

WPSA Enhancement Proposal on IR diagnostic

2021, March 18th

FROM RESEARCH TO INDUSTRY

RO: X. Courtois / L. Dubus

Commissariat à l'énergie atomique et aux énergies alternatives - www.cea.fr



INRODUCTION

CEA/IRFM has a long experience from the conception to the exploitation of IR diagnostics since beginning of Tore Supra (90's).

Fields of expertise:

- Design, manufacturing, commissioning, exploitation and maintenance of IR diagnostics
- Slides hereafter

=> proposal to participate to New Infrared Diagnostics development for protection and/or Physics studies for JT60SA

- Interpretation of IR measurements, T°C accuracy management, development Synthetic diagnostics to help in the interpretation of complex thermal scene.
- Next presentation MH. Aumeunier "WPSA Proposal on Temperature Measurement Enhancement" => proposal for Development of an integrated approach aiming to get more reliable optical measurement, currently applied to WEST, ASDEX-Upgrade and W7-X devices



For WEST machine, IRFM has done an intensive work during the last 8 years for the **development of 14 infrared views**, from a sub-millimeter IR-view up to wide angle view:

- Design of home-made IR cameras, endoscopes optics, data acquisition system (hardware + software), and real time processing of IR data (machine protection and plasma discharges optimization)
- □ Whole system commissioning in laboratory (calibration, optical characterisation,...) and in-situ
- **C** Exploitation and maintenance during the first 5 experimental campaigns of WEST.

In addition, IRFM is deeply involved in the conception of the IR Wide Angle Viewing System of ITER.

Cea Infrared views on DIVERTOR and ANTENNAS

5 endoscopes on WEST

Upper port endoscopes - 3 Lines of Sight / endoscope







exemples of IR endoscopes views







- □ C4 + C5 campaign ≈ 2500 pulses with 12 IR cam = 8 TByte data
- □ Good reliability: ≈1 % of pulses with IR data lost when required
- Real time monitoring routinely used
 - => 30% of pulses with LHCD and/or ICRH power controlled by IR temperature threshold saved some components, in particular LH/IC lateral protections or upper divertor cooling pipes.
- □ Example of physics analysis:

Estimation of heat flux deposition on Divertor based on IR measurement using surface temperature inversion method.





IR Wide Angle tangential view



1.5m length

✓ Mirrors based design✓ actively cooled

- Wide Angle view on 1/6 of the vessel
- **Optimized to operate at 1.7 or 4.3** μm -> 100 - 3000°C range
- IR WEST Camera : 512*640px 50 to 200 Hz depending on Integration Times
 - **Resolution 3 to 8 mm/pix** depending on the viewing angle and distance of the component

Real time data processing for power feedback control since mid-C4 -> real time protection of upper divertor, inner bumpers, baffle and upper ports





Wide Angle view

Boron Powder Dropper from upper port during pulse



Very High resolution IR view on WEST Divertor

20





Melting experiment with Very High resolution IR view



WPSA PPM Enhancement: IR Diagnostic



Fast Infrared camera

Dedicated to physics studies:

- Transient events thermal load Analysis e.g. Disruptions, ELMS, ...
- Analysis of synchrotron radiation during runaway electrons

Specifications

- InSb 80K detector
- 320 x 256 pixels
- 3 kHz full frame
- Up to 100 kHz in windowed mode
- 8 wavelengths in the 1.5-5µm bandwidth

Available for C7 campaign on Wide Angle view



cea

Diagnostic IR/Vis on ITER Equatorial Port Plug

IRFM is in charge of the design and prototyping of ITER equatorial port Wide Angle Viewing System (WAVS)

□ WAVS will provide real time measurements

of the **visible and IR emissions** from the divertor and the main chamber.

will contribute to Machine Protection, to plasma control and Physics

□ The diagnostic covers

- o 4 Equatorial Ports (EP#3, 9,12 & 17)
- 15 lines of sight in total (with IR & visible band for each)
- EP#12 available for first plasma (3 lines of sight)





Work plan proposal for WPSA PPM on IR Diagnostics

On the basis of experience in IR thermography diagnostics on actively cooled fusion devices, Carbon / Metals PFCs, IRFM may propose :

2021 (0.6 pm) : Participate to the scope studies

- \checkmark Assessment of the need
- ✓ Preliminary specifications

2022-25

Work plan to be defined depending on needs and allocated resources



FROM RESEARCH TO INDUSTRY

Thanks for your attention

Commissariat à l'énergie atomique et aux énergies alternatives - www.cea.fr