# HPC project:
## tectonic plates computation

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# Contents



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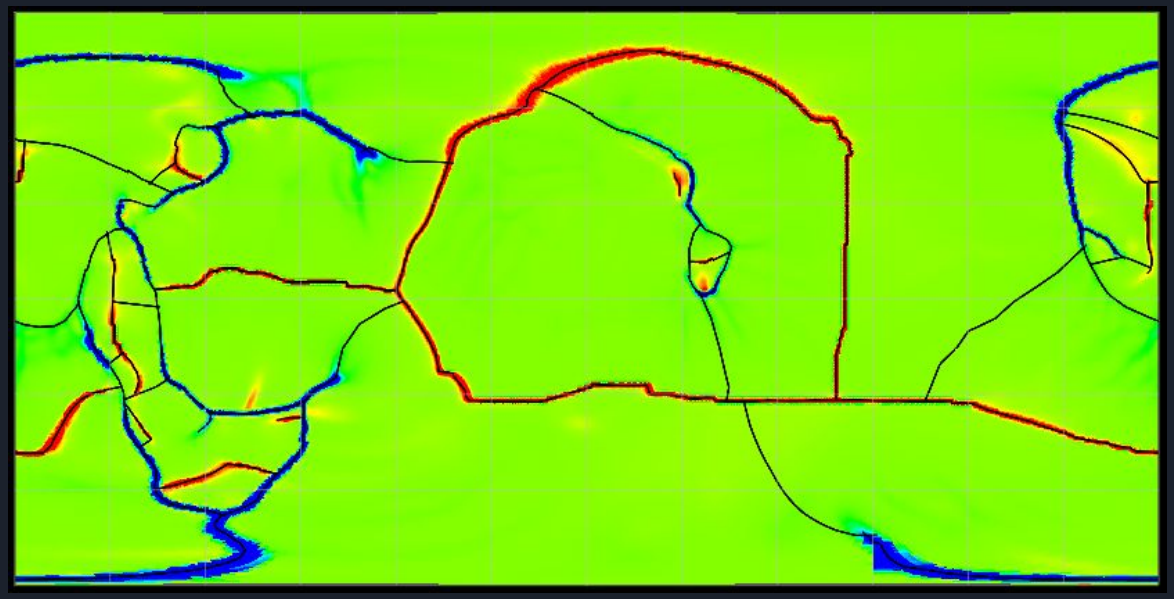
# Introduction
## What do we want ?

Compute the plate limits on a geoid model

Accuracy

Speed



# Introduction
## What do we have ?

Input data file with :
- coordinates
- velocities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# Introduction
## What do we have ?

Input data file with :
- coordinates
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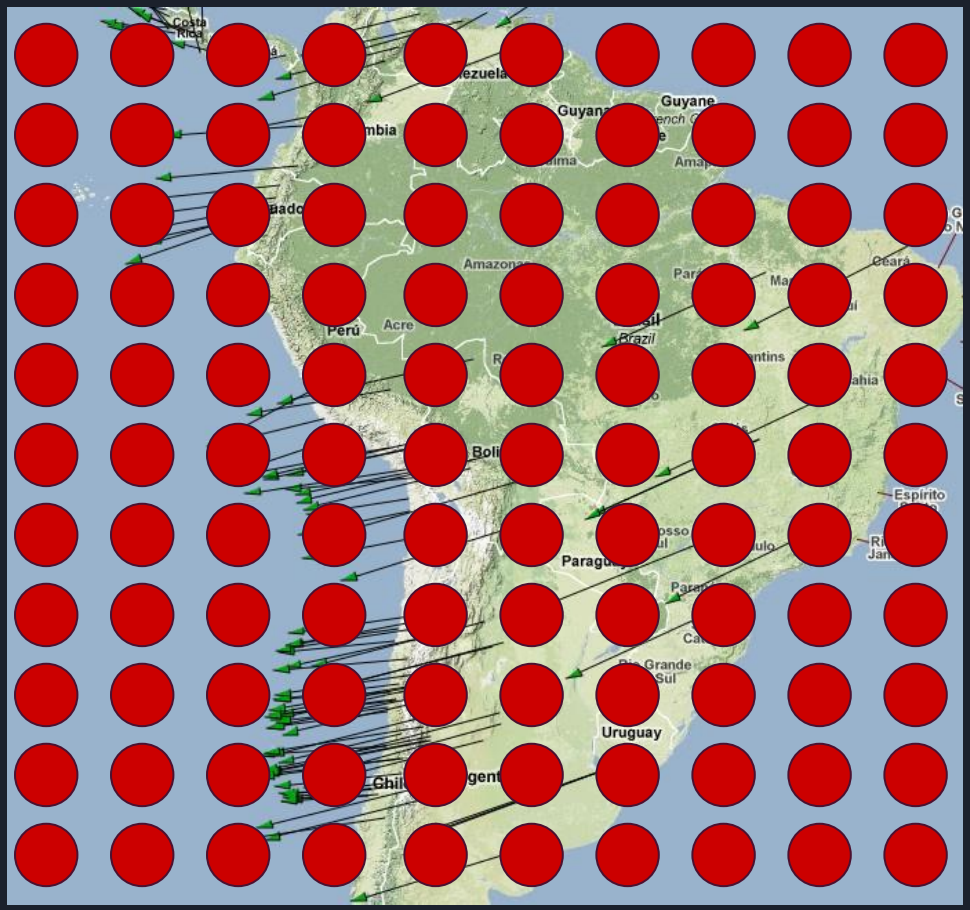
That’s it.

