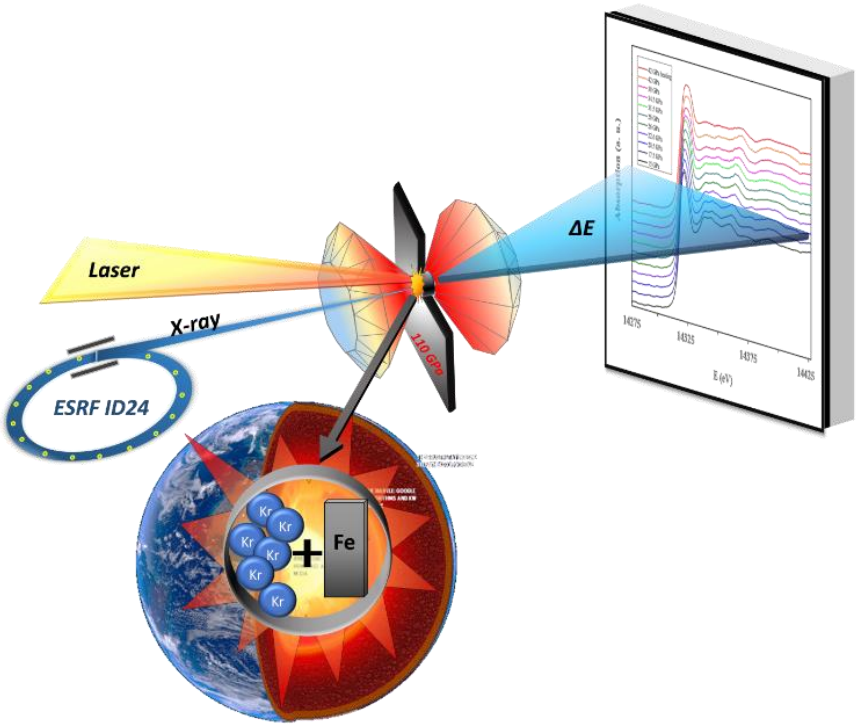
Extreme conditions programme at BM23/ID24 after the EBS upgrade



ESRF-EBS

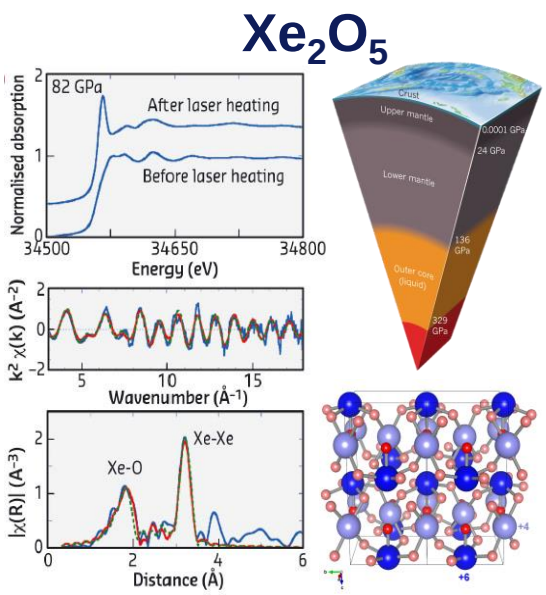
A.D. Rosa

O. Mathon, S. Pascarelli, C. Clavel, N. Sevelin-Radiguet, R. Torchio, K. Lomachenko, S. Pasternak, F. Perrin, H. Gonzalez, A-R. Ruiz-Bailon, F. Torrecillas, F. Villar, G. Berruyer

