DIII-D Boundary and Pedestal Experimental Plan for 2012

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Overall Plan for Boundary and Pedestal Research in 2012

- **ELM control**
  - Develop the physics basis for utilizing ELM control in ITER
  - Examine techniques; 3D fields (RMP), Pellet ELM pacing, QH-mode, I-mode
- **Pedestal Physics**
  - Pedestal structure; Identify Kinetic Ballooning Modes (KBM) regulating local pressure gradient
  - Examine the role of edge recycling fueling of density pedestal; Based on physics models determine fueling requirements (pellets) for ITER
- **Boundary Plasma**
  - Divertor heat flux width; Radial transport processes determining peak heat flux
  - Divertor shaping; Examine Super-X and Snowflake divertor configurations
- **Materials**
  - Test models for erosion, re-deposition and migration of high-Z and low-Z materials

ELM control Experiments

- **QH-mode**
  - Sustained operation with ITER relevant parameters; High β, low input torque, NTV driven velocity shear
  - Other issues to address; EHO mode control, ECH dominant heating, SOL and divertor modification
- **Pellet ELM pacing**
  - Pellet ELM pacing dependence on Power/Power$_{LH}$, shape, q_{95}, torque
  - Combine rapid pellets with HFs fueling
  - Piggyback; Minimum size pellet penetration for ELM triggering
- **I-mode**
  - Define operating space in LSN, Rev. B_t
  - I-mode with ECH and FW comparison with C-Mod

NTV: Neoclassical toroidal viscous

EHO: Edge harmonic oscillation

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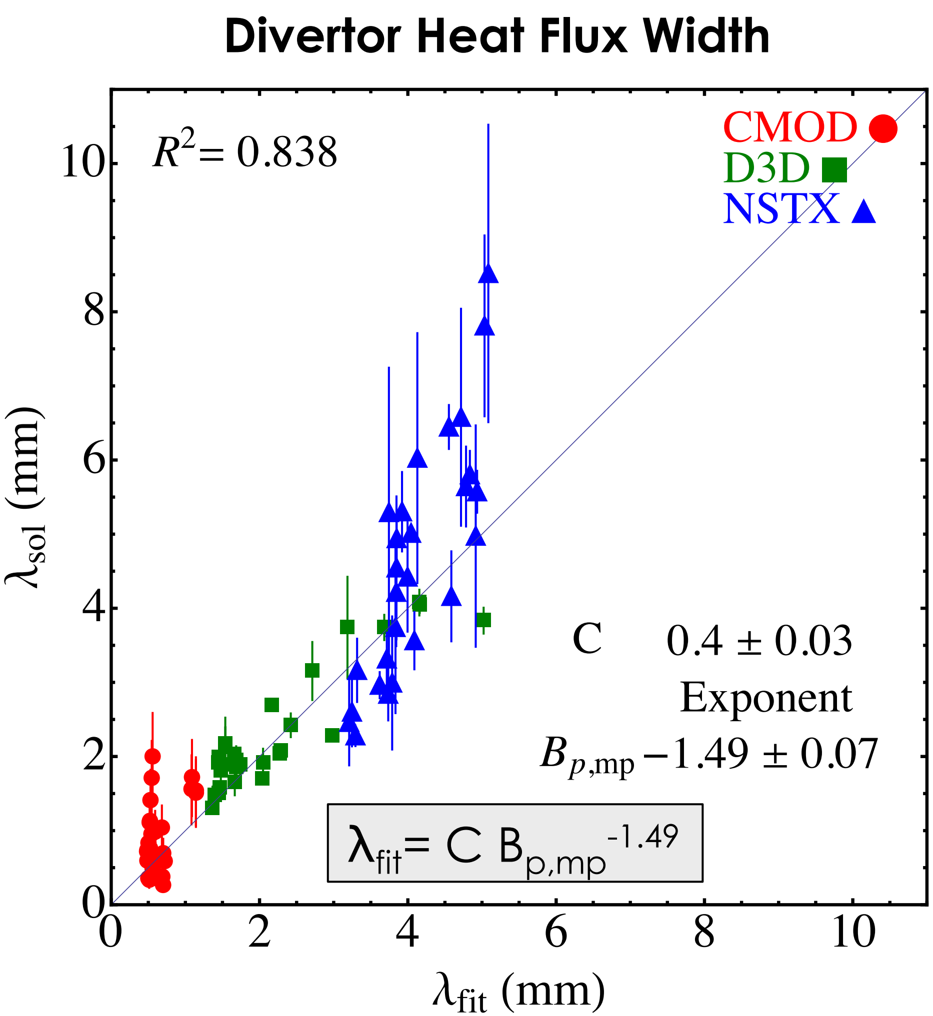
Pedestal Physics Experiments

