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April 2003-March 2004

- **Configuration of existent USXR system for *partial tomographic capability***
- **Addition of toroidally displaced vertical array for *RWM research***
- **Upgrade of USXR system to 600 kHz sampling**

April 2004-March 2005

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

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

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

April 2005-March 2006

1. **Addition of *in-vessel* arrays for m=2-3 and coupled mode tomographic capability (supplemental)**

2. **Fast and space-resolved T_e diagnostic using multi-energy linear MPGD as 'ECE substitute' (supplemental)**

3. **Test of *multi-energy linear MPGD (APD)* configuration for current profile diagnostic using tangential T_e or X-ray profiles (supplemental)**

4. **Construction of *prototype 2-D optical array* (256 channels, 100 kHz) for *continuous* tangential USXR imaging (supplemental)**

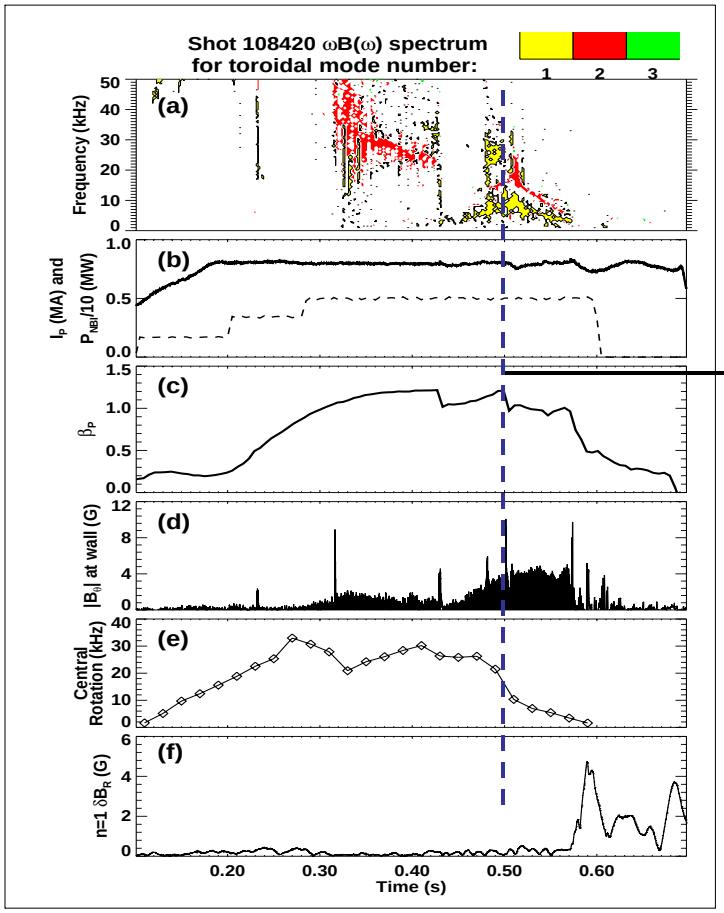
2006-2009 research

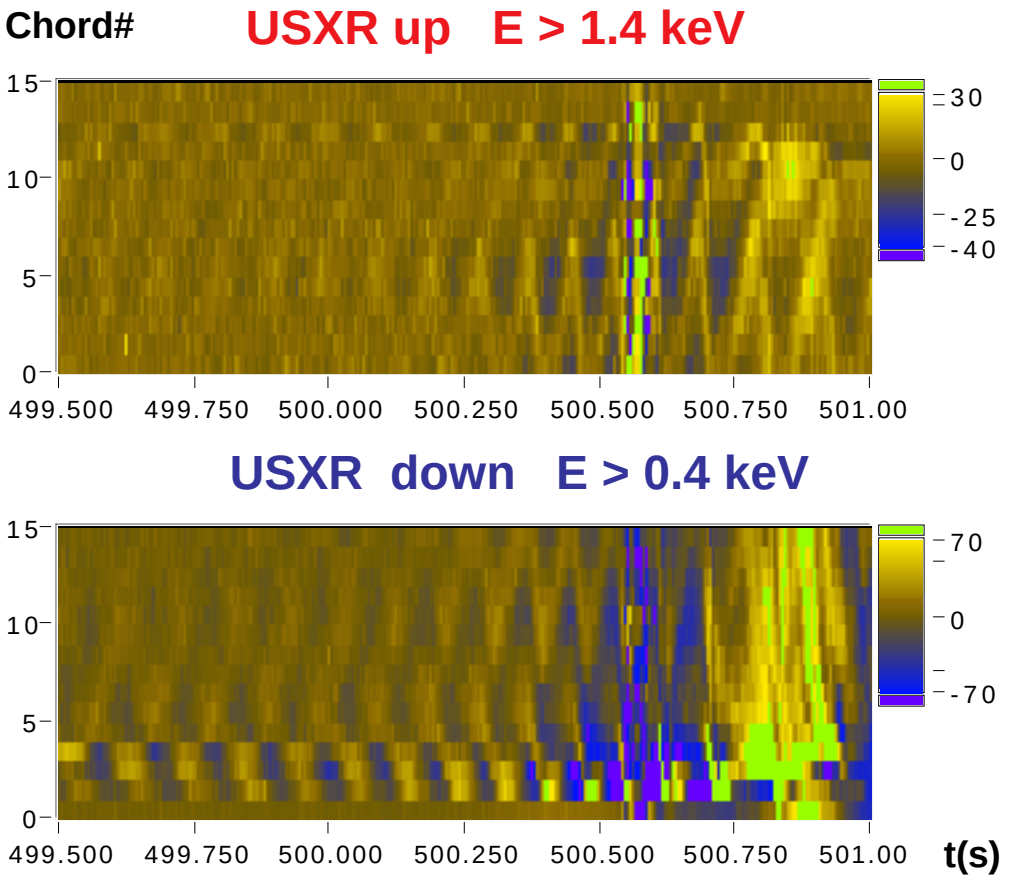
- **Construction and operation of *continuously sampling 2-D tangential USXR array* (100 kHz, 1500 channels)**

- **Construction and operation of *fast (100 μs), two-dimensional T_e diagnostic* based on multi-energy linear MPGD arrays (two orthogonal devices having 32 chords each)**

- ***Current profile* diagnostic based on tangential T_e profile measurements with multi-energy linear MPGD/APD arrays**

