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Supported by U.S. DEPARTMENT OF ENERGY Office of Science

JHU Diagnostic Plans for NSTX-U

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U Illinois
U Maryland
U Rochester
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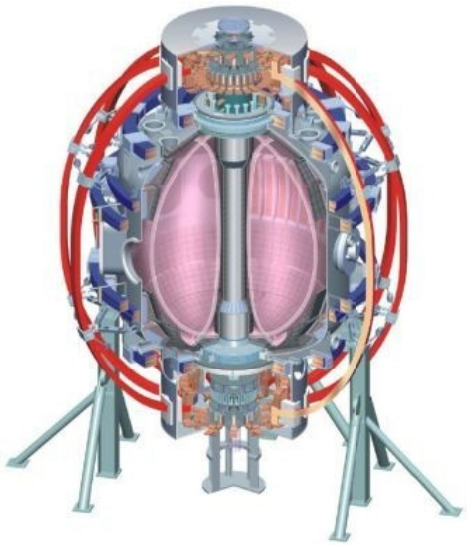
presented by

Kevin Tritz

for the JHU Plasma Spectroscopy Group

NSTX-U Diagnostic Planning Meeting
PPPL, Princeton, NJ
July, 26th 2012



Culham Sci Ctr
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ASCR, Czech Rep
U Quebec

Several XUV/SXR diagnostic funded under recent DoE solicitation for NSTX-U (2012-2016)

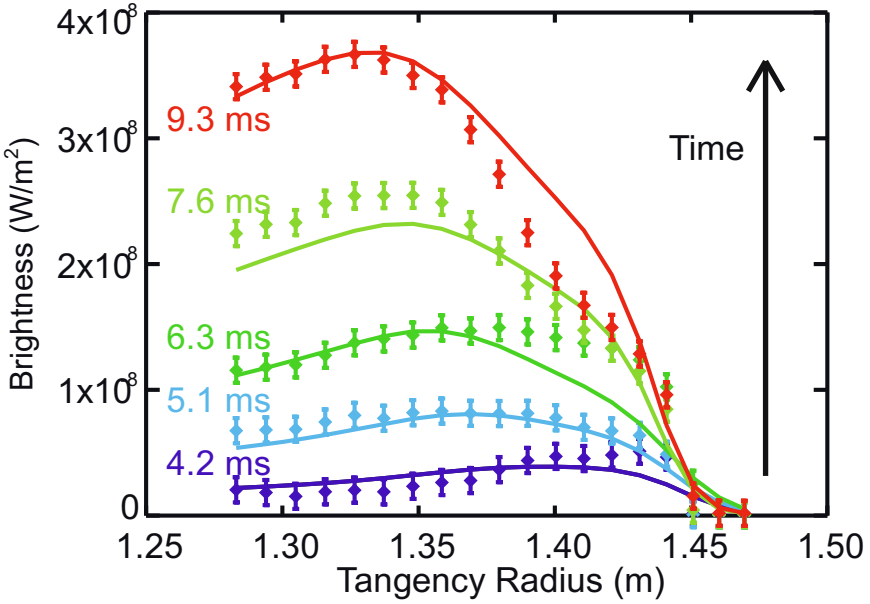
- 96 channel, in-vessel EDGE tangential ME-SXR array (**EDGE ME-SXR**)
- 96 channel, in-vessel CORE tangential ME-SXR array (**CORE ME-SXR**)
  - Tangential SXR profiles, 4-5 energy bands (few eV - several keV, $\Delta t \geq 10\mu s$)
  - EDGE: 0.6<r/a<1.1, $\Delta R \approx 1$cm; CORE: 90cm<R_{tan}<140cm, $\Delta R \approx 2.5$cm
  - Impurity and electron perturbative transport using gas puffs and repetitive LBO
  - Fast (10kHz) Te, nz profiles for ELM dynamics & stability, RWMs, disruptions
  - Edge and core MHD studies (NTM/island detection and dynamics)

- Fast Transmission Grating Imaging Spectrometer (**f-TGIS**)
  - Low-Z and high-Z impurity fractions for ME-SXR modeling and impurity monitoring
  - 90cm<R_{tan}<150cm, $\Delta R \approx 2$ cm, $\Delta t \geq 10$ms, 50-700 Å, $\Delta\lambda \approx 8$ Å

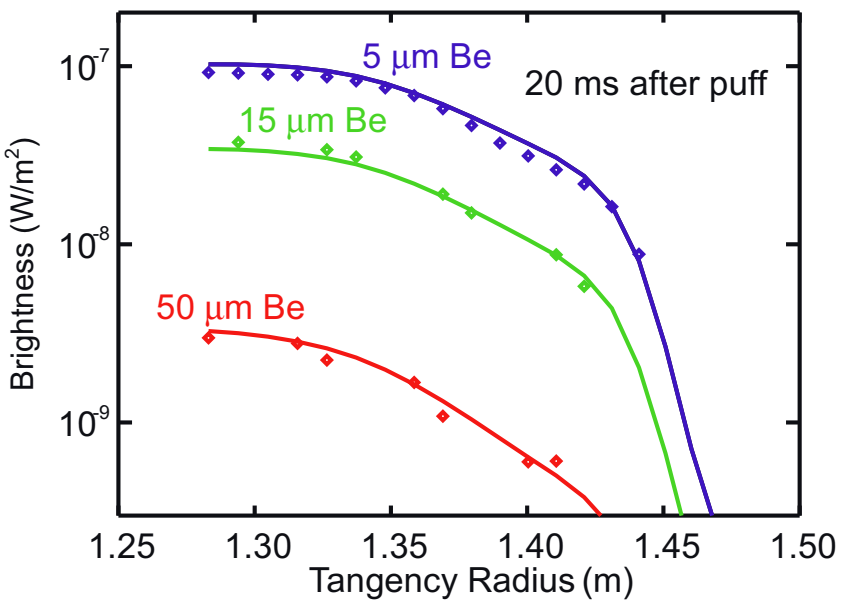
- Repetitive laser blow-off impurity injection system (**LBO**)
  - Repetitive (10Hz) and controlled injection of low to high-Z impurities
  - Multiple impurity/electron transport measurements during single discharge
  - High accuracy edge impurity transport using ME-SXR + non-recycling impurity (Si)

