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

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

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

- Dewar size is strongly depend on Optical circuit
- Optical circuit depend on Antenna specification such F/D, Edge taper and frequency
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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.
70 GHz HP Dichroic
30 GHz HP Dichroic
35 - 50 GHz Band
Dichroic
18 - 26 GHz Band
85 - 110 GHz Band

18~26GHz Band
30~50GHz Band
85 - 110 GHz Band

30GHz LPF

70 GHz HP Dichroic
Model performance of second 30GHz low pass dichroic

Blue line is reflection and Red line transmission. The shaded areas show 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)

- Diameter of circular waveguide: 7.8 mm
- Horn aperture diameter: 50.99 mm

Frequency vs. Return Loss

- 33GHz
- 43GHz
- 50GHz

Farfield Directivity Ludwig 3 Horizontal (Phi=90)

- Cross-pol

Farfield Directivity Ludwig 3 Vertical (Phi=90)

- Cross-pol
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

Phases Difference [S12]

Return Loss

Insertion Loss [S12]

Axial Ratio [S12]

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M.-H. Chung
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 the OMT split-block.

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

“cross-polarization of the D-band OMT was measured to be greater than expected 1”
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
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
• 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.
- 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

22GHz window

7.93°

Secondary focus

22GHz

43GHz

43GHz

43GHz

43GHz

43GHz

43GHz

43GHz
Thanks for your attention