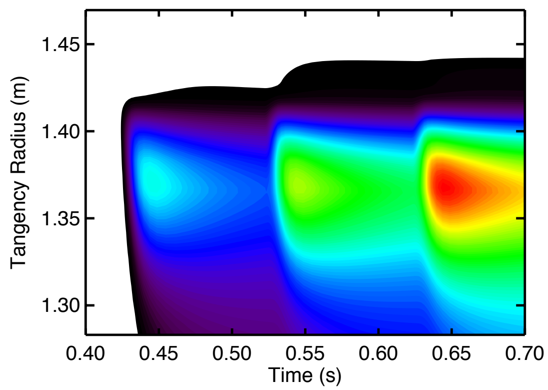
Direct Perturbative Transport Measurements with Proposed Diagnostics

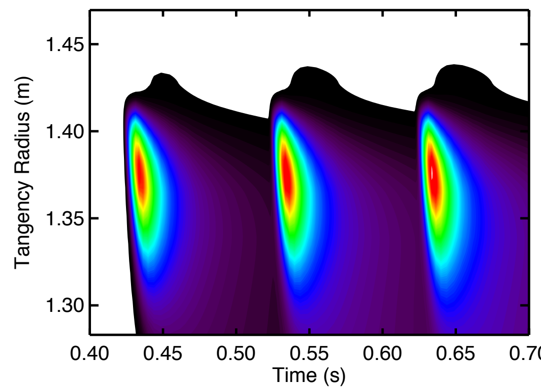
D. Clayton for the JHU Plasma Spectroscopy Group

- Laser ablation provides a well-defined, non-recycling impurity source
  - Better-constrained impurity source provides more accurate transport measurements
    - Short (1-2 ms) pulses of fast (a few eV) neutral atoms (~10^{17} particles per pulse, variable)
    - Injected source is monitored by a filtered diode
    - Impurities are non-recycling, removing additional source terms from model
  - Wider variety of impurities to choose from (C, Mo, non-intrinsic materials)
  - Multiple transport measurements per discharge (less impurity accumulation)
  - Laser ablation can also provide cold pulses for electron heat transport
- New ME-SXR arrays will cover the core as well as the edge plasma
  - Fast (~10-100 kHz) emission measurements for impurity transport
  - Fast T_e measurements between Thomson pulses for heat transport
- Upgraded TGIS will provide faster time resolution (5-10 ms) impurity profiles
  - Assists ME-SXR temperature modeling

ME-SXR Model: Recycling Impurity



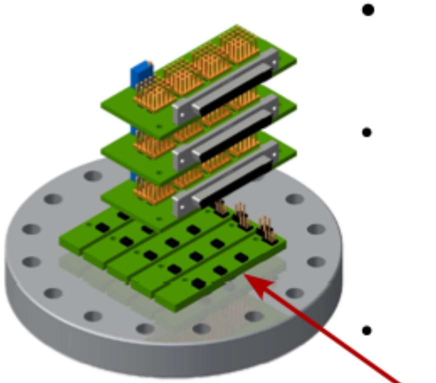
ME-SXR Model: Non-Recycling Impurity

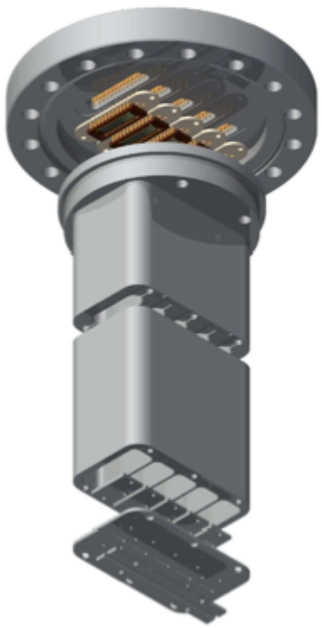


Backup Slides

Toroidally Displaced In-vessel ME-SXR arrays

K. Tritz for the JHU Plasma Spectroscopy Group





- **We propose a system of two toroidally displaced, tangential edge/core multi-energy SXR (ME-SXR) arrays**

- **Each array contains:**
  - edge sub-array (130<R<150) ~1cm resolution, 5 diode arrays @ 20ch. ea.
  - core sub-array (40<R<140) ~3cm resolution, 3 diode arrays @ 32ch ea.
  - time resolution 10-100kHz

- **In-vessel design reduces port crowding, increases placement flexibility**
  - design 1: electronics in re-entrant can @ atmosphere with air cooling
  - design 2: vacuum compatible first stage electronics on detector PCB
  - potential to incorporate A/D, (fiber?) serial output for reduced wire count

