

Лекция 2

Инструменты отладки и профилирования:

- `cuda-gdb`
- Data Display Debugger (ddd)
- Nsight Eclipse Plugins
- Nsight Visual Studio Code Edition
- `nvprof`
- `nvvp`
- Nsight Compute CLI
- Nsight Compute

```
> ~Lecture3/Lab3-gdb> g++ lab3a.cpp -g3 -o lab3a
> ~Lecture3/Lab3-gdb> gdb lab3a
```

```
(gdb) list main
```

```
.....
36         gettimeofday(&t, NULL);
37         Start =(double)t.tv_sec*1000000.0 +
(double)t.tv_usec;
38         hTest(N,a,b);
39         gettimeofday(&t, NULL);
40         Finish =(double)t.tv_sec*1000000.0 +
(double)t.tv_usec;
```

```
(gdb) b 38
```

```
Breakpoint 1 at 0x400865: file lab3a.cpp, line 38.
```

(gdb) **run 256**

Starting program: ~/Lecture3/Lab3-gdb/lab3a 16

(gdb) **step**

hTest (N=16, a=0x613e70, b=0x613ec0) at lab3a.cpp:7

```
7         for(int i=0; i<N;i++)
```

(gdb) list hTest

```
1         #include <malloc.h>
```

```
2         #include <stdio.h>
```

```
3         #include <stdlib.h>
```

```
4         #include <sys/time.h>
```

```
5
```

```
6         void hTest(int N, int* a, int* b){
```

```
7             for(int i=0; i<N;i++)
```

```
8                 a[i]+=b[i];
```

```
9             }
```

```
(gdb) info args
```

```
N = 16
```

```
a = 0x613e70
```

```
b = 0x613ec0
```

```
(gdb) info locals
```

```
i = 0
```

```
(gdb) next 8
```

```
7         for(int i=0; i<N;i++)
```

```
(gdb) info locals
```

```
i = 3
```

```
(gdb) print b[2]
```

```
$1 = 5
```

```
(gdb) print a[2]
```

```
$2 = 9
```

```
gdb) break 8 if i==12
```

```
Breakpoint 3 at 0x400705: file lab3a.cpp, line 8.
```

```
(gdb) c
```

```
Continuing.
```

```
Breakpoint 3, hTest (N=16, a=0x613e70, b=0x613ec0) at  
lab3a.cpp:8
```

```
8          a[i]+=b[i];
```

```
(gdb) info locals
```

```
i = 12
```

```
(gdb) finish
```

```
Run till exit from #0 hTest (N=16, a=0x613e70,  
b=0x613ec0) at lab3a.cpp:8
```

```
main (argc=2, argv=0x7fffffffdd9b8) at lab3a.cpp:39
```

```
39      gettimeofday(&t, NULL);
```

(gdb) **x/16d b**

0x613ec0:	1	3	5	7
0x613ed0:	9	11	13	15
0x613ee0:	17	19	21	23
0x613ef0:	25	27	29	31

(gdb) **x/16d a**

0x613e70:	1	5	9	13
0x613e80:	17	21	25	29
0x613e90:	33	37	41	45
0x613ea0:	49	53	57	61

(gdb) **print a[2]-b[2]**

\$16 = 4

(gdb) **c**

Continuing.

Elapsed time: 9.57138e+06 ms

0	1	1
1	5	3
2	9	5
3	13	7
4	17	9
5	21	11

..... • •

13	53	27
14	57	29
15	61	31

[Inferior 1 (process 4272) exited normally]

