SMITEK

# COMPACT ANTENNA TEST RANGE SYSTEMS

# CATR OVERVIEW

A Compact Antenna Test Range (CATR) is used for measurements of electrically large antennas at a significantly shorter distance in comparison with traditional far-field test range. Compact ranges use a feed antenna to radiate a spherical wave from the focal point of a parabolic reflector, collimating it into a planar wave.

The antenna under test (AUT) couples to this plane wave creating the measured radiation pattern and so the quality of the plane wave defines the accuracy of AUT radiation pattern measurement. This region of pseudo plane wave is called the quiet zone (QZ). The QZ quality is determined by amplitude and phase variations in the volume of field.

The scattering characteristics of the AUT (or other object) can be obtained by receiving the scattered signal back at the CATR horn feed. This enables radar cross-section (RCS) measurements to be performed in a compact indoor secure environment.

CATR lowest operational frequency is determined by the size of the reflector, horn feeds and its edge treatment. Smitek produces reflectors with two types of edge treatments: serrated edge for general purpose applications, and rolled edge for higher accuracy applications.

- CATR system includes the following components:
- Reflector
- Feeds with positioner
- Antenna under test (AUT) positioner
- Software
- Anechoic chamber
- RF measurement equipment and accessories

Full CATR system including full set of components can be purchased directly from Smitek. The reflector, feeds and positioners are manufactured at Smitek facility and can be ordered as individual components.

We develop custom systems for all applications and AUT form-factors. Most common CATR systems based on different reflector sizes are listed below.

# CONTENTS

# CATR WITH 3M QZ

**The system is optimized for testing large antennas (up to 3m) for radar and satellite communications across the frequency range from 0.75 up to 50 GHz (upgradable up to 110 GHz). CATR is designed for antenna and RCS measurement.**

## A. CATR SYSTEM DESIGN

A side feed geometry reflector is placed on special concrete basement with a column for the feed positioner. The chamber size is 22x14x12m (LxWxH), but can be reduced down to 21x12x10m (LxWxH) upon request. Chamber is covered with different absorber height from 30 up to 60 cm and different geometry types: pyramids and wedges. The absorber layout is designed to be suitable for both antenna and RCS measurements.

The quite zone performance is equal or better than the specifications, with less than ±0.5 dB co-polar amplitude variations, phase variations within ±4 deg, and cross-polarization better than -30 dB in cubic quiet zone.

## B. REFLECTOR

Reflector and its basement are made of the same material – aluminum. The basement and reflector surface have the same temperature linear extension coefficient, which is important for measurement repeatability and reduces requirements for temperature stabilization. The milling process is performed at 22±1 deg C temperature. We recommend the chamber temperature deviation to be 23±2 deg.

The reflector surface accuracy is ±0.085 mm peak-to-peak and 0.03 mm RMS. Reflector consists of 21 parts. In the parabolic area mostly effected to the quite zone performance the accuracy of surface is ±0.05 mm peak-to-peak and 0.02mm RMS.

