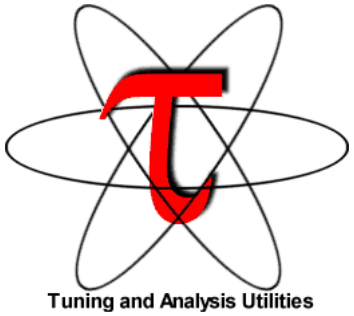
TAU Performance System®



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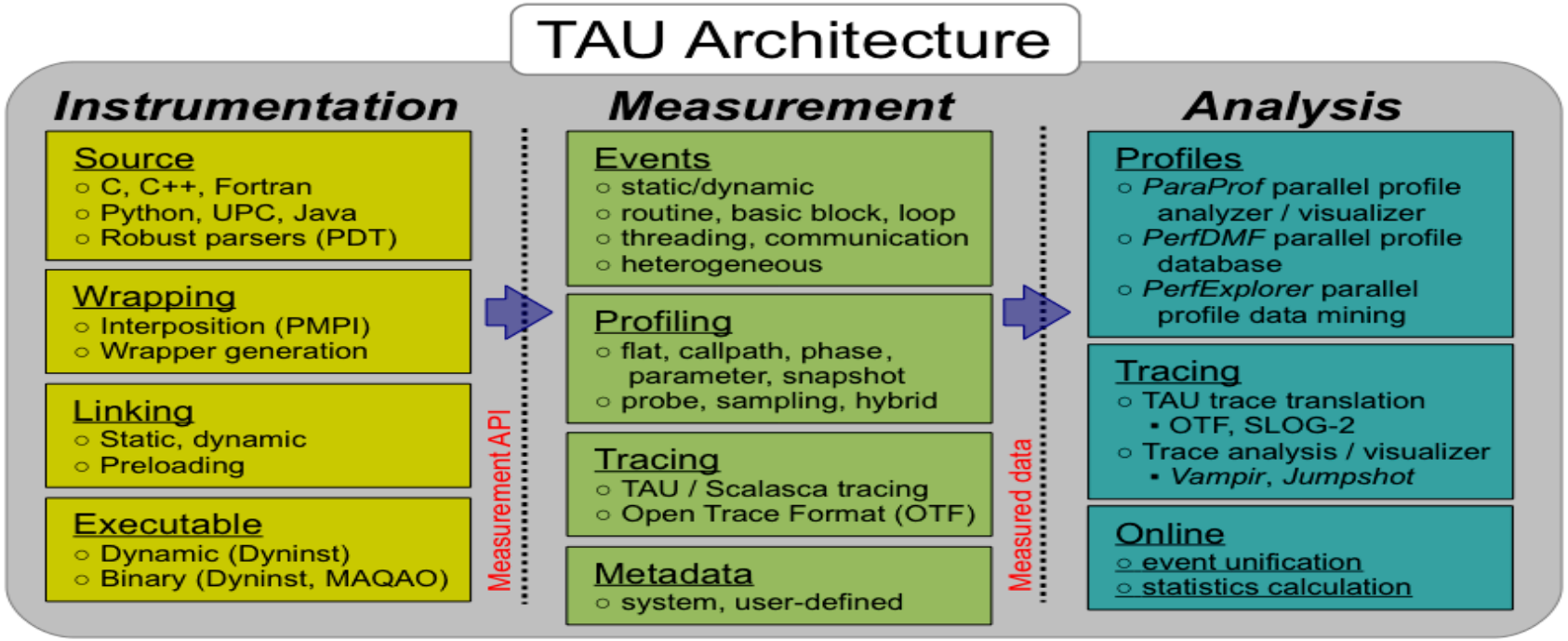
TAU Performance System®

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



TAU 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
% 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)
```

Automatic Source Instrumentation using PDT

```
% module load tau; ls $TAU/Makefile.*
Makefile.tau-icpc-papi-mpi-pdt
Makefile.tau-icpc-papi-mpi-pthread-pdt
Makefile.tau-icpc-papi-ompt-mpi-pdt-openmp
Makefile.tau-gnu-papi-mpi-pdt
Makefile.tau-papi-mpi-pdt-openmp-opari-scorep
Makefile.tau-papi-mpi-pdt-scorep
Makefile.tau-papi-mpi-pthread-pdt
Makefile.tau-papi-pthread-pdt
Makefile.tau-papi-shmem-mpi-pdt
```

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

Makefile.tau-mpi-pdt

- Supports MPI instrumentation & PDT for automatic source instrumentation

```
% export TAU_MAKEFILE=$TAU/Makefile.tau-icpc-papi-ompt-mpi-pdt-openmp
% tau_f90.sh matmult.f90 -o matmult
% mpirun -np 256 ./matmult
% paraprof
```

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

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
```

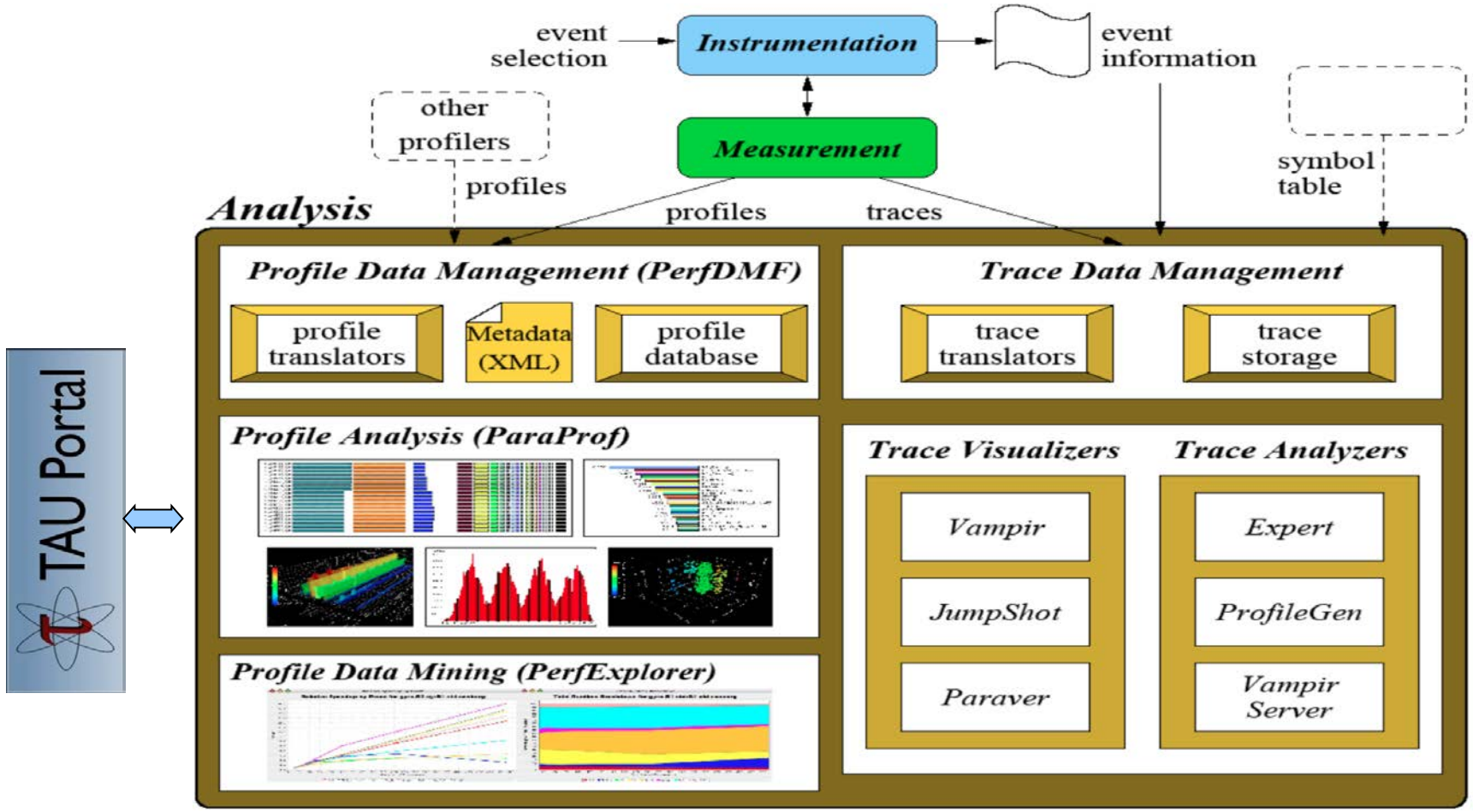
- Pebil [UC San Diego]:

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

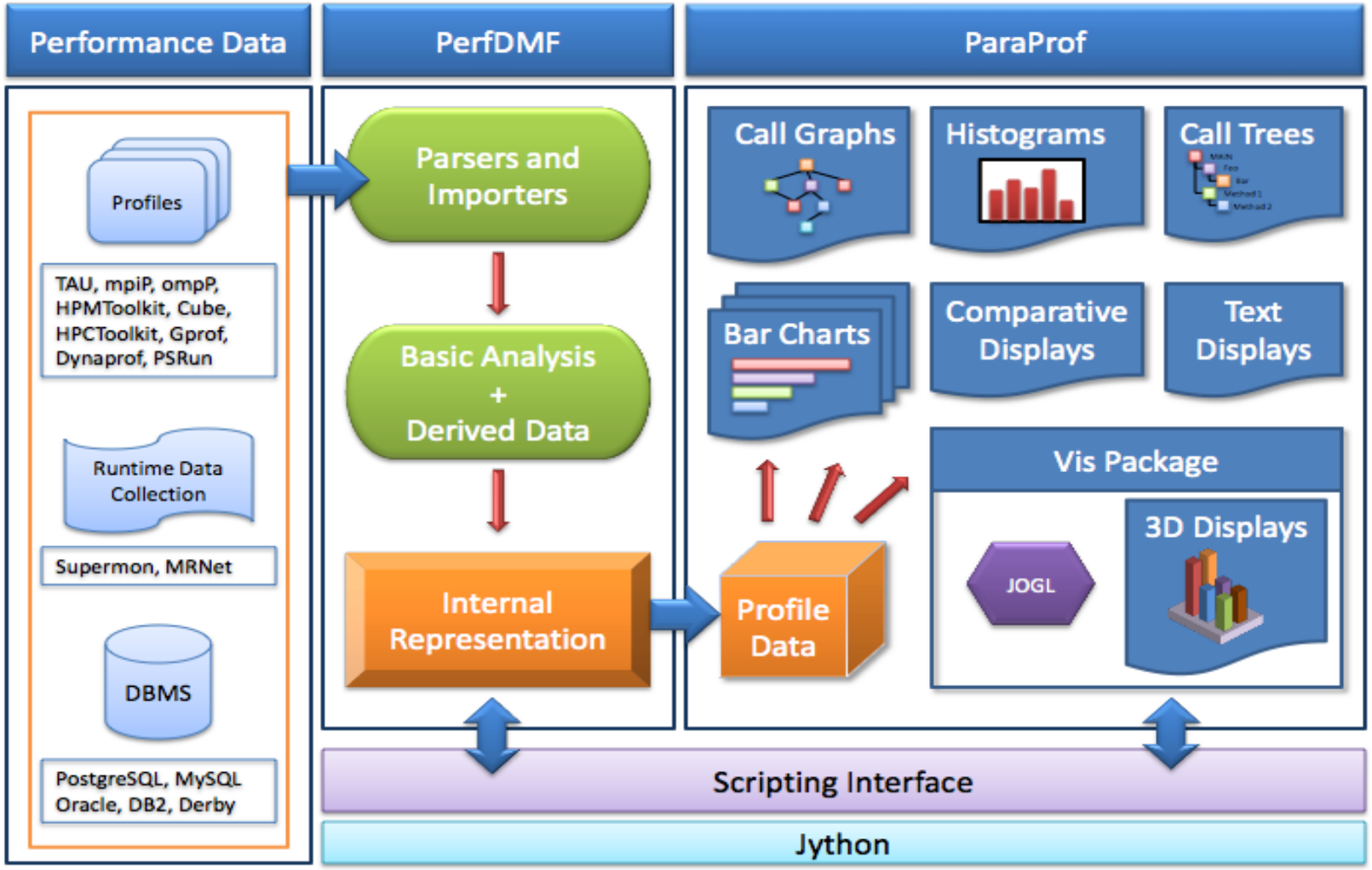
- Execute the application to get measurement data:

```
% mpirun –np 256 ./a.inst
```

