NSTX

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NSTX impurity analysis using Transmission Grating Imaging Spectrometer

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and the NSTX Research Team

Monday physics meeting,
PPPL
23rd May 2011

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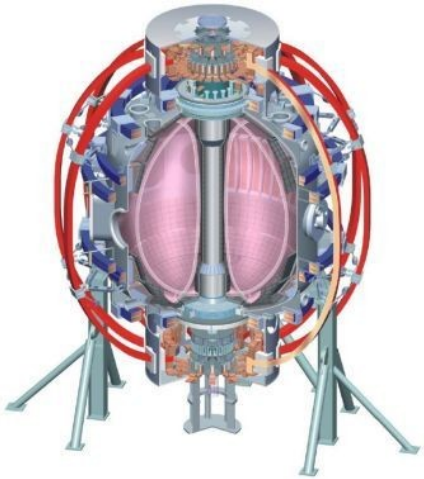
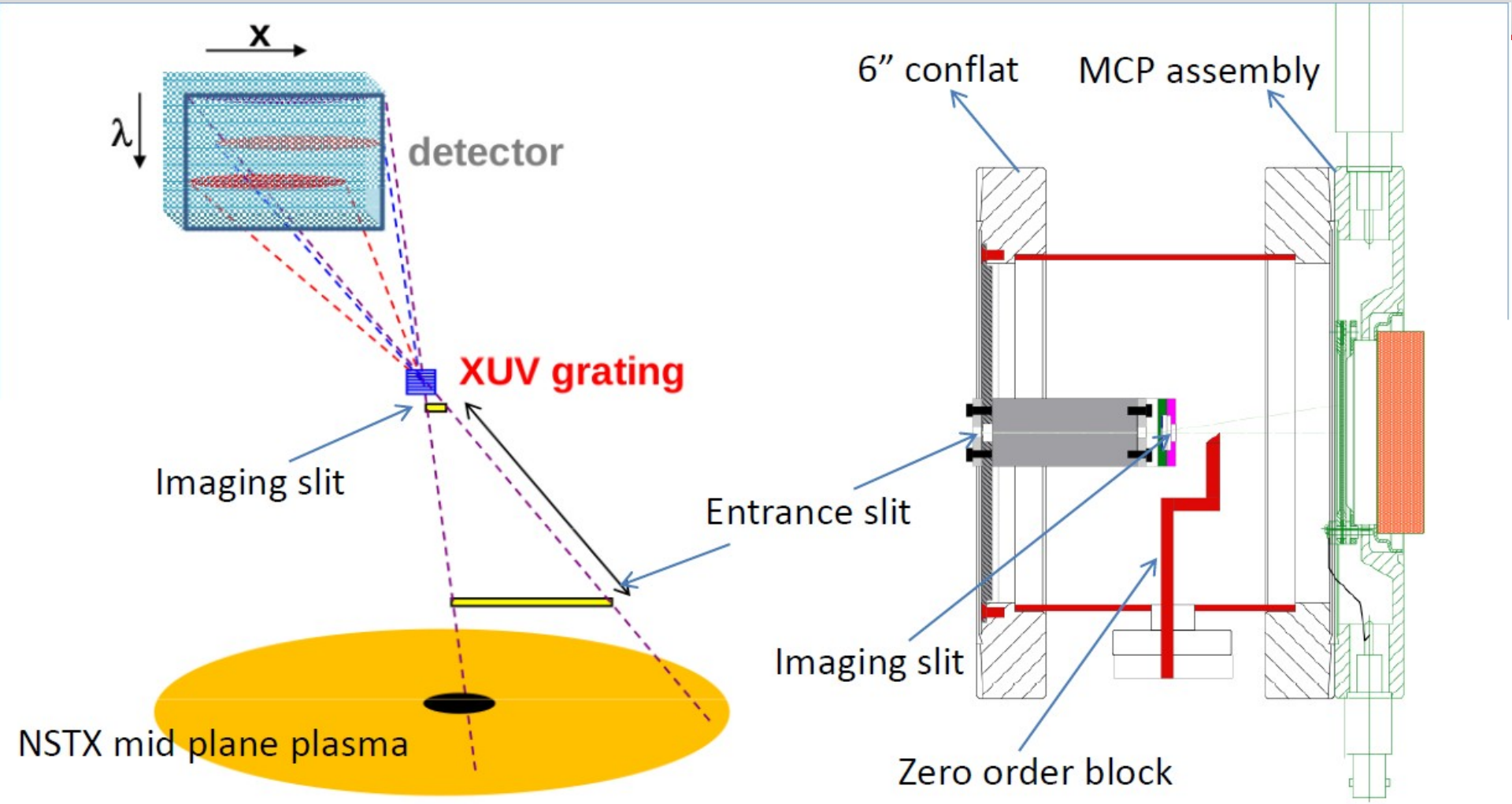
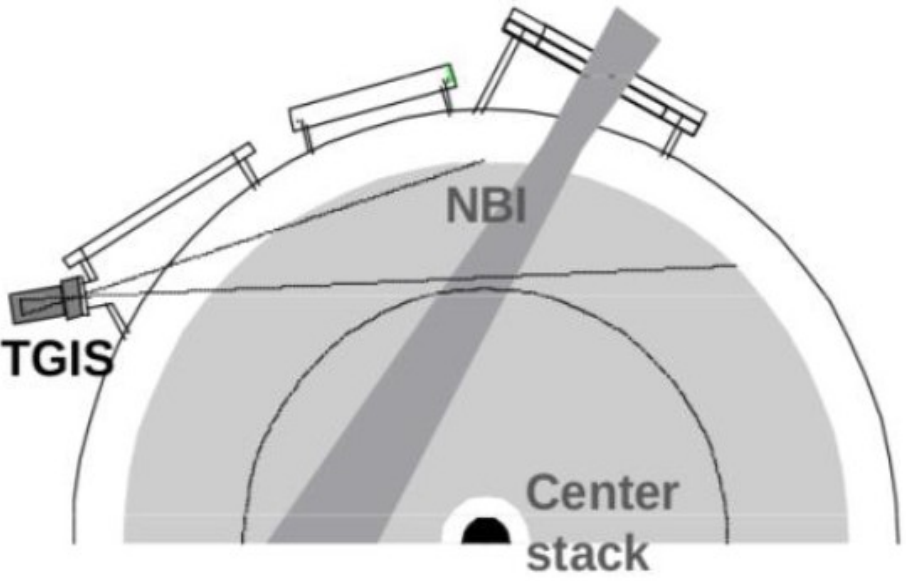


