

# **The Motional Stark Effect (MSE) Diagnostic for KSTAR**

**F. M. LEVINTON**



**Presented at the US-Korea Workshop  
Opportunities for Expanded Fusion Science and  
Technology Collaborations with the KSTAR Project**

**May 19-20, 2004**

**San Diego, California**

# Principle of the Motional Stark Effect

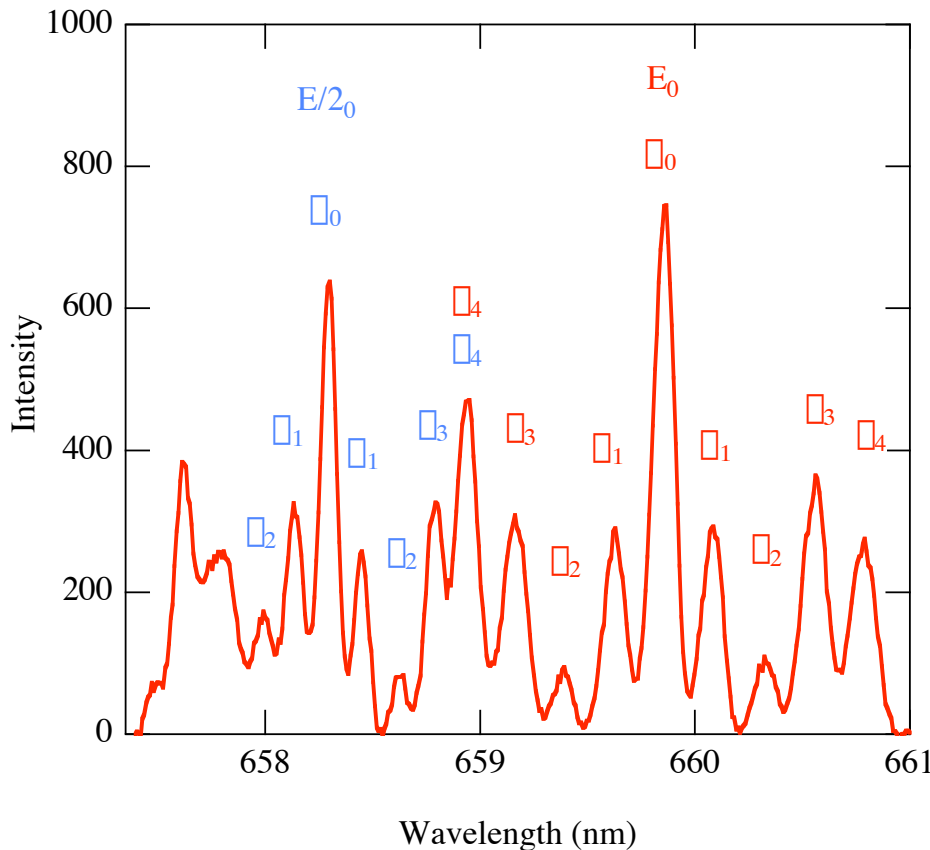
---

*Nova Photonics, Inc.*

- Based on  $\vec{E} = \vec{v} \times \vec{B}$  electric field induced by propagation of a neutral beam across a magnetic field.
- Electric field causes **spectral splitting** and **linear polarization** of the emitted radiation known as the Stark effect.
- Background plasma causes excitation of neutral beam atoms and Doppler shifted emission ( $H_\alpha$ ).
- Good beam penetration.
- Good spatial resolution-intersection of sightline with neutral beam.

