

Evaluation of the pointing accuracy of the X-Ray Imaging and Spectroscopy Mission (XRISM) during the first year

(13 May 2025, IACHEC)

Yoshiaki Kanemaru^[1],

Ryo lizuka^[1], Yoshitomo Maeda^[1], Kazuhiro Kiyokane^[2], Takashi Kominato^[2], Yuto Nihei^[2], Chikara Natsukari^[1], Shin Watanabe^[1], Manabu Ishida^[1], Takashi Okajima^[3], Takayuki Hayashi^[3], Kosuke Sato^[4], Yukikatsu Terada^[1, 4], and SOT members

([1]: ISAS/JAXA, [2] NEC, [3] GSFC/NASA, [4] Saitama University)

Contents



- 1. Introduction
- 2. Aimpoint shift
- 3. Control and determination accuracies

Exploded schematic view of XRISM

X-Ray Imaging and Spectroscopy Mission



- XRISM carries three star trackers (STTs) on the top panel and two inertial reference units (IRUs) on the base plate. These components are mainly used for pointing determination.
- In the normal mode, the attitude is controlled using two STTs as long as there is no earth occultation blocking their FOV. If this condition isn't met, IRUs take over the attitude control.

Status of pointing accuracy evaluation

Risk X-Ray Imaging and Spectroscopy Mission



Commissioning phase:

2024/8/31

- The onboard alignment matrix has been updated.
- The Xtend nominal aimpoint has been updated as the CALDB parameters.
- Pointing requirements were met under a conservative evaluation.

• Verification was based on < 1 month of data, mainly observed before the second alignment-matrix update.

 \rightarrow Long-term performance was evaluated with the PV data (> 2 Ms)

