DIII–D COLLABORATIONS OVERVIEW

by

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DIII–D
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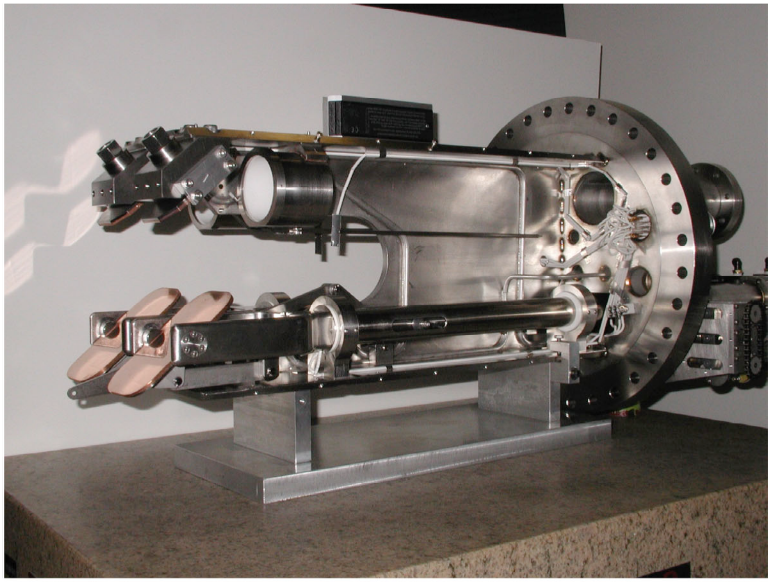
PPPL Role in the AT Physics Program on DIII-D

Accomplishments in FY02-03:

- Steady State Research
  - current profile control with ECCD and Fast waves
  - FW support
  - fabrication and installation of P2002 EC launcher



- High beta physics above the no-wall limit (w/Columbia, GA)
  - RWMs power supplies
  - Thrust 4 leadership
  - shape modeling and high beta at high J_{BS}
- Turbulence and Transport
  - CER system upgrade, new post doc.
  - Reflectometer simulation (w/ UCLA)
  - microstability modeling with GS2
- One FTE operations support

PPPL Planned accomplishments in FY04-05

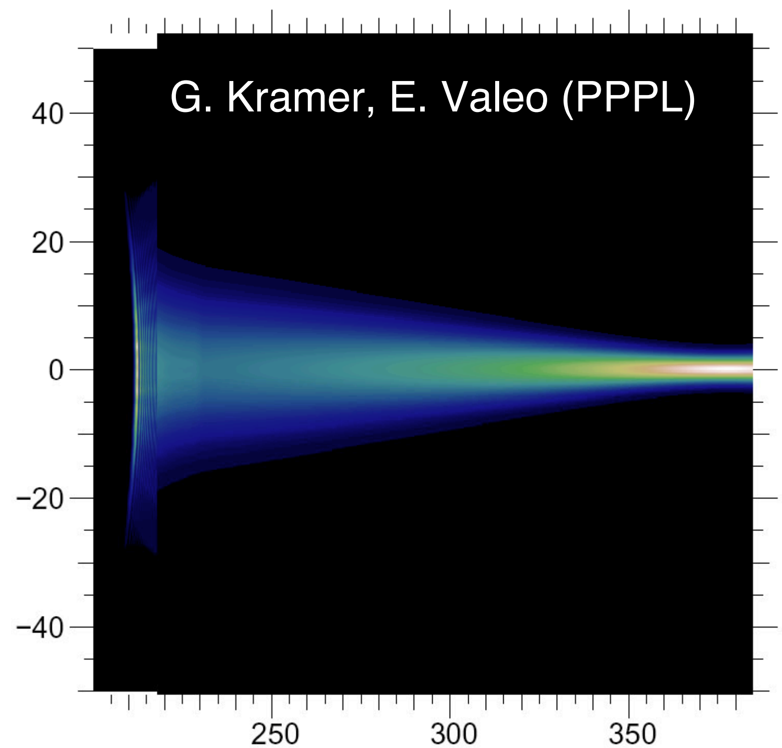
- Steady State Research: Current profile control with ECCD & Fastwaves
  - FW support, upgrade of ABBs
  - fabrication and installation of fast scanning P2005 EC launcher

