First observation and analysis of spatial solitons in polymer-stabilized nematic liquid crystal

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FRANCE

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Outline

1. Introduction: all-optical interconnects requirements
2. Coupling efficiency measurements in solitons
3. Nonlocality, stability and noise
4. Reduction of the noise by controlling the nonlocality
    a) Using a polymer stabilized NLC
    b) Using a multi-electrodes LC cell
5. Conclusion and perspectives

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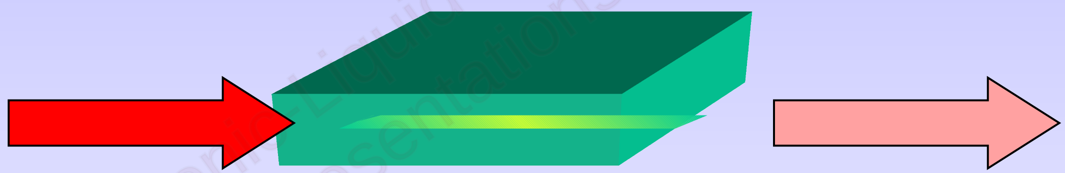
1. All-optical interconnects requirements

- Low insertion losses (difficult for silica to organic coupling)
- Compatibility with optical fibers
- Good S/N
- low polarization dependance



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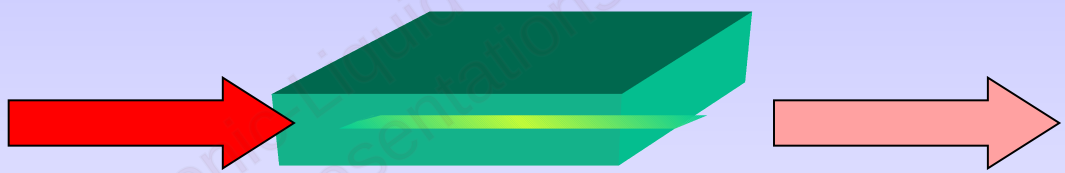
1. All-optical interconnects requirements

motivation

- Low insertion losses (difficult for silica to organic coupling)
- Compatibility with optical fibers
- Good S/N
- low polarization dependance



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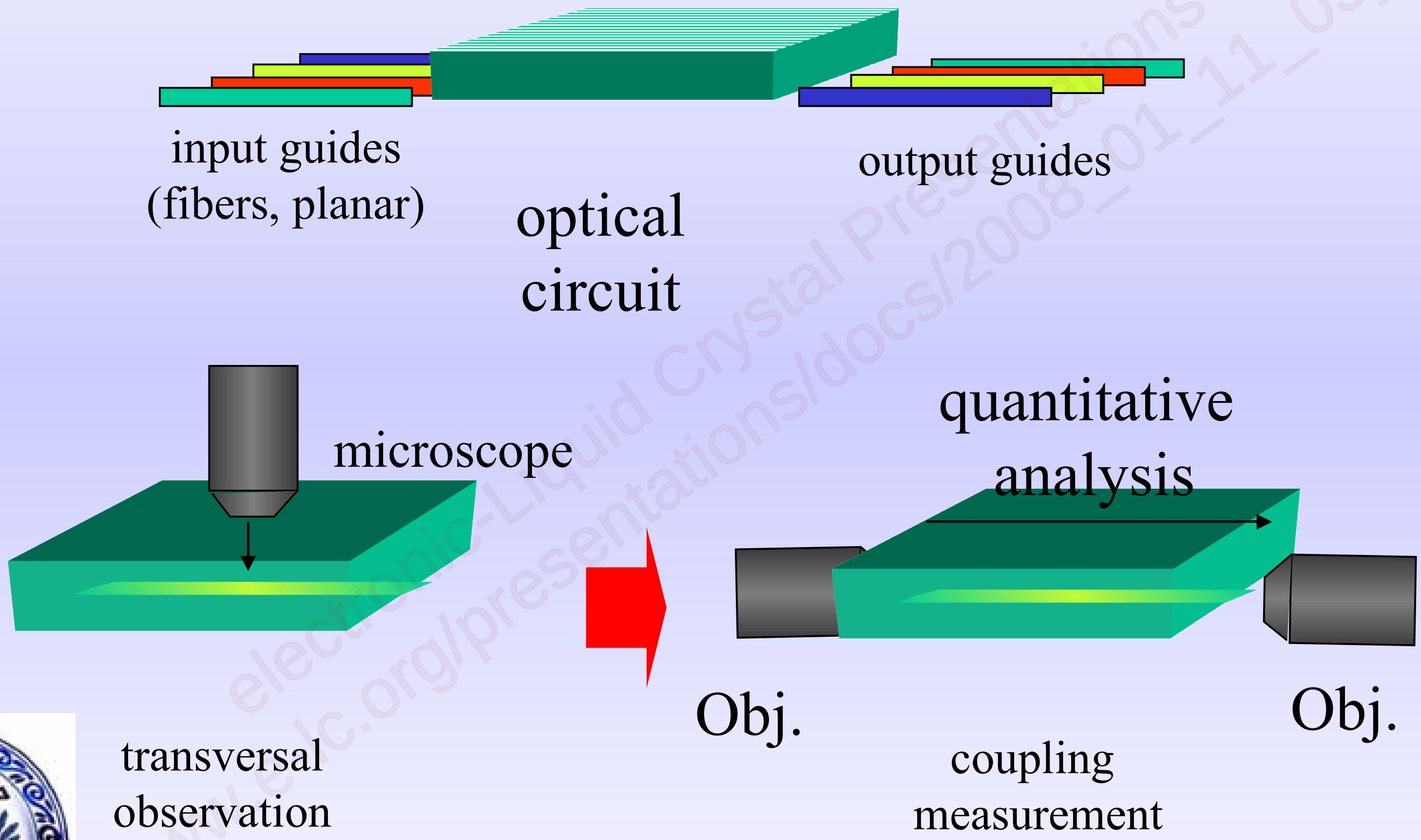
2. Coupling efficiency measurements



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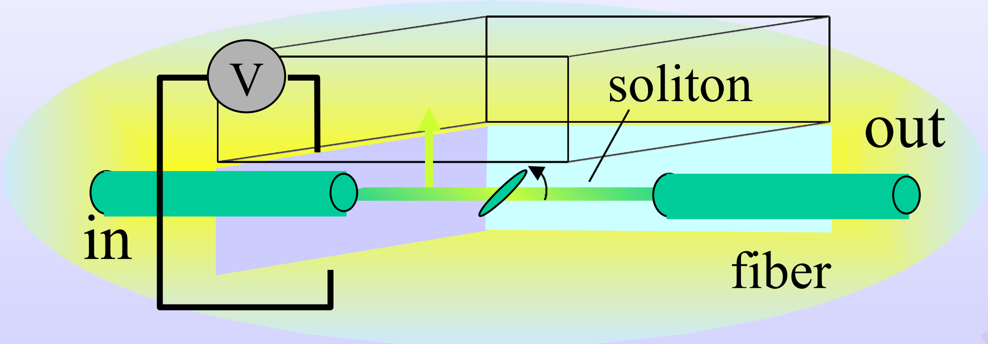
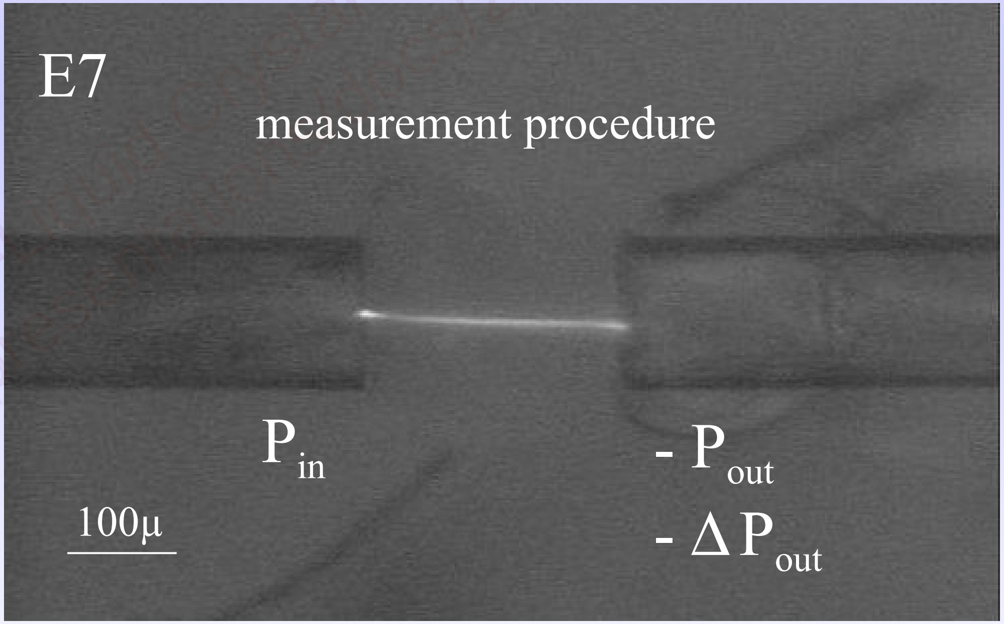
2. Coupling efficiency measurements in solitons



- compactness
- optical fiber compatibility

λ=532 nm

Control parameters
- Bias voltage
- Fibers positions
- Gap between fibers
- Thickness = 160μ



