2015 IEEE International APS Symposium
THP-A1.6P.40

Empirical and Theoretical Characterization of Multioctave Planar Phased Arrays

Johnson J. H. Wang, Life Fellow

Wang Electro-Opto Corporation, Marietta, Georgia, USA

email: jjhwang@weo.com

ACKNOWLEDGEMENT

The material in this paper is based on work supported by the Naval Sea Systems Command under Contract No. N00024-13-C-4526.

The author is grateful for the technical support and collaboration of the Ohio State University ESL team, since 2007, led by Dr. John Volakis.

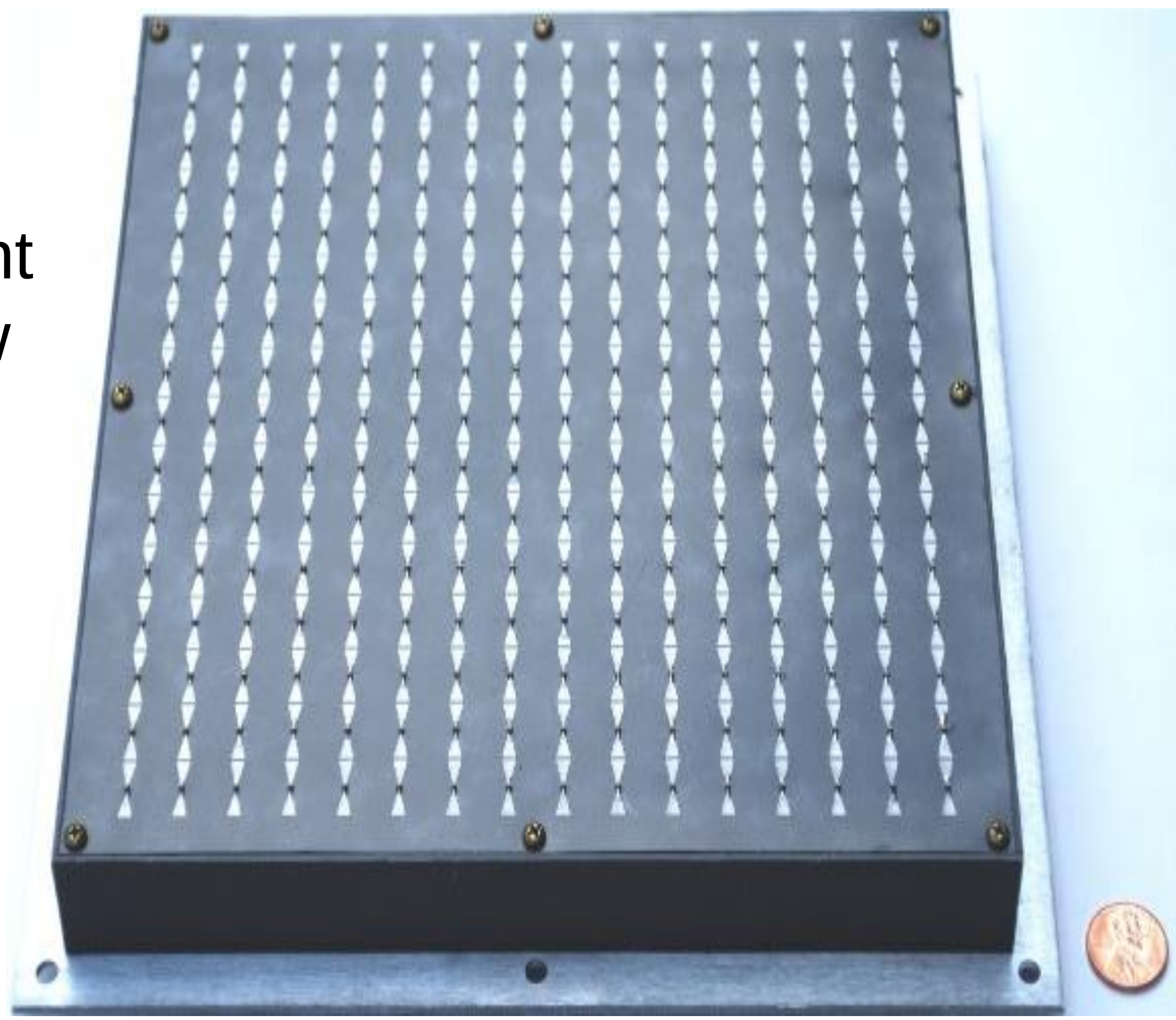
Introduction

- Characterization of *Multioctave Planar Phased Arrays* (MPPA) has been by indirect and incomplete methods due to high cost and complexity
  - except for flared-notch elements under development since 1980
- This paper discusses theoretical and empirical characterization of an MPPA called *Traveling-Wave Antenna* (TWA) *Array*, or TWAA.
- Performance: 2-12 GHz, ±60° scan (E & H planes)

