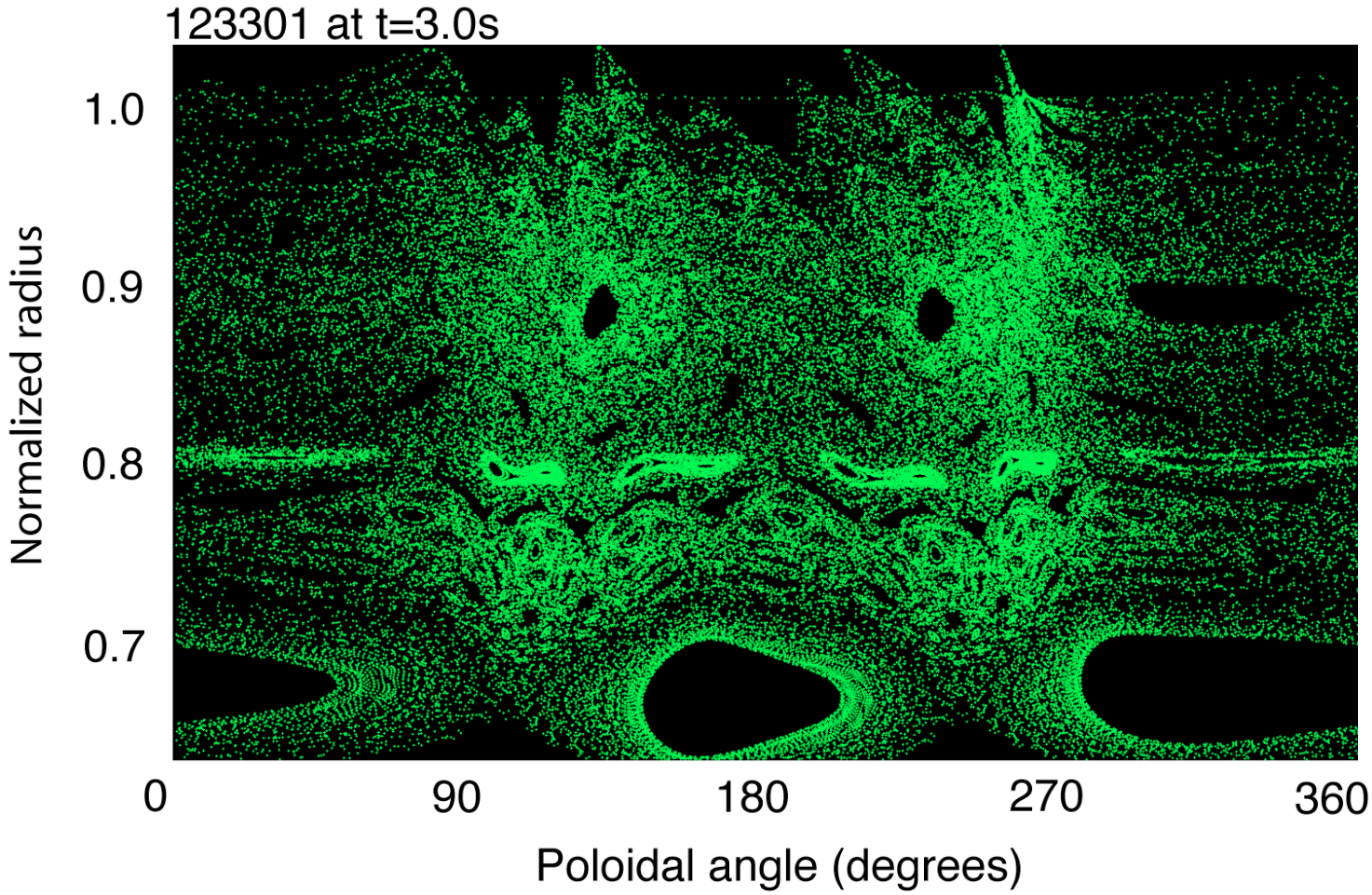
Non-axisymmetric coils for pedestal and divertor heat flux control



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Why install non-axisymmetric edge RMP coils on NSTX?

