Performance of A Liquid Crystal Optical Gate for Suppressing Laser Backscatter in Monostatic Kilohertz SLR Systems

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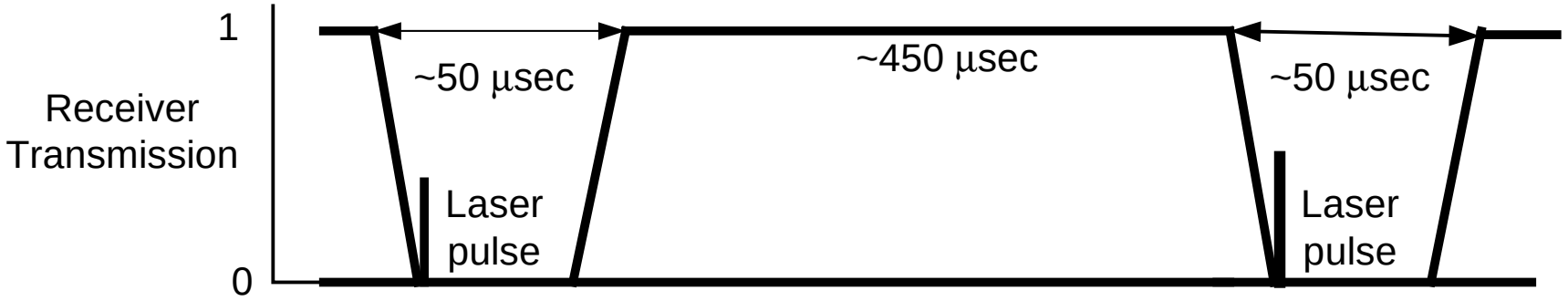
OPTICAL GATE GOAL

•Optical gate extends photocathode life by protecting the sensitive and expensive photon-counting MCP/PMT from internal and atmospheric laser backscatter

•Simultaneously varying the laser fire time to avoid “collisions” between outgoing and incoming pulses totally eliminates backscatter during the most critical period when the MCP/PMT is gated on, minimizes data loss, and prevents corruption of the quadrant detector pointing correction



