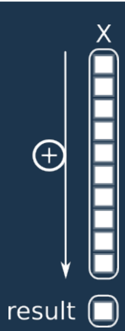
ESCAPE 824064

Laboratoire d'Annecy de Physique des Particules

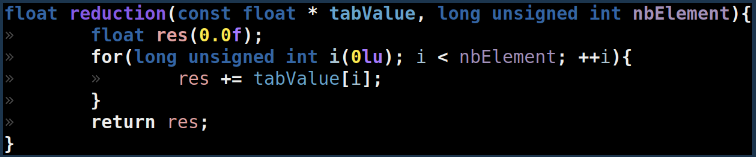
Optimisation : Reduction

Pierre Aubert

The Reduction (sum)



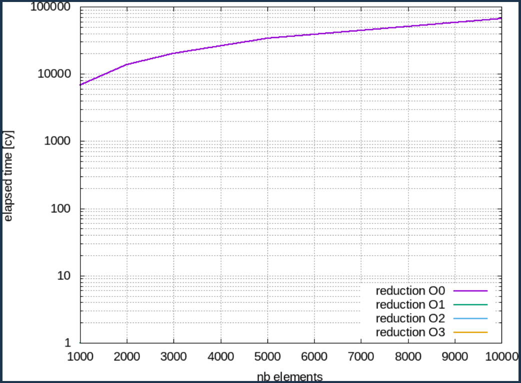
$$\alpha = \sum_{i=1}^{N} x_i$$



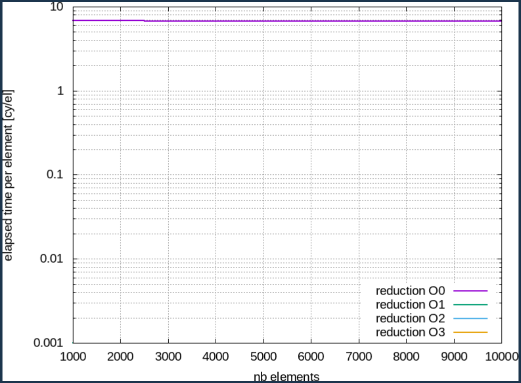
```
float reduction(const float * tabValue, long unsigned int nbElement){
        float res(0.0f);
        for(long unsigned int i(0lu); i < nbElement; ++i){
                res += tabValue[i];
        }
        return res;
}
```

The reduction : first performances

Total Elapsed Time (cy)

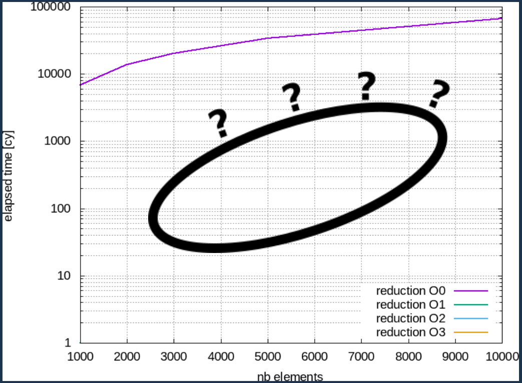


Elapsed Time per element (cy/el)

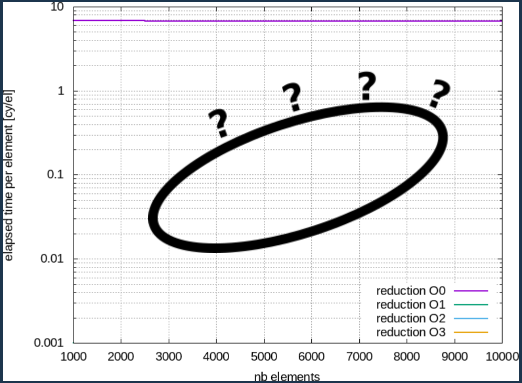


The reduction : first performances

Total Elapsed Time (cy)



Elapsed Time per element (cy/el)



The Performance : what is the issue ?

