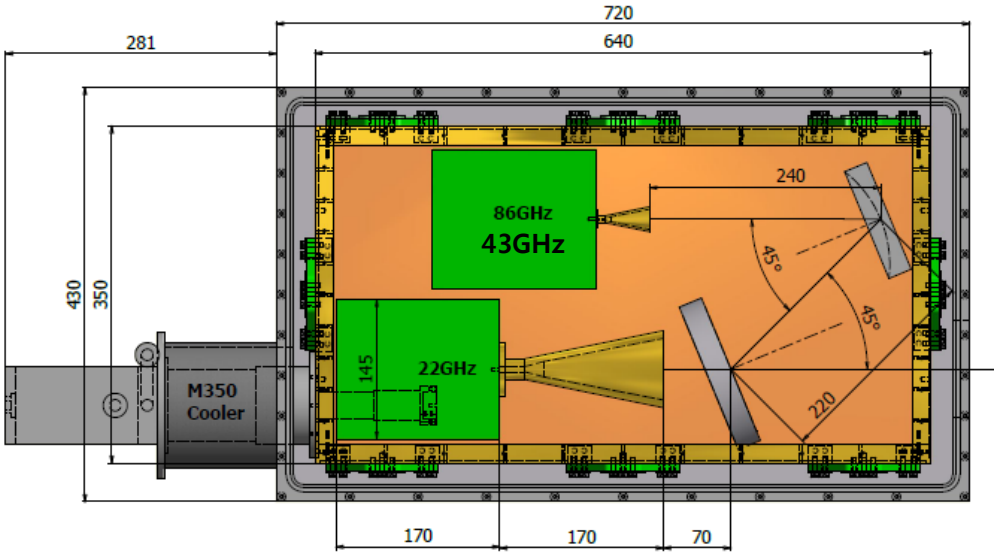
Losses of KVN optic circuit

Freq. [GHz]	Transmission and/or Reflection Loss [%] (LPF1+ LPF2/LPFs)	Tnoise @300K [K]
22	3.30 (Transmission only)	9.90
43	3.74 (Transmission + Reflection)	11.1
86	9.60 (Reflection + Transmission)	28.8
129	5.60 (Reflection only)	16.8

Needed cooling down to improve receiver noise temperature

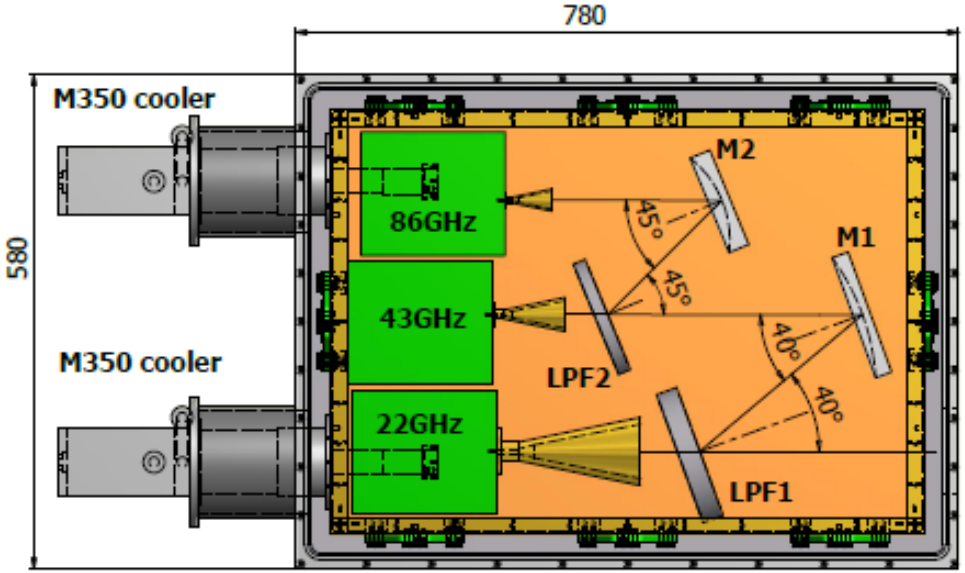
II. Conceptual design

22/86 GHz or 22/43GHz receiving system



- Dewar size is strongly depend on Optical circuit
- Optical circuit depend on Antenna specification such F/D, Edge taper and frequency
- Given space of receiver cabin(room)