# Stark Spectra from TFTR

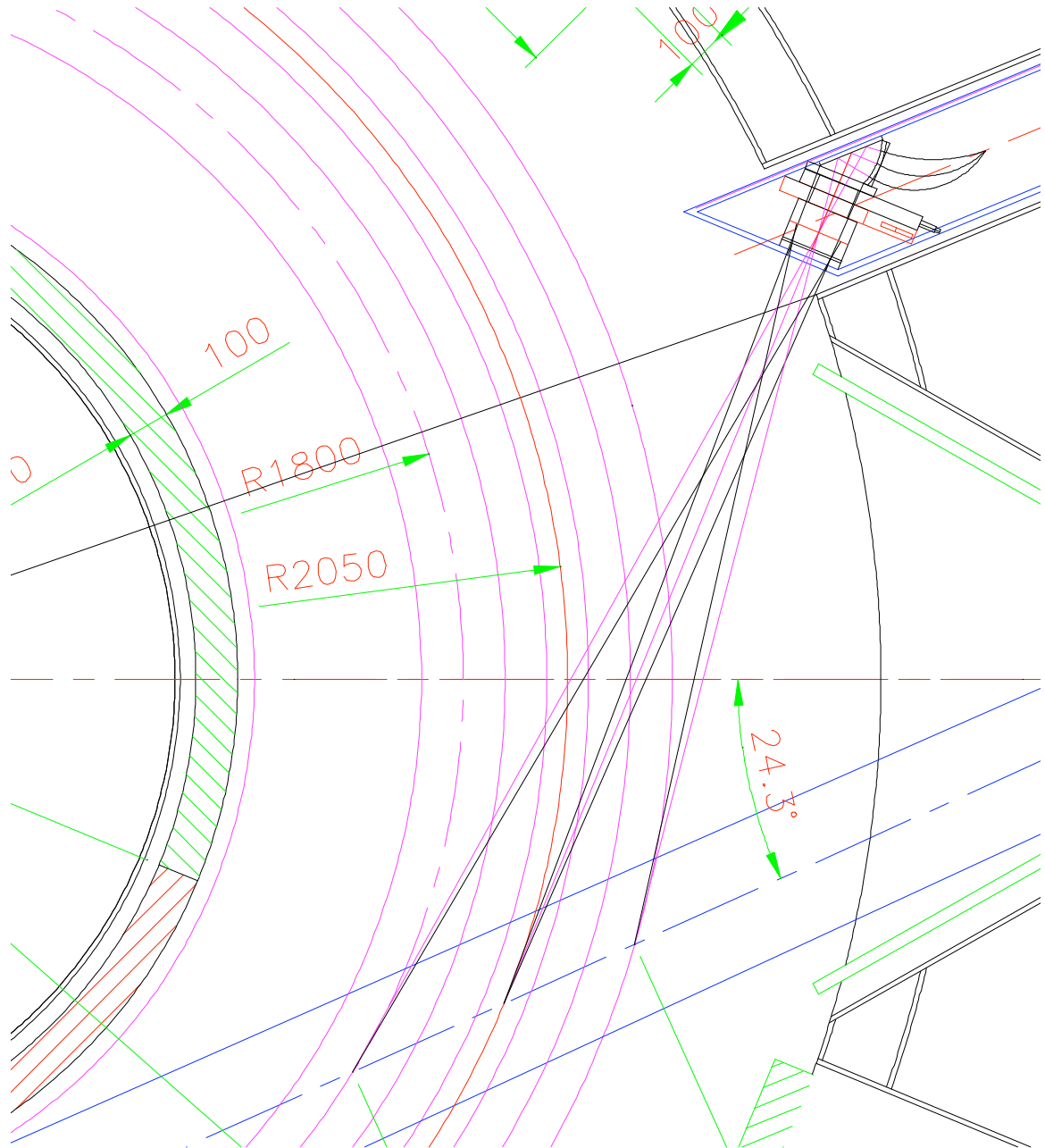
*Nova Photonics, Inc.*



- $\vec{E} = \vec{v} \times \vec{B}$  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. Provide a measure of  $\vec{B}$  direction.
- Spectral linewidth is determined by geometric broadening and beam temperature.
- Spectral overlap between  $\pi$  and  $\sigma$  lines reduces polarization fraction and signal-to-noise.

