总结

- 1. 发现nvvp和nvprof不支持在算力比较高 (8.9) 的显卡上使用,于是使用了nsight systems
- 2. 将测量的GPU运行时间调整为测量数据拷贝时间和kernel运行时间
- 3. 经过多次测试,原版运行时间大约为**675ms**;使用pinned memory的运行时间大约为**173ms**;使用breadth-first 2 streams和pinned memory的运行时间大约为**168ms**;使用breadth-first 3 streams和pinned memory的运行时间大约为**178ms**
- 4. 在使用2 streams的情况下,使用breadth-first和depth-first两种方式的运行时间没有测量出明显区别,通过nsight systems可以看出stream的运行顺序变了,时间上没有明显区别应该是和显卡有关
- 5. 对于原版和pinned memory版本来说,[6/8]+[7/8]的时间近似就是测出来的时间;而当stream的数量超过1时,这个约等式不再成立,根据stream的作用可以得出测量的时间理论上不再是kernel的时间和数据拷贝的时间线性和,根据nsight systems给出的timeline可知,此时的kernel执行和数据拷贝存在overlap,提高了运行效率。
- 6. 使用2streams比单纯使用pinned memory大概快了5ms,使用3streams又比单纯使用pinned memory大概慢了5ms。通过下一章节的数据可以看出stream增加会导致创建成本同步成本等成本增加,结果上慢了一点应该是因为3streams的排布不如2streams的效率高
- 7. 多次测量时发现3streams的用时不如2streams的稳定,应该和3不是2的幂有关

数据

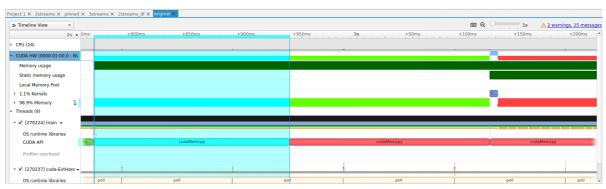
包含了命令行的分析总结和GUI的timeline

原版

```
$ nsys profile --stats=true ./main
[Vector addition of 104857600 elements]
A ok!B ok!C ok!Copy input data from the host memory to the CUDA device
CUDA kernel launch with 409600 blocks of 256 threads
Copy output data from the CUDA device to the host memory
GPU Time used: 674.0 ms
CPU Time used: 902.5 ms
Test PASSED
Generating '/tmp/nsys-report-9fb9.qdstrm'
[2/8] [=========100%] report1.sqlite
[3/8] Executing 'nvtxsum' stats report
SKIPPED: /home/admini/code/generalgpu/stream/build/report1.sqlite does not
contain NV Tools Extension (NVTX) data.
[4/8] Executing 'osrtsum' stats report
Time (%) Total Time (ns) Num Calls Avg (ns)
                                              Med (ns) Min (ns)
  Max (ns) StdDev (ns)
          1,871,878,762 2 935,939,381.0 935,939,381.0 1,726,358
    36.4
1,870,152,404 1,321,176,727.3 sem_wait
    33.2 1,703,924,428 27 63,108,312.1 100,202,545.0
                                                                 1,620
  100,267,667 46,615,563.2 poll
```

29.2 1	,500,403,355		3 5	500,134,451.7	500,152,039.0	500,083,832
	44,5					, ,
1.1	56,953,982		446	127,699.5	5,043.5	1,021
17,756,478	1,168,65	57.0	ioctl			
					7,885.0	3,223
	101,0					
					97,007.0	4,728
	82,77					
0.0					7,336.5	1,922
25,047					FC 014 0	24 540
120,088	329,887			d_create	56,914.0	34,540
0.0					3,184.0	1,090
	13,94			0,133.3	3,104.0	1,050
0.0				3,524.0	2,845.0	1,136
9,218						
0.0	65,996			5,999.6	3,947.0	1,318
19,637	5,25	50.1	munmap			
0.0	42,311		4	10,577.8	8,134.5	3,029
23,013						
0.0				3,450.2	2,703.0	1,105
5,652						
0.0				6,031.0	6,031.0	3,641
8,421 0.0				2,318.2	2,314.0	1,614
3,527				2,310.2	2,314.0	1,014
0.0				7,056.0	7,056.0	7,056
7,056			connect		.,000.0	7,000
	6,929				1,324.0	1,145
1,844	. 20	67.2	fclose			
0.0	5,918		1	5,918.0	5,918.0	5,918
5,918	1	0.0	pipe2			
0.0	5,409		3	1,803.0	1,916.0	1,269
	. 48			4 560 0	4 560 0	4 252
0.0			2	1,569.0	1,569.0	1,353
1,785				2 141 0	2,141.0	2,141
2,141			fopen64		2,141.0	2,141
0.0			1		2,014.0	2,014
2,014				_,,	_,	_,
[5/8] Executin	g 'cudaapisum'	sta	ts repo	^t		
Time (%) Tot	al Time (ns)	Num	Calls	Avg (ns)	Med (ns)	Min (ns)
	StdDev (ns)		Nar	_		
88.6	673,424,071		3 2	224,474,690.3	182,700,874.0	174,260,069
	79,776,038.4					
	81,183,968				40,591,984.0	696
	57,404,750.0				2 105 675 0	262 047
	4,564,216 1,090,013.2			1,521,405.3	2,105,675.0	263,817
	310,990			310 990 0	310,990.0	310 990
	0.0				310,330.0	510,550
310,330	0.0					

