Real-time protection of the “ITER-like Wall at JET”

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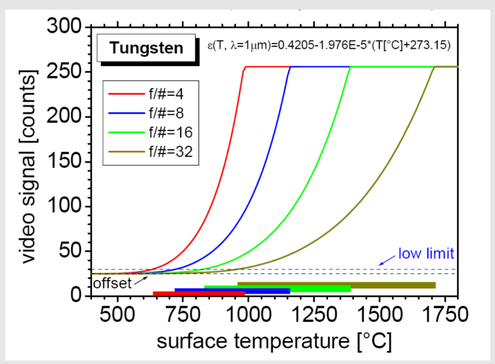
ABSTRACT

During the last JET tokamak shutdown a new ITER-Like Wall [1] has been installed using Tungsten and Beryllium materials. To ensure plasma facing component (PFC) integrity, the real-time protection of the wall has been upgraded through the “Protection for the ITER-like Wall” project (PIW). 13 CCD robust analogue cameras view the main areas of plasma wall interaction and regions of interest (ROI) are used for monitoring in real time the surface temperature of the PFCs. For each camera, ROIs will be set up pre-pulse and, during plasma operation, surface temperatures from these ROIs will be sent to the real time processing system for monitoring and preventing damages on PFCs by modifying the plasma parameters. Since 2005 a real time safety system for the monitoring of the PFCs is routinely used on the tokamak Tore Supra [2]. Based on this successful experience, a similar video and associated control system has been implemented at JET for the PIW. The overall system and the first results are presented in this poster.

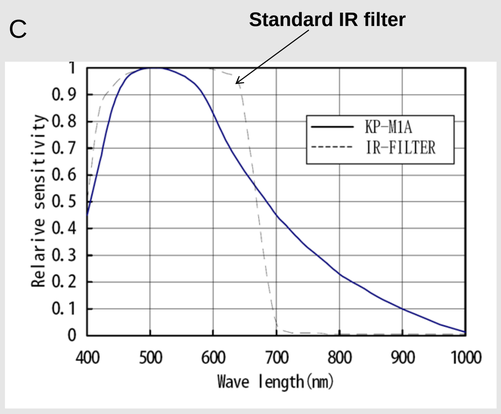
B/W CCD camera

- Already proven to work on JET
- Sensor: 752x576 pixels (8.72x6.52mm)
- Output: Analogue Video (non interlaced 752x288)
- 50 field per second
- External synchronisation
- Exposure time: 20ms
- Standard IR cut filter removed and replaced with 1µm NIR bandpass filter (Δλ : 50 nm)
- Temperature range from 750 to more than 1500 ° C

