CALIBRATION AND SOFTWARE FOR THE ASTRO-H TIME ASSIGNMENT

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ON BEHALF OF ASTRO-H TEAM

CALIBRATION REQUIREMENT FOR TIME

Science Goals
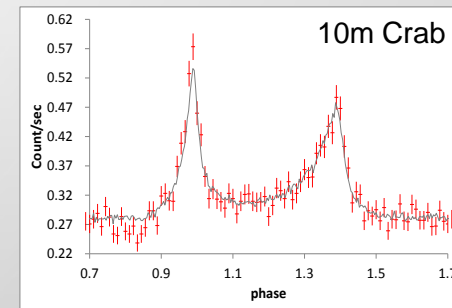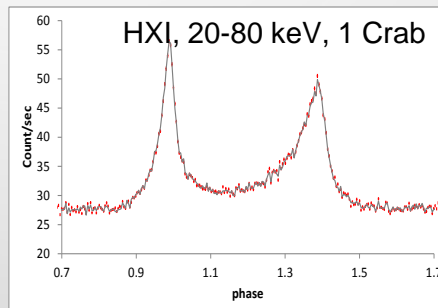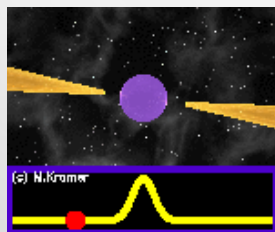
One of Science Goals for ASTRO-H
- Understand physical processes in extreme environment
- ...

Expectation on future observations

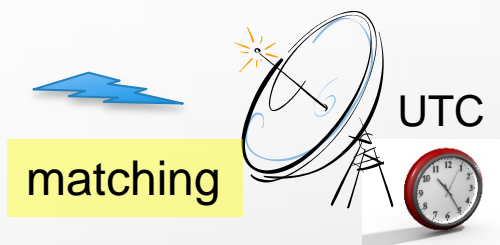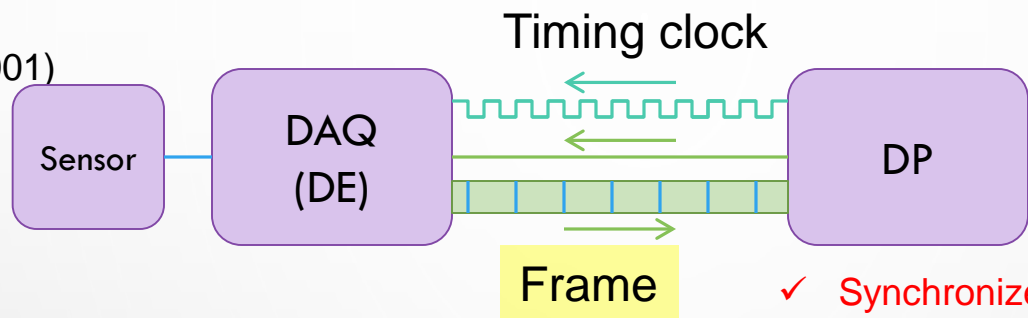Pulsars, black holes, neutron stars, AGNs, etc..

Calibration requirements

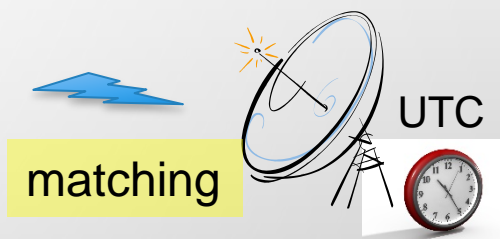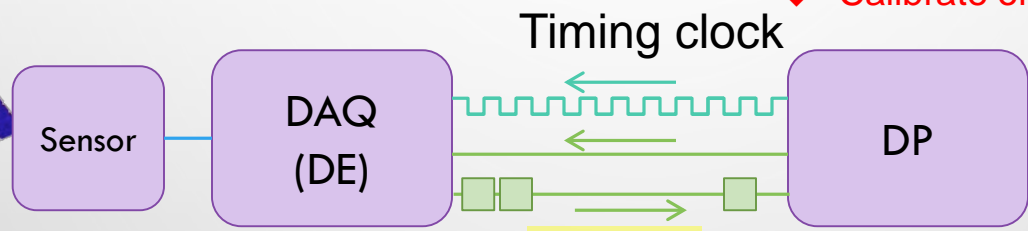| Requirement	Goal
300 µs on absolute time	30 µs on absolute time

