# Design of the High-Yield, Time-Gated X-Ray Hot-Spot Imager for OMEGA

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Low-mode 3-D nonuniformities of the compressed core in inertial confinement fusion (ICF) implosions are important to diagnose because they represent inefficiency in the conversion of kinetic to internal energy of the core.[1] X-ray projection to infer 3-D shape is incisive for understanding drive nonuniformities and their potential mitigations.[2] Demonstration of using time-integrated x-ray imaging has been developed,[3,4] which is transferrable to time-resolved analysis with a suite of time-synchronized detectors with sufficient signal. Drift-tube imagers[5,6] coupled to high-speed hybrid complementary metal-oxide semiconductor (hCMOS) detectors[7] have a number of advantages over framing cameras[8] especially for being fieldable in a harsh neutron environment such as those found near the target chamber during high-yield implosions. Radiation-hardened electronic readout is essential to provide real-time data. A third, time-gated x-ray line of sight is proposed for OMEGA to provide an additional view to allow for time-resolved 3-D tomographic reconstruction of the hot-spot shape. The simultaneous operation of this new imager with the existing time-gated x-ray imaging lines of sight on OMEGA[9,10] will enable a time-resolved reconstruction of the low-mode shape of the ICF hot spot.

The x-ray hot-spot imager consists of three distinct subassemblies illustrated schematically in Fig. 1: A 22.5× magnification pinhole-array imager provides a multitude of images at an intermediate plane located outside of the OMEGA tank wall on a large-format photocathode. The x rays are converted to photoelectrons, which are imaged by a demagnifying, dilation drift tube that reduces the photoelectron image by 2× on a detector plane while providing temporal magnification of 100 to 350×. The demagnification serves two purposes, first it allows the imager to operate at a larger magnification that serves to lower the current at the photocathode. Demagnification is required in order to form the image to a suitable size to be detected by available solid-state detectors. In this case the photoelectron images are recorded by two side-by-side hCMOS[10] sensors, which are capable of recording eight sequential frames with an adjustable integration time in the range of 1 to 10 ns. The temporal magnification maps eight 20-ps sequential frames onto the hCMOS with a varying duration from 2 to 7 ns. This magnification allows the entire x-ray emission history of the hot spot to be captured.

The photoelectrons are constrained by a homogeneous axial magnetic field to move helical orbits along the axis of the drift tube, providing an upright photoelectron image onto the hCMOS detector. The design of the tube is segmented with the magnetic-field strength increasing in the latter two segments to provide the 2:1 demagnification of the drifting photoelectron signal as it traverses the tube. Simulations using magnetostatic modeling using the field solver *COMSOL* have been performed to measure the effect of segmentation of the solenoidal field into four separate tube parts working together. The overall effect is negligible relative to the sizes of the imager point-spread function and blurring caused by the drift tube.

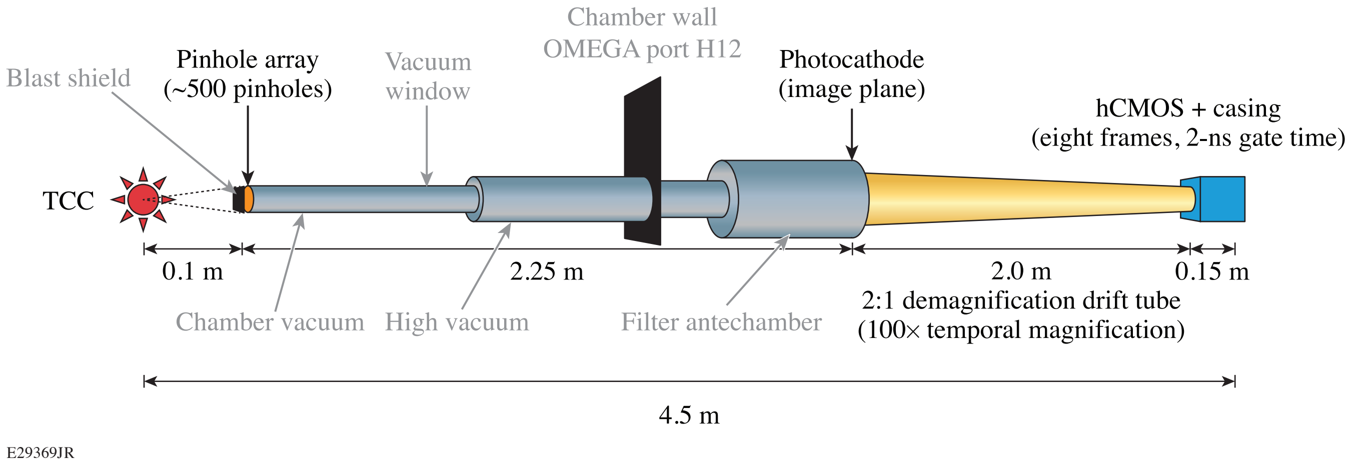

Figure 1
Schematic of the overall x-ray imaging system. A pinhole array is situated 100 mm from the target chamber center (TCC). The x-ray images pass through a beryllium vacuum window located in a re-entrant tube inside the tank that separates the tritium-contaminated tank vacuum from a separate clean vacuum volume that includes the instrument inclusive of the drift tube. The x-ray image emerges from the target chamber out of OMEGA port H12 to an intermediate image plane located 2.25 m from the pinhole array. An access hatch forward of the image plane allows for x-ray filters to be introduced over some or all of the x-ray images. The x-ray imager casts >500 images onto a 50-mm × 50-mm intermediate image plane.

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