- Performances **-O0** : slow but reasonable
- Other performances (**-O1**, **-O2**, **-O3**, **-Ofast**) are too fast (non sence)

GCC is smart of guileful depending on the points of view.

- GCC noticed you **do not** use the result of the **reduction** function.
- The call to **reduction** is considered as dead code (or never called code).

To avoid that, you have to compile the **reduction** function in an other file.

Dead code for compiler

Dead code for compiler

Dead code for compiler

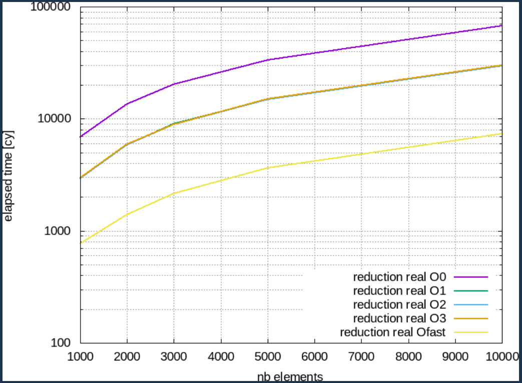
Dead code for compiler

Dead code for compiler

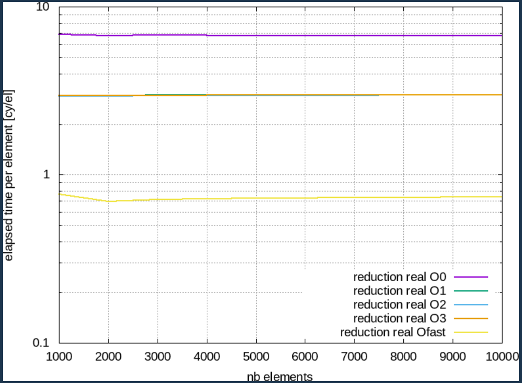
Dead code for compiler

The reduction : real performances

Total Elapsed Time (cy)



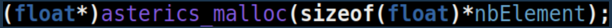
Elapsed Time per element (cy/el)



Modifications for vectorization

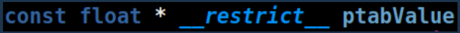
- Data alignement :
  - All the data to be aligned on vectorial registers size.
  - Change **new** or **malloc** to **memalign** or **posix_memalign**

  You can use **asterics_malloc** to have LINUX/MAC compatibility (in **evaluateReduction**):



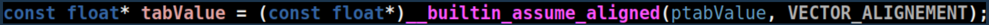
```
(float*)asterics_malloc(sizeof(float)*nbElement);
```

  The **__restrict__** keyword (arguments of **reduction** function):



```
const float * __restrict__ ptabValue
```

  The **__builtin_assume_aligned** function call (in **reduction** function):

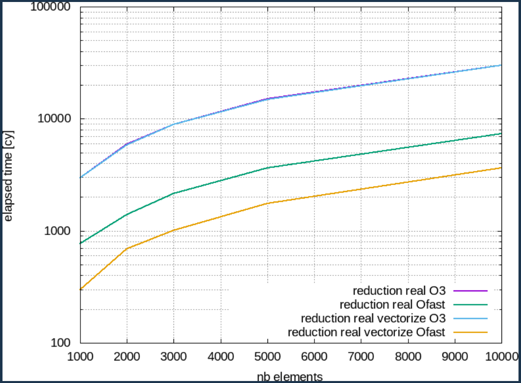


```
const float* tabValue = (const float*)__builtin_assume_aligned(ptabValue, VECTOR_ALIGNEMENT);
```