(gdb) **quit**

Отладка многопоточных программ

```
~/Lecture3/Lab3-gdb> gdb lab3b
```

```
(gdb) list hTest
```

```
16 void* hTest(void* arg) {  
17     struct targ* s arg=(struct targ*)arg;  
18     int length=s arg->length;  
19     int offset=s_arg->num_thread*length;  
20     int i;  
21     for(i=0;i<length;i++)  
22         a[i+offset]+=/*1000*sin((double) */b[i+offset];  
23     return NULL;  
25 }
```

```
(gdb) break lab3b.cpp:22
```

```
Breakpoint 1 at 0x40083f: file lab3b.cpp, line 22.
```



```
(gdb) run 4 16
```

```
Starting program: ../Lecture3/Lab3-gdb/lab3b 4 16
```

```
[Thread debugging using libthread_db enabled]
```

```
Using host libthread_db library
```

```
"/lib64/libthread_db.so.1".
```

```
[New Thread 0x7ffff6ed1700 (LWP 10741)]
```

```
[New Thread 0x7ffff66d0700 (LWP 10742)]
```

```
[New Thread 0x7ffff5ecf700 (LWP 10743)]
```

```
[Switching to Thread 0x7ffff6ed1700 (LWP 10741)]
```

```
Thread 2 "lab3b" hit Breakpoint 1, hTest (arg=0x614e70)  
at lab3b.cpp:22
```

```
22          a[i+offset]+=/*1000*sin((double)*/b[i+offset];
```

(gdb) **info threads**

	Id	Target Id		Frame
1	Thread	0x7ffff7fc0740 (LWP 10737)	"lab3b"	clone ()
at	../sysdeps/unix/sysv/linux/x86_64/clone.S:78			
* 2	Thread	0x7ffff6ed1700 (LWP 10741)	"lab3b"	hTest
(arg=0x614e70)	at	lab3b.cpp:22		
3	Thread	0x7ffff66d0700 (LWP 10742)	"lab3b"	hTest
(arg=0x614e7c)	at	lab3b.cpp:22		
4	Thread	0x7ffff5ecf700 (LWP 10743)	"lab3b"	clone ()
at	../sysdeps/unix/sysv/linux/x86_64/clone.S:78			

```
(gdb) print offset
```

```
$1 = 0
```

```
(gdb) thread 3
```

```
[Switching to thread 3 (Thread 0x7ffff66d0700 (LWP  
10742))]
```

```
#0  hTest (arg=0x614e7c) at lab3b.cpp:22
```

```
22
```

```
a[i+offset] += /*1000*sin((double)*/b[i+offset];
```

```
(gdb) print offset
```

```
$2 = 4
```

```
(gdb) break 22 thread 3
```

Note: breakpoint 1 (all threads) also set at pc
`0x40083f`.

Breakpoint 2 at `0x40083f`: file `lab3b.cpp`, line 22.

```
(gdb) info breakpoints
```

Num	Type	Disp	Enb	Address	What
1	breakpoint	keep y		<code>0x0000000000040083f</code>	in <code>hTest(void*)</code> at <code>lab3b.cpp:22</code>
	breakpoint already hit 1 time				
2	breakpoint	keep y		<code>0x0000000000040083f</code>	in <code>hTest(void*)</code> at <code>lab3b.cpp:22</code> thread 3
	stop only in thread 3				

```
(gdb) delete 1
```

```
(gdb) x/16d a
```

0x614ee0:	0	2	4	6
0x614ef0:	8	10	12	14
0x614f00:	16	18	20	22
0x614f10:	24	26	28	30

```
(gdb) continue
```

```
Continuing.
```

```
Thread 3 "lab3b" hit Breakpoint 2, hTest (arg=0x614e7c)
at lab3b.cpp:22
```

```
22          a[i+offset]+=/*1000*sin((double)*/b[i+offset];
```

```
(gdb) c
```

```
.....
(gdb) x/16d a
```

0x614ee0:	1	2	4	6
0x614ef0:	17	21	12	14
0x614f00:	33	37	20	22
0x614f10:	49	53	28	30

(gdb) **c**

Continuing.

[Thread 0x7ffff5ecf700 (LWP 10743) exited]

[Thread 0x7ffff66d0700 (LWP 10742) exited]

Thread-specific breakpoint 2 deleted - thread 3 no longer in the thread list.

[Thread 0x7ffff56ce700 (LWP 11167) exited]

[Thread 0x7ffff6ed1700 (LWP 10741) exited]

Elapsed time: 2.22941e+06 ms

0	1	1
1	3	5
2	5	9

.....

