



U.S. DEPARTMENT OF
ENERGY

Office of
Science



Divertor studies using tangential imaging system

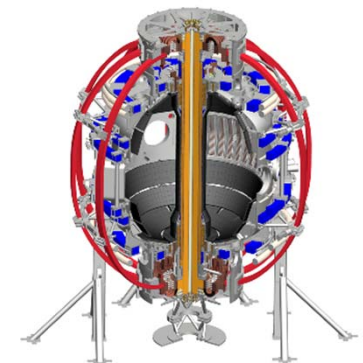
R. J. Maqueda

X Science LLC

Diagnostic Research Plan Meeting

PPPL

May 17, 2016



Physics studies

- Divertor physics and development fundamental for achieving NSTX-U goals.
- Physics studies include:
 - Further development of snowflake divertor and other advanced configurations
 - Development and assessment of divertor detachment
 - Study of 3-D effects on divertor physics
 - Reduction and transport of impurities from divertor sources
- Study changes with the introduction of high-Z metallic PFCs and assist in the research leading to a lower divertor cryo-pump.

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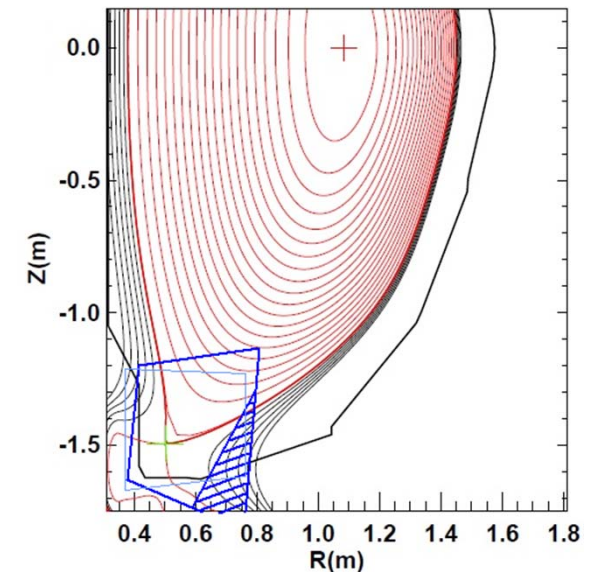
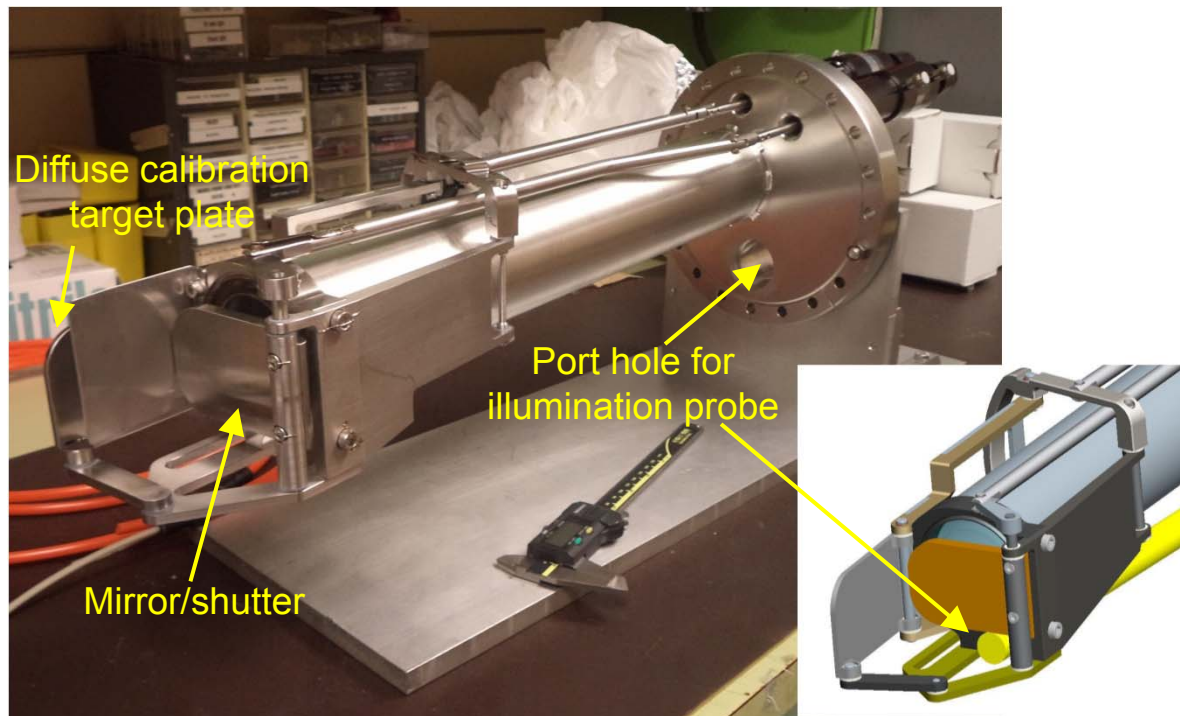
Divertor Tangential Imaging (DTI)

