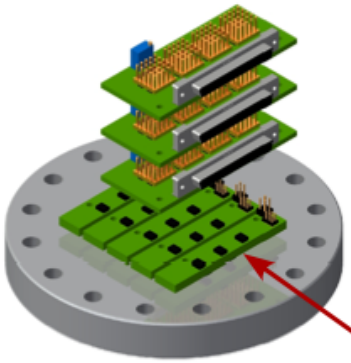
JHU Diagnostic Upgrades for SFPS research

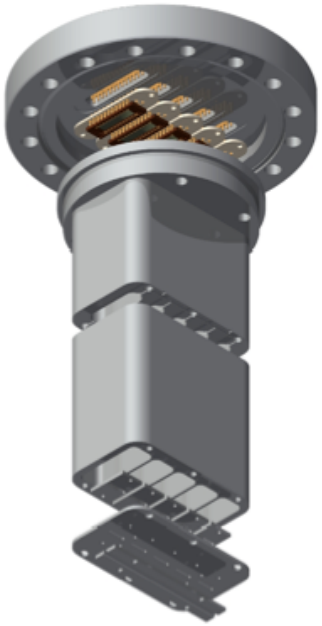
- **In-vessel ME-SXR arrays will provide fast measurements of T_e/n_e evolution**
  - Thin filters/bolometer mode suitable for initial CHI or plasma gun startup plasmas
  - Thicker filters can be used to monitor heating deposition during RF ramp-up
- **Transmission grating imaging spectrometer will measure impurity distribution**
  - Upgraded system well suited to measure fast (~5-10ms) profiles of key impurities (Fe, Mo, O, C, ...)
  - Knowledge of impurity content important for successful generation and sustainment of NI plasmas
- **Divertor transmission grating imaging radiometer can monitor impurity sources**
  - Coverage of CHI gap may provide information on impurity sources from CHI electrodes
  - Spatially resolved radiometer measurements help constrain power-balance calculations of startup plasma
- **Laser blow-off system provides controlled impurity sources for transport**
  - Understanding impurity generation/transport may be key to successful non-inductive startup & sustainment
  - Controlled impurity sources can be injected during any phase of startup/rampup for transport measurements

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

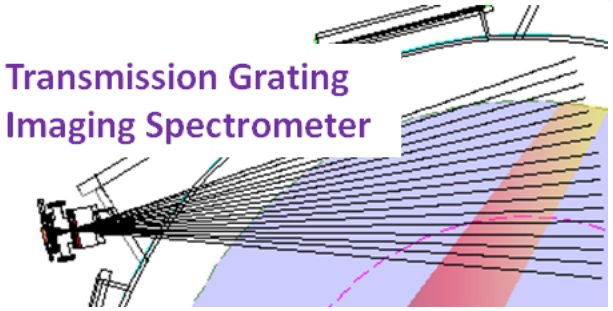
Fast Transmission Grating Imaging Spectrometer (TGIS) for NSTX-U

