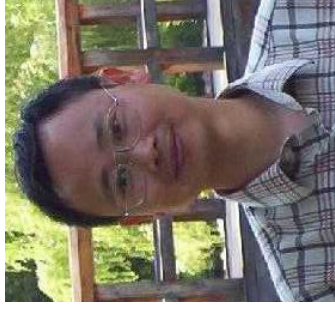


Digital Processing with Semiconductor Optical Amplifiers

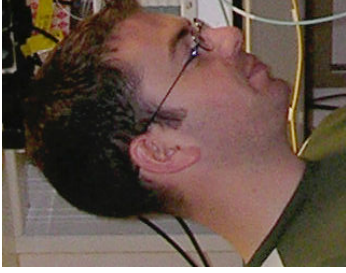
Photonic Systems Group: SOA Team



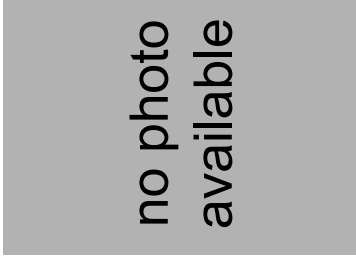
Bob Manning



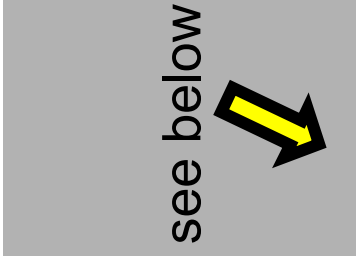
Xuelin Yang



Robin Giller



Alan Riordan



Rod Webb



Photonic Systems Group

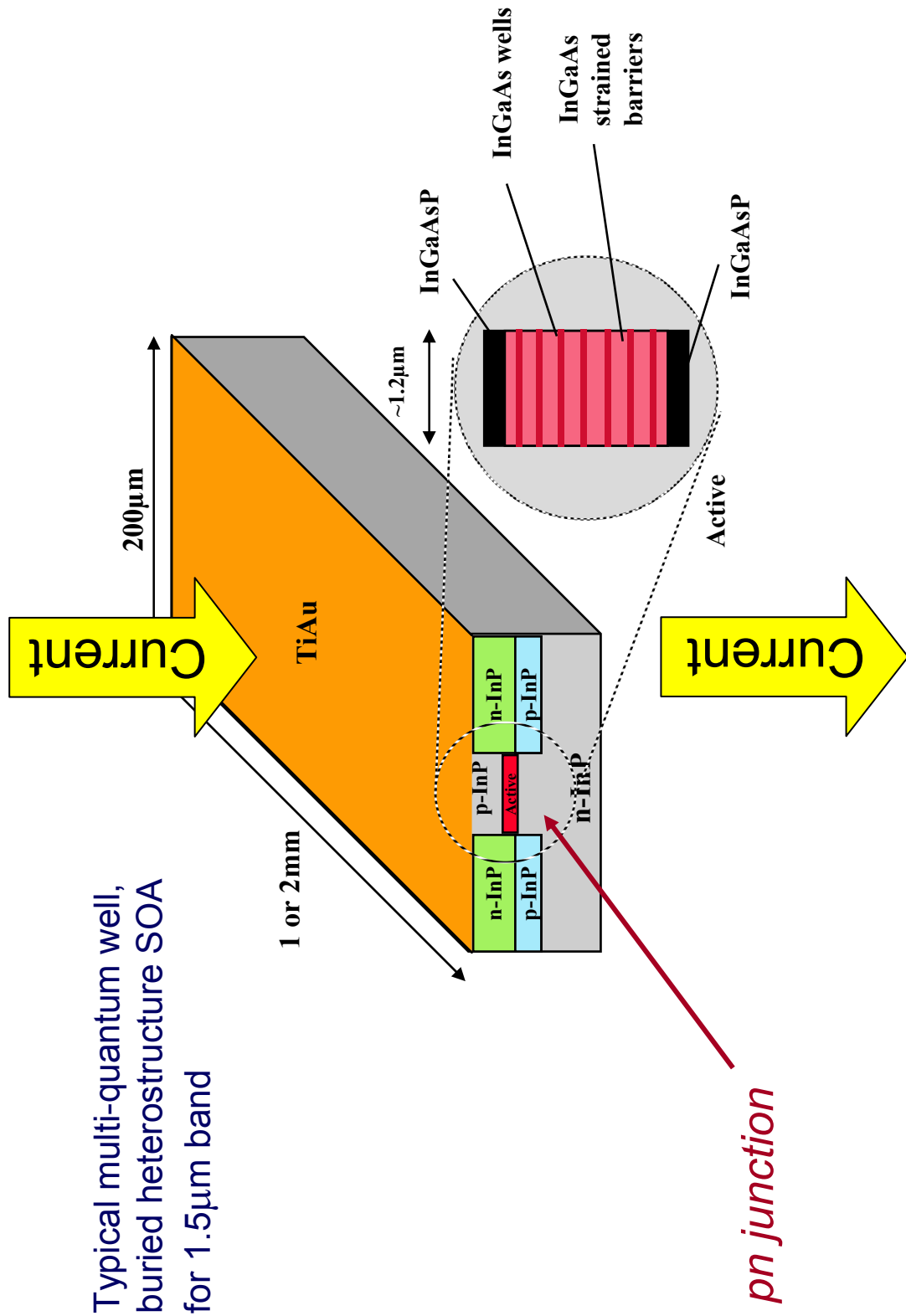


Outline

- Semiconductor optical amplifiers (SOAs) as optical switches
- Examples of activity in PSG
 - Study of switching speed
 - An example optical logic circuit
- Project

