IACHEC Timing WG report 2023

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Timing Working Group

Goals of this working group

1. Share information on Timing calibration methods/protocol, lessons learned (to enhance timing capability)
2. In-orbit timing calibration (coordinated) observations/ planning, studies
3. Studies on Timing products

ML: iachec-time@heal.phy.saitama-u.ac.jp (to be updated)
SLAC: iachec.slack.com #timing

Current Members:

Yukikatsu Terada (Suzaku,Hitomi, XRISM),
Craig Markwardt (NICER),
Teruaki Enoto (NICER),
Matteo Bachetti (NuSTAR),
Katja Pottschmidt (NuSTAR),
Kristin Madsen (NuSTAR)
Felix Fuerst (XMM-Newton),
Simon Rosen (XMM-Newton),
Vinay Kashyap (Chandra),
Arnold Rots (Chandra),
Amy Lien (Swift),
Giancarlo Cusumano (Swift),
Guillaume Belanger(INTEGRAL),
Volodymyr SAVCHENKO(INTEGRAL),
Lucien Kuiper(INTEGRAL)
Xiaobo LI (HXMT),
Gulab Dewangan (Astrosat),
Dipankar Bhattacharya(Astrosat)
Michael Freyberg (eROSITA),
Makoto Sawada(XRISM),
Takaaki Tanaka (XRISM)
Minami Sakama (XRISM),
Takumi Shioiri (XRISM),
Juan Zhang (EP)

Presentations at the 15th IACHEC

Item #1; Share information on Timing calibration methods/protocol, lessons learned

1. "XRISM Timing System Design and Timing Accuracy"
   by Yukikatsu Terada

2. "Verification of XRISM Timing System Using Thermal-vacuum Test Data"
   by Megumi Shidatsu

3. "Insight-HXMT in-orbit timing calibration"
   by Youli Tuo

Item 1a) Summary of Timing calibration status of missions

Output:

https://wikis.mit.edu/confluence/display/iachec/Timing

Current Status

- 1st version completed last year (2022) on the MIT Wiki page;
  RXTE, Chandra, XMM-Newton, INTEGRAL, Swift, Suzaku, NuSTAR, Fermi, AstroSat, Insight-HXMT, Hitomi, NICER, and XRISM

- Definitions of columns have been re-arranged (2022): offset and reference time.

Action items

1. The table must be updated according to the definitions above.
2. Fill values on the following instruments
   eROSITA
   XMM-Newton EPIC-MOS
   INTEGRAL SPI

The Timing working group members will maintain the table.

Item 1a) Summary of Timing calibration status of missions

https://wikis.mit.edu/confluence/display/iachec/Timing

Mission/Instruments	Science Requirement Absolute Time		Timing System Design		Timing Calibration Status				In-orbit Timing Calibration Targets	Reported Issues	Reference
	Requirement	Goal	GPS Receiver	Clock Stability	Offset from the Reference	Deviation, sigma	Reference Time	Notes			
RXTE/PCA ★	10μsec	none	No		Calibrated: 1 μsec Uncalibrated: ~0 usec (Absolute, not relative to radio)	Calibrated: 3.4 μsec Uncalibrated: 100 usec (max) ~50 usec (std)	TAI	Calibration: Spline-based calibration against ground timing standards, including ground time assignment error. Uncalibrated: Mission operations maintained on-board clock to within 100 usec of UTC using clock frequency steering	PSR B1821-24 60 μsec	Before 1997-04-29, increased timing jitter 8 μsec	rxte_time.html Timing Budget Jahoda et al. 2006 (10.1086/500659) PSR B1821 Rots et al. 1998 (10.1086/305836) Crab Rots et al. 2004 (10.1086/420842)
RXTE/HEXTE★	10 μsec	none			See above	See above		Event by event has 7.6 μsec resolution. "the HEXTE absolute time reference is accurate within a fraction of a millisecond.(10.1086/305377)"	delay 0-1 μsec (corrected?)	None	HXTE Timing (10.1086/305377)
Chandra/ACIS	0.25625 s (one minor frame start time)	0.001 s (synchronize minor frame starts)	No (sync DSN)	3.2 μsec	285 ± 6 μsec			Number is dominated by estimated engineering systematic uncertainty. Further analysis is required to figure out offset from Crab.		None at present	Davis et al. 2003 (davis.pdf)
Chandra/HRC		16 μsec			4 ± 4 μsec				Crab PSR B1821-24	Note: Precision relative to RXTE. Due to a wiring problem, photon time tag gets attached to next event; correctable under special mode for HRC-S which telemeters all events and then reassigns times on the ground. In order to avoid telemetry saturation, a higher value of the lower-level discriminator is set, which causes low PHA events to be discarded on board. This results in significant loss in QE for epochs when gain is low.	Davis et al. 2003 (davis.pdf) Rots 2006 (CXOClock.pdf)
XMM-Newtion/EPIC-PN	1 ms	none	No	-	-354±11 μsec	108 μsec (1 sigma)		Note: Timing = -306 +/- 16 μsec, Burst = -387+/-13 μsec. Timing mode is affected by pile up. Note: XMM-Newton EPIC-MOS was deleted from the table.	Crab pulsar (bi-annual)	None currently	Kirsch et al, SPIE, 5165, 85 (10.1117/12.503559) Martin-Carrillo et al, A&A, 545, A126 (2012) (10.1051/0004-6361/201116576) ~~CAL-TN-0220-1-4.pdf (Limited access)~~ CAL-TN-0220-1-5.pdf
INTEGRAL/SPI											L.Kuiper 2003 (10.1051/0004-6361:20031353)

