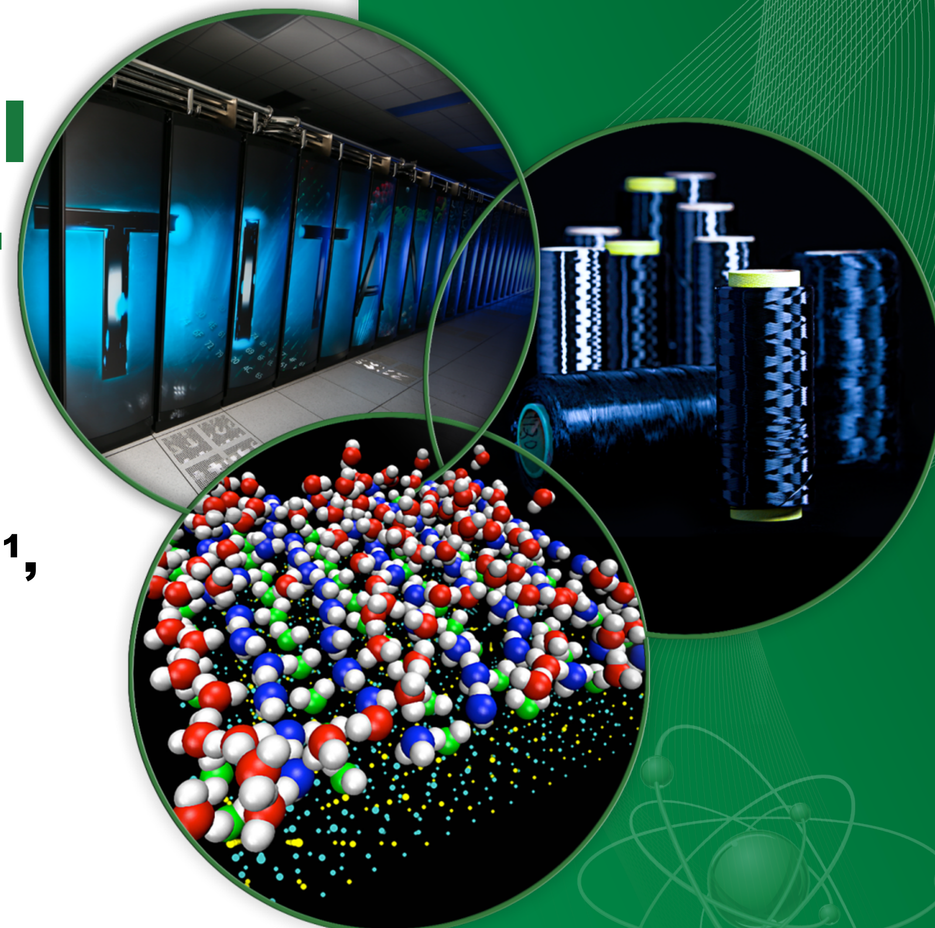
# Perspectives on the Final Design Review process from the US ITER Diagnostic Residual Gas Analyzer team.

UO3.00006



Presented at the
**56th APS Division of Plasma Physics Meeting**


**T.M. Biewer[1], P. Andrew[2], B. DeVan[1], V. Graves[1], D.W. Johnson[3], C.C. Klepper[1], C. Marcus[1]**

[1]Oak Ridge National Laboratory

[2]ITER International Organisation

[3]Princeton Plasma Physics Laboratory


New Orleans, LA, USA

October 27th – 31st, 2014


ORNL is managed by UT-Battelle
for the US Department of Energy


china eu india japan korea russia usa

# Motivation for this talk

- The ITER Diagnostic Residual Gas Analyzer system (PA 5.5.P1.US.01) was presented at a Final Design Review (part 1) on July 29-30, 2014 at the ITER building in France.

- This was the "first US-credited diagnostic to reach FDR."
  - Provisionally passed; Cat. 1 Chits currently being resolved.
- This was the "second diagnostic system to reach FDR of all DA's."
  - First was the Rogowski Coil System (EU)
- Motojima: "Please complete the DRGA design as quickly as possible."

