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3D Machine Description of Fusion Devices

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Introduction

The ASDEX Upgrade (AUG) in-vessel geometry, including diagnostic front ends, is described to a high level of detail in the construction drawings created by the CAD system MEDUSA. However, The handling of these complex 3D-CAD models is very time consuming and requires access to the drawing database and knowledge of its structure and interlinks. In practice, this limits its usability as a visualisation tool. However, since an increasing number of 2D imaging diagnostics as well as modelling codes require 3D data visualisation, a general and easy-to-use interface between the 3D-CAD model and external applications is highly desirable. Recently, such a tool has been developed at ASDEX Upgrade. The complex 3D geometry information is exported from the CAD construction drawings as a data set consisting of as many as 20.000.000 triangles. This data set, rendered by modern graphics cards within only a few seconds, is displayed together with the geometry of different diagnostics, magnetic flux surfaces or plasma profiles computed by 3D plasma codes, like EMC3-Eirene[1, 2, 3]. Several examples of application are discussed below.

Working principle

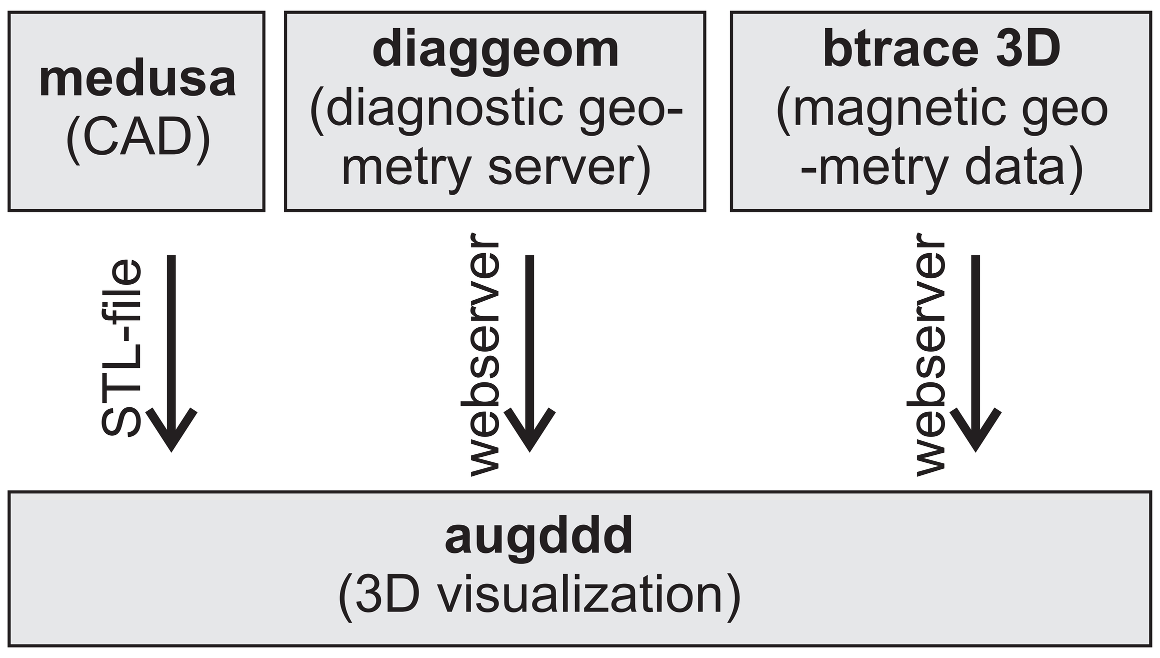

Figure 2: Working principle augddd

advantages	disadvantages
-extremely simple	-no information about the surface materials
-provided by almost any CAD software	-no information about the relationship between triangles
-no further (time consuming) triangulation required	

Table 1: Features STL

Applications

Overplotting 2D images recorded by cameras in the visible or infrared range allows an accurate spatial calibration of the viewing geometry, hardly possible with mechanical techniques inside the vacuum vessel. This accurate calibration is of high practical as well as scientific importance.

