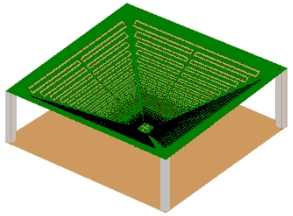
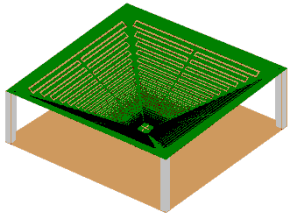


Development of a Cooled 1-14 GHz Eleven antenna for VLBI 2010

Per-Simon Kildal, Jian Yang, Leif Helldner, Miroslav Pantaleev

Chalmers University of Technology

Sweden



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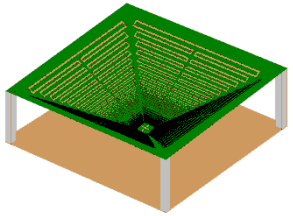
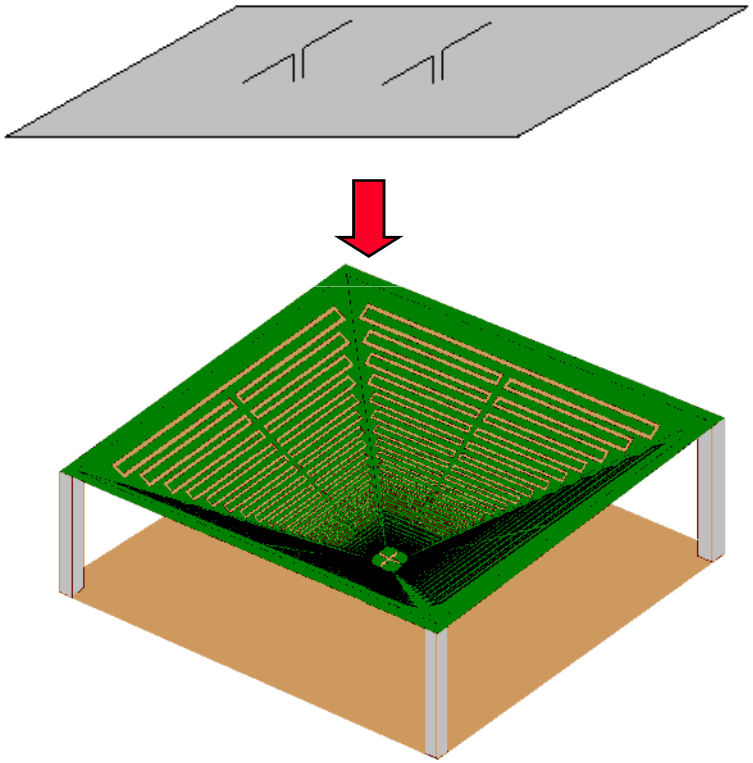
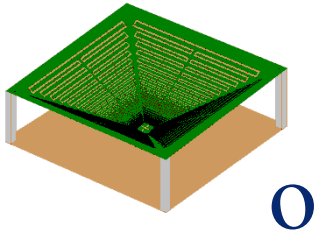


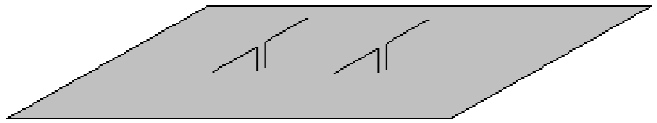
Idea behind Eleven feed new invention

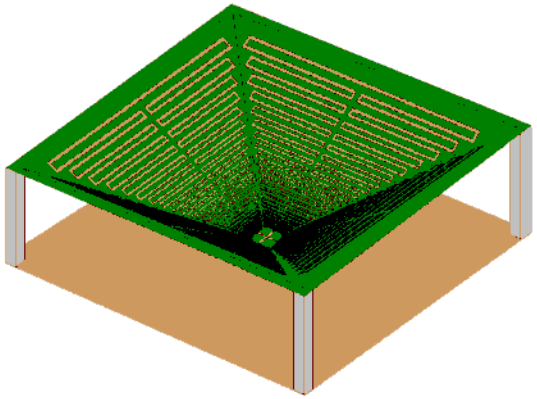
- Two parallel dipoles over ground (Eleven configuration)
  - from book by Christiansen and Högbom Radio Telescopes
  - equal E- and H-plane patterns
  - phase center is locked to the ground plane
  - low far-out sidelobes and backlobes.
- Decade bandwidth by
  - Logperiodic
  - Folded dipoles

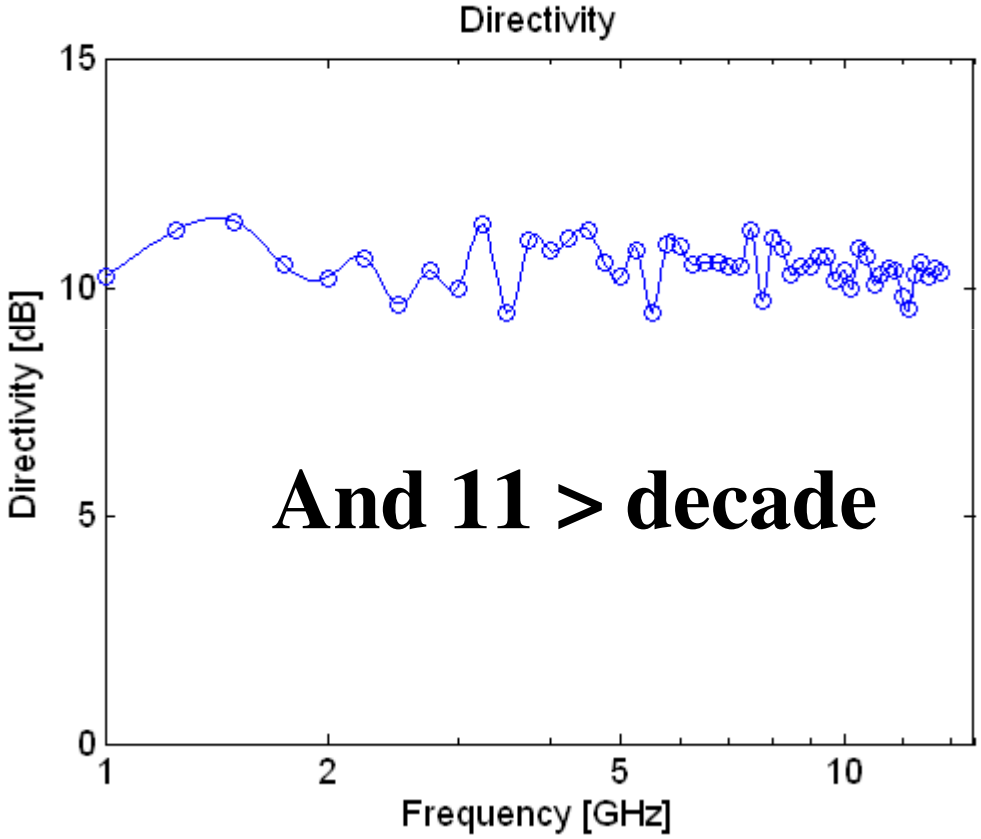


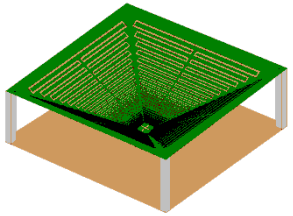


Directivity 11 dBi
over more than a decade bandwidth



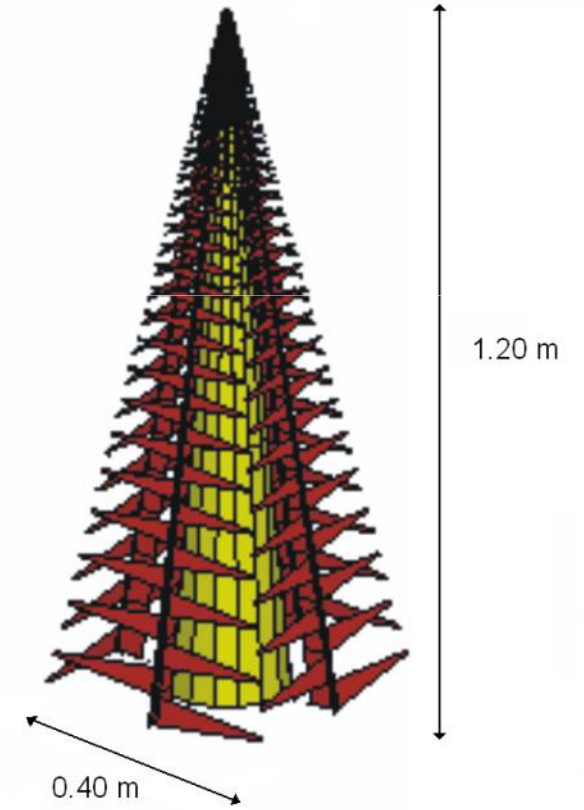


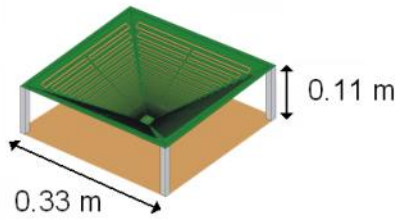




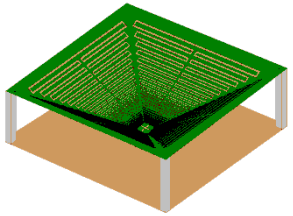
Size and complexity for f_{min} = 500 MHz

