Status of Suzaku/HXD Timing Calibration

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on behalf of Suzaku HXD team

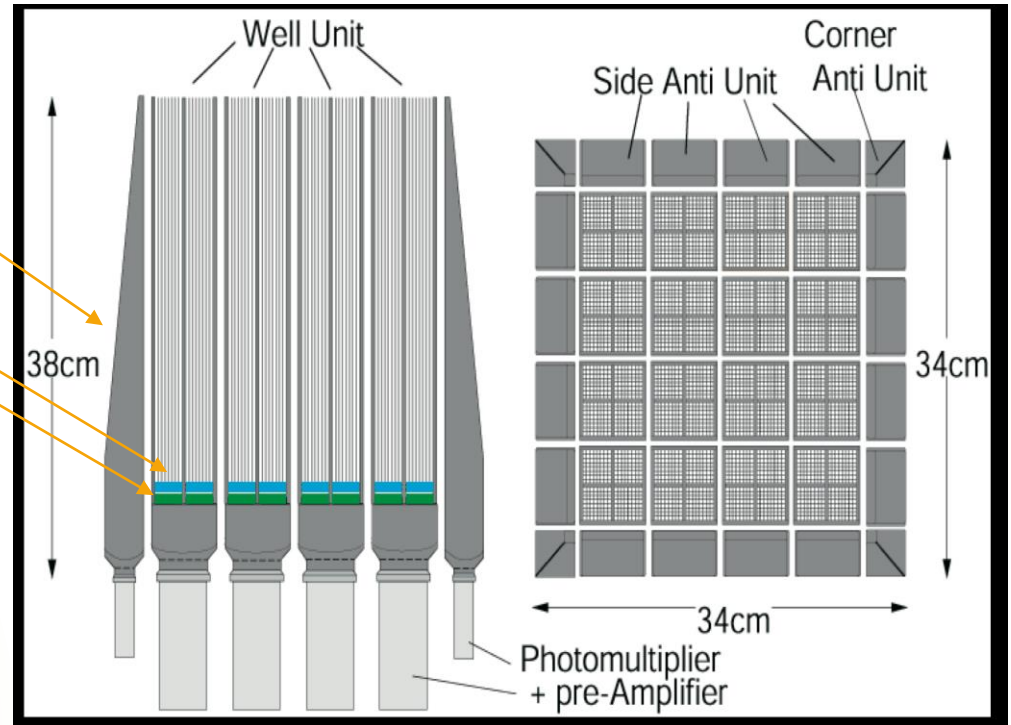9th IACHEC meeting at Airlie Center 12-15 May 2014

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   HXD and Suzaku timing system

2. Status 1: Timing Drift
   (seen in 2012-2013)

3. Status 2: New Issue
   (latest observation in Mar. 2014)

4. Summary

Suzaku Hard X-ray Detector

(shield)
BGO

(Sensor)
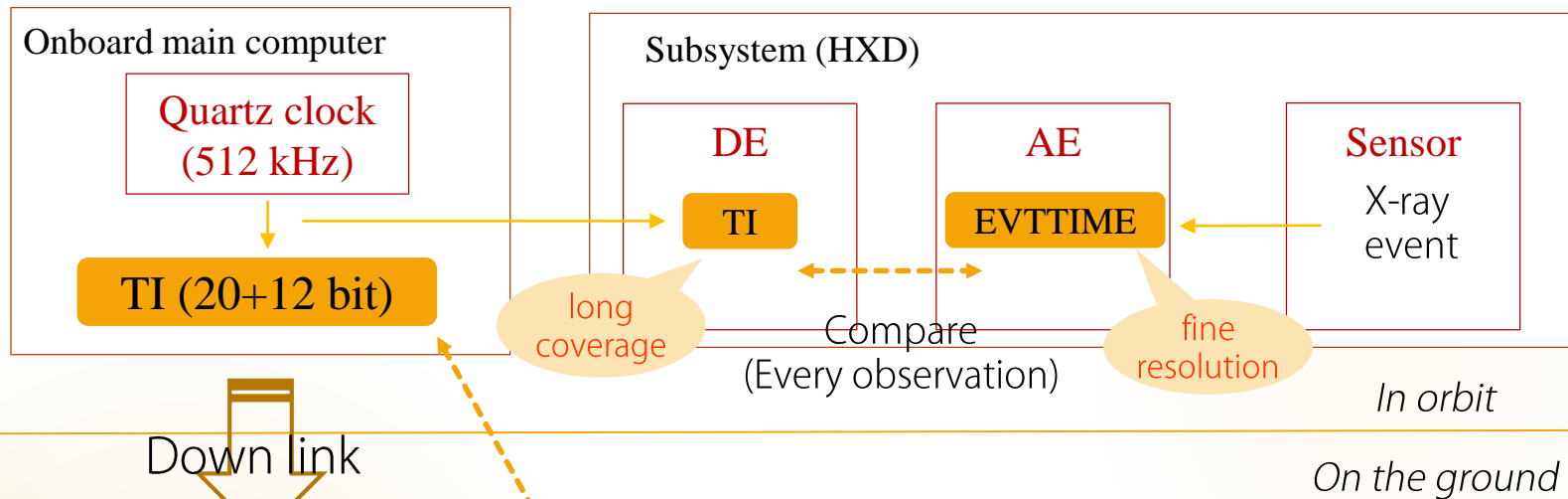PIN (10-70 keV)
GSO(40-600 keV)

Characters of HXD
- Wide energy band (10-600 keV)
- Low background
- Time resolution of 64 usec

Strong point to science
- Timing analysis for pulsars
- Searching for unknown pulsar
- High frequency QPO of black hole binaries

Timing "accuracy" is very important.
HXD timing have been calibrated by Crab pulsar
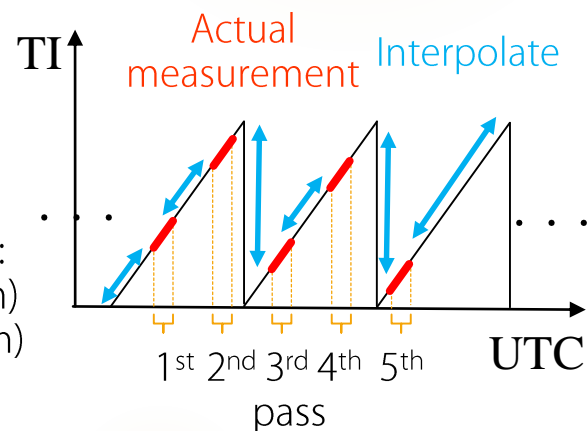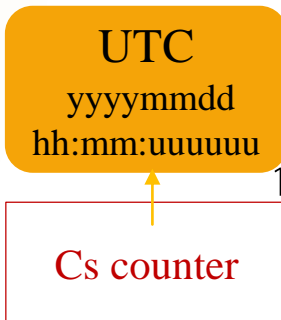compering to radio observation. (Terada et al. 2008)

Timing System onboard Suzaku

Onboard main computer

Quartz clock
(512 kHz)

TI (20+12 bit)

Subsystem (HXD)

DE

TI

long coverage

Compare
(Every observation)

AE

EVTTIME

fine resolution

Sensor

X-ray event

In orbit

Down link

On the ground

Uchinoura **S**pace **C**enter

34 m antenna

20 m antenna

Cs counter

Compare
each contact
(5 passes / day)

