LIGO- LIGO-T0900289-v4
15 June 2009

LIGO Instrument Science Priority Matrix

The following matrix is intended as a companion to the LSC 2009 Instrument Science White Paper (LIGO-T0900276). The purpose is to identify the tasks and goals outlined in the white paper with phases or goals within the larger framework of GW science development. Specifically, four major motivations for the white paper activities were identified:

- Fundamental Science which lays the groundwork broadly for GW development,
- AdvLIGO Risk Mitigation (tasks which address problems that might crop up in the planned AdvLIGO program),
- "Enhanced AdvLIGO" (developments which might be suitable to incorporate into AdvLIGO after a couple of years of AdvLIGO operation and which might give a moderate performance improvement at a modest cost), and
- Third Generation Detectors, which offer very significant performance improvements (either in sensitivity or frequency coverage) but would require major changes or possibly new facilities.

Each task was evaluated to identify which of these categories provided the primary motivation for the activity and further, each task was assigned a priority (high, medium, or low). Many of the tasks also have one or more secondary motivations, and these were also identified and prioritized.

White Paper section	Topic	Goal	Funda-mental Science	AdvLIGO Risk Mitigation	"Enhanced" AdvLIGO	Third Generation Detectors
2. Suspensions and Isolation						
2.2.1.2	Advanced seismometers	Reduce tilt/horizontal coupling in seismometers for active anti-seismic systems		Secondary-medium	Primary-medium	Secondary-medium
2.2.1.3	Suspension point interferometers	Investigate systems for measuring the rotation and position sensing of seismic platforms relative to each other to improve lock acquisition and reduce final stage dynamic range		Primary-high	Secondary-medium	Secondary-medium

White Paper section	Topic	Goal	Funda-mental Science	AdvLIGO Risk Mitigation	"Enhanced" AdvLIGO	Third Generation Detectors
2.2.2.1	Excess thermal noise from clamps and break-offs	Investigate of alternative metal wire clamping techniques for reducing thermal noise		Secondary - medium	Primary- medium	
2.2..2.2	Multiple Pendulum Suspensions, mechanical and control aspects	Improve understanding of AdvLIGO prototype performance, develop novel control strategies for local and global control		Primary - high	Secondary - medium	
2.2.2.3	Development of monolithic final stage	a) characterize AdvLIGO baseline design b) possible improvements		a) Primary high	a) Secondary high b)Primary high	b) Secondary- medium
2.2.2.4	Violin mode damping	Develop means to sense and damp violin mode motion		Primary- high	Secondary - medium	
2.2.2.5	Creep noise	Investigate the rate and amplitude distribution of non-Gaussian noise events in wire and fused silica fiber suspensions		Primary- medium	Secondary - medium	Secondary - medium
2.2.2.6	Low noise blade springs	Develop fused silica or alternate material blades for vertical isolation			Primary - medium	Secondary medium
2.2.2.7	Low Frequency Noise	Study noise in low frequency blades relating to higher frequency behaviour and consider possible methods to mitigate		Primary - medium	Secondary medium	
2.2.2.8	Control aspects and different payloads	Integrate suspension and seismic isolation models to investigate high power effects		Primary- medium	Secondary - medium	
2.3.1.1	Newtonian coupling	Understand Newtonian noise and test techniques to mitigate it			Primary high	Primary high
2.3.2.1	Silicon suspensions	Develop flexures of silicon and measure their properties				Primary - High

White Paper section	Topic	Goal	Funda-mental Science	AdvLIGO Risk Mitigation	"Enhanced" AdvLIGO	Third Generation Detectors
2.3.2.2	Attachment techniques	Investigate alternates to silicate bond attachments			Secondary low	Primary medium
2.3.2.3	Larger masses	Investigate suspensions for larger Test masses/optics			Secondary - high	Primary high
2.3.2.4	Cryogenics – suspension aspects	Study designs concepts for cryogenic suspensions and isolation				Primary high
2.3.2.5	Cryogenics – radiative cooling	Investigate radiative and evanescent wave cooling			Secondary - medium	Primary medium
3. Optics						
3.1.1	Optical coating research	Investigate materials and techniques (e.g., annealing) for improving coating performance for GW interferometry	Secondary medium	Primary-high	Secondary - high	Secondary - high
3.1.2	Fused silica test mass research	Investigate possible trade-off between optical loss and mechanical loss in fused silica, measure uniformity		Primary-low	Secondary - medium	Secondary - medium
3.1.3	Thermal compensation research	Investigate techniques such a barrel coatings that might ease the thermal compensation requirements for high power operation		Primary-medium	Secondary - medium	
3.1.4	High power effects in Advanced LIGO	Investigate parametric instabilities and means to control them		Primary-high	Secondary - high	
3.1.5	Modeling thermal effects in Advanced LIGO	Develop improved computer models for simulating thermal effects in Advanced LIGO		Primary - High	Secondary - High	
3.1.6	Diagnostics for Advanced LIGO optics	Develop improved performance for sensing distortions of AdvLIGO optics in-situ			Primary-medium	
3.1.7	High power optical components	Develop EOMs and FIs capable of higher power operation		Primary-high	Secondary - high	
3.1.8	Charging of test masses	Directly measure noise due to charge build-up on test mass optics, and develop techniques for controlling charging		Primary - High	Secondary - High	
3.1.9	Variable reflectivity signal recycling mirror	Develop control systems and other hardware needed to implement a variable reflectivity signal recycling mirror			Primary medium	Secondary medium

