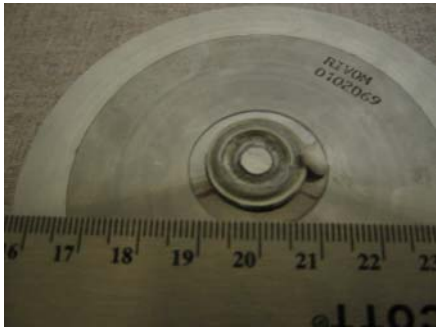
A reconnaissance study of some techniques and devices of promise for neutron scattering

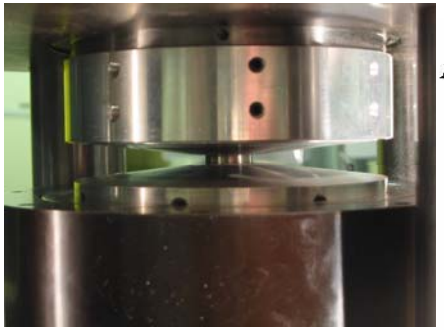
Chris A. Tulk
Spallation Neutron Source
Oak Ridge National Laboratory

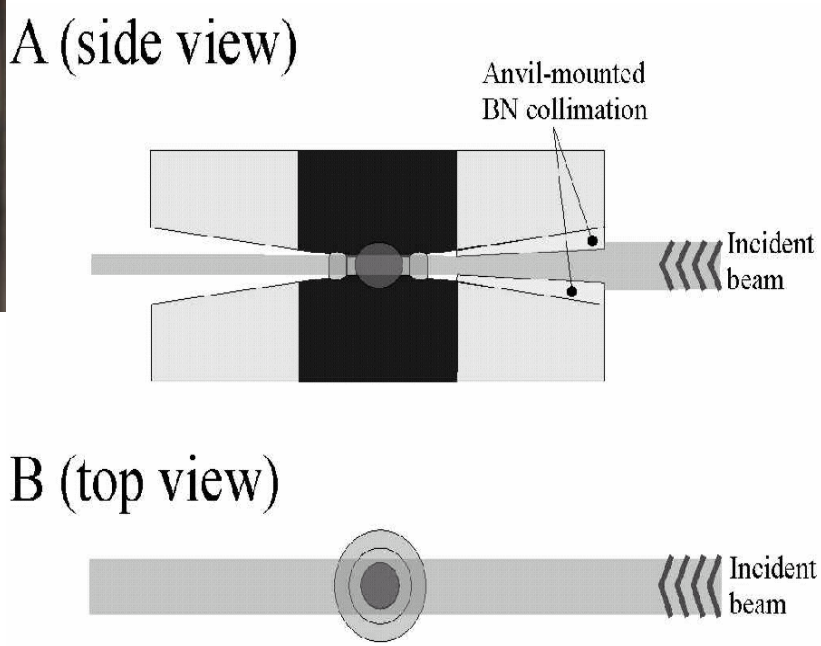
Thinking of extreme sample conditions, particularly high pressure

