German Aerospace Center
Institute of Solar Research

A High-Resolution Optical Measurement System for Rapid Acquisition of Radiation Flux Density Maps

Martin Thelen, Christian Raeder, Christian Willsch, Gerd Dibowski

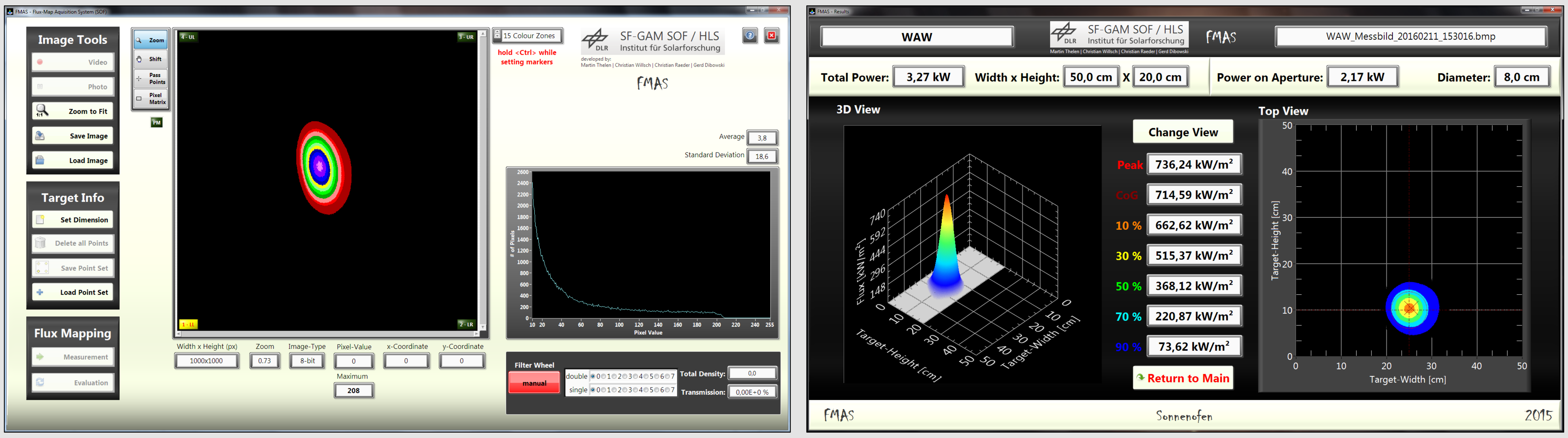

Figure 1: User interface with color illustration of a raw image (left) and representation of the flux density distribution and the radiation power (right)

The Development of FMAS

The radiation flux in [kW] and the flux density in [kW/m²] of concentrated solar radiation in the DLR facilities solar furnace (SOF) and High-Flux Solar Simulator (HFSS) were determined with the camera-based measuring system FATMES (Flux and Temperature Measurement System). The computer architecture used required a new development because of the increasing number of failed components. The resulting measurement system FMAS (Flux Mapping Acquisition System) uses hardware on the prior art and is compatible with modern operating systems due to the implementation with LabVIEW. The duration of an analysis is reduced by a factor 60 compared to FATMES. The new system is no longer linked to the facilities solar furnace and High-Flux Solar Simulator and enables measurements at any desired location. The data can be exported and all algorithms for digital image processing are completely transparent. The accuracy of FMAS is ± 3%. The measured deviations from FATMES are at least 2% higher.

Measuring Principle

Figure 2 illustrates the basic construction of an optical measuring flux density measurement. A camera measures a two-dimensional gray-scale image, which is scaled by means of a flux density sensor. The sensor supplies the flux density in a defined area of the camera image.

The area which is irradiated with concentrated light has lambertian properties with $\Theta_{max} \approx 30°$.

