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Status of Cryogenic Payload Overall Design

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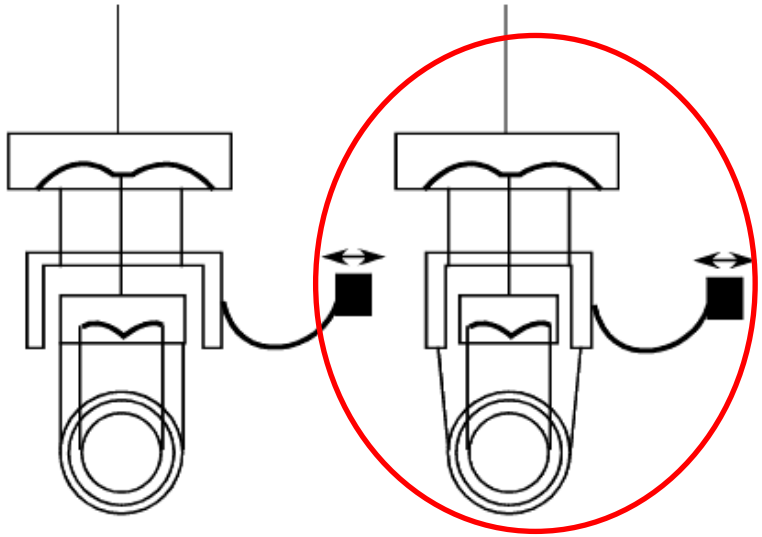
Meeting @Stanford

- KAGRA SAS status talk
- Simulink control model for aLIGO seismic isolation
- Reasons to design mechanics with control in mind
- Study from AEI-SAS, LIGO SEI, SUS
- Discussion: how to build type-A SAS design?
  how to set the requirement

Design Direction

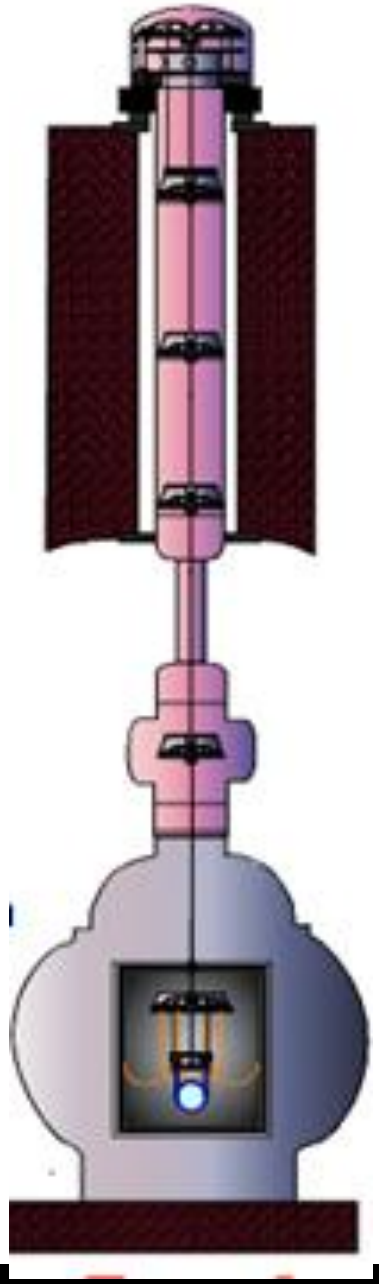
- Suspension thermal noise from RM can be large.
- Fundamental noises (seismic, thermal noise) should be considered in first priority. Controllability is the second issue.
- LIGO-like design should be chosen.



Control Noise

1. Making SAS model, with top-stage (IP) control.
2. Designing control filters at the lower stages so that it meets the **requirement**.
3. Calculate the TF from sensor/actuator noise to the TM displacement.
4. Set the requirement on sensor/actuator noise

$$n_{\text{sen/act, req}} = \frac{x_{\text{TM,req}}}{\text{T.F.}_{\text{Nsen/act to xTM}}}$$



TM Requirement

- Seismic displacement noise
  - 2 x 10^{-20} m/rtHz @10 Hz, 3 x 10^{-22} m/rtHz @100 Hz : Longitudinal
  - 2 x 10^{-18} m/rtHz @10 Hz, 3 x 10^{-20} m/rtHz @100 Hz : Vertical
  - 10^{-7} m RMS without global control (2.5 x 10^{-7} m in adv. LIGO differential)
  - 10^{-7} m/sec RMS without global control
  - (10^{-15} m RMS DARM in close-loop in adv. LIGO)
  - (10^{-12} m RMS MICH in close-loop in adv. LIGO)
- Angular noise
  - 2 x 10^{-17} rad/rtHz @10 Hz, 3 x 10^{-19} rad/rtHz @100 Hz : Pitch / Yaw
  - 10^{-7} rad RMS without global control
    (10^{-7} rad in adv. LIGO <0.1 Hz, ~10^{-6} rad in iLIGO)
- Damping time
  - 1/e damping time: < 60 sec (10 sec in adv. LIGO)

aLIGO Quantitative Test Goals

Category/Subsystems	Goal
Initial alignment	Sustained flashes of optical resonances in the arm cavity
Cavity locking/ISC	Green laser locked to cavity for 10 minutes or more
TransMon/ALS	Active beam pointing error on the TransMon table below 1 urad rms in angle and below 100 um rms in transverse motion
SEI	Relative motion at the suspension point between the two SEI platforms below 250 nm rms (without global feedback)
Cavity length control / SEI/SUS/ALS	Relative longitudinal motion between ITM and ETM below 10 nm rms for frequencies below 0.5 Hz
Cavity alignment fluctuations / SEI/SUS	Relative alignment fluctuations between the TIM and ETM below 100 nrad rms for frequencies above 0.1 Hz (without global feedback)
Controls / SUS	Decoupling of length-to-angle at the level of 0.05 rad/m or less, for frequencies below 0.5 Hz
Controls / ISC	Fully automated cavity locking sequence; long term cavity locking
TCS	Ring heater wavefront distortion, as measured by the Hartmann sensor, in agreement with the model at the 10 nm rms level.
Optical levers	Optical lever long term drift below 1 urad
Calibration	ETM displacement calibration at the 20% level
ALS	Ability to control frequency offset between 1064 nm and 532 nm resonances at the 10 Hz level
ALS	Relative stability of the 1064 nm and 532 nm resonances at the 10 Hz level for frequencies below 0.5 Hz

Meeting @Stanford

- Mon: Control model in Stanford (Brian)
- Tue: KAGRA overview talk (Eiichi)
  Study from AEI 10m SAS (Conor)
  KAGRA-SAS modeling (Takanori)
- Wed: Cryogenic payload design (Takanori)
  Thu: Reasons to design mechanics with control in mind (Jeff)
  Guardian (Charles)
  Prototype test plan in aLIGO (Jeff)
- Fri: Discussion
  How to build Type-A SAS design?
  How to set the requirement?