White Paper section	Topic	Goal	Funda-mental Science	AdvLIGO Risk Mitigation	“Enhanced” AdvLIGO	Third Generation Detectors
3.1.10	Investigation into sources of non-Gaussian noise	Measure non-Gaussian transient noise burst in optics and understand causes		Primary - Low	Secondary - Medium	
3.2.1	Beam Shaping	Develop and test auto alignment sensing schemes for mesa beam optical cavities			Primary medium	Secondary medium
3.2.2	Development and characterization of novel optical substrate materials	Develop and characterize sapphire and/or silicon for optical substrates	Secondary medium		Secondary low	Primary high
3.2.3	Directional radiative cooling	Develop cryogenic radiative cooling of test masses directly to quietly reduce thermal loading in input cavity mirrors.			Secondary – high	Primary - high
3.2.4	High efficiency grating development and characterization	Develop, characterize and model large area high efficiency gratings for use in GW interferometers	Secondary medium		Secondary - Medium	Primary - Medium
3.2.5	Low loss nonlinear optical materials for squeezed light interferometry	Study loss mechanisms in non-linear materials to improve performance for squeezing and improve long term reliability	Secondary - High		Primary - High	Secondary - Medium
3.2.6	Composite masses	Study composite test masses as a way of reducing quantum radiation pressure noise				Primary - High
3.2.7	Shorter Wavelength Light					
3.2.8	Coating-less or coating-reduced optics	Develop and experimentally test coating-free or reduced coating interferometers				Primary-high
4. Lasers						
4.2.1	High power concepts – Yb:YAG	Characterize Yb:YAG for kilowatt class lasers for GW interferometers	Primary-high			Secondary - medium
4.2.2	High power concepts – slabs, rods	Model and characterize slabs and birefringence compensated rods for higher power laser designs			Primary - Medium	Secondary - medium

White Paper section	Topic	Goal	Funda-mental Science	AdvLIGO Risk Mitigation	"Enhanced" AdvLIGO	Third Generation Detectors
4.2.3	High power concepts – amplifiers	Investigate performance and longevity of optical fiber amplifiers	Secondary-high		Secondary - medium	Primary - medium
4.2.4	High power concepts – adaptive optics	Develop static and/or dynamic wavefront correction techniques for matching laser beam profiles to optical cavities			Secondary low	Primary Medium
4.3.1	Squeezed light generation	Develop reliable high efficiency squeezed light (squeezed vacuum) sources	Secondary - High	Primary - high	Primary high	
4.3.2	Squeezed light implementation	demonstrate compatibility of squeezing with configuration		Primary - high	Primary - high	Secondary - high
4.2.5	Laser Stabilization	Development of laser stabilization techniques, particularly relative intensity stabilization		Primary - high	Secondary high	
4.2.6	Photodiodes	Develop high efficiency, high power photodiodes		Primary - high	Secondary - high	
5. Advanced Interferometer Configurations						
5.1	Advanced LIGO and possible enhancements	a) test interferometer sensing and control component parts for AdvLIGO b) optimize readout parameters and analysis of AdvLIGO sensing and control scheme c) Investigate alternative and modified sensing schemes for AdvLIGO		a)Primary-high b) Primary-high c) Secondary-medium	c) Primary - high	
5.2	Simulation	a) Model non-linear effects including lock-acquisition b) analyze thermal effects and optical aberrations c) Study control schemes d) Study quantum radiation pressure, optical spring effects and squeezing e) study alternative cavity mode shapes for reduced thermal noise f) Prototype as motivated by above		a) Primary-high b) Primary-high c) Primary-high	a) Secondary - medium d) Secondary – medium e) Secondary – medium f) Secondary - medium	d) Secondary – medium e) Primary – medium f) Secondary - medium

White Paper section	Topic	Goal	Funda-mental Science	AdvLIGO Risk Mitigation	“Enhanced” AdvLIGO	Third Generation Detectors
5.3	Beyond Advanced LIGO: quantum techniques	a) development of squeezed light sources b) development of optical spring configurations c) Prototypes as motivated by above	a) Secondary – medium		a) Primary-high b) Primary-high c) Secondary - medium	a) Primary – high b) Seconday-high c) Secondary - medium
5.4	Generic techniques in configurations	a) control of high power coupled cavity systems b) new readout schemes c) theoretical modeling of radiation pressure in coupled cavities d) interferometer configurations based on diffractive or polarizing optics e) testing configurations using non-Gaussian modes f) white light cavities	c) Secondary - medium		a) Primary-high b) Primary-high c) Primary-high f) Primary-medium	b) Secondary - medium d) Primary – high e) Primary - medium
6	Third-Generation GW Detector System Considerations		Primary - high			Primary - high