PFC

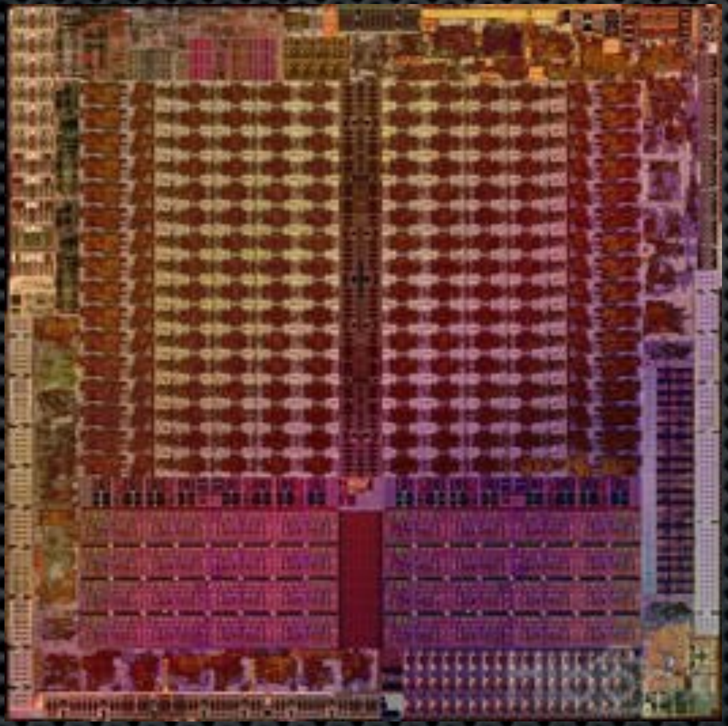
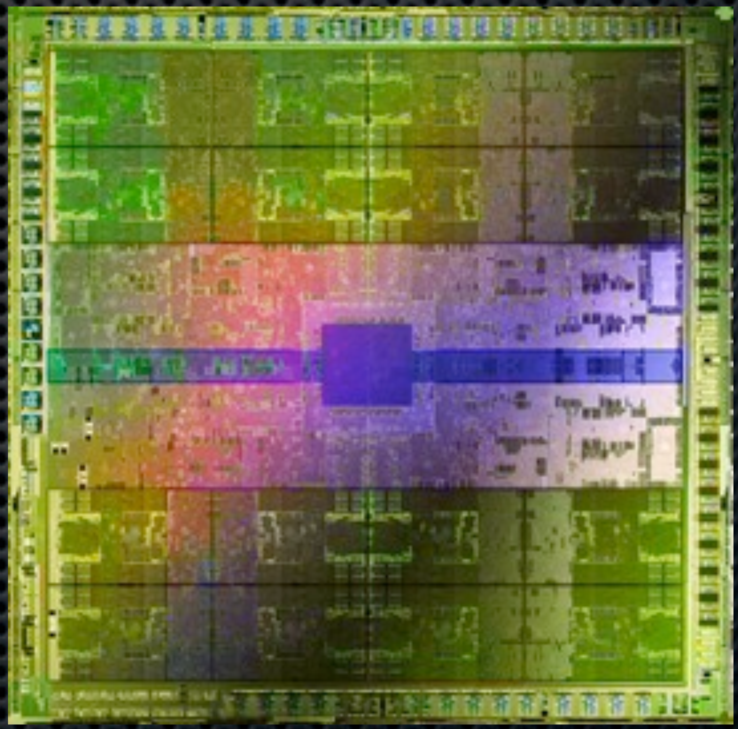
OpenCL based machine learning labeling of biomedical datasets

Project goals

- Learn OpenCL
- Test OpenCL
- Improve performance (reduce execution time) of a Medical imaging program

Project scope

NVIDIA architecture

OpenCL +  + 

ATI architecture

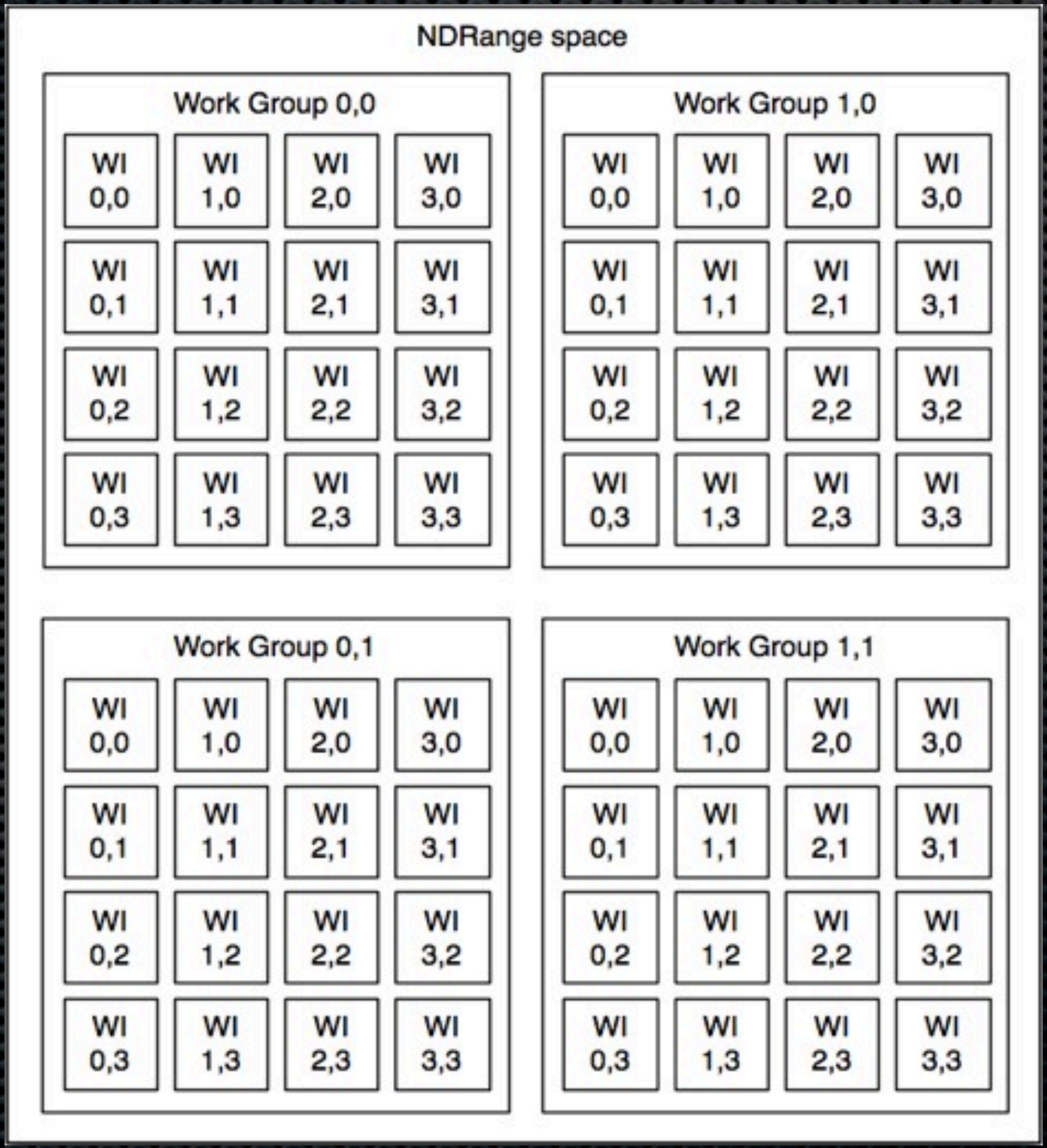
Project environment

- Adaboost algorithm for classifying datasets
- Medical imaging techniques to visualize body datasets

