INVESTIGATING THE MICROBUNCHING INSTABILITY AT DIAMOND LIGHT SOURCE

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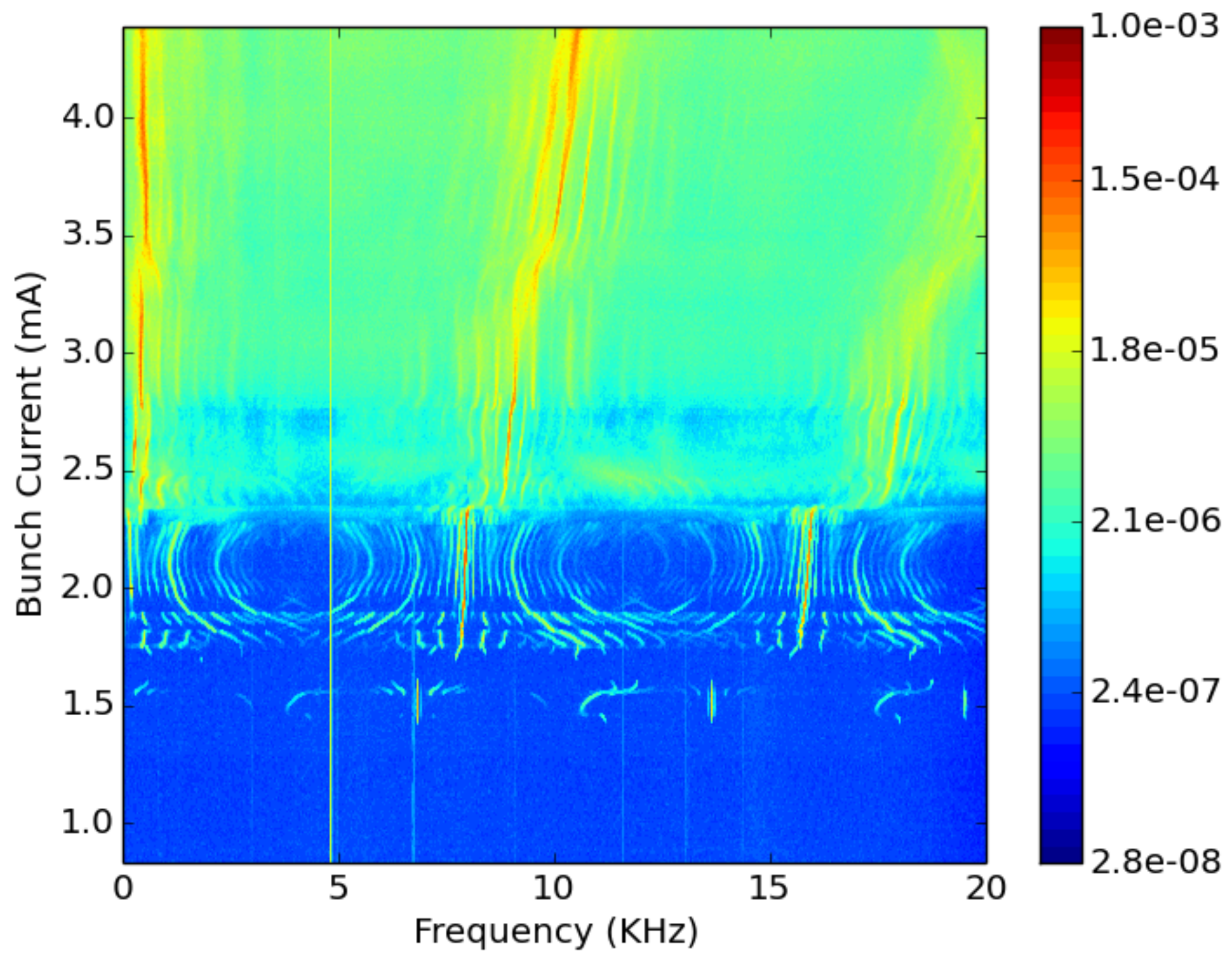
Abstract

Diamond Light Source is a third generation synchrotron facility dedicated to producing radiation of outstanding brightness. Above a threshold current, the electron bunches are susceptible to a phenomenon known as the microbunching instability. The key feature of this instability is the emission of coherent radiation bursts, which have wavelengths of the order of the bunch length and smaller. The bursting at the threshold is emitted quasi-periodically, however increasing to a higher current results in the bursting to appear random in nature. The high frequencies involved in these emissions make characterizing the phenomenon a challenging task. A setup at Diamond has been built, dedicated to the investigation of this phenomenon. An overview of the project will be presented, including the experimental setup, and recent results.