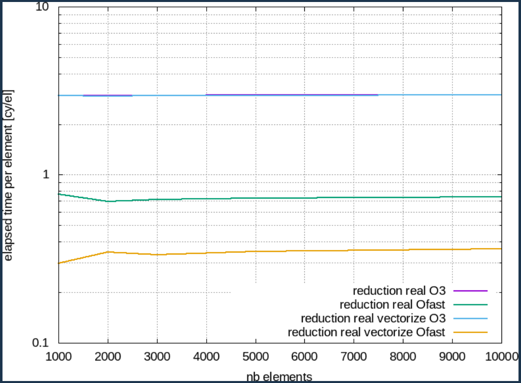
  - The Compilation Options become :
    - **-O3 -ftree-vectorize -march=native -mtune=native -mavx2**

The reduction : vectorize performances

Total Elapsed Time (cy)

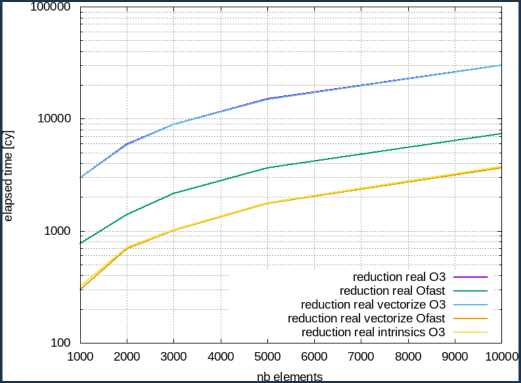


Elapsed Time per element (cy/el)

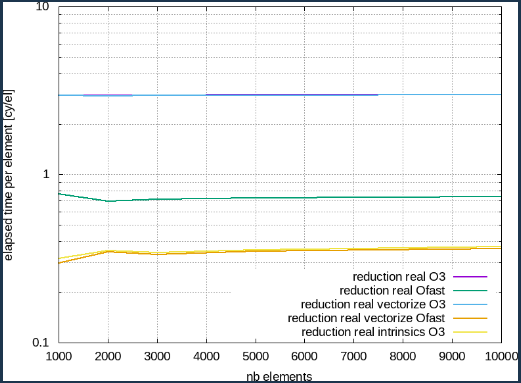


The reduction : intrinsics performances

Total Elapsed Time (cy)



Elapsed Time per element (cy/el)

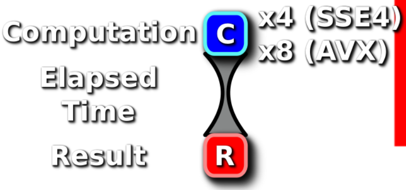


Reduction optimisation

Reduction optimisation

Computation
C
Elapsed Time
Result
R

Reduction optimisation



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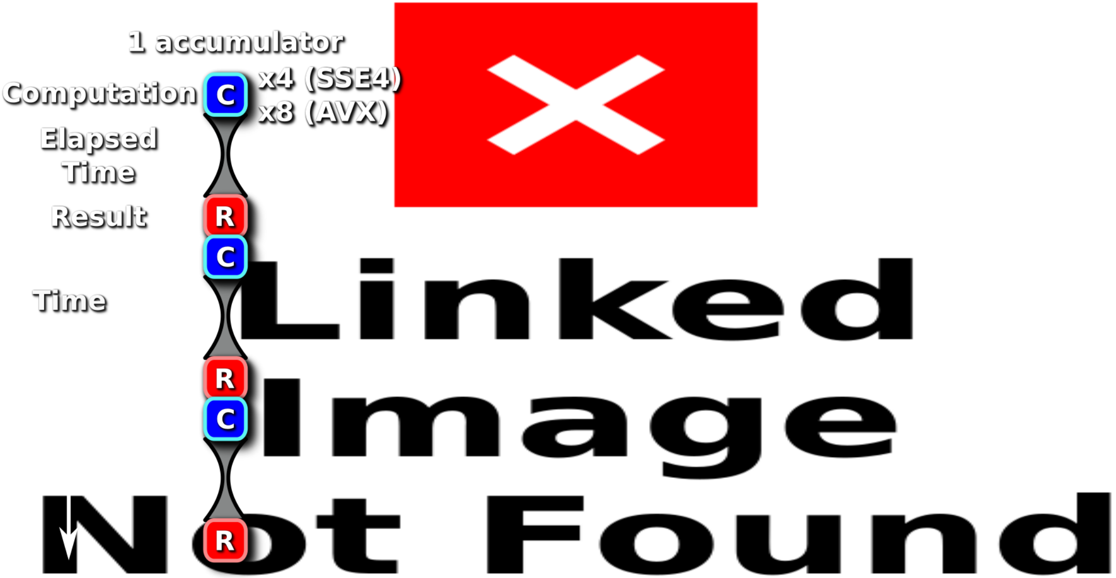
Reduction optimisation



