IOC performance on F3RP61

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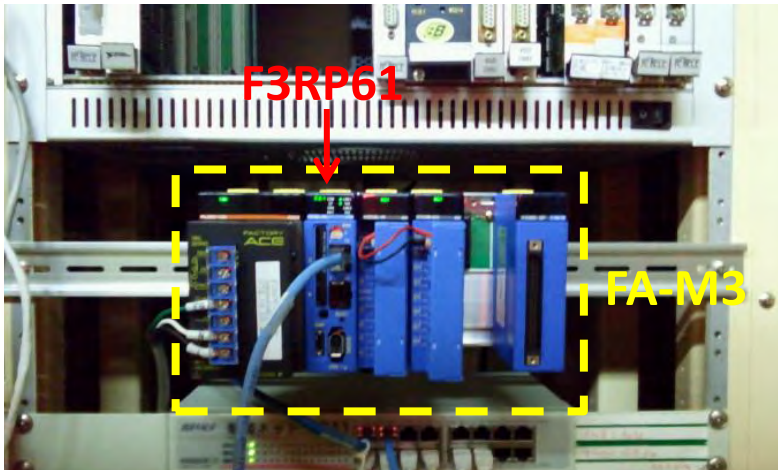
F3RP61

- Embedded CPU module
  - for PLC FA-M3
  - Linux OS
  - compact size
- We started to use as IOC since 2008.



- Stepping motor controller for movable beam mask at KEKB

- Power supply for electro-static septum and septum magnets at the slow extraction line of J-PARC MR.

- Current monitor at the neutrino beam line of J-PARC MR.

Manufacturer	Yokogawa
Base	PLC FA-M3
Type	CPU module
CPU	32bit, 533MHz
Memory	128 Mbyte
Storage	64 MB flash ROM
OS	ELDK Linux 4.2
Network port	10BASE-T/100BASE-TX (2ch)

We studied detailed performances before largely adopting at SuperKEKB.

Read/Write performance with IO modules

Process time for following access is studied.

Access type	Accessed Module
Analog read	AD08-1R
Analog write	DA08-1X
Binary read	XD32-3F

Process time is studied at two level

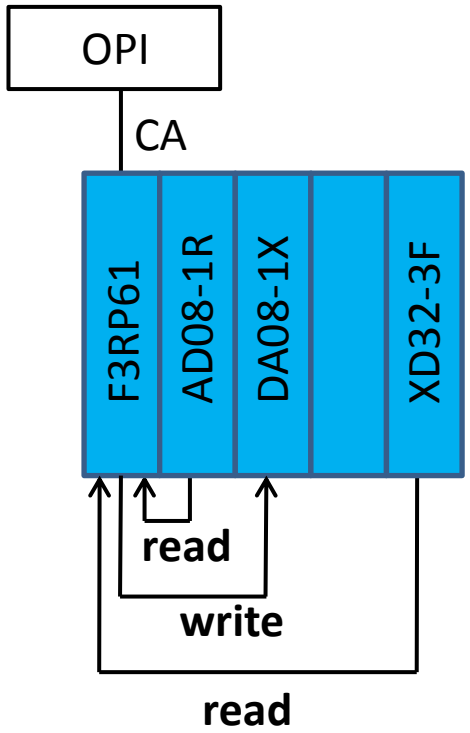
Module access driver level (driver level):

- This driver is released by manufacturer.
- Intrinsic process time for F3RP61 and FA-M3 is measured.

Record level:

- Followings are called from ai, ao, and bi records,
record support ⇒ device support
⇒ driver support ⇒ module access driver
- Practical process time for EPICS user is measured.

For each study, average of 1000000 processes is taken to avoid influence of fluctuation by environmental condition.



Driver level measurement

Expended time to call 'module access driver' 1000000 times is measured.

- Measurement is performed with both real time and processor time. (Note, Linux Kernel version: 2.6.26.8-rt16).
- There is no difference.
- Only one of those results is shown here.

(These numbers have already been divided by 1000000.)