- **Pedestal evolution**
  - Utilize slow ELM evolution to measure a number of pedestal structure processes; 1) Turbulence, 2)Pedestal top inward propagation, 3) Bootstrap current, 4) Density rise vs. fueling
  - Repeat shots with scans of power and current
  - Build on 2011 JRT
- **High density pedestal with low fueling**
  - High Ip, low additional gas puffing, adequate power to maintain T_e pedestal
  - Obtain divertor data needed for modeling
  - Divertor detachment data may also be acquired (possibly with gas injection)

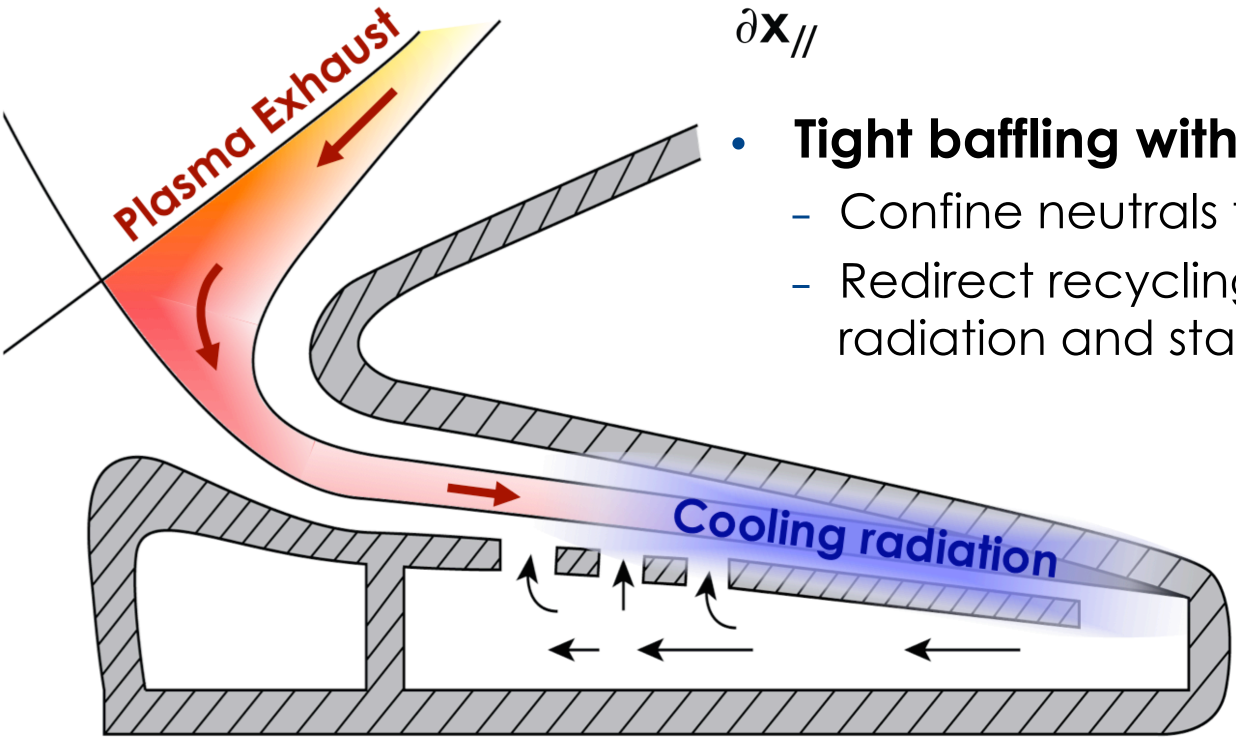
Emerging Heat Flux Scaling Indicates More Difficult Challenge



- **New scaling predicts narrower heat flux profile than previously expected**
  - ITER width projection, ~1-2 mm
  - Similar scaling from EU study, JET/AUG comparison
- **Simple stability model would suggest significantly greater width in ITER**
  - Ideal ballooning would suggest ~5-10 mm
- **We aim to resolve these divergent views with divertor and SOL measurements**
  - Examine simultaneous SOL profile and divertor heat flux scaling vs. density and power
  - Stability code analysis from high quality SOL Thomson scattering profiles

