Proposal for Core and Edge Thomson Systems

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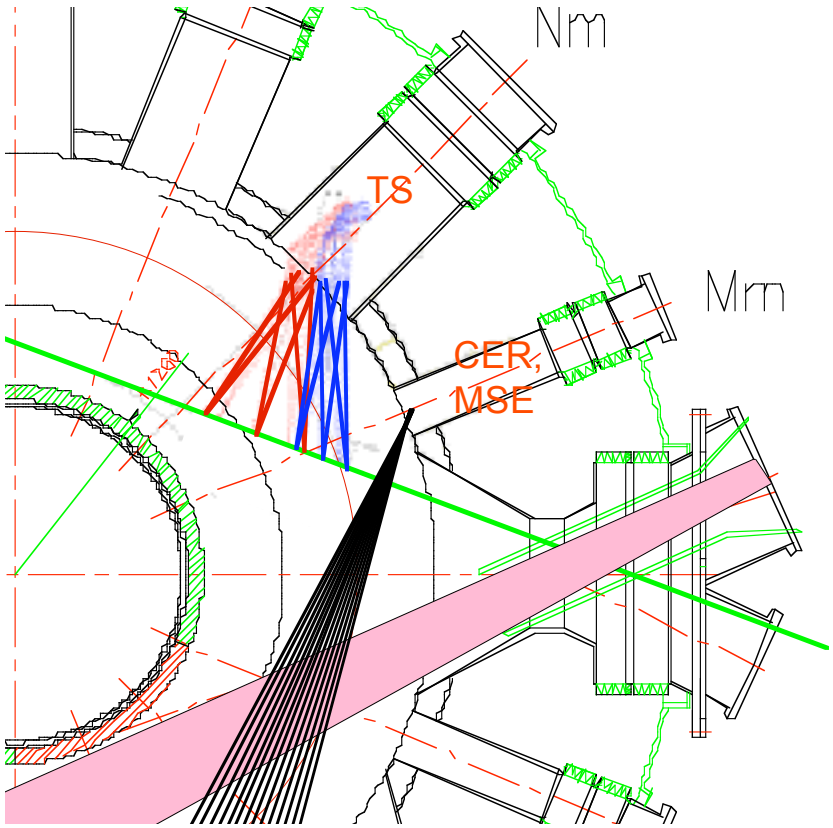
Profile Diagnostics are Essential to Quality KSTAR Research

- Thomson Scattering — $n_e(R)$, $T_e(R)$
- Charge Exchange Recombination Spectroscopy — $T_i(R)$, $v_\phi(R)$, $Z^c_{eff}(R)$
- Motional Stark Effect Polarimetry — $J(R)$, $E_r(R)$

- These profiles form the basis for high-level analysis of transport and stability.
- Availability of these diagnostics EARLY in KSTAR operation will guarantee that results from these phases will have strong impact, providing momentum to a growing AT research program.
- Maximizing spatial resolution and minimizing measurement uncertainties will make these diagnostics relevant for the KSTAR AT research program with real-time profile control.

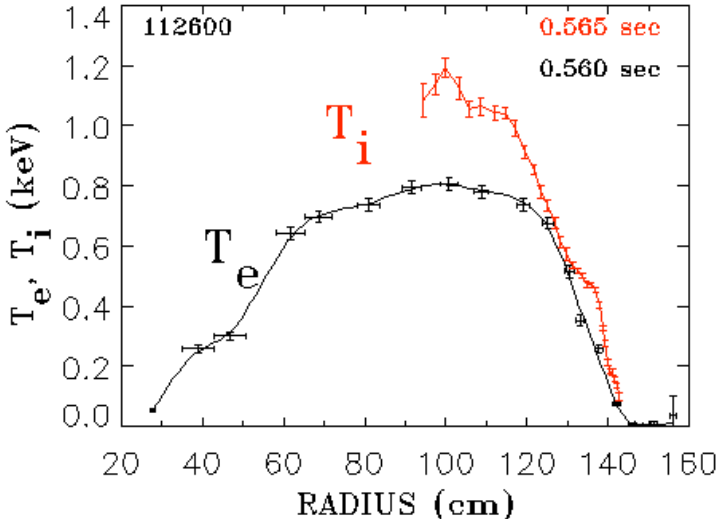
	proposed spatial channels (just inside axis to edge)
TS	55
CER	50
MSE	20-30