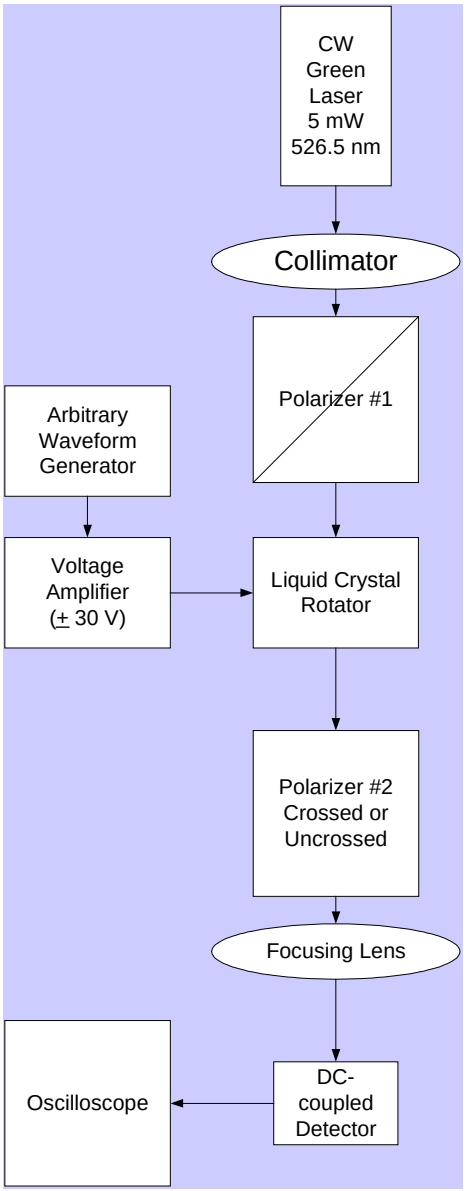
Optical Gate Requirements

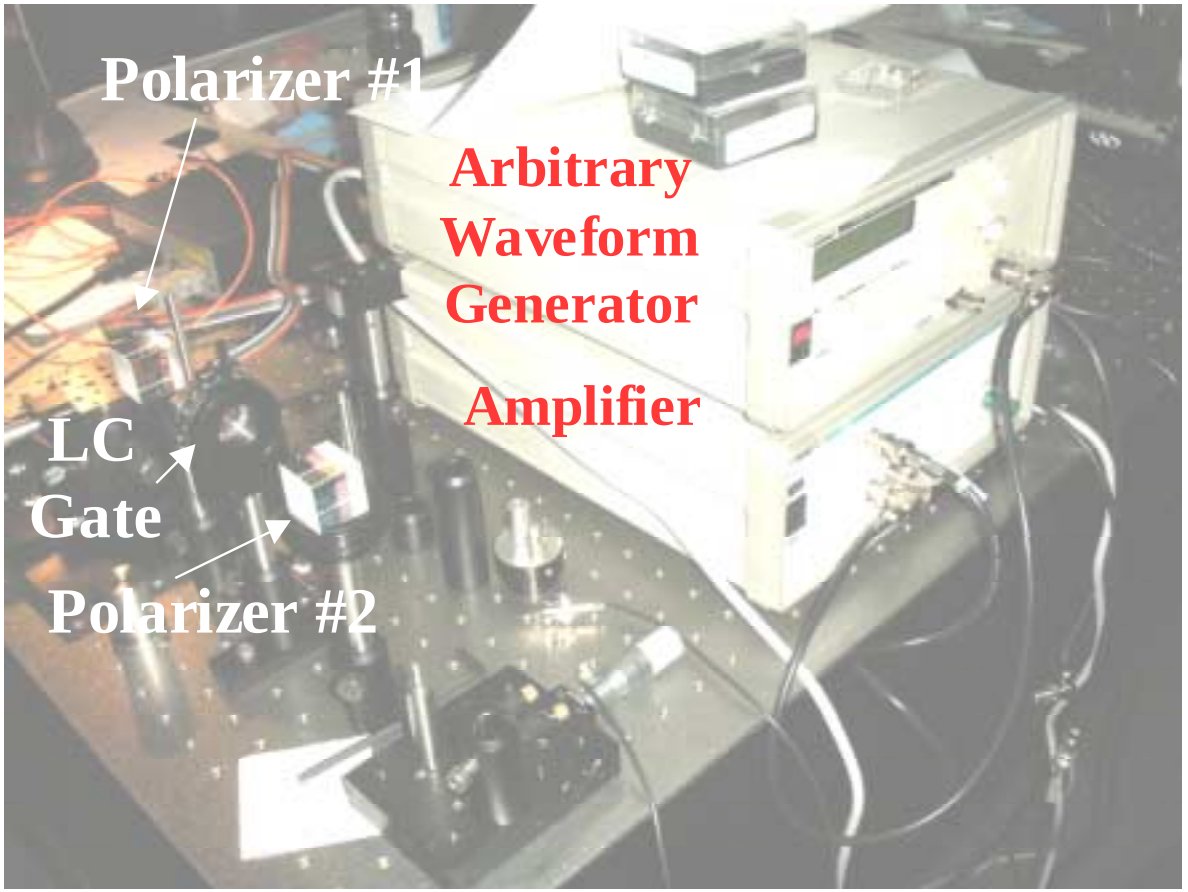
- Operate at SLR2000 2 kHz laser fire rate
- Accommodate a 13 mm receiver beam diameter
- Block atmospheric backscatter for several tens of microseconds following laser fire
- High backscatter extinction in blocked mode
- High transmission in unblocked mode
- Fast transition between blocked and unblocked modes
- Accommodate variable fire rate used to avoid “pulse collisions”
- Can take advantage of linearly polarized light in two SLR2000 receiver channels if necessary

Gate Approaches Considered

Gating Approach	Speed	Aperture	Transmission	Gate Duration
Mechanical	Poor	Poor	Excellent	Poor
Electro-optic	Excellent	Good	Good	Poor (2-3 kV)
Acousto-optic	Good	Poor	Fair	Good
Liquid Crystal	Good	Good	Good	Good (±30V)