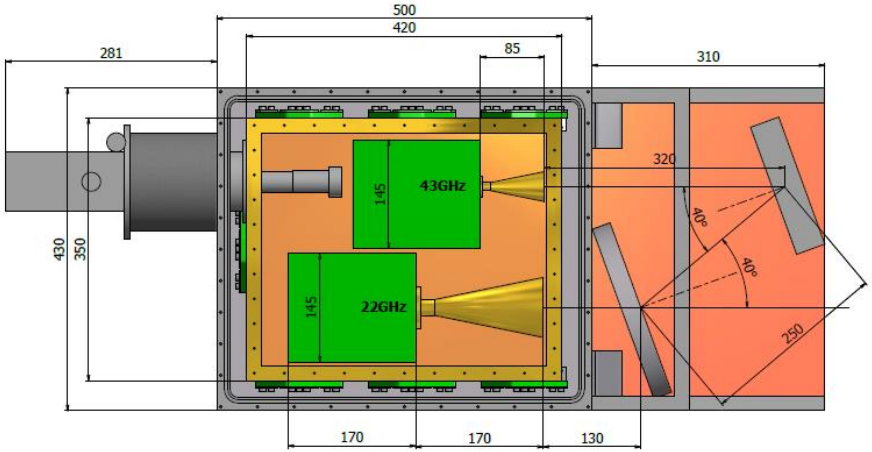
22/43/86GHz receiving system



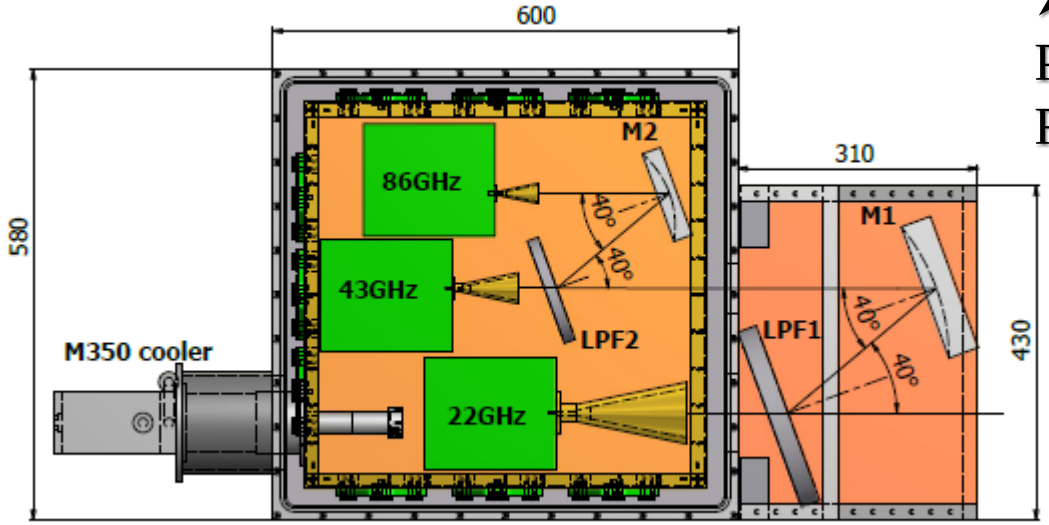
II. Conceptual design

Room temperature optical circuit

22/86 GHz or 22/43GHz receiving system



22/43/86GHz receiving system



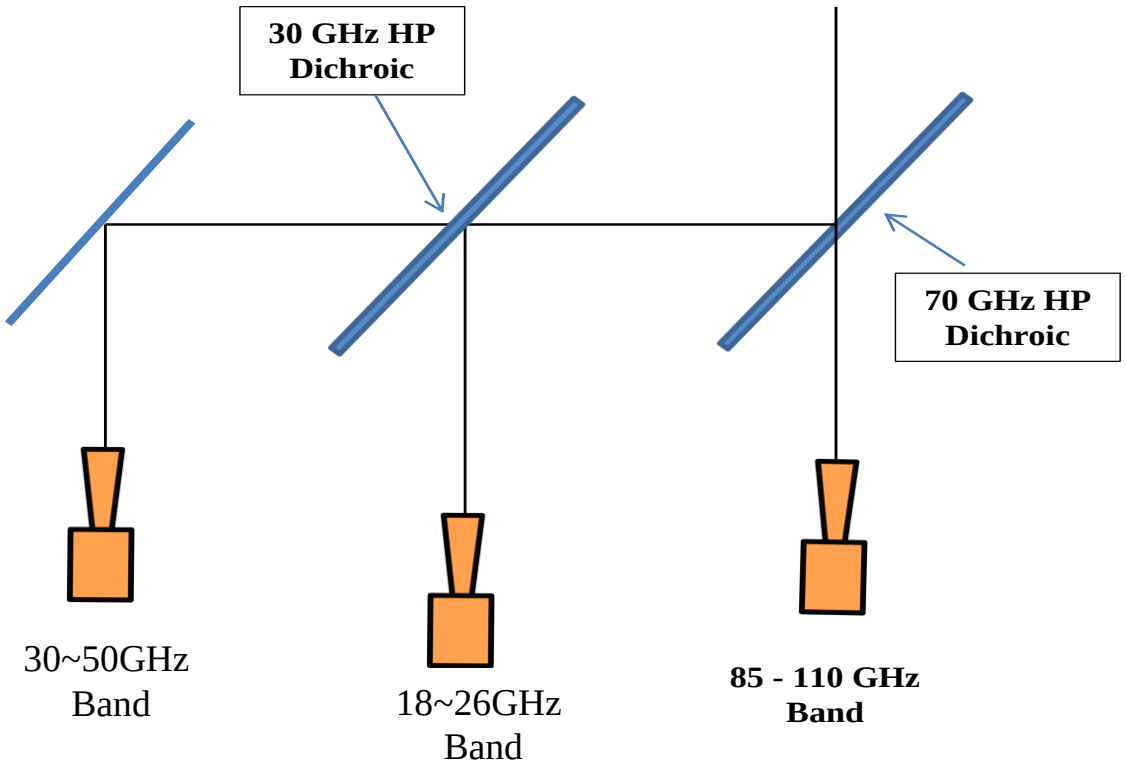
- Compare Room and Cryosat Performance in term of Receiver noise temperature

III. What crucial components are needed

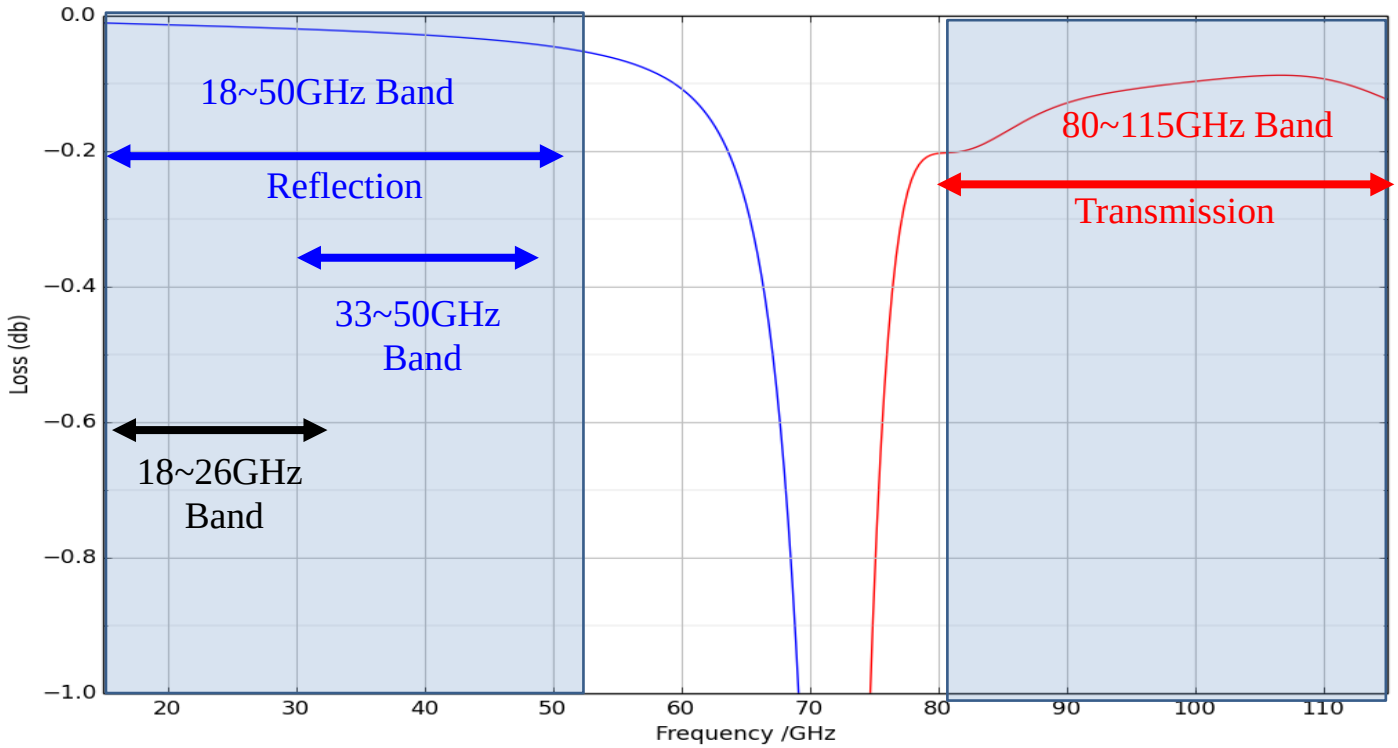
1. LPF and HPF

Schematic Dichroic layout with two High pass elements

- We would need to keep the beam incidence angles to below 22.5 degrees (not 45 as shown.)

