VULCAN Commissioning Results

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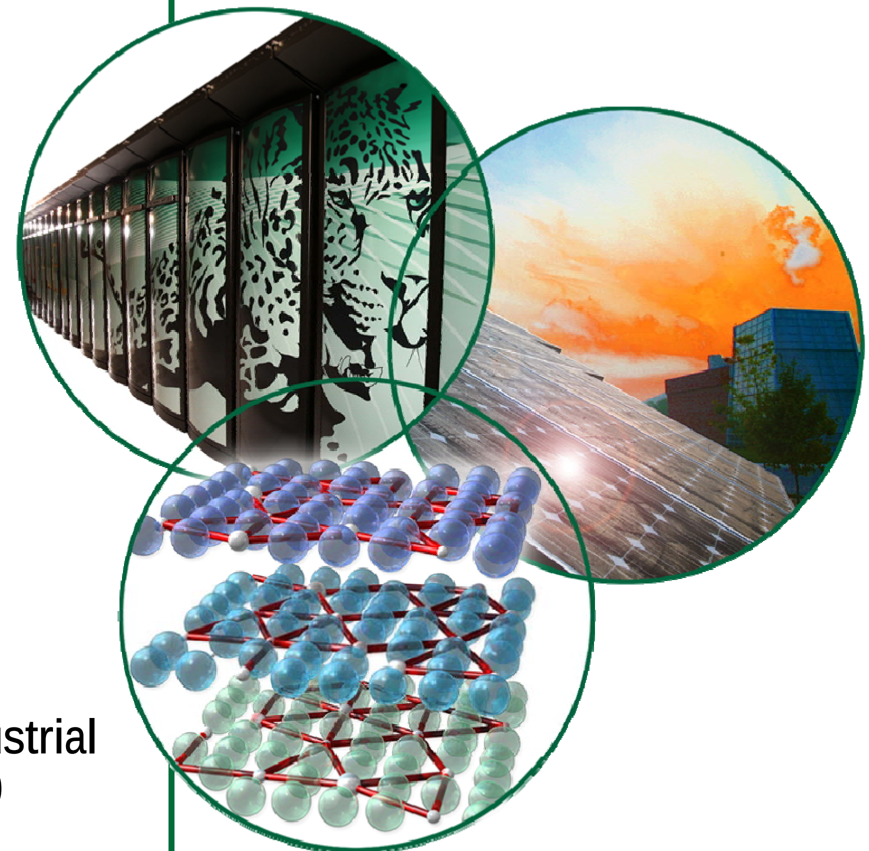
Neutron Scattering Science Division

Oak Ridge National Laboratory

VULCAN at the SNS: Scientific Opportunities, Industrial Applications, and Challenges, January 21-22, 2010



U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY

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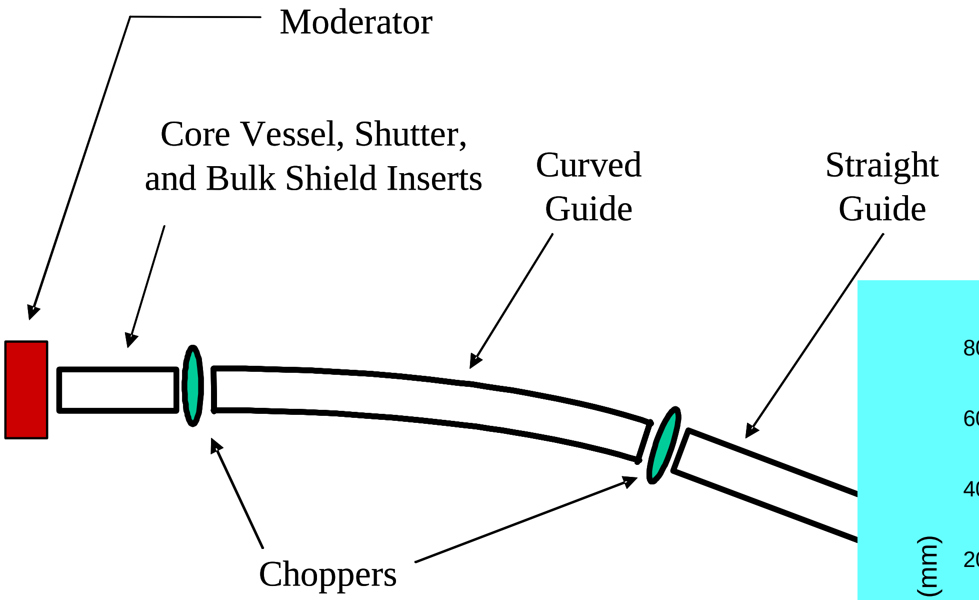
Presentation Outline

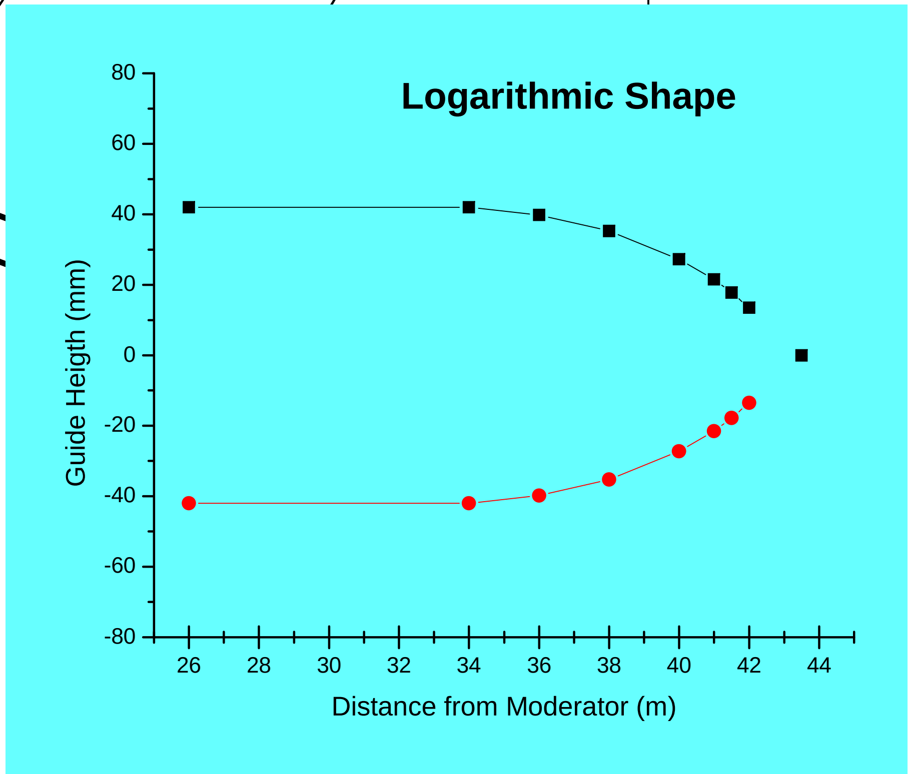
- Historical account
- Instrument layout and key design goals
- Commissioning results
  - Neutronic performance
  - Scientific experiments
- Summary & outlook

A brief history of VULCAN

- January 20-21, 2000, Atlanta Workshop finalizing performance requirement
- May 2000, instrument named
- June 2000, conceptual design presented and approved
- June 2002, Canada Foundation for Innovation grant
- November 2003, engineering design begun
- August 2004, US NSF grant for load-frame(s)
- November 2005, US DOE-EERE grant for additional detector coverage
- June 2006, ground-breaking for VUCLAN building
- June 26, 2009, shutter opened for the first time
- January 21-22, 2010, this workshop

VULCAN Schematic Layout





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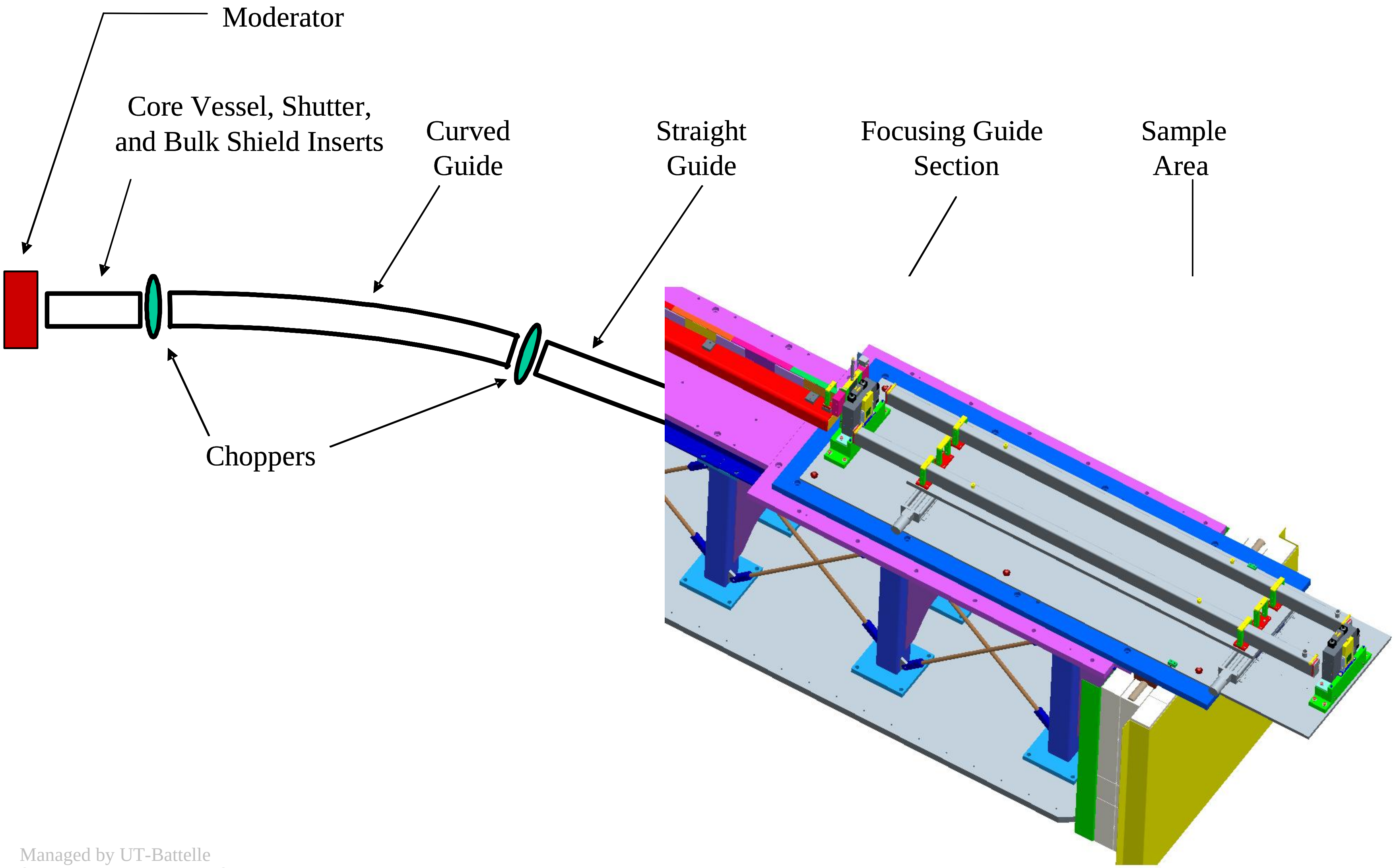
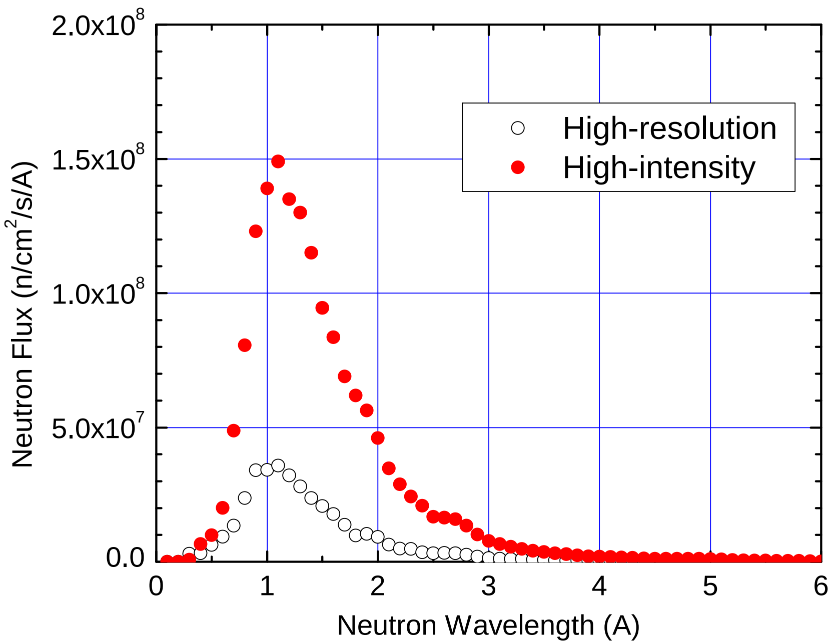
VULCAN Schematic Layout

