US Plans for ITER diagnostics

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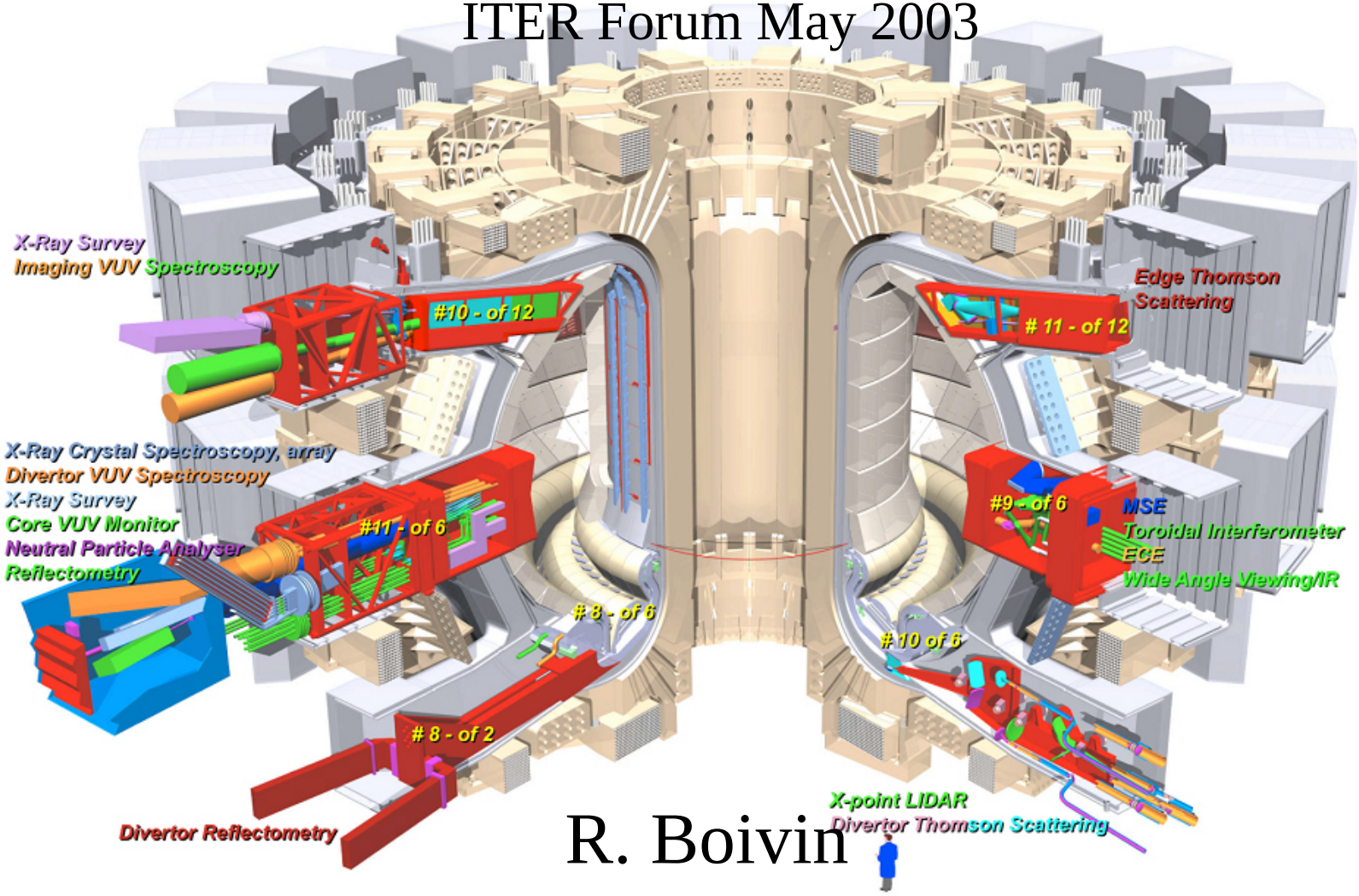

R. Boivin

DIII-D Diagnostic Coordinator

ITER is the next frontier

- ITER as a burning plasma experiment will provide one of the most interesting and challenging fusion endeavor
- ITER diagnostics will also be at the frontier of new and state-of-the-art measurements
  - Challenges and opportunities make it a thriving experiment

Why should we get involved in providing diagnostics?

