Interface-parameter meeting #2

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1．中間マス温度

2．点状散乱と輻射シールド

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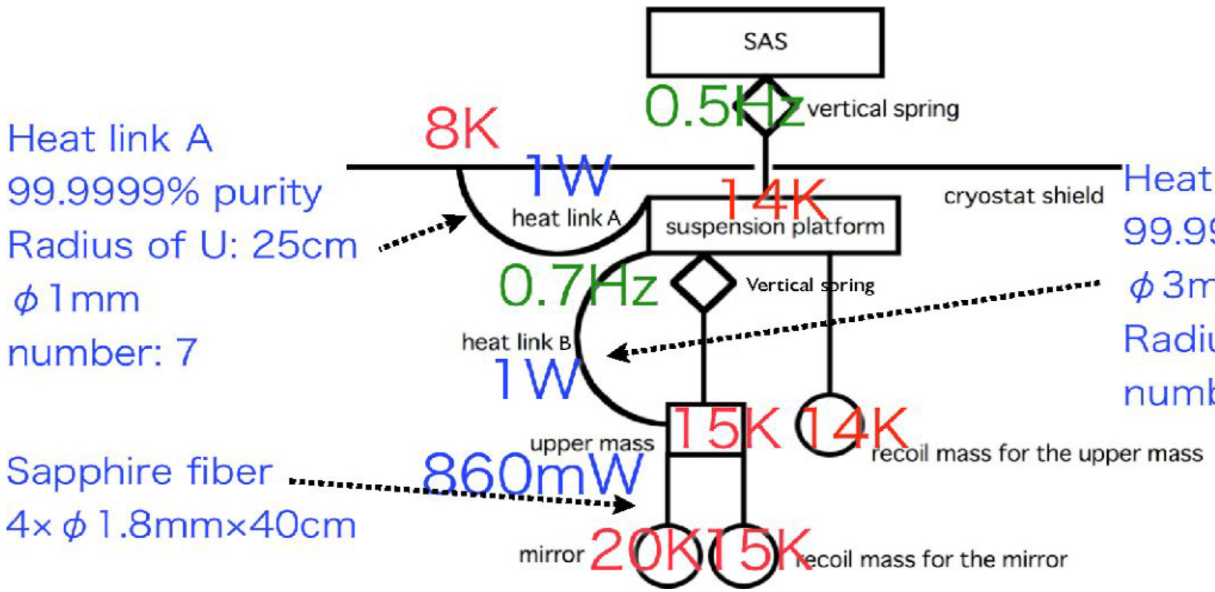
4．高次モードとOMC

重要そうなものを
先にやっつけます

5．Parameter list (cont'd from the last time)