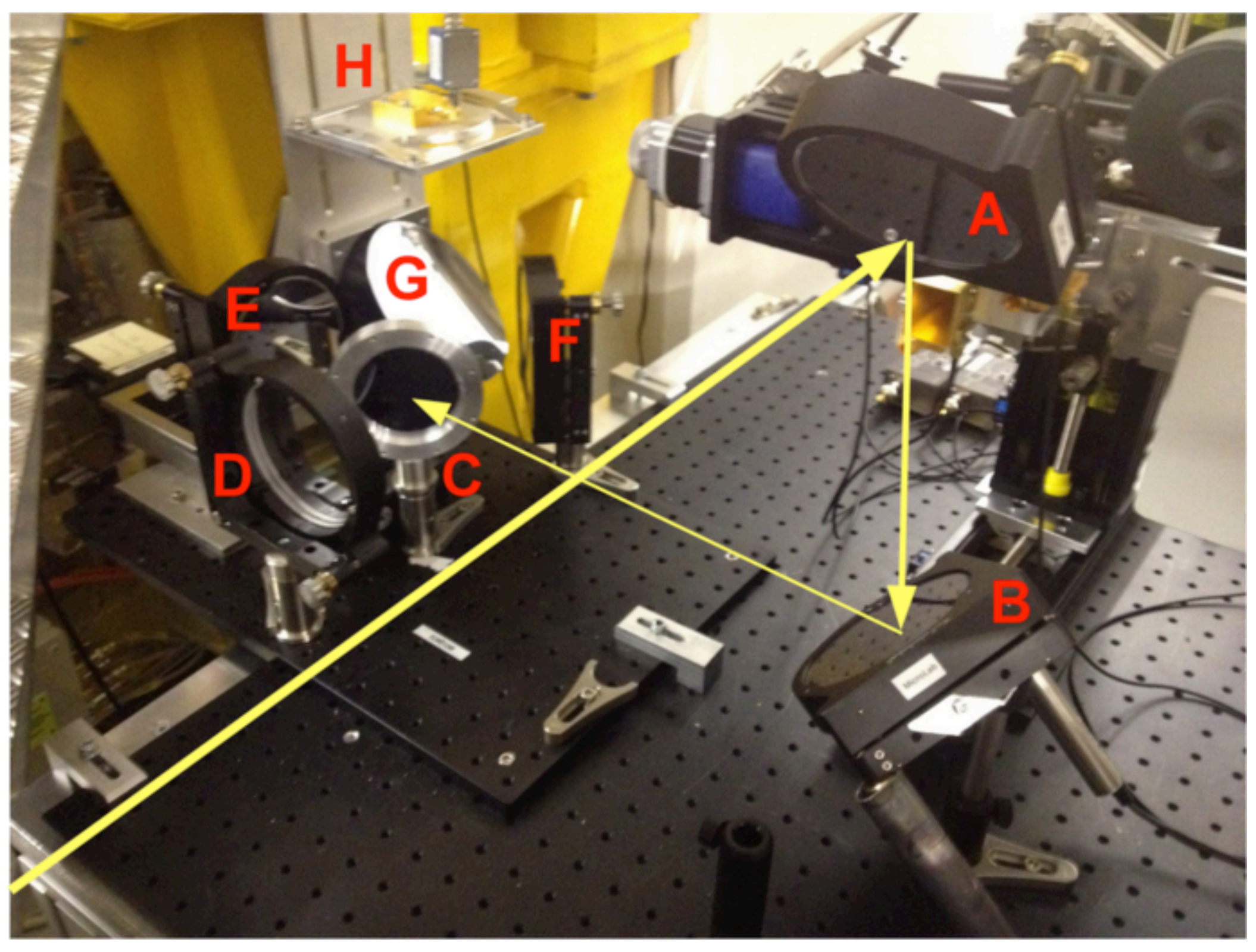
Instability Detection

- The microbunching instability has been observed in previous experiments at Diamond Light Source through detection of coherent emissions in the mm-wave range [1-3].



- Initial detection experiments investigated the modulation around the bunch revolution frequency.
- Longitudinal motion within the bunch causes drifts in the signal sidebands at low current.
- Increasing the bunch current caused the spectra to transition from quasi-periodic to the chaotic regime.

Interferometer



- To measure the emitted spectra as a result of the instability, a Michelson interferometer has been installed at a port dedicated to mm-wave diagnostics.
- The position and incidence angle of coherent radiation is controlled through transfer line mirrors (components A and B).