TIME ASSIGNMENT SYSTEM

ASCA (1993-2001)

Timing clock

Sensor → DAQ (DE) → DP

matching UTC

Frame

✓ Synchronize
✓ Well-defined timing
◆ Calibrate onboard clock

Suzaku (2005-)

Timing clock

Sensor → DAQ (DE) → DP

matching UTC

Packet DS link
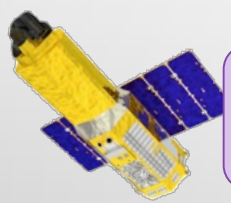
✓ Synchronize
◆ Time stamp in packet *(New)*
◆ Calibrate onboard clock

Terada+08

ASTRO-H (2014-)

No timing clock

Sensor → DAQ (DE) → SMU

Packet SpaceWire link

GPS

UTC

backup
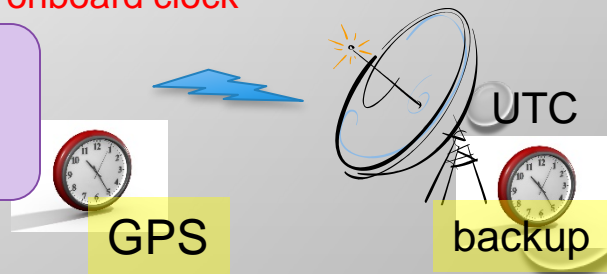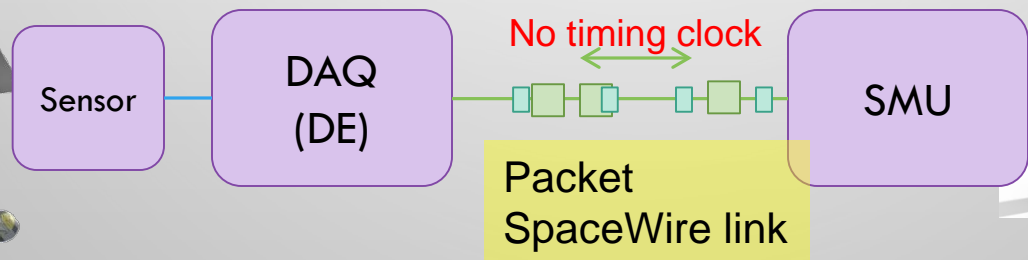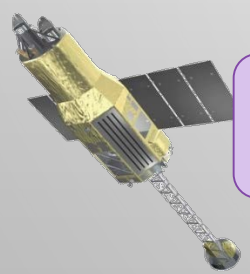
◆ Synchronize but delay *(New)*
◆ Time stamp in packet
✓ GPS receiver on board *(New)*

SPACEWIRE NETWORK & FINER TIME RESOLUTION

SpaceWire : Standard network protocol based on IEEE1355

GPS

SMU

SpaceWire

Router

130 nodes !

DE

DE

DE

. . .

Free-run clock

Spacecraft time: TI (time indicator, 38-bit)

