



U.S. DEPARTMENT OF
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Science



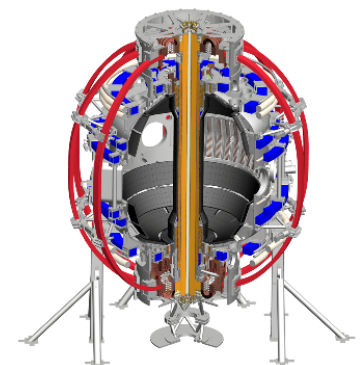
Spectroscopy Diagnostic Upgrades: HAL, CHERS, ERD

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NSTX-U Diagnostic Research Plans 2016-2018

PPPL

May 26, 2016



Planned NSTX-U Diagnostics Improvements

- HAL spectrometer will move to NSTX-U
 - Designed for NSTX-U
 - Operated on LTX since 2013
 - High-throughput spectrometer
 - Charge exchange spectroscopy: Li, B, O, Ne, ...
 - General purpose spectroscopy: divertor, core, FIDA, NB species mix
- Upgrade of CHERS, ERD diagnostics
 - New cameras
 - Improved throughput
 - Higher data acquisition rates possible

HAL spectrometer

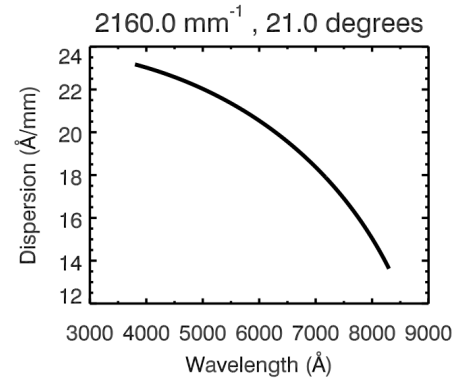
- High-throughput Accurate-wavelength Lens-based (HAL) spectrometer
- Developed at PPPL for NSTX-U, Operated on LTX
- Wavelength Range 4000-8200 Å
- Spectral Interval 110-190 Å
- 200 mm telephoto lenses ($f/1.8$) allows stigmatic imaging
- Large ruled grating (154 x 128 mm) with 2160 lines/mm
- Low-etaloning CCD (512 x 512, 16 μ pixels) with high QE (= 60-95 %)
- Interchangeable fiber holders accommodates fibers 210, 400, 600 μ
- Computer-controlled hardware allows automated control of wavelength, timing, f-number, automated data collection, and wavelength calibration

