[DP1.105]

Thomson scattering on the MST RFP: Progress and Plans

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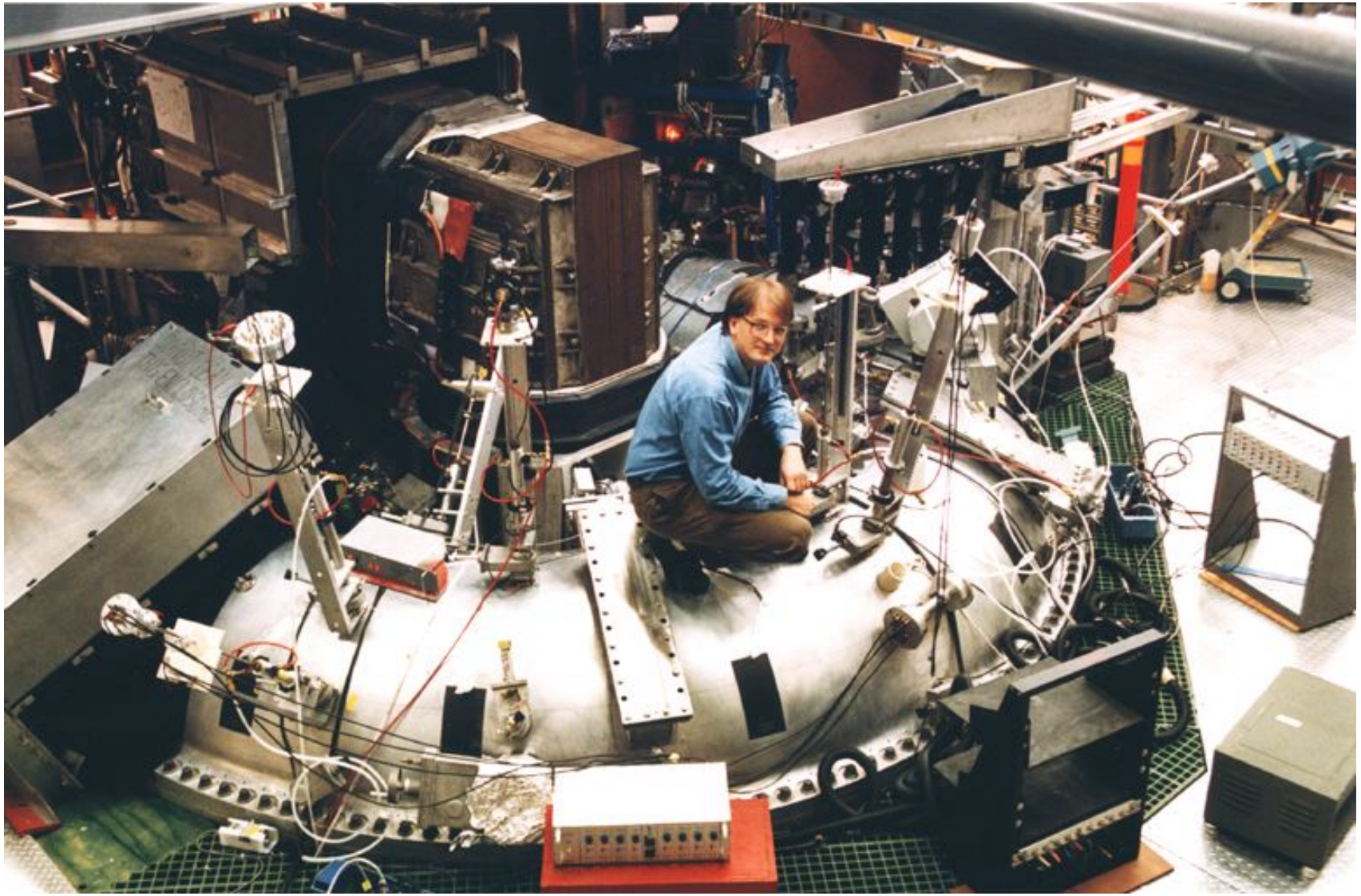
The single-point Thomson scattering diagnostic on MST has been upgraded and a new multi-point, multi-pulse diagnostic is being constructed. The ruby laser single-point system has been upgraded with avalanche photodiode detectors, resulting in increased quantum efficiency, broader wavelength coverage, and improved system etendue. The low density limit for reliable measurement of electron temperature has been reduced by a factor of five. In addition, the improved sensitivity will allow double-pulsing the laser to yield measurement of rapid (10 - 500 microseconds) temperature changes during a discharge. The new Thomson scattering diagnostic being constructed will feature 20 radial measurement points and two Nd:YAG lasers, each capable of 2 J/pulse. Each laser can be pulsed at an arbitrary time during the discharge, or may be repetitively pulsed at 50 Hz with reduced pulse energy. Filter polychromators have been purchased from General Atomics; collection optics and fiber bundles are being procured. We present measurements of component performance and projections of system performance. First operation of the multi-point system is expected in 2001.

