WEPV003

THE DYNAMIC MODELING AND THE CONTROL ARCHITECTURE OF THE NEW HIGH-DYNAMIC DOUBLE-CRYSTAL MONOCHROMATOR (HD-DCM-Lite) FOR SIRIUS/LNLS

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Double Crystal Monochromator

Figure 1. Double Crystal Monochromator.

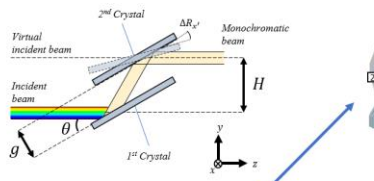
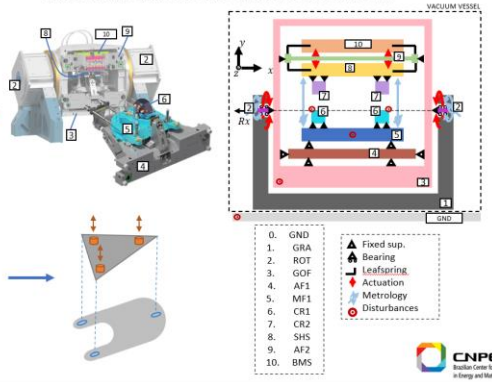


Figure 2. High-Dynamics Double-Crystal Monochromator Lite.



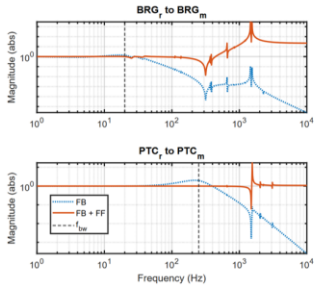
BRG → Energy Selection (CR1)
GAP → Vertical Displacement
PTC → Energy Selection (CR2)
RLL → Horizontal Displacement

Crystal Cage (CCG)

Control Architecture

- Independent SISO systems (BRG, GAP, PTC, RLL)
- Second-order system approximation
- Robust feedback controllers via loop-shaping
  - Simple PID with practical "rules of thumb"
  - A few notches added for stability
- Feedforward in order to expand scanning frequency possibilities

Figure 3. BRG and PTC transfer functions for feedback (closed-loop) and feedback plus feedforward.



Disturbance Models

- Mechanical
  - Ground vibrations (GND)
  - Flow-Induced Vibrations (FIV)
- Electronic
  - Sensors
  - Actuators
  - Sub-divisional Errors (SDE)

Sub-divisional Errors (SDE)

- Periodic errors
- Encoders and Interferometers
- Interpolation errors
- Frequency dependent

Figure 4. SDE Power Spectrum Density.

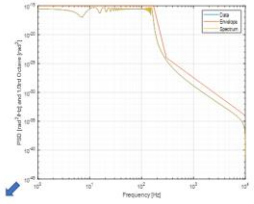
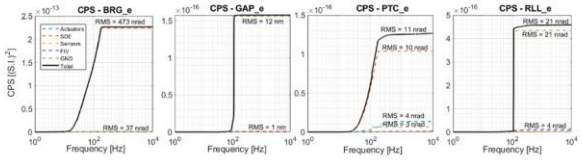


Figure 5. Cumulative power spectrum of control error in simulation for all disturbance sources.



Performance Predictions

Figure 6. In position stability, HD-DCM to HD-DCM-Lite comparison.

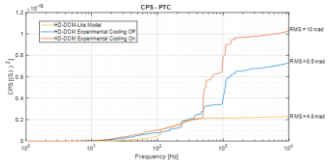
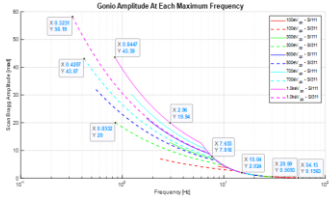


Table 1. Control error RMS for different scan amplitudes θ_A and frequencies f between 1 Hz to 2.5 kHz

θ_A [nrad]	f [Hz]	BRG_e [nrad]	GAP_e [nm]	PTC_e [nrad]	RLL_e [nrad]
60	0.3	470	12	11	21
40	0.4	450	12	11	21
40	0.9	430	12	9.6	21
20	0.9	460	12	11	21
20	3.0	780	12	13	21
7.0	2.4	1000	12	22	21
8.0	7.7	1600	12	24	22
2.0	15	1800	13	36	22
0.5	30	1300	13	30	22
0.2	54	1600	13	38	22
No SDE:		55	12	4.8	21
Spec:		150	300	10	90

Figure 7. Representative scan conditions.



