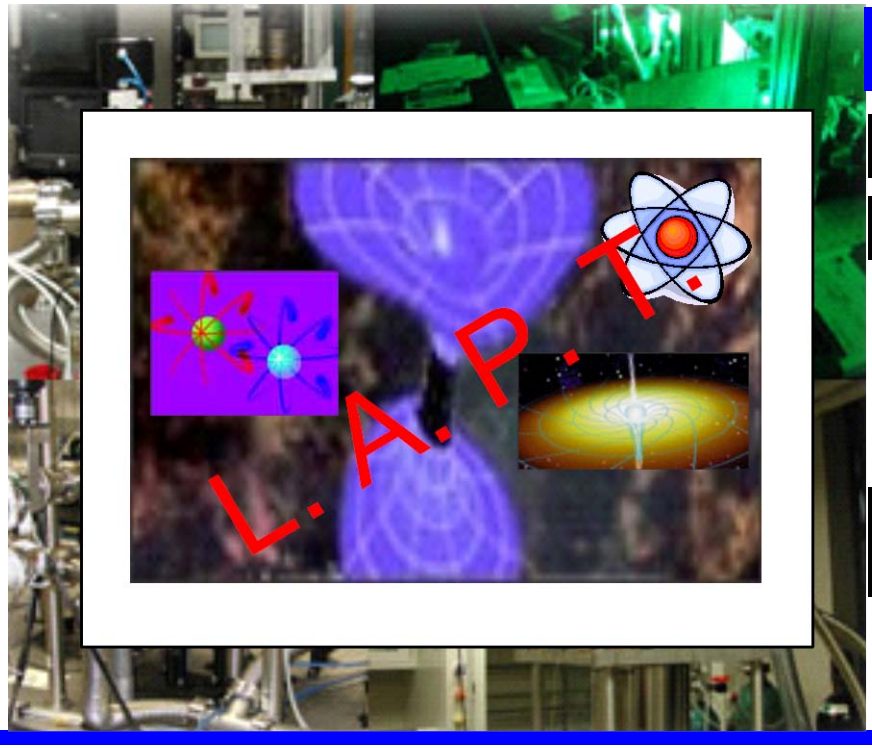
Design constraints and optimization for a white light cavity based GW interferometer including power and signal recycling



Selim Shahriar, Northwestern University

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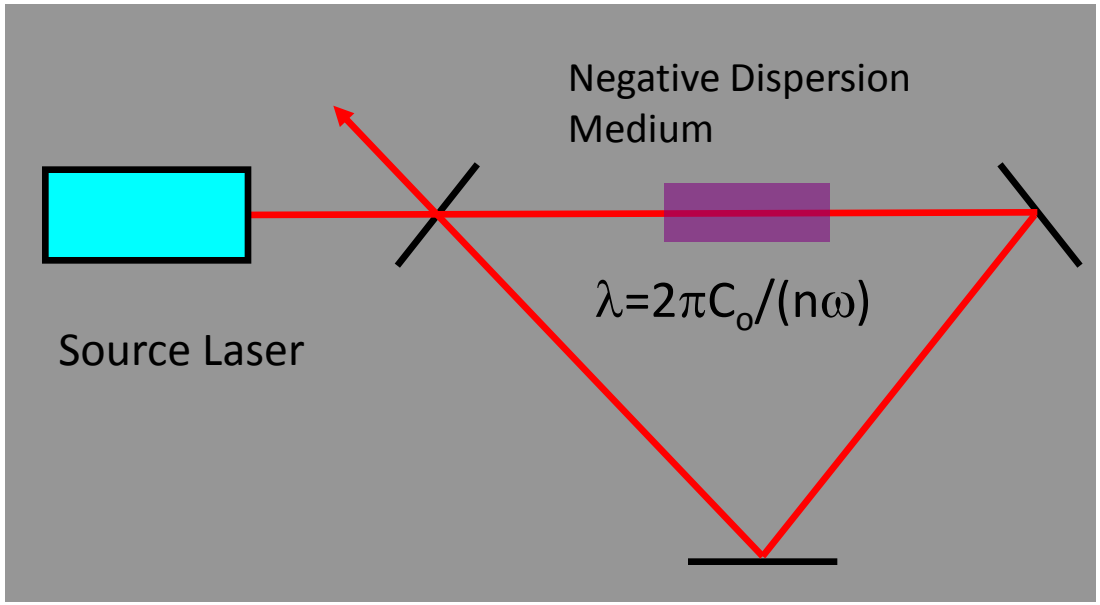
URL: http://lapt.ece.northwestern.edu

Northwestern University Gravitational Wave Astrophysics Workgroup (Head: Vicky Kalogera)

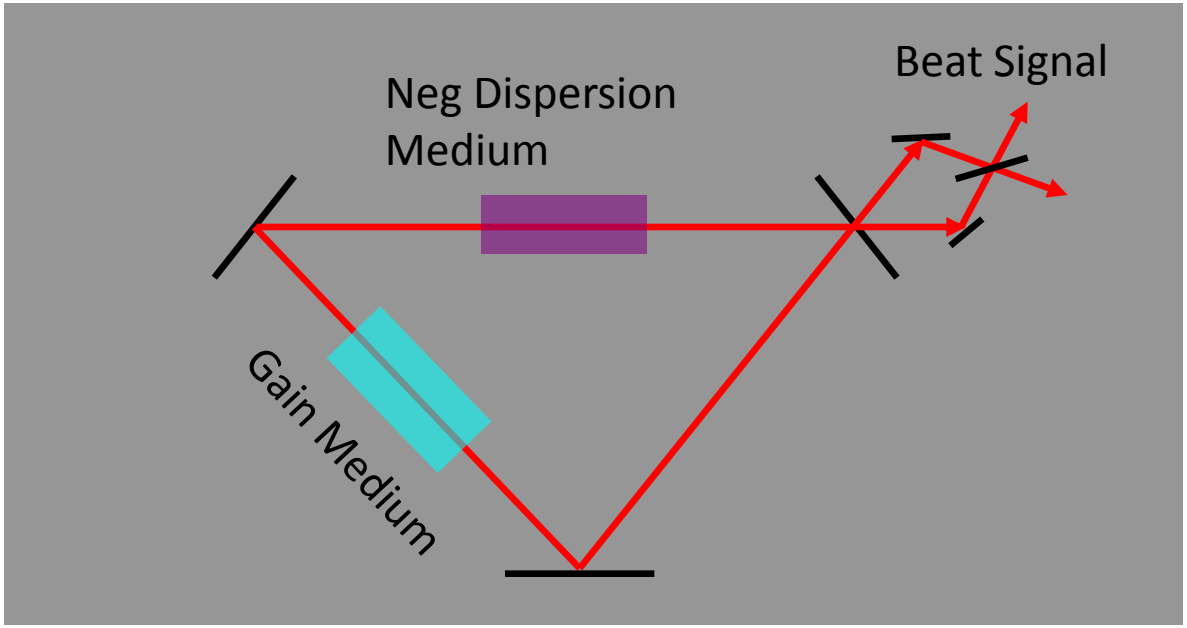
White Light Cavity: Basic Idea



$$\left.\frac{\partial(n\omega)}{\partial\omega}\right|_{\omega_o} = 0 \quad \Rightarrow \quad \left.\frac{\partial n}{\partial\omega}\right|_{\omega_o} = -\frac{n_o}{\omega_o}$$

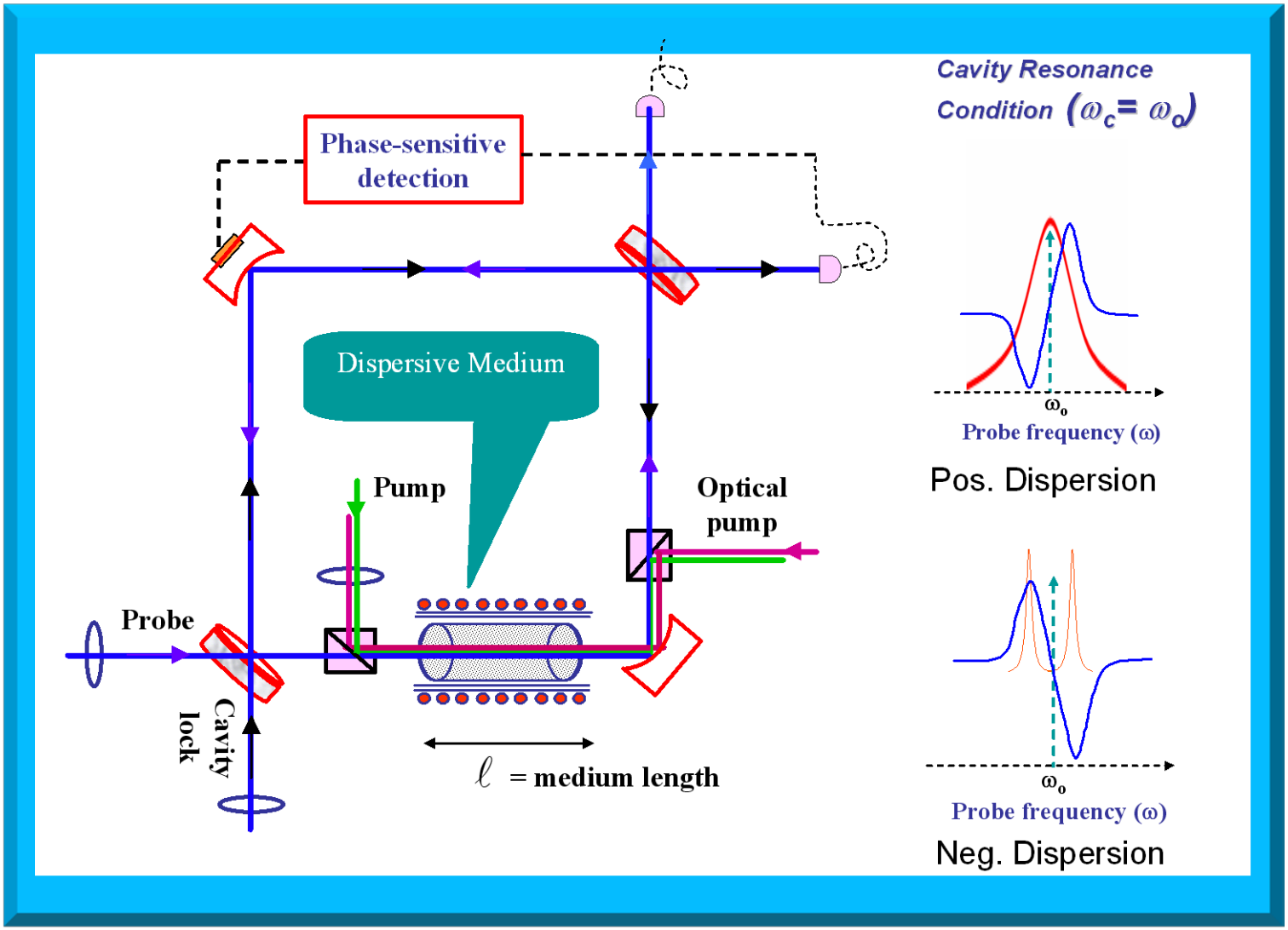
- Ideal WLC is infinitely broadened, without any drop in storage time / sensitivity
- Ideal WLC is also infinitely sensitive to variation in cavity length
- In practice, broadening and sensitivity limited by finite bandwidth of negative dispersion

Active Superluminal Cavity: Superluminal Ring Laser (SRL)

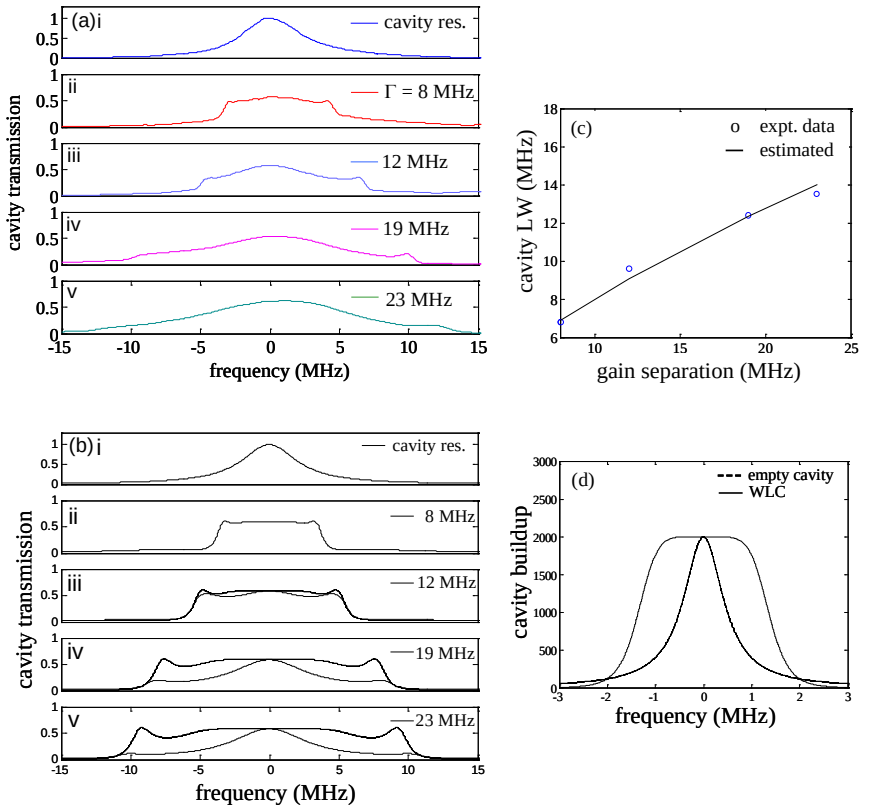


- Frequency change is enhanced in sensitivity by a factor of 10 million
- Beat note does not experience the broadening effect

