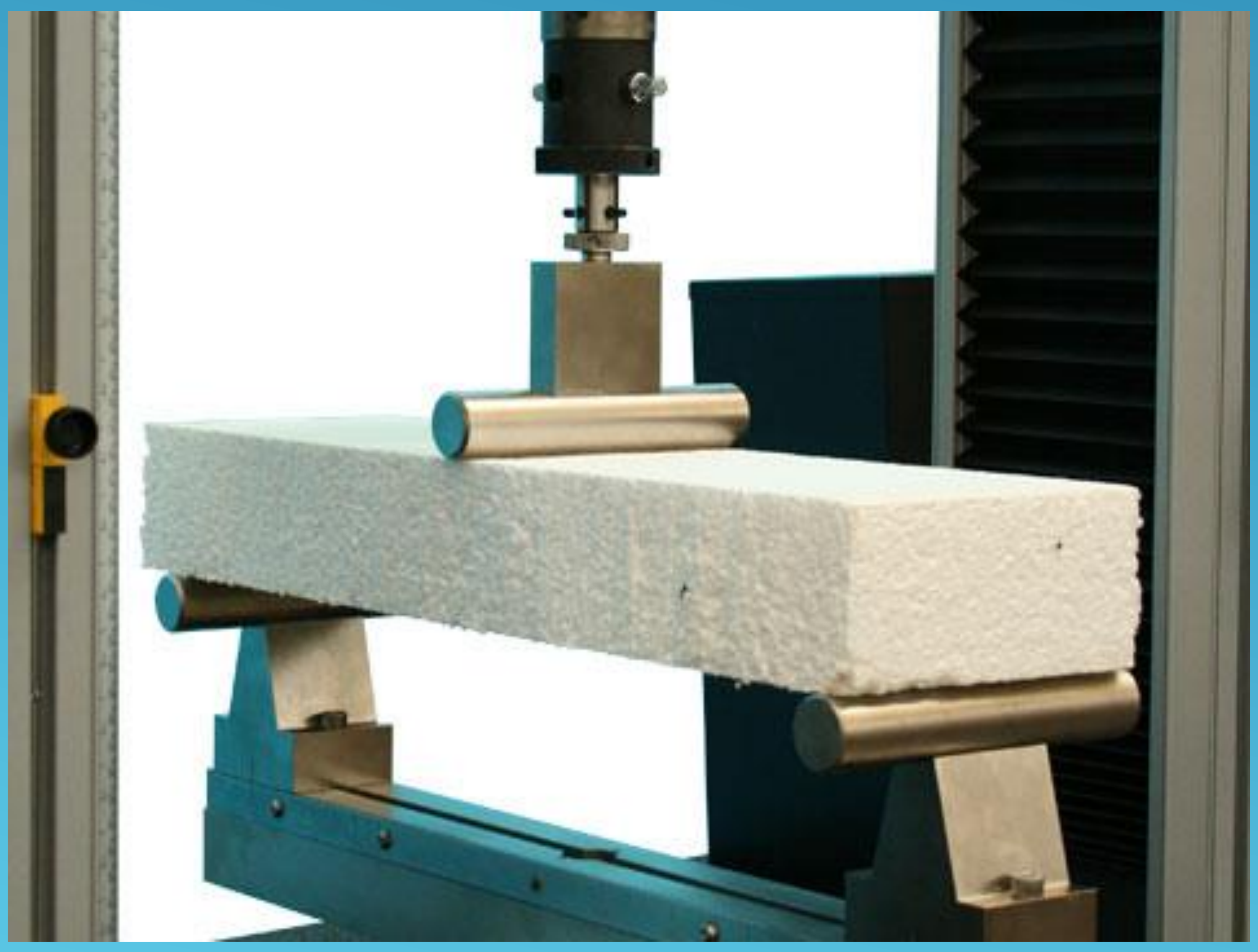
36. OPTIMIZATION OF FRACTURE TESTS SIMULATION IN CIVIL ENGINEERING

Bc. Gabriel Bordovský

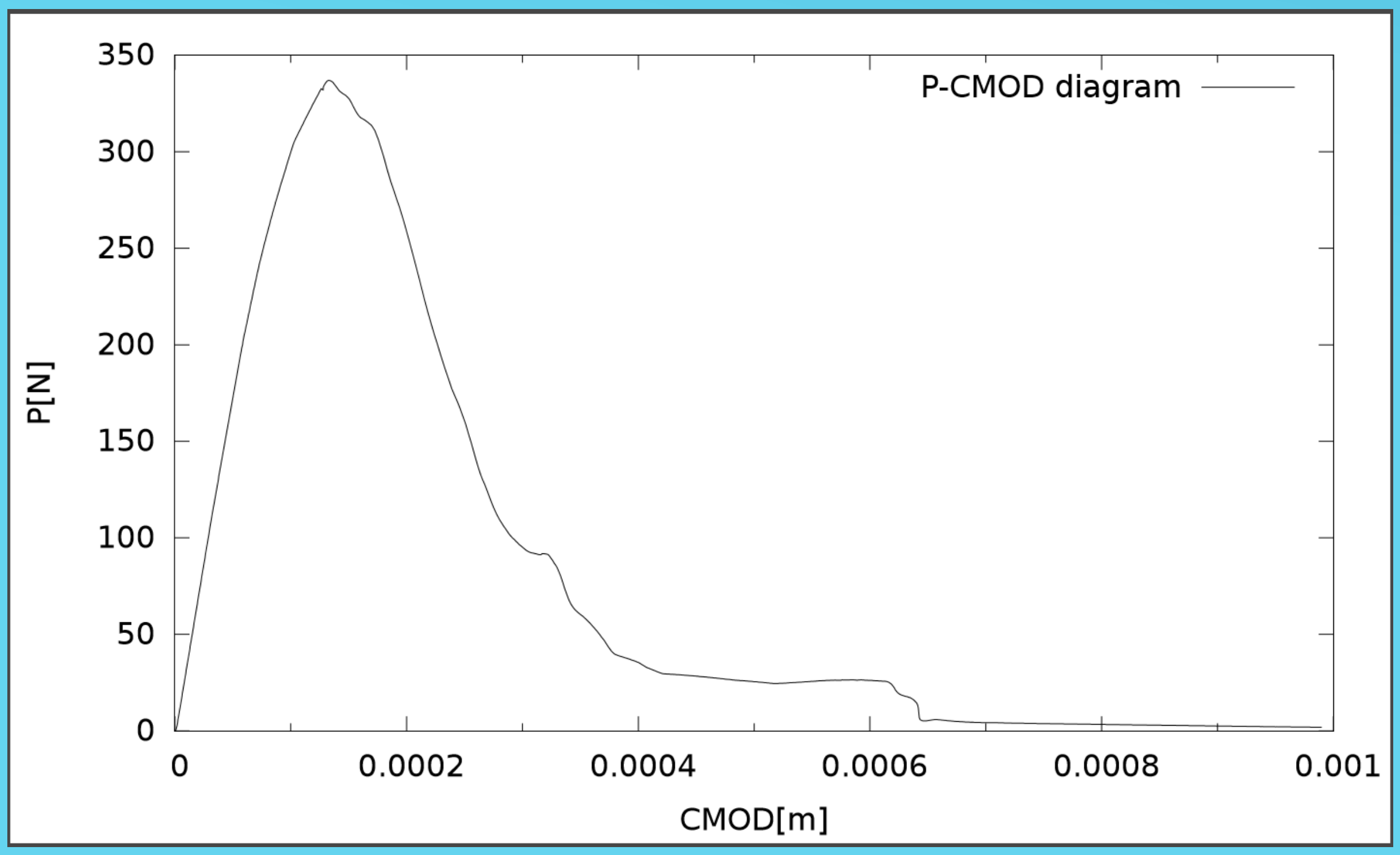
Up to 21 times faster on the same processor!

1) The three point bending fracture test