- Use metric to assess the importance of diagnostics
- Can also be used to select the individual systems

1. How does the activity position the US for research on ITER?
2. Is the proposed activity or package "cost-effective" from the perspective of (ITER-value / dollar)?
3. Is this activity's area one of US relative strength or leverage?
4. What does the activity contribute to US fusion program?
5. Does the activity enhance the fusion-relevant capability of US industry?
6. Is the activity an opportunity for US industry?
7. Does the activity contribute to the development of the US fusion workforce?

1. Vital research tools

- Diagnostics are the windows to the science
- They are the means by which we get involved in the scientific undertaking
- They are the tools that are used for all experiments, and will also form the basis of sophisticated control systems
- Will lead to DEMO technology

2. Diagnostics are a good ITER value

- Many techniques are well established, being tested on many experiments for many years
  - Should not underestimate the importance of testing and R&D
- Huge impact on the success of the experiment for injected level of resources/funding

3. The US has pioneered many techniques

- US is a leader in diagnostics innovation
- Expected that the US will contribute to many important systems
- Experience and expertise can be found in many systems
- Examples abound:
  - Beam diagnostics(CER, MSE, BES), Spectroscopy, Fast ions, Fluctuations...

4. Contributions to the US program are multiple

- There will always be a need for diagnostics
  - Diagnostics are mostly independent of configuration
  - New techniques can benefit existing experiments
  - Testing and prototyping will benefit the US fusion program

5.-6. Diagnostics provide opportunities for industry (small and large)

- ITER diagnostics will use state-of-the-art technology
- New environment will create opportunities, development of new systems, materials, techniques
- Will bring wealth of information during OPS - learning experience

7. Training and development

- Diagnostics are a natural vehicle for bringing a new generation into the field
  - Students, Post-docs
  - Lead to career paths, long-term involvement
- Systems will require testing, prototyping
  - Great synergy with smaller, existing experiments
- Diagnostics need a strong base program

ITER will offer a new paradigm for diagnostics

- Similar to HEP, need to look at forming teams.
  - Systems are relatively large
  - White papers are a good way to articulate ideas, plans, teams
- Universities, Labs, industry can work together for diagnostic systems
  - Design, integration, calibration, analysis, etc.

The U.S. ATLAS Collaboration offers an example

Subsystem	Institutions
Silicon	**UC-Berkeley/LBNL, UC-Santa Cruz, Iowa State, New Mexico, Ohio State, Oklahoma, SUNY-Albany, Wisconsin**
TRT	**Duke, Hampton, Indiana, Michigan, Pennsylvania**
Liquid-Argon Calorimeter	**Arizona, BNL, Columbia, Pittsburgh, Rochester, Southern Methodist U., SUNY-Stony Brook**
Tile Calorimeter	**ANL, Chicago, Illinois-Champaign/Urbana, Michigan State, UT-Arlington**
Muon Spectrometer	**Boston, BNL, Brandeis, Harvard, MIT, Michigan Northern Illinois, SUNY-Stony Brook, Tufts, UC-Irvine, Washington**
Trigger and DAQ	**ANL, UC-Irvine, Michigan State, Wisconsin**
Common Projects	**All institutions**

Which systems are the most interesting?

