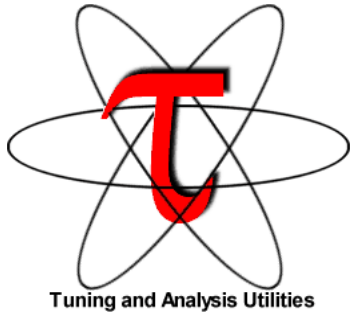
TAU Performance System®



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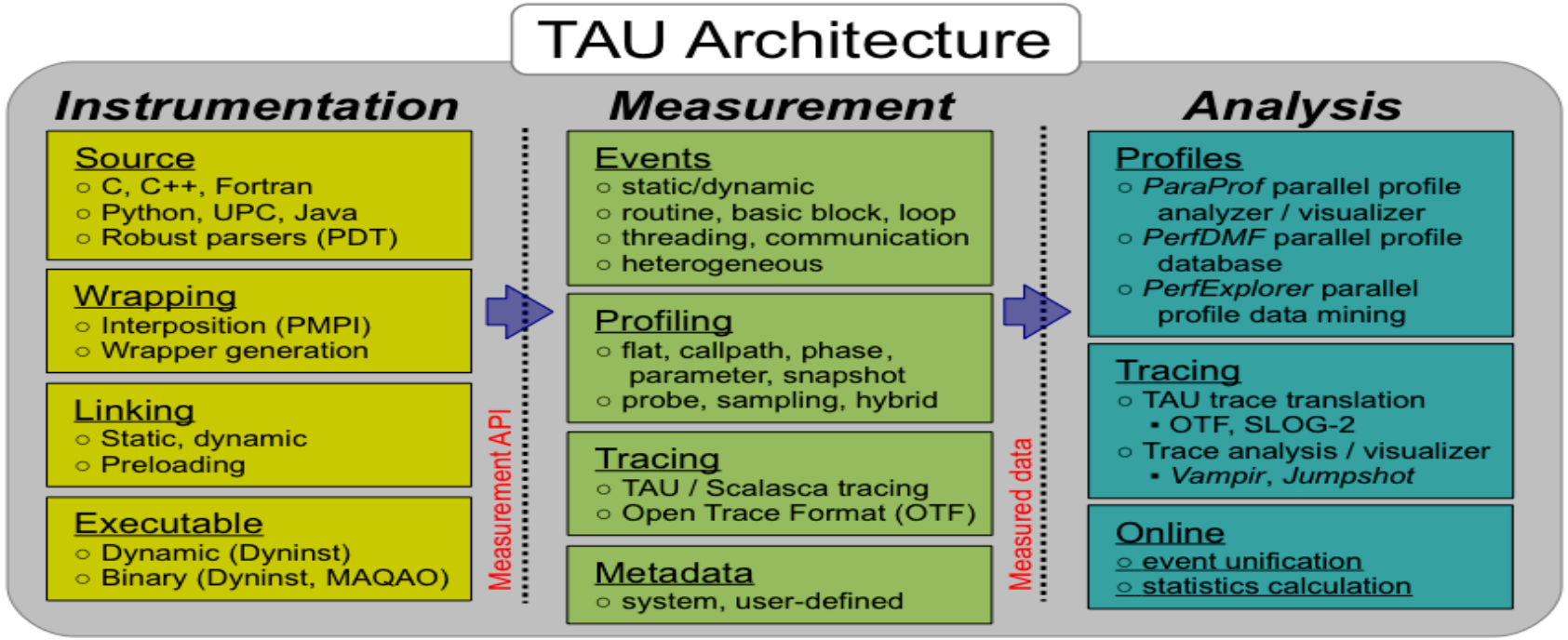
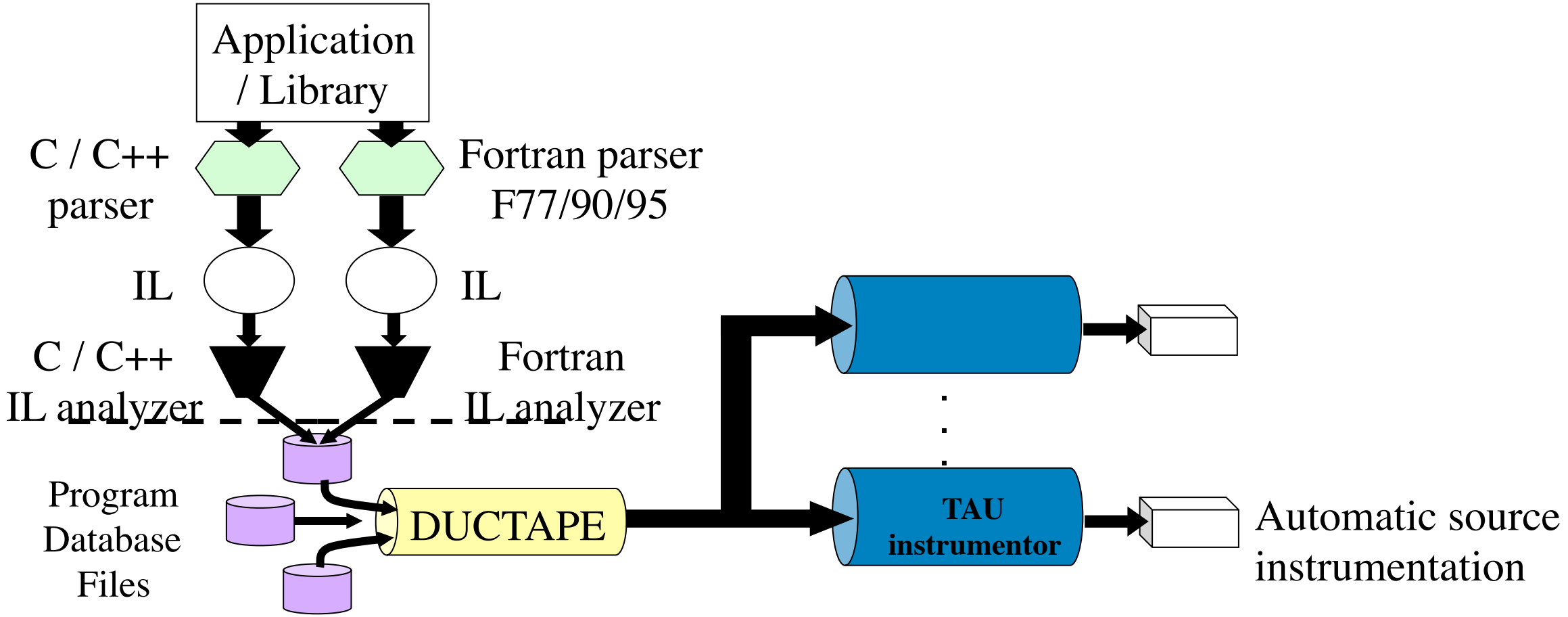
TAU Performance System®

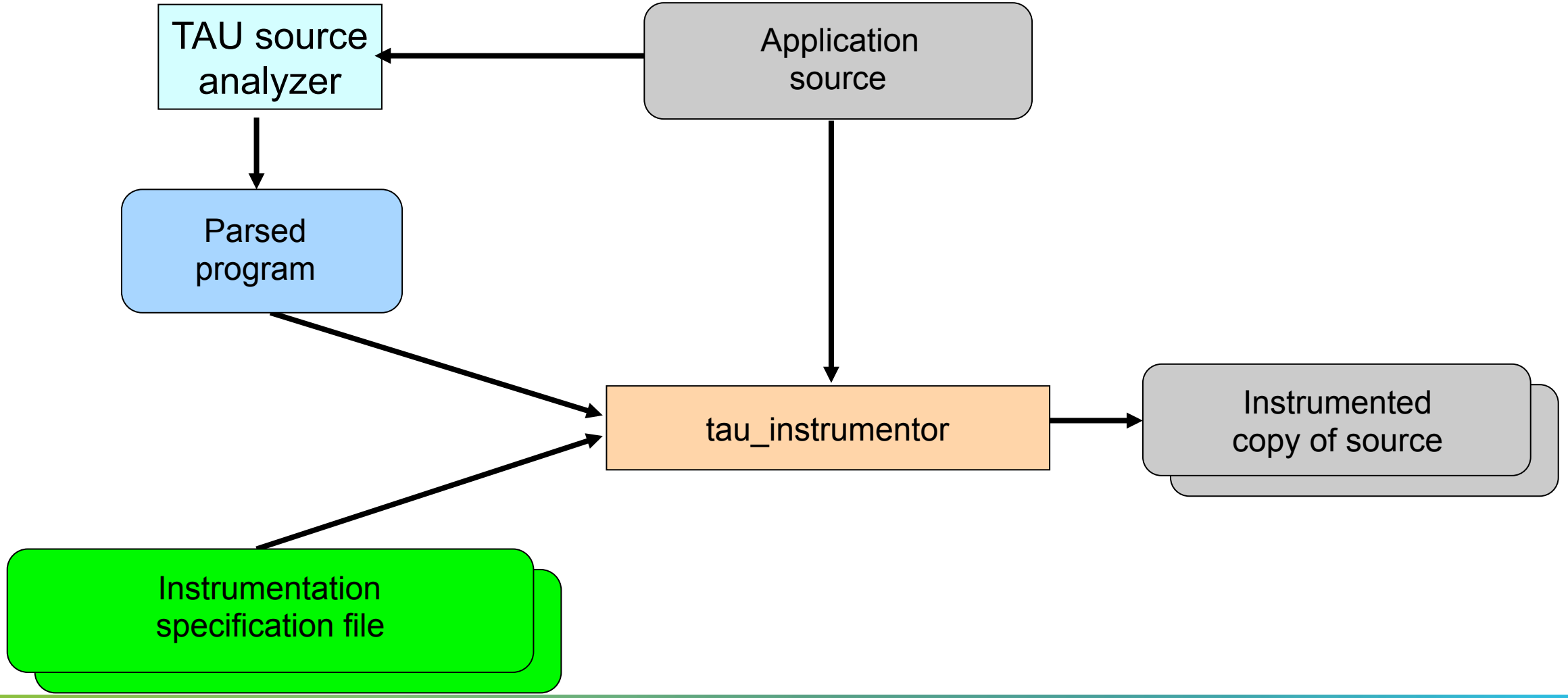
- Parallel performance framework and toolkit
  - Supports all HPC platforms, compilers, runtime system
  - Provides portable instrumentation, measurement, analysis



TAU's Static Analysis System: Program Database Toolkit (PDT)



Automatic Source Instrumentation using PDT



TAU Performance System

- Instrumentation
  - Fortran, C++, C, UPC, Java, Python, Chapel
  - Automatic instrumentation
- Measurement and analysis support
  - MPI, OpenSHMEM, ARMCI, PGAS, DMAPP
  - pthreads, OpenMP, OMPT interface, hybrid, other thread models
  - GPU, CUDA, OpenCL, OpenACC
  - Parallel profiling and tracing
  - Use of Score-P for native OTF2 and CUBEX generation
  - Efficient callpath proflles and trace generation using Score-P
- Analysis
  - Parallel profile analysis (ParaProf), data mining (PerfExplorer)
  - Performance database technology (TAUdb)
  - 3D profile browser

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TAU Performance System

- TAU supports both sampling and direct instrumentation
- Memory debugging as well as I/O performance evaluation
- Profiling as well as tracing
- Interfaces with Score-P for more efficient measurements
- TAU's instrumentation covers:
  - Runtime library interposition (tau_exec)
  - Compiler-based instrumentation
  - PDT based Source level instrumentation: routine & loop
  - Event based sampling (TAU_SAMPLING=1 or tau_exec -ebs)
  - Callstack unwinding with sampling (TAU_EBS_UNWIND=1)
  - OpenMP Tools Interface (OMPT, tau_exec –T ompt)
  - CUDA CUPTI, OpenCL (tau_exec -T cupti -cupti)

Application Performance Engineering using TAU

- How much time is spent in each application routine and outer *loops*? Within loops, what is the contribution of each *statement*? What is the time spent in OpenMP loops?
- How many instructions are executed in these code regions?
  Floating point, Level 1 and 2 *data cache misses*, hits, branches taken? What is the extent of vectorization for loops on Intel MIC?
- What is the memory usage of the code? When and where is memory allocated/de-allocated? Are there any memory leaks? What is the memory footprint of the application? What is the memory high water mark?
- How much energy does the application use in Joules? What is the peak power usage?
- What are the I/O characteristics of the code? What is the peak read and write *bandwidth* of individual calls, total volume?
- What is the contribution of each *phase* of the program? What is the time wasted/spent waiting for collectives, and I/O operations in Initialization, Computation, I/O phases?
- How does the application *scale*? What is the efficiency, runtime breakdown of performance across different core counts?

Using TAU

- TAU supports several compilers, measurement, and thread options
  - Intel compilers, profiling with hardware counters using PAPI, MPI library, CUDA…
  - Each measurement configuration of TAU corresponds to a unique stub makefile (configuration file) and library that is generated when you configure it
- To instrument source code automatically using PDT
  - Choose an appropriate TAU stub makefile in <arch>/lib:

```
% module load tau

% export TAU_MAKEFILE=$TAU/Makefile.tau-icpc-papi-mpi-pdt-openmp-opari
% export TAU_OPTIONS= '-optVerbose …'  (see tau_compiler.sh )
```

  - Use tau_f90.sh, tau_cxx.sh, tau_upc.sh, or tau_cc.sh as F90, C++, UPC, or C compilers respectively:

```
% mpif90 foo.f90        changes to
% tau_f90.sh foo.f90
```

- Set runtime environment variables, execute application and analyze performance data:

```
% pprof   (for text based profile display)
% paraprof  (for GUI)
```

Installing and Configuring TAU

- Installing PDT:
  - wget http://tau.uoregon.edu/pdt_lite.tgz
  - ./configure –prefix=<dir>; make ; make install
- Installing TAU:
  - wget http://tau.uoregon.edu/tau.tgz
  - ./configure –arch=x86_64 -bfd=download -pdt=<dir> -papi=<dir> ...
  - For MIC:
  - ./configure –arch=mic_linux –pdt=<dir> -pdt_c++=g++ -papi=dir …
  - make install
- Using TAU:
  - export TAU_MAKEFILE=<taudir>/x86_64/lib/Makefile.tau-<TAGS>
  - make CC=tau_cc.sh CXX=tau_cxx.sh F90=tau_f90.sh

Different Makefiles for TAU Compiler and Runtime Options

```
%  module load tau
% ls $TAU/Makefile.*
Makefile.tau-intel-mpi-pdt
Makefile.tau-intel-papi-mpi-pdt
Makefile.tau-intel-mpi-pdt-openmp-opari
Makefile.tau-intel-papi-mpi-pdt-openmp-opari
Makefile.tau-intel-papi-ompt-mpi-pdt-openmp
Makefile.tau-intel-mpi-python-pdt
```

For an MPI+OpenMP+F90 application with Intel MPI, you may choose

```
Makefile.tau-intel-papi-mpi-pdt-openmp-opari
```

- Supports MPI instrumentation & PDT for automatic source instrumentation

```
% export TAU_MAKEFILE=$TAU/Makefile.tau-intel-papi-mpi-pdt-openmp-opari

% tau_f90.sh matmult.f90 -o matmult
% mpirun -np 256 ./matmult
% paraprof
```

Compile-Time Options

Optional parameters for the TAU_OPTIONS environment variable:

% tau_compiler.sh

-optVerbose	Turn on verbose debugging messages
-optCompInst	Use compiler based instrumentation
-optNoCompInst	Do not revert to compiler instrumentation if source instrumentation fails.
-optTrackIO	Wrap POSIX I/O call and calculates vol/bw of I/O operations (configure TAU with *–iowrapper*)
-optTrackGOMP	Enable tracking GNU OpenMP runtime layer (used without –opari)
-optMemDbg	Enable runtime bounds checking (see TAU_MEMDBG_* env vars)
-optKeepFiles	Does not remove intermediate .pdb and .inst.* files
-optPreProcess	Preprocess sources (OpenMP, Fortran) before instrumentation
-optTauSelectFile=”<file>"	Specify selective instrumentation file for *tau_instrumentor*
-optTauWrapFile=”<file>"	Specify path to *link_options.tau* generated by *tau_gen_wrapper*
-optHeaderInst	Enable Instrumentation of headers
-optTrackUPCR	Track UPC runtime layer routines (used with tau_upc.sh)
-optLinking=""	Options passed to the linker. Typically $(TAU_MPI_FLIBS) $(TAU_LIBS) $(TAU_CXXLIBS)
-optCompile=""	Options passed to the compiler. Typically $(TAU_MPI_INCLUDE) $(TAU_INCLUDE) $(TAU_DEFS)
-optPdtF95Opts=""	Add options for Fortran parser in PDT (f95parse/gfparse) …

Compile-Time Options (contd.)

