

# Chirped-pulse WDM

Bahram Jalali

UCLA

jalali@ucla.edu

# Report Documentation Page

*Form Approved  
OMB No. 0704-0188*

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE <b>18 APR 2000</b>	2. REPORT TYPE <b>N/A</b>	3. DATES COVERED <b>-</b>	
4. TITLE AND SUBTITLE <b>Chirped Pulse WDM</b>		5a. CONTRACT NUMBER	
		5b. GRANT NUMBER	
		5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)		5d. PROJECT NUMBER	
		5e. TASK NUMBER	
		5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>University of California LA</b>		8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)	
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>			
13. SUPPLEMENTARY NOTES <b>DARPA/MTO, WDM for Military Platforms Workshop held in McLean, VA on April 18-19, 2000, The original document contains color images.</b>			
14. ABSTRACT			
15. SUBJECT TERMS			
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>	<b>UU</b>
			18. NUMBER OF PAGES <b>16</b>
			19a. NAME OF RESPONSIBLE PERSON

# Applications

Telecom

Mux/Demux

Analog-to-Digital Conversion

Sampler

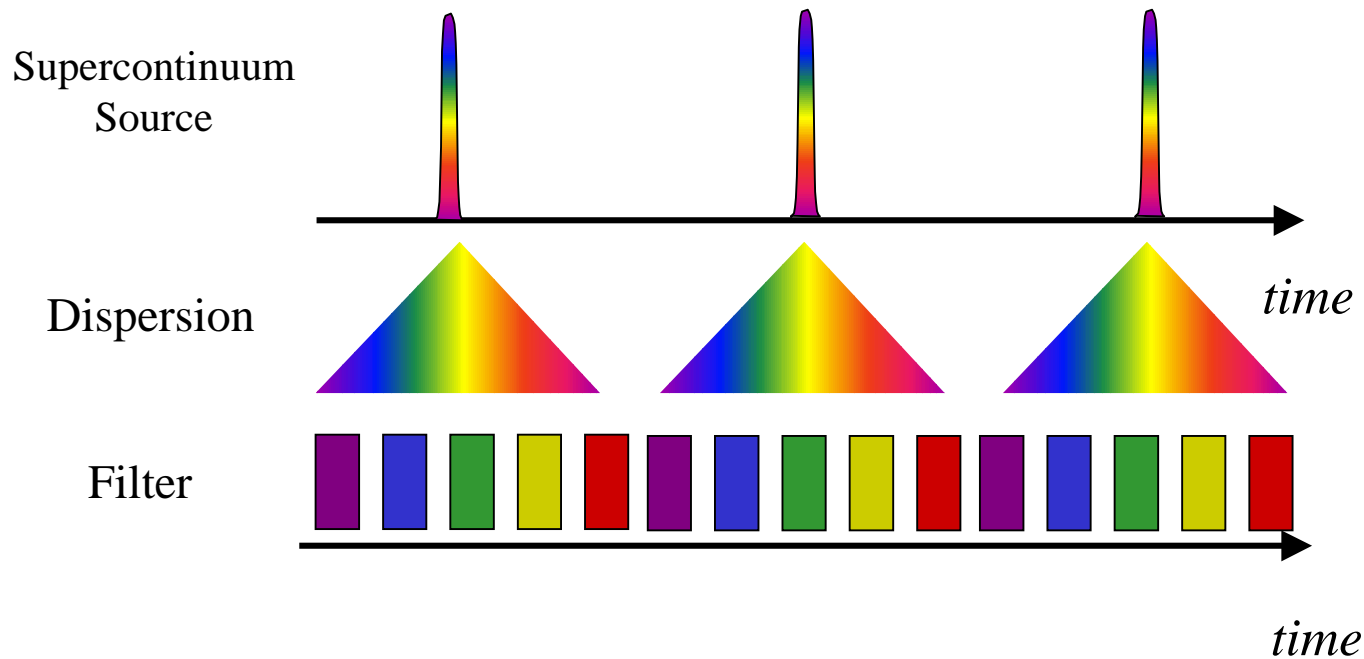
Time Stretch

Spectroscopy

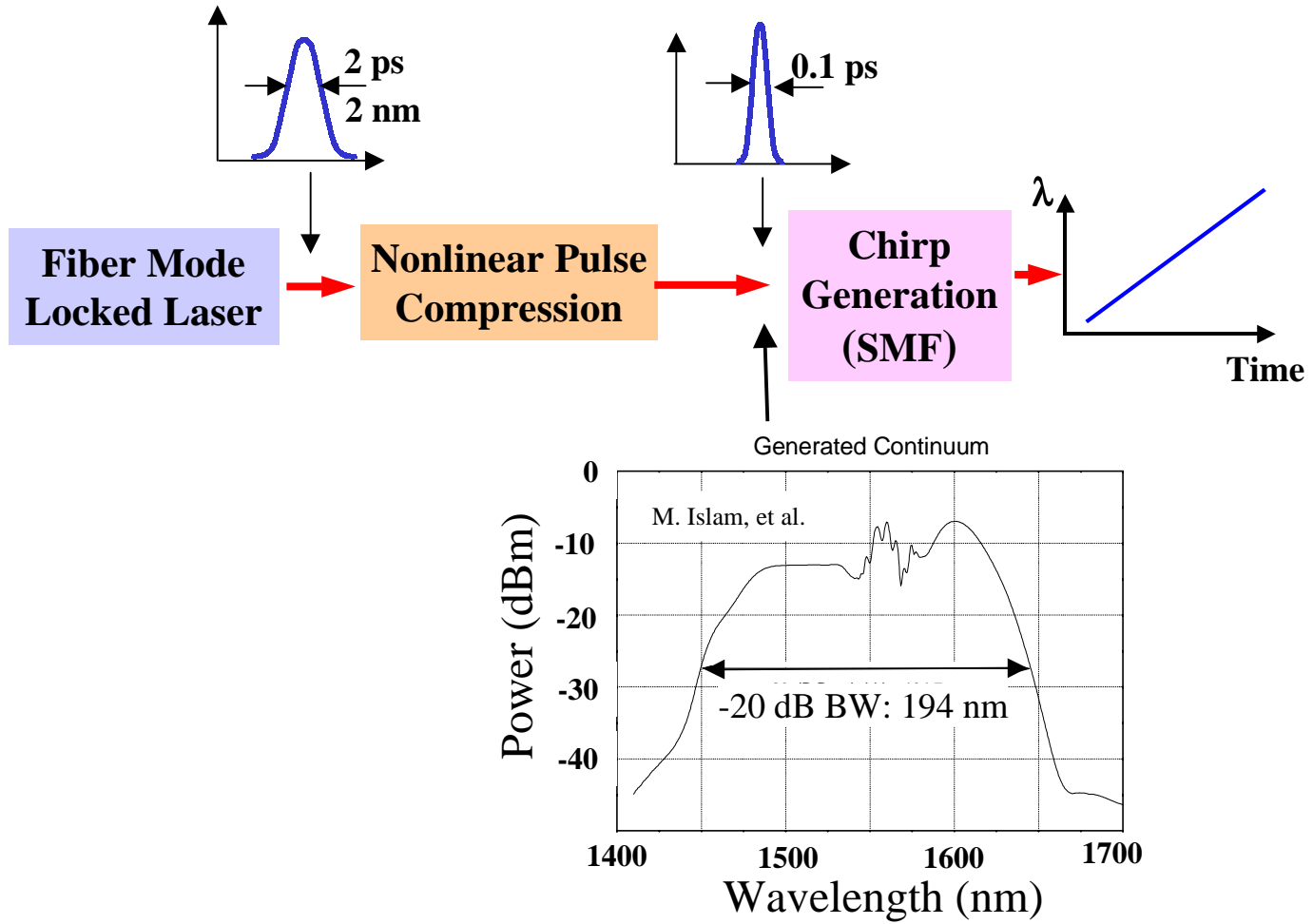
Time domain spectral measurements

Other?

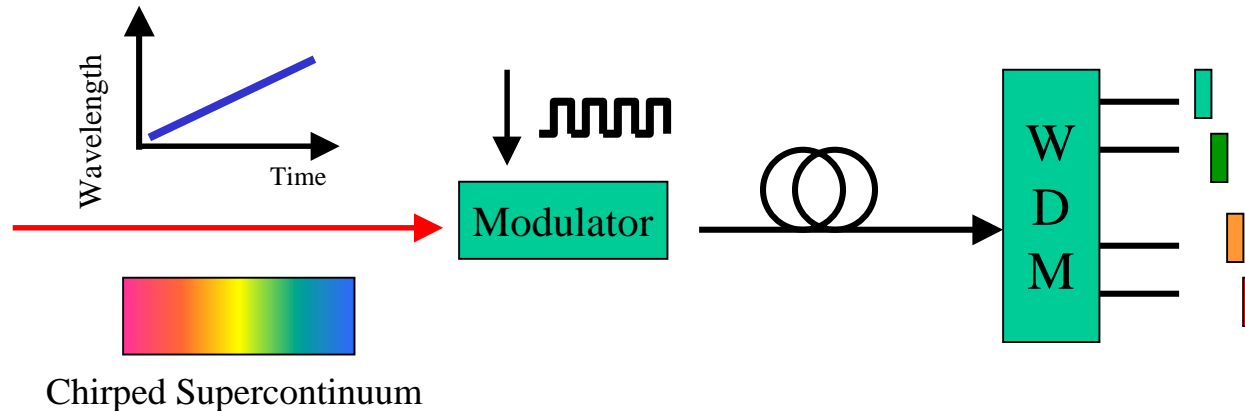
# Spectral Slicing of Chirped Supercontinuum Pulses