UTC
yyyymmdd
hh:mm:uuuuuu

Resolution:
10 us (34 m)
100 us (20 m)
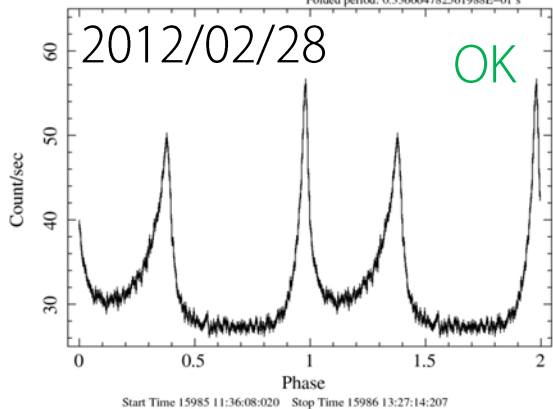
TI

Actual measurement   Interpolate

1st 2nd 3rd 4th 5th
pass

UTC

Status 1: Timing Drift

Timing Calibration with Crab pulse

HXD-PIN CRAB pulse
folded with radio ephemeris(Jodrell Bank)

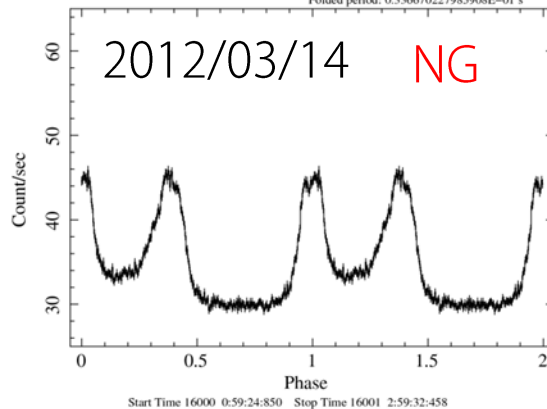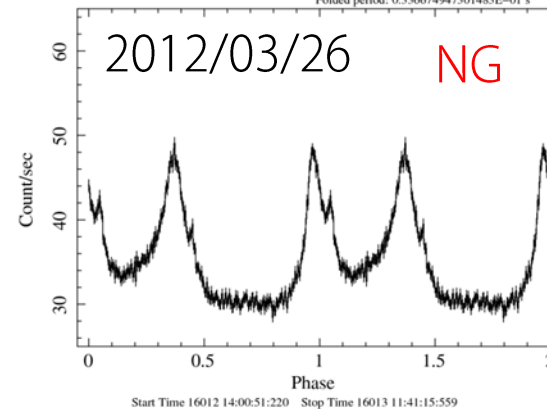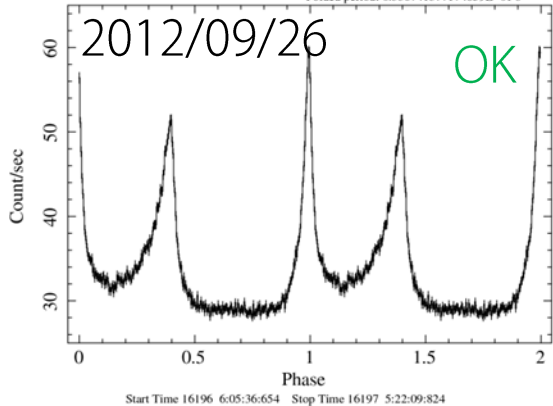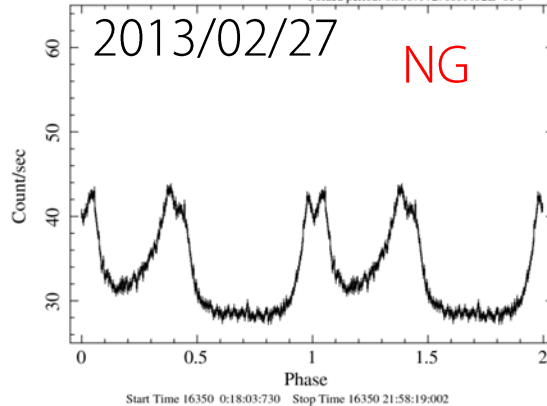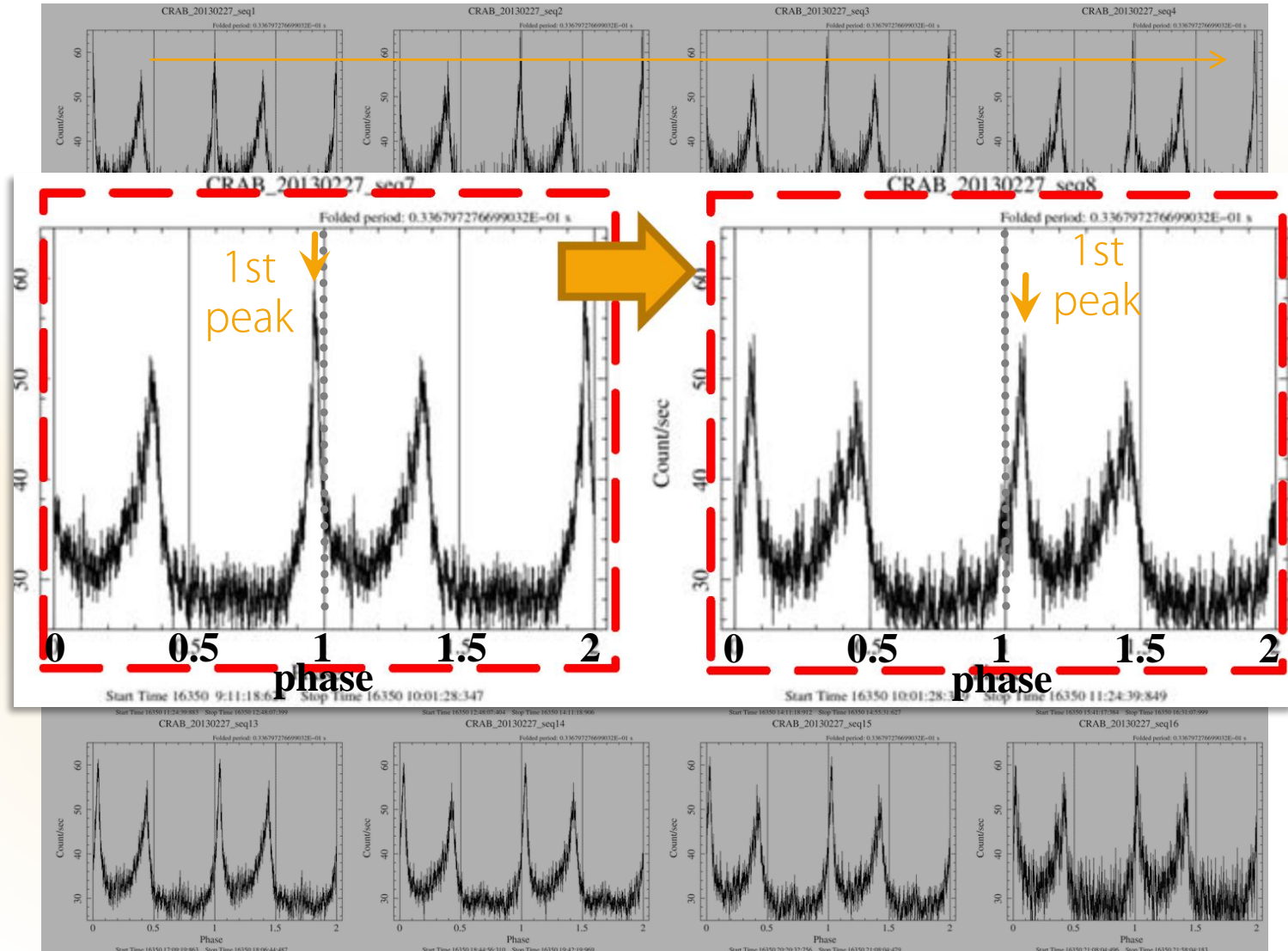- Observations before Feb 2012 are OK

