LCGT Interface Control Document

System Engineer Office (SEO)

February 7, 2013

1 Overview

This document presents the interface information that should be shared by more than one of the 14 existing LCGT subsystems. The interface information includes (i) definition of each subsystem, (ii) interface parameter list, and (iii) optical layout of the detector. The document is uploaded on the LCGT SVN server (`https://granite.phys.s.u-tokyo.ac.jp/svn/LCGT/trunk/ICD`) and the contents are to be updated on a real-time basis.

2 Allocation of the tasks for LCGT

The scope of each subsystem and the boundaries of subsystems are defined so that all the LCGT components must be included in one or more subsystems. The components shared by more than one subsystems, namely *interface components*, should be carefully controlled to avoid a contradictory assumption of the setup.

2.1 List of the subsystems and 3-letter codes

Analog Electronics (AEL)
Auxiliary Optics (AOS)
Cryogenics (CRY)
Digital System (DGS)
Facility (FCL)
Input and Output Optics (IOO)
Laser (LAS)
Main Interferometer (MIF)
Mirror (MIR)
Tunnel (TUN)
Vacuum (VAC)
Vibration Isolation System (VIS)

3 Interface parameters

3.1 AEL

The components that the AEL subsystem is in charge are as follows:

EOM for PMC, RF oscillator for PMC EOM, PD for PMC control, piezo actuators for PMC, EOPM for RC, AOM for RC, PD for RC control, piezo actuators for RC, AOM for gr1, AOM for gr2, EOM for PMC for gr1, EOM for PMC for gr2, EOM for gr1 PDH, EOM for gr2 PDH, RF oscillator for gr1 PMC, RF oscillator for gr2 PMC, RF oscillator for gr1 PDH, RF oscillator for gr2 PDH, PD for gr1 PMC, PD for gr2 PMC, PD for gr1 PDH, PD for gr2 PDH, piezo for green PMCs, f1 PM EOM, f2 PM EOM, f1 AM EOMs, Pockels cell actuator for MZ, PD for MZ refl, PD for MZ trans, PD for MC refl, PD for MC trans, QPDs for MC, CCDs for MC, PD for ISS, PD for REFL (high/low), PD for POP (high/low), PD for ASp (high/low), PD for POX, PD for POY, PD for X-trans, PD for Y-trans, QPDs for REFL (high/low), QPDs for POP (high/low), QPDs for AS (high/low), CARM demodulator, DARM demodulator (RF), PRCL demodulator, MICH demodulator, SRCL demodulator, OMC breadboard actuators, piezo actuators for OMC, QPD for OMC refl, PD for OMC trans,

and the related interface parameters are listed in Table 1.

3.2 AOS

The components that the AOS subsystem is in charge are as follows:

FIs (4), FIs for green (2), MMT for gr1, MMT for gr2, lenses for MC WFS, oplev for MC, beam shutter, steering mirrors, pico-motors for steering mirrors, beam dampers, oplev for core optics, holes on baffles, in-vacuum mirror cleaning tools, TCS (if necessary), beam reducing telescope, blackholes for OMC refl stray, output Faraday Isolator,

and the related interface parameters are listed in Table 2.

3.3 CRY

The components that the CRY subsystem is in charge are as follows:

radiation shields (8K, 80K), radiation shield supports, PTC head, compressor, valve unit, valve unit support, vibration reduction system, 1st cold stage, 2nd cold stage, heat conductors, vacuum chamber for PTC, defrosters, heat link A, heat link B, IM wire, RM wire, TM fiber (sapphire),

and the related interface parameters are listed in Table 3.

3.4 DGS

The components that the DGS subsystem is in charge are as follows:

digital system for MC, digital system for MIF, main system PC, ADC/DAC, AA/AI filters, whitening/dewhitening filters, real-time OS, control software, monitor software, data storage, timing system,

and the related interface parameters are listed in Table 5.

3.5 FCL

The components that the FCL subsystem is in charge are as follows:

buildings, car parking, power supply system, clean assy rooms, air conditioners, optical fibers, cranes, vacuum access, clean booth on access, acoustic isolation boxes,

and the related interface parameters are listed in Table 6.

3.6 GIF

The components that the GIF subsystem is in charge are as follows:

thermometers, seismometers, particle meters, microphones, hygrometers, baseline interferometers, barometers, accelerometers,

and the related interface parameters are listed in Table 7.

3.7 IOO

The components that the IOO subsystem is in charge are as follows:

PMC mirrors, RC mirrors, RC servo, phase-lock system for green, PMC for gr1, PMC for gr2, MC servo, variable attenuator, ISS servos, OMC breadboard,

and the related interface parameters are listed in Table 8.

3.8 LAS

The components that the LAS subsystem is in charge are as follows:

40W SFA, Laser modules, water chiller, power supply, green laser 1 (X arm), green laser 2 (Y arm),

and the related interface parameters are listed in Table 9.

3.9 MIF

The components that the MIF subsystem is in charge are as follows:

lenses for REFL WFS, lenses for POP WFS, lenses for AS WFS, CCDs for trans (X,Y), CCDs for REFL, attenuation mirror for REFL, CARM servo, oscilloscopes, network analyzer, optical spectrum analyzer, control scripts,

and the related interface parameters are listed in Table 10.

3.10 MIR

The components that the MIR subsystem is in charge are as follows:

dielectric mirrors, MZ mirrors, MC mirrors, MMT mirrors, ITM (silica), ETM (silica), ITM (sapphire), ETM (sapphire), BS, PRM, PR2, PR3, SRM, SR2, SR3, ASp pickoff mirror, OMC mirrors,

and the related interface parameters are listed in Table 11.

3.11 TUN

The components that the TUN subsystem is in charge are as follows:

3km tunnels, center room, two-story end rooms, Water drainage system, entrance tunnel,

and the related interface parameters are listed in Table 13.