0.0	205,717	3	68,572.3	57,842	49,91	.1
97,964	25,761.0	cudaMalloc				
0.0	13,111	2	6,555.5	6,555	6,22	6
6,885	466.0	cudaEventRed	cord			
0.0	3,080	1	3,080.0	3,080	3,08	0
3,080	0.0	cudaEventSyr	nchronize			
0.0	1,156	2	578.0	578	28	7
869	411.5	cudaEventDes	stroy			
0.0	905		905.0	905	90	5
905	0.0	cuModuleGet	_oadingMode			
Time (%) To	ing <mark>'gpukernsum</mark> otal Time (ns)	Instances	Avg (ns)	Med (ns)	Min (ns) Max	
(ns) StdDev	v (ns) Gri	dXYZ	BlockXYZ			
Name						
		-				
100.0	7,083,616				.,,	
7,083,616 *, const doub [7/8] Execut	0.0 40 ble *, double * ing 'gpumemtime	sum' stats re	1 256 1		Add(const doub	ole
7,083,616 *, const doub [7/8] Execut	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns)	sum' stats re	1 256 1		Add(const doub	ole
7,083,616 *, const doub [7/8] Execut	0.0 40 ble *, double * ing 'gpumemtime	sum' stats re	1 256 1		Add(const doub	ole
7,083,616 *, const doub [7/8] Execut	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns)	sum' stats re	1 256 1		Add(const doub	ole
7,083,616 *, const doub [7/8] Execut Time (%) To Max (ns)	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns)	csum' stats re Count Ave Operation	1 256 1 eport g (ns) M	Med (ns)	Add(const doub	le
7,083,616 *, const doub [7/8] Execut Time (%) To Max (ns)	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns) StdDev (ns)	Count Ave Operation 2 178,3	1 256 1 eport g (ns) M 338,234.0 178	Med (ns)	Add(const doub	ole
7,083,616 *, const doub [7/8] Execut Time (%) To Max (ns) S	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns) StdDev (ns) 356,676,468	Count Ave Operation 2 178,3	1 256 1 eport g (ns) M 338,234.0 178	Med (ns)	Min (ns)	nle
7,083,616 *, const doub [7/8] Execut Time (%) To Max (ns) 9 53.6 182,549,533 46.4	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns) StdDev (ns)	Count Aveous Count	1 256 1 eport g (ns) M 338,234.0 178 HtoD] 821,854.0 308	Med (ns)	Min (ns)	ole
7,083,616 *, const doub [7/8] Execut Time (%) To Max (ns)	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns) StdDev (ns)	Count Aveous Count	1 256 1 eport g (ns) M 338,234.0 178 HtoD] 821,854.0 308	Med (ns)	Min (ns)	ole
7,083,616 *, const doub [7/8] Execut Time (%) To Max (ns)	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns) StdDev (ns)	Count Ave Operation 2 178,3 [CUDA memcpy 1 308,8 [CUDA memcpy	1 256 1 eport g (ns) M 338,234.0 178 HtoD] 321,854.0 308 DtoH]	Med (ns)	Min (ns)	ole
7,083,616 *, const doub [7/8] Execut Time (%) To Max (ns)	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns) StdDev (ns) 356,676,468 5,955,676.2 308,821,854 0.0	Count Ave Operation 2 178,3 [CUDA memcpy 1 308,8 [CUDA memcpy sum' stats re	1 256 1 eport g (ns) M	Med (ns) 3,338,234.0 3,821,854.0	Min (ns)	ole
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7,083,616 *, const doub [7/8] Execut Time (%) To Max (ns) 9 53.6 182,549,533 46.4 308,821,854 [8/8] Execut Total (MB)	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns) StdDev (ns) 356,676,468 5,955,676.2 308,821,854 0.0 ing 'gpumemsize	Count Ave Operation 2 178,3 [CUDA memcpy 1 308,8 [CUDA memcpy sum' stats re	1 256 1 eport g (ns) M	Med (ns) 3,338,234.0 3,821,854.0	Min (ns)	ole
7,083,616 *, const doub [7/8] Execut Time (%) To Max (ns) 9 53.6 182,549,533 46.4 308,821,854 [8/8] Execut Total (MB) Operation	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns) StdDev (ns) 356,676,468 5,955,676.2 308,821,854 0.0 ing 'gpumemsize Count Avg (MB	Count Aveous Count C	1 256 1 eport g (ns) M	Med (ns) 3,338,234.0 3,821,854.0	Min (ns)	ole
7,083,616 *, const doul [7/8] Execut Time (%) To Max (ns) 9 53.6 182,549,533 46.4 308,821,854 [8/8] Execut Total (MB) Operation	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns) StdDev (ns) 356,676,468 5,955,676.2 308,821,854 0.0 ing 'gpumemsize Count Avg (MB	Count Aveous Count C	1 256 1 eport g (ns) M	Med (ns) 3,338,234.0 3,821,854.0	Min (ns)	ole
7,083,616 *, const doul [7/8] Execut Time (%) To Max (ns)	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns) StdDev (ns) 356,676,468 5,955,676.2 308,821,854 0.0 ing 'gpumemsize Count Avg (MB	Count Aveous Operation 2 178,3 [CUDA memcpy 1 308,8 [CUDA memcpy 8 sum' stats reads) Med (MB)	1 256 1 eport g (ns) M	Med (ns) 3,338,234.0 3,821,854.0	Min (ns)	ole
7,083,616 *, const doub [7/8] Execut Time (%) To Max (ns)	0.0 40 ble *, double * ing 'gpumemtime otal Time (ns) StdDev (ns) 356,676,468 5,955,676.2 308,821,854 0.0 ing 'gpumemsize Count Avg (MB	Count Aveous Operation 2 178,3 [CUDA memcpy 1 308,8 [CUDA memcpy 8 sum' stats reads) Med (MB)	1 256 1 eport g (ns) M	Med (ns) 3,338,234.0 3,821,854.0 (MB) StdDe	Min (ns) 174,126,935 308,821,854 EV (MB) 0.000 [CUDA	ole