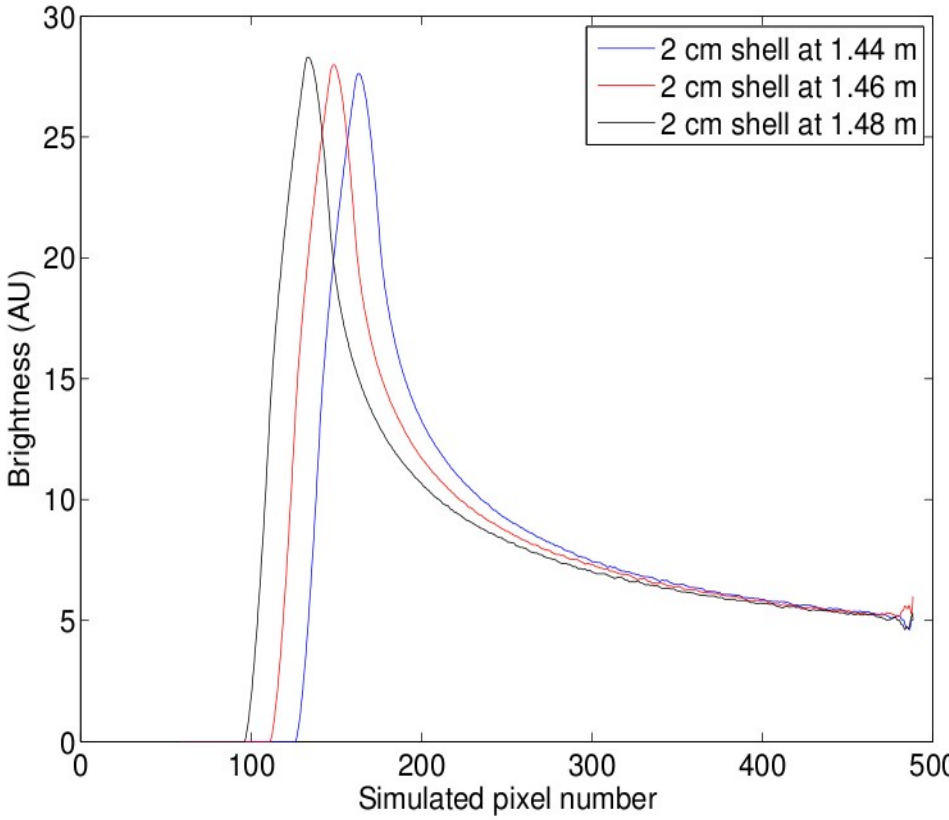
Setup of TGIS – space resolved spectra



2010 run parameters: Wavelength coverage 30-700 Å, Resolution 10 Å, Spatial resolution 1^0 (3 cm), Time response 0.4 s

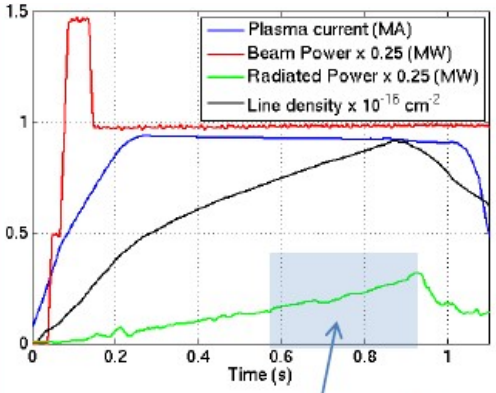
Tangential line integrated view of TGIS





Recap from 2010 talk

Traces of Cl found in "almost" every NBI heated shot.
O, Li and C are major NSTX impurities. Fe occasionally present.



Exposure time of spectra

Shot: 142192

Traces of Cl

CX signals

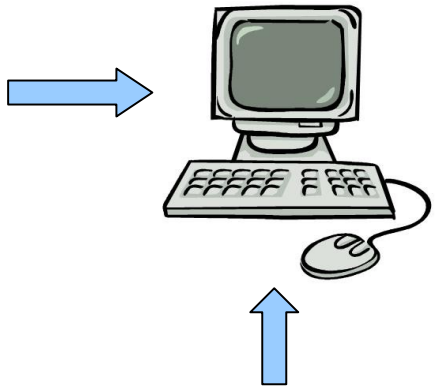
630 A : O V + O VIII$_{5-4}$
521 A : C VI$_{4-3}$
415 A : Cl XV
384 A : Cl XV
364 A : 2 x 182 A
335 A: Fe XVI
293 A : O VIII$_{4-3}$
268 A : 2 x 135 A
237 A : Cl XIV
200 A : 2 x 100 A
182 A : C VI$_{3-2}$
135 A : C VI$_{4-2}$ + Li$_{2-1}$ + NVII$_{3-2}$
102 A : 3 x 34 A + O VIII$_{3-2}$
66 A : 2 x 33 A
55 A : 2 x 28 A

