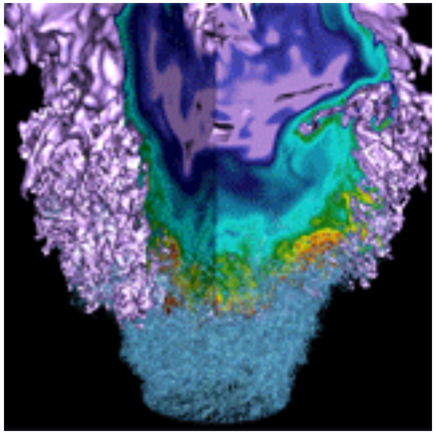
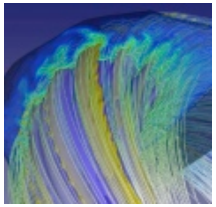
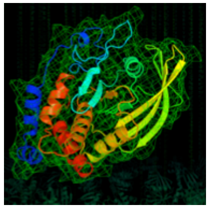
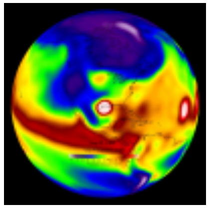
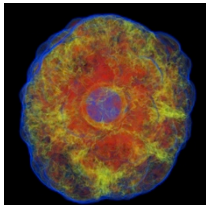
Profiling your application with Intel VTune at NERSC

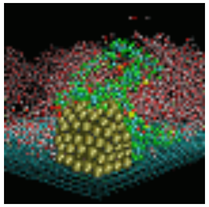












VTune background and availability

- **Focus: On-node performance analysis**
  - Sampling and trace-based profiling
  - Performance counter integration
  - Memory bandwidth analysis
  - On-node parallelism: vectorization and threading
- **Pre-defined analysis experiments**
- **GUI and command-line interface (good for headless collection and later analysis)**
- **NERSC availability (as the `vtune` module)**
  - Edison (Dual 12-core Ivy Bridge)
  - Babbage (Dual 8-core Sandy Bridge + Dual Xeon Phi)

Running VTune on Edison I

- **Use the Cray `cc` or `ftn` wrappers for the Intel compilers**
- **Suggested compiler flags:**
  - `-g` : enable debugging symbols
  - `-O2` : use production-realistic optimization levels (not `-O0`)
- **To use VTune on Edison, you have to:**
  - Run within a CCM job (batch or interactive)
  - Use dynamic linking if profiling OpenMP code (`-dynamic`)
  - Use a working directory on a Lustre $SCRATCH filesystem

```
edison09:BGW > ftn -dynamic -g -O2 -xAVX -openmp bgw.f90 -
o bgw.x
edison09:BGW > mkdir $SCRATCH/vtune-runs
edison09:BGW > cp bgw.x $SCRATCH/vtune-runs/
edison09:BGW > cd $SCRATCH/vtune-runs/
edison09:vtune-runs > qsub -I -q ccm_int -l mppwidth=24
 wait ...
```

Running VTune on Edison II

- **Once you're in a CCM job (either interactive or batch script)**
  - cd to your submission directory
  - Launch VTune to profile your code <u>on a compute node</u> with `aprun`

```
CCM Start success, 1 of 1 responses
nid02433:~ > cd $PBS_O_WORKDIR
edison09:vtune-runs > module load vtune
nid02433:vtune-runs > aprun -n 1 amplxe-cl -collect
experiment_name -r result_dir -- ./bgw.x
```

- `amplxe-cl` **is the VTune CLI**
  - `-collect` : specifies the collection experiment to run
  - `-r` : specifies an output directory to save results
- **Set** `OMP_NUM_THREADS` **and associated** `aprun` **options (**`-d`**,** `-S`**,** `-cc depth`**,** `-cc numa_node`**) as needed**
- **Results can be analyzed by launching** `amplxe-gui` **and navigating to the result directory (preferably in NX)**