3.12 VAC

The components that the VAC subsystem is in charge are as follows:

chambers (A,B,C1,C2), beam tubes, module tubes, borehole tubes, bellows, baffles for gas molecules, baffles for radiation, viewports, gate vulves, vacuum gauges, vacuum pumps (turbo, ion), feedthrough,

and the related interface parameters are listed in Table 14.

3.13 VIS

The components that the VIS subsystem is in charge are as follows:

Type-A IP, Type-B IP, Type-A filter0, Type-A filter1, Type-A filter2, Type-B filter0, Type-B filter1, MGAS, horizontal-LVDT, piezo-motor (filter2, PF), mini-GAS on PF, motor slider on PF, position sensors (PF, MB), coil-magnet actuators (PF, MB), ESD actuators, PF local control servos, MB local control servos, IM local control servos, PF, MB, IM, Type-A RM, Type-B RM, Type-C RM, stacks for Type-C, stacks for Type-B (iLCGT), 300K IM wire, 300K RM wire, 300K mirror wire,

and the related interface parameters are listed in Table 15.

4 Optical layout

The Optical layout of bLCGT is shown in JGW-D1100685-v1 (dxf file).

5 Schedule

The Schedule of LCGT is shown here: http://gwlcgt.icrr.u-tokyo.ac.jp:13013/PWA (mpp file; password protected).

6 Glossary

AA : *anti-aliasing*
ADC : *analog-digital converter*
AI : *anti-imaging*
AOM : *acoustic-optic modulator*
AR : *anti-reflective coating*
AS : *anti-symmetric port*
BS : *beamsplitter*
CARM : *common-mode arm length change*
CMR(R) : *common-mode rejection (rate)*
DAC : *digital-analog converter*
DARM : *differential-mode arm length change*
EOM : *electro-optic modulator*
ESD : *electro-static drive*
ETM : *end test mass*
FI : *Faraday isolator*
FSS : *frequency stabilization system*
HOM : *higher order mode*
IM : *intermediate mass*
IP : *inverted pendulum*
ISS : *intensity stabilization system*
ITM : *input test mass*
LVDT : *linear variable differential transformer*
MB : *magnet block*
MC : *mode-cleaner*
MGAS : *monolithic geometrical anti-spring*
MICH : *differential length change of BS and ITMs*
MMT : *mode-matching telescope*
MZ : *Mach-Zehnder*
OMC : *output mode-cleaner*
PD : *photo-detector*
PDH : *Pound-Drever-Hall method*

PF : *platform*
PMC : *pre-mode-cleaner*
POM : *pick-off mirror*
POP : *pick-off port in PRC*
POX : *pick-off port from ITMx AR*
POY : *pick-off port from ITMy AR*
PRCL : *power-recycling cavity length change*
PRM : *power-recycling mirror*
PTC : *pulse tube cooler*
QPD : *quadrant photo-detector*
RC : *recycling cavity*
REFL : *reflection port*
RM : *recoil mass*
RMS : *root mean square*
RMTM : *recoil mass of test mass*
RoC : *radius of curvature*
SAS : *seismic attenuation system*
SFA : *single frequency amplifier*
SRCL : *signal-recycling cavity length change*
SRM : *signal-recycling mirror*
TCS : *thermal compensation system*
TM : *test mass*
WFS : *wave-front sensing*

7 Other constants

Other constants are listed in Table 16.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
drange_PD	TBD		PD dynamic range							IF	DG	EL	IO		AO		
drange_QPD	TBD		QPD dynamic range							IF	DG	EL	IO		AO		
aperture_rfpd_hi	3.00.E-03	m	RF PD aperture (high							IF		EL					
aperture_rfpd_lo	3.00.E-03	m	RF PD aperture (low							IF		EL					
aperture_dcpd_hi	3.00.E-03	m	DC PD aperture (high							IF		EL					
aperture_dcpd_lo	3.00.E-03	m	DC PD aperture (low							IF		EL					
input_rfpd_high	3.00.E-01	W	RF PD input power (h							IF		EL					
input_rfpd_low	1.00.E-01	W	RF PD input power (l							IF		EL					
input_dcpd_high	1.00.E-01	W	DC PD input power (h							IF		EL					
input_dcpd_low	1.00.E-02	W	DC PD input power (l							IF		EL					
RFHOMsuppressi	TBD		RF HOM suppression a							IF		EL					
dcpowersupply	2.40.E+01	V	DC power supply							IF		EL					
dcvoltage	1.00.E-01	V	maximum DC voltage f							IF		EL			AO		
noise_PD	1.00.E-09	V/rtHz	electric noise on de							IF		EL			AO		
error_IQ	1.00.E-02		error of 90deg for I							IF	DG	EL					
loss_PD	5.00.E-02		1 - quantum efficien							IF		EL	IO		AO		
noise_QPD	1.00.E-09	V/rtHz	QPD noise							IF	DG	EL	IO		AO		
actuator_IM	TBD		actuator power on IM				VI			IF		EL					
actuate_range	TBD		actuation range (AC)				VI			IF		EL					
noise_actuator	TBD		actuator noise				VI			IF		EL					
actuator_ITM	TBD		actuator power on IT				VI			IF		EL			AO		
actuator_ETM	TBD		actuator power on ET				VI			IF		EL			AO		

Table 1: Interface parameters that AEL subsystem is in charge of.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
emissiv_baf_TM	TBD		emissivity of baffle					MI	CR						AO		
emissiv_baf_rs	TBD		emissivity of baffle					MI	CR						AO		
heat_viewport	1.00.E−02	W	heat from view ports			VA			CR	IF					AO		
FI_extinction	4.00.E+01	dB	extinction ratio of							IF			IO		AO		
outFI_extinction	4.00.E+01	dB	extinction ratio of							IF			IO		AO		
loss_outFI	2.00.E−02		optical loss of outp							IF			IO		AO		
centering	1.00.E−04	m	Beam centering error					MI		IF			IO		AO		
num_viewport	1.00.E+00		number of view ports			VA			CR	IF					AO		