Sample synthesis—changing material properties with pressure

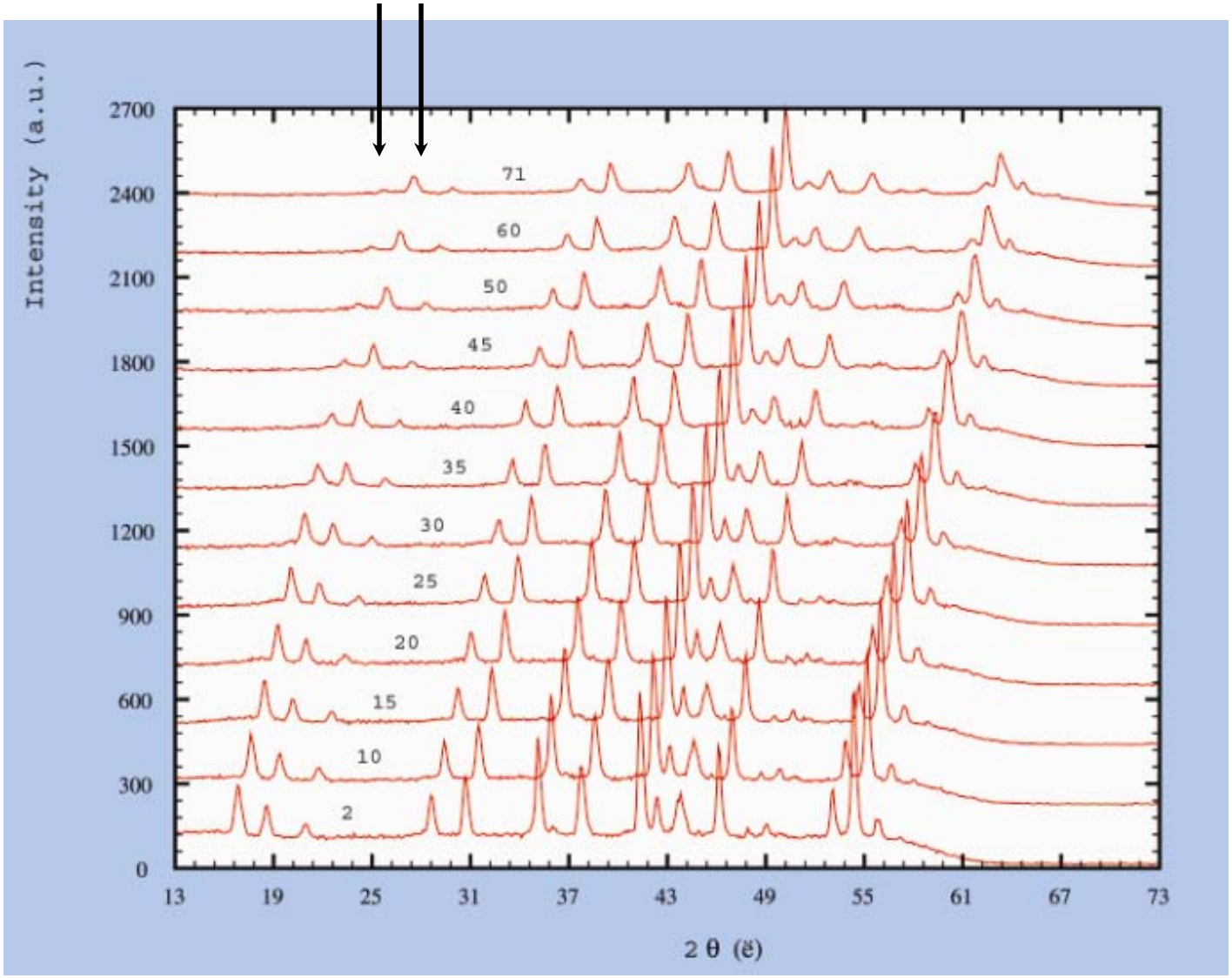


Samples typically 100 mm^3
Pressure limited to < 200 kbar





Nano Particles of Hematite (Fe_2O_3), in Paris-Edinburgh Cell on C2 at CRL (magnetic transitions)