- Spectra is dominated by low Z CX signals.
- With traces of Cl

Region of intense beam interaction

Calibration of TGIS

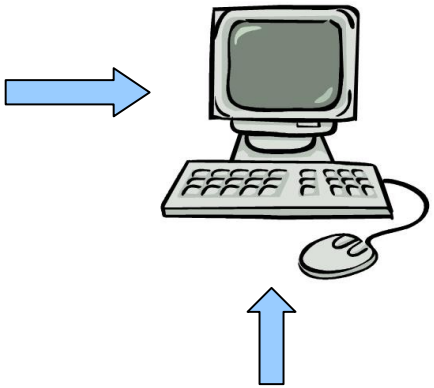
Calculate neutral beam attenuation profile



Calibration from C CX lines

n(C VII) from CHERS

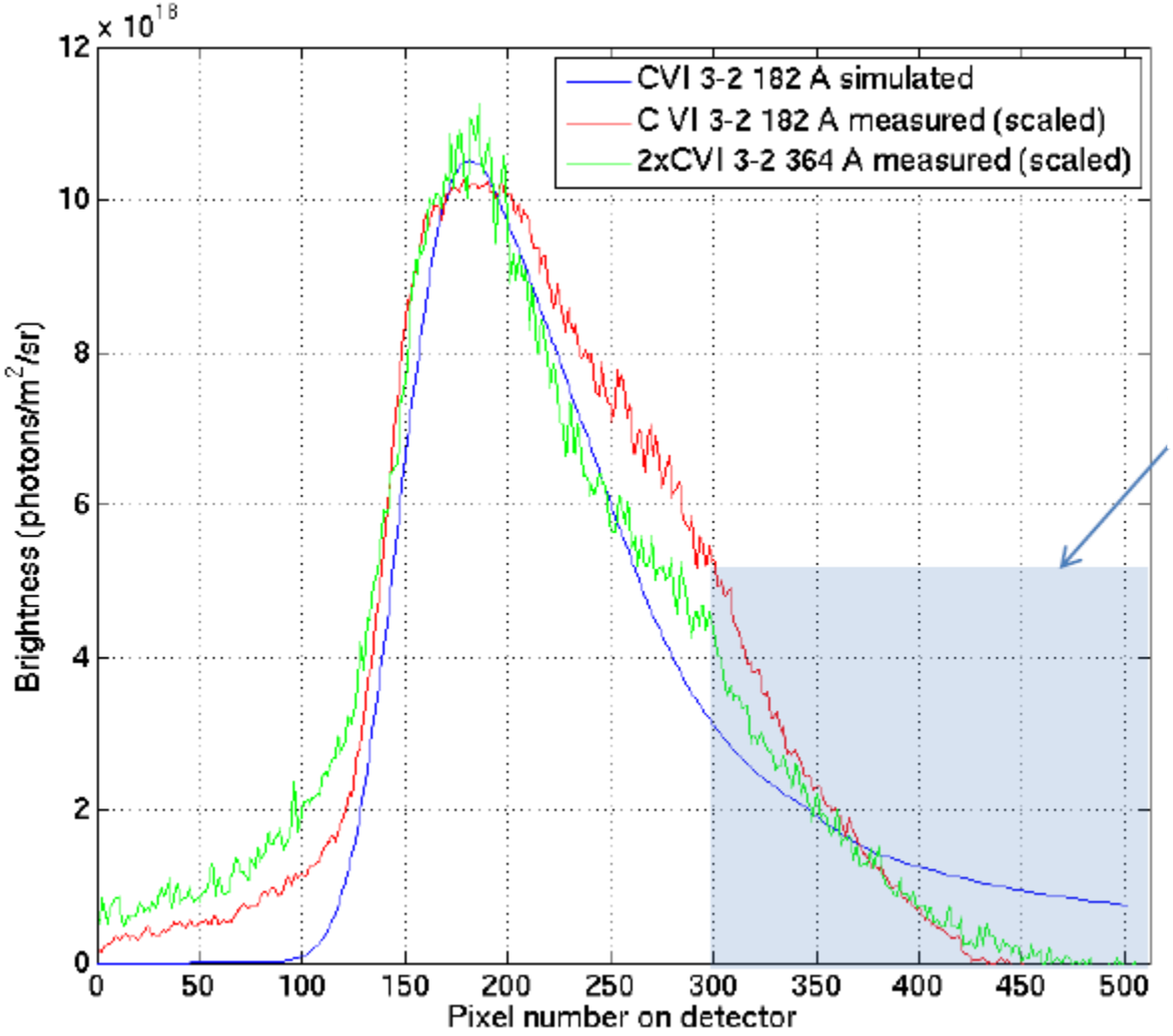
MPTS (n_e,T_e)



Simulate and compare brightness of CX/collisional lines (Thermal CX and transport not included)

