Progress and Plans for MSE-CIF

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Outline

- **Background and motivation.**
- **Birefringent filter development.**
- **Present status of MSE-CIF.**
- **MSE-CIF plans: Shakedown, calibration, data analysis.**

Stark Spectra from TFTR

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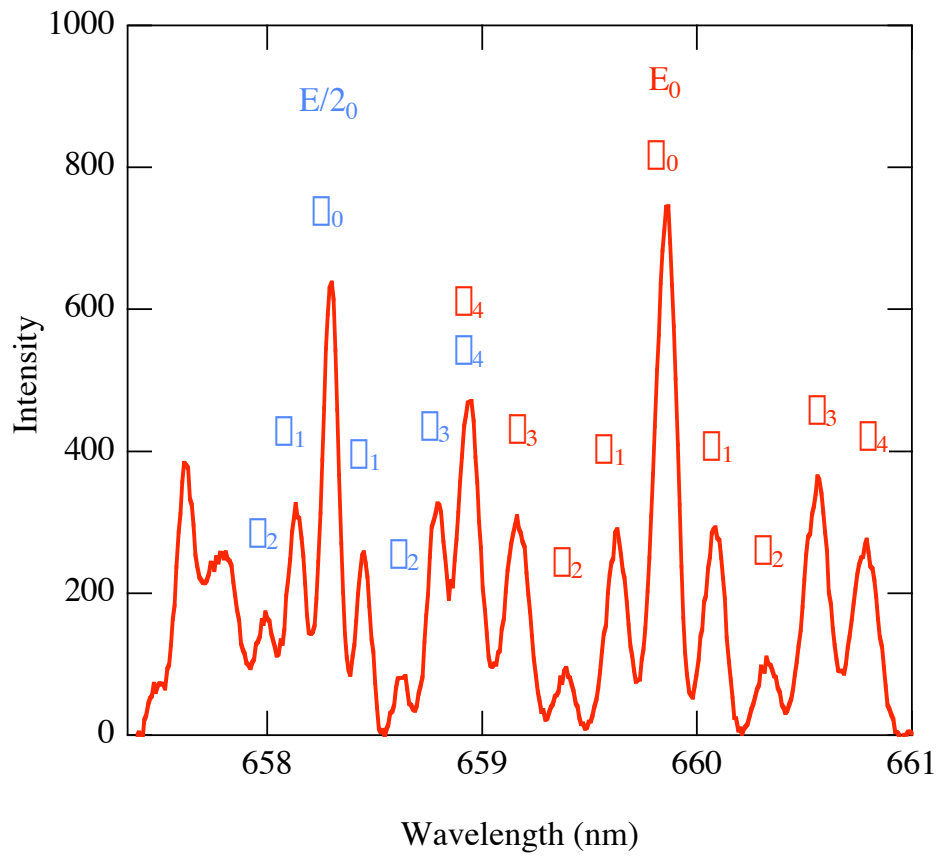

- $\vec{E} = \vec{v} \times \vec{B}$ electric field is $\sim$ 200 kV/cm at 4.5 T, resulting in a spectral splitting.
- $\Delta m = 0(\pm 1)$, $\pi(\sigma)$ component, are polarized parallel (perpendicular) to the electric field.
- Spectral linewidth is determined by geometric broadening and beam temperature.
- Spectral overlap between π and σ lines reduces polarization fraction and signal-to-noise.