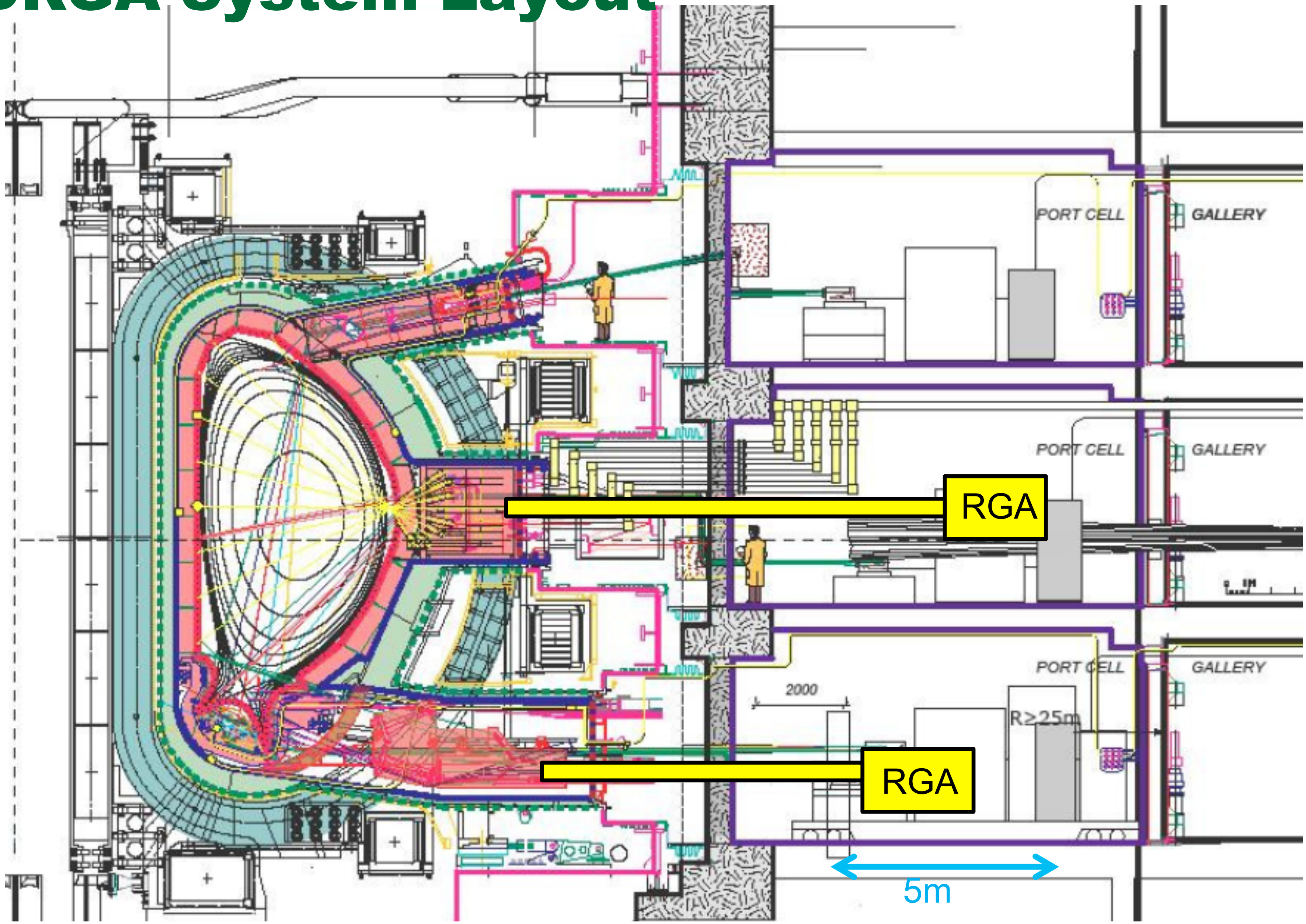
# Thanks to ITER DRGA team

- ITER International Organization
  - Philip Andrew (Technical Responsible Officer)
- US ITER (Domestic Agency of the US)
  - Dave Johnson (WBS manager), Bill DeVan, Emil Nassar
- ORNL F&MNS Division (subcontract to US ITER)
  - Ted Biewer, Chris Klepper, Van Graves, Chris Marcus, Tim Younkin
- National Resource Management (subcontract to ORNL, engineering analysis & design)
  - Chris Bett, et al.
- DeNuke Inc. (subcontract to ORNL, scheduling)
  - Mike Morris