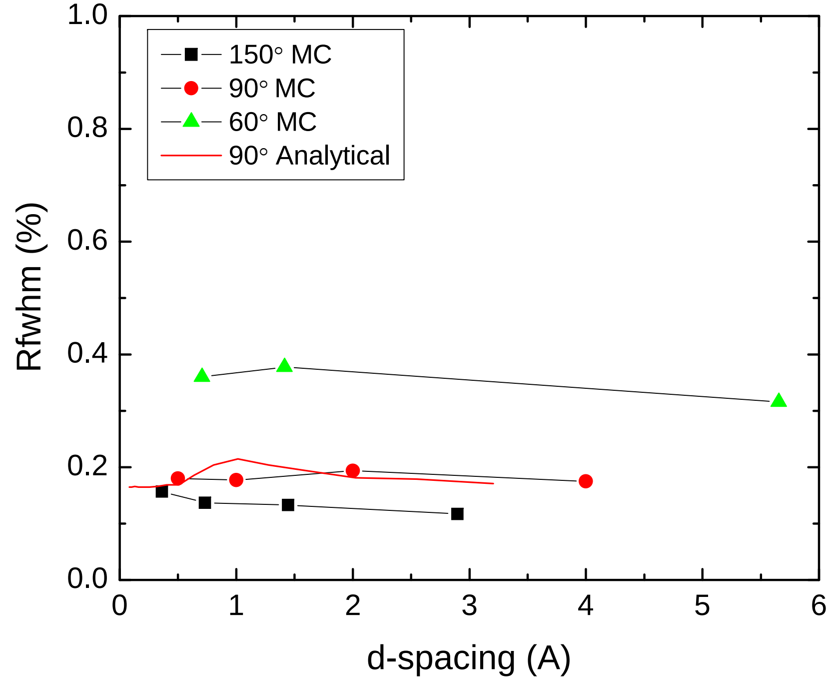


Calculated Flux and Resolution



Flux on Sample Reaches 10^8 n/cm²/s in High-intensity Mode

Resolution is 0.2% in high-resolution mode



Our engineering team is first rate

George Rennich

Amy Black

Bill Turner

A talented scientific team

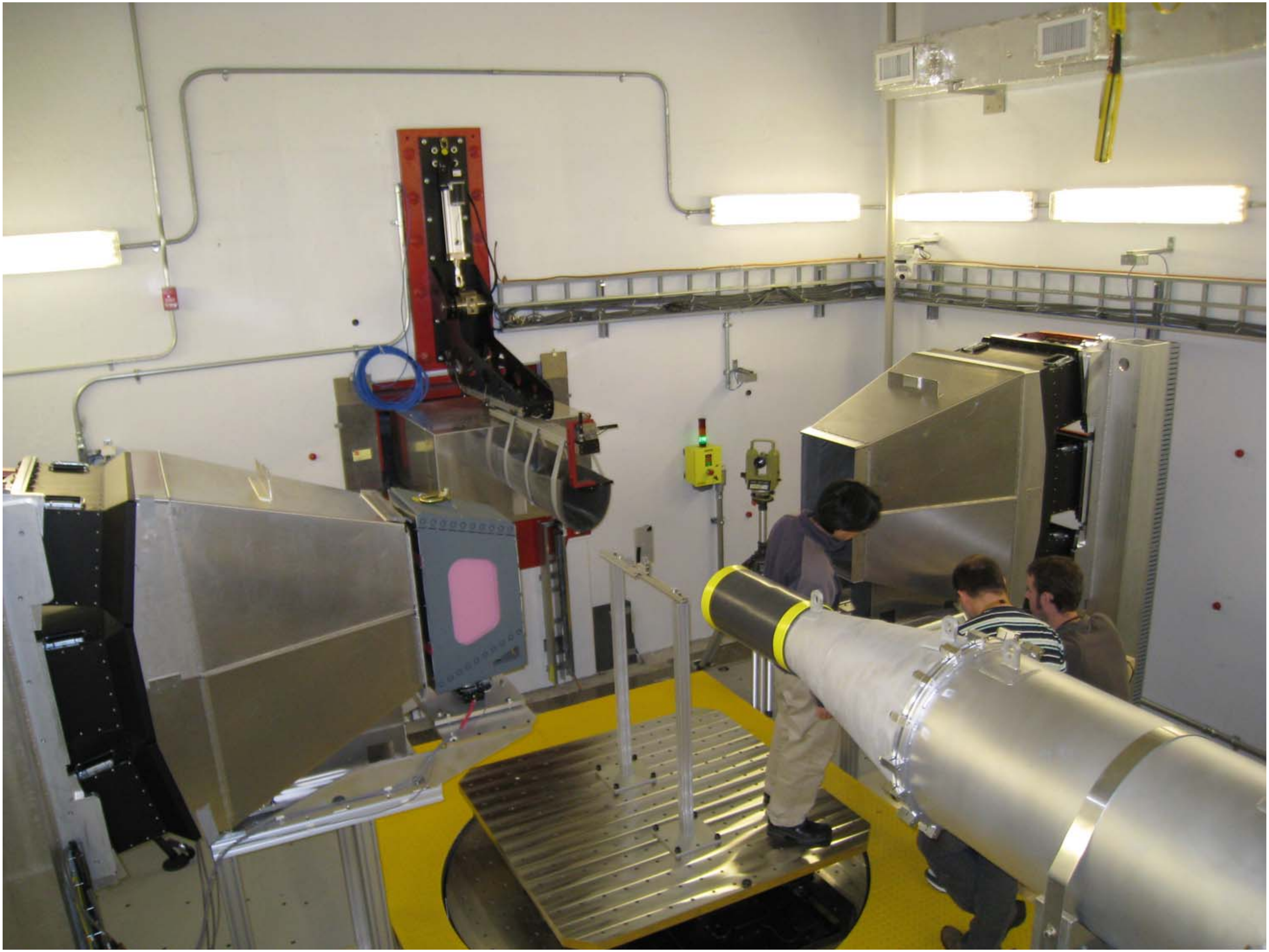
Ke An

Ducu Stoica

Harley Skorpenske

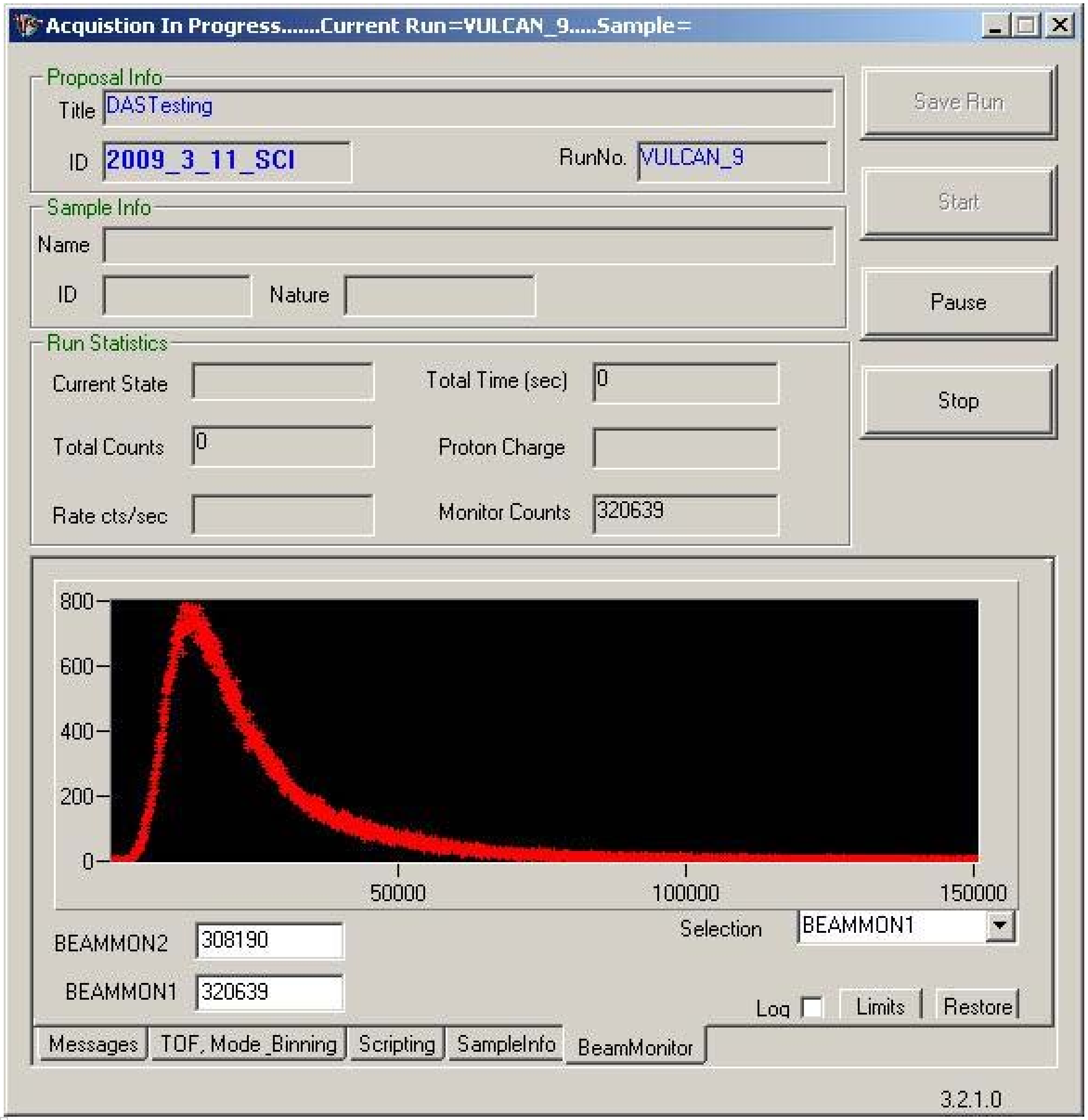
Dong Ma

Sheng Cheng (UT)

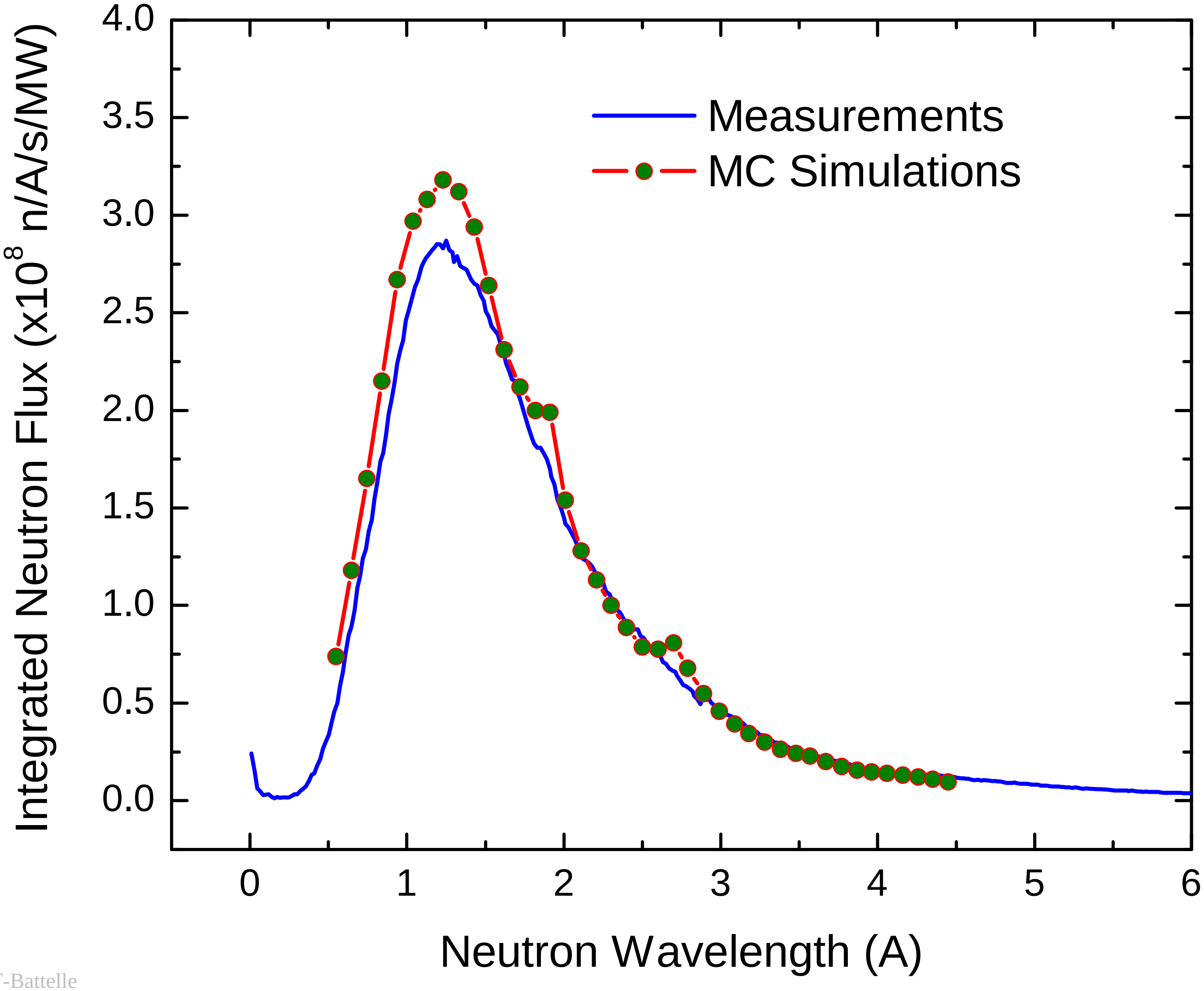



June 26, 2009

First spectrum out of VULCAN



Integrated neutron flux at sample position (measured at 25 kw)