中間マス温度

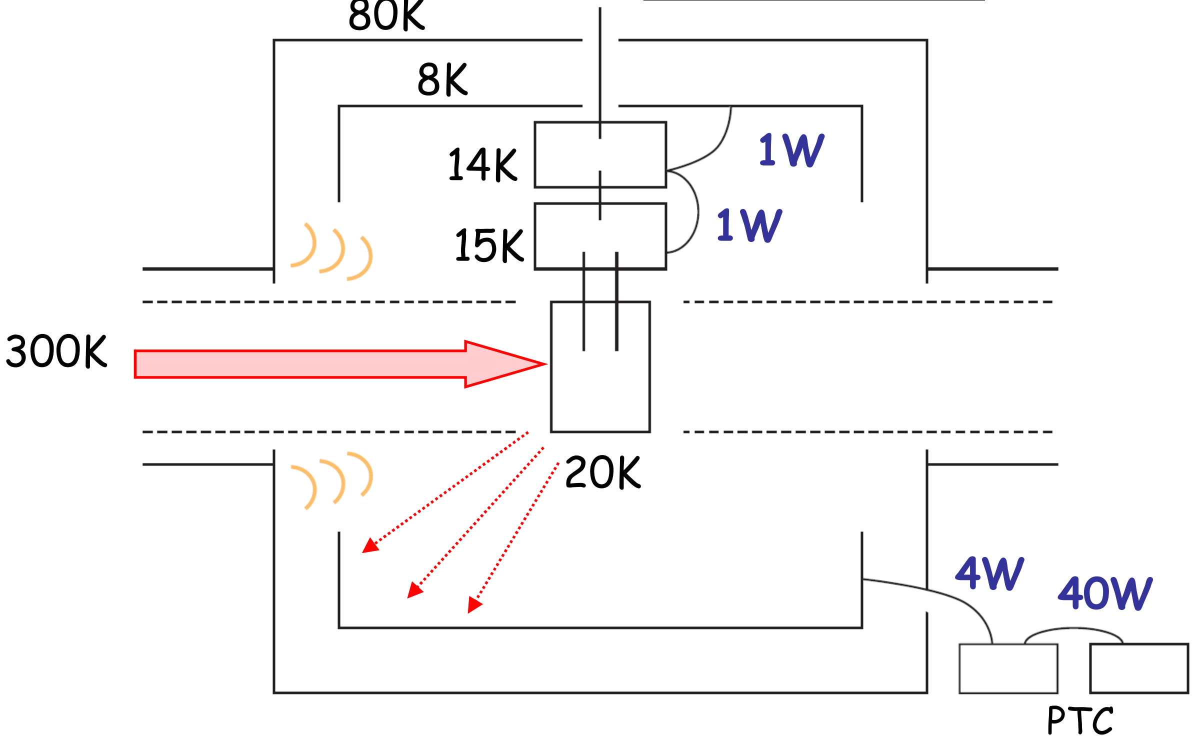


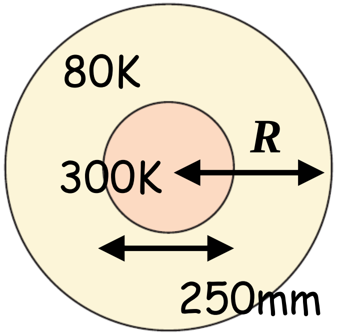
- 10K説と15K説が混在 (LCGT Documentでは10Kと書いてある)
- 10Kだと1Wの熱伝送が可能、15Kだと0.74W (まるめて1W)
- 中間マス以上が全て15Kを想定して設計されていた
- 10Kだとヒートリンクの数が増大し、現実的に厳しいby内山さん

⇒ 15Kとする (熱吸収の要求値は厳しくなる)

安全係数はすでに2に満たない

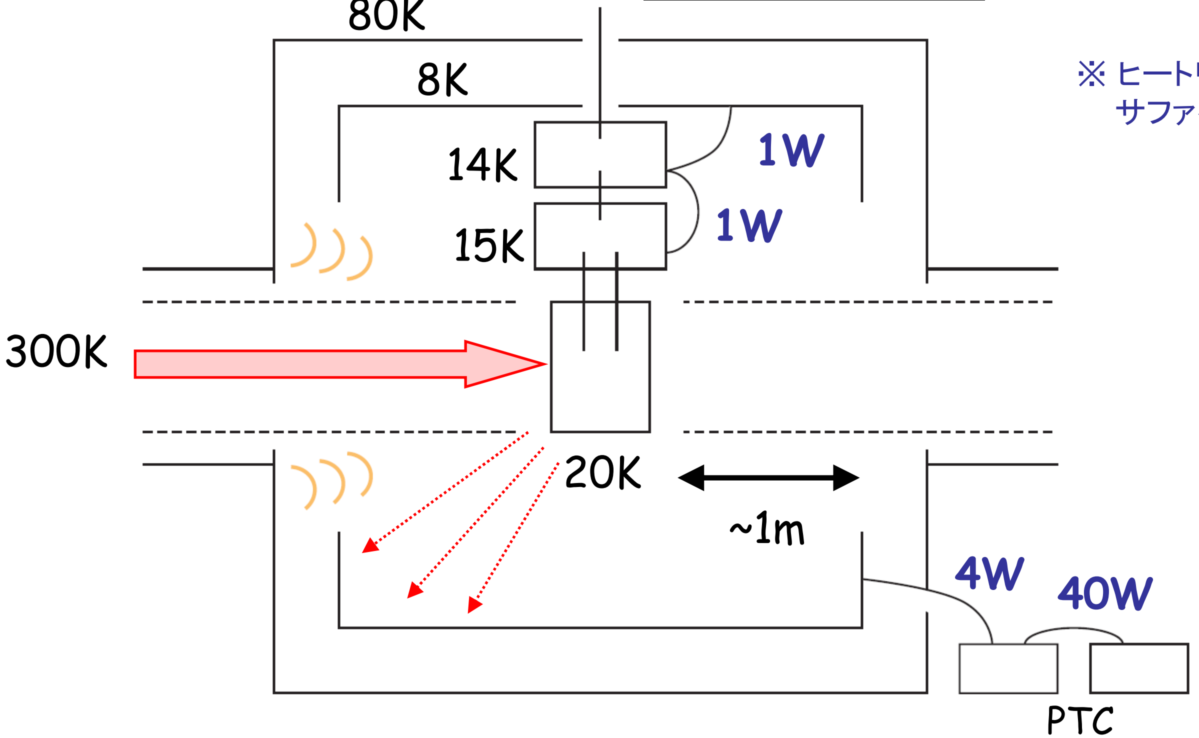
点状散乱



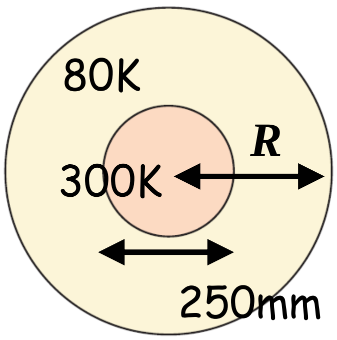


- 8Kの開口が狭いと点状散乱光が8Kシールドを加熱 (デフォルトではφ250)
- 8Kの開口が広いと80Kシールドからの熱輻射が増大
- 光吸収が0.44W、15Kの中間マスへの熱伝送が0.69W→残り250mW
- 300Kの熱輻射吸収は28.7mW×2×0.05=3mW程度 (バッフルby榊原)