  * spare tube for ABB, upgrade all launchers to fast scanning
- High beta physics above the no-wall limit
  - RWM experimental program
  - shaping optimization for high beta at high J_{BS}
- Turbulence and Transport
  - CER and rotation physics
  - reflectometer simulation
  - microstability modeling with GS2

  *poloidal rotation CER upgrade

  *poloidal reflectometer/ECE upgrade
- One FTE full time operations support

*Incrementals

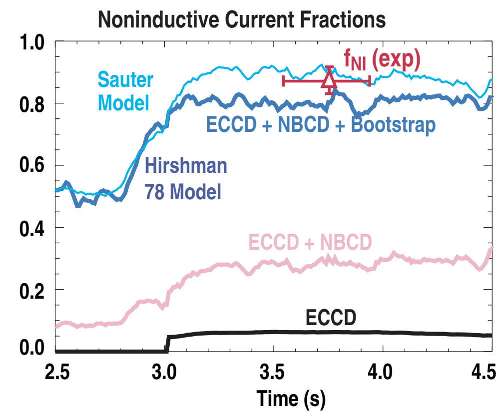


Full wave reflectometer simulation on DIII-D

ORNL/DIII-D ACCOMPLISHMENTS IN THREE MAJOR AREAS

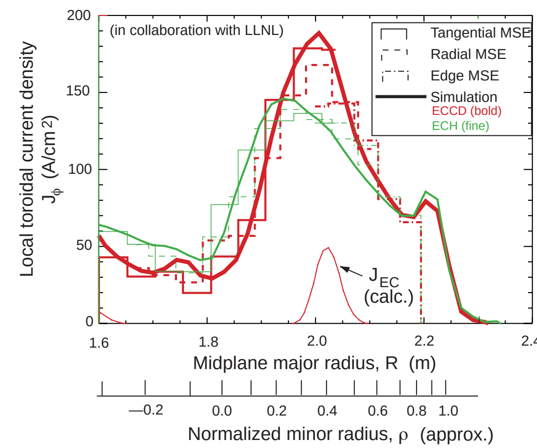
1. CONFINEMENT AND MHD STABILITY

- **Predictive modeling guided experiment and aided in interpretation of results**
- **Demonstrated off-axis-ECCD to modify and sustain current density profile**
  - Over 90% of the current generated non-inductively with $\beta > 3\%$
- **Good agreement between equilibria reconstructed by VMEC and EFIT**
  - Benefits both NCSX and DIII-D (“3D” effects)



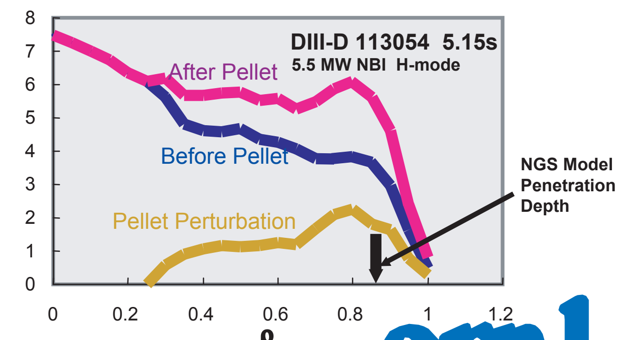
2. WAVE-PLASMA INTERACTION

- **The 285°antenna vacuum conditioned and ready for plasma operation**
  - Represents the first step in the fast wave restart



3. MASS TRANSPORT

- **High-field-side pellet injection demonstrated early 100% fueling efficiency and fueling into r = 0.4 in H-mode**
- **Disruption mitigation experiment indicated cold pulse associated with the gas penetrates at near sonic speeds.**
- **Novel spectroscopic analysis discriminated physical vs chemical sputtering**



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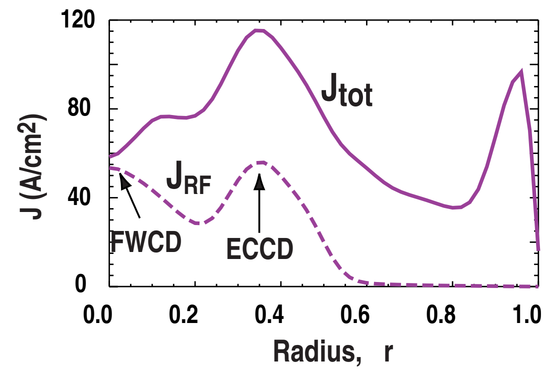
ORNL/DIII-D FY04 – FY05 PLANS IN THREE MAJOR AREAS