Chianti/ADAS/other sources

Simulated brightness of CX lines agrees well with measurements

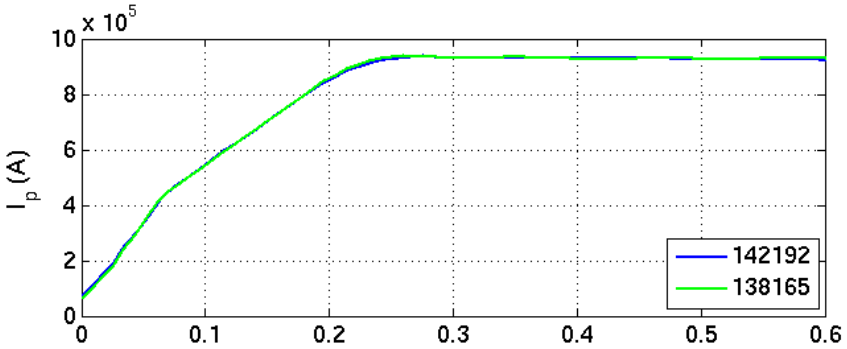


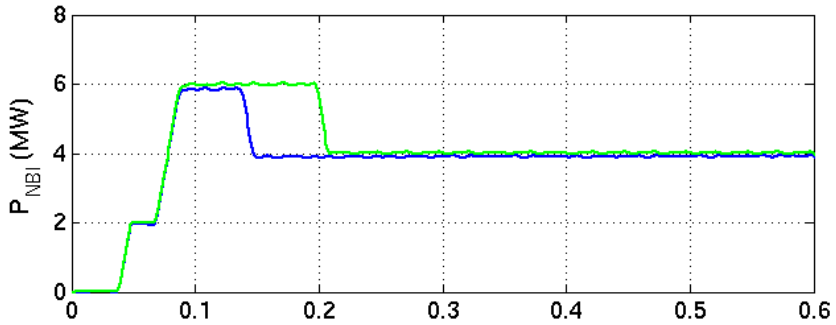
Comparison of CX brightness of O lines yields n(O) ~ 0.1 x n(C)

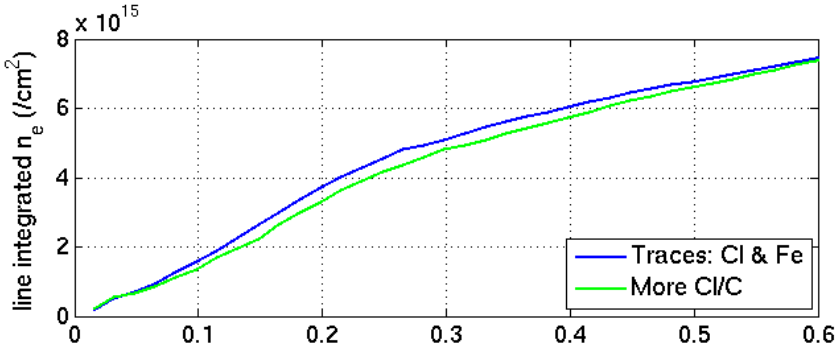
Open questions from 2010 talk

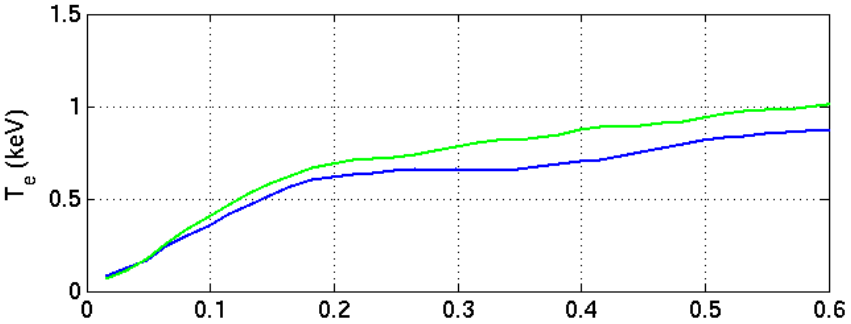
- How much Cl is present? What is the importance in P_{rad}?
  - What is the source of Cl?
  - Is Cl related to Lithium?
- Instead of directly answering these questions (complicated answer), I motivate the answer by the following graphs -

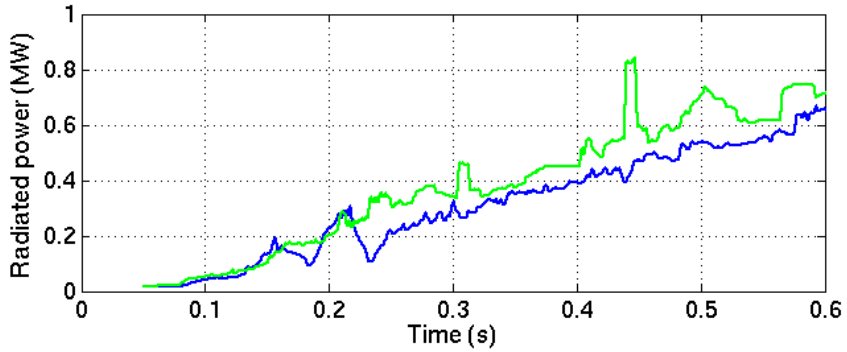
Analysis of 2 NBI heated shots (varying impurity content)