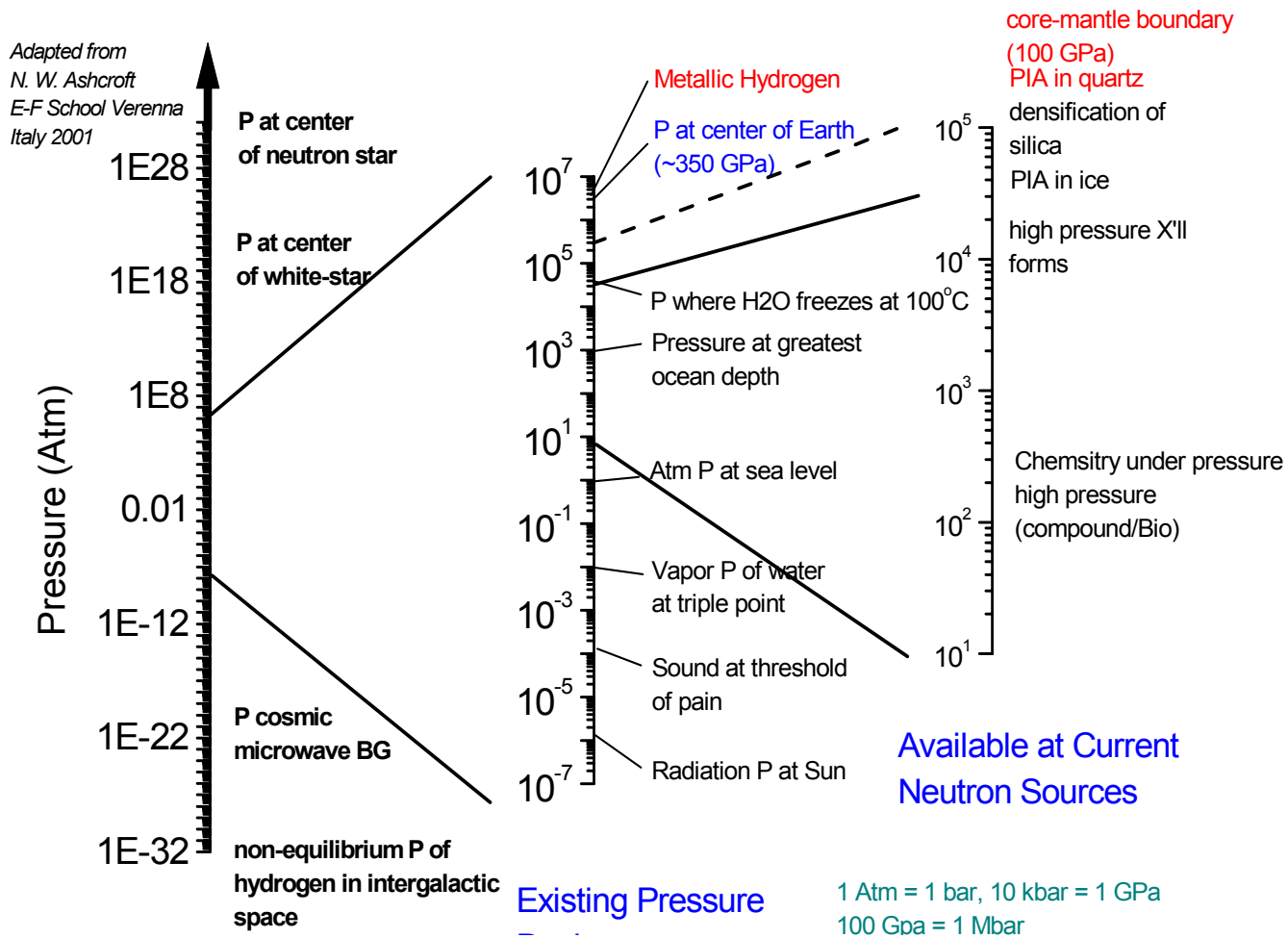


Locke, Tulk, Parise and CRL researchers

Can we ever imagine taking our micro x-ray samples to a neutron facility?

More generally, can we reduce the sample size problem (synthesis problem) for neutrons to the sub 50 micron level?

Where can we go with high pressure diffraction at neutron sources (sample size)? (pressure as a tool crosscutting many applications)