# Supercontinuum Generation



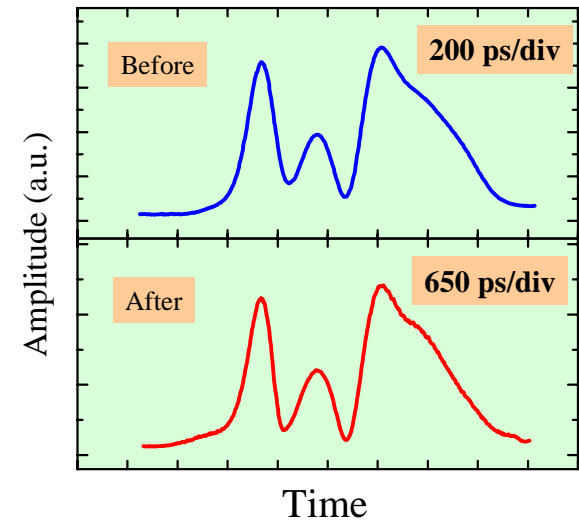
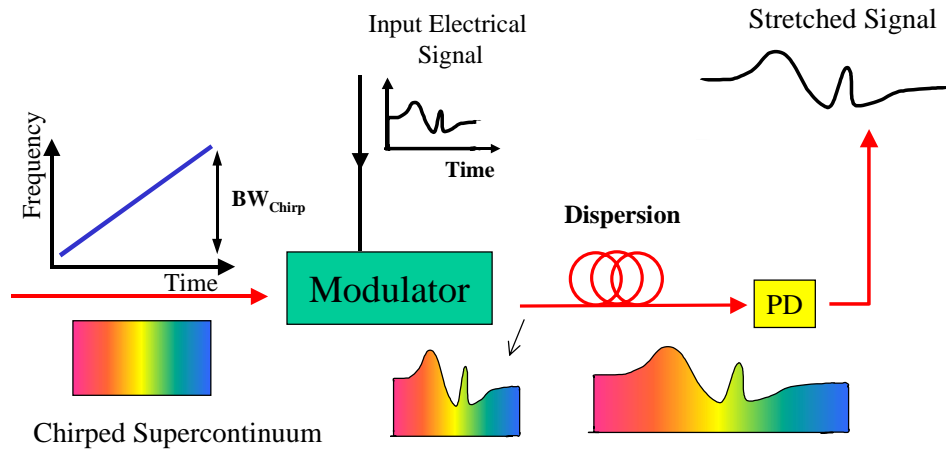
# Chirped Pulse WDM



## Multiplexing / Demultiplexing:

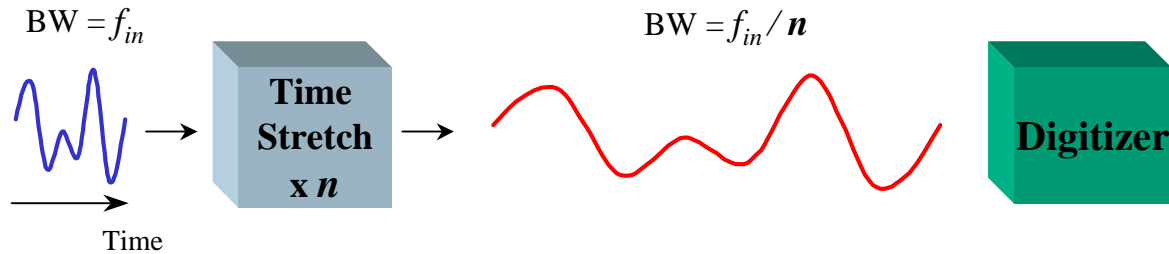
- Morioka, T.; Kawanishi, S.; Takara, H.; Saruwatari, M. *Electron. Lett.*, 1994, vol.30, (no.23), pp.1959-60
- Cundiff, S.T., Knox, W.H., and Nuss, M.C. *Electron. Lett.*, 1997, **33**, (1), pp.10 – 11

