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Success Story

Highly Collimated Solar Simulator

Version 2.0.0 January 2018

About Us:

Sciencetech has been designing and manufacturing optical spectroscopy instruments in Canada since 1985. Our instruments have been used in fields as diverse as medical research, biotechnology, space sciences, material research, applied physics, security, environmental research, and many others. Sciencetech's in-house team of designers, software programmers, and engineers have decades of experience in the field of optical spectroscopy. This, combined with our low-volume manufacturing expertise, makes the company an ideal choice for customers looking for instrumentation far beyond the capabilities of off-the-shelf suppliers.

About the Customer:

Sciencetech's customer is a prominent national space agency and a previous customer of Sciencetech's.

The agency has a range of projects with requiring solar simulation and when a new project appeared with more stringent requirements than any before, they approached Sciencetech again to provide a highly accurate simulation system.

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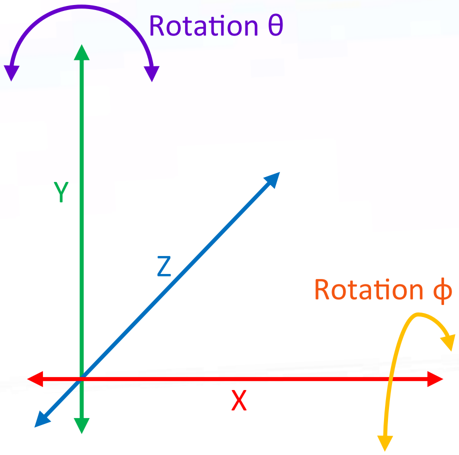
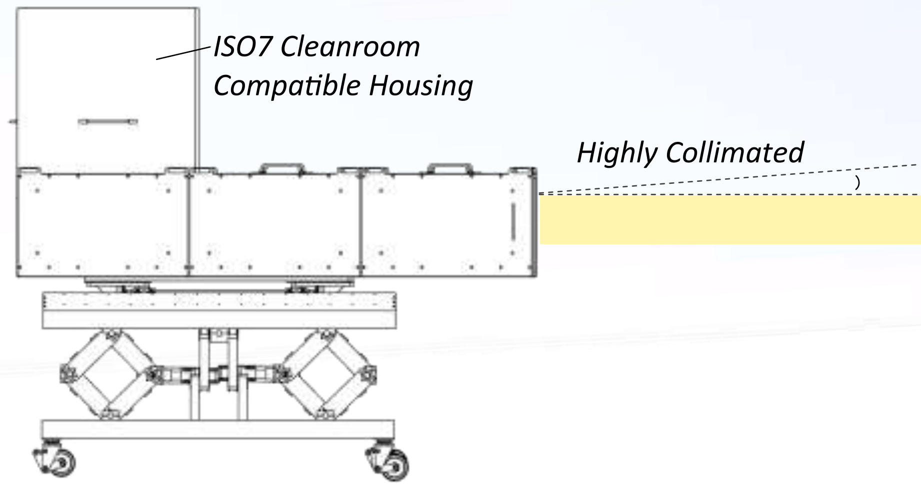
Highly Collimated Aerospace Solar Simulator



5 Automated Movement Axes



Initial Requirements

Some members of the customer agency had hands-on experience using one of Sciencetech's highly collimated solar simulators several years ago. For a new project testing their satellite sensors prior to launch, they required a larger, more sophisticated version. They reached out to Sciencetech and asked if we could provide a solar simulator with an extraordinarily close match to the Sun in terms of irradiance, collimation angle, and spectral match.

Additionally, they wanted automation to manipulate the solar simulator in X, Y, Z axes and 2 rotation angles. Initial discussions considered several automation implementations and initial engineering analysis determined that the physical limitations of xenon short arc lamps would make it very challenging to meet the desired specifications for collimation along with the other criteria. Sciencetech determined a method to achieve the most important specifications and presented it to the customer. The national space agency and Sciencetech signed the contract and initialed the project.

