

CNCS BL-5 Cold Chopper Neutron Spectrometer

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ORNL is managed by UT-Battelle, LLC for the US Department of Energy

Beamline Review Checklist

1. CNCS overview
2. Scientific Mission and Impact
3. General user program and beam time usage
4. Beamline Productivity
5. Adequacy and reliability of software, sample environment and ancillary equipment
6. Science Highlights
7. Risks
8. Future instrument science and development plan
9. Response to instrument specific recommendations from last review
10. Summary

CNCS overview

Georg has moved on at NSD



Georg Ehlers

Lead Instrument Scientist (2003 to 2017)

| | |
|---|----------------|
| Funding obtained | May 2000 |
| Project Completion as originally promised | September 2006 |

| | |
|-------------------|------------|
| Georg joined CNCS | March 2003 |
|-------------------|------------|

| | |
|-------------------------------------|----------------|
| Neutron Guide Procurement | March 2003 |
| High-Speed Disk Chopper Procurement | April 2004 |
| Core Vessel Insert Installation | October 2004 |
| Primary Shutter Installation | May 2005 |
| Project Review at DOE headquarter | May 2005 |
| Building Design Start-Over | July 2005 |
| 300 Hz Fermi Chopper Procurement | September 2005 |
| Building Construction Start | June 2006 |

| | |
|-------------------------------|--------------|
| Instrument Readiness Review | March 2008 |
| First Beam | April 2008 |
| Andrey Podlesnyak joined CNCS | June 2008 |
| First User Experiment | May 2009 |
| First Paper | October 2009 |

CNCS overview

Instrument team 2017-2019



Daniel Pajeroski
Instrument Scientist
Spectroscopy group
Neutron Science
Division

Andrey Podlesnyak
Instrument Scientist
Spectroscopy group
Neutron Science
Division

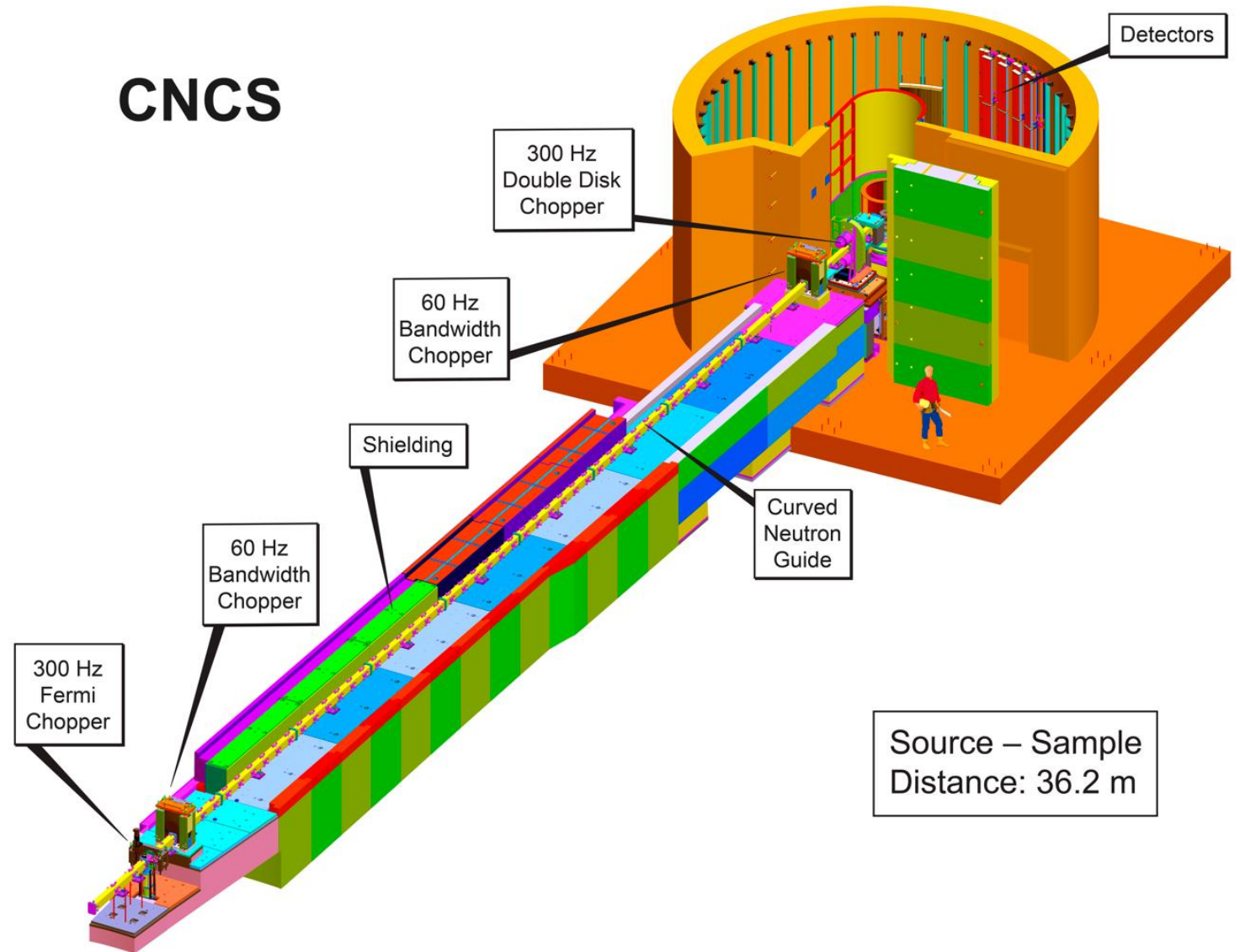
Chris Schmitt
Scientific Associate
(CNCS, BASIS)
Operations group
Neutron Science
Division

Andrei Savici
Computational
Instrument Scientist
(HYSPEC, SEQ,
ARCS, CNCS)
Spectroscopy group
Neutron Science
Division

