Princeton Plasma Physics Laboratory

NSTX Machine Proposal

Title: Scanning of Divertor Strike-point for Langmuir Probe Profiles

OP-XMP-46	Revision: **0**	Effective Date: March 3, 2006 *(Ref. OP-AD-97)* Expiration Date: 3/3/2008 *(2 yrs. unless otherwise stipulated)*

Procedure Approvals

Author: C. Bush, V. Soukhanovskii, D. Gates, D. Mueller	Date 3/3/06
ATI (NSTX Physics Ops): D. Mueller	Date 3/3/06
RLM (NSTX Experimental Research Ops): M. Bell	Date 3/3/06

Responsible Division: **Experimental Research Operations**

Procedure Requirements
designated by RLM

	NSTX Work Permit (TBD)		Lockout/Tagout (OP-AD-61)
	TFTR Work Permit (OP-AD-09)		Door Permit (OP-G-93)
	Tritium Work Permit (OP-AD-49)		T-MOD (OP-AD-03)
	RWP (HP-OP-20)		Lift Procedure (ENG-021)
	Confined Space Permit		DCA/DCN (OP-AD-104)
	Pre-job brief (OP-AD-79)		ATI Walkdown
	USQD (OP-AD-63)		Independent Review
	Master Equip. List Mod (OP-AD-112)		ES&H Review (NEPA, IH, etc)

MINOR MODIFICATIONS

REVIEWERS (designated by RLM)
ATI
Test Director
Independent Reviewer
D-Site Shift Supervisor
NSTX
TFTR Caretaking
Vacuum
Computer
Tritium
QA/QC
AC Power
FED
ECS/MG
FED
ERWM
Water
NB
RF
Diagnostics

TRAINING (designated by RLM)

Training required: No ■ Yes ☐ Instructor _____

Personnel (group, job title or individual name)	Read Only	Instruction	Hands-On

Training Rep. _____

RLM _____

NSTX MACHINE PROPOSAL

TITLE: Scanning of Divertor Strike-point for Langmuir Probe Profiles **OP-XMP-46**

AUTHORS: C. Bush, R. Kaita, V.A. Soukhanovskii, et al. DATE:

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1. Overview of experiment:

The goal of this XMP is to cross-check strike-point location with probe profiles. Also, to develop a strike-point sweep rate which is fast (rate of 5 cm per 50 to 100 ms) compared to the density rise-time for use in the daily fiducial and other experiments.

2. Justification:

The technique will provide information useful for NSTX experiments in general. However, it will be especially useful for the experiments early in the run, including the XP by V. Soukhanovskii, "Divertor heat load and detachment", and that by K. Williams, "Demonstrate and execute a controlled density scan." Results and fiducials will also be used by C. Bush to insure consistent Isat, Te and ne throughout the run and also to back check past data and for continuing probe physics studies (L-H transition, ELMs, etc.).

3. Plan:

Scan the strike points across the outer divertor plates to determine how well the deduced strike-point position agrees with the measured positions of the flush mounted Langmuir probes. **Figure 1** shows two possible X-point situations relative to the Langmuir probe locations. Both dynamic and static (shot-to-shot variation} strike-point scans will be used. Also, machine operators have indicated that it is difficult to scan the strike-points over the relevant radial positions in a single large dynamic scan. Use rtEFIT for control of strike-point.

Part 1. Outboard divertor scan only
To simplify, only the three outboard divertor plate probes will be scanned. This will allow
— Faster digitization rate (more IV points if needed) at same normal 100 Hz IV sweep rate
— Or normal 10 kHz digitization rate at IV rate of 100-400 Hz.

Possible means of scanning (sweeping) strike-point:

1) Raise and lower X-point height **(See Figure 2)**
   — or for single large sweep, start at low position and move up as far as possible without change in plasma.
2) Vary current in PF1A or PF3L
   — Also, possible use of PF1B or PF2L
3) Static or quasi-static maximization of Isat on one or more probe – determine coarse Isat and Te distributions. They are not necessarily symmetric about the strikepoint.
4) Vary kappa
5) Other (?)

