Status and plans for USXR systems on NSTX

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2003 NSTX Research Opportunities Forum

Summary

1. Configuration of existent USXR system for partial tomographic capability

2. Addition of toroidally displaced vertical array for RWM research

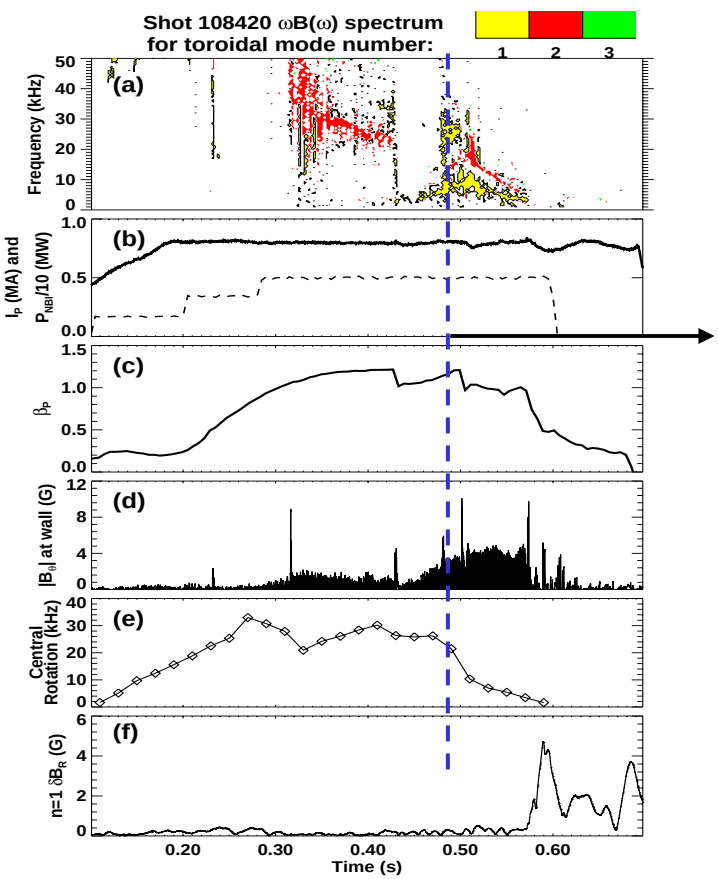
3. Upgrade of USXR system to 600 kHz sampling

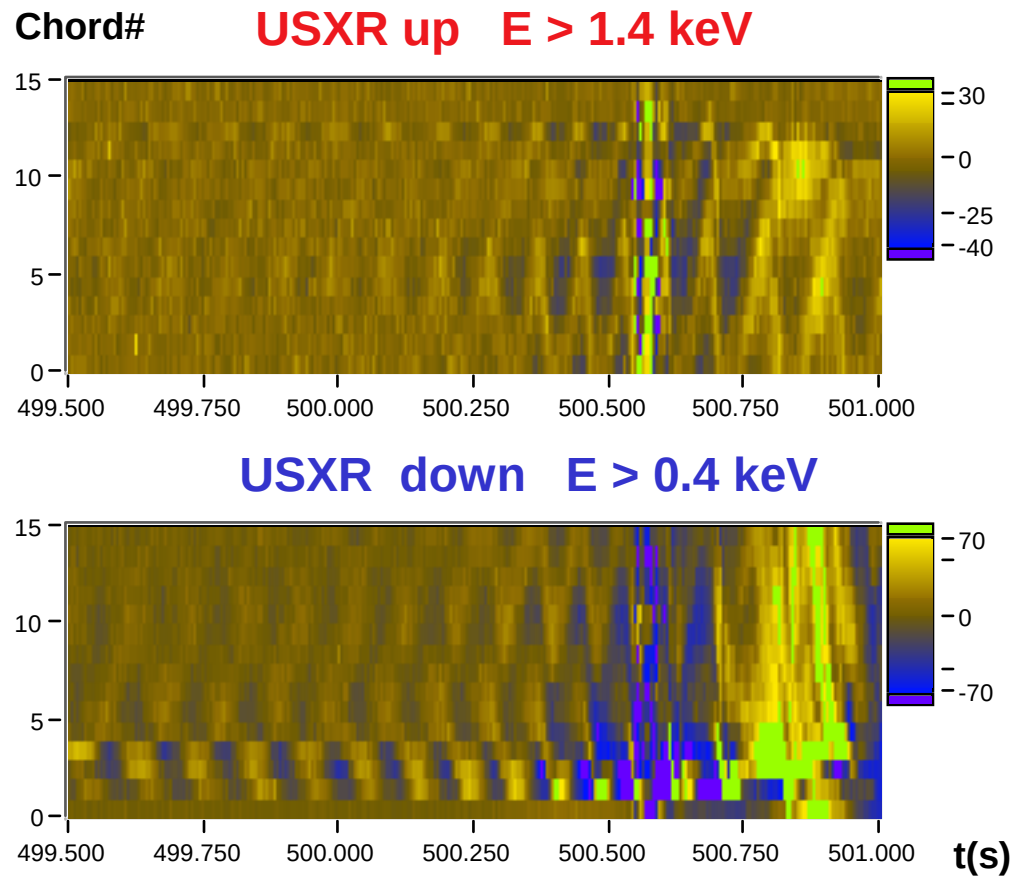
- Addition of second re-entrant array for improved tomography (supplemental)

