Application Profiling

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Introduction

You will learn:

- how application profiling is implemented
- the setup necessary before doing profiling
- how to do the profiling and analyse the results both:
  - while the application is running
  - after the application has gone away

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Topics:

- **Overview**
- **Sampling and Call Count Profiling**
- **Function Instrumentation Profiling**
- **Conclusion**

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Overview

Application profiling:

- is a way of finding out where in your process time is being spent
- tells you:
  1. how often each function was called and by whom
  2. how long was spent in each function (sampling or instrumentation)
  3. how much CPU time was used for individual lines of code (sampling)
- this helps you:
  - tune algorithms
  - find bottlenecks
  - ...

note: sampling methods result in approximated values

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Overview

Three types of application profiling:

1. Statistical profiling
2. Sampling and Call Count instrumentation profiling
3. Function Instrumentation profiling

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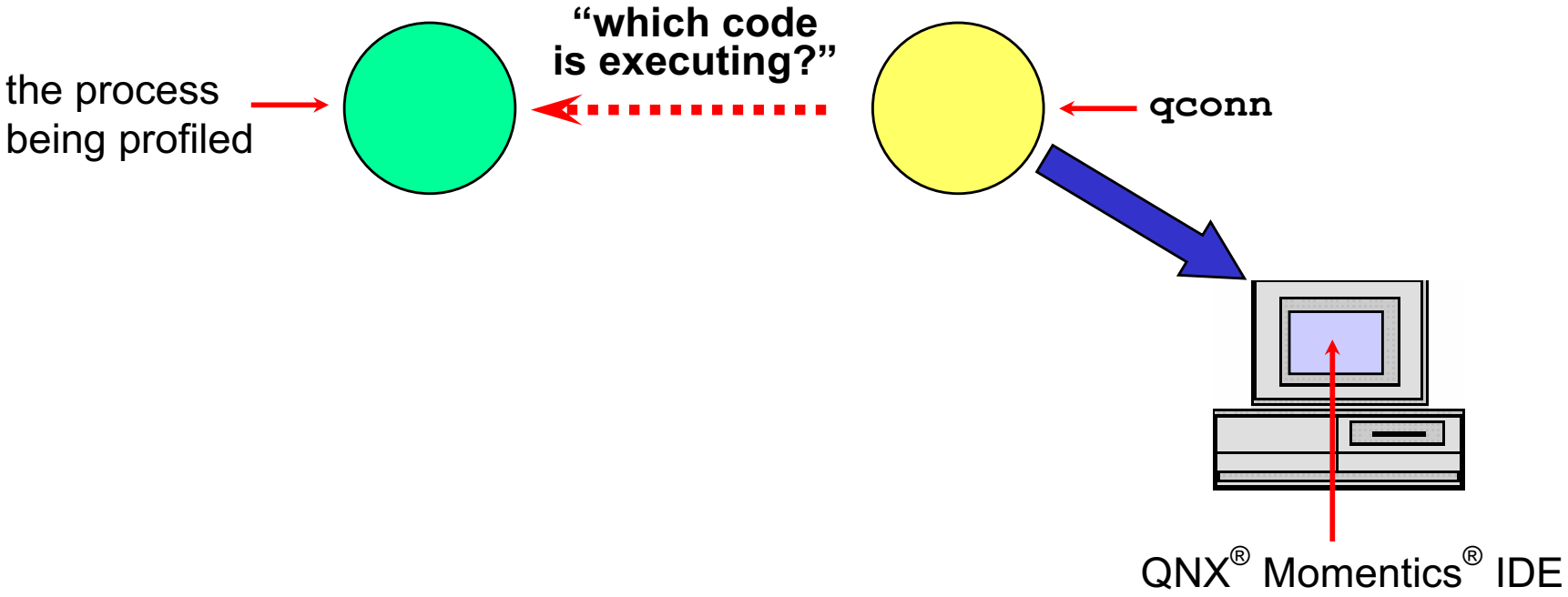
Statistical profiling:

- `qconn` periodically samples to find out which code in your process is executing
- the longer the time you profile it, the more accurate the results



- you don't need to do anything special to your executable for this to work

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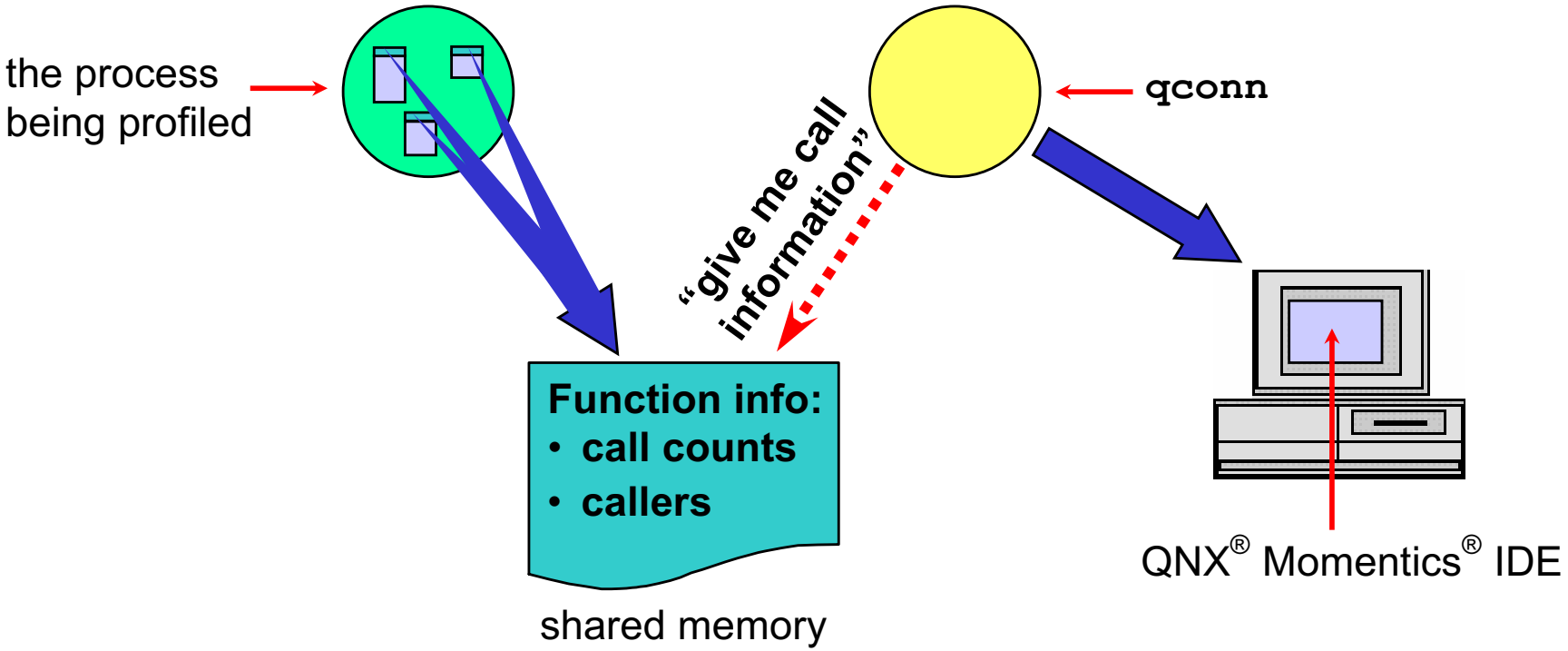
Sampling and Call Count instrumentation:

- code inserted at the beginning of each function stores information about who called it and how often



- you must build with profiling enabled for this to work (we'll see how later)