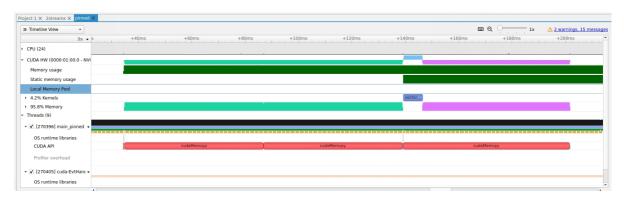


使用pinned memory

```
$ nsys profile --stats=true ./main_pinned
[Vector addition of 104857600 elements]
Copy input data from the host memory to the CUDA device
CUDA kernel launch with 409600 blocks of 256 threads
Copy output data from the CUDA device to the host memory
GPU Time used: 172.5 ms
CPU Time used: 913.8 ms
Test PASSED
Done
Generating '/tmp/nsys-report-3171.qdstrm'
[2/8] [==============100%] report10.sqlite
[3/8] Executing 'nvtxsum' stats report
SKIPPED: /home/admini/code/generalgpu/stream/build/report10.sqlite does not
contain NV Tools Extension (NVTX) data.
[4/8] Executing 'osrtsum' stats report
Time (%) Total Time (ns) Num Calls Avg (ns)
                                             Med (ns)
(ns) Max (ns) StdDev (ns)
                              Name
 4,218,830,129 2 2,109,415,064.5 2,109,415,064.5
2,212,856 4,216,617,273 2,980,033,941.9 sem_wait
         4,008,072,448 50
                               80,161,449.0 100,203,911.0
2,159 100,252,674 38,729,981.0 poll
   28.0 3,500,954,069 7 500,136,295.6 500,151,025.0
,064,024 500,172,517 40,436.2 pthread_cond_timedwait
500,064,024 500,172,517
           673,308,632 471 1,429,530.0
    5.4
1,008 191,342,389 15,095,320.8 ioctl
    0.9
         115,111,404 26
                                4,427,361.7
                                                8,188.5
1,384 39,305,693 12,486,171.8 mmap
           1,072,952 9 119,216.9 106,741.0
    0.0
          237,809 51,550.8 sem_timedwait
71,567
           837,156
    0.0
                        27
                                  31,005.8
                                                 6,891.0
3,690
          505,067 95,274.6 mmap64
          350,722
                       5
                                   70,144.4 61,090.0
    0.0
          133,131 40,148.9 pthread_create
30,247
          329,321 44
16,303 3,092.1 open64
    0.0
                                    7,484.6
                                                 7,321.0
1,813
          109,739 17
19,686 4,972.1 munmap
    0.0
                                    6,455.2
                                                 4,434.0
1,783
              107,127
                          30
                                    3,570.9
    0.0
                                                 2,567.5
           19,068 3,558.4 fopen
1,081
              44,352
    0.0
                        4
                                   11,088.0
                                                  9,451.0
           22,120 8,930.3 fgets
3,330
              23,051
                                    4,610.2
    0.0
                           5
                                                  4,044.0
           7,160 1,865.1 fread
2,459
              22,552
                        5
                                    4,510.4
    0.0
1,236
          11,171 4,143.1 open
    0.0
               10,382
                         2
                                    5,191.0
                                                 5,191.0
           7,562 3,353.1 socket
2,820
```

