Comments on Diagnostic Upgrade Options

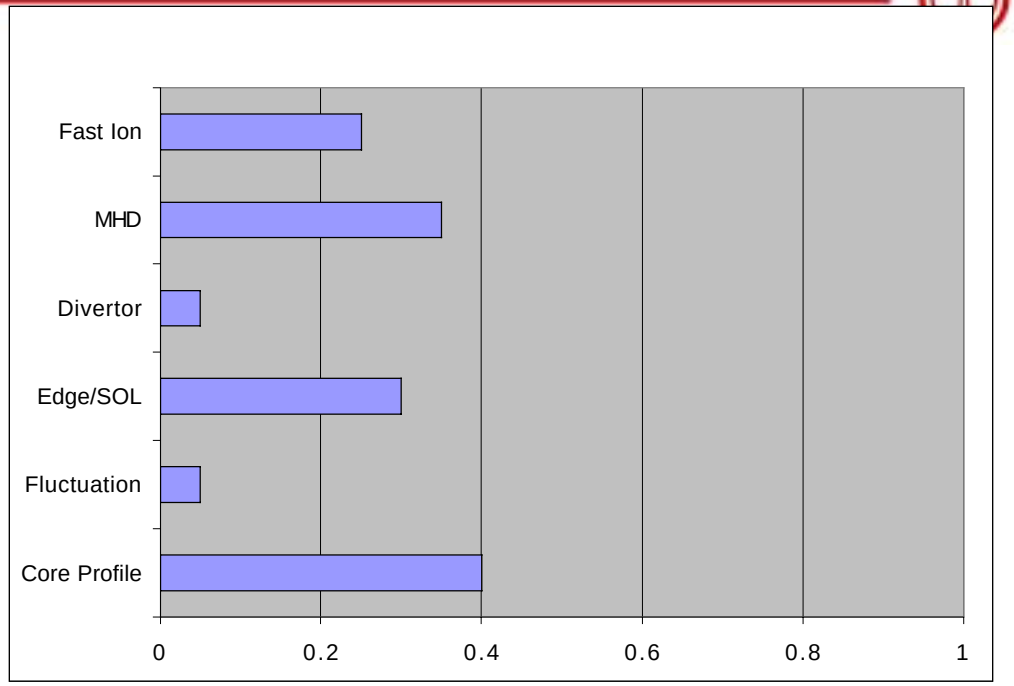
David Johnson

Presented at 5-year Plan Review

June 24 - 26, 2002

NSTX Diagnostic Status

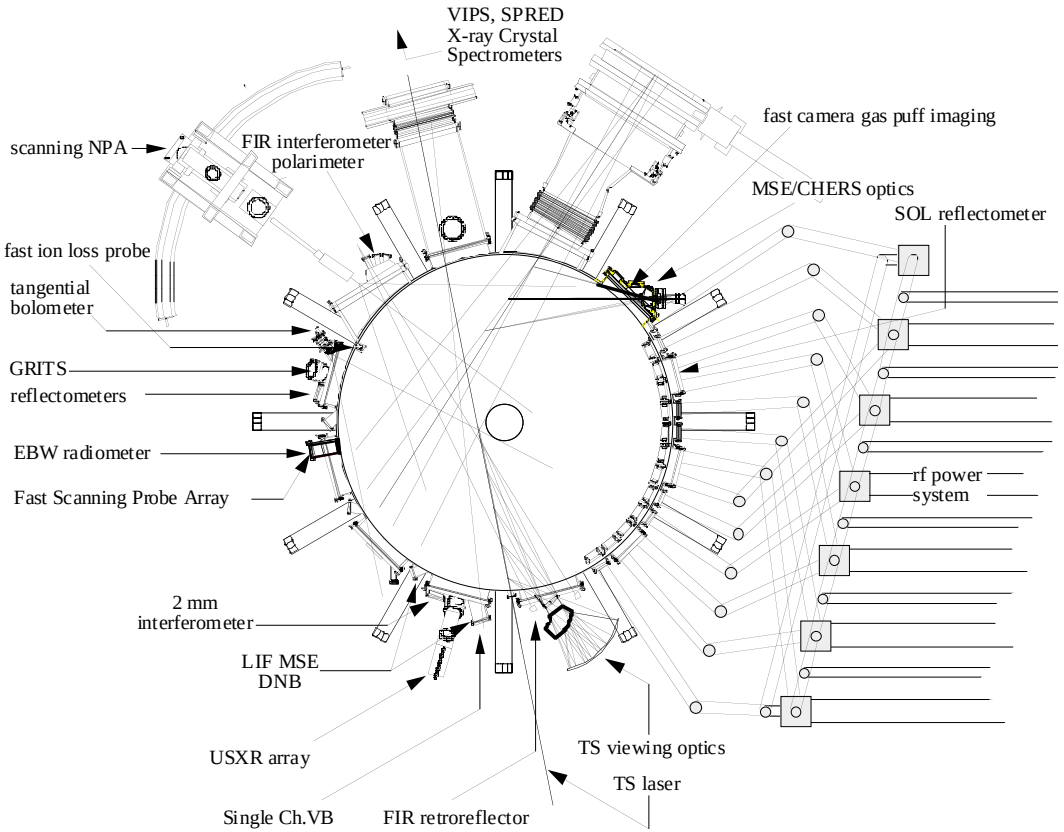
(personal assessment in AU)



- By design, the current diagnostic capabilities are stronger in some areas than in others.
- Obviously, there is a tension between focusing on specific topical areas vs bringing up capabilities in all areas.
- There is also a tension between time and money for run time vs upgrades. Over the next few years, run time appears to have high priority.

