Threading Performance Measurements with VTune



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VTune is an Intel performance measurement system

Can measure

Concurrency efficiency Cross threads locks and waits CPU hardware counters GPU performance

Can do measurements from the GUI or command line tool Data generated by command line tool can be read into the GUI for analysis

OpenLab has a cross CERN license https://twiki.cern.ch/twiki/bin/view/Openlab/IntelTools#Intel_Parallel_Studio_XE_201_ANI



VTune did not work 'out of the box' on cmsRun

Steps needed to work

Had to use most recent VTune beta older releases all had assertion failures /afs/cern.ch/sw/IntelSoftware/linux/x86_64/xe2016/vtune_amplifier_xe_2016.1.0.424694 Tell VTune to ignore processes started by ROOT

Tell VTune to ignore processes started by ROOT -strategy=ld-linux.so.2:nt:nt,ld-linux-x86-64.so.2:nt:nt VTune is unable to instrument these processes

Had to enable signal 38

Problem seen

GUI sometimes only shows measurements from some of the threads Do not know if failure was during data collection or in viewing





VTune configuration concurrency measurement skip first 5 minutes of job sample every 100us unlimited data collection size



VTune GUI

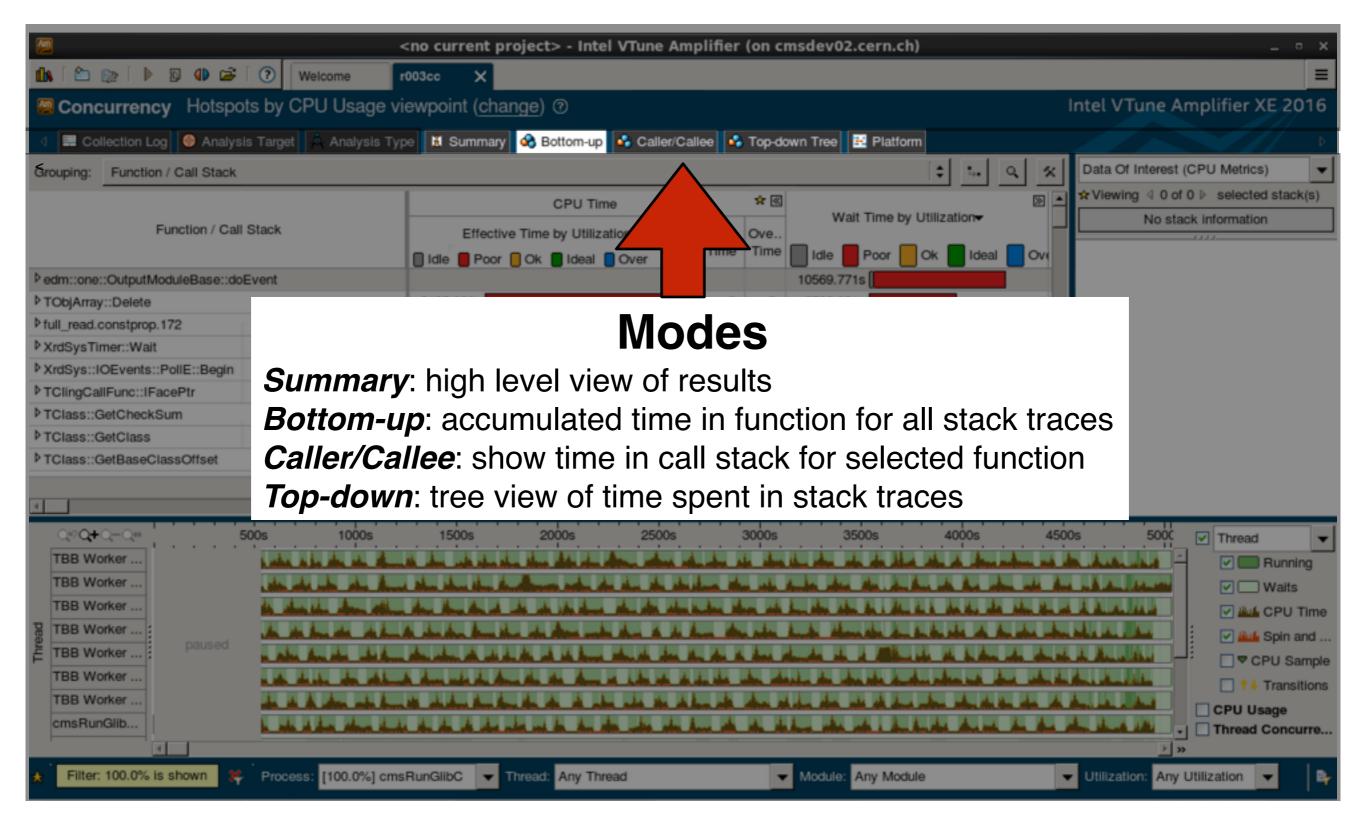


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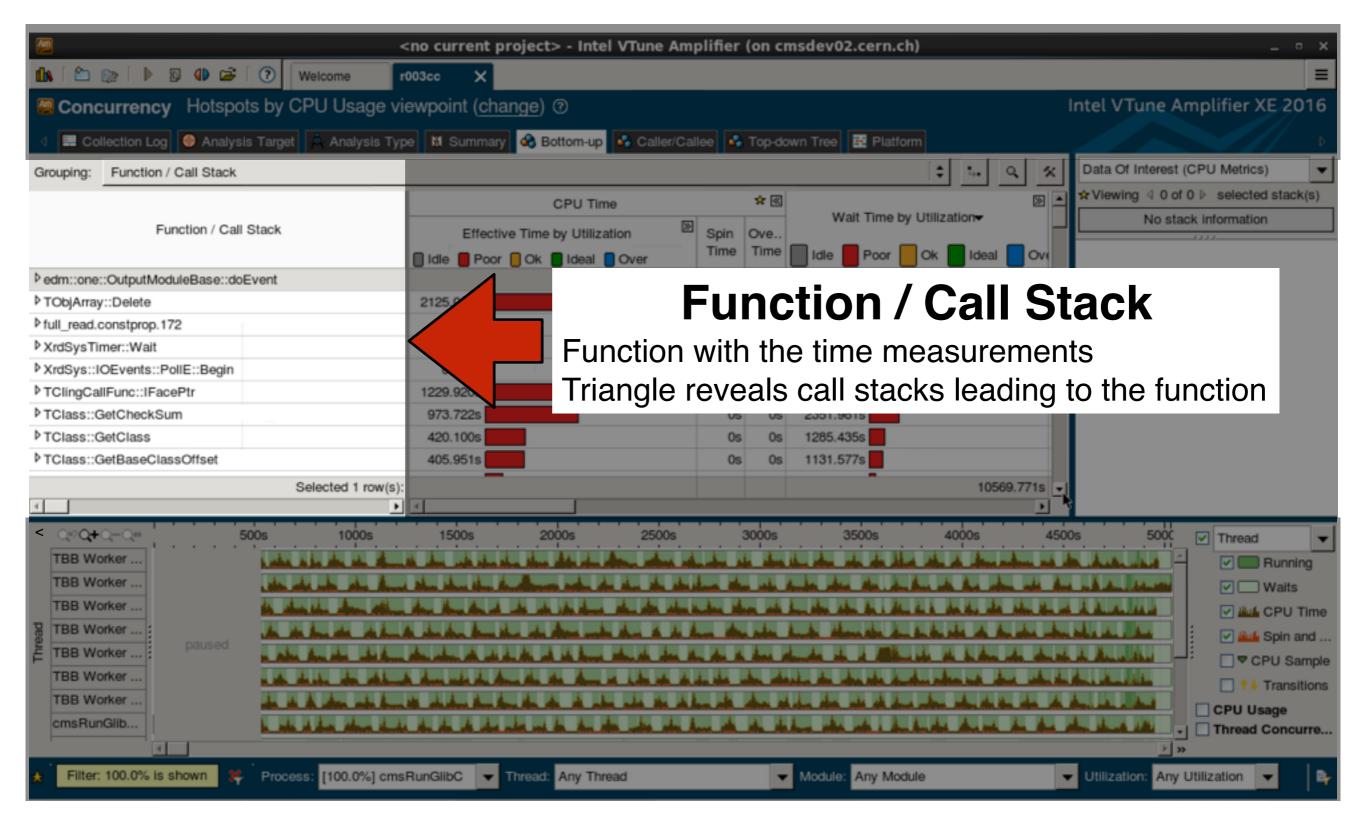






