FY11 Joint Research Target: Status and Planning on Alcator C-Mod

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Including slides from:

(1) ECC Meeting on FY2010 and FY2011 Joint Research Milestones, ***April 12, 2010***

(2) Alcator C-Mod FY10 Q3 Review, ***July 26, 2010***

Predictive capability for the H-mode pedestal is the subject of the FY11 JRT

Alcator C-Mod

Statement of the FY2011 FES Joint Theory and Experiment Research Target

Improve the understanding of the physics mechanisms responsible for the structure of the pedestal and compare with the predictive models described in the companion theory milestone. Perform experiments to test theoretical physics models in the pedestal region on multiple devices over a broad range of plasma parameters (e.g., collisionality, beta, and aspect ratio). Detailed measurements of the *height and width* of the pedestal will be performed augmented by measurements of the *radial electric field*. The *evolution of these parameters* during the discharge will be studied. Initial measurements of the *turbulence in the pedestal region* will also be performed to improve understanding of the relationship between edge turbulent transport and pedestal structure.

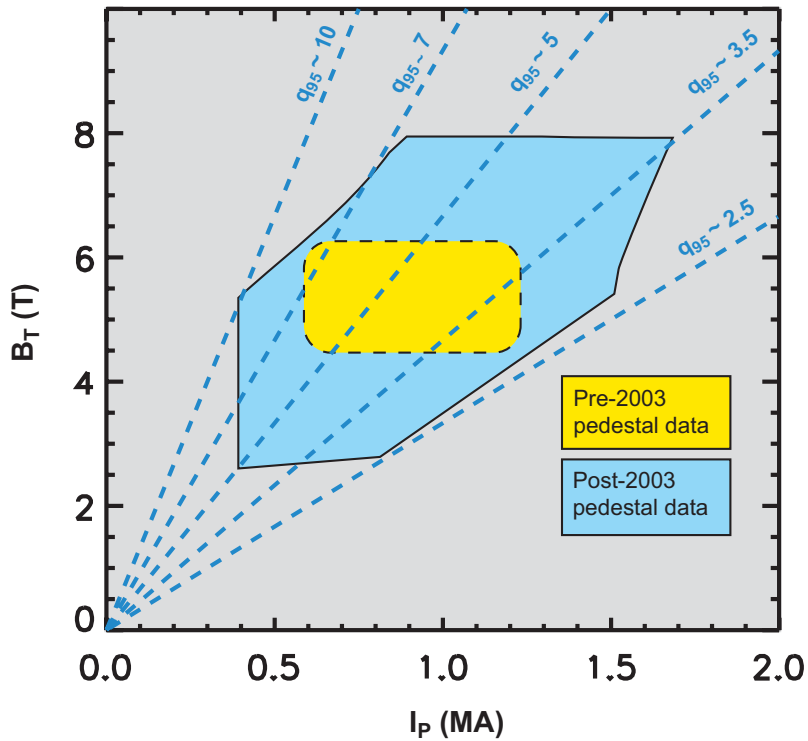
A focused analytic theory and computational effort, including large-scale simulations, will be used to identify and quantify relevant physics mechanisms controlling the structure of the pedestal. The performance of future burning plasmas is strongly correlated with the pressure at the top of the edge transport barrier (or pedestal height). Predicting the pedestal height has proved challenging due to a wide and overlapping range of relevant spatiotemporal scales, geometrical complexity, and a variety of potentially important physics mechanisms. Predictive models will be developed and key features of each model will be tested against observations, to clarify the relative importance of various physics mechanisms, and to make progress in developing a validated physics model for the pedestal height.