Port Space Limited

- Midplane port access very limited
  - Even gaps between large midplane port nearly fully utilized
- Divertor access currently limited.
  - Use of horizontal divertor ports requires in-situ machining of support structures



CS/κ=3.0 Upgrade Implications

- New CS ™ MPTS laser re-aiming necessary
  - Modify laser beam input
  - may not be possible to use pumping duct ™ new dump

- New PP structure ™ optical systems for many key profile diagnostics (MPTS, CHERS, MSE) optimized for maximum resolution (~0.5 cm) at current outer edge location. Rework needed to provide comparable performance if outer edge moved in ~ 20 cm.
- New passive plate structure may impede views of other diagnostics
- May want to consider new outer cylinder with more optimized access while down for new passive structure
- PP redesign may provide opportunity for increased diagnostic access to divertor region.

Warnings on Data Analysis Time

- Recently full-up analysis for 20 point MPTS evolutions has been put on parallel processors, in order to be available between shots.

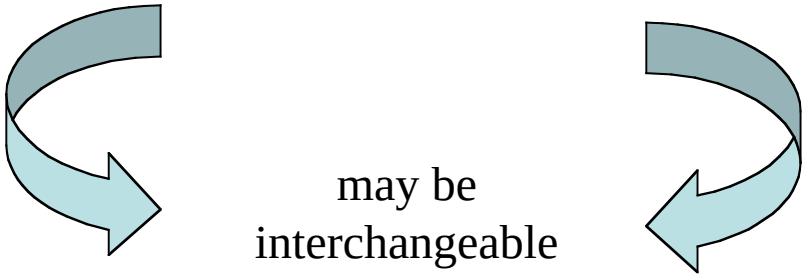
- Based on scaling from current analysis, full 51 channel CHERS system will require > 1 hour for full profile time evolution of single shot. Need to parallelize.

- Between shot kinetic EFIT analysis will need this data.

Diagnostic Type

Diagnostic ideas being considered
at this meeting for:

- Current capability
- Next 2 years
- More distant future



- issues, gaps, etc

FORMAT FOR MUCH OF WHAT FOLLOWS

Magnetics

- Extensive complement of flux loops, 1-D and 2-D B_z sensors for control.
- Mirnov coil arrays (500 kHz)
  - 12 toroidal
  - 12 poloidal gap
- High freq. Mirnov coils

- Repair CS sensors
- GMS sensors (12 B_r, 12 B_z ™ 24/24??)
- CHI absorber flux loops
- Improve DAQ for high freq. & more time for existing sensors.
- Improve leads and shielding for high f noise immunity.

- ??

- CHI vessel current monitors?
- High freq. Mirnov sensor on fast scanning probe?

Visible and IR Cameras

- 3 fast cameras
  Wide angle (LANL)
  GPI (LANL, PSI)
  Divertor (Hiros.)
- 2 compact IR cameras (problems with speed, reliability)
- 2 1-D CCD cameras
  Divertor view
  CS view

- Increase throughput and tweak position of GPI view optics
- Increase senitivity of discrete detectors for GPI view
- 2-color GPI imaging
- Change position of divertor fast camera
- Fast, reliable IR camera with IR periscope
- Better edge view for H_α 1-D CCD camera

- LIF with Ar for edge turbulence

- Widen existing wide angle view to see edge???
- Vertical, wide-angle visible, IR view of lower divertor???
- Pellet plume measurements of pitch angle (CMOD, TFTR, JET, MAST,??)

Probes

- Tile-mounted Langmuir probes in divertor
- Midplane Fast scanning edge probe with 10 tips
- Dynamo probe head for fast scanning midplane probe
- Inner and outer divertor plate probe arrays
- Divertor fast scanning probe
- DIMES probe

- RF probe??
- Can fast Mirnov coil be used on fast scanning probe?
- Divertor fast scanning edge probe will probably require rework of lower dome flange on vessel.

Thomson Scattering

- 20 channel, 60 Hz complete profile

- 90 Hz (new laser)
- Consider rearrangment to use existing detectors & electronics for 30 spatial channels, higher edge resolution
- Use MPTS optics for VB measurements of Z_{eff} routinely
- Input raw MPTS data into PCS system

- Instrument full 40+ channel capability on existing system
- Divertor TS ??

- ??