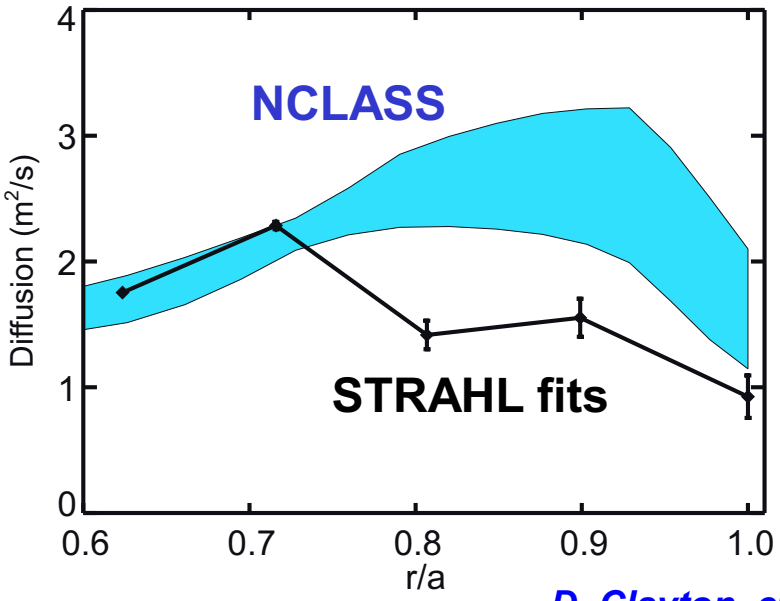
Fits to SXR emission from neon puffs using Edge ME-SXR data provides edge impurity transport measurement

