

International HPC Summer School 2017: Analysis report examination with Cube

Christian Feld Jülich Supercomputing Centre



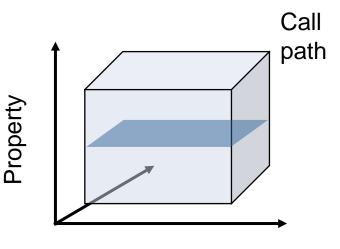


Cube

- Parallel program analysis report exploration tools
 - Libraries for XML+binary report reading & writing
 - Algebra utilities for report processing
 - GUI for interactive analysis exploration
 - Requires Qt4 \geq 4.6 or Qt 5
- Originally developed as part of the Scalasca toolset
- Now available as a separate component
 - Can be installed independently of Score-P, e.g., on laptop or desktop
 - Latest release: Cube 4.3.5 (May 2017)

Analysis presentation and exploration

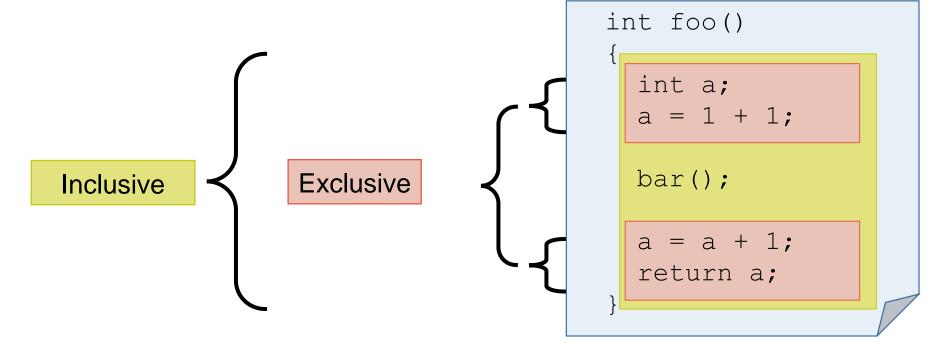
- Representation of values (severity matrix) on three hierarchical axes
 - Performance property (metric)
 - Call path (program location)
 - System location (process/thread)
- Three coupled tree browsers
- Cube displays severities
 - As value: for precise comparison
 - As color: for easy identification of hotspots
 - Inclusive value when closed & exclusive value when expanded
 - Customizable via display modes





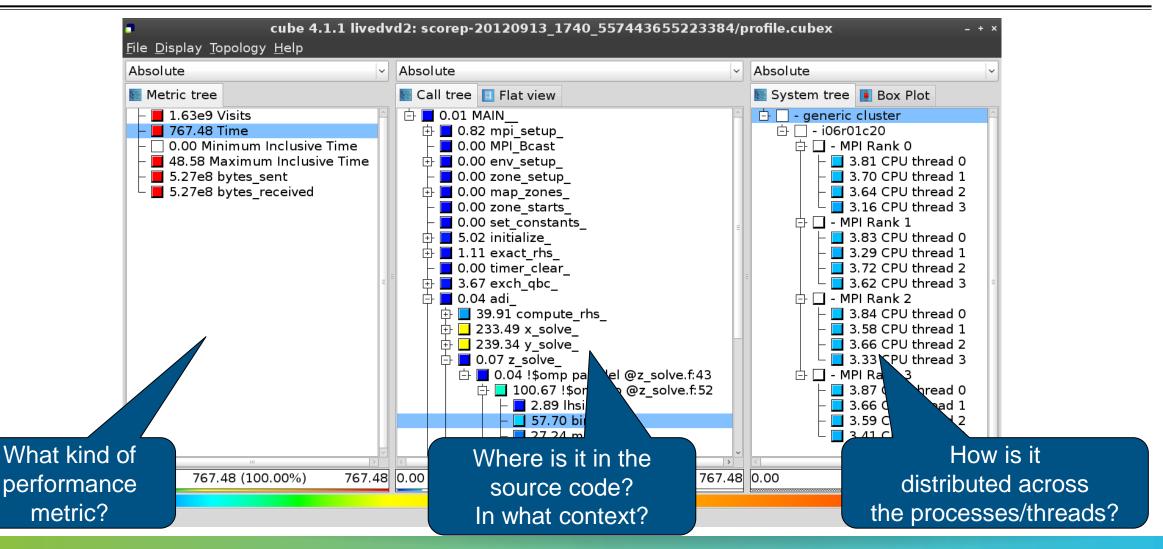
Inclusive vs. exclusive values

- Inclusive
 - Information of all sub-elements aggregated into single value
- Exclusive
 - Information cannot be subdivided further



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Analysis presentation

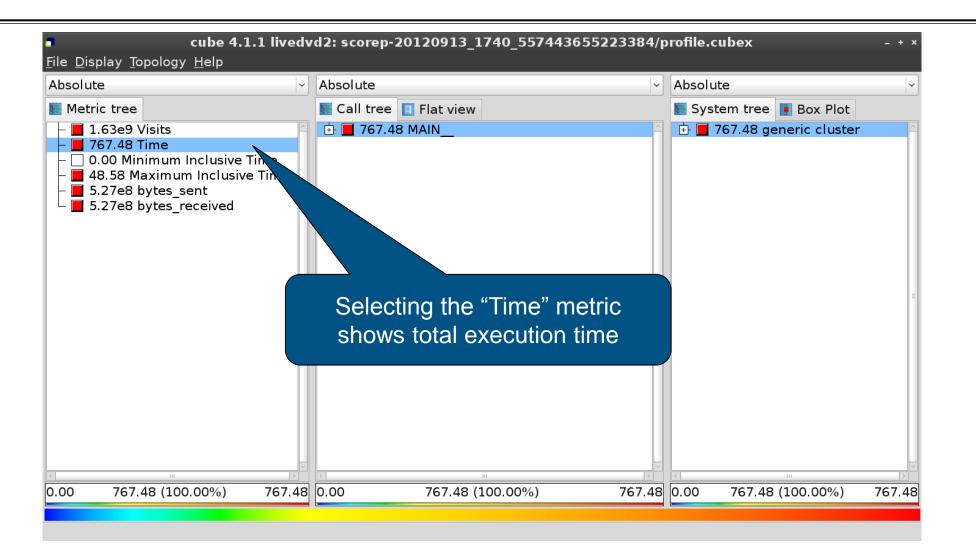


Score-P analysis report exploration (opening view)

Absolute		Absolute		 ~]	Absolute		~
🔙 Metric tree		🔚 Call tr	ee 🔲 Flat view		🔚 System tree	🚺 Box Plot	
 1.63e9 Visits 767.48 Time 0.00 Minimum Inclusiv 48.58 Maximum Inclusiv 5.27e8 bytes_sent 5.27e8 bytes_received 	sive Time	▲ 1.€	53e9 MAIN	E		eneric cluster	
1.63e9 (100.00%)	>	9 0	1.63e9 (100.00%)	1.63e9	<	100.00%)	1.63es

