# HNCO
# Visualization of Walsh transforms of various functions defined on bit vectors

April 11, 2019

**Abstract**

This document proposes a visualization of Walsh (or Fourier) transforms of various functions defined on bit vectors (hypercube) of size $n = 10$. For each function, two graphics are displayed. In the first one, coefficients of the Walsh transform are sorted in decreasing order of amplitude and normalized relatively to the largest amplitude. The second graphics displays the energy (sum of squares of coefficients) as a function of the feature Hamming weight. This can be thought of as a power spectrum. The coefficient of the feature zero has been filtered out. Coefficients $c$ such that $0 < |c/c_{\max}| < 10^{-10}$ have also been filtered out as they mostly result from accumulated errors in floating point arithmetic.

## Contents

**1 All functions** **2**

**2 one-max** **3**

**3 lin** **4**

**4 leading-ones** **5**

**5 ridge** **6**

**6 jmp-2** **7**

**7 jmp-4** **8**

**8 djmp-2** **9**

**9 djmp-4** **10**

**10 fp-2** **11**

**11 fp-4** **12**

**12 nk** **13**

**13 max-sat** **14**

**14 labs** **15**

**15 ep** **16**

**16 cancel** **17**

**17 trap** **18**

**18 hiff** **19**

**19 plateau** **20**

**20 needle** **21**

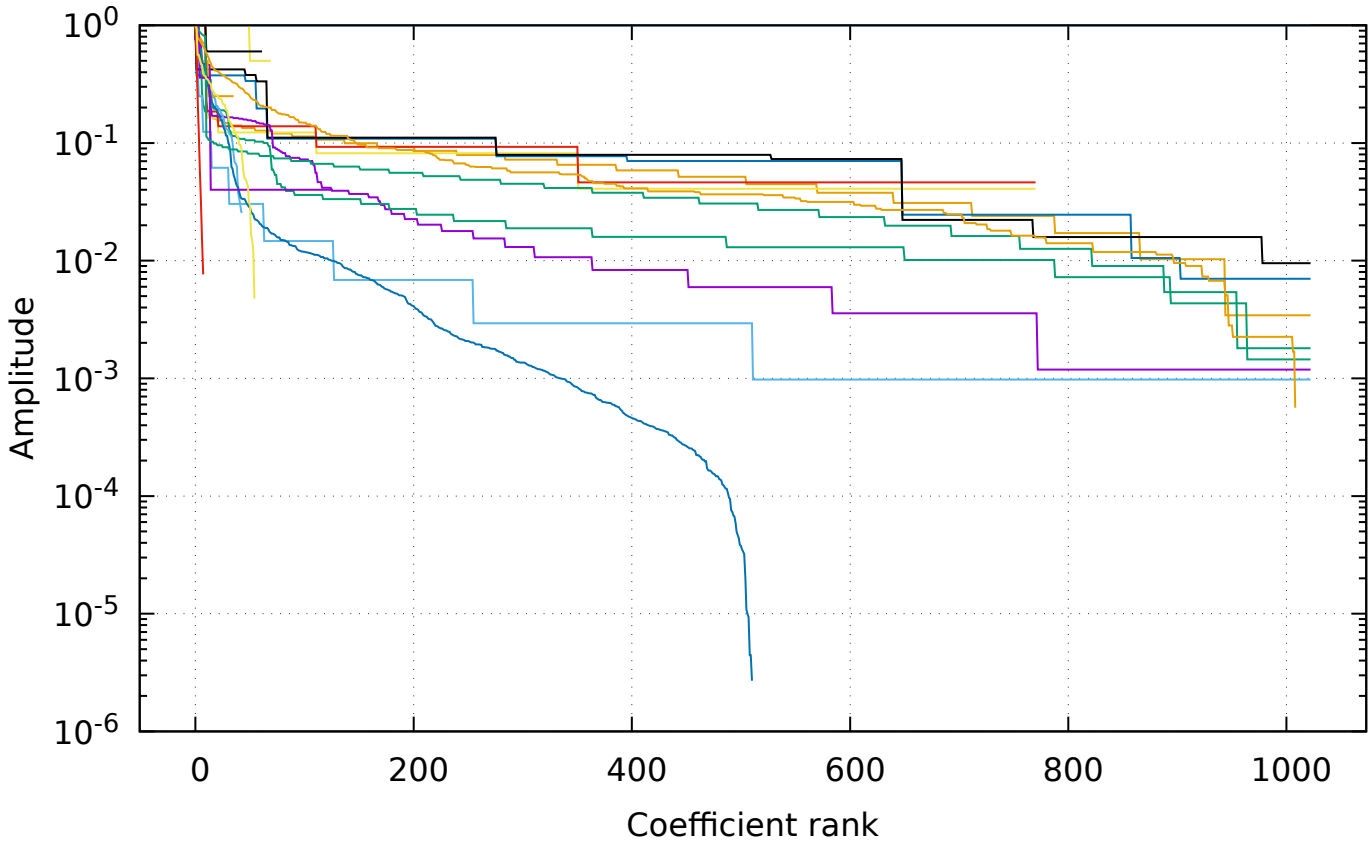
**21 long-path** **22**

**22 walsh2** **23**

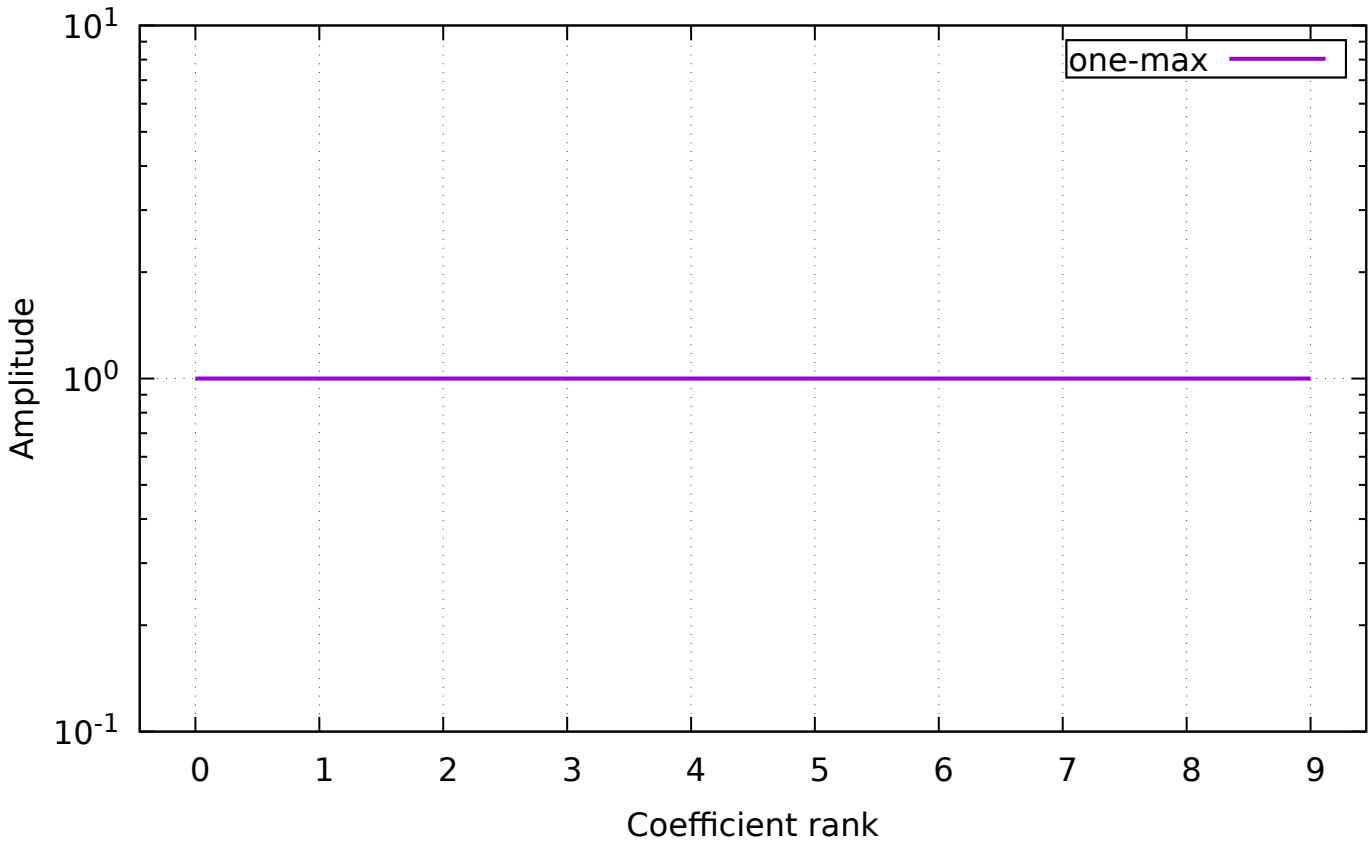
**A Plan** **23**

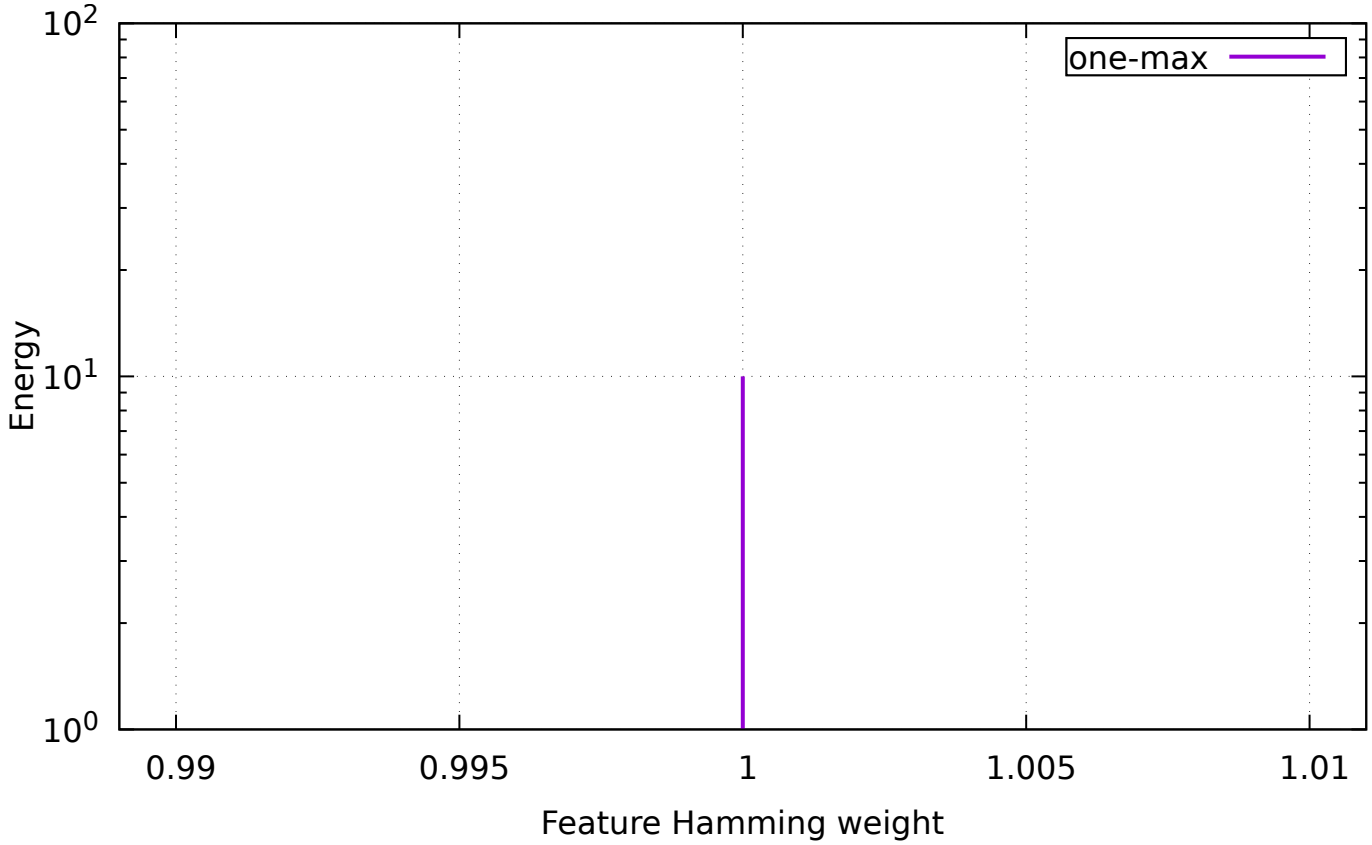
**B Default parameters** **25**

# 1 All functions

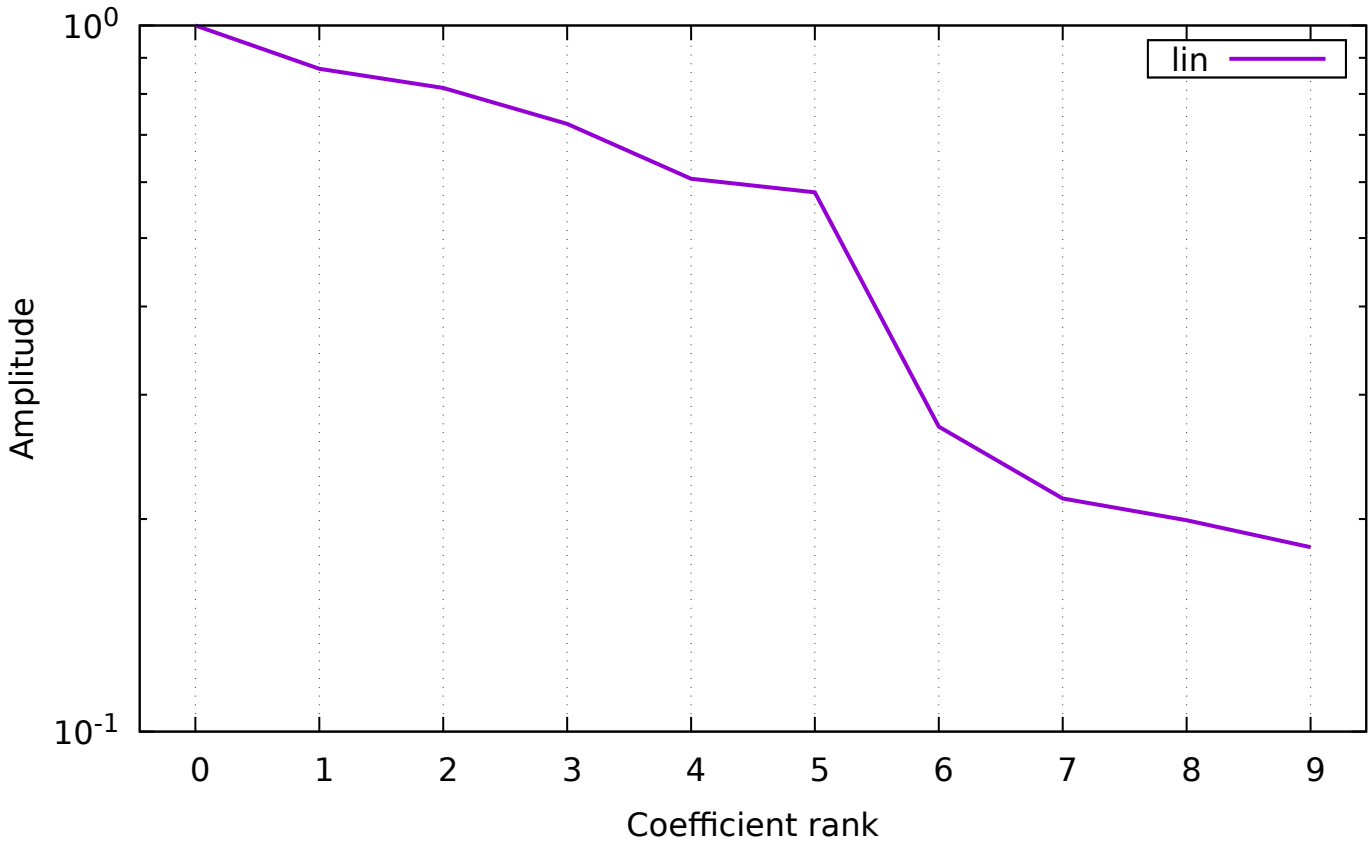


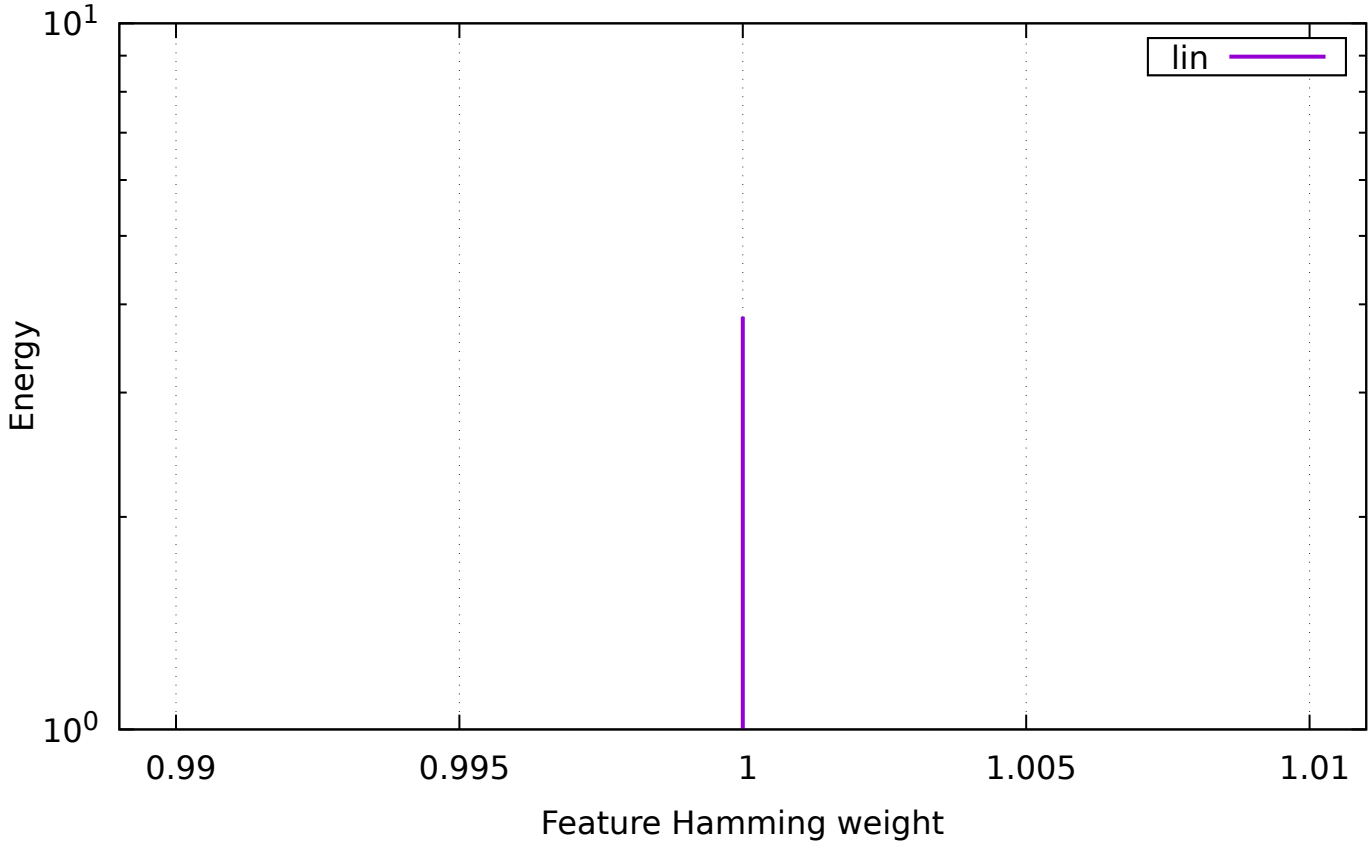
## 2 one-max


one-max
Amplitude
Coefficient rank
$10^1$
$10^0$
$10^{-1}$
0
1
2
3
4
5
6
7
8
9

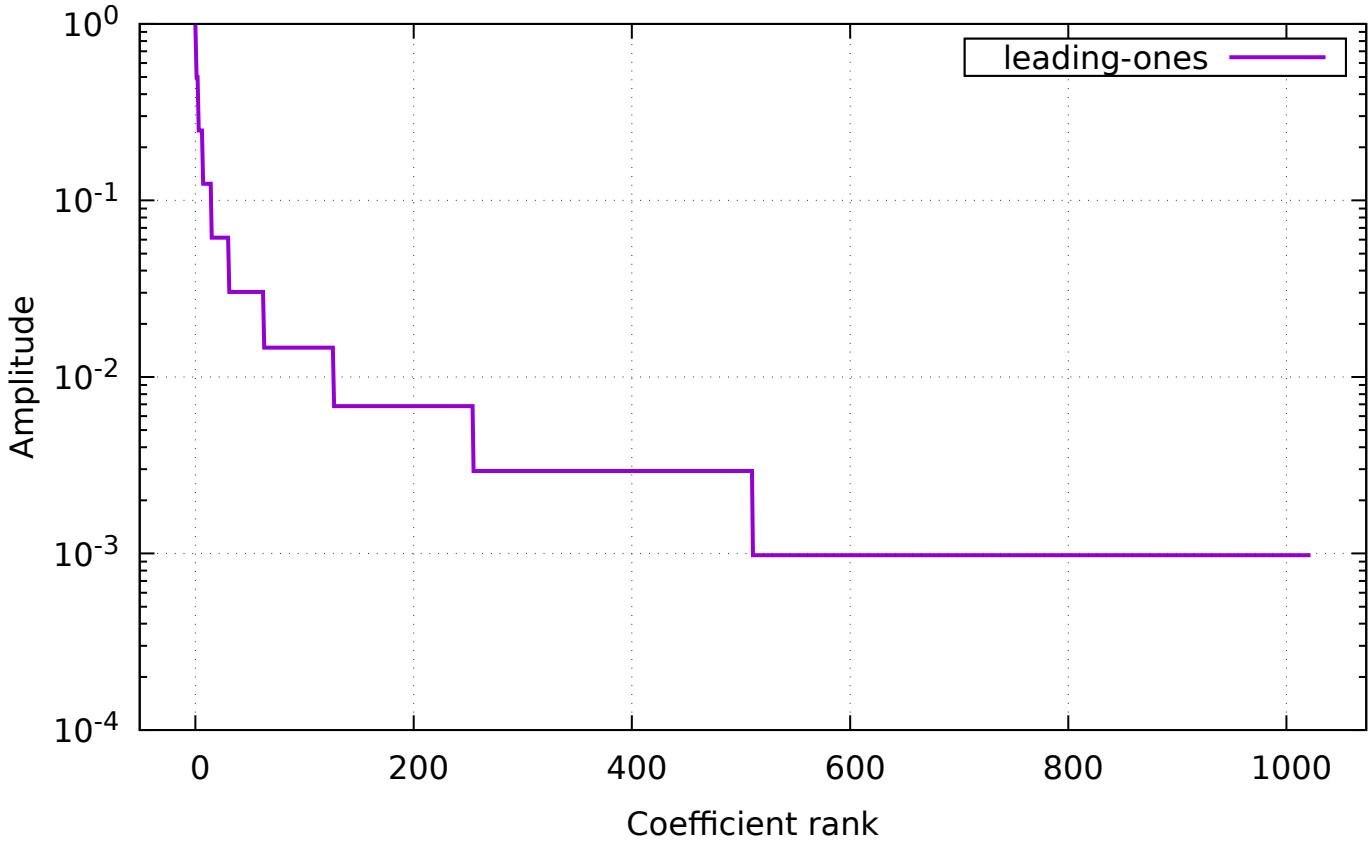

one-max
Energy
Feature Hamming weight
$10^2$
$10^1$
$10^0$
0.99
0.995
1
1.005
1.01

