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TNO Optical system design and analysis for fusion diagnostics

Ad Verlaan[1], Peter Giesen[1], Pascal van Grol[1], James Day[1], Jan de Vreugd[1], Matthew Smiley[1], Josh Vasquez[1], Mike LeSher[1]

[1]TNO, Delft
Ad.verlaan@tno.nl
[2]General Atomics, San Diego CA

Optical systems for fusion diagnostics are complex instruments due to the combination of extreme environmental conditions, and the performance requirements. A harsh Tokamak or Stellarator environment comprises a mixture of vacuum operation, with heat load, nuclear radiation, and magnetic field that all can vary over time or between modes of operation. Scientific operation requires measurement accuracy, which translates in to imaging resolution, collection aperture, stray light levels and stability of the system.
In the recent past TNO participated in the design and realization of various optical systems like endoscopes and spectrometers for diagnostic systems to be used of different facilities like JET, ASDEX, W7X and ITER. (TNO contribution vary per project). Designs often are initiated on the basis of analogy to other systems and then are adapted to the specific needs of the project. Key success factors of this process are thorough understanding of optics, thermal mechanical design and a combined performance analysis. TNO has developed a method for full system optical performance analysis where the complex influences introduced by its environment are incorporated in an accurate, and repeatable manner with built-in verifications. This Structural Thermal Optical Performance (STOP) Analysis provides a direct and reproducible link between the structural thermal analysis for combined load cases comprising nuclear heating, cooling water pressure and temperature, gravity and mounting stresses (in Ansys) and the associated changes of the optical performance, including imaging quality and alignment (in Zemax OpticStudio). This enables assessing the impact of a variety of load cases on optical performance.
This new analysis process is demonstrated on the Upper port Wide Angle Viewing System in the ITER tokamak as well as on the telescopes and UV1 spectrometer of the Sentinel 5 instrument in the EUMETSAT environment monitoring satellite. Here up to 80 different operational load cases are analyzed to accurately assess the optical performance during the various phases of the system operation.

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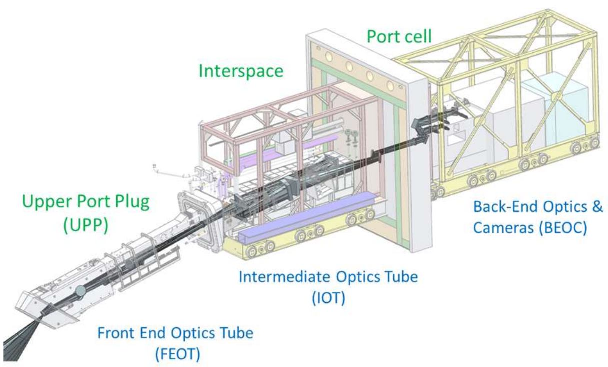
References

[1] C. Lasnier, “ITER Upper Port Wide Angle Viewing System Requirements” project report 304243-S00001a, 2017
[2] A. Ushakov, A. Rijfers, A. Verlaan et al. “ITER UWAVS first mirror plasma cleaning prototype development”, 29th Symposium on Fusion Technology SOFT-2016, Prague Chech Republic 2016.
[3] Verlaan, A., Fusion Engineering and Design (2018), https://doi.org/10.1016/j.fusengdes.2018.04.043
[4] J. Cantarini, D. Hildebrandt, R. König, F. Klinkhamer, K. Moddemeijer, W. Vliegenthart, and R. Wolf, “Optical design study of an infrared visible viewing system for wendelstein 7-X divertor observation and control,” Rev. Sci. Instrum. 79(10), 10F513 (2008). https://doi.org/10.1063/1.2979880
[5] E. Gauthier, H. Roche, E. Thomas, S. Droineau, B. Bertrand, J.B. Migozzi, W. Vliegenthart, L. Dague, P. Andrew, T. Tiscornia, D. Sands, ITER-like wide-angle infrared thermography and visible observation diagnostic using reflective optics, Fusion Engineering and Design, 82-5–14(2007) 1335-1340



System for visible light and IR viewing.