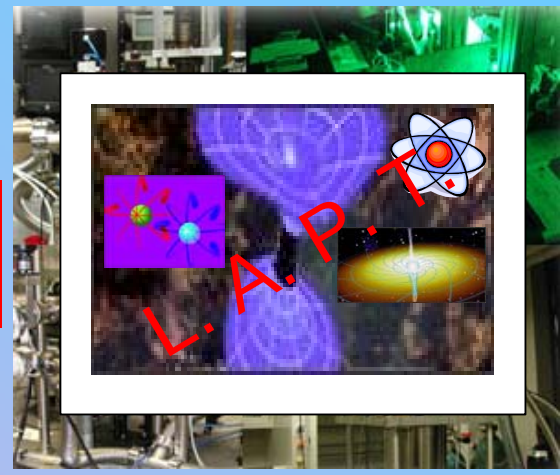
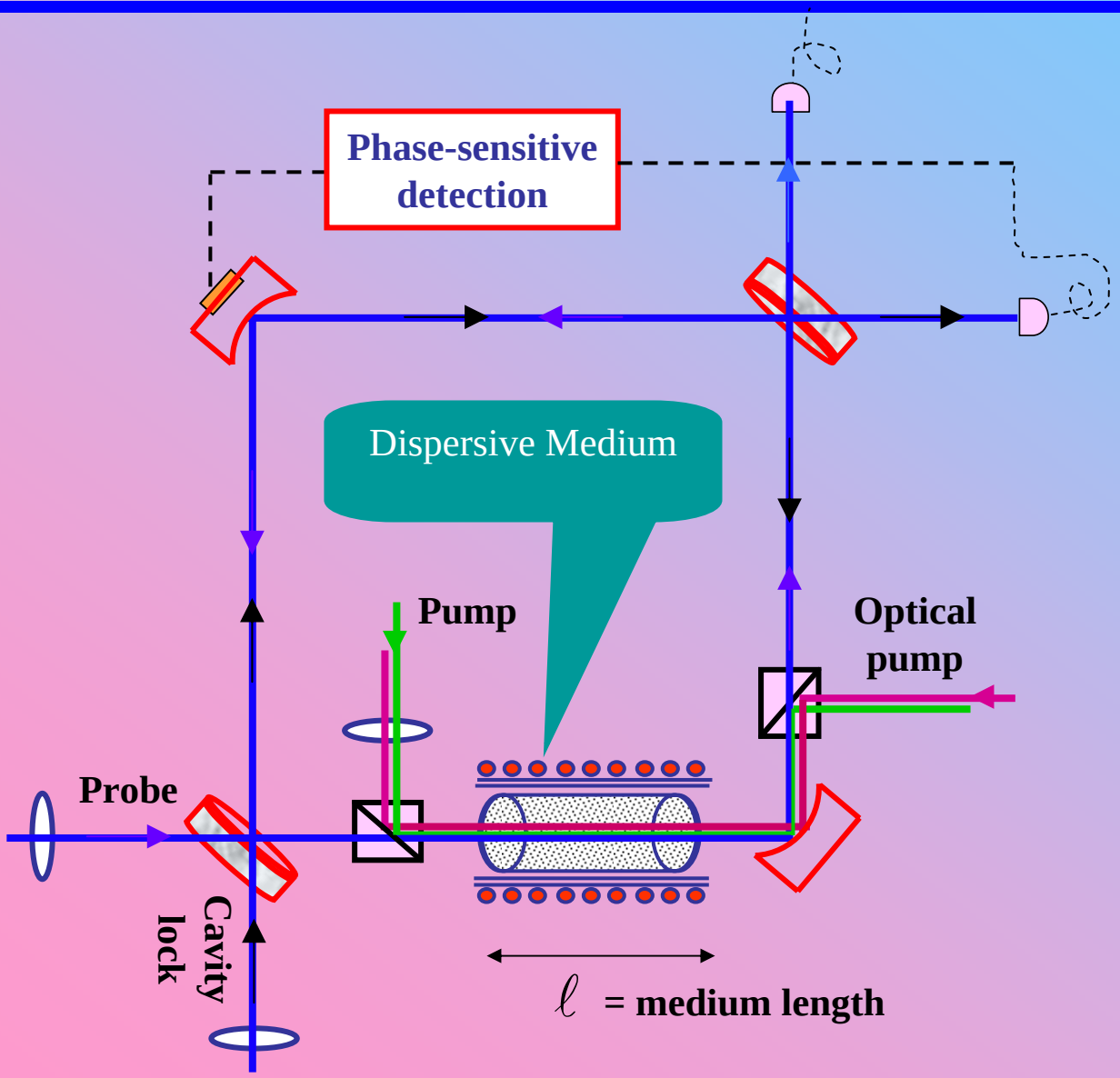
Summary of Proposed Collaboration with the LIGO Scientific Consortium (LSC)

