Recent Trends in Canadian Neutron Scattering: A Comparative Bibliographic Study

Patrick Clancy, *Trent University*

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CAP Congress, Queen's University, Kingston ON

Historical Motivation

- Why is neutron scattering in a CAP session on the history of physics?

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Scattering of Neutrons by Spin Waves in Magnetite

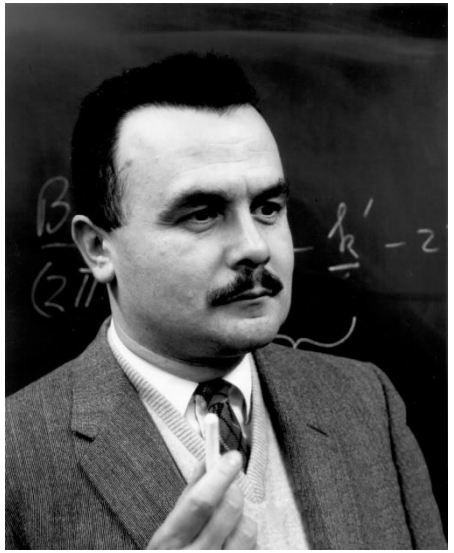
B. N. Brockhouse
General Physics Branch, Atomic Energy of Canada Limited, Chalk River, Ontario, Canada
(Received February 19, 1957)

Measurements of energy distributions of 1.5 A neutrons diffusely scattered by a single crystal of magnetite in the region of the 111 reciprocal lattice point were carried out. Neutron groups were observed which satisfy momentum and energy conservation between the neutron and one wave-excitation quantum, and which are assigned a magnetic origin. The intensities of the neutron groups are consistent with spin wave theory within the limits of the analysis. The measurements are not sufficiently exact to enable the form of the frequency-wave number relation of the spin waves to be deduced, but assuming the quadratic relation of Kaplan a value for the A-B exchange integral of 2×10^{-3} ev is obtained.

- 2017: 60th anniversary of Brockhouse's original paper on magnetic inelastic neutron scattering

Historical Motivation

- **Bertram Neville Brockhouse (1918-2003)**
  - Born in Lethbridge, AB
  - B.A. from University of British Columbia (1947)
  - M.A. from University of Toronto (1948)
  - Ph.D. from University of Toronto (1950)
  - AECL, Chalk River (1950-1962)
  - McMaster University (1962-1984)
- Nobel Prize 1994 (shared with Clifford Shull)



"For pioneering contributions to the development of neutron scattering techniques for studies of condensed matter" and "for the development of neutron spectroscopy"

Historical Motivation

- First measurement of collective magnetic excitations (spin waves)

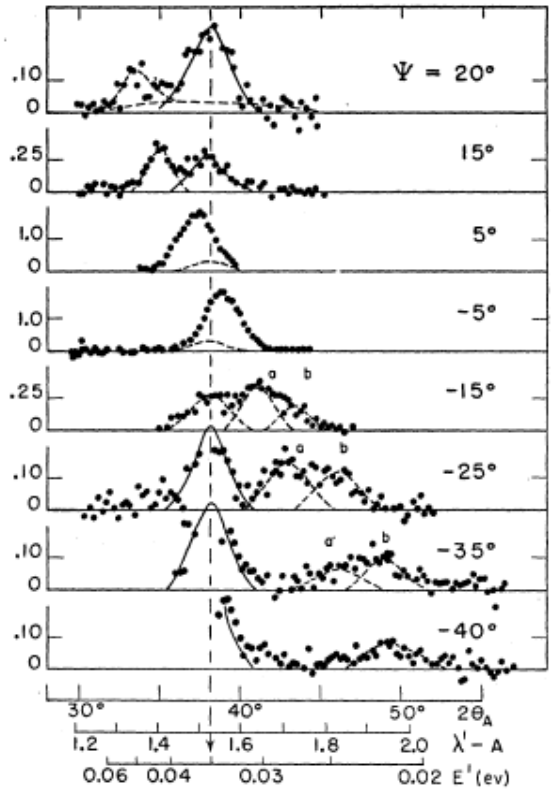


FIG. 3. Reduced counting rates with background subtracted, as a function of the angle of the counter of the analyzing spectrometer ($2\theta_A$) for various magnetite crystal orientations. Attention is drawn to the different ordinate scales. The dashed vertical line is at the incoming energy.