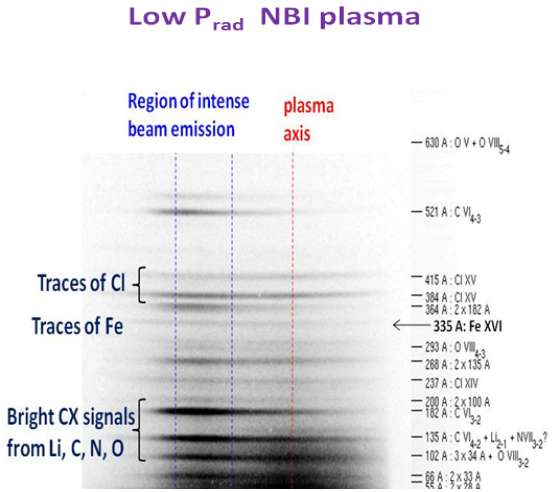
D. Stutman for the Johns Hopkins Group

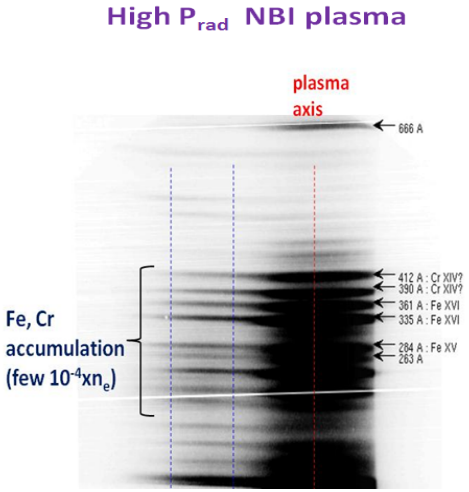
- **Fast tangential TGIS for space-resolved XUV (50-800 Å) impurity spectra:**
  - **Space/time resolved impurity fractions for improved ME-SXR modeling**
  - **Low to high-Z impurity monitoring for start-up to non-inductive sustainment**
  - **Stand-alone' impurity transport (V pinch)**

- **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

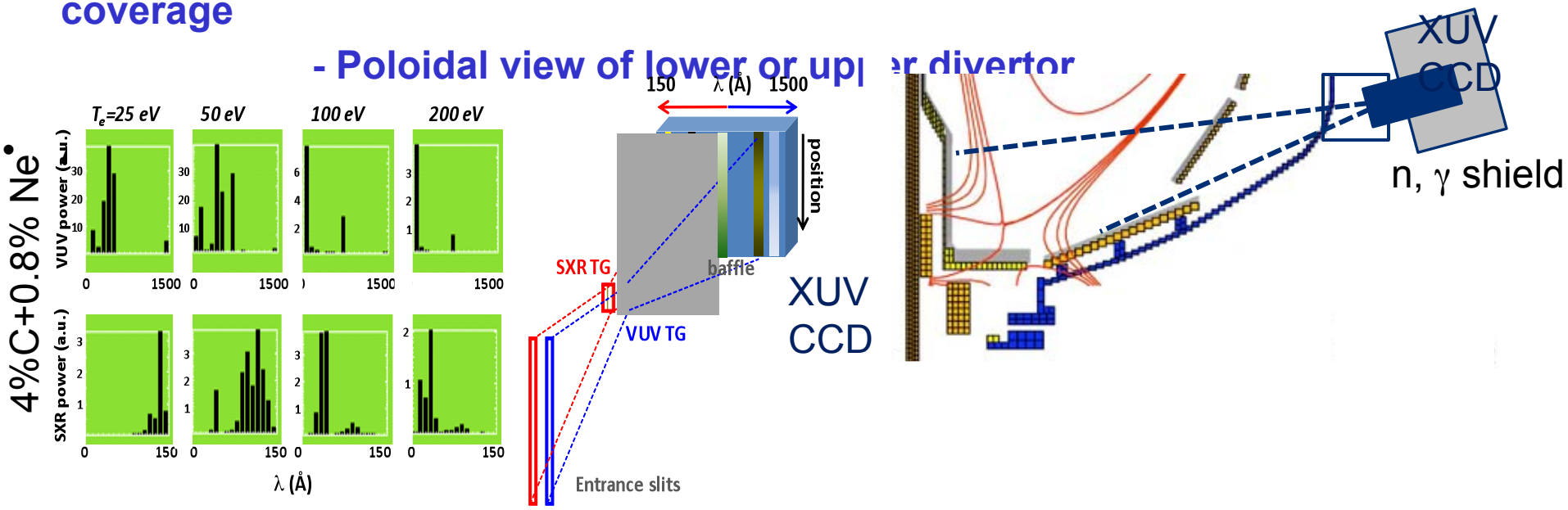
  divertor modeling (M. Jaworski)