Low Polarization Fraction at Low Field

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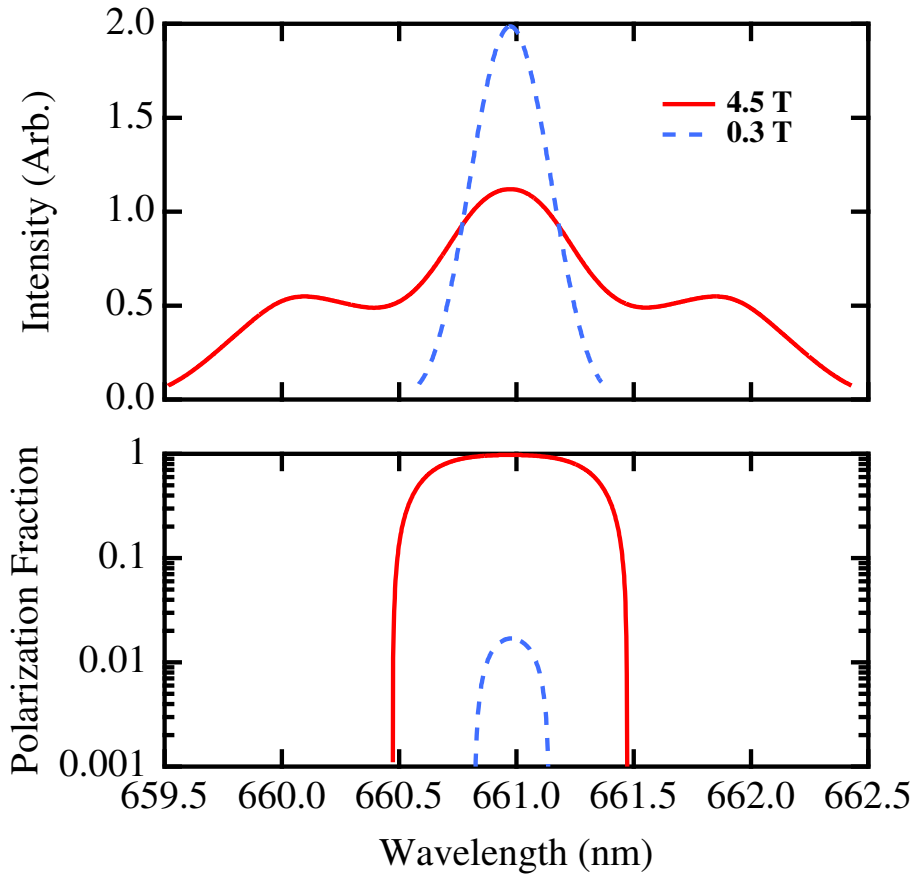

$$P_f = \frac{I_{\parallel} - I_{\perp}}{I_{\parallel} + I_{\perp}}$$

$$S/N \propto P_f \sqrt{I}$$

- **Numerical convolution of the MSE spectra including filter, beam, and optics broadening.**
- **At 4.5 T there is a good separation of the π and σ components. At 3 kG overlap of spectral lines leads to a low polarization fraction.**

Novel Optics Design to Reduce Geometric Doppler Broadening

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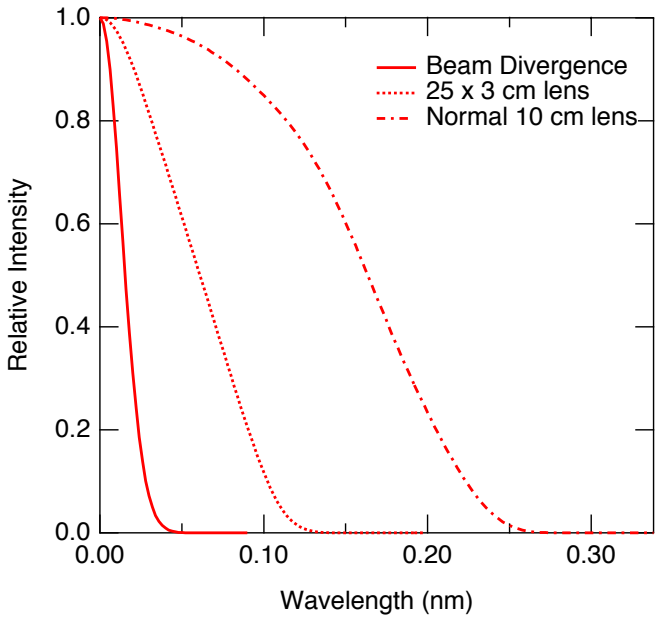