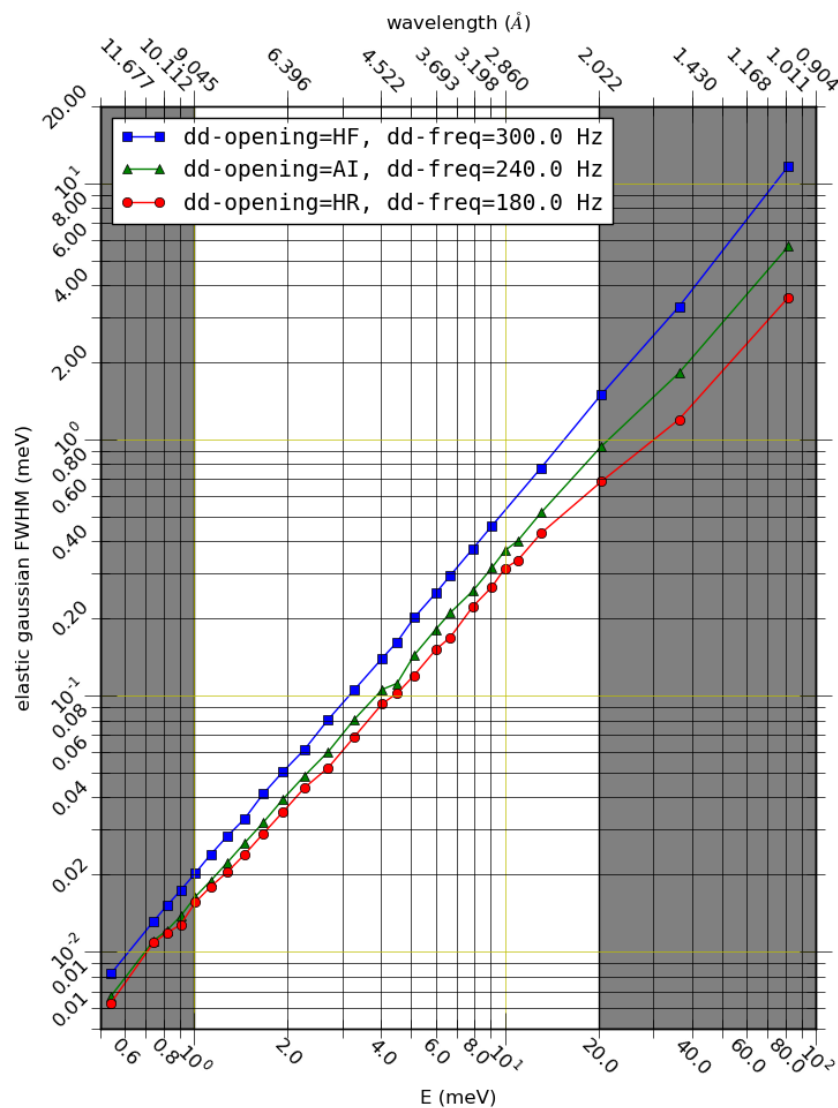
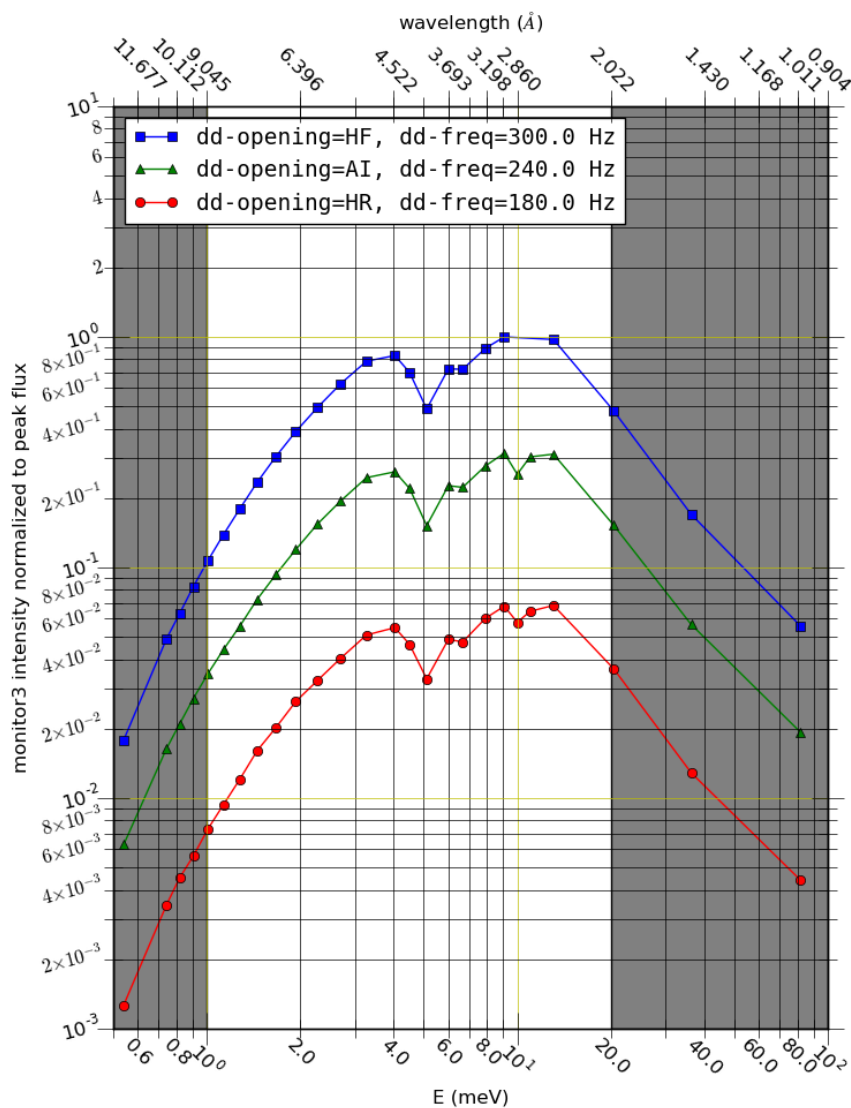
Gabriele Sala
Post-doctoral
associate working
with Georg Ehlers
Left CNCS in 2019
to join STS

CNCS overview

A direct geometry chopper spectrometer that provides a high flux of cold neutrons (≈ 2 -4 times greater on sample than other in-class instruments LET and IN5) and benefits from a large position sensitive detector array (≈ 1.7 sr). Excels for high-resolution measurements having incident energies less than 3.7 meV.



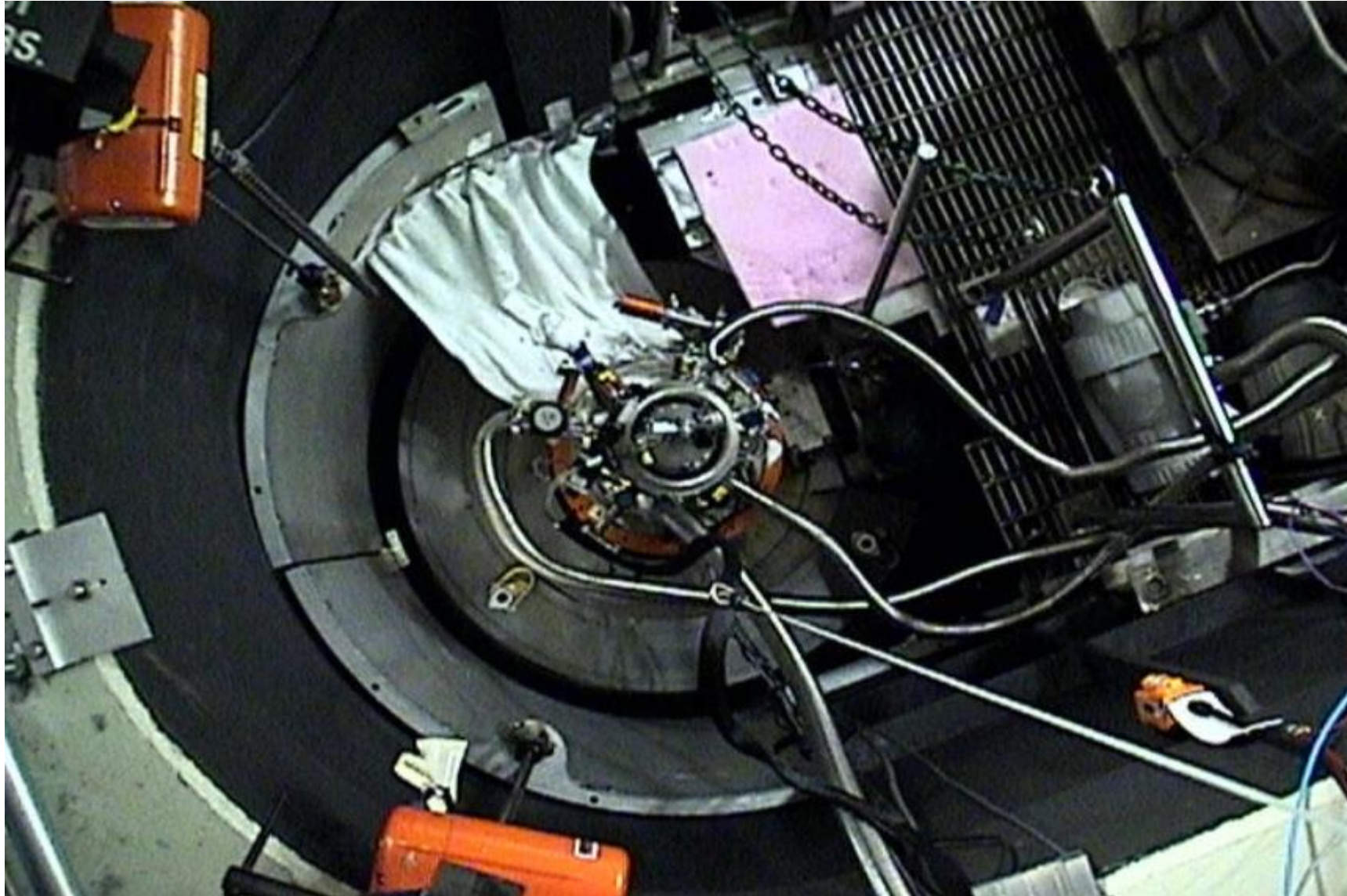
CNCS overview



Three popular chopper settings:

1. **HF = high flux**
 9° DD opening
 $\approx 5\%E_i$ at elastic line
2. **AI = all intermediate**
 4.4° DD opening
 $\approx 2.5\%E_i$ at elastic line
3. **HR = high resolution**
 2° DD opening
 $\approx 1.9\%E_i$ at elastic line