- A 100 μm thick silicon crystal wafer beamsplitter, is used in the interferometer (part C). Additional mirrors were included to reflect and focus the emissions.
- A pyroelectric detector and quasi-optical Schottky barrier diode detector were employed in separate experiments to measure the emissions.
- Detector specifications:

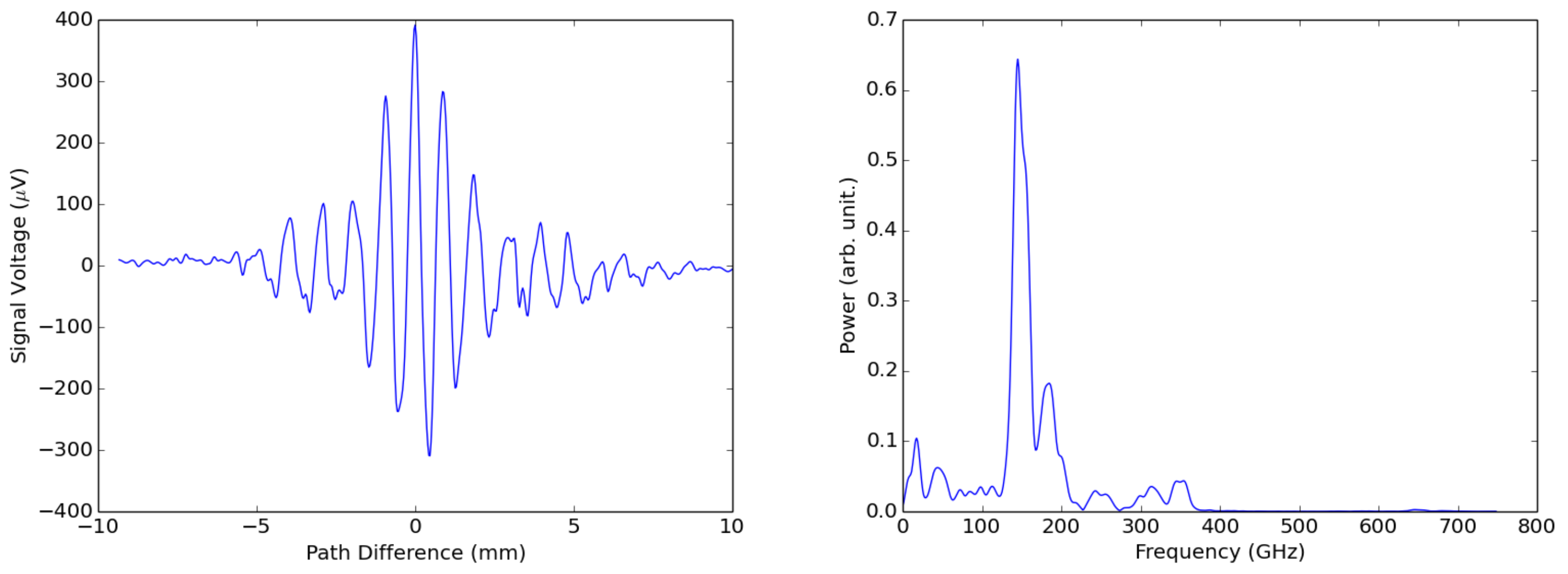
Model	Quasi-Optical	Pyroelectric
Frequency range (GHz)	100 - 1000	100 - 30,000+
Wavelength (mm)	3 - 0.3	3 - 0.01
Responsivity (V/W)	500	70,000
Noise Equivalent Power (pW/$\sqrt{\text{Hz}}$)	10	1000

Standard Optics Results

- Tests in user mode were conducted for various RF voltages, and a fill pattern consisting of a single high current bunch.
- Interferograms were successfully recorded using both detectors, similarly displaying interference over an extent of ± 15mm from the point of zero path difference.