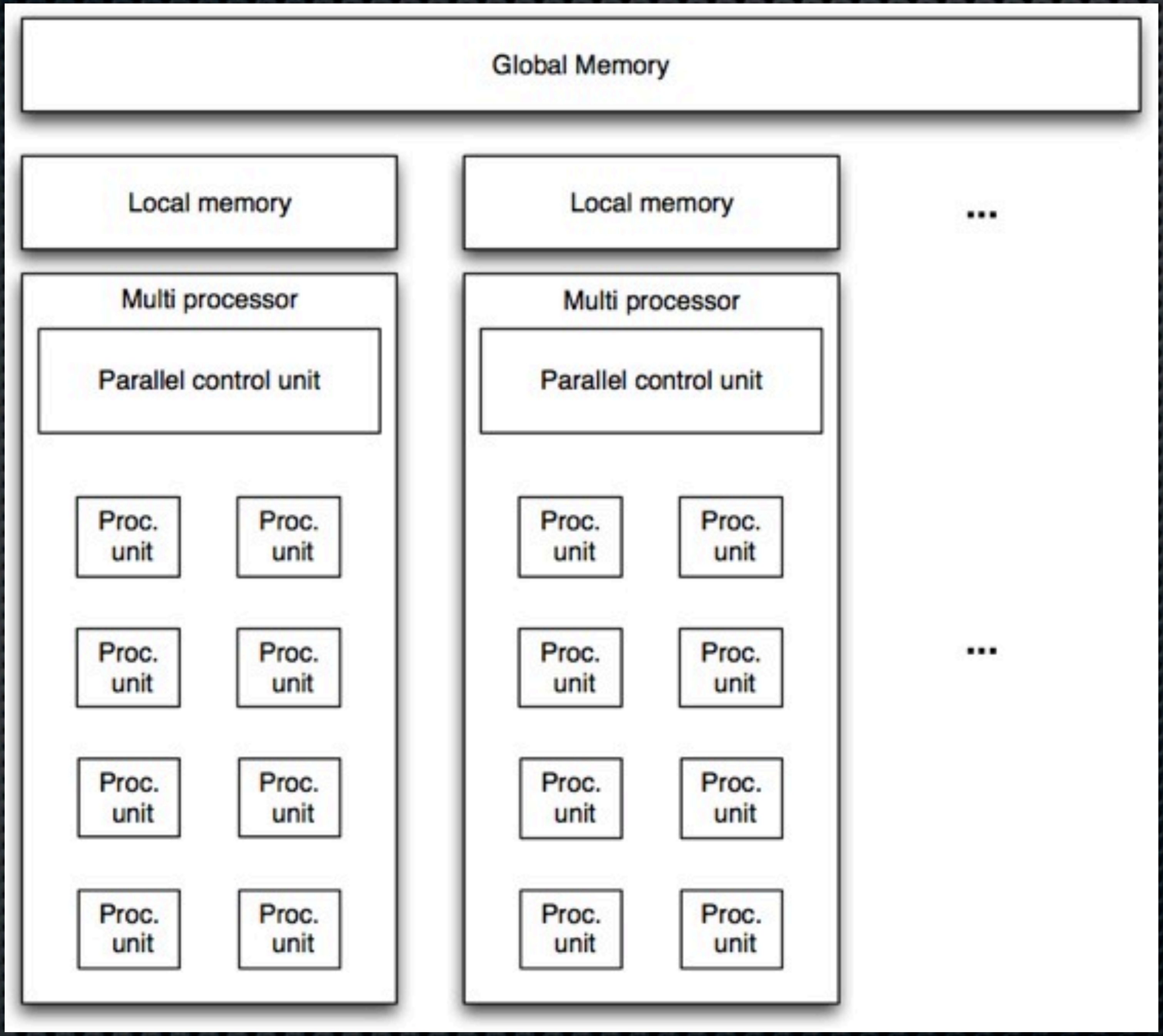
Algorithm

- alfaclass = rc[j1];
- polaritat= gc[j1];
- thresh = bc[j1]*255;
- sumalfa = sumalfa + alfaclass;
- valida = fabs(polaritat)>0.0001;
- positiu=(polaritat>0.5);
- mesgran = i>thresh;
- sum = sum + valida*(positiu*mesgran*alfaclass+ (1-positiu)*(1-mesgran) *alfaclass);