Madison Symmetric Torus

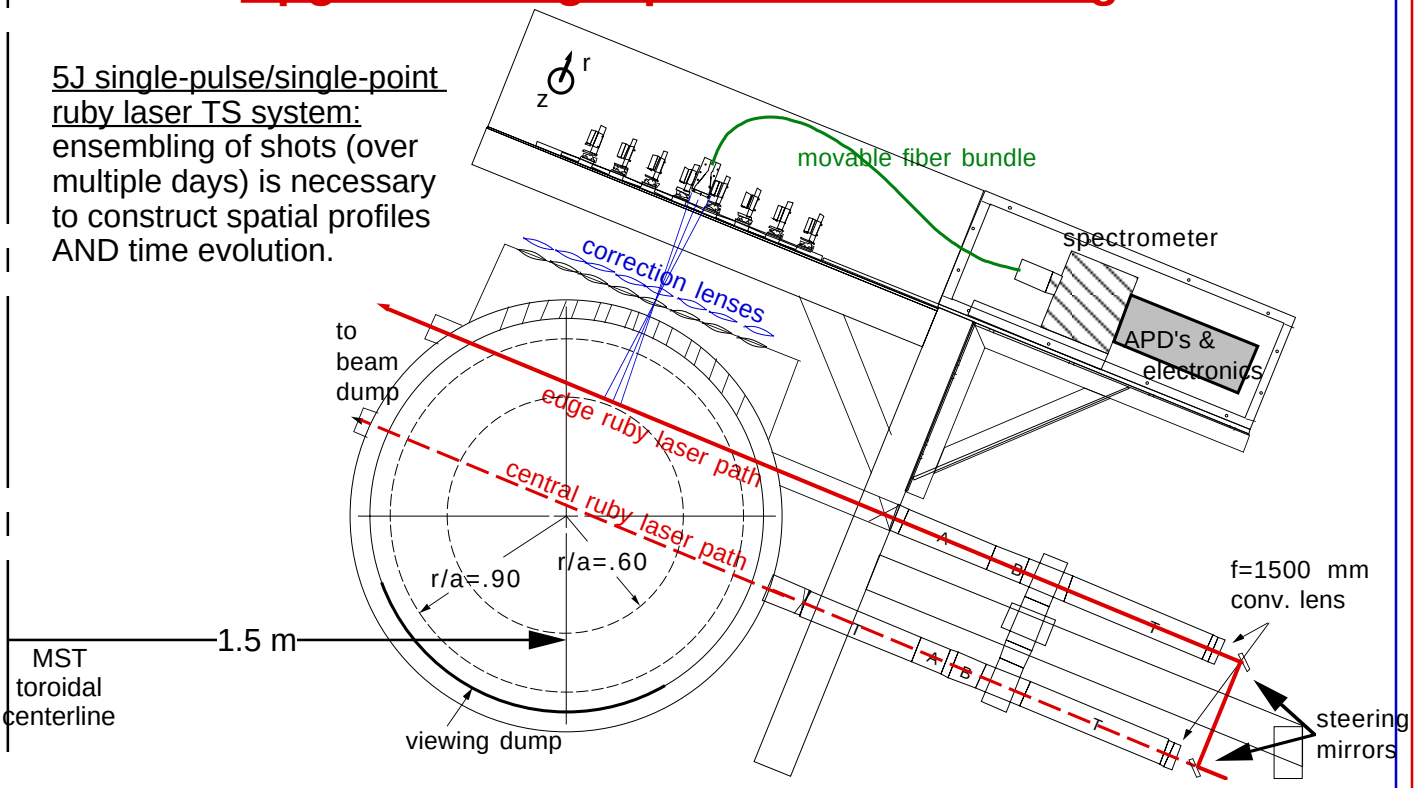


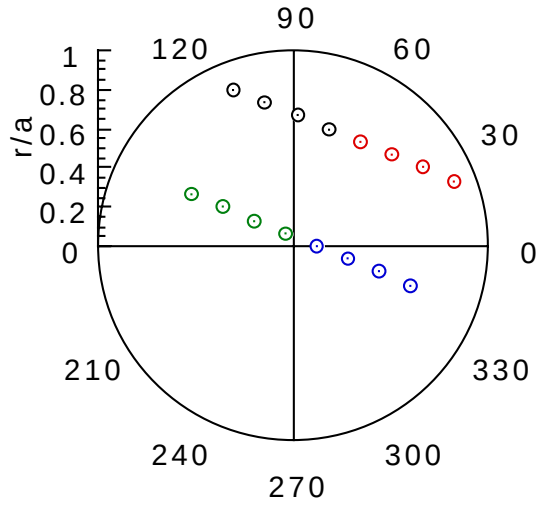
MST Reversed Field Pinch

- Plasma current: **500 kA**
- Discharge duration: **60 msec**
- Best confinement times: **5 msec**
- Typical $\mathbf{n_e = 10^{19}\ m^{-3}}$, highest $\mathbf{T_e = 800\ eV}$
- R = **1.5m**, a = **0.52m**
- **50mm** thick aluminum wall serves as 1 turn toroidal field coil, stabilizing shell and vacuum vessel

Upgraded single-point Thomson Diagnostic

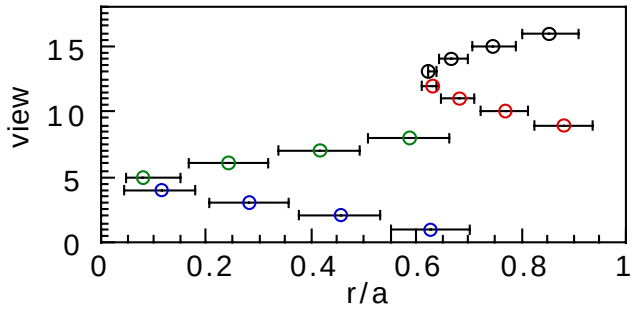
5J single-pulse/single-point ruby laser TS system: ensembling of shots (over multiple days) is necessary to construct spatial profiles AND time evolution.





