XRISM X-Ray Imaging and Spectroscopy Mission

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XRISM Timing System Design and Timing Accuracy

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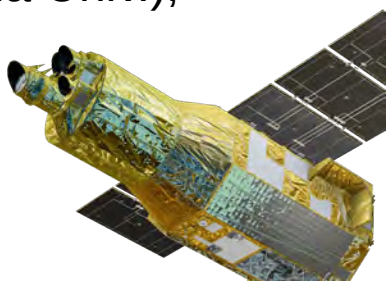
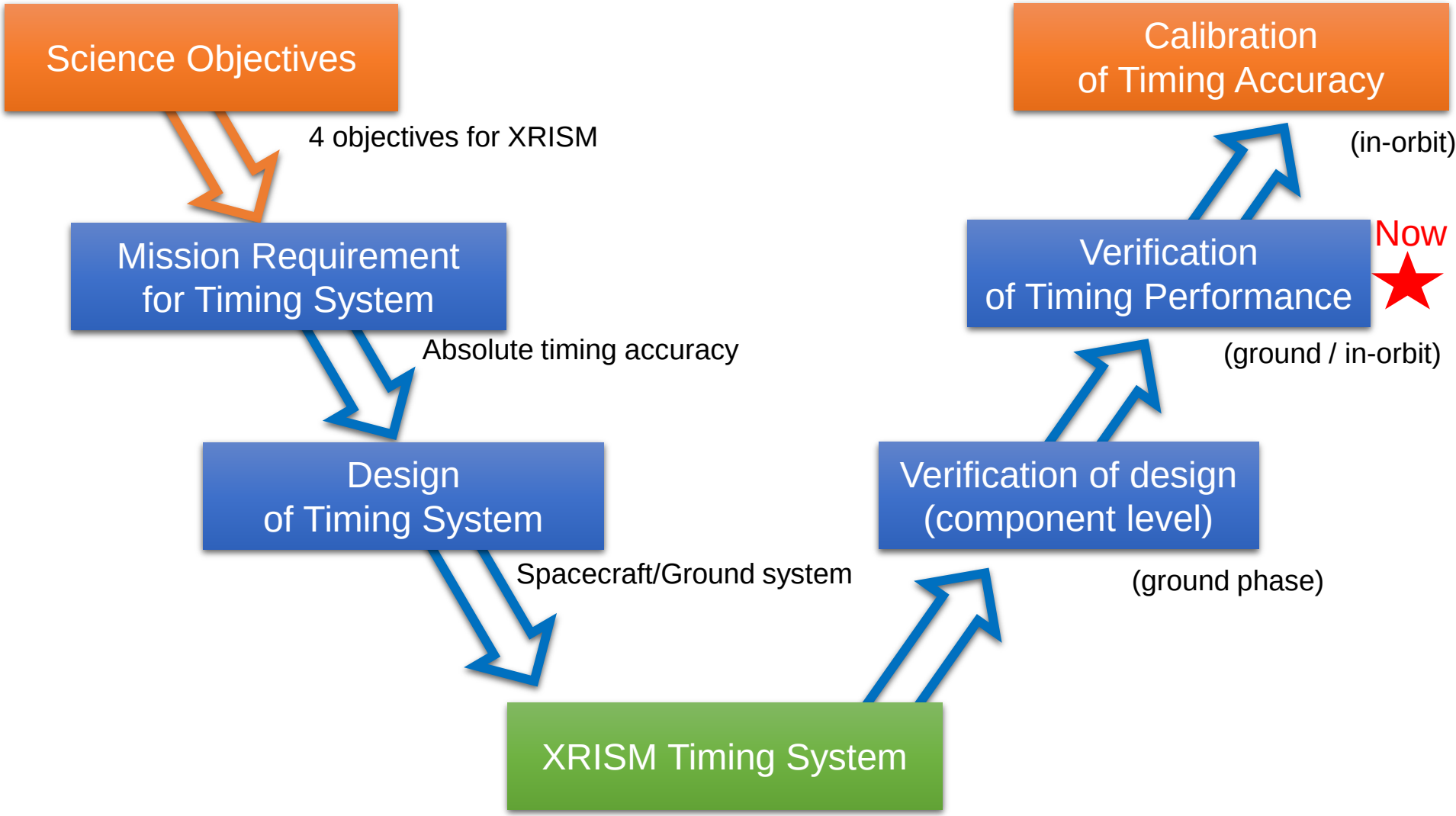
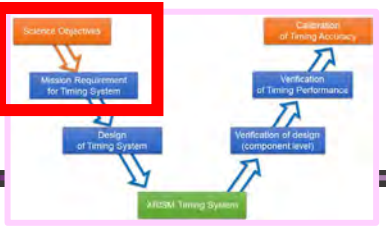