- Optimization of X-ray imaging with the Micro-Pattern Gas Detector (MPGD) and USXR arrays for q_0 (current profile) constraint (supplemental)

- Construction of Transmission Grating Imaging Spectrometer (TGIS) for integrated impurity diagnostic (supplemental)

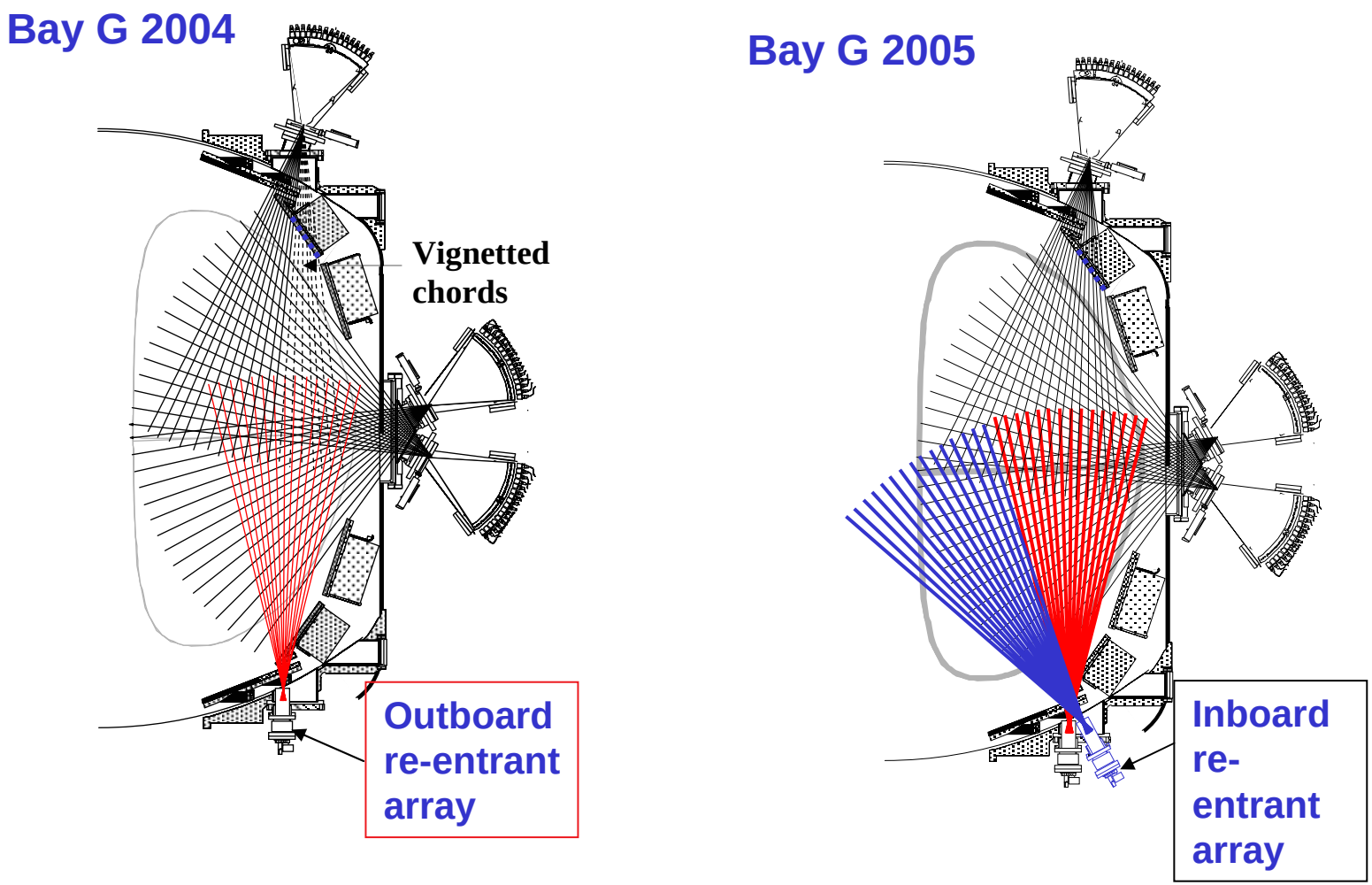
Internal MHD diagnostic essential for NSTX





- Majority of high beta discharges exhibit internal MHD
- Poloidal USXR arrays have good sensitivity and speed
- Tomographic reconstruction for mode localization / structure

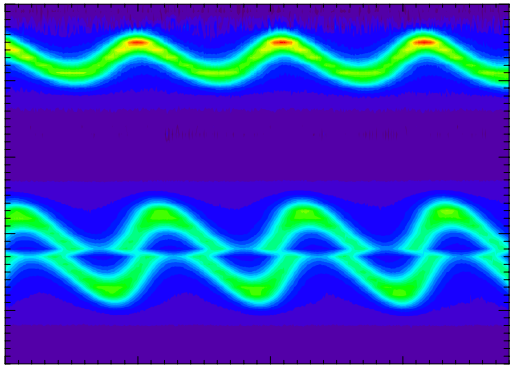
Partial tomographic capability with Bay G USXR system