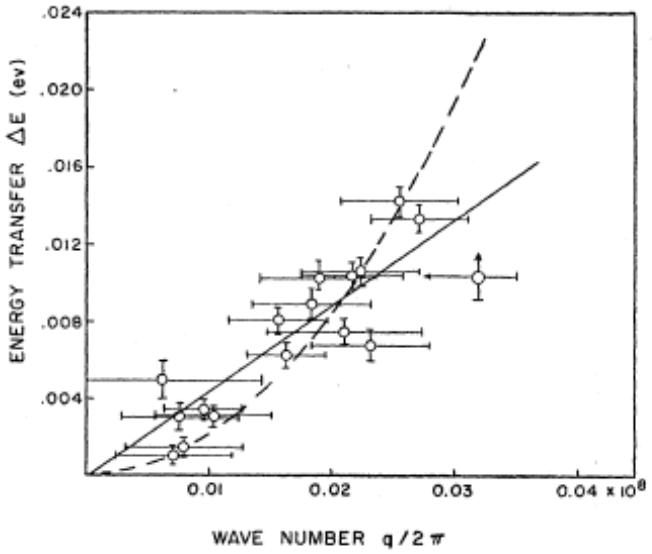
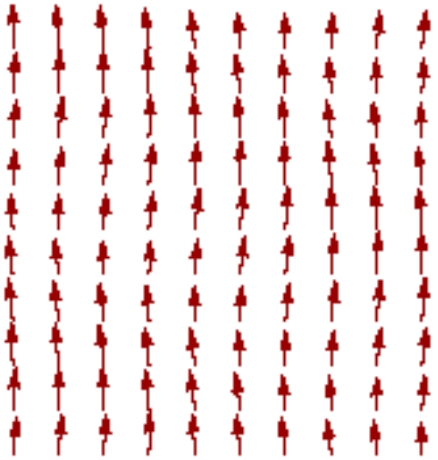


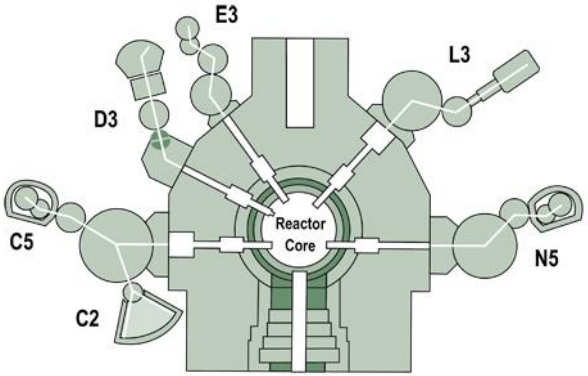
FIG. 5. The energy transfer ΔE as a function of $|\mathbf{q}|/2\pi$, the "spin wave" wave number.



Brockhouse, Phys. Rev. (1957)

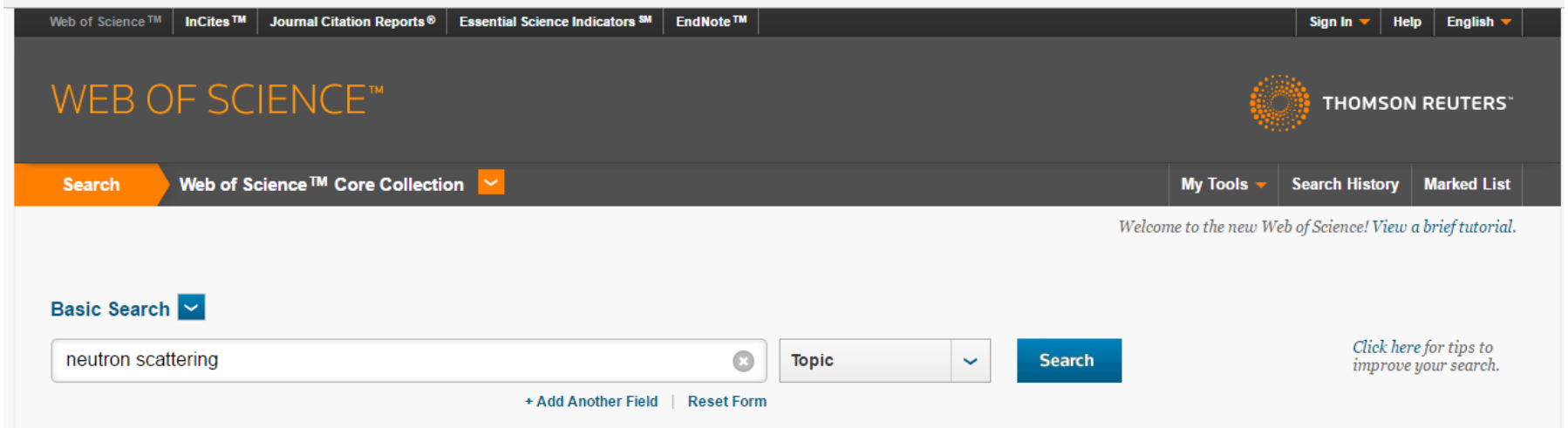
Chalk River Laboratories

NRU Instrument Floor Plan



- Home of Canadian Neutron Beam Centre (CNBC) and the National Research Universal (NRU) reactor
- 135 MW multipurpose reactor used for isotope production, nuclear engineering, neutron scattering/materials research
- First went critical in 1957, currently operating 6 neutron beamlines
- Impending shutdown at the end of March 2018