Thomson Scattering Views

view	r/a	ϕ
1	0.627	-18.46
2	0.455	-16.93
3	0.283	-13.53
4	0.115	0
5	0.080	123.91
6	0.244	147.06
7	0.415	151.39
8	0.587	153.19
9	0.882	22.28
10	0.769	31.41
11	0.681	43.26
12	0.630	57.76
13	0.625	73.61
14	0.666	88.59
15	0.746	101.10
16	0.854	110.82

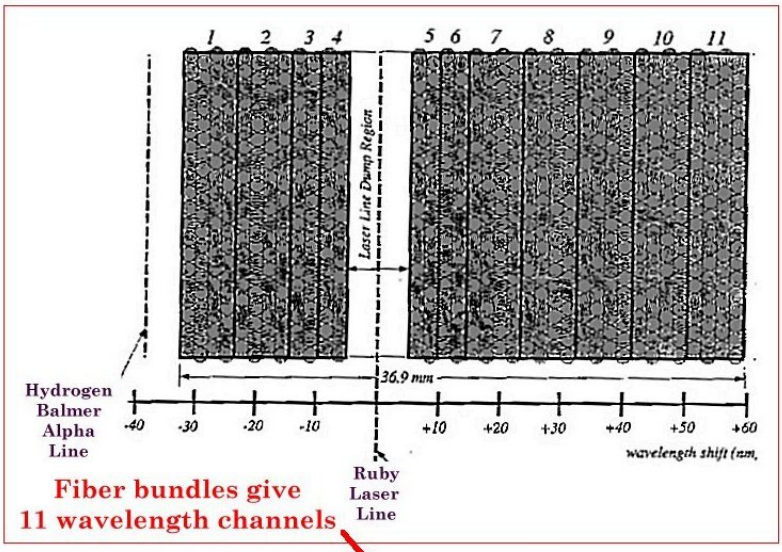


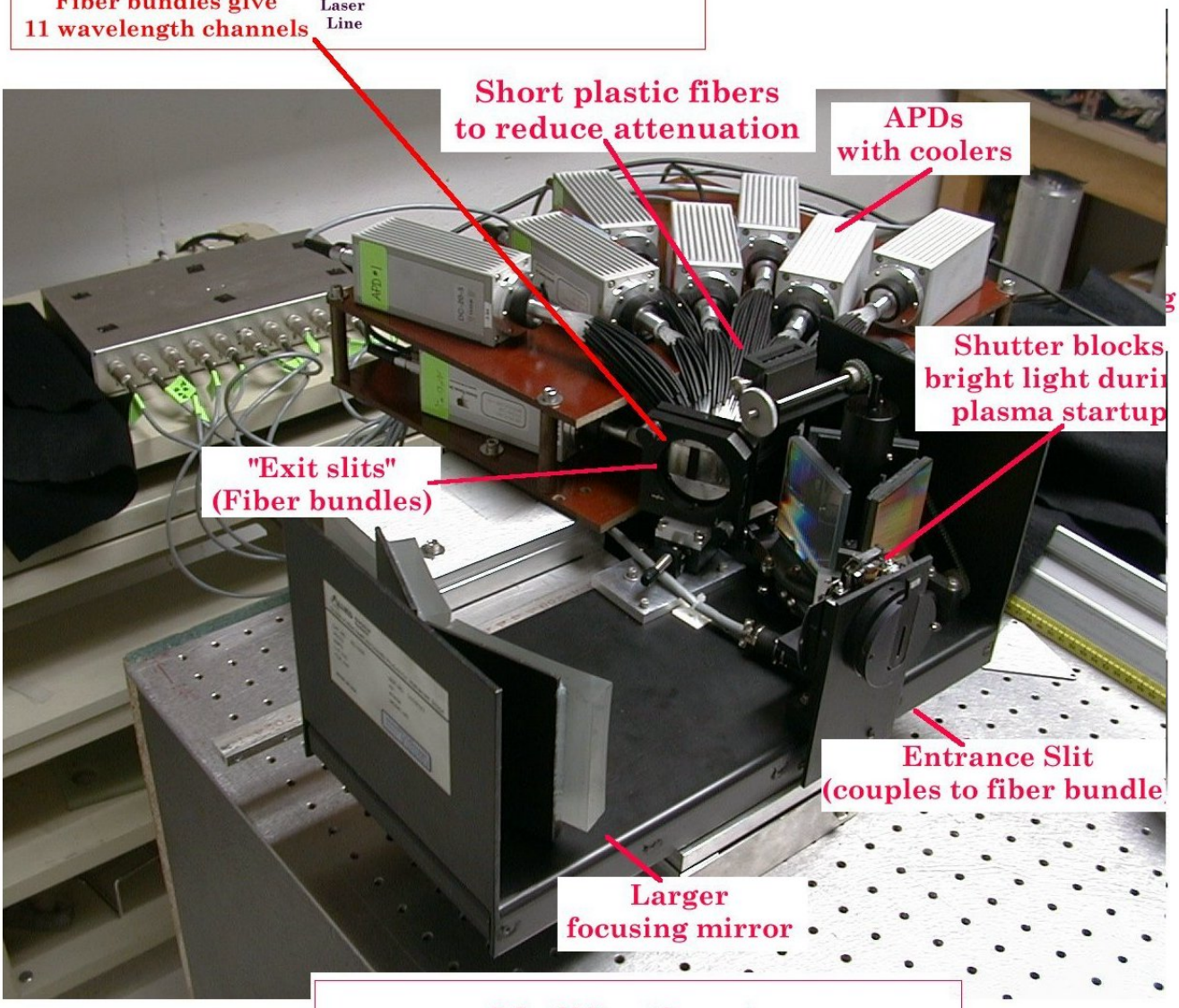
error bars indicate radial range of scattering volume on each view