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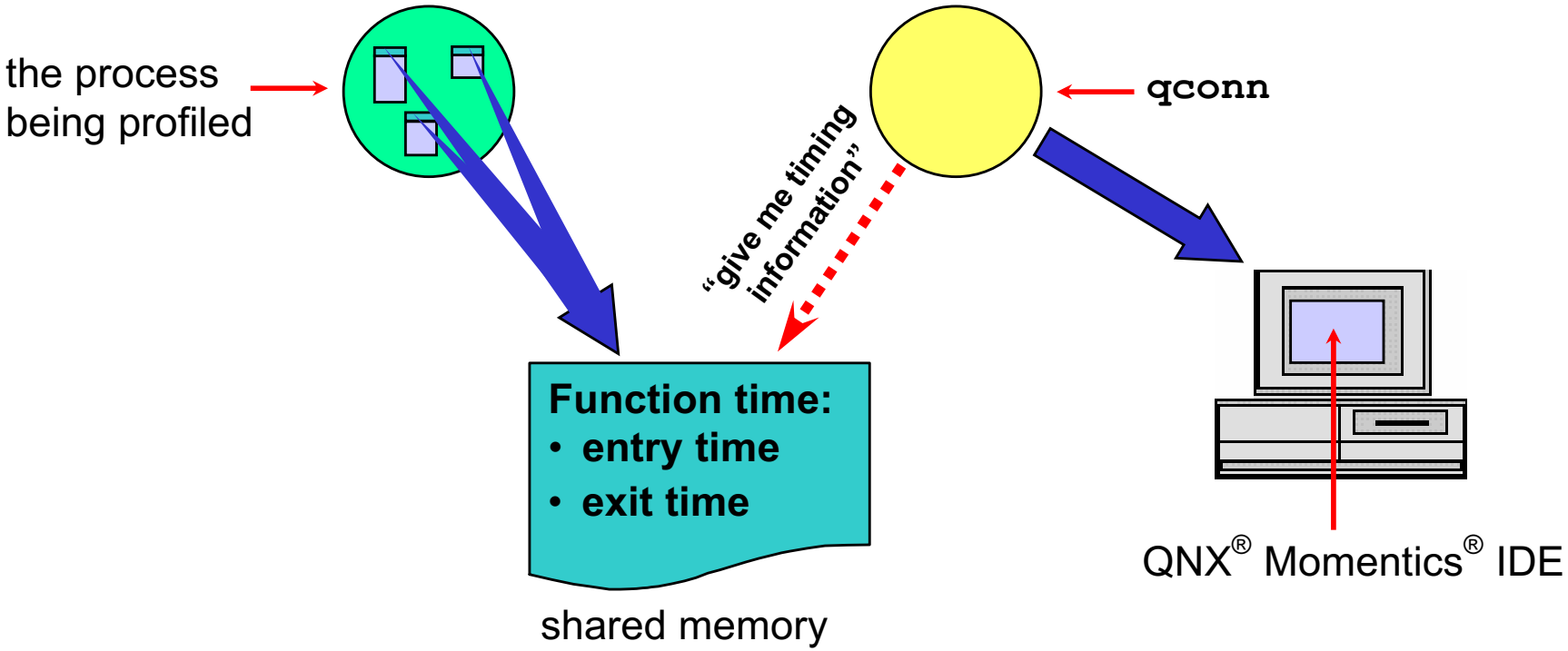
Function Instrumentation:

- code inserted just after entrance to and just before the exit from every function call, providing precise function run time information



-must be built with special compile and link options

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Topics:

- **Overview**
- → **Sampling and Call Count Profiling**
- **Function Instrumentation Profiling**
- **Conclusion**

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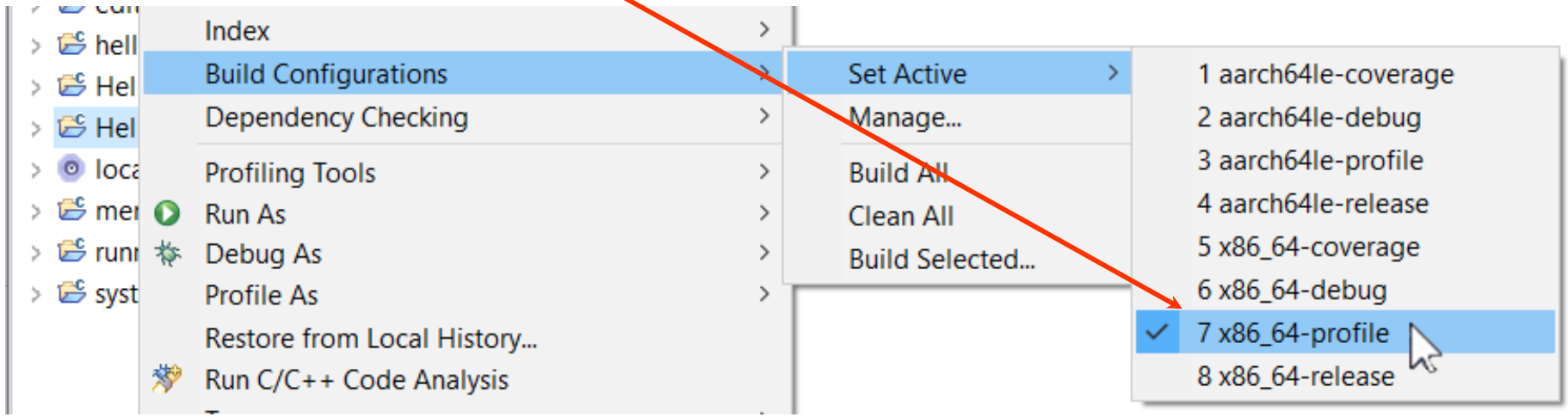
Building for Call Count Profiling:

- this will instrument your code
  - insert code before each function to gather call information
- for an existing QNX C/C++ Application Project:
  - select the “profile” variant as the active Build Configuration



- if using your own build environment (e.g. Makefile):
  - add the `-p` option to your compile and link command lines

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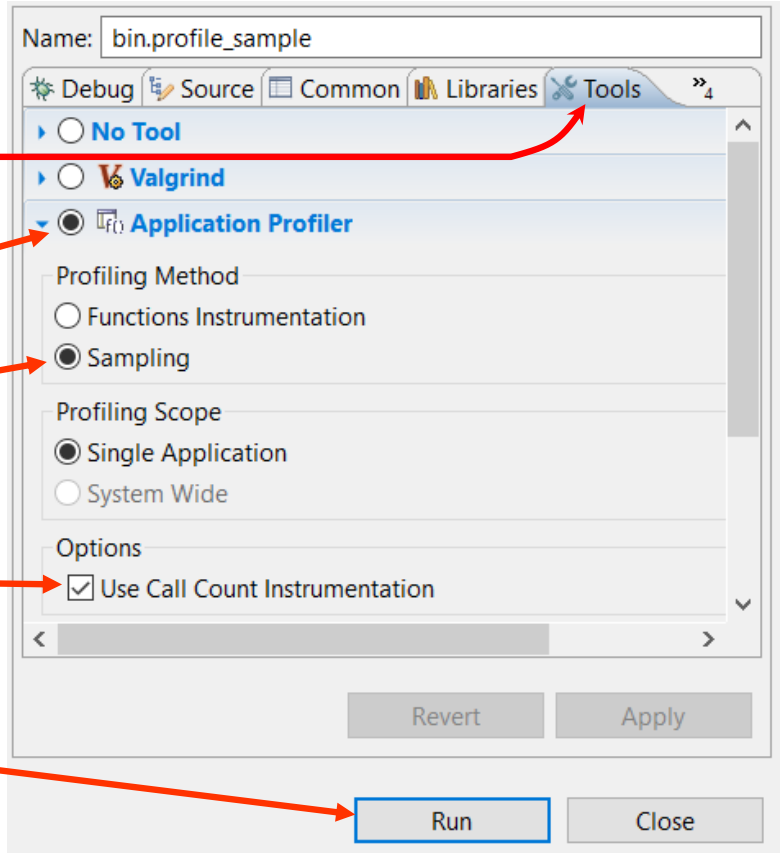
Setting up for Profiling - Call Count profiling