Observations

TargetObs-IDNominal attitude $ \theta_{SuxX}, \theta_{SuxZ} $ Z-sun angleNote angleAbell231900011000 $(^200.2999, 43.923, 256.2165)$ (-6.1, -8.0)96.13Abell231900013000 $(^200.2972, 43.9447, 256.2134)$ (-3.4, -2.2)93.4 $^3(Verification)$ AD-Pc000116000 $(^203.9272, 43.9447, 256.2143)$ (-3.4, -2.2)93.3 $^4(Case 5)$ AD-Pc000116000 $(^243.8229, -3.1782, 248.660)$ (-18.7, 0.0)108.7 $^4(Case 4)$ LMC.X-3.Case5000119000 $(^24.7384, -64.0853, 154.423)$ (-3.4, -2.0)93.2 $^4(Case 1)$ LMC.X-3.Case5000112000 $(^24.7384, -64.0853, 154.423)$ (-3.4, -2.0)93.2 $^4(Case 1)$ LMC.X-3.Case5000112000 $(^24.7384, -64.0853, 154.423)$ (-3.4, -2.0)93.2 $^4(Case 1)$ LMC.X-3.Case500012000 $(^28.738, -64.0856, 153.209)$ (-3.1, -0.9)86.95NGC415100013000(182.6345, 93.4065, 106.6398)(-16.6, -0.2)10.65NGC45100013000(185.274, -40.5541, 154.797)(-20.4, 2.0)110.25Vela.X-1.4000142000(155.274, -40.5541, 154.2403)(-20.2, 0.3)110.75Vela.X-1.5000144000(155.274, -40.5541, 154.2403)(-20.2, -0.0)100.25Vela.X-1.4000142000(155.274, -40.5541, 154.2403)(-20.2, -0.0)100.25Vela.X-1.4000142000(155.274, -40.5541, 154.2403)(-20.2, -0.0)100.25Crea.X-3							1
Abell 219 Other (A), Dec, Roll) Constraints and/e Angle Constraints Abell 2319 Cori 000101000 ² (200.297, 43.9447, 256.2140) (-4.8, 5.2) 94.8 ³ (Verification) Abell 2319 Cori 000102000 ² (200.297, 43.9446, 256.2140) (-4.8, 5.2) 94.8 ³ (Verification) AD, Pac 000110000 ² (84.7376, -64.0857, 154.4243) (-3.2, -0.0) 93.2 ⁴ (Case 5) LMC, X-3. Casel 000121000 ² (84.7384, -64.0850, 153.4133) (-3.4, -2.00) 93.2 ⁴ (Case 1) EBL Carrinac 000121000 ² (84.7384, -64.0850, 153.029) (-3.1, -0.1) 93.1 ⁴³ (Verification) NGC4151 000120000 ² (84.7384, -64.0850, 153.029) (-3.1, -0.1) 93.1 ⁴³ (Verification) Velax X-1.1 000120000 ¹ (84.7360, -64.0856, 115.2029) (-3.1, -0.1) 9.1 ⁴³ (Verification) Velax X-1.4 000140000 (135.5274, -0.05540, 151.4777 (-2.0.1) 10.6 5 Velax X-1.4 000142000 (135.5274, -0.05541, 159.4203) (-2.0.9, 2.0) 110.9 5 </td <td>Target</td> <td>Obs-ID</td> <td>Nominal attitude</td> <td>$^{1}(\theta_{sunv}, \theta_{sun7})$</td> <td>Z-sun</td> <td>Note</td> <td></td>	Target	Obs-ID	Nominal attitude	$^{1}(\theta_{sunv}, \theta_{sun7})$	Z-sun	Note	
$ \begin{array}{llllllllllllllllllllllllllllllllllll$			(RA, Dec, Roll)	(Sull , Sull)	angle	1	
Abell 2319_Cor1 000102000 -(20.2972, 43.9447, 526.2140) (-4.8, 5.2) 93.8 ⁴ (Verification) Abell 2319_0071 000103000 ² (20.2972, 43.9447, 556.2143) (-3.4, 2.2) 93.4 ⁴ (Case 3) AD Pac 000116000 ² (8.47380, 64.0857, 154.8243) (-3.4, 2.0.0) 93.2 ⁴ (Case 3) JMC X-3. Case1 000120000 ² (8.47380, 64.0853, 154.4243) (-3.2, 0.0) 93.2 ⁴ (Case 3) JMC X-3. Case1 000120000 ² (8.47380, 64.0853, 154.2243) (-3.2, 0.0) 93.2 ⁴ (Case 3) JMC X-3. Case1 000120000 ² (8.47380, 64.0853, 154.2243) (-3.2, 0.0) 93.2 ⁴ (Case 2) LMC X-3. Case1 00012000 (182.6344, 93.4065, 106.6398) (-3.1, -0.1) 95.4 ⁴ (Case 2) Vela X-1.1 00013000 (135.527, 40.554, 147.499) (-20.2, 0.3) 110.2 5 Vela X-1.4 000142000 (135.527, 40.554, 147.499) (-20.2, 0.3) 110.7 5 Vela X-1.4 000143000 (135.527, 40.554, 147.499) (-20.2, 0.3) 110.7 5 Vela X-1.5 000141000 (135.527, 40.554, 147.499) (-20.2, 0.3) </td <td>Abell2319</td> <td>000101000</td> <td>²(290.2999, 43.9232, 256.2165)</td> <td>(-6.1, -8.0)</td> <td>96.1</td> <td></td> <td></td>	Abell2319	000101000	² (290.2999, 43.9232, 256.2165)	(-6.1, -8.0)	96.1		
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	Abell2319_Cor1	000102000	2(290.2972, 43.9447, 256.2140)	(-4.8, 5.2)	94.8	³ (Verification)	
LMC X-3. Case 5 000115000 {*(347376, -64.0857, 168.8675) {<:35, 20.0)	Abell2319	000103000	2(290.2972, 43.9446, 256.2134)	(-3.4, -2.2)	93.4	³ (Verification)	
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	LMC_X-3_Case5	000115000	² (84.7376, -64.0857, 168.8675)	(-3.5, 20.0)	93.3	⁴ (Case 5)	
LMC X-3. Case 3 000119000 ¹ {(44,738, -64.085, 133.4133) (-3.4, -20.0) 93.2 ⁴ (Case 3) LKC X-3. Case 1 000121000 ² {(161.2671, -59.6845, 89.7839) (23.8, -0.0) 66.2 ⁴ (Case 2) LMC X-3. Case 1 000121000 ² {(161.2671, -59.6845, 89.7839) (23.8, -0.0) 66.2 ⁴ (Case 2) LMC X-3. Case 1 000127000 (182.6349, 39.4065, 121.1046) (310.1) 93.1 ⁴⁻⁵ (Verins case) NGC4151 000137000 (182.6349, 39.4065, 10.66.398) (-16.6, -0.2) 106.6 5 Vela. X-1.1 00014000 (135.527, 40.5541, 154.4799) (-20.2, -3.3) 110.6 5 Vela. X-1.5 00014000 (135.527, 40.5541, 152.4203) (-20.7, 0.3) 110.7 5 Vela. X-1.6 00014000 (135.527, 40.5541, 152.4203) (-20.7, 0.3) 110.7 5 Vela. X-1.6 00014000 (135.527, 40.5541, 152.4201) (-11.2, -3.1) 11.1 5 GCG-63.015 00014000 (135.527, 40.5541, 152.4901) (-11.4, 0.1) 101.4 5 Cremus. X-1 300003010 (20.3737, -40.529, 118.8210) (-21.4, -2.3) 111.5	AO_Psc	000116000	2(343.8229, -3.1782, 248.6630)	(-18.7, 0.0)	108.7	⁴ (Case 4)	