14	29	57
15	31	61

[Inferior 1 (process 10737) exited normally]

```
(gdb) print a[1]
```

```
..... •
```

```
(gdb) info locals
```

```
..... •
```

```
(gdb) info args
```

```
arg = 0x614e7c
```

```
(gdb) print ((struct targ*)arg)->length
```

```
$1 = 4
```


Отладка программ, выполняемых на GPU

<https://docs.nvidia.com/cuda/archive/11.2.0/cuda-gdb/index.html>

```
> nvcc -g -G ...
```

```
~/Workshop/VSC> cuda-gdb lab3c
```

```
(cuda-gdb) list main
```

```
23  __global__ void gSum(int* a, int *b){  
24      int i=threadIdx.x+blockIdx.x*blockDim.x;  
25      a[i]+=b[i];  
26  }
```

```
27
```

```
28  int main(){  
29      int N=VECTOR_LENGTH;  
30      int *a, *b;  
31      int *a_h;  
32
```

```
(cuda-gdb) break 25
```

```
Breakpoint 1 at 0x403fdd: file lab3c.cu, line 26.
```

```
(cuda-gdb) run
```

(cuda-gdb) **info cuda threads**

BlockIdx	ThreadIdx	To	BlockIdx	ThreadIdx	Count	VirtualPC
						Filename Line
Kernel 0						
*	(0,0,0)	(0,0,0)	(0,0,0)	(3,0,0)	4	
0x00007fffe525c3e0						
.../Lecture3/Lab3-cuda-gdb/lab3c.cu				9		
	(1,0,0)	(0,0,0)	(3,0,0)	(3,0,0)	12	
0x00007fffe525c2b0						
.../Lecture3/Lab3-cuda-gdb/lab3c.cu				8		

```
cuda-gdb) cuda block 2 thread 3
```

```
[Switching focus to CUDA kernel 0, grid 1, block  
(2,0,0), thread (3,0,0), device 0, sm 2, warp 0, lane 3]
```

```
8          b[i]=2*i+1;
```

```
(cuda-gdb) print i
```

```
$2 = 11
```

```
(cuda-gdb) n
```

```
9          }
```

```
(cuda-gdb) x/16d b
```

```
0x7fffecc00200: 1          3          5          7
```

```
0x7fffecc00210: 0          0          0          0
```

```
0x7fffecc00220: 0          0          0          0
```

```
0x7fffecc00230: 0          0          0          0
```

```
malkov@192:~> ssh cyber.sibsutis.ru
```

```
malkov@linux-47dw: ~/WORKSHOP/PGP-2023> cuda-gdb lab3c
```

```
(cuda-gdb) break 8
```

```
Breakpoint 1 at 0x403851: file lab3c.cu, line 8.
```

```
(cuda-gdb) run
```

```
Starting program: /home/malkov/WORKSHOP/PGP-2023/lab3c
```