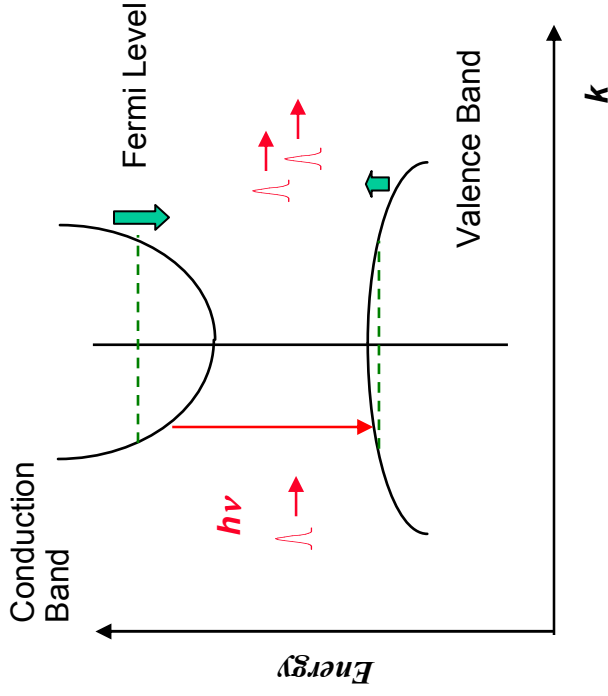
SOA: Structure

Typical multi-quantum well,
buried heterostructure SOA
for 1.5 μm band

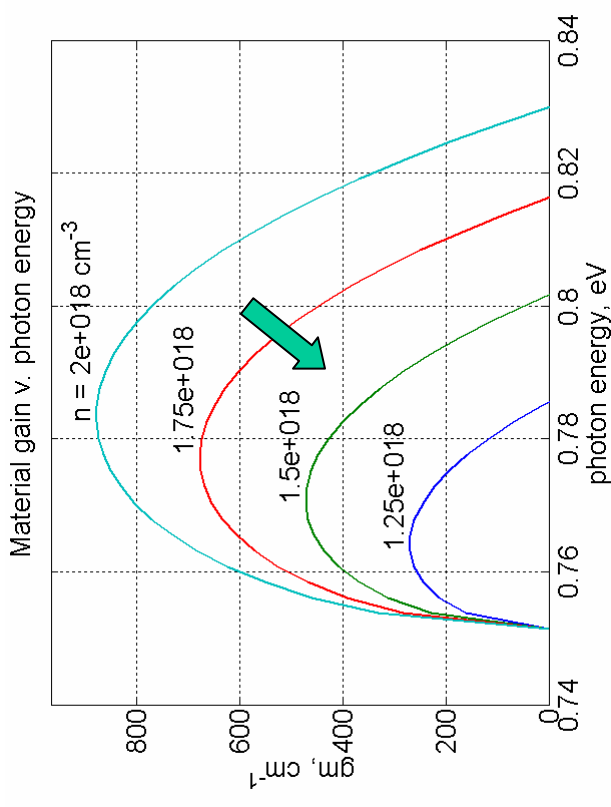


SOA: Cross-Modulation

Stimulated Emission



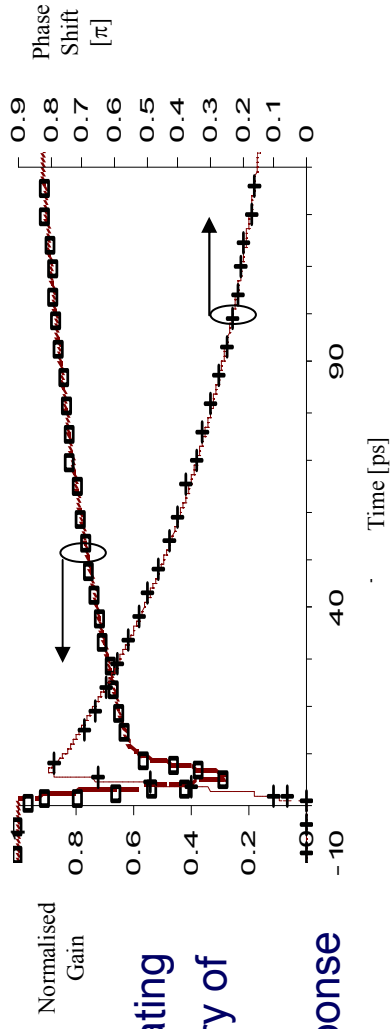
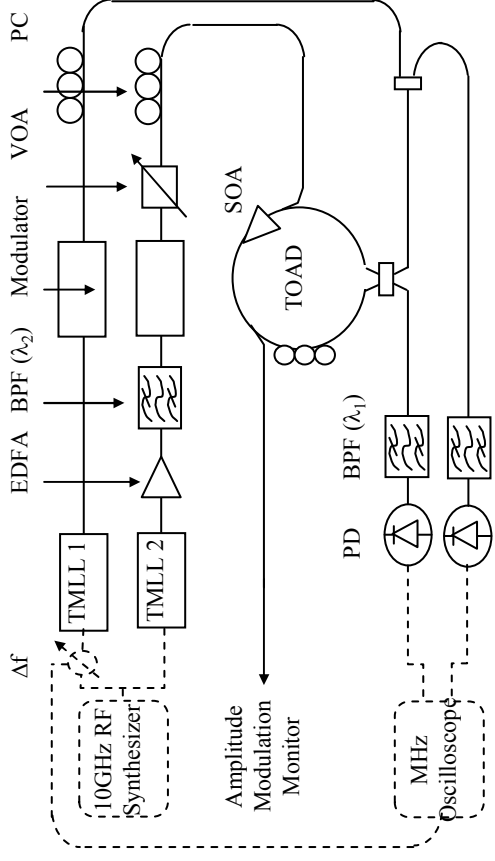
Gain Spectra



