Advanced Upgrade of Diamond Anvil Cell Program at GSECARS

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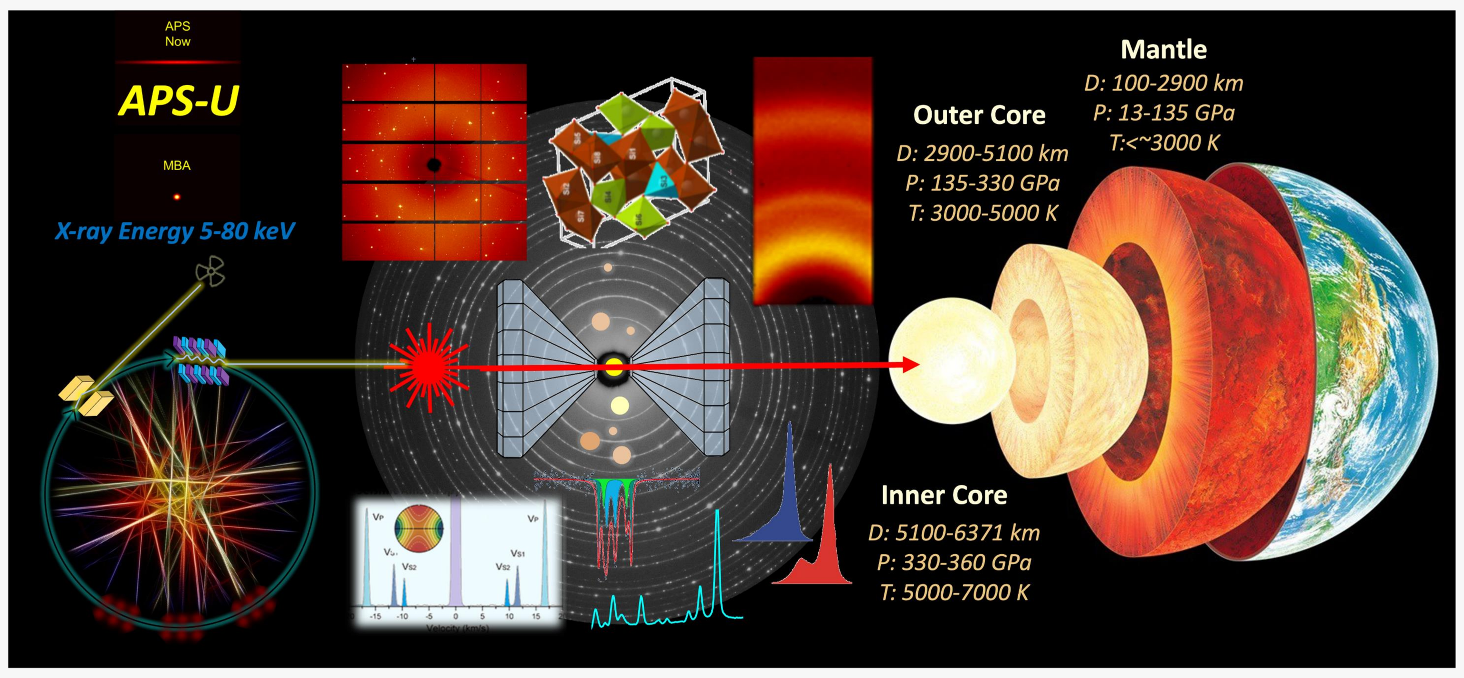
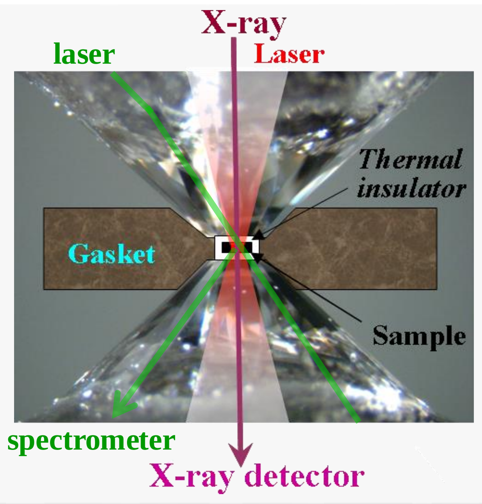
Understanding the complex nature of the deep interiors of the Earth and other planets requires the knowledge of the physical and chemical properties of their constituting elements and compounds at relevant conditions.