ATA feed: Problem with phase center variations

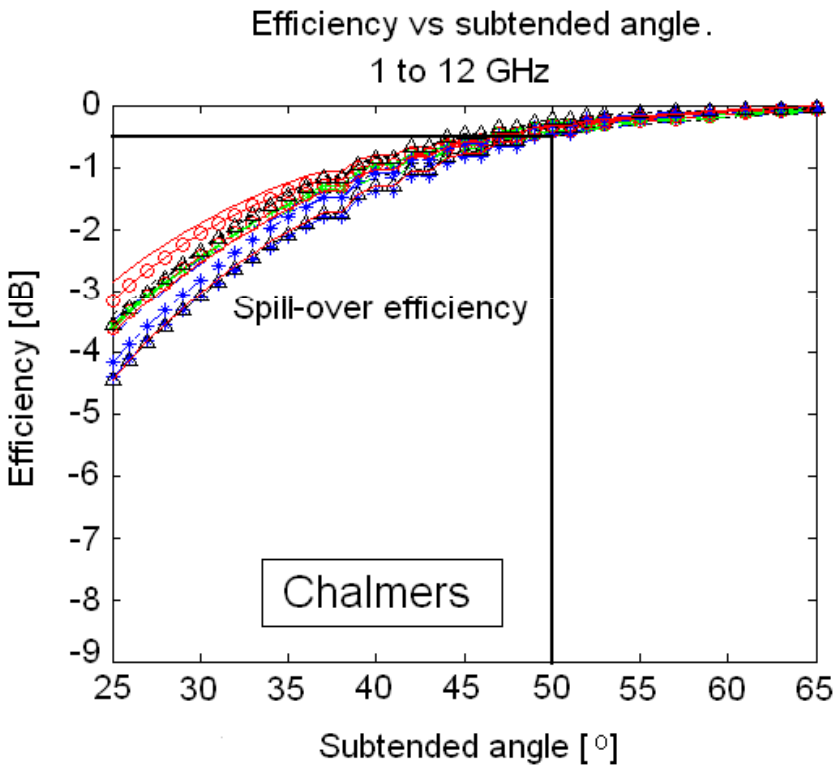


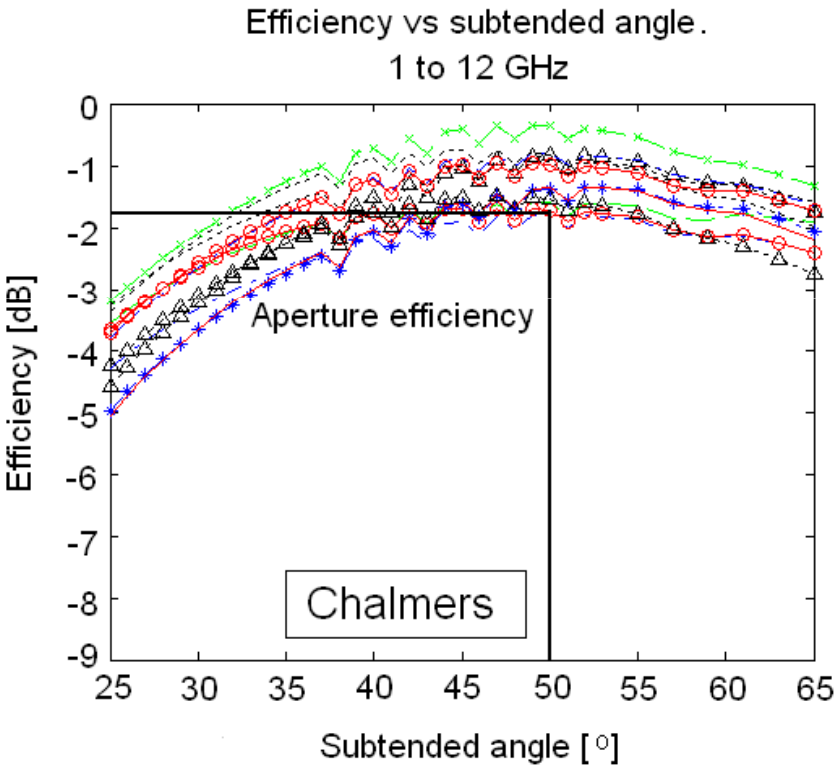


Eleven feed: No problem with phase center variations



Efficiency vs. subtended half angle





Optimum subtended angle >50 deg

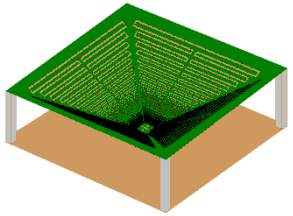
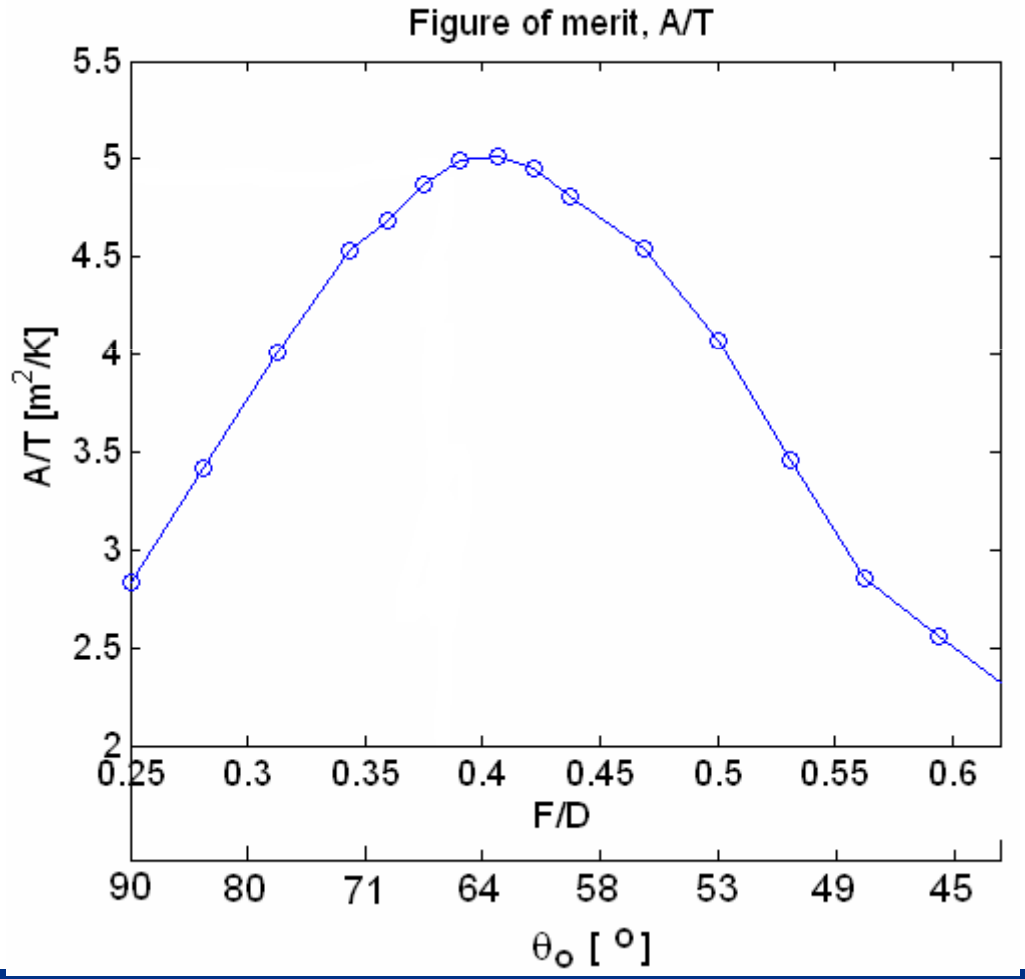
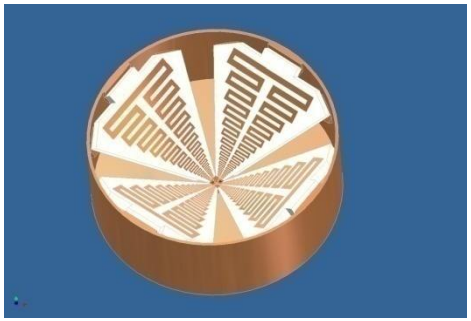


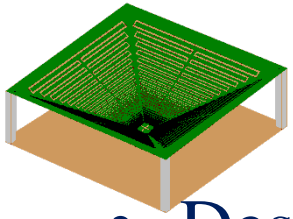
Figure of Merit

optimum F/D = 0.4 (i.e. 64 deg)

F/D=0.33 also OK (i.e. 75 deg)

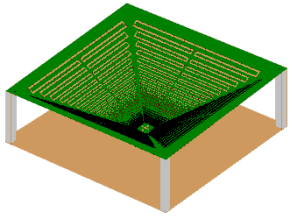






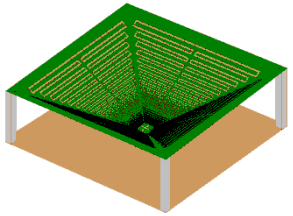
History

- Description of Eleven feed (invention from 2003)
- Different low frequency models:
  - 2005: 150-1500 MHz model for Green Bank in US
  - 2007: 150-700 MHz for GMRT in India
  - 2008: 500-3000 MHz for RATAN in Russia
- 2008: 1-13 GHz un-cooled model.
  - Worked for linear polarization only
- From Sept 2008: Developments of a 2-14 GHz cooled model



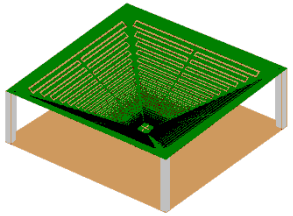
Team for developing cooled hardware from Sept 2009

- Department of Signals and Systems:
  - Prof Per-Simon Kildal, Dr Jian Yang, Yogesh Karandikar
- Department of Radio and Space Sciences:
  - Dr Miroslav Pantaleev, Leif Helldner
- Department of Microtechnology and Nanoscience
  - Niklas Wadefalk
- Chalmers Industriteknik (CIT) for helping to commercialize:
  - Anna Aspgren, Henric Rhedin, Stephan Mangold, Johan Felix
- Enabled by hardware orders from Vertex and Statkart

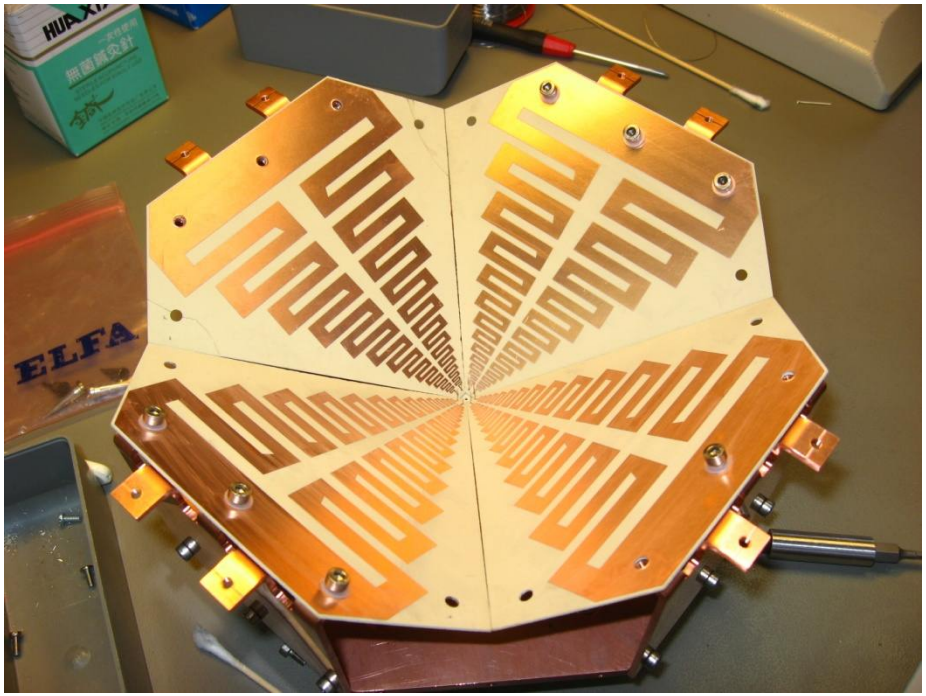


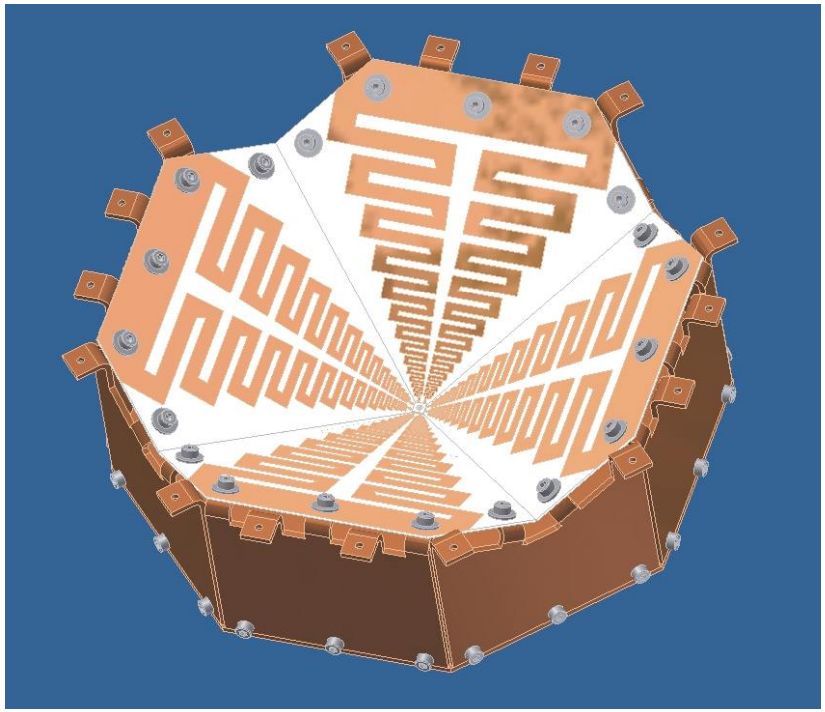
The following choices were done during the project

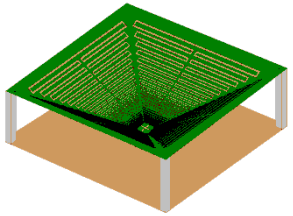
- All materials MUST stand cryogenic environment
- 4 separate panels (petals) with log-periodic dipoles
- PCB technology for antenna petals
- Minimize thickness of dielectric in center
- 2x4 ports with no crossing lines in center puck
- Differential feed line impedance 200 Ohms
- Experimental model has 2x4 coaxial ports, transf to 50 Ohms
- This concept requires 4 differential 200 Ohms LNAs, 2 per polarization



Results







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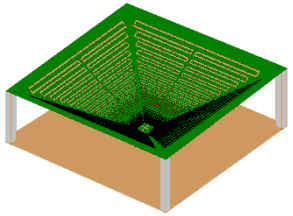

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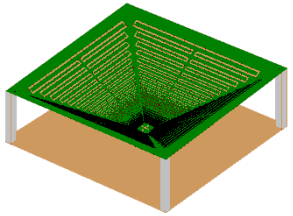
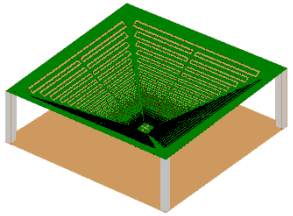


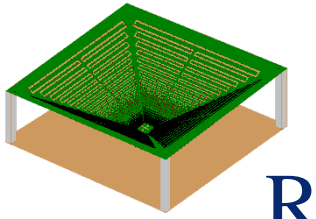
Summary of measurement results

- Hardware: Good. Appears solid and appealing
- Matching by calibrating out poser dividers:
  - S11<-10 dB up to 13 GHz
- Independent gain measurements at Technical University of Denmark
  - Losses: Uncertain due to multiple reflections between 180 deg hybrid, 3dB power divider and antenna. We believe <-0.5 dB. Were not calibrated out.
  - Radiation patterns: Good between 2.5 and 9 GHz. Outside this band low BOR1 efficiency
  - Feed efficiency: >2 dB between 2.5 and 9 GHz



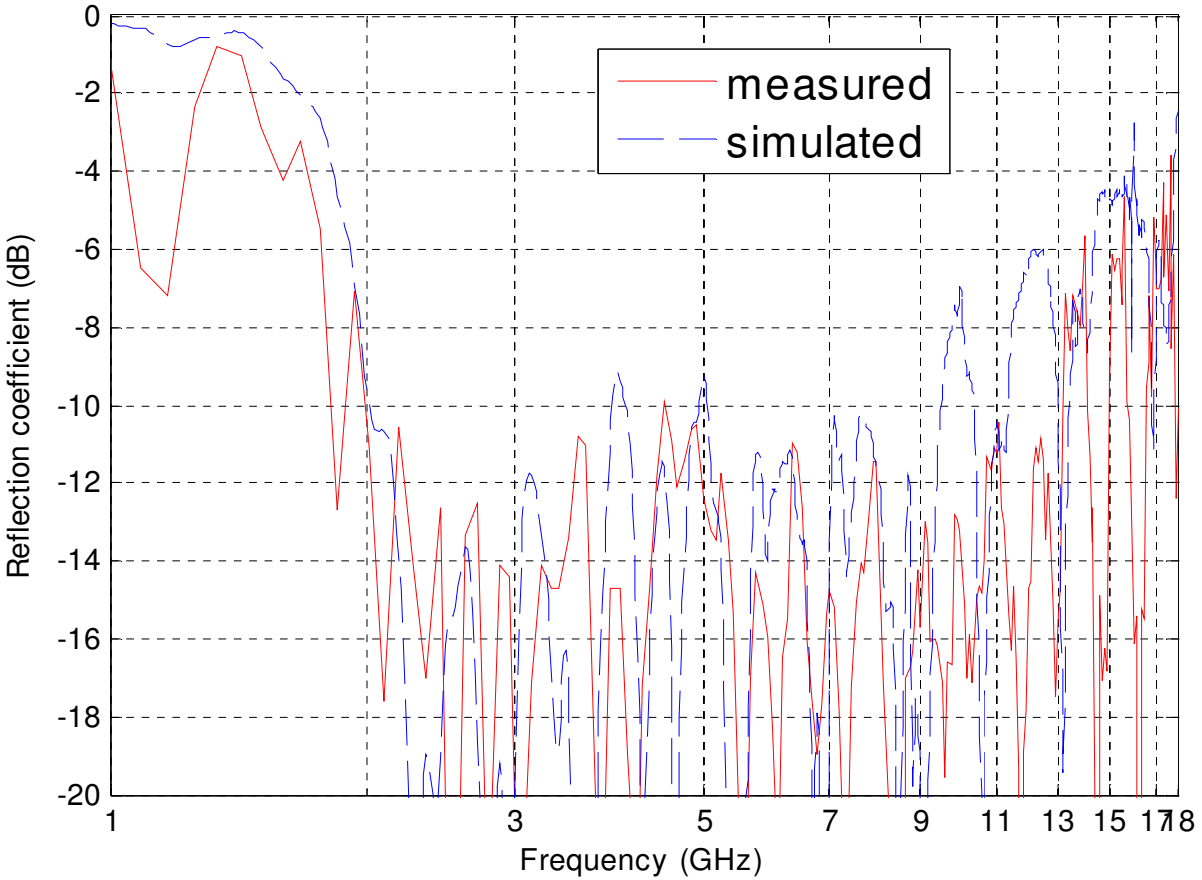
What to do next

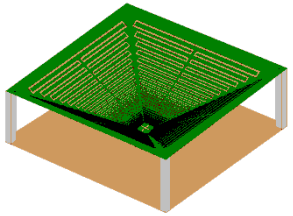
- Verify that low BOR1 efficiency above 9 GHz is due to surface waves (1 Month)
- Redesign feed to remove surface waves (3 months)
- Include octagonal “Dewar box” in electrical design to improve low frequency performance (2 months)
- Cryogenic tests of existing hardware (1 month?)
- More things needing additional funding:
  - Realize more hardware
  - Design room temperature LNA
  - Design cryogenic LNA
  - More testing (patterns and noise temperature)