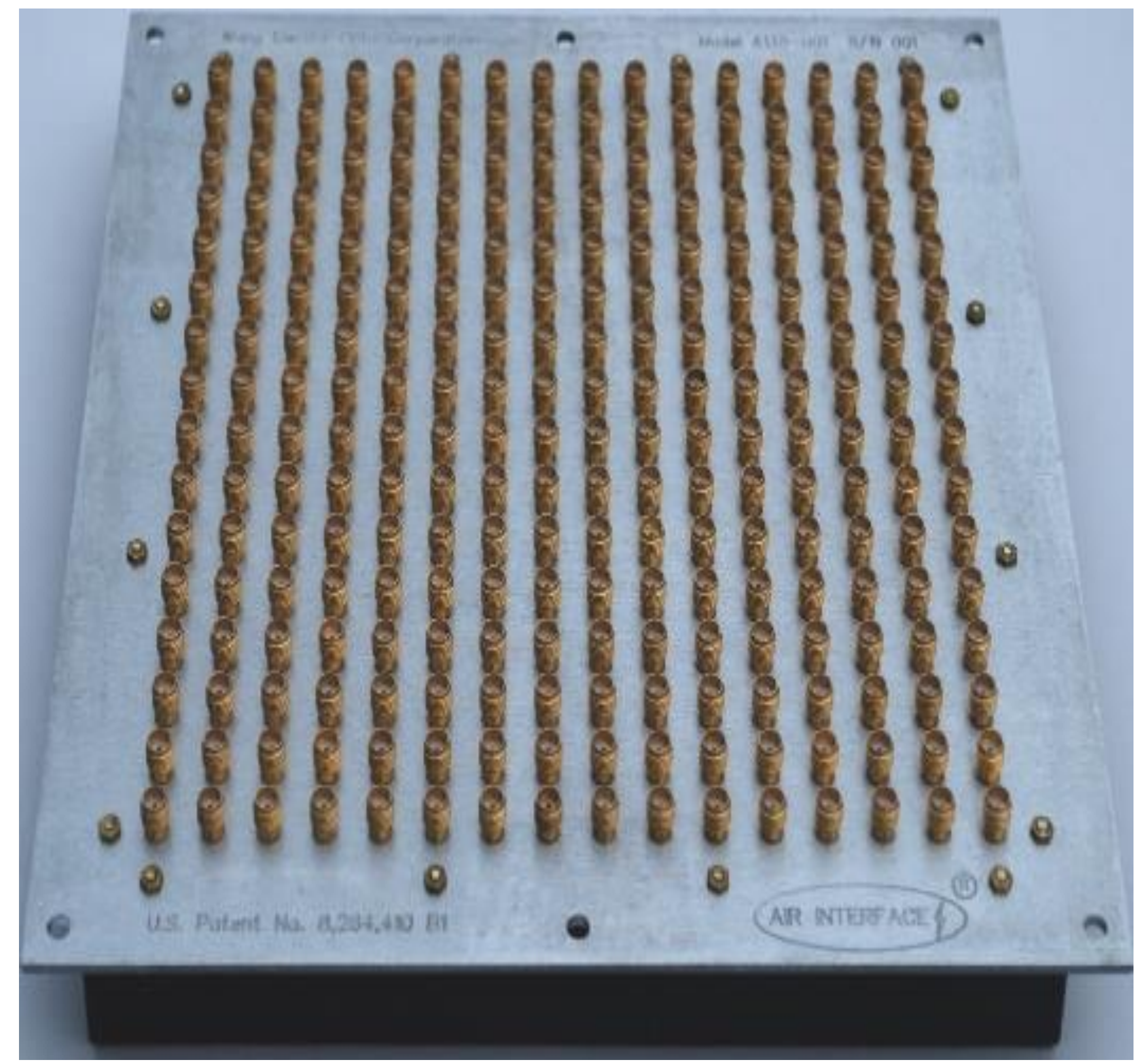
Traveling-Wave Antenna Array (TWAA)

- 16×16-element
  - Scalable to other frequencies & numbers of elements

Front view



Back view showing 256 SMA feed connectors



J. J. H. Wang, *2013 IEEE International Symposium on Phased Array Systems & Technology*, Boston, MA, pp. 207-213, October 2013.