1 accumulator

Computation

x4 (SSE4)

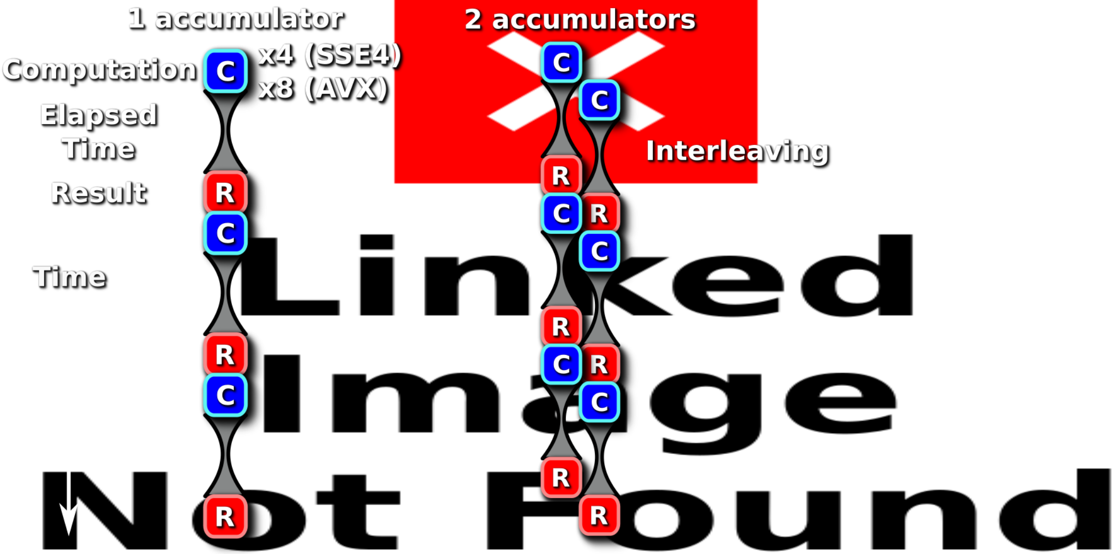
x8 (AVX)

Elapsed Time

Result

Time

Reduction optimisation



1 accumulator

Computation

x4 (SSE4)

x8 (AVX)