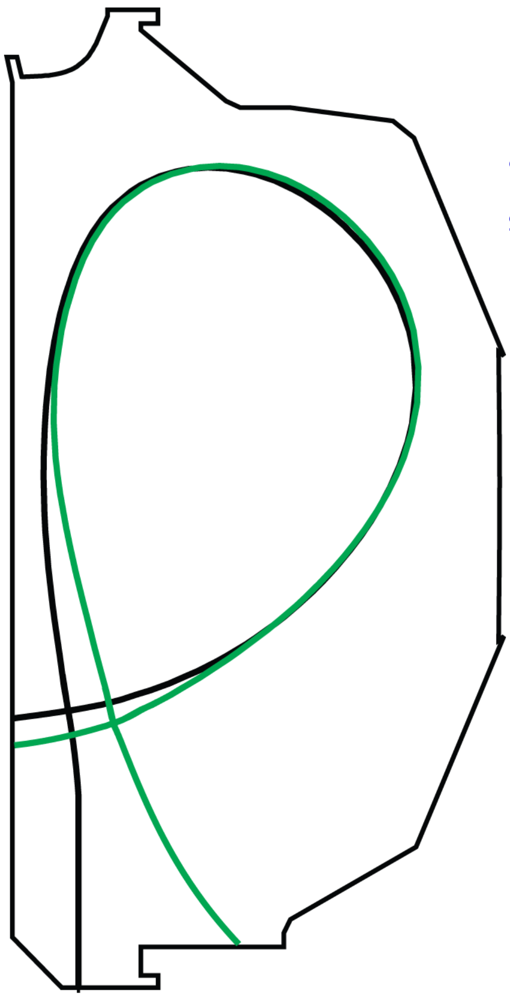
Divertor Strike-point at Large Major Radius May Mitigate Deficiencies of a Conventional Divertor Geometry

- **Strike-point at large major radius**
  - Reduced $q_{||}$ for lower core density at detachment
  - $\frac{\partial \mathbf{q}_{//}}{\partial \mathbf{x}_{//}}$ to stabilize detachment front

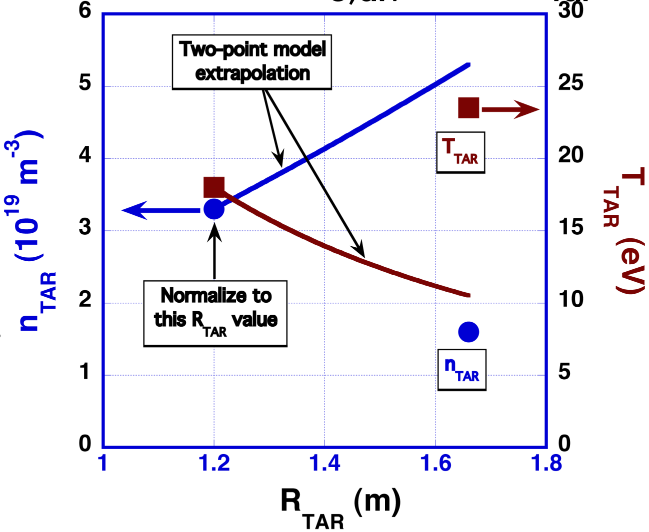


- **Tight baffling with neutral bypass**
  - Confine neutrals to divertor region
  - Redirect recycling neutrals for optimal radiation and stability of detachment front

Initial Tests Indicate Importance of Neutral Recycling (from two configurations)