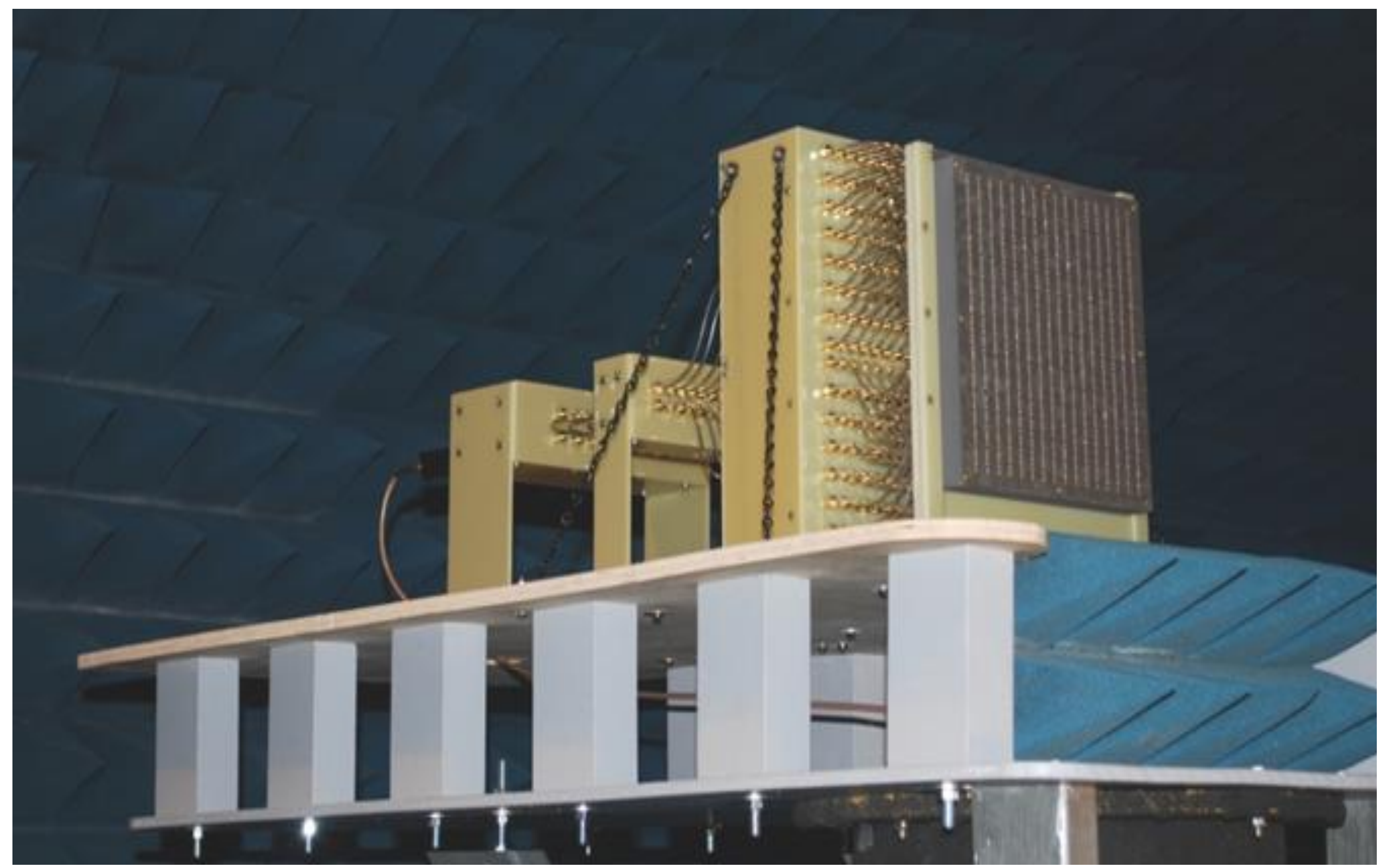
J. J. H. Wang, “Planar broadband traveling-wave beam-scan array antennas,” U.S. patent #8,264,410 B1, filed 31 July 2007, awarded 11 September 2012.