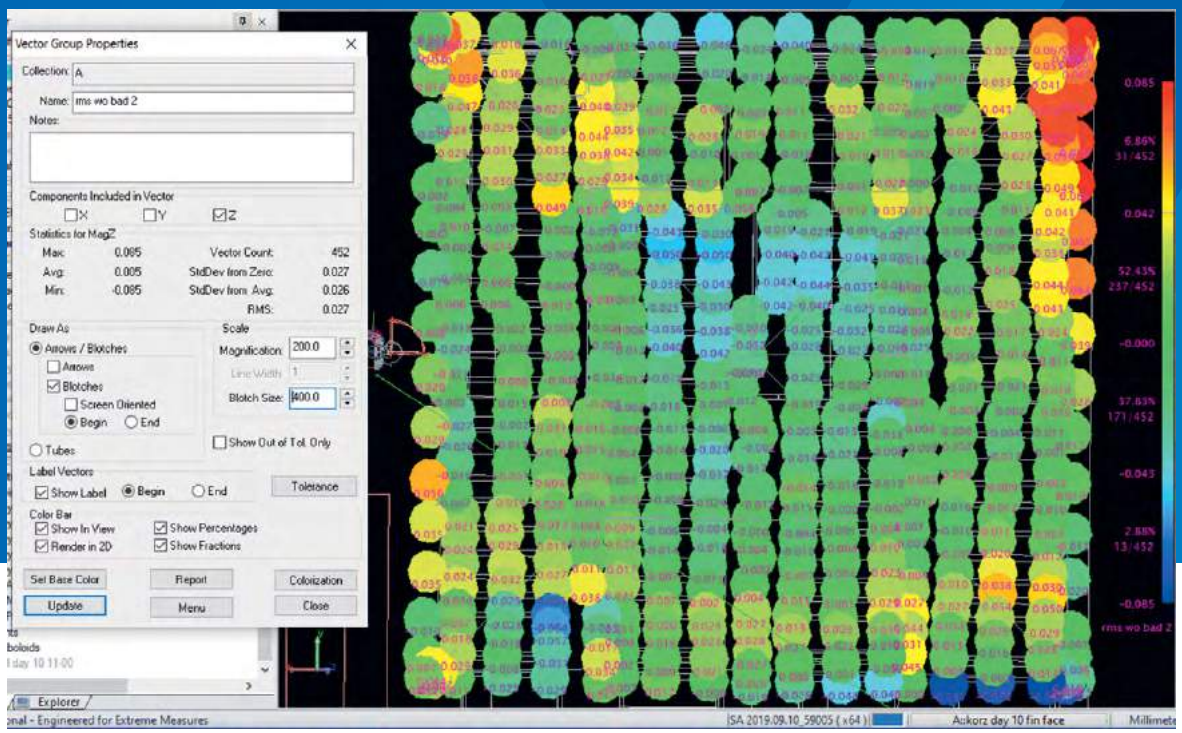



**Fig. 1.** Surface accuracy of 6x6m reflector

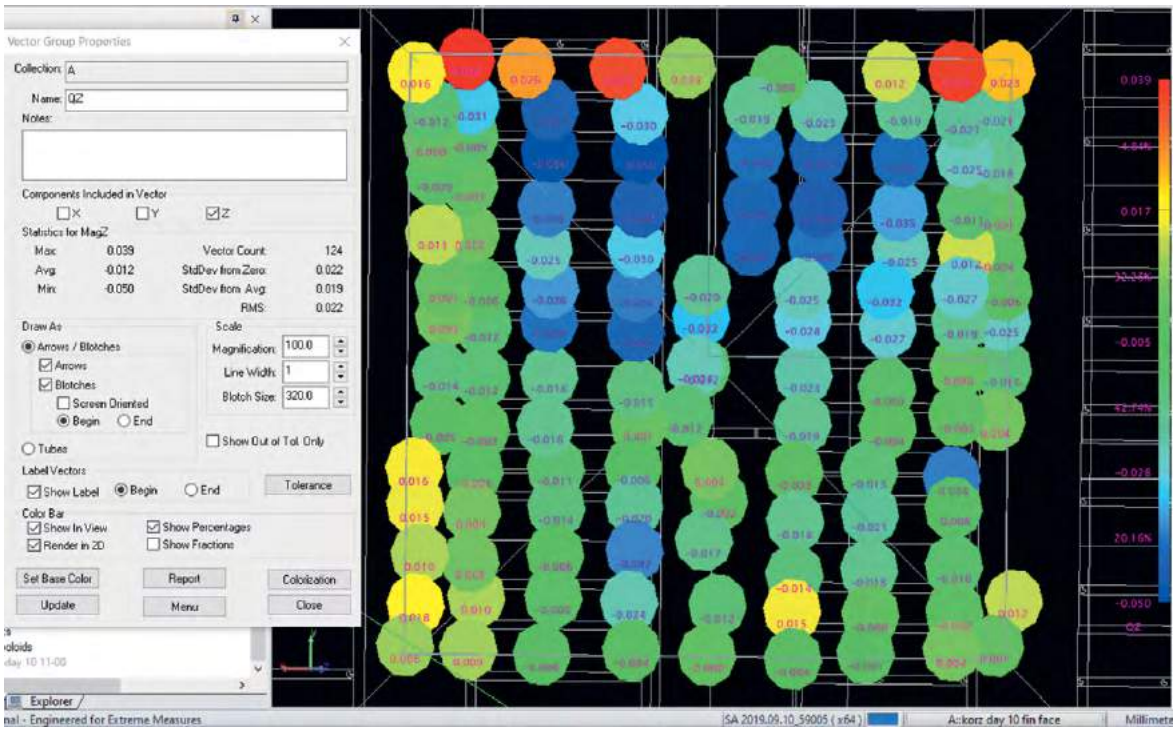



**Fig. 2.** Surface accuracy in 4x4m area (Parabolic zone)

## C. CHAMBER LAYOUT

Feed positioner is placed on a rigid concrete column. This design is optimized for reducing chamber size and keeping reflector's center of mass inside of the basement area ensuring a long-term stability of its geometry.

The feed leakage is highly reduced by the shield system with absorber and use of the time and space filtration algorithms applied to the data acquisition process.

Corner feed of floor feed layout can be ordered upon request.