0.0 7,352 3 2,450.7 1,236.0 1,133 4,983 2,193.7 fclose 0.0 7,180 1 7,180.0 7,180.0 7,180 7,180 0.0 connect 0.0 5,352 1 5,352.0 5,352.0 5,352 5,352 0.0 pipe2 0.0 4,978 3 1,659.3 1,854.0 1,194 1,930 404.8 read 0.0 4,410 2 2,205.0 2,205.0 1,665 2,745 763.7 write 0.0 3,491 1 3,491.0 3,491.0 3,491 3,491 0.0 fopen64 0.0 3,373 1 3,373.0 3,373.0 0.0 fcntl 0.0 1,040 1 1,040.0 1,040.0 1,040 1,040 0.0 fflush 5/8] Executing 'cudaapisum' stats report Trime (%) Total Time (ns) Num Calls Avg (ns) Med (ns) Min (ns) Max (ns) StdDev (ns) Name 66.8 661,479,223 3 220,493,074.3 193,939,888.0 188,565,64 278,973,690 50,716,934.3 cudaHostAlloc 17.4 172,042,881 1 3,492.0 357,347,627.0 57,250,147.0 52,753,57 62,039,162 4,643,562.4 cudaWemcpy 15.3 151,670,130 3 50,556,710.0 49,837,796.0 49,608,29 52,224,035 1,448,498.1 cudaFreeHost 0.5 4,568,332 3 1,522,777.3 2,108,546.0 250,47 2,209,307 1,102,993.9 cudaFree 0.0 456,910 0 cudaLaunchKernel 0.0 285,434 184,506 77,392.7 cudaMalloc 0.0 16,719 2 8,359.5 8,359.5 3,94 12,775 6,244.5 cudaeVentRecord 0.0 1,149 7,383.7 cudaeVentRecord 0.0 11,906 2 5,953.0 5,953.0 41 12,775 6,244.5 cudaeVentRecord 0.0 1,134 2 567.0 567.0 27,83 2,783 0.0 cudaeVentRecord 0.0 1,134 2 567.0 567.0 27,83 2,783 0.0 cudaeVentSynchronize 0.0 1,061 1 1,061.0 1,061.0 1,066 0.0 1,061 0.0 cudwoduleGetLoadingMode 6/8] Executing 'gpukernsum' stats report Time (%) Total Time (ns) Instances Avg (ns) Med (ns) Min (ns) Max ame						
7,180 7,180 1 7,180.0 7,180.0 7,180.0 7,180.0 7,180 0.0 connect 0.0 5,352 1 5,352.0 5,					0.7 1,2	36.0
7,180 7,180 0.0 connect 0.0 5,352 1 5,352.0 5,352.0 5,352 0.0 pipe2 0.0 4,978 3 1,659.3 1,854.0 1,194 1,930 404.8 read 0.0 4,410 2 2,205.0 2,205.0 1,665 2,745 763.7 write 0.0 3,491 0.0 fopen64 0.0 3,491 1,00 fopen64 0.0 3,373 1 3,373.0 3,373.0 3,373 3,373 0.0 fcntl 1,040 1,040 0.0 fflush 5/8] Executing 'cudaapisum' stats report Time (%) Total Time (ns) Num Calls Avg (ns) Med (ns) Min (ns) Max (ns) StdDev (ns) Name 66.8 661,479,223 3 220,493,074.3 193,939,888.0 188,565,64 278,973,690 50,716,934.3 cudaHostalloc 17.4 172,042,881 3 57,347,627.0 57,250,147.0 52,753,57 62,039,162 4,643,562.4 cudaHostalloc 17.4 172,042,881 3 50,556,710.0 49,837,796.0 49,608,29 22,224,035 1,448,498.1 cudaFreeHost 0.5 4,568,332 3 1,522,777.3 2,108,546.0 250,47 2,209,307 1,102,993.9 cudaFree 0.0 456,910 0.0 cudaLaunchKernel 0.0 285,434 3 95,144.7 51,202.0 49,72 1456,910 0.0 cudaLaunchKernel 0.0 285,434 3 95,144.7 51,202.0 49,72 1456,910 0.0 cudaLaunchKernel 0.0 16,719 2 8,359.5 8,359.5 3,94 12,775 6,244.5 cudaEventecord 0.0 1,719 2 8,359.5 8,359.5 3,94 12,775 6,244.5 cudaEventRecord 0.0 1,719 2 8,359.5 8,359.5 3,94 12,775 6,244.5 cudaEventRecord 0.0 1,719 2 8,359.5 8,359.5 3,94 12,775 6,244.5 cudaEventRecord 0.0 1,719 2 8,359.5 8,359.5 3,94 12,775 6,244.5 cudaEventRecord 0.0 1,719 2 8,359.5 8,359.5 3,94 12,775 6,244.5 cudaEventRecord 0.0 1,719 2 8,359.5 8,359.5 3,94 12,775 6,244.5 cudaEventRecord 0.0 1,719 2 8,359.5 8,359.5 3,94 12,775 6,244.5 cudaEventRecord 0.0 1,714 2 567.0 567.0 27 0.0 1,344 2 567.0 567.0 27 0.0 1,344 2 567.0 567.0 27 0.0 1,344 2 567.0 567.0 27 0.0 1,344 2 567.0 567.0 27 0.0 1,061 1 1,061.0 1,061.0 1,061.0 1,061 0.0 cudaEventDestroy 0.0 1,061 1 1,061.0 1,061.0 1,061.0 1,061 0.0 cudaGetLoadingMode						
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5,352 5,352 0.0 pipe2 0.0 4,978 3 1,659.3 1,854.0 1,194 1,930 404.8 read 0.0 4,410 2 2,205.0 2,205.0 1,665 2,745 763.7 write 0.0 3,491 1 3,491.0 3,491.0 3,491 0.0 fopen64 0.0 1,040 1 1,040 0.0 ffortl 0.0 1,040 1 1,040.0 1,040.0 1,040 1,040 0.0 fflush S/8] Executing 'cudaapisum' stats report Time (%) Total Time (ns) Num Calls Avg (ns) Med (ns) Min (ns) Max (ns) StdDev (ns) Name 66.8 661,479,223 3 220,493,074.3 193,939,888.0 188,565,64 278,973,690 50,716,934.3 cudaHostAlloc 17.4 172,042,881 57,347,627.0 57,250,147.0 52,753,57 62,039,162 4,643,562.4 cudaMencpy 15.3 151,670,130 3 50,556,710.0 49,837,796.0 49,608,29 55,224,035 1,448,498.1 cudaFreeHost 0.5 4,568,332 3 1,522,777.3 2,108,546.0 250,47 2,209,307 1,102,993.9 cudaFree 0.0 456,910 1 456,910.0 456,910.0 456,910 456,910 0.0 cudaLaunchKernel 0.0 285,434 3 95,144.7 51,202.0 49,72 12,775 6,244.5 cudaEventRecord 0.0 11,906 2 5,953.0 5,953.0 41 11,493 7,834.7 cudaEventRecord 0.0 11,906 2 5,953.0 5,953.0 41 11,493 7,834.7 cudaEventRecord 0.0 1,134 2 567.0 567.0 21 922 502.0 cudaEventRecord 0.0 1,134 2 567.0 567.0 21 922 502.0 cudaEventPostroy 0.0 1,061 1 1,061.0 1,061.0 1,066.6/8] Executing 'gpukernsum' stats report Time (%) Total Time (ns) Instances Avg (ns) Med (ns) Min (ns) Max ns) StdDev (ns) Gridxyz Blockxyz						5 2.0