# Outline

- Admittedly, a RGA is a relatively *simple* diagnostic to implement, technologically.
  – Send a simple system down the path (of implementation) to find where the landmines/potholes are.
  – Path to implementation is still steep for subsequent (more complicated) systems, but it may be less rocky.
- Nothing is easy in a nuclear environment; <u>technologically</u> or <u>procedurally</u>.
  – Technical: radiation, magnetic field, stress (baking),etc.
  – Procedural: documents, traceability, RAMI, seismic, etc.
- Recognize and respond to "dynamical nature of constraints" on the system design.
  – Being early in the schedule leads to more susceptibility to changing constraints.

# DRGA System Layout



# Measurement Requirements of the DRGA Systems

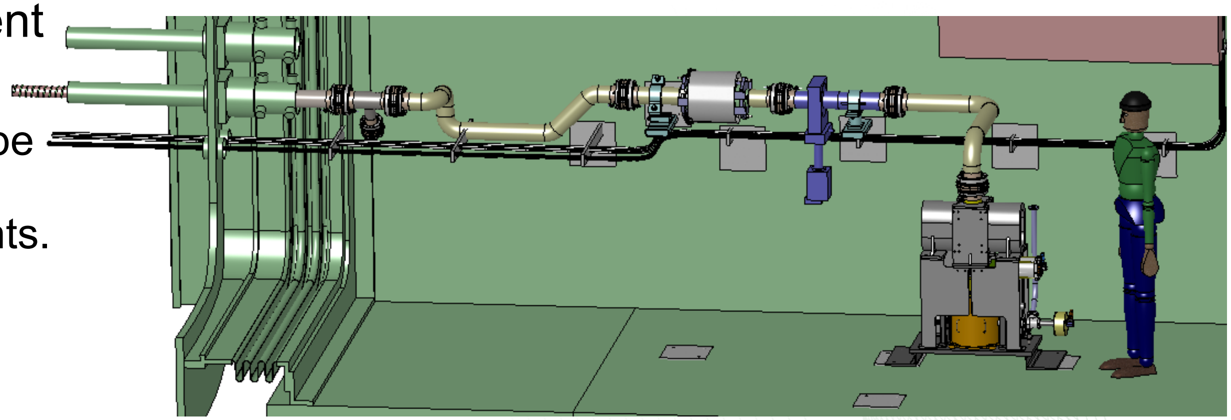
- DRGA measurements **during pulse**
  - Group 1a2 measurements needed for basic machine control.
  - Goal: measure fuel ratios, He (ash), and impurity concentrations
  - 1-100 amu range, with 0.5 amu or better
  - Time response: <1 s in divertor, <10 s at midplane




OAK RIDGE National Laboratory

# Measurement Requirements of the DRGA Systems


- DRGA measurements **<u>during pulse</u>**
  - Group 1a2 measurements needed for basic machine control.
  - <u>Goal</u>: measure fuel ratios, He (ash), and impurity concentrations
  - 1-100 amu range, with 0.5 amu or better
  - Time response: <1 s in divertor, <10 s at midplane
- Nuclear-qualified environment drives the design
  - Particularly challenging to be robust against "off-normal" loads, conditions, and events.



# The process of diagnostic delivery

## General Milestones

- CDR – Conceptual Design
- PDR – Preliminary Design
- FDR – Final Design Review
- MRR – Manufacturing Readiness Review
- FAT – Factory Acceptance Test
- SAT – Site Acceptance Test
- Installation & Commissioning
- Operation

# The process of diagnostic delivery

## General Milestones

- CDR – Conceptual Design
- PDR – Preliminary Design
- FDR – Final Design
- MRR – Manufacturing Readiness Review
- FAT – Factory Acceptance Test
- SAT – Site Acceptance Test
- Installation & Commissioning
- Operation

## Dates for DRGA System

- CDR – July 2010 ✔
- PDR – April 2013 ✔
- FDR1 – July 2014 ✔

---

- FDR2 – >Fall 2016
- MRR – >Fall 2017
- FAT – >Spring 2019
- SAT – >Fall 2019

Preliminary: To stay within US ITER spending profile

- Installation (advisory)
- Commissioning (advisory)

- Operation (not in scope)
  - 1st plasma ~2023?