Table 2: Interface parameters that AOS subsystem is in charge of.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
emissivity_TM	8.00.E-02		emmisivity of surfac					MI	CR								
Tm_TM	2.00.E+01	K	temperature					MI	CR	IF							
specificheat_TM	6.90.E-01	J/K/kg	specific heat of TM				VI	MI	CR								
kappa_TM	1.57.E+04	W/m/K	thermal conducutivit				VI	MI	CR								
diameter_cryo8K	5.00.E-01	m	radiation shield dia			VA			CR								
emissivity_vacuu	3.00.E-02		duct emissivity			VA			CR								
heat_fromBS	1.00.E-01	W	radiation from BS ch			VA			CR	IF							
heat_fromArm	1.00.E-01	W	radiation from arm c			VA			CR	IF							
heat_cryoshield	1.00.E-01	W	heat from radiation			VA			CR	IF							
diameter_apertur	2.50.E-01	m	radiation shield ape			VA			CR	IF					AO		
heat_scatter_tos	4.00.E+00	W	max heat from scatte			VA		MI	CR	IF					AO		
seis_cryostat	TBD		vibration at cryosta	TU	FA	VA			CR	IF							
diameter_tophole	1.50.E-01	m	top hole diameter (t			VA	VI		CR	IF							
heat_fromtop	1.00.E-02	W	radiation from upper			VA	VI		CR	IF							
Tm_cryo8K	8.00.E+00	K	inner shield temepra			VA	VI		CR	IF							
Tm_cryo80K	8.00.E+01	K	duct shield temperat			VA	VI		CR	IF							
kappa_heatlink	4.00.E+03	W/m/K	heat link thermal co				VI		CR								
num_HL1	7.00.E+00		number of HL1 (Sh-PF				VI		CR								
RRR_HL1	4.00.E+03		RRR of HL1 (Sh-PF)				VI		CR								
RoU_HL1	5.00.E-01	m	HL1 radius of U				VI		CR								
lsus_HL1	7.50.E-01	m	HL1 length				VI		CR								
ksus_HL1	TBD		HL1 spring constant				VI		CR								
diameter_HL1	1.00.E-03	m	HL1 diameter				VI		CR								
loss_HL1	5.00.E-05		HL1 loss				VI		CR								
num_HL2	5.00.E+00		number of HL2 (PF-IM				VI		CR								
RRR_HL2	4.00.E+03		RRR of HL2 (Sh-PF)				VI		CR								
RoU_HL2	4.00.E-01		HL2 radius of U				VI		CR								
lsus_HL2	6.28.E-01	m	HL2 length				VI		CR								
ksus_HL2	TBD		HL2 spring constant				VI		CR								
diameter_HL2	3.00.E-03	m	HL2 diameter				VI		CR								
loss_HL2	5.00.E-05		HL2 loss				VI		CR								
num_HL3	4.00.E+00		number of HL3 (IM-RM				VI		CR								
RRR_HL3	4.00.E+03		RRR of HL3 (Sh-PF)				VI		CR								
RoU_HL3	3.00.E-01		HL3 radius of U				VI		CR								
lsus_HL3	4.71.E-01		HL3 length				VI		CR								
ksus_HL3	TBD		HL3 spring constant				VI		CR								
diameter_HL3	1.60.E-03		HL3 diameter				VI		CR								
loss_HL3	5.00.E-05		HL3 loss				VI		CR								
m_IM	6.00.E+01	kg	mass of IM				VI		CR								
RRR_IM	2.00.E+01		RRR of IM				VI		CR								
width_IM	3.10.E-01	m	IM width				VI		CR								
depth_IM	2.00.E-01	m	IM depth				VI		CR								
thickness_IM	1.10.E-01	m	IM thickness				VI		CR								
Tm_IM	TBD	K	temperature of IM				VI		CR								
emissivity_IM	2.00.E-02		emmisivity of surfac				VI		CR								
Cs_IM	TBD		specific heat of IM				VI		CR								
kappa_IM	TBD		thermal conducutivit				VI		CR								
num_IMwires	4.00.E+00		number of wires (IM)				VI		CR								
E_IMwire	1.61.E+11	Pa	wire Young's modulus				VI		CR								
tensile_IM	5.00.E+09	Pa	wire tensile strengt				VI		CR								
loss_Imwire	1.00.E-04		loss				VI		CR								
kappa_Imwire	TBD		thermal conductivity				VI		CR								
lsus_IM	4.00.E-01	m	length				VI		CR								
dsus_IM	7.20.E-04	m	diameter				VI		CR								
rho_Imwire	1.93.E+04	kg/m^3	density				VI		CR								
Tm_Imwire	1.00.E+01	K	temperature of IM wi				VI		CR								
Tm_RM	1.50.E+01	K	temperature of RMTM				VI		CR								
emissivity_RM	2.00.E-02		emmisivity of surfac				VI		CR								
Cs_RM	TBD		specific heat of RMT				VI		CR								
kappa_RM	TBD		thermal conducutivit				VI		CR								
kappa_RMwire	TBD		thermal conductivity				VI		CR								
lsus_RM	3.00.E-01	m	length (RM wire)				VI		CR								
dsus_RM	4.00.E-04	m	diameter (RM wire)				VI		CR								
num_RMwire	4.00.E+00		number of fibers (RM				VI		CR								
E_RMwire	1.30.E+11	Pa	Young's modulus (RM				VI		CR								

Table 3: Interface parameters (1) that CRY subsystem is in charge of.