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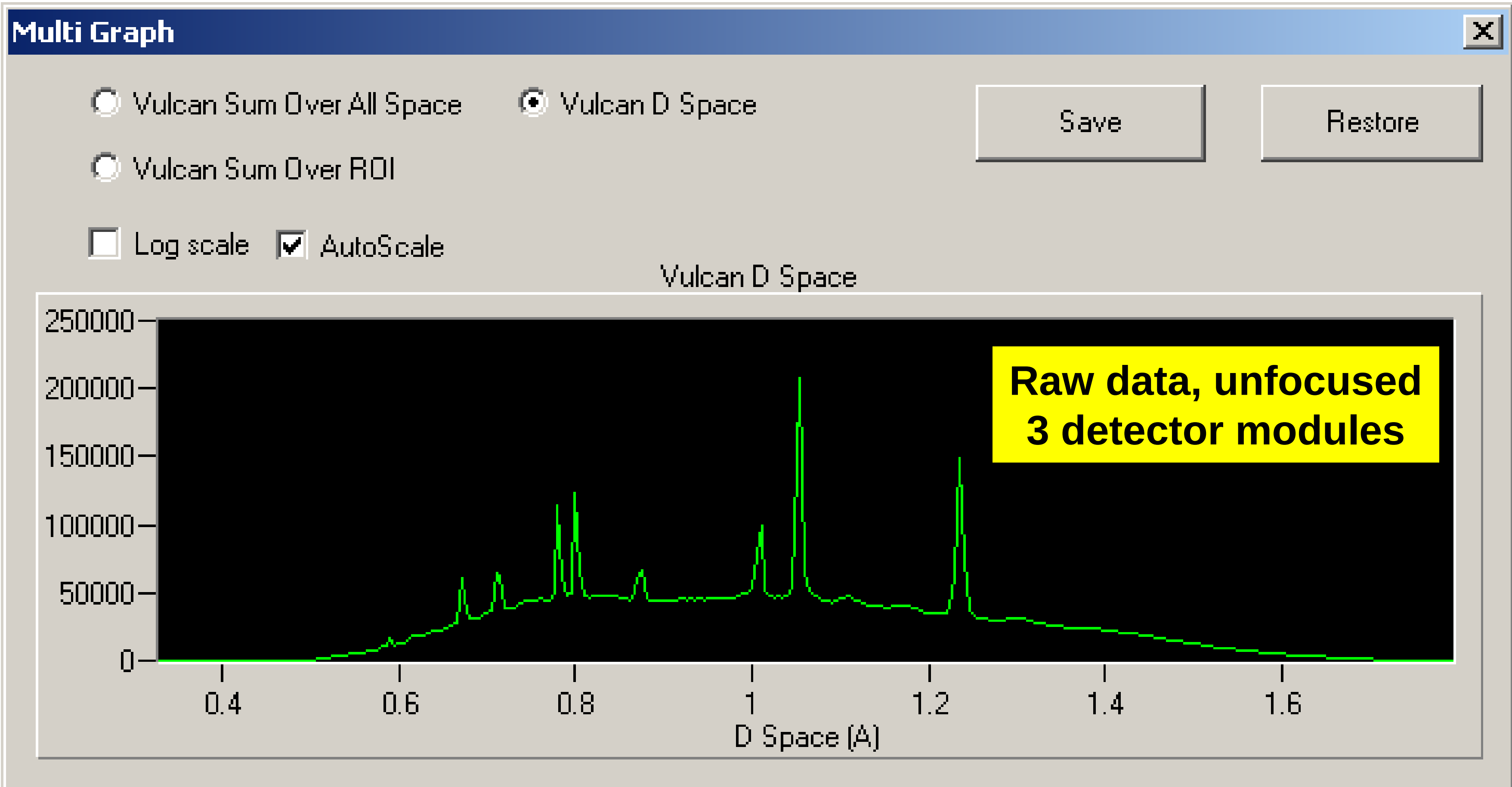
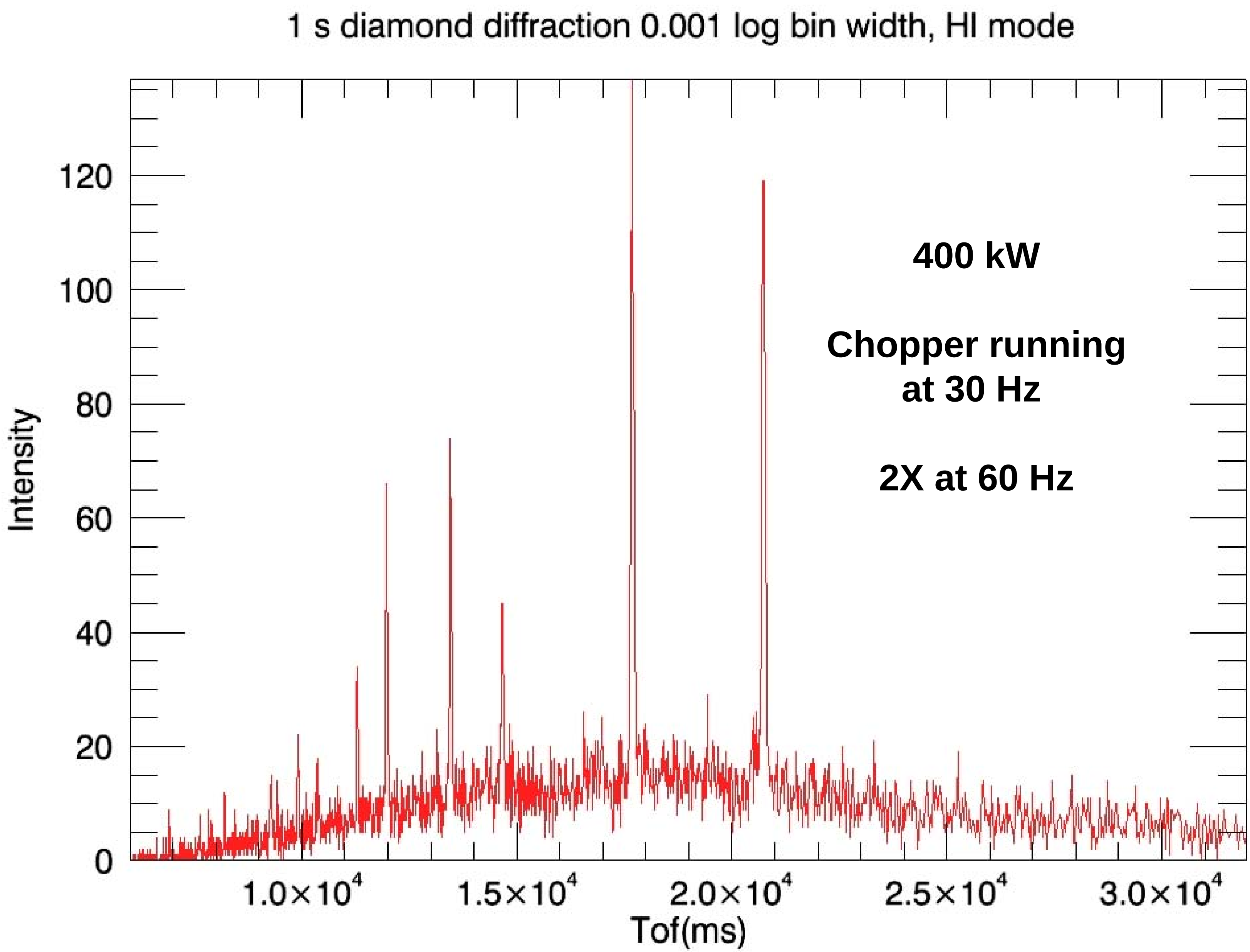
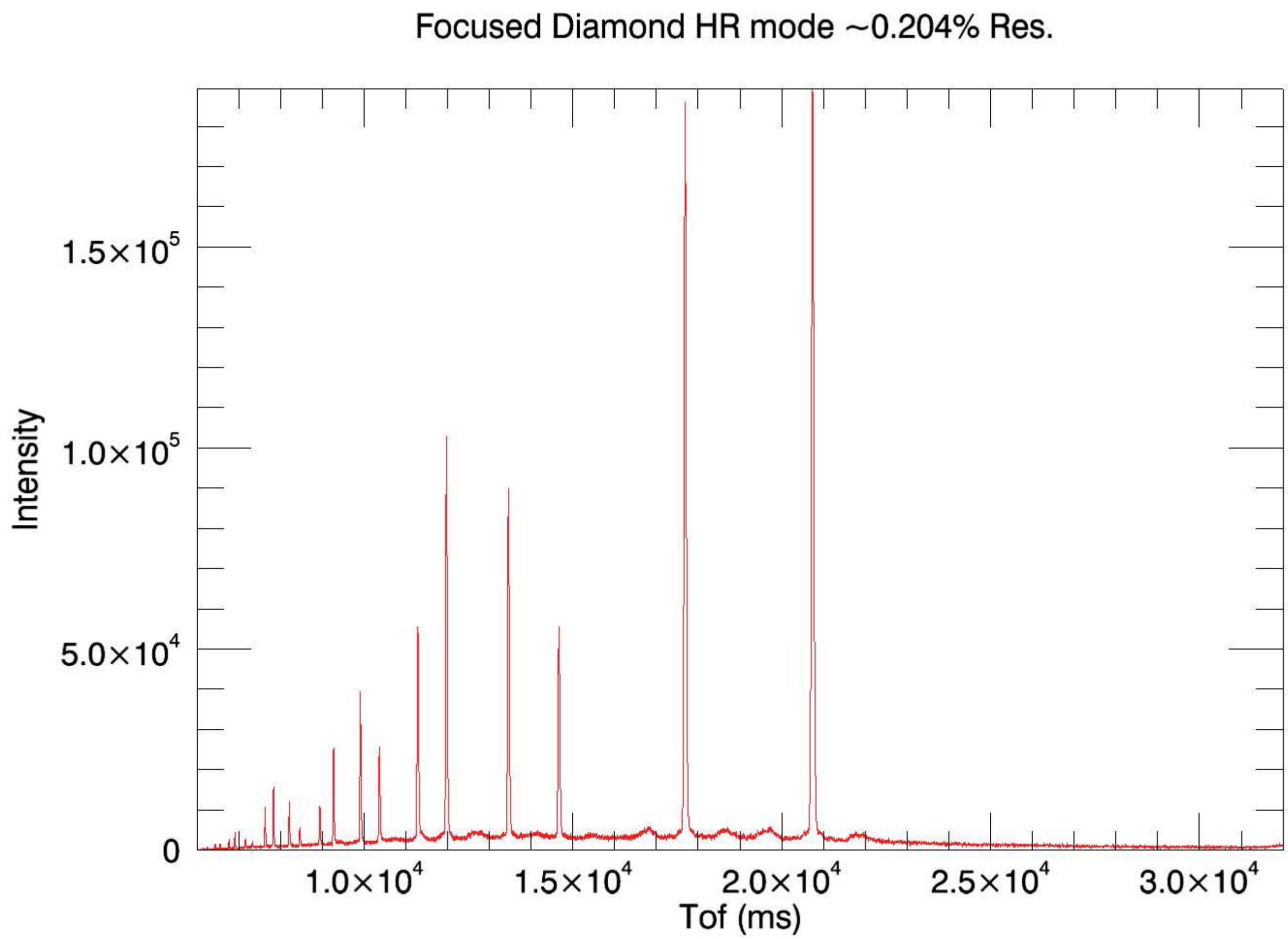
First recorded diffraction pattern (high intensity – 10 minutes at 400 kw)