1. Confinement and Stability:

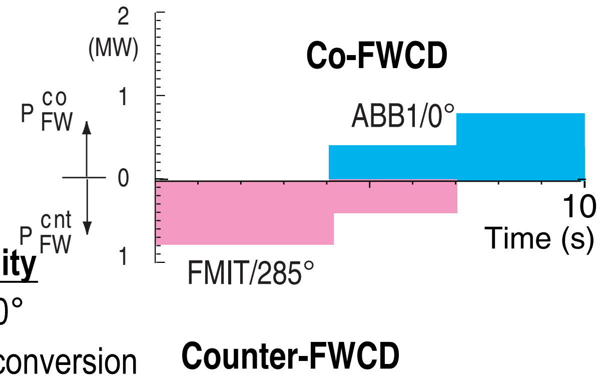
Scenario Development and modeling:

- **High bootstrap fraction AT regime**
  - Experiment and modeling of off-axis (ECCD) and axial (FW) CD in AT
- **Hybrid regime**
  - Experiment and modeling --stationary, q_0 ~ 1 plasmas for ITER
- **Conventional sawtooth regime experiments**



2. Wave-Particle Interaction

- **Fast Wave system will benefit AT scenario development through:**
  - Control of q_{min} and magnetic shear to optimize confinement and stability
  - Electron heating to increase off-axis ECCD
- **Restart of the Fast Wave system-- 3-way collaboration (GA,ORNL,PPPL)**



Antenna & Transmitter **Main Responsibility**

FY2004: Two antennae available (0° and 285°). ORNL responsible for ABB1/0°

FY2005: All three antennae available (~ 4 MW). PPPL responsible for ABB2 conversion

Incremental: Start design of a long-pulse "ITER-like" replacement for 285°antenna

3. Mass Transport

- **Improve HFS fueling capabilities to aid in deep plasma fueling and ELM mitigation**
  - Install additional HFS 1.8-mm pellet injector

Incremental: Post-doc to continue the (discontinued) edge spectroscopic work

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LLNL continues to be a strong contributor to the DIII-D team (2003)

- **Edge, SOL, and pedestal physics**
  - Peer review resulted in renewed emphasis in this area FY2002
  - Started ELM studies - ITER issue
    - -- Increased time resolution - visible and IRTV (with UCSD)
    - -- Thrust leadership, European TTF talk
  - UEDGE fluid modeling with drifts - ITER issue
  - BOUT edge transport code used for pedestal and x-point physics

- **Measurement and modeling of J(r) and E_r in AT plasmas** -
  - Improved calibration techniques, on-site physics and technician
  - Core modeling of current profiles and stability (CORSICA)
    - --Time-dependent stability analysis with DCON, benchmarked to GATO
    - --Edge bootstrap current calculations for pedestal physics

- **On-site presence with important contributions to the DIII-D program**
  - 11 FTE's on site, 8 live in San Diego
  - Thrust leader, topical science leader, vice-chairman research council
  - Operate MSE, IRTV, TTV, Bolometer diagnostics and analyze data
  - Participate in JET collaboration (Helium, QDB) - with DIII-D funds

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Plans for the LLNL collaboration on DIII-D: FY 2003-2005