Simulations and Measurements

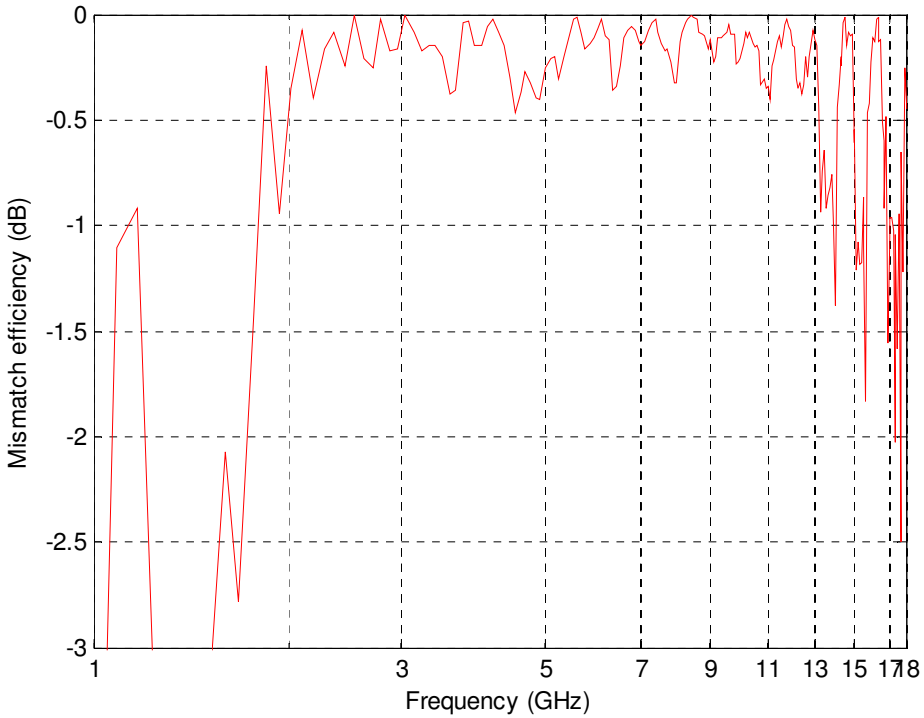
Reflection coefficient including centre puck

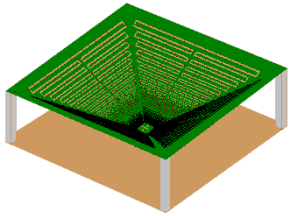




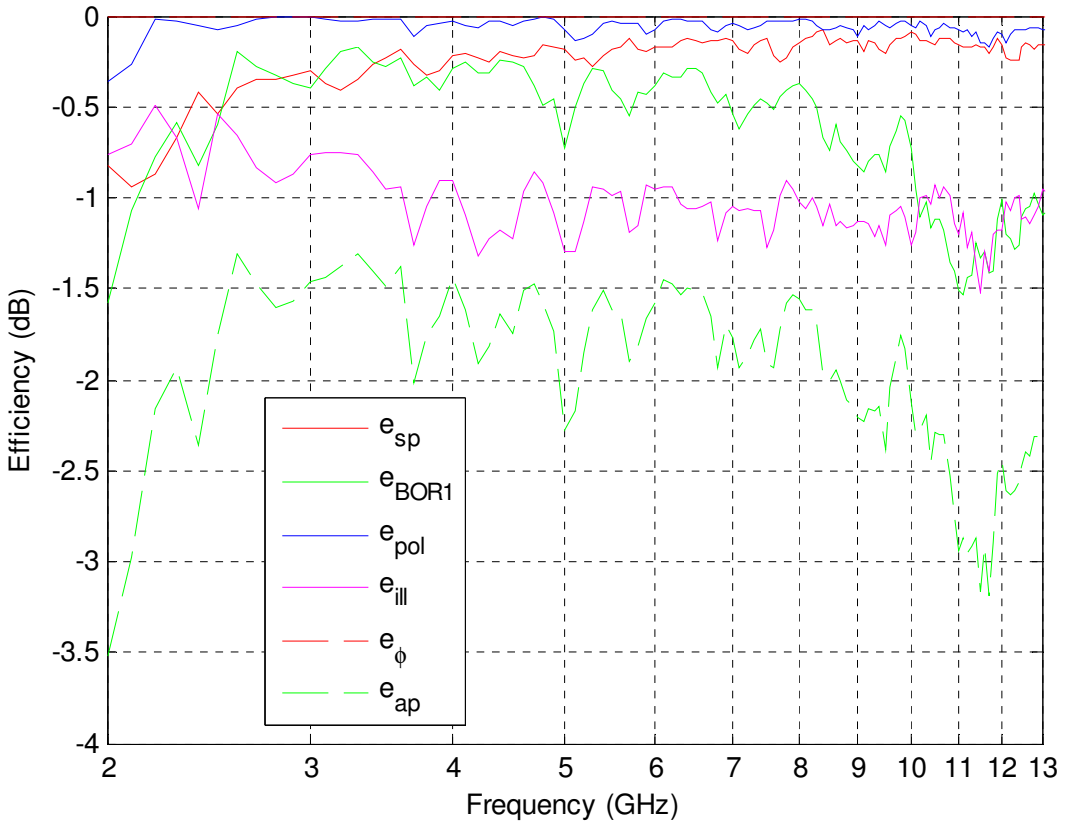
Simulations and Measurements

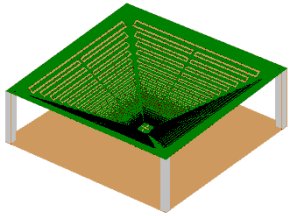
Measured mismatch efficiency



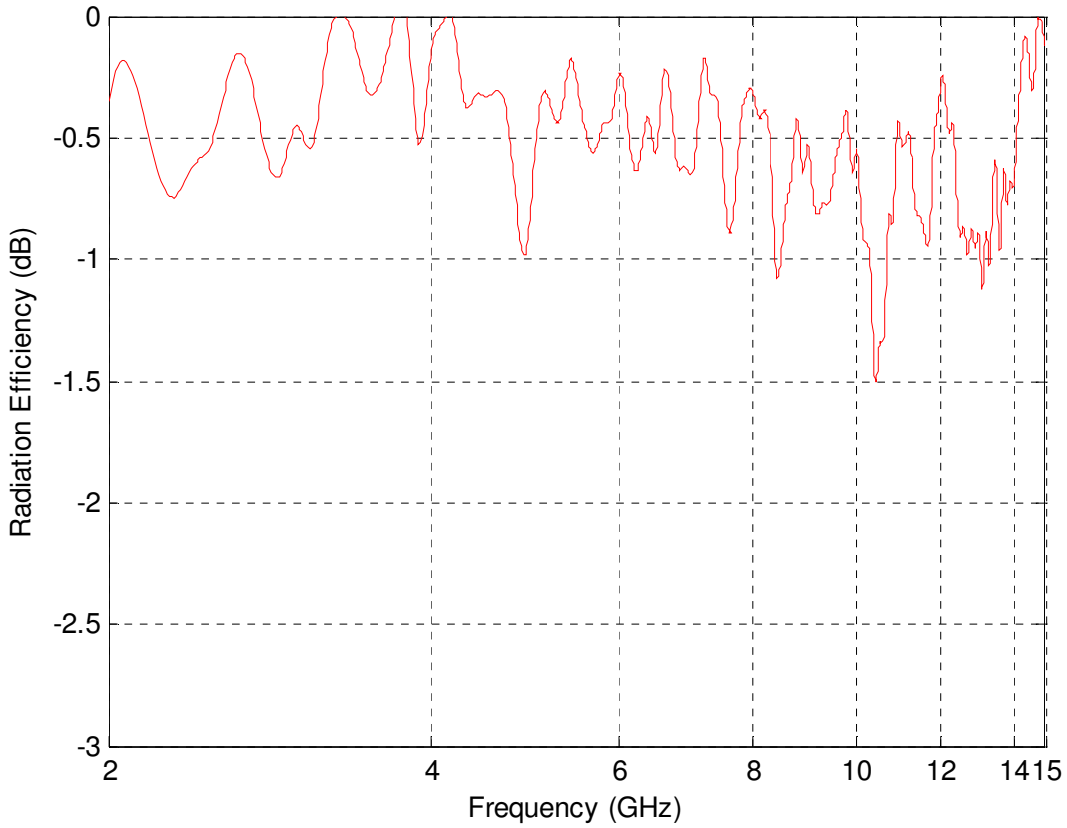


Measured Sub-efficiencies

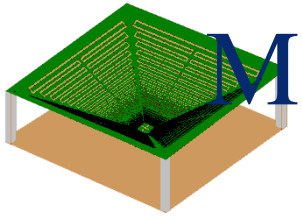




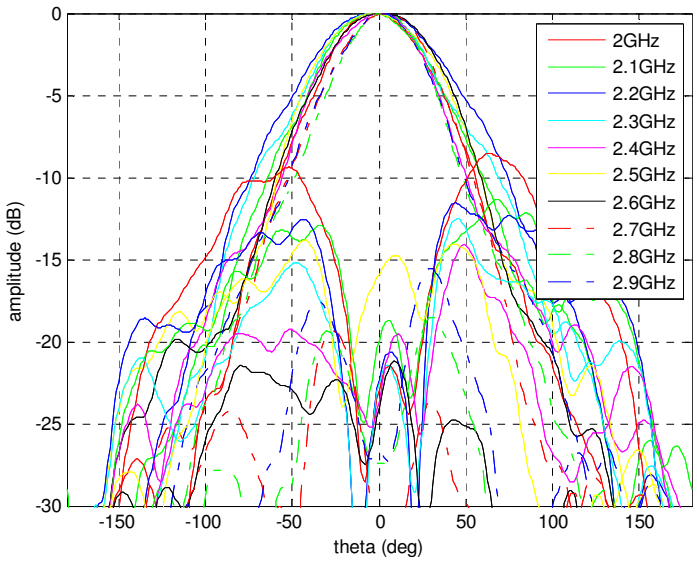
Measured Radiation Efficiency

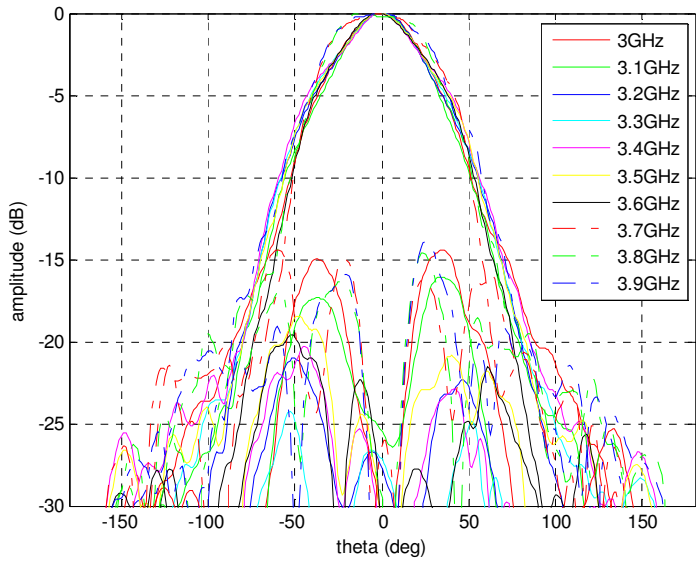


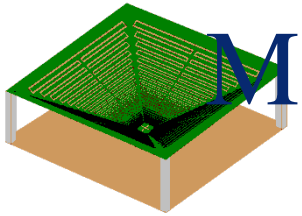
- Not very accurate due to the multiple reflections in the feeding network, specially for high frequencies.