点状散乱



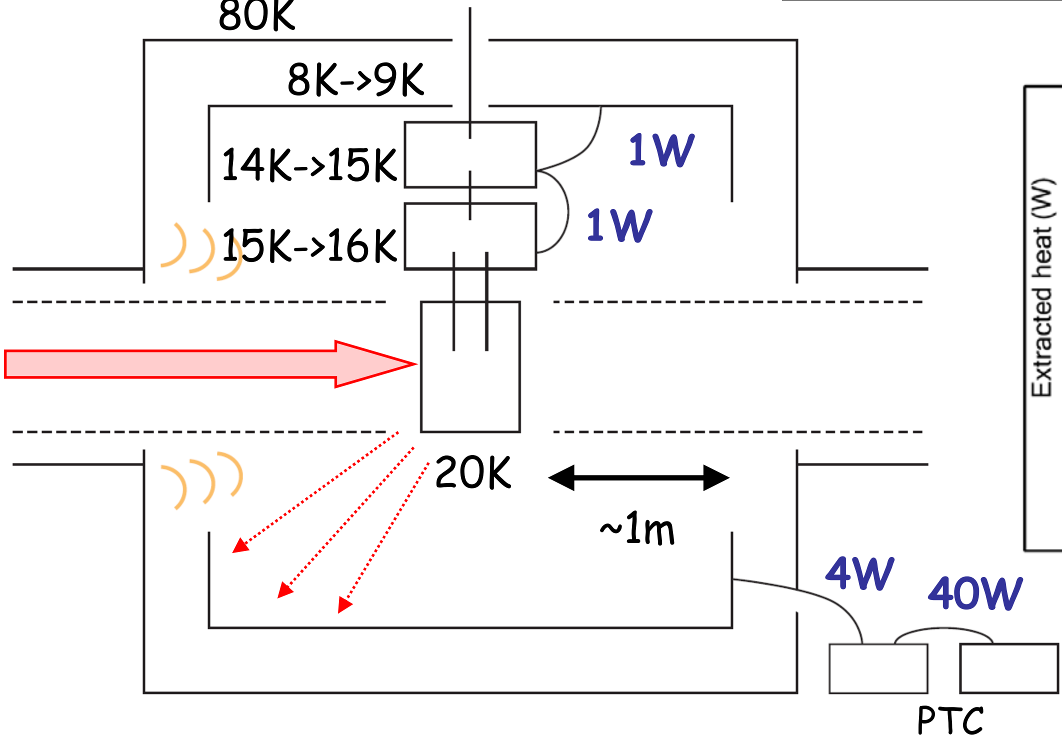
※ ヒートリンクの熱伝導率は8K付近でピーク
　サファイアファイバーは30K付近でピークを示す

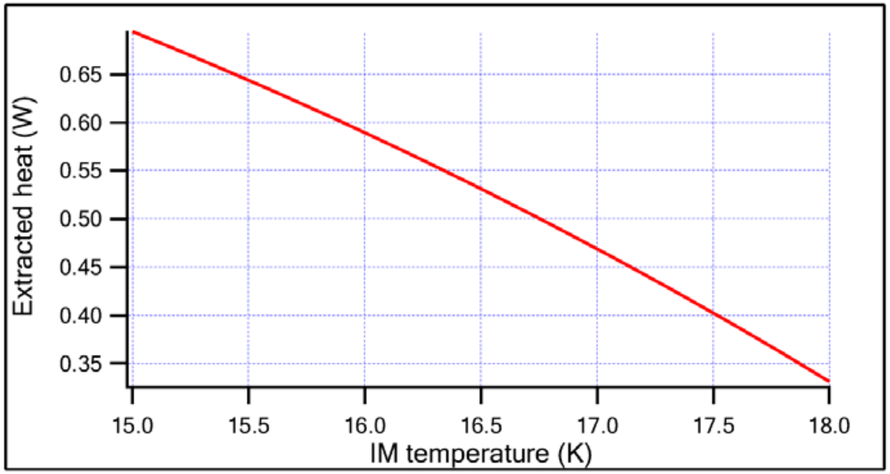


- 開口からの入熱 = 0.05 x 80^4 x (R-0.125)^2 x 3.14 x 5.67e-8
  ~ 0.365 x R'^2 [W] → 吸熱 = 0.0182 x R'^2 [W]
- 1ppmの点状散乱から8Kシールドへの入熱
  = 400kW x 1ppm x [1-atan(R-0.125)^2/(3.14/2)^2]
  ~ 0.4 - 0.162 x R'^2 [W]