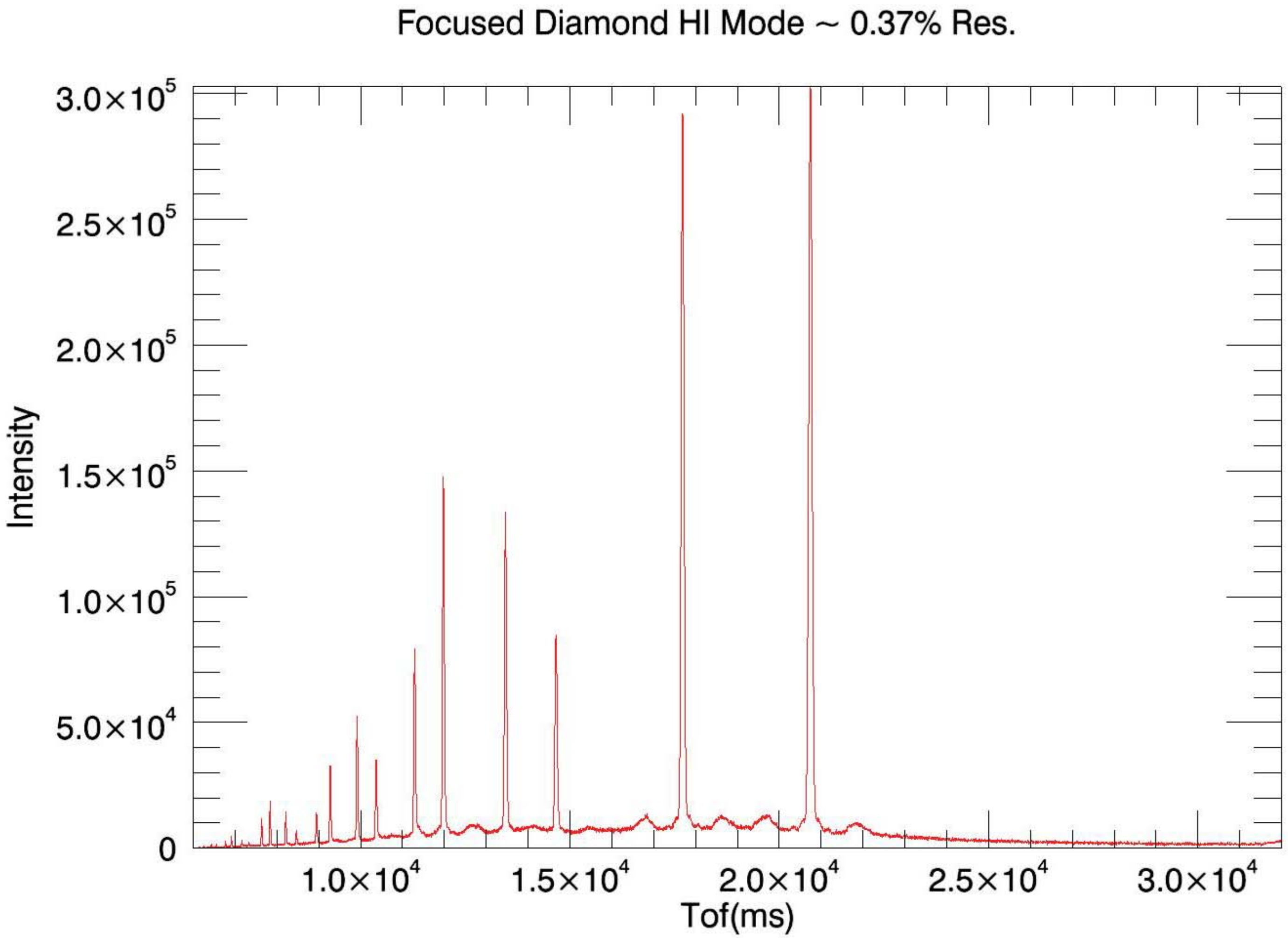
- >1000 peak counts per second at full power, enough to resolve structure evolution with seconds time resolution


1 s diamond diffraction 0.001 log bin width, HI mode
Intensity
Tof(ms)
0
20
40
60
80
100
120
1.0×10^4
1.5×10^4
2.0×10^4
2.5×10^4
3.0×10^4
400 kW
Chopper running at 30 Hz
2X at 60 Hz

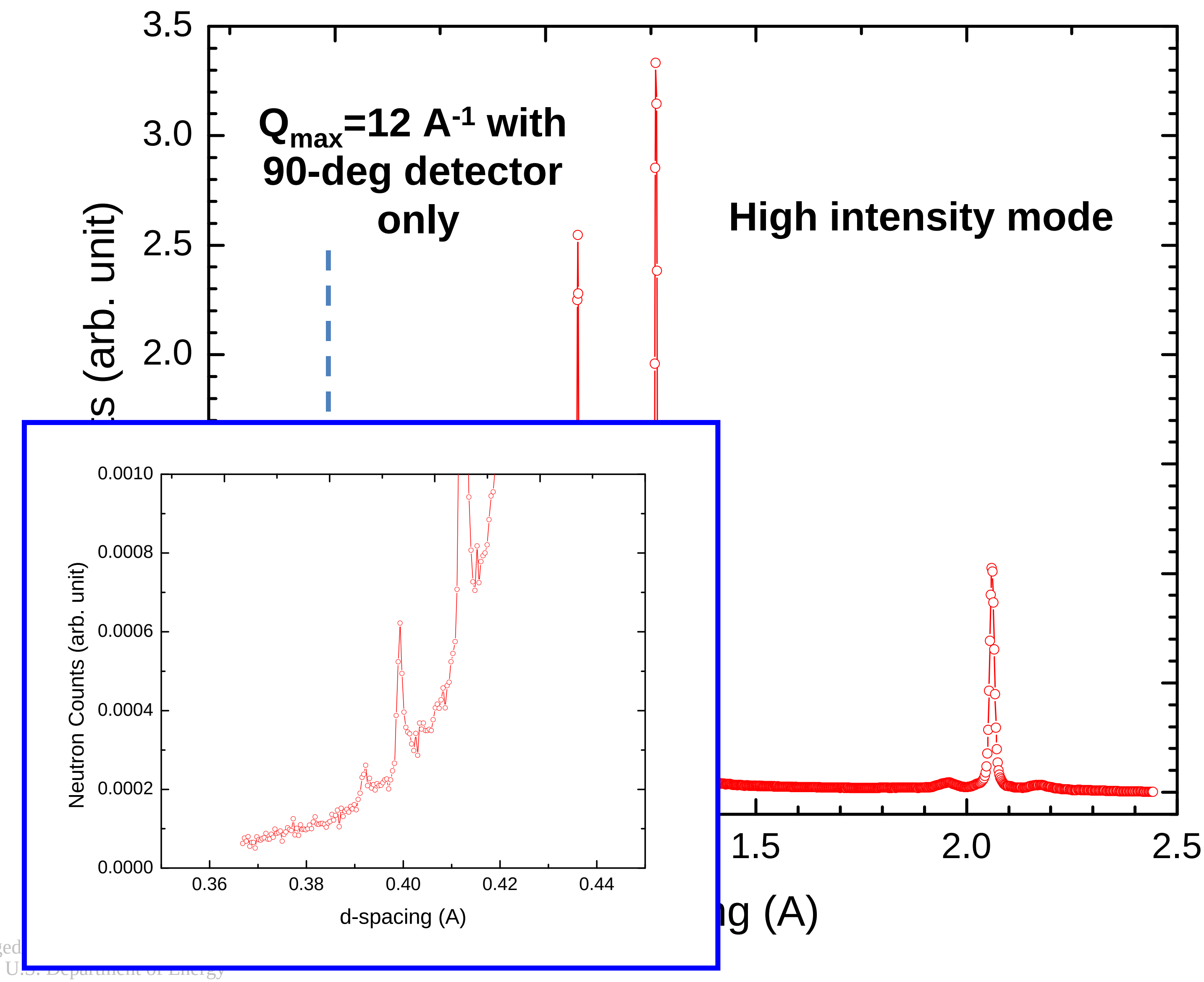
Time-focused Data – High Resolution Mode



Time-focused Data – High Intensity Mode



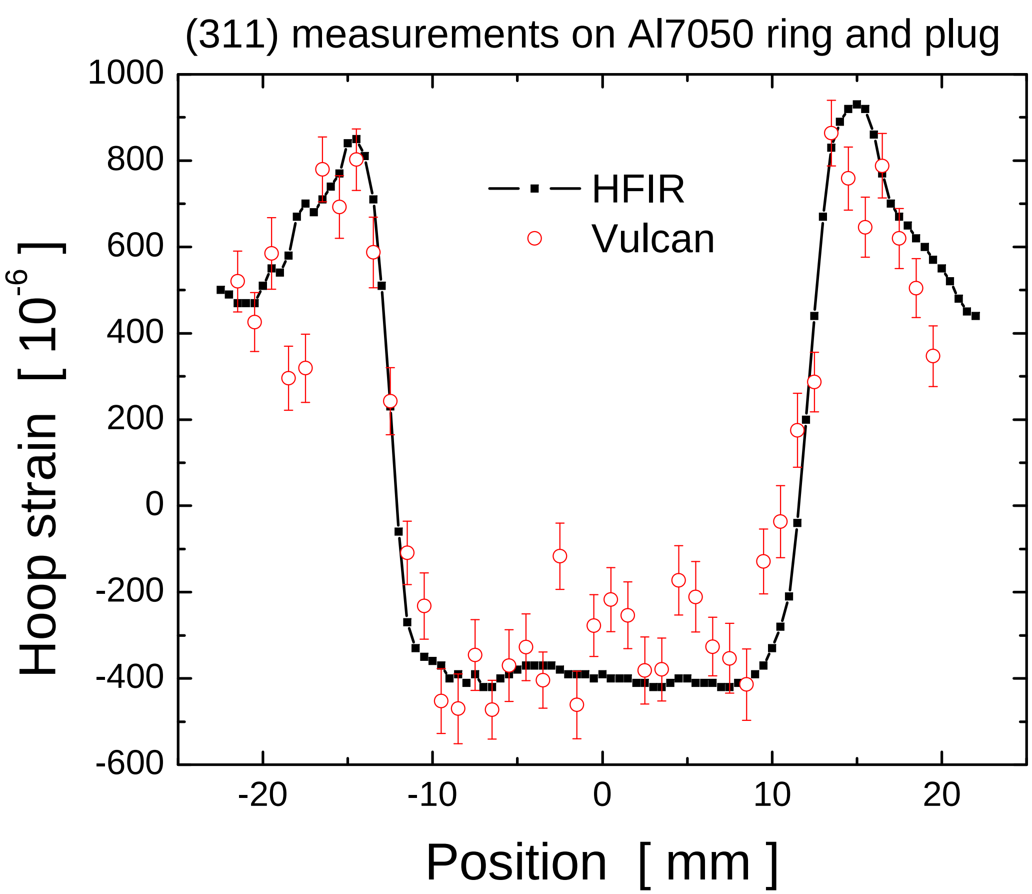
Diamond data with 5-mm radial collimator