Each 5 ks folding

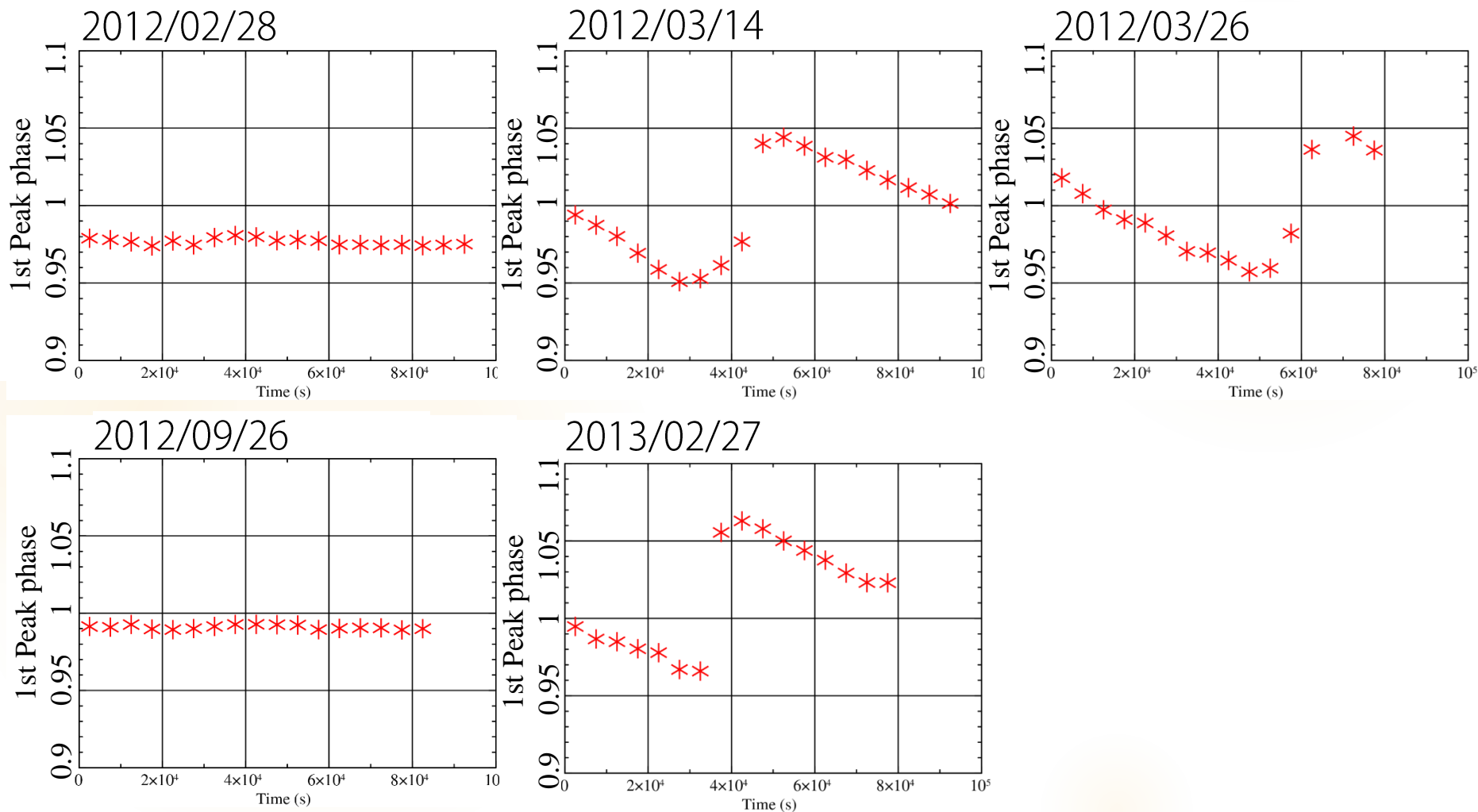2013/02/27　folded light curves per 5000 sec
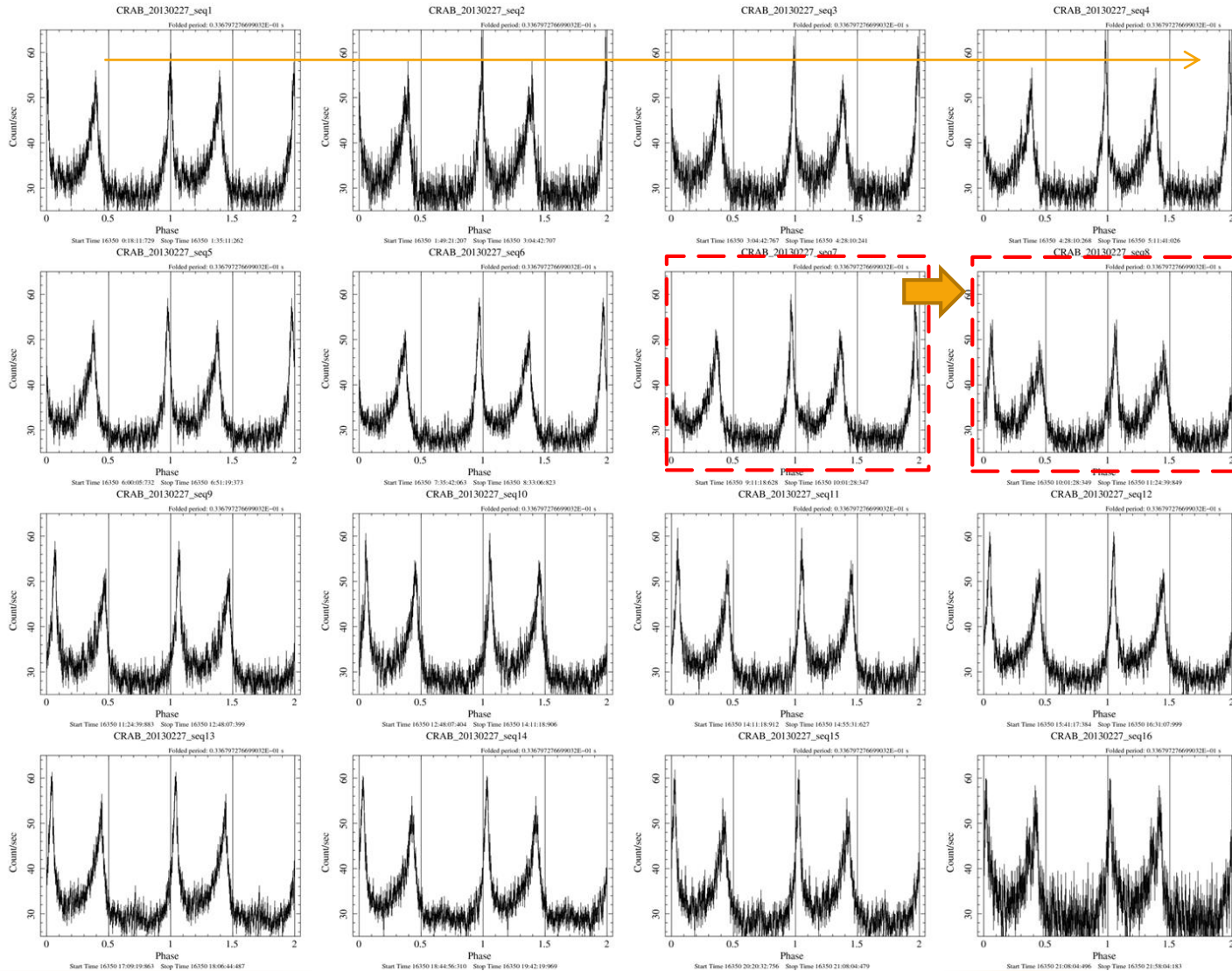
Each 5 ks folding