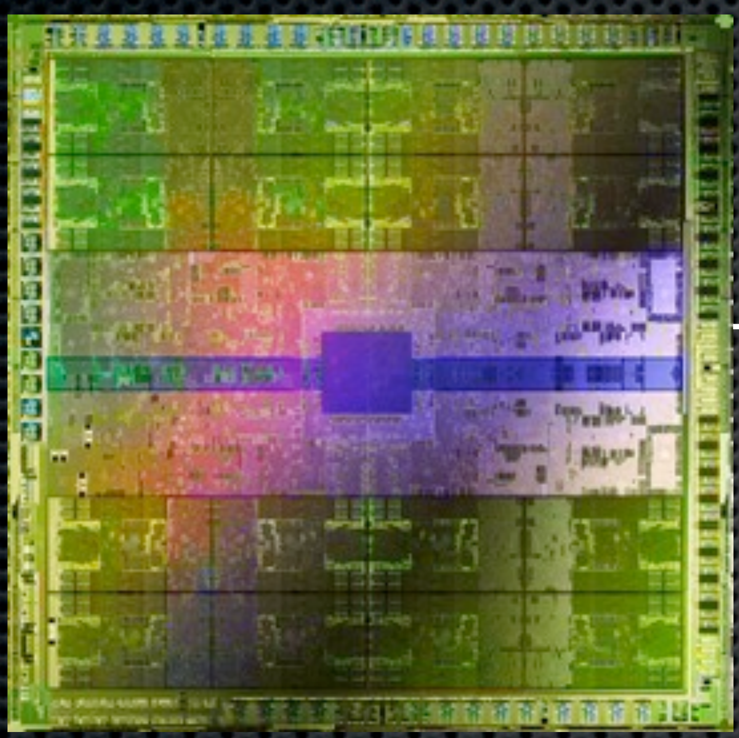
OpenCL: NDRange space

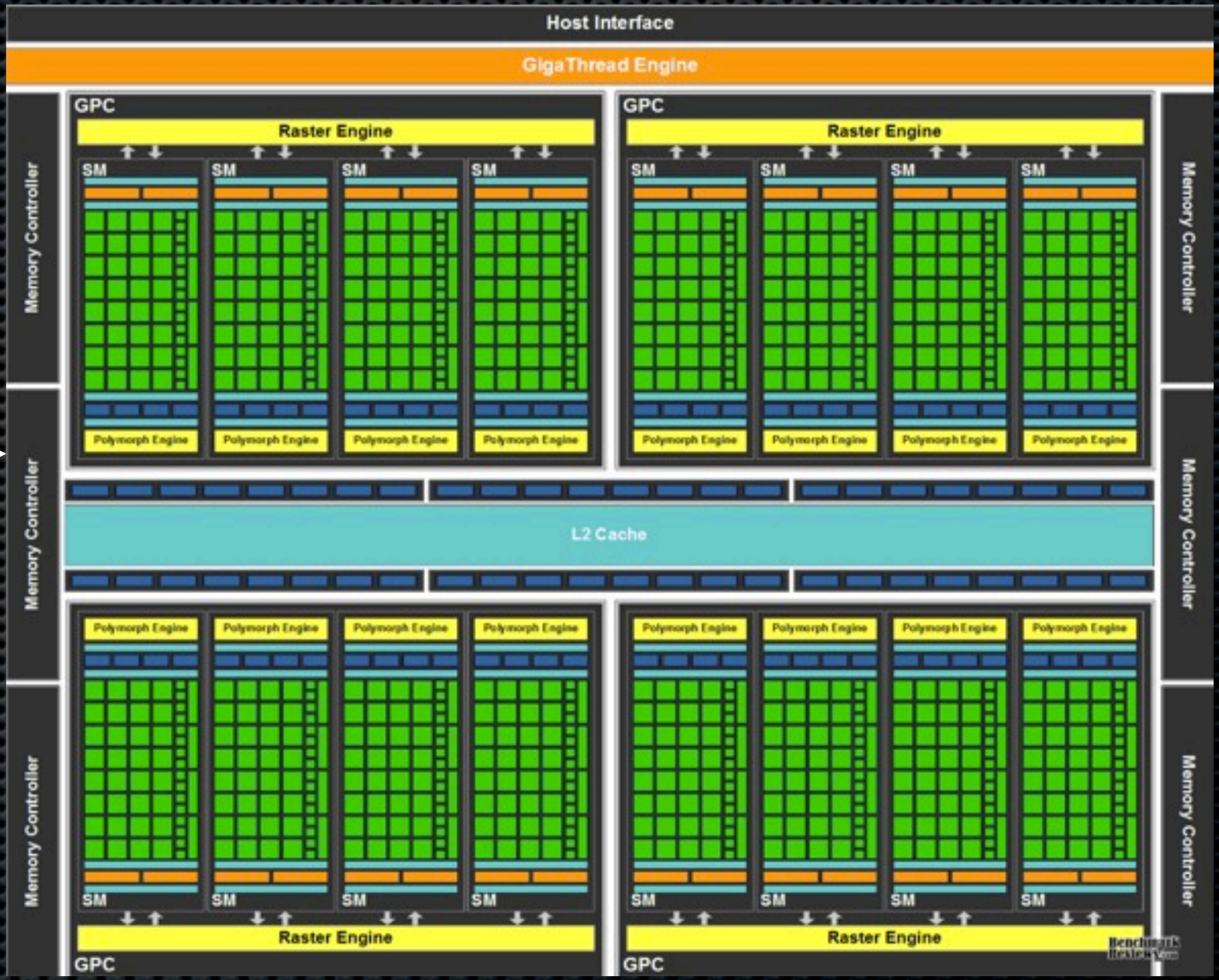


GPGPU architecture

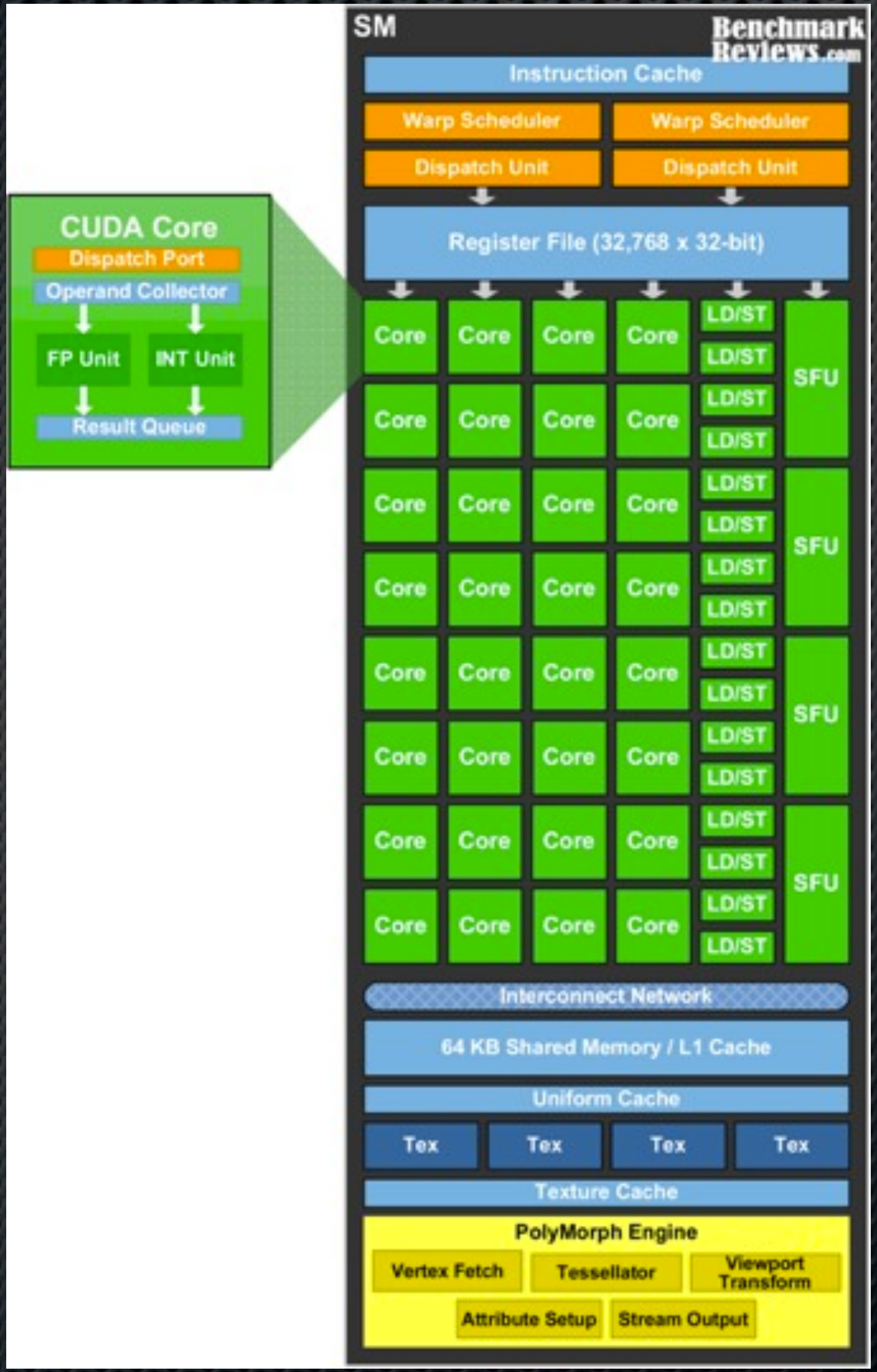


NVIDIA Fermi architecture

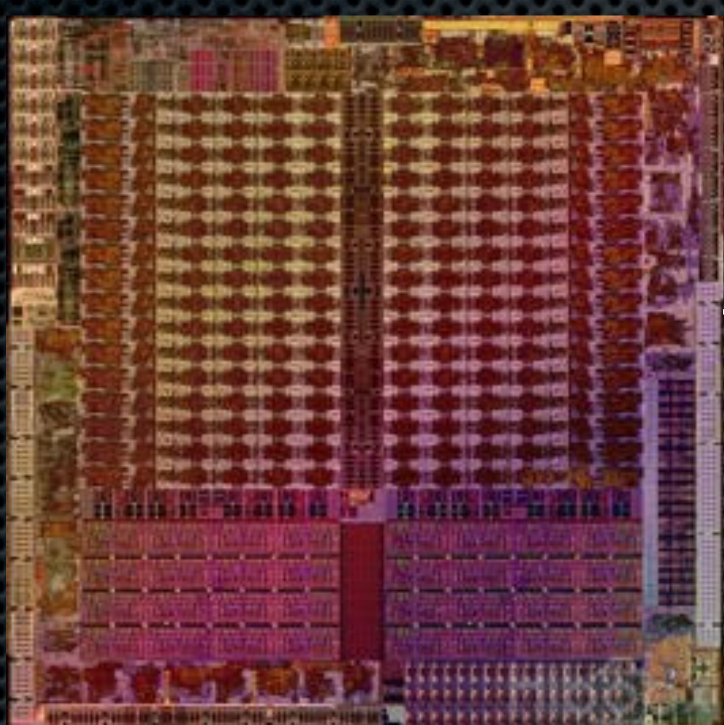


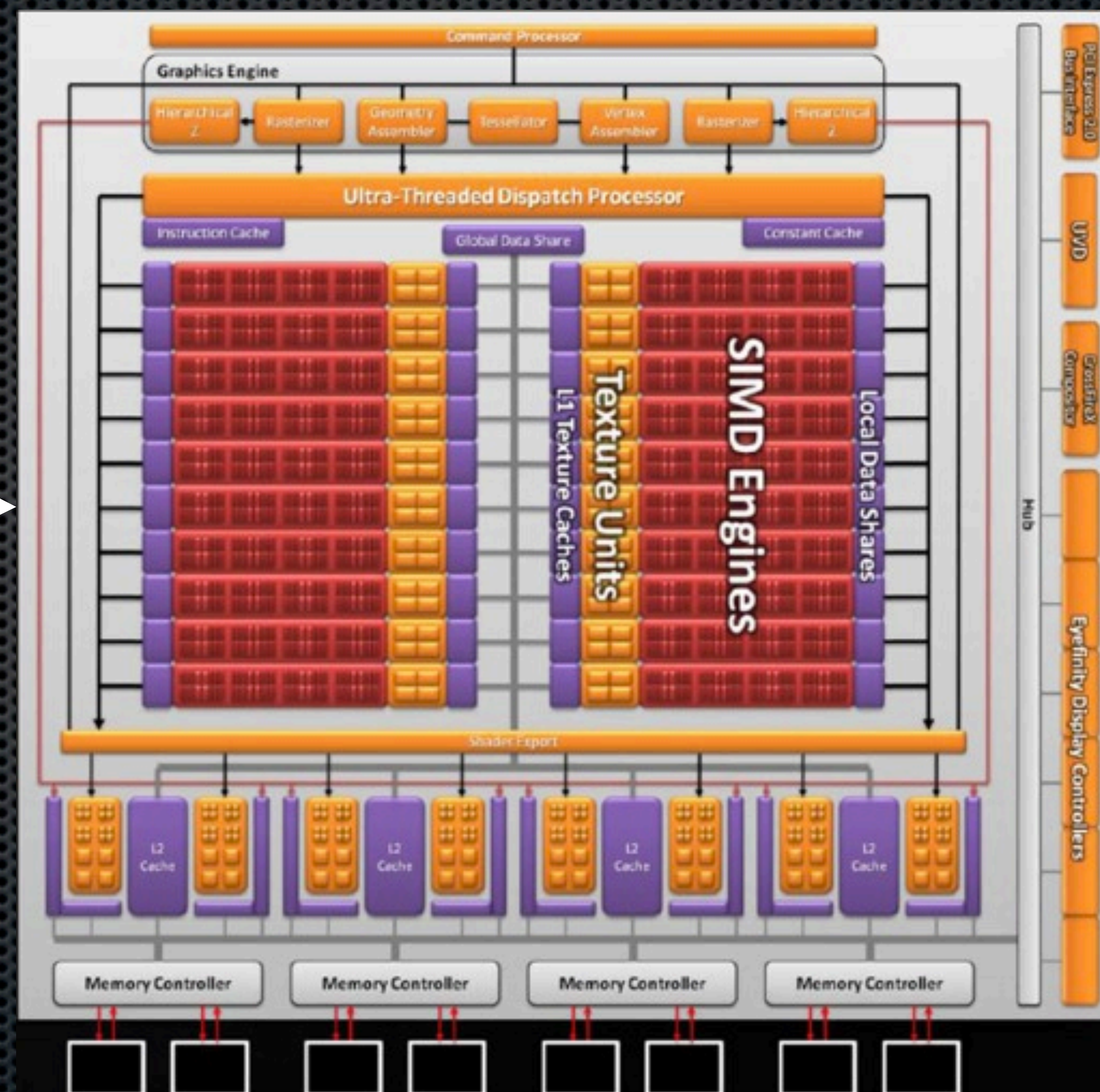


NVIDIA Fermi architecture

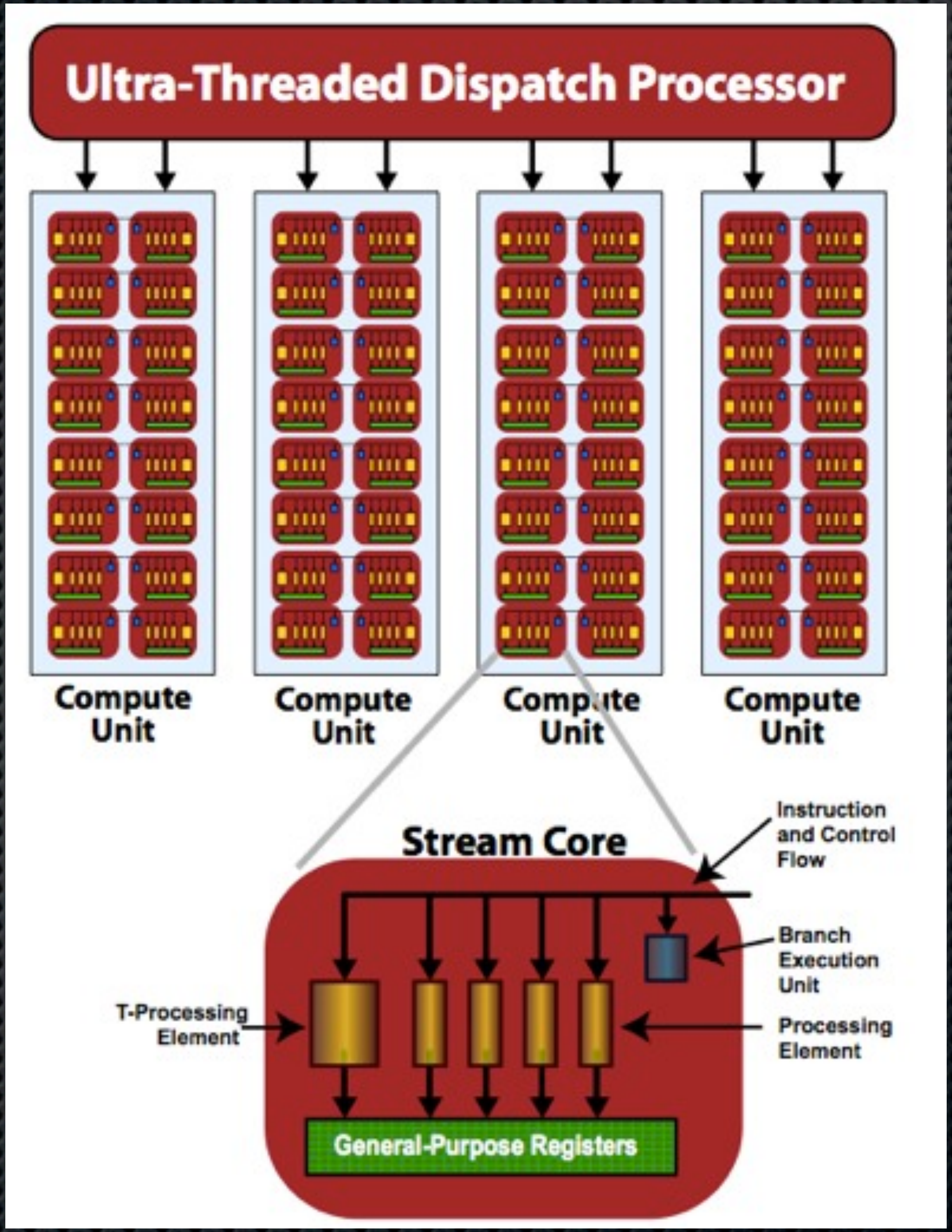


ATI architecture





ATI architecture



OpenCL: code example

ATI thread and instruction level parallelism code

```
__kernel void operation( __global float4 input,
                   __global float4 output ){

