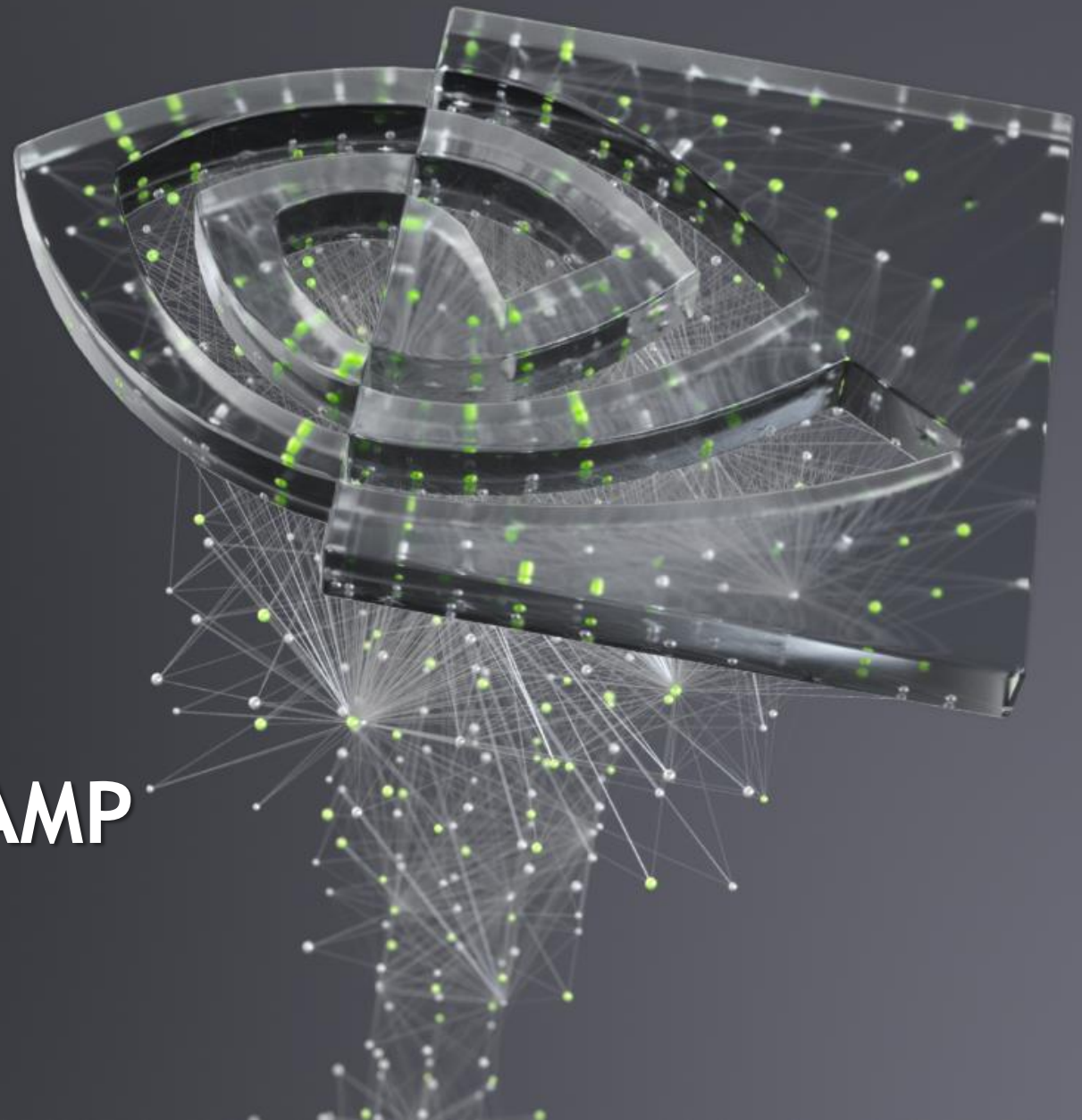
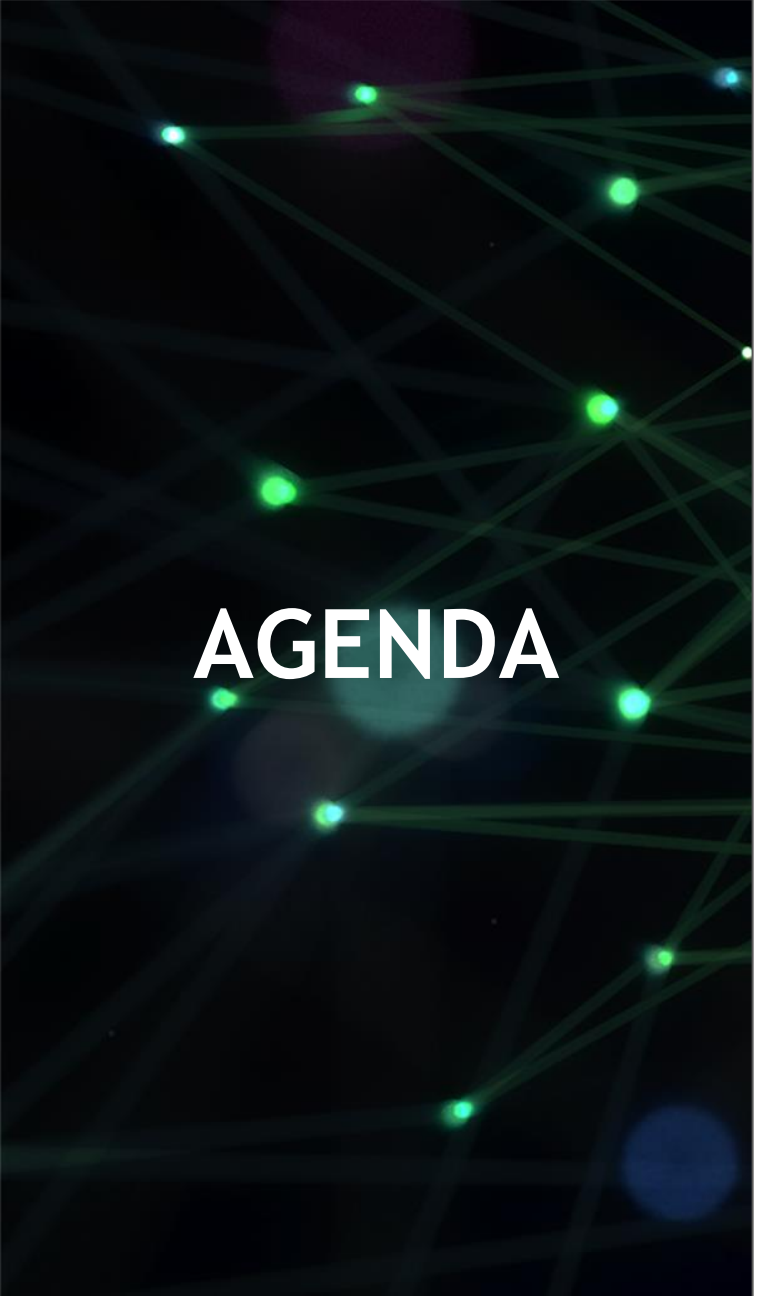


N-WAYS GPU BOOTCAMP

NSIGHT SYSTEM PROFILING



일정표:

Agenda:
1일차 (Intro): 2021년 7월 26일 (월) 9시 - 16시

- 강사 소개 (Moderator) : 09:00 AM - 09:15AM (Lecture)
- 클러스터 연결하기 (okta login) : 09:15 AM - 09:30 AM (Lecture)
- GPU 컴퓨팅 개요 : 09:30 AM - 10:15 AM (Lecture)
- 프로파일링 툴 개요 : 10:15 AM - 11:00 AM (Lecture)
- 점심 시간 : 11:00 AM - 12:30 PM
- 클러스터 연결하기 : 12:30 PM - 13:00 PM (Lecture)
- OpenMP/OpenACC기반 가속 : 13:00 PM - 15:30 PM (Lecture + Lab)
- Std C++ , Fortran 기반 가속 : 15:30 PM - 16:00 PM (Lecture + Lab)

Day 2 (Advanced): 2021년 7월 27일 (화) 9시 - 15시 30분

- 클러스터 연결하기 (okta login) : 09:00 AM - 09:15 AM (Lecture)
- CUDA C 프로그래밍 : 09:15 AM - 11:00 AM (Lecture + Lab)
- 점심 시간 : 11:00 AM -12:30 PM
- 미니 챌린지 : 12:30 PM - 14:30 PM (Lab)
- 마무리 : 14:30 PM - 15:30 PM (Feedback)

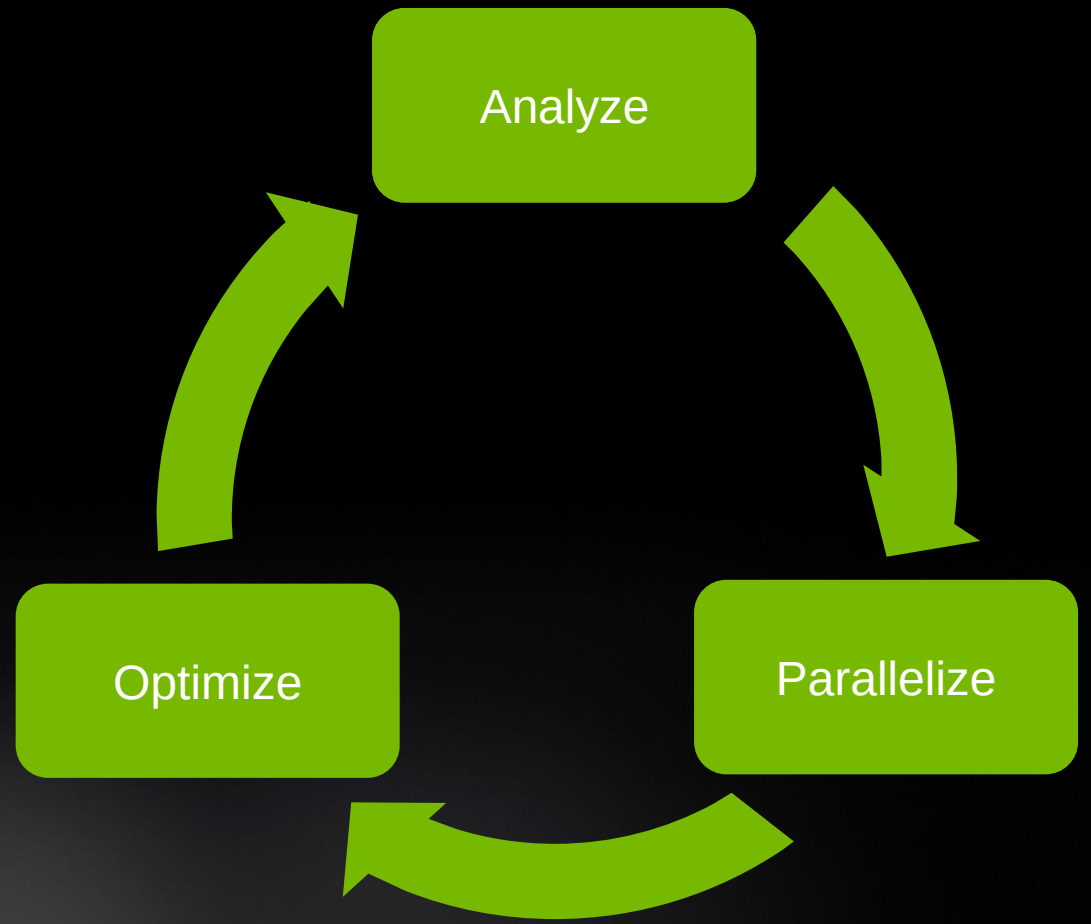
NSIGHT SYSTEM

What to expect?

- Basic introduction to Nsight family of tools
- Using Nsight Systems

DEVELOPMENT CYCLE

- **Analyze** your code to determine most likely places needing parallelization or optimization.
- **Parallelize** your code by starting with the most time consuming parts and check for correctness.
- **Optimize** your code to improve observed speed-up from parallelization.



PROFILING SEQUENTIAL CODE

Profile Your Code

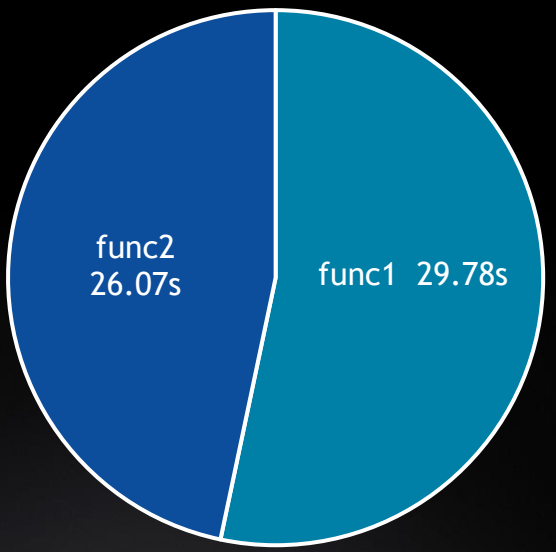
Obtain detailed information about how the code ran.

This can include information such as:

- Total runtime
- Runtime of individual routines
- Hardware counters

Identify the portions of code that took the longest to run. We want to focus on these “hotspots” when parallelizing.

