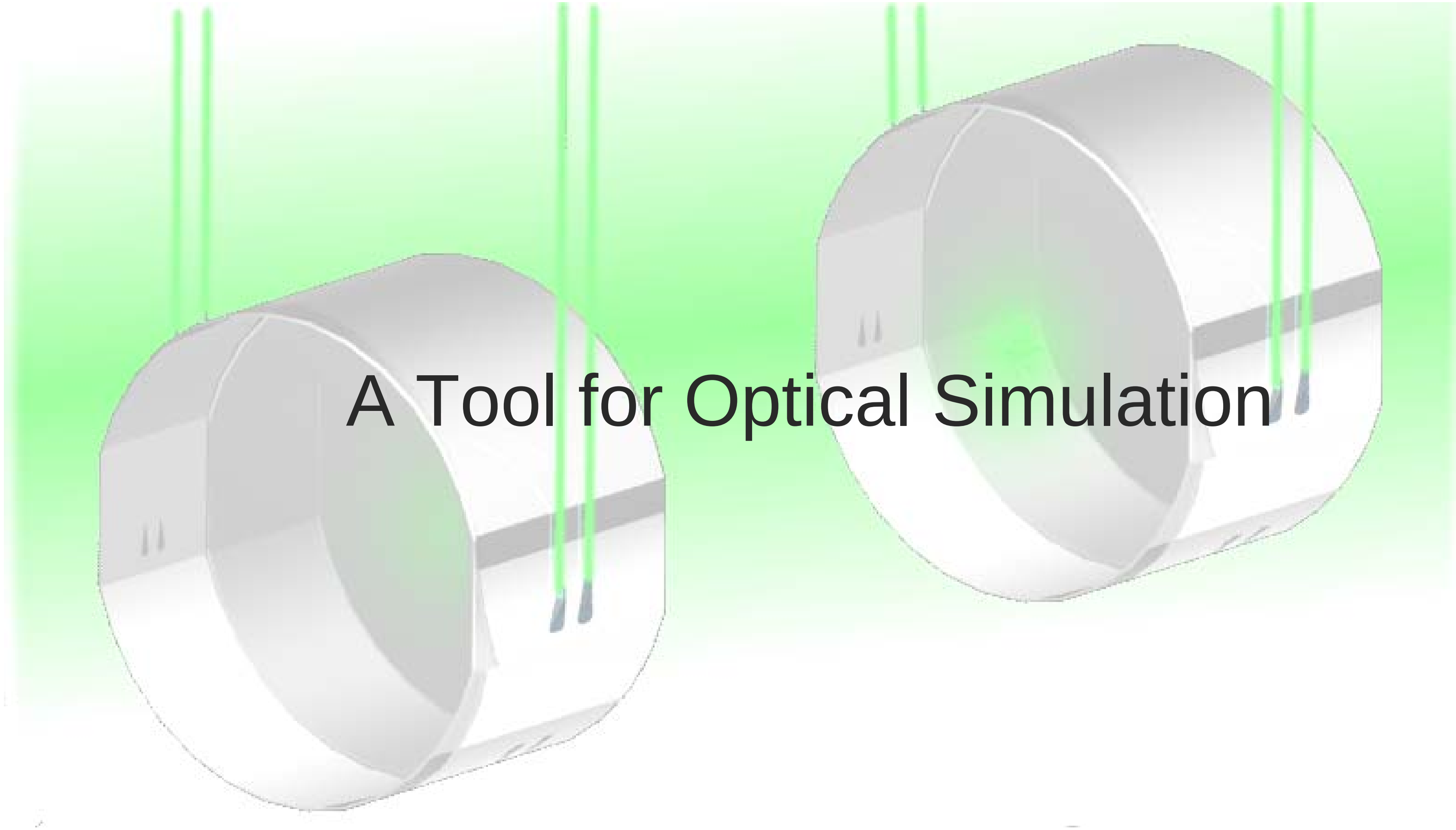
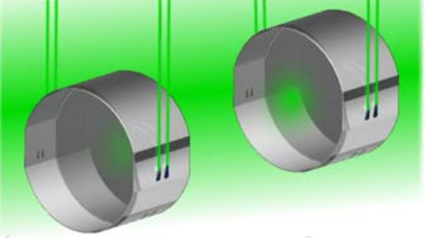
Optickle