1/64s since 1980/1/6

TI   s

via RMAP
(every s)
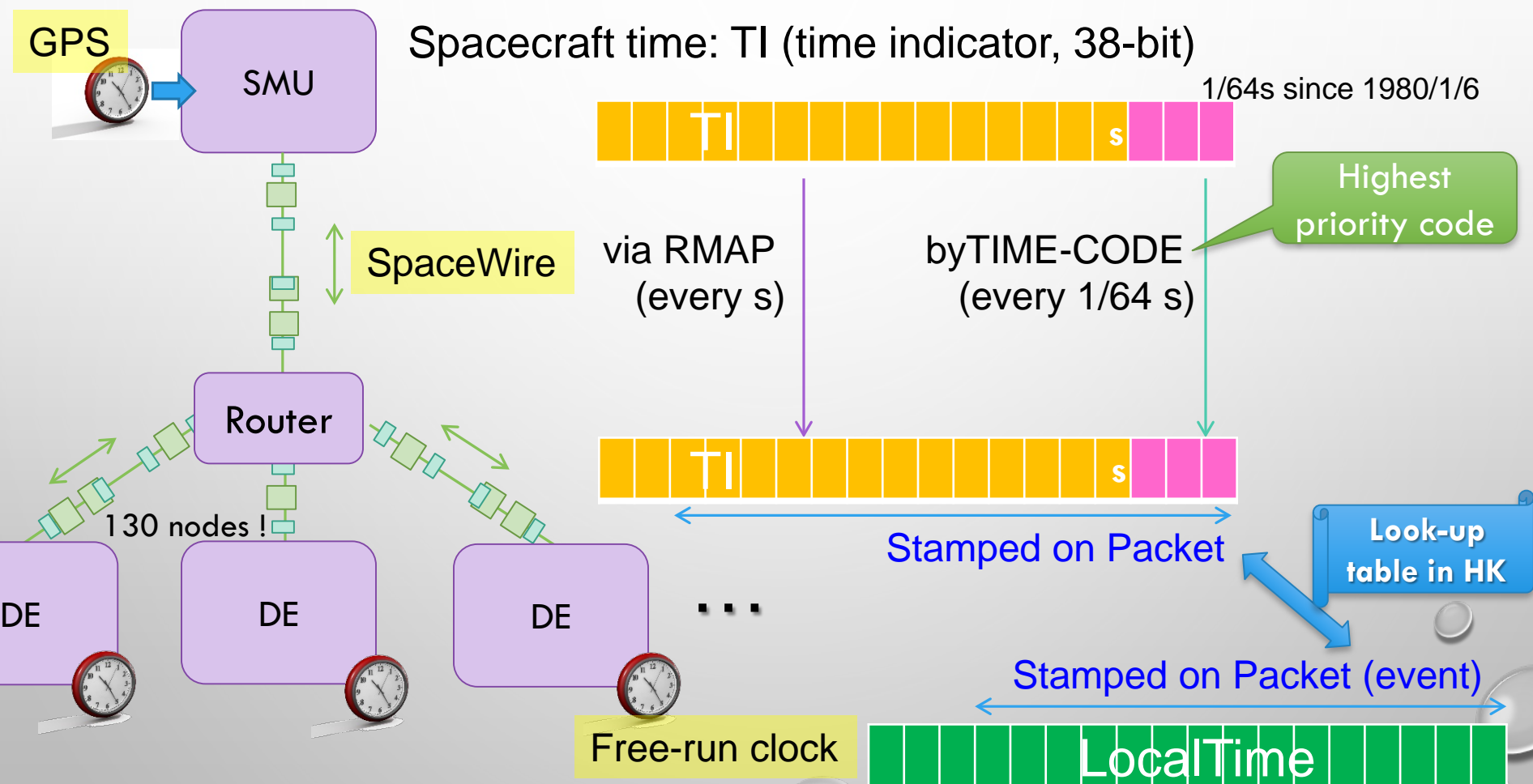
byTIME-CODE
(every 1/64 s)

Highest priority code

TI   s

Stamped on Packet

Look-up table in HK

Stamped on Packet (event)