Hotspot Analysis




NVIDIA NSIGHT FAMILY

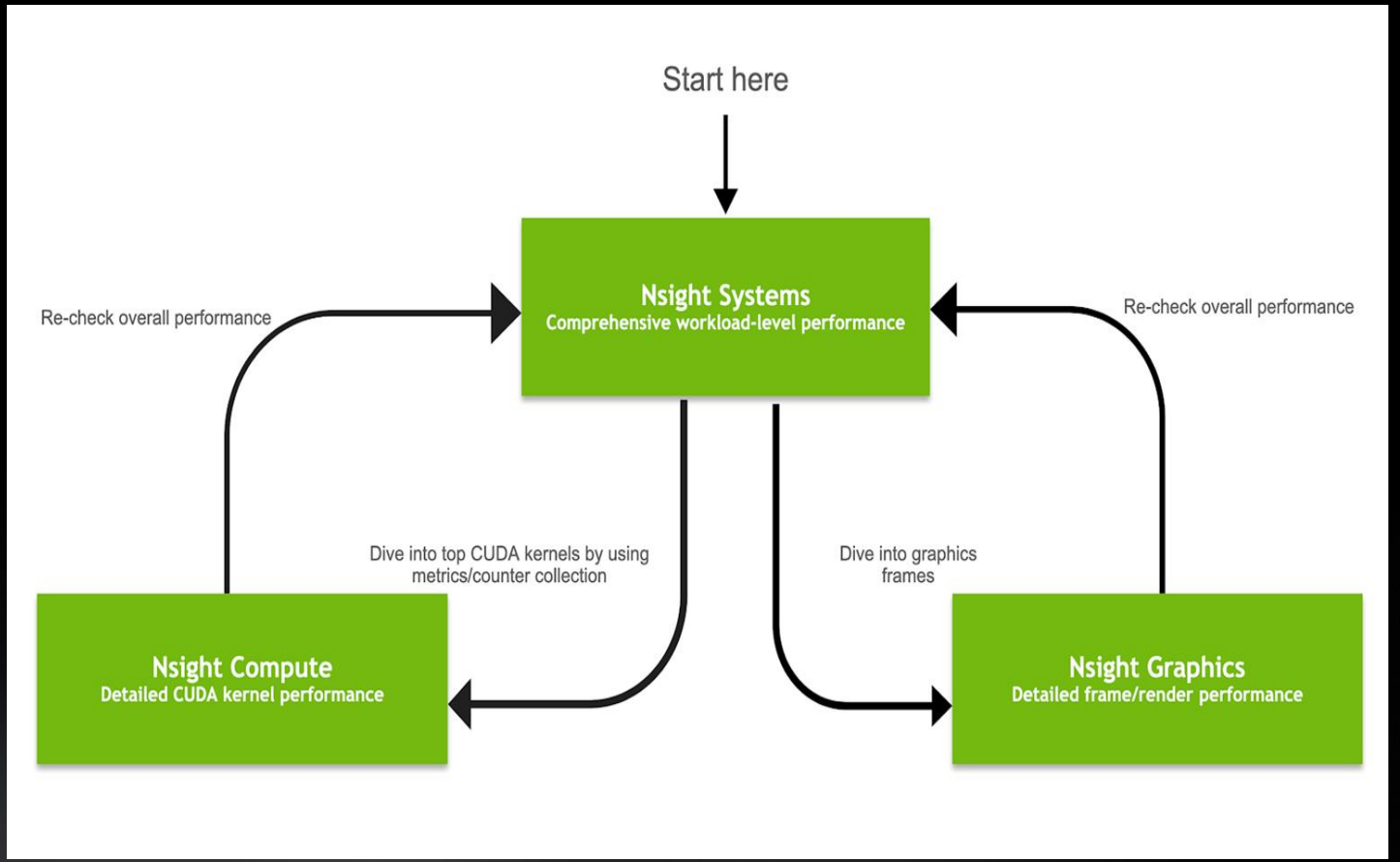
Nsight Product Family

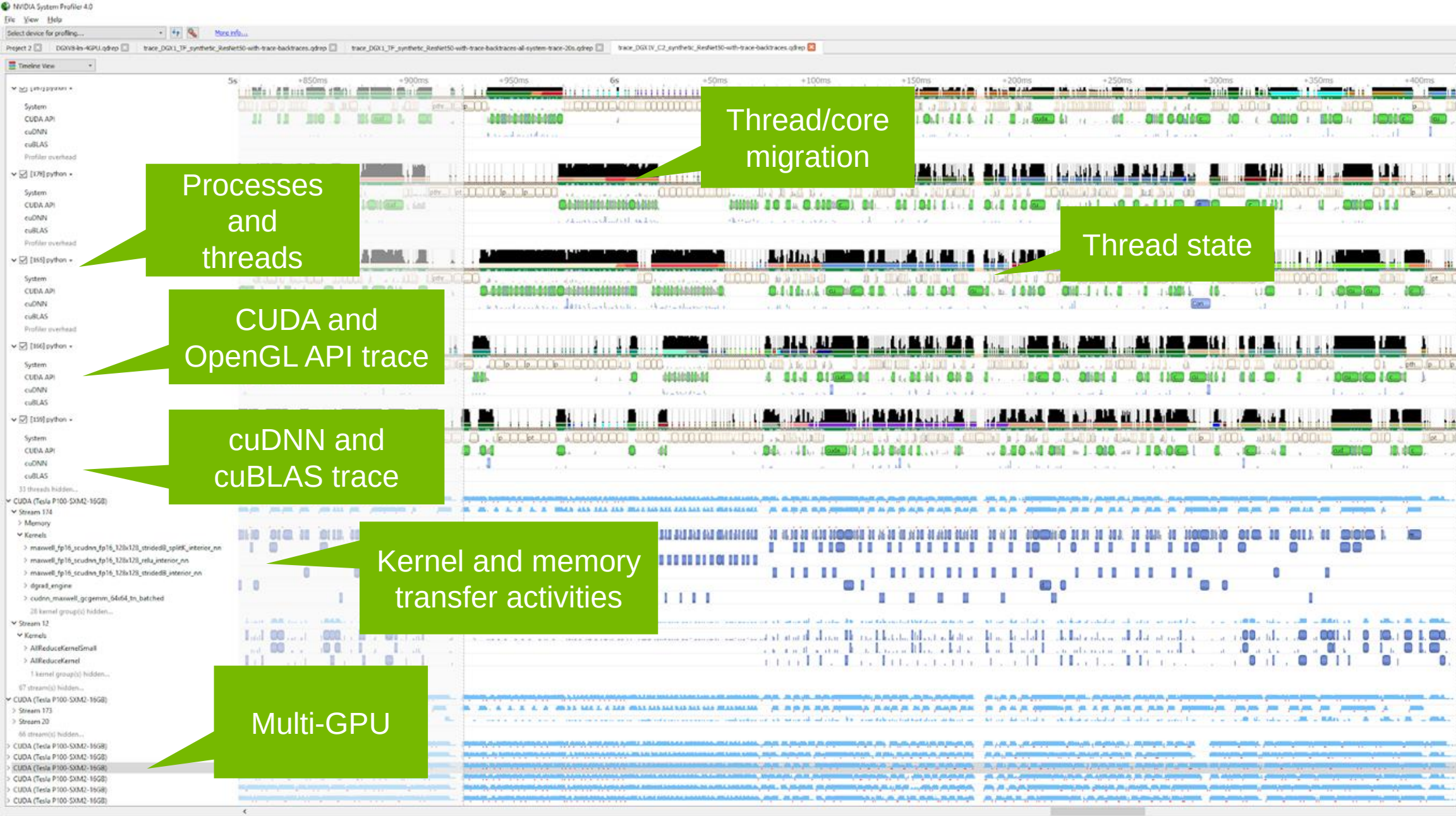
Workflow

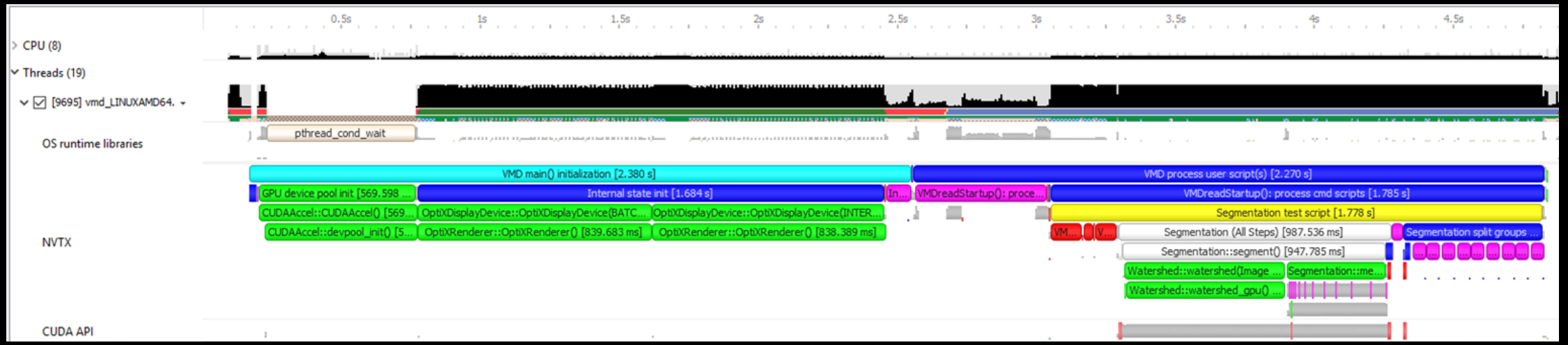
Nsight Systems - Analyze application algorithm system-wide

Nsight Compute - Debug/optimize CUDA kernel

Nsight Graphics - Debug/optimize graphics workloads