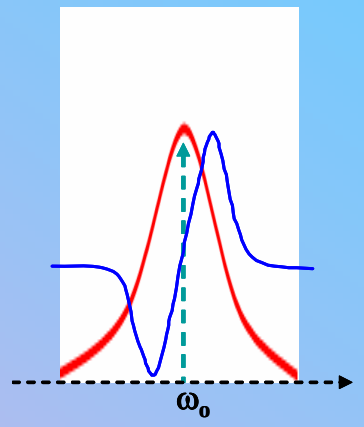


Group Name:	Northwestern University White Light Cavity Experiment Group (**NUWLCEG**)
Team Leader:	Prof. Selim Shahriar, Northwestern University
Collaborators:	Profs. Marlan Scully and Suhail Zubairy, Texas A&M Univeristy
Advisers:	Prof. Vicky Kalogera, Northwestern University Dr. Raymond Beausoleil, HP Profs. Shaoul Ezekiel and Nergis Mavalvala, MIT

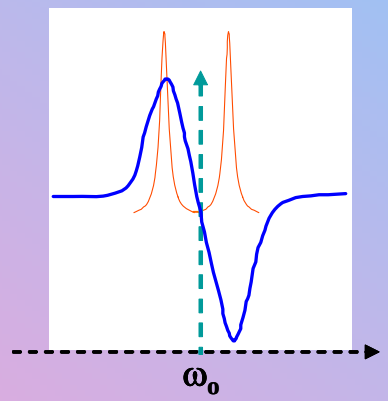
A WHITE LIGHT CAVITY



Cavity Resonance Condition ($\omega_c = \omega_o$)