Internal MHD diagnostic is essential for NSTX

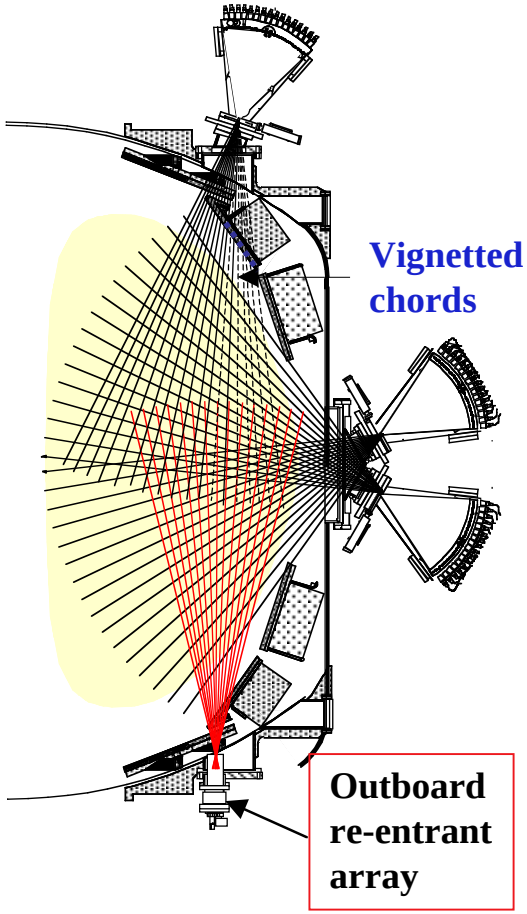




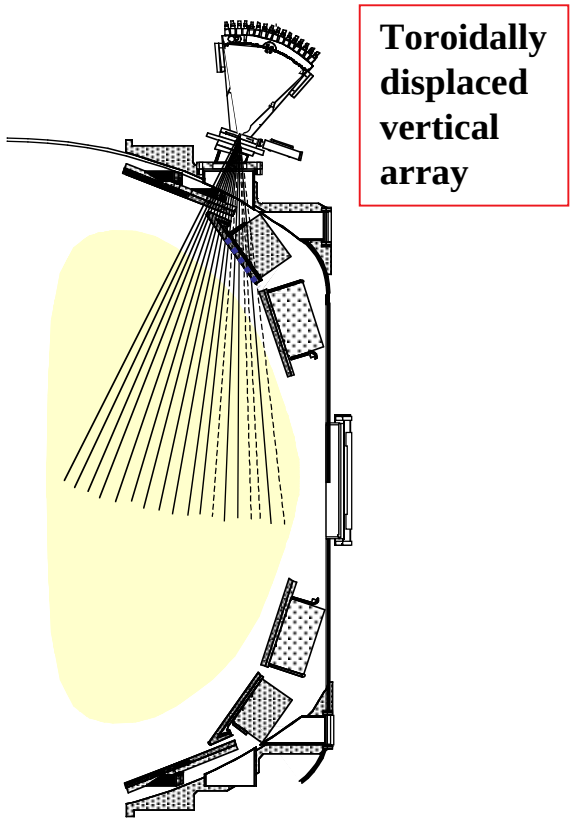
- All high beta discharges encounter internal MHD (J Menard, 5-year Plan)
- USXR *only option* for internal MHD diagnostic in NSTX (no ECE at low field)
- *Tomographic reconstruction* needed for mode localization and structure

Layout of the USXR system for 03-04

Bay G

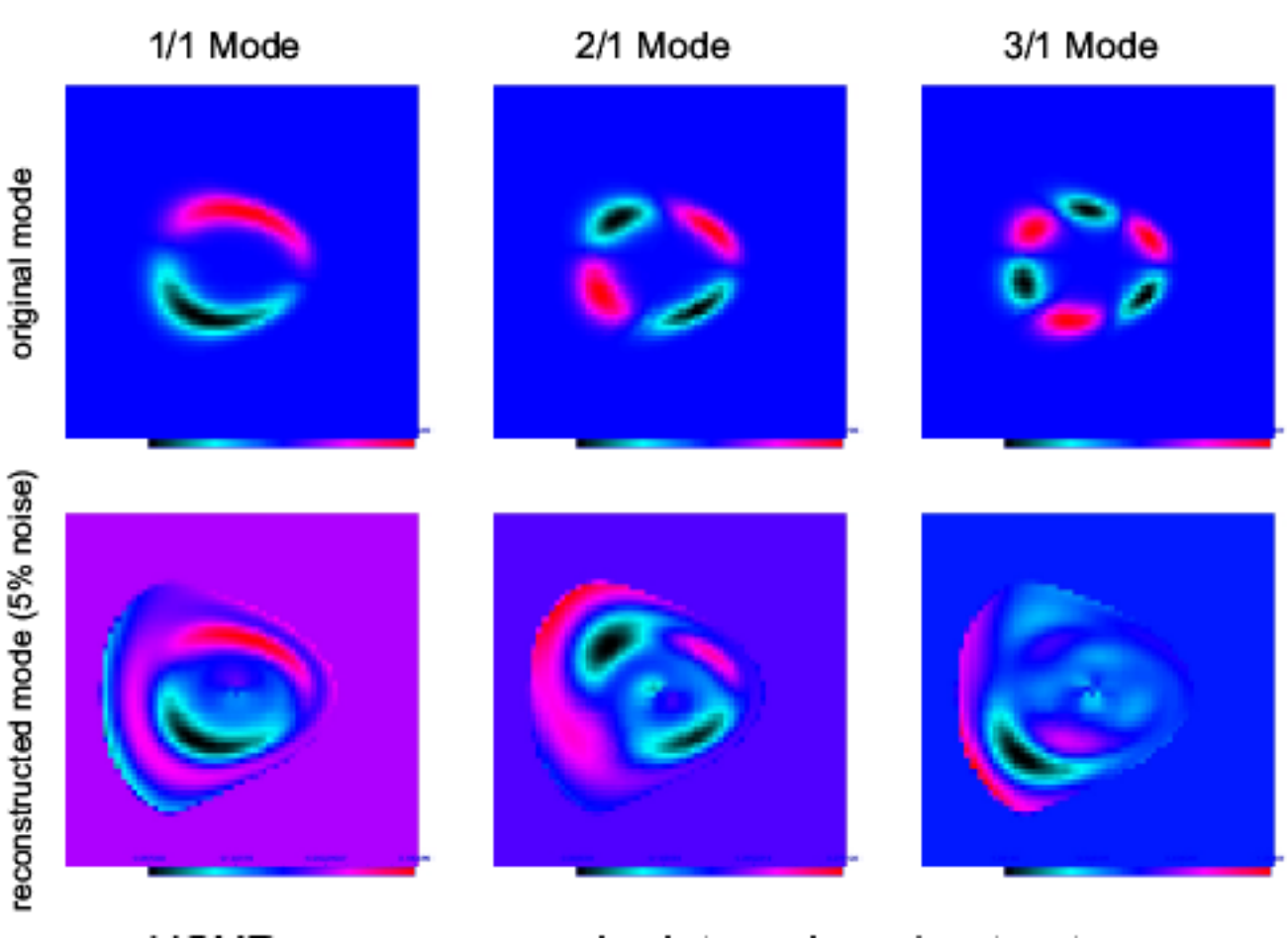


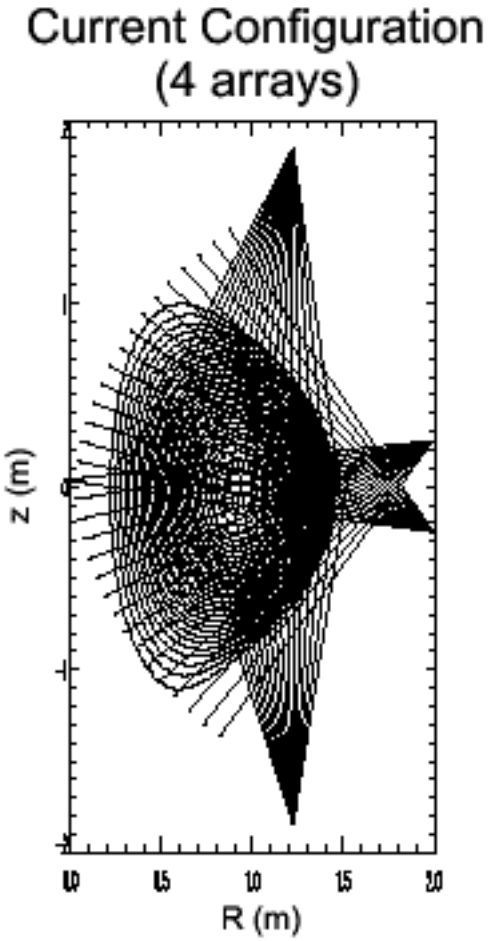
Bay J



- **Partial tomographic reconstruction capability** (m=1 perturbations)
- Toroidal imaging capability for **Resistive Wall Mode diagnostic**
- **600 kHz** sampling rate

