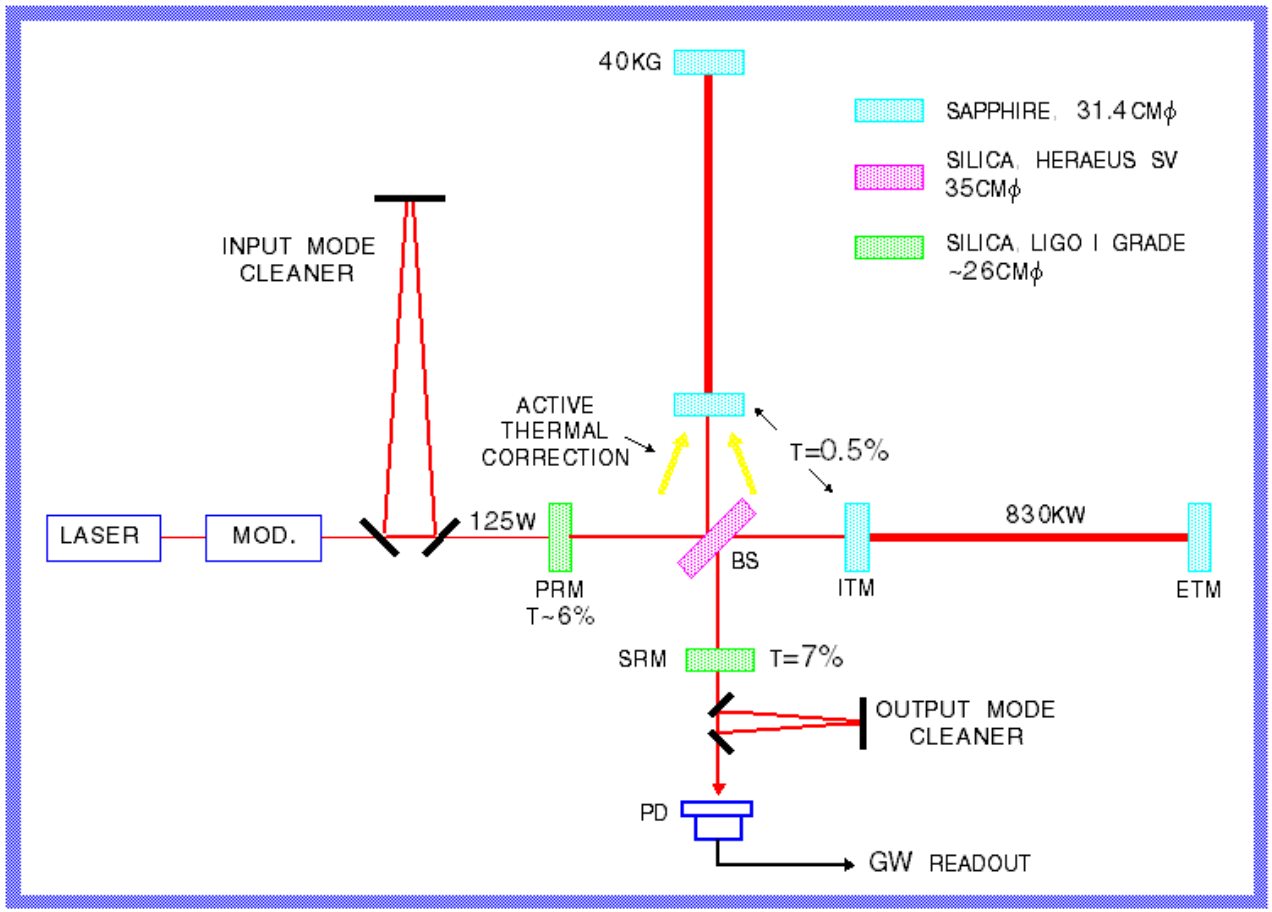
LIGO

Advanced LIGO Sensing

Peter Fritschel, Nergis Mavalvala, Ken Strain
& members of AIC
Presented by: David Tanner, University of Florida