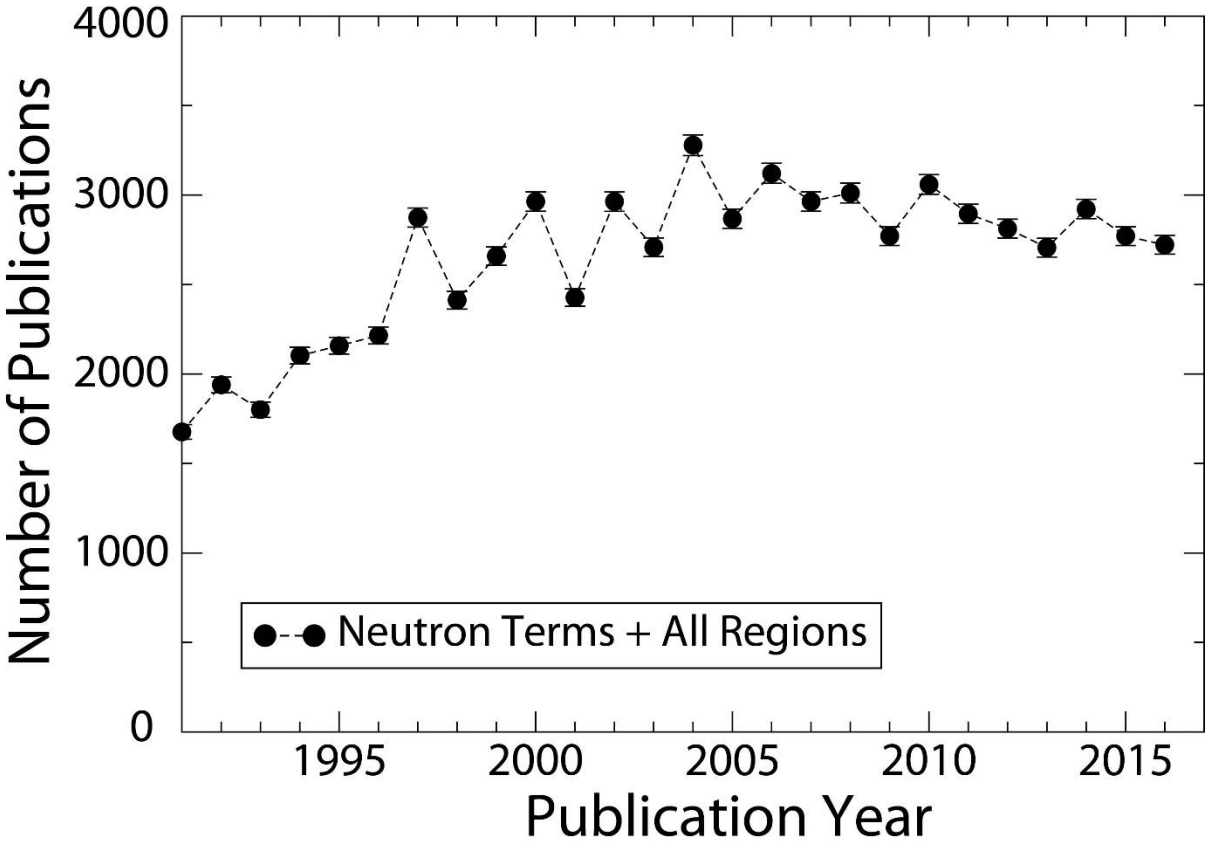
What can we learn from bibliographic data?



- Analyze neutron publication data using Web of Science database (not a perfect metric, but one of the easiest to quantify)
- Seek to investigate two primary questions:
- Can we predict impact of NRU closure on Canadian neutron scattering community?
- Can we identify any (interesting) historical trends in this field?

Analysis of neutron scattering publications

- Search database for topic = “neutron scattering” OR “neutron diffraction” OR “neutron spectroscopy”



Total of 78,802 publication hits in database

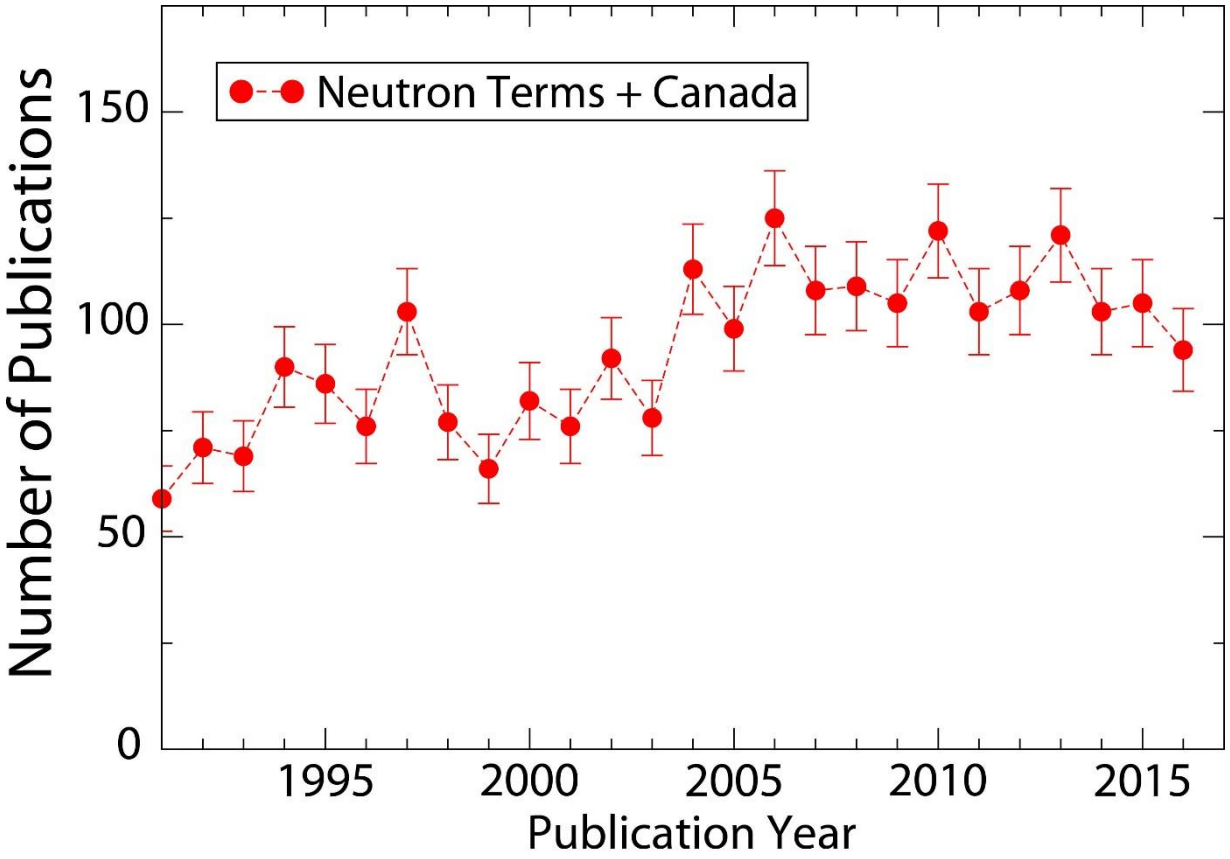
~2800 neutron scattering publications/year