Access type	Accessed Module	Process time
Analog read	AD08-1R	15.73 μs
Analog write	DA08-1X	12.34 μs
Binary read	XD32-3F	13.02 μs

Record level measurement

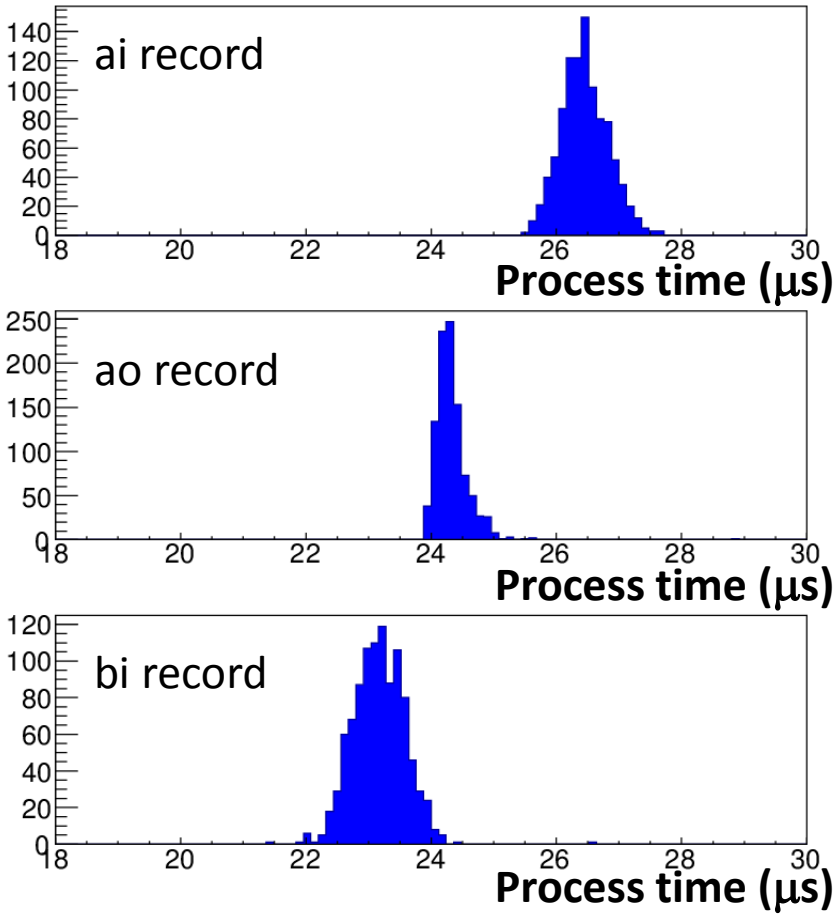
All results from now are studied with R3.14.12.1.

1001 records linked with each IO module are produced and chained via FLNK.

Δtime and process time are calculated after process first record.

Δtime: = time stamp(last) – time stamp(first)

Process time: = Δtime/1000



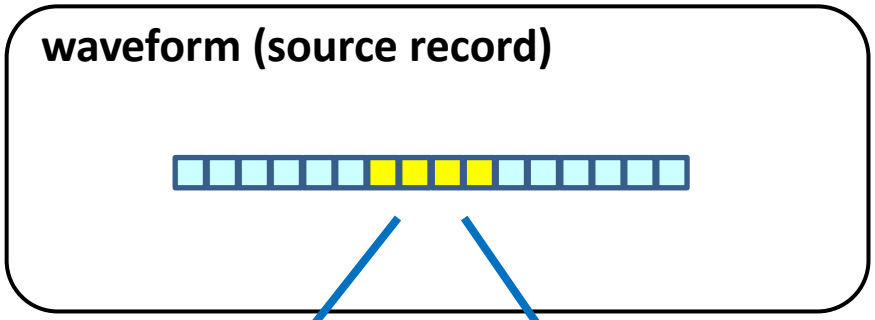
Iterate this procedure 1000 times with 1 second interval.
Mean values are treated as the result.

	Record level	Driver level
ai	26.46 ± 0.01 μs	15.73 μs
ao	24.32 ± 0.01 μs	12.34 μs
bi	23.17 ± 0.01 μs	13.02 μs