rho_RMwire	8.36.E+03	kg/m^3	density (RM wire)				VI		CR								
Tm_RMwire	1.60.E+01	K	effective temperatur				VI		CR								
loss_yaw_IM	TBD		yaw-mode loss (IM)				VI		CR	IF							
loss_pitch_IM	TBD		pitch-mode loss (IM)				VI		CR	IF							
f_yaw_IM	TBD		yaw-mode resonant fr				VI		CR	IF					AO		
f_pitch_IM	TBD		pitch-mode resonant				VI		CR	IF					AO		
inertia_yaw_IM	TBD		yaw-mode moment of i				VI		CR	IF					AO		
inertia_pitch_IM	TBD		pitch-mode moment of				VI		CR	IF					AO		

Table 4: Interface parameters (2) that CRY subsystem is in charge of.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
noise_adc	2.00.E-06	V/rtHz	ADC noise				VI			IF	DG	EL	IO	LA			
noise_dac	1.50.E-06	V/rtHz	DAC noise				VI			IF	DG	EL	IO	LA			
max_adc	2.00.E+01	V	ADC maximum input vo				VI			IF	DG	EL	IO	LA			
max_dac	1.00.E+01	V	DAC maximum output v				VI			IF	DG	EL	IO	LA			
sampling	1.64.E+04	Hz	sampling frequency				VI			IF	DG	EL	IO	LA			DA
loopdelay	1.00.E-04	sec	loop time delay (>20				VI			IF	DG	EL	IO	LA			DA
bandwidth	7.40.E+03	Hz	observation bandwidt							IF	DG						DA

Table 5: Interface parameters that DGS subsystem is in charge of.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
Tm_room	2.90.E+02	K	room temperature		FA				CR	IF						GI	
clean_manu	1.00.E+1		cleanliness in manuf		FA			MI									
clean_lab	1.00.E+2		cleanliness in lab		FA			MI									
clean_buil	1.00.E+3		cleanliness in build		FA			MI									

Table 6: Interface parameters that FCL subsystem is in charge of.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
barometer	TBD		barometer resolution		FA	VA	VI			IF	DG					GI	DA
hygrometer	TBD		hygrometer resolutio		FA	VA	VI			IF	DG					GI	DA
thermometer	TBD		thermometer resoluti		FA		VI			IF	DG					GI	DA
microphone	TBD		microphone resolutio		FA		VI			IF	DG					GI	DA
particlemeter	TBD		particle meter resol	TU	FA	VA	VI			IF	DG					GI	DA
accelerometer	TBD		accelerometer resolu				VI			IF	DG					GI	DA
seismometer	TBD		seismometer resoluti	TU	FA		VI			IF	DG					GI	DA

Table 7: Interface parameters that GIF subsystem is in charge of.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
L_PMC	4.88.E-01	m	PMC length										IO				
noise_oscillator	-1.60.E+02	dBc	RF oscillator phase							IF		EL	IO				
L_RC	1.50.E-01	m	Ref Cav length										IO		AO		
finesse_RC	1.00.E+04		Ref Cav finesse										IO		AO		
trans_MC	8.00.E-01		MC transmittance										IO	LA			
noise_FSSPD	1.00.E-09	V/rtHz	FSS PD noise level							IF		EL	IO		AO		
power_FSS	1.00.E-01	W	pick-off power for F							IF			IO		AO		
angle_MCend	5.42.E-01	deg	angle of incidence o							IF			IO		AO		
w_MCend	4.38.E-03	m	beam radius on MC-en							IF			IO		AO		
w_MCin	2.53.E-03	m	beam radius on MC-in							IF			IO		AO		
w_MCout	2.53.E-03	m	beam radius on MC-ou							IF			IO		AO		
finesse_MC	5.00.E+02		MC finesse							IF			IO		AO		
beamjitter_MC	TBD		MC output beam jitte							IF			IO		AO		
L_MCout_MMT1	6.133.E+00	m	distance of MC-waist							IF			IO		AO		
L_MMT1_MMT2	3.10.E+00	m	distance of MMT1 and							IF			IO		AO		
L_MMT2_PRM	5.063.E+00	m	distance of MMT2 and							IF			IO		AO		
L_OMC	1.74.E+00	m	OMC rt length							IF			IO		AO		
num_mirror_OMC	4.00.E+00		number of mirrors (O					MI		IF			IO		AO		
loss_OMC	2.00.E-02		OMC optical loss					MI		IF			IO		AO		
finesse_OMC	7.00.E+02		OMC finesse					MI		IF			IO		AO		
num_mirror_PMC	4.00.E+00		number of mirrors (P					MI					IO				
finesse_PMC	1.55.E+02		PMC finesse					MI					IO				
diameter_MMT	1.00.E-01	m	MMT mirror diameter					MI					IO		AO		
thickness_MMT	3.00.E-02	m	MMT mirror thickness					MI					IO		AO		
RoC_MMT1	-1.2258.E+	m	MMT1 RoC					MI					IO		AO		
RoC_MMT2	1.8146.E+0	m	MMT2 RoC					MI					IO		AO		
R_MCend	1.00.E+00		MC-end reflectivity					MI		IF			IO		AO		
R_MCin	9.94.E-01		MC-in reflectivity					MI		IF			IO		AO		
R_MCout	9.94.E-01		MC-out reflectivity					MI		IF			IO		AO		
L_MC	5.33.E+01	m	MC length (roundtrip			VA				IF			IO		AO		
mass_OMCplatfor	TBD		mass of OMC platform				VI						IO				
reso_OMCsusp	TBD		resonant freq of OMC				VI						IO				

Table 8: Interface parameters that IOO subsystem is in charge of.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
wavelength	1.06.E-06	m	wavelength											LA			
FN	1.00.E+02	Hz/rtHz	free-run FN (at 100H											LA			
IN	1.00.E-04	W/W/rtH	free-run IN											LA			
laser_linewidth	TBD		linewidth											LA			
chiller	1.50.E+01	deg	chiller temperature											LA			
laser_temperatur	TBD		Laser temperature											LA			
laserpower	1.80.E+02	W	laser power							IF			IO	LA			
laserpower_green	1.00.E-01	W	Green Laser power							IF			IO	LA	AO		
freq_gap_green	1.00.E+08	Hz	Green laser's freque							IF			IO	LA	AO		