HITACHI KP-M1

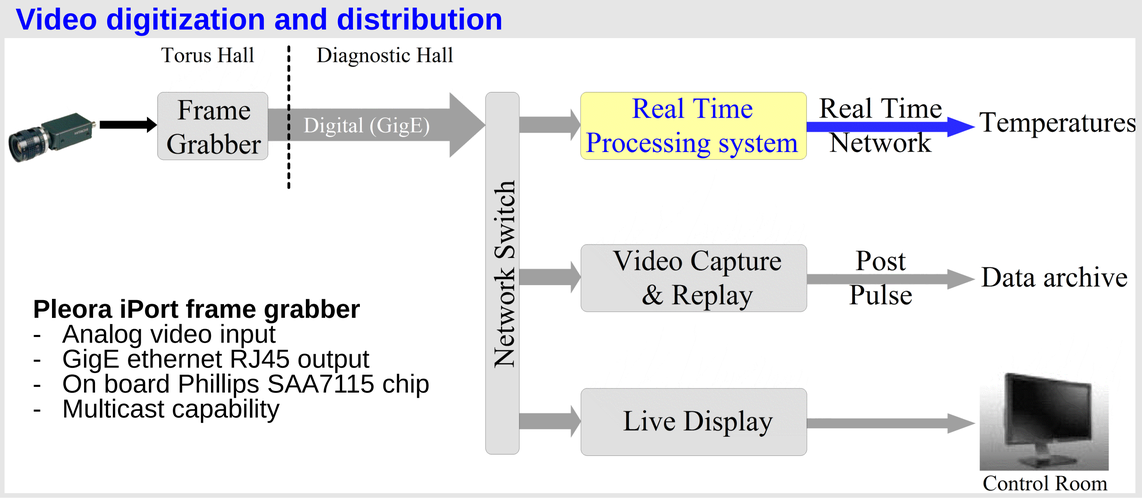


Hitachi camera dynamic range
NIR filter : 1µm , Δλ : 50 nm



Hitachi camera spectral response

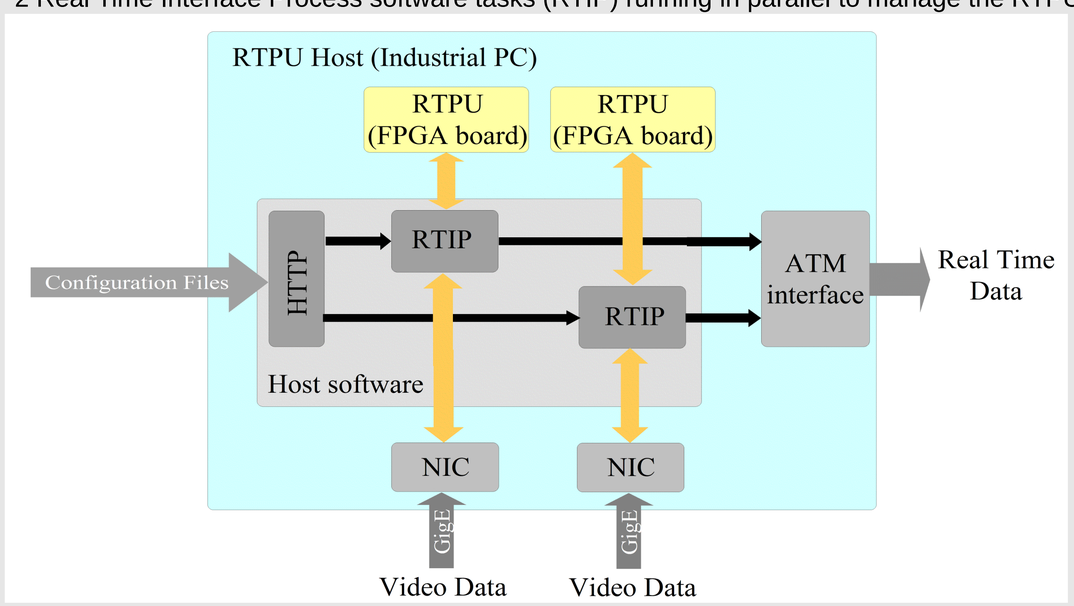
Video digitization and distribution



Pleora iPort frame grabber
- Analog video input
- GigE ethernet RJ45 output
- On board Phillips SAA7115 chip
- Multicast capability

Real Time Processing System (RTPS)

- 13 CCD cameras ➔ 13 video flux to be processed
- 2 Real Time Processing Units (RTPU) per PC (RTPU Host) ➔ 7 industrial PCs
- 2 Real Time Interface Process software tasks (RTIP) running in parallel to manage the RTPU



The real time data are sent to JET’s Vessel Thermal Map (VTM) [3]