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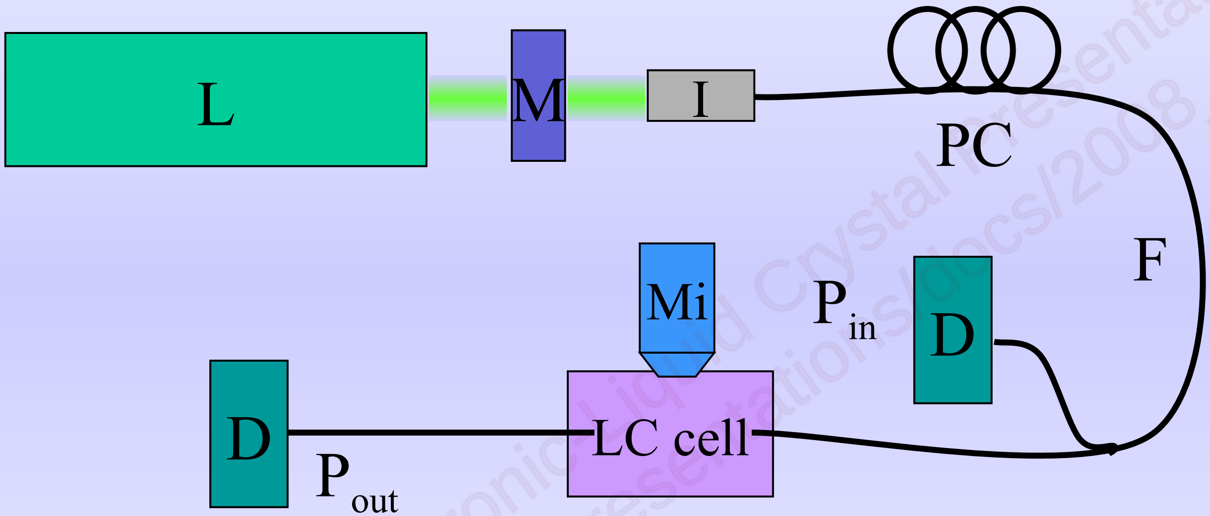
2. Coupling efficiency and S/N measurements



L laser
M modulator
I injector
PC polar. contr.
F fiber
Mi microscope
D detector

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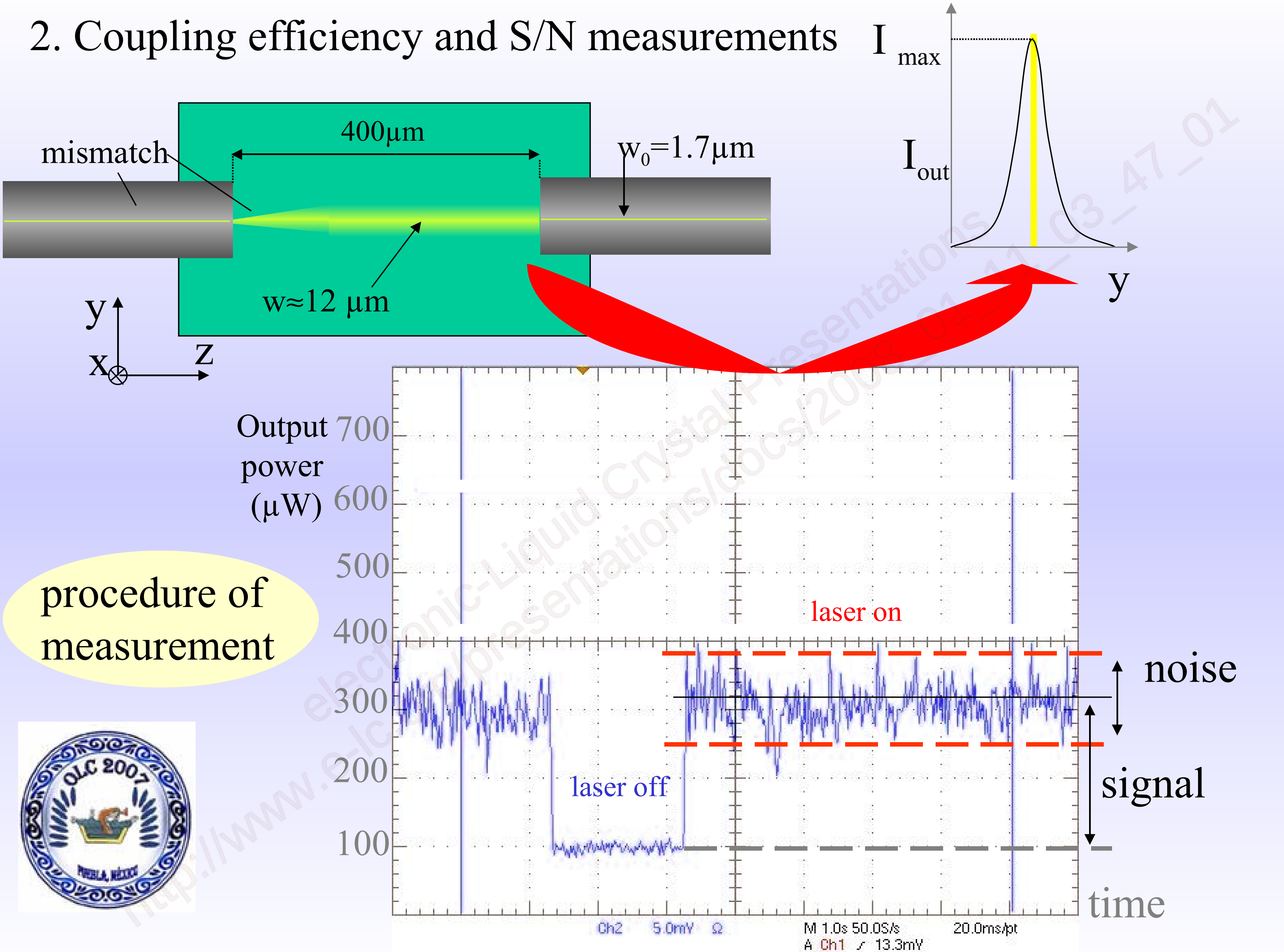

procedure of measurement

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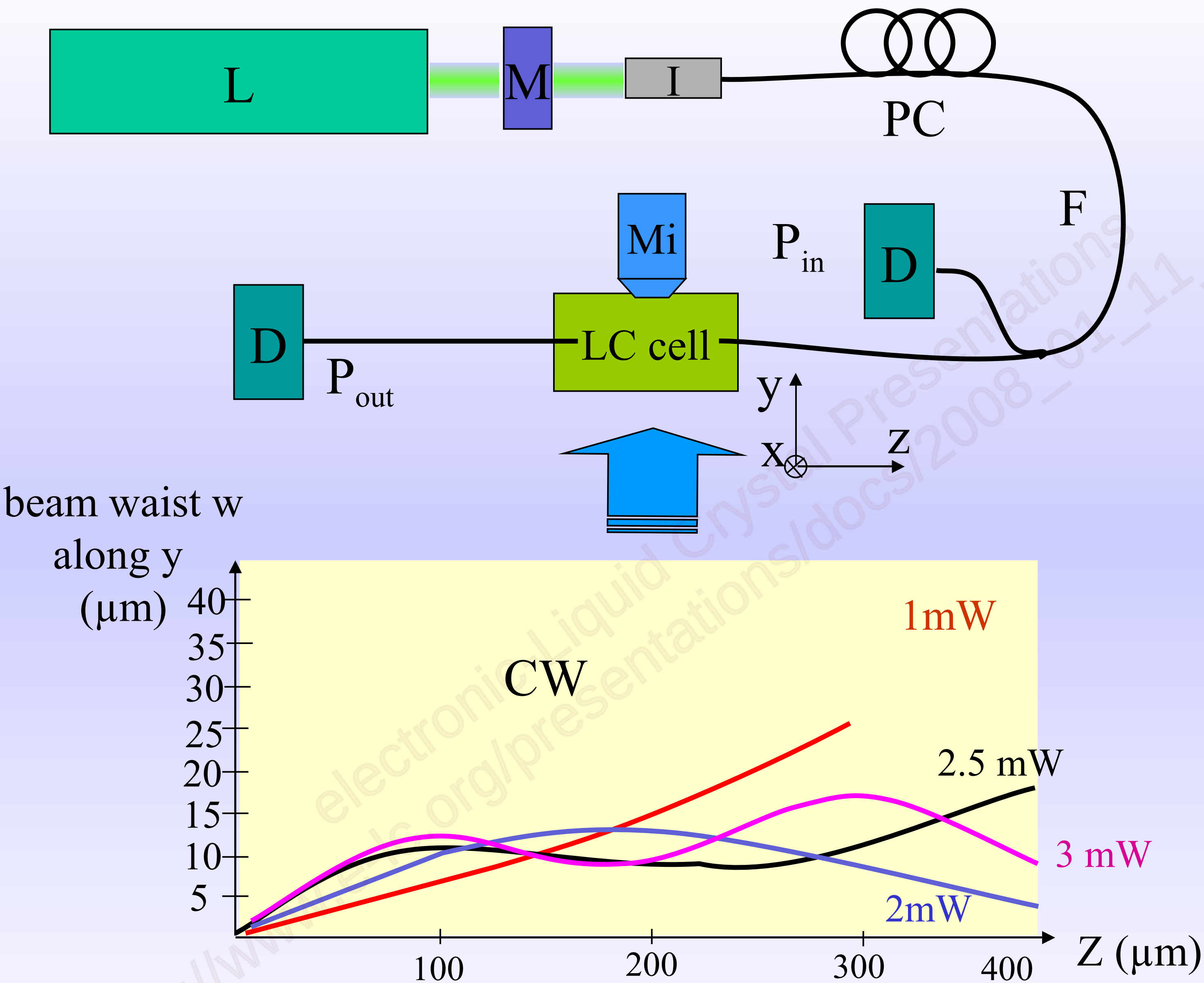

