Thoughts on an SPI for AdLIGO
SPI: **S**uspension **P**oint **I**nterferometer, or **S**eismic **P**latform **I**nterferometer

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Goal: significantly reduce arm velocity for lock acquisition

- Lock acquisition comparison

	Relative velocity	Arm finesse	Mass	Force	F/M (m/sec^2)
Initial LIGO	0.5-1 um/sec	200	10 kg	25 mN	2.5 milli
40m	0.5 um/sec	1100	1 kg	7 mN	7 milli
Ad LIGO	0.3 um/sec	1100	40 kg	0.02 mN	0.5 micro

How much force is needed?

- Rough estimate of force needed to lock an arm:

  Force * Time = Mass * velocity

  Time = lambda / finesse / v

  F = M * (finesse / lambda) * v^2

  = 4000 uN, vs 20 uN available

SPI

- Some sort of ‘easy interferometry’ between corner and ends: 1 DOF (each arm)
  - Low finesse cavity
  - Michelson
- Feedback to end station, to the same point that is sensed (SEI or SUS)
- Performance guess:
  - 5-10 Hz bandwidth
  - Factor of 100 reduction of relative velocity
    - Residual motion would be comparable to arm cavity linewidth
  - Limited by cross-coupling of other DOF to test masses

Sensing limits at 1 nm level

- Frequency fluctuations: ~100 Hz
  - Use the same laser source, or something whose frequency is locked to it at this level
- Power fluctuations, allowing for non-zero locking point: dP/P ~ 1e-3

Where and how to sense

- TM-to-TM, with different color beam
  - Frequency needs to be tied to main beam, could double to 532nm
  - Needs to be co-aligned with main beam to ~1 urad
  - Mirror coating requirements
- PM-to-PM
  - Could use sample of main beam: frequency shift it with an AOM
  - Optic is there, with controls
  - Only have ~0.1 urad of angle control on ETMs
  - Would it screw up the suspension local damping?
- UIM-to-UIM (or top-mass to top-mass)
  - Controls exist, would need to add optic
  - Enough control further down for main beam
- SEI platform
  - Would need to add orientation-controllable mirrors

Size of SPI beam

- Make smaller in corner station, allow to double in size at end station
  - Waist = 2.8 cm, 5.6 cm at end
  - Optic size:

Mirror diam / beam radius	Power transmission	Mirror diam, corner	Mirror diam, ends
Pi	99%	8.8 cm (4’’)	17.6 cm (7’’)
2.5	95%	7 cm (3”)	14 cm (6”)
2	86%	5.6 cm (3”)	11.2 cm (5”)

Considerations

- Motivated here by lock acquisition of the arms
- What about while the interferometer is locked? running in low noise mode? Would it be useful to design the SPI so that it can be run at these times as well?
- What about SPI between chambers in the corner station?