The customer had precise guidelines:

- AM0 1 Sun irradiance
- Collimation 0.7° full angle
- Spectral Match AM0
- Attenuation 1:1000 of 1 Sun
- ISO7 cleanroom compliance
- 5-axis automated movement

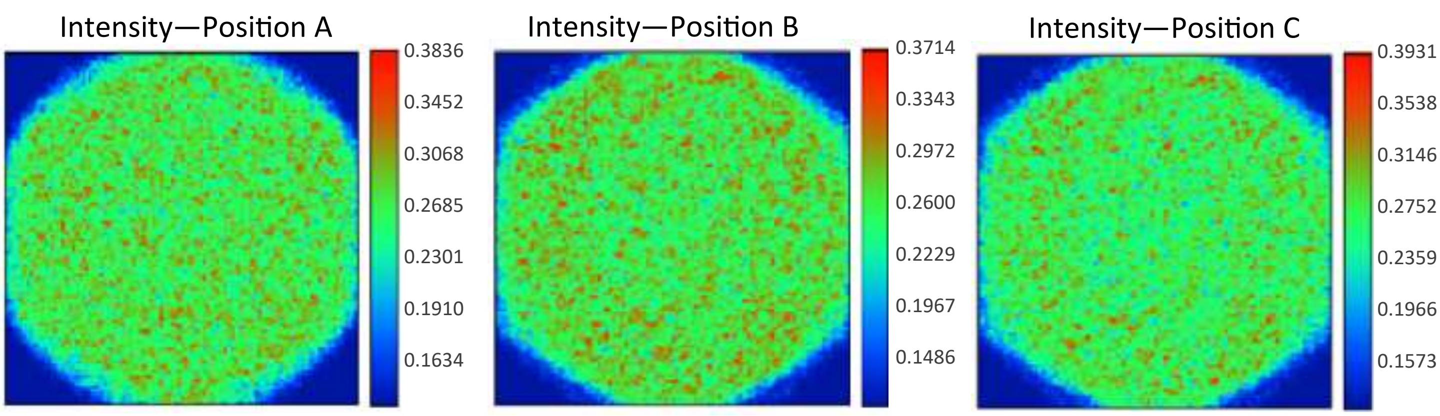
They were confident that Sciencetech's in-house R&D department was up to the task of meeting all their technical requirements.

Phase 1: Design—Optical

Our customer presented us with a multi-faceted design challenge. How do you make a highly uniform and intense light source with a large target area, specific spectral match and a divergence angle approaching that of the sun?

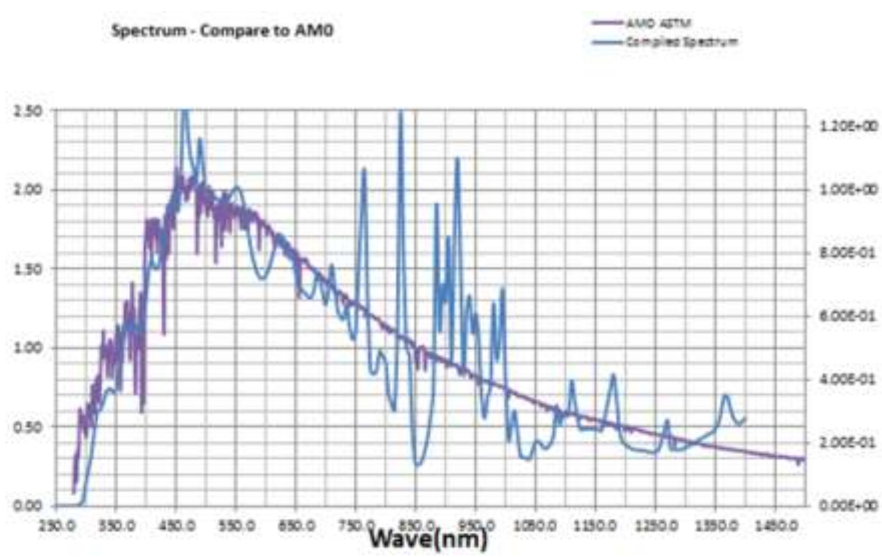
Using our expertise in optical modeling and years of experience building xenon short arc lamp-based light sources and solar simulators, Sciencetech took up the challenge.

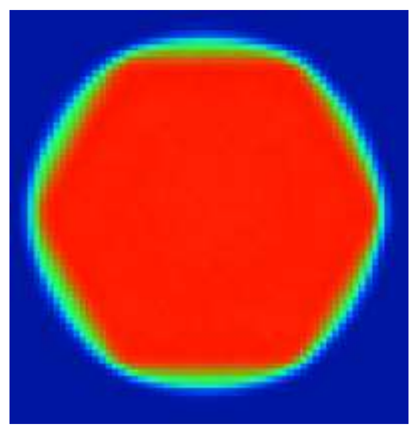
During the design process a combination of optical modeling and mathematical analysis was used.