Timing System for XRISM

Development of the XRISM Timing system with the V-shape model





1. Science Requirement

XRISM X-Ray Imaging and Spectroscopy Mission

XRISM Scientific objectives

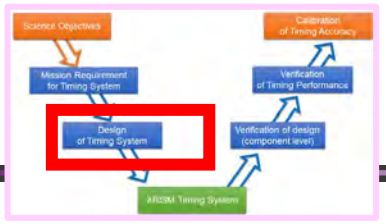
1. Revealing the structure formation of the Universe and evolution of clusters of galaxies
2. Understanding the circulation history of baryonic matters in the Universe
3. Investigating the transport and circulation of energy in the Universe
4. Realizing the new science with high-resolution X-ray spectroscopy

- No major requirement on timing accuracy
- Requirement for X-ray observatory (#4)

Science Requirement for Timing

Absolute timing accuracy ≤ 1 msec (in 1 sigma)

(*) Relaxed from Hitomi, <350 usec



2. Design and Budget

Bus system design

1. Same bus system as Hitomi spacecraft
   → well verified
2. Carries GPS receiver (GPSR)
   → good timing accuracy (in nsec)
3. SpaceWire network for telemetry/command communication
   → used for timing synchronization

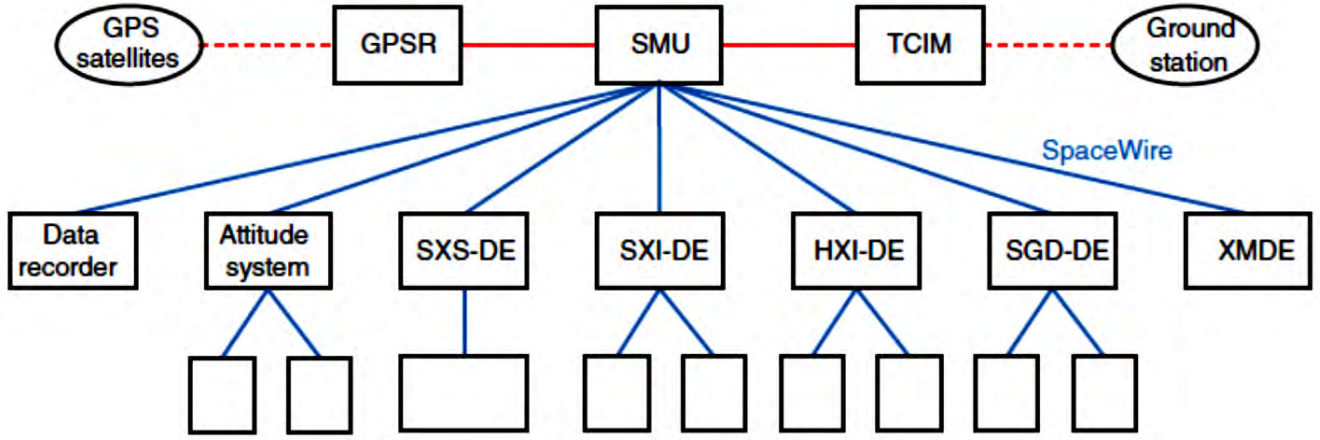


Fig. 1 A schematic diagram of the logical topology of the Hitomi network.[9] Boxes represent components onboard the spacecraft and ellipses are GPS satellites or the ground station. Communication lines (in blue) are realized by SpaceWire.