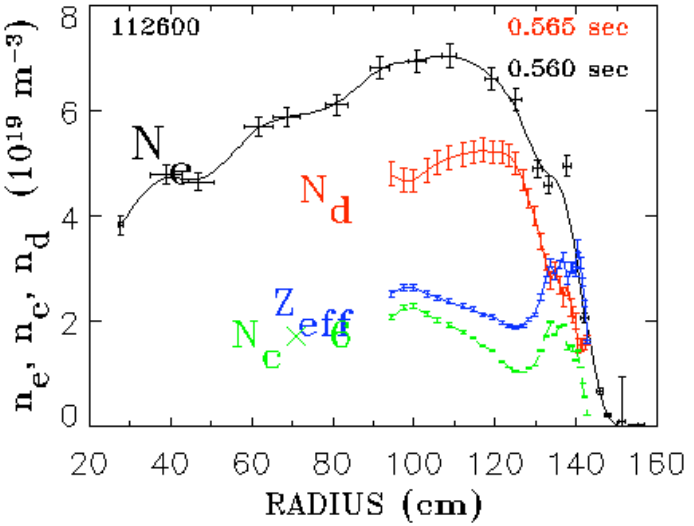
KSTAR Profile Diagnostic Viewing Geometries

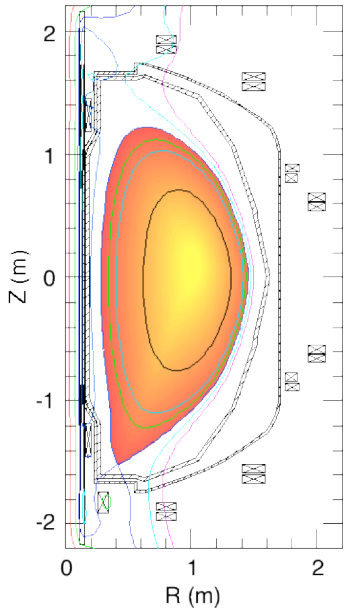


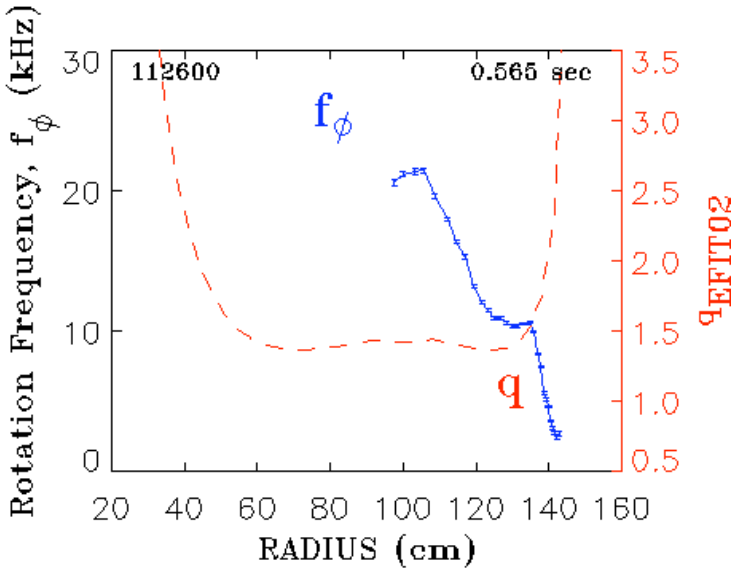
- PPPL has worked with KSTAR to provide designs for several midplane diagnostic cassettes, including those for important profile diagnostics.
- Available geometries for viewing the laser beam and the heating beam provide these systems with radial resolutions of ≤ 1 cm at the outer separatrix and ≥ 1 cm near the magnetic axis.
- PPPL proposes to work with other US experts and with KSTAR to provide state-of-the-art profile diagnostics as a basis for a productive research program.

