Virtual Institute – High Productivity Supercomputing

SOFTWARE

FAST SOLUTIONS

☐ 0.00 <<time step loop>>
☐ 0.00 updatedt
☐ 6.62 updatex
☐ 372.85 updateien
☐ 0.00 gene
☐ 0.00 <<iteration loop>>
☐ 293.65 genbc

☑ PAPI_L1_DCM
☑ PAPI_L1_ICM
☐ PAPI_L2_DCM
☑ PAPI_L2_ICM
☐ PAPI_L1_TCM
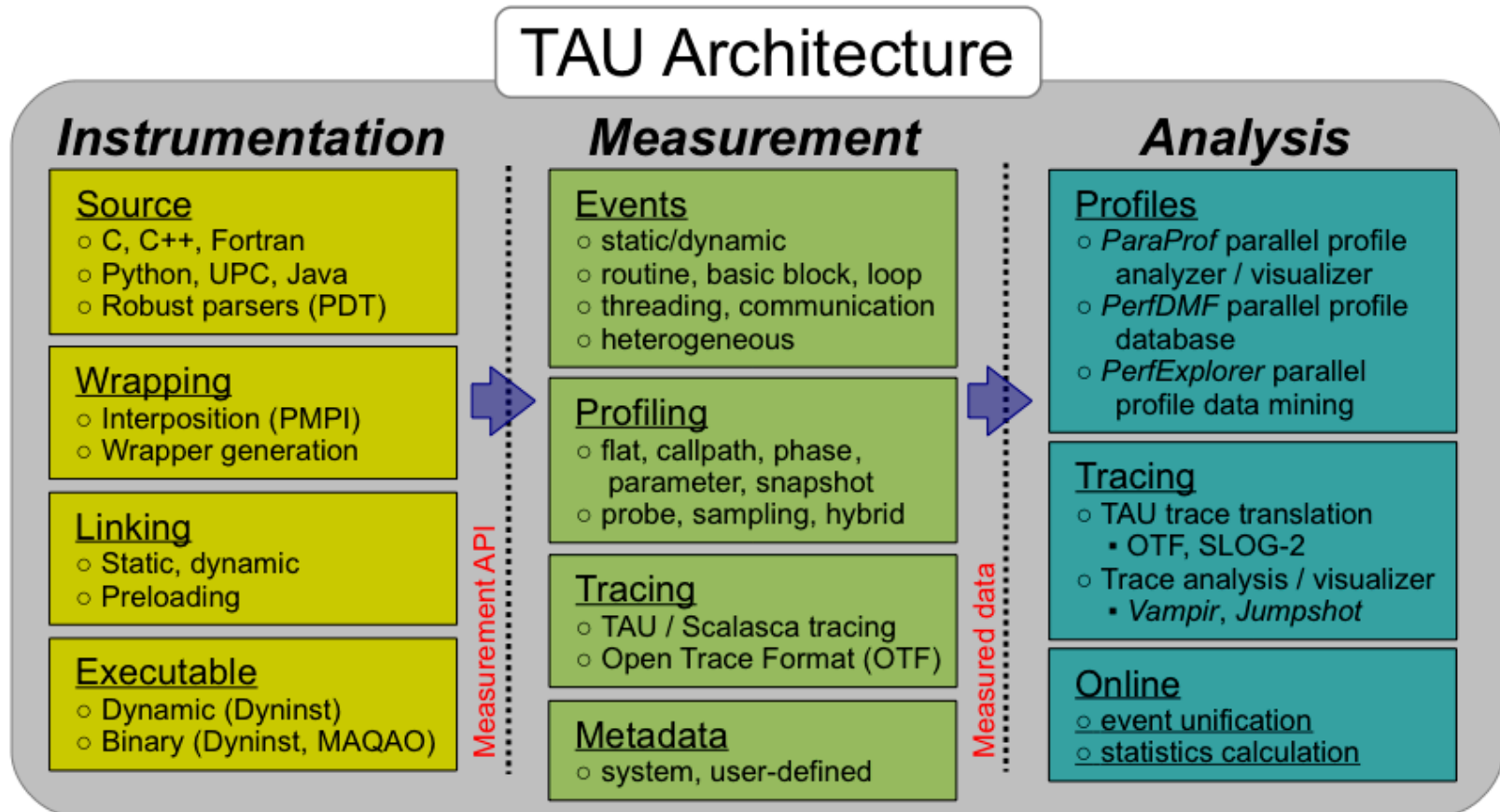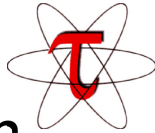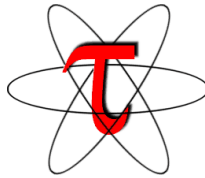☐ PAPI_L2_TCM

PRODUCTIVITY

Profile Analysis with ParaProf

Tuning and Analysis Utilities
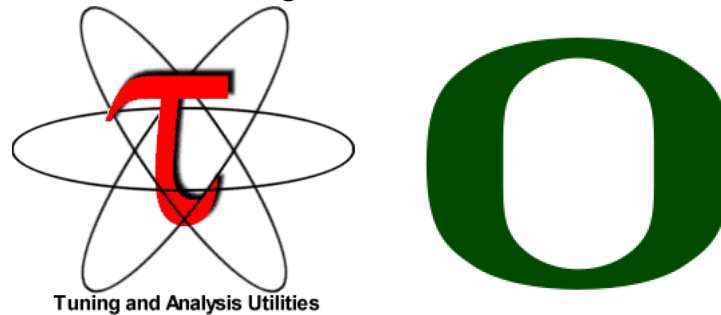
Sameer Shende

Performance Reseaerch Lab, University of Oregon

http://TAU.uoregon.edu

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

TAU Architecture

Instrumentation

Source
- C, C++, Fortran
- Python, UPC, Java
- Robust parsers (PDT)

Wrapping
- Interposition (PMPI)
- Wrapper generation

Linking
- Static, dynamic
- Preloading

Executable
- Dynamic (Dyninst)
- Binary (Dyninst, MAQAO)

Measurement API

Measurement

Events
- static/dynamic
- routine, basic block, loop
- threading, communication
- heterogeneous

Profiling
- flat, callpath, phase, parameter, snapshot
- probe, sampling, hybrid

Tracing
- TAU / Scalasca tracing
- Open Trace Format (OTF)

Metadata
- system, user-defined

Measured data

Analysis

Profiles
- *ParaProf* parallel profile analyzer / visualizer
- *PerfDMF* parallel profile database
- *PerfExplorer* parallel profile data mining

Tracing
- TAU trace translation
  - OTF, SLOG-2
- Trace analysis / visualizer
  - *Vampir, Jumpshot*

Online
- event unification
- statistics calculation

# TAU Performance System®

- Instrumentation
  - Fortran, C++, C, UPC, Java, Python, Chapel
  - Automatic instrumentation

- Measurement and analysis support
  - MPI, OpenSHMEM, ARMCI, PGAS, DMAPP
  - pthreads, OpenMP, hybrid, other thread models
  - GPU, CUDA, OpenCL, OpenACC
  - Parallel profiling and tracing
  - Use of Score-P for native OTF2 and CUBEX generation
  - Efficient callpath profiles and trace generation using Score-P