  - 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

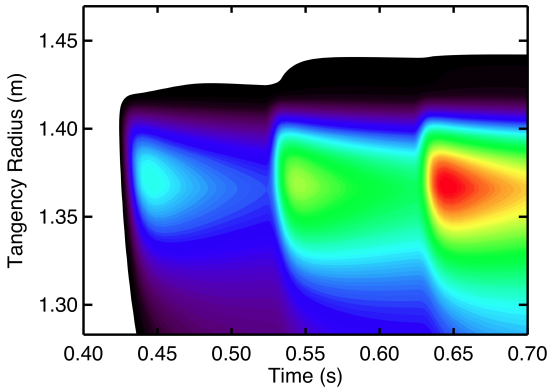


Repetitive Laser Blow-off Impurity Injection System

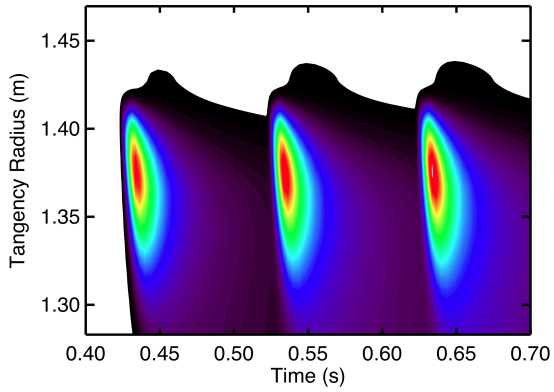
D. Clayton for the JHU Plasma Spectroscopy Group

- 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

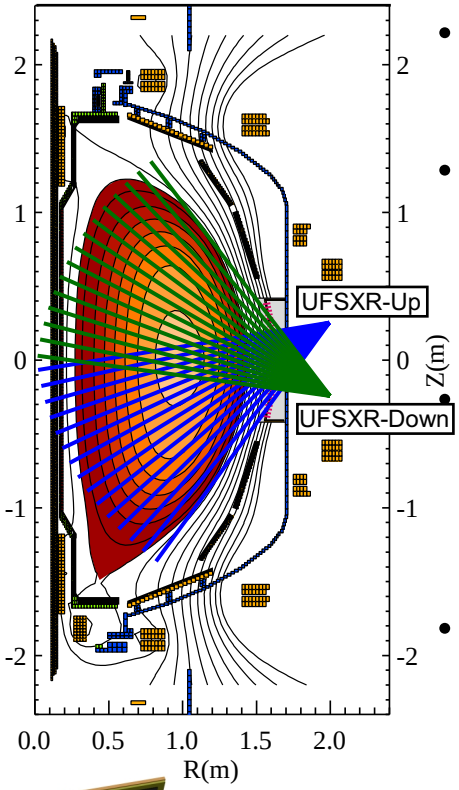


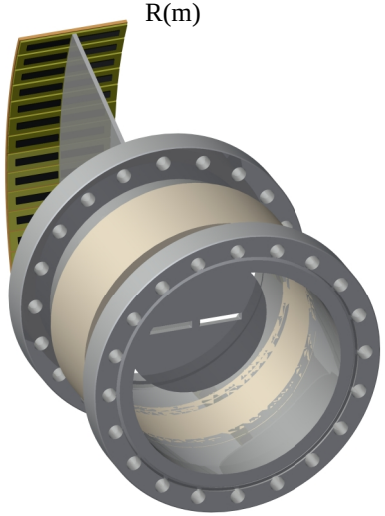
ME-SXR Model: Non-Recycling Impurity



Dual-energy Ultra-Fast SXR arrays

K. Tritz for the JHU Plasma Spectroscopy Group





- **The JHU Group is proposing to build and implement on NSTX-U a system of two poloidal, dual-energy UltraFast SXR (UFSXR) arrays**

- **Each array contains:**
  - 2x16 channels viewing poloidally through two different filters ~2-3cm resolution
  - at least 1 set of 16 channels will have a variable filter setting
  - time resolution ~4MHz

- **Upgraded system would replace current H-Up, H-Down USXR arrays**
  - maintain spatial resolution
  - significantly increase temporal resolution
  - dual-energy capability provides temperature/density discrimination $\Delta Te/Te \geq 0.5\%$

- **Projected physics capabilities for NSTX-U:**
  - Maintain/improve physics capabilities of present USXR system
  - Measure high-frequency *AE modes, including poloidal structure
  - Provide T_e/n_e discrimination and phase measurement to distinguish CAE/GAE
  - Provide validation data for fast MHD simulations with good time/spatial resolution
  - *AE measurements in conjunction with transport measurements for χ_e studies

- **Supports NSTX-U research priorities:**
  - II-1: investigate *AE effects on electron thermal transport
  - IV-2: measure *AE modes for simulation validation, projection to FSNF
  - IV-3: investigate effects of *AE on RF heating of plasma using T_e discrimination
  - VI-2: identification of high-frequency precursors to disruptions for mitigation/control

- **Suitable as joint JHU/NSTX collaboration**