- Optional parameters for the TAU_OPTIONS environment variable:

% tau_compiler.sh

-optMICOffload	Links code for Intel MIC offloading, requires both host and MIC TAU libraries
-optShared	Use TAU's shared library (libTAU.so) instead of static library (default)
-optPdtCxxOpts=""	Options for C++ parser in PDT (cxxparse).
-optPdtF90Parser=""	Specify a different Fortran parser
-optPdtCleanscapeParser	Specify the Cleanscape Fortran parser instead of GNU gfparser
-optTau=""	Specify options to the tau_instrumentor
-optTrackDMAPP	Enable instrumentation of low-level DMAPP API calls on Cray
-optTrackPthread	Enable instrumentation of pthread calls

See tau_compiler.sh for a full list of TAU_OPTIONS.

…

Compiling Fortran Codes with TAU

- If your Fortran code uses free format in .f files (fixed is default for .f), you may use:
  % export TAU_OPTIONS= '-optPdtF95Opts="-R free" -optVerbose '

- To use the compiler based instrumentation instead of PDT (source-based):
  % export TAU_OPTIONS= '-optCompInst -optVerbose'

- If your Fortran code uses C preprocessor directives (#include, #ifdef, #endif):
  % export TAU_OPTIONS= '-optPreProcess -optVerbose -optDetectMemoryLeaks'

- To use an instrumentation specification file:
  % export TAU_OPTIONS= '-optTauSelectFile=select.tau -optVerbose -optPreProcess'
  % cat select.tau
  BEGIN_INSTRUMENT_SECTION
  loops routine="#"
  # this statement instruments all outer loops in all routines. # is wildcard as well as comment in first column.
  END_INSTRUMENT_SECTION

Runtime Environment Variables

Environment Variable	Default	Description
TAU_TRACE	0	Setting to 1 turns on tracing
TAU_CALLPATH	0	Setting to 1 turns on callpath profiling
TAU_TRACK_MEMORY_FOOTPRINT	0	Setting to 1 turns on tracking memory usage by sampling periodically the resident set size and high water mark of memory usage
TAU_TRACK_POWER	0	Tracks power usage by sampling periodically.
TAU_CALLPATH_DEPTH	2	Specifies depth of callpath. Setting to 0 generates no callpath or routine information, setting to 1 generates flat profile and context events have just parent information (e.g., Heap Entry: foo)
TAU_SAMPLING	1	Setting to 1 enables event-based sampling.
TAU_TRACK_SIGNALS	0	Setting to 1 generate debugging callstack info when a program crashes
TAU_COMM_MATRIX	0	Setting to 1 generates communication matrix display using context events
TAU_THROTTLE	1	Setting to 0 turns off throttling. Throttles instrumentation in lightweight routines that are called frequently
TAU_THROTTLE_NUMCALLS	100000	Specifies the number of calls before testing for throttling
TAU_THROTTLE_PERCALL	10	Specifies value in microseconds. Throttle a routine if it is called over 100000 times and takes less than 10 usec of inclusive time per call
TAU_COMPENSATE	0	Setting to 1 enables runtime compensation of instrumentation overhead
TAU_PROFILE_FORMAT	Profile	Setting to “merged” generates a single file. “snapshot” generates xml format
TAU_METRICS	TIME	Setting to a comma separated list generates other metrics. (e.g., ENERGY,TIME,P_VIRTUAL_TIME,PAPI_FP_INS,PAPI_NATIVE_<event>:<subevent>)

Runtime Environment Variables (contd.)

Environment Variable	Default	Description
TAU_TRACK_MEMORY_LEAKS	0	Tracks allocates that were not de-allocated (needs –optMemDbg or tau_exec –memory)
TAU_EBS_SOURCE	TIME	Allows using PAPI hardware counters for periodic interrupts for EBS (e.g., TAU_EBS_SOURCE=PAPI_TOT_INS when TAU_SAMPLING=1)
TAU_EBS_PERIOD	100000	Specifies the overflow count for interrupts
TAU_MEMDBG_ALLOC_MIN/MAX	0	Byte size minimum and maximum subject to bounds checking (used with TAU_MEMDBG_PROTECT_*)
TAU_MEMDBG_OVERHEAD	0	Specifies the number of bytes for TAU's memory overhead for memory debugging.
TAU_MEMDBG_PROTECT_BELOW/ABOVE	0	Setting to 1 enables tracking runtime bounds checking below or above the array bounds (requires –optMemDbg while building or tau_exec –memory)
TAU_MEMDBG_ZERO_MALLOC	0	Setting to 1 enables tracking zero byte allocations as invalid memory allocations.
TAU_MEMDBG_PROTECT_FREE	0	Setting to 1 detects invalid accesses to deallocated memory that should not be referenced until it is reallocated (requires –optMemDbg or tau_exec –memory)
TAU_MEMDBG_ATTEMPT_CONTINUE	0	Setting to 1 allows TAU to record and continue execution when a memory error occurs at runtime.
TAU_MEMDBG_FILL_GAP	Undefined	Initial value for gap bytes
TAU_MEMDBG_ALINGMENT	Sizeof(int)	Byte alignment for memory allocations
TAU_EVENT_THRESHOLD	0.5	Define a threshold value (e.g., .25 is 25%) to trigger marker events for min/max

Simplifying TAU's usage (tau_exec)

- Uninstrumented execution
  - % mpirun -np 4 ./a.out
- Track MPI performance
  - % mpirun -np 4 tau_exec ./a.out
- Track POSIX I/O and MPI performance (MPI enabled by default)
  - % mpirun -np 4 tau_exec –T mpi,pdt –io ./a.out
- Track memory operations
  - % export TAU_TRACK_MEMORY_LEAKS=1
  - % mpirun –np 8 tau_exec –memory_debug ./a.out (bounds check)
- Use event based sampling (compile with –g)
  - % mpirun –np 8 tau_exec –ebs ./a.out
  - Also –ebs_source=<PAPI_COUNTER> -ebs_period=<overflow_count>
- Load wrapper interposition library
  - % mpirun –np 8 tau_exec –loadlib=<path/libwrapper.so> ./a.out
- Track GPGPU operations
  - % mpirun –np 8 tau_exec –cupti ./a.out
  - % mpirun –np 8 tau_exec –opencl ./a.out
  - % mpirun –np 8 tau_exec –openacc ./a.out

Binary Rewriting Instrumentation

- Support for both static and dynamic executables
- Specify a list of routines to instrument
- Specify the TAU measurement library to be injected
- MAQAO [UVSQ, Intel Exascale Labs]:

```
% tau_rewrite -T [tags] a.out -o a.inst
```

- DyninstAPI [U. Maryland and U. Wisconsin, Madison]:

```
% tau_run -T [tags] a.out -o a.inst
```

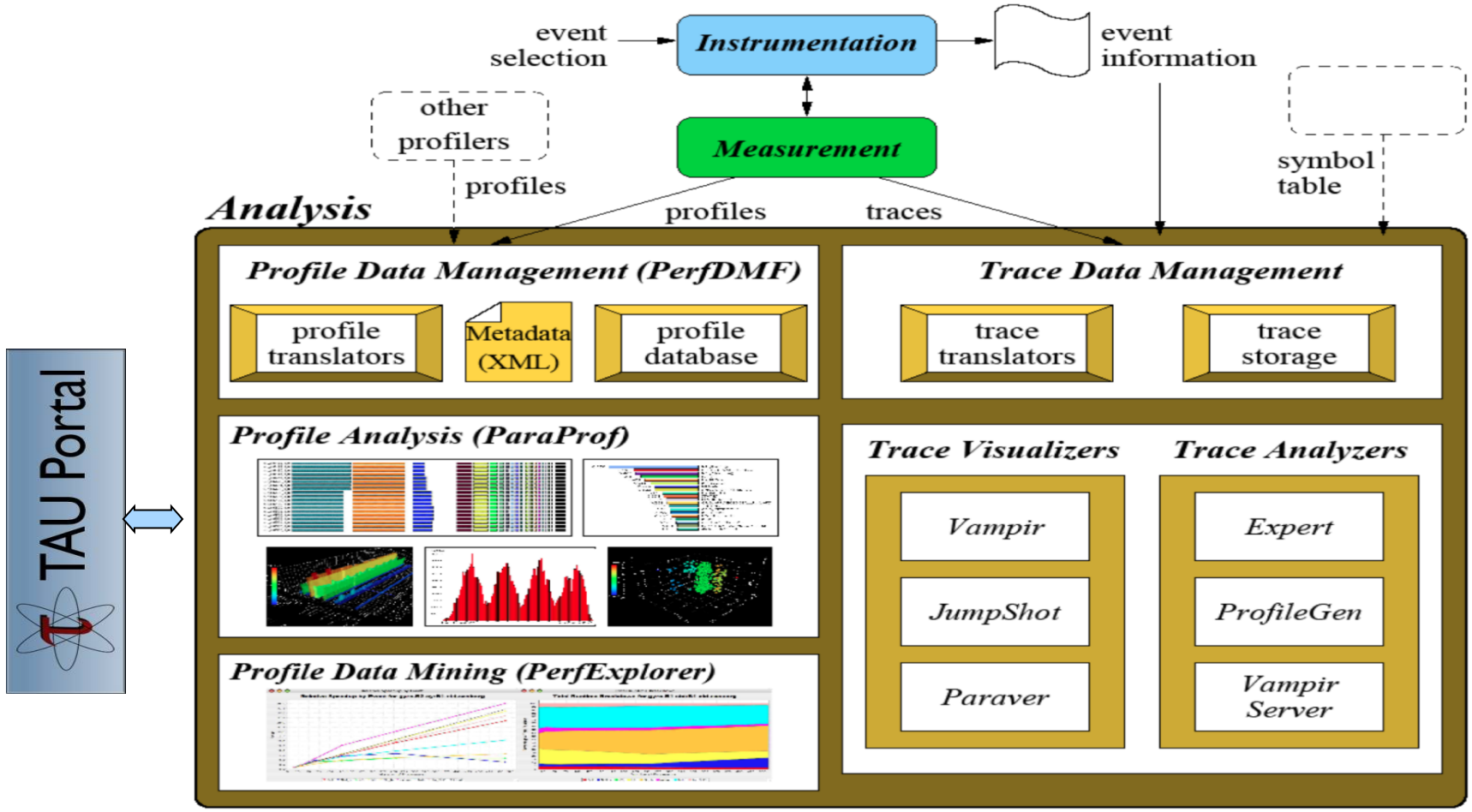
- Pebil [UC San Diego]:

```
% tau_pebil_rewrite -T [tags] a.out -o a.inst
```

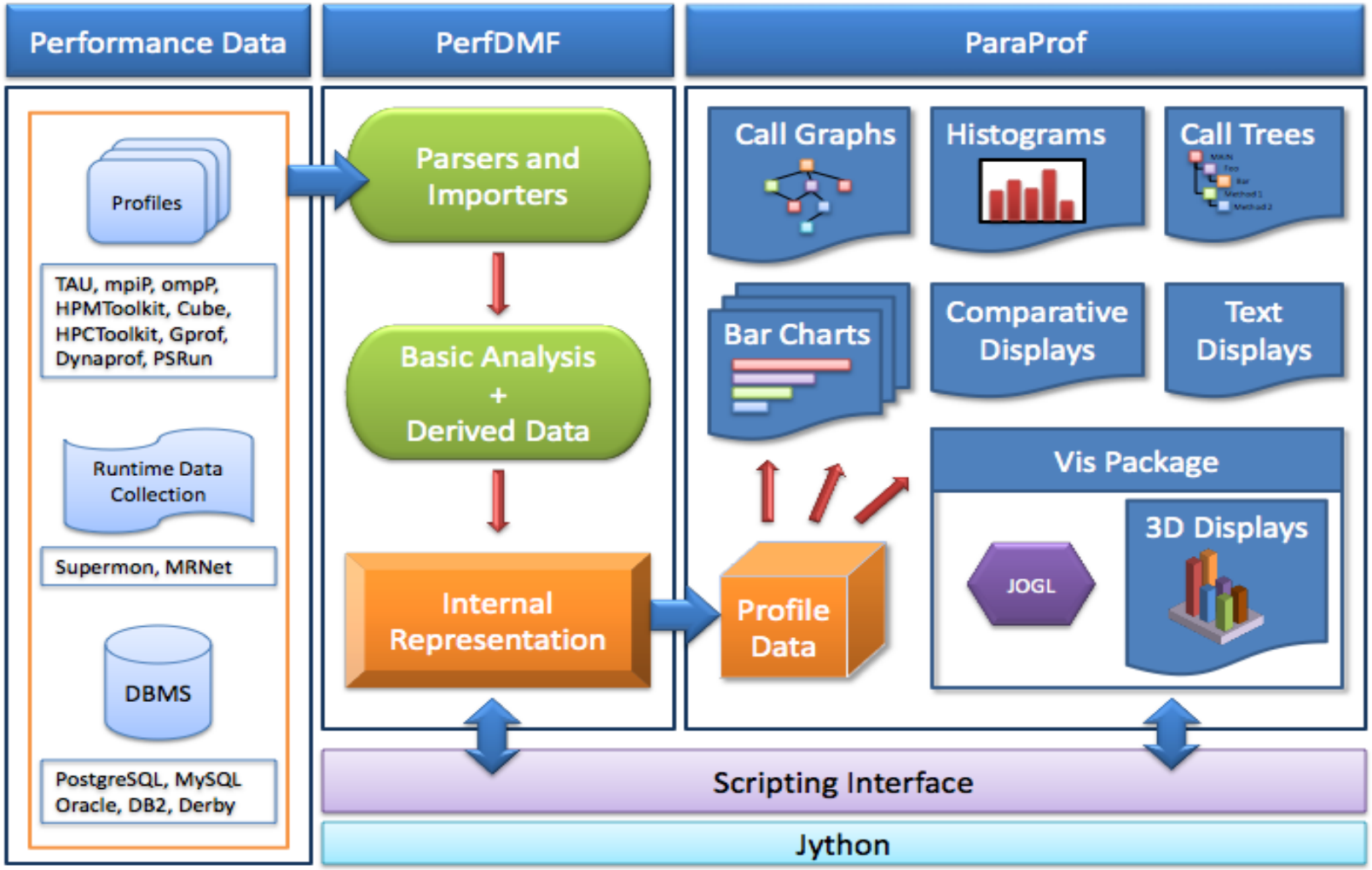
- Execute the application to get measurement data:

```
% mpirun -np 256 ./a.inst
```