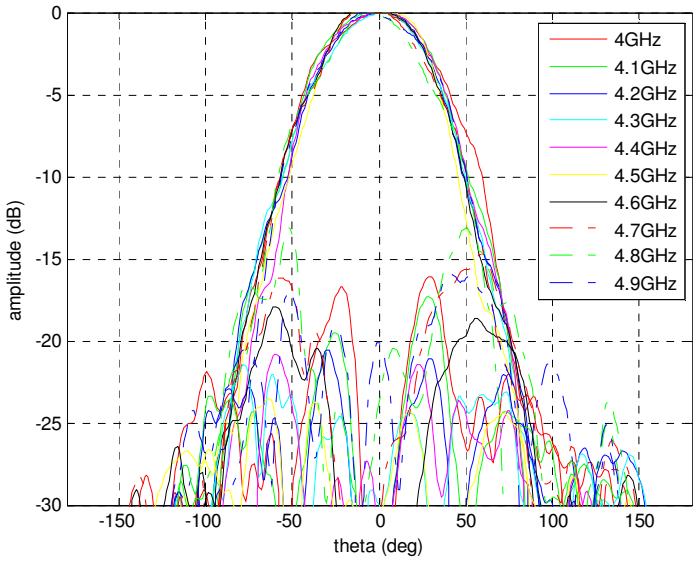
Measured patterns in 45 deg plane, 2-3 and 3-4 GHz

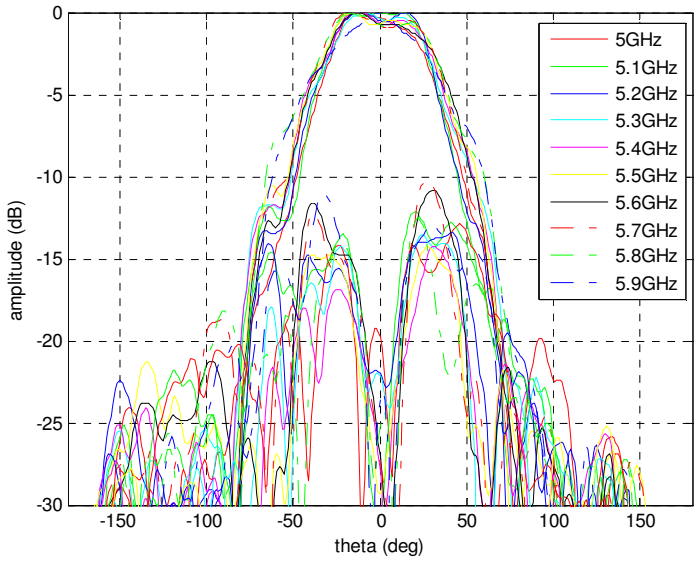


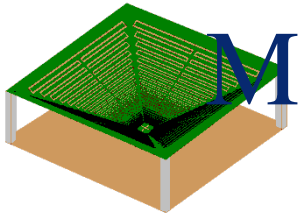




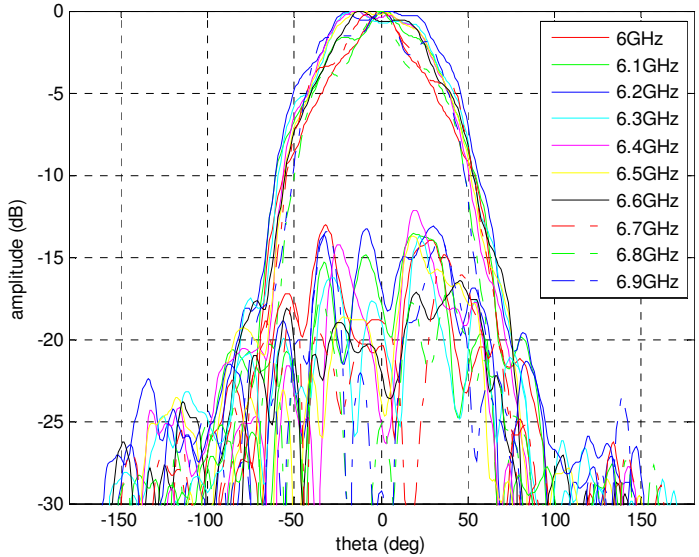
Measured patterns in 45 deg plane, 4-5 and 5-6 GHz

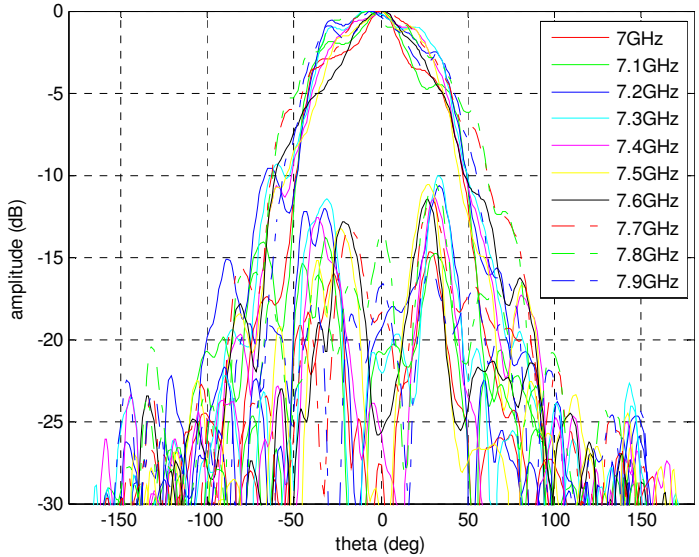


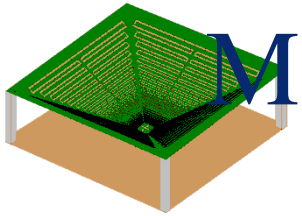




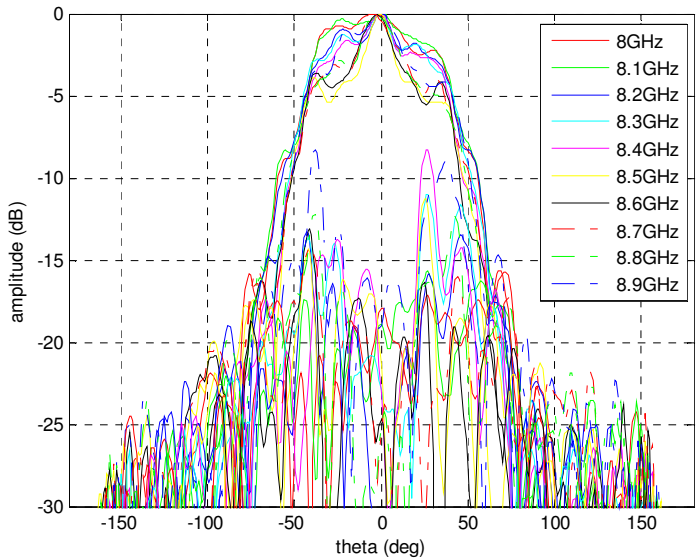
Measured patterns in 45 deg plane, 6-7 and 7-8 GHz

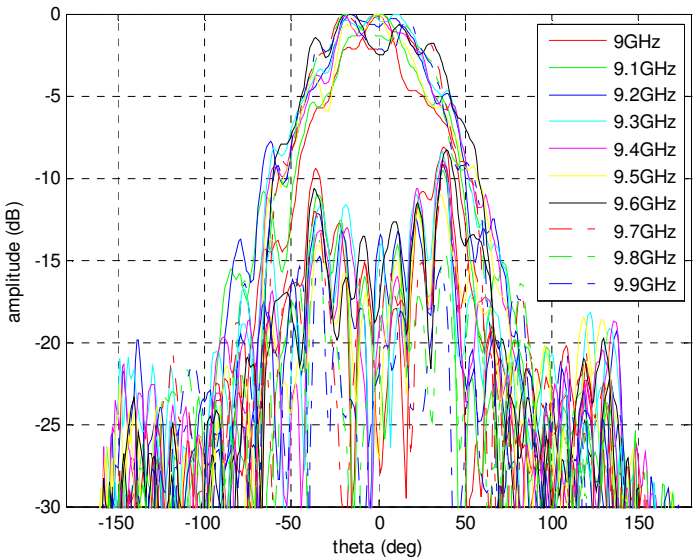


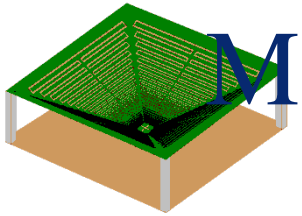




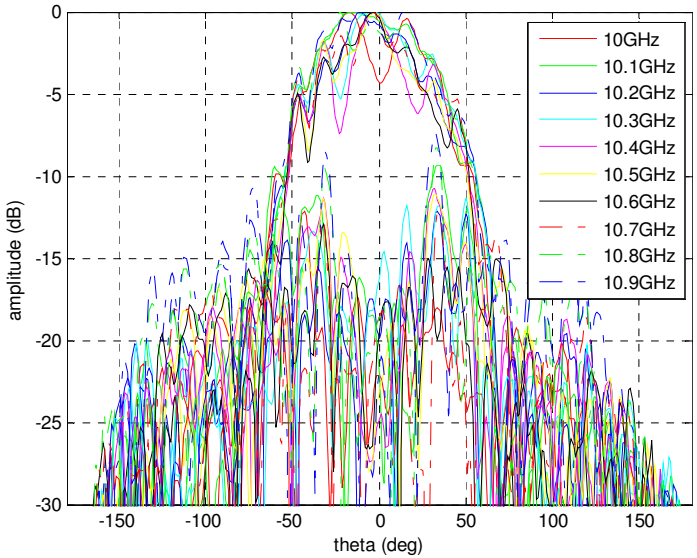
Measured patterns in 45 deg plane, 8-9 and 9-10 GHz

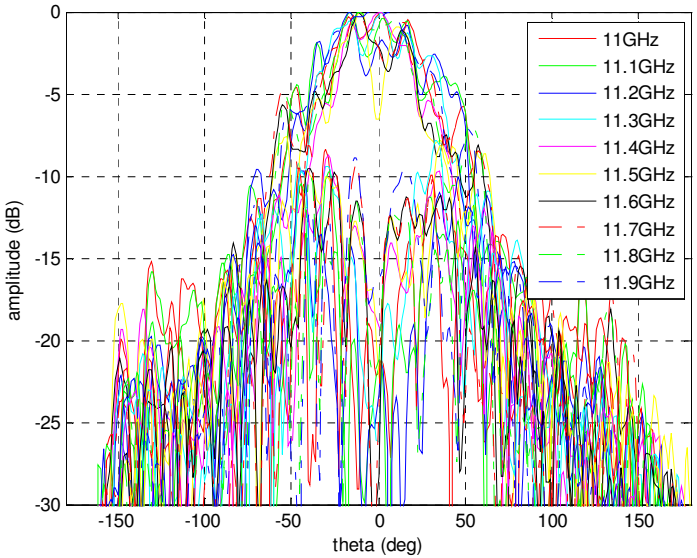


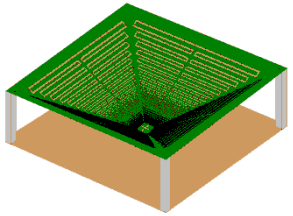




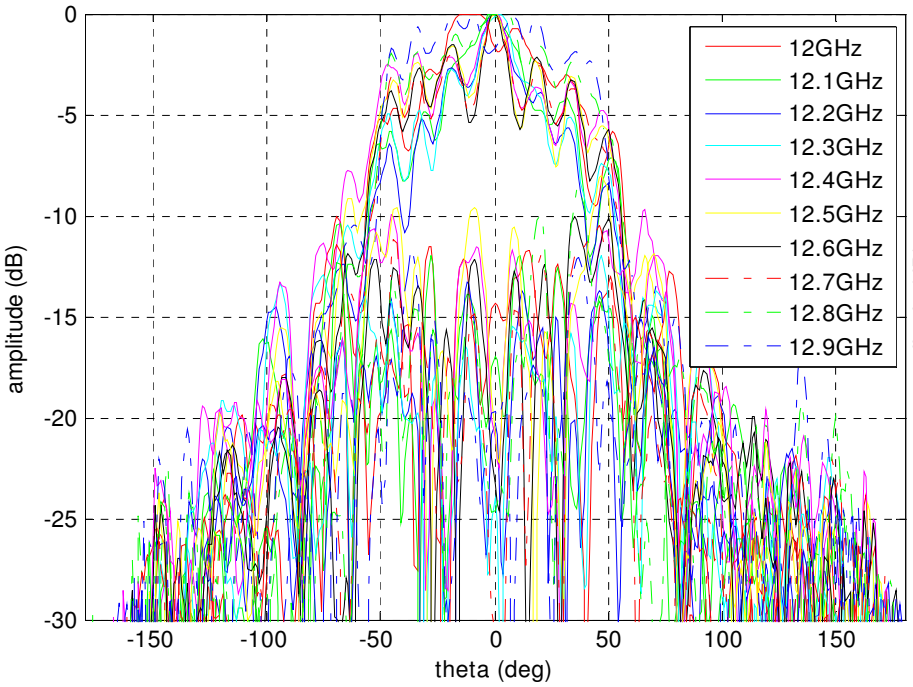
Measured patterns in 45 deg plane, 10-11 anbd 11-12 GHz