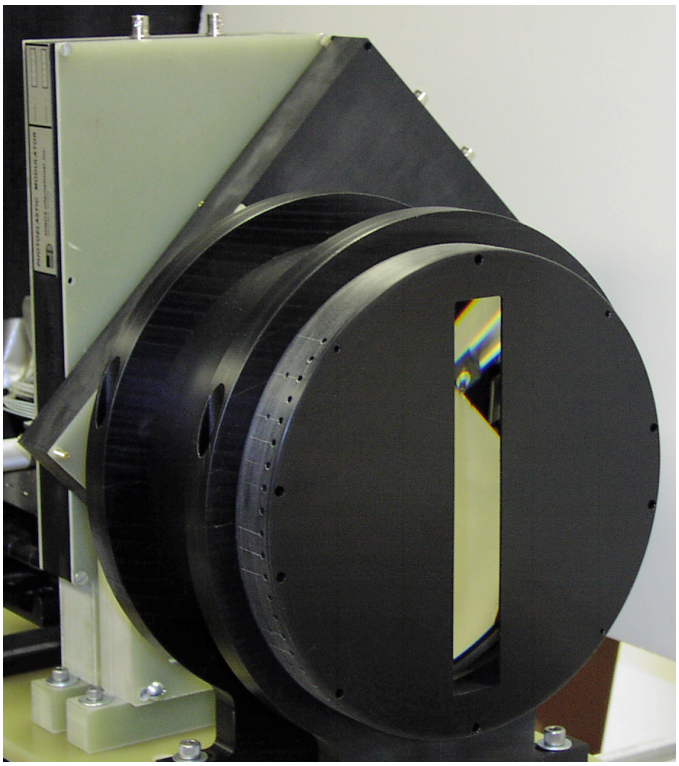

- **Optics design, combined with high throughput, high resolution birefringent filter, is computed to increase the polarization fraction to $\sim 30\%$.**

High Resolution, High Throughput, Lyot Spectral Filter

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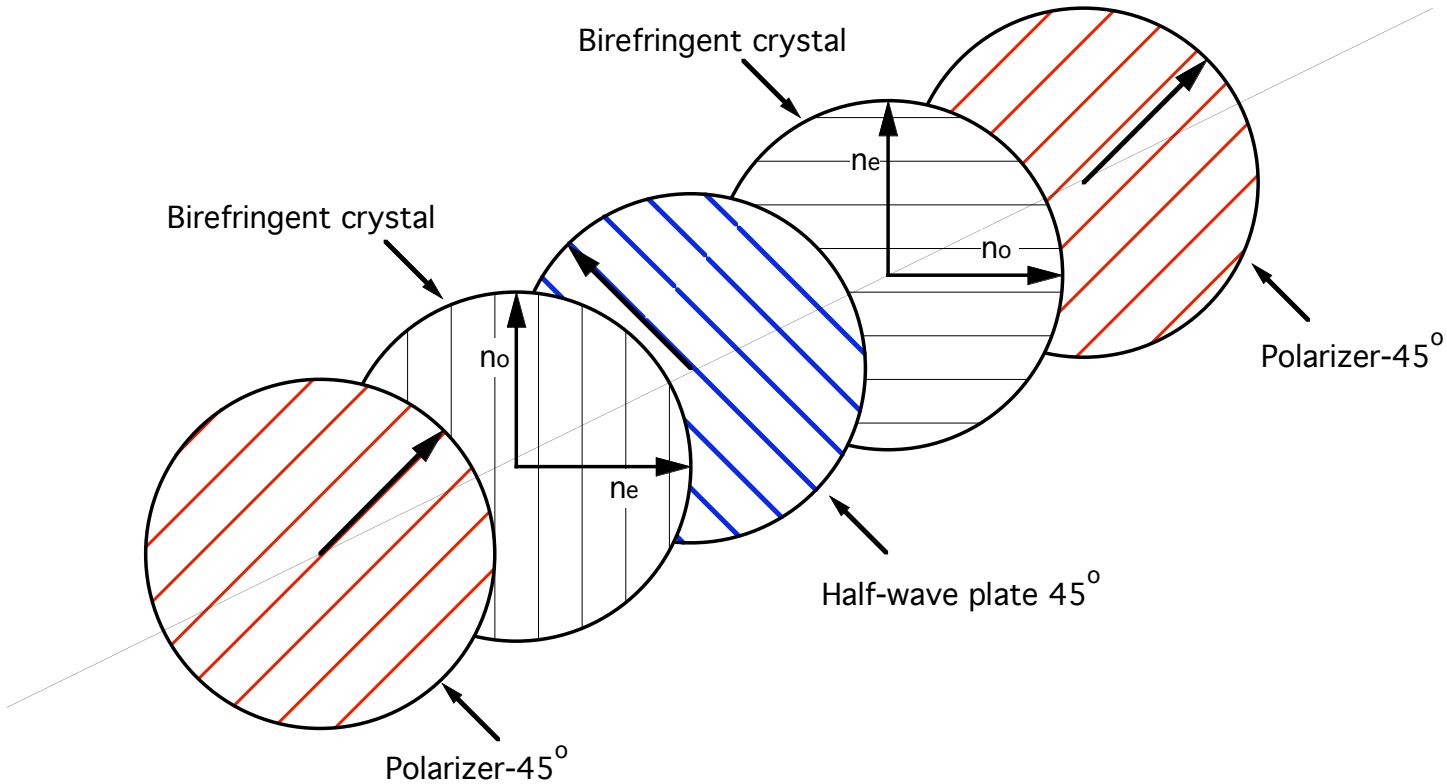