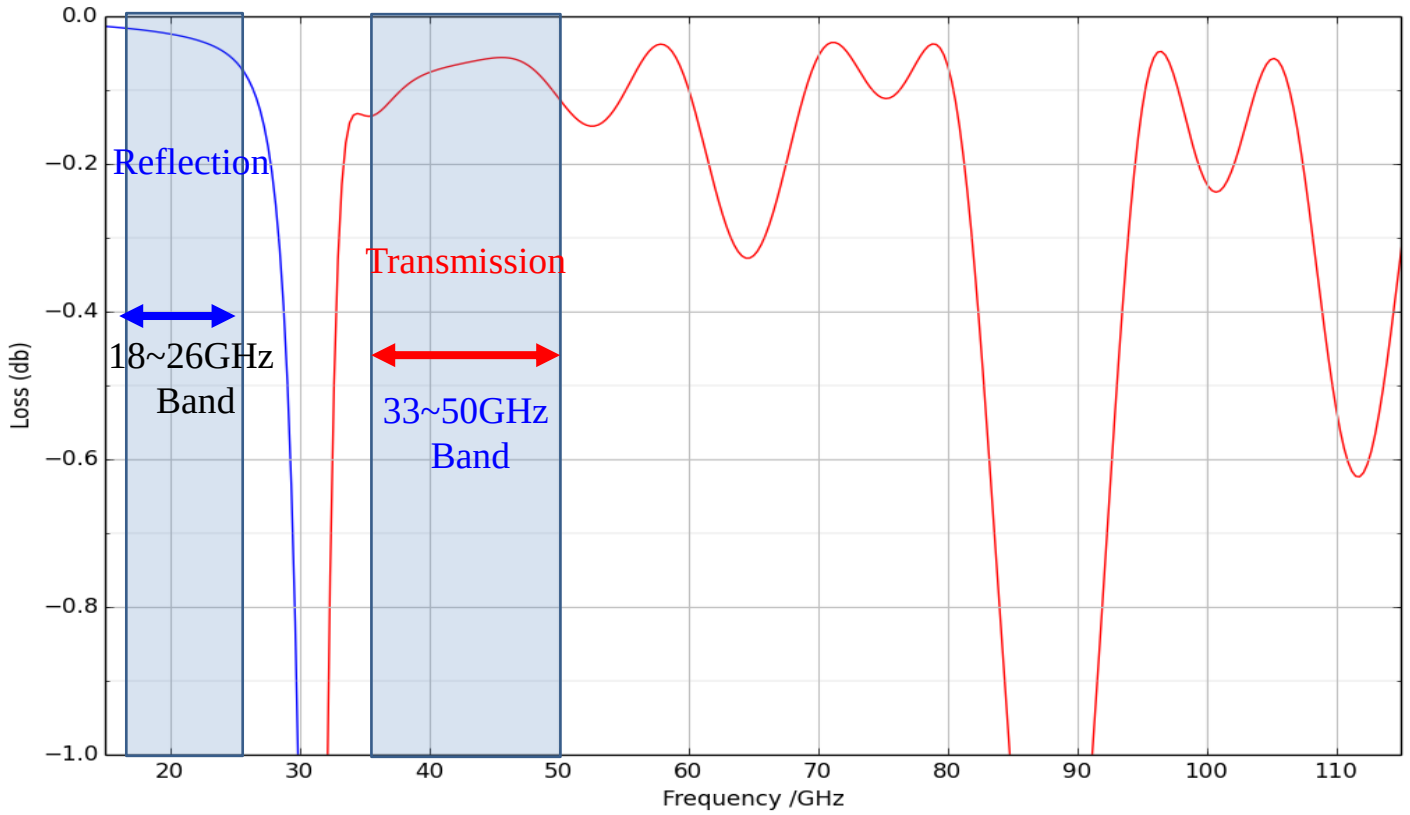


Model performance of first 70GHz high pass dichroic



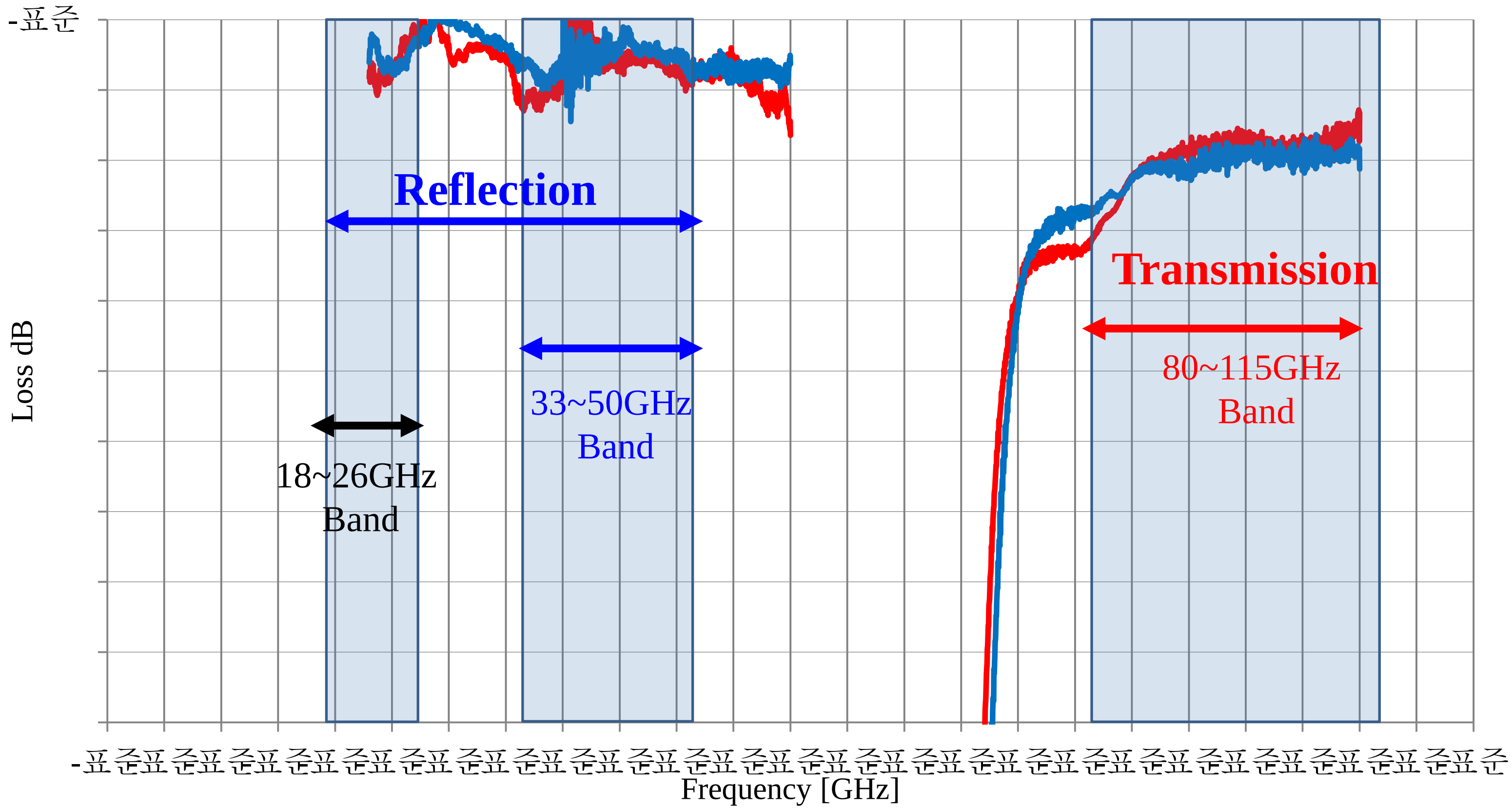
- Red line is Transmission. Blue line is reflection.
- The shaded areas represent the radiometric bands

Model performance of second 30GHz high pass dichroic



Red line is Transmission. Blue line is reflection.
The shaded areas represent the radiometric bands

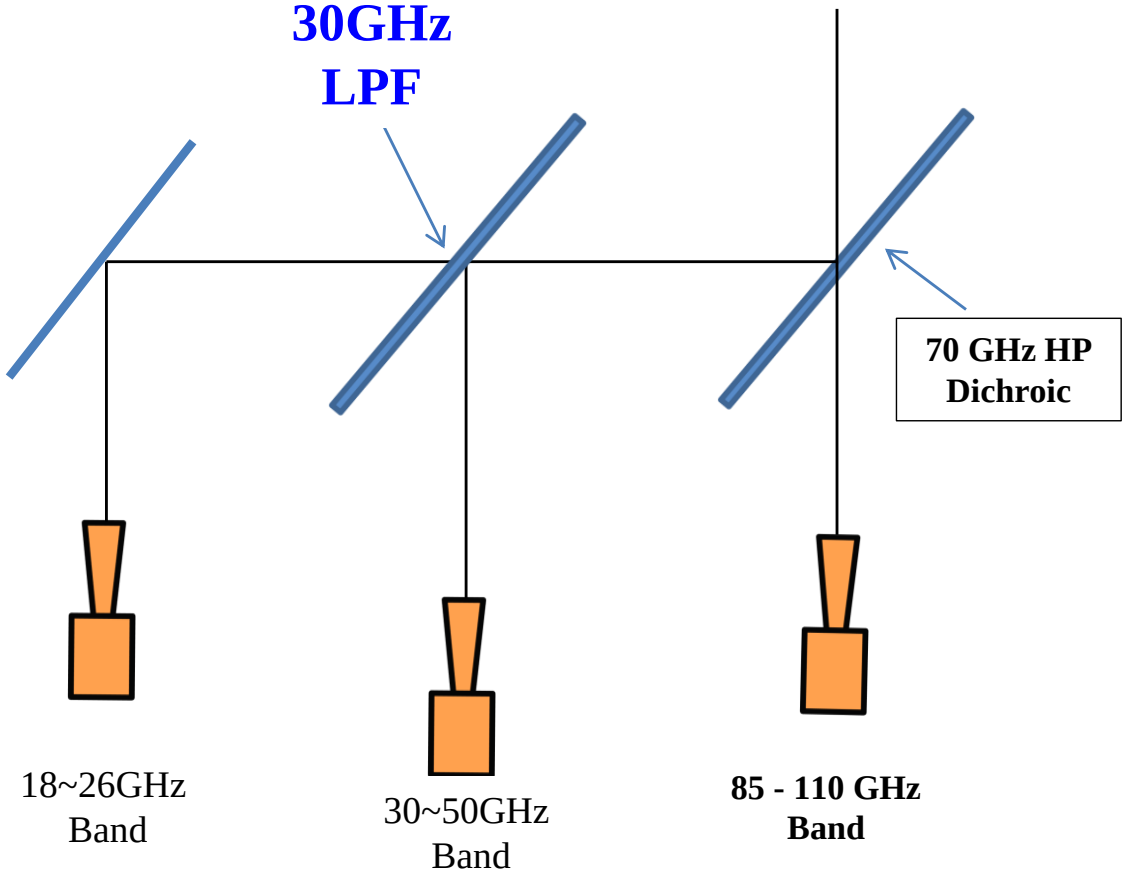
D1 70GHz dichroic measured at 22.5 degree incidence