- Analysis
  - Parallel profile analysis (ParaProf), data mining (PerfExplorer)
  - Performance database technology (PerfDMF, TAUdb)
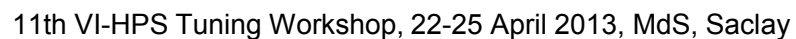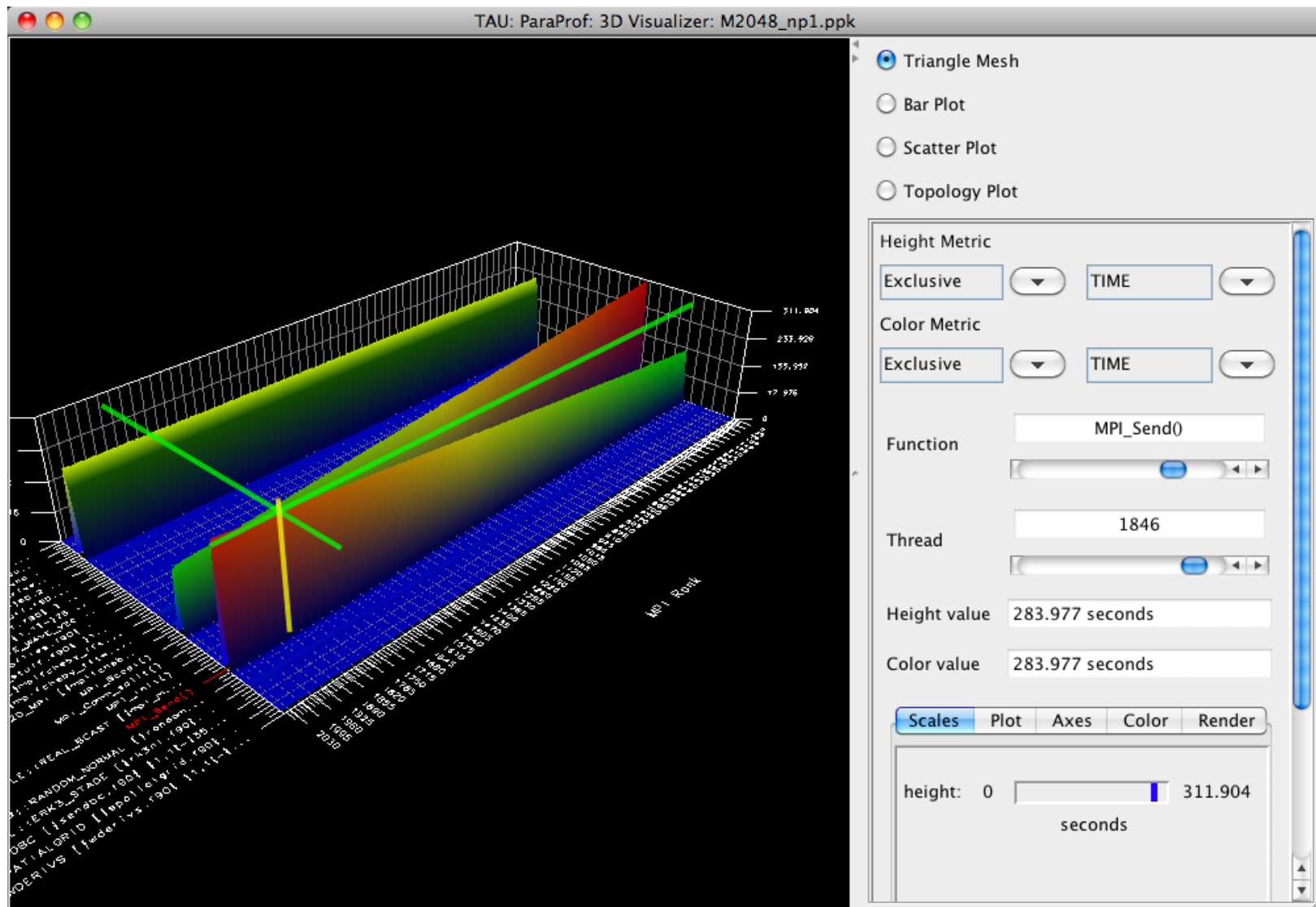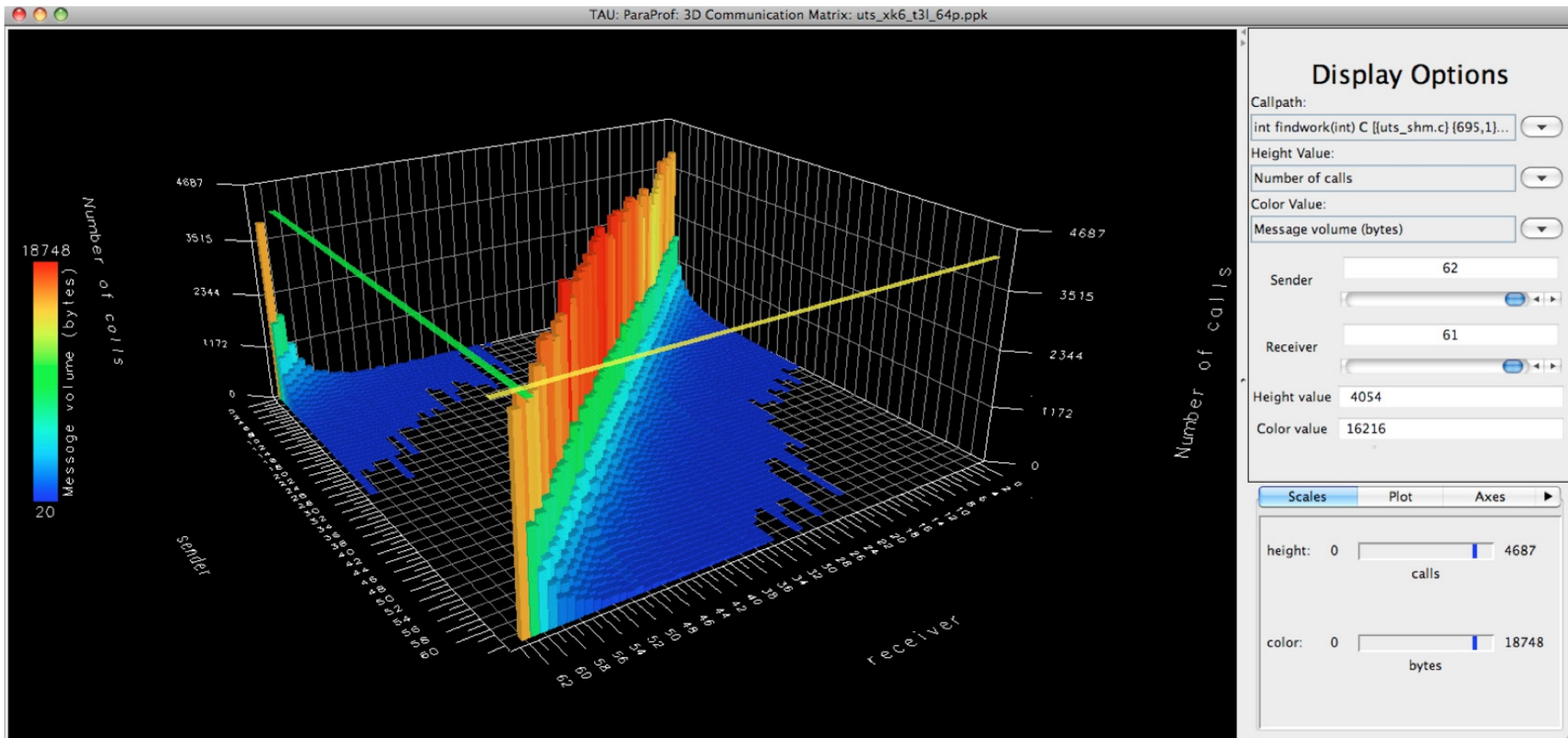 - 3D profile browser
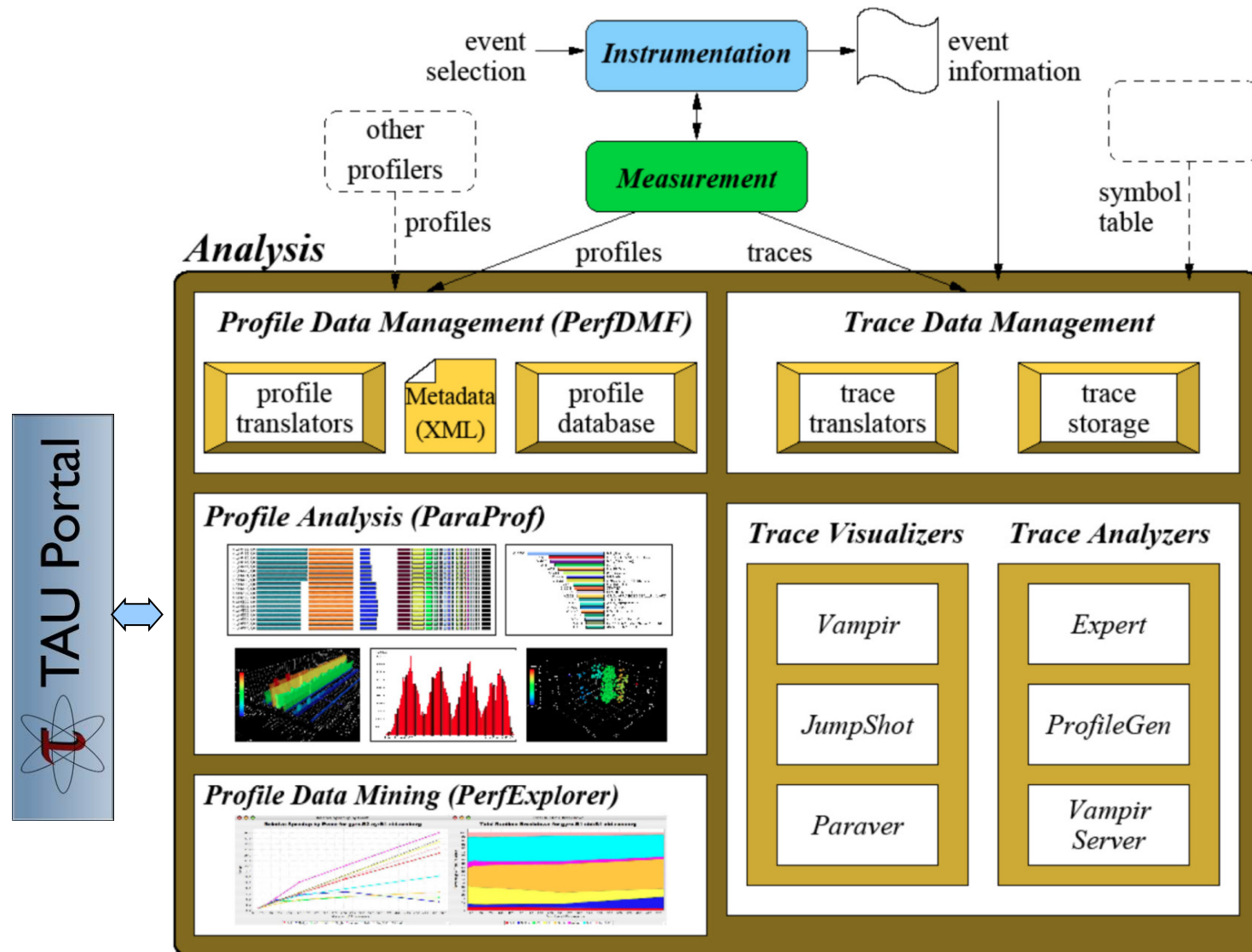
ParaProf Profile Analysis Framework
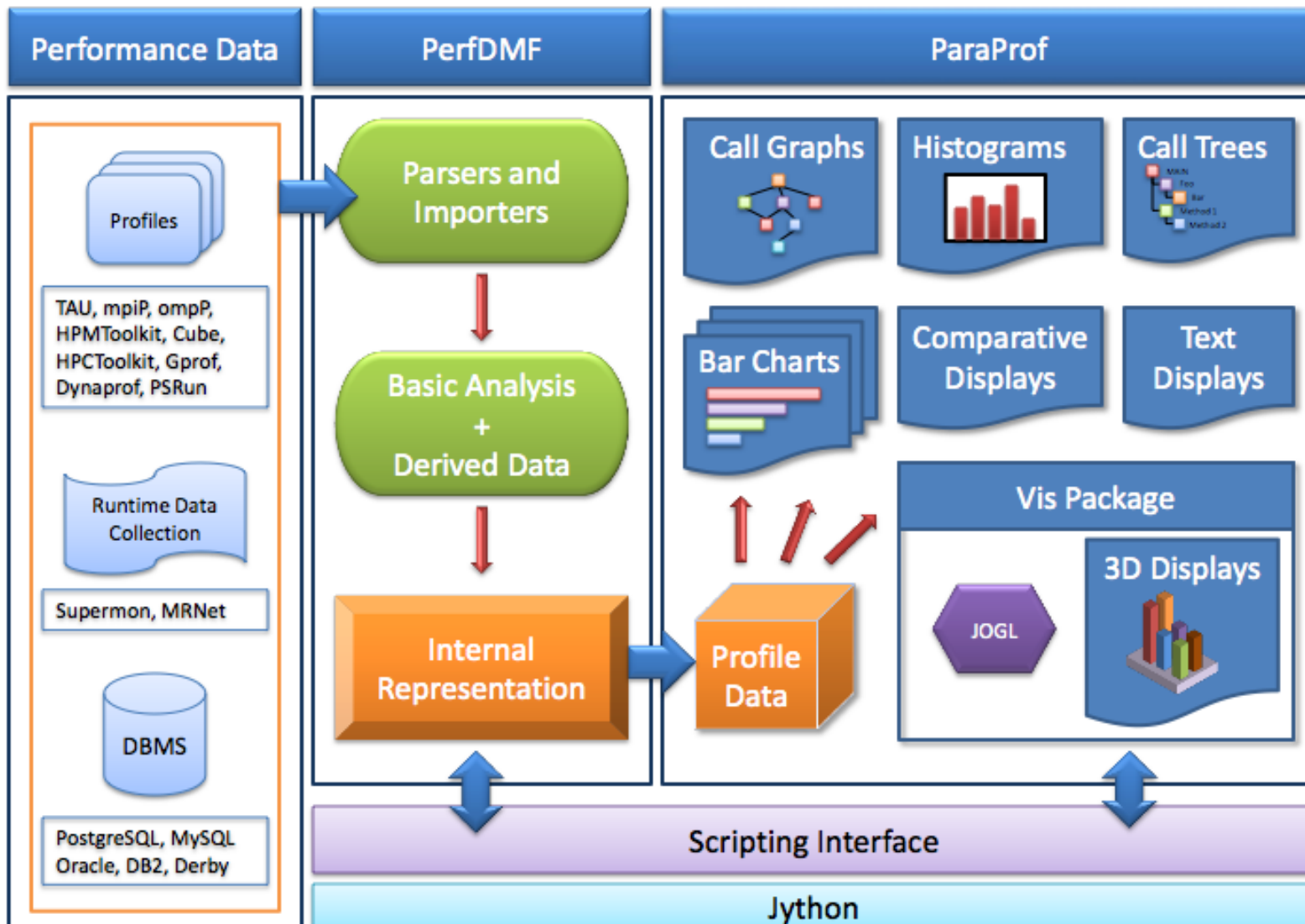
- ## The Live-DVD contains Score-P experiments of BT-MZ
  - class "B", 4 processes with 4 OpenMP threads each
  - collected on a dedicated node of the SuperMUC HPC system at Leibniz Rechenzentrum (LRZ), Munich, Germany

```
% cd
% cd workshop-vihps/supermuc_expts
% ls
periscope-1.5                              scorep_bt-mz_B_4x4_sum
README                                     scorep_bt-mz_B_4x4_sum+mets
run.out                                    scorep_bt-mz_B_4x4_trace
scorep-20120913_1740_557443655223384
```

