NCSX Diagnostic Planning

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PRINCETON PLASMA
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NATIONAL COMPACT
NCSX
STELLARATOR PROGRAM

Measurement Needs for Phases 1 and 2

MEASUREMENT	PHASE	RANGE	RESOLUTION temporal	RESOLUTION spatial	ACCURACY	DIAGNOSTIC TECHNIQUE
plasma current	1	1-400 kA	1 ms	integral	1% + 0.1KA	Roqowski coils
conductivity	1		1 ms	integral	1%	flux loops + plasma current
plasma boundary position and shape	1	??	5 ms		2.0 cm on gap	magnetics + 3-D EFIT
visible image of plasma/wall	1	3 views	20 ms	0.5 cm		video cameras with optional filters
total stored energy	1	10 kJ - 500 kJ	1 ms	integral	10 kJ	diamagnetic loop
line integrated density	1	10^{18} -5x10^{20} m^{-2}	1 ms	integral	5-10%	1 mm interferometer
total radiated power	1	0.05-10 MW	1 ms	integral	15%	wide angle foil bolometer
central electron temperature	1	0.1-1 keV	1 ms	integral	20%	filtered SX diodes + abs. UV spectroscopy
impurity identification	1	200 - 1000 nm	5 ms	integral	0.1 nm	visible spectrometer
impurity concentration	1	10 - 150 nm	5 ms	integral	0.1 nm	abs. UV spectroscopy
low (m,n) MHD modes, sawteeth, disruptions	1		50 kHz	6 cm with inv?	10%	Mirnov coils
hydrogen recycling	1	several sightlines	20 ms	integral	10%	H_α filterscopes
vacuum flux surfaces	2	v = ? plane	30 ms	0.2 cm	0.2 cm	e-beam probe + fluorescent rod/screen probe + high dyn. range CCD

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Diagnostics for Phases 1 and 2

DIAGNOSTIC TECHNIQUE	PHASE	DESCRIPTION	DATA CHANNELS	SPEED
plasma current Rogowskis	1	3 coils	3	10 kHz
flux loops	1	24 loops	24	10 kHz
saddle loops	1	36 loops	36	10 kHz
B-dot probes	1	36 probes	36	50 kHz
diamagnetic loop	1	2 loops	2	10 kHz
standard video cameras	1	2 cameras with optional filters	2	video grabber
fast visible camera	1	1 kHz full frame rate w filters	1	video grabber
1 mm interferometer	1	with inner wall reflector	2	200 kHz
wide angle foil bolometer	1	4 channels	4	10 kHz
filtered SX diodes	1	2 diodes with different filters	2	10 kHz
visible spectrometer	1	survey instrument, several fibers	1	video grabber
abs. UV spectroscopy	1	vac. UV survey instrument, single sightline	1	video grabber
visible filterscopes	1	several sightlines	3	10 kHz
e-beam probe	2	retractable, radially scanning	4	10 kHz
fluorescent rod probe	2	retractable, pivoting	4	10 kHz
high dynamic range CCD	2	standard frame rate	1	video grabber

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Measurement Needs for Phase 3

plasma boundary position and shape	3		1 ms		0.5 cm on gap	enhanced magnetics + 3-D EFIT
core electron temperature profile	3	0.05-3.0 keV full profile	1 ms	1 cm	5%	Thomson scattering
core electron density profile	3	$5xl0^{l8}$ -$5xl0^{2O}$ m^{-3}	10 ms	2 cm	5%	Thomson scattering
low (m,n) MHD modes, sawteeth, disruptions	3		100 kHz	3 cm with inv?	10%	multiple compact SXR arrays
magnetic axis position	3	v = 0 plane	.01 ms		1.0 cm	compact SXR arrays + 3-D EFIT
magnetic axis position	3	v = 1/2 plane	.01 ms		1.0 cm	Thomson scattering
core radiated power profile	3	0-30 w/cm^3 with inversion	1 ms	integral	15%	core foil bolometer array
Zeff profile	3	1-10	5 ms	3 cm with inversion	20%	vis. Bremsstrahlung array
edge neutral pressure	4	0 - 10 mtorr	10 ms		5%	gauges at midplane and banana tips

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Diagnostics for Phase 3

enhanced magnetics	3	TBD expect 50 channels	50	10 kHz
Thomson scattering	3	ultimate 50 spatial channels, initially 25 ch, 50 Hz	100	500 MHz
compact SXR arrays	3	8 arrays of 16 channels	128	200 kHz
core foil bolometer array	3	16 channel array	16	10 kHz
vis. Bremsstrahlung array	3	16 channel array	16	10 kHz
compact IR camera	3	possibly work without periscope, standard frame rate	1	video grabber

