The Software and Hardware Architectural Design of the Vessel Thermal Map Real-Time System in JET

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INTRODUCTION

ITER-like Wall ... Why?

• *Be* is predicted to provide substantially lower tritium retention than *CFC*

ITER-like Wall ... At what cost?

• Lower thermal resilience

Requirement ... PIW project!

• Ensure wall integrity during high-power JET operation
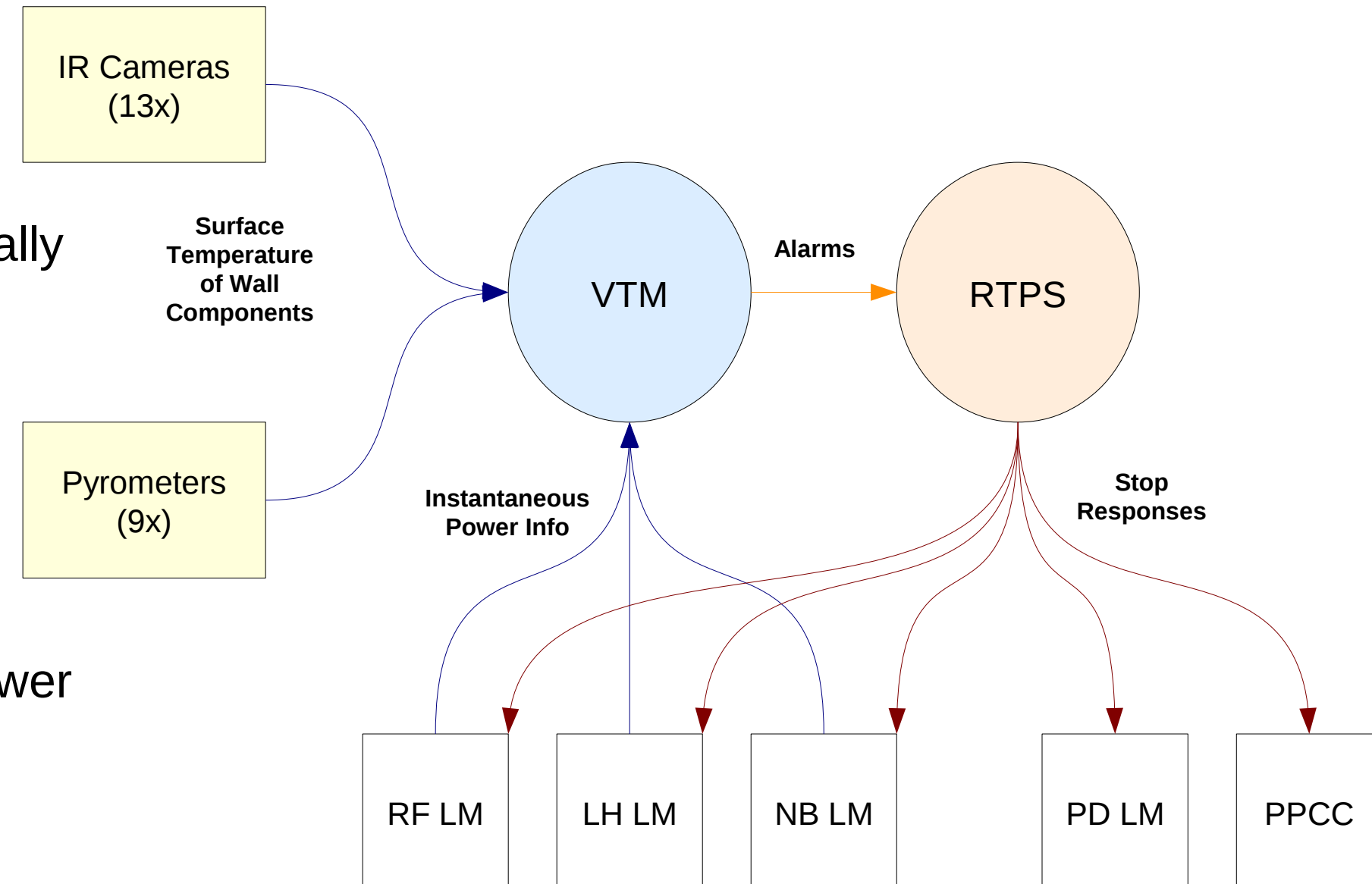
How?