Upgrade to present Thomson system gives 5x improvement

- System upgrades:
  - Replace MCP detector with APDs
  - Modify Spectrometer
  - Fiber Optic light collection
- Te measurement now possible at 5x lower density

Spectrometer was modified to increase wavelength coverage





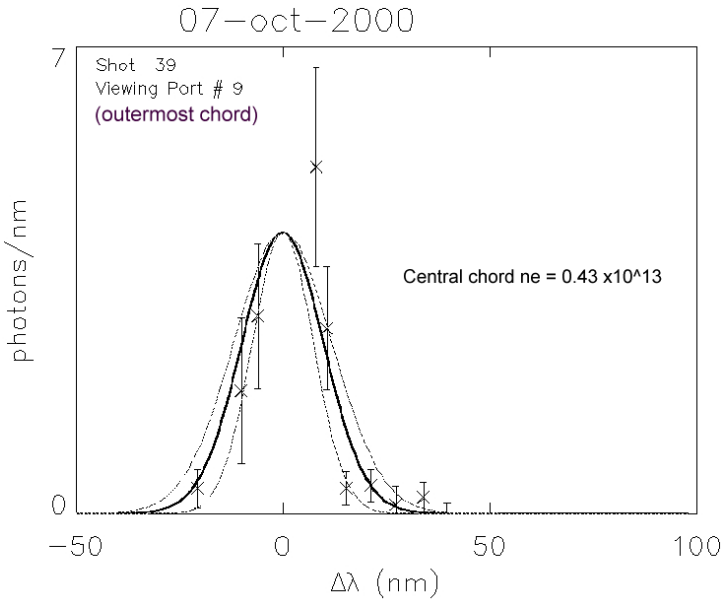
Modifications to Jarrell-Ash 275 mm spectrometer

APDs improve S/N

- Original detector: MicroChannel Plate
  - photocathode Quantum Efficiency q.e.=6.5 %
  - MCP amplification adds noise: noise factor F = 2.2, gives η_{eff}**=3 %**
- Upgrade detectors: Avalanche Photodiode
  - η=85 %
  - APD amplification adds noise: noise factor F = 2.8, gives η_{eff}**=30 %**
  - APDs are Advanced Photonics, have built-in Thermoelectric Cooler

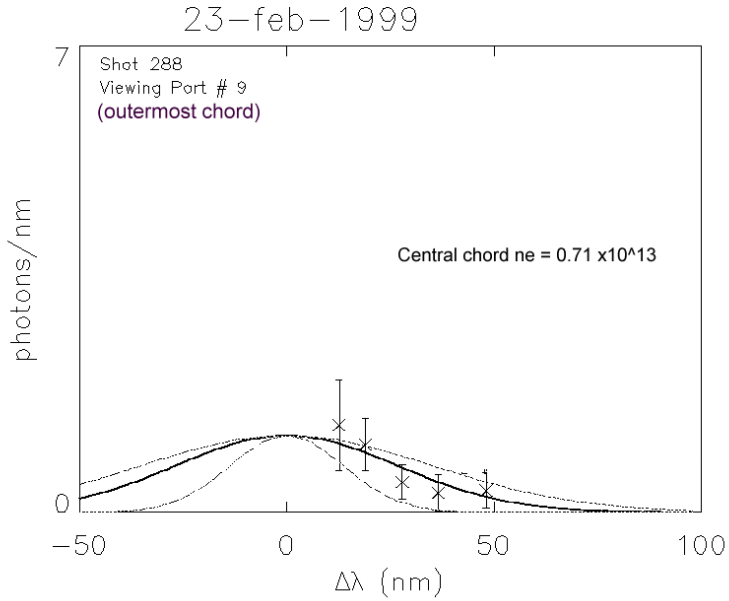
Upgraded system gives improved Te measurement at low density

Upgraded system gives good Te measurement even on outer chords.