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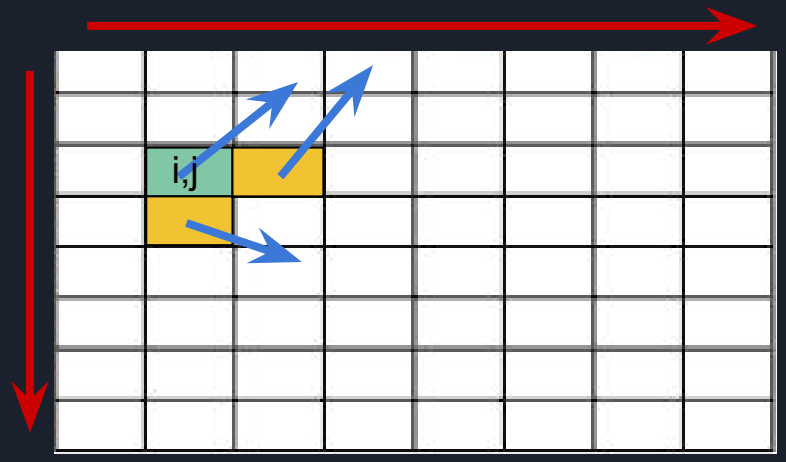
# Introduction
## How do we get it ?

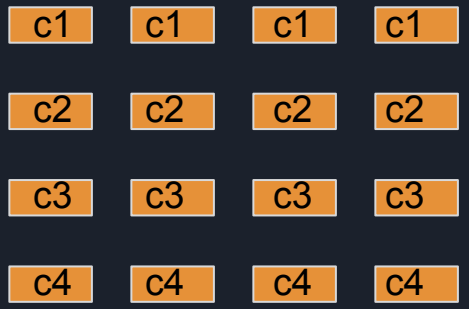
- **Process all the model matrix**
- Working on pairs of points
- Cutoff for velocity difference
- **Trying with different cutoffs**