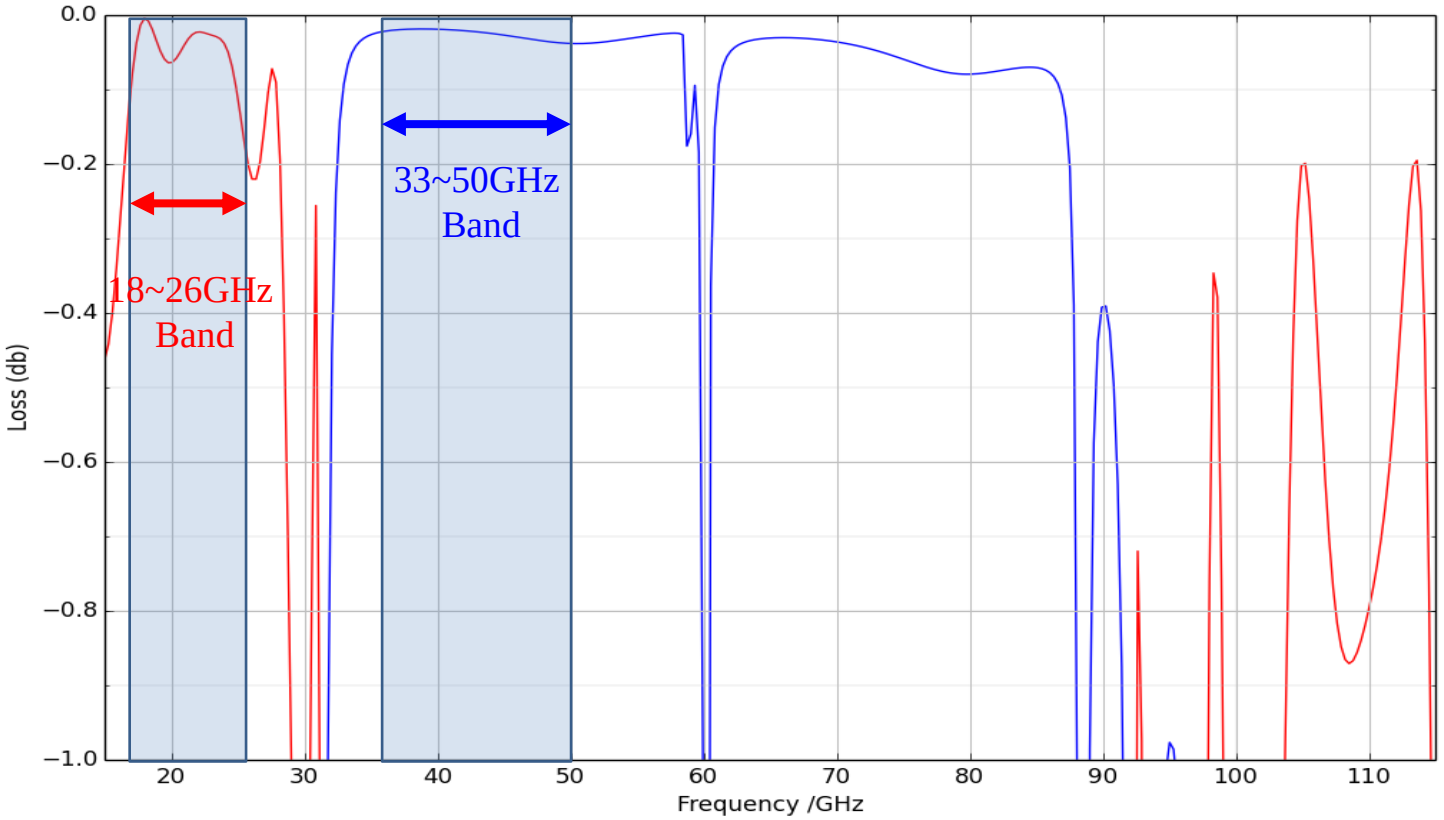
For reference the above plot shows the measured performance of a similar dichroic for both S & P polarisation vectors . Reference to the model performance of D1 shows good agreement giving confidence that the performance of D2 will be achieved.

QMC INSTRUMENTS

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD


30GHz
LPF
70 GHz HP
Dichroic
18~26GHz
Band
30~50GHz
Band
85 - 110 GHz
Band

Model performance of second 30GHz low pass dichroic



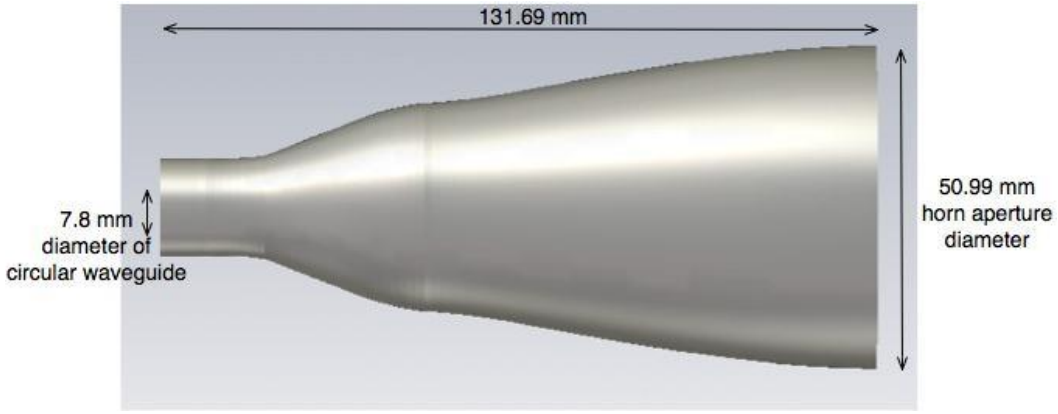
Blue line is reflection and Red line transmission. The shaded areas s how the radiometric bands.

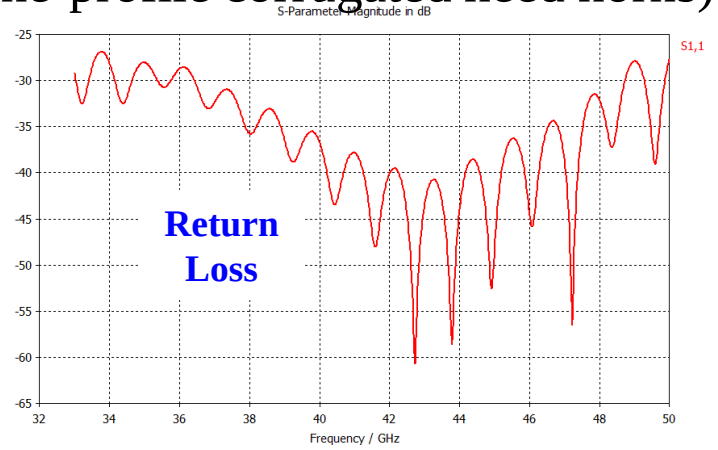
Notes on performance

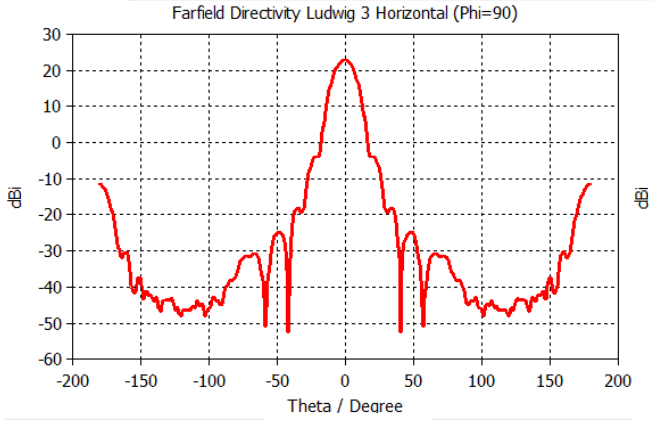
- The dichroics do not perform well at incidence angles greater than 22.5 degrees
- The devices work well for both vertical & horizontal polarisation
- The loss is typically below 0.2dB across the wanted bands
- The low pass option can be better tuned for the transmission band 18 – 26 GHz
- The measured device had an diameter of 160mm
- The dichroics are robust and not easily damaged
- Operated well at cryogenic temperature.

Special thanks to Dr. Peter Ade, Professor of Cardiff University

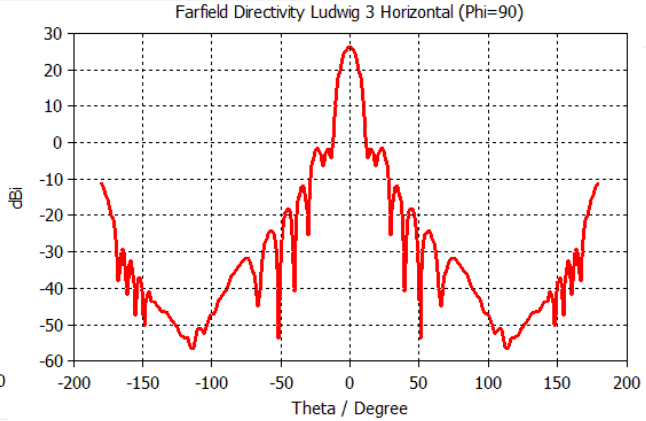
2. Compact and Ultra wide band feed horn(Spline-profile corrugated heed horns)