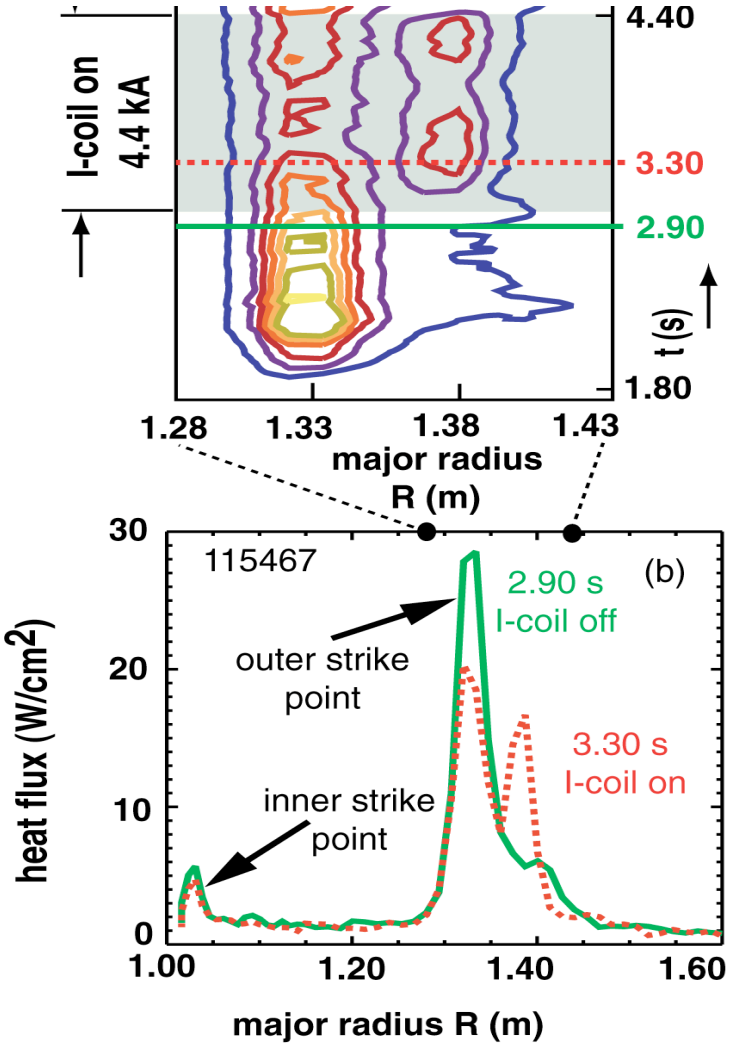
- Edge localized Resonant Magnetic Perturbations (RMPs) can be used to control:
  - density, temperature, pressure and rotation profiles
  - MHD instabilities (ELMs)
  - transport barrier properties (E_r, turbulence)
  - H-mode power thresholds
  - Impurities, radiation, cx, …..
  - Divertor power deposition profiles (2x spreading demonstrated)
- Control of the edge plasma opens up possibilities for:
  - improved operating regimes
  - new physics discoveries
- The RWM/EF coil is not optimized for edge control application
  - large core perturbations
  - poor poloidal and toroidal mode number flexibility