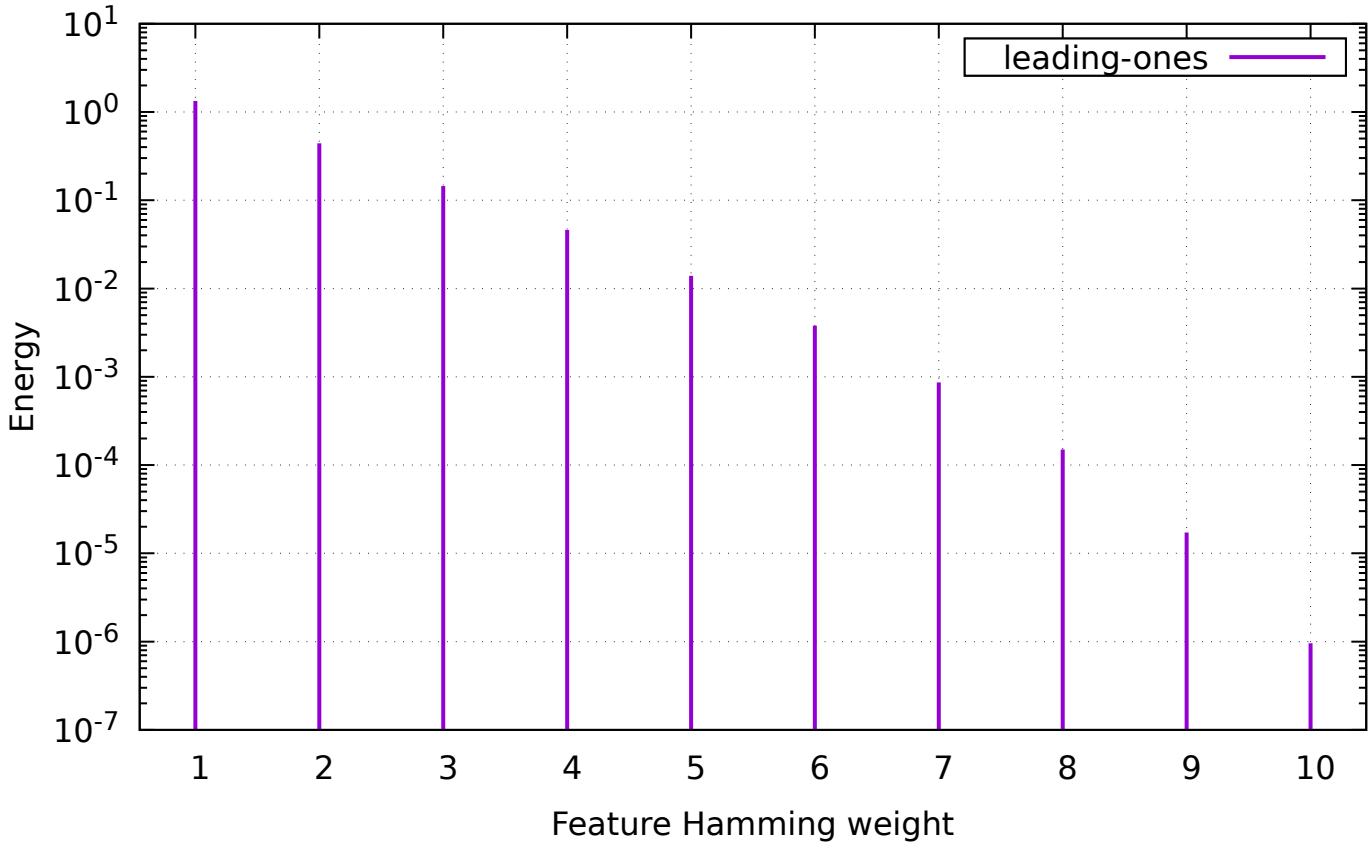
## 3 lin


lin
Amplitude
Coefficient rank
$10^0$
$10^{-1}$
0
1
2
3
4
5
6
7
8
9

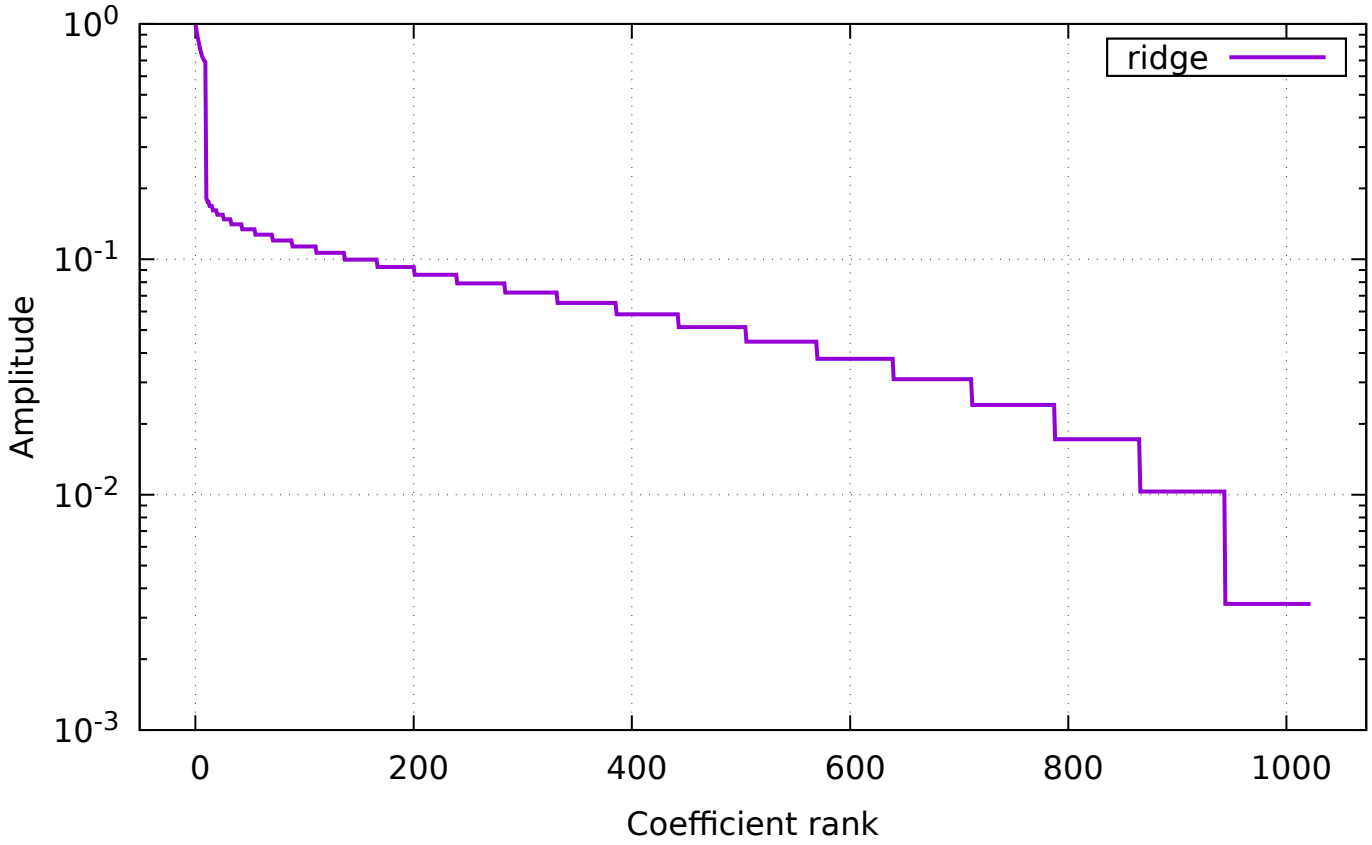

lin
Energy
Feature Hamming weight
$10^1$
$10^0$
0.99
0.995
1
1.005
1.01

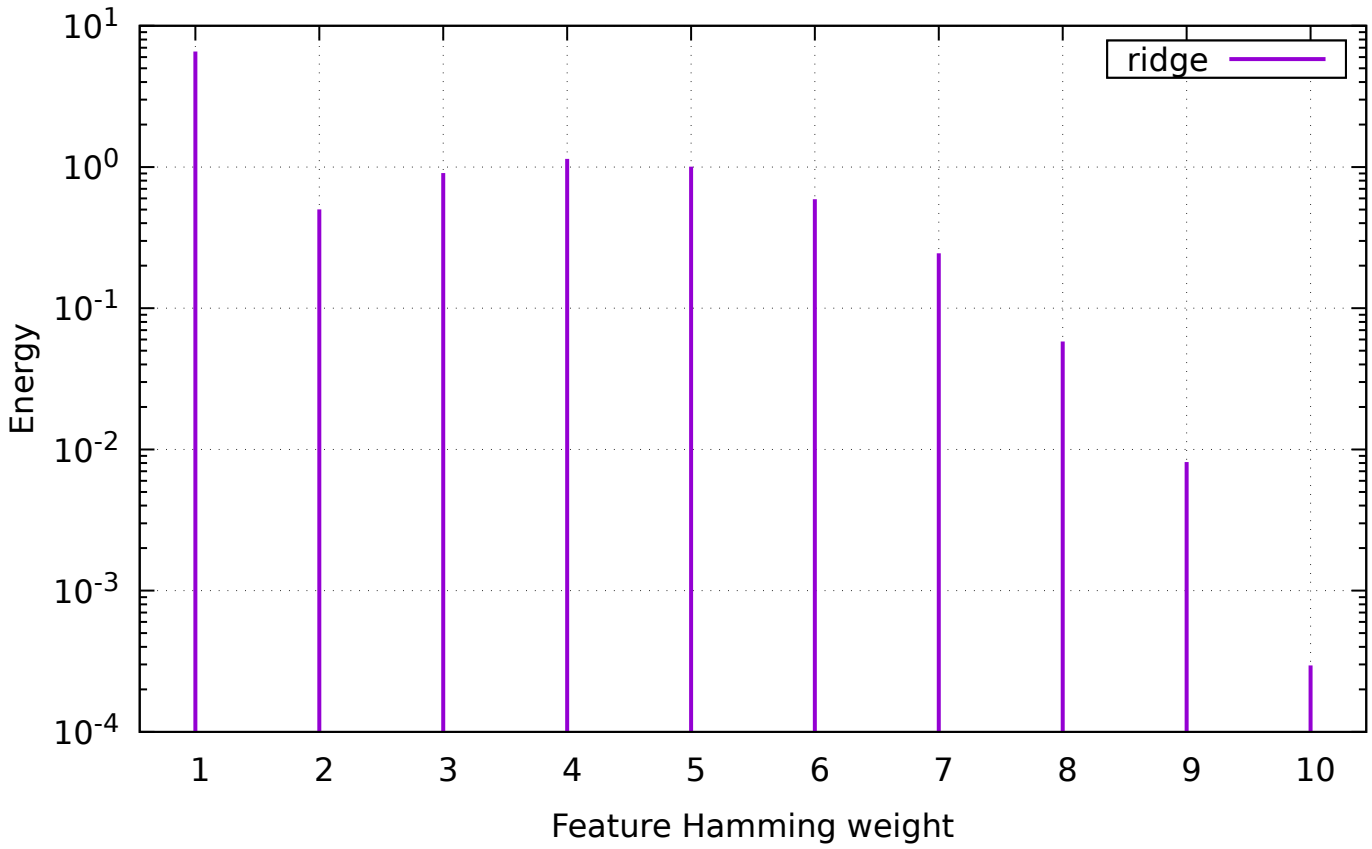
## 4 leading-ones



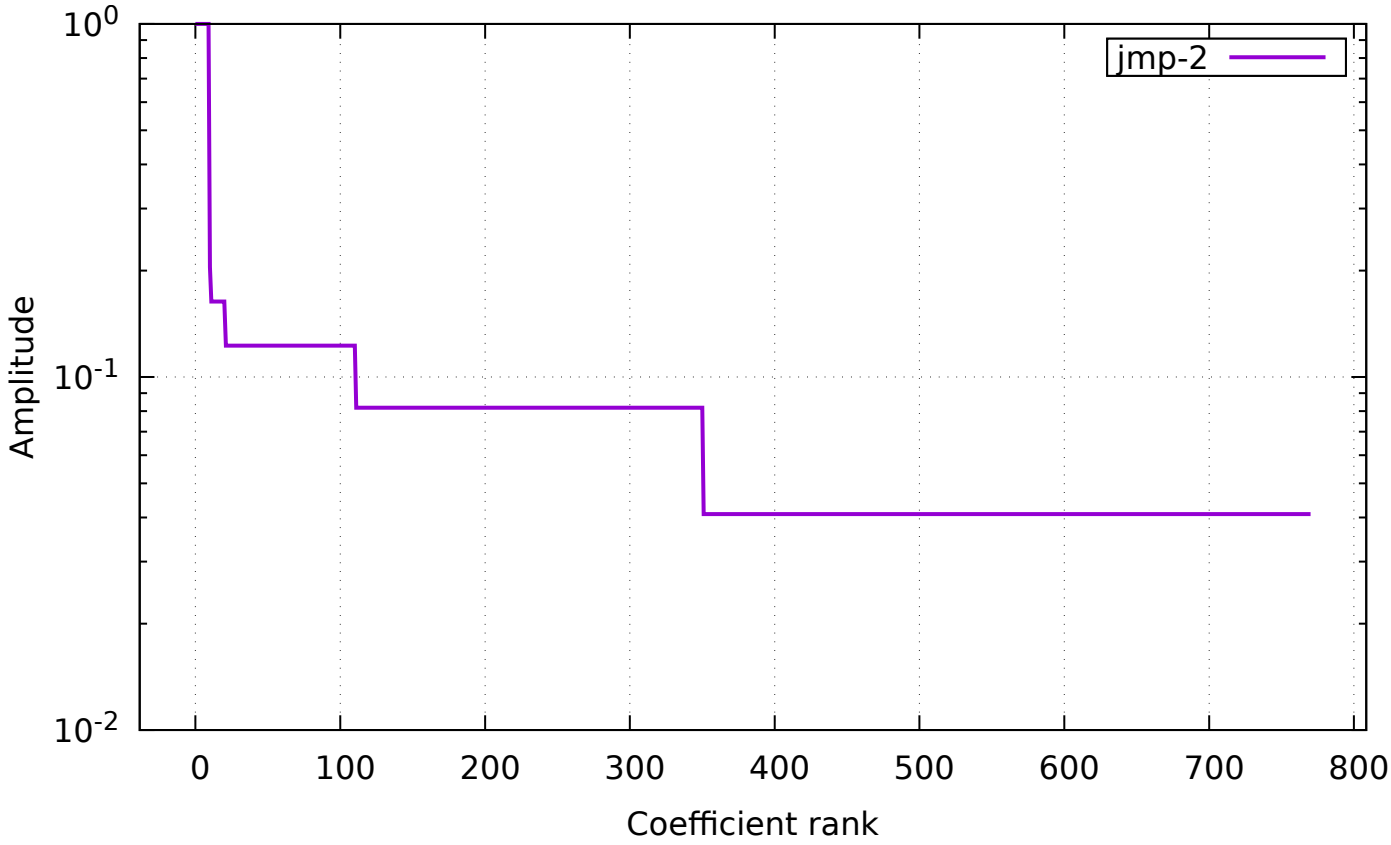



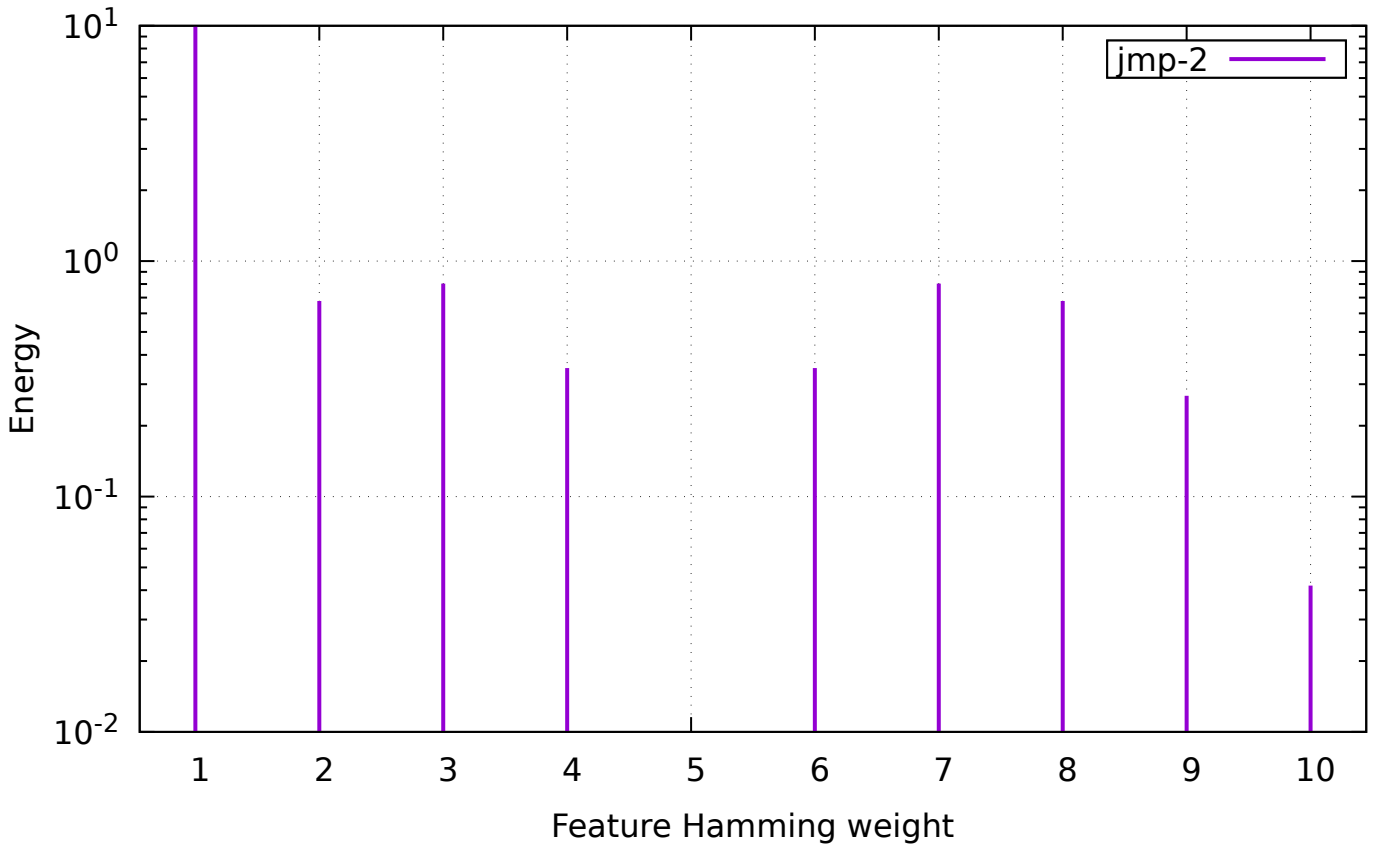
## 5 ridge


ridge
Amplitude
Coefficient rank
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
0
200
400
600
800
1000

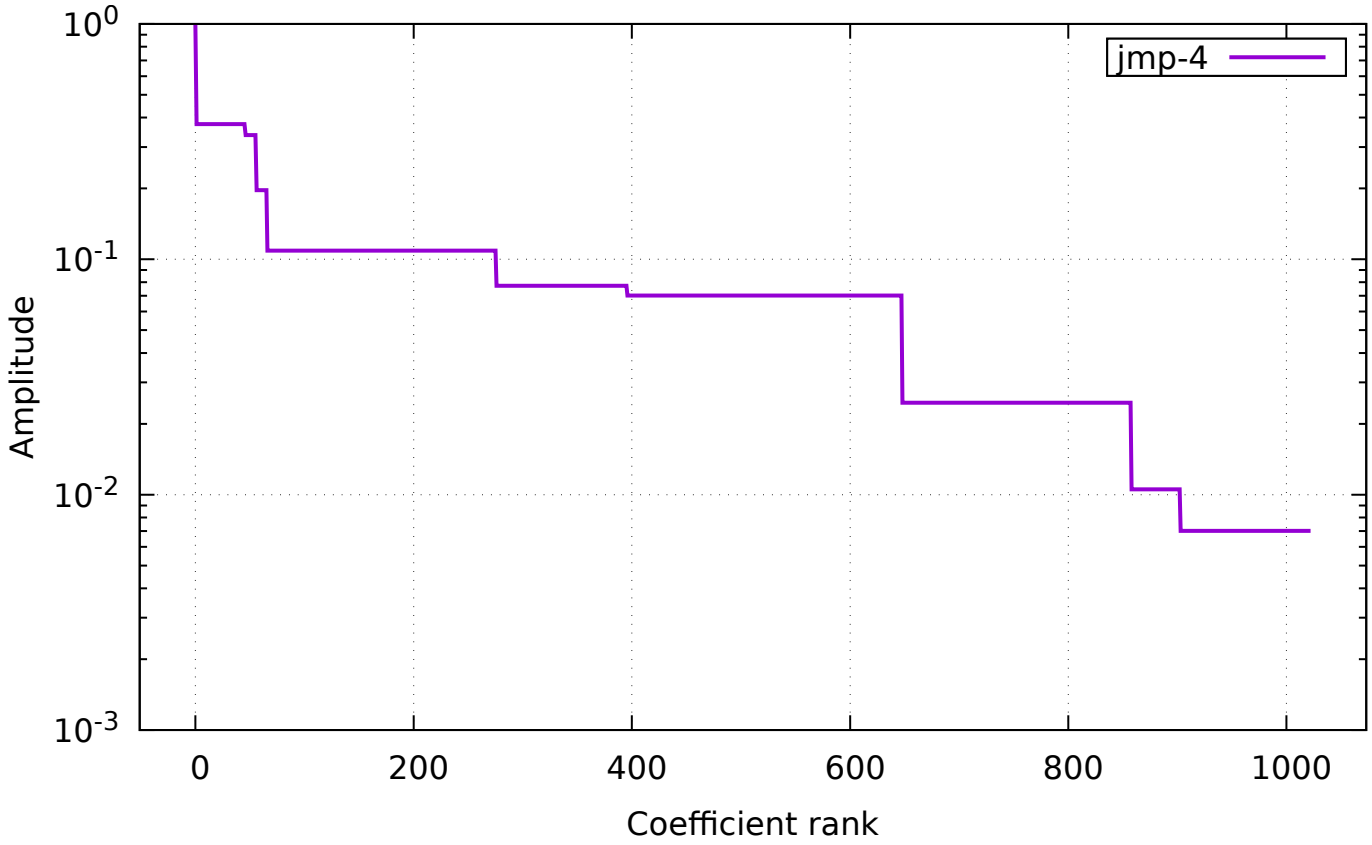

ridge
Energy
Feature Hamming weight
$10^{1}$
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
1
2
3
4
5
6
7
8
9
10