# MSE Layout on KSTAR

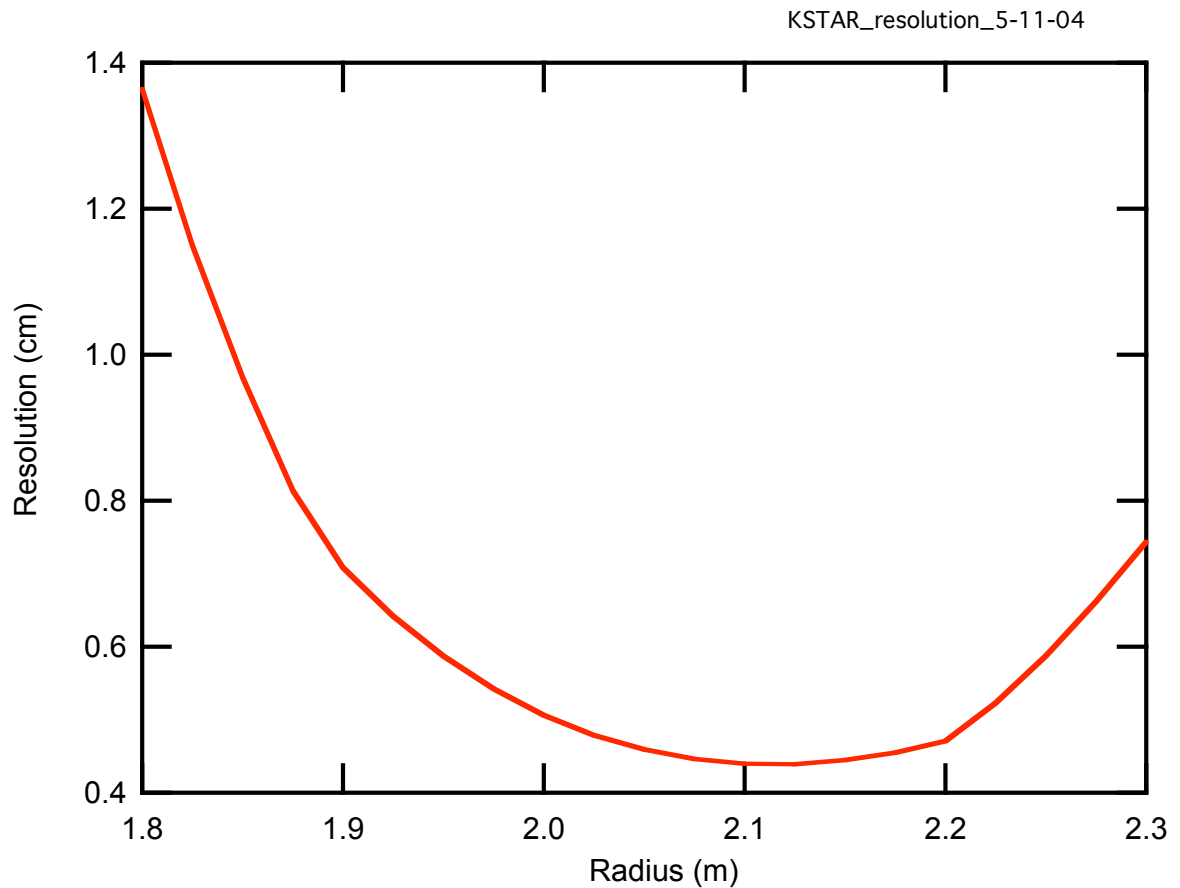
*Nova Photonics, Inc.*



# MSE View has Good Spatial Resolution

---