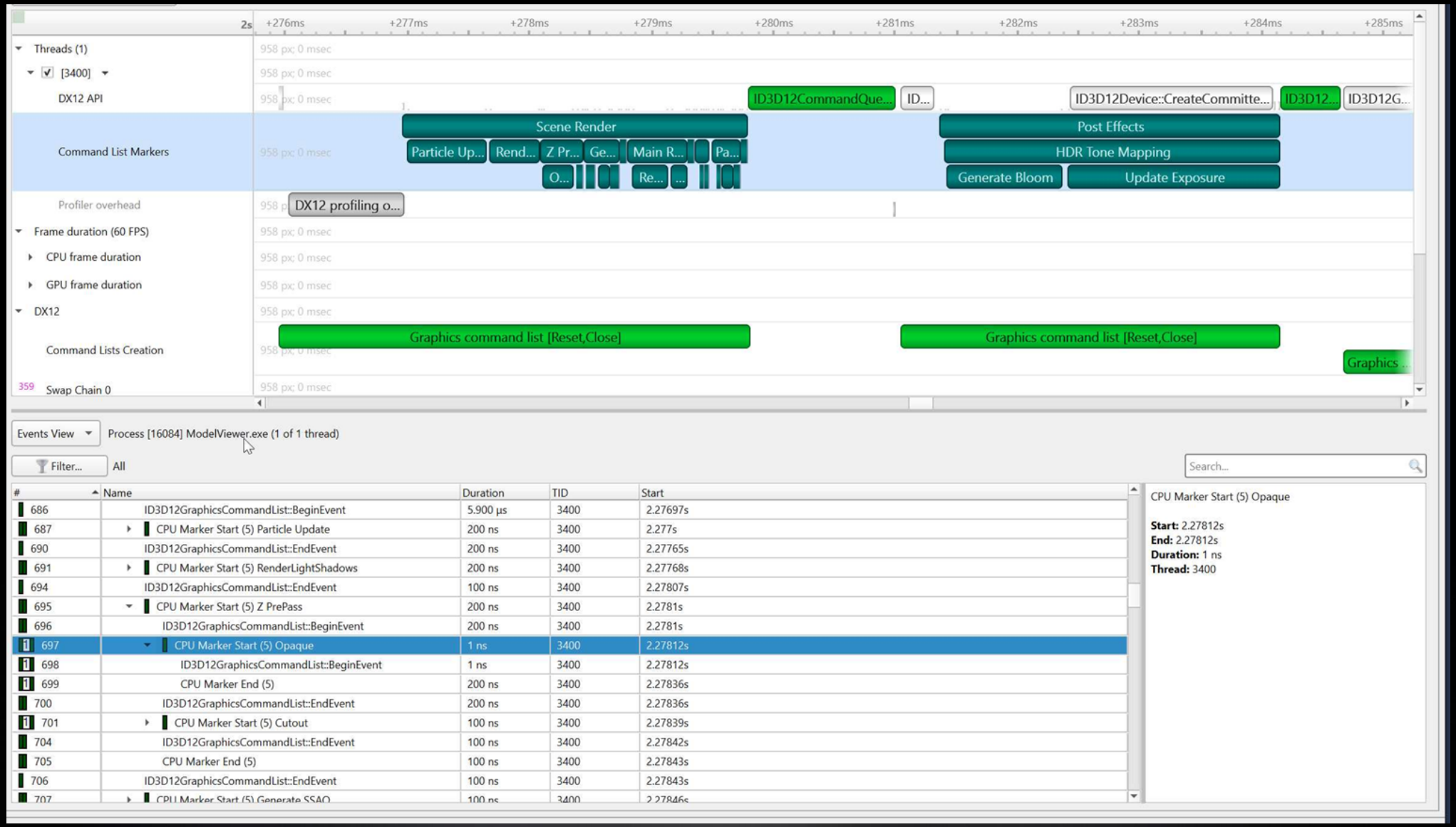



Thread/core migration
Processes and threads
Thread state
CUDA and OpenGL API trace
cuDNN and cuBLAS trace
Kernel and memory transfer activities
Multi-GPU



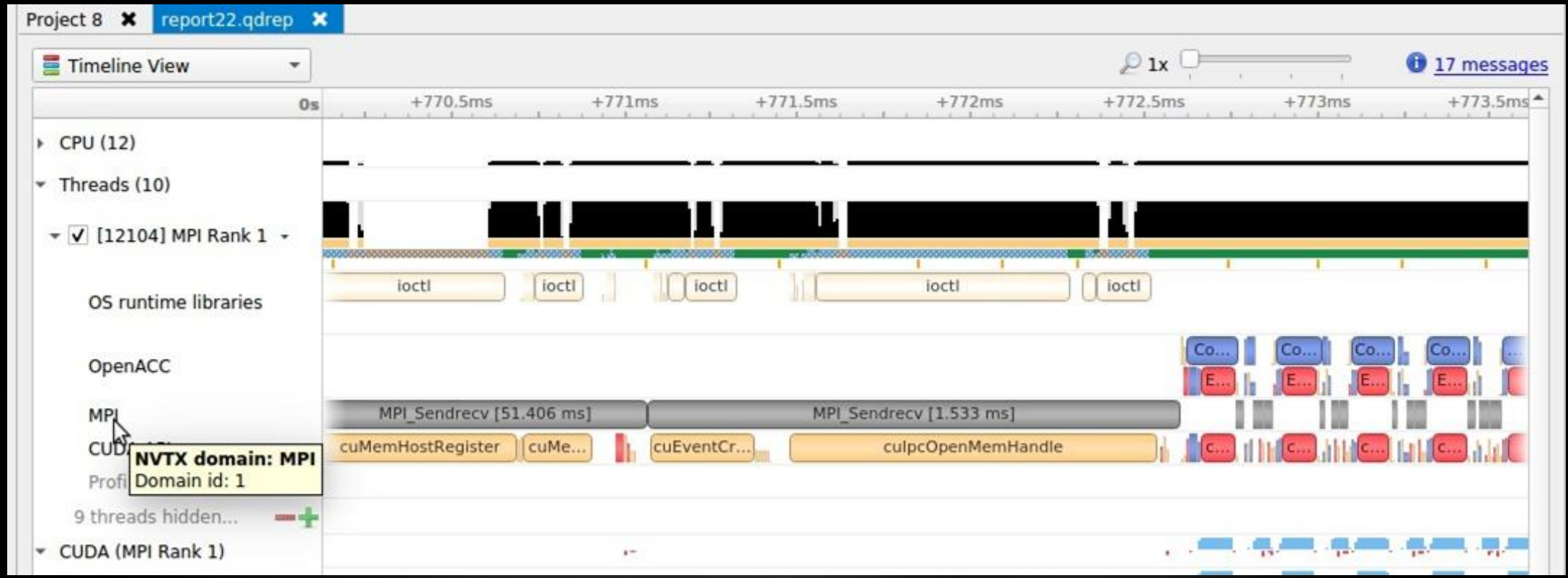
USER ANNOTATIONS APIS FOR CPU & GPU
NVTX, OPENGL, VULKAN, AND DIRECT3D PERFORMANCE MARKERS