To provide new constraints on models for planetary evolution and origin, key properties (melting, structure, phase relation, chemical reactions and kinetics, transport, elastic, electronic and optical properties) of a wide range of minerals must be studied in-situ at extreme conditions of pressure and temperature.



Combination of X-ray, electrical and optical probes coupled with ex situ characterization of sample texture and composition provides a powerful approach for acquiring the kinds of multi-faceted data needed to develop realistic models of how the interior of Earth and other planets formed, evolved, and currently operates

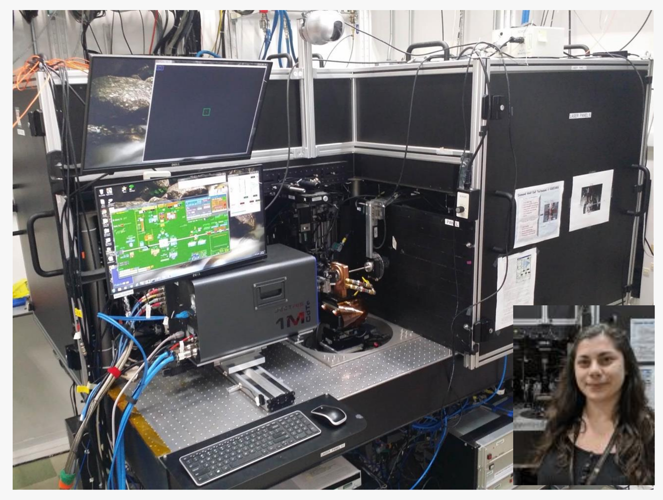
Multiple optical axes (X-ray, lasers, spectroscopy and imaging) should be aligned with sub-micron precision on the sample inside the diamond anvil cell.



13-IDD

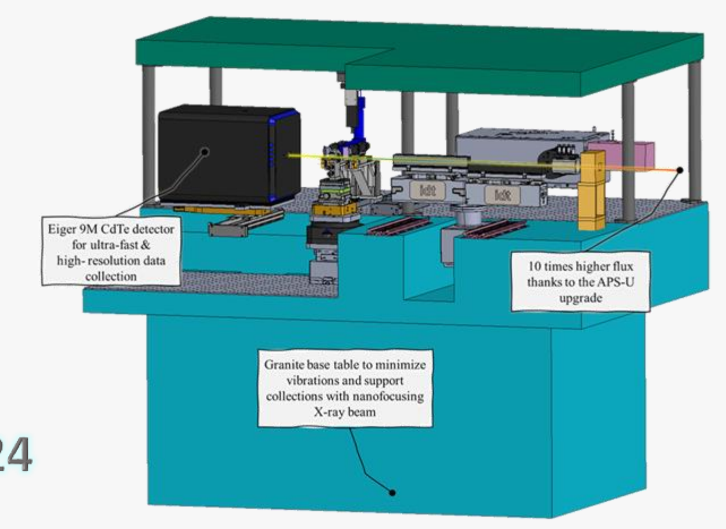
X-ray energy 5 - 80 keV, beam size ~0.3 - 2 µm

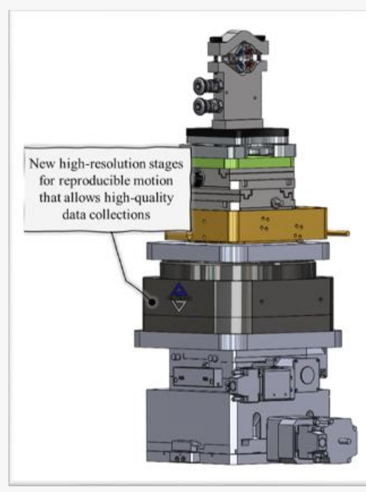
XRD, SCXRD, XES, on-line laser heating, Raman and VIS-IR spectroscopy