*Nova Photonics, Inc.*

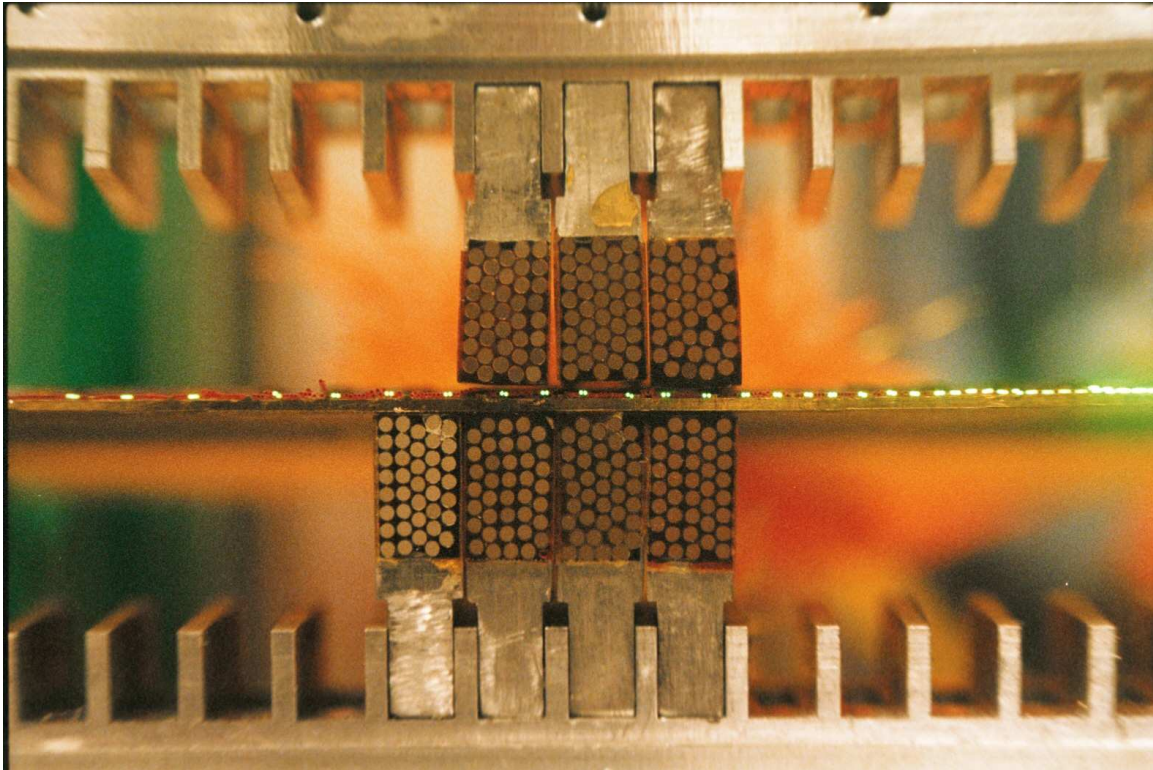


- **Tangential view of heating beam provides good spatial resolution for KSTAR.**