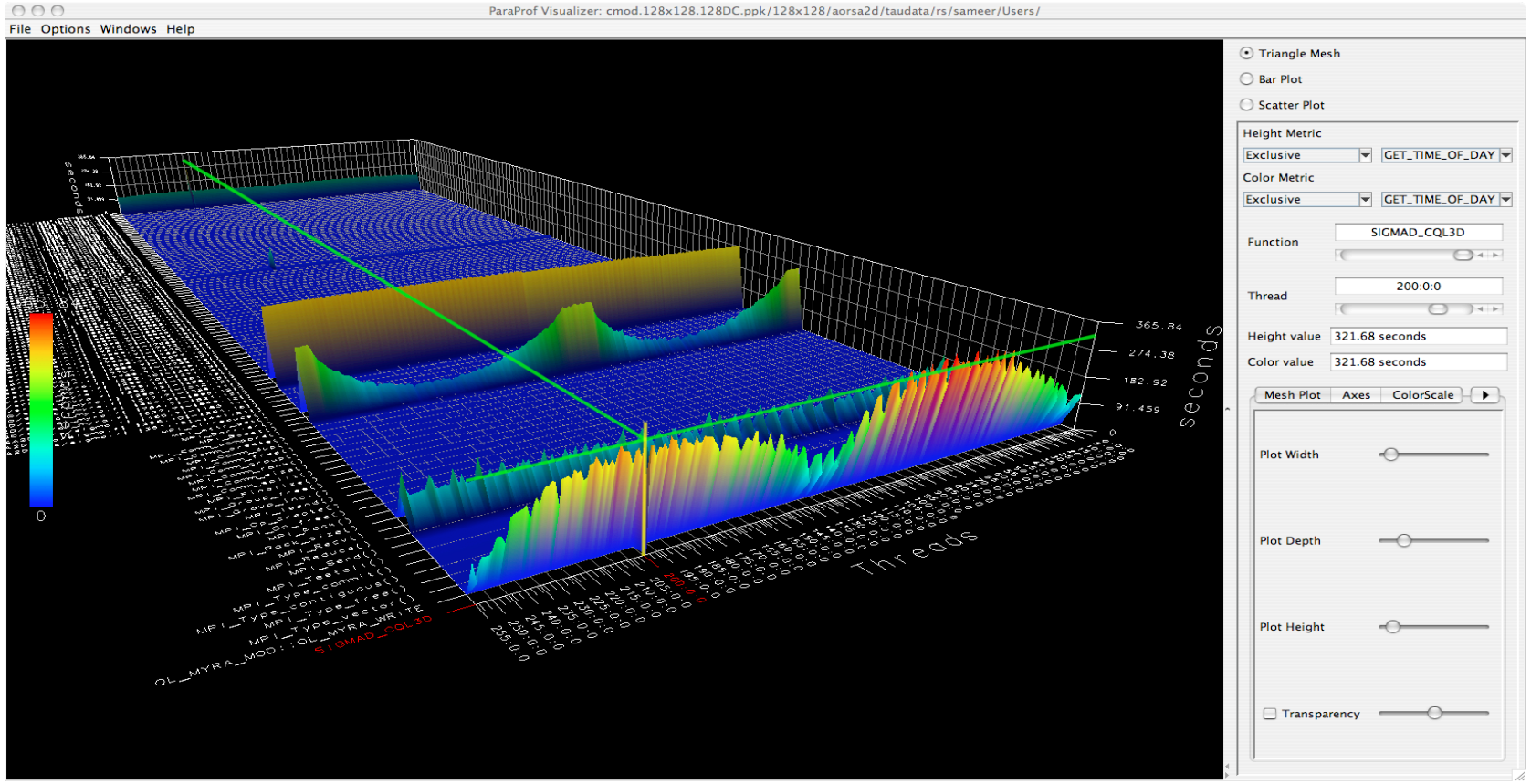
TAU Analysis



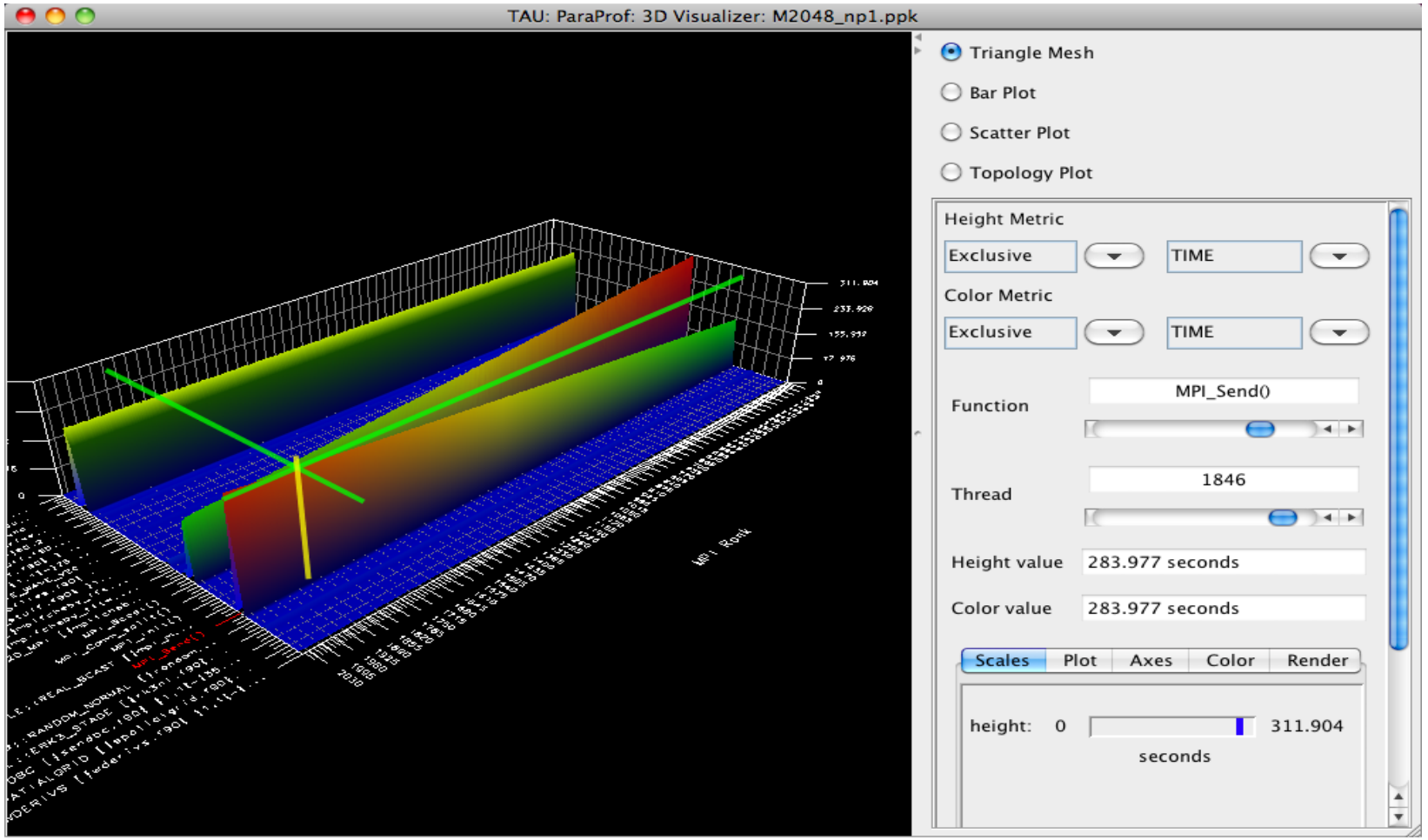
ParaProf Profile Analysis Framework



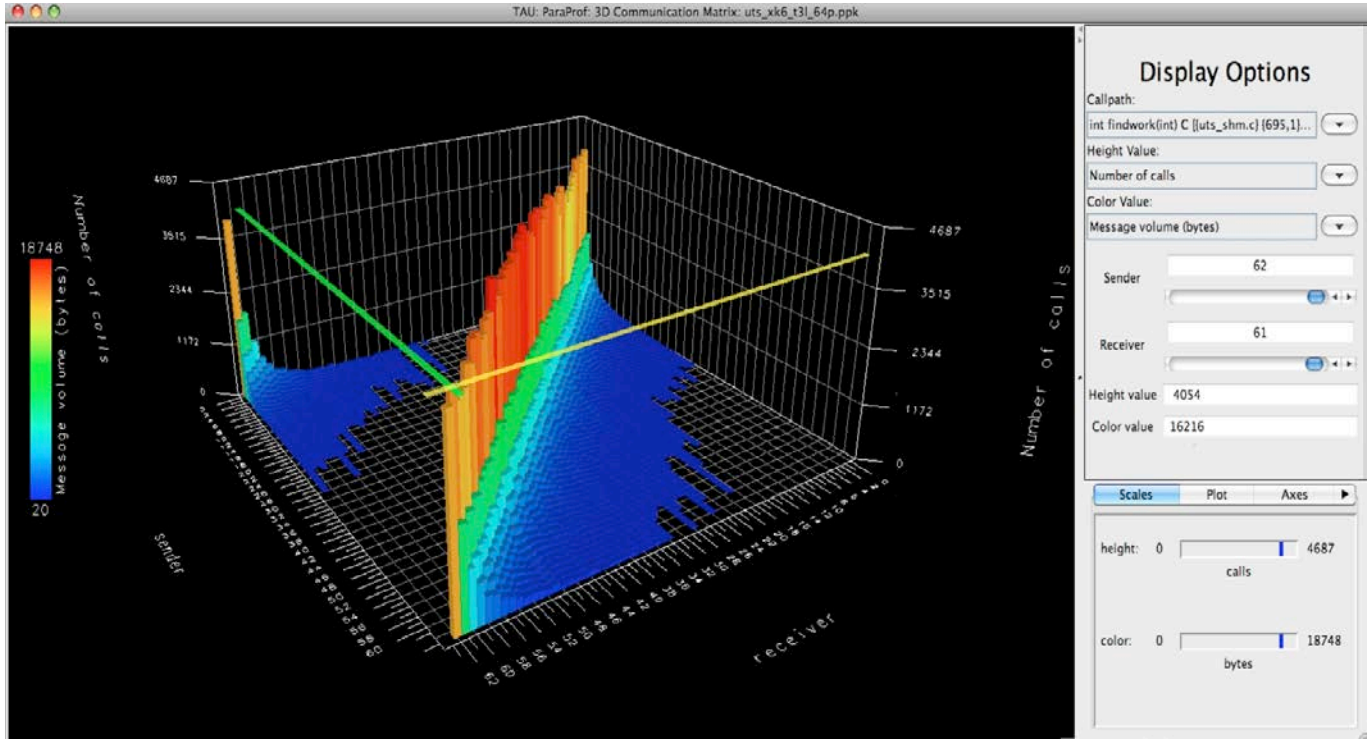
Parallel Profile Visualization: ParaProf