※ 8Wの入熱でIM温度が3度上昇する by 木村さん

点状散乱

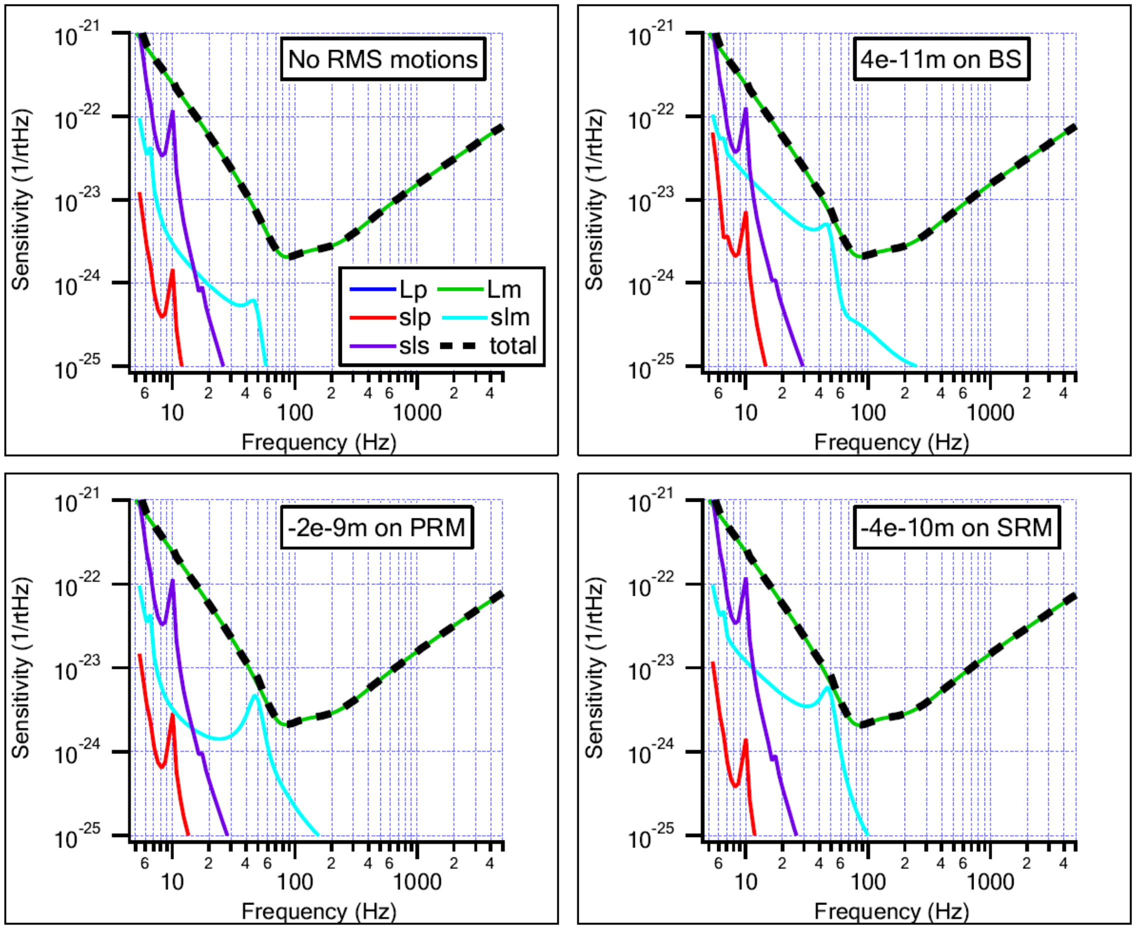




※ 下線部はかなり大雑把な計算です

- 8Kシールドの温度上昇→IM温度はほぼそのまま上昇
- サファイアファイバーの熱伝送低下；1度上昇で100mW分の低下
- 温度上昇が<u>0.4度/W</u>とすると、入熱 = (0.4-0.16*R'^2)*0.4*0.1 [W]
- 点状散乱が1ppmだと開口を広げないべき (8Kからの輻射=0.018*R'^2 [W])
- 点状散乱が3ppm以上ならば広げられるだけ広げるべき
- 15ppm以上だと冷却の許容値を超え、TMの温度が上昇する

RMS



- Type-AのRMS要求値はDC readoutから決まる
  → 1e-14m程度 (要確認)
- Type-BのRMS要求値をOptickleで計算
  → BSが4e-11mずれるとIRが1%落ちる
- 左記のずれが同時に発生するとIRは5.5%低下する
- 要求値は各鏡1e-11m程度

- 上記の議論は制御後のRMS → MIFとVISへ要求の振り分け
- フィルタを想定すればUGFの要求値と橋げた安定度の要求値が決まる
- 低周波のFeedforward functionの要求値も決まる