    output[get_local_id(0)]=
        input[get_local_id(0)]+input[get_local_id(0)];

}
```

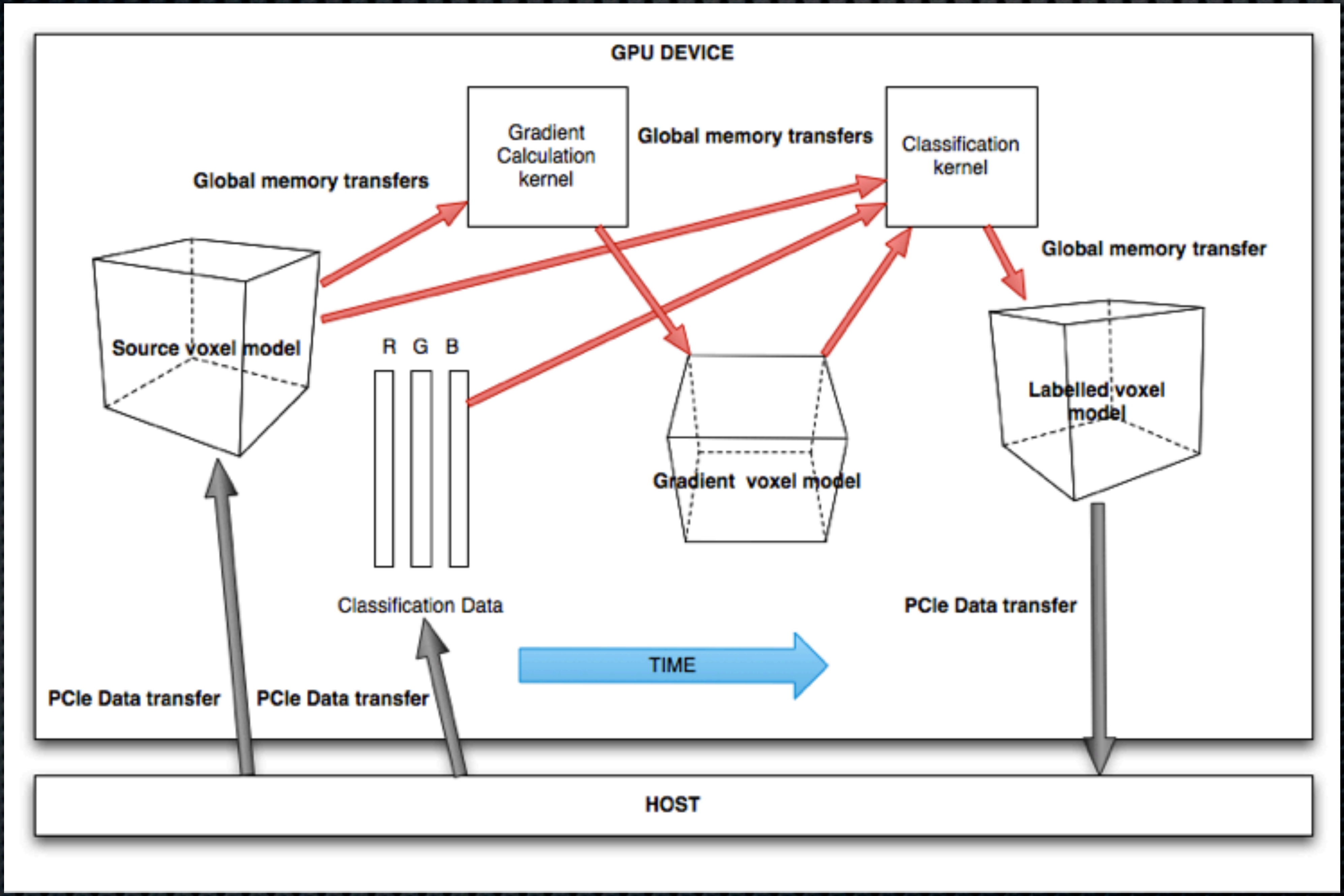
NVIDIA thread level parallelism code

```
__kernel void operation( __global float input,
                   __global float output ){

    output[get_local_id(0)]=
        input[get_local_id(0)]+input[get_local_id(0)];

}
```

OpenCL medical imaging implementation

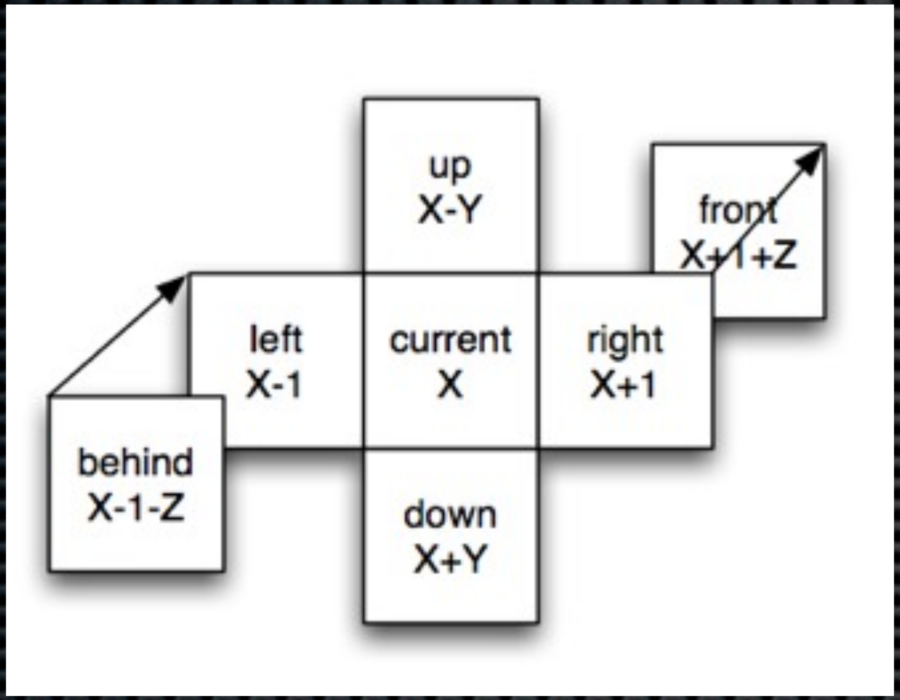
- Reducing PCIe usage to 1/64th
- Adding an extra kernel
- First step to test and validate

