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# Design of a Streaked Radiography Instrument for ICF Ablator Tuning Measurements

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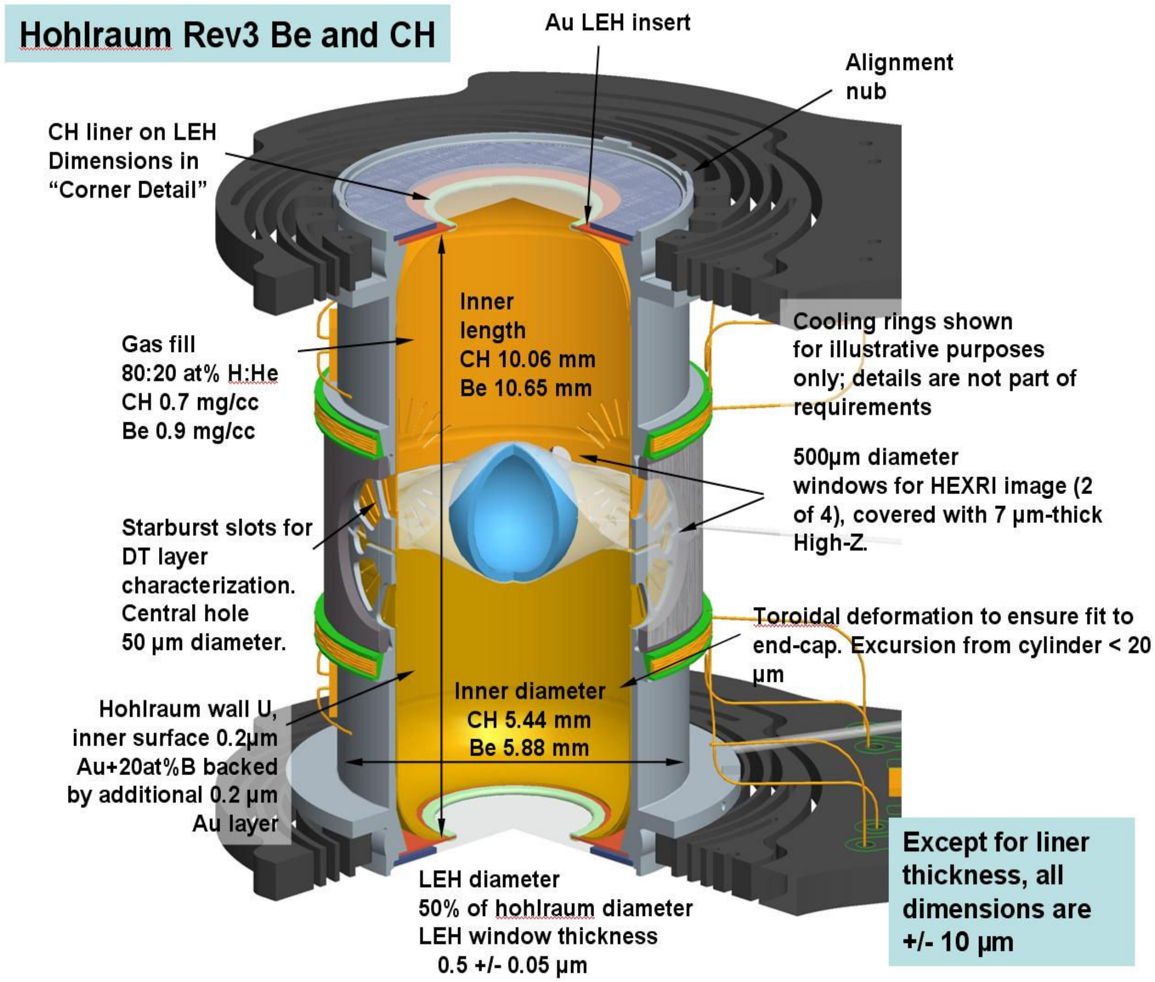
# Design of a Streaked Radiography Instrument for ICF Ablator Tuning Measurements

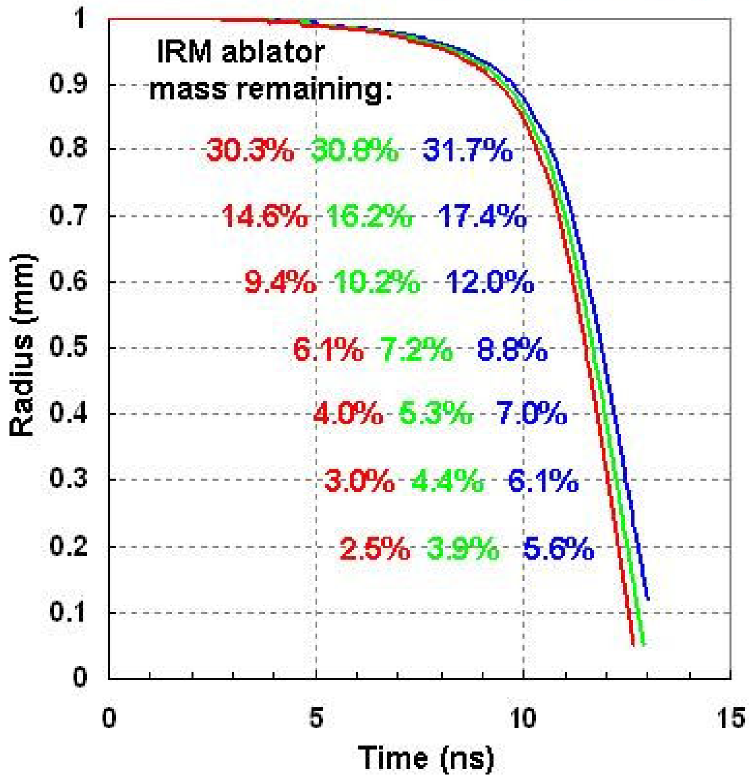
Thermonuclear ignition via indirect-drive Inertial Confinement Fusion (ICF) is the goal of the National Ignition Campaign (NIC) and is one of the primary motivations for the construction of the National Ignition Facility (NIF). For success at the NIF, it is thought that the spherically-imploding capsule must be tuned so that 95% +/- 1% of the original ablator is removed at the time of peak implosion velocity, which must be in excess of 350 µm/ns. If the ablation rate is lower than anticipated there will be too much remaining payload, and the required peak velocity (and, hence, the required hot spot energy density at stagnation) will not be achieved. On the other hand, if the ablation rate is higher than anticipated, the ablator will burn through, and the DT will be preheated and cannot be compressed to the *r*R required for ICF ignition. The NIC has chosen a streaked radiography technique to determine the ablator mass remaining in a NIF ignition capsule at peak velocity. This instrument, the "HXRI-5", has been designed to fit within a NIF Diagnostic Instrument Manipulator (DIM). The HXRI-5 will be built at Sandia National Laboratories (SNL), and initial testing will be done at the SNL Z-Beamlet Facility. In this presentation, we will describe the NIC HXRI-5 requirements, the design, and the planned test experiments.