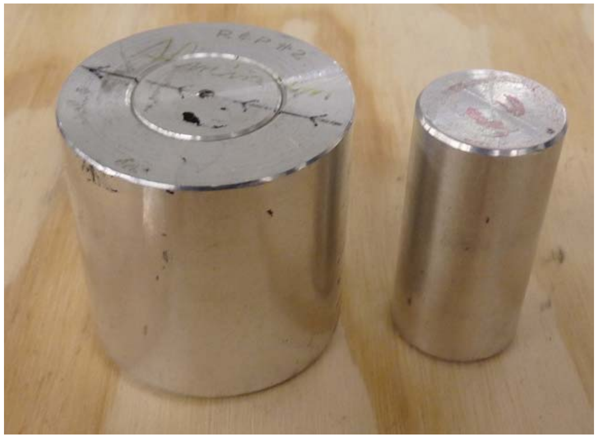


Early Commissioning Experiments Targeted Three Areas of Applications

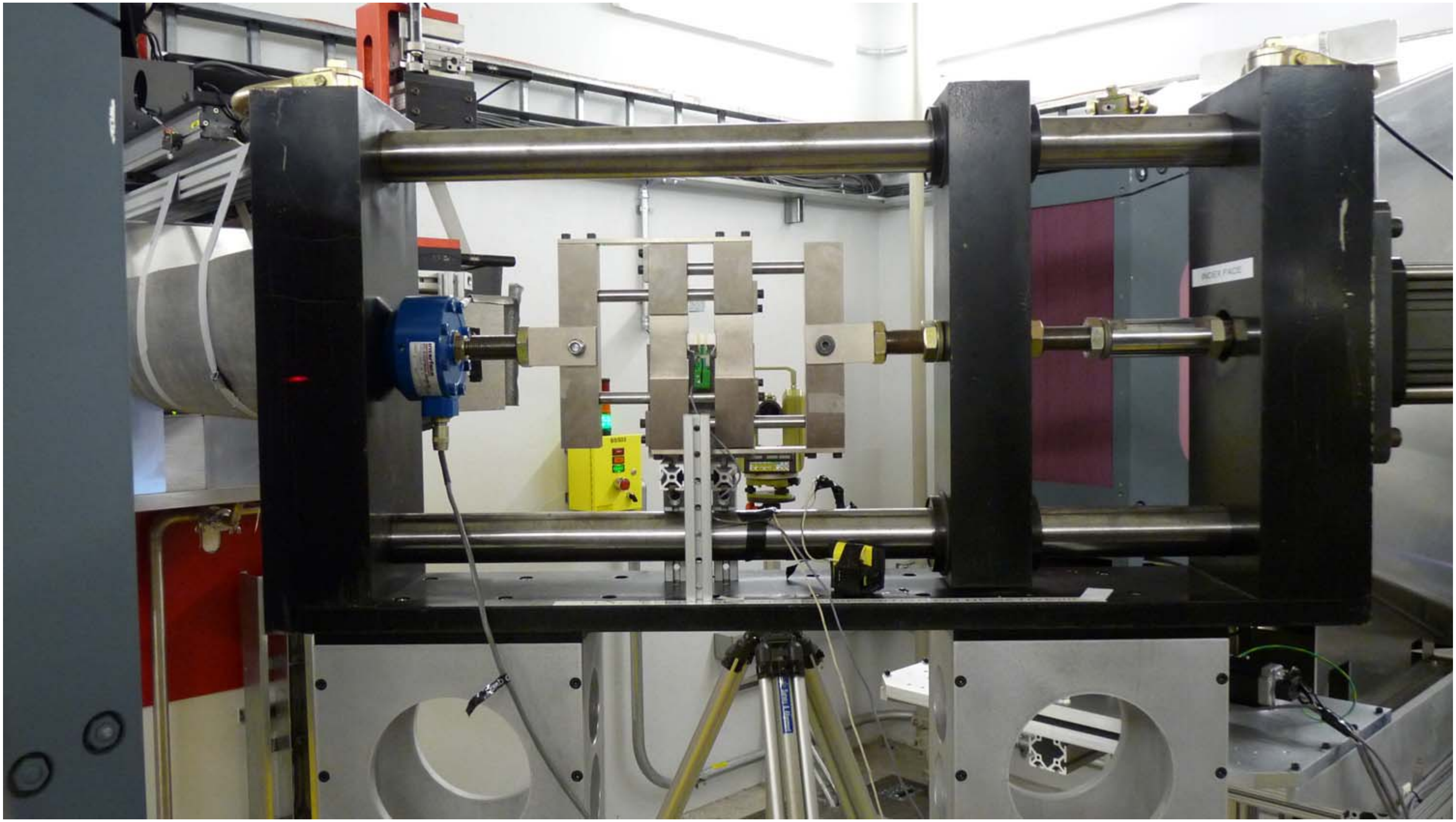
- Stress mapping & in-situ processing
- In-situ deformation studies
- High-temperature phase transformation

Strain mapping in VAMAS ring-and-plug round-robin specimen



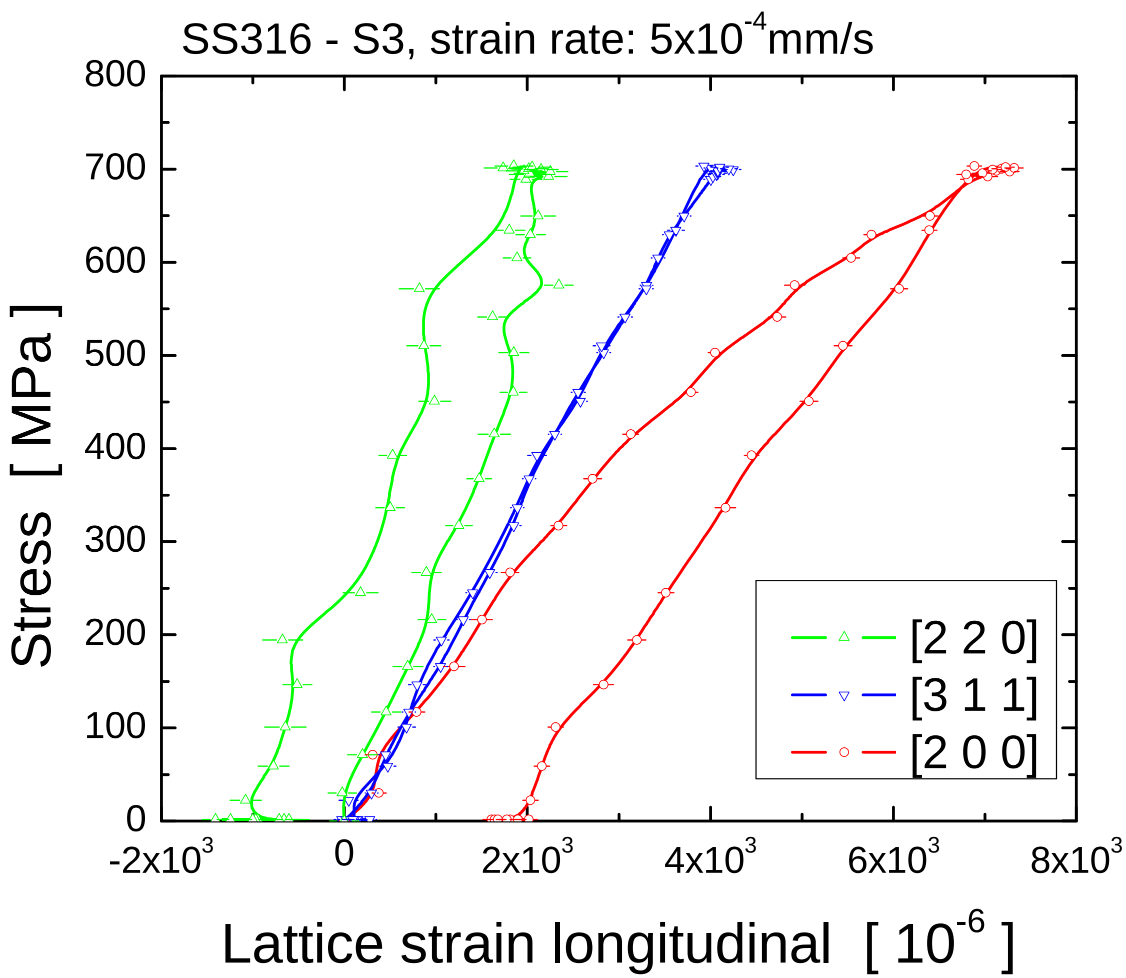


- ~4 hour run in HR mode
- 1.6x2x30 mm^3 gauge volume
- 6 min each point
- 500 kW
- Chopper at 30 Hz
- (311) results shown only
- ~30-100x better at full power 60 Hz chopper at high-intensity mode with Rietveld



With Ercan Cakmak & Hahn Choo on load-frame borrowed from NRSF2

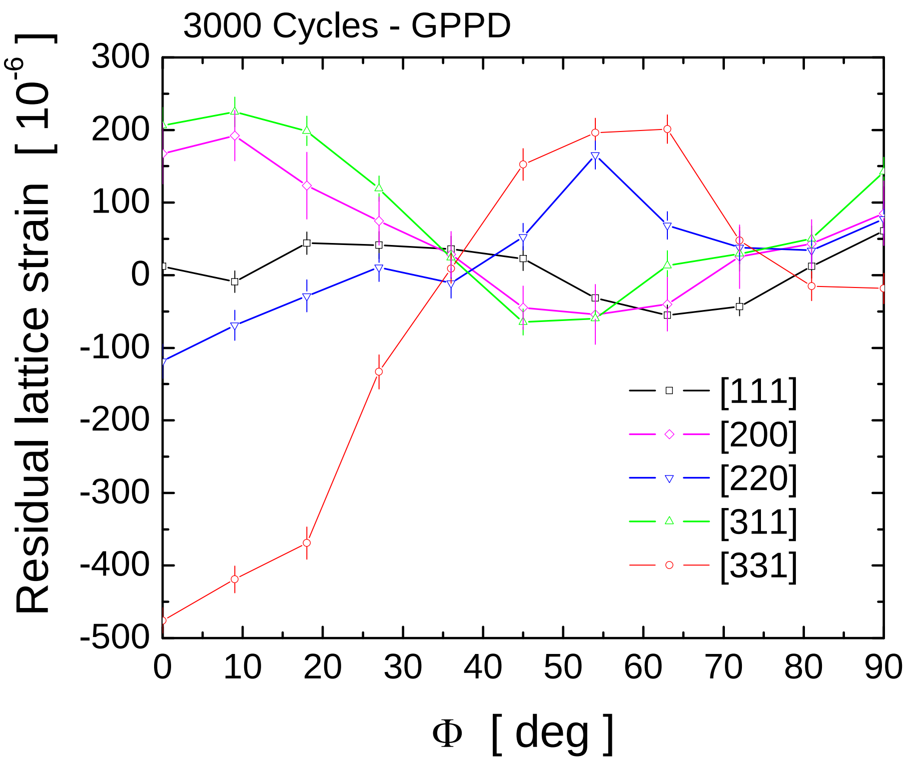
In-situ loading experiments

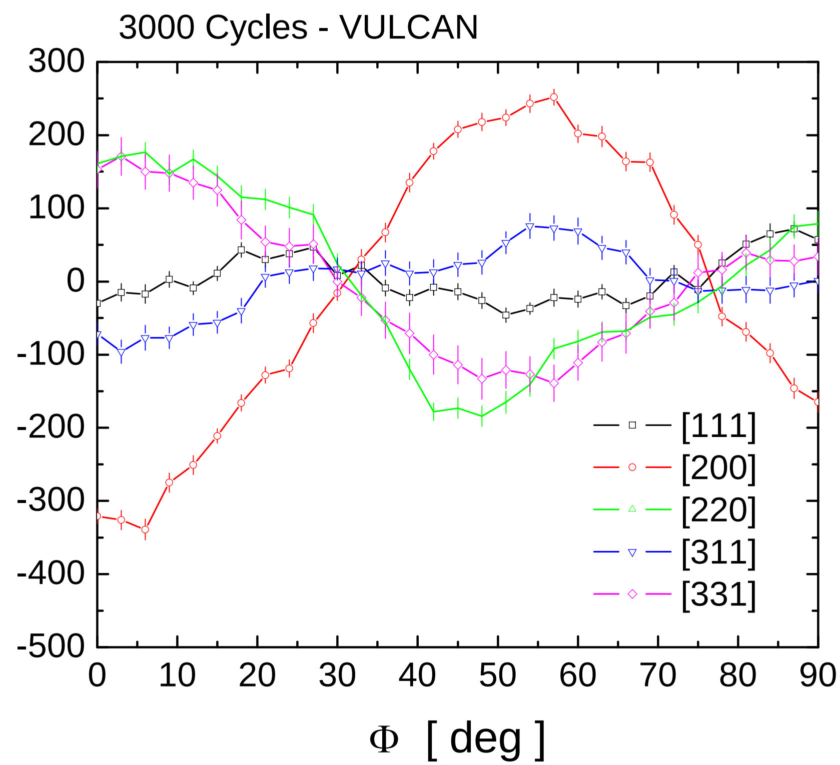


- ~5 hour run in HR mode
- 5x6x5 mm^3 gauge volume
- Continuous loading and data acquisition
- Data chopped in 4 min increment
- 500 kW
- Chopper at 30 Hz
- ~10x better at full power with 60 Hz chopper in high-intensity mode
- Higher strain rate is possible