1,194					2.0 5,3	52.0
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0.0 16,719 2 8,359.5 8,359.5 3,94 12,775 6,244.5 cudaEventRecord 0.0 11,906 2 5,953.0 5,953.0 41 11,493 7,834.7 cudaEventCreate 0.0 2,783 1 2,783.0 2,783.0 2,78 2,783 0.0 cudaEventSynchronize 0.0 1,134 2 567.0 567.0 21 922 502.0 cudaEventDestroy 0.0 1,061 1 1,061.0 1,061.0 1,061 1,061 0.0 cuModuleGetLoadingMode 6/8] Executing 'gpukernsum' stats report Time (%) Total Time (ns) Instances Avg (ns) Med (ns) Min (ns) Max ns) StdDev (ns) GridXYZ BlockXYZ				95,144.	7 51,202.0	49,72
12,775 6,244.5 cudaEventRecord 0.0 11,906 2 5,953.0 5,953.0 41 11,493 7,834.7 cudaEventCreate 0.0 2,783 1 2,783.0 2,783.0 2,78 2,783 0.0 cudaEventSynchronize 0.0 1,134 2 567.0 567.0 21 922 502.0 cudaEventDestroy 0.0 1,061 1 1,061.0 1,061.0 1,061 1,061 0.0 cuModuleGetLoadingMode 6/8] Executing 'gpukernsum' stats report Time (%) Total Time (ns) Instances Avg (ns) Med (ns) Min (ns) Max (ns) StdDev (ns) GridXYZ BlockXYZ				8 350	5 8 250 5	2 0/
0.0 11,906 2 5,953.0 5,953.0 41 11,493 7,834.7 cudaEventCreate 0.0 2,783 1 2,783.0 2,783.0 2,78 2,783 0.0 cudaEventSynchronize 0.0 1,134 2 567.0 567.0 21 922 502.0 cudaEventDestroy 0.0 1,061 1 1,061.0 1,061.0 1,061 1,061 0.0 cuModuleGetLoadingMode 6/8] Executing 'gpukernsum' stats report Time (%) Total Time (ns) Instances Avg (ns) Med (ns) Min (ns) Maxns) StdDev (ns) GridXYZ BlockXYZ					5 6,559.5	3,34
11,493					n 5 953 N	<i>Δ</i> 1
0.0 2,783 1 2,783.0 2,783.0 2,78 2,783 0.0 cudaEventSynchronize 0.0 1,134 2 567.0 567.0 21 922 502.0 cudaEventDestroy 0.0 1,061 1 1,061.0 1,061.0 1,061 1,061 0.0 cuModuleGetLoadingMode 6/8] Executing 'gpukernsum' stats report Time (%) Total Time (ns) Instances Avg (ns) Med (ns) Min (ns) Max (ns) StdDev (ns) GridXYZ BlockXYZ					3,333.0	7.
2,783					0 2.783.0	2.78
0.0 1,134 2 567.0 567.0 21 922 502.0 cudaEventDestroy 0.0 1,061 1 1,061.0 1,061.0 1,06 1,061 0.0 cuModuleGetLoadingMode 6/8] Executing 'gpukernsum' stats report Time (%) Total Time (ns) Instances Avg (ns) Med (ns) Min (ns) Max ns) StdDev (ns) GridXYZ BlockXYZ					_,	_,,,
922 502.0 cudaEventDestroy 0.0 1,061 1 1,061.0 1,061.0 1,06 1,061 0.0 cuModuleGetLoadingMode 6/8] Executing 'gpukernsum' stats report Time (%) Total Time (ns) Instances Avg (ns) Med (ns) Min (ns) Max ns) StdDev (ns) GridXYZ BlockXYZ					0 567.0	21
1,061 0.0 cuModuleGetLoadingMode 6/8] Executing 'gpukernsum' stats report Time (%) Total Time (ns) Instances Avg (ns) Med (ns) Min (ns) Max ns) StdDev (ns) GridXYZ BlockXYZ	922					
1,061 0.0 cuModuleGetLoadingMode 6/8] Executing 'gpukernsum' stats report Time (%) Total Time (ns) Instances Avg (ns) Med (ns) Min (ns) Max ns) StdDev (ns) GridXYZ BlockXYZ	0.0				0 1,061.0	1,06
6/8] Executing 'gpukernsum' stats report Time (%) Total Time (ns) Instances Avg (ns) Med (ns) Min (ns) Max ns) StdDev (ns) GridXYZ BlockXYZ	1,061		cuModuleGet			
		ng 'gpukernsum				n (nc) May
	Time (%) To			_	Med (ns) Mi	II (IIS) Max

```
100.0 7,085,974 1 7,085,974.0 7,085,974.0 7,085,974
 7,085,974
               0.0 409600 1 1 256 1 1 vectorAdd(const double
*, const double *, double *, int)
[7/8] Executing 'gpumemtimesum' stats report
 Time (%) Total Time (ns) Count Avg (ns) Med (ns) Min (ns)
                                                             Max
(ns) StdDev (ns) Operation
        109,913,699 2 54,956,849.5 54,956,849.5 52,674,590
 57,239,109 3,227,602.3 [CUDA memcpy HtoD]
    33.3 54,949,107 1 54,949,107.0 54,949,107.0 54,949,107
 54,949,107
               0.0 [CUDA memcpy DtoH]
[8/8] Executing 'gpumemsizesum' stats report
 Total (MB) Count Avg (MB) Med (MB) Min (MB) Max (MB) StdDev (MB)
Operation
 1,677.722 2 838.861 838.861 838.861 0.000 [CUDA
memcpy HtoD]
            1 838.861 838.861 838.861 0.000 [CUDA
  838.861
memcpy DtoH]
```