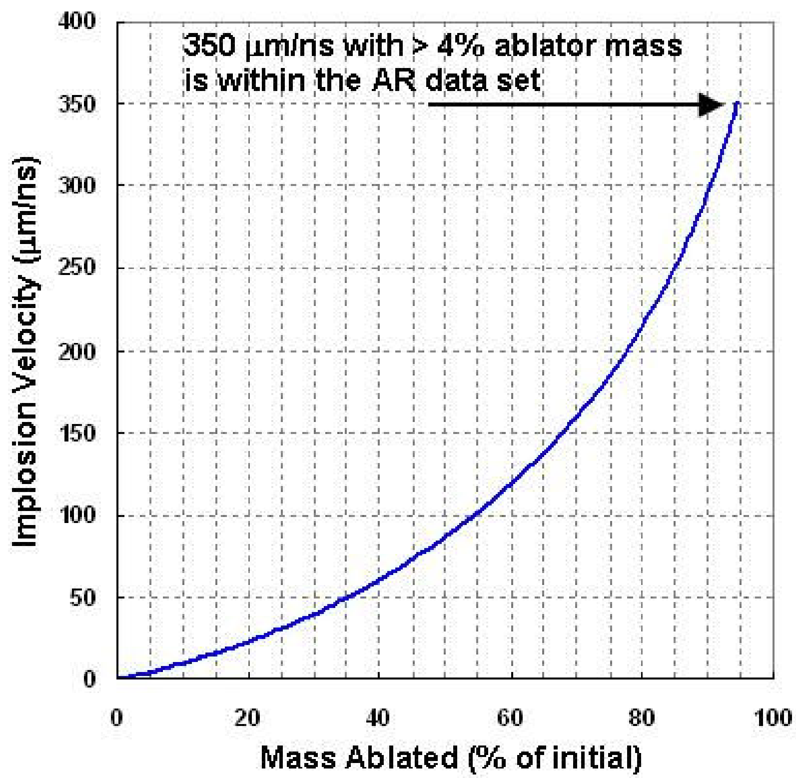
# The NIF ignition target employs a capsule with a graded-doped ablator – either CH+Ge or Be+Cu.



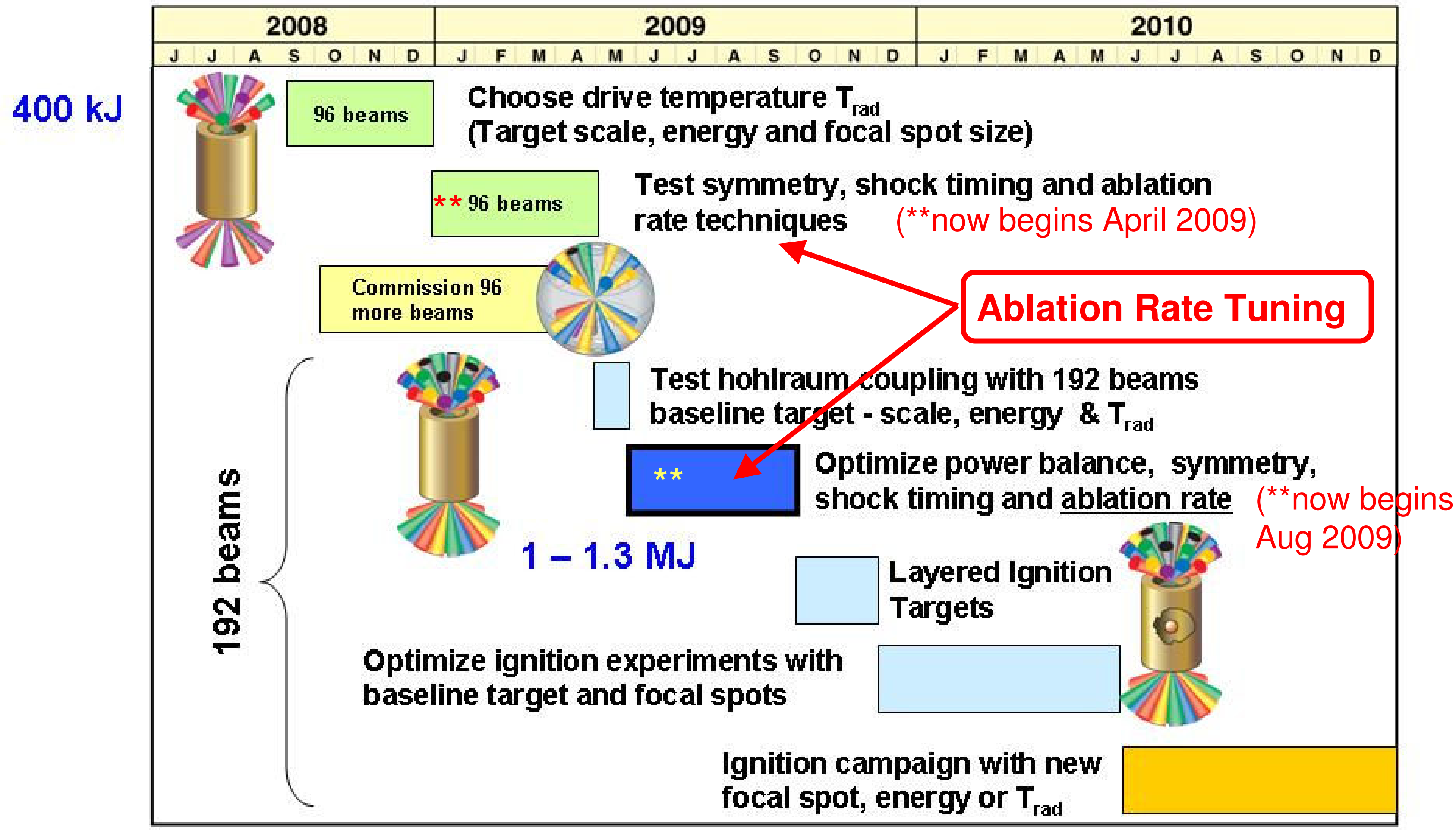
# The ablation rate must be tuned to a peak implosion velocity > 350 μm/ns with > 4% of the ablator mass remaining.

*If ~>97% of mass is ablated, the DT preheat is excessive.*
*If ~<95% is ablated, the implosion (with peak NIF power) is too slow.*



# Ignition campaign experiments will be used to empirically tune key aspects of the target design.

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# The streaked radiograph technique has been chosen as the way to determine ablator mass remaining at peak velocity.