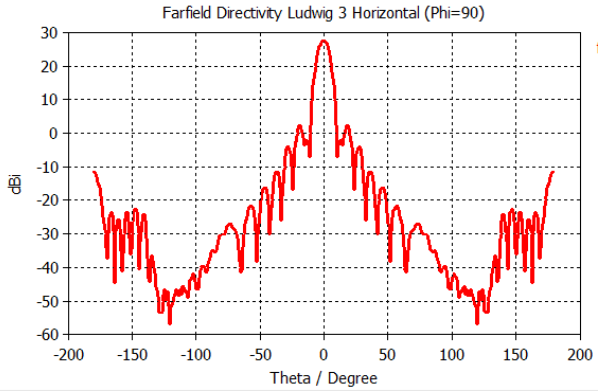




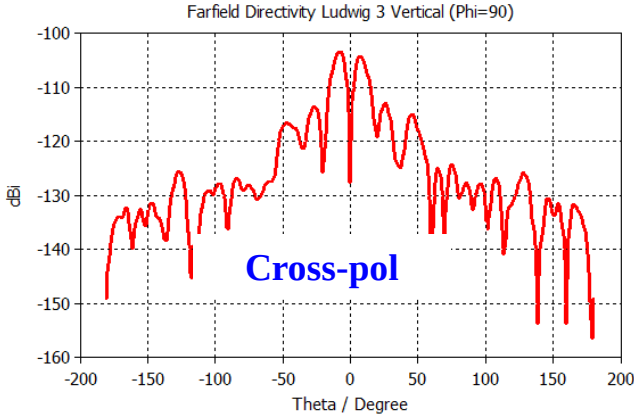
33GHz

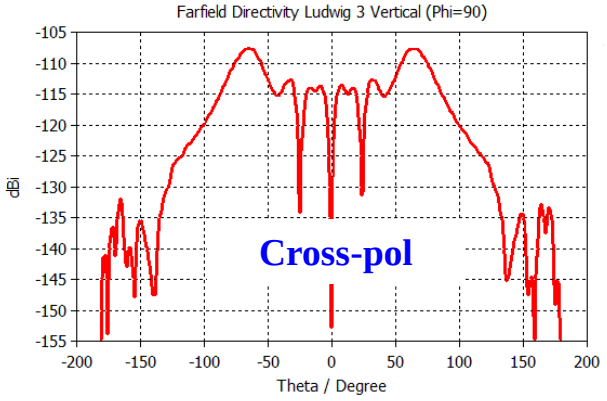


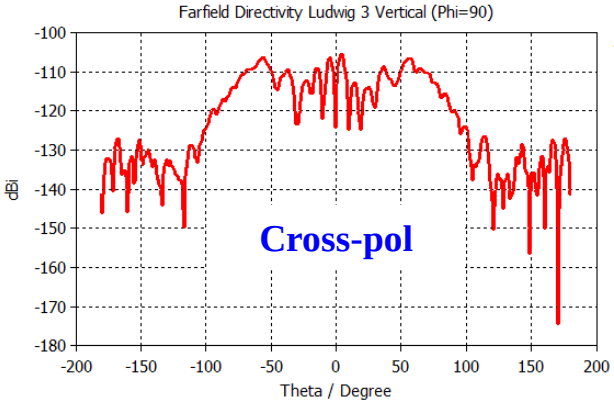
43GHz



50GHz







Notes on performance and development timeline

- Q-band spline-profile feed horn test : the end of 2015
  - Return loss, cross polarization and co-pol. pattern are good enough
- K-band spline-profile feed horn design : 2016
  - Scale up from Q-band one
- W-band will be considered choosing conventional one or spline profile one

Those have been developing by Dr. Moon-Hee Chung, our colleague

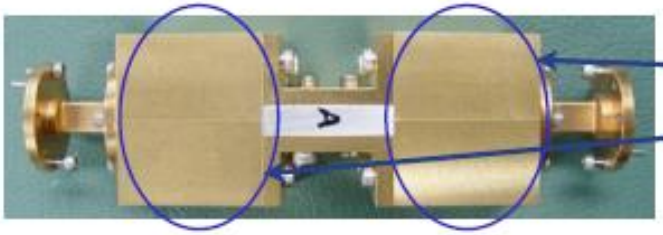
➢ Need collaboration with Asia ALMA group

3. Utrawide band phase shifter

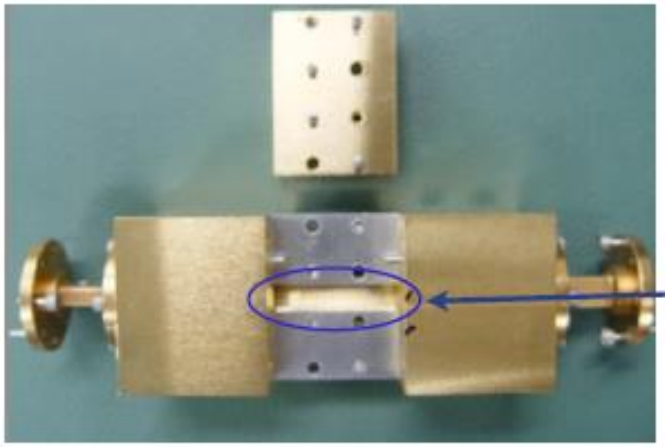
3.1 Q-band phase shifter(43 GHz)

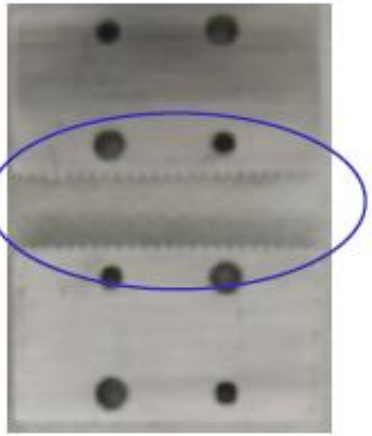
Differential Phase Shifter

Q-band 90-deg Differential Phase Shifter using
Two-Wall Corrugated Square Waveguide:



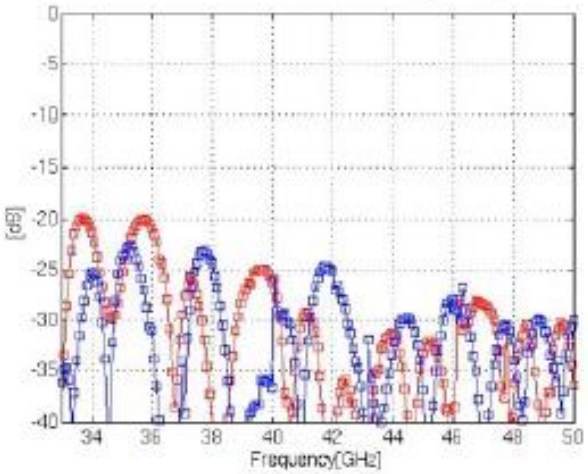
Rectangular to Square Waveguide Transition



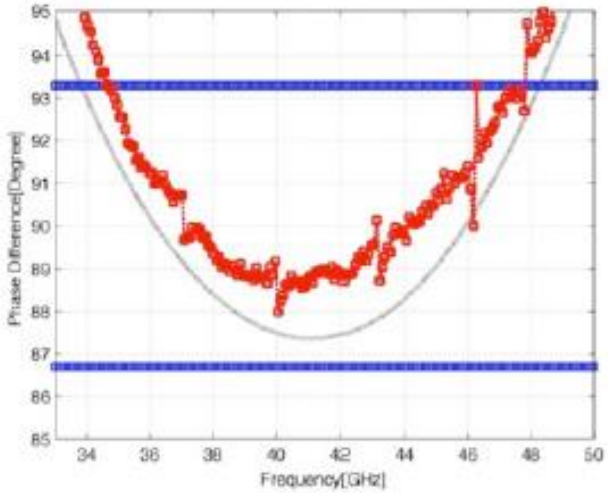


Differential Phase Shifter

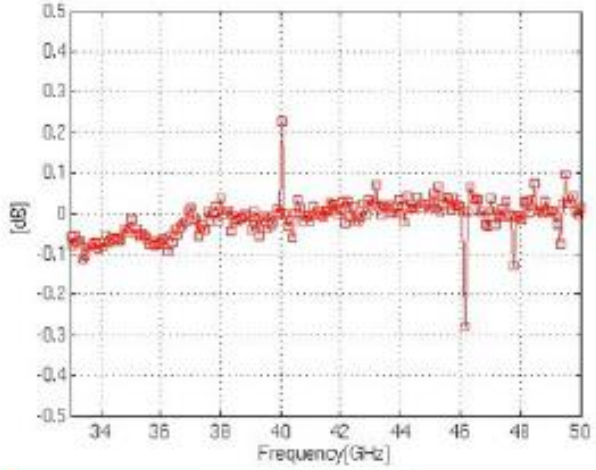
Return loss for the two orthogonal polarizations