Above: Uniformity simulation at 3 widely separated distances in the beam path.

Below: Spectral match simulation using filter design and lamp output spectrum





Above: Irradiance simulation at proposed target plane

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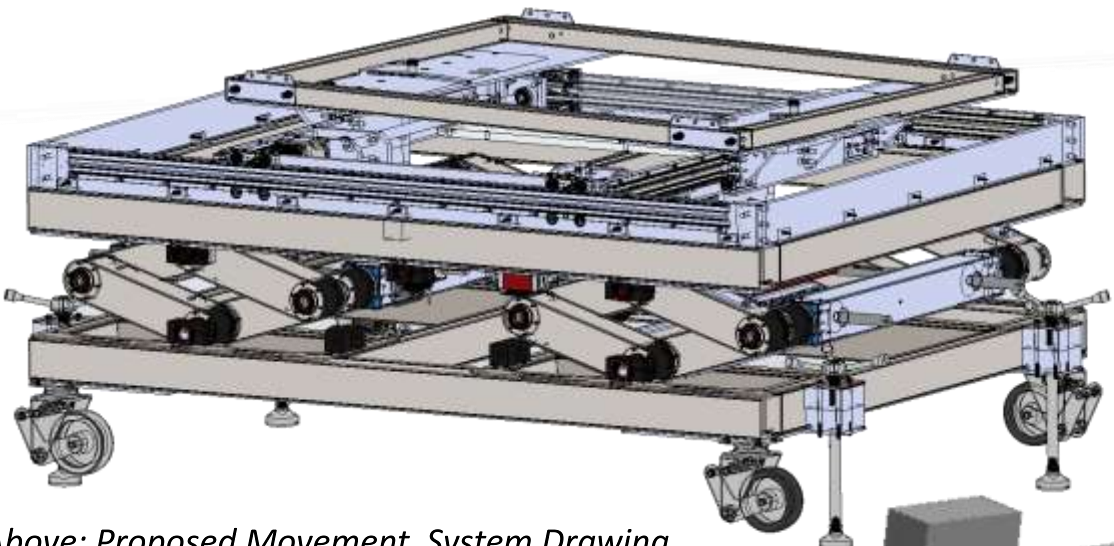
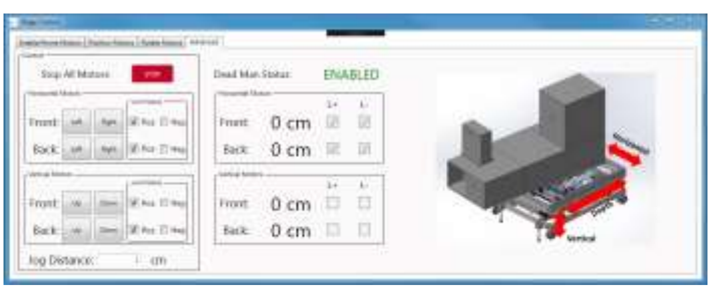
Phase 1: Design—Mechanical

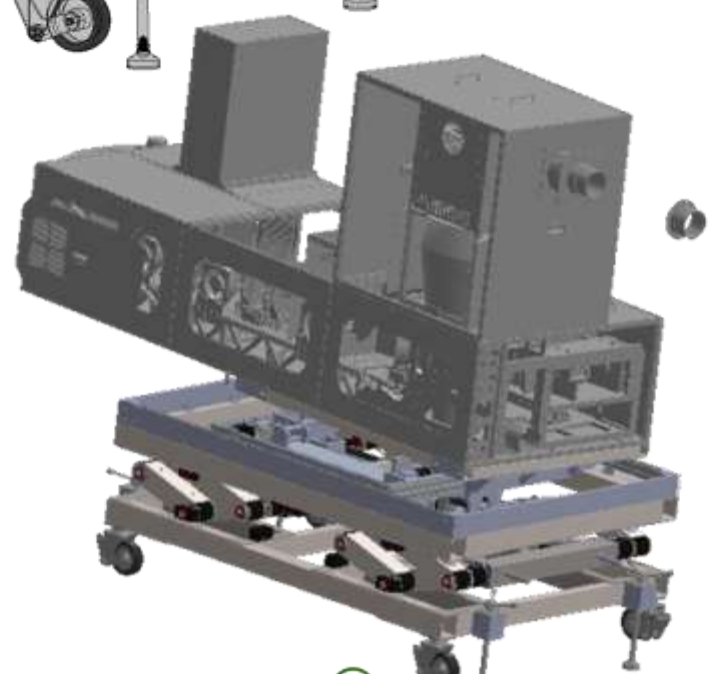
Our customer required automated motion of the entire solar simulator in 5 axes—X, Y, and Z, as well as 2 axes of rotation. Additionally, the entire system needed to operate inside an ISO7 cleanroom, necessitating isolation of the solar simulator's air cooling system.

