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# Radio frequency and microwave photonic integrator based on soliton crystal Kerr microcombs

David J. Moss

**Abstract**—We demonstrate a photonic RF integrator based on an integrated soliton crystal micro-comb source. By multicasting and progressively delaying the input RF signal using a transversal structure, the input RF signal is integrated discretely. Up to 81 wavelengths are provided by the microcomb source, which enable a large time-bandwidth product of 81. Our approach also features a high degree of reconfigurability, by simply adjusting the value of dispersion (i.e., the length of dispersive fibre), the integration time window and resolution can be reconfigured to accommodate a diverse range of applications. We employed 13 km of standard single-mode fibre to achieve a large integration time window of ~6.8 ns, a time resolution as fast as ~84 ps, with a broad bandwidth of 11.9 GHz. In addition, we perform signal integration of a diverse range of input RF signals including Gaussian pulses with varying time widths, dual pulses with varying time intervals and a square waveform. The experimental results show good agreement with theory. These results verify our microcomb-based integrator as a competitive approach for RF signal integration with high performance and potentially lower cost and footprint.

**Index Terms**—Integrator, Kerr micro-comb, RF signal processing.

## I. INTRODUCTION

Temporal integration is a basic function that has a wide range of applications in signal processing systems. In contrast to electrical integrators that are subject to the electronic bandwidth bottleneck, photonic techniques offer distinct advantages such as a broad bandwidth, strong immunity to electromagnetic interference, and low loss [1-3], thus holding great promise to overcome the limitations of their electrical counterparts.

Extensive effort has been made to achieve photonic integrators (see Table 1), such as those based on gratings [4-6], and micro-ring resonators (MRRs) [7-9]. These approaches achieve optical signal integration with a time feature as fast as 8 ps [7] and a large time-bandwidth product with high-Q resonant structures.

However, these approaches still face limitations for RF signal processing, as they are not reconfigurable in terms of temporal resolution and the length of the integration window, thus lacking the flexibility of processing RF signals with different bandwidths and varying target integration time windows. In addition, those approaches are specifically designed to process optical signals, thus they cannot directly process RF signals until being further equipped with electrical to optical interfaces.

Other approaches to photonic integrators based on transversal structures offer high reconfigurability and accuracy owing to the parallel scheme where each path can be controlled independently [10-12]. By tailoring the progressive delay step, RF signal integration with a reconfigurable operation bandwidth was achieved [10-12]. Yet

these integrators still face limitations arising from the limited number of channels. To establish multiple wavelength channels, discrete laser arrays or electro-optical comb sources are generally employed, which suffer from a trade-off between the number of wavelengths and system complexity and ultimately lead to limited channel numbers, and in turn, time-bandwidth products.

Recently, a novel multi-wavelength source — integrated microcombs [13-19] — has attracted significant interest in RF photonic systems [20, 21]. These arise from optical parametric oscillation in ultra-high-Q monolithic MRRs and offer many advantages over traditional multi-wavelength sources, including a much higher number of wavelengths and a greatly reduced footprint and complexity for the system. A wide range of RF applications have been demonstrated based on microcombs, such as RF true time delays [22, 23], transversal signal processors [24-29], frequency conversion [30], phase-encoded signal generators [31], and channelizers [32, 33].

In this paper, we demonstrate a highly reconfigurable photonic RF integrator using an integrated soliton crystal micro-comb source [34, 35]. The input RF signal is multicast onto the flattened microcomb lines and progressively delayed via dispersion, and then summed upon detection to achieve temporal integration. The large number of wavelengths — up to 81 — offered by the microcomb enable a large integration time window of ~6.8 ns with a time resolution as fast as ~84 ps. A comb shaping system is developed to compensate for the nonuniform spectral output of the soliton crystal microcomb. We successfully tested the system with a range of different input signals. The experimental results match with theory well, verifying the performance and feasibility of our approach towards the realization of large-time-window photonic RF integration with potentially lower cost and footprint.

## II. EXPERIMENTAL RESULTS

Figure 1 illustrates the operation principle of the photonic RF integrator. The integration process can be achieved via a discrete time-spectrum convolution operation between the RF input signal  $f(t)$  and the flattened microcomb. With a delay step of  $\Delta t$ , the operation can be described as:

$$y(t) = \sum_{k=1}^N f(t+k \cdot \Delta t) \quad (1)$$

where  $N$  is the total number of wavelength channels. After the replicas of  $f(t)$  are delayed progressively and summed together, the integration of  $f(t)$  can be achieved, with a time feature [10] of  $\Delta t$ , an operation bandwidth of  $1/\Delta t$ , and a total integration time window of  $T = N \times \Delta t$ .

We note that the frequency-domain transmission response of an ideal non-discrete integrator is linear to  $1/(j\omega)$ , where  $j^2 = -1$ ,  $\omega$  is the angular frequency. The frequency transmission response of our discrete integrator is a low pass sinc filter [24, 25], and can be described as

$$H(\omega) = \sum_{n=0}^{N-1} e^{-j\omega n \Delta t} \quad (2)$$

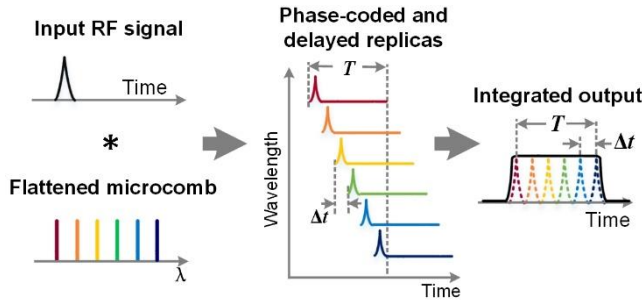


Figure 1. Schematic diagram of the photonic RF integration.

Figure 2 shows the experimental up of the photonic RF integrator using a microcomb source. The microcomb was generated by pumping a nonlinear high-Q MRR (Q factor > 1.5 million, free spectral range =  $\sim 0.4$  nm or  $\sim 48.9$  GHz, as presented in our previous publications [25, 30]) with a continuous-wave (CW) laser. As the pump power and wavelength detuning were adjusted to provide sufficient parametric gain, soliton crystal microcombs were generated. The soliton crystal microcombs [21], leading to tightly packed solitons circulating in the MRR, were generated in our experiments due to a mode crossing at  $\sim 1552$  nm of the MRR. The distinctive palm-like comb spectra (Fig. 3) is a result of the spectral interference between the circulating solitons. The soliton crystal microcomb featured very low intensity noise to the extent that it has even been used as a photonic local oscillator [30]. Thus, the noise of our microcomb source did not introduce any observable deterioration in the overall noise performance of the integrator.

We then flattened the microcomb spectral lines in the C band with two stages of WaveShapers (Finisar 4000S). The input RF signal was imprinted onto the comb lines via intensity modulation of the optical field achieved by an electro-optical modulator (EOM), thus generating replicas across all wavelength channels. The replicas were progressively delayed by a spool of standard single-mode fibre ( $\sim 13$  km) and summed upon photodetection using a high-speed photodetector (Finisar, 40 GHz bandwidth).

The delay step between the adjacent wavelength channels  $\Delta t$ , or referred as the time feature of the integrator [10], was measured to be  $\sim 84$  ps, which was determined by the dispersion and length of the fibre and the spectral spacing between the comb lines. As such, the operation bandwidth of the integrator is given as  $1/\Delta t = 11.9$  GHz. We note that the fastest time feature is determined by the delay step of the wavelength channels, and thus in theory can become arbitrarily small by reducing the amount of dispersion, although with a tradeoff that the integration window also decreases proportionally.