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To make our highlights more visible

IACHEC

International Astronomical Consortium for High-Energy Calibration

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Current Activities

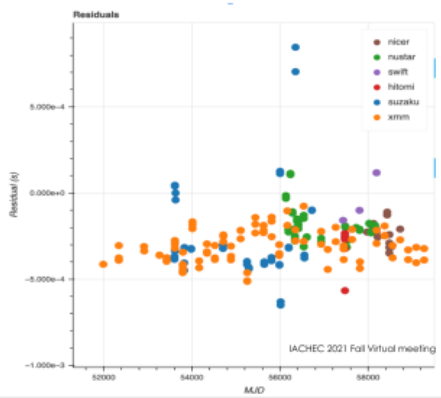
Working Group Active Projects and Results

Timing WG

The timing group has been collecting and maintaining the timing accuracy and stability for current and past missions:

RXTE, Chandra, XMM-Newton, INTEGRAL, Swift, Suzaku, NuSTAR, Fermi, AstroSat, Insight-HXMT, Hitomi, NICER, eROSITA, and XRISM

The results are maintained on a wiki page which can be seen here: https://wikis.mit.edu/confluence/display/iachec/Timing



MISSION LINKS

ASTROSAT
Chandra
Insight-HXMT
Integral
NICER
NuSTAR
Swift
XMM-Newton
XRISM

NEWSLETTER SIGNUP

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Timing WG as a first example

Item 1b) Systematic timing cross-calibration with archive

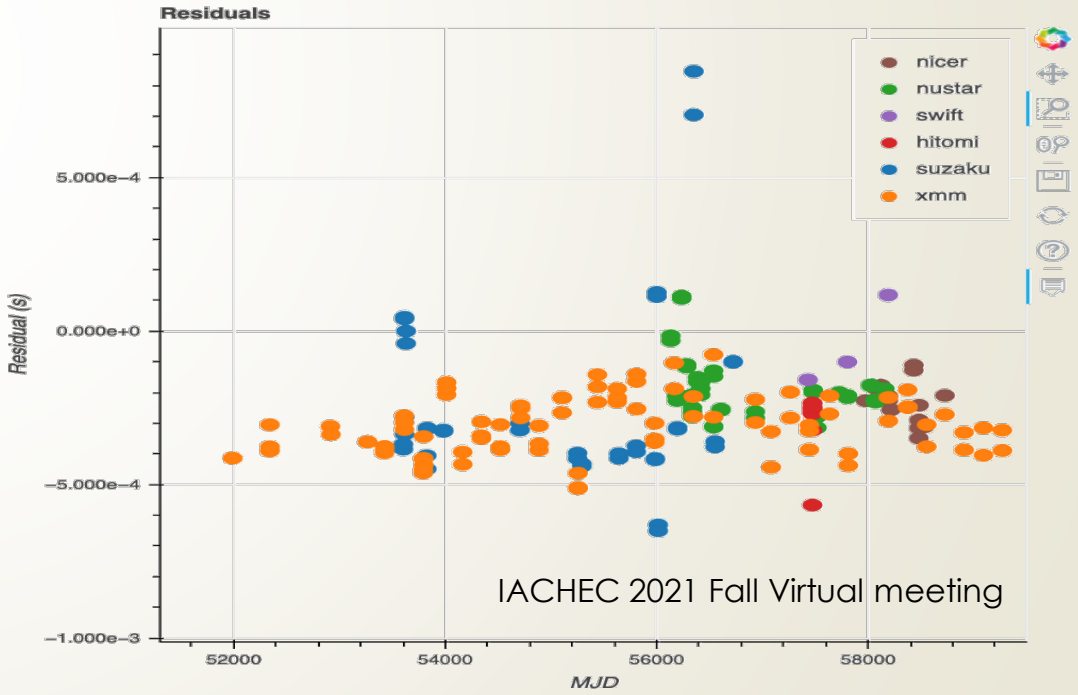
Status

In 2022, we gathered the event files of Crab observations of
XMM-Newton, Suzaku, NuSTAR, Astrosat, Hitomi, and Swift,
and compared the ephemeris among instruments (mainly by Matteo Bachetti).

→ No updates

Action Items

1. Set up WG virtual meeting on the detail information on this task with Matteo
2. Consider the paper publication



Item 2) Planning Timing Cross-calibration observation

The XRISM team propose to set up
semi-simultaneous observation of Crab
with XRISM, NICER, and other X-ray satellites + radio observatories
→ Coordinated observation WG

When: Dec 2023 - June 2024 (XRISM PV+Cal)
Visibility opens in Feb 2024 (no visible in calibration month in Dec)

Observatories to join & Point-of-contact on timing observation/analysis

- XRISM (Yukikatsu Terada)
- NICER (Craig Markwardt)
- Radio in Japan (Teru Enoto; to be confirmed)
- HXMT(Xiaobo Li)
- EP (Juan Zhang) … not decided yet

Thanks.