Evolution of the beam size when the input power is increased

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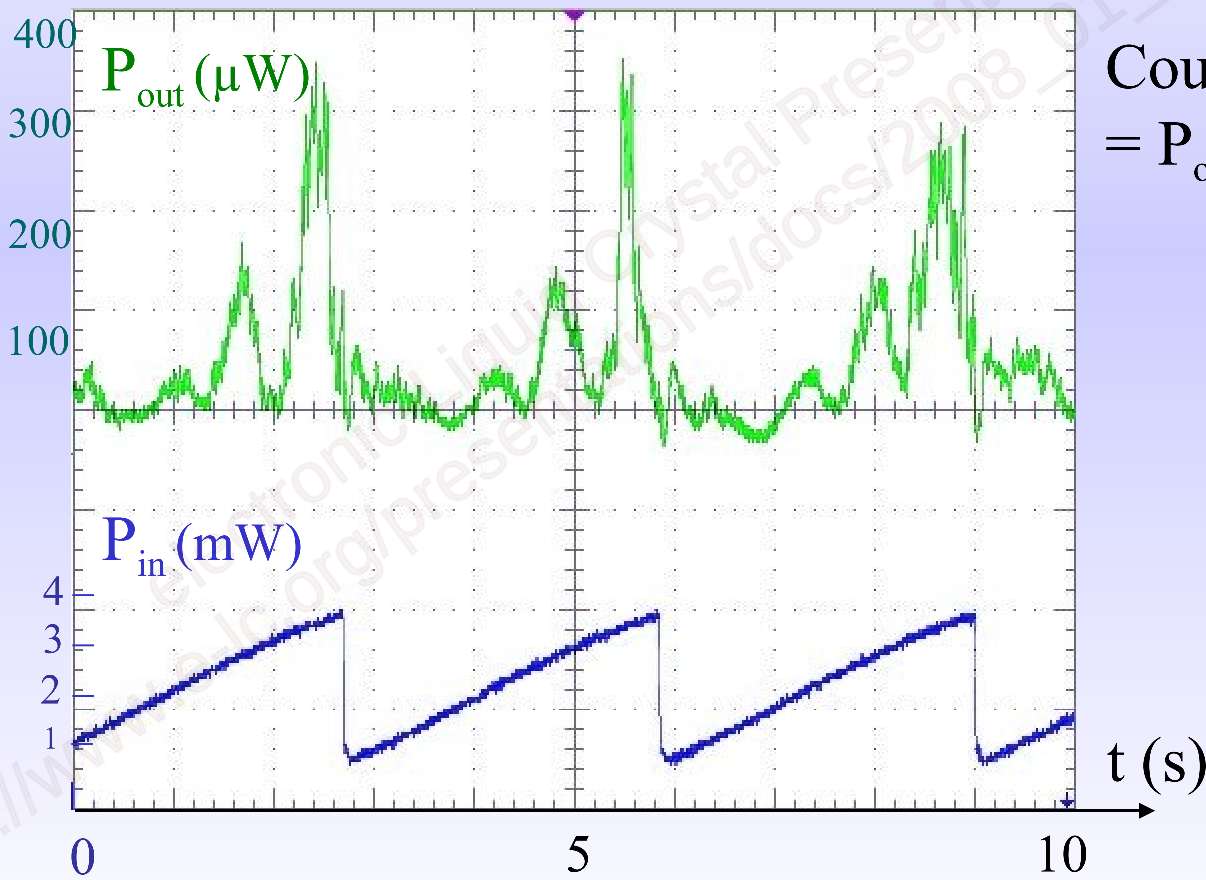
2. Coupling efficiency and S/N measurements

Evolution of the output power when the input one is increased



Coupling eff

$= P_{out}/P_{in} \approx 10\%$

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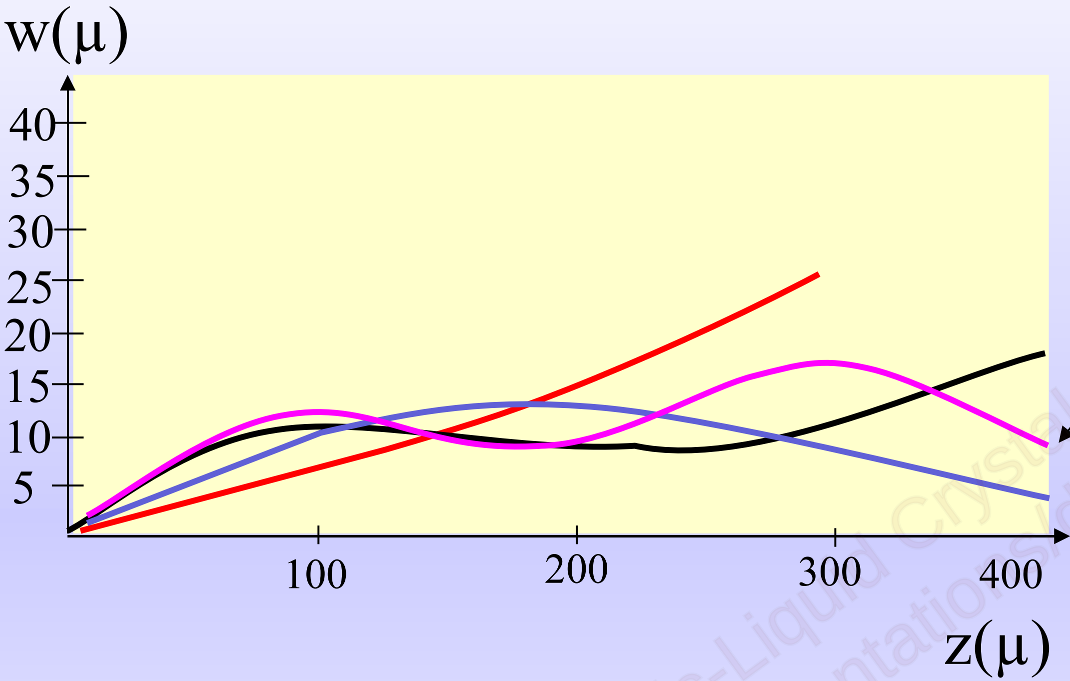
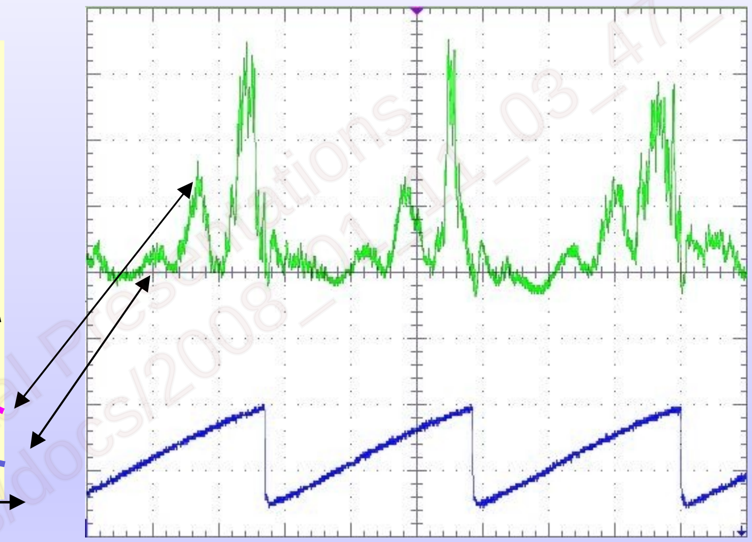
2. Coupling efficiency and S/N measurements





The pics in the transmission curve correspond to the evolution of the self-focusing process (focal point arising at the tip of the fiber)

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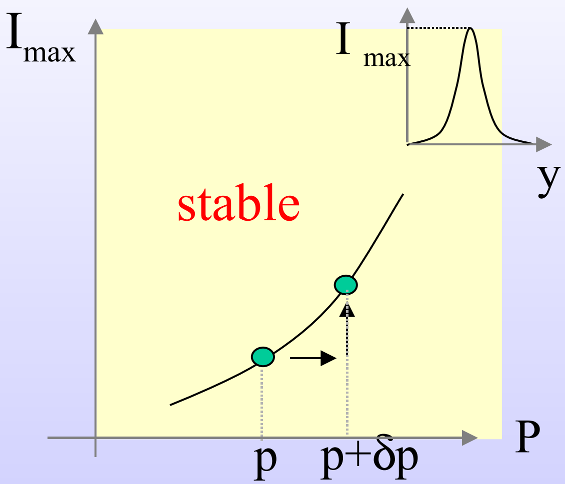
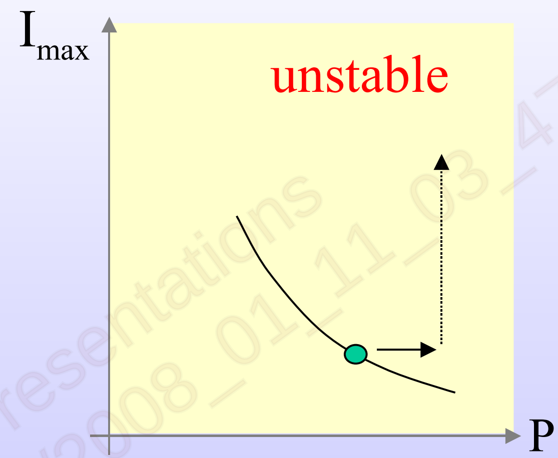
3. Nonlocality, stability and noise