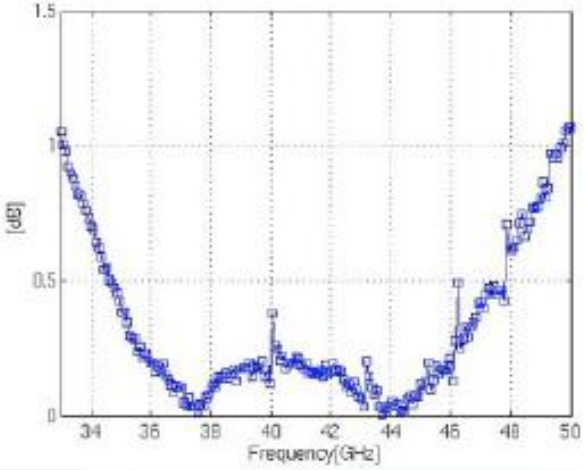
Phase difference between TE10 & TE01 modes



Amplitude imbalance between TE10 and TE01 modes

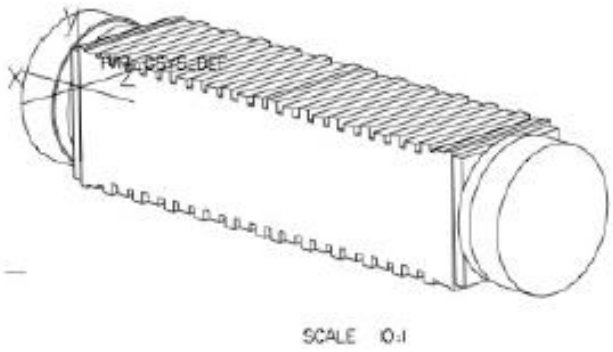


Axial ratio



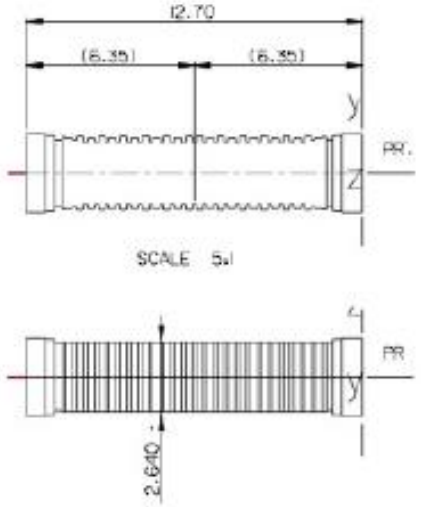
3.2 W-band phase shifter (86 GHz)

Differential Phase Shifter



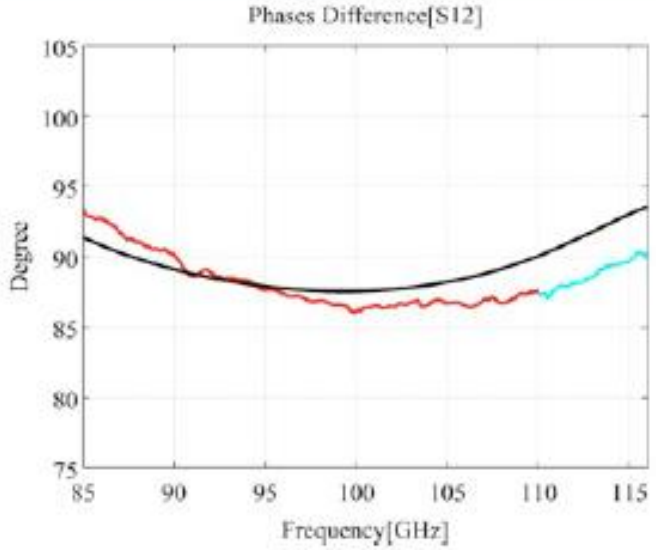
- Differential Phase Shifter has been fabricated using electroforming technique at Thomas Keating Inc.

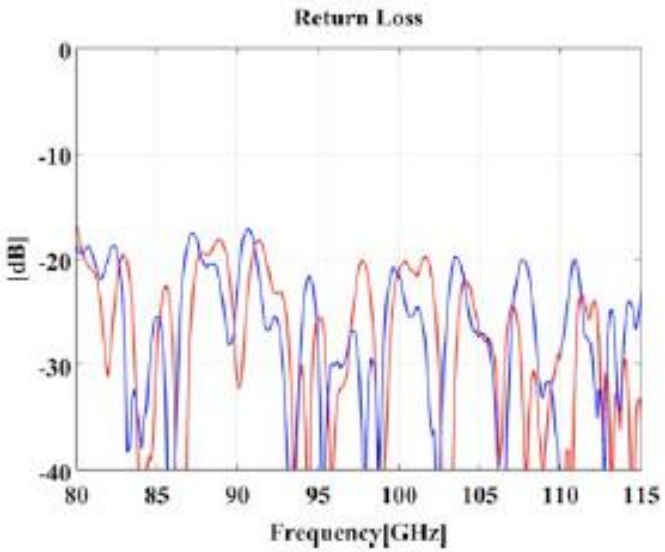
Mandrel for fabrication of the 86GHz band Differential Phase Shifter

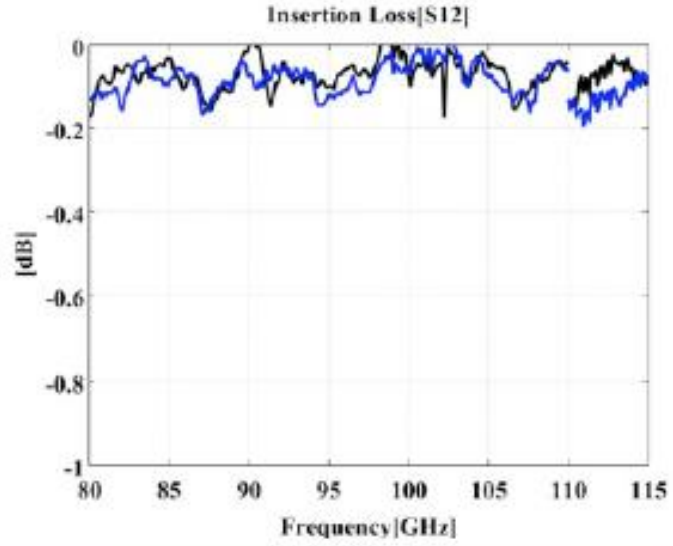


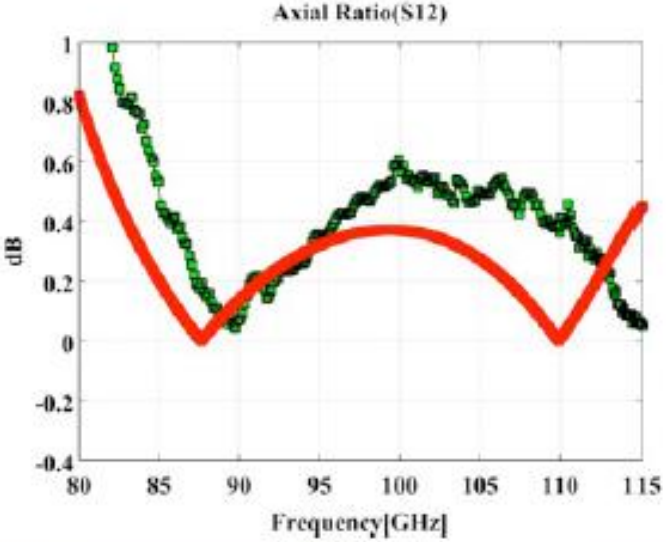
Fabricated 86GHz band Differential Phase Shifter

Differential Phase Shifter









3.3 W-band OMT (86 GHz)

W-band OMTs(Orthomode Transducers)

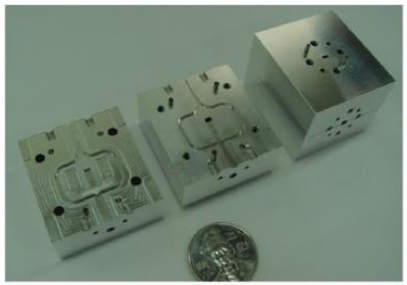


Fig. 9. Two halves split-blocks (two on the left side) and assembled OMT (on right side).

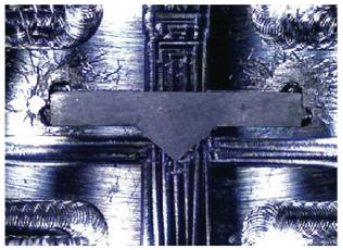


Fig. 10. Aluminum septum being placed on the surface of he OMT split-block.

W-band OMTs(Orthomode Transducers)

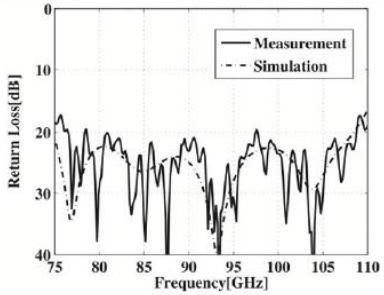


Fig. 14. Measured and calculated return losses for the vertically polarized wave.