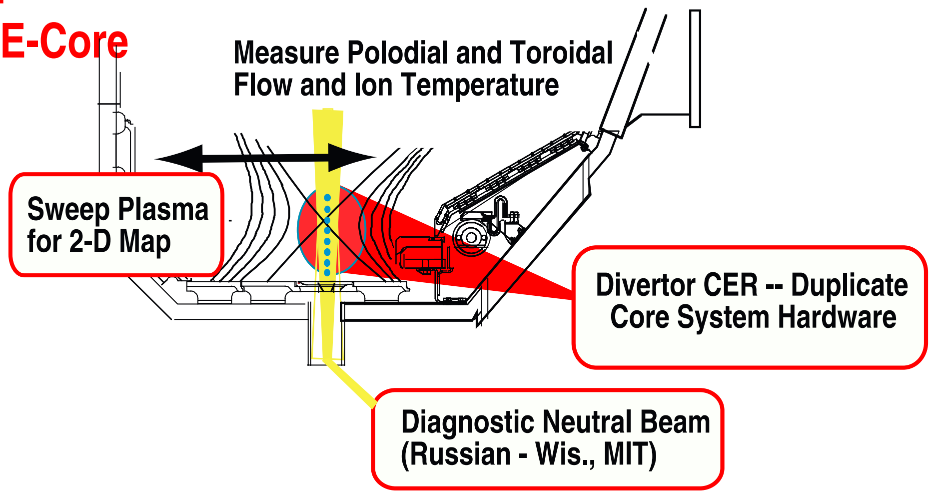
- Flat guidance budget will:
  - Operate existing MSE, IRTV, TTV, Bolometer, analyze data, computations support
  - Continue UEDGE modeling, (UEDGE-BOUT coupling funded with LLNL internal funds)
  - Continue support for edge pedestal experiments, QDB
  - Continue undesirable trend of (~0.4 - 1 FTE) staff reduction every year (2 retire in FY03)
  - No funds for projects - would have to further decrease staff

Mass Transport: ITER tritium inventory in carbon -- with ELMing H-mode

- Measurements of T_i (ion temperature) & v(flow velocity) in SOL - DCER
  - — On-site engineer, beam and camera
- Increased time resolution measurements for ELMS
  - — Faster, newer PCI based data acquisition
- Coupled models: BOUT-UEDGE, UEDGE-Core

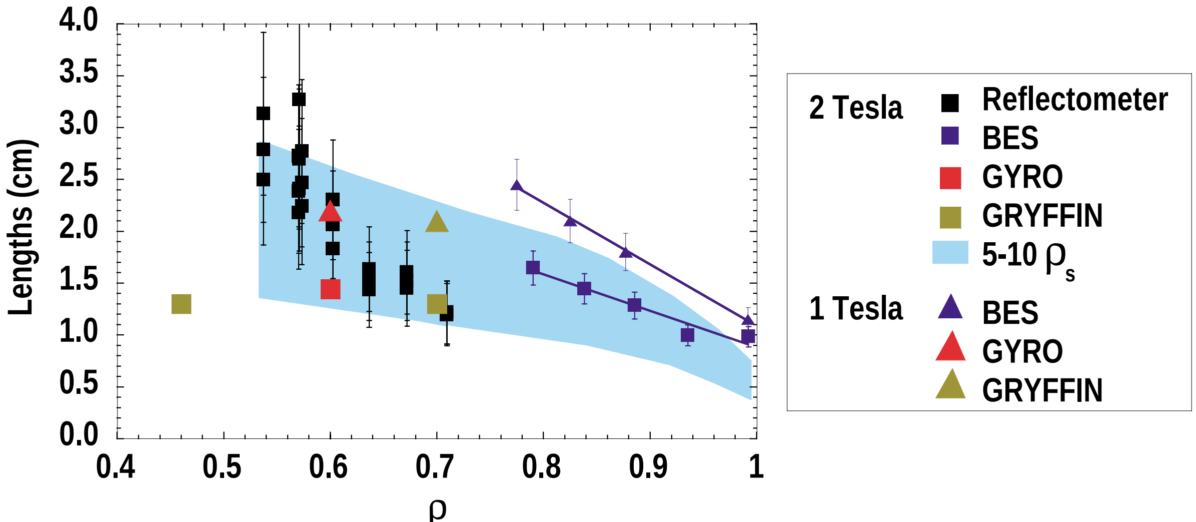
AT physics: Measure and model J(r) profiles

- QDB physics
- High resolution MSE - counter beam
- MSE design for ITER



UCLA—DIII-D COLLABORATION, RECENT ACHIEVEMENTS

- Major involvement in science of edge and core turbulence and transport studies:
  - Direct, quantitative comparisons of turbulence characteristics to gyrokinetic simulation predictions (T. Rhodes, IAEA 2002)



