# 2D AND 3D IMAGING AND VISUALIZATION OF PLASMA MODES AND TURBULENCE: GRAND DIAGNOSTIC CHALLENGE 2000-2010

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**Plasma turbulence and coherent plasma modes such MHD and plasma wave modes in fusion devices are known to have complex two and three dimensional structures which evolve in time. Fusion plasma physics would clearly be advanced by systematic measurements of the full 2 and 3D nature of these structures. Such measurements would need to provide direct images or tomographic reconstructions of these mode structures.**

## ISSUES

### Plasma Turbulence: μsec time scale, mm spatial scale

- 2D (3D) imaging of turbulence would map directly onto turbulence simulation code predictions providing a unique test of theory.
- 2D imaging could be used to demonstrate that the turbulent eddies deform and compress radially at the transport barrier in fusion grade plasmas.
- Both core and boundary turbulence imaging techniques are needed.

### MHD Modes: msec time scale, cm spatial scale

- Modeling of beta limiting modes predicts complex 3D structures, experiments need to measure those structures and compare with 3D MHD theory.
- Feedback control, smart wall stabilization experiments need to understand the details of those mode structures in order to optimize the feedback coils.
- Confirm ballooning mode structure, tearing mode structure, and others.

### 3D equilibria (e.g. stellarators): long time scale, mm spatial scales

- Imaging diagnostics needed to confirm flux surface geometry, magnetic island structures, stochastic regions.

### Injected Plasma Waves: long timescale, mm – cm spatial scales

- Mapping of 3D wave fields and polarization in region near antennas for ICRF, LHCD, ECH.

- Wave propagation needs to be tracked into the core and regions of absorption.

## RELATED DEVELOPMENTS

- 3D turbulence and MHD mode modeling is emerging as a focus for fusion computations and theory. Supercomputing hardware development projected over the next decade will make these computations increasingly powerful. Experiments are needed to map onto these models.

- 3D time dependent imaging software environments used in theory and modeling can be applied to experimental data visualization.

- Medical imaging data analysis tools make use of highly sophisticated visualization techniques. We need to take advantage of these developments.

- Flow visualization experiments have been highly successful in the field of classical fluid turbulence, we need to learn from that community.

## OPPORTUNITIES:

- MAKE USE OF EXISTING DIAGNOSTICS WITH NEW ANALYSIS METHODS

  E.g. upgrade data analysis techniques, generalized inverse methods using soft x-ray detector arrays, magnetic probe arrays, bolometer and other detector array diagnostics and combinations of diagnostics

- DEVELOP HIGH DENSITY DETECTOR ARRAYS TO OBTAIN HIGHER SPATIAL AND TEMPORAL RESOLUTION.

- DEVELOP A NEW GENERATION OF PLASMA IMAGING TECHNIQUES TO HAVING SUPERIOR SPATIAL AND TEMPORAL RESOLUTION. E.g. sheet Thomson scattering, high resolution tomography, imaging screens, fast robot arm probes, etc.

## STRATEGY:

- It is appropriate to hold an international workshop on imaging and visualization of plasma modes and turbulence.

- Fusion plasma imaging diagnostics development should be a priority in the US fusion energy science program plan. Such a plan would include support for development of novel diagnostics having plasma imaging capability, development of analysis and visualization capabilities for standard diagnostics, upgrades for standard diagnostics to support imaging, tomography, and the like.