*This technique has been tested in a series of Omega experiments.*

View of hohlraum from streak camera

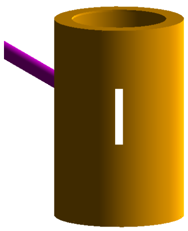
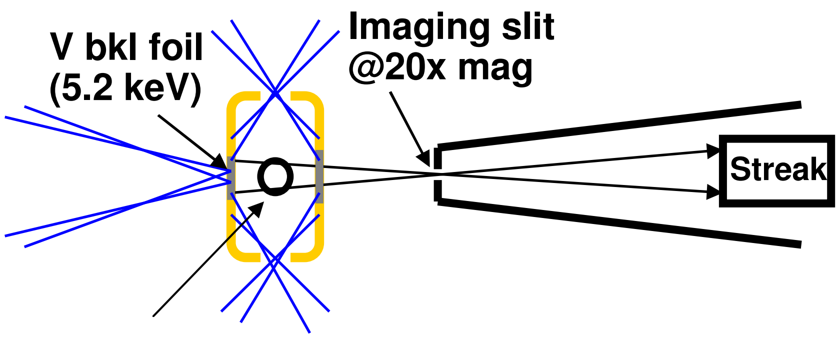
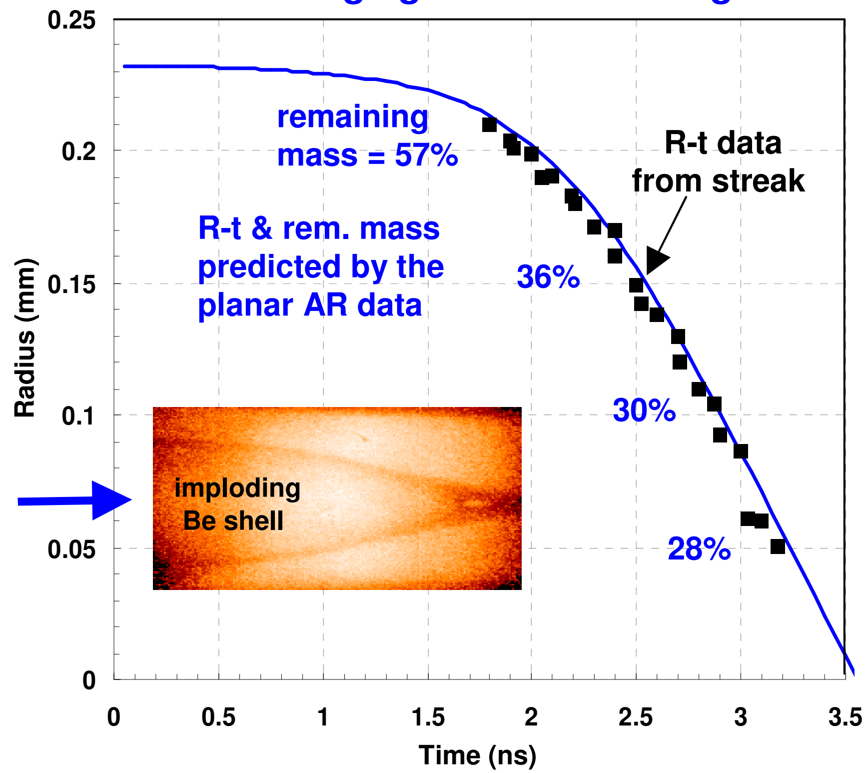


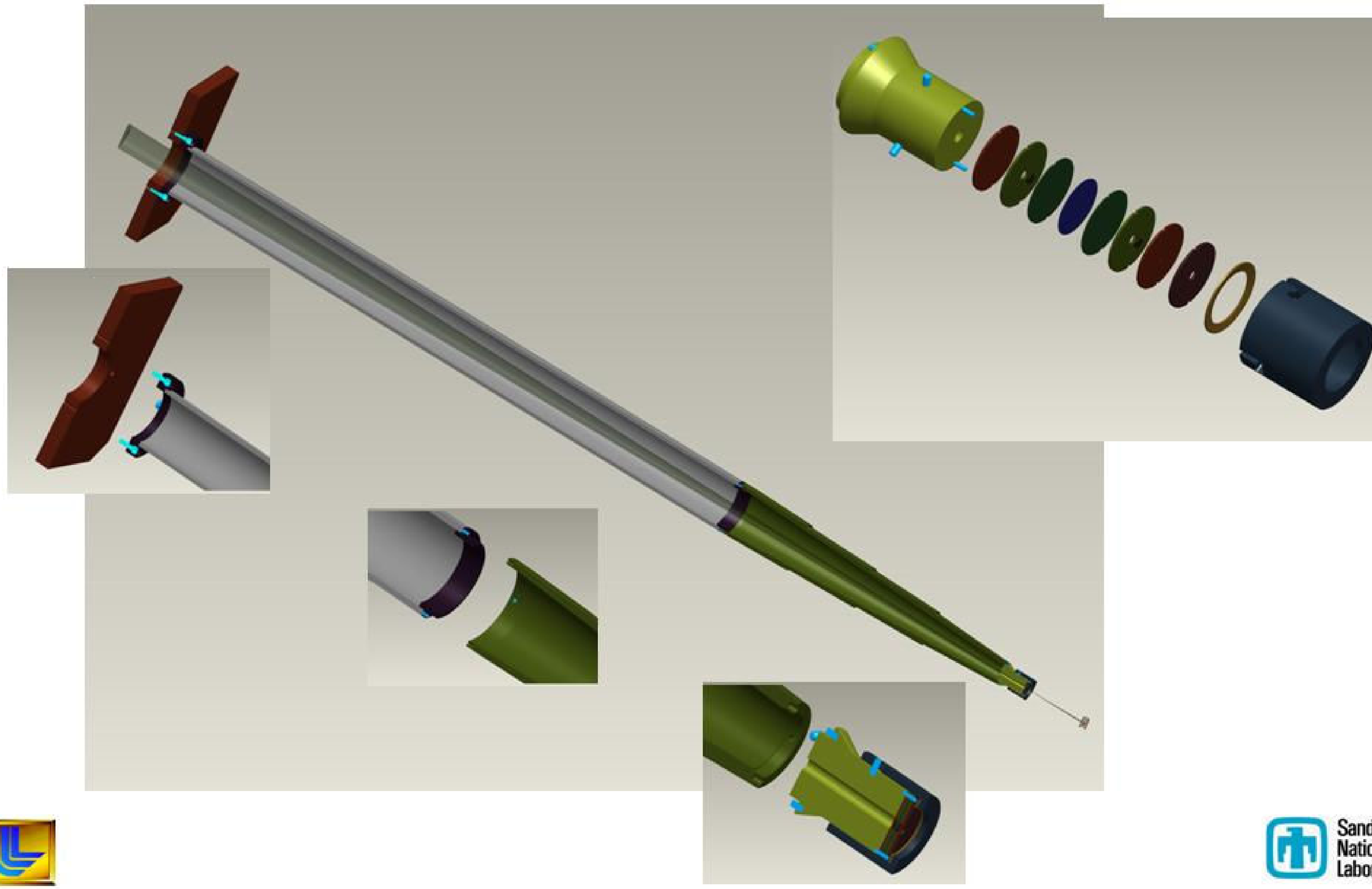
Illustration of the Omega experiment




Cross-slit streaked high energy radiography of converging Be shell at Omega.