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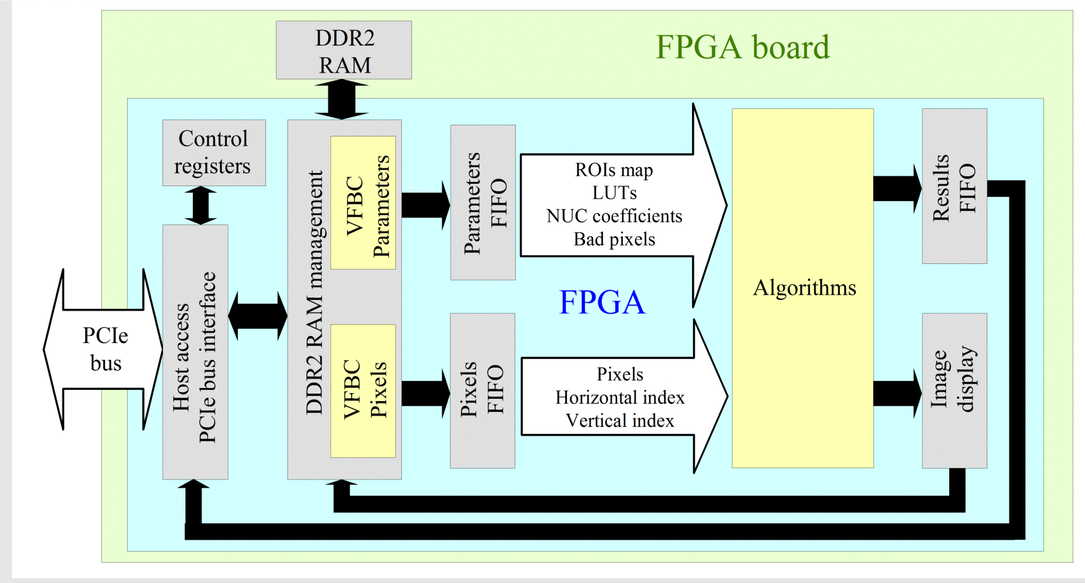
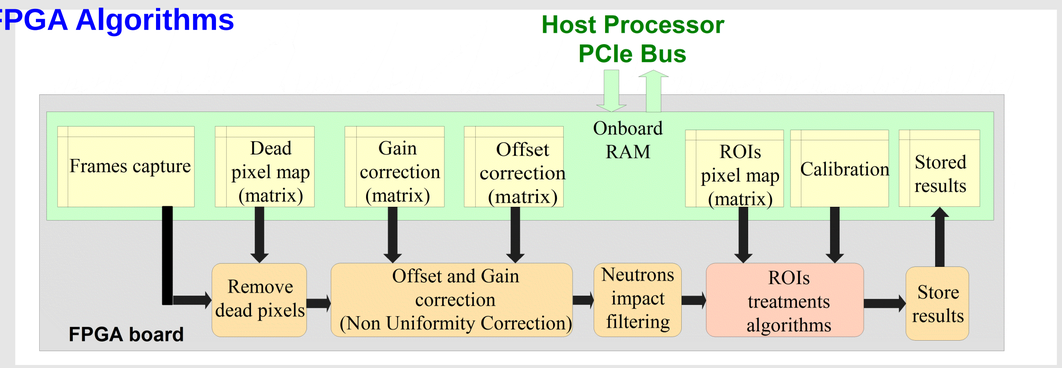
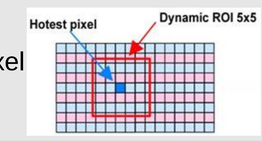
RTPU architecture



FPGA Algorithms



- Dead pixels and NUC corrections } *Image pre-correction algorithms*
- Neutrons impacts filtering
- Up to 96 different region of interest (ROI) with any shape defined pixel by pixel
- Each pixel can belong to 6 ROIs
- Apparent surface temperature calculation using LUT (Lookup Table): 1 LUT per ROI
  - 6 available LUTs ➔ 6 different materials (Beryllium, Tungsten, Tungsten coating…)
- For each ROI :
  - Hottest pixel apparent temperature calculation T
  - Hottest pixel position
  - Uncertainty estimation using dynamic sub ROI centered on hottest pixel
    - Count number of pixel N in the sub ROI with value > X % of T
    - Hottest pixel is valid if N > threshold