Elapsed Time

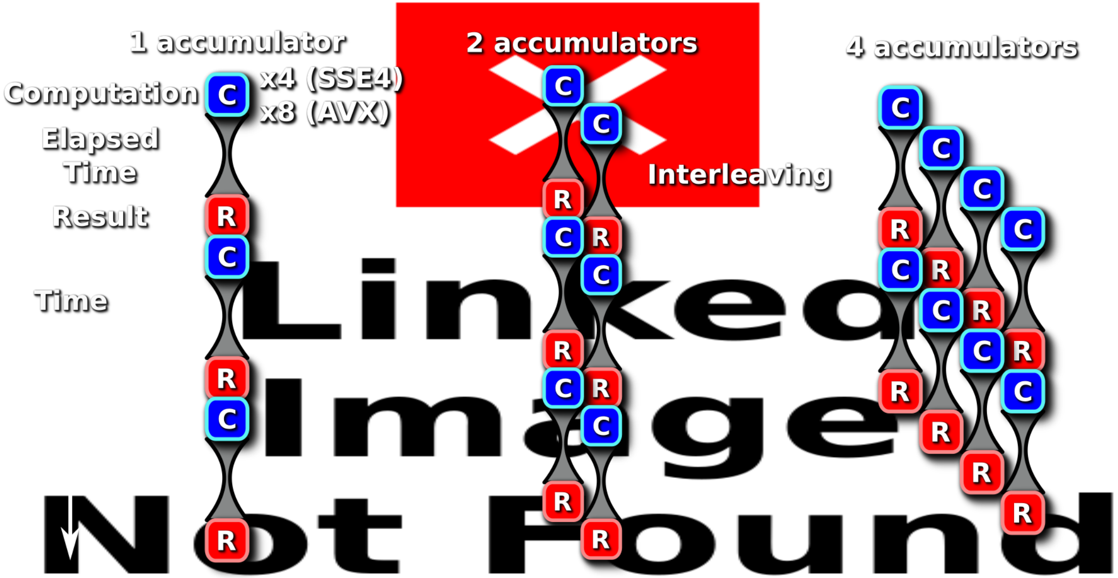
Result

Time

2 accumulators

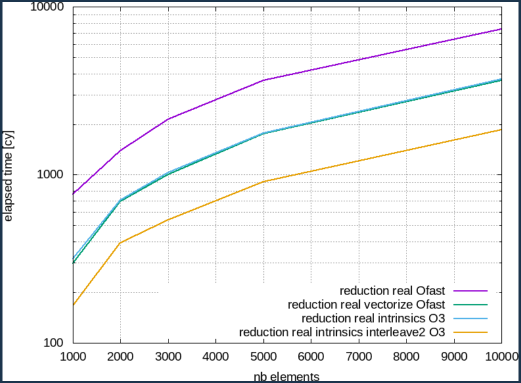
Interleaving

Reduction optimisation

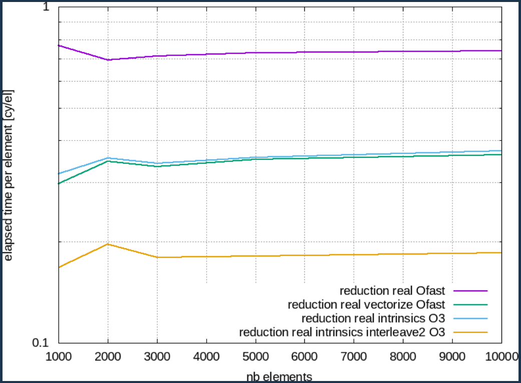


The reduction : intrinsics interleaved 2

Total Elapsed Time (cy)

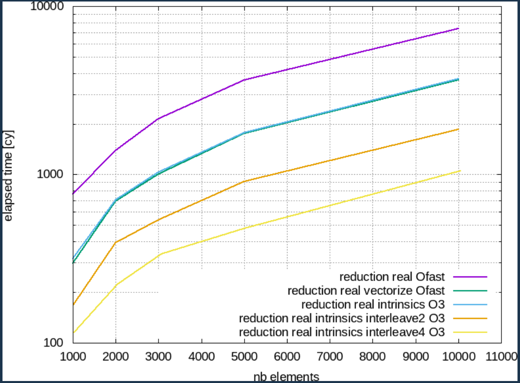


Elapsed Time per element (cy/el)

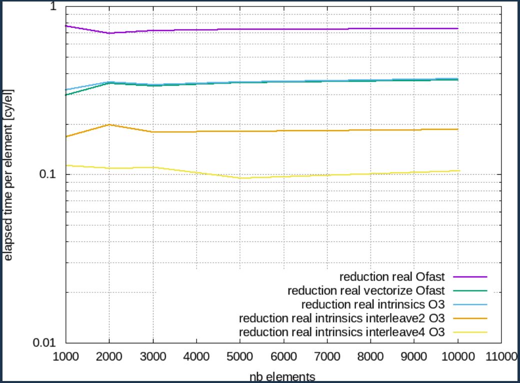


The reduction : intrinsics interleaved 4

Total Elapsed Time (cy)