- SDE is the main additional noise during scans, specially on BRG loop
- Leading signal for CCG comes from BRG reference instead of sensor

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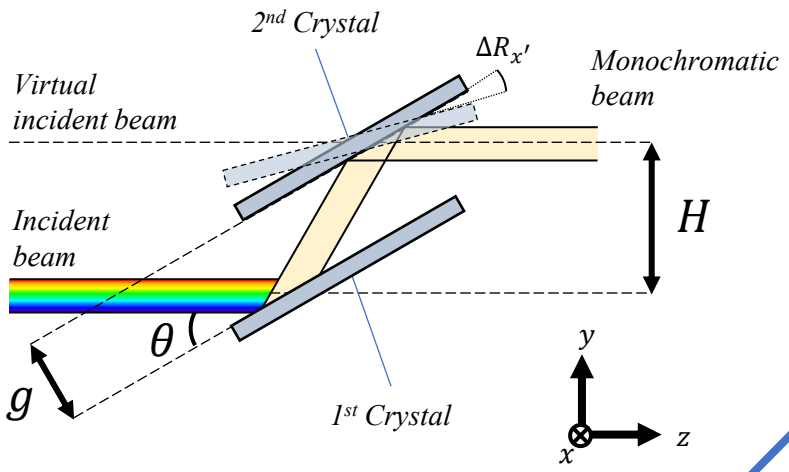

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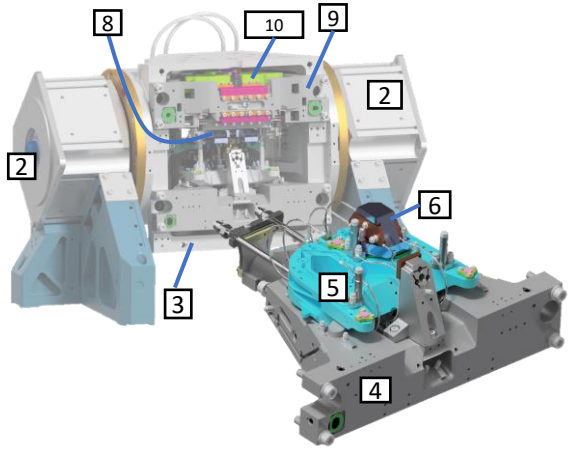

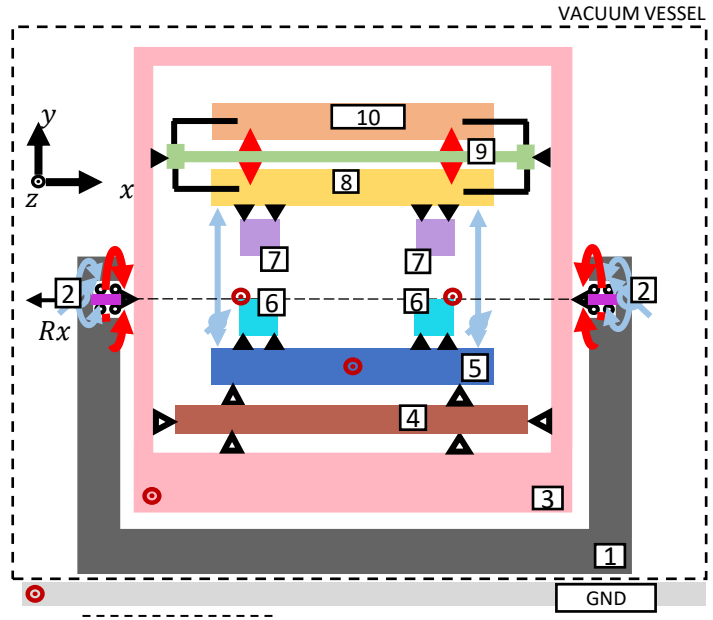

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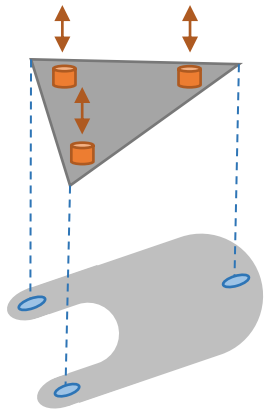

