

TO: L. Dudek
FROM: B. Stratton

SUBJECT: NCSX Job 3801 Electron Beam mapping Systems

Date: October 8, 2008

Scope

This job consists of providing an electron-beam field line mapping diagnostic that will measure a 2-D map of the vacuum field line structure. At the time of NCSX project termination, it was planned that this would be done by ORNL in collaboration with Auburn University. Some of the hardware would be borrowed from Auburn University. The system will be similar to electron beam field line mapping diagnostics used on other stellarators. An electron gun mounted on a linear translator will inject a low energy electron beam that follows the field lines as it circulates around the vacuum vessel. It will strike a stationary fluorescent screen or a swept fluorescent wand, emitting visible light, which is captured by a visible camera. The linear translator moves the electron gun radially to build up a complete 2-D field line map at the screen or wand. Options for either a stationary screen or one or more swept wands were under consideration at the time of NCSX project termination. The former is simple to implement but has the disadvantage that a vacuum opening would be required to install the screen and other vacuum opening would be needed to remove it after field line mapping is complete. The latter is more complex, but could possibly be designed to be deployed while under vacuum. A sketch of the swept wand concept is shown below. The emission from the fluorescent screen or wands would be viewed by the visible TV camera (job 3601).

Status

No design work was started at the time of NCSX project termination.

Interfaces

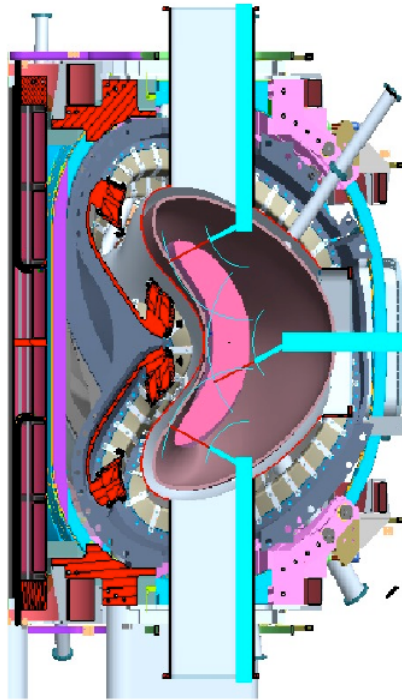
1. The NCSX vacuum vessel. Ports for linear motion translator to hold electron gun and for swept wands would be required. This could require a re-entrant assembly depending on which port is chosen. No port would be required for the stationary screen concept.
2. Data acquisition and hardware control for electron gun, linear feedthrough, and rotary actuator if swept wand concept is used.

Specifications

Provide an electron-beam field line mapping diagnostic that will measure a 2-D map of the vacuum field line structure. The system should allow coverage of a large fraction of a plasma cross section.

Schematics and PIDs

Sketch from WBS 3 presentation to SC Project Review, April 9-10, 2008:



Models

None

Drawings

None

Analyses

None

Testing

None

Costs

No updates

Remaining Work

- Perform conceptual design of system and have it reviewed.
- Perform detailed design of port structures, screen or wands, and associated data acquisition and control.
- Fabricate/procure components.
- Install system and commission it.

WBS 3 - Diagnostics

B. Stratton

NCSX WBS 3 Manager

Outline

- Requirements
- Interfaces
- Design, fabrication, and installation status or plans and schedule by job
- Estimates to complete
- Risks and mitigation

Diagnostics requirements-cont.

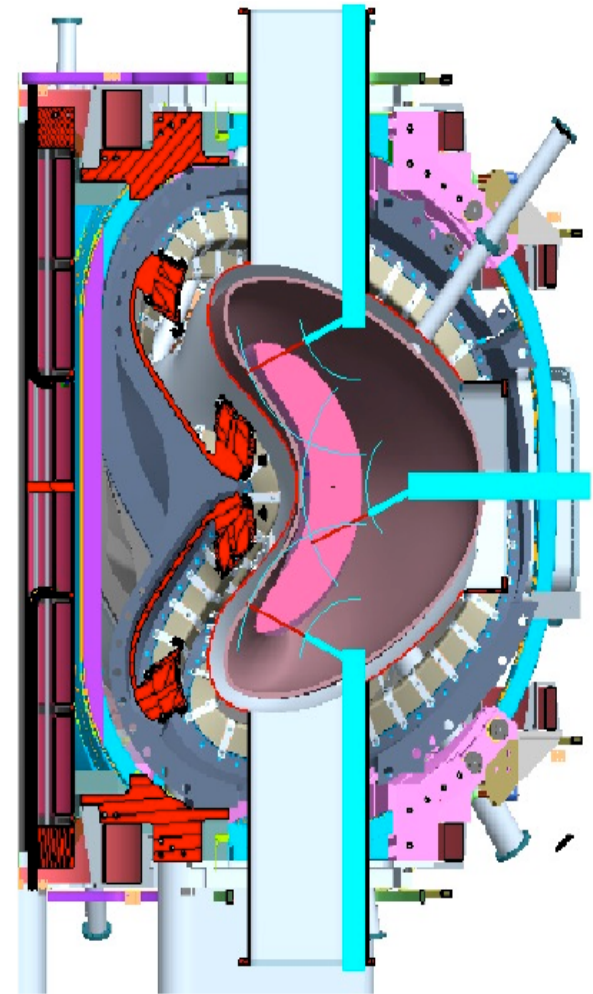
- Visible TV camera system (job 3601)
 - Capable of observing plasma shape during first plasma operation
- Electron beam field line mapping system (job 3801):
 - Capable of field line mapping following first plasma
- Diagnostics integration (job 3901):
 - Management of WBS 3 jobs