Results classified on basis of “Research Area”:

1. Physics (52%)
2. Chemistry (35%)
3. Material Science (21%)

Analysis of Canadian neutron publications

- Refine search results by "Country/Territory"
- Focus on publications with Canadian affiliation:



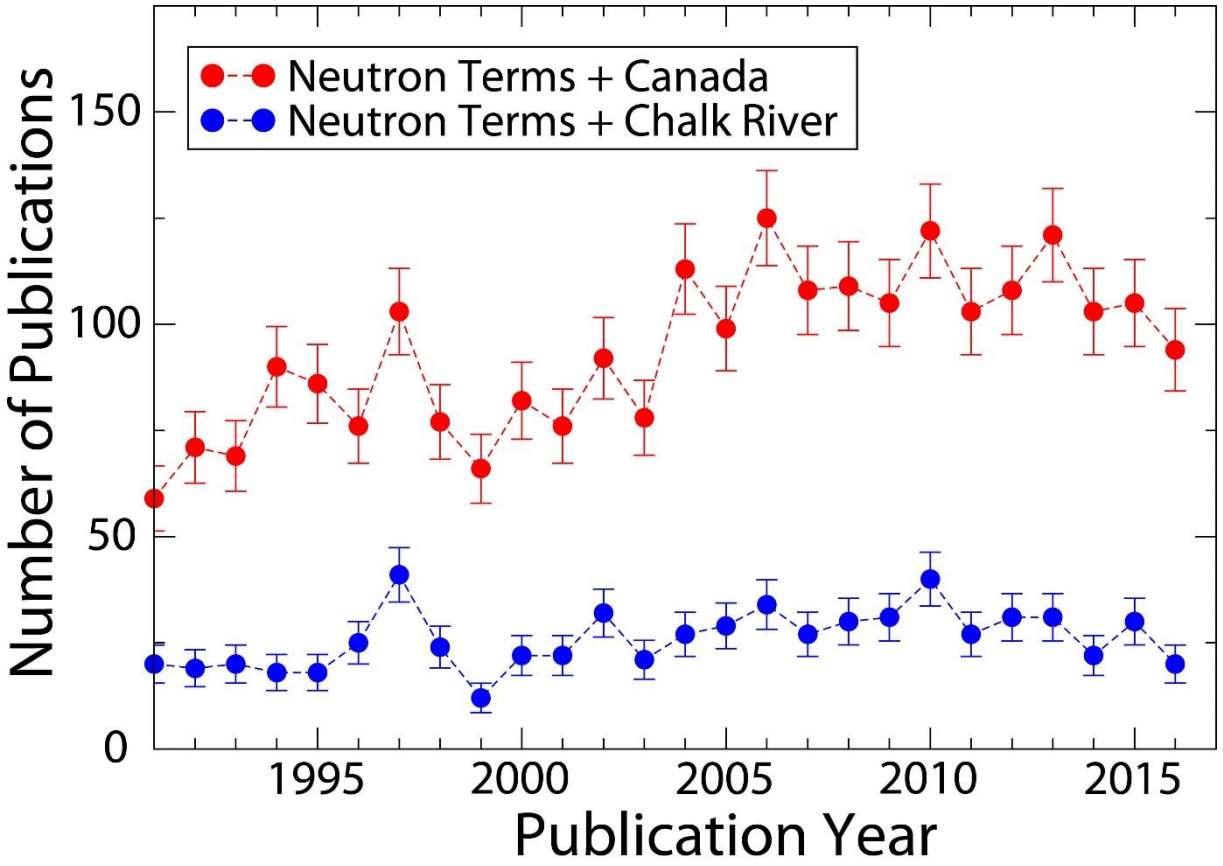
Total of 2667 Canadian publications in database (12th ranked country)