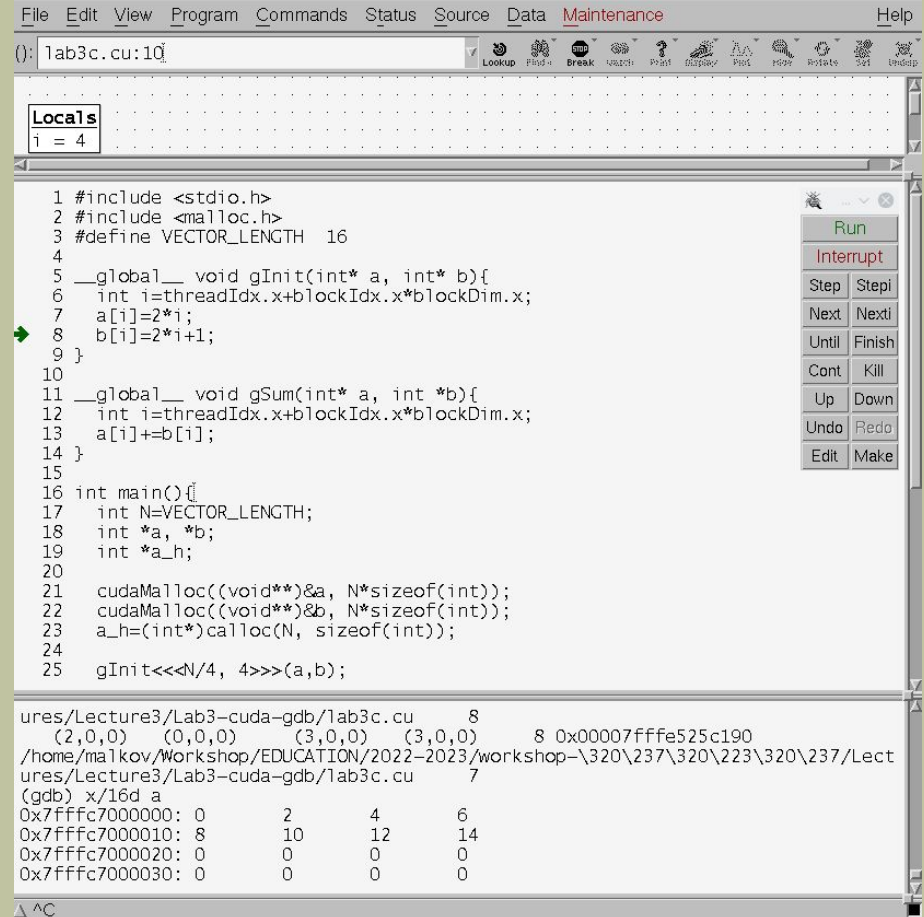
```
.....  
[Switching focus to CUDA kernel 0, grid 1, block  
(0,0,0), thread (0,0,0), device 0, sm 0, warp 0, lane 0]  
Thread 1 "lab3c" hit Breakpoint 1,  
gInit<<<(4,1,1),(4,1,1)>>> (a=0x7fffe6800000,  
b=0x7fffe6800200) at lab3c.cu:8  
8           b[i]=2*i+1;
```

Data Display Debugger (ddd)

```
.../Lecture3/  
Lab3-cuda-gdb>  
ddd cuda-gdb lab3c
```

```
malkov@192:~> ssh  
cyber.sibsutis.ru -X
```

```
malkov@linux-47dw:  
~/WORKSHOP/PGP-2023>  
ddd cuda-gdb lab3c
```



The screenshot shows the Data Display Debugger (ddd) interface. The top menu bar includes File, Edit, View, Program, Commands, Status, Source, Data, Maintenance, and Help. The toolbar contains icons for various debugging actions like LookUp, Find, Break, Watch, Print, Display, Step, Next, Until, Cont, Up, Down, Undo, Redo, Edit, and Make. The main window displays the source code of a CUDA program (lab3c.cu) with line numbers 1 through 25. A green arrow points to line 8, indicating the current execution point. The 'Locals' pane on the left shows the variable 'i' with a value of 4. The bottom pane shows the memory dump for the variable 'a' at address 0x7fffc7000000, displaying a 4x4 grid of values.

```
1 #include <stdio.h>  
2 #include <malloc.h>  
3 #define VECTOR_LENGTH 16  
4  
5 __global__ void gInit(int* a, int* b){  
6     int i=threadIdx.x+blockIdx.x*blockDim.x;  
7     a[i]=2*i;  
8     b[i]=2*i+1;  
9 }  
10  
11 __global__ void gSum(int* a, int* b){  
12     int i=threadIdx.x+blockIdx.x*blockDim.x;  
13     a[i]+=b[i];  
14 }  
15  
16 int main(){  
17     int N=VECTOR_LENGTH;  
18     int *a, *b;  
19     int *a_h;  
20  
21     cudaMalloc((void**)&a, N*sizeof(int));  
22     cudaMalloc((void**)&b, N*sizeof(int));  
23     a_h=(int*)calloc(N, sizeof(int));  
24  
25     gInit<<<N/4, 4>>>>(a,b);
```