Edge RMP coils provide unique physics and technology opportunities

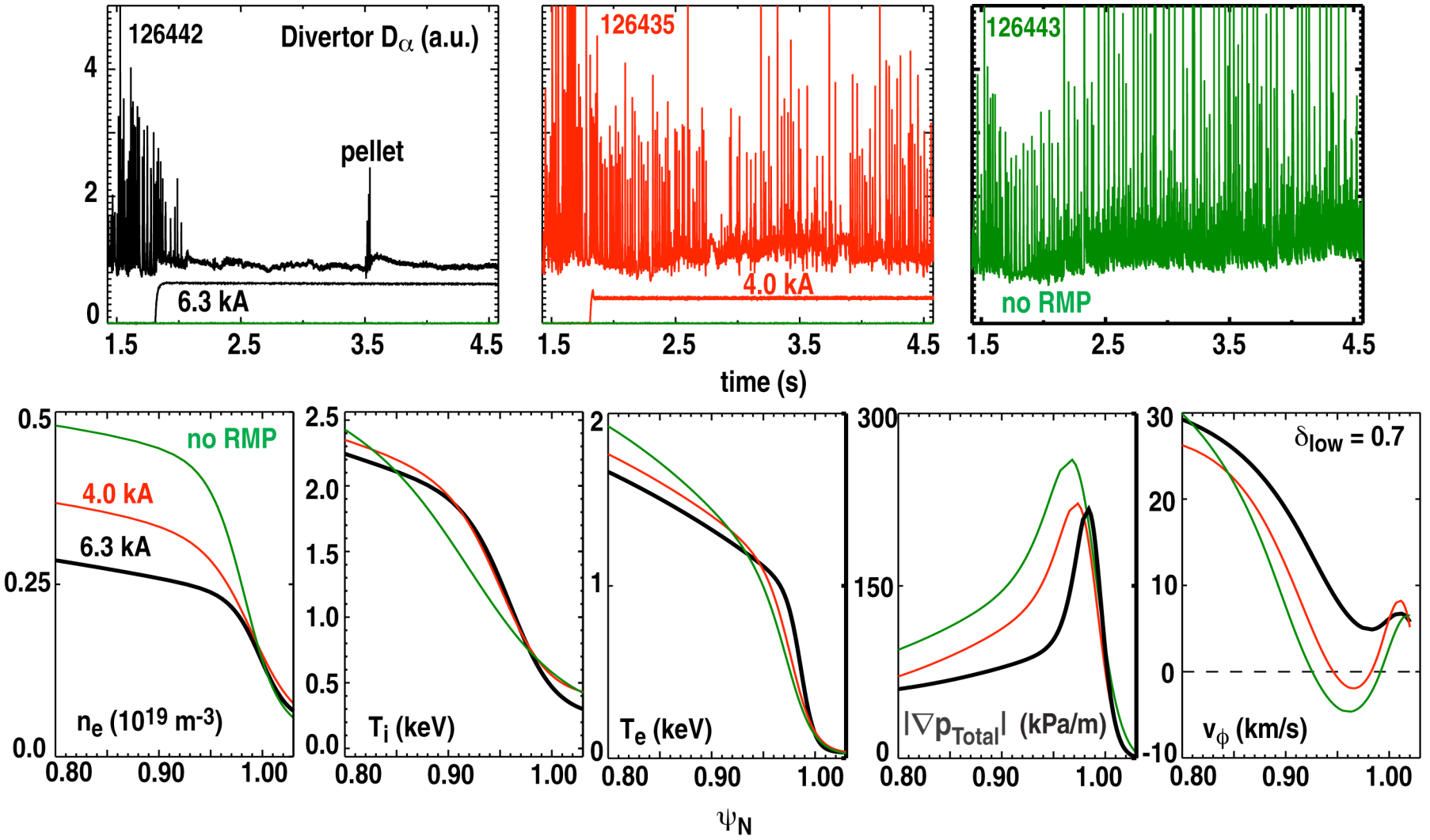
- ITER and burning plasma pedestal, SOL and divertor solutions:
  - ELMs (including pedestal profile control)
  - Core T_e control: $\Delta T_e^{ped} = 0.1$ keV $\rightarrow \Delta T_e^{core} = 1.0$ keV (stiff profile)
  - Density, radiation (impurity?) and recycling control
- High divertor heat flux control in future burning plasma deviced
- Stellarator boundary physics and control
- Fundamental physics studies
  - Transport barriers (turbulence, E_r, momentum, etc.)
  - Separatrix splitting, bifurcations and stochasticity
- Validation of 3D physics models in numerical codes

Divertor heat flux spreading during I-coil pulses in DIII-D consistent with TRIP3D-E3D modeling

- During n=3 I-coil pulses in DIII-D the divertor heat flux:
  - Splits into a double peak structure
  - Peak heat flux reduced ~2x
  - Structure is non-axisymmetric
    - Consistent with separatrix splitting due to applied RMP
- Linear time averaged radial divertor profile produced when the RMP is slowly rotated
- Qualitative heat flux structure matches TRIP3D-E3D modeling
- An optimized RMP coil design is expected to produce ~4x reduction in the peak heat flux in NSTX