NSTX Profile Examples







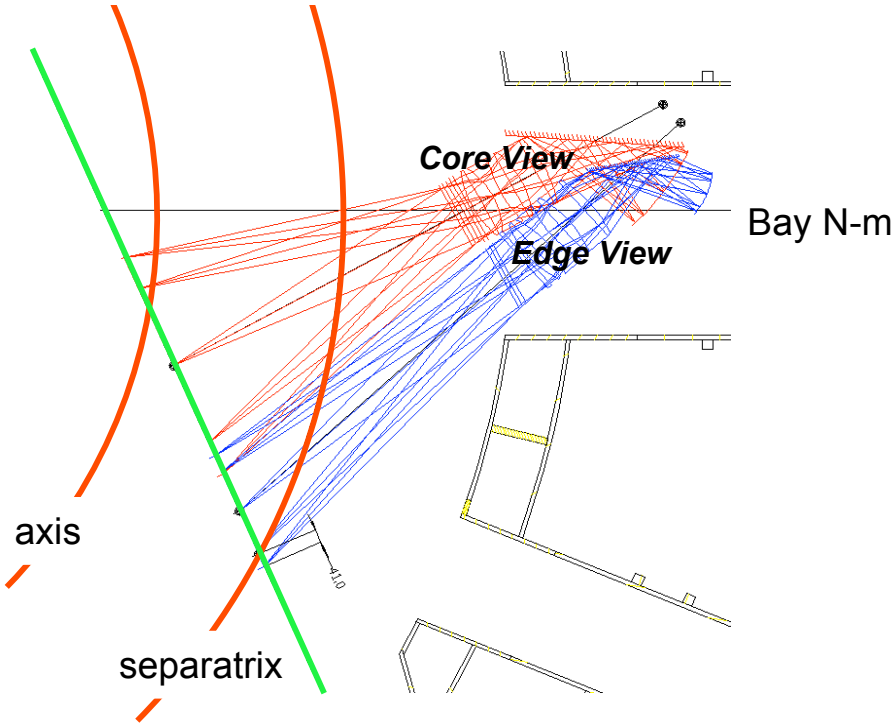


Technical Benefits to the US Program from US Involvement in KSTAR Profile Diagnostics

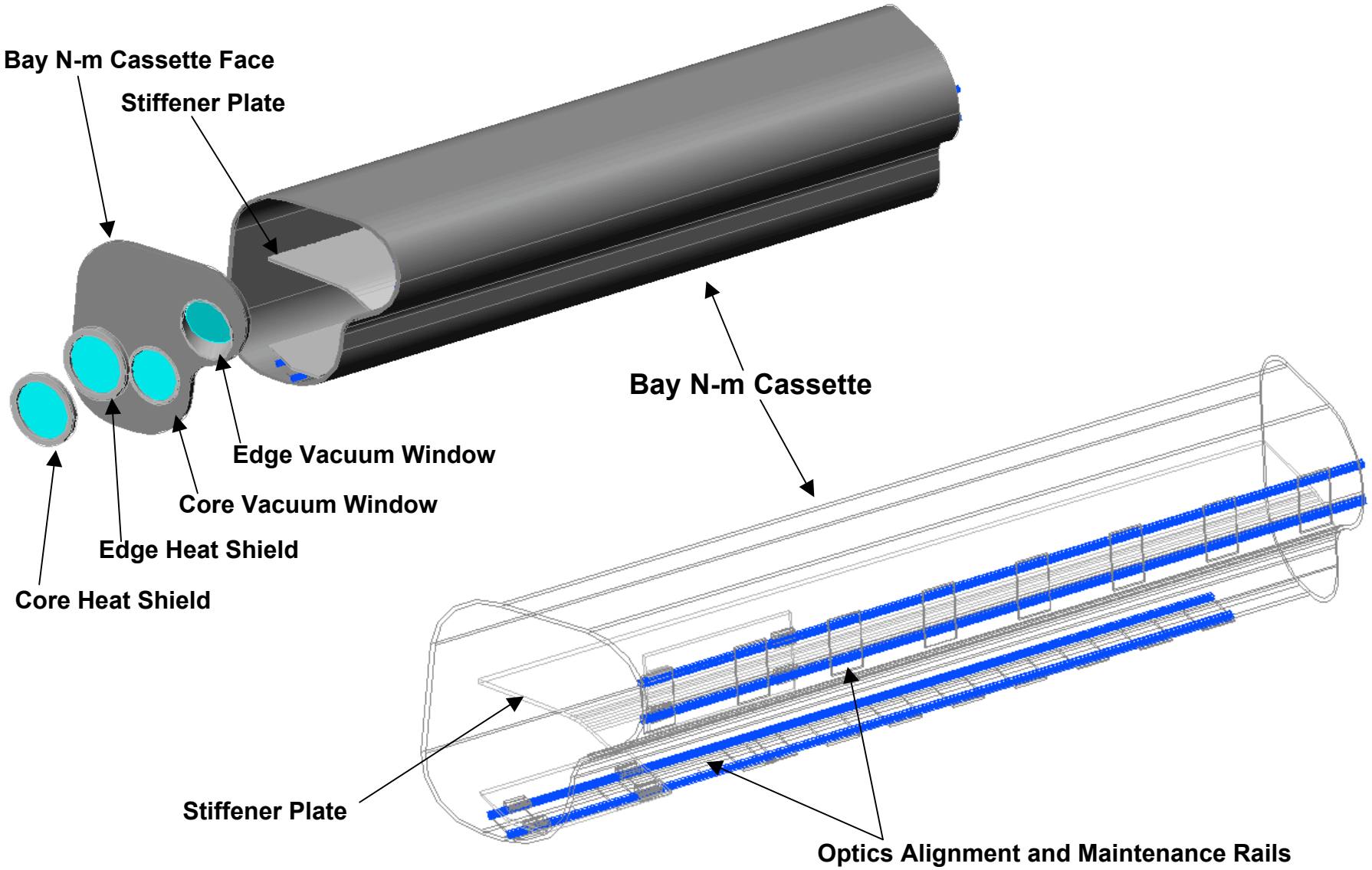
- Thomson Scattering
  - Multiplexing multiple spatial channels into each polychromator - proposed for edge channels on KSTAR
  - Development of real-time alignment control for long pulses
- Charge Exchange Recombination Spectroscopy
  - Further development of high-throughput, imaging spectrometers
  - Development of fast scientific CCD cameras
- Motional Stark Effect Polarimetry - (ITER MSE is proposed to be provided by US)
  - Development of higher throughput interference filter systems
  - In-situ polarimetry calibration techniques
- Generic issues for re-entrant optical systems in long-pulse environment
  - Optimizing the use of long re-entrant systems. Systems require temperature control and be must be ruggedized to survive significant eddy current forces and thermal cycles.
  - Alignment stability and referencing of spatial calibration. Real-time alignment for some systems.
  - For long pulse compatibility, development of cooled shutters that operate during a plasma-pulse.
  - Monitoring and mitigation of degradation due to deposition on viewing windows.