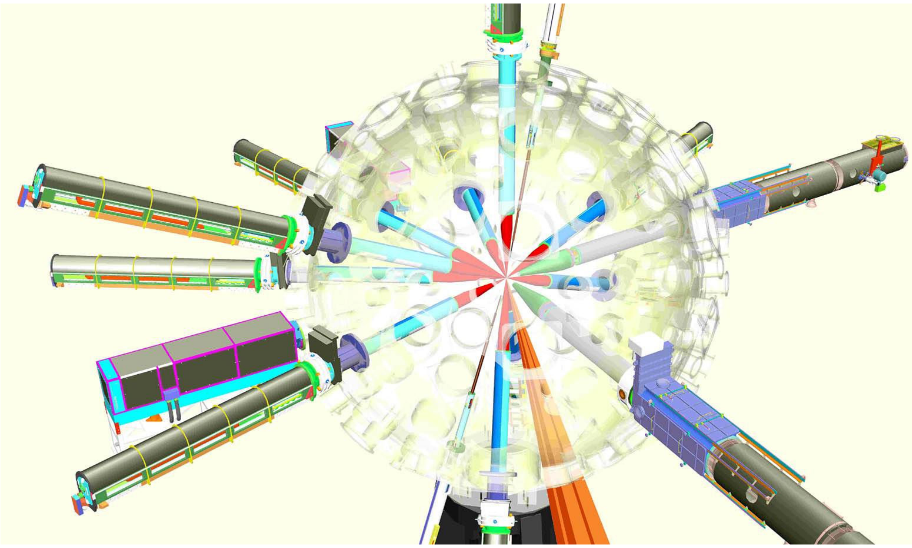


# SNL will design, build, and test the NIF streaked radiography instrument (HXRI-5).

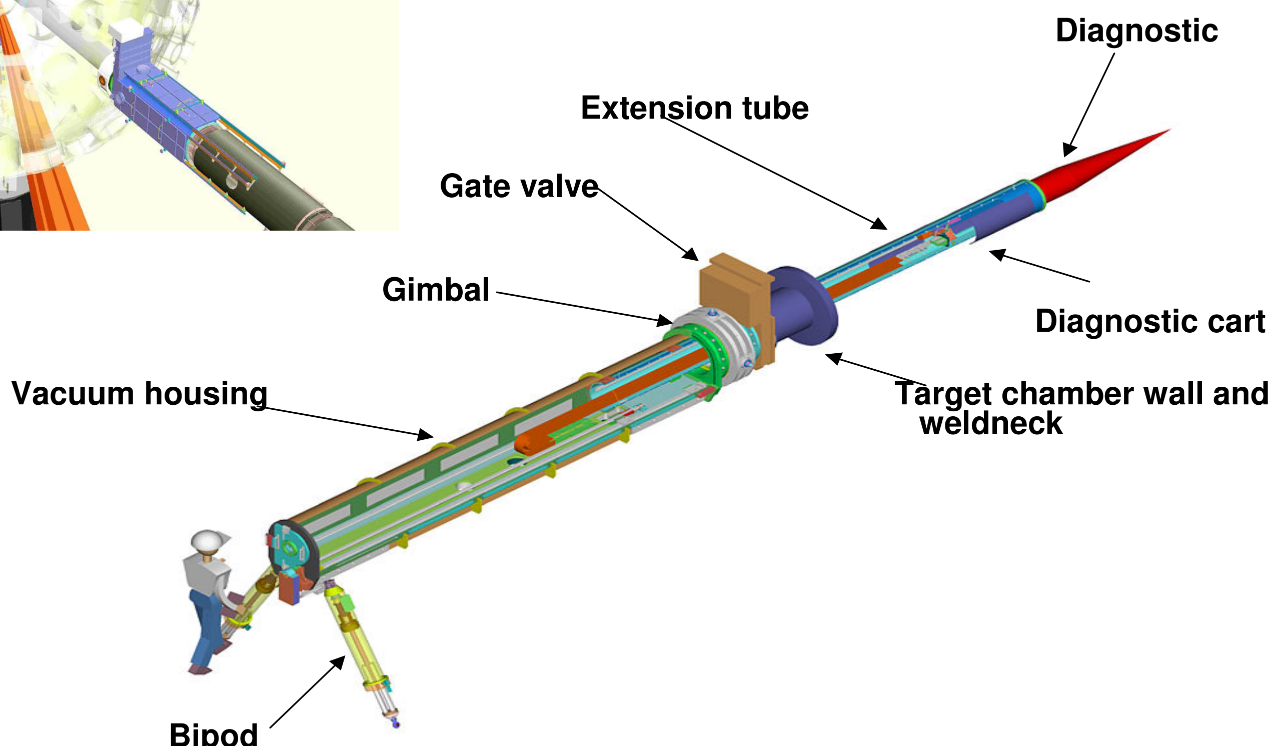


# The HXRI-5 is designed to fit in a NIF DIM.





For convergent ablation measurements, HXRI-5 diagnostic will be in DIM (90,315).