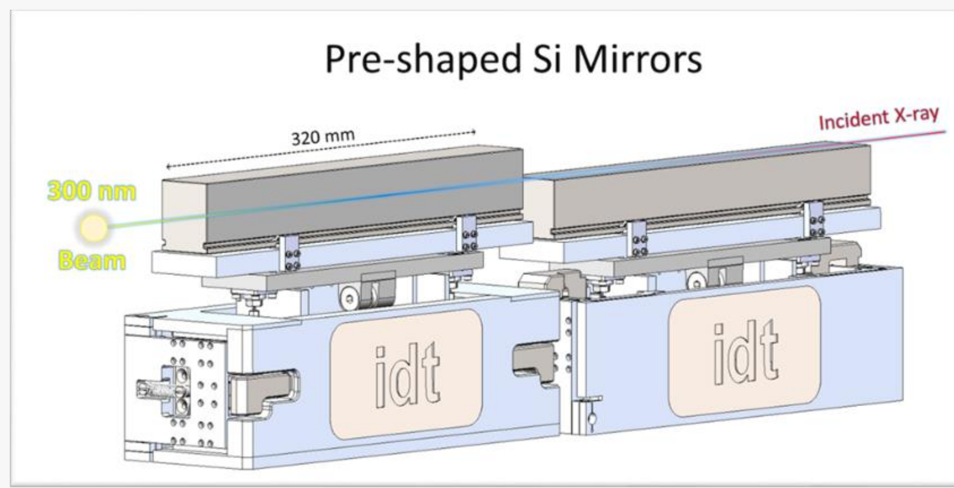


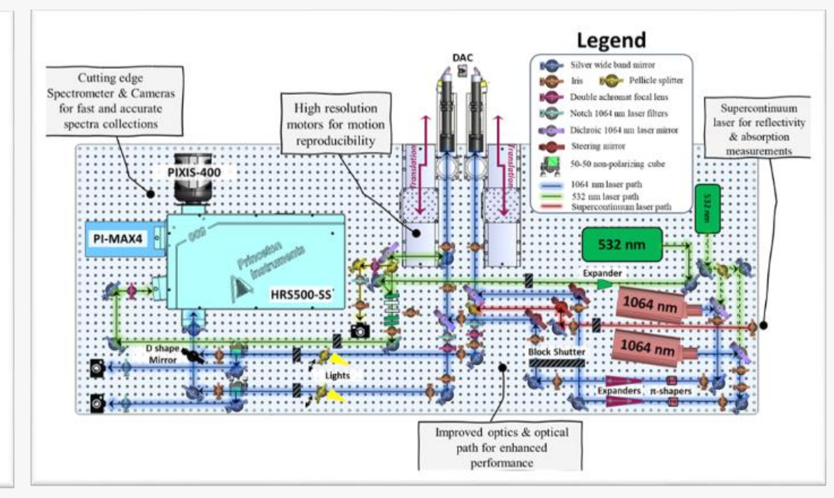
- ✓ *10-100 times more photons*
- ✓ *300 nm X-ray focal spot*
- ✓ *Vibration free granite table*
- ✓ *Air-bearing rotary stage*
- ✓ *9M Eiger CdTe detector*
- ✓ *Supercontinuum laser*
- ✓ *X-ray scan across LH spot*