Table 9: Interface parameters that LAS subsystem is in charge of.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
contrastdefect	5.00.E-03		contrast defect (ali							IF					AO		
guoy_PRC	2.00.E+01	deg	Gouy phase shift in							IF					AO		
guoy_SRC	2.00.E+01	deg	Gouy phase shift in							IF					AO		
offset_arm	2.00.E-12	m	differential offset							IF			IO				
detune	3.50.E+00	deg	detune phase							IF			IO				
f1	1.69.E+07	Hz	f1 sideband frequenc							IF			IO		AO		
mod_f1	2.00.E-01		f1 sideband modulati							IF			IO		AO		
f2	4.50.E+07	Hz	f2 sideband frequenc							IF			IO		AO		
mod_f2	2.00.E-01		f2 sideband modulati							IF			IO		AO		
f3	3.94.E+07	Hz	f3 sideband freq (if							IF			IO		AO		
mod_f3	0.00.E+00		f3 sideband modulati							IF			IO		AO		
RIN_AF	TBD		AF RIN							IF			IO	LA	AO		
RIN_RF	1.00.E-09	W/W/rtH	RF RIN (>15MHz)							IF			IO	LA	AO		
num_coat_ETM	1.80.E+01		number of layers on					MI		IF							
num_coat_ITM	9.00.E+00		number of layers on					MI		IF							
m_ETM	2.28.E+01	kg	ETM mass					MI		IF							
m_ITM	2.28.E+01	kg	ITM mass					MI		IF							
finesse_green	1.90.E+01		Green arm finesse (I					MI		IF					AO		
R_BS_green	1.00.E-02		BS reflectivity for					MI		IF					AO		
R_PR2_green	1.00.E-02		PR2 reflectivity for					MI		IF					AO		
R_PR3_green	1.00.E-02		PR3 reflectivity for					MI		IF					AO		
R_SR2_green	1.00.E-02		SR2 reflectivity for					MI		IF					AO		
R_SR3_green	1.00.E-02		SR3 reflectivity for					MI		IF					AO		
R_PRM	9.00.E-01		PRM reflectivity					MI		IF					AO		
loss_PRM	1.00.E-04		PRM optical loss					MI		IF					AO		
loss_PR2	1.00.E-04		PR2 optical loss					MI		IF					AO		
loss_PR3	1.00.E-04		PR3 optical loss					MI		IF					AO		
RoC_PRM	3.70.E+02	m	RoC of PRM					MI		IF					AO		
RoC_PR2	4.17.E+00	m	RoC of PR2					MI		IF					AO		
RoC_PR3	3.23.E+01	m	RoC of PR3					MI		IF					AO		
R_SRM	9.00.E-01		SRM reflectivity					MI		IF					AO		
loss_SRM	1.00.E-04		SRM optical loss					MI		IF					AO		
loss_SR2	1.00.E+04		SR2 optical loss					MI		IF					AO		
loss_SR3	1.00.E+04		SR3 optical loss					MI		IF					AO		
RoC_SRM	3.70.E+02	m	RoC of SRM					MI		IF					AO		
RoC_SR2	4.17.E+00	m	RoC of SR2					MI		IF					AO		
RoC_SR3	3.23.E+01	m	RoC of SR3					MI		IF					AO		
R_ETM	1.00.E+00		ETM reflectivity					MI		IF					AO		
R_ITM	9.96.E-01		ITM reflectivity					MI		IF					AO		
R_ASp	0.00.E+00		AS POM reflectivity					MI		IF			IO		AO		
w_ETM	4.53.E-02	m	beam radius on ETM					MI		IF			IO		AO		
w_ITM	3.43.E-02	m	beam radius on ITM					MI		IF			IO		AO		
wedge_PRM	3.00.E-01	deg	wedge angle of PRM (			VA		MI		IF			IO		AO		
wedge_SRM	3.00.E-01	deg	wedge angle of SRM			VA		MI		IF			IO		AO		
L_arm	3.00.E+03	m	arm length			VA				IF							
L_PRM_PR2	1.4761.E+0	m	PRM-PR2 distance			VA				IF					AO		
L_PR2_PR3	1.2067.E+0	m	PR2-PR3 distance			VA				IF					AO		
L_PR3_BS	1.4764.E+0	m	PR3-BS distance			VA				IF					AO		
L_SRM_SR2	1.4764.E+0	m	SRM-SR2 distance			VA				IF					AO		
L_SR2_SR3	1.2067.E+0	m	SR2-SR3 distance			VA				IF					AO		
L_SR3_BS	1.4764.E+0	m	SR3-BS distance			VA				IF					AO		
foldangle_PRC	6.293.E-01	deg	PRC folding angle			VA				IF					AO		
foldangle_SRC	6.293.E-01	deg	SRC folding angle			VA				IF					AO		
L_BS_ITM	2.50285.E+	m	BS-ITM average dista			VA				IF					AO		
L_asym	3.33.E+00	m	asymmetry length			VA				IF					AO		
rms	1.00.E-14	m	rms fluctuation of D				VI			IF							
UGF_CARM	1.00.E+04	Hz	CARM UGF				VI			IF		EL					
UGF_DARM	2.00.E+02	Hz	DARM UGF				VI			IF		EL					
UGF_PRCL	2.00.E+01	Hz	PRCL UGF				VI			IF		EL					
UGF_MICH	2.00.E+01	Hz	MICH UGF				VI			IF		EL					
UGF_SRCL	2.00.E+01	Hz	SRCL UGF				VI			IF		EL					
FF_PRCL	1.00.E+02		PRCL FF gain				VI			IF		EL					
FF_MICH	1.00.E+02		MICH FF gain				VI			IF		EL					
FF_SRCL	1.00.E+02		SRCL FF gain				VI			IF		EL					