Parallel Profile Visualization: ParaProf

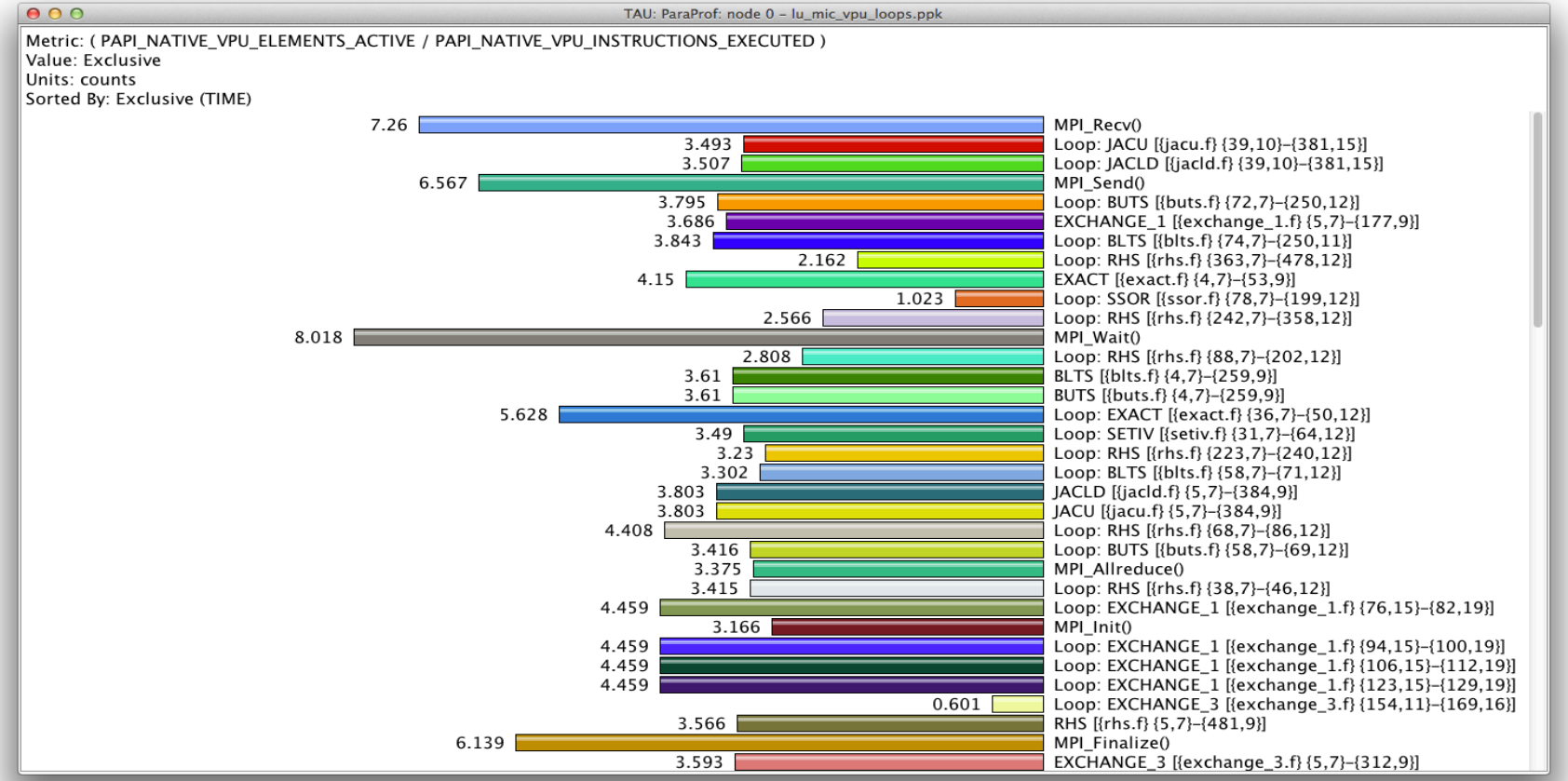


ParaProf 3D Communication Matrix



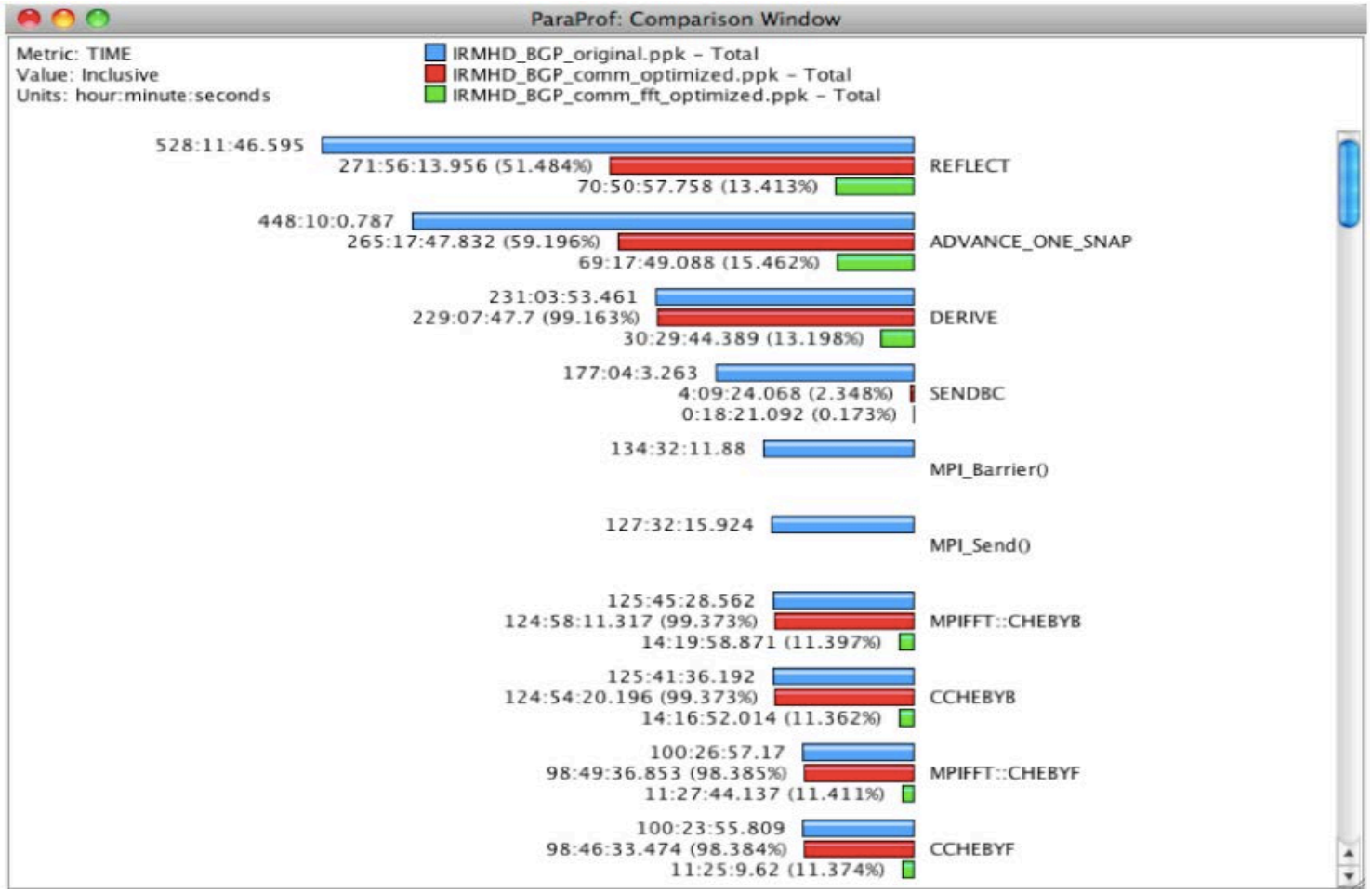
% export TAU_COMM_MATRIX=1

ParaProf Derived Metric Window: Intel MIC

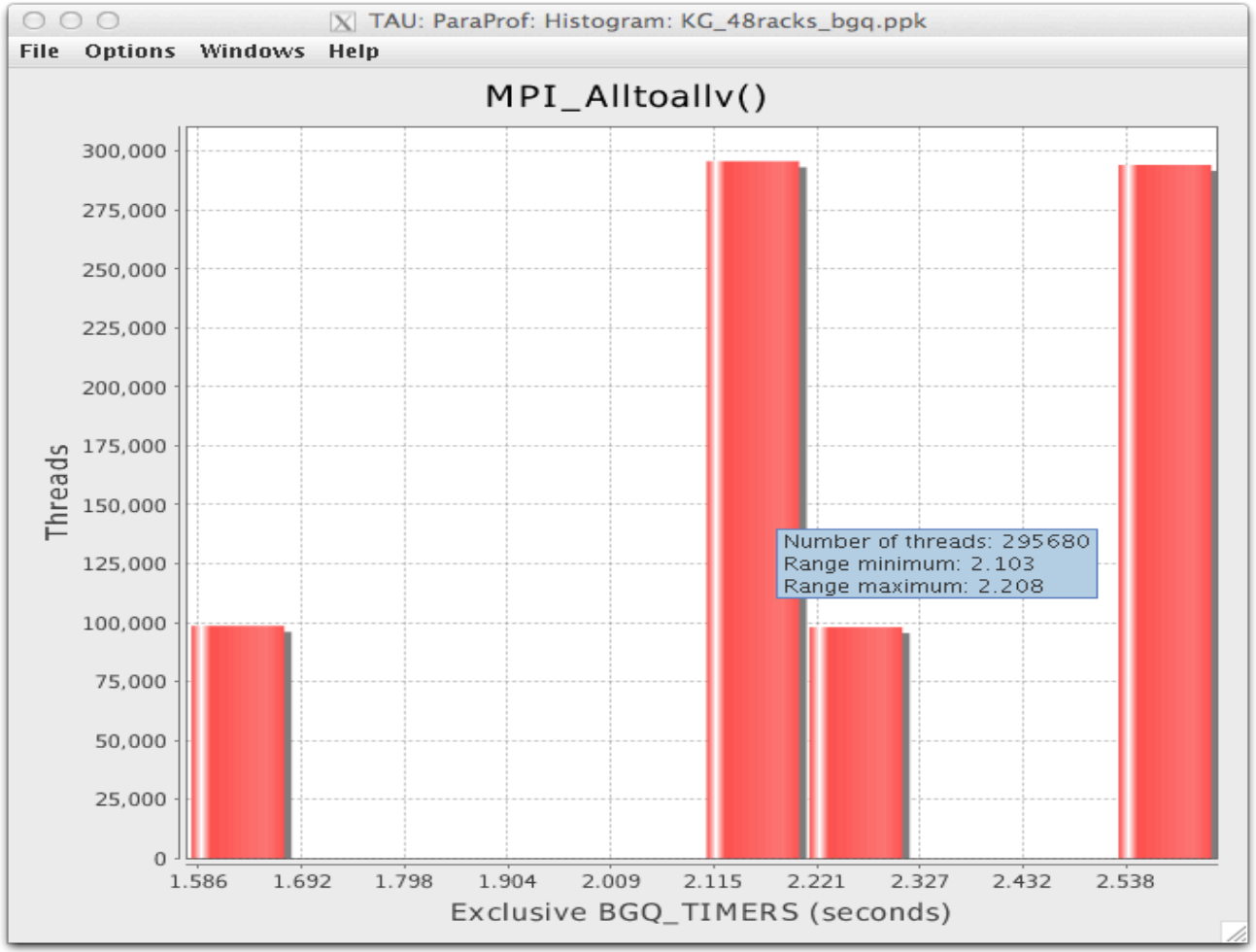


% export TAU_MAKEFILE=$TAUROOT/mic_linux/lib/Makefile.tau-icpc-papi-mpi-pdt
% export TAU_METRICS=TIME,PAPI_NATIVE_VPU_ELEMENTS_ACTIVE,PAPI_NATIVE_VPU_INSTRUCTIONS_EXECUTED