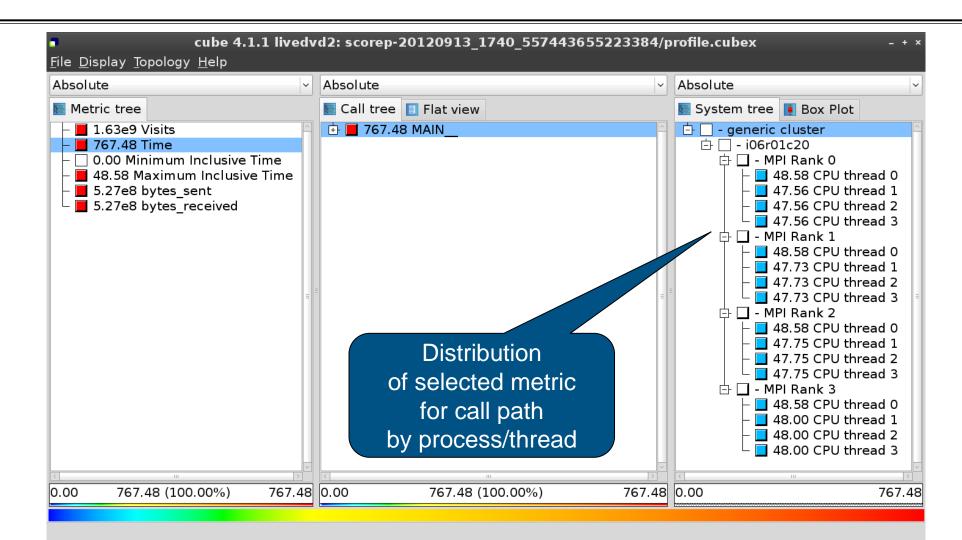
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Metric selection



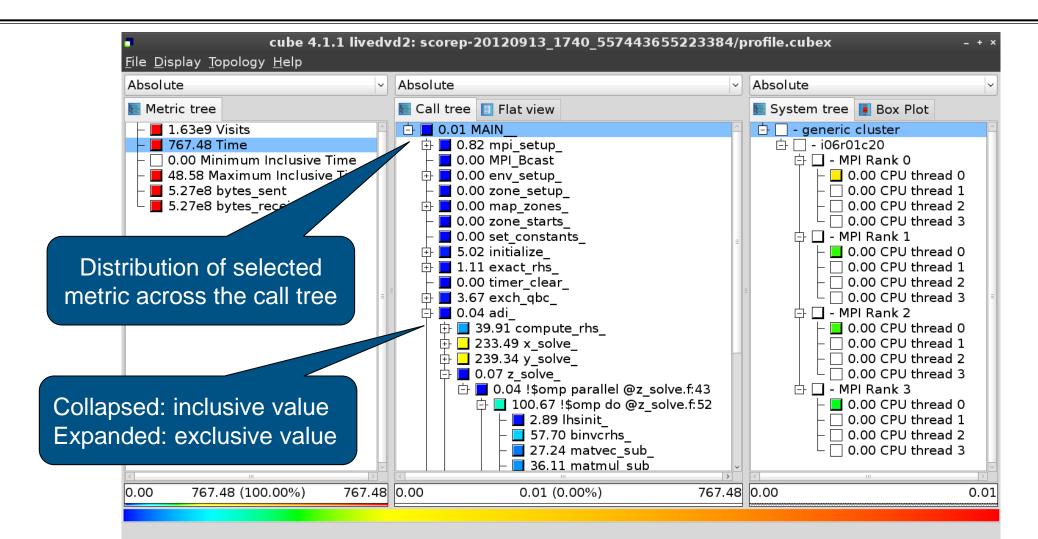
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Expanding the system tree