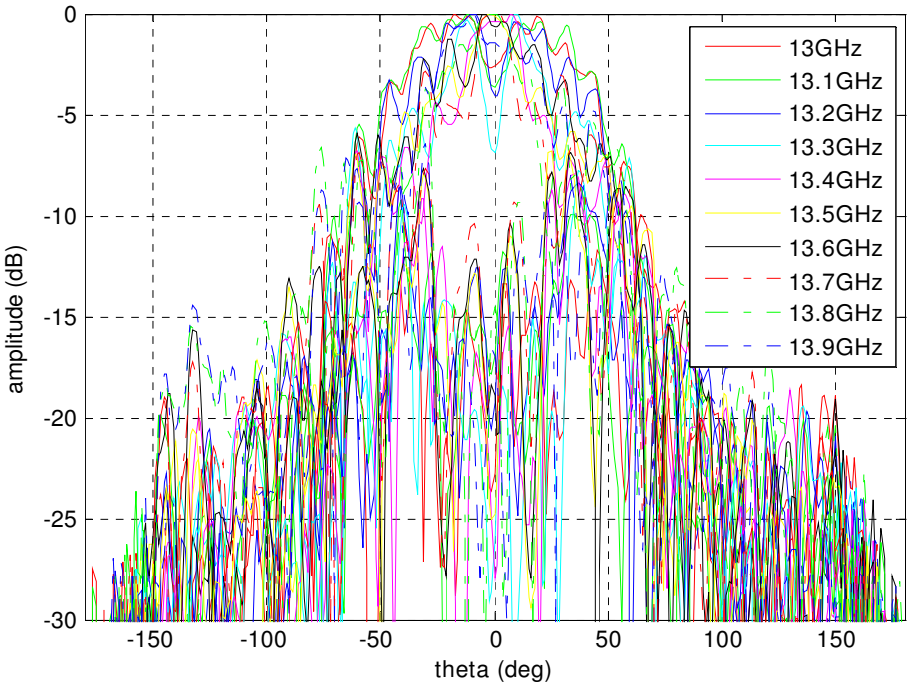


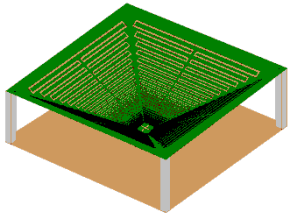




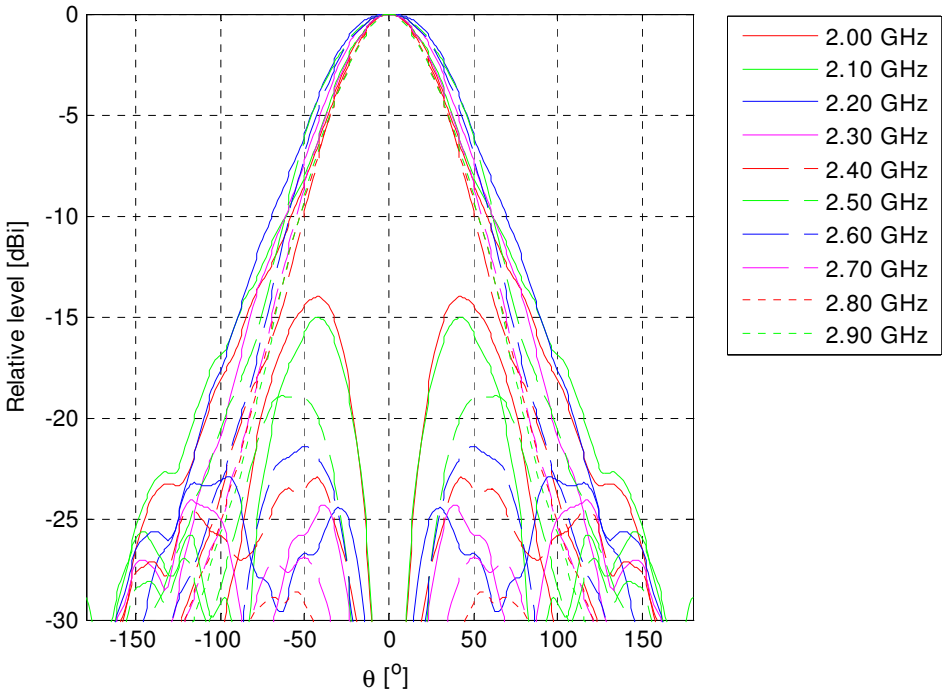
45 deg patterns 12-13 and 13-14 GHz

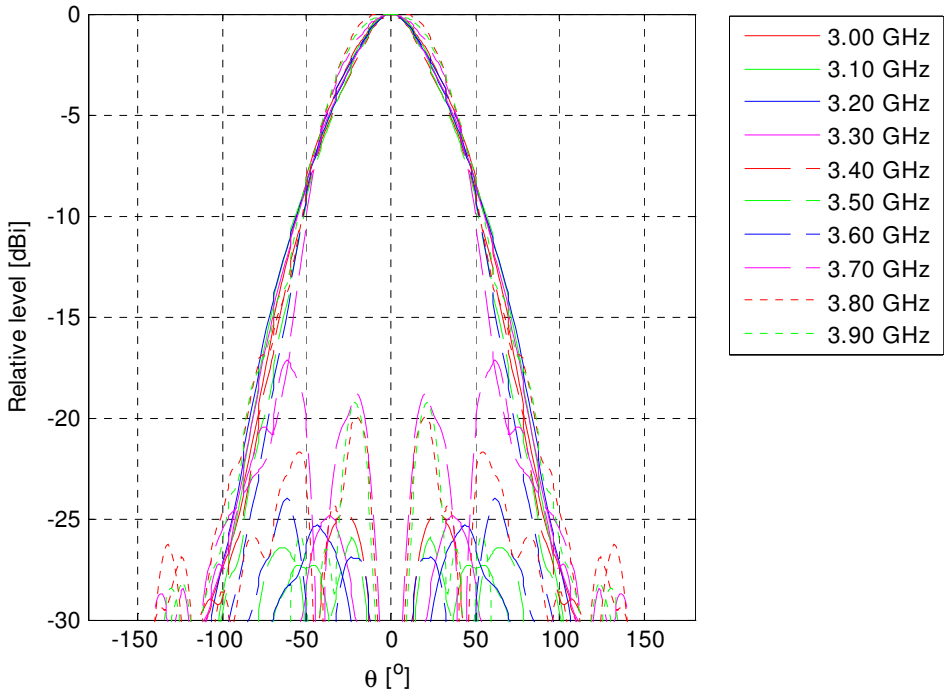


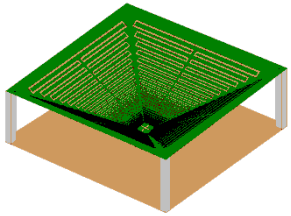




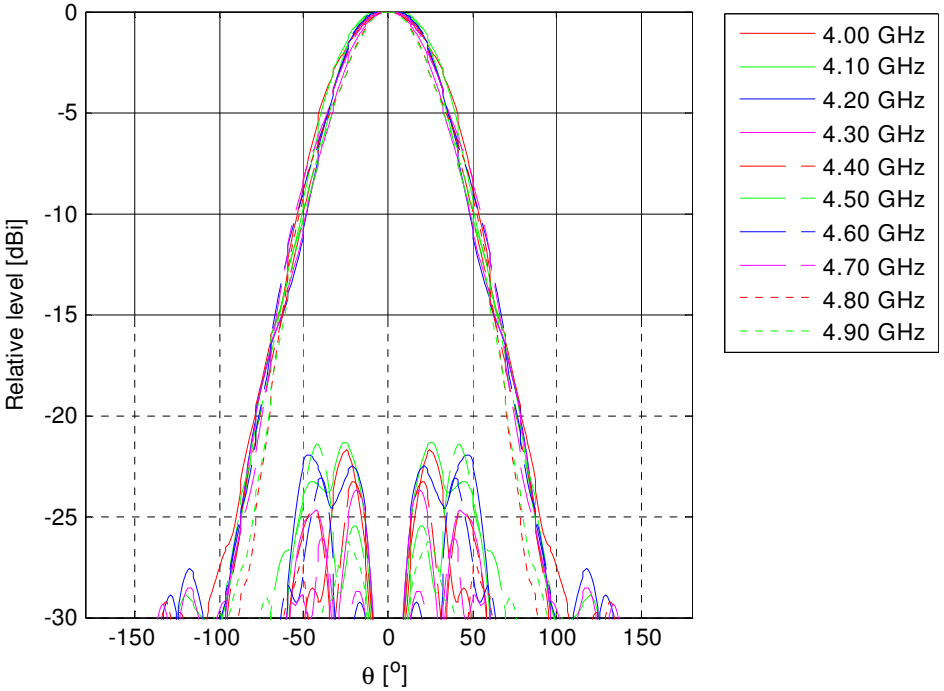
Measured Radiation Patterns of BOR1 Components, 2-3 GHz, 3-4 GHz

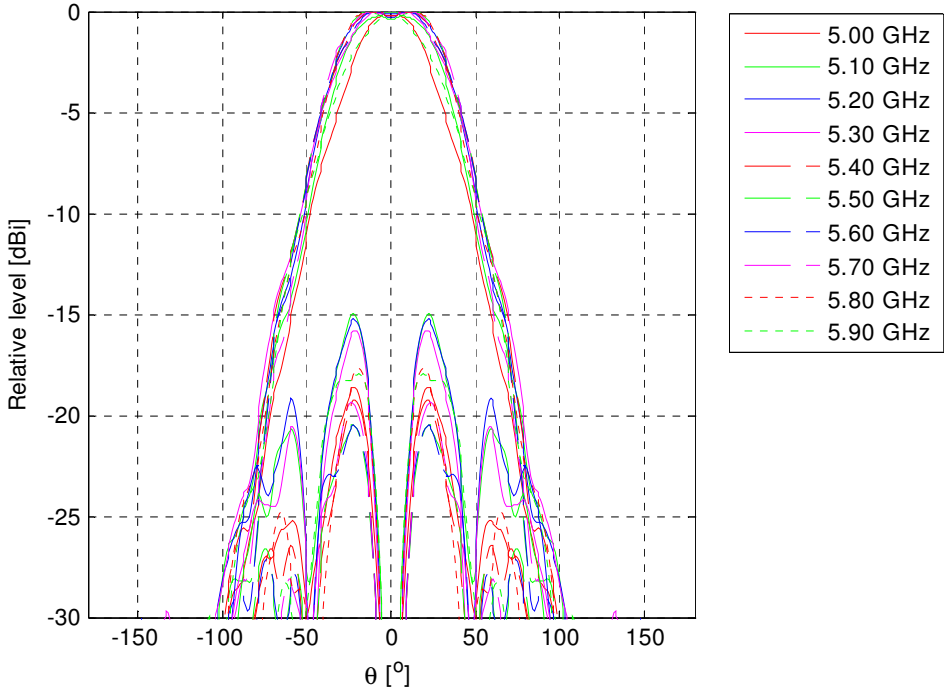


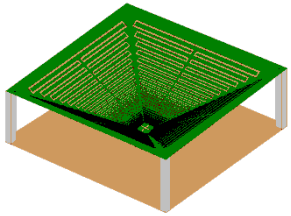




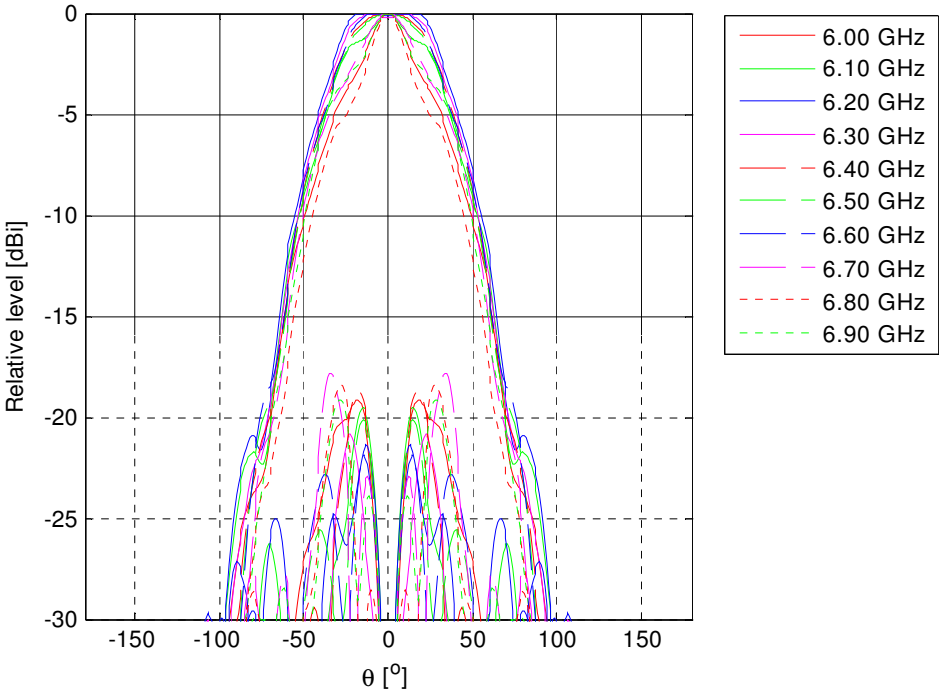
Measured Radiation Patterns of BOR1 Components, 4-5 GHz, 5-6 GHz