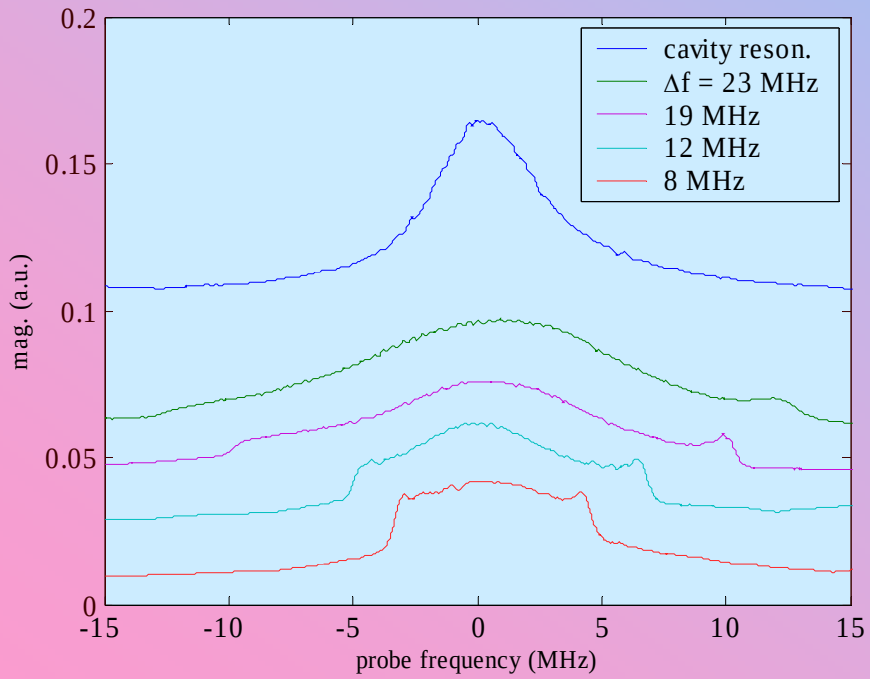
Pos. Dispersion



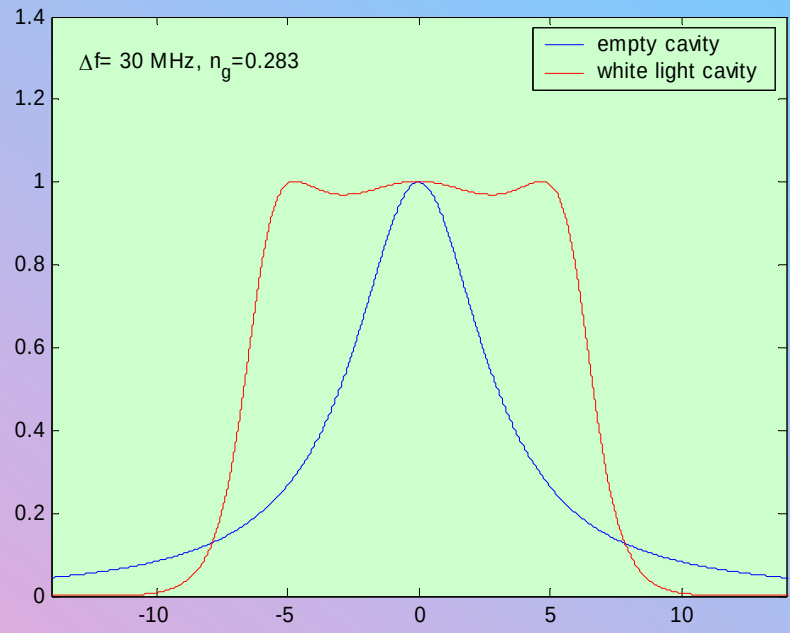
Neg. Dispersion

WLC Demonstration using Double-Gain Anomalous Dispersion

Experiment



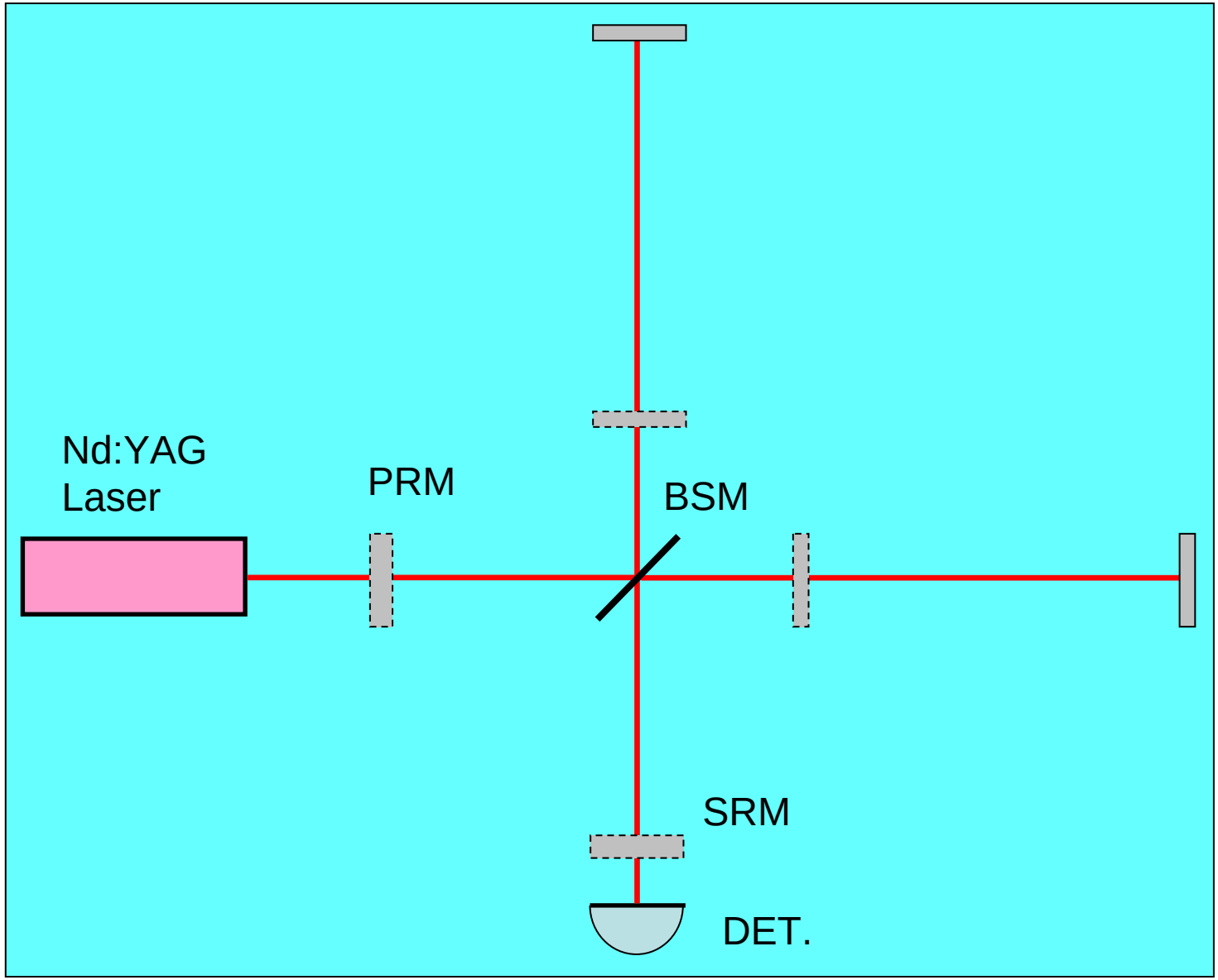
Simulation