Main parameters to monitor: Isat(+)

Shot Plan OP-XMP-46

Pre-preparation – Run codes, equilibrium code and Isolver to determine coil/current combinations to get the desired movement of the strike point. Use this information in the techniques and shot list below.

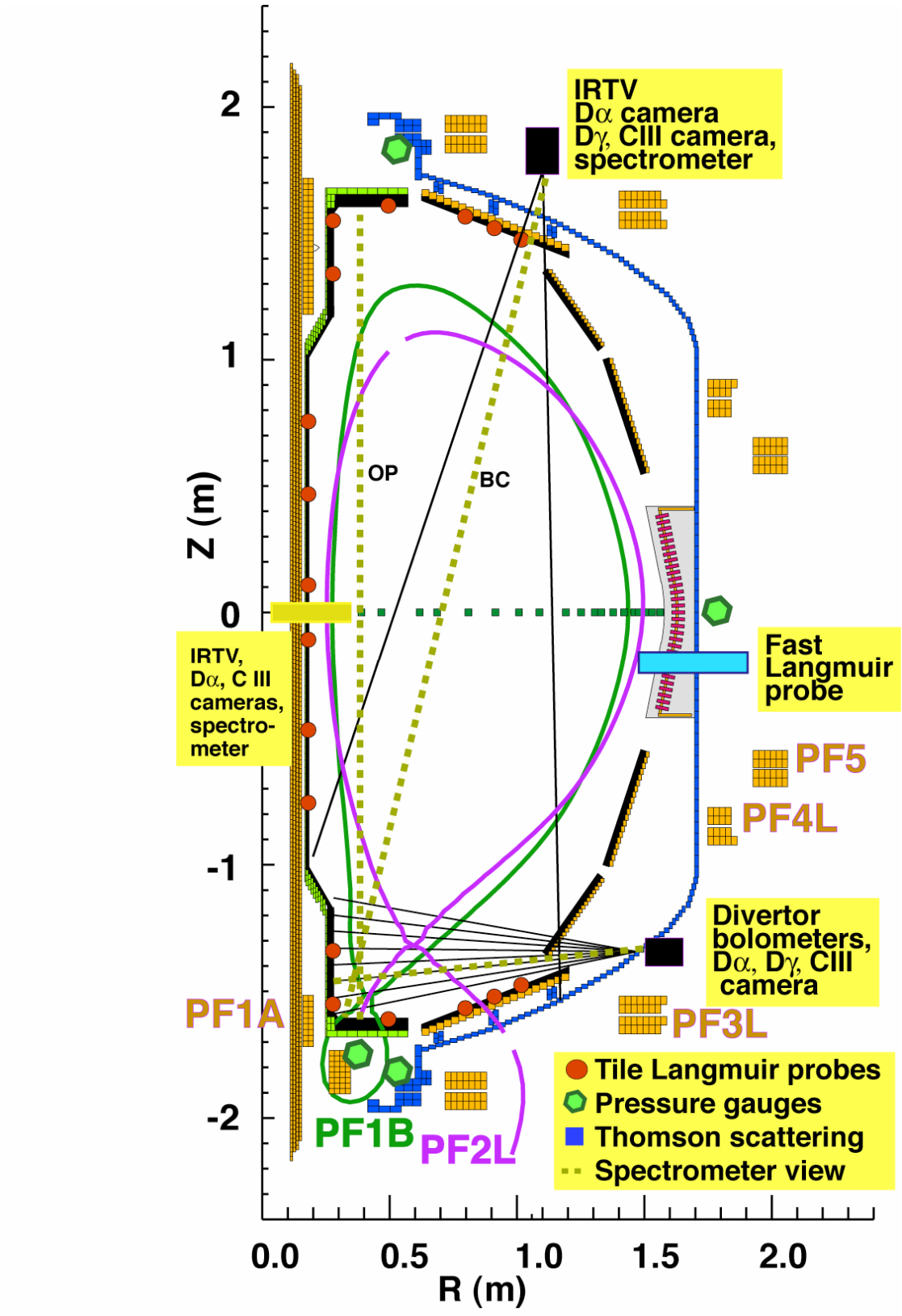
Results from Isolver are shown in **Figures 3 and 4.** These show values of various coils in going from one strike-point (X-point) to another.