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	LMC_X-3_Case3	000119000	² (84.7384, -64.0850, 133.4133)	(-3.4, -20.0)	93.2	⁴ (Case 3)	
End Carrinac 000121000 ² (161.2671, -59.6845, 89.7839) (23.8, -0.0) 66.2 ⁴ (Verification) NGC 451 00012000 (84.736, 0.640.836, 165.0209) (-3.1, -0.9) 86.9 5 PKS2155-304 000127000 (182.6349, 39.4065, 166.60.92) (16.6, -0.2) 106.6 5 Velax X-1.1 000130000 (185.5275, -40.5538, 149.4804) (-20.2, 0.3) 110.2 5 Velax X-1.2 000140000 (135.5276, -40.5541, 150.4202) (-20.7, 0.3) 110.6 5 Velax X-1.4 00014000 (135.5276, -40.5541, 150.4202) (-20.7, 0.3) 110.7 5 Velax X-1.6 000144000 (135.5276, -40.5541, 150.4202) (-20.7, 0.3) 110.1 5 Velax X-1.6 000144000 (135.5276, -40.5541, 152.4203) (-20.9, 2.0) 110.4 5 Crem X-3 300003010 (170.3127, -60.6239, 156.7998) (-13.7, 0.3) 103.7 5 Cryg X-3 300006010 (243.666, 1.47.3292, 9.1789) (53.6, -0.2) 10.4 5 GX13+1 300026010 (247.0120, -49.1981,	LMC_X-3_Case1	000120000	² (84.7380, -64.0853, 154.4243)	(-3.2, -0.0)	93.2	⁴ (Case 1)	
LMC.X.3.2.Gase1 000124000 (84,7360, -64.0386, 163.2029) (-3.1, -0.1) 93.1 4 ³ (Verification) NGC4151 000127000 (182.6349, 93.0405, 121.1046) (3.1, -0.9) 86.9 5 NGC4151 000137000 (182.6345, 39.4005, 106.6398) (-16.6, -0.2) 106.6 5 Vela.X.1.1 00014000 (135.527, 40.5534, 149.4804) (-20.2, 0.3) 110.2 5 Vela.X.1.4 00014000 (135.527, 40.5541, 150.4202) (-20.7, -2.3) 110.4 5 Vela.X.1.4 00014000 (135.527, 40.5541, 150.4202) (-20.7, 0.3) 110.7 5 Vela.X.1.4 00014000 (135.527, 40.5541, 150.4202) (-20.7, 0.3) 110.7 5 Crcrians.X.1 00014000 (135.527, 40.5541, 152.4203) (-20.2, 0.1) 100.2 5 MCG-6-30-15 000161000 (203.9737, -34.2951, 118.1216) (-11.4, 0.1) 101.4 5 Crcrians.X.1 3000050101 (203.0737, -34.2951, 118.1216) (-11.4, 0.1) 101.4 5 Cyg.X.3 3000050101 (204.029, 11.5288) (26.3, -0.2) 63.7 5 Cyg.X.3	Eta_Carinae	000121000	² (161.2671, -59.6845, 89.7839)	(23.8, -0.0)	66.2	⁴ (Case 2)	
NGC4151 000125000 (182,6349, 39.4065, 121,1046) (3.1, -0.9) 86.9 5 PKS2155.304 000127000 (182,6349, 39.4065, 126,6398) (-16,6, -0.2) 106.6 5 Vela.X-1.1 000137000 (182,6345, 39.4065, 106,6398) (-16,6, -0.2) 106.6 5 Vela.X-1.2 000140000 (135,527, -40.5544, 147,4799) (-20,4, 2.0) 110.6 5 Vela.X-1.5 000140000 (135,527, -40.5544, 152,4202) (-20,9, 2.0) 110.9 5 Vela.X-1.5 000140000 (135,527, -40.5544, 152,4203) (-21, -2.3) 111.1 5 3C273 000140000 (135,527, -40.5544, 147,4799) (-20, -2, 0.0) 100.2 5 Cricnius.X-1 300003010 (170,3127, -60,6239, 156,7998) (-13, -0.1) 101.4 5 Cricnius.X-1 300003010 (273,5036, -17,1567, 91,3903) ⁴ (-23, -0.4) 628, -5 - Xtend: ~2.5 Msec - Yulf624-490 300040101 (247,102, -49,1981, 12.2588) (-26, -0.1) 96.2 5 5 Cyg.X-3 3000450010 (235, 6776, 43,3581, 159.971) (-22, -0.1) 96.2 <t< td=""><td>LMC_X-3_Case1</td><td>000124000</td><td>(84.7360, -64.0836, 163.2029)</td><td>(-3.1, -0.1)</td><td>93.1</td><td>^{4 5} (Verification)</td><td>Observation used in the analysis</td></t<>	LMC_X-3_Case1	000124000	(84.7360, -64.0836, 163.2029)	(-3.1, -0.1)	93.1	^{4 5} (Verification)	Observation used in the analysis
PKS2155-304 000127000 (329.7174, -30.2250, 256.5119) (23.2, 0.1) 66.8 5 NGC4151 000137000 (182.6345, 39.4065, 106.6398) (-16.6, -0.2) 100.6 5 Vela.X-1.1 000139000 (135.5275, -40.5538, 149.4804) (-20.2, 0.3) 110.6 5 Vela.X-1.3 000140000 (135.5276, -40.5541, 150.4202) (-20, 7, 0.3) 110.7 5 Vela.X-1.4 000140000 (135.5276, -40.5541, 150.4202) (-20, 9, 2.0) 110.6 5 Vela.X-1.5 000140000 (135.5276, -40.5541, 150.4202) (-20, 9, 2.0) 110.7 5 Sc.77 000145000 (135.5276, -40.5541, 12.4203) (-20, 9, 2.0) 110.2 5 Gc.n.X-3 3000030100 (170.3127, -60.6239) 156.7998) (-13.7, 0.3) 103.7 5 Cyg.X-3 300065010 (230.6776, -43.564, 112.4290) (-21, 2, -0.1) 76.1 5 Sy.CYGNI 300040010 (247.0103, -49.1981, 126.9970) (-24, -0.2) 102.4 5 SS.CYGNI 3000407020 (182.652, 39.4068, 308.8715) (-12, 4, -0.2) 102.4 5 SS.CYGNI 300	NGC4151	000125000	(182.6349, 39.4065, 121.1046)	(3.1, -0.9)	86.9	5	
NGC4151 000137000 (182.6345, 39.4065, 106.6398) (-16.6, -0.2) 100.6 5 Vela.X-1.2 000140000 (135.5275, 40.5538, 149.4804) (-20.2, 0.3) 110.2 5 Vela.X-1.2 000140000 (135.5274, 40.5540, 151.4797) (-20.4, 2.0) 110.4 5 Vela.X-1.4 00014000 (135.5276, 40.5541, 150.4202) (-20.7, 0.3) 110.6 5 Vela.X-1.5 00014000 (135.5276, 40.5541, 152.4202) (-20.7, 0.3) 110.7 5 Vela.X-1.6 00014000 (135.5276, 40.5541, 152.4203) (-20.2, -0.0) 100.2 5 Vela.X-1.6 00014000 (135.5276, 40.5541, 182.4203) (-21.1, -2.3) 111.1 5 30273 00014000 (135.757, 40.5541, 183.216) (-11.4, 0.1) 101.4 5 Cricinus.X-1 300028010 (230.1706, 57.1665, 103.9934) (64, 0.2) 83.6 5 GX13-1 300036010 (247.0103, 49.198, 112.5997) (-24.2, 14.1) 113.5 5 Cyg.X-3 300040010 (247.0103, 49.198, 115.9971) (-24.2, -11.9) 66.2 5 SS.CYGNI 300040020	PKS2155-304	000127000	(329.7174, -30.2250, 256.5119)	(23.2, 0.1)	66.8	5	 Point sources were observed