Memory dump for variable 'a' (x/16d):

Address	Value	Address	Value
0x7fffc7000000: 0	2	0x7fffc7000010: 8	10
0x7fffc7000010: 8	10	0x7fffc7000020: 0	0
0x7fffc7000020: 0	0	0x7fffc7000030: 0	0
0x7fffc7000030: 0	0		

Nsight Eclipse Plugins

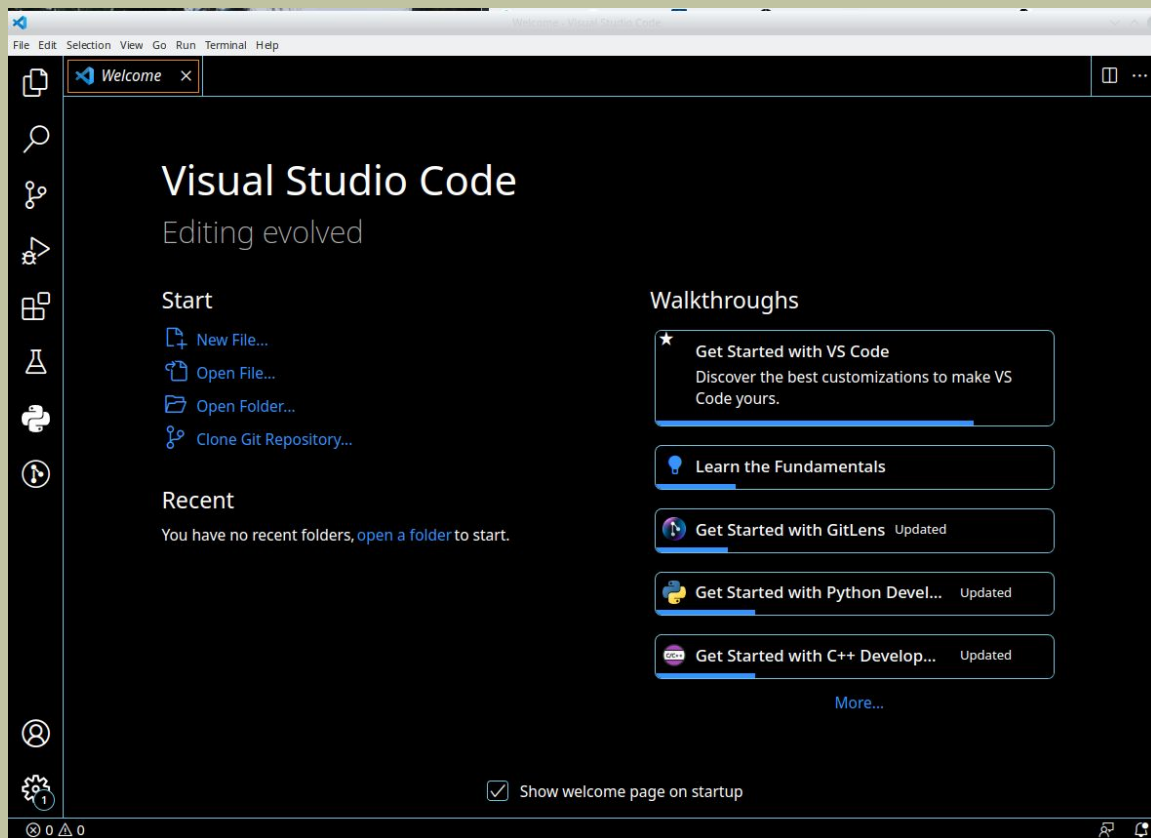
The screenshot displays the Nsight Eclipse IDE interface for debugging a CUDA application. The main components are:


- Project Explorer:** Shows the project structure for 'lab3 [C/C++ Application]'. It includes a 'gSum' target on a NVIDIA GeForce RTX 2060. The 'All Kernel Threads' section shows a hierarchy of threads and blocks, with the current thread being 'Thread #5 [lab3] 11138 [core: 4] (Suspended : Container)'.
- Source Code Editor:** Displays the file 'vector_types.h'. The code defines a vector length and implements a global sum function. The current line of execution is highlighted in blue: `a_h=(int*)calloc(N, sizeof(int));`.
- Variable Window:** Shows the state of variables. The variable 'b' is expanded, showing an array of 20 generic integers. The details for 'b' are: {1, 3, 5, 7, 9, 11, 13, 15, 17, 19, ...}. The default value is 0x7ffff7000200, and the decimal value is 140736532054528.
- Console Window:** Shows the execution log. It indicates that the application is running on a local CUDA 11.2 environment. The log shows the creation of three new threads (LWP 11136, 11137, and 11138). A breakpoint hit is reported for Thread 1 at line 13: `a[i]+=b[i];`.

Nsight Visual Studio Code Edition











<https://developer.nvidia.com/nsight-visual-studio-code-edition>

<https://docs.nvidia.com/nsight-visual-studio-code-edition/cuda-debugger/index.html>





File Edit Selection View Go Run Terminal Help



EXPLORER

...

▼ vsc

> coveragelab3c.cu

> OUTLINE



> TIMELINE

0 0 0

Tests ✓ 0 × 0

coverage: progress

> Home > Workshop > VSC

Name	Modified	Size
 coverage	2024-02-11 19:42	
 <u>lab3c.cu</u>	2023-09-23 18:04	



RUN AND DEBUG: RUN

...



Open a file which can be debugged or run.

Run and Debug



To customize Run and Debug create a launch.json file.



Show all automatic debug configurations.



RUN AND DEBUG: RUN

Open a file which can

Run a

To customize Run and
launch.json file.

Show all automatic de

Extensions (Ctrl+Shift+X)

Select debugger

CUDA C++ (CUDA-GDB)

CUDA C++ (CUDA-GDBSERVER)

CUDA C++ QNX (CUDA-GDBSERVER)

CMake Debugger

Node.js

Python

Web App (Chrome)

Web App (Edge)

Install extension...

RUN AND DEBUG: RUN

Open a file which can

Run a

To customize Run and
launch.json file.

Show all automatic de

Select debugger

CUDA C++ (CUDA-GDB)

Suggested

CUDA C++ (CUDA-GDBSERVER)

CUDA C++ QNX (CUDA-GDBSERVER)

CMake Debugger

Node.js

Python

Web App (Chrome)

Web App (Edge)

Install extension...

```
> VSC:bach — Konsole
File Edit View Bookmarks Settings Help
(base) malkov@192:~/Workshop/VSC> ls -la
итого 4
drwxr-xr-x 4 malkov users 53 Feb 11 19:48 .
drwxr-xr-x 8 malkov users 93 Feb 11 19:37 ..
drwxr-xr-x 2 malkov users 6 Feb 11 19:42 coverage
-rw-r--r-- 1 malkov users 1084 Sep 23 18:04 lab3c.cu
drwxr-xr-x 2 malkov users 25 Feb 11 19:48 .vscode
(base) malkov@192:~/Workshop/VSC> ls -la .vscode
итого 4
drwxr-xr-x 2 malkov users 25 Feb 11 19:48 .
drwxr-xr-x 4 malkov users 53 Feb 11 19:48 ..
-rw-r--r-- 1 malkov users 534 Feb 11 19:48 launch.json
(base) malkov@192:~/Workshop/VSC> █
```

.vscode > { } launch.json > ...


```
1  {
2      // Use IntelliSense to learn about possible attributes.
3      // Hover to view descriptions of existing attributes.
4      // For more information, visit: https://go.microsoft.com/fwlink/?linkid=829397
5      "version": "0.2.0",
6      "configurations": [
7          {
8              "name": "CUDA C++: Launch",
9              "type": "cuda-gdb",
10             "request": "launch",
11             "program": ""
12         },
13         {
14             "name": "CUDA C++: Attach",
15             "type": "cuda-gdb",
16             "request": "attach"
17         }
18     ]
19 }
```


