NVIDIA Parallel Nsight™

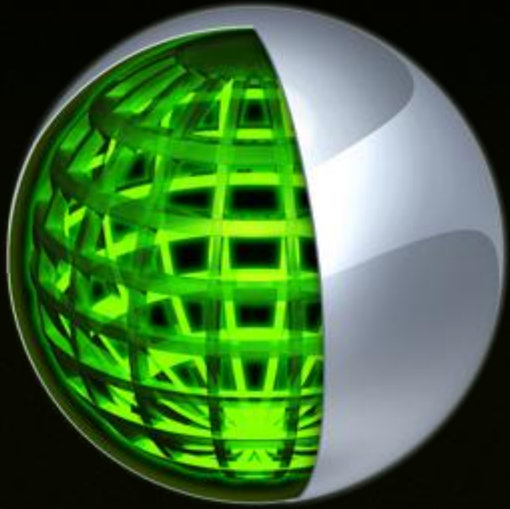
SuperComputing 2010 | New Orleans

Agenda

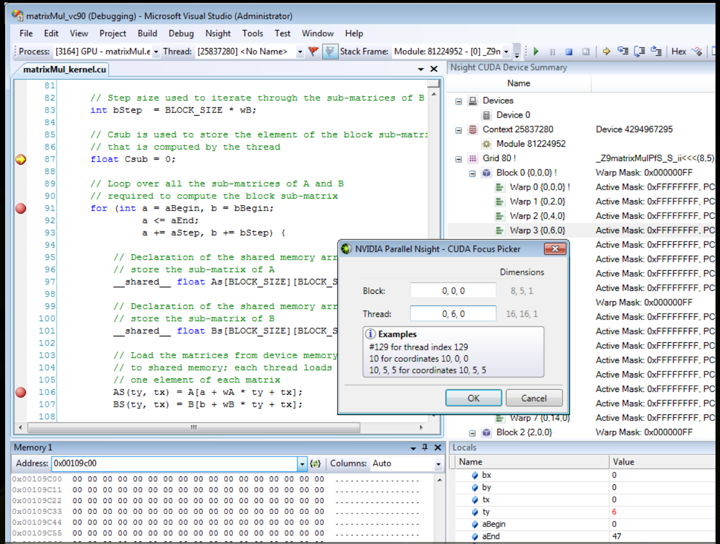
- Introduction to Parallel Nsight
- CUDA C/C++ Source Debugging
- Analysis/System Trace
- Q&A

What is Parallel Nsight?

- Development environment for heterogeneous platforms (CPU and GPU)
- Fully integrated into Microsoft Visual Studio 2008 and 2010
- Dramatic productivity improvement in common development tasks



Parallel Nsight for Compute


matrixMul_vc90 (Debugging) - Microsoft Visual Studio (Administrator)

matrixMul_kernel.cu

```
    // Step size used to iterate through the sub-matrices of B
    int bStep  = BLOCK_SIZE * wB;

    // Csub is used to store the element of the block sub-matri
    // that is computed by the thread
    float Csub = 0;

    // Loop over all the sub-matrices of A and B
    // required to compute the block sub-matrix
    for (int a = aBegin, b = bBegin;
             a <= aEnd;
             a += aStep, b += bStep) {

        // Declaration of the shared memory arr
        // store the sub-matrix of A
        __shared__ float As[BLOCK_SIZE][BLOCK_S

        // Declaration of the shared memory arr
        // store the sub-matrix of B
        __shared__ float Bs[BLOCK_SIZE][BLOCK_S

        // Load the matrices from device memory
        // to shared memory; each thread loads
        // one element of each matrix
        AS(ty, tx) = A[a + wA * ty + tx];
        BS(ty, tx) = B[b + wB * ty + tx];
```

NVIDIA Parallel Nsight - CUDA Focus Picker

		Dimensions
Block:	0, 0, 0	8, 5, 1
Thread:	0, 6, 0	16, 16, 1

Examples
#129 for thread index 129
10 for coordinates 10, 0, 0
10, 5, 5 for coordinates 10, 5, 5

Nsight CUDA Device Summary

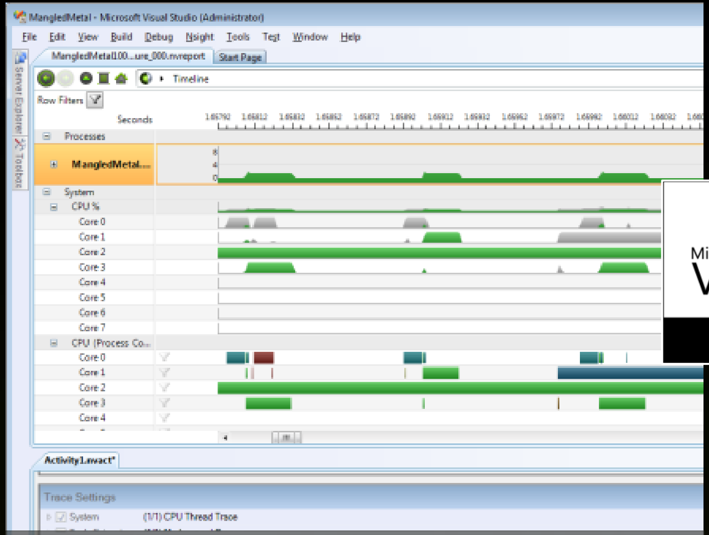
Name	
Devices	
Device 0	
Context 25837280	Device 4294967295
Module 81224952	
Grid 80 !	_Z9matrixMulPfS_S_ii<<<(8,5)
Block 0 {0,0,0} !	Warp Mask: 0x000000FF
Warp 0 {0,0,0} !	Active Mask: 0xFFFFFFFF, PC
Warp 1 {0,2,0}	Active Mask: 0xFFFFFFFF, PC
Warp 2 {0,4,0}	Active Mask: 0xFFFFFFFF, PC
Warp 3 {0,6,0}	Active Mask: 0xFFFFFFFF, PC
Warp 7 {0,14,0}	Active Mask: 0xFFFFFFFF, PC
Block 2 {2,0,0}	Warp Mask: 0x000000FF