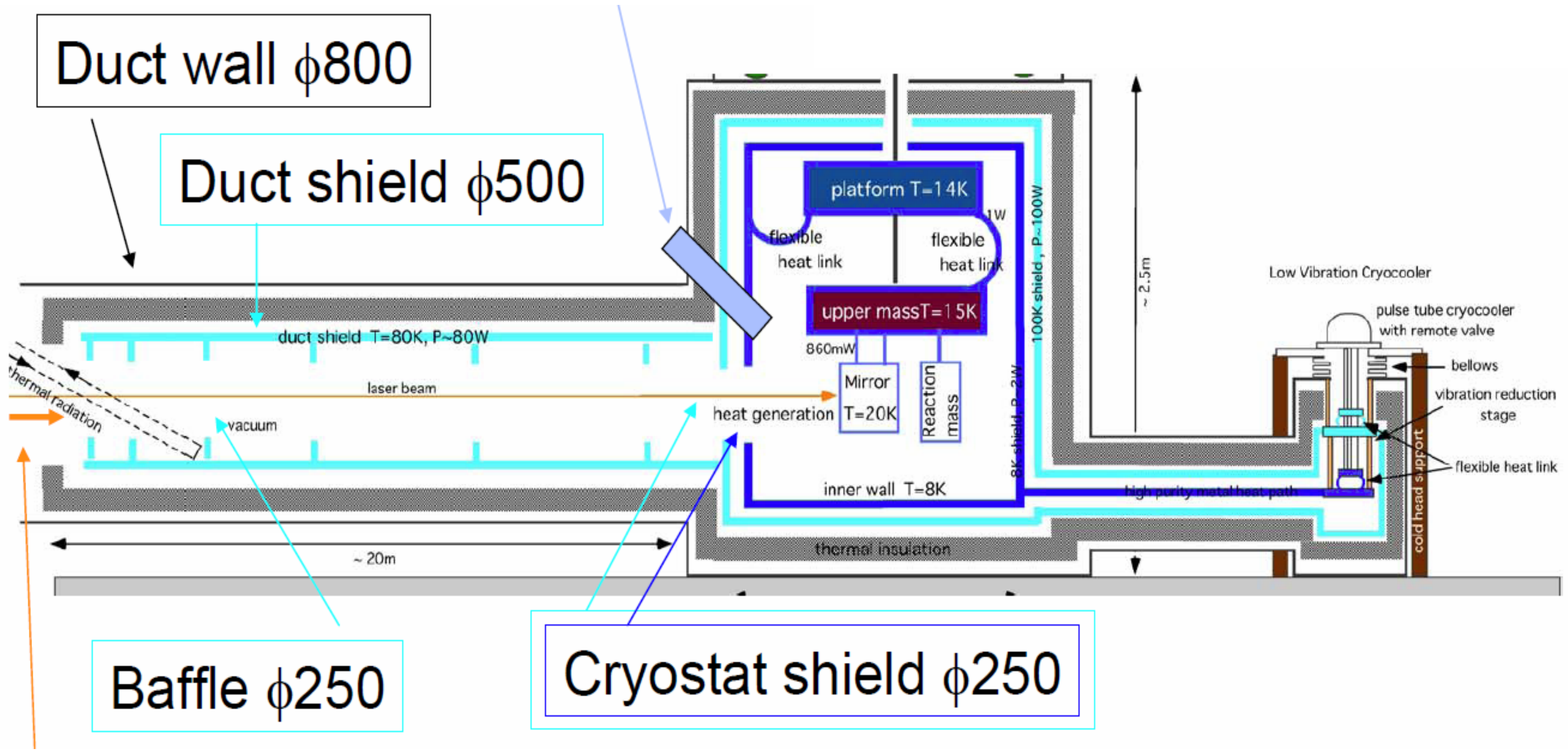
OMC

間に合いませんでした。

インフラ

Facility	tunnel width/height		4m	TU	FA	VA			
Facility	tunnel tilt		1/300	TU	FA	VA			IF
Facility	chamber room size (2nd floor)		8m x 12m	TU	FA	VA			IF
Facility	chamber room size (1st floor)		20m x 12m	TU	FA	VA		CR	IF
Facility	diamter of borehole for SAS		1.2m	TU	FA	VA	VI		
Facility	duct height from floor		1.2m from the floor		FA	VA			IF
Facility	duct diameter		80cm		FA	VA			IF
Facility	room temperature		290K		FA				
Cryostat	radiation shield diameter		50cm			VA		CR	
Cryostat	radiation shield aperture (diameter)		25cm			VA		CR	IF
Cryostat	top hole diameter (to SAS)		15cm			VA	VI	CR	IF
Cryostat	heat from shield aperture		4W			VA		CR	
Cryostat	heat from vacuum duct support		24W			VA		CR	
Cryostat	radiation from upper stages	*	10mW			VA	VI	CR	IF
Cryostat	radiation from BS chamber		60mW x 0.05			VA		CR	IF
Cryostat	radiation from arm cavity		60mW x 0.05			VA		CR	IF
Cryostat	heat from 80K radiation shield	*	TBD			VA		CR	IF
Cryostat	heat from point scattering light	*	TBD			VA		CR	IF
Cryostat	heat from view ports		0.4W x 0.05			VA		CR	IF
Cryostat	heat link thermal conductivity at 10K		4kW/m/K				VI	CR	
Cryostat	number of view ports		11			VA		CR	IF
Cryostat	vibration at cryostat		5e-11m/rtHz(10Hz)	TU	FA	VA	VI	CR	IF
Cryostat	inner shield temeprature		8K			VA	VI	CR	IF
Cryostat	duct shield temperature		80K			VA	VI	CR	IF

インフラ(図)



Position of baffles x [m]	P/P_0	P [mW]
0,20	0.0487	110
0,4,20	0.0359	81.0
0,5,10,15,20	0.0199	44.9
0,3,10,15,20	0.0127	**28.7**

$$P_0 = \epsilon \sigma T^4 A = 2.25\ \mathrm{W}$$

$\epsilon = 0.1$: Emissivity of duct (SUS)