Plenary Instrument Science Session I
LSC meeting August 2002

Advanced Interferometer Concept



New features:

- » Signal recycling
- » 180-watt laser
- » 40 kg Sapphire test masses
- » Larger beam size
- » Higher arm finesse
- » Moderate recycling factor
- » Active thermal correction
- » Output mode cleaner

LIGO

GW channel readout: 2 candidates

- RF readout, as in initial LIGO
  - » Phase modulate at interferometer input
  - » Arrange parameters for high transmission of RF sidebands (one anyway) to output port
- DC readout
  - » Small offset from carrier dark fringe
  - » GW signal produces linear baseband intensity changes
  - » Advantages compared to RF readout:
    - – Output mode cleaner simpler
    - – Photodetector easier, works at DC
    - – Lower sensitivity to laser AM & FM
    - – Laser/modulator noise at RF frequencies not critical
    - – Appears to have better quantum-limited sensitivity (comparison calculations still in progress)
- Either would be used with an output mode cleaner to greatly reduce the detected power
- Chosen scheme will be tested on a suspended prototype
  - » DC readout would be prototyped first at MIT
  - » Caltech 40m, possibly also Glasgow

Why is DC now possible?

There are several contributing factors that favour the use of DC readout, inconceivable just a few years ago.

- Circulating light power MUST be stable to keep radiation pressure induced TM motion within spec.
  - » Requires development of a photodetector good enough for DC readout
- Higher arm finesse, moderate recycling gain and output modecleaner all help to keep the light power that must be detected well down (mW not W)
  - » Shot noise limited measurement is technically feasible
- The very low power recycling cavity pole (0.8 Hz) provides substantial passive stabilisation of the light power, at 100 Hz (peak sensitivity)

LIGO

Why is RF hard?

- There is no filtering provided by arm cavities
  - » (“One arm bandit” methods would allow filtering, but are complicated when RSE is employed)
- The RF sidebands are UNBALANCED
- The reduced power recycling gain provides no filtering of the RF sidebands at ~100 Hz (peak of sensitivity)

➡ extremely tough specifications on allowed phase noise in the RF detection system (oscillators etc.)

- Constraints on output modecleaner length
  - » Require a long output modecleaner carefully servoed to both carrier and RF sidebands

LIGO

So is the choice easy?

- The above technical considerations point very strongly to DC being chosen as the baseline readout method
- Quantum limited performance has, however, overriding importance as a fundamental noise contribution and significant performance limit
- The choice will be based on the result of a soon to be completed analysis of the quantum noise
- The choice will be backed up by experimental tests as part of the Advanced LIGO Configurations Prototype tests

LIGO

AIC Goals & Activities

David Tanner and Ken Strain

LIGO

Goals

- Advanced LIGO
  - » Selection and proving of sensing and control scheme
- LIGO III
  - » Schemes for interferometer configuration, followed by experimental tests

LIGO

Activities

- Advanced LIGO
  - » Dual recycling benchtop experiments: completed (ANU, Caltech, Florida) and papers submitted to Appl. Opt.
  - » SR/RSE suspended interferometer at Glasgow: initial locking, final results expected soon
  - » Mini-suspension RSE experiment at Tokyo - good progress.
  - » Full RSE suspended experiment at Glasgow (with Florida participation): interferometer optics are being installed now.
  - » 40m prototype: refurbishment and installation on schedule
  - » Selection of sensing scheme - expected soon
- LIGO III
  - » Planning of QND, white light cavity, all reflective experiments underway (Caltech, MSU, Florida, ANU, GEO, Stanford, MIT…)
  - » Topic for March03 LSC meeting

Tomorrow

AIC committee meeting

Tue, 20 August, 1:15 - 2:15 pm

- LIGO III research plans (all)
- Speed Meters for LIGO III, Yanbei Chen
- RF readout quantum theory, Nergis Mavalvala