2023 → 2024







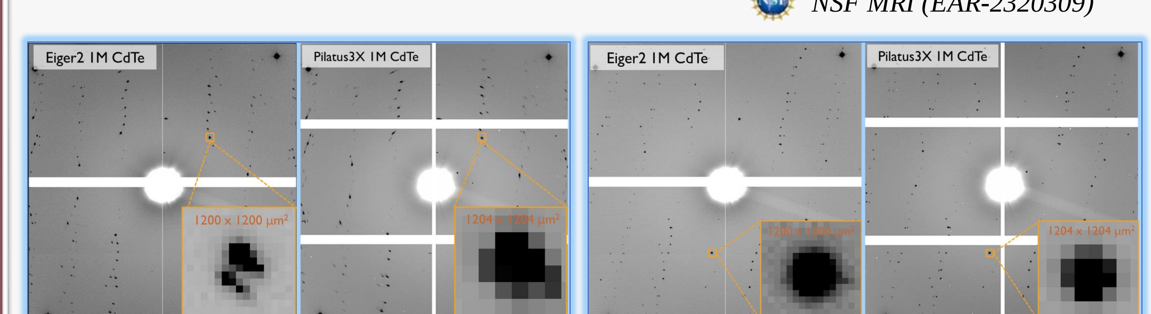


New Eiger2X 9M CdTe X-ray detector

- ✓ *Detect photons with energies of up to100 keV with a spatial resolution at the single-pixel level of 75 µm*

- ✓ *Fast frame rate, dead-time free readout*
- ✓ *The second energy discriminating threshold allows imaging of samples in two energy bins or cut higher harmonics to reduce background*
- ✓ *High spatial resolution and precise peak for single crystal structural information on individual grains*

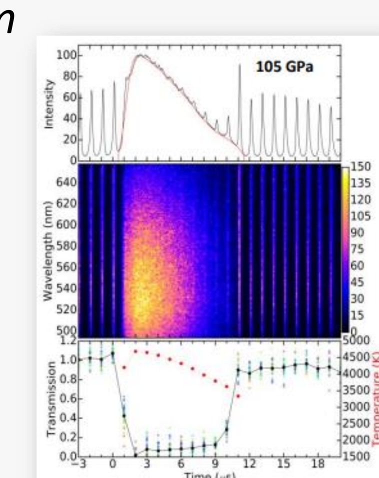
NSF MRI (EAR-2320309)



Supercontinuum laser for spectroscopy

In radiometric temperature determination of laser heated samples, T is usually derived indirectly by fitting Planck's law to the thermal radiation spectrum in assumption that at high T optical properties of the sample do not change and emissivity is wavelength-independent.

For improved accuracy in temperature determination in the LH-DAC we will install at 13ID-D station the optical system to measure sample reflectivity/absorption in-situ at high temperatures with superbright supercontinuum laser in both transmission and reflection geometries.



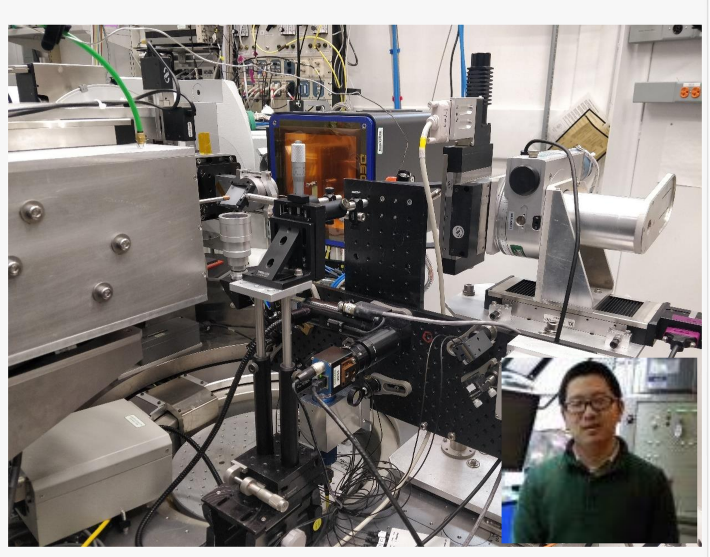
The middle panels are the raw streak camera images (wavelength (nm) vs time (µs)) from the sample heating event (spectrograms). The top panels show the averaged streak camera image along the horizontal axis (black) with a broad thermal background (red). The vertical lines are the optical probe (supercontinuum laser) spaced every microsecond apart.
Prakapenka et al. 2021