Snyder (JOSA)

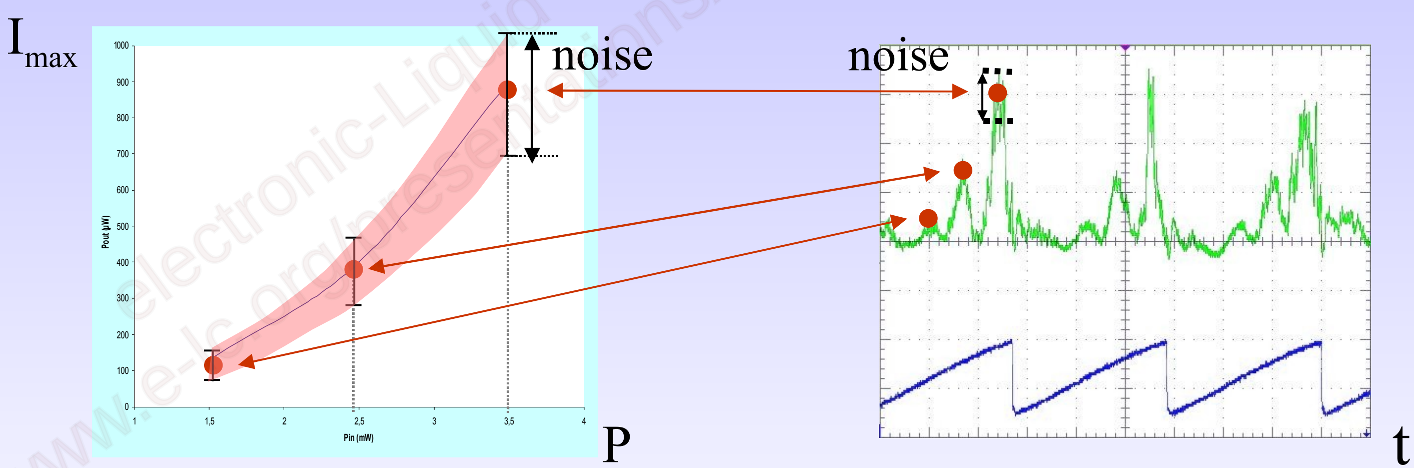
stability
slope > 0





P ↗ → broadening → diffraction ↘ → focusing → I_{max} ↗

Nonlocal
case



Nonlocality ↗ → stability ↗ → noise ↗

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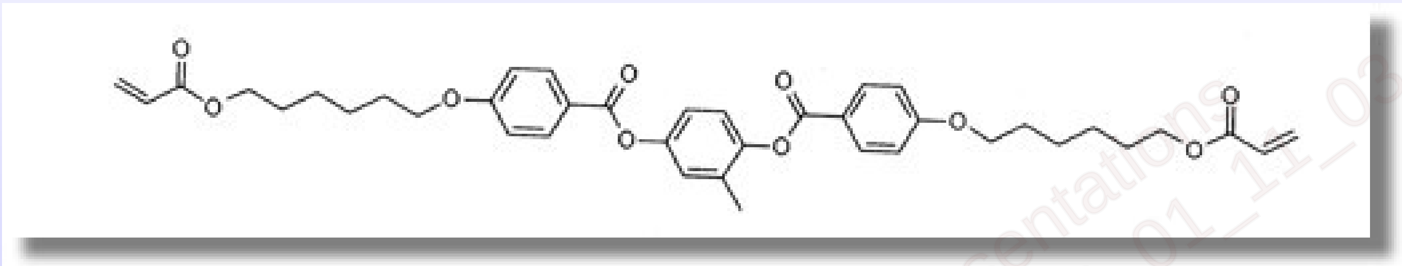
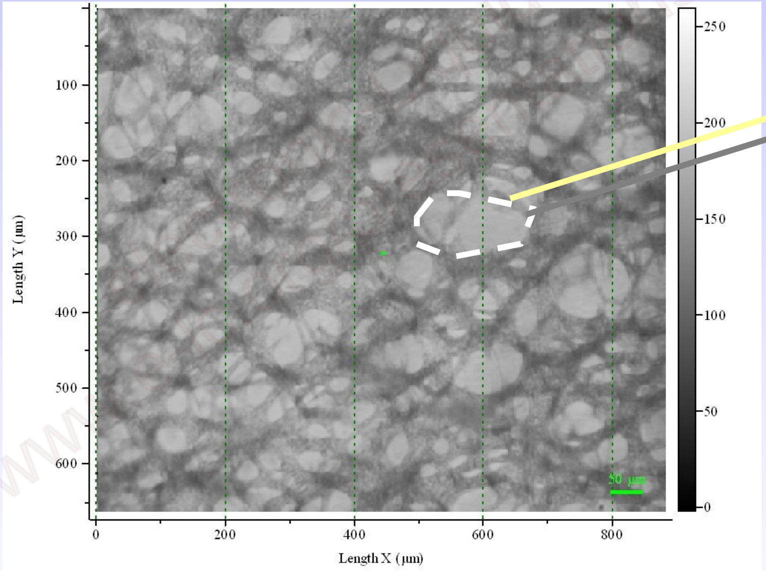
4. Reduction of the noise by controlling the nonlocality

a) Using a polymer stabilized NLC



3% of diacrylate in E7



reduction of LC mobility
by new anchoring
conditions inside
the polymer network

4. Reduction of the noise by controlling the nonlocality

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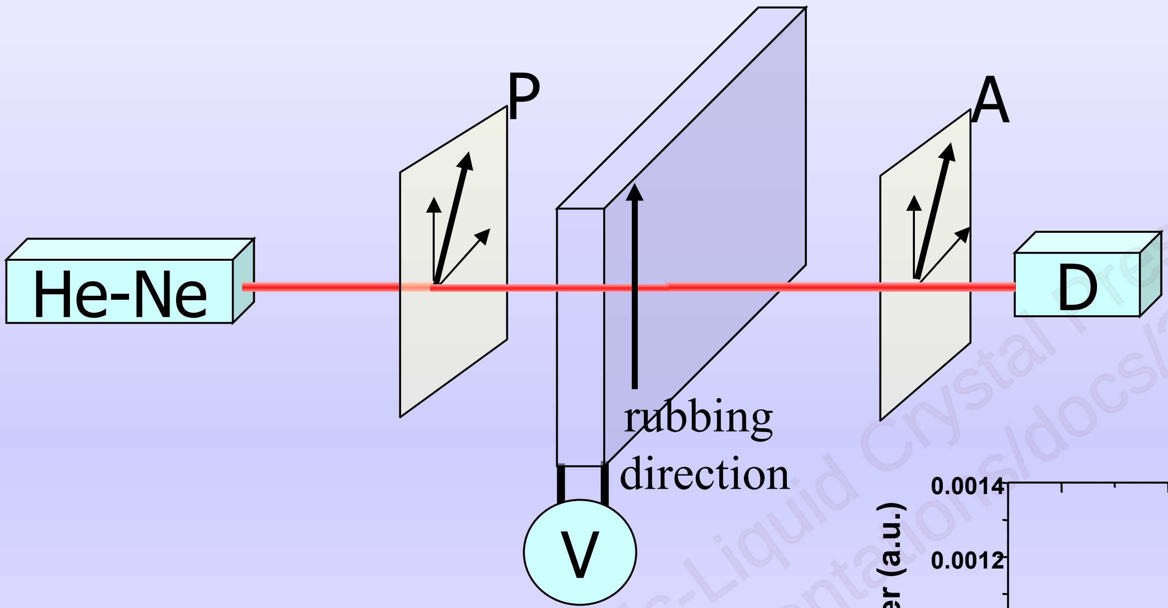
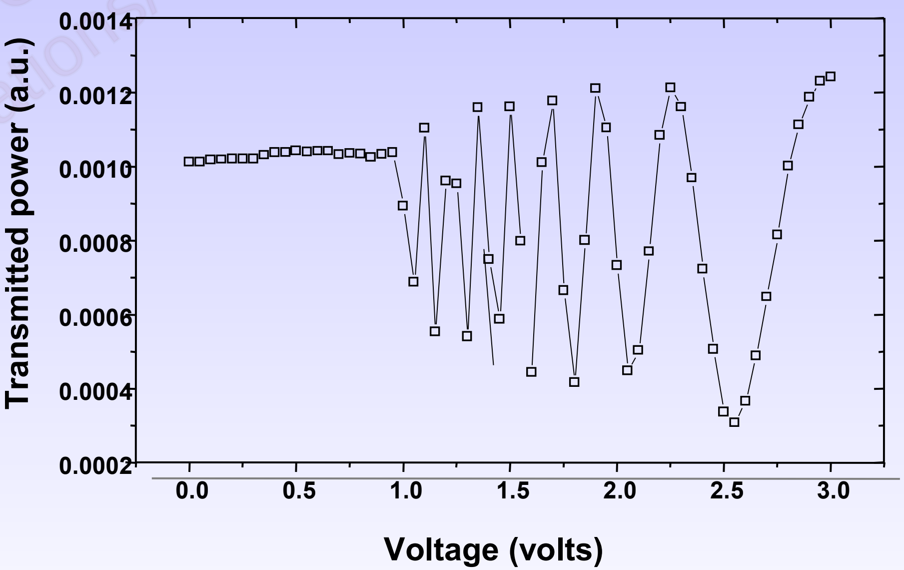