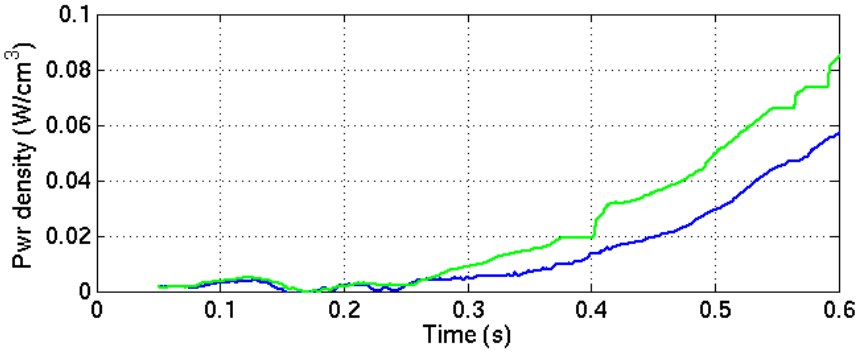




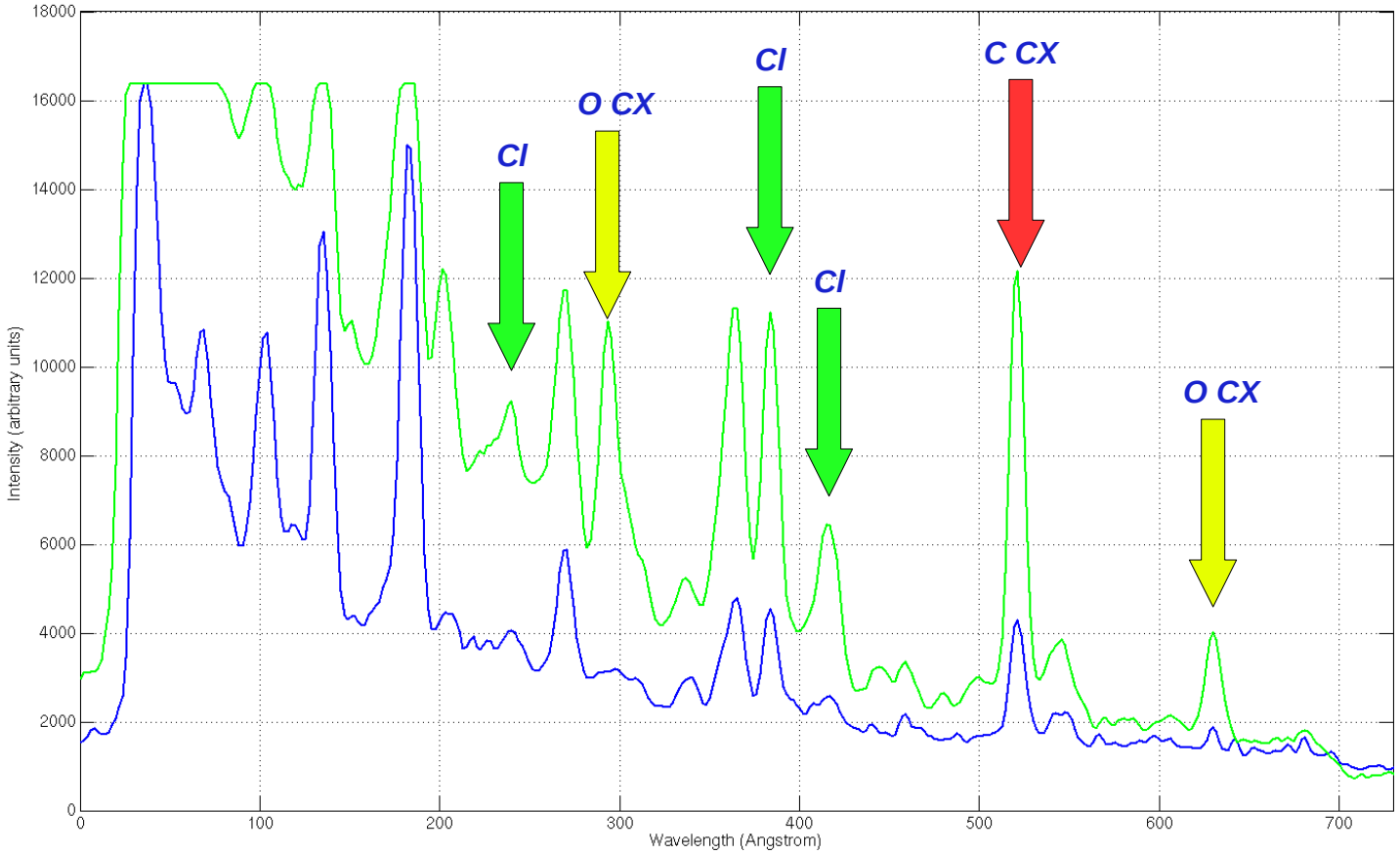








Analysis of 2 NBI heated shots (varying impurity content)



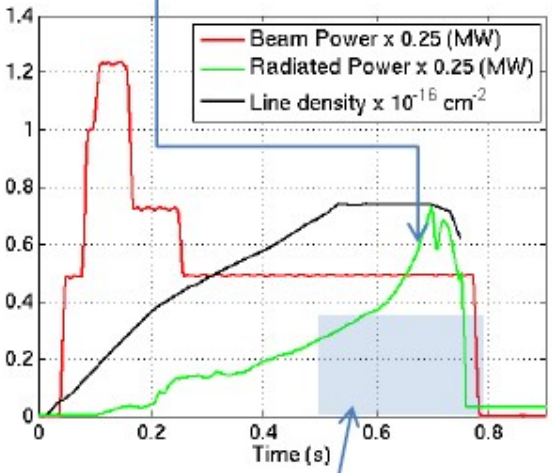
CI fraction decreased consistently from ~ 10^{-3} x n_e to ~10^{-4} x n_e during the run campaign 2010.

CI fraction is ~ 10^{-3} x n_e and contributes less than 20% of P_{rad}.