2013/02/27 folded light curves per 5000 sec

Timing Drift

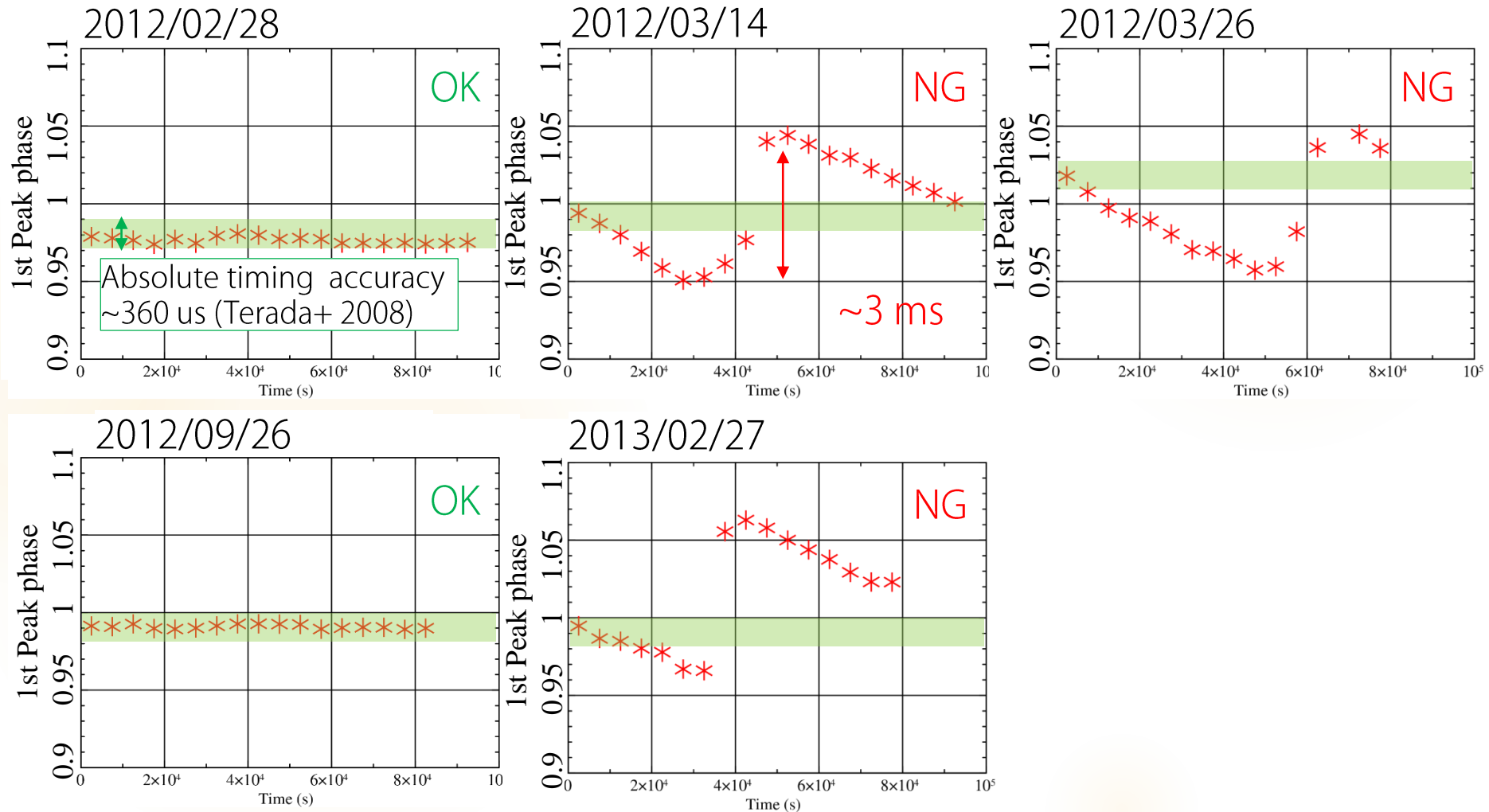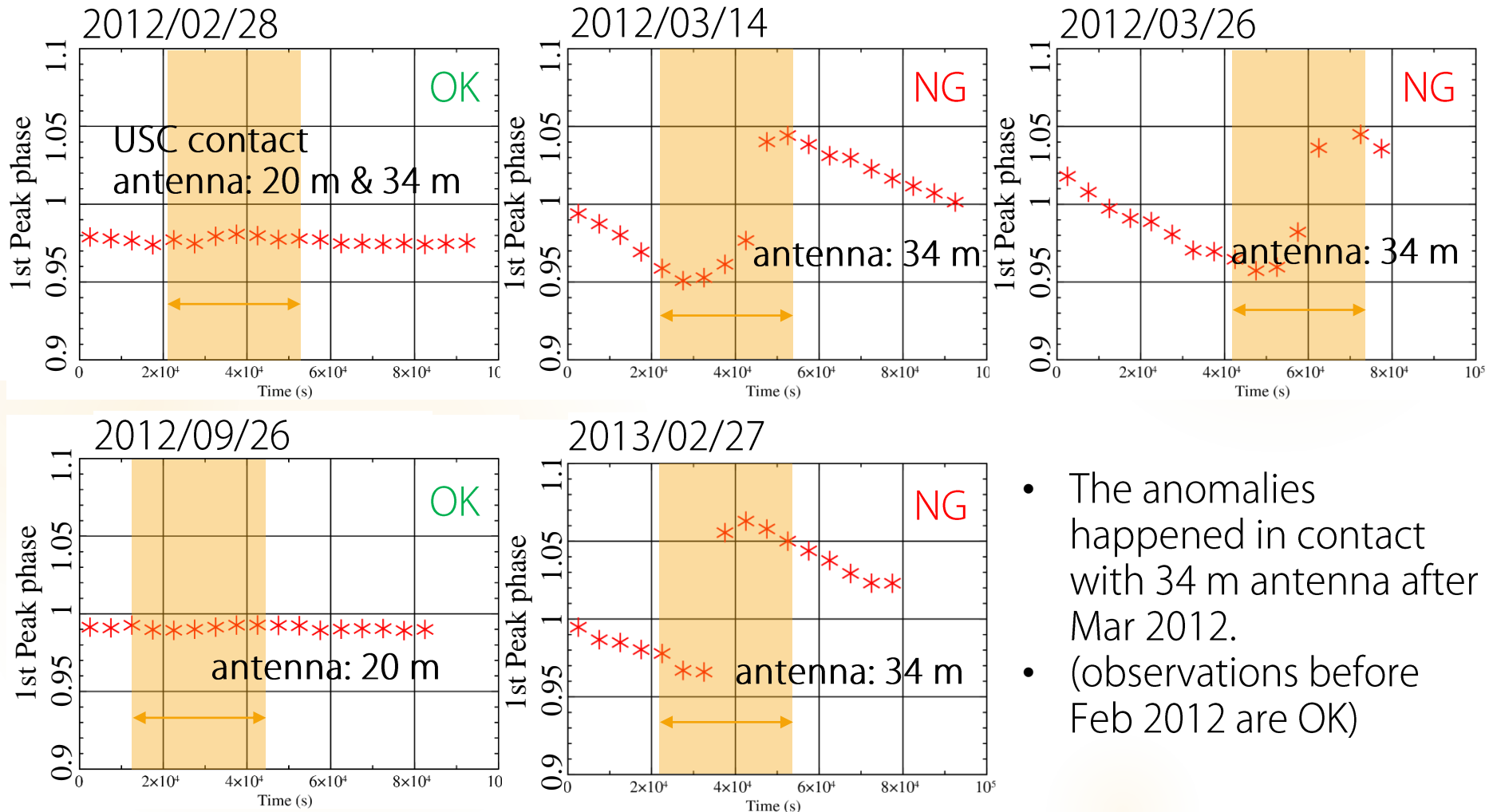1st peak phase(radio) in each 5 ks folding