Electro-optic measurements



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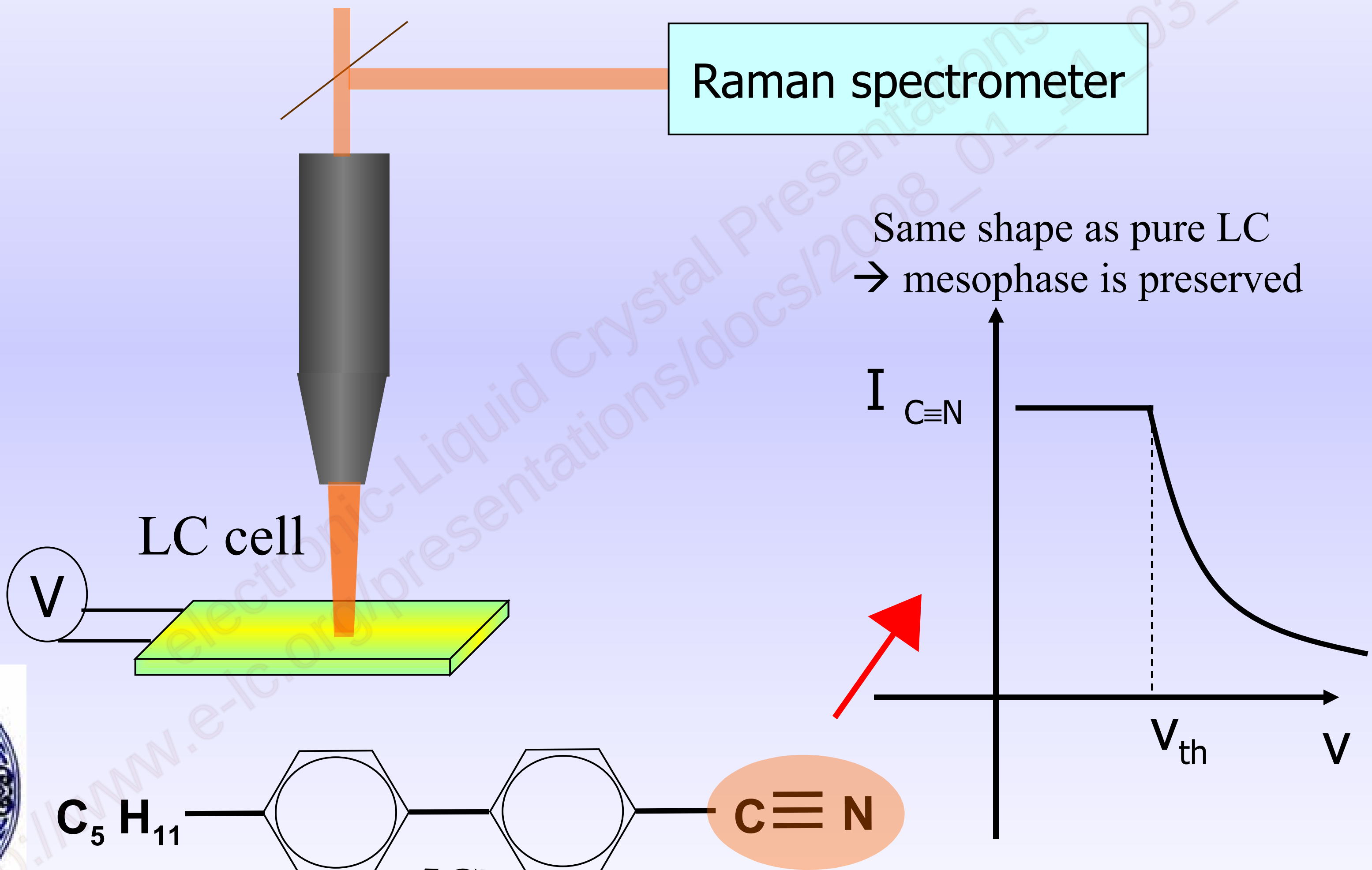

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4. Reduction of the noise by controlling the nonlocality

a) Using a polymer stabilized NLC

both methods

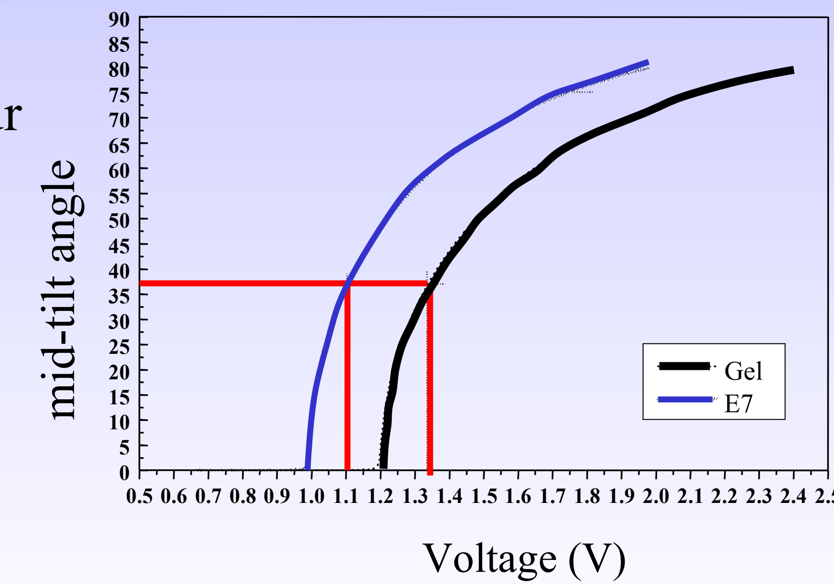
Gel
V_{th}=1.2 V

E7
V_{th}=0.99 V

$$V_{th} = \pi \sqrt{\frac{4.\pi.K}{\Delta\,\varepsilon}}$$

threshold voltage
(mesomorphic behaviour preserved in gel)

→K is higher in gel
→ damping is stronger



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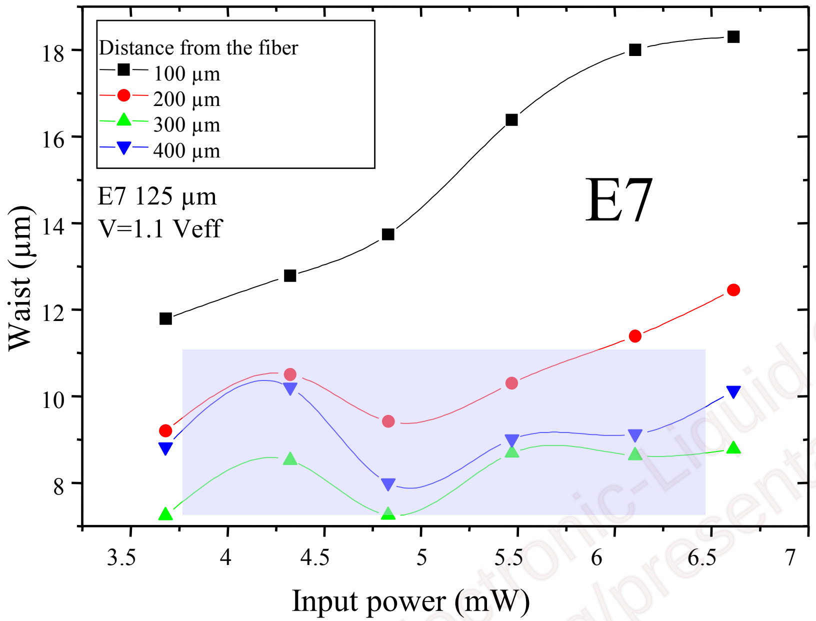
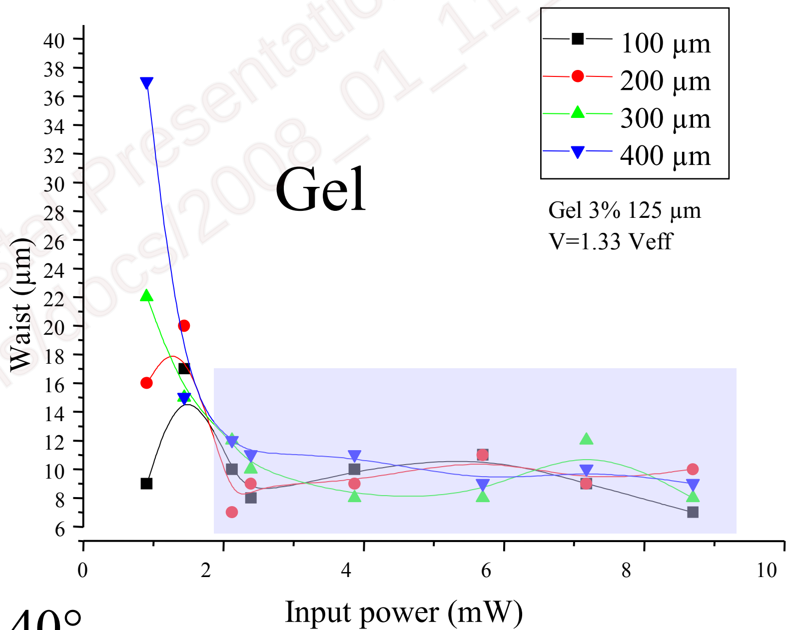
Beam size evolution along the propagation axis for different input powers