# "ITER is a construction project, not a research program."

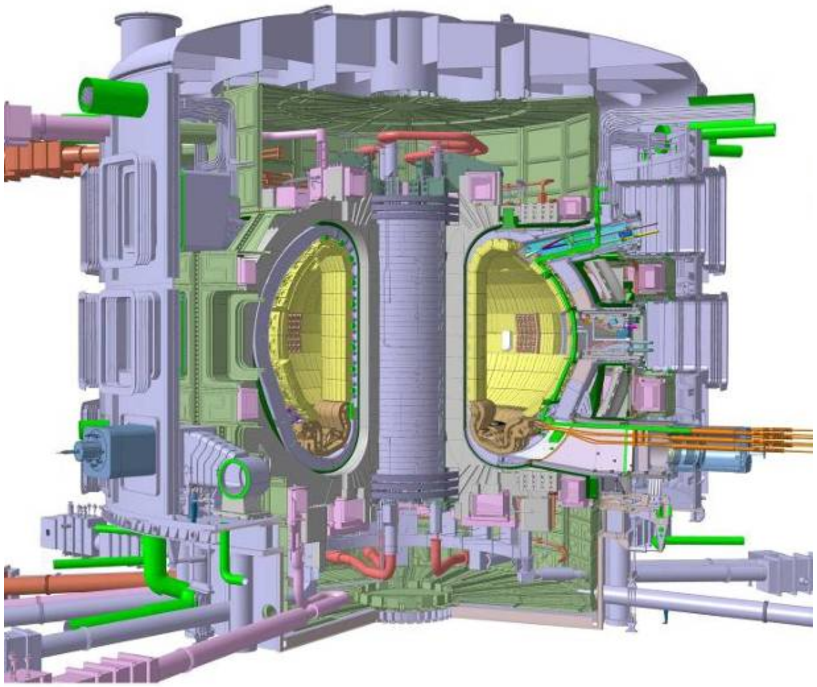
- Technical solutions [i.e. new diagnostics] (if identified today) would still require ~10 years as an engineering design Project to be installed on ITER.
- ITER (like NASA) will be "flying missions" with (somewhat) obsolete, but qualified, technologies.
  - Instrumentation choice is proven technology but "state-of-the-art" is a moving target.
- ITER IO recognizes that splitting FDR's can allow for the design of front-end components (necessary for integration), while allowing instrumentation to evolve and be designed later.

# Dynamical nature of design constraints

- Simultaneous construction and design of interfacing systems creates challenges
  - E.g. location of embedded plates in floors/walls.
  - E.g. estimation of severity of off-normal events (engineering loads) continues to evolve.
- ITER has prescribed environmental parameters, but actual (predicted) values have not been calculated in some instances.
  - E.g. DRGA FDR1 design sought to minimize the moments and forces on elements whose allowable limits have not been established.
- Integration activities will drive the DRGA milestones going forward.