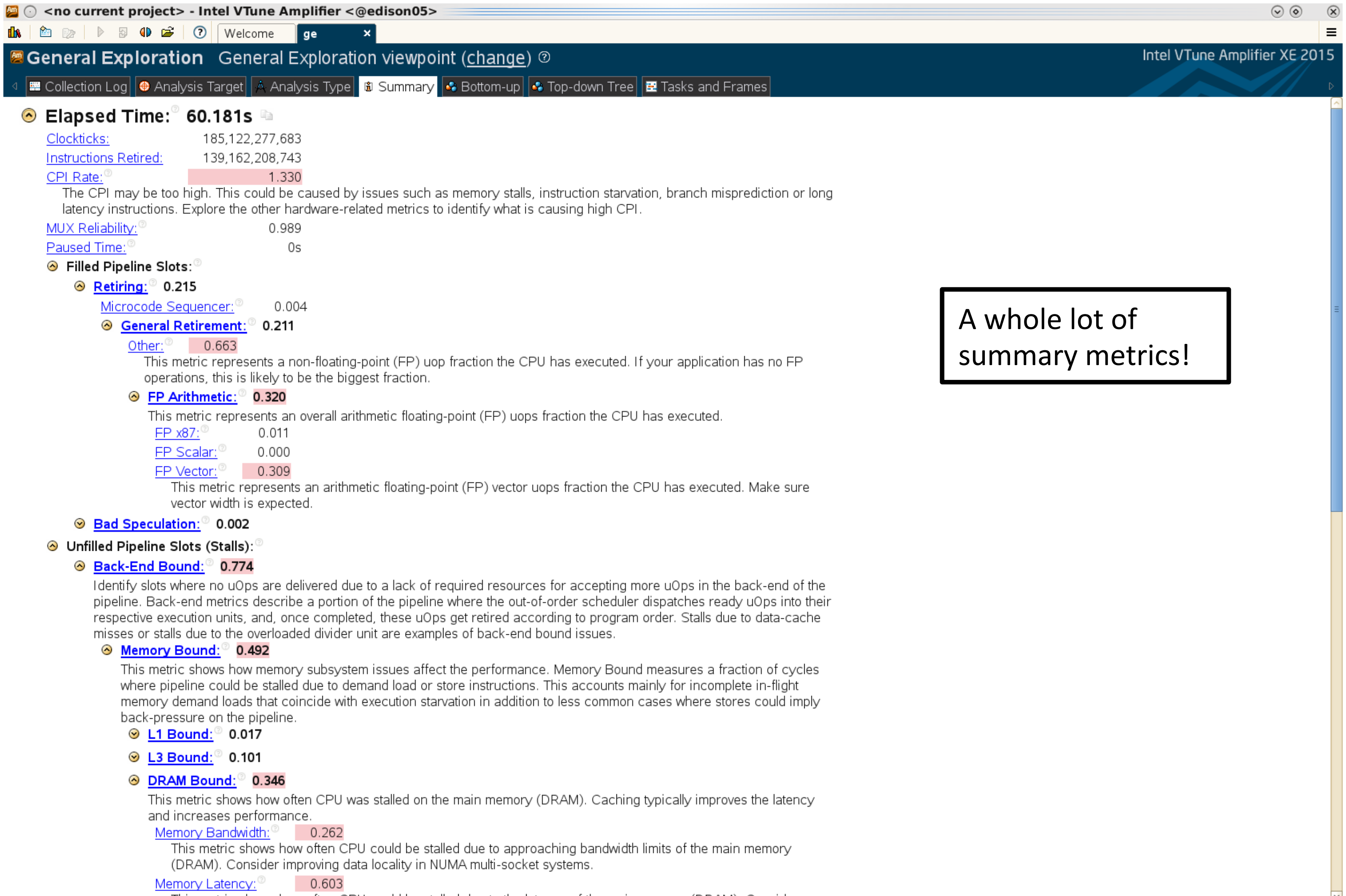
Experiments: General exploration

- **Available on Edison and Babbage (SNB + Xeon Phi)**

```
nid02433:vtune-runs > aprun -n 1 amplxe-cl -collect gener
al-exploration –r ge_results -- ./bgw.x
```