1. Measure surface temperature of plasma facing components using *IR* cameras and pyrometers. **Real-Time Image Processing Units**[1];

2. Group and validate temperature measurements issuing alarms according to spatial location and offending heat source -> Plasma load, Lower Hybrid (LH), Radio Freq. (RF) and Neutral Beam (NB). **Vessel Thermal Map** (VTM);

3. Orchestrate responsive action of all Local Managers (LM) including Plasma Density (PD) and the Plasma Position and Current Control (PPCC) system to safe land the plasma. **Real-Time Protection Sequencer** (RTPS)[2].

VESSEL THERMAL MAP

60 Wall Segments
> 400 Tiles

VTM Expert GUI (Level-1)

HARDWARE

• Standard x86 6-core processor;
• 4GB RAM;
• ATM PCI NIC for Real-Time I/O;
• Onboard Ethernet NIC for remote administration.

SOFTWARE

Linux vanilla 2.6.35.9 kernel   CPU isolation   SET IRQ & THREAD AFFINITY   MARTe real-time framework[3]

Real-Time Performance

Interrupt driven cycle triggering based on ATM packet arrival

Worst case jitter < 1%

JET Pulse #80455

MARTe[3]

• Multi-platform (Linux, RTAI, VxWorks, Solaris and Windows);
• Data driven (everything is configured);
• Event driven (configurable internal state machine);
• Modular (dynamic linkage);
• Multi-threading;
• Logging (UDP);
• Introspection (HTTP);
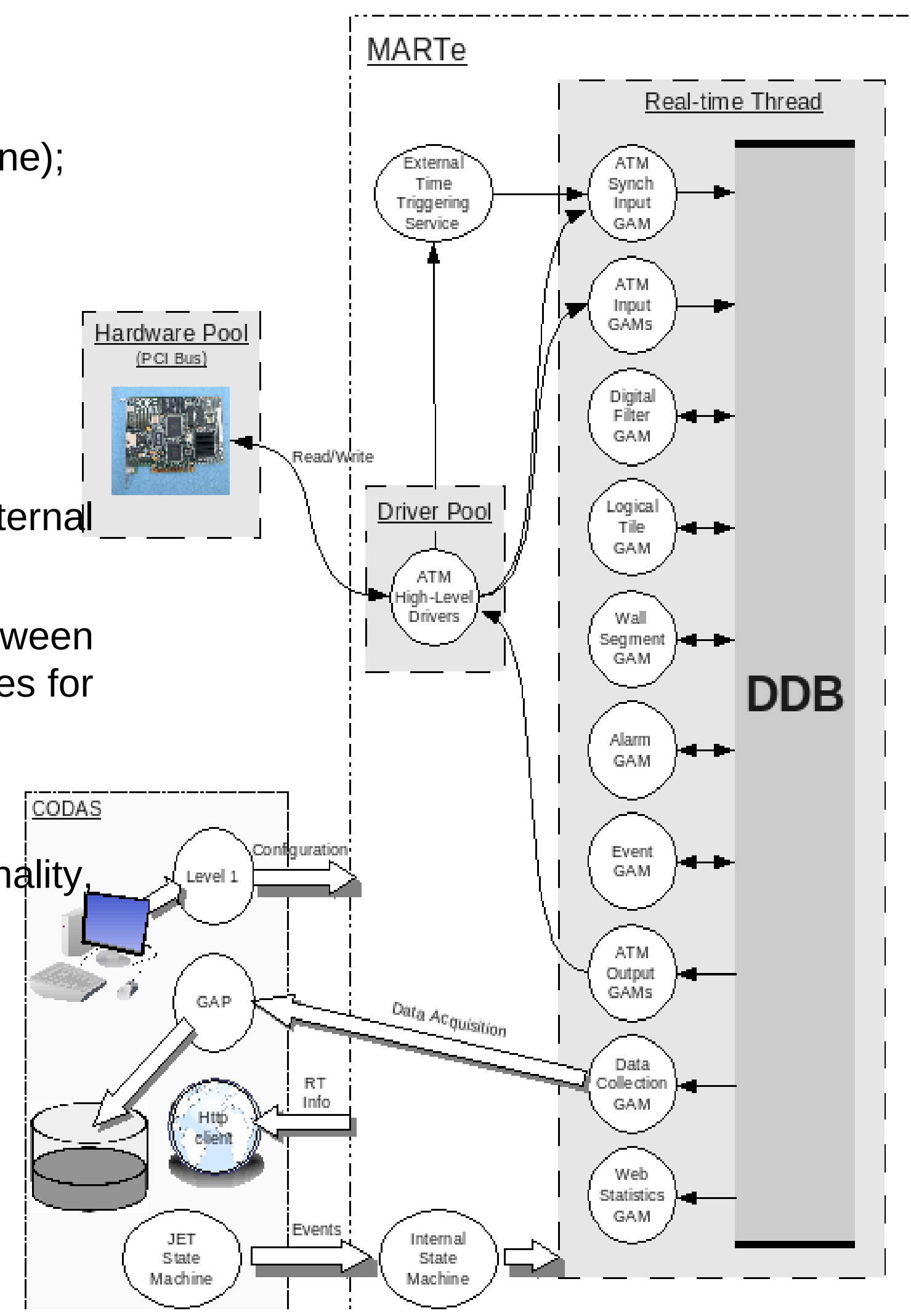• Interrupt or polling synch mechanisms (External Time Triggering Service);
• Device independent high-level interface between hardware components and MARTe user modules for real-time i/o operations;
• Message handling interface;
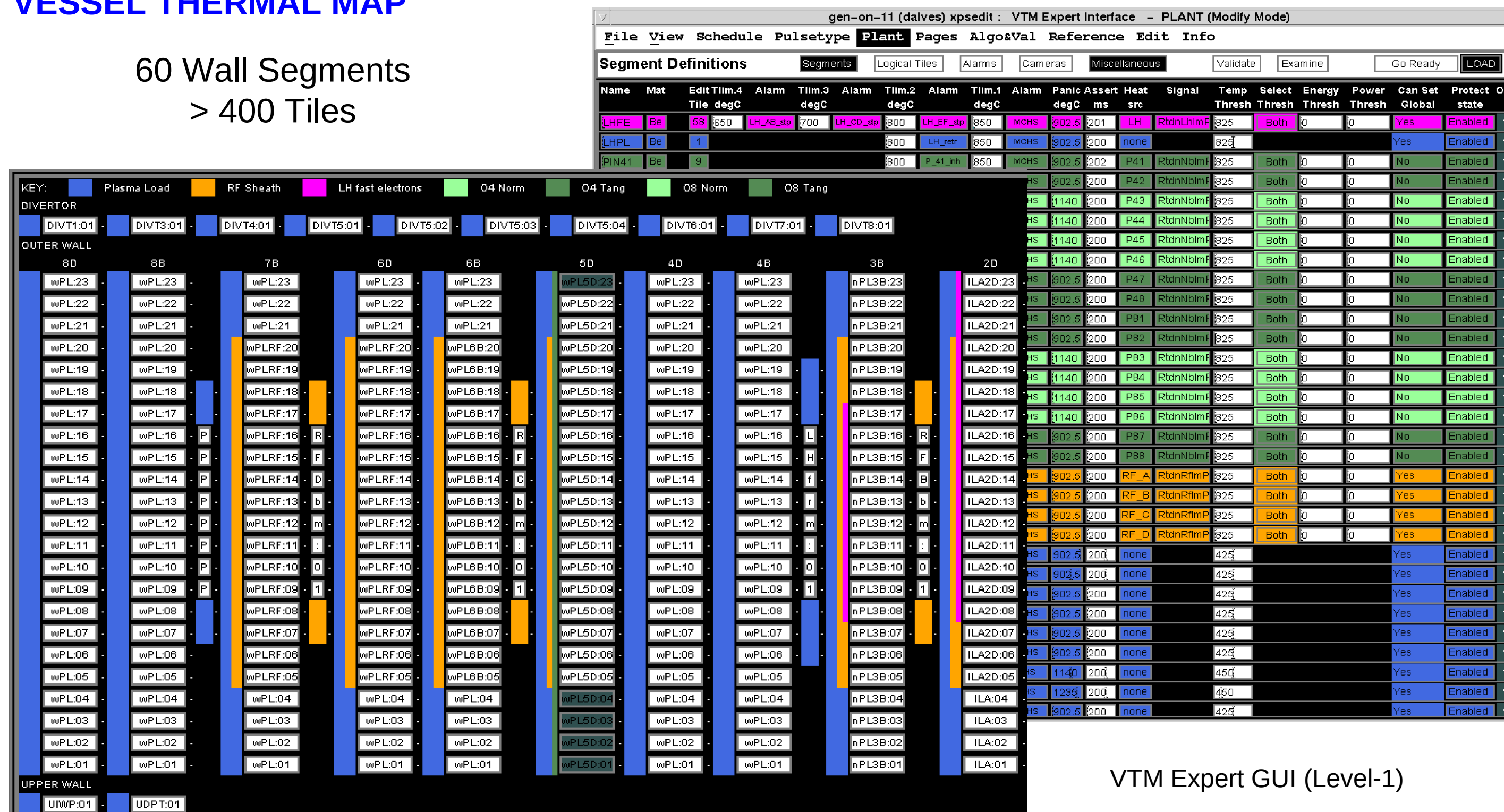• API imposed separation of core functionality, drivers and user software modules.