Demonstration of White Light Cavity

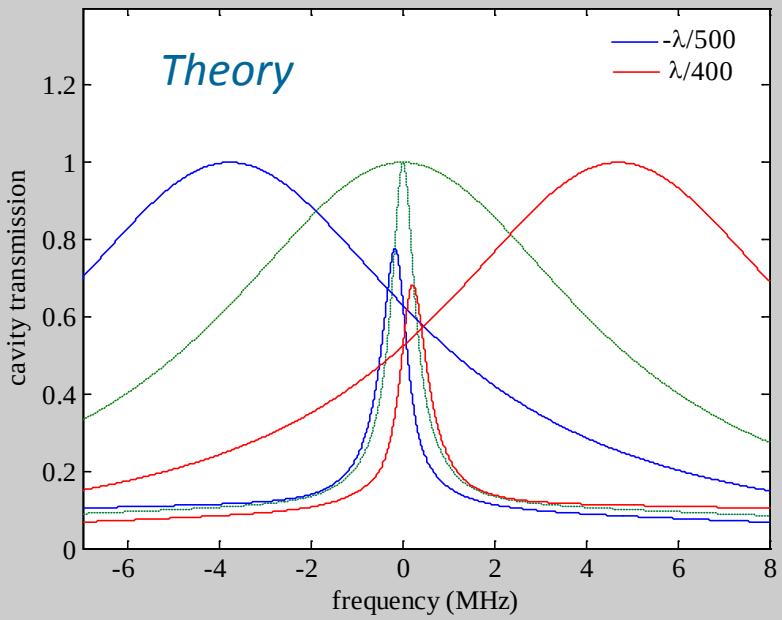


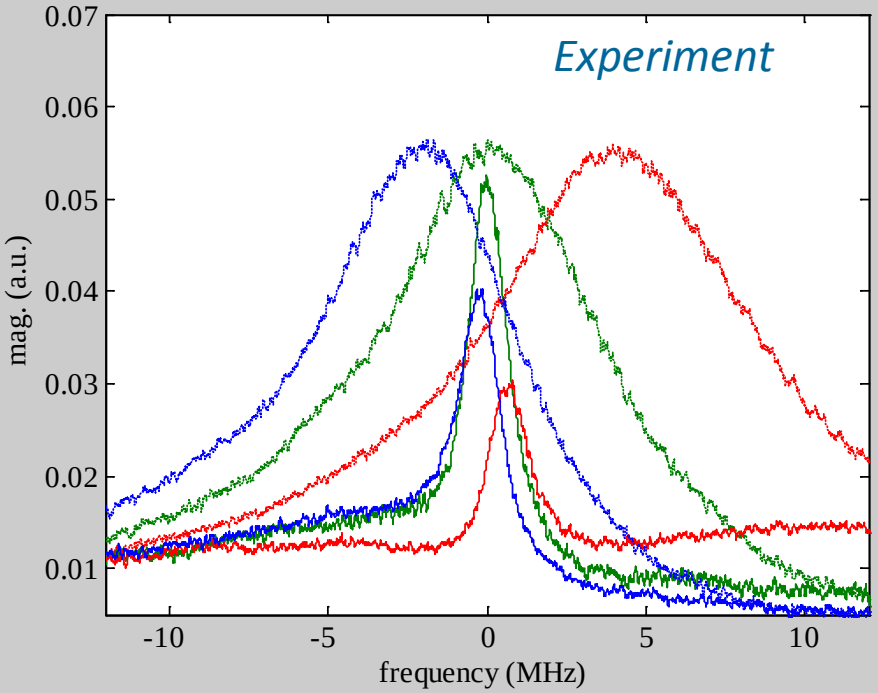
Demonstration of White Light Cavity



G.S. Pati, M. Messal, K. Salit, M.S. Shahriar, "Demonstration of a tunable-bandwidth white light interferometer using anomalous dispersion in atomic vapor," Phys. Rev. Lett. 99, 133601 (2007)

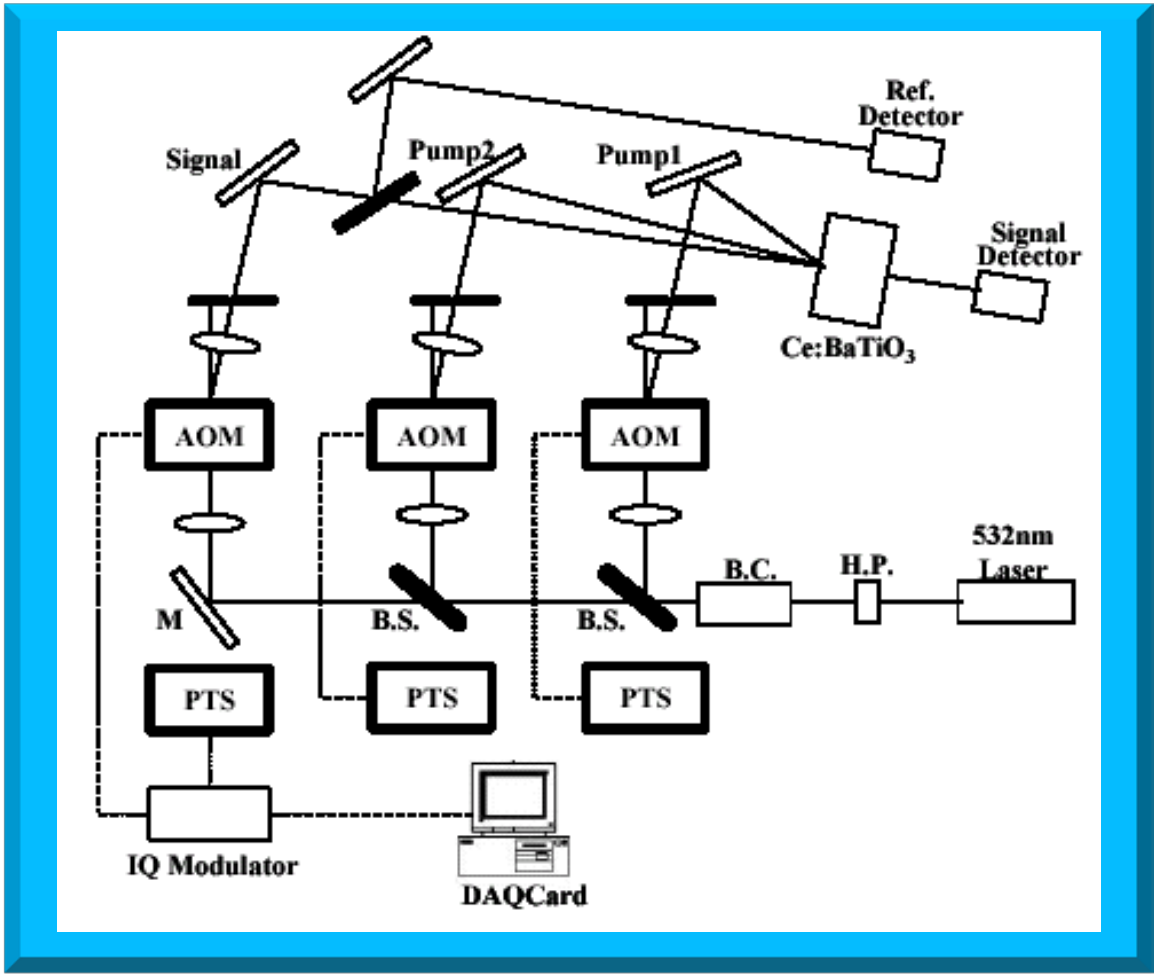
Demonstration of White Light Cavity





G.S. Pati, M. Messal, K. Salit, M.S. Shahriar, Optics Communications, 281 (19), p.4931-4935, (2008)

Fast-light in Photorefractive Crystal for WLC



H.N. Yum, M. Salit, G.S. Pati, S. Tseng, P.R. Hemmer, and M.S.Shahriar, Optics Express, Vol. 16 Issue 25, 20448 (2008)

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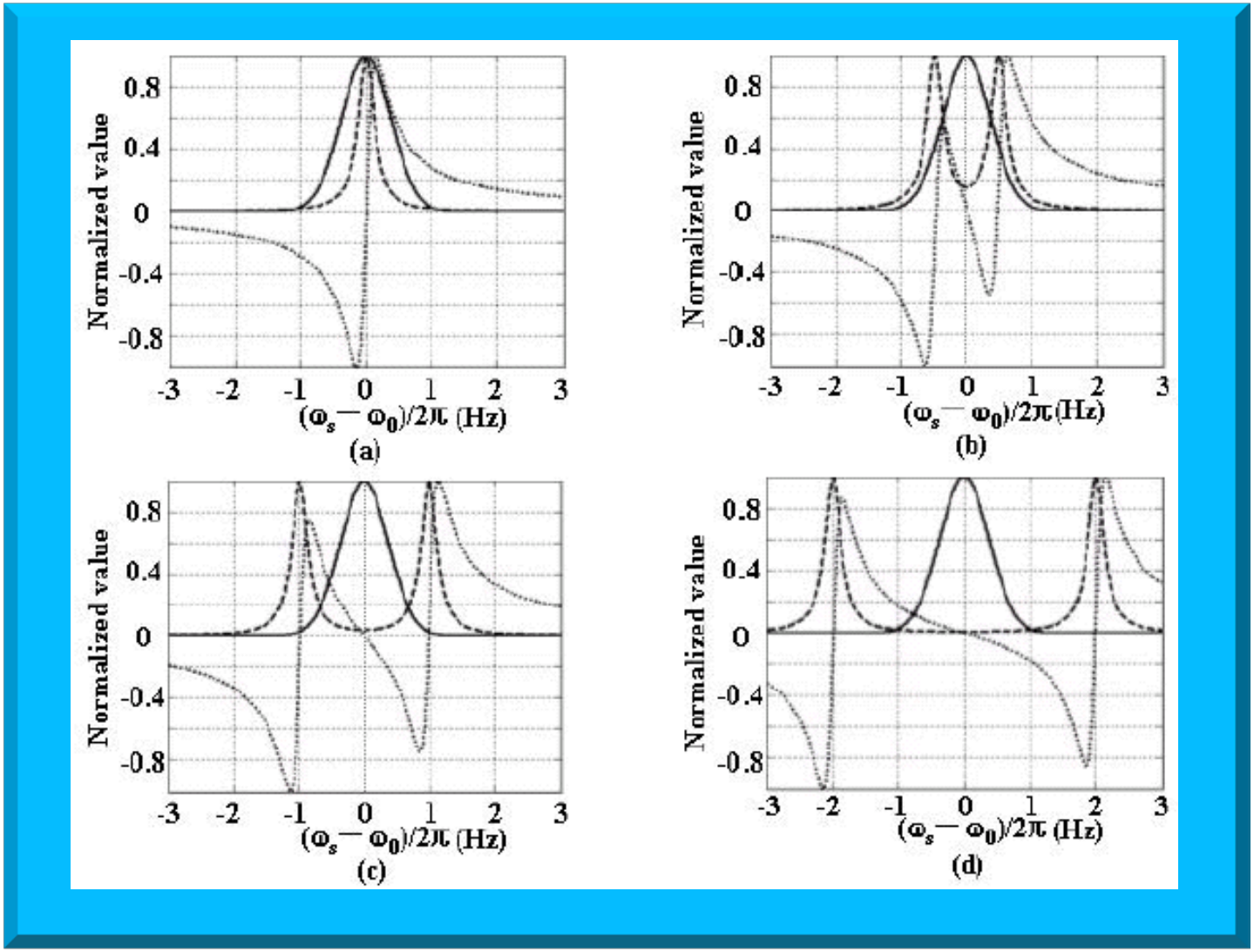