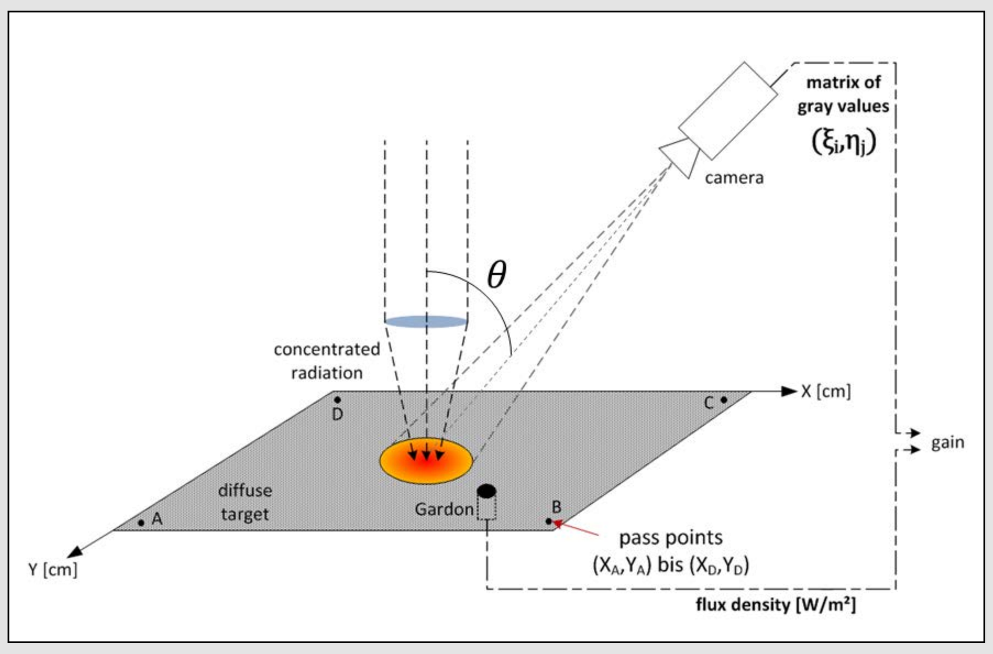

Figure 2: Sketch of an optical flux map acquisition with camera and radiometer.

Comparative Measurements

Measurements with both systems in the solar furnace and High-Flux Solar Simulator show both the influence of the image resolution and the image correction on the accuracy. The difference between the measurement systems FATMES and FMAS is the resolution of the cameras used. FATMES compatible measuring cameras provided images with only 512 x 512 pixels. The chip of the FMAS camera has 1 million pixels. Figure 3 shows the effects of different image resolutions.

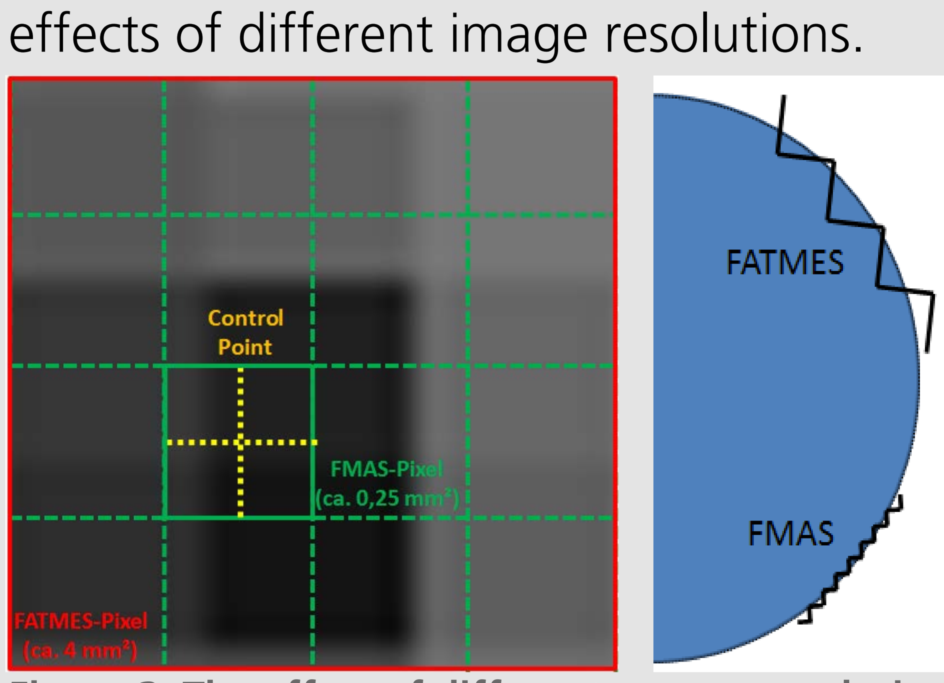

Figure 3: The effect of different camera resolutions in comparison

The more pixels the camera has, the more accurate is the flux density distribution represented by the measurement. Linked to this fact is the influence of the image resolution on correction mechanisms such as projective image rectification with four control points.
From Figure 3 it is evident that high-resolution FMAS-images allow more accurate control point markers.
This results in an error of 2.8% with FATMES (Figure 4). The FMAS images are negligibly influenced by the rectification.