A Tool for Optical Simulation

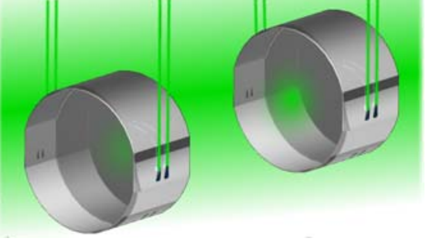
LIGO-G070728-00-Z



What is already out there?

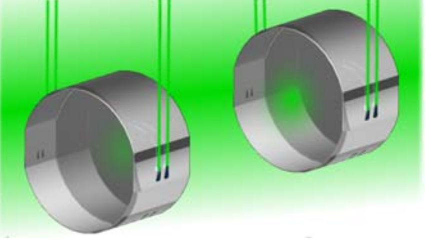
- Finesse
  - Many modes
- Static FFT models
  - Non ideal optics
- E2E, Siesta
  - Time domain

- Optickle
  - TEM00 and 01 only
- Optickle
  - Ideal optics
- Optickle
  - Frequency domain



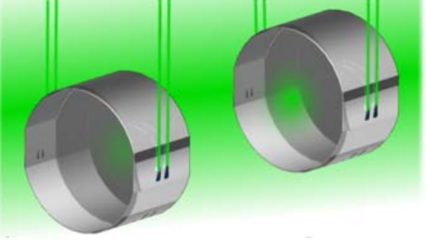
Why Optickle?

- Includes radiation pressure directly
- Computes quantum noises starting from vacuum fluctuations at all loss points
- Matlab based
  - Commonly used environment, especially for control system development and noise analysis (Simulink interface recently added)
  - Convenient plotting and post-processing
  - Avoids many portability problems



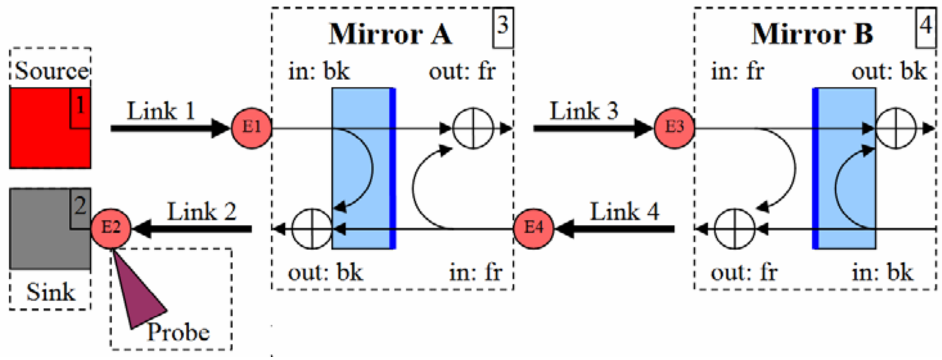
What can it do?