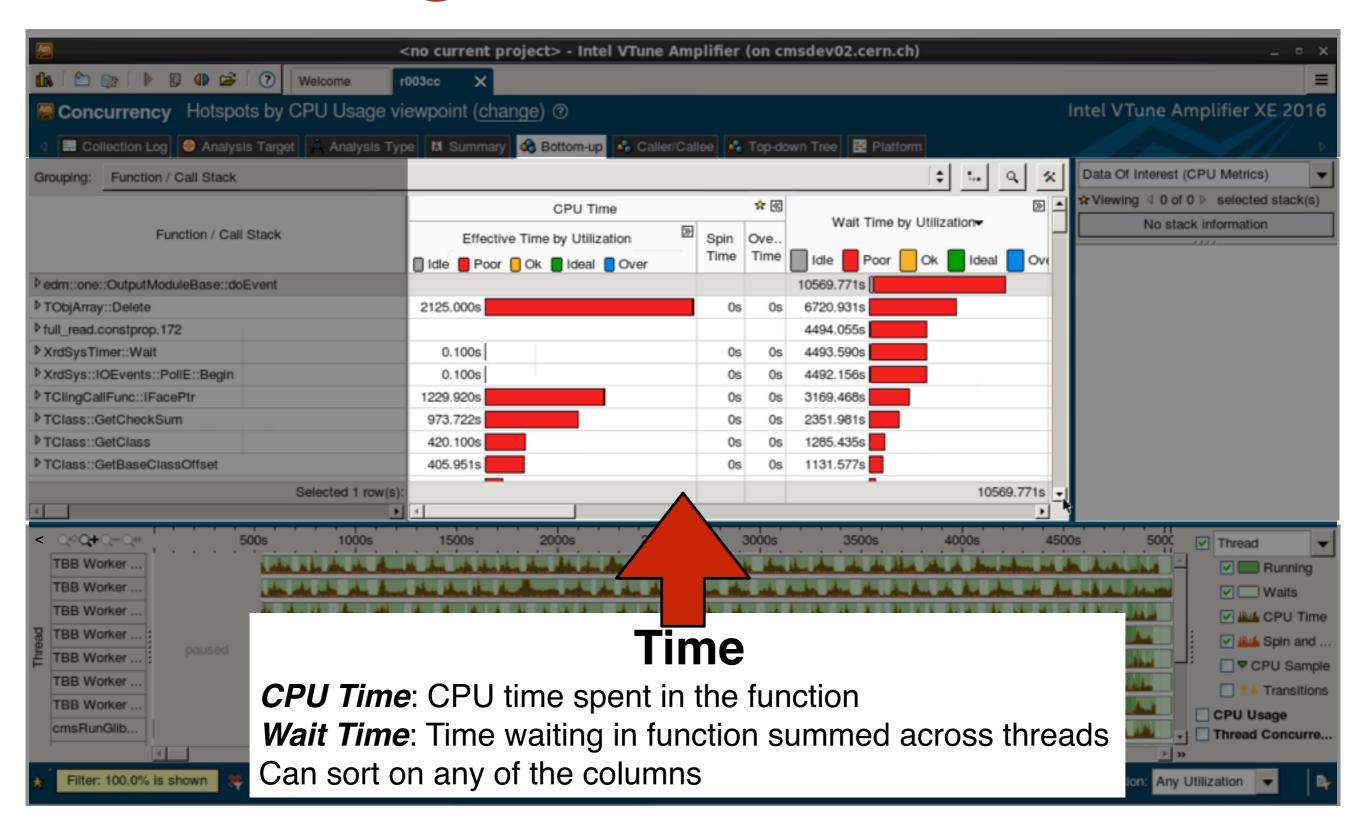






VTune GUI

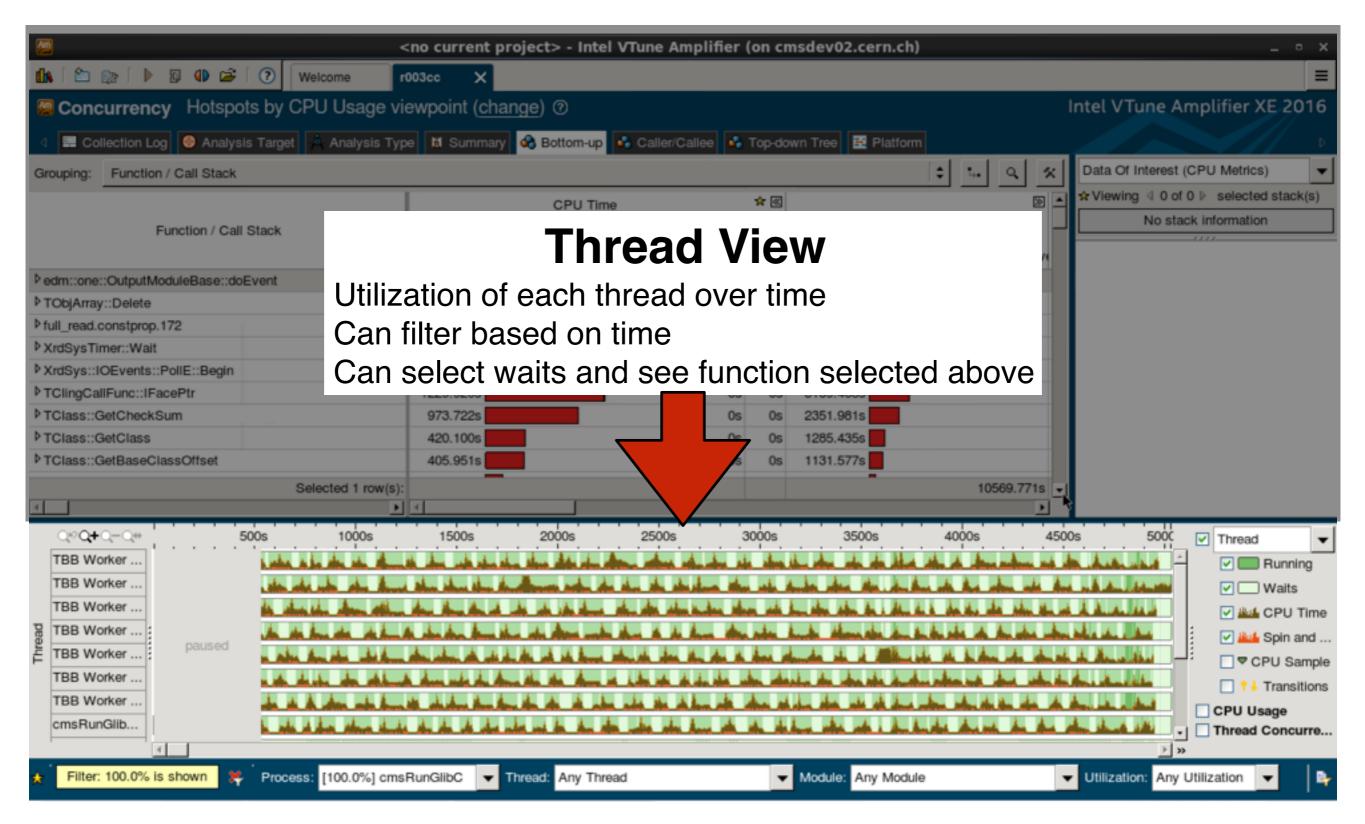




Measurements with VTune





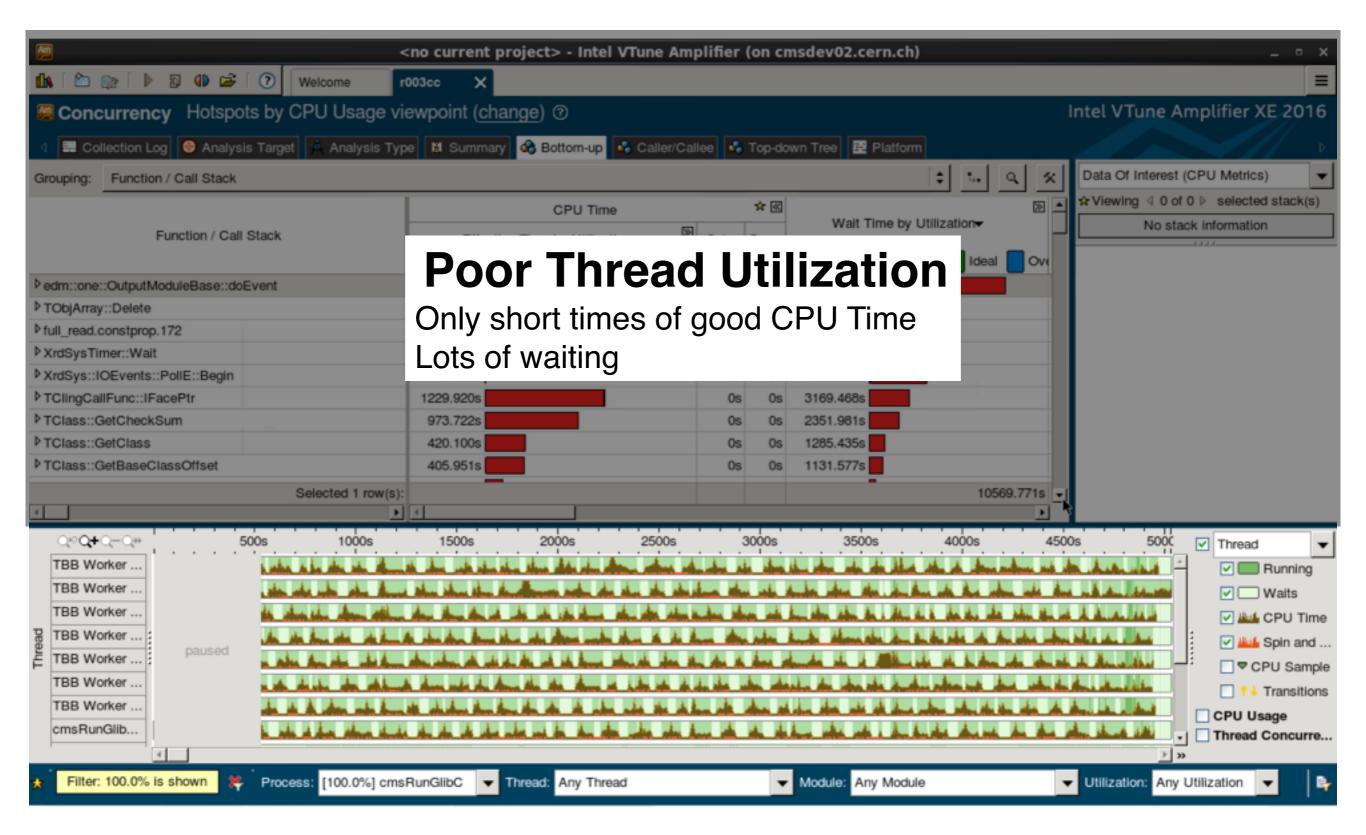


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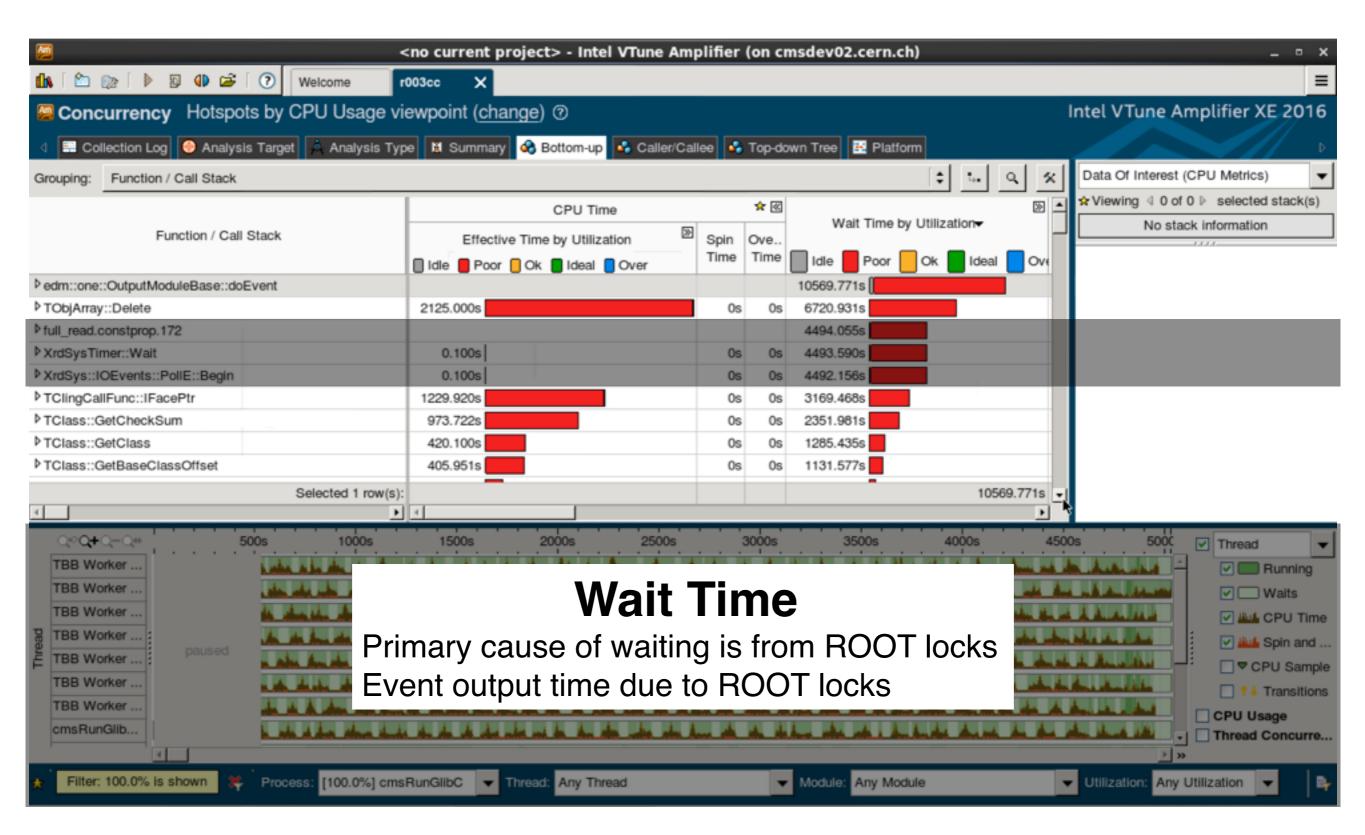
Measurements with VTune

Initial Measurement



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Measurements with VTune



CMS

Waiting on TFormula A new TFormula made each time a jet correction was called

Waiting on ROOT calls from cut parser Calling functions via the ROOT interface used always took a lock

Waiting on output I/2 time waiting to talk to a particular instance of output module I/2 minutes waiting on ROOT lock during TTree::Fill Vast majority from TClass::GetCheckSum

Philippe Canal made changes to ROOT to reduce lock use TFormula copying should avoid taking locks Calling TTree::Fill will avoid most locks Decreasing the cost of using ROOT to find base class offsets