C-Mod activities are aligned to quarterly targets

	Quarterly Target	C-Mod Activity
Q1	Develop a preliminary research plan coordinated among the three facilities, delineating the planned experiments aimed at developing understanding of the physics mechanisms responsible for the structure of the pedestal. Provide to the theoretical community a sample set of existing preliminary pedestal data prior-to and following an ELM, including density and temperature, suitable for initial comparisons with simulation. Develop a preliminary coordinated research plan for simulation activities, delineating a planned set of simulations aimed at comparison with experiment. The theoretical community will begin the process of developing code interfaces to compare the code predictions with experimental data.	FY11 Experimental Campaign, Part 1 •Complete first round of EPED validation experiments •Perform additional pedestal experiments (pedestal transport control, species dependence, effects of magnetic shear) Provide initial datasets for the modeling of EDA and ELMy H-mode
Q2	Initial planned experiments will have been carried out on at least one of the three facilities and results conveyed to the theoretical community to inform the simulation program activities. Initial comparison of theory and experiment using the existing sample data set will have been carried out with at least two models. Results from the comparison will be conveyed to the experimental community to inform plans for remaining experiments.	Up-to-air for installation of new 4-strap ICRF antenna Design new experiments based on results of Part 1 experiments, and parallel modeling efforts
Q3	Continue experiments accompanied by preliminary reduction of initial data, with results made available to the theoretical community. Comparison of theory and experiment will be extended to include a broader set of experimental conditions. Based on the results of experiments and simulations, remaining experimental plans will be adjusted and simulation models will be refined and extended.	FY11 Experimental Campaign, Part 2 Complete experiments contributing to JRT
Q4	Complete experiments and simulations. Compare key features of relevant theoretical models against observations to clarify the relative importance of various physics mechanisms. Submit a report documenting completion of these activities, which includes summary data, simulation results, implications for future work, and a brief, preliminary assessment of the implications for ITER.	Perform final round of comparisons between theory and experiment

An extensive C-Mod pedestal database exists

- **C-Mod pedestal scalings over *expanded range* of engineering parameters: *e.g.* B_T, I_P, n_e**
- **Increased studies of operation with "alternative" magnetic topology**
  - Extremes in *shaping*
  - Unfavorable ion ∇B drift direction (in both normal and reversed B_T direction)
  - Near double null
- **Lower collisionality with above techniques, cryopumping**
- **ELMy regimes**



We have expanded the range of operational space for pedestal studies

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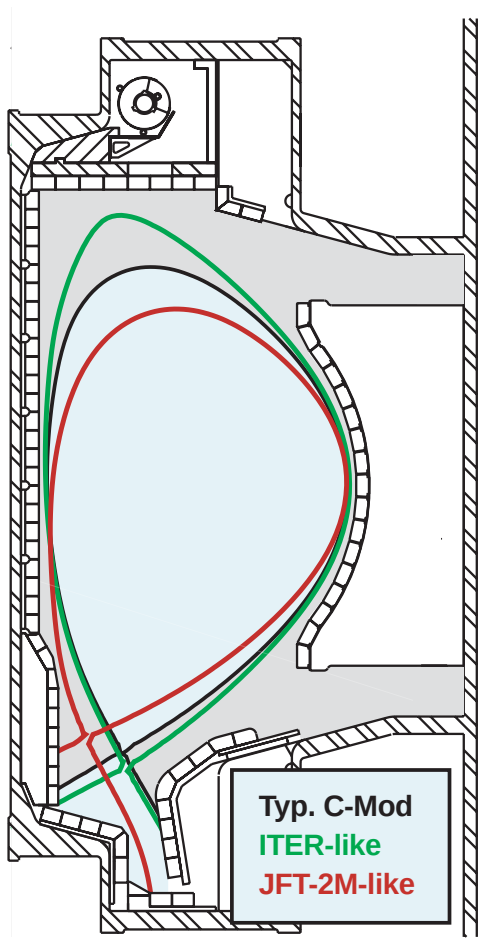