- Population inversion reaches balance between pump current and recombination
- Gain saturates readily – cross-gain modulation
- Refractive index change accompanies gain change – cross-phase modulation

High-Speed SOA Characterisation

- Pump-probe lasers sample response with 3ps resolution.
- SOA under test placed in interferometer.
- Amplitude and phase response calculated from outputs.

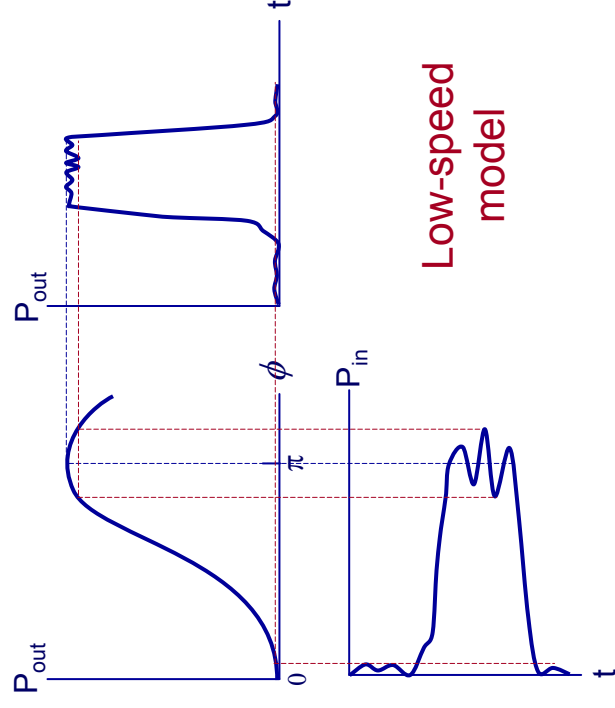
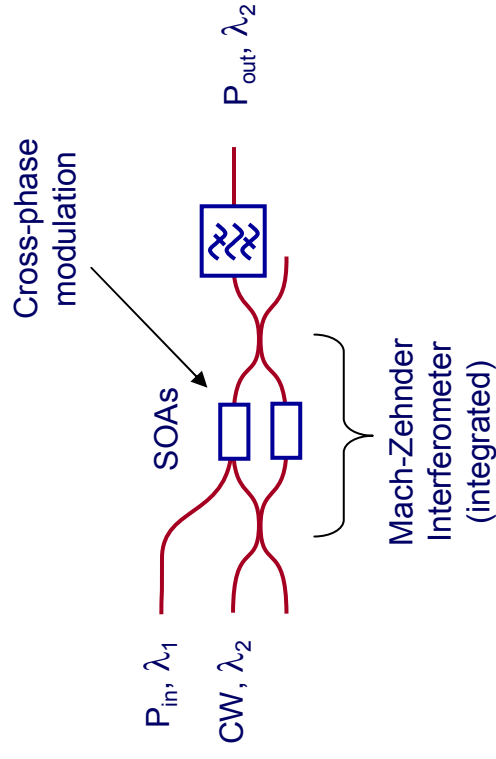


- Gain shows 2-stage recovery
 - Fast (1ps) due to carrier heating
 - Slow (~50ps) due to recovery of population inversion
- Phase shows negligible fast response