Memory 1 — Address: 0x00109c00 — Columns: Auto

```
0x00109C00  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0x00109C11  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0x00109C22  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0x00109C33  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0x00109C44  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0x00109C55  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
```

Locals

Name	Value
bx	0
by	0
tx	0
ty	6
aBegin	0
aEnd	47



Parallel Compute Debugger

Examine compute kernels directly on GPU hardware

Debug CUDA C/C++ and DirectCompute applications

Visualize thousands of threads executing in parallel using Visual Studio

Use conditional breakpoints to correct errors in massively parallel code

System Analyzer (Pro only)

Capture and visualize CPU and GPU level events on a single correlated timeline

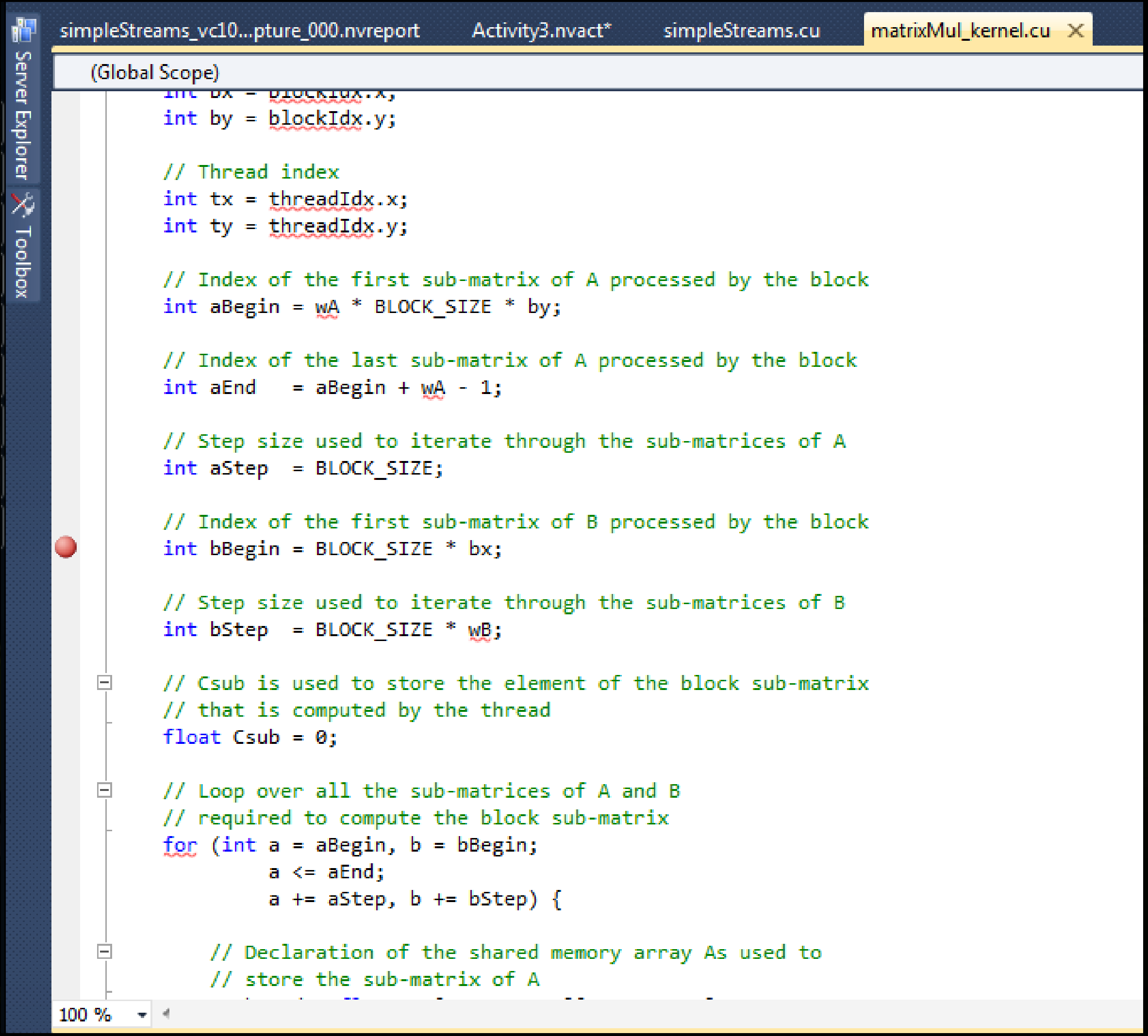
Inspect workload dependencies using the Timeline View

