2011年7月29日

LCGT ASC現状報告
(g-factorを変えた場合のIR)

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これまでの現状報告ファイル

- http://gwwiki.icrr.u-tokyo.ac.jp/JGWwiki/LCGT/subgroup/ifo/ISC/Meetings?action=AttachFile&do=view&target=LCGT_ASC_status20110517_michimura.pdf
  ASC計算の方法、構造などについて記述あり
  iLCGTの計算あり(pitchのみ)
- http://gwwiki.icrr.u-tokyo.ac.jp/JGWwiki/LCGT/subgroup/ifo/ISC/Meetings?action=AttachFile&do=view&target=LCGT_ASC_status20110705_michimura.pdf
  negative/positive g-factorでのbLCGTの計算(pitchのみ)
- http://gwwiki.icrr.u-tokyo.ac.jp/JGWwiki/LCGT/subgroup/ifo/ISC/Meetings?action=AttachFile&do=view&target=LCGT_ASC_yaw_michimura.pdf
  negative/positive g-factorでのbLCGTのyawの計算
  (WFS制御しない場合のみ)

今回やったこと

- bLCGTに関して、positive/negative g-factorのASC計算をpitchとyaw共に行い、トータルの残留角度揺れがIRをどの程度変化させるか見積もった
- サスペンションデザインが若干変わった(recycling mirrorのリコイルマスと鏡の重心を一致させるデザインになった、etc)
- eddy current damping込みのサスペンション伝達関数を使用
  dampingはSASの一番上部分(Filter1)のみ
  関口くんによる計算(7/26時点のもの)

結果まとめ

- 角度揺れを考えないとIR = 275 Mpc(VDRSE)だったのが

  positive g-factor(ITM:flat, ETM:7km)の場合
  IR = 262 Mpc に

  negative g-factor(ITM:1.5km, ETM:1.9km)の場合
  IR = 268 Mpc に
- IR低下の原因はpitchの20Hzあたりの共振ピーク
  サスペンションのデザインが、WFSの散射雑音でリミットされるレベルに達していない
- negative g-factorの方が低下が少ないのはビームスポットの動きがnegativeの方が小さいため

- IR低下を回避するには
  サスペンションデザインの改良
  (20Hz付近のpitch共振をどうにかする)
  有効なローカルダンピング
  (RMSに寄与する0.2Hz付近のピークを抑える)

注意点

- Type-Aで、リコイルマスから加えたトルクからテストマス角度のpitchの伝達関数がおかしい
  バグ？　関口くんが調査中
  (IRがこれで大きく変わるような話ではない)

- WFSのノイズは散射雑音(50mW入射)しかなく、ASに汚い光が全く出てこないという非常に楽観的な見積もり
- フィルタの形も雑な大雑把(詳細に設計する段階ではない)
- リコイルマスからの制御しかまだ考えていない
- サスペンション伝達関数はとりあえずのもの。サスペンションデザインは変わる(変えなければならない)

輻射圧不安定性まとめ

- Pin=379 kW
- positive g-factorの場合
  pitch: fmech=2.00 Hz　fSOFT=0.97i Hz　fHARD=2.15 Hz
  yaw : fmech=0.05 Hz　fSOFT=2.18i Hz　fHARD=0.79 Hz
- negative g-factorの場合
  pitch: fmech=2.00 Hz　fSOFT=1.82 Hz　fHARD=2.85 Hz
  yaw : fmech=0.05 Hz　fSOFT=0.80i Hz　fHARD=2.00 Hz

fmechは単振り子でフィッティングした場合の機械的な共振周波数
iは不安定なことを表し、絶対値が大きいほど不安定性が大きい

- ちなみに、テストマスの直径22cm(23kg)にすると
- positive g-factorの場合
  pitch: fmech=2.50 Hz　fSOFT=1.20i Hz　fHARD=2.69 Hz
  yaw : fmech=0.07 Hz　fSOFT=2.70i Hz　fHARD=0.98 Hz
- negative g-factorの場合
  pitch: fmech=2.50 Hz　fSOFT=2.28 Hz　fHARD=3.56 Hz
  yaw : fmech=0.07 Hz　fSOFT=1.00i Hz　fHARD=2.47 Hz

制御的にはあまり変わらなそう

目次

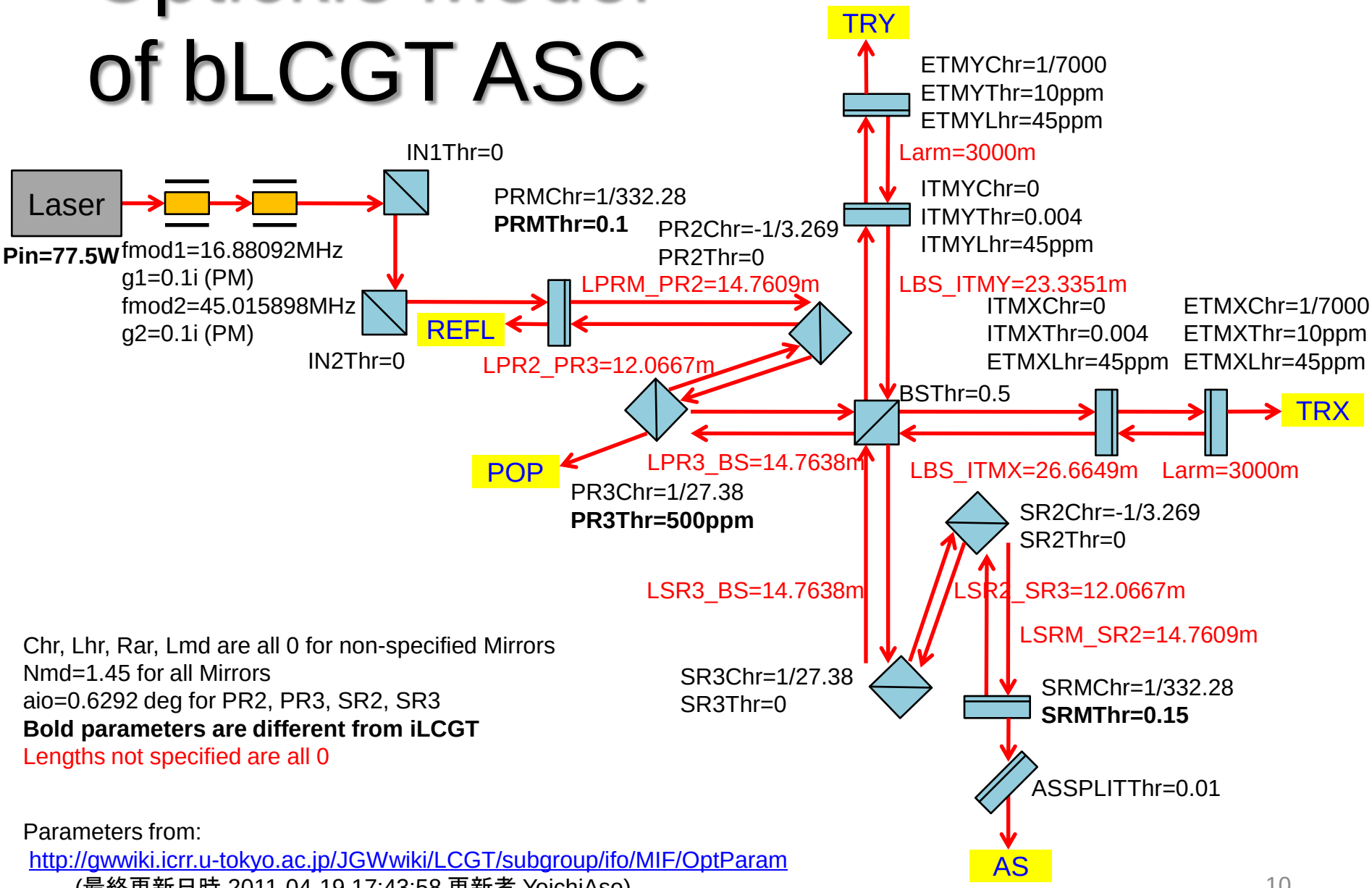
- bLCGT ASC (positive g-factorの場合)
  - ASCの方針、sensing matrix
  - pitch
  - yaw
- bLCGT ASC (negative g-factorの場合)
  - sensing matrix
  - pitch
  - yaw
- positive/negativeそれぞれの場合のIR

bLCGT ASC
(positive g-factorの場合)

bLCGT WFS計算の方針

- 制御したい鏡
  ETMX, ETMY, ITMX, ITMY, BS, PR3, PR2, PRM, SR3, SR2, SRM
- 制御自由度
  CS, CH, DS, DH, BS, PR3, PR2, PRM, SR3, SR2, SRM
  (他の選び方もあり得る)
- SR2はWFSでは全く制御しない
- WFSのショットノイズを導入しないように、極力UGFを下げる
- 特にテストマスはほぼDC的なドリフト制御しかしない
  (輻射圧で不安定な場合はUGFを上げざるを得ない)
- 全てリコイルマスから制御

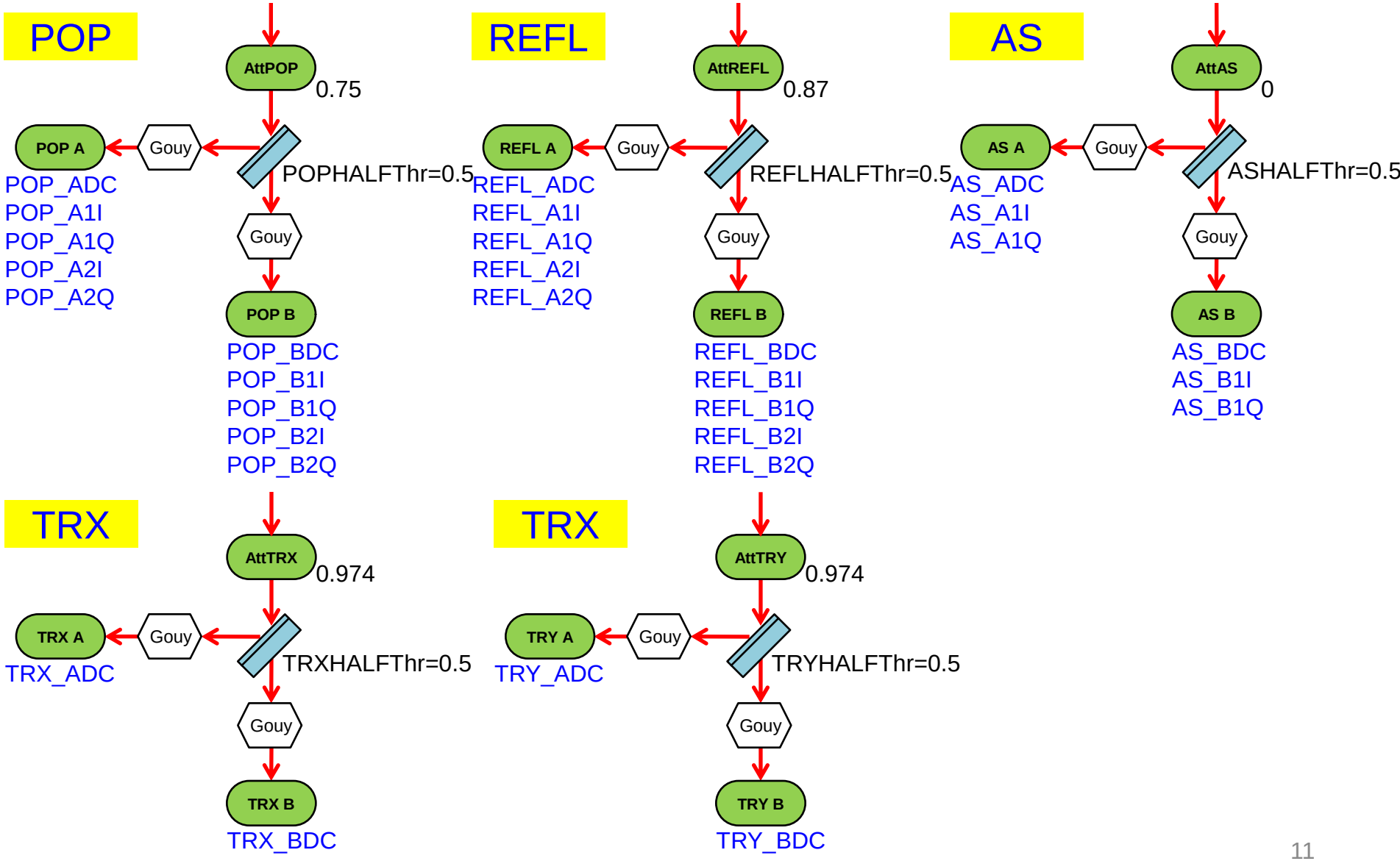
Optickle Model of bLCGT ASC



Chr, Lhr, Rar, Lmd are all 0 for non-specified Mirrors
Nmd=1.45 for all Mirrors
aio=0.6292 deg for PR2, PR3, SR2, SR3
Bold parameters are different from iLCGT
Lengths not specified are all 0

Parameters from:
http://gwwiki.icrr.u-tokyo.ac.jp/JGWwiki/LCGT/subgroup/ifo/MIF/OptParam
(最終更新日時 2011-04-19 17:43:58 更新者 YoichiAso)
http://gwwiki.icrr.u-tokyo.ac.jp/JGWwiki/LCGT/subgroup/OCG/parametermeeting?action=AttachFile&do=view&target=interface_parameter_%28selected%29.pdf

Sensing Ports



各所でのDC光量

- Laser: 77.5 W
- from PR3 to BS: 799 W
- intra-cavity: 379 kW
- 各ポート
  POP: 50.9 mW
  REFL: 51.1 mW
  AS: 0.018 mW
  TRX/Y: 49.3 mW

キャリアのみのDC光量

各ポートに関しては、
サイドバンドも含めた全DC光量
ASはサイドバンドしか出ないことになってる(DC readoutに対応していないし、腕の非対称性を導入していない)

AS以外、大体50mWになるように調整

ポートの選択と位相の最適化

min XXはXXの信号を最初にするようにGouy phaseを決めるということ
何も条件が書いていないのは他でGouyを決められてしまったもの(Gouyをどう頑張っても分離できないもの)

POP DC

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	-19.4	-22.0	-24.7	-81.4	-44.3	-46.9	88.1	87.0	64.5	64.5	64.5
max ampl	-42003.1	-7661.3	-8.2	-0.5	-507.3	-1310.5	-3375.0	-1680.9	1.3	0.2	0.1
Gouy	-2	-2	NaN	NaN	71	71	70	70	NaN	NaN	NaN
ampl	-28338.6	-5091.0	NaN	NaN	153.3	433.5	-2268.6	-1136.5	NaN	NaN	NaN
contami	1.2	6.8	NaN	NaN	29.4	10.4	2.0	3.9	NaN	NaN	NaN
N big sig	1	2	NaN	NaN	6	3	1	2	NaN	NaN	NaN

POP_ADC (min CS)

REFL DC

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	-3.5	3.8	-0.8	-16.8	2.1	3.9	4.0	36.0	83.8	83.8	83.8
max ampl	-66522.5	-57318.2	-57.7	43.8	-28726.4	-81234.2	-9402.2	-3818.7	-2485.2	-297.9	-156.4
Gouy	-86	86	NaN	NaN	-6	86	86	-87	-86	-86	-86
ampl	-6172.3	-5533.9	NaN	NaN	-20108.3	-7887.1	-923.3	1472.1	1729.5	207.3	108.9
contami	1.7	3.7	NaN	NaN	8.6	2.6	22.4	7.3	6.1	50.9	96.9
N big sig	1	2	NaN	NaN	4	1	6	3	2	5	6

POP f1 demodulation

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	17.1	-32.9	51.8	51.8	39.3	-28.6	-27.3	19.6	-25.5	-25.5	-25.5
max demod	0.1	0.1	-89.9	-89.9	-71.0	-0.1	-0.1	0.5	-0.0	-0.0	-0.0
max ampl	118.7	-119.7	53.4	-65.5	48.4	-70.7	-8.2	-8.3	-164.2	-19.7	-10.3
Gouy	64	-73	-81	-81	-82	-73	-73	-38	-73	-73	-73
demod	0	-2	-89	-89	-89	-2	-2	-90	-2	-2	-2
ampl	81.1	-91.5	-36.3	44.5	-32.3	-50.5	-5.7	0.1	-110.7	-13.3	-7.0
contami	1.3	3.3	3.1	2.5	3.6	6.0	52.9	13.1	2.7	22.7	43.2
N big sig	1	2	2	1	3	3	7	6	1	5	6

POP_B1Q　　POP_B1I (min CS)

REFL f1 demodulation

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	89.9	85.9	71.8	71.1	-13.8	-22.3	-57.0	19.2	-6.2	-6.2	-6.2
max demod	0.0	0.0	77.6	-88.3	0.6	0.0	0.0	0.0	-0.1	-0.1	-0.1
max ampl	161213.2	26218.0	-128.0	-153.4	-909.2	-3111.6	-620.1	6313.7	-384.4	-46.1	-24.2
Gouy	-71	0	0	0	0	0	0	0	0	NaN	NaN
demod	1	-3	-90	-90	-90	-3	-3	-3	-4	NaN	NaN
ampl	152357.5	-1858.0	40.5	-49.7	35.9	-2876.0	-337.4	5954.7	-381.3	NaN	NaN
contami	1.2	6.7	3.3	2.7	3.7	4.4	37.1	2.1	32.8	NaN	NaN
N big sig	1	3	2	1	3	2	6	1	5	NaN	NaN

REFL_B1I (min CS)

POP f2 demodulation

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	72.6	76.6	81.8	79.5	75.5	75.5	75.5	75.4	81.5	81.5	81.5
max demod	0.1	0.1	-26.9	-23.0	0.0	0.1	0.1	0.1	-90.0	-90.0	-90.0
max ampl	-5076.6	2282.9	2.8	-4.0	1947.9	5511.2	660.5	335.8	0.0	0.0	0.0
Gouy	-17	-20	70	70	68	-20	-20	-14	NaN	NaN	NaN
demod	-70	-70	90	90	90	-70	-70	75	NaN	NaN	NaN
ampl	-90.6	-55.7	-1.3	1.6	-2.6	-98.2	-11.6	-4.2	NaN	NaN	NaN
contami	1.2	3.7	6.7	5.6	4.9	2.1	17.8	36.2	NaN	NaN	NaN
N big sig	1	2	4	2	2	1	4	5	NaN	NaN	NaN

REFL f2 demodulation

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	-89.9	84.0	76.4	-86.7	-74.9	-75.4	-78.1	26.3	-79.3	-79.3	-79.3
max demod	0.1	0.2	8.5	-16.5	0.0	0.0	0.0	-0.0	89.8	89.8	89.8
max ampl	163972.4	19501.2	-21.6	13.3	-4926.0	-14407.0	-2073.0	6213.0	0.0	0.0	0.0
Gouy	-78	40	NaN	-79	40	40	40	-1	NaN	NaN	NaN
demod	90	-90	NaN	-90	-90	-90	-90	-87	NaN	NaN	NaN
ampl	265.0	105.4	NaN	3.7	67.6	185.4	21.8	291.7	NaN	NaN	NaN
contami	1.2	3.7	NaN	87.6	5.7	2.1	17.8	1.2	NaN	NaN	NaN
N big sig	1	2	NaN	3	3	1	4	1	NaN	NaN	NaN

REFL_A2I (max CS)

AS DC

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	-16.9	-16.9	-87.3	-30.2	-6.2	-24.9	-26.6	83.7	-13.3	-12.9	23.8
max ampl	-7.5	9.2	-0.2	0.3	-2.7	5.7	0.6	0.9	12.7	1.6	1.1
Gouy	-66	-66	74	77	73	77	77	73	64	65	73
ampl	-3.5	4.3	0.1	-0.1	-0.4	-0.8	-0.1	0.6	2.0	0.2	0.5
contami	5.5	4.5	22.3	53.4	8.4	3.9	31.1	4.9	3.1	24.5	5.9
N big sig	3	2	6	9	5	1	8	1	1	7	4

AS_BDC (min CS/CH)

TRX DC

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	-25.6	74.8	-25.6	74.8	-10.4	0.5	0.4	-0.6	-36.3	-36.3	-36.3
max ampl	-43183.8	15641.0	-43183.3	15640.8	0.0	-43.4	-5.2	-2.6	0.0	0.0	0.0
Gouy	-15	64	-15	64	NaN	NaN	NaN	NaN	NaN	NaN	NaN
ampl	-30013.6	10865.5	-30013.4	10865.4	NaN	NaN	NaN	NaN	NaN	NaN	NaN
contami	2.0	2.0	2.0	2.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
N big sig	1	1	2	2	NaN	NaN	NaN	NaN	NaN	NaN	NaN

TRX_ADC (min CS/DS)

AS f1 demodulation

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	84.8	81.4	89.5	86.2	-13.4	89.6	89.5	88.6	76.8	77.1	-67.5
max demod	-90.0	-90.0	-90.0	-90.0	-90.0	-90.0	-90.0	-90.0	-90.0	-90.0	89.3
max ampl	-0.3	-0.0	-1511.0	-245.9	9.2	0.5	0.1	0.0	-0.0	-0.0	-0.0
Gouy	NaN	NaN	-4	0	-1	NaN	NaN	NaN	NaN	NaN	NaN
demod	NaN	NaN	0	0	0	NaN	NaN	NaN	NaN	NaN	NaN
ampl	NaN	NaN	0.0	-0.0	0.0	NaN	NaN	NaN	NaN	NaN	NaN
contami	NaN	NaN	1.1	2.3	3.9	NaN	NaN	NaN	NaN	NaN	NaN
N big sig	NaN	NaN	1	1	3	NaN	NaN	NaN	NaN	NaN	NaN