CNCS overview

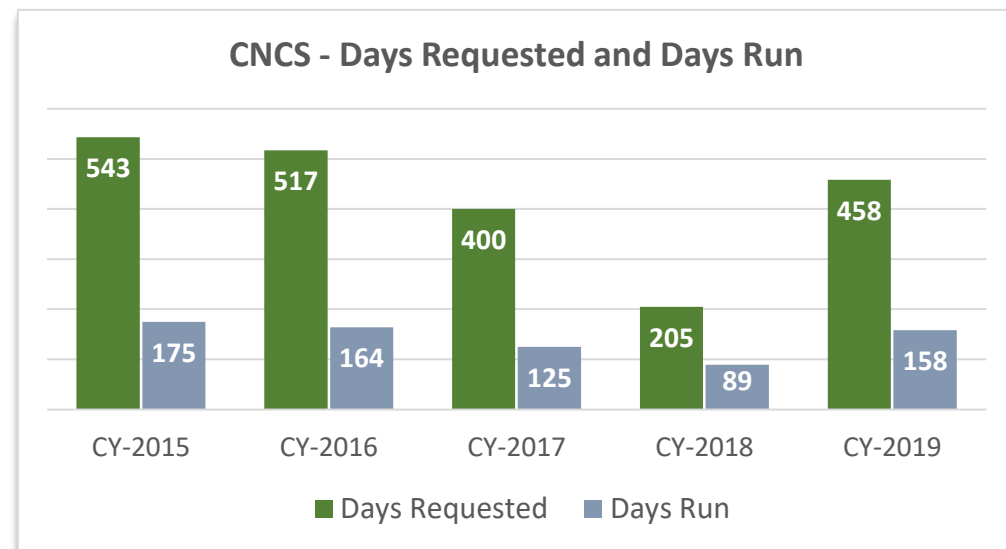
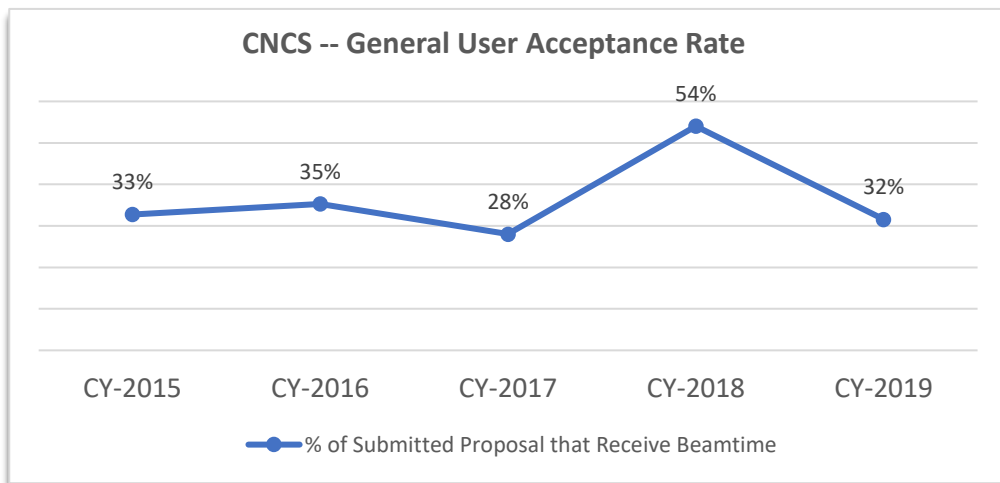
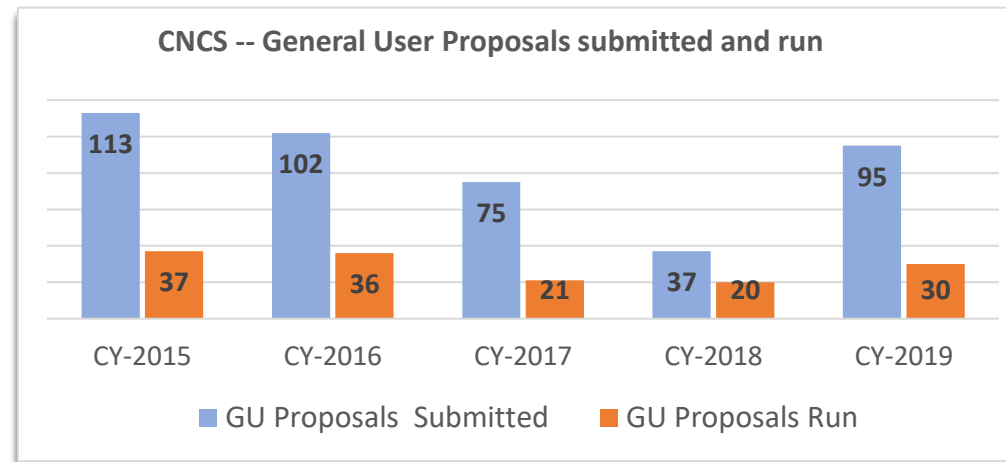
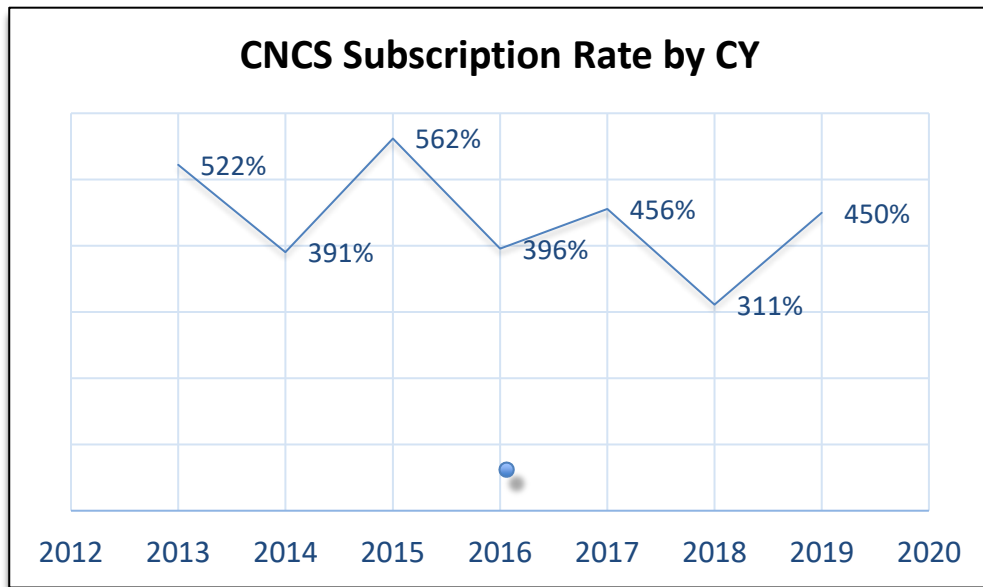


Large sample space is in air allowing for flexibility in deployment of sample environments. Large magnets, sample levitators, furnaces, refrigerators, and custom setups.