Hot spot localisation

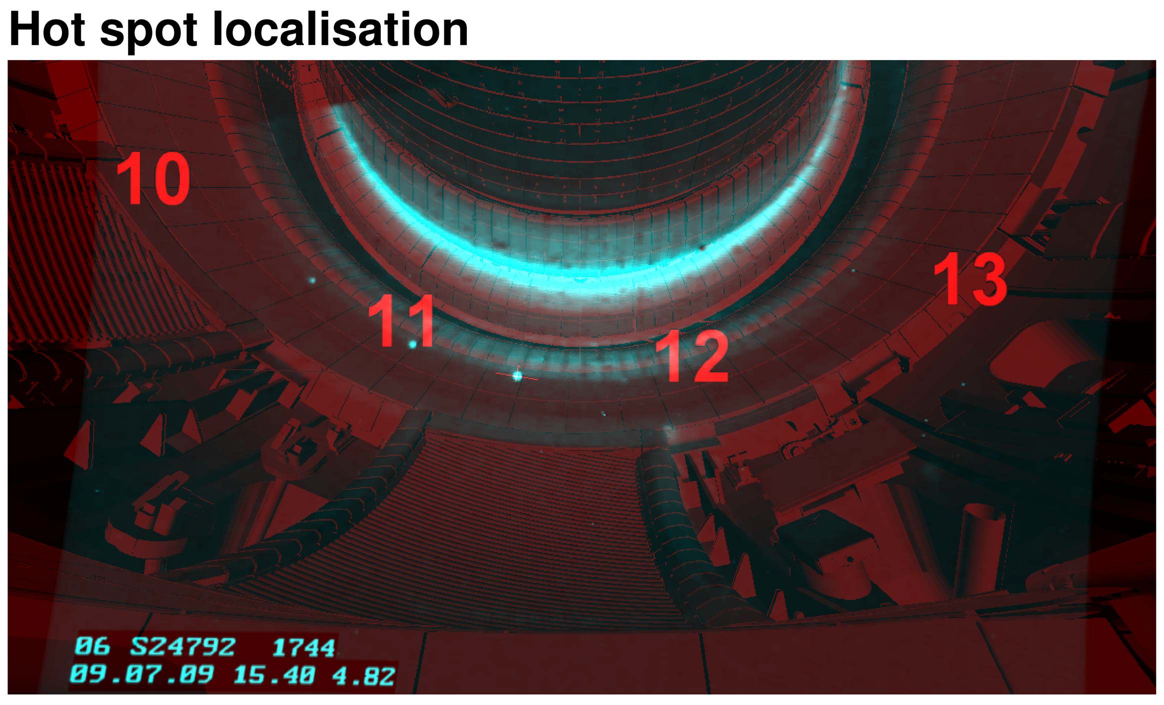

Figure 3: Hot spots provoked by extraordinary high heat fluxes in the vessel can be localised accurately

It allows, for example, the accurate localisation of hot spots (cf. Fig. 3) on plasma facing components during experimental operation and thus a better control of the operational parameters.