Timing Drift

1st peak phase(radio) in each 5 ks folding

2012/02/28 — OK — Absolute timing accuracy ~360 us (Terada+ 2008)

2012/03/14 — NG — ~3 ms

2012/03/26 — NG

2012/09/26 — OK

2013/02/27 — NG

Timing Drift

1 st peak phase(radio) in each 5 ks folding

2012/02/28 — OK — USC contact antenna: 20 m & 34 m

2012/03/14 — NG — antenna: 34 m

2012/03/26 — NG — antenna: 34 m

2012/09/26 — OK — antenna: 20 m
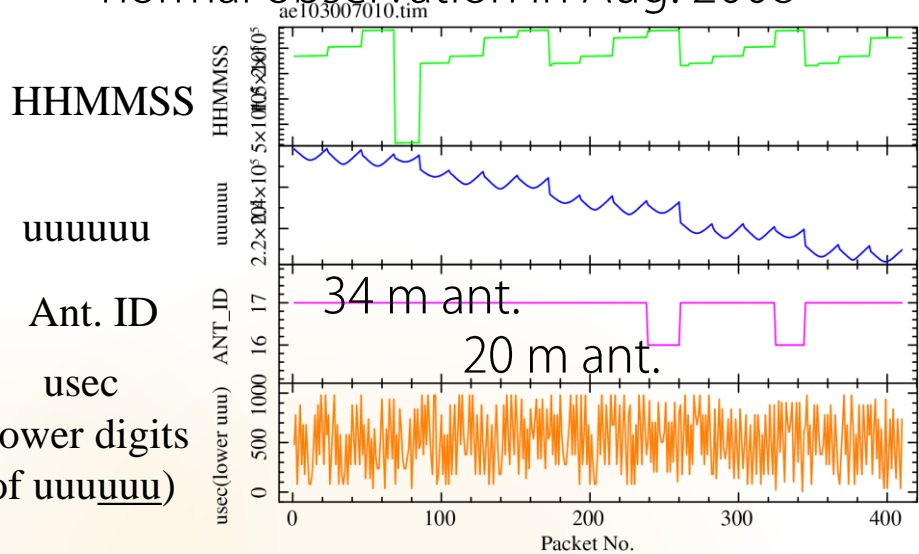
2013/02/27 — NG — antenna: 34 m

- The anomalies happened in contact with 34 m antenna after Mar 2012.
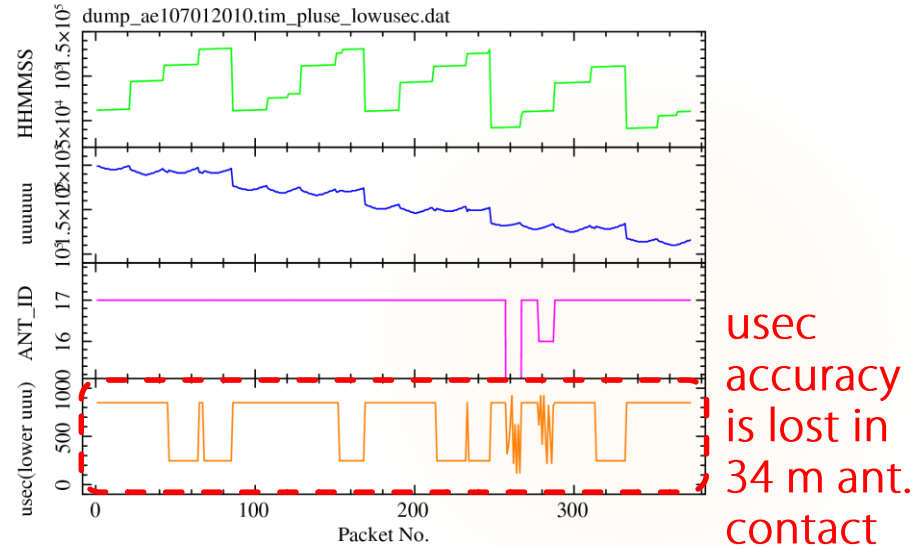- (observations before Feb 2012 are OK)

UTC assignment to data packets
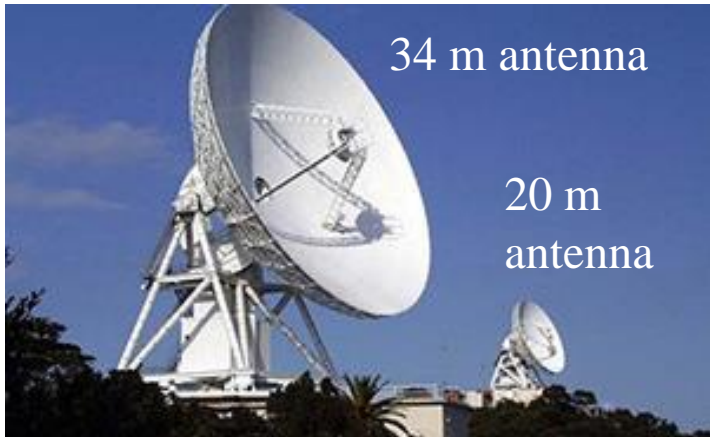
[Time packets during contact passes]

normal observation in Aug. 2008

anomalous observation in Mar. 2012

HHMMSS

uuuuuu

Ant. ID

usec
(lower digits
of uuuuuu)

34 m ant.