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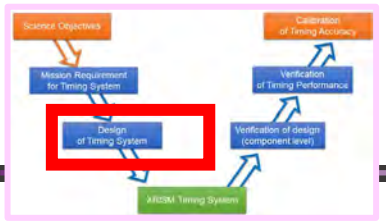
Timing system = Spacecraft + Ground system



2. Design and Budget

Timing chart and Timing Error items

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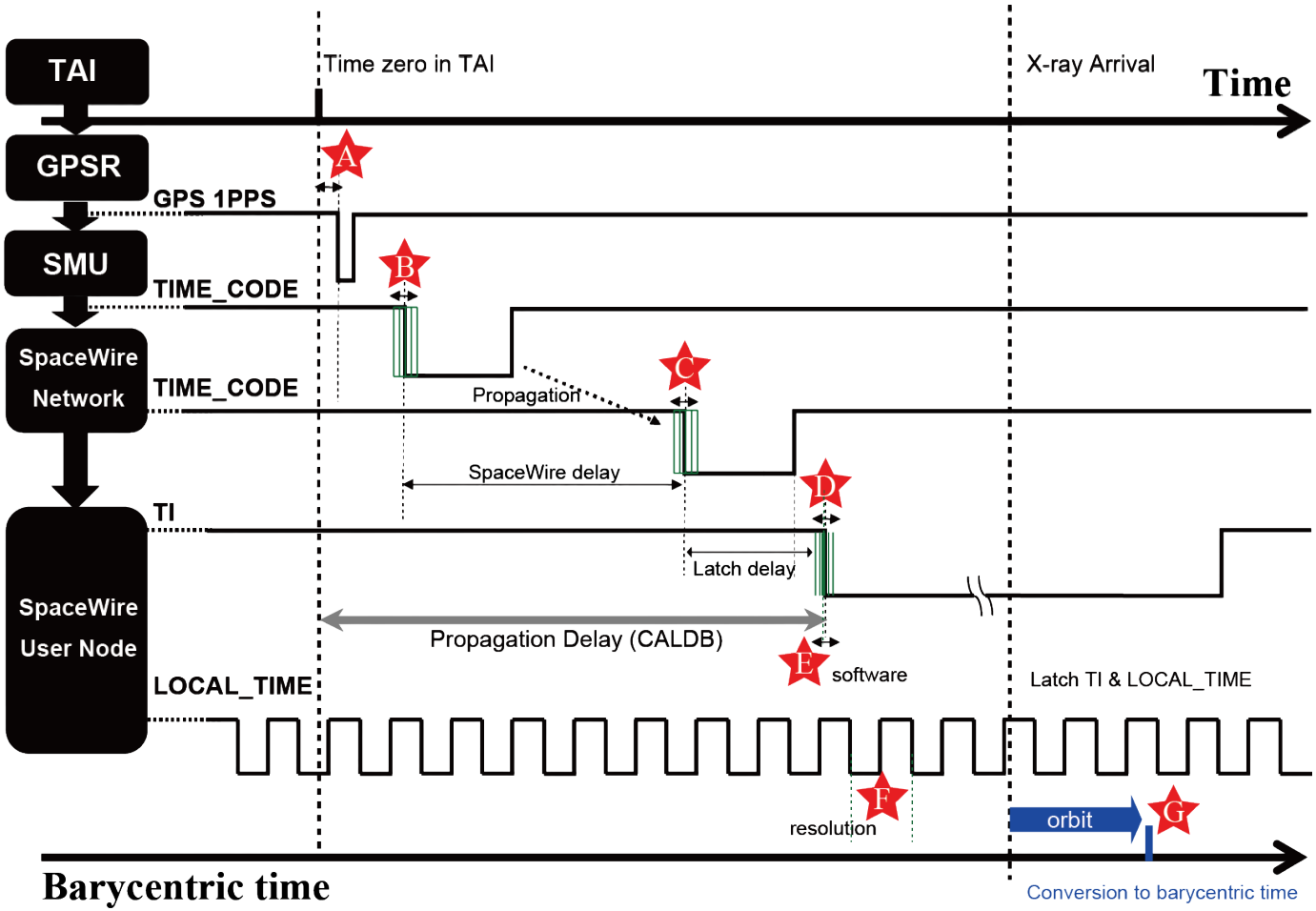

