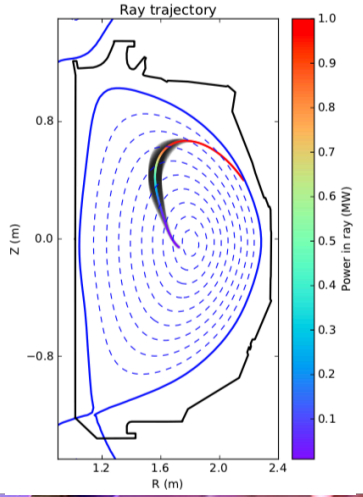
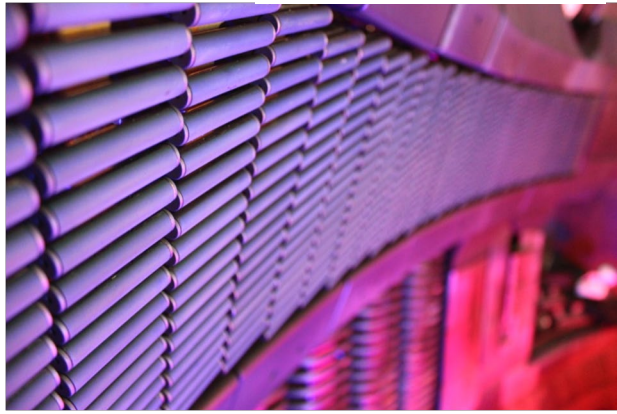
Helicon H&CD thrust

- **Long range goal:**
  - Qualifying and quantifying helicon heating and current drive as as a possible actuator for fusion power plants
- **DIII-D need:**
  - DIII-D has commissioned helicon system, and can run plasmas with predicted strong single pass absorption for helicon waves
  - need to quantify helicon H&CD soon for it to impact FPP designs
- **Priority for FY24-25 studies**
  - Power deposition studies (ECE), current drive studies (MSE)
  - Enhanced diagnostics (DFSS, Helicon DBS, He beam, PCI)
  - Modeling/comparisons with GENRAY/TRANSP
- **Deliverable**
  - Helicon H&CD efficiencies in wide range of parameter space
  - Model validation for extrapolation to fusion power plants

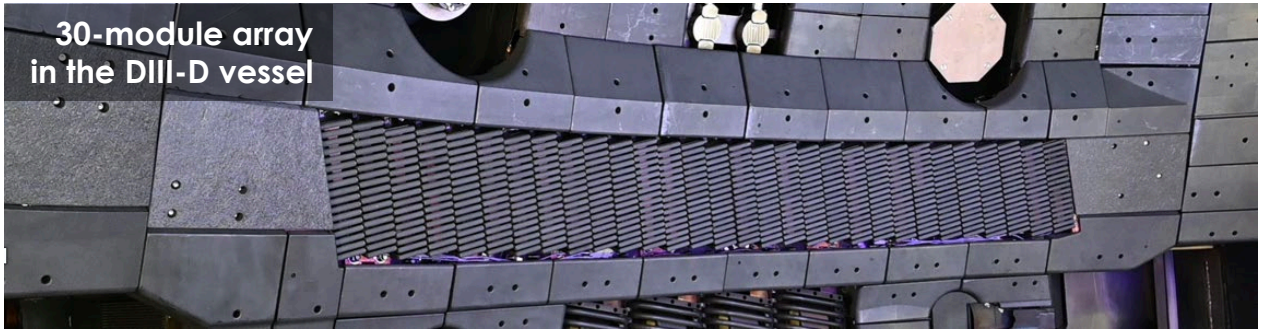




DIII-D NATIONAL FUSION FACILITY

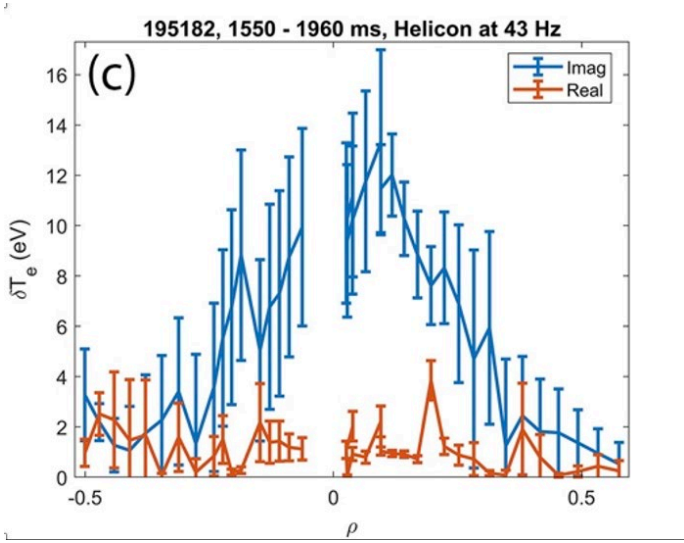
Proposed FY25 milestone: Determination of the efficiency of helicon H&CD with a ~ 1MW system

Helicons (fast waves at very high harmonics of the ion cyclotron frequency) have been proposed as an effective way to drive current off-axis in steady-state tokamaks beyond ITER. The DIII-D tokamak is an excellent facility for performing the validation because of its high beta plasmas and excellent diagnostics for current drive. A new MW-level RF system with a comb-line traveling wave antenna operating at 476 MHz has been installed, commissioned and conditioned on DIII-D to power levels which are predicted to be sufficient to drive measurable non-inductive current. The non-inductive current profile will be deduced from measurements of the internal magnetic pitch angles for co- and counter-current drive. Power deposition profiles will be measured using electron temperature diagnostics or inferred from the current drive profiles. Estimates of power coupled to the plasma based on the antenna's S-parameters and pickup coils embedded in the antenna will be compared to the measured power deposited in the plasma to assess anomalous power losses. Both L-mode and high-performance H-mode plasmas are targeted, with the former expected to have core-absorption, and with the latter predicted to have full first pass absorption with current driven in the mid-radius region. Detailed comparisons of the measured heating and current drive efficiencies to predictions from GENRAY and possibly full-wave codes will be done for a range of plasma parameters.



Experiments to date

- **Power levels on the order of ~800 kW out of the klystron for second long pulses**
- **Limited to feeding 210° side of antenna due to issue with coax on 150° side, i.e., helicon would drive counter-current in 'normal Ip' shots. No possibility to compare counter-current to co-current shots.**
- **Demonstrated load-resiliency in ELMy H-mode**
- **Experiments done in L-mode and H-mode looking for power deposition. Evidence seen of core-absorption (ongoing analysis)**



T_e response in quadrature with helicon modulated power in recent L-mode shot (courtesy J. B. Lestz)

2024-2025 campaign

- **Improved diagnostic coverage vs previous campaign; will aid in understand antenna coupling and identifying possible loss channels**
  - DFSS: near-field wave measurements; was ready in previous campaign but had issue with vibration of a mirror
  - Helicon DBS: far-field wave measurements; already online, but will benefit from launching from 150 side
  - He beam diagnostic: density profile near antenna + impurities (if any)
  - PCI: far-field wave measurements
- **Fix of 150° side enables comparison of helicon co-and counter-current drive**
- **Continue power deposition and current drive measurements in both L- and H-mode for comparisons to GENRAY/TRANSP modeling**
- **Estimated run days needed: 4 days -- L-mode, H-mode, high-beta H-mode + diagnostic shakeout**

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- **Risk and deliverable**
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