# Introduction
## Two parallelization methods

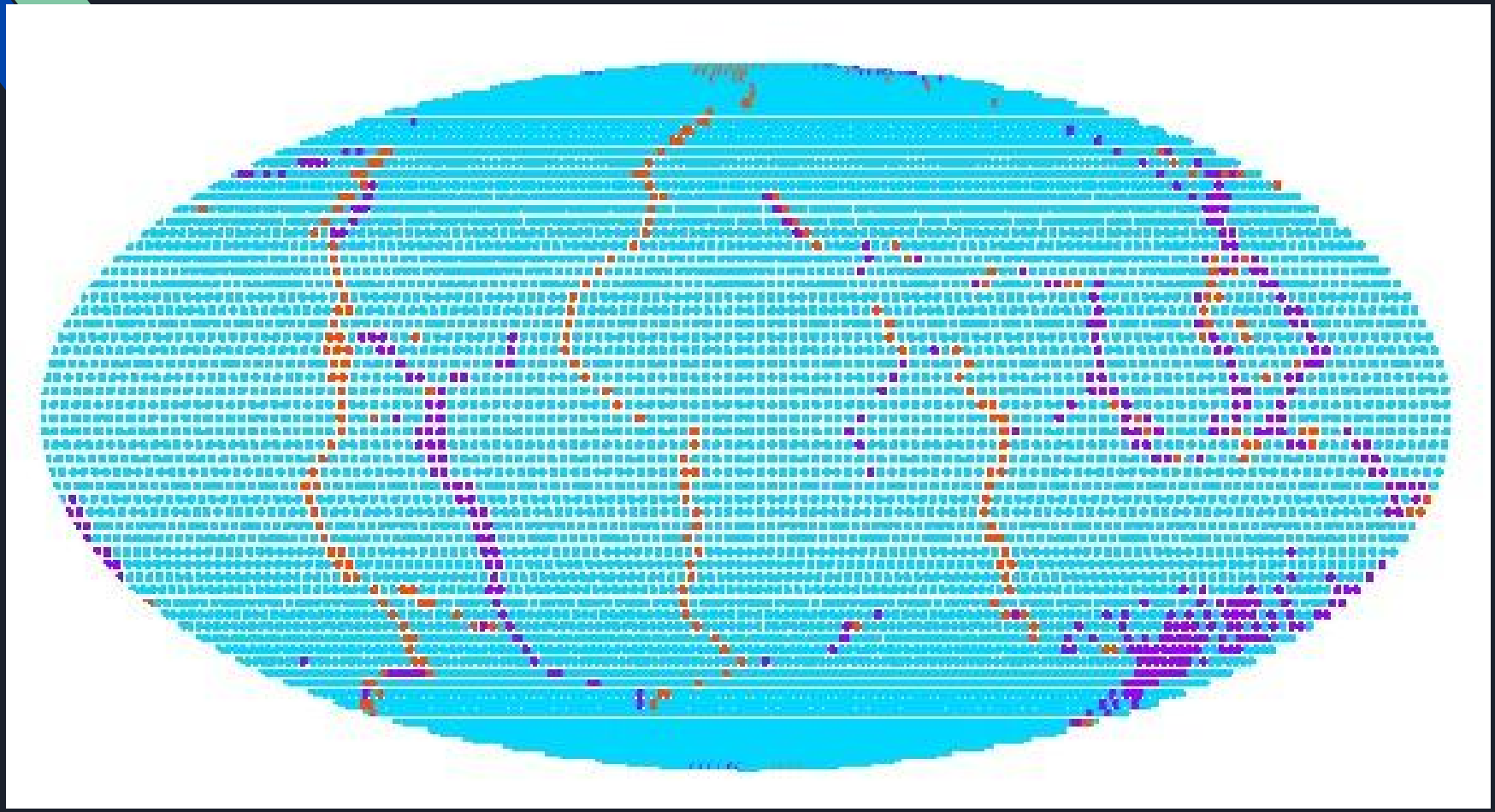
- Cutoff parallelization (-c)


- Matrix parallelization (-m)




