\section*{Characterizing Debris-Shield Transmission Degradation and Estimating On-Target Energy}

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\textbf{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 to -20% of the "clean" blast-window-assembly (BWA) condition.
- Blowthrough 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 (PIs) 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 -15 to 10%.

\textbf{Target debris collects on the surface of the debris shield and reduces the UV on-target energy.}

- The BWA consists of a vacuum window and a debris shield.
- Surface contamination often occurs in the UV range (190-350 nm).
- Processing of BWA's is labor intensive and requires:
  - Controlled surface contamination areas (CSAs).
  - Qualified radiation workers.
  - Hardware decontamination.
  - Recutting or replacing debris shield.

- A "laser-cleaning effect" is observed after shooting the beam through a low-transmission debris shield.
  - High-loss beams generally recover up to 80% of clean transmission after the beam is fired.
  - A majority of the laser-cleaning effect is realized after a single shot.

\textbf{Blowthrough OTIS of two witness beam pairs is used to estimate individual transmission of all 60 beams.}

- Each witness beam pair is fired in a series of OTIS runs.
- Blowthrough OTIS predicts:
  - -3% beam average transmission to -10%.
  - Individual beam transmission for beams that are shot to -2% rms.

\textbf{UV on-target energy is calculated based on an energy measurement made upstream of the target chamber.}

- A harmonics-energy detector (HED) measures UV along with residual IR and green.
- HED is calibrated semi-annually using short and long-cycle beams from a conventional calorimeter.

\textbf{Mid-cycle" OTIS measurements of all 60 beams are now taken to understand debris-shield transport degradation after two weeks of target shots.}

- Overall system, as well as beam-to-beam transmission, vary widely.
- Historical HED report specifies UV on-target energy based on clean debris-shield transmission.

\textbf{Several factors contribute to the magnitude and distribution of debris-shield transmission degradation.}

- Total OTIS lost measured on mid-cycle OTIS, October 2010 to February 2011.

\textbf{OTIS is used to measure absolute UV transmission of all 60 individual beams when new BWAs are installed (-monthly).}

- OTIS measurements are made to estimate individual transmission.

\textbf{UV transmission throughout each BWA cycle is highly campaign dependent.}

- The OTIS is a 4-hour operation.

\textbf{Operations now provide an HED report that estimates UV on-target energy as a function of beamline.}

- Estimated DPP transmission is included in this report.
- Individual DPP transmission is beam specific.
- Individual DPP transmission is used to estimate the overall system average.
- Individual beam transmission is calculated based on each beam's historical correlation to the system average.
- Blowthrough OTIS predicts:
  - -3% beam average transmission to -10%.
  - Individual beam transmission for beams that are shot to -2% rms.
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 ~90% of the “clean” blast-window-assembly (BWA) condition.
- Blowthrough 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 (PI’s) 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 ~15× in FY12.
UV on-target energy is calculated based on an energy measurement made upstream of the target chamber.

- A 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

- The BWA consists of a vacuum window and a debris shield
- Surface contamination often exceeds $10^6$ dpm*/100 cm²
- Processing of BWA’s is labor intensive and requires
  - controlled surface contamination areas (CSCA)
  - qualified radiation workers
  - hardware decontamination
  - recoating or replacing debris shield

*dpm: disintegrations per minute
“Mid-cycle” OTIS measurements of all 60 beams are now taken to understand debris-shield transport degradation after two weeks of target shots.

- Overall system, as well as beam-to-beam, transmission can vary widely.
- Historical HED report specifies UV on-target energy based on clean debris-shield transmission.
UV transmission throughout each BWA cycle is highly campaign dependent.
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
- A majority of the laser-cleaning effect is realized after a single shot

![Graph showing beam transmission loss over OTIS runs and self-cleaning after high-loss shots.](image)
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 in 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 “blowthrough OTIS” measurements are used to monitor debris-shield transmission degradation in a subset of beams.

Full OTIS is a 4+ hour operation. Blowthrough OTIS on a subset of beams takes <30 min.
Blowthrough OTIS of two witness beam pairs is used to estimate individual transmission of all 60 beams.

- Historical correlation of witness beam-pair blowthrough 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.
- Blowthrough OTIS predicts:
  - 60-beam average transmission to ~1%
  - individual beam transmission for beams that are shot to <2% rms*

\*rms: root mean square
Examples of blowthrough-estimated individual beam losses compared to actual OTIS measurements

Blowthrough estimated (%)

June 2011

July 2011

October 2011

November 2011

August 2011

August 2011—Fired beams only

Actual transmission measured by full OTIS run (%)

G9487
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