AS_A1Q (max DS)

TRY DC

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	-25.6	74.8	-25.6	74.8	0.5	0.5	0.4	-0.6	-23.9	-23.9	-23.9
max ampl	-43183.8	15641.0	43183.4	-15640.8	-30.6	-43.4	-5.2	-2.6	-0.0	-0.0	-0.0
Gouy	-15	64	-15	64	NaN	NaN	NaN	NaN	NaN	NaN	NaN
ampl	30013.7	10865.5	30013.5	-10865.4	NaN	NaN	NaN	NaN	NaN	NaN	NaN
contami	2.0	2.0	2.0	2.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
N big sig	1	1	2	2	NaN	NaN	NaN	NaN	NaN	NaN	NaN

TRY_ADC (min CS/DS)

全Sensing Matrix

WFS Sensing Matrix [W/mrad/sqrt(2/pi)]

(Gouy phases at POP A:70.6, POP B:-72.9 REFL A:-89.9, REFL B:-0.1, AS A:89.5, AS B:73.1, TR A:64.4 deg)

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
POP_ADC	0.03	0.24	0.00	0.00	0.15	0.43	-2.28	-1.14	0.00	0.00	0.00
POP_BDC	-17.67	-3.42	-0.00	-0.00	-0.31	-0.83	2.26	1.12	-0.00	-0.00	-0.00
POP_A1I	0.07	0.03	-0.00	0.00	-0.00	0.01	0.00	-0.01	0.02	0.00	0.00
POP_A1Q	0.00	0.00	-0.05	0.06	-0.04	0.00	0.00	0.00	0.00	0.00	0.00
POP_B1I	-0.00	-0.09	0.00	-0.00	0.02	-0.05	-0.01	0.00	-0.11	-0.01	-0.01
POP_B1Q	-0.00	-0.00	0.03	-0.04	0.03	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
POP_A2I	-5.07	2.27	0.00	-0.00	1.94	5.49	0.66	0.33	-0.00	-0.00	-0.00
POP_A2Q	-0.00	-0.00	-0.00	0.00	-0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00
POP_B2I	4.18	-1.97	-0.00	0.00	-1.66	-4.69	-0.56	-0.29	-0.00	-0.00	-0.00
POP_B2Q	0.05	-0.02	0.00	-0.00	-0.02	-0.05	-0.01	-0.00	0.00	0.00	0.00
REFL_ADC	-2.99	2.65	-0.00	0.01	0.72	3.80	0.45	1.58	1.75	0.21	0.11
REFL_BDC	-46.95	-40.43	-0.04	0.03	-20.30	-57.30	-6.63	-2.18	-0.19	-0.02	-0.01
REFL_A1I	161.21	26.15	0.03	0.00	-0.22	-1.18	-0.52	-2.06	-0.04	-0.01	-0.00
REFL_A1Q	0.08	0.01	0.12	-0.14	0.10	-0.00	-0.00	-0.00	-0.01	-0.00	-0.00
REFL_B1I	0.27	-1.81	-0.00	-0.00	-0.88	-2.88	-0.34	5.96	-0.38	-0.05	-0.02
REFL_B1Q	-0.00	0.00	-0.04	0.05	-0.04	-0.00	-0.00	0.00	0.00	0.00	0.00
REFL_A2I	163.97	19.39	0.02	0.01	-4.76	-13.95	-2.03	-2.74	0.00	0.00	0.00
REFL_A2Q	0.23	0.06	0.00	-0.00	0.02	0.04	0.00	-0.00	0.00	0.00	0.00
REFL_B2I	0.42	-2.01	-0.01	0.00	-1.30	-3.66	-0.43	5.57	-0.00	-0.00	-0.00
REFL_B2Q	0.19	-0.09	-0.00	0.00	-0.07	-0.21	-0.02	-0.00	0.00	0.00	0.00
AS_ADC	0.00	-0.00	0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00
AS_BDC	-0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00
AS_A1I	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
AS_A1Q	0.00	0.00	1.51	0.25	0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00
AS_B1I	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00
AS_B1Q	0.00	0.00	1.45	0.24	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00
TRX_ADC	0.03	10.88	0.03	10.88	0.00	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00
TRX_BDC	30.54	1.99	30.54	1.99	-0.00	0.03	0.00	0.00	-0.00	-0.00	-0.00
TRY_ADC	0.03	10.88	-0.03	-10.88	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00
TRY_BDC	30.54	1.99	30.54	-1.99	0.02	0.03	0.00	0.00	0.00	0.00	0.00

SR2はWFSでは制御しない

選択後のSensing Matrix

WFS Sensing Matrix [W/mrad/sqrt(2/pi)]

(Gouy phases at POP A:70.6, POP B:-72.9 REFL A:-89.9, REFL B:-0.1, AS A:89.5, AS B:73.1, TR A:64.4 deg)

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
REFL_A2I	-163.97	19.39	0.02	0.01	-4.76	-13.95	-2.03	-2.74	0.00	0.00	0.00
TRX_ADC	0.03	10.88	0.03	10.88	0.00	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00
AS_A1Q	0.00	0.00	1.51	0.25	0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00
TRY_ADC	0.03	10.88	-0.03	-10.88	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00
POP_B1Q	-0.00	-0.00	0.03	-0.04	0.03	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
REFL_BDC	-46.95	-40.43	-0.04	0.03	-20.30	-57.30	-6.63	-2.18	-0.19	-0.02	-0.01
POP_ADC	0.03	0.24	0.00	0.00	0.15	0.43	-2.28	-1.14	0.00	0.00	0.00
REFL_B1I	0.27	-1.81	-0.00	-0.00	-0.88	-2.88	-0.34	5.96	-0.38	-0.05	-0.02
POP_B1I	-0.00	-0.09	0.00	-0.00	0.02	-0.05	-0.01	0.00	-0.11	-0.01	-0.01
AS_BDC	-0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00

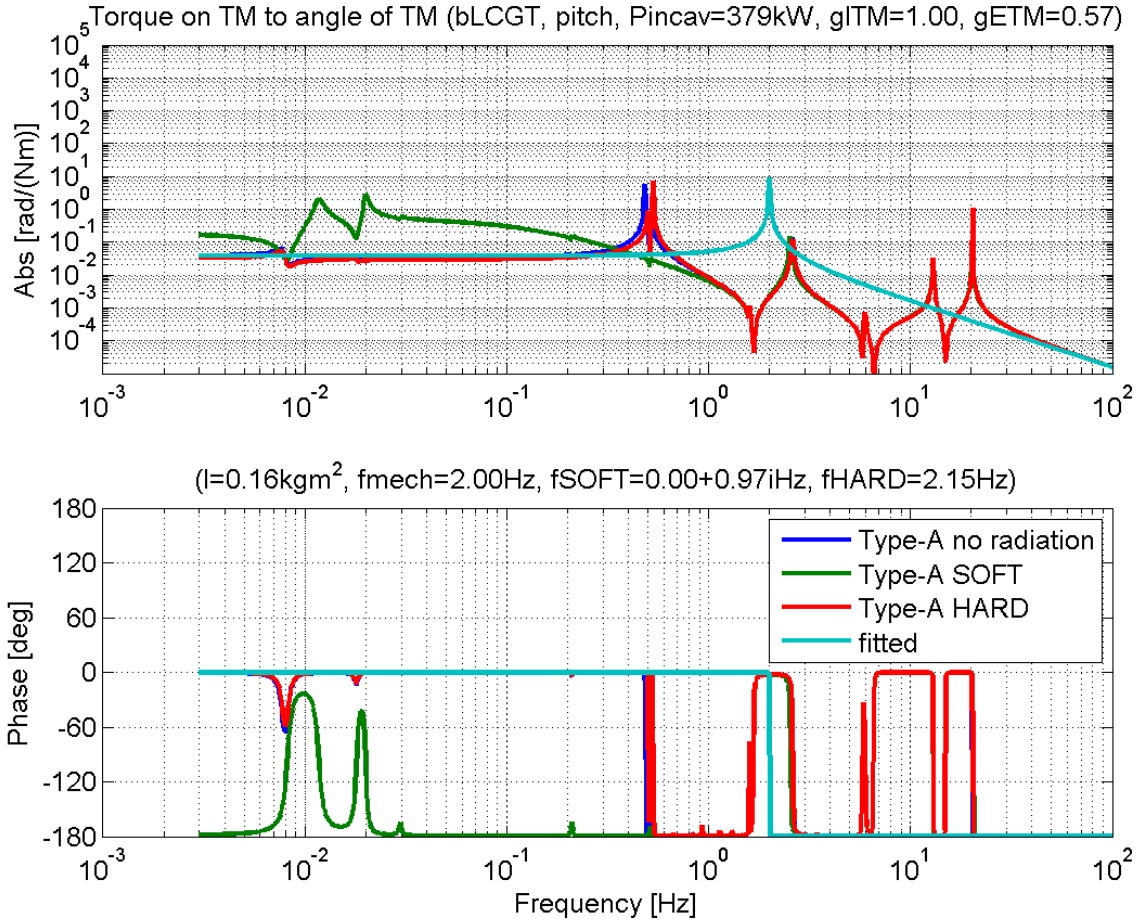
SR2はWFSでは制御しない

bLCGT ASC for pitch
(positive g-factorの場合)

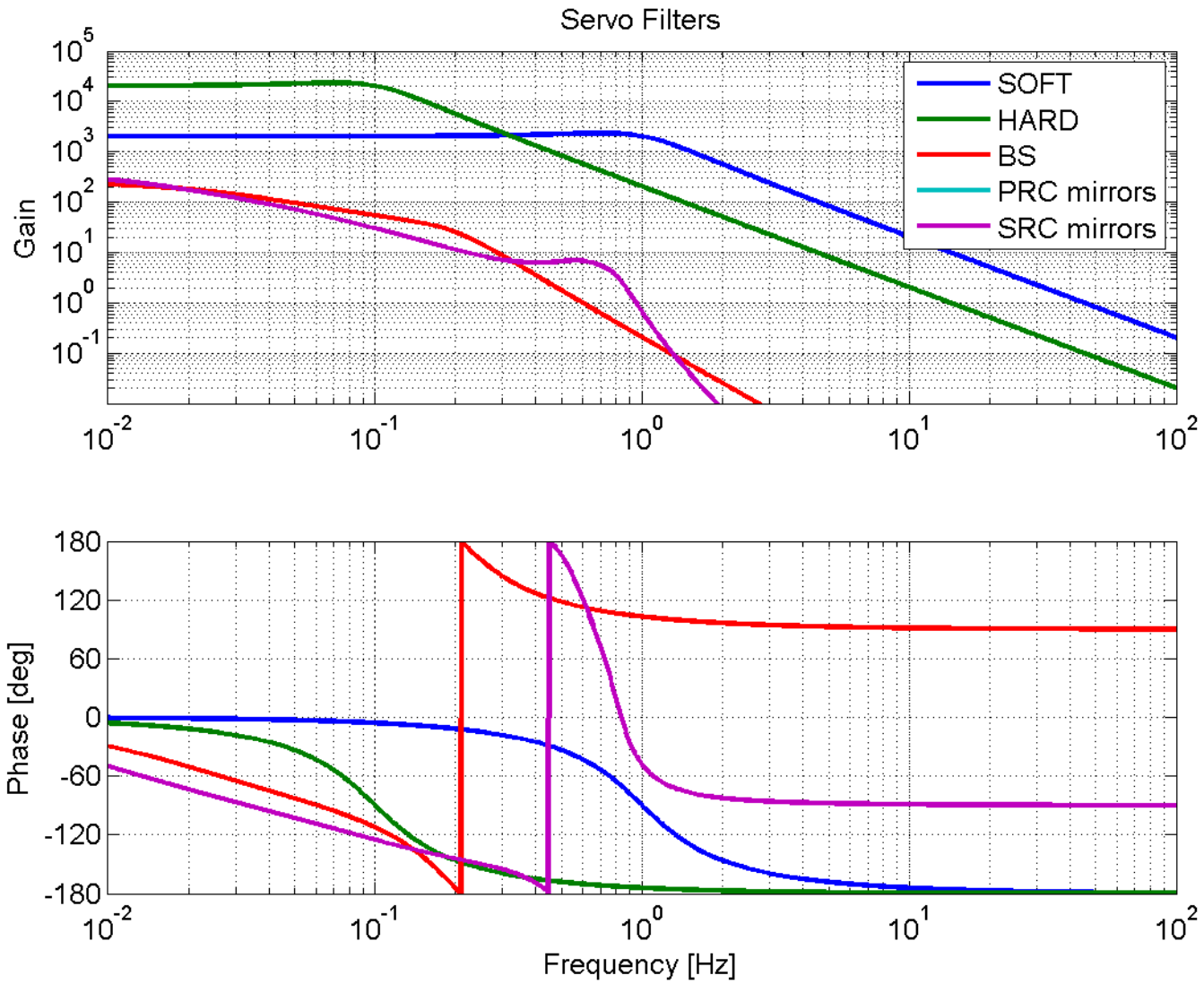
Opto-mechanical TF

- 鏡に加えたトルクから鏡の角度へのTF
  青が輻射圧(Pincav=379kW)下で緑と赤に

SOFTモードは
unstable
(1 Hzあたりまで制御
必要)

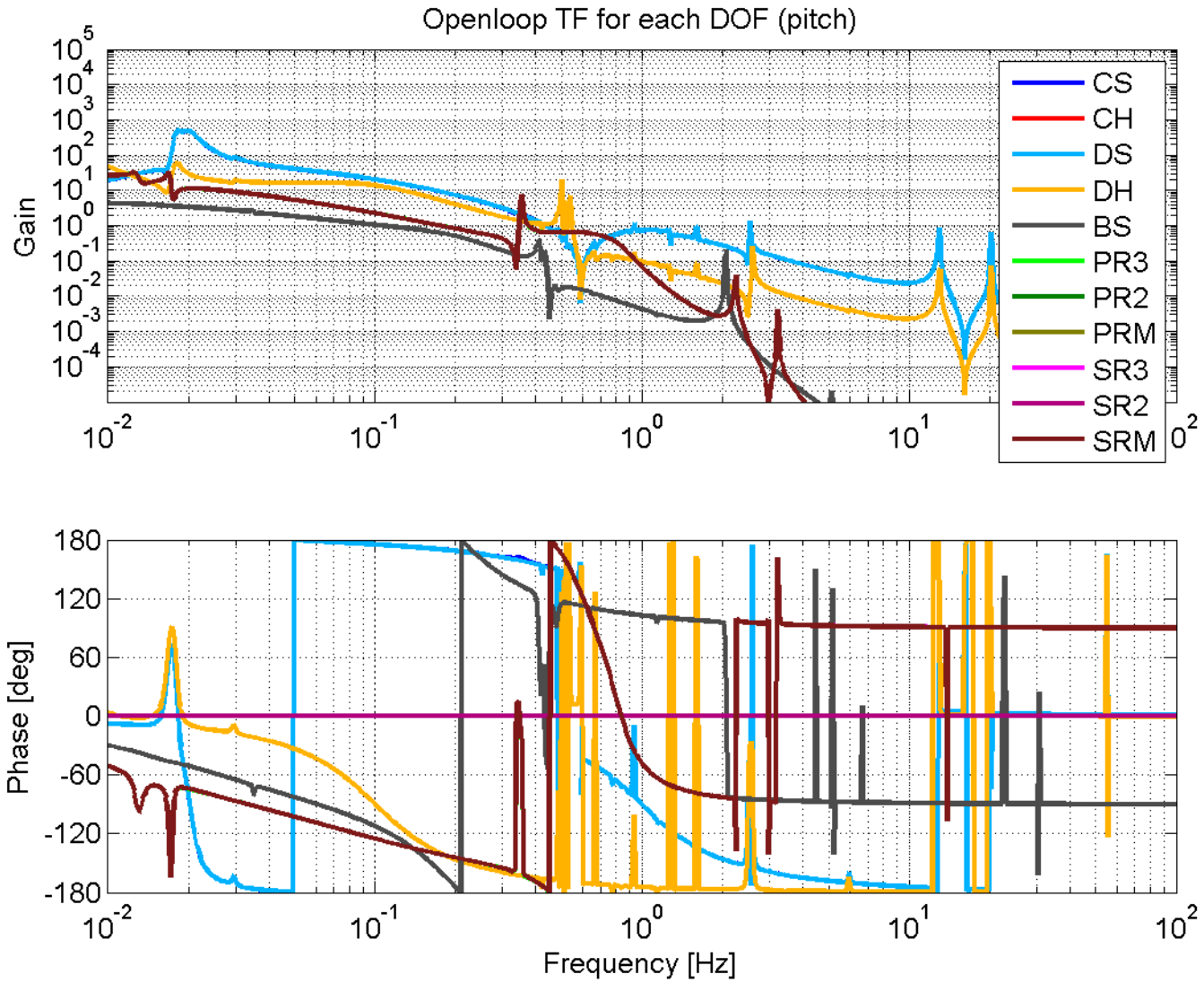


制御フィルタ



TypeAのpitchに関してはサスペンション伝達関数にバグがあるらしいのでフィルタの形は適当

オープンループ伝達関数

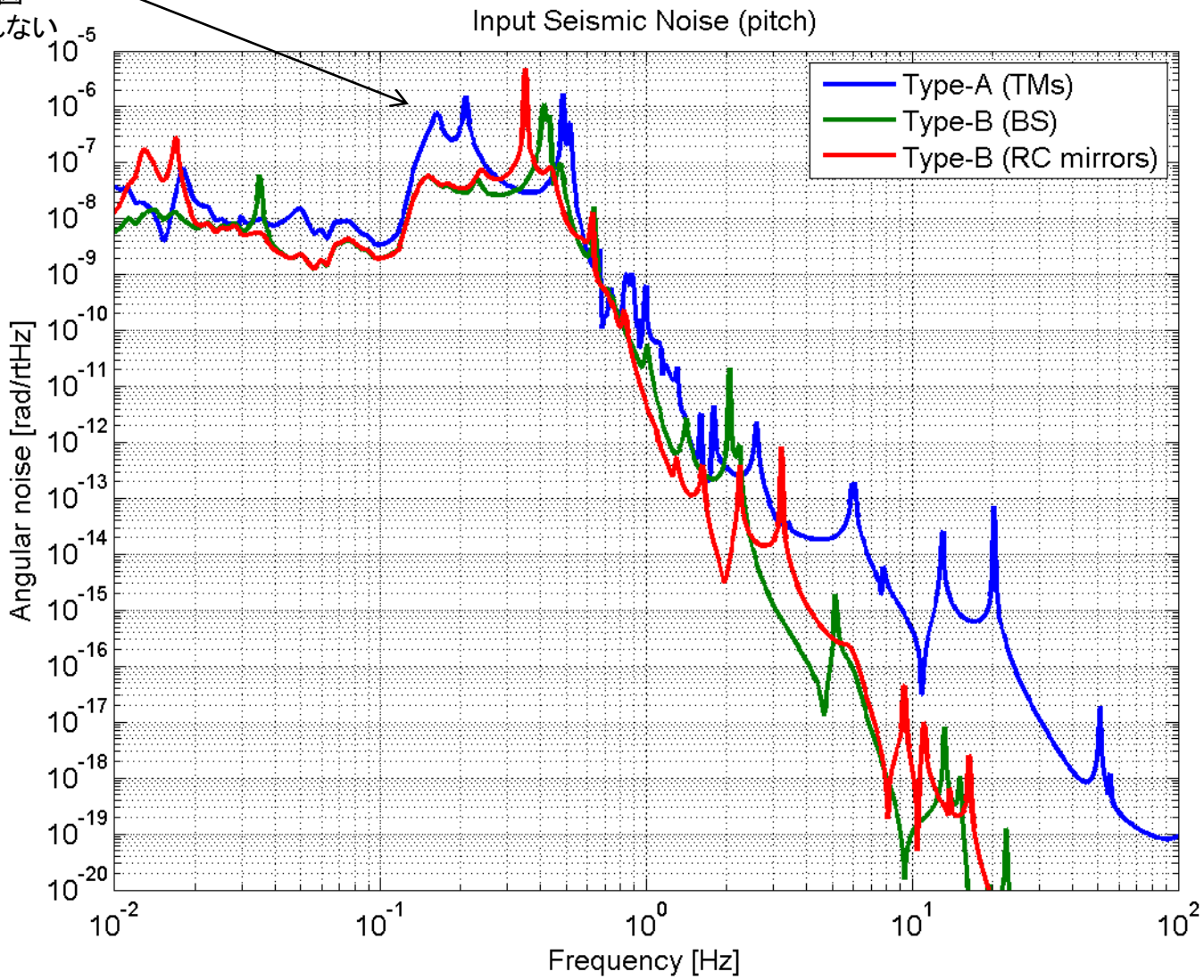


TMの制御は位相がおかしくなっている。(サスペンション剛体モデルのバグ？→関口くんが調査中)

