NSTX

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XP1046: Effect of externally applied 3-D fields on divertor profiles

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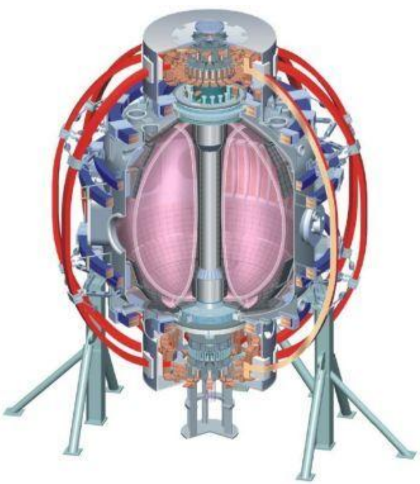
NSTX BSG Review
PPPL, June 29, 2010



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Motivation

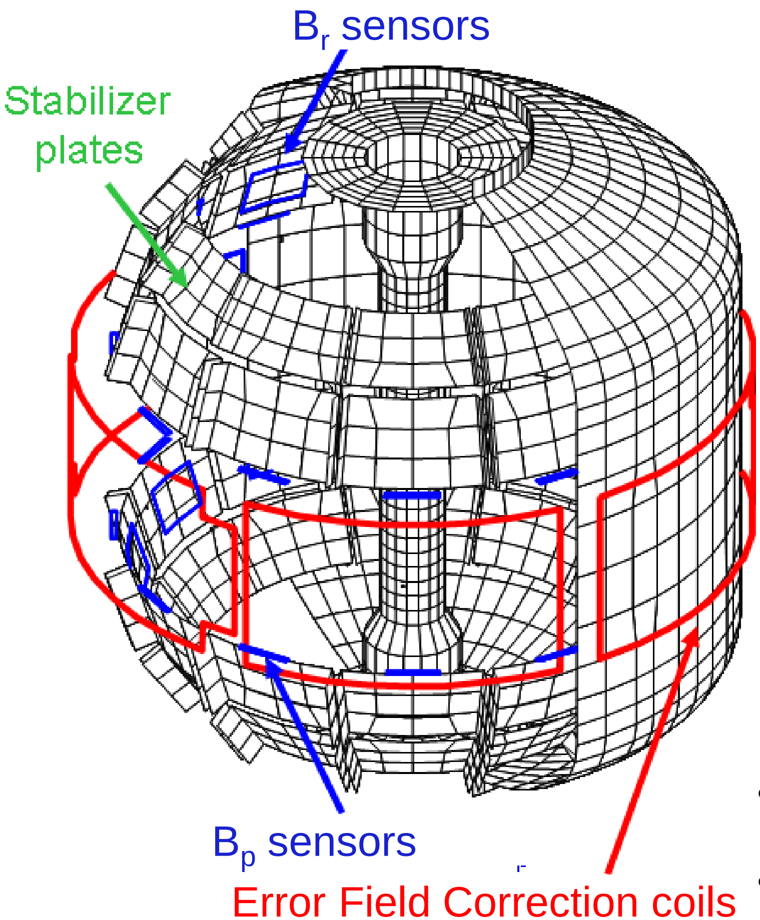
- Small external magnetic perturbations used for ELM control
  - ELM suppression (DIII-D) and mitigation (JET)
  - ELM triggering (NSTX, MAST)