  - High spatial (sub-cm) and temporal (25 µs) resolution density profile measurements for ELM, L-H transition and edge physics studies. ITER relevant techniques
  - Diagnosis of turbulent flows in the edge and core using poloidal correlation reflectometry
    - ★ Collaboration with PPPL
- Active role in DIII-D Thrusts, e.g. main AT thrust (Thrust 8) and QH-mode thrust (Thrust 9)
- Increased role in program governance: T. Peebles, DIII-D Executive Committee, FESAC panel, ITPA TG; E. Doyle deputy leader of Thrust 9, DIII-D research council, ITPA TG chair; T. Rhodes DIII-D turbulence WG chair

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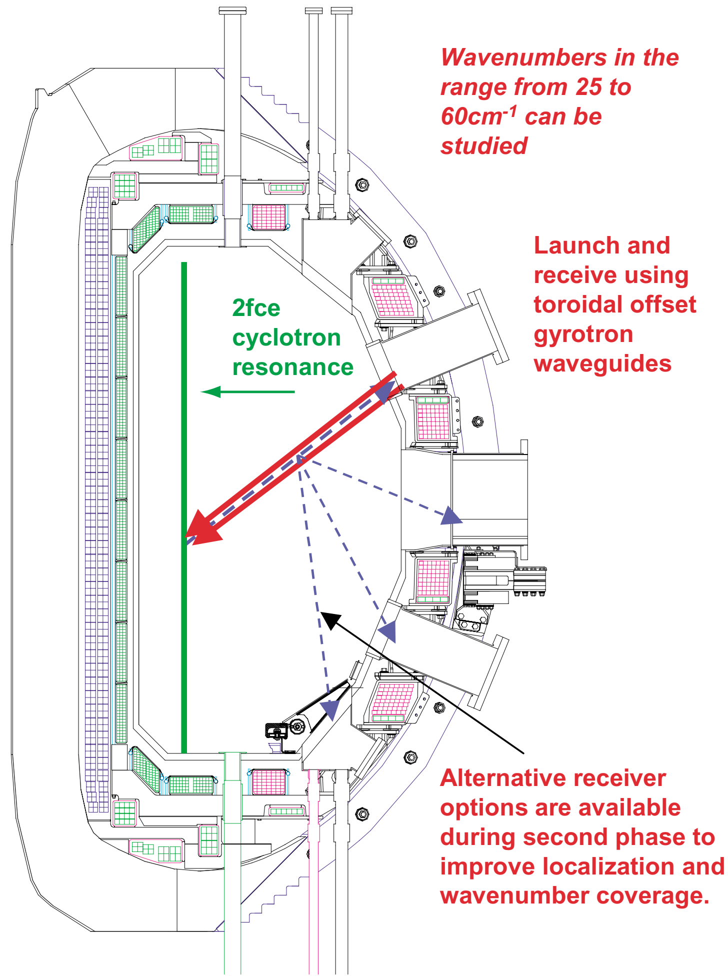
UCLA

FUTURE: ADDITIONAL UCLA FOCUS IS TO CONTRIBUTE TO UNDERSTANDING ELECTRON TRANSPORT

- **Goal:** provide capability to compare theory-based simulations to experimental measurements for electron thermal transport
  - Such a capability exists for ion transport, but gyrokinetic simulations have outstripped diagnostic measurement capability for electron transport
  - Essential for validating theory and models and provide understanding for this long-standing scientific challenge
  - Need ability to measure medium to short wavelength turbulence
- Improved understanding can also lead to a transport control tool for optimizing pressure profiles and thereby AT fusion performance in DIII-D
- UCLA will soon be investigating short-wavelength turbulence in DIII-D:
  - Modification to FIR (300 GHz) scattering system to probe 10-20 cm^{-1} turbulence almost complete
  - With University of New Mexico, microwave back scattering is being pursued to search for 30-60 cm^{-1} turbulence. This approach is well-suited to ITER and other burning plasma devices



Possible backscattering geometry

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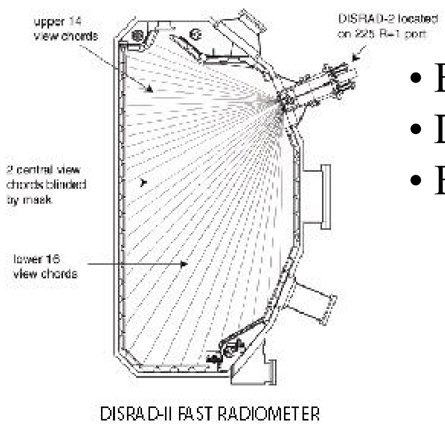
UCLA