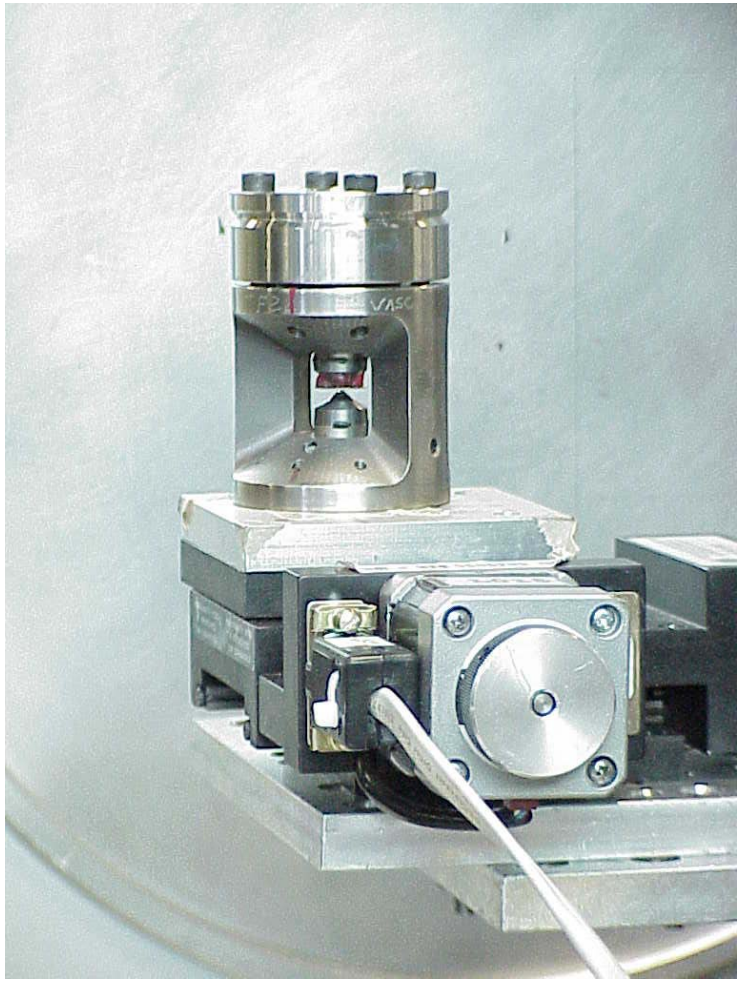


We have the high pressure cells capable of much higher pressures up to several 1 Mbars, however…

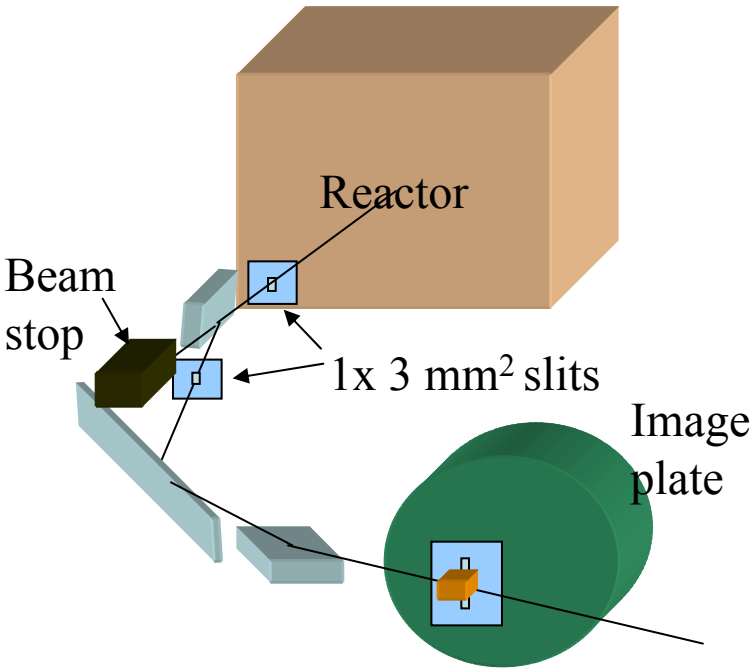
we cannot use any of them at ANY existing neutron source

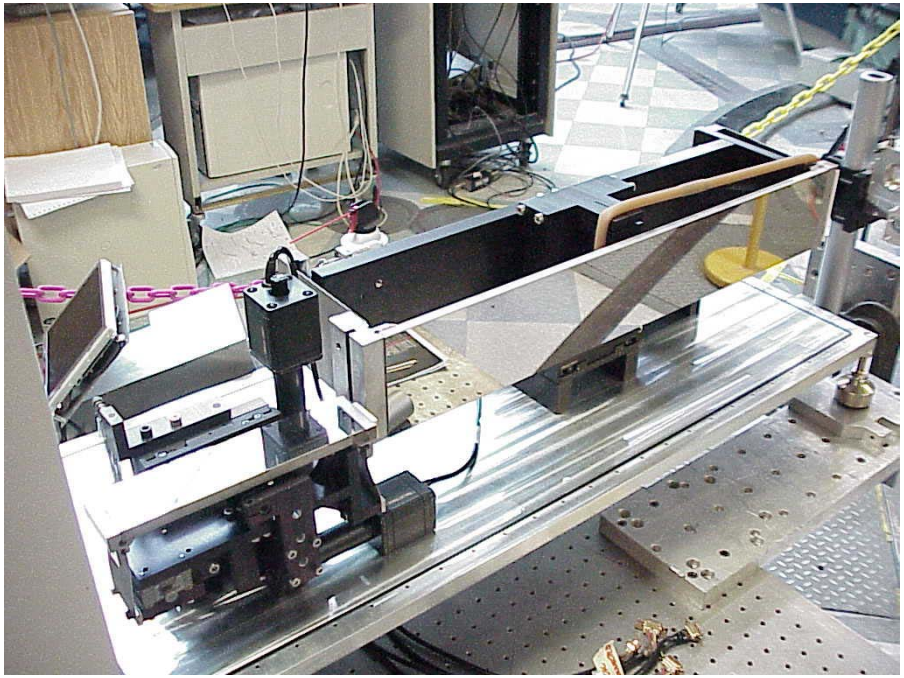
Samples are WAY TOO SMALL for neutron scattering… several 10's of microns

