

NSTX X-Ray Imaging Crystal Spectrometer

Status Report, December 2005 - M. Bitter, K. Hill, and C. Bush



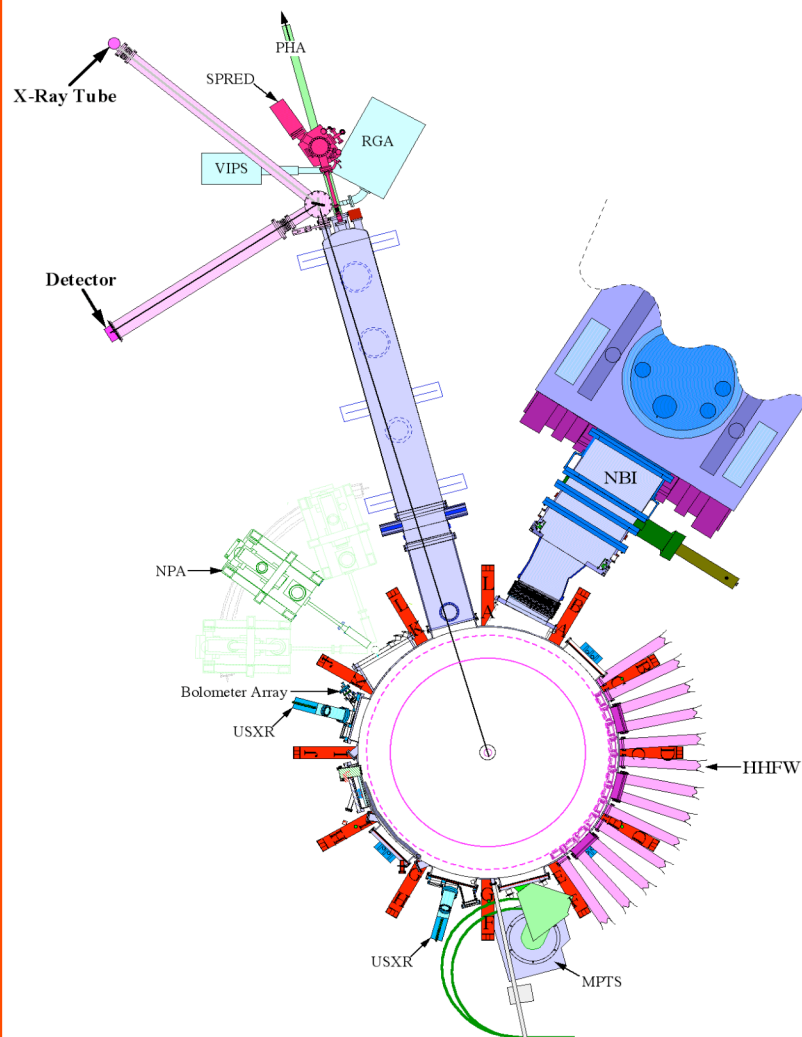
- The diagnostic is a development project, which is being funded by since 2002 the DOE Initiative for the Development of Advanced Diagnostics in Magnetic Confinement Fusion Energy Research.
- It is pursued in a collaboration with Alcator C-Mod, KBSI, KAERI, and TEXTOR.
- MAIN PURPOSE: MEASUREMENT OF TI-PROFILES
- On NSTX, the most important applications are measurements of Ti profiles in the absence of a neutral beam, i. e. in plasmas with pure Ohmic heating and RF heating - as a complementary diagnostic to CHERS.
- The spectrometer is ITER relevant for the diagnosis of Ti-profiles, and the instrumental concept has already been adopted for the design of X-ray crystal spectrometers on ITER. - It could become the main central Ti diagnostic on ITER if the neutral beams do not penetrate to the center of the plasma.



KAERI



NSTX X-Ray Imaging Crystal Spectrometer



- The spectrometer consists of a spherically bent crystal and a 2D position-sensitive detector.

- On NSTX, it records spatially resolved spectra of ArXVII from an 80 cm high plasma cross-section.

- The spatial resolution in the plasma in a direction perpendicular to the NSTX mid-plane is 2.5 cm.

- In addition to Ti-profiles, the spectrometer can also provide profiles of Te and the ion charge state equilibrium.

- It is in principle also possible to measure profiles of the plasma rotation.

OUTLINE



•RESULTS from OP-XMP-33:

- Optimization of argon injection: Minute amounts of argon, which are undetectable by SPRED and negligible compared to intrinsic impurities, are sufficient to operate the diagnostic.

- Documentation of spectrometer and detector performance: The throughput of the spectrometer is very high (several MHz), but detector limits count rate to 150 kHz