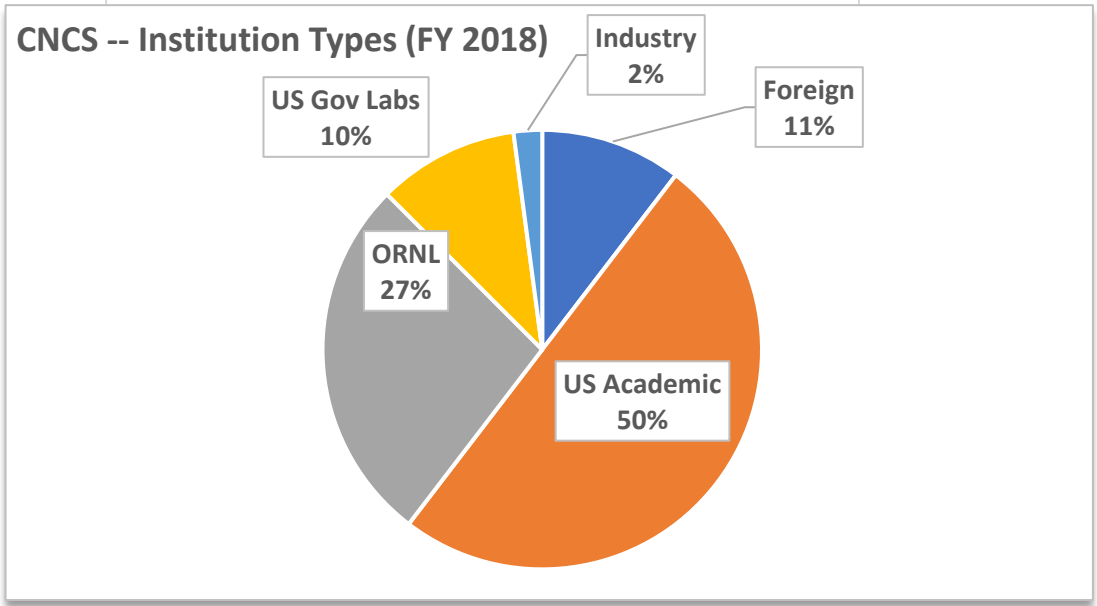
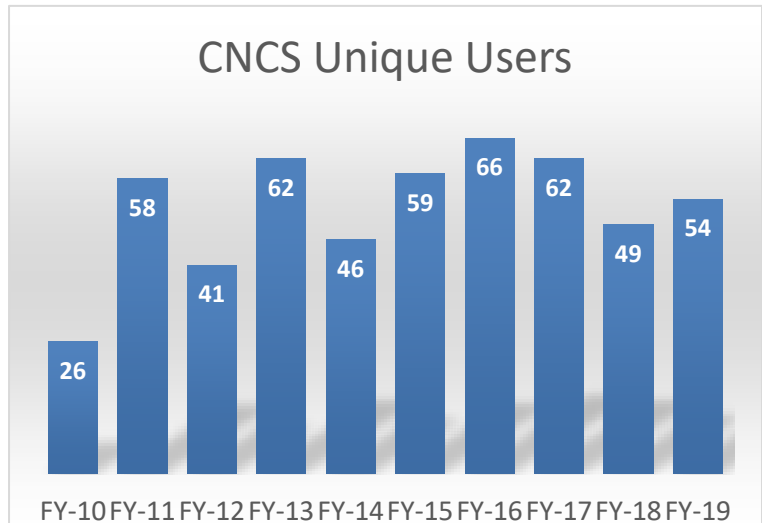
Scientific Mission and Impact

- The CNCS facilitates the investigation of correlations in materials having excitations from nominally 50 μeV to 10 meV to further fundamental and applied science.
- The momentum range and resolution along with the energy resolution make CNCS an exceptional neutron spectrometer for low energy studies.
- In the past 3 years, these measured correlations have advanced the fields of quantum magnetism, bulk magnetism, single-molecule magnets, multiferroics, thermoelectrics, structural phase transitions, crystallization of metals, liquid dynamics, and molecular vibrations.

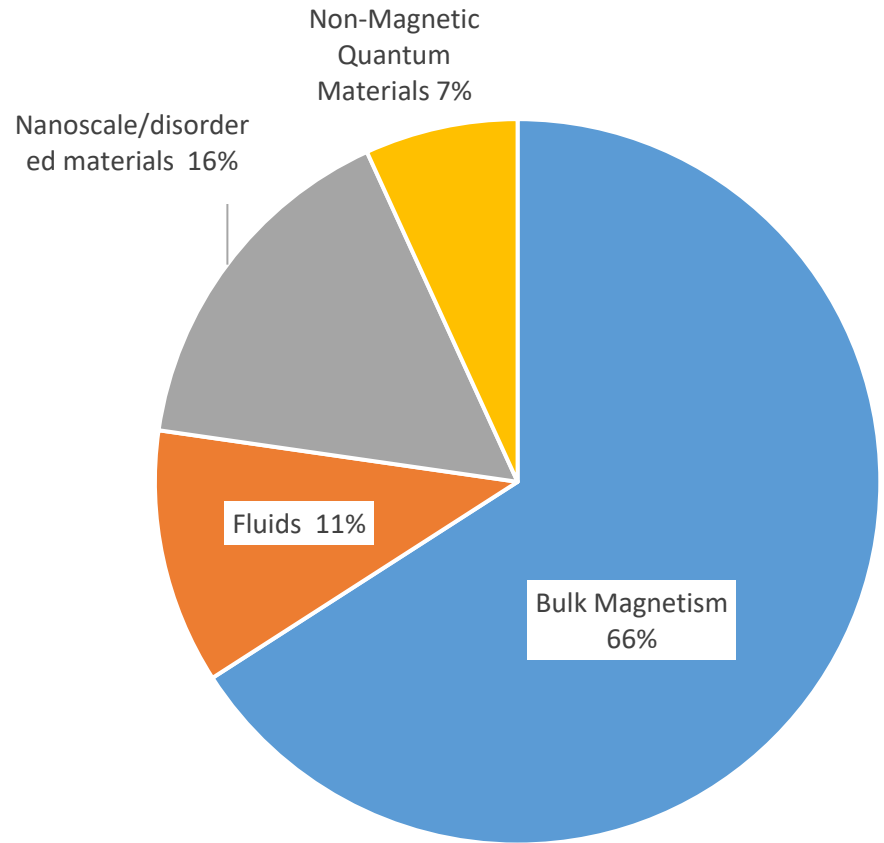
General user program and beam time usage



General user program and beam time usage



CNCS Research Areas (2019)

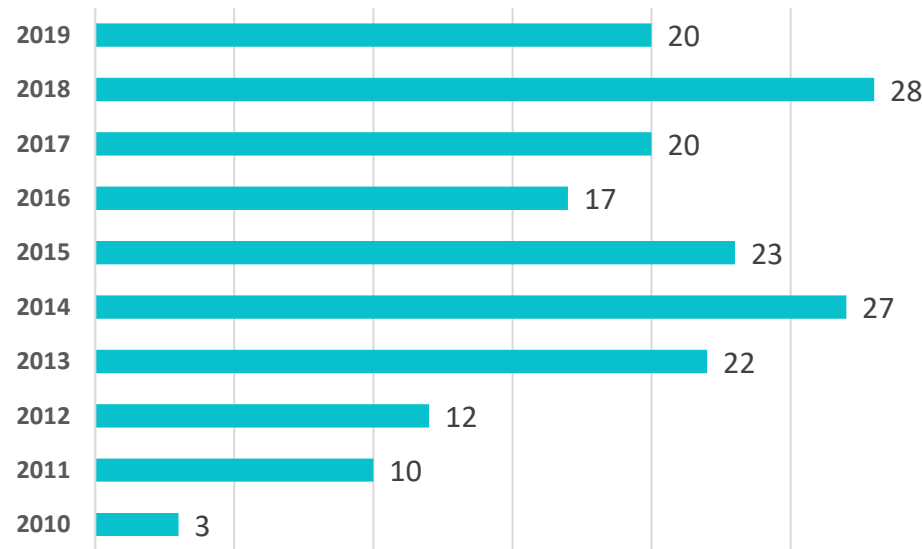


Beamline productivity

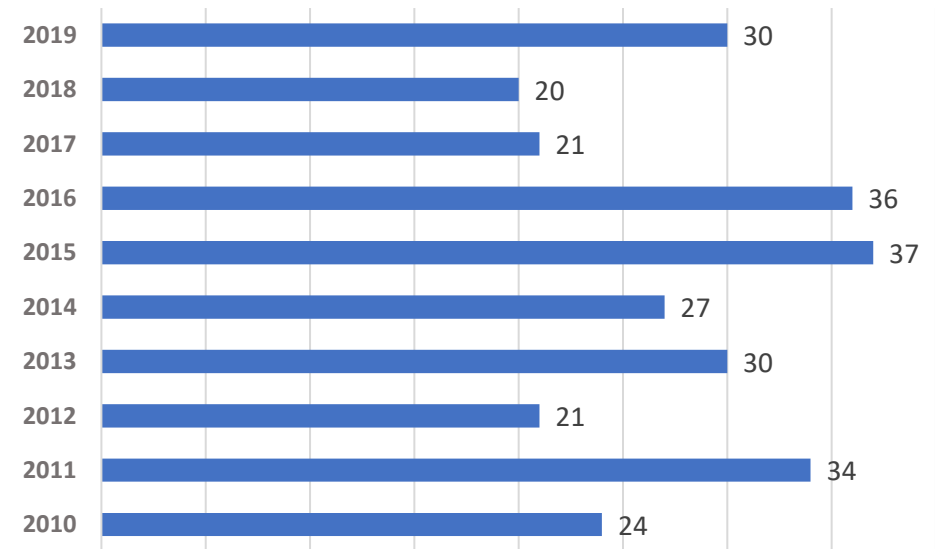
- Total Publications: 189
- Instrument H-Index: 29
- Publication Impact: 22% publications with a high impact factor (recent 3 years)