Method A: Use the LSN divertor configuration. Raise X-point height on successive shots.
First attempts may require acceptance of some change in horizontal position.
(Note: Major radii of the three outermost outboard probes –R1, R2, R3 equal 0.797, 0.911, and 1.017 meters respectively.)
Start with shot **116488** 2 shots
Begin with Low X-point (Figure 4).
Use PF1AL – Go from 10 kA to -10 kA – Use rtEFIT if available
Static up/down positions of strike-point (use EFIT2 And LRDFIT)
Raise X-point until strike point reaches High X-point (Figure 3). 4 shots

Checkpoint: Does plasma change significantly from Low to High?

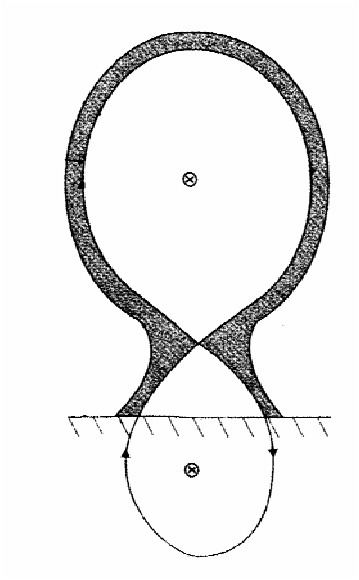
If NO, then do a dynamic up/down sweep from Low to High within a shot 2 shots

Method B: Vary current in PF1AL and/or PF3L or as required from Isolver
Locate strike-point at R2 (return to previous) 1 shot
Change PF1AL and or PF3L until strike-point goes
from R2 to R3. 2 shots
Checkpoint: Was there a significant variation in
plasma shape and properties?
If NO then do a dynamic scan of strike-point
using PF1A and or PF3L or other required 2 shots

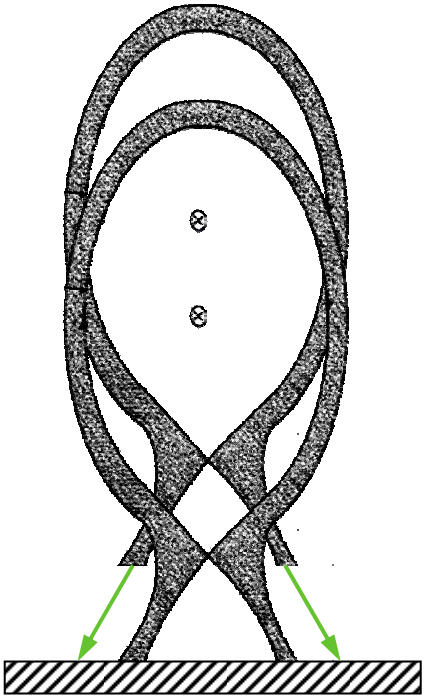


Soukhanovskii

Figure 1 – Shows the location of the Langmuir probes in NSTX. Also shows location of other diagnostics used in boundary physics.



Scrape off Layer (SOL)