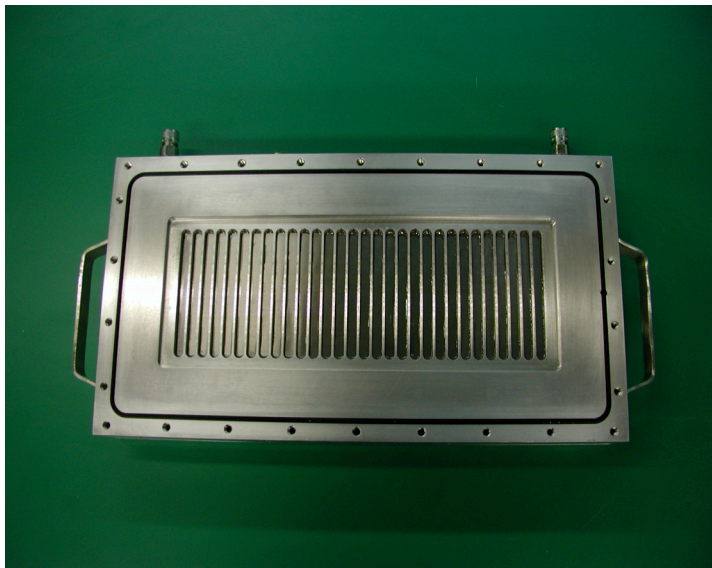
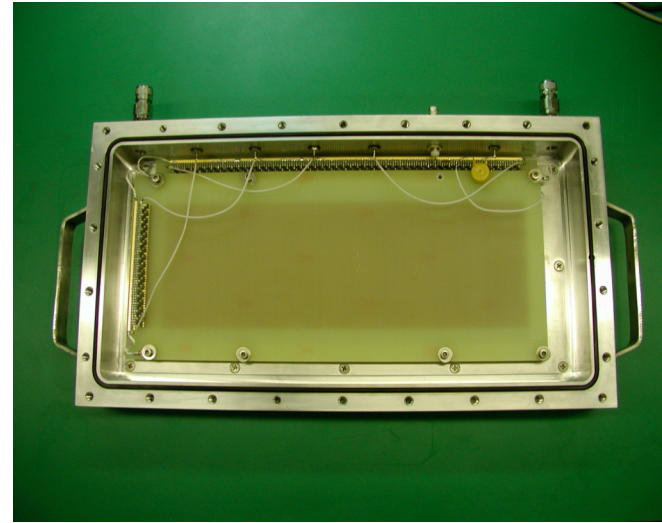
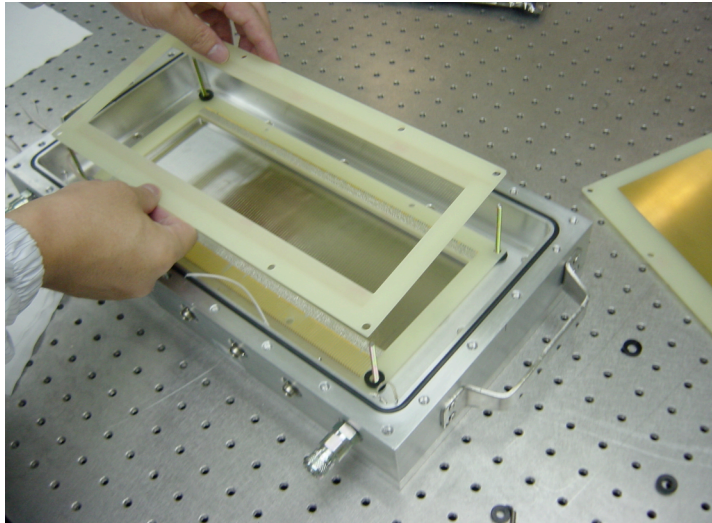
- Spatially resolved spectra from Ohmic Shots: Profiles of resonance line w, Te, and ArXVI/ArXVII; the statistics not yet sufficient for Ti-profile measurements

• FUTURE PLANS

- Detector developments: Segmented MWPC and Pilatus II detector

- Experiments on NSTX and Alcator C-Mod

IV. 2D position-sensitive Detector



Sensitive area: 100 mm (X-axis)
300 mm (Y-axis)