USXR arrays can provide tomographic reconstruction

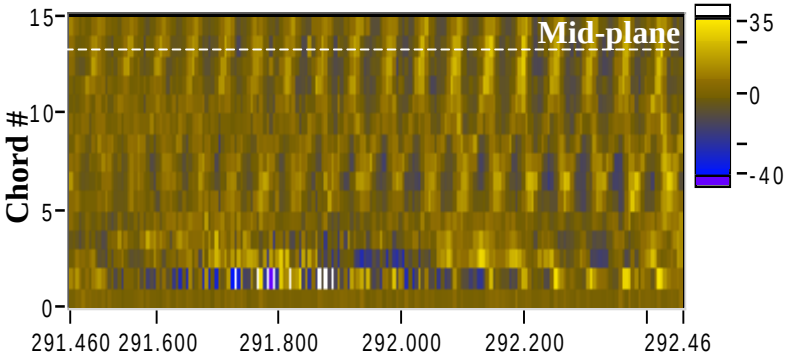




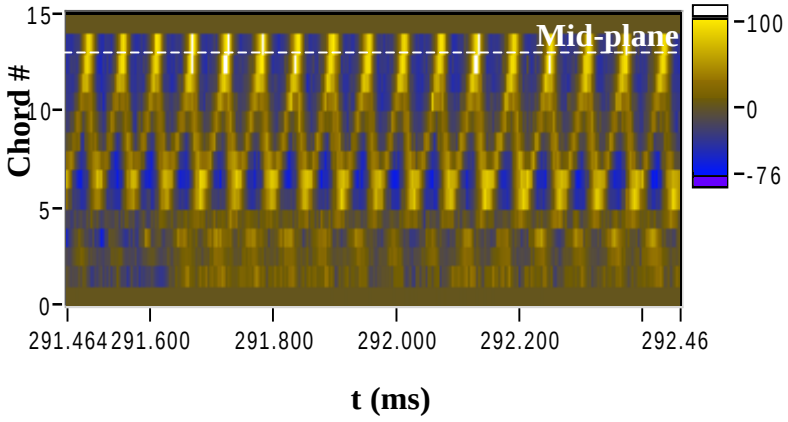
- Reconstruction will allow comparison with M3D predictions (mode structure, rotation effects, pressure vs. magnetic perturbation)
- 'Theory guided' MHD avoidance will be essential for NSTX progress
- 1/1 mode partly resolved with current configuration, 2/1 only cos 2θ

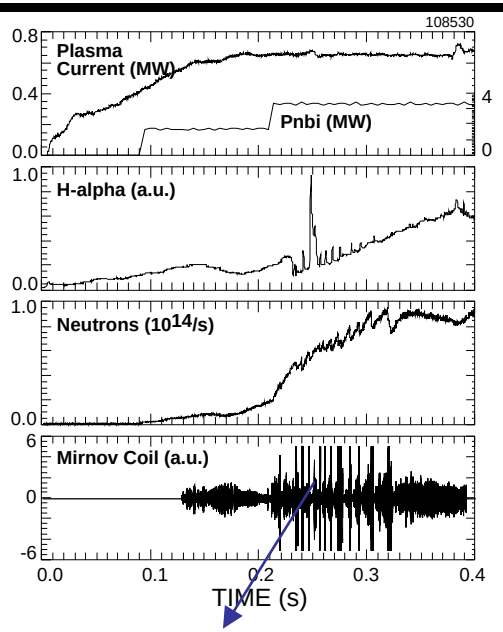
600 kHz sampling improves imaging capability