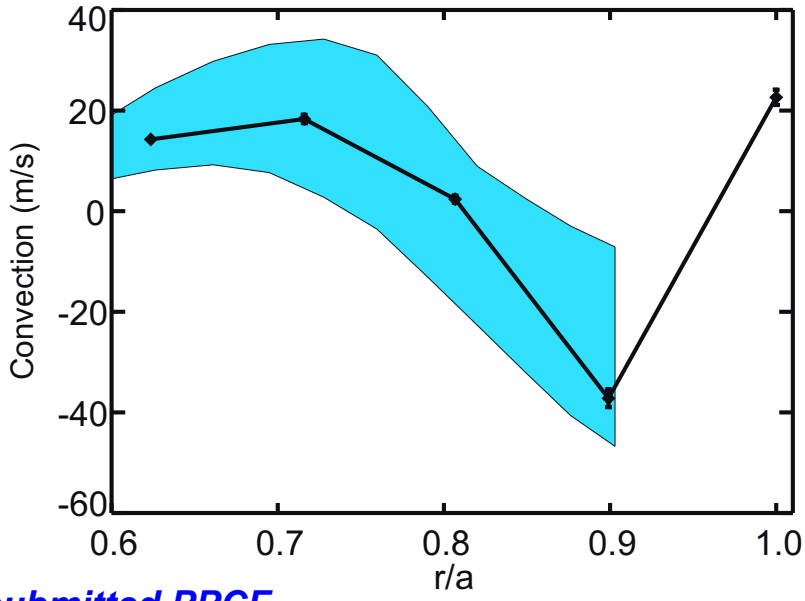
Time evolution of 5μm Be filtered array



Fit to multi-filter ME-SXR profiles



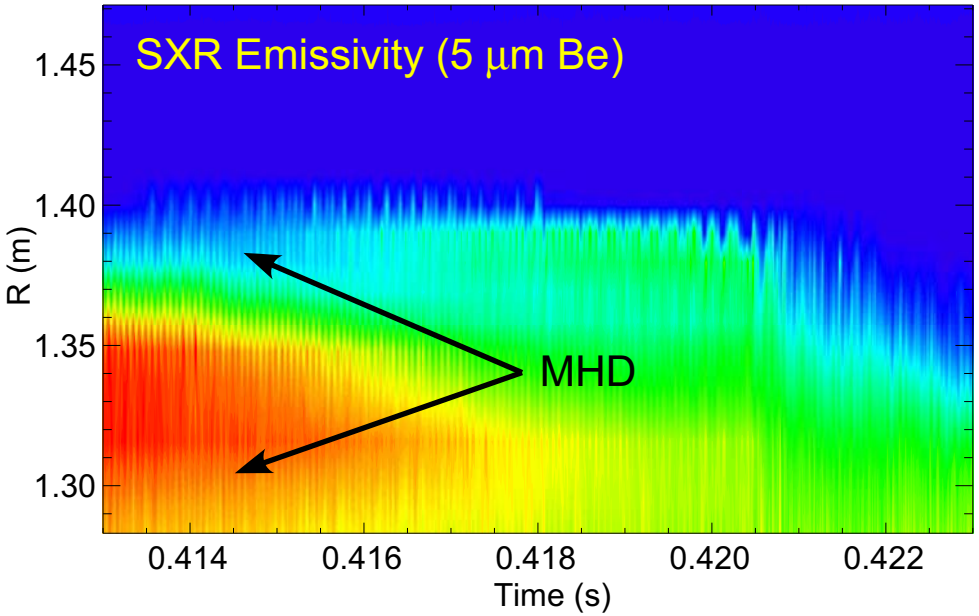


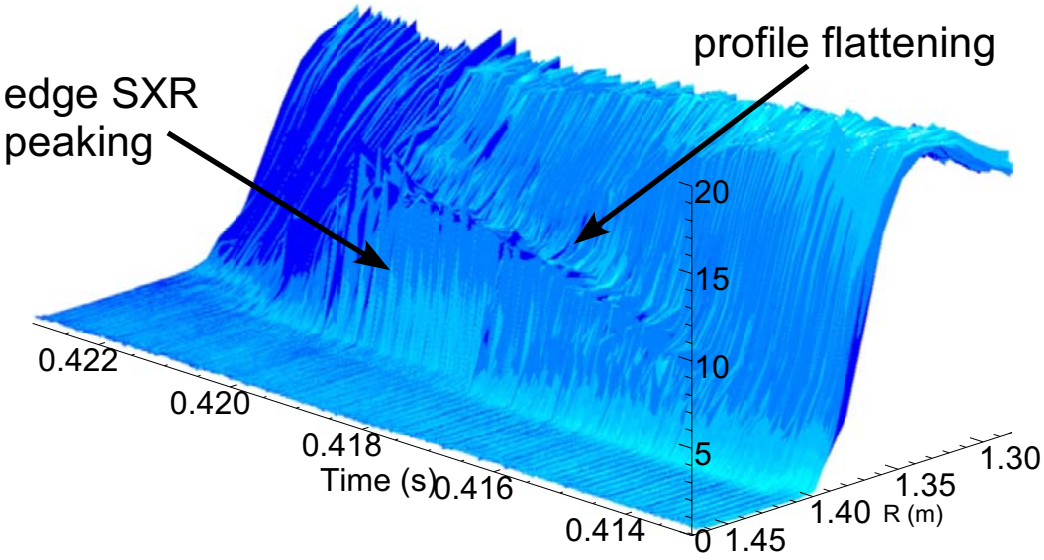