20 m ant.

usec
accuracy
is lost in
34 m ant.
contact

Uchinoura Space Center

34 m antenna

20 m
antenna

Resolution:
~~10 us~~ (34 m)
100 us (20 m)

UTC
yyyymmdd
hh:mm:uuuuuu

Cs counter

TI

Actual
measurement

Interpolate

UTC

UTC assignment to data packets

[Time packets during contact passes]

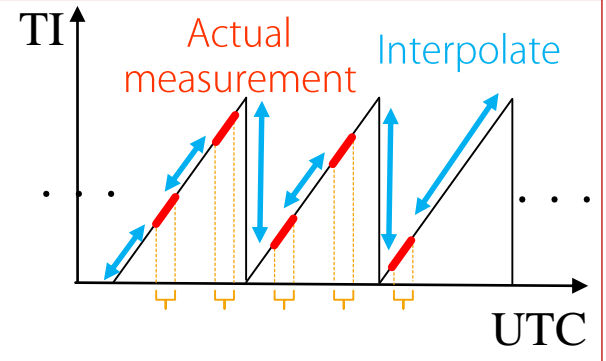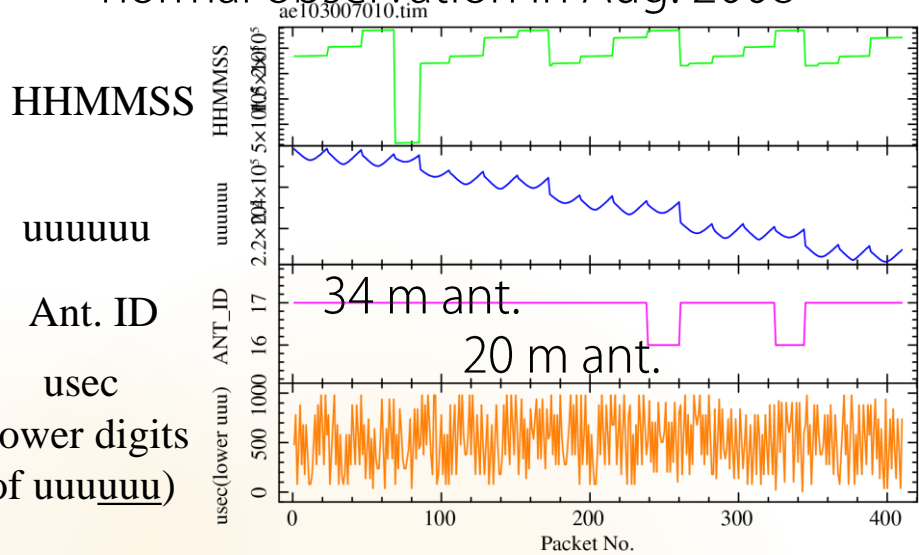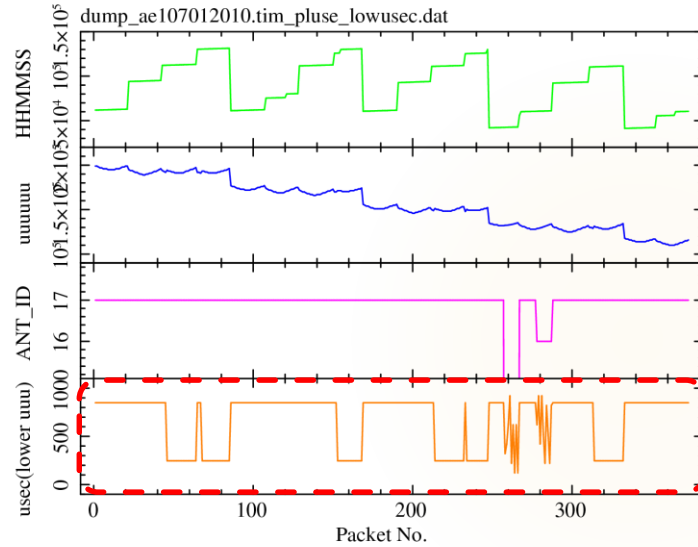normal observation in Aug. 2008

anomalous observation in Mar. 2012

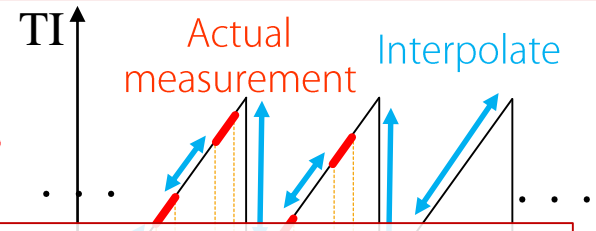ae103007010.tim

dump_ae107012010.tim_pluse_lowusec.dat

HHMMSS

uuuuuu

Ant. ID

34 m ant.

20 m ant.

usec
(lower digits
of uuu_uuu_)

usec
accuracy
is lost in
34 m ant.
contact

Packet No.

Packet No.

Uchinoura **S**pace **C**enter

34 m antenna

20 m
antenna

Resolution:
~~10 us~~ (34 m) -> 1 ms
100 us (20 m)

UTC
yyyymmdd
hh:mm:uuuuuu

Cs counter

TI

Actual
measurement

Interpolate

UTC

Timing resolution of 34 m antenna
had become 1 ms since ground
system update in Feb 2012.
⇒ fixed to 10 us in 1st Mar 2014.
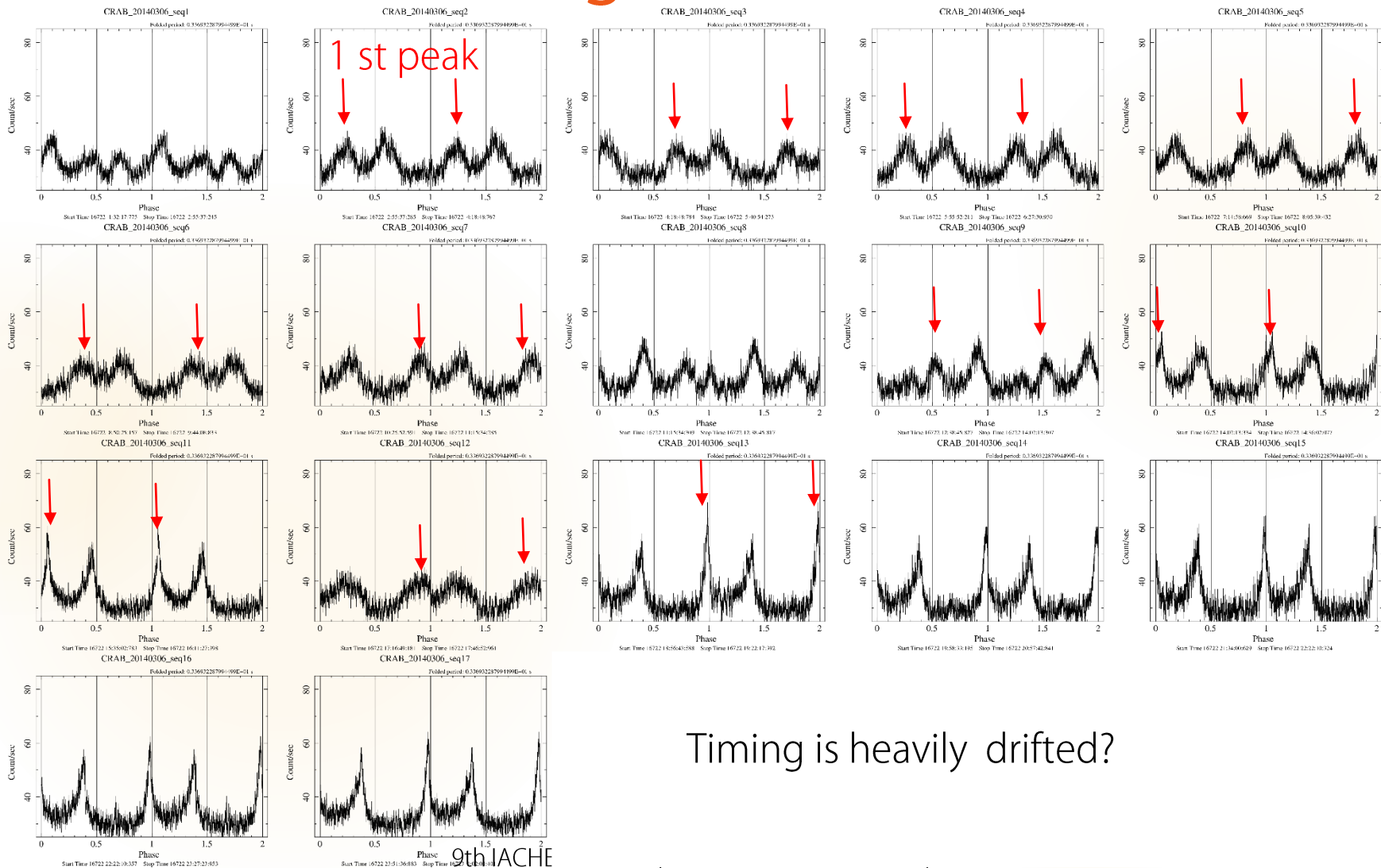
Status 2: New Issue