- Lower divertor tangential view is photometrically calibrated* [i.e., photons/(m³ s)].
- Remote controlled filter wheel is used to select spectral lines/bands (D_α, D_γ, CII, CIII, CIV, CD band, LiI, LiII).
- Known reference points in vessel together with CAD modelling used for spatial calibration of images.
- **2-D line/band emission profiles in R-Z plane** through image inversion software.
 - Spatial resolution of 5 mm or better
 - Time resolution of >10 kHz (D_α, LiI), ≥1 kHz (C, LiII lines)

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New re-entrant tube for DTI

Design by R. Ellis and team of CAD and mech. engineers



DTI view on high κ , δ NSTX-U equilibrium (S. Gerhardt)

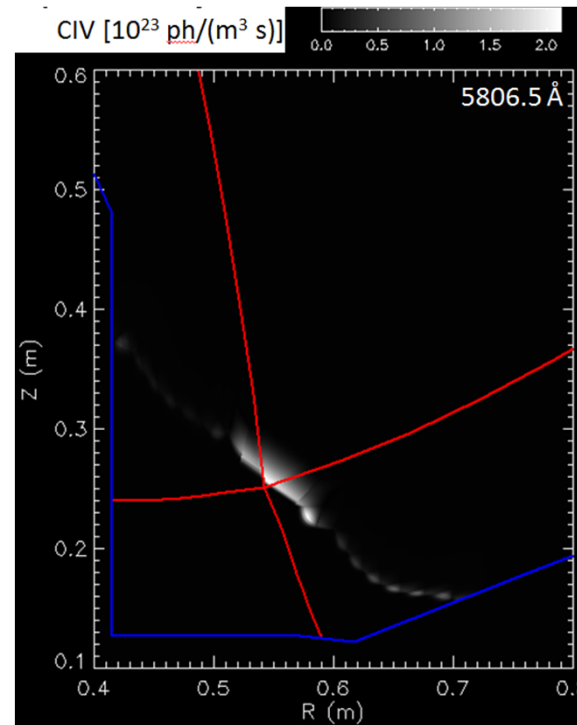
- Priorities (schedule/delays) precluded insertion while manned access to vessel.
- Unexpected issue found when insertion was tried between CD-4 and ops. startup.
- Currently using old re-entrant tube (L. Roquemore, ~2003).

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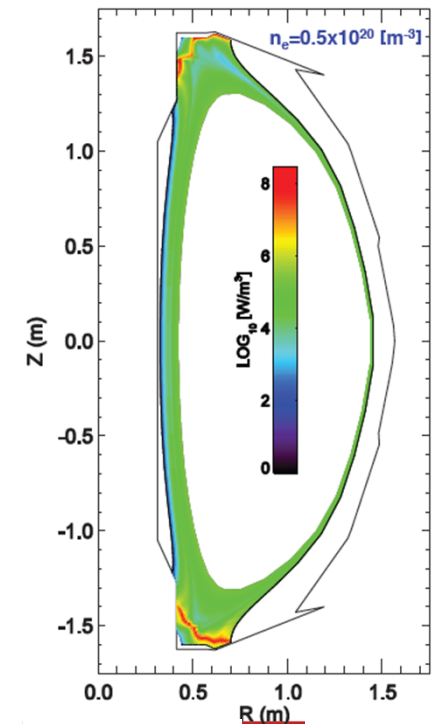
Edge/divertor modelling essential

- Much physics understanding will come from interaction with edge and divertor modelling.
- 2-D emission profiles will be compared between experiments and models.
- Experiments will hopefully guide model development.