CPU #	Tasks
0	Linux & MARTe Services
1	ATM IRQs
2	ATM Synch Rx Thread
3	ATM Rx Threads
4	ATM Rx Threads
5	Real-Time Thread

CPU AFFINITIES
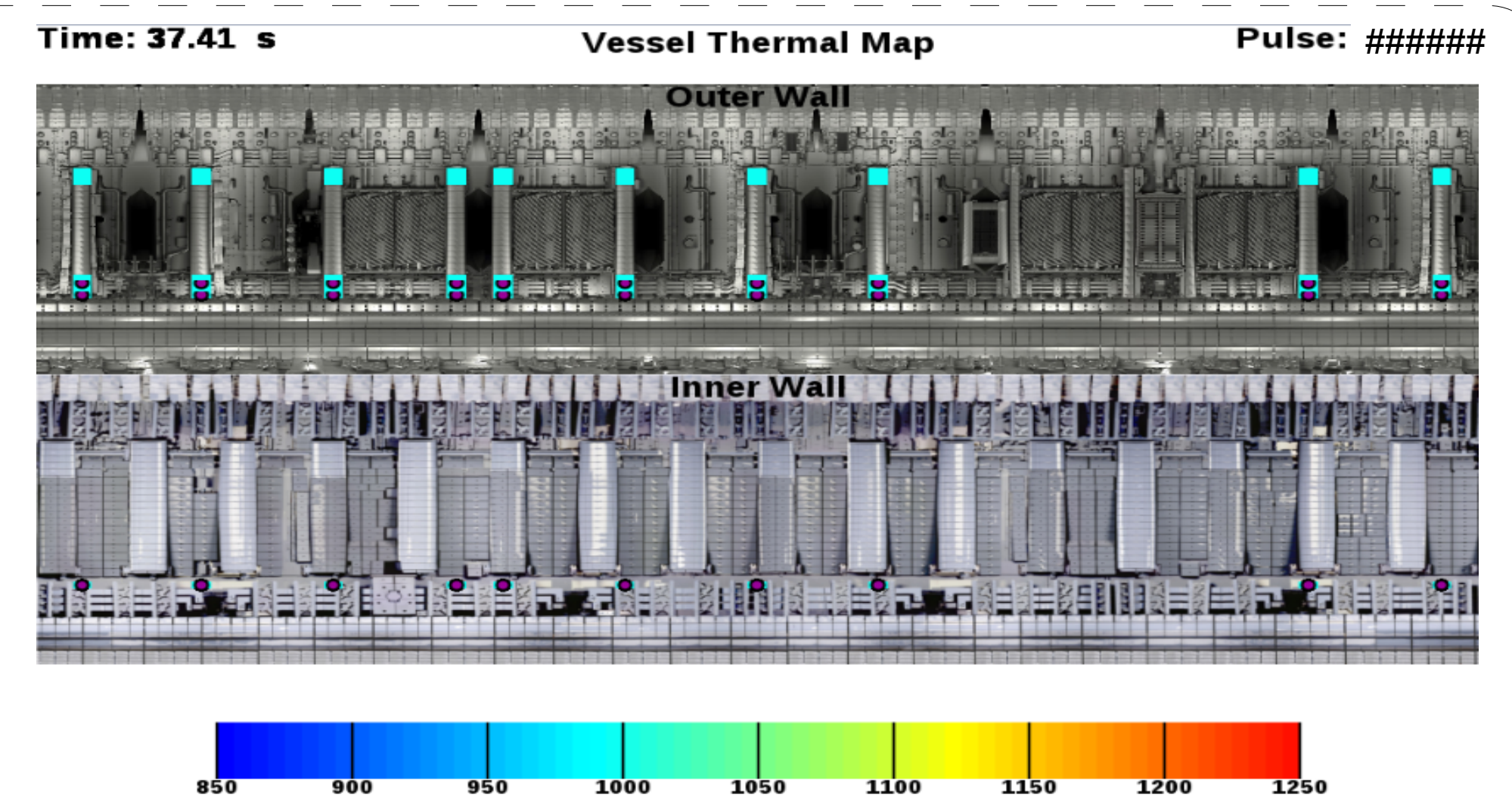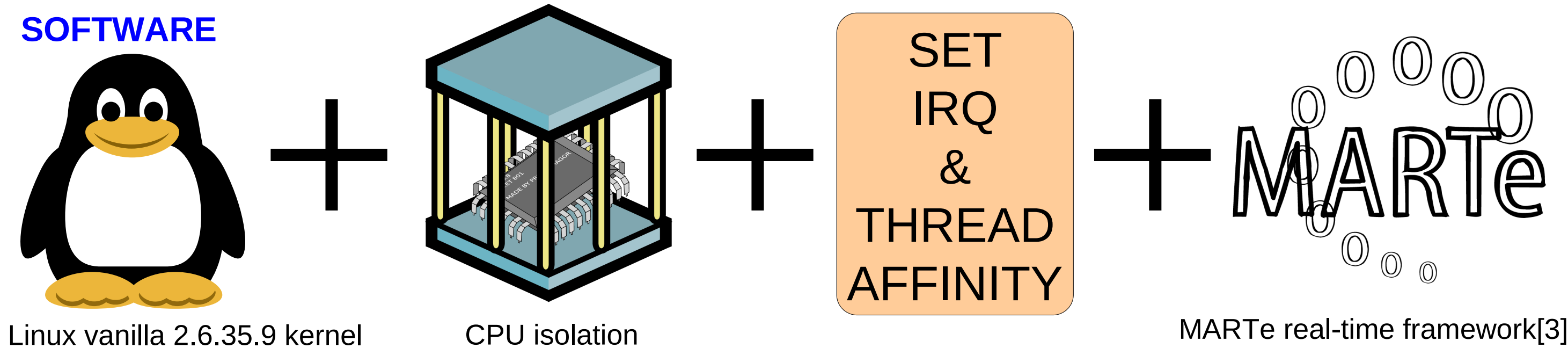
REAL-TIME MONITORING