Entrance window : 100 μm Be foil

29 supporting ribs : 2 mm wide

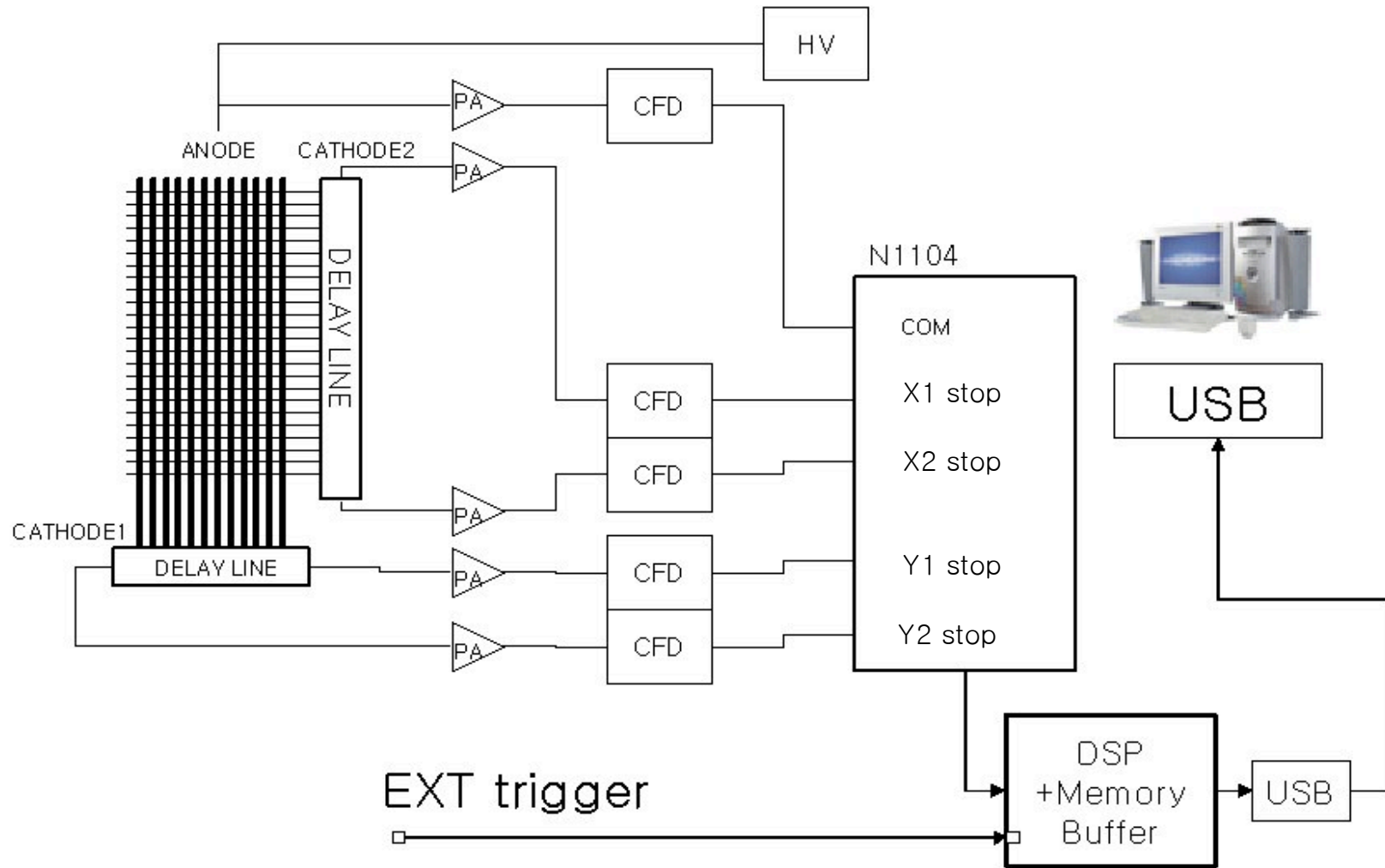
5 mm high

Gas mixture : Xenon 78%

C_2H_6 20%

CF_4 2%

Readout & data acquisition system for 2D detector

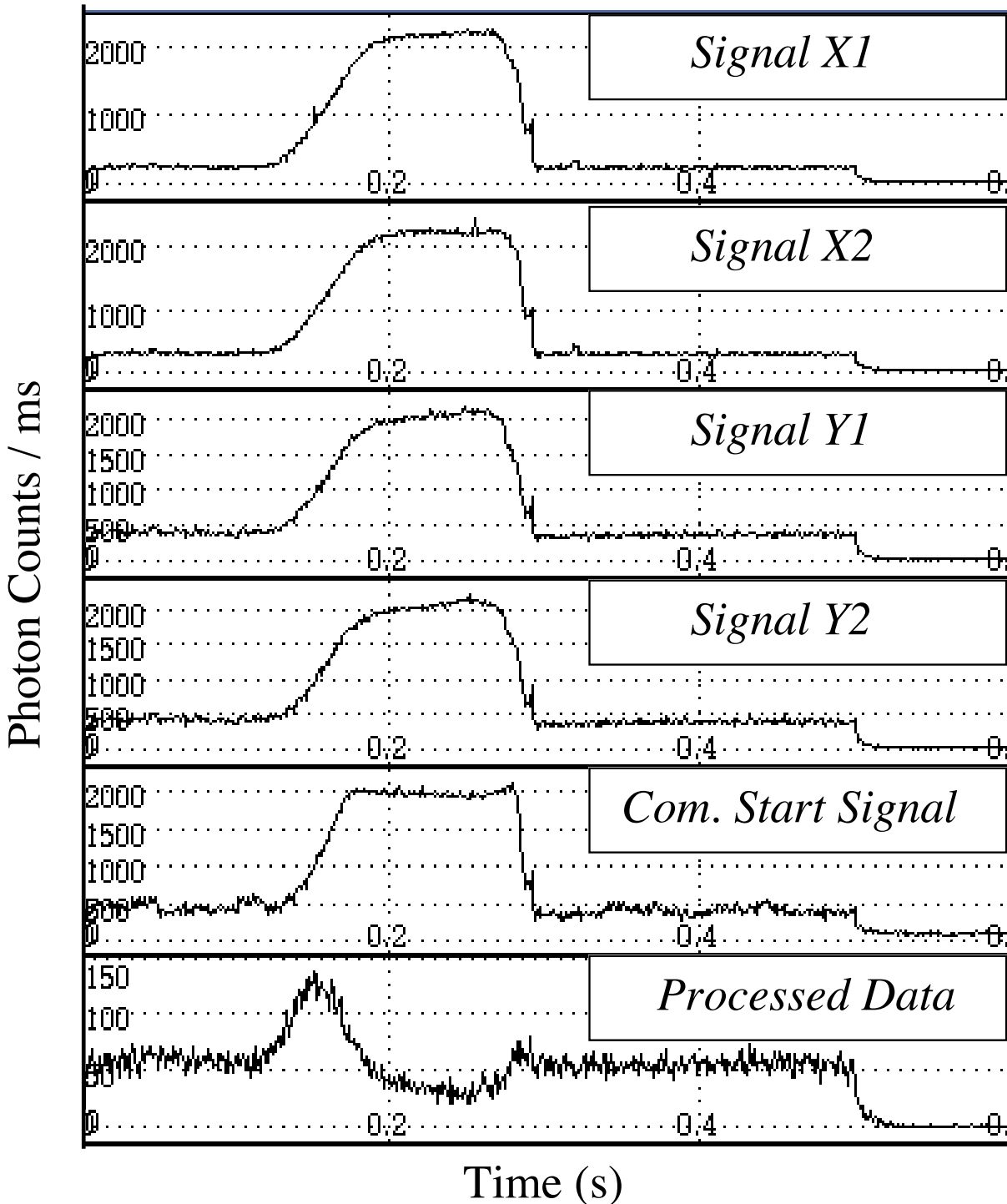