- **Optics layout for a single stage of filter.**
- **Required resolution and throughput can be satisfied with a wide-field Lyot filter.**
- **Unique feature – *electro-optically tunable.***

Filter and Optics Enclosure

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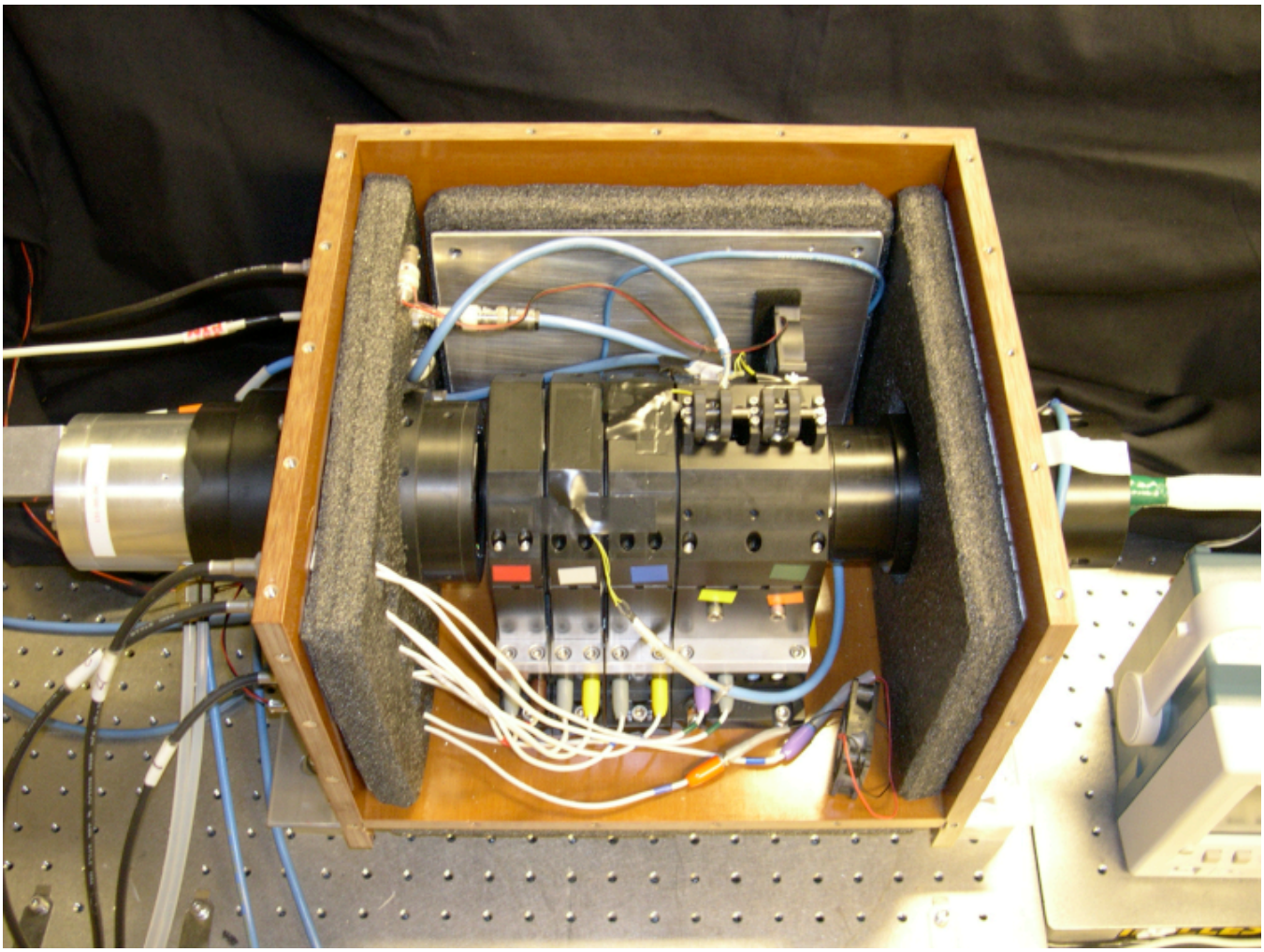