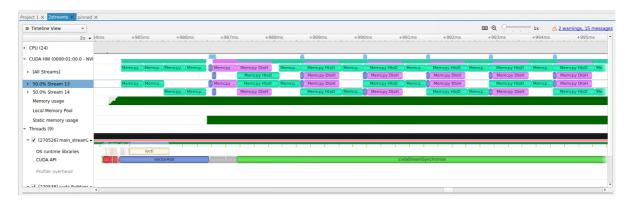


使用breadth-first 2 streams with pinned memory

	lax (ns) Sto				
 33.7	4,216,700,547	 2	2.108.350.273.5	 2.108.350.273.5	
	4,214,908,525 2			2,200,330,27313	
	4,007,147,145			100.157.232.0	
	.00,265,535 38			_00,_01,_0210	
	3,501,004,838		•	500.154.704.0	
	56 500,185,178				
	659,203,703				
	.90,723,960 14			5, ==510	
	113,875,176			8.649.0	
	38,445,928 12			.,	
	971,456			101.601.0	
	240,729				
	858,116				
	504,523			,	
	357,565			7.419.0	
	19,493			.,	
0.0			63,345.8	54,978.0	
	102,779				
	132,251				
	45,746			3,003.0	
	113,997			2,656.0	
	109,908			2,03010	
0.0				5,697.5	
	15,034			3,037.13	
	56,817			10,827.0	
	22,150			10,027.0	
	34,889			7.271.0	
	11,161				
0.0	21,559			2,161.0	
	11,048			_,	
0.0	12,461		4,153.7	1,925.0	
1,053				_,	
0.0				5,310.5	
2,739			socket	•,•=•••	
0.0			3,247.5	3,247.5	
1,026			fcntl	-, -	
0.0			6,287.0	6,287.0	
5,287	6,287		connect	,	
0.0				4,964.0	
1,964			pipe2	,,,,,,,	
0.0			1,565.7	1,560.0	
L,065			write	,	
0.0				2,177.0	
	2,177			2,2.7.0	
5/8] Execu	ıting 'cudaapisum'	stats repo	rt		
Time (%)	Total Time (ns)	Num Calls	Avg (ns)	Med (ns) Mi	n (ns)
	StdDev (ns)		_		

```
67.5 655,500,064 3 218,500,021.3 189,408,152.0 188,918,602
277,173,310 50,813,148.1 cudaHostAlloc
        165,402,785
                       2 82,701,392.5 82,701,392.5 2,006,154
   17.0
163,396,631 114,120,300.7 cudaStreamSynchronize
        146,382,491
   15.1
                           3 48,794,163.7 48,410,921.0 48,264,711
 49,706,859
             793,790.9 cudaFreeHost
                          100 22,659.0 1,432.0 1,303
    0.2
             2,265,903
  2,117,081
            211,558.0 cudaLaunchKernel
    0.1
             870,543
                           6 145,090.5 152,592.5 106,198
   155,931
              19,206.8 cudaFree
                          300 1,372.2 1,251.0 1,111
    0.0
              411,664
    15,376
              901.6 cudaMemcpyAsync
    0.0
             253,447
                           6 42,241.2 24,633.5
                                                          20,003
              37,705.3 cudaMalloc
    116,901
                               20,736.5 20,736.5 3,078
    0.0
               41,473
                            2
    38,395
             24,972.9 cudaStreamCreate
    0.0
               25,099
                           2 12,549.5 12,549.5
                                                         12,413
    12,686
                193.0 cudaEventRecord
    0.0
               18,547
                            2 9,273.5 9,273.5 2,236
               9,952.5 cudaStreamDestroy
    16,311
                                              3,962.0
    0.0
               3,962
                           1
                                   3,962.0
                                                          3,962
     3,962
                 0.0 cudaEventSynchronize
                                1,924.5 1,924.5
    0.0
               3,849
                            2
                                                             291
     3,558
               2,310.1 cudaEventCreate
    0.0
               1,601
                           2
                                    800.5
                                                800.5
                                                             278
     1,323
                738.9 cudaEventDestroy
    0.0
                1,549
                            1
                                   1,549.0 1,549.0 1,549
                 0.0 cuModuleGetLoadingMode
     1,549
[6/8] Executing 'gpukernsum' stats report
Time (%) Total Time (ns) Instances Avg (ns) Med (ns) Min (ns) Max (ns)
StdDev (ns)
            GridXYZ
                         BlockXYZ
                                                        Name
            7,949,572 100 79,495.7 79,125.0 72,182 86,420
  100.0
1,842.8 4096 1 1 256 1 1 vectorAdd(const double *, const double
*, double *, int)
[7/8] Executing 'gpumemtimesum' stats report
Time (%) Total Time (ns) Count Avg (ns) Med (ns) Min (ns) Max (ns)
StdDev (ns) Operation
   64.6
          165,767,568 200 828,837.8 930,461.5 445,698 1,700,914
334,854.8 [CUDA memcpy HtoD]
            90,989,003 100 909,890.0 787,554.0 596,013 1,467,986
218,980.9 [CUDA memcpy DtoH]
[8/8] Executing 'gpumemsizesum' stats report
Total (MB) Count Avg (MB) Med (MB) Min (MB) Max (MB) StdDev (MB)
Operation
```

1,677.722	200	8.389	8.389	8.389	8.389	0.000	[CUDA
memcpy HtoD]							
838.861 memcpy DtoH]	100	8.389	8.389	8.389	8.389	0.000	[CUDA

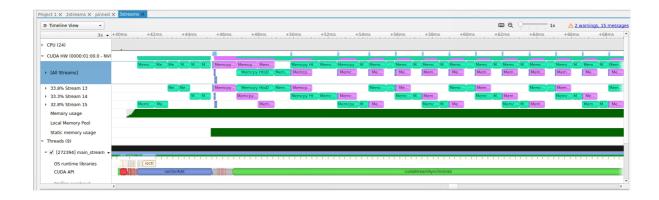


使用breadth-first 3 streams with pinned memory

```
$ nsys profile --stats=true ./main_stream
[Using 3 streams]
[Vector addition of 104857600 elements]
Copy input data from the host memory to the CUDA device
GPU Time used: 178.8 ms
CPU Time used: 896.9 ms
Test PASSED
Generating '/tmp/nsys-report-a07b.qdstrm'
[2/8] [=========================100%] report13.sqlite
[3/8] Executing 'nvtxsum' stats report
SKIPPED: /home/admini/code/generalgpu/stream/build/report13.sqlite does not
contain NV Tools Extension (NVTX) data.
[4/8] Executing 'osrtsum' stats report
Time (%) Total Time (ns) Num Calls Avg (ns)
                                                 Med (ns)
                                                               Min
(ns)
        Max (ns) StdDev (ns)
                                          Name
          4,186,965,546 2 2,093,482,773.0 2,093,482,773.0
    33.6
1,742,187 4,185,223,359 2,958,167,905.7 sem_wait
    32.2 4,008,465,393 50 80,169,307.9 100,200,993.5
1,752 100,258,175 38,841,113.4 poll
    28.1 3,500,932,635 7 500,133,233.6 500,146,474.0 
,083,535 500,155,643 28,284.4 pthread_cond_timedwait
500,083,535 500,155,643
         650,852,838 502 1,296,519.6
                                                       5,386.0
1,008 189,760,444 14,390,698.1 ioctl
     0.9 114,510,670 28 4,089,666.8
                                                    7,610.5
1,249 40,036,719 12,003,406.1 mmap
0.0 823,544 27 30,501.6 8,058.0 3,773 476,307 89,647.8 mmap64
```