Vela X-1.1 000139000 (135,5275, 40,5538, 149,4804) (-20.2, 0.3) 110.2 5 Vela X-1.2 000140000 (135,5274, 40,5540, 151,4777) (-20,4,2.0) 110.4 5 Vela X-1.3 000141000 (135,5276, 40,5541, 150,4202) (-20,7,0.3) 110.7 5 Vela X-1.5 000143000 (135,5276, 40,5541, 150,4202) (-20,7,0.3) 110.7 5 Vela X-1.6 000144000 (135,5276, 40,5541, 152,4203) (-20,2,0,2.0) 110.9 5 30273 000145000 (135,5276, 40,5541, 152,4203) (-21,1,-2.3) 111.1 5 30273 000145000 (135,5278, 40,5545, 148,4201) (-11,4,0.1) 101.4 5 Circinus X-1 300003010 (170,6,57,1655, 103,9934) (-64,0.2) 83.6 5 Cyg X-3 300065010 (247,0103, -49,1981, 126,9970) (-24,2, 14,1) 113.5 5 CYGNUS X-1 300040010 (247,0103, -49,1985, 115,9971) (-27,9,0.2) 117.9 5 SCYGNI 300040010 (247,0103, -49,1985, 115,9971) (-27,9,0.2) 117.9 5 SS_CYGNI 300047020 <td< td=""><td>NGC4151</td><td>000137000</td><td>(182.6345, 39.4065, 106.6398)</td><td>(-16.6, -0.2)</td><td>106.6</td><td>5</td><td>as on-axis targets</td></td<>	NGC4151	000137000	(182.6345, 39.4065, 106.6398)	(-16.6, -0.2)	106.6	5	as on-axis targets
Vela.X-1.2 000140000 (135.5274, 40.5540, 151.4797) (-20.4, 2.0) 110.4 5 Vela.X-1.3 000140000 (135.5279, 40.5541, 150.4202) (-20.6, -2.3) 110.6 5 Vela.X-1.5 000142000 (135.5276, 40.5541, 152.4203) (-20.7, 0.3) 110.7 5 Vela.X-1.6 000144000 (135.5276, 40.5541, 152.4203) (-20.9, 2.0) 110.9 5 3C273 00014000 (135.5276, 40.5541, 152.4203) (-10.2, -0.0) 100.2 5 MCG-6-30-15 00016100 (203.9737, -34.2951, 118.1216) (-11.4, 0.1) 101.4 5 Cen.X-3 300003010 (170.3127, 60.6239, 156.799.8) (-13.7, 0.3) 103.7 5 GX13+1 300036010 (230.170.6, 57.1665, 103.9934) (64, 0.2) 83.6 5 Cyg.X-3 300040010 (247.0103, 49.1985, 115.9971) (-22.9, 0.2) 117.9 5 GYGUS_X-1 300040010 (247.0103, 49.1985, 115.9971) (-27.9, 0.2) 117.9 5 SS_CYGNI 300042020 (325.6778, 43.5860, 76.8692) (14.6, 0.3) 75.4 5 NGC4151 300047020 <	Vela_X-1_1	000139000	(135.5275, -40.5538, 149.4804)	(-20.2, 0.3)	110.2	5	
Vela.X-1.3 000141000 (135.5279, -40.5544, 147,4799) (-20.6, -2.3) 110.6 5 Vela.X-1.4 000142000 (135.5276, -40.5541, 150.4202) (-20.7, 0.3) 110.7 5 Vela.X-1.5 000144000 (135.5276, -40.5541, 152.4203) (-20.9, 2.0) 110.9 5 Vela.X-1.6 000144000 (135.5276, -40.5541, 152.4203) (-20.9, 2.0) 110.9 5 XCG-6-30-15 00014000 (137.5764, 2.0529, 112.4320) (-10.2, -0.0) 100.2 5 Cricrinus.X-1 300028010 (20.3)737, -34.2951, 118.1216) (-11.4, 0.1) 101.4 5 Cyg.X-3 300005010 (230.1706, -57.1665, 103.9934) (-64, 0.2) 83.6 5 4U1630-472 900001010 (248.5066, -47.3929, 91.7899) (15.3, -0.1) 74.7 5 GYI31+1 300036010 (230.1704, -57.1665, 103.9934) (-62, 02) 87.7 5 4U1624-490 300040020 (235.6775, 43.5860, 76.8692) (14.6, -0.3) 75.4 5 SCYGNI 300042000 (325.6780, 43.5827, 60.4388) (2.6, -0.2) 87.4 5 5 1 Nonial sun direction expressed by	Vela_X-1_2	000140000	(135.5274, -40.5540, 151.4797)	(-20.4, 2.0)	110.4	5	• Total natiovnogura:
Vela.X-1.4 000142000 (135.5276, 40.5541, 152.4203) (-20.7, 0.3) 110.7 5 - Resolve: ~2.8 Msec Vela.X-1.6 00014000 (135.5276, 40.5541, 152.4203) (-20.9, 2.0) 110.9 5 3C273 000145000 (187.2764, 2.0529, 112.4320) (-10.2, -0.0) 100.2 5 MCG-6-30-15 000161000 (203.9737, -34.2951, 118.1216) (-11.4, 0.1) 101.4 5 Cen.X-3 300003010 (170.3127, -60.6239, 156.798) (-13.7, 0.3) 103.7 5 GX13+1 300028010 (20.1706, 57.1665, 103.9934) (6.4, 0.2) 83.6 5 YU1624-490 300040010 (247.0120, 49.1981, 126.9970) (-22.2, -0.4) 62.8 5 CYGNUS_X-1 300040010 (247.0120, 49.1981, 12.9970) (-22.2, -0.4) 66.2 5 SCYGNI 300040010 (247.0120, 49.1981, 12.5987) (-27.9, 0.2) 117.9 5 SS_CYGNI 300042010 (225.6775, 43.5860, 76.8692) (14.6, -0.3) 75.4 5 SGC4151 300047020 (182.6359, 39.4058, 292.3487) (-9.4, -0.3) 80.6 5 NG	Vela_X-1_3	000141000	(135.5279, -40.5544, 147.4799)	(-20.6, -2.3)	110.6	5	• Total het exposure.
Vela_X-1.5 000143000 (135.5276, -40.5541, 152.4203) (-20.9, 2.0) 110.9 5 Vela_X-1.6 000144000 (135.5281, -40.5545, 148.4201) (-21.1, 2.3) 111.1 5 3C273 000145000 (187.2764, 2.0529, 112.4320) (-10.2, -0.0) 100.2 5 MCG-6-30-15 000161000 (203.9737, -34.2951, 118.1216) (-11.4, 0.1) 101.4 5 Cen_X-3 30003010 (170.3127, -60.6239, 156.7998) (-13.7, 0.3) 103.7 5 GX13+1 3000305010 (23.01706, -57.1665, 103.9934) (-6.4, 0.2) 83.6 5 Cyg_X-3 300065010 (308.1071, 40.9586, 112.2588) (26.3, -0.2) 63.7 5 4U1624-490 300040010 (247.0103, -49.1981, 126.9970) (-24.2, 14.1) 113.5 5 VGGNLS_X-1 300039010 (289.5894, -5.2380, 79.9732) (-6.2, -0.1) 96.2 5 SS_CYGNI 300040200 (325.6775, 43.5867, 60.4388) (2.6, -0.2) 87.4 5 NGC4151 300047030 (182.6358, 39.4058, 292.3487) (-9.4, -0.3) 80.6 5 NGC4151 300047040 <	Vela_X-1_4	000142000	(135.5276, -40.5541, 150.4202)	(-20.7, 0.3)	110.7	5	- Resolve: ~2.8 Msec