KSTAR TS Conceptual Design

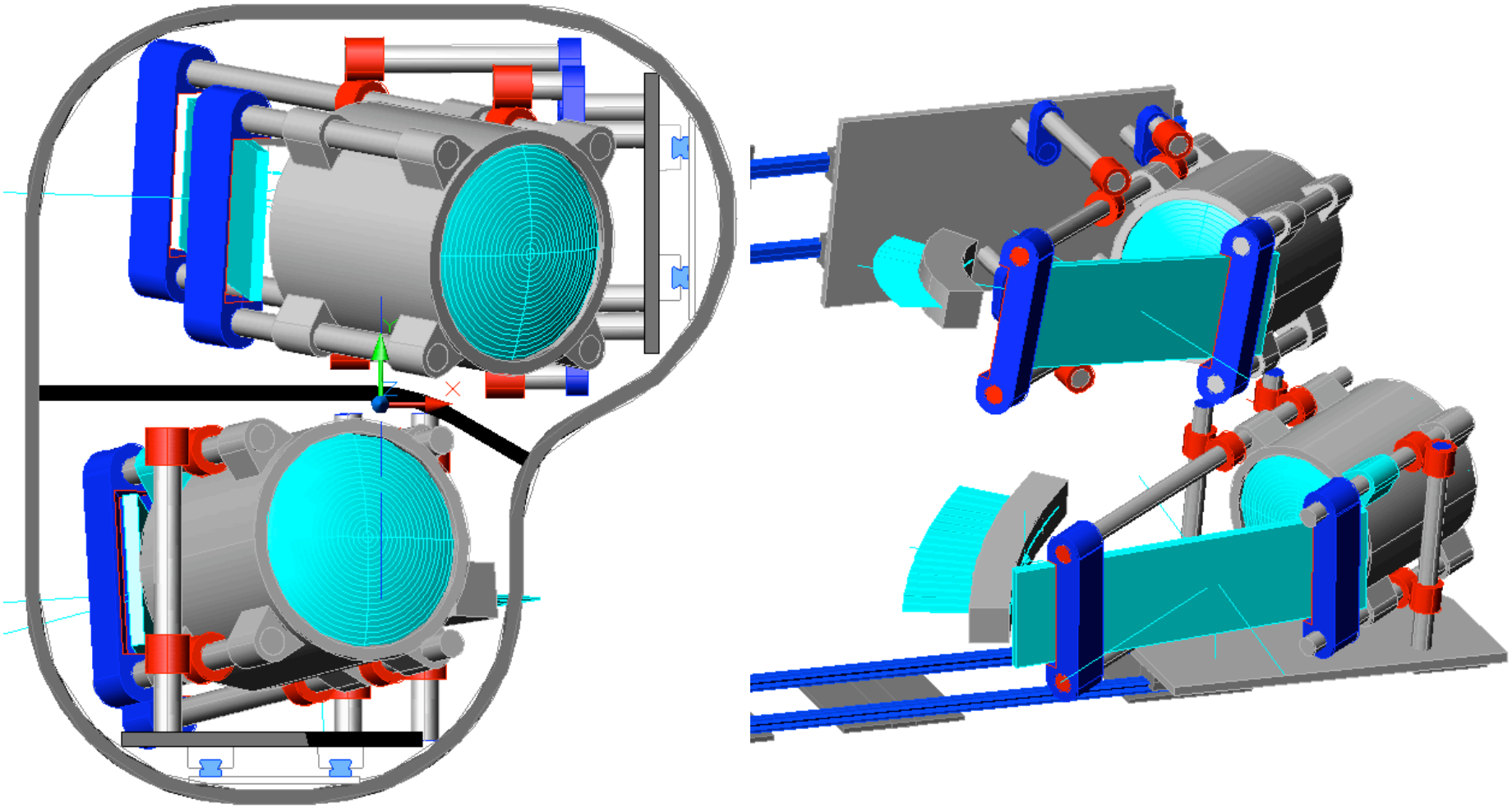
- PPPL has been working with Dr. H. G. Lee at KBSI to develop the design concept for the core and edge Thomson systems.
- The conceptual design review for the Bay N cassette and the Thomson viewing optics was held in Korea on February 2, 2004.
- This work was presented in a paper at the HTPD Conference last month.
- A preliminary design review is scheduled for December, 2004.