Raise X-point and strike-point moves

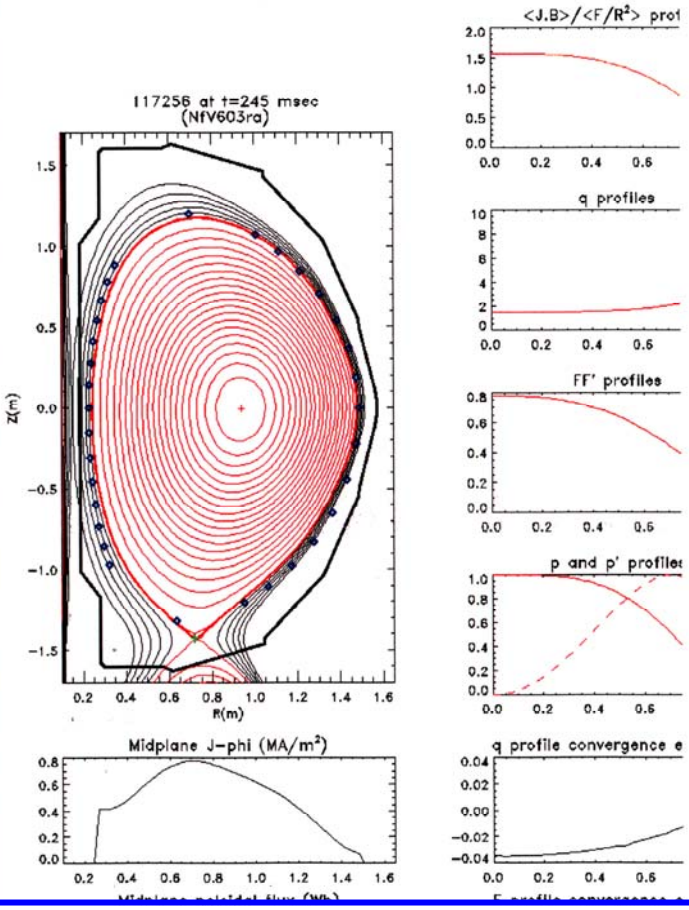
Figure 2 – Shows how strike-point position is changed by raising and lowering the X-point.

```
IDL> @iterate.idl
=====> F^2 iteration change =    2.8140306e-15
------------------------------------------------------------------------------
Plasma geom. center  R0 (m) =       0.86493466
Vacuum toroidal B at R0 (T) =      -0.43744780
Aspect ratio                =        1.4051060
Boundary elongation         =        2.0845644
Elongation at axis          =        1.7175994
Upper triangularity         =       0.22180188
Lower triangularity         =       0.23745546
q(0)                        =        1.4417240
q(95)                       =        6.1781746
q(99)                       =        7.7084209
q(min)                      =        1.4417240
rho q(min)                  =        0.0000000
Internal inductance         =       0.67116947
beta-t (%)                  =       0.030962447
beta-N                      =      0.0092704534
Stored energy          (MJ) =     0.00042379462
Ip                     (MA) =       0.89994335
ITF                    (MA) =       -1.8918188
beta-t     specified/actual =        1.0001488
Ip         specified/actual =        1.0000629
<J.B>      specified/actual =        1.0000629
------------------------------------------------------------------------------
Rescaled equilibrium profiles: p' and <J.B>/<Bt/R2>
Computing new plasma Jphi...
Computing poloidal flux from new plasma Jphi...
Finding optimal coil currents for boundary match...
Found possible poloidal field O-point at R,Z (m) [1] =   0.93926 -0.00887
------------------------------------------------------------------------------
   Coil  Current (kA)      % Change
     OH     -11.892032        0.0084
   PF1AU      0.000004       -0.0100
    PF2U      0.000031        0.0169
    PF3U     -2.300834        0.0322
     PF5     -6.576097       -0.0091
    PF3L     -4.406653        0.0303
    PF2L      5.203116        0.0142
   PF1AL     -9.999997        0.0000
    PF1B      0.000000       -0.0032
RMS change in coil currents (A) =       0.68527851
------------------------------------------------------------------------------
===> Using x-point boundary <===
Found possible poloidal field O-point at R,Z (m) [1] =   0.93931 -0.00895
   Iteration #, convergence error =   1,  2.875438e-01
   Iteration #, convergence error =   2,  8.141766e-05
  Changing theta coordinates to:  EQUAL-ARC...
Flux coordinates computed in 0.35642195 seconds.
Sized PostScript image...

Finishing PostScript file creation and stopping ...

RMS boundary change during iteration (mm) =      0.022538704
RMS boundary error at this iteration (mm) =       56.918604
Cycle count =          36
europa being added to access control list
birch being added to access control list
kees being added to access control list
IDL>
```