To profile while running:

- create a C\C++ QNX Application Run Configuration:

1. in the Tools tab
2. select Application Profiler
3. select Sampling and Use Call Count Instrumentation
4. click Run



- use the debug version of the executable if you want to see sampling results per line of code

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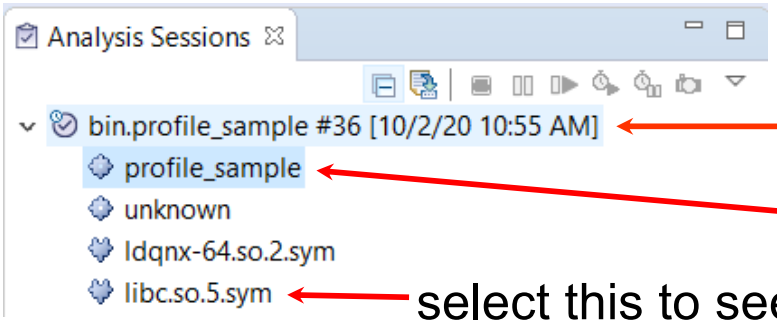
Doing the Profiling - Call Count profiling

Open the QNX Analysis perspective:



select this to see functions from all components in the Sampling Information view

select this to see functions from your program only

select this to see functions from **`libc.so.5.sym`** only

Execution Time

bin.profile_sample #36 - Function Table

Name	Deep Time		Shallow Time		Count	Location
[<0.01%] _mcount_	<0.01%	14.000 ms	<0.01%	14.000 ms		mcount.c:110
[] _start						mcrt1.S:28
[] app_prof_hdlr					1	profile_sample.c:199
[<0.01%] dofuncs	<0.01%	2.000 ms	<0.01%	2.000 ms	7086	profile_sample.c:109
[36.11%] func1	36.11%	63.989 s	36.11%	63.989 s	7086	profile_sample.c:123
[63.86%] func2	63.86%	113.160 s	63.86%	113.160 s	7086	profile_sample.c:147
[<0.01%] main	<0.01%	2.000 ms	<0.01%	2.000 ms	1	profile_sample.c:42
[] options					1	profile_sample.c:171
[<0.01%] other_thread	<0.01%	1.000 ms	<0.01%	1.000 ms	1	profile_sample.c:91

select this to see Function Table pane

☞ shared library and DLL information is not available for postmortem profiling

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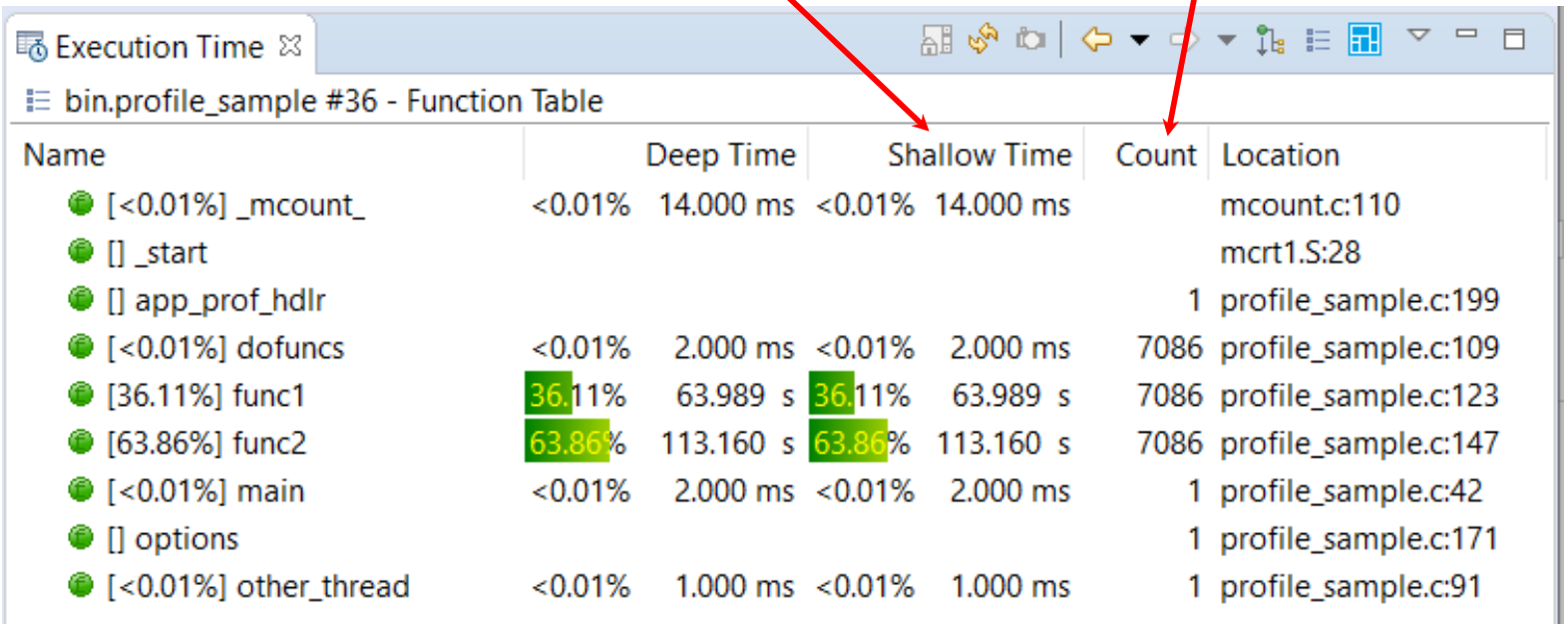
Sampling information:

approx time the processor spent in the function

number of times a function was called



Name	Deep Time		Shallow Time		Count	Location
[<0.01%] _mcount_	<0.01%	14.000 ms	<0.01%	14.000 ms		mcount.c:110
[] _start						mcrt1.S:28
[] app_prof_hdlr					1	profile_sample.c:199
[<0.01%] dofuncs	<0.01%	2.000 ms	<0.01%	2.000 ms	7086	profile_sample.c:109
[36.11%] func1	36.11%	63.989 s	36.11%	63.989 s	7086	profile_sample.c:123
[63.86%] func2	63.86%	113.160 s	63.86%	113.160 s	7086	profile_sample.c:147
[<0.01%] main	<0.01%	2.000 ms	<0.01%	2.000 ms	1	profile_sample.c:42
[] options					1	profile_sample.c:171
[<0.01%] other_thread	<0.01%	1.000 ms	<0.01%	1.000 ms	1	profile_sample.c:91