UCSD Contribution to the DIII-D Mission

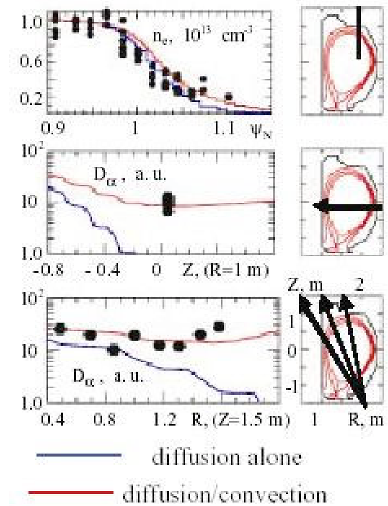
DISRAD-II

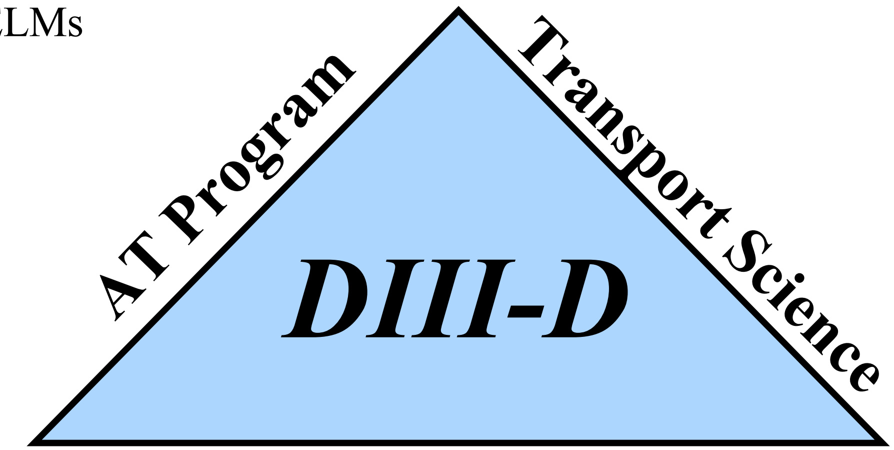


- Edge Pressure Gradient
- Disruptions
- ELMs

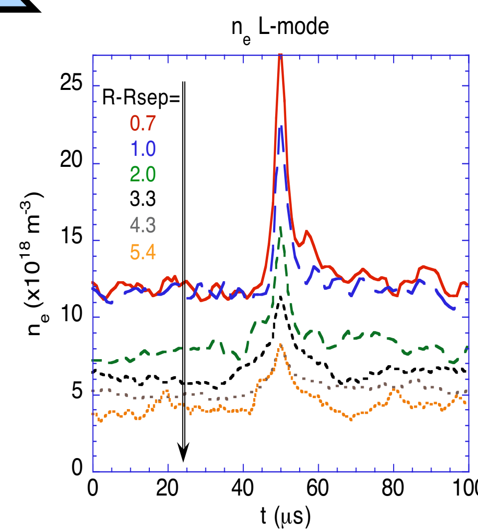
Modeling

- Edge Transport
- Intermittent Transport & First Wall Interaction





Bursty Transport



- EM turbulence and asymmetries
- SOL and divertor parallel flows
- Intermittent radial transport
- ELM Physics in SOL
- Stochastic layer effects on pedestal/ELMs
- Erosion, Redeposition
- Tritium Inventory

Mass Transport In BPX Boundary

Edge Probes & DiMES

UC San Diego

UCSD Accomplishments and Plans on DIII-D

Highlights FY03

- **DISRAD 30 channel fast radiometer re-calibrated and re-installed on DIII-D. Wide bandwidth radiated power diagnostic for disruptions, ELMS, gas jet mitigation, etc.**
- **Joint proposal for imaging of Disruption Mitigation Gas Jet Approved for FY03 DIII-D run period.**
- **Experiments Show Bursty Transport Behavior; Convective-diffusive transport model Implemented in UEDGE and validated in analysis of DIII-D.**
- **Turbulent Heat Flux Measured in Ohmic, L-mode, H-mode**
- **3D & Stochastic Effects Characterized in Boundary**
- **First Midplane Probe ELM Studies Showing ELM Plasma Ejection into SOL**