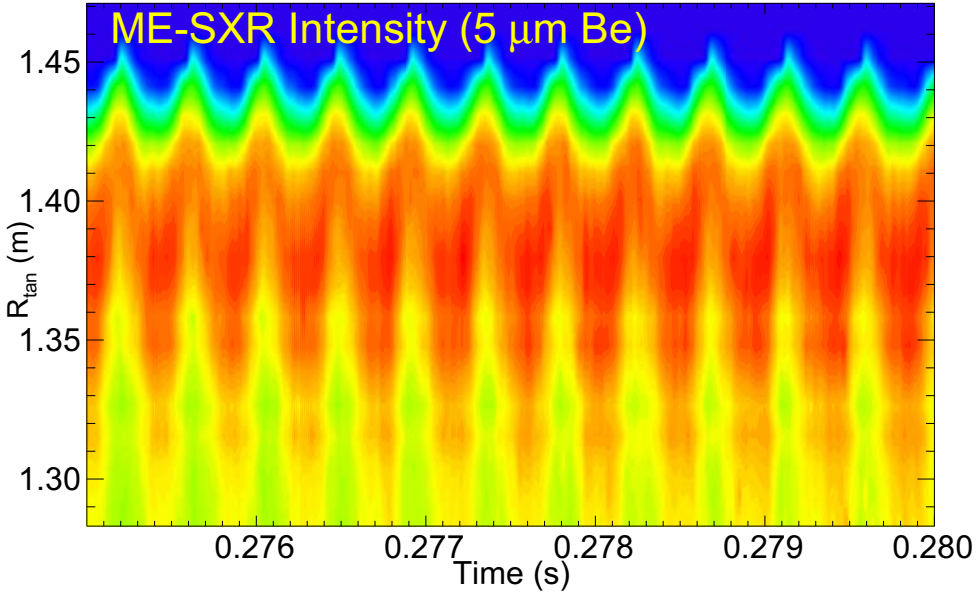
D. Clayton, et al., submitted PPCF

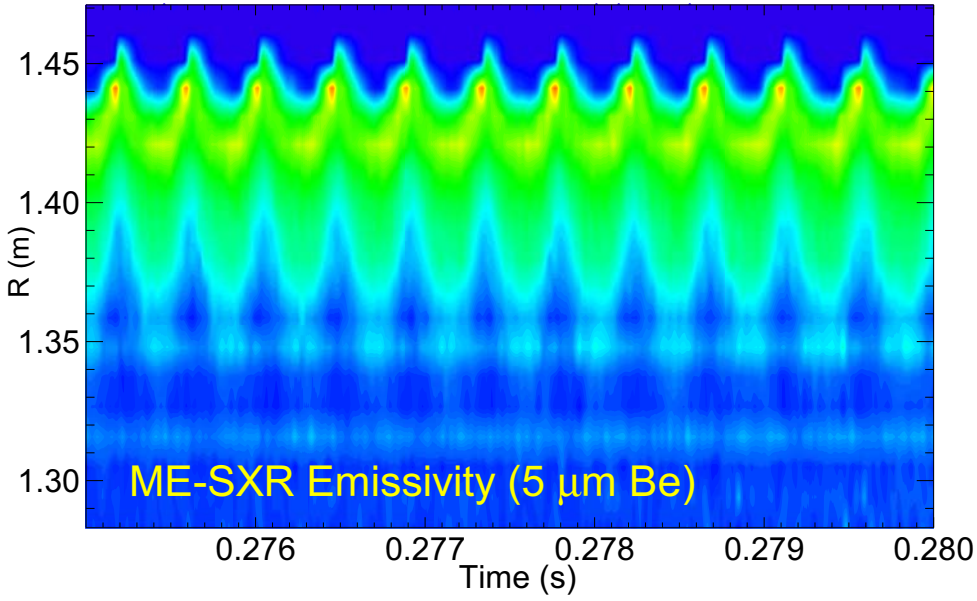
Abel inversion of tangential ME-SXR data provides improved spatial resolution for edge dynamics and MHD