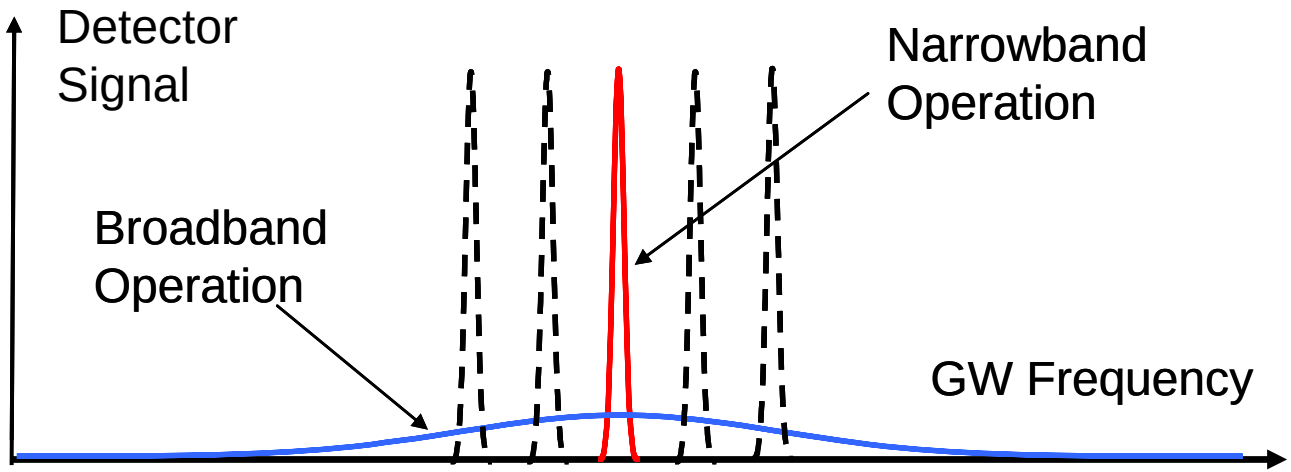
Relevance of WLC to Ad-LIGO

- The WLC would enhance the Sensitivity-Bandwidth Product of the Advanced LIGO
- We believe the WLC can, at some point, be added to the existing arhitecture of the Advanced LIGO