Profile CUDA kernels using GPU performance counters

CUDA C/C++ Debugging

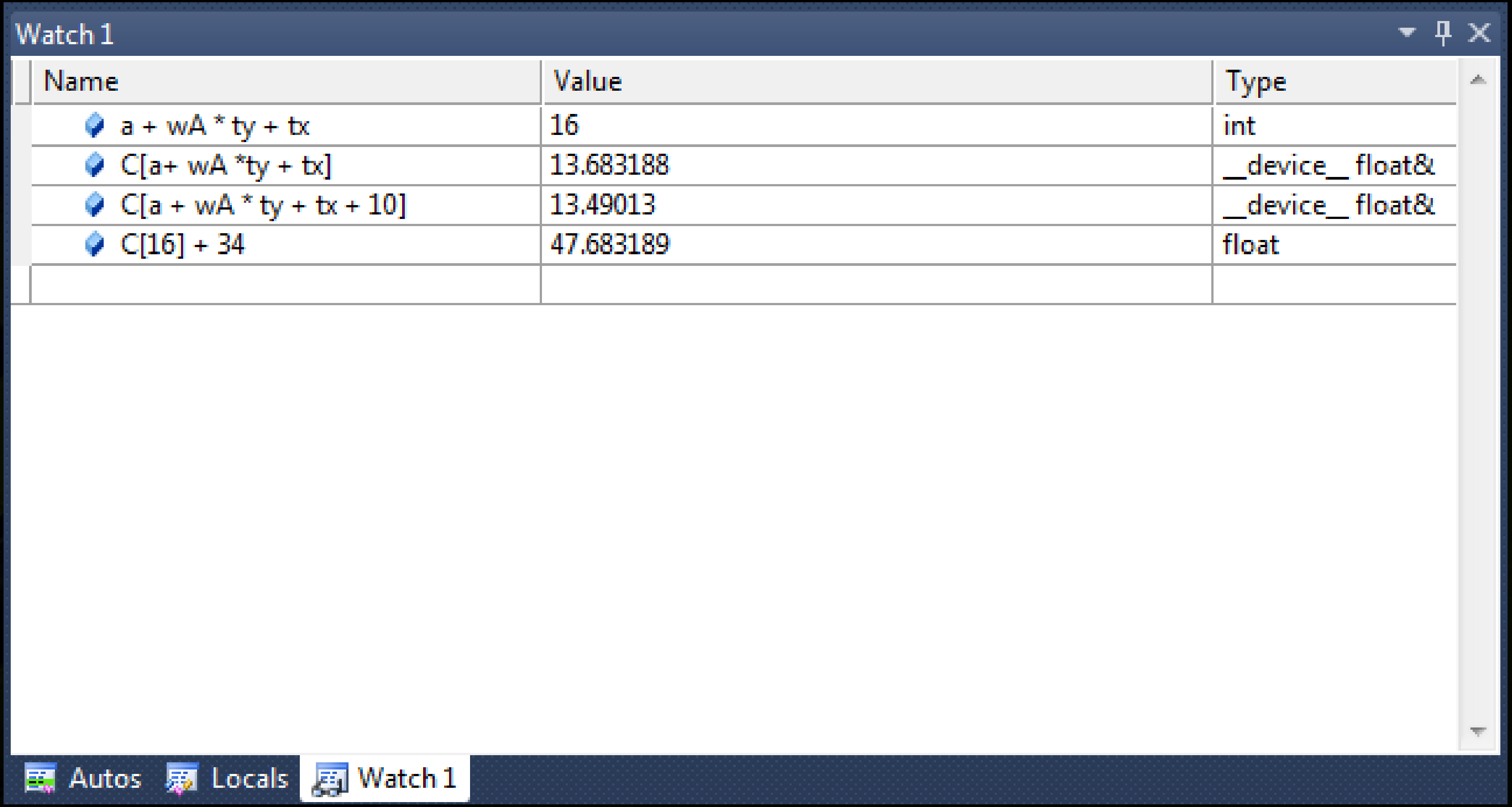
- Compile your code with Debug flag
- Use the familiar Visual Studio interface to debug your GPU code
- Dramatic productivity improvements
  - Explore memory during a live session vs. coding specific transfers
  - Immediately view live variables vs. printf/recompile loop
  - Set data breakpoints on memory area vs. trial and error
  - And much more!

Setting Breakpoints



```
    int by = blockIdx.y;

    // Thread index
    int tx = threadIdx.x;
    int ty = threadIdx.y;

    // Index of the first sub-matrix of A processed by the block
    int aBegin = wA * BLOCK_SIZE * by;

    // Index of the last sub-matrix of A processed by the block
    int aEnd   = aBegin + wA - 1;

    // Step size used to iterate through the sub-matrices of A
    int aStep  = BLOCK_SIZE;

    // Index of the first sub-matrix of B processed by the block
    int bBegin = BLOCK_SIZE * bx;

    // Step size used to iterate through the sub-matrices of B
    int bStep  = BLOCK_SIZE * wB;

    // Csub is used to store the element of the block sub-matrix
    // that is computed by the thread
    float Csub = 0;

    // Loop over all the sub-matrices of A and B
    // required to compute the block sub-matrix
    for (int a = aBegin, b = bBegin;
             a <= aEnd;
             a += aStep, b += bStep) {

        // Declaration of the shared memory array As used to
        // store the sub-matrix of A
```