An extensive C-Mod pedestal database exists

- **C-Mod pedestal scalings over wide range of engineering parameters: *e.g.* B_T, I_P, n_e**
- **Increased studies of operation with "alternative" magnetic topology**
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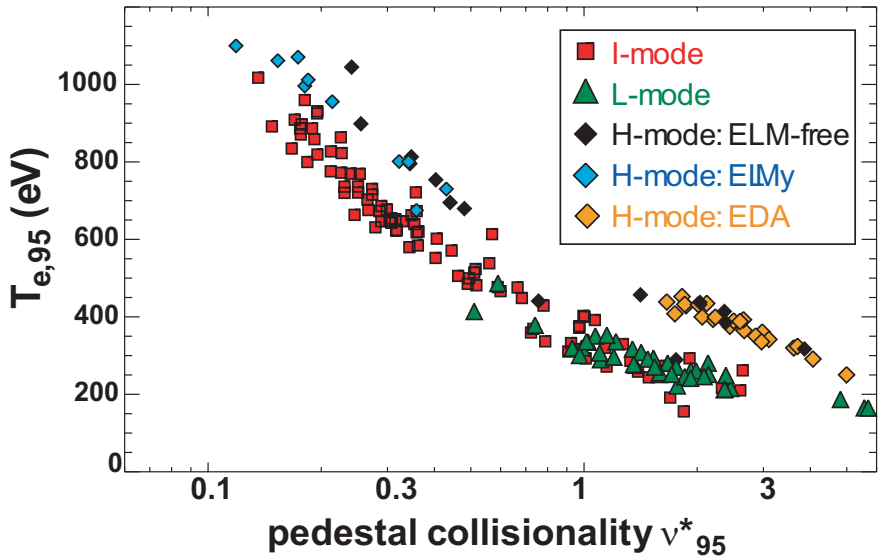
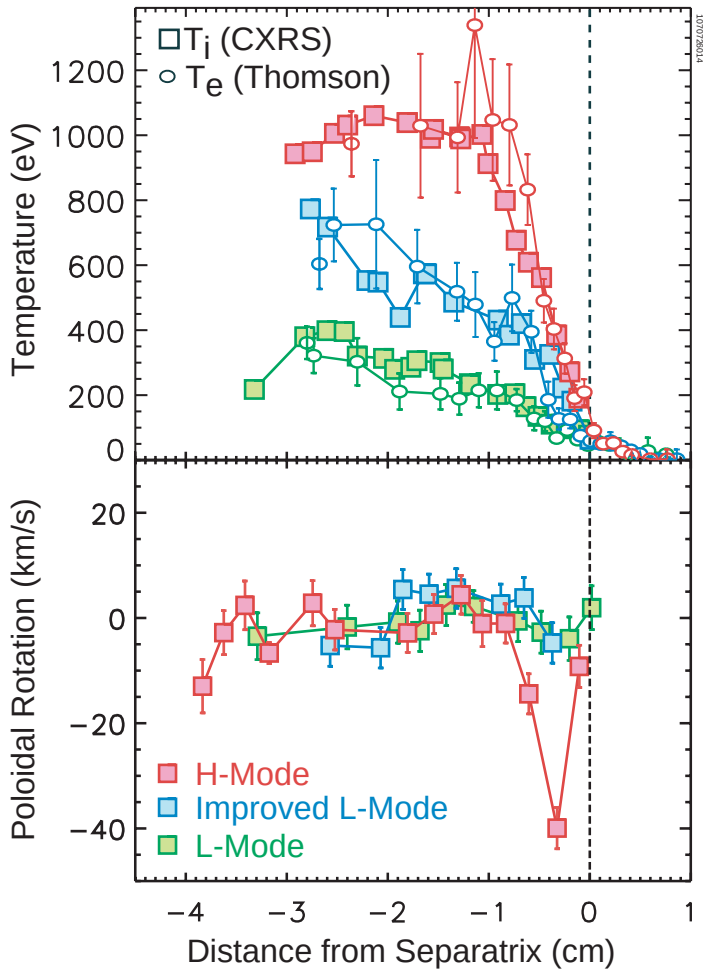


- **Lower collisionality with above techniques + cryopumping**
- **ELMy regimes provide common H-mode case for all devices**
- **EDA H-modes, I-modes can be studied as well**