~110 neutron scattering publications/year

~50% categorized as Physics

Importance of Chalk River neutron source

- Further refine search by "Address"
- Focus on number of publications with Chalk River affiliation:



Total of 756 Chalk River publications in database

~28% of Canadian neutron scattering publications involve Chalk River affiliation

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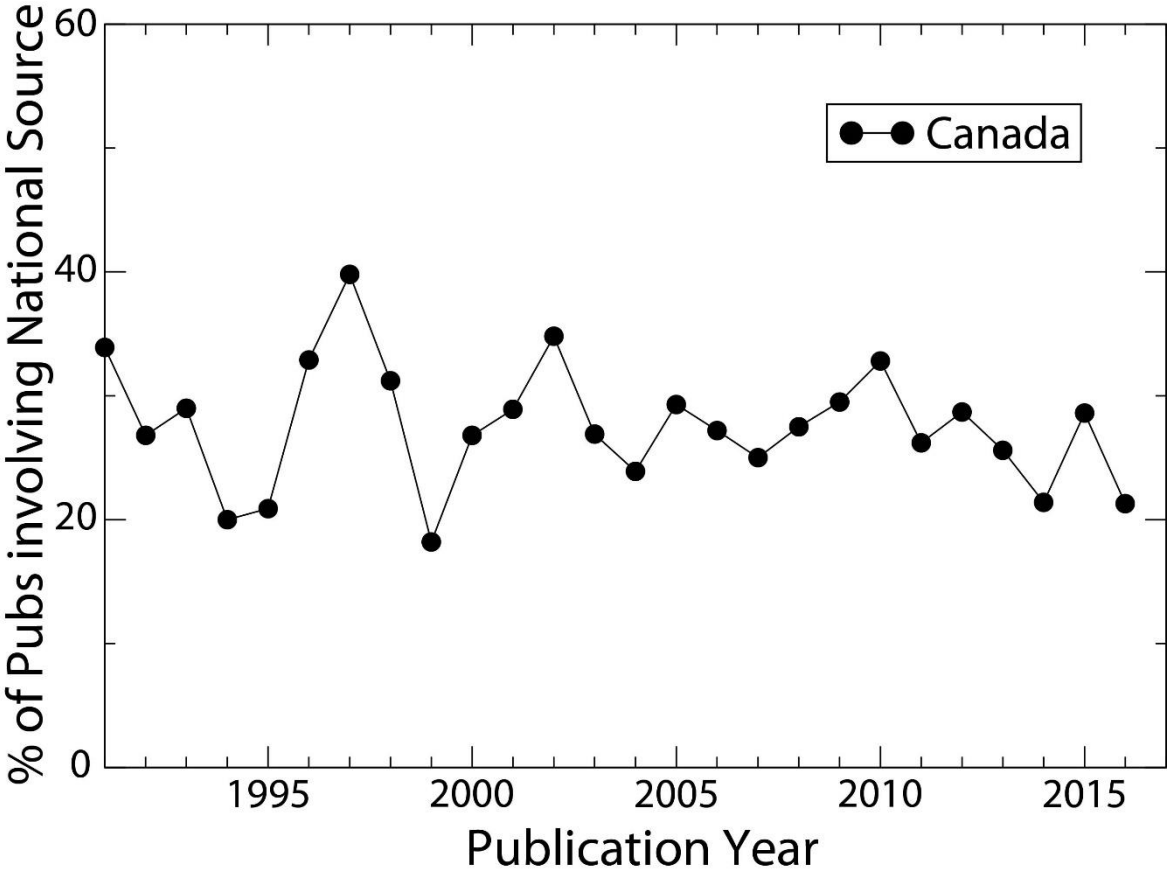


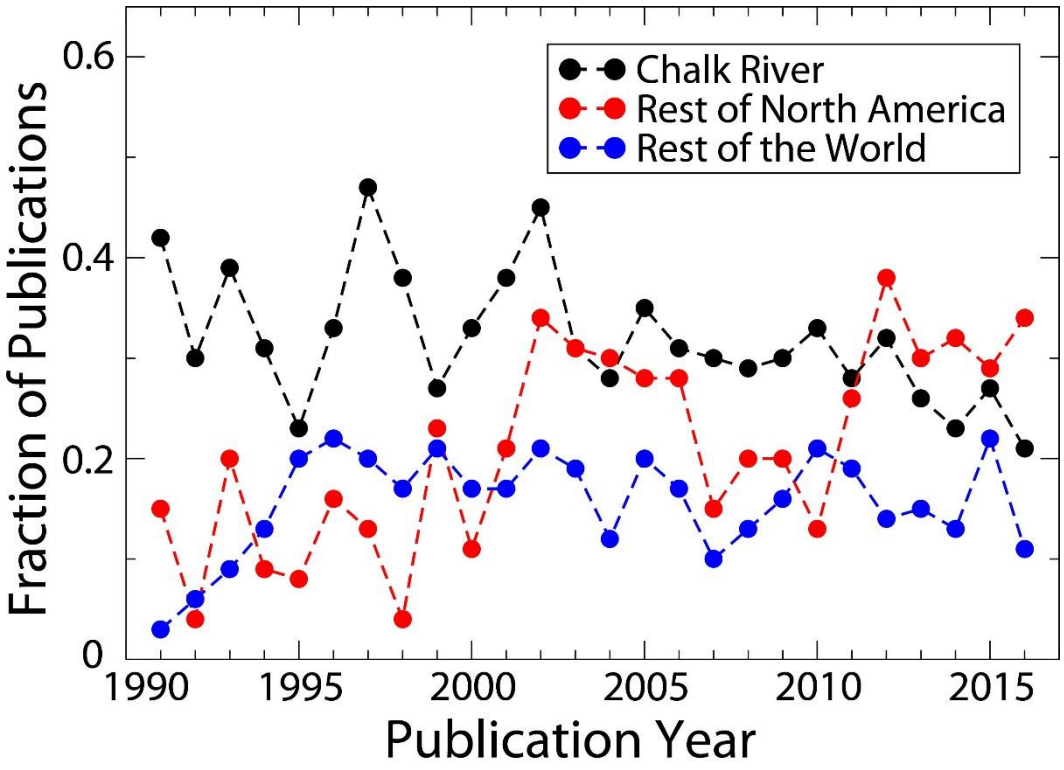
Total of 756 Chalk River publications in database