midtilt: 40°

the beam size variations are reduced in gel → the stability is improved

~~Experiment of coupling between fibers (texture of gel not preserved)~~

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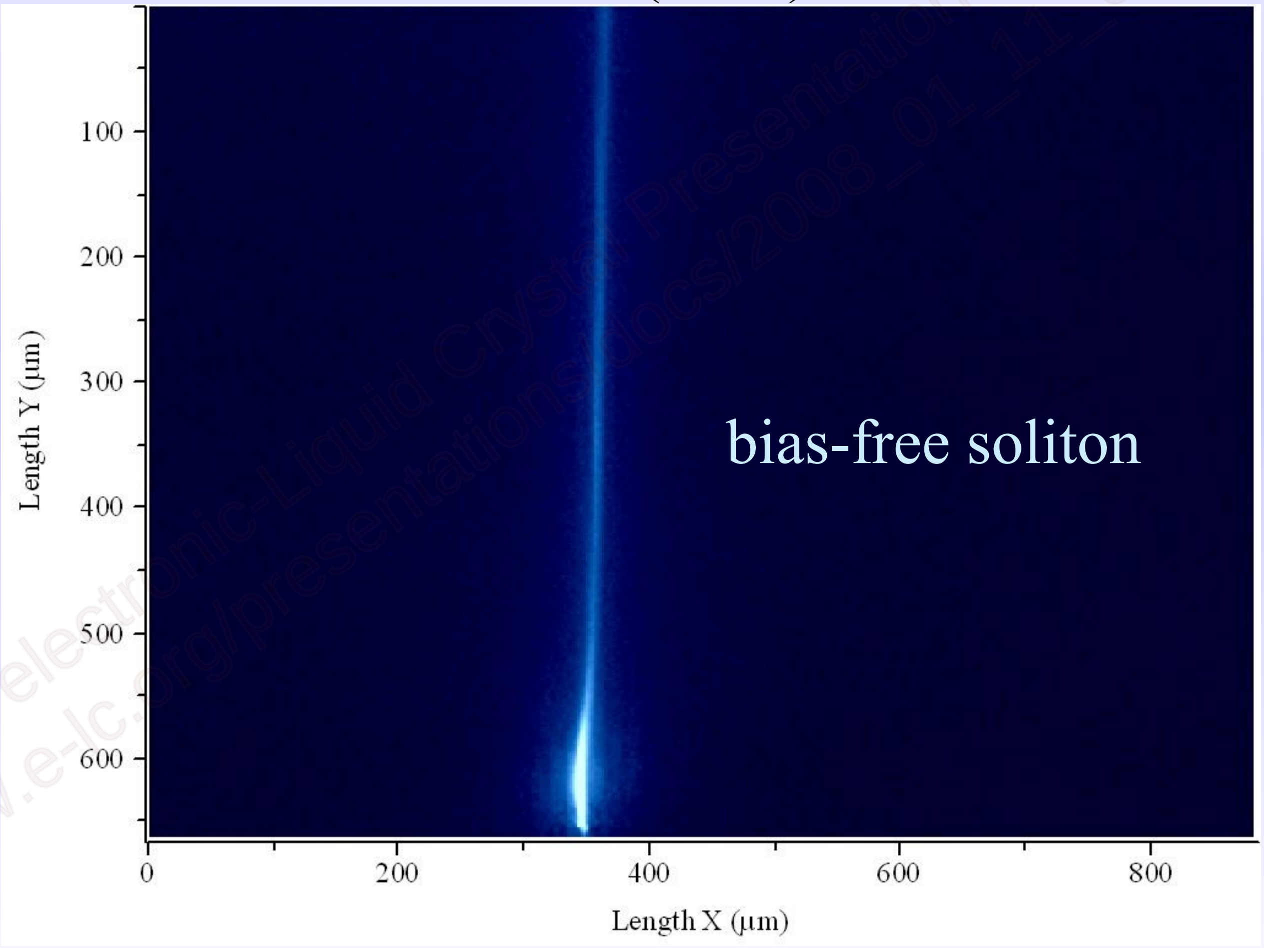
→Bias and soliton are applied simultaneously during curing then bias is removed

JOSA B (2007)



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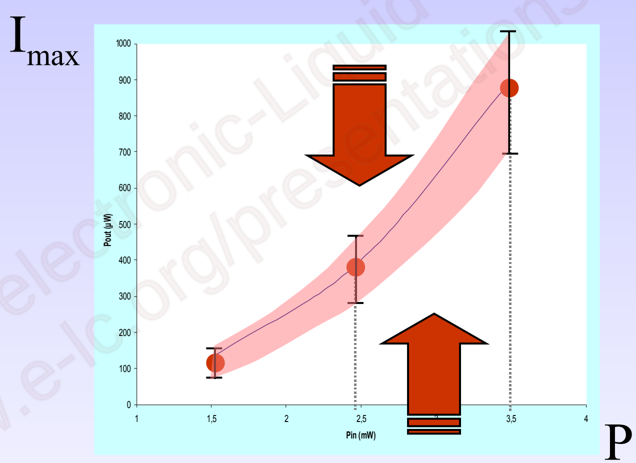
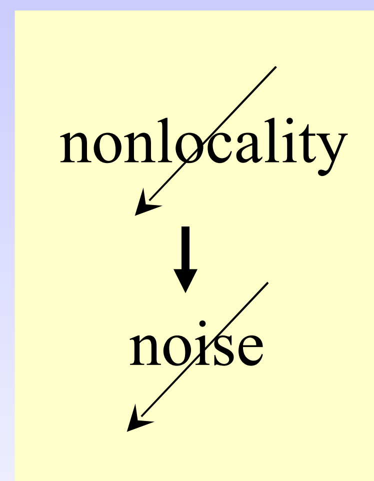
4. Reduction of the noise by controlling the nonlocality

b) By using a multi-electrodes LC cell (voltage applied in the plane of the cell to stabilize the propagation)

→ Tuning of the nonlocality is possible by changing the bias voltage value
(Peccianti et al, Opt. Lett. 30, 4 (2005)415)



precise tuning



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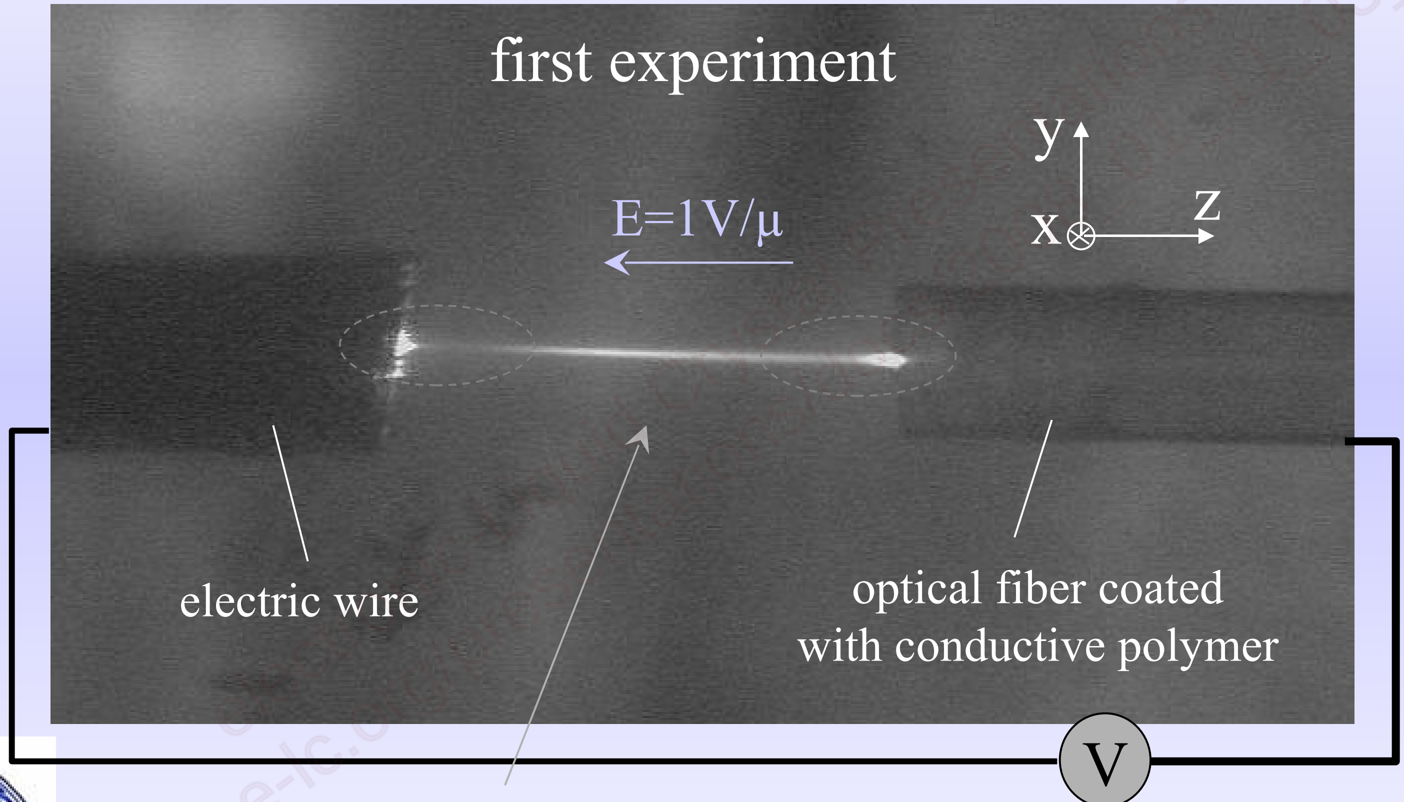
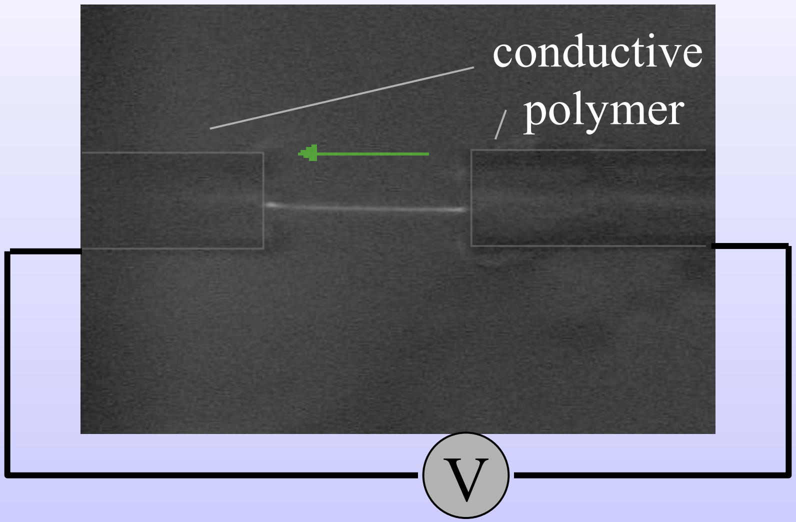