Intergranular Strains in 316 Staineless Steel due to Fatigue

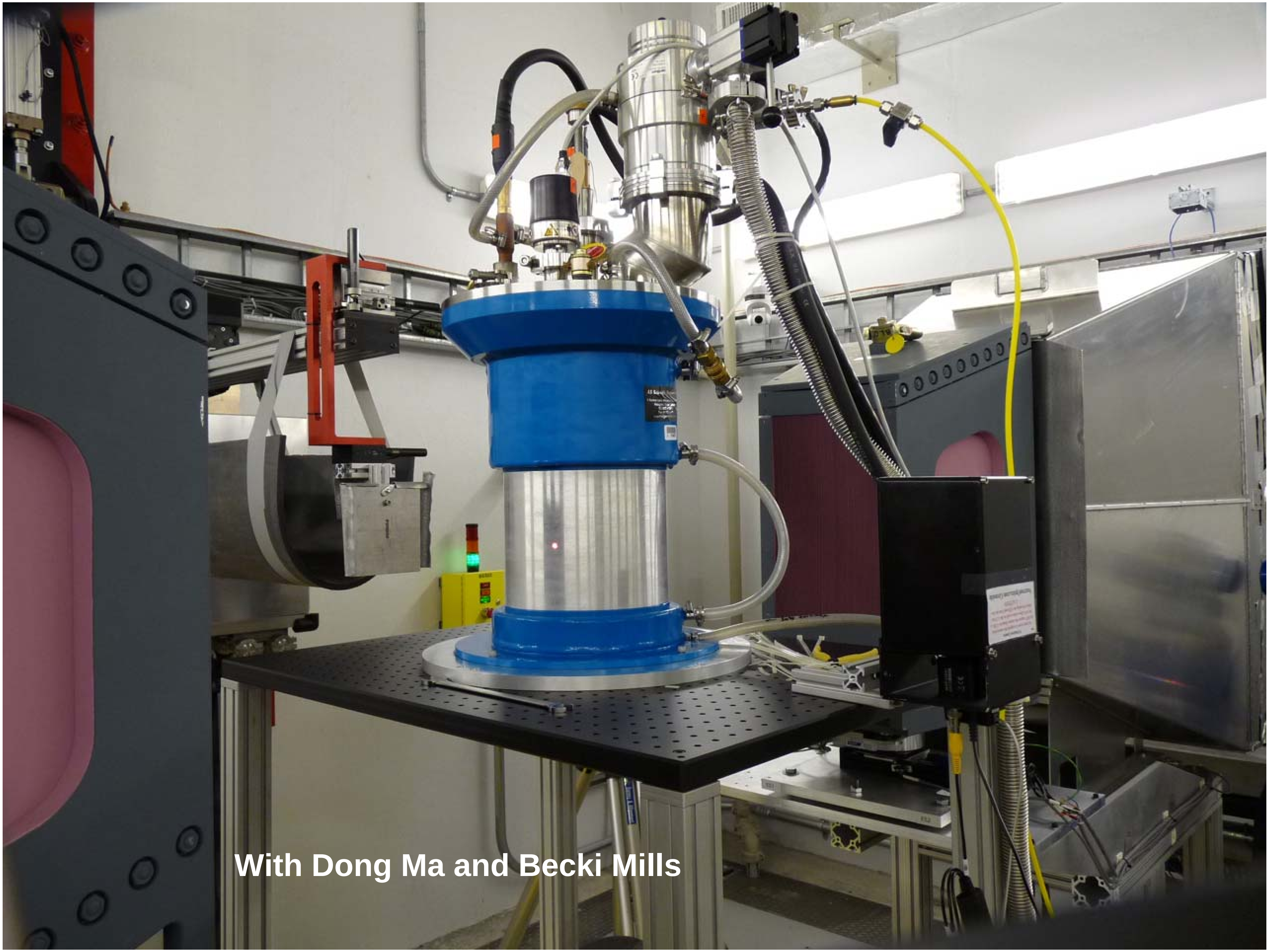
Wang et al., Nature Mat., 2003



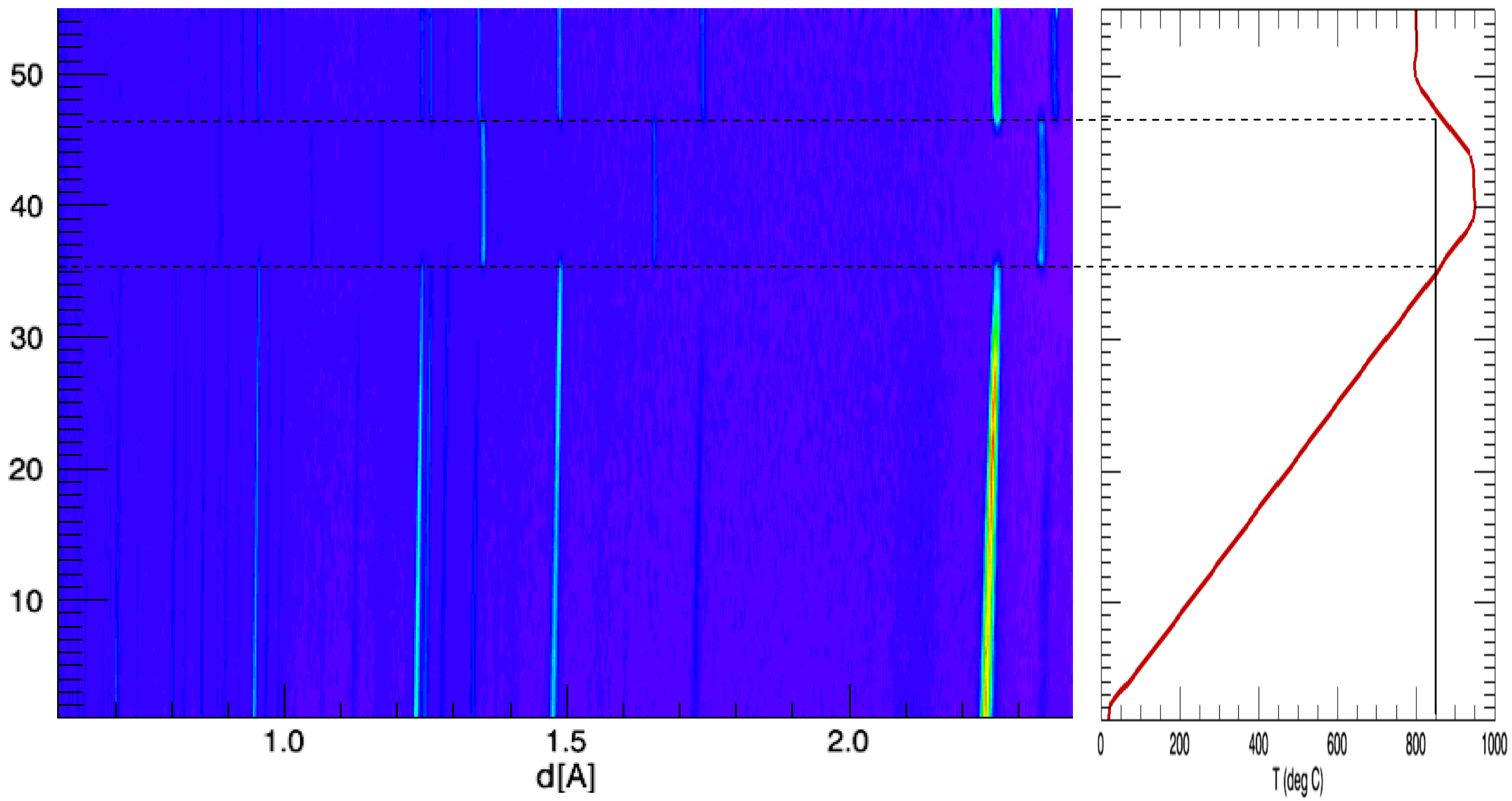


$$\varepsilon_{hkl} = f_0 + f_1(A_{hkl})P_2^0(\Psi) + f_2(A_{hkl}, C_{hkl})P_4^0(\Psi) + \ldots$$

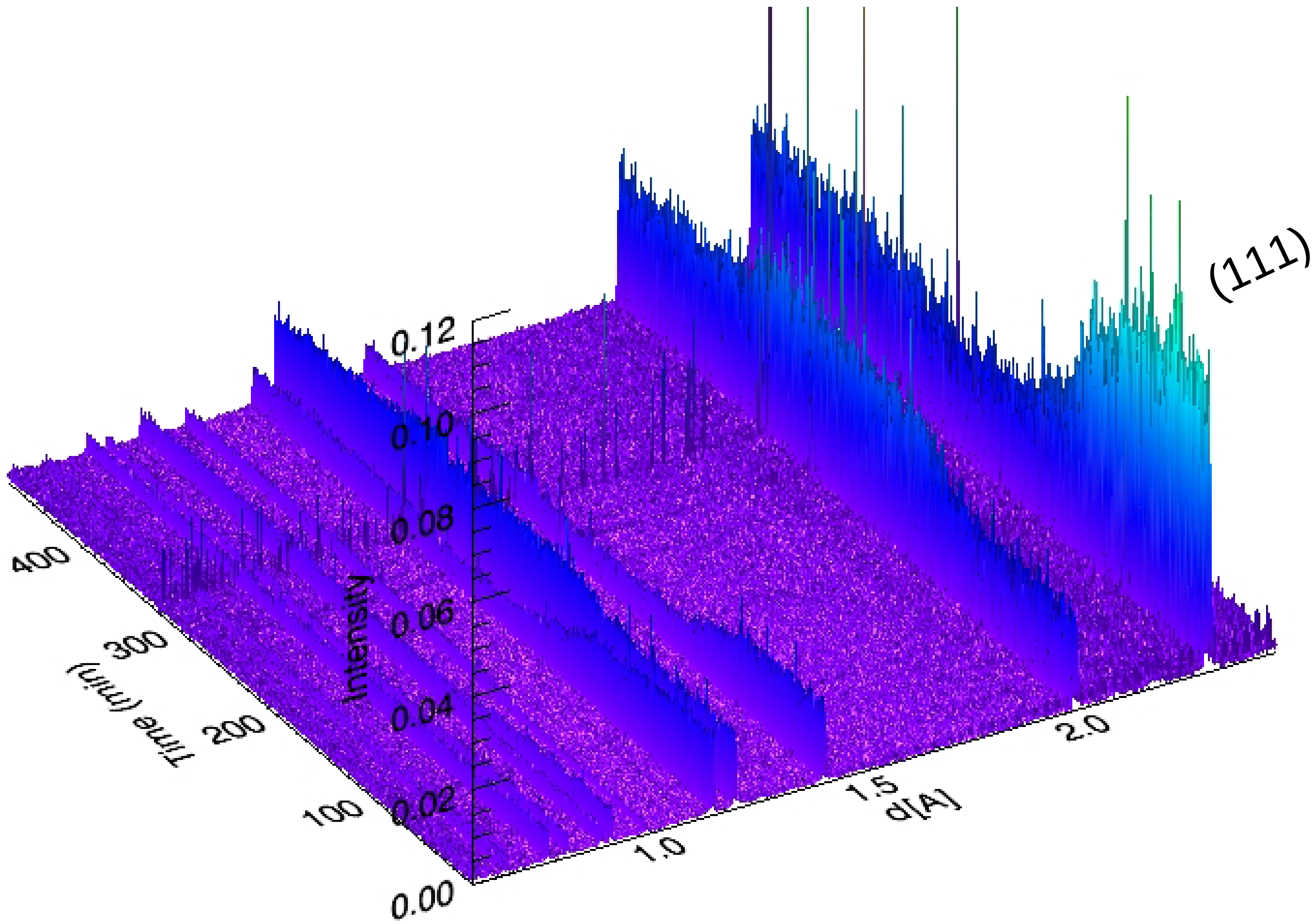
- Universal Ψ dependence – P_4 term only, crosses zero at Ψ~30, 71° as predicted
- 2-D strain pole figures possible in ~ 5-6 hours