# Time Stretching

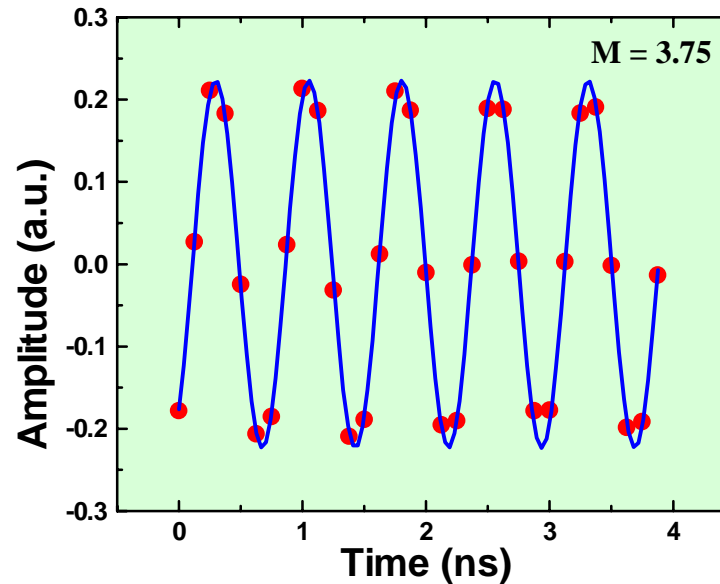


F. Coppinger, A. Bhsuah, B. Jalali, *Electronics Letters*, 34 (4), 1998.

# Time Stretch ADC (TSADC)



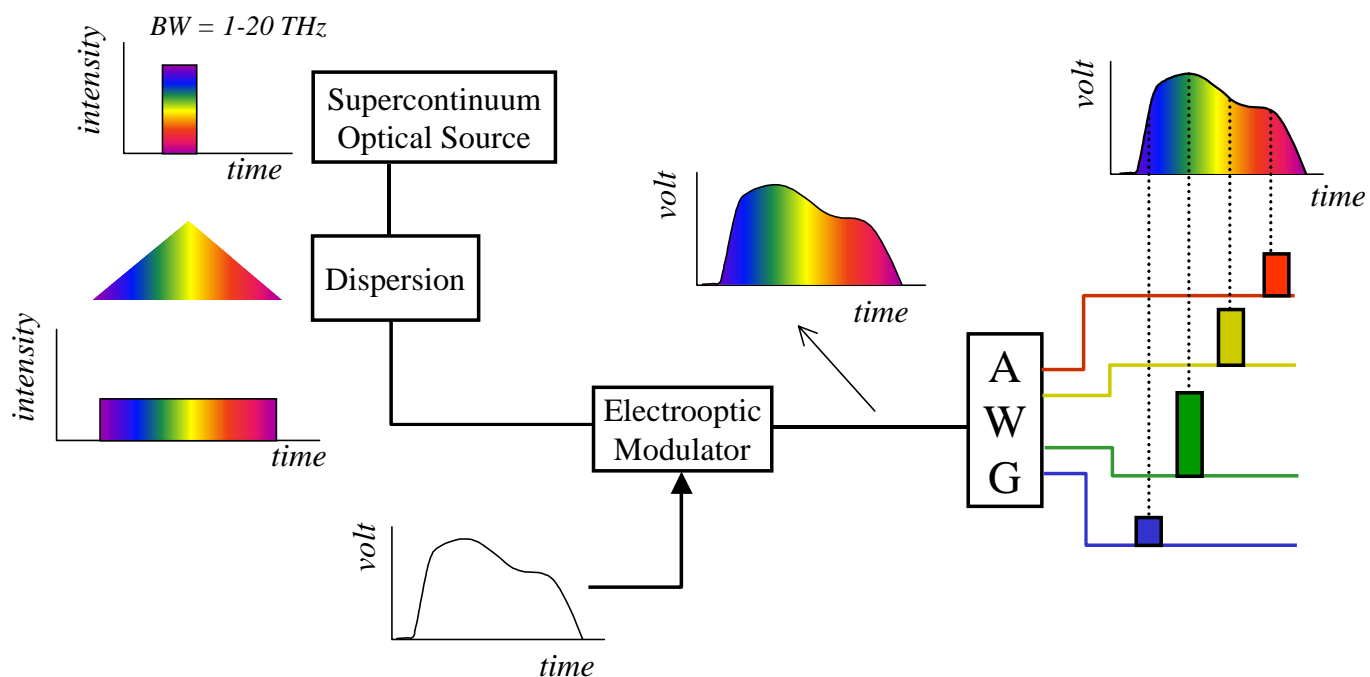
**30 GSample/s, 5 GHz input, 4 bit**



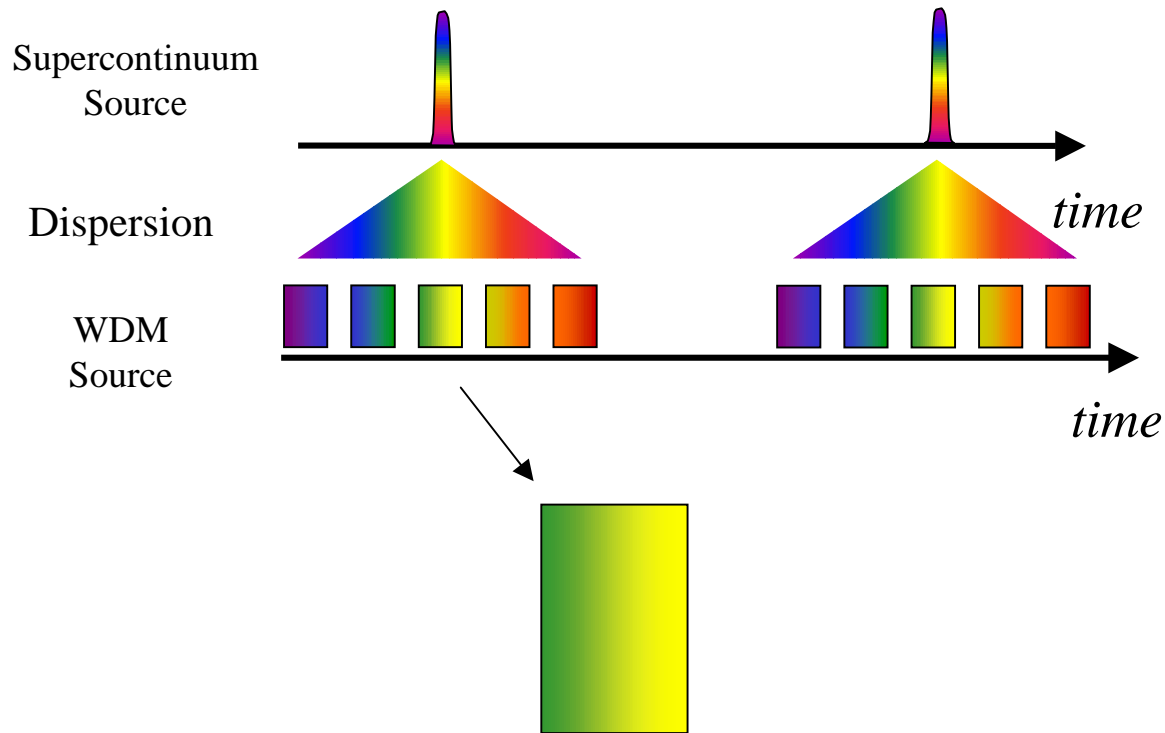