Sciencetech designed an automated mechanical stage and custom software to meet these automation goals, and provided a special cooling design, instrument components, and housing design to meet these needs.



Above: Proposed Movement System Drawing





Above: Proposed Software

Right: Proposed Enclosure Model

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Phase 2: Build

All components were procured and assembled at Sciencetech's London Ontario facility. The motorized movement system was built and tested and its software was created in-house. The solar simulator was built and tested in the facility.

Frequent contact with the customer's team allowed Sciencetech's engineers to make modifications to the design to ensure a better transition to the customer, and to help the customer gain confidence in the capabilities of the device they ordered.

The movement system, housing, software, and optical elements were completed according to the customer's specifications, and the completed instrument moved on to testing.

Above: Final Complete Build (Access Panels Open, Attenuation System Removed)

Above: Final Movement System Build

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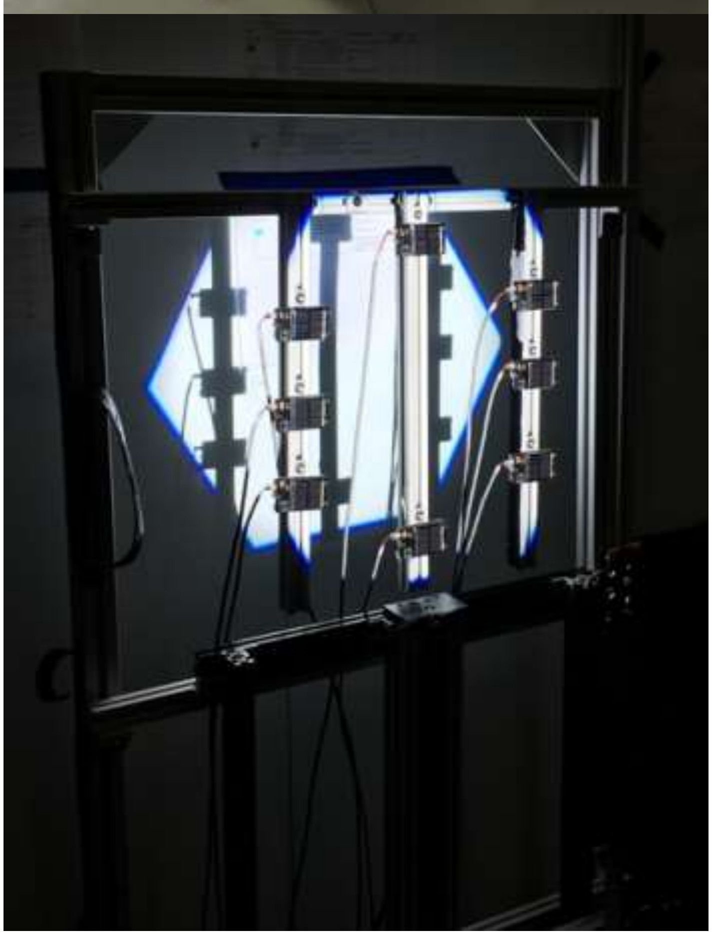
Phase 3: Test



Top left: Early alignment test in progress
Bottom left: Uniformity test in progress
Below: Custom testing instrument

The final acceptance test was created in conjunction with the customer's engineers, ensuring the instrument would operate within the parameters they needed the moment the device left Sciencetech.

Dedicated testing instrumentation was designed and manufactured to prove our designs in the testing phase.

At this point the final integration of hardware and software was completed, and the device passed acceptance testing with full approval of the end user.

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Results—Optical

With the completion of testing, the customer was able to achieve their key specifications in a several areas.