EXTREME CONDITIONS XAS STUDIES AT ID24/BM23

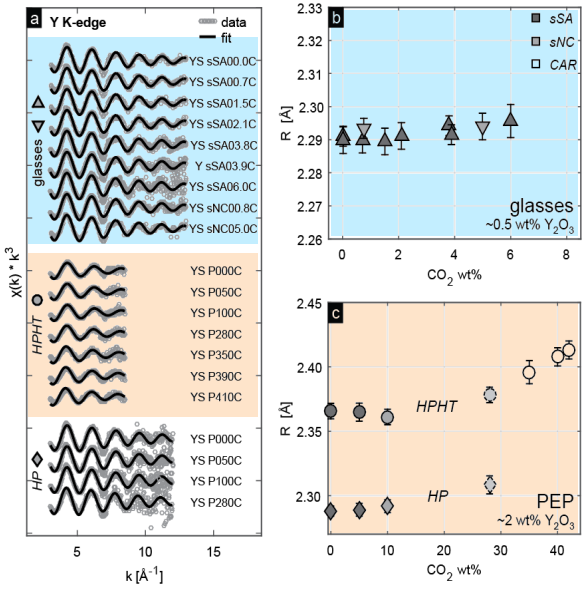
Since 2012 ~ 40 % of beamtime

Matter in planetary interiors



Dewaele et al., 2016, Nature Chemistry

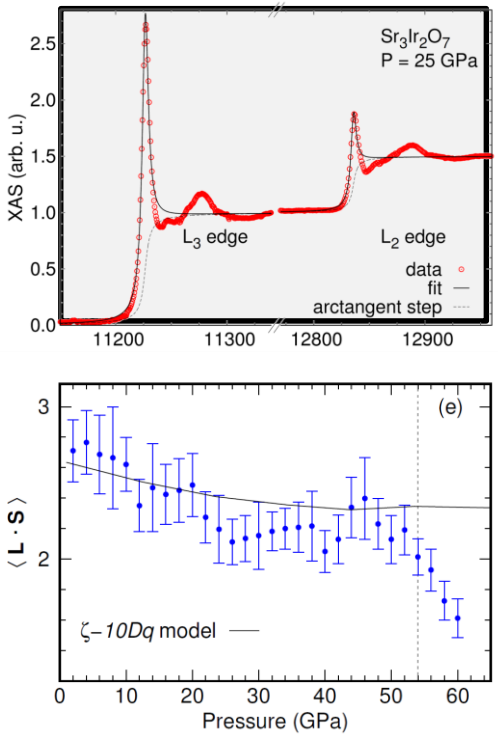
Matter at high dilution levels



Trace elements in glass or melt:
Clear difference!

Pohlenz et al., 2018, Chemical Geology

Electronic and magnetic structure of condensed matter



e_g- t_{2g} spin orbital splitting

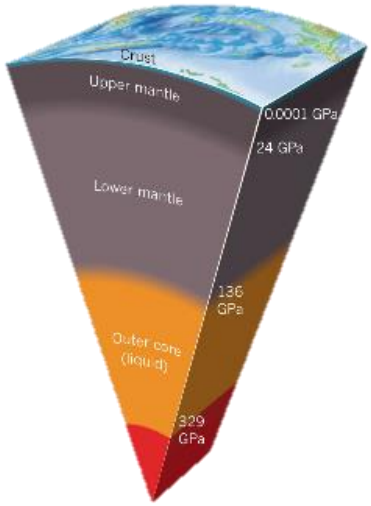
Donnerer et al., 2018, PRB

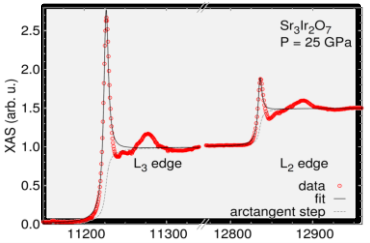
OPPORTUNITIES WITH EBS

current limitations

ID24:

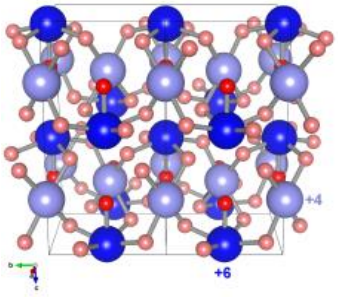
- Variable beam size (increase with E, at Kr 50 µm FWHM)
- 120 GPa, 3500 K
- Mostly XANES often no EXAFS
- Major elements
- No spatial resolution, XRF very challenging

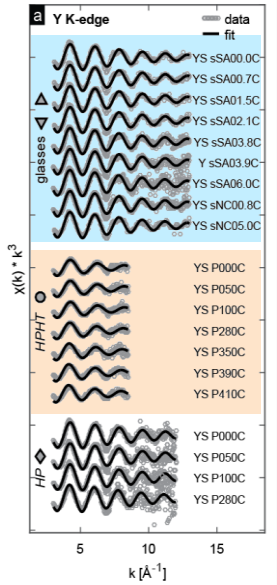




BM23

- Limited flux
- No access to real dilution levels at high P/T
- Major elements and high Z elements 150 GPa





With the EBS these limitations will be overcome !