14 bit word for X, Y and Time information for single photon counts

Signal Traces from 2D Detector & Throughput of Processed Data



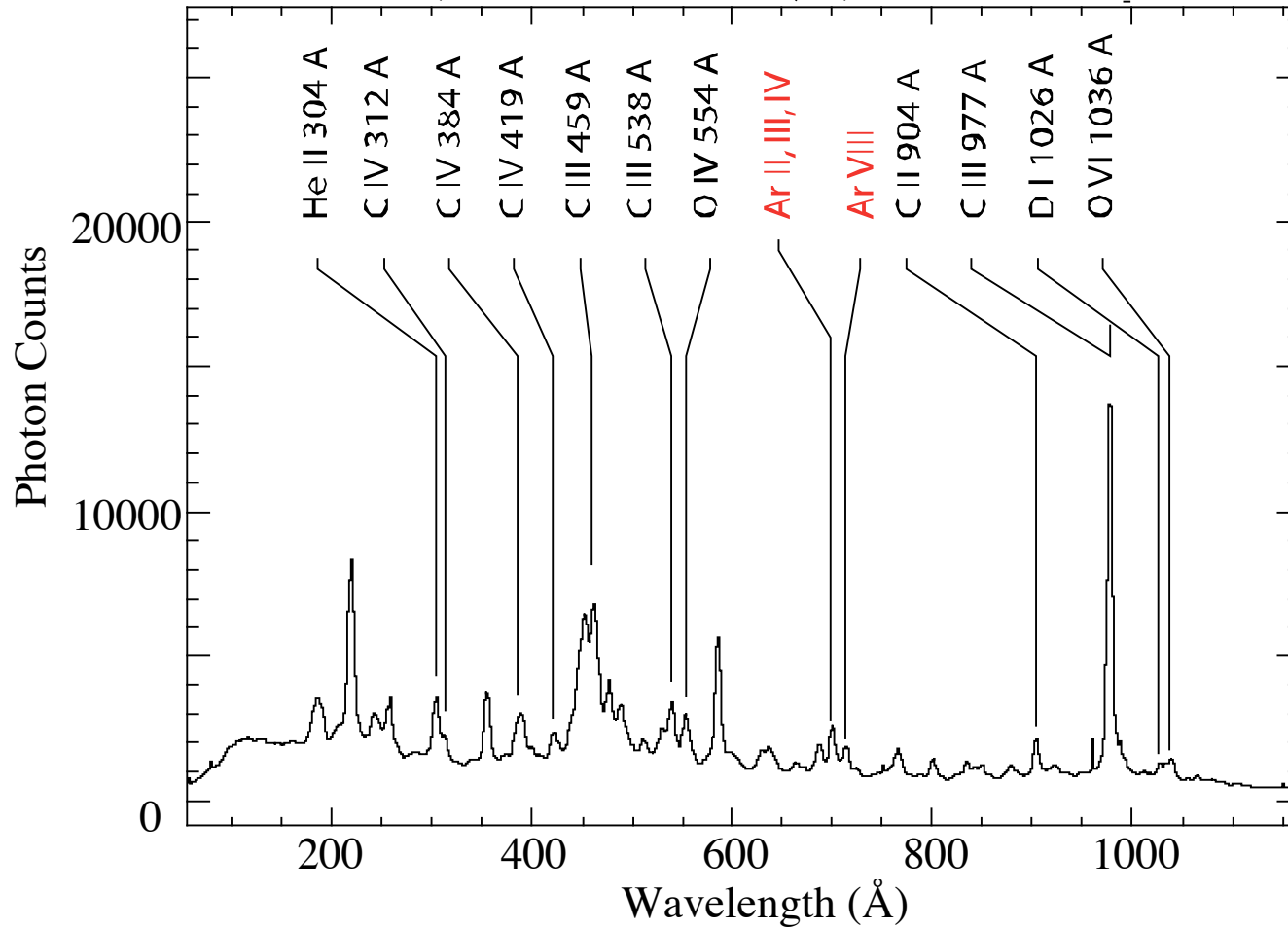
Shot: 117315; argon puff @ -1.0 s for 250 ms