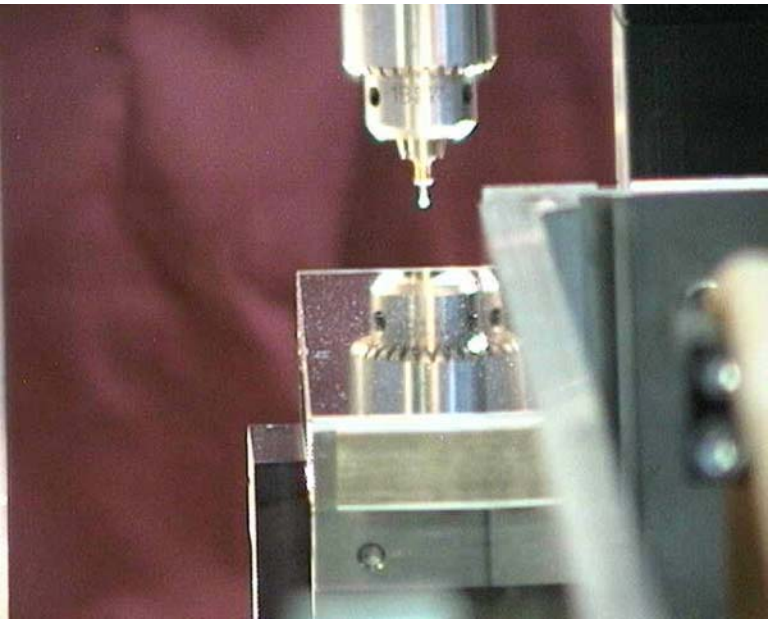
e.g. Diamond anvil cell on the left is capable of reaching a mega bar pressure and contains a single crystal of deuterium… (why D…why not H… we tried!!!)