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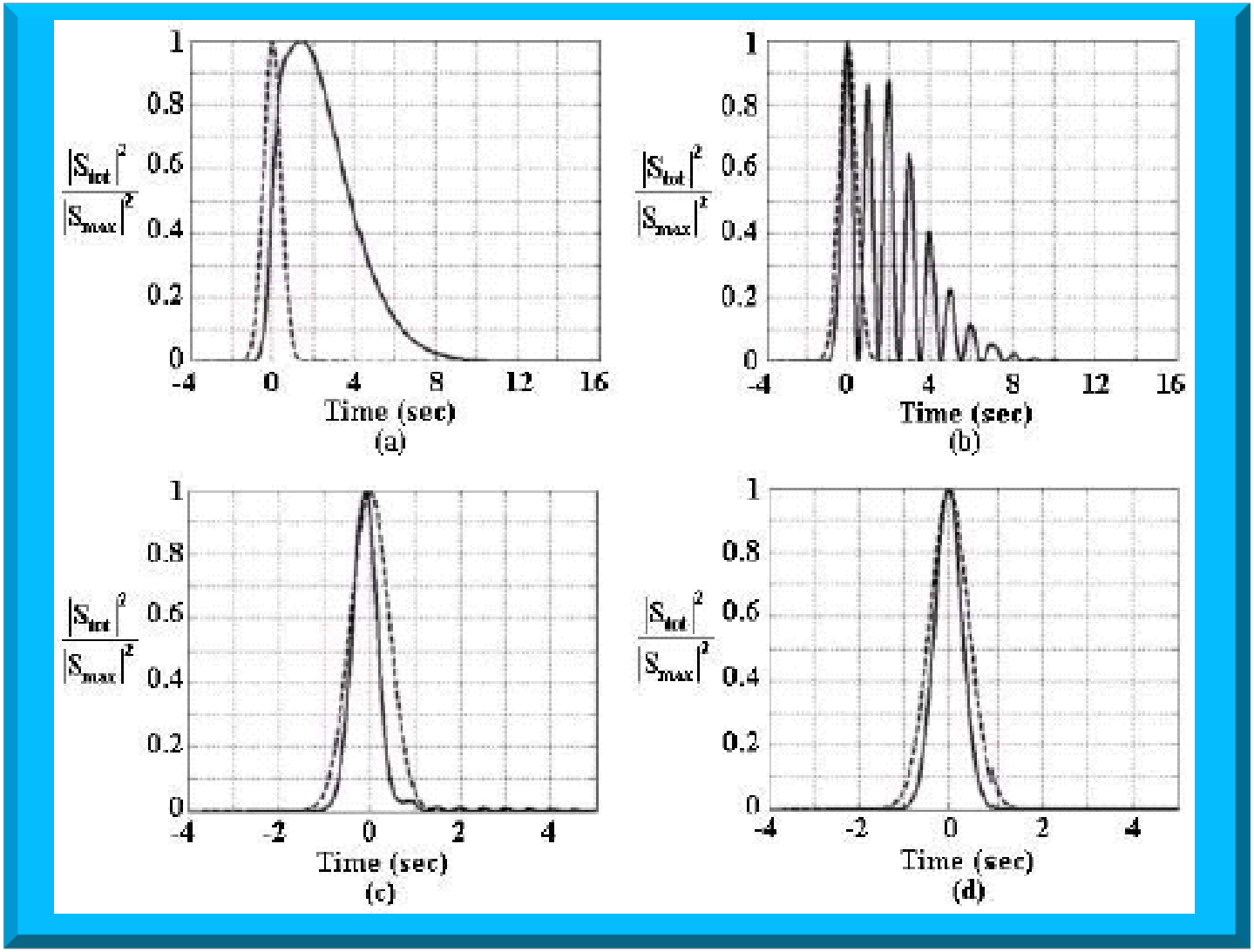
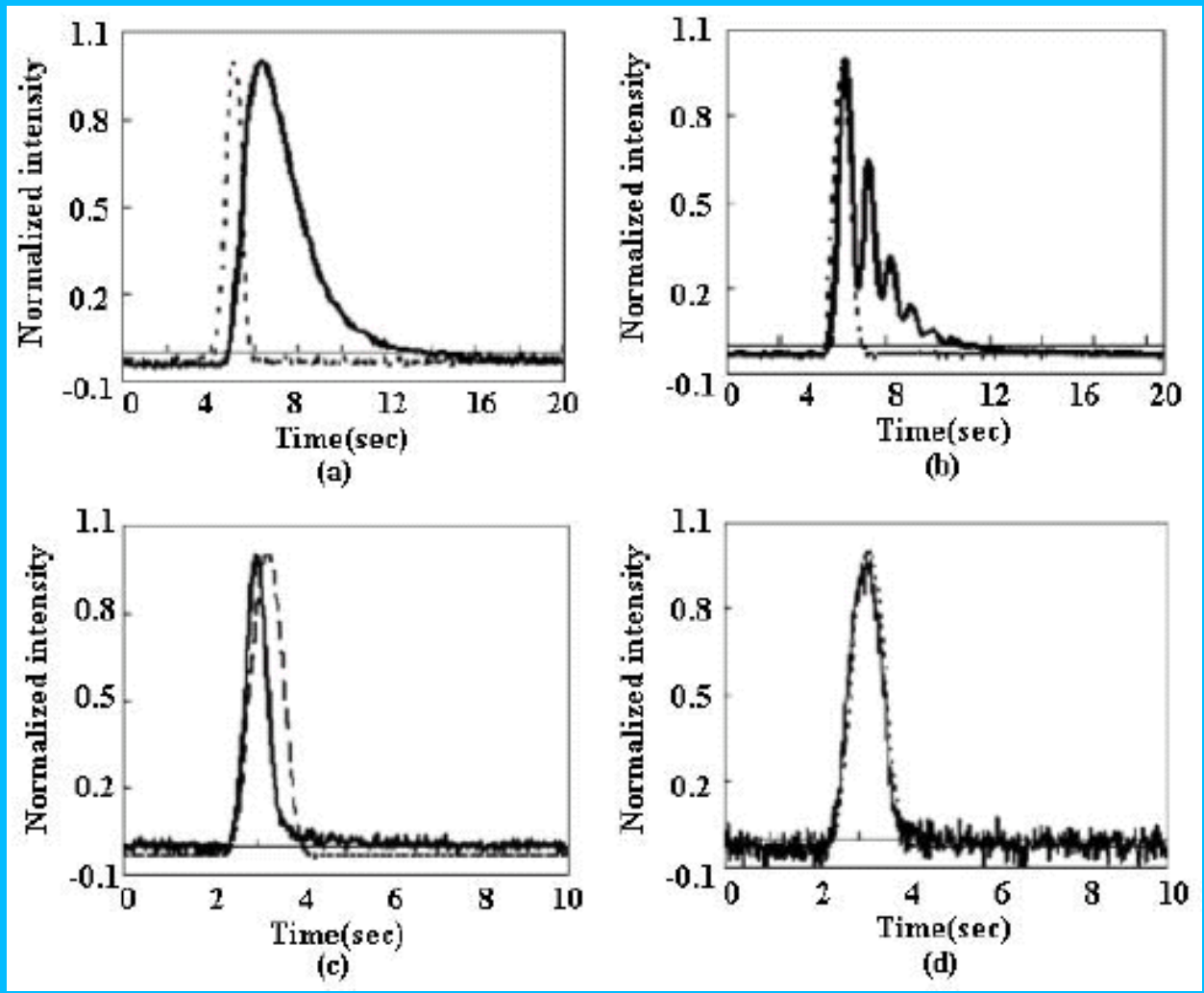
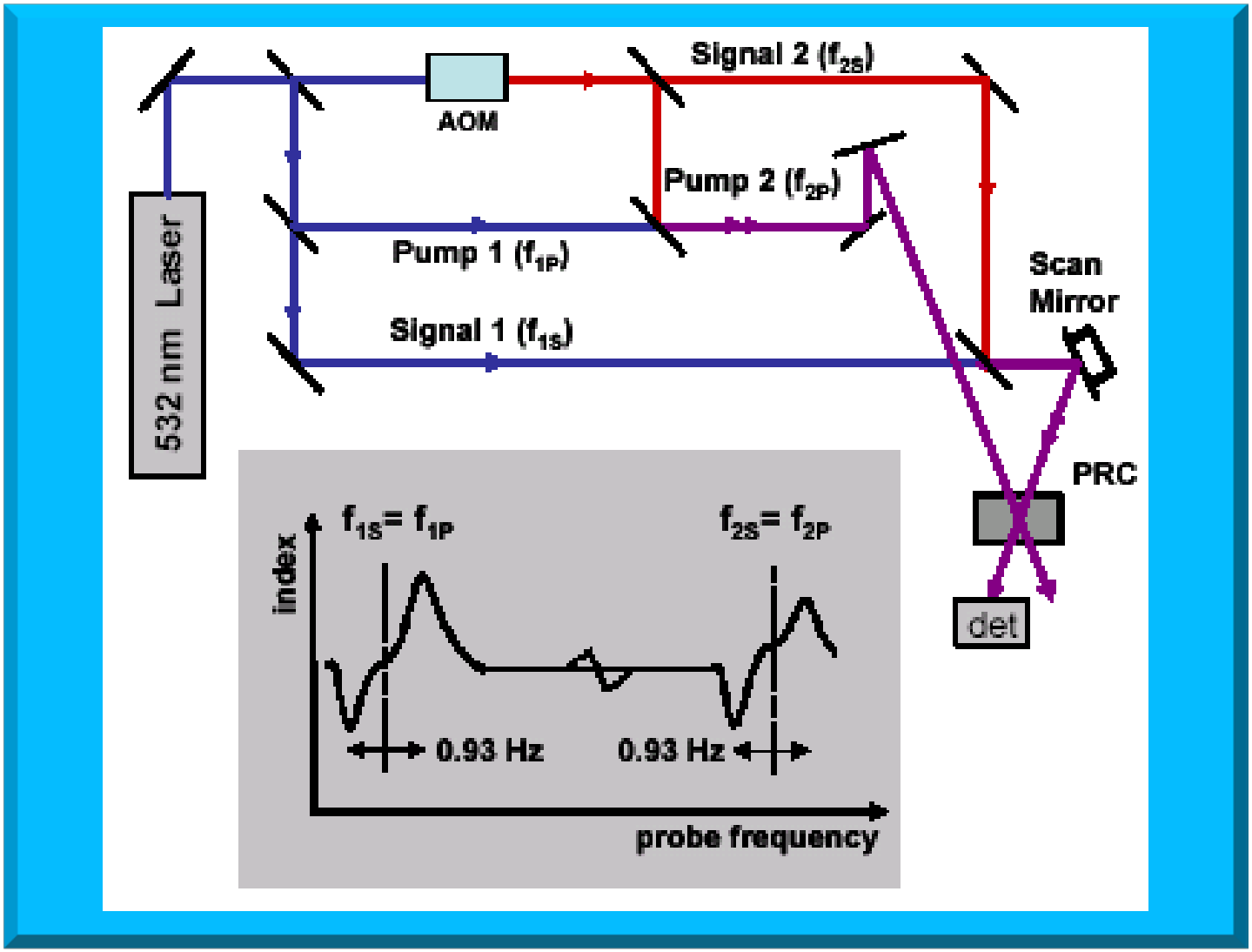


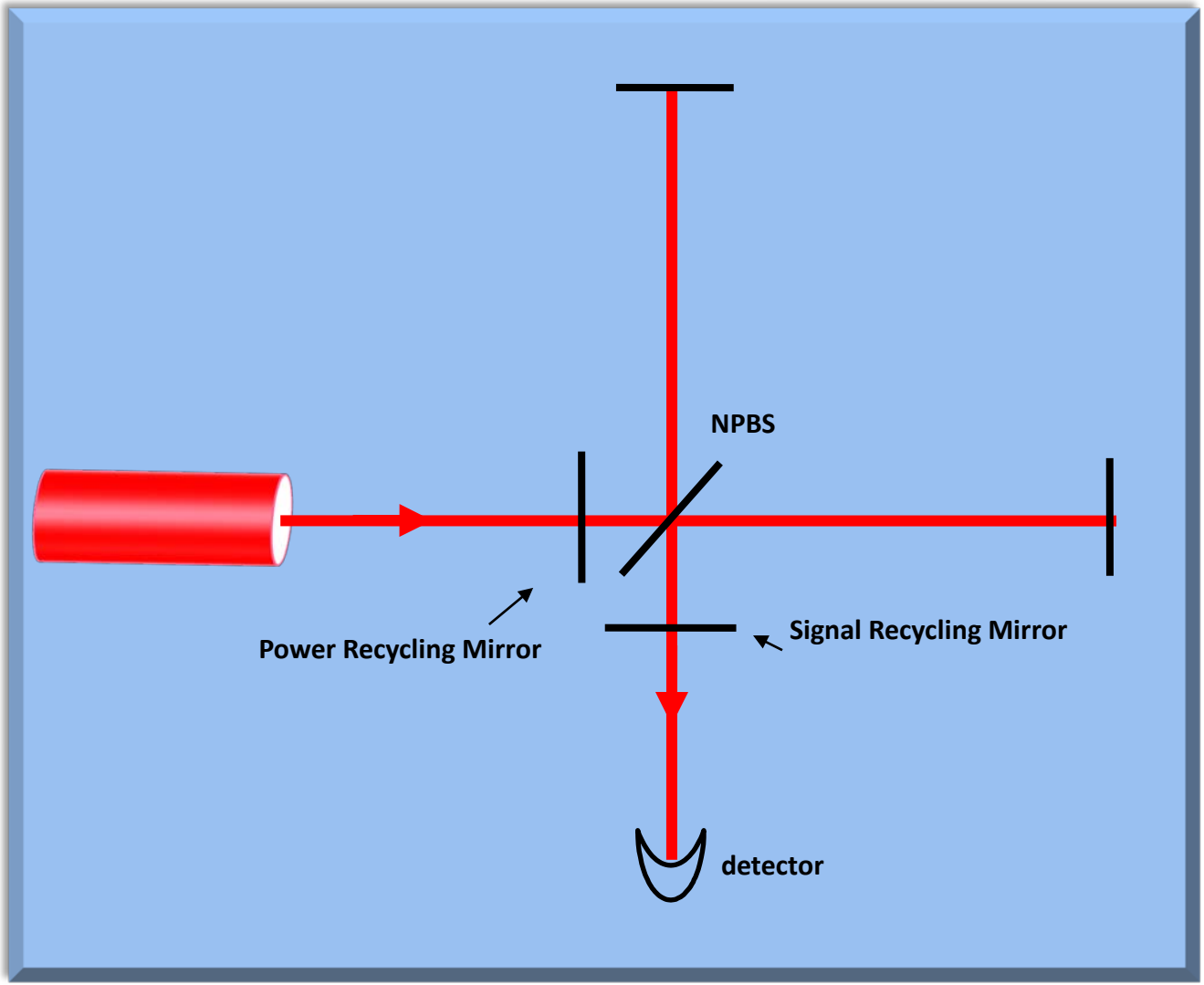
Fast-light in Photorefractive Crystal for WLC