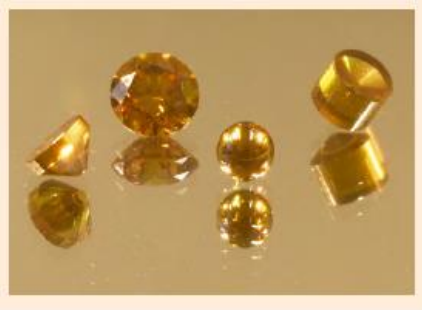
ESRF-EBS

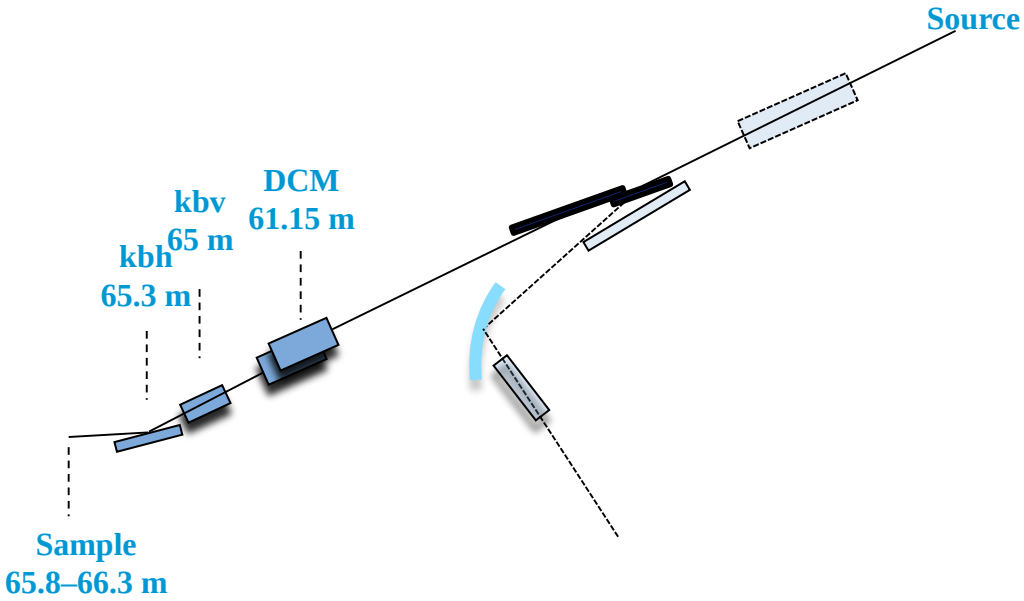
The European Synchrotron | ESRF

NEW BEAMLINE CAPABILITIES ID24-DCM BM23

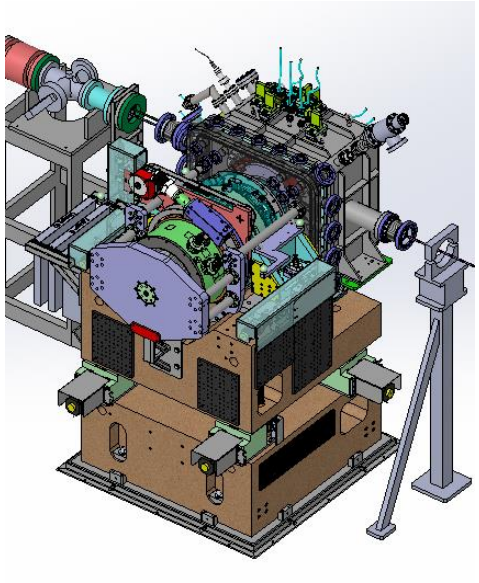
	ID24 DCM	BM23
EXAFS	5-45 keV	5-75 keV
	up to 20 $Å^{-1}$, $\Delta E/E = 10^{-5}$	
Spot size	0.6*0.6 μm^2	3*3 μm^2
Flux ph/s	$8*10^{11} – 2*10^{13}$ One order of magnitude	$2*10^{9} – 2*10^{10}$ Factor 2-3
Time resolution	Quick EXAFS (1s/EXAFS)	
XRF	With spatial resolution	

If combined with nano polycrystalline diamonds (T. Irifune)





NEW DOUBLE CRYSTAL MONOCHROMATOR
ID24 DCM BM23



Outstanding performance:

Extremely high energy and position stability and reproducibility

- angular stability 0.05 µrad
- Bragg angular position repeatability (0.1 µrad)
- spot position stability on sample (below 1 µm)

Over E scan of 30º (4.5 keV)
New feedback system - real time control of crystal parallelism

Ideal for:

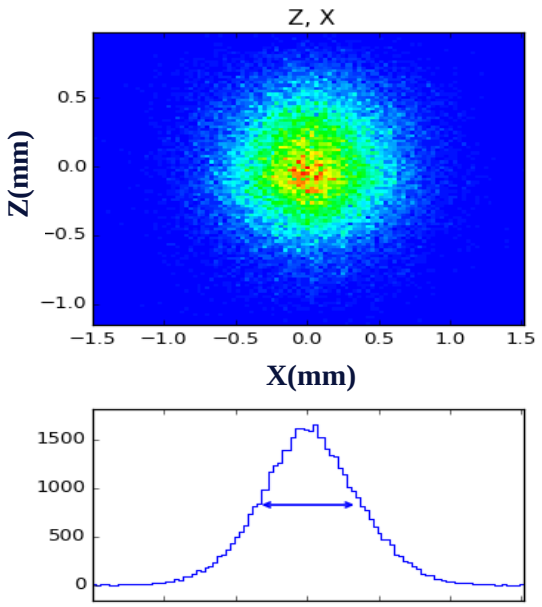
- **Long acquisitions on highly diluted samples**
- **Time resolved studies (quick scans, mapping)**
- **Change of energy for XRD - XAS**

KB SYSTEM ON ID24

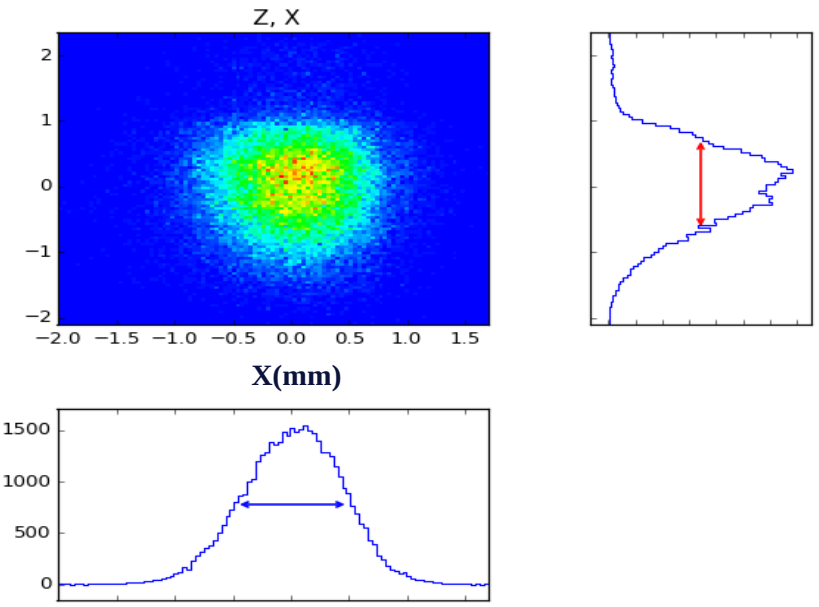
Enhanced focusing capabilities

With possibility of a variable spot size on sample

0.6 x 0.6 µm²



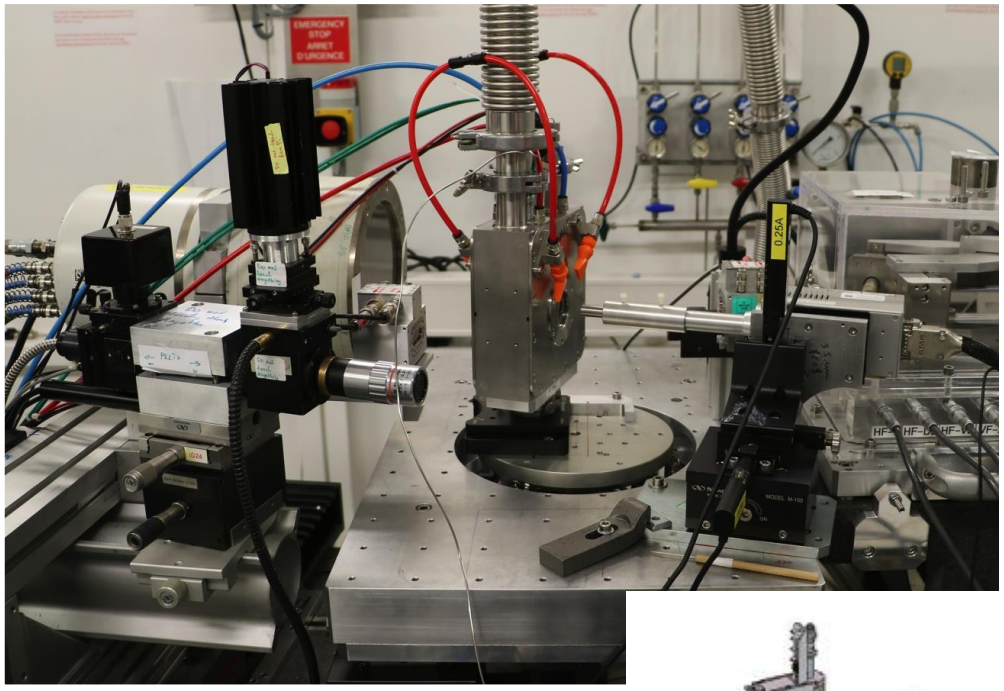