0.	GND
1.	GRA
2.	ROT
3.	GOF
4.	AF1
5.	MF1
6.	CR1
7.	CR2
8.	SHS
9.	AF2
10.	BMS

Fixed sup.
Bearing
Leafspring
Actuation
Metrology
Disturbances

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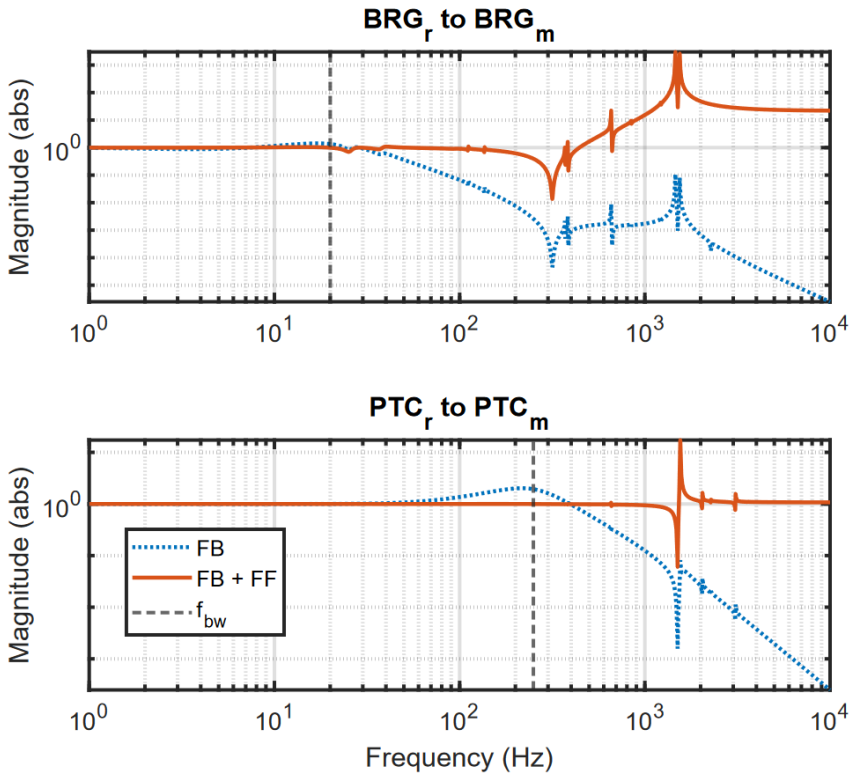

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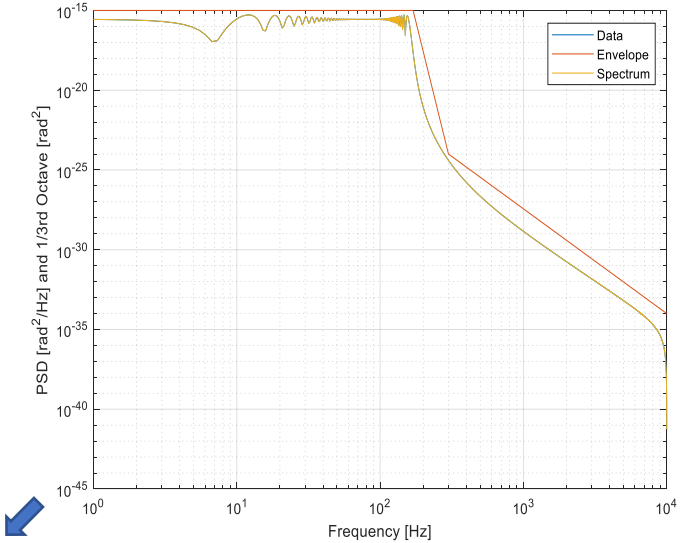
$f = 0.3$ Hz $\quad \theta_A = 0.06$ rad