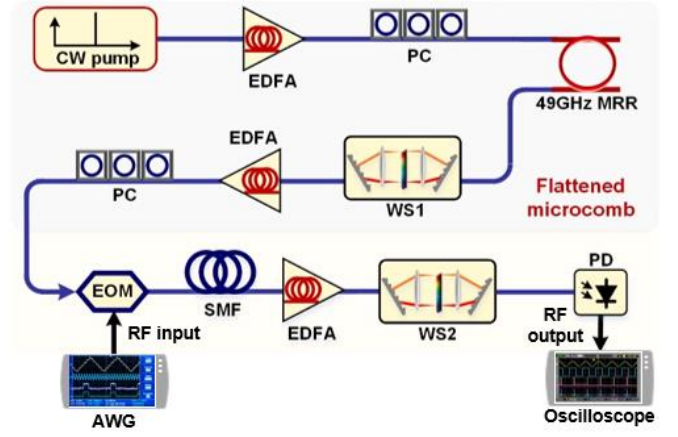


Figure 2. Experimental setup of the photonic RF integrator based on a micro-comb source. EDFA: erbium-doped fibre amplifier. PC: polarization controller. MRR: micro-ring resonator. WS: WaveShaper. EOM: Mach-Zehnder modulator. SMF: single mode fibre. PD: photodetector. AWG: RF arbitrary waveform generator. The input RF signal was generated by the AWG (Keysight M8195A). The output RF signal was measured by the oscilloscope (Keysight DSOZ504A).

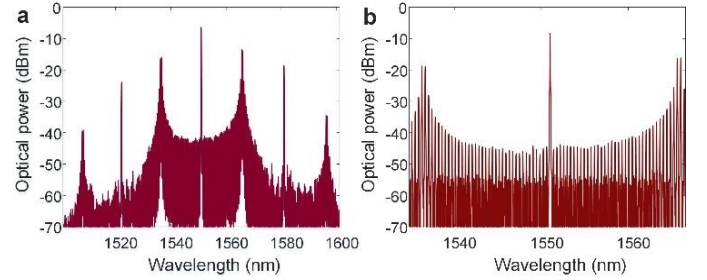


Figure 3. Optical spectra of the generated soliton crystal microcomb with spans of (a) 100 nm and (b) 30 nm.

We note here that, although theoretically only one WaveShaper is required to flatten the microcomb lines, we employed two WaveShapers in our setup to achieve better performance. The first WaveShaper flattened the microcomb to ensure uniform wavelength channel link gain and a higher signal-to-noise ratio, as well as to reduce the required loss control range for the second WaveShaper. Including two WaveShapers therefore resulted in a higher overall shaping resolution due to the inherent properties of the WaveShaper. The second WaveShaper was employed for accurate comb shaping assisted by feedback control.

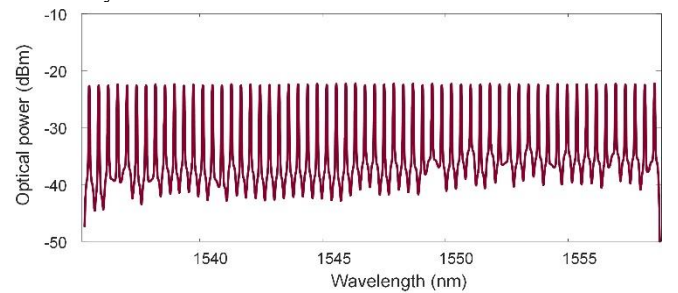


Figure 4. Optical spectrum of the shaped microcomb.

waveform exhibits a triangular shape that matches well with ideal

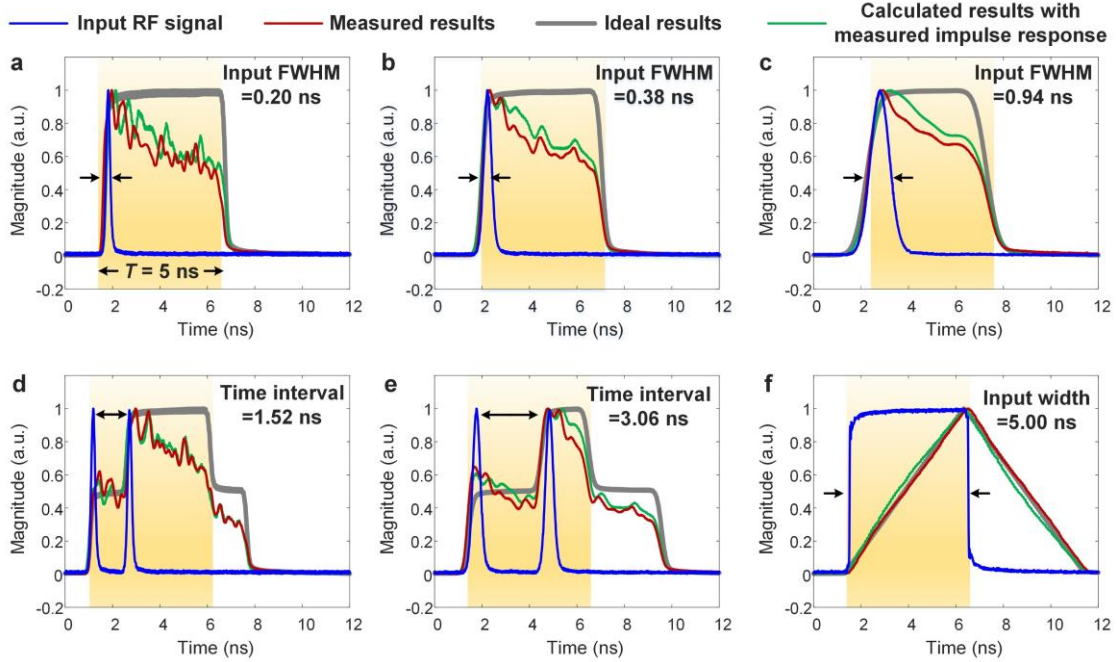


Figure 5. Experimental results of the microcomb-based RF integrator after comb optical power shaping for input (a-c) Gaussian pulses with FWHM of 0.20, 0.38 and 0.94 ns, (d-e) dual Gaussian pulses with time intervals of 1.52 and 3.06 ns, and (f) a triangular waveform with a width of 5.00 ns. The blue curves denote the input signal, the red curves denote the measured integration results, the gray curves denote the ideal integration results, and the green curves denote the integration results calculated with the measured impulse response of the system.

The error signal was generated by reading and comparing the comb lines' power with the desired channel weights, which are all equal for the integrator. The measured optical spectrum after comb shaping is shown in Fig. 4.

We selected 60 comb lines in the C-band for the integration, yielding a total integration time window ( $T=N \times \Delta t$ ) which reached up to  $60 \times 84 \text{ ps} = 5.04 \text{ ns}$ , as denoted by the yellow shaded region in Fig. 5. To verify the performance of our approach, we performed signal integration for different RF input signals. The red curves in Fig. 5(a-c) show the integration results for Gaussian pulses (blue curves) with a full width at half maximum (FWHM) varying from 0.20 ns to 0.94 ns, where the demonstrated integration window  $T$  ( $\sim 5 \text{ ns}$ ) matched well with theory (5.04 ns). Fig. 5(d-e) shows the integration results of dual Gaussian pulses with different time intervals of 1.52 ns and 3.06 ns, respectively. The measured results (red curves) clearly illustrate the performance of our integrator by exhibiting three distinct intensity steps in the integration waveforms. The left step corresponds to the integration of the first pulse while the middle step indicates the integration of both the two initial pulses, and the right step shows the integration of only the second pulse since it is beyond the integration window of the first pulse. Moreover, the performance of the integrator is further demonstrated by an input signal with a rectangular input waveform with its width equal to the integration window (5 ns). The measured integrated

integration results (gray curve).

### III. RESULT ANALYSIS AND OPTIMIZATION

As shown in Fig. 5, we note that there are residual discrepancies between the measured (red curves) and the ideal (grey curves). Considering that the optical power of the comb lines has been flattened well, we deduce that the errors were introduced by the non-ideal impulse response of the system, caused by the non-flat transmission response of the optical amplifier, the modulation and the photodetector across the wavelength channels.

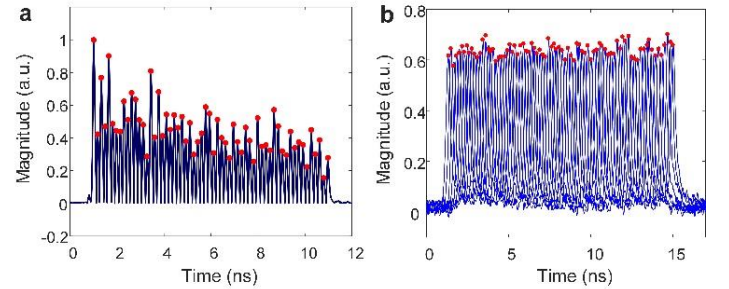


Figure 6. Measured impulse response of the integrator (a) after comb optical power shaping and (b) after impulse response shaping using a Gaussian RF input pulse.