SPRED Survey Spectrum of Impurities from NSTX



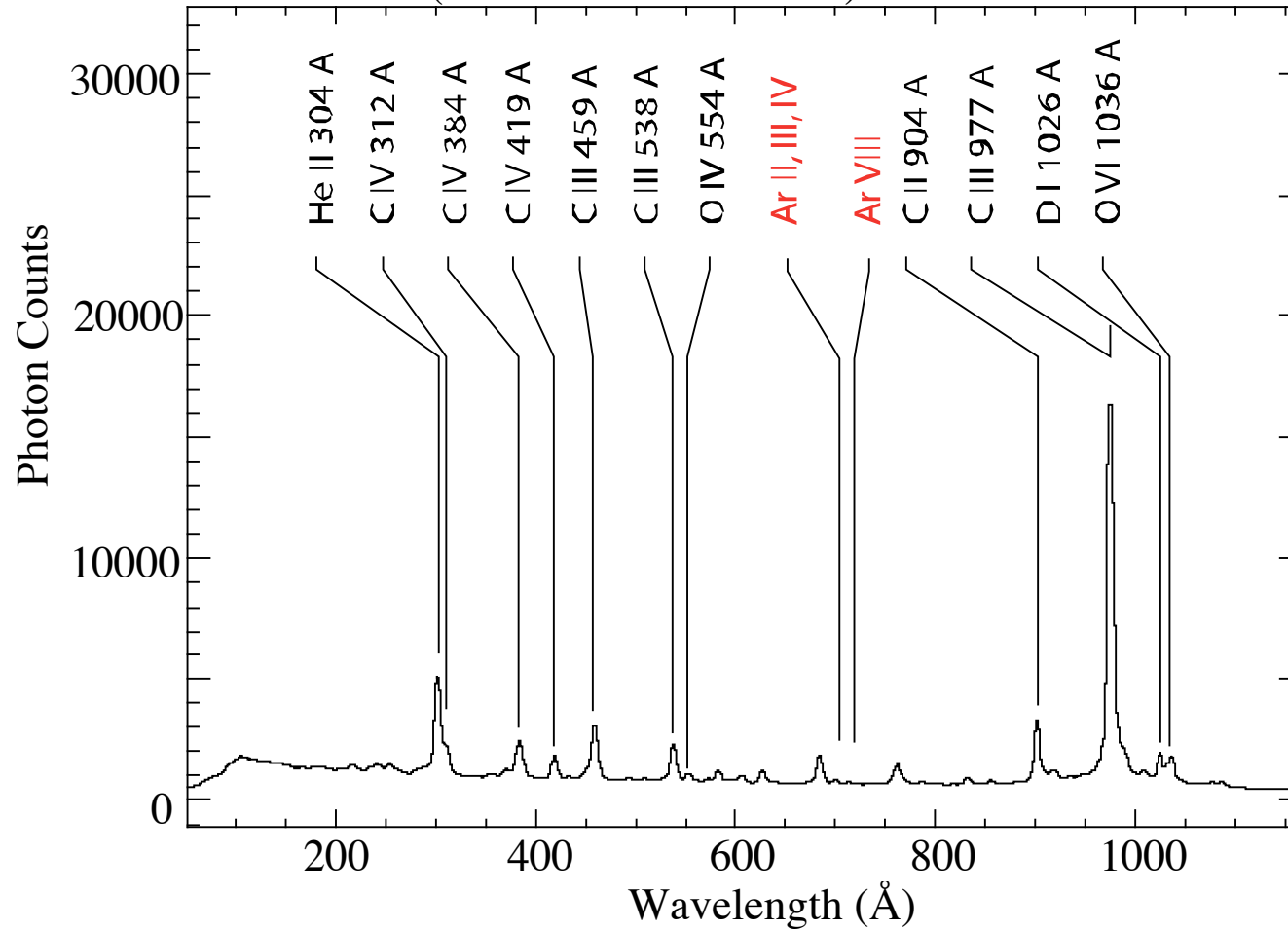
Shot 117315 (Time: 0150 s - 0160 s)



