Direct Kernel Evaluation

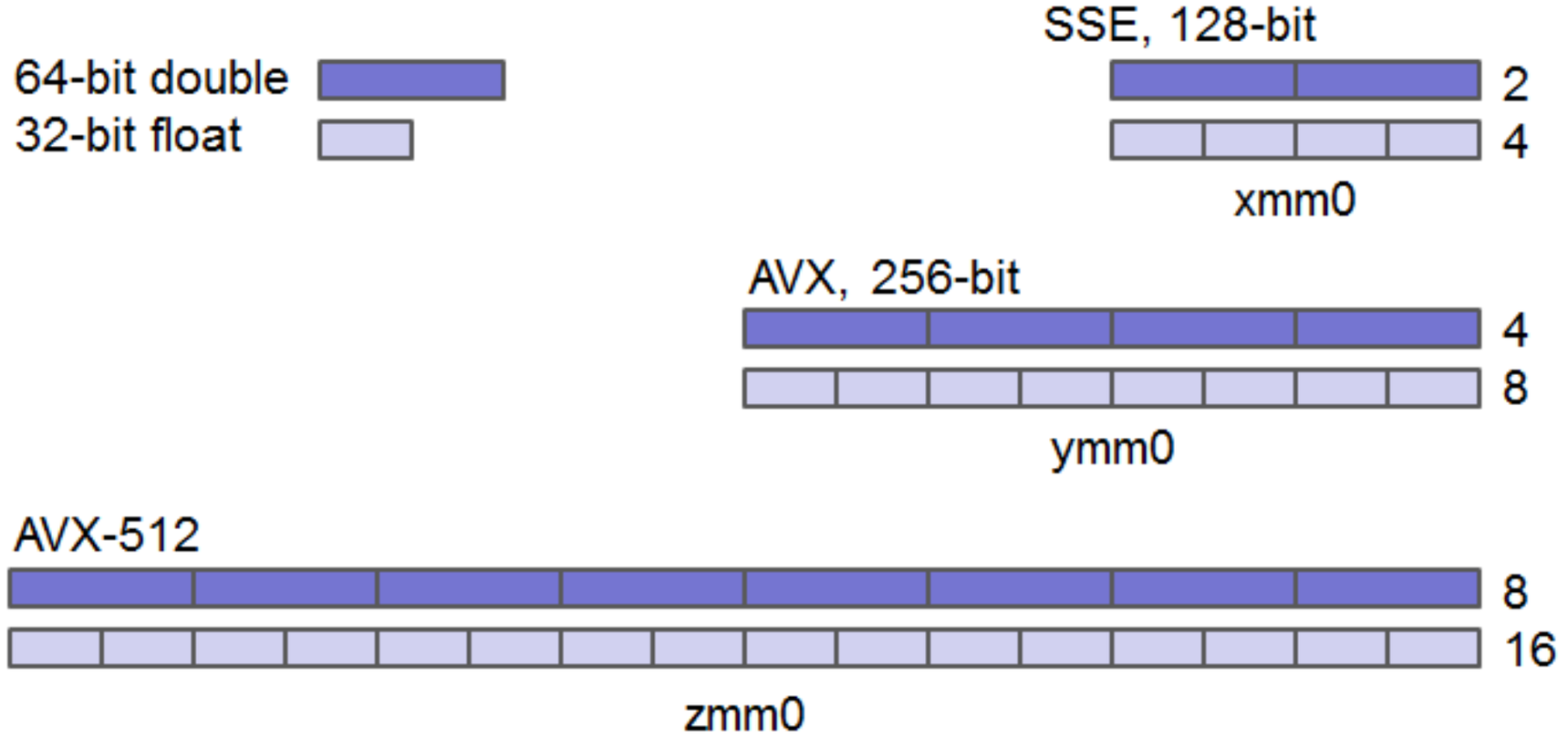
Helmholtz

$$u(x_i) = \sum_{j=1}^{N_s} c_j \frac{e^{ik\|x_i - y_j\|}}{\|x_i - y_j\|} - v_j \cdot \nabla \left(\frac{e^{ik\|x_i - y_j\|}}{\|x_i - y_j\|} \right)$$