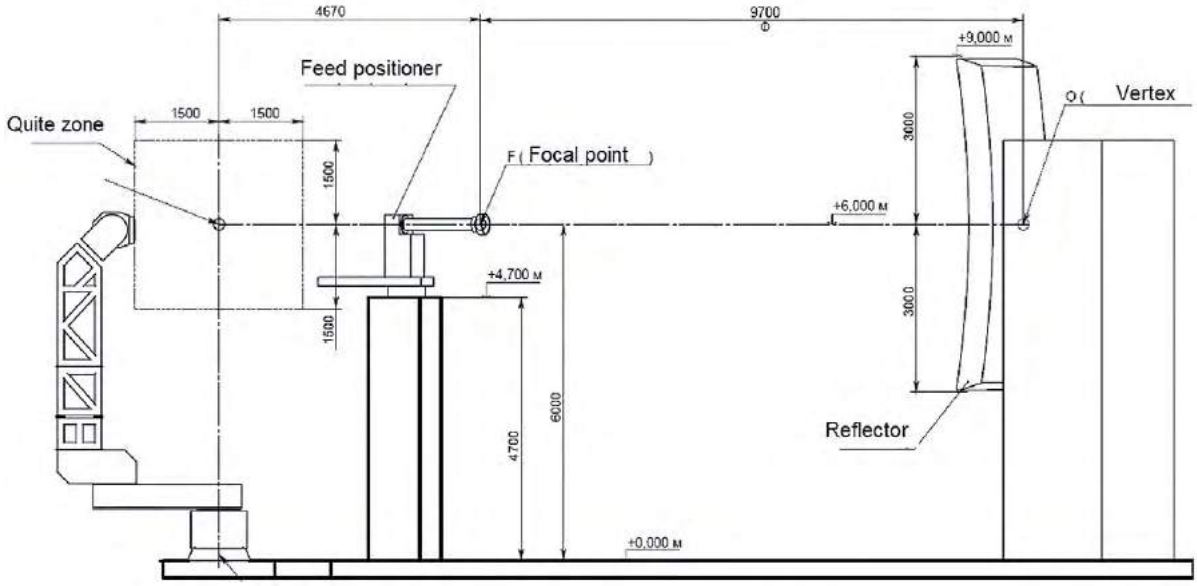



**Fig. 3.** Chamber Layout side view

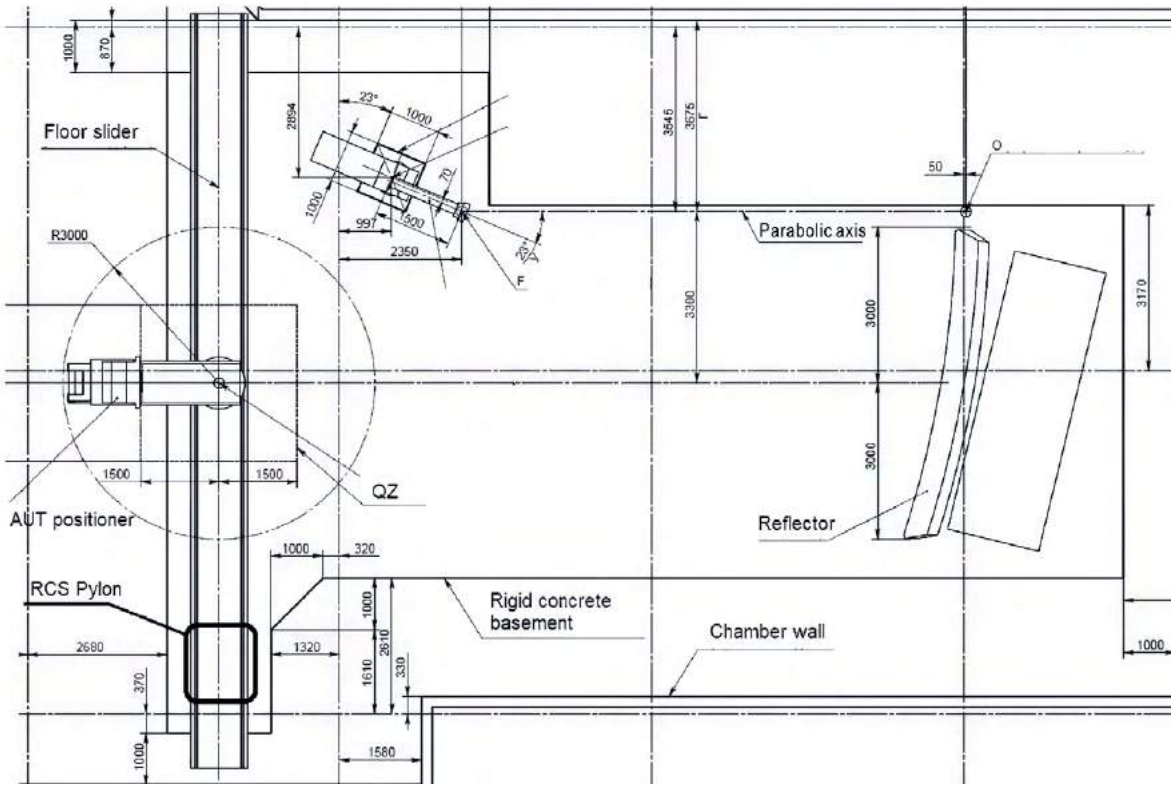
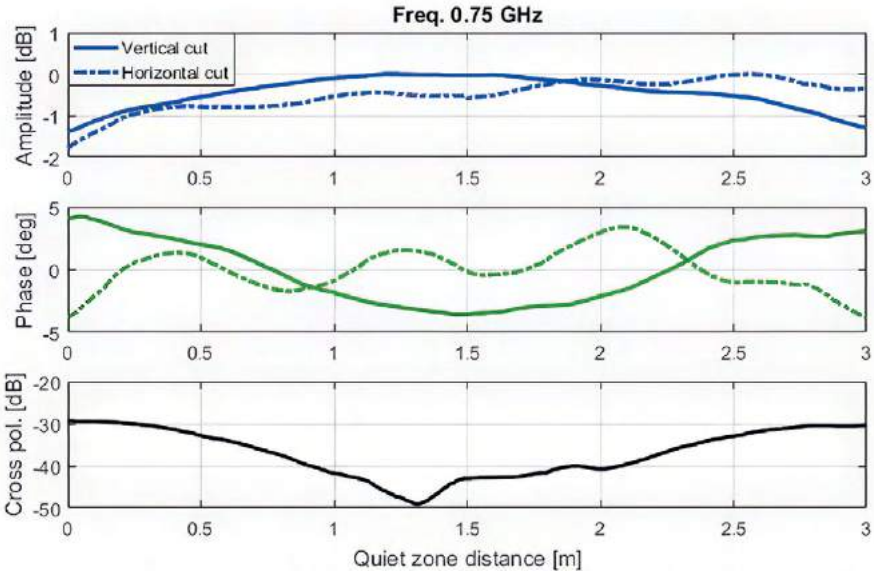
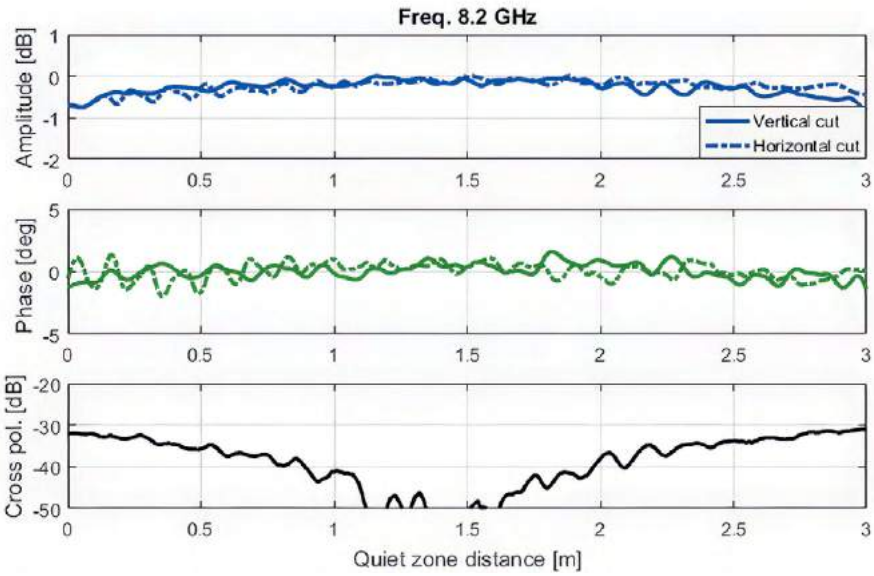


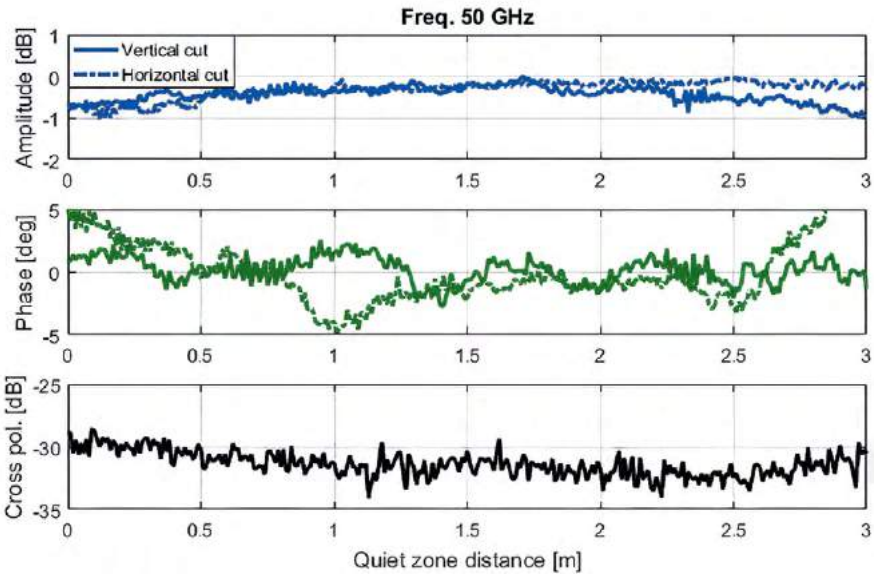

**Fig. 4.** Chamber Layout top view

## D. QUITE ZONE PERFORMANCE

The following plots show the measured co- and cross polarization performance in the horizontal and vertical cuts at the QZ area at frequency 0.75, 8.2, 50 GHz



# CATR WITH 90CM QZ

**The system is optimized for testing automotive radars, 5G base stations and other types of antennas with aperture up to 90 cm covered by frequency range 3-110 GHz. CATR has rolled edge reflector with a cube 0.9x0.9.0.9m quite zone.**

## A. CATR SYSTEM DESIGN

A corner feed geometry reflector is placed on special concrete basement. The chamber size is 8.5x4.5x4m (LxWxH), but can be reduced down to 8x4x3m (LxWxH) upon request.