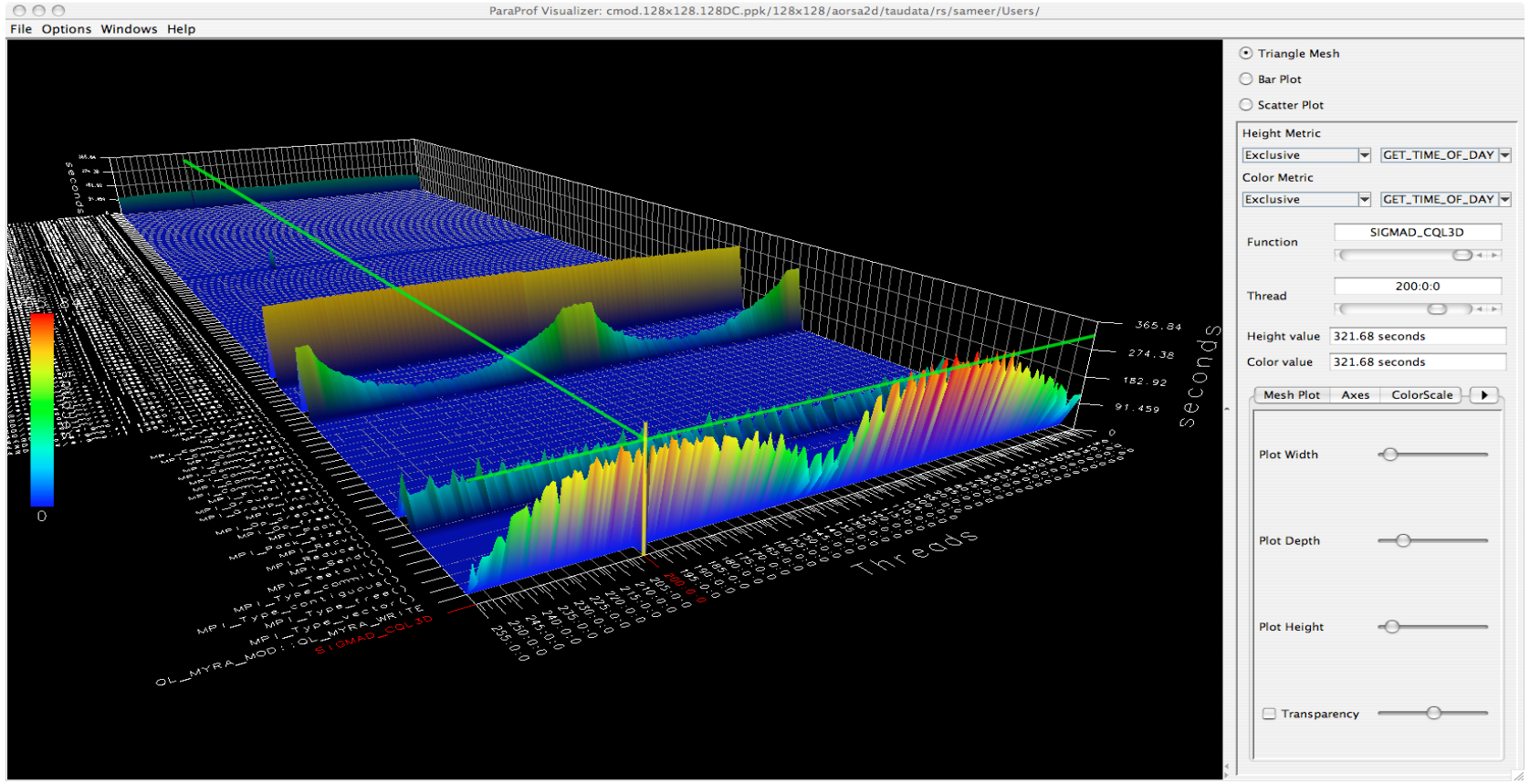
TAU Analysis



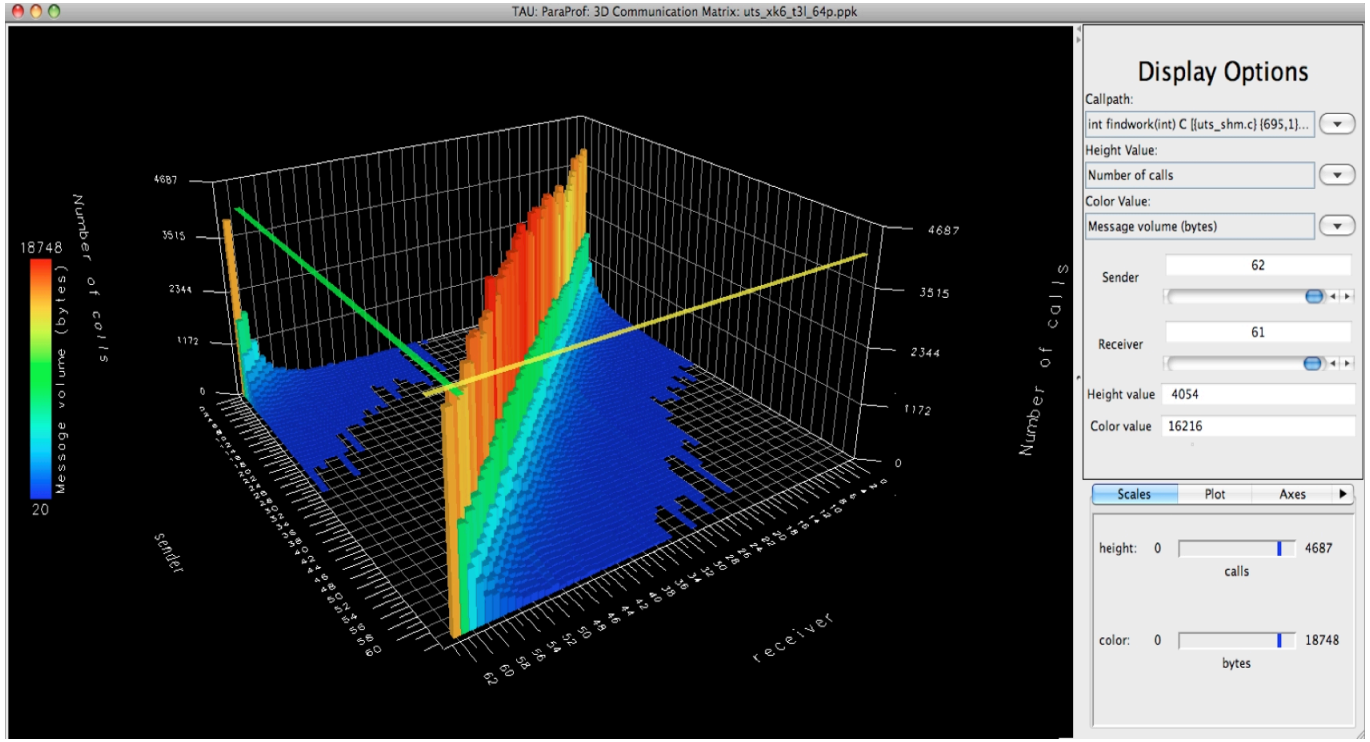
ParaProf Profile Analysis Framework



Parallel Profile Visualization: ParaProf



ParaProf 3D Communication Matrix



% export TAU_COMM_MATRIX=1

TAU tutorial exercise objectives

- Familiarise with usage of TAU tools
  - complementary tools' capabilities & interoperability
- Prepare to apply tools productively to *your* applications(s)
- Exercise is based on a small portable benchmark code
  - unlikely to have significant optimisation opportunities

- Optional (recommended) exercise extensions
  - analyse performance of alternative configurations
  - investigate effectiveness of system-specific compiler/MPI optimisations and/or placement/binding/affinity capabilities
  - investigate scalability and analyse scalability limiters
  - compare performance on different HPC platforms
  - …

Local Installation (*U. Cambridge*)

- Setup preferred program environment compilers
  - Default set Intel Compilers with Intel MPI
  - Generate profile files using Score-P

```
% paraprof profile.cubex &
```

For PerfExplorer:

```
% wget http://tau.uoregon.edu/data.tgz; tar zxf data.tgz; cd data
% cat README
And follow the steps
% cd tau; ./upload.sh; perfexplorer &
Charts -> Total Time, etc.
```

NPB-MZ-MPI Suite

- The NAS Parallel Benchmark suite (MPI+OpenMP version)
  - Available from:

    http://www.nas.nasa.gov/Software/NPB
  - 3 benchmarks in Fortran77
  - Configurable for various sizes & classes
- Move into the NPB3.3-MZ-MPI root directory

```
% ls
bin/     common/  jobscript/  Makefile  README.install   SP-MZ/
BT-MZ/   config/  LU-MZ/      README    README.tutorial  sys/
```

- Subdirectories contain source code for each benchmark
  - plus additional configuration and common code
- The provided distribution has already been configured for the tutorial, such that it's ready to “make” one or more of the benchmarks and install them into a (tool-specific) “bin” subdirectory

NPB-MZ-MPI / BT: config/make.def

```
#                SITE- AND/OR PLATFORM-SPECIFIC DEFINITIONS.
#
#-----------------------------------------------------------------------

#-----------------------------------------------------------------------
# Configured for generic MPI with GCC compiler
#-----------------------------------------------------------------------
#OPENMP  = -fopenmp      # GCC compiler
OPENMP = -openmp         # Intel compiler

...
#-----------------------------------------------------------------------
# The Fortran compiler used for MPI programs
#-----------------------------------------------------------------------
# MPIF77 = mpiifort # Intel compiler

# Alternative variant to perform instrumentation
MPIF77 = tau_f90.sh
# PREP is a generic preposition macro for instrumentation preparation
#MPIF77 = $(PREP) mpif77 -f77=ifort
#MPIF77 = scorep …
...
```

Default (no instrumentation)

Uncomment TAU's compiler wrapper to do source instrumentation with TAU
Comment out Score-P wrapper

Building an NPB-MZ-MPI Benchmark

```
% make
  ========================================
  =      NAS PARALLEL BENCHMARKS 3.3     =
  =      MPI+OpenMP Multi-Zone Versions  =
  =      F77                             =
  ========================================

  To make a NAS multi-zone benchmark type

        make <benchmark-name> CLASS=<class> NPROCS=<nprocs>

  where <benchmark-name> is "bt-mz", "lu-mz", or "sp-mz"
        <class>          is "S", "W", "A" through "F"
        <nprocs>         is number of processes

  [...]

 ***********************************************************
 * Custom build configuration is specified in config/make.def  *
 * Suggested tutorial exercise configuration for HPC systems:  *
 *       make bt-mz CLASS=B NPROCS=8                           *
 ***********************************************************
```

- Type "make" for instructions

Building an NPB-MZ-MPI Benchmark

```
% make suite
make[1]: Entering directory `BT-MZ'
make[2]: Entering directory `sys'
cc  -o setparams setparams.c -lm
make[2]: Leaving directory `sys'
../sys/setparams bt-mz 30 B
make[2]: Entering directory `../BT-MZ'
tau_f90.sh -c  -O3 -g -openmp       bt.f
[…]
tau_f90.sh -c  -O3 -g -openmp       mpi_setup.f
cd ../common;  mpiifort -c  -O3 -g -openmp        print_results.f
cd ../common;  mpiifort -c  -O3 -g -openmp        timers.f
tau_f90.sh -O3 -g -openmp   -o ../bin.tau/bt-mz_B.8 bt.o
 initialize.o exact_solution.o exact_rhs.o set_constants.o adi.o
 rhs.o zone_setup.o x_solve.o y_solve.o  exch_qbc.o solve_subs.o
 z_solve.o add.o error.o verify.o mpi_setup.o ../common/print_results.o
 ../common/timers.o
make[2]: Leaving directory `BT-MZ'
Built executable ../bin.tau/bt-mz_B.8
make[1]: Leaving directory `BT-MZ'
```

- Specify the benchmark configuration
  - benchmark name: **bt-mz**, lu-mz, sp-mz
  - the number of MPI processes: NPROCS=**30**
  - the benchmark class (S, W, A, B, C, D, E): CLASS=**B**

Shortcut: `% make suite`

NPB-MZ-MPI / BT (Block Tridiagonal Solver)

- What does it do?
  - Solves a discretized version of the unsteady, compressible Navier-Stokes equations in three spatial dimensions
  - Performs 200 time-steps on a regular 3-dimensional grid
- Implemented in 20 or so Fortran77 source modules

- Uses MPI & OpenMP in combination
  - 30 processes each with 4 threads should be reasonable

  - bt-mz_B.30 should take around 40 seconds

TAU Source Instrumentation

- Edit config/make.def to adjust build configuration
  - Uncomment specification of compiler/linker: MPIF77 = tau_f90.sh
  - Make clean and build new tool-specific executable

```
% make clean
% make bt-mz CLASS=B NPROCS=8
Built executable ../bin.tau/bt-mz_B.8
```

- OR use make MPIF77=tau_f90.sh suite on the command line
- Change to the directory containing the new executable before running it with the desired tool configuration

```
% cd bin.tau
% cp ../jobscript/darwin/bt-mz.job .
% sbatch bt-mz.job
```

NPB-MZ-MPI / BT with TAU

```
% cd bin.tau
% cp ../jobscript/darwin/bt-mz.job .
% sbatch bt-mz.job
% cat out.txt
 NAS Parallel Benchmarks (NPB3.3-MZ-MPI) - BT-MZ MPI+OpenMP Benchmark
 Number of zones:   8 x 8
 Iterations:  200   dt:   0.000300
 Number of active processes:     30
 Total number of threads:       120 (  4.0 threads/process)

 Time step    1
 Time step   20
  [...]
 Time step  180
 Time step  200
 Verification Successful

 BT-MZ Benchmark Completed.
 Time in seconds = 39.03
% paraprof &
% paraprof --pack bt.ppk
<Copy file over to desktop using scp>
% paraprof bt.ppk  &
```

- Copy jobscript and launch as a hybrid MPI+OpenMP application

Hint: save the benchmark output (or note the run time) to be able to refer to it later

tau_exec

```
$ tau_exec

Usage: tau_exec [options] [--] <exe> <exe options>

Options:
        -v              Verbose mode
        -s              Show what will be done but don't actually do anything (dryrun)
        -qsub           Use qsub mode (BG/P only, see below)
        -io             Track I/O
        -memory         Track memory allocation/deallocation
        -memory_debug Enable memory debugger
        -cuda           Track GPU events via CUDA
        -cupti          Track GPU events via CUPTI (Also see env. variable TAU_CUPTI_API)
        -opencl         Track GPU events via OpenCL
        -openacc        Track GPU events via OpenACC (currently PGI only)
        -ompt           Track OpenMP events via OMPT interface
        -armci          Track ARMCI events via PARMCI
        -ebs            Enable event-based sampling
        -ebs_period=<count> Sampling period (default 1000)
        -ebs_source=<counter> Counter (default itimer)
        -um           Enable Unified Memory events via CUPTI
        -T <DISABLE,GNU,ICPC,MPI,OMPT,OPENMP,PAPI,PDT,PROFILE,PTHREAD,SCOREP,SERIAL> : Specify TAU tags
        -loadlib=<file.so>    : Specify additional load library
        -XrunTAUsh-<options> : Specify TAU library directly
        -gdb            Run program in the gdb debugger

Notes:
           Defaults if unspecified: -T MPI
           MPI is assumed unless SERIAL is specified
```

- Tau_exec preloads the TAU wrapper libraries and performs measurements.

No need to recompile the application!

tau_exec Example (continued)

```
Example:
    mpirun -np 2 tau_exec -T icpc,ompt,mpi  -ompt ./a.out
    mpirun -np 2 tau_exec -io ./a.out
Example - event-based sampling with samples taken every 1,000,000 FP instructions
    mpirun -np 8 tau_exec -ebs -ebs_period=1000000 -ebs_source=PAPI_FP_INS ./ring
Examples - GPU:
    tau_exec -T serial,cupti -cupti ./matmult (Preferred for CUDA 4.1 or later)
    tau_exec -openacc ./a.out
    tau_exec -T serial -opencl ./a.out (OPENCL)
    mpirun -np 2 tau_exec -T mpi,cupti,papi -cupti -um ./a.out (Unified Virtual Memory in CUDA 6.0+)

qsub mode (IBM BG/Q only):
    Original:
      qsub -n 1 --mode smp -t 10 ./a.out
    With TAU:
      tau_exec -qsub -io -memory -- qsub -n 1 … -t 10 ./a.out

Memory Debugging:
    -memory option:
      Tracks heap allocation/deallocation and memory leaks.
    -memory_debug option:
      Detects memory leaks, checks for invalid alignment, and checks for
      array overflow.  This is exactly like setting TAU_TRACK_MEMORY_LEAKS=1
      and TAU_MEMDBG_PROTECT_ABOVE=1 and running with -memory
```

- tau_exec can enable event based sampling while launching the executable using the –ebs flag!
- On stampede, you need to put perl-mic/bin in your path
- ibrun.symm –m test.sh
- Within test.sh call tau_exec –T ompt

Using tau_exec

- Edit bt-mz.job to use:
- module load tau
- application="tau_exec –T intel,ompt,mpi,papi,pdt –ompt ./bt-mz_B.8"

```
% vi bt-mz.job
module use tau
application="tau_exec -T intel,ompt,mpi,papi,pdt -ompt ./bt-mz_B.8"
```