Tomography

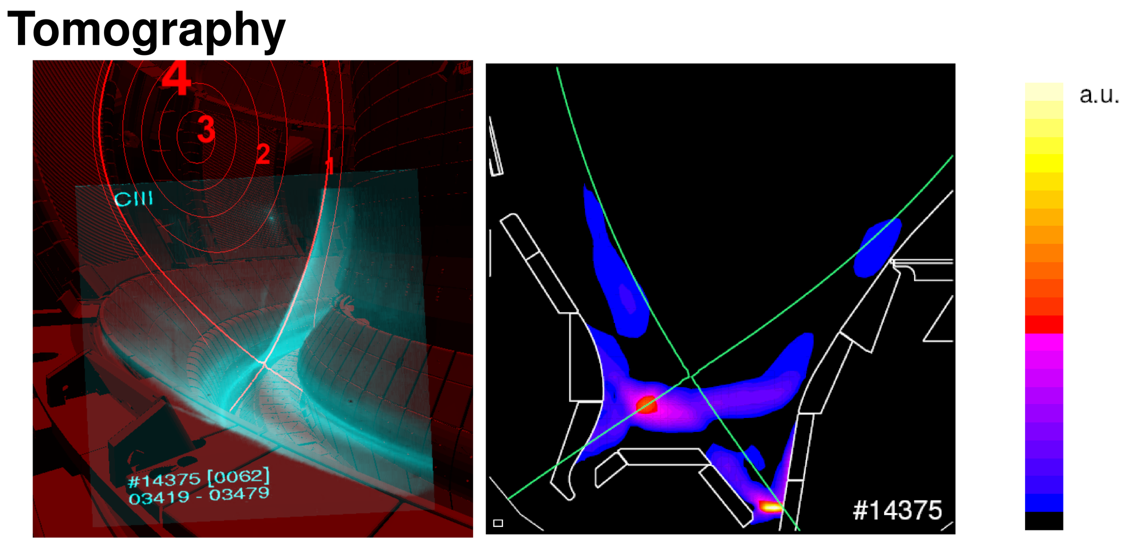

Figure 4: Tomography

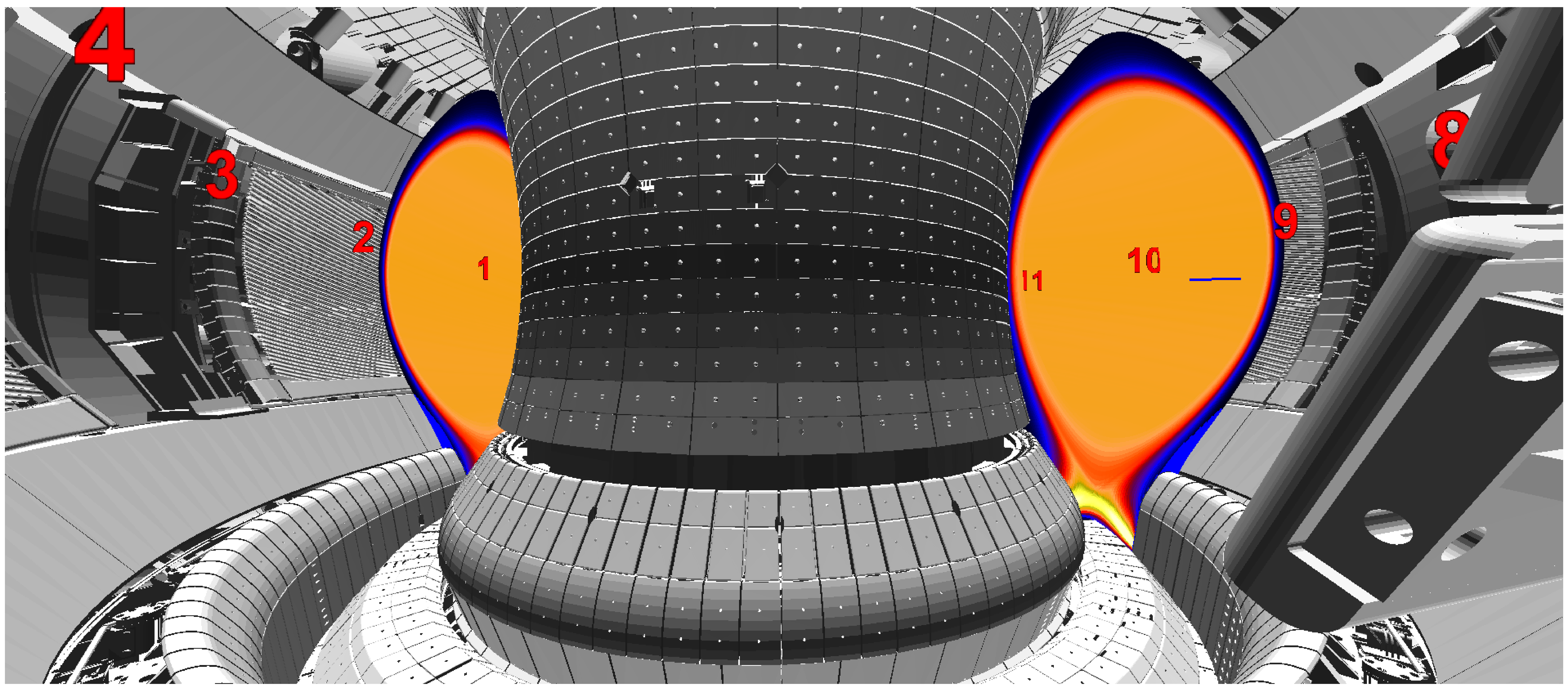

Figure 1: Virtual view into the AUG vacuum vessel together with the plasma density computed with EMC3-Eirene

The calibration is also essential when performing tomography. At AUG this technique is used to determine the poloidal cross section of an emission profile from a 2D camera image, which is useful for impurity transport studies. By assuming toroidal symmetry Gafert [4] and Fuchs [5] performed a