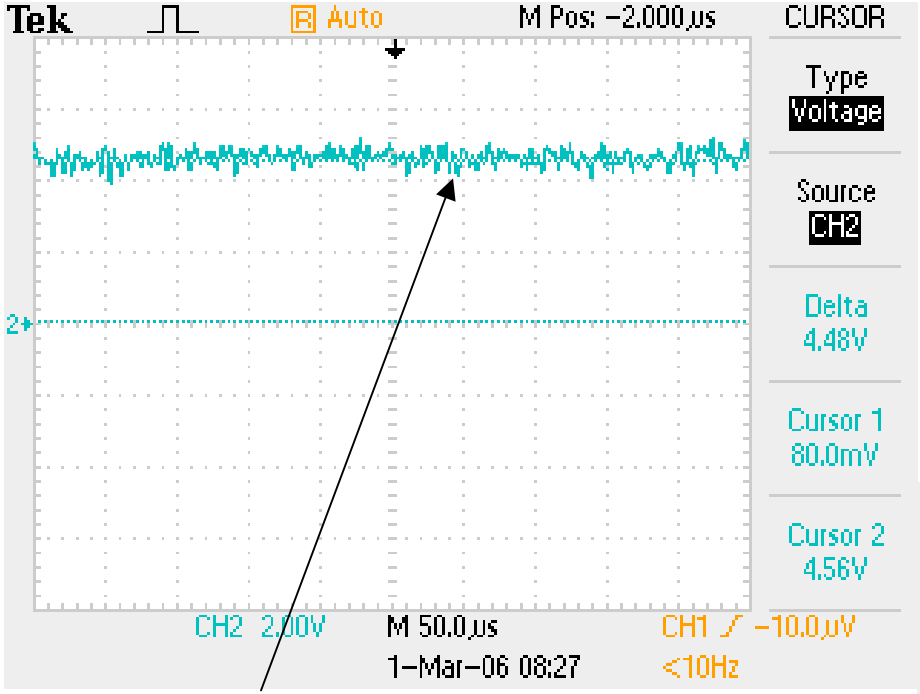
Experiment Configuration





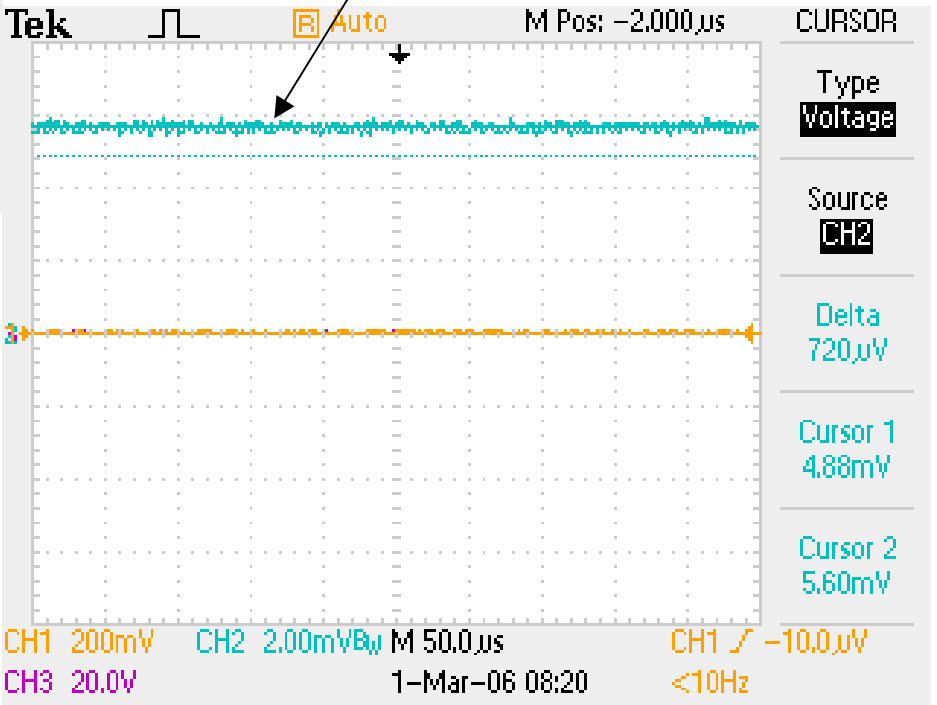
Extinction of Crossed Polarizers

(no liquid crystal rotator)