- **Projected physics capabilities for NSTX-U:**
  - impurity/electron perturbative transport measurements from the edge to the core using gas puff and repetitive laser blow-off
  - fast, high resolution edge T_e, n_e, and n_z profiles for ELM studies and code validation; edge stability analysis
  - fast, toroidally resolved edge T_e, n_e, and n_z profiles for RWM/RFA studies
  - fast, toroidally resolved core T_e, n_e, and n_z profiles for disruption studies
  - real-time T_e measurements for stability prediction and feedback control development
  - enhanced, non-magnetic MHD mode identification

- **Supports NSTX-U research priorities:**
  - I-1-4: macrostability research of RWMs, NTMs, effect of 3D fields, disruptions
  - II-3: impurity transport research (also pert. electron transport measurements)
  - III-3: measure response of edge plasma to applied 3D fields
  - VI-1,2: real-time T_e for stability feedback control, detection of instability precursors

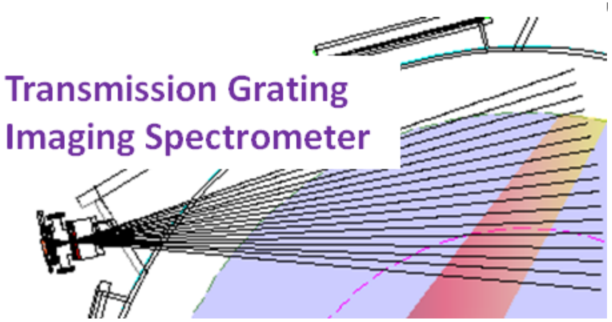
Fast Transmission Grating Imaging Spectrometer (TGIS) for NSTX-U

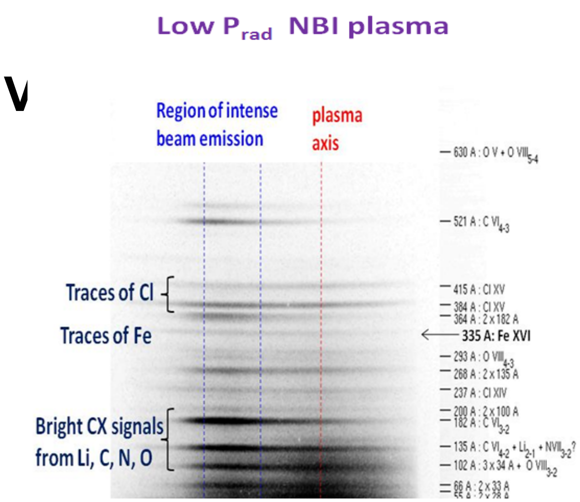
D. Stutman for the Johns Hopkins Group

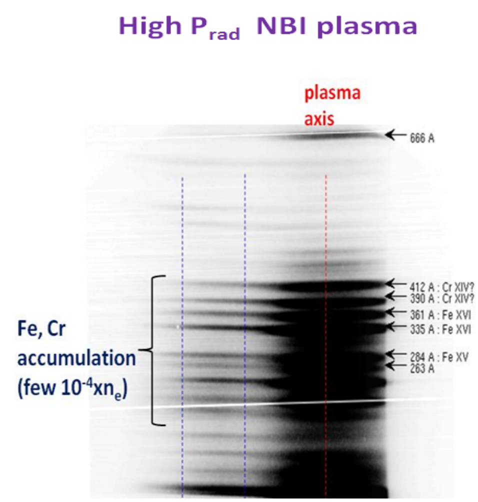
- **Fast tangential TGIS for space-resolved XUV (50-800 Å) impurity spectra:**
  - Space/time resolved impurity fractions for improved ME-SXR modeling
  - Low to high-Z impurity monitoring for start-up to non-inductive sustainment
  - Stand-alone' impurity transport (V pinch)

- **Parameters:** - ≥2 cm/5-10 ms space/time resolution, 90 ≤R ≤ 150 cm
  - Beam view for low-Z /CX , high-Z /electron-excited spectra
  - Enhanced Mo detection capability