- OR copy the job script

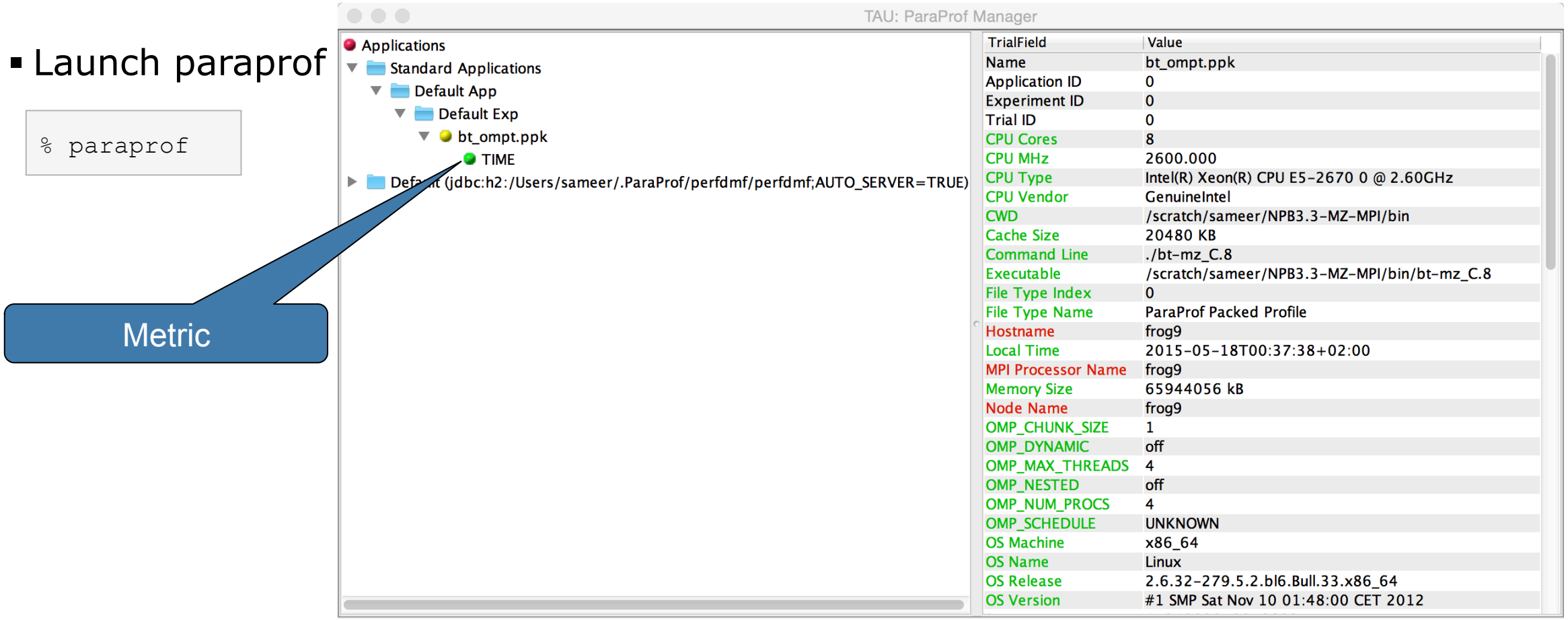
```
% cd bin
% cp ../jobscript/bt-mz.tau_exec.job .
% sbatch bt-mz.tau_exec.job
```

- You may also add –ebs flag later for a subsequent run to see line level information.
- In this case, there is no change to the source code, build system and tau_exec operates on an uninstrumented binary.

TAU Analysis Tools: paraprof

- Launch paraprof

```
% paraprof
```

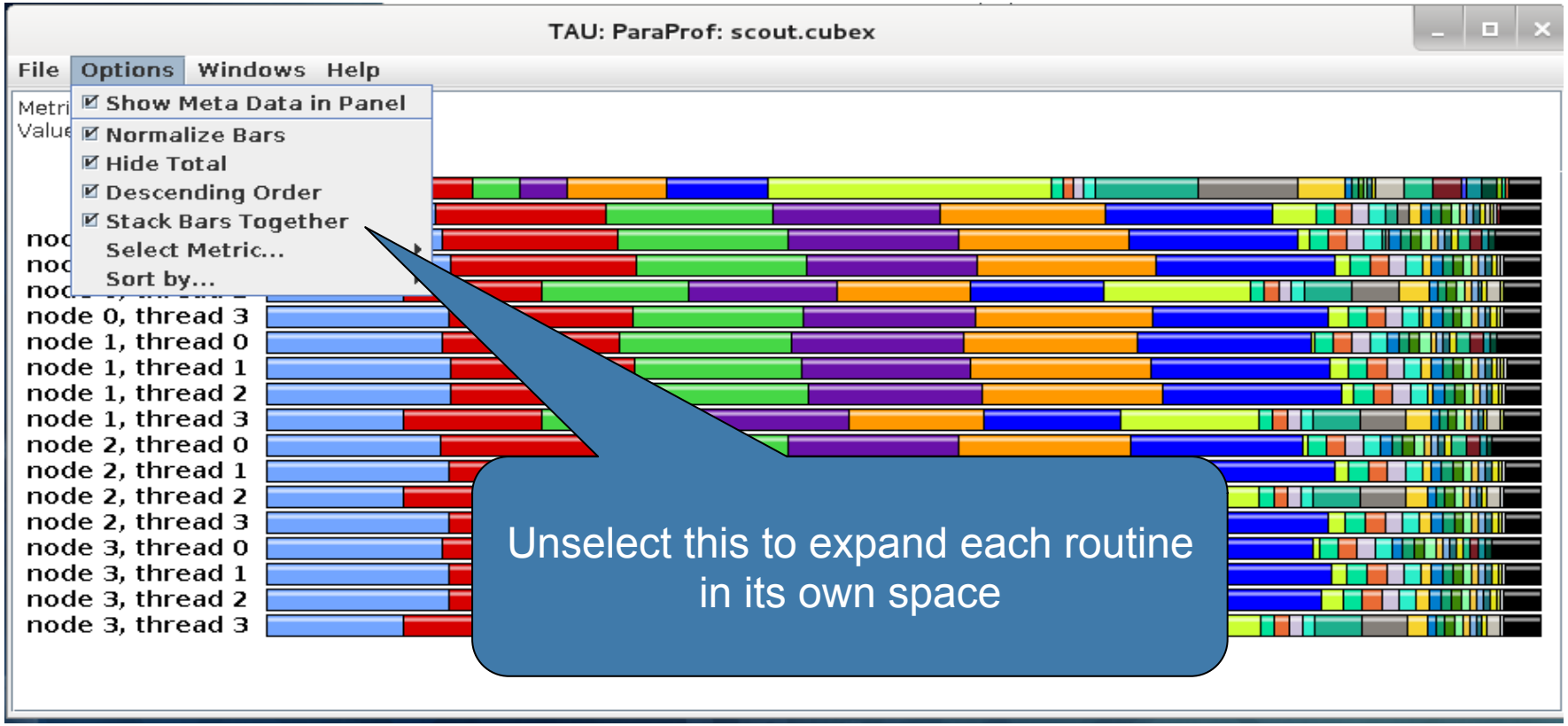


Paraprof main window

Colors represent code regions

Options -> uncheck Stack Bars Together

Paraprof main window



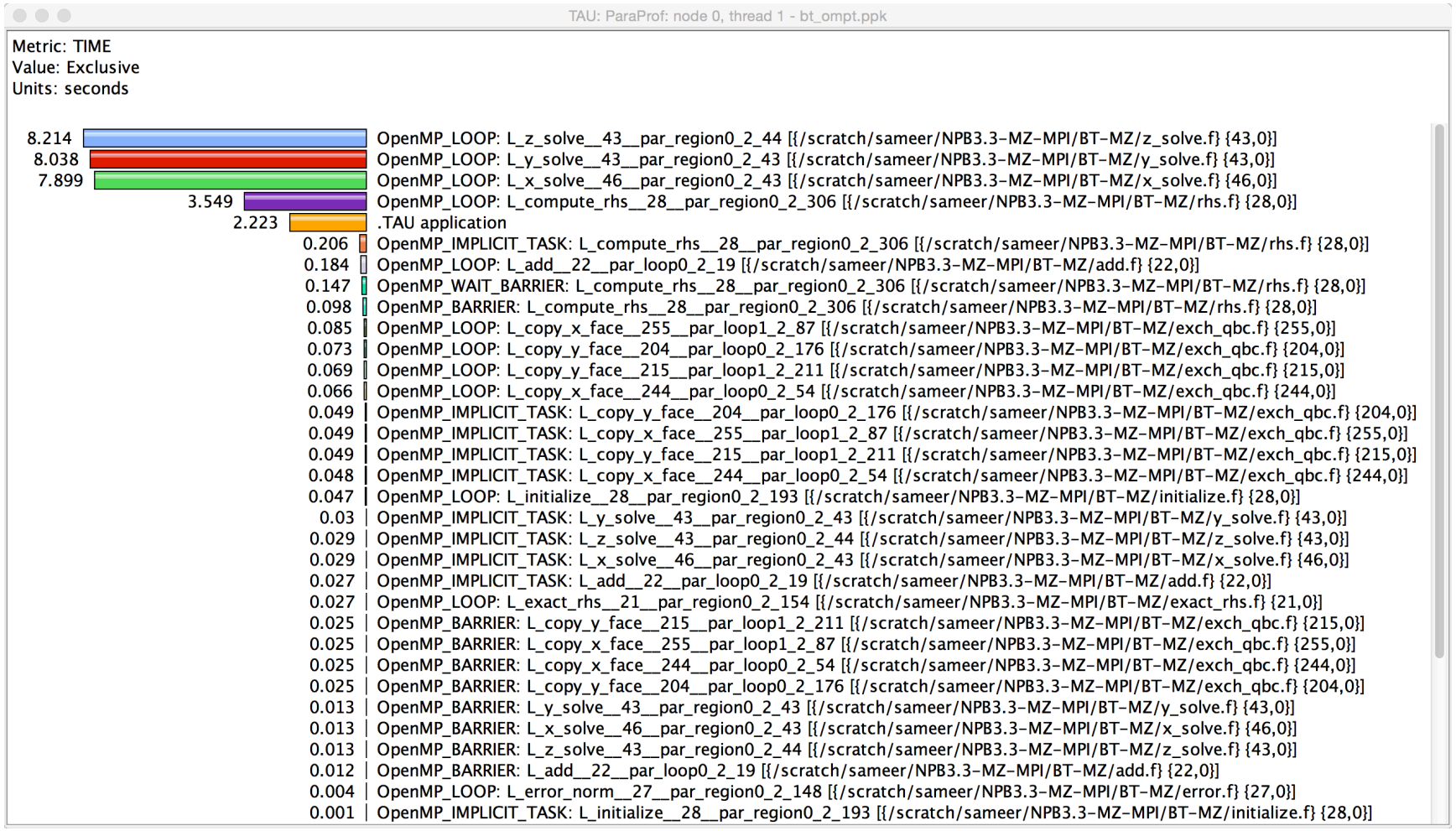
Paraprof main window

Left/right click here

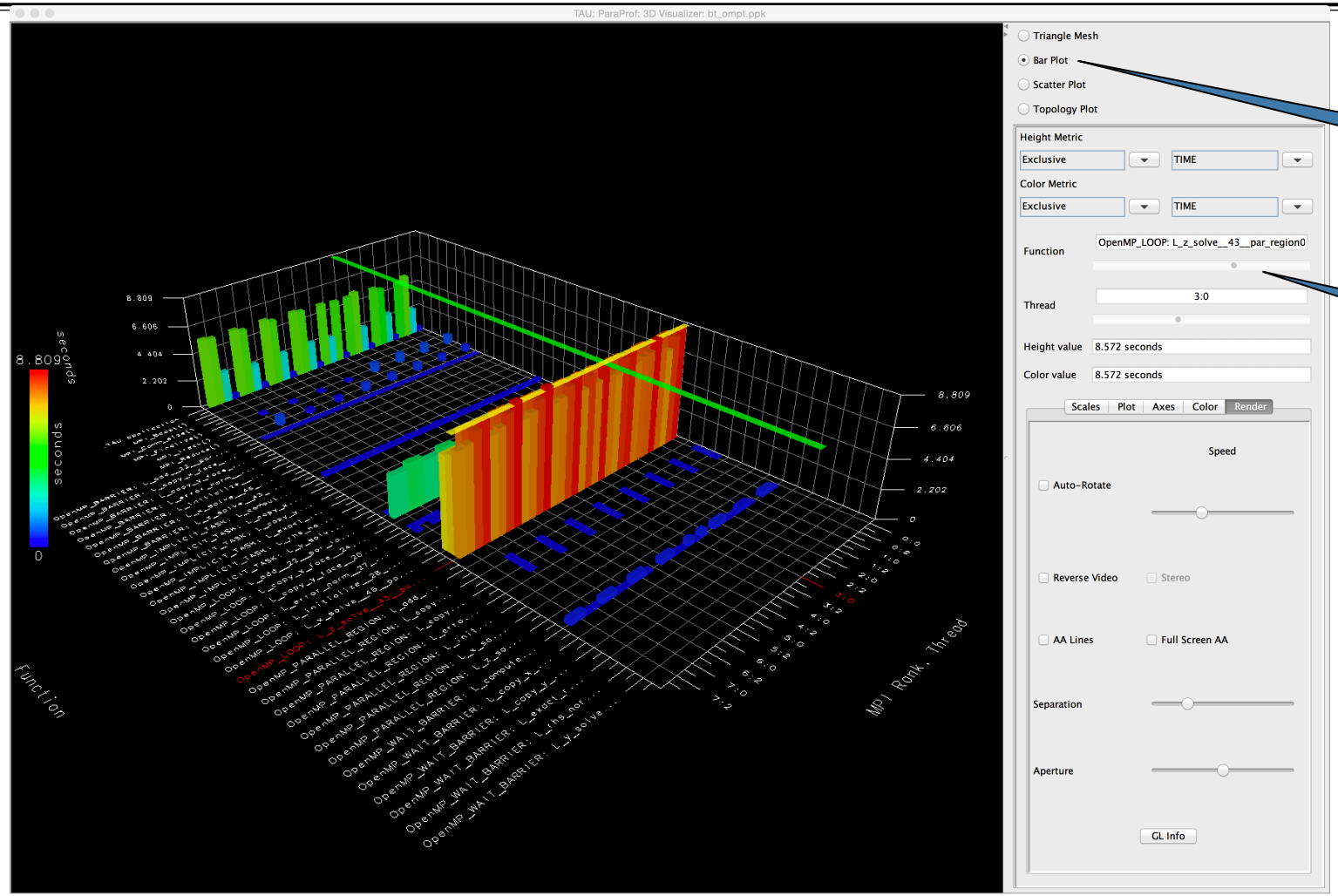
Each routine occupies its own space. Can see the extent of imbalance across all threads.