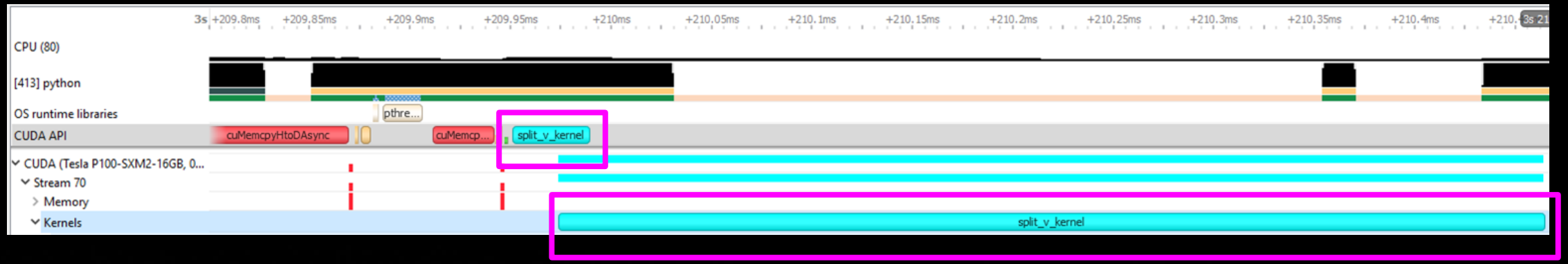
EXAMPLE: VISUAL MOLECULAR DYNAMICS (VMD) ALGORITHMS VISUALIZED WITH NVTX ON CPU



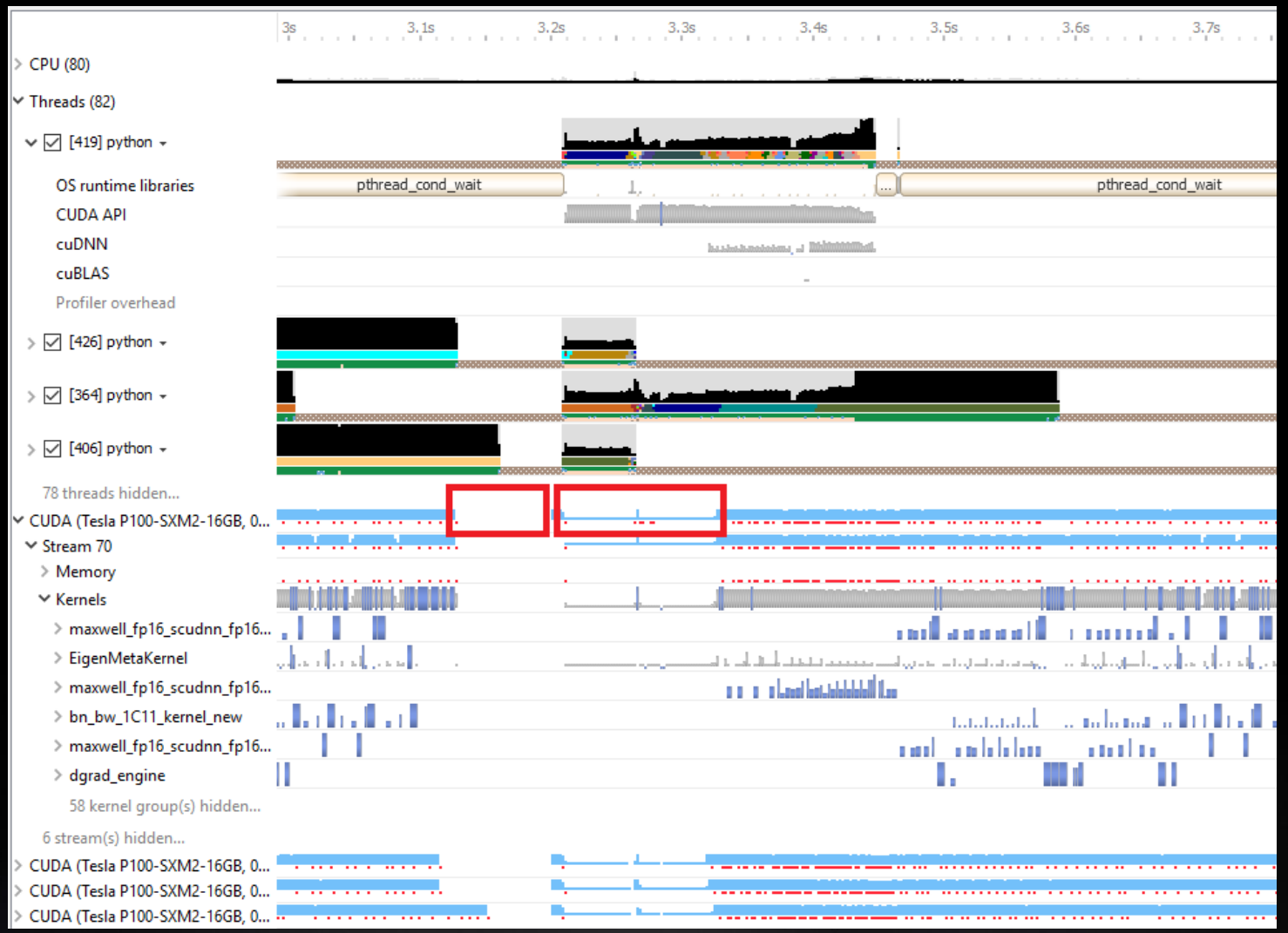
EVENT TABLE

MPI & OPENACC TRACE



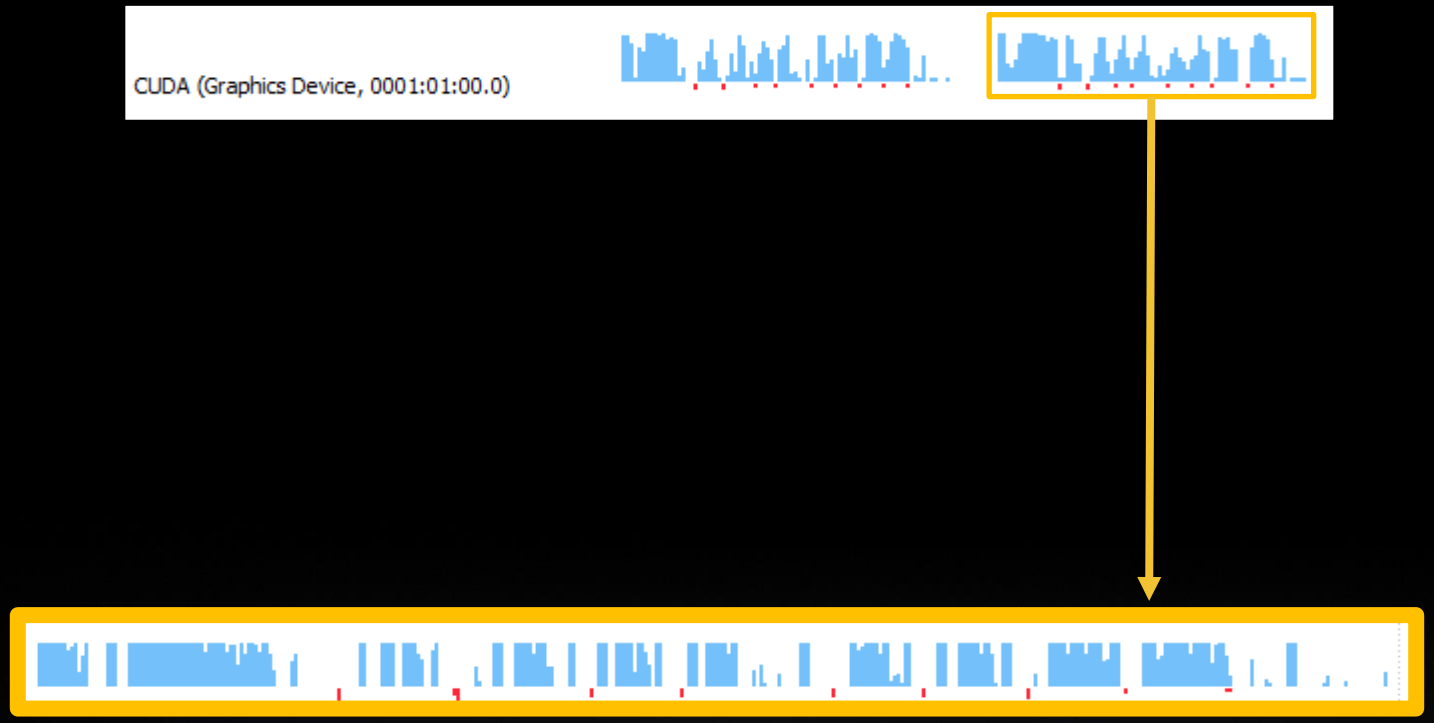


GPU API LAUNCH TO HW WORKLOAD CORRELATION

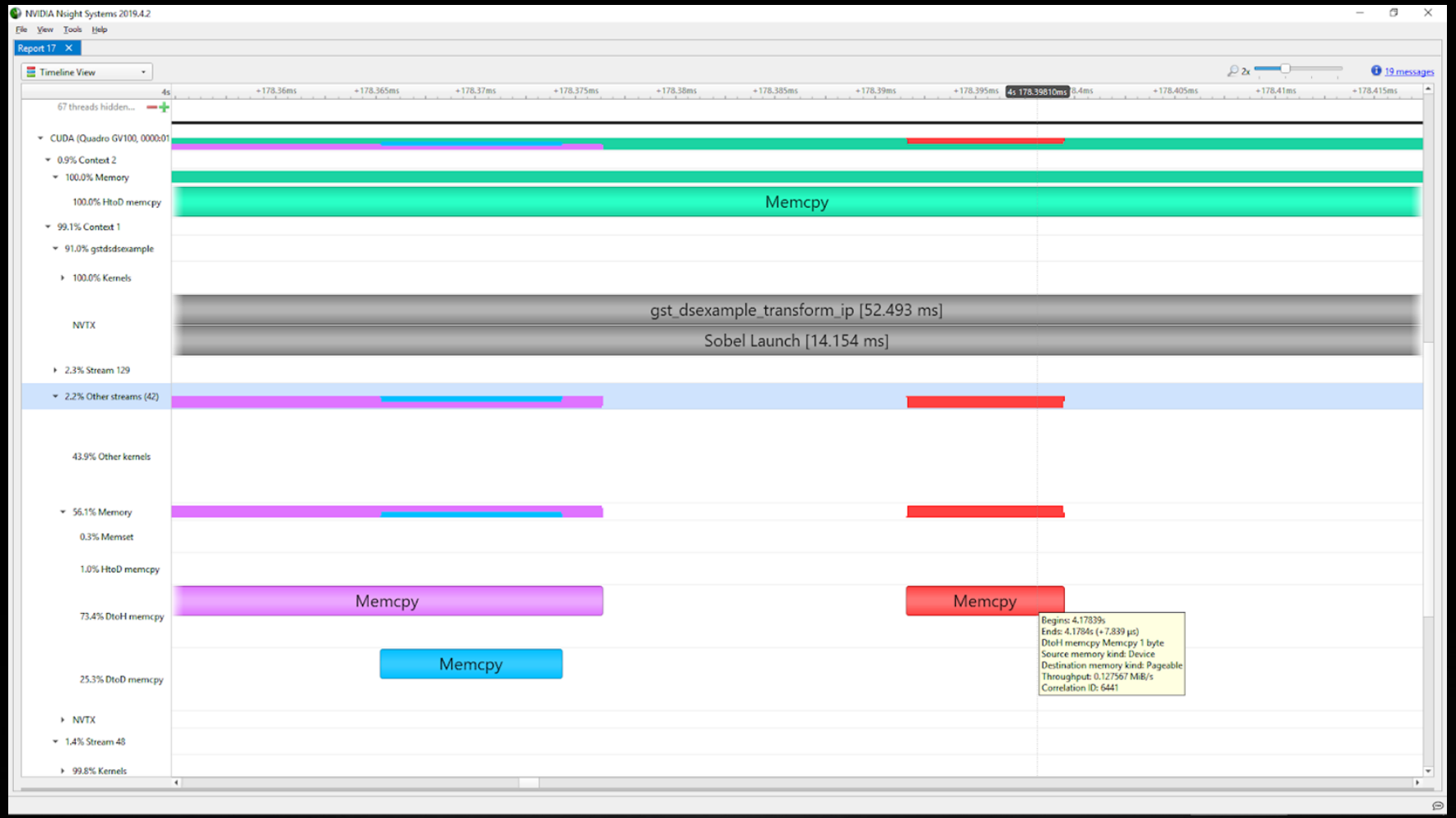


GPU IDLE AND LOW UTILIZATION LEVEL OF DETAIL

GPU UTILIZATION BASED ON PERCENTAGE TIME COVERAGE



ZOOMING IN REVEALS GAPS WHERE THERE WERE VALLEYS



CUDA MEMORY TRANSFER COLOR PALLETTE SHOW DIRECTION AND PAGEABLE MEMORY HAZARDS

CUDA UNIFIED VIRTUAL MEMORY (UVM) TRANSFERS


PROFILING WITH NSIGHT
SYSTEM
AND NVTX

PROFILING SEQUENTIAL CODE

Using Command Line Interface (CLI)

NVIDIA Nsight Systems CLI provides

- Simple interface to collect data
- Can be copied to any system and analysed later
- Profiles both serial and parallel code
- For more info enter `nsys --help` on the terminal

To profile a serial application with NVIDIA Nsight Systems, we use NVIDIA Tools Extension (NVTX) API functions in addition to collecting backtraces while sampling.