~28% of Canadian neutron scattering publications involve Chalk River affiliation

Fairly stable over time…

Role of international neutron sources

- Over 2/3 of neutron scattering publications with Canadian involvement don't involve Chalk River
- Where do their neutrons come from?



(5 Year Averages)

In early 1990s:

33% CR/11% NA/10% RW

In early 2010s:

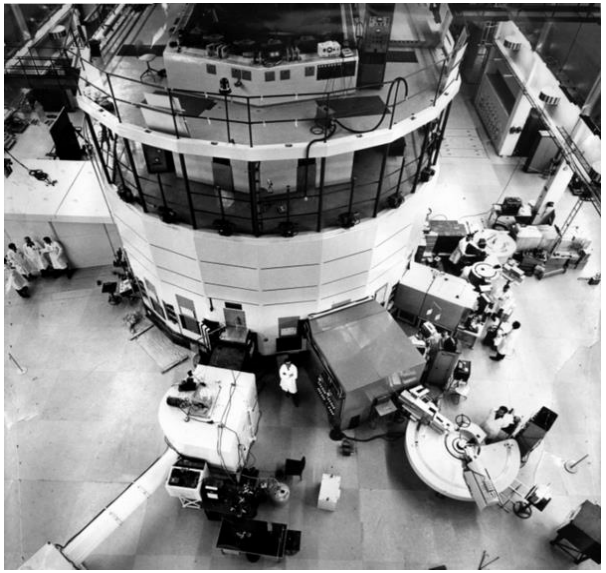
27% CR/31% NA/17% RW

Increasing emphasis on international neutron sources, but what happens when Chalk River becomes unavailable?

Drawing International Parallels

- Look for historical precedents: what has happened in other countries which have lost a national neutron source?

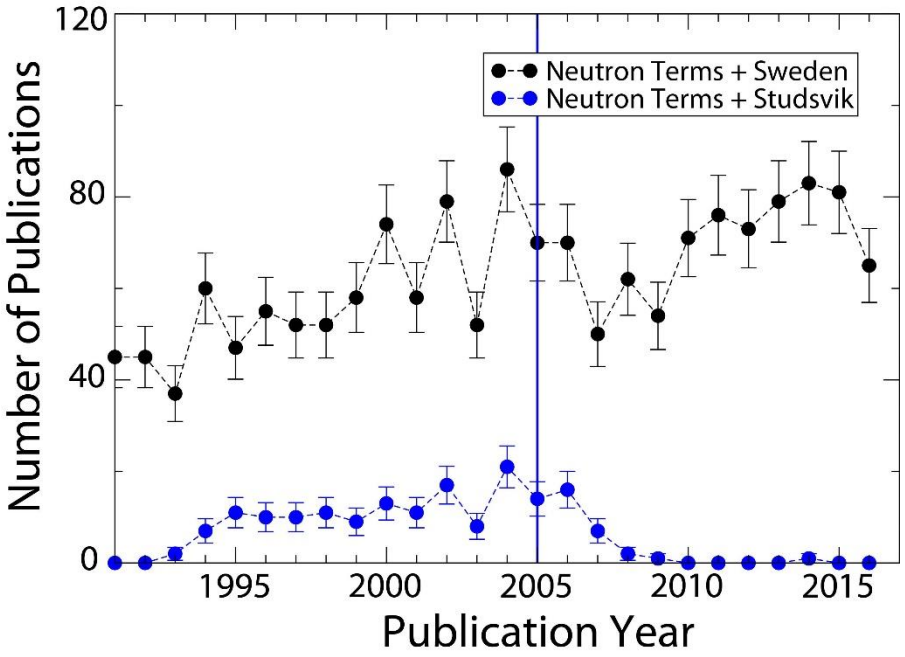
DR-3 Reactor at Riso National Lab in Denmark (Closed in 2000)