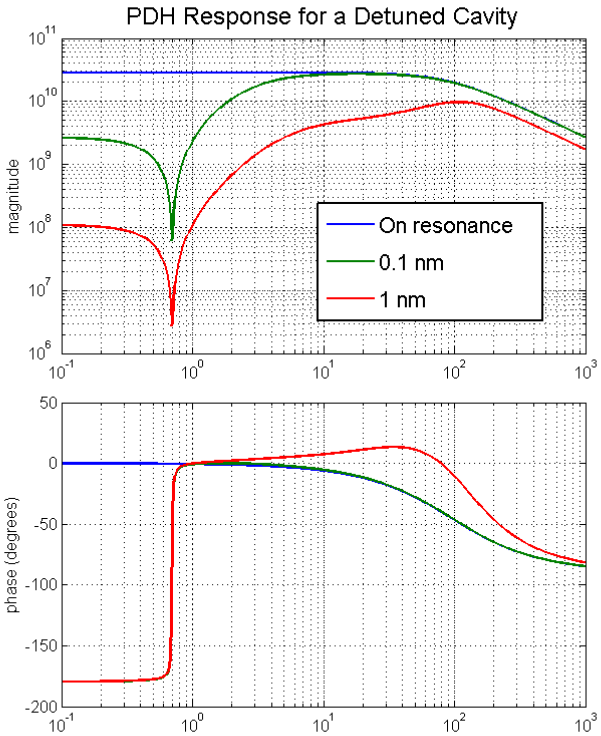
- Simulates a well aligned, well matched optical system
- Modular structure allows for many interferometer configurations
- Computes longitudinal and angular transfer functions, including radiation pressure
- Computes DC signals, and quantum noises