R. Giller and R.J. Manning, OFC, 2006

Optical Logic Gate

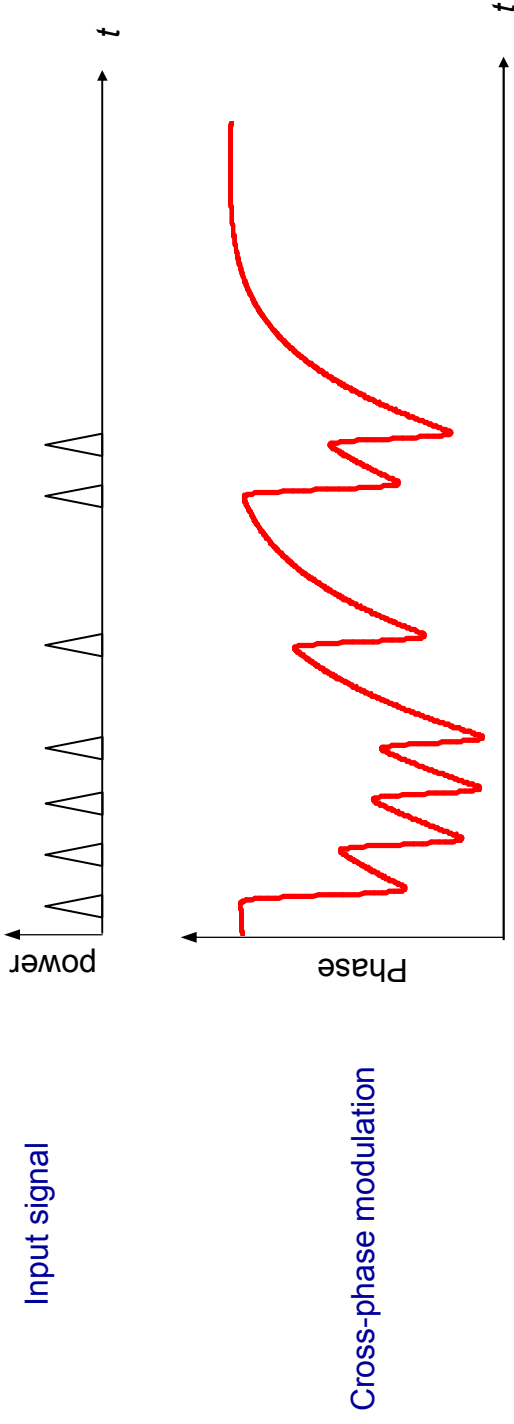
Interferometer converts phase change to amplitude change



Interferometer characteristic => regenerative response

Recovery Time Limitation

At 40Gbit/s, population inversion does not fully recover between bits.

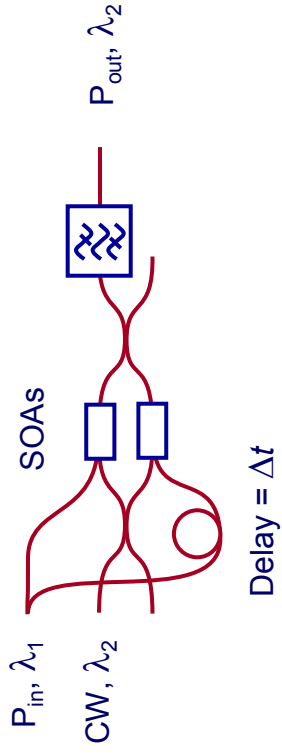


Solution:

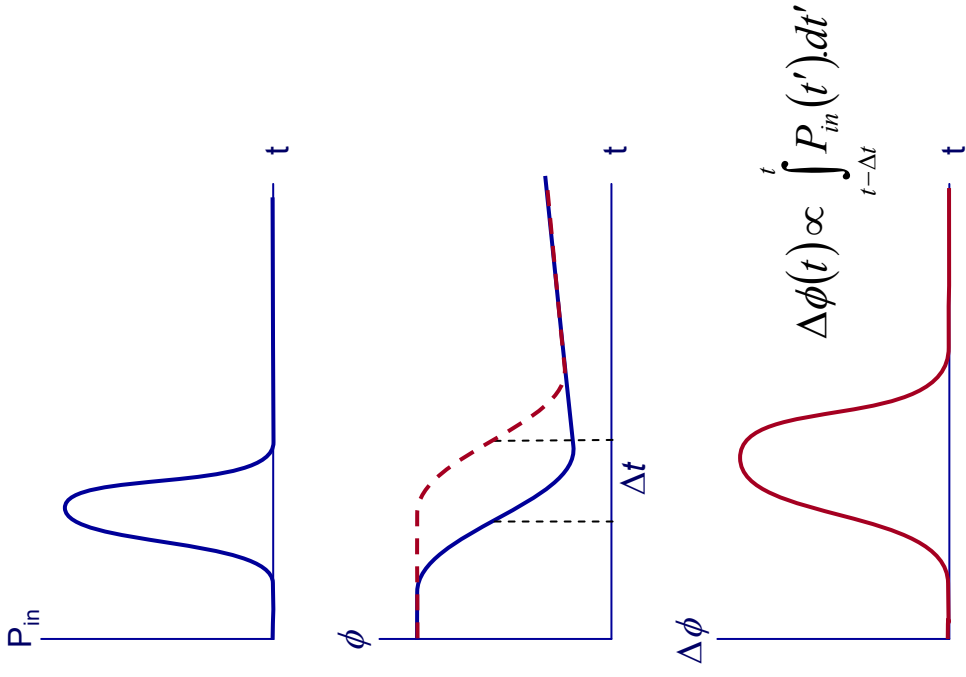
- Increase speed by
 - amplifier design
 - holding beam
- Use differential operation