- Partial reconstruction capability for m=1 perturbations
- Mode structure, rotation effects, pressure perturbation ('Two-color')
- Full m=1 and improved m=2 capability with inboard re-entrant array

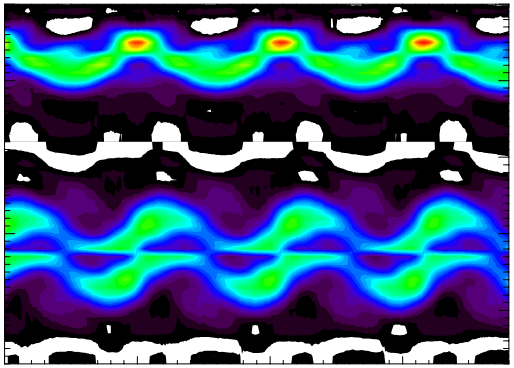
Tomographic Reconstructions Shows Rotating m=1 Mode

SXR Intensity Data



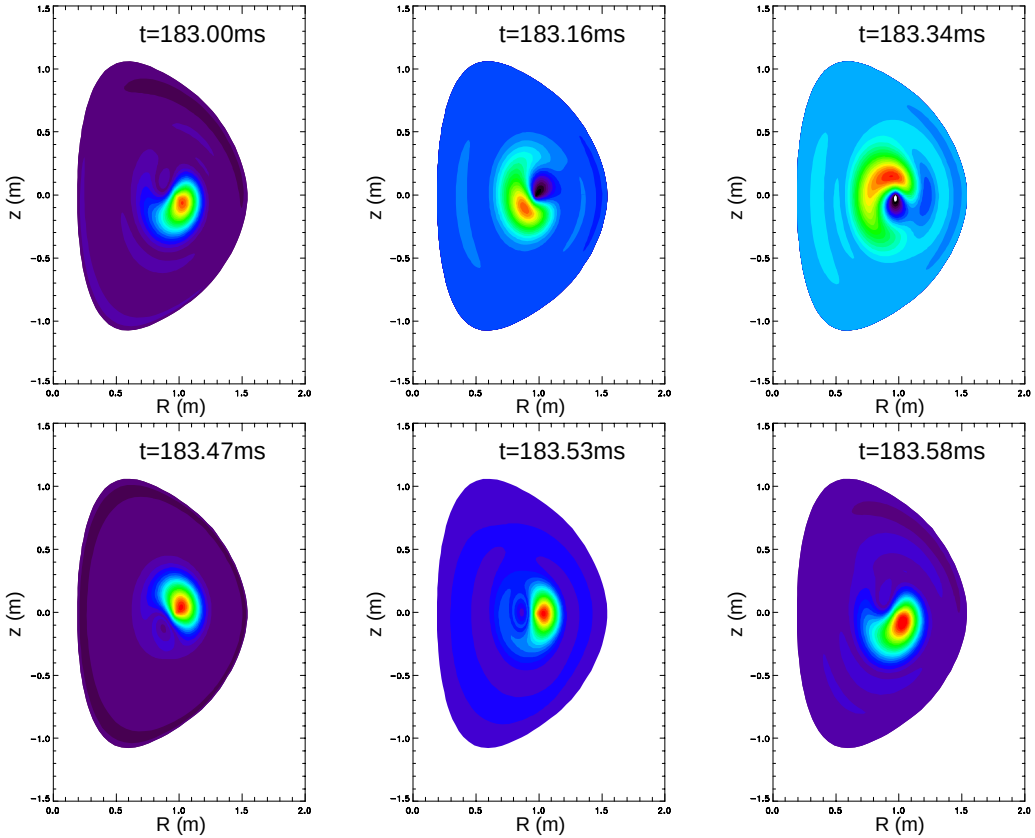
183 Time (ms) 185

Reconstructed Intensity Data



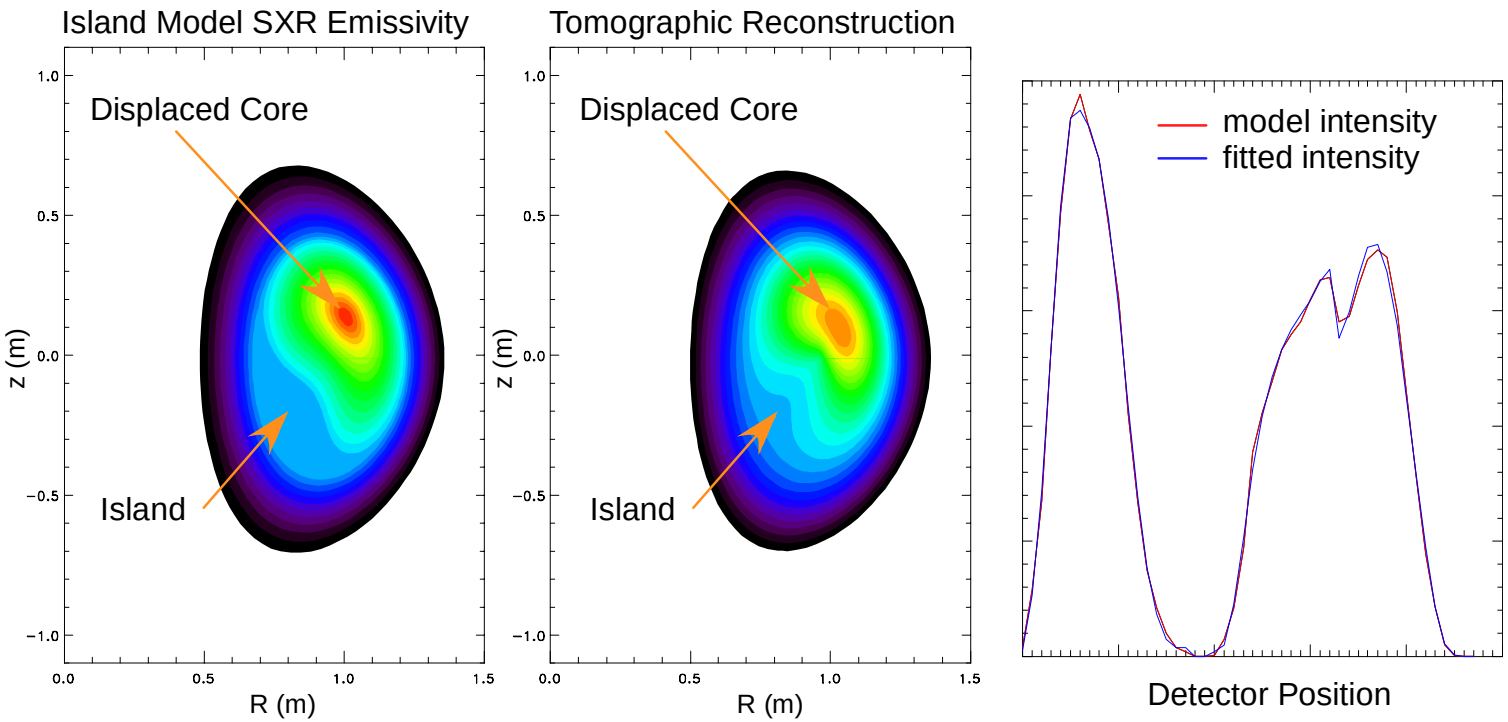
183 Time (ms) 185

Shot 106910 – Ohmic discharge



- **Improved reconstruction using spline basis functions, SVD fitting, flux surface coordinates (modified from MIT code, R. Granetz)**