LocalTime

- Synchronization of TI is performed by highest priority code in SpaceWire
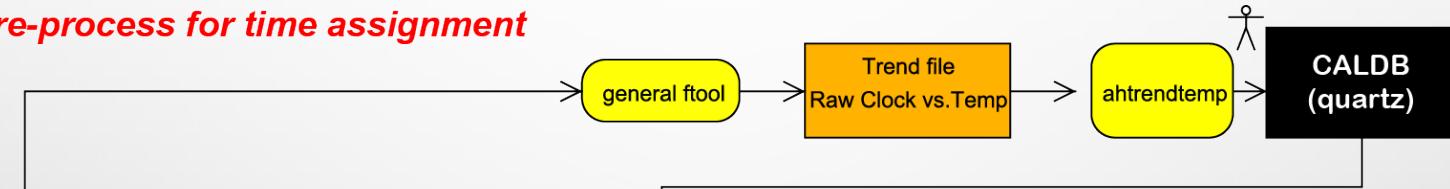- Finer timing resolution is covered by free-run clock on instrument side.
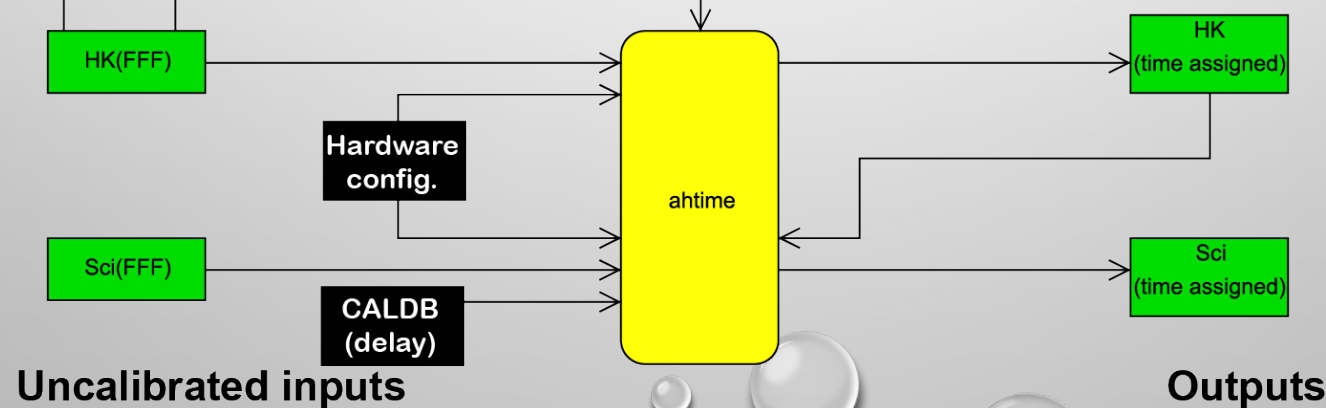
SOFTWARE DESIGN FOR TIME ASSIGNMENT

Design policy:

- ✓ Common for 4 payload instruments & HKs (hardware configuration is in CALDB)
- ✓ Simple task division
  - pre-process for backup plan when GPSR fails
  - Calculation for finer time resolution is done in one main task, *ahtime*.

