The Far-Infrared Beamline at the Canadian Light Source

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Abstract:

This poster summarizes some of the capabilities of the far-infrared (Far-IR) beamline at the Canadian Light Source (CLS). The Far-IR beamline at the CLS is a state of the art facility, which offers significantly more Far-IR brightness than conventional globar sources. While there is the potential to direct this advantage to many research areas, to date most of the effort has been directed toward high-resolution gas phase studies. The infrared radiation is collected from a bending magnet through a 55 X 37 mrad^2 port to a Bruker IFS 125 HR spectrometer, which is equipped with a 9 compartment scanning arm, allowing it to achieve spectral resolution better than 0.001 cm^{-1}. Currently the beamline has been commissioned in the 120-800 cm^{-1} region, where the S/N ratio achieved using the synchrotron light is significantly better than is possible with a traditional globar source. Proposals for research pertaining to this spectral range are currently being accepted. Work continues to increase the commissioned range of the beamline, with the ultimate goal of having the full synchrotron advantage available between 10 and 1000 cm^{-1}. Furthermore, the experiments into the generation and use of Coherent THz synchrotron radiation, offering intensities up to 1000 times that of non-coherent synchrotron radiation have shown great promise.

Instruments:

The beamline is equipped with a Bruker IFS 125 HR spectrometer, which due to a maximum optical path difference of 942 cm can achieve spectral resolutions below 0.001 cm^{-1}. A broad range of detectors, beamsplitters and sources are available, providing access to entire spectrum from 5-20 000 cm^{-1}.

Currently two multi-pass gas cells are available for use for the study of stable species:

30 cm ambient temperature cell, with maximum path length of 12 meters

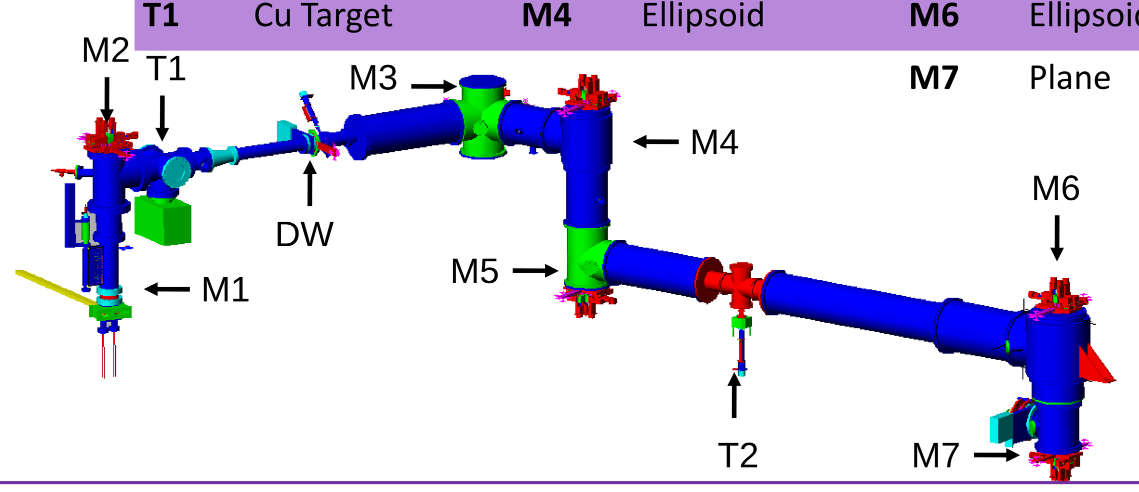
2 meter variable temperature cell capable of reaching -70^{0}C, with a maximum path length of 100 meters

Beamsplitter	Spectral Range
Mylar 6 µm	30-630 cm^{-1}
Mylar 75 µm	12-35 cm^{-1}
Ge/KBr	400-4800 cm^{-1}
CaF_2	1850-20000 cm^{-1}
Detectors	
MCT N (Liquid Nitrogen Cooled)	600-10000 cm^{-1}
MCT B (Liquid Nitrogen Cooled)	450-10000 cm^{-1}
DTGS	100-3000 cm^{-1}
DTGS PE	15-700 cm^{-1}
Si Bolometer (Liquid Helium Cooled)	10-370 cm^{-1}
Ge:Cu (Liquid Helium Cooled)	300-1850 cm^{-1}
Internal Sources	
Globar	10 – 13000 cm^{-1}
Hg – Lamp	10 – 1000 cm^{-1}
Tungsten Lamp	1000-25000 cm^{-1}