σ: Stefan-Boltzmann constant

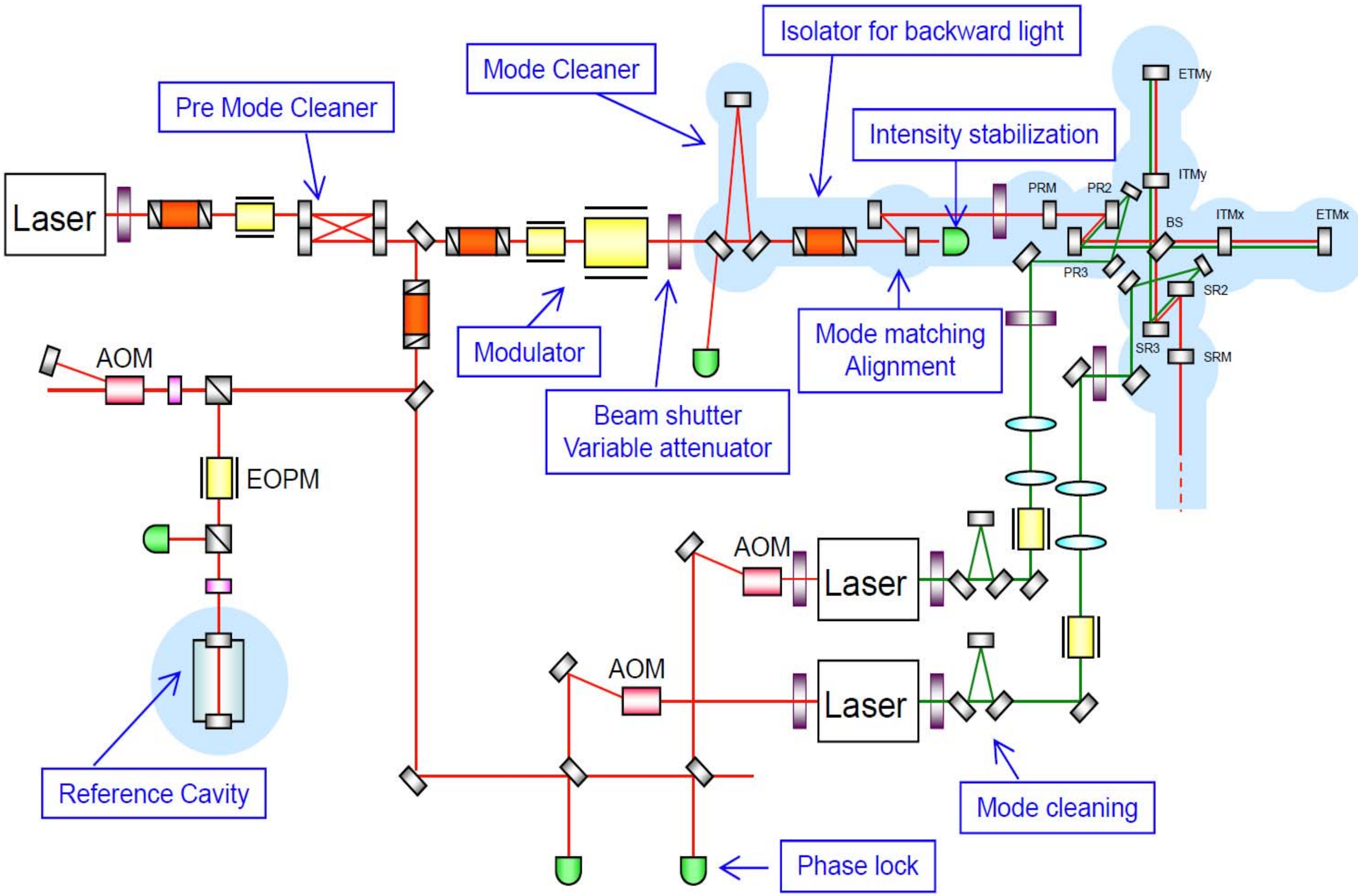
$T = 300$ K

A: Area of opening

光学系1

Laser	laser power		180W				IF		IO	LA
Laser	free-run frequency noise		100Hz/rtHz at 100Hz				IF		IO	LA
Laser	free-run intensity noise		1e-4 W/W/rtHz				IF		IO	LA
PMC	cavity length	*	48.8cm						IO	
PMC	finesse	*	155						IO	
IOO	AF RIN (requirement)		TBD				IF		IO	LA
IOO	RF RIN (requirement; f>15MHz)		1e-9W/W/rtHz				IF		IO	LA
IOO	FSS gain at 100Hz		300dB				IF	EL	IO	LA
IOO	FSS gain at 1kHz		180dB				IF	EL	IO	
IOO	pick-off power for FSS		100mW					EL	IO	
IOO	COF between EOM and PZT		TBD				IF	EL	IO	LA
IOO	COF between PZT and MC length		TBD				IF		IO	LA
IOO	COF between MC length and thermal		TBD				IF		IO	LA
IOO	RF oscillator phase noise		-160dBc				IF		IO	
IOO	power attenuation range		100%-0.1%				IF		IO	
IOO	extinction ratio of Faraday Isolator		40dB				IF		IO	
MC2	MC-in and MC-out RoC	*	>500km			MI	IF		IO	
MC2	MC-end RoC		40m			MI	IF		IO	
MC2	MC mirror dimension		f100mm, t30mm			MI	IF		IO	
MC2	distance of MC-in and MC-out		0.5m				IF		IO	
MC2	beam radius on MC-end		4.377m				IF		IO	
MC2	beam radius on MC-in and MC-out		2.527m				IF		IO	
MC2	MC-end reflectivity		99.99%			MI	IF		IO	
MC2	MC-in and MC-out reflectivity		99.37%			MI	IF		IO	
MC2	MC finesse		500	VA		MI	IF		IO	
MC2	output polarization		S-polarization			MI	IF		IO	
MMT	MMT mirror dimension		f100mm, t30mm			MI			IO	
MMT	MMT1 RoC		20.6m			MI			IO	
MMT	MMT2 RoC		26.1m			MI			IO	
PRM (SRM)	PM1 radius		12.5cm		VI	MI				
PRM (SRM)	PM1 thickness		10cm		VI	MI				
PRM (SRM)	PM2 radius		12.5cm		VI	MI				
PRM (SRM)	PM2 thickness		10cm		VI	MI				
PRM (SRM)	PM3 radius		12.5cm		VI	MI				
PRM (SRM)	PM3 thickness		10cm		VI	MI				
PRM (SRM)	PRM/SRM reflectivity		90%/85%			MI	IF			
PRM (SRM)	PRM optical loss		100ppm			MI	IF			