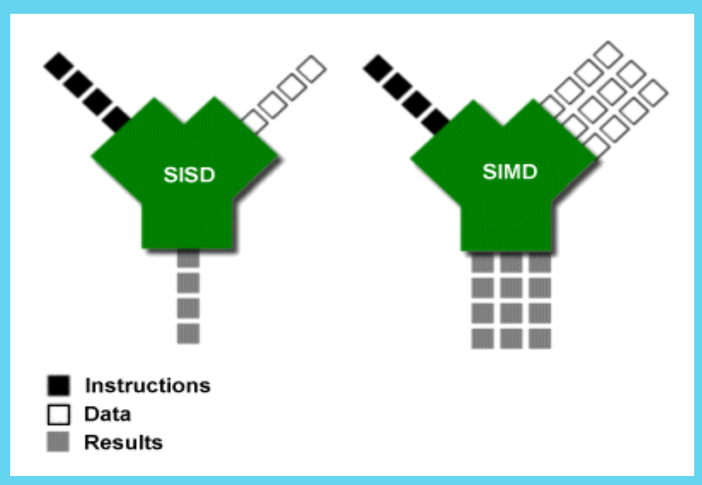
This test may be executed to obtain **material characteristics** of the sample. Characteristics for **quasi-bristle** material such as **sandstone** or steelless concreate are not easy to read from the test result.