200 kHz sampling

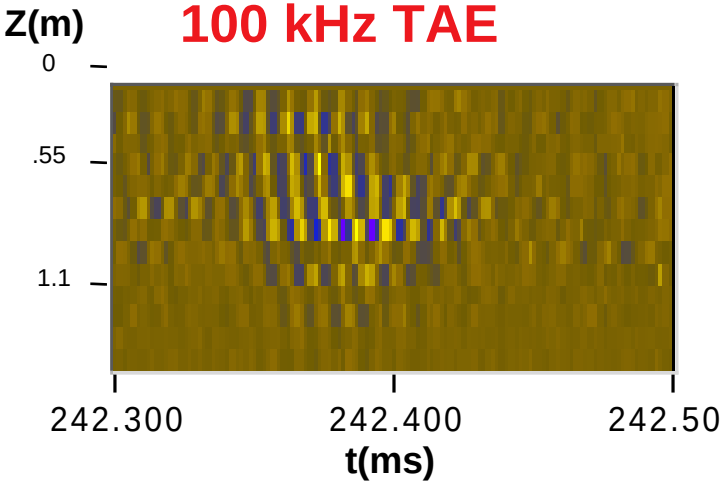


600 kHz sampling



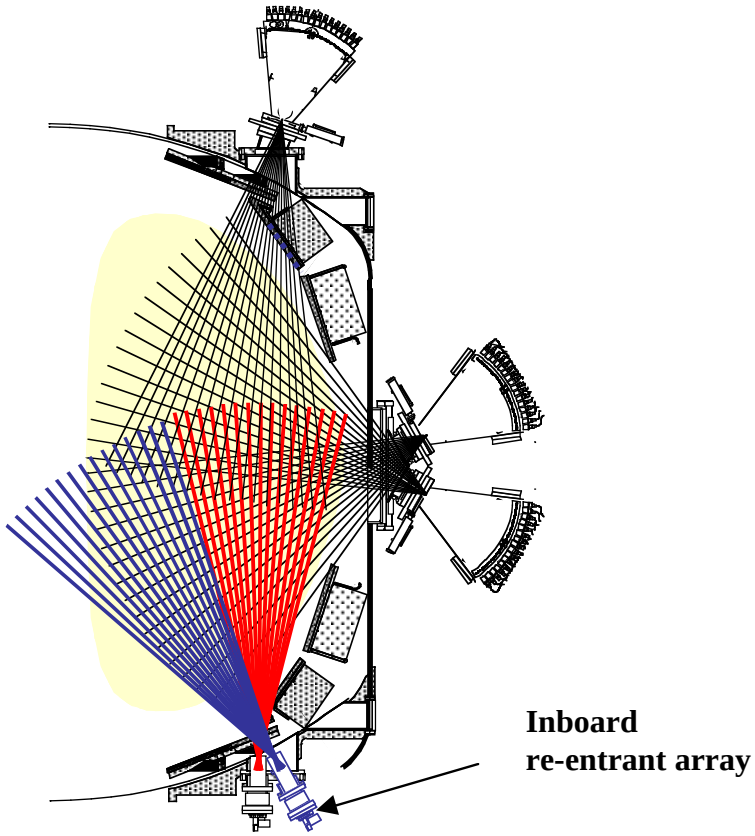


100 kHz TAE



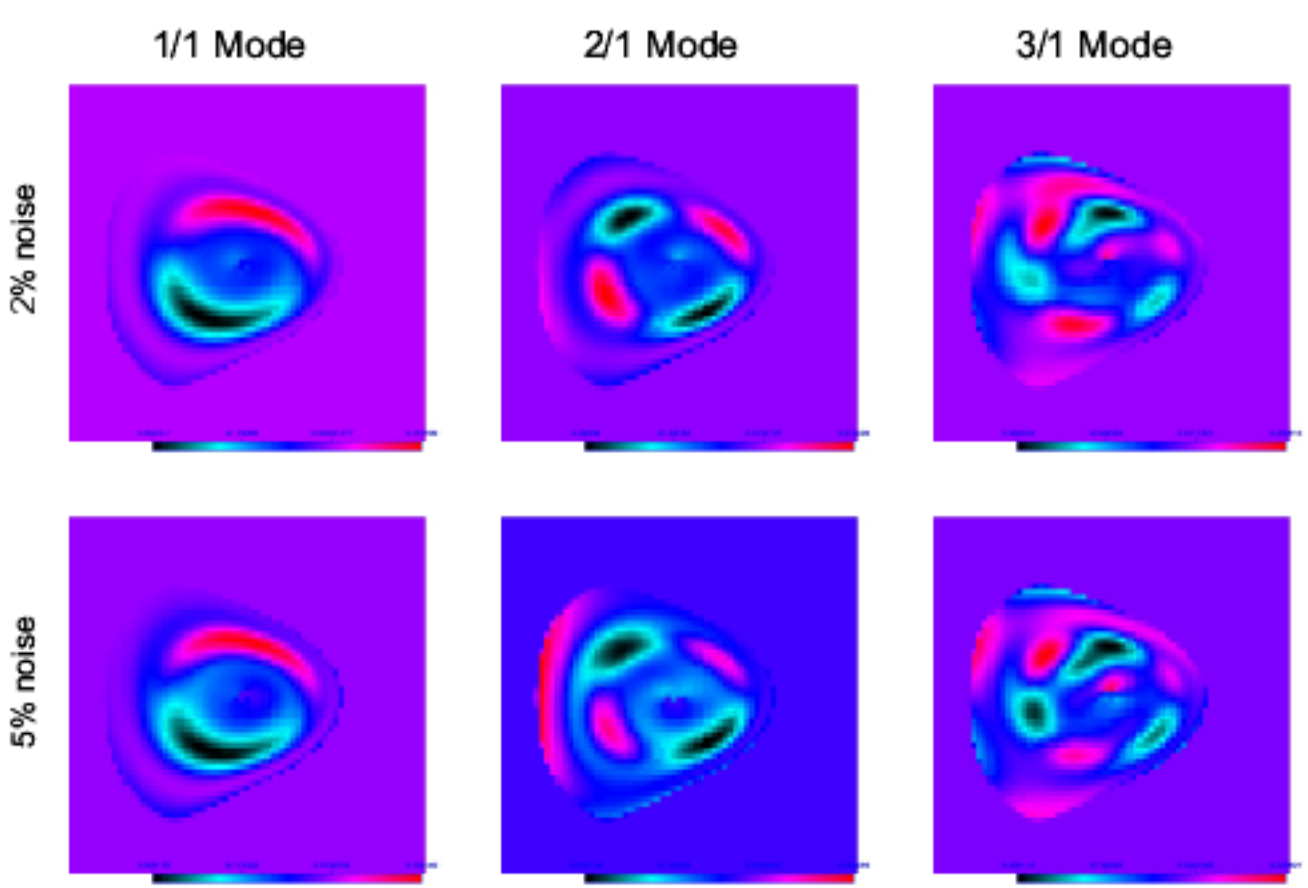
- **Much clearer picture of rotating modes during NBI**
- **TAE mode localization and structure for ‘MHD spectroscopy’**

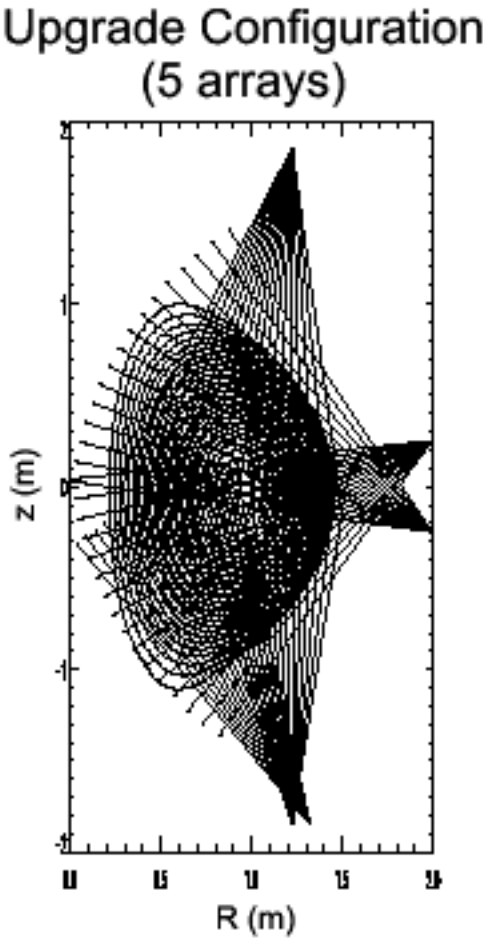
Second re-entrant array improves tomography (04-05)



- Full m=1, improved m=2, some m=3 capability
- Stabilizing plate repositioning will likely affect external array views and make necessary in-vessel redesign

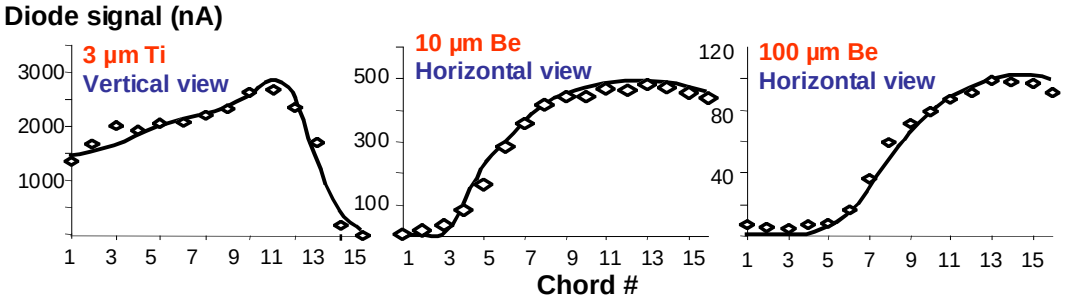
Second re-entrant array improves reconstruction