Typically process time is:
= Driver level + 10 μs

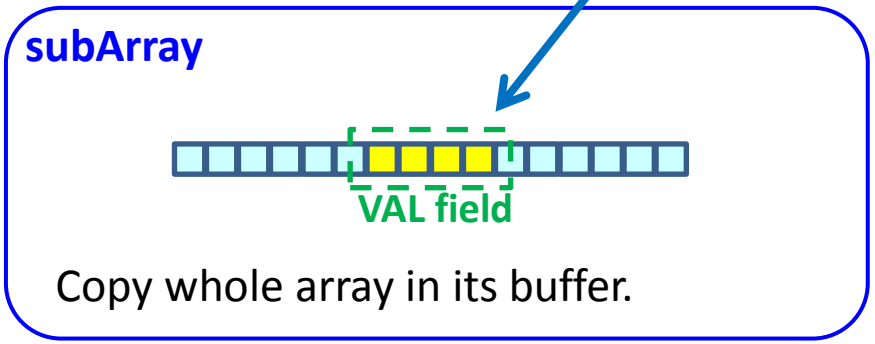
subArray and compactSA

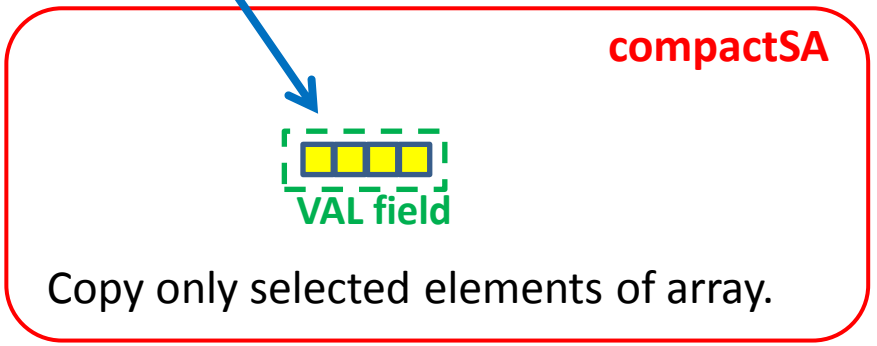
The subArray (SA) and compactSA (CSA) are studied as examples of soft records.
Process time and memory usage on F3RP61 are measured.



Both records take out part of array from source record.
Same information is stored in VAL field.

The compactSA is developed at KEK to suppress memory usage and is not included in public EPICS version.



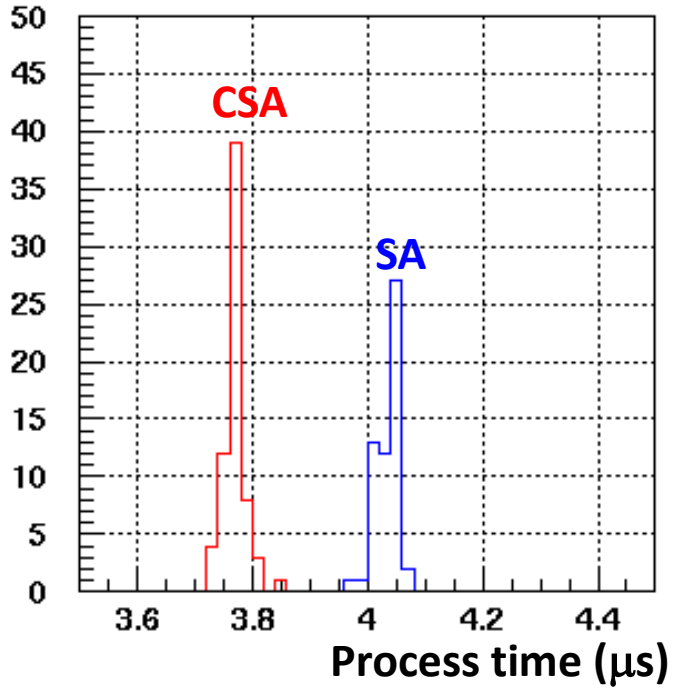


All results from now are studied with double type array.

How to measure process time

Process that 10 elements are taken out from waveform is studied.
- compared between SA and CSA
- compared with changing number of elements of waveform

Waveform: 600000 elements
SA, CSA: 10 elements



Average of 10000 processes:

- One waveform and 100 SA/CSA records are produced and chained via FLNK.
- Process time is calculated with time stamps of waveform and last SA/CSA.
- Measurement is performed 100 times.

(The right plot is an example with 600000 elements of waveform.)