Differential Operation

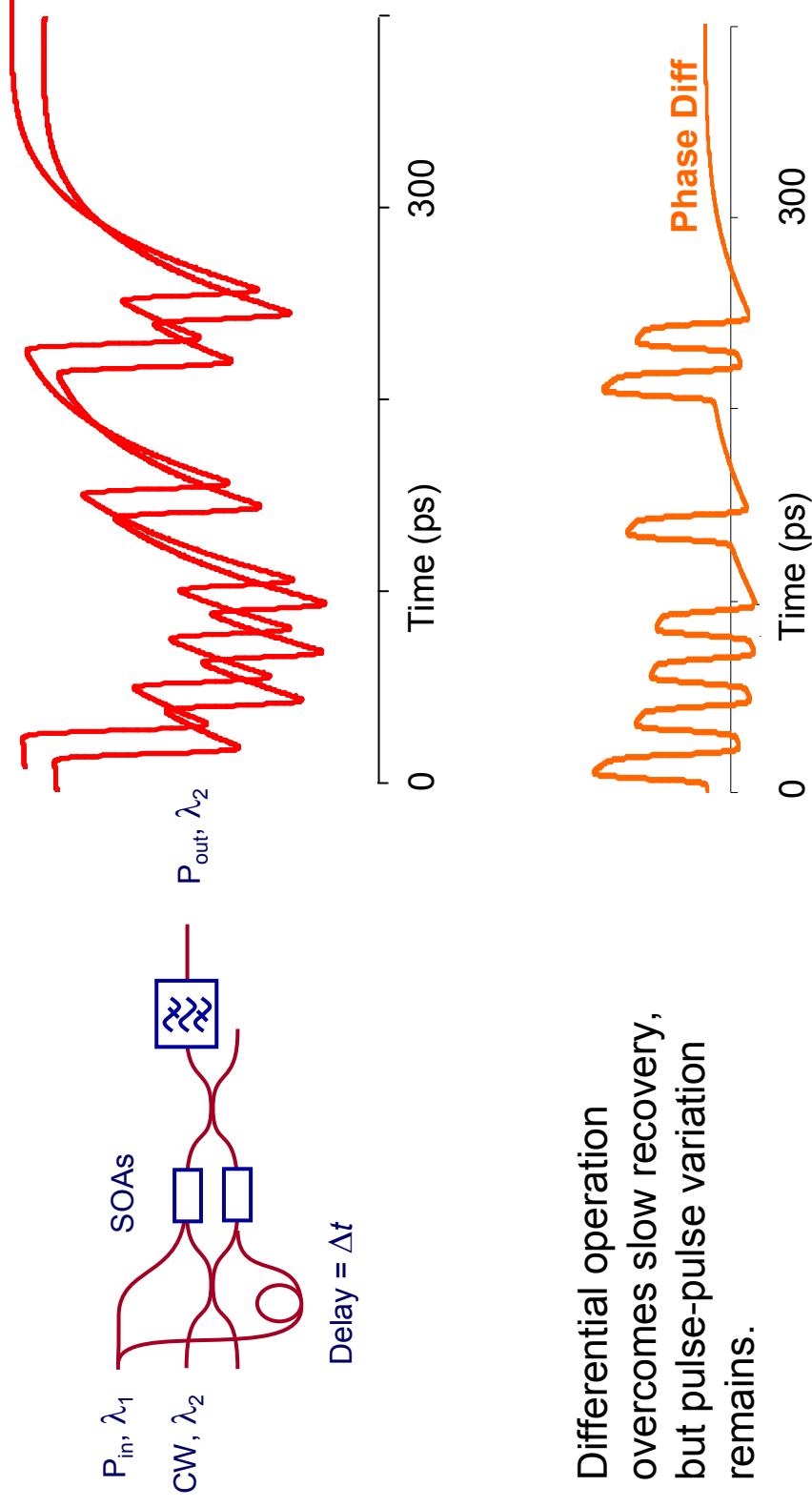
Push-pull arrangement.
Transmission depends on phase difference between interferometer arms.



Overcomes “linear” patterning, but
“nonlinear” patterning remains.