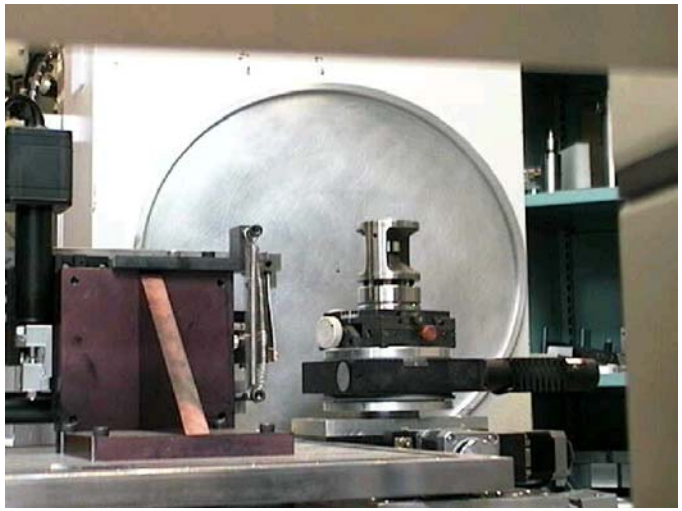
Effective micro-focusing for neutrons





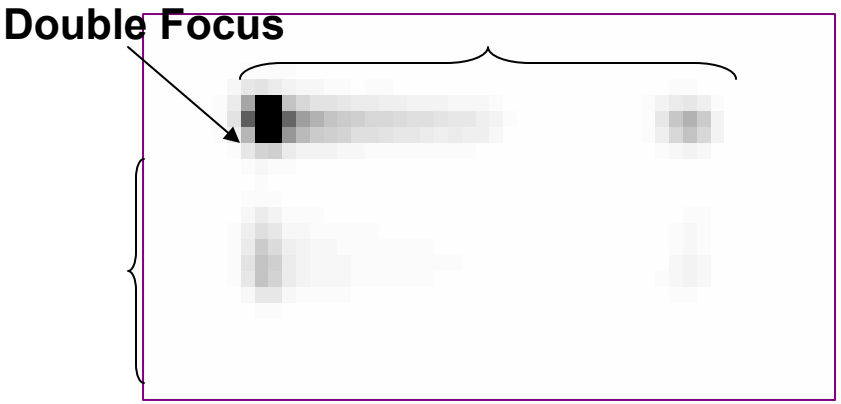


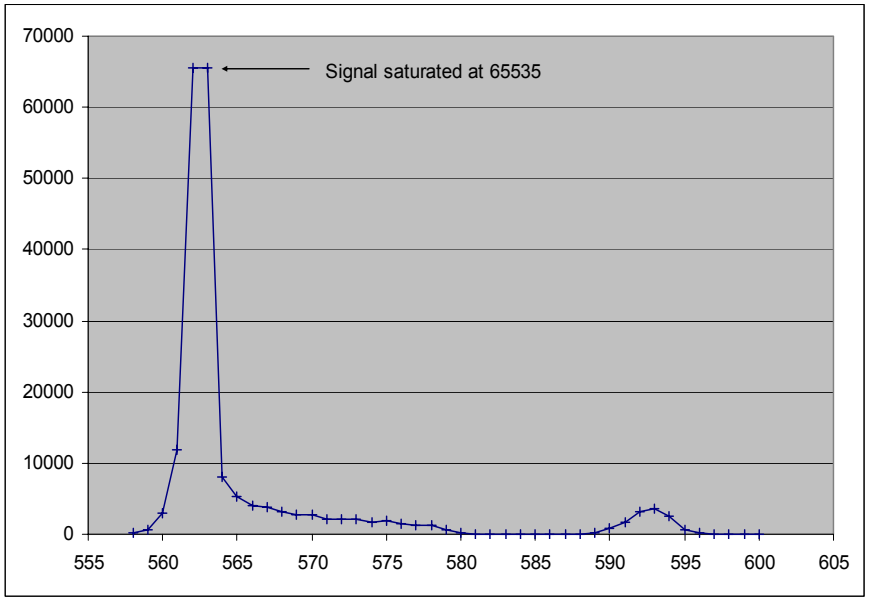
Prototype mirror pairs developed G. Ice, et al. at Oak Ridge National Lab



Recent Achievements: Testing and Optimization of Optical Components

- A new prototype *microfocusing* system tested.
- Measured spot size (90 x 90 um) with less than 30 mrad on sample.
- Diffraction data from free standing 300x300 μm samples and from 200 um FeO single crystal sample in a panoramic cell--under pressure