ParaProf Comparison Window



ParaProf Histogram Window



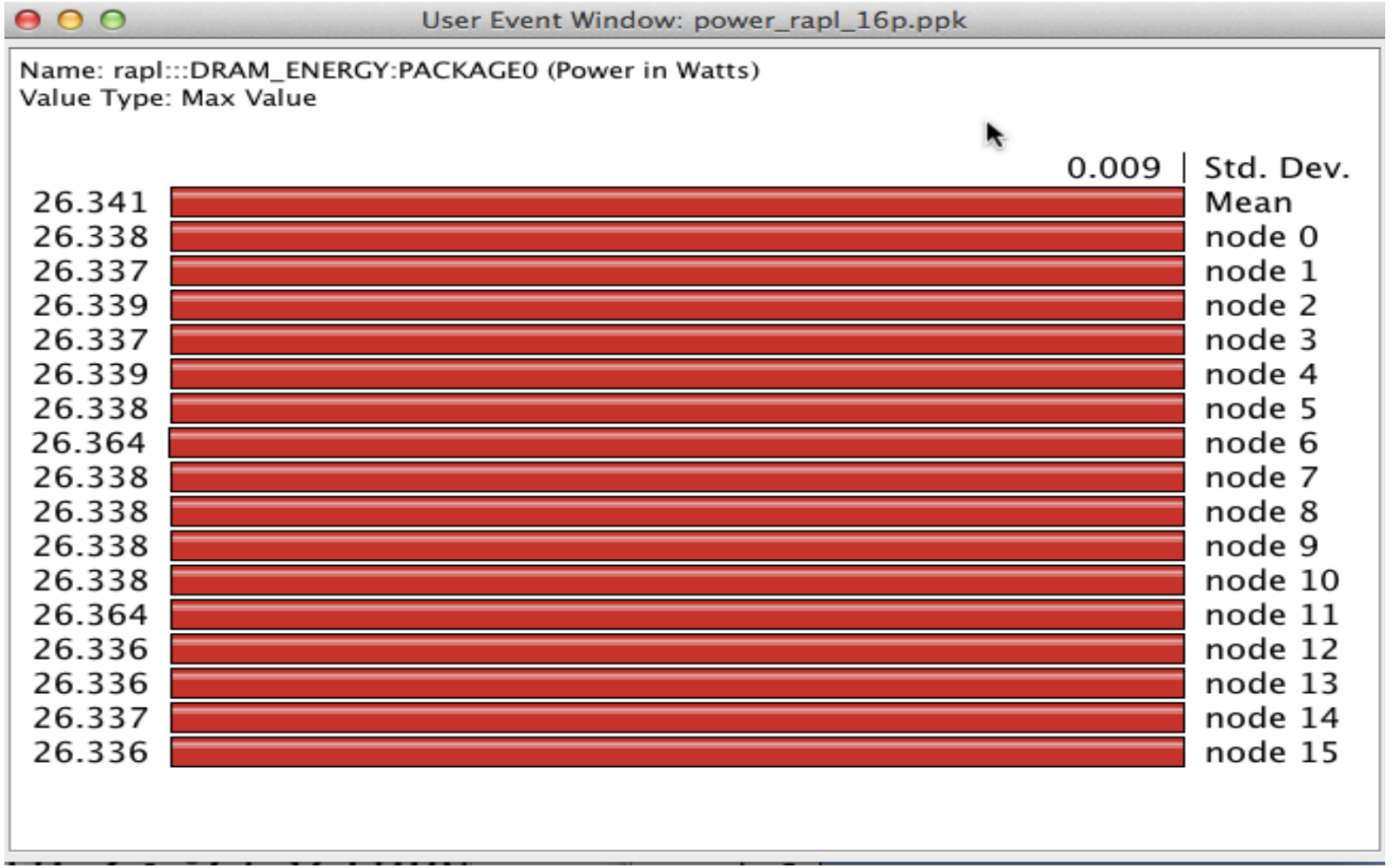
Marker Events in TAU Show Sudden Spikes

TAU: ParaProf: Context Events for: node 2 – rapl_marker_16p.ppk

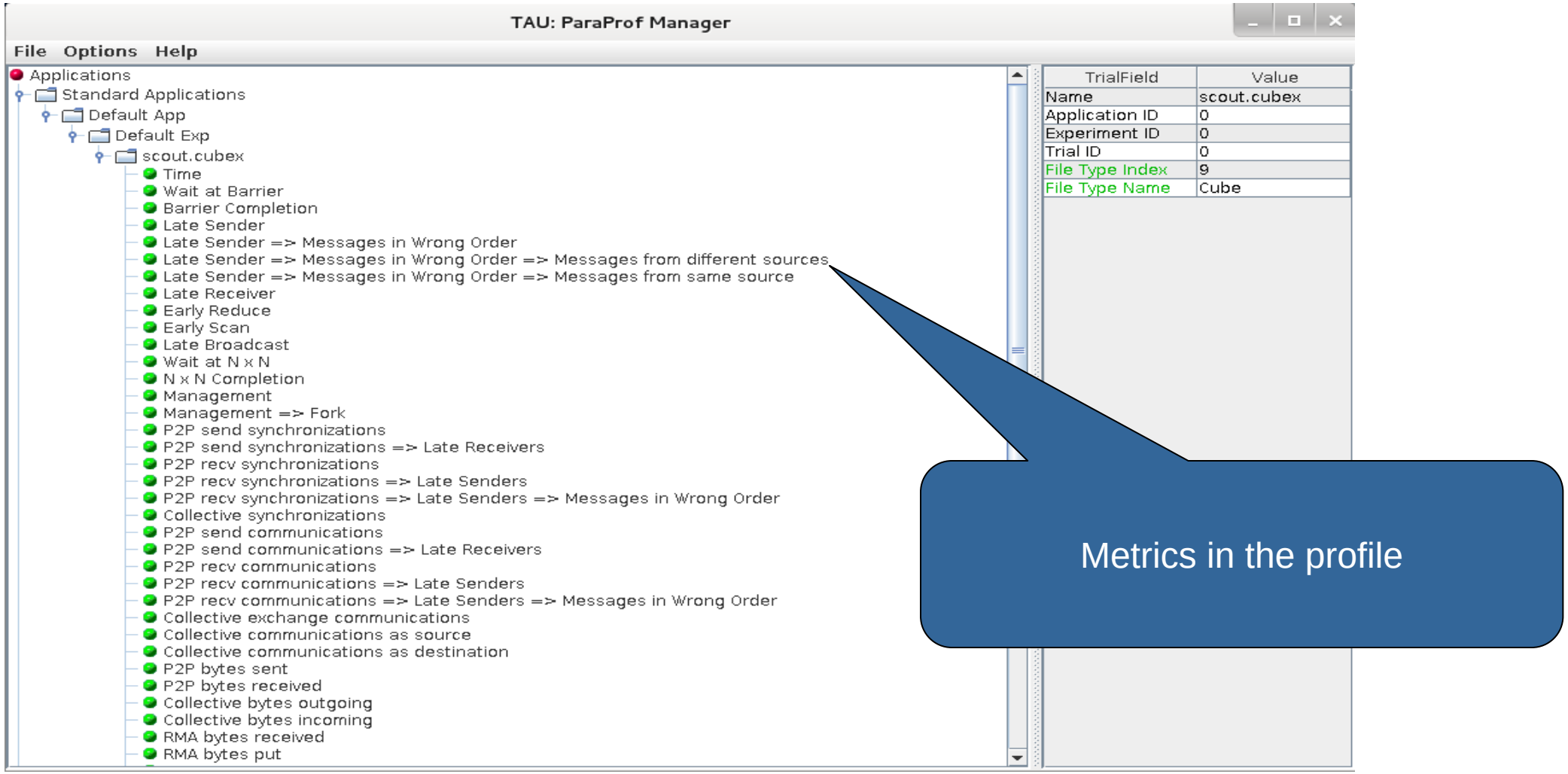
Name	MaxValue	MinValue	NumSamples	MeanValue	Std. Dev.
int main(int, char **) C [{matmult.c} {165,1}–{237,1}]					
double do_work(void) C [{matmult.c} {126,1}–{157,1}]					
void compute(double **, double **, double **, int, int, int) C [{matmult.c} {84,1}–{103,1}]					
[GROUP=MAX_MARKER] rapl:::DRAM_ENERGY:PACKAGE0 (Power in Watts)	17.585	17.469	5	17.521	0.037
[GROUP=MAX_MARKER] rapl:::DRAM_ENERGY:PACKAGE1 (Power in Watts)	15.261	15.218	4	15.237	0.016
[GROUP=MAX_MARKER] rapl:::PACKAGE_ENERGY:PACKAGE0 (Power in Watts)	118.903	114.923	22	116.98	1.201
[GROUP=MAX_MARKER] rapl:::PACKAGE_ENERGY:PACKAGE1 (Power in Watts)	113.466	110.207	22	111.778	0.996
[GROUP=MAX_MARKER] rapl:::PP0_ENERGY:PACKAGE0 (Power in Watts)	100.138	96.266	24	98.206	1.13
[GROUP=MAX_MARKER] rapl:::PP0_ENERGY:PACKAGE1 (Power in Watts)	95.846	92.758	24	94.319	0.937
[GROUP=MIN_MARKER] rapl:::DRAM_ENERGY:PACKAGE0 (Power in Watts)	17.397	17.303	4	17.358	0.035
[GROUP=MIN_MARKER] rapl:::DRAM_ENERGY:PACKAGE1 (Power in Watts)	15.048	15.042	2	15.045	0.003
int mysleep(int) C [{matmult.c} {46,1}–{49,1}]					
[GROUP=MIN_MARKER] rapl:::DRAM_ENERGY:PACKAGE0 (Power in Watts)	15.84	15.84	1	15.84	0
[GROUP=MIN_MARKER] rapl:::DRAM_ENERGY:PACKAGE1 (Power in Watts)	14.275	14.275	1	14.275	0
[GROUP=MIN_MARKER] rapl:::PACKAGE_ENERGY:PACKAGE1 (Power in Watts)	96.853	96.853	1	96.853	0
[GROUP=MIN_MARKER] rapl:::PACKAGE_ENERGY:PACKAGE0 (Power in Watts)	93.125	93.125	1	93.125	0
[GROUP=MIN_MARKER] rapl:::PP0_ENERGY:PACKAGE0 (Power in Watts)	75.096	75.096	1	75.096	0
[GROUP=MIN_MARKER] rapl:::PP0_ENERGY:PACKAGE1 (Power in Watts)	79.646	79.646	1	79.646	0
void compute_interchange(double **, double **, double **, int, int, int) C [{matmult.c} {105,1}–{124,1}]					
[GROUP=MAX_MARKER] rapl:::DRAM_ENERGY:PACKAGE0 (Power in Watts)	26.064	25.711	2	25.887	0.176
[GROUP=MAX_MARKER] rapl:::DRAM_ENERGY:PACKAGE1 (Power in Watts)	24.373	23.965	4	24.232	0.159
[GROUP=MAX_MARKER] rapl:::PACKAGE_ENERGY:PACKAGE0 (Power in Watts)	126.872	125.182	6	125.732	0.557
[GROUP=MAX_MARKER] rapl:::PACKAGE_ENERGY:PACKAGE1 (Power in Watts)	124.377	116.689	5	122.428	2.885
[GROUP=MAX_MARKER] rapl:::PP0_ENERGY:PACKAGE0 (Power in Watts)	103.981	102.21	6	102.769	0.584
[GROUP=MAX_MARKER] rapl:::PP0_ENERGY:PACKAGE1 (Power in Watts)	102.615	101.693	4	102.115	0.33
rapl:::DRAM_ENERGY:PACKAGE0 (Power in Watts)	26.064	15.84	36	19.053	3.39
rapl:::DRAM_ENERGY:PACKAGE1 (Power in Watts)	24.373	14.275	36	16.435	3.155
rapl:::PACKAGE_ENERGY:PACKAGE0 (Power in Watts)	126.872	93.125	36	117.729	5.403
rapl:::PACKAGE_ENERGY:PACKAGE1 (Power in Watts)	124.377	96.853	36	112.961	4.776
rapl:::PP0_ENERGY:PACKAGE0 (Power in Watts)	103.981	75.096	36	98.208	4.466
rapl:::PP0_ENERGY:PACKAGE1 (Power in Watts)	102.615	79.646	36	94.872	3.662

```
% export TAU_EVENT_THRESHOLD 0.5
```