# MSE & CHERS Fiber Optic Holder

---

*Nova Photonics, Inc.*

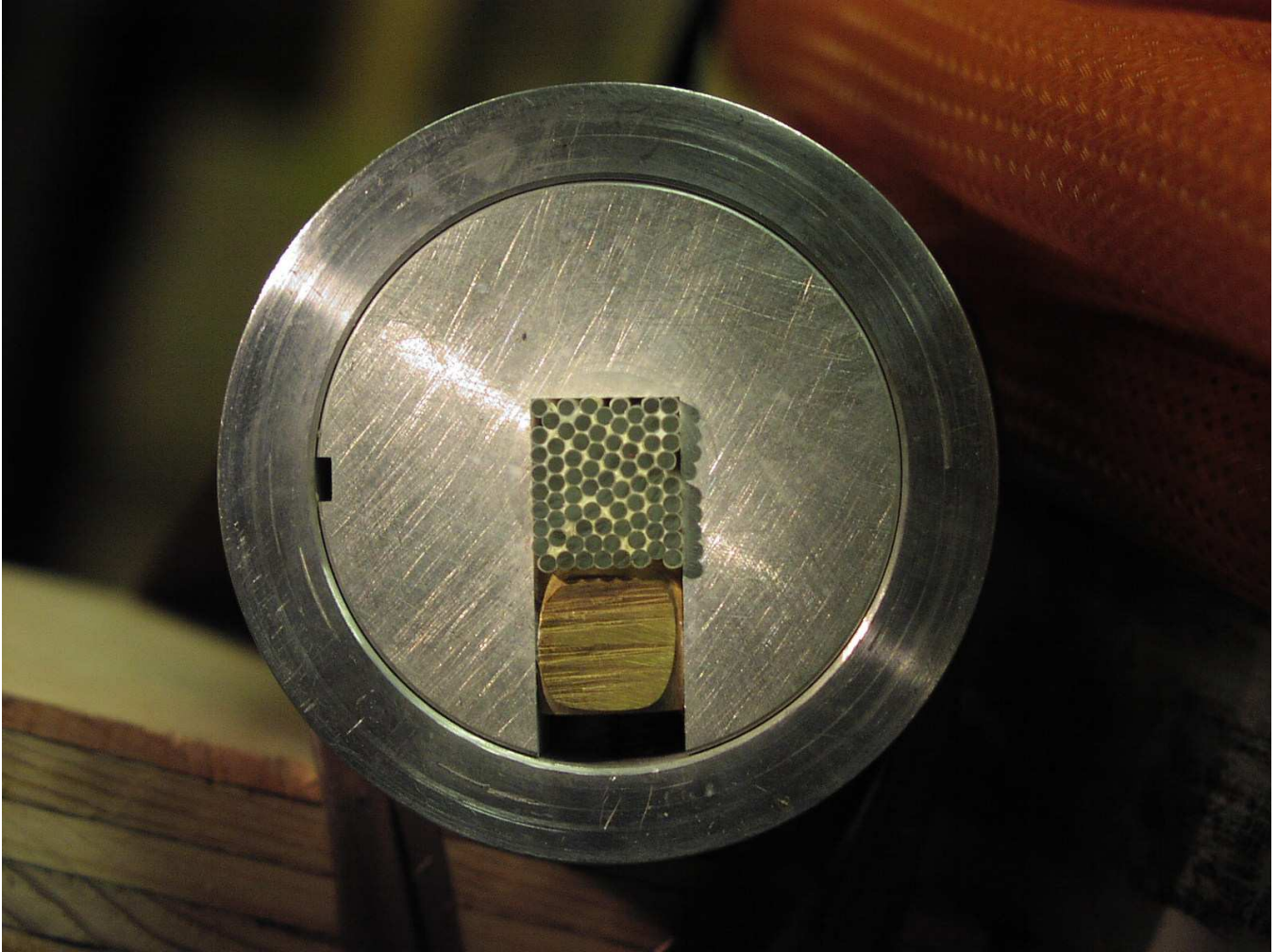


- **View of fiber holder for NSTX with a few MSE fiber ferrules installed.**
- **CHERS fibers are the small fibers in the mid-plane. Ratio of light collection is about 1000:1.**

# Output Fiber Optic Holder

---

*Nova Photonics, Inc.*



- **On NSTX we developed techniques to assemble large bundles of fibers for very high etendue.**
- **NSTX input fiber bundle;  $76 \times 1$  mm diameter fibers.**