The quite zone performance is equal or better than the specifications, with less than ±0.5 dB co-polar amplitude variations, phase variations within ±4 deg, and cross-polarization better than -30 dB in cubic quiet zone.

## B. REFLECTOR

Reflector and its basement made of the same material – aluminum. So the basement and reflector surface have the same temperature linear extension coefficient. To keep the QZ performance characteristic the reflector should keep the overall dimensions. The milling process is performed at 23 deg C temperature. We recommend the chamber temperature deviation to be 23±2 deg.

The surface of the reflector has 0.1 mm peak-to-peak and 0.02 mm RMS surface accuracy. Reflector is made of 3 parts (45-90-45 cm width) to avoid interconnections in the center of the reflector.

## C. CHAMBER LAYOUT

The chamber covered by 30 cm absorber. The size of the door is 2x2 m. The chamber has a concrete/ wooden floor (12 cm height).

Dimensions of the chamber can be found below:

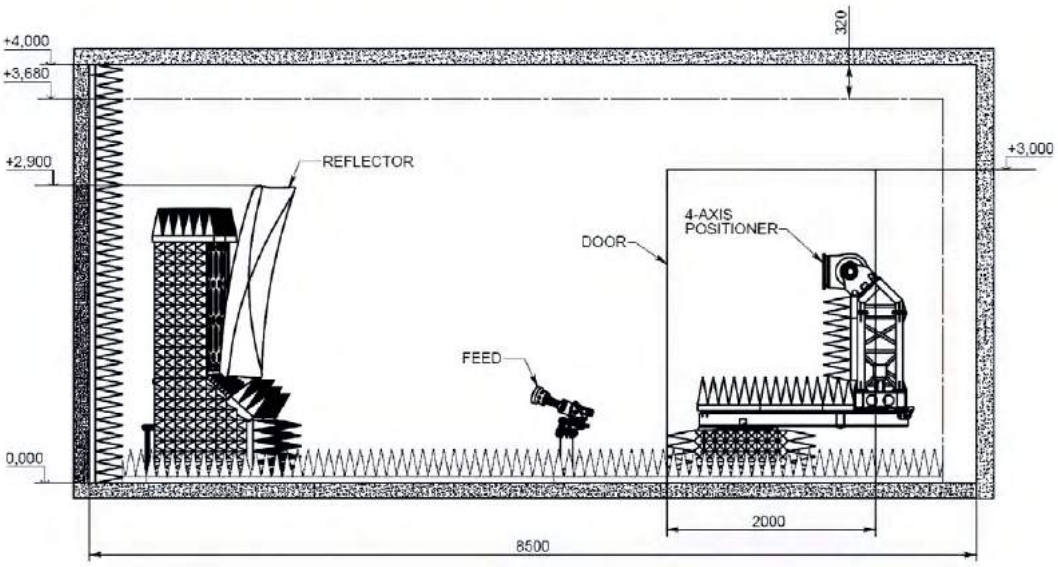



**Fig. 5.** Chamber size and layout

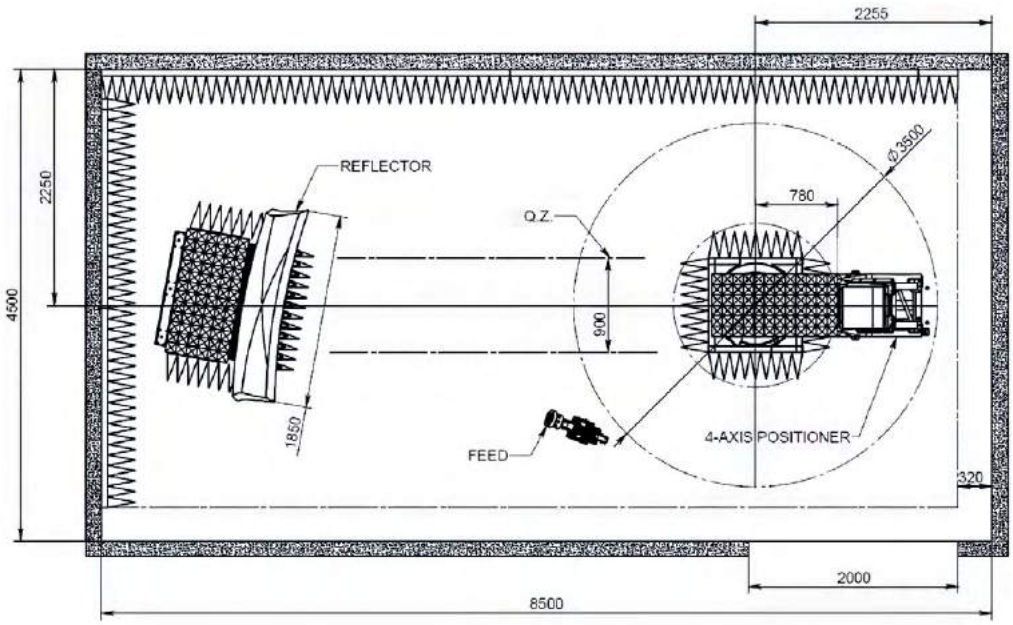



**Fig. 6.** Chamber size and layout

# CATR FEEDS

**For the best test zone performance, a compact range is typically illuminated with a corrugated horn. Feed horns exhibit a stable rotationally symmetric radiation pattern with very low cross-polarization level.**

Smitek offers single linear polarized feed and dual linear polarized feeds.

Dual linear polarized feeds combine a high performance broadband orthomode transducer (waveguide above 1.1 GHz and coaxial below 1.1 GHz) with precision circular waveguide feeding a circularly symmetric waveguide aperture. Feeds can be ordered with waveguide or coaxial ports.

Typical compact antenna test range feed:

