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Incorporation of Coating Optimization Algorithm into Bench

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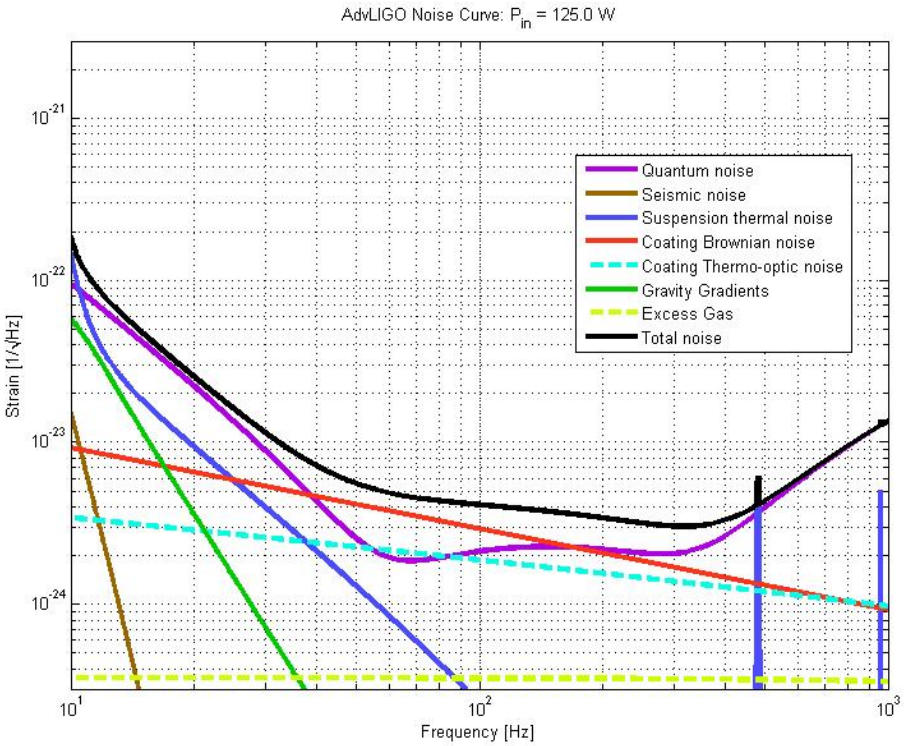
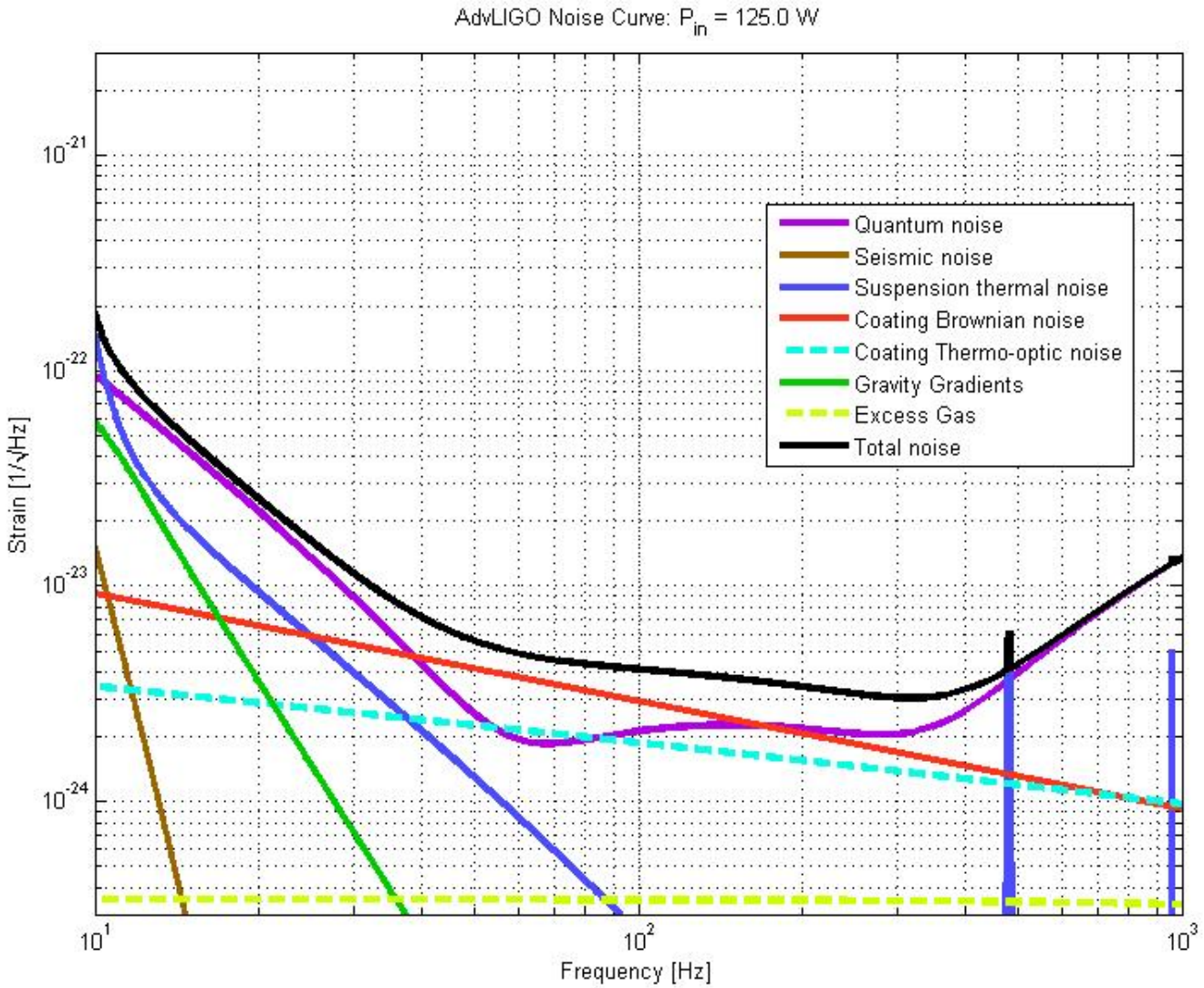
What is Bench?