To verify this, we measured the impulse response of the system with a Gaussian pulse input. Considering that the time resolution of the system ( $\sim 84$  ps) was much smaller than the duration of the input pulse, we separated the wavelength channels into multiple subsets (each with a much larger spacing between the adjacent comb lines and thus obtained a temporal resolution larger than the input pulse duration), and measured their impulse response sequentially. Figure 6(a) shows the measured impulse response of the system, which was not flat in magnitude even when the comb lines were perfectly flattened. We used the measured impulse response and the input RF signal in Fig. 5 to calculate the corresponding integral output, with the results matching the experimentally measured integration well — verifying our deductions that the experimental errors were induced by the non-ideal impulse responses of the system.

In order to reduce these errors, we developed a more accurate comb

We then performed integration with the same RF inputs as for previous measurements, the results of which are shown in Fig. 7. Note that during this measurement, 81 wavelength channels were enabled by the impulse response shaping process, so that the integration time window ( $T = N \times \Delta t$ ) increased to  $81 \times 84\text{ps} = 6.804$  ns, resulting in an operation bandwidth of  $1/84\text{ps} = 11.9$  GHz and a time-bandwidth product of  $6.804\text{ns} \times 11.9\text{GHz} \sim 81$  (approximately equal to the number of channels  $N$ ). The measured integrated results (red curves, Fig. 7) show significantly better agreement with theory, indicating the success of the impulse response shaping method, and the feasibility of our approach to photonic RF integration based on microcombs.

We note that the system can be further simplified in terms of the number of optical amplifiers and optical spectral shapers. By optimizing the microcomb's energy conversion efficiency along with the RF photonic link gain and minimizing the loss and the shaping

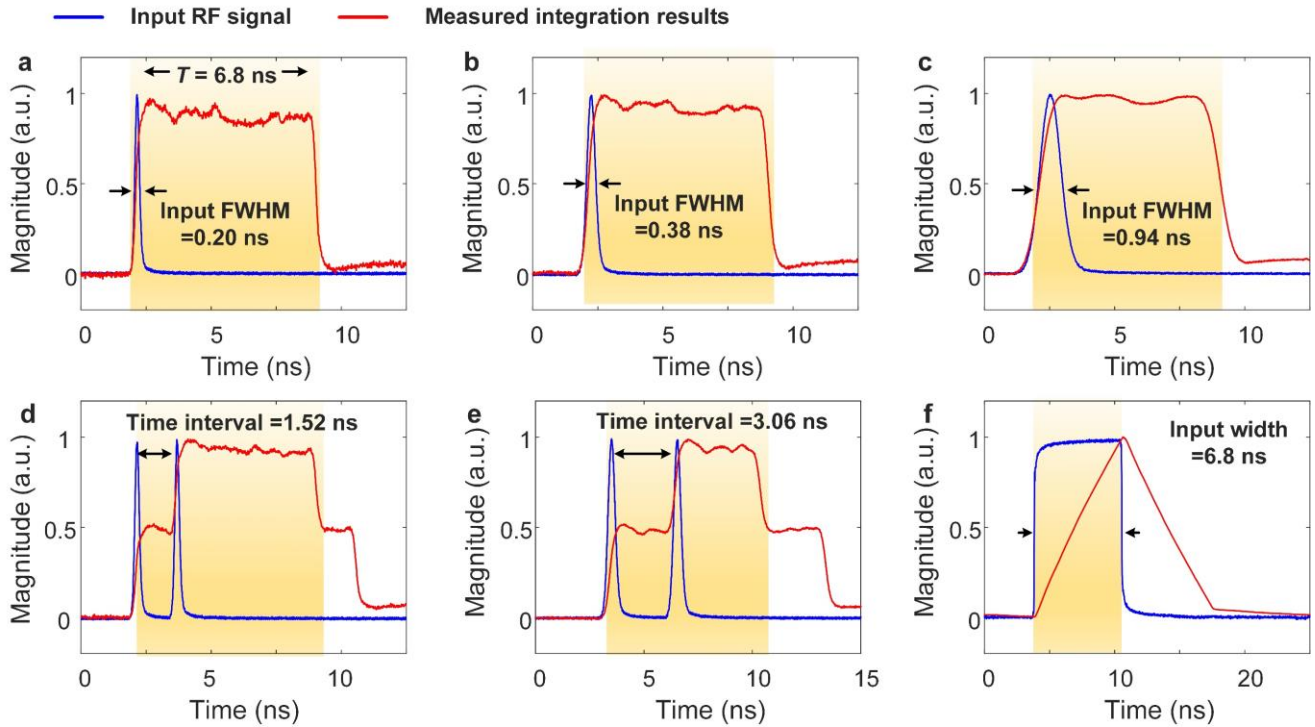


Figure 7. Experimental results of the microcomb-based RF integrator after impulse response shaping for input (a-c) Gaussian pulses with FWHM of 0.20, 0.38 and 0.94 ns, (d-e) dual Gaussian pulses with time intervals of 1.52 and 3.06 ns, and (f) a triangular waveform with a width of 5.00 ns. The blue curves denote the input signal, the red curves denote the measured integration results.

shaping approach, where the error signal of the feedback loop was generated directly by the measured impulse response, instead of the optical power of the comb lines. First, an RF Gaussian pulse was employed as the input of the integrator. Next, the replicas of the input pulse at all wavelength channels were measured to obtain the impulse response of the system, whose peak intensities were further extracted to obtain accurate RF-to-RF wavelength channel weights. Then, the extracted channel weights were subtracted from the desired channels weights to obtain an error signal. Finally, the error signal was used to program the loss of the Waveshaper. After 3 iterations of the comb shaping loop, flattened impulse response was obtained, as shown in Fig. 6(b), which is much closer to the ideal impulse response than Fig. 6(a).

resolution of the optical spectral shaper, only one optical amplifier (to offer sufficient parametric gain for microcomb generation) and one spectral shaper (to flatten the microcomb spectrum) would be needed. In addition, our integrator has the potential to be monolithically integrated with current nanofabrication techniques, as the most challenging component — the multi-wavelength source — has been demonstrated with the microcomb source fabricated on a CMOS compatible platform. Other components needed for microwave photonic integrators [36-41] and other microwave photonic signal processors based on microcombs [42-98] such as the electro-optical modulator, optical spectral shaper, dispersive media, tunable dispersion compensators and photodetector have all been realized in integrated (or compact) form [99-107].

Table 1. Comparison of photonic RF integrators

| Method   | Reconfigurability | Time window | Time resolution | Bandwidth | Time-bandwidth product |
|--|-------------------|-------------|-----------------|-----------|------------------------|
| Fiber Bragg grating [4]                              | ×                 | N.A.        | 6ps             | N.A.      | N.A.                   |
| Active fiber Bragg grating [5]                       | ×                 | ~5 ns       | 50 ps           | 20 GHz    | 100                    |
| Apodized uniform period fiber Bragg grating [6]      | ×                 | 60 ps       | 2.5 ps          | 400 GHz   | 24                     |
| Passive high-Q MRR [7]                               | ×                 | 800 ps      | 8 ps            | 200 GHz   | 100                    |
| InP-InGaAsP MRR [8]                                  | ×                 | 6.33 ns     | < 54 ps         | >15 GHz   | >117                   |
| Passive MRR [9]                                      | ×                 | 12.5 ps     | 1.9 ps          | 400 GHz   | 6.6                    |
| Incoherent light source [10]                         | √                 | 200 ps      | 7 ps            | >18 GHz   | 28.5                   |
| Multi-wavelength fiber laser [11]                    | √                 | 1.24 ns     | ~27 ps          | 36.8 GHz  | ~45.9                  |
| Incoherent light source and fiber Bragg grating [12] | √                 | 7 ns        | 344 ps          | 2.9 GHz   | 20.3                   |
| Microcomb (this work)                                | √                 | 6.8 ns      | 84 ps           | 11.9 GHz  | 81                     |

#### IV. CONCLUSIONS

We demonstrate a photonic RF integrator using an integrated soliton crystal micro-comb source. Through broadcast and delay processes employing 81 wavelength channels generated by the microcomb source, discrete temporal integration of RF signals is achieved with a large time-bandwidth product of 81. An impulse response shaping approach was developed to compensate for the non-flat optical transmission response of the system to guarantee uniform channel weights for the integrator. A large integration time window of 6.8 ns is demonstrated, together with a time feature as fast as 84 ps and a broad bandwidth of 11.9 GHz. A range of different input signals were successfully integrated. In addition, although we did not do so in this initial work, our device has the potential to be reconfigured in terms of the integration time window and resolution. This can be readily achieved by adjusting the value of the accumulated dispersion (i.e., the length of dispersive fibre). For example, with the length of fibre varying from 130 m to 130 km, the progressive delay, or the time resolution, varies from 0.84 ps to 840 ps, together with the integration time window varying from 680 ps to 68 ns. These results verify that our RF integrator is a competitive approach towards integrating high-speed photonic RF signals with high performance, flexibility, and potentially reduced cost and footprint.