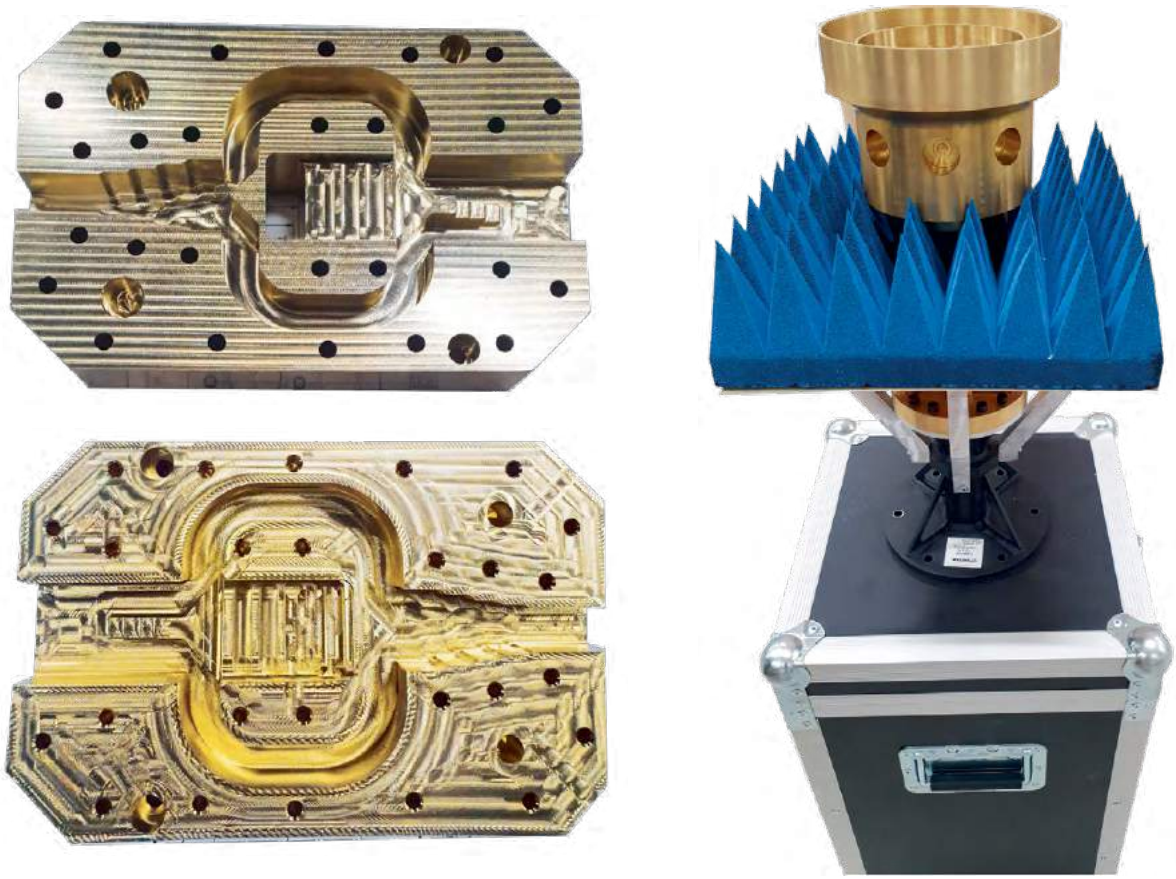


**Fig. 7.** Corrugated circular waveguide horn 18-26 GHz

## SPECIFICATIONS

| | |
|---|---|
| **Cross-Polarization Discrimination** | > 40 dB |
| **Isolation (Port-to-Port)** | > 40 dB (Dual linear polarized feed) |
| **Gain (Nominal)** | 11.5 dBi ±1 dBi |
| **Maximum power at coaxial port** | 40 Watts (type N), 20 Watts (3.5 mm), 15 Watts (2.92 mm), 10 Watts (2.4 mm) |
| **Operating Temperature Range** | 5°C – 50°C |
| **Frequency Range** | |
| **Dual linear polarized feed** | 0.75 – 60 GHz |
| **Single linear polarized feed** | 0.75 – 220 GHz |

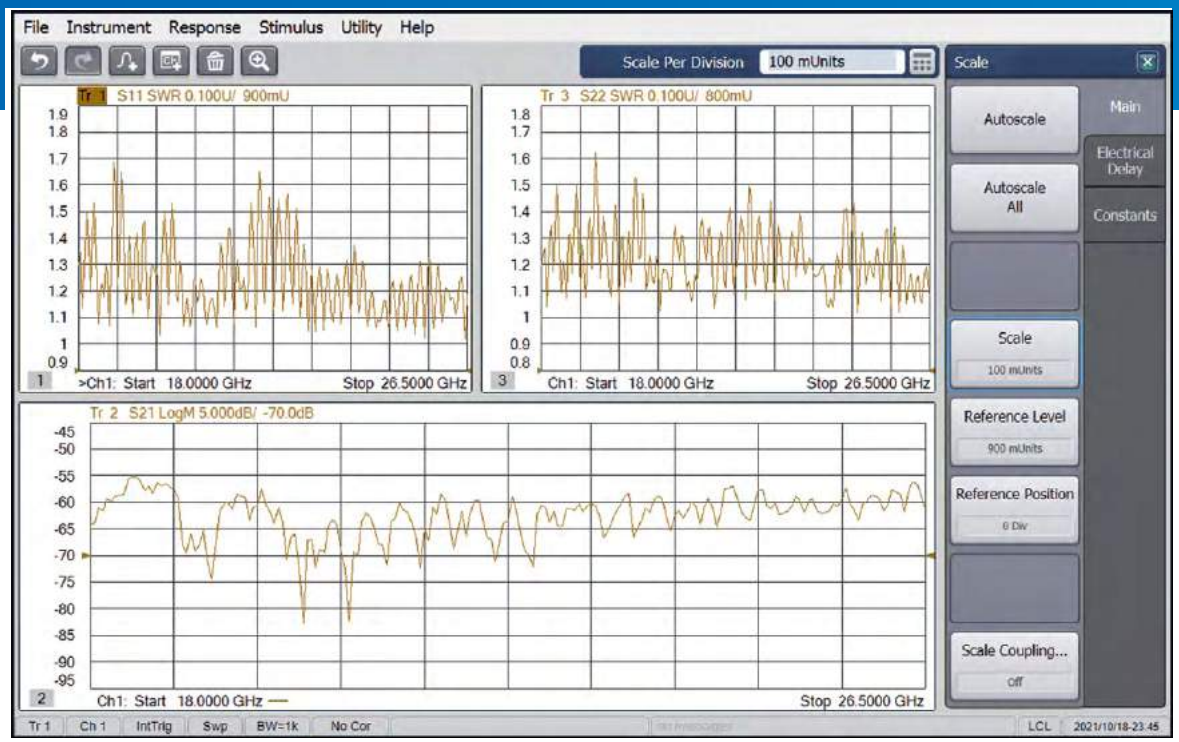



Fig. 8. Measured VSWR (both ports) and port to port isolation of dual polarized feed 18-26 GHzt

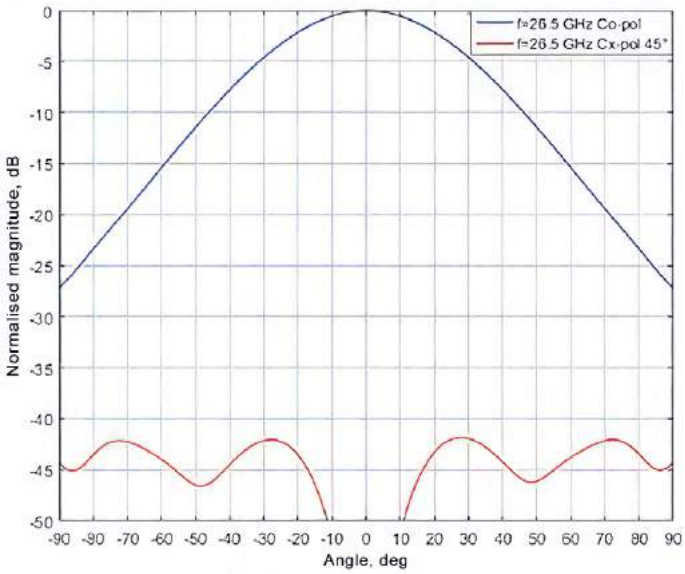



Fig. 9. Co-pol and cx-pol 45° magnitude patterns of the corrugated circular waveguide horn 18-26 GHz

# AUT POSITIONER

Variety of AUT positioners can be found in Smitek product catalog. The most common AUT positioner is 4-axis version with the following axis layout: Azimuth, Offset slider, Elevation, Roll (polarization). Floor slide and lower elevation could be added as an option for easier AUT installation.