- **Enclosure containing Lyot filter, collimating and focusing optics, APD detector, HV for tuning, and temperature control.**

Four Stage Wide-Field Lyot Filter Meets our Requirements

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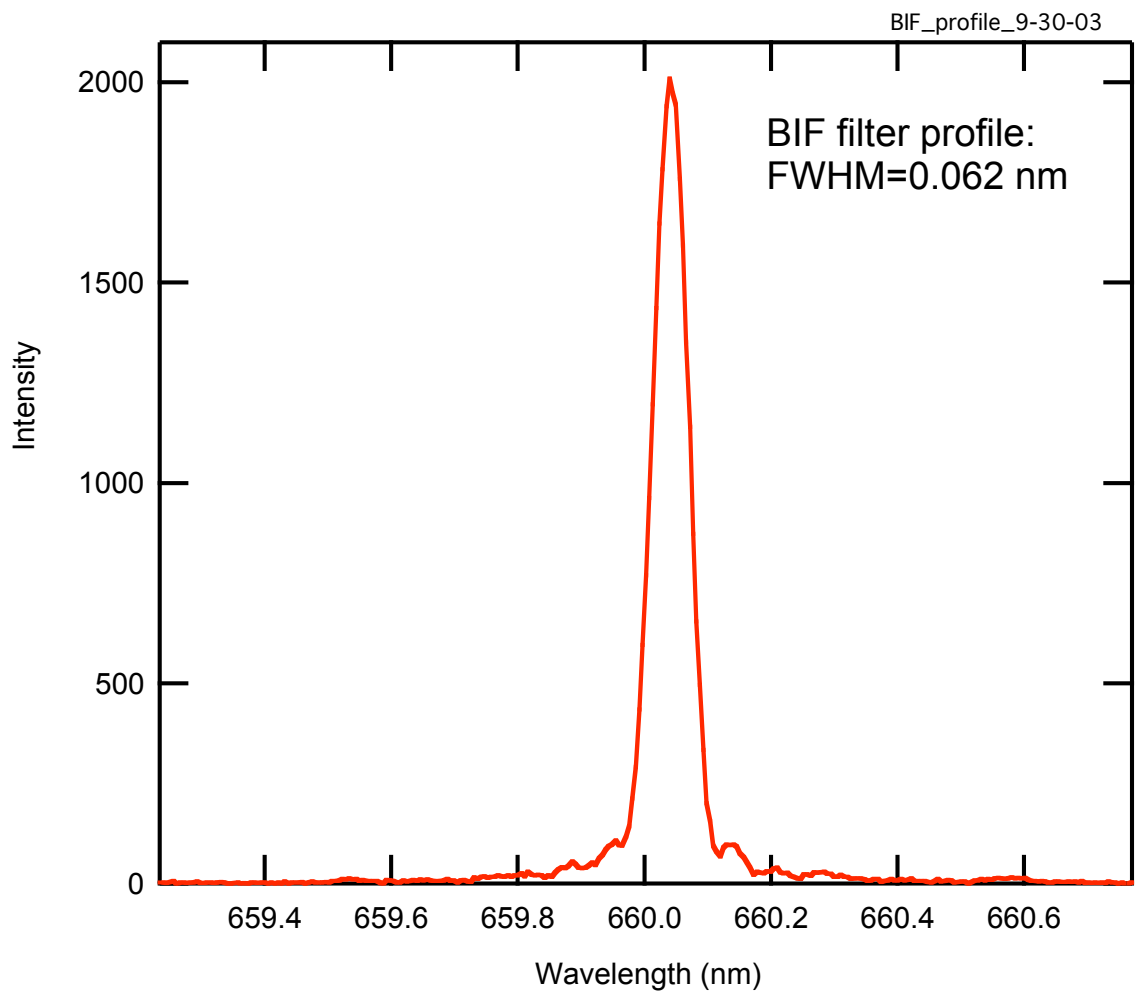