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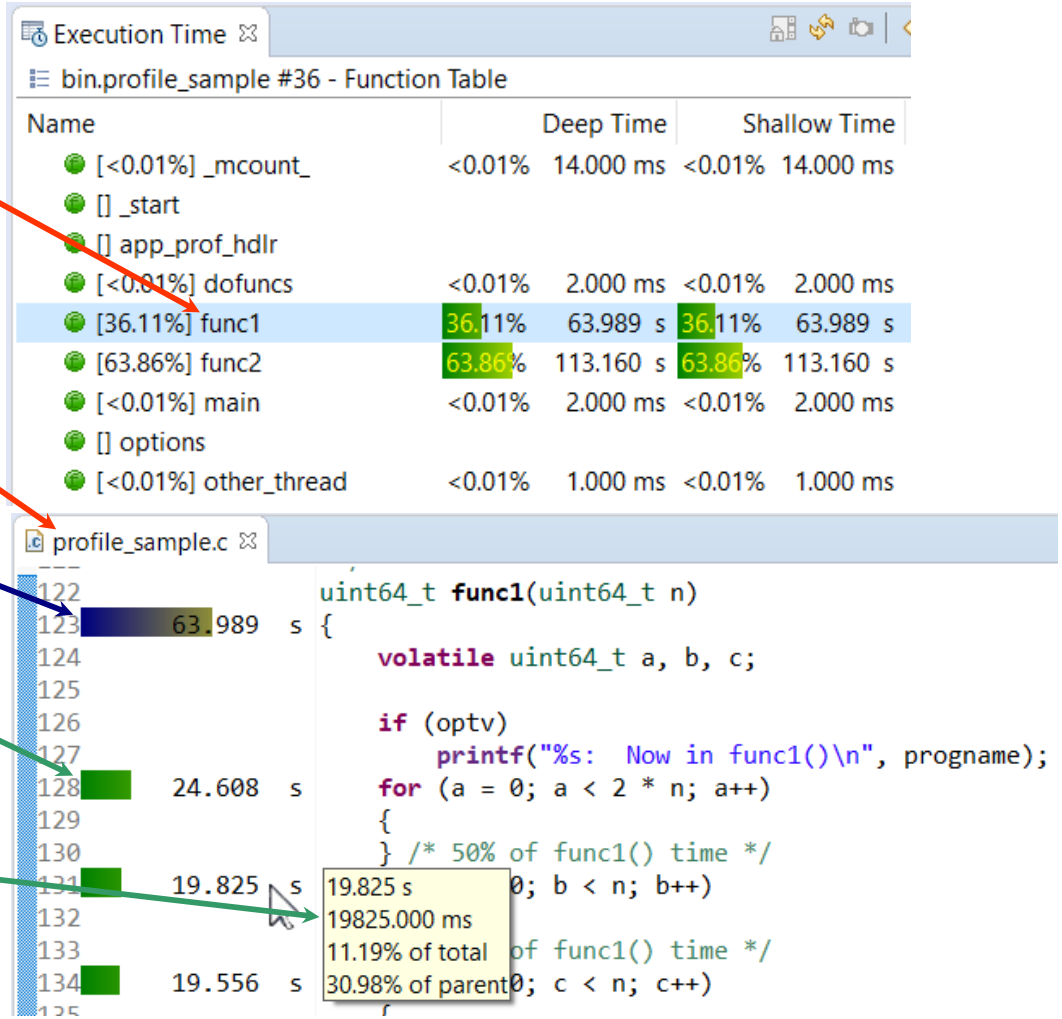
Using the editor:

double-click on a function in the Function Table and the editor appears with the function annotated

time for function relative to total time

time for line relative to total time.

hover to show time for line:
- as percent of total time
- as percent of function time



☞ you must have had debugging information in your executable for this to work

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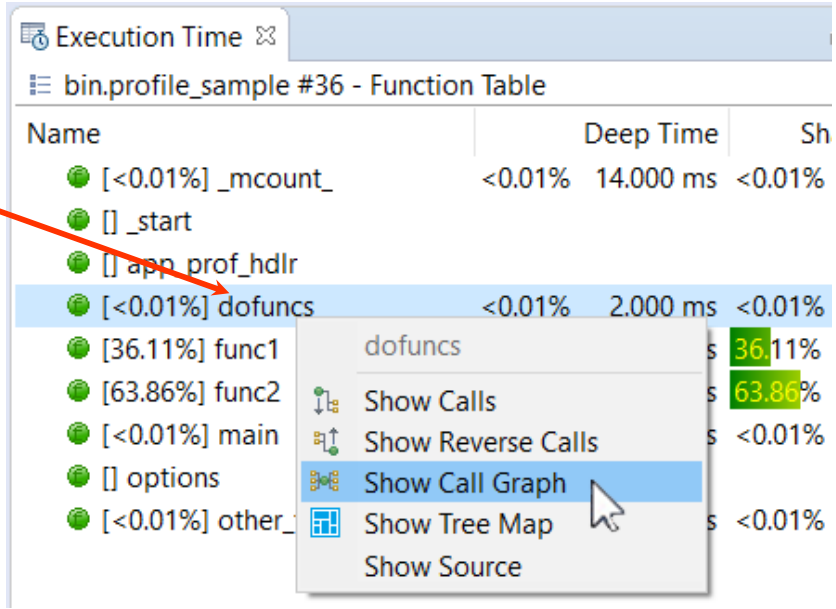
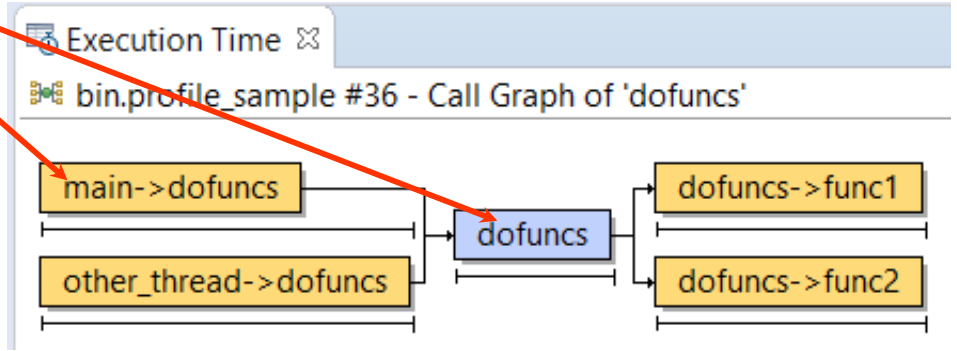
Call Information:

right click on function and select Show Call Graph



click on the various functions to move through the call graph



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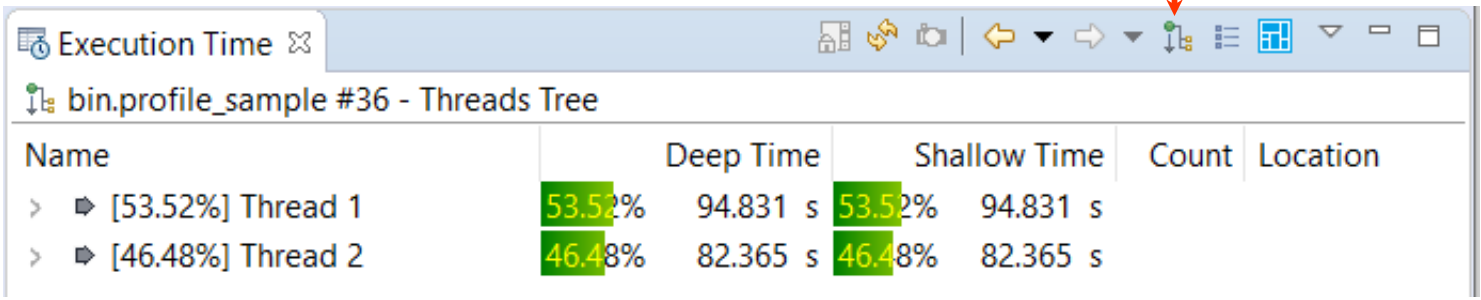
Thread information:

– the Thread Info view shows the processor time and percent time that each thread has run so far

click on Show Threads Tree icon



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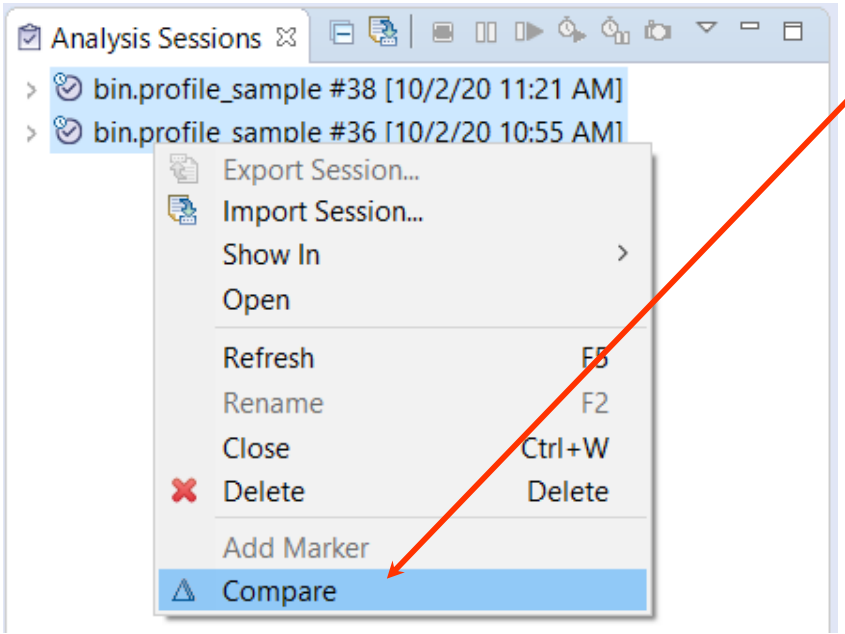
Doing the Profiling – Comparing Sessions

Did you improve things?

- after you've made changes, did the improve the behaviour?
- compare two sessions:
  - select two sessions, then menu → Compare:



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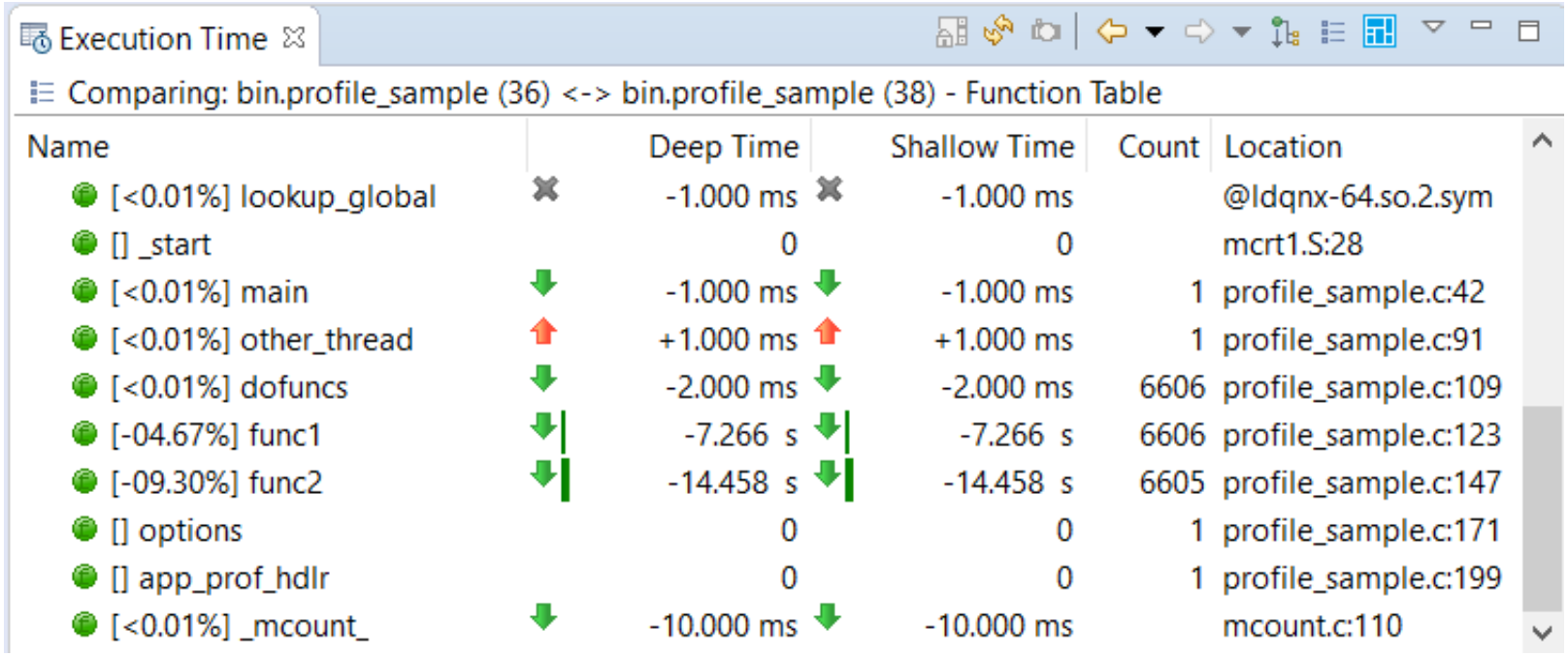
Compared sessions look like:



Name	Deep Time	Shallow Time	Count	Location
[<0.01%] lookup_global	-1.000 ms	-1.000 ms		@ldqnx-64.so.2.sym
[] _start	0	0		mcrt1.S:28
[<0.01%] main	-1.000 ms	-1.000 ms	1	profile_sample.c:42
[<0.01%] other_thread	+1.000 ms	+1.000 ms	1	profile_sample.c:91
[<0.01%] dofuncs	-2.000 ms	-2.000 ms	6606	profile_sample.c:109
[-04.67%] func1	-7.266 s	-7.266 s	6606	profile_sample.c:123
[-09.30%] func2	-14.458 s	-14.458 s	6605	profile_sample.c:147
[] options	0	0	1	profile_sample.c:171
[] app_prof_hdlr	0	0	1	profile_sample.c:199
[<0.01%] _mcount_	-10.000 ms	-10.000 ms		mcount.c:110

- time used increased for this function
- time used decreased for this function
- function is only in the 2nd run dataset
- function is only in the 1st run dataset

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EXERCISE

Profiling while running:

- build your **`application_profiling`** project. This will result in an executable called **`profile_sample`**
- do the steps you just learned to profile it while it runs
- examine the various views
- which function is consuming the most CPU time?
  - which lines in the function are consuming the most CPU time?

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Topics:

- **Overview**
- **Sampling and Call Count Profiling**
- → **Function Instrumentation Profiling**
- **Conclusion**

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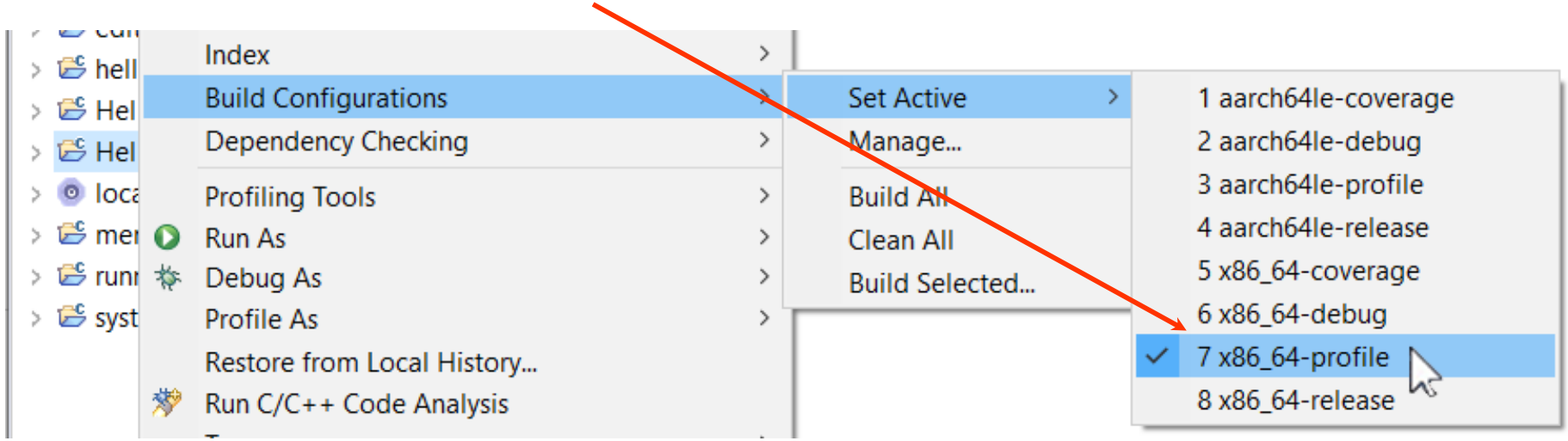
Building for Function Instrumentation Profiling:

- this will instrument your code
  - by inserting code in each function to gather timing information
- for an existing QNX Executable Project:
  - select the “profile” variant as the active Build Configuration



continued...

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Building for Function Instrumentation Profiling (continued):

- if using your own build environment (e.g. Makefile):
  - add the **`-finstrument-functions`** option to your compile command line
  - add **`-lprofilingS`** option to your link command line after your objects (.o files)

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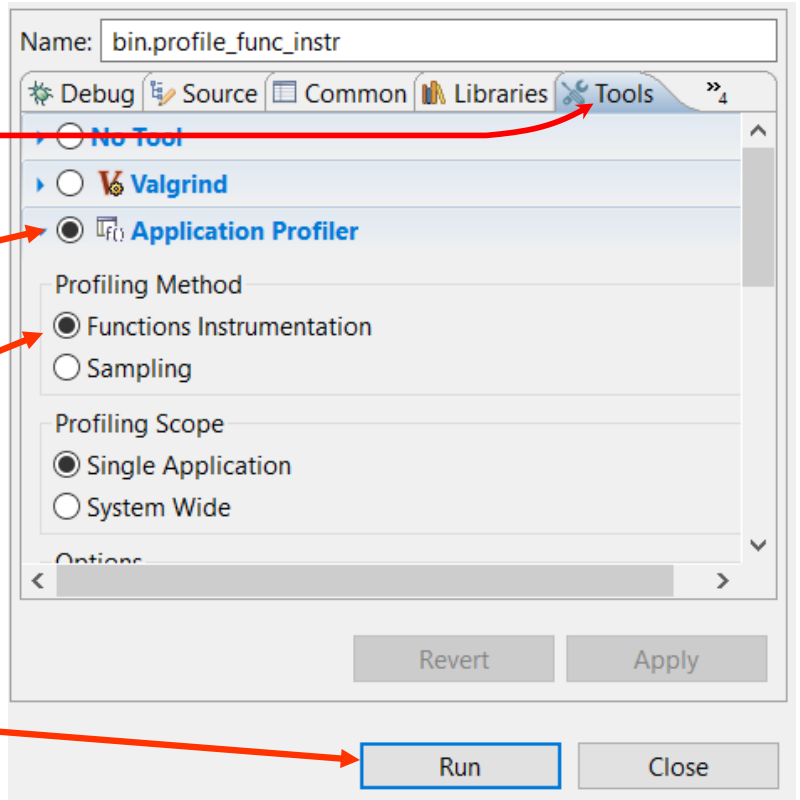
Setting up for Profiling – Function Instrumentation

To profile while running:

- create a C\C++ QNX Application Run Configuration:

1. in the Tools tab
2. select Application Profiler
3. select Function Instrumentation
4. click Run



- use the debug version of the executable if you want to see sampling results per line of code

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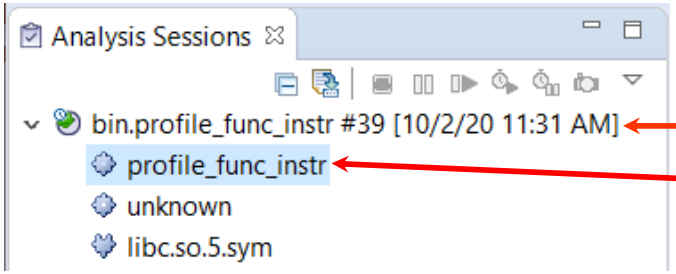
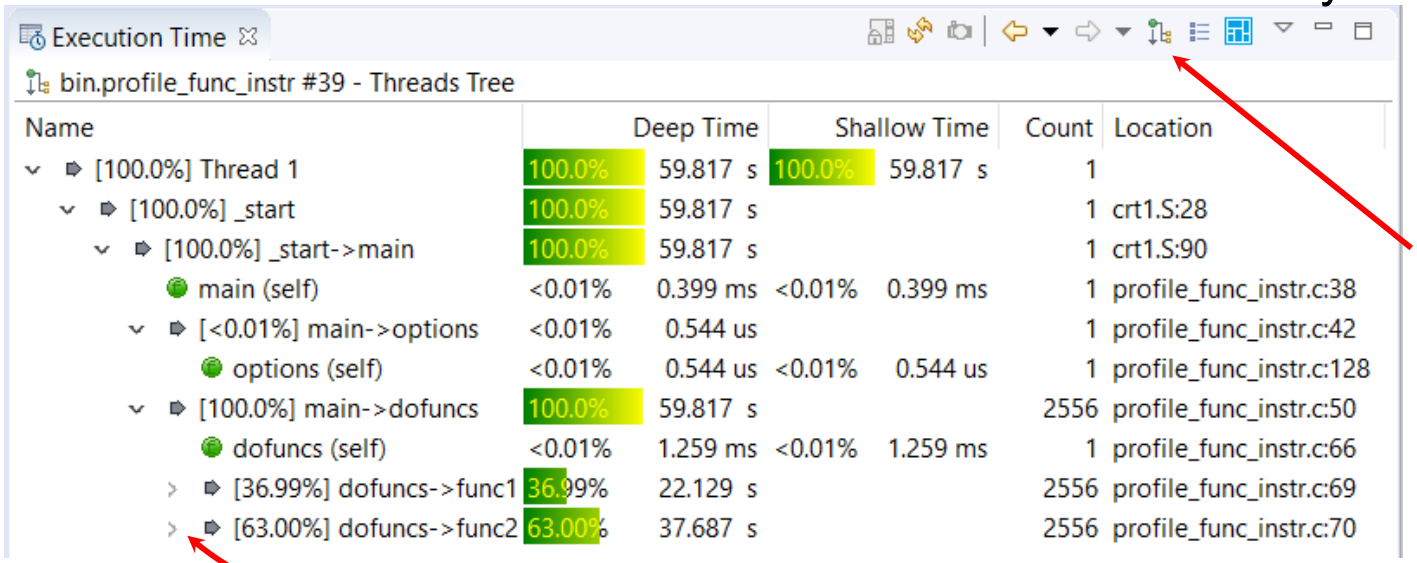
Doing the Profiling - Function Instrumentation

Execution Time view – Threads Tree:



select this to see functions from all components in the Sampling Information view

select this to see functions from your program only



select this to see Threads Tree pane

select here to expand the tree

– you can see exactly where the application spends its time, and which functions are used in the process.