- Software for generating noise curves, figures of merit
- Takes into account various physical noise sources, calculates based on interferometer parameter file
- Calculates power spectral densities (PSD), converts to and displays equivalent strain noise

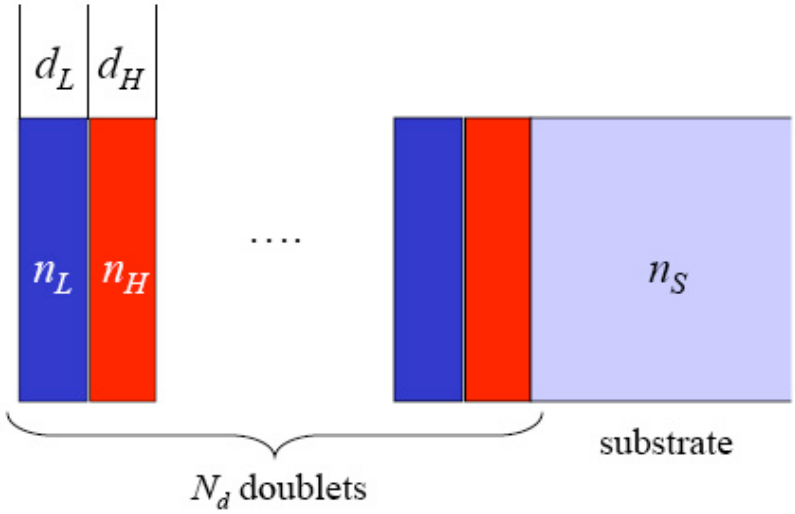


The AdLIGO Noise Curve



Ways to Reduce Coating Thermal Noise

- Optimization of coating design
  - Ta_2O_5 (high index material) is significantly noisier (factor of ~5) than SiO_2 – lower noise by designing with less of the noisy material.



$$d_{L,H} = \left(\frac{\lambda_0}{n_{L,H}}\right) z_{L,H}, \quad z_{L,H} = \frac{1}{4} \pm \xi$$

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Why do we need Bench to optimize coatings?

- Bench is very useful for answering questions of the following type:

  "If I can squeeze an extra 10% out of parameter X, what does that really buy me in the full interferometer?"

- Thermal noise depends on coating noise parameters not only directly, but also through the physical structure of the coating, i.e. *through the optimization algorithm*