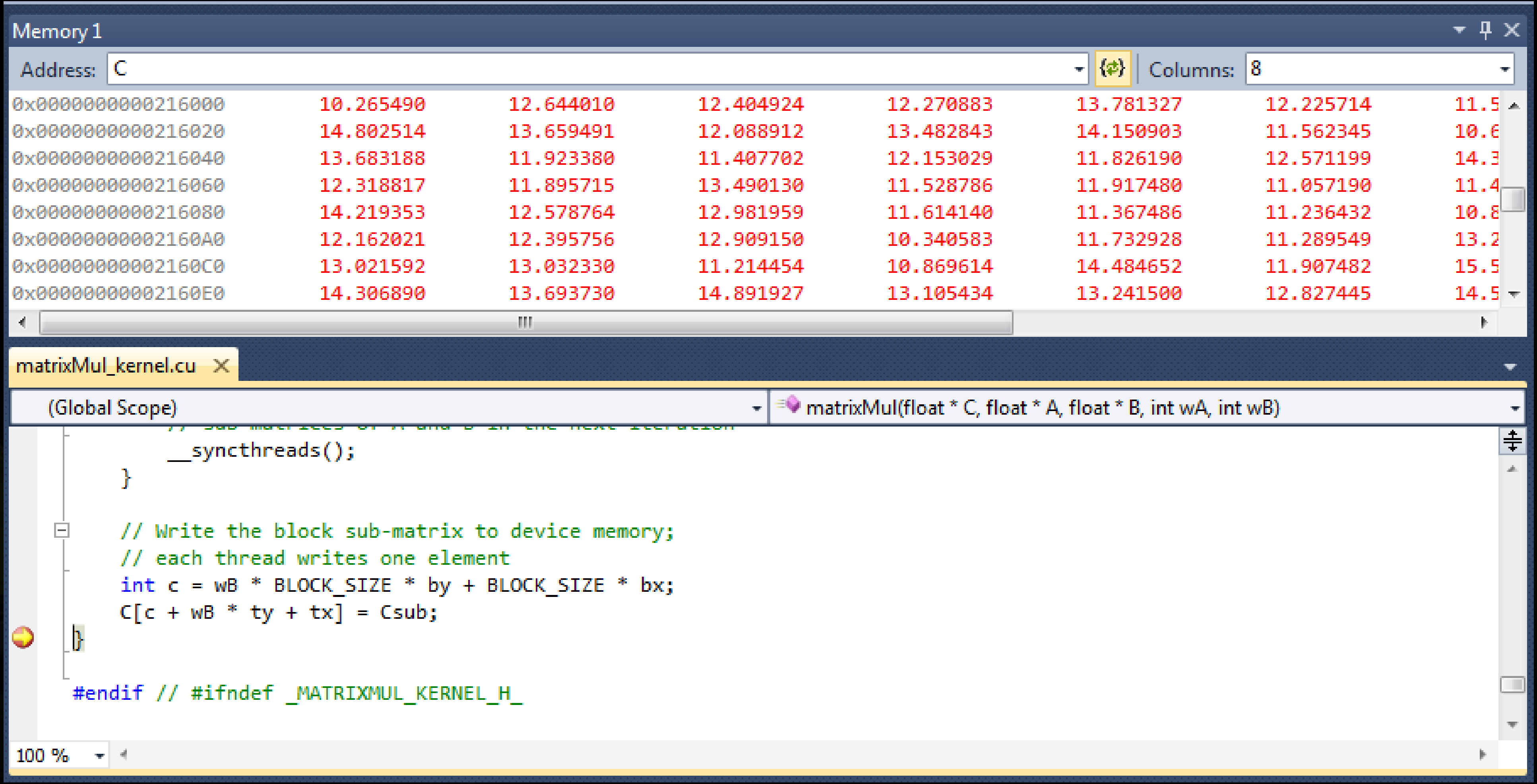
Viewing Variable Values



Watch 1

Name	Value	Type
a + wA * ty + tx	16	int
C[a+ wA *ty + tx]	13.683188	__device__ float&
C[a + wA * ty + tx + 10]	13.49013	__device__ float&
C[16] + 34	47.683189	float