- **Additional arrays, algorithm optimizations will allow m>1**
- **Peaked emission profiles provide improved sensitivity**

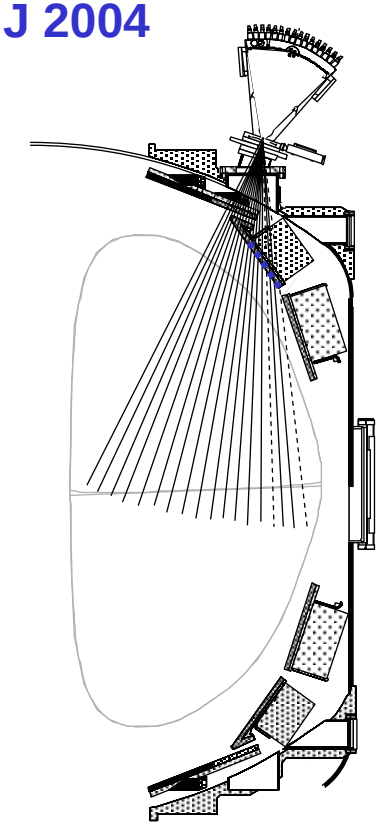
Tomography Compares Well with Island Model (J. Menard)



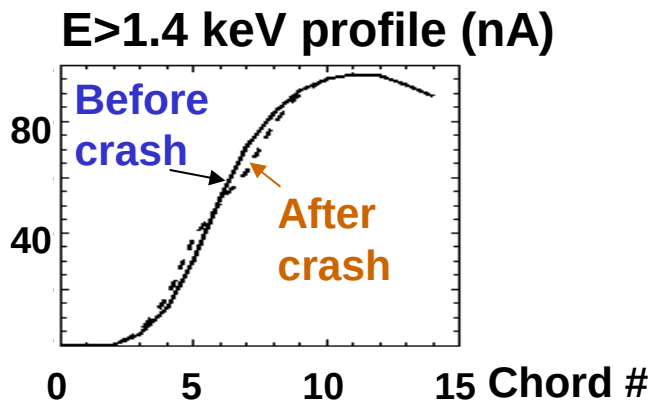
- **Island model uses helical perturbation of equilibrium flux to generate island mode structure (J. Menard)**
- **Fitted intensity and reconstructed emissivity from tomography match island model very well**
- **Validates upgraded tomography algorithm for helical m=1 modes**