**Do they give the same results ?**
**Which one is better ?**

# Results



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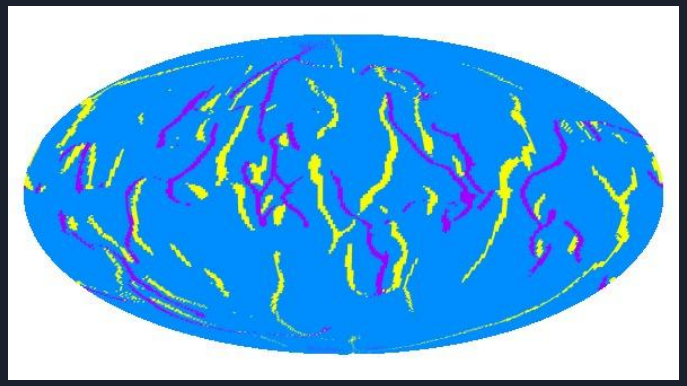
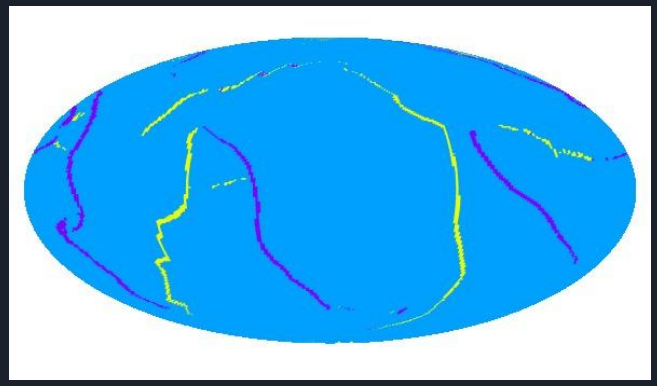
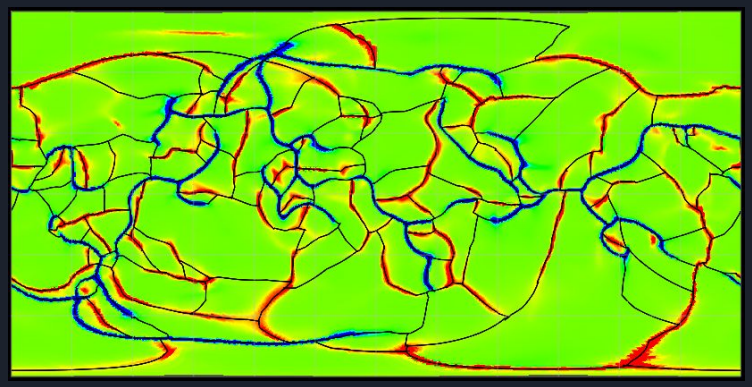
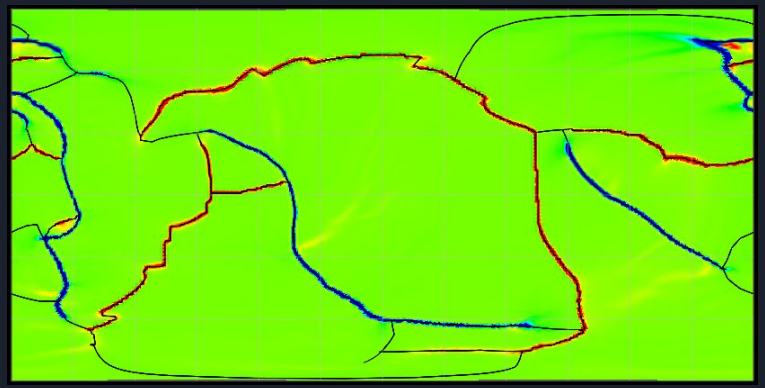
# Results









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# Results analysis

Running the program on two machines:

**My machine**

**HPC compute node**

# Results analysis
## Architectures

```
yann debian8 ~/ $ lscpu
Architecture :          x86_64
Mode(s) opératoire(s) des processeurs : 32-bit, 64-bit

Processeur(s) :         4

Nœud(s) NUMA :          1

Nom de modèle :         Intel(R) Core(TM) i5-2520M CPU @ 2.50GHz

Vitesse du processeur en MHz : 1665.820
Vitesse maximale du processeur en MHz : 3200,0000
Vitesse minimale du processeur en MHz : 800,0000

Cache L1d :             32K
Cache L1i :             32K
Cache L2 :              256K
Cache L3 :              3072K
```

```
[yanndroy@hpc-class-13 Project]$ lscpu
Architecture :          x86_64
Mode(s) opératoire(s) des processeurs : 32-bit, 64-bit

Processeur(s) :         16

Nœud(s) NUMA :          2

Nom de modèle :         Intel(R) Xeon(R) CPU E5-2650 0 @ 2.00GHz

Vitesse du processeur en MHz : 1394.609
CPU max MHz:            2800,0000
CPU min MHz:            1200,0000

Cache L1d :             32K
Cache L1i :             32K
Cache L2 :              256K
Cache L3 :              20480K
```