0.0 4,815	710,264		78,918.2 sem_timedwait		9.0
	355,792				5.0
1,843	20,589		open64		
0.0	269,955		53,991.0		9.0
31,977	74,228	16,884.3	pthread_create	5	
0.0	134,231	28	4,794.0	1,88	37.0
1,019	62,922	11,533.0	fopen		
0.0	123,533	14	8,823.8	6,64	9.5
2,371	24,455	7,031.4	munmap		
0.0	58,341	5	11,668.7	2 10,38	88.0
4,060	21,645	6,573.5	fread		
0.0	50,422	4	12,605.	12,72	3.0
3,010	21,966	8,324.8	fgets		
0.0	21,804	5	4,360.8	3 2,44	0.0
1,505	10,193	3,659.8	open		
0.0	11,854	2	5,927.0	5,92	27.0
3,733	8,121	3,102.8	socket		
0.0	9,904	2	4,952.0	4,95	2.0
1,075	8,829	5,482.9	fclose		
0.0	9,719	2	4,859.	4,85	9.5
1,264	8,455	5,084.8	fcntl		
0.0	7,548	1	7,548.0	7,54	8.0
7,548	7,548	0.0	connect		
0.0	6,291	3	2,097.0	1,91	.8.0
1,189	3,184	1,009.5	read		
0.0	4,977	1	4,977.0	4,97	7.0
4,977	4,977	0.0	pipe2		
0.0	4,076	1	4,076.0	4,07	6.0
4,076	4,076	0.0	fopen64		
0.0	3,016	2	1,508.0	1,50	08.0
1,283			write		
0.0	1,002	1		1,00	2.0
1,002	1,002	0.0	bind		
[5/8] Execu	iting 'cudaapisum	' stats repo	rt		
Time (%)	Total Time (ns)	Num Calls	Avg (ns)	Med (ns)	Min (ns)
Max (ns)	StdDev (ns)	Na	me		
66.1	643,273,511	3	214,424,503.7	193,410,487.0	186,957,316
262,905,70	8 42,109,752.2	cudaHostA]]	ос		
17.8	173,154,857	3	57,718,285.7	978.0	402
173,153,47	7 99,969,808.2	cudaStreamS	ynchronize		
	148,948,984		49,649,661.3	48,677,567.0	47,536,326
	2,732,309.4	cudaFreeHos	t		
	5,011,884	100	50,118.8	1,696.5	1,334
	483,334.9	cudaLaunchK			
0.1	1,340,812	9		152,502.0	117,379
	8 13,399.9	cudaFree	,	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	,
0.1	757,061	9	84 117 9	37,770.0	28,239
	117,024.6	cudaMalloc	07,117.3	57,770.0	20,233
	515,217	300	1,717.4	1,443.0	1,185
		cudaMemcpyA		1,443.0	Ι, 100
40,13	2,402.7	CudamenicpyA	Sylic		