(typical single-shot edge measurement, upgraded system)

Old system signal from outer chords was too weak to measure single-shot Te.



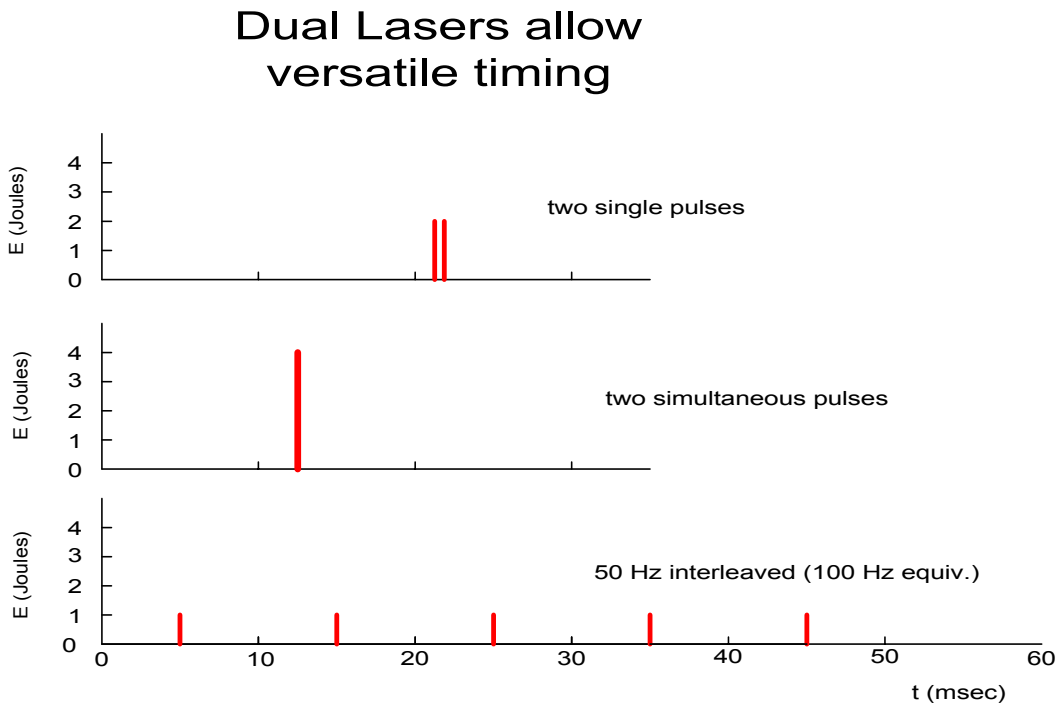
(typical single-shot edge measurement, old system)

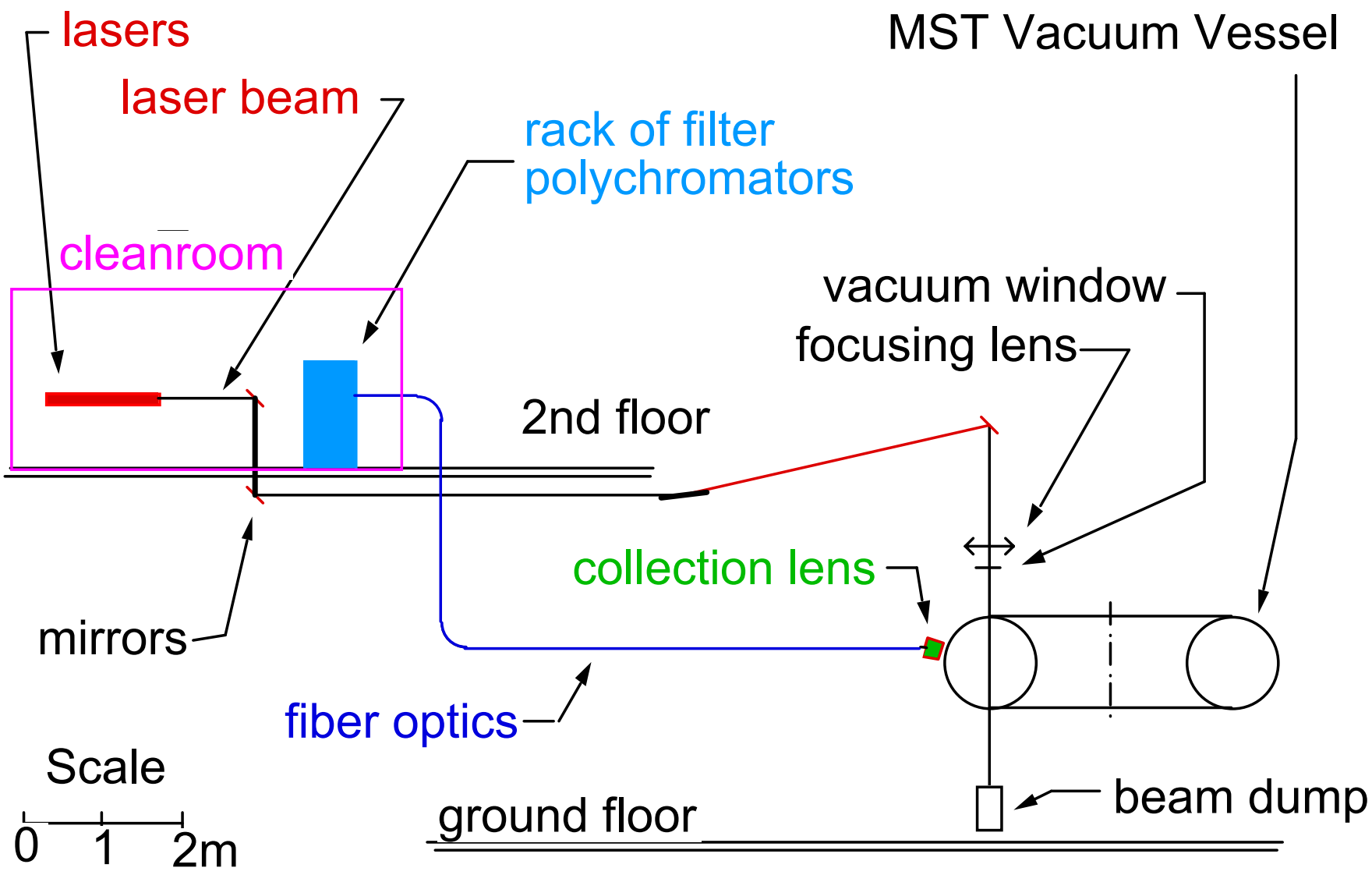
Data from upgraded system (left trace) shows