OpenCL implementation



OpenCL implementation

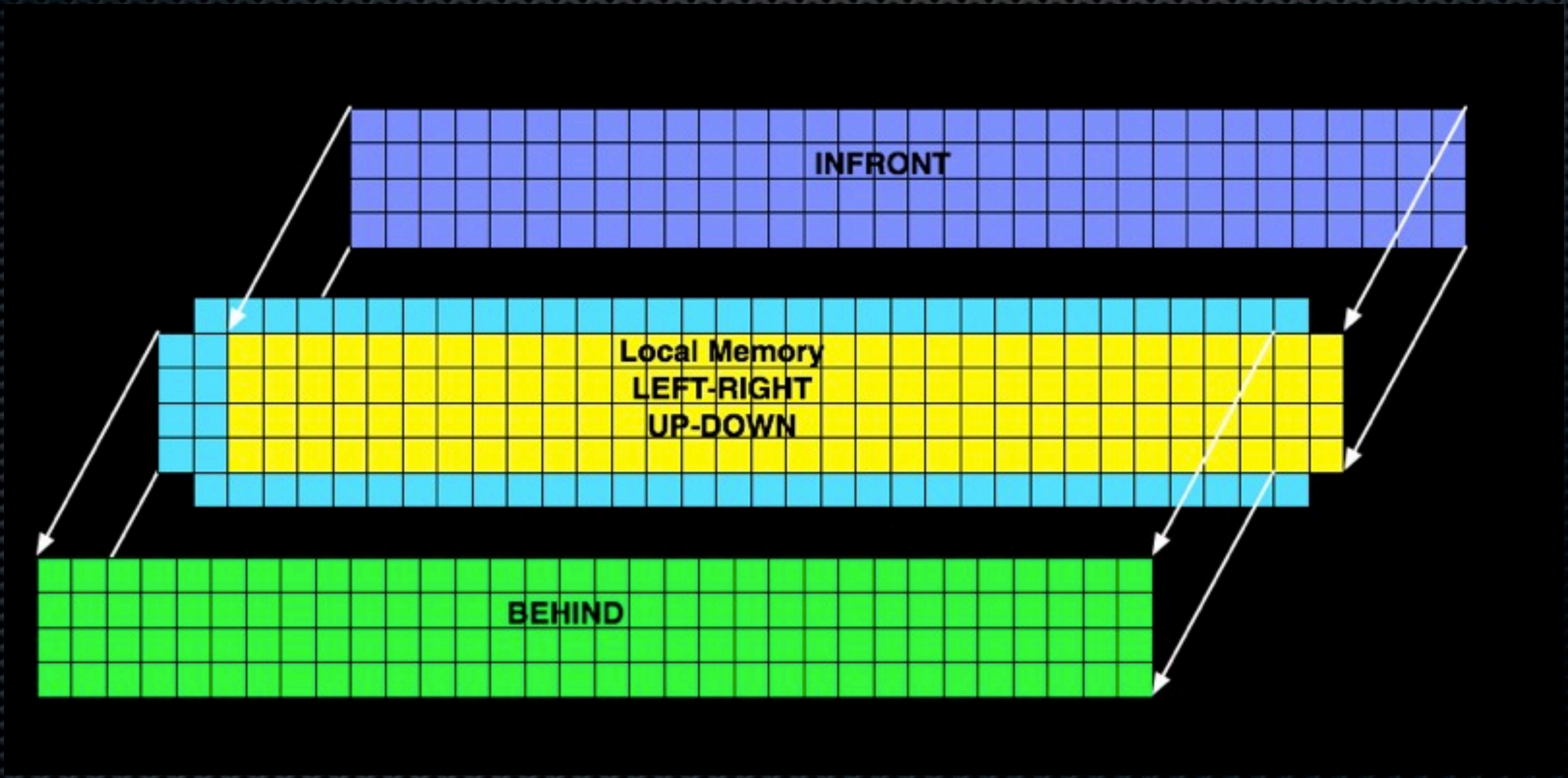
- Gradient Kernel




```
#define BLOCK_DIMX     32
#define BLOCK_DIMY     4

__kernel void kernelGradient( __global unsigned char* values,
                              __global float* gradients,
                              __local float* local_gradients,
                              int dimx,
                              int dimy,
                              int dimz) {

    __local float tile[BLOCK_DIMY + 2 ][BLOCK_DIMX + 2 ];
    float infront;
    float behind;

    //fill tile and infront

    for ( k = 1 ; k < dimz-1 ; k++)
    {

        behind = tile[get_local_id(1)][get_local_id(0)-1];
        tile[get_local_id(1)][get_local_id(0)+1] = infront;

        // calculate gradients

        // copy results from registers
        // to local memory (4 transfers per thread 128x4, 1024 lost cycles)

        // copy results from local to global memory
        // (4 transfers each 16 threads 8x4, 19200 lost cycles)

        // we loose 20.224 cycles instead of 307.200 cycles
    }
}
```

OpenCL implementation

- Gradient Kernel



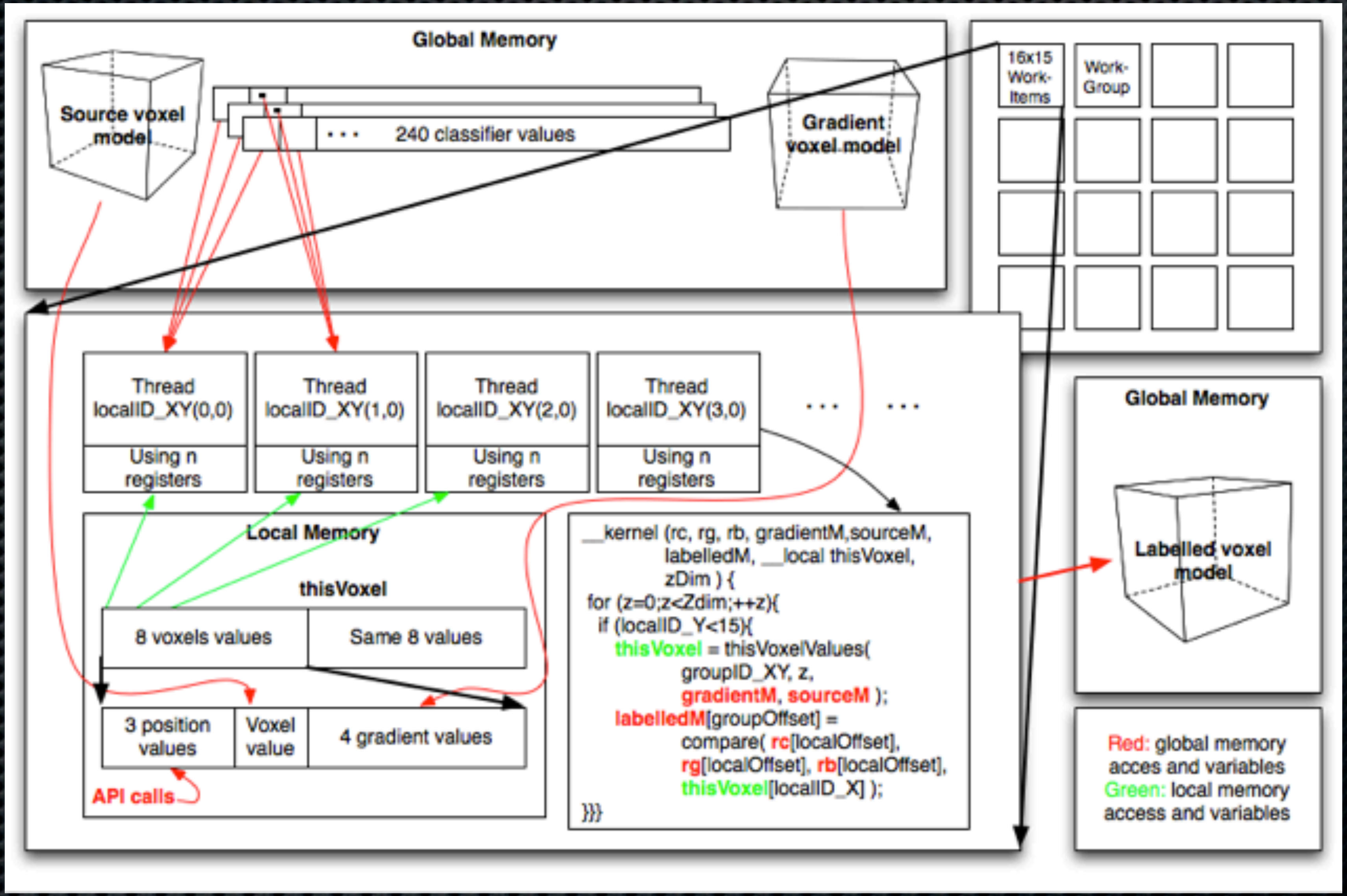
OpenCL implementation

- Classification kernel

```
__kernel void kernelClassif( __global unsigned char* values,
                             __global float* gradients,
                             __global unsigned char* voxelsOut,
                             __global float* rc,
                             __global float* gc,
                             __global float* bc,
                             __constant int* var,
                             __local float* sumArr,
                             __local float* sumalfaArr,
                             __local float* thisVoxel) {

   // Read alfaclass, polaritat, thresh

   // Fill thisVoxel first 2 values

   for (z=1;z<(var[4]-1);++z){

       // Fill the next 6 thisVoxel values

       // Copy the first 8 thisVoxel values to the last 8 thisVoxel positions

       // Calculate two matrix of 240 values and do reduction for each one

       voxelsOut[get_group_id(0)+(get_num_groups(0)*get_group_id(1))+(get_num_groups(0)*get_num_groups(1)*(z-1))] =
       // Compare the two final values to obtain 1 or 0

   }
}
```