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# Results analysis

## Cross analysis of cache misses

**cutoff**

**my machine**

```
==32656== I   refs:      39,082,442,675
==32656== I1  misses:             7,482
==32656== LLi misses:             7,163
==32656== I1  miss rate:           0.00%
==32656== LLi miss rate:           0.00%
==32656==
==32656== D   refs:      16,084,035,453
==32656== D1  misses:        18,539,835
==32656== LLd misses:         8,326,109
==32656== D1  miss rate:           0.1%
==32656== LLd miss rate:           0.0%
==32656==
==32656== LL refs:           18,547,317
==32656== LL misses:          8,333,272
==32656== LL miss rate:            0.0%
```

**HPC node**

```
==3121== I   refs:      39,452,559,444
==3121== I1  misses:             11,374
==3121== LLi misses:              1,955
==3121== I1  miss rate:            0.00%
==3121== LLi miss rate:            0.00%
==3121==
==3121== D   refs:      16,009,114,565
==3121== D1  misses:        16,437,278
==3121== LLd misses:           112,769
==3121== D1  miss rate:            0.1%
==3121== LLd miss rate:            0.0%
==3121==
==3121== LL refs:           16,448,652
==3121== LL misses:            114,724
==3121== LL miss rate:             0.0%
```

**matrix**

```
==662== I   refs:      39,110,497,090
==662== I1  misses:             26,163
==662== LLi misses:             26,118
==662== I1  miss rate:             0.00%
==662== LLi miss rate:             0.00%
==662==
==662== D   refs:      16,104,084,057
==662== D1  misses:        14,509,239
==662== LLd misses:        13,829,276
==662== D1  miss rate:             0.0%
==662== LLd miss rate:             0.0%
==662==
==662== LL refs:           14,535,402
==662== LL misses:         13,855,394
==662== LL miss rate:              0.0%
```

```
==3154== I   refs:      41,128,210,276
==3154== I1  misses:             27,817
==3154== LLi misses:              1,932
==3154== I1  miss rate:            0.00%
==3154== LLi miss rate:            0.00%
==3154==
==3154== D   refs:      16,264,042,463
==3154== D1  misses:        15,874,484
==3154== LLd misses:            73,532
==3154== D1  miss rate:            0.1%
==3154== LLd miss rate:            0.0%
==3154==
==3154== LL refs:           15,902,301
==3154== LL misses:             75,464
==3154== LL miss rate:             0.0%
```

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# Results analysis

## Processor **affinity** & binding

```
[yanndroy@hpc-class-25 Project]$ export GOMP_CPU_AFFINITY='0'
[yanndroy@hpc-class-25 Project]$ bin/PAD -c guided data_files/model1/velocity_YS1_30ma.neu 8 10 40 100
9.297374
[yanndroy@hpc-class-25 Project]$ bin/PAD -m guided data_files/model1/velocity_YS1_30ma.neu 8 10 40 100
18.224214
[yanndroy@hpc-class-25 Project]$ export GOMP_CPU_AFFINITY='0 0 0 0 1 1 1 1'
[yanndroy@hpc-class-25 Project]$ bin/PAD -c guided data_files/model1/velocity_YS1_30ma.neu 8 10 40 100
5.381035
[yanndroy@hpc-class-25 Project]$ bin/PAD -m guided data_files/model1/velocity_YS1_30ma.neu 8 10 40 100
16.394253
[yanndroy@hpc-class-25 Project]$ export GOMP_CPU_AFFINITY='0 0 1 1 2 2 3 3'
[yanndroy@hpc-class-25 Project]$ bin/PAD -c guided data_files/model1/velocity_YS1_30ma.neu 8 10 40 100
3.942407
[yanndroy@hpc-class-25 Project]$ bin/PAD -m guided data_files/model1/velocity_YS1_30ma.neu 8 10 40 100
15.592971
```