BASIC FEATURES OF ADVANCED LIGO

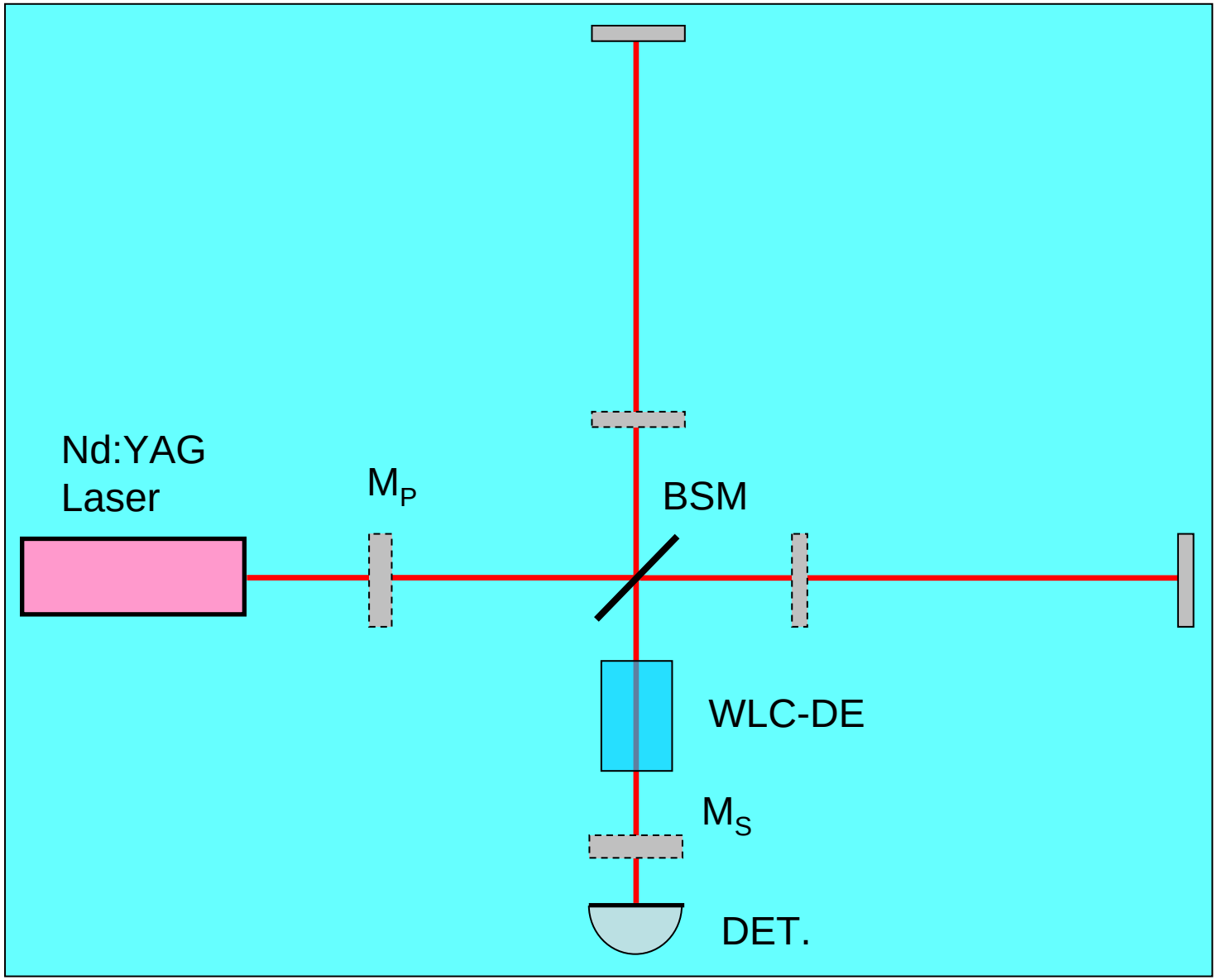


Limitation of Advanced LIGO: Sensitivity-Bandwidth Product



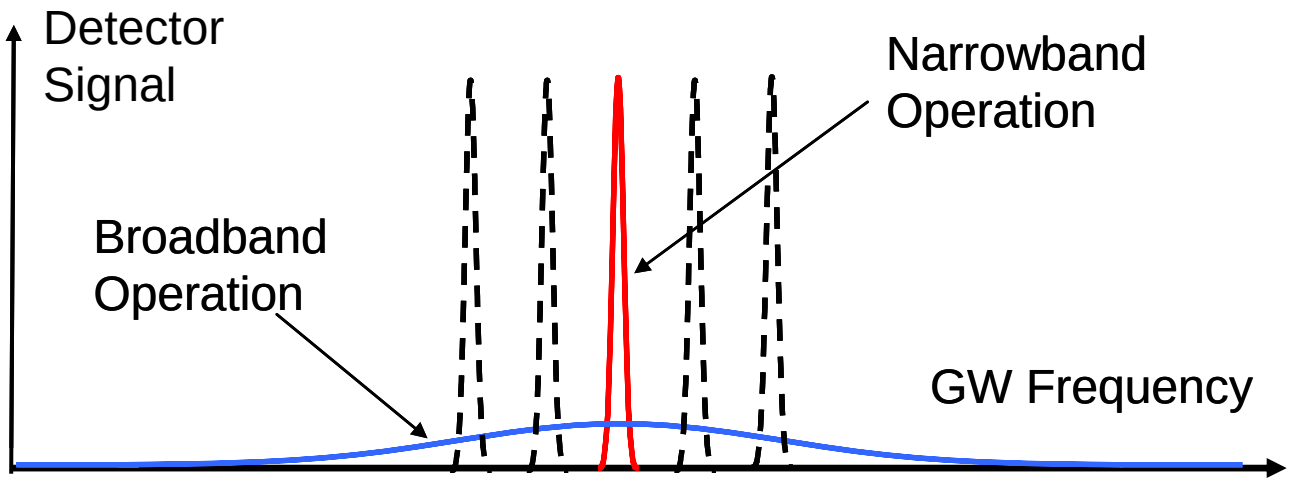
- Sensitivity-Bandwidth Product is fixed by system parameters
- Sensitivity is of paramount importance for Advanced LIGO design
- Problem for inherently broadband and chirped sources
- Several ideas have been proposed to solve this problem. These include (i) Simply broadband dual recycling (ii) Frequency agile interferometers that can follow a chirp, and (iii) input/output cavity techniques that can make optimal filters for specific source spectra. Our approach seems the simplest, and is to be compared/contrasted with these as part of this collaboration