- Results from use of both facilities: 20%
- Results from use of multiple instruments: 49%
- Unique authors 2017-2019: 393

CNCS Publications by CY



CNCS - Experiments by CY



Adequacy and reliability of software, sample environment and ancillary equipment

SOFTWARE

- Planning – DGSPPlanner, PyChop (web, GUI, or Python library)
- Acquisition – EPICS (Phoebus), Python scripting, ONCat, web-opi, crystal alignment tool usually works
- Reduction – Auto-reduction
- Visualization - Auto-visualization, MANTID (needs documentation), Horace, DAVE
- Analysis – SpinWaveGenie, SpinW, VASP+phonopy+Oclimax, various crystal field programs

Adequacy and reliability of software, sample environment and ancillary equipment

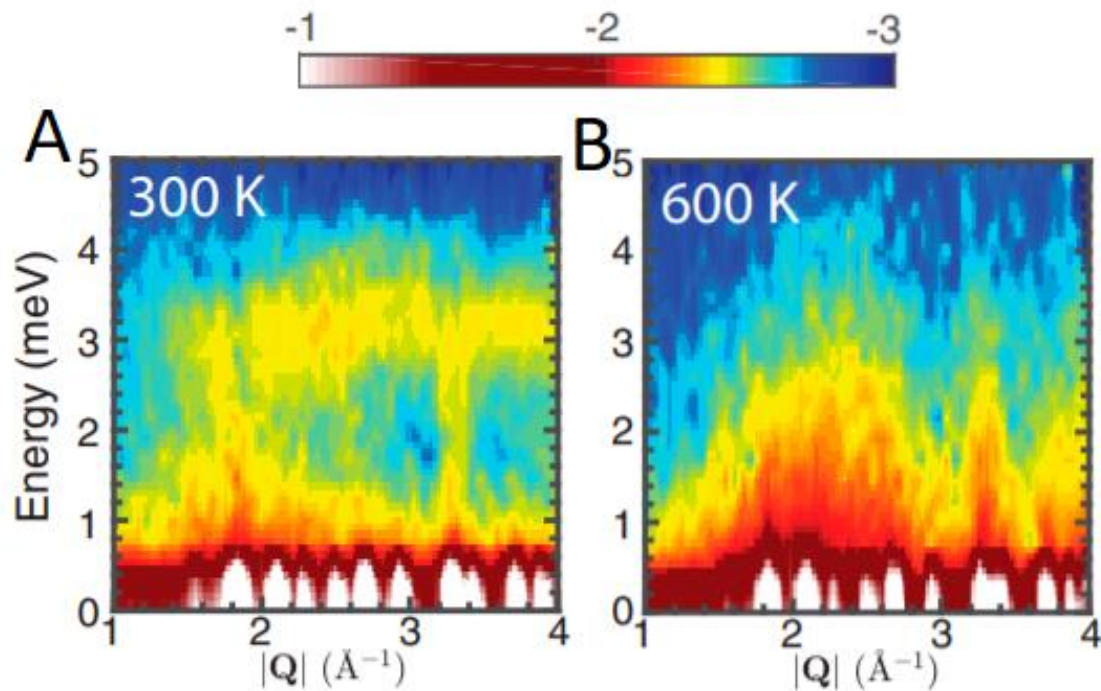
SAMPLE ENVIRONMENT

- Work-horse wet 4He cryostat (cryo-006, has 3-sample rotation changer)
- 3He inserts, dil-fridge (necessary for cold neutrons, turning down GU experiments due to SE staffing resources)
- Newly commissioned NESL (300 K to 2727 K)
- 5 T magnet, 8 T magnet
- Testing underway for 14 T magnet
- Top loader CCR not optimal (CCR-18: 50 mm ID, high background)
- Vacuum furnaces (CCR-10: 5 K to 750 K, HOT-006: 30° C to 1600° C)
- Clamp pressure cells up to 3 Gpa
- Permanent magnet assembly up to 0.9 T

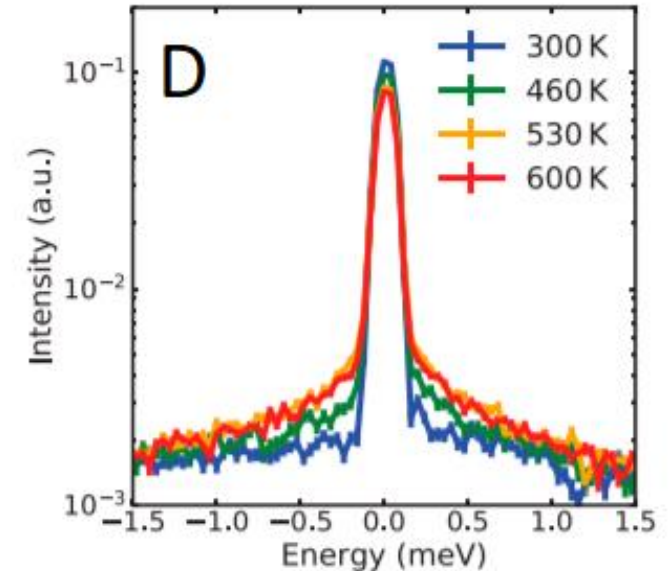
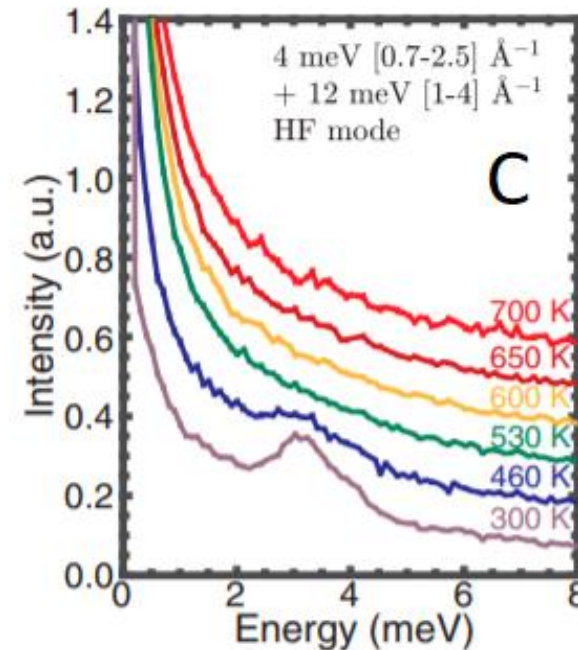


Science highlights

- Ding J., Niedziela J., Bansal D., Wang J., He X., May A.F., Ehlers G., Abernathy D.L., Said A.H., Alatas A., Ren Y., Arya G., Delaire O., "[Anharmonic lattice dynamics and superionic transition in AgCrSe₂](#)", *Proceedings of the National Academy of Sciences of the United States of America*, 117, 3930-3937 (2020).