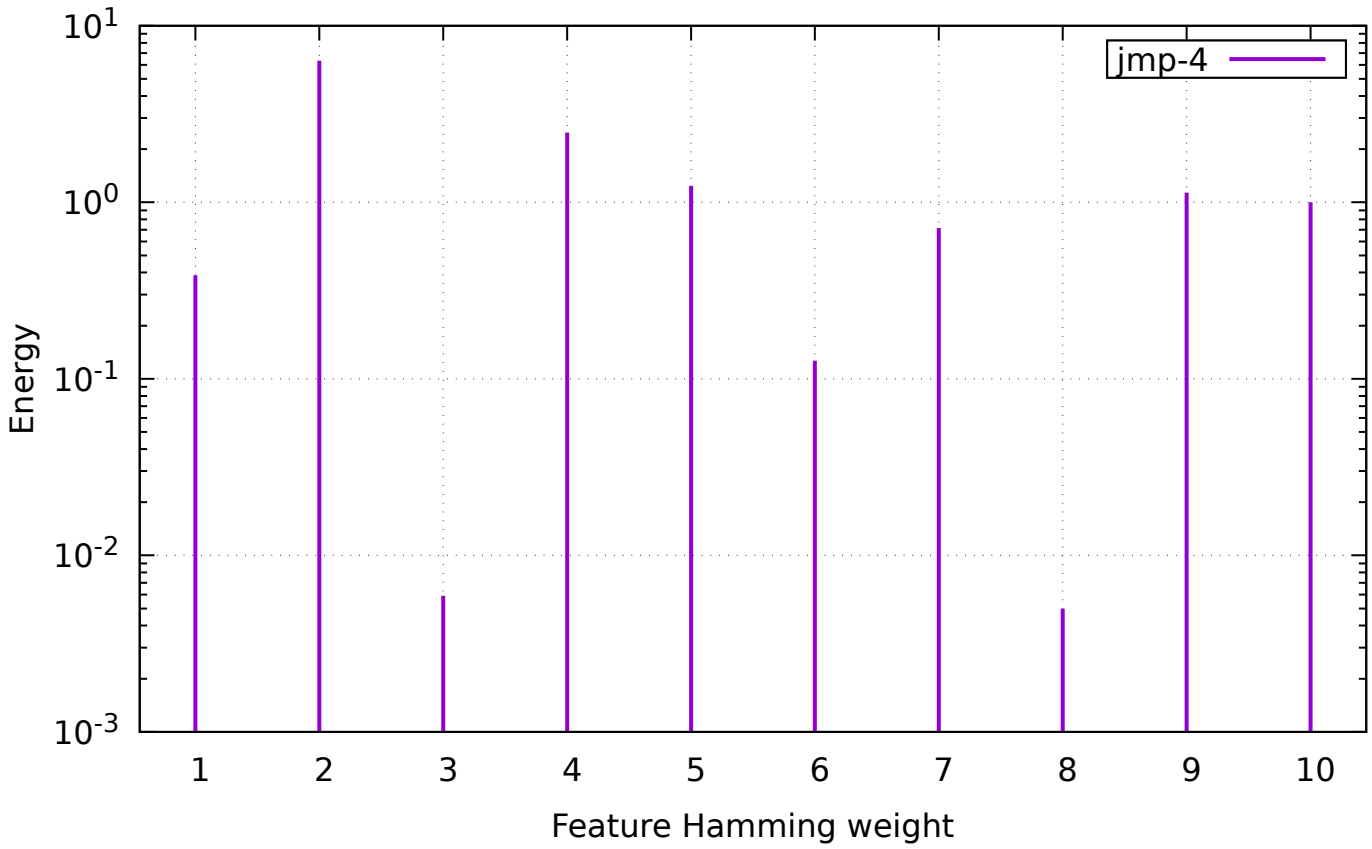
## 6 jmp-2


jmp-2
Amplitude
Coefficient rank
$10^0$
$10^{-1}$
$10^{-2}$
0
100
200
300
400
500
600
700
800

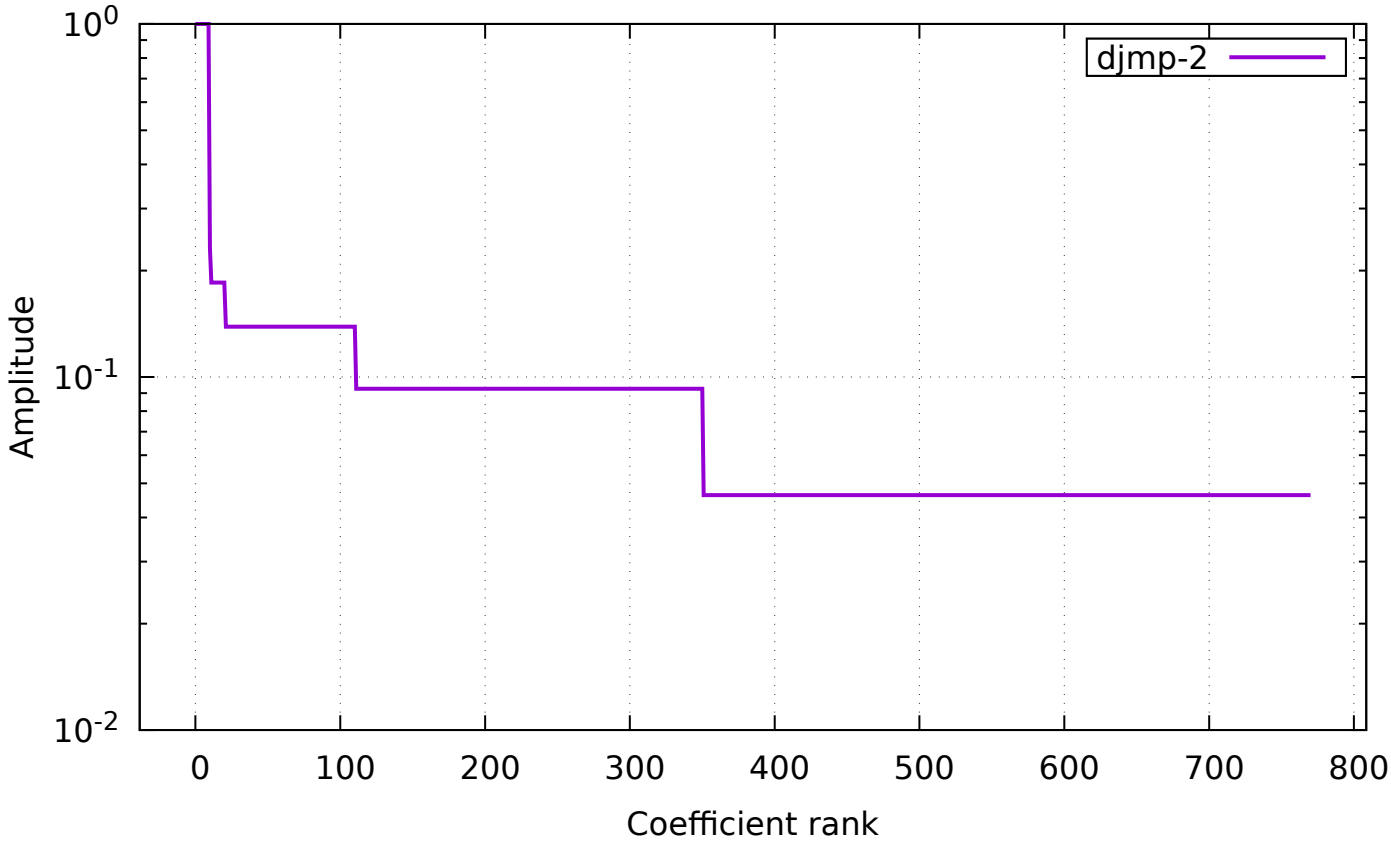

jmp-2
Energy
Feature Hamming weight
$10^1$
$10^0$
$10^{-1}$
$10^{-2}$
1
2
3
4
5
6
7
8
9
10

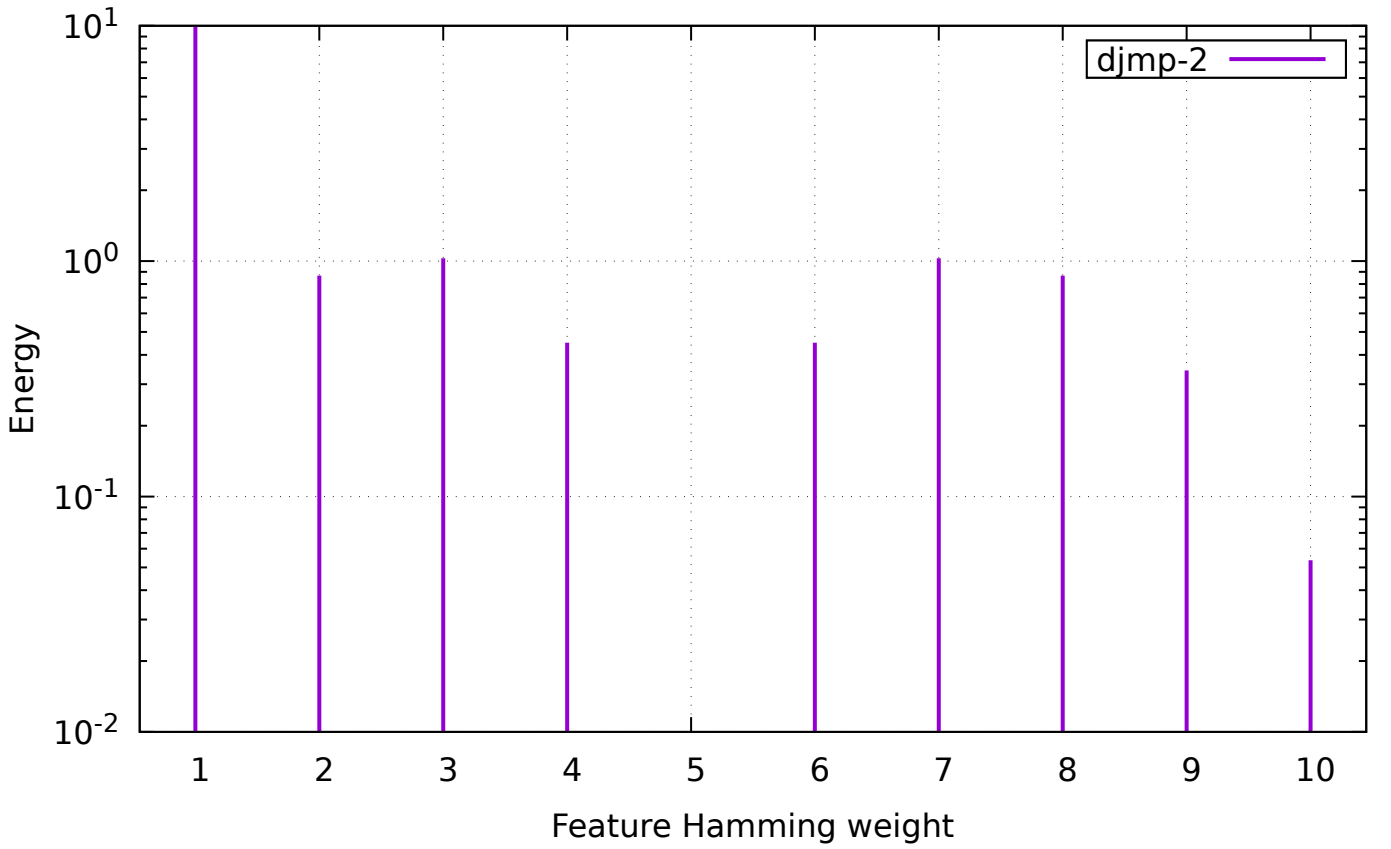
## 7 jmp-4


jmp-4
Amplitude
Coefficient rank
$10^0$
$10^{-1}$
$10^{-2}$
$10^{-3}$
0
200
400
600
800
1000