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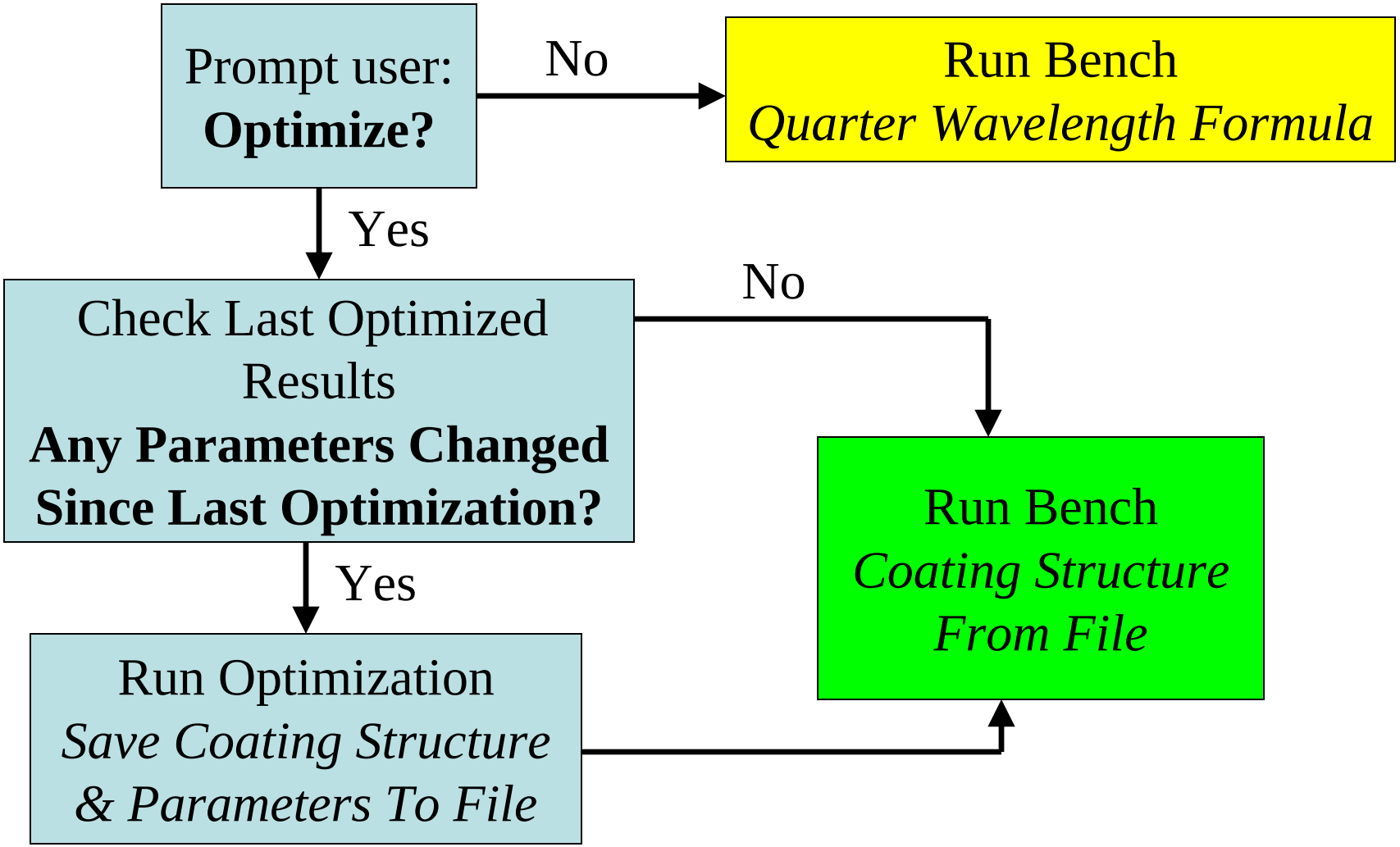
What We Did

- Optimization code was written by Innocenzo Pinto
  - Theory well documented, see e.g. G070309-00-Z
  - Used to design optimized coating tested and verified in TNI
- Innocenzo's code in Mathematica, Bench in Matlab
  - Clare Bayley and I went to Benevento to work with and consult Innocenzo during the process of porting the code for inclusion into Bench

Integration into Bench



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Optimization Algorithm Details

- The Algorithm:
  1. Given materials parameters and goal transmittance, calculate quarter-wavelength design and noise
  2. Vary relative thickness of layers for a set of points (designs), calculate thermal noise (Brownian + thermooptic) for these designs
  3. Fit polynomial to [noise as a function of relative thickness], find minimum
  4. Tweak top layer to squeeze an extra ~3% out of thermal noise
- Details of noise PSD and individual coating thicknesses will be written to a file
  - Optimization algorithm will run only if parameters have changed
  - Users can look manually to make sure optimized design is sensible

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News from Benevento Trip

- As of the end of January
  - Code ported, tested
  - Reproduces results of Innocenzo's code
  - Yields lower thermal noise PSD in Bench
- Trip was a success

More Plans for Bench

- Clare has many updates for Bench in the works
  - Coating Optimization
  - More Efficient Computation
  - Online Interface
- For more details, come to her talk Friday (as part of the coating workshop)
  - Friday 2:45pm, Room 201 Bridge

Special thanks to Innocenzo and his group in Benevento for their hospitality!