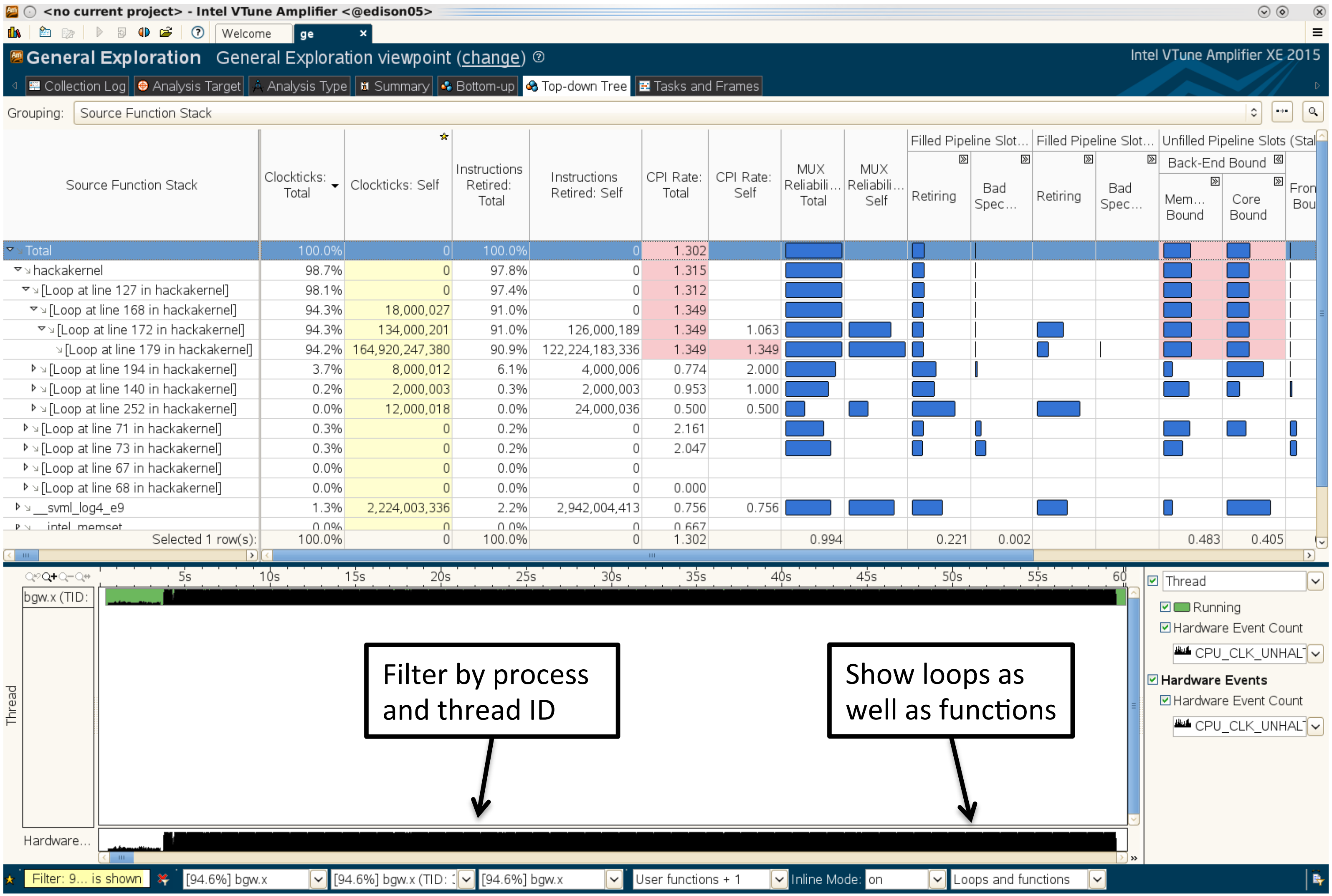
- **Detailed characterization of relevant performance metrics throughout your application**
  - Default: low-level detail aggregated into summary metrics
    - Mouse-over for explanation of their significance
    - Can be used to characterize locality issues, poor vectorization, etc.
- **Multiple "viewpoints" available:**
  - Direct access to hardware event counters
  - Spin / sync overhead for OpenMP threaded regions

Experiments: General exploration



A whole lot of summary metrics!