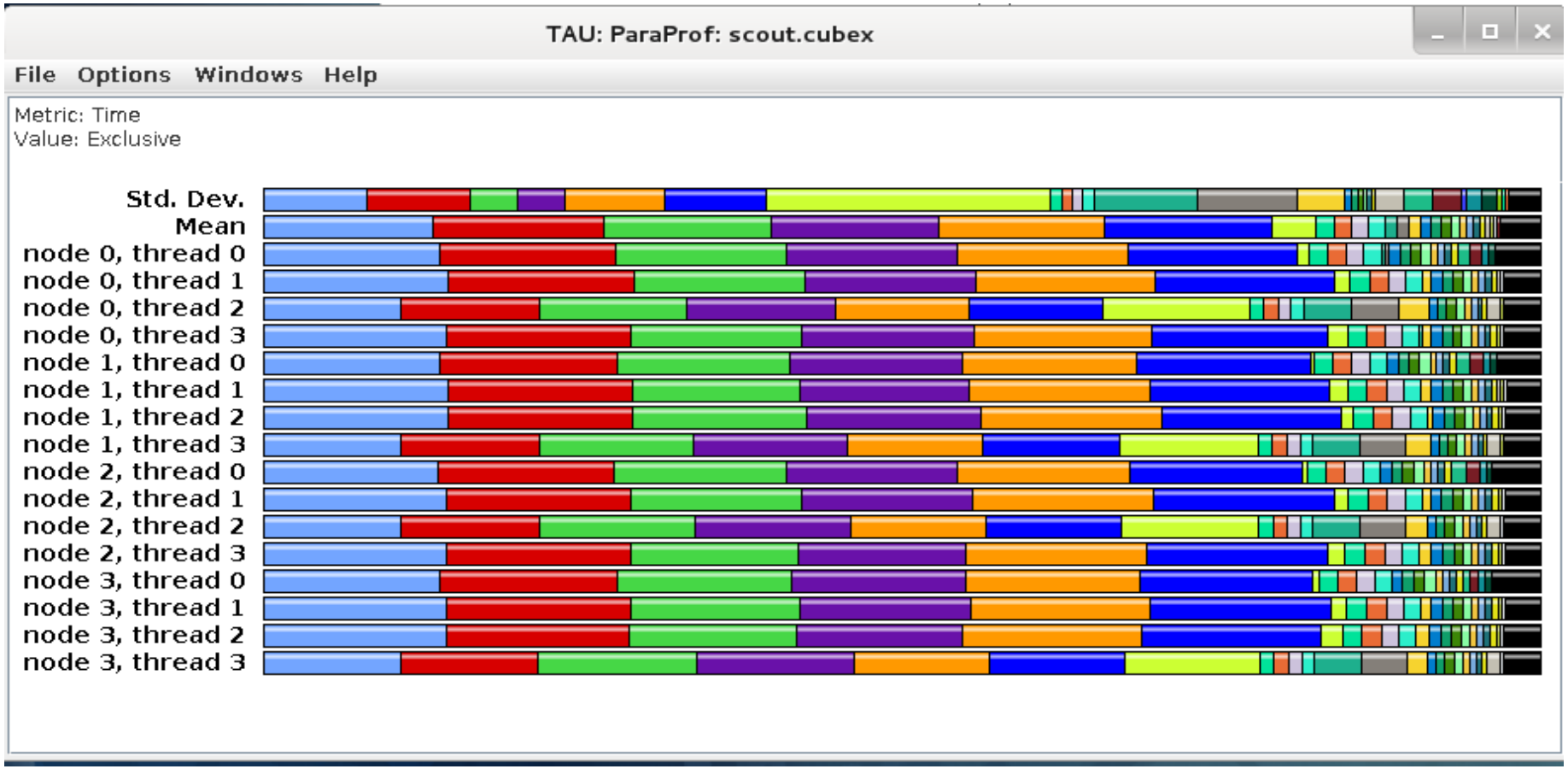
Energy Profiling in TAU



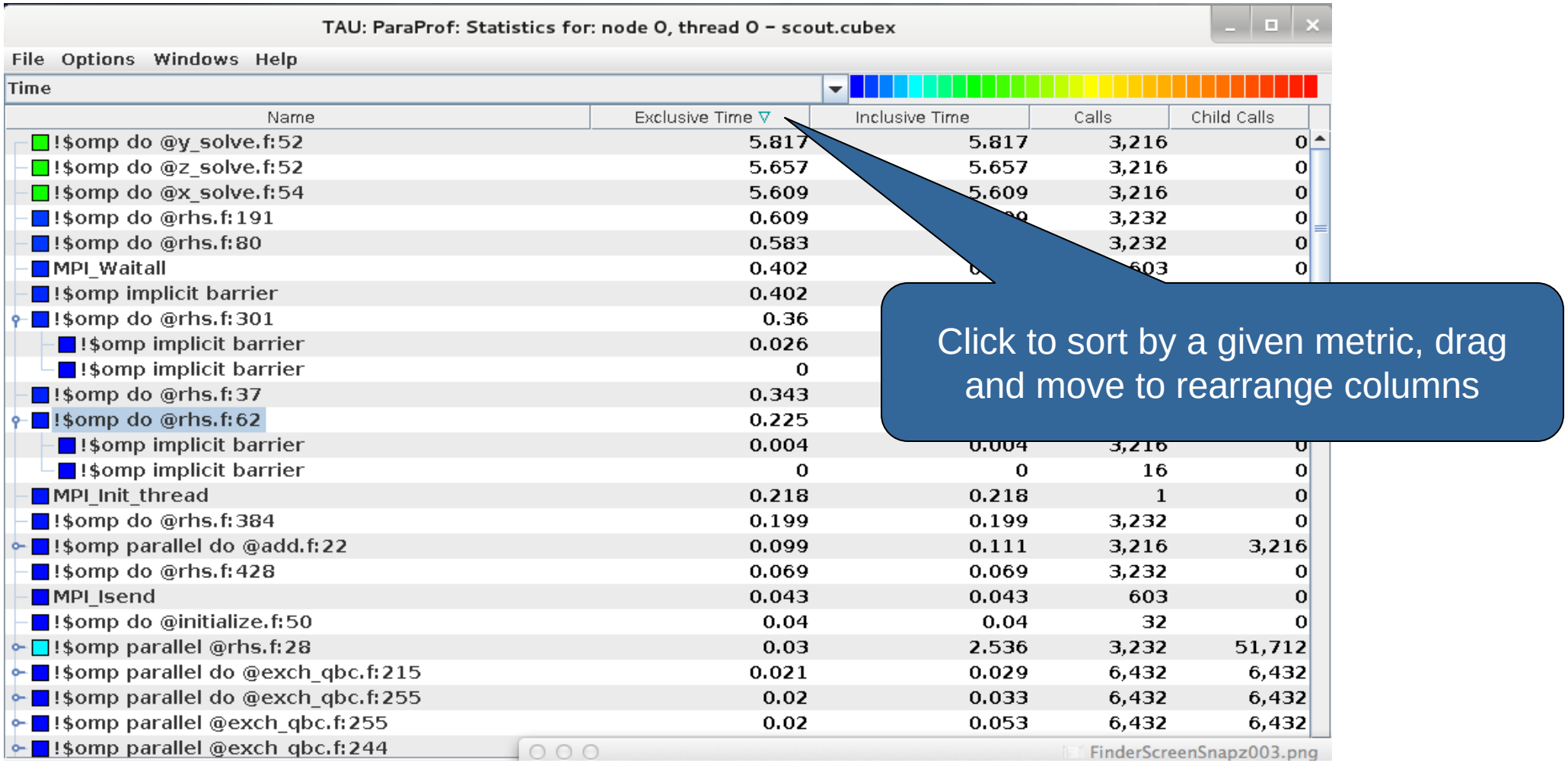
ParaProf Manager Widow: scout.cubex



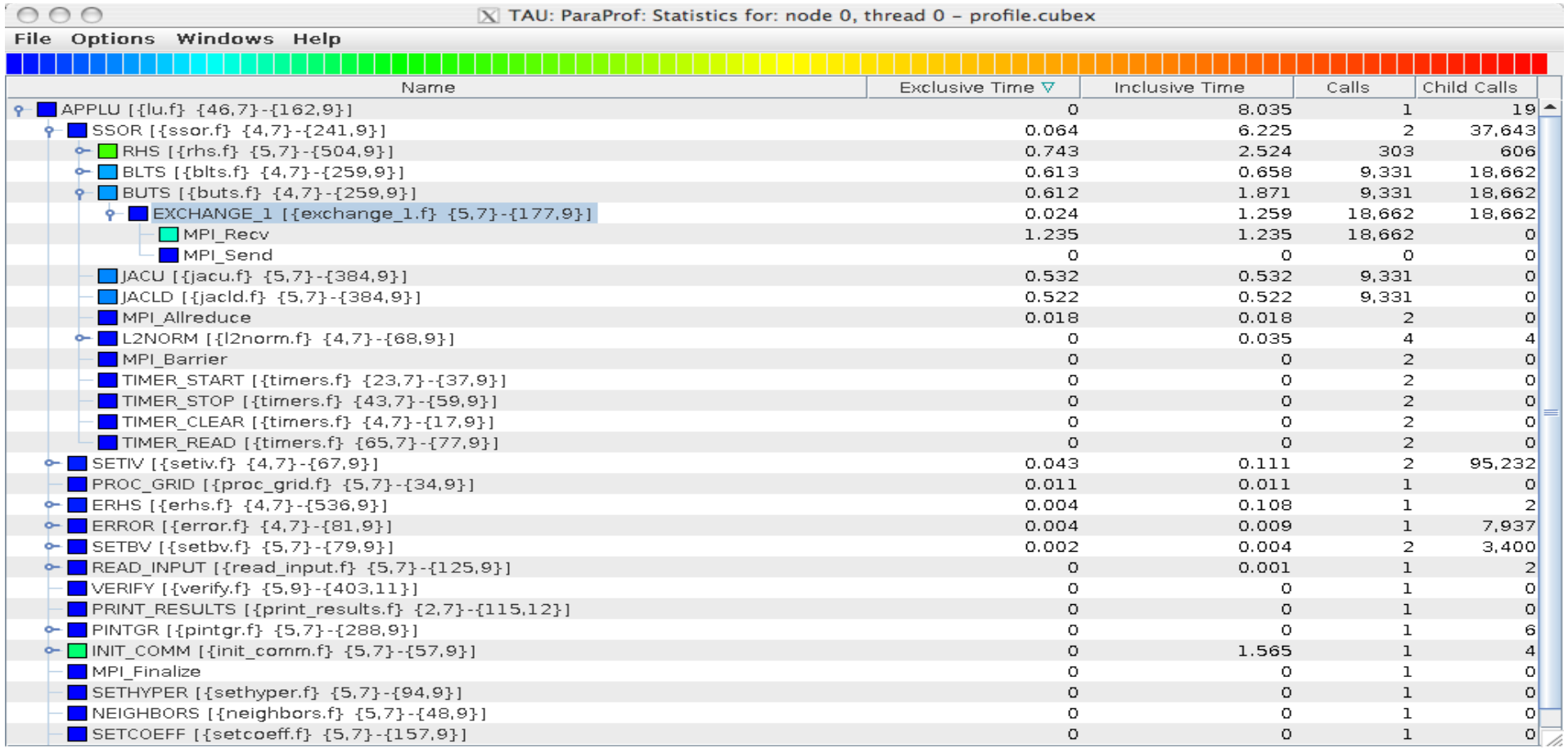
ParaProf: Main Window



ParaProf: Thread Statistics Table



Example: Score-P with TAU (NPB LU)



Name	Exclusive Time	Inclusive Time	Calls	Child Calls
APPLU [{lu.f} {46,7}-{162,9}]	0	8.035	1	19
SSOR [{ssor.f} {4,7}-{241,9}]	0.064	6.225	2	37,643
RHS [{rhs.f} {5,7}-{504,9}]	0.743	2.524	303	606
BLTS [{blts.f} {4,7}-{259,9}]	0.613	0.658	9,331	18,662
BUTS [{buts.f} {4,7}-{259,9}]	0.612	1.871	9,331	18,662
EXCHANGE_1 [{exchange_1.f} {5,7}-{177,9}]	0.024	1.259	18,662	18,662
MPI_Recv	1.235	1.235	18,662	0
MPI_Send	0	0	0	0
JACU [{jacu.f} {5,7}-{384,9}]	0.532	0.532	9,331	0
JACLD [{jacld.f} {5,7}-{384,9}]	0.522	0.522	9,331	0
MPI_Allreduce	0.018	0.018	2	0
L2NORM [{l2norm.f} {4,7}-{68,9}]	0	0.035	4	4
MPI_Barrier	0	0	2	0
TIMER_START [{timers.f} {23,7}-{37,9}]	0	0	2	0
TIMER_STOP [{timers.f} {43,7}-{59,9}]	0	0	2	0
TIMER_CLEAR [{timers.f} {4,7}-{17,9}]	0	0	2	0
TIMER_READ [{timers.f} {65,7}-{77,9}]	0	0	2	0
SETIV [{setiv.f} {4,7}-{67,9}]	0.043	0.111	2	95,232
PROC_GRID [{proc_grid.f} {5,7}-{34,9}]	0.011	0.011	1	0
ERHS [{erhs.f} {4,7}-{536,9}]	0.004	0.108	1	2
ERROR [{error.f} {4,7}-{81,9}]	0.004	0.009	1	7,937
SETBV [{setbv.f} {5,7}-{79,9}]	0.002	0.004	2	3,400
READ_INPUT [{read_input.f} {5,7}-{125,9}]	0	0.001	1	2
VERIFY [{verify.f} {5,9}-{403,11}]	0	0	1	0
PRINT_RESULTS [{print_results.f} {2,7}-{115,12}]	0	0	1	0
PINTGR [{pintgr.f} {5,7}-{288,9}]	0	0	1	6
INIT_COMM [{init_comm.f} {5,7}-{57,9}]	0	1.565	1	4
MPI_Finalize	0	0	1	0
SETHYPER [{sethyper.f} {5,7}-{94,9}]	0	0	1	0
NEIGHBORS [{neighbors.f} {5,7}-{48,9}]	0	0	1	0
SETCOEFF [{setcoeff.f} {5,7}-{157,9}]	0	0	1	0

ParaProf: Callpath Thread Relations Window

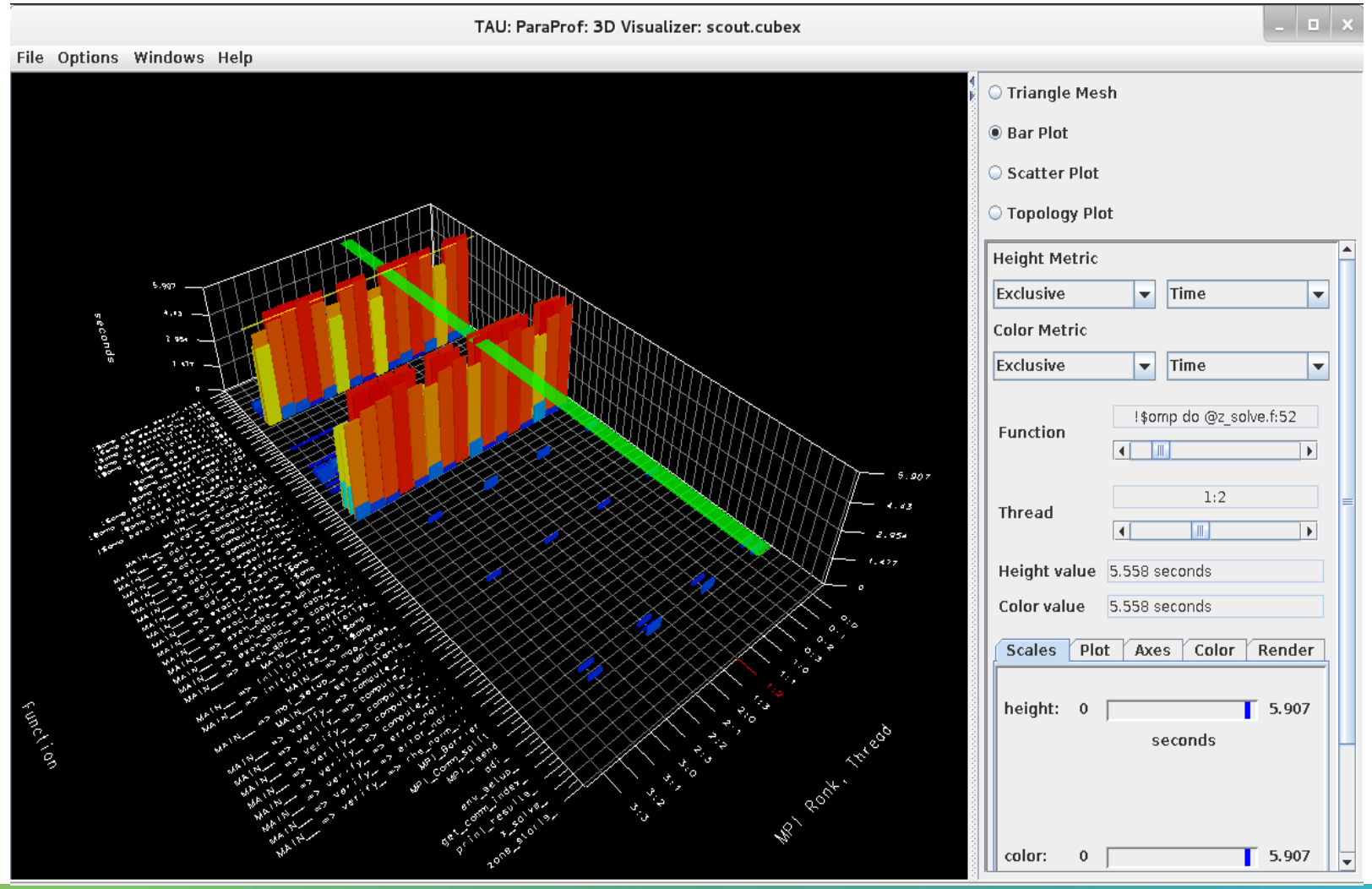
TAU: ParaProf: Call Path Data n,c,t, 0,0,0 – scout.cubex

File Options Windows Help

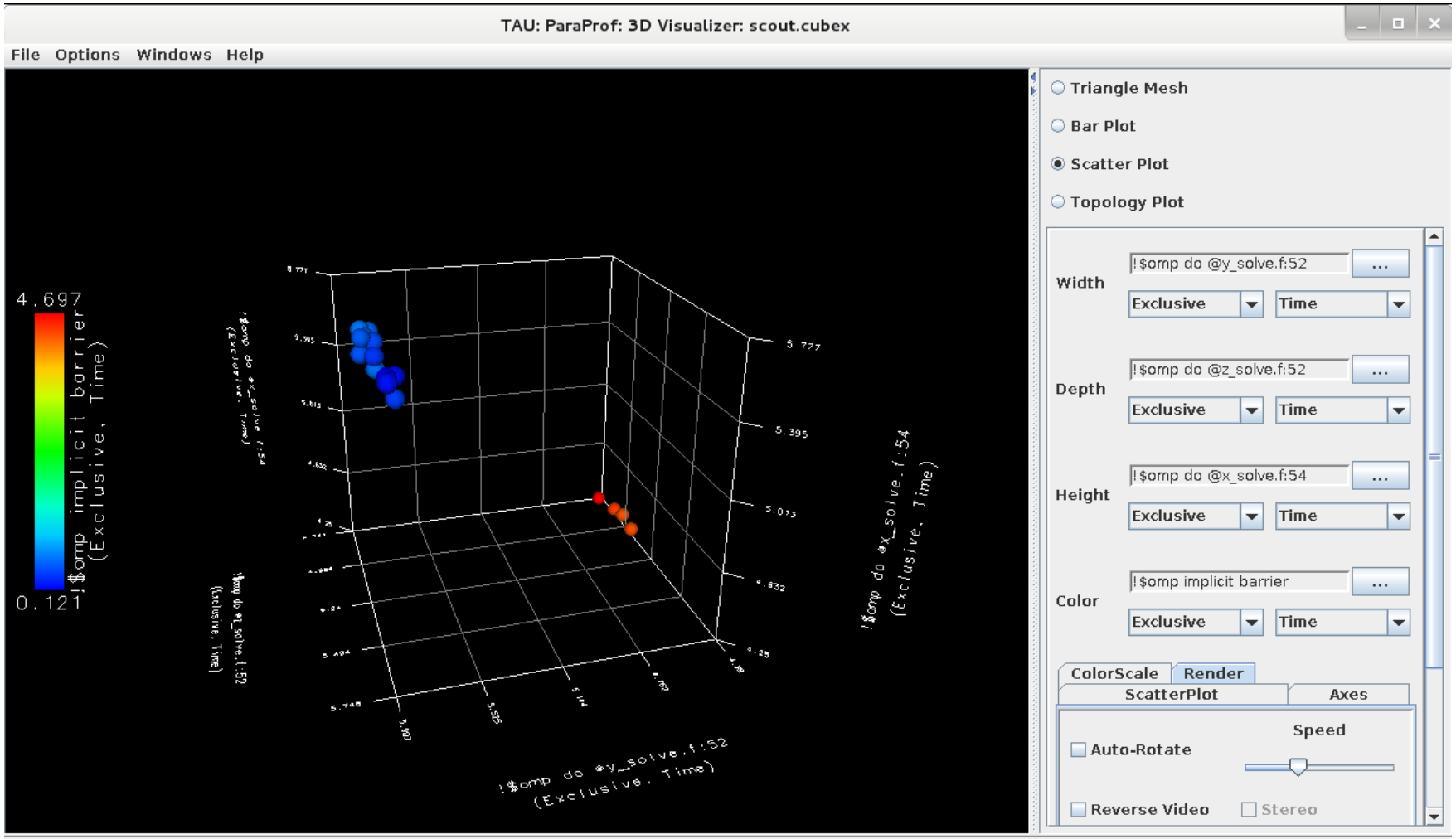
Metric Name: Time
Sorted By: Exclusive
Units: seconds