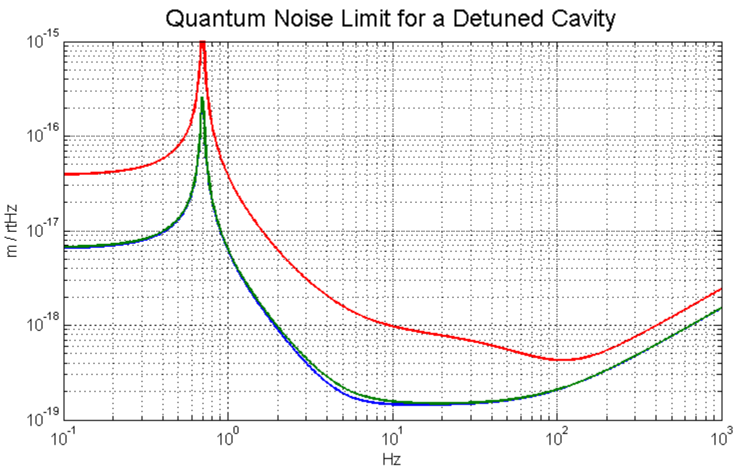


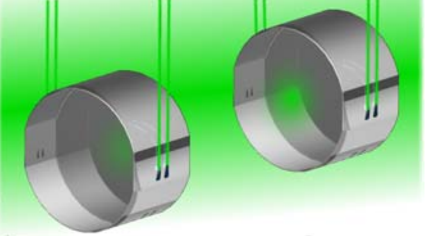
Longitudinal Example: Detuned Cavity

- Radiation pressure effects
- Quantum noise



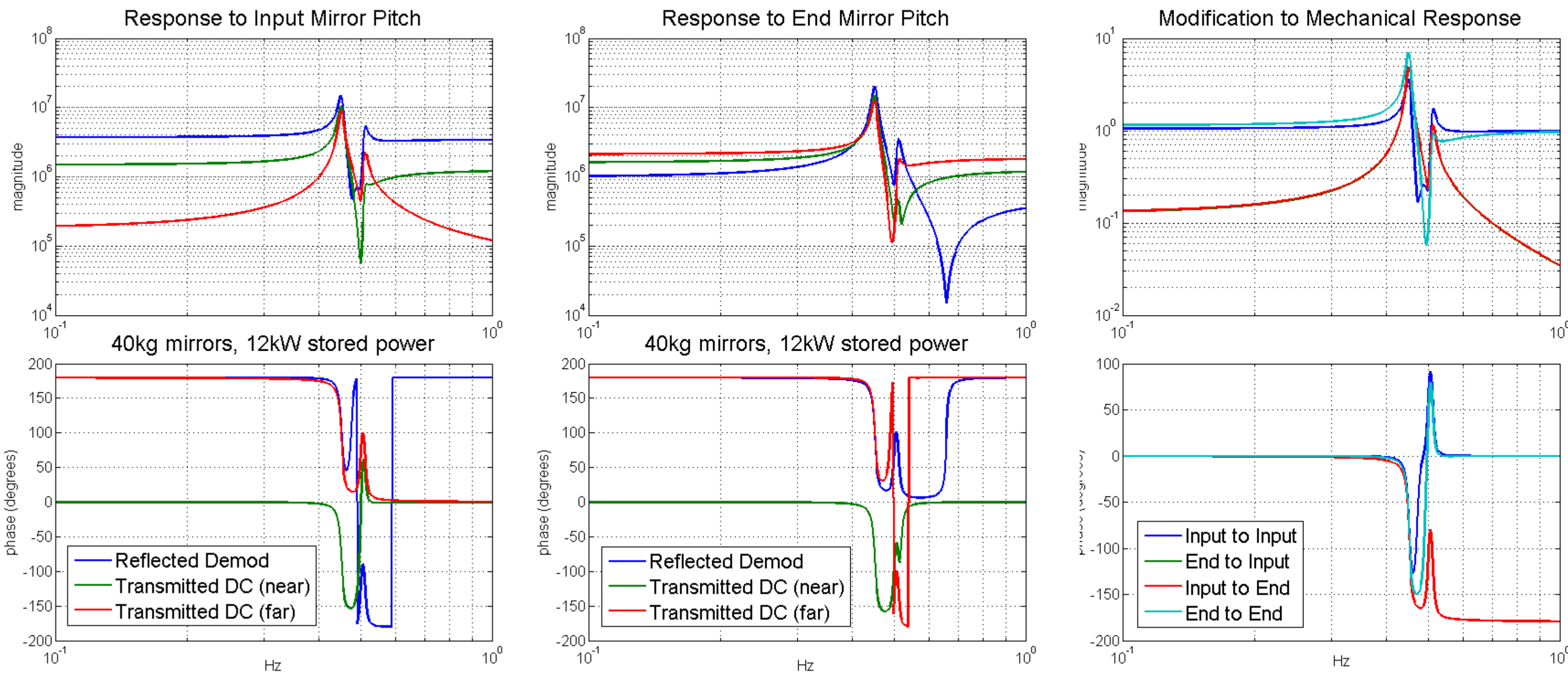


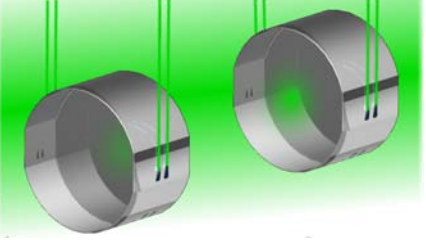




Angular Example: Flat-Curved Cavity

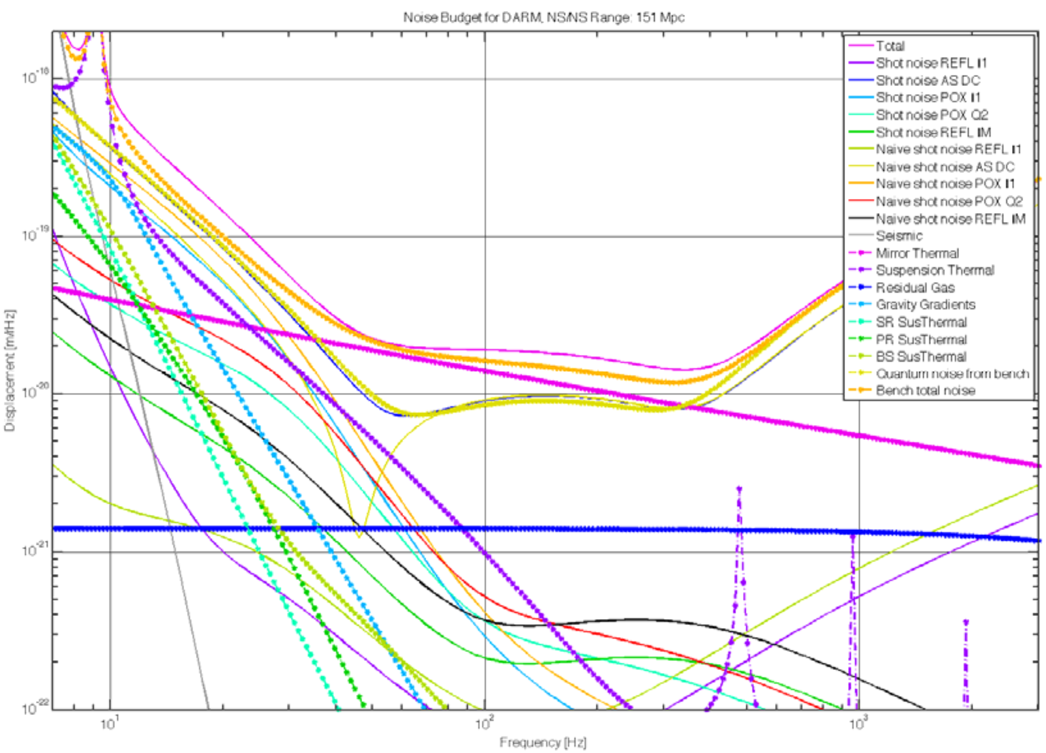
- Radiation pressure effects present in angular response