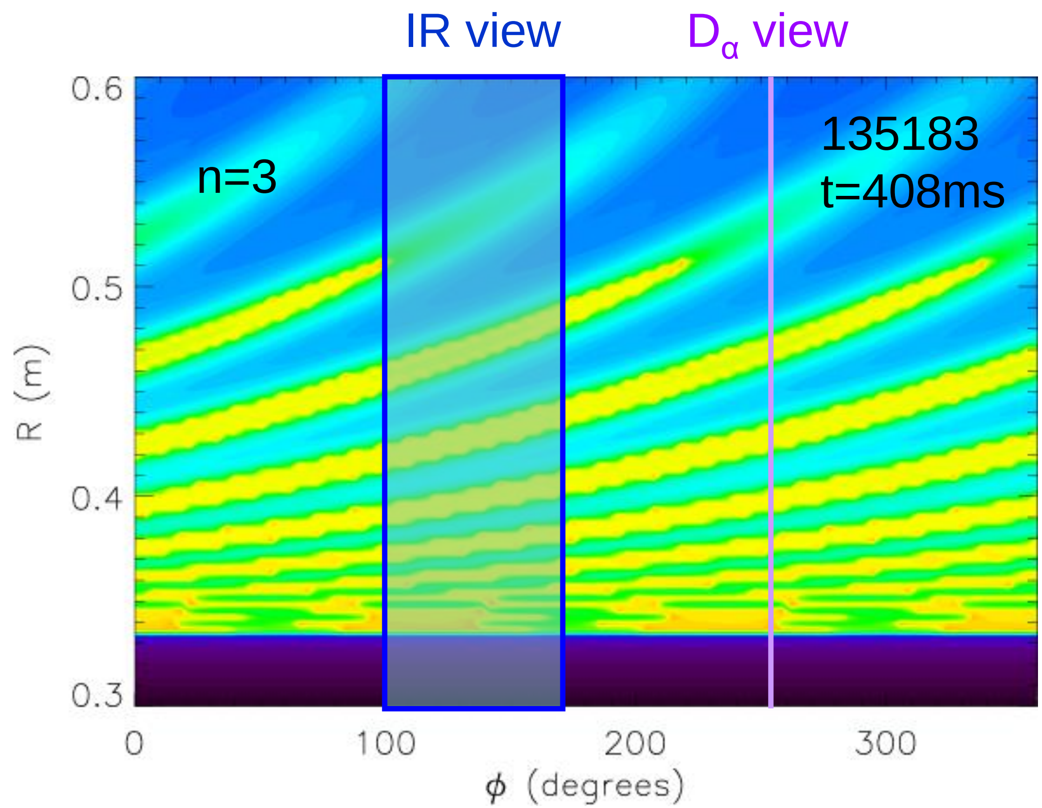
- The 3-D nature of RMP application can cause toroidally asymmetric heat and particle deposition

- Understanding of heat and particle transport in the presence of 3-D fields, both externally applied and/or internally arisen, is important for divertor performance projections

- The proposed use of 3-D field triggered ELMs in a controlled manner requires detailed understanding of heat and particle deposition pattern during the ELMs