.vscode > { } launch.json > ...

```
1 {
2     // Use IntelliSense to learn about possible attributes
3     // Hover to view descriptions of existing attributes
4     // For more information, visit: https://go.microsoft.com/fwlink/?linkid=829397
5     "version": "0.2.0",
6     "configurations": [
7         {
8             "name": "CUDA C++: Launch",
9             "type": "cuda-gdb",
10            "request": "launch",
11            "program": "${workspaceFolder}/lab3c"
12        }
13    ]
14 }
```

>tasks

Tasks: Run Build Task

Ctrl + Shift + B recently used 

Tasks: Configure Default Build Task 

Tasks: Configure Default Test Task

Tasks: Configure Task

other commands

Tasks: Manage Automatic Tasks

Tasks: Open User Tasks

Tasks: Rerun Last Task

Tasks: Restart Running Task

Tasks: Run Task

Tasks: Run Test Task

Tasks: Show Running Tasks

Tasks: Show Task Log

Tasks: Terminate Task

Select the task to be used as the default build task

Nsight: autostart (localhost)

Nsight: autostart (remote)

Nsight: autostart (secure copy executable binary, remote)

Nsight: autostart (remote QNX)

Nsight: autostart (secure copy cuda-gdbserver binary, remote QNX)

markdownlint: Lint all Markdown files in the workspace with markdownlint



Welcome to GitLens

{ } tasks.json 1 X


{ } launch.json

VSC > .vscode > { } tasks.json > ...


```
1  {
2      "version": "2.0.0",
3      "tasks": [
4          {
5              "type": "shell",
6              "label": "Nsight: autostart (localhost)",
7              "command": "nvcc -g -G lab3c.cu -o lab3c",
8              "problemMatcher": ["$nvcc"],
9              "group": {
10                 "kind": "build",
11                 "isDefault": true
12             }
13         }
14     ]
15 }
```

>build|

Tasks: Configure Default **Build** Task

recently used 

Tasks: Run **Build** Task

Ctrl + Shift + B 

(Internal) **Build** a Target by Name

other commands

npm: Run **Build**

5

6

7

8



"type": "shell",

"label": "Nsight: autostart (1

"command": "make dbg=1",

"problemMatcher": ["\$gcc"]

EXPLORER	...	{ } launch.json	{ } tasks.json 1	lab3c.cu ×
✓ vsc		lab3c.cu > main()		
✓ .vscode	●	27		
{ } launch.json		28	int main(){	
{ } tasks.json	1	29	int N=VECTOR_LENGTH;	
> coverage		30	int *a, *b;	
≡ lab3c		31	int *a_h;	
lab3c.cu		32		
Makefile		33	cudaMalloc((void**)&a, N*sizeof(int));	
		34	cudaMalloc((void**)&b, N*sizeof(int));	
		35	a_h=(int*)calloc(N, sizeof(int));	
		36		
		● 37	gInit<<<N/128, 128>>>(a,b);	
		38	cudaDeviceSynchronize();	
		39	CUDA_CHECK_RETURN(cudaGetLastError());	

R...  CUDA C++  ...

▼ VARIABLES

▼ Local

N: 256

▼ a: 0x7fffc7000000

*a: 0




> b: 0x7fffc7000400


▼ a_h: 0xd25c30









*a_h: 0

> Registers

▼ WATCH

 launch.json

       lab3c.cu 

lab3c.cu > main()

```
27
28 int main(){
29     int N=VECTOR_LENGTH;
30     int *a, *b;
31     int *a_h;
32
33     cudaMalloc((void**)&a, N*sizeof(int));
34     cudaMalloc((void**)&b, N*sizeof(int));
35     a_h=(int*)calloc(N, sizeof(int));
36
37     gInit<<<N/128, 128>>>(a,b);
38     cudaDeviceSynchronize();
39     CUDA_CHECK_RETURN(cudaGetLastError());
```