#### REFERENCES

- [1] J. Capmany, and D. Novak, "Microwave Photonics combines two worlds," *Nature Photonics*, vol. 1, pp. 319-330, Jun. 2007.
- [2] J. Yao, "Microwave Photonics," *Journal of Lightwave Technology*, vol. 27, no. 3, pp. 314-335, Feb. 2009.
- [3] R. C. Williamson, R. D. Esman, "RF Photonics," *Journal of Lightwave Technology*, vol. 26, no. 9, pp. 1145-1153, May 2008.
- [4] Y. Park, T.-J. Ahn, Y. Dai, J. Yao, and J. Azaña, "All-optical temporal integration of ultrafast pulse waveforms," *Optics Express*, vol. 16, no. 22, pp. 17817-17825, 2008/10/27. 2008.
- [5] R. Slavík, Y. Park, N. Ayotte, S. Doucet, T.-J. Ahn, S. LaRochelle, and J. Azaña, "Photonic temporal integrator for all-optical computing," *Optics Express*, vol. 16, no. 22, pp. 18202-18214, 2008/10/27. 2008.
- [6] M. H. Asghari, Y. Park, and J. Azaña, "New design for photonic temporal integration with combined high processing speed and long operation time window," *Optics Express*, vol. 19, no. 2, pp. 425-435, 2011/01/17. 2011.
- [7] M. Ferrera, Y. Park, L. Razzari, B. E. Little, S. T. Chu, R. Morandotti, D. J. Moss, and J. Azaña, "On-chip CMOS-compatible all-optical integrator," *Nature Communications*, vol. 1, no. 1, pp. 29, 2010/06/15. 2010.
- [8] W. Liu, M. Li, R. S. Guzzon, E. J. Norberg, J. S. Parker, L. A. Coldren, and J. Yao, "A Photonic Temporal Integrator With an Ultra-Long Integration Time Window Based on an InP-InGaAsP Integrated Ring Resonator," *Journal of Lightwave Technology*, vol. 32, no. 20, pp. 3654-3659, 2014.
- [9] M. Ferrera, Y. Park, L. Razzari, B. E. Little, S. T. Chu, R. Morandotti, D. J. Moss, and J. Azaña, "All-optical 1st and 2nd order integration on a chip," *Optics Express*, vol. 19, no. 23, pp. 23153-23161, 2011/11/07. 2011.
- [10] Y. Park, and J. Azaña, "Ultrafast photonic intensity integrator," *Optics Letters*, vol. 34, no. 8, pp. 1156-1158, 2009/04/15. 2009.
- [11] A. Malacarne, R. Ashrafi, M. Li, S. LaRochelle, J. Yao, and J. Azaña, "Single-shot photonic time-intensity integration based on a time-spectrum convolution system," *Optics Letters*, vol. 37, no. 8, pp. 1355-1357, 2012/04/15. 2012.
- [12] J. Zhang, and J. Yao, "Microwave photonic integrator based on a multichannel fiber Bragg grating," *Optics Letters*, vol. 41, no. 2, pp. 273-276, 2016/01/15. 2016.
- [13] T. J. Kippenberg, A. L. Gaeta, M. Lipson, and M. L. Gorodetsky, "Dissipative Kerr solitons in optical microresonators," *Science*, vol. 361, no. 6402, pp. 8083. 2018.
- [14] D. J. Moss, R. Morandotti, A. L. Gaeta, and M. Lipson, "New CMOS-compatible platforms based on silicon nitride and Hydex for nonlinear optics," *Nature Photonics*, vol. 7, no. 8, pp. 597-607, Aug. 2013.
- [15] A. L. Gaeta, M. Lipson, and T. J. Kippenberg, "Photonic-chip-based frequency combs," *Nature Photonics*, vol. 13, no. 3, pp. 158-169, Mar. 2019.
- [16] A. Pasquazi, M. Peccianti, L. Razzari, D. J. Moss, S. Coen, M. Erkintalo, Y. K. Chembo, T. Hansson, S. Wabnitz, P. Del'Haye, X. X. Xue, A. M. Weiner, and R. Morandotti, "Micro-combs: A novel generation of optical sources," *Physics Reports-Review Section of Physics Letters*, vol. 729, pp. 1-81, Jan 27. 2018.
- [17] M.-G. Suh, and K. J. Vahala, "Soliton microcomb range measurement," *Science*, vol. 359, no. 6378, pp. 884-887. 2018.
- [18] W. Liang, D. Eliyahu, V. S. Ilchenko, A. A. Savchenkov, A. B. Matsko, D. Seidel, and L. Maleki, "High spectral purity Kerr frequency comb radio frequency photonic oscillator," *Nature Communications*, vol. 6, pp. 7957. 2015.
- [19] D. T. Spencer, T. Drake, T. C. Briles, J. Stone, L. C. Sinclair, C. Fredrick, Q. Li, D. Westly, B. R. Ilic, and A. Bluestone, "An optical-frequency synthesizer using integrated photonics," *Nature*, vol. 557, no. 7703, pp. 81-85. 2018.
- [20] J. Wu, X. Xu, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and D. J. Moss, "RF Photonics: An Optical Microcombs' Perspective," *IEEE Journal of Selected Topics in Quantum Electronics*, vol. 24, no. 4, pp. 1-20. 2018.