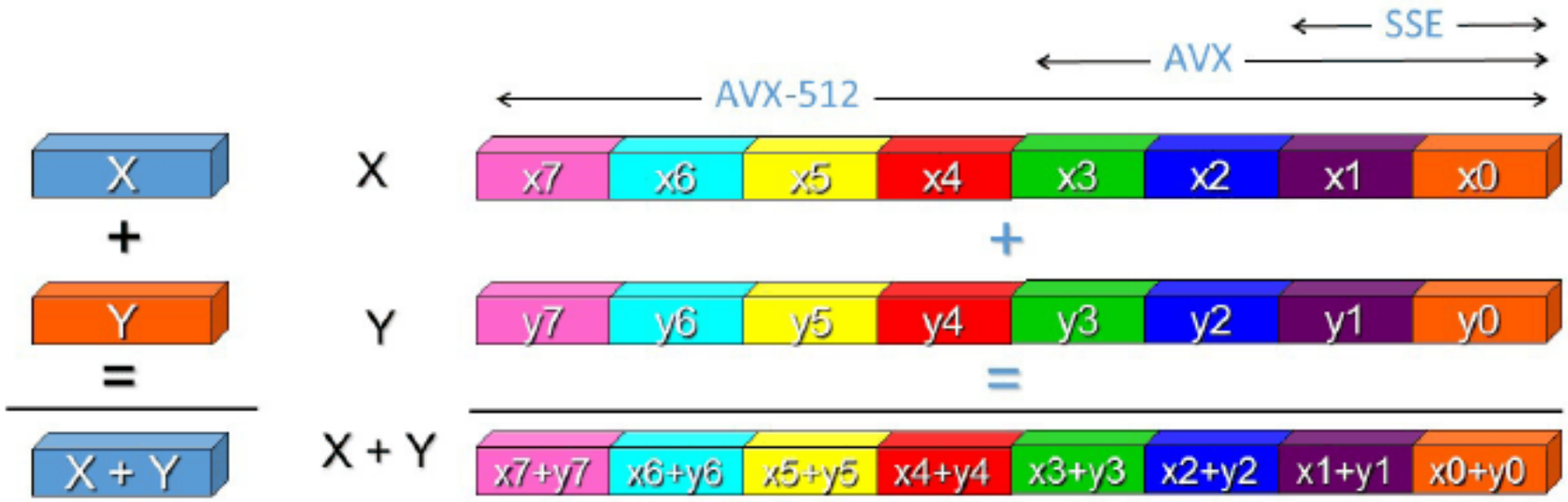
Laplace

$$u(x_i) = \sum_{j=1}^{N_s} c_j \frac{1}{\|x_i - y_j\|} - v_j \cdot \nabla \left(\frac{1}{\|x_i - y_j\|} \right)$$

i = 1, 2, …, N_t




```
double *x, *y, *z;
for (i=0;  i<n;  i++)      z[i] = x[i] + y[i];
```



- Compiler Auto Vectorization (-O2,3 flag)
    - software.intel.com/en-us/cpp-compiler-developer-guide-and-reference-vectorization
- Explicit Vectorization (#pragma omp simd)
    - software.intel.com/en-us/cpp-compiler-developer-guide-and-reference-vectorization
- Manual Vectorization (__mm512_add_pd(x1, x2), etc)
    - vectorization with intrinsics (C/C++ only)

Template Vector Class

- Scientific Computing Template Library
  - github.com/dmalhotra/SCTL
- Vector Class
  - github.com/vectorclass

Non-vec - icc
Non-vec - gcc
Vec - icc
Vec - gcc

Kernel evals/sec x 10^6

300
225
150
75
0

$$G(x,y) = \frac{e^{ik\|x-y\|}}{\|x-y\|}$$

$G(x, y_j)c_j$

$G(x, y_j)c_j$,

$\nabla_x G(x, y_j)c_j$

$\nabla_y G(x, y_j)v_j$

$\nabla_y G(x, y_j)v_j$,

$\nabla_x \nabla_y G(x, y_j)v_j$,

$G(x, y_j)c_j +$
$\nabla_y G(x, y_j)v_j$,

$G(x, y_j)c_j +$
$\nabla_y G(x, y_j)v_j$,

$\nabla_x \left(G(x, y_j)c_j + \right.$

$\left. \nabla_y G(x, y_j)v_j \right)$,