US Active Spectroscopy Diagnostics for ITER

- white paper -

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The proposal

To provide a diagnostic package for ITER, which would include all of the active spectroscopy diagnostics for ITER

Active Spectroscopy Diagnostics:

- Motional Stark Effect - MSE
- Charge Exchange Recombination Spectroscopy - CXRS
- Beam Emission Spectroscopy - BES

- These diagnostics all provide spatially resolved measurements in conjunction with a diagnostic neutral beam(DNB) or heating neutral beam.

  currently: MSE (Heating beam) CXRS & BES (DNB)

- This proposal does not include the diagnostic neutral beam for ITER; however, the US has the expertise to take on the DNB task.
  - G. Wurden has a white paper on the US providing a DNB
  - combining the DNB and the active spectroscopy diagnostics will make an even more attractive US diagnostic package for ITER

Active Spectroscopy Diagnostics
-What they measure -

- **MSE**
  - Measured : Local magnetic field pitch angle and Lorentz field
  - Deduced: q-profile (safety factor) and current profile
- **CXRS**
  - Helium Ash measurement (He density, He concentration)
  - Impurity ion densities (He, C, Be, Ne, Ar, Kr, …)
  - Fuel mixture and density (H, D, T)
  - Plasma rotation (V_{rot})
  - Ion Temperature (T_i)
  - Particle transport properties (D, χ)
- **BES**
  - Local Beam Density
  - Localization of active beam volume
  - Density Fluctuations

Benefit to US Fusion Program

- Active Spectroscopy measurements provide a wealth of information to address burning plasma physics issues
- Provides the necessary data to continue the burning plasma physics database and to continue the development of US theory and modeling programs in support of future burning plasma devices
- MSE, CXRS, and BES were first conceived and developed in the US and presently most innovations in this area are coming from US

  Newest innovations include:

  - Low magnetic field MSE
  - Poloidal rotation
  - BES imaging
  - CXRS He Ash measurements on JET
- US should continue our (historically) strong efforts in diagnostic development

Common Features of Active Spectroscopy Diagnostics

- All require a neutral beam, as well as a detailed knowledge of beam
- Each diagnostic utilize similar spectrometers, detectors, and light collection optics.
  - Similar design tasks on each diagnostic
  - Should result in cost savings for the package of 3 diagnostics
- Large number of spectrometers and detectors will be required (≈ 70)
  - Using several innovations in US spectrometer designs with multiple entrance slits and improvements in optical design the number of spectrometer/CCD detectors can be reduced by ~ 50%.
  - Maintaining the absolute calibrations of these diagnostics is a labor intensive effort; reducing the number of spectrometer systems to be calibrated is a key consideration.

US Interest in Active Spectroscopy Program

- *Taking a leadership role in this ITER diagnostic activity will maintain the present US lead in diagnostic development and capability.*
- *Likely to result in increased international collaboration opportunities (e.g., on DIII-D, JET ,NSTX) for testing of advanced spectrometer and optical detection systems.*
- *Results will be available for implementation on present and planned US experiments - providing direct benefits to the US program.*
- *Major US participation in physics experiments on ITER will be much more likely, if the US is responsible for a major contribution in the ITER diagnostic effort.*
- *US laboratories have seen in the past that hardware and diagnostics delivered to international machines have led to substantial US participation in experimental programs using the equipment.*
- *US theory support will be needed during the design, construction, and operation of the diagnostic system as the design and operating scenarios are further refined.*

US Expertise, possible program participants

	Relevant Expertise
General Atomics	CXRS, MSE, BES
Oak Ridge National Lab	CXRS, BES
Princeton Plasma Physics Lab	CXRS, MSE, BES
Los Alamos Nat. Lab	Pulsed Power Beams
Lawrence Livermore Nat. Lab	CXRS, MSE, BES
University of Wisconsin	CXRS, MSE, BES
Nova Photonics, Inc.	MSE

Summary

Utilizing the combined efforts of the US National Labs, Universities, and Industry, the US has the capability to design, fabricate, and deliver an active spectroscopy diagnostic system to ITER.

Diagnostics: MSE, CXRS, BES

Benefit:

This diagnostic package will provide access to a wealth of burning plasma physics information that will be used to evaluate the performance of ITER and provide further information that will be directly applicable to the fusion program, as it proceeds toward the next step of a DEMO power plant.