# Results analysis

## Processor affinity & **binding**

```
[yanndroy@hpc-class-25 Project]$ export OMP_PROC_BIND='FALSE'
[yanndroy@hpc-class-25 Project]$ bin/PAD -c guided data_files/model1/velocity_YS1_30ma.neu 10 10 40 100
3.417804
[yanndroy@hpc-class-25 Project]$ bin/PAD -c guided data_files/model1/velocity_YS1_30ma.neu 50 10 40 100
2.982359
[yanndroy@hpc-class-25 Project]$ bin/PAD -c guided data_files/model1/velocity_YS1_30ma.neu 100 10 40 100
3.054605
[yanndroy@hpc-class-25 Project]$ bin/PAD -m guided data_files/model1/velocity_YS1_30ma.neu 10 10 40 100
15.385397
[yanndroy@hpc-class-25 Project]$ bin/PAD -m guided data_files/model1/velocity_YS1_30ma.neu 50 10 40 100
15.402048
[yanndroy@hpc-class-25 Project]$ bin/PAD -m guided data_files/model1/velocity_YS1_30ma.neu 100 10 40 100
16.296180
[yanndroy@hpc-class-25 Project]$ export OMP_PROC_BIND='TRUE'
[yanndroy@hpc-class-25 Project]$ bin/PAD -c guided data_files/model1/velocity_YS1_30ma.neu 10 10 40 100
3.872487
[yanndroy@hpc-class-25 Project]$ bin/PAD -c guided data_files/model1/velocity_YS1_30ma.neu 50 10 40 100
4.277984
[yanndroy@hpc-class-25 Project]$ bin/PAD -c guided data_files/model1/velocity_YS1_30ma.neu 100 10 40 100
4.675281
[yanndroy@hpc-class-25 Project]$ bin/PAD -m guided data_files/model1/velocity_YS1_30ma.neu 10 10 40 100
16.459799
[yanndroy@hpc-class-25 Project]$ bin/PAD -m guided data_files/model1/velocity_YS1_30ma.neu 50 10 40 100
15.402206
[yanndroy@hpc-class-25 Project]$ bin/PAD -m guided data_files/model1/velocity_YS1_30ma.neu 100 10 40 100
15.431102
```

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# Results analysis

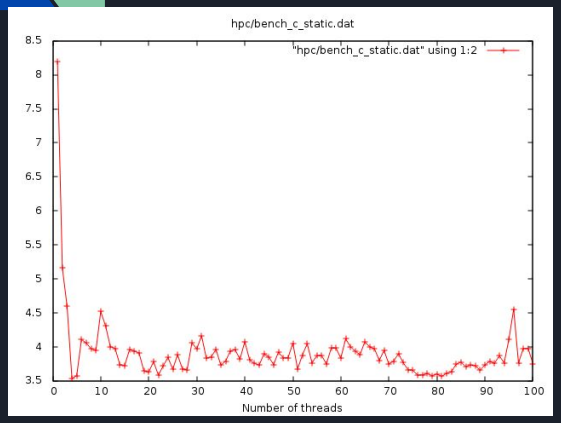
## Cutoff vs. matrix parallelization performance on HPC node

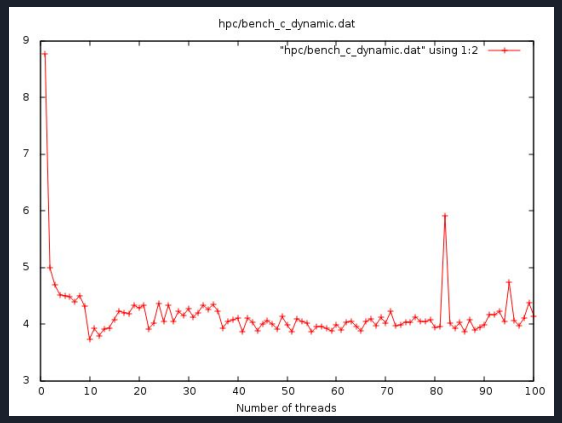
```
Performance counter stats for 'bin/PAD -c guided data_files/model1/velocity_YS1_30ma.neu 10 10 40 50' (10 runs):

      4869,966509      task-clock (msec)         #    2,332 CPUs utilized            ( +-  0,34% )
            3 441      context-switches          #    0,707 K/sec                    ( +-  1,06% )
               11      cpu-migrations            #    0,002 K/sec                    ( +-  5,91% )
            3 526      page-faults               #    0,724 K/sec                    ( +-  0,03% )

   20 141 619 143      instructions              #    1,61  insn per cycle

       16 442 316      branch-misses             #    0,40% of all branches          ( +-  0,09% )

      2,087984111 seconds time elapsed                                               ( +-  1,37% )
```