Paraprof node window (function barchart window)

Exclusive time spent in each code region (OpenMP loop) is shown here for MPI rank 0 thread 1



Paraprof 3D visualization window



Click Bar Plot

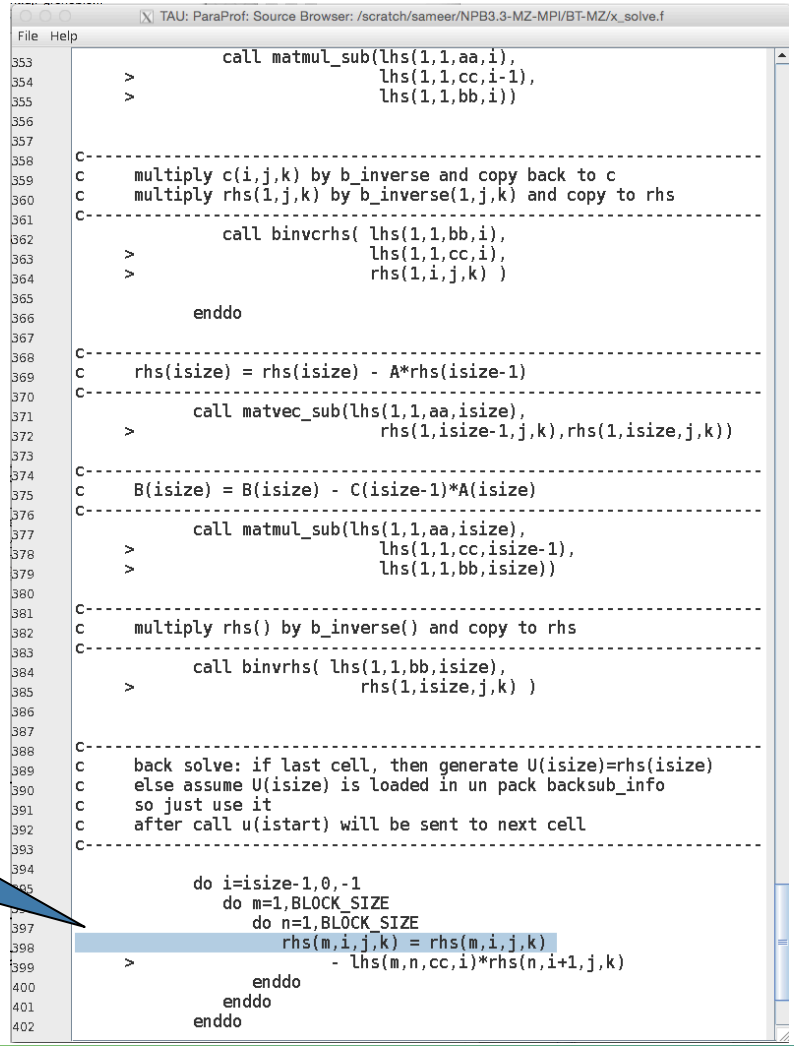
Move Function and Thread Sliders

Windows -> 3D visualization

Paraprof Thread Statistics Table with TAU_SAMPLING=1

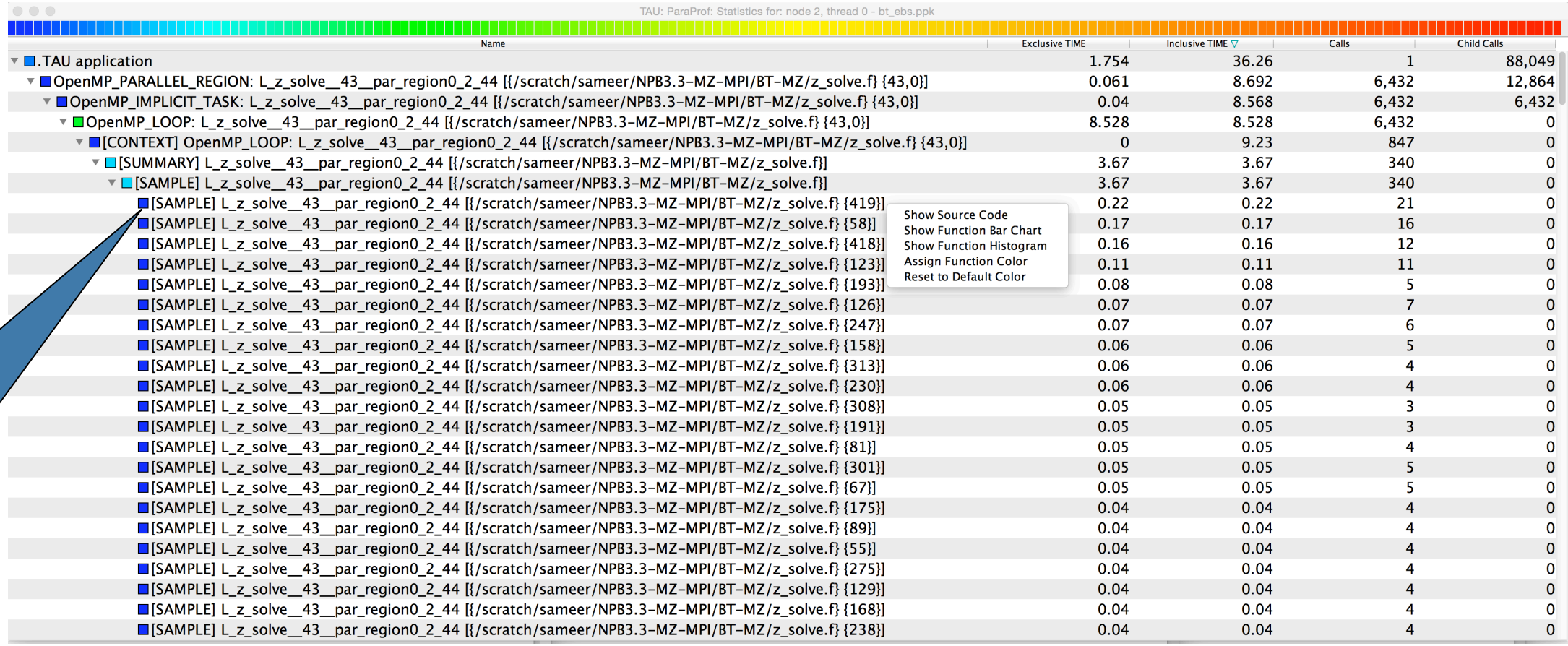
Right click here

Statement Level Profiling with TAU



Source location where samples are taken. Compute intensive region.

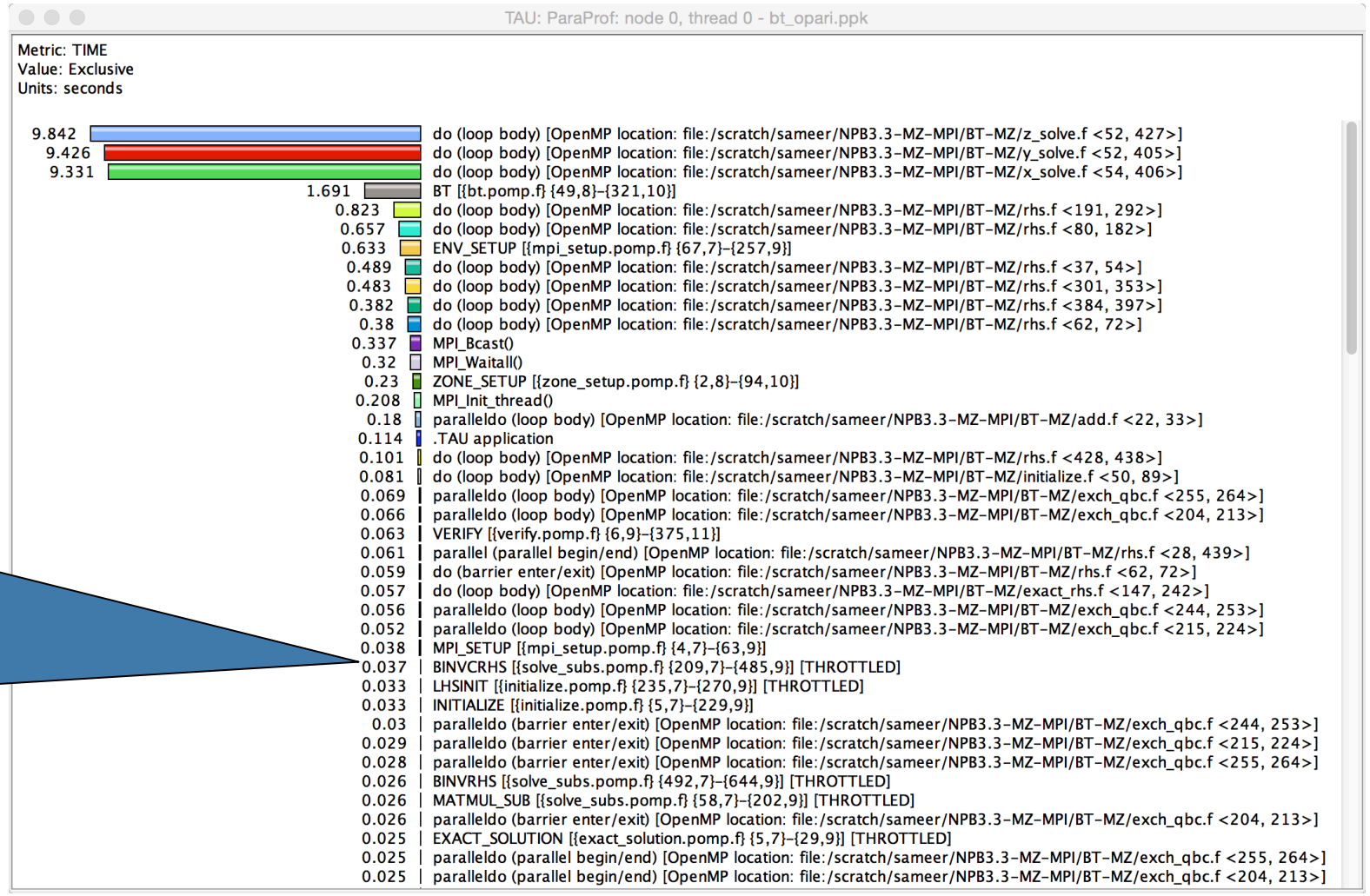
Paraprof Thread Statistics Table



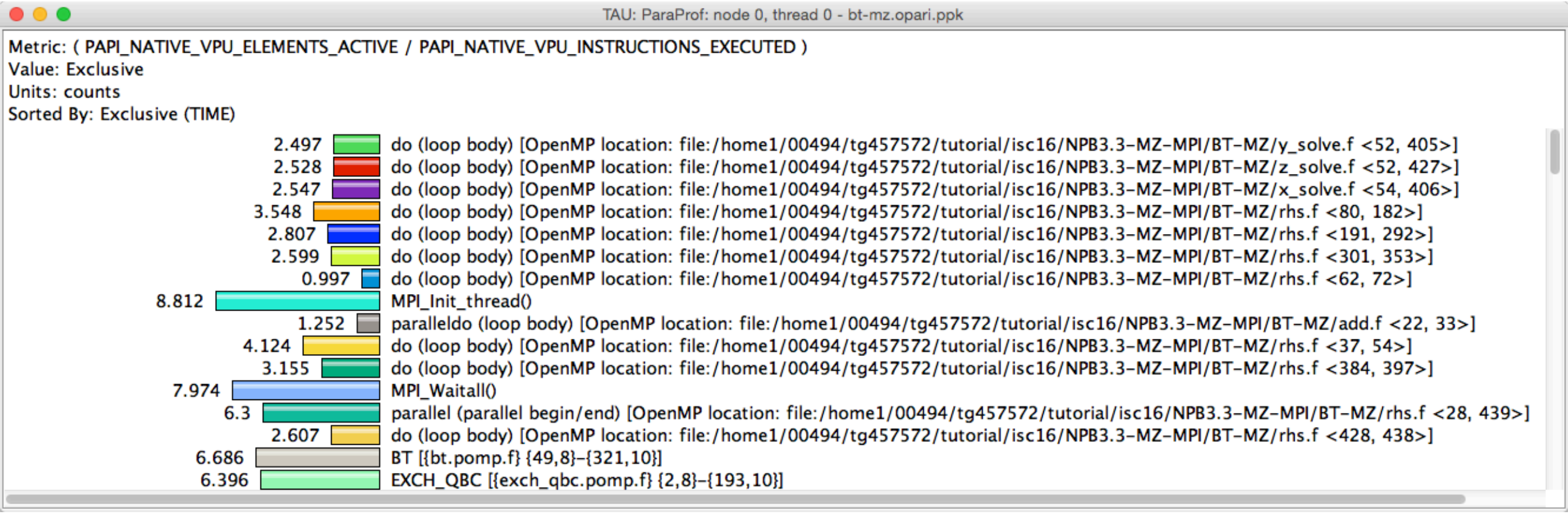
Right click here and choose “Show Source Code” for a sample

Instrumenting Source Code with PDT and Opari

Frequently executing lightweight routines are automatically throttled at runtime. Reduces runtime dilation.

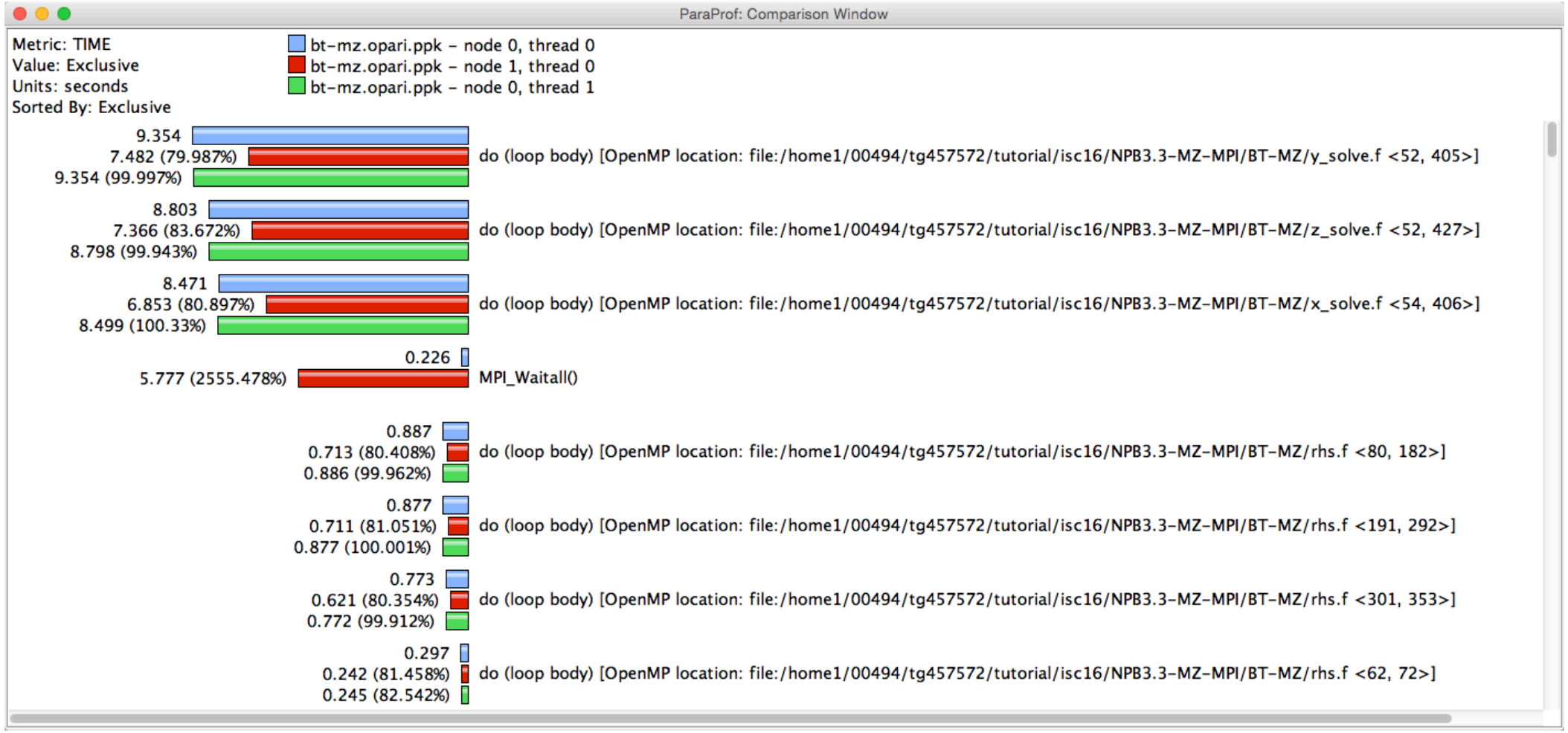


ParaProf Derived Metric Window: Intel MIC Vectorization Intensity

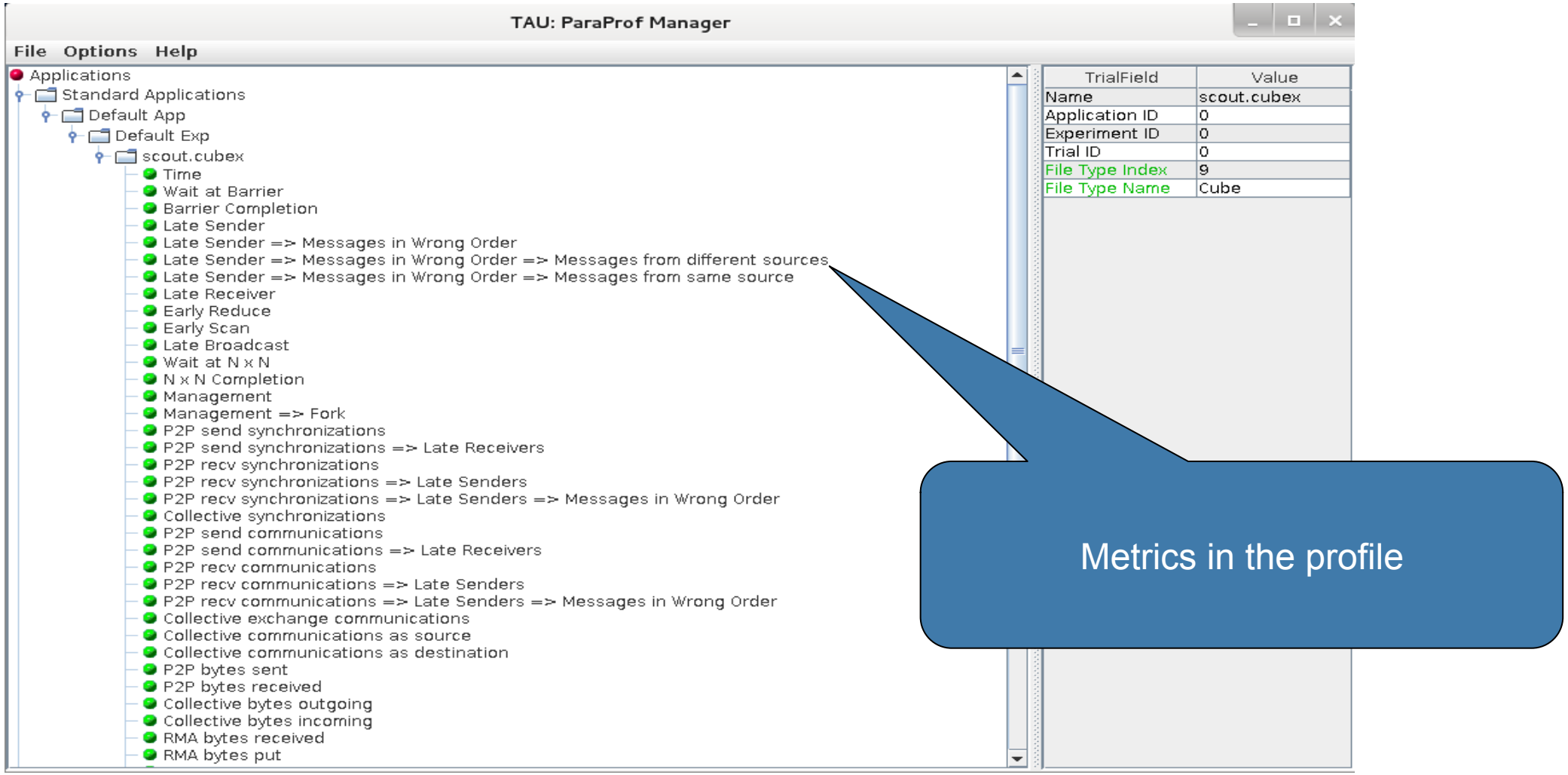



```
% export TAU_MAKEFILE=$TAU/Makefile.tau-icpc-papi-mpi-pdt-openmp-opari
% export TAU_METRICS=TIME,PAPI_NATIVE_VPU_ELEMENTS_ACTIVE,PAPI_NATIVE_VPU_INSTRUCTIONS_EXECUTED
% export TAU_PROFILE_FORMAT="merged"
% scp stampede:tauprofile.xml . ; paraprof tauprofile.xml  [Options -> Show Derived Metric Panel ]
```