Latest observation of Crab Mar. 2014
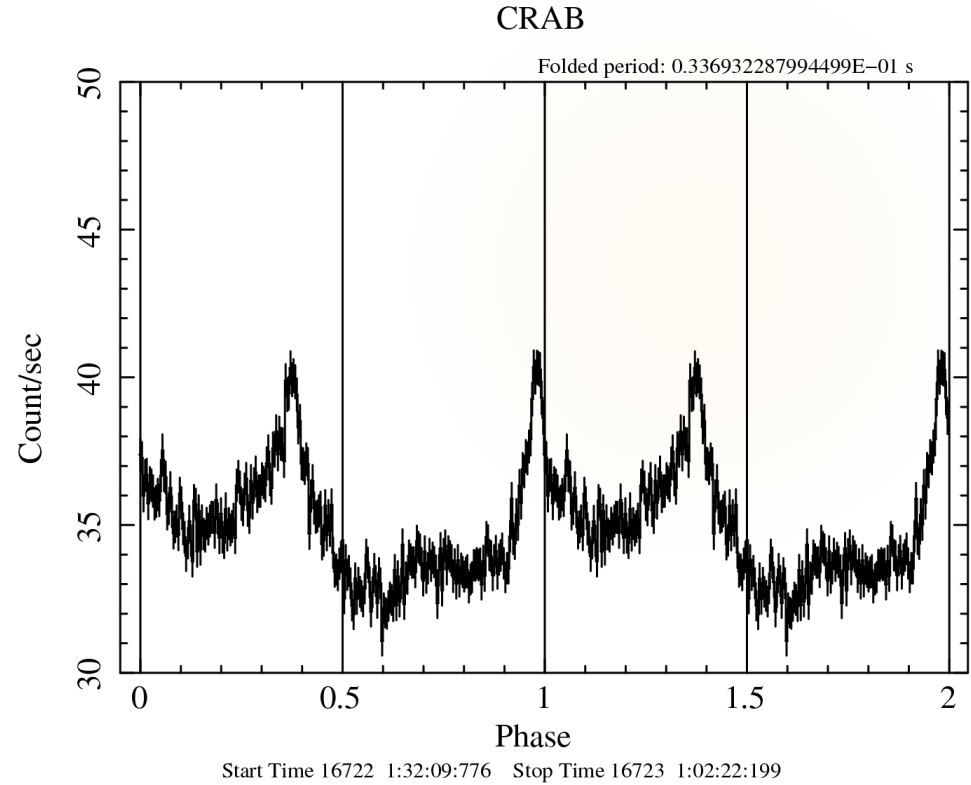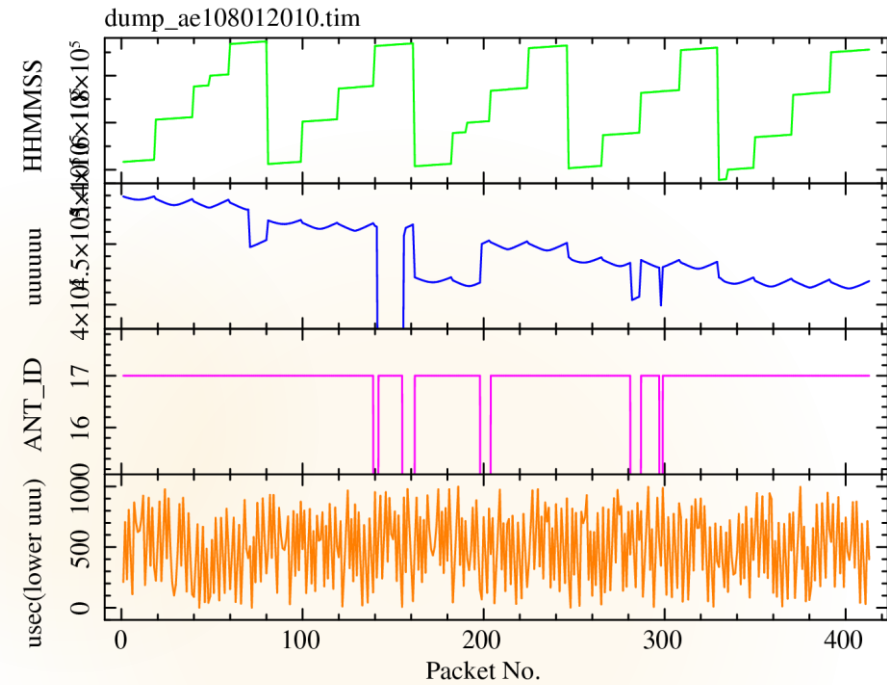
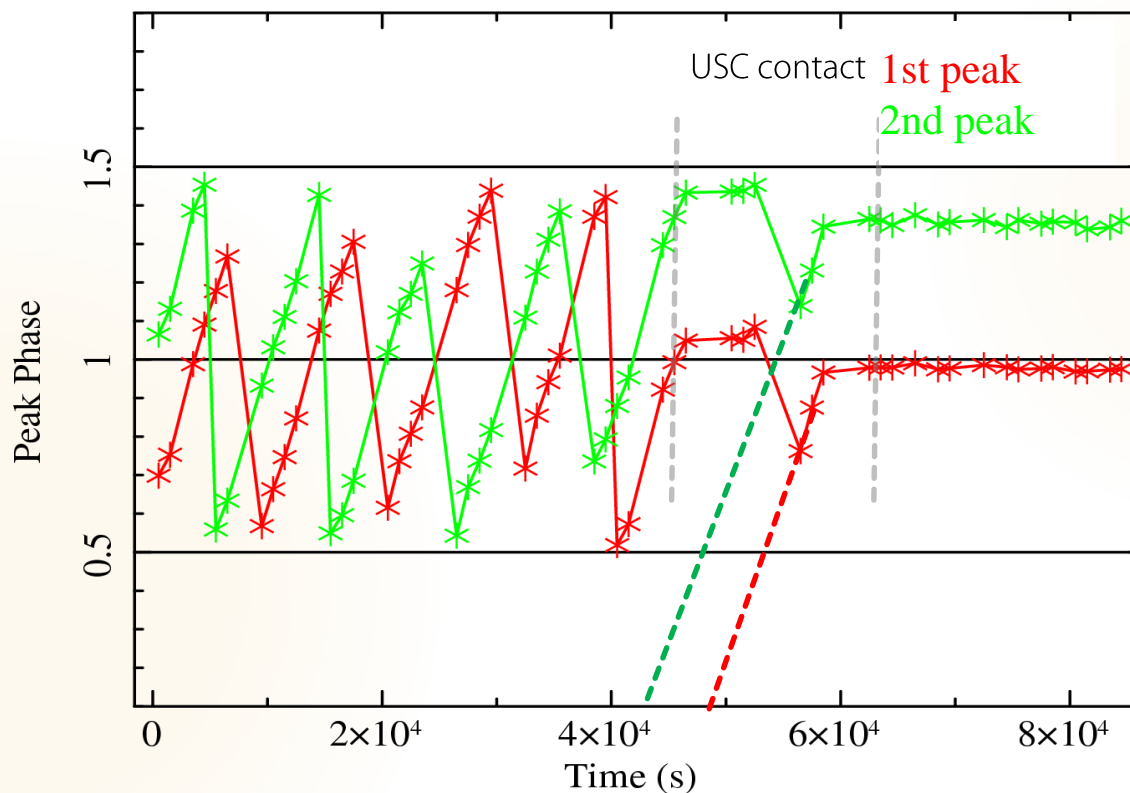Resolution of 34 m telemeter is recovered to 10 us successfully.