- **Four stage filter development completed.**
- **Wavelength tuned electro-optically.**

MSE-CIF Layout on NSTX

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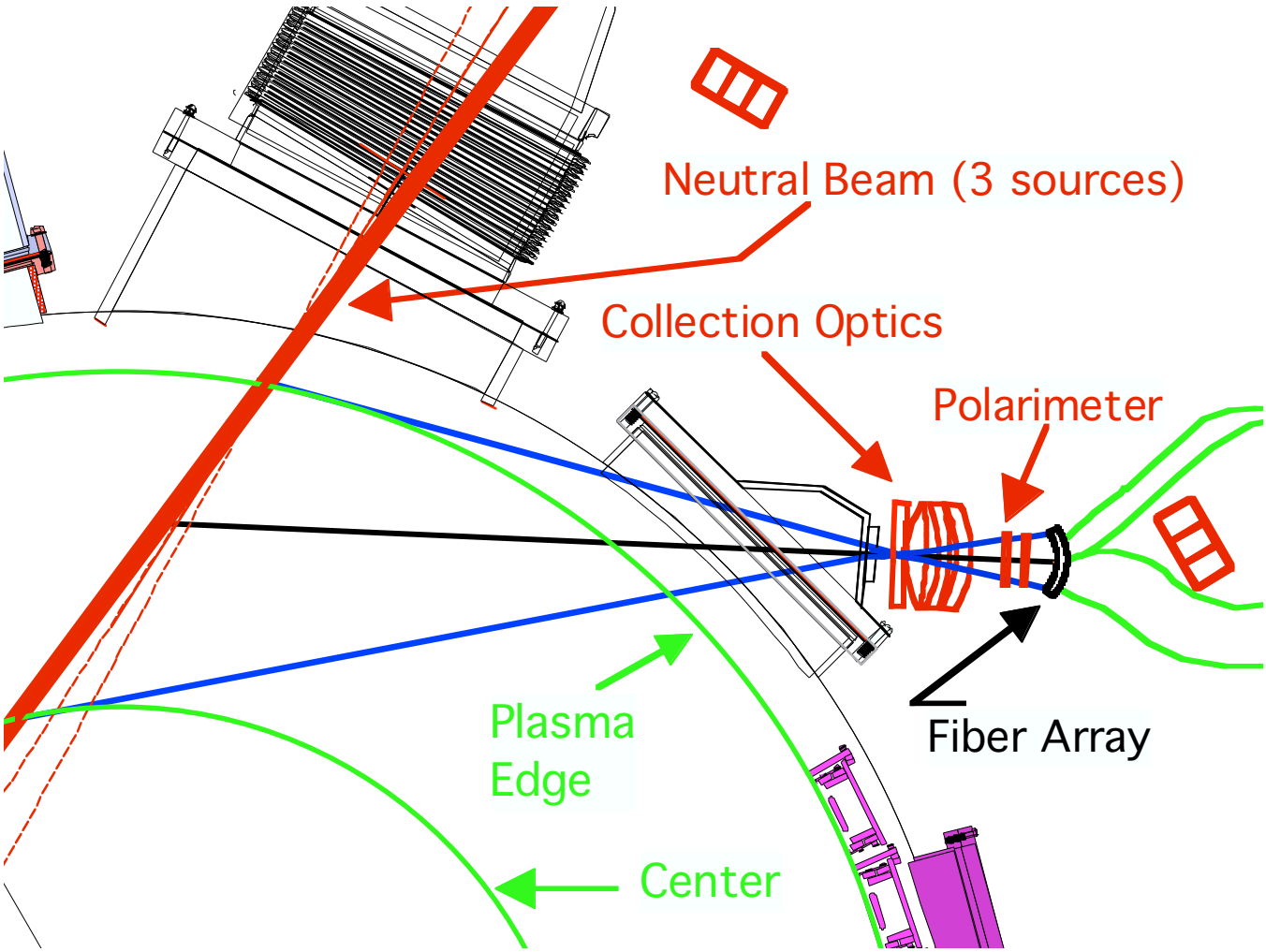