BBQ configuration of AUT positioner can be ordered as well.

**Fig. 10.** 4-axis AUT positioner

**Fig. 11.** BBQ-type AUT positioner

- High movement speed
- Backlash of less than 1 angular minute
- Positioning accuracy of less than 0.003 deg
- Absolute encoders
- Documented SCPI command reference

| Parameter | Positioner model |
|---|---|
| Maximum vertical load, kg | 30 - 10000 |
| Maximum torque in elevation, kg-m | 20 - 4000 |
| Nominal speed, rpm | 0.5 - 5 |
| Travel range in azimuth, deg | 0-360 (580) |
| Travel range in elevation, deg | From – 90 to 90 |
| Travel range in polarization, deg | 0 - 360 (580) |
| Positioning accuracy, deg | 0.05 (optional 0.003) |

# RL-BEAM SOFTWARE

**RL-BEAM- software is developed by Smitek for data acquisition, visualization and analysis**

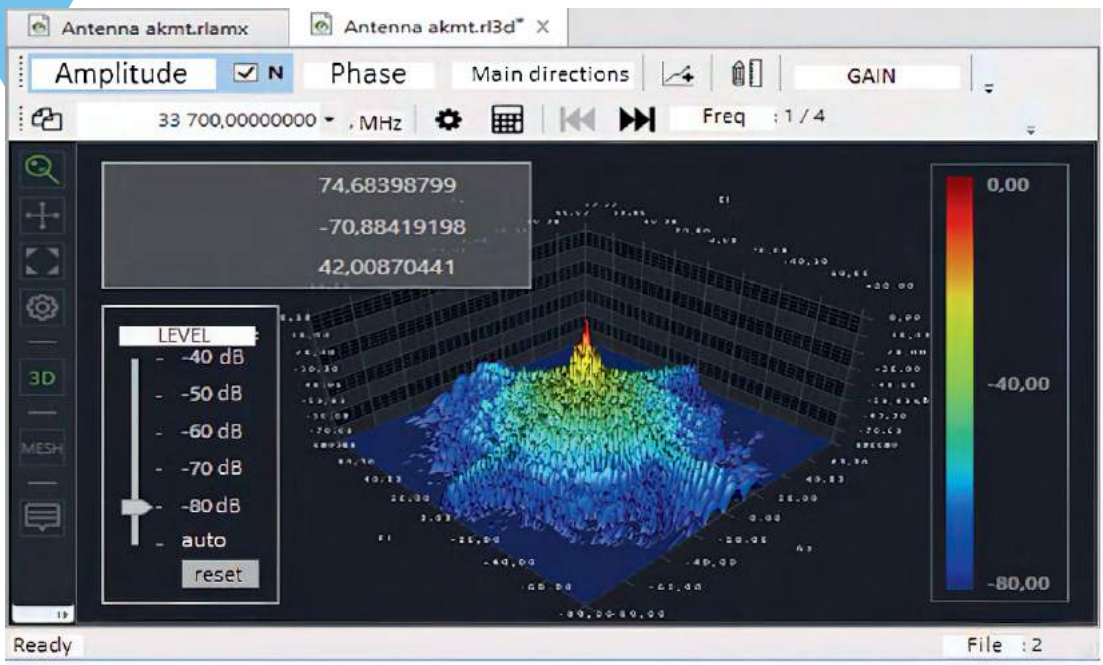



Fig. 12. Antenna patter 3D plot

## FEATURES

- Control of the RF equipment and positioner;
- Scanning and data acquisition synchronization;
- Mathematical data processing, measurement results storage and view;
- Measurement reports automated generation in compliance with the customer's requirements.

## DATA ANALYSIS

- Amplitude radiation pattern, phase radiation pattern (2D/3D plot)
- Far-field amplitude radiation pattern and phase radiation pattern (2D/3D plot)
- Gain
- Directivity
- Polariztion characteristics
- Phase center etc.