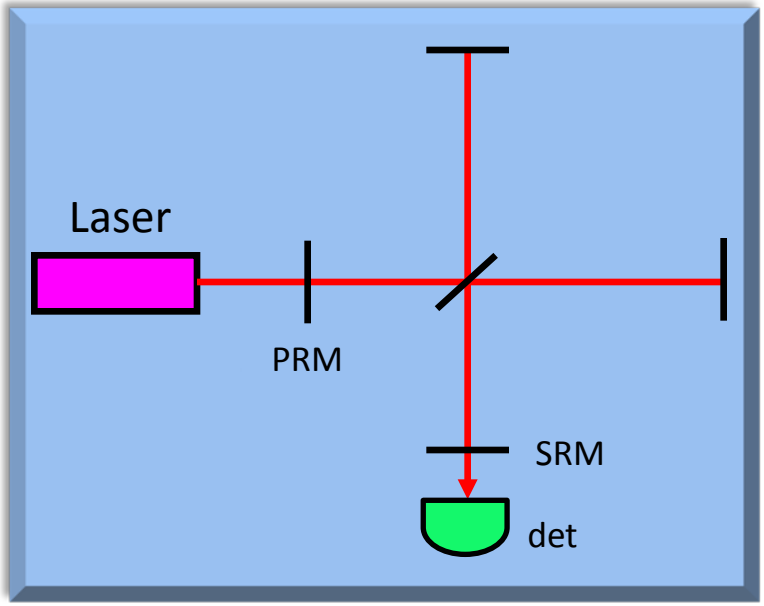
Fast-light in Photorefractive Crystal for WLC

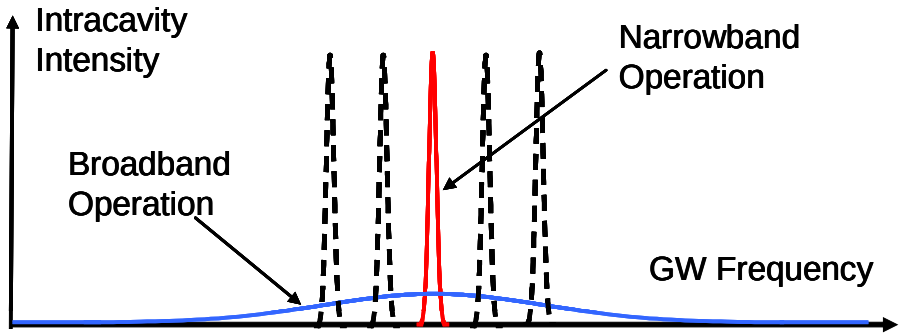


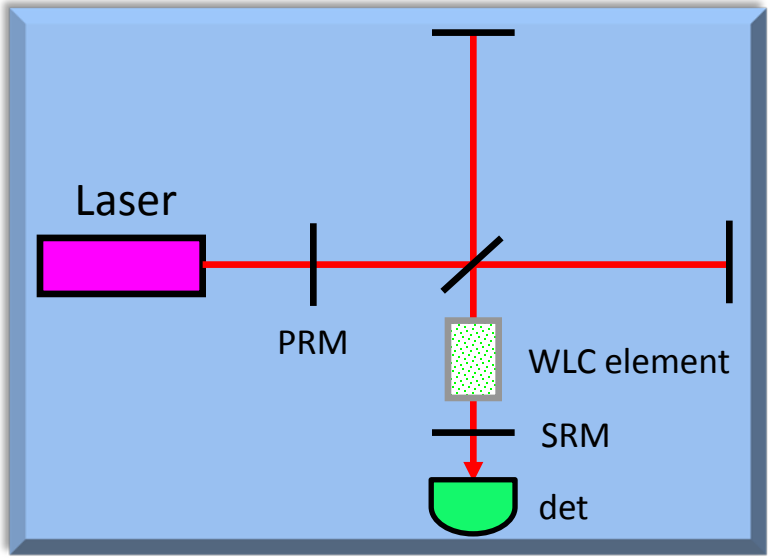
Simple (Meers) Model for Signal and Power Recycling