We are enabled by an extensive set of well-resolved edge diagnostics

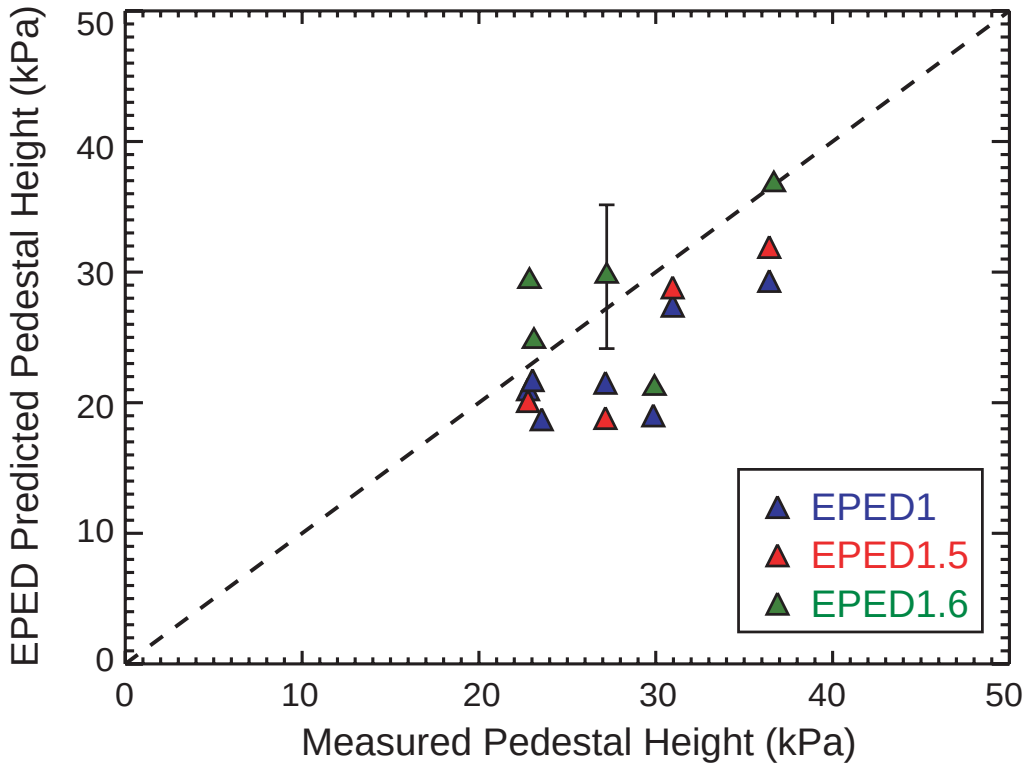
Pedestal diagnostic set emphasizes ***millimeter-resolution*** profiles, fluctuations

- Thomson scattering (T_e, n_e)
- CXRS (T_I, $v_{I\theta}$, $v_{I\phi}$, E_r)
  - Inner wall toroidal views (passive and gas-puff assisted)
  - Pedestal beam-based CXRS (*toroidal* and *poloidal* views)
- Scanning Mach probes, HFS+LFS (T_e, n_e, v)
- Electron cyclotron emission (T_e)
- Visible bremsstrahlung ($n_e Z_{eff}^{1/2}$)
- Soft x-rays (n_I)
- Neutral emissivity measurements
- Reflectometer (n_e fluctuations, localized)
- Phase-contrast imaging (n_e flucts, chord-integrated)
- Gas puff imaging (n_e flucts, 2D localized)