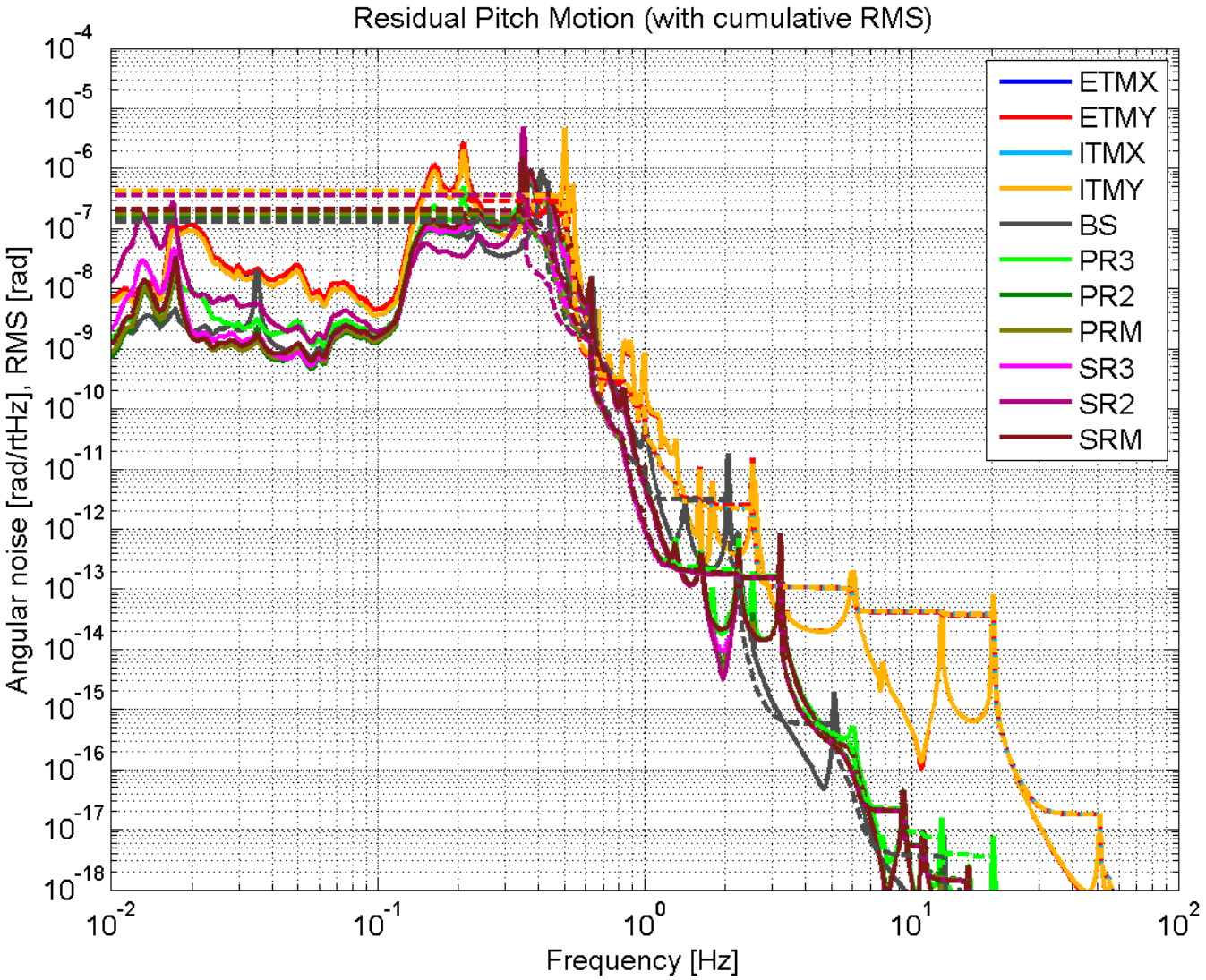
とりあえずゲインだけ見てUGFの位置を。実際にはこんなにゲインを上げられないだろう

地面振動による角度揺れ

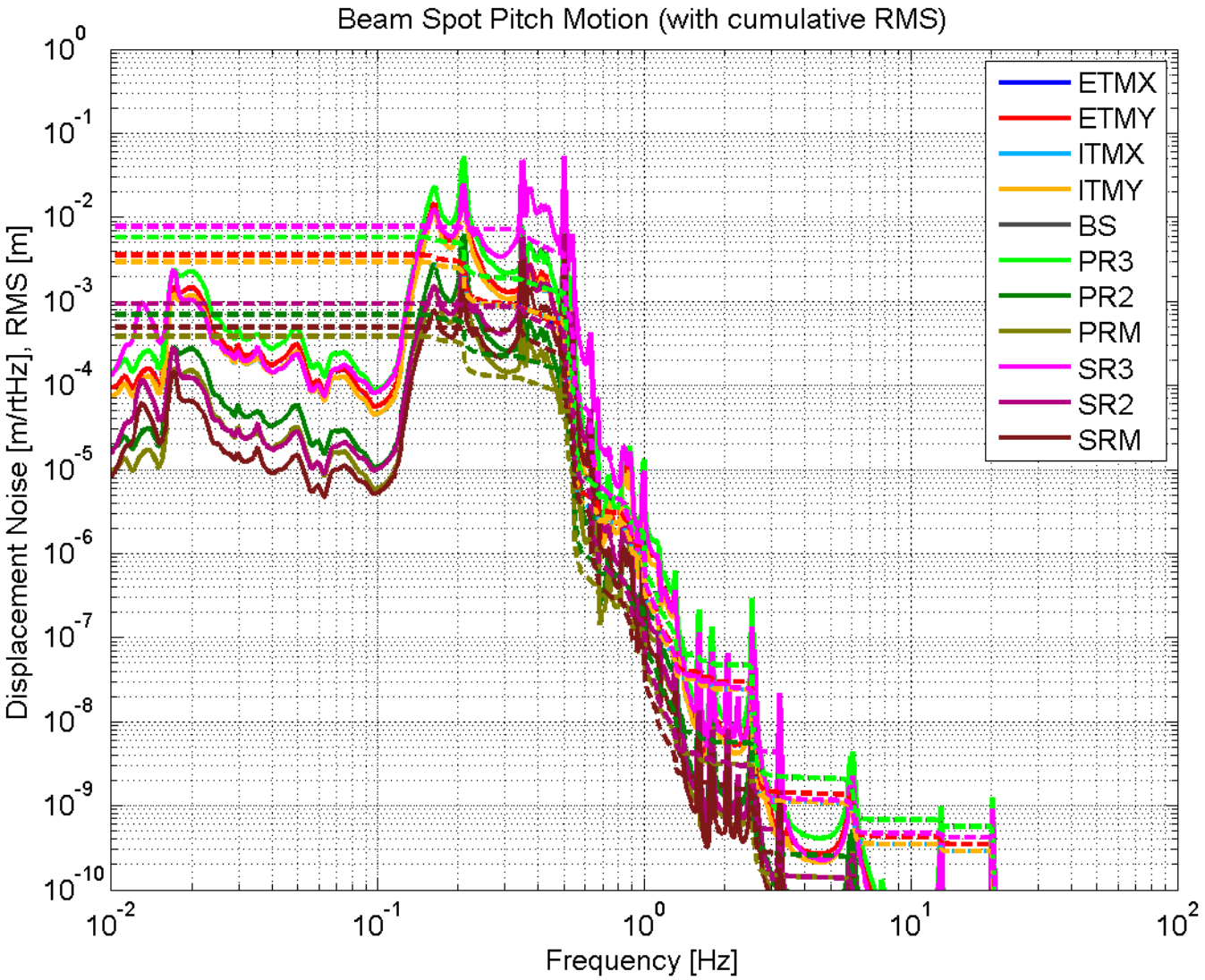
地面振動のこのピークが
RMSを増やす要因
制御でも抑えられない



残留角度揺れ


Residual Pitch Motion (with cumulative RMS)
Angular noise [rad/rtHz], RMS [rad]
Frequency [Hz]
ETMX
ETMY
ITMX
ITMY
BS
PR3
PR2
PRM
SR3
SR2
SRM

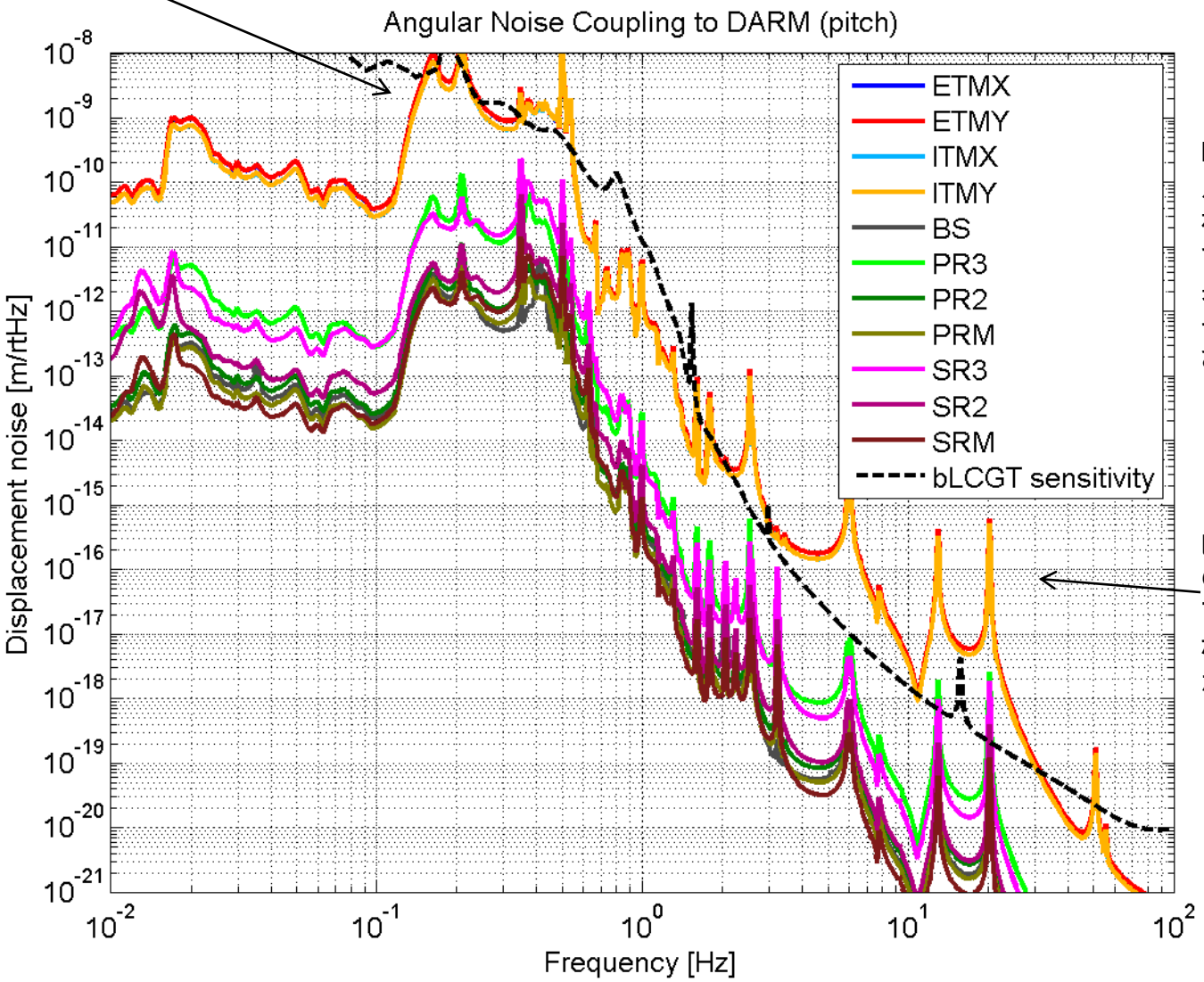
ビームスポットの動き


Beam Spot Pitch Motion (with cumulative RMS)
Displacement Noise [m/rtHz], RMS [m]
Frequency [Hz]
ETMX
ETMY
ITMX
ITMY
BS
PR3
PR2
PRM
SR3
SR2
SRM

DARMへのカップリング

RMSに最も寄与する
ピーク

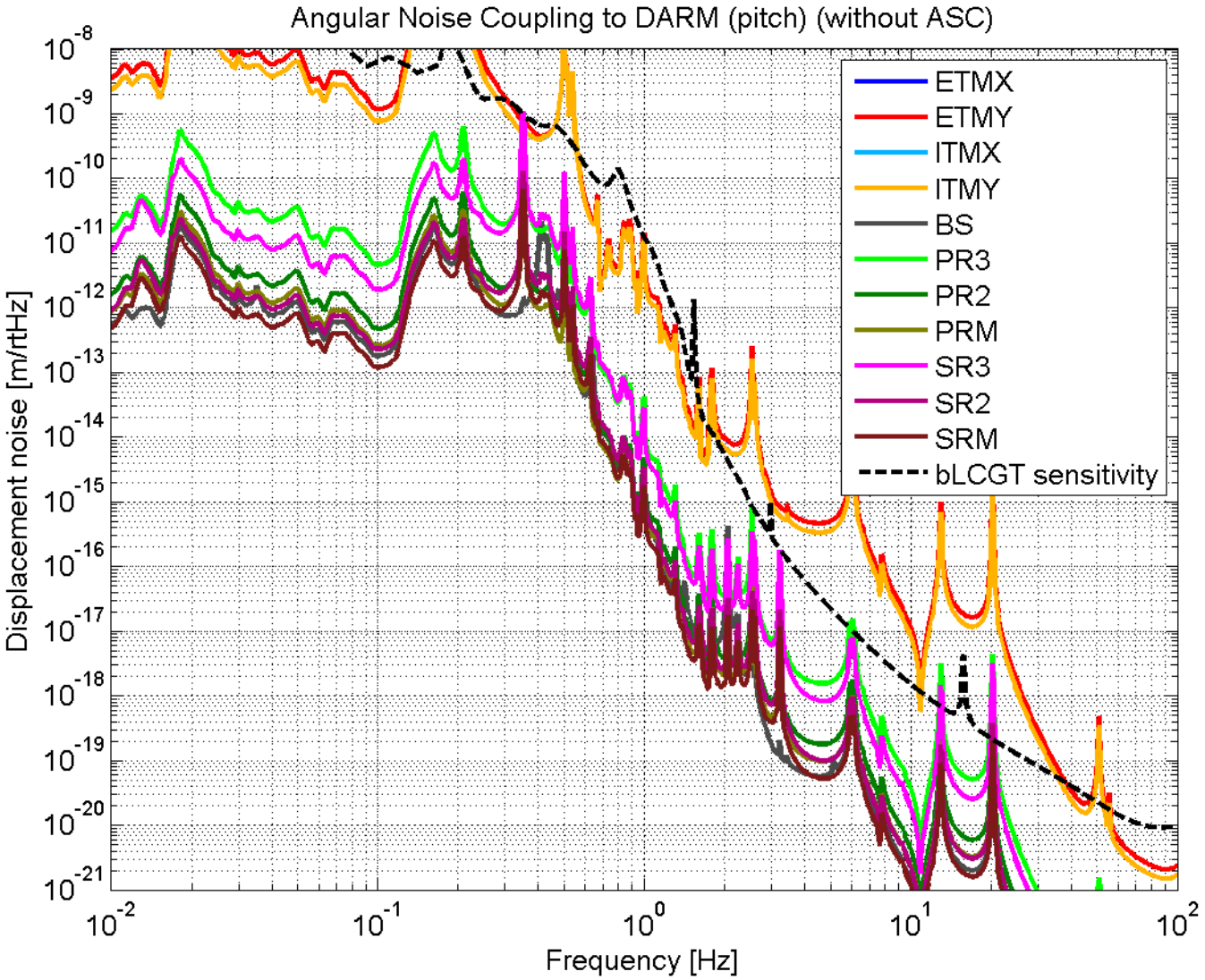
$$\Delta L(f) = c \cdot d_{\mathrm{spot}}(f) * \theta_{\mathrm{Mirror}}(f)$$



ETM/ITMはオープンループ伝達関数の位相を無視しているのでかなり楽観的な結果になっている。
それでも感度を悪化させる。

ビームスポットの動きのRMSが制御により下がったため、制御しない時より、ここも下がる

制御しないと……

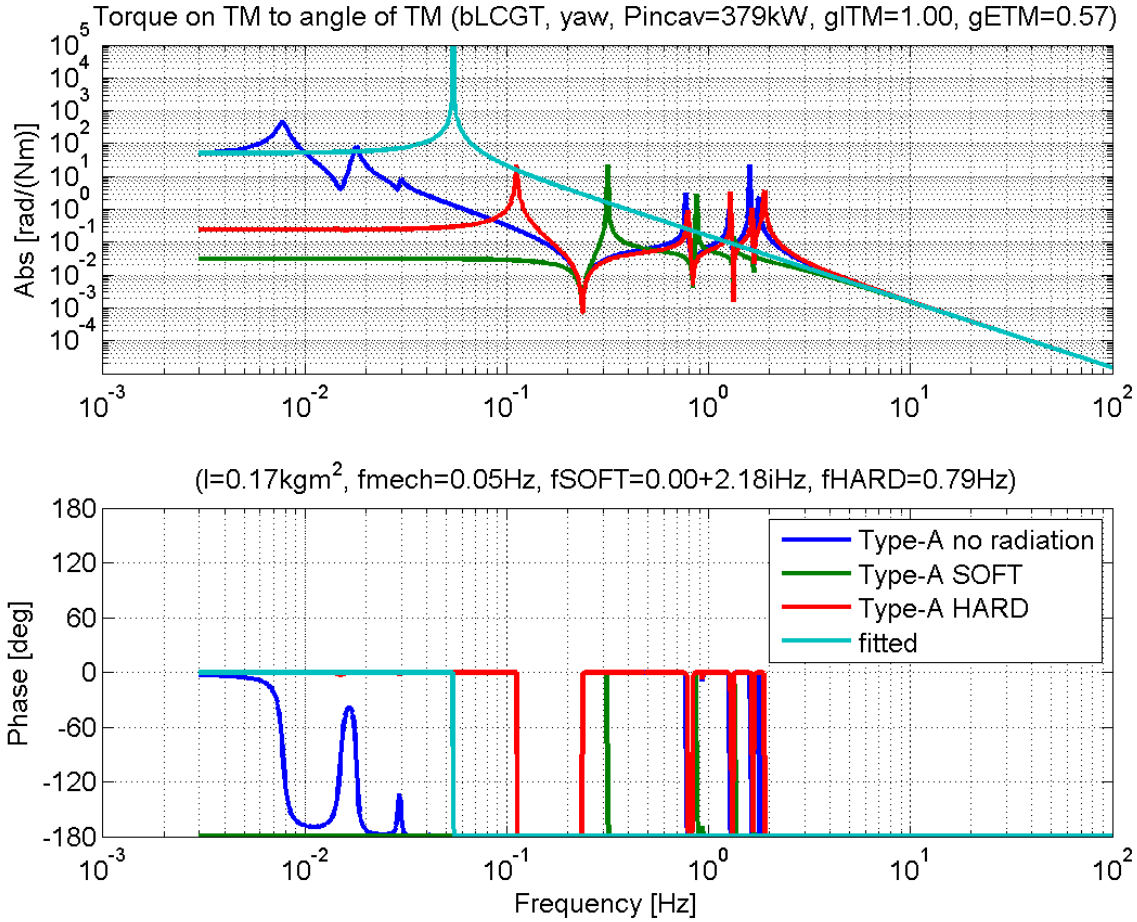

Angular Noise Coupling to DARM (pitch) (without ASC)
Displacement noise [m/rtHz]
Frequency [Hz]
ETMX
ETMY
ITMX
ITMY
BS
PR3
PR2
PRM
SR3
SR2
SRM
bLCGT sensitivity

bLCGT ASC for yaw
(positive g-factorの場合)