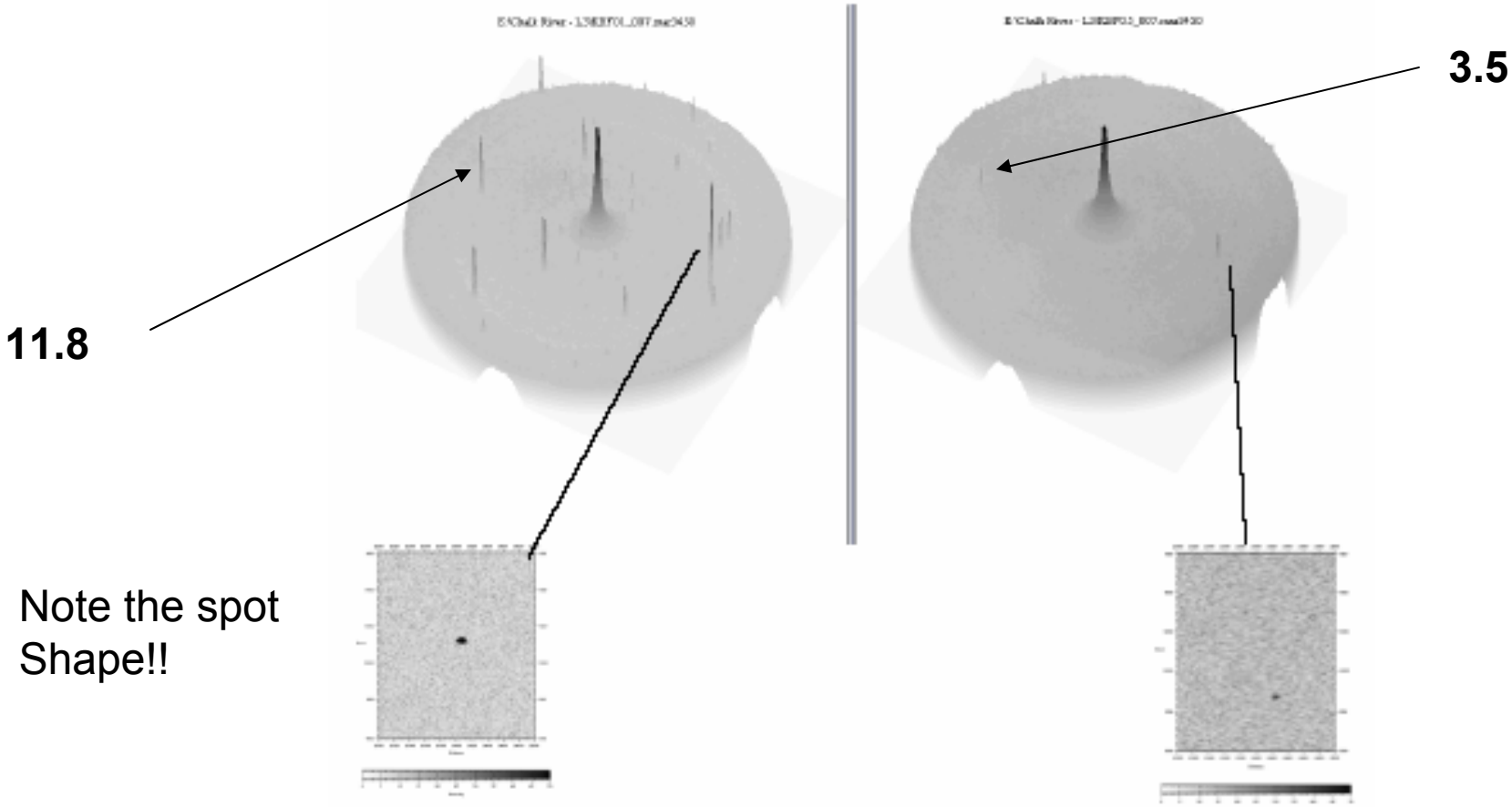




Tulk, Ice, Locke, Xu, Ice, Parise, et al. (2004), ORNL, NRCC, Stony Brook and Carnegie Institution.

KB mirrors on the L3 diffractometer at Chalk River Labs

White Beam Laue with a MAR 345 image plate detector
and 2 hour data collection time for both



Note the spot
Shape!!