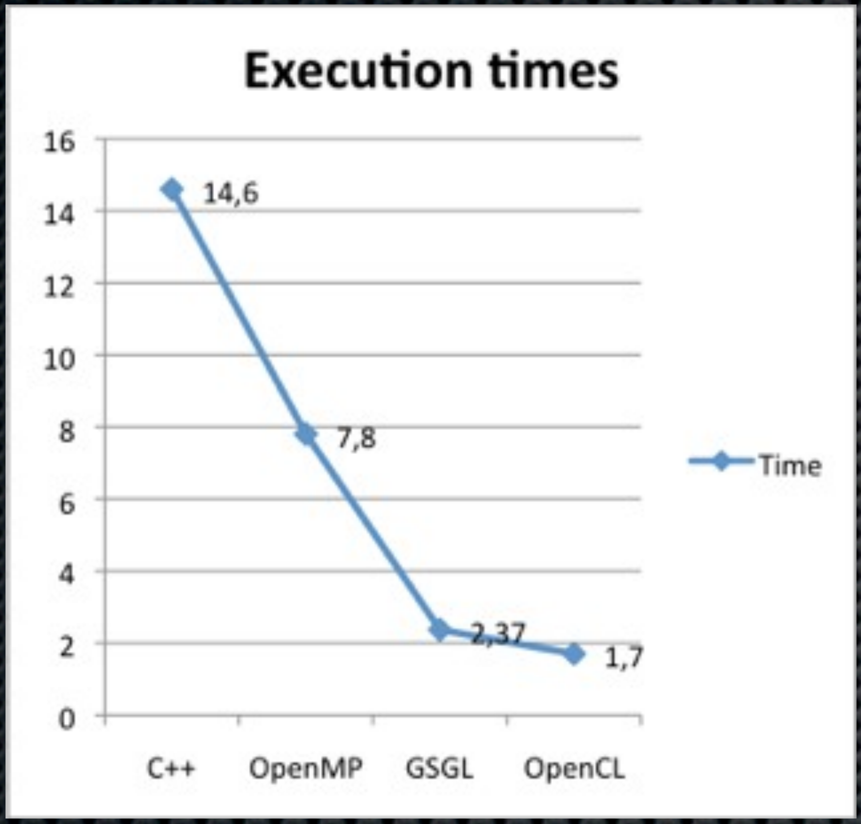
OpenCL implementation

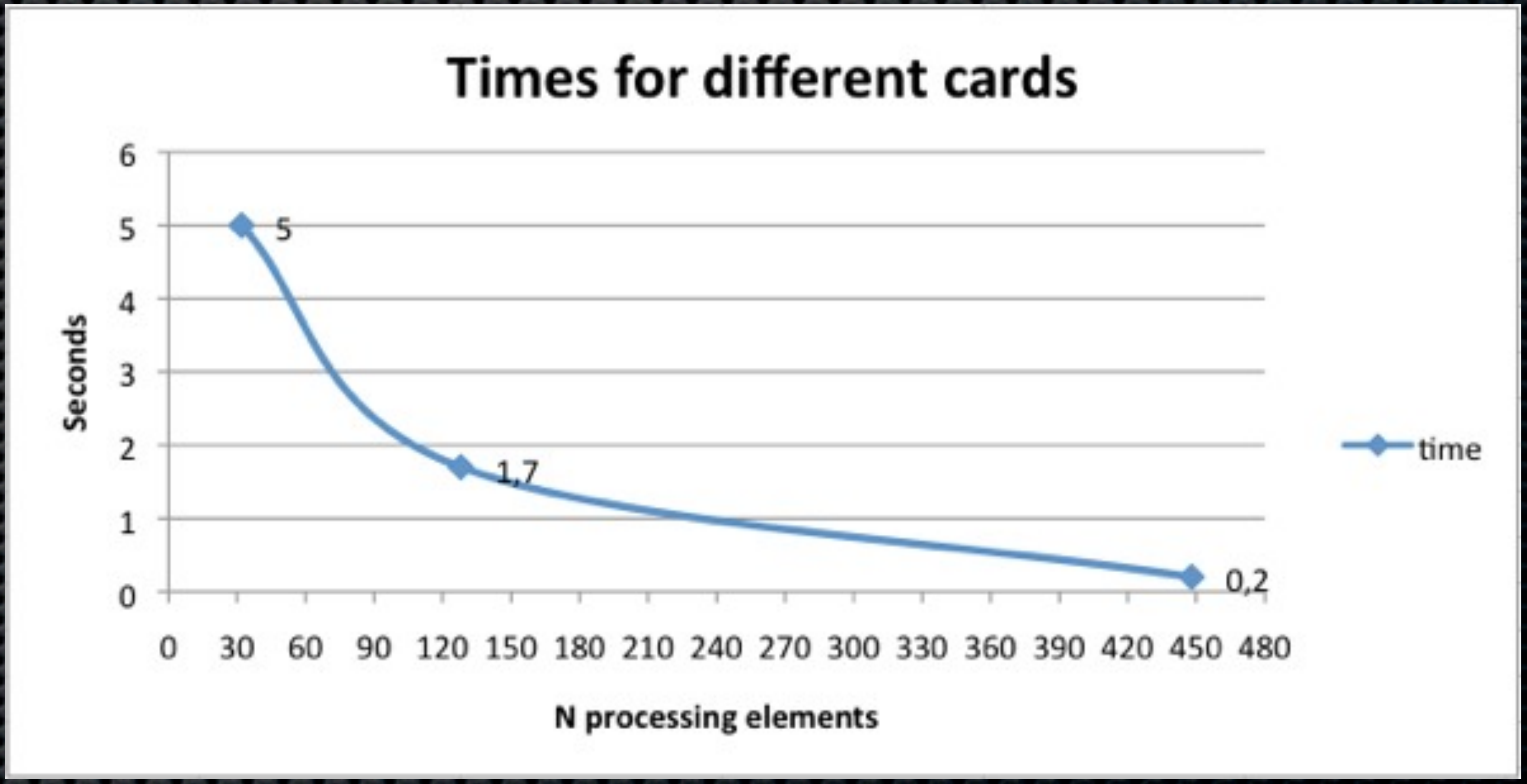
- Classification kernel



OpenCL implementation

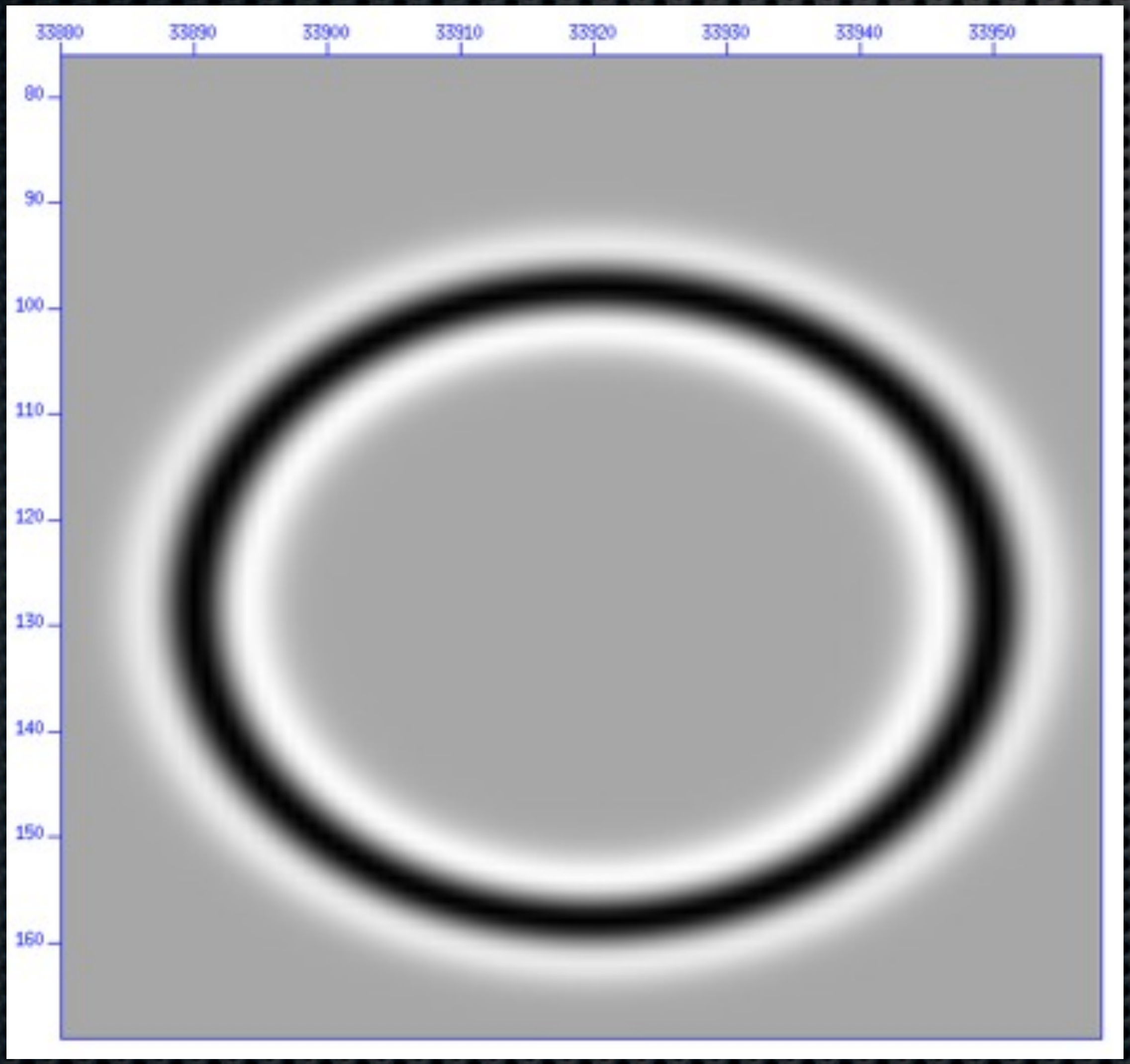