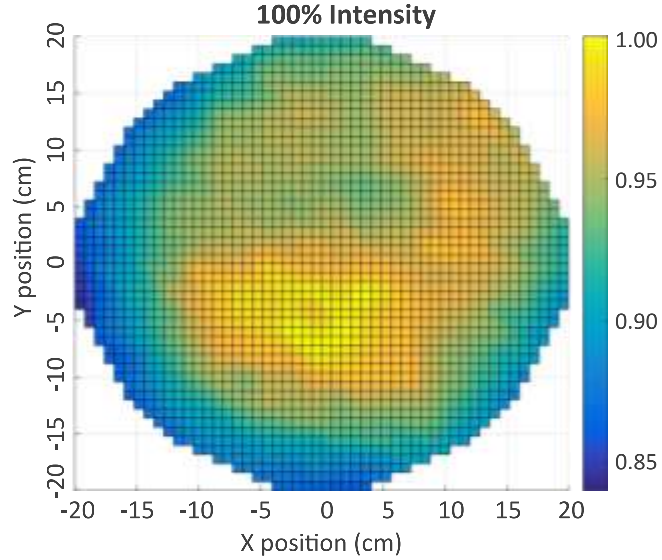
Sciencetech tested the spatial non-uniformity with multiple configurations of the attenuation system. The attenuation system maintained the spatial non-uniformity.

Collimation Full Angle:	90% power within 0.69°
Aperture Size:	40 mm
Target Size:	33 cm diameter
Spatial Non-uniformity:	2.95% (Class A)
Temporal Instability:	1.5% (Class A)
Intensity:	1366 W/m^2 (AM0 spectral match)
Attenuated Intensity (Minimum):	1.366W/m^2
Output Direction:	Horizontal

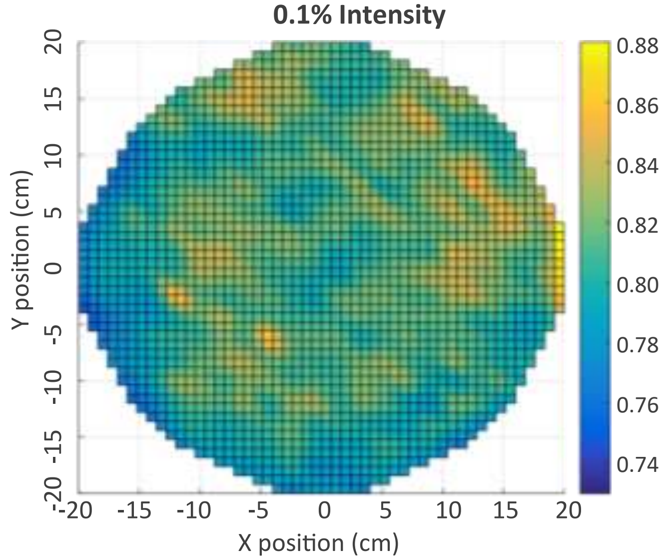
The xenon lamp spectrum was modified using an air mass filter to meet AM0 spectral matching criteria.

The temporal instability was measured over short, medium and long-term periods and met Class A specifications.

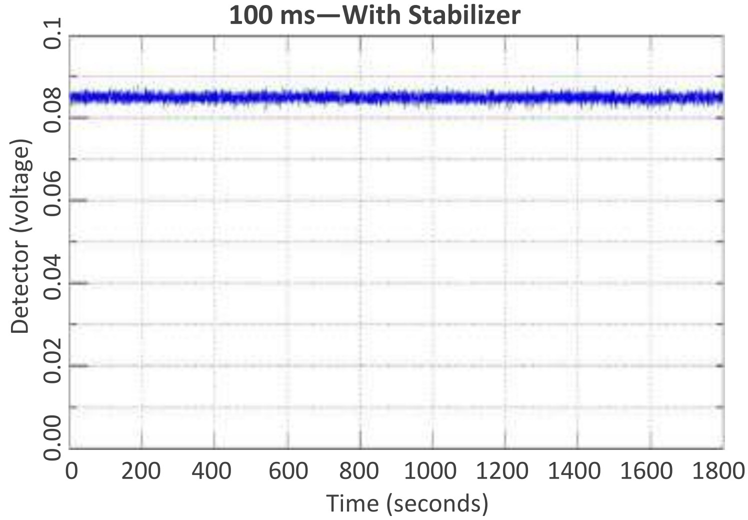
40 mm Aperture Spatial Non-uniformity Map, 100% Intensity