Modelling for high performance, high density, detached operation in NSTX-U



CIV emission from **UEDGE/ADAS** (E. T. Meier, V. A. Soukhanovskii, F. Scotti, LLNL)

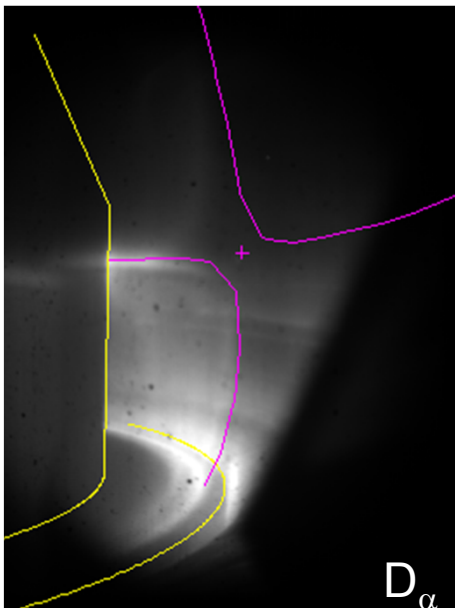


Total radiation from **SOLPS** (J. D. Lore, M. L. Reinke, ORNL)

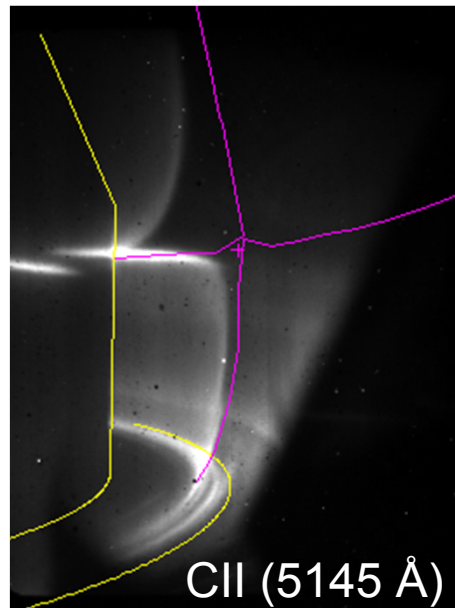
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DTI images from NSTX-U

