Characterizing Debris-Shield Transmission Degradation and Estimating On-Target Energy

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Summary

OMEGA Now Provides an Estimate of On-Target Transmission Losses Resulting from Target Debris Contamination of Blast Window Assemblies

- Transmission of OMEGA debris shields is highly dependent on the type of experimental campaign.
- A laser cleaning effect generally maintains individual beam transmission by 90% of the "clean" Blast-Window-Assembly (BWA) condition.
- Blow-through OMEGA Transport Imaging System (OTIS) measurements are used to monitor debris shield transmission throughout the BWA cycle.
- An energy report is now provided to the principal investigators depicting estimated UV transmission losses.
- Experiments with low debris impact are generally scheduled at the start of a BWA cycle, and high-impact shots precede refurbishment.

Target Debris Collects on the Surface of the Debris Shield and Reduces the UV On-Target Energy

- BWA consists of a vacuum window and a debris shield.
- Surface contamination often exceeds 10^6 cm^2.
- Processing of BWAs is labor intensive and requires:
  - Controlled surface contamination areas (CSM)
  - Qualified radiation workers
  - Decontamination of bare metal
  - Replacing debris in place.

A "Laser-Cleaning Effect" is Observed After Shooting the Beam Through a Low-Transmission Debris Shield

- High-loss beams generally recover up to 90% of initial transmission after the beam is fired.
- Majority of laser cleaning effect is realized after a single shot.

UV On-Target Energy is Reported Based on an Energy Measurement Made Upstream of the Target Chamber

- Harmonic-energy detector (HED) measures can also UV within a residual IR and green.
- HED is calibrated semiannually (seven shots) and checked monthly (one shot) against a conventional calorimeter.

"Mid-cycle" OTIS Measurements of all 60 Beams are Now Taken to Understand Debris-Shield Transport Degradation After Two Weeks of Target Shots

- OTIS: Optical Transport Imaging System
- Average UV transport losses measured in mid-cycle OTIS (October 2010 to February 2011)
- Target type and quantity
- Which beams are fired
- Beam location on target chamber

Several Factors Contribute to the Magnitude and Distribution of Debris-Shield Transmission Degradation

- OTIS runs (June 2011 to August 2011)
- Blow-through estimated OTIS on a subset of beams takes ~20 min.
- Blow-through OTIS is used to monitor Debris-Shield Transmission Degradation in a Subset of Beams

OTIS is Used to Measure Absolute UV Transmission of all 60 Individual Beams When New BWAs are Installed (Monthly)

- Estimated DPP transmission is included in this report.
- OTIS runs used to characterize beam-specific.
- Measurement for OTIS energy are the average for that DPP type.
- This report is qualified to:
  - A target
  - A tool
  - OMEGA Data Viewer

Operations Now Provides an HED Report That Estimates UV On-Target Energy as a Function of Beamline

- Average loss for all 60 beams (%) - Low
- Average loss for all 60 beams (%) - High
- Initial loss
- Historical OTIS correlation of witness beam-pairs blow-through transmission is used to determine the overall system average.
- Individual beam transmissions are calculated based on each beam's historical correlation to the system average.
- Blow-through OTIS predicts:
  - 60-beam average transmission to ±5%.
  - Individual beam transmission for beams that are shot to ±2% rms.
Summary

OMEGA Now Provides an Estimate of On-Target Transmission Losses Resulting from Target Debris Contamination of Blast Window Assemblies

• Transmission of OMEGA debris shields is highly dependent on the type of experimental campaigns

• A laser-cleaning effect generally maintains individual beam transmission to $\sim$90\% of the “clean” Blast-Window-Assembly (BWA) condition

• Blow-through Omega Transport Imaging System (OTIS) measurements are used to monitor debris shield transmission throughout the BWA cycle

• An energy report is now provided to the principal investigators depicting estimated UV transmission losses

• Experiments with low debris impact are generally scheduled at the start of a BWA cycle, and high-impact shots precede refurbishment