- ## Start TAU's paraprof GUI with default profile report

```
% paraprof scorep-20120913_1740_557443655223384/profile.cubex
OR
% paraprof scorep_bt-mz_B_4x4_trace/scout.cubex
```
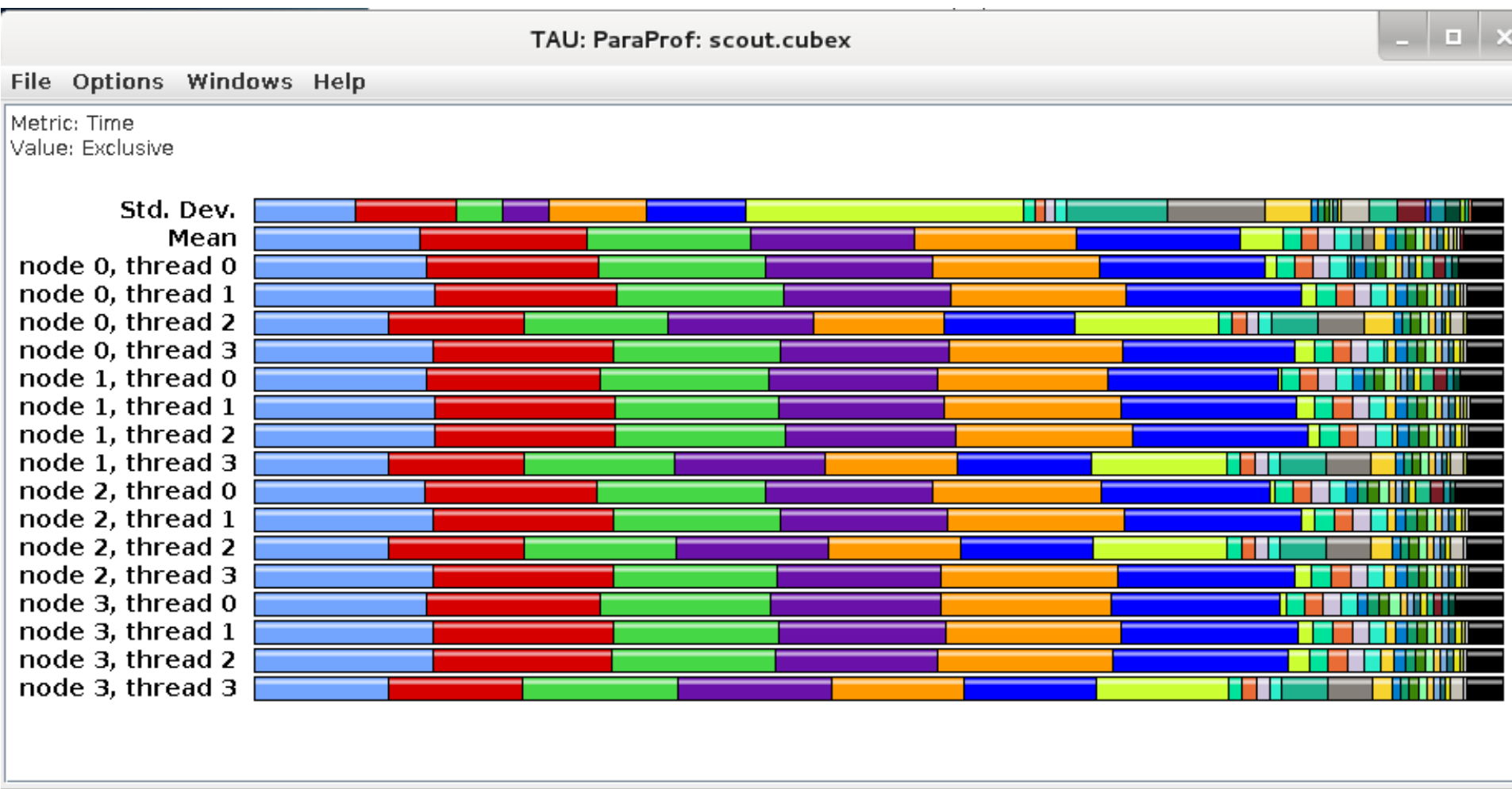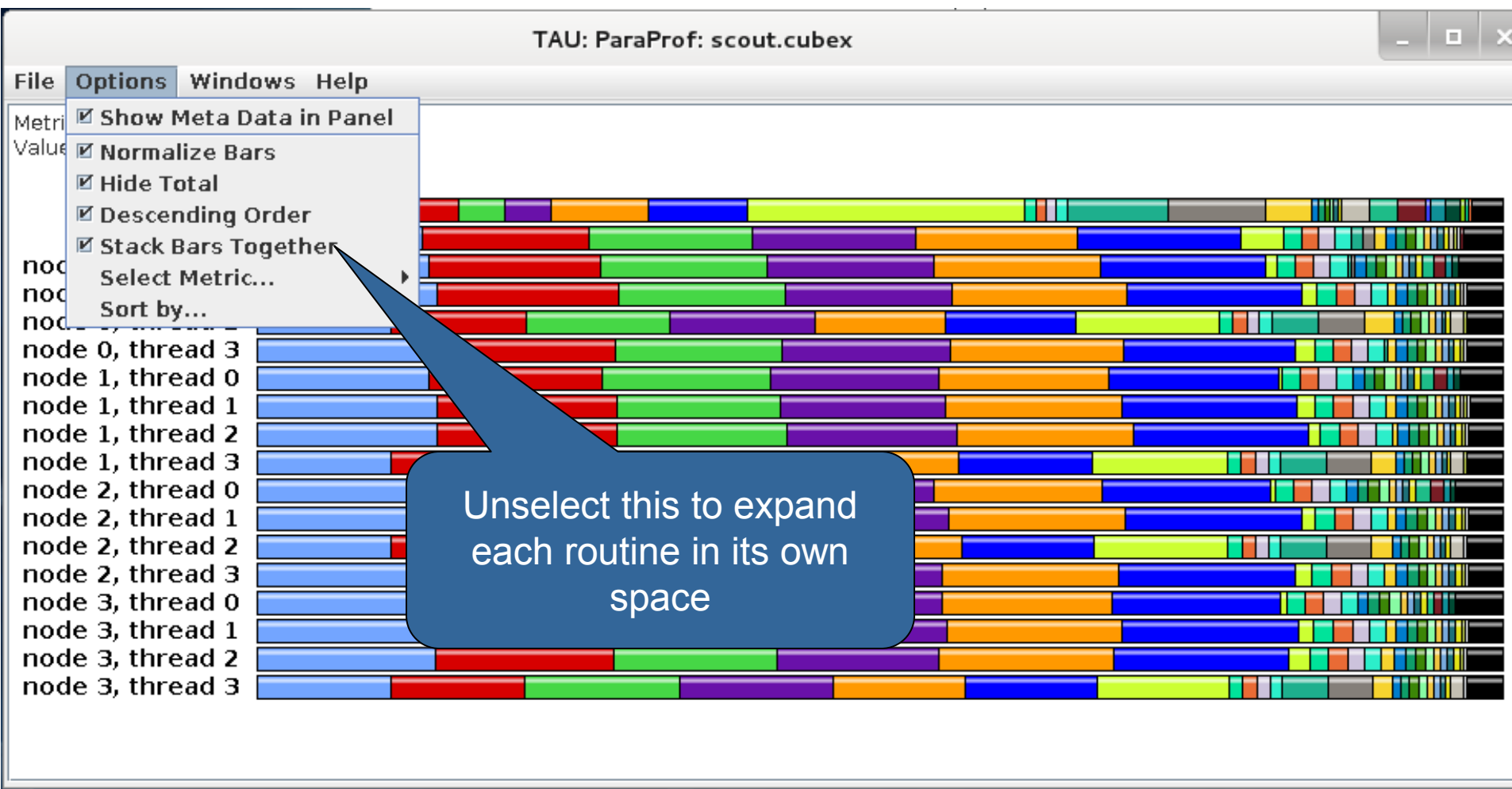
ParaProf: Main window

