



ENG-033 - CRR - CHIT RESOLUTION REPORT

TF Inner Bundle Twist Laser Measurement Chit Resolution Report

NSTXU_1-7-3-4-5_CRR_100

Work Planning #:
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Chit Resolution Report for TF Inner Bundle Twist Laser Measurement

NSTXU_1-7-3-4-5_CRR_100, Rev 0

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Summary of Chits

Review	ID	Chit	Status
Magnets DVVR	MTF18	Method of measuring twist in center stack. DIII-D uses a mirror mounted to center stack and a laser is pointed at mirror and reflected signal is monitored during a shot to measure twist. Consider for measuring for twist of center stack since it is likely highest stress of TF system	Closed
TF Twist Laser Measurement CDR	TFTWISTCDR01	A blank target with a few reference points would be much easier to analyze than a fine grid target.	Closed
TF Twist Laser Measurement CDR	TFTWISTCDR02	Document that the twist at the edge of the umbrella structure is very similar to that of the TF bundle and that large corrections are not needed. This is to justify the location of the mirror, which from other considerations makes a great deal of sense.	Closed
TF Twist Laser Measurement CDR	TFTWISTCDR03	Consider what it would take to mount an extension from the casing flange to the laser elevation so that this instrument could be used for disruptions as well	Closed
TF Twist Laser Measurement CDR	TFTWISTCDR04	At least have sufficient time resolution to register global twist during a disruption	Closed
TF Twist Laser Measurement CDR	TFTWISTCDR05	Consider the effect of ambient light on the signal to noise of the system. Does the ambient light fluctuate?	Closed
TF Twist Laser Measurement FDR	TFTWISTFDR01	Provide a capability to override the laser interlock so that people can do alignment and maintenance in the test cell.	Closed
TF Twist Laser Measurement FDR	TFTWISTFDR02	CDR Chit Resolution Report, NSTXU_1-7-3-4-5_CRR_100 needs to be finalized (signed and filed). Approval to be provided by the DRC.	Closed
TF Twist Laser Measurement FDR	TFTWISTFDR03	Consider adding a fiducial or other method to synchronize the video data with the facility clock	Closed
TF Twist Laser Measurement FDR	TFTWISTFDR04	Complete SQA Categorization forms for PPPL software, and NI camera software. Verify LabVIEW has been categorized.	Closed



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Introduction

This report provides resolution of TF Bundle Twist Laser Measurement, project SBS 1.7.3.4.5, (integrated into Recovery WBS 1.04.01.01) chits and recommendations originating from the TF Bundle Twist Laser Measurement CDR, FDR, and from the Magnets DVVR.

The chits in the NSTX-U Recovery chit log can cite the sections in this report as evidence of closure. The chit resolution described herein is aligned with the chit tables in the Magnets DVVR and TF Bundle Twist Laser Measurement CDR and FDR dashboards.

1 CLOSED: MTF18 – Consider DIII-D Laser Measurement System

Review	ID	Chit	Review Board Comment
Machine Instrumentation on DVVR	MTF18	Method of measuring twist in center stack. DIII-D uses a mirror mounted to center stack and a laser is pointed at mirror and reflected signal is monitored during a shot to measure twist. Consider for measuring for twist of center stack since it is likely highest stress of TF system	N/A

A standalone SBS number, 1.7.3.4.5, has been assigned to a laser measurement system like that used at DIII-D. The selected twist measurement mechanism was confirmed at the TF Bundle Twist Laser Measurement CDR, completed on 10/04/19. The chits and design reviews described herein directly address the laser measurement of the twist of the bundle.

2 CLOSED: TFTWISTCDR01 – Shoot at Blank Target

Review	ID	Chit	Review Board Comment
TF Twist Laser Measurement CDR	TFTWISTCDR01	A blank target with a few reference points would be much easier to analyze than a fine grid target.	Concur

As recommended by the chit, a blank target with a reference scale taped onto the target was implemented into the prototype test completed in support of the TF Bundle Twist Laser Measurement PDR. The blank target allowed for easy image processing of the intensity of the laser spot. Such a target, using either a scale or reference points, will be implemented for the final design of the laser system.

3 CLOSED: TFTWISTCDR02 – Document Twist at Umbrella

Review	ID	Chit	Review Board Comment
TF Twist Laser Measurement CDR	TFTWISTCDR02	Document that the twist at the edge of the umbrella structure is very similar to that of the TF bundle and that large corrections are not needed. This is to justify the location of the mirror, which from other considerations makes a great deal of sense.	Concur

Per the results of the Hi-Fidelity model presented at the TF Bundle Stage 2 Review, External Load Path, the twist angles calculated from the models are as follows:

At the bundle outer radius:

No delamination: 0.25 mrad
With delamination 1.20 mrad

At the hub, which is in proximity and mechanically linked to the umbrella:

No delamination: 1.04 mrad
With delamination: 1.07 mrad

These results indicate the twist angles of the bundle twist and hub twist. As shown by prototype results at the PDR, a laser measurement of the twist will have good sensitivity towards benchmarking any of these global model values. While the 30 microradian difference between the delaminated and laminated case is on the lower end of sensitivity, a change is still possible to detect.