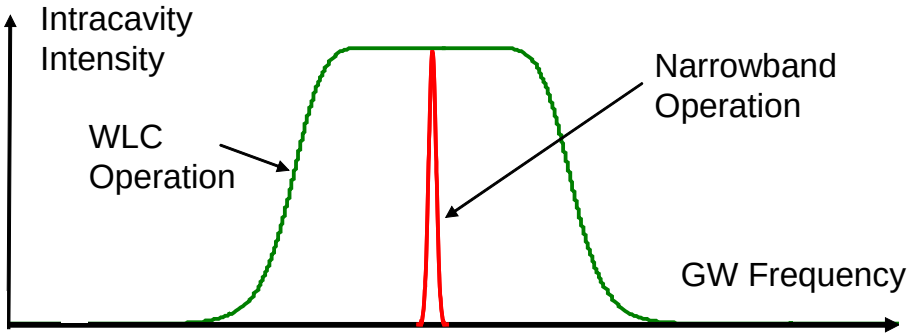


Enhancing the bandwidth-sensitivity product

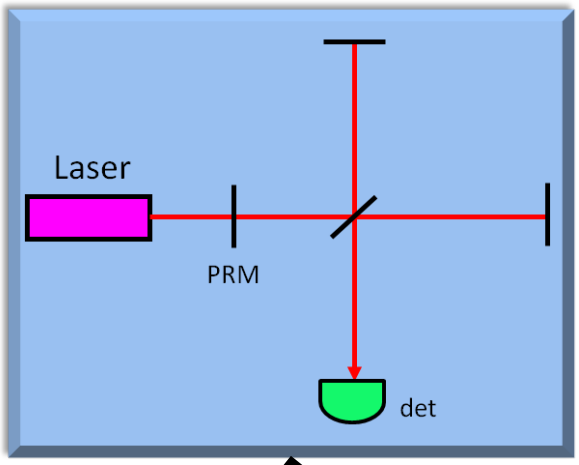


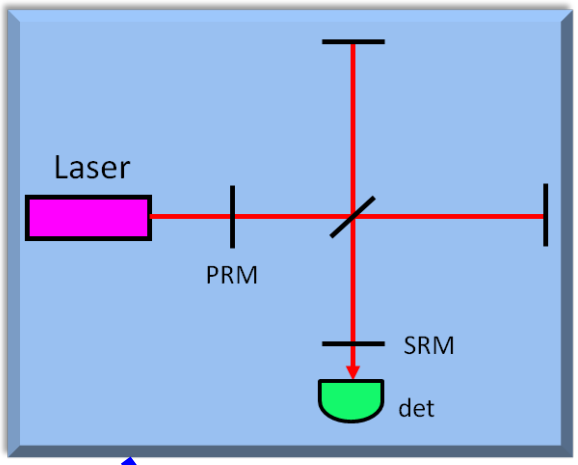


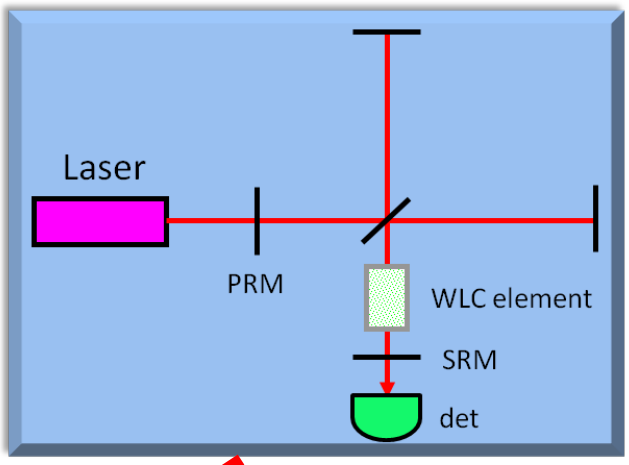


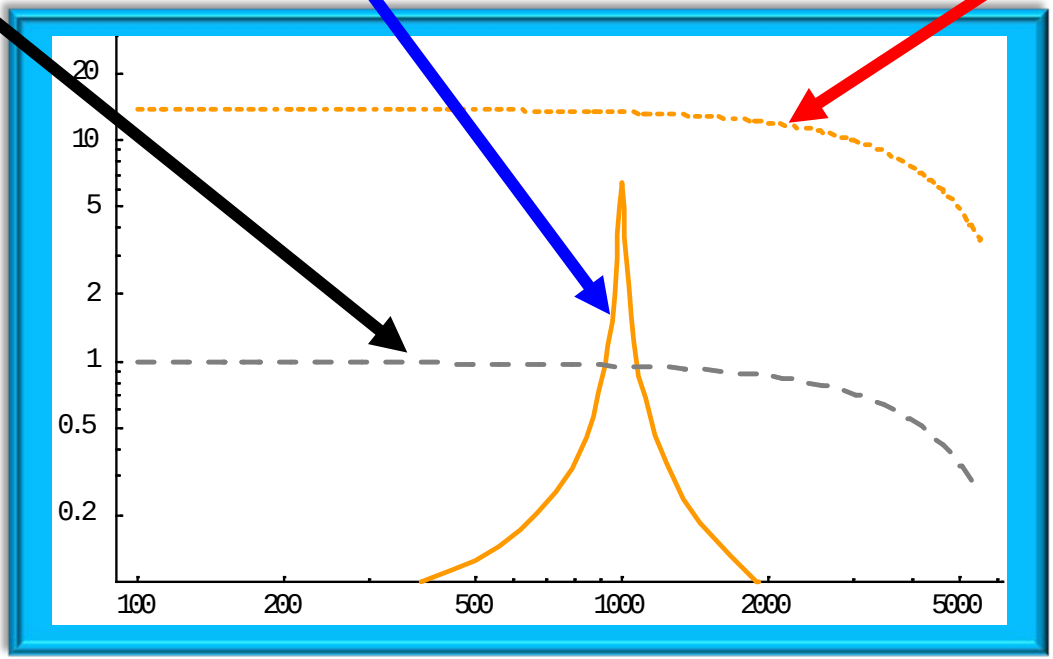


Enhancing the bandwidth-sensitivity product

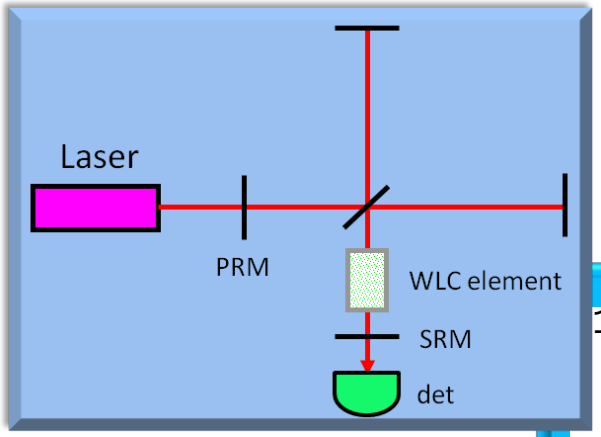


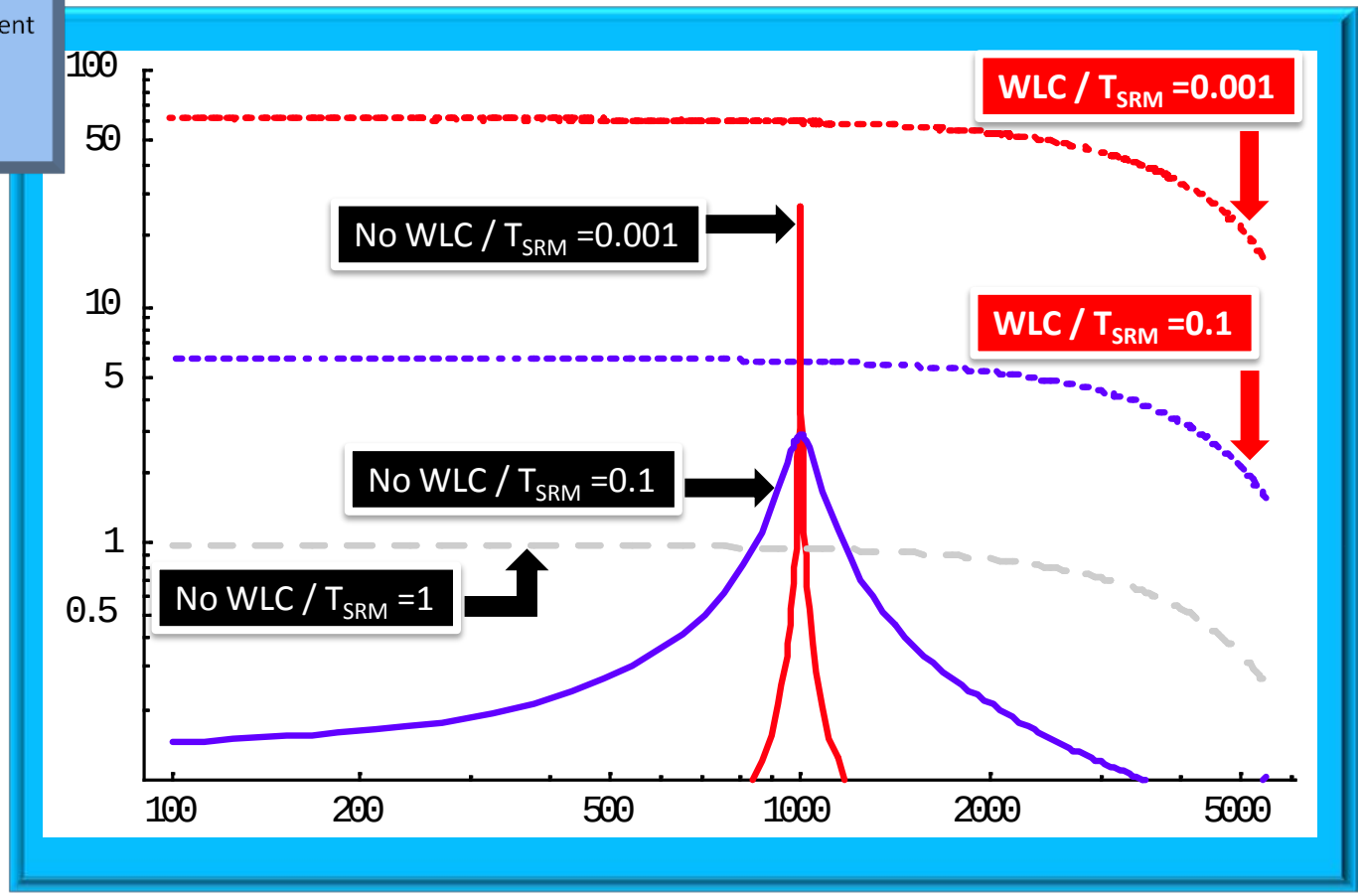




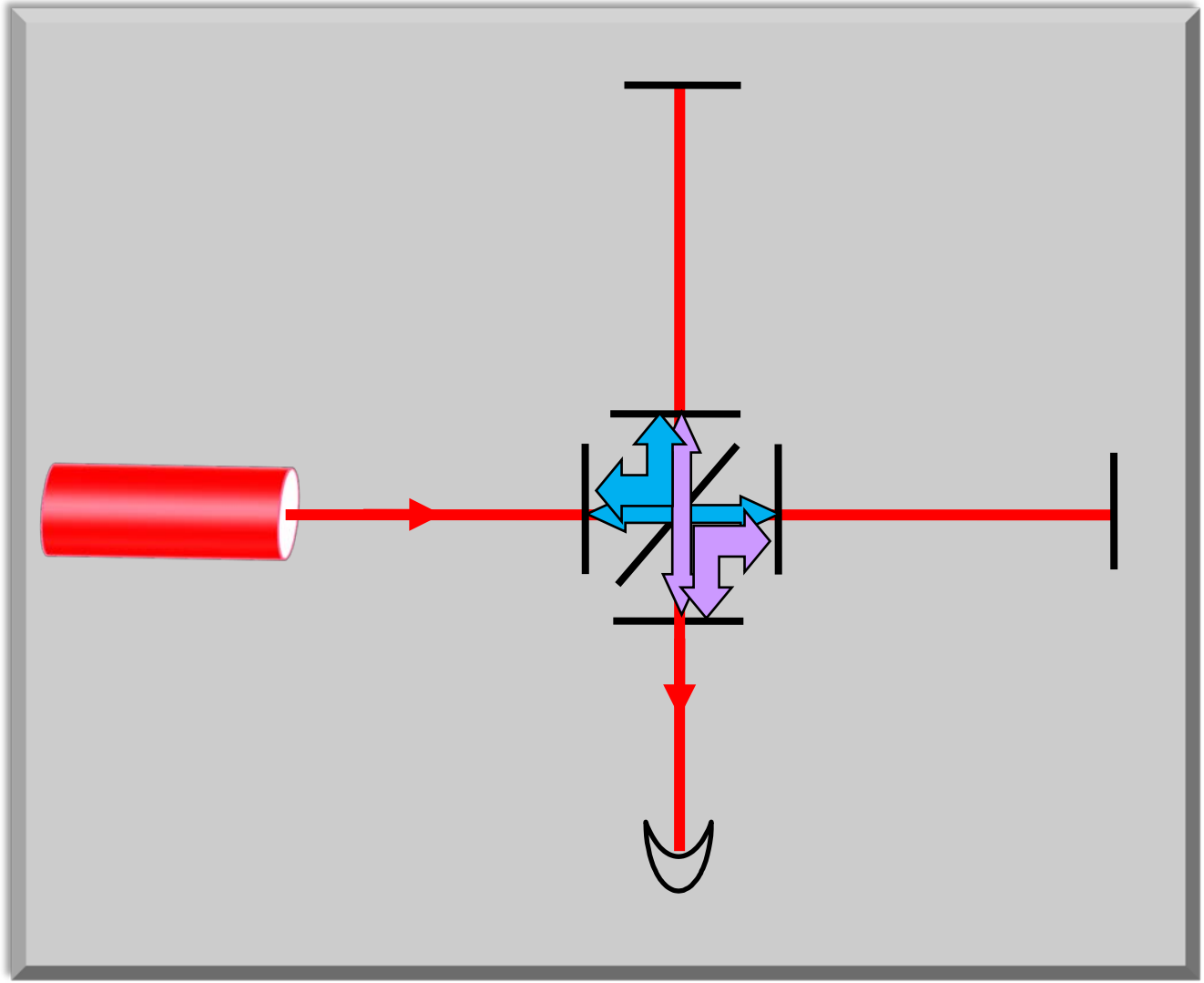


Enhancing the bandwidth-sensitivity product





Signal and Power Recycling in the Presence of Arm Cavities



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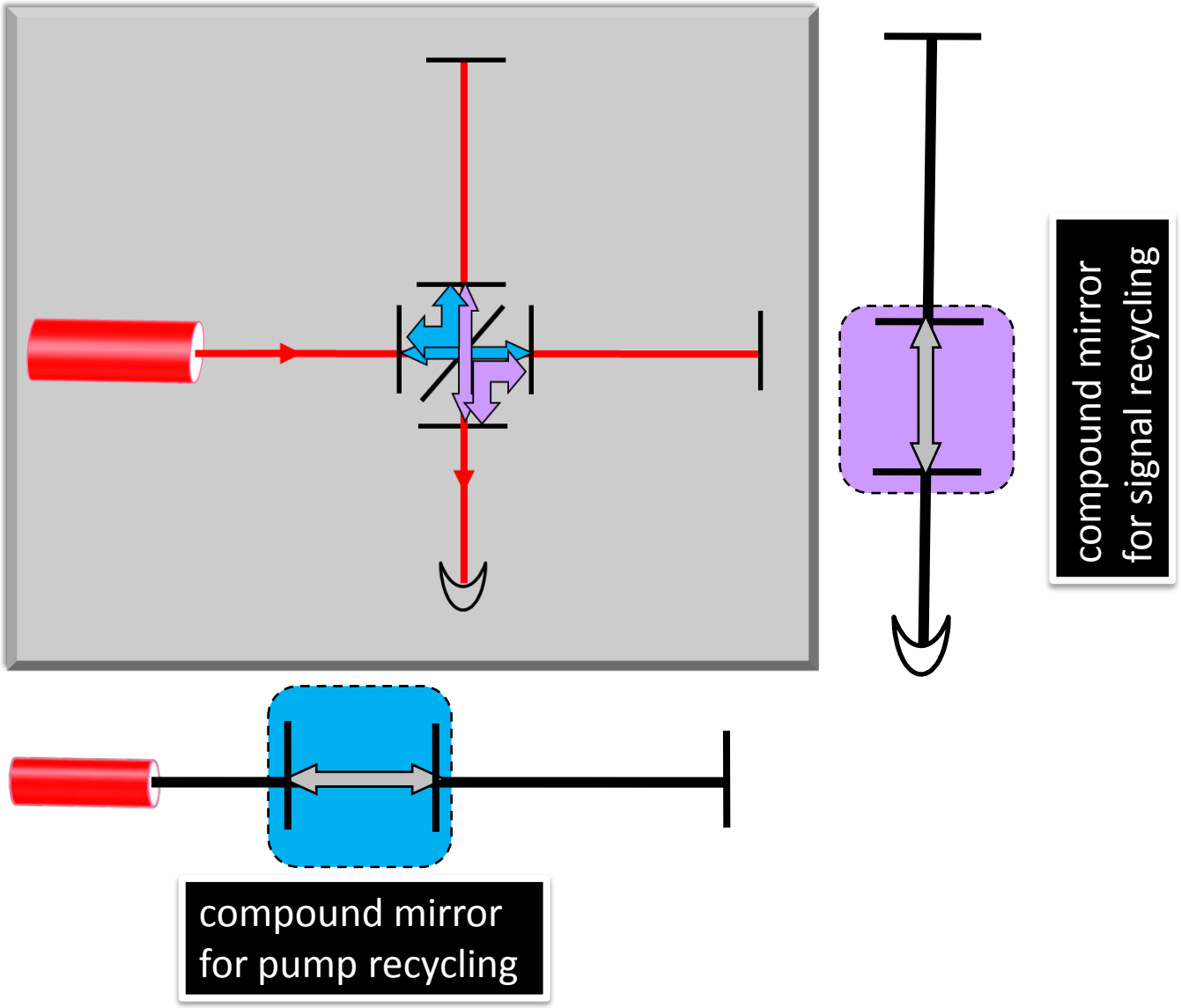
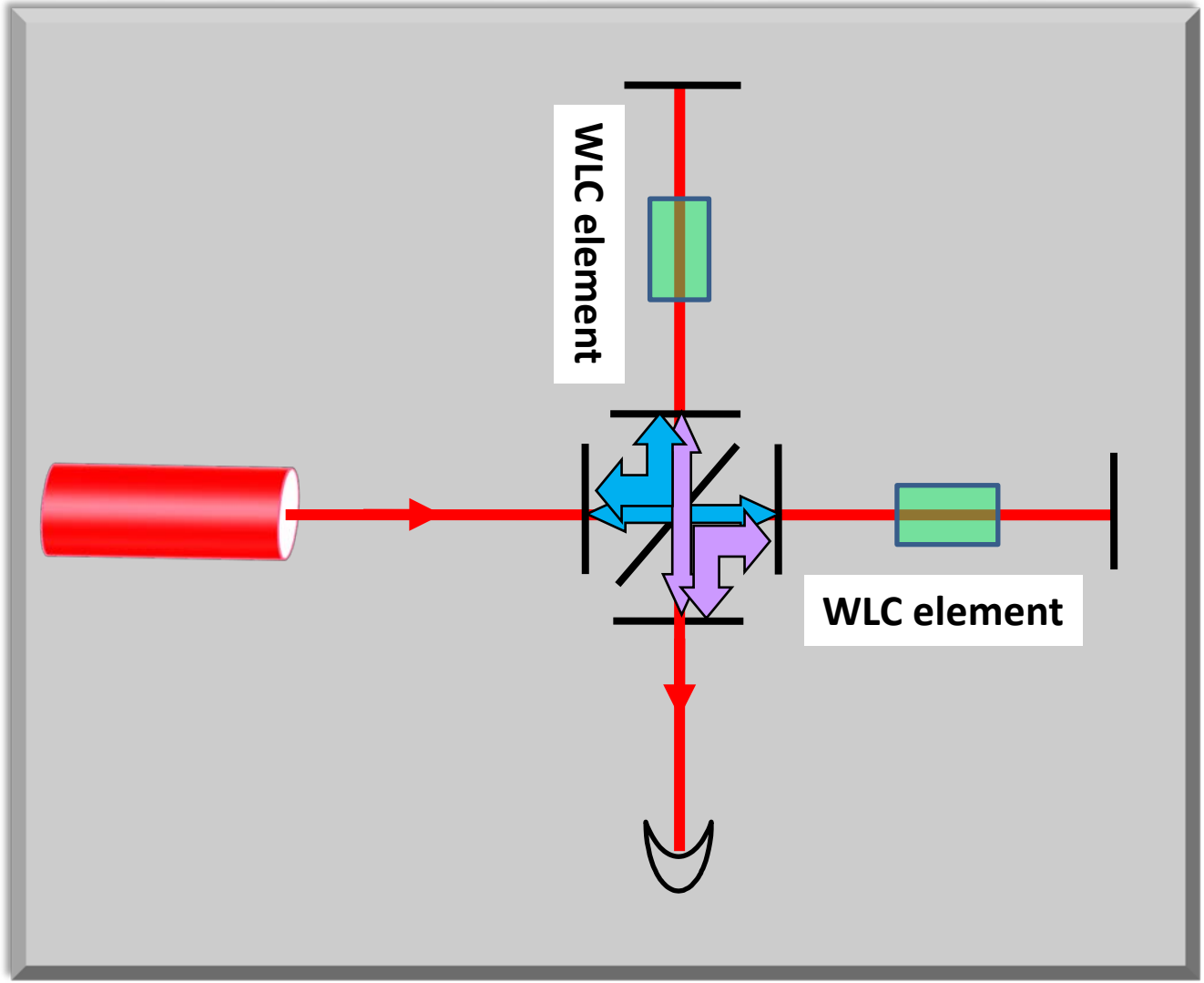