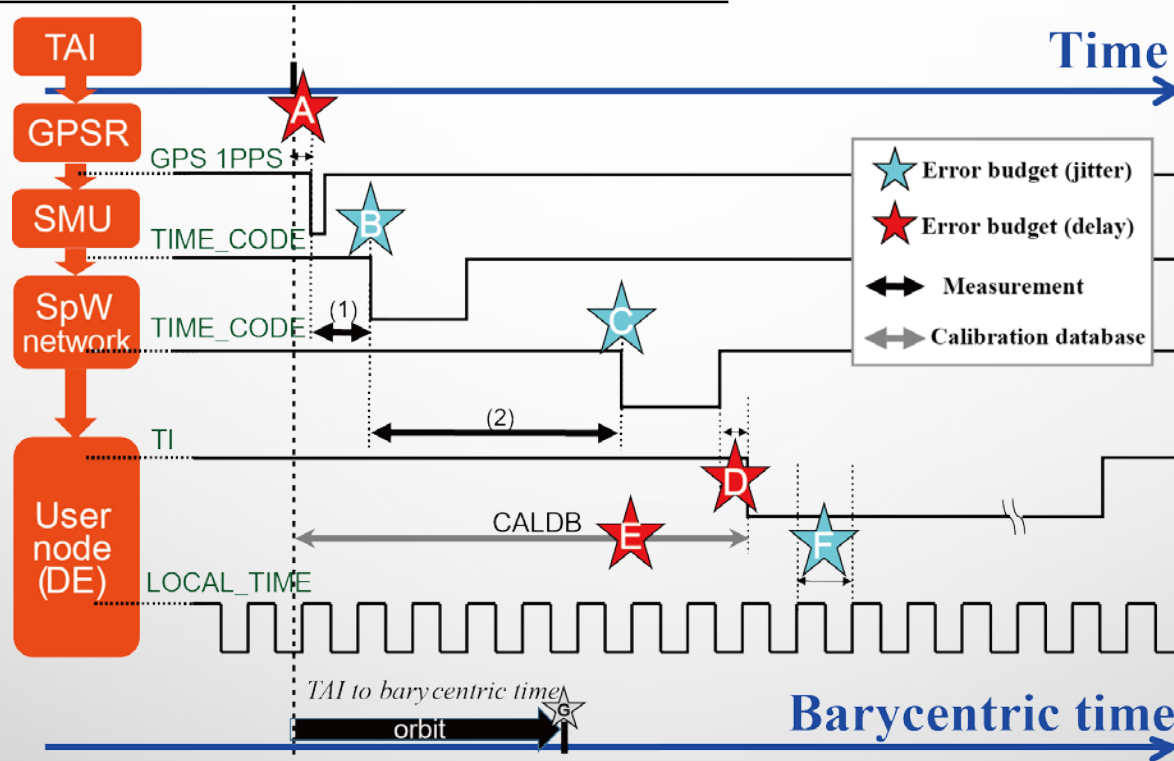**Pre-process for time assignment**

general ftool → Trend file Raw Clock vs.Temp → ahtrendtemp → CALDB (quartz)

TIM → ahmktim → GPS gti → TIM(fine)

Main process for time assignment

HK(FFF), Hardware config., Sci(FFF), CALDB (delay) → ahtime → HK (time assigned), Sci (time assigned)

Uncalibrated inputs   **Outputs**

ERROR BUDGET FOR TIMING

Timing chart for distribution of TIME information

Error budget for Timing accuracy

ID	Component	Error Items	Error Allowed
A	GPSR	Jitter between atomic time and 1PPS signal output	$< 0.02\mu s$
B	SMU	Jitter between 1PPS signal from GPSR and TIME_CODE	$< 0.5\mu s$
C	SpaceWire network	Jitter of TIME_CODE at user node	$< 2.0\mu s$
D	SpaceWire network	Systematic error in the correction of TIME_CODE jitter at user node	$< 1.0\mu s$
E	SpaceWire user node (DE)	Timing uncertainties in receiving TIME_CODE and TI generation	$< 1.0\mu s$
F	SpaceWire user node (DE)	Timing uncertainties for periodic signals due to finite timing resolution of LOCAL_TIME	$< 20.0\mu s$
G	Ground System	Accuracy of orbit determination of the spacecraft	$< 3.0\mu s \ (= 1 \text{ km})$

GROUND CALIBRATION (1)