MSE & CHERS Fiber Optic Holder

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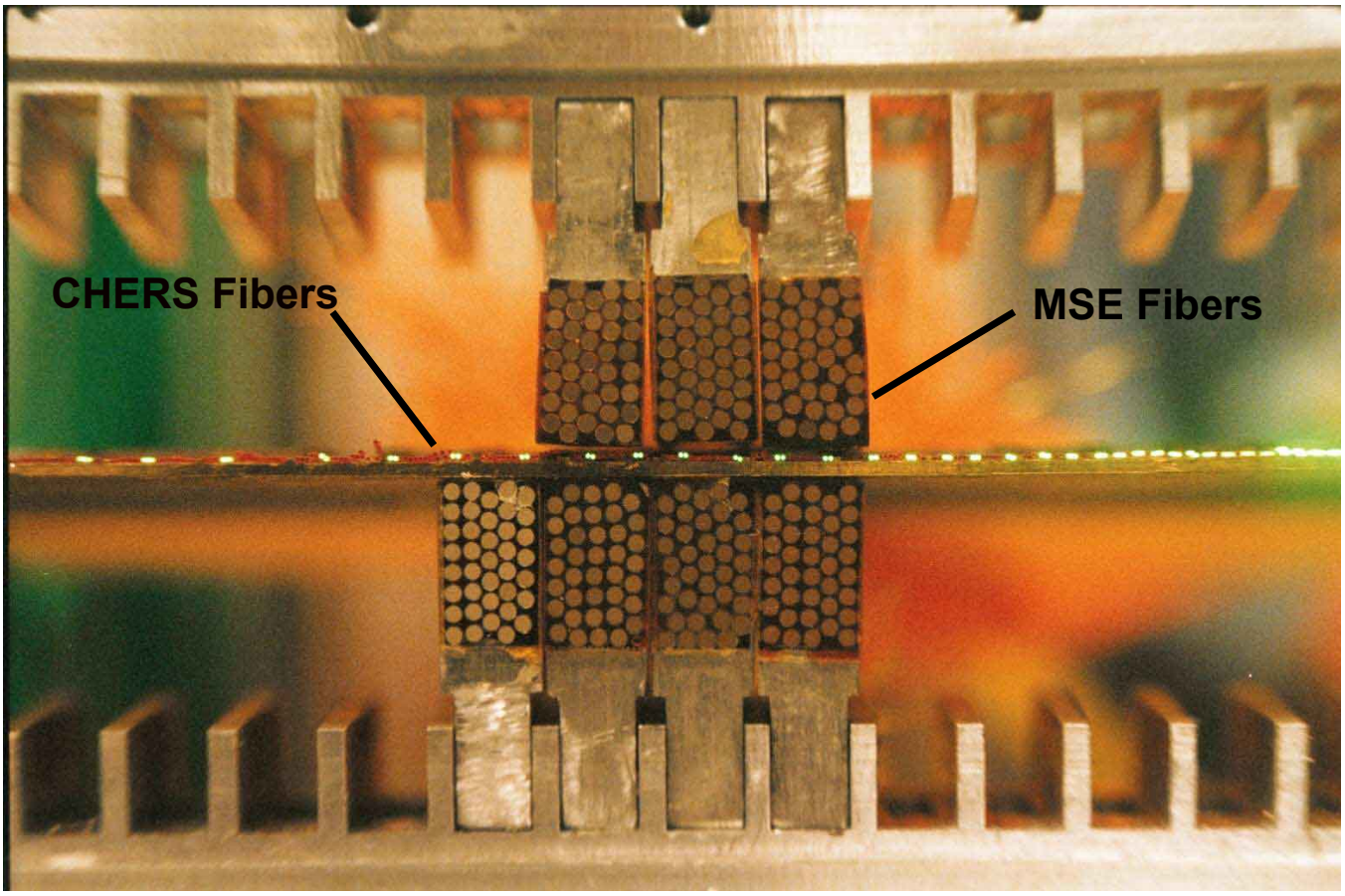