KSTAR Bay N-m Diagnostic Cassette Conceptual Design

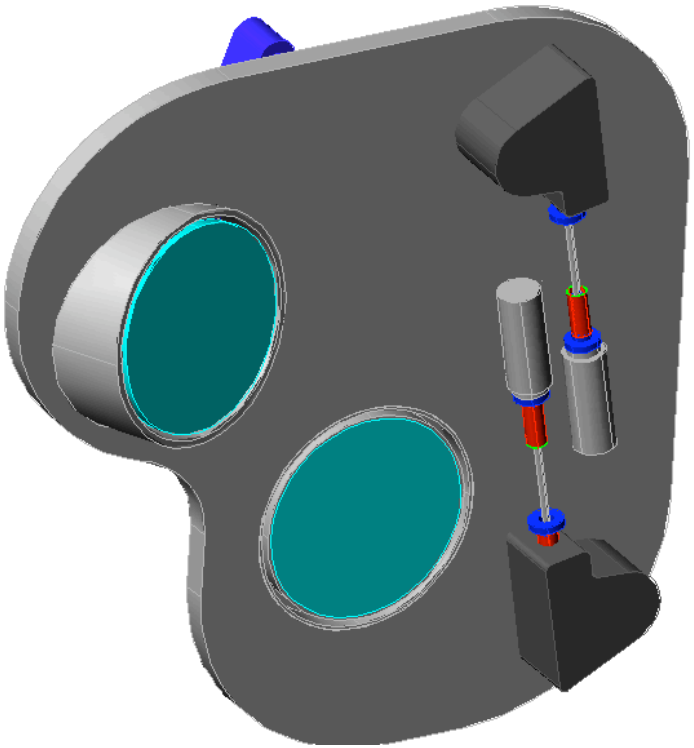


Conceptual Design Exists for Optics Carriages Compatible with Cassette

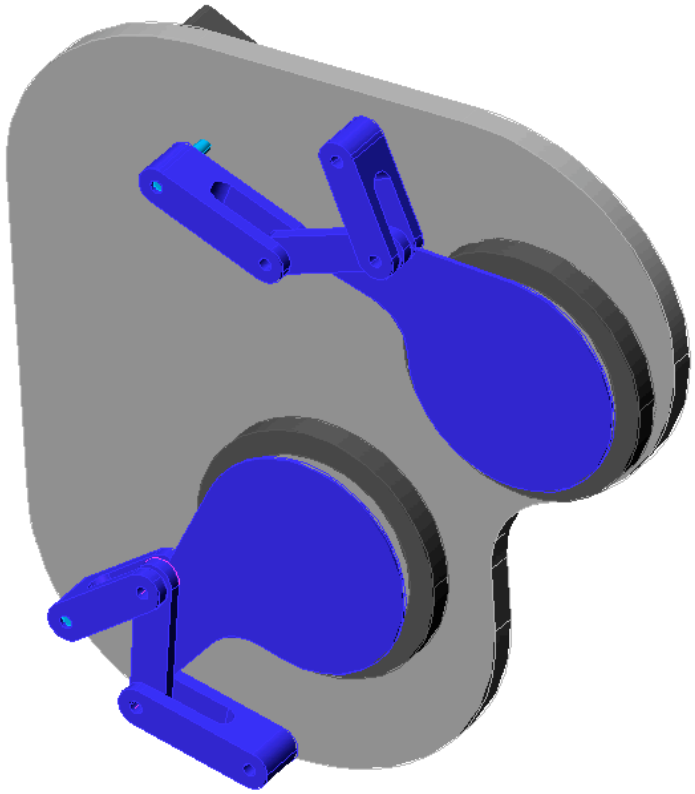


KSTAR MPTS Bay-Nm Cassette Conceptual Design

Shutter Design

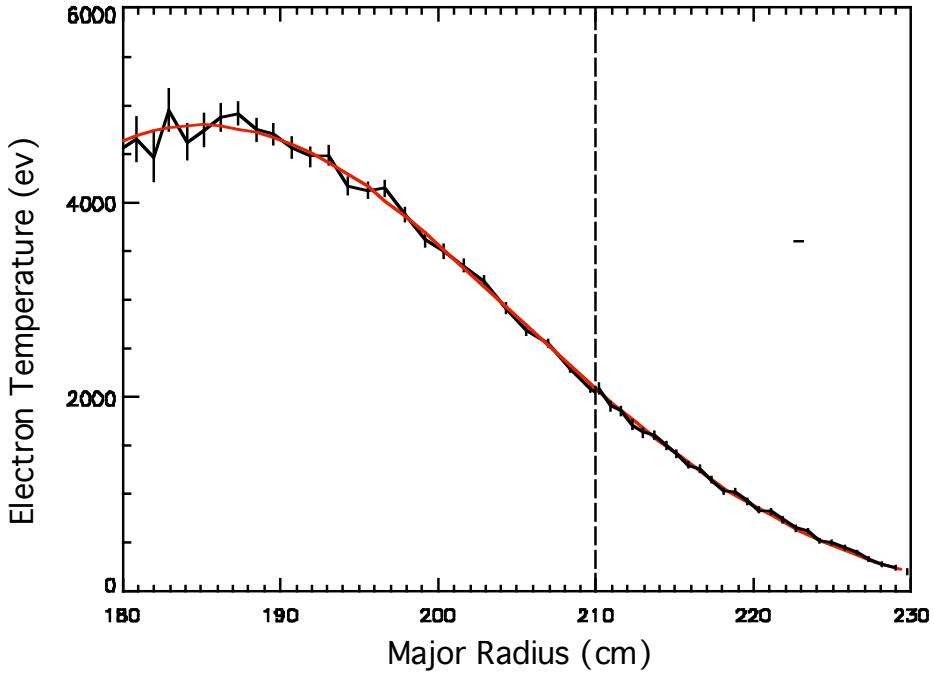


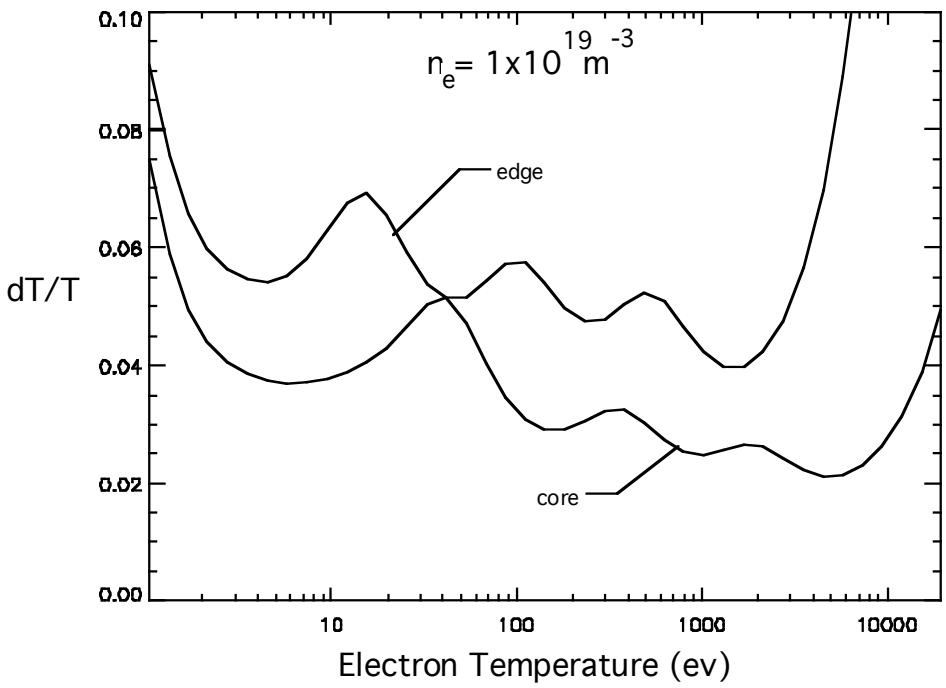
Shutters, Atmosphere Side Actuators



Shutters Shown in Closed Position

Simulations Indicate Excellent Performance Over Range of KSTAR Conditions





- Using a performance simulation code benchmarked on NSTX, the KSTAR TS systems are predicted to perform well at high spatial resolution.
- For the conceptual design, the etendue of a single core channel is well matched to that of the GA polychromator. However, this simulation assumes that light from a pair of edge channels is multiplexed into one polychromator.