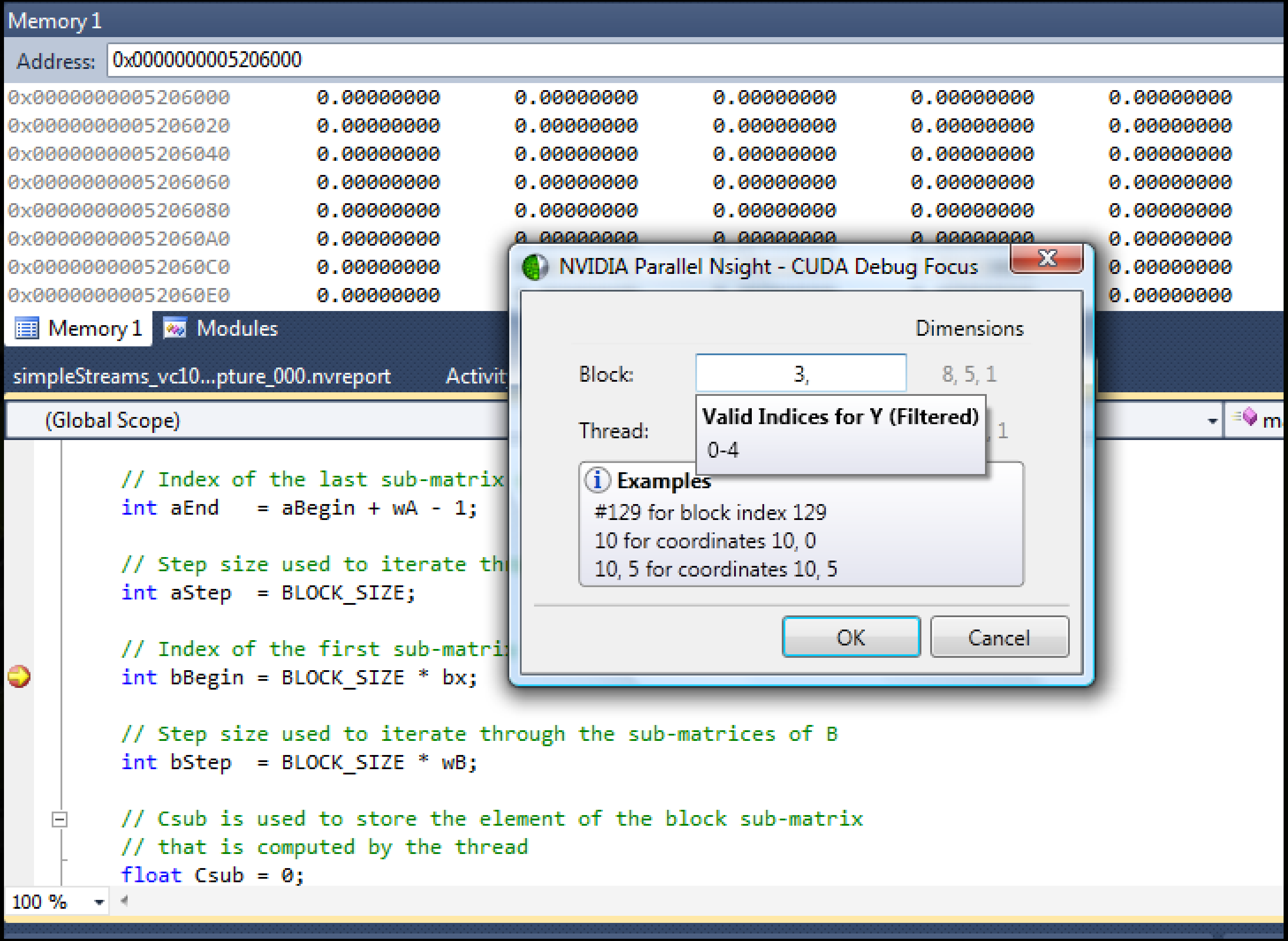
Viewing GPU Memory



```
0x0000000000216000      10.265490    12.644010    12.404924    12.270883    13.781327    12.225714    11.5
0x0000000000216020      14.802514    13.659491    12.088912    13.482843    14.150903    11.562345    10.6
0x0000000000216040      13.683188    11.923380    11.407702    12.153029    11.826190    12.571199    14.3
0x0000000000216060      12.318817    11.895715    13.490130    11.528786    11.917480    11.057190    11.4
0x0000000000216080      14.219353    12.578764    12.981959    11.614140    11.367486    11.236432    10.8
0x00000000002160A0      12.162021    12.395756    12.909150    10.340583    11.732928    11.289549    13.2
0x00000000002160C0      13.021592    13.032330    11.214454    10.869614    14.484652    11.907482    15.5
0x00000000002160E0      14.306890    13.693730    14.891927    13.105434    13.241500    12.827445    14.5
```

```
            __syncthreads();
        }

        // Write the block sub-matrix to device memory;
        // each thread writes one element
        int c = wB * BLOCK_SIZE * by + BLOCK_SIZE * bx;
        C[c + wB * ty + tx] = Csub;
}

#endif // #ifndef _MATRIXMUL_KERNEL_H_
```

Switching Between Threads



Memory 1

Address: 0x0000000005206000

```
0x0000000005206000    0.00000000    0.00000000    0.00000000    0.00000000    0.00000000
0x0000000005206020    0.00000000    0.00000000    0.00000000    0.00000000    0.00000000
0x0000000005206040    0.00000000    0.00000000    0.00000000    0.00000000    0.00000000
0x0000000005206060    0.00000000    0.00000000    0.00000000    0.00000000    0.00000000
0x0000000005206080    0.00000000    0.00000000    0.00000000    0.00000000    0.00000000
0x00000000052060A0    0.00000000    0.00000000    0.00000000    0.00000000    0.00000000
0x00000000052060C0    0.00000000                                              0.00000000
0x00000000052060E0    0.00000000                                              0.00000000
```

```
    // Index of the last sub-matrix
    int aEnd   = aBegin + wA - 1;

    // Step size used to iterate thr
    int aStep  = BLOCK_SIZE;

    // Index of the first sub-matri
    int bBegin = BLOCK_SIZE * bx;

    // Step size used to iterate through the sub-matrices of B
    int bStep  = BLOCK_SIZE * wB;

    // Csub is used to store the element of the block sub-matrix
    // that is computed by the thread
    float Csub = 0;
```