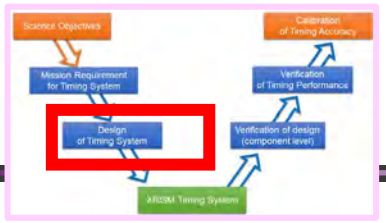

2. Design and Budget

Timing Error budget for Hitomi to XRISM

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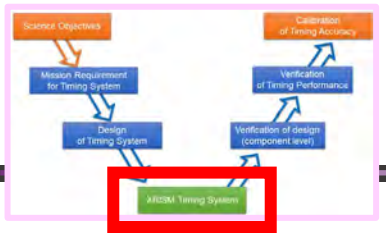
Table 2 Error budget in time assignments.

ID	Component	Error items	Hitomi Error budget (μs)	XRISM BUS	XRISM Resolve
A	GPSR	Jitter between TAI and GPSR timing signal	<0.02 (GPS-ON)	< 0.2 us	
B	SMU	Jitter between GPSR timing and TIME_CODE	<0.5 (GPS-ON)	< 0.5 us	
			<270 (GPS-OFF)	< 350 us	
C	SpaceWire network	Jitter between TIME_CODE at SMU and User node	<2.0	< 2.0 us	
D	SpaceWire user node	Jitter between TIME_CODE and reconstructed TI	<1.0	}	<0.5ms
E	Software ahtime	Uncertainty in reconstruction of TI	<1.0	}	
F	SpaceWire user node	Resolution of LOCAL_TIME	<25.6	}	
G	Ground system	Accuracy of orbital elements	<3.0 (= 1 km)	< 3.0 us	

Tot. <0.5 ms

※ From Hitomi to XRISM

1. Timing requirement has been relaxed from Hitomi (350 us → 1 ms)
2. Division of the responsibility for on-board components changed.



3. Fabrication

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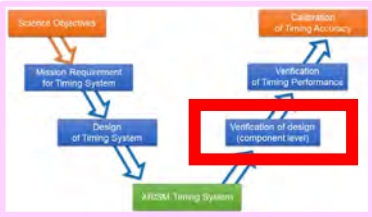
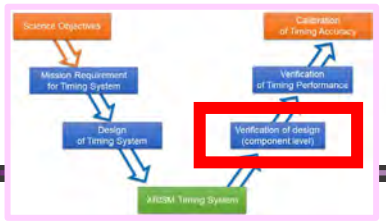
We have a spacecraft and ground system for XRISM



4. Verification by component

Verification by Timing Error items (A – G)

ID	Item	Verification/Analsys
GPSR alive		
A	Jitter bw TAI – GPSR	spec sheet (0.1us) / ok
B	Jitter bw GPSR – SMU	Hitomi measurement
GPSR failure		
AB’	Uncertainties in GPS unsync. mode	Suzaku / New
Common		
C	Jitter bw SMU -- Resolve	Hitomi measurement
D	Uncertainties in Resolve inc. time assignment in off-line	spec sheet (1 us) / ok
E		
F		
G	Determination of Orbital element	Hitomi in-orbit (<1ns) / ok