Experiments: General exploration



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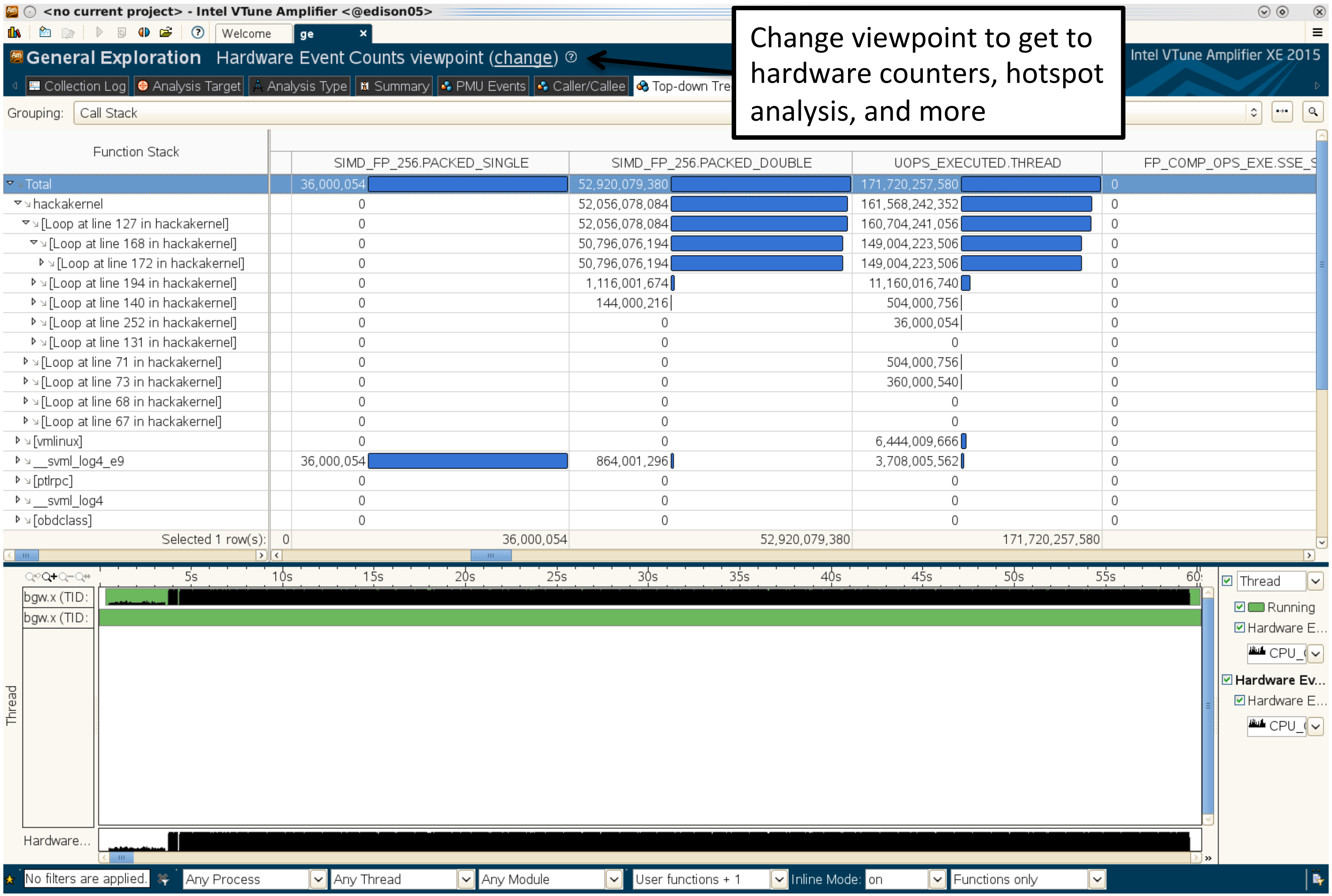
Experiments: General exploration