NVIDIA Parallel Nsight - CUDA Debug Focus

Dimensions

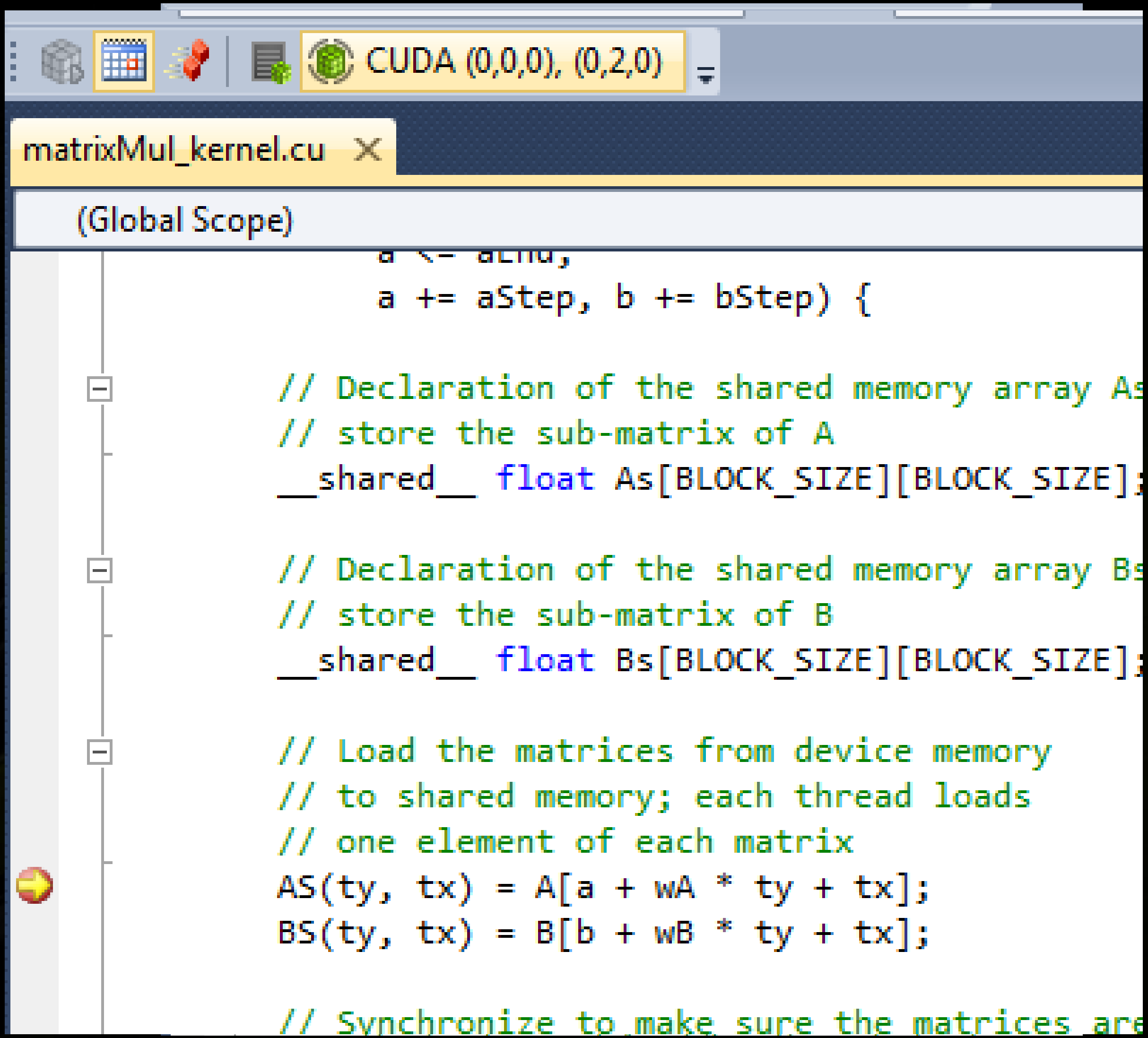
Block: 3, — 8, 5, 1

Thread: — 1

Valid Indices for Y (Filtered)
0-4

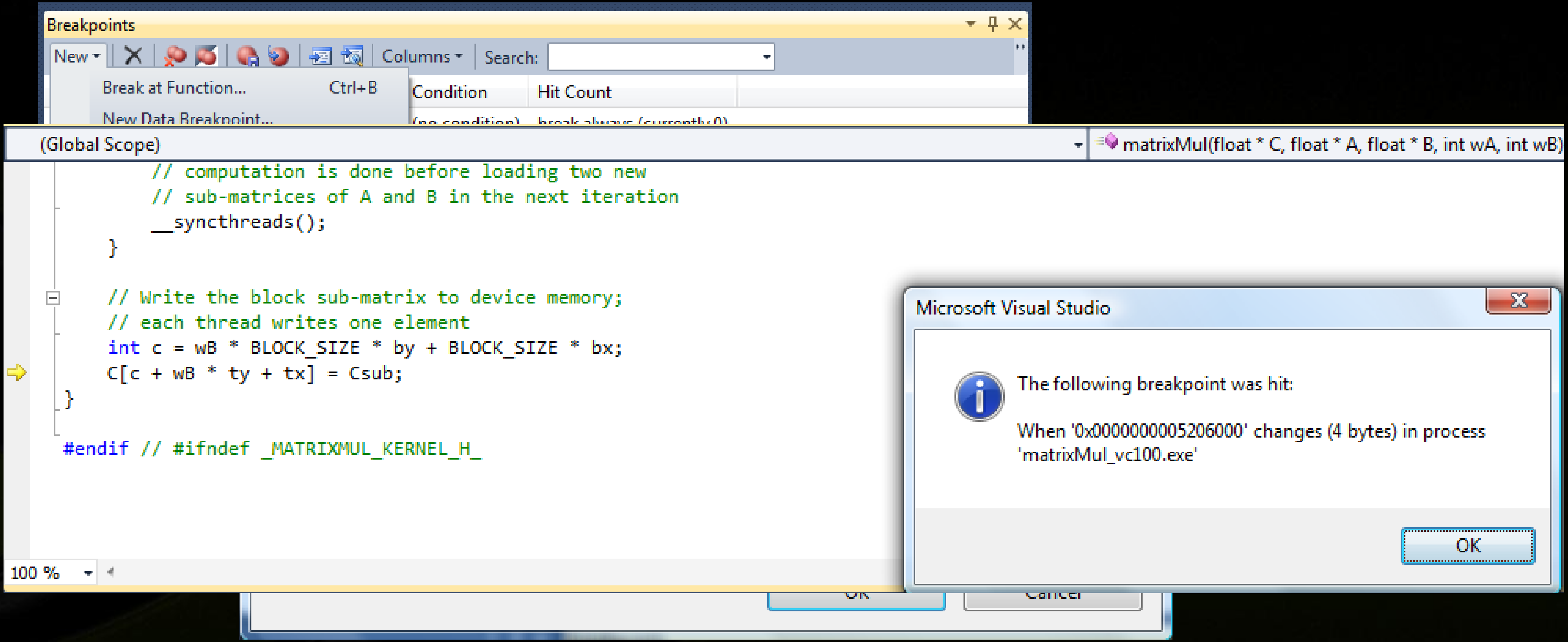
Examples
#129 for block index 129
10 for coordinates 10, 0
10, 5 for coordinates 10, 5