ParaProf: Thread Statistics Table
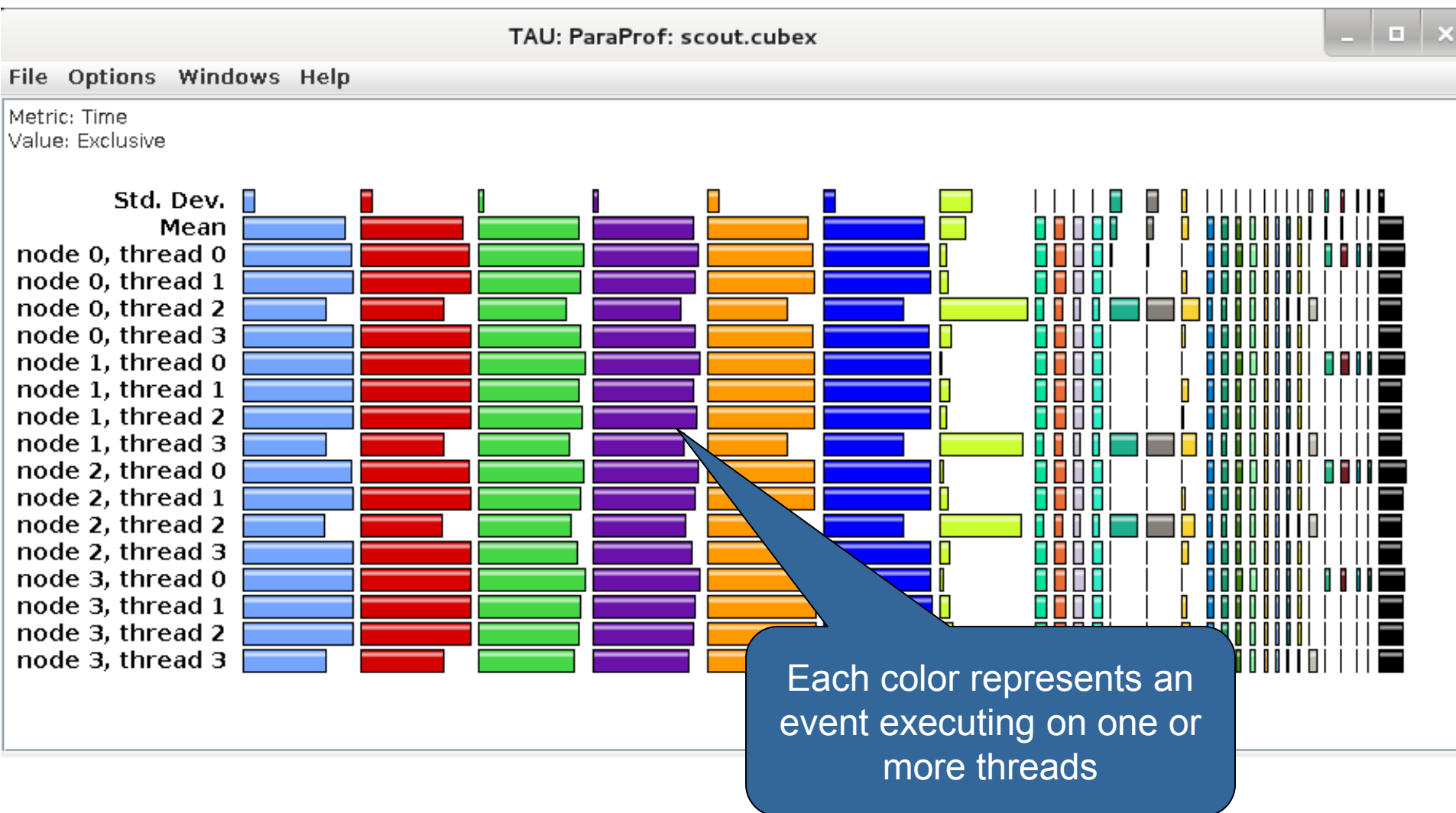
Example: Score-P with TAU (LU NPB)