1.0 x 1.4 µm²



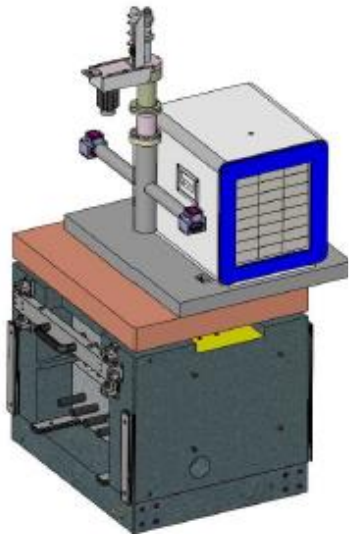
0.4 m distance sample to KB mirror **1 m**

NEW DETECTION SYSTEMS FOR XRF AND XRD

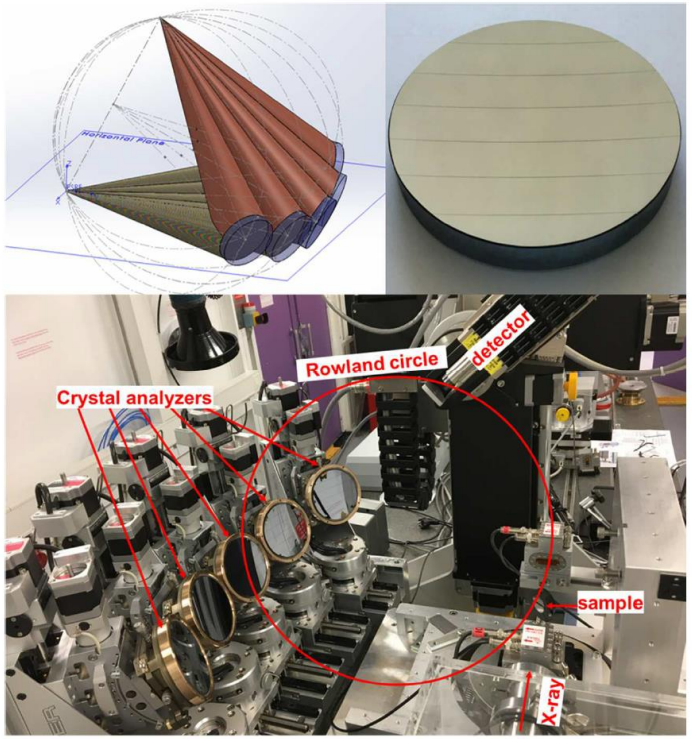
- **Poly-capillary** + SDD + high P/T sample environments



- **Pilatus 2M** XRD detector



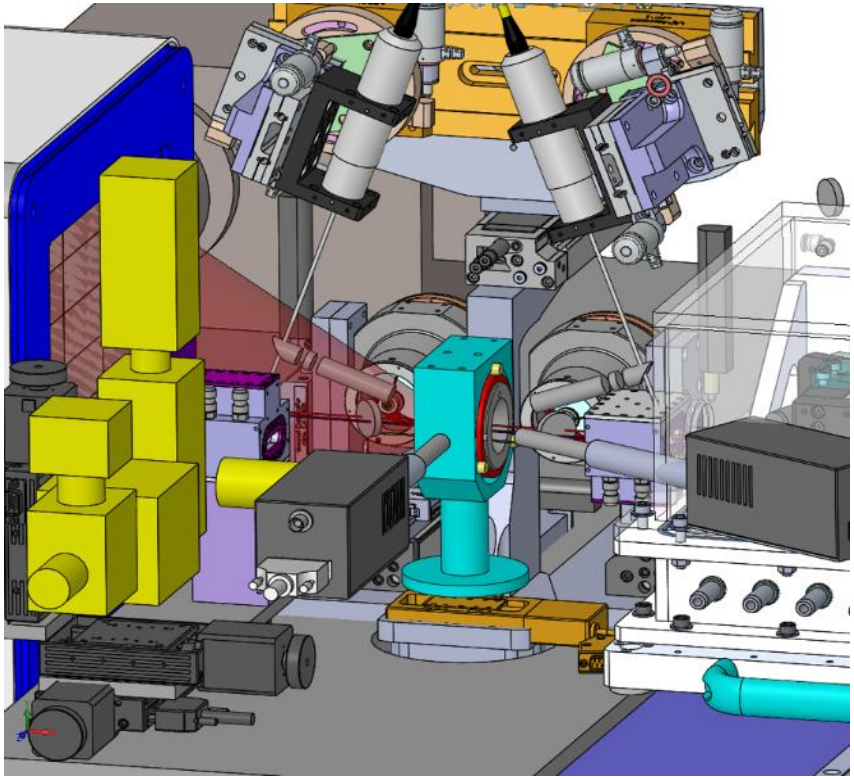
- **Crystal analyzer** coupled to µm beam and high P/T sample environments