Vela_X-1.6 000144000 (135.5281, 40.5545, 148.4201) (-21.1, -2.3) 111.1 5 - Xtend: ~2.5 Msec 3C273 000145000 (187.2764, 2.0529, 112.4320) (-10.2, -0.0) 100.2 5 MCG-6-30-15 000161000 (203.9737, -34.2951, 118.1216) (-11.4, 0.1) 101.4 5 Cen_X-3 300028010 (203.1706, -57.1665, 103.9934) (6.4, 0.2) 83.6 5 4U1630-472 900001010 (248.5066, -47.3929, 91.7899) (15.3, -0.1) 74.7 5 GX13+1 300036010 (27.7, 60.0508, 112.2588) (26.3, -0.2) 63.7 5 4U1624-490 300040010 (247.0103, 49.1981, 126.9970) (-24.2, 14.1) 113.5 5 4U1916-053 300039010 (299.5897, 35.2012, 89.7827) (13.9, -0.6) 76.1 5 SS_CYGNI 300042020 (325.6775, 43.5860, 76.8692) (14.6, -0.2) 102.4 5 NGC4151 300047020 (182.6356, 39.4053, 929.23487) (9.4, -0.3) 80.6 5 SS_CYGNI 300047030 (182.6356, 39.4059, 292.3487) (9.4, -0.3) 80.6 5 Aitude corrected according to the aimp	Vela_X-1_5	000143000	(135.5276, -40.5541, 152.4203)	(-20.9, 2.0)	110.9	5	
3C273 000145000 (187.2764, 2.0529, 112.4320) (-10.2, -0.0) 100.2 5 MCG-6-30-15 000161000 (203.9737, -34.2951, 118.1216) (-11.4, 0.1) 101.4 5 Cen_X-3 300003010 (170.3127, -60.6239, 156.7998) (-13.7, 0.3) 103.7 5 Circinus,X-1 300028010 (223.1706, -57.1665, 103.9934) (6.4, 0.2) 83.6 5 4U1630-472 90001010 (248.5066, -47.3929, 91.7899) (15.3, -0.1) 74.7 5 GX13+1 300036010 (273.6305, -17.1567, 91.3903) ⁶ (27.2, -0.4) 62.8 5 Cyg_X-3 300040010 (247.0103, -49.1981, 12.69970) (-24.2, 14.1) 113.5 5 4U1624-490 300040020 (247.0103, -49.1981, 12.59971) (-27.9, 0.2) 117.9 5 CYGNUS_X-1 300049010 (299.5897, 35.2012, 89.7827) (13.9, -0.6) 76.1 5 SS_CYGNI 300042010 (325.6775, 43.5860, 76.8692) (14.6, -0.3) 75.4 5 NGC4151 300047020 (182.6355, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 ¹ Nominal sun direction expressed by the rotation angles abou	Vela_X-1_6	000144000	(135.5281, -40.5545, 148.4201)	(-21.1, -2.3)	111.1	5	- Xtend: ~2.5 Msec
MCG-6-30-15 000161000 (203.9737, -34.2951, 118.1216) (-11.4, 0.1) 101.4 5 Cen_X-3 300003010 (170.3127, -60.6239, 156.7998) (-13.7, 0.3) 103.7 5 Circinus_X-1 300028010 (230.1706, -57.1665, 103.9934) (6.4, 0.2) 83.6 5 4U1630-472 900001010 (248.5066, 47.3929, 91.7899) (15.3, -0.1) 74.7 5 GX1311 300036010 (273.6305, -17.1567, 91.3903) ⁶ (27.2, -0.4) 62.8 5 4U1624-490 300040010 (247.0120, -49.1981, 126.9970) (-24.2, 14.1) 113.5 5 4U1624-490 300040020 (247.0103, -49.1985, 115.9971) (-27.9, 0.2) 117.9 5 CYGNUS_X-1 300049010 (299.5897, 35.2012, 89.7827) (13.9, -0.6) 76.1 5 SS_CYGNI 300042020 (325.6775, 43.5860, 76.8692) (1-4.4, -0.2) 102.4 5 SS_CYGNI 300042010 (325.6780, 43.5857, 60.4388) (2.6, -0.2) 87.4 5 NGC4151 300047030 (182.6356, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 1 Nominal sun direction expressed by the rotation angles a	3C273	000145000	(187.2764, 2.0529, 112.4320)	(-10.2, -0.0)	100.2	5	
Cen.X-3 300003010 (170.3127, -60.6239, 156.7998) (-13.7, 0.3) 103.7 5 Circinus.X-1 300028010 (230.1706, -57.1665, 103.9934) (6.4, 0.2) 83.6 5 4U1630-472 900001010 (248.5066, -47.3929, 91.7899) (15.3, -0.1) 74.7 5 GX13+1 300036010 (273.6305, -17.1567, 91.3903) ⁶ (27.2, -0.4) 62.8 5 Cyg_X-3 30006010 (308.1071, 40.9586, 112.2588) (26.3, -0.2) 63.7 5 4U1624-490 300040010 (247.0103, -49.1981, 126.9970) (-24.2, 14.1) 113.5 5 4U1624-490 300040020 (247.0103, -49.1985, 115.9971) (-27.9, 0.2) 117.9 5 CYGNUS_X-1 300049010 (289.6984, -5.2380, 79.9732) (-6.2, -0.1) 96.2 5 SS_CYGNI 300042020 (325.6775, 43.5860, 76.8692) (14.6, -0.3) 75.4 5 SS_CYGNI 300047020 (182.6352, 39.4063, 308.8715) (-12.4, -0.2) 102.4 5 SS_CYGNI 300047020 (182.6357, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 1 Nominal sun direction expressed by the rotat	MCG-6-30-15	000161000	(203.9737, -34.2951, 118.1216)	(-11.4, 0.1)	101.4	5	
Circinus X-1 300028010 (230.1706, -57.1665, 103.9934) (6.4, 0.2) 83.6 5 4U1630-472 90001010 (248.5066, -47.3929, 91.7899) (15.3, -0.1) 74.7 5 GX13+1 300036010 (273.6305, -17.1567, 91.3903) ⁶ (27.2, -0.4) 62.8 5 Cyg X-3 300040010 (247.0120, -49.1981, 126.9970) (-24.2, 14.1) 113.5 5 4U1624-490 300040000 (247.0103, -49.1985, 115.9971) (-27.9, 0.2) 117.9 5 CYGNUS X-1 300040010 (295.897, 35.2012, 89.7827) (13.9, -0.6) 76.1 5 SS_CYGNI 300042020 (325.6775, 43.5860, 76.8692) (14.6, -0.3) 75.4 5 SS_CYGNI 300042010 (325.6780, 43.5857, 60.4388) (2.6, -0.2) 87.4 5 NGC4151 300047020 (182.6352, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 NGC4151 300047000 (182.6356, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 NGC4151 300050010 (174.757, -37.7390, 310.1910) (14.1, 0.2) 75.9 5 NGC3783 3000050010 (174.7	Cen_X-3	300003010	(170.3127, -60.6239, 156.7998)	(-13.7, 0.3)	103.7	5	