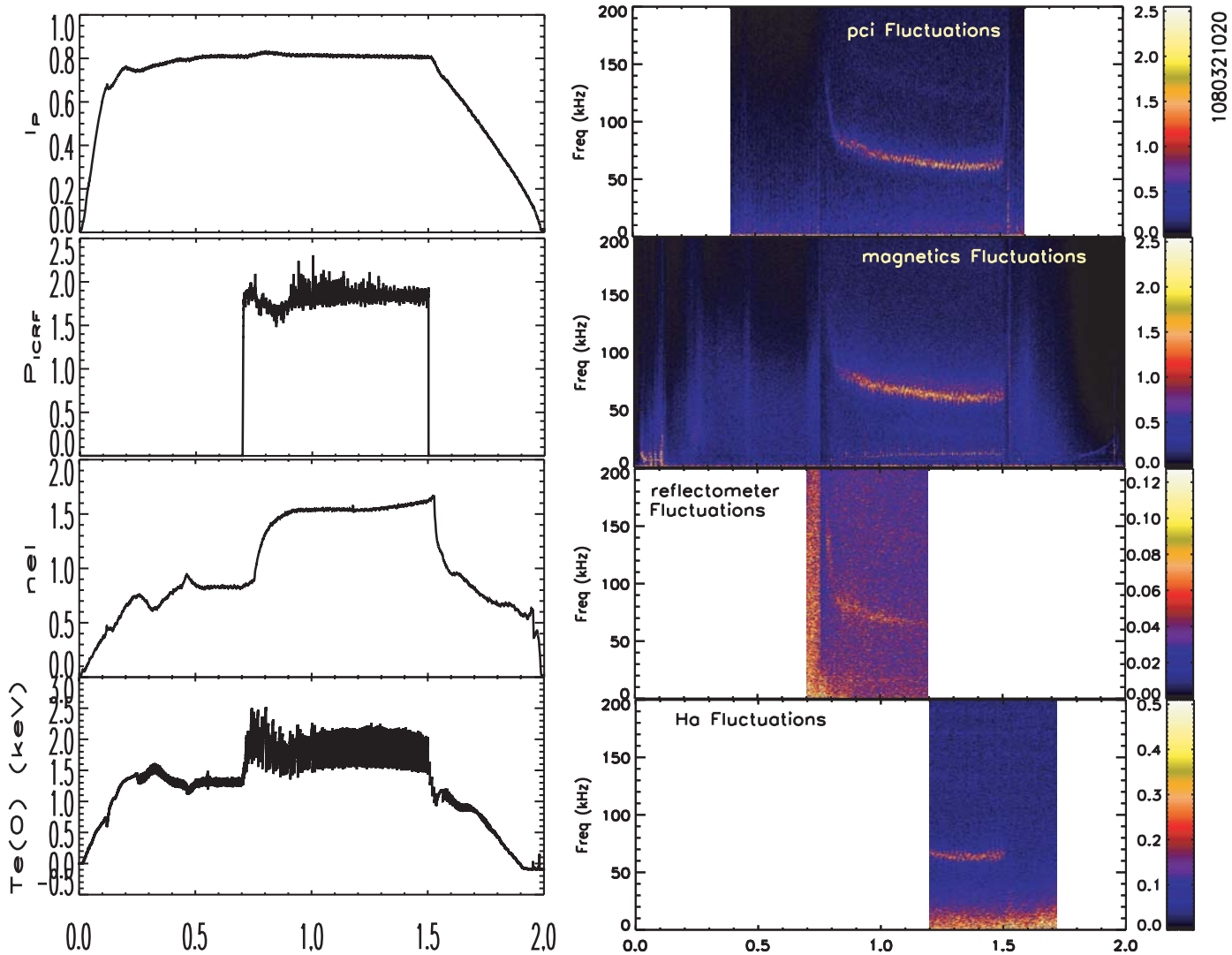


ELMy H-mode: EPED model, experimental results are converging

- Experiment to test EPED predictions was proposed by P. Snyder (GA), had initial run time in 2009
- Pedestal data have undergone preliminary, time-averaged analysis for width and height
- Comparisons with EPED look promising
- Continued analysis, experiments planned for FY11
- Pedestal scaling also can be studied with coupled XGC0/ELITE (Pankin)