TAU: ParaProf: Statistics for: node 0, thread 0 – profile.cubex

File Options Windows Help

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

Click on options to choose a different color or to resize the box based on metrics
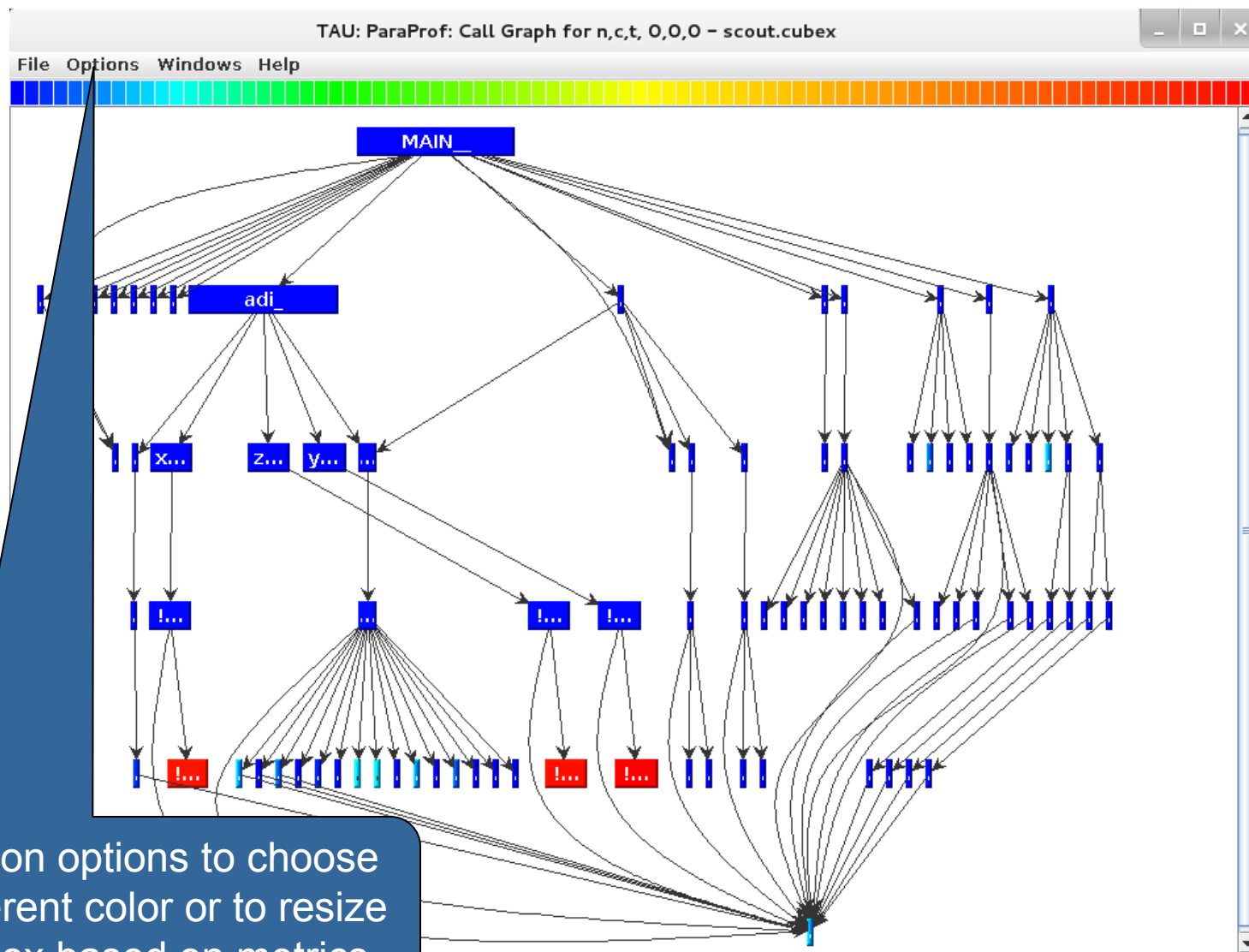
ParaProf: Callpath Thread Relations Window