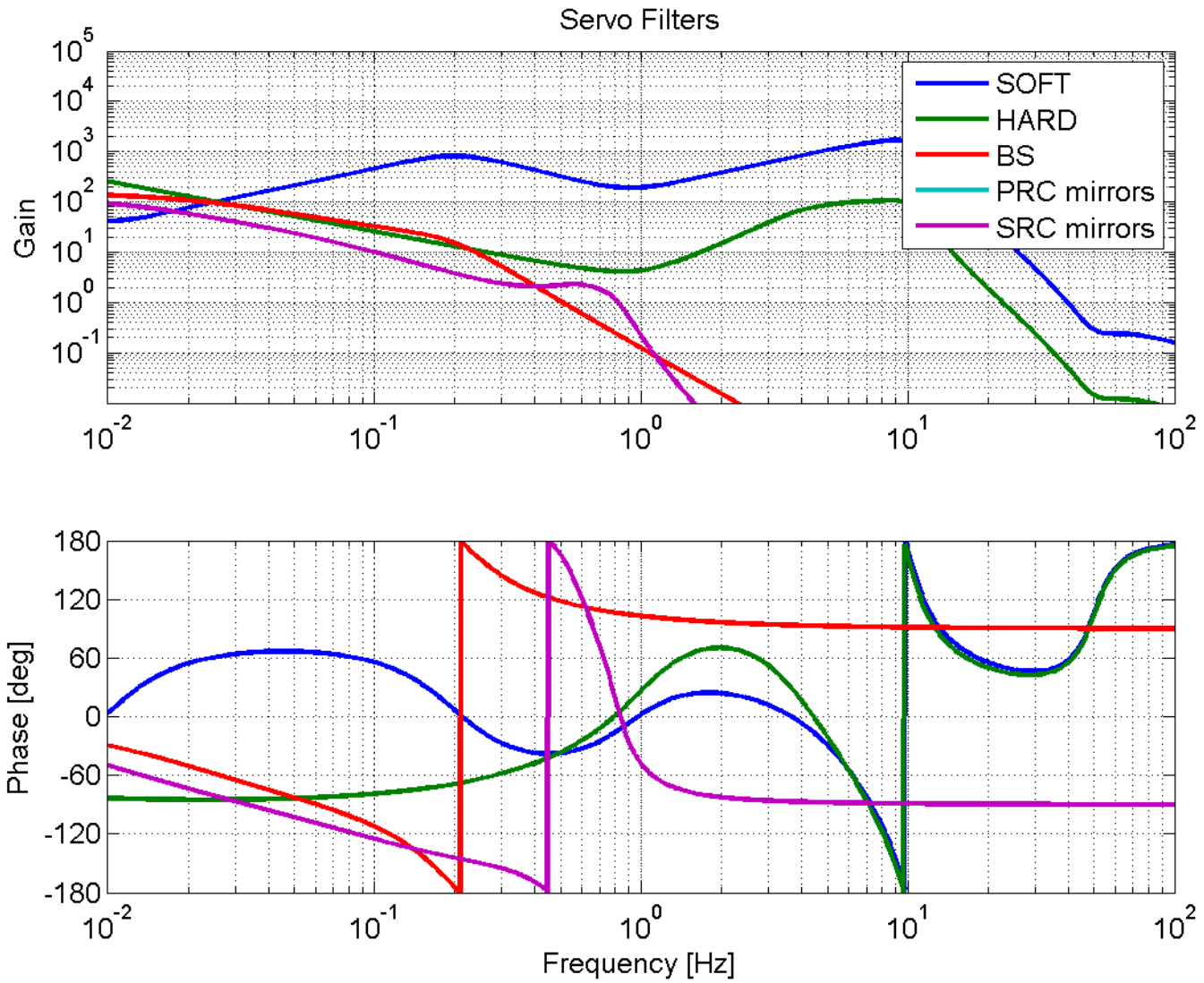
Opto-mechanical TF

- 鏡に加えたトルクから鏡の角度へのTF
  青が輻射圧(Pincav=379kW)下で緑と赤に

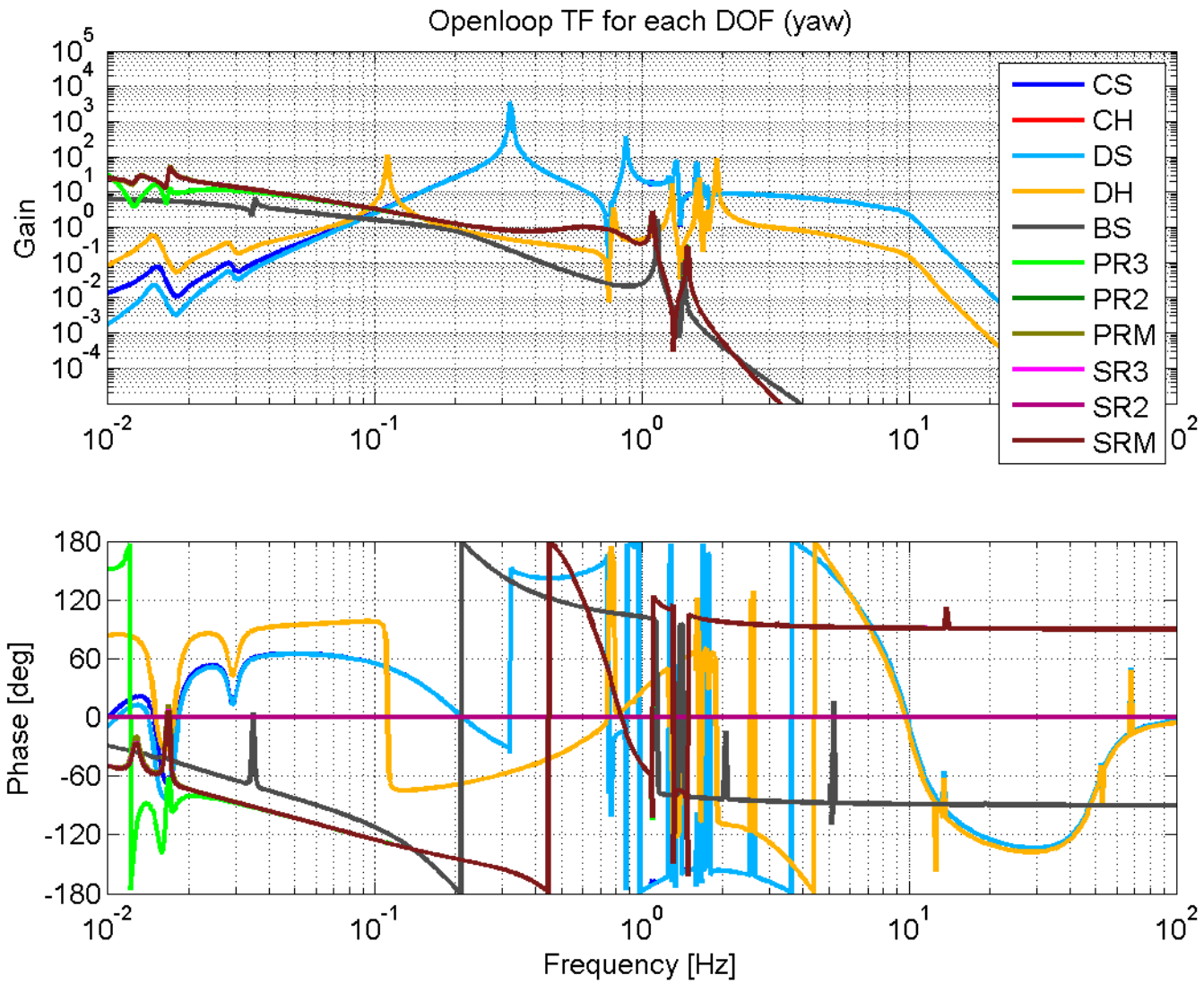
SOFTモードは
unstable
(2Hzあたりまで制御
必要)



制御フィルタ


Servo Filters
Gain
SOFT
HARD
BS
PRC mirrors
SRC mirrors
Phase [deg]
Frequency [Hz]

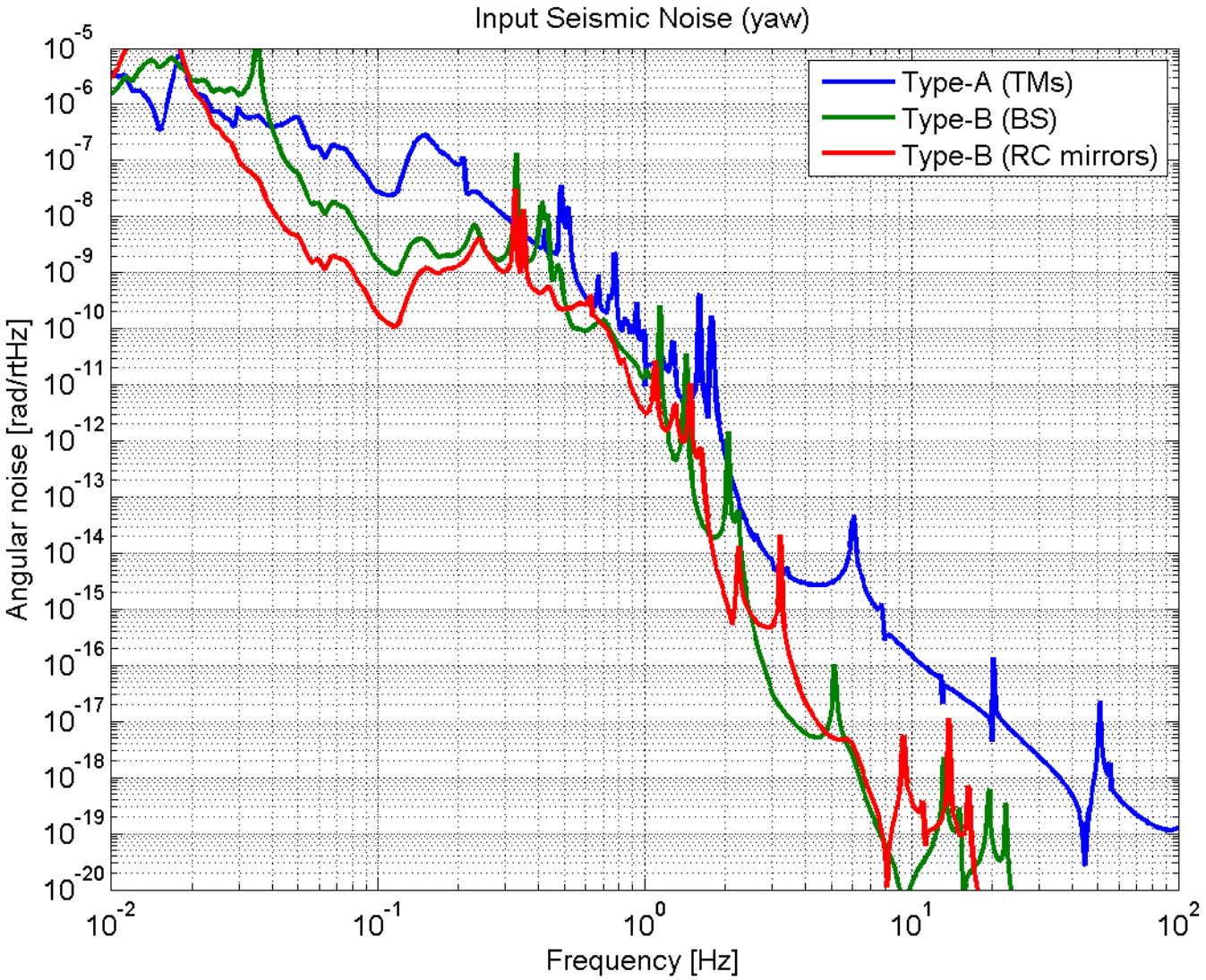
オープンループ伝達関数



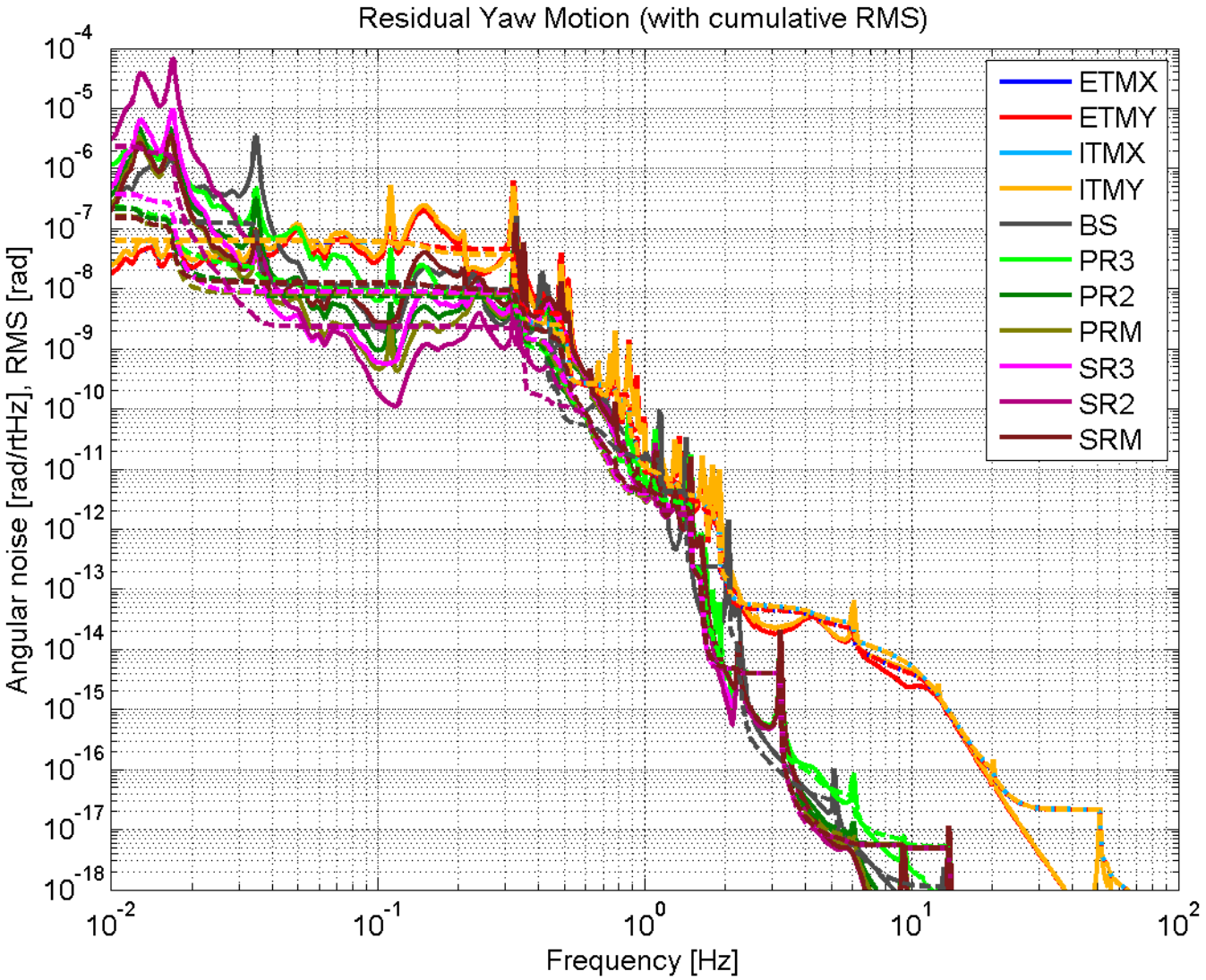
テストマスは更に低周波にもう1つ2次のpoleがある。

multiple UG crossingの細かいチェックはできていませんし、まだする気もありません。

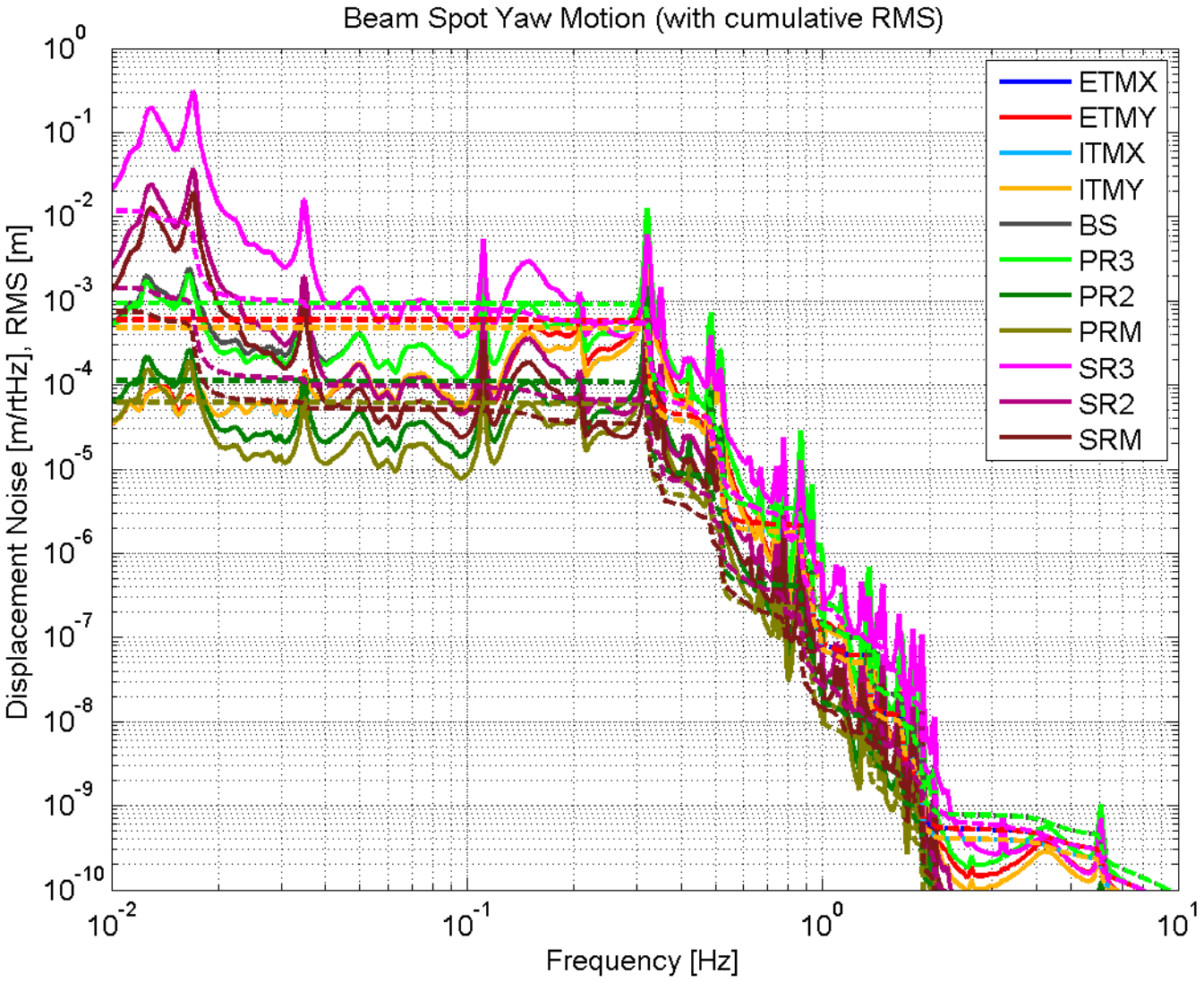
地面振動による角度揺れ



残留角度揺れ

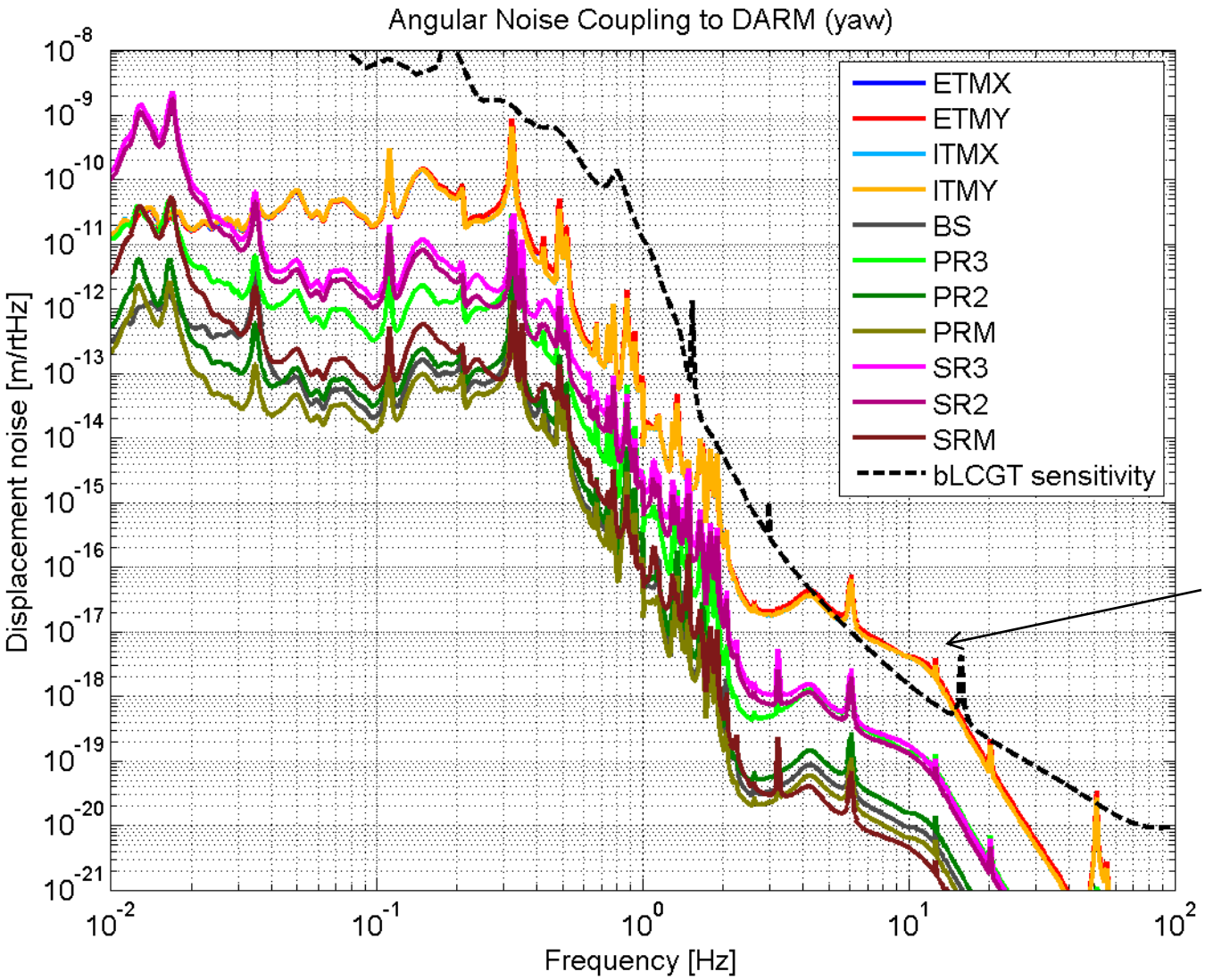

Residual Yaw Motion (with cumulative RMS)
Angular noise [rad/rtHz], RMS [rad]
Frequency [Hz]
ETMX
ETMY
ITMX
ITMY
BS
PR3
PR2
PRM
SR3
SR2
SRM