			47 670 0	8,063.0	0 2,199
0.0	143,010	3	47,670.0	0,003.0	2,199
132,748		cudaStreamCrea			
0.0	43,083	2	21,541.5	21,541.	5 5,216
37,867		cudaEventReco	rd		
0.0	28,084	3	- ,	2,505.0	0 1,342
24,237		cudaStreamDes			
0.0			5,591.5	5,591.	5 304
10,879		cudaEventCrea ⁻			
0.0			2,973.0	2,973.0	0 2,973
2,973		cudaEventSyncl			
0.0	1,056	2		528.0	0 220
		cudaEventDest			
0.0	954	_	954.0	954.0	0 954
954	0.0	cuModuleGetLo	adingMode		
Time (%) Tota		Instances Avo	g (ns) Med (r	ns) Min (ns)) Max (ns) Name
100.0	 8,070,334	100 80	,703.3 79,733	1.0 77,17	1 94,929
100.0		100 80 256 1 1			
2,560.5 4096	1 1				1 94,929 , const double
2,560.5 4096	1 1				
2,560.5 4096 f, double *, in	1 1 t)	256 1 1	vectorAdd(com		
2,560.5 4096 f, double *, in	1 1 t)	256 1 1	vectorAdd(com		
2,560.5 4096 , double *, in	1 1 t) 'gpumemtime	256 1 1 sum' stats repo	vectorAdd(com	nst double *	, const double
2,560.5 4096, double *, information of the control	1 1 t) 'gpumemtime l Time (ns)	256 1 1 sum' stats repo	vectorAdd(com	nst double *	, const double
2,560.5 4096, double *, information of the control	1 1 t) 'gpumemtime l Time (ns)	256 1 1 sum' stats repo	vectorAdd(com	nst double *	, const double
2,560.5 4096 , double *, in 7/8] Executing Time (%) Tota	1 1 t) 'gpumemtime l Time (ns)	256 1 1 sum' stats repo	vectorAdd(com	nst double *	, const double
2,560.5 4096 c, double *, inc 7/8] Executing Time (%) Tota EtdDev (ns)	1 1 'gpumemtime 'Time (ns) Operation	256 1 1 sum' stats repo	vectorAdd(comort s) Med (ns)	nst double * Min (ns)	, const double Max (ns)
2,560.5 4096 c, double *, inc 7/8] Executing Time (%) Tota EtdDev (ns)	1 1 t) 'gpumemtime Time (ns) Operation 176,471,298	256 1 1 sum' stats report Count Avg (notes)	vectorAdd(comort s) Med (ns)	nst double * Min (ns)	, const double Max (ns)
2,560.5 4096 , double *, inf 7/8] Executing Time (%) Tota StdDev (ns) 66.3	1 1 t) 'gpumemtime l Time (ns) Operation	256 1 1 sum' stats report Count Avg (notes)	vectorAdd(conditions) Med (ns) 6.5 978,240.0	Min (ns) 0 448,119	, const double Max (ns)
2,560.5 4096 , double *, inf 7/8] Executing Time (%) Total tdDev (ns) 66.3 355,294.3 [CUI 33.7	1 1 t) 'gpumemtime Time (ns) Operation 176,471,298 DA memcpy Ht 89,836,346	256 1 1 sum' stats report Count Avg (ns., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1	vectorAdd(conditions) Med (ns) 6.5 978,240.0	Min (ns) 0 448,119	, const double Max (ns)
2,560.5 4096 , double *, inf 7/8] Executing Time (%) Total tdDev (ns) 66.3 355,294.3 [CUI 33.7 200,773.8 [CUI	1 1 t) 'gpumemtime Time (ns) Operation	256 1 1 sum' stats report Count Avg (ns., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1	vectorAdd(conditions) Med (ns) 6.5 978,240.0 789,983.0	Min (ns) 0 448,119	, const double Max (ns)
2,560.5 4096 , double *, inf 7/8] Executing Time (%) Tota stdDev (ns) 66.3 355,294.3 [CUI 33.7 200,773.8 [CUI	1 1 t) 'gpumemtime Time (ns) Operation	256 1 1 sum' stats report Count Avg (ns., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1	vectorAdd(conditions) Med (ns) 6.5 978,240.0 789,983.0	Min (ns) 0 448,119	, const double Max (ns)
2,560.5 4096 c, double *, inf controlled (%) Total	1 1 t) 'gpumemtime l Time (ns) Operation 176,471,298 DA memcpy Ht 89,836,346 DA memcpy Dt 'gpumemsize	256 1 1 sum' stats report Count Avg (nstats) 200 882,350 OD] 100 898,365 OH] sum' stats report	vectorAdd(conditions) Med (ns) 6.5 978,240.0 3.5 789,983.0	Min (ns) 0 448,119 0 464,692	, const double Max (ns)
2,560.5 4096 c, double *, inf c7/8] Executing Time (%) Total ctdDev (ns) 66.3 355,294.3 [CUI 33.7 200,773.8 [CUI 8/8] Executing Total (MB) Coi	1 1 t) 'gpumemtime l Time (ns) Operation 176,471,298 DA memcpy Ht 89,836,346 DA memcpy Dt 'gpumemsize	256 1 1 sum' stats report Count Avg (nstats) 200 882,350 OD] 100 898,365 OH] sum' stats report	vectorAdd(conditions) Med (ns) 6.5 978,240.0 3.5 789,983.0	Min (ns) 0 448,119 0 464,692	, const double Max (ns)
2,560.5 4096 f, double *, inf 7/8] Executing Time (%) Total 5tdDev (ns) 66.3 355,294.3 [CUI 33.7 200,773.8 [CUI 8/8] Executing Total (MB) Coi	1 1 t) 'gpumemtime l Time (ns) Operation 176,471,298 DA memcpy Ht 89,836,346 DA memcpy Dt 'gpumemsize	256 1 1 sum' stats report Count Avg (nstats) 200 882,350 OD] 100 898,365 OH] sum' stats report	vectorAdd(conditions) Med (ns) 6.5 978,240.0 3.5 789,983.0	Min (ns) 0 448,119 0 464,692	, const double Max (ns)
2,560.5 4096 c, double *, inf c7/8] Executing Time (%) Total stdDev (ns) 66.3 355,294.3 [CUI 33.7 200,773.8 [CUI [8/8] Executing Total (MB) Couperation	1 1 t) 'gpumemtime 'gpumemtime Time (ns) Operation 176,471,298 DA memcpy Ht 89,836,346 DA memcpy Dt 'gpumemsize unt Avg (MB	256 1 1 Sum' stats report Count Avg (nstats report 200 882,350 D] 100 898,360 OH] sum' stats report Med (MB) Minument	vectorAdd(condition ort) s) Med (ns)	Min (ns) 0 448,119 0 464,692 (MB) StdDev	, const double Max (ns) 2,578,555 1,461,233 (MB)
2,560.5 4096 f, double *, inf f/8] Executing Time (%) Total fidDev (ns) 66.3 355,294.3 [CUI 33.7 200,773.8 [CUI [8/8] Executing Total (MB) Coul peration 1,677.722	1 1 t) 'gpumemtime 'gpumemtime Time (ns) Operation 176,471,298 DA memcpy Ht 89,836,346 DA memcpy Dt 'gpumemsize unt Avg (MB	256 1 1 sum' stats report Count Avg (nstats) 200 882,350 OD] 100 898,365 OH] sum' stats report	vectorAdd(condition ort) s) Med (ns)	Min (ns) 0 448,119 0 464,692 (MB) StdDev	, const double Max (ns)
2,560.5 4096 *, double *, inf [7/8] Executing Time (%) Tota StdDev (ns) 66.3 355,294.3 [CUI 33.7 200,773.8 [CUI [8/8] Executing Total (MB) Cou Operation 1,677.722 nemcpy HtoD]	1 1 t) 'gpumemtime 'gpumemtime l Time (ns) Operation 176,471,298 DA memcpy Ht 89,836,346 DA memcpy Dt 'gpumemsize unt Avg (MB	256 1 1 Sum' stats report Count Avg (nstats report 200 882,350 D] 100 898,360 OH] sum' stats report Med (MB) Minument	vectorAdd(condition ort) s) Med (ns) 6.5 978,240.0 3.5 789,983.0 ort in (MB) Max (1) 8.389 8	Min (ns) 448,119 464,692 (MB) StdDev	, const double Max (ns) 2,578,555 1,461,233 (MB)



使用depth-first 2 streams with pinned memory