4U1630-472 90001010 (248.5066, -47.3929, 91.7899) (15.3, -0.1) 74.7 5 GX13+1 300036010 (273.6305, -17.1567, 91.3903) ⁶ (27.2, -0.4) 62.8 5 Cyg.X-3 300065010 (308.1071, 40.9586, 112.2588) (26.3, -0.2) 63.7 5 4U1624-490 300040010 (247.0120, -49.1981, 126.9970) (-24.2, 14.1) 113.5 5 4U1624-490 300040020 (247.0103, -49.1985, 115.9971) (-27.9, 0.2) 117.9 5 CYGNUS_X-1 300049010 (299.5897, 35.2012, 89.7827) (13.9, -0.6) 76.1 5 4U1916-053 300039010 (289.6984, -5.2380, 79.9732) (-62, -0.1) 96.2 5 SS_CYGNI 300042020 (325.6775, 43.5860, 76.8692) (14.6, -0.3) 75.4 5 NGC4151 300047020 (182.6352, 39.4063, 308.8715) (-12.4, -0.2) 102.4 5 NGC4151 300047030 (182.6359, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 NGC4151 300047030 (182.6359, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 NGC3783 300050010 (1	Circinus_X-1	300028010	(230.1706, -57.1665, 103.9934)	(6.4, 0.2)	83.6	5	
GX13+1 300036010 (273.6305, -17.1567, 91.3903) ⁶ (27.2, -0.4) 62.8 5 Cyg.X-3 300065010 (308.1071, 40.9586, 112.2588) (26.3, -0.2) 63.7 5 4U1624-490 300040010 (247.0120, -49.1981, 126.9970) (-24.2, 14.1) 113.5 5 4U1624-490 300040020 (247.0103, -49.1985, 115.9971) (-27.9, 0.2) 117.9 5 CYGNUS_X-1 300049010 (299.5897, 35.2012, 89.7827) (13.9, -0.6) 76.1 5 4U1916-053 300039010 (289.6984, -5.2380, 79.9732) (-6.2, -0.1) 96.2 5 SS_CYGNI 300042020 (325.6775, 43.5860, 76.8692) (14.6, -0.3) 75.4 5 NGC4151 300042010 (325.6780, 43.5857, 60.4388) (2.6, -0.2) 87.4 5 NGC4151 300047030 (182.6356, 39.4059, 292.3487) (9.4, -0.3) 80.6 5 NGC4151 300047040 (182.6356, 39.4059, 292.3480) (14.5, 3.7) 75.5 5 NGC4151 300047040 (182.6356, 39.4059, 292.3480) (14.5, 3.7) 75.5 5 NGC3783 300050010 (174.757	4U1630-472	900001010	(248.5066, -47.3929, 91.7899)	(15.3, -0.1)	74.7	5	
Cyg_X-3 300065010 (308.1071, 40.9586, 112.2588) (26.3, -0.2) 63.7 5 4U1624-490 300040010 (247.0120, -49.1981, 126.9970) (-24.2, 14.1) 113.5 5 4U1624-490 300040020 (247.0103, -49.1985, 115.9971) (-27.9, 0.2) 117.9 5 CYGNUS_X-1 300049010 (299.5897, 35.2012, 89.7827) (13.9, -0.6) 76.1 5 4U1916-053 300039010 (289.6984, -5.2380, 79.9732) (-6.2, -0.1) 96.2 5 SS_CYGNI 300042020 (325.6775, 43.5860, 76.8692) (14.6, -0.3) 75.4 5 NGC4151 300047020 (182.6352, 39.4063, 308.8715) (-12.4, -0.2) 102.4 5 NGC4151 300047030 (182.6356, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 NGC4151 300047040 (182.6356, 39.4058, 292.3480) (14.5, 3.7) 75.5 5 NGC3783 300050010 (174.7575, -37.7309, 310.1910) (14.1, 0.2) 75.9 5 GT_MUIS 300000010 (174.8730, -65 3978, 331.1673) (7 5.0 4) 82 5 5	GX13+1	300036010	$(273.6305, -17.1567, 91.3903)^6$	(27.2, -0.4)	62.8	5	
4U1624-490 300040010 (247.0120, -49.1981, 126.9970) (-24.2, 14.1) 113.5 5 4U1624-490 300040020 (247.0103, -49.1985, 115.9971) (-27.9, 0.2) 117.9 5 CYGNUS_X-1 300049010 (299.5897, 35.2012, 89.7827) (13.9, -0.6) 76.1 5 4U1916-053 300039010 (289.6984, -5.2380, 79.9732) (-6.2, -0.1) 96.2 5 SS_CYGNI 300042020 (325.6775, 43.5860, 76.8692) (14.6, -0.3) 75.4 5 NGC4151 300047020 (182.6352, 39.4063, 308.8715) (-12.4, -0.2) 102.4 5 NGC4151 300047030 (182.6359, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 NGC4151 300047040 (182.6356, 39.4059, 292.3480) (14.5, 3.7) 75.5 5 NGC3783 300050010 (174.7575, -37.7390, 310.1910) (14.1, 0.2) 75.9 5 GT MUIS 300000010 (174.8730, -65.3978, 331.1673) (7.5, 0.4) 82.5 5	Cyg_X-3	300065010	(308.1071, 40.9586, 112.2588)	(26.3, -0.2)	63.7	5	
4U1624-490 300040020 (247.0103, -49.1985, 115.9971) (-27.9, 0.2) 117.9 5 CYGNUS_X-1 300049010 (299.5897, 35.2012, 89.7827) (13.9, -0.6) 76.1 5 4U1916-053 300039010 (289.6984, -5.2380, 79.9732) (-6.2, -0.1) 96.2 5 SS_CYGNI 300042020 (325.6775, 43.5860, 76.8692) (14.6, -0.3) 75.4 5 NGC4151 300042010 (325.6780, 43.5857, 60.4388) (2.6, -0.2) 87.4 5 SS_CYGNI 300047030 (182.6356, 39.4059, 292.3487) (9.4, -0.3) 80.6 5 NGC4151 300047040 (182.6356, 39.4059, 292.3480) (14.5, 3.7) 75.5 5 NGC3783 300050010 (174.7575, -37.7390, 310.1910) (14.1, 0.2) 75.9 5 GT_MUS 300000010 (174 8730, -65 3978, 331.1673) (75 0.4) 82 5 5	4U1624-490	300040010	(247.0120, -49.1981, 126.9970)	(-24.2, 14.1)	113.5	5	
CYGNUS_X-1 300049010 (299.5897, 35.2012, 89.7827) (13.9, -0.6) 76.1 5 4U1916-053 300039010 (289.6984, -5.2380, 79.9732) (-6.2, -0.1) 96.2 5 SS_CYGNI 300042020 (325.6775, 43.5860, 76.8692) (14.6, -0.3) 75.4 5 NGC4151 300047020 (182.6352, 39.4063, 308.8715) (-12.4, -0.2) 102.4 5 SS_CYGNI 300042010 (325.6780, 43.5857, 60.4388) (2.6, -0.2) 87.4 5 NGC4151 300047030 (182.6359, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 NGC4151 300047040 (182.6356, 39.4059, 292.3480) (14.5, 3.7) 75.5 5 NGC3783 300050010 (174.7575, -37.7390, 310.1910) (14.1, 0.2) 75.9 5 GT MUS 300000010 (174 8730 -65 3978 331 1673) (75 0.4) 82 5 5	4U1624-490	300040020	(247.0103, -49.1985, 115.9971)	(-27.9, 0.2)	117.9	5	