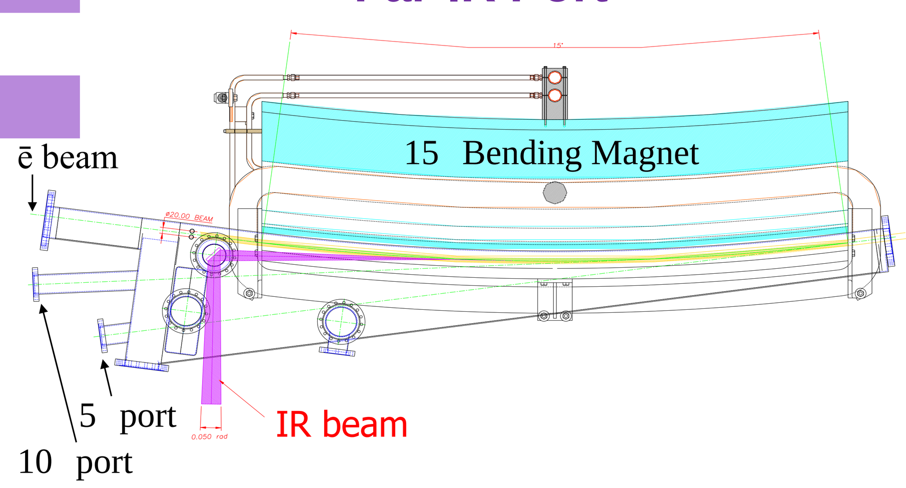
Beamline and Components:

Synchrotron Radiation from a bending magnet is collected at the Far-IR port and steered to the end station using a slotted flat mirror (M1). All optics and vacuum chambers were designed for optimal performance in the Far-IR region

Label	Optical Element	Label	Optical Element	Label	Optical Element
M1	*Plane*	DW	Window	M5	Plane
M2	Ellipsoid	M3	Plane	T2	Cu Target
T1	Cu Target	M4	Ellipsoid	M6	Ellipsoid
				M7	Plane