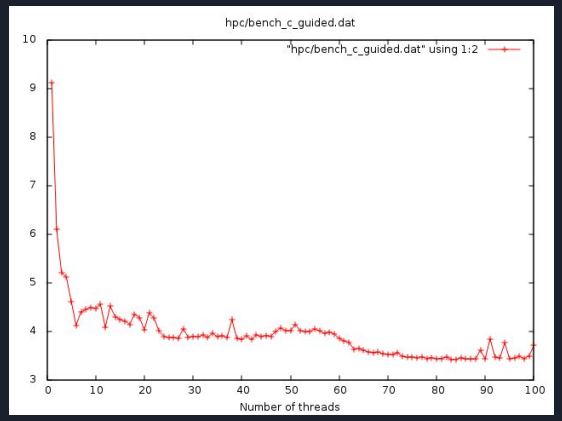
```
Performance counter stats for 'bin/PAD -m guided data_files/model1/velocity_YS1_30ma.neu 10 10 40 50' (10 runs):

      6278,878720      task-clock (msec)         #    0,755 CPUs utilized            ( +-  0,15% )
            1 345      context-switches          #    0,214 K/sec                    ( +-  0,50% )
               83      cpu-migrations            #    0,013 K/sec                    ( +- 10,55% )
            2 795      page-faults               #    0,445 K/sec                    ( +-  0,01% )

   21 993 792 638      instructions              #    1,29  insn per cycle

       16 745 693      branch-misses             #    0,36% of all branches          ( +-  0,10% )

      8,315060893 seconds time elapsed                                               ( +-  0,27% )
```

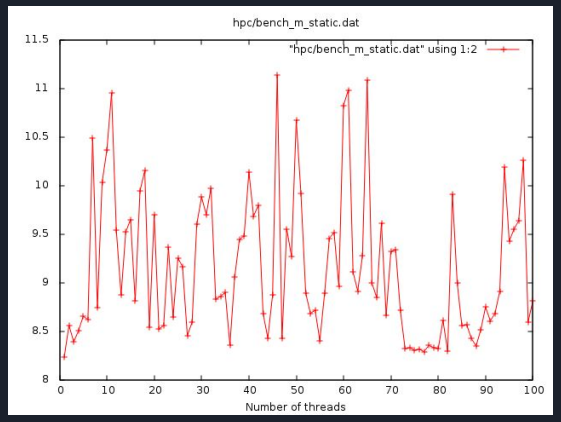
# Results analysis

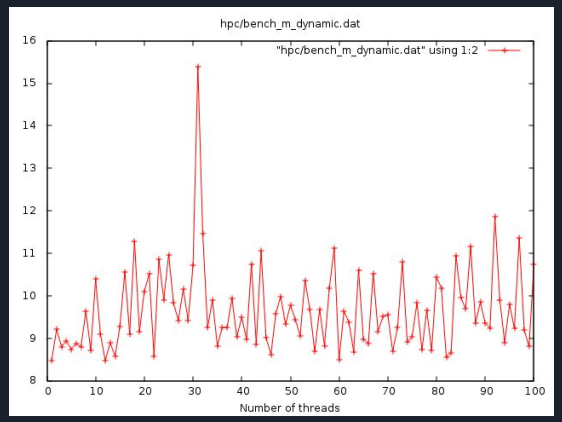
## Cutoff vs. matrix parallelization output times on HPC node