# SMITEK PORTFOLIO

**Some of our installed systems presented below:**

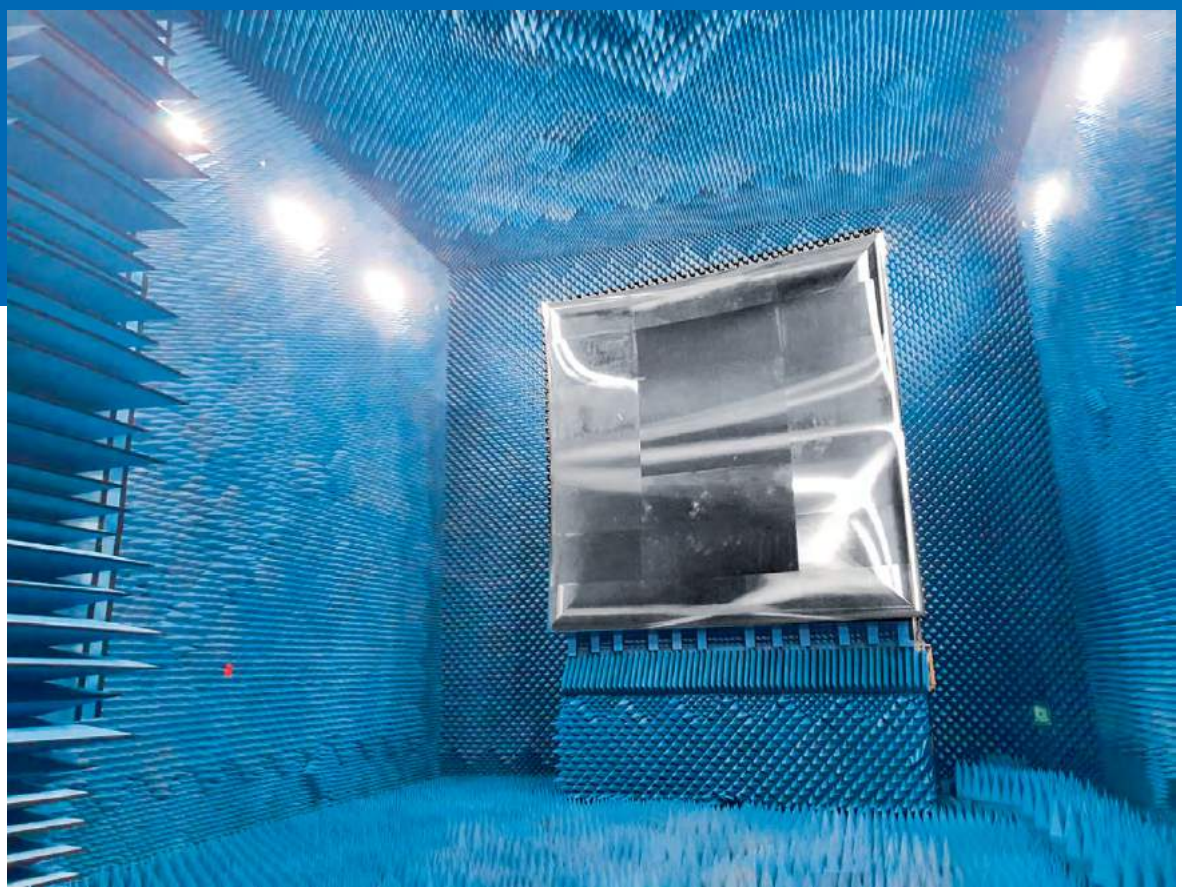


**Fig. 13.** 3x3m QZ CATR with rolled edge reflector, 0.75-50 GHz with 7 axis AUT positioner for RCS and antenna measurement – Russia