Strike point splitting is predicted by 3-D field application

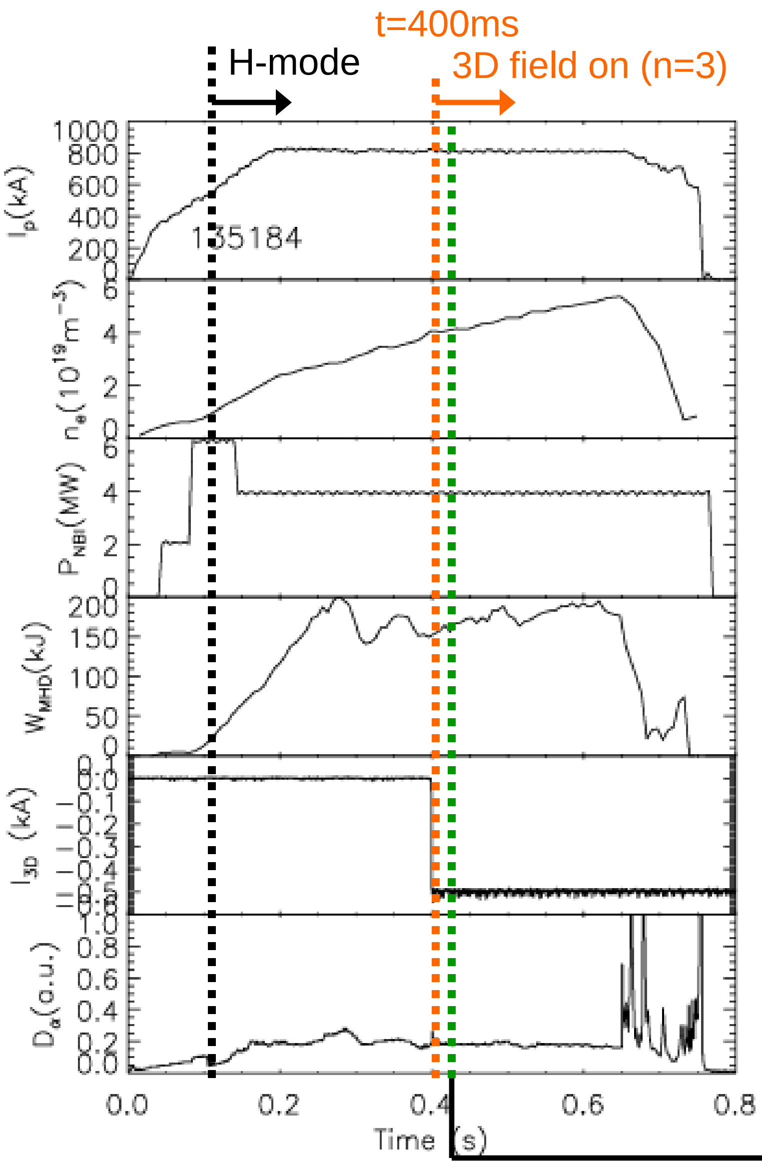


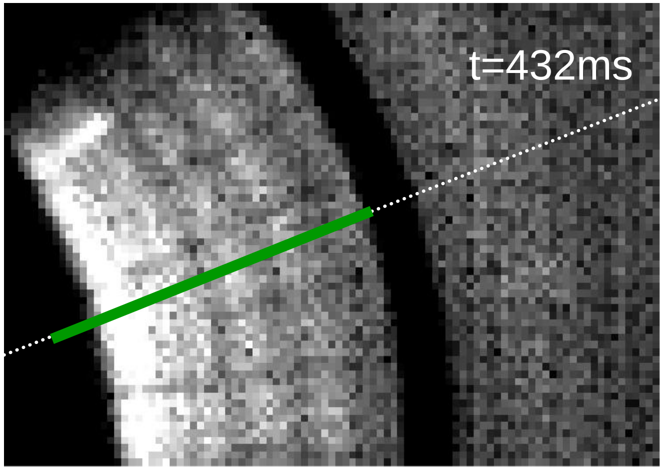


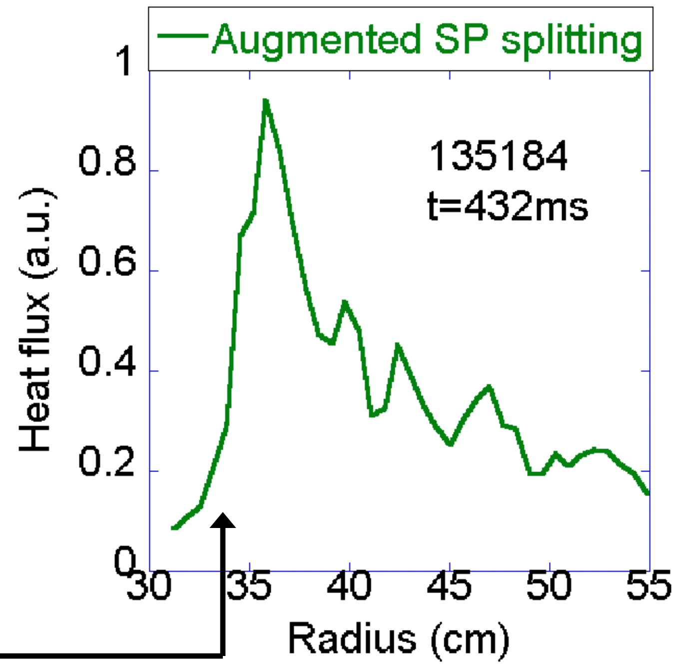
J-W. Ahn, Nucl. Fusion (2010), 045010

- 3-D fields (n=1, 2, 3) can be applied externally
- Connection length for field lines at divertor target, computed by vacuum field line tracing (J.M. Canik)
- Field line tracing uses superposition of vacuum n=3 fields and 2-D equilibrium fields