K. Tritz, et al., RSI (2012)



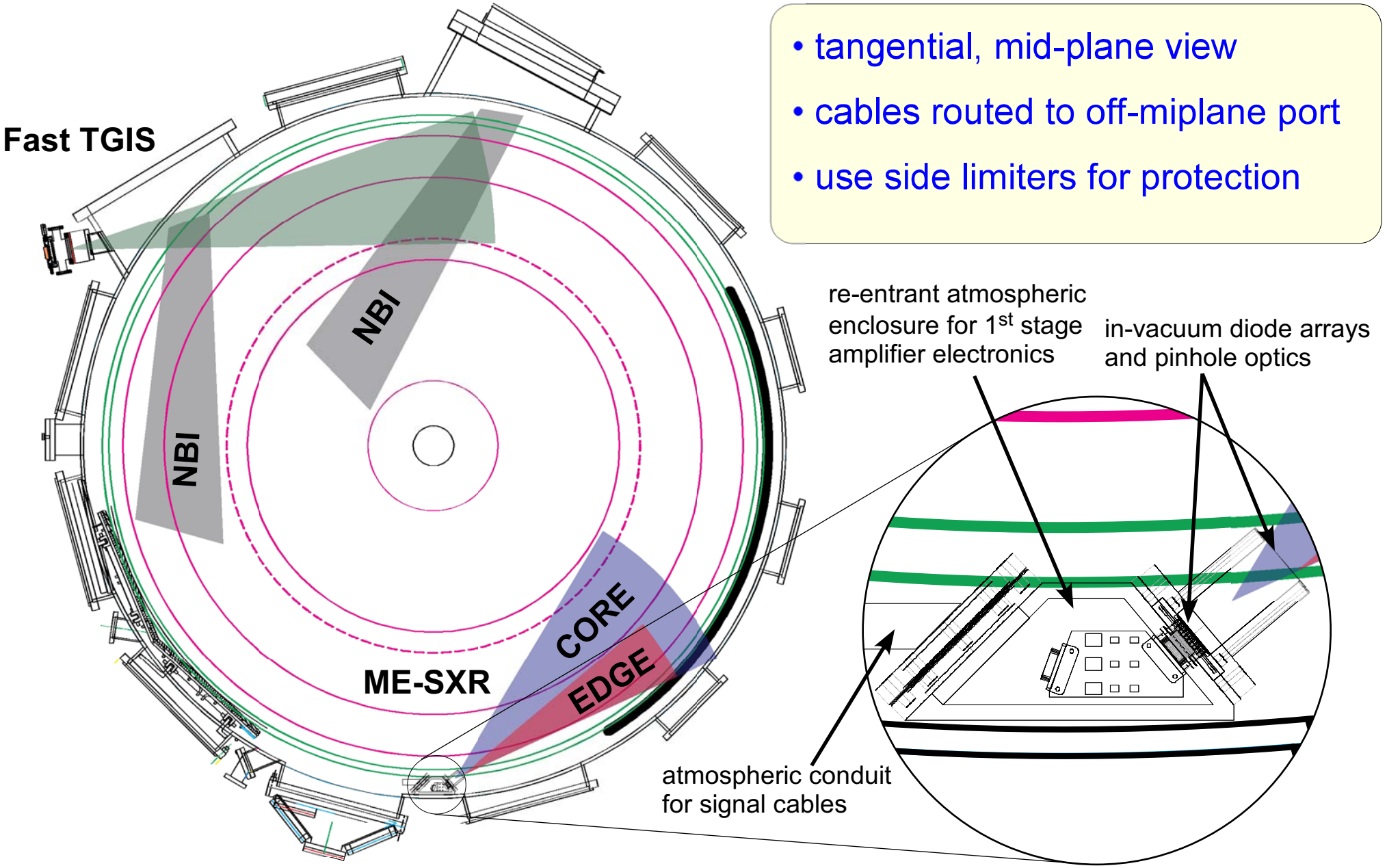




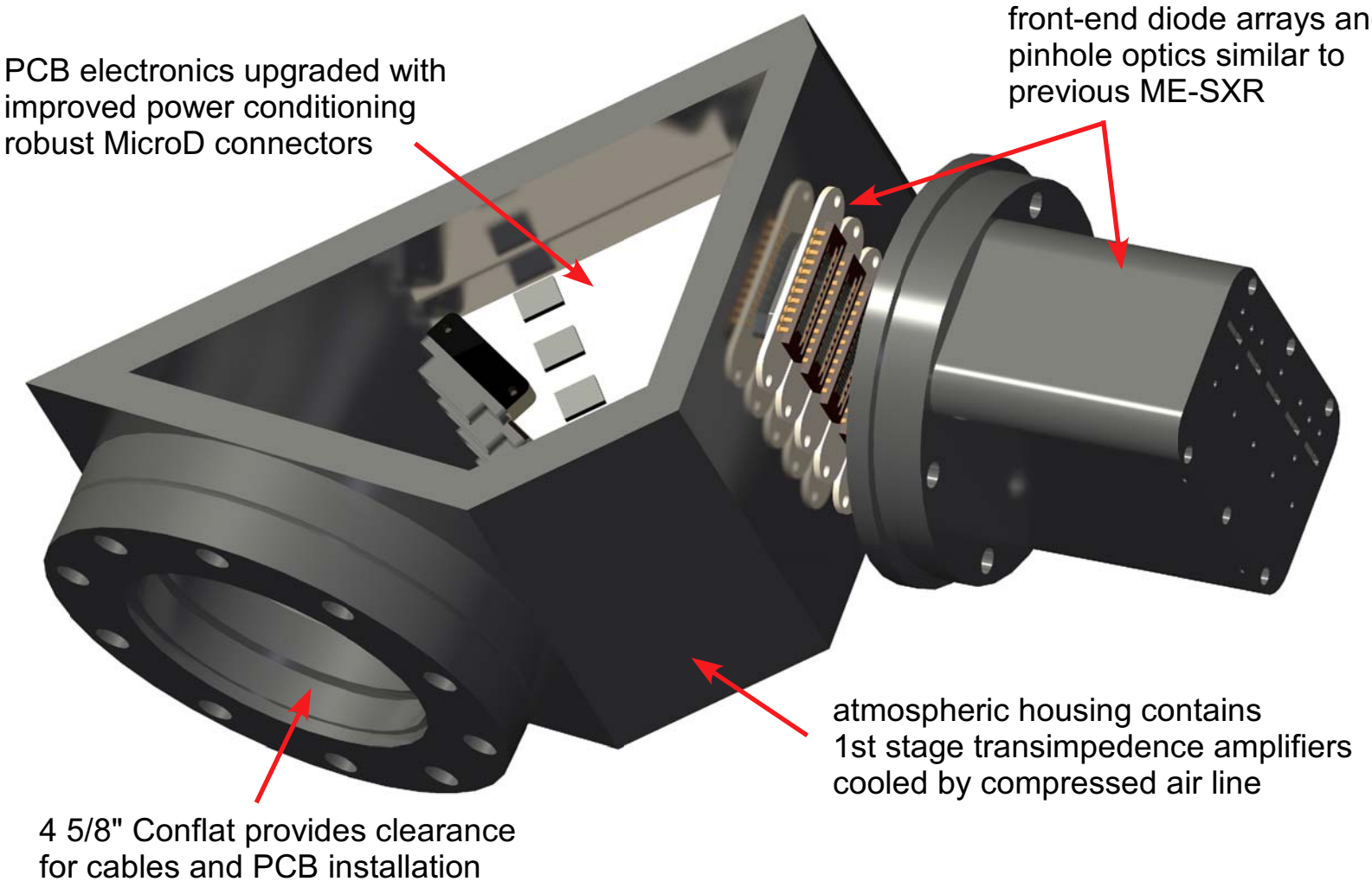


In-vessel ME-SXR design provides flexibility for diagnostic placement and FOV

- tangential, mid-plane view
- cables routed to off-miplane port
- use side limiters for protection

