Monitoring Laser Optics by Tracking Damage with an Optic-Independent Coordinate System

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Tracking optic damage from high energy laser shots provides information needed for protecting, repairing and recycling optics. Inspection image data from different cameras and with different illuminations, both on and off the beamline, must map to common coordinate systems in order to track defects throughout their lifetimes. For tracking sites from beamline to laboratory inspections, pinpoint fiducial patterns on optics (when available) provide a reference to physical positions on an optic, primarily for localizing sites with sub-mm accuracy for repair. For beamline inspections, especially when fiducials are not available, we have defined an optic-independent coordinate system, called beam space, to specify the damage site locations relative to the center of the laser beam. This allows discovery of sites that are co-located, along the laser beam path and allows tracking sites from images where fiducials are not available. Beam space coordinates inform the use of blockers which protect sites from further exposure to high laser fluence. Combining the mapping methods (transforms) to and from both of these coordinate systems and employing pre-defined reference data, provides flexible tracking through space and/or time for evaluating, improving and extending the health of the optics.

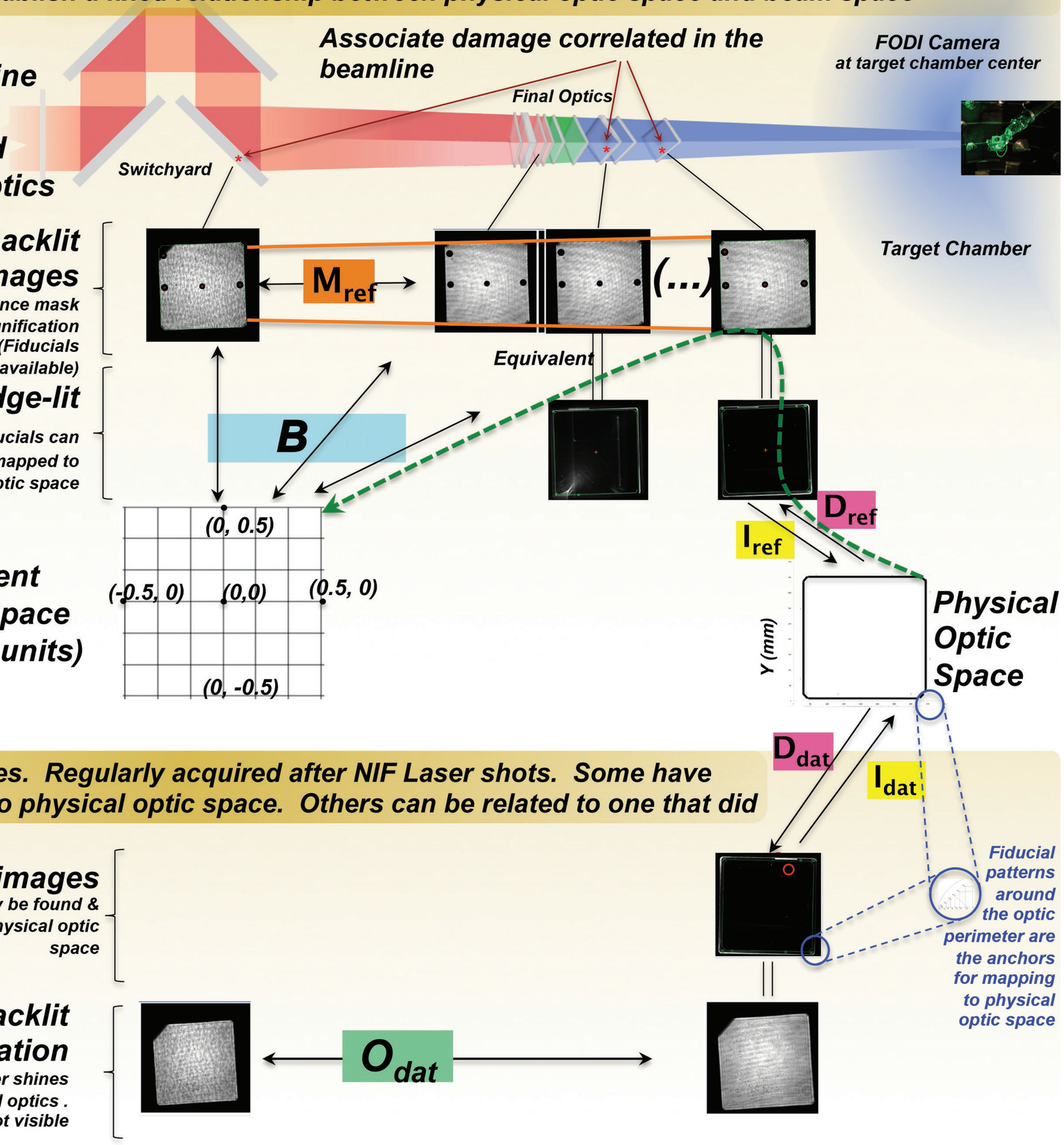
Reference Data. Establish a fixed relationship between physical optic space and beam space

M: Pre-established relative magnification and orientation transformation for any backlit image to any other. Also applies to corresponding edge-lit images)

D_{ref}: Pre-established relationship from physical coordinates to reference beam. (Corresponding edge and backlit images have same image coordinates.)

I_{ref}: Pre-established transformation to physical optic space,

B: Pre-established transformation from reference beam images to a coordinate system representing a 2-D cross section of the laser beam, "Beam Space"



Standard Inspection images. Regularly acquired after NIF Laser shots. Some have fiducials that can be mapped to physical optic space. Others can be related to one that did

O_{BF}: Measured offset (x,y shift) from beam center to beam center in backlit images

I_{dat}: Calculate transformation to physical optic space, by mapping fiducials

D_{dat} Inverse of I_{dat}.

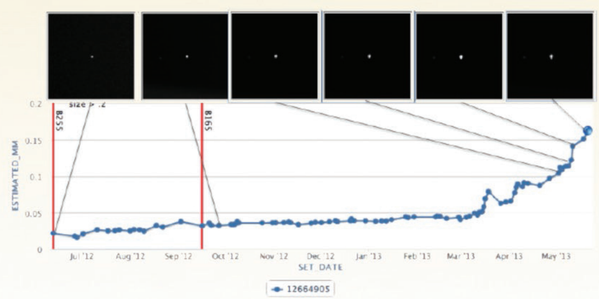
Results. Combine transformations above to get to optic-independent Beam Space coordinates from various types of inspection images

Edge-lit, fiducials & ref data available : $I_{dat} \rightarrow D_{ref} \rightarrow B$

Edge-lit, no fiducials (final optics): $M_{ref} \rightarrow I_{dat} \rightarrow D_{ref} \rightarrow B$,
where I_{dat} is for an optic with found fiducials

Backlit (switchyard optics): $M_{ref} \rightarrow O_{dat} \rightarrow I_{dat} \rightarrow D_{ref} \rightarrow B$

Backlit (final optics): $M_{ref} \rightarrow I_{dat} \rightarrow D_{ref} \rightarrow B$
(O, offset transformation is too small here to determine)



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