EFDA Task Force
Integrated Tokamak Modelling
EUROPEAN FUSION DEVELOPMENT AGREEMENT

Simulation of MSE spectra from predictive fusion plasma simulations

A. Dinklage[1] , R. Fischer[1] , A. Kus[1] , M. Reich[1] , R. Reimer[1] , R. Wolf[1], C. Konz[1], D. Coster[1] and R. Coelho[2]

[1] Max-Planck-Institut für Plasmaphysik, EURATOM Association, Garching, Greifswald, *Germany*
[2] Integrated Tokamak Modelling Task Force, Instituto de Plasmas e Fusão Nuclear, Associação EURATOM/IST, Lisbon, *Portugal*

Introduction

Synthetic diagnostics (SD): tool to predict signals from plasma modeling elements in integrated fusion data analysis, simulation of diagnostics capabilities.

By developing a SD one gains:

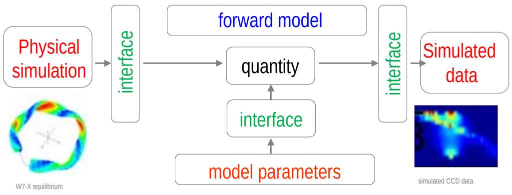
- access to the simulation of experimental data with "arbitrary" complexity of the embedding physics, which is difficult to extract with conventional data analysis codes
- assessment of measuring capabilities of present diagnostic
- assistance to the development of future concept designs.

This pilot project is to assess technical feasibility and capabilities of forward models as used in Bayesian analyses (IDA [1]) as synthetic diagnostics.

FOCUS of ITM-TF during 2010 : Forward modeling of MSE diagnostic (WP10-DIA-05-01-03/IPP) on work-programme of the Experimentalist and Diagnosticians Resource Group (EDRG).

Scope

Simulation of MSE spectra from predictive plasma simulations to provide a validated tool for physics design.



Conceptual Approach

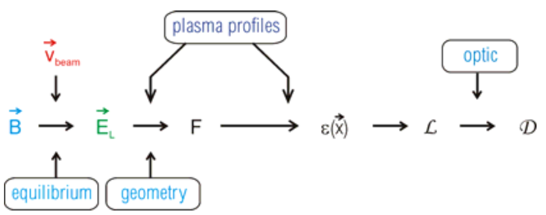
Forward modeling (as for Integrated Data Analysis [1]) – idea: employ the same (validated) software modules for simulation, analysis and design optimization [2].

Development Approach

Transfer physical forward simulations to software modules. Interfaces to comply with functional requirements – CPOs assessed and to be incorporated with feed-back for adoptions

Guided by software development standard (ISO9126).

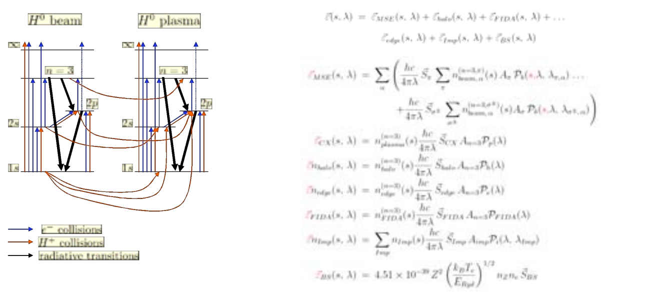
Forward Model



Physical model and logical structure of interfaces

The detected signal is modeled from the emitted light from the plasma, detector optics geometry, sensitivity and transmission dependence on light polarization. The plasma parameters are provided by from predictive simulations [3]. Each 'block' represents a software module.

Forward Model Details



Model for Diagnostic Design

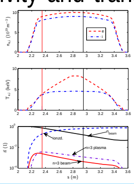
A coupled beam-plasma collisional radiative model simulates the population densities for MSE multiplet intensities and CX plasma emission. Phys. input: predictive profiles (n, T, Er, Z_{eff}) and equilibria.

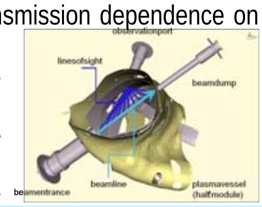
Signal model

The detected signal is modeled from the emitted light from the plasma, detector, optics geometry, sensitivity and transmission dependence on light polarization:

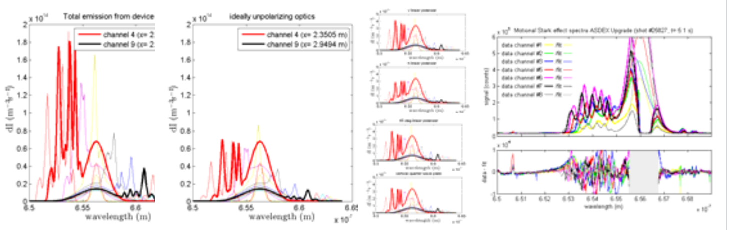
$$\mathcal{D}(\text{pixel}) = \varsigma(\text{pixel}) \times \Pi \times \ldots$$

$$\ldots \times \int_{A_p}\int_{\Omega} \frac{\Delta\mathcal{L}(\text{pixel}(\lambda))}{\Delta \text{pixel}} \cos\zeta \, dA_p \, d\Omega$$





Results and Model Validation



MSE spectra simulation for W7-X. *Fit of forward model to ASDEX Upgrade spectra.*

Validation of simulations: confidence in synthetic diagnostics

Simulations done for W7-X MSE proposal. Fit version of code applied to MSE spectra obtained from ASDEX –Upgrade [4].

Status and Outlook

Status:

- ✓ Requirement Analysis
- ✓ Technical specification (documentation not yet complete)
- ✓ Prototype simulations

Present Activities:

- Transfer code from MATLAB® to F90 (ITM compliance)
- Interface adoption (equilibrium/coreprof/mse CPOs for input ongoing, *Emission/Optics/Exp.data output CPO granularity to be pursued*)
- Implementation for running experiment (ASDEX Upgrade)

Outlook (2011-12):

- o Application of the concept on further diagnostics
- o Optimization studies for Wendelstein 7-X

[1] R. Fischer, A. Dinklage, Rev. Sci. Instrum. 75, 4237 (2004).
[2] H. Dreier, A. Dinklage, R. Fischer, et al., Rev. Sci. Instrum. 79, 10E712 (2008).
[3] Yu. Turkin, H. Maaßberg, C. Beidler, et al., Fusion Sci. Technol. 50, 387 (2006).
[4] R. Reimer, A. Dinklage, J. Geiger, et al., Contrib. Plasmaphys. 50, 731 (2010).

Funded within the EFDA Workprogramme 2010 (WP10-DIA-05-01-03/IPP).