LH-SYSTEM UPGRADE ID24 ESRF

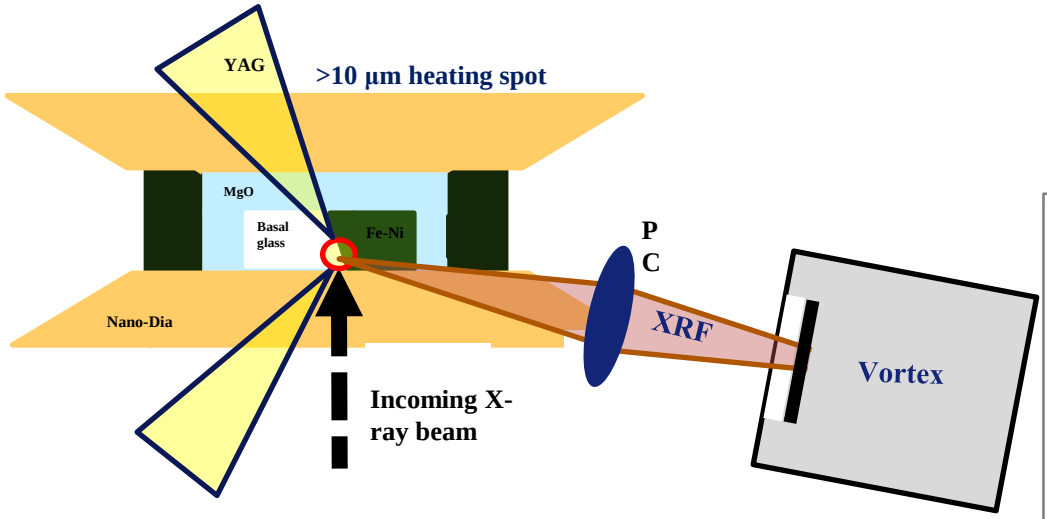
Highly diluted elements at extreme *P/T* conditions, high spatial resolution

- **EXAFS, XRD and XRF + poly-capillary**
- **Color filter system to measure thermal gradients**
- **Modular crystal to variate YAG laser frequency**
- **Beam shapers**



SCIENTIFIC POSSIBILITIES

Partitioning and speciation experiments of minor elements at Earth's core conditions

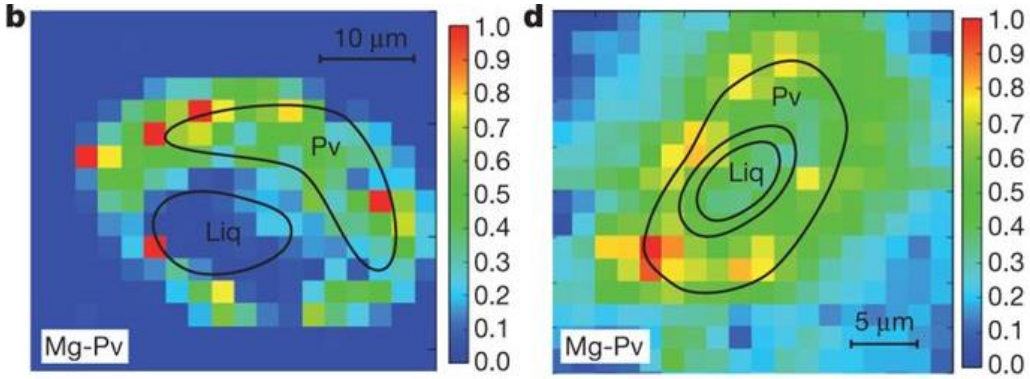


+ XAS/XRF
(speciation, distribution)

+ T gradient
(partitioning and melting experiments)

+ XRD
(complementary structural information, P determination)