光学系(図)



Isolator for backward light
Mode Cleaner
Pre Mode Cleaner
Intensity stabilization
ETMy
ITMy
PRM
PR2
BS
ITMx
ETMx
PR3
SR2
SR3
SRM
Laser
AOM
Modulator
Mode matching
Alignment
Beam shutter
Variable attenuator
EOPM
AOM
Laser
AOM
Laser
Reference Cavity
Mode cleaning
Phase lock

光学系2

前回やったのはこの辺くらいまで →

PRM (SRM)	RoC of PRM		370m			MI		IF	IO
PRM (SRM)	RoC of PR2		4.17m			MI		IF	IO
PRM (SRM)	RoC of PR3		32.34m			MI		IF	IO
PRM (SRM)	RoC error of PRM		1%			MI		IF	IO
PRM (SRM)	RoC error of PR2		1%			MI		IF	IO
PRM (SRM)	RoC error of PR3		1%			MI		IF	IO
PRM (SRM)	wedge angle of PRM (horizontal)	*	0.3deg	VA		MI		IF	IO
BS	BS radius		19cm			MI		IF	
BS	BS thickness		12cm			MI		IF	
BS	BS HR surface optical loss		50ppm			MI		IF	
BS	BS AR surface reflectivity		50ppm			MI		IF	
BS	RoC of BS		>500km			MI		IF	
BS	BS absorption	*	1.5ppm/cm			MI		IF	
BS	AR wedge of BS		0.383deg	VA		MI		IF	
BS	AR wedge error of BS		2.5%	VA		MI		IF	
BS	SAS motion range for compensation		+/-1cm	VA		MI		IF	
TM	dimension		f250 x t150		VI	MI	CR		
TM	temperature		20K		VI	MI	CR		
TM	Outer Diameter		25cm		VI	MI	CR		
TM	Outer Diameter Flat to Flat	*	24.6cm		VI	MI	CR		
TM	local actuator of TM		ESD		VI	MI	CR		
TM	RRR of material		TBD		VI	MI	CR		
TM	central region surface rms		0.3nm (d<12cm)		VI	MI	CR	IF	
TM	outer region surface rms	*	1nm (d>12cm)		VI	MI	CR	IF	
TM	beam radius on ETM		4.53cm			MI		IF	IO
TM	beam radius on ITM		3.43cm			MI		IF	IO
TM	mirror mechanical loss of ETM		1e-8			MI	CR		
TM	mirror mechanical loss of ITM		1e-8			MI	CR		
TM	silica coating loss		3e-4			MI	CR		
TM	tantala coating loss		5e-4			MI	CR		
TM	number of layers on ETM		18			MI	CR		
TM	number of layers on ITM		9			MI	CR		
TM	coating absorption		0.5ppm			MI	CR		
TM	AR surface absorption		1ppm			MI	CR		
TM	ETM reflectivity		0.999945			MI		IF	
TM	ITM reflectivity		0.996			MI		IF	
TM	ETM optical loss		45ppm			MI		IF	

光学系3

TM	ITM optical loss		45ppm			MI		IF			
TM	optical loss imbalance		+/-15ppm			MI		IF			
TM	finesse imbalance		0.5%			MI		IF			
TM	ITM substrate optical loss		20ppm/cm			MI	CR	IF			
TM	ITM AR surface optical loss	*	1000ppm			MI		IF			
TM	ETM mass		30kg			MI		IF			
TM	ITM mass		30kg			MI		IF			
TM	RoC error of ETM	*	1%			MI		IF			
TM	RoC error of ITM	*	1%			MI		IF			
TM	RoC of ETM		7km			MI		IF			
TM	RoC of ITM		>500km			MI		IF			
TM	RoC imbalance in two arms	*	0.5%			MI		IF			
TM	wedge angle of ETM	*	0.3deg	VA		MI		IF			
TM	wedge angle of ITM	*	0.3deg	VA		MI		IF			
TM	wedge angle error of TMs		TBD	VA		MI		IF			
OMC	OMC optical loss	*	1%			MI		IF		IO	
OMC	OMC length	*	38cm	VA				IF		IO	
OMC	OMC finesse	*	1000 (too high for 1% loss)					IF		IO	
OMC	RF reduction ratio		110dB					IF		IO	
MIF	(laser power in PRC)		825W					IF		IO	LA
MIF	(total optical loss in SRC)		2%			MI		IF		IO	
MIF	quantum efficiency (DC PD)		90%					IF	EL	IO	
MIF	differential offset on arm cavities		+/- 2e-12m					IF		IO	
MIF	detune phase		3.55deg					IF			
MIF	folding angle		0.6293deg	VA				IF			
MIF	f1 PM/AM sideband frequencies		16.875MHz					IF		IO	
MIF	f1 modulation depths (PM)	*	0.2 at IFO					IF		IO	
MIF	f2 PM sideband frequencies		45MHz					IF		IO	
MIF	f2 modulation depths	*	0.2 at IFO					IF		IO	
MIF	f3 AM sideband freq (if any)		39.375MHz					IF	EL	IO	
MIF	f3 modulation depths (if any)		TBD					IF		IO	
MIF	MZ configuration		single, if any					IF		IO	
MIF	Beam centering error on TM	*	0.1mm		VI			IF			
MIF	CARM UGF		10kHz		VI			IF	EL		
MIF	DARM UGF		200Hz		VI			IF	EL		
MIF	PRCL UGF		20Hz		VI			IF	EL		
MIF	MICH UGF		20Hz		VI			IF	EL		