Core and Edge Thomson Scattering Systems including Bay N Cassette **(possible division of effort)**	DESIGN ($k) (work to-date not included)		FABRICATE / PROCURE ($K)		INSTALL / COMMISSION ($K)		Possible US participants
	US	KO	US	KO	US	KO	
Bay N cassette							
cassette body optimize	50			75		20	PPPL
viewing windows, weldment	4			10		8	PPPL
window covers, mounts	20			5		2	PPPL
shutters & actuators	30			20		15	PPPL
optics rail supports	10			5		5	PPPL
temperature control	5	5		5		5	PPPL
reviews and research support	20	5					PPPL
Collection optics (edge (30 ch) & core (25 ch))							
adjustments	50		90		20	10	PPPL
optimize 2 optical designs	60						PPPL/GA
2 collection lens assemblies	10		40				PPPL
2 sets lens mounts	10		10				PPPL
2 fiber optic holders	60		60				PPPL
2 set fiber bundles (2x25x50 m)	20		200				PPPL
assemble and test 2 systems					70	20	PPPL
reviews and research support	50	5					PPPL/GA
Detection system (20 polychromators initially)							
temperature controlled room with services		10		50			
polychromators			250				GA
electronics (5 ch per poly)	20		250				PPPL/GA
synchronization	20		30				GA
data acquisition	20		40				GA
data analysis software			60				GA
calilbration hardware & software	20		60				GA
initial calibrations					60	30	GA
reviews and research support	50	5					GA/PPPL

Core and Edge Thomson Scattering Systems including Bay N Cassette

(possible division of effort)

	DESIGN ($k) (work to-date not included)		FABRICATE / PROCURE ($K)		INSTALL / COMMISSION ($K)		Possible US participants
	US	KO	US	KO	US	KO	
Laser systems (1 50 Hz Nd:YAG laser initially)							
laser-safe room with services		20		20			
Nd:YAG laser		10		100			
control and timing interface		20		20			
optical benches, supports		10		30			
multi-beam delivery optics, mounts, shutters, power meters, etc		25		30			
baffled input tube with window, valve		20		20			
beam dump		20		20			
laser system commissioning						50	
reviews and research support	20	20					GA/PPPL
Commission with plasma					80		GA/PPPL
totals	529	175	1090	410	150	165	

Summary		US	KO
Design		529	175
Procure or Fabricate		1090	410
Install and Commission		150	165
	Subtotal	1769	750
Escalation	(8%		
= average over 3 years)		142	113
Contingency 20%		382	173
	Total	2293	1035