The edge of the umbrella structure offers significant advantages in ease of installation and design. The flange on top of the umbrella offers a clear line-of-sight to the north wall of the test cell. This eliminates the need for the design of a welded post or extension to elevate the reflector to the correct height. Implementing an extension creates an inherent lever arm for background vibrations of the machine, which may reduce measurement sensitivity.

The combination of these factors makes it impractical and expensive to implement a reflector towards the center of the bundle, instead of on the umbrella structure.

The primary purpose of this laser system is to measure global stiffness and to benchmark our models, including the umbrella structure and associated structures. The testing performed for the PDR has shown sufficient measurement sensitivity to support the primary goal of this system and to meet the requirement sensitivity of 40 microradian.

4 CLOSED: TFTWISTCDR03 – Consider Casing Flange Measurement

Review	ID	Chit	Review Board Comment
TF Twist Laser Measurement CDR	TFTWISTCDR03	Consider what it would take to mount an extension from the casing flange to the laser elevation so that this instrument could be used for disruptions as well	Consider

Reject - as detailed in section 3 of this report, implementing an extension or a post from the casing flange to the laser elevation creates an inherent lever arm which will amplify background noise and vibrations from the machine/test cell. Additionally, the cost of implementing a welded structure and the possible interference with the installation of other machine structures/instrumentation in this area disqualify this idea.

5 CLOSED: TFTWISTCDR04 – Account for Time Resolution

Review	ID	Chit	Review Board Comment
TF Twist Laser Measurement CDR	TFTWISTCDR04	At least have sufficient time resolution to register global twist during a disruption	Consider

The currently selected National Instruments Smart Camera has a published maximum framerate of 290 fps. This is approximately 1/3rd too slow to measure a 1 ms disruption. The cost of a 1000+ fps camera is approximate 5 to 10 times that of the current camera, which was selected for ease of integration with our current data acquisition systems.

290 fps is enough for a few data points over 50-500 ms to examine the vessel time constant and inertial effect of the disruption. Because this laser measurement system is almost entirely modular, there is the always the option to upgrade the camera in the future.

6 CLOSED: TFTWISTCDR05 – Consider Ambient Light

Review	ID	Chit	Review Board Comment
TF Twist Laser Measurement CDR	TFTWISTCDR05	Consider the effect of ambient light on the signal to noise of the system. Does the ambient light fluctuate?	Concur

The intensity of ambient light is orders of magnitude below that of the laser spot on the detector. By reducing the exposure time of the camera, the saturation of the image decreases. This reduces the signal of the ambient light. The results of the PDR show that the background noise due to small light fluctuations is not a concern. If there are large light fluctuations observed in the test cell, a filter that selects for only the wavelength of the red light of the laser is easy and inexpensive to implement.

7 CLOSED: TFTWISTFDR01 – Provide Interlock Override

Review	ID	Chit	Review Board Comment
TF Twist Laser Measurement FDR	TFTWISTFDR01	Provide a capability to override the laser interlock so that people can do alignment and maintenance in the test cell.	Concur

The design was updated to include a fourth relay that will be controlled by the LabVIEW VI to allow laser power to bypass the CCS interlocks. This will allow for technicians to provide power to the laser for calibration and testing while in the test cell. See drawing 9D11578 for updated design.

8 CLOSED: TFTWISTFDR02 – Fully Signed CRR

Review	ID	Chit	Review Board Comment
TF Twist Laser Measurement FDR	TFTWISTFDR02	CDR Chit Resolution Report, NSTXU_1-7-3-4-5_CRR_100 needs to be finalized (signed and filed). Approval to be provided by the DRC.	Concur

The chit resolution report, NSTXU_1-7-3-4-5_CRR_100, has been updated with FDR chits and fully signed as per this report, by the DRC and project engineer.

9 CLOSED: TFTWISTFDR03 – Synchronize Data with Facility Clock

Review	ID	Chit	Review Board Comment
TF Twist Laser Measurement FDR	TFTWISTFDR03	Consider adding a fiducial or other method to synchronize the video data with the facility clock	Concur

The design was updated to include a second fiber from rack CTC-EE441 to the TF Twist control box. This fiber will interface to an RTU and send a T-10 pulse back to the TF Twist control box where it will be read by the LabVIEW VI to synchronize the data to the shot clock. See drawing 9D11578 for updated design.

10 CLOSED: TFTWISTFDR04 – Complete SQA Forms

Review	ID	Chit	Review Board Comment
TF Twist Laser Measurement FDR	TFTWISTFDR04	Complete SQA Categorization forms for PPPL software, and NI camera software. Verify LabVIEW has been categorized.	Concur

The applicable SQA process for an A3 software categorization will be followed to finalize the software design.