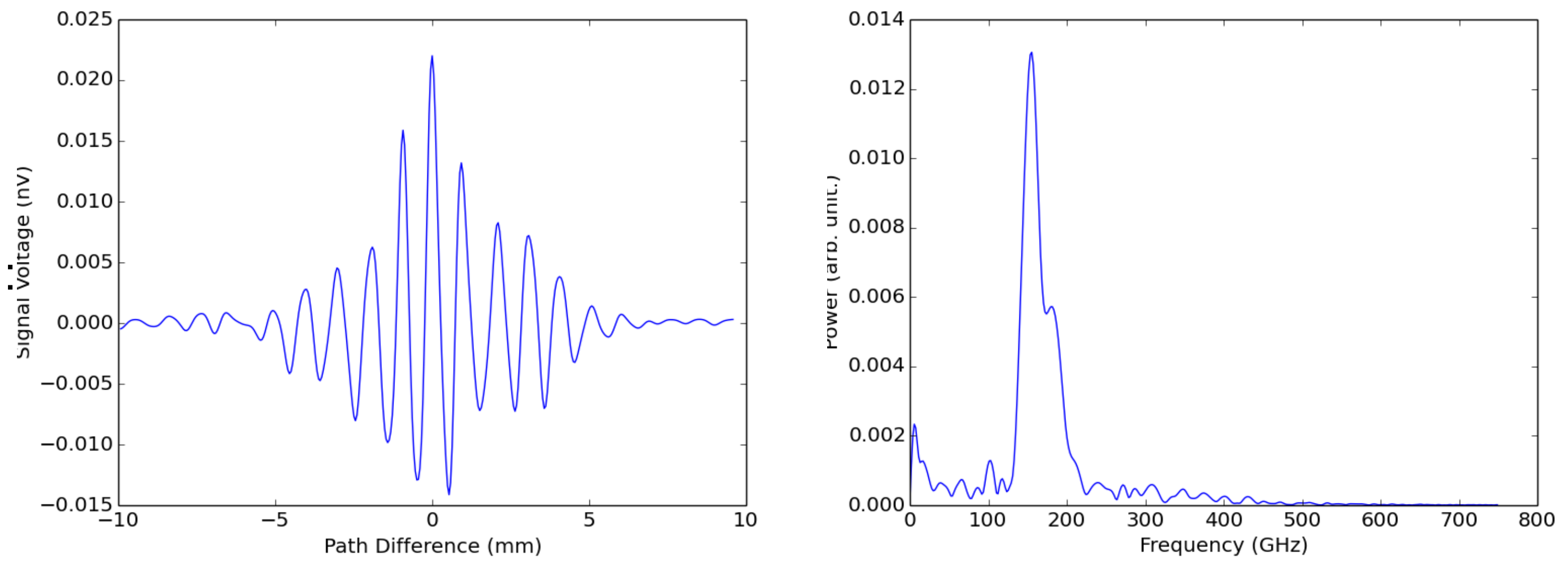
Standard Optics Results Continued

Pyroelectric:



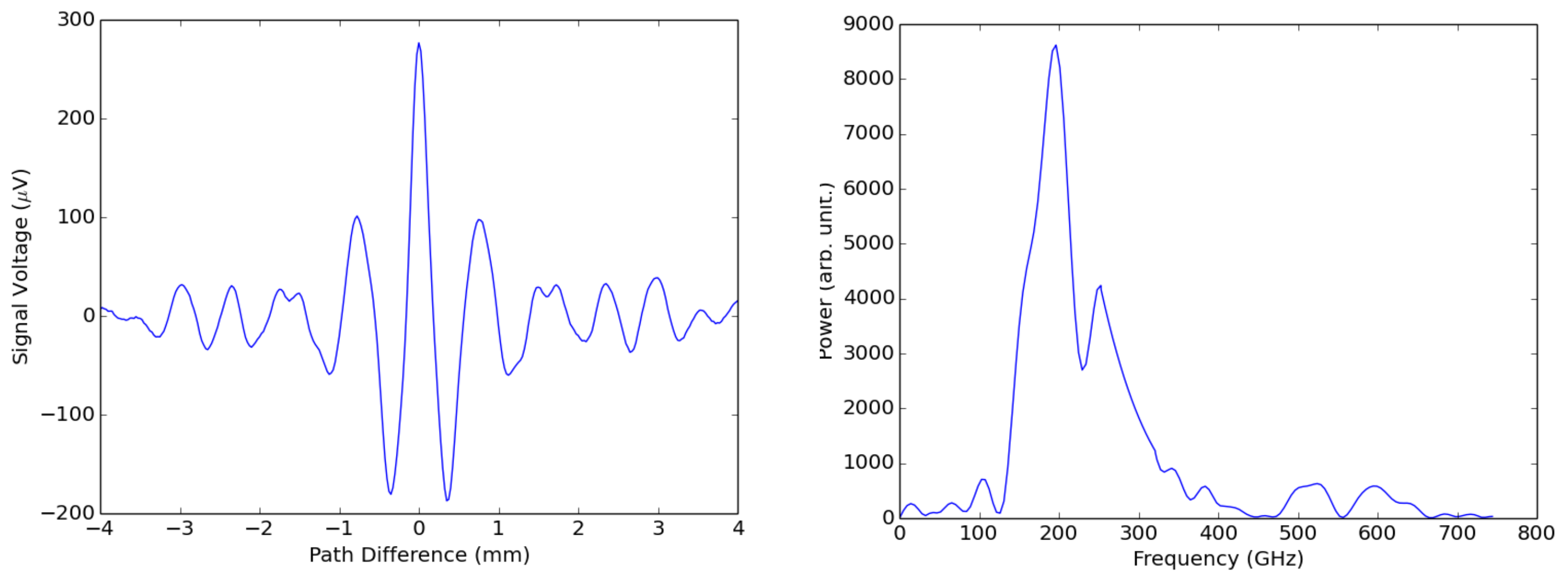
- A fast Fourier transform of the interferograms shows the calculated spectra with signals between 140 and 200 GHz.