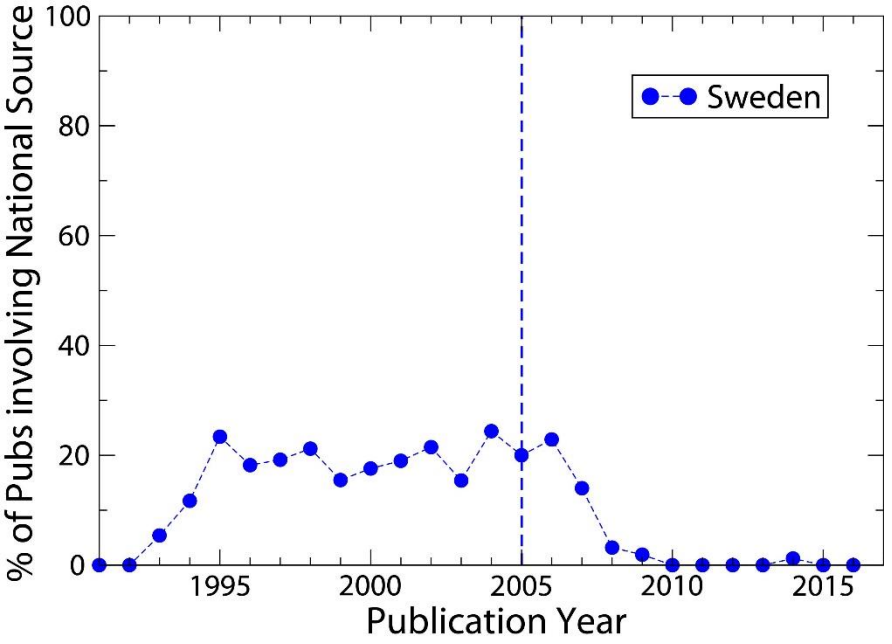


R2 Reactor at Studsvik Neutron Research Lab in Sweden (Closed in 2005)

Analysis of Swedish Neutron Publications

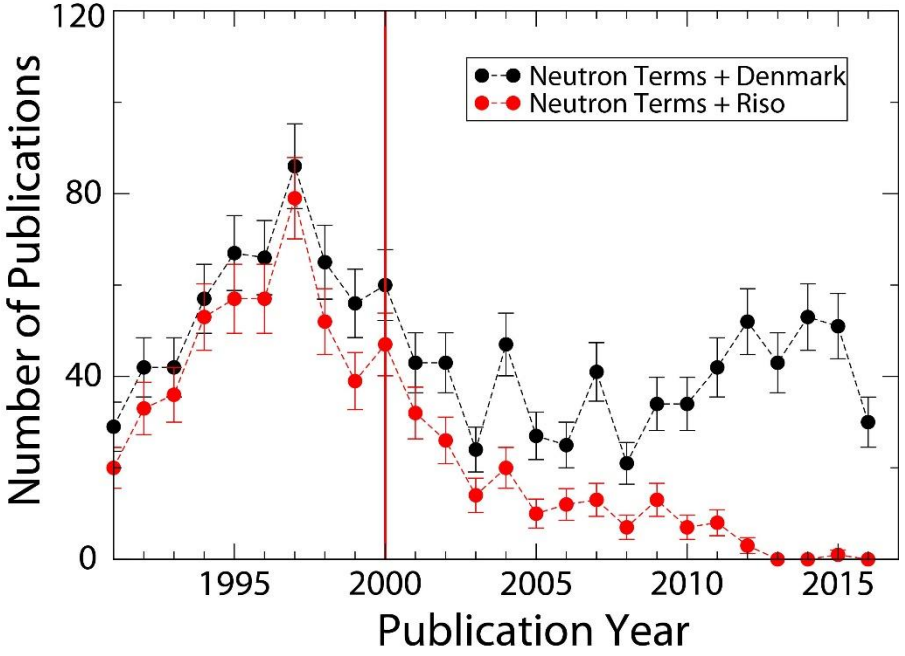
- Swedish neutron scattering community similar in size to Canada (1634 publications in database)
- Not as heavily reliant on national source (171 publications from Studsvik, ~10% of total output)

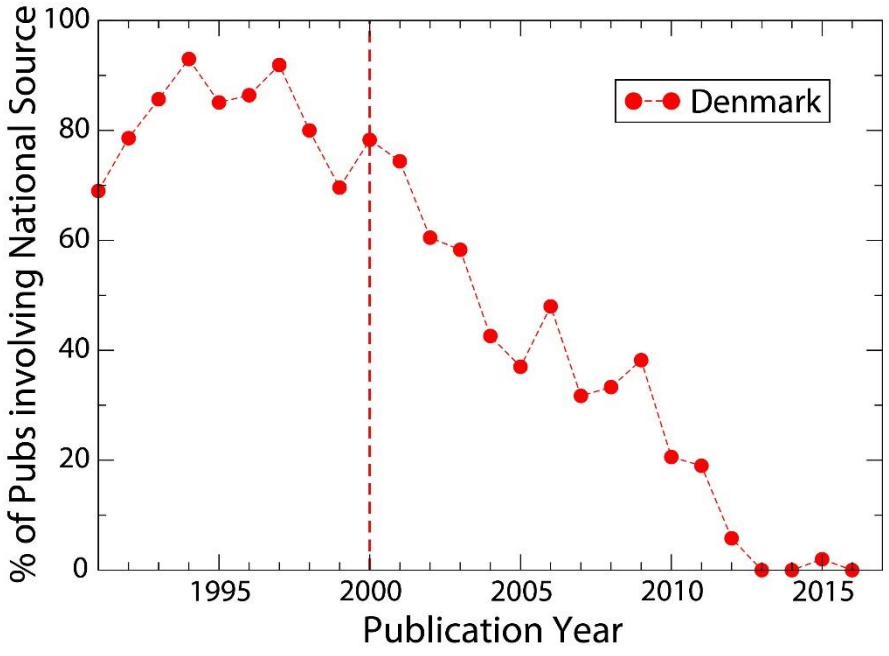




Analysis of Danish Neutron Publications

- Danish community somewhat smaller (1180 publications in database)
- Much more heavily dependent on national source (639 publications from Riso, or ~54% of total output)