– more photons / wavelength channel
– more wavelength coverage (11 channels vs. old 5 channels)
– larger signal even though density in this shot is lower

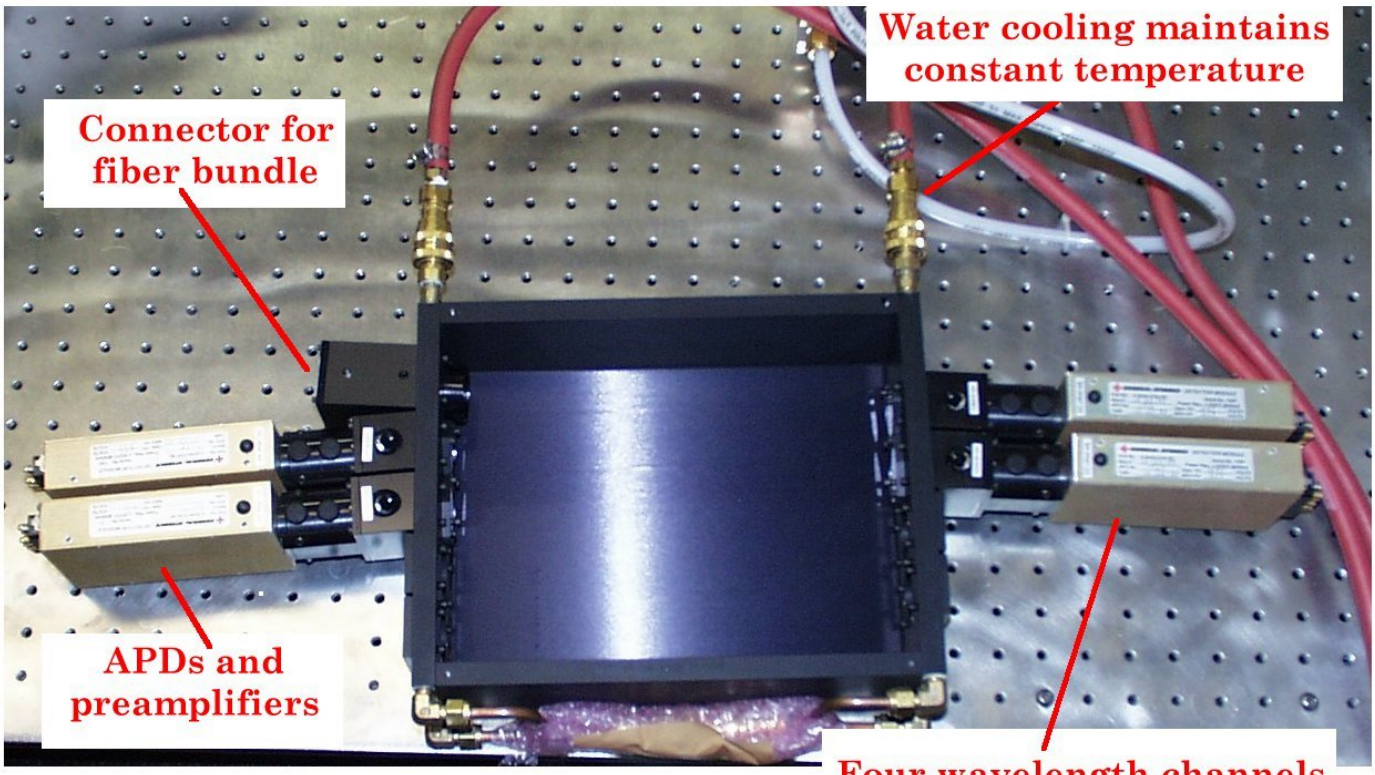
New Multipoint Multipulse Thomson System is under construction