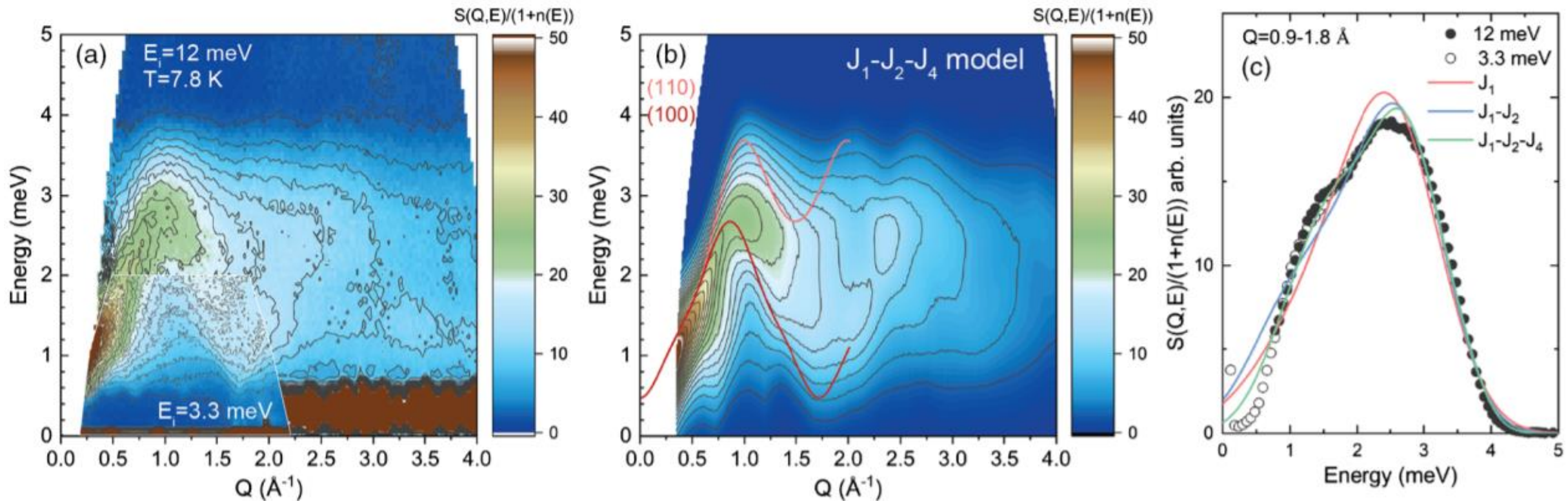
High resolution, large momentum coverage



QENS

Science highlights

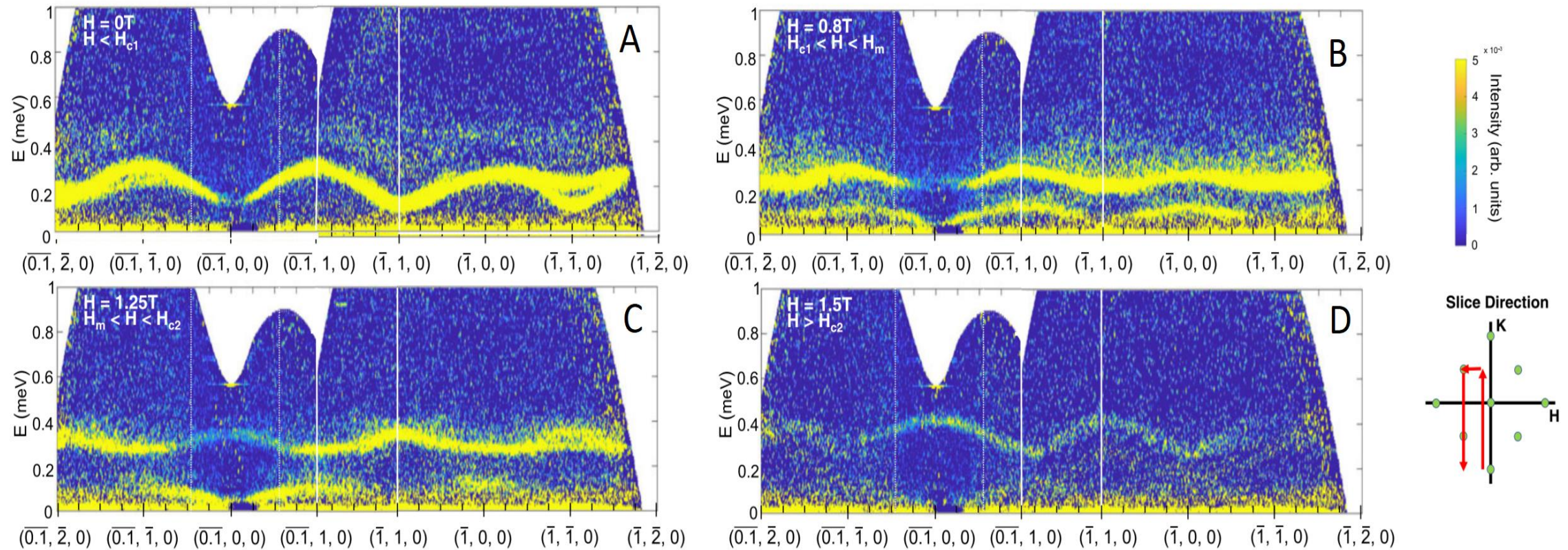
- Li B., Yan J.Q., Pajerowski D.M., Gordon E.E., Nedic A.M., Sizyuk Y., Ke L., Orth P.P., Vaknin D., McQueeney R.J., "[Competing Magnetic Interactions in the Antiferromagnetic Topological Insulator MnBi₂Te₄](#)", *Physical Review Letters*, 124, 167205 (2020).



CNCS brightness allows for powder samples to be studied quickly

Science highlights

- Hester G., Nair H.S., Reeder T., Yahne D.R., DeLazzer T., Berges L., Ziat D., Neilson J.R., Aczel A.A., Sala G., Quilliam J.A., Ross K.A., "[Novel Strongly Spin-Orbit Coupled Quantum Dimer Magnet: Yb2Si2O7](#)", *Physical Review Letters*, 123, 027201 (2019).



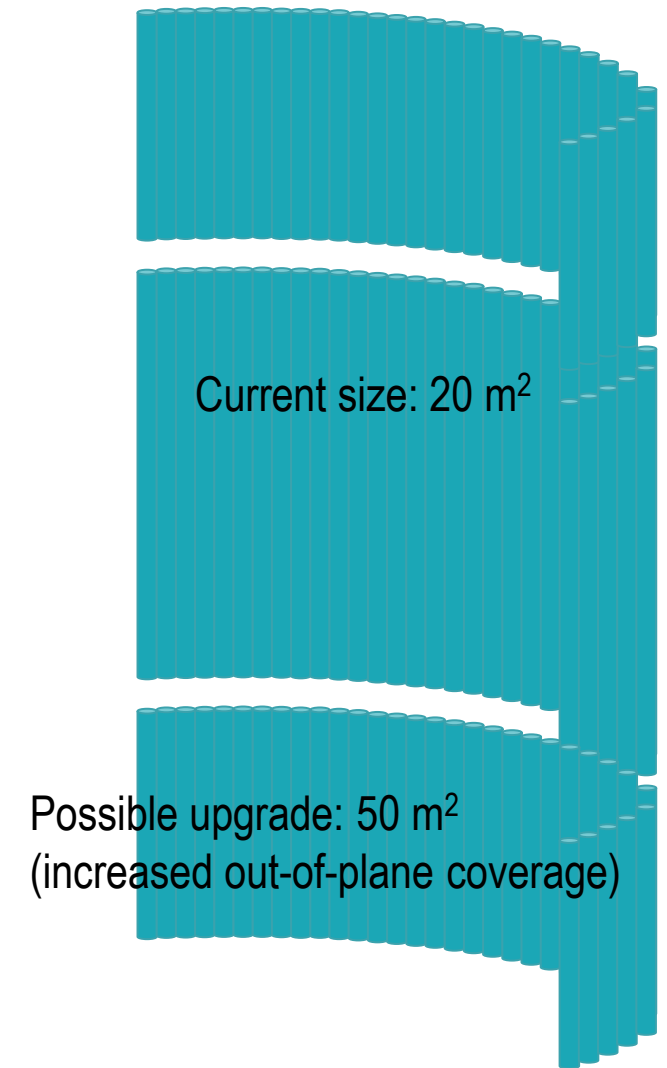
CNCS has an excellent background for high magnetic fields and ultra-low temperatures

Risks

- Inadequate staffing of sample environment causes experiments to be turned away, which may weaken user base and lose out on science to other facilities
- Next generation sources may out-pace the flux at the CNCS
- Increasing SNS flux without increasing beamline staff will increase down-time
- Catastrophic failure of chopper systems could cause large downtime; now have backups for all disk choppers