→ Soliton propagates straight forward

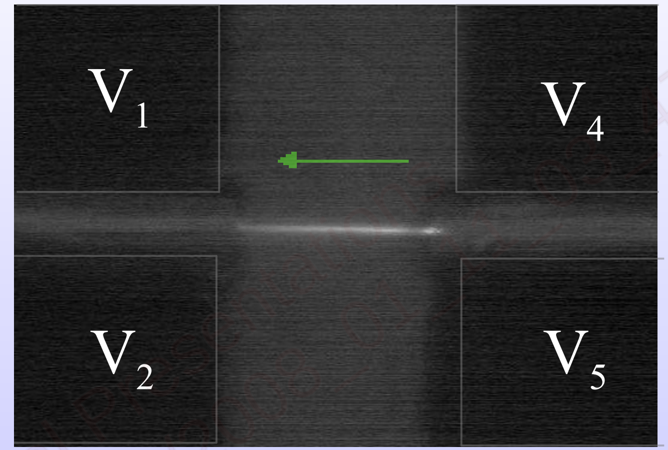
→ insertion losses are reduced (-25%)

1 "in-line electrodes" configuration

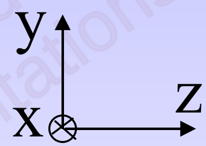


+ bias voltage (x)

2 "4 electrodes" configuration



+ bias voltage (x)



→Homogeneity of the director along z (microscope view)

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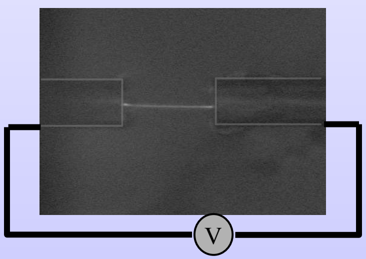
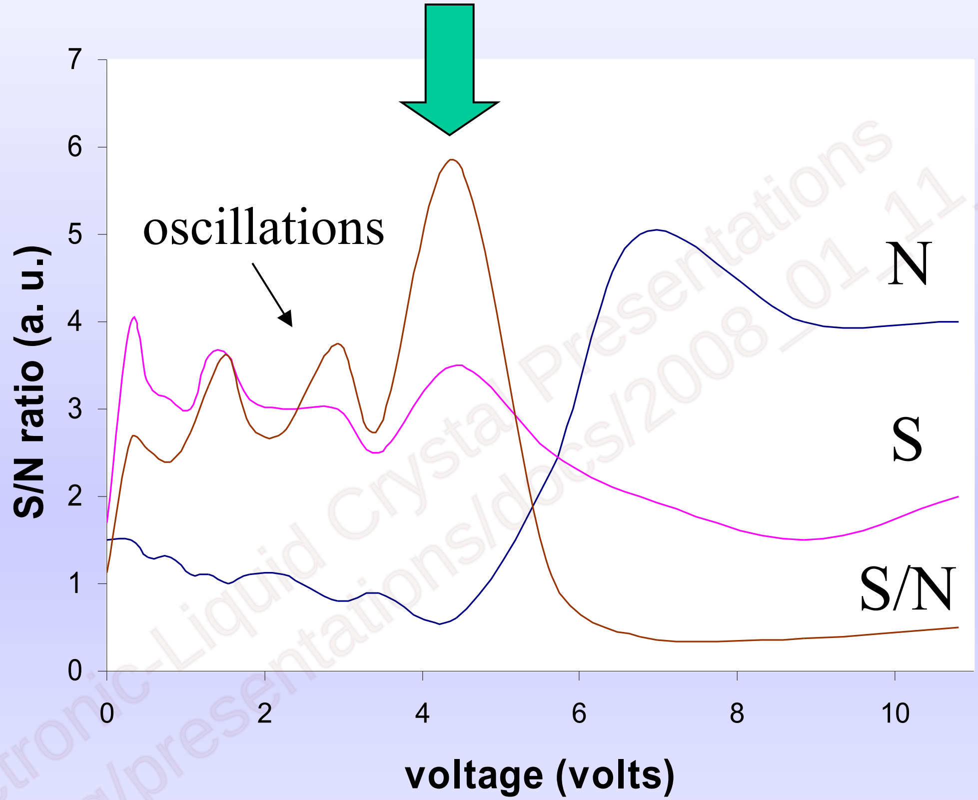
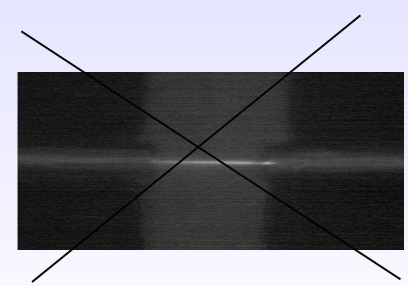
Results:





→ Stabilizing voltage reduces the noise and the beam becomes narrower (microscope)



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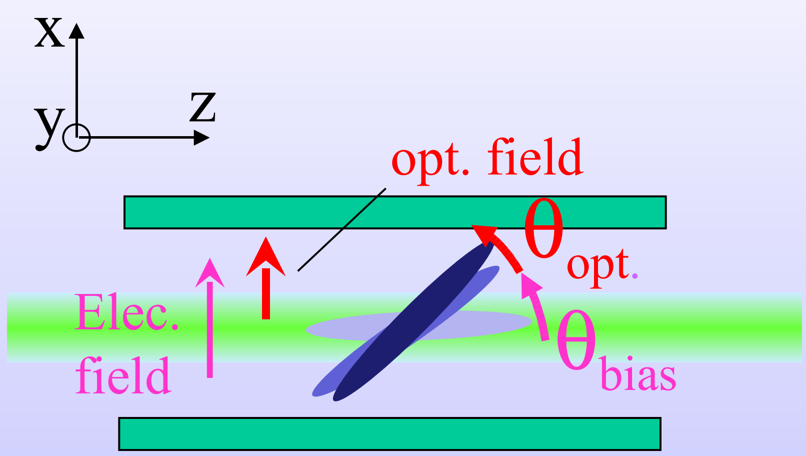
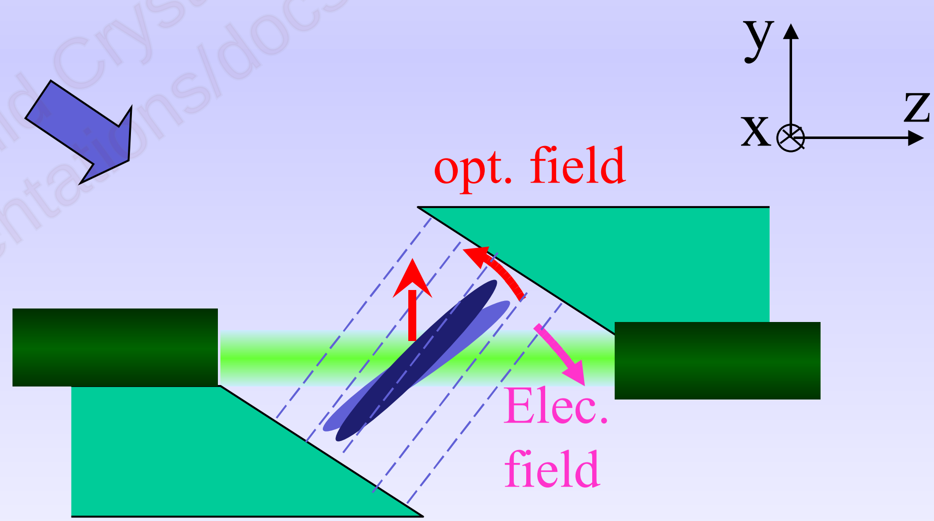
3 "Tilted" configuration: new geometry of the electrodes



Usual case: The bias field is applied in the same direction as the optical one → does not contribute to the molecular stability



Electric field damps the director fluctuations without preventing the self-focusing