Figure 3
High
X-point

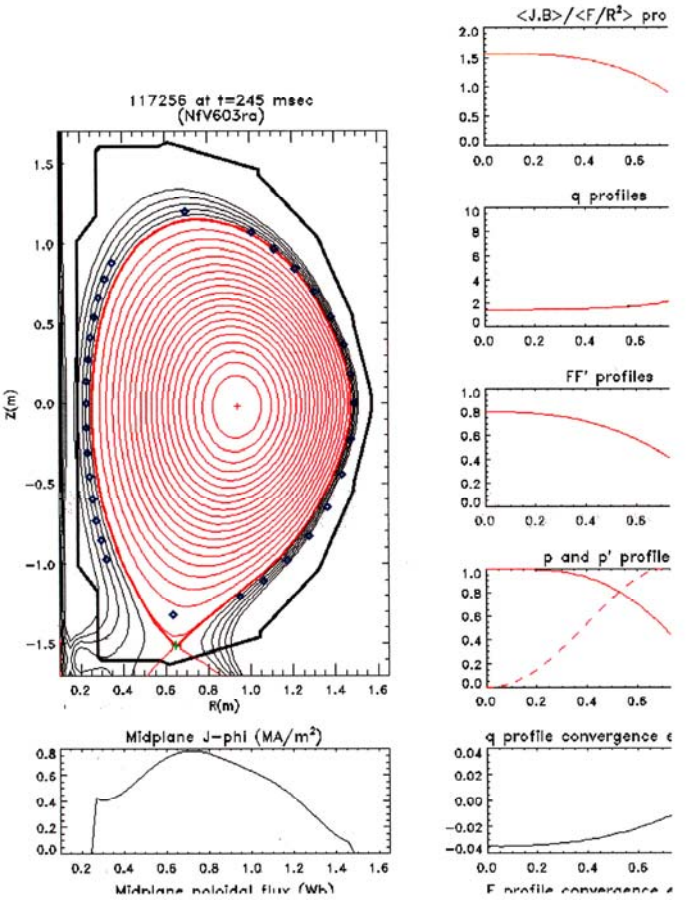



```
=====> F^2 iteration change =    3.6362552e-15
------------------------------------------------------------------------------
Plasma geom. center  R0 (m) =       0.86886085
Vacuum toroidal B at R0 (T) =      -0.43547107
Aspect ratio                =        1.4289954
Boundary elongation         =        2.1385802
Elongation at axis          =        1.7268062
Upper triangularity         =       0.21177191
Lower triangularity         =       0.39063426
q(0)                        =        1.4136737
q(95)                       =        6.0689340
q(99)                       =        7.8467639
q(min)                      =        1.4136737
rho q(min)                  =        0.0000000
Internal inductance         =       0.69124224
beta-t (%)                  =       0.030981922
beta-N                      =      0.0091151622
Stored energy          (MJ) =     0.00041788503
Ip                     (MA) =       0.89995884
ITF                    (MA) =       -1.8918188
beta-t     specified/actual =        1.0001657
Ip         specified/actual =        1.0000457
<J.B>      specified/actual =        1.0000457
------------------------------------------------------------------------------
Rescaled equilibrium profiles: p' and <J.B>/<Bt/R2>
Computing new plasma Jphi...
Computing poloidal flux from new plasma Jphi...
Finding optimal coil currents for boundary match...
Found possible poloidal field O-point at R,Z (m) [1] =   0.94125 -0.01990
------------------------------------------------------------------------------
   Coil  Current (kA)      % Change
     OH     -10.727196        0.0140
   PF1AU      0.000004        0.0097
    PF2U      0.000030        0.0203
    PF3U     -1.986627        0.0590
     PF5     -6.712957       -0.0053
    PF3L     -2.988652        0.0359
    PF2L      2.981856        0.0419
   PF1AL     10.000001       -0.0000
    PF1B      0.000000       -0.0054
RMS change in coil currents (A) =       0.89672239
------------------------------------------------------------------------------
===> Using x-point boundary <===
Found possible poloidal field O-point at R,Z (m) [1] =   0.94116 -0.02029
   Iteration #, convergence error =   1,  3.603643e-01
   Iteration #, convergence error =   2,  1.040650e-04
   Iteration #, convergence error =   3,  3.407267e-06
  Changing theta coordinates to:  EQUAL-ARC...
Flux coordinates computed in 0.41412783 seconds.
Sized PostScript image...

Finishing PostScript file creation and stopping ...

RMS boundary change during iteration (mm) =      0.020296077
RMS boundary error at this iteration (mm) =       81.721800
Cycle count =          35
europa being added to access control list
birch being added to access control list
kees being added to access control list
IDL>
```