EXAMPLE:

Monitoring plasma facing components' temperatures using Ajax. **4 Hz refresh rate without compromising real-time performance!!!**
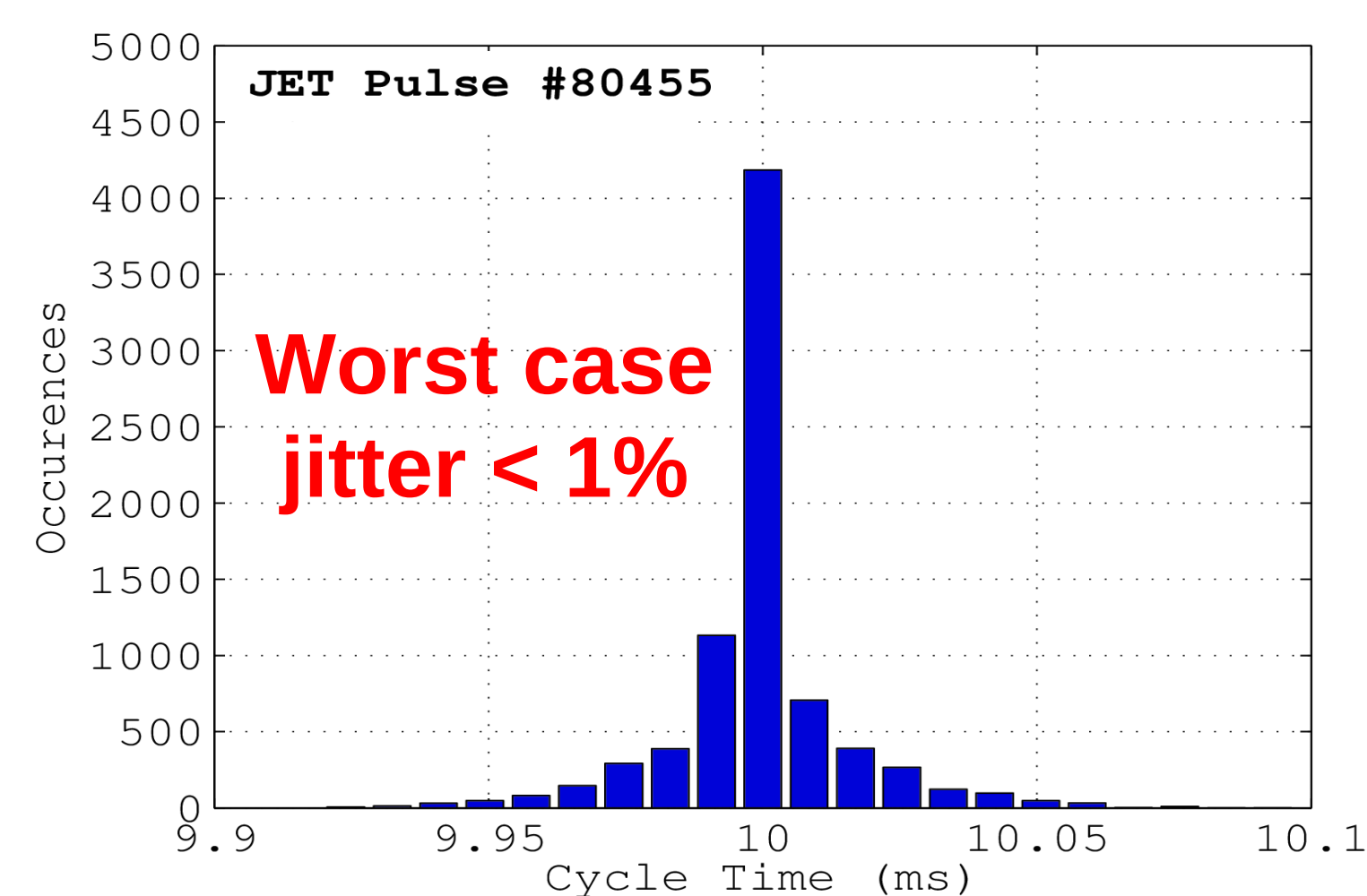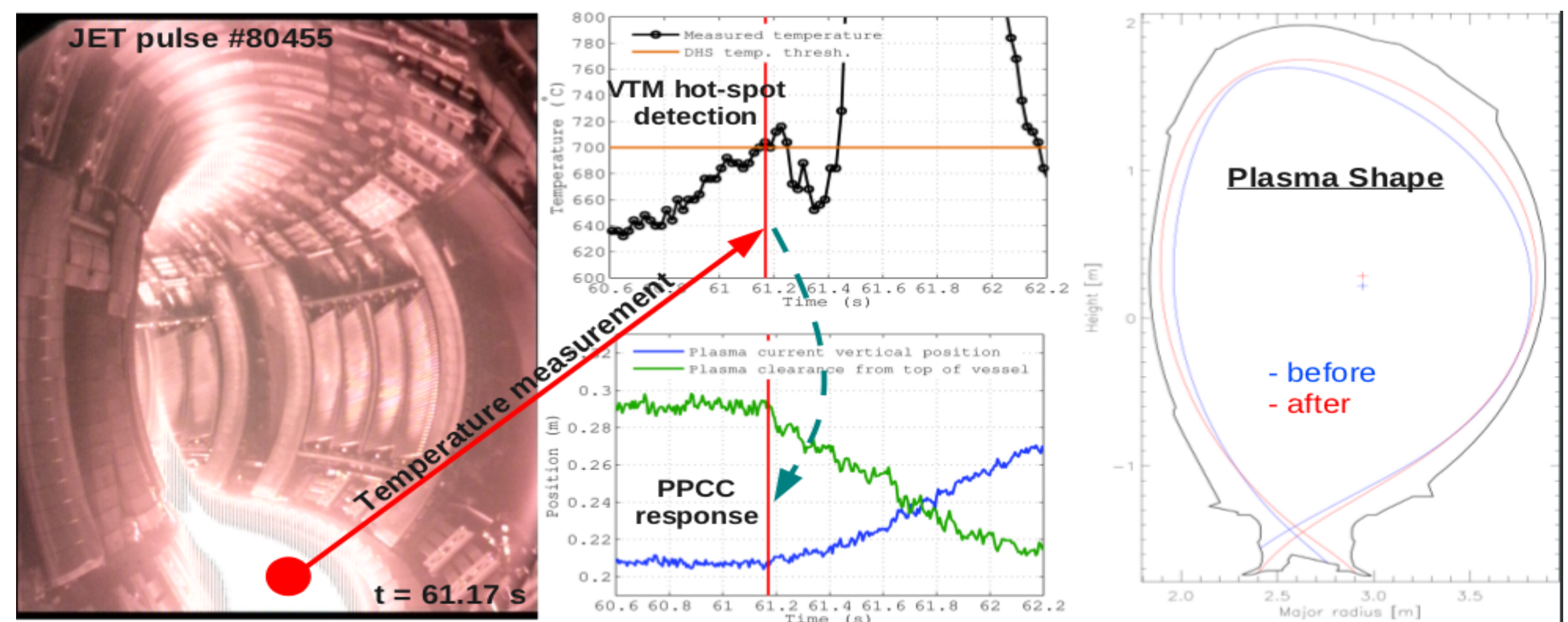

COMMISSIONING RESULTS

REFERENCES

[1] M. Jouve et al, ""Real-time protection of the ITER-like Wall at JET", this conference;
[2] A. Stephen et al, "Centralised Coordinated Control To Protect The JET ITER-like Wall", this conference;
[3] A. Neto et al, Nuclear Science, IEEE Transactions on 57 (2010).