With KB mirrors in place

90 x 90 micron beam

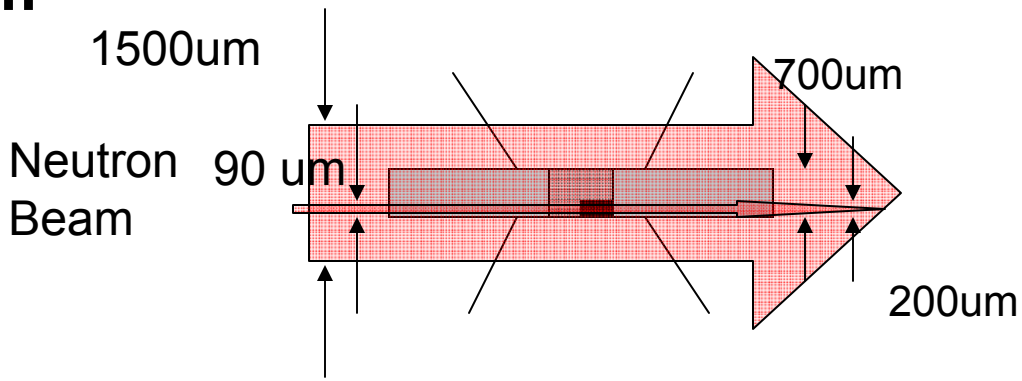
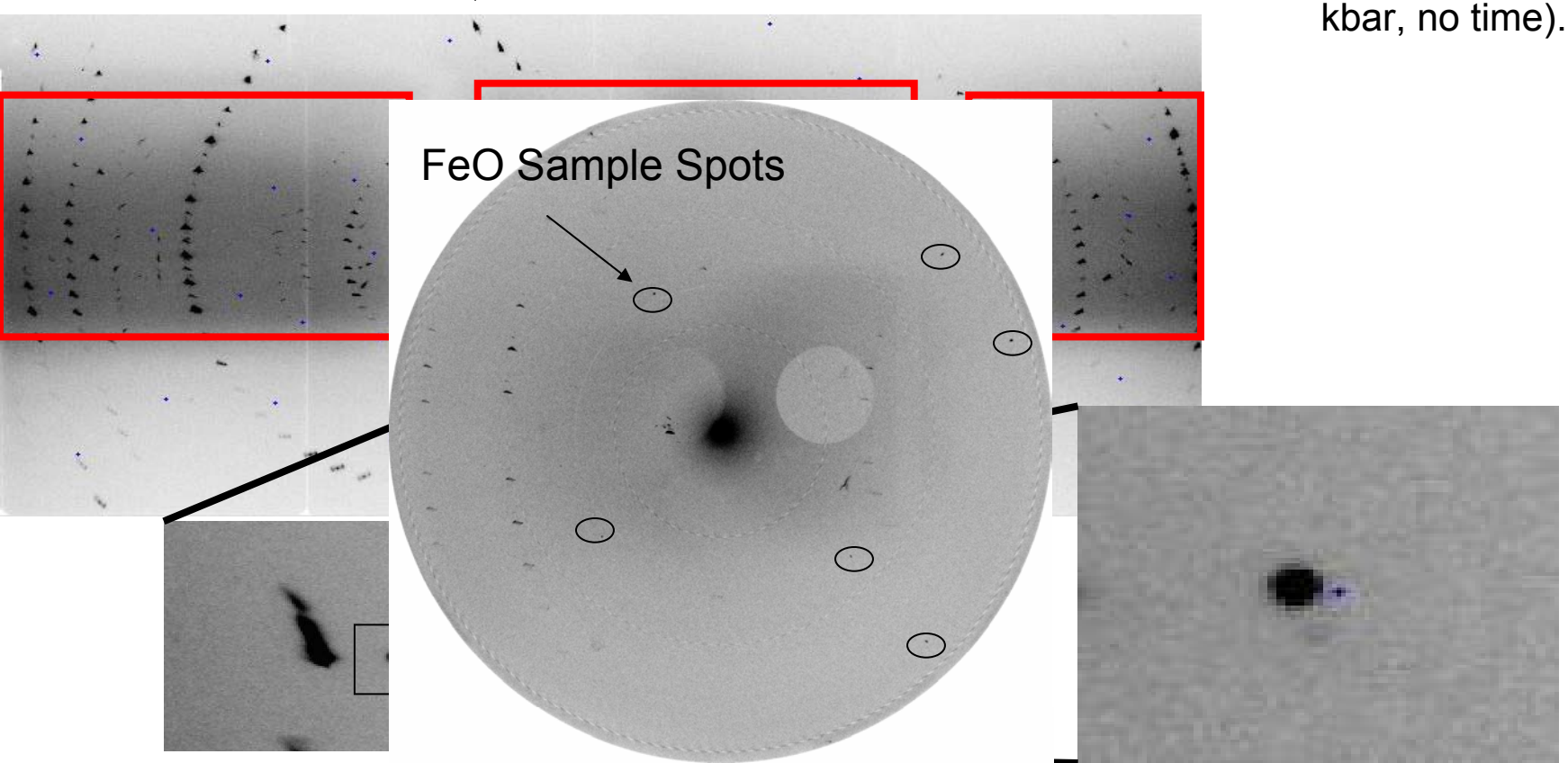
SCATTERING VOLUME ~ 0.0045 mm^3
Forserite - Mg_2SiO_4
Φ = 170°

Without KB mirrors in place

Beam much larger than sample

SCATTERING VOLUME ~ 0.05 mm^3
Forserite - Mg_2SiO_4
Φ = 170°

Use with high pressure Cells—
Current instrumentation, no focusing standard guide system



- No focusing, 1.5 mm beam.
- 150 micron sample of FeO 10 kbar, SiC anvils (increased P to~ 25 kbar, no time).