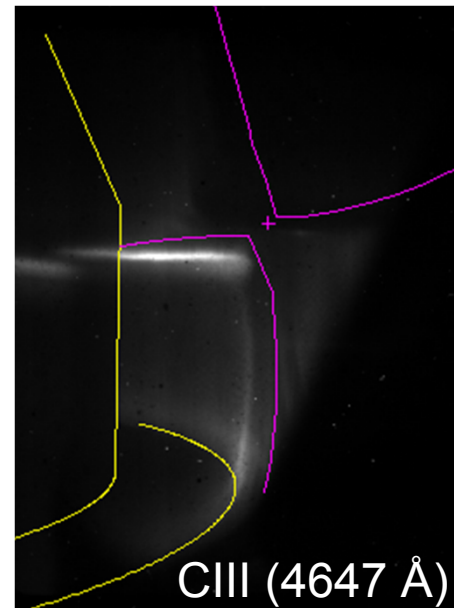
204046 – 0.439 s



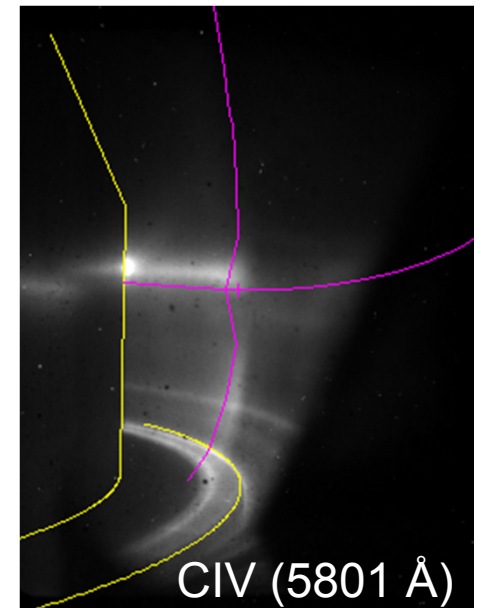
204056 – 0.465 s



204058 – 0.409 s



204052 – 0.470 s

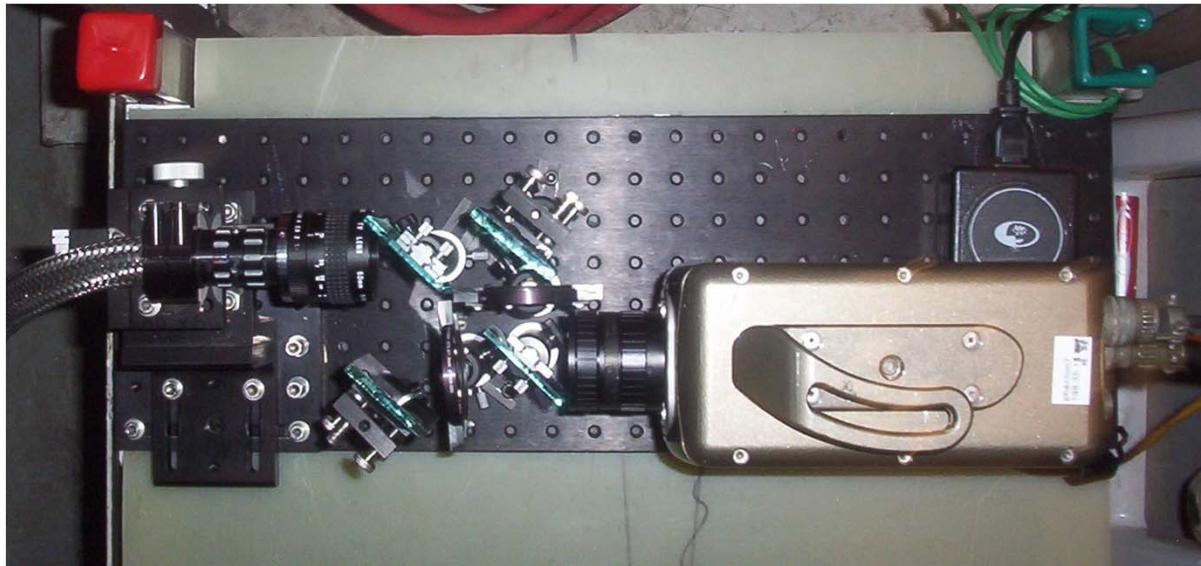


- **Raw DTI images** with CAD PFC overlays (yellow) and EFIT02 X-point and \sim separatrix (purple).
- Different medium- κ , low density, attached shots.

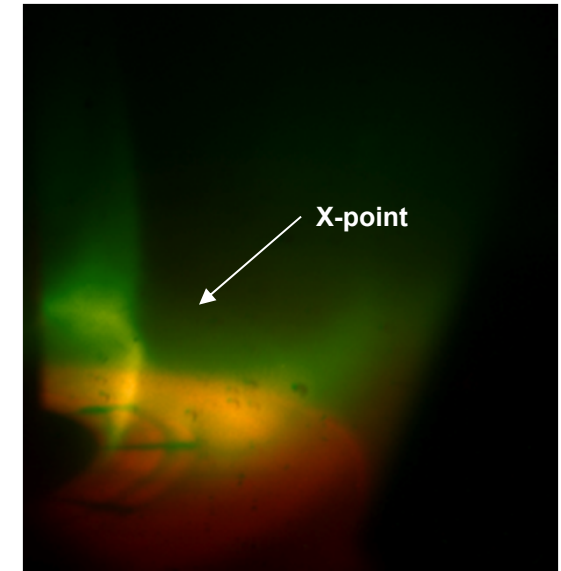
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2-color imaging for DTI

Prototype 2-color optics used in 2009 (NSTX)
New system will use remote controlled filter wheels



Composite image: Lil
(red), Lill (green)
NSTX shot 132595



- Simultaneous imaging of 2 lines/bands will be achieved with new optical system.
- Avoid reproducibility uncertainties and tackle temperature dependence of emission rates.

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Summary

- Absolutely calibrated imaging system will provide 2-D emission profiles in the divertor region.
- Simultaneous 2-color imaging will greatly enhance capabilities and reduce uncertainties.
- Results will provide physics understanding throughout the development leading to successful operation of high performance NSTX-U shots: snowflake, detachment, heat mitigation techniques, impurity transport, etc.
- Interaction with edge/divertor modelling key in this research.

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