- Diagnostics: 40+ systems
- Initial level of interest can be found in the White paper
- Individual White Paper is a great way to create teams and to support each activity

• 25% of the systems is a reasonable target
• Other systems can be added (ITPA process)

		Category	Level of Interest	Scale of Involvement	Potential US Contributor
			H,M,L,F	A to G	(not complete)
5.5.A	**Magnetic Diagnostics**	**1a**	M	D	GA, PPPL, Columbia
5.5.B	**Neutron Diagnostics**				
5.5.B.01	Radial Neutron Camera	1b	M	D	PPPL,LANL
5.5B.02	Vertical Neutron Camera	1b	M	E	PPPL,LANL
5.5B.03	Microfission Chambers (in-vessel)	1a	L	G	
5.5B.04	Flux Monitor (ex-vessel)	1a	M	D	
5.5B.07	*Gamma-Ray Spectrometers**	*2*	L	G	CSM, MIT
5.5B.08	Neutron Activation System	1b	H	B	
5.5B.09	*Lost Alpha Detectors**	*1b*	H	B	PPPL, CSM
5.5B.10	*Knock-on Tail Neutron Spect.**	*2*	M	D	GA

Complete list in White Paper

Form consortia

- Expertise can be found across the community

Institution	Expertise
Auburn University	ECE
Columbia University	Magnetics
Colorado School of Mines	Alphas, fast ions, gamma, neutrons
General Atomics	Magnetics*, CHERS*, Thomson, Alphas, Neutrons*, Interferometer/Polarimeter*, Fast Wave Reflectometer*, Generic Packages*
Johns Hopkins University	Spectroscopy
Lawrence Livermore National Laboratory	MSE, IR cameras, imaging
Los Alamos National Laboratory	Imaging, Intense Diagnostic Neutral Beam*, Bolometry*, Neutrons*, CHERS
Massachusetts Institute of Technology	Collective Thomson Scattering, Phase Contrast Imaging, Spectroscopy, Gamma, MHD spectroscopy
Nova Photonics	MSE, LiF
Oak Ridge National Laboratory	Neutrals, Spectroscopy, Pellets, Collective Thomson Scattering*, Generic Packages*
Princeton Plasma Physics Laboratory	Thomson, MSE, Spectroscopy*, Fast ions*, Neutrons*, CHERS, ECE, Reflectometry*, Generic Packages*
Rensselaer Polytechnic Institute	Heavy Ion Beam Probes[1]
Sandia National Laboratory	Probes, First wall diagnostics
University of Maryland	Spectroscopy, ECE
University of California, Davis	ECE, reflectometry
University of California, Irvine	Fast ions
University of California, Los Angeles	Reflectometry*, Scattering, ECE, Polarimetry
University of California, San Diego	Probes, Bolometry
University of Idaho	ECE
University of Texas, Austin	ECE, fluctuation diagnostics, CHERS, BES, Visible Bremmstrahlung, Spectroscopy
University of Washington	Interferometry, neutrals
University of Wisconsin, Madison	CHERS, BES, Polarimetry, First wall diagnostics
West Virginia University	Neutrals, LiF

A wide range of R&D activities are envisioned and are of interest for the US

Measurement	R&D required	priority	Current party interest	US strength/interest
Confined alpha particles	New techniques	High	All	Strong
Lost alpha particles	New techniques	High	All	Strong
Magnetics	Radiation effects	High	All	Moderate
Current Profile	Improved techniques	High	EU	Strong
Optical Diagnostics	Erosion/redeposition	High	All	Moderate
Measurement of fuel composition	Fast wave reflectometry	Intermediate	None	Very Strong
Tile Erosion	New techniques	Intermediate	None	Strong
Impurity measurements	New techniques	Intermediate	None?	Moderate
Core fluctuations	New techniques?	Long-term	None	Strong
Dust	New technique	Long-term	RF	Moderate

ITER diagnostics are a great opportunity for the US fusion program

- Direct link to physics and engineering
- Involve many groups
- Natural training grounds
- Explore the next frontier of fusion and diagnostics.
- Direct path to DEMO