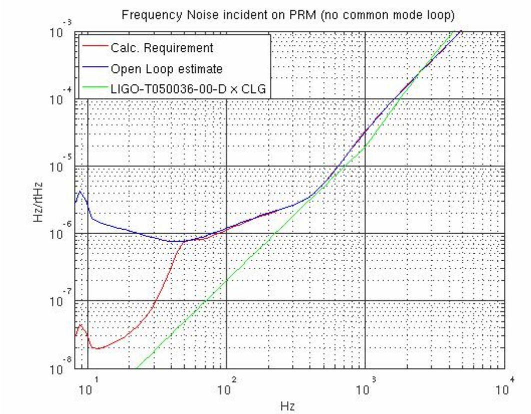


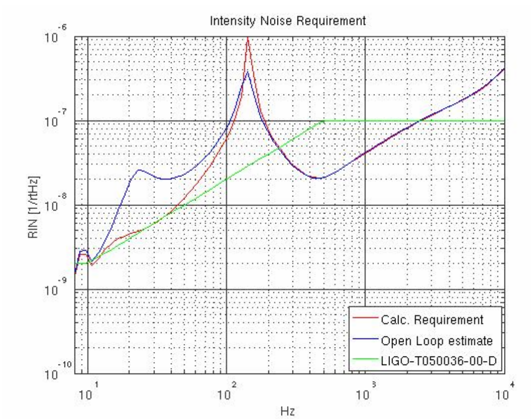


Some Applications (Stefan Ballmer)