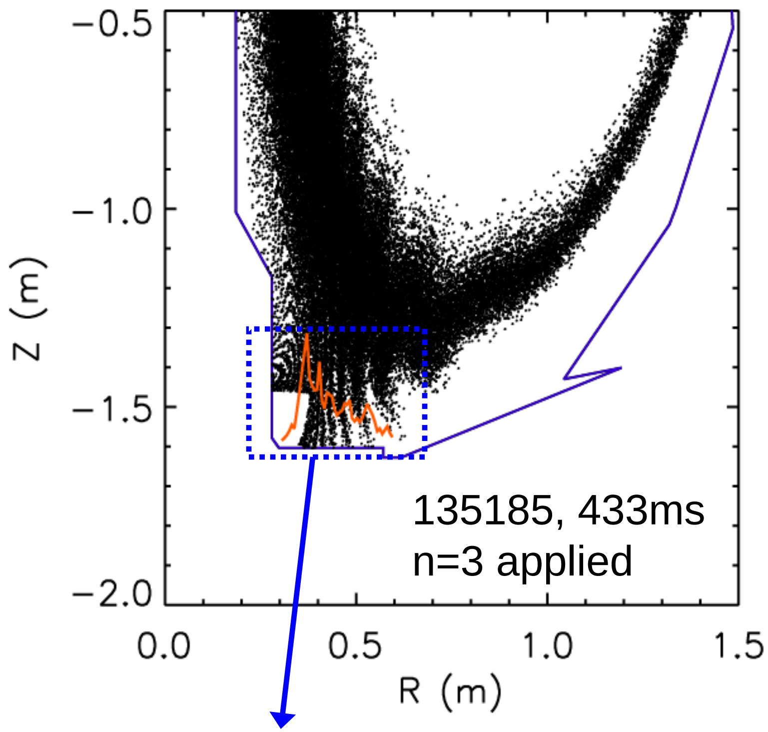
'Augmented strike point splitting' by 3-D field application

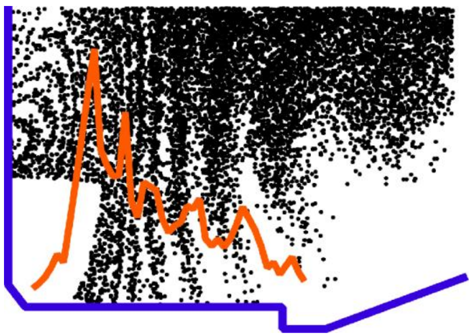






Distribution of lobe locations agrees well between measurement and vacuum field line tracing





- Measured heat flux profile (red) overlaid with vacuum field line tracing plot

- Dense regions in the puncture plot correspond to long connection length lobes, therefore expected to have higher heat and particle fluxes

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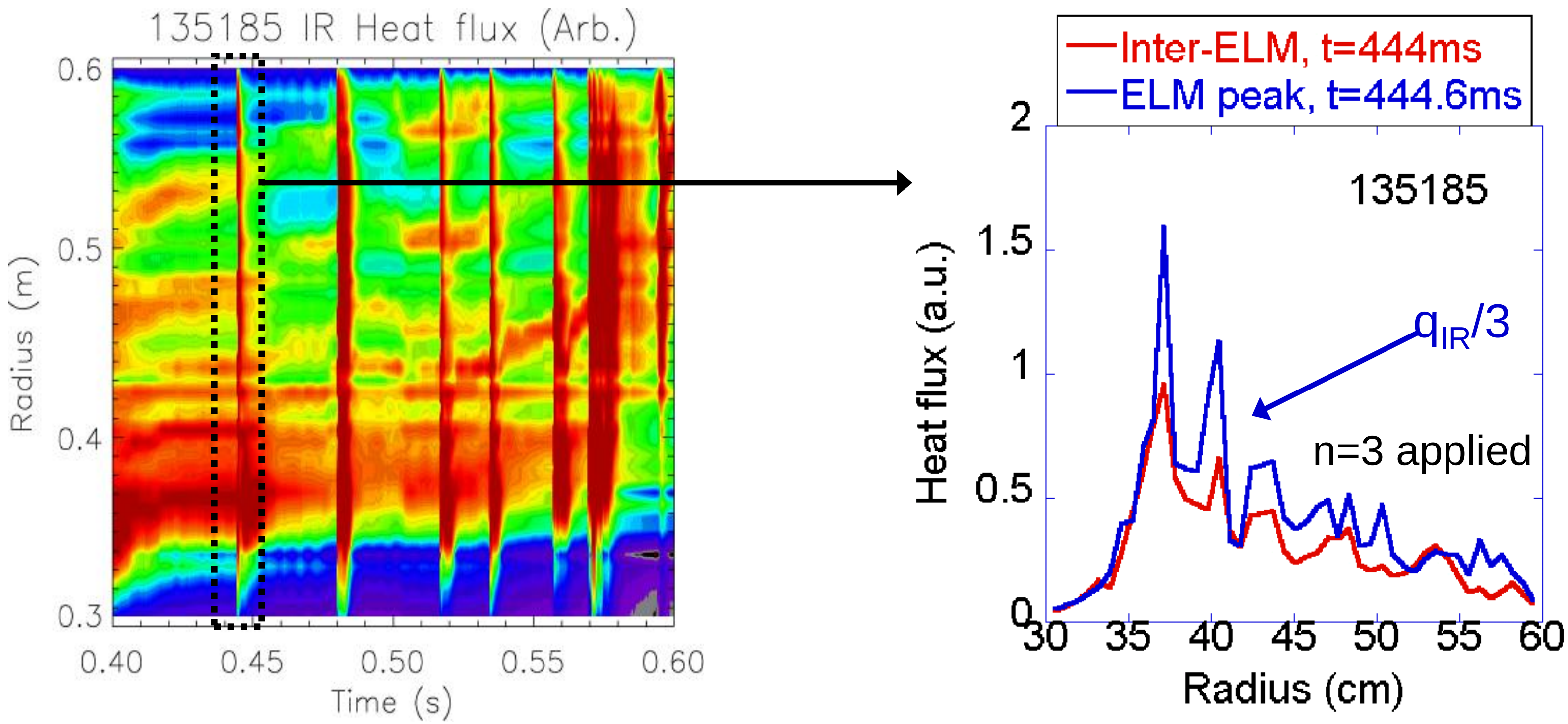
Heat flux profile from ELMs triggered by n=3 fields appears to follow imposed field structure