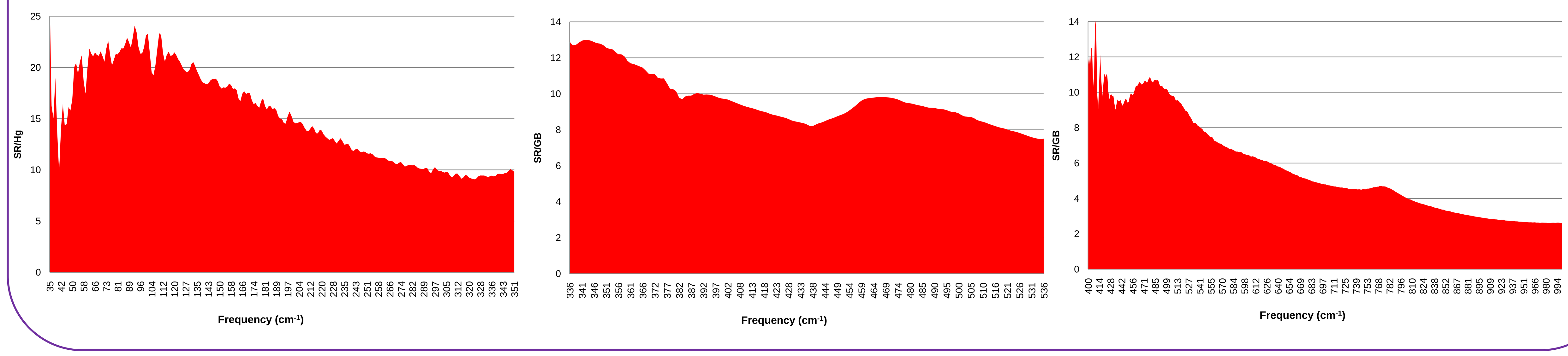


Far-IR Port



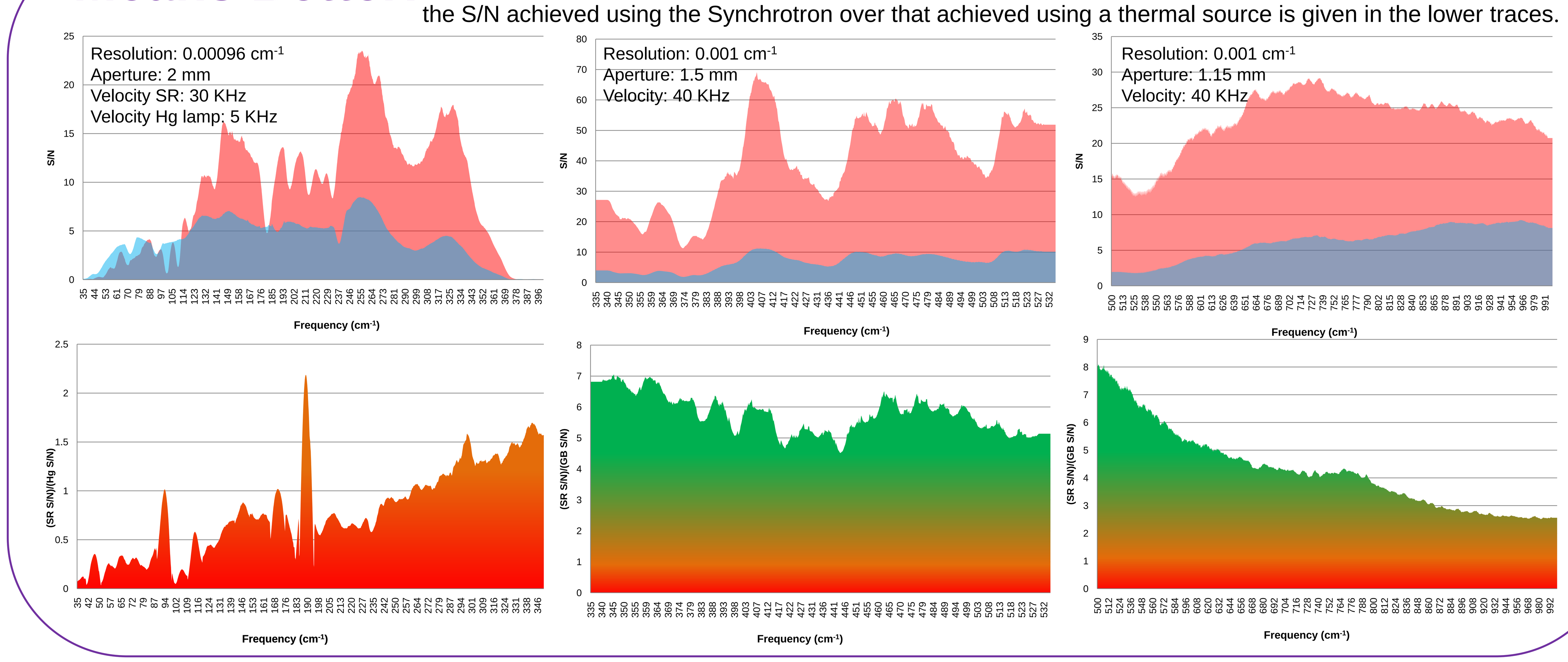
Brighter :

Due to the higher brightness of the synchrotron radiation, superior signal intensities compared to traditional blackbody sources can be achieved. The 3 traces shown below, demonstrate that in the regions of interest synchrotron radiation consistently produces stronger signal intensity than the thermal source.