- **Addresses II.3, III.3, V.1.2, V**





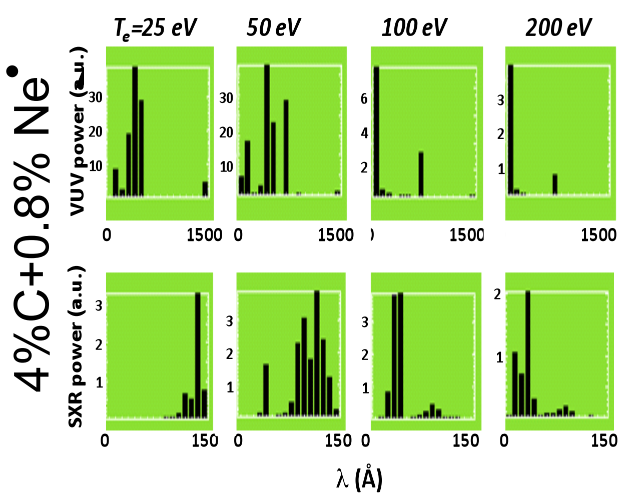


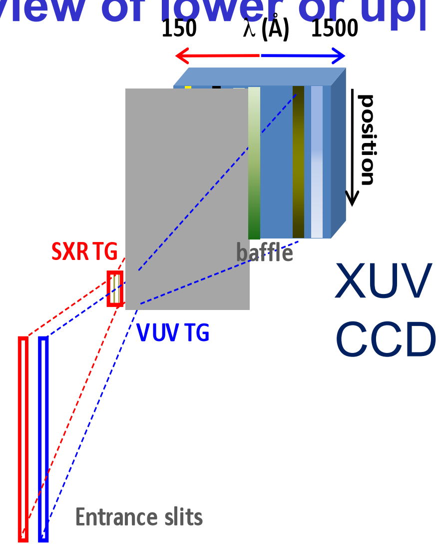
SXR/VUV Imaging Radiometer for NSTX-U divertor

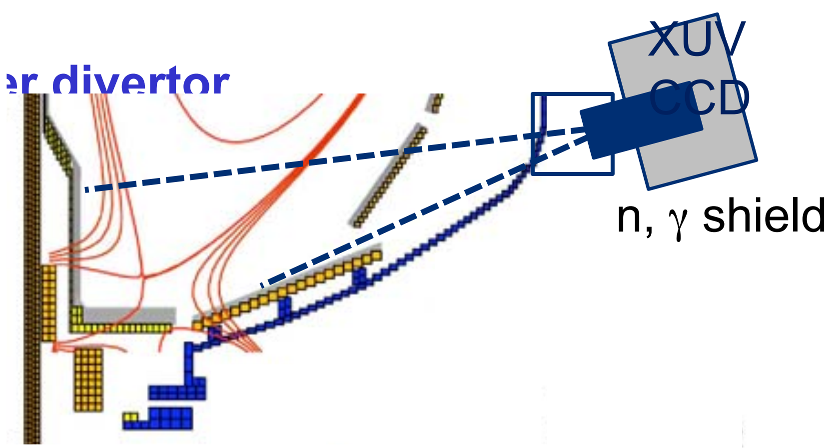
D. Stutman for the Johns Hopkins Group

- **Space/time resolved radiated power in $\lambda/\Delta\lambda \sim 1/20$ spectral bins covering the 0-150 Å ('SXR') and 0-1500 Å ('VUV) ranges**
  - $P_{rad}(\lambda)$, impurity type, charge state distribution for enhanced constraints on divertor modeling (M. Jaworski)
  - Approximate line-of-sight T_e (with e.g., Neon seeding)

- **Parameters:** **- Dual transmission grating + absolute XUV CCD for $P_{rad}(\lambda)$**
  - ≥2 cm/5-10ms space/time resolution, strike to above X-point coverage
  - Poloidal view of lower or upper divertor





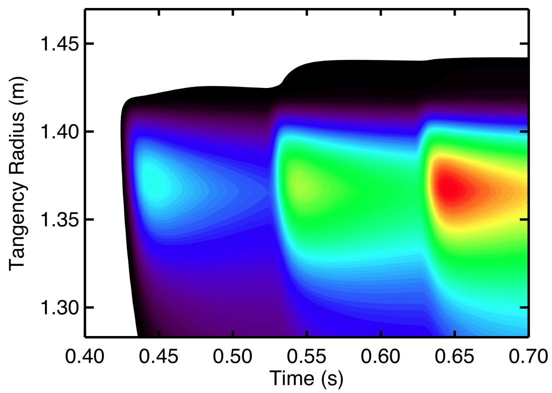


Repetitive Laser Blow-off Impurity Injection System

D. Clayton for the JHU Plasma Spectroscopy Group

- We propose a repetitive laser blow-off impurity injection system for transport measurements of non-recycling impurities
  - Laser with ≥ 10 Hz rep rate, 100's of mJ per pulse, scans target throughout discharge
  - Based on C-Mod system, cost within scope of a university collaboration
  - Impurity transport measurements will be made with JHU's proposed in-vessel ME-SXR arrays and fast TGIS diagnostics
  - Other possible uses include T_e transport measurements via cold pulse propagation
- Benefits of laser ablation of non-recycling impurities include:
  - More NSTX-relevant impurities (Li, C, Mo, etc.)
  - Better-constrained impurity source term for transport modeling
  - Multiple transport measurements per discharge (less impurity accumulation)
- Reflex discharge plasma will be used to characterize impurity injection
  - Simulate SOL conditions to determine source term and test STRAHL SOL model

ME-SXR Model: Recycling Impurity



ME-SXR Model: Non-Recycling Impurity