40 mm Aperture Spatial Non-uniformity Map, 0.1% Intensity



30 Minute Test—Data Rate 1kHz—Data Integration 100 ms—With Stabilizer



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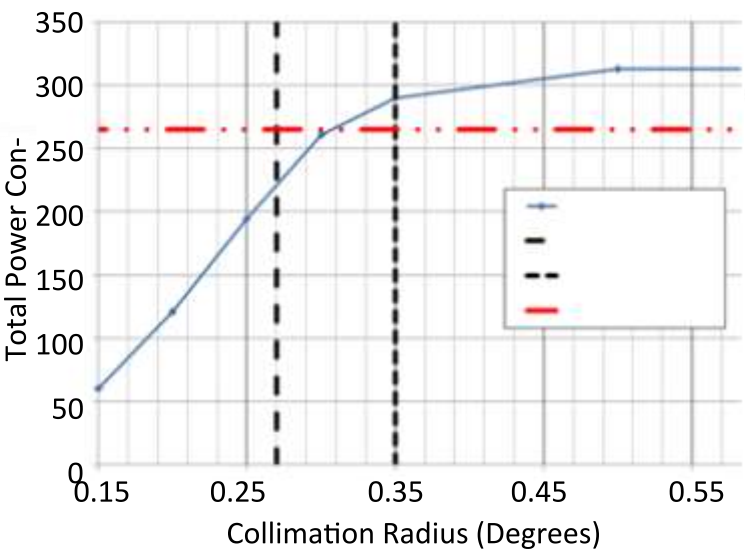
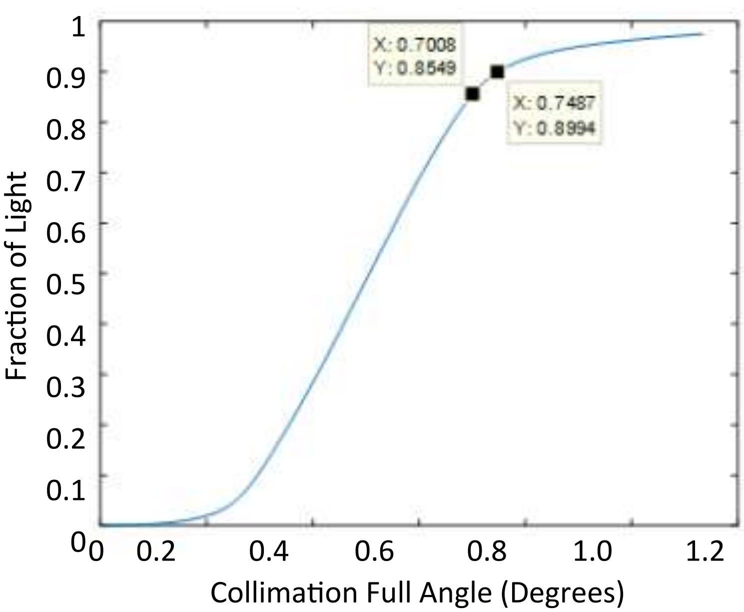
Results—Optical

With the completion of testing, the customer was able to achieve their key specifications in a several areas.

Measured radiance was very similar to design radiance:

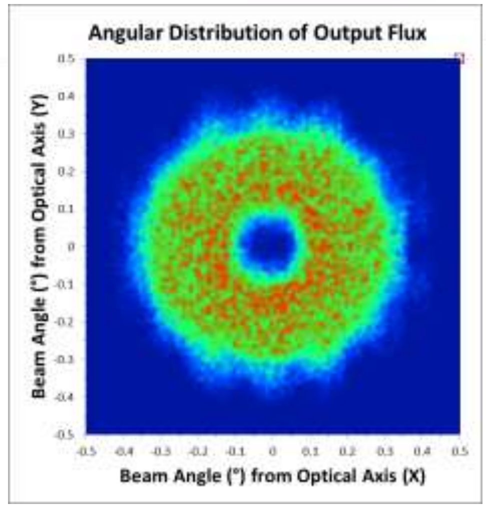


Above: Radiance design expectation with respect to collimation angle
Below: Radiance measurement with respect to collimation angle

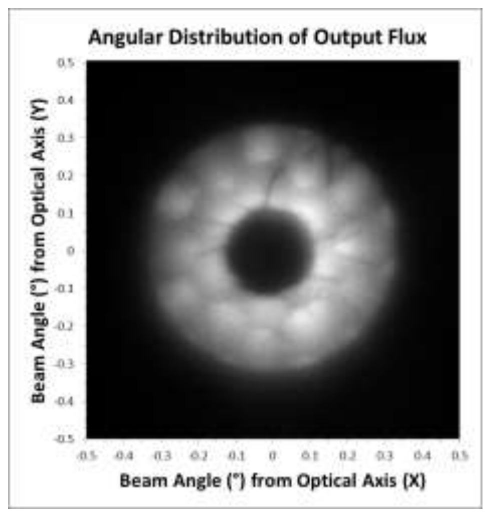


We achieved a high degree of collimation with 90% power within 0.69° full angle. At the sacrifice of collimation, increasing the lens aperture size used could increase other factors, like uniformity.