Figure 4
Low
X-point



4. Required machine, beam, ICRF and diagnostic capabilities:

Physics Operations Request and Diagnostic Checklist are attached.

Diagnostic capabilities: Tile Langmuir probes, IR cameras, main plasma and divertor bolometers, and the D_α, $D_\gamma$cameras should be operational. Lower divertor Langmuir probe locations are (major radii, m): 0.2775, 0.4952, 0.7970, 0.9110, 1.0170.

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Verification, if appropriate

5. Sign-off and Documentation

5.1 Permission to Proceed:

_____

Head, Experimental Research Operations Division

5.2 Documentation of results:

Documentation of the results completed, attached to proposal and sent to Ops. Center with copies to Cognizant Physicist and Head of Boundary Physics.

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Test Director

PHYSICS OPERATIONS REQUEST

OP-XMP-???

Scanning of Divertor Strike-point for Langmuir Probe Profiles

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **-52.5** Flattop start/stop (s): **-0.02/1.0**

I_P (MA): **0.8** Flattop start/stop (s): **0.12/0.6**

Configuration: **Lower Single Null**

Outer gap (m): **0.1**, Inner gap (m): **0.05-0.1**

Elongation κ: **1.9-2.0**, Triangularity δ: **0.5**

Z position (m): **0.00**

Gas Species: **D / He / Ne**, Injector: **Midplane / Inner wall / Lower Dome**

NBI - Species: **D**, Sources: **A/B/C**, Voltage (kV): **80**, Duration (s): **0.6**

ICRF – Power (MW): **0**, Phasing: **Heating / CD**, Duration (s): _____

CHI: **Off**

Either: List previous shot numbers for setup: **116488**

Gas setup: CS Injector – D_2, LDGIS - D_2, Injector 1 – He, Injector 2 – D_2

Injector Bay B High Flow - D_2or He for GPI

Diagnostic Checklist			OP-XMP-46
Diagnostic	**Need**	**Desire**	**Instructions**
Bolometer – tangential array	✔		
Bolometer array - divertor	✔		
CHERS	✔		
Diamagnetism	✔		
Divertor fast camera	✔		
EBW radiometer		✔	
Edge pressure gauges			
Edge rotation spectroscopy	✔		
Fast lost ion probes	✔		
Filterscopes	✔		
FIReTIP	✔		
Gas puff imaging	✔		
H□ camera - 1D	✔		
Infrared cameras	✔		
Interferometer - 1 mm			
Langmuir probe array	✔		
Magnetics - Flux loops	✔		
Magnetics - Locked modes			
Magnetics - pickup coils	✔		
Magnetics - Rogowski coils	✔		
Magnetics - RWM sensors			
Mirnov coils – high frequency	✔		
MSE			
Neutral particle analyzer			
Neutron measurements			
Plasma TV	✔		
Reciprocating probe			
Reflectometer – core			
Reflectometer - SOL			
SPRED	✔		
Thomson scattering	✔		
Ultrasoft X-ray arrays	✔		
Visible bremsstrahlung det.			
Visible spectrometer (VIPS)			
X-ray crystal spectrometer - H	✔		
X-ray crystal spectrometer - V			
X-ray pinhole camera			