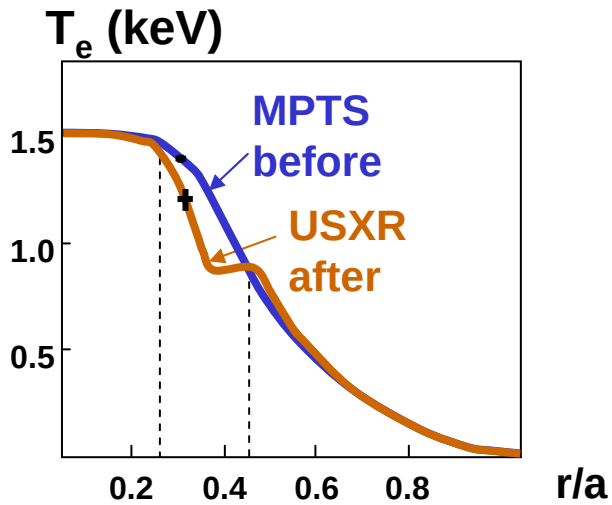
Toroidally displaced vertical array at Bay J

Bay J 2004



Toroidally displaced vertical array

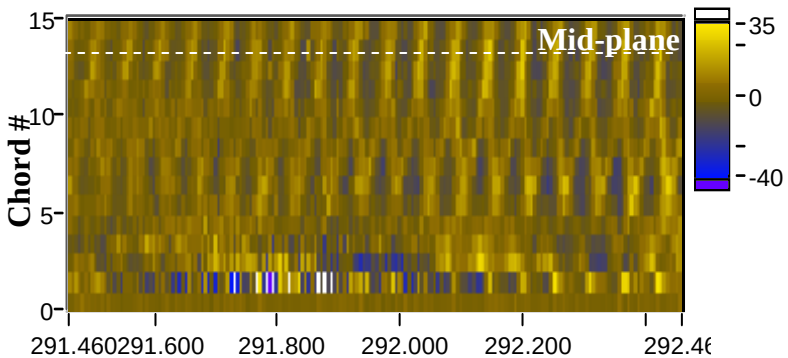




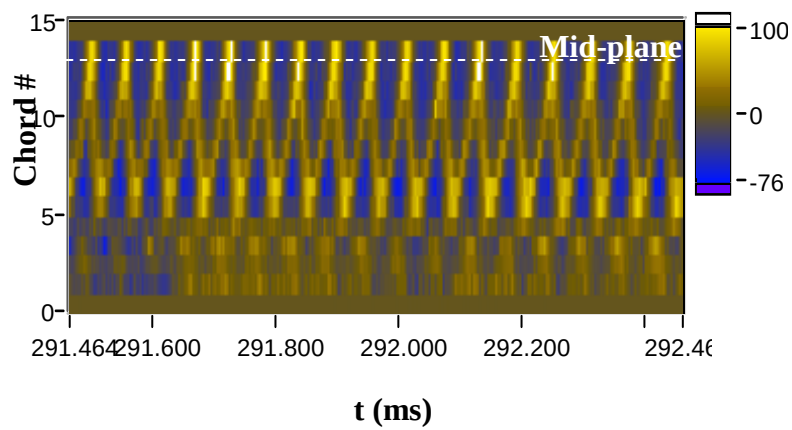
- Toroidal measurements for RWM and n-analysis
- Digitally filtered, 'contrast enhancing' imaging identifies slowly rotating modes (N. Bogatu)
- 'Two-color' measurements of fast T_e perturbations

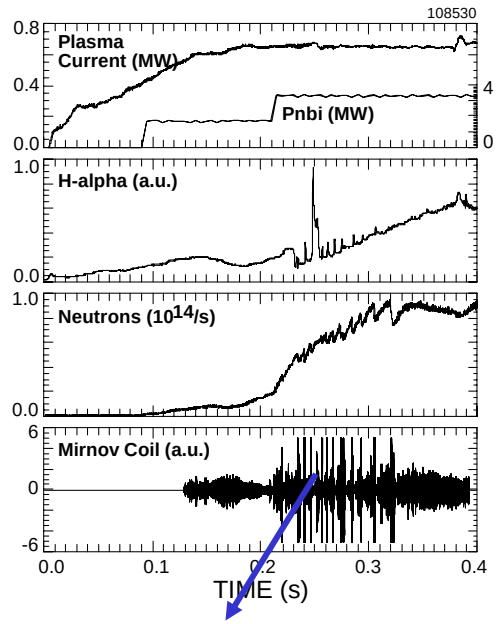
600 kHz sampling for improved imaging capability