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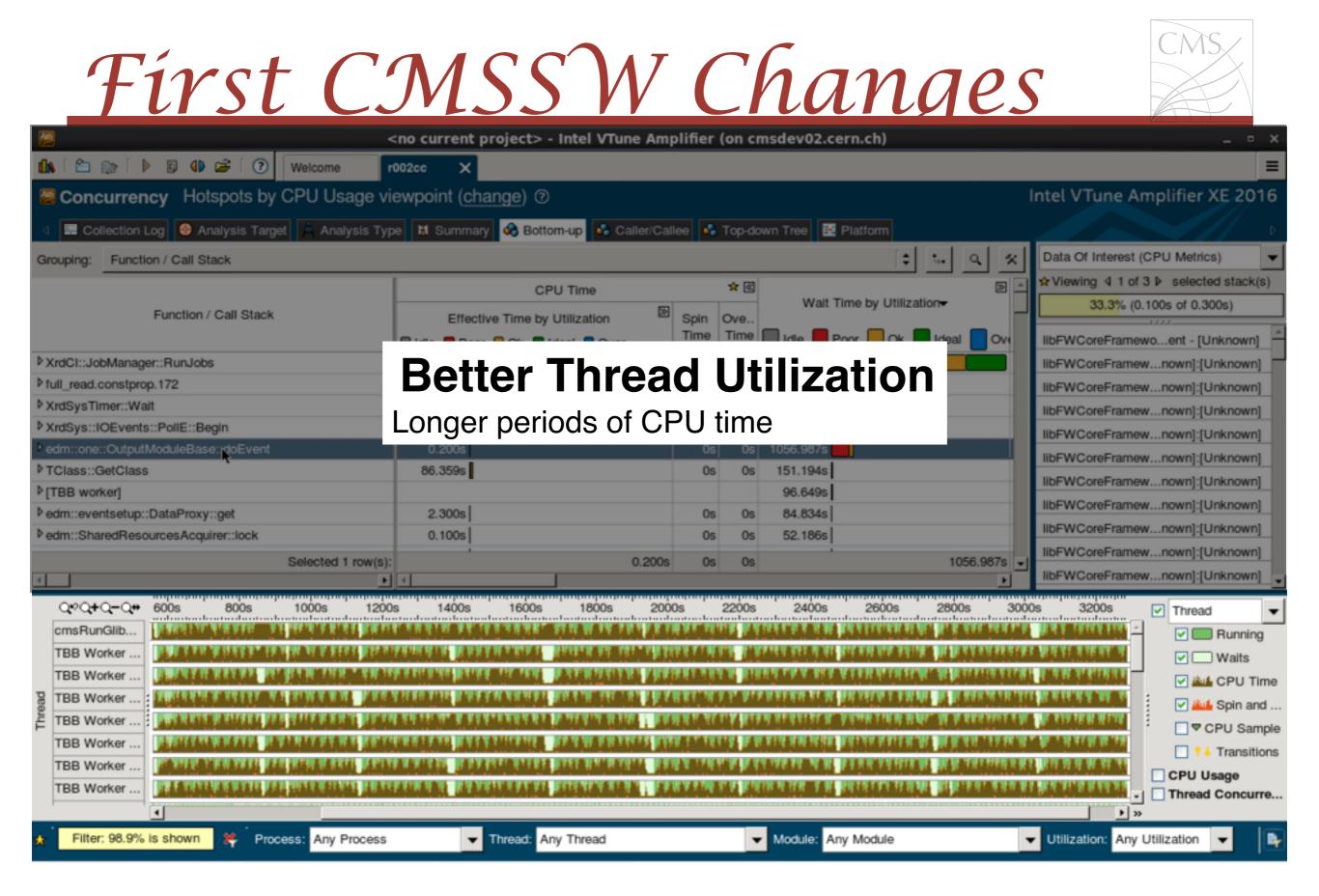


Cut parser changes needed

Philippe Canal added API to TMethod to allow caching of function pointer from cling

TFormula changes were insufficient Problem mitigated in ROOT 6.04 with new TFormula implementation Replaced with a hand made parser and executor handles a subset of TFormula expressions fully stateless parser and executor so extremely thread efficient

small memory footprint



First CMSSW Changes

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Measurements with VTune

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TBB time from calls to SerialTaskQueue CMS class meant to protect a resource from simultaneous access

SerialTaskQueue inappropriately used in an 'event' data class Class was doing a lazy evaluation of elements in its container First request for each item put task into the SerialTaskQueue Code wasn't actually thread safe anyway other pieces of code were accessing the container outside of the SerialTaskQueue