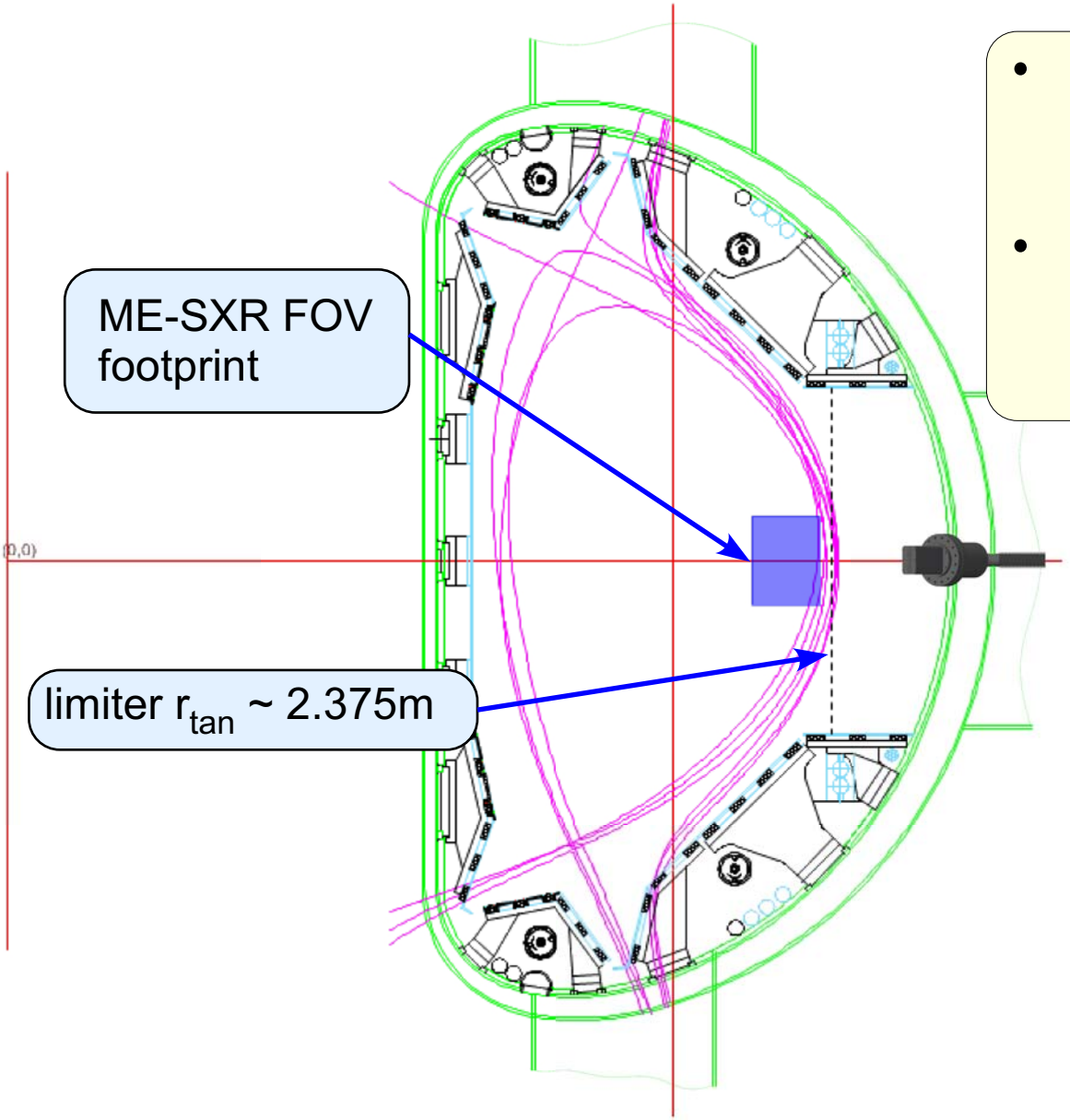


In-vessel ME-SXR design adapted from system previously tested on NTX



- Additional development will explore vacuum compatible electronics
- Local A/D, serial output conversion could significantly reduce cabling

Re-entrant atmospheric in-vessel ME-SXR design to be tested on EAST



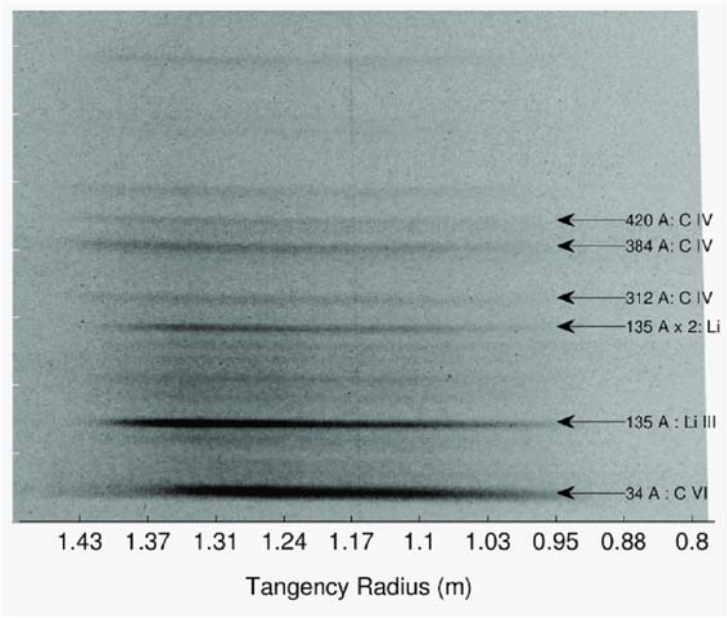
EAST side view

- ME-SXR provides coverage from edge to mid-radius
- FOV footprint in plasma can be adjusted by changing mounting position/angle

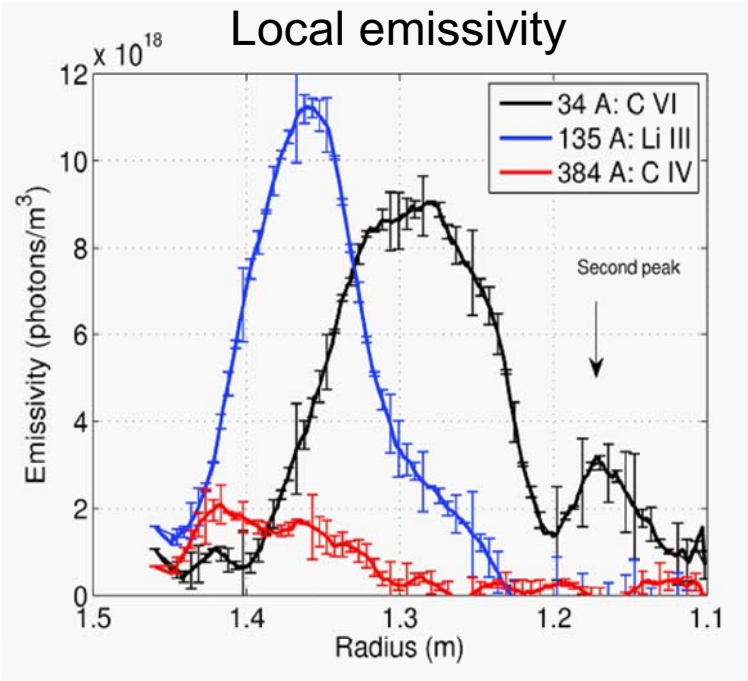
3D view of ME-SXR

Transmission Grating Imaging Spectrometer provides impurity fractions to assist ME-SXR modeling

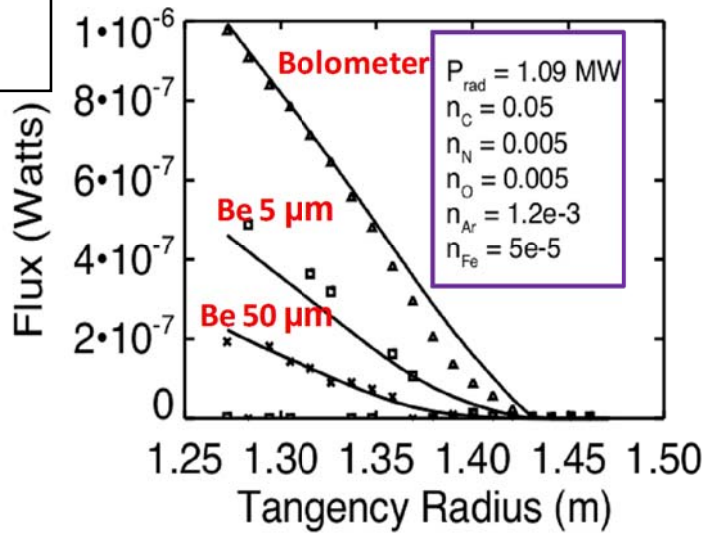
TGIS space-resolved spectrum (ohmic)