Change viewpoint to get to hardware counters, hotspot analysis, and more

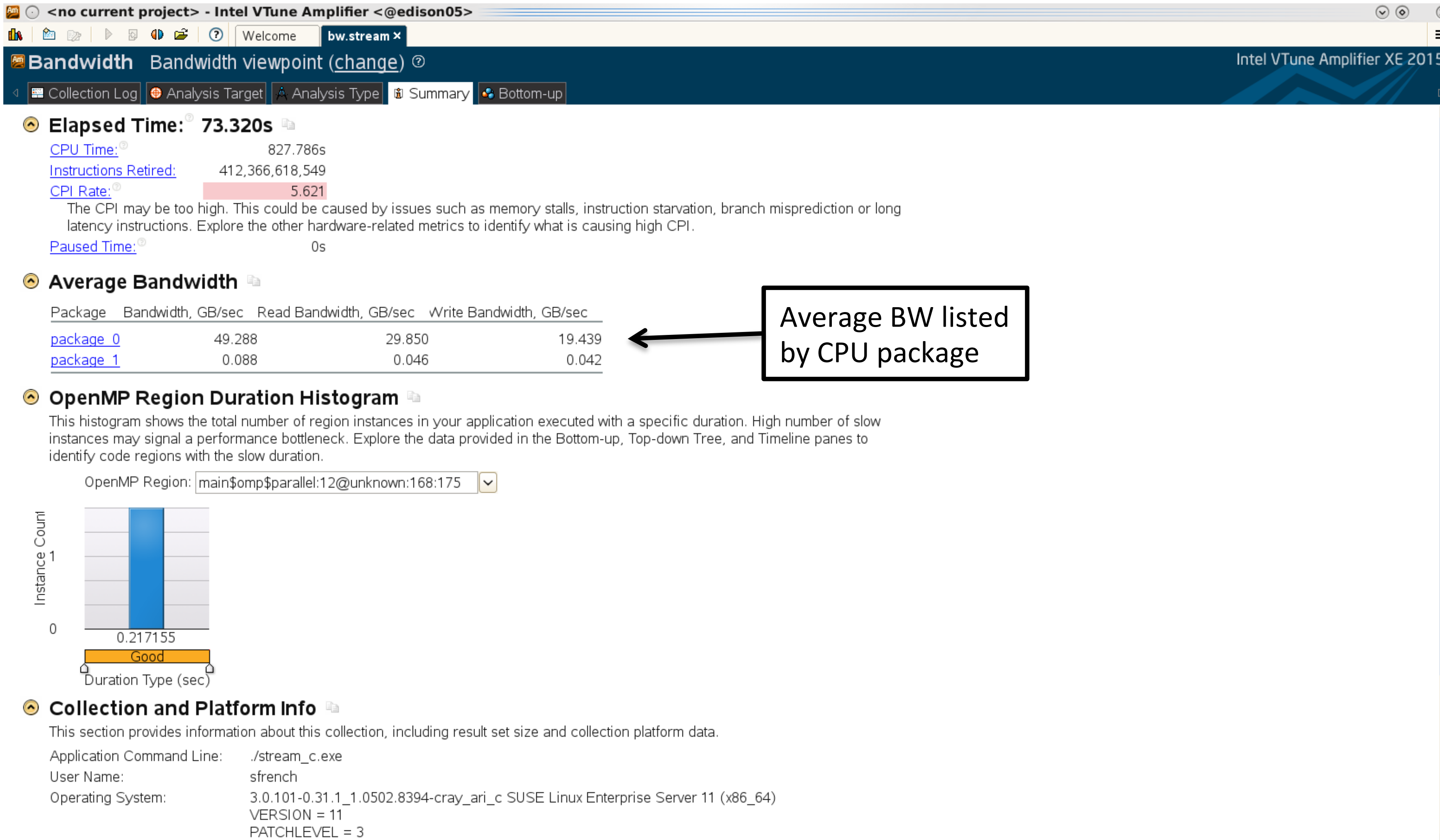
Experiments: Memory bandwidth

- **Available on Edison and Babbage (Xeon Phi only)**
  - **Caveat**: avoid Babbage SNB for now (node will lock up)