With Dong Ma and Becki Mills

Phase transformation in Ti alloy

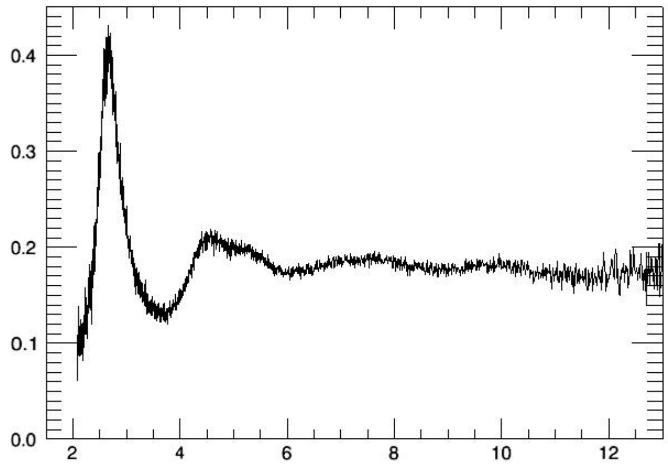


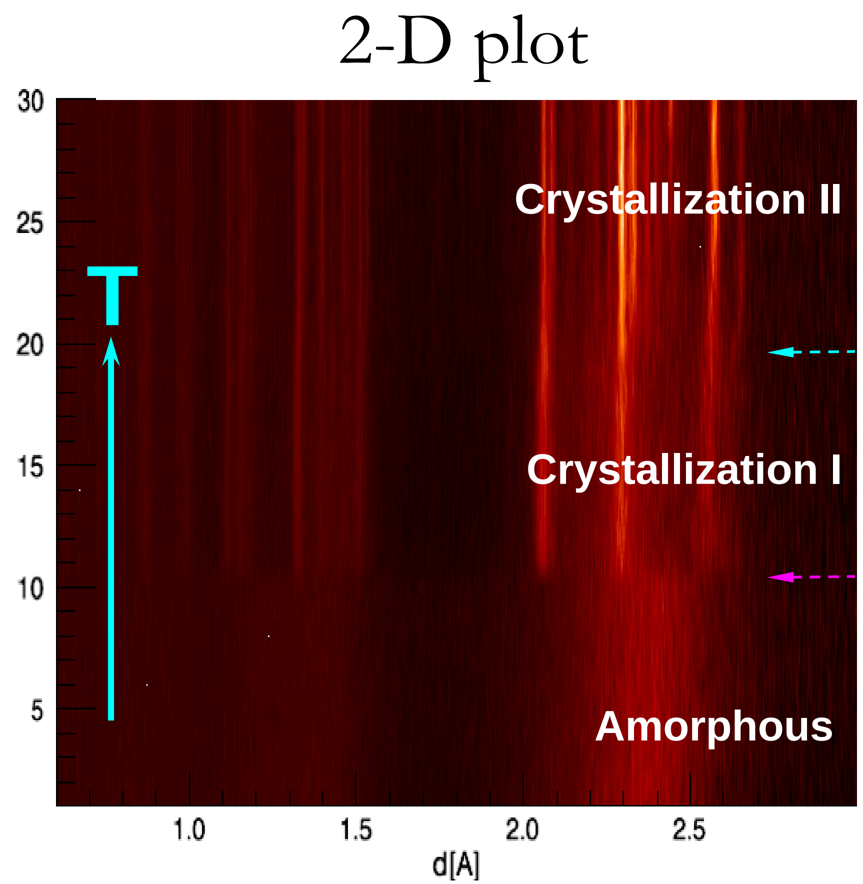
Recrystallization in Al alloys



For more details, see Radhakrishnan's talk tomorrow

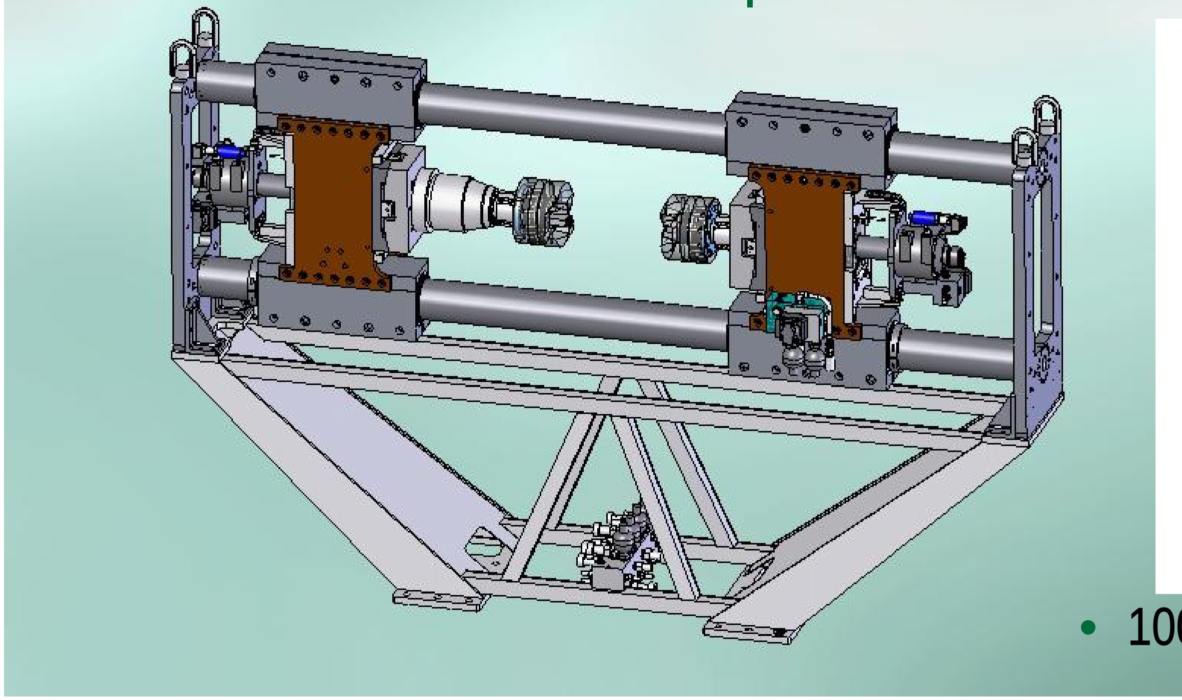
Crystallization in Bulk Metallic Glasses

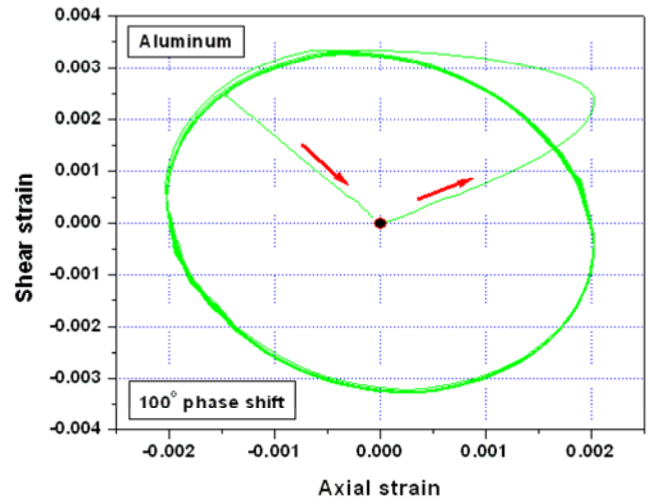




In-situ neutron scattering measurement of crystallization in BAM11 upon heating at 10 ^{o}C/min using Vulcan

VULCAN load-frame allows the study of deformation behavior under complex stress states



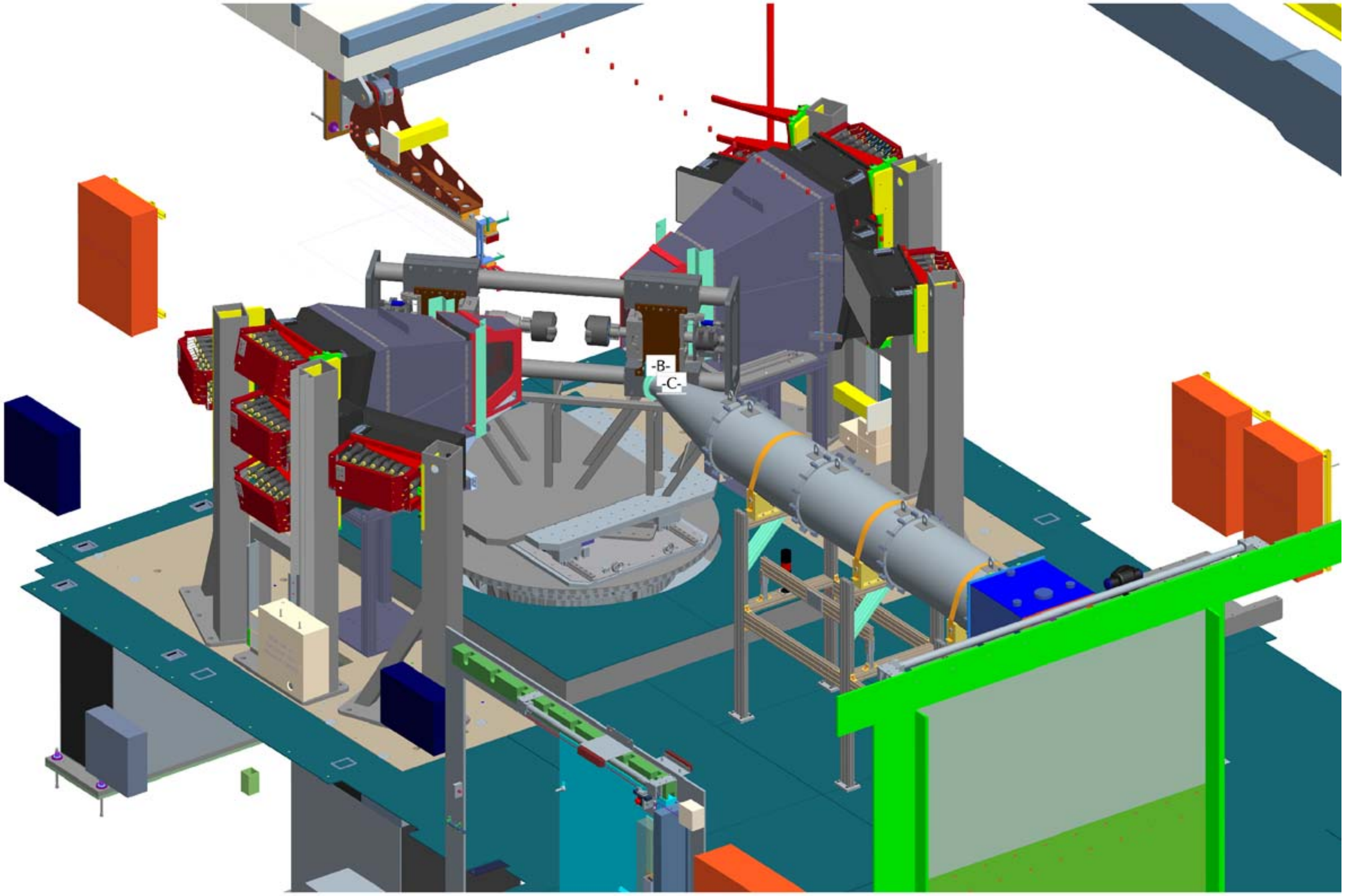


- 100 KN load capacity
- up to 30 Hz for fatigue tests
- Multi-axial loading including torsion
  - Dual actuators for tension or compression
  - Dual actuators for torsion
- Lamp and Vacuum Furnaces
  - temperatures ranging 25-1500 C

Funded by NSF

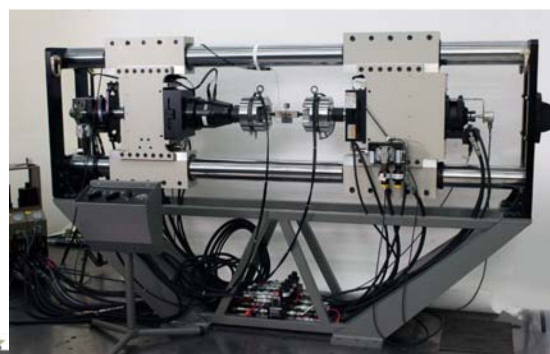
The use of opposing actuators ensures that the measurement location is fixed in space. This brings up the possibility of multi-probe analysis

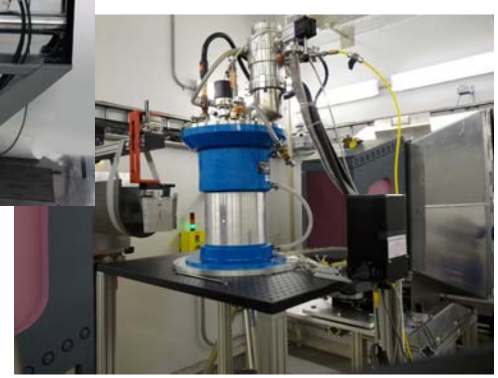
NSF & DOE-EERE investment significantly enhances VULCAN capability



Summary

- VULCAN commissioning has gotten off a great start
- The neutronic performance is in agreement with design calculations
- Several different types of science studies are demonstrated
- The instrument is (almost) ready but not done (upgrades)
- Available equipment:





Call for Proposals

Neutron Scattering Science – Oak Ridge National Laboratory

Due March 3, 2010

Proposals for beam time at Oak Ridge National Laboratory's High Flux Isotope Reactor (HFIR) and Spallation Neutron Source (SNS) will be accepted via the web-based proposal system until 11:59 p.m. eastern time, Wednesday, March 3, 2010. This call is for experiments anticipated to run from June through November 2010.