Enhancing Sensitivity-Bandwidth Product with WLC

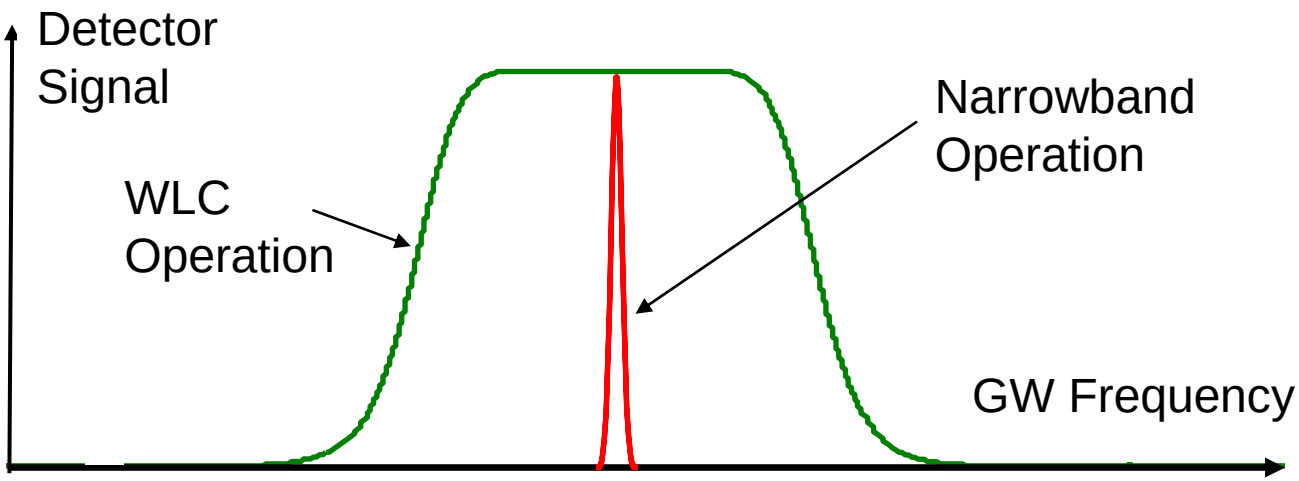


Enhancing Sensitivity-Bandwidth Product with WLC

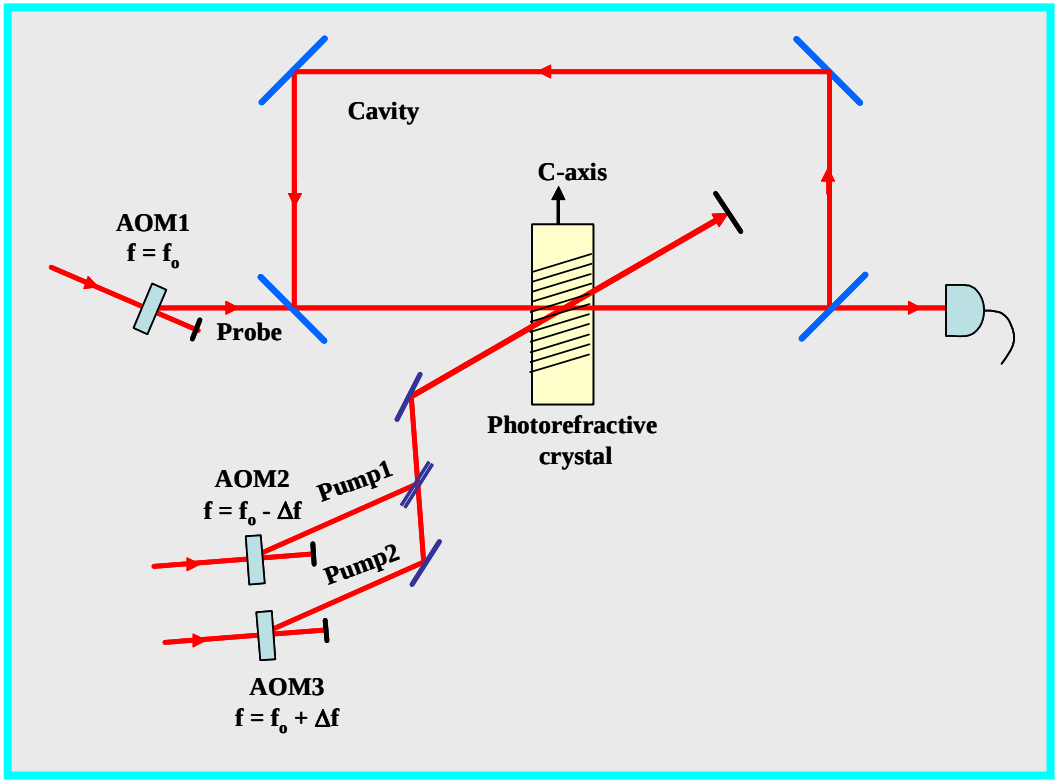
Without WLC



With WLC



Concern: WLC needs to be demonstrated for Nd:YAG frequency



- Photorefractive crystal has already been used to demonstrate Fast Light
- TAMU group recently showed Slow-Light with Photorefractive crystal
- We will use dual-frequency pump to create a tunable group-index anomalous dispersion necessary for WLC suitable for LIGO, using an SPS($Sn_2P_2S_6$) crystal

Plan for Next Year in Collaboration with (ODG and) ADCDG

1. Construct And Test A Table-Top Version Of the Ad-LIGO Interferometer, Including SR and PR Mirrors, in the Rb-Compatible Wavelength Regime:

This will be done with optics in the 780 nm range, suitable for using the Rb-based WLC demonstrated by NUWLCEG. The strain due to a + polarized gravitational wave will be simulated by modulating the position of the extremal mirros of the FPC's inside the MI. The system parameters will be adjusted in order to go from narrow-band to wide-band operations, and the concomitant drop in measurement sensitivity will be catalogued.

During this experiment, NUWLCEG will consult extensively with (ODG and) ADCDG in order to ensure that the features of AdLIGO are reproduced with as much fidelity as possible.

2. Add A WLC Dispersive Element To This System, And Demonstrate The Bandwidth Enhancement Effect:

Once the model AdLIGO is operational, we will insert a Rb-vapor cell based WLC in front of the SR mirror. We will demonstrate how the complete system achieves the same bandwidth as the broad-band case when the WLC is activated, without losing the sensitivity.

During this experiment, NUWLCEG will work closely with (ODG and) ADCDG, both at the design phase as well at the operational phase.

Furthermore, NUWLCEG will seek detailed advice from (ODG and) ADCDG as it makes plans to move to the next phase where the system will operate in the actual AdLIGO wavelength region.

Team and Facilities

- Prof. Shahriar, the PI, received his Sb (Physics), SB, SM and PhD (EECS) from MIT. His adviser was Prof. Shaoul Ezekiel, who was the first student graduated by Ray Weiss. Dr. Shahriar has extensive experience in precision metrology, including atomic clocks, atomic interferometers, and optical gyroscopes. He has also worked in the field of quantum information processing, cooling and trapping of atoms, squeezing, and slow and fast light.

- The laboratory at NU is is equipped with four Ti-Sapphire lasers, many diodelasers, stable optical tables, Nd-YAG laser, trapped atoms, atomic beams, optical components, microwave components, and sophisticated measurement tools.

- TAMU PI (Scully) was the first to propose the use of WLC for LIGO,and has a strong background in analysis of noise in atomic and optical systems.