ビームスポットの動き


Beam Spot Yaw Motion (with cumulative RMS)
Displacement Noise [m/rtHz], RMS [m]
Frequency [Hz]
ETMX
ETMY
ITMX
ITMY
BS
PR3
PR2
PRM
SR3
SR2
SRM

DARMへのカップリング

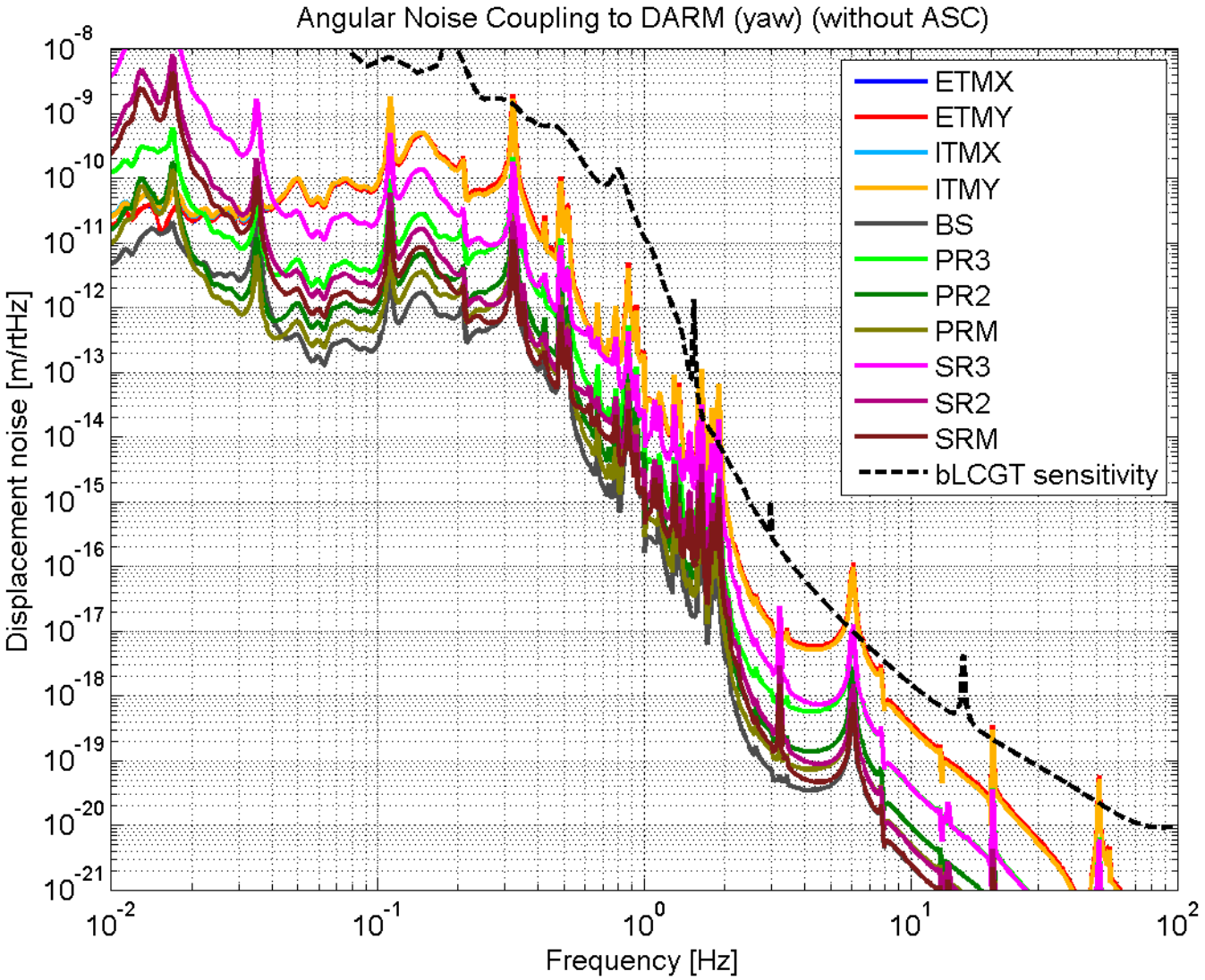
$$\Delta L(f) = c \cdot d_{\mathrm{spot}}(f) * \theta_{\mathrm{Mirror}}(f)$$



ショットノイズ(UGFを高くしないとSOFTモードを制御できないので仕方ない)

yawはサスペンションがきれいなので、感度を汚す量はpitchよりは小さい

制御しないと……


Angular Noise Coupling to DARM (yaw) (without ASC)
Displacement noise [m/rtHz]
Frequency [Hz]
ETMX
ETMY
ITMX
ITMY
BS
PR3
PR2
PRM
SR3
SR2
SRM
bLCGT sensitivity

bLCGT ASC
(negative g-factorの場合)

negative g-factor

- ITM曲率を1.5 km、ETM曲率を1.9 kmに変えただけで、positiveと同じ計算をする
- 信号の出方は変わってくるのでポート選択やsensing matrixは異なる

ポートの選択と位相の最適化

min XXはXXの信号を最初にするようにGouy phaseを決めるということ
何も条件が書いていないのは他でGouyを決められてしまったもの(Gouyをどう頑張っても分離できないもの)

POP DC

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	-8.8	-9.4	5.8	56.8	-14.6	-14.0	84.9	84.4	78.8	78.8	78.8
max ampl	-11670.6	-34918.5	-4.0	2.4	-984.2	-2686.2	-3851.9	-3333.6	1.0	0.1	0.1
Gouy	-5	-5	NaN	NaN	-6	-6	81	81	NaN	NaN	NaN
ampl	-8234.5	-24619.0	NaN	NaN	-688.2	-1880.9	-2717.4	-2353.2	NaN	NaN	NaN
contami	4.3	1.4	NaN	NaN	51.6	18.9	2.0	2.3	NaN	NaN	NaN
N big sig	2	1	NaN	NaN	4	3	1	2	NaN	NaN	NaN

POP_ADC (min CH)

REFL DC

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	17.0	4.6	21.3	21.7	8.0	8.7	8.8	21.3	87.7	87.7	87.7
max ampl	37117.5	160219.7	-174.6	205.1	-59212.6	169542.6	21685.7	-18870.1	-1882.9	-244.2	-222.6
Gouy	-85	-81	NaN	NaN	-68	-86	-86	-82	-82	NaN	NaN
ampl	-5444.3	-8645.6	NaN	NaN	-10095.6	9794.9	1275.8	3064.4	1310.1	NaN	NaN
contami	4.2	2.1	NaN	NaN	7.8	2.7	21.0	5.6	13.1	NaN	NaN
N big sig	2	1	NaN	NaN	3	1	6	3	5	NaN	NaN

POP f1 demodulation

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	8.4	-47.8	53.3	53.3	4.8	-12.2	-10.7	9.6	-11.2	-11.2	-11.2
max demod	0.1	0.4	-89.5	-89.5	-25.8	0.0	0.0	0.4	0.1	0.1	0.1
max ampl	72.4	-110.0	19.8	-24.6	27.0	-53.4	-6.8	-13.0	-124.4	-16.1	-14.7
Gouy	43	79	2	2	3	42	42	43	42	42	42
demod	1	0	-90	-90	90	1	1	1	1	1	1
ampl	59.6	65.9	12.4	-15.4	-11.3	-31.2	-4.1	-10.8	-74.5	-9.7	-8.8
contami	3.6	1.5	3.2	2.5	3.5	6.9	52.1	19.6	2.9	22.3	24.4
N big sig	2	1	2	1	3	3	8	5	1	6	7

POP_B1I (min CS)

REFL f1 demodulation

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	-88.8	89.1	62.4	62.4	-17.2	-25.2	-55.1	9.4	-2.3	-2.3	-2.3
max demod	0.0	0.0	85.8	-79.9	0.5	0.0	0.0	0.0	-0.0	-0.0	-0.0
max ampl	48630.4	126604.3	-46.4	-58.6	-981.7	-3118.1	-634.4	12312.2	-291.2	-37.8	-34.4
Gouy	-81	-81	0	0	0	-1	-1	-1	-1	NaN	NaN
demod	11	10	-90	-90	-90	0	0	0	0	NaN	NaN
ampl	47296.5	122818.6	21.5	-26.8	19.8	-2845.2	-371.9	12111.9	-291.1	NaN	NaN
contami	3.6	1.4	3.5	2.9	3.9	6.5	50.0	1.5	63.9	NaN	NaN
N big sig	2	1	2	1	3	2	5	1	6	NaN	NaN

REFL_A1I (min PRM)　REFL_B1I (min CH)

POP f2 demodulation

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	88.7	-83.5	-77.6	-78.1	-89.8	-89.8	-89.9	-89.8	-76.6	-76.6	-76.6
max demod	-0.2	-0.1	-12.7	-12.6	-0.2	-0.1	-0.1	-0.1	89.5	89.5	89.5
max ampl	-5302.3	-3335.6	-12.0	15.1	-4001.9	-11461.8	-1486.6	-1318.2	0.0	0.0	0.0
Gouy	-3	-4	66	66	-6	4	4	-51	NaN	NaN	NaN
demod	-60	-66	89	89	-82	-54	-54	-89	NaN	NaN	NaN
ampl	-72.4	-153.5	-3.1	3.7	67.7	751.5	98.1	6.7	NaN	NaN	NaN
contami	3.7	1.4	8.9	7.5	6.2	2.2	16.6	18.6	NaN	NaN	NaN
N big sig	2	1	4	3	3	1	4	5	NaN	NaN	NaN

POP_A2I

REFL f2 demodulation

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	-87.6	88.0	-64.2	-76.2	-75.7	-76.2	-77.4	24.2	-67.6	-67.6	-67.6
max demod	-0.0	0.2	-13.5	-11.1	-0.2	-0.2	-0.2	-0.4	89.3	89.3	89.3
max ampl	58223.3	111998.4	-25.2	43.2	-9828.7	-28554.6	-4022.9	12046.5	0.0	0.0	0.0
Gouy	-66	79	-71	-71	-7	-36	-36	-1	NaN	NaN	NaN
demod	80	89	-90	-90	89	-90	-90	-83	NaN	NaN	NaN
ampl	-9514.1	-2286.3	-6.4	7.9	-342.8	509.1	66.4	1404.2	NaN	NaN	NaN
contami	3.6	1.4	52.7	42.8	6.2	2.1	16.5	1.1	NaN	NaN	NaN
N big sig	2	1	5	4	3	1	4	1	NaN	NaN	NaN

AS DC

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	-23.8	-23.8	-63.3	-32.4	-10.1	-38.9	-43.9	87.8	-16.6	-15.7	56.3
max ampl	-2.7	3.4	-0.4	0.4	-1.1	2.3	0.3	1.2	4.8	0.7	1.3
Gouy	-33	-33	73	-34	51	74	74	67	-2	-2	66
ampl	-1.9	2.4	0.2	0.2	-0.4	-0.6	-0.1	0.8	3.3	0.5	0.9
contami	6.0	4.8	18.0	45.7	12.5	5.4	38.5	3.9	3.3	24.0	3.4
N big sig	3	2	6	8	6	3	7	2	1	7	1

AS_ADC

AS_A1Q (max DH)

TRX DC

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	85.5	22.2	85.5	22.2	-15.8	0.2	0.1	-0.3	-45.1	-45.1	-45.1
max ampl	17425.5	37097.7	17425.3	37097.4	0.0	-42.0	-5.4	-4.7	0.0	0.0	0.0
Gouy	-68	-4	-68	-4	NaN	NaN	NaN	NaN	NaN	NaN	NaN
ampl	-11029.7	23528.4	-11029.5	23528.4	NaN	NaN	NaN	NaN	NaN	NaN	NaN
contami	2.0	2.0	2.0	2.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
N big sig	1	2	2	1	NaN	NaN	NaN	NaN	NaN	NaN	NaN

TRX_ADC (min CH/DH)

AS f1 demodulation

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	81.7	79.8	-89.2	89.0	-16.4	89.8	89.7	89.3	73.8	74.6	-34.9
max demod	-90.0	-90.0	-90.0	-90.0	-90.0	-90.0	-90.0	-90.0	-89.6	-89.7	89.3
max ampl	-0.0	-0.1	455.7	-1186.6	9.7	0.5	0.1	0.1	-0.0	-0.0	-0.0
Gouy	NaN	NaN	-1	1	-1	NaN	NaN	NaN	NaN	NaN	NaN
demod	NaN	NaN	0	0	0	NaN	NaN	NaN	NaN	NaN	NaN
ampl	NaN	NaN	0.0	-0.0	0.0	NaN	NaN	NaN	NaN	NaN	NaN
contami	NaN	NaN	1.7	1.3	2.6	NaN	NaN	NaN	NaN	NaN	NaN
N big sig	NaN	NaN	1	1	2	NaN	NaN	NaN	NaN	NaN	NaN

AS_B1Q(min DH)

TRY DC

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
max Gouy	85.5	22.2	85.5	22.2	0.2	0.2	0.1	-0.3	-51.0	-51.0	-51.0
max ampl	17425.5	37097.6	17425.3	37097.4	-29.2	-41.9	-5.4	-4.7	-0.0	-0.0	-0.0
Gouy	-68	-4	-68	-4	NaN	NaN	NaN	NaN	NaN	NaN	NaN
ampl	-11029.7	23528.3	11029.5	23528.4	NaN	NaN	NaN	NaN	NaN	NaN	NaN
contami	2.0	2.0	2.0	2.0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
N big sig	1	2	2	1	NaN	NaN	NaN	NaN	NaN	NaN	NaN

TRY_ADC (min CH/DH)

全Sensing Matrix

WFS Sensing Matrix [W/mrad/sqrt(2/pi)]

(Gouy phases at POP A:80.8, POP B:42.2 REFL A:80.6, REFL B:-0.9, AS A:89.0, AS B:-1.0, TR A:-67.8 deg)

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
POP_ADC	-0.06	0.08	-0.00	0.00	0.07	0.16	-2.72	-2.35	0.00	0.00	0.00
POP_BDC	-5.20	-15.34	-0.00	0.00	-0.38	-1.06	-2.00	-1.75	0.00	0.00	0.00
POP_A1I	0.02	0.07	0.00	0.00	-0.00	0.00	0.00	-0.00	0.00	0.00	0.00
POP_A1Q	0.00	0.00	-0.02	0.02	-0.02	0.00	0.00	-0.00	0.00	0.00	0.00
POP_B1I	0.06	-0.00	0.00	-0.00	0.02	-0.03	-0.00	-0.01	-0.07	-0.01	-0.01
POP_B1Q	0.00	0.00	-0.02	0.02	-0.02	0.00	0.00	-0.00	0.00	0.00	0.00
POP_A2I	-5.25	3.21	0.01	-0.01	3.95	11.31	1.47	1.30	-0.00	-0.00	-0.00
POP_A2Q	0.04	-0.04	-0.00	0.00	-0.03	-0.09	-0.01	-0.01	-0.00	-0.00	-0.00
POP_B2I	-3.65	1.95	0.01	-0.01	2.68	7.67	1.00	0.88	-0.00	-0.00	-0.00
POP_B2Q	0.14	-0.09	-0.00	0.00	-0.11	-0.30	-0.04	-0.03	-0.00	-0.00	-0.00
REFL_ADC	-11.66	-27.45	-0.06	0.07	-12.55	-37.22	-4.78	-6.81	-1.32	-0.17	-0.16
REFL_BDC	-24.98	-112.77	-0.11	0.13	-41.36	-118.21	-15.12	-12.36	-0.03	-0.00	-0.00
REFL_A1I	-47.80	-125.23	-0.00	-0.01	0.13	0.85	0.45	3.96	-0.04	-0.00	-0.00
REFL_A1Q	-0.02	-0.06	-0.04	0.05	-0.04	0.00	0.00	0.00	0.00	0.00	0.00
REFL_B1I	1.76	-0.15	0.00	-0.00	-0.94	-2.84	-0.37	12.12	-0.29	-0.04	-0.03
REFL_B1Q	0.00	0.00	-0.02	0.03	-0.02	-0.00	-0.00	0.01	0.00	0.00	0.00
REFL_A2I	-56.99	-111.06	0.02	-0.04	9.00	26.25	3.73	6.67	-0.00	-0.00	-0.00
REFL_A2Q	0.11	-0.35	-0.01	0.01	-0.16	-0.43	-0.06	-0.04	-0.00	-0.00	-0.00
REFL_B2I	3.35	-2.10	-0.01	0.01	-2.59	-7.24	-0.94	10.91	-0.00	-0.00	-0.00
REFL_B2Q	0.40	-0.23	-0.00	0.00	-0.29	-0.84	-0.11	-0.08	0.00	0.00	0.00
AS_ADC	0.00	-0.00	0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00
AS_BDC	-0.00	0.00	-0.00	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
AS_A1I	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
AS_A1Q	0.00	0.00	0.46	1.19	0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00
AS_B1I	-0.00	-0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
AS_B1Q	0.00	0.00	-0.01	-0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-0.00
TRX_ADC	-11.01	-0.03	-11.01	-0.03	0.00	-0.01	-0.00	-0.00	0.00	0.00	0.00
TRX_BDC	5.53	26.23	5.53	26.23	0.00	-0.03	-0.00	-0.00	0.00	0.00	0.00
TRY_ADC	-11.01	-0.03	11.01	0.03	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00
TRY_BDC	5.53	26.23	-5.53	-26.23	-0.02	-0.03	-0.00	-0.00	-0.00	-0.00	-0.00

SR2はWFSでは制御しない

選択後のSensing Matrix

WFS Sensing Matrix [W/mrad/sqrt(2/pi)]

(Gouy phases at POP A:80.8, POP B:42.2 REFL A:80.6, REFL B:-0.9, AS A:89.0, AS B:-1.0, TR A:-67.8 deg)

	CS	CH	DS	DH	BS	PR3	PR2	PRM	SR3	SR2	SRM
TRX_ADC	-11.01	-0.03	-11.01	-0.03	0.00	-0.01	-0.00	-0.00	0.00	0.00	0.00
REFL_A1I	-47.80	-125.23	-0.00	-0.01	0.13	0.85	0.45	3.96	-0.04	-0.00	-0.00
TRY_ADC	-11.01	-0.03	11.01	0.03	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	-0.00
AS_A1Q	0.00	0.00	0.46	1.19	0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00
AS_B1Q	0.00	0.00	-0.01	-0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-0.00
POP_A2I	-5.25	3.21	0.01	-0.01	3.95	11.31	1.47	1.30	-0.00	-0.00	-0.00
POP_ADC	-0.06	0.08	-0.00	0.00	0.07	0.16	-2.72	-2.35	0.00	0.00	0.00
REFL_B1I	1.76	-0.15	0.00	-0.00	-0.94	-2.84	-0.37	12.12	-0.29	-0.04	-0.03
POP_B1I	0.06	-0.00	0.00	-0.00	0.02	-0.03	-0.00	-0.01	-0.07	-0.01	-0.01
AS_ADC	0.00	-0.00	0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00

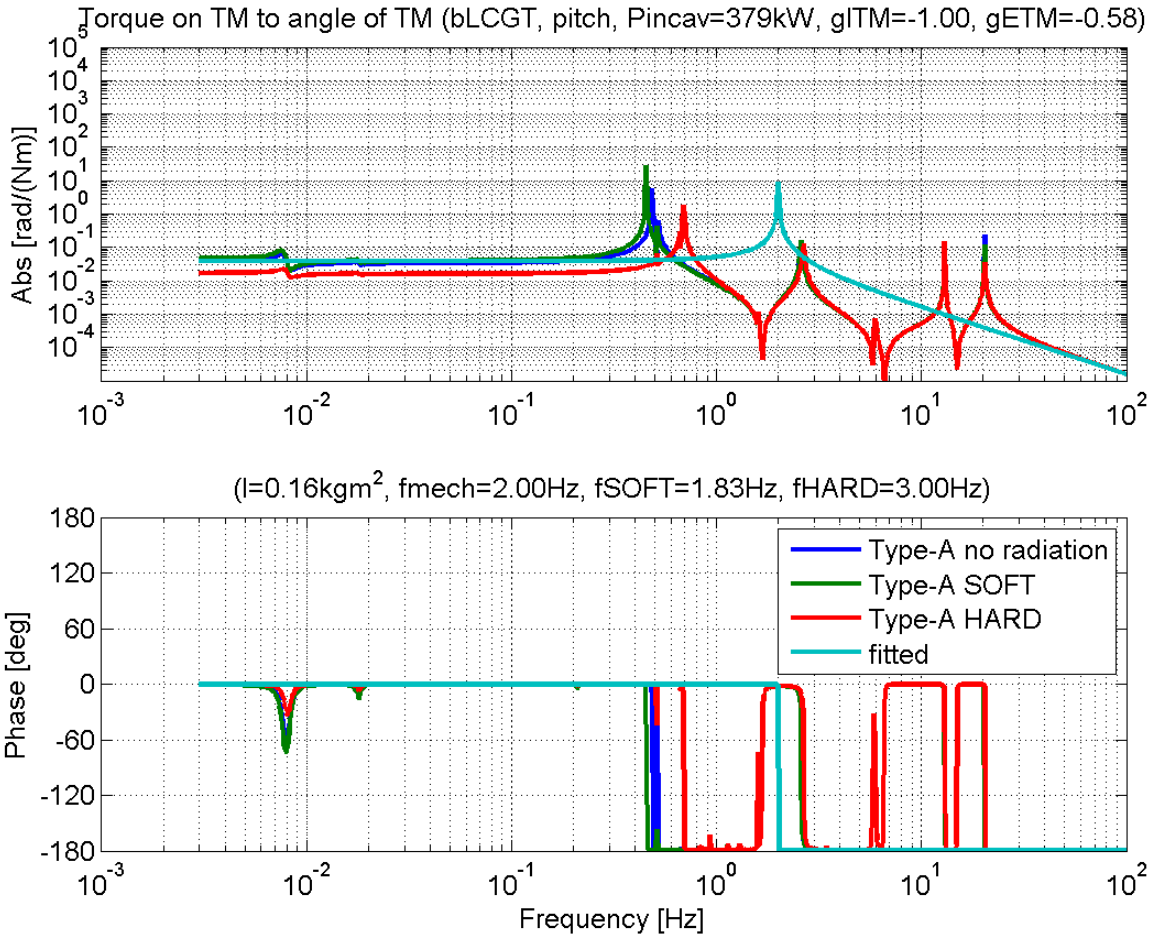
SR2はWFSでは制御しない

bLCGT ASC for pitch
(negative g-factorの場合)