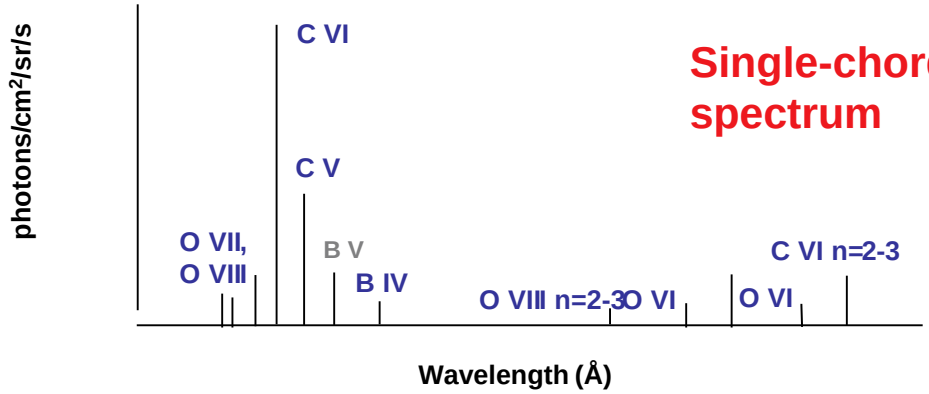




- **Full m=1 improved m=2, and partial m=3**

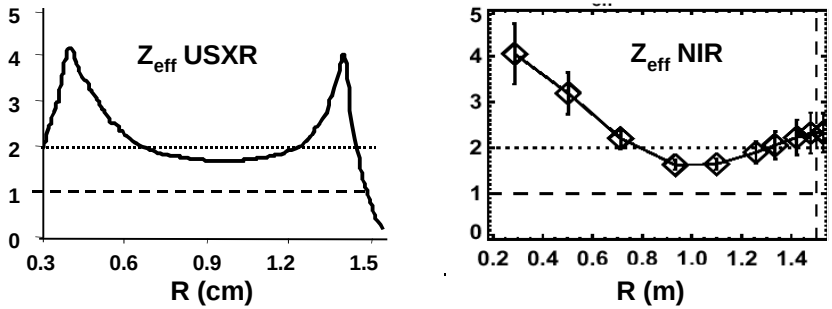
Integrated impurity diagnostic package





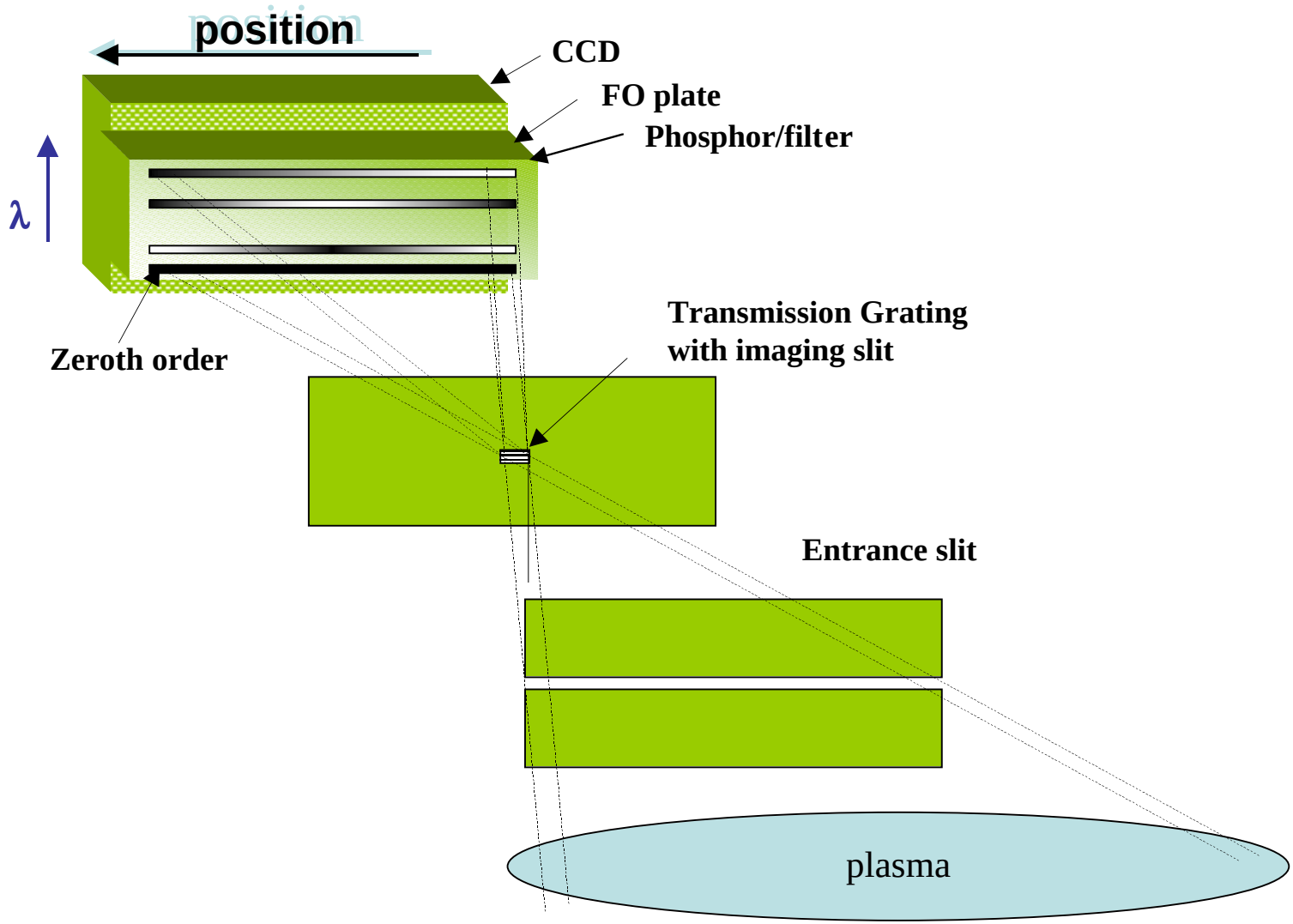
Single-chord GRITS spectrum

b)



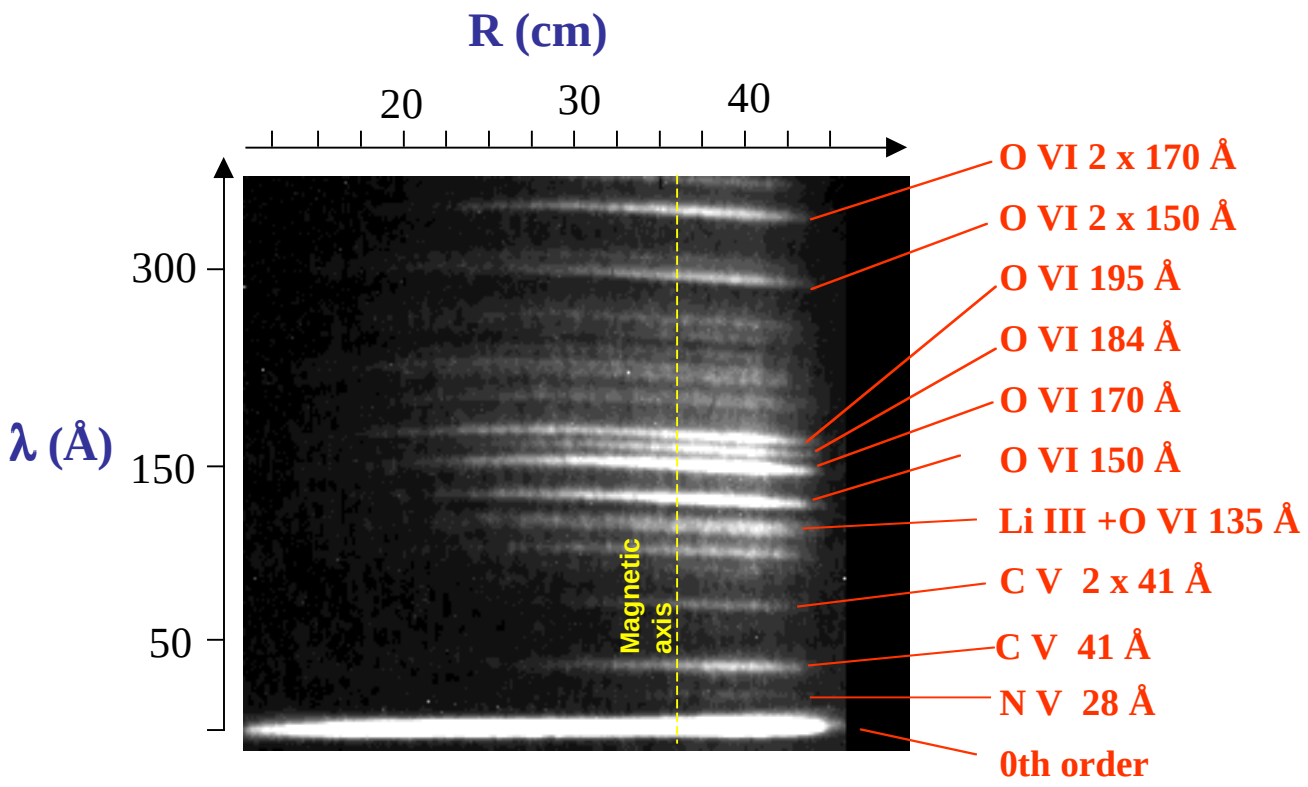
- **Integration of TGIS, USXR and CHERS for N_{imp}, Z_{eff} profiles, 2-D P_{rad}**