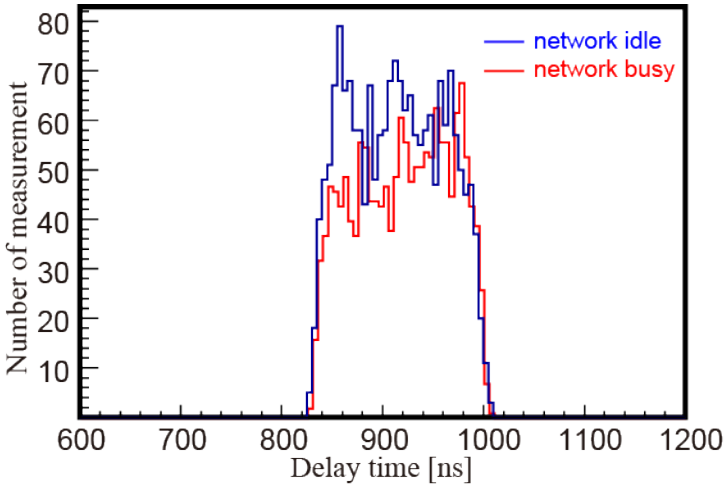


4. Verification by component

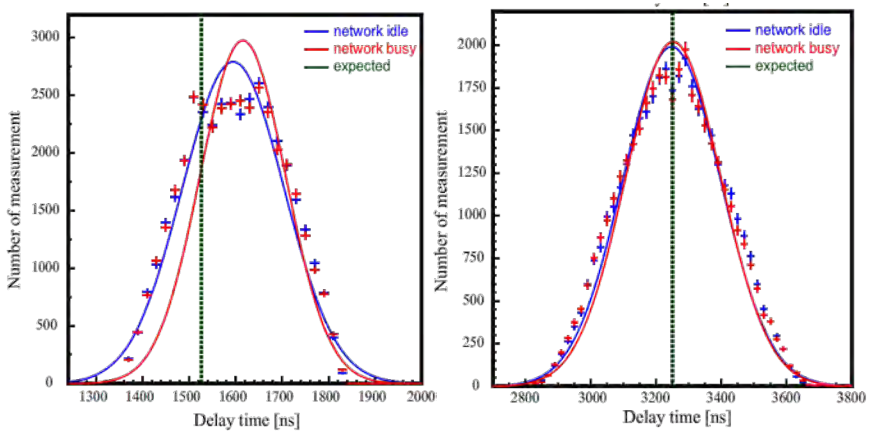
Hitomi measurement

Item = B (GPSR -- SMU)

(*) Intrinsic delay (375 ns) is included

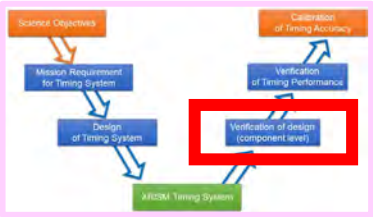


Item = C (SMU – Hitomi SGD)



0.143 μsec < 0.5 μsec // **OK**

0.3 ~ 0.8 μsec < 1.0 μsec // **OK**

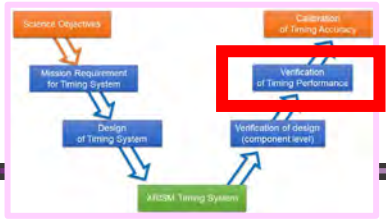


4. Verification by component

New measurement for XRISM

Item = AB’ (GPSR failure mode)

see the next talk by Shidatsu et al !

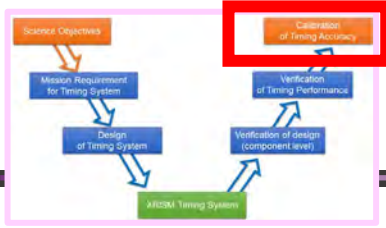


5. Confirmation in orbit

Confirmation of the timing performance of the Timing System

- When: During the commissioning phase (3 months after launch)
- Purpose: Check the pulse profile of one NS pulsar, listed below.
- Simultaneous observation NOT required.