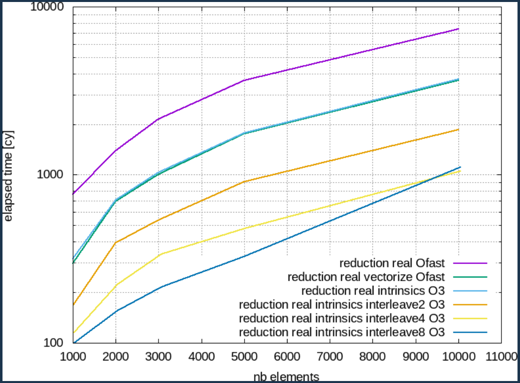


Elapsed Time per element (cy/el)

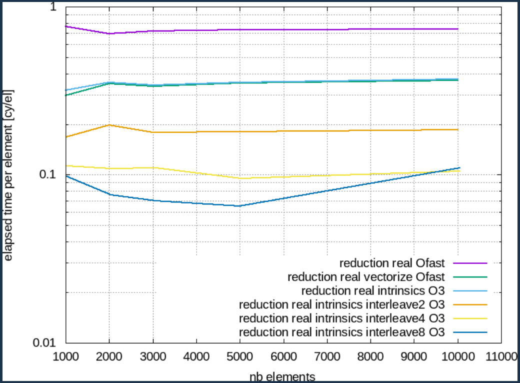


The reduction : intrinsics interleaved 8

Total Elapsed Time (cy)

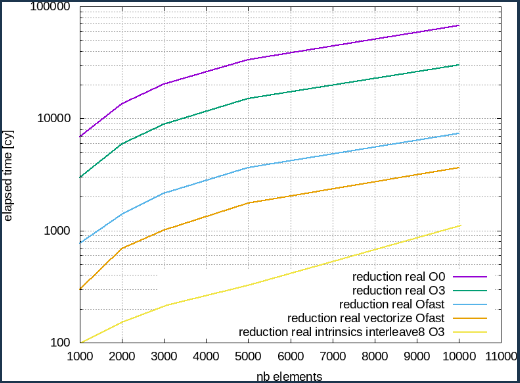


Elapsed Time per element (cy/el)

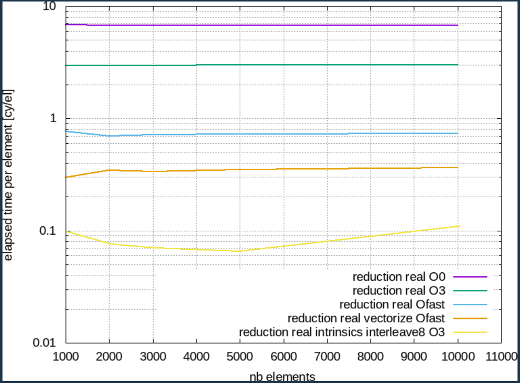


The reduction : summary

Total Elapsed Time (cy)



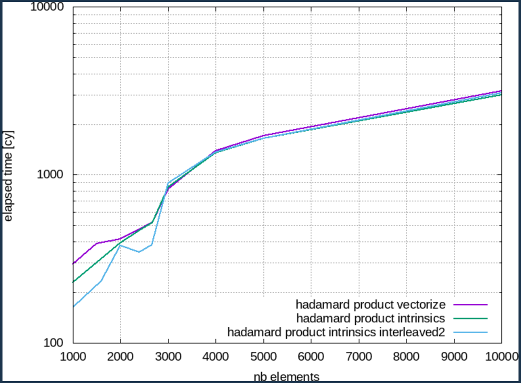
Elapsed Time per element (cy/el)