SPRED Survey Spectrum of Impurities from NSTX



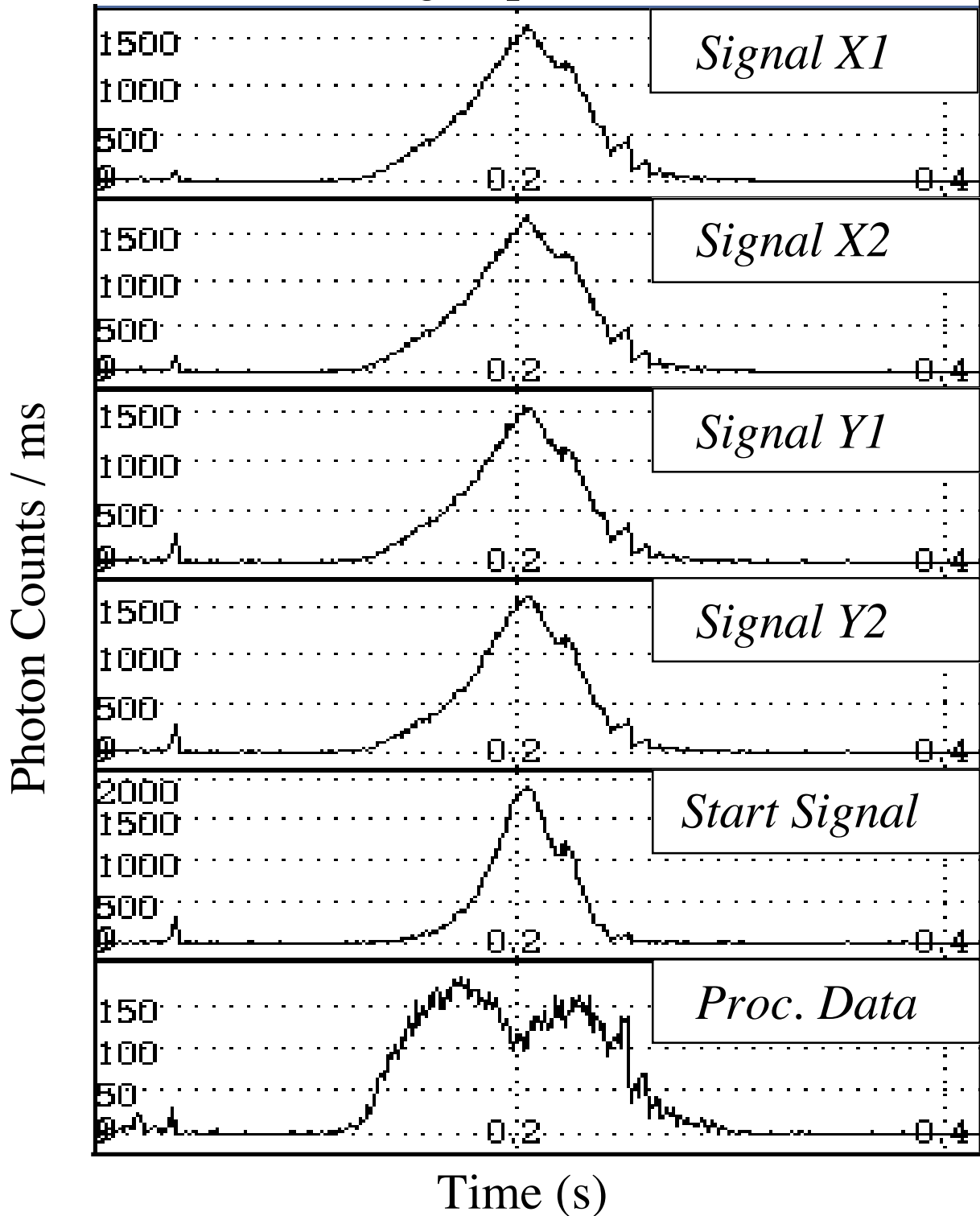
Shot 117329 (Time: 0150 s - 0160 s)



Signal Traces from 2D Detector & Throughput of Processed Data



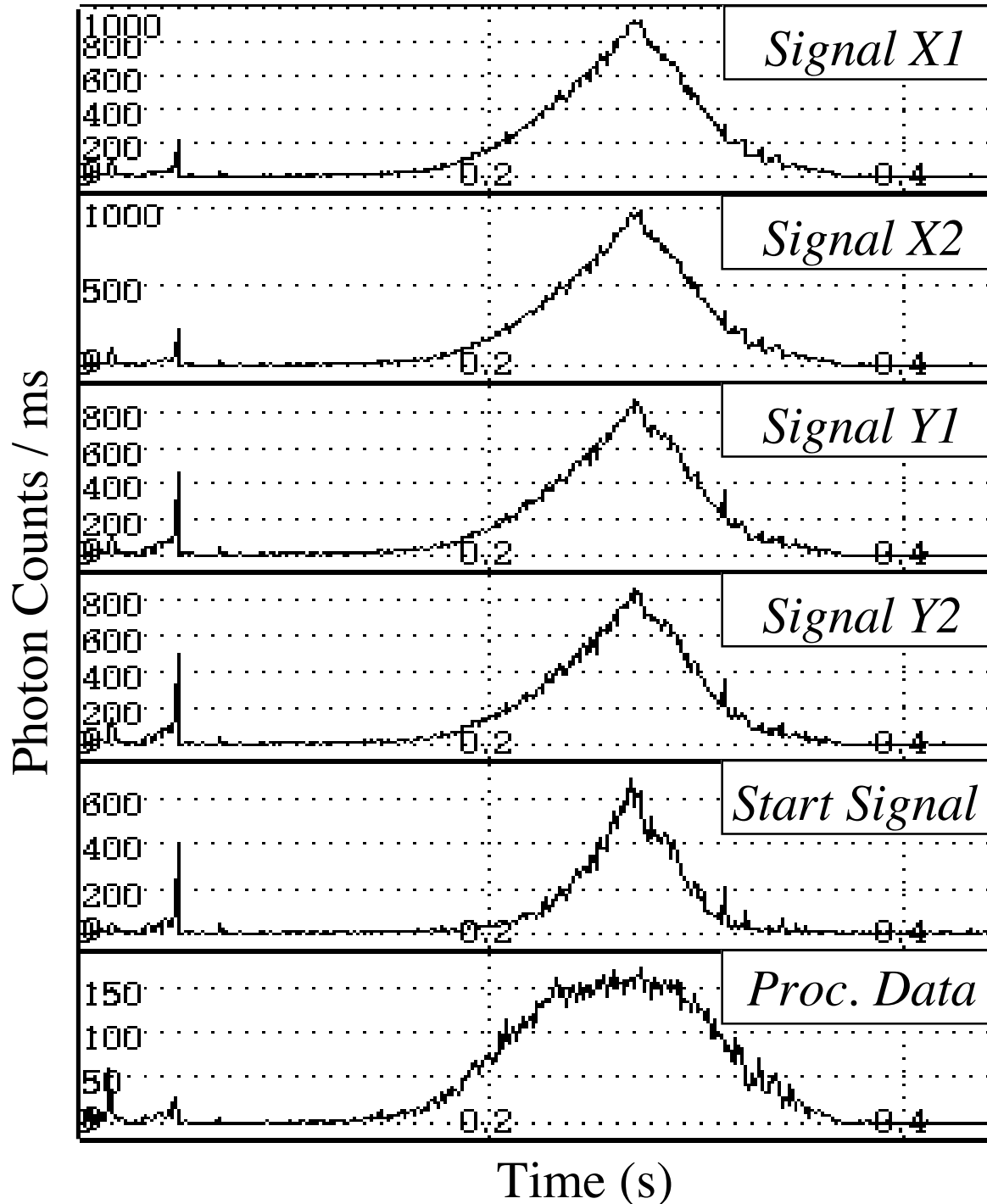
Shot: 117329; argon puff @ -1.0 s for 100 ms