200 kHz sampling

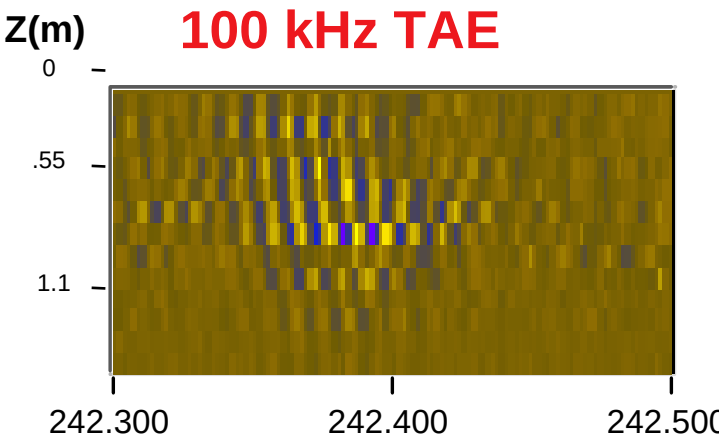


600 kHz sampling





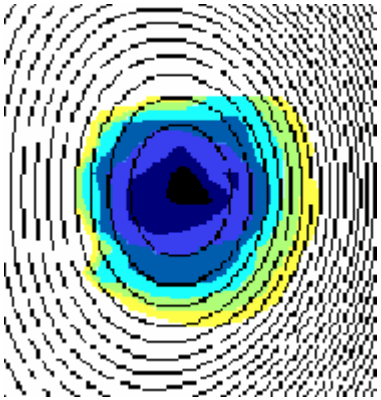
100 kHz TAE



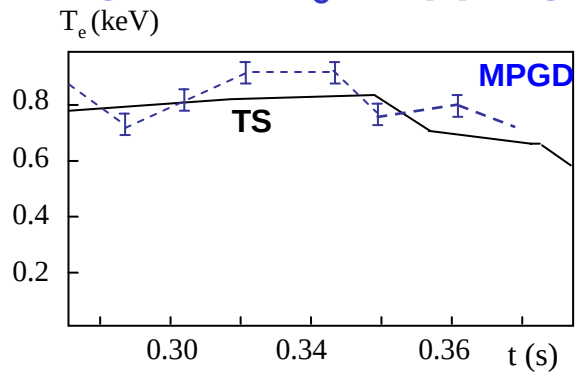
- Clearer picture of fast rotating core modes
- TAE localization/structure for 'MHD spectroscopy'

Tangential X-ray MPGD for q(0) constraint

X-ray iso-intensity mapping



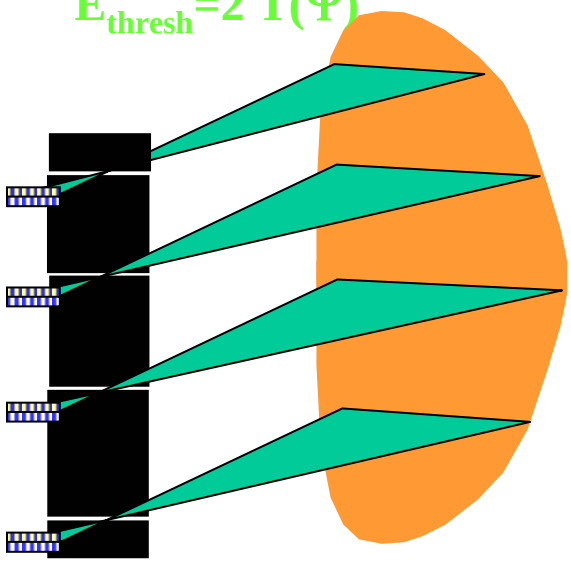
Tangential T_e mapping



Tangential T_e 'slicing'