Process time:

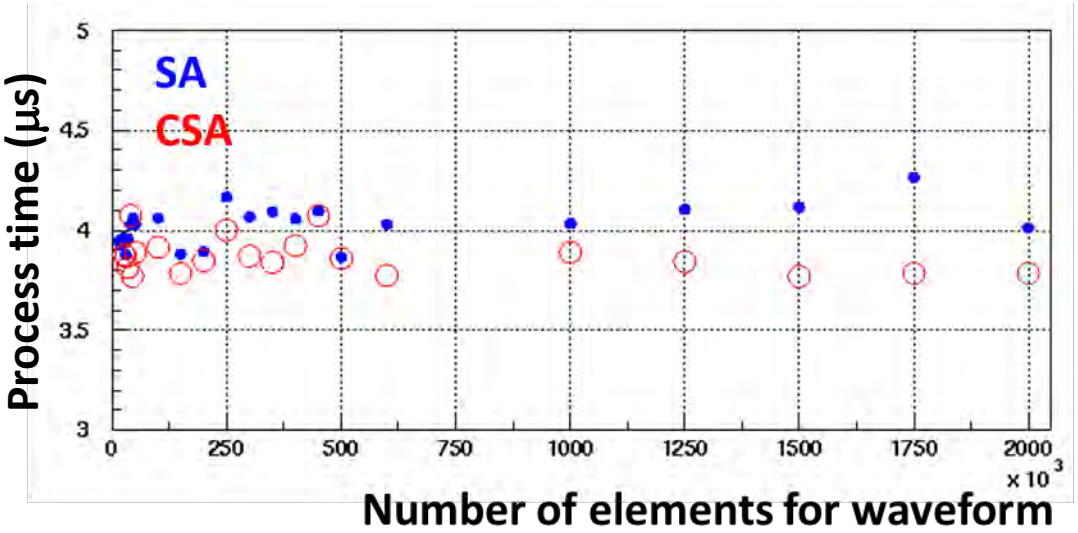
SA	4.03 μs/record
CSA	3.77 μs/record

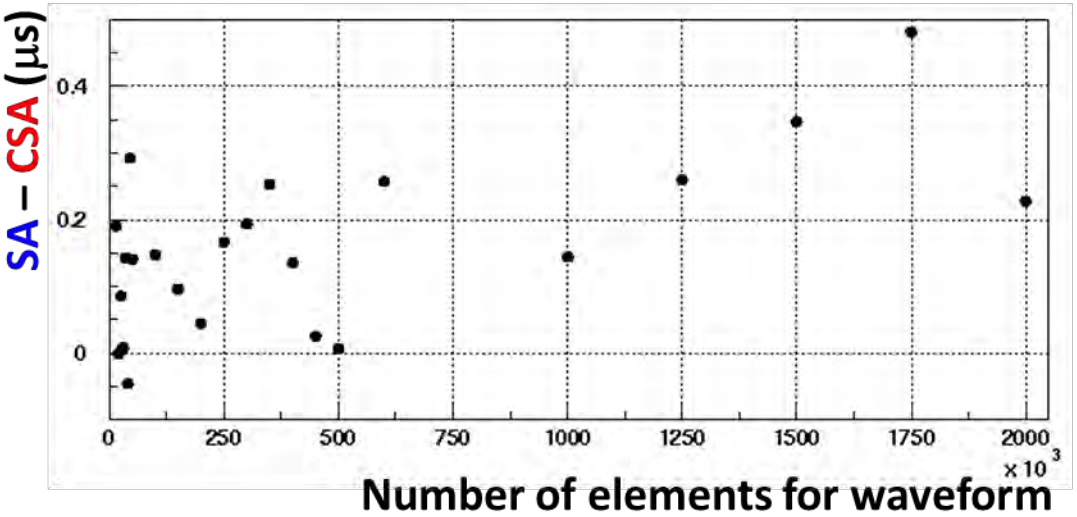
Process time of subArray/compactSA

Process time on F3RP61 is ~4μs.

Difference of process time seems to be increased with number of elements for waveform.
However there is no clear correlation.

They are at most
500 ns at >1000000 elements.





There is no significant difference of process time between SA and CSA.