Sensitivity-Bandwidth Enhancement for AdLIGO Configuration



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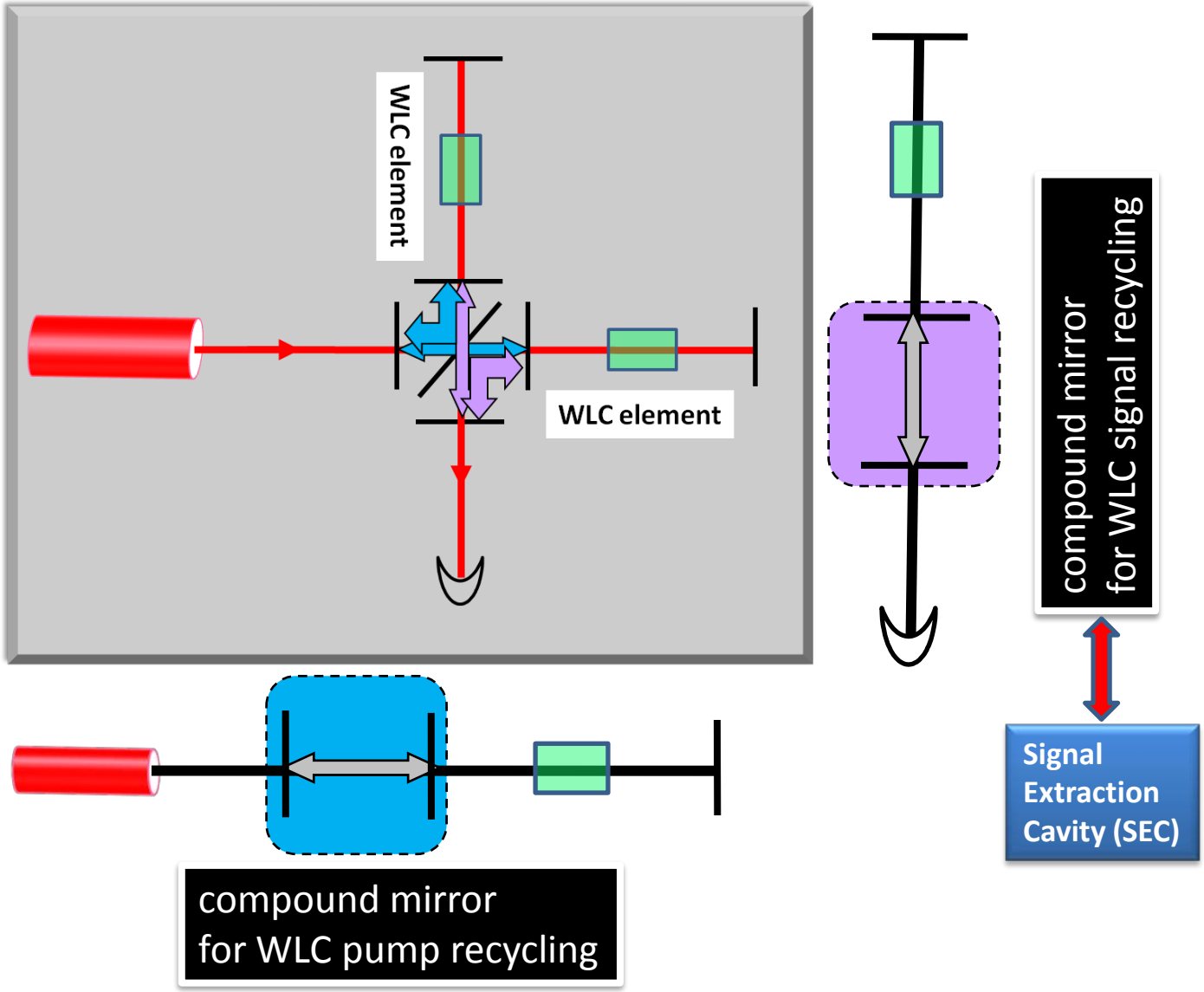

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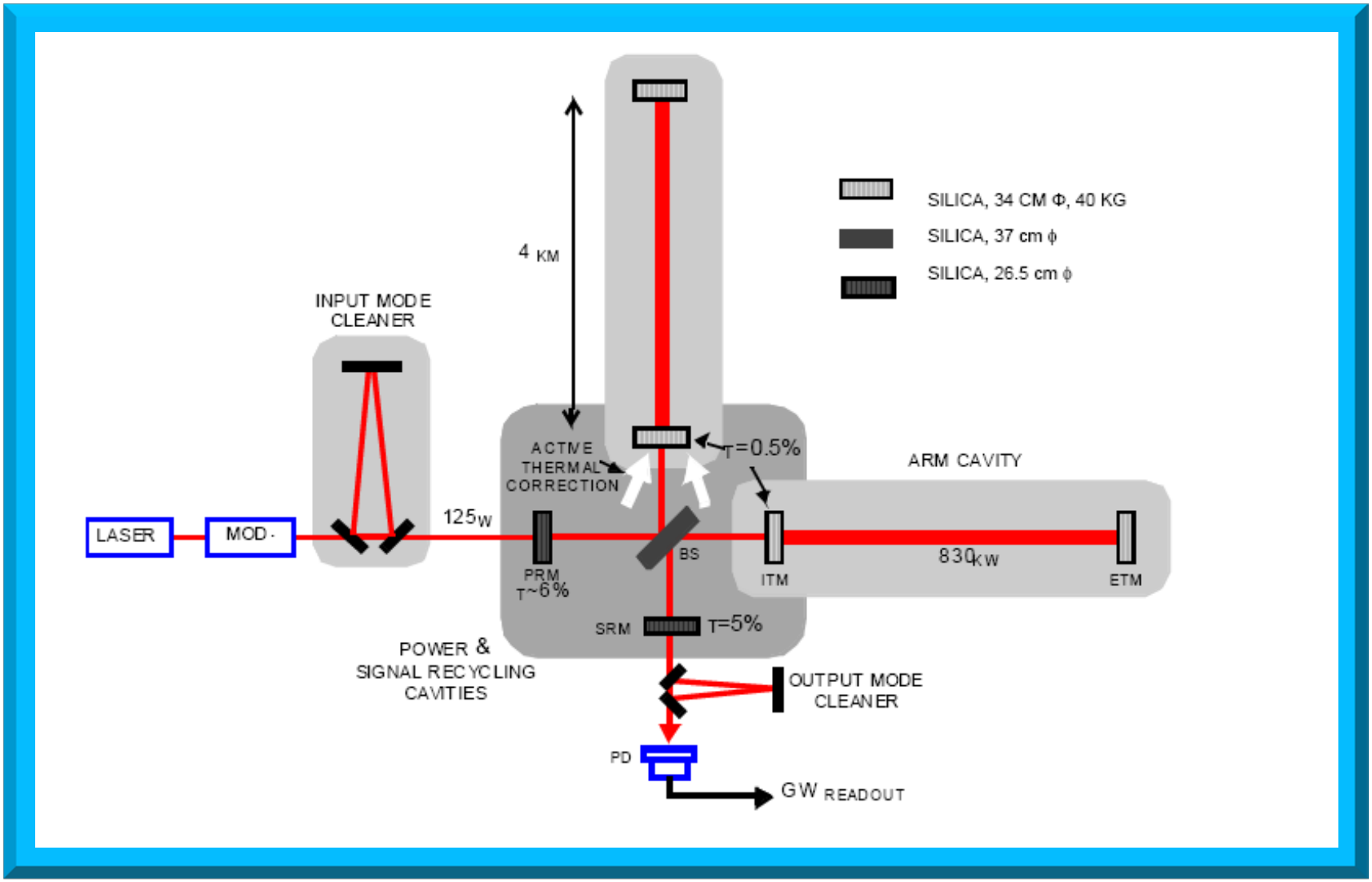
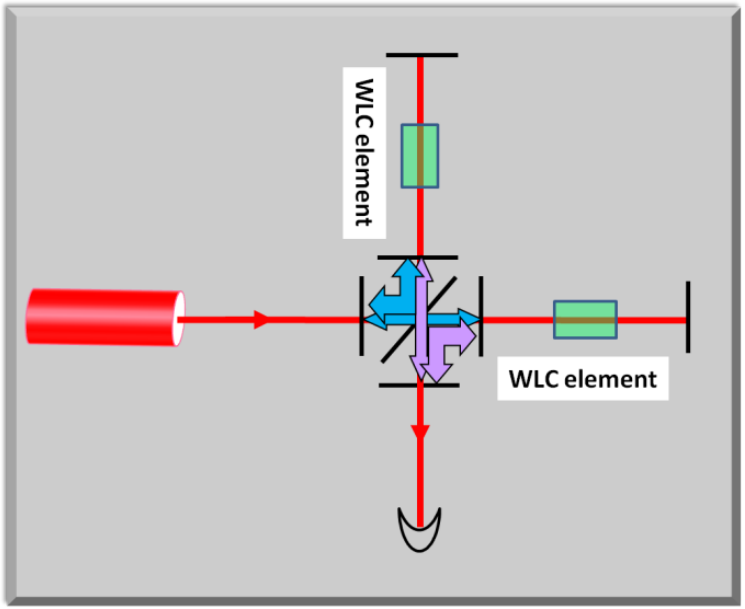
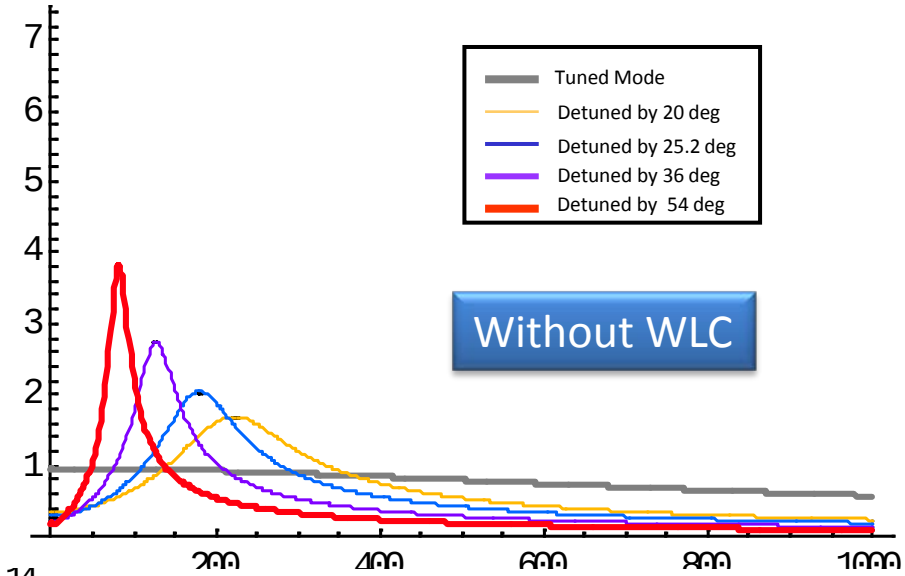
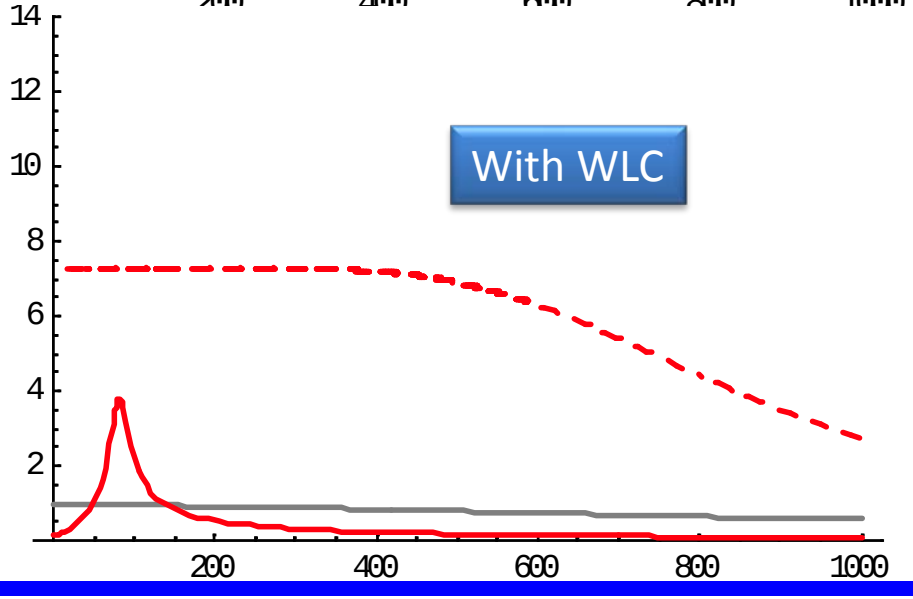