4U1916-053 300039010 (289.6984, -5.2380, 79.9732) (-6.2, -0.1) 96.2 5 SS_CYGNI 300042020 (325.6775, 43.5860, 76.8692) (14.6, -0.3) 75.4 5 NGC4151 300047020 (182.6352, 39.4063, 308.8715) (-12.4, -0.2) 102.4 5 SS_CYGNI 300042010 (325.6780, 43.5857, 60.4388) (2.6, -0.2) 87.4 5 NGC4151 300047030 (182.6359, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 NGC4151 300047040 (182.6356, 39.4059, 292.3480) (14.5, 3.7) 75.5 5 NGC3783 300050010 (174.7575, -37.7390, 310.1910) (14.1, 0.2) 75.9 5 GT_MUS 300000010 (174 8730, -65 3978, 331 1673) (7 5 0.4) 82 5 5	CYGNUS_X-1	300049010	(299.5897, 35.2012, 89.7827)	(13.9, -0.6)	76.1	5	
SS_CYGNI 300042020 (325.6775, 43.5860, 76.8692) (14.6, -0.3) 75.4 5 NGC4151 300047020 (182.6352, 39.4063, 308.8715) (-12.4, -0.2) 102.4 5 SS_CYGNI 300042010 (325.6776, 43.5857, 60.4388) (2.6, -0.2) 87.4 5 NGC4151 300047030 (182.6359, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 NGC4151 300047040 (182.6356, 39.4059, 292.3480) (14.5, 3.7) 75.5 5 NGC3783 300050010 (174.7575, -37.7390, 310.1910) (14.1, 0.2) 75.9 5 GT_MUS 30000010 (174.8730, -65.3978, 331.1673) (7.5, 0.4) 82.5 5	4U1916-053	300039010	(289.6984, -5.2380, 79.9732)	(-6.2, -0.1)	96.2	5	
NGC4151 300047020 (182.6352, 39.4063, 308.8715) (-12.4, -0.2) 102.4 5 SS_CYGNI 300042010 (325.6780, 43.5857, 60.4388) (2.6, -0.2) 87.4 5 NGC4151 300047030 (182.6359, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 NGC4151 300047040 (182.6356, 39.4059, 292.3480) (14.5, 3.7) 75.5 5 NGC3783 300050010 (174.7575, -37.7390, 310.1910) (14.1, 0.2) 75.9 5 GT_MUS 30000010 (174.8730, -65.3978, 331.1673) (7.5, 0.4) 82.5 5	SS_CYGNI	300042020	(325.6775, 43.5860, 76.8692)	(14.6, -0.3)	75.4	5	
SS_CYGNI 300042010 (325.6780, 43.5857, 60.4388) (2.6, -0.2) 87.4 5 NGC4151 300047030 (182.6359, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 NGC4151 300047040 (182.6356, 39.4059, 292.3487) (9.4, -0.3) 80.6 5 NGC3783 300050010 (174.7575, -37.7390, 310.1910) (14.1, 0.2) 75.9 5 GT_MUS 30000010 (174 8730, -65 3978, 331 1673) (7 5, 0.4) 82 5 5	NGC4151	300047020	(182.6352, 39.4063, 308.8715)	(-12.4, -0.2)	102.4	5	
NGC4151 300047030 (182.6359, 39.4058, 292.3487) (9.4, -0.3) 80.6 5 rule. NGC4151 300047040 (182.6356, 39.4059, 292.3487) (9.4, -0.3) 80.6 5 2 Attude corrected according to the aimpoint search results. NGC4151 300047040 (182.6356, 39.4059, 292.3480) (14.5, 3.7) 75.5 5 3 Aimpoint search Step 1 observation. NGC3783 300050010 (174.7575, -37.7390, 310.1910) (14.1, 0.2) 75.9 5 5 8 Referred to as the one-year data. GT_MUIS 300000010 (174 8730, -65 3978, 331 1673) (7 5, 0.4) 82 5 5 6 InCluding an offset of about +5 arcseconds in RA, caused by a discrepancy between the direction registered in the AICS on the activel covere providence.	SS_CYGNI	300042010	(325.6780, 43.5857, 60.4388)	(2.6, -0.2)	87.4	5	¹ Nominal sun direction expressed by the rotation angles about the SATX and SATZ axes, following the right-hand
NGC4151 300047040 (182.6356, 39.4059, 292.3480) (14.5, 3.7) 75.5 5 ³ Aimpoint search Step 1 observation. NGC3783 300050010 (174.7575, -37.7390, 310.1910) (14.1, 0.2) 75.9 5 ³ Referred to as the one-year data. GT_MUIS 300000010 (174 8730, -65 3978, 331 1673) (7 5, 0.4) 82 5 5 ⁵ Construction.	NGC4151	300047030	(182.6359, 39.4058, 292.3487)	(9.4, -0.3)	80.6	5	rule. ² Attitude corrected according to the aimpoint search results.
NGC3783 300050010 (174.7575, -37.7390, 310.1910) (14.1, 0.2) 75.9 5 Referred to as the one-year data. GT_MUIS 300000010 (174.8730, -65.3978, 331.1673) (7.5, 0.4) 82.5 5 6 Including an offset of about +5 arcseconds in RA, caused by a discrepancy between the direction registered in the actival curve aperitor.	NGC4151	300047040	(182.6356, 39.4059, 292.3480)	(14.5, 3.7)	75.5	5	³ Aimpoint search Step 1 observation.
GT MUS 30000010 $(174\ 8730\ -65\ 3978\ 331\ 1673)$ $(7\ 5\ 0\ 4)$ 82.5 5 6 Including an offset of about +5 arcseconds in RA, caused by a discrepancy between the direction registered in the	NGC3783	300050010	(174.7575, -37.7390, 310.1910)	(14.1, 0.2)	75.9	5	⁵ Referred to as the one-year data.
	GT_MUS	30000010	(174.8730, -65.3978, 331.1673)	(7.5, 0.4)	82.5	5	^b Including an offset of about +5 arcseconds in RA, caused by a discrepancy between the direction registered in the AOCS and the actual source position.