Table 10: Interface parameters that MIF subsystem is in charge of.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
rho_ETM	4.00.E+03	kg/m^3	mirror bulk density					MI									
rho_ITM	4.00.E+03	kg/m^3	mirror bulk density					MI									
E_ETM	4.00.E+11	Pa	Young's modulus of E					MI									
E_ITM	4.00.E+11	Pa	Young's modulus of I					MI									
sigma_ETM	2.90.E-01		mirror bulk Poisson					MI									
sigma_ITM	2.90.E-01		mirror bulk Poisson					MI									
alpha_ETM	5.6.E-9	1/K	mirror thermal expan					MI	CR								
alpha_ITM	5.6.E-9	1/K	mirror thermal expan					MI	CR								
Cs_ETM	6.90.E-01	J/K/kg	mirror specific heat					MI	CR								
Cs_ITM	6.90.E-01	J/K/kg	mirror specific heat					MI	CR								
kappa_ETM	1.57.E+04	W/m/K	mirror thermal condu					MI	CR								
kappa_ITM	1.57.E+04	W/m/K	mirror thermal condu					MI	CR								
E_coat_silica	7.20.E+10	Pa	silica coating Young					MI	CR								
E_coat_tantala	1.40.E+11	Pa	tantala coating Youn					MI	CR								
sigma_coat_silic	1.70.E-01		silica coating Poiss					MI	CR								
sigma_coat_tanta	2.30.E-01		tantala coating Pois					MI	CR								
Cv_coat_silica	1.64.E+06	J/K/m^3	silica coating speci					MI	CR								
Cv_coat_tantala	2.10.E+06	J/K/m^3	tantala coating spec					MI	CR								
alpha_coat_silic	5.10.E-07	1/K	silica coating therm					MI	CR								
alpha_coat_tanta	3.60.E-06	1/K	tantala coating ther					MI	CR								
alpha_coat_silic	1.38.E+00	W/m/K	silica coating therm					MI	CR								
alpha_coat_tanta	3.30.E+01	W/m/K	tantala coating ther					MI	CR								
diamter_TM	2.20.E-01	m	TM diameter					MI	CR	IF					AO		
thickness_TM	1.50.E-01	m	TM thickness					MI	CR	IF					AO		
abso_AR	1.00.E-06		AR surface absorptio					MI	CR	IF					AO		
R_BS	5.00.E-01		BS reflectivity					MI		IF							
loss_BS_HR	5.00.E-05		BS HR surface optica					MI		IF							
RoC_BS	5.00.E+05	m	RoC of BS					MI		IF							
abso_BS	1.50.E-04	1/m	BS substrate absorpt					MI		IF							
radisu_BS	1.90.E-01	m	BS radius					MI		IF					AO		
thickness_BS	1.20.E-01	m	BS thickness					MI		IF					AO		
loss_BS_AR	5.00.E-05		BS AR surface reflec					MI		IF					AO		
diameter_PRM	2.50.E-01	m	PRM diamter					MI		IF					AO		
thickness_PRM	1.00.E-01	m	PRM thickness					MI		IF					AO		
diameter_PR2	2.50.E-01	m	PR2 diamter					MI		IF					AO		
thickness_PR2	1.00.E-01	m	PR2 thickness					MI		IF					AO		
diameter_PR3	2.50.E-01	m	PR3 diameter					MI		IF					AO		
thickness_PR3	1.00.E-01	m	PR3 thickness					MI		IF					AO		
diameter_SRM	2.50.E-01	m	SRM diamter					MI		IF					AO		
thickness_SRM	1.00.E-01	m	SRM thickness					MI		IF					AO		
diameter_SR2	2.50.E-01	m	SR2 diamter					MI		IF					AO		
thickness_SR2	1.00.E-01	m	SR2 thickness					MI		IF					AO		
diameter_SR3	2.50.E-01	m	SR3 diameter					MI		IF					AO		
thickness_SR3	1.00.E-01	m	SR3 thickness					MI		IF					AO		
surfacerms_cente	3.00.E-10	m	central region surfa					MI		IF					AO		
surfacerms_outer	1.00.E-09	m	outer region surface					MI		IF					AO		
surfacecenter	1.20.E-01	m	border of central re					MI		IF					AO		
flatness_AR_TM	TBD		AR side surface flat					MI		IF					AO		
RoC_TM_fromAR	TBD		ROC seen from AR sid					MI		IF					AO		
birefringence	TBD		birefringence					MI		IF					AO		
loss_ETM	4.50.E-05		ETM optical loss					MI		IF					AO		
loss_ITM	4.50.E-05		ITM optical loss					MI		IF					AO		
loss_imbalance	1.50.E-05		optical loss imbalan					MI		IF					AO		
finesse_imbalanc	5.00.E-03		finesse imbalance ra					MI		IF					AO		
RoCerror_ETM	1.00.E-02		RoC error of ETM					MI		IF					AO		
RoCerror_ITM	1.00.E-02		RoC error of ITM					MI		IF					AO		
RoC_ETM	7.00.E+03	m	RoC of ETM					MI		IF					AO		
RoC_ITM	5.00.E+05	m	RoC of ITM					MI		IF					AO		
RoCerror_diff	5.00.E-03		RoC imbalance in two					MI		IF					AO		
BRDF	1.40.E-05		BRDF					MI	CR	IF					AO		
mloss_ETM	1.00.E-08		mirror mechanical lo					MI	CR	IF							
mloss_ITM	1.00.E-08		mirror mechanical lo					MI	CR	IF							
mloss_coat_silic	3.00.E-04		silica coating loss					MI	CR	IF							
mloss_coat_tanta	5.00.E-04		tantala coating loss					MI	CR	IF							
loss_sleeks	TBD		scratches and sleeks					MI	CR	IF					AO		