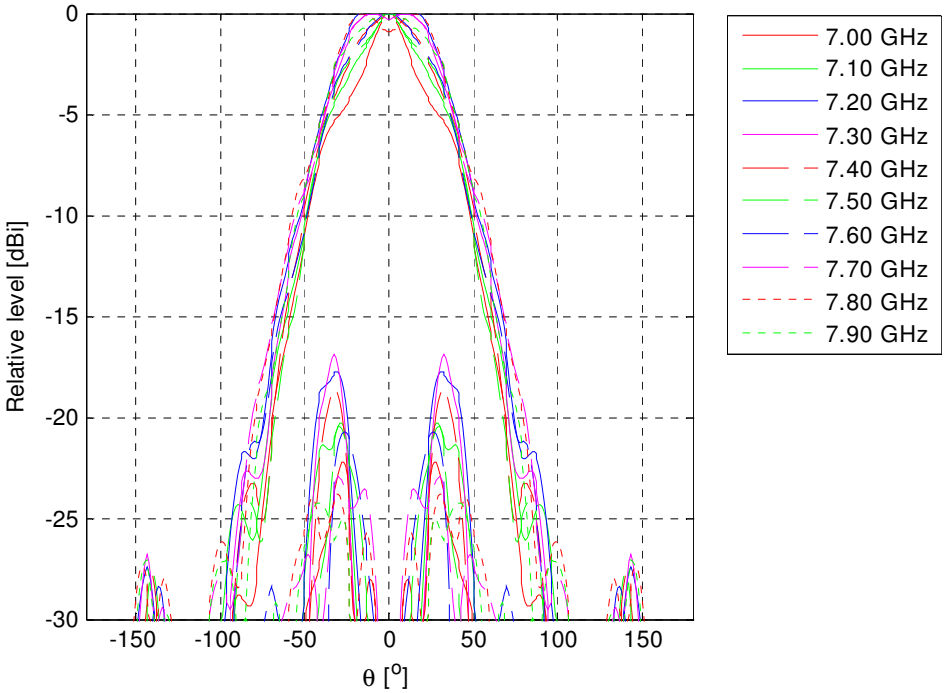


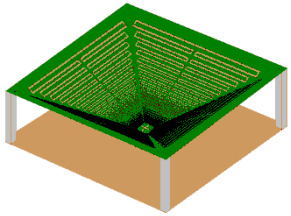




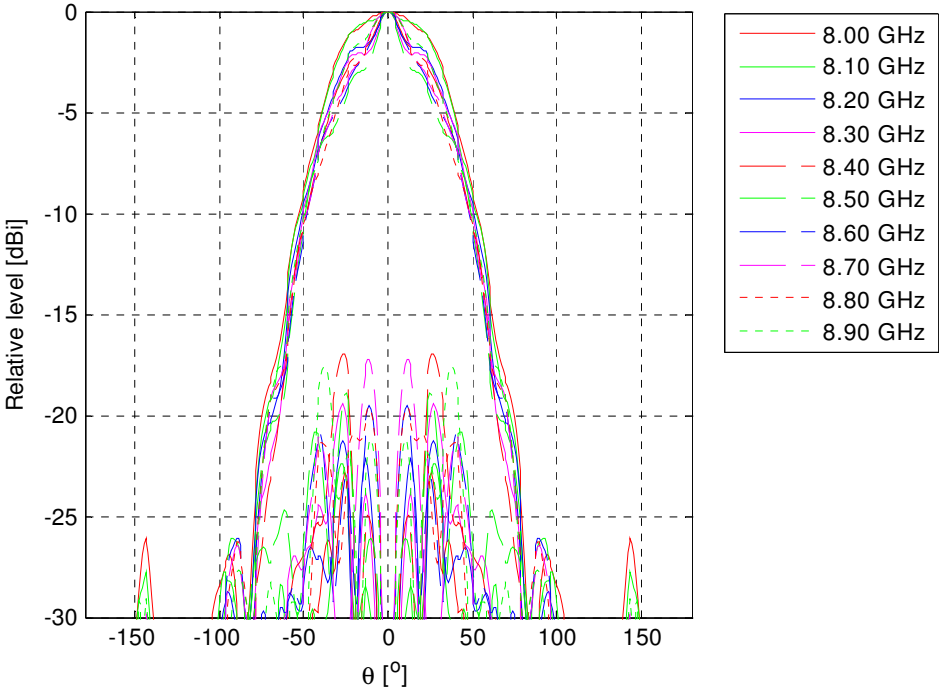
Measured Radiation Patterns of BOR1 Components, 6-7 GHz, 7-8 GHz

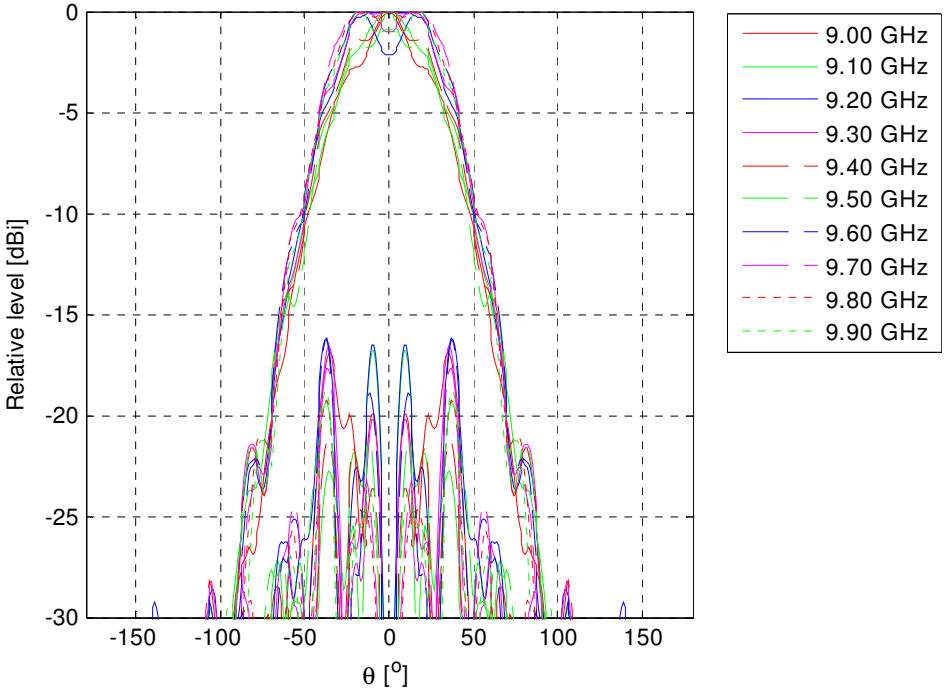


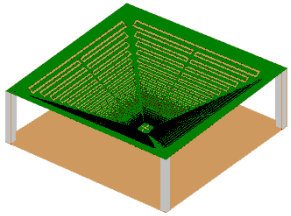




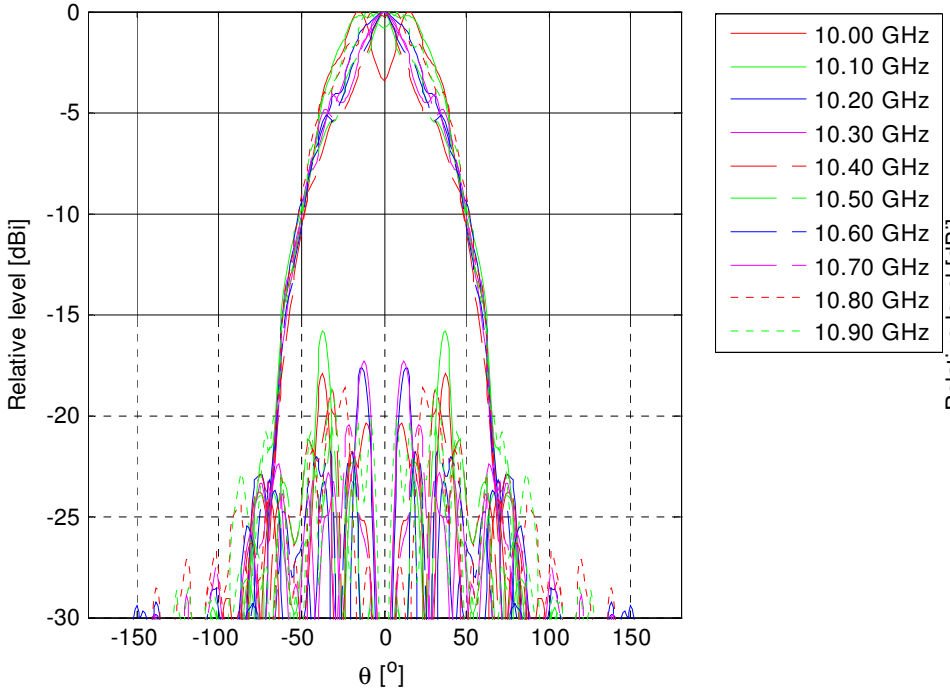
Measured Radiation Patterns of BOR1 Components, 8-9 GHz, 9-10 GHz

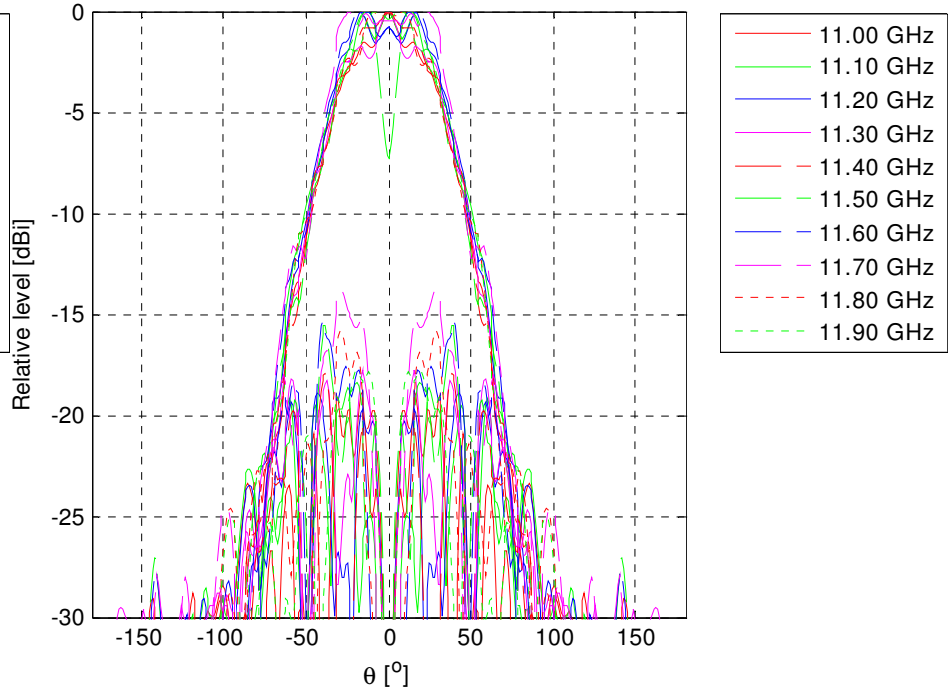


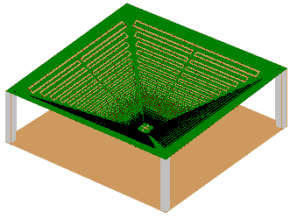




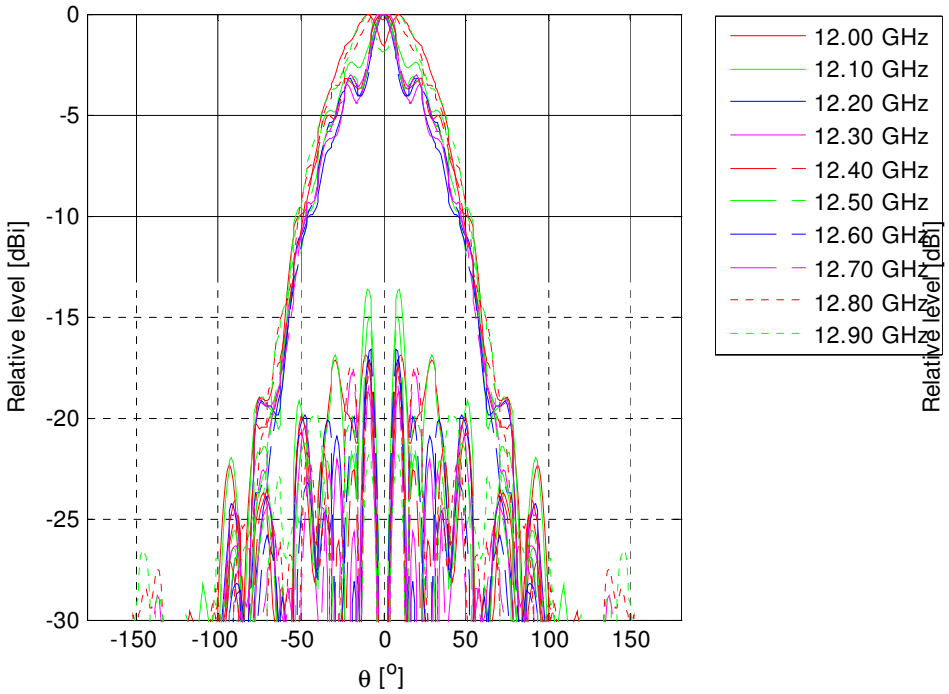
Measured Radiation Patterns of BOR1 Components, 10-11 GHz, 11-12 GHz