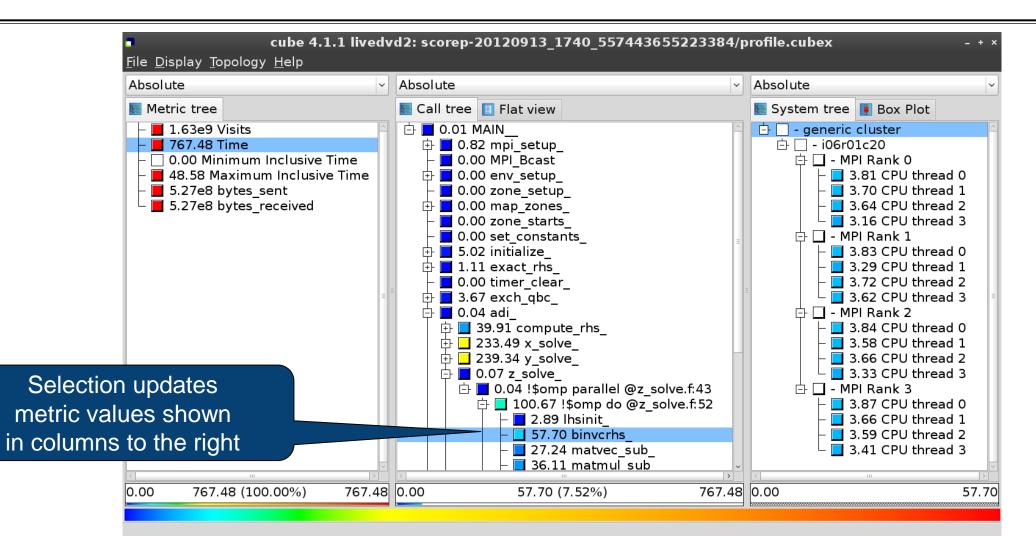


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Expanding the call tree

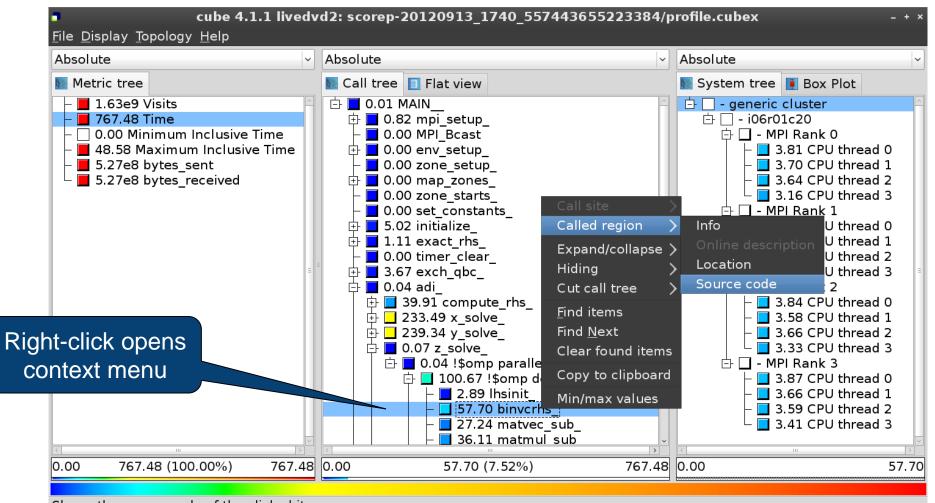


Selecting a call path



Winter the second second

Source-code view via context menu



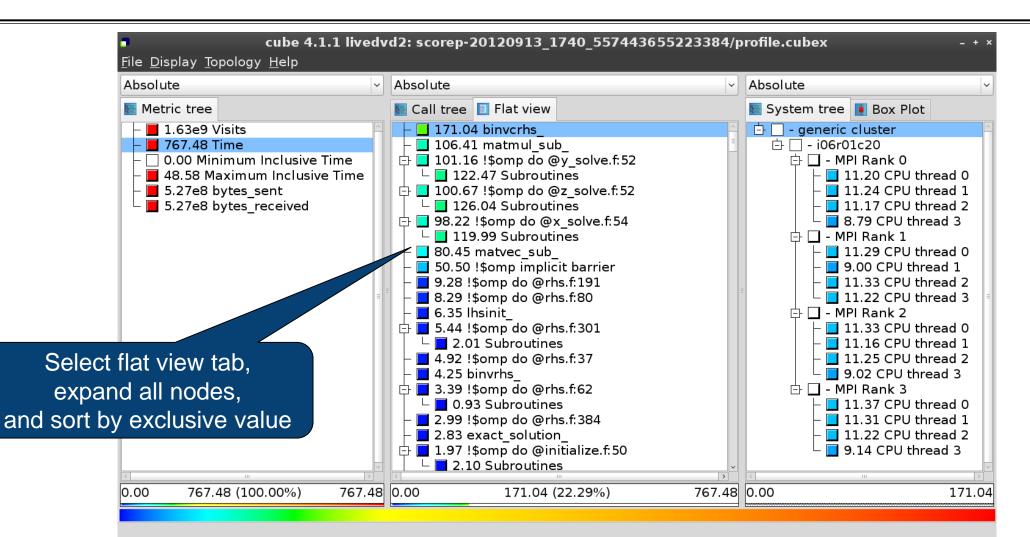
Shows the source code of the clicked item

Source-code view

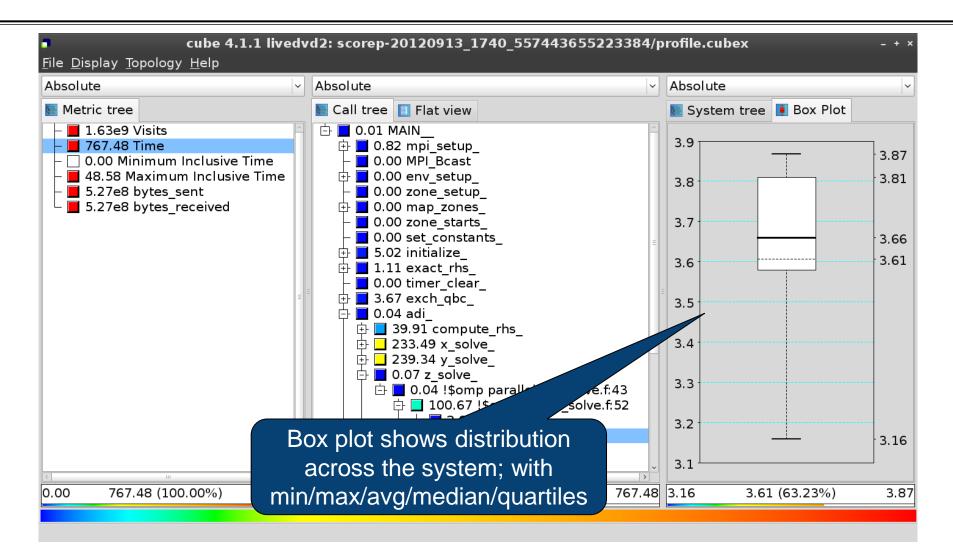
2	/home/geimer/Proje	cts/Tests/NPB3.3-MZ-MPI/	BT-MZ/solve_subs.f	×	
subroutine binvcrhs(lh c c	s,c,r)	-			
c c implicit none double precision pivot, dimension lhs(5,5) double precision c(5,5)		-		=	
<pre>cc c c</pre>	t	-	number info instrumentati	Note : depends on f ormation provi on, i.e., it may be available	ded by the
c(1,2) = c(1,2)*pivot c(1,3) = c(1,3)*pivot c(1,4) = c(1,4)*pivot • Read only	Save	Save as	Font	Close	

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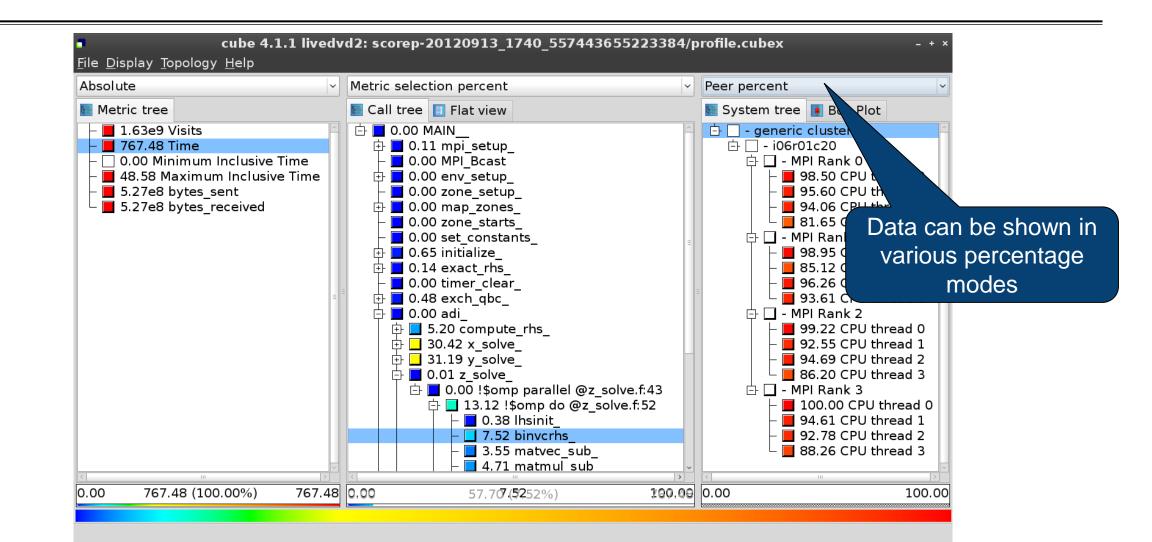
Flat profile view