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
```
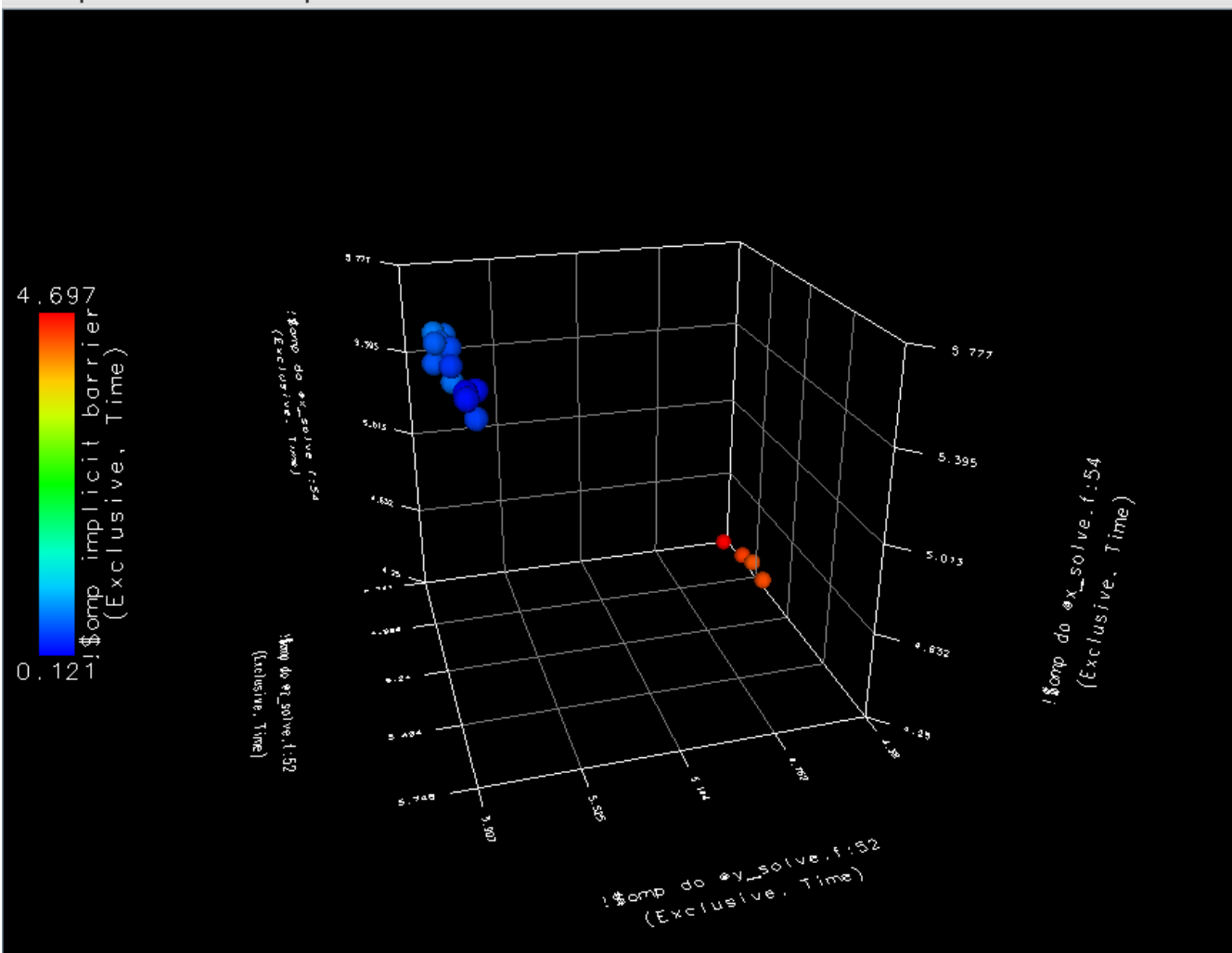
ParaProf: Node View
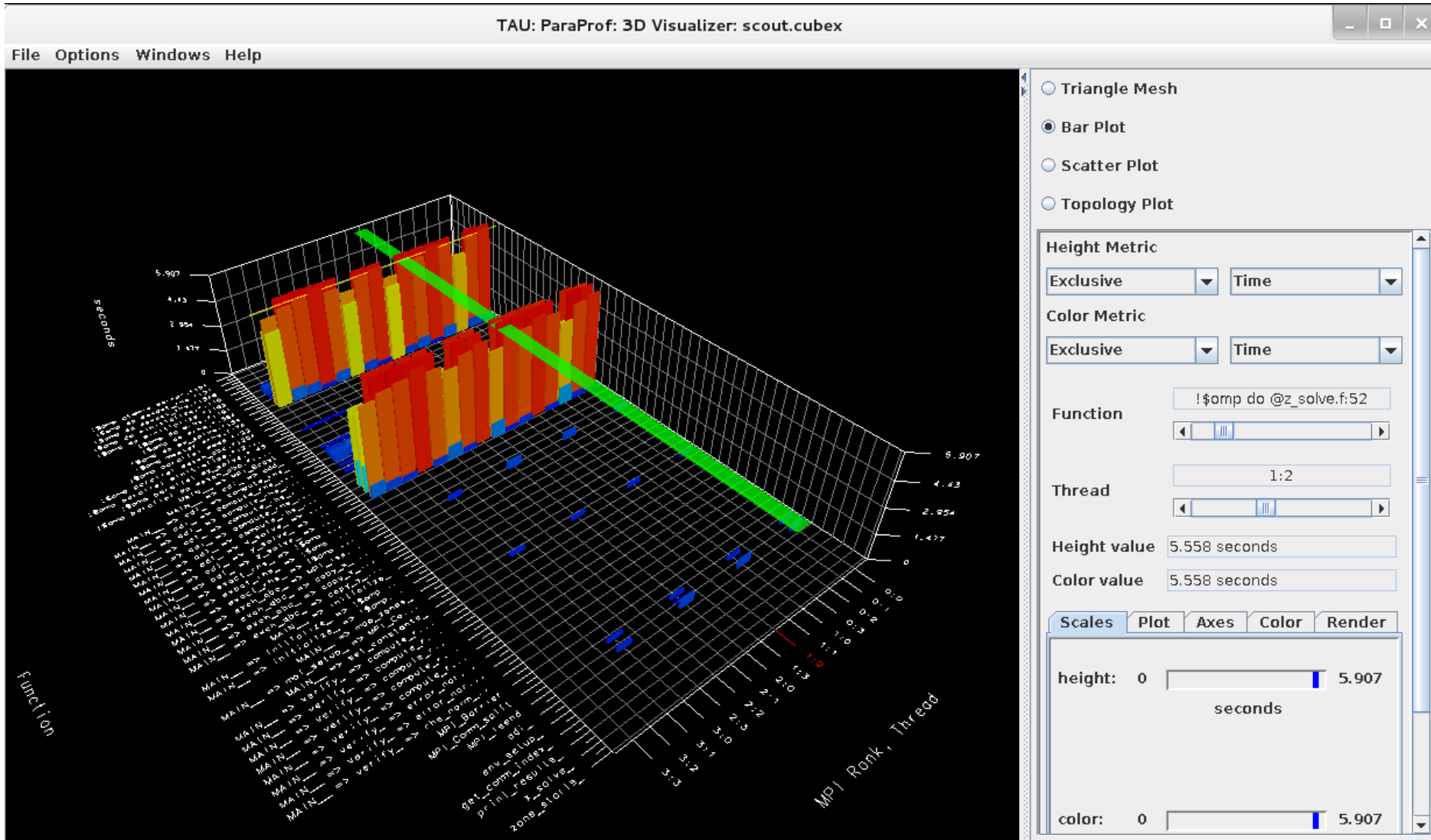
TAU: ParaProf: node 0, thread 0 – profile.cubex

File   Options   Windows   Help

Metric: Time
Value: Exclusive
Units: seconds

Value	Label
3.71	MAIN__ => adi_ => y_solve_ => !$omp parallel @y_solve.f:43 => !$omp do @y_solve.f:52
3.71	!$omp do @y_solve.f:52
3.593	MAIN__ => adi_ => z_solve_ => !$omp parallel @z_solve.f:43 => !$omp do @z_solve.f:52
3.593	!$omp do @z_solve.f:52
3.55	MAIN__ => adi_ => x_solve_ => !$omp parallel @x_solve.f:46 => !$omp do @x_solve.f:54
3.55	!$omp do @x_solve.f:54
0.4	!$omp do @rhs.f:191
0.398	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28 => !$omp do @rhs.f:191
0.383	!$omp do @rhs.f:80
0.381	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28 => !$omp do @rhs.f:80
0.352	!$omp implicit barrier
0.299	!$omp parallel @rhs.f:28
0.298	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28
0.28	!$omp do @rhs.f:37
0.279	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28 => !$omp do @rhs.f:37
0.261	!$omp do @rhs.f:301
0.259	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28 => !$omp do @rhs.f:301
0.228	!$omp do @rhs.f:62
0.227	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28 => !$omp do @rhs.f:62
0.214	MAIN__ => mpi_setup_ => MPI_Init_thread
0.214	MPI_Init_thread
0.161	MAIN__ => exch_qbc_ => copy_x_face_
0.161	copy_x_face_
0.16	MAIN__ => exch_qbc_ => copy_y_face_
0.16	copy_y_face_
0.15	MAIN__ => exch_qbc_
0.15	exch_qbc_
0.141	!$omp do @rhs.f:384
0.14	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28 => !$omp do @rhs.f:384
0.127	MAIN__ => exch_qbc_ => MPI_Waitall
0.127	MPI_Waitall
0.103	MAIN__ => adi_
0.103	adi_
0.094	MAIN__ => adi_ => add_ => !$omp parallel @add.f:22 => !$omp parallel do @add.f:22
0.094	!$omp parallel do @add.f:22
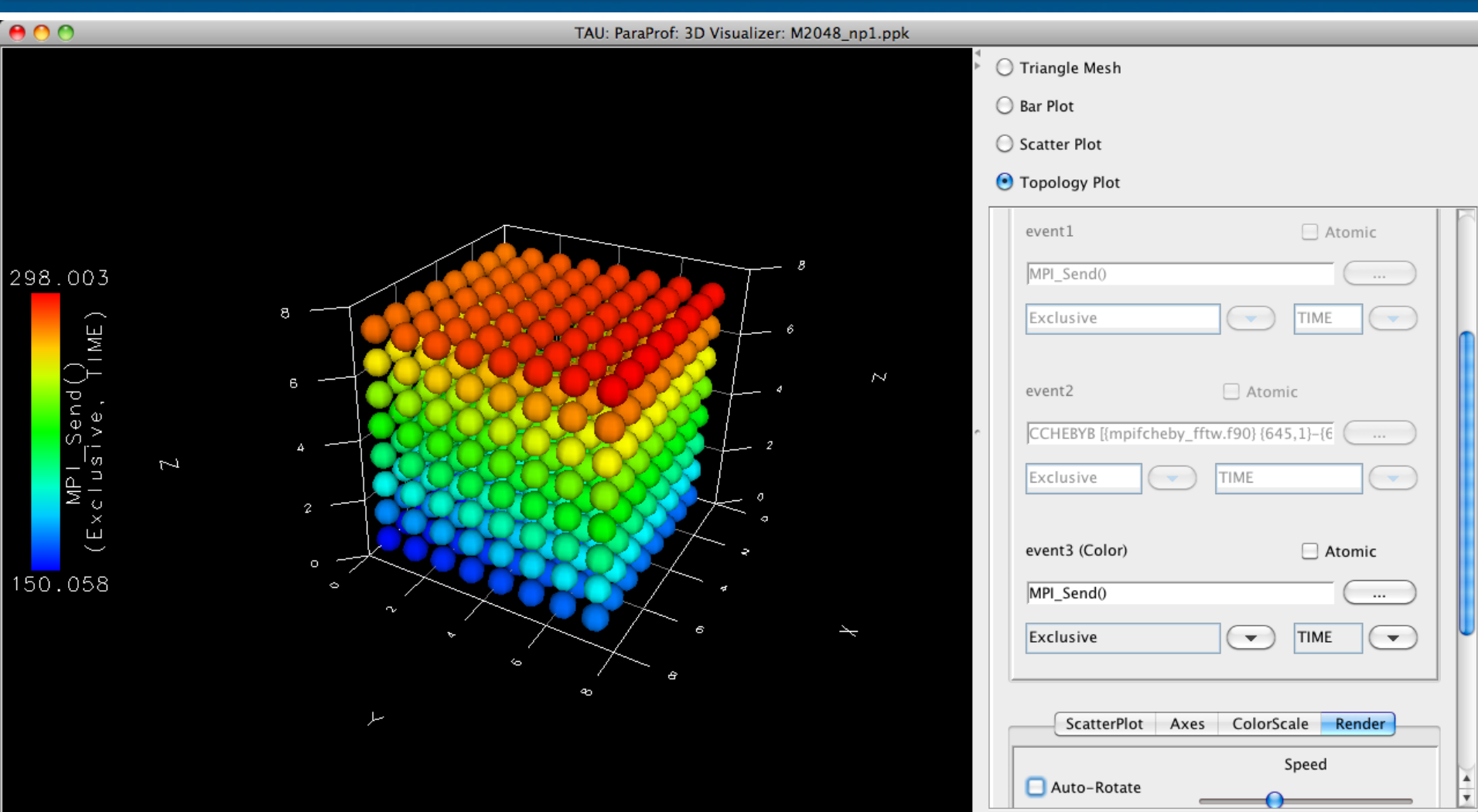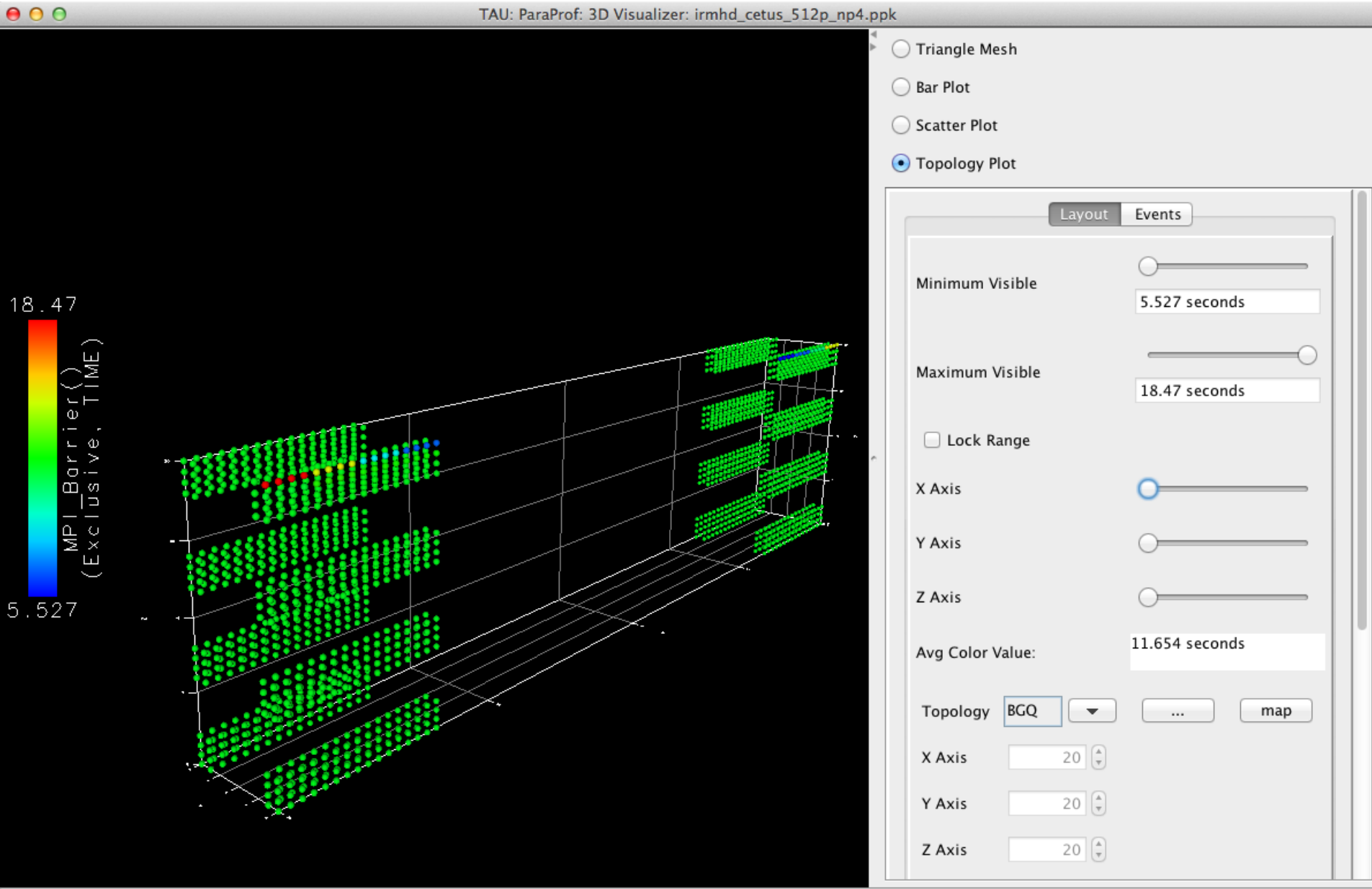
ParaProf: Add Thread to Comparison Window