The high collimation provided an equally uniform spot at several distances from the solar simulator output:



Above: Radiance distribution design
Below: Radiance distribution measurement



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Results—Mechanical

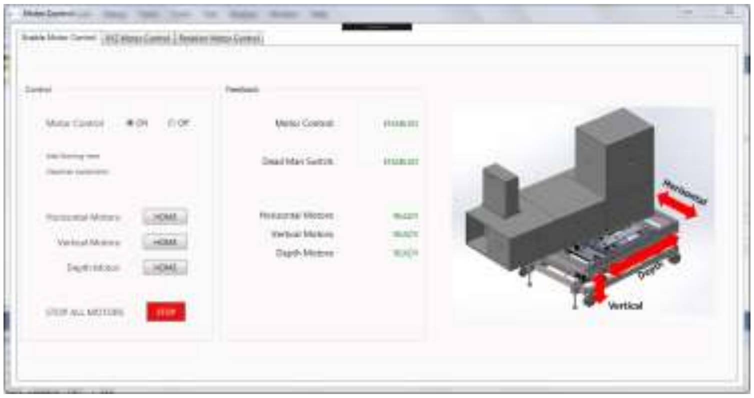
The automated movement system met the required specifications for all 5 axes of movement and a software GUI was included for easy control.

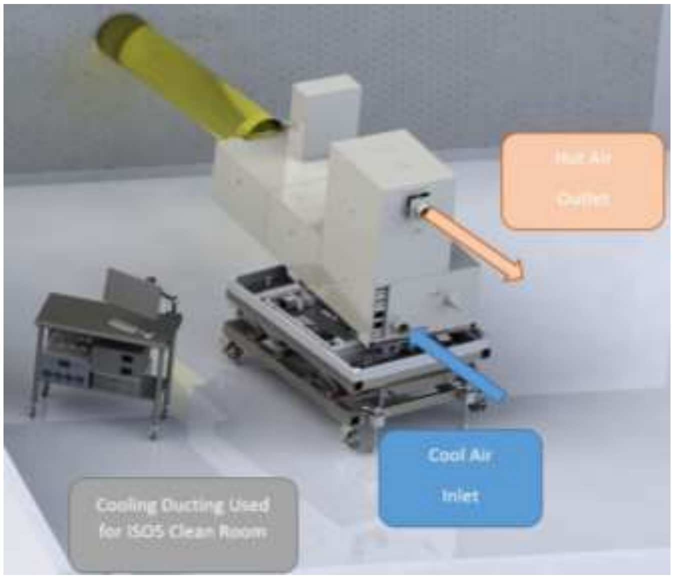
The entire system was sealed for use in an ISO7 cleanroom, including an isolated air cooling system .

After meeting the customer's requirements, the system was put into use in a top aerospace facility.

Parameter	Requirement	Result
G1 – Z-Axis	MS moves SS ±200 mm up and down about 1.5 m nominal optical axis height.	Maximum height = 1.70 m Minimum height = 1.26 m Pass
G2 – Y-Axis	MS moves SS ±300 mm back and forth in nominal direction of optical axis.	Maximum +ΔY = 300 mm Maximum -ΔY = 300 mm Pass
G3 – X-Axis	MS moves SS ±300 mm side to side in horizontal direction perpendicular to nominal direction of optical axis.	Maximum +ΔX = 300 mm Maximum -ΔX= 300 mm Pass
G4 – θ-Axis	MS moves SS ±15° about vertical z-axis.	Maximum +Δθ > 15° Maximum -Δθ > 15° Pass
G5 – ϕ-Axis	MS moves SS ±12° about horizontal y-axis.	Maximum +Δϕ = 12° Maximum -Δϕ = 12° Pass*

*Angles beyond ±12° are not recommended due to the extreme tilt imparted to the solar simulator.





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