Future instrument science and development plan

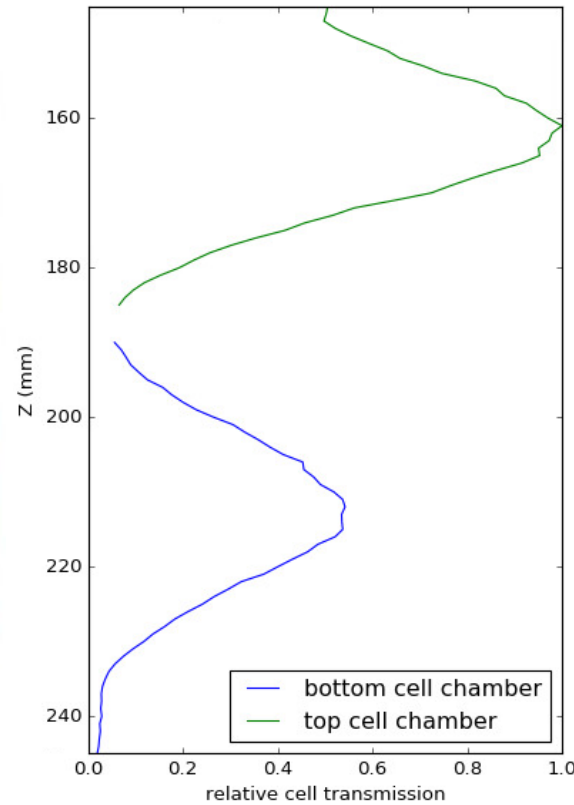
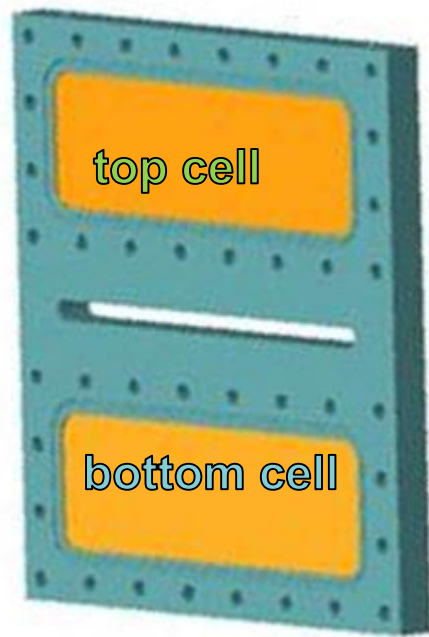
- Increased out-of-plane coverage using PHAROS detectors
- Upgrading the guides could make CNCS comparable to CHSS aside from the source limited flux (???)x).
- This generation of instrument is set to perform parametric inelastic powder studies programmatically via sample changers.



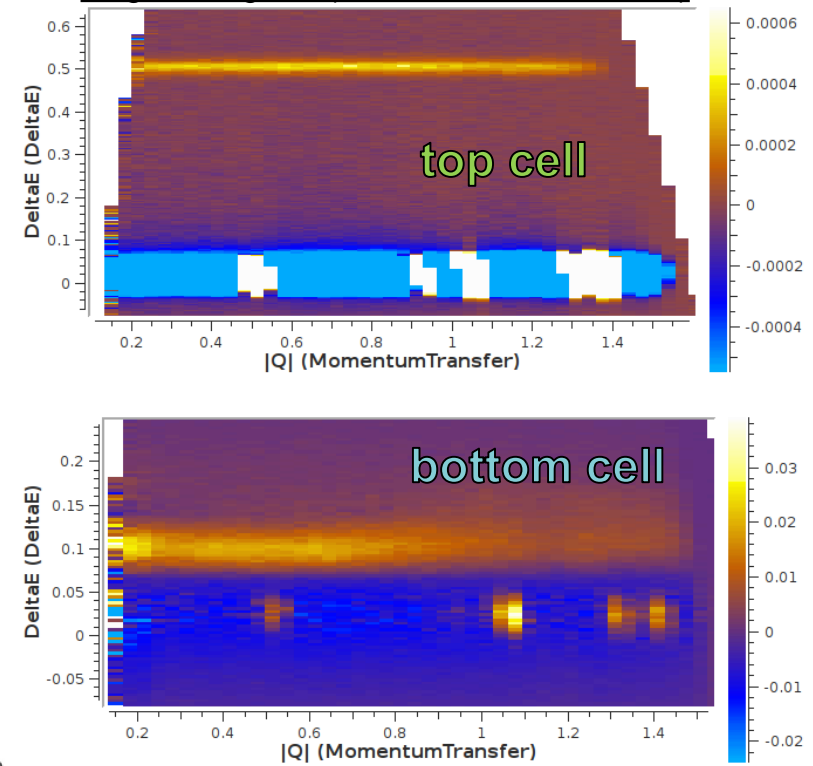
Future instrument science and development plan

SAMPLE CHANGERS

Triton NANO dil fridge double aluminum/copper powder flat-plate



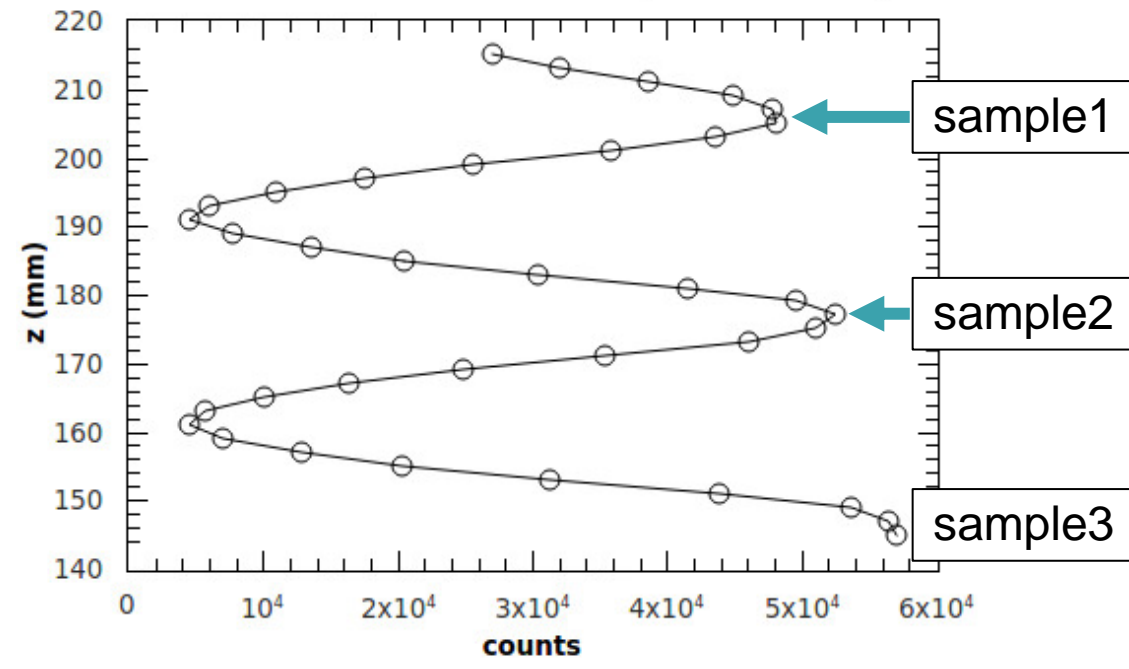
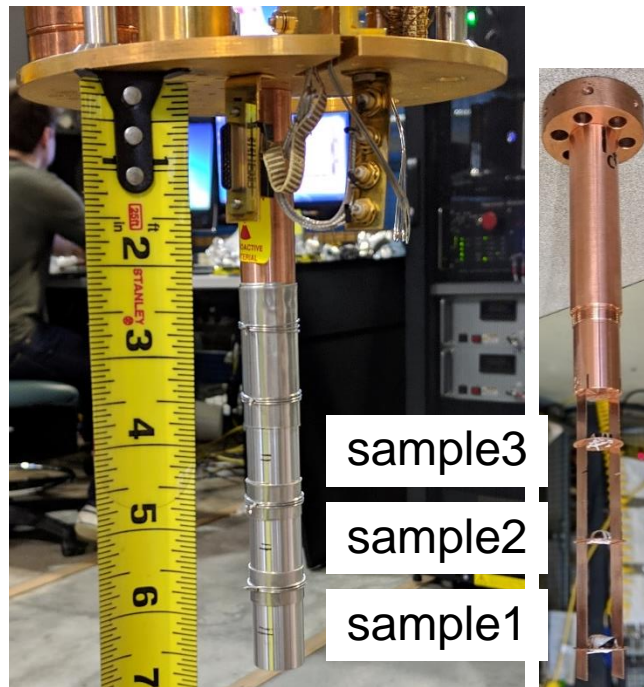
Magnetic signals (0.07 K minus 1.5 K data)