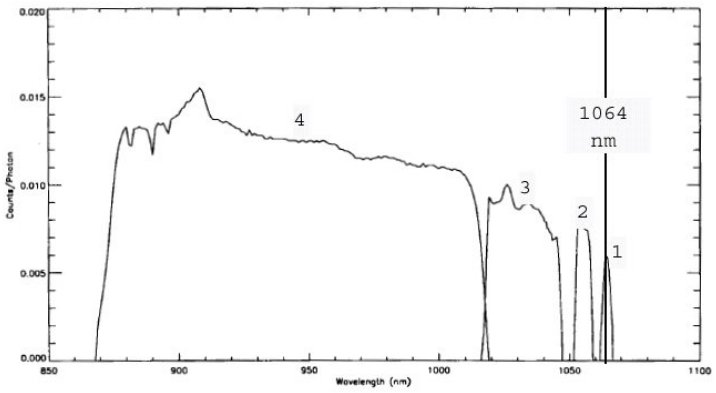
- 20 point profile
- Optimized filter polychromators (G. A.)
- Dual Nd:YAG lasers for versatile pulse timing
- First data expected 2001



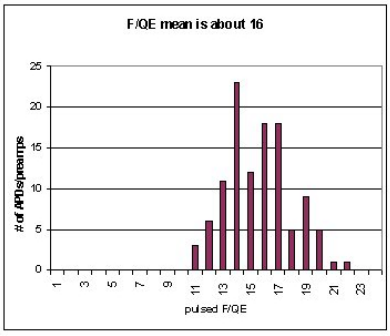

lasers
laser beam
rack of filter
polychromators
MST Vacuum Vessel
cleanroom
vacuum window
focusing lens
2nd floor
collection lens
mirrors
fiber optics
Scale
0 1 2m
ground floor
beam dump

Filter polychromator (one of twenty) by General Atomics



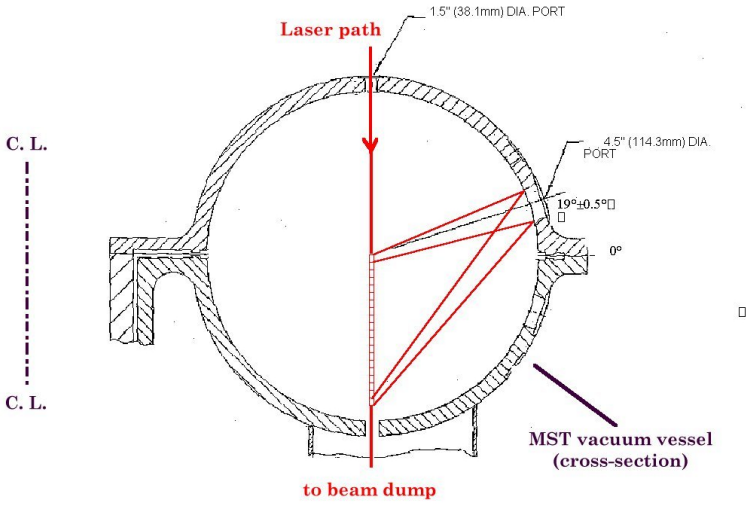


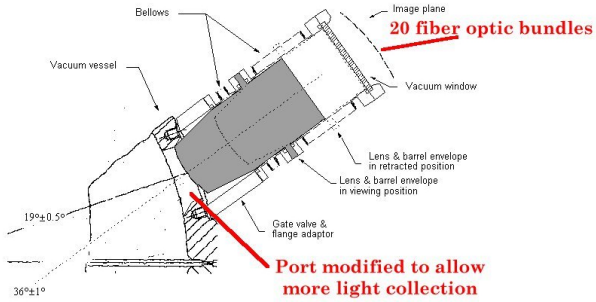
3 wavelength bands (plus center wavelength)



APDs were not selected for low noise

Lens collects light from 20 radial locations

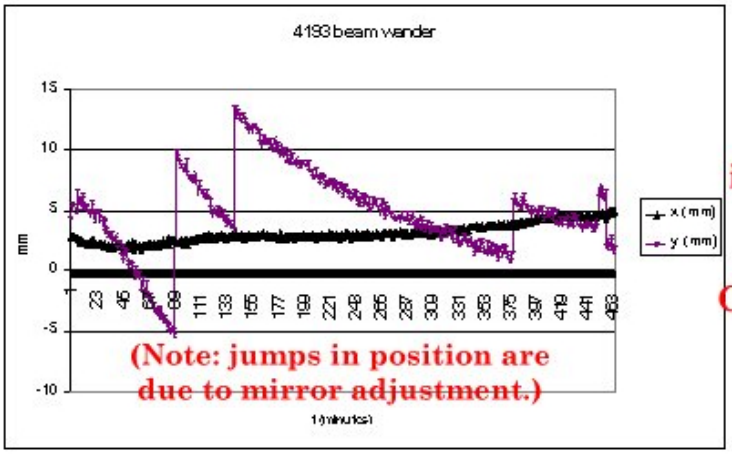




Vacuum chamber moves < 0.2 mm during plasma shot -- can mount optics to vacuum vessel.