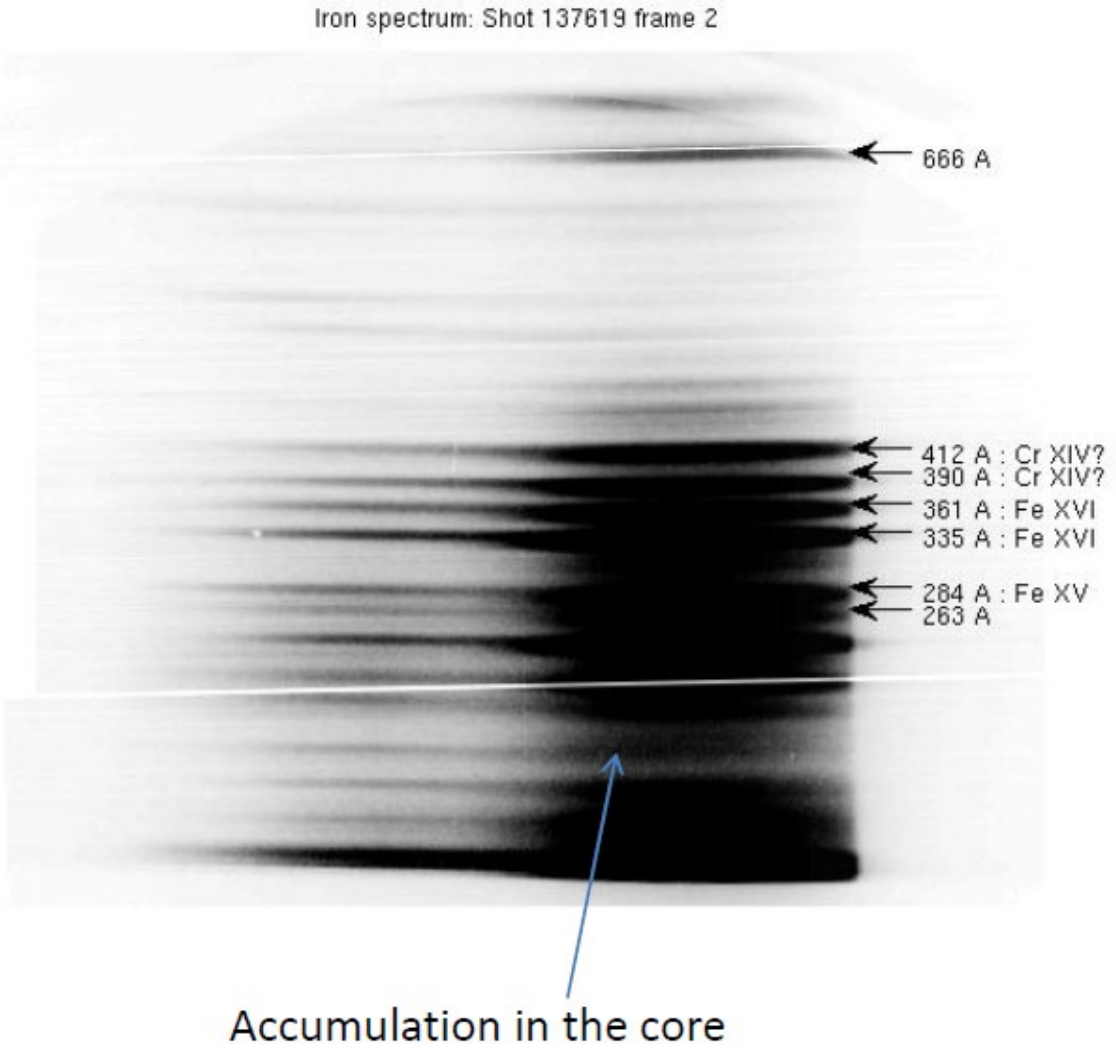
Consistent with radiative cooling coefficient of 3 x 10^{-20} erg cm^3/sec.

Fe accumulation seen in some shots

The radiated power is very high because of impurity accumulation



Exposure time of spectra

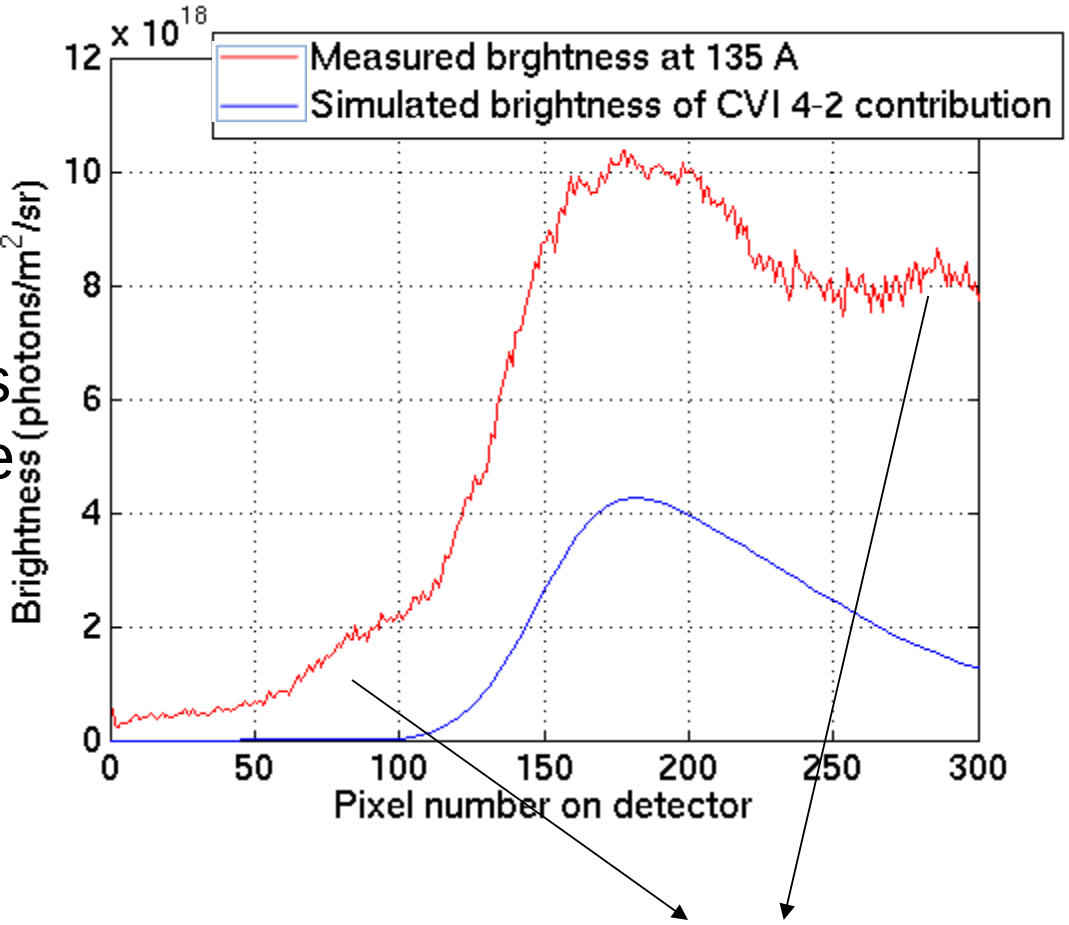


Accumulation in the core

Note: Fe accumulation of ~ 10^{-3} x n_e can radiate a MW power.