How to measure memory usage

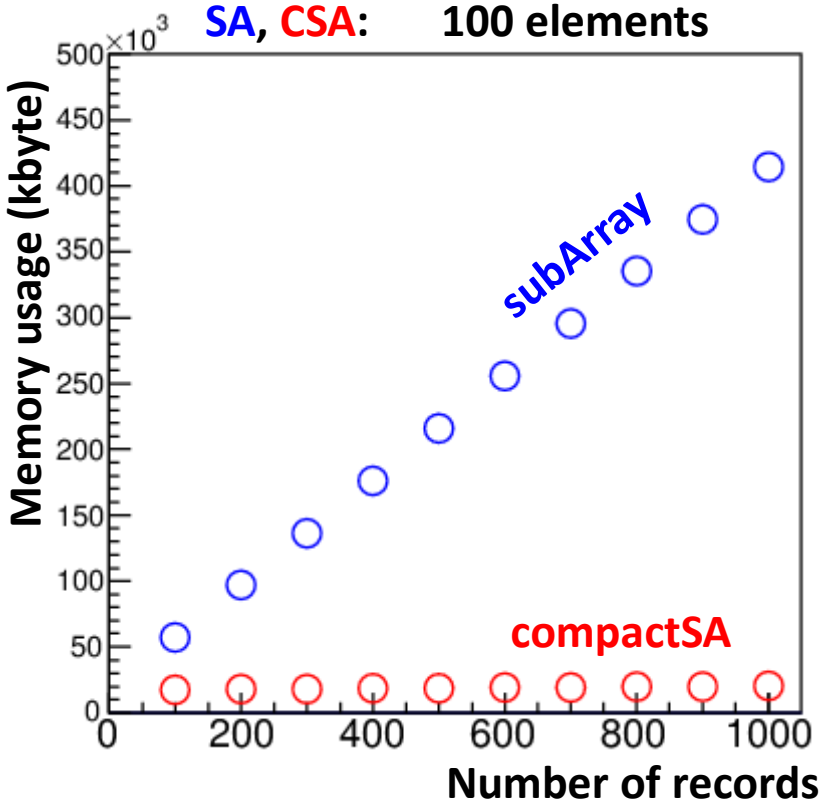
1. Total memory usage on linux is measured, simply ‘free’ command, with changing number of SA/CSA records.
2. Memory usage for one record is determined from slope of the measurement.

Measurement is performed with changing the number of elements of waveform and SA/CSA.

As a example, result of following condition is shown on the right plot.

- waveform with 200000 elements
- SA/CSA with 100 elements

Waveform: 200000 elements
SA, CSA: 100 elements

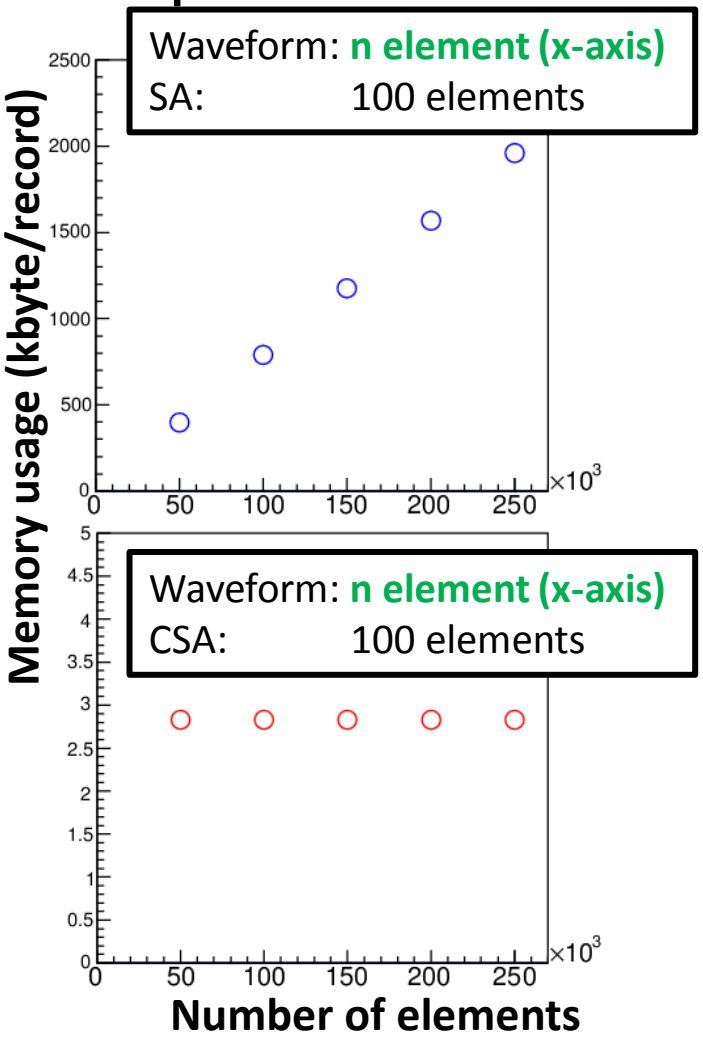


Memory usage:

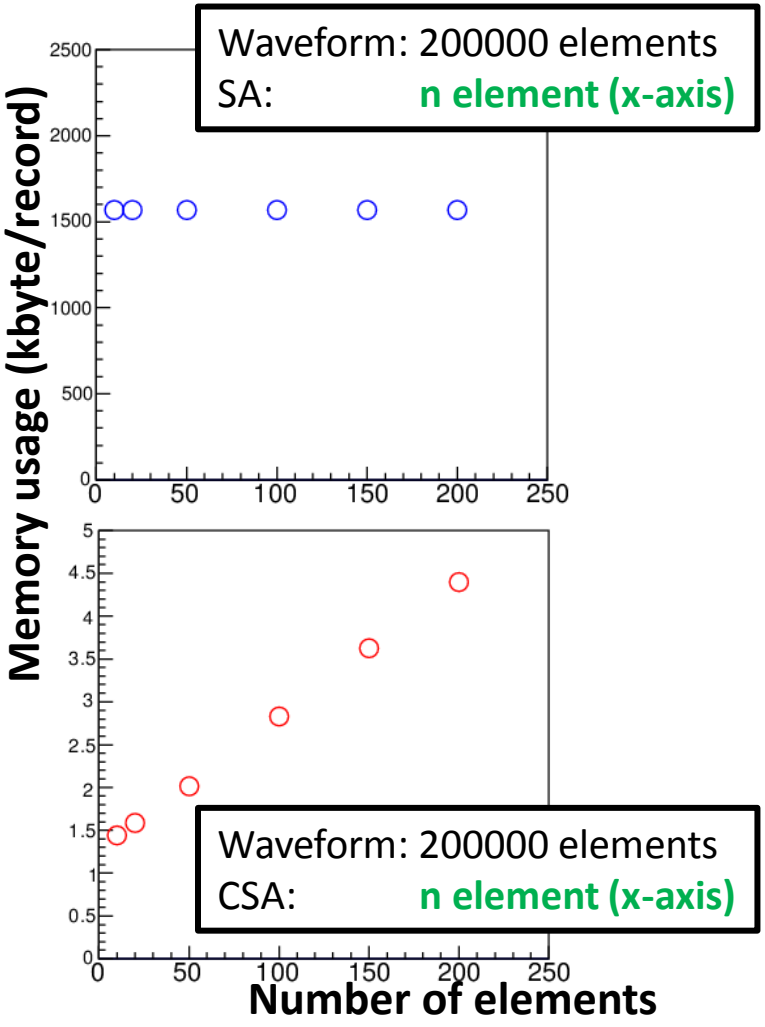
subArray	1570 kbyte/record
compactSA	2.83 kbyte/record

Comparison with number of elements

Memory usage is significantly suppressed in case of CSA.
Its dependence on number of elements of SA/CSA and waveform is reasonable.



○ subArray
○ compactSA



Memory usage of SA depends on number of elements of "parent" waveform.

Memory usage of CSA depends on its number of elements.

Summary

- F3RP61 is CPU module which:
  - we use as IOC.
  - we largely adopt at SuperKEKB.

- The process time of ai, ao, and bi records are studied.
  - Intrinsic process time of device is ~15μs.
  - Read/write process needs ~25μs on EPICS.

- The performance of soft record is studied with subArray and compactSA.
- Process time is ~4μs and there is no significant differencebetween subArray and compactSA.

- The memory usage is significantly suppress by using compactSA.
  - For example, waveform(200000) case,
    they are 1570 kbyte for SA(100) and 2.83 kbyte for CSA(100).
  - Its dependence on number of elements (array length) is reasonable.