Measurement for Error budget B

$$914 \pm 150 \ (ns)$$

Jitter (3 sigma)
< error budget B
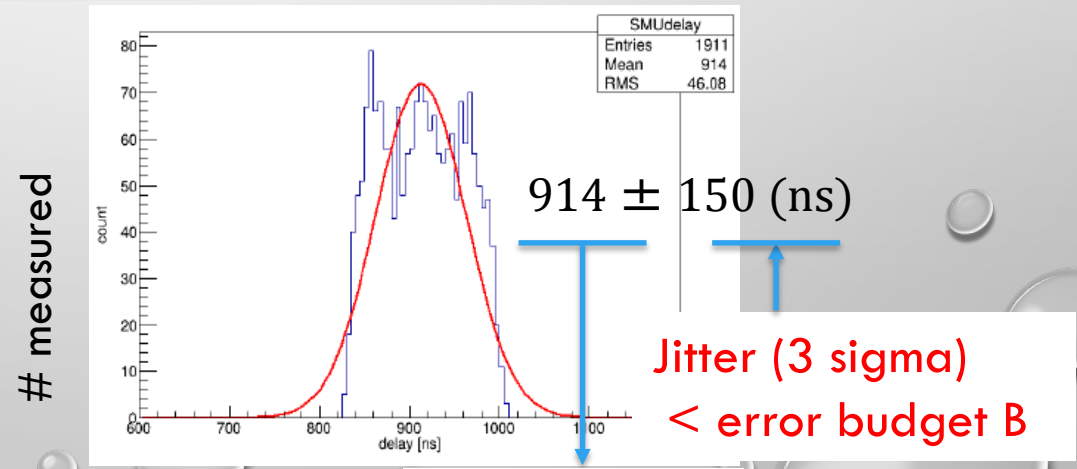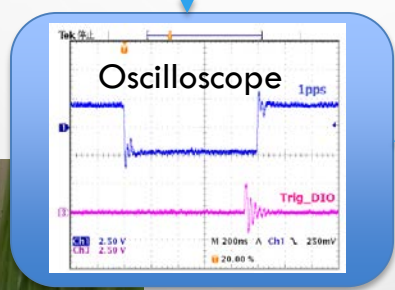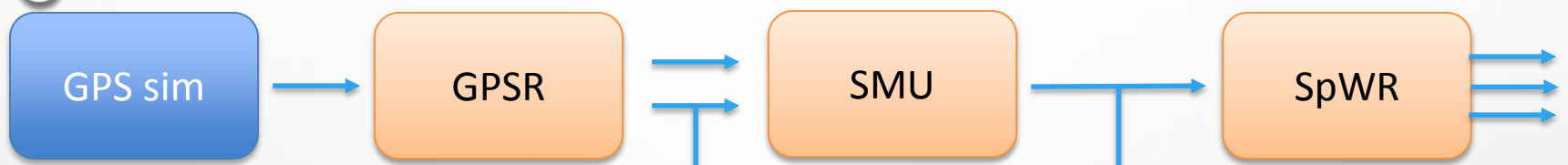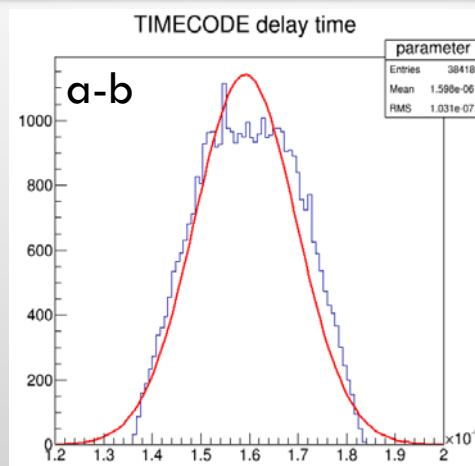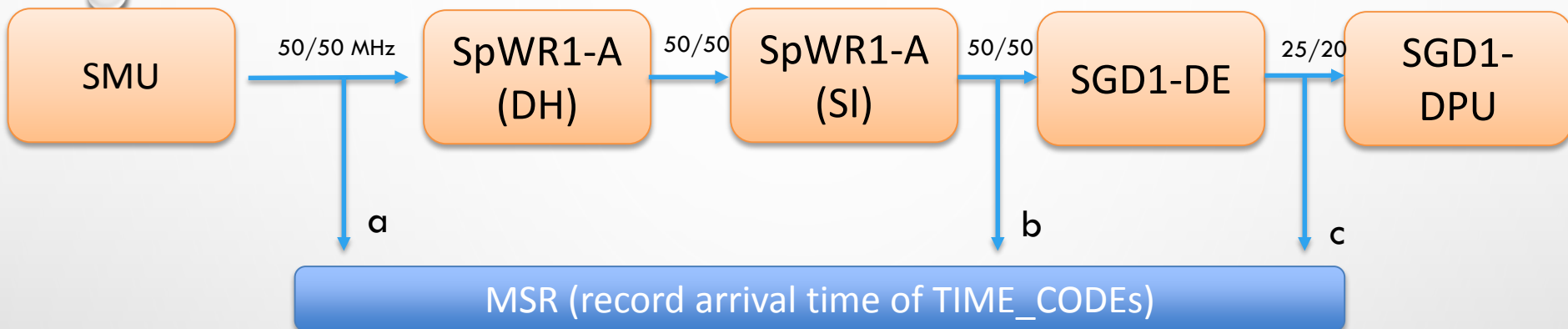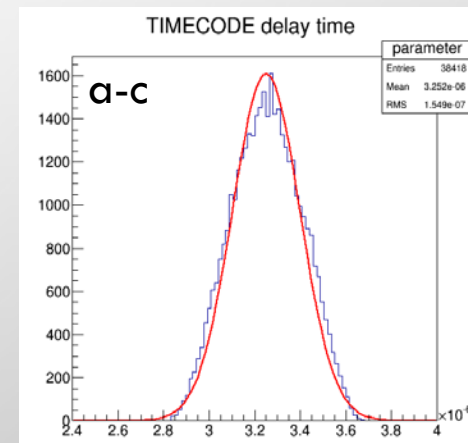
CALDB-delay

measured

GROUND CALIBRATION (2)

Measurement for Error budget C & D

1600 ± 315 (ns)

3250 ± 444 (ns)

CALDB-delay: delay ~ Sum of delay & jitter of each component (**Confirmed**)
Error budget: jitter < budget D (1000 ns) → OK

THANKS!