Local emissivity



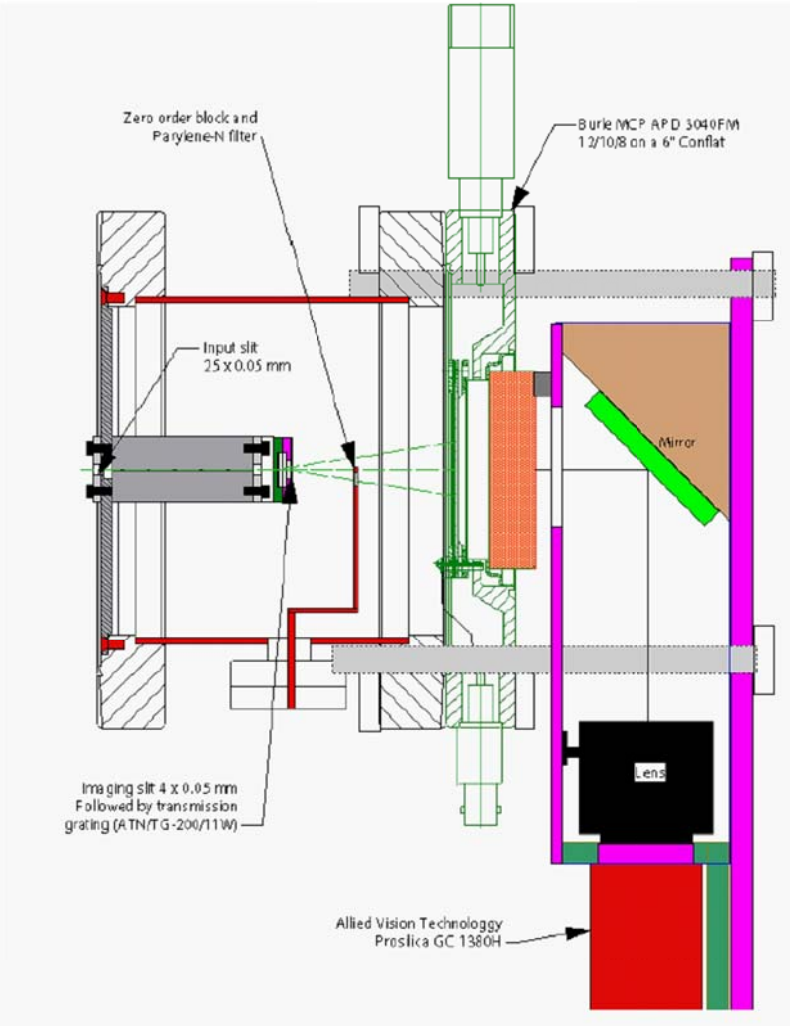
Comparison of measured and computed ME-SXR profiles using TGIS impurity fractions



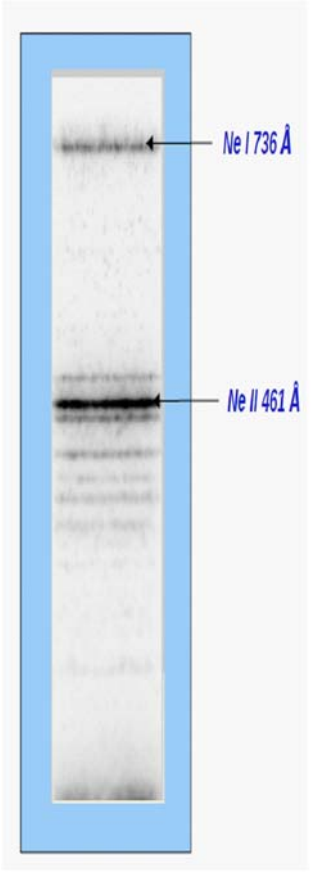
- TGIS also provides stand-alone plasma impurity monitor

Fast TGIS will improve time resolution of measured impurity profiles for NSTX-U

Fast CCD readout f-TGIS



100 Hz TGIS spectrum of Penning laboratory plasma



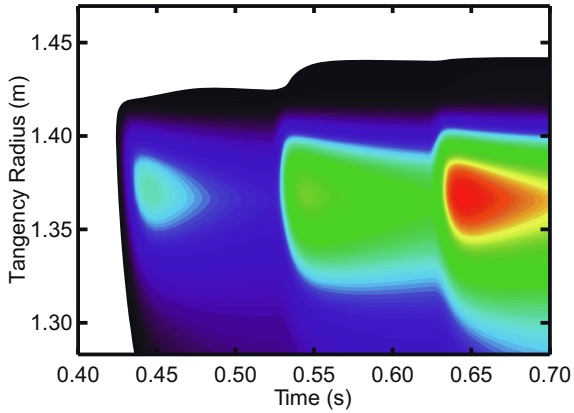
D. Kumar, et al., 38th EPS (2011)

- Inexpensive CCD readout can be replaced if damaged by neutrons
- High-Z (Mo, W) TG to be developed under advanced diagnostics