Table 11: Interface parameters (1) that MIR subsystem is in charge of.

loss_points	1.00.E−05		point defects loss					MI	CR	IF					AO		
loss_ITMsubstrat	5.00.E−03	1/m	ITM substrate optica					MI	CR	IF					AO		
abs_coat	1.00.E−06		absorption at coatin					MI	CR	IF					AO		
loss_AR_ITM	1.00.E−04		ITM AR surface optic					MI	CR	IF					AO		
RoC_MCin	5.00.E+05	m	MC−in RoC					MI		IF			IO		AO		
RoC_MCout	5.00.E+05	m	MC−out RoC					MI		IF			IO		AO		
RoC_MCend	4.00.E+01	m	MC−end RoC					MI		IF			IO		AO		
diameter_MC	1.00.E−01	m	MC mirror diameter					MI		IF			IO		AO		
thickness_MC	3.00.E−02	m	MC mirror thickness					MI		IF			IO		AO		
wedge_BS	3.83.E−01	deg	AR wedge of BS			VA		MI		IF					AO		
wedge_ETM	3.00.E−01	deg	wedge angle of ETM			VA		MI		IF					AO		
wedge_ITM_sap	2.00.E−01	deg	wedge angle of ITM (			VA		MI		IF					AO		
wedge_ITM_sil	3.35.E−01	deg	wedge angle of ITM (			VA		MI		IF					AO		
ear_distance	2.46.E−01	m	distance of flat ear				VI	MI									

Table 12: Interface parameters (2) that MIR subsystem is in charge of.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
tunnelsize	4.00.E+00	m	tunnel width/height	TU	FA	VA			CR								
tilt_tunnel	3.33.E−03		tunnel tilt (diff at	TU	FA	VA			CR	IF			IO				
cmrr_seis	TBD		CMRR (3km)	TU	FA	VA	VI										
cmrr_cutoff	TBD		CMR cutoff frequency	TU	FA	VA	VI										
diameter_borehol	1.20.E+00	m	diamter of borehole	TU	FA	VA	VI										

Table 13: Interface parameters that TUN subsystem is in charge of.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
flatness_flange	1.00.E-04	m	flange flatness			VA											
thickness_flange	3.00.E-02	m	flange thickness			VA											
diameter_duct	8.00.E-01	m	duct diameter			VA			CR	IF					AO		
num_pump	3.00.E+01		number of pumps per		FA	VA											
speed_ionpump	1.00.E+03	L/s	pumping speed of ion		FA	VA											
speed_turbopump	2.00.E+03	L/s	pumping speed of tur		FA	VA											
num_gv800	4.00.E+00		number of gv (DN800)		FA	VA											
num_gv1000	3.00.E+00		number of gv (DN1000		FA	VA											
vacuum	2.00.E-07	Pa	vacuum pressure		FA	VA				IF							

Table 14: Interface parameters that VAC subsystem is in charge of.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
k_GAS4	4.73.E+02	kg/s^2	spring constant of 4				VI										
loss_GAS4blade	1.00.E-02		loss of GAS filter b				VI										
m_joint	1.00.E-01	kg	mass of GAS filter j				VI										
lsus_GASPF	2.10.E+00	m	wire length btw 4th				VI										
d_GAS4	3.11.E-03	m	wire diameter (4th G				VI										
n_GAS4	1.00.E+00		number of wires (4th				VI										
E_GAS4	1.86.E+11	Pa	wire youg's modulus				VI										
tensile_GAS4	2.00.E+09	Pa	wire tensile strengt				VI										
loss_GAS4wire	TBD		loss of wire (4th GA				VI										
lsus_GAS4	2.10.E+00	m	wire length btw 4th				VI										
m_payload	1.20.E+02	kg	total mass suspended				VI										
m_RM	3.00.E+01	kg	mass of RMTM				VI		CR								
diameter_RMout	2.90.E-01	m	outer diameter				VI		CR								
diameter_RMin	2.60.E-01	m	inner diameter				VI		CR								
thickness_RM	2.60.E-01	m	thickness				VI		CR								
loss_RMwire	5.00.E-06		loss (RM wire)				VI		CR								
f_yaw_RM	TBD		yaw-mode resonance (				VI		CR								
f_pitch_RM	TBD		pitch-mode resonance				VI		CR								
loss_yaw_RM	TBD		yaw-mode loss (RM wi				VI		CR								
loss_pitch_RM	TBD		pitch-mode loss (RM				VI		CR								
inertia_yaw_RM	TBD		yaw-mode moment of i				VI		CR								
inertia_pitch_RM	TBD		pitch-mode moment of				VI		CR								
kappa_fiber_TM	7.00.E+03	W/m/K	thermal conductivity				VI		CR								
lsus_TM	3.00.E-01	m	length (TM)				VI		CR								
dsus_TM	1.60.E-03	m	diameter (TM)				VI		CR								
num_TMfiber	4.00.E+00		number of fibers (TM				VI		CR								
E_TMfiber	4.00.E+11	Pa	Young's modulus (TM				VI		CR								
rho_TMfiber	4.00.E+03	kg/m^3	density (TM fiber)				VI		CR								
Tm_TMfiber	1.60.E+01		effective temperatur				VI		CR								
mloss_TMfiber	2.00.E-07		loss (TM fiber)				VI		CR								
loss_yaw_TM	TBD		yaw-mode loss (TM)				VI		CR								
loss_pitch_TM	TBD		pitch-mode loss (TM)				VI		CR								
inertia_yaw_TM	TBD		yaw-mode moment of i				VI		CR								
inertia_pitch_TM	TBD		pitch-mode moment of				VI		CR								
f_yaw_TM	TBD		yaw-mode resonant fr				VI		CR						AO		
f_pitch_TM	TBD		pitch-mode resonant				VI		CR						AO		
dT_GAS4	TBD		T dependence of spri				VI		CR	IF							
dsus_GAS4	3.74.E-03	m	wire diameter (4th G				VI				DG	EL					
num_GAS4wire	1.00.E+00		number of wires (4th				VI				DG	EL					
adjust_range	1.00.E-02	m	adjustable distance				VI			IF		EL					
rms_SAS	1.00.E-07	m	RMS displacement				VI			IF	DG	EL					
rms_SAS_velocity	1.00.E-07	m/s	RMS velocity				VI			IF	DG	EL					
rms_pitch	TBD		RMS pitch				VI			IF	DG	EL					
rms_yaw	TBD		RMS yaw				VI			IF	DG	EL					
VHC	5.00.E-03		Vertical horizontal	TU	FA	VA	VI			IF						GI	

Table 15: Interface parameters that VIS subsystem is in charge of.