# The HXRI-5 snout is 16X with a 1.3 mm FOV.

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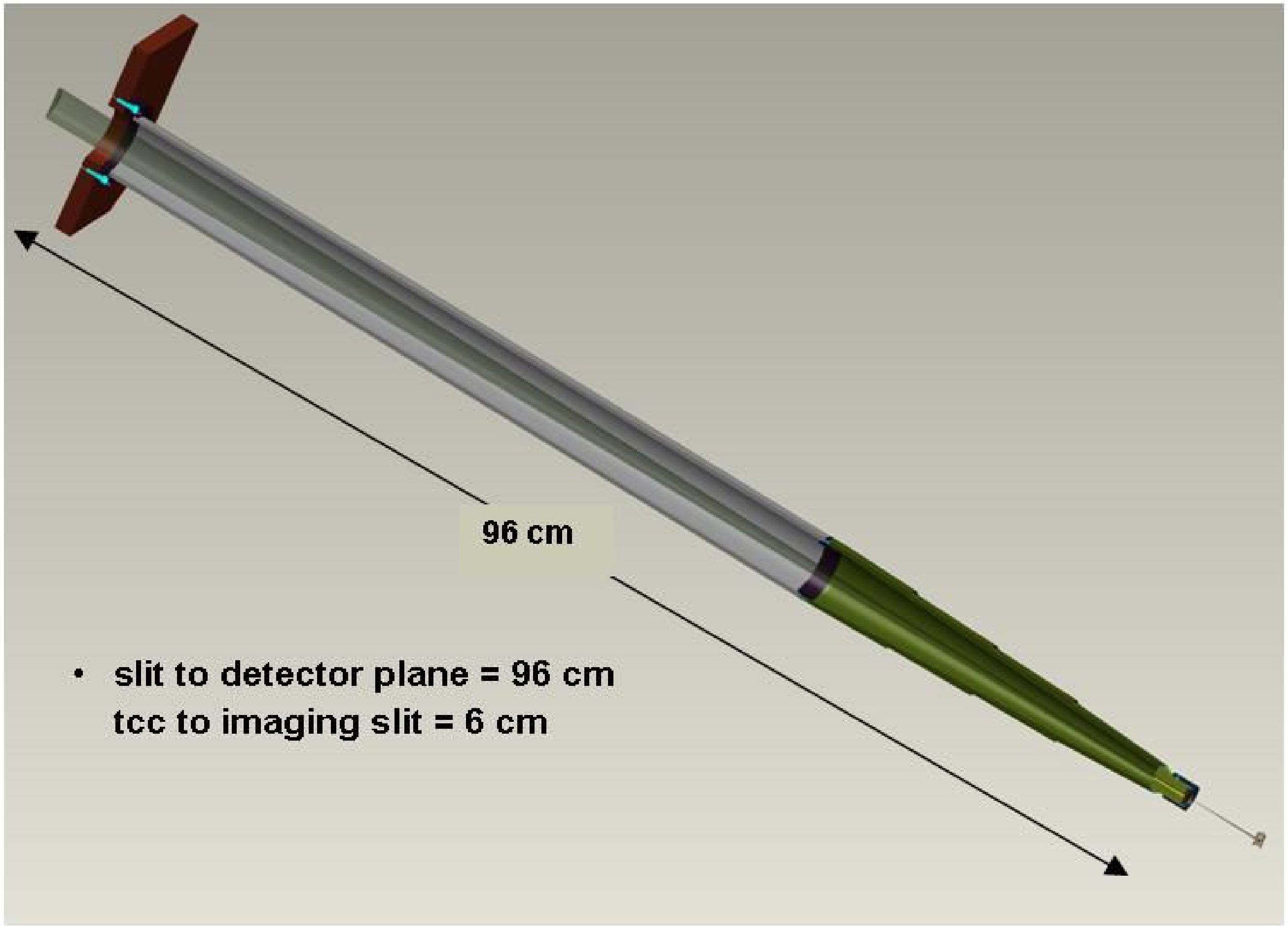
***The 1.3 mm FOV will include the final 75% of the implosion and, even with a large pointing inaccuracy, would still catch the peak implosion velocity.***
***The 16X design will place this FOV onto the central 20 mm of the photocathode.***




- slit to detector plane = 96 cm
  tcc to imaging slit = 6 cm

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# The HXRI-5 snout has three main components.

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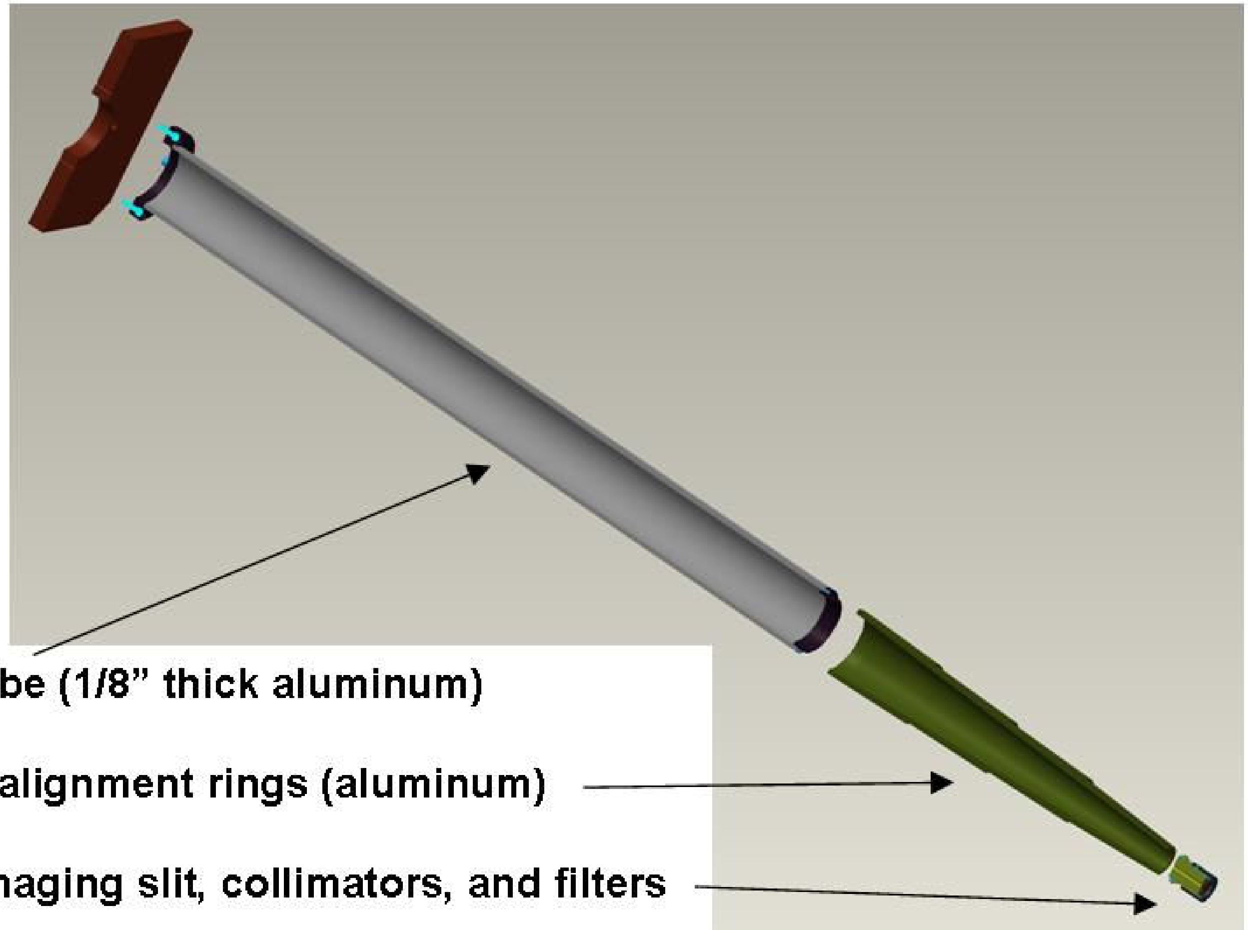
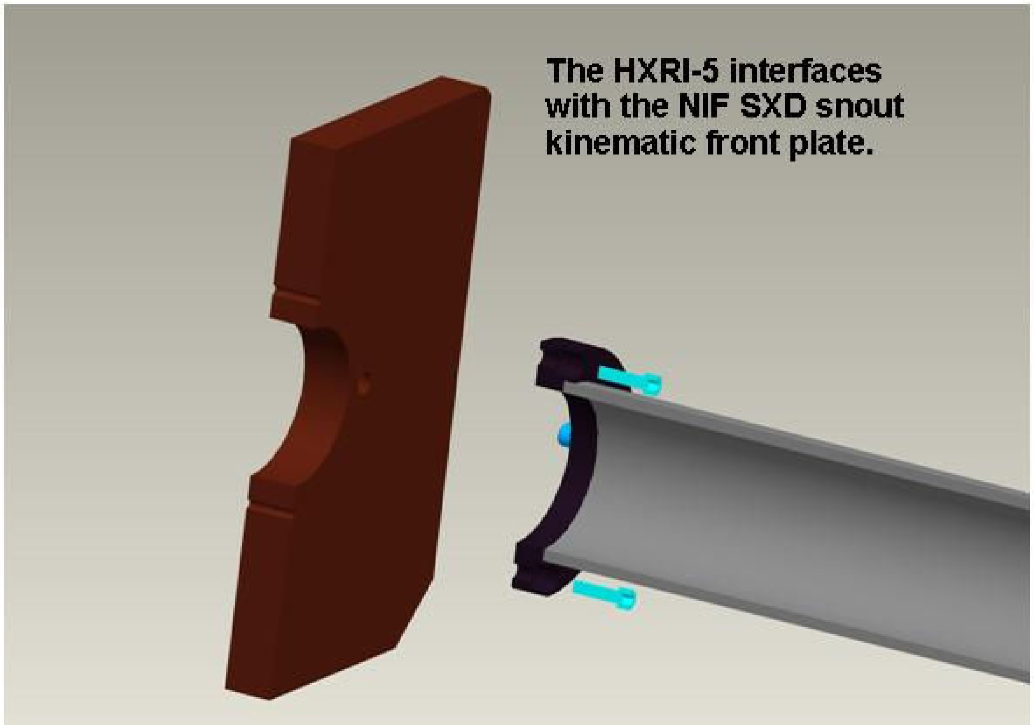