Transmission Grating Imaging Spectrometer

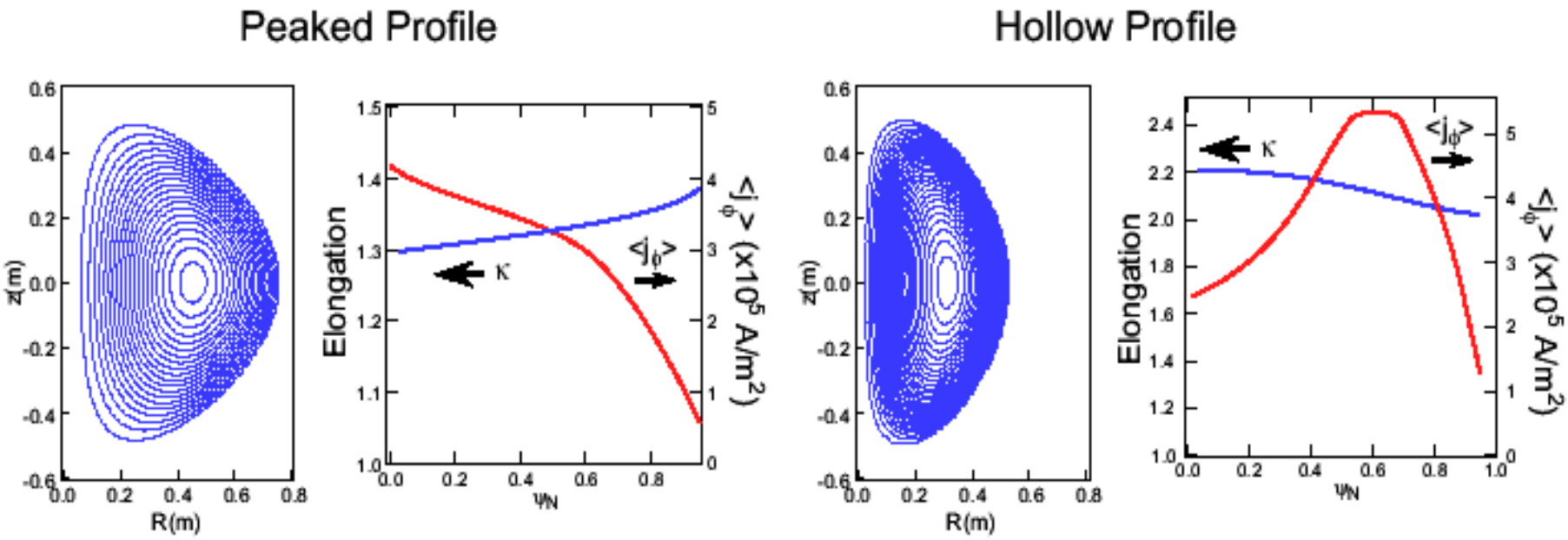


Prototype developed on CDX-U and NSTX

TGIS provides 10-300 Å space-resolved spectra



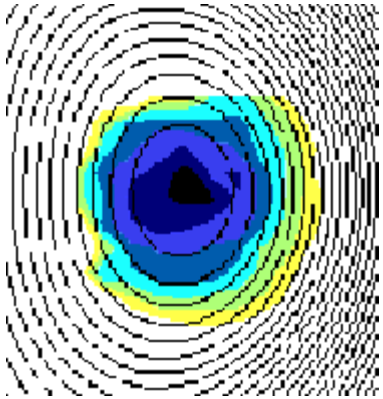
X-ray MPGD imaging for q_0/crt. profile diagnostic



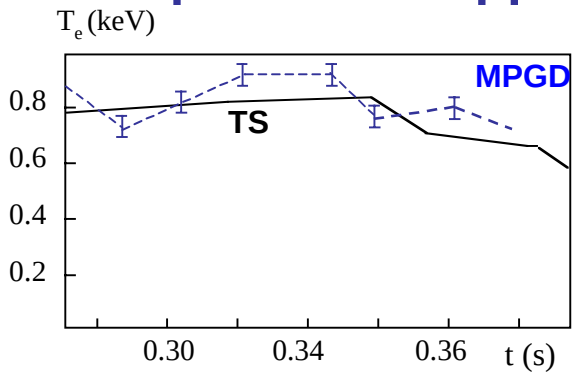
- **Measurement of flux surface shape strongly constrains reconstruction of current profile in spherical tokamak (R. Fonck, K. Tritz)**
- **X-ray iso-intensity surfaces are typically used**
- **Electron temperature iso-surfaces should provide better constraint**

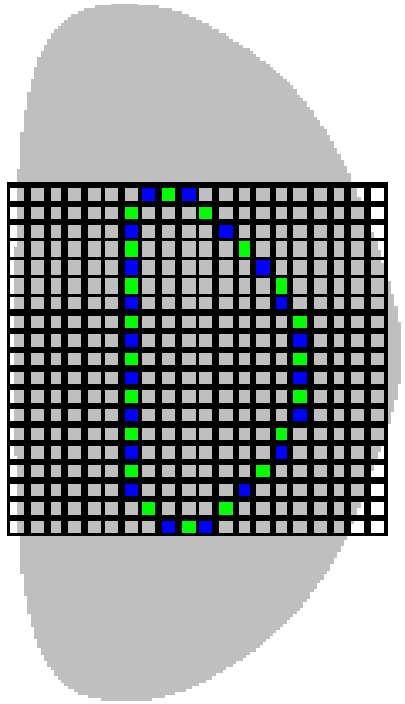
X-ray MPGD imaging for q_0 constraint (cont'd)

Iso-intensity imaging



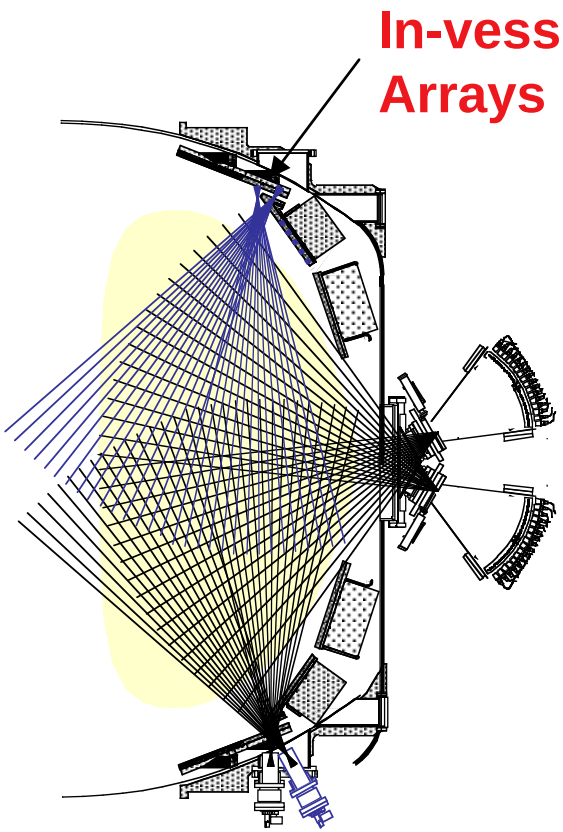
Iso-temperature mapping





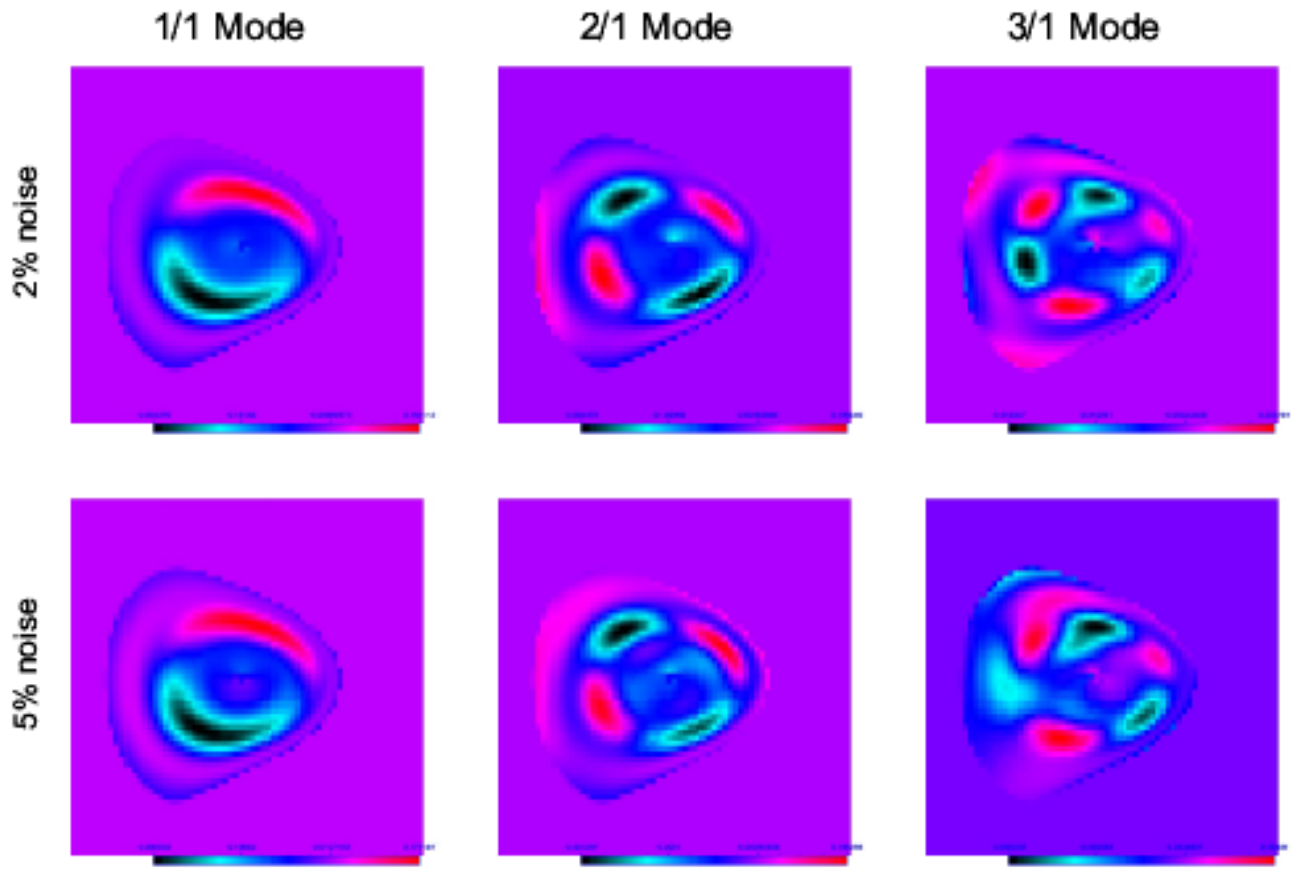
- **Test and optimization of each technique**
- **Integration in magnetic reconstruction code**
- **Best technique will be applied for q(0) in 2005-2006**