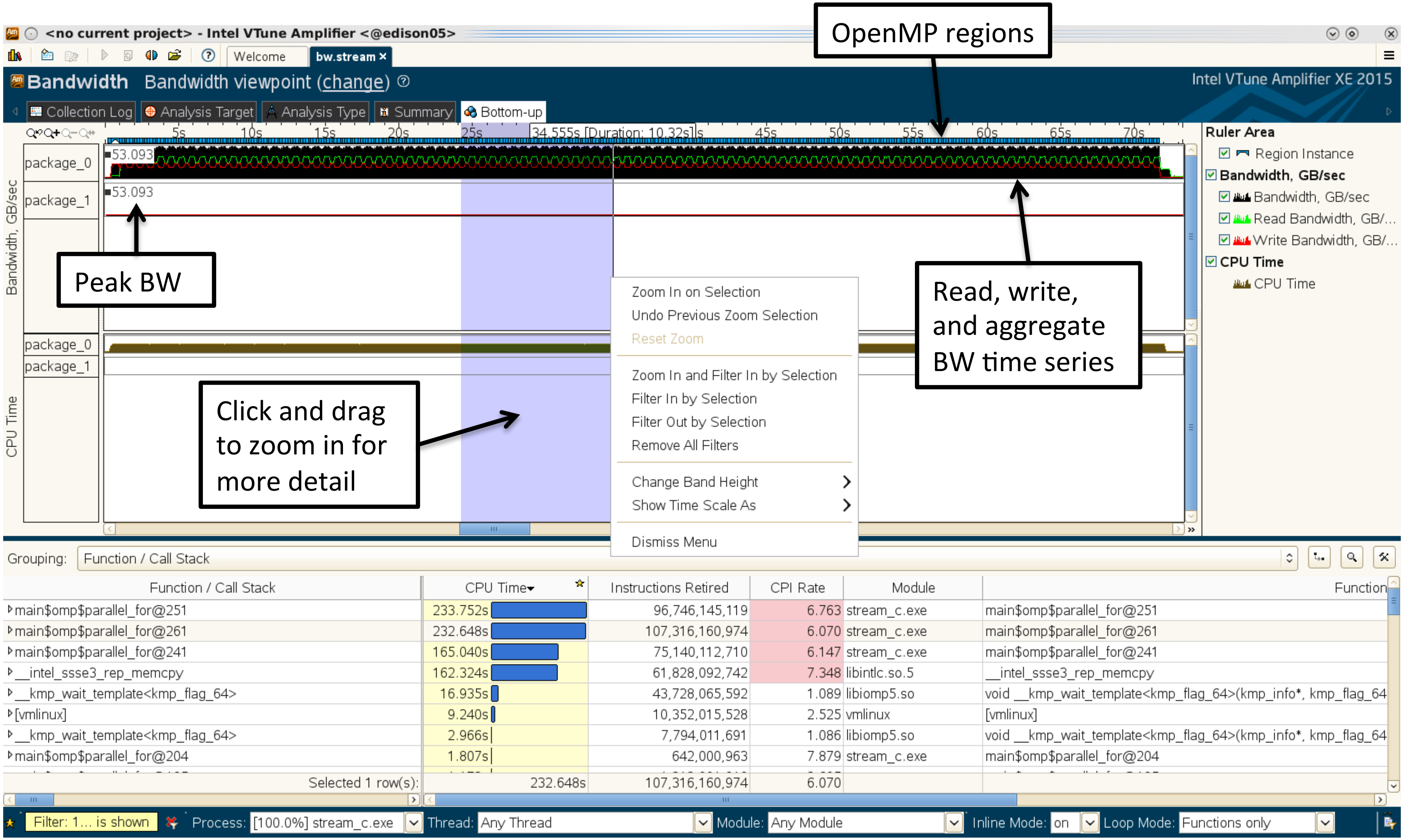
```
nid02433:vtune-runs > aprun -n 1 amplxe-cl –collect bandwi
dth –r bw_results -- ./bgw.x
```

- **Gives DRAM read / write traffic as a function of time during program execution**
- **Useful to first calibrate with a well-understood code on the same platform (e.g. `STREAM`)**
- **Can help determine whether your code is at least partially (effectively) BW bound**

Experiments: Bandwidth



Experiments: Bandwidth



More resources

- **At NERSC**
  - On our debugging and profiling tools pages: http://www.nersc.gov/users/software/debugging-and-profiling/vtune/
  - More details on how to run your analysis on both the Edison compute nodes and the Babbage Xeon Phis
  - Pointers to materials from previous NERSC trainings
- **At Intel**
  - Main documentation for 2015 version: https://software.intel.com/en-us/node/529213
  - Detailed descriptions of the various experiment types
  - Pointers to tutorials on specific topics or platforms