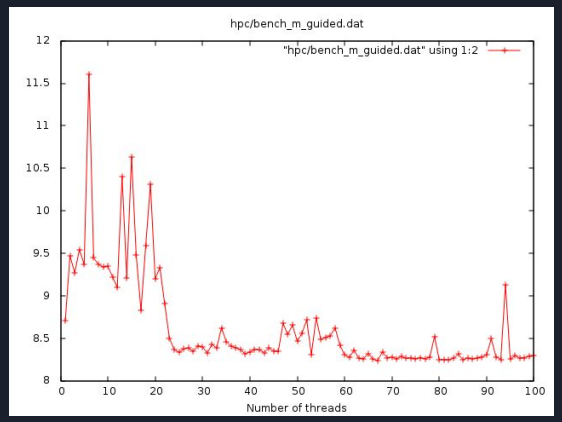
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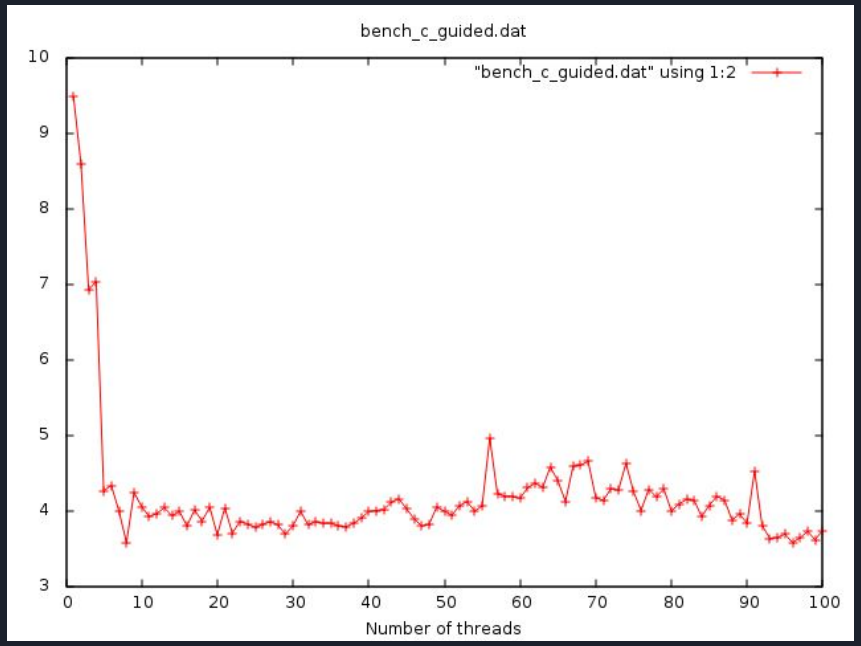
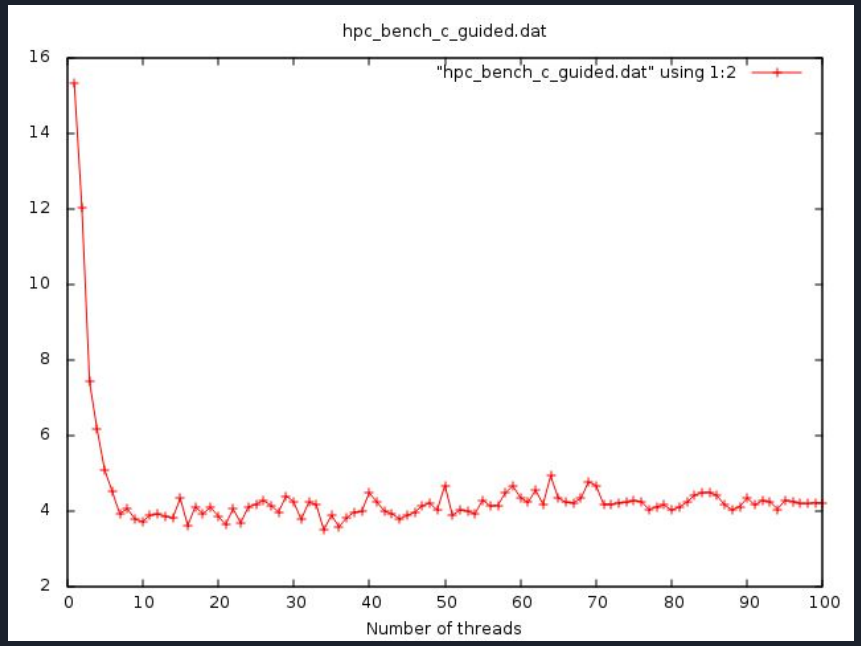
# Results analysis

## Cutoff parallelization output times on both machines

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# Conclusion

- Cutoff parallelization is way more effective
- Guided scheduling is better
- Quite the same throughput but HPC node has better performances.

  **Why ?**

Thank you

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