				TU	FA	VA	VI	MI	CR	IF	DG	EL	IO	LA	AO	GI	DA
hb	1.05457.E−34	J*s	reduced Planck constant							IF			IO		AO		
c	2.99792458.E+08	m/s	speed of light							IF			IO	LA	AO		
kb	1.38.E−23	J/K	Boltzmann's constant			VA	VI	MI	CR								
g	9.8.E+00	m/s^2	acceleration of gravity			VA	VI	MI	CR	IF					AO		
lambda	1.064.E−06	m	wavelength			VA		MI	CR	IF			IO	LA	AO		
rho_sap	4.0.E+03	kg/m^3	density of Sapphire				VI	MI	CR								
Y_sap	4.0.E+11	Pa	Young's modulus of Sapphire				VI	MI	CR								
sigma_sap	2.9.E−01		Poisson ratio of Sapphire				VI	MI	CR								
alpha_sap	5.6.E−09	1/K	thermal expansion of Sapphire at 20K					MI	CR								
Cs_sap	6.9.E−01	J/kg/K	specific heat of Sapphire					MI	CR								
kappa_sap	1.57.E+04	W/m/K	thermal conductivity of Sapphire					MI	CR								
n_sap	1.754.E+00		refractive index of Sapphire			VA		MI		IF					AO		
tensile_sap	TBD	Pa	tensile strength of Sapphire fiber				VI		CR								
rho_sil	2.2.E+03	kg/m^3	density of Silica				VI	MI									
Y_sil	7.2.E+10	Pa	Young's modulus of Silica				VI	MI		IF							
sigma_sil	1.7.E−01		Poisson ratio of Silica					MI									
alpha_sil	5.1.E−07	1/K	thermal expansion of Silica at 290K					MI									
Cs_sil	1.64.E+06	J/m^3/K	specific heat of Silica					MI									
kappa_sil	1.38.E+00	W/m/K	thermal conductivity of Silica					MI									
n_sil	1.45.E+00		refractive index of Silica			VA		MI		IF					AO		
Y_tan	1.4.E+11	Pa	Young's modulus of Tantala				VI	MI		IF							
sigma_tan	2.3.E−01		Poisson ratio of Tantala					MI									
alpha_tan	3.6.E−06	1/K	thermal expansion of Tantala at 290K					MI									
Cs_tan	2.1.E+06	J/m^3/K	specific heat of Tantala					MI									
kappa_tan	3.3.E+01	W/m/K	thermal conductivity of Tantala					MI									
n_tan	2.07.E+00		refractive index of Tantala			VA		MI		IF					AO		
rho_Cu	8.93.E+03	kg/m^3	density of Copper				VI		CR								
Y_Cu	1.298.E+11	Pa	Young's modulus of Copper				VI		CR								
sigma_Cu	3.43.E−01		Poisson ratio of Copper				VI		CR								
alpha_Cu	TBD	1/K	thermal expansion of Copper at 20K						CR								
Cs_Cu	TBD	J/kg/K	specific heat of Copper at 20K						CR								
kappa_Cu	TBD	W/m/K	thermal conductivity of Copper at 20K						CR								
RRR_Cu	2.0.E+01		RRR of Copper						CR								
tensile_Cu	TBD	Pa	tensile strength of Cu fiber				VI		CR								
rho_Al	2.69.E+03	kg/m^3	density of Aluminum				VI		CR								
Y_Al	7.03.E+11	Pa	Young's modulus of Aluminum				VI		CR								
sigma_Al	3.45.E−01		Poisson ratio of Aluminum				VI		CR								
alpha_Al	TBD	1/K	thermal expansion of Aluminum at 20K						CR								
Cs_Al	TBD	J/kg/K	specific heat of Aluminum at 20K						CR								
kappa_Al	TBD	W/m/K	thermal conductivity of Aluminum at 20K						CR								
RRR_Al	4.0.E+03		RRR of Aluminum						CR								
tensile_Al	TBD	Pa	tensile strength of Al fiber				VI		CR								
rho_bol	7.60.E+03	kg/m^3	density of Bolfur				VI		CR								
Y_bol	1.568.E+11	Pa	Young's modulus of Bolfur				VI		CR								
sigma_bol	TBD		Poisson ratio of Bolfur				VI		CR								
alpha_bol	TBD	1/K	thermal expansion of Bolfur						CR								
Cs_bol	TBD	J/kg/K	specific heat of Bolfur						CR								
kappa_bol	TBD	W/m/K	thermal conductivity of Bolfur						CR								
RRR_bol	TBD		RRR of Bolfur						CR								
tensile_bol	3.528.E+09	Pa	tensile strength of 100um Bolfur fiber				VI		CR								
bigG	6.673.E−11	m^3/kg/s^2	Gravitational constant														DA
ms	1.989.E+30	kg	solar mass														DA
neutron	1.4.E+00	solar mass	neutron star mass														DA
fmax	1.570.E+00	Hz	end freq of BNS inspiral														DA
snr	8.0.E+00		SNR for IR calculation														DA

Table 16: Other constants.