- [21] X. Xu, M. Tan, J. Wu, R. Morandotti, A. Mitchell, and D. J. Moss, "Microcomb-based photonic RF signal processing," *IEEE Photonics Technology Letters*, vol. 31, no. 23, pp. 1854-1857. 2019.
- [22] X. Xu, J. Wu, T. G. Nguyen, T. Moein, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and D. J. Moss, "Photonic microwave true time delays for phased array antennas using a 49 GHz FSR integrated optical micro-comb source," *Photonics Research*, vol. 6, no. 5, pp. B30-B36, May 1. 2018.
- [23] X. Xue, Y. Xuan, C. Bao, S. Li, X. Zheng, B. Zhou, M. Qi, and A. M. Weiner, "Microcomb-Based True-Time-Delay Network for Microwave Beamforming With Arbitrary Beam Pattern Control," *Journal of Lightwave Technology*, vol. 36, no. 12, pp. 2312-2321, Jun. 2018.
- [24] X. Xu, J. Wu, T. G. Nguyen, M. Shoeiby, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and D. J. Moss, "Advanced RF and microwave functions based on an integrated optical frequency comb source," *Optics Express*, vol. 26, no. 3, pp. 2569-2583, Feb 5. 2018.
- [25] X. Xu, M. Tan, J. Wu, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and D. J. Moss, "Advanced Adaptive Photonic RF Filters with 80 Taps Based on an Integrated Optical Micro-Comb Source," *Journal of Lightwave Technology*, vol. 37, no. 4, pp. 1288-1295, Feb. 2019.
- [26] X. X. Xue, Y. Xuan, H. J. Kim, J. Wang, D. E. Leaird, M. H. Qi, and A. M. Weiner, "Programmable Single-Bandpass Photonic RF Filter Based on Kerr Comb from a Microring," *Journal of Lightwave Technology*, vol. 32, no. 20, pp. 3557-3565, Oct 15. 2014.
- [27] X. Xu, J. Wu, M. Shoeiby, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and D. J. Moss, "Reconfigurable broadband microwave photonic intensity differentiator based on an integrated optical frequency comb source," *APL Photonics*, vol. 2, no. 9, 096104. Sep. 2017.
- [28] M. Tan, X. Xu, B. Corcoran, J. Wu, A. Boes, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and D. J. Moss, "Microwave and RF Photonic Fractional Hilbert Transformer Based on a 50 GHz Kerr Micro-Comb," *Journal of Lightwave Technology*, vol. 37, no. 24, pp. 6097-6104. 2019.
- [29] M. Tan, X. Xu, B. Corcoran, J. Wu, A. Boes, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and D. J. Moss, "RF and microwave fractional differentiator based on photonics," *IEEE Transactions on Circuits and Systems II: Express Briefs*, Volume: 67, Issue: 11, Page(s): 2767-2771 (2020). DOI: 10.1109/TCSII.2020.2965158
- [30] X. Xu, J. Wu, M. Tan, T. G. Nguyen, S. Chu, B. Little, R. Morandotti, A. Mitchell, and D. J. Moss, "Micro-comb based photonic local oscillator for broadband microwave frequency conversion," *Journal of Lightwave Technology*, vol. 38, no. 2, pp. 332-338. 2020.
- [31] X. Xu, M. Tan, J. Wu, A. Boes, B. Corcoran, T. G. Nguyen, S. T. Chu, B. Little, R. Morandotti, and A. Mitchell, "Photonic RF phase-encoded signal generation with a microcomb source," *Journal of Lightwave Technology*, vol. 38, no. 7, pp. 1722-1727. 2020. DOI: 10.1109/JLT.2019.2958564
- [32] X. Xu, M. Tan, J. Wu, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and D. J. Moss, "High performance RF filters via bandwidth scaling with Kerr micro-combs," *APL Photonics*, vol. 4, no. 2, pp. 026102. 2019.
- [33] X. Xu, J. Wu, T. G. Nguyen, S. Chu, B. Little, A. Mitchell, R. Morandotti, and D. J. Moss, "Broadband RF channelizer based on an integrated optical frequency Kerr comb source," *Journal of Lightwave Technology*, vol. 36, no. 19, pp. 4519-4526, 2018.
- [34] D. C. Cole, E. S. Lamb, P. Del'Haye, S. A. Diddams, and S. B. Papp, "Soliton crystals in Kerr resonators," *Nature Photonics*, vol. 11, no. 10, pp. 671. 2017.
- [35] W. Wang, Z. Lu, W. Zhang, S. T. Chu, B. E. Little, L. Wang, X. Xie, M. Liu, Q. Yang, and L. Wang, "Robust soliton crystals in a thermally controlled microresonator," *Optics Letters*, vol. 43, no. 9, pp. 2002-2005. 2018.
- [36] Marcello Ferrera, Yongwoo Park, Luca Razzari, Brent E. Little, Sai T. Chu, Roberto Morandotti, Dave J. Moss, Jose Azana, "Ultra-Fast On-Chip All-Optical Integration", Paper FTh11, Optical Society of America Annual Meeting, Frontiers in Optics, Rochester, NY Oct. 24-28 (2010). DOI: 10.1364/FIO.2010.FTh11
- [37] M. Ferrera, Y. Park, L. Razzari, Brent E. Little, Sai T. Chu, R. Morandotti, D. J. Moss, and J. Azana, "Ultra-Fast Integrated All-Optical Integrator", Paper CFL2, IEEE / OSA Conference for Lasers and Electro-Optics, San Jose, CA, May (2010). doi:10.1364/CLEO.2010.CFL2.
- [38] M. Ferrera, Y. Park, L. Razzari, B. Little, S. Chu, R. Morandotti, D. J. Moss, and J. Azana, "Ultra-fast All-Optical Integration on a Silicon Chip," paper W12, *Latin America Optics and Photonics Conference*, Recife, Brazil, September 27 (2010). DOI:10.1364/LAOP.2010.W12
- [39] M. Ferrera, Y. Park, L. Razzari, B. E. Little, S. T. Chu, R. Morandotti, D. J. Moss, and J. Azana, "All-optical 1<sup>st</sup> and 2<sup>nd</sup> order integration in a CMOS compatible chip", IEEE / OSA Conference for Lasers and Electro-Optics (CLEO), Paper JW4A.4, San Jose, CA, May (2012). DOI:10.1364/CLEO\_AT.2012.JW4A.4.
- [40] M. Ferrera, Y. Park, L. Razzari, B. E. Little, S. T. Chu, R. Morandotti, D. J. Moss, and J. Azana, "On-Chip 1<sup>st</sup> and 2<sup>nd</sup>-Order 400GHz All-Optical Integrator", Paper 1012.00, IEEE/OSA Conf. for Lasers and Electro-Optics Pacific Rim, Sydney, Australia, August (2011). DOI: [10.1109/IOEC-CLEO.2011.6193799](https://doi.org/10.1109/IOEC-CLEO.2011.6193799)
- [41] X. Xu, M. Tan, J. Wu, A. Boes, B. Corcoran, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and D. J. Moss, "Photonic RF and microwave integrator with soliton crystal microcombs", *IEEE Transactions on Circuits and Systems: Express Briefs*, Volume: 67, Issue: 12, pp. 3582-3586 (2020). DOI:10.1109/TCSII.2020.2995682.
- [42] Mengxi Tan, X. Xu, J. Wu, A. Boes, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and David J. Moss, "RF and microwave photonic, fractional differentiation, integration, and Hilbert transforms based on Kerr micro-combs", Paper No. 11713-16, PW21O-OE803-24, Next-Generation Optical Communication: Components, Sub-Systems, and Systems X, SPIE Photonics West, San Francisco CA March 6-11 (2021). [doi.org/10.1117/12.2584018](https://doi.org/10.1117/12.2584018)
- [43] Xingyuan Xu, Mengxi Tan, Bill Corcoran, Jiayang Wu, Andreas Boes, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Damien G. Hicks, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "11 TOPs photonic convolutional accelerator for optical neural networks", *Nature* **589** (7840) 44-51 (2021).
- [44] Mengxi Tan, Xingyuan Xu, Jiayang Wu, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "RF and microwave photonic temporal signal processing with Kerr micro-combs", *Advances in Physics X*, VOL. 6, NO. 1, 1838946 (2021). DOI:10.1080/23746149.2020.1838946.
- [45] Mengxi Tan, X. Xu, J. Wu, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and David J. Moss, "Orthogonally polarized Photonic Radio Frequency single sideband generation with integrated micro-ring resonators", *IOP Journal of Semiconductors* **42** (4), 041305 (2021). DOI: 10.1088/1674-4926/42/4/041305.
- [46] Mengxi Tan, X. Xu, J. Wu, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and David J. Moss, "Photonic Radio Frequency Channelizers based on Kerr Optical Micro-combs", *IOP Journal of Semiconductors* **42** (4), 041302 (2021).
- [47] Mengxi Tan, Yang Li, Xingyuan Xu, Bill Corcoran, Jiayang Wu, Andreas Boes, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Damien G. Hicks, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "11 Tera-OPS/s photonic convolutional accelerator and deep optical neural network based on an integrated Kerr soliton crystal microcomb", Paper LA203-15, SPIE-LASE, Laser Resonators, Microresonators, and Beam Control XXIV, SPIE-Opto, SPIE Photonics West, San Francisco CA January 22 - 27 (2022). doi: 10.1117/12.2607906
- [48] Mengxi Tan, Yang Sun, Yang Li, Xingyuan Xu, Andreas Boes, Bill Corcoran, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "RF and microwave photonic signal generation and processing based on Kerr micro-combs", Paper No. PW22O-OE106-17, SPIE-Opto, Terahertz, RF, Millimeter, and Submillimeter-Wave Technology and Applications XV, SPIE Photonics West, San Francisco CA January 22 - 27 (2022). DOI: [10.1117/12.2607905](https://doi.org/10.1117/12.2607905).
- [49] Mengxi Tan, Yang Li, Yang Sun, Xingyuan Xu, Jiayang Wu, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Versatile, high bandwidth, RF and microwave photonic Hilbert transformers based on Kerr micro-combs", Paper No. PW22O-OE201-21, SPIE-Opto, Integrated Optics: Devices,