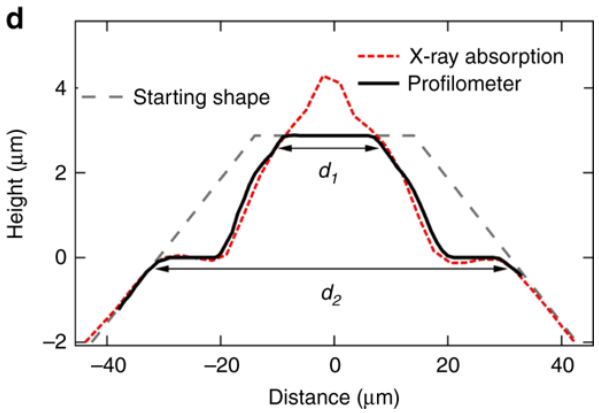
Fe partitioning melt-crystal 113 GPa



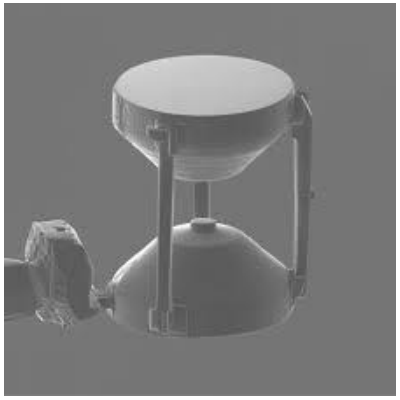
Andrault et al. (2012) Nature

SCIENTIFIC POSSIBILITIES

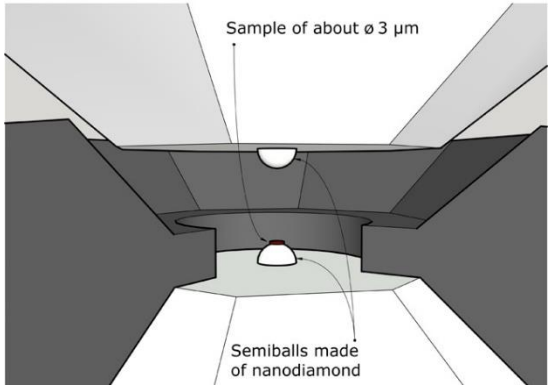
Ultra-high pressure experiments > 400 GPa for users



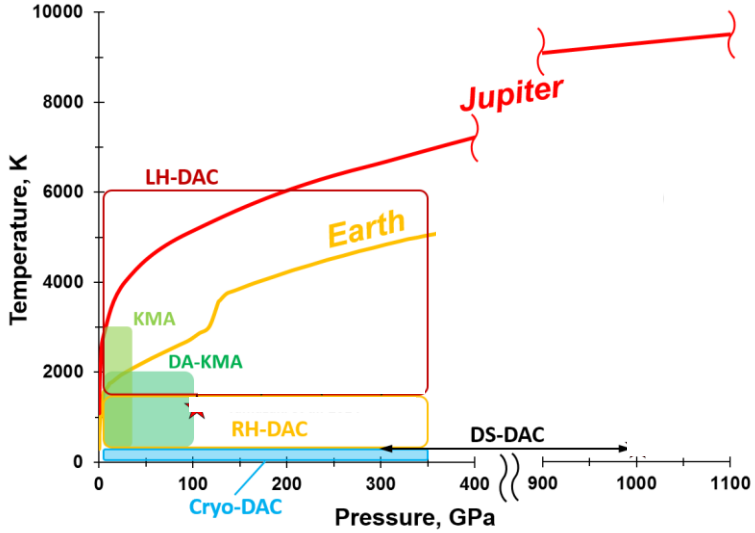
Dewaele et al. (2018)
Nature Com.



Sakai et al. 2018



Dubrovinskaia et al. 2016
Scientific Advances



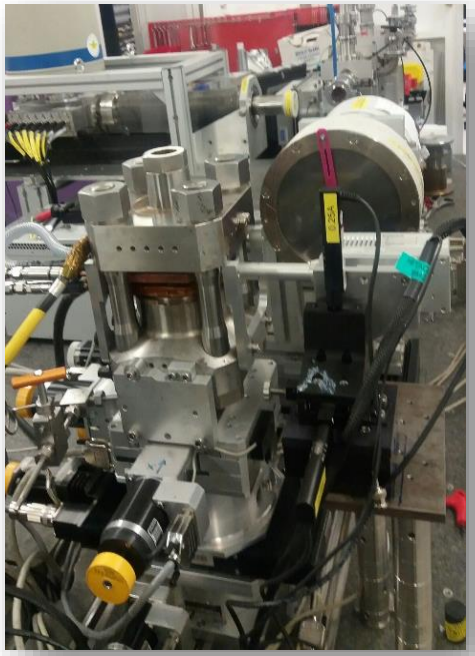
+ XAS
(speciation / local order)