Collection lens specs have been sent to vendors for bid.

Lasers will be housed in air-conditioned room. (Initial tests were done with no room temperature control.)



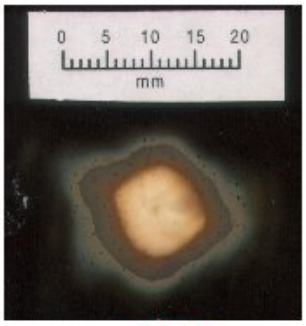
Slow drift (30 mm at distance 17 m, time 8 hrs) is due mainly to thermal motion of mirrors and laser.

Cooling and active beam steering will correct slow motion.

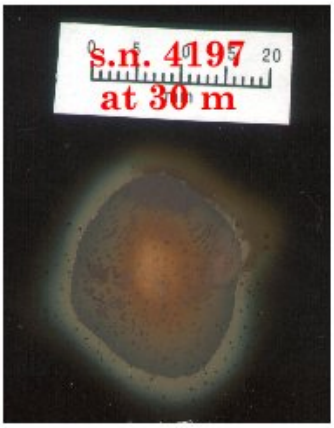
Residual fluctuations (1.5 mm at 17 m) are tolerable

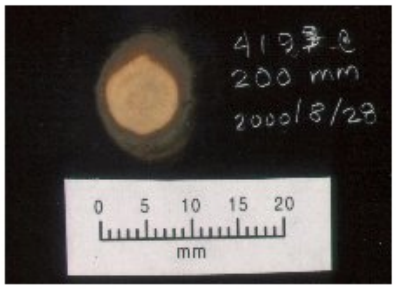
Burn patterns show laser beam quality good in single pulse mode (2J/pulse). (50 Hz beams not yet satisfactory)

s.n. 4197
at laser
(single pulse)

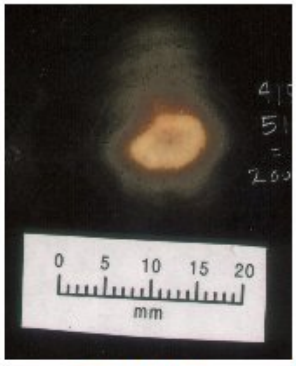


s.n. 4197
at 15 m
(single pulse)

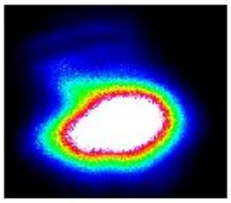


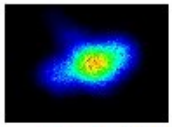


s.n. 4193
at laser
(single pulse)



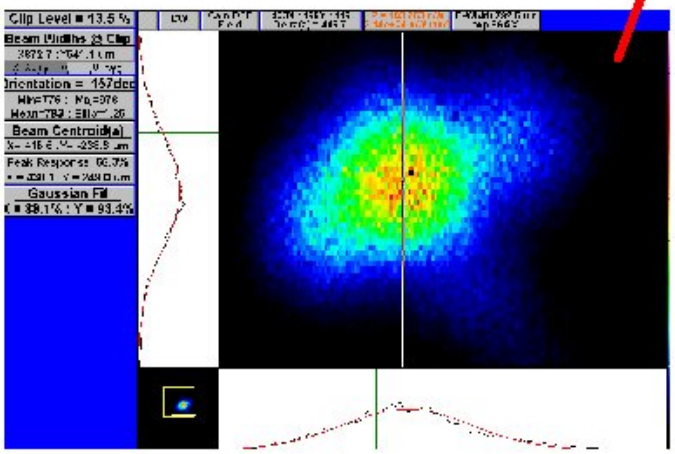
s.n. 4193
at 13 m
(single pulse)



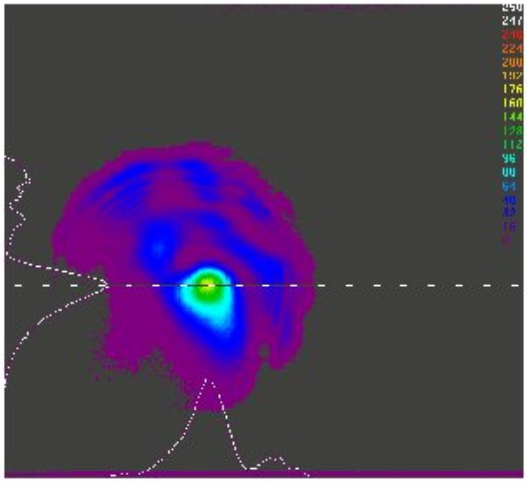


s.n. 4193
at 13 m (ccd)
(single pulse)

s.n. 4193
at 17 m
(single pulse)



profile at 17 m (single shot)
approx. gaussian



Typical far field ccd image
at 50 Hz rep rate

Conclusion

- MST's single-point Thomson system has been upgraded to increase its sensitivity 5x.

- MST's multi-point, dual laser Thomson system, will measure Te at 20 locations, several times per plasma shot. First operation is expected in 2001.

Note: Electronic copy (.pdf) of this poster is available at