Signal Traces from 2D Detector & Throughput of Processed Data



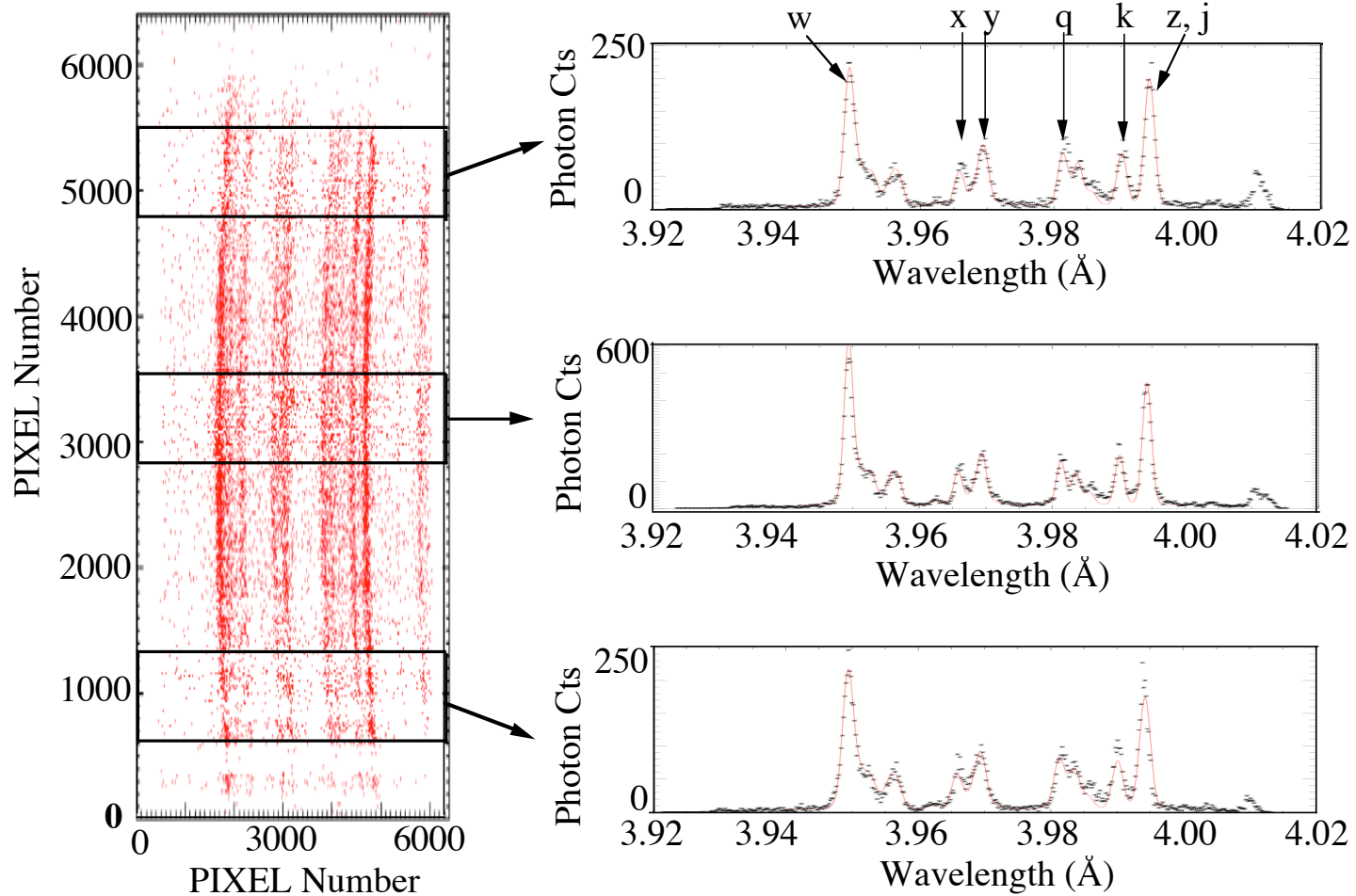
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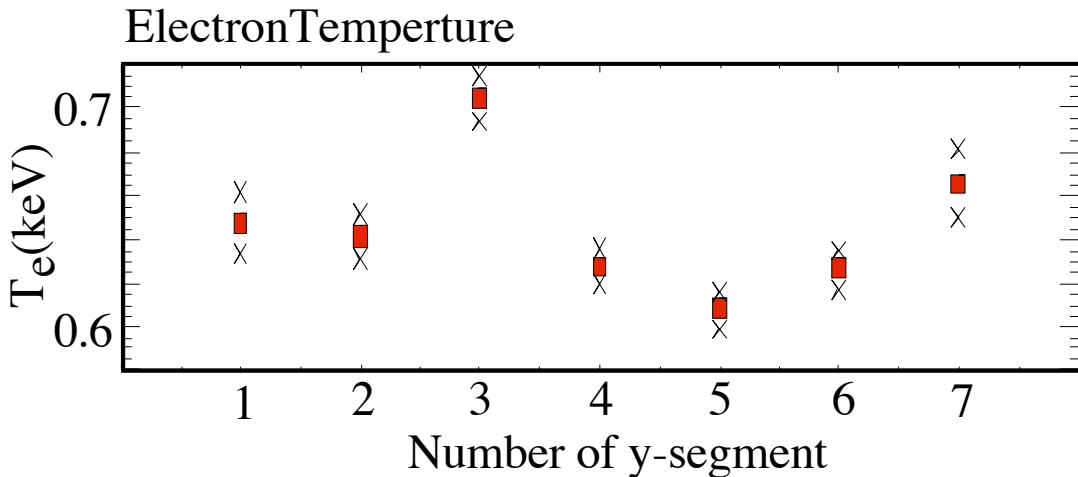
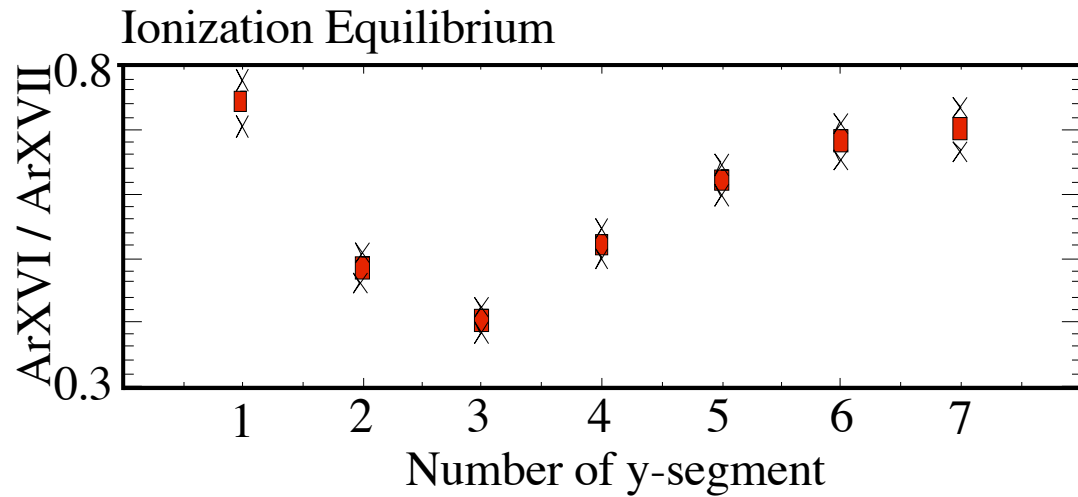
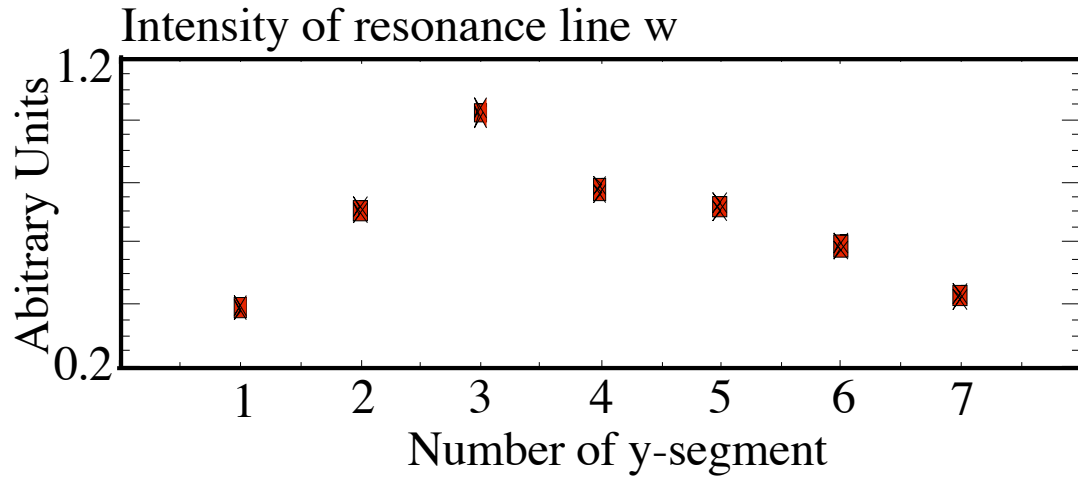
Spatially resolved X-ray spectra of ArXVII from NSTX



Accumulated data from shots: 117848, 117849, 117853-117857



Profiles of plasma Parameters from least-squares fit results with Vainshtein's Theory



Development of high count rate detectors (Pilatus II)



Pilatus II Module



<http://pilatus.web.psi.ch/pilatus.htm>

Conclusions



- The spectrometer has a sufficiently high throughput for time-resolved measurements. Photon fluxes of several MHz can easily be obtained with minute argon puffs, which do not perturb the plasma. However, the throughput is limited by to < 400 kHz with the presently used multi-wire proportional counters.

- Two new detector concepts:

- (1) segmented multi-wire proportional counters, and
- (2) new silicon diode arrays, the so-called 'Pilatus' detector,

will be used in future experiments on NSTX and Alcator C-Mod