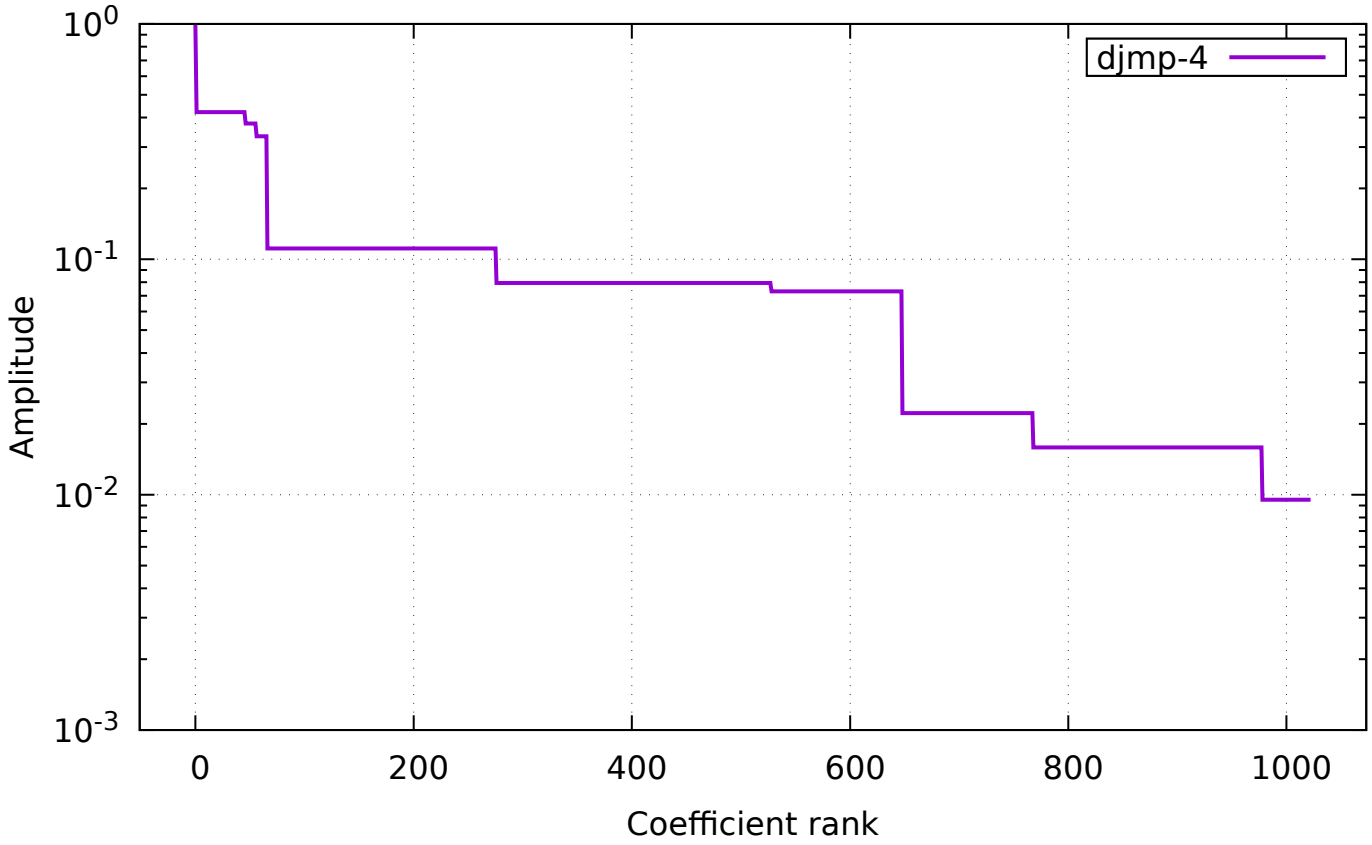

jmp-4
Energy
Feature Hamming weight
$10^1$
$10^0$
$10^{-1}$
$10^{-2}$
$10^{-3}$
1
2
3
4
5
6
7
8
9
10

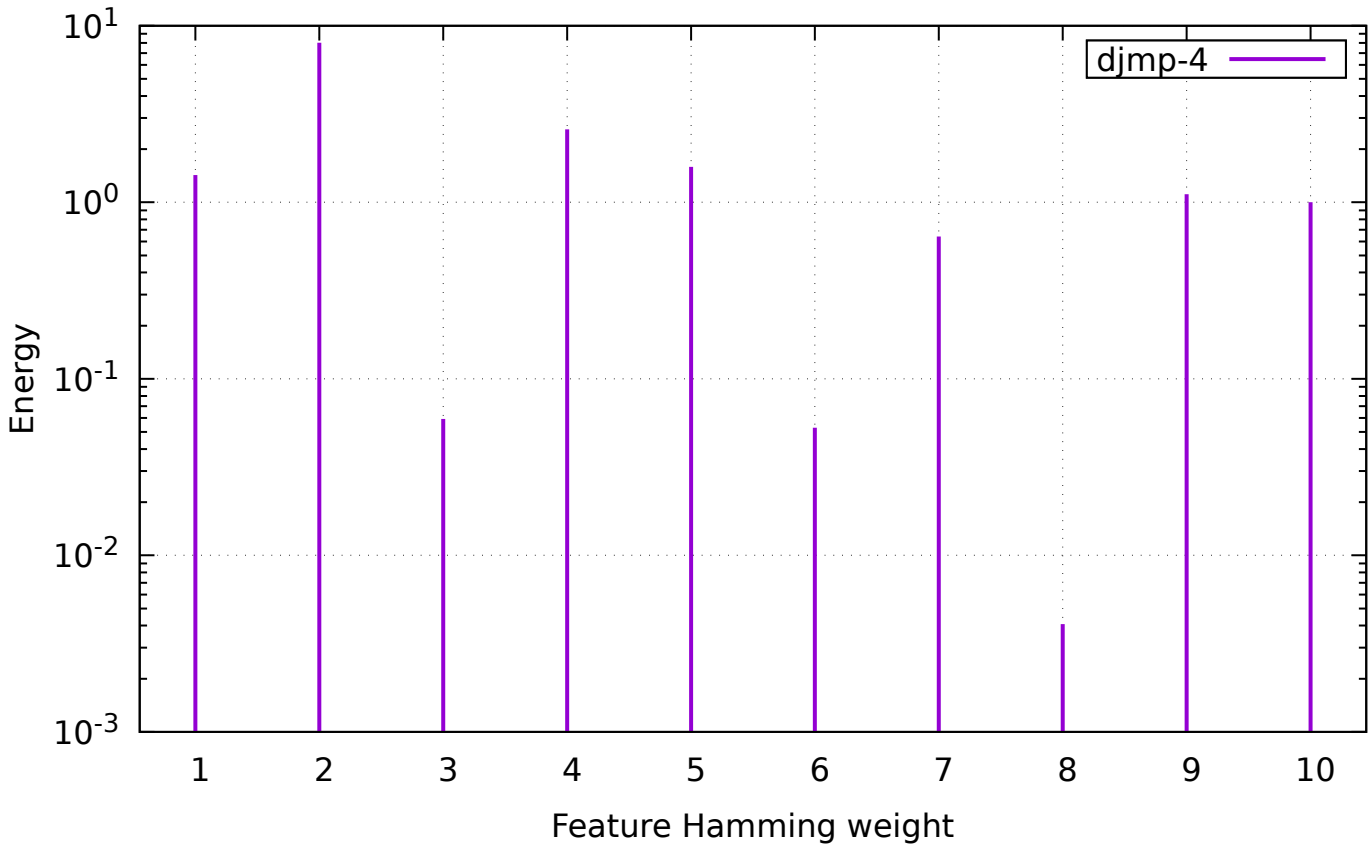
## 8 djmp-2


djmp-2
Amplitude
Coefficient rank
$10^0$
$10^{-1}$
$10^{-2}$
0
100
200
300
400
500
600
700
800

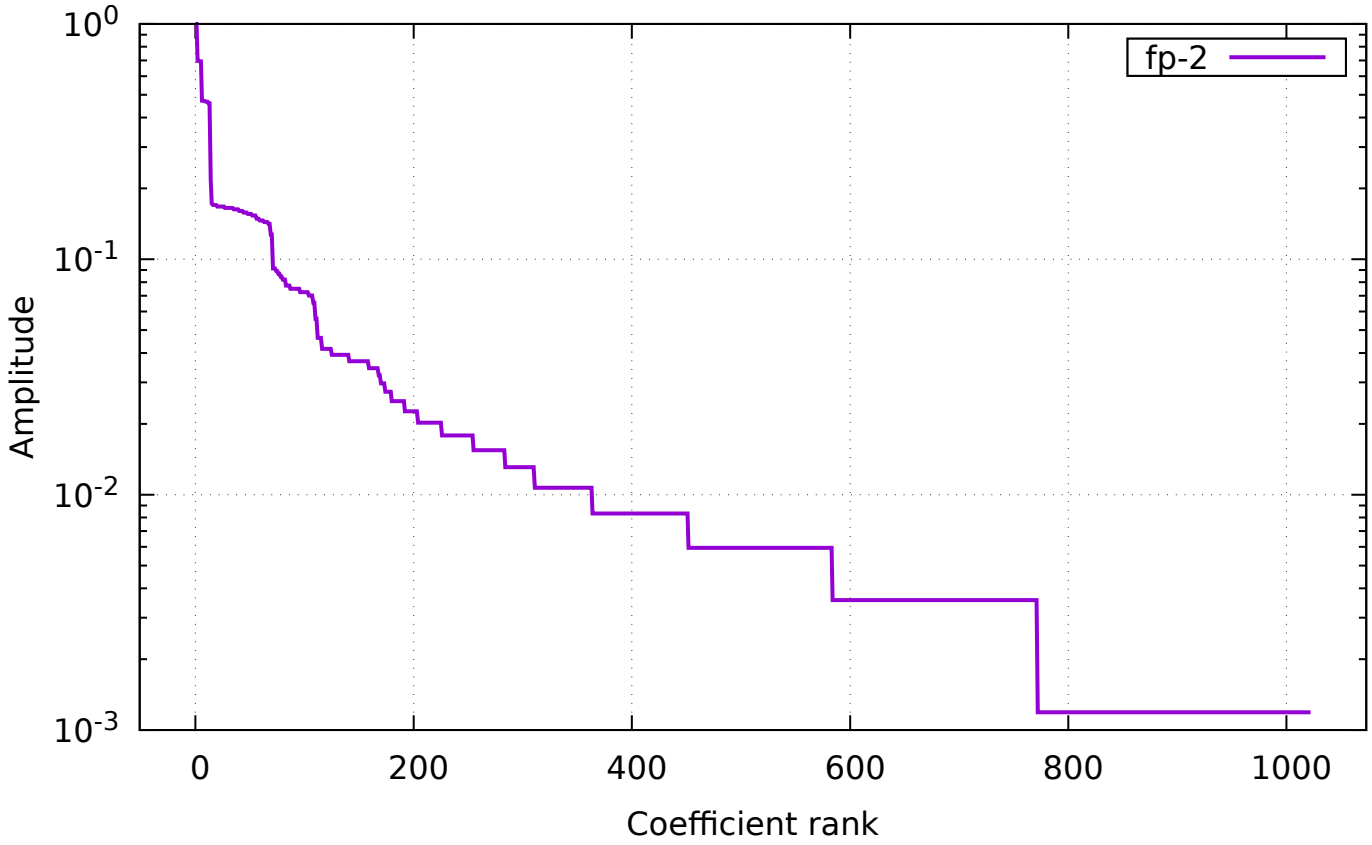

djmp-2
Energy
Feature Hamming weight
$10^1$
$10^0$
$10^{-1}$
$10^{-2}$
1
2
3
4
5
6
7
8
9
10

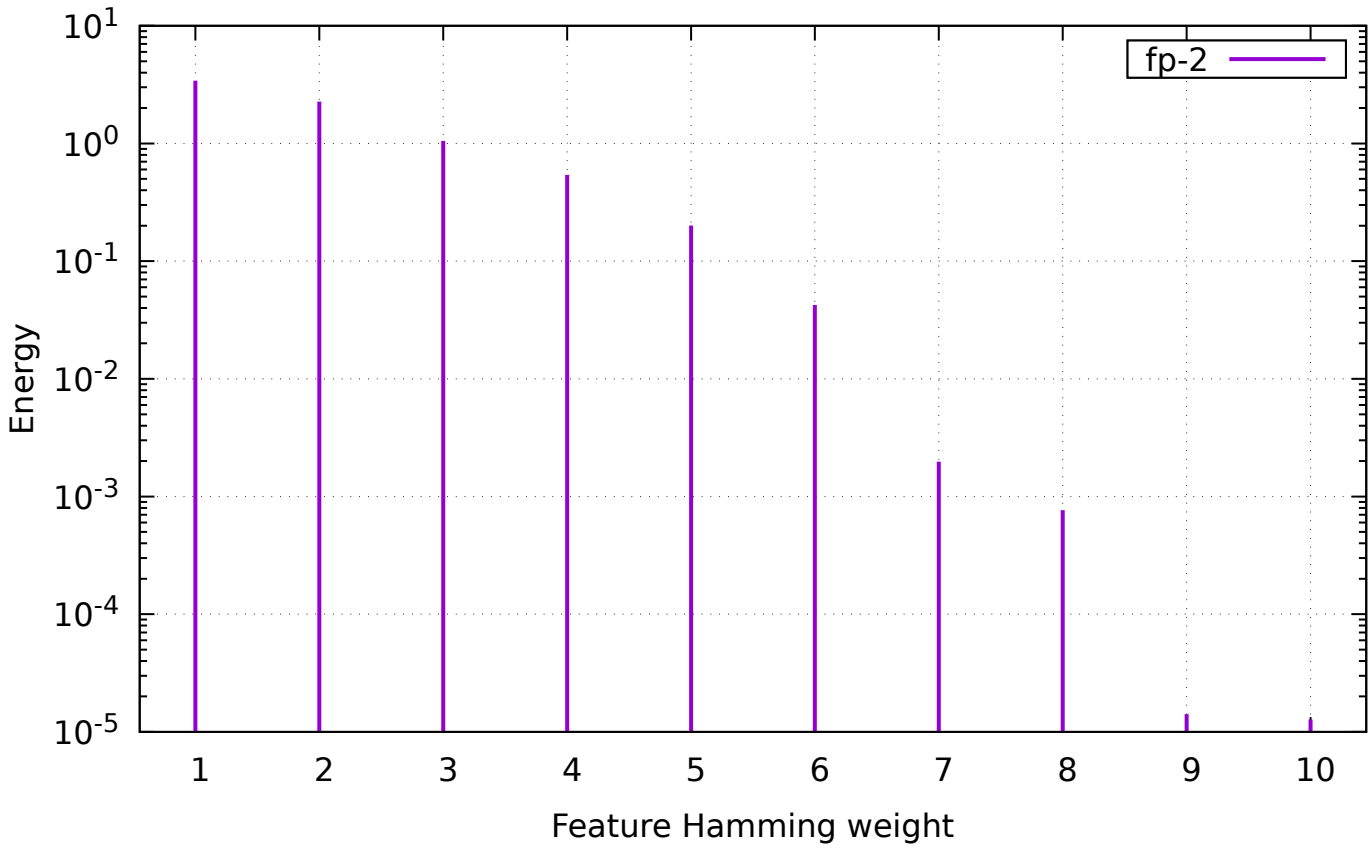
## 9 djmp-4


djmp-4
Amplitude
Coefficient rank
$10^0$
$10^{-1}$
$10^{-2}$
$10^{-3}$
0
200
400
600
800
1000