Sensitivity-Bandwidth Enhancement for AdLIGO Configuration







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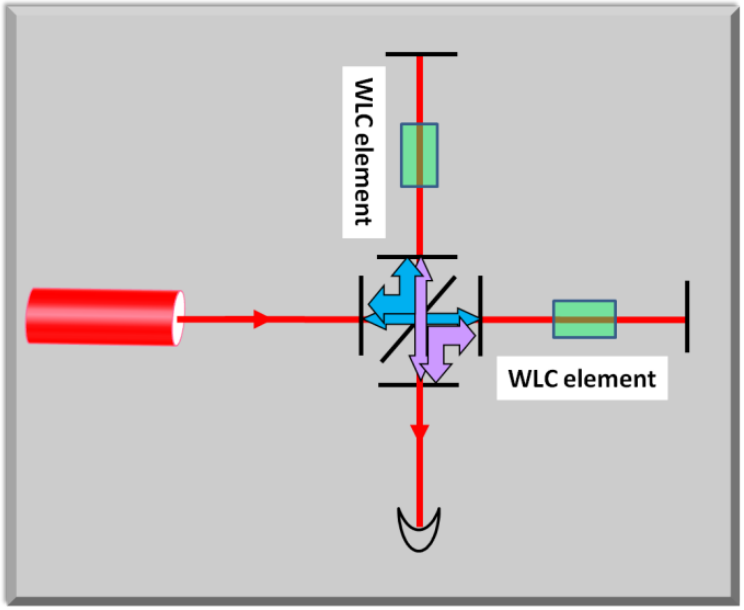
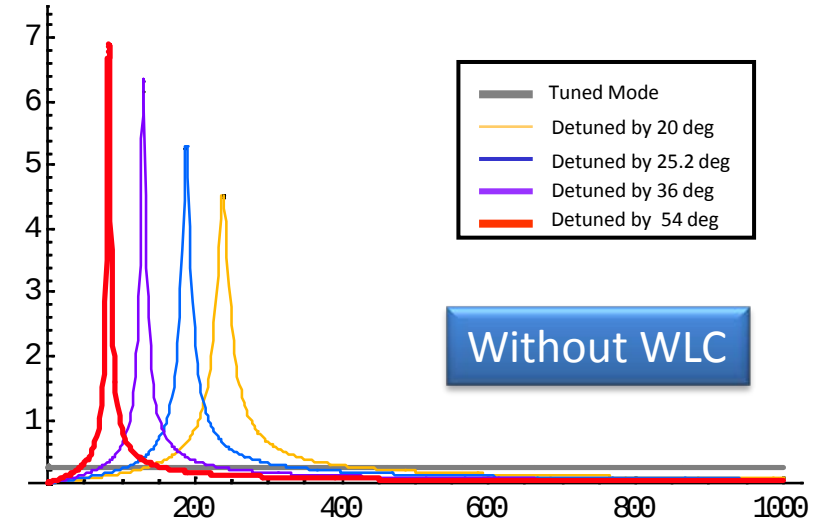
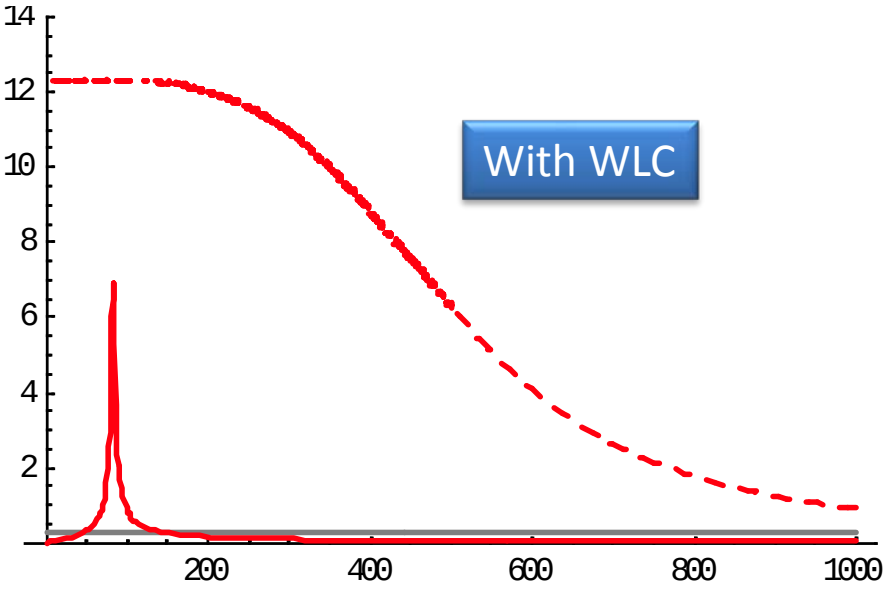
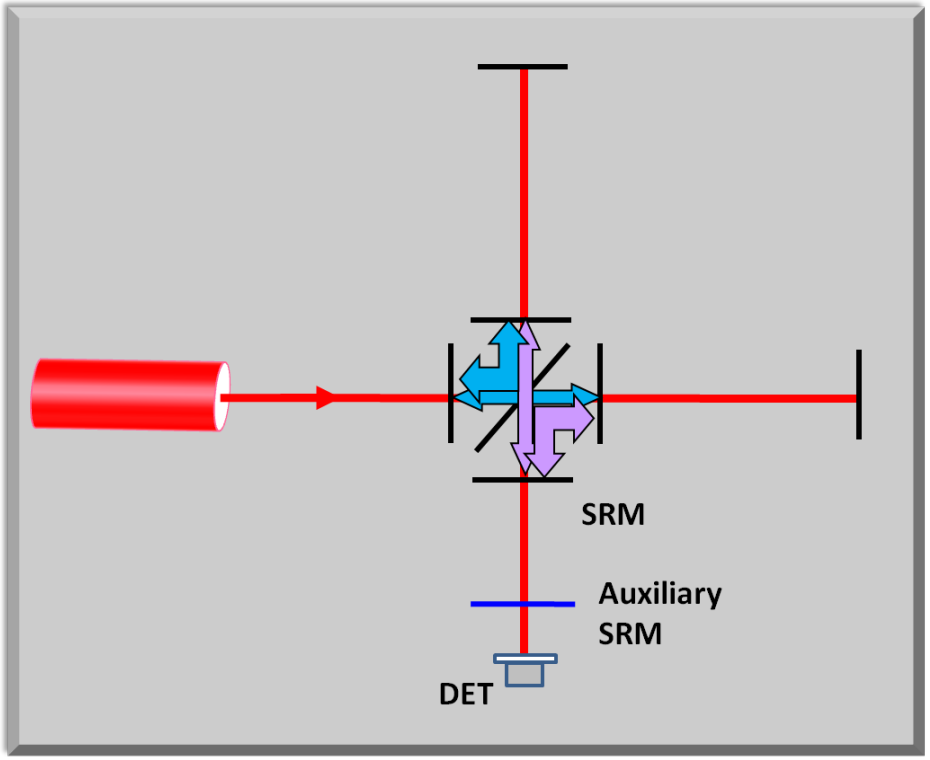
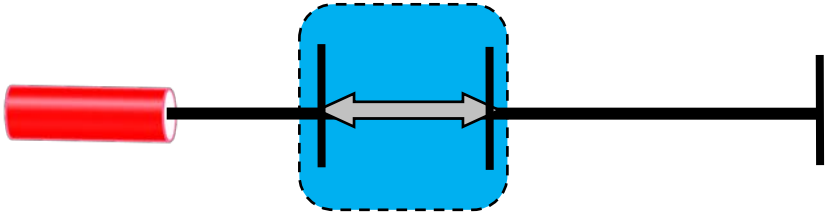




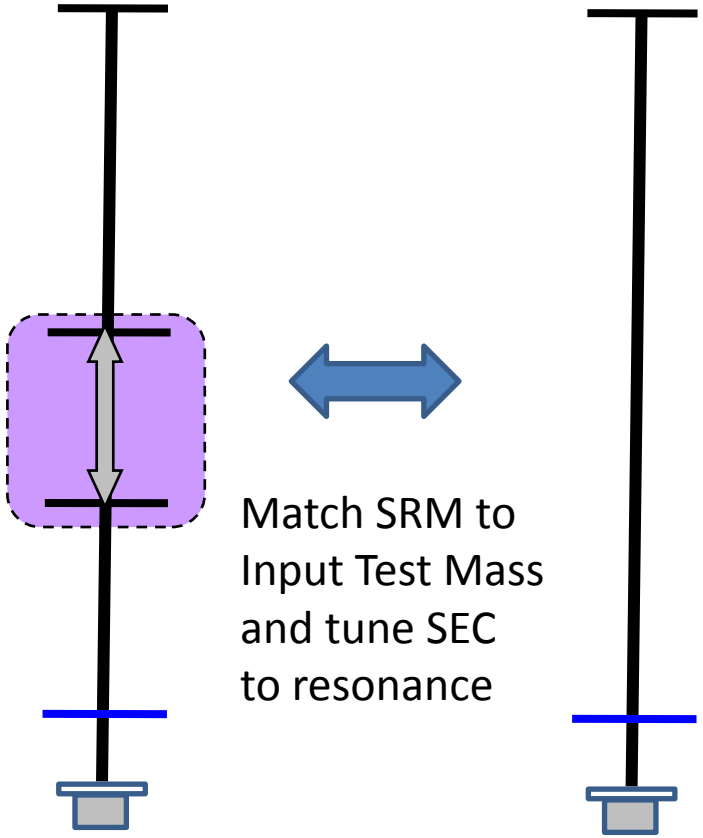


Proposal for Adding an Auxiliary Mirror for Practical WLC



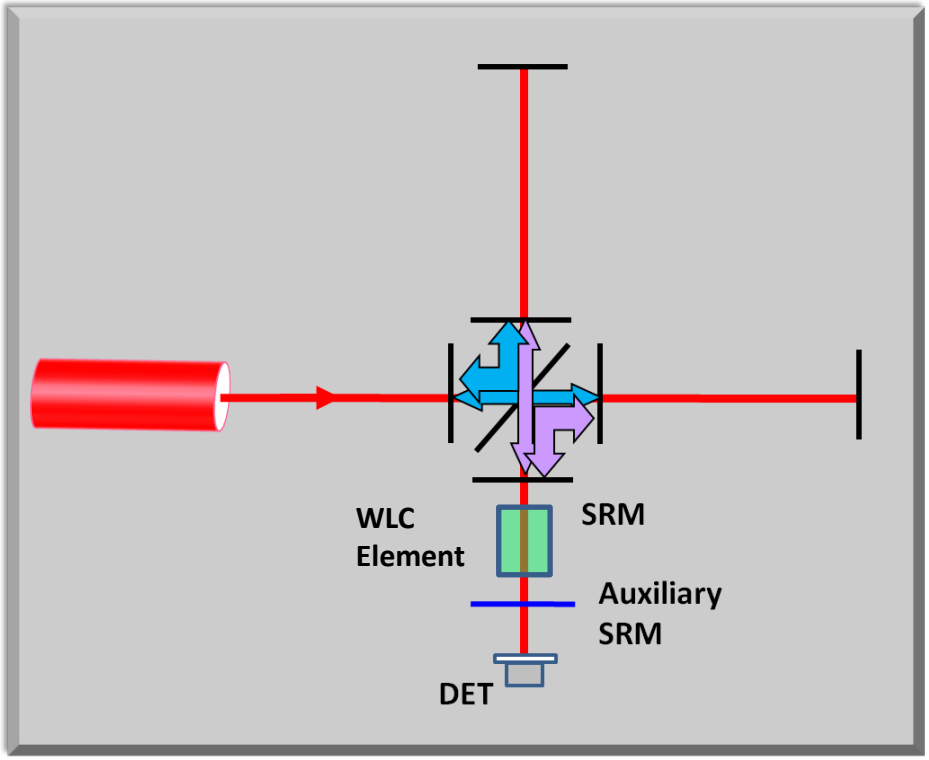


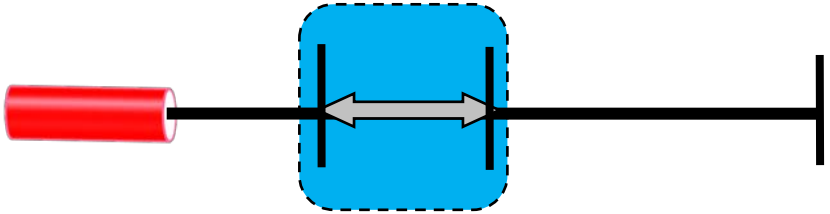
compound mirror
for pump recycling



Match SRM to
Input Test Mass
and tune SEC
to resonance

Proposal for Adding an Auxiliary Mirror for Practical WLC





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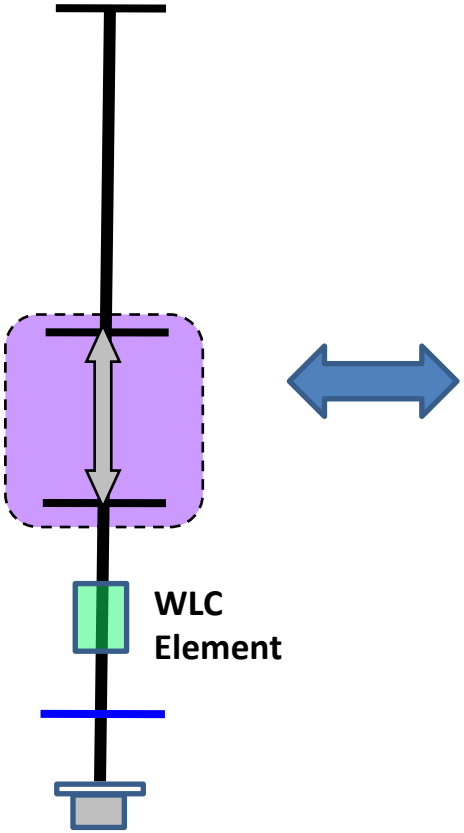