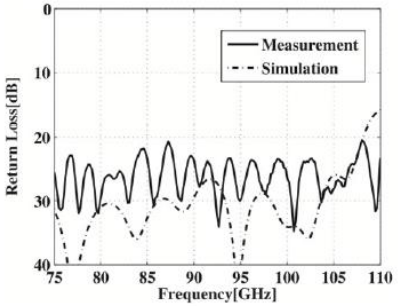


Fig. 15. Measured and calculated return losses for the horizontally polarized wave.

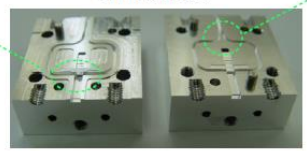
3.4 D-band OMT (130 GHz)

D-band OMTs(Orthomode Transducers)

Fabricated OMT(Aluminum alloy 6061)

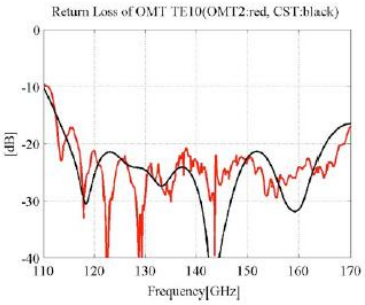
Fabricated OMT(Brass with gold-plating)

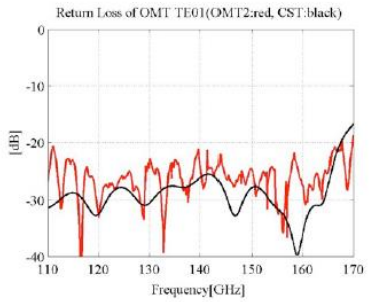
OMT block halves



D-band OMTs(Orthomode Transducers)

- Measurement Results:





"cross-polarization of the D-band OMT was measured to be greater than expected !"

Notes on performance and development timeline

- Up grade of Q-band polarizer : 2016
  - Return loss, cross polarization and co-pol. pattern are good enough
  - Need more upgrade of wide band properties such 33~50GHz

- K-band polarizer : 2016
  - Scale up from Q-band one

- W-band polarizer : 2016~2017

Those have been developing by Dr. Moon-Hee Chung, our colleague

- Need collaboration with Asia ALMA group
- Collaboration with Cardiff University for triple bands polarizer

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

4. Wide band LNAs

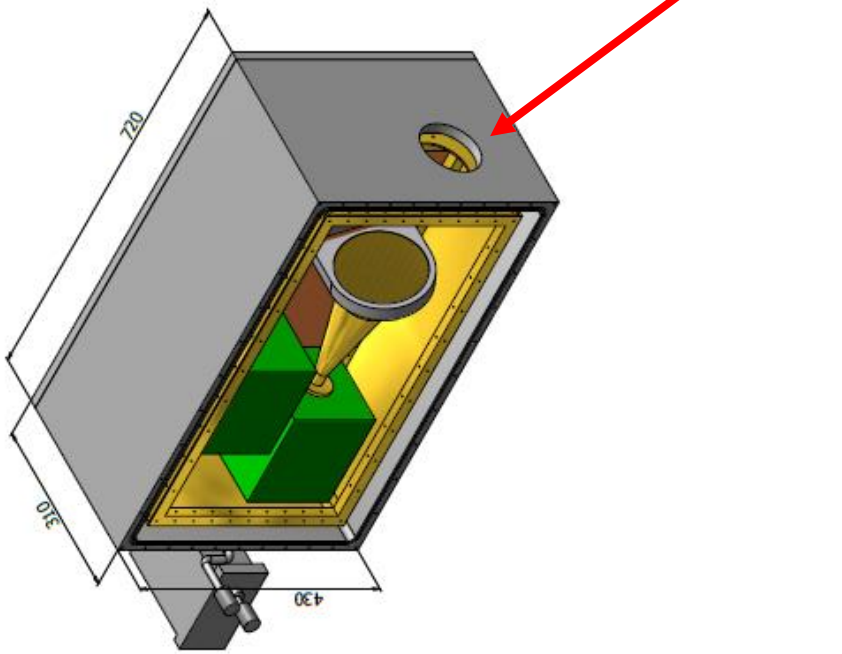
- Wide band K , Q- and W- band LNAs : well satisfied our bands
  - collaboration with NRAO, Caltech, JPL

5. Wide band Ellipsoidal mirrors

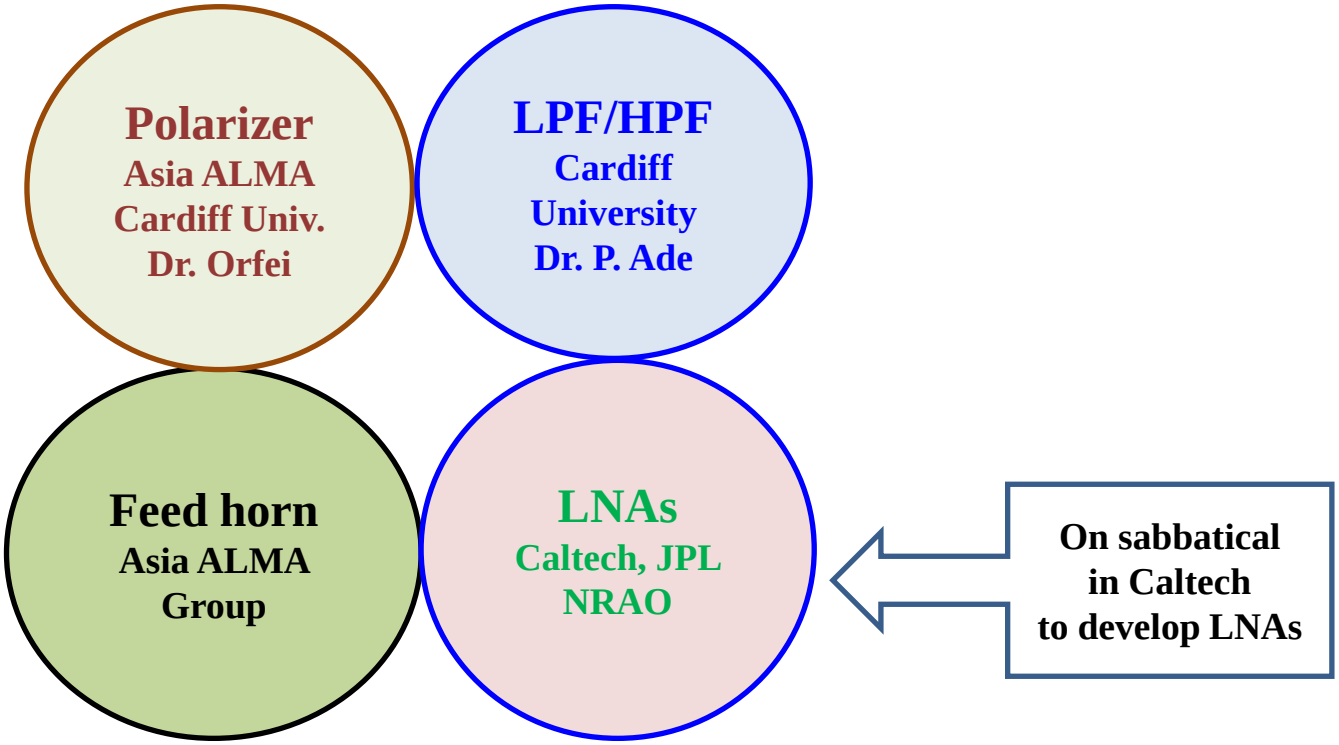
- Well proven technology

6. Wide band vacuum window(18~110GHz)

- Collaboration with East Asia ALMA group



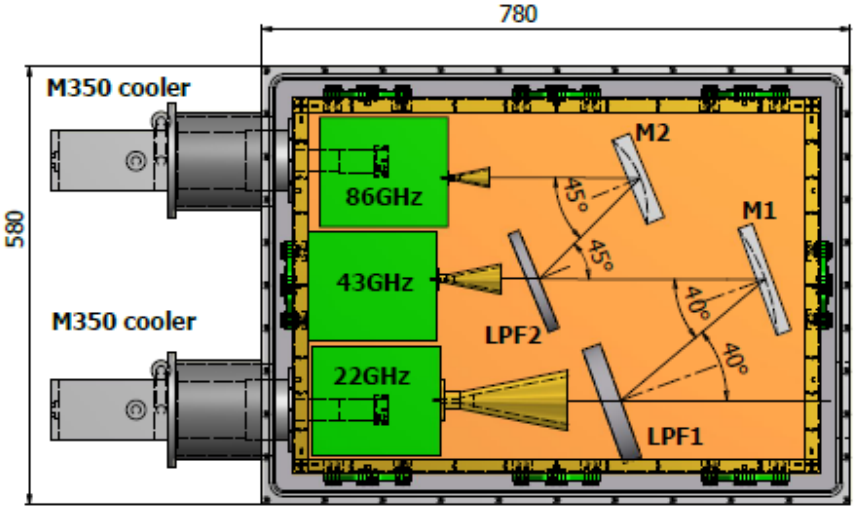
IV. Strategy and Summary



- KVN has been sustainedly conducting this project
  so that KVN, E-KVN and/ or some VLBI stations could be used any time and any where

