Phase Noise Interferometer
MOTIVATION & OBJECTIVES

Peter Fritschel
20 March 1996

- **Phase Noise**: fringe measurement noise which remains when mirrors are fixed in inertial space
- LIGO needs high phase sensitivity ~ 10^{-10} rad/$\sqrt{\text{Hz}}$
  - to measure strain of $h \sim 10^{-23}/\sqrt{\text{Hz}}$ at 150 Hz
    - ›› Noise due to Poisson photon statistics, 'shot noise' $\sim \sqrt{P}$
      - – Need optical power at beamsplitter of 150 W (1 micron)
    - ›› Noise due to other sources scales more quickly with power
      - – Example: laser beam pointing fluctuations

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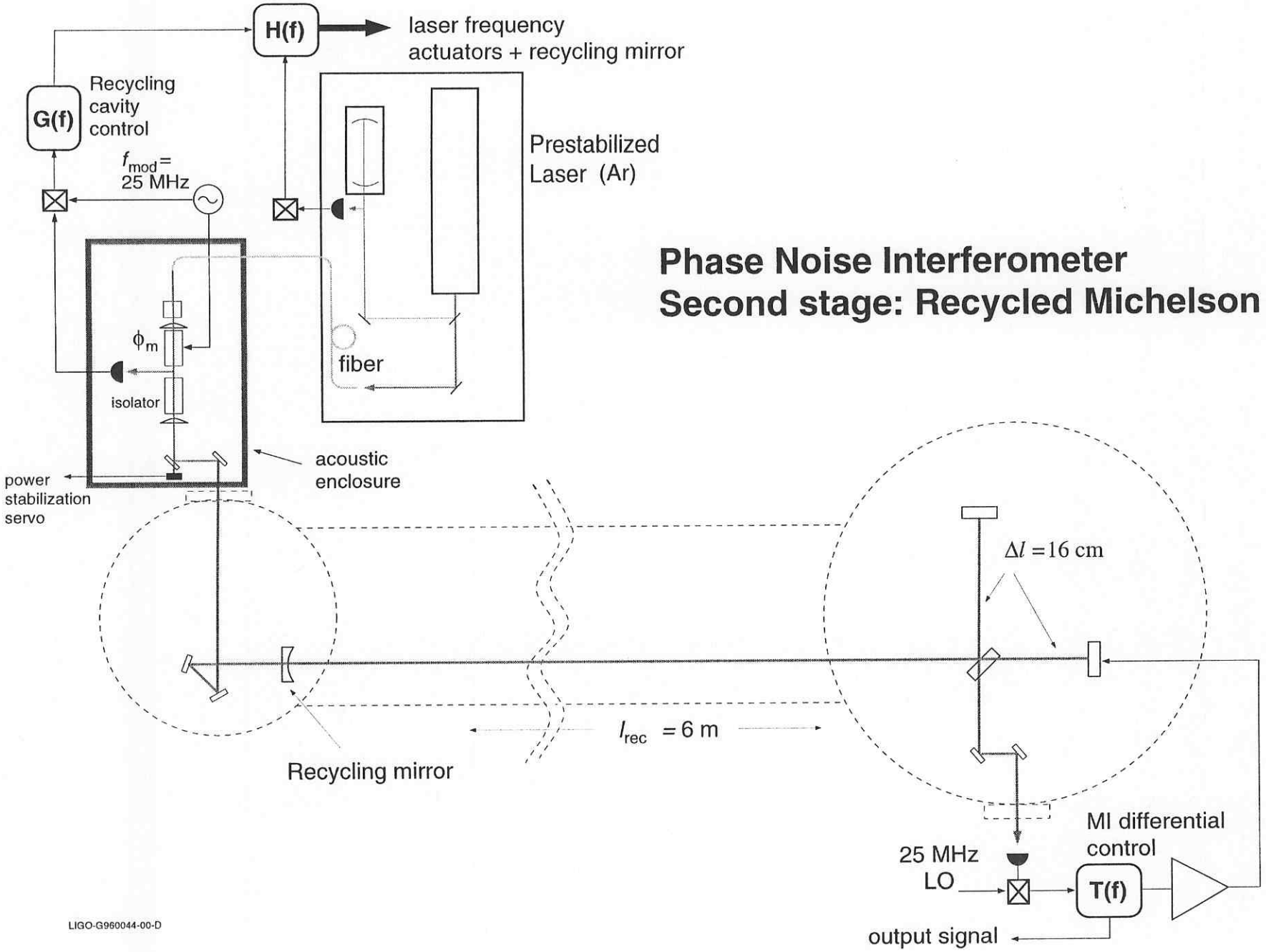
- Demonstrate phase sensitivity of initial LIGO
  - ›› System test of phase sensing scheme (rf modulation/ demodulation; asymmetry based detection)
  - ››Task is to control other optical noise sources as power is increased
- High phase sensitivity tests of LIGO technology
  - – phase modulators (residual AM, beam wiggle, osc. reqs)
  - – photodetectors (power handling, non-linearity)
  - – laser stabilization (frequency, amplitude, beam direction)
- Training of scientists
  - ›› Working with a suspended prototype interferometer