Backup slides

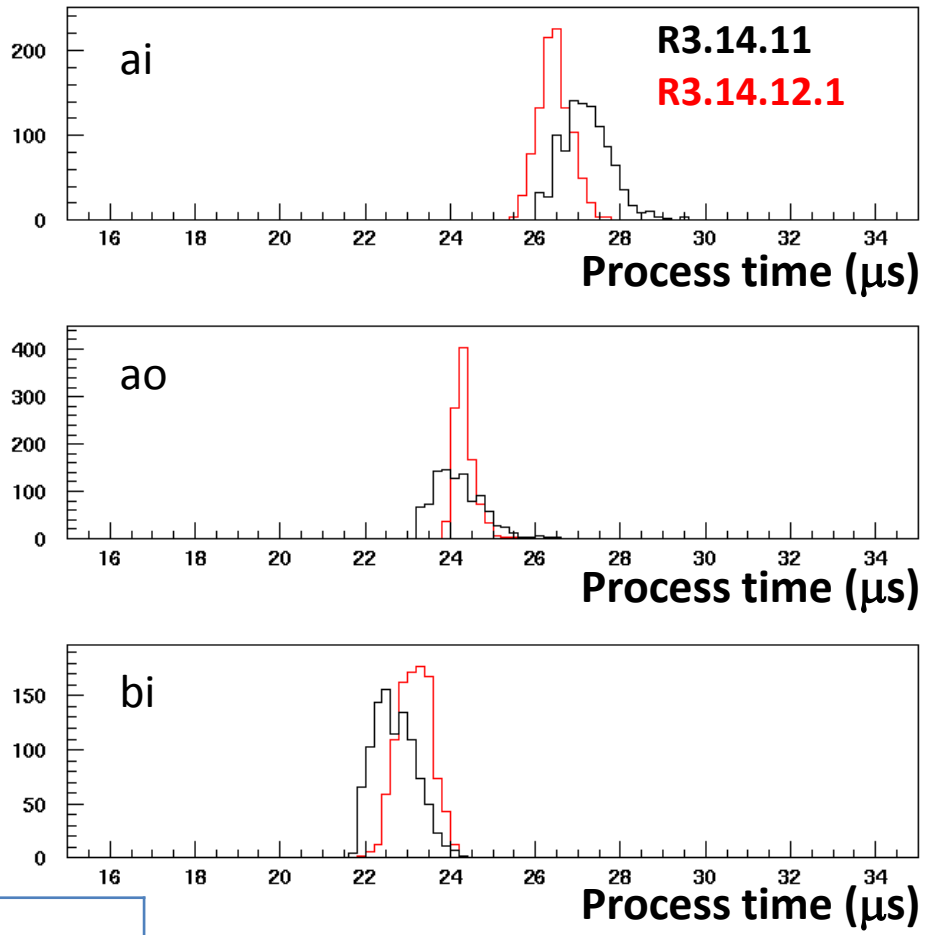
More information

- F3RP61 software:
  http://www-linac.kek.jp/cont/epics/f3rp61/

- Application example:
  http://www-linac.kek.jp/cont/epics/f3rp61/#pre
  http://www-linac.kek.jp/cont/epics/f3rp61/#art

Process time dependence on EPICS version

Same study as page 5 is performed for both EPICS versions R3.14.11 and R3.14.12.1.



	R3.14.11	R3.14.12.1
ai	27.21 ± 0.02 μs	26.46 ± 0.01 μs
ao	24.18 ± 0.02 μs	24.32 ± 0.01 μs
bi	22.71 ± 0.02 μs	23.17 ± 0.01 μs

There are small differences.
But it is <1μs.

Memory usage for others

Memory usage of followings is determined by same method as page 9.
Results are compared with those of MVME5500(VxWorks).

	OS	sequencer
F3RP61	ELDK Linux	20.7 kbyte
MVME5500	VxWorks 5.5.1	25.6 kbyte

	ai	ao	bi	bo	mbbi	mbbo
F3RP61	0.90 kbyte	0.95 kbyte	0.75 kbyte	0.83 kbyte	1.20 kbyte	1.24 kbyte
MVME5500	1.05 kbyte	1.12 kbyte	0.91 kbyte	1.00 kbyte	1.37 kbyte	1.40 kbyte

Process time dependence on CPU

Process time of subArray is compared among different servers.

Condition:
waveform(5000elements,double) ⇒ subArray(20elements)

CPU	**533MHz**	**3658 MHz**	**3481MHz**
OS	ELDK Linux	Red Hat Linux	Windows XP
Process time	µs	1.94 µs	2.26 µs