Interfaces

- Ex-vessel magnetic sensors:
 - Vacuum vessel (WBS 12)
 - Conventional coils (WBS 13)
 - Modular coils (WBS 14)
 - Cryostat (WBS 17)
 - Data acquisition (WBS 53)
 - Field period assembly (WBS 18)
- Extension and termination of thermocouple and heater tape leads:
 - Vacuum vessel (WBS 12)
- Visible TV camera system:
 - Vacuum vessel (WBS 12)
 - Data acquisition (WBS 53)
- Electron beam field line mapping system:
 - Vacuum vessel (WBS 12)
 - Data acquisition (WBS 53)
 - Cryostat (WBS 17)

Electron-beam field line mapping plan

- Injected low energy electrons follow field lines and emit visible light when they strike a swept fluorescent rod or stationary screen. Visible camera images rod to provide map of field line structure in poloidal plane.
 - Hardware will be borrowed from Auburn University/University of Wisconsin.
 - WBS 3 and WBS 5 responsible for vacuum interface and control/data acquisition hardware



Electron-beam field line mapping status



38 - Electron Beam (EB) Mapping									
Job: 3801 - Electron Beam Mapping-STRATTON									
380-010		E-beam mapping- Prelim Design	40		02MAR09*	24APR09	372	66,396.32	R//RM2 =240hr; EM//EM =60hr; EA//SB =98hr; 35=03\$K ;
380-015		E-beam mapping - PDR	1	R	27APR09	27APR09	372	0.00	
380-100		E-beam mapping-Final Design	40		28APR09*	23JUN09	372	104,685.32	R//RM2 =240hr; EM//EM =60hr; EA//SB =98hr; EC//EM =100hr ;
380-110		E-beam mapping - FDR	1	R	24JUN09	24JUN09	372	0.00	
380-115		E-beam mapping-Procure Rack,xfrm,r,cable	65		01JUL10*	01OCT10	120	13,393.16	41=5\$K ; em/em=40
380-120		E-beam mapping-Procure Ports	65		01JUL10	01OCT10	120	5,350.03	41=04\$K ;
380-130		E-beam mapping-Procure Data Acquisition	65		01JUL10*	01OCT10	120	13,375.08	41=10\$K ;
380-135		E-beam mapping- Assemble	65		04OCT10*	12JAN11	120	54,862.24	R//RM2 =160hr; EM//EM =20 EMT/TB =578 ; ee//em=8 ea//tb=16
380-135M	2	E-beam mapping apparatus ready for Installation	0			12JAN11	120	0.00	

- Design not started
- Medium risk: interface between hardware and NCSX not well defined-could be complex

Estimates to complete

Job	Mech. Eng. (hrs)	Sr. Mech. Tech. (hrs)	Mech. Tech. (hrs)	Design. (hrs)	Elect. Tech. (hrs)	Elect. Eng. (hrs)	Comp. Eng. (hrs)	Res. Staff (hrs)	Travel (k\$)	M&S (k\$)
Ex-vessel Mag.	1023	1816	460	188	128	32	0	0	0	29.7
Visible Camera	40	0	88	80	16	0	0	0	0	3.5
E-beam Mapping	160	0	576	196	16	8	300	480	3.0	19.0
Diag. Integ.	0	0	0	0	0	0	0	778	0	0
TOTAL	1223	1816	1124	464	160	40	300	1258	3.0	52.2

- Estimates to complete based on:
 - Ex-vessel magnetics: experience to date on these tasks; vendor quotes
 - Visible TV camera: experience with similar systems on NSTX; vendor quotes
 - Electron beam field line mapping system: discussion with Auburn University personnel, in-house estimates for specific components; vendor quotes
 - Diagnostics integration: experience to date

Risks and mitigation plans

- Electron beam mapping system design not started-could be complex
 - Mitigate risk by starting design soon-summer 2008
 - This job will be transferred to ORNL in collaboration with Auburn University and University of Wisconsin
 - Plan takes advantage of extensive shared experience in field line mapping at Auburn, UW, and ORNL, who worked as a team on this task for ATF
- There is some risk of damage to VV flux loops, spacer flux loops, Rogowski coils, and heater and thermocouple leads when modular coil three-packs are placed over VVSAs and during machine assembly. Repairs could be on the critical path.