	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

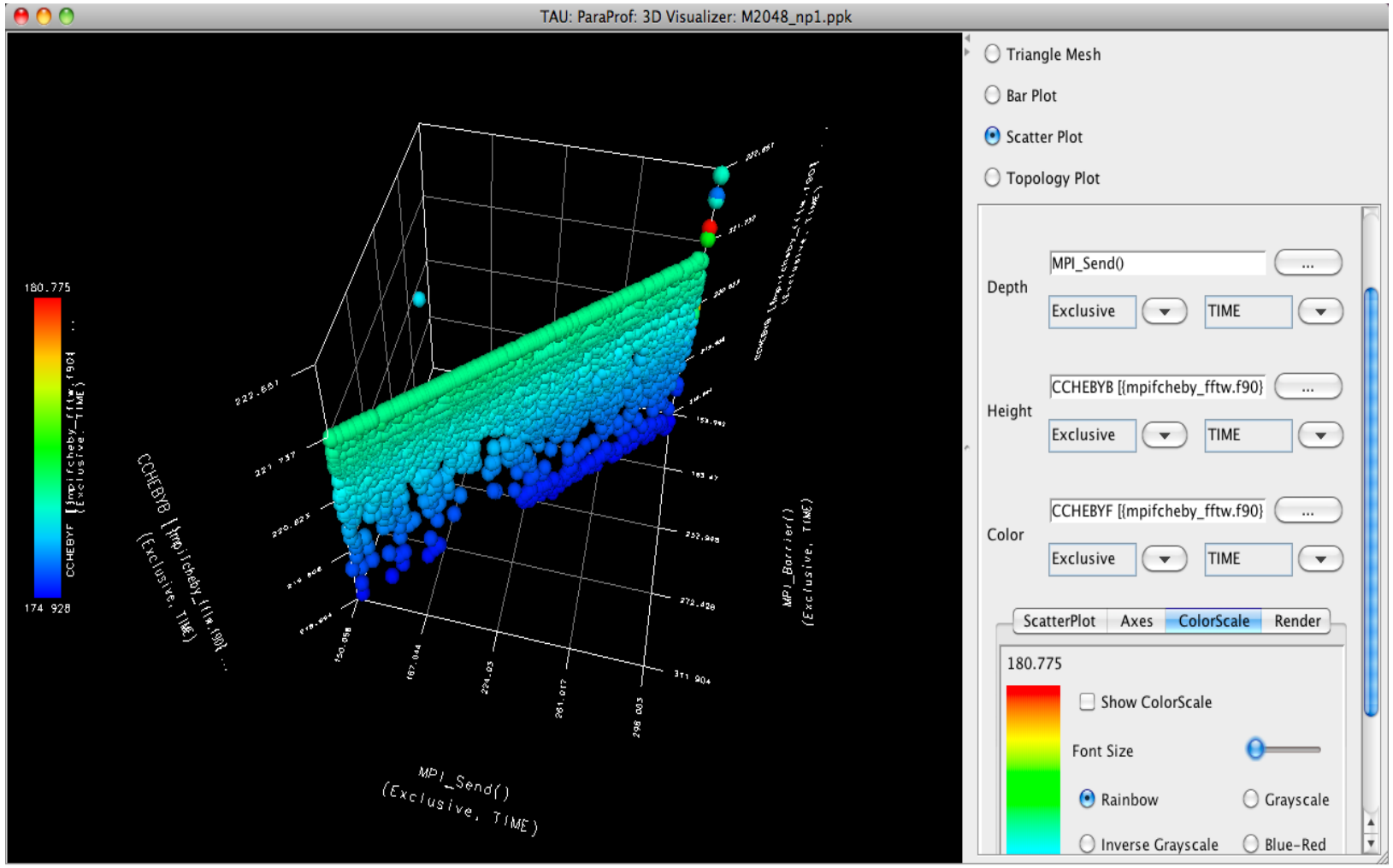
ParaProf: 3D Visualization Window



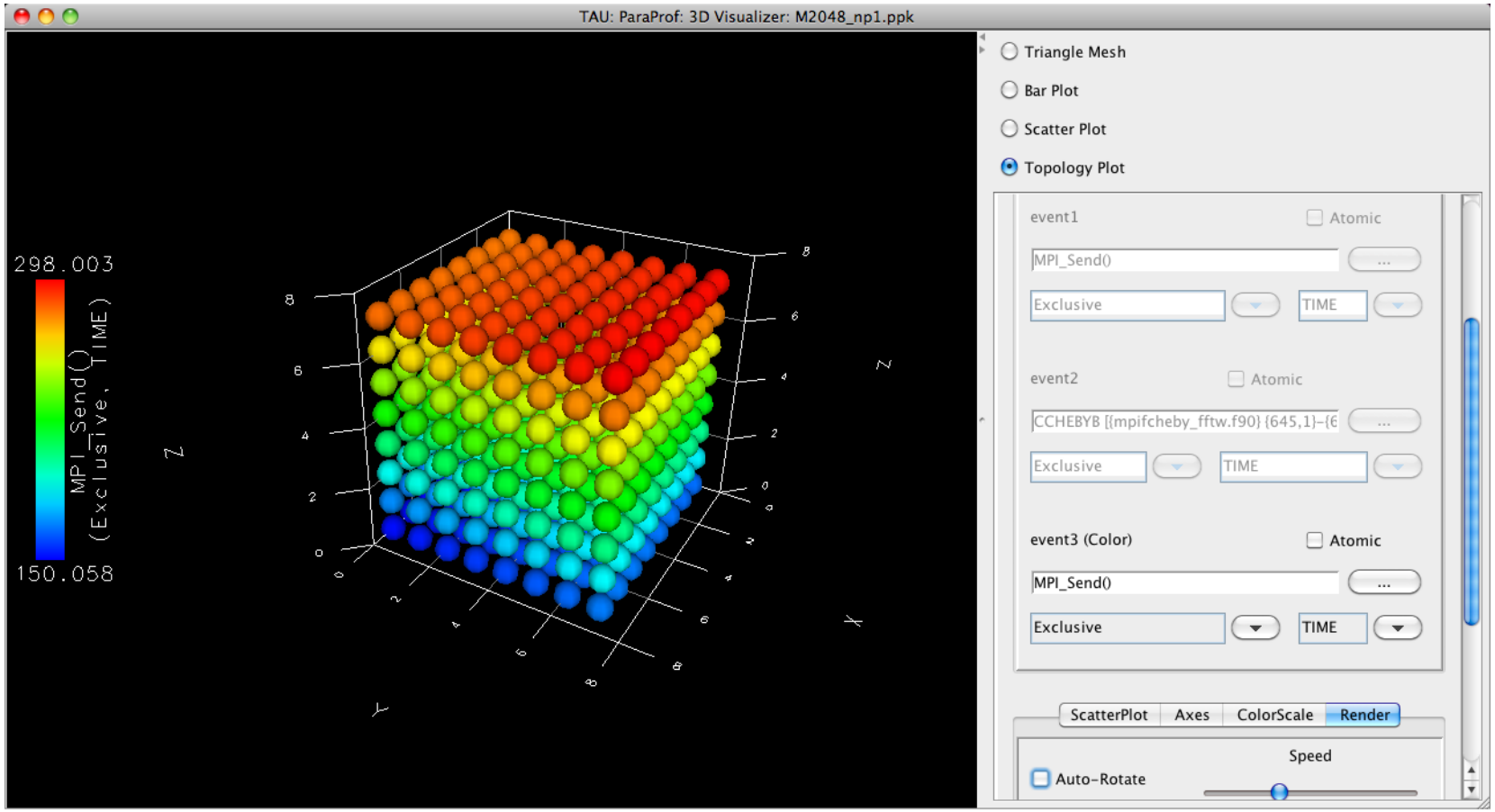
ParaProf: 3D Scatter Plot



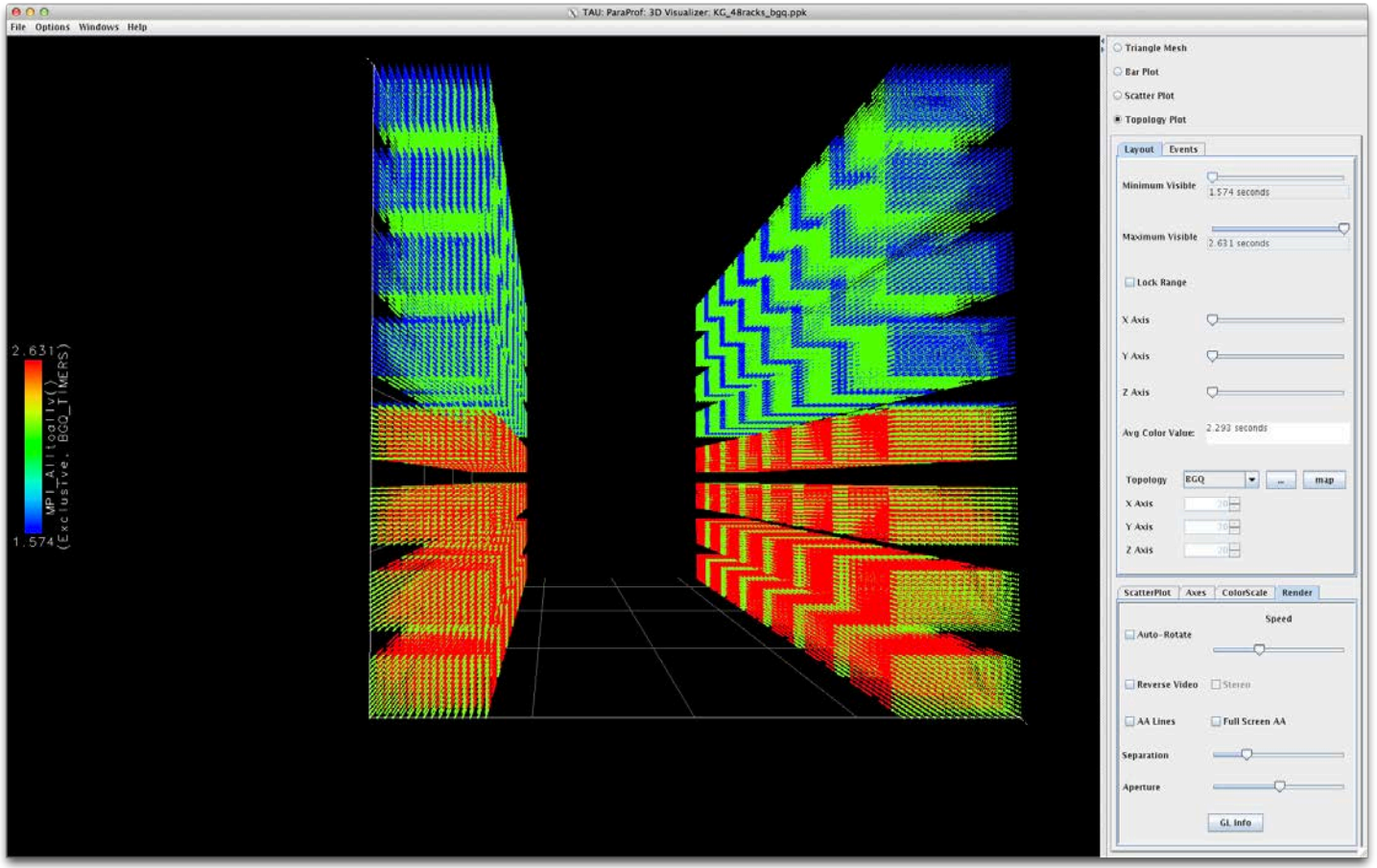
ParaProf: Scatter Plot



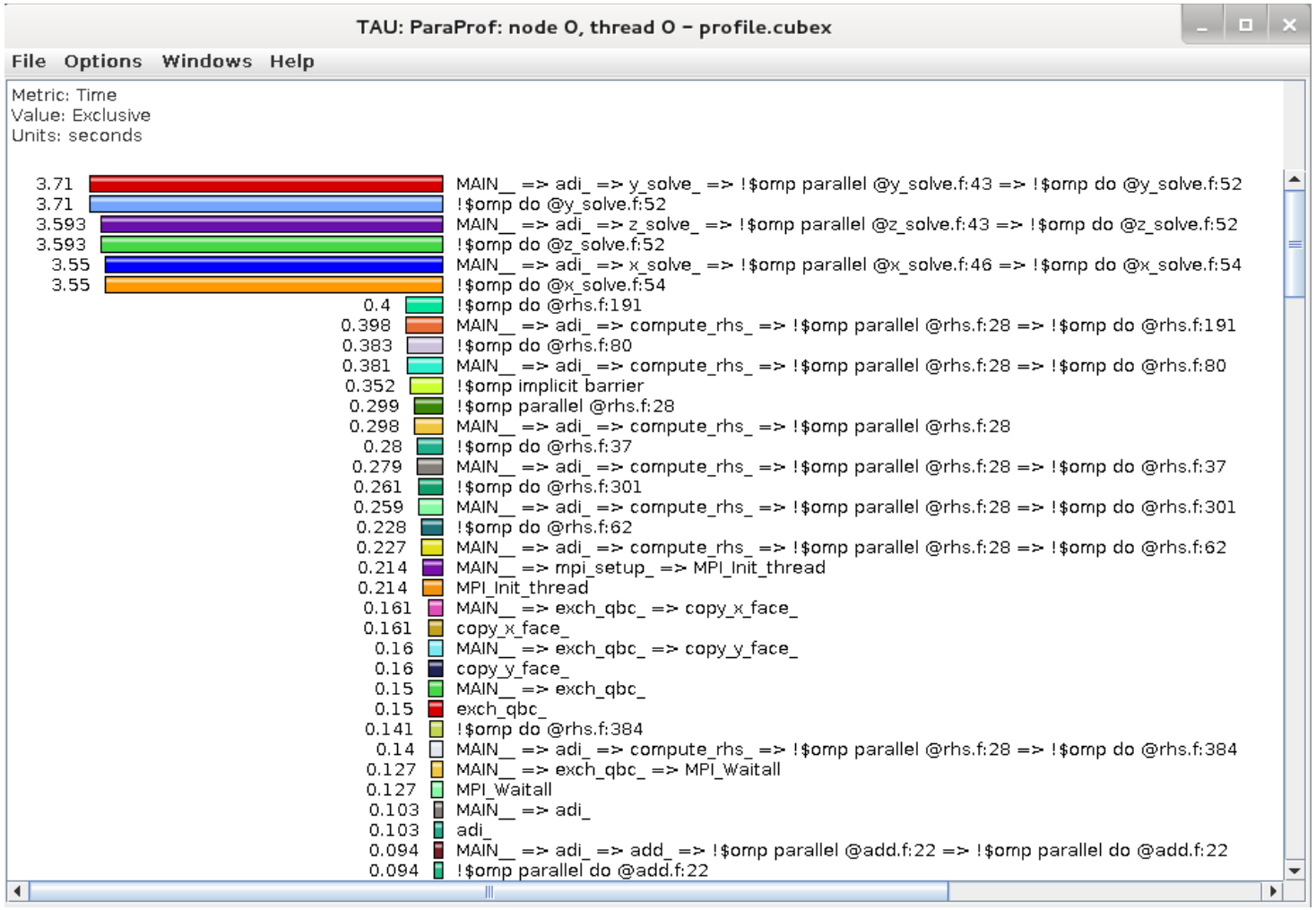