*A.S. Bhushan et al., CLEO 2000.*



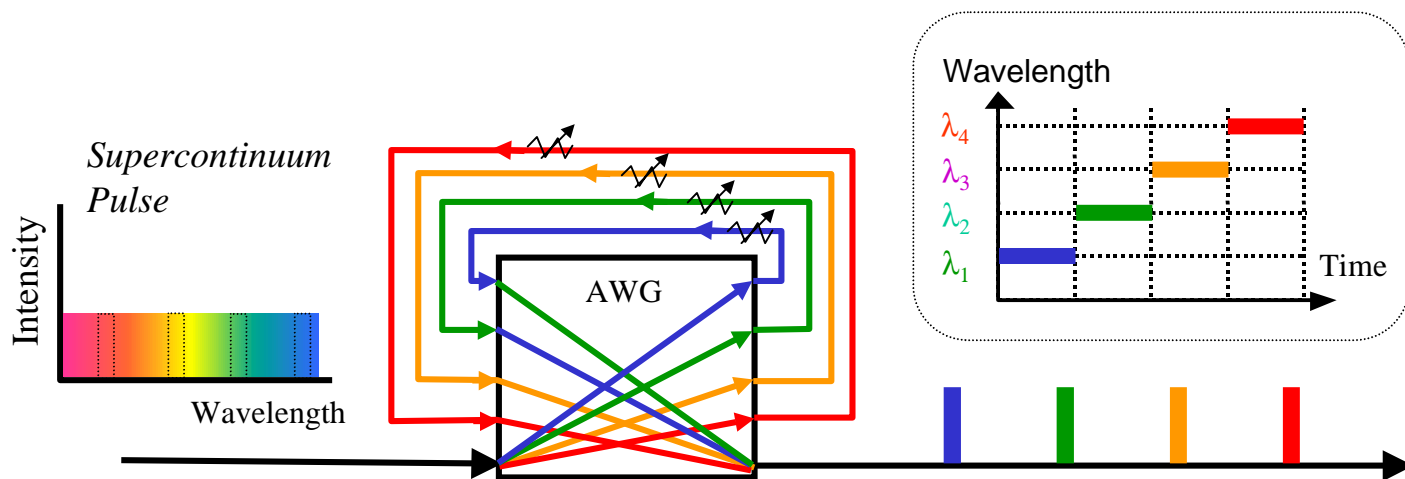
# Wavelength Division Sampling



# Problem with Dispersive Chirp Generation



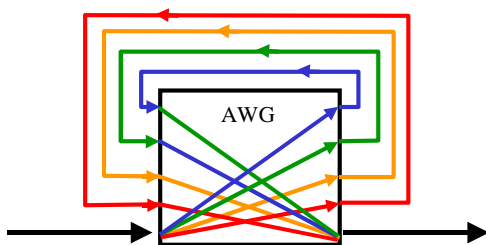
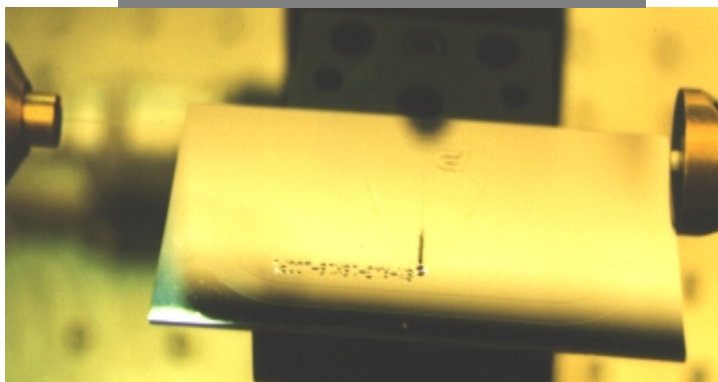
# Chirp-Free WDM Source Using True Time Delay