Presence of Li

- The Li Ly-alpha is blended with CVI 4-2. However, the signature of edge emission from Li III is certain.
- The absence of Li III (1-3) CX line implies that there is no appreciable Li inside the plasma, only in the edge.

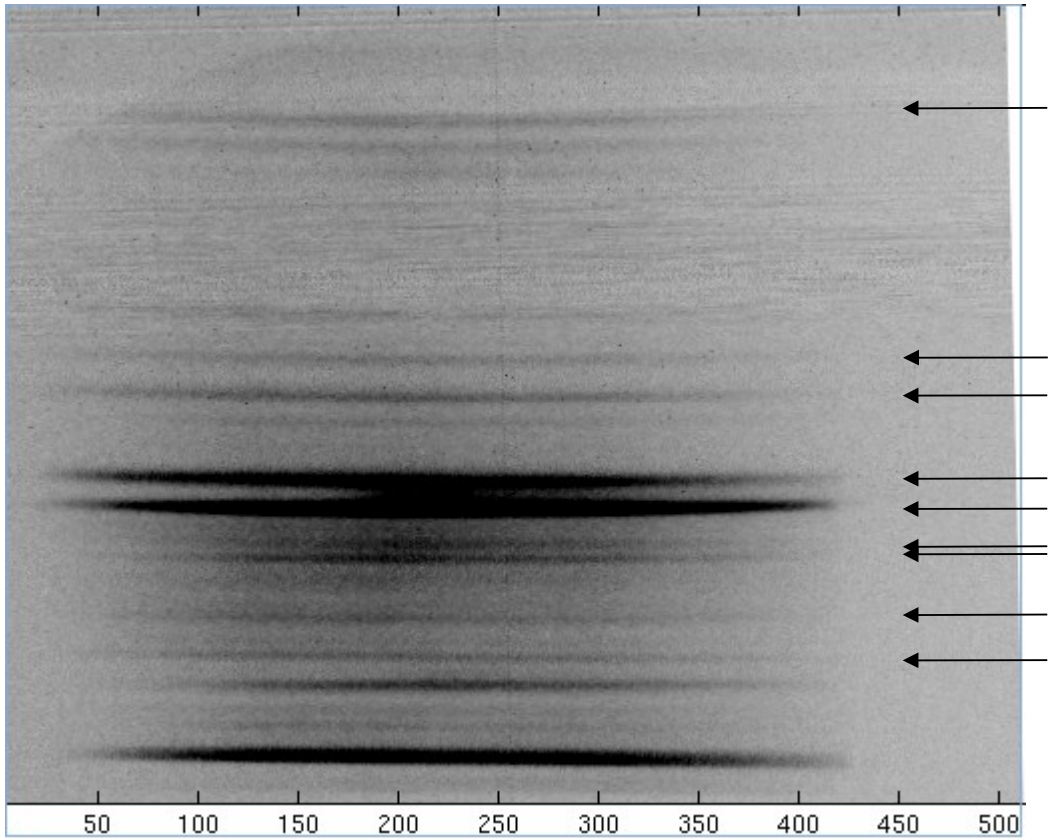


Li III edge emission

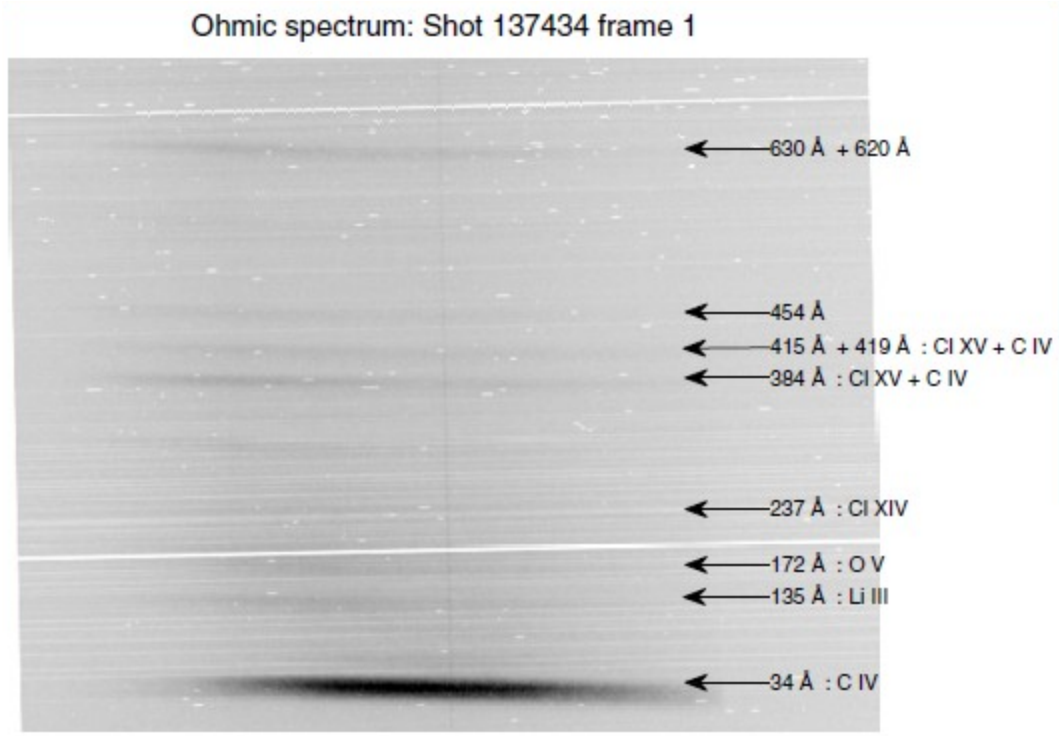
Summary of NBI shots from 2010

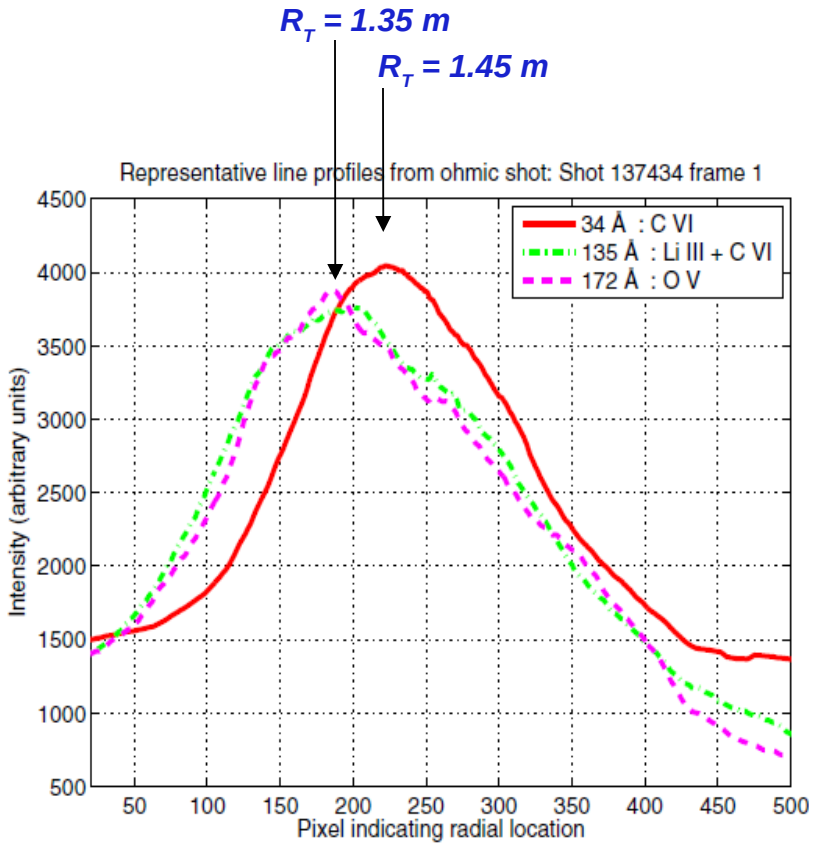
- The concentration of Cl diminished through the run cycle. Typical concentration levels are ~ 10^{-4} x n_e.
- Oxygen concentration is about 10% of carbon concentration.
- Li present only in the edge (not inside).
- Nitrogen (due to the leak) and Ar (due to the vent) were observed during 2010 run campaign.