*The 2 cm o.d. collimators will block the FOV from the entire hohlraum length.*
*A 1 degree snout tilt will be used to prevent imaging of strait-thru x-rays.*
*The opposing-port alignment telescope can focus on cone rings and front slit.*

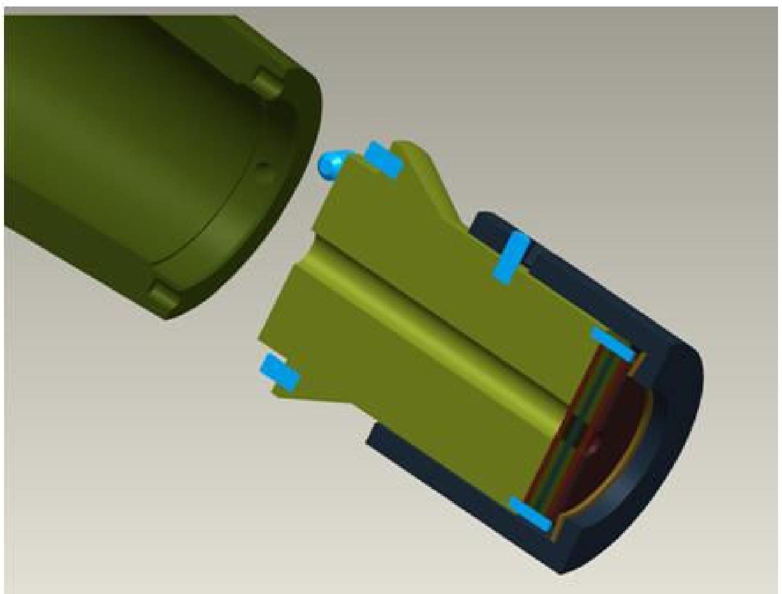
# The HXRI-5 interfaces with the NIF SXD snout kinematic front plate.

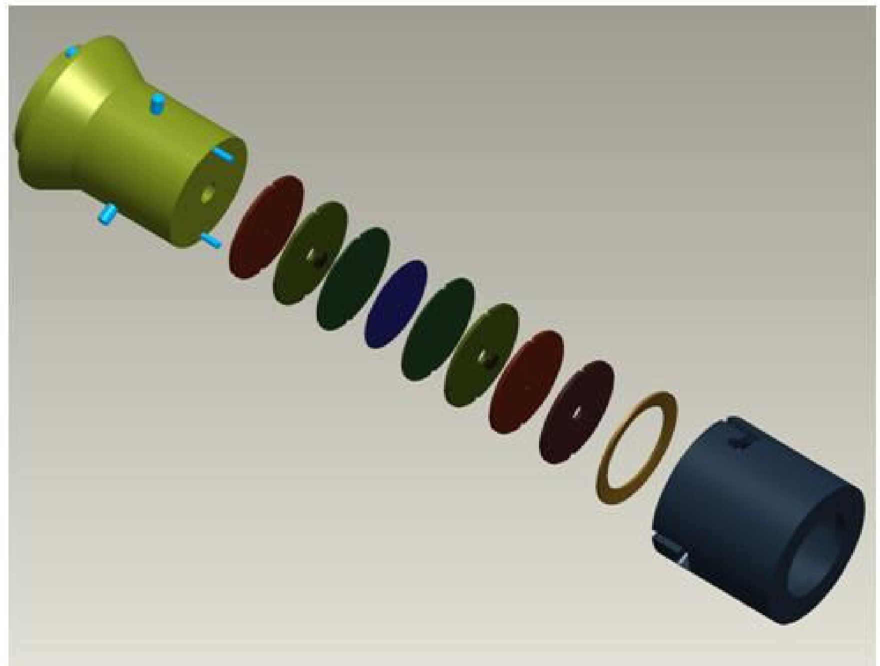
- The SXD/HXRI-5 interface is based upon UCRL-MI-232627.
- Interface details are included in the HXRI-5 Pro/E model