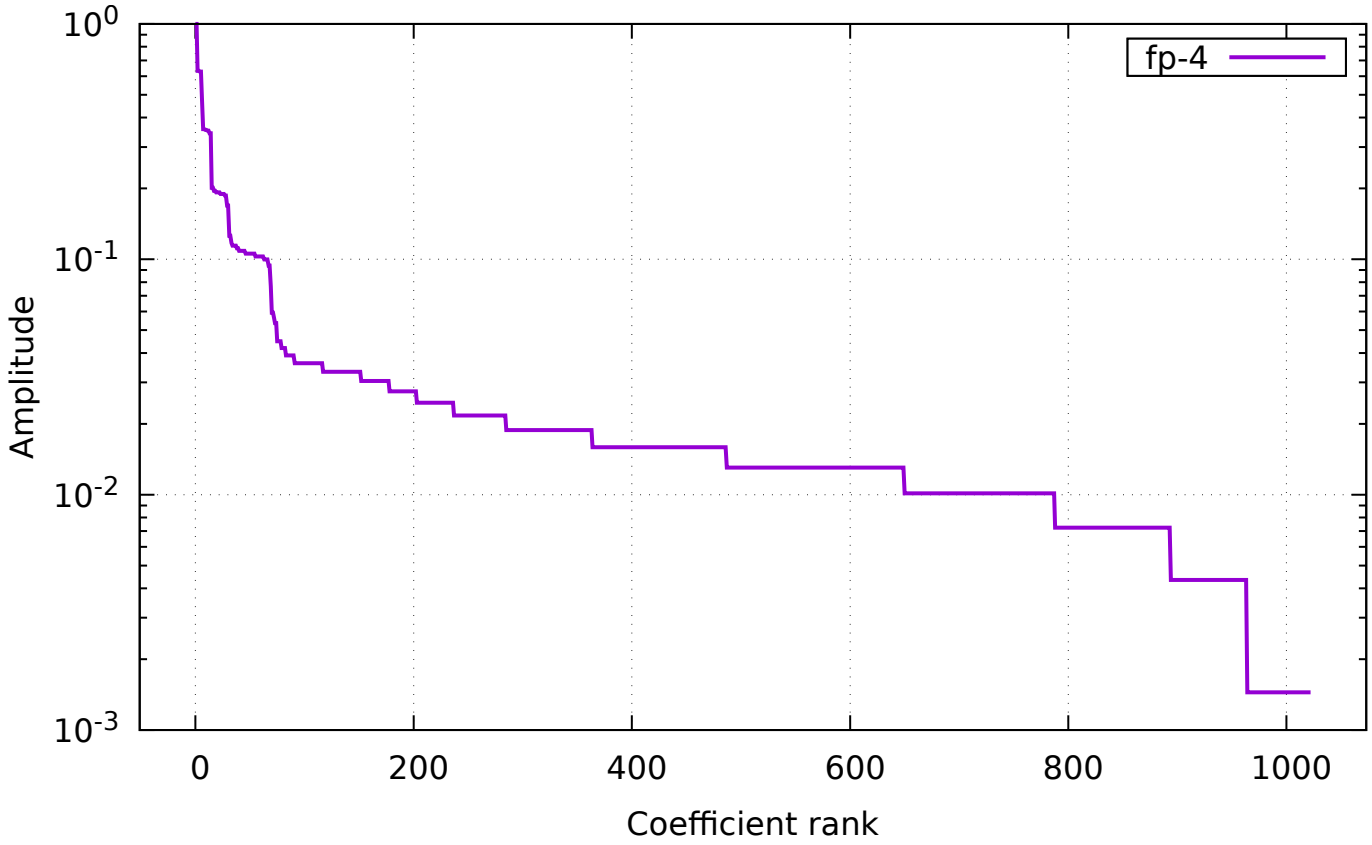

djmp-4
Energy
Feature Hamming weight
$10^1$
$10^0$
$10^{-1}$
$10^{-2}$
$10^{-3}$
1
2
3
4
5
6
7
8
9
10

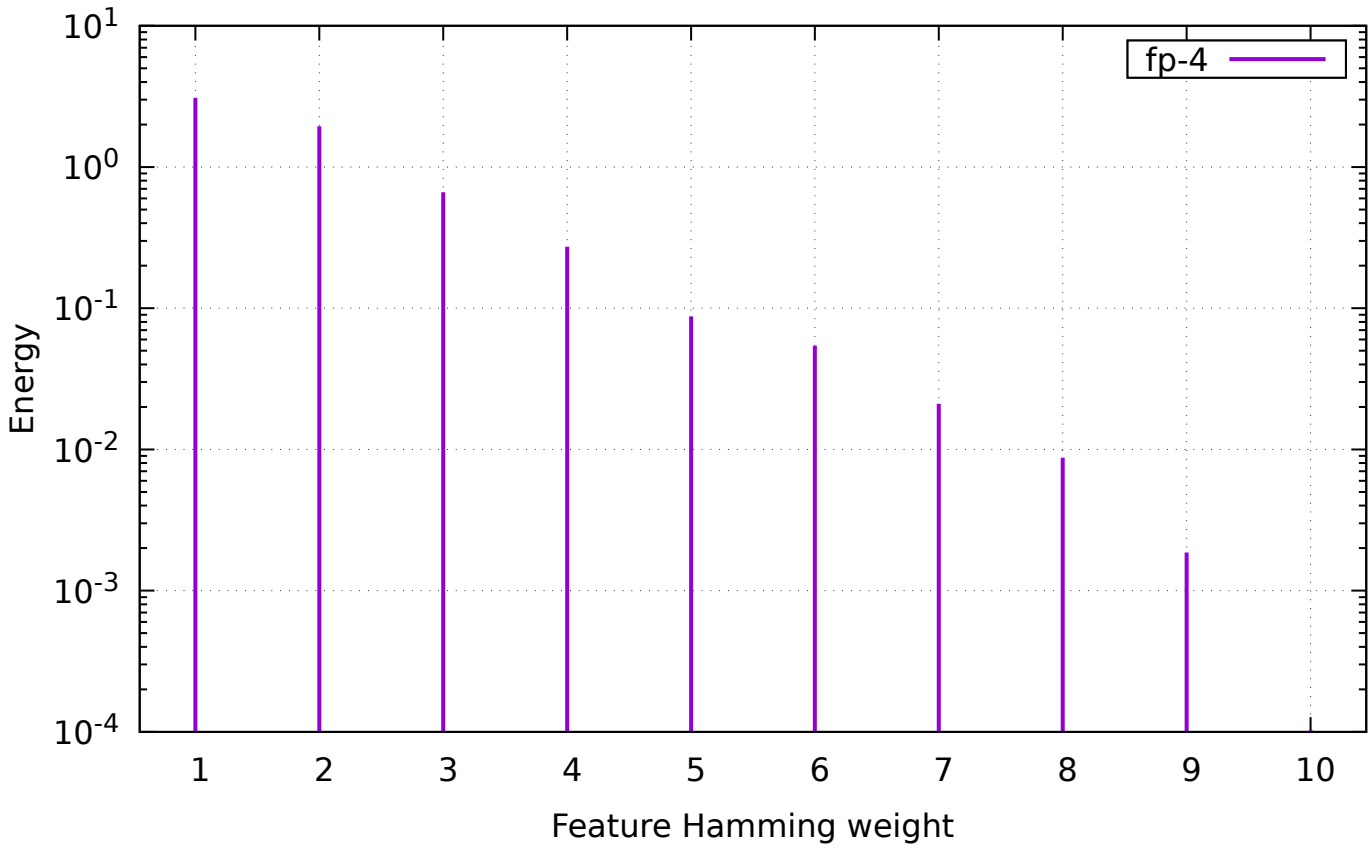
## 10 fp-2

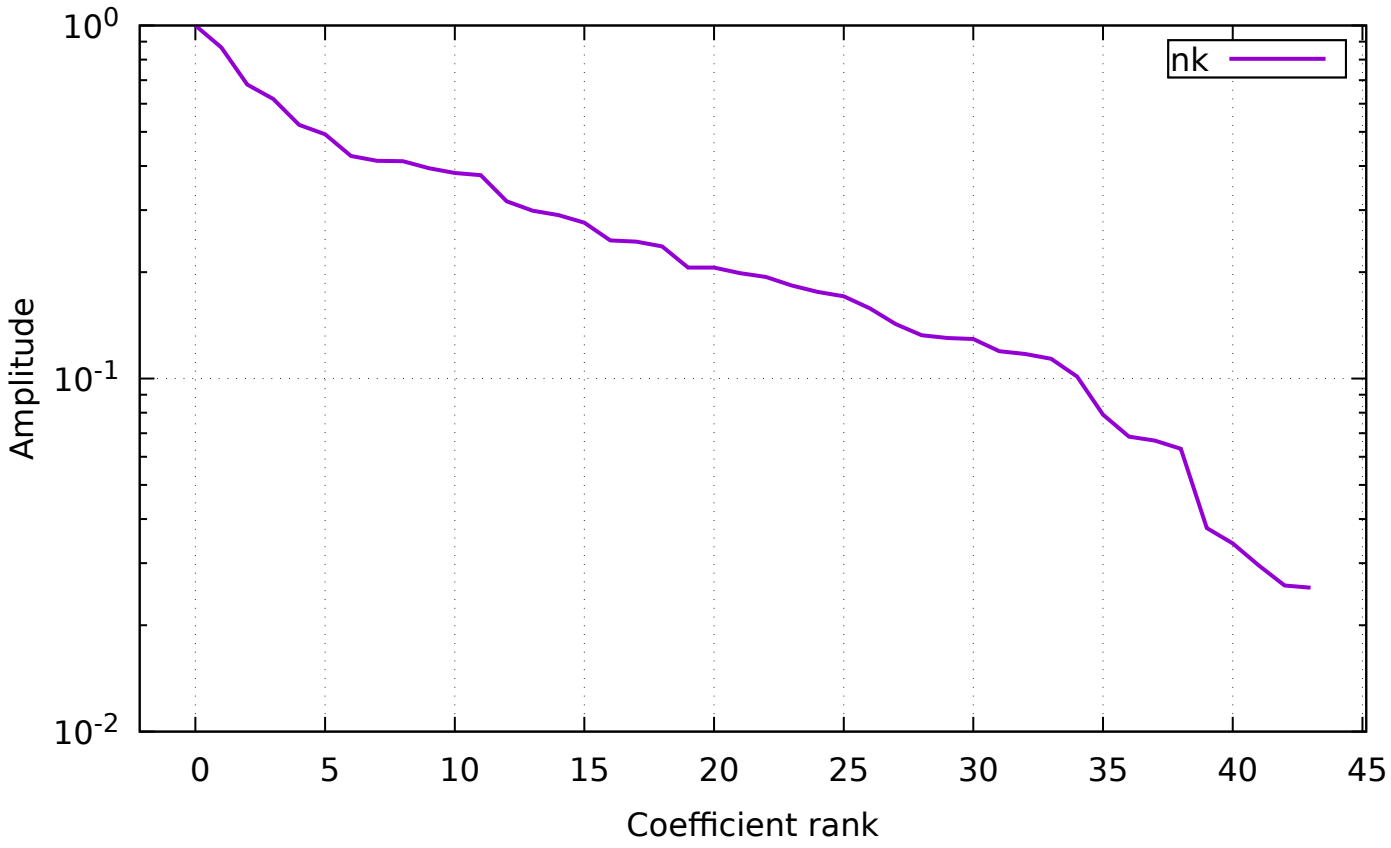

fp-2
Amplitude
Coefficient rank
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
0
200
400
600
800
1000

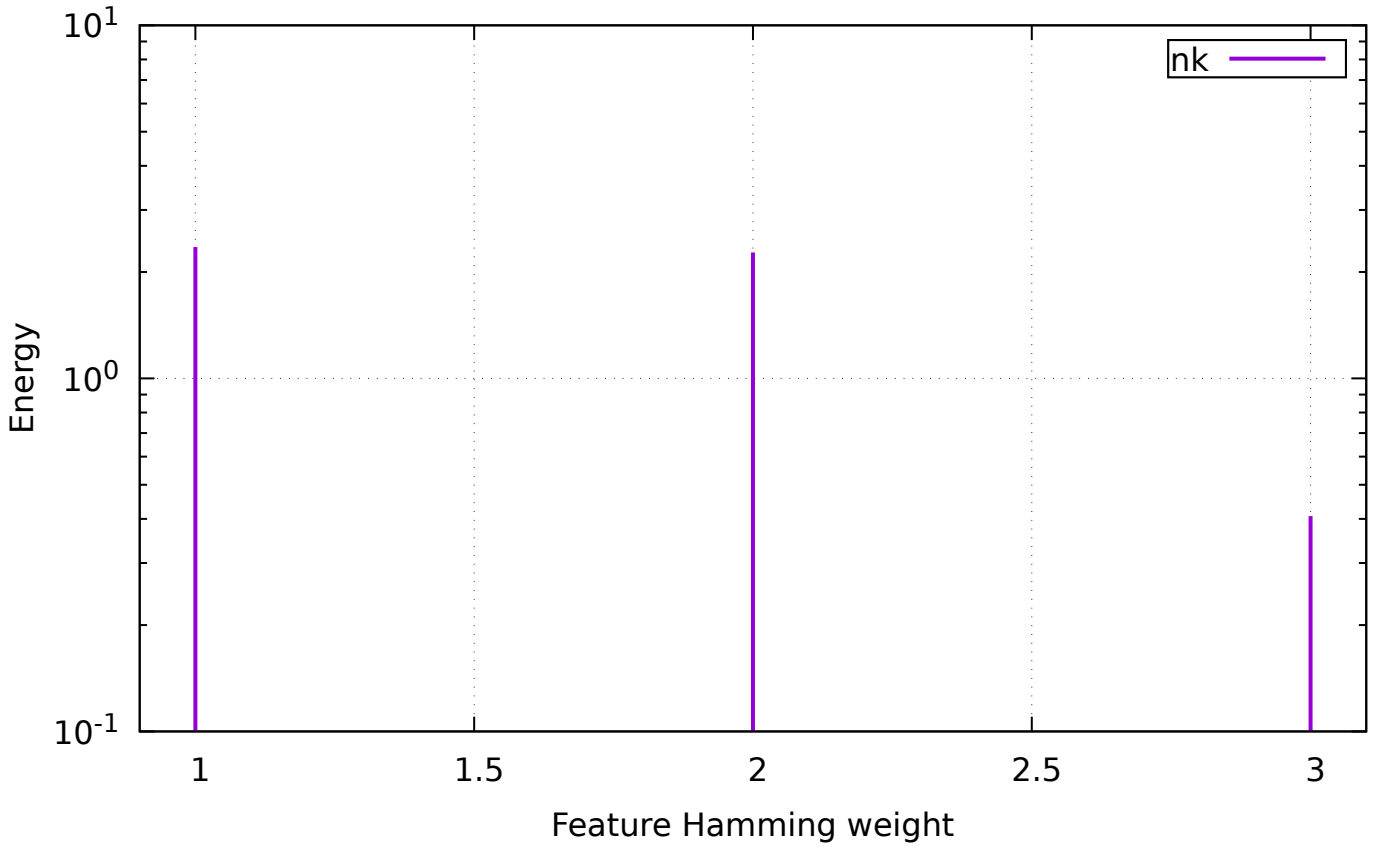

fp-2
Energy
Feature Hamming weight
$10^{1}$
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
$10^{-5}$
1
2
3
4
5
6
7
8
9
10