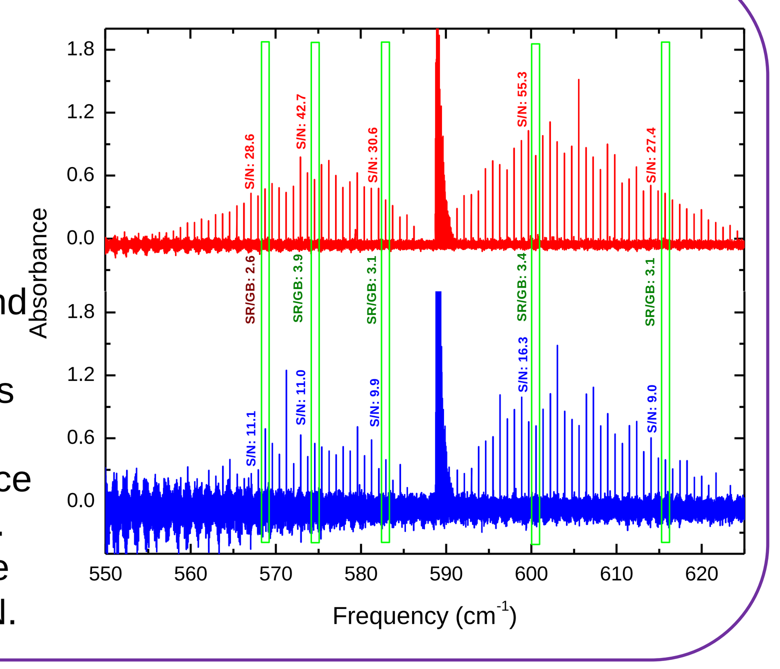
Means Better:

The top set of traces below show the Signal to noise ratios (S/N) that have been obtained using both the synchrotron and thermal sources (Hg lamp in the 35-350 cm^{-1} region and the globar elsewhere). The ratio of the S/N achieved using the Synchrotron over that achieved using a thermal source is given in the lower traces.



Example:

Spectra of 0.003 torr of N_2O shown to the right were both collected at 0.002 cm^{-1} resolution using a 24 m pathlength, a MCTWD detector, a 1.7 m aperture and both are averages of 18 scans. The red spectrum was collected using the synchrotron and the blue trace was collected using a globar. The green boxes indicate the regions used to estimate S/N.



Moving Forward:

We are continually striving to improve and innovate.

The following is only a partial list of our efforts:

- Investigating adding new gas phase capabilities
  - 150 cm multipass electric discharge cell
  - 70 cm dual pass discharge/furnace cell
- Investigating increasing condensed phase capabilities
  - Diamond anvil cell
  - Grazing Angle Incidence
  - Attenuated Total Reflectance
- Actively striving to reduce the sources of noise
- Actively attempting to isolate the beamline from vibrations
- Photo acoustic Spectroscopy
- Support user initiatives

Publications:

McKellar, A. R. W., Tokaryk, D.W., Xu, Li-Hong, Appadoo, D. R. T., May, T., " High Resolution analysis of the v_{12} and v_{17} fundamental bands of acrolein CH_2CHCHO in the 600 cm^{-1} region" J. Mol. Spect. 242 (2007) 31.

McKellar, A. R. W., Tokaryk, D.W., Xu, Appadoo, D. R. T., " The far-infrared spectrum of acrolein, CH_2CHCHO: (v_{17} + v_{18})- v_{18} hot bands" J. Mol. Spect. 244 (2007) 146.

Van Wijngaarden, J., Tokaryk, D. W., "High resolution synchrotron-based study and analysis of the v14 band of thiophene" 251 (2008) 365.

McKellar, A. R. W., Appadoo, D. R. T., "High-resolution synchrotron far infrared spectroscopy of acrolein: the vibrational levels below 700 cm^{-1}" J. Mol. Spect. 250 (2008) 106.

Lees, R. M., Murphy, R-J., Moruzzi, G., Predoi-Cross, A., Xu, L-H., Appadoo, D. R. T., Billinghurst, B. E., Goulding, R. R. J., Zhao, R., "Fourier transform spectroscopy of the CO-stretching band of O-18 methanol" J. Mol. Spect. Accepted, February 2009.

Borvayeh, L., Ozier, I., Bauder, A., Moazzen-Ahamdi, N., "High-resolution infrared spectrum and global analysis of v_5, and v_{12} and v_{12}+ v_6 - v_6" J. Mol. Spect. Accepted, March, 2009.

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