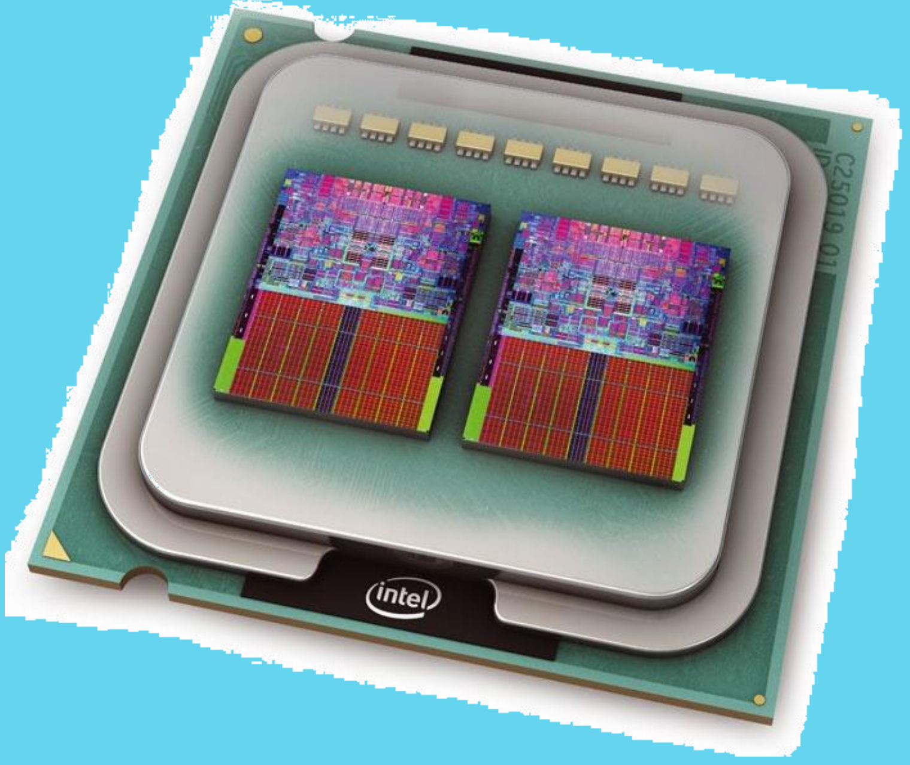
2) Simulation



The simulation of this test may be used to get the same results as from the real test. The input for the simulation is a model of the sample and expected material characteristics such as **fracture energy**. The result of the simulation should match the real test. The simulation has to be **run again** with different parameters if the result does not match.

3) Paralell and vector processing





The simulation process a **3D mesh of points,** connected by bonds together forming so called finite elements, or bricks. In each iteration representing time moment are the brick processed. Work inside of them may be **vectorized(SIMD)**. The brick in one iteration may be processed in **parallel**.