ParaProf: Topology 3D View (IBM BG/P)



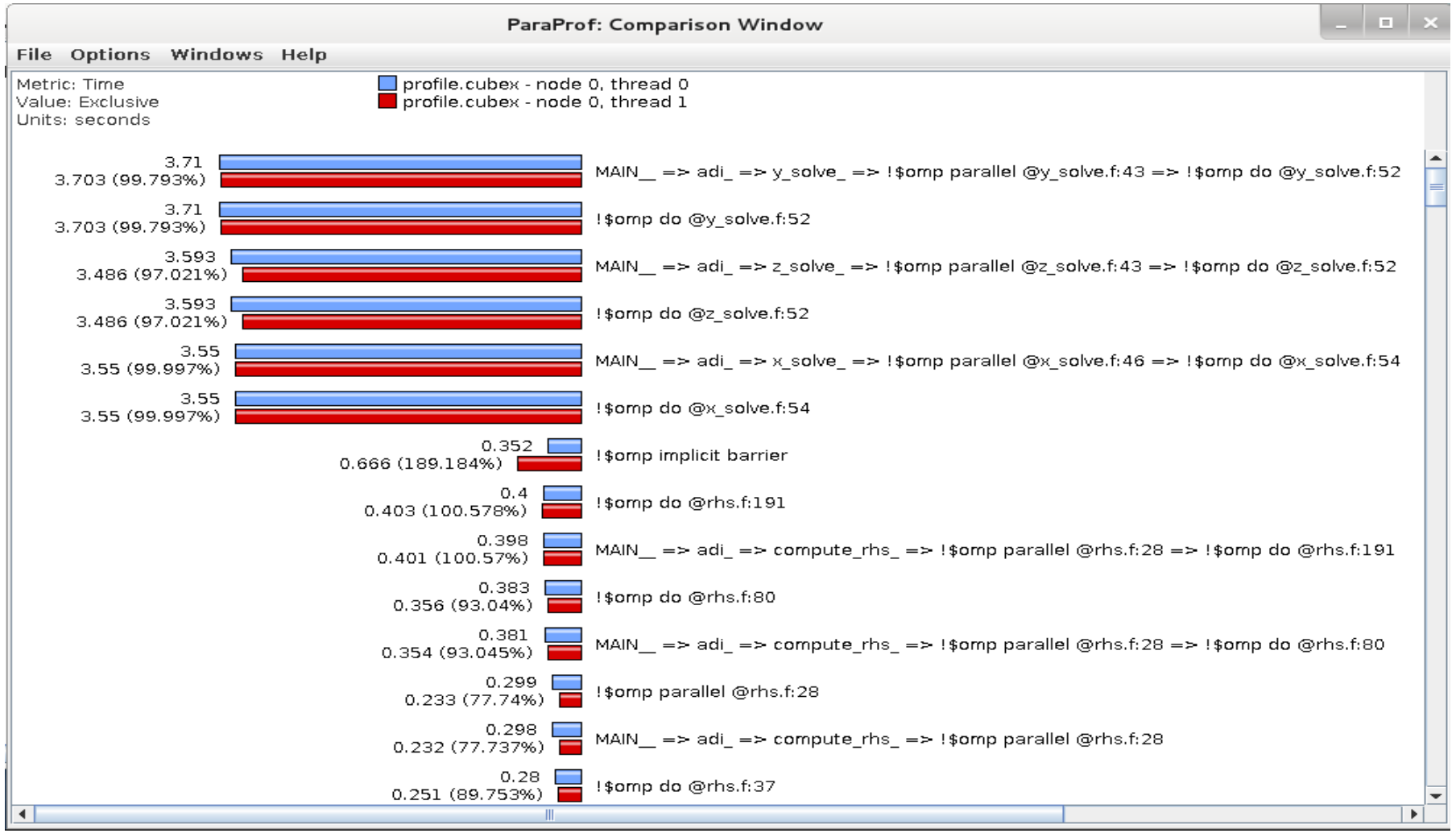
ParaProf: Topology View Torus (IBM BG/Q)



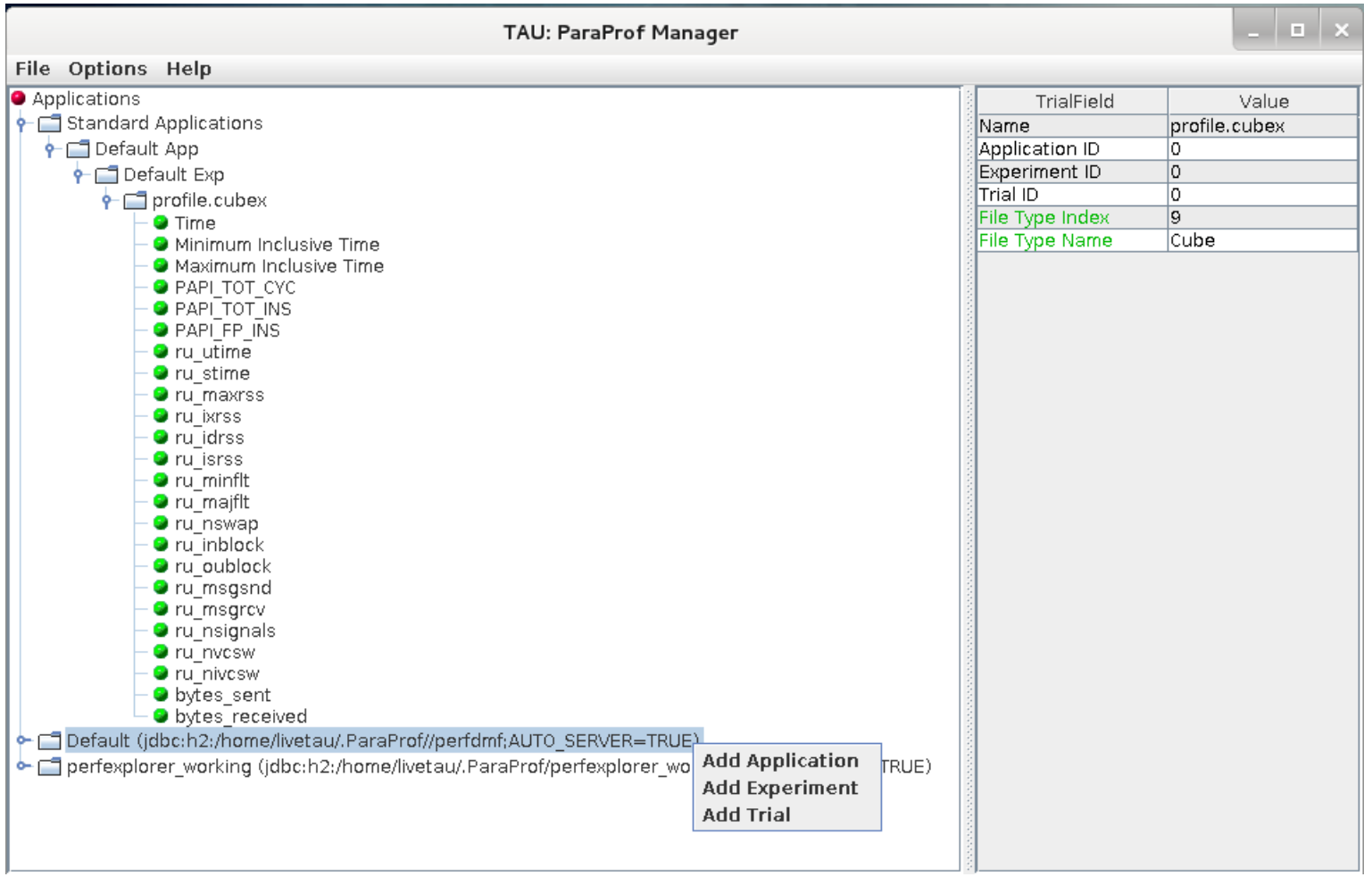
ParaProf: Node View



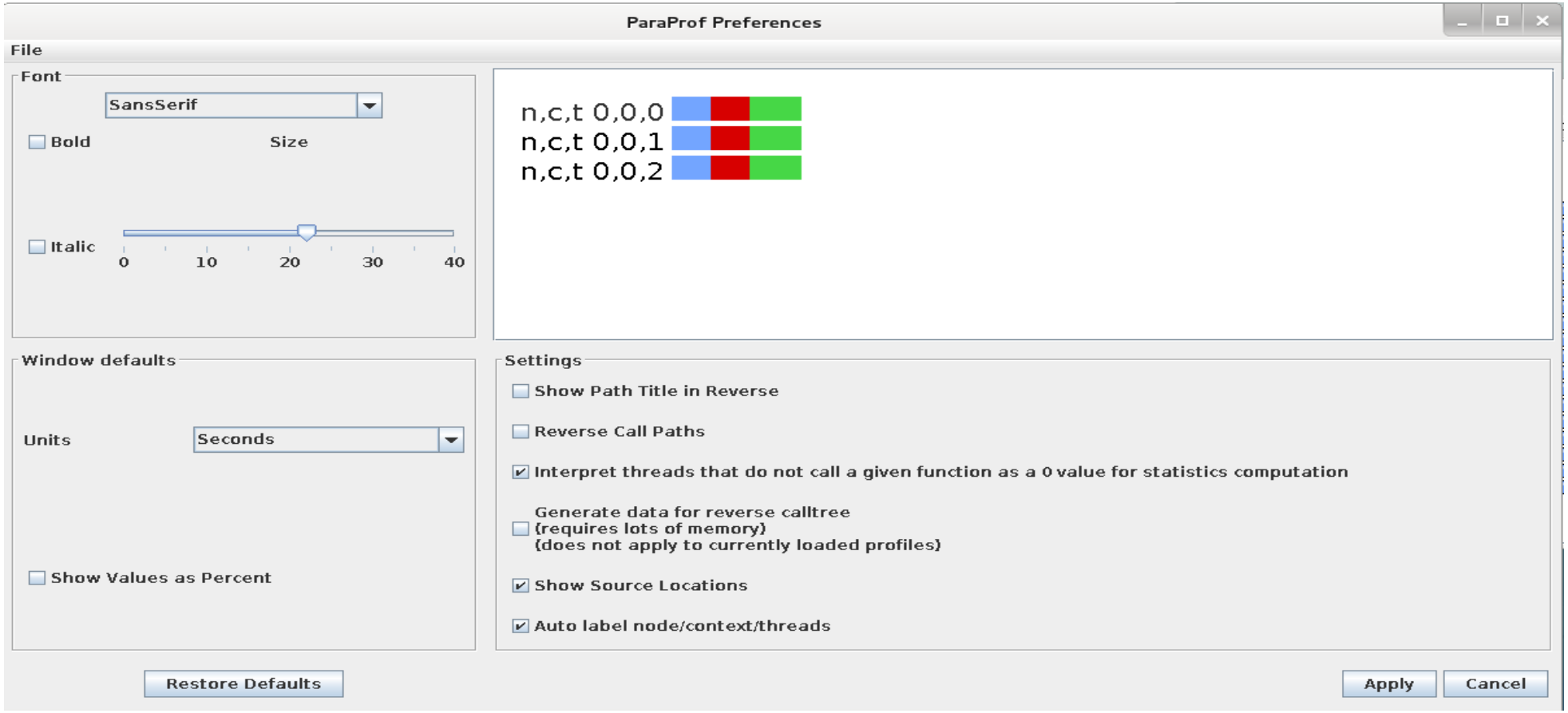
ParaProf: Add Thread to Comparison Window