- Results

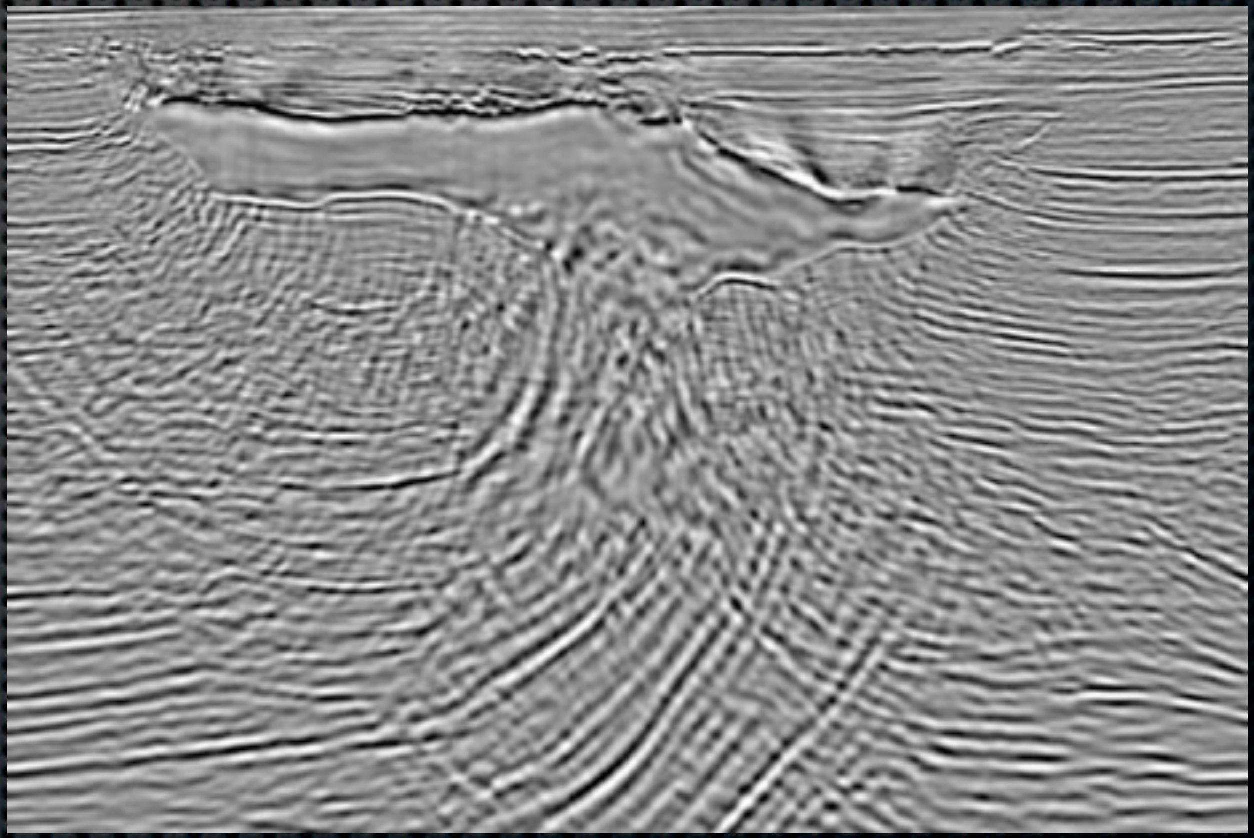




OpenCL analysis

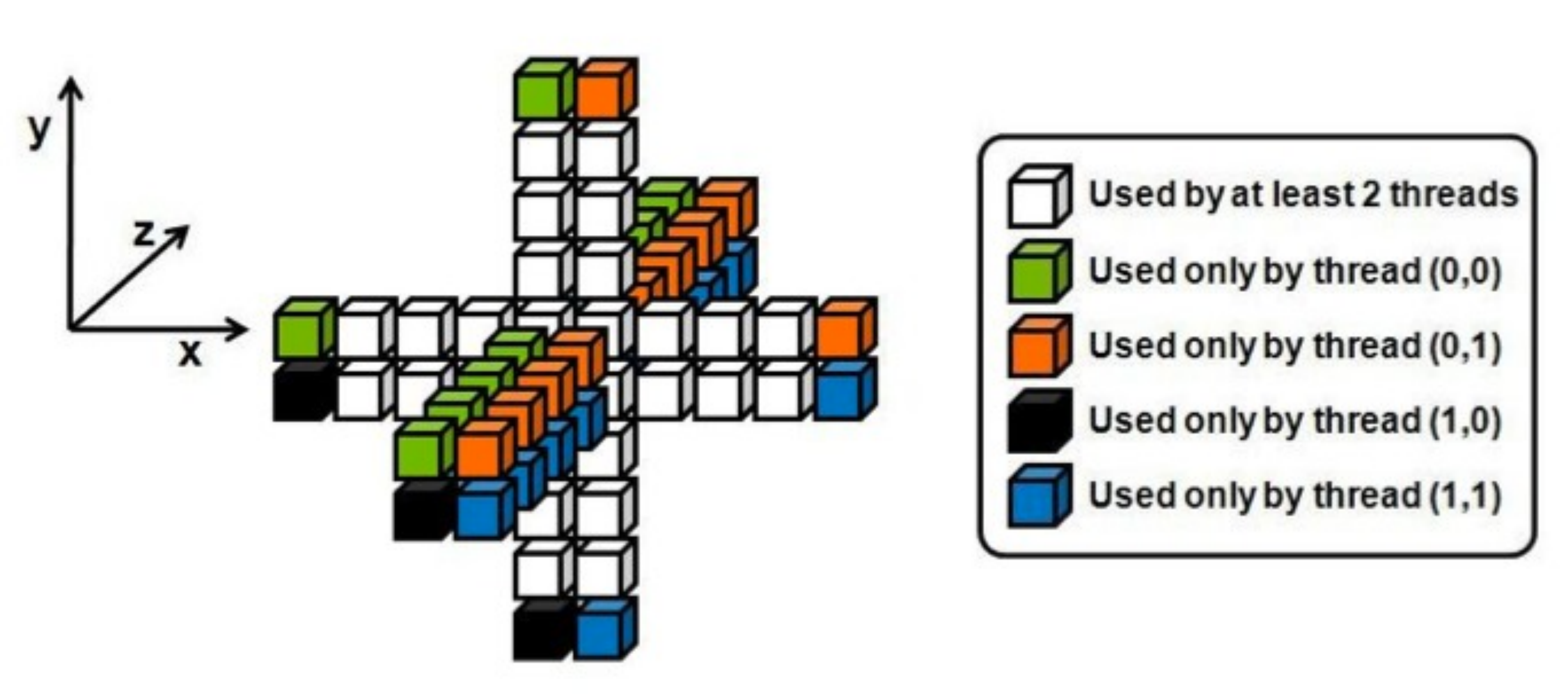
- Stencil method for wave propagation simulations