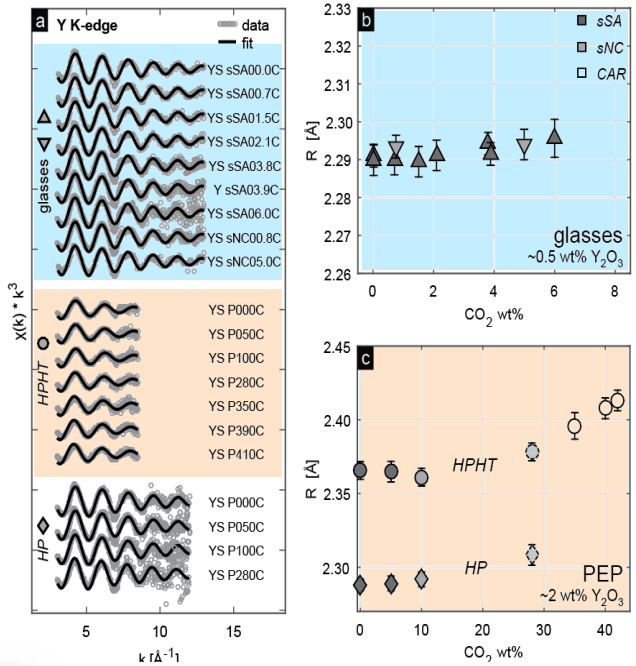
+ XRD
(complementary structural information, P determination)

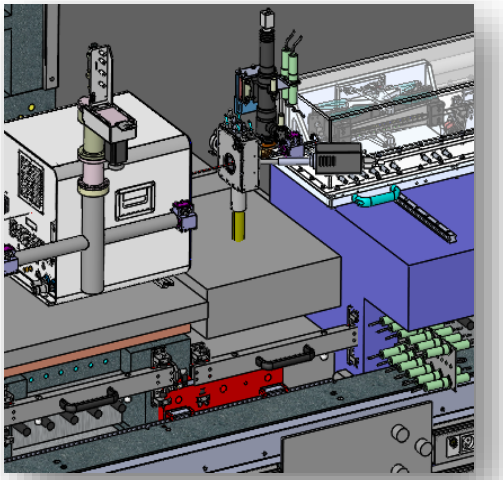
https://www.wikiwand.com/en/Diamond_anvil_cell

SCIENTIFIC POSSIBILITIES

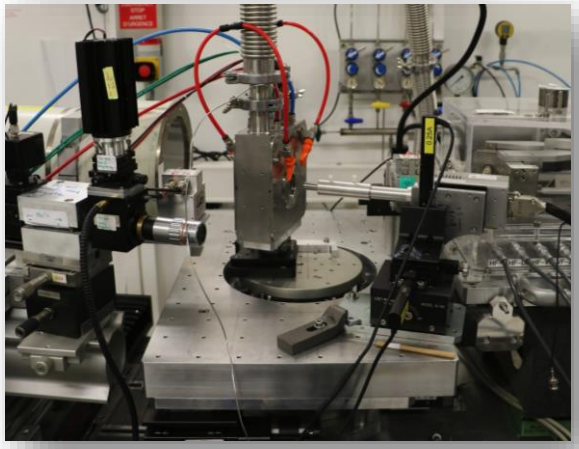
Standard EXAFS experiments at high dilutions with high k-range





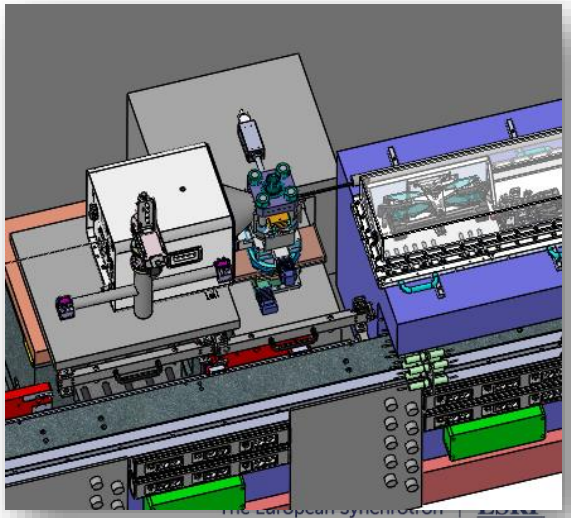


Pohlenz et al., 2018, Chemical Geology



+ spatial resolution
(partitioning experiments)

+ tomography



Proposal deadlines
March 2020/2021

BM23 user operation 01/2021
ID-24 DCM user operation 01/2022

Thank you for your attention