13-BMC

X-ray energy 15 or 28.6 keV, size ~20 µm

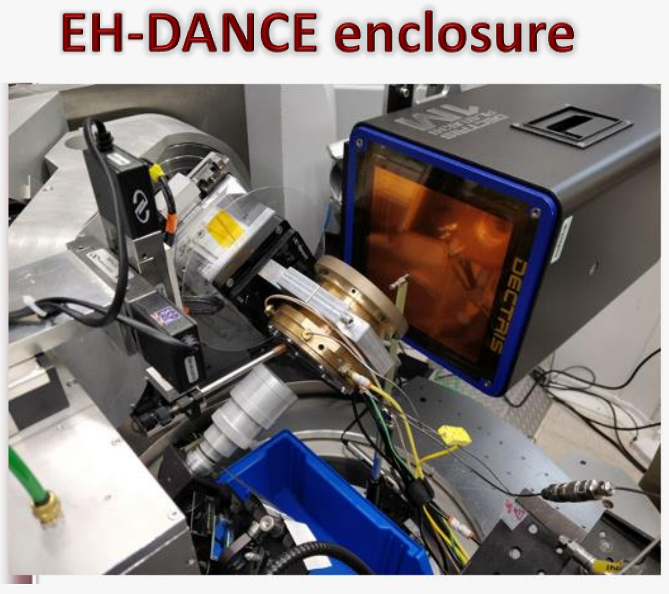
SCXRD, radiography, on-line laser heating, Raman and VIS spectroscopy

- ✓ *High energy X-ray efficient Pilatus3 1 M CdTe detector will be available for most DAC experiments*
- ✓ *Fast shutter-less gated optical detector PI-MAX3 will be installed for radiometric temperature measurements above 1000 K with optional synchronization with laser heating pulses*



- ✓ *Updated enclosure for precise high temperature experiments with resistive heating DAC up to 1400 K*
- ✓ *Compact cryostat for low temperature DAC experiments with rotation capabilities for SCXRD measurements*
- ✓ *Rowland circle monochromator upgrade: adding another Si crystal to enable energy >35 keV.*