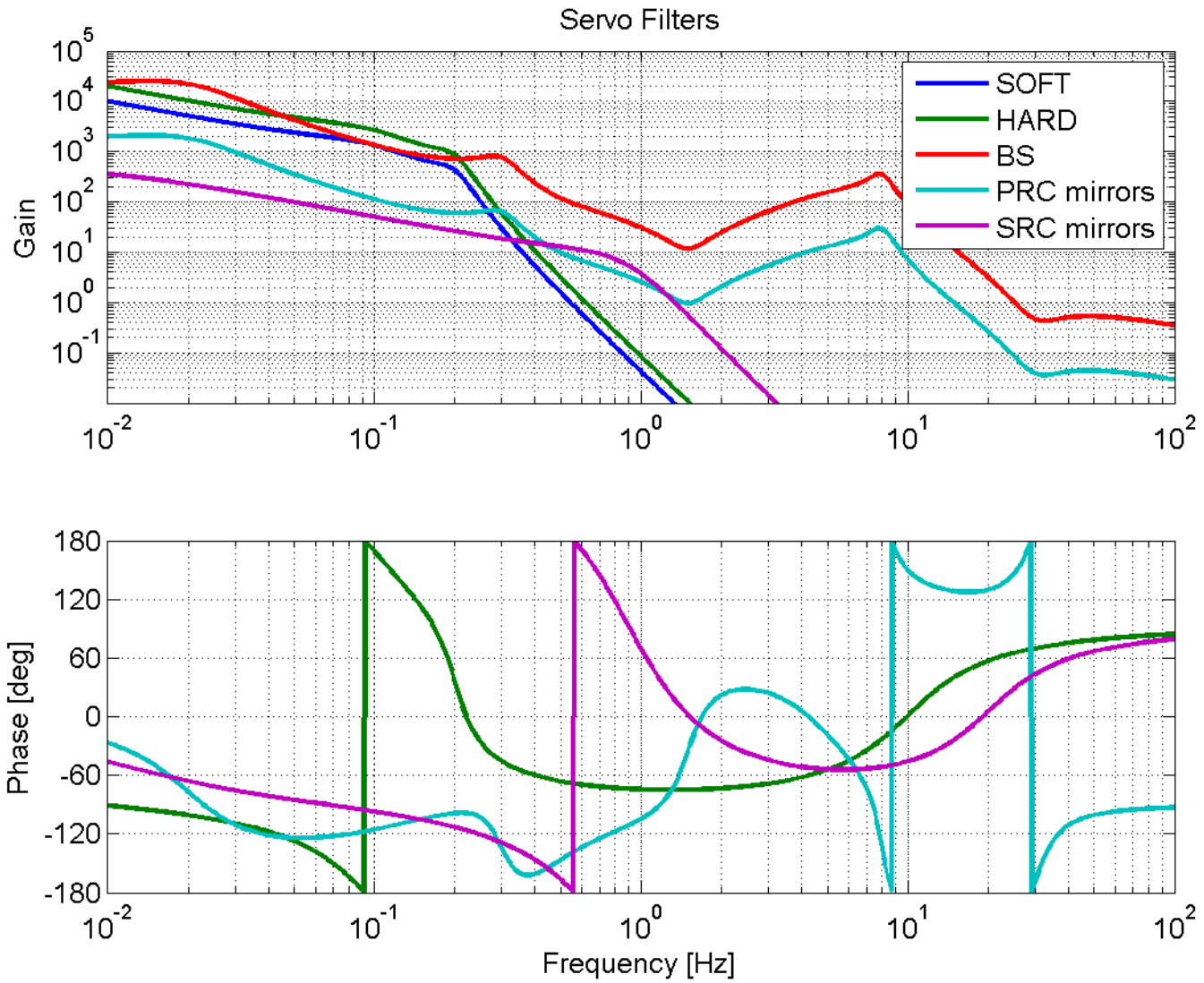
Opto-mechanical TF

- リコイルマスに加えたトルクから鏡の角度へのTF(pitch)
  青が輻射圧(Pincav=379kW)下で緑と赤に

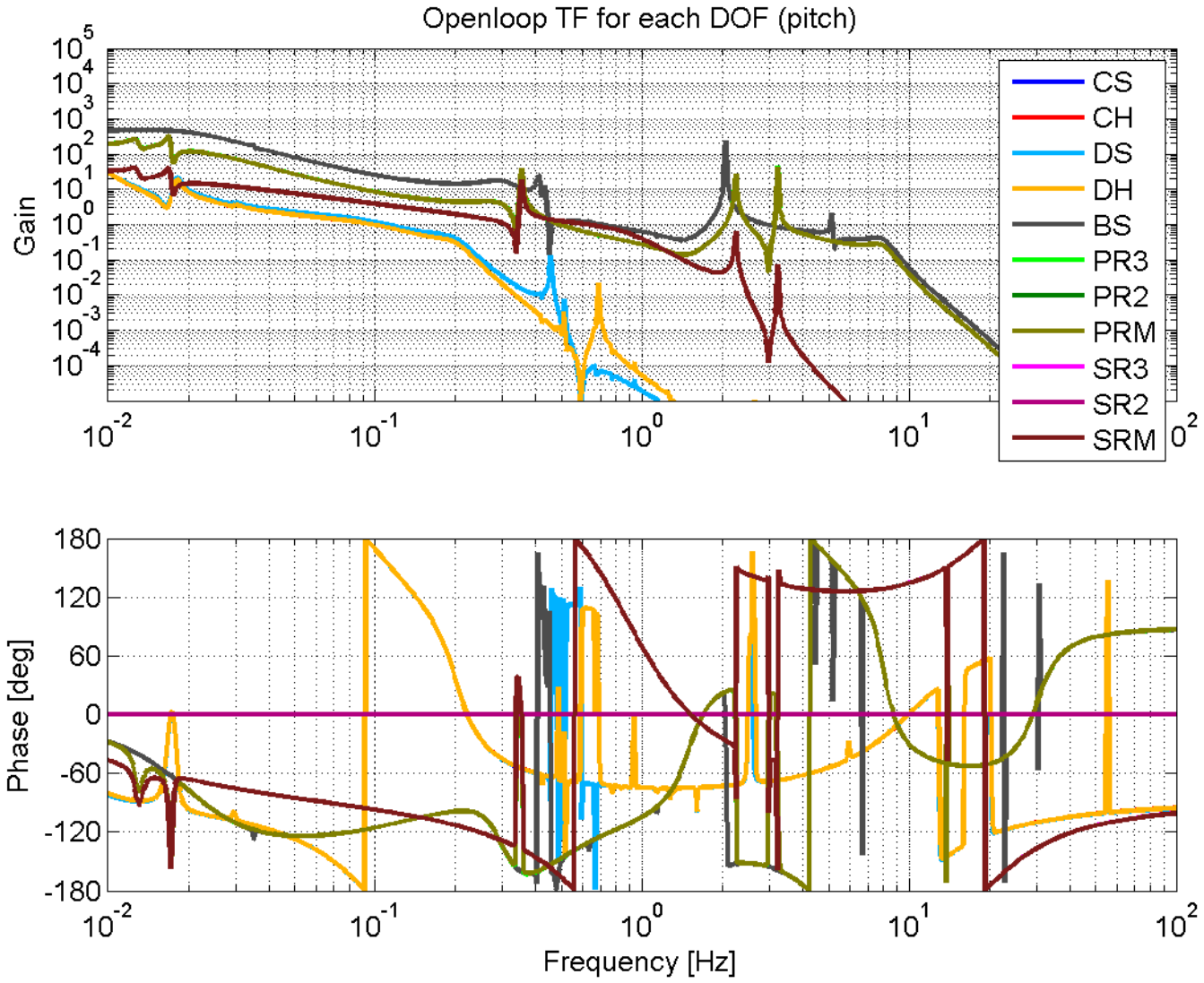
SOFTモードはstable



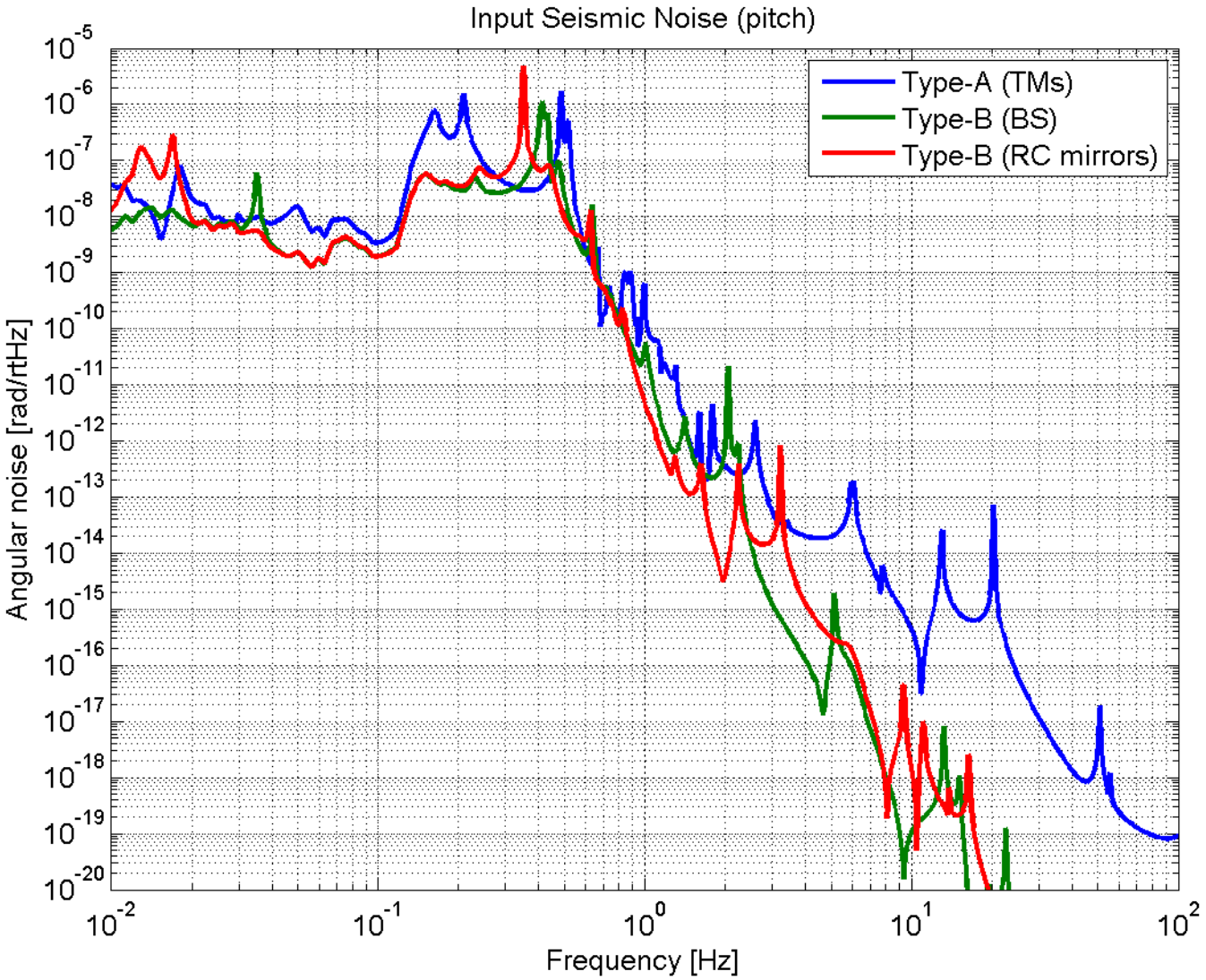
制御フィルタ


Servo Filters
Gain
SOFT
HARD
BS
PRC mirrors
SRC mirrors
Phase [deg]
Frequency [Hz]

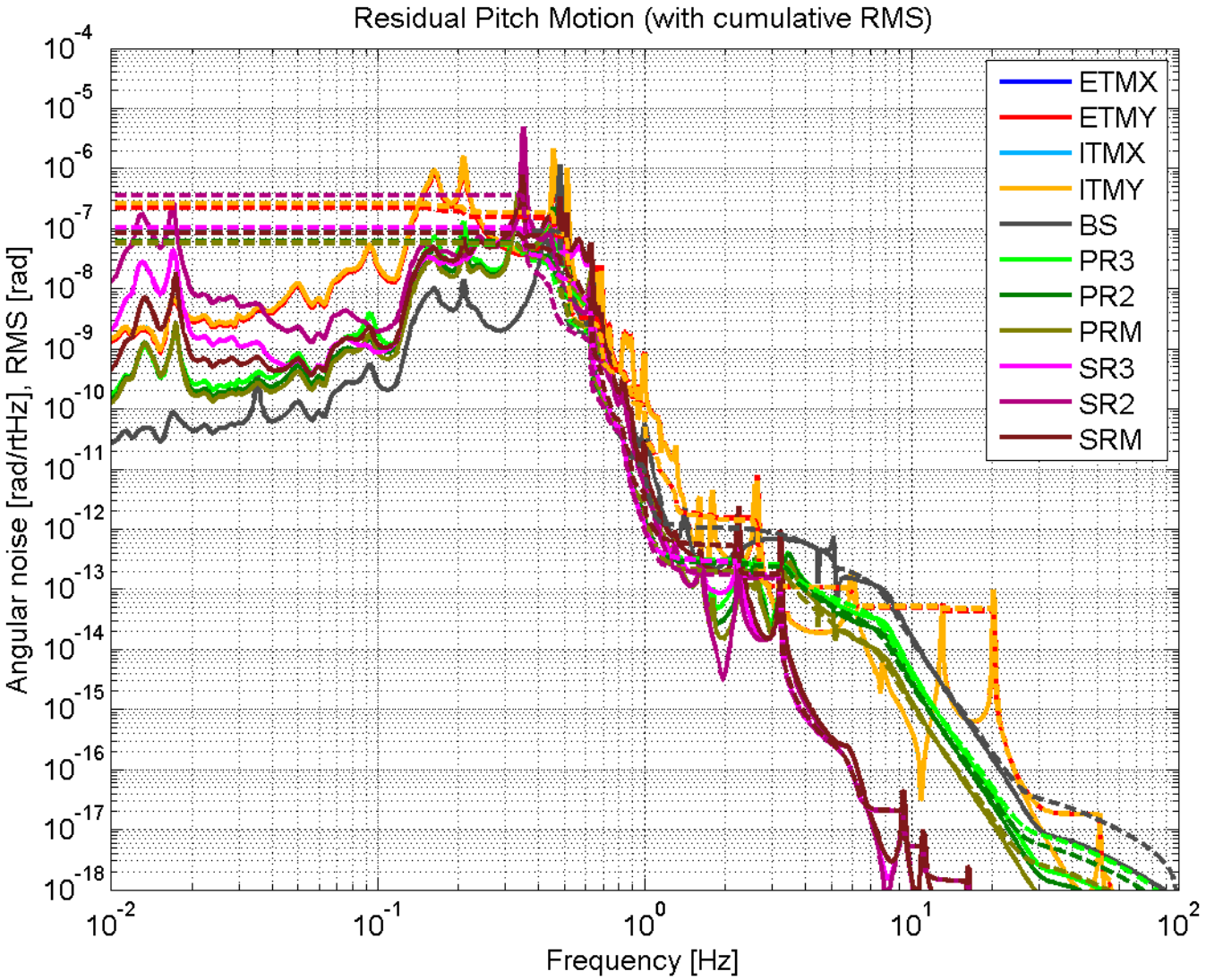
オープンループ伝達関数



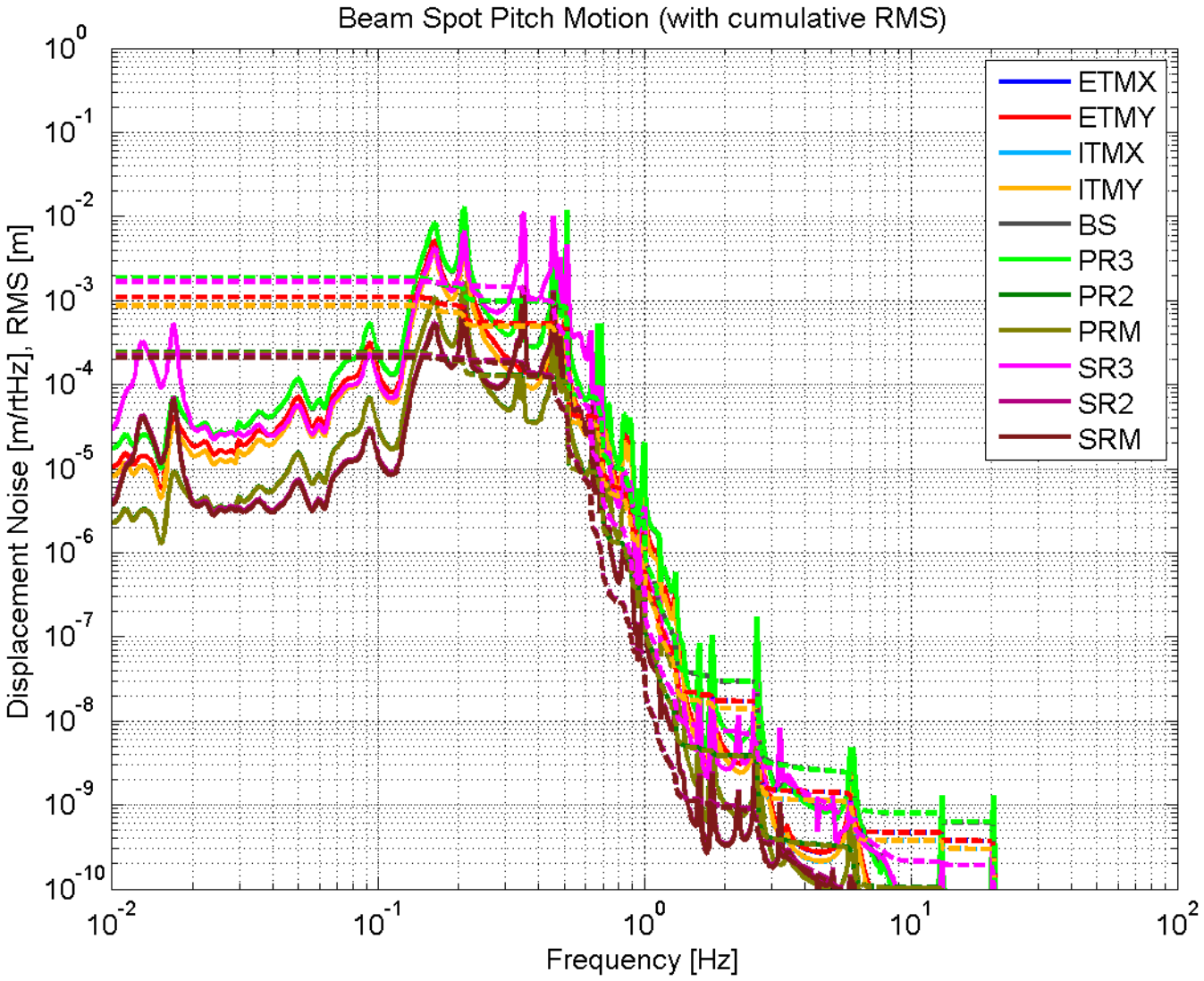
地面振動による角度揺れ



残留角度揺れ

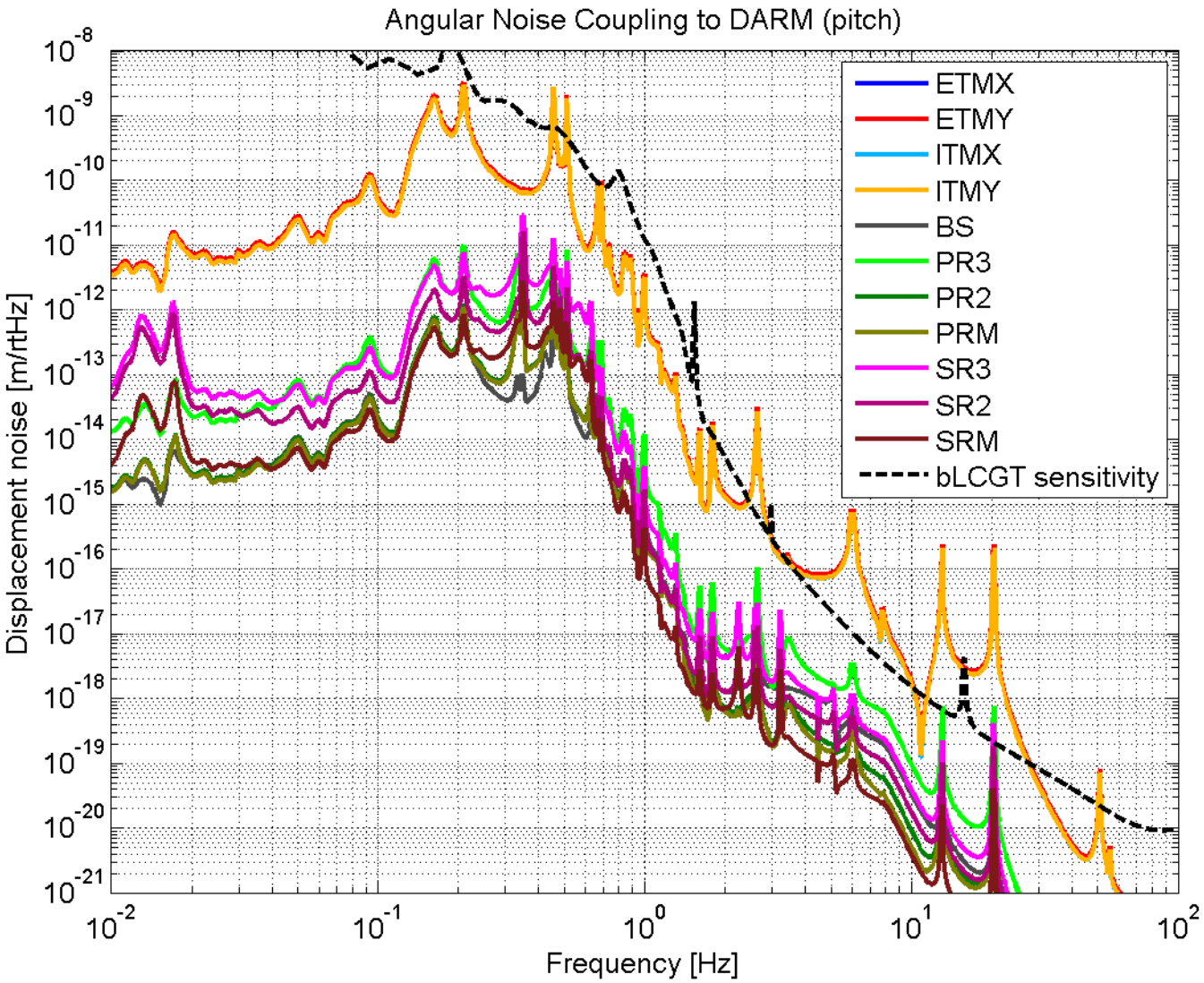

Residual Pitch Motion (with cumulative RMS)
Angular noise [rad/rtHz], RMS [rad]
Frequency [Hz]
ETMX
ETMY
ITMX
ITMY
BS
PR3
PR2
PRM
SR3
SR2
SRM