- Materials, and Technologies XXVI, SPIE Photonics West, San Francisco CA January 22 - 27 (2022). doi: [10.1117/12.2607903](https://doi.org/10.1117/12.2607903)
- [50] Mengxi Tan, Xingyuan Xu, Bill Corcoran, J. Wu, A. Boes, T. G. Nguyen, Sai T. Chu, Brent E. Little, Damien G. Hicks, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Optical Neuromorphic Processor at 11 TeraOPs/s based on Kerr Soliton Crystal Micro-combs", paper Tu3G.1, OSA/IEEE Optical Fibre Communications Conference, San Diego CA, March 6 - 10 (2022). DOI: [10.1364/OFC.2022.Tu3G.1](https://doi.org/10.1364/OFC.2022.Tu3G.1).
  - [51] Mengxi Tan, Xingyuan Xu, Jiayang Wu, Bill Corcoran, Andreas Boes, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Integral order photonic RF signal processors based on a soliton crystal micro-comb source", *IOP Journal of Optics* **23** (11) 125701 (2021). <https://doi.org/10.1088/2040-8986/ac2eab>
  - [52] Mengxi Tan, Xingyuan Xu, Jiayang Wu, Bill Corcoran, Andreas Boes, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arthur Lowery, Arnan Mitchell, and David J. Moss, "Highly Versatile Broadband RF Photonic Fractional Hilbert Transformer Based on a Kerr Soliton Crystal Microcomb", *Journal of Lightwave Technology* **39** (24) 7581-7587 (2021). DOI: [10.1109/JLT.2021.3101816](https://doi.org/10.1109/JLT.2021.3101816).
  - [53] M. Tan, X. Xu, J. Wu, A. Boes, B. Corcoran, T. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, D. G. Hicks, Mitchell, and David J. Moss, "Tera-OP/s Neuromorphic Processing with Kerr Microcombs", W. Bogaerts, K. Morito, S. Ben Yoo, M. Fiorentino, K. Ishii, and B. Offrein, eds., OSA Technical Digest (Optica Publishing Group, 2021), paper Tu5B.1. Photonics in Switching and Computing 2021, Washington, DC United States, 27-29 September 2021. <https://doi.org/10.1364/PSC.2021.Tu5B.1>.
  - [54] Mengxi Tan, X. Xu, J. Wu, A. Boes, T. G. Nguyen, S. T. Chu, B. E. Little, D. Hicks, R. Morandotti, A. Mitchell, and David J. Moss, "Photonic convolutional accelerator and neural network in the Tera-OPs regime based on Kerr microcombs", Paper SpM5C.1, Signal Processing in Photonic Communications, OSA Advanced Photonics Congress, Montreal, Canada, 26 - 29 July (2021). DOI: [10.1364/SPPCOM.2021.SpM5C.1](https://doi.org/10.1364/SPPCOM.2021.SpM5C.1)
  - [55] Mengxi Tan, Bill Corcoran, Xingyuan Xu, Andrew Boes, Jiayang Wu, Thach Nguyen, S.T. Chu, B. E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Optical data transmission with high spectral efficiency at 44TeraB/s with a soliton crystal micro-comb", Paper SpM1F.2, Signal Processing in Photonic Communications (SPPCom), OSA Advanced Photonics Congress, Montreal, Canada, 26 - 29 July (2021). DOI: [10.1364/SPPCOM.2021.SpM1F.2](https://doi.org/10.1364/SPPCOM.2021.SpM1F.2).
  - [56] Mengxi Tan, Xingyuan Xu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Applications of Kerr microcombs", Paper MA3.1, Photonics for Information Processing, IEEE Summer Topical Meeting, Cabo San Lucas, Mexico 19-21 July (2021). DOI: [10.1109/SUM48717.2021.9505771](https://doi.org/10.1109/SUM48717.2021.9505771)
  - [57] Mengxi Tan, X. Xu, J. Wu, A. Boes, B. Corcoran, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and David J. Moss, "Advanced applications of Kerr microcombs", Proc. SPIE 11775, Integrated Optics: Design, Devices, Systems and Applications VI, 1177504; Integrated Optics Conference, SPIE Optics and Optoelectronics Symposium, April 19 - 22 (2021), Prague, Czech Republic. [doi.org/10.1117/12.2588733](https://doi.org/10.1117/12.2588733).
  - [58] Mengxi Tan, Xingyuan Xu, Jiayang Wu, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, Bill Corcoran, Damien Hicks, and David J. Moss, "Kerr micro-combs for high-speed, scalable, optical neural networks", or "Single perceptron at 12 GigaOPs based on a microcomb for versatile, high-speed scalable, optical neural networks", Paper No. 11690-21, PW21O-OE202-28, Smart Photonic and Optoelectronic Integrated Circuits XXIII, SPIE Photonics West, San Francisco CA March 6-11 (2021). DOI: [10.1117/12.2584011](https://doi.org/10.1117/12.2584011)
  - [59] Mengxi Tan, X. Xu, J. Wu, A. Boes, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and David J. Moss, "Broadband photonic RF channelizer with 90 channels based on a soliton crystal microcomb", or "Photonic microwave and RF channelizers based on Kerr micro-combs", Paper No. 11685-22, PW21O-OE106-49, Terahertz, RF, Millimeter, and Submillimeter-Wave Technology and Applications XIV, SPIE Photonics West, San Francisco CA March 6-11 (2021). [doi.org/10.1117/12.2584015](https://doi.org/10.1117/12.2584015)
  - [60] Mengxi Tan, X. Xu, J. Wu, A. Boes, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and David J. Moss, "Advanced microwave signal generation and processing with soliton crystal microcombs", or "Photonic convolutional accelerator and neural network in the Tera-OPs regime based on Kerr microcombs", Paper No. 11689-38, PW21O-OE201-67, Integrated Optics: Devices, Materials, and Technologies XXV, SPIE Photonics West, San Francisco CA March 6-11 (2021). DOI: [10.1117/12.2584017](https://doi.org/10.1117/12.2584017)
  - [61] Mengxi Tan, Bill Corcoran, Xingyuan Xu, Andrew Boes, Jiayang Wu, Thach Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Optical data transmission at 40 Terabits/s with a Kerr soliton crystal microcomb", Paper No.11713-8, PW21O-OE803-23, Next-Generation Optical Communication: Components, Sub-Systems, and Systems X, SPIE Photonics West, San Francisco CA March 6-11 (2021). DOI: [10.1117/12.2584014](https://doi.org/10.1117/12.2584014).
  - [62] Sun, Yang; Wu, Jiayang; Tan, Mengxi; Xu, Xingyuan; Li, Yang; Morandotti, Roberto; Mitchell, Arnan; Moss, David J., "Applications of optical microcombs", Advances in Optics and Photonics, Volume 15, (1) 86-175 (2023).
  - [63] Mengxi Tan, X. Xu, J. Wu, A. Boes, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and David J. Moss, "RF and microwave photonic, fractional differentiation, integration, and Hilbert transforms based on Kerr micro-combs", Paper No. 11713-16, PW21O-OE803-24, Next-Generation Optical Communication: Components, Sub-Systems, and Systems X, SPIE Photonics West, San Francisco CA March 6-11 (2021). DOI: [10.1117/12.2584018](https://doi.org/10.1117/12.2584018)
  - [64] Xingyuan Xu, Mengxi Tan, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Photonic RF fractional Hilbert transformers and filters based on integrated soliton crystal microcombs", Paper SW4J.7, Virtual Conference, OSA/IEEE Conference on Lasers and Electro-Optics, San Jose CA, May (2020). DOI: [10.1364/CLEO\\_SI.2020.SW4J.7](https://doi.org/10.1364/CLEO_SI.2020.SW4J.7).
  - [65] Mengxi Tan, Xingyuan Xu, Jiayang Wu, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Photonic RF and microwave filters based on 49GHz and 200GHz Kerr microcombs", *Optics Communications* Feb. 22, **465**, Article: 125563 (2020).
  - [66] Xingyuan Xu, Mengxi Tan, Jiayang Wu, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, Bill Corcoran, Damien Hicks, and David J. Moss, "Photonic perceptron based on a Kerr microcomb for scalable high speed optical neural networks", *Laser and Photonics Reviews* **14** (8) 2000070 (2020).
  - [67] Mengxi Tan, Xingyuan Xu, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "True time delays for phased array antennas based on a microcomb", Poster Paper [11200-96], AOS Australian Conference on Optical Fibre Technology and Australian Conference on Optics, Lasers, and Spectroscopy and SPIE Micro + Nano Materials, Devices, and Applications, RMIT University, Melbourne, December 8-12, (2019). DOI: [10.1117/12.2540414](https://doi.org/10.1117/12.2540414)
  - [68] Xingyuan Xu, Mengxi Tan, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "High Q RF transversal filter based on an 80-channel integrated microcomb source", Paper [11200-104], AOS Australian Conference on Optical Fibre Technology (ACOFT) and Australian Conference on Optics, Lasers, and Spectroscopy (ACOLS) and SPIE Micro + Nano Materials, Devices, and Applications, RMIT University, Melbourne, December 8-12, (2019). DOI: [10.1117/12.2541202](https://doi.org/10.1117/12.2541202).
  - [69] Mengxi Tan, Xingyuan Xu, Jiayang Wu, Andy Boes, Bill Corcoran, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Reconfigurable microwave signal processor for fractional and regular Hilbert transform based on a microcomb", Paper [11200-78], AOS Australian Conference on Optical Fibre Technology (ACOFT) and Australian Conference on Optics, Lasers, and Spectroscopy (ACOLS) and SPIE Micro + Nano Materials, Devices, and Applications, RMIT University, Melbourne, December 8-12, (2019). DOI: [10.1117/12.2540404](https://doi.org/10.1117/12.2540404)