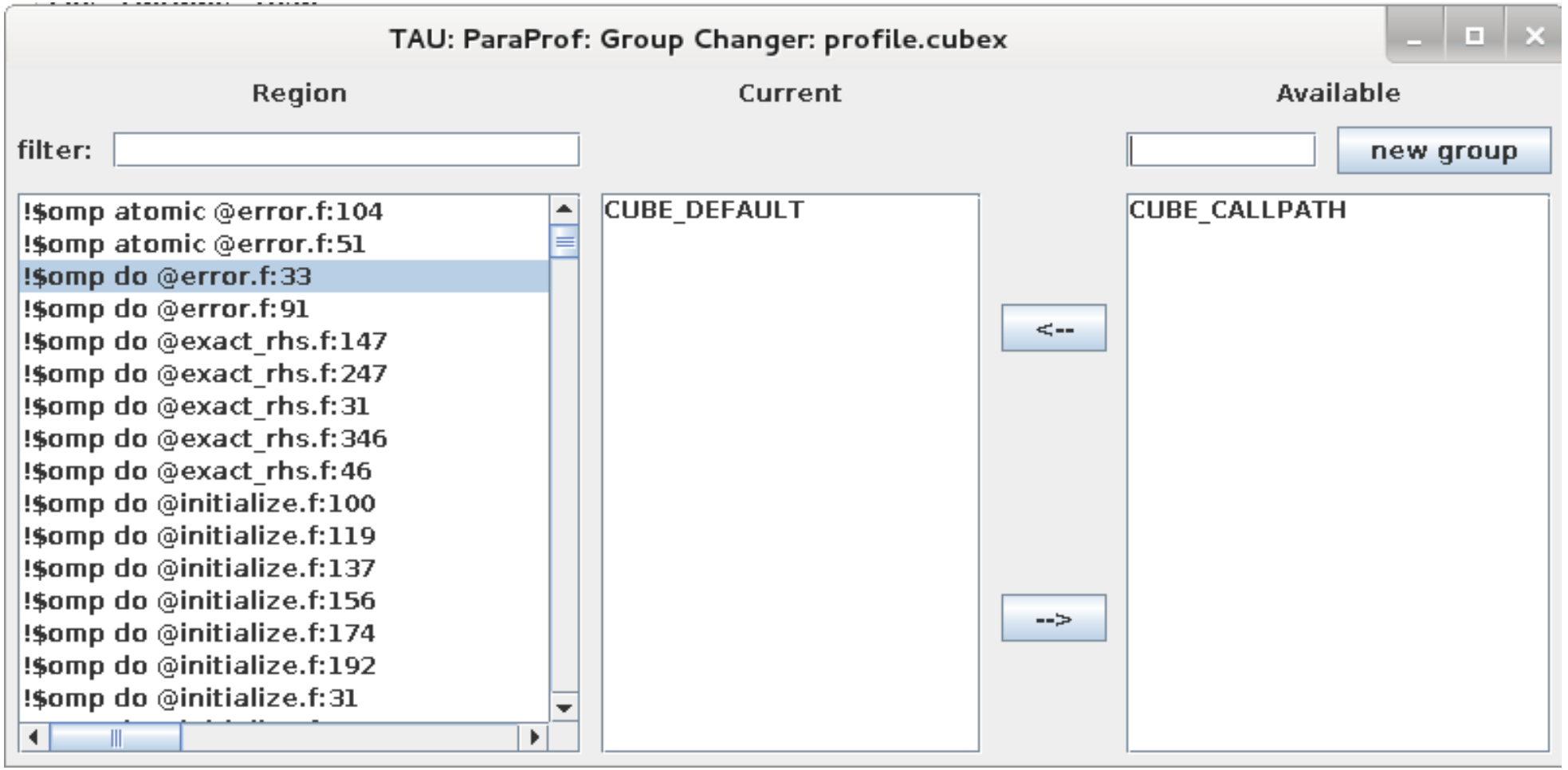
ParaProf: Score-P Profile Files, Database



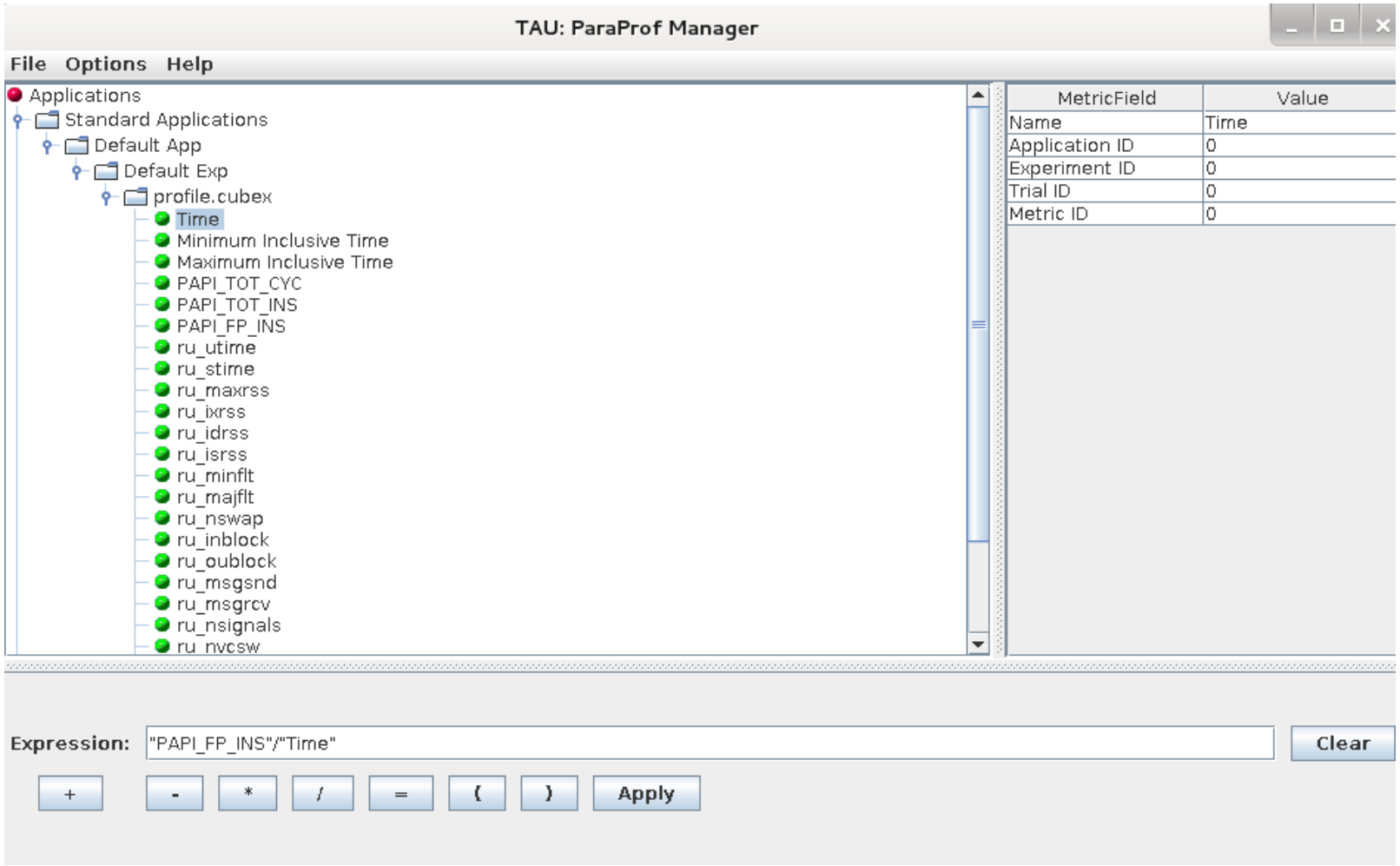
ParaProf: File Preferences Window



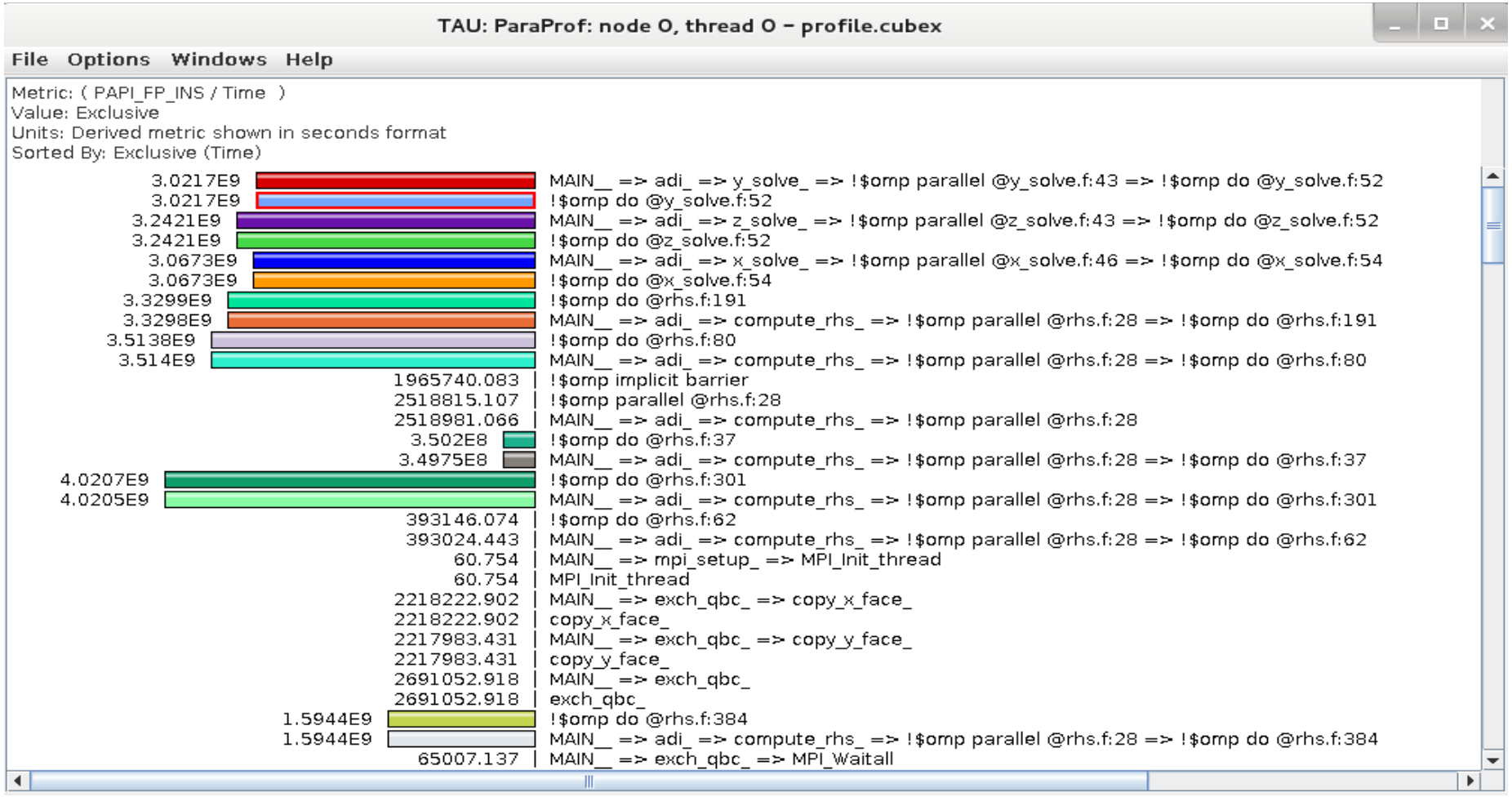
ParaProf: Group Changer Window



ParaProf: Derived Metric Panel in Manager Window



Sorting Derived FLOPS metric by Exclusive Time



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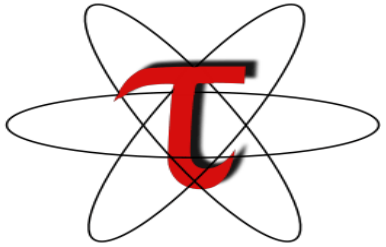

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