ビームスポットの動き

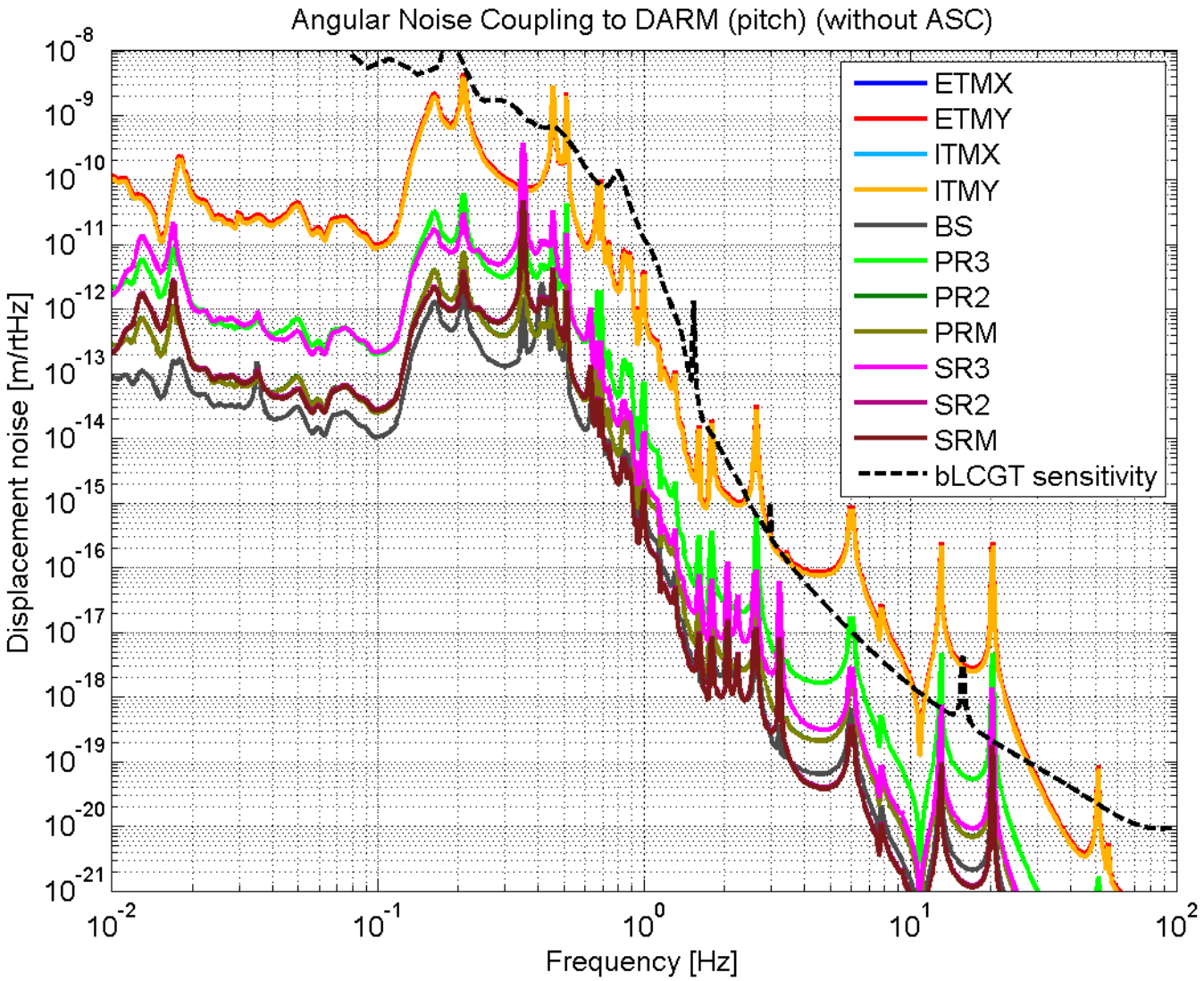

Beam Spot Pitch Motion (with cumulative RMS)
Displacement Noise [m/rtHz], RMS [m]
Frequency [Hz]
ETMX
ETMY
ITMX
ITMY
BS
PR3
PR2
PRM
SR3
SR2
SRM

DARMへのカップリング

$$\Delta L(f) = c \cdot d_{\mathrm{spot}}(f) * \theta_{\mathrm{Mirror}}(f)$$



制御しないと……

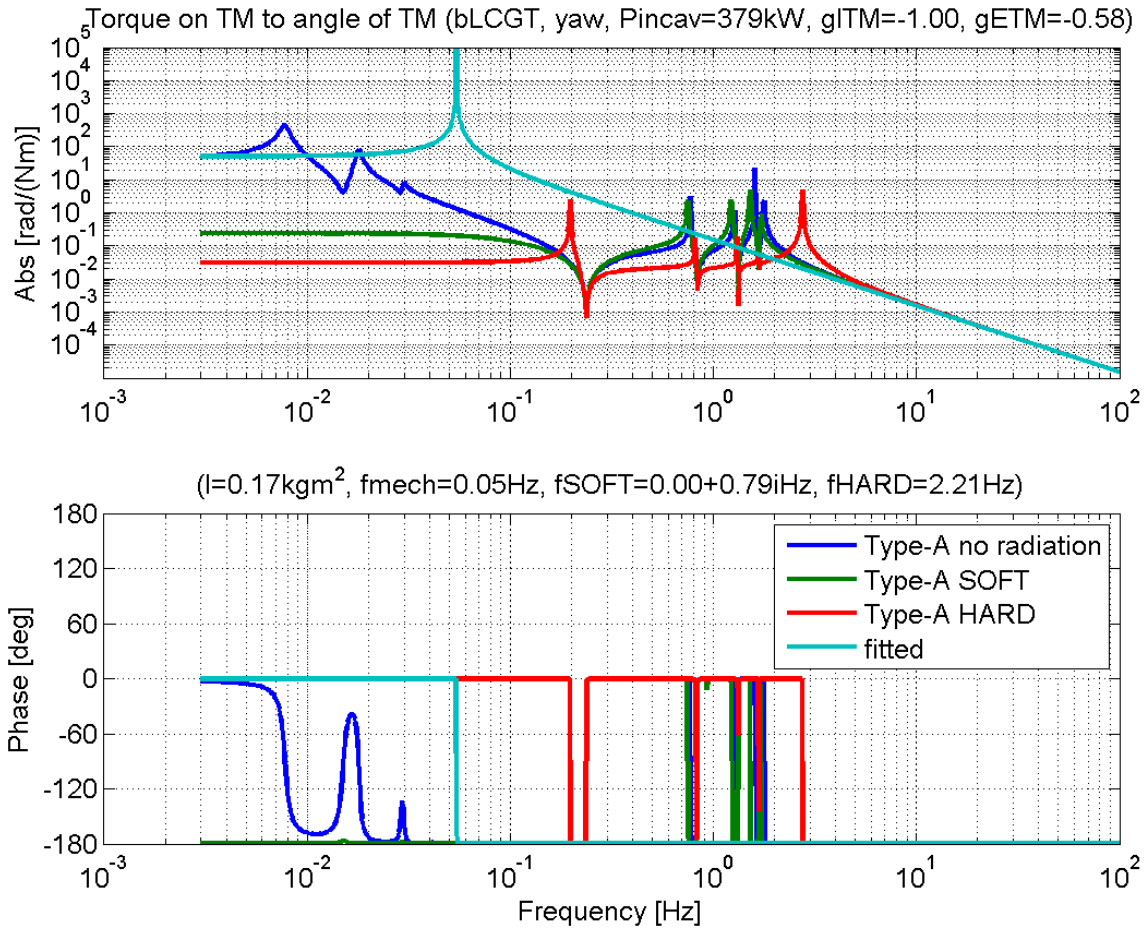

Angular Noise Coupling to DARM (pitch) (without ASC)
Displacement noise [m/rtHz]
Frequency [Hz]
ETMX
ETMY
ITMX
ITMY
BS
PR3
PR2
PRM
SR3
SR2
SRM
bLCGT sensitivity

bLCGT ASC for yaw
(negative g-factorの場合)

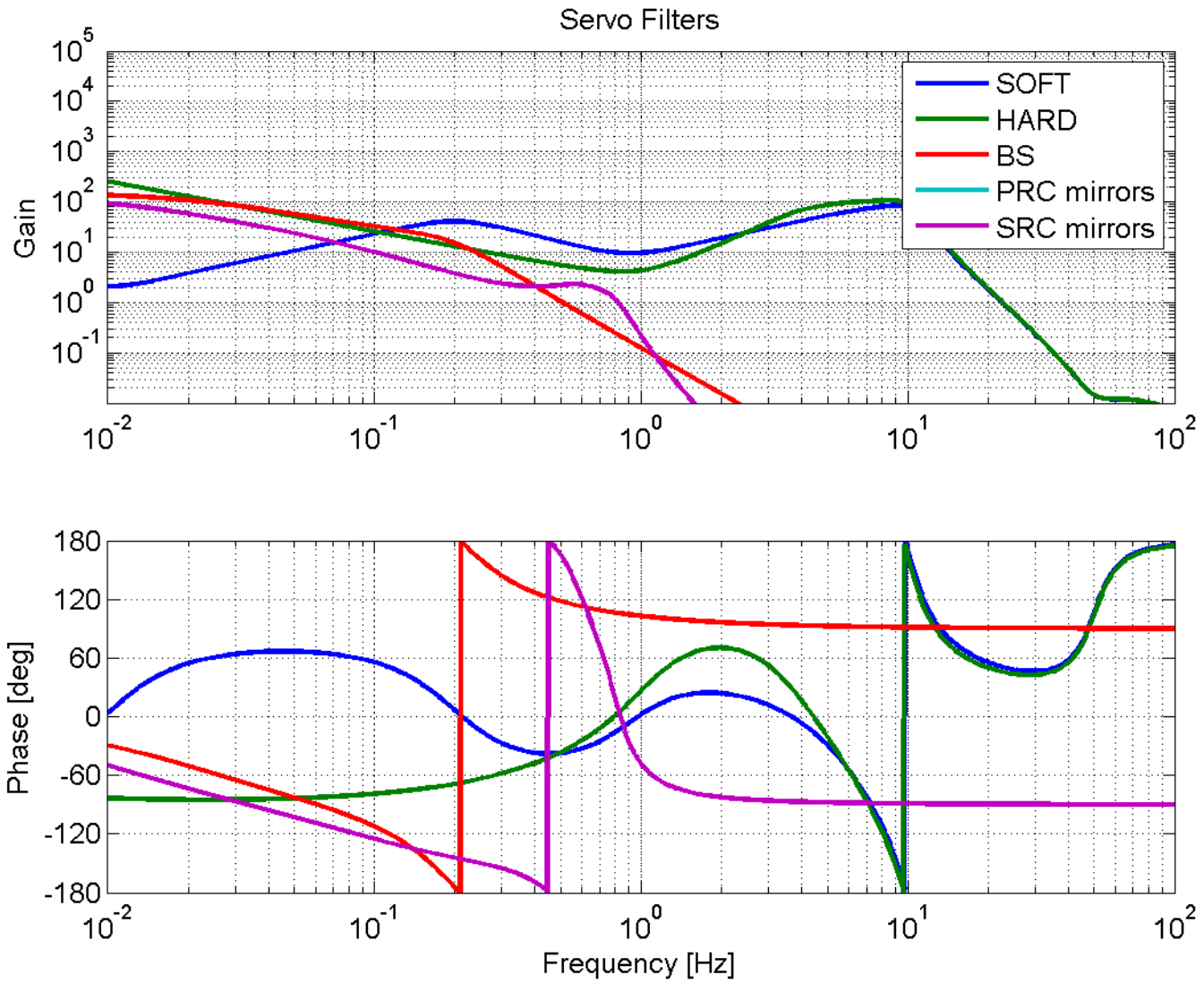
Opto-mechanical TF

- リコイルマスに加えたトルクから鏡の角度へのTF(pitch)
  青が輻射圧(Pincav=379kW)下で緑と赤に

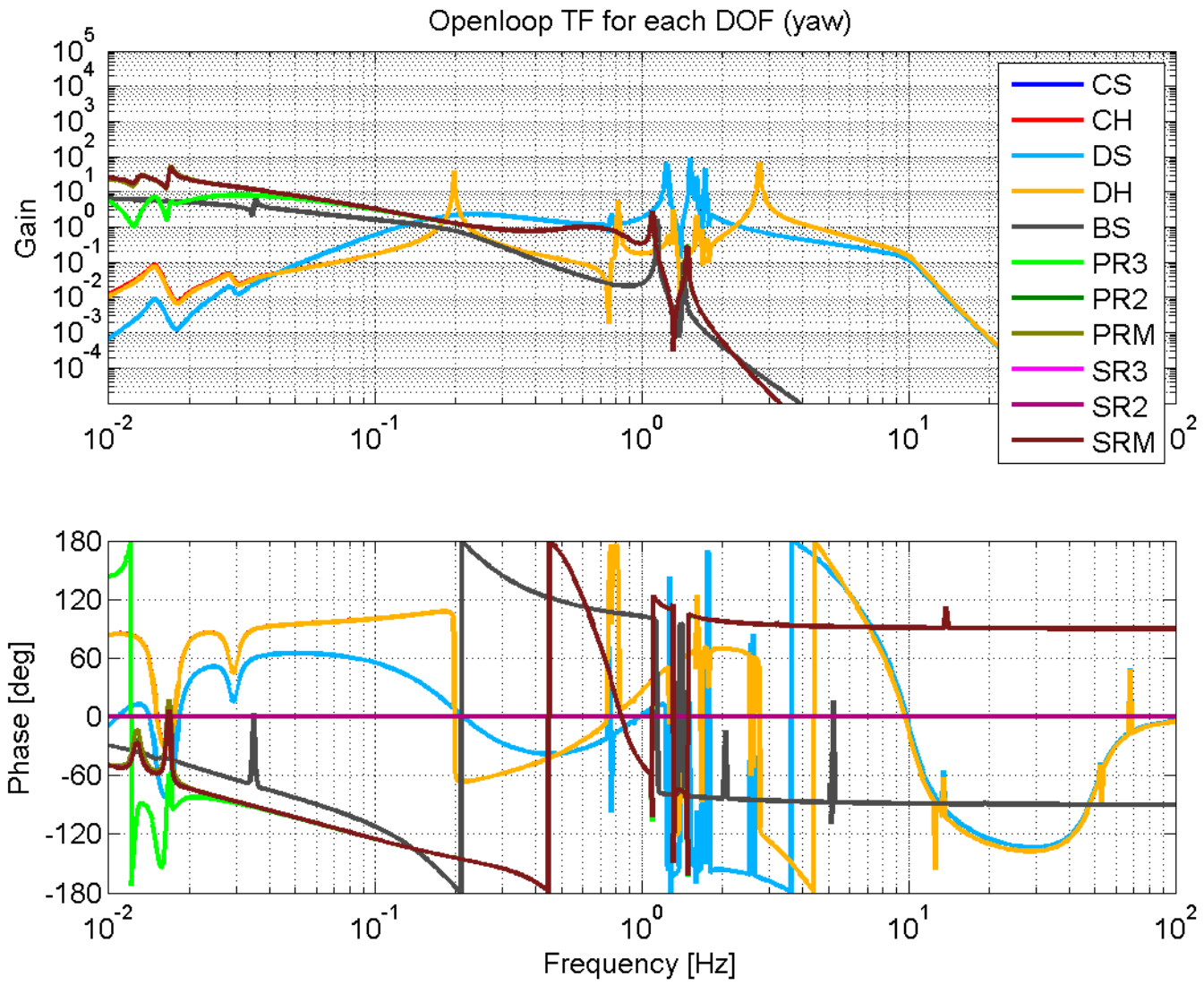
SOFTモードは
unstable
(0.8Hzあたりまで制御必要)



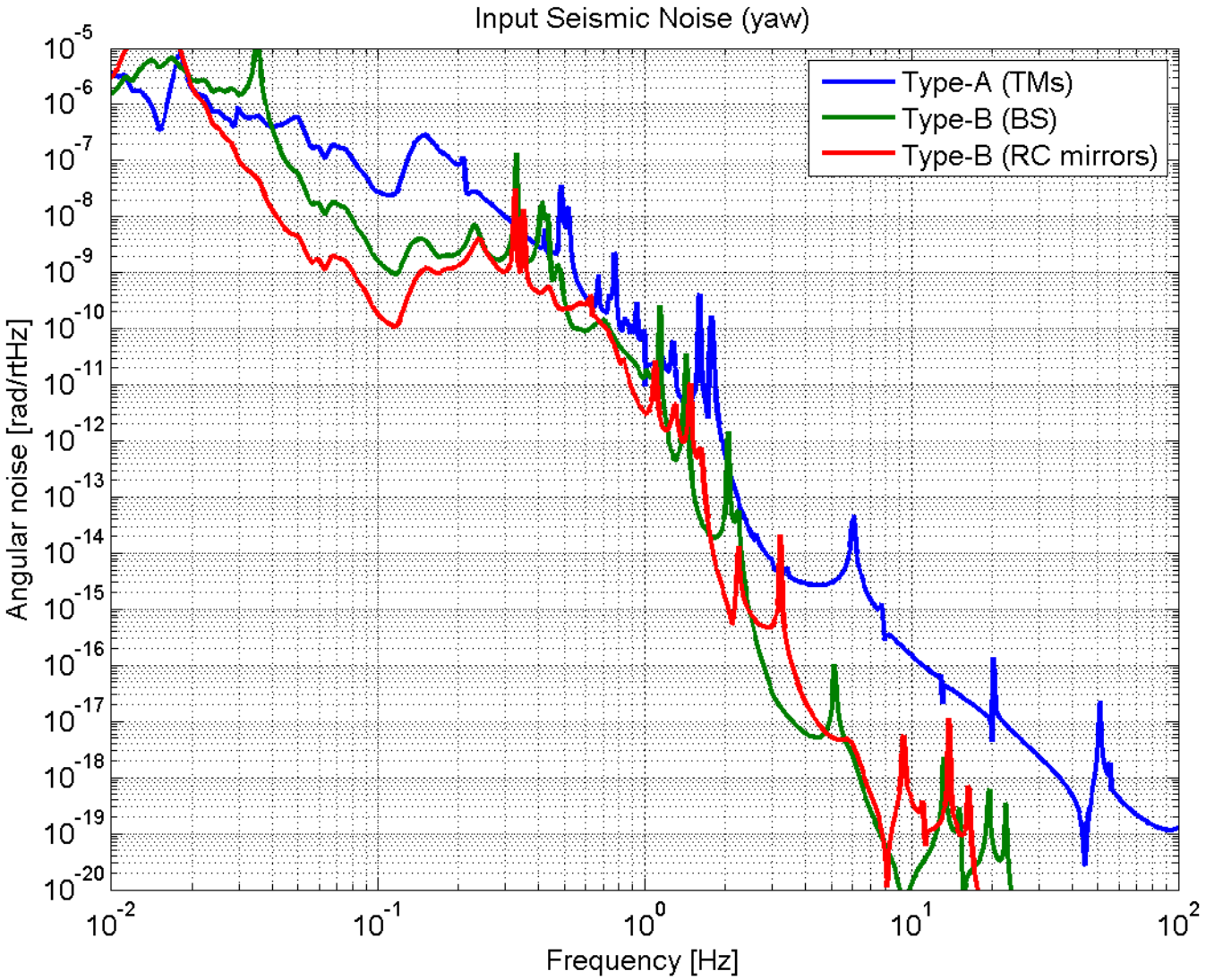
制御フィルタ


Servo Filters
Gain
SOFT
HARD
BS
PRC mirrors
SRC mirrors
Phase [deg]
Frequency [Hz]