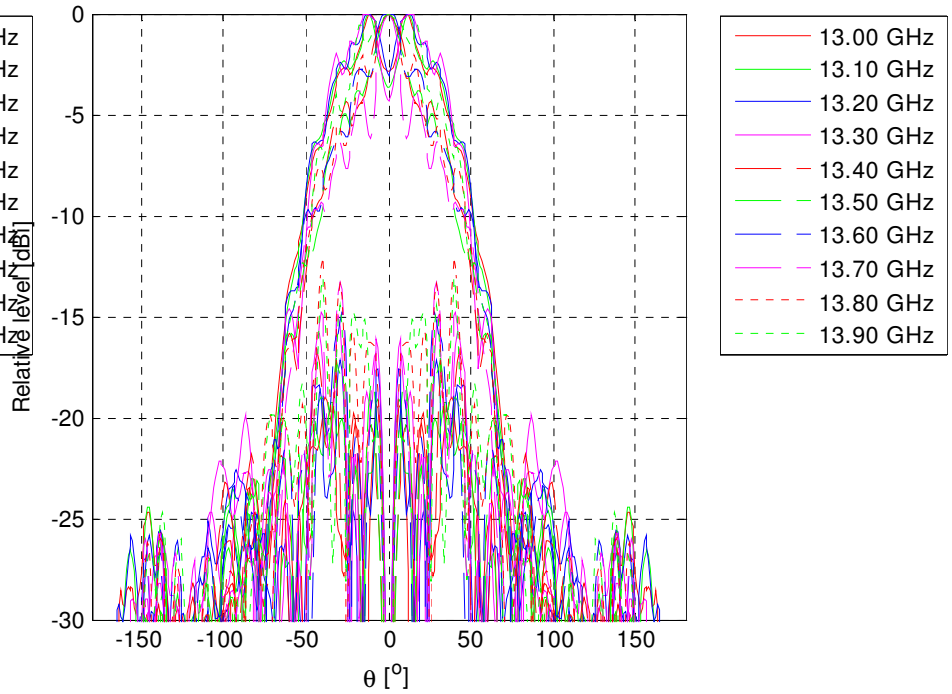


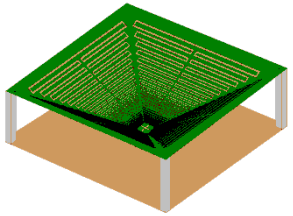




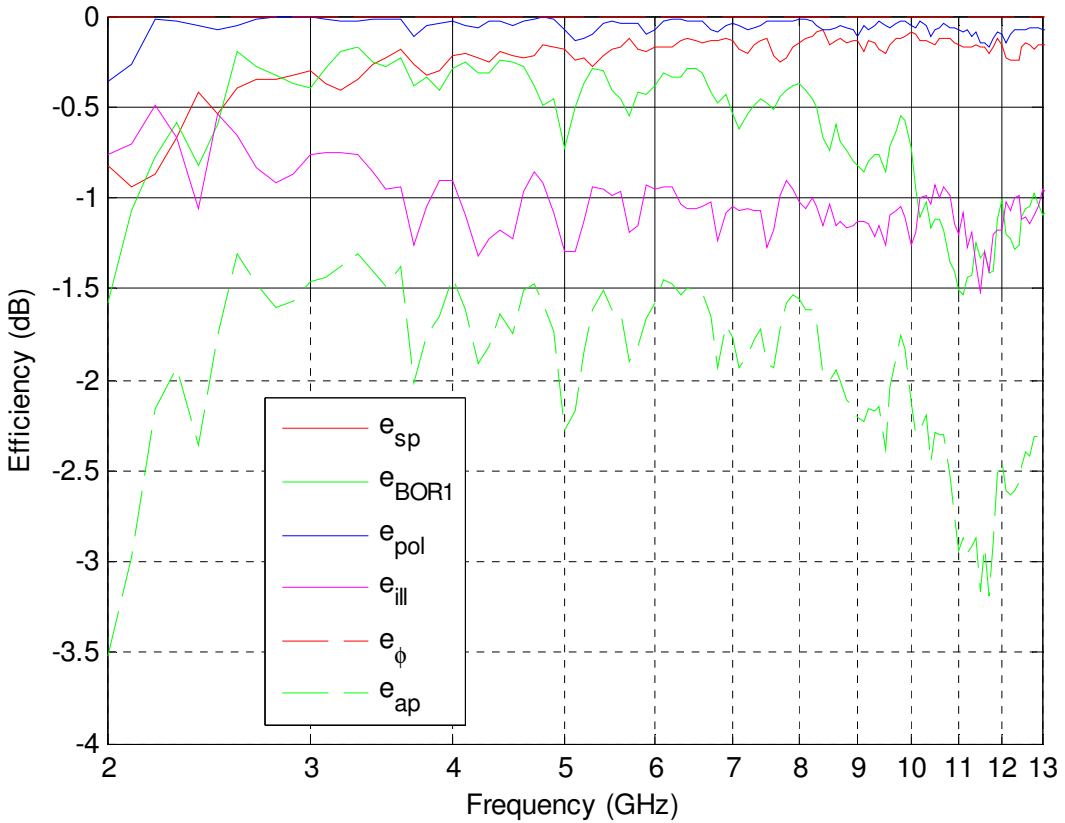
Measured Radiation Patterns of BOR1 Components, 12-13 GHz, 13-14 GHz

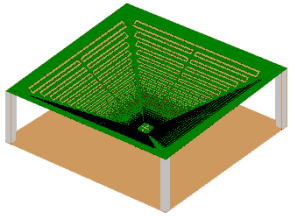






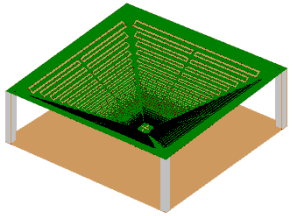
Measured Sub-efficiencies





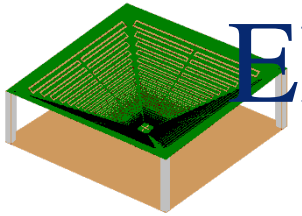
Summary of measurement results

- Hardware: Good. Appears solid and appealing
- Matching by calibrating out poser dividers:
  - S11<-10 dB up to 13 GHz
- Independent gain measurements at Technical University of Denmark
  - Losses: Uncertain due to multiple reflections between 180 deg hybrid, 3dB power divider and antenna. We believe <-0.5 dB. Were not calibrated out.
  - Radiation patterns: Good between 2.5 and 9 GHz. Outside this band low BOR1 efficiency
  - Feed efficiency: >2 dB between 2.5 and 9 GHz

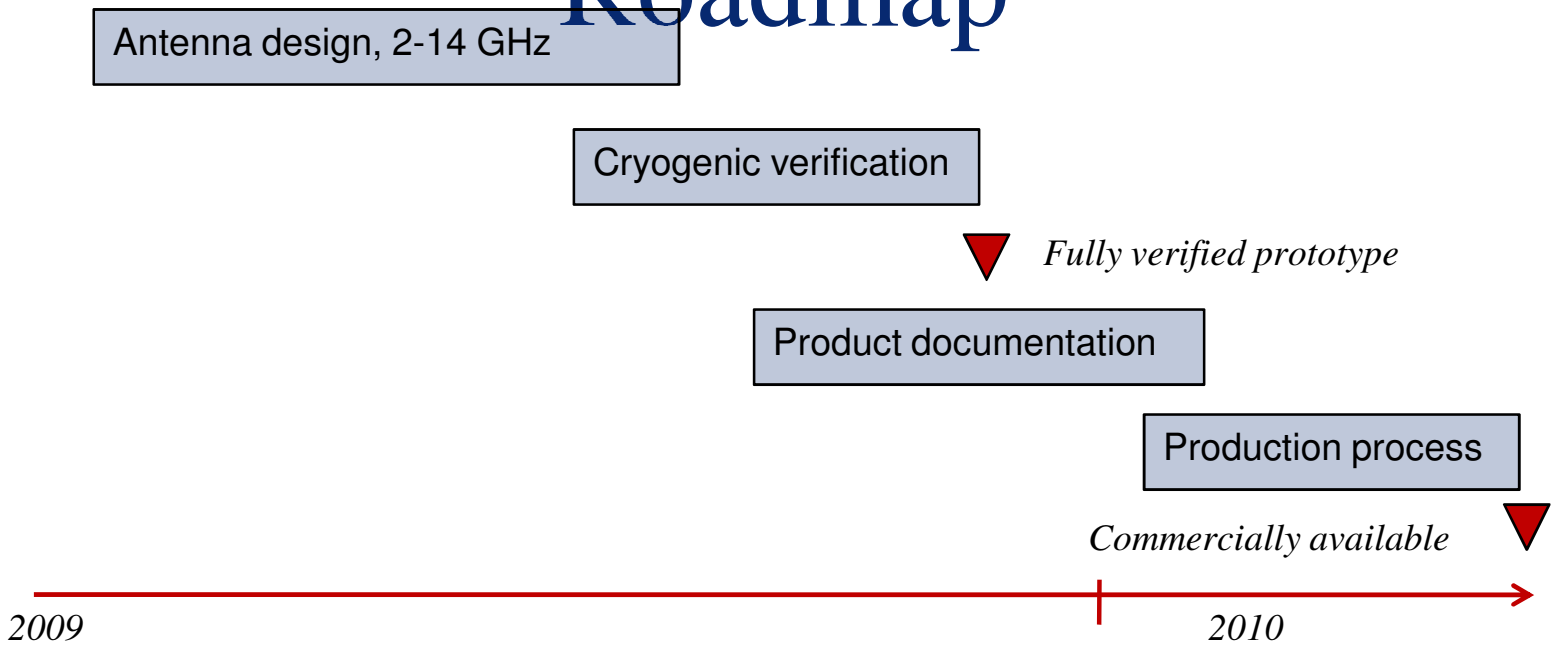


What to do next

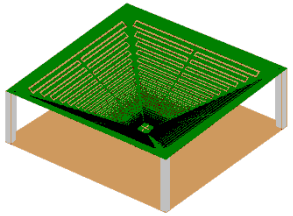
- Verify that low BOR1 efficiency above 9 GHz is due to surface waves (1 Month)
- Redesign feed to remove surface waves (3 months)
- Include octagonal “Dewar box” in electrical design to improve low frequency performance (2 months)
- Cryogenic tests of existing hardware (1 month?)
- More things needing additional funding:
  - Realize more hardware
  - Design room temperature LNA
  - Design cryogenic LNA
  - More testing (patterns and noise temperature)



Eleven Antenn – Development Roadmap

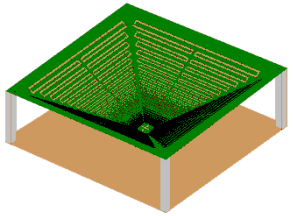


The Eleven Antenna will be further developed in cooperation between ***Chalmers Industriteknik, Chalmers Antenna research department and Onsala Space Observatory***



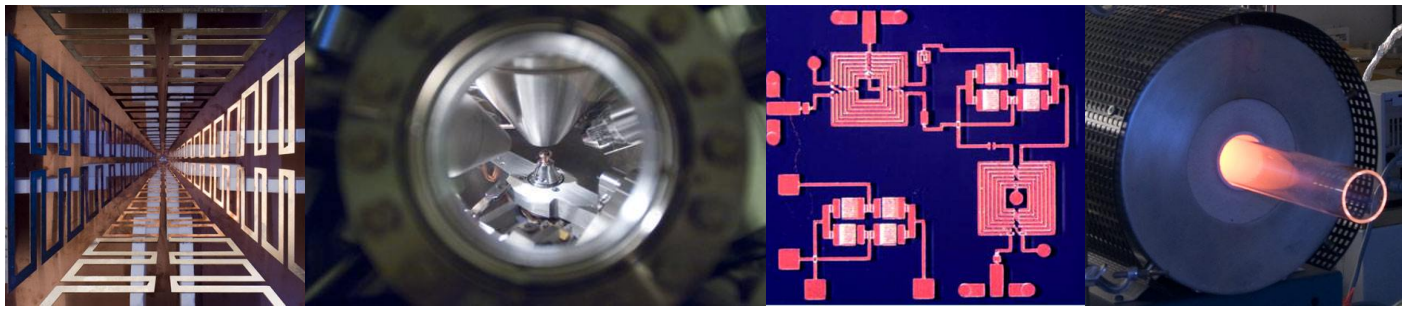
STIFTELSEN CHALMERS INDUSTRITEKNIK

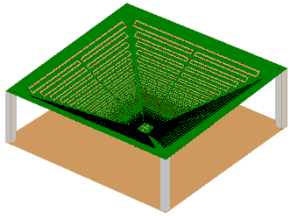
- Foundation within Chalmers University of Technology
- 61 MSEK annual revenue
- 62 employees of which 31 with PhD degrees



Mission

- Research and development for industrial companies on commercial terms
- Find industrial projects for Chalmers University of Technology
- Project managers for projects carried out at Chalmers University of Technology