Phase Noise Interferometer
Second stage: Recycled Michelson

LIGO-G960044-00-D

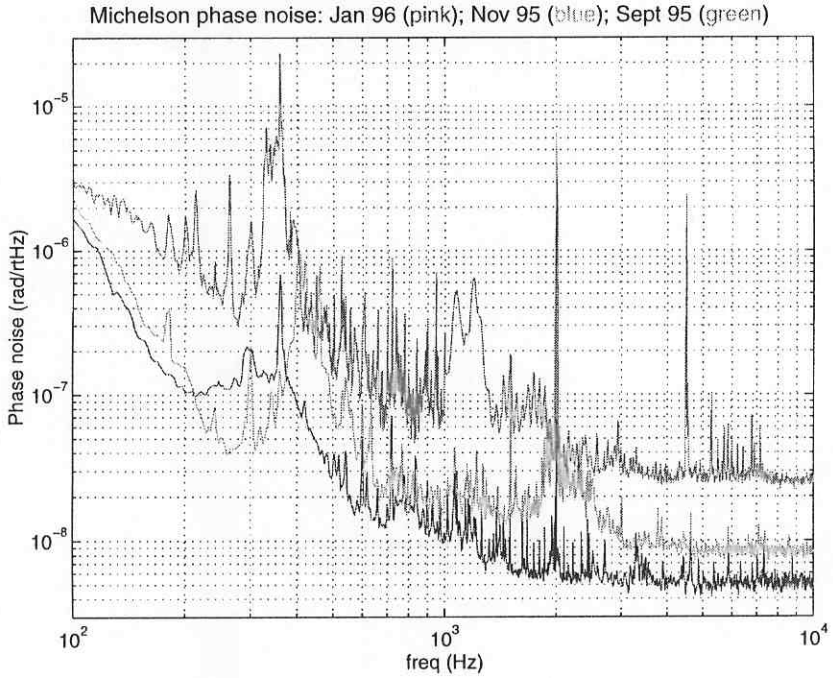
Phase Noise Interferometer
PEOPLE

- Scientists:
  - Peter Fritschel - 0.5 FTE (leader)
  - Gabriela Gonzalez - 0.75 FTE
- Graduate students
  - Partha Saha
  - Brian Lantz
- Technician
  - Ed Kruzel - 1 FTE
- Electronics engineer
  - Ralph Burgess - 0.5 FTE
- + support from LIGO CDS when needed
- New Hire: near-term postdoc, to work on conversion to YAG laser

Phase Noise Interferometer
STATUS OF RESEARCH

- Interferometer construction: mid 94 - mid 95
  - prestabilized laser
  - input optics
  - seismic isolation system
  - suspended optics
- Testing of commercial active seismic isolation system (Barry Controls' STACIS)
- Simple Michelson research: mid 95 - end 95
  - ›› LIGO technical report written on interferometer performance *(LIGO-T950121-01-R)*
- Recycled Michelson construction: Dec 95 - Feb96
  - ›› first locking of recycled Michelson: beginning March
  - ›› shakedown and noise studies now begin

Phase Noise Interferometer
NOISE SPECTRUM PROGRESS



Phase Noise Interferometer
PLANS

- Near term:
  - ›› refine length/laser frequency control system
  - ›› implement 1 wavefront sensor to stabilize the differential alignment of the Michelson
- Research with Ar^+ laser
  - ›› continue through with noise studies of recycled Michelson
  - ›› ~ 4 months additional work
  - ›› thesis work for P Saha

Phase Noise Interferometer
PLANS

- Important to test laser system in a high phase sensitivity interferometer
- Conversion to Nd:YAG, 1.064 μm
  - ›› 'core' optics in production - delivery by end of May
  - ›› start with 700 mW NPRO; copy prestabilization system currently being developed at Caltech (tests complete early Aug)
  - ›› new postdoc to integrate & test prestabilization in parallel with Ar laser interferometer research
- Research with Nd:YAG source
  - ›› 2 Options for start (Aug 96):
    - simple Michelson, as previously
    - two mirror cavity → frequency noise and laser control (new)
  - ›› quickly move to recycled Michelson
  - ›› tests of a prototype LSC photodetector (end 96)
  - ›› integrate high power laser when available (~1.5-2 yrs)
    - PNI to receive 1 of initial group of 3 high power lasers
  - ›› thesis work for B Lantz