- View of fiber holder with a few MSE fiber ferrules installed.
- All 19 channels are now populated.
- CHERS fibers are the small fibers in the midplane. Ratio of light collection is about 1000:1.
- This system collects 10× more light than MSE on TFTR did–uses 76×1 mm fibers per channel.

MSE-CIF Status

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- **Installation of collection optics and fiber optics is complete.**
- **Development of a *tunable*, *high resolution*, *high throughput* spectral filter is complete.**
  - **One complete filter-with HV, temperature control, optics, detector.**
  - **Two additional filters in February.**
- **Installation of control electronics for remote control of PEM's and LED calibration source is complete.**
- **Computer for data acquisition and control has been installed. Most control software is complete.**
- **Mechanical fabrication for four channels is complete.**

Ready for "First Light" This Month

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- **Tasks to complete prior to turning on one channel.**
  - **PCI computer card for decoding NSTX facility clock.**
  - **Data acquisition software.**
  - **Complete final testing and installation of filter.**
  - **Water cooling for APD detectors.**

Diagnostic shakedown with 1-3 channels when NBI begins injection into plasma

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- Measure Doppler shifted beam emission with 1/2 meter spectrometer-verifies viewing geometry, complete purchase of additional interference filters.
- Optimize birefringent filters. Additional sidelobe rejection if necessary. Wider scan range.
- Measure polarization fraction.
- Reflections in vacuum vessel.
- Faraday rotation effects in optics from TF, PF, plasma current.
- Optimize detector/amplifier gains and purchase additional detectors.
- Dedicated run time (1-2 days) for developing and testing calibration procedure.

Begin taking profile data with 10 channels: ∼June 2004

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- Complete polishing and coating crystals.
- Complete additional electronics chassis for high voltage and temperature control.
- Complete fabrication of filter enclosures and crystal holders.
- Assembly of crystals, polarizers and half-wave retarders.
- Data analysis.
  - Dedicated run time (1-2 days) for calibration.
  - E_R correction: Estimated to be $< 20\%$ correction. Near term use CHERS/NCLASS. Eventually will have MSE-LIF.
  - Pitch angles input into equilibrium reconstruction code such as EFIT or ESC to obtain J(r) and q(r).

Future Improvements/Plans/Ideas

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- Additional physicist (Howard Yuh) joining our group in near future.
- Increase number of channels, to 19, in 2005.
- Magnetic fluctuations.
- High edge resolution.
- Development of rapid filter scanning-
  - Fast T_i
  - Pressure profile from $|B|$ measurement?