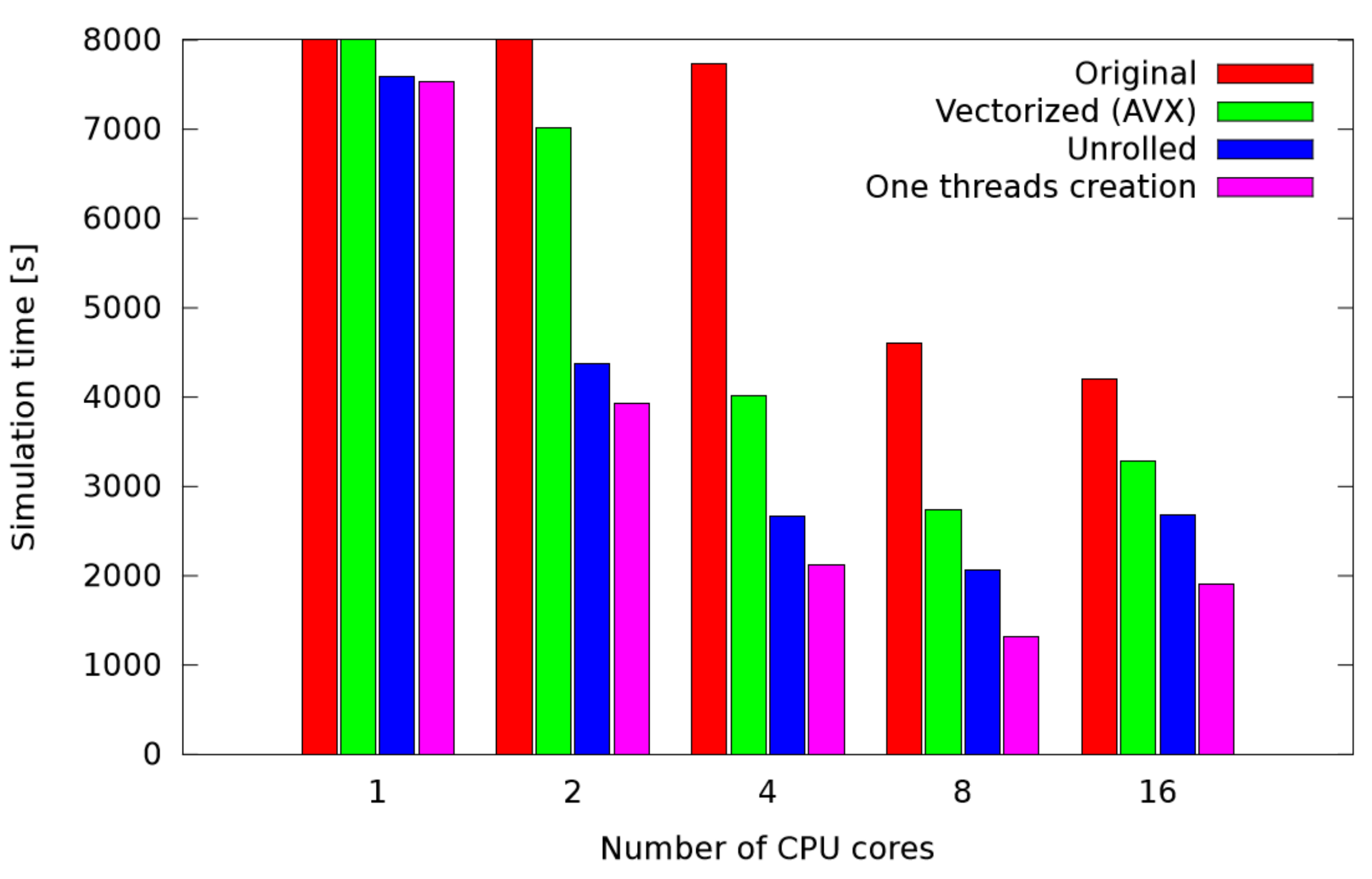
4) Loop unrolling

```
sum =0;
for (i=0; i<N; i++)
  sum += array[i];
```

```
sum =0;
for (i=0; i<N; i+=4) {
  sum += array[i];
  sum += array[i+1];
  sum += array[i+2];
  sum += array[i+3];
}
```

The method of loop unrolling helps to **reduce the loop overhead** by removing the condition test and exploiting instruction level parallelism. Also when loop has more work inside, the processor has more time to **prefetch the data** for the next loop and allows better loop performance.

5) Optimized results



The original execution time was **27 815s** (circa 7 hours) on processor Intel Xeon E5-2470. Thanks to the AVX vectorization and loop unrolling the **single thread** runtime **was reduced to 7 531s** (circa 2 hours). That is **3.69 times** faster. With use of **8 physical cores,** the resulted time was **1 320s** (circa 21 minutes). That is **21 times faster** than original code.

6) Futher work

In the futher work the code should be moved to the graphic card using the **CUDA**. Current problem analyze shown problem with the CUDA straming processing such as **exclusive write** and **unaligned read** that leads to serialization of the compute process.

BRNO UNIVERSITY OF TECHNOLOGY
FACULTY OF INFORMATION TECHNOLOGY

Excel@FIT 2017