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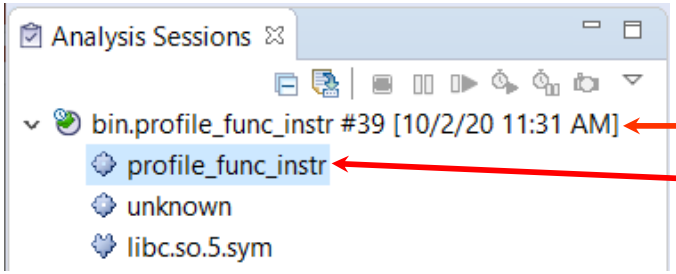
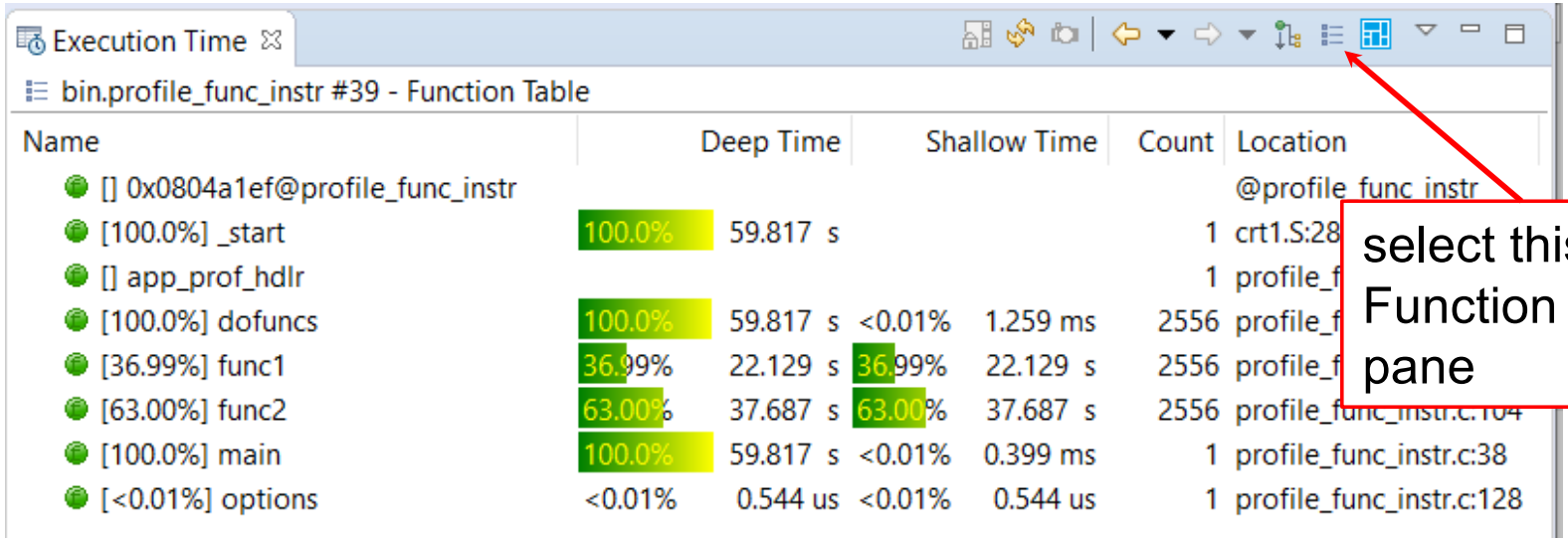
Execution Time view – Function Table:



select this to see functions from all components in the Sampling Information view

select this to see functions from your program only



select this to see Function Table pane

- helps you identify those functions that take the longest to complete

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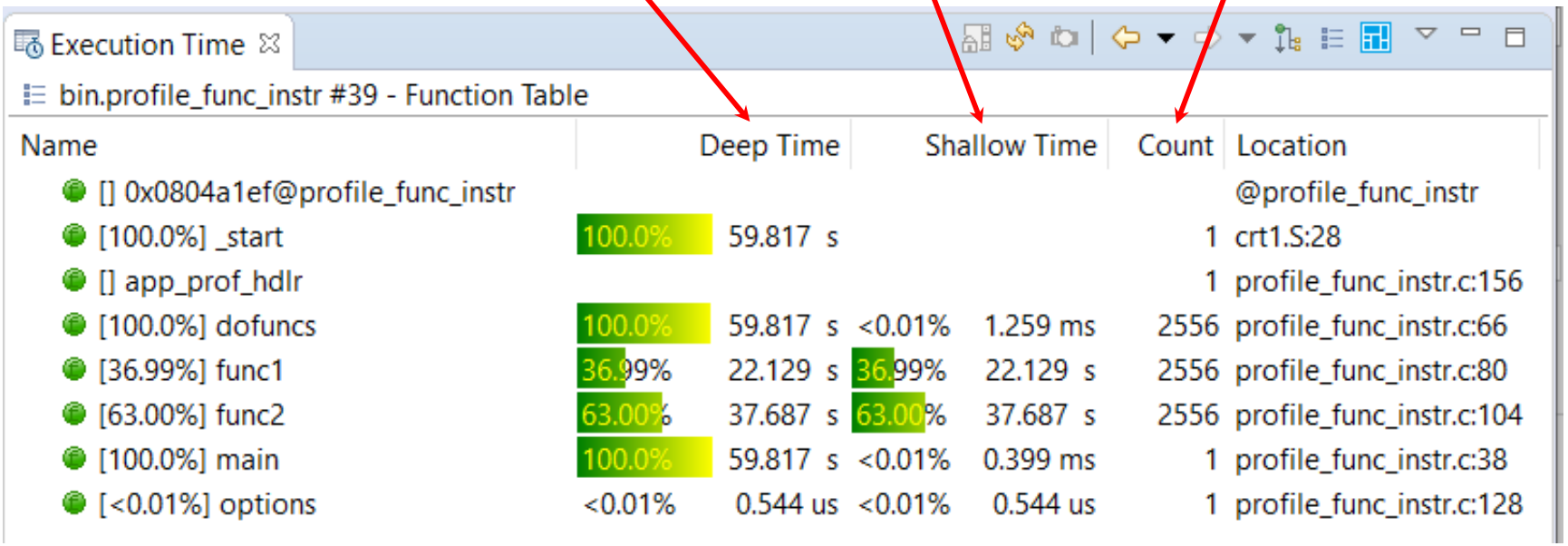
Sampling Information:

time for the function and all of its descendants

time spent in this function (and descendants without data)

number of times a function was called



Name	Deep Time		Shallow Time		Count	Location
[] 0x0804a1ef@profile_func_instr						@profile_func_instr
[100.0%] _start	100.0%	59.817 s			1	crt1.S:28
[] app_prof_hdlr					1	profile_func_instr.c:156
[100.0%] dofuncs	100.0%	59.817 s	<0.01%	1.259 ms	2556	profile_func_instr.c:66
[36.99%] func1	36.99%	22.129 s	36.99%	22.129 s	2556	profile_func_instr.c:80
[63.00%] func2	63.00%	37.687 s	63.00%	37.687 s	2556	profile_func_instr.c:104
[100.0%] main	100.0%	59.817 s	<0.01%	0.399 ms	1	profile_func_instr.c:38
[<0.01%] options	<0.01%	0.544 us	<0.01%	0.544 us	1	profile_func_instr.c:128

☞ There's currently a known problem with Deep Time having a value less than the sum of the Shallow Times if the process is multi-threaded. For single-threaded processes, Deep Time should be correct.