Measurement Needs for Phase 4

magnetic axis position	4	v = 1/2 plane	5 ms		2.0 cm	DNB + MSE polarimeter + 3-D EFIT
core electron density profile	4	5xl0 ^{l8}-5xl0 ^{2O} m^{-3} with inversion	.01 ms	10-15 cm with inversion	1 fringe	multichord FIR interferometer/ polarimeter
higher (m,n) MHD modes	4		100 kHz		10%	additional multiple compact SXR arrays
flux surface topology	4		2 ms		5%	tangential, 2-D, x-ray pinhole camera + 3-D EFIT
ion temperature profile	4	0.1-3 keV	5 ms	2 cm	5%	DNB + toroidal CHERS
toroidal rotation profile	4	10 - 200 km/sec	5 ms	2 cm	5%	DNB + toroidal CHERS
poloidal rotation profile	4	10 - 200 km/sec	5 ms	5 cm	10%	DNB + poloidal CHERS
iota profile	**4**	0.1 - 1.0	5 ms	2 cm	5%	DNB + MSE polarimeter + 3-D EFIT
fast ion loss	**4**	.01 -10 μA/cm ^{2}	0.1 ms	integral	20%	fast ion loss probe
ion energy distribution	4	5-100 keV	0.1 ms	integral	5%	netral particle analyser
neutron flux	4		0.1 ms	integral	10%	epithermal neutron detector
first wall surface temperature	4	20° C - 3000° C	30 ms	1 cm	1%	compact IR camera
high frequency MHD(<5Mhz)	4		5 MHz		5%	high frequency Mirnov coils

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Diagnostics for Phase 4

diagnostic neutral beam	4	50 kV, 6 amps neutrals, 6 cm dia., midplane	10	10 kHz
MSE polarimeter	4	uses DNB, midplane view	20	10 kHz
toroidal CHERS	4	uses DNB, midplane view	1	video grabber
poloidal CHERS	4	uses DNB, vertical view	1	video grabber
multichord FIR interferometer/ polarimeter	4	# chords TBD, λ TBD, geometry TBD	TBD	100 kHz
enhanced x-ray tomography	4	additional 8 compact SXR arrays	128	200 kHz
tangential, 2-D, x-ray pinhole camera	4	uses unused beam port	1	video grabber
fast ion loss probe	**4**	geometry TBD	1	video grabber
neutral particle analyser	4	geometry TBD	50	50 kHz
epithermal neutron detector	4		1	10 kHz
high frequency Mirnov coils	4	6 larger TFTR style coils	6	5 MHz
neutral pressure gauges	4	midplane and banana tips	4	10 kHz

Measurement Needs for Phase 5

divertor radiated power profile	5	0-100 w/cm ^{3} with inversion	1 ms	integral	15%	divertor foil bolometer arrays
divertor plate temperature	5	20° C - 3000° C	1 ms	0.5 cm	1%	fast IR camera
core density fluctuation amplitude	5	$\delta n/n > 10^{-4}$	100 kHz	2 cm	10%	fluctuation diagnostic TBD
edge electron temperature profile	5	outer midplane	.1 ms	0.5 cm	10%	fast scanning edge probe
edge electron density profile	5	outer midplane	.1 ms	0.5 cm	10%	fast scanning edge probe
core helium density	5	$(10^{-1} - 10^{-4}) n_e$	5 ms	2 cm	20%	DNB + He CHERS system
divertor target surface temperature	5	20° C - 3000° C	1 sec	5 cm	1%	divertor thermocouples
target Te, ne	5	1 - 100 eV $1xl0^{l9}$-$1xl0^{21}$ m^{-3}	.1 ms	2 cm	10%	plate mounted Langmuir probes
divertor recycling	5	2-D imaging	30 ms	0.5 cm	10%	divetor filterd CCD camera
divertor impurity concentrations, flows	5	200 - 1000 nm	1 ms	integral	0.1 nm	divertor UV spectroscopy

Diagnostics for Phase 5

divertor foil bolometer arrays	5	2 crossed, 16 channel arrays	16	10 kHz
fast IR camera	5	needs periscope	1	video grabber
fast scanning edge probe	5	outer midplane, v = ?	6	100 kHz
He CHERS system	5	uses DNB	1	video grabber
plate mounted Langmuir probes	5	array of fixed probes	10	.1 ms
divertor thermocouples	5	instrumented divertor tiles	30	1 Hz
divertor UV spectroscopy	5	dedicated divertor view	1	video grabber
fluctuation diagnostic	5	TBD	TBD	TBD