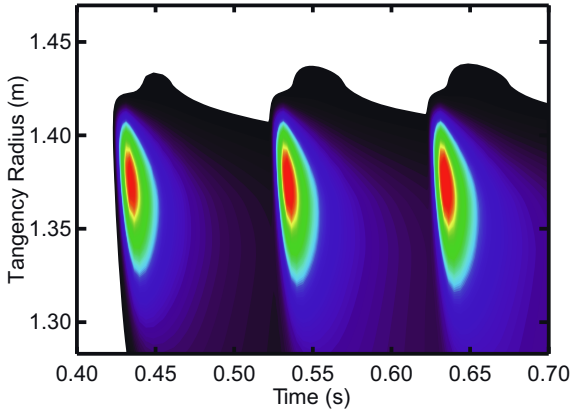
Repetitive (10Hz) Laser Blow-Off (LBO) system provides significant impurity injection flexibility

- Wide choice of LBO materials
  - from low to high-Z (Li through W)
  - non-recycling for better source characterization, STRAHL modeling
  - higher injection energy, improved penetration
- Repeated injection for transport evolution
  - Z-scaling of impurity transport
  - use optimal Z for cold pulse χ_e measurements
- Inject during ELMs, applied 3D fields
  - measure change in edge impurity transport
  - strongly coupled to ME-SXR measurements
- Initial LBO tests on LTX
  - inject Li, Li compounds (Li_2O, ...)
  - use existing ME-SXR/filtered diode arrays

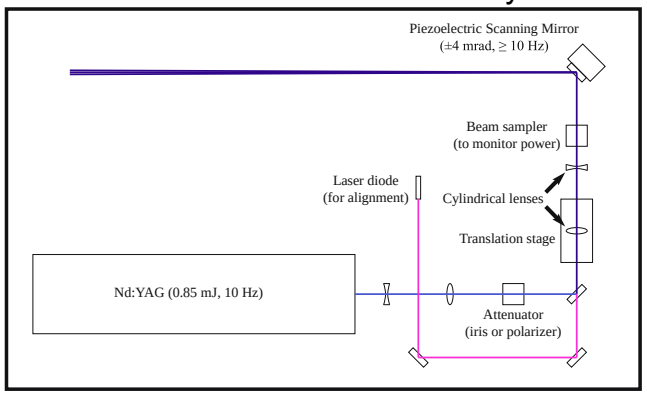
Recycling impurity buildup (STRAHL)



Non-recycling impurity injection (STRAHL)



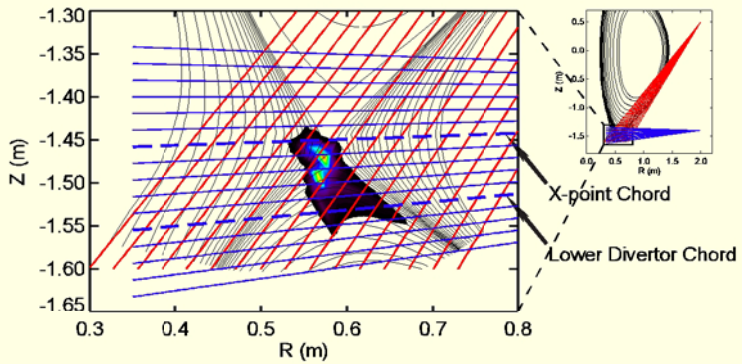
LBO based on Alcator C-MOD system

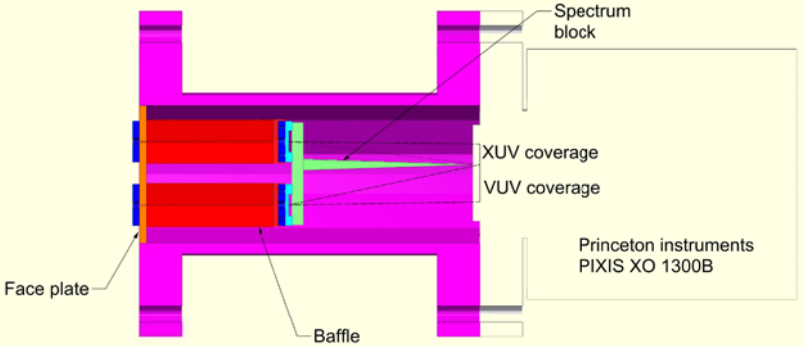


Additional diagnostic systems for NSTX-U proposed under Advanced Diagnostics program (2013-2016)

- High-Z TGIS for Mo, W profile/transport measurements
  - Mo/W spectrum contains broad 'envelope' of emission
  - study using spectrally optimized TGIS and extensive atomic modeling
  - will be deployed to measure W emission on FTU, T_e ~ 2keV
  - relevant to NSTX-U with Mo/W PFC (also ITER pedestal region)

- Dual XUV-VUV TG/CCD radiometer for $P_{rad}(\lambda,r)$ measurements in the divertor
  - measure impurity content/transport, estimates of T_e
  - strong validation of edge modeling codes (e.g. OEDGE)





- Non-magnetic SXR sensors for 'long-pulse' plasma boundary detection
  - compact, in-vessel sensor modules provide real-time edge detection
  - expanded sensor set for increased boundary shape control, plasma centroid
  - filter optimization may provide deeper plasma mode detection (RWM)

JHU diagnostic development timeline stages availability for projected 2014 operation and full 2015 run

NSTX-U Diagnostics Grant

development deployment

	FY2012	FY2013	FY2014	FY2015
CORE ME-SXR			NSTX-U	
EDGE ME-SXR				NSTX-U
EAST ME-SXR		EAST		
f-TGIS			NSTX-U	
LBO		LTX		NSTX-U

Advanced Diagnostics Proposal

	FY2013	FY2014	FY2015	FY2016
High-Z TG	FTU	ASDEX		NSTX-U?
Divertor Radiometer		NSTX-U		
Non-magnetic sensors			NSTX-U	expanded