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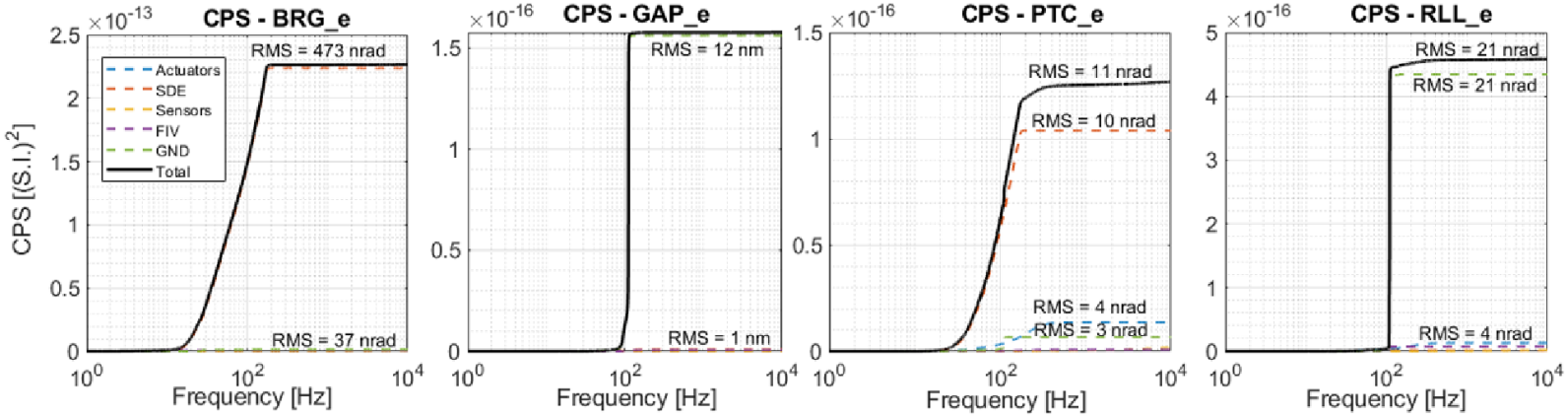

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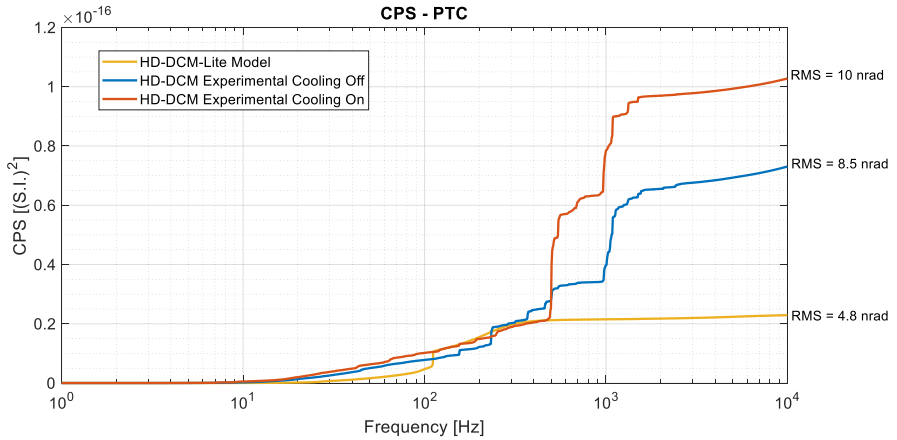

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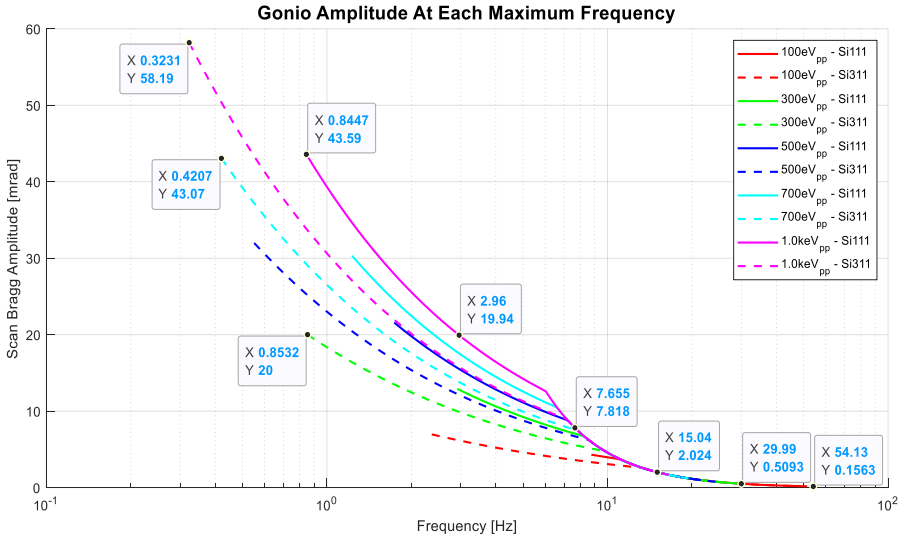

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