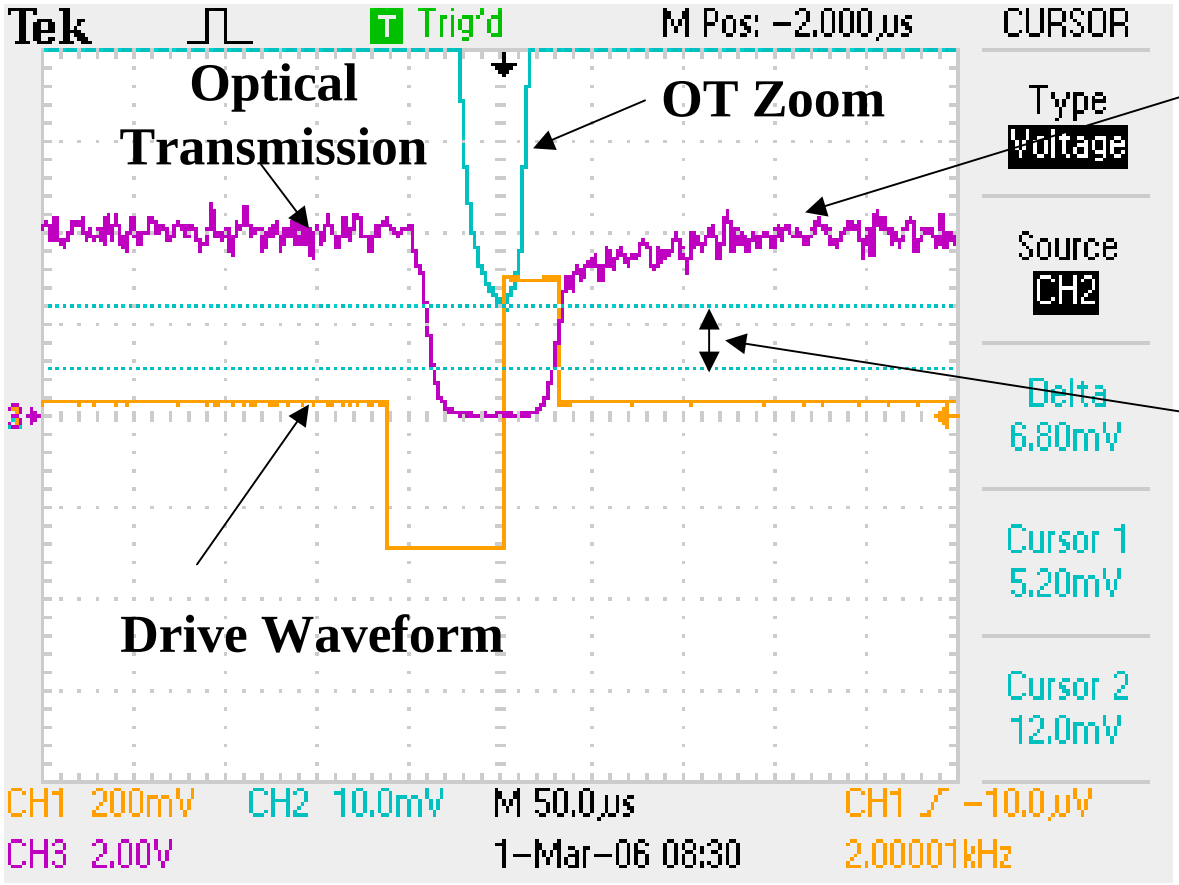


One Polarizer
DC level = 4.48V

With Second Crossed Polarizer
DC level = 720 µV
Extinction = 720µV/4.48V = 6222:1



LC Drive & Gate Waveforms



4.0V/4.48V = 89.3% transmission in gate "open" mode

6.8 mV/4.48V = 0.15% transmission in gate "closed" mode (Extinction = 659:1)

Drive Waveform Notes:

Average voltage over 500 µsec pulse interval must be close to zero to prevent ion migration which can damage the LC.