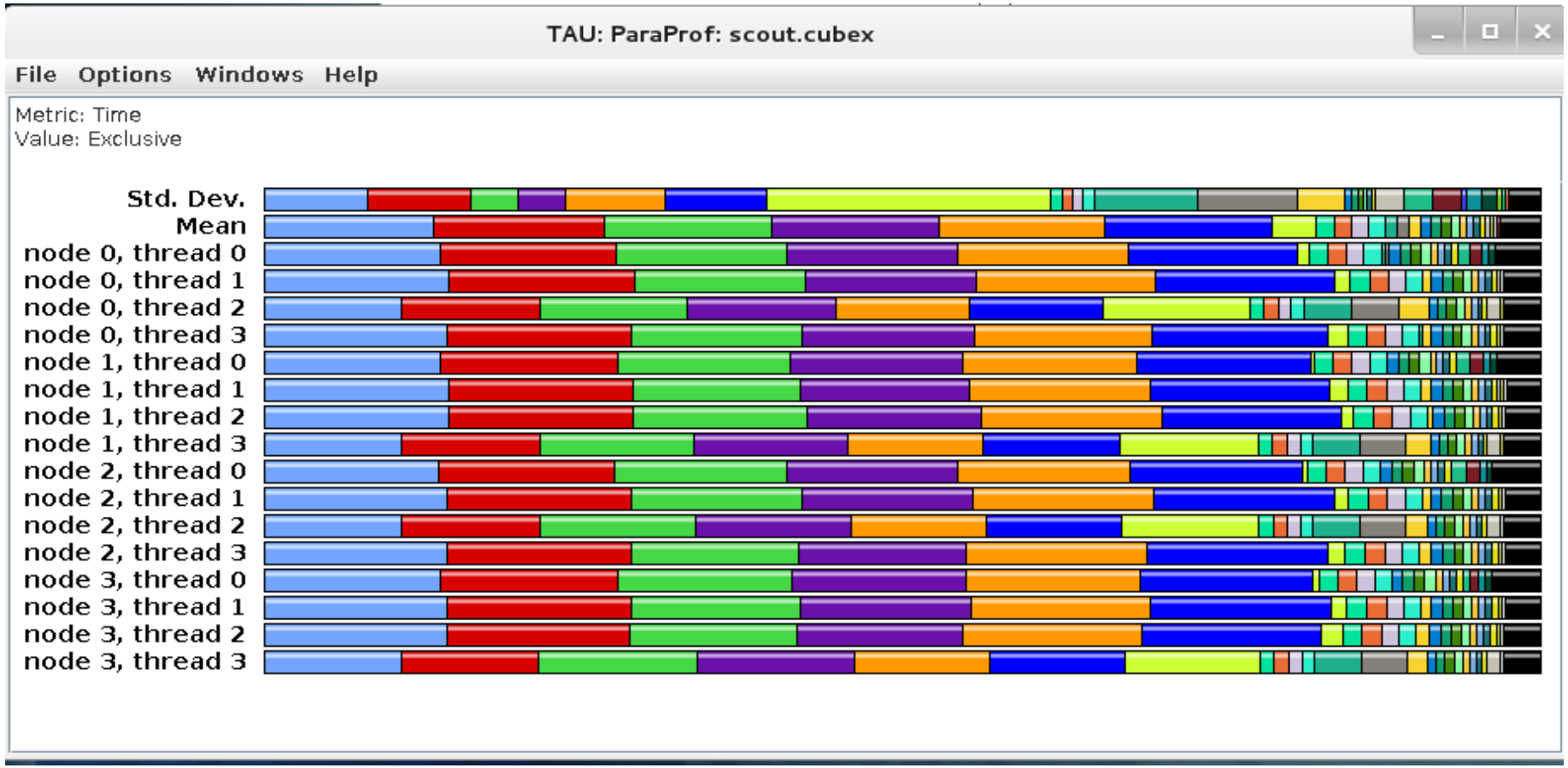
ParaProf Comparison Window



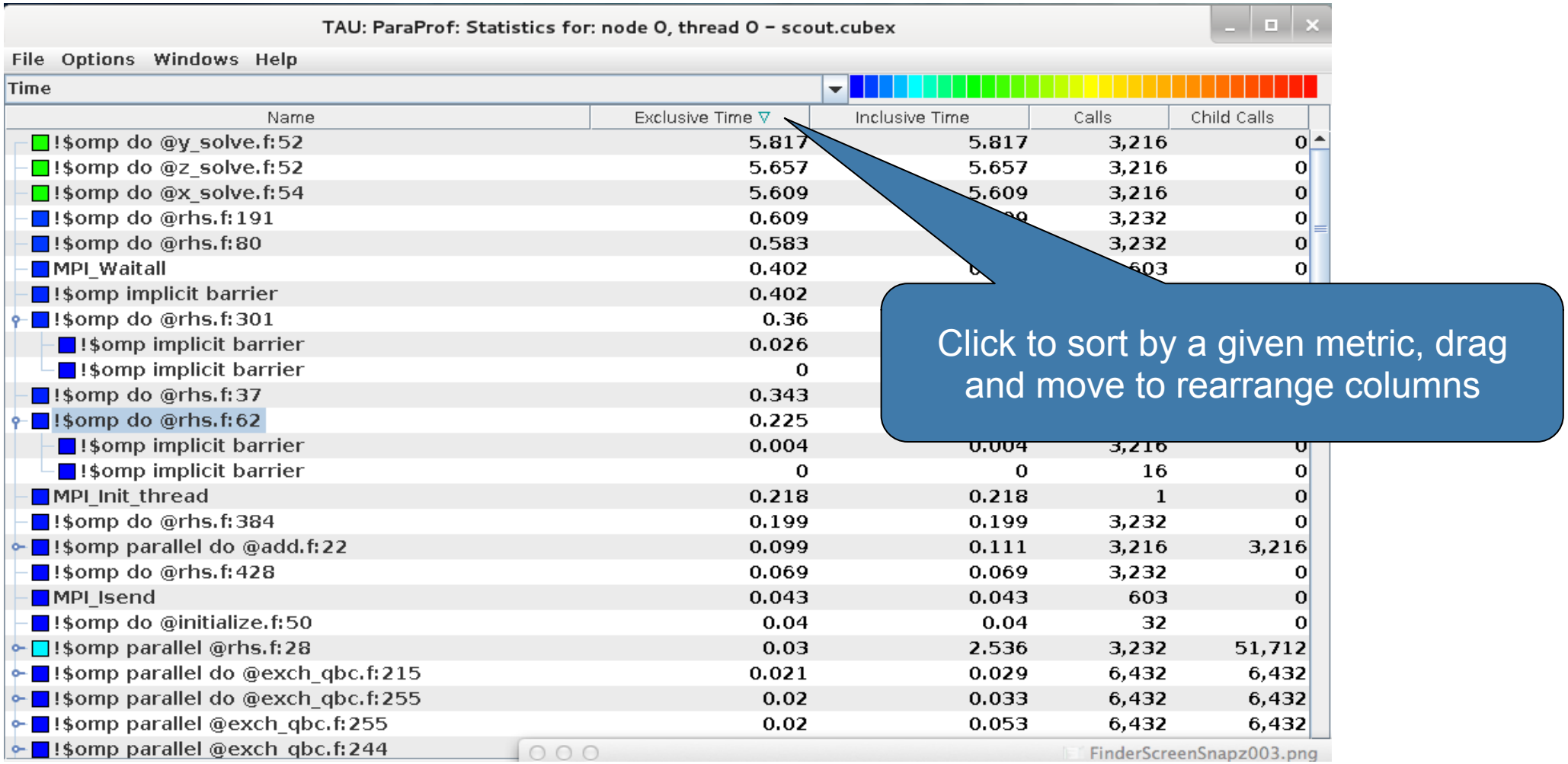
ParaProf Manager Widow: scout.cubex



ParaProf: Main Window



ParaProf: Thread Statistics Table



ParaProf: Callpath Thread Relations Window

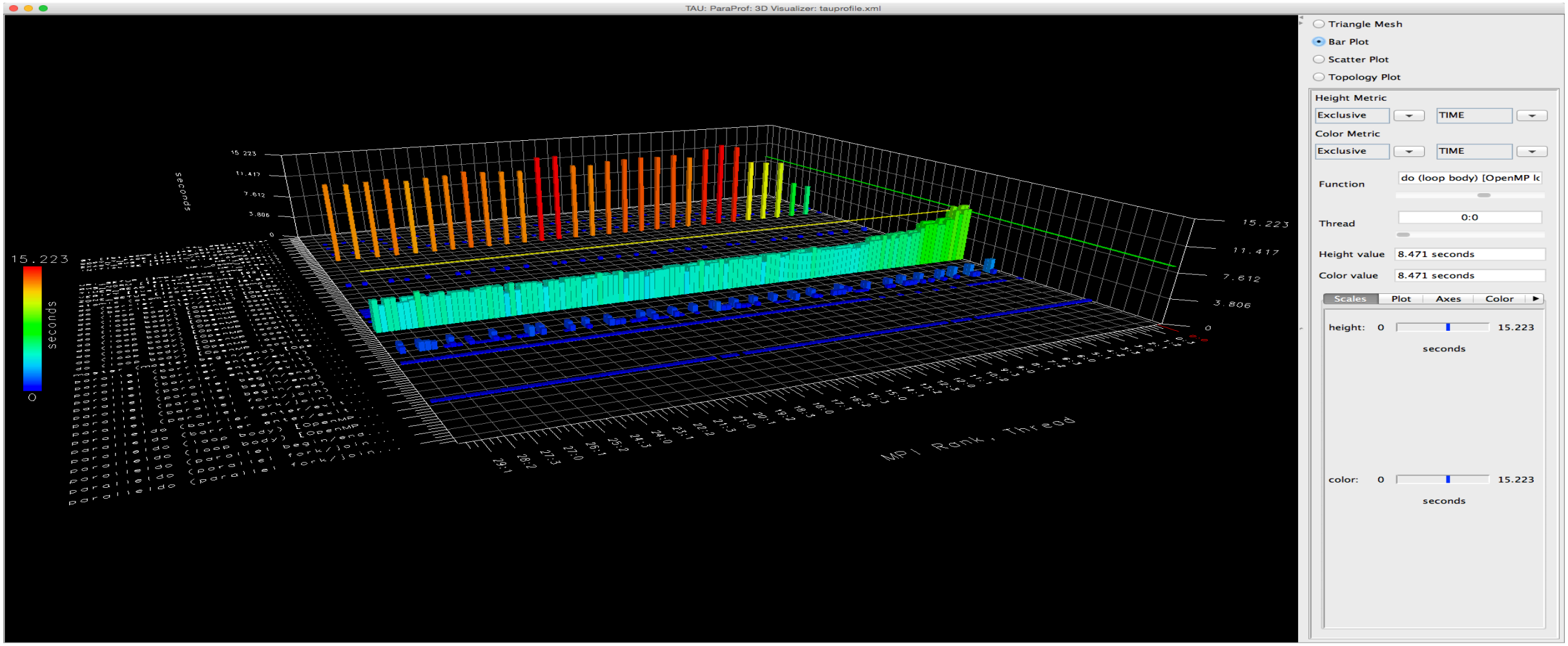
TAU: ParaProf: Call Path Data n,c,t, 0,0,0 – scout.cubex

File Options Windows Help

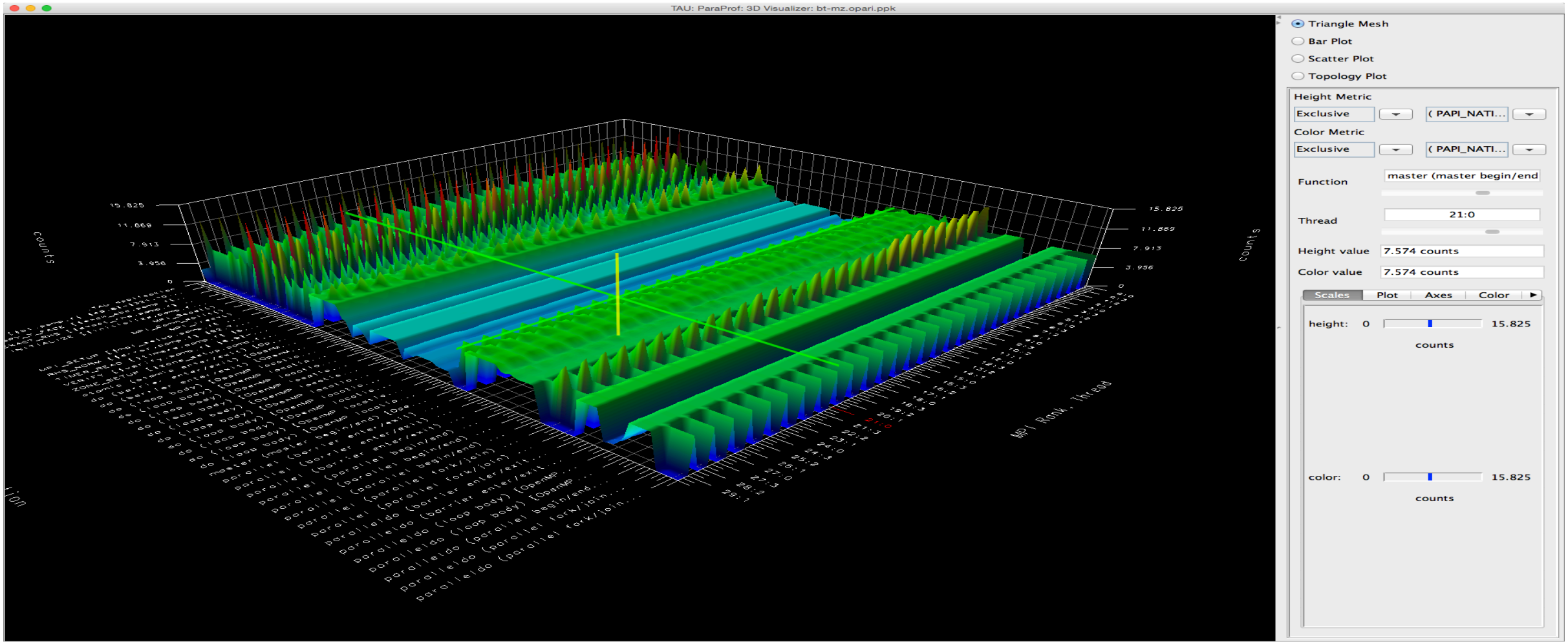
Metric Name: Time
Sorted By: Exclusive
Units: seconds