tomography computation for the emission of radiation at 465 nm (C III) as shown in Fig. 4.

Wall rasterisation

For many applications the structure of the entire vessel is not required but only the 3D structure of the inner wall. By means of a rasterization method a strongly reduced data set for the 3D first wall can be generated.

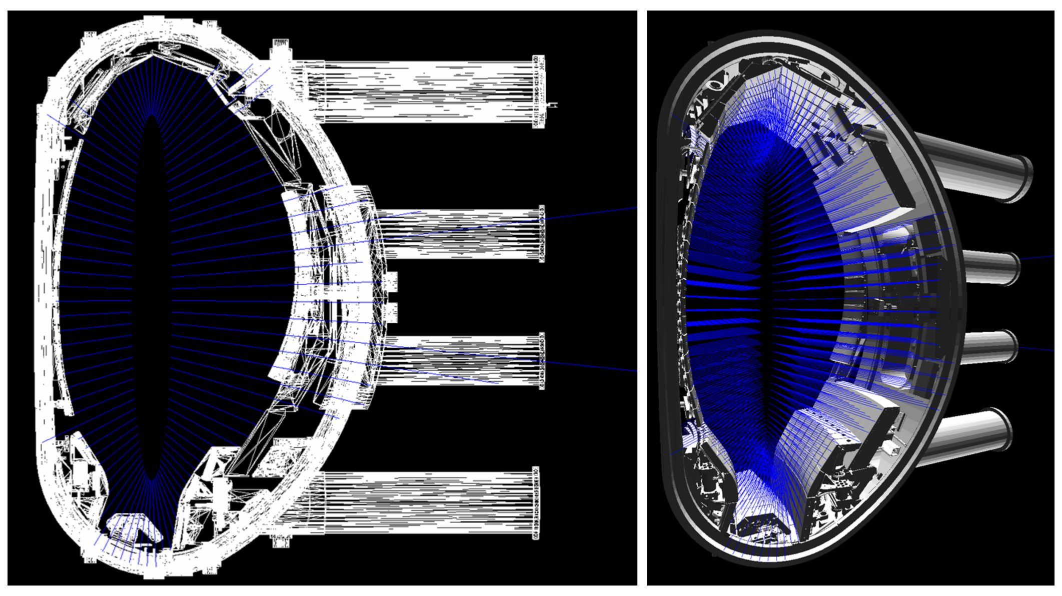

Figure 5: Rasterization of the inner AUG wall

By means of the ASCOT code [6] power deposition pattern caused by fast particles can be computed.