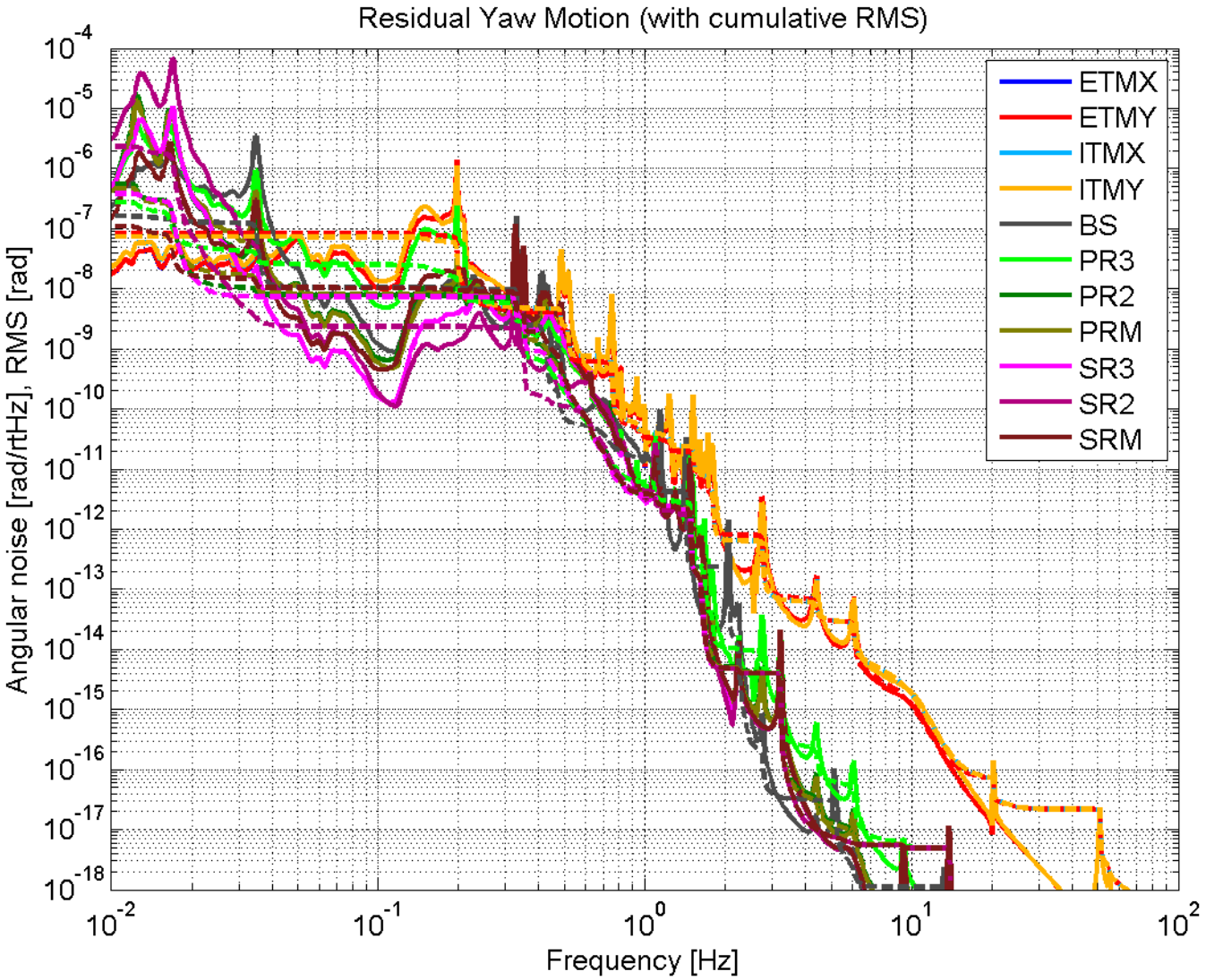
オープンループ伝達関数



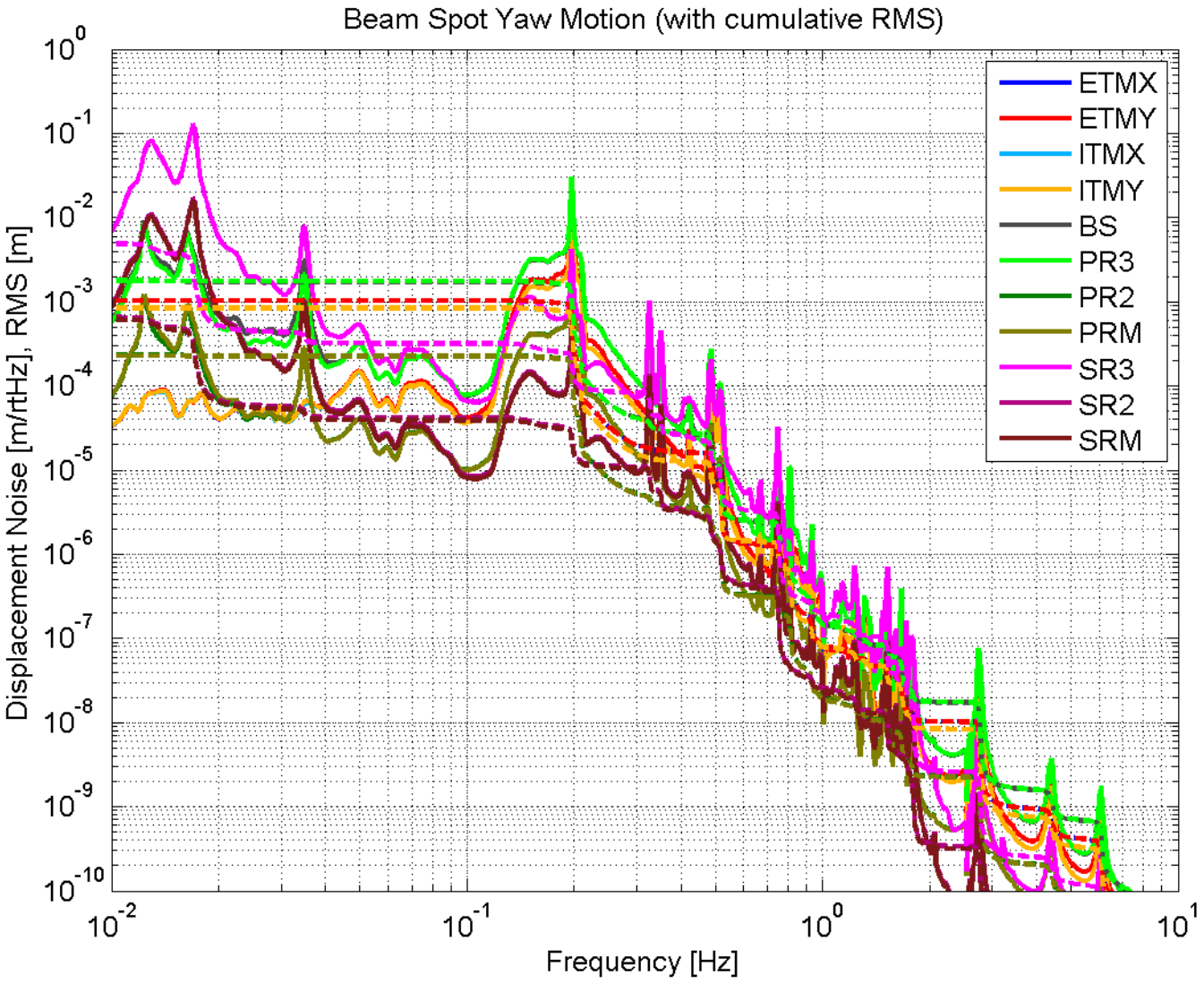
地面振動による角度揺れ



残留角度揺れ

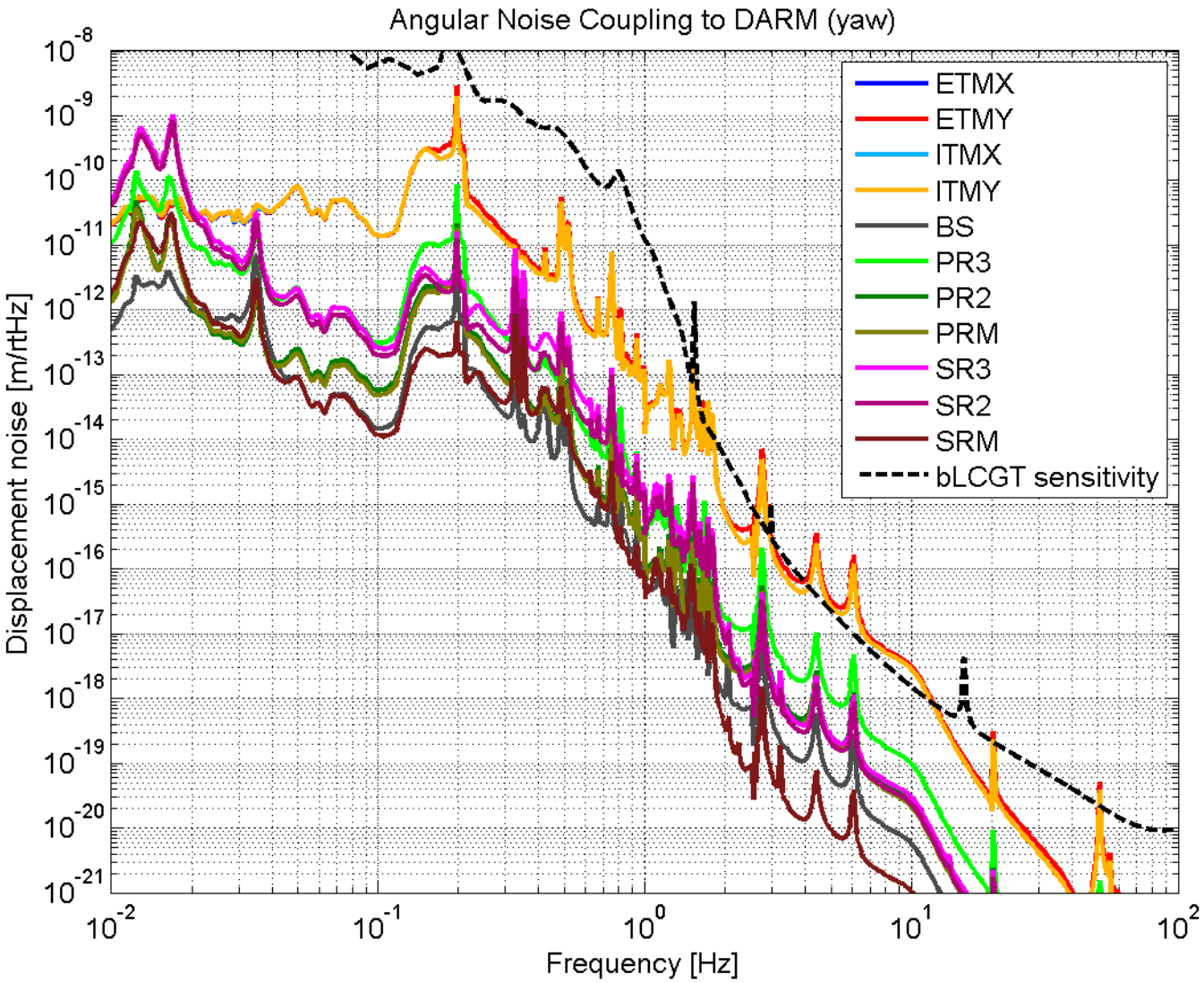

Residual Yaw Motion (with cumulative RMS)
Angular noise [rad/rtHz], RMS [rad]
Frequency [Hz]
ETMX
ETMY
ITMX
ITMY
BS
PR3
PR2
PRM
SR3
SR2
SRM

ビームスポットの動き

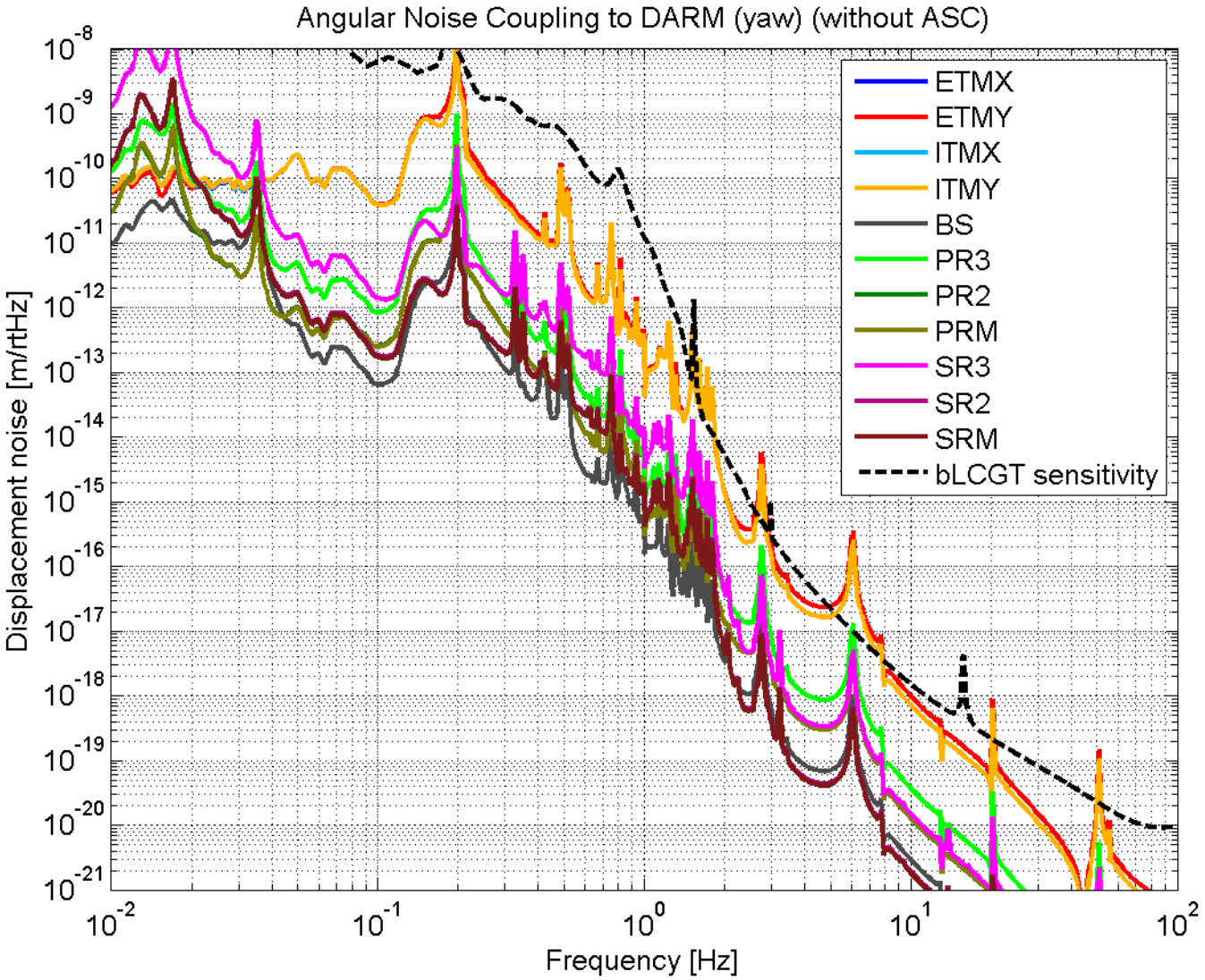

Beam Spot Yaw Motion (with cumulative RMS)
Displacement Noise [m/rtHz], RMS [m]
Frequency [Hz]
ETMX
ETMY
ITMX
ITMY
BS
PR3
PR2
PRM
SR3
SR2
SRM

DARMへのカップリング

$$\Delta L(f) = c \cdot d_{\mathrm{spot}}(f) * \theta_{\mathrm{Mirror}}(f)$$



制御しないと……

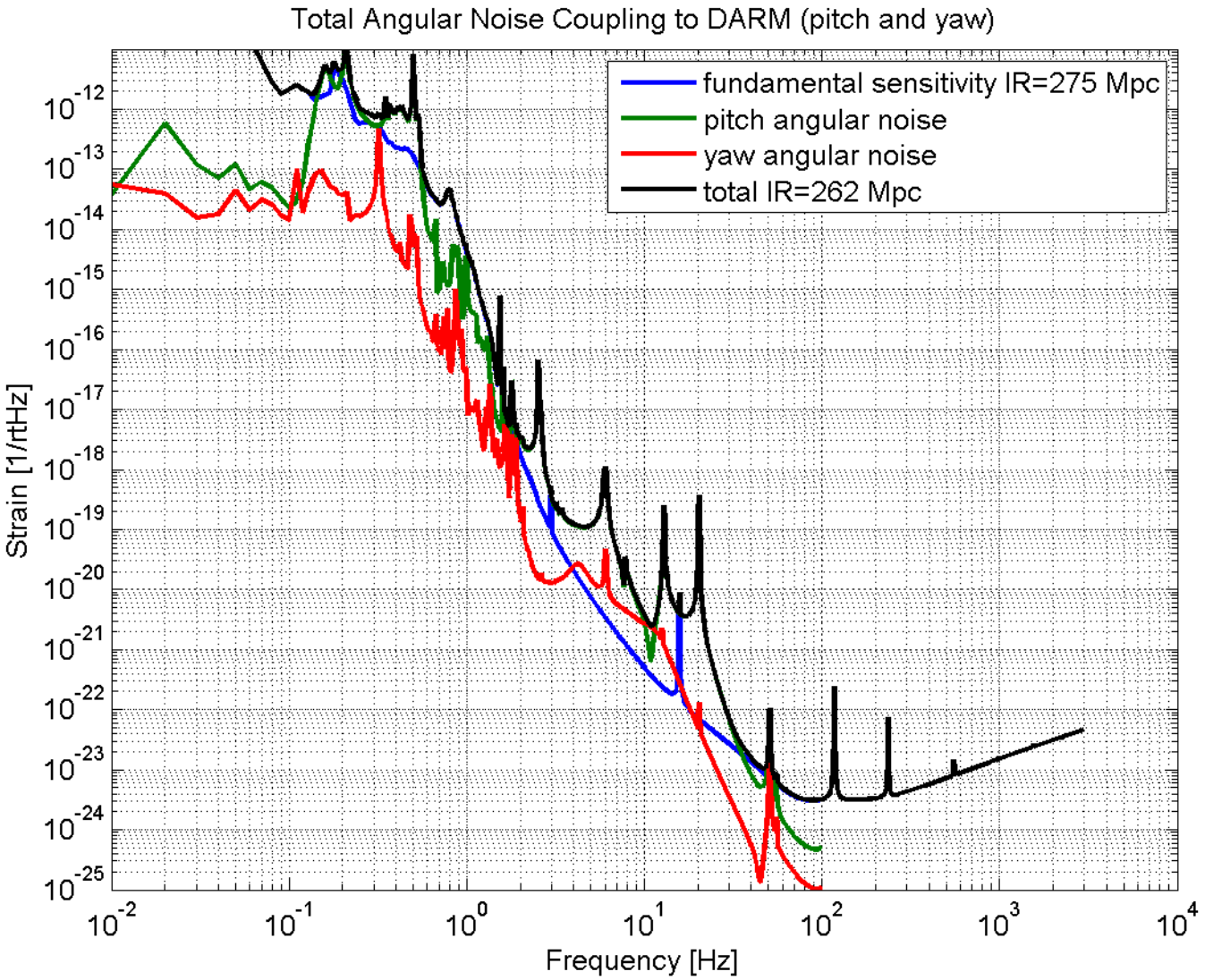

Angular Noise Coupling to DARM (yaw) (without ASC)
Displacement noise [m/rtHz]
Frequency [Hz]
ETMX
ETMY
ITMX
ITMY
BS
PR3
PR2
PRM
SR3
SR2
SRM
bLCGT sensitivity

positive/negative
それぞれの場合のIR

IR計算の積分は
10 Hzから1.6 kHzまで

positiveの場合

サスペンションのデザイン(pitch)がまだWFSの散者雑音を気にする段階に達していない



IR計算の積分は
10 Hzから1.6 kHzまで

negativeの場合

それでも若干negativeの方がいいのは曲率半径が小さい分、テストマスの傾きによるビームスポットの動きが小さいから