# Preliminary Budget and Tasks

**Nova Photonics, Inc.**

MSE Tasks and Budget

5/17/04

|   | DESIGN (\$k)                |     | FABRICATE / PROCURE (\$K) |     | INSTALL / COMMISSION (\$K) |     | Possible US participants |
|---|-----------------------------|-----|---------------------------|-----|----------------------------|-----|--------------------------|
|   | (work to-date not included) |     | US                        | KO  | US                         | KO  |                          |
|   | US                          | KO  |                           |     |                            |     |                          |
| Bay M cassette*                           |                             |     |                           |     |                            |     |                          |
| cassette body                             | 50                          |     |                           | 75  |                            | 20  | PPPL                     |
| viewing windows, weldment                 | 4                           |     |                           | 10  |                            | 8   | PPPL                     |
| window covers, mounts                     | 5                           |     |                           | 5   |                            | 2   | PPPL                     |
| shutters & actuators                      | 10                          |     |                           | 20  |                            | 15  | PPPL                     |
| optics rail supports                      | 5                           |     |                           | 5   |                            | 5   | PPPL                     |
| temperature control                       | 5                           |     |                           | 5   |                            | 5   | PPPL                     |
| Collection optics (20 channels)           |                             |     |                           |     |                            |     |                          |
| optics carriages, rails, adjustments*     | 25                          |     | 30                        |     | 8                          | 8   | Nova                     |
| optical design*                           | 60                          |     |                           |     |                            |     | Nova                     |
| Collection lens*                          |                             |     | 10                        |     |                            |     | Nova                     |
| Photoelastic modulator                    |                             |     | 40                        |     |                            |     | Nova                     |
| Optics mount*                             | 30                          |     | 20                        |     |                            |     | Nova                     |
| Fiber optic holder                        | 50                          |     | 30                        |     |                            |     | Nova                     |
| Fiber bundles (30x20x100 m)               | 20                          |     | 600                       |     |                            |     | Nova                     |
| Calibration polarizer assemble and test   | 20                          |     | 20                        |     | 100                        | 20  | Nova                     |
| Detection system (20 channels)            |                             |     |                           |     |                            |     |                          |
| temperature controlled room with services |                             | 10  |                           | 50  |                            |     |                          |
| Filters                                   |                             |     | 40                        |     |                            |     | Nova                     |
| collimating optics                        | 15                          |     | 50                        |     |                            |     | Nova                     |
| Thermal enclosure                         | 20                          |     | 30                        |     |                            |     | Nova                     |
| Electronics for thermal enclosure         | 15                          |     | 40                        |     |                            |     | Nova                     |
| Detectors & electronics                   | 25                          |     | 60                        |     |                            |     | Nova                     |
| focusing optics for detectors             | 20                          |     | 50                        |     |                            |     | Nova                     |
| data acquisition                          | 10                          |     | 40                        |     |                            |     | Nova                     |
| data analysis software                    |                             |     |                           |     | 100                        |     | Nova                     |
| initial calibrations                      |                             |     |                           |     | 40                         | 20  | Nova                     |
| Reviews and travel                        |                             |     |                           |     |                            |     |                          |
| Design review and travel                  | 30                          |     |                           |     |                            |     | Nova                     |
| totals                                    | 419                         | 10  | 1060                      | 170 | 248                        | 103 |                          |
| Summary                                   | US                          | KO  |                           |     |                            |     |                          |
| Design                                    | 419                         | 10  |                           |     |                            |     |                          |
| Procure or Fabricate                      | 1060                        | 170 |                           |     |                            |     |                          |
| Install and Commission                    | 248                         | 103 |                           |     |                            |     |                          |
|   | 1727                        | 283 | 2010                      |     |                            |     |                          |

\* Items also included in CER budget and tasks

# MSE on KSTAR

---

*Nova Photonics, Inc.*

- **Proposed MSE system on KSTAR would take about 3 years from design to commissioning.**
- **20 channels with coverage from geometric center to outboard edge. Future expansion of number of channels to increase edge resolution to  $\sim 1$  cm is possible.**
- **A very high throughput design is possible for KSTAR— about  $\times 5$  more light collection than MSE system on TFTR.**
- **High throughput would provide higher time resolution and/or better sensitivity for non-inductive current drive measurements.**
- **Would incorporate a in-situ calibration system that could be a prototype for ITER MSE design.**