Box plot view



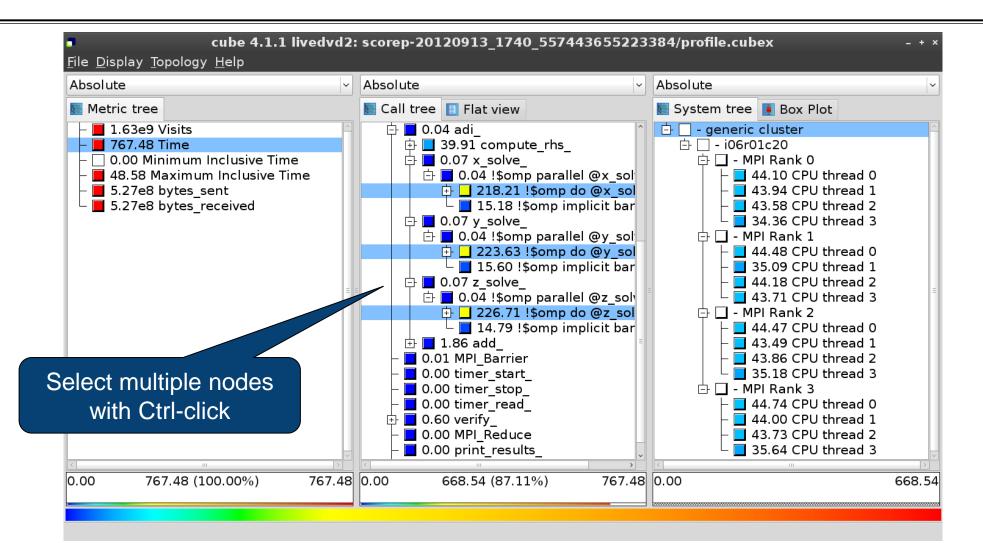
Alternative display modes



Important display modes

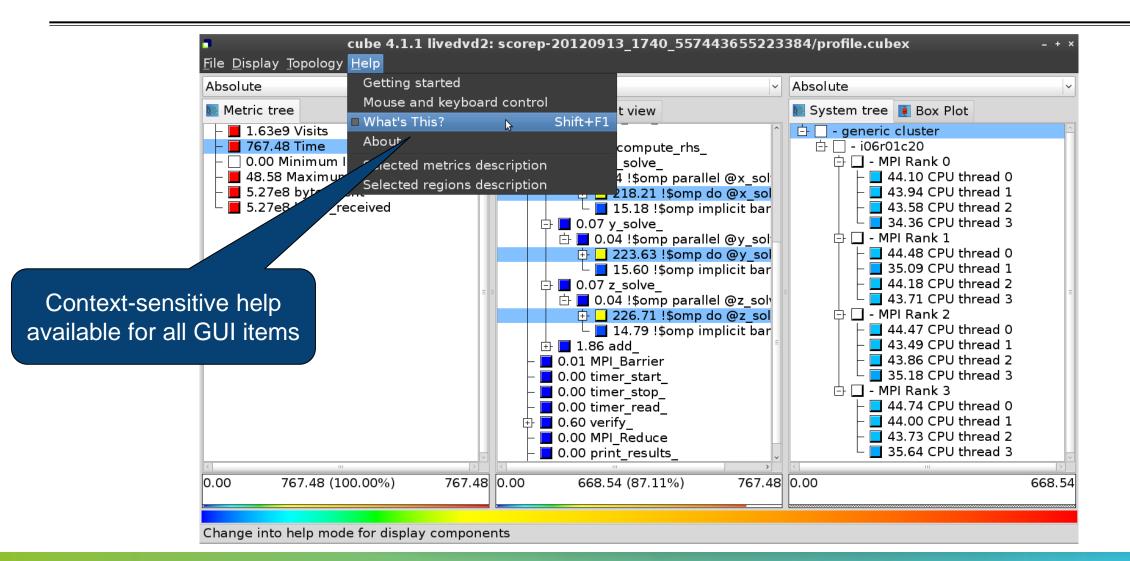
- Absolute
 - Absolute value shown in seconds/bytes/counts
- Selection percent
 - Value shown as percentage w.r.t. the selected node "on the left" (metric/call path)
- Peer percent (system tree only)
 - Value shown as percentage relative to the maximum peer value