EDA H-mode: Well-diagnosed discharge has been identified for modeling



Modelers actively collaborate with C-Mod

- **Numerous edge modeling collaborations have been instituted to enhance the FY10 JRT research**
- **Ongoing work helps develop a starting point for FY11 JRT**
- **Examples of collaborations that have already begun**
  - EPED1 validation (Snyder)
  - Simulations of the quasi-coherent mode with M3D (Sugiyama)
  - Neoclassical and anomalous pedestal width evaluated from XGC0 (Chang, Pankin)
  - I-mode simulations with XGC1 (Chang, Ku)

Tentative machine schedule through FY11

- **Currently up-to-air for invessel maintenance, LH launcher installation**
- **July—August ’10: Complete FY10 research operation**
  - Nominally 3.3 run weeks remaining; may run more if budget and scheduling allow
- **October—December ’10: Begin FY11 research operation**
  - 7—8 run weeks of our 15 weeks guidance
- **January—March ’11: Up-to-air (chiefly for installation of new 4-strap ICRF antenna)**
- **May—July ’11: Complete FY11 research operation**

Upgrades enhancing pedestal research on Alcator C-Mod

- **Profile diagnostics**
  - FY10: Repair or replace source for diagnostic neutral beam
  - FY10: Inner wall charge exchange recombination has been upgraded to allow for *inboard poloidal flow measurement*, in addition to toroidal flow
  - FY11: Scrape-off layer Thomson scattering will provide additional n_e, T_e points *near pedestal foot* (~2mm resolution, 60Hz)
- **Fluctuation diagnostics**
  - FY10: Scanning correlation reflectometry --- useful for studying n_e *fluctuations* in stationary moderate-to-high density pedestals (*e.g.* EDA at low q_{95})
  - FY10: Enhanced 2D gas puff imaging has been implemented for determining k_R and k_θ of *pedestal/SOL fluctuations*
- **Facilities upgrades**
  - FY11: Field-aligned 4-strap ICRF antenna for *improved power handling*
  - FY11: Fast ferrite tuners for the ICRF antennas to improve *coupling through ELMs and other edge events* (ARRA $, est. spring '11)
  - FY10: Lower hybrid launcher with improved efficiency being installed during current up-to-air --- *couple >1.5MW LH power* to plasma
  - FY11: Increases in available LH source power from 3 to 4MW

A number of proposed experiments have potential to contribute to JRT

- **Existing mini-proposals**
  - MP578: Experimental tests of EPED1 pedestal prediction in ELMy H-Mode
  - MP580: Comparison of Type I ELM access and characteristics in He4 and D plasmas in C-Mod
  - MP564: Power requirements for high confinement H-modes and the role of radiated power spatial distribution.
  - MP559: Species effects on the H-mode threshold in He4(H), D(H), and H(He3) plasmas.
  - MP614: Lower hybrid modification of the H-mode pedestal and edge relaxation mechanisms.
  - MP595: Analysis of the Radial Impurity Transport at the Pedestal Region.
- **Proposals still at the conceptual stage, but with MPs to be written**
  - MPxxx: Physics basis for I-mode
  - MPxxx: Magnetic shear and pedestal width.
  - MPxxx: Core fueling from plasma transport vs. neutral penetration.
  - MPxxx: Isotope and Ip scaling of transport
  - MPxxx: Radial width of the QC mode
- **We seek to expand this list with fresh ideas . . .**

We are holding a workshop for pedestal research on both C-Mod and NSTX

- **Occurring at PPPL on September 7—8, 2010. (est. 1½ days)**
- **Broader experimental and theoretical community encouraged to attend, or remotely participate**
- **Purpose: Gather testable ideas from experimentalists, theorists and modelers for research that can advance the predictive capability for the H-mode pedestal**
  - specific experimental tests of theory and modeling predictions of pedestal transport and structure
  - extended experiments and modeling to enhance the understanding of prior experimental results
- **Ideas for novel experimental techniques and uses of diagnostics are encouraged**
- **Will review and build upon the results of the Feb. 2010 "DIII-D Pedestal Transport Workshop" (J. Callen, R. Groebner)**
- **Opportunity for the JRT representatives to meet before APS**