Information and instructions

To learn more about submitting a proposal for beam time, go to neutrons.ornl.gov/users/user_news.shtml or directly to the proposal system at www.ornl.gov/sci/iums/ipts/. Previously submitted proposals may be used as the basis for new proposals. All proposals will be reviewed for feasibility, safety, and the potential for high-impact science. Before beginning approved experiments, users must complete access and training requirements and ensure that the appropriate user agreements are in place.

Available instruments

The ORNL Neutron Sciences web site, neutrons.ornl.gov, provides specific information about each of these instruments.

Instruments fully available for general users

HFIR

- HB-1 Polarized Triple-Axis Spectrometer
- HB-1A Fixed-Incident-Energy Triple-Axis Spectrometer
- HB-2A Neutron Powder Diffractometer
- HB-3 Triple-Axis Spectrometer
- HB-3A Four-Circle Diffractometer
- CG-2 General-Purpose SANS
- CG-3 Bio-SANS

SNS

- BL-2 Backscattering Spectrometer (BASIS)
- BL-3 Spallation Neutrons and Pressure Diffractometer (SNAP)
- BL-4A Magnetism Reflectometer (MR)
- BL-4B Liquids Reflectometer (LR)
- BL-5 Cold Neutron Chopper Spectrometer (CNCS)
- BL-17 Fine-Resolution Fermi Chopper Spectrometer (SEQUOIA)
- BL-18 Wide Angular-Range Chopper Spectrometer (ARCS)

Instruments with limited availability for general users

- HB-2B Neutron Residual Stress Mapping Facility

- BL-6 Extended Q-Range SANS (EQ-SANS)
- BL-7 Engineering Materials Diffractometer (VULCAN)
- BL-11A Powder Diffractometer (POWGEN)
- BL-12 Single Crystal Diffractometer (TOPAZ)
- BL-15 Neutron Spin Echo Spectrometer (NSE)

For more information:

Neutron Scattering Science User Office, neutronusers@ornl.gov or (865) 574-4600

These facilities are funded by the U.S. Department of Energy.

neutrons.ornl.gov

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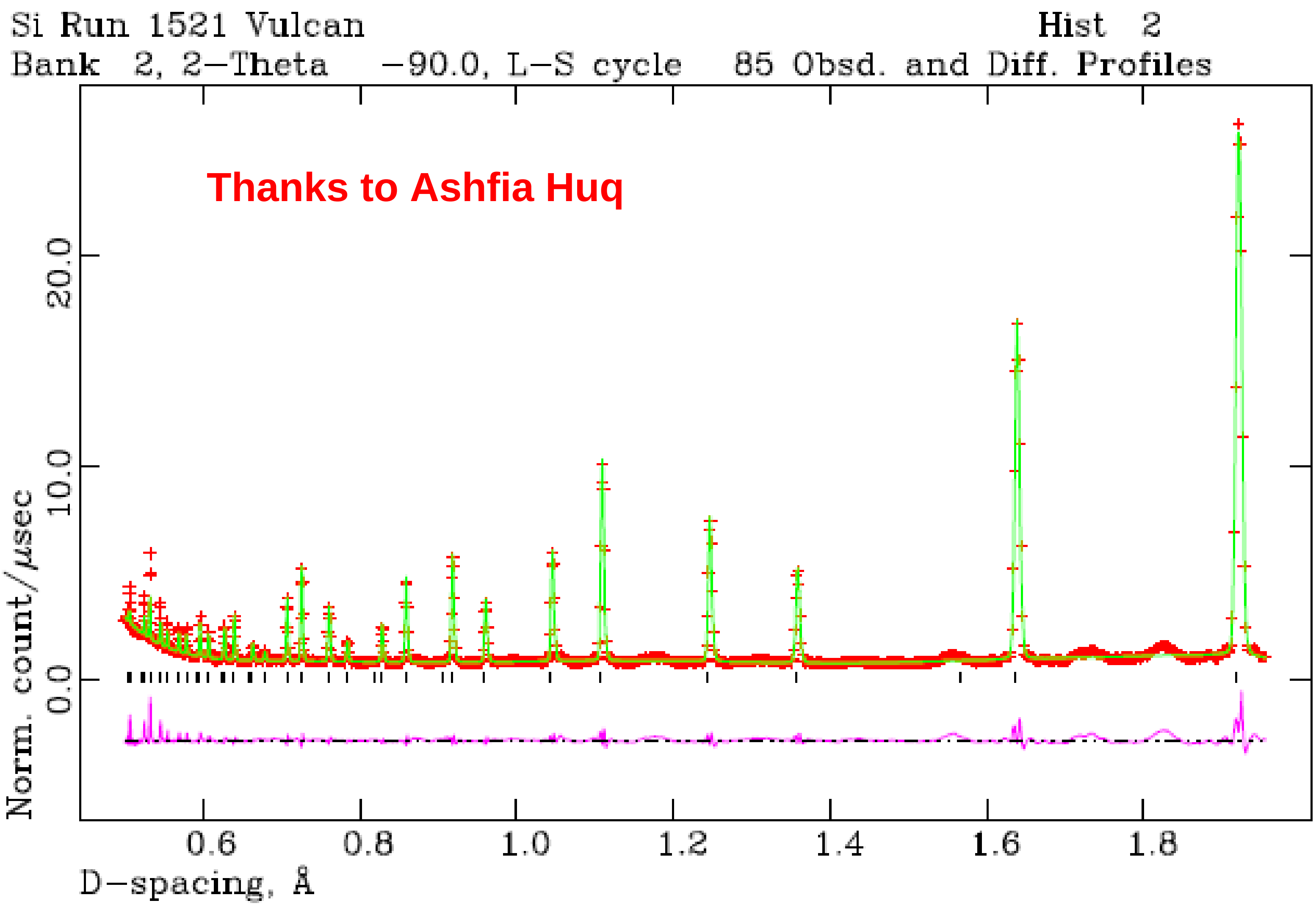
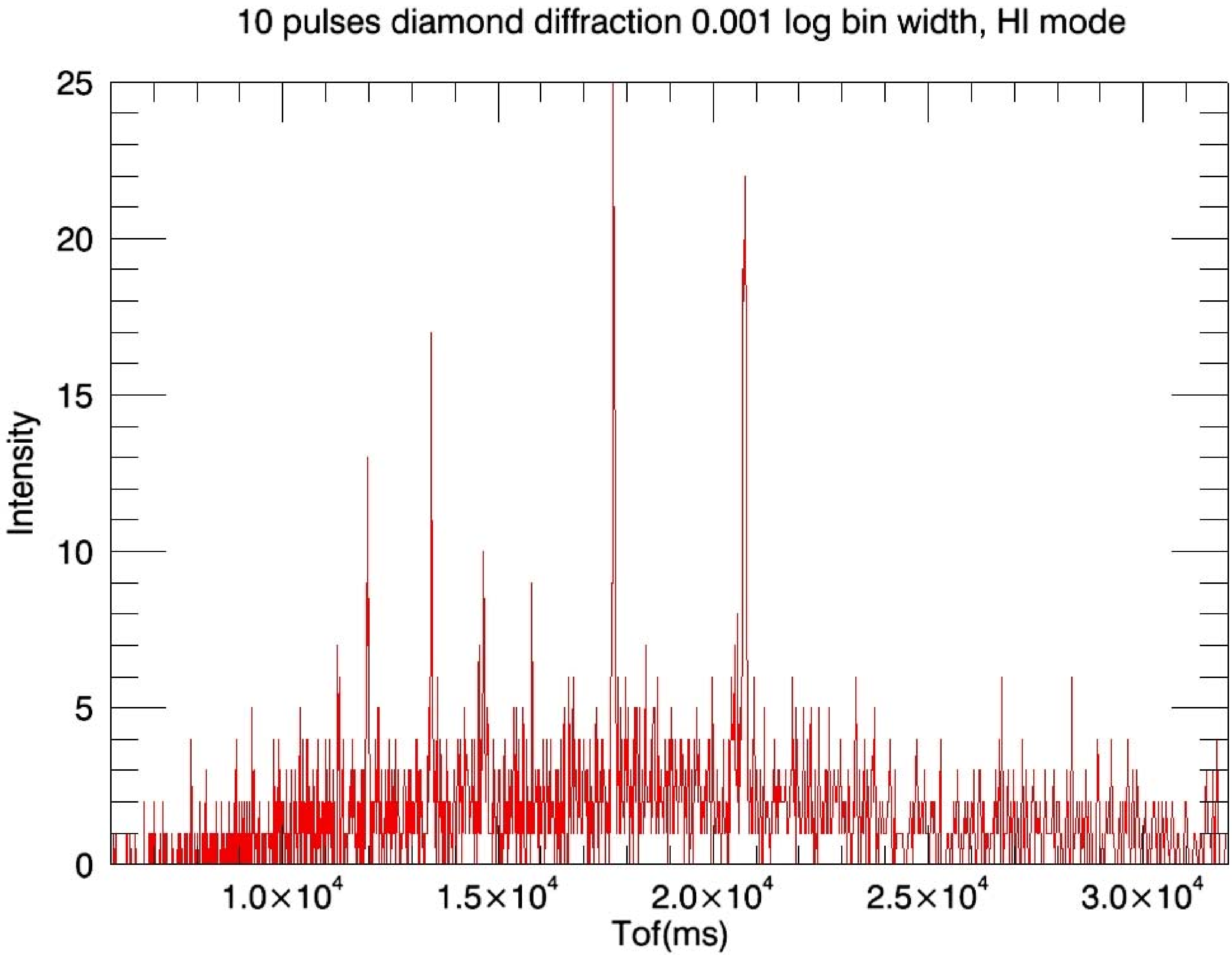
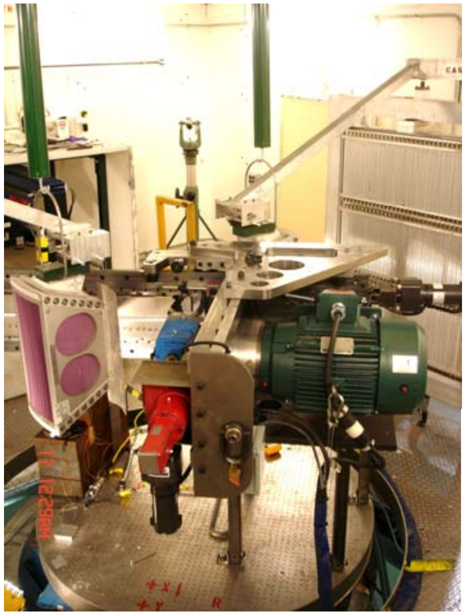
Refinement of Si Data

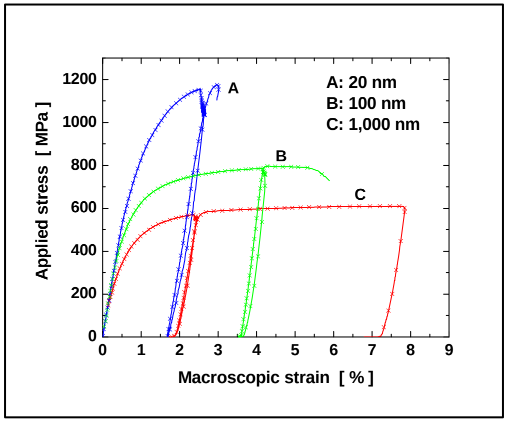



10 pulses diamond diffraction 0.001 log bin width, HI mode
Intensity
Tof(ms)
25
20
15
10
5
0
1.0×10^4
1.5×10^4
2.0×10^4
2.5×10^4
3.0×10^4

Exciting New Opportunities Are Awaiting with the Commissioning of VULCAN



- Stress Mapping in components
  - In-situ study of processing
- In-situ deformation
  - Uni-axial and torsion loading
  - Cyclic loading
  - Small length scales
  - Glass & polymers



- Kinetic studies
  - Multi-length scale phase transformation phenomena