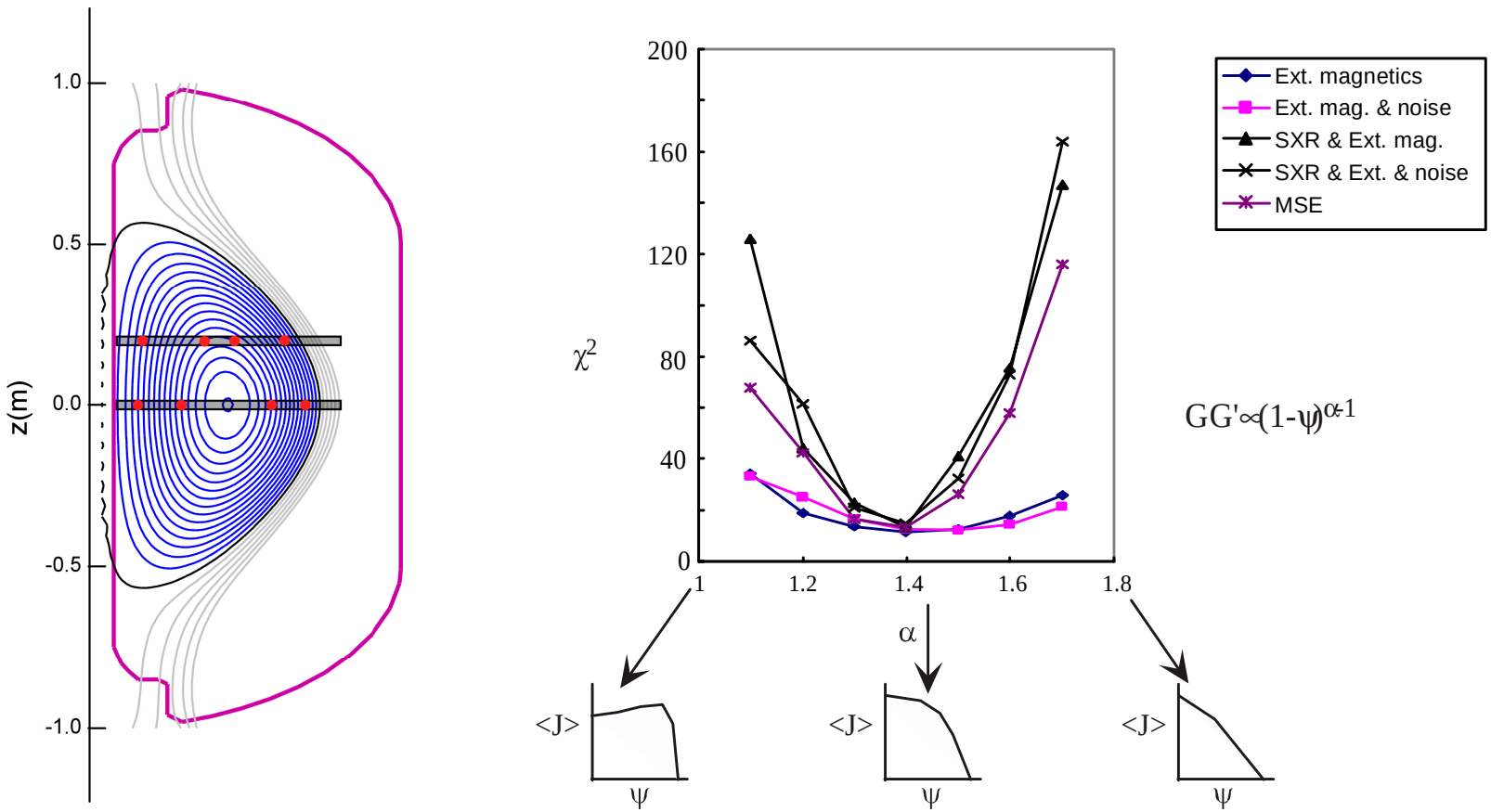
$E_{thresh}=T(\Psi)$

$E_{thresh}=2\ T(\Psi)$



- Test and optimization of each technique (2004)
- Best technique will be integrated in magnetic reconstruction code
- Linear energy resolved X-ray arrays for q-profile

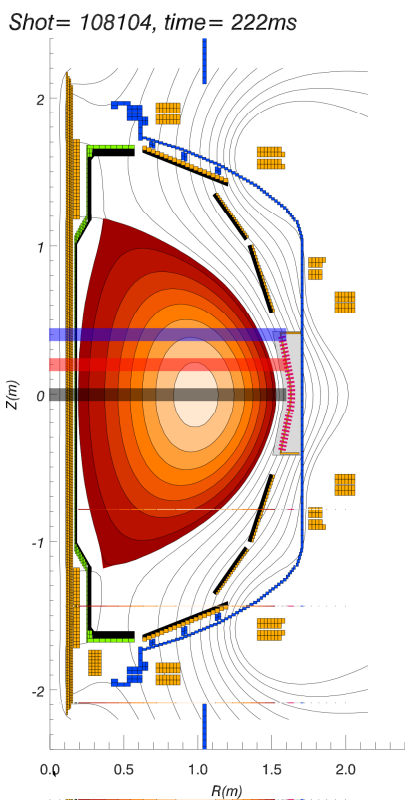
1-D tangential imaging for q profile reconstruction



- **1-D SXR constraint demonstrates current profile sensitivity similar to MSE measurement (R. Fonck, K. Tritz)**
- **Initial modeling indicates several sets of arrays needed, N~5**

Energy Resolved X-ray Profiles Determine Te(R,z)

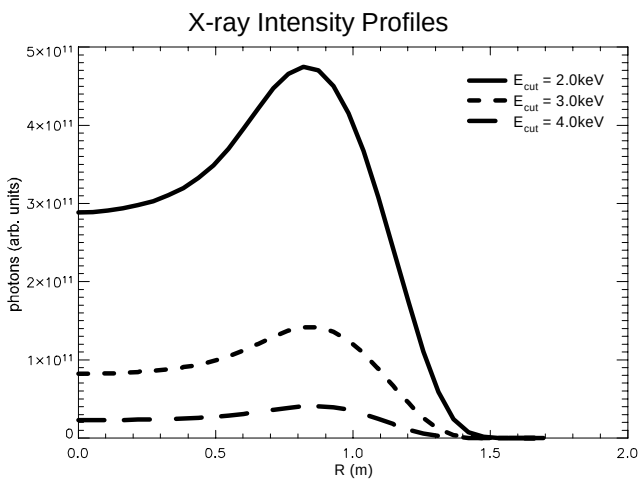
- **Energy resolved X-ray measurements using threshold capability of GEM device (or can use X-ray detectors w/ varying filters)**
- **Horizontal intensity profiles are Abel-inverted for X-ray emissivity profiles**
- **Emissivity profile ratios used to fit Te profiles for specification of iso-temperature flux surfaces**
- **Initial estimates show promise for use as a q profile constraint**