Key differences between TWAA and Other MPPAs

Features	TWAA	Other MPPAs
Bandwidth and scan angle	Inherently wide bandwidth and scan angle	Limited in achieving both wideband and wide scan simultaneously
Dissipative or exotic material (e.g., ferrite or metamaterial)	• Not used	• Often needed/used, thus low producibility • Large cost, weight & thickness
Substrates/ superstrates of special dielectric property	Not used (standard PCB used only for structural support); thus lower cost, weight, thickness. Easily air cooled for high power!	Generally necessary; thus high cost, weight, thickness. Difficult to air cool, thus low power handling!

Empirical Characterization

– Far-field tests on sufficiently large array (16×16 elements)
– 2-18 GHz BSN (Beam Steering Network)
  - True-Time-Delay (TTD) lines using phase-matched semirigid coaxial-cable corporate feed network
– Discrete TTD lines
– Scan to 0°, ±30°, ±45°, ±60°
– Test over 2-12 GHz
– 0.25 GHz increments

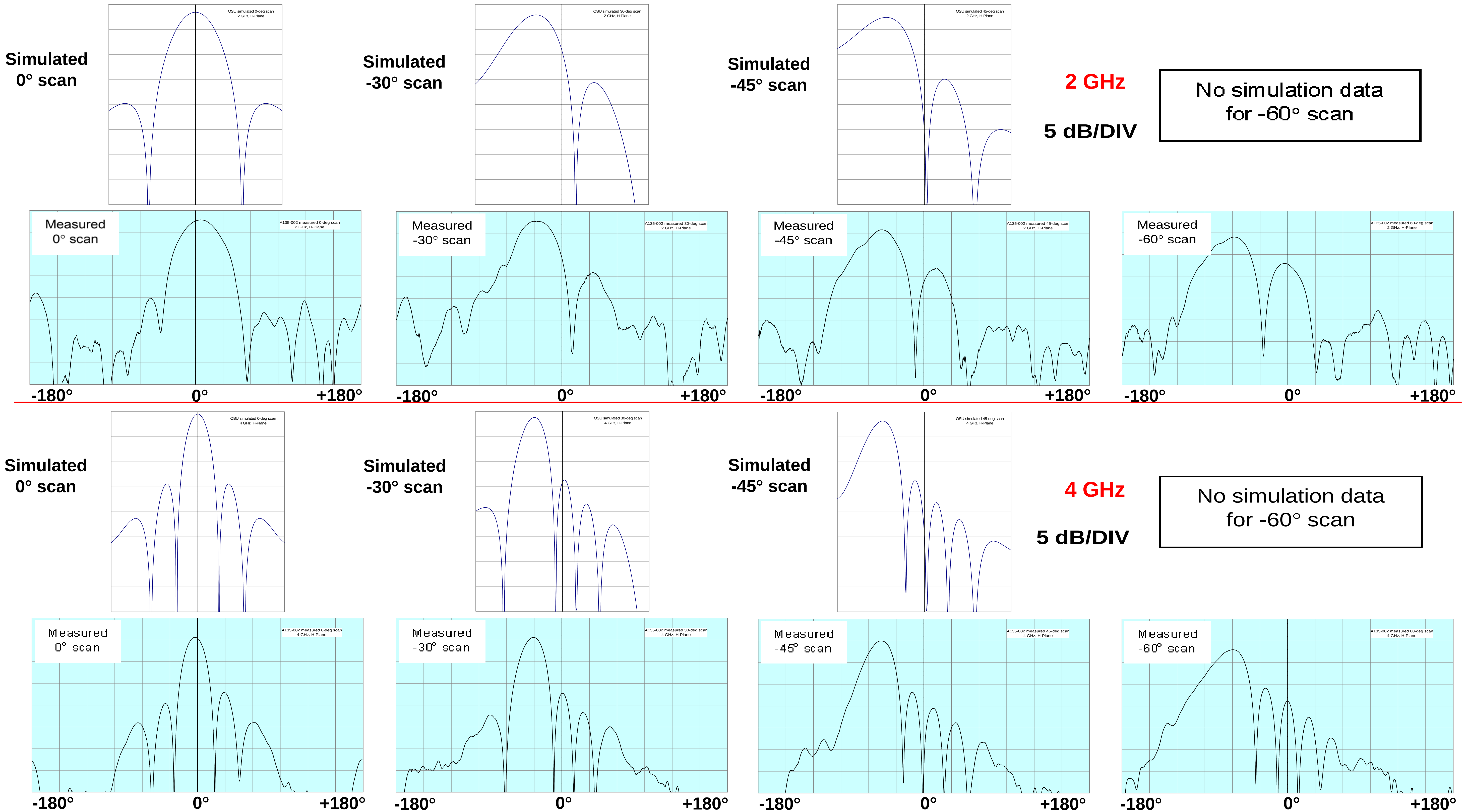


Theoretical Characterization

- Simulated gain patterns generated by ElectroScience Laboratory (ESL) of Ohio Sate University (OSU)
  - multiplying array factor and Scan Element Gain (SEG) patterns of infinite array using commercial software based on moment-method.
- Simulation for transmit mode, with special attention to feed structure and equivalent source.
- Simulation data not generated for
    - large scan at 60°.
    - below half-space—beyond (-90° to +90°)

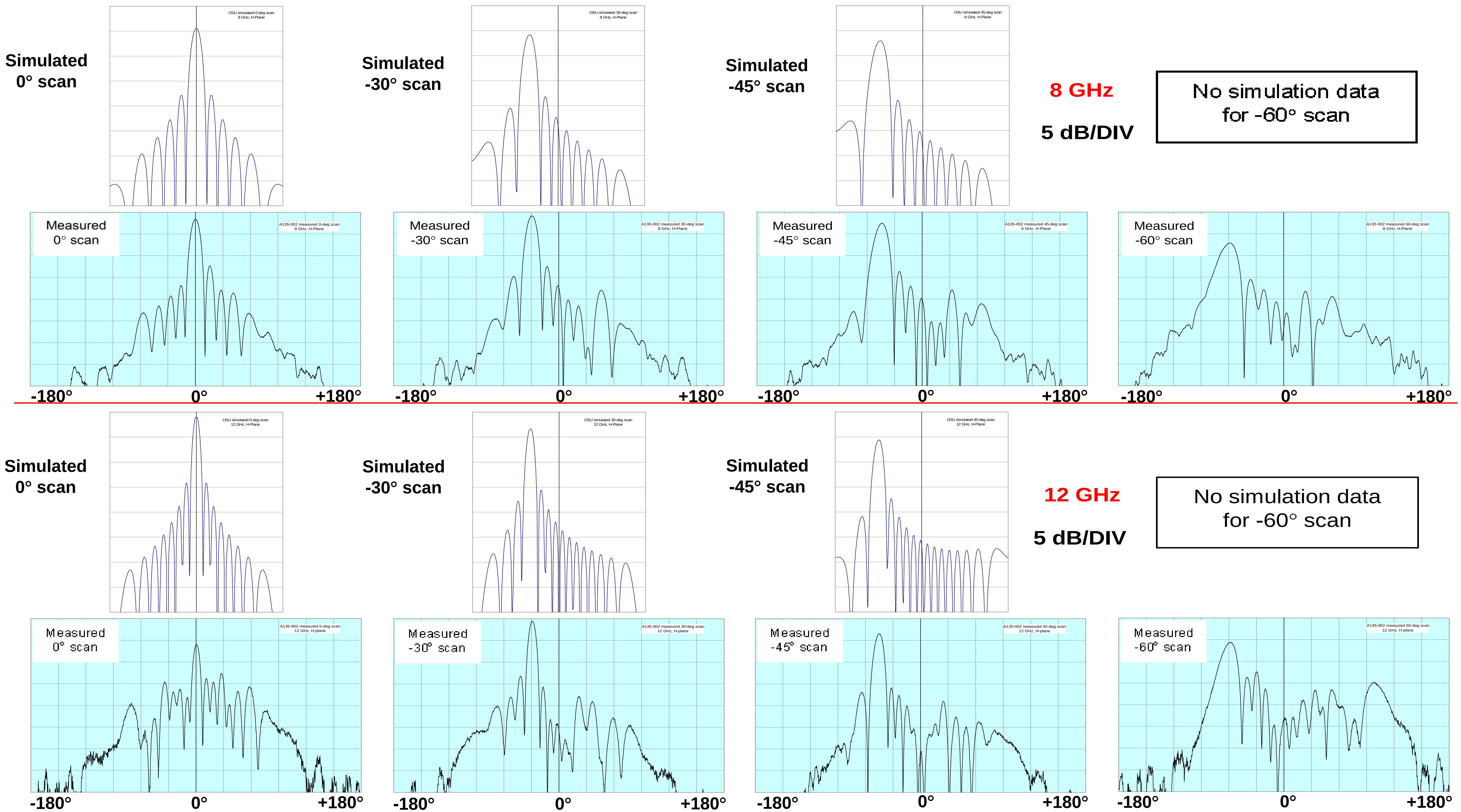
(due to limitations of software, computer and infinite-array model)