- Fe was present intermittently towards the end of the campaign with concentrations ~ 10^{-5} x n_e.

Example of RF spectra – presence of Cu+Li



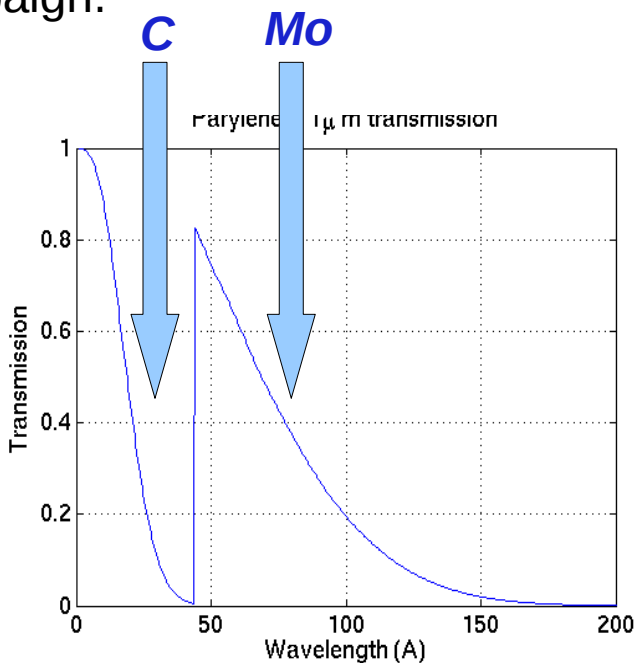
Example of Ohmic spectra





TGIS upgrades for 2011-12 campaigns

- Spatial resolution has been increased from 1^0 to 0.5^0 (3 cm to 1.5 cm).
- Wavelength resolution has been improved from 10 Å to 6 Å.
- Vignetting has been fixed to provide a full 22^0 view of the plasma.
- The negative spectrum will be observed through 1 um Parylene-N filter – to absorb low wavelength radiation and thus enhance Mo emission.
- A CCD based fast detection (10 ms time response) will be tested during the campaign.



2 ms exposure Ne spectra from PID.

Ne I 730 A ***Ne II 460 A***

THANK YOU!

Detector pixel to NSTX tangency radius