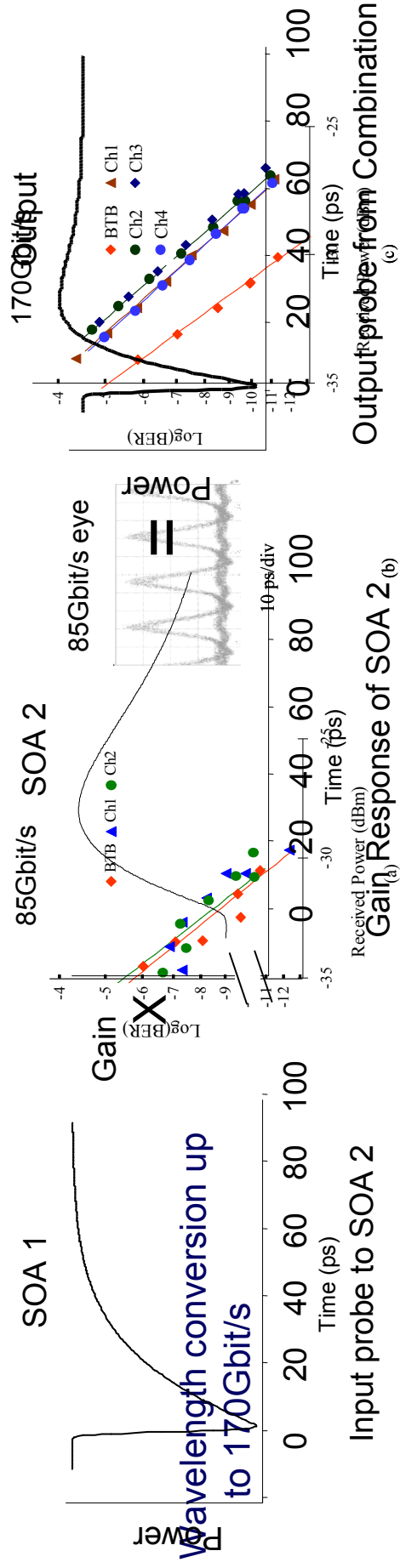
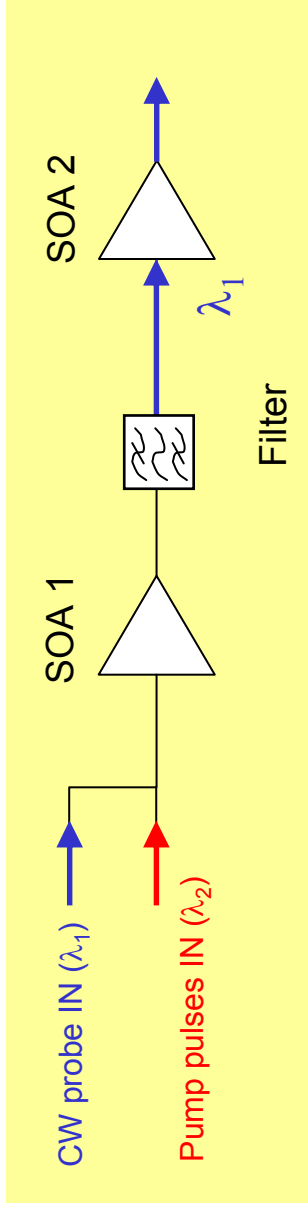


Nonlinear Patterning



Differential operation
overcomes slow recovery,
but pulse-pulse variation
remains.

“Turboswitch”

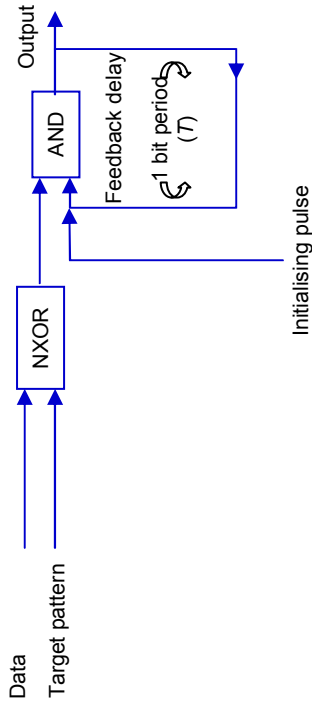


R.J. Manning, X. Yang, R.P. Webb, R. Giller, F.C. Garcia Gunning, A.D. Ellis, OFC 2006

Rod Webb, Photonic Systems Group

Example Application: Pattern Recognition

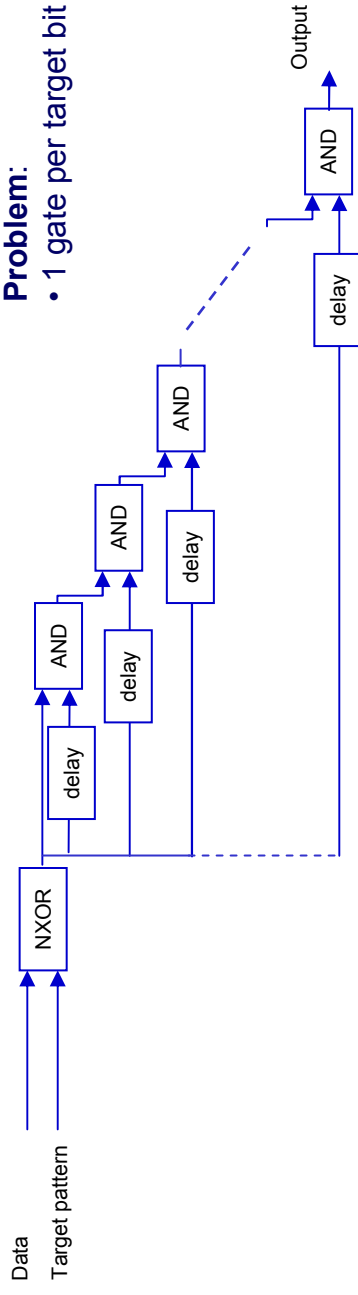
System A: feedback



Problem:

- 1 bit period at 40Gb/s = 25ps
- SOA propagation time = 10-20ps

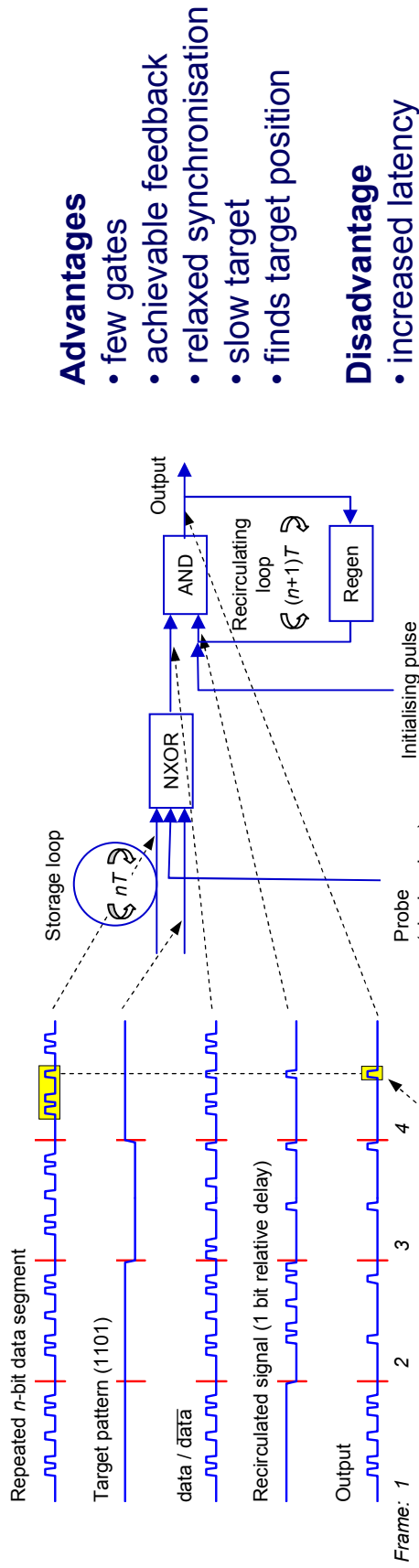
System B: pipelined



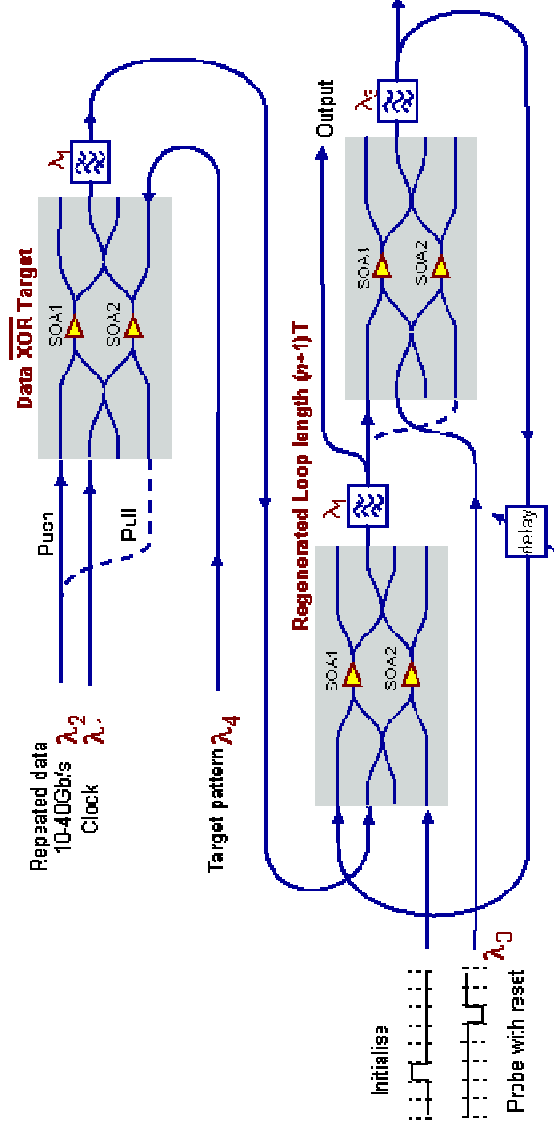
Problem:

- 1 gate per target bit

Pattern Recognition System

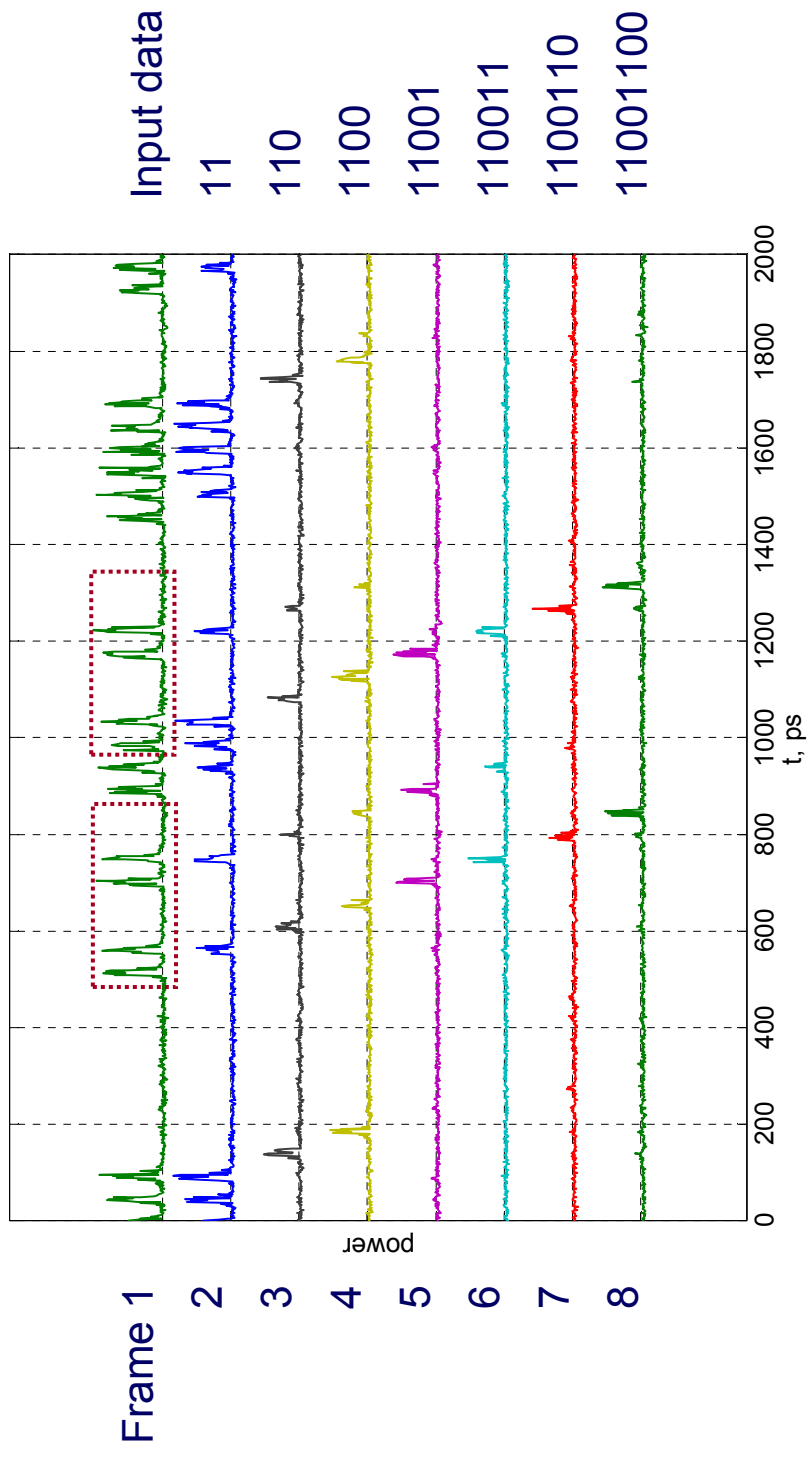


Outline of experiment

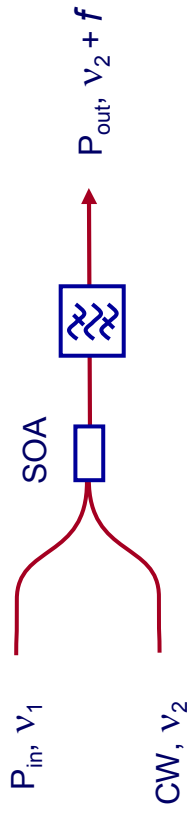


Pattern Recognition Demonstration

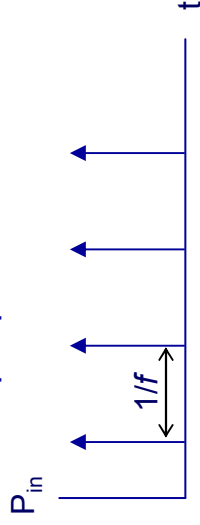
Experiment at 20Gb/s. Target = 11001100



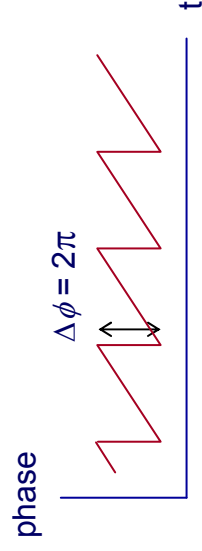
Project: Frequency Shifter



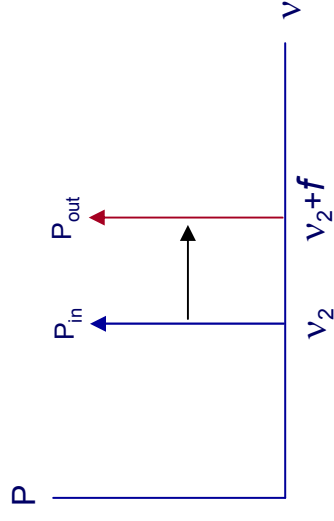
Input pulse train



SOA response



Output spectrum



Conclusions

- We do optical switching
- We've got a cool project