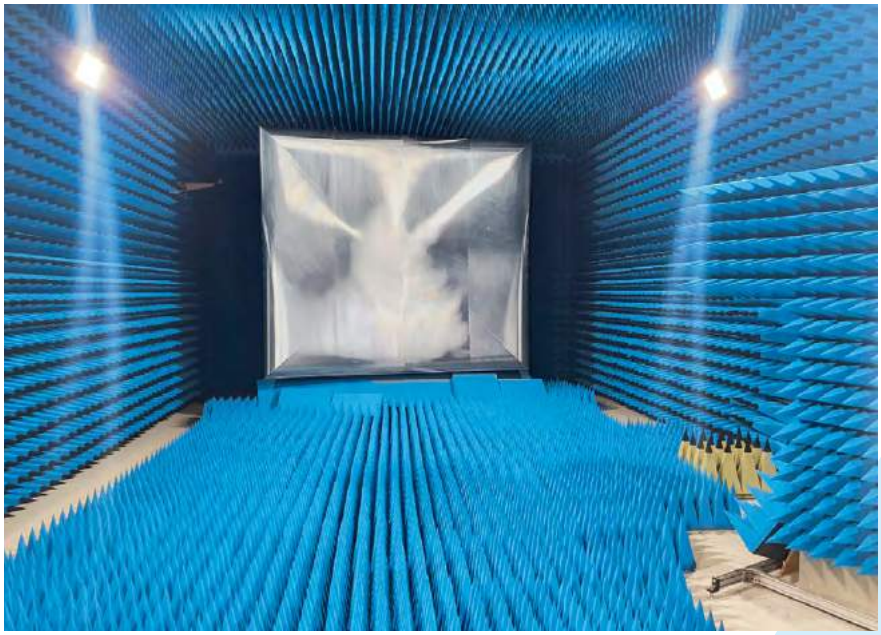


**Fig. 14.** 1.8x1.5m QZ CATR with rolled edge reflector, 1.7-220 GHz with BBQ positioner for base station test – Europe

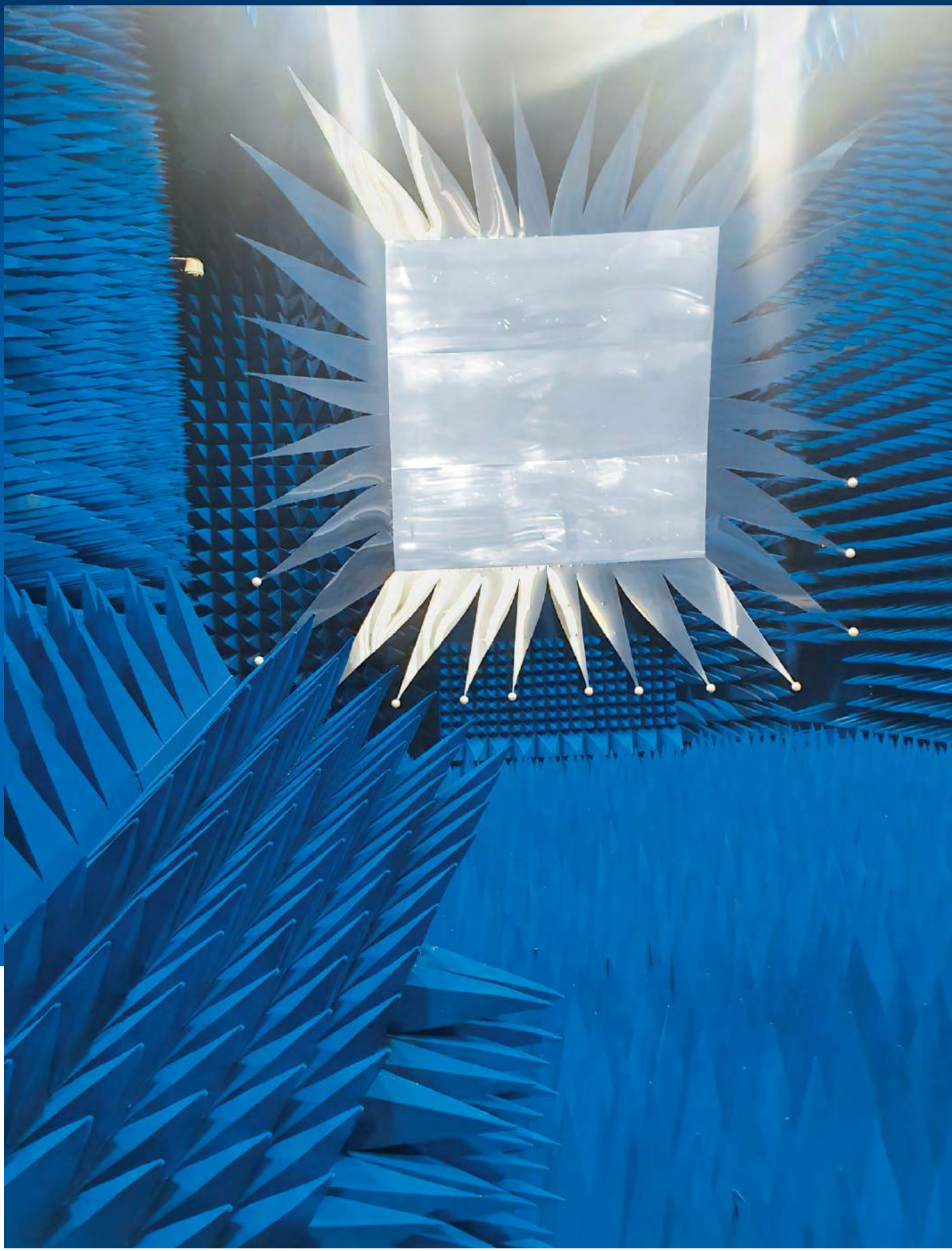


**Fig. 15.** 1.8x1.8m QZ with serrated edge reflector, 0.75-26 GHz with 6 axis 600 kg payload positioner – Russia

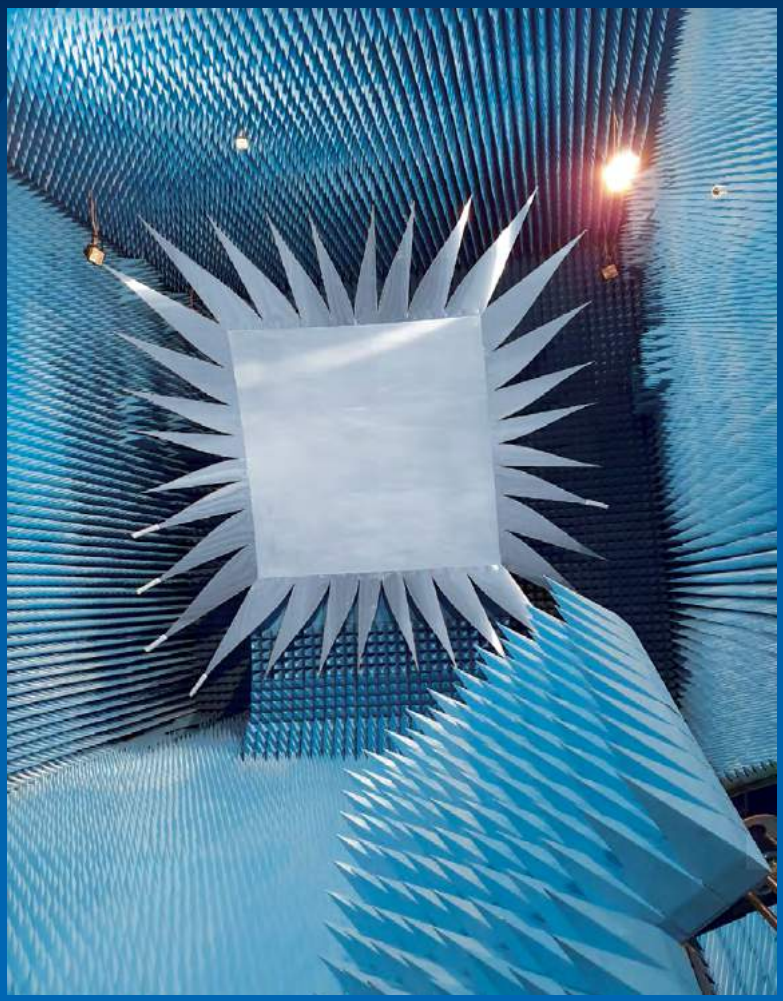


**Fig. 16.** 1.5x1.5m QZ with serrated edge reflector, 1.1-40 GHz with 5 axis 200 kg payload positioner – Asia

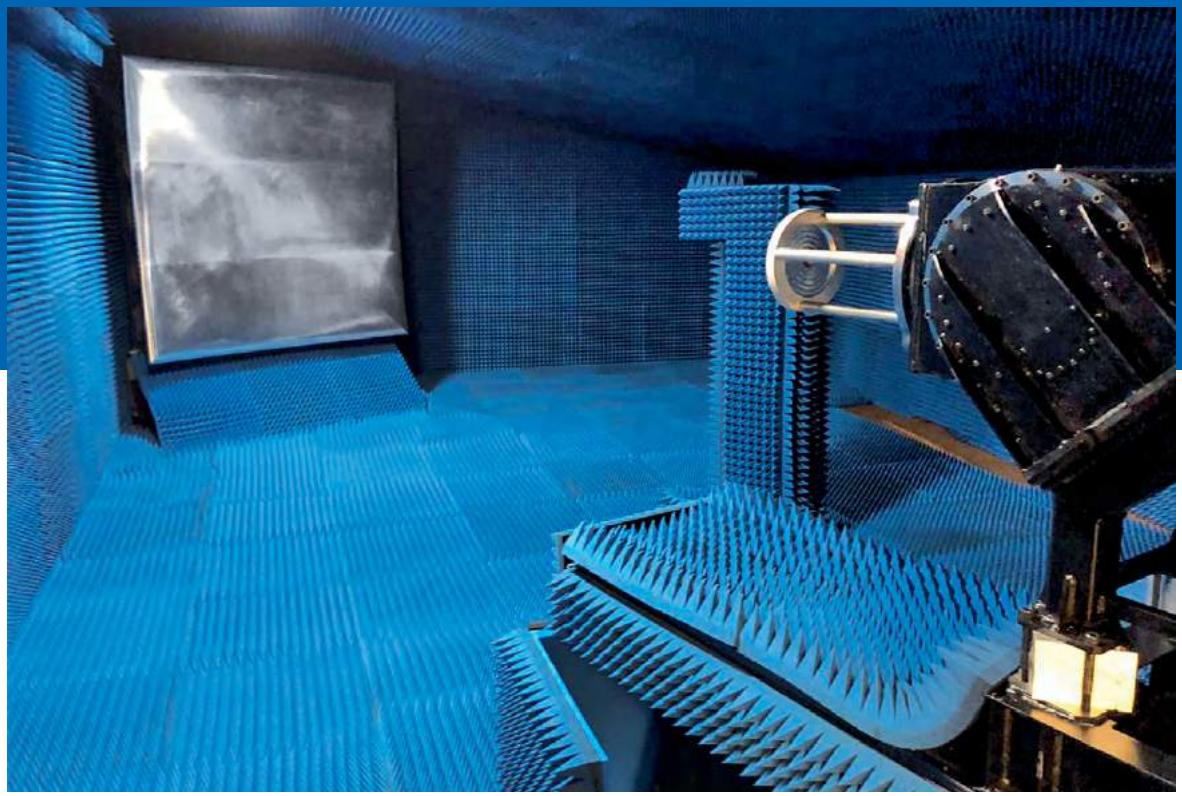


**Fig. 17.** 0.9 x0.9 m QZ with rolled edge reflector, 0.75-90 GHz with 5 axis 100 kg payload positioner – Russia

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