## 11 fp-4

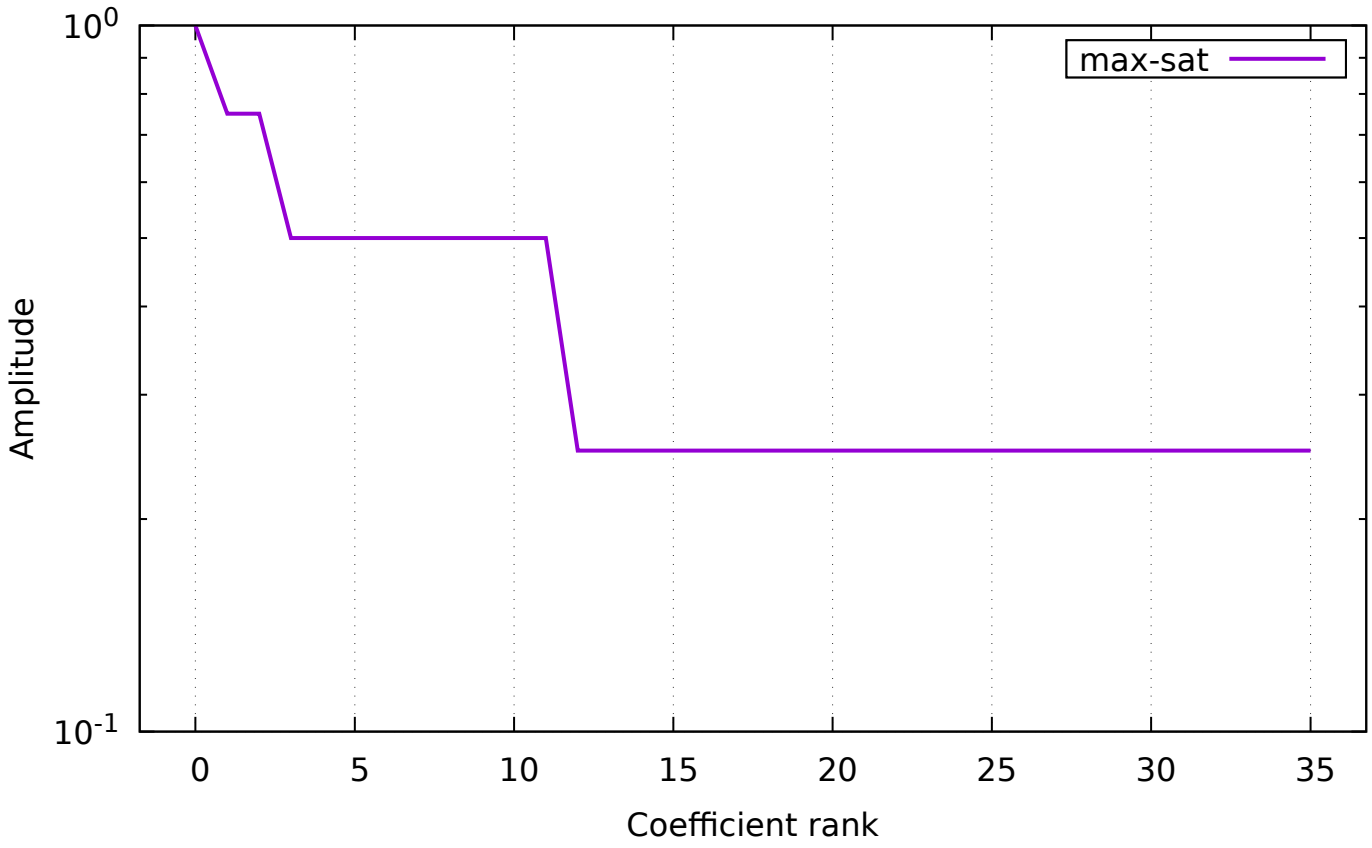

fp-4
Amplitude
Coefficient rank
$10^0$
$10^{-1}$
$10^{-2}$
$10^{-3}$
0
200
400
600
800
1000

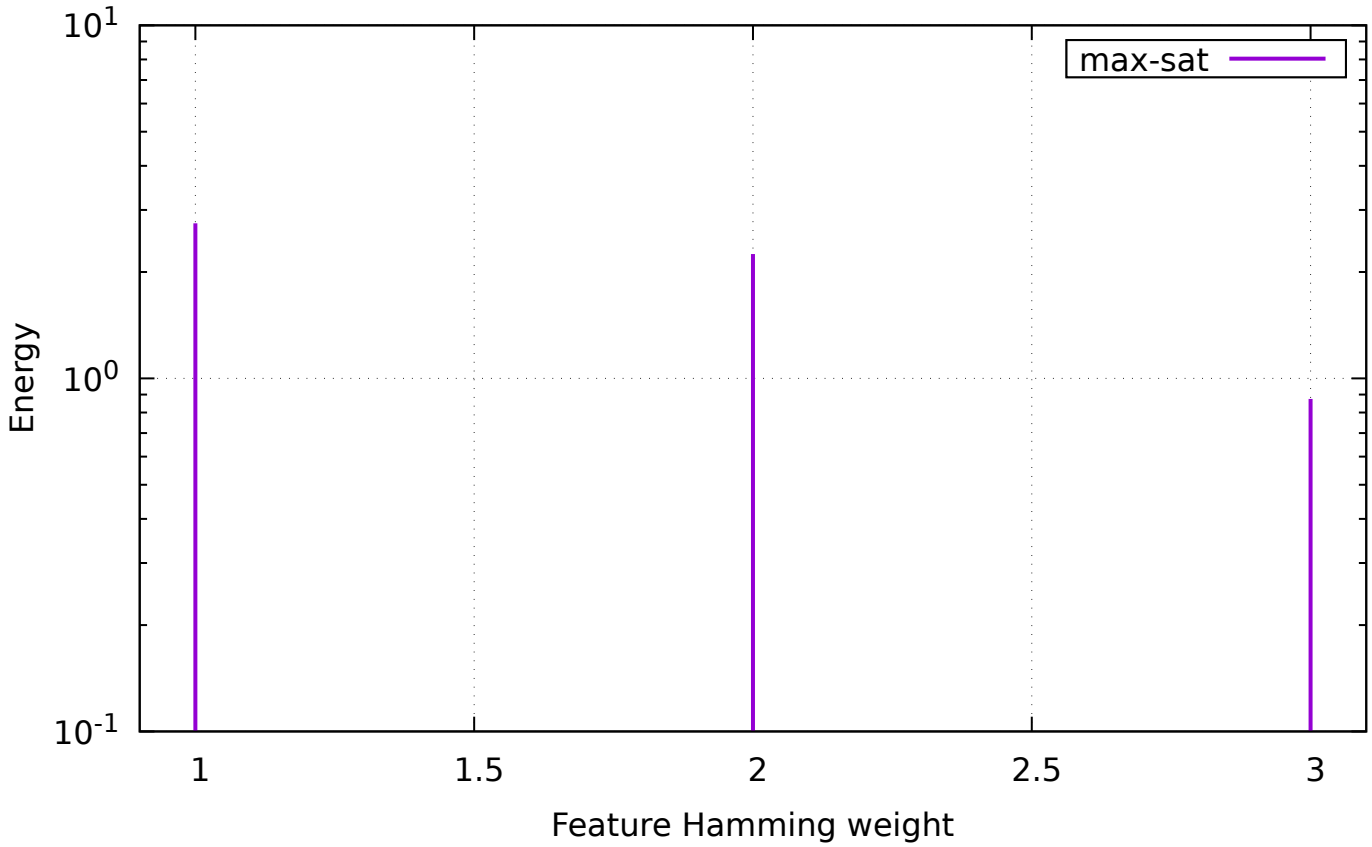

fp-4
Energy
Feature Hamming weight
$10^1$
$10^0$
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
1
2
3
4
5
6
7
8
9
10


nk
Amplitude
Coefficient rank
$10^0$
$10^{-1}$
$10^{-2}$
0
5
10
15
20
25
30
35
40
45