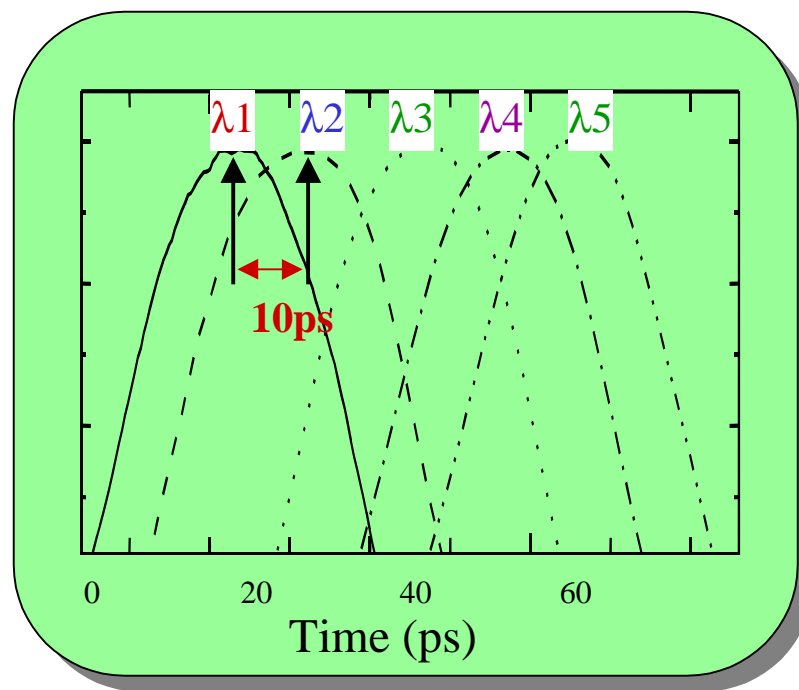
\*Jalali and Yegnanarayanan, US Patent No. 5,793,907

# Experimental Results

- 16 Channel Filter
- Integrated Delay Lines
- 10 ps Incremental delay



**100 Gbit/s**



$$\Delta\tau \Delta f = 0.49$$

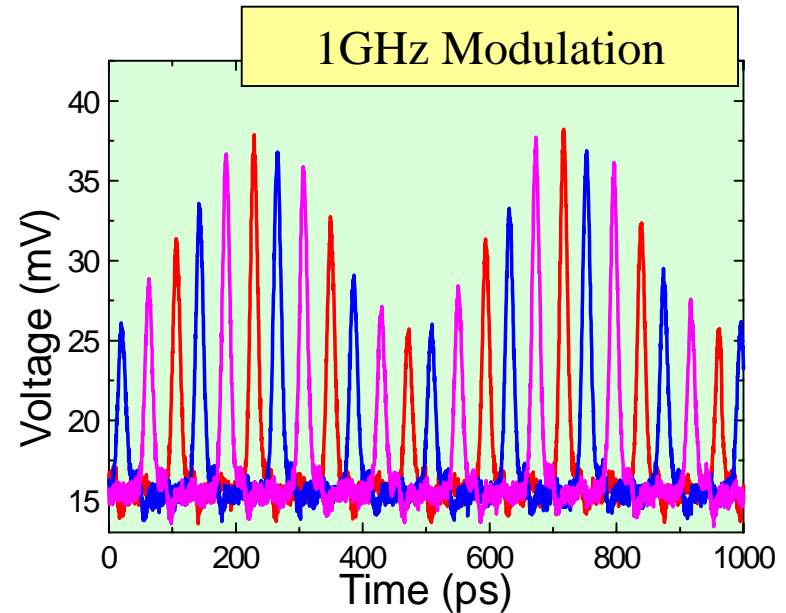
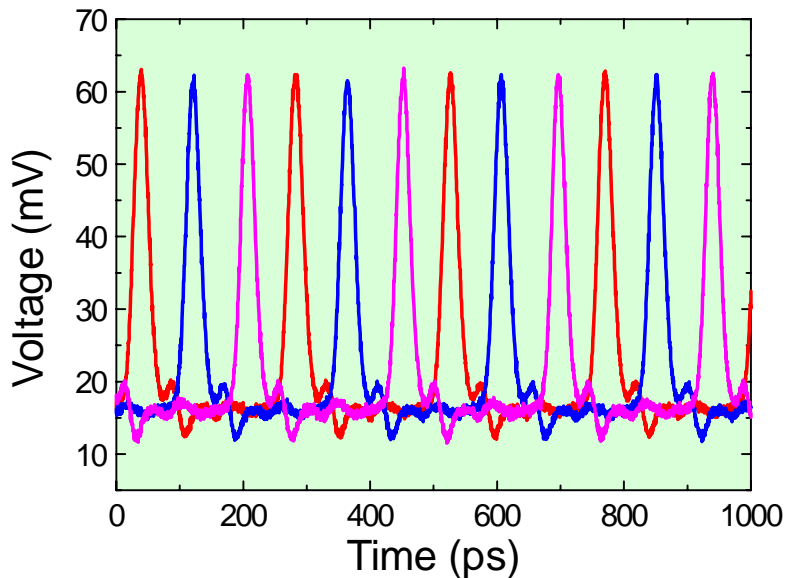
(Autocorrelation)

A.S. Bhushan, F. Coppinger, S. Yegnanarayanan and B. Jalali, *Optics Letters*, vol. 24, (11), 1999.