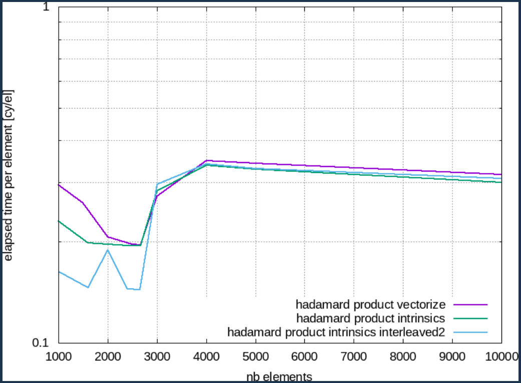
5000 elements, Intrinsics is **166** times faster than -**O0** and 7 times faster than -**Ofast** vectorized

What about the Hadamard product ?

Total Elapsed Time (cy)

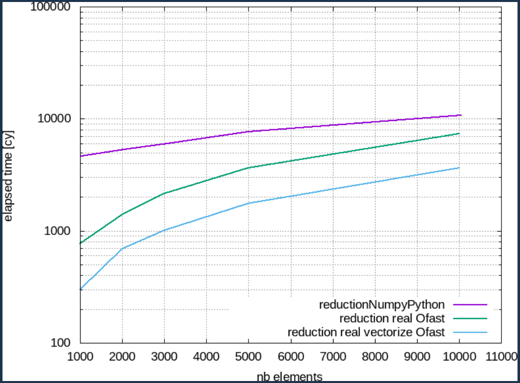


Elapsed Time per element (cy/el)

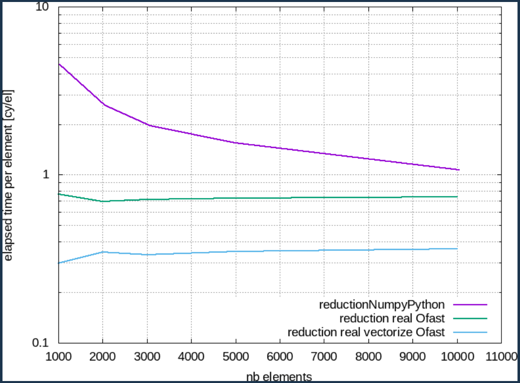


The reduction : Python

Total Elapsed Time (cy)



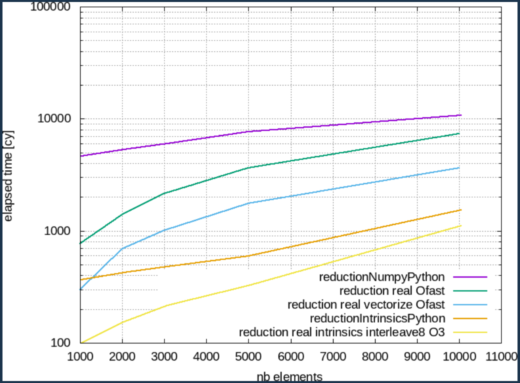
Elapsed Time per element (cy/el)



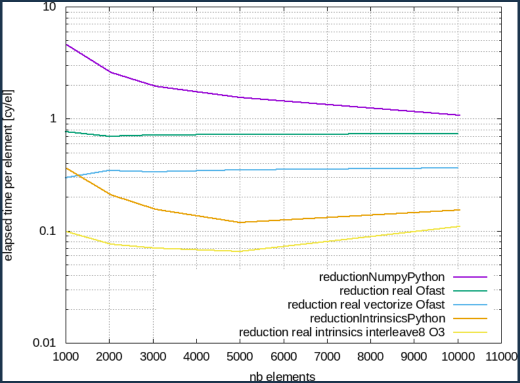
1000 elements, GCC vectorized version is **13** times faster than **numpy** sum

The reduction : Python Summary

Total Elapsed Time (cy)



Elapsed Time per element (cy/el)



1000 elements, our python reduction is **10** times faster than **numpy** sum