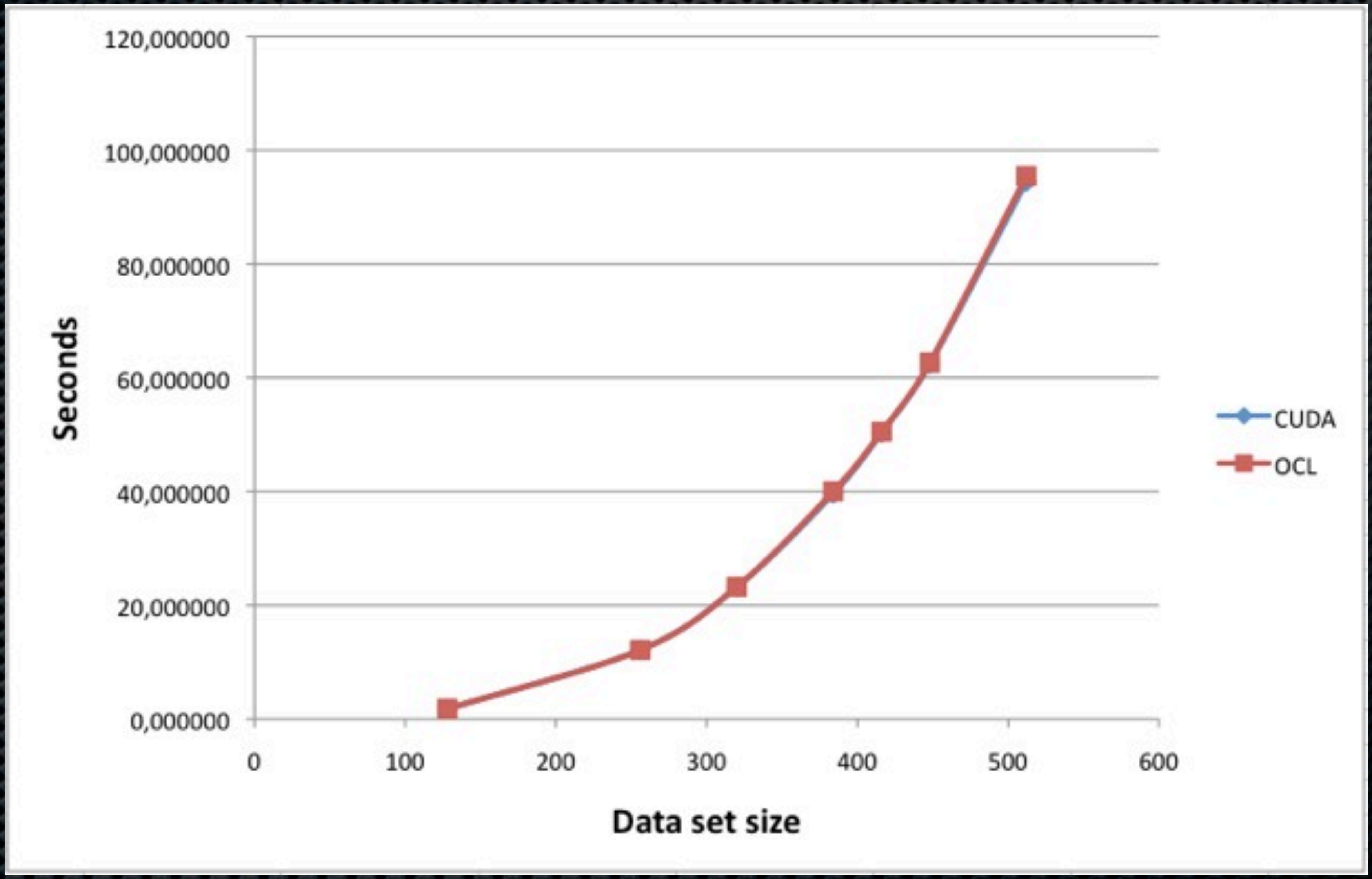
OpenCL analysis

- Based on Micikevicius GPU algorithm



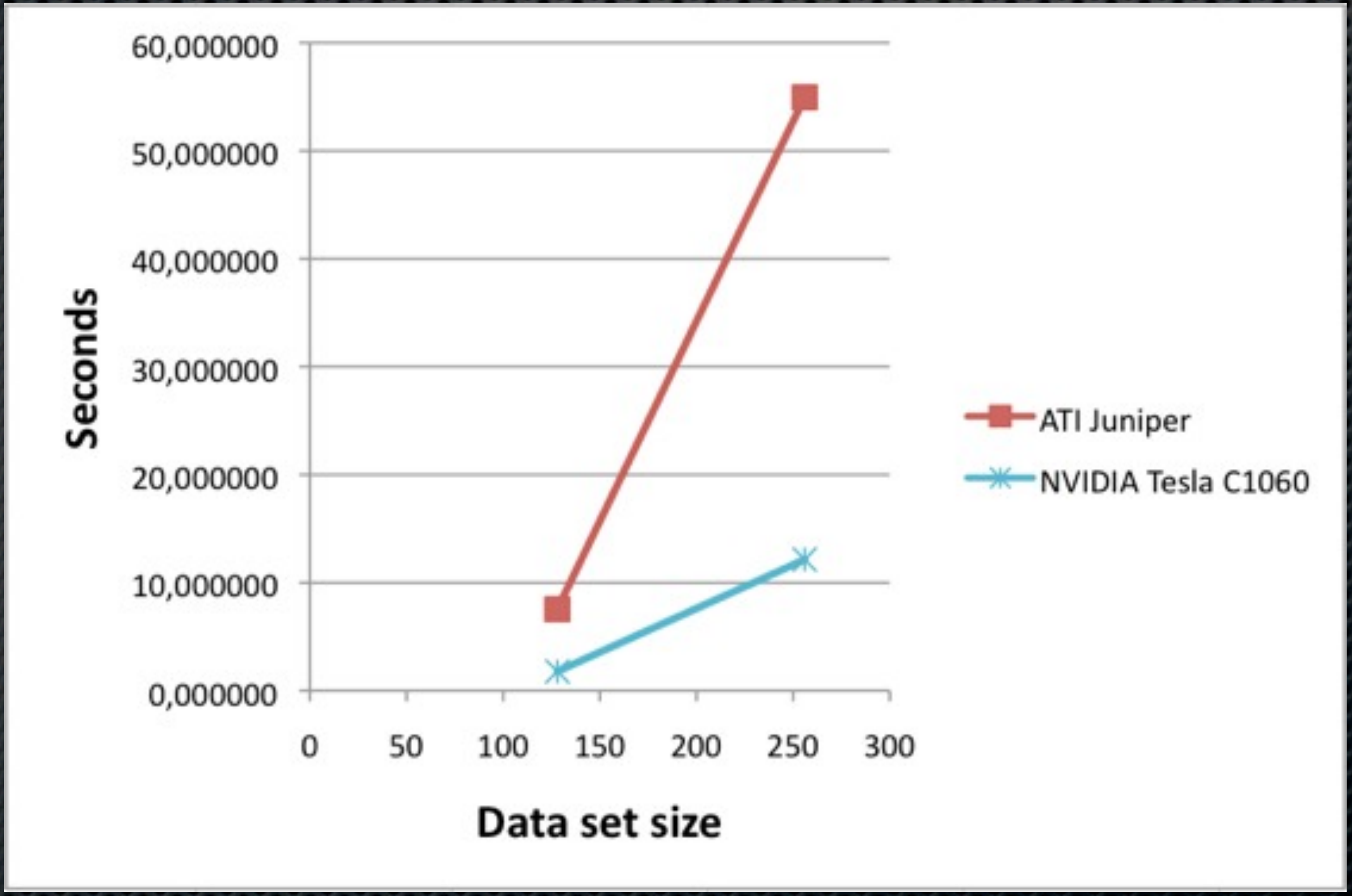
OpenCL performance

- Comparing CUDA with GPU-OpenCL



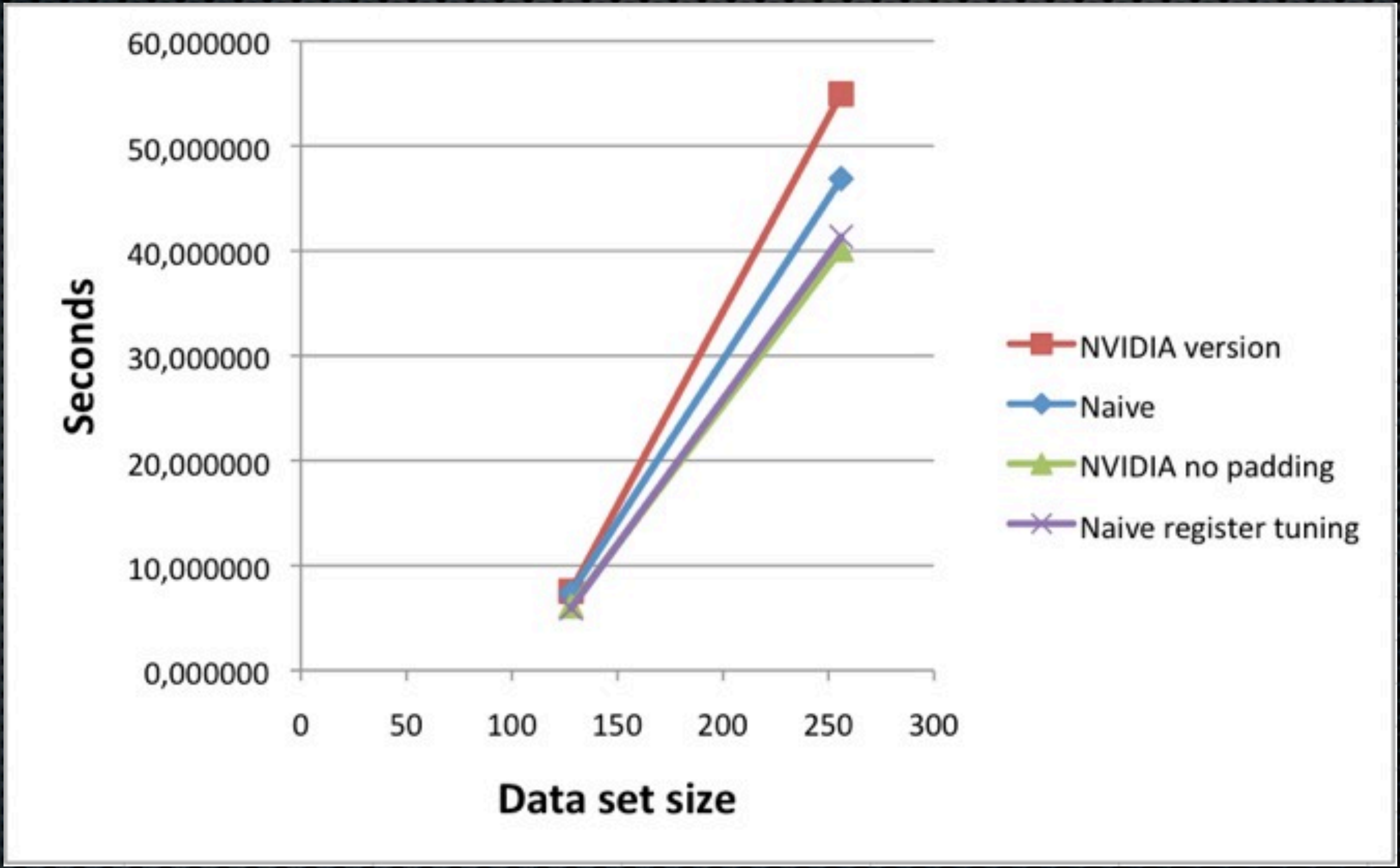
OpenCL portability

- Testing a working and tuned code for NVIDIA in an ATI card



OpenCL for ATI

- Exploring ATI architecture



Architectural trends

- CPU and GPU integration
- Intel Sandy Bridge CPU
- AMD APU (Accelerated Processing Unit)
- Lots of startups: Tilera, Zii, Smooth Stone...
- Low power consumption for HPC (GPU's,ARM,Godson)

Conclusions

- OpenCL for GPU’s is a good option for data-parallel
- GPU’s for HPC have still a way to walk
- Possible convergence of CPU and GPU architectures
- What is sure is that future looks parallel