PROFILING SEQUENTIAL CODE

NVIDIA Tools Extension API (NVTX) library

What is it?

- A C-based Application Programming Interface (API) for annotating events
- Can be easily integrated to the application
- Can be used with NVIDIA Nsight Systems

Why?

- Allows manual instrumentation of the application
- Allows additional information for profiling (e.g: tracing of CPU events and time ranges)

How?

- Import the header only C library `nvToolsExt.h`
- Wrap the code region or a specific function with `nvtxRangePush()` and `nvtxRangPop()`

```c
#include <string.h>
#include <stdio.h>
#include <stdlib.h>
#include <omp.h>
#include "laplace2d.h"
#include <nvtx3/nvToolsExt.h>

int main(int argc, char** argv)
{
    const int n = 4096;
    const int m = 4096;
    const int iter_max = 1000;

    const double tol = 1.0e-6;
    double error = 1.0;

    double *restrict A    = (double*)malloc(sizeof(double)*n*m);
    double *restrict Anew = (double*)malloc(sizeof(double)*n*m);

    nvtxRangePushA("init");
    initialize(A, Anew, m, n);
    nvtxRangePop();

    printf("Jacobi relaxation Calculation: %d x %d mesh\n", n, m);

    double st = omp_get_wtime();
    int iter = 0;

    nvtxRangePushA("while");
    while ( error > tol && iter < iter_max )
    {
        nvtxRangePushA("calc");
        error = calcNext(A, Anew, m, n);
        nvtxRangePop();

        nvtxRangePushA("swap");
        swap(A, Anew, m, n);
        nvtxRangePop();

        if(iter % 100 == 0) printf("%5d, %0.6f\n", iter, error);

        iter++;
    }
    nvtxRangePop();

    double runtime = omp_get_wtime() - st;

    printf(" total: %f s\n", runtime);

    deallocate(A, Anew);

    return 0;
}
```

jacobi.c
(starting and ending of ranges are highlighted with the **same** color)

-t	Selects the APIs to be traced (nvtx in this example)
--status	if true, generates summary of statistics after the collection
-b	Selects the backtrace method to use while sampling. The option dwarf uses DWARF's CFI (Call Frame Information).
--force-overwrite	if true, overwrites the existing results
-o	sets the output (qdrep) filename

```
mozhgank@prm-dgx-32:~/Code/openacc-training-materials/labs/module4/English/C/solutions/parallel$ nsys profile -t nvtx --stats=true -b dwarf --force-overwrite true -o laplace-seq ./laplace-seq
Collecting data...
Jacobi relaxation Calculation: 4096 x 4096 mesh
    0, 0.250000
  100, 0.002397
  200, 0.001204
  300, 0.000804
  400, 0.000603
  500, 0.000483
  600, 0.000403
  700, 0.000345
  800, 0.000302
  900, 0.000269
 total: 55.754501 s
Processing events...
Capturing symbol files...
Saving intermediate "/home/mozhgank/Code/openacc-training-materials/labs/module4/English/C/solutions/parallel/laplace-seq.qdstrm" file to disk...

Importing [===============================================100%]
Saved report file to "/home/mozhgank/Code/openacc-training-materials/labs/module4/English/C/solutions/parallel/laplace-seq.qdrep"
Exporting 70802 events: [=================================================100%]

Exported successfully to
/home/mozhgank/Code/openacc-training-materials/labs/module4/English/C/solutions/parallel/laplace-seq.sqlite

Generating NVTX Push-Pop Range Statistics...
NVTX Push-Pop Range Statistics (nanoseconds)

Time(%)      Total Time   Instances         Average         Minimum         Maximum  Range
-------  --------------  ----------  --------------  --------------  --------------  --------
   49.9     55754497966           1   55754497966.0     55754497966     55754497966  while
   26.5     29577817696        1000      29577817.7        29092956        65008545  calc
   23.4     26163892482        1000      26163892.5        25761418        60129514  swap
    0.1       137489808           1     137489808.0       137489808       137489808  init
```

NVTX range statistics

"calc" region (calcNext function) takes 26.6%
"swap" region (swap function) takes 23.4% of total execution time

Open laplace-seq.qdrep with Nsight System GUI to view the timeline

PROFILING CODE

Open the generated report files (*.qdrep) from command line in the Nsight Systems profiler.