- [70] Xingyuan Xu, Mengxi Tan, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Photonic wideband RF mixer based on an integrated microcomb source", Paper [11200-81], AOS Australian Conference on Optical Fibre Technology (ACOFT) and Australian Conference on Optics, Lasers, and Spectroscopy (ACOLS) and SPIE Micro + Nano Materials, Devices, and Applications, RMIT University, Melbourne, December 8-12, (2019). doi: 10.1117/12.2541201
- [71] Xingyuan Xu, Mengxi Tan, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "High Q RF transversal filter based on an 80 channel integrated microcomb source", Paper FW6C.4, OSA, Frontiers in Optics, Washington, DC September (2019). DOI: [10.1364/FIO.2019.FW6C.4](https://doi.org/10.1364/FIO.2019.FW6C.4)
- [72] Jiayang Wu, Xingyuan Xu, Mengxi Tan, Thach G. Nguyen, Yang Qu, Linnan Jia, Yuning Zhang, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Applications of Kerr Micro-combs to RF Photonics", Paper FW6C.5, OSA Frontiers in Optics, Washington, DC September (2019). DOI: [10.1364/FIO.2019.FW6C.5](https://doi.org/10.1364/FIO.2019.FW6C.5)
- [73] Xingyuan Xu, Mengxi Tan, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Microcomb-based reconfigurable photonic RF transversal filters", IEEE International Topical Meeting on Microwave Photonics (MWP), Ottawa, Canada, October (2019). DOI: [10.1109/MWP.2019.8892063](https://doi.org/10.1109/MWP.2019.8892063)
- [74] Mengxi Tan, Xingyuan Xu, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Reconfigurable fractional microwave signal processor based on a microcomb", IEEE International Topical Meeting on Microwave Photonics (MWP), Ottawa, Canada, October (2019). DOI: [10.1109/MWP.2019.8892024](https://doi.org/10.1109/MWP.2019.8892024).
- [75] Xingyuan Xu, Mengxi Tan, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Microcomb-based high-resolution photonic RF channelization", IEEE International Topical Meeting on Microwave Photonics (MWP), Ottawa, Canada, October (2019).
- [76] Jiayang Wu, Xingyuan Xu, Mengxi Tan, Thach G. Nguyen, Yang Qu, Linnan Jia, Yuning Zhang, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David Moss, "Microwave and RF applications based on Kerr micro-combs", Control Number: 3220646, Paper ITA.6, OSA Advanced Photonics Congress, Topical Meeting on Integrated Photonics Research (IPR), Burlingame, CA, July 28-August 1 (2019).
- [77] Xingyuan Xu, Jiayang Wu, Mengxi Tan, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "RF and Microwave Applications of Micro-combs", **Invited Talk**, Paper T1E.1, Asia Pacific Communications (ACP) Conference, Chengdu, China, November 2-4 (2019).
- [78] Bill Corcoran, Mengxi Tan, Xingyuan Xu, Jiayang Wu, Andrew Boes, Thach Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Ultra-high bandwidth network transmission field trial using a soliton-crystal micro-comb source", ECOC, Dublin Sept. (2019). doi: 10.1049/cp.2019.0882.
- [79] Xingyuan Xu; Jiayang Wu; Mengxi Tan; Thach Nguyen; Sai Chu; Brent Little; Roberto Morandotti; Arnan Mitchell; David Moss; "Microwave applications of micro-combs", **Invited Talk**, 10th International Conference on Materials for Advanced Technologies (ICMAT), Materials Research Society (MRS), 23 - 28 June (2019), Marina Bay Sands, Singapore.
- [80] Mengxi Tan; Xingyuan Xu; Jiayang Wu; Thach Nguyen; Sai Chu; Brent Little; Roberto Morandotti; Arnan Mitchell; David Moss; "Tunable Photonic RF Bandpass Filters based on an 80 Channel Kerr Micro-Comb Source", Paper SF2N. 4, Control Number: 3160275, IEEE/OSA Conference of Lasers and Electro-Optics (CLEO), San Jose, CA, May 5-10 (2019). DOI: 10.1364/CLEO\_SI.2019.SF2N.4
- [81] Jiayang Wu; Xingyuan Xu; Mengxi Tan; Thach Nguyen; Sai Chu; Brent Little; Roberto Morandotti; Arnan Mitchell; David Moss; "Broadband Local Oscillator Free Photonic Microwave Mixer based on a Coherent Kerr Micro-Comb Source", Paper SF2N.2, Control Number: 3159319, IEEE/OSA Conference of Lasers and Electro-Optics (CLEO), San Jose, CA, May 5-10 (2019). DOI: 10.1364/CLEO\_SI.2019.SF2N.2
- [82] Xingyuan Xu, Jiayang Wu, Mengxi Tan, Thach Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Microwave and Communications Applications of Microcombs", Paper AT4I.1, IEEE/OSA Conference for Lasers and Electro-Optics (CLEO), San Jose, CA, May 5-10 (2019). DOI: 10.1364/CLEO\_AT.2019.AT4I.1
- [83] Xingyuan Xu, Mengxi Tan, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Microcomb based photonic local oscillator for broadband microwave frequency conversion", Paper Th3C.2, IEEE/OSA Optical Fiber Communications Conference (OFC), San Diego CA., March (2019). DOI: 10.1364/OFC.2019.Th3C.2.
- [84] Xingyuan Xu, Mengxi Tan, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Orthogonally polarized optical single sideband generation based on integrated microring resonators", Paper M1B.5, IEEE/OSA Optical Fiber Communications Conference (OFC), San Diego CA., March (2019). DOI: 10.1364/OFC.2019.M1B.5.
- [85] Xingyuan Xu, Jiayang Wu, Mengxi Tan, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Broadband photonic RF channelizer based on micro-combs", Paper PW19O-OE106-20, 10917-75, Poster Paper, Wed. Feb 6, 6-8pm, Terahertz, RF, Millimeter, and Submillimeter-Wave Technology and Applications XII, SPIE Photonics West, San Francisco, CA, 4 - 7 February (2019). DOI: 10.1117/12.2506942
- [86] Xingyuan Xu, Jiayang Wu, Mengxi Tan, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, Paper PW19O-OE110-26, [10921-3], 11:10am, Monday February 4, "Reconfigurable microwave photonic transversal filter based on an integrated optical micro-comb source", Integrated Optics: Devices, Materials, and Technologies XXIII, SPIE Photonics West, San Francisco, CA, 4 - 7 February (2019). DOI: 10.1117/12.2508152
- [87] Xingyuan Xu, Jiayang Wu, Mengxi Tan, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "High performance microwave photonic true time delays based on an integrated optical micro-comb source", Paper PW19O-OE110-24, [10921-2], Monday Feb. 4, 10:50am, Integrated Optics: Devices, Materials, and Technologies XXIII, SPIE Photonics West, San Francisco, CA, 4 - 7 February (2019). doi: 10.1117/12.2508146
- [88] H. Bao, A. Cooper, M. Rowley, L. Di Lauro, J. Sebastian T. Gongora, S.T. Chu, B. E. Little, G.-L. Oppo, R. Morandotti, D. J. Moss, B. Wetzel, M. Peccianti and A. Pasquazi, "Laser Cavity-Soliton Micro-Combs", *Nature Photonics* **13** (6) 384–389 (2019).
- [89] M. Kues, C. Reimer, B. Wetzel, P. Roztock, B.E. Little, S.T. Chu, David J. Moss, and R. Morandotti, "An ultra-narrow spectral width modelocked laser", *Nature Photonics* **11** (3) 159 (2017).
- [90] Maxwell Rowley, Pierre-Henry Hanzard, Antonio Cutrona, Hualong Bao, Sai T. Chu, Brent E. Little, Roberto Morandotti, David J. Moss, Gian-Luca Oppo, Juan Sebastian Totoro Gongora, Marco Peccianti and Alessia Pasquazi, "Self-emergence of robust solitons in a micro-cavity", *Nature* **608** (7922) (August 11) 303 – 309 (2022).
- [91] Mengxi Tan, X. Xu, J. Wu, A. Boes, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and David J. Moss, "Broadband photonic radio frequency channelizer with 90 channels based on a soliton crystal microcomb", IEEE Topical Meeting on Microwave Photonics, pp. 9-13, Matsue, Japan, November 24-26, 2020. DOI: [10.23919/MWP48676.2020.9314605](https://doi.org/10.23919/MWP48676.2020.9314605).