光学系4

MIF	SRCL UGF	20Hz		VI		IF	EL		
MIF	PRCL/MICH/SRCL FF gain	100				IF			
MIF	Green Laser finesse in arms	19 (ITM80%-ETM90%)			MI	IF			
MIF	Green Laser power	100mW				IF		IO	LA
MIF	Green laser's frequency gap (X and Y)	100MHz				IF		IO	LA
MIF	Green laser Injection Point	PR3 and SR3	VA			IF		IO	
MIF	BS reflectivity for green	<1%			MI	IF			
MIF	PR2, SR2 reflectivity for green	<1%			MI	IF			
MIF	PR3, SR3 reflectivity for green	**>99%**			MI	IF			
MIF	rms fluctuation of DARM	1e-14m		VI		IF		IO	

懸架系

4th GAS	T dependence of spring constant		TBD				**VI**		CR	IF	
HL (Sh-PF)	radius of U		25cm				VI		**CR**		
HL (Sh-PF)	diameter		1mm				VI		**CR**		
HL (PF-IM)	radius of U		20cm				VI		**CR**		
HL (PF-IM)	diameter		3mm				VI		**CR**		
HL (PF-IM)	loss		5e-5				VI		**CR**		
IM	temperature of IM		15K				**VI**		CR		
IM	emmisivity of surface of IM	*	0.02				**VI**		CR		
IM fiber	loss		1e-4				**VI**		CR		
IM fiber	length		0.4m				**VI**		CR		
IM fiber	diameter		0.72mm				**VI**		CR		
IM fiber	temperature		15K				**VI**		CR		
RM	mass of RMTM		30kg				**VI**		CR		
RM	material of RMTM		Cu				**VI**		CR		
RM	outer diameter		29cm				**VI**		CR		
RM	inner diameter		26cm				**VI**		CR		
RM	thickness		26cm				**VI**		CR		
RM	temperature of RMTM	*	20K				**VI**		CR		
RM fiber	length		30cm				**VI**		CR		
RM fiber	diameter		0.4mm				**VI**		CR		
RM fiber	loss		5e-6				**VI**		CR		
TM fiber	length		30cm				**VI**		CR		
TM fiber	diameter		1.6mm				VI		**CR**		
TM fiber	effective temperature	*	16				VI		**CR**		
TM fiber	loss		2e-7				VI		**CR**		
SAS	Vertical horizontal coupling		1/200	TU	FA	VA	**VI**	MI		IF	GE

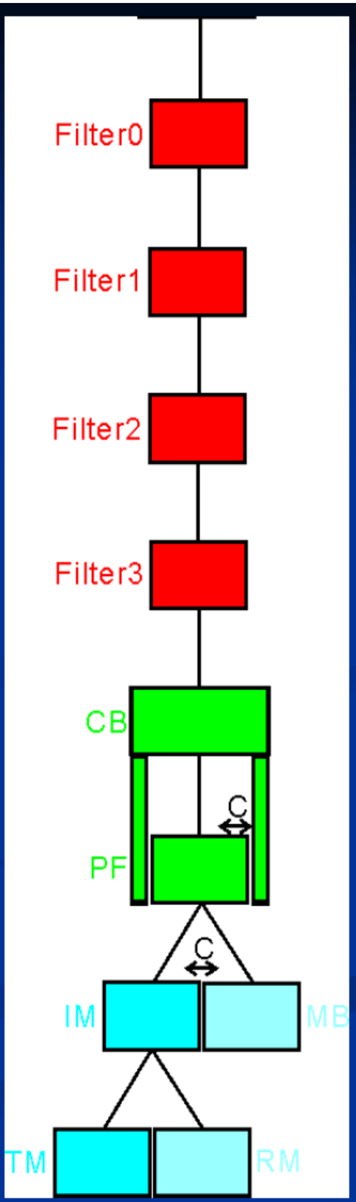
懸架系(図)

Modeling for displacement

Type-A

- Equation of motion of 10 material points model
- 10x10 stiffness matrix
- 2-layer structure
- Calculated by MATLAB

	m [kg]	Q	f0 [Hz]	C [kg·Hz]
Filter0	120	5	0.03	-
Filter1	90	5	0.34	-
Filter2	90	10	0.34	-
Filter3	90	10	0.34	-
CB	60	10	0.35	376
PF	60	100	0.5	376
IM	60	1000	0.7	530
MB	60	1000	0.7	530
TM	30	1000	0.8	-
RM	30	6	0.8	-



電気系少々

Electronics	PD aperture	*	3mm	IF	EL
Electronics	RF PD input power (high power)	*	300mW	IF	EL
Electronics	RF PD input power (low power)	*	100mW	IF	EL
Electronics	DC PD input power (high power)	*	100mW	IF	EL
Electronics	DC PD input power (low power)	*	10mW	IF	EL

- PD入力パワーはループ雑音の計算に関わってくる

以上です