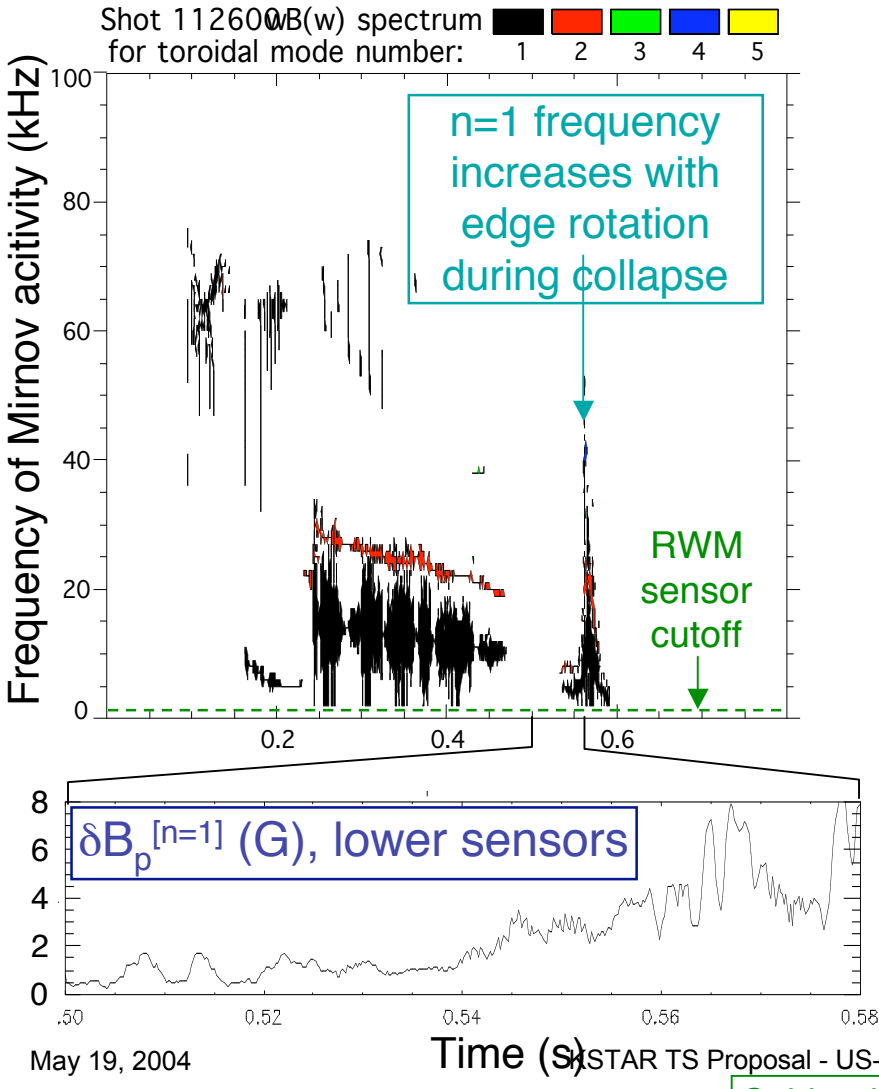
3 Year Program if fully funded

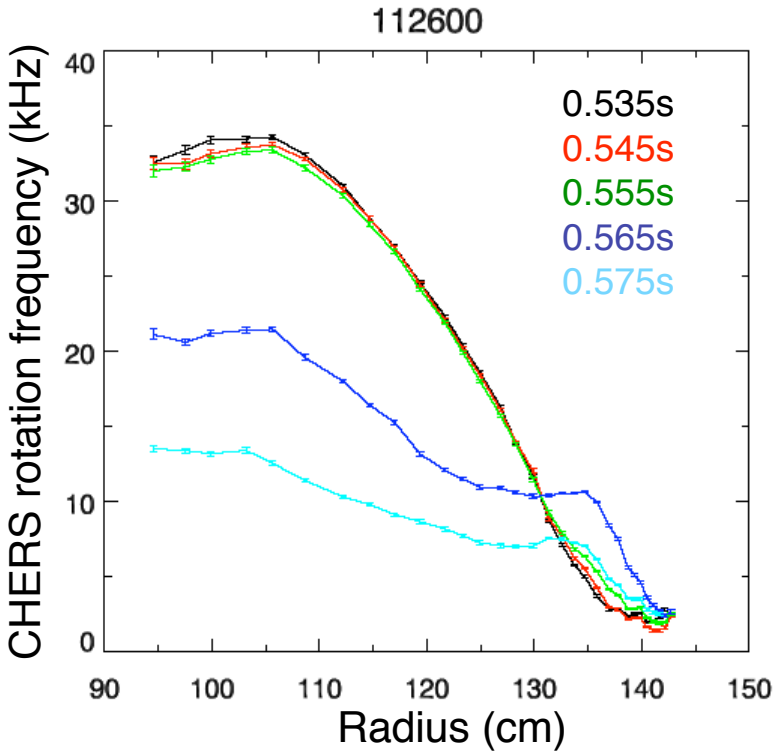
Summary

- Profile diagnostics will be essential to the success of the KSTAR research program, and early implementation will guarantee maximum impact for a growing program.
  - Proven expertise in the US is interested in teaming with KSTAR to provide TS, CER, and MSE diagnostics.
  - If the US is involved in these systems, it will confront many technical challenges that will benefit the US program and US participation in ITER diagnostics.
  - Two to three years will be needed to implement these systems, including a commissioning phase of several months.

- KSTAR has an excellent start on a Thomson system. However, work needs to accelerate to be able to provide basic profiles needed for early research.
  - PPPL and GA propose to provide major components for core and edge Thomson systems and to team with KSTAR to implement and commission these systems.

RWM Sensors Detect Mode in High β_T Plasma





- Global rotation collapse consistent with neoclassical viscosity due to ideal RWM perturbation

Sabbagh, Bell, Menard