Future instrument science and development plan

SAMPLE CHANGERS

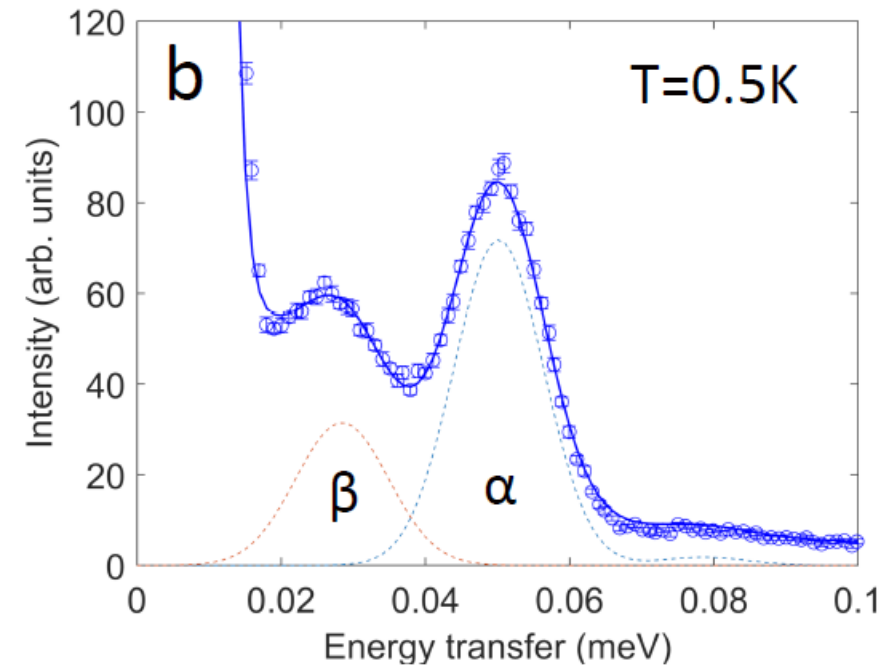
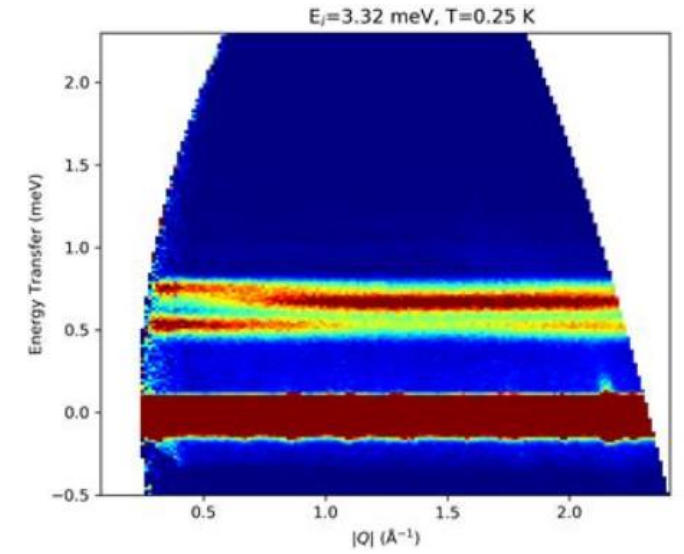
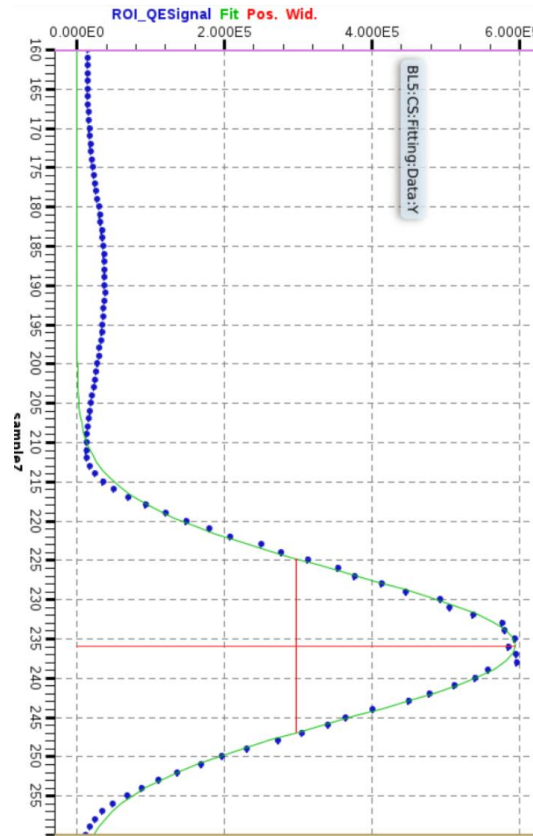
Triton NANO dil fridge triple-crystal stack



Future instrument science and development plan

SAMPLE CHANGERS

3He insert double stack aluminum cylinders



Future instrument science and development plan

SAMPLE CHANGERS

1.7 K base, 800 K maximum CCR with > 20 sample changer



Response to instrument specific recommendations from last review

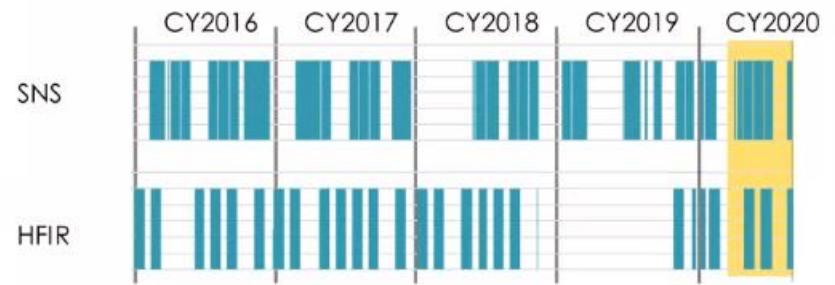
- “Expanding the detector coverage should be of high priority.”
- “Returns on a T0 chopper and Rep-rate multiplication are thought to not be commensurate with the investment required.”
- “For the longer term (~10 years) several cold TOF instruments will become available that will outperform CNCS in sheer numbers of flux and resolution, in particular instruments planned at ESS and also at STS.”

Summary

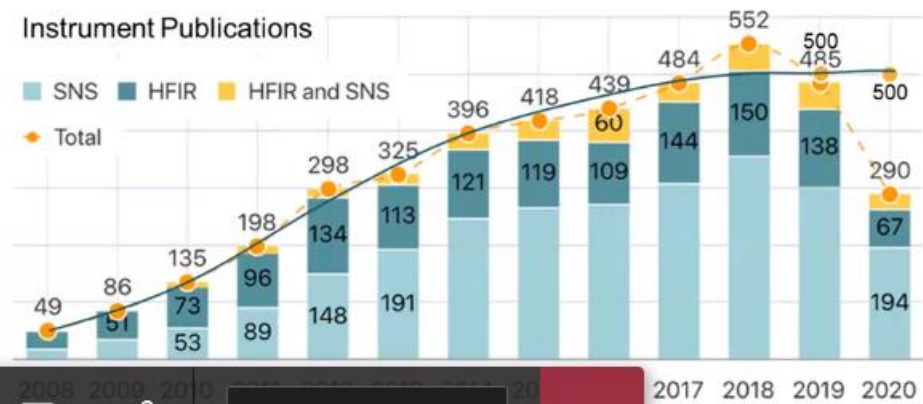
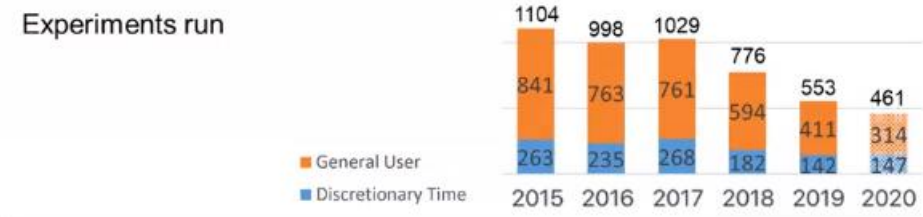
- CNCS continues to perform well
- CNCS continues to have a high-subscription rate
- Room for improvement in software
- Room for extension of scientific areas not historically represented at CNCS (e.g. biology, geology, other –gies)
- 14 T magnet testing is on the horizon

Despite operational challenges, the number of publications remains high

SNS and HFIR operation schedule



29% of CY2020 publications are in journals with IF>7



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