# Summary and Conclusions

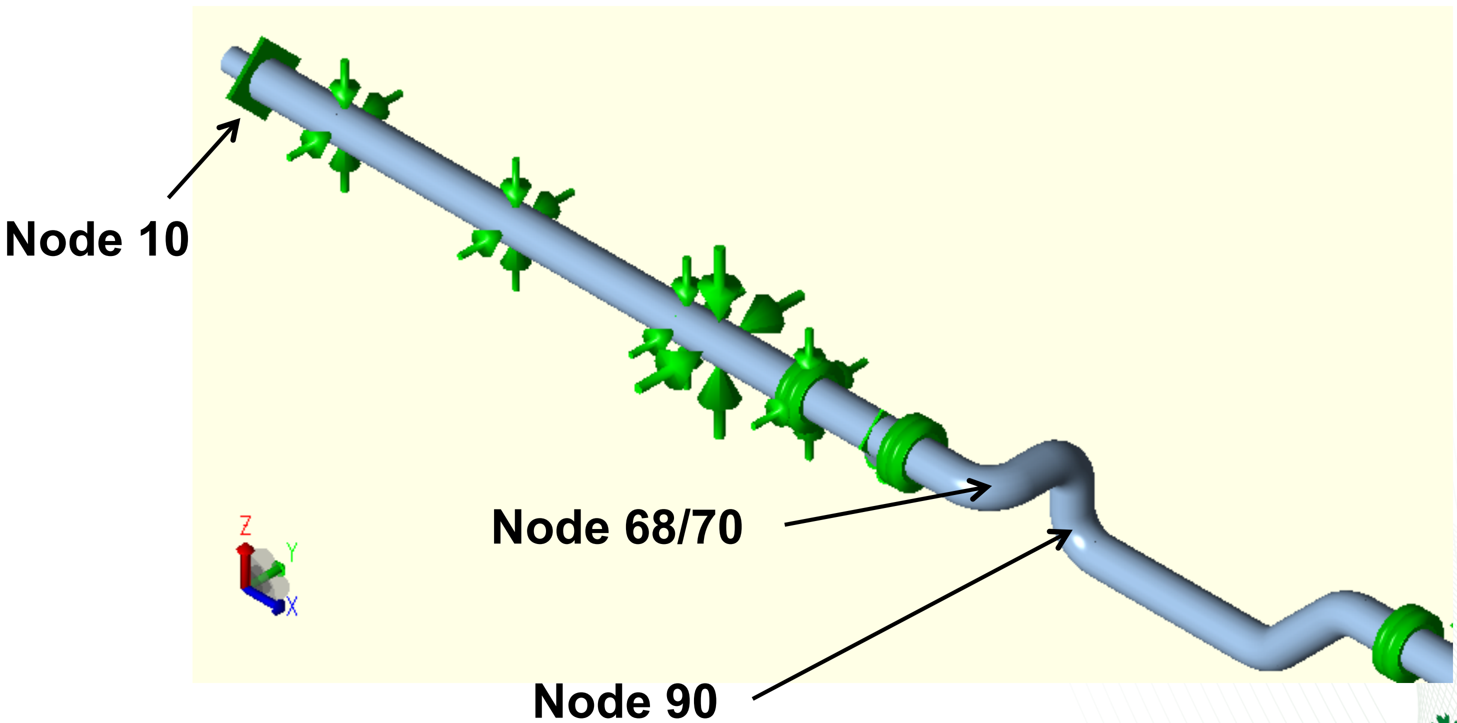
- The ITER DRGA system is the first US-credited diagnostic to reach the FDR milestone.
- The process of achieving the split FDR1 milestone has been educational to ORNL, US ITER, and ITER IO.
- As more sophisticated diagnostics systems strive for implementation on ITER, the challenges will grow.
- Hopefully, some pitfalls have been identified and removed as a result of lessons learned from the DRGA project.
- **Rigor of the design process (when applied to all systems, plus their integration) gives the DRGA team confidence that ITER will be a technical success.**



# *Thanks for your attention*

# Example: Cryostat Pass-through & IGP Compliance with ASME – Results

- Node points of interest are:
  - Node 10, Vacuum Vessel
  - Node 68, Elbow at Node 70 …worst case for thermal stress in-port
  - Node 90, Elbow …worst case for primary stress in-port



# Example: CP-t & Inner Guard Pipe Compliance with ASME – Results

- Dyn14 – VDE4

```
****  B31.3 -2010, March 31, 2011
****  CODE STRESS CHECK FAILED

HIGHEST STRESSES: (    KPa     )
   CODE STRESS %:               246.7  @NODE   10
          STRESS:            269919.7  ALLOWABLE:   109434.
   BENDING STRESS:           268516.6  @NODE   10
   TORSIONAL STRESS:          23795.8  @NODE   79
   AXIAL STRESS:               2925.0  @NODE   80
   3D MAX INTENSITY:         271087.2  @NODE   10
```

150%

180566 kPa

- Results for piping in scope are 99% of 189 MPa allowable at Node 68.
- Node 10 is located on the out-of-scope inner guard pipe.
- The allowable limits are adjusted by hand to correspond to B31E.