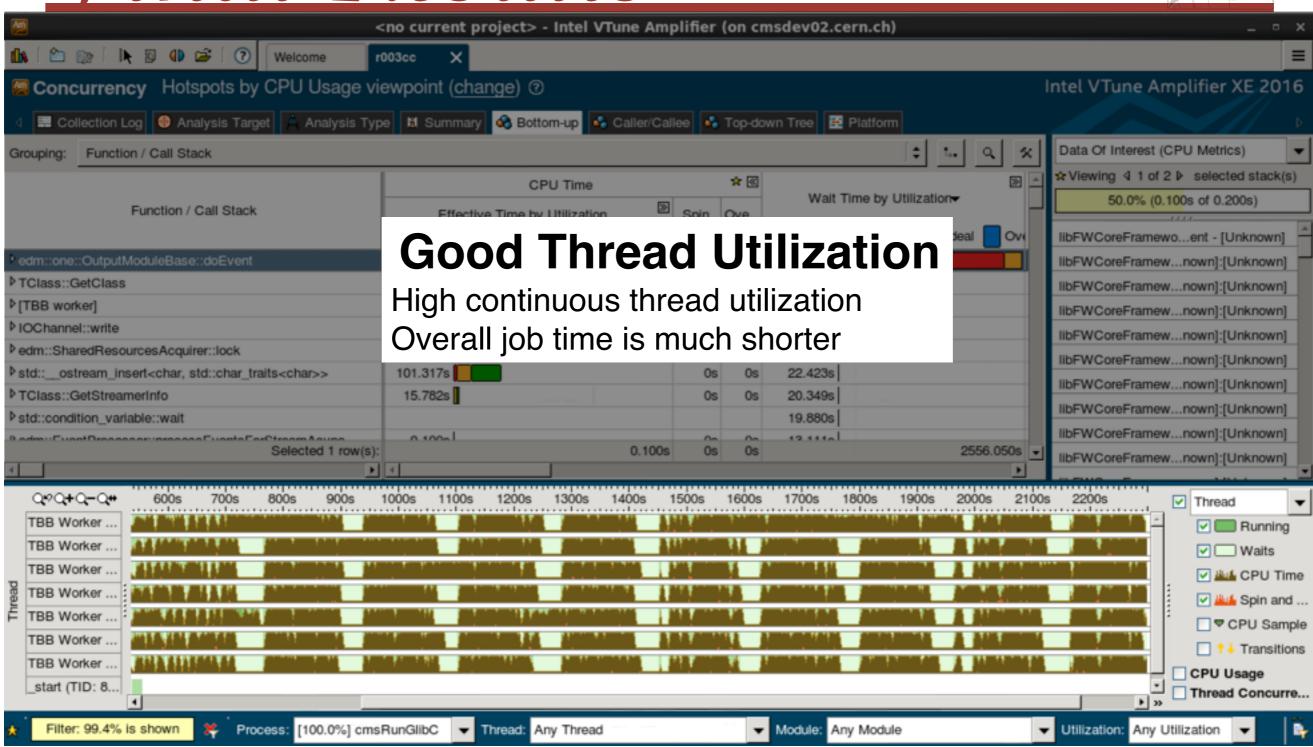
Change: remove the use of SerialTaskQueue Removing the lazy evaluation had no impact on performance the code had been prematurely optimized

Final Results

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Measurements with VTune

Final Results



Final Results

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Measurements with VTune

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Full CMSSW threading framework implementation Switching to TBB task per module will work around output module If event 1 is running the output module event 2 could run a different module

Work on output module to make more thread efficient Decrease time in a single thread Look into utilizing multiple threads when compressing buffers





The value VTune gives for 'concurrency' does not correspond to timing measurements of program

VTune much more pessimistic

Increased VTune concurrency does correspond to real world speedups

Program Changes	Speedup	Regular Job Time (s)		VTune Job Time (s)
Initial	5.5	1826	2.1	16440
ROOT	5.7	1748	2.6	9884
CMSSW I	6. I	1641	7.2	3363
Final	6.2	1605	5.0*	2429

* fraction of the job was in the end of job single threaded part. GUI histogram of thread utilizations showed most time spent at 7 cores active with second most at 1.

Conclusion



VTune is a useful tool It is capable of running on HEP frameworks It does identify code that hampers threading performance

Not without its problems Sometimes fails to report work done on some threads Data gathering appears to strongly affect job running time and distort findings

The problems are not sufficient to stop me from using VTune