Debris shields will be changed $\sim$15× in FY12.
UV On-Target Energy is Reported Based on an Energy Measurement Made Upstream of the Target Chamber

- Harmonic-energy detector (HED) measures on-shot UV along with residual IR and green
- HED is calibrated semi-annually (seven shots) and checked monthly (one shot) against a conventional calorimeter
OTIS is Used to Measure Absolute UV Transmission of all 60 Individual Beams When New BWA’s are Installed (~Monthly)

Result:
- Absolute-UV transport measurements to <2%
- Relative-UV transport measurements to <1%
Target Debris Collects on the Surface of the Debris Shield and Reduces the UV On-Target Energy

- BWA consists of a vacuum window and a debris shield
- Surface contamination often exceeds $10^6$ DPM/100 cm$^2$
- Processing of BWA’s is labor intensive and requires
  - controlled surface contamination areas (CSCA’s)
  - qualified radiation workers
  - decontamination of hardware
  - recoating or replacing debris shield
“Mid-cycle” OTIS Measurements of all 60 Beams are Now Taken to Understand Debris-Shield Transport Degredation After Two Weeks of Target Shots

- Overall system, as well as beam-to-beam, transmission can vary widely
- Historical HED energy report specifies UV on-target energy based on clean debris-shield transmission
UV Transmission Throughout each BWA Cycle is Highly Campaign Dependent

**November 2011**

- Benage- ABEX
- Heeter- Mboop
- Li- PProbe
- Loomis- Shear
- Sangster- CRYO
- Stoeckl- Preheat

**May 2011**

- Sangster- CRYO
- Mancini- 3-D Core
- Loomis- CHaRM
- Smalyuk- Toto
- Theobald- AmbientBL

- Sangster- CRYO
- Li- PartStop
- Comley- ShockLaue
- Casner- ImplDyn
- Rygg/Smith- EOS

**June 2011**

- Sangster- CRYO
- Kim- DTRat
- Theobald- ShockIgn
- Park- ColdPlasmas
- Smalyuk- KHInstability

**July 2011**

- Seka- 4ω ISE
- Fiksel- Spherical RT
- Ping- Atwood_11b
- Cobble- PDD

- Froula- CBET
- Smith- RampComp
- Smith- PhaseKin
A “Laser-Cleaning Effect” is Observed After Shooting the Beam Through a Low-Transmission Debris Shield

- High-loss beams generally recover up to ~90% of clean transmission after the beam is fired
- Majority of laser-cleaning effect is realized after a single shot

Beams with transmission loss >5% over the last ten mid-cycle OTIS runs

Self-cleaning after high-loss shots
Several Factors Contribute to the Magnitude and Distribution of Debris-Shield Transmission Degradation

- Target type and quantity
- Which beams are fired (i.e., laser-cleaning)
- Experiment geometry
- Beam location on target chamber

Average UV transport losses measured on mid-cycle OTIS runs (October 2010 to February 2011)

Scale:
19 (worst) = −10.7%
22 (best) = −2.5%
Daily “Blow-through OTIS” Measurements are used to Monitor Debris-Shield Transmission Degradation in a Subset of Beams.
Blow-Through OTIS of Two Witness Beam Pairs is Used to Estimate Individual Transmission of all 60 Beams

- Historical correlation of witness beam-pairs blow-through transmission is used to determine the overall system average
- Individual beam transmissions are calculated based on each beam’s historical correlation to the system average
- Blow-through OTIS predicts
  - 60-beam average transmission to ~1%
  - individual beam transmission for beams that are shot to <2% rms
Examples of Blow-Through Estimated Individual Beam Losses Compared to Actual OTIS Measurements
Operations Now Provides an HED Report That *Estimates* UV On-Target Energy as a Function of Beamline

- Estimated DPP transmission is included in this report
  - SG4 DPP transmission is beam specific
  - non-SG4 DPP’s are not beam specific; quoted transmission are the average for that DPP type

- This report is included in
  - PI Packet
  - shot Images and reports page
  - OMEGA Data Viewer