# The HXRI-5 front end contains the imaging slit, four Ta collimators, and two Be filters.

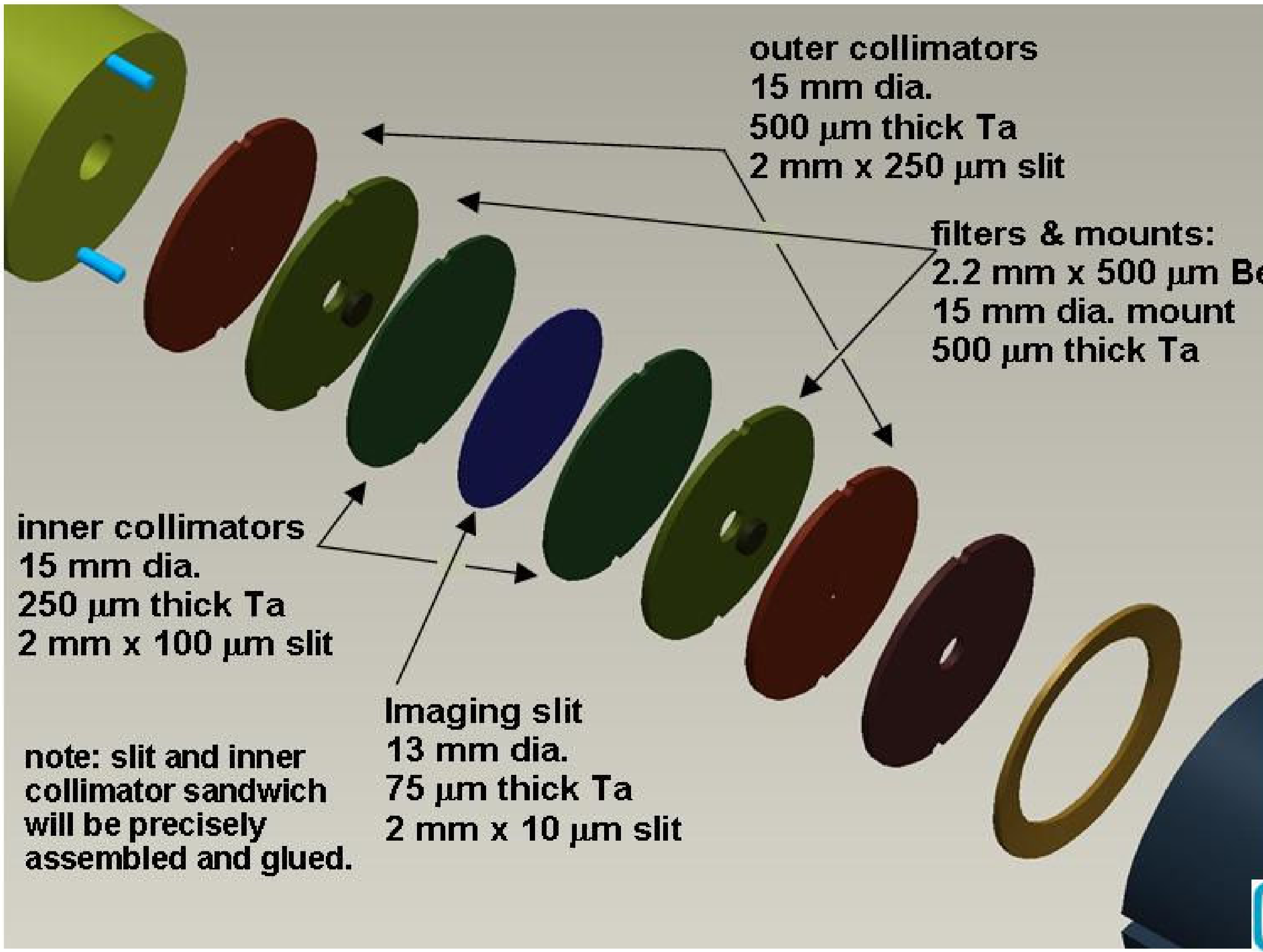
- The nosepiece slides onto the front of the conical section.
- The collimators, slit, and filter mounts slide onto 2 pins.
- The front end includes a spring washer and bayonet cap.





# Dimensions and tolerances for the slit, collimators, filters, and mounts have been specified.

**Suppliers have been identified for the materials and fabrication of these components and some samples have been obtained.**



# A prototype slit + inner collimator sandwich has been assembled and characterized.

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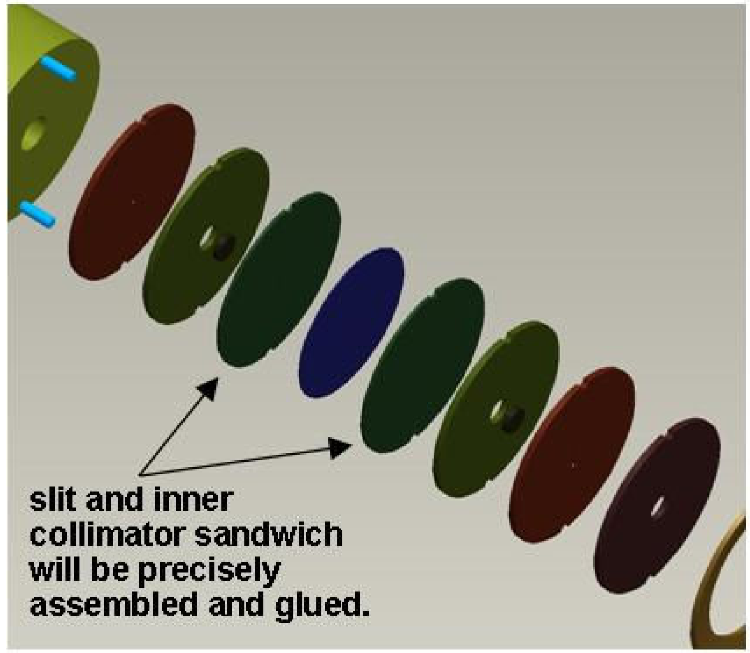
Photo of imaging slit + inner collimator sandwich




**Imaging slit:**
nominal slit width = 10 μm
actual slit width = 10.0 – 11.2 μm
nominal thickness = 75 μm
actual thickness = 83 μm

**Inner collimator slit:**
nominal slit width = 100 μm
actual slit width = 102 μm
nominal thickness = 250 μm
actual thickness = 270 μm