Good array scan performance in both E and H planes (measured vs. OSU simulation) (H-plane cases shown)



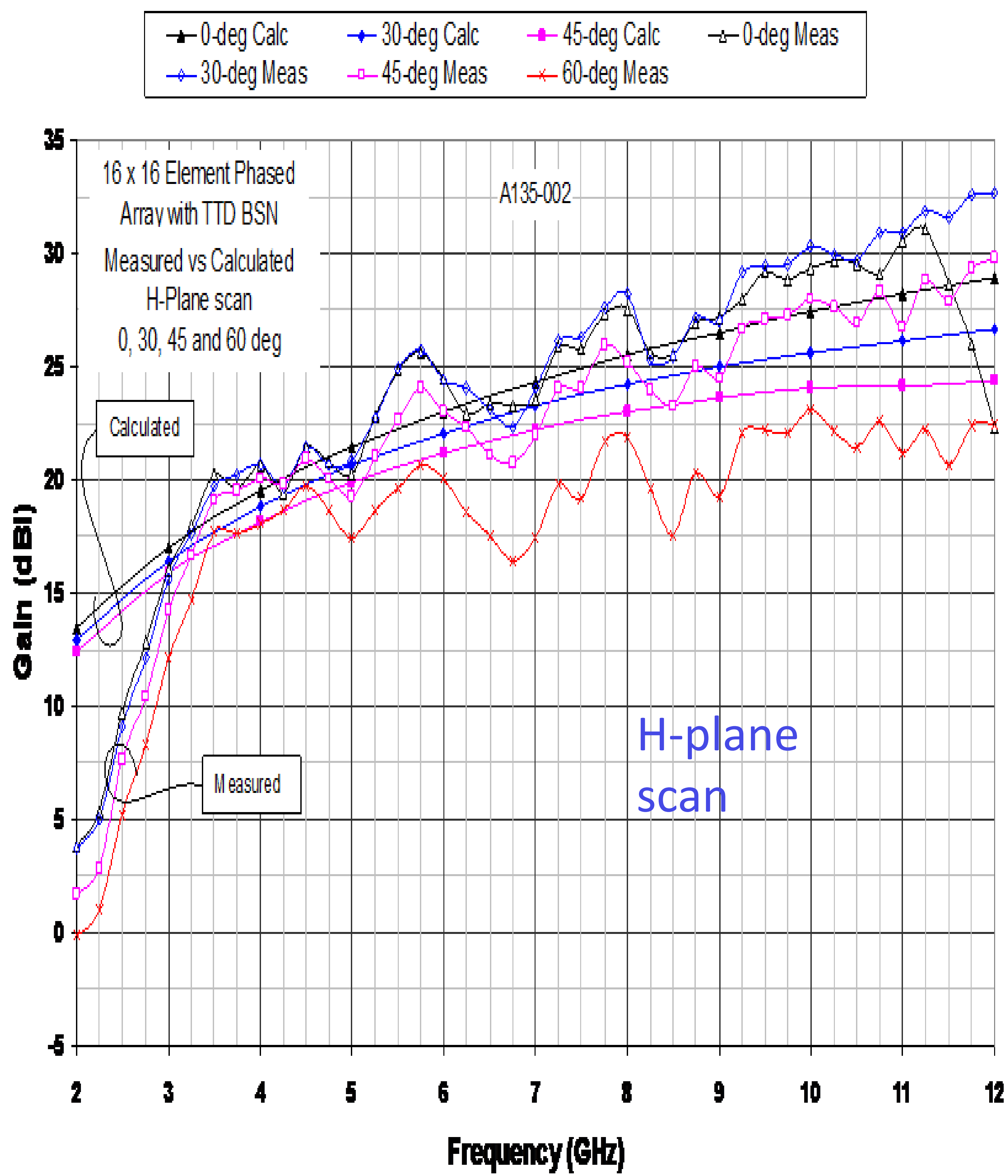
2 & 4 GHz, H-Plane

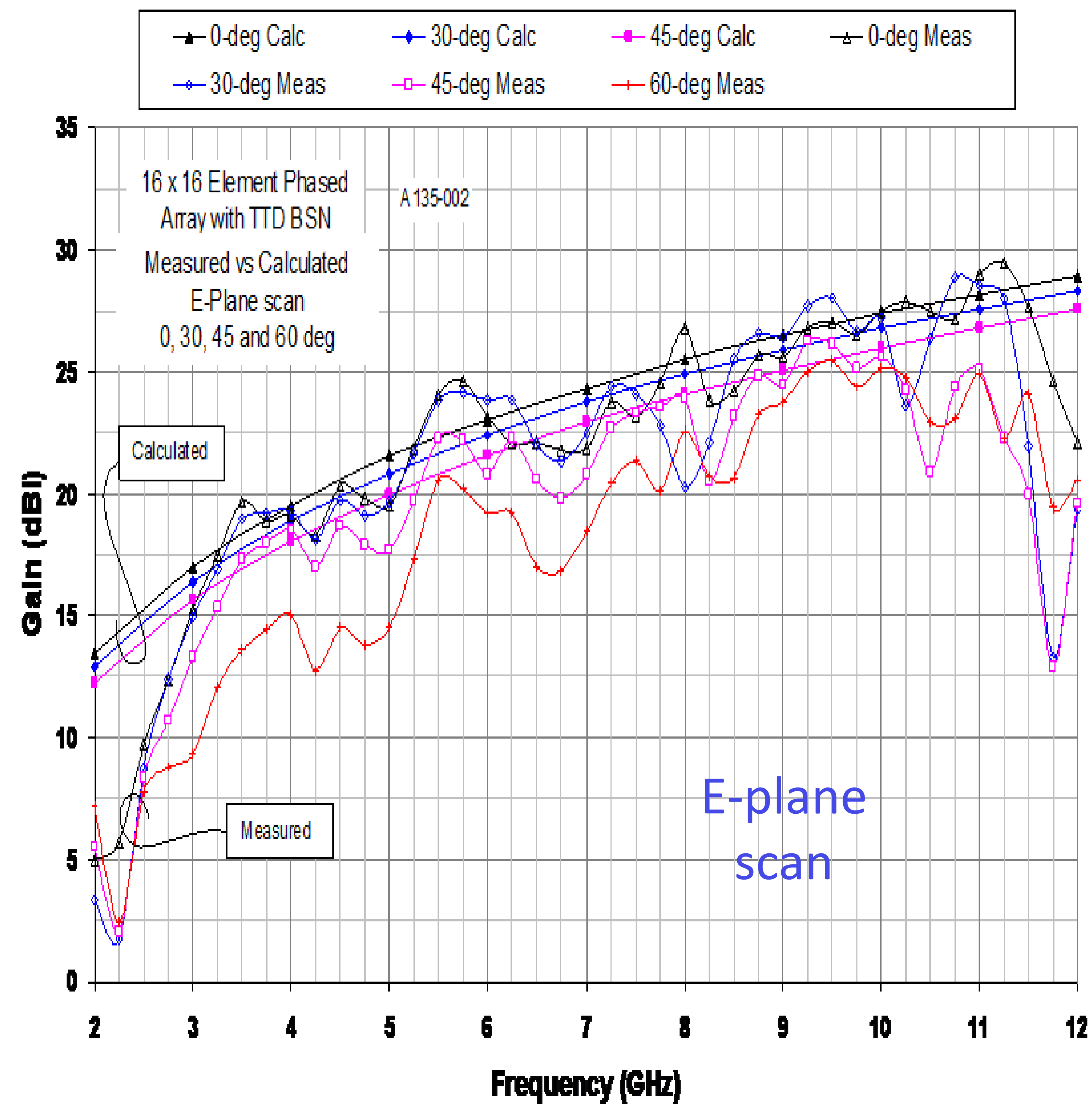
Good array scan performance in both E and H planes (measured vs. OSU simulation) (H-plane cases shown)



8 & 12 GHz, H-Plane

Good E & H-plane scan gain (measured versus calculated)





Conclusions

- Good agreements between theoretical and empirical performance—except for numerical modeling for wide scan beyond 45°.
- Measured data beyond 45° scan revealed
  - Severe limitations in computing for wide-angle scan beyond 45° (due to software and computer)
  - TWAA's potential for wider scan-angle than conventional planar phased array.