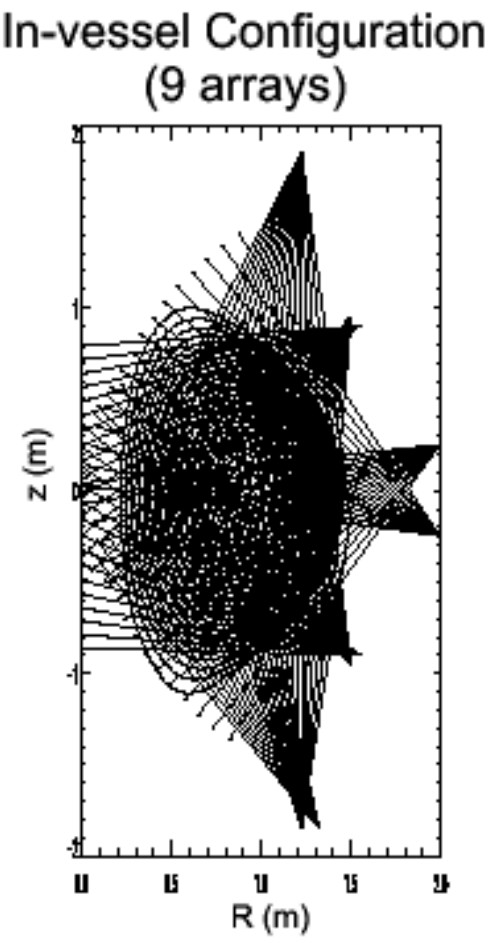
Additional arrays for m=2-3 tomography



- Two additional arrays for m=2,3 capability
- SVD enhanced tomography for coupled mode reconstruction
- Final design/configuration will depend on stabilizing plate redesign

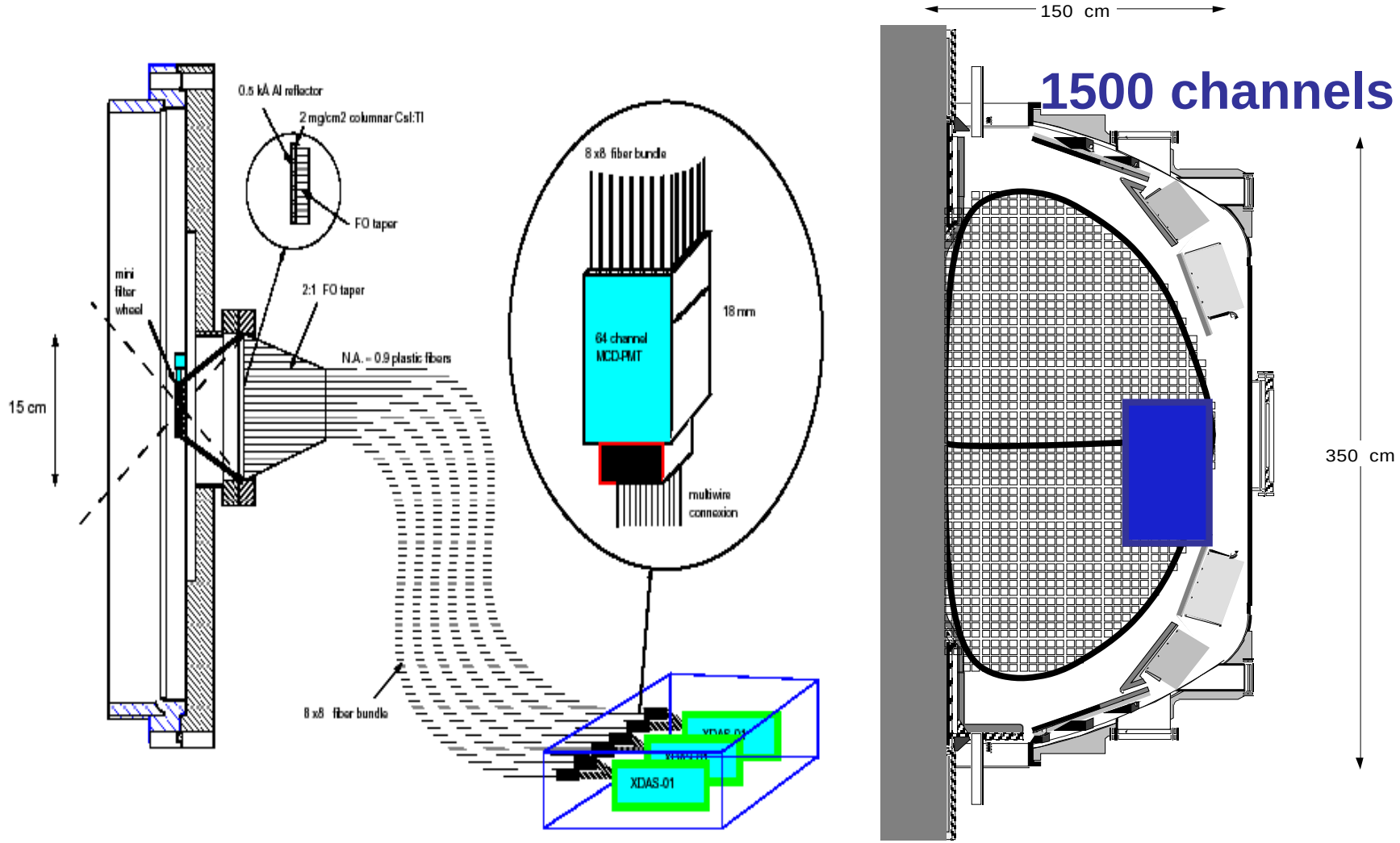
In-vessel arrays may allow higher-m and coupled mode reconstruction