Higher $T_{e,div}$ with R_{tar}

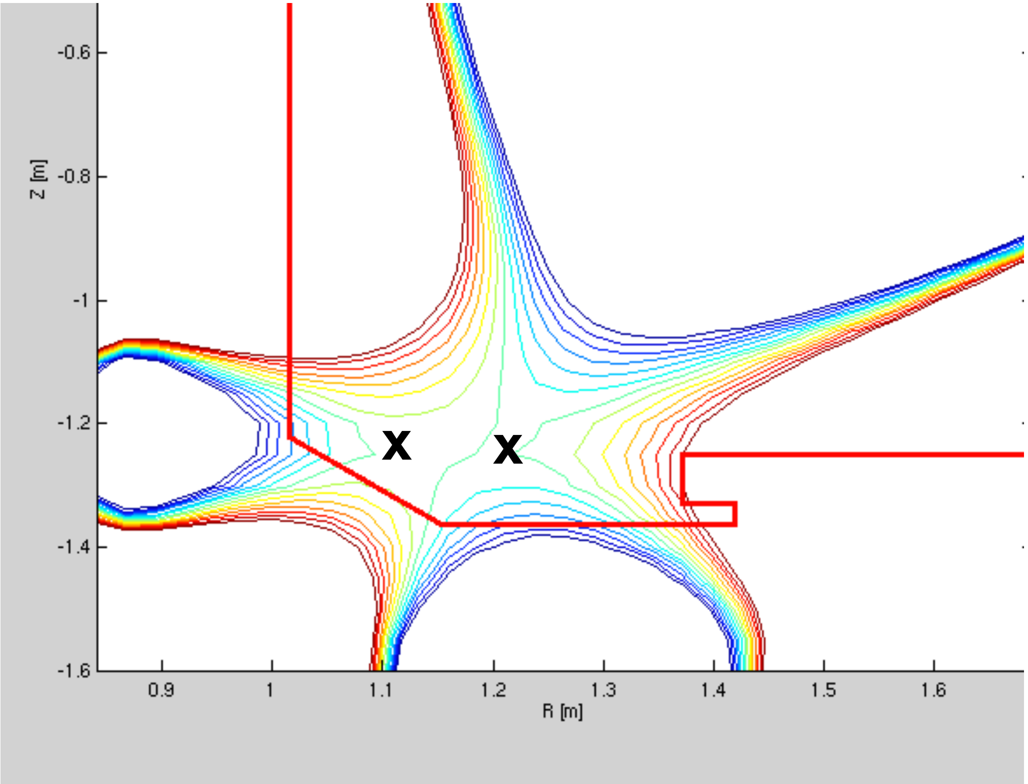


- **Initial results defied expectations at high R_{target}**
- **SOLPS analysis indicates results due to reduced neutral confinement at large R**
  - More open divertor
  - Less poloidal flux expansion

2012 experiments to examine role of neutral in detachment onset as a function of strike-point major radius

Snowflake configuration exhibits attractive features

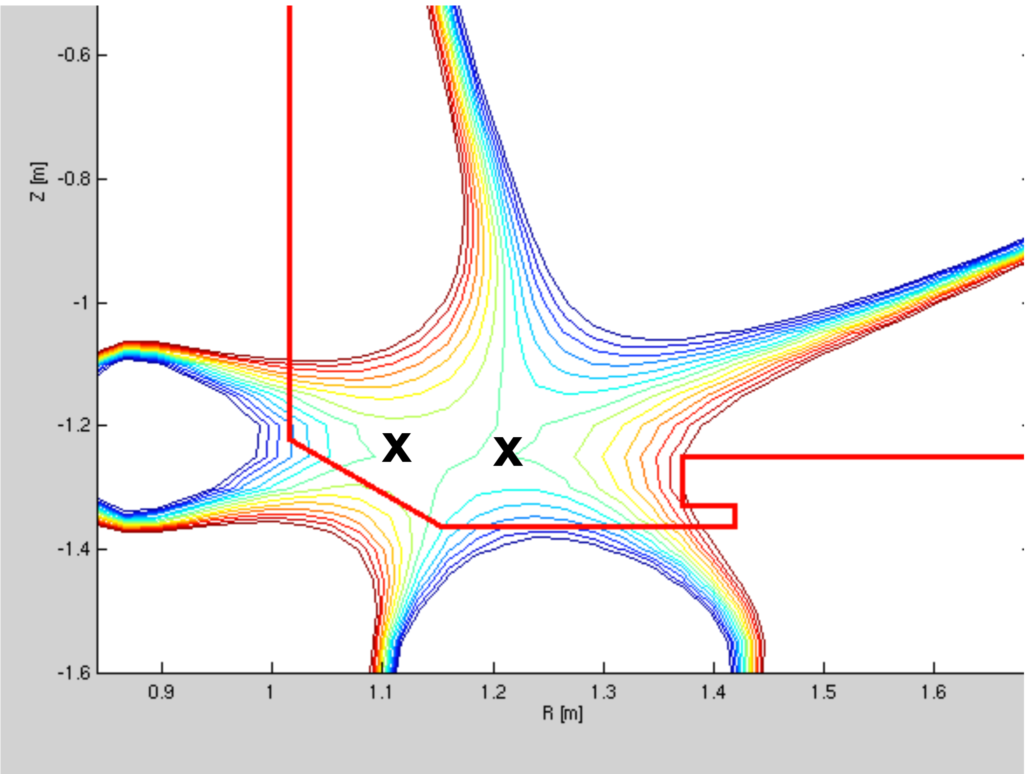
Proposed Snowflake in DIII-D



- **Large flux expansion to spread heat flux, steady state and ELMs**
- **Large divertor volume in compact configuration**
  - Enhanced detachment on NSTX
- **Improved pedestal stability**
  - Higher core performance
  - May aid ELM control

Explore Applications of Snowflake concept in DIII-D

Proposed Snowflake in DIII-D



- **Snowflake shape control**
  - Control of multiple field nulls
  - Provide protection for divertor shelf supports
- **Divertor detachment**
  - Increased connection length
  - 2D geometry effects
- **Pedestal stability and ELMs**
  - Pedestal pressure dependence
  - Interaction with ELM control

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Plasma Material Interactions

- **High-Z erosion measurement**
  - Test of erosion/re-deposition models of Mo and W
- **Low-Z-erosion**
  - Al proxy for Be; Test erosion and migration models for ITER first wall lifetime
- **Piggyback, or a few dedicated shots**
  - Sheath power transmission
  - Arcing on divertor surfaces
  - Dust
  - W-fuzz
- **ITER Langmuir probe**
  - Being developed between SWIP and SNL-L
  - To utilize the DiMES facility for testing