Multiple selection

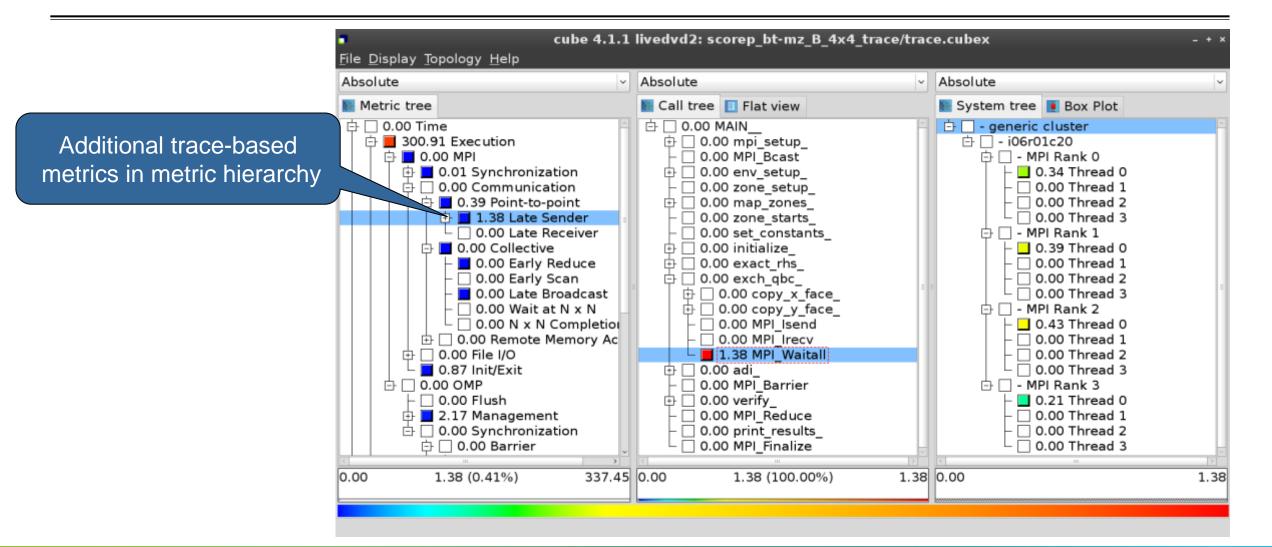


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Context-sensitive help

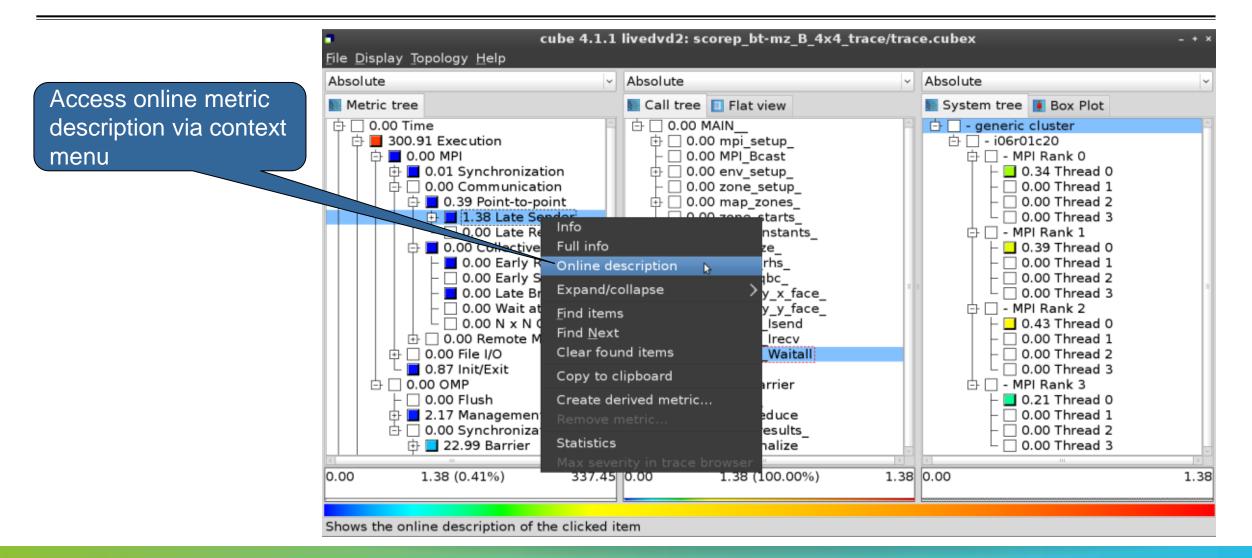


Post-processed trace analysis report

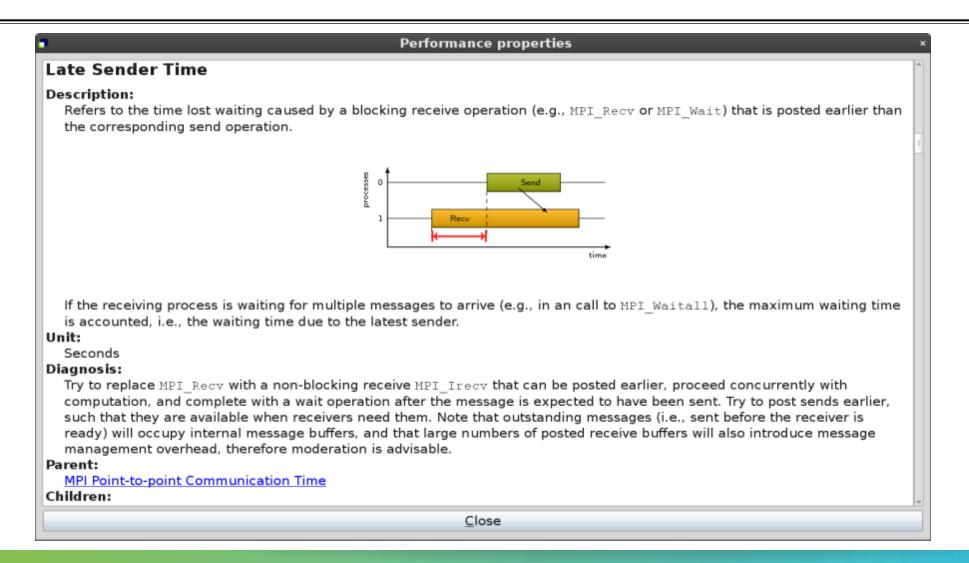


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Online metric description



Online metric description

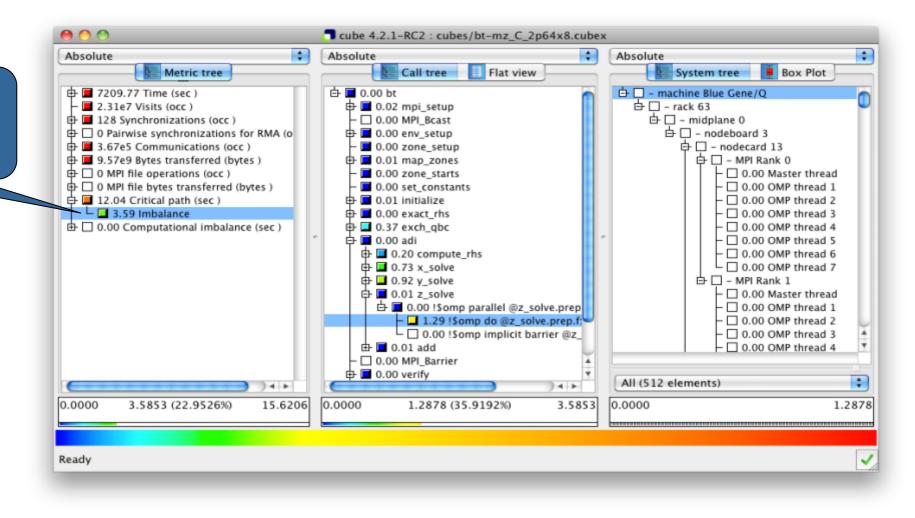


Critical-path analysis

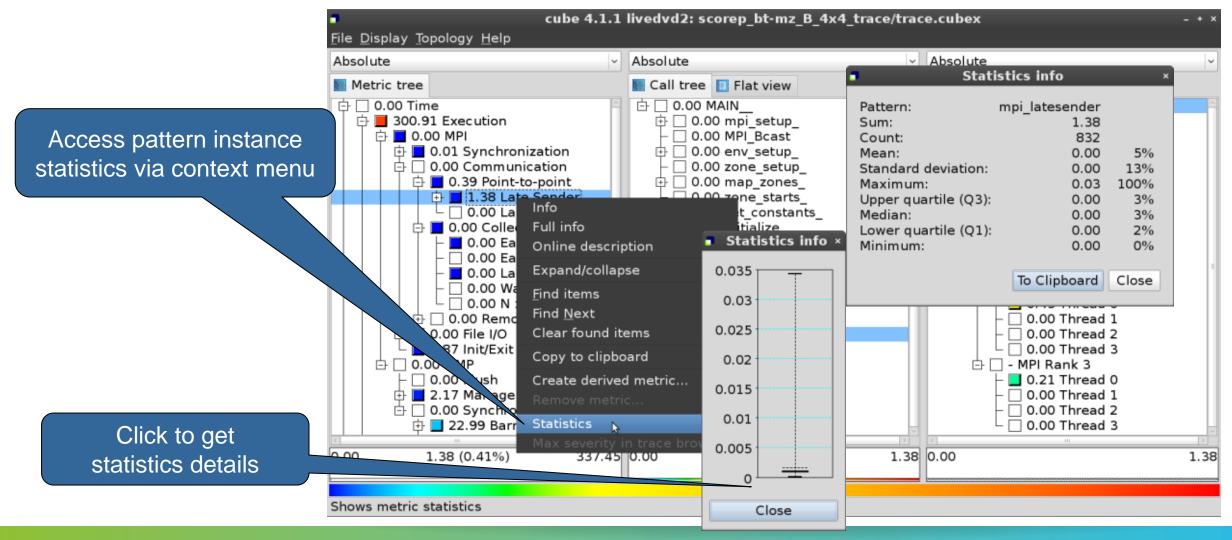
cube 4.2.1-RC2 : cubes/bt-mz C 2p64x8.cubex \$ • Absolute **†** Absolute Absolute Call tree Metric tree Flat view System tree Box Plot 由 📕 7209.77 Time (sec) 白 🗖 0.01 bt 🗄 🗌 – machine Blue Gene/Q 占 🗌 – rack 63 2.31e7 Visits (occ) 🖶 🔲 0.03 mpi_setup 占 🗆 – midplane 0 128 Synchronizations (occ) 0.00 MPI_Bcast Critical-path profile shows O Pairwise synchronizations for RMA (o 占 🗌 – nodeboard 3 🖶 🔲 0.00 env_setup 占 🗌 - nodecard 13 B 3.67e5 Communications (occ) 0.00 zone setup wall-clock time impact 占 🗆 – MPI Rank 0 🕀 📕 9.57e9 Bytes transferred (bytes) 🗗 🔲 0.01 map_zones O MPI file operations (occ) 0.00 zone_starts 0.00 Master thread O MPI file bytes transferred (bytes) 0.00 set constants 0.00 OMP thread 1 15.62 Critical path (sec) 0.04 initialize 0.00 OMP thread 2 0.00 Computational imbalance (sec) 🖶 🔲 0.02 exact_rhs 0.00 OMP thread 3 🕀 🖬 1.06 exch abc 0.00 OMP thread 4 🗗 🔲 0.02 adi - 🗌 0.00 OMP thread 5 1.49 compute_rhs 0.00 OMP thread 6 🕁 🗖 3.74 x solve - 🗌 0.00 OMP thread 7 🕀 💶 4.49 y solve 占 🗌 – MPI Rank 1 🗗 🗖 0.04 z_solve 0.00 Master thread 占 🔲 0.01 !\$omp parallel @z_solve.prep 0.00 OMP thread 1 - 4.49 !Somp do @z_solve.prep.f: 0.00 OMP thread 2 0.01 !\$omp implicit barrier @z 0.00 OMP thread 3 ¥ 由 🔲 0.13 add 0.00 OMP thread 4 0.00 MPI Barrier 🖶 🔲 0.02 verify All (512 elements) + 14 1 4.1 0.0000 15.6206 0.0000 15.6206 0.0000 15.6206 (100.0000%) 4.4934 (28.7656%) 4.4934 ~ Ready