HAL spectrometer

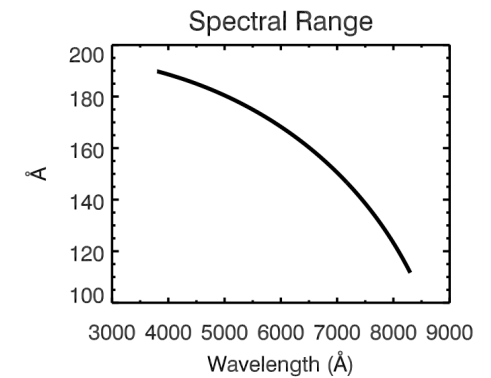


Spectrometer on mobile platform with computer and all associated hardware at LTX

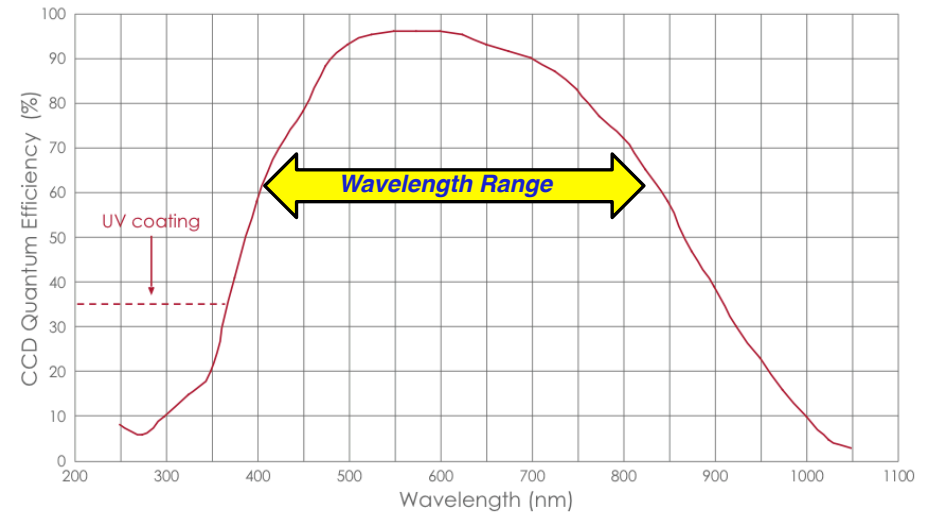
4000 – 8200 Å



110-190 Å interval

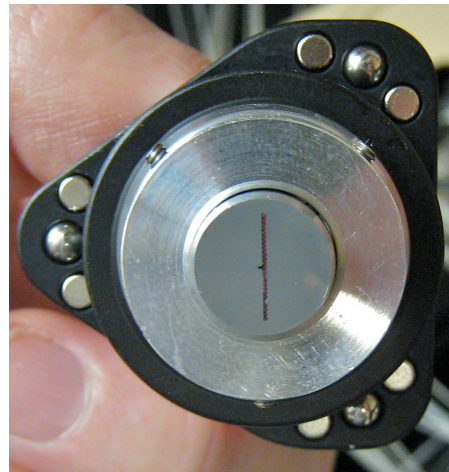
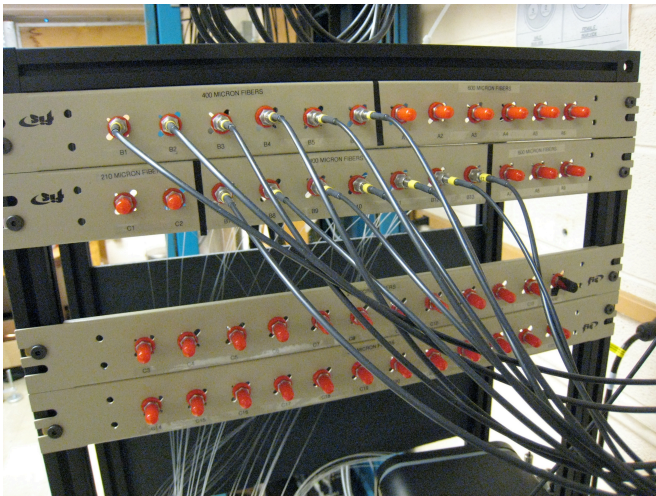


Princeton Instruments ProEm – eXelon Camera
Quantum Efficiency: 60-95 %



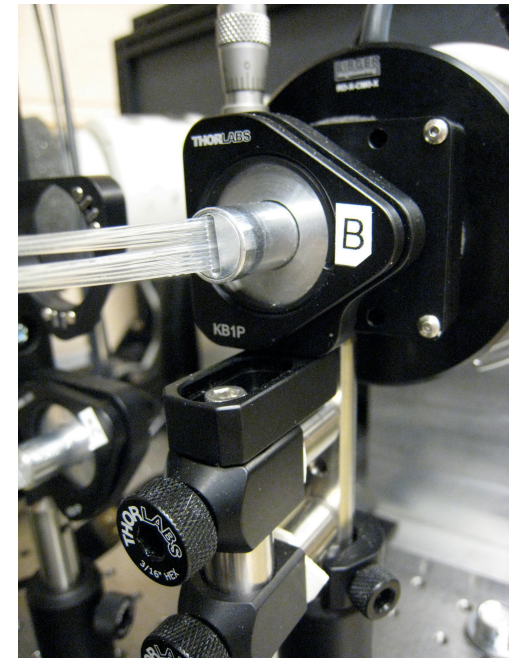
HAL spectrometer patch panel accepts multiple sets of SMA terminated fibers

- Kinematic mounts allow quick exchange of fiber optic sets
- Patch panel can accept SMA terminated fibers from any source in DARM
 - (CHERS, PCHERS, RTV, Divertor, Core, tFIDA, ...)
- Transfers fibers required to connect to existing fibers in DARM



Fiber holder in kinematic mounting carriage

- SMA Patch panel:
 - 23 fibers with 210 μm core
 - 13 fibers with 400 μm core
 - 9 fibers with 600 μm core



Fiber holder mounted at entrance slit

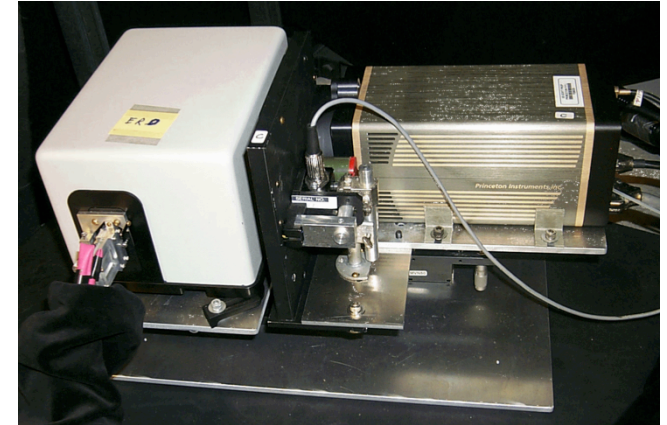
Examples of HAL spectrometer applications on NSTX-U

- Complement to C VI CHERS measurements
 - Lithium, Oxygen, Boron, Neon densities (2017)
 - Requires terminating/connecting to unused CHERS fibers
- Neutral beam species measurement
 - Use fibers from RTV or tFIDA (2016?)
- FIDA experiment
 - use PCHERS fibers to get UP/DOWN views on HAL (2016?)
- General purpose spectroscopy (throughput is $7 \times$ DIMS, $13 \times$ VIPS2)
 - Divertor views
 - Core views
 - Any available fibers in DARM

CHERS/ERD Upgrade for FY2017

- Replace cameras
 - Existing cameras unsupported
 - Pentamax, 19 years old
 - 12 bit digitization, 5 MHz readout
 - 100 Hz data acquisition
 - New cameras have been purchased
 - ProEM-HS
 - 16 bit digitization, 20 MHz readout
 - Up to 500 Hz data acquisition
 - Eliminate Choppers
 - Variable exposure time
 - CHERS S/N improvement of 2-3
 - Improved support of NB modulation
 - Higher QE Camera
 - Higher transmission filters
 - Another factor of 1.4 increase with wider MSE aperture
 - ERD operation up to 750 Hz
 - Present radial coverage
 - New spectrometer mounts designed

Present Holospec spectrometer, chopper, Pentamax camera



New ProEm-HS camera & mount

CHERS/MSE Lens