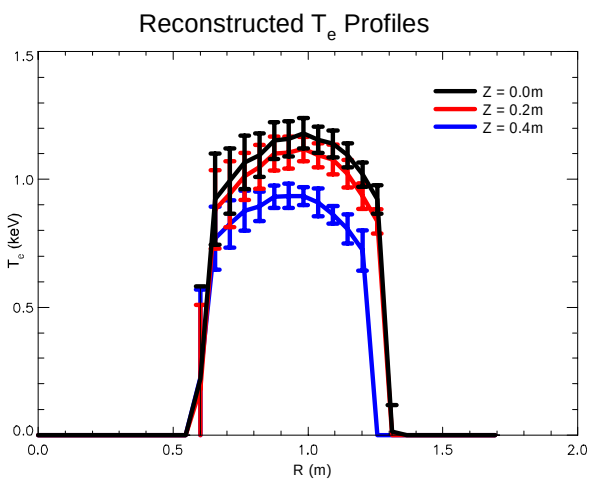


Reasonable Te profiles achievable with SNR~100

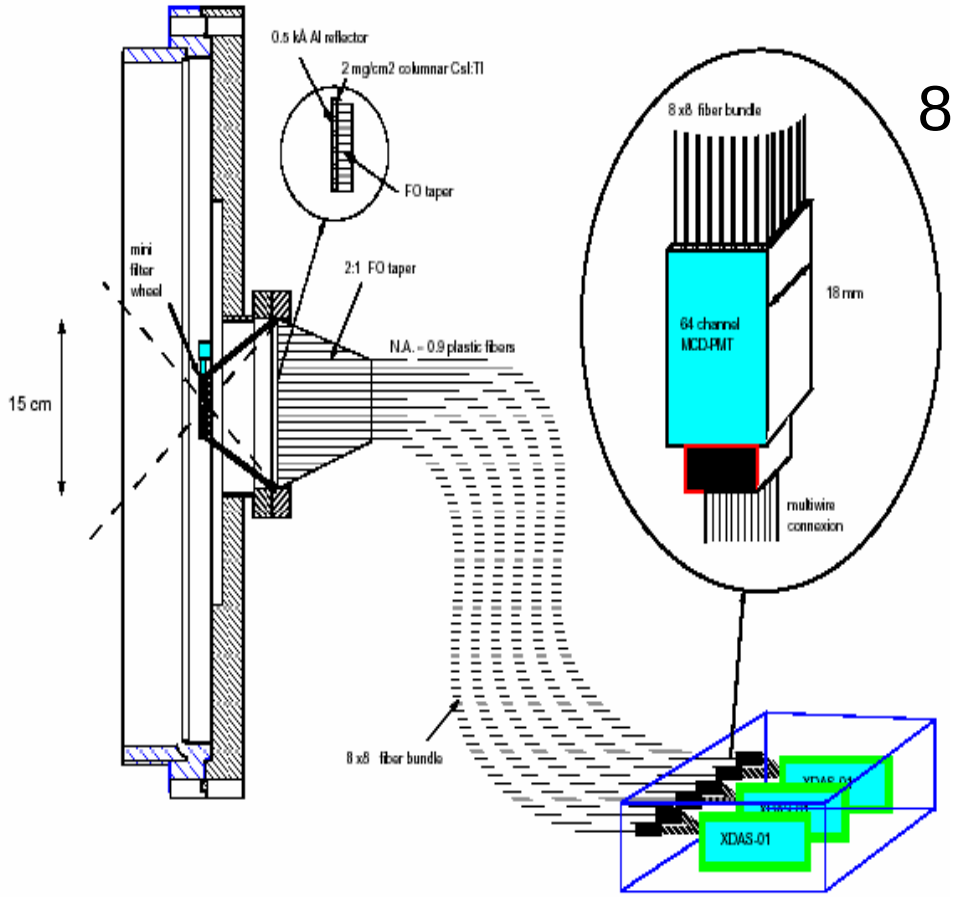
Will determine q profile sensitivity with modeling using EFIT flux-surface constraint

Model Te Reconstructions

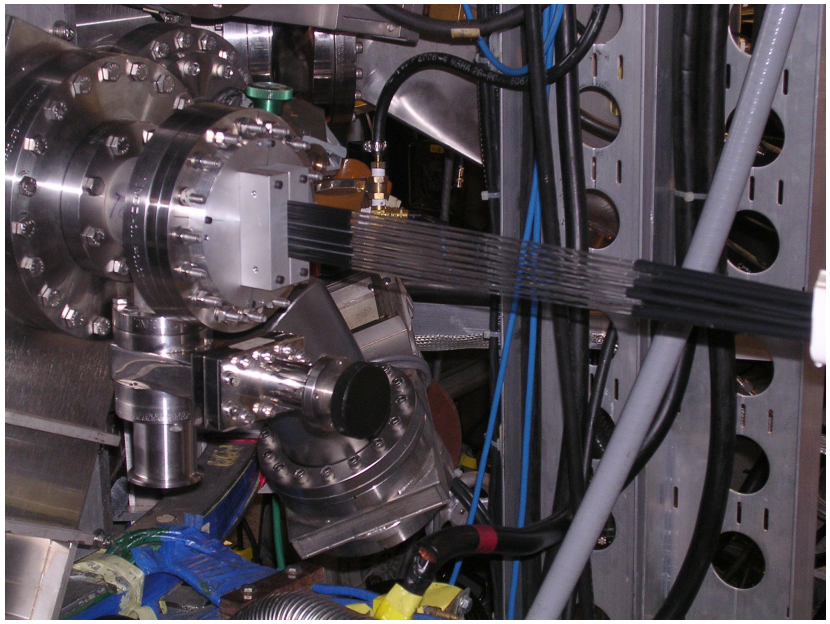




Tests of prototype continuously sampling optical array



8-channel optical array on CDX-U



- Continuously sampling optical USXR array under development for large channel-count MHD systems (e.g., 1400-channel tangential array)
- Possibly more sensitive than diode based systems
- Tests on NSTX for speed, SNR, neutron rejection