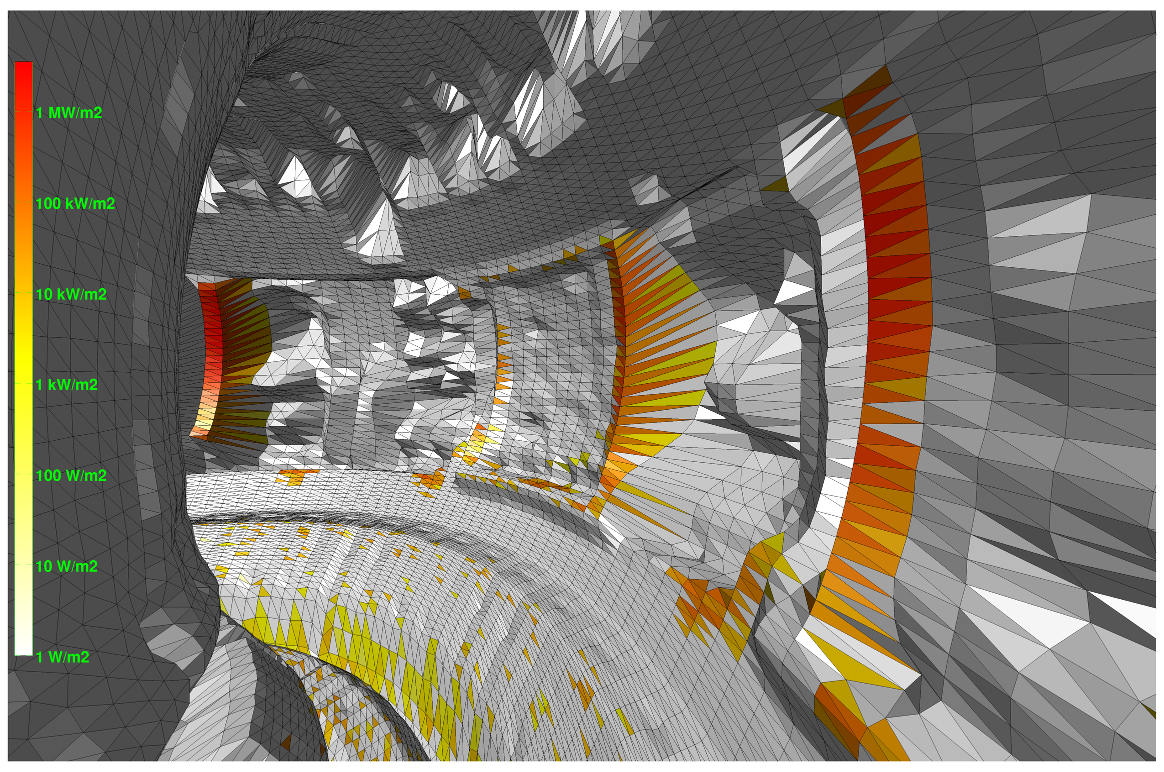

Figure 6: Power losses from fast particles caused by 2.5 MW NBI.

Reconstruction of dust/pellet trajectories

Certain plasma volumes in AUG are observed simultaneously by two cameras with different viewing angles (cf. Fig. 7) enabling the reconstruction of the 3D trajectories of pellets or other strongly emitting objects like dust.