Critical-path analysis

Critical-path imbalance highlights inefficient parallelism

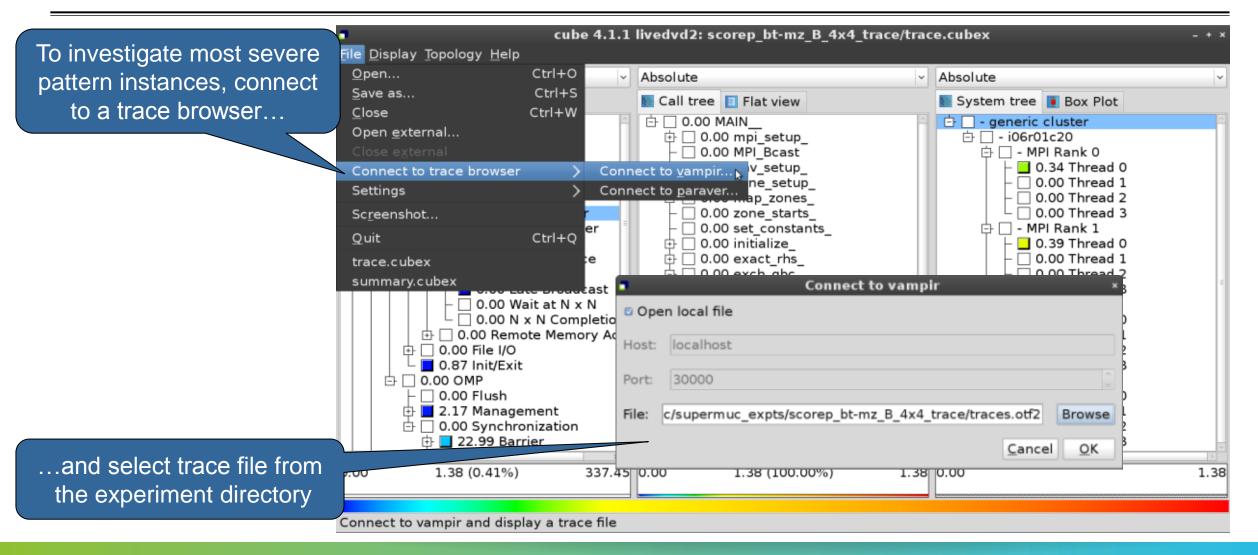


Pattern instance statistics



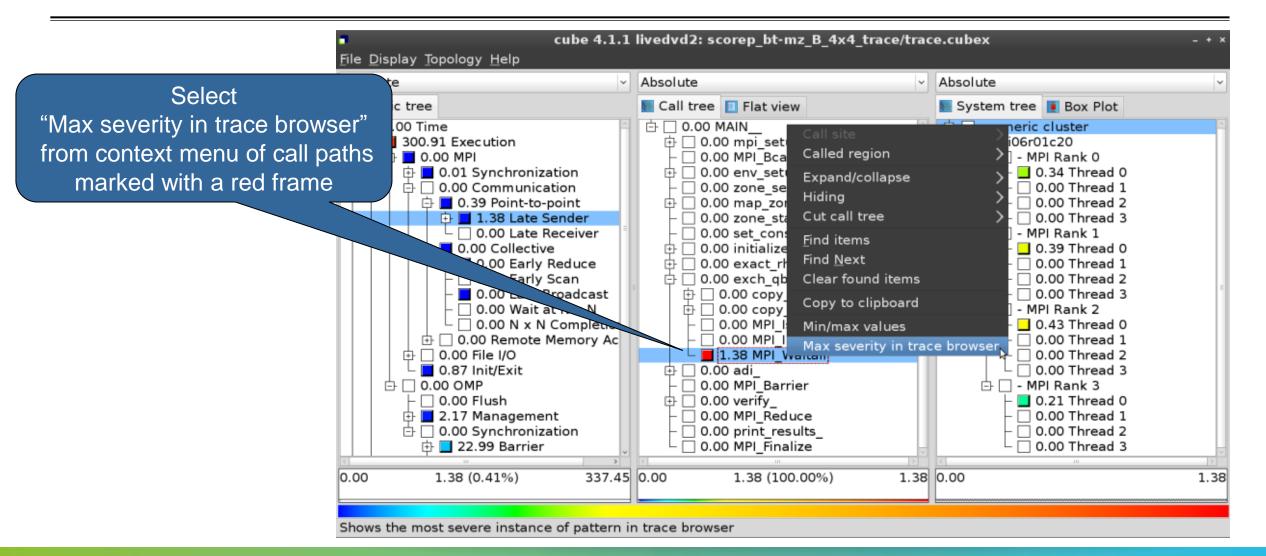
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Connect to Vampir trace browser