EH-DANCE enclosure



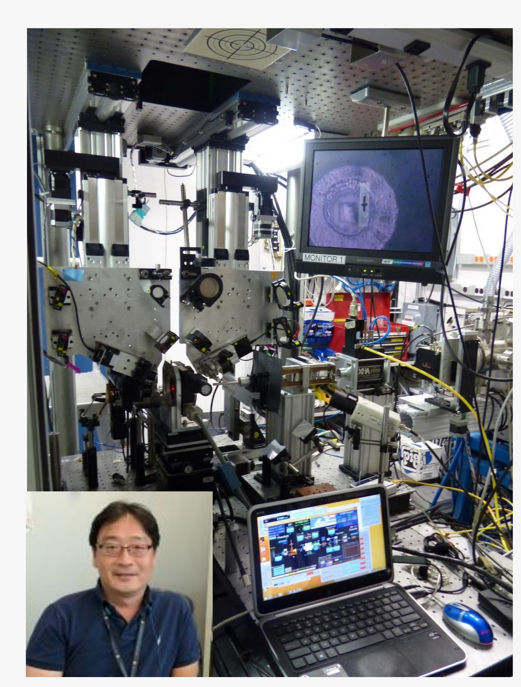
Compact Cryostat

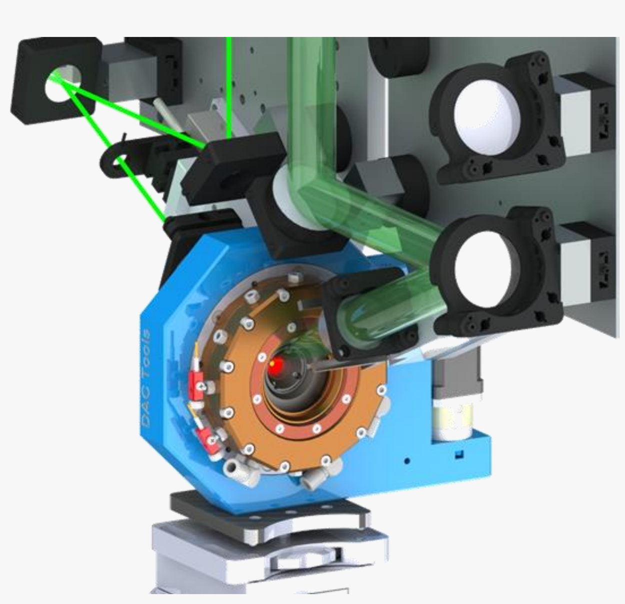
13-BMD

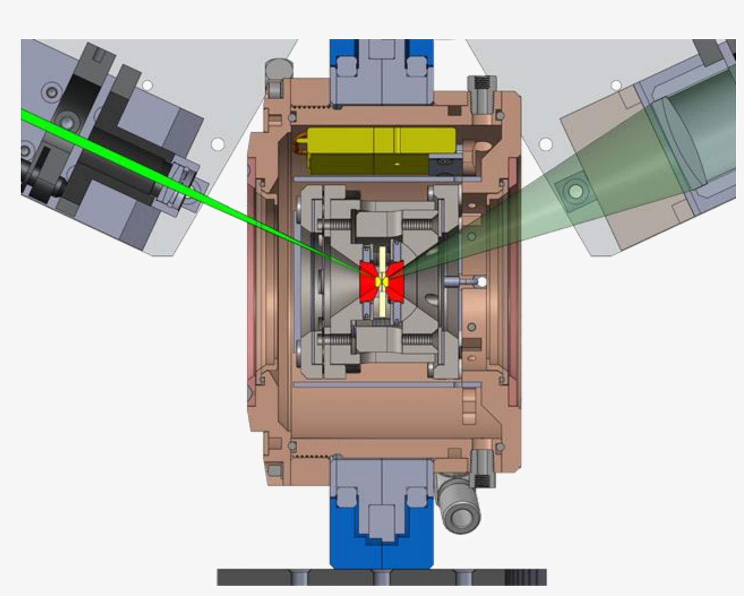
X-ray energy 5 - 80 keV, beam size ~6x12 µm

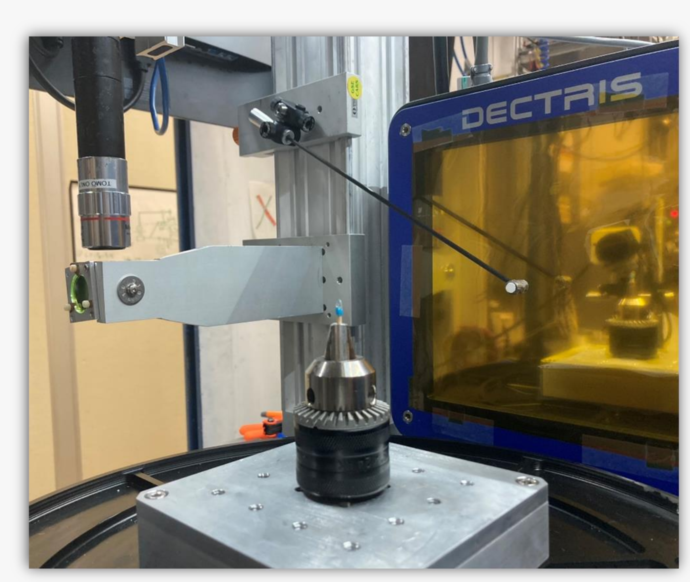
XRD, SCXRD, 3D tomography with SCXRD, on-line Brillouin, Raman and VIS-IR spectroscopy

- ✓ *High resolution (spatial and spectral) Raman spectroscopy in backscattering geometry with dedicated optical path*
- ✓ *High precision motorized stages for 12x zoom microscope to improve sample imaging, alignment and reproducibility*
- ✓ *Modification of the focusing and collecting platforms in the Brillouin system to fit new large high temperature enclosure for externally heated DAC with custom designed rotation stage. The system has been developed in collaboration with DACTools and Hanyang University*
- ✓ *Combination of 3D computer tomography with tightly focused XRD (single-crystal or powder) to study micro-inclusions inside bulky matrix*









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