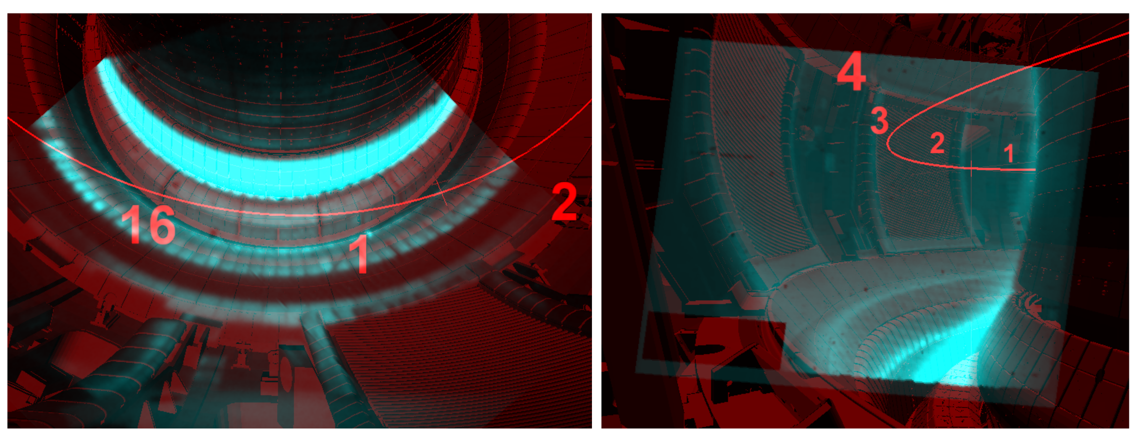

Figure 7: Two different views observing the same plasma volume

3D plasma simulation / virtual diagnostics

In addition to the vessel and diagnostics geometry, solutions of 3D plasma simulation codes can be displayed (cf. Fig. 1). With a few mouse clicks profiles of computed plasma parameters can be determined along a line of sight of a certain optical diagnostics. This 'virtual diagnostics' can then be compared to the experimental one (Fig. 8).

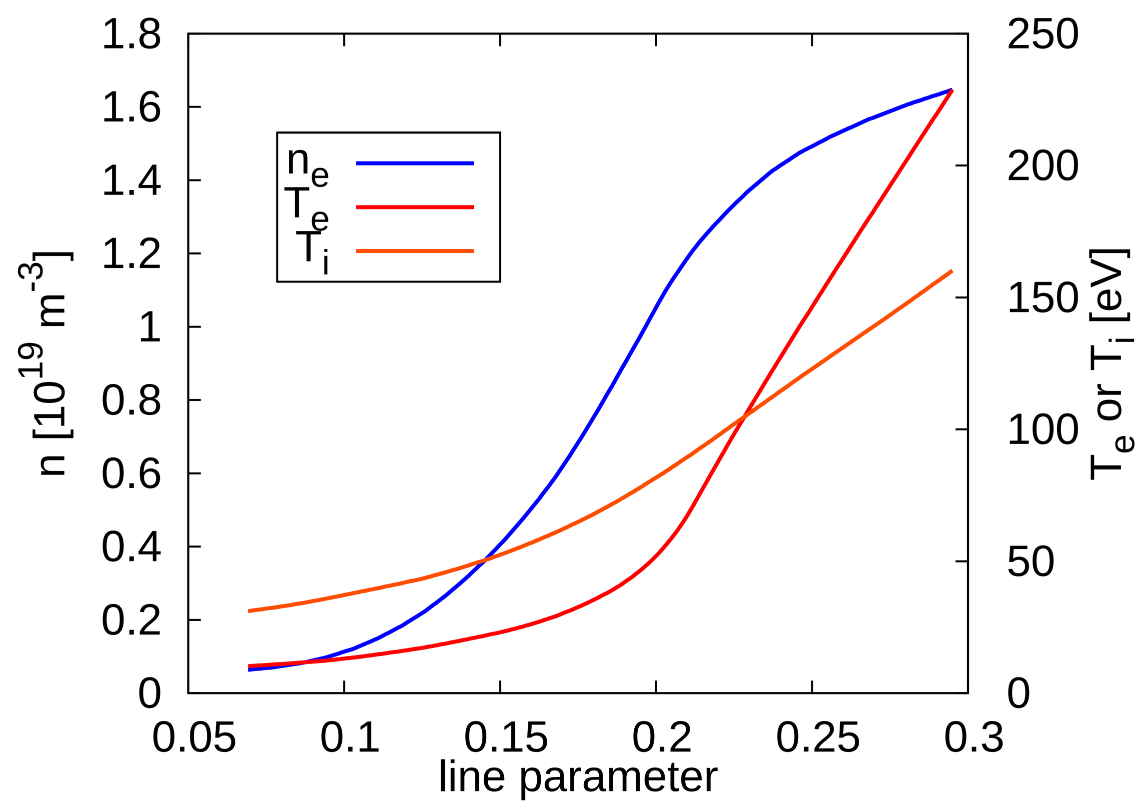

Figure 8: Virtual diagnostics

Collision detection

The viewer can also be used to optimise the viewing geometry of new diagnostics and to detect conflicts between new in-vessel components and existing diagnostics in an early phase of component implementation. For example, this technique was applied during the design of the ELM control coils in AUG.