Future plans FY04 (incremental in red)

- **Develop roadmap for disruption mitigation in burning plasma experiments.**
- **Continue analysis of disruption mitigation experiments on DIII-D for validation of 0-D, 1-D and higher dimensional models.**
- **Model SOL and pedestal region during L-H transition with UEDGE. Determine width of good confinement region and relationship to neutral penetration depth.**
- **E-M Turbulence & Reynolds Stress in L-H Transition**
- **ELM pulse propagation studies in the SOL and divertor**
- **Fast imaging of disruption gas jet and ELMs**
- **Gas puff imaging of turbulence and stochastic boundaries (Incremental)**
- **Update Probe Heads for Te –fluc, Magnetic Fluctuations, flows, fast ion loss (Incremental)**

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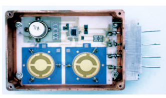
Collaborator's role important in DIII-D carbon transport -- ITER tritium

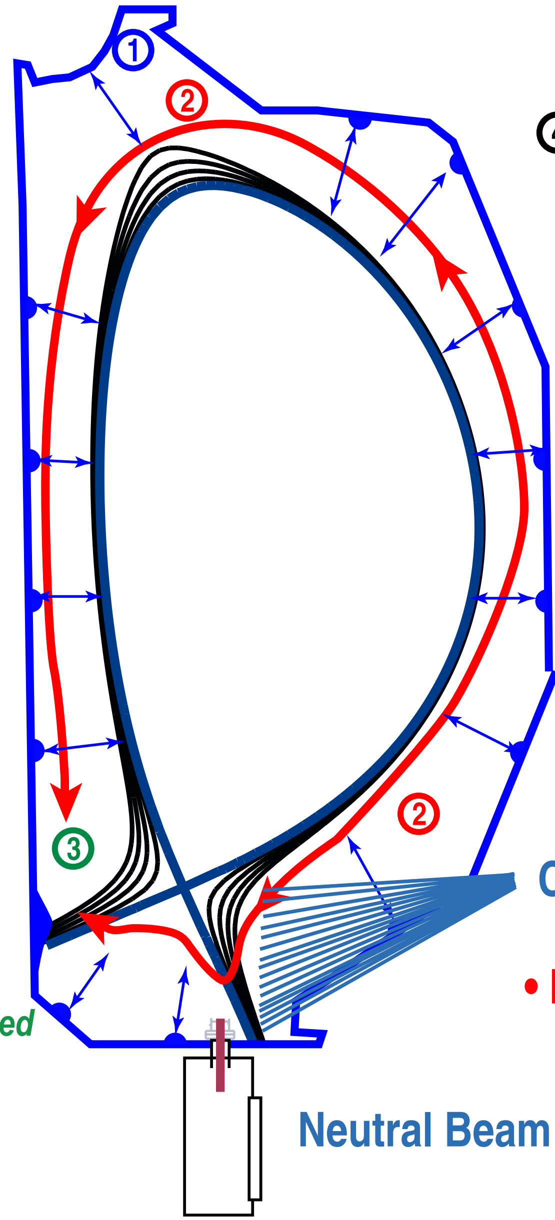
① *Carbon Influx from walls*



- Quartz microbalances measure carbon erosion-redeposition (GA, U. Wis.)
- CCD cameras measure poloidal carbon distribution (LLNL) (ELM upgrade)
- C-13 Tracer Experiments

Change divertor
③ *for local codeposition control*

- C sputtering (ORNL)
- *Technology of tritium removal from co-deposited layers (SNL)*



④ *ELMs and Pedestal Physics (Faster Data Acquisition)*

- Edge Turbulence Measurements Probes (UCSD), BES (U. Wis.)
- Divertor Thomson Scattering for T_e
- Langmuir Probes for T_e , flux (ELM upgrade)

② *Fast SOL FLOW Moves Carbon (inner strike point)*

- Divertor CER measures C flows and ion temperature (LLNL & GA)