File > Open

Using Nsight Systems

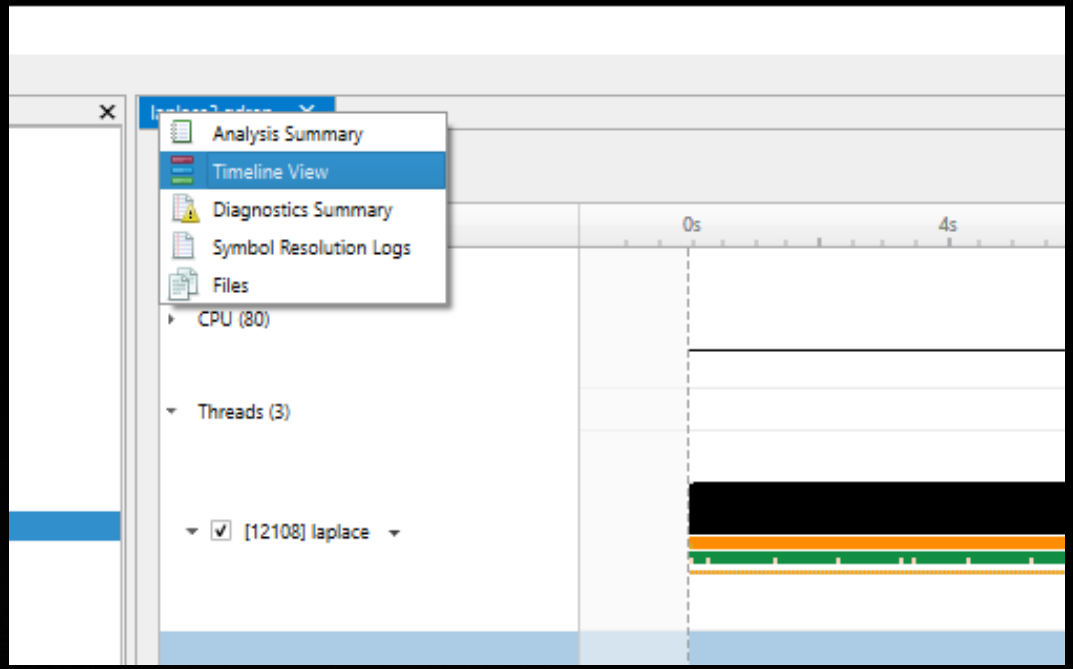
PROFILING CODE

Navigate through the “view selector”.
Using Nsight Systems

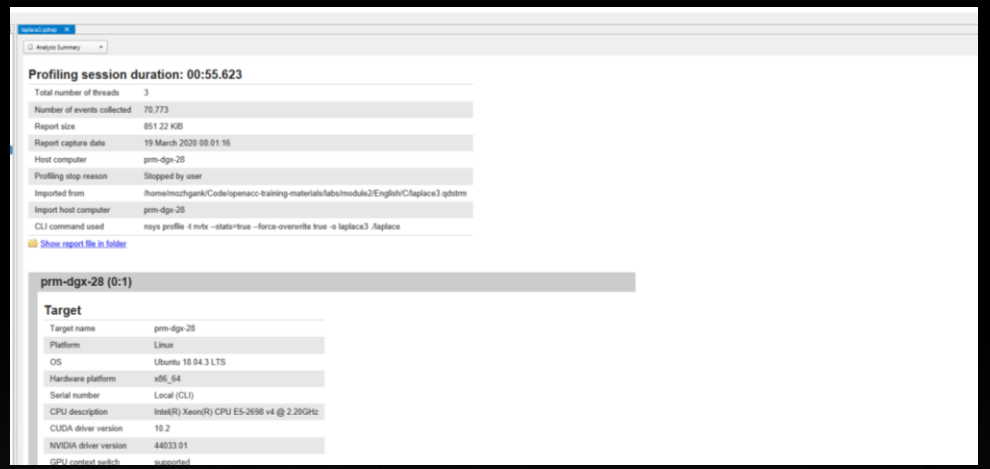
“Analysis summary” shows a summary of the profiling session. To review the project configuration used to generate this report, see next slide.

“Timeline View” contains the timeline at the top, and a bottom pane that contains the events view and the function table.

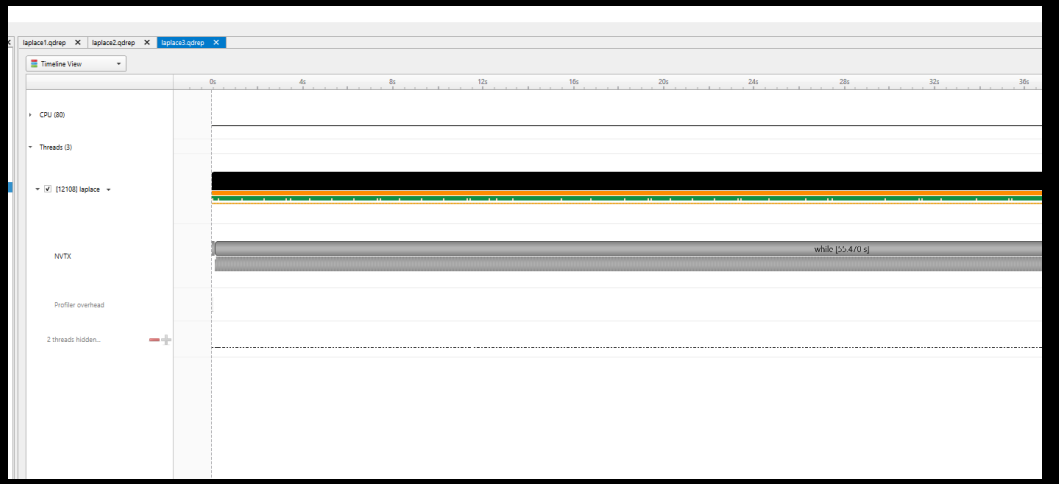
Read more: https://docs.nvidia.com/nsight-systems



PROFILING CODE



Analysis Summary



Timeline view
(charts and the hierarchy on the top pane)

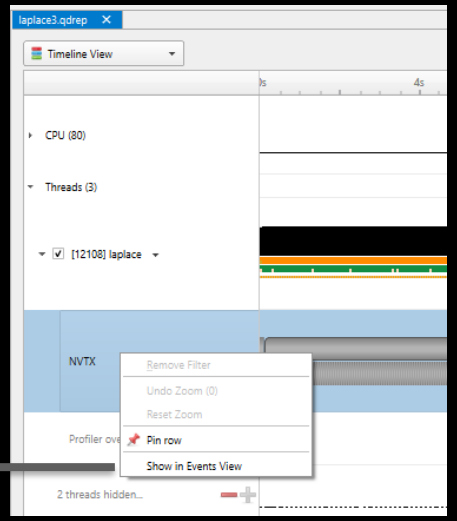
Timeline view
(event view and function table on the bottom pane)

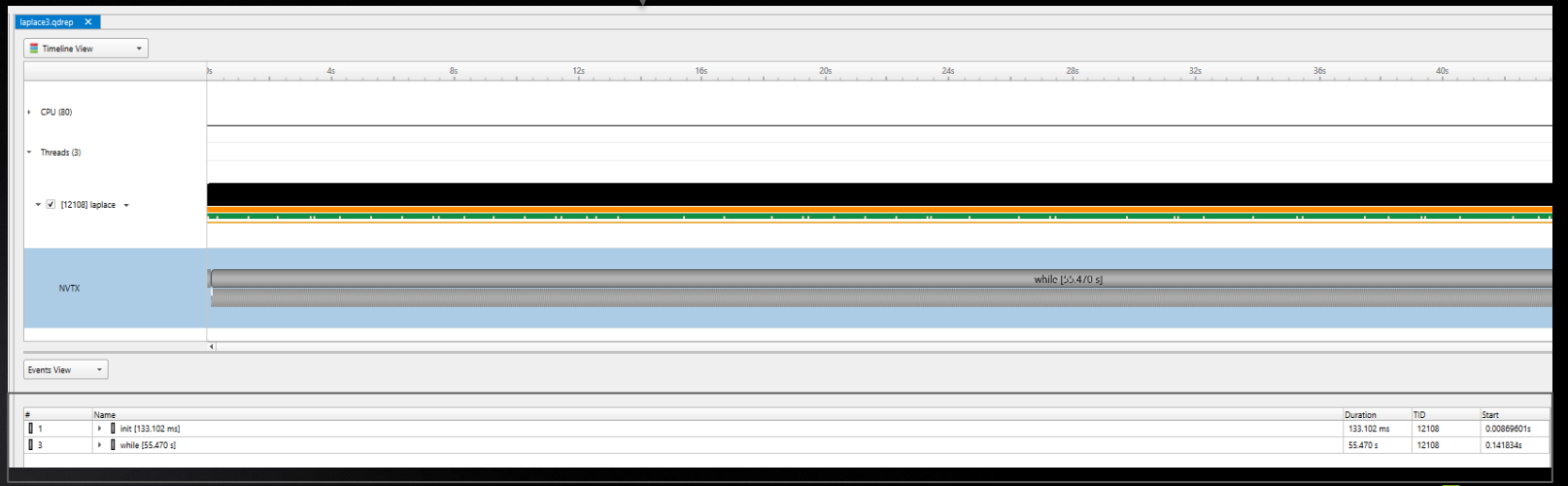
PROFILING CODE

Viewing captured NVTX events and time ranges via Nsight Systems GUI

From the Timeline view, right click on the “NVTX” from the top pane and choose “Show in Events View”.

From the bottom pane, you can now see name of the events captured with the duration.





REFERENCES

https://docs.nvidia.com/nsight-systems

https://developer.nvidia.com/hpc-sdk


THANK YOU
NVIDIA