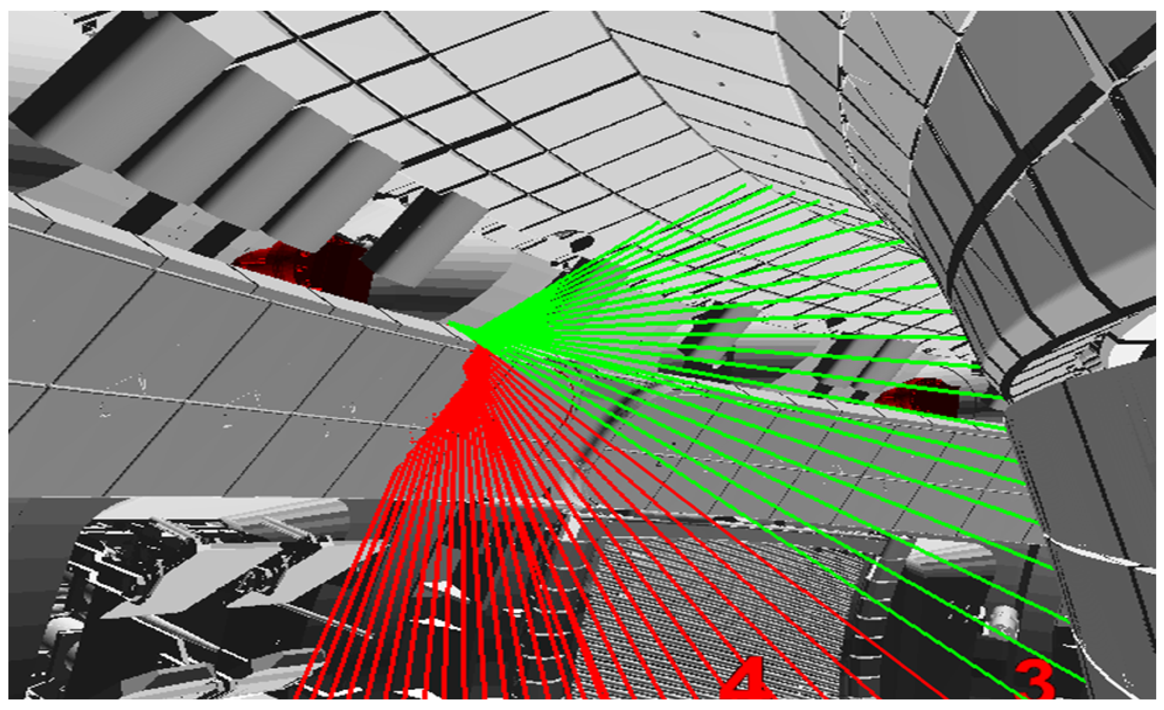

Figure 9: Collision detection for lines of sight

Summary

A generally available and easy-to-use software tool to visualise the complete 3D vessel structure of ASDEX Upgrade, diagnostic and magnetic geometry data and solutions of 3D plasma simulation codes was developed. By overplotting the 2D camera images an accurate calibration of the viewing geometry is achieved. This calibration allows for example an accurate and easy localisation of hot spots on plasma facing components, generation of input files for tomography algorithms and the reconstruction of dust or pellet trajectories. The tool furthermore can be used to compare the data of EMC3-Eirene simulations with experimental data and to test the compatibility of lines of sight with newly installed in vessel components. By means of a wall rasterisation method a strongly reduced data set can be generated, which can be used e.g. for fast particle deposition simulations with ASCOT.

References

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