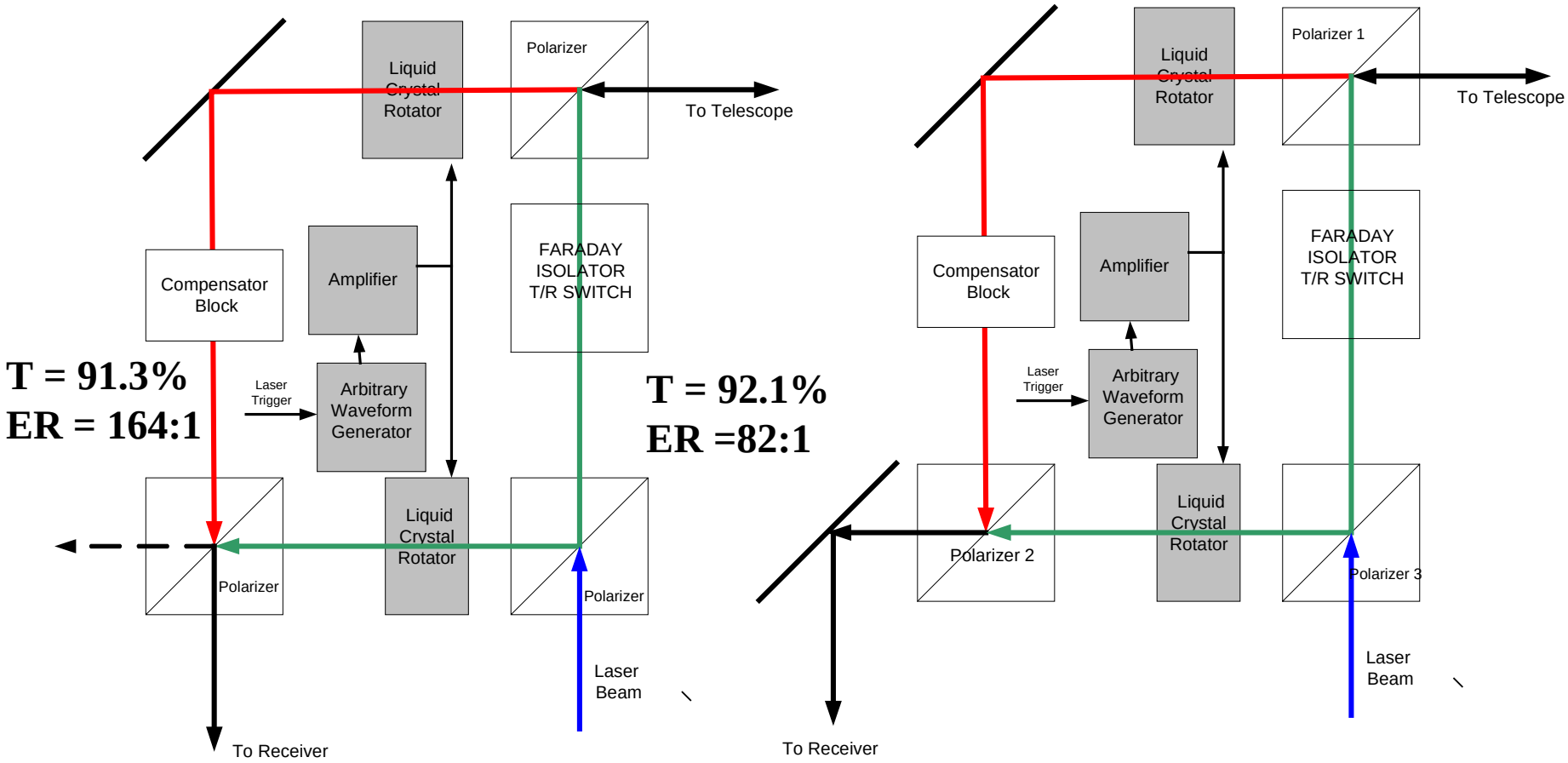
-30V for 64 µsec; +30V for 36 µsec; 2.1V for 400 µsec

Final low voltage holds LC molecules in "open" position.

Experimental Results

Polarizer 1	Liquid Crystal Gate	Polarizer 2	Transmission (gate open)	Extinction (gate closed)
P	No	S	NA	6222:1
P	Yes	S	89.3%	588:1
P	Yes	P	91.3%	164:1
S	Yes	S	92.1%	82:1

Installation in SLR2000



Current SLR2000 Configuration Uncrossed Polarizers	
T = 91.7%	ER = 123:1

Better Configuration Crossed Polarizers	
T= 89.3%	ER = 588:1

Summary

- We have demonstrated that liquid crystals, when used as a 90^{o} polarization rotator between two cube polarizers, can:
  - reduce the amount of laser backscatter by 2 to 3 orders of magnitude in the “closed” state exhibit high transmission (~90%) in the “open” state
  - operate at few kHz rates
  - handle large aperture beams (~15 mm)
  - switch states in less than 10 microseconds with low voltage ($<\pm 30V$)
  - produce flexible gate waveforms of arbitrary shape and duration
  - work in tandem with variable laser fire rates to avoid “collisions” between incoming and outgoing pulses