- Some items are well proven technology, but needed more investigation
  - International collaboration be absolutely required

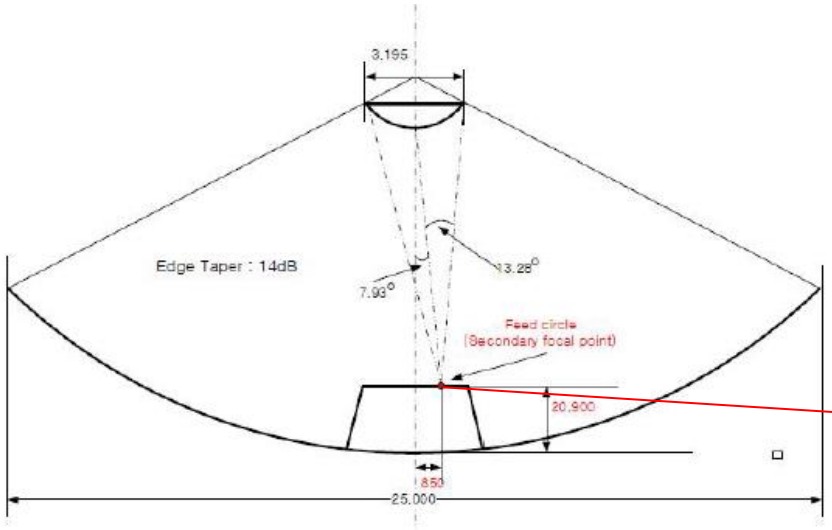
Korean Geodesy observatory

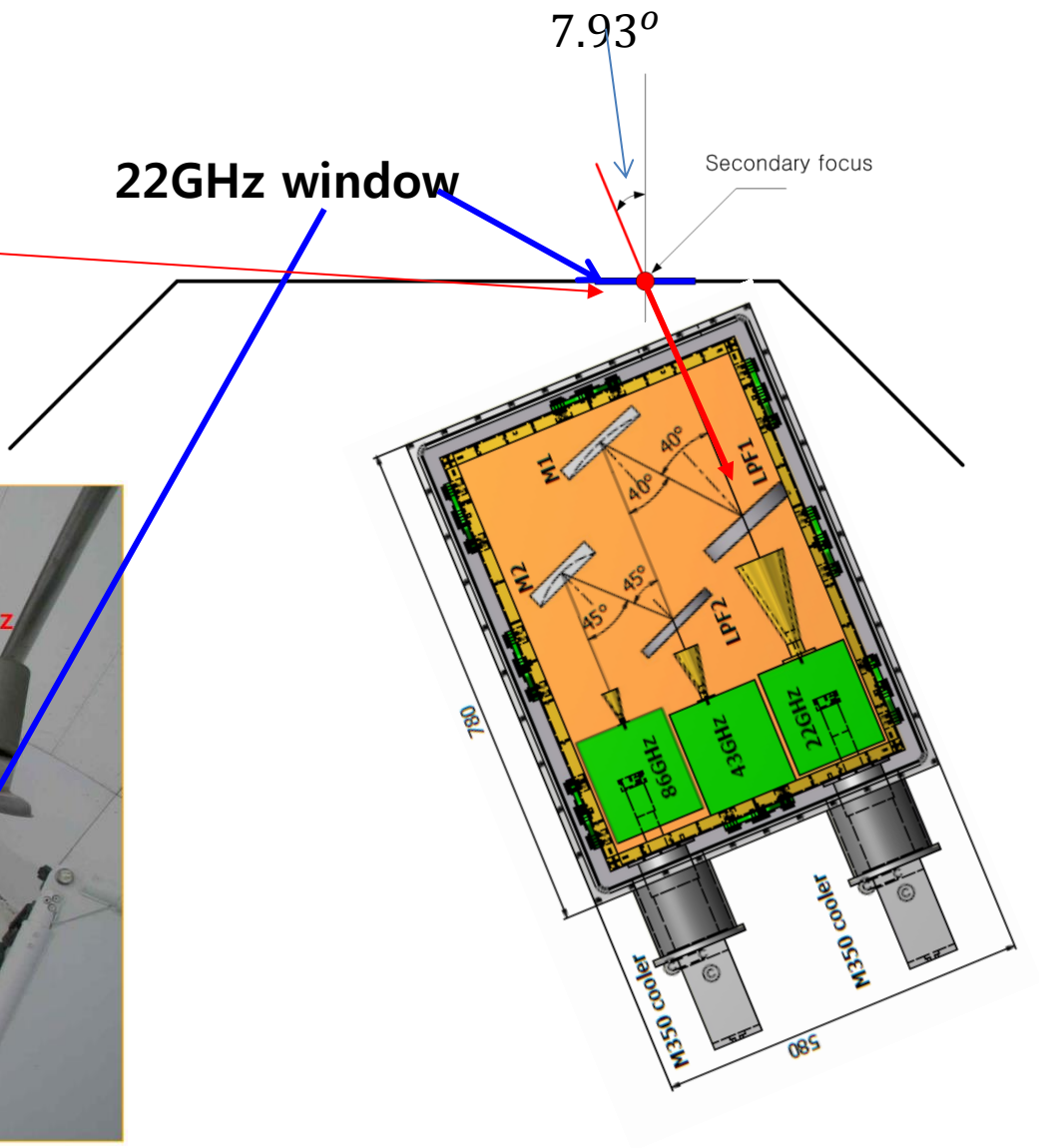


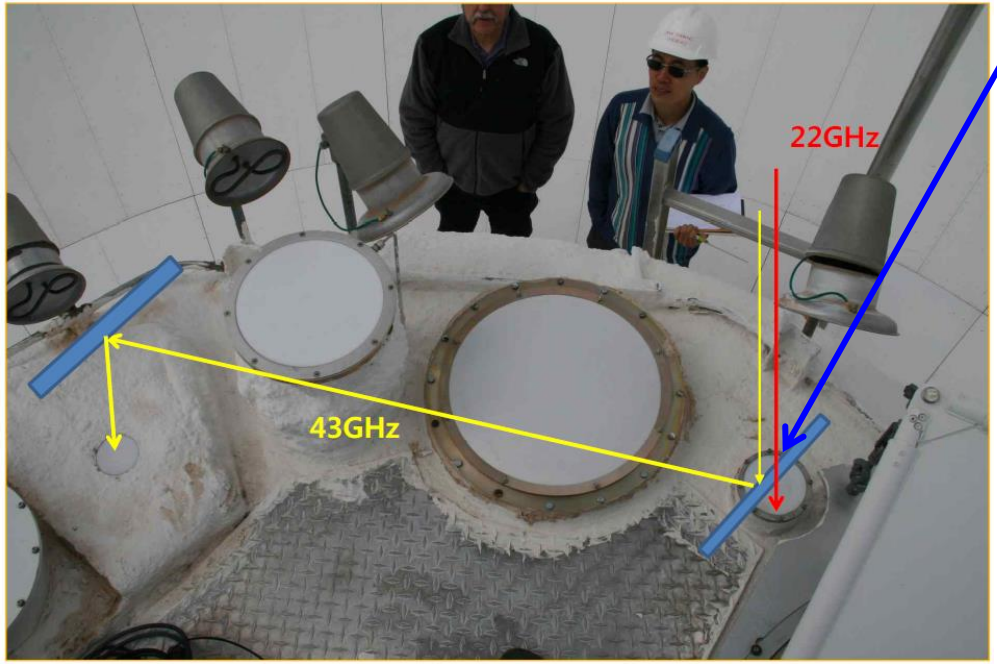
- **Built in 2013 : 20 km apart from KASI.**
- **22m in diameter Cassergrain radio telescope : made by "High Gain Antenna" company, Korea**
- **2/8GHz :Geodesy observation, but hard from RFIs**
- **22/43GHz(Simultaneous observation KVN does) : Radio astronomy**
  - *** Aperture efficiency @ 22GHz : 59%, @43GHz : 54% , 45% more @86GHz**
  - *** has been done successfully fringe test with KVN for K/Q band simultaneously**

We are considering to install "TRIBAND RECEIVER (22/43/86GHz) on this telescope.

VLBI : Pie town station







KASI 한국천문연구원

Korea Astronomy and

Thanks for your attention