	0.04	0.04	32/32	!$omp parallel @initialize.f:28
-->	0.04	0.04	32	!$omp do @initialize.f:50
	0.03	2.536	3232/3232	compute_rhs_
-->	0.03	2.536	3232	!$omp parallel @rhs.f:28
	9.8E-4	9.8E-4	3232/3232	!$omp master @rhs.f:424
	0.225	0.228	3232/3232	!$omp do @rhs.f:62
	0.002	0.002	3232/3232	!$omp master @rhs.f:74
	0.002	0.002	3232/3232	!$omp master @rhs.f:293
	0.199	0.199	3232/3232	!$omp do @rhs.f:384
	0.002	0.002	3232/3232	!$omp master @rhs.f:183
	0.343	0.343	3232/3232	!$omp do @rhs.f:37
	0.016	0.016	3232/3232	!$omp do @rhs.f:372
	0.014	0.027	3232/3232	!$omp do @rhs.f:413
	0.609	0.609	3232/3232	!$omp do @rhs.f:191
	0.36	0.386	3232/3232	!$omp do @rhs.f:301
	0.583	0.583	3232/3232	!$omp do @rhs.f:80
	0.019	0.019	3232/3232	!$omp do @rhs.f:400
	0.006	0.006	3232/51680	!$omp implicit barrier
	0.069	0.069	3232/3232	!$omp do @rhs.f:428
	0.015	0.015	3232/3232	!$omp do @rhs.f:359
	0.021	0.029	6432/6432	!$omp parallel @exch_qbc.f:215
-->	0.021	0.029	6432	!$omp parallel do @exch_qbc.f:215
	0.007	0.007	6432/51680	!$omp implicit barrier
	0.02	0.033	6432/6432	!$omp parallel @exch_qbc.f:255
-->	0.02	0.033	6432	!$omp parallel do @exch_qbc.f:255
	0.013	0.013	6432/51680	!$omp implicit barrier

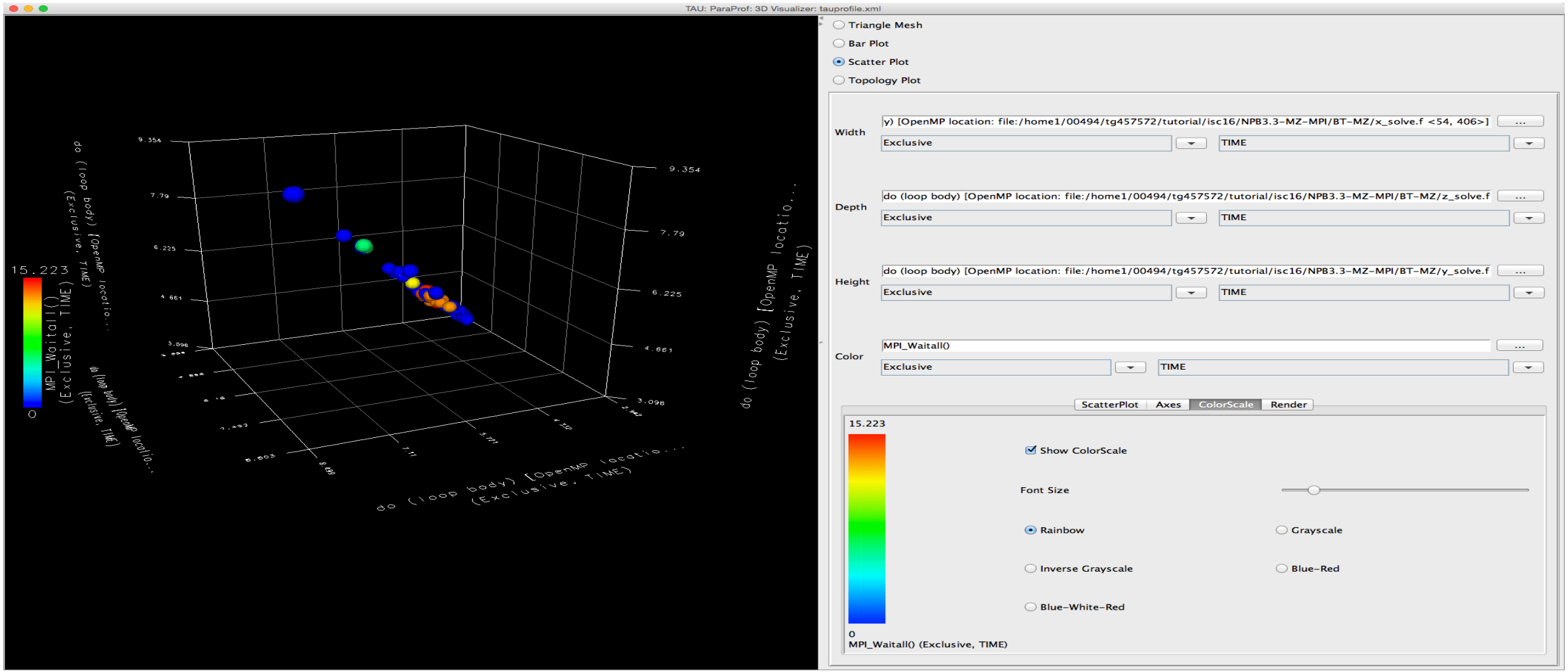
ParaProf: 3D Visualization Window Showing Entire Profile



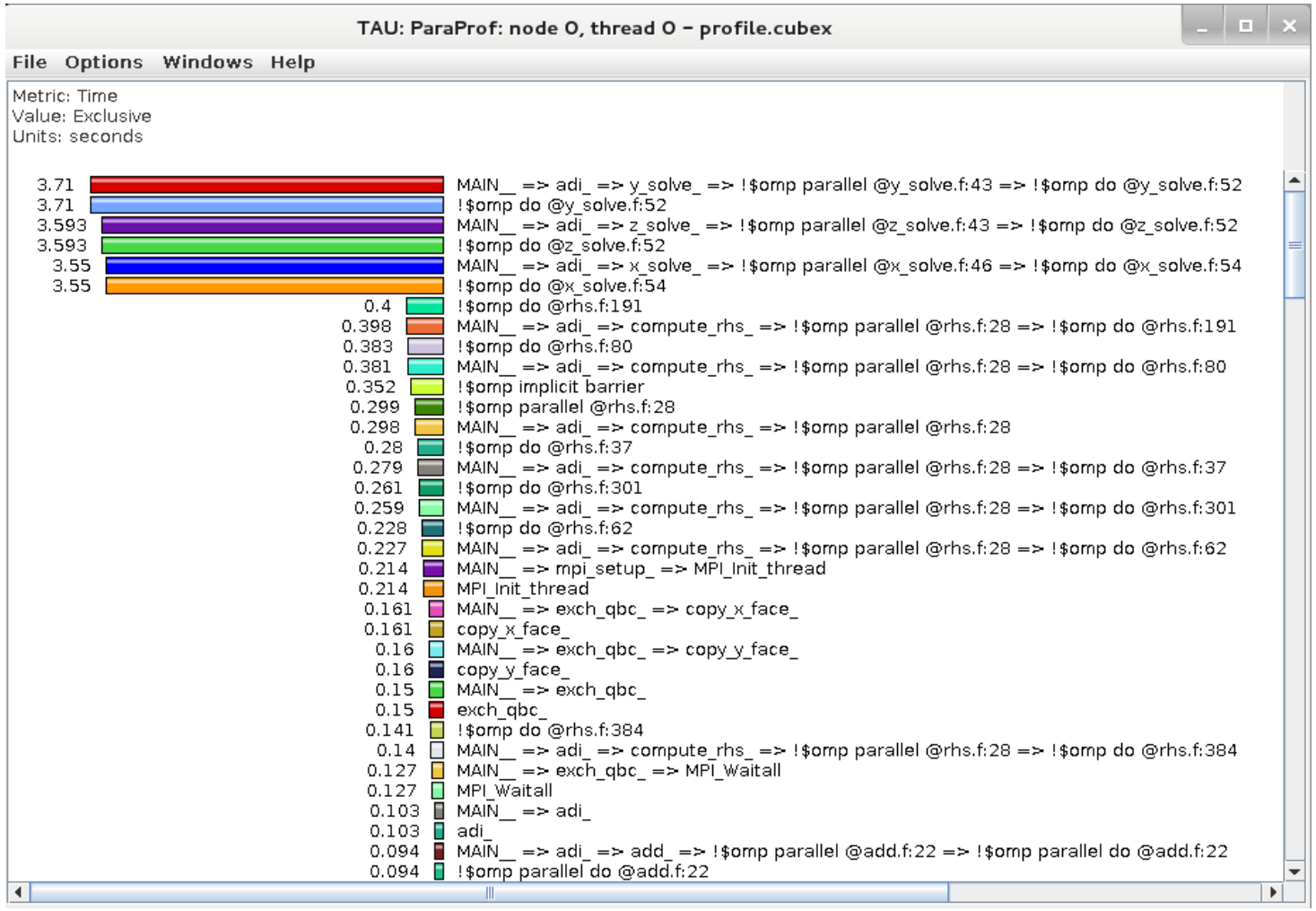
ParaProf: 3D Visualization Window MIC Vectorization Intensity