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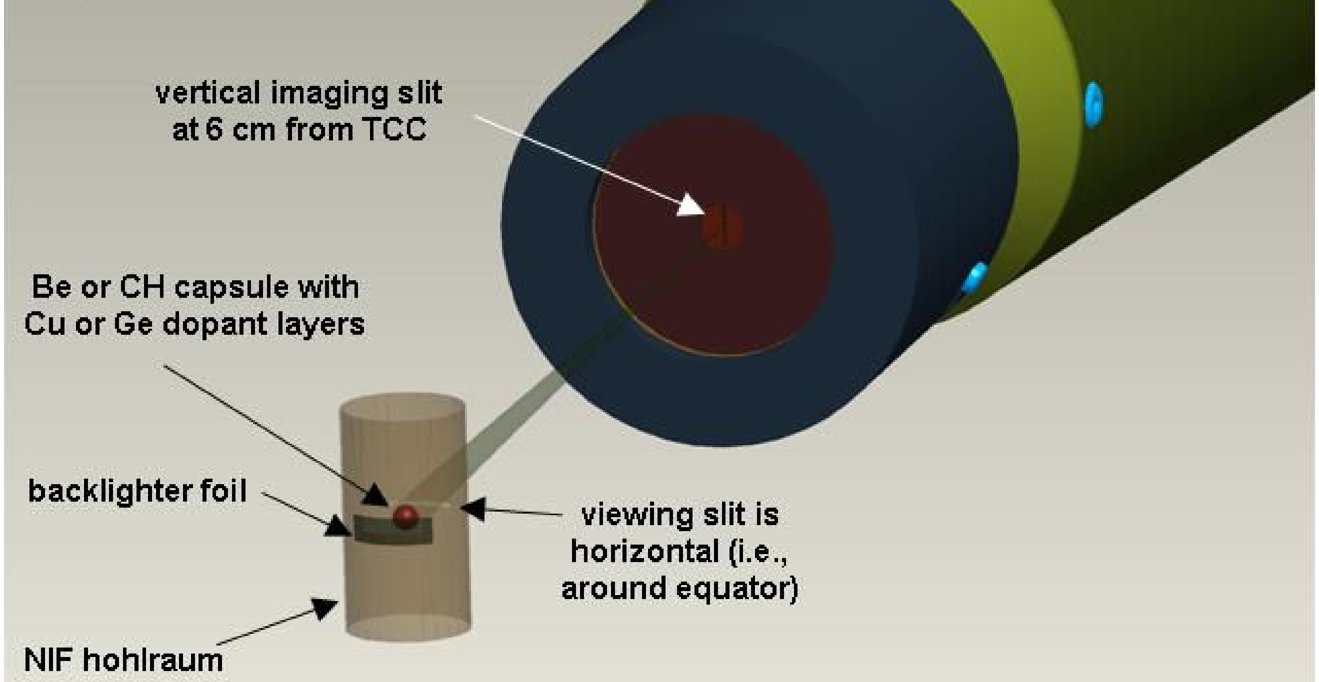
## NIF/NIC Parameters:

| | |
|---|---|
| Magnification | 16 |
| Target resolution | 10-12 μm |
| Field-of-view | 1250 μm |
| Hohlraum slit width | 100-150 μm |
| Sweep length | 2.5 or 5 ns |
| Bkl photon energy | 6.7 keV |
| Bkl intensity | $3 \times 10^{15}$ w/cm$^2$ |



# We plan to test the HXRI-5 in the ZBL cal chamber.

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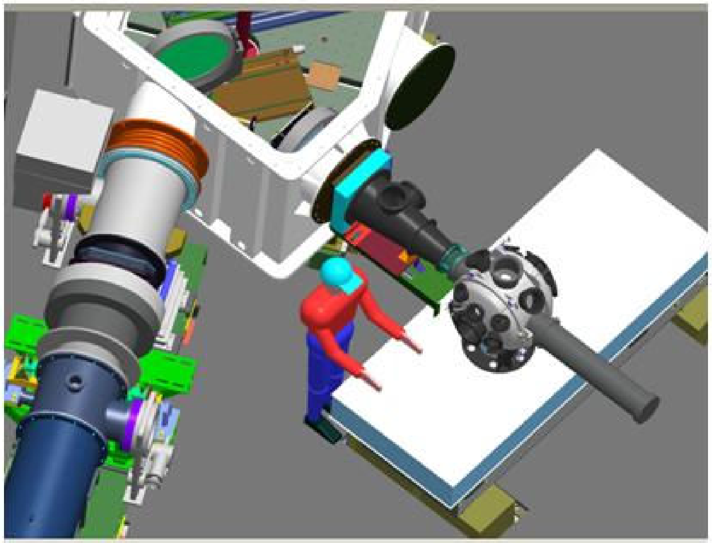
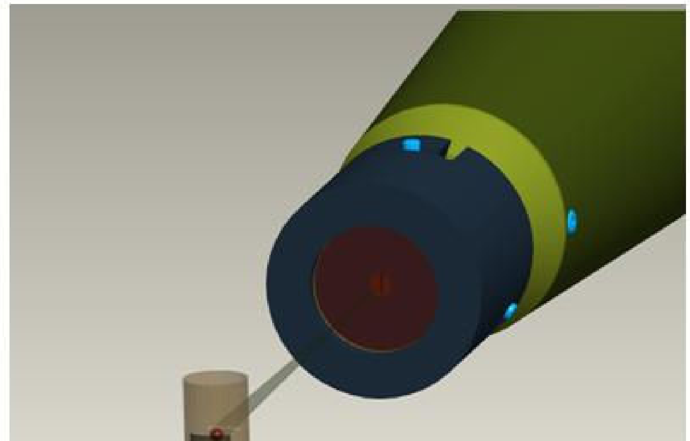
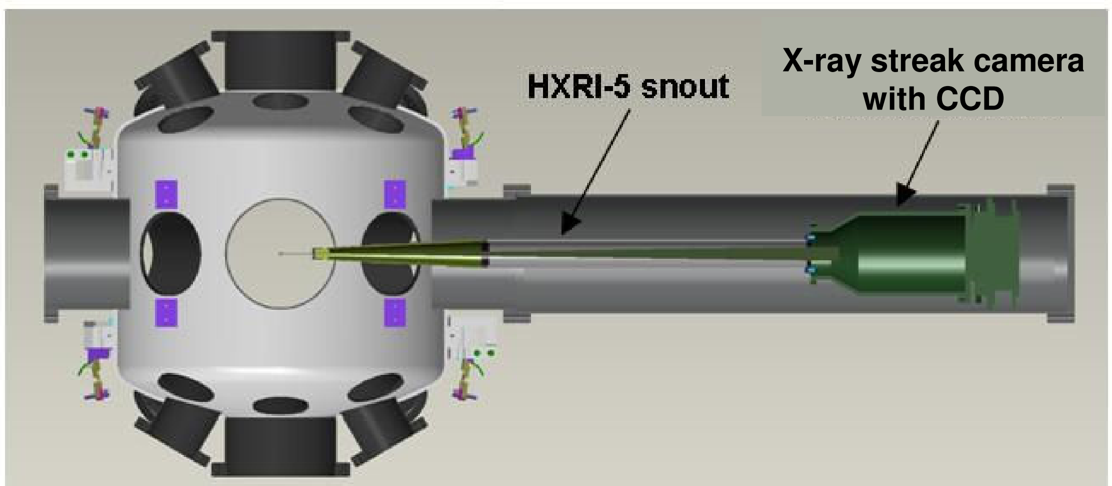




~ $3\times10^{15}$ w/cm$^2$ ZBL pulse
(streak is of a static capsule)

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