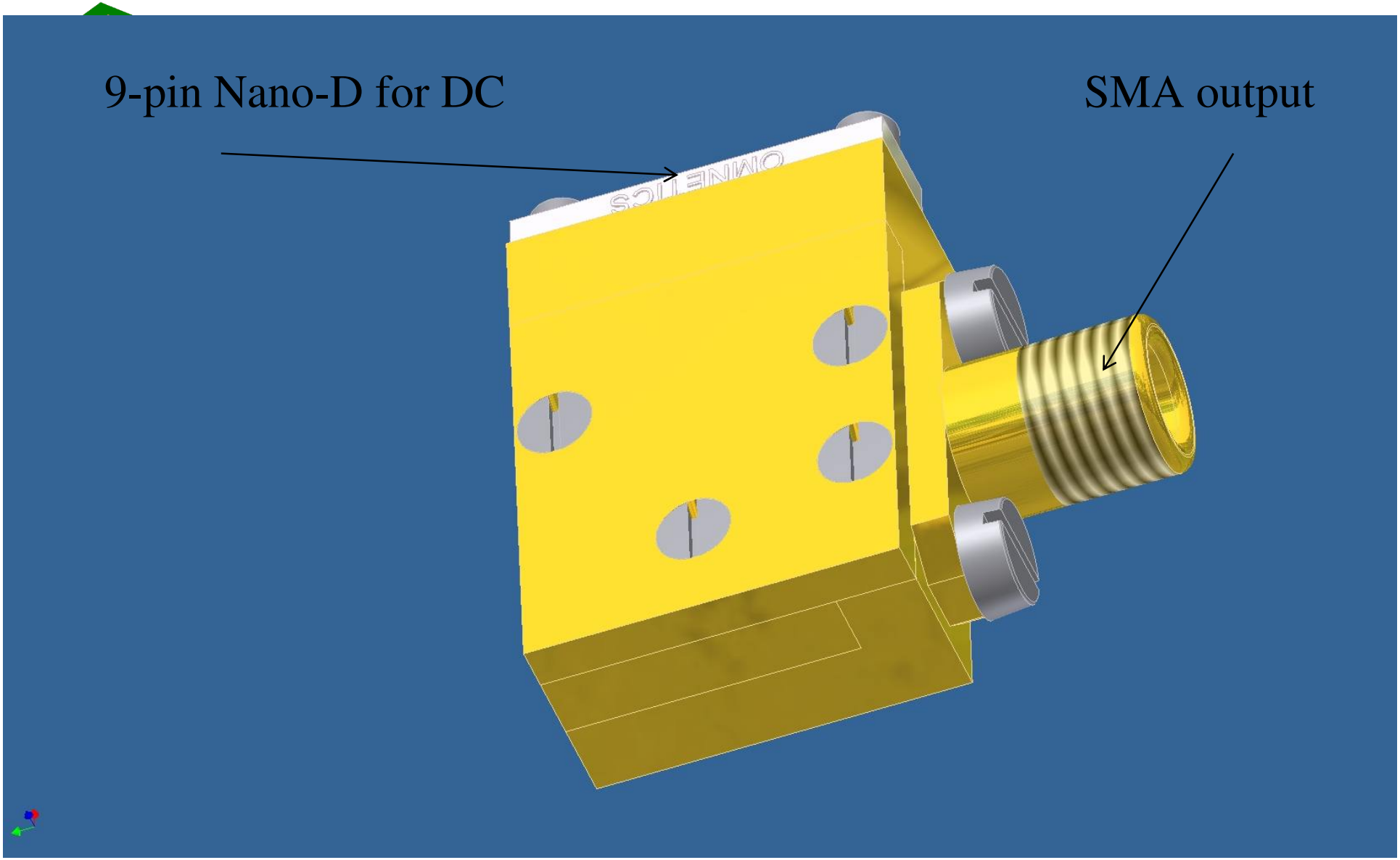




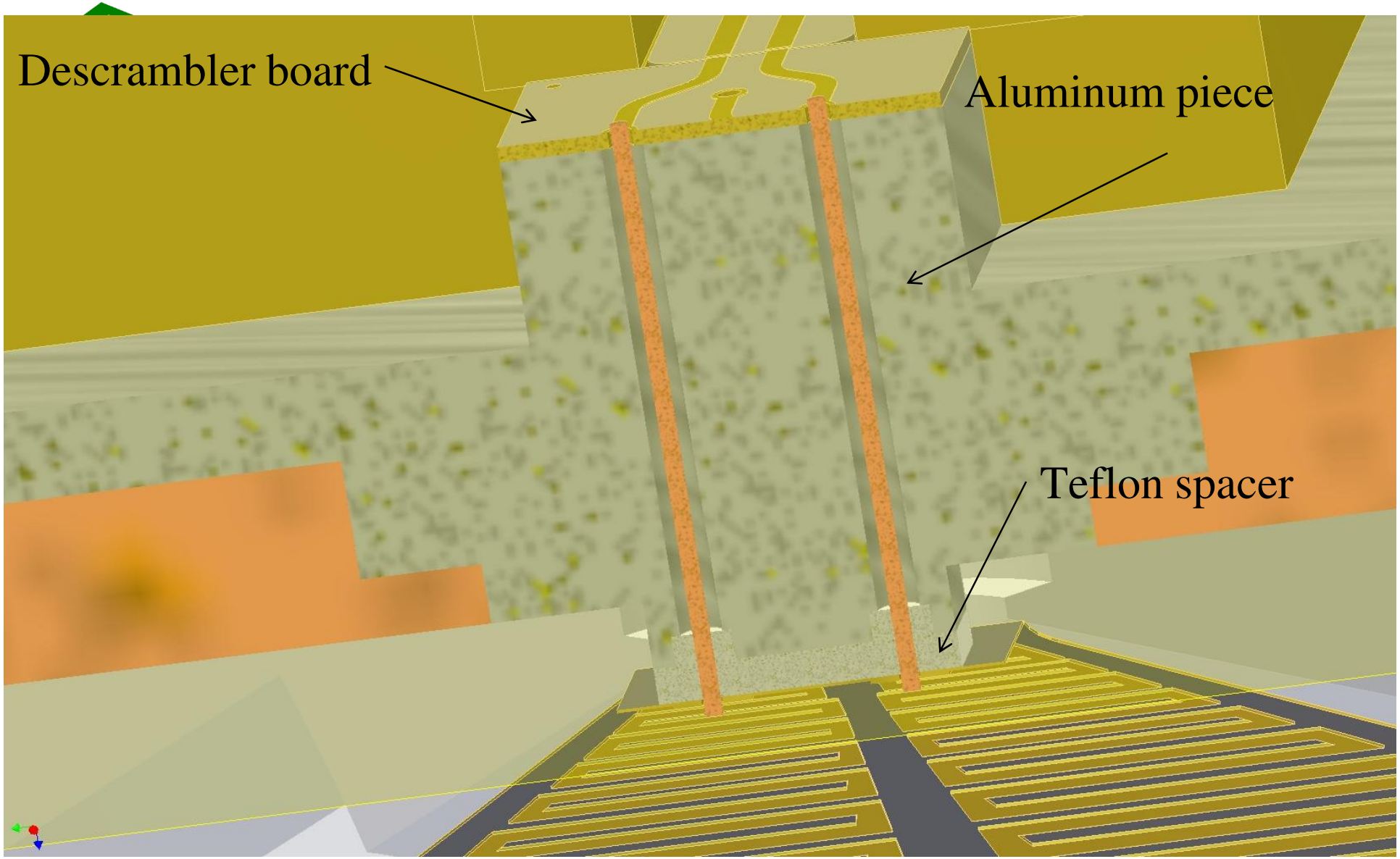
Contacts

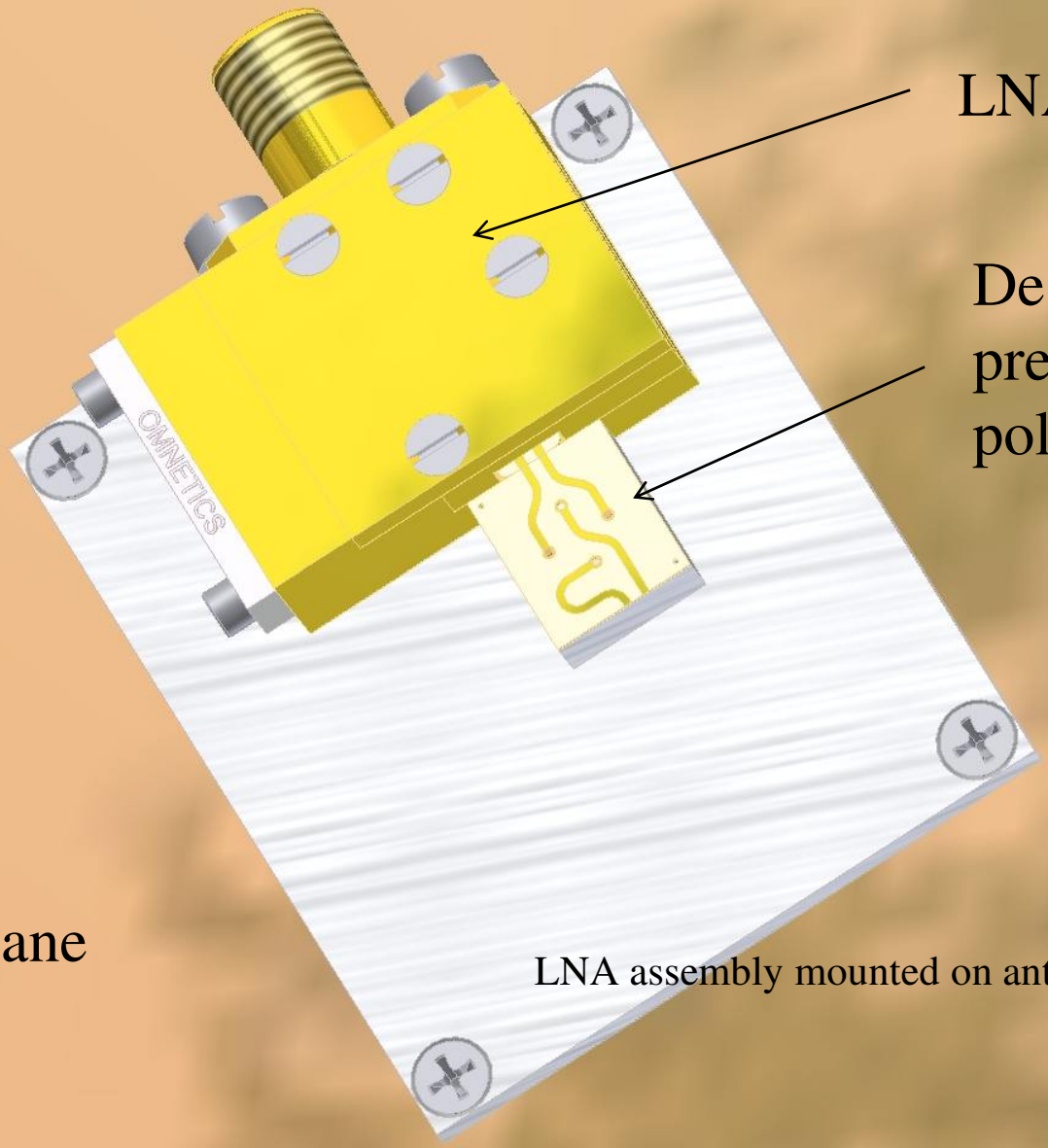
Henric Rhedin, PhD henric.rhedin@cit.chalmers.se

LNA module



Section view





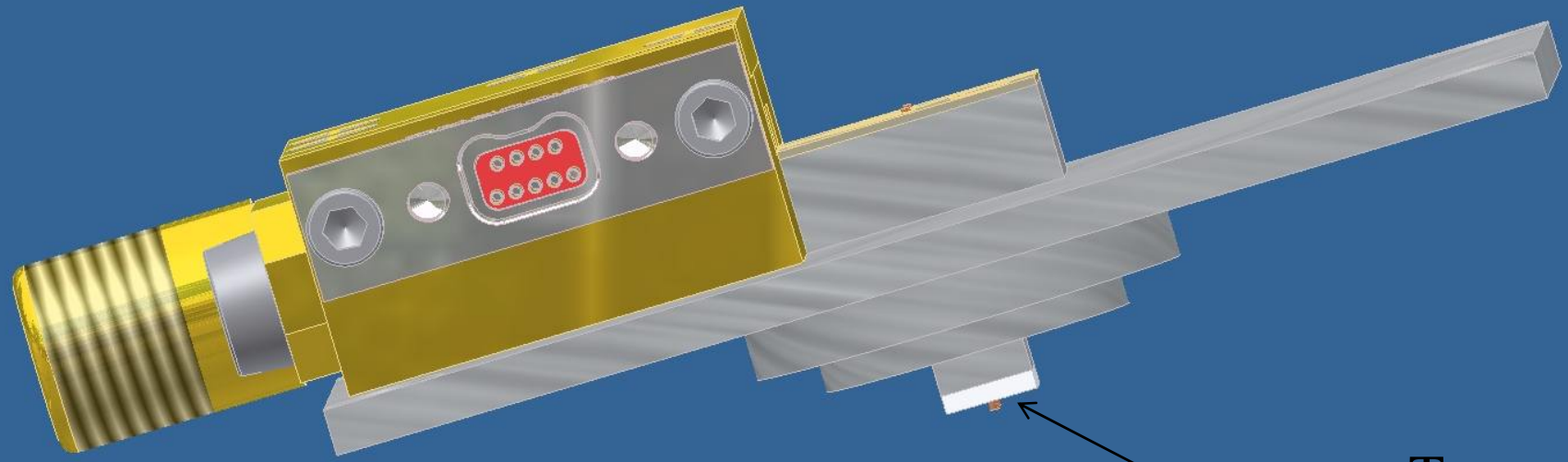
LNA

Descrambler board prepared for dual polarization feed

Ground plane

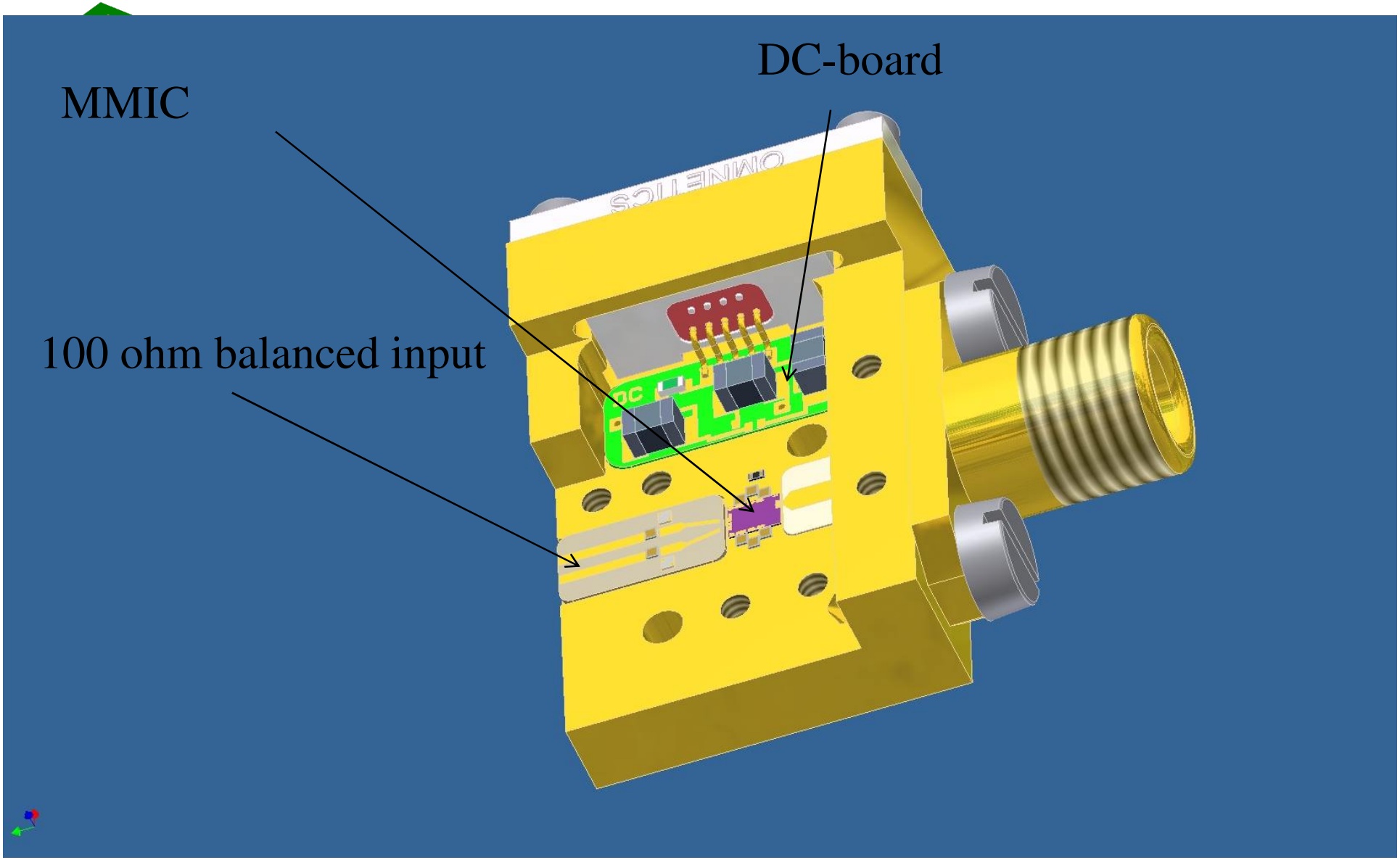
LNA assembly mounted on antenna ground plane with 4*M2

LNA assembly



Two coax lines going to antenna terminals

LNA module without sublid



LNA module without lid