- Striations in the heat flux profile appear in the same locations as was before the ELM
- 3-D field triggered ELMs appear to be phase-locked to the externally applied perturbation structure

Issues to be investigated

- Data in FY09 were obtained from limited plasma conditions, *ie* v^*_e~1, q95~11, β_N~4. Therefore, conclusions are also valid only for those conditions.

  → We need a wide parameter scan to see how divertor profiles are affected by the plasma conditions

- Collisionality is a parameter expected to play an important role in the transport processes, separate from field line tracing

  → In DIII-D, no footprint striation was observed for $v^*_e < 0.5$

  → ITER is interested in high density/collisionality H-mode

  → Target range of scan: $0.2 \le v^*_e \le 5$

  → Comparison of data with field line tracing

- At v^*_e~1, no change in total heat flux was observed

  → Change in total heat and particle fluxes at different v^*_e?

Issues to be investigated - continued

- q95 is a parameter playing an important role in determining locations of resonant surfaces

  → q95 scan is a good tool to investigate effect of resonant contributions to the divertor profile modification

  → Also, narrow q95 windows discovered for ELM suppression in DIII-D. What about NSTX? (focus of J.-K. Park's XP-1048)

  → Target range of scan: $7 \le q95 \le 13$

- Only n=3 perturbation data have been taken so far (I_{OH}=0 at time of 3-D field application, no intrinsic n=1 field).

  → Apply n=1 perturbation to see the effect on divertor profiles

- Possibility of toroidal hot spot with the imposed 3-D fields

  → n=3 not possible to rotate

  → Application of n=1 AC, freq=25-30Hz, I_{3D}=800A

Shot plan

- Reference shot:

  135185 (Ip=800kA, I_{3D}=-750A, 3-D field applied at t=400ms (I_{OH}~0), ELMs were triggered later during the 3-D field application

- Collisionality scan:

  3 density levels x two NBI powers (P_{NBI}=3, 6MW)

  → total of 6 collisionality levels (6 shots)

- q95 scan:

  Bt=0.45T, Ip=700, 950, 1200kA (3 shots)

- Collisionality scan at Ip=1200kA (6 shots) – narrower inter-ELM SOL width, larger ELM sizes

- n=1 AC:

  → Maximum $I_{3D,peak}$=800A to avoid locking, freq=25-30Hz

  → Collisionality + q95 scan (9 shots)

Total of 21 shots needed