X-Ray Imaging and Spectroscopy Mission



Aimpoint shift

Z-sun angle and BP temperature

X-Ray Imaging and Spectroscopy <u>Mission</u>



temperature measurement point

• Base panel (BP) temperature and its dependence on Z-sun angle

- Z-sun angle: angular separation between the spacecraft boresight (SAT +Z) and the Sun direction.
- Z-sun angle shows a clear correlation with the temperature of the lower spacecraft structure.
- **BP_TEMP** (temp. sensor at the center of the base panel) is an indicator for the BP temperature.

Z-sun angle and BP temperature



• Base panel (BP) temperature and its dependence on Z-sun angle

- Z-sun angle: angular separation between the spacecraft boresight (SAT +Z) and the Sun direction.
- Z-sun angle shows a clear correlation with the temperature of the lower spacecraft structure.
- **BP_TEMP** (temp. sensor at the center of the base panel) is an indicator for the BP temperature.

X-Ray Imaging and

Spectroscopy Mission

Observational aimpoints



Observational aimpoints from each observation



Observational aimpoints derived from on-axis point-source observations

- For both Resolve and Xtend, the aimpoints scatter around the nominal aimpoint.
 - No irreversible significant shift has been observed, including during the gate-valve opening operation.
 - The nominal aimpoints and alignment matrices remain appropriate.
- The aimpoints of Resolve show a correlation with the BP_TEMP.

Observational aimpoints



Correlations of aimpoints for Resolve and Xtend



DETX direction

• Resolve and Xtend aimpoints shift **together in the same direction**, likely from attitude-control error.

DETY direction

• Resolve and Xtend aimpoints shift differently from one another.

DETY shift





DETY shift





Schematic drawing of the BP and detectors

- Ground tests for Hitomi demonstrated that thermal expansion of the aluminum rocket interface ring can cause BP distortion.
- The heat expansion of the ring causes the base panel to distort into a downwardly concave shape.
- The focal planes of Resolve and Xtend are approximately 108 cm and 22 cm away from the BP surface. The difference in these distances may account for the different offset amounts in the DETY direction between Resolve and Xtend.
- After one year in orbit, thermal distortion introduces only a few-arcsec offset for Resolve.
 - The resulting photon loss is < 1 %, which is negligible.

Worst-case estimation at EOL



- Pre-launch worst-case estimate predicted an offset up to 18".
 - One year after launch, BP_TEMP and the other thermal measurement points remain stable. <u>No clear evidence of degradation has been detected.</u>
 - The spacecraft body is designed to meet the performance requirements for five years after launch.

X-Ray Imaging and

Spectroscopy Mission



Control and Determination accuracies





- Example history of the angular offset of the satellite attitude from the aimed target attitude.
 - During target observations, at least one STT remains active, allowing attitude determination on the ground.
 - Control accuracy was evaluated during the STT-controlled period, whereas determination accuracy was evaluated during the STT-active period.

Absolute control accuracy





Absolute control accuracy

- defined as the deviation between the target direction and the telescope's boresight direction during the onboard attitude control
- Resolve: $9.5'' \pm 1.8'' (3\sigma)$
- Xtend: 7.6" \pm 1.0" (3 σ)
 - (derived from the mean and standard deviations of aimpoints for each observation, then statistically combined)

• Although Resolve aimpoints spread along the DETY direction due to thermal distortion, the shifts are minor, and the resulting absolute control accuracy 2024/5/15 remains well within the mission requirement (55").

Absolute determination accuracy



X-Ray Imaging and

Spectroscopy

Absolute determination accuracy

- defined as the angular distance between the target's celestial coordinates and its measured coordinates
- **Resolve**: $5.8'' \pm 0.9'' (3\sigma)$
- Xtend: $5.5'' \pm 0.7'' (3\sigma)$

• (derived from the mean and standard deviations of aimpoints for each observation, then statistically combined)

•ASCA SIS and Suzaku XIS/HXI required temperature-dependent corrections, yet their 90 % error circles still lay in the ten-arcsecond range. XRISM achieves



Nominal parameters:

- The nominal aimpoints and alignment matrices remain valid.

Aimpoint shift:

- Thermal distortion produces a few-arcsecond shift in the DETY direction, resulting in a negligible photon loss of < 1 %.
- Pre-launch worst-case simulations allowed offsets up to 18" in the DETY direction, yet no evidence of thermal-control degradation has been observed.

Absolute determination accuracy:

 Resolve and Xtend achieve 5–6", a clear improvement over the ≥ 10" error circles of ASCA and Suzaku.