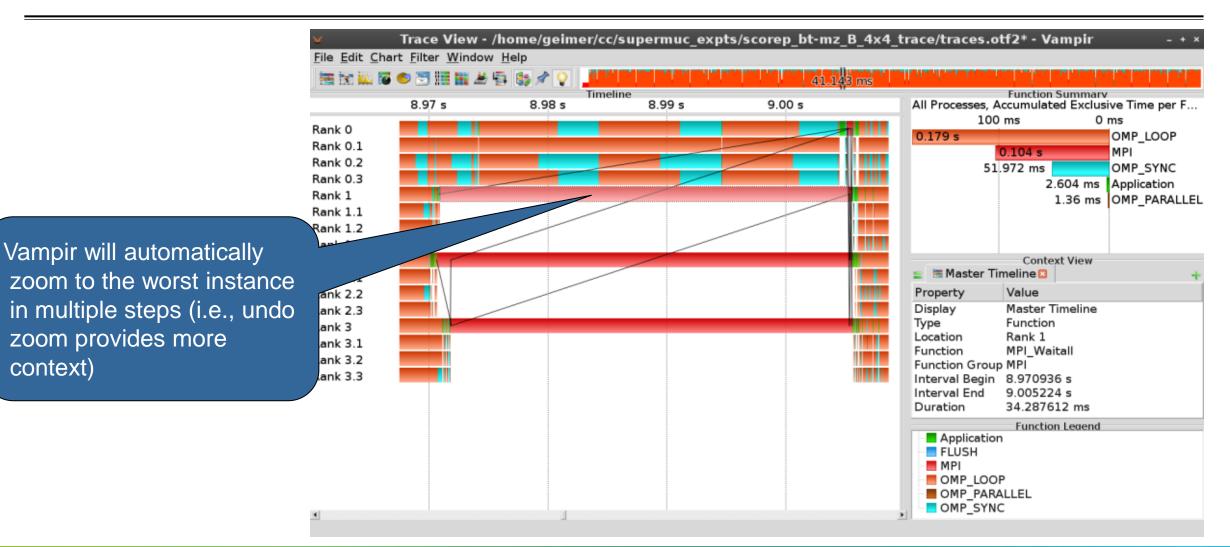


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Show most severe pattern instances



Investigate most severe instance in Vampir



Derived metrics

Derived metrics are defined using CubePL expressions, e.g.:

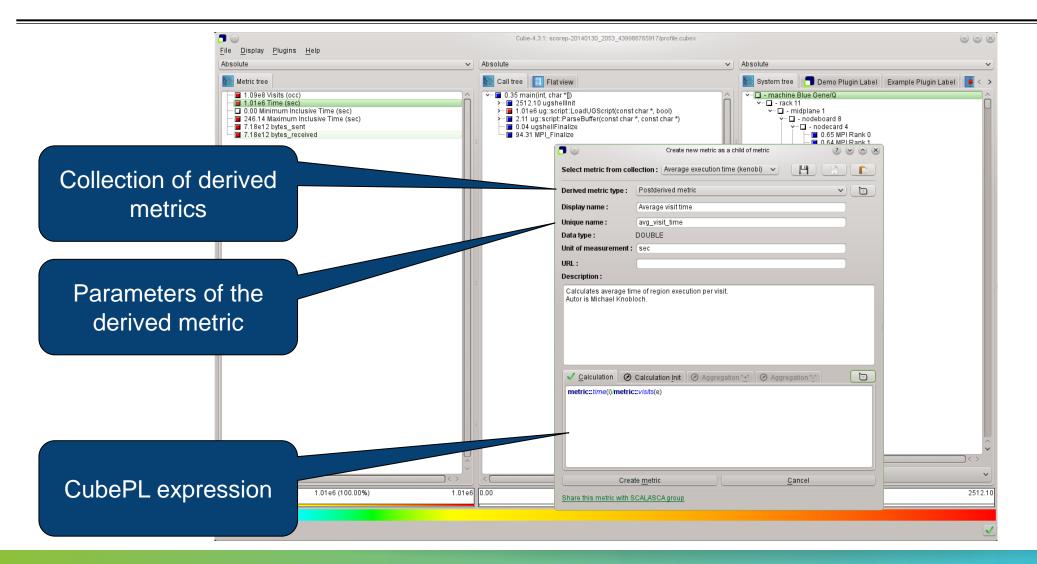
metric::time(i)/metric::visits(e)

- Values of derived metrics are not stored, but calculated on-the-fly
- Types of derived metrics:
 - Prederived: evaluation of the CubePL expression is performed before aggregation
 - Postderived: evaluation of the CubePL expression is performed after aggregation
- Examples:
 - "Average execution time": Postderived metric with expression

metric::time(i)/metric::visits(e)

 "Number of FLOP per second": Postderived metric with expression metric::FLOP()/metric::time() V VIRTUAL INSTITUTE - HIGH PRODUCTIVITY SUPERCOMPUTING

Derived metrics in Cube GUI



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Example: FLOPS based on PAPI_FP_OPS and time

	Cu	be-4.3.1: scorep_8x4_sum/profile.cubex (on froggy1)	×				
	<u>F</u> ile <u>D</u> isplay <u>P</u> lugins <u>H</u> elp						
	📗 Restore Setting 🔻 Save Settings						
Edit metric FLOPS (on froggv1)	Absolute	Absolute	Absolute				
Select metric from collection : please select 🗵 📳 🗈 💼	Metric tree	Call tree Flat view	System tree Barplot Heatmap Boy				
Derived metric type: Postderived metric	■ 1148.49 Time (sec)	■ ■ 7.04e5 mpi_setup_	e-□ - node frog6				
Display name : FLOPS	□ 0.00 Minimum Inclusive Time (sec)	■ 6.34e4 MPI_Bcast	□ - MPI Rank 0				
Unique name : flops	■ 41.57 Maximum Inclusive Time (□ 0 bytes put (bytes)	■ 2.05e5 env_setup_ ■ 7.39e5 zone setup	□ □ 1.17e9 Master thread □ □ 9.43e8 OMP thread 1				
Data type : DOUBLE	□ 0 bytes_put (bytes)	■ ■ 9.31e5 map_zones_	9.43e8 OMP thread 2				
Unit of measurement :	- ■ 5.75e12 PAPI TOT INS (#)	- 9.39e4 zone starts	9.47e8 OMP thread 3				
URL :	□ 2.69e12 PAPI TOT CYC (#)	□ 0.16e5 set constants	□ - MPI Rank 1				
Description :	■ 2.12e12 PAPI FP OPS (#)	■ 5.91e8 initialize	□ □ 1.17e9 Master thread				
	■ 3.12e9 bytes sent (bytes)	□ □ 0.00 exact rhs	9.87e8 OMP thread 1				
	■ 3.12e9 bytes_received (bytes)	□ ■ 145.62 !\$omp parallel @exac	■ 9.68e8 OMP thread 2				
	□ 1.84e9 FLOPS		9.72e8 OMP thread 3				
		9.65e8 !\$omp do @exact_r	🖻 🗆 - MPI Rank 2				
		⊕ 🖬 9.62e8 !\$omp do @exact_r	□ 1.10e9 Master thread				
		🗉 🖬 8.14e8 !\$omp do @exact_r	- ■ 8.97e8 OMP thread 1				
✓ <u>Calculation</u> ⊘ Calculation Init ⊘ Aggregation " <u>+</u> " ⊘ Aggregation " <u>-</u> "		-■ 1.21e5 !\$omp do @exact_r	■ 8.77e8 OMP thread 2				
metric::PAPI_FP_OPS()/metric::time()		□ 0.00 !\$omp implicit barrier	■ 8.76e8 OMP thread 3				
			🖻 🗆 - MPI Rank 3				
		🗉 🖬 1.94e9 adi_	1.09e9 Master thread				
		■ 2.19e5 MPI_Barrier	■ 9.06e8 OMP thread 1				
		■ ■ 1.92e9 < t_iter>> (200 itera	■ 9.04e8 OMP thread 2				
		■ ■ 1.98e8 verify_	9.02e8 OMP thread 3				
Edit <u>m</u> etric <u>C</u> ancel		□ □ 1.05e5 MPI_Reduce					
Share this metric with SCALASCA group			All (32 elements)				
Share all means man Scalabora group	0.00 1.84e9 (100.00%) 1.84	e9 0.00 9.65e8 (-0.00%) -12858016489314434.00	0.00179769313486231570814527423731704356798070				
	Selected "!\$omp do @exact_rhs.f:46"		•				