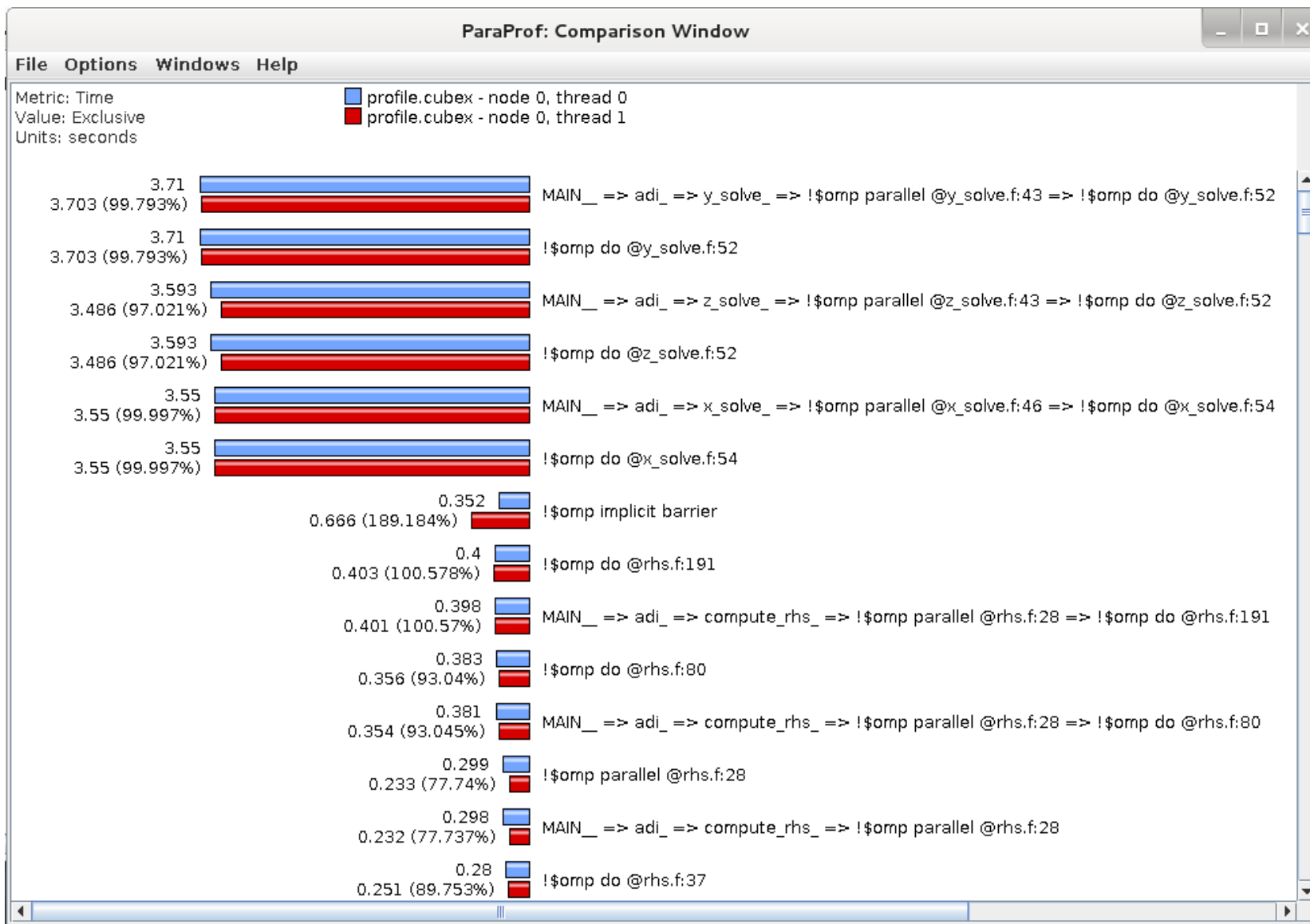
ParaProf: Score-P Profile Files, Database

TAU: ParaProf Manager

File   Options   Help

- Applications
  - Standard Applications
    - Default App
      - Default Exp
        - profile.cubex
          - Time
          - Minimum Inclusive Time
          - Maximum Inclusive Time
          - PAPI_TOT_CYC
          - PAPI_TOT_INS
          - PAPI_FP_INS
          - ru_utime
          - ru_stime
          - ru_maxrss
          - ru_ixrss
          - ru_idrss
          - ru_isrss
          - ru_minflt
          - ru_majflt
          - ru_nswap
          - ru_inblock
          - ru_oublock
          - ru_msgsnd
          - ru_msgrcv
          - ru_nsignals
          - ru_nvcsw
          - ru_nivcsw
          - bytes_sent
          - bytes_received
- Default (jdbc:h2:/home/livetau/.ParaProf//perfdmf;AUTO_SERVER=TRUE)
- perfexplorer_working (jdbc:h2:/home/livetau/.ParaProf/perfexplorer_wo...TRUE)

Add Application
Add Experiment
Add Trial

TrialField	Value
Name	profile.cubex
Application ID	0
Experiment ID	0
Trial ID	0
File Type Index	9
File Type Name	Cube

TAU: ParaProf: Group Changer: profile.cubex

Region	Current	Available

filter: [   ]   [   ] [new group]

Region:
- !$omp atomic @error.f:104
- !$omp atomic @error.f:51
- !$omp do @error.f:33
- !$omp do @error.f:91
- !$omp do @exact_rhs.f:147
- !$omp do @exact_rhs.f:247
- !$omp do @exact_rhs.f:31
- !$omp do @exact_rhs.f:346
- !$omp do @exact_rhs.f:46
- !$omp do @initialize.f:100
- !$omp do @initialize.f:119
- !$omp do @initialize.f:137
- !$omp do @initialize.f:156
- !$omp do @initialize.f:174
- !$omp do @initialize.f:192
- !$omp do @initialize.f:31

Current:
- CUBE_DEFAULT

Available:
- CUBE_CALLPATH

`<--`   `-->`

Sorting Derived Flops Metric by Exclusive Time

TAU: ParaProf: node 0, thread 0 – profile.cubex

File   Options   Windows   Help

Metric: (PAPI_FP_INS / Time)
Value: Exclusive
Units: Derived metric shown in seconds format