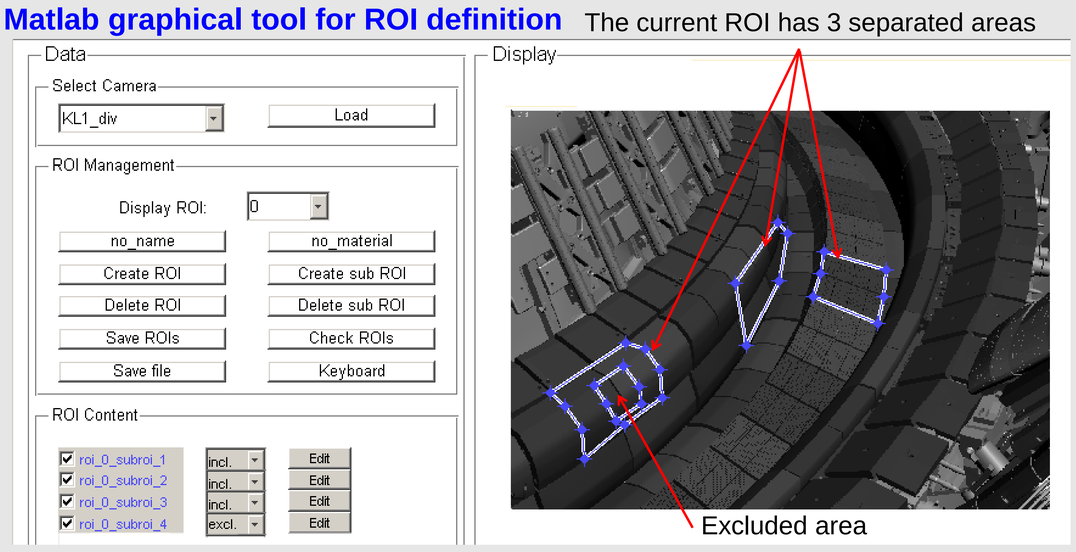


Used FPGA board

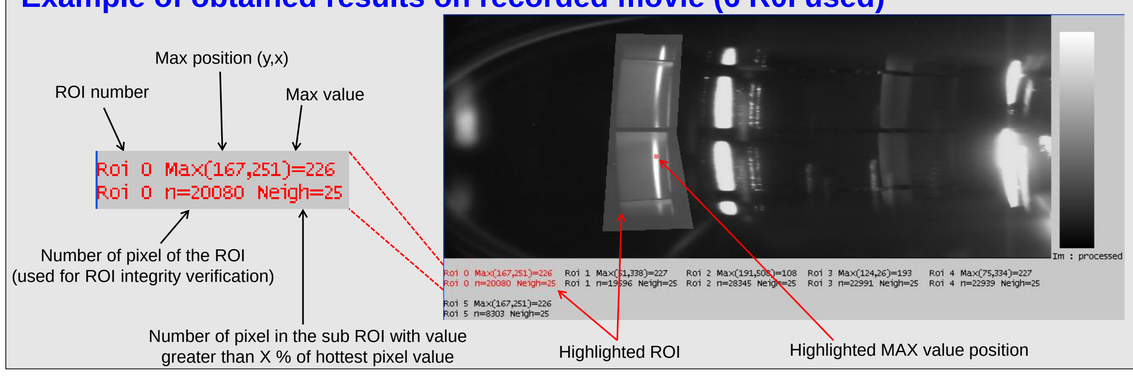
Sundance Multiprocessor SMT122T FX70T
- 4 lane PCI express interface
- FPGA Virtex5 FX70T FGG665
- 2 DDR2 memory banks (256 Mbytes per bank)
- Serial 64Mbit PROM
- 2 Marvell 10/100/1000 Ethernet PHYs

Matlab graphical tool for ROI definition

The current ROI has 3 separated areas



Example of obtained results on recorded movie (6 ROI used)



Conclusion

-A real time protection system has been installed for JET’s Iter Like Wall protection during last shutdown
-The system is based on one commercial FPGA boards per protection camera
-Each FPGA board can manage up to 96 ROIs
-For each ROI the value and position of the hottest pixel are delivered and sent to JET’s VTM
-The system has been successfully tested during JET’s restart 2 (September 2011)
-Specific plasmas have been used for validation and have been stopped by PIW system

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