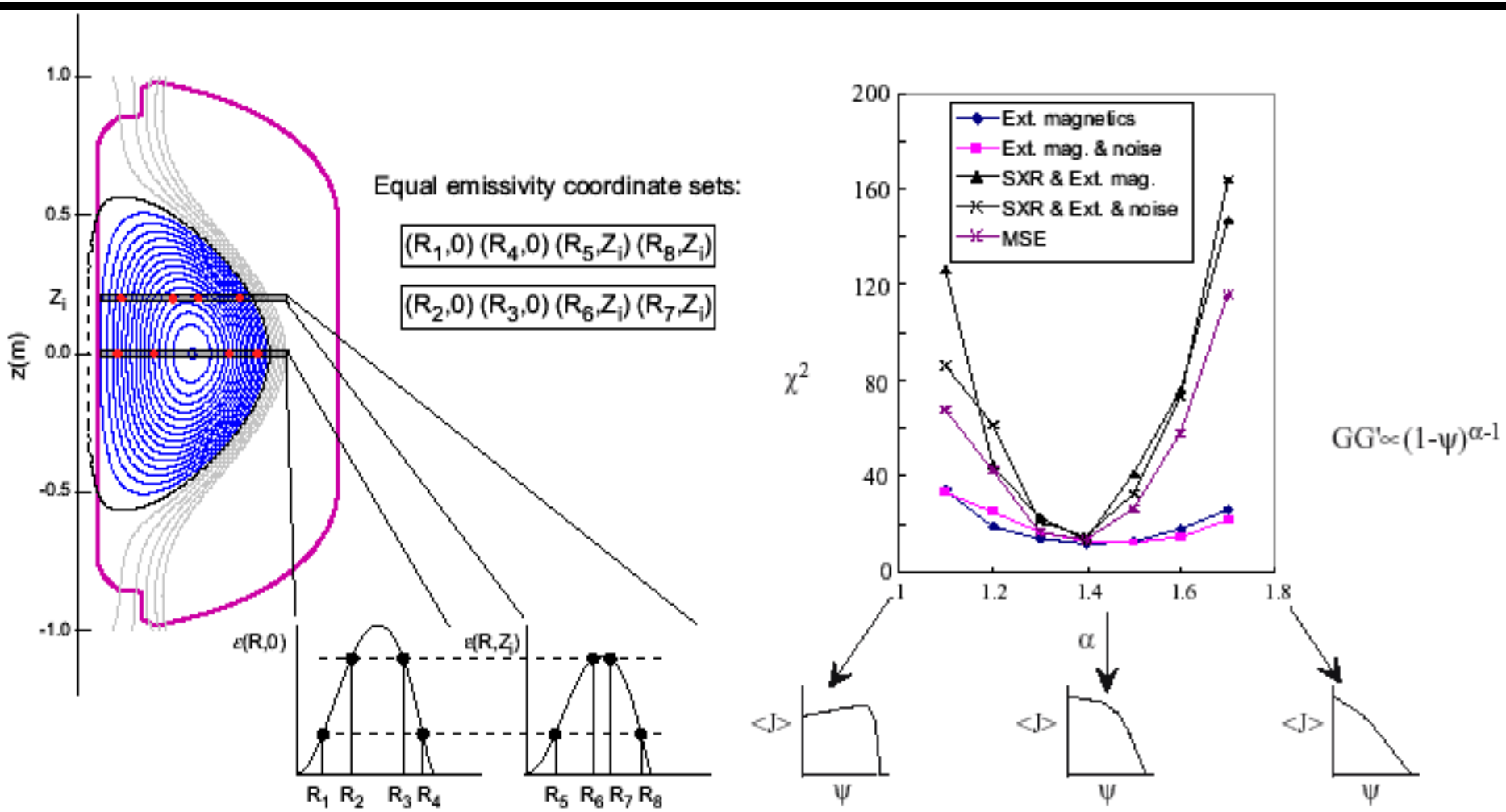
- In-vessel arrays circumvent vignetting from passive plate positioning
- 3/1 mode resolved with 2% and 5% statistical noise

Continuously sampling prototype optical array



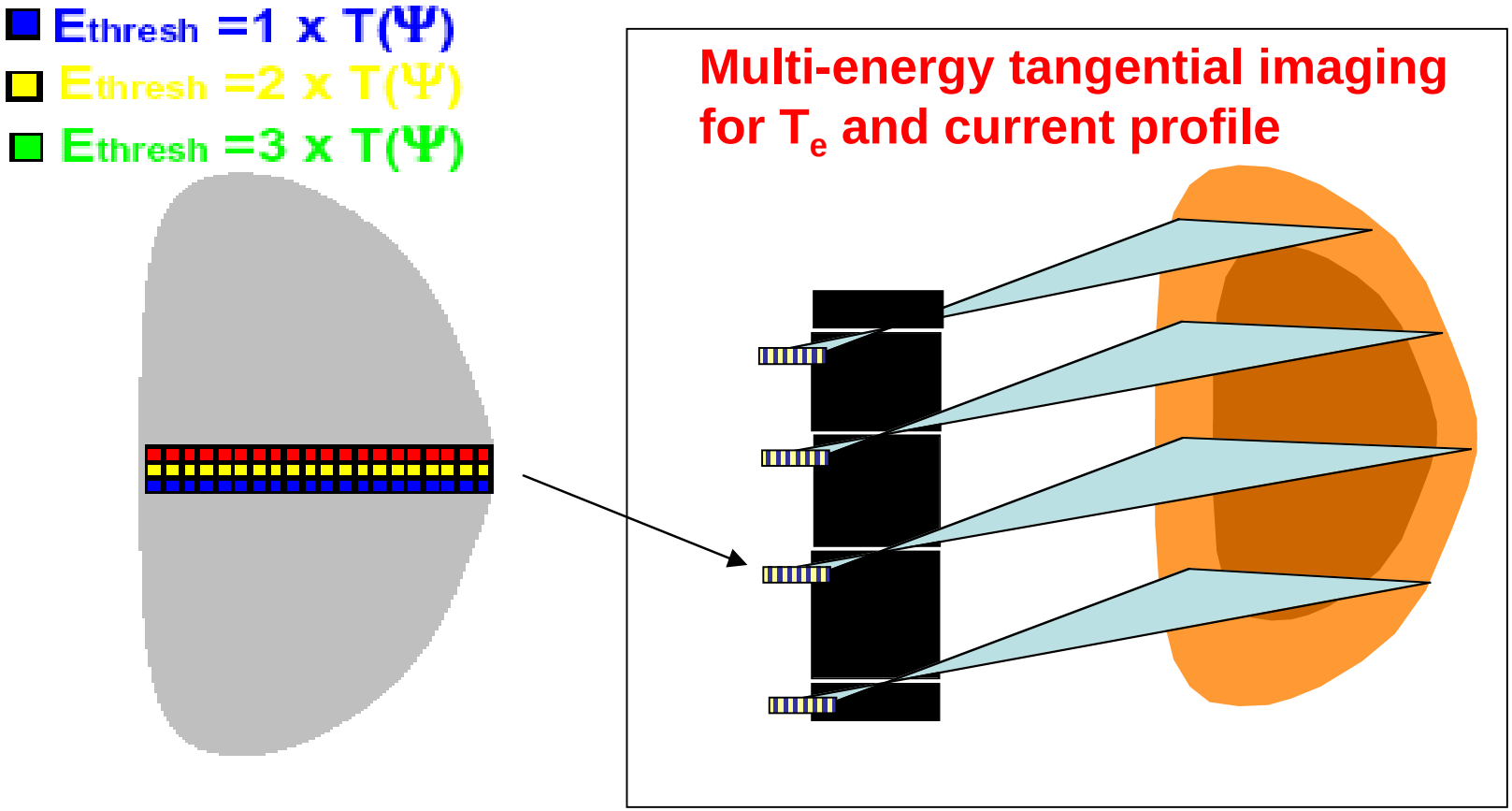
- **Poloidal imaging not adequate for high-m modes** (structure at inboard)
- **100 kHz 256-channel prototype tangential array with XDAS readout**
- **Continuous sampling essential in NSTX**

1-D tangential imaging for improved current profile



- **Tangentially viewing, stacked 1-D arrays instead of pinhole camera**
- **Constraint is as good, or better than Motional Stark Effect (Fonck, Tritz)**

Multi-energy linear MPGD configuration



- **Tangential T_e and X-ray profiles will be explored for current reconstruction**
- **Multi-energy linear MPGDs with increasing threshold energy for T_e profile**
- **Poloidal multi-energy MPGD for fast (100 μs) T_e diagnostic (ECE substitute)**