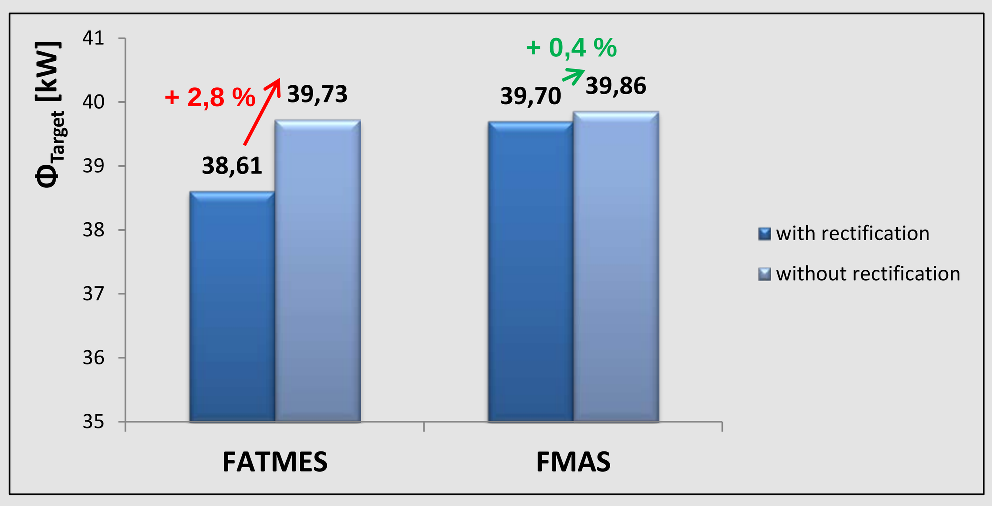

Figure 4: Benchmarking FATMES vs. FMAS with and without error influence by image rectification

In the High-Flux Solar Simulator, the deviations between the calculated optical power and the FMAS results after five independent measurements amount to a minimum of 0.2% and a maximum of 2.1%.

FMAS Picture Processing

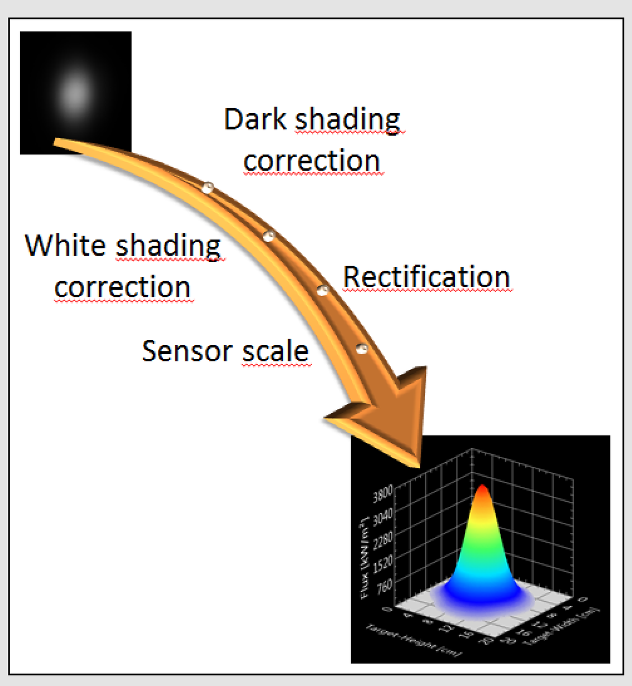

Figure 5: Flow of the image correction of the new measuring system FMAS

Contact: **Institute of Solar Research** | Institute of Solar Research | Facilities and Solar Materials | Linder Höhe | 51147 Köln | Germany
Dipl.-Ing. (FH) Martin Thelen | Phone: +49 2203/601 3421| email: martin.thelen@dlr.de
Dr. Christian Raeder | Phone: +49 2203/601 2379 | email: christian.raeder@dlr.de

DLR Deutsches Zentrum für Luft- und Raumfahrt