- Loop shapes and noise couplings for Advanced LIGO design



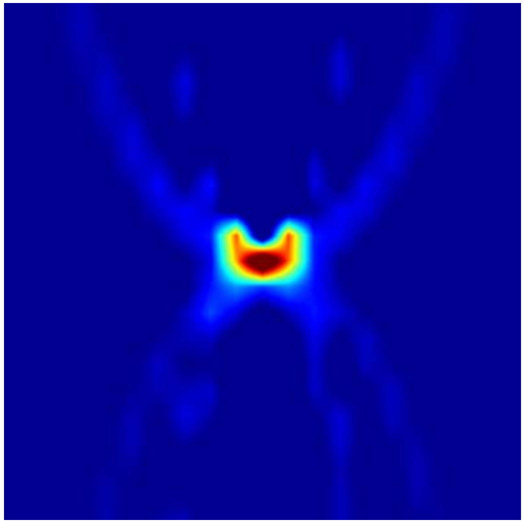




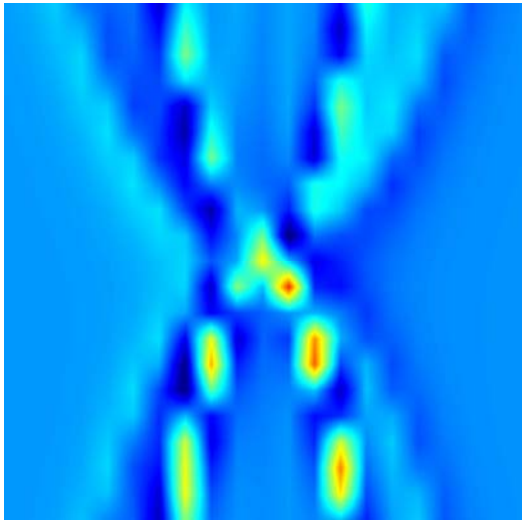
Some Applications (Lisa Barsotti)

- Phase space exploration for Advanced LIGO locking algorithm

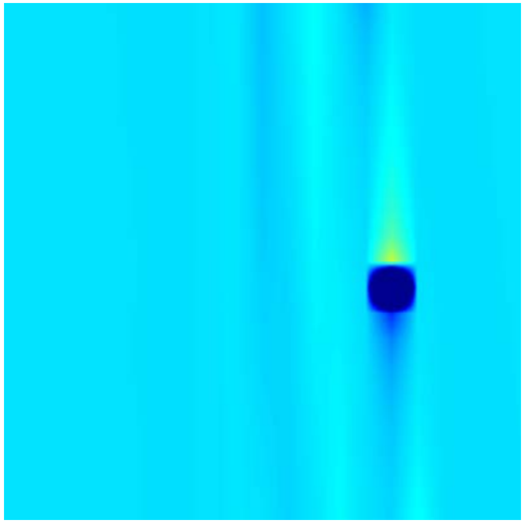
REFL31I vs PRCL

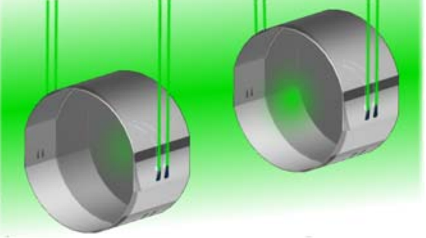


REFL31Q vs MICH



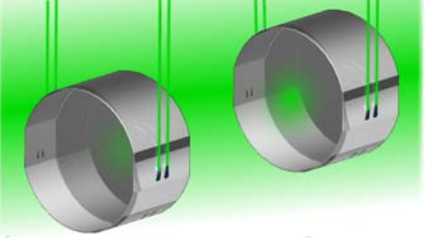
REFL32I vs SRCL





Conclusion

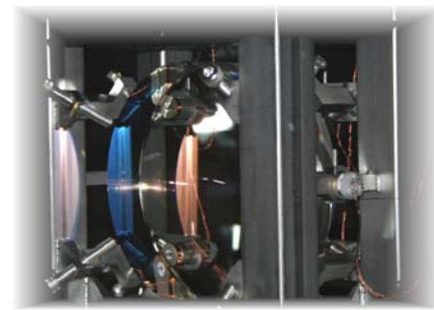
- Optickle was written to facilitate advanced interferometer design
  - Radiation pressure effects are large in both longitudinal and angular responses
  - Quantum noise is not easily divided into shot noise and radiation pressure noise
- Optickle is being used in Advanced LIGO design (Stefan, Lisa, Rana, …)
- Development is complete!



Optickle Modules

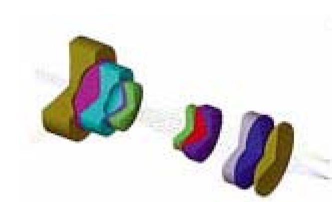
- Mirror
- Beam Splitter
- Source
- Sink
- Modulator
- RF Modulator
- Telescope