Quasi-Optical:



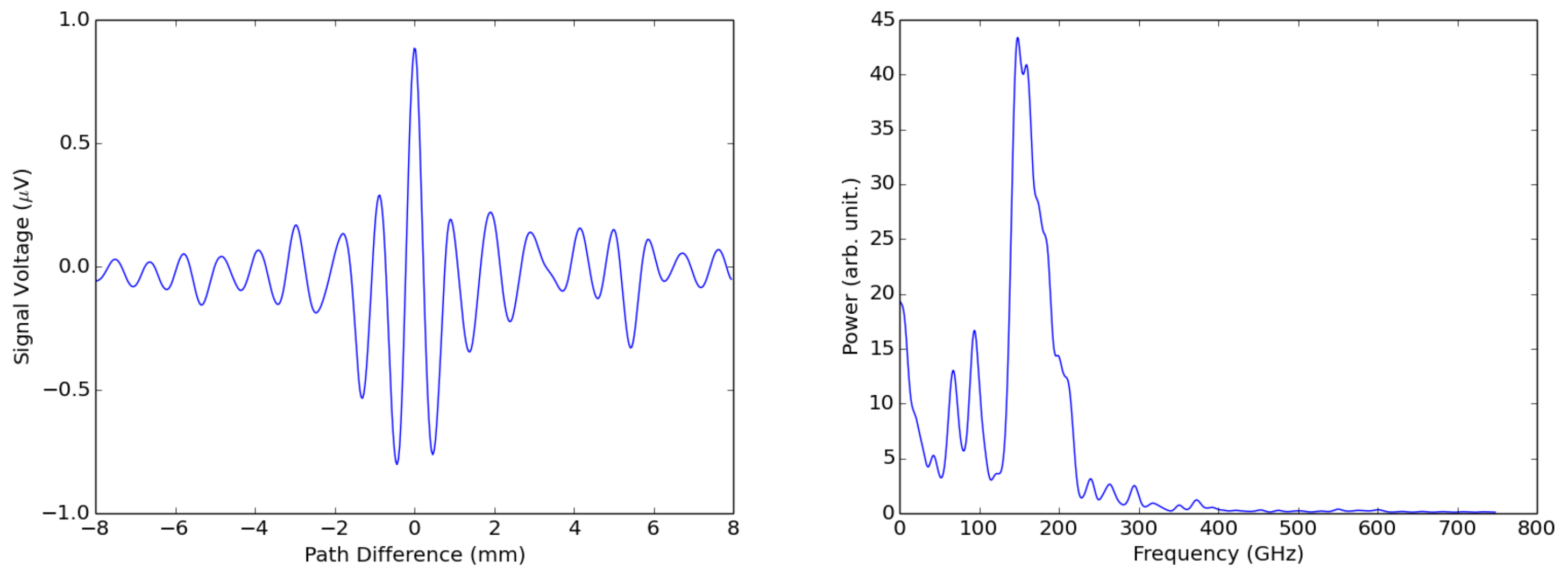
Low-Alpha Optics Results

Pyroelectric:



- Interferograms were additionally recorded using a low-alpha lattice, with multiple low current bunches.
- Spectral dips primarily due to Fresnel reflections in the fused silica viewport window.
- Low frequency cutoff due to a combination of detector and diffraction based effects.

Quasi-Optical:



Summary

- A Michelson interferometer has been installed and the first results have been successfully recorded.
- User mode experiments show signal up to 200 GHz, and low-alpha operation up to 600 GHz.

References

1. G. Rehm et al. DIPAC '09, Basel, Switzerland, (2009).
2. W. Shields et al., J. Phys. Conf. Ser., **357**, 012037, (2012).
3. W. Shields et al., IPAC '12, New Orleans, USA, (2012).

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