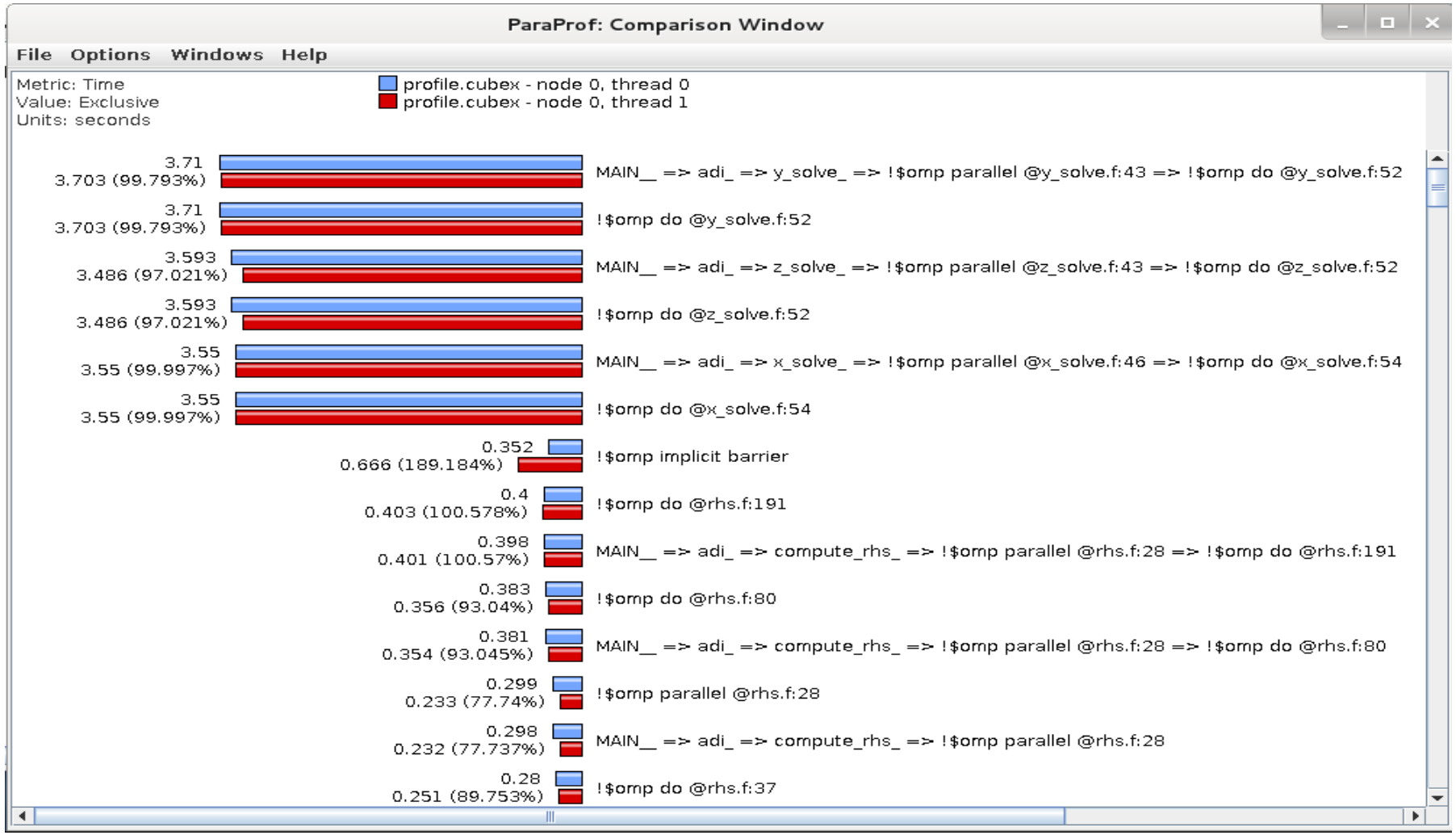
ParaProf: 3D Scatter Plot



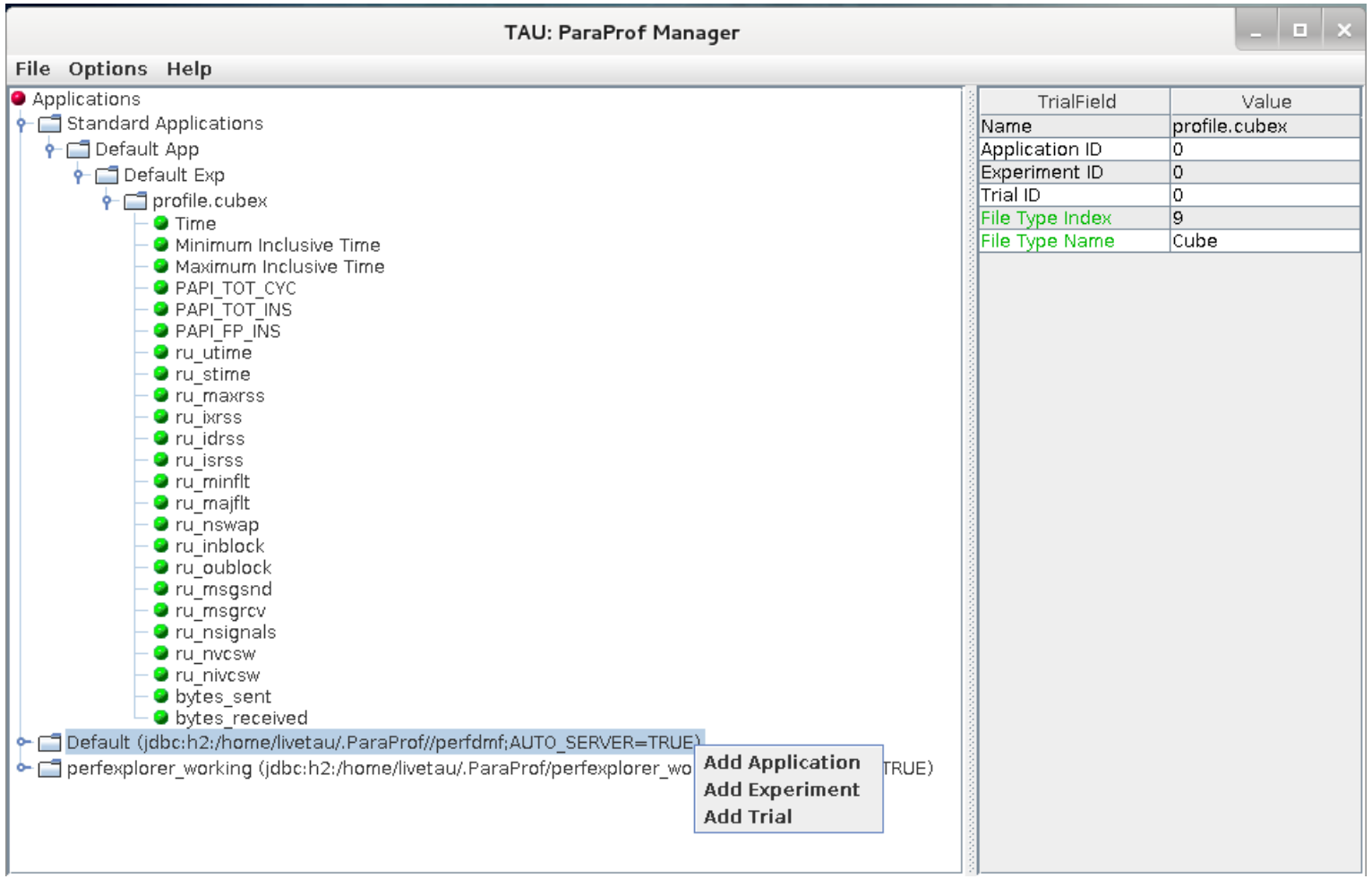
ParaProf: Node View



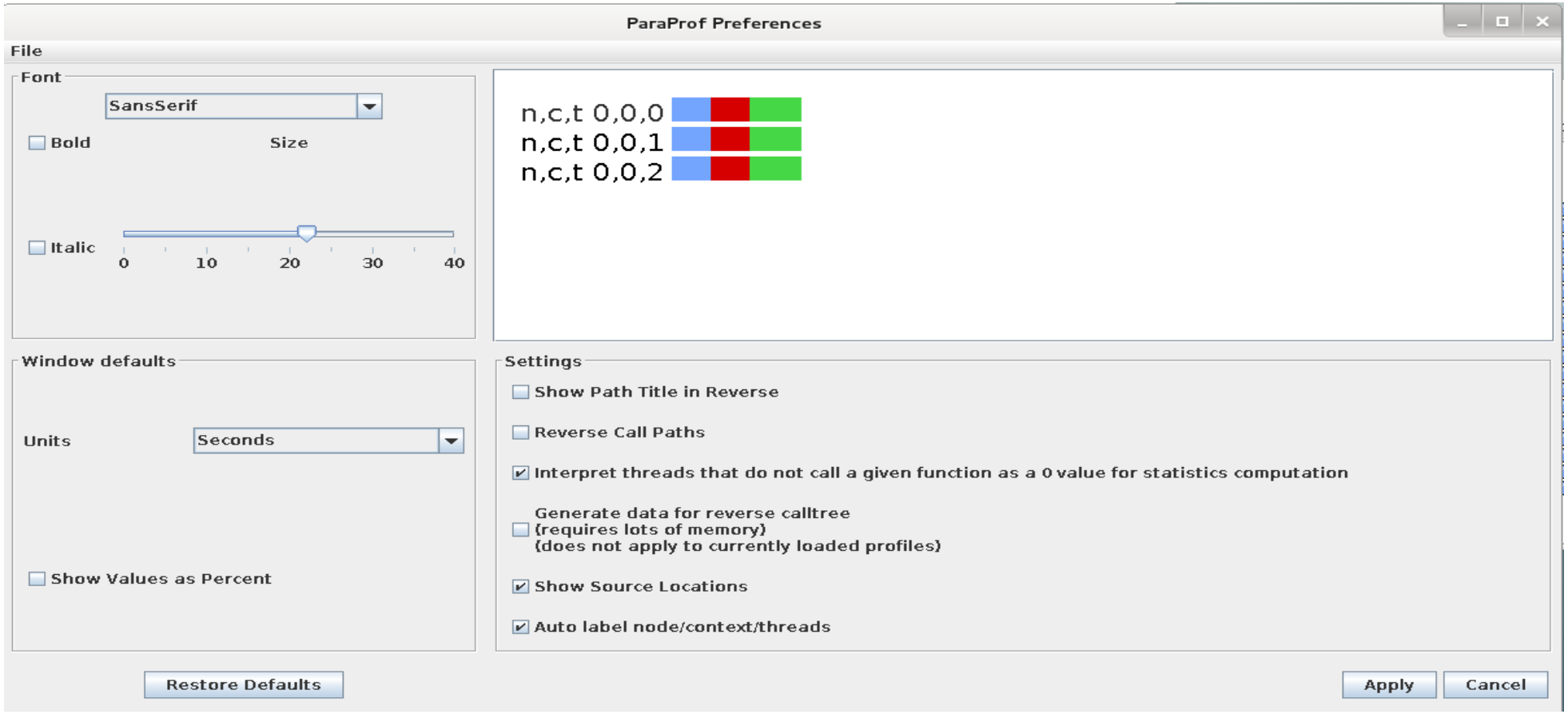
ParaProf: Add Thread to Comparison Window



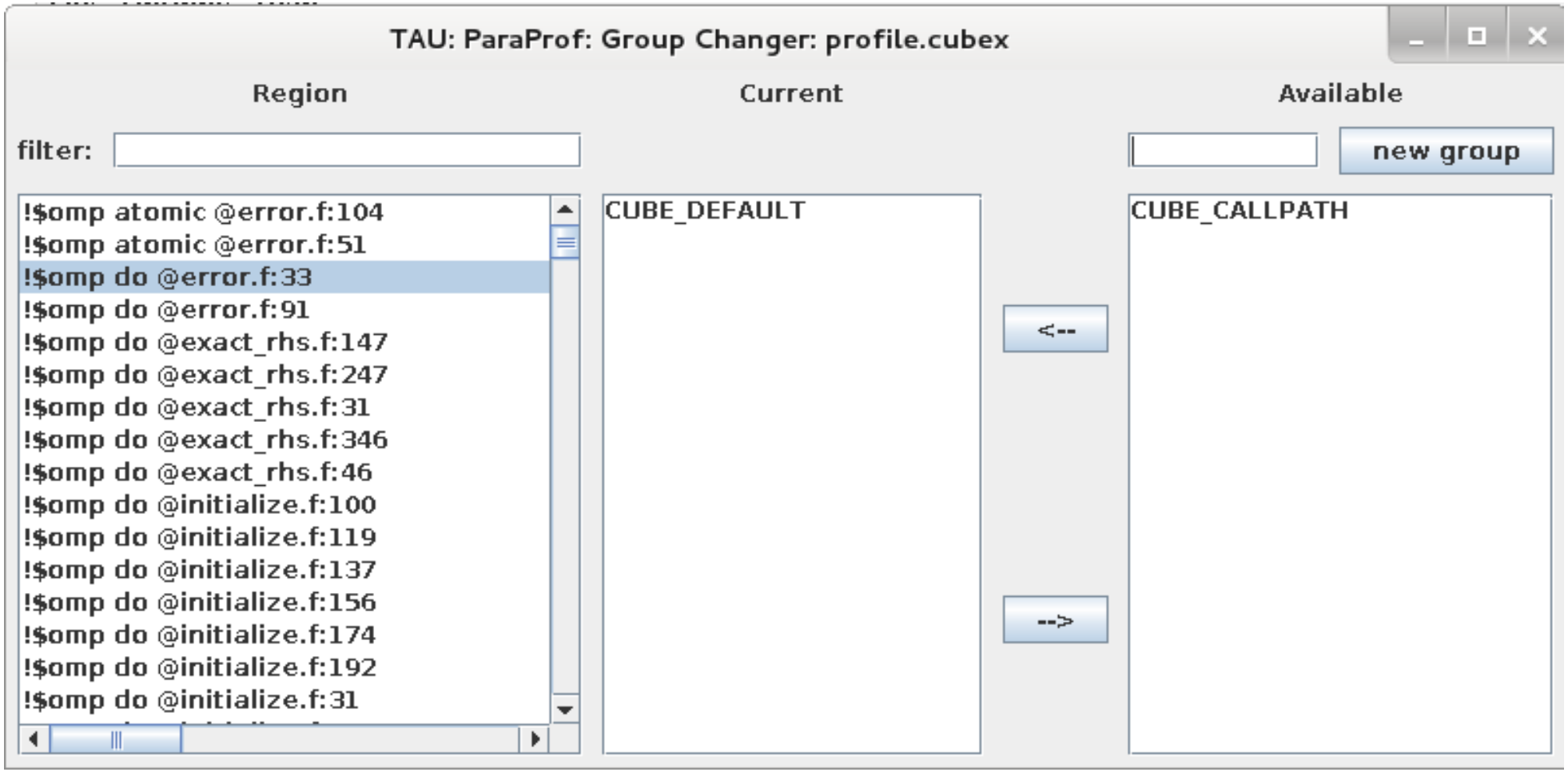
ParaProf: Score-P Profile Files, Database



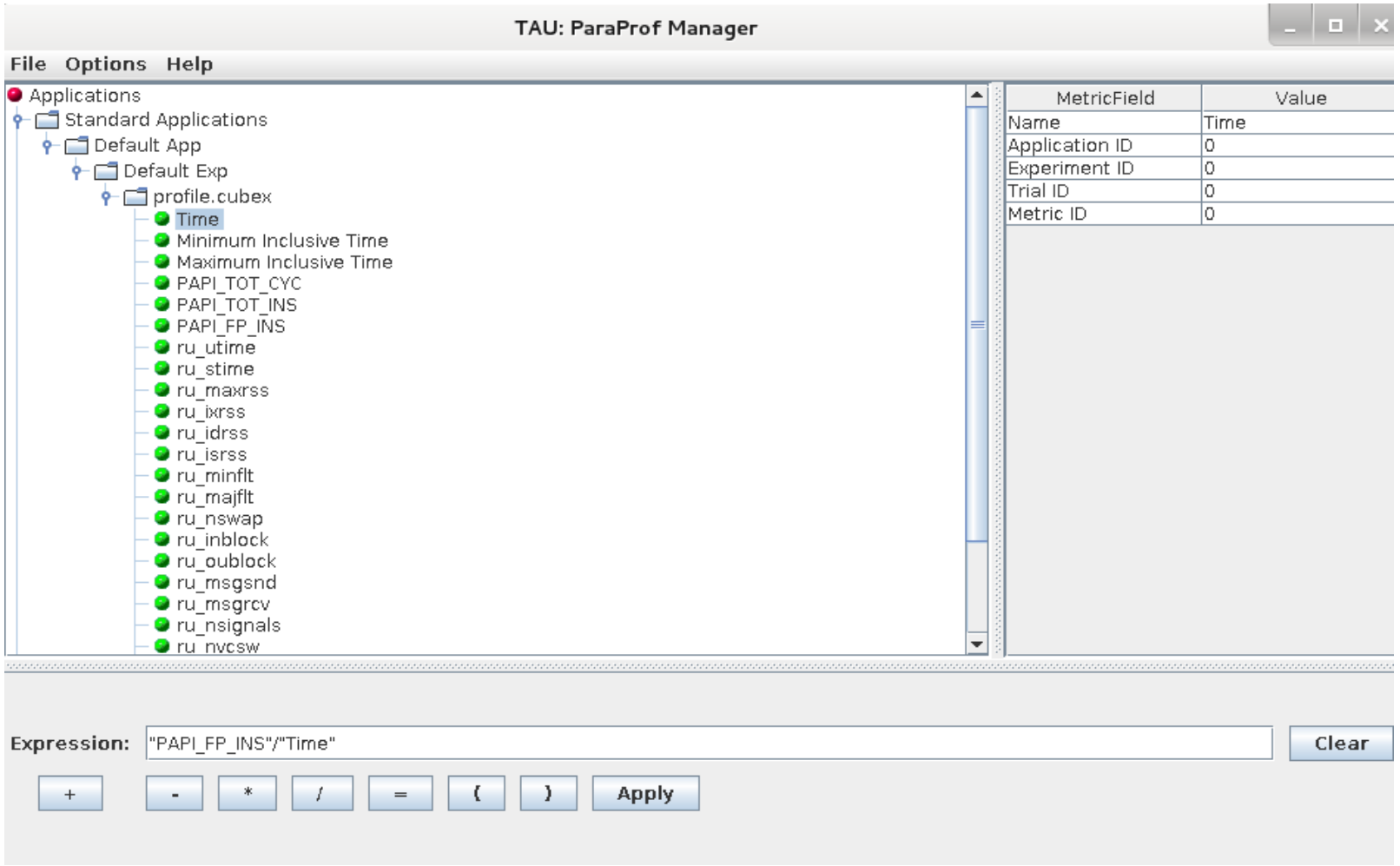
ParaProf: File Preferences Window



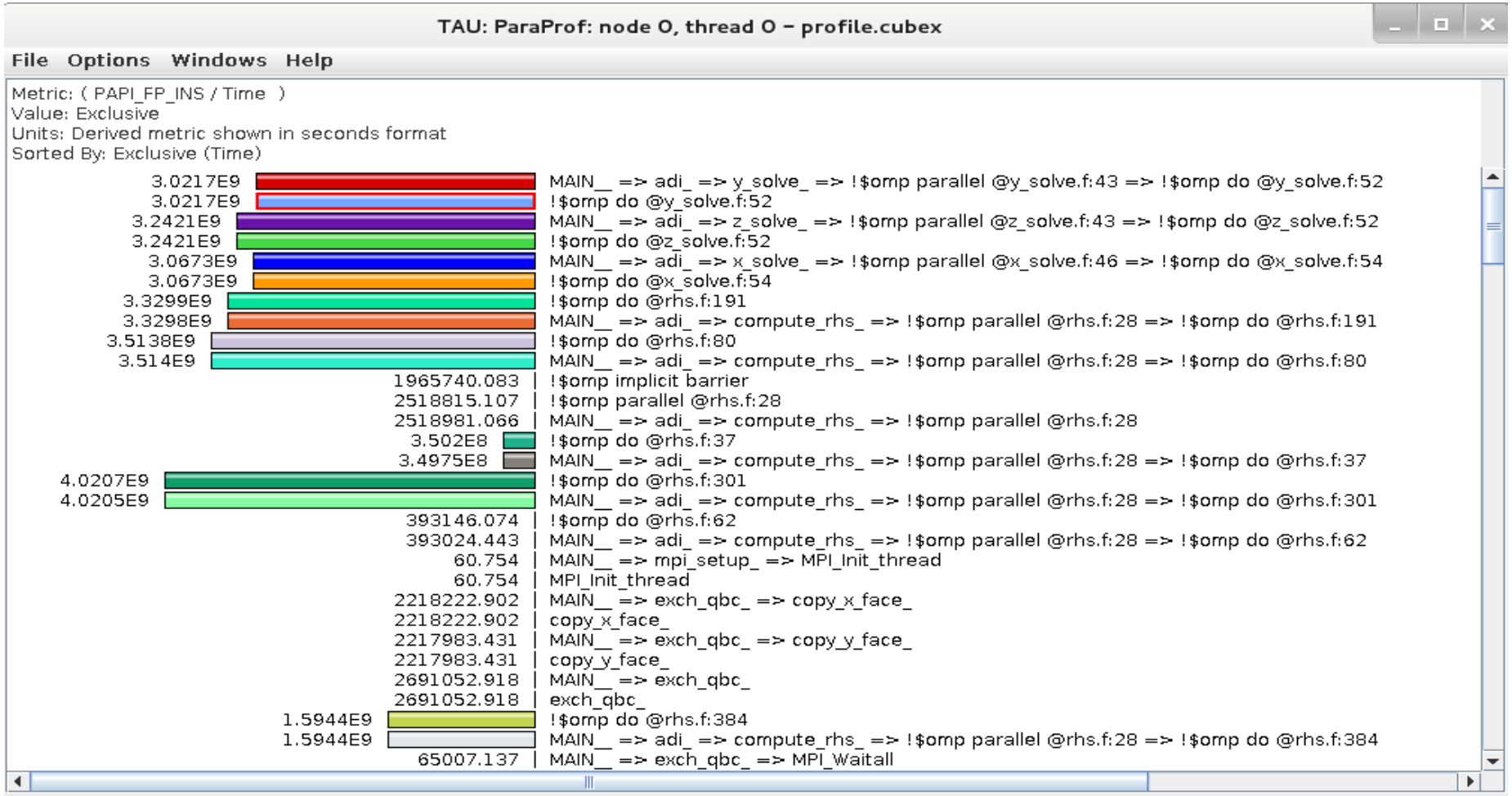
ParaProf: Group Changer Window



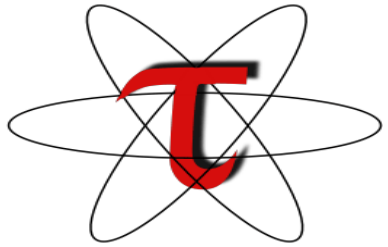
ParaProf: Derived Metric Panel in Manager Window



Sorting Derived FLOPS metric by Exclusive Time



Download TAU from U. Oregon



http://tau.uoregon.edu

http://www.hpclinux.com [LiveDVD, OVA]

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