# Wavelength Division Sampling

Experimental 12 Gs/s  
continuous-time sampling

- 1547.8nm
- 1548.6nm
- 1549.4nm



# 12 Gsample/s Wavelength Division ADC

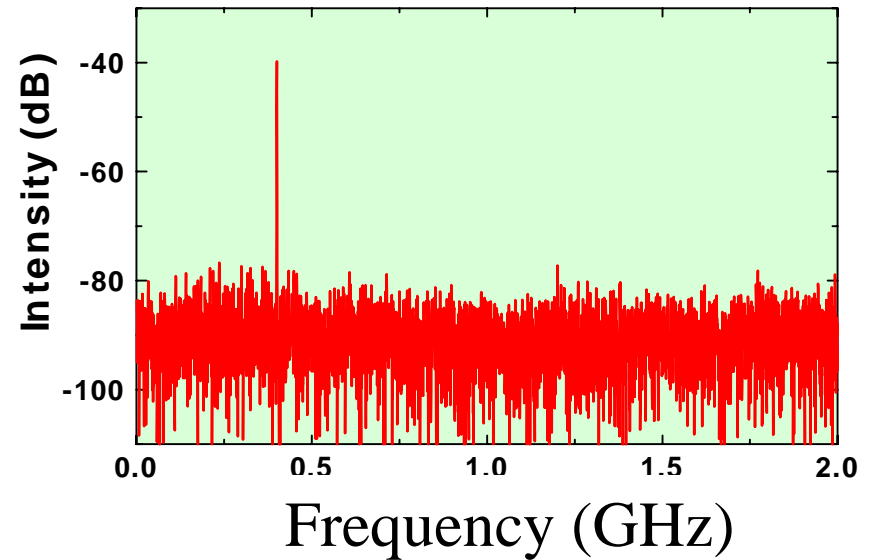
Modulation Frequency: 3600MHz

Aliased peak 400MHz

SFDR: 40dB

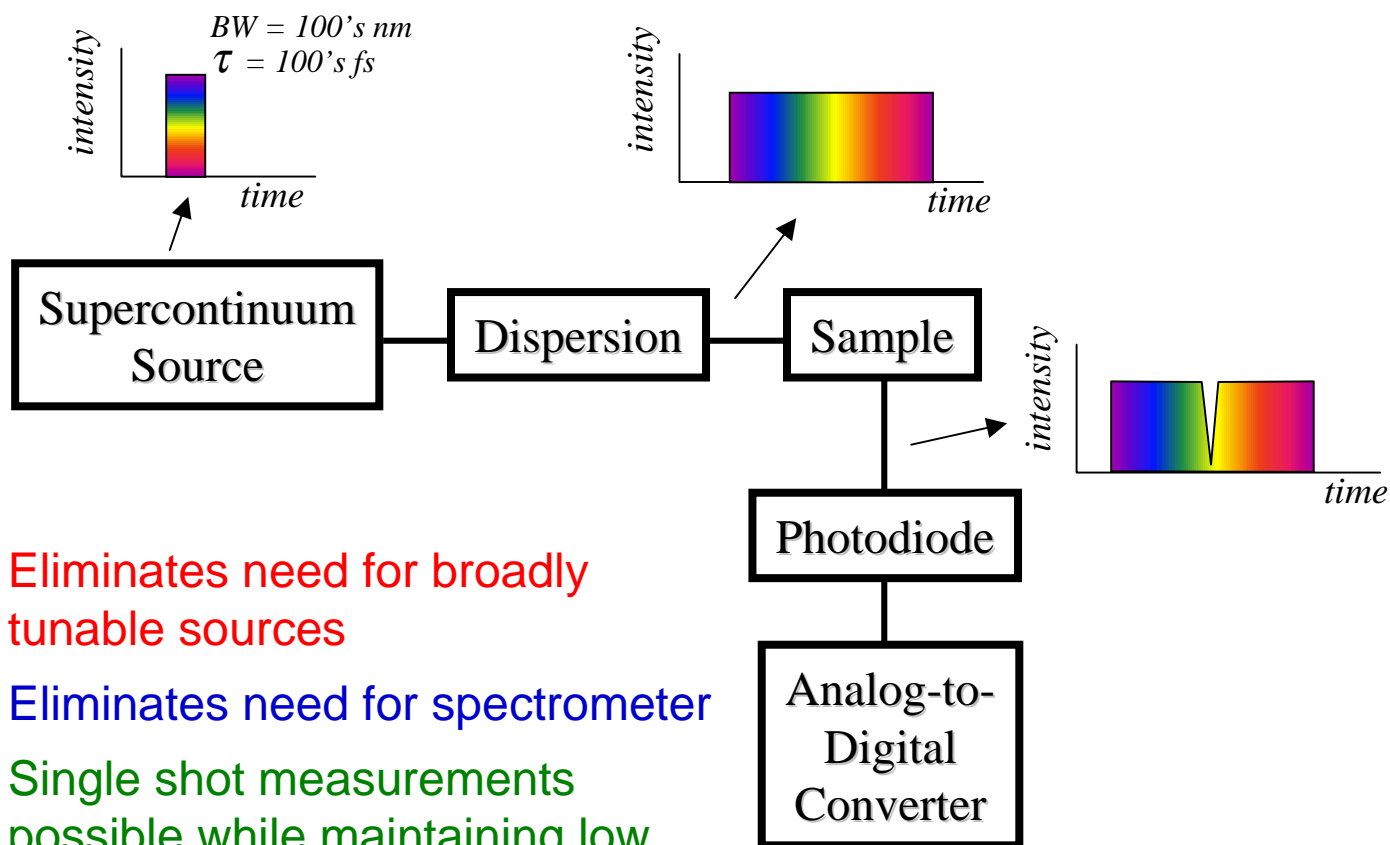
SNR: 32dB (5 bits)