CUBE algebra utilities

Extracting solver sub-tree from analysis report

% cube_cut -r '<<ITERATION>>' scorep_bt-mz_B_mic15p30x4_sum/profile.cubex Writing cut.cubex... done.

Calculating difference of two reports

% cube_diff scorep_bt-mz_B_mic15p30x4_sum/profile.cubex cut.cubex
Writing diff.cubex... done.

- Additional utilities for merging, calculating mean, etc.
- Default output of cube_utility is a new report utility.cubex
- Further utilities for report scoring & statistics
- Run utility with `-h' (or no arguments) for brief usage info

Iteration profiling

Show time dependent behavior by "unrolling" iterations

Preparations:

Mark loop body by using Score-P instrumentation API in your source code

```
SCOREP_USER_REGION_DEFINE( scorep_bt_loop )
SCOREP_USER_REGION_BEGIN( scorep_bt_loop, "<<bt_iter>>", SCOREP_USER_REGION_END( scorep_bt_loop )
```

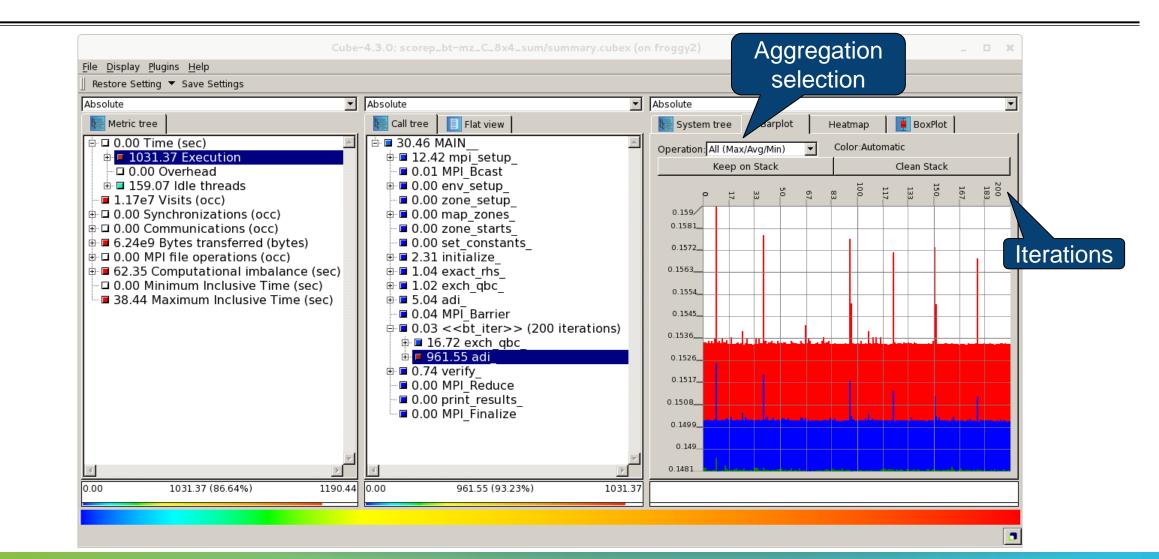
- Result in the Cube profile:
 - Iterations shown as separate call trees
 - Useful for checking results for specific iterations

or

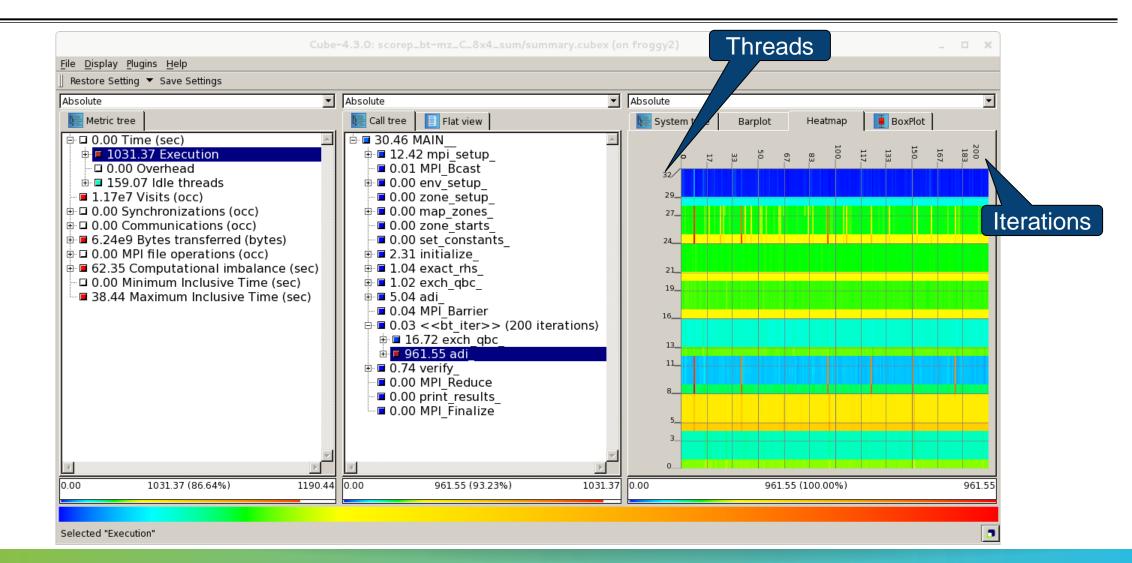
- Select your user-instrumented region and mark it as loop
- Choose "Hide iterations"
- > View the Barplot statistics or the (thread x iterations) Heatmap

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Iteration profiling: Barplot



Iteration profiling: Heatmap



Cube: Further information

- Parallel program analysis report exploration tools
 - Libraries for XML report reading & writing
 - Algebra utilities for report processing
 - GUI for interactive analysis exploration
- Available under 3-clause BSD open-source license
- Documentation & sources:
 - http://www.scalasca.org
- User guide also part of installation:
 - `cube-config --cube-dir`/share/doc/CubeGuide.pdf
- Contact:
 - mailto: scalasca@fz-juelich.de