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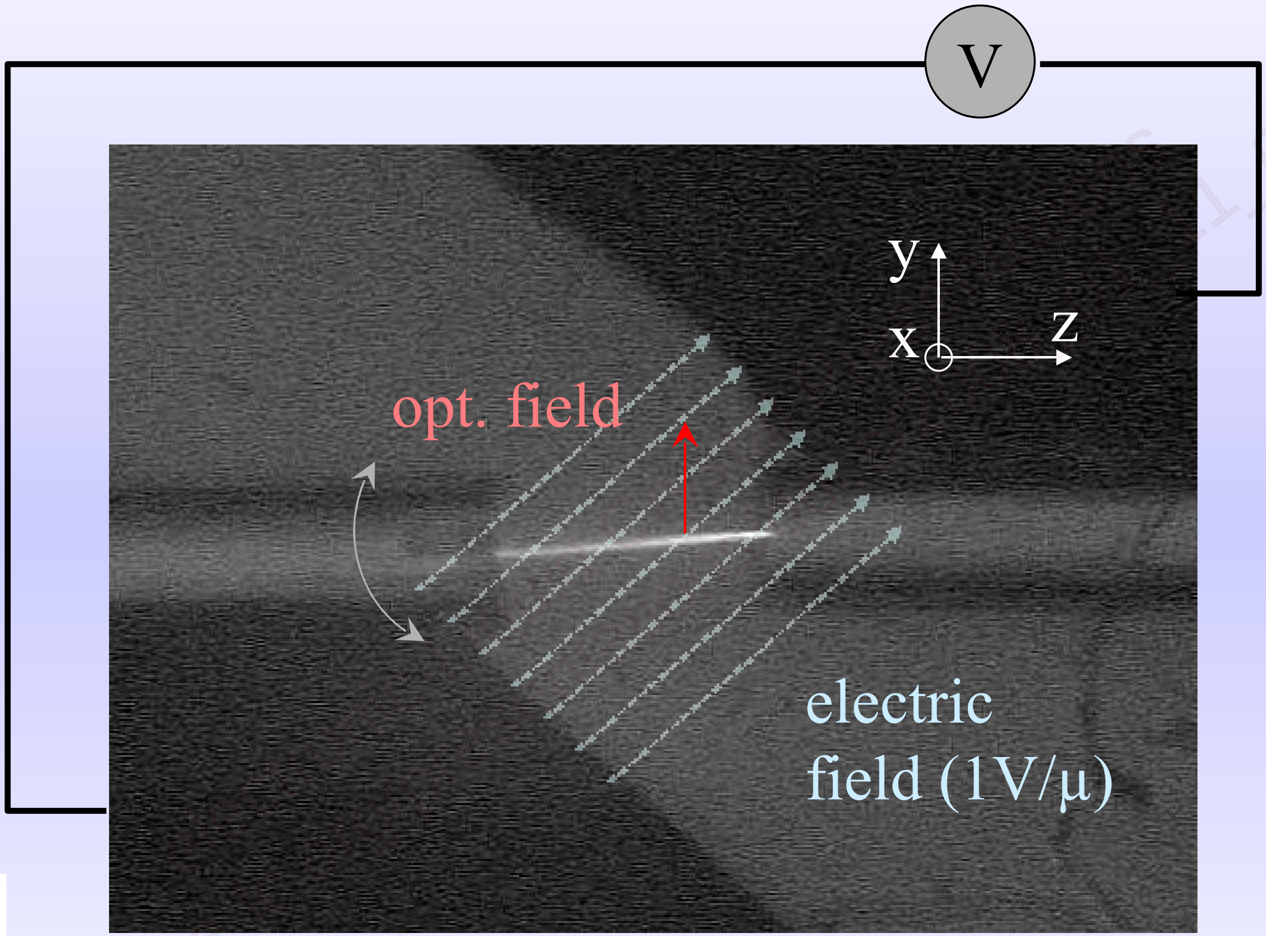
3 "Tilted" configuration



the beam is weakly walking-off

http://www.e
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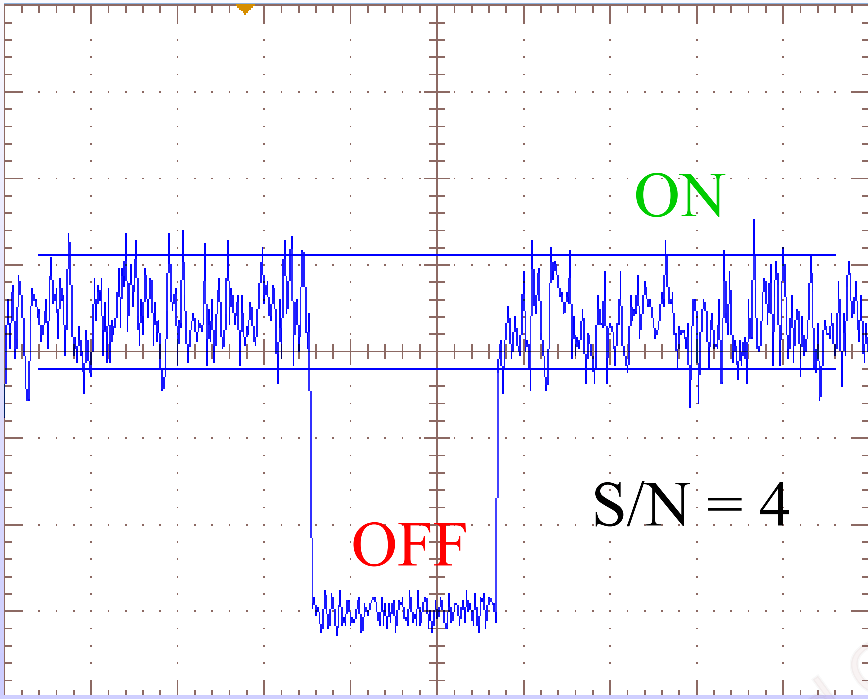
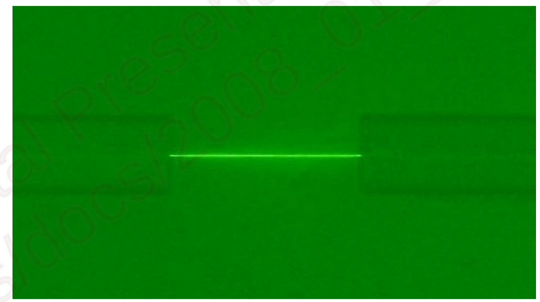
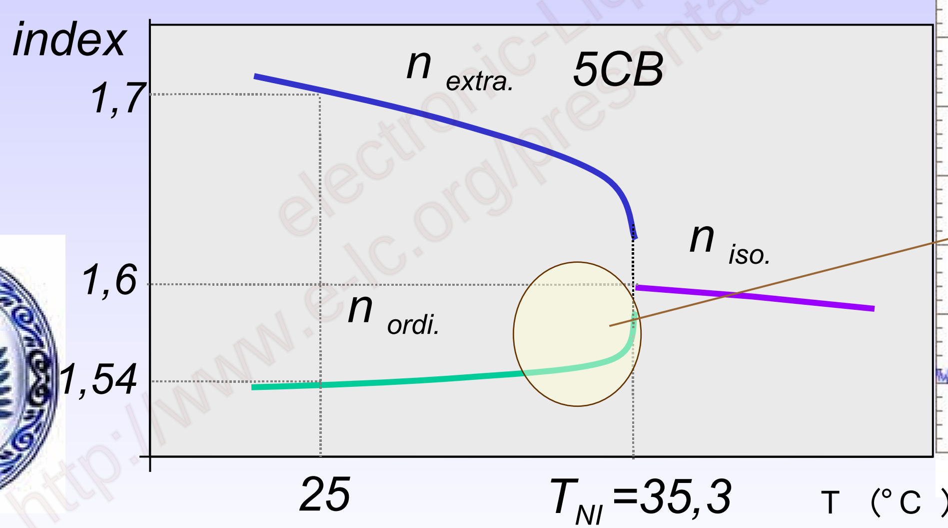
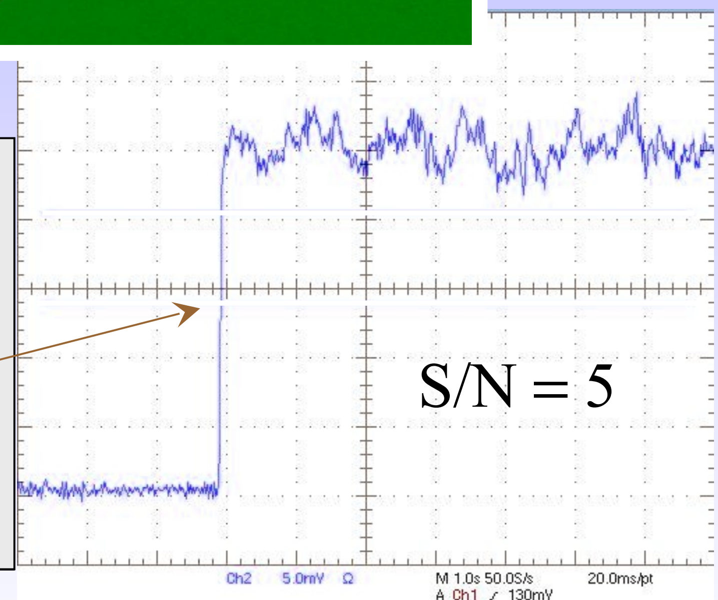


S/N is quite
the same that for
the thermal effect



homeotropic
align.





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Conclusion

- It is possible to improve the S/N in soliton-based optical interconnects by
    1) reducing the LC mobility (gel)
    2) by applying a voltage in the plane of the cell