Sorted By: Exclusive (Time)

Value	Function
3.0217E9	MAIN__ => adi_ => y_solve_ => !$omp parallel @y_solve.f:43 => !$omp do @y_solve.f:52
3.0217E9	!$omp do @y_solve.f:52
3.2421E9	MAIN__ => adi_ => z_solve_ => !$omp parallel @z_solve.f:43 => !$omp do @z_solve.f:52
3.2421E9	!$omp do @z_solve.f:52
3.0673E9	MAIN__ => adi_ => x_solve_ => !$omp parallel @x_solve.f:46 => !$omp do @x_solve.f:54
3.0673E9	!$omp do @x_solve.f:54
3.3299E9	!$omp do @rhs.f:191
3.3298E9	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28 => !$omp do @rhs.f:191
3.5138E9	!$omp do @rhs.f:80
3.514E9	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28 => !$omp do @rhs.f:80
1965740.083	!$omp implicit barrier
2518815.107	!$omp parallel @rhs.f:28
2518981.066	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28
3.502E8	!$omp do @rhs.f:37
3.4975E8	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28 => !$omp do @rhs.f:37
4.0207E9	!$omp do @rhs.f:301
4.0205E9	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28 => !$omp do @rhs.f:301
393146.074	!$omp do @rhs.f:62
393024.443	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28 => !$omp do @rhs.f:62
60.754	MAIN__ => mpi_setup_ => MPI_Init_thread
60.754	MPI_Init_thread
2218222.902	MAIN__ => exch_qbc_ => copy_x_face_
2218222.902	copy_x_face_
2217983.431	MAIN__ => exch_qbc_ => copy_y_face_
2217983.431	copy_y_face_
2691052.918	MAIN__ => exch_qbc_
2691052.918	exch_qbc_
1.5944E9	!$omp do @rhs.f:384
1.5944E9	MAIN__ => adi_ => compute_rhs_ => !$omp parallel @rhs.f:28 => !$omp do @rhs.f:384
65007.137	MAIN__ => exch_qbc_ => MPI_Waitall

11th VI-HPS Tuning Workshop, 22-25 April 2013, MdS, Saclay

- U.S. Department of Energy (DOE)
  - Office of Science
  - ASC/NNSA, Tri-labs (LLNL,LANL, SNL)
- U.S. Department of Defense (DoD)
  - HPC Modernization Office (HPCMO)
- NSF Software Development for Cyberinfrastructure (SDCI)
- Juelich Supercomputing Center, NIC
- Argonne National Laboratory
- Technical University Dresden
- ParaTools, Inc.
- NVIDIA