Conditional Breakpoints



```
         a += aStep, b += bStep) {

     // Declaration of the shared memory array As
     // store the sub-matrix of A
     __shared__ float As[BLOCK_SIZE][BLOCK_SIZE];

     // Declaration of the shared memory array Bs
     // store the sub-matrix of B
     __shared__ float Bs[BLOCK_SIZE][BLOCK_SIZE];

     // Load the matrices from device memory
     // to shared memory; each thread loads
     // one element of each matrix
     AS(ty, tx) = A[a + wA * ty + tx];
     BS(ty, tx) = B[b + wB * ty + tx];

     // Synchronize to make sure the matrices are
```

Data Breakpoints



```
        // computation is done before loading two new
        // sub-matrices of A and B in the next iteration
        __syncthreads();
    }

    // Write the block sub-matrix to device memory;
    // each thread writes one element
    int c = wB * BLOCK_SIZE * by + BLOCK_SIZE * bx;
    C[c + wB * ty + tx] = Csub;
}

#endif // #ifndef _MATRIXMUL_KERNEL_H_
```

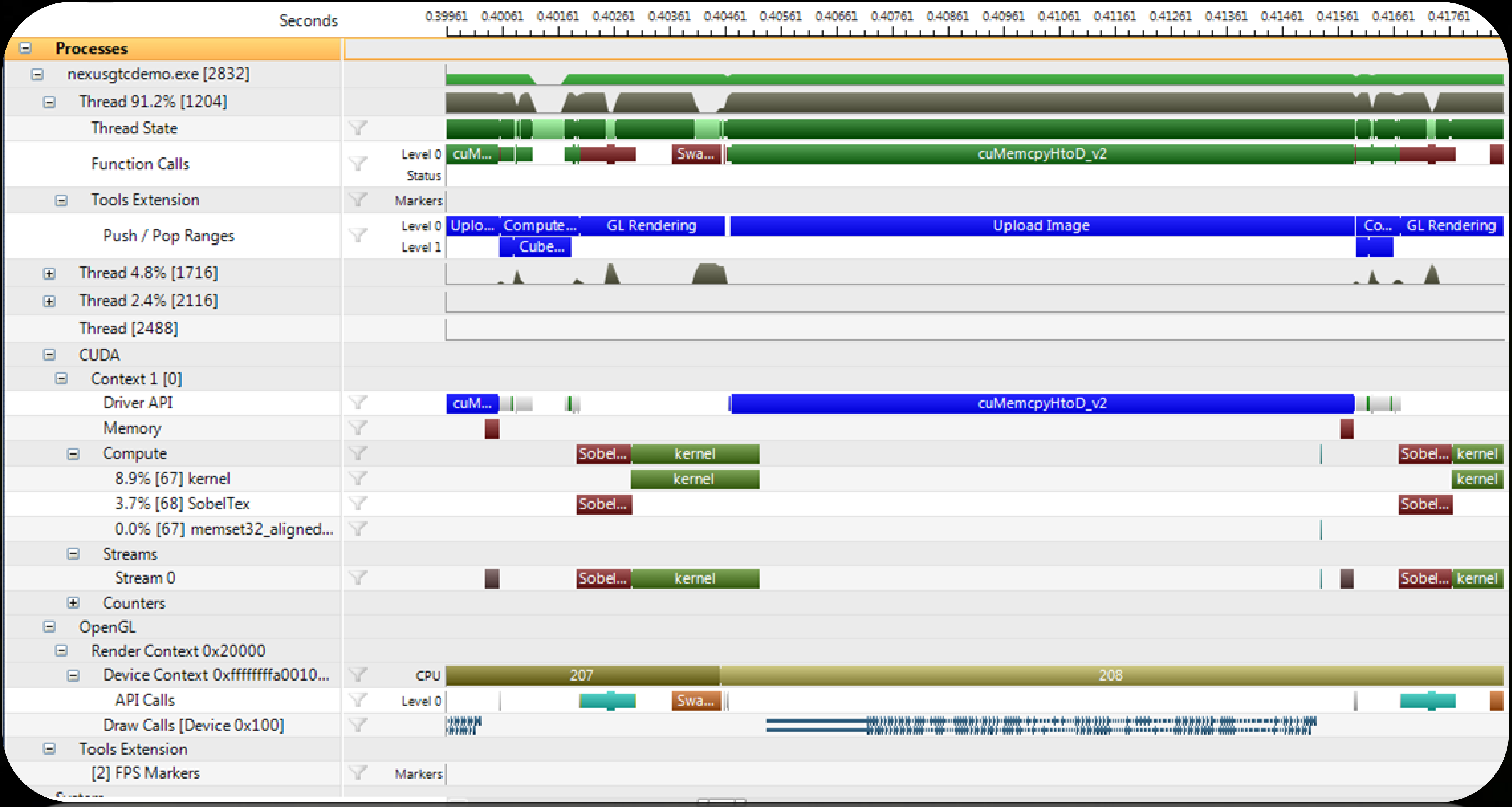
The following breakpoint was hit:

When '0x0000000005206000' changes (4 bytes) in process 'matrixMul_vc100.exe'

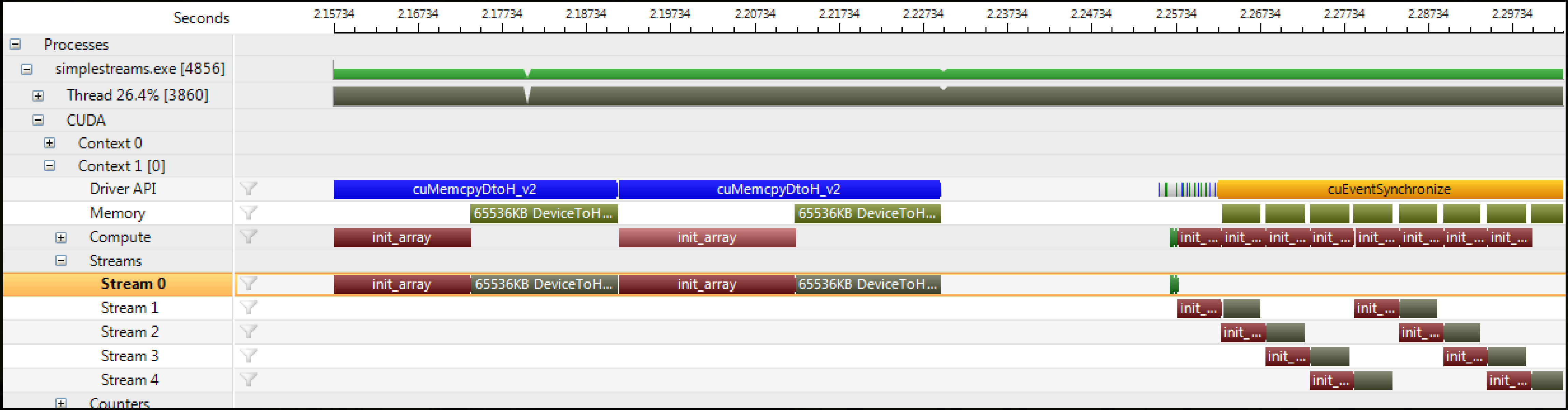
Trace

- Powerful performance tool
- Correlated timeline between CPU and GPU
- Bottleneck identification
    - Find CPU vs. GPU boundedness
    - Find memory transfer vs. kernel computation bounded
    - Get macro-level information on which CUDA kernels use the most time

Trace across the CPU and GPU



Trace – Overlap Memory Transactions



Tesla Compute Cluster Support (TCC)

- TCC is a special driver mode for Windows 7, Vista, and HPC Server 2008.
  - Included in our most recent R260 driver release.

- Benefits
  - Lower overhead to kernel launches = higher performance
  - Running CUDA on a MS Remote desktop

- Parallel Nsight 1.5 now supports debugging on GPUs using a TCC driver.

4 Flexible GPU Development Configurations

Desktop

Single machine, Single NVIDIA GPU

Analyzer, Graphics Inspector

NEW

Single machine, Dual NVIDIA GPUs

Analyzer, Graphics Inspector, Compute Debugger

Networked

Two machines connected over the network

Analyzer, Graphics Inspector, Compute Debugger, Graphics Debugger

Workstation SLI

SLI Multi OS workstation with two Quadro GPUs

Analyzer, Graphics Inspector, Compute Debugger, Graphics Debugger

Parallel Nsight 1.5 Feature Support

	Standard (no cost)	Professional ($349) *available for purchase in December*
Compute Debugger	✓	✓
DirectX 10 & 11 Debugger & Graphics inspector	✓	✓
GeForce Support: 9 series or higher	✓	✓
Tesla Support: C1050/S1070 or higher	✓	✓
Quadro Support: G9x or higher	✓	✓
Windows 7, Vista and HPC Server 2008	✓	✓
Visual Studio 2008 SP1 and Visual Studio 2010	✓	✓
Compute Analyzer		✓
OpenGL and OpenCL Analyzer		✓
DirectX 10 & 11 Analyzer		✓
Tesla Compute Cluster (TCC) Debugging		✓

http://www.nvidia.com/GetParallelNsight

Parallel Nsight Resources

- Parallel Nsight GPU Computing Forum
- The Parallel Nsight User Guide
  - Installed with the Host installer
  - Available on the Web
- Links to these from: http://developer.nvidia.com/ParallelNsight

developer.nvidia.com/ParallelNsight

Free Download

Videos

Documentation