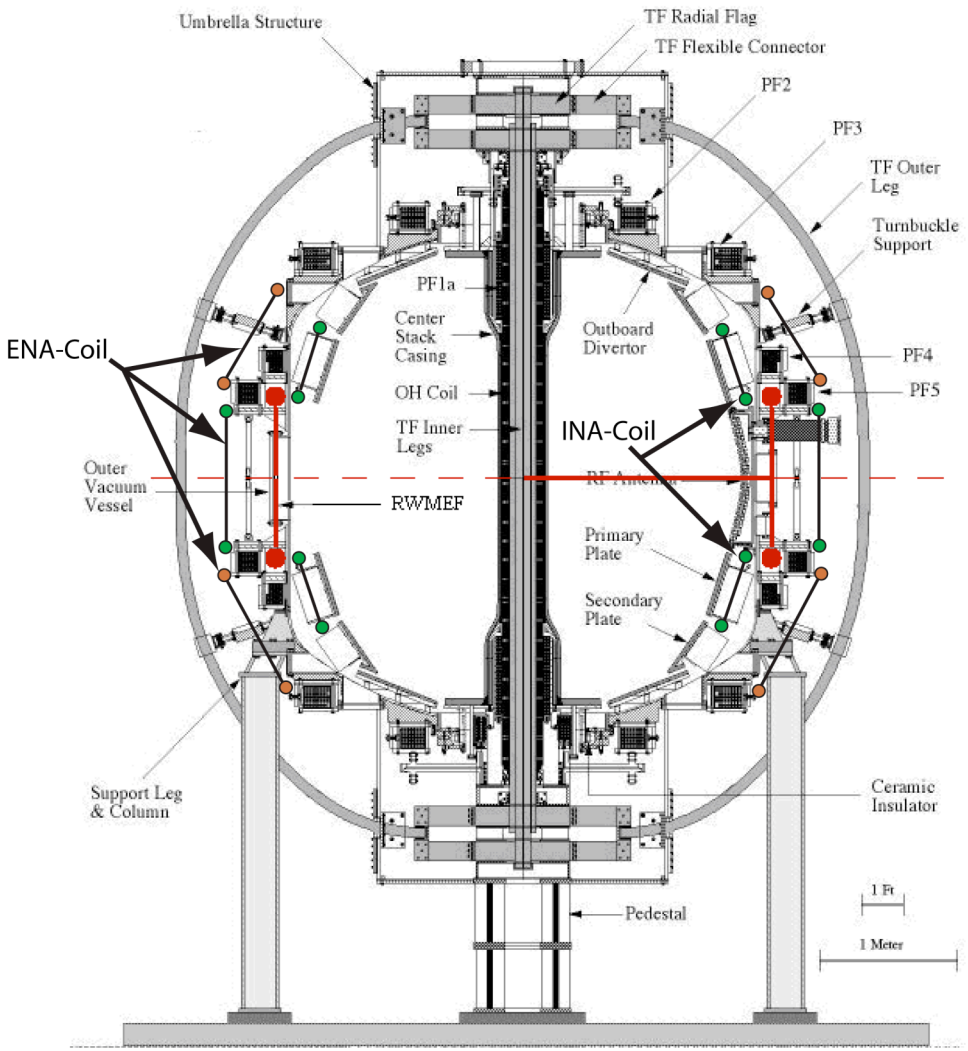


Pedestal profiles and ELMs are controlled using n=3 RMPs in DIII-D



Examples of several internal and external non-axisymmetric RMP coil options for NSTX

- Internal Non-Axisymmetric (INA) coils:
  - 12 toroidal segments
  - multi-turn (low current)
  - DC -> 10 kHZ
- External Non-Axisymmetric (ENA) coils:
  - 12 toroidal segments
  - DC
- Design parameter optimization:
  - TRIP3D
  - SURFMN
  - NIMROD
- Heat flux modeling
  - E3D, EMC3-EIRENE



Additional comments

- ENA coils combined with INA coils are useful for understanding internal versus external RMP physics issues:
  - RMP ELM control coil design issues for ITER
  - Evaluate relative loss of high m modes with distance from plasmas
- ENA coils may be easier to install than INA coils
- INA coils can be based on a relatively simple design
  - Lower current (multi-turn)
  - Shorter pulse (2-3 sec.) -> water cooling not required
- Multiple power supplies needed
- Flexible patch panel design needed
- Density and ELM control may also be possible in NSTX with lithium walls and optimized RMP coils