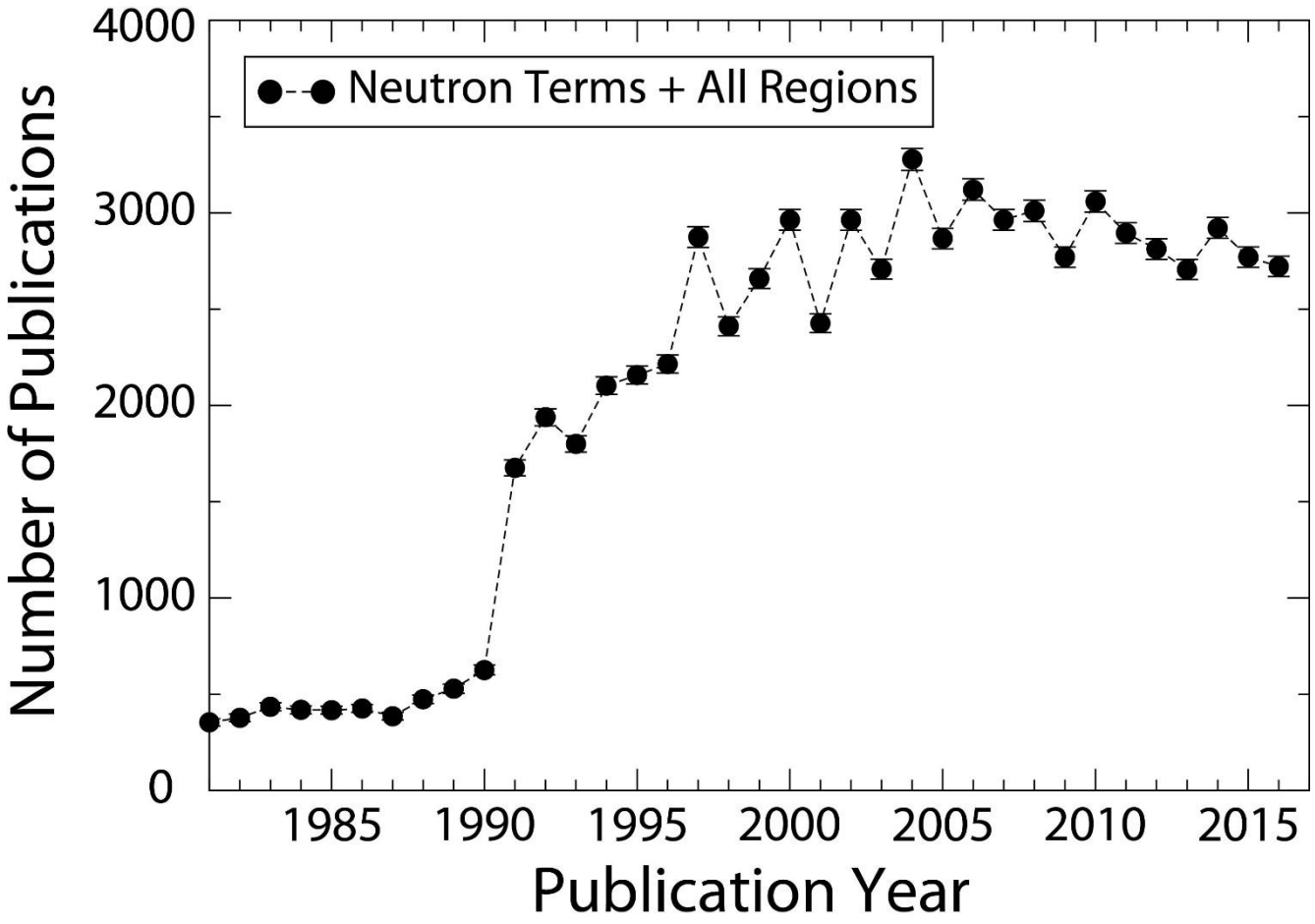




Summary and Conclusions

- This year marks significant milestones for Canadian neutron scattering: 60th anniversaries of Brockhouse magnons and NRU

- Serious concerns over impending shutdown of NRU, but perhaps some reasons for optimism (or not total despair):
- Canadian neutron scattering community has increasingly international focus
- Experience of Swedish/Danish communities show recovery is possible, but strategic planning is important

- Opportunities in Canada:
- Become involved in the Canadian Institute for Neutron Scattering (www.cins.ca)
- Proposals for beamtime at CNBC until end of March 2018
- New SANS beamline coming online at McMaster Nuclear Reactor (Fall 2018?)

Why do we focus on 1991 to 2016?