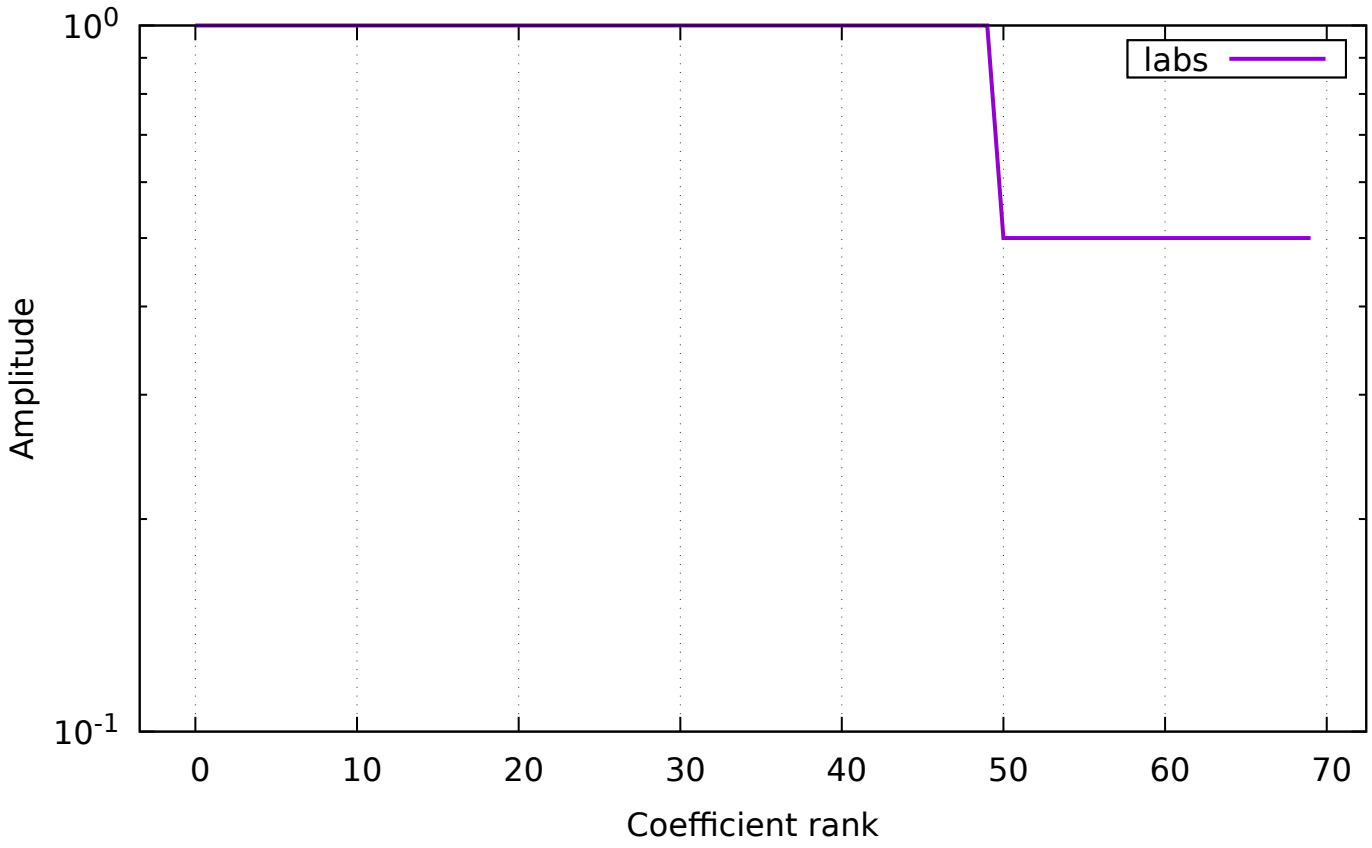

nk
Energy
Feature Hamming weight
$10^1$
$10^0$
$10^{-1}$
1
1.5
2
2.5
3

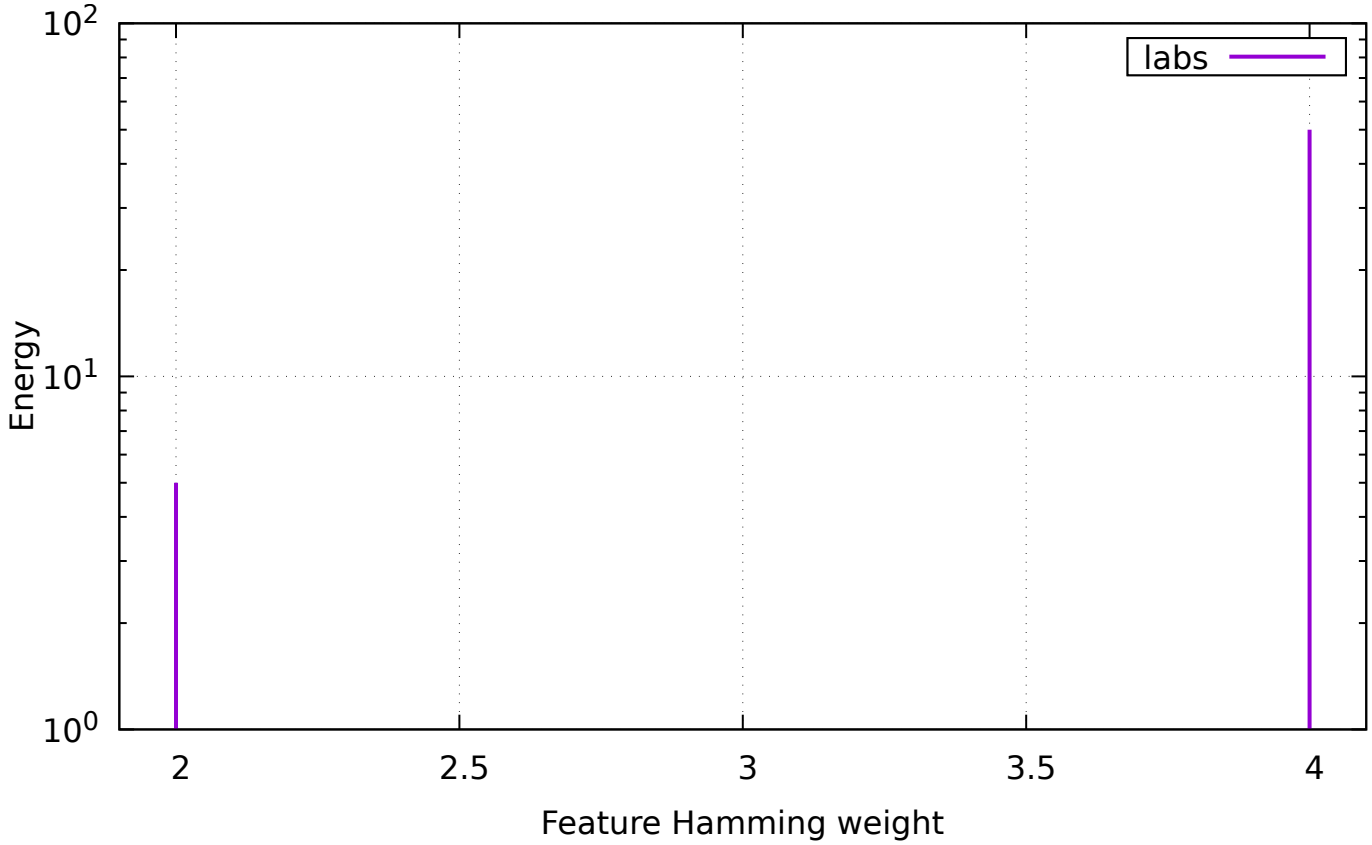
## 13 max-sat


max-sat
Amplitude
Coefficient rank
$10^0$
$10^{-1}$
0
5
10
15
20
25
30
35

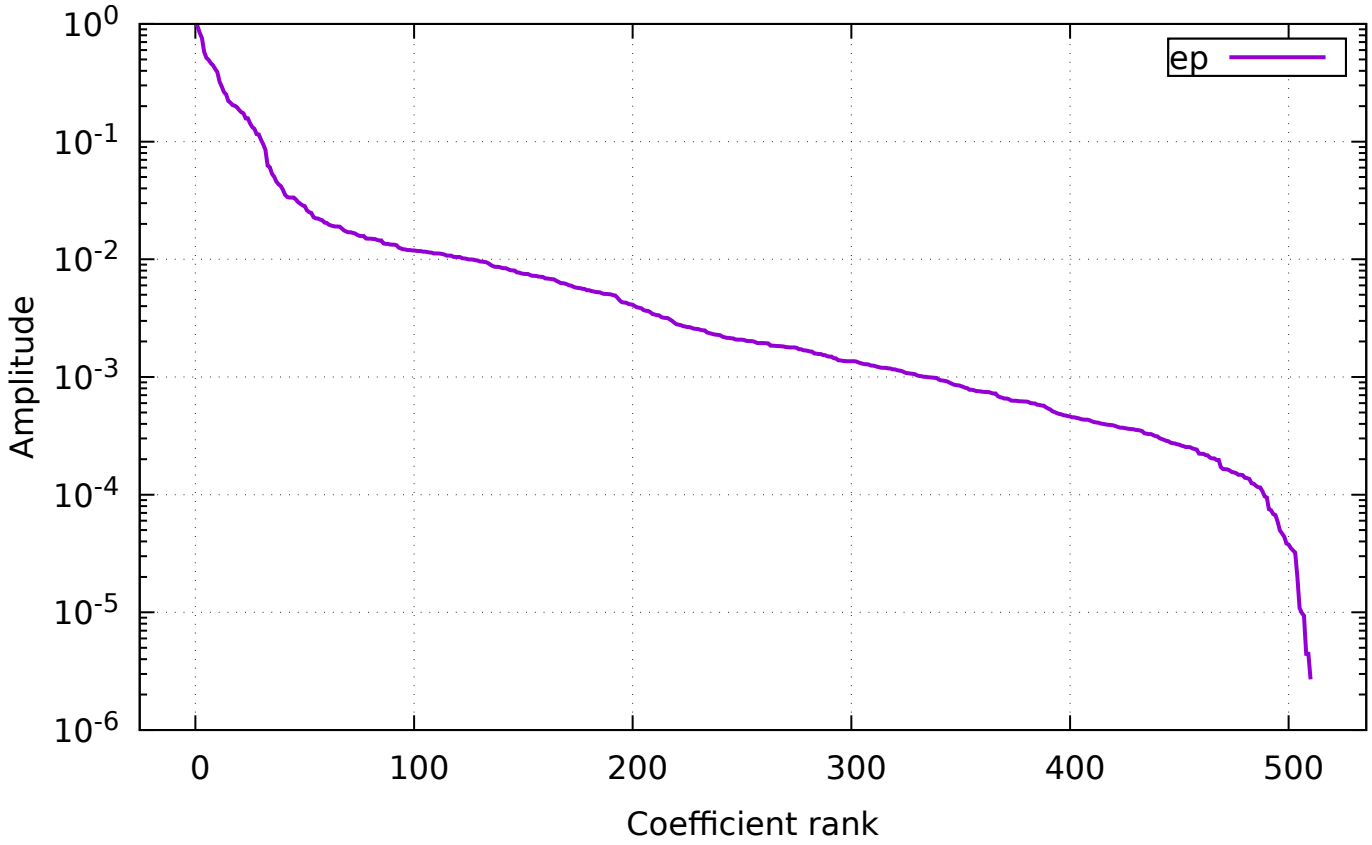

max-sat
Energy
Feature Hamming weight
$10^1$
$10^0$
$10^{-1}$
1
1.5
2
2.5
3

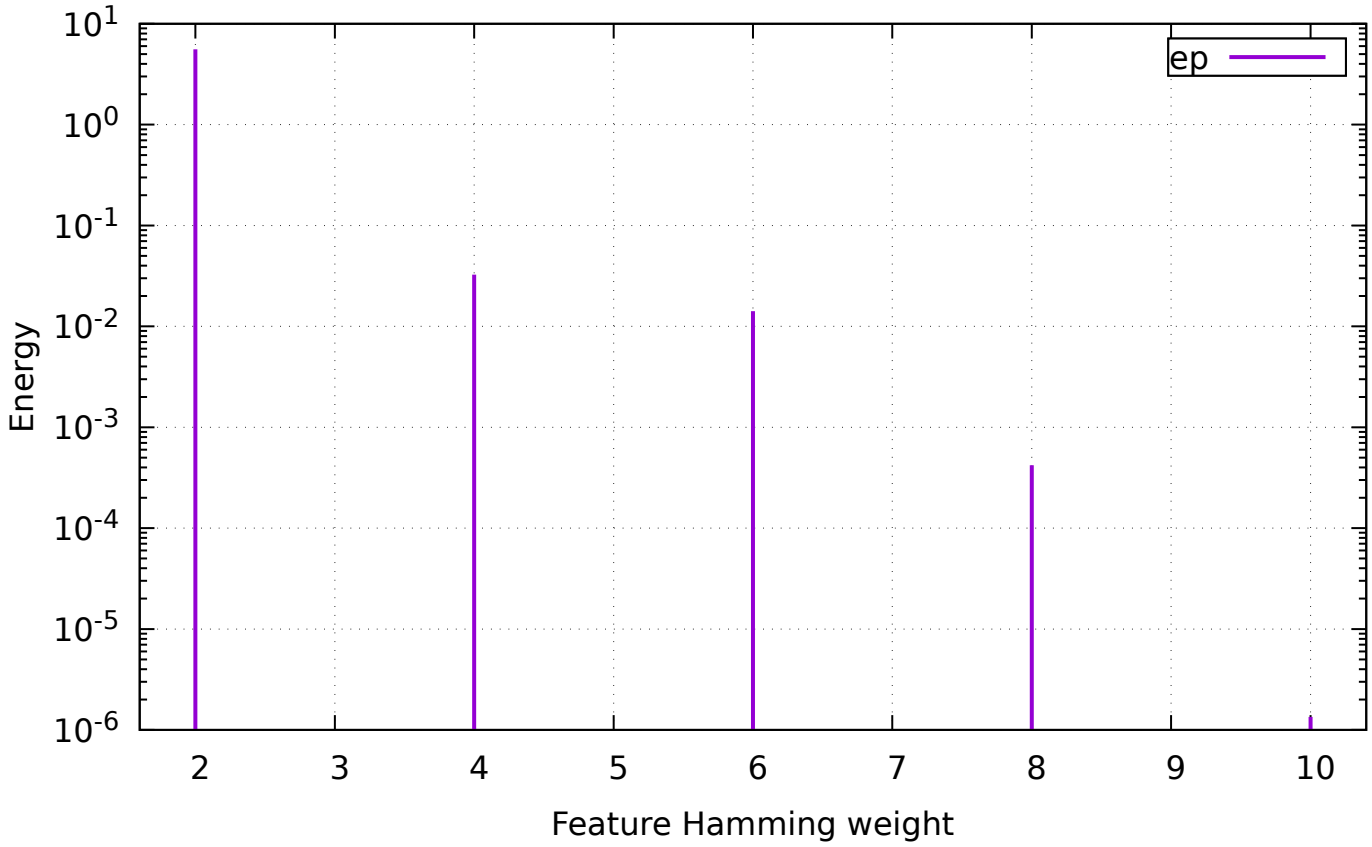
## 14 labs

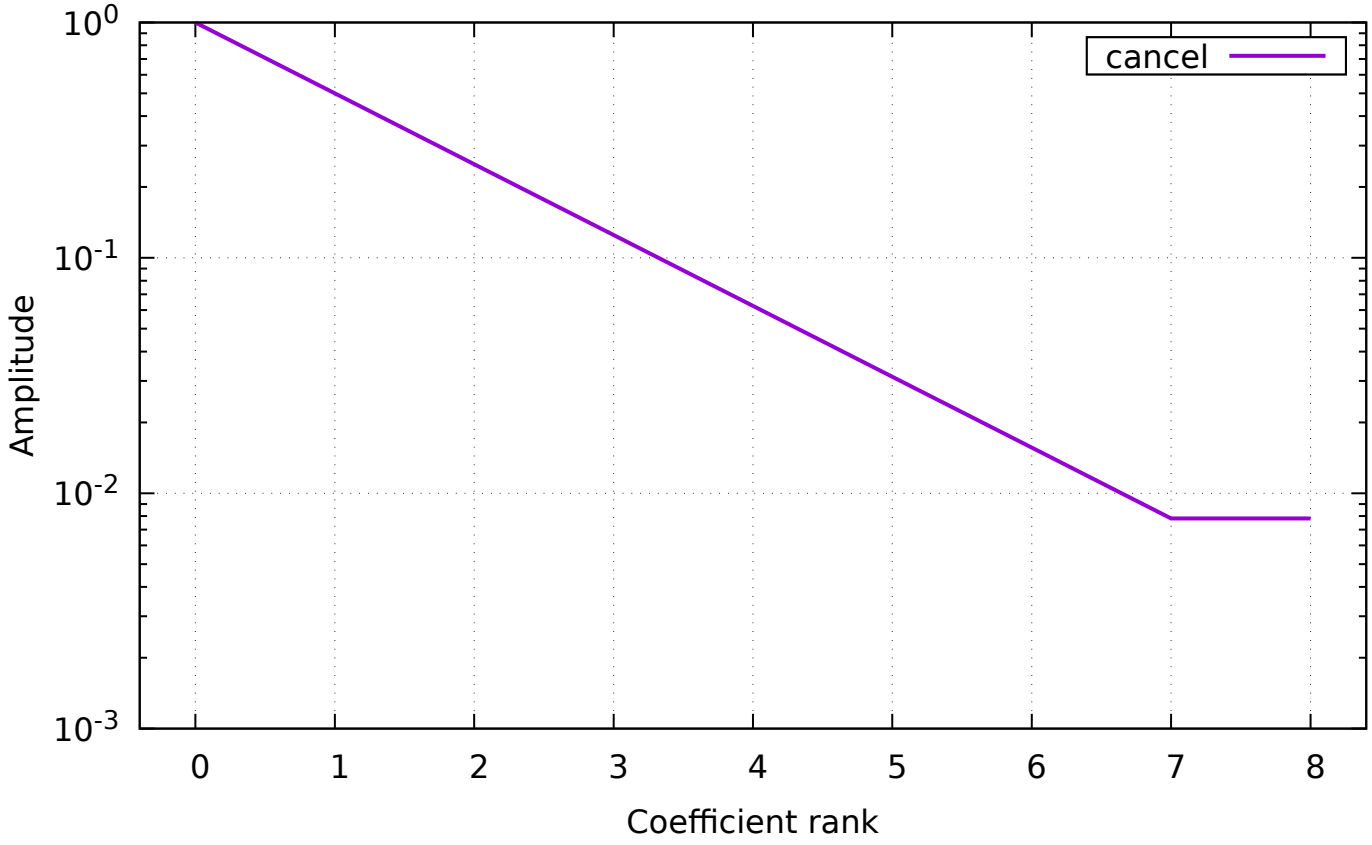

labs
Amplitude
Coefficient rank
$10^0$
$10^{-1}$
0
10
20
30
40
50
60
70

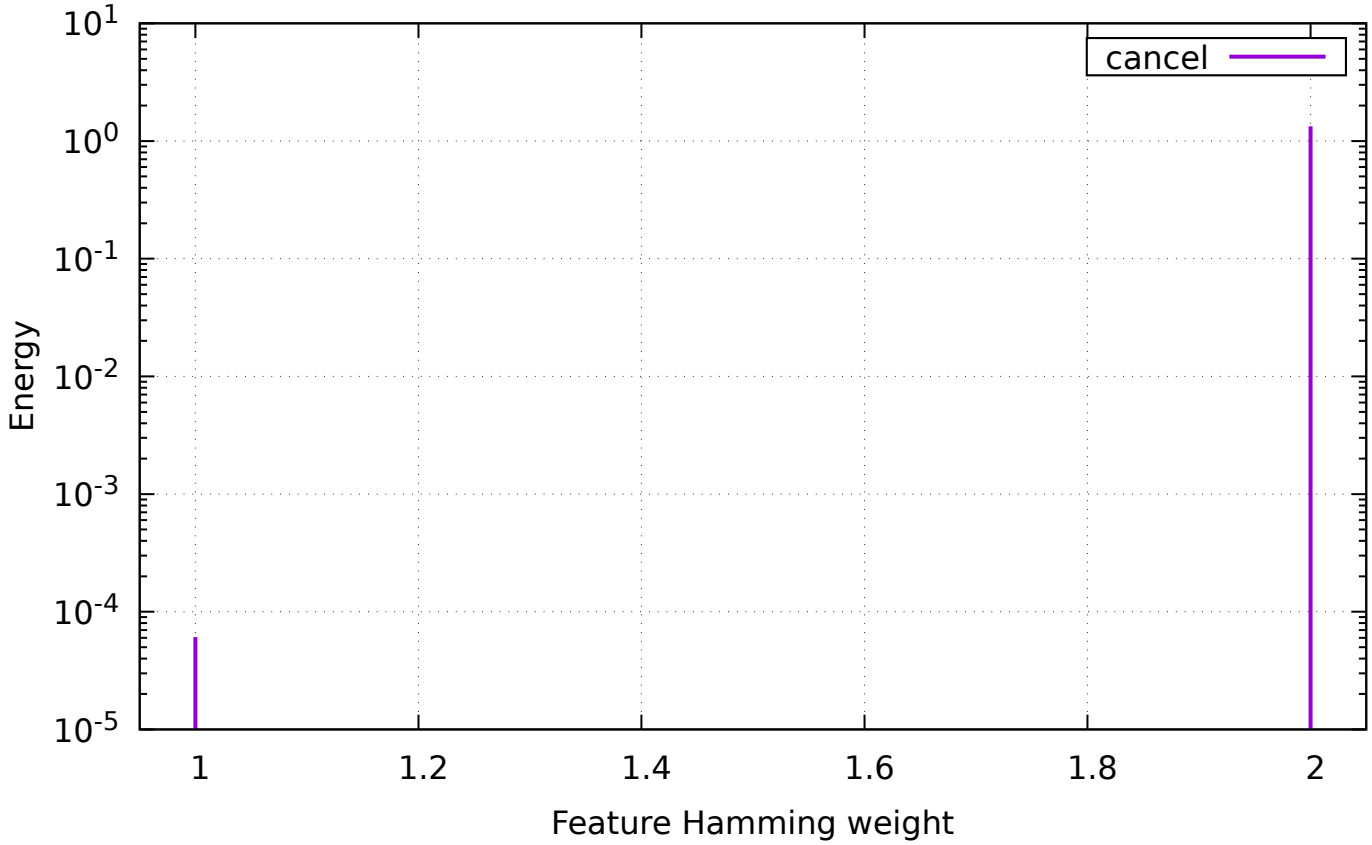

labs
Energy
Feature Hamming weight
$10^2$
$10^1$
$10^0$
2
2.5
3
3.5
4

## 15 ep