FFT of one channel  
of digitized data



F. Coppinger, A.S. Bhushan, B. Jalali, IEEE Microwave Photonics Conference, MWP 1999

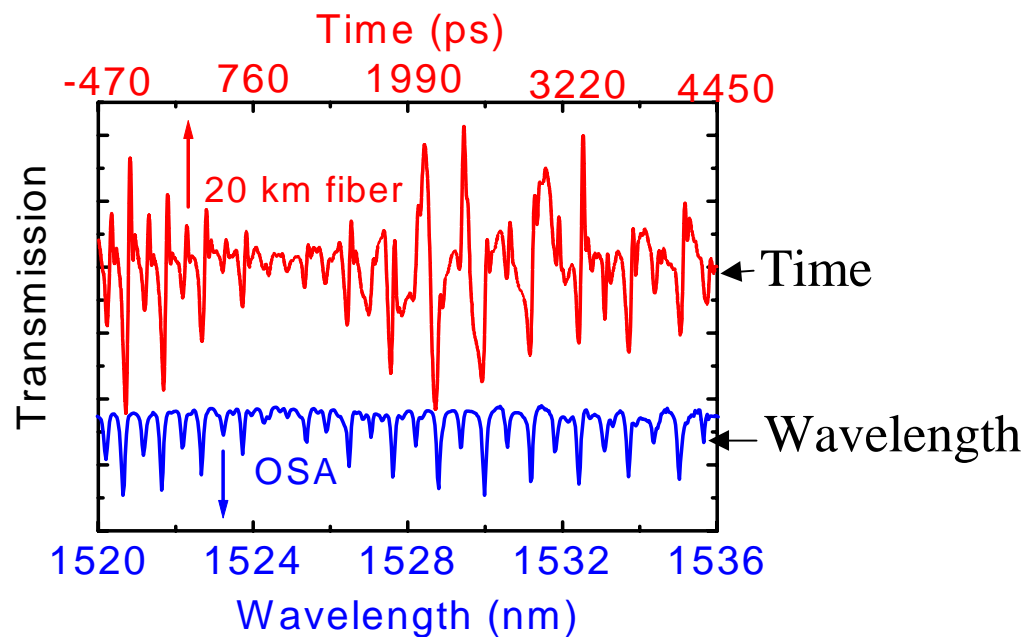
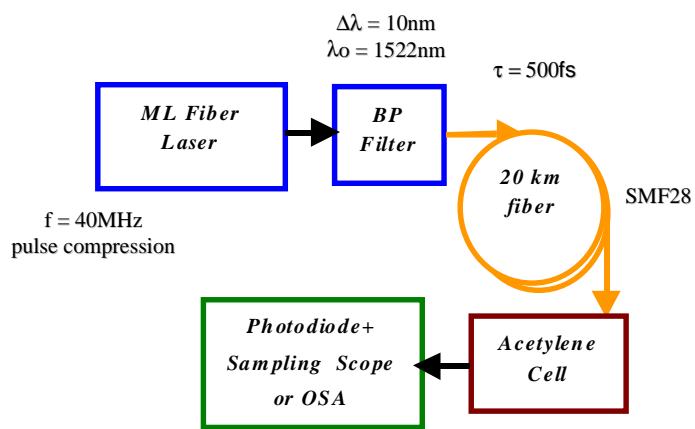
# Time Domain Spectroscopy



- Eliminates need for broadly tunable sources
- Eliminates need for spectrometer
- Single shot measurements possible while maintaining low peak power

P. V. Kelkar, F. Coppinger, A. S. Bhushan, , B. Jalali, Electronic Letters, Vol 35 (19), p. 1661-1663, (1999).

# Experimental Verification



Resolution is comparable to the highest resolution,  
**0.08 nm**, available for HP optical spectrum analyser (OSA).

P. V. Kelkar, F. Coppinger, A. S. Bhushan, B. Jalali, *Electronic Letters*, Vol 35 (19), p. 1661-1663, (1999).



# Future Work

- Alternative low cost supercontinuum sources
  - Low cost fiber lasers
  - Alternative sources
  - Low cost, high power optical amplifiers
  - Other wavelength bands
- Beyond telecom, ADC, spectroscopy