CHERS (T_i, v_θ, v_ϕ, $N_{carbon}(R)$)

- 15 channel, 50 Hz, axis to outer midplane edge, viewing, viewing C
- 51 ch. (0.5 cm edge, 3.0 cm core), 100 Hz, viewing C.
- Edge rotation
- Poloidal rotation (dual view of axis to edge)
- Other lines (He, B, ??)
- HFCHERS?
- ??

MSE

- MSE/CIF (03)
  2 ™ 10 ™ 19 channels,
  5 ms
- MSE/LIF (04-05)
  19 channels
  5 ms
- High resolution edge MSE
- HFCHERS with high throughput MSE view & detectors?

- MSE highly developmental - need backup
  - Pellet plume measurements
  - Reflectometer measurements of pitch angle at edge
  - Dual mode reflectometer measurements of |B| at edge
  - Radial polarimetry for q(0)
  - T_e contours by x-ray imaging

Other Active Spectroscopy

- Helium line ratio edge spectroscopy for T_e, n_e in SOL, edge, perhaps with supersonic jet helium source.
- Laser blow-off for perturbative impurity transport
- TESPEL pellet + x-ray telescope for impurity transport

- BES fluctuation imaging to extend fluctuation imaging farther into core $0.75<\rho<1.0$.

Passive Spectroscopy

- VIPS-1 and VIPS-2 visible survey instruments (one with UV view).
- SPRED UV survey instrument
- TGS UV imaging spectrometer prototype
- Filterscopes (D_α, C, VB, B, etc.)
  - ??

- Detector upgrades for VIPS-1 and SPRED
- High resolution filtered AXUV array for fast pedestal measurements.
- TGS routine operation

- Divertor SPRED
- High throughput spectrometer for divertor flow measurements

Bolometry

- 18 channel tangential AXUV camera
- 4 channel prototype horizontal divertor foil bolometer
- 16 channel horizontal divertor foil bolometer
- 16 channel vertical divertor foil bolometer
- ??

Fast Ion Diagnostics

- Horiz.& vertical scanning NPA
- iFLIP Faraday cup fast ion loss probe, radial resolution only
- 2 natural diamond detectors with crude energy resolution
- Neutron flux monitors
- Scintillator-based fast neutron detector
- IR camera views of RF antenna, beam armor

- ??

- Increase NPA scanning range
- sFLIP scintillator fast ion loss probe with pitch angle and energy resolution

- ??

X-ray Crystal Spectroscopy (T_i, T_e)

- Single sightline, horizontal system viewing core, uses Ar puff

- 2-D detector upgrades to provides an array of ~8 sightlines resolved to ~ 5 cm

- Vertical viewing system for line ratio measurements of Fe, other impurities relevant to solar flare research

- ??

X-ray Imaging

- 4 x 16 ch AXUV arrays
- Tangential pinhole camera 12x12 GEM detector (100 kHz)
- ??

- Additional reentrant 16 ch. AXUV array for good vertical view
- Ultra-fast, wide angle, tangential soft x-ray camera, large image tube and PSI CCD, 64x64 pixels, 300 frames @ 1 MHz)
- 32x32 GEM camera

- 64x64 channel scintillator-based, ASIC processors for ‘continuous’ sampling at 100kHz
- ??

EBW Emission ($T_e(R,t)$)

- EBW receiver at 2 locations viewing normal to edge
  - Looking thru midplane reentrant window
  - ORNL reflectometer at RF antenna
- Normal receiver with 2 movable limiters for grad-n_e control, and with integral reflectometer for local grad-n_e measurement
- ??
- ??

Interferometry/Polarimetry

- 2 channels FIReTIP tangential interf./polarim.

- 4 ™ 7 ch FIReTIP
- Single channel, radial 1 mm interferometer (reflect off centerstack) for $n_e l$ measurements, line integrated fluctuation measurement (low k)
- Multichannel 1 mm interf./ polarim. for B-fluctuations, q(0), in addition to above

- Radial multichannel FIR polarimetry??

- PCI diagnostic for RF wave physics??

Reflectometry

- SOL reflectometer in RF antenna (ORNL) SOL n_e profiles
- Edge reflectometer (UCLA) for edge n_e profiles, correlation lengths, |B|

- Add higher frequency channel to UCLA system to extend to smaller R.
- Instrument additional Bay J horns for pitch angle measurements
- Imaging reflectometer (like on TEXTOR) for imaging low-k fluctuations

- ??

- Limitations due to flat density profile.
- Imaging reflectometry needs large midplane window.
- Reflectometry for RF wave physics??

Microwave Scattering

- Tangential 1 mm scattering for high k measurements (k_r ~10,20,30 cm^{-1}) at ρ ~.75.
- Radial 1 mm forward scattering provides both k_{perp} and radial resolution over much of profile??
- Radial 3 mm backscatter probes k_r ~ 35 - 40 cm^{-1}

- Radial forward scattering system requires extensive modifications to pumping duct for viewing access.