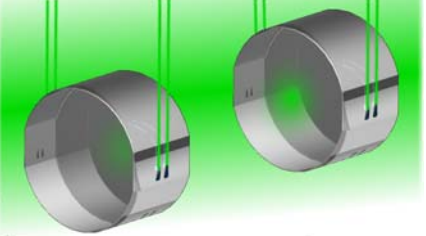






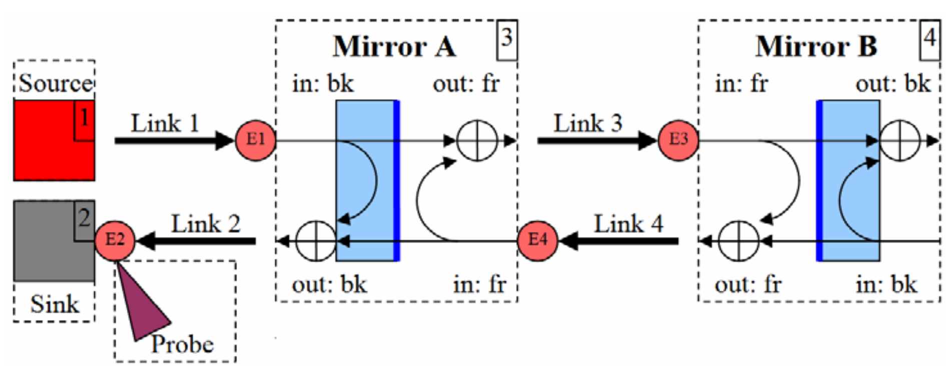




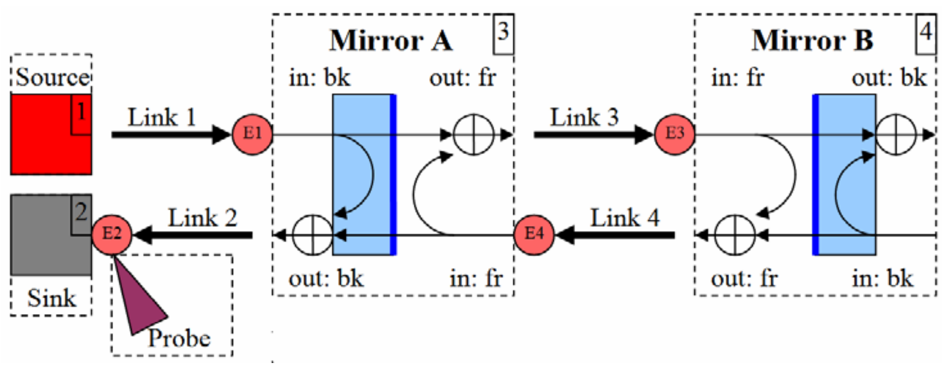
Optickle Glue

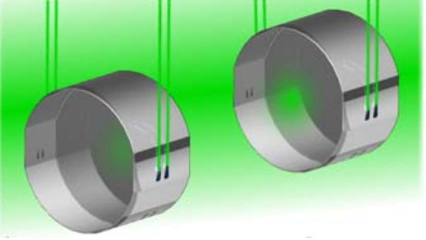
- Links
  - Used to define the relationships between the optical modules
  - Connect from one module output to another module input, with some length



Optickle Output

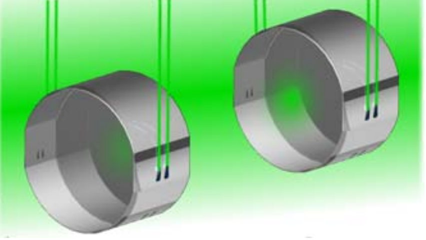
- Probes
  - Used to extract information about the fields in the simulation
  - Often attached to the input of a Sink, thus making a photo-detector





Optickle Interface

- Direct
  - Vector of DC signals from probes
  - Matrix of transfer functions from all drives to all ports (probes and drives)
  - Quantum noise at all ports
- Indexing can be painful
  - Functions for getting indexes by name
- Control loops added externally
  - e.g., looptickle



Optickle Interface

- Simulink
  - Reduces transfer matrix to the inputs and outputs specified by the user
  - Control systems are easier
  - Coherent noises are easier