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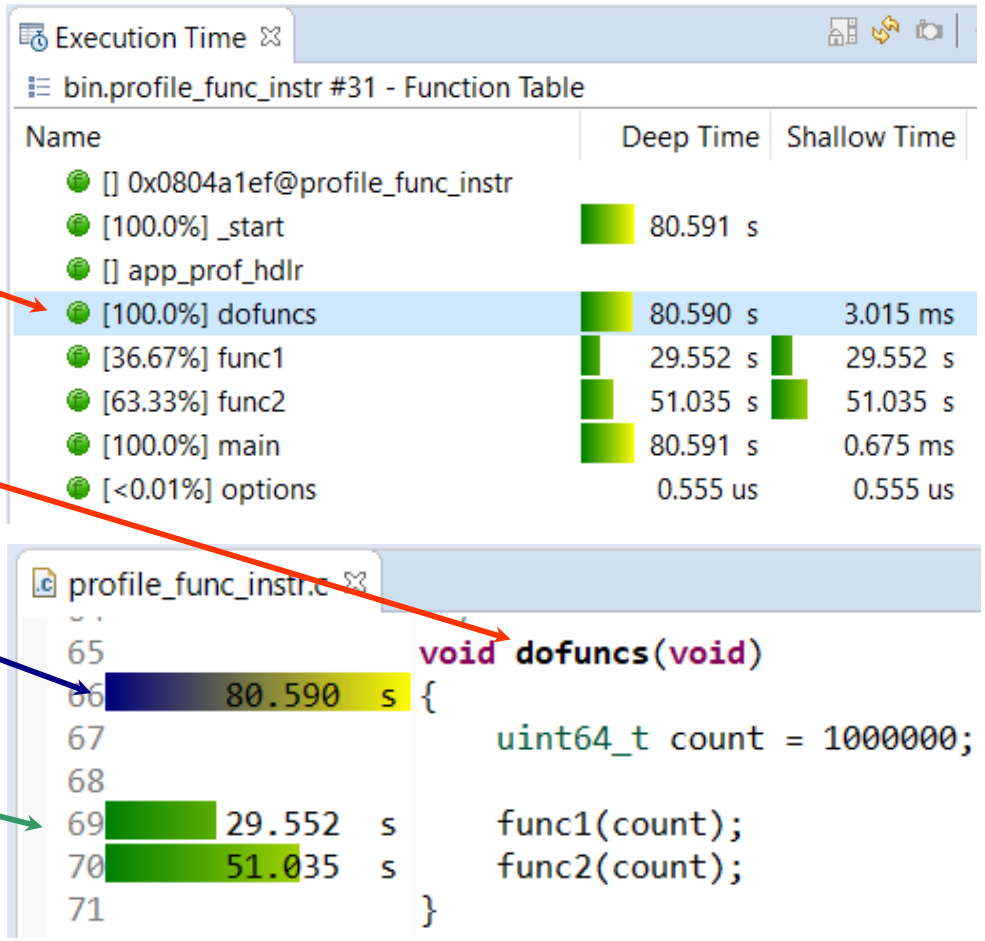
Using the editor:



double-click on a function in the Function Table and the editor appears with the function annotated

time for function relative to total time

time for the called functions relative to total time

call Information is available by right-clicking in the Execution Time view and selecting Show Call Graph

☞ you must have had debugging information in your executable for this to work

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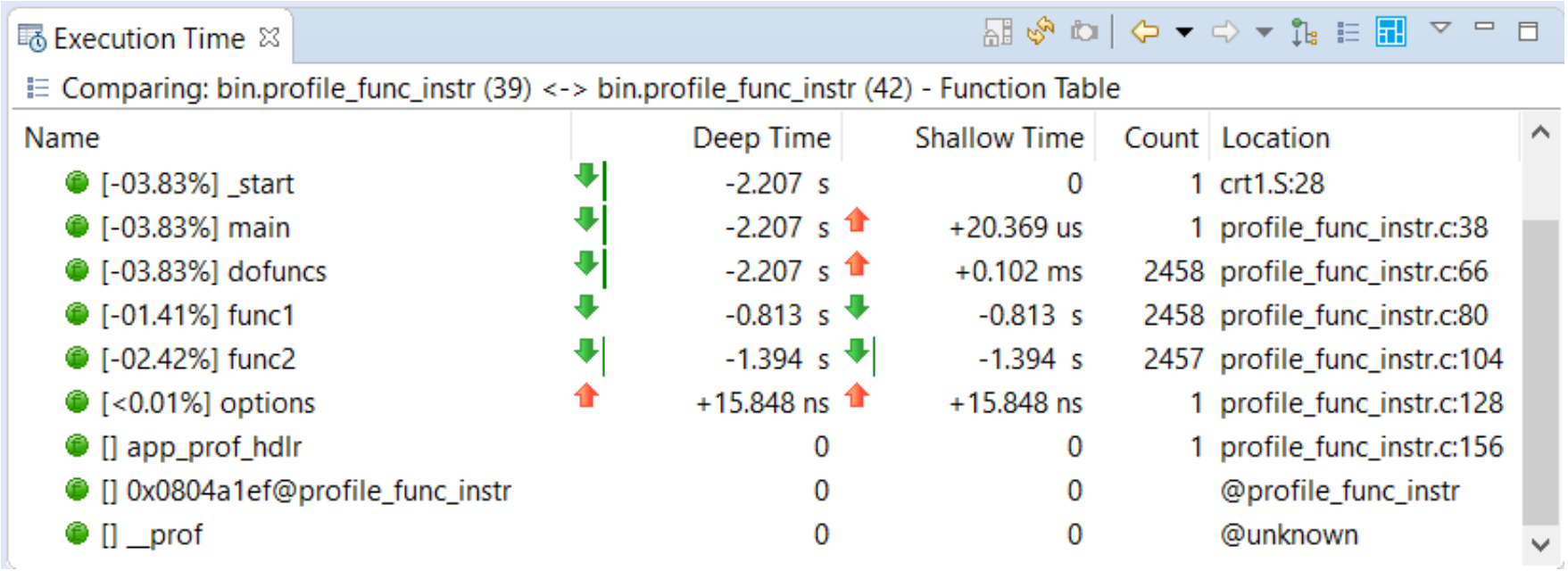
Function Instrumentation - Comparing

We can also compare function instrumentation results:



Name	Deep Time	Shallow Time	Count	Location
[-03.83%] _start	-2.207 s	0	1	crt1.S:28
[-03.83%] main	-2.207 s	+20.369 us	1	profile_func_instr.c:38
[-03.83%] dofuncs	-2.207 s	+0.102 ms	2458	profile_func_instr.c:66
[-01.41%] func1	-0.813 s	-0.813 s	2458	profile_func_instr.c:80
[-02.42%] func2	-1.394 s	-1.394 s	2457	profile_func_instr.c:104
[<0.01%] options	+15.848 ns	+15.848 ns	1	profile_func_instr.c:128
[] app_prof_hdlr	0	0	1	profile_func_instr.c:156
[] 0x0804a1ef@profile_func_instr	0	0		@profile_func_instr
[] __prof	0	0		@unknown

- time used increased for this function
- time used decreased for this function
- function is only in the 2nd run dataset
- function is only in the 1st run dataset

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EXERCISE

Profiling while running:

- build your **`application_profiling`** project. This will result in an executable called **`profile_func_instr`**
- do the steps you just learned to profile it while it runs
- examine the various views
- which function has taken the longest to complete?
  - which function in its own code has taken longest to complete?

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- → **Conclusion**

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Statistical vs Instrumented Profiling

Statistical Profiling:

- sampling based
  - driven by timer interrupt
    - not useful for anything driven by timers
    - clock-tick precision (usually 1ms)
- frequency of line-of-code execution
  - per-function data is derived from per-line data

Instrumented Profiling:

- measured by instrumentation
  - *ClockCycles()* precision (usually sub-microsecond)
- elapsed-time based
  - includes time preempted or blocked
  - time to complete an operation
- only per-function data, no per-line data

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Conclusion

You learned:

- how profiling is implemented:
  - statistical profiling is used to gather execution frequency for individual lines of code
  - instrumented profiling is used to gather call information or precise function time information
- the setup needed to do profiling
- how to do analysis:
  - while the application is running

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