Object Name	RA (J2000)	Dec (J2000)	P (ms)	Hp rate(c/s) (no/with GV)
Crab	83.633080	22.014500	33.7	30/42
PSR B1821-24	276.133371	-24.869750	3.05	0.020/0.006
PSR J1937+21	294.915100	21.622700	1.56	0.011/0.004
PSR J0218+4232	34.526502	42.538157	2.32	0.023/0.006



6. In-orbit Calibration

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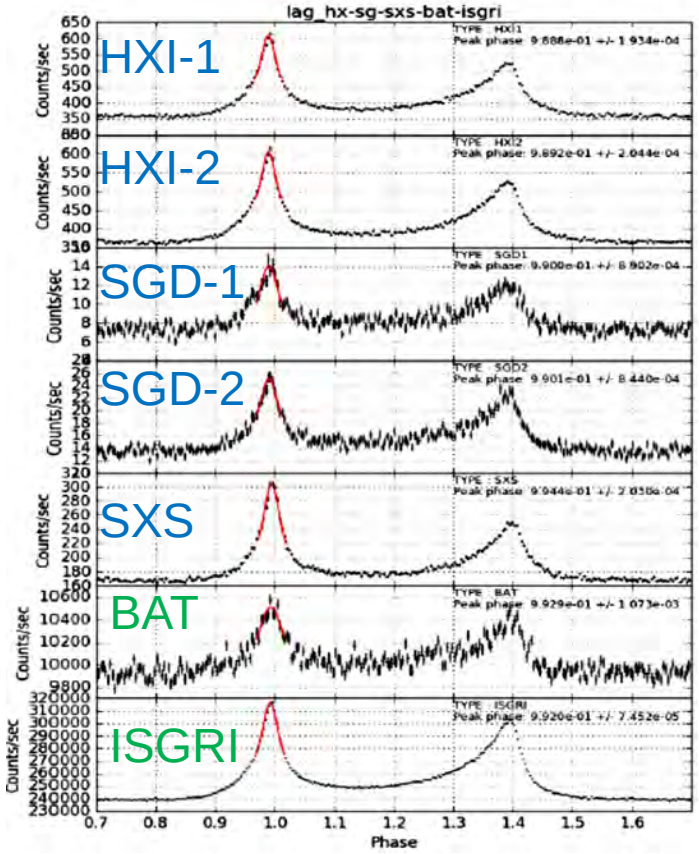
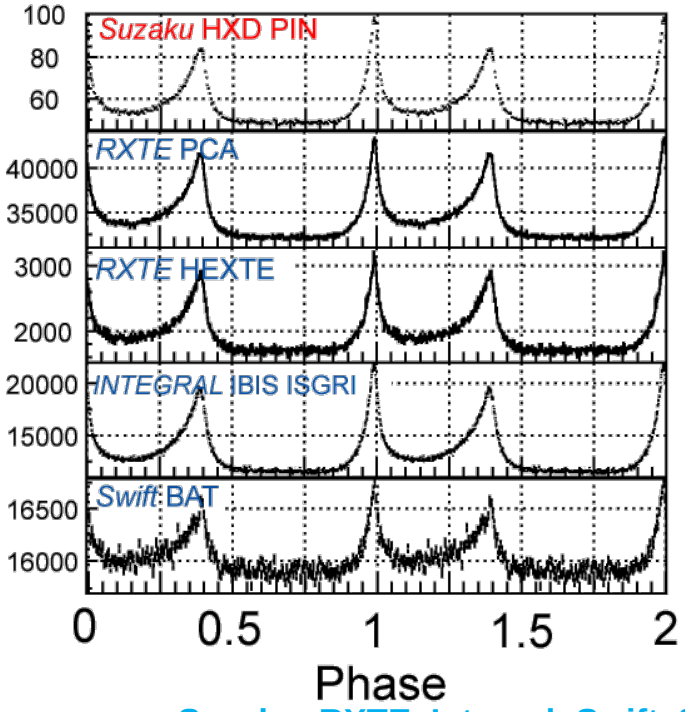
Final stage: numerical measurement of timing accuracy

- When: During the PV/Calibration phase (3, 4 ~ 10 months after launch)
- Purpose: Calibrate absolute time using arrival time of the pulses from Neutron Star pulsar (same candidate)
- Simultaneous observation with Radio and/or X-ray, NICER.

12th IACHEC meeting
4th IACHEC meeting
Terada et al 2008



Hitomi, Swift, Integral, NICT, Iidate (radio), 2016



Suzaku, RXTE, Integral, Swift, 2007

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