- [92] X. Xu, M. Tan, J. Wu, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, B. Corcoran, D. Hicks, and D. J. Moss, "Photonic perceptron based on a Kerr microcomb for scalable high speed optical neural networks", IEEE Topical Meeting on Microwave Photonics (MPW), pp. 220-224, Matsue, Japan, November 24-26, 2020. DOI: [10.23919/MWP48676.2020.9314409](https://doi.org/10.23919/MWP48676.2020.9314409)
- [93] Mengxi Tan, Bill Corcoran, Xingyuan Xu, Andrew Boes, Jiayang Wu, Thach Nguyen, S.T. Chu, B. E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Ultra-high bandwidth optical data transmission with a microcomb", IEEE Topical Meeting on Microwave Photonics (MPW), pp. 78-82. Virtual Conf., Matsue, Japan, November 24-26, 2020. DOI: [10.23919/MWP48676.2020.9314476](https://doi.org/10.23919/MWP48676.2020.9314476)
- [94] Mengxi Tan, Xingyuan Xu, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "RF photonic fractional signal processor based on a 50GHz Kerr micro-comb", Paper OE106-35, Paper 11279-78, SPIE Photonics West, Terahertz, RF, Millimeter, and Submillimeter-Wave Technology and Applications XIII, San Francisco, CA, 4 - 7 February (2020).
- [95] Xingyuan Xu, Mengxi Tan, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Photonic RF frequency conversion using microcombs", SPIE Photonics West, SPIE Vol. 11279, Terahertz, RF, Millimeter, and Submillimeter-Wave Technology and Applications XIII Paper No. OE106-34, Paper 11279-77, San Francisco, CA, 4 - 7 February (2020).
- [96] Mengxi Tan, Xingyuan Xu, Andreas Boes, Bill Corcoran, Jiayang Wu, Thach G. Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, David J. Moss, "Photonic RF arbitrary waveform generator based on a soliton crystal micro-comb source", *Journal of Lightwave Technology* **38** (22) Page(s): 6221-6226 (2020). DOI: 10.1109/JLT.2020.3009655.
- [97] X. Xu, M. Tan, J. Wu, A. Boes, T. G. Nguyen, S. T. Chu, B. E. Little, R. Morandotti, A. Mitchell, and David J. Moss, "Broadband photonic radio frequency channelizer with 90 channels based on a soliton crystal microcomb", *Journal of Lightwave Technology* **38** (18) 5116 - 5121 (2020). doi: 10.1109/JLT.2020.2997699.
- [98] Bill Corcoran, Mengxi Tan, Xingyuan Xu, Andrew Boes, Jiayang Wu, Thach Nguyen, Sai T. Chu, Brent E. Little, Roberto Morandotti, Arnan Mitchell, and David J. Moss, "Ultra-dense optical data transmission over standard fiber with a single chip source", *Nature Communications* **11** Article number: 2568, May 22 (2020).
- [99] A. J. Metcalf et al., "Integrated line-by-line optical pulse shaper for high-fidelity and rapidly reconfigurable RF-filtering," *Optics Express*, vol. 24, no. 21, pp. 23925-23940. 2016.
- [100] E. Sahin, K. J. A. Ooi, C. E. Png, and D. T. H. Tan, "Large, scalable dispersion engineering using cladding-modulated Bragg gratings on a silicon chip," *Applied Physics Letters*, vol. 110, 161113. 2017.
- [101] C. Wang et al., "Integrated lithium niobate electro-optic modulators operating at CMOS-compatible voltages," *Nature*, vol. 562, pp.101 2018.
- [102] D.J. Moss, M.Lamont, S.Mclaughlin, G.Randall, P.Colbourne, S.Kiran and C.A.Hulse, "Tunable dispersion and dispersion slope compensators for 10Gb/s using all-pass multicavity etalons", IEEE Photonics Technology Letters vol. 15, no. (5), 730-732 (2003). DOI: 10.1109/LPT.2003.809921.
- [103] L.M. Lunardi, D.Moss, S.Chandrasekhar, L.L.Buhl, A. Hulse, P.Colbourne, G.Randall, S.Mclaughlin, "Tunable dispersion compensators based on multi-cavity all-pass etalons for 40Gb/s systems", *Journal of Lightwave Technology*, vol. 20, no. 12, 2136 (2002). DOI: 10.1109/JLT.2002.806768.
- [104] D.J. Moss, S.Mclaughlin, G.Randall, M.Lamont, M. Ardekani, P.Colbourne, S.Kiran and C.A.Hulse, "Multichannel tunable dispersion compensation using all-pass multicavity etalons", paper TuT2 Optical Fiber Communications Conference, Anaheim (2002). Postconference Technical Digest (IEEE Cat. No.02CH37339). Opt Soc. America. Part vol.1, 2002, pp. 132-3. Washington, DC, USA.
- [105] D.J.Moss, et al., "Tunable dispersion compensation at 10 Gb/s and 40 Gb/s using multicavity all-pass etalons", Optical Fiber Communications Conference (OFC) paper TuD1, page 162, Atlanta, GA, March (2003). Post-conference Digest (IEEE Cat. No.03CH37403). Opt. Soc. America. Part vol.1, 2003, pp. 162-3. Washington, DC, USA.
- [106] L.M. Lunardi, D.J. Moss, S. Chandrasekhar, L.L. Buhl, "An Etalon-Based Tunable Dispersion Compensator (TDC) Device for 40-Gbit/s Applications", European Conference on Optical Communications (ECOC), Paper 5.4.6 Copenhagen, Sept. (2002). IEEE. Part vol. 2, 2002, pp. 2 vol. 2. Piscataway, NJ, USA. Print ISBN: 87-90974-63-8. Print ISBN: 87-90974-63-8.
- [107] V.G. Ta'eed et al., "Error free all optical wavelength conversion in highly nonlinear As-Se chalcogenide glass fiber", *Optics Express* vol. 14 (22), 10371-10376 (2006).