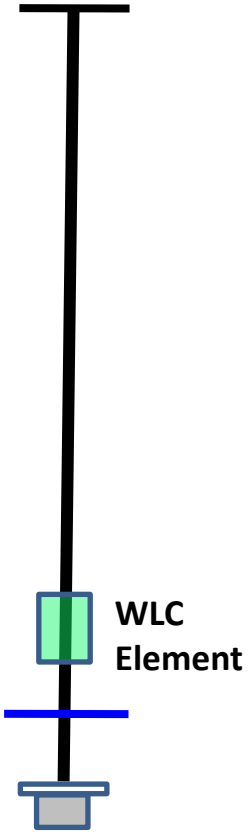

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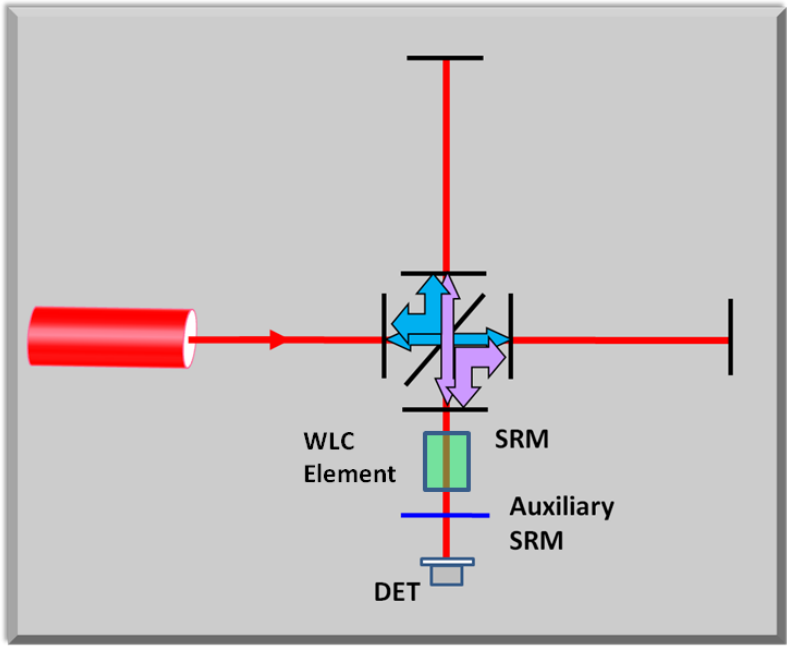

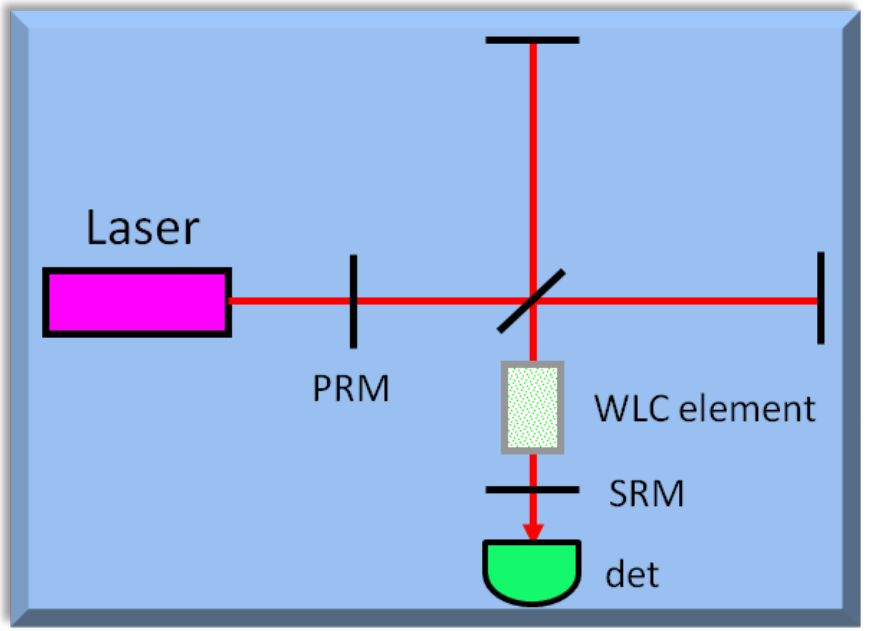

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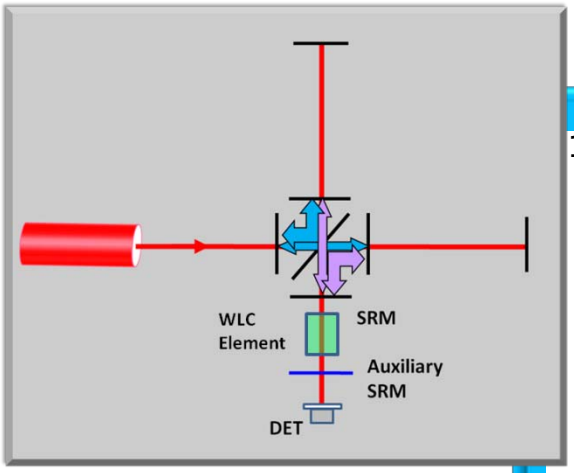
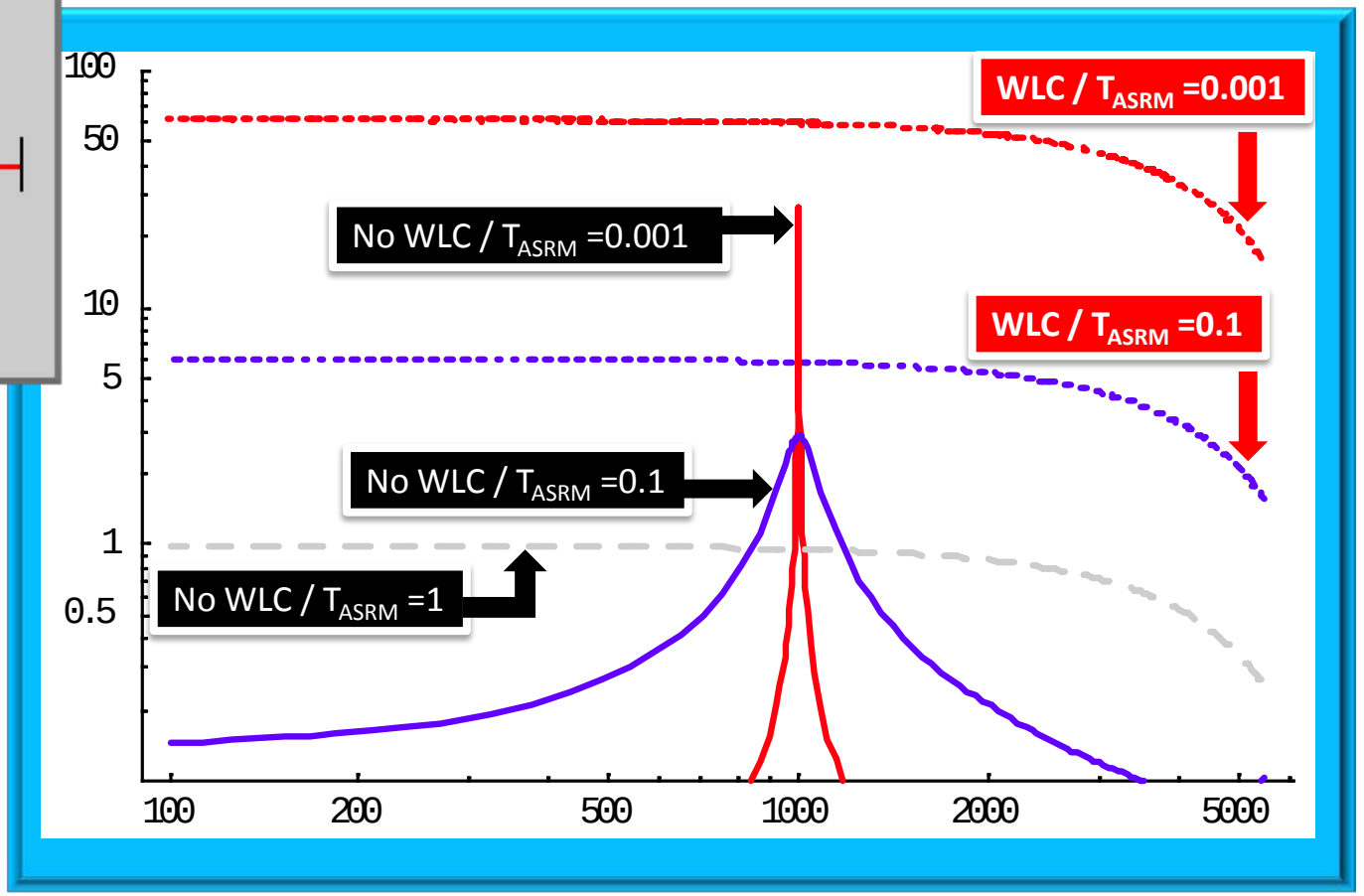




M. Salit and M.S. Shahriar, "Enhancement of Sensitivity-Bandwidth Product of Interferometric Gravitational Wave Detectors using White Light Cavities," (http://arxiv.org/ftp/arxiv/papers/0809/0809.4213.pdf)

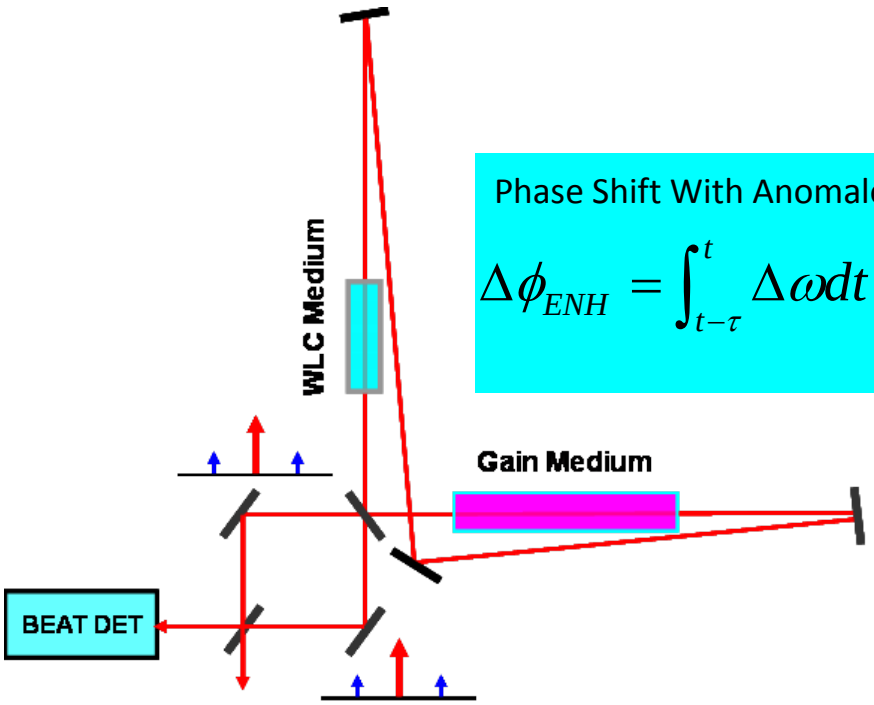
Active Sagnac Ring Laser in a WLC for Enhancing Strain Sensitivity

Phase Shift Without Anomalous Dispersion

$$\Delta\phi = \int_{t-\tau}^{t} \frac{\omega h}{2} Cos(\omega_g t')dt' = \int_{t-\tau}^{t} \Delta\omega_o dt'$$

Phase Shift With Anomalous Dispersion

$$\Delta\phi_{ENH} = \int_{t-\tau}^{t} \Delta\omega dt' = \int_{t-\tau}^{t} \frac{1}{n_g}\Delta\omega_o dt' = \int_{t-\tau}^{t} \frac{1}{n_g}\frac{\omega h}{2} Cos(\omega_g t')dt'$$



M.S. Shahriar and M. Salit, (2008) Journal of Modern Optics Vol. 55, Nos. 19–20, 10–20 November 2008, 3133–3147

M. S. Shahriar and M. Salit, "A Fast-Light Enhanced Zero-Area Sagnac Ring Laser Gravitational Wave Detector," (http://lapt.eecs.northwestern.edu/preprints/FE-ZASRLGWD.pdf)

Journal publications and preprints

G.S. Pati, R. Tripathi, V. Gopal, M. Messal, Phys. Rev. A 75, 053807 (2007)

G.S. Pati, M. Messal, K. Salit, M.S. Shahriar, Phys. Rev. Lett. 99, 133601 (2007)

M. Salit, G.S. Pati, K. Salit, and M.S. Shahriar, (2007) Journal of Modern Optics, 54:16, 2425 - 2440

G.S. Pati, M. Messal, K. Salit, M.S. Shahriar, Optics Communications, 281 (19), p.4931-4935, (2008)

H.N. Yum, M. Salit, G.S. Pati, S. Tseng, P.R. Hemmer, and M.S.Shahriar, Optics Express, Vol. 16 Issue 25, 20448 (2008)

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