Pulse phase is roughly right, but pulsed flux is low and bridge shape is anomalous.

Latest observation:
each 5 ks folding

1 st peak

Timing is heavily drifted?

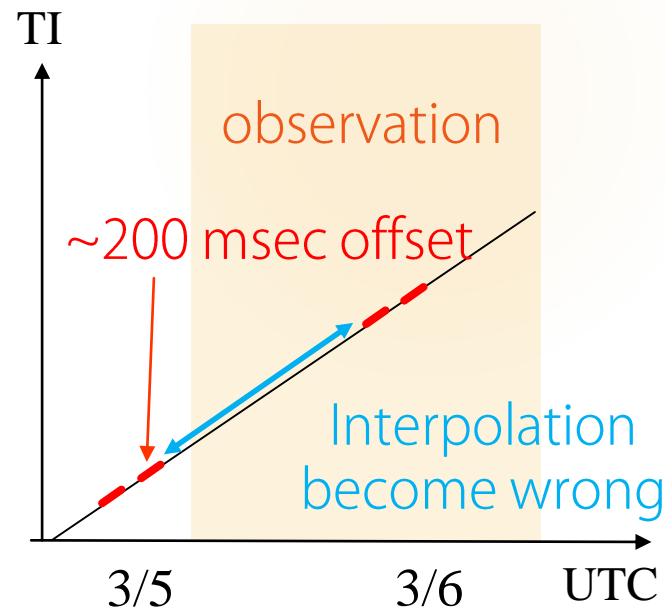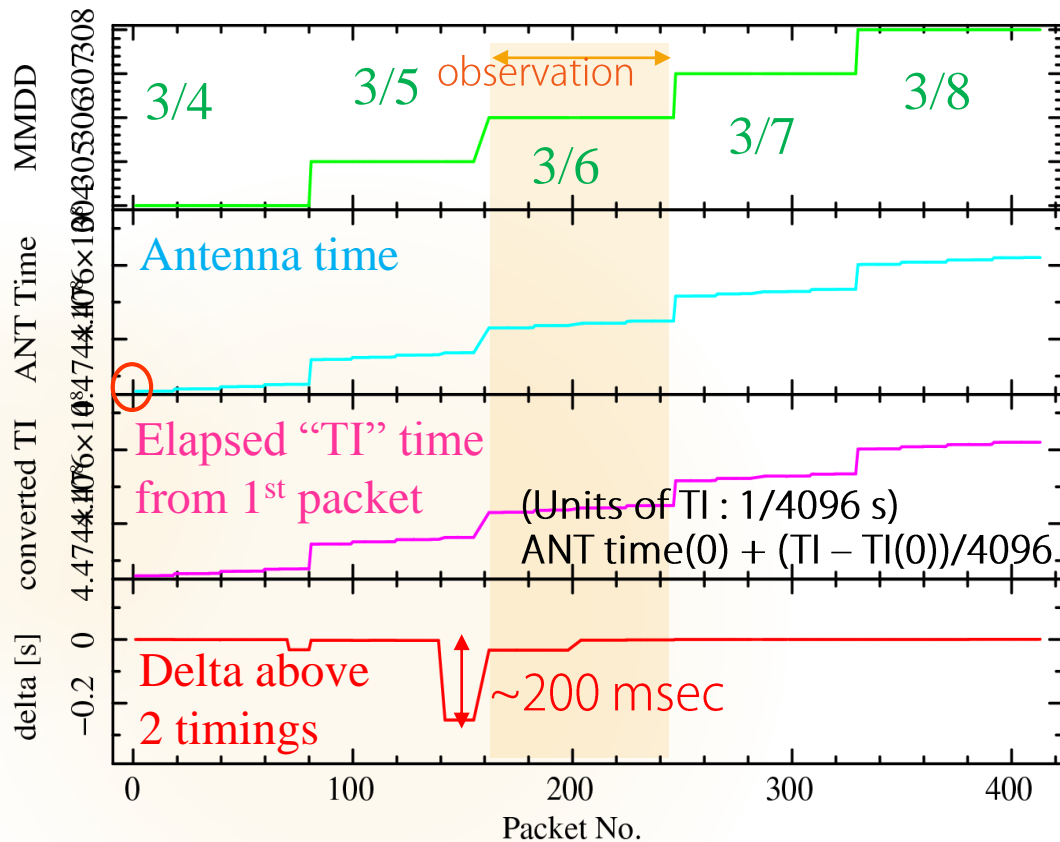# Latest observation : pulse phase delay

CRAB_20140306 Peak Phase Drift

≧6 phases(~180 ms) delayed

Latest observation : Timing offset

Packet received timing during contact passes

If TI is right ~200 m sec offset in antenna time -> consistent to Crab ~>6 phases delay .

Still working for more detail.

Summary

- From Suzaku/HXD observation of Crab pulsar, timing drift of ~3 ms was found during 2012 - 2013.

- The loss of timing accuracy is caused to that the time resolution of 34 m antenna became 1 ms at the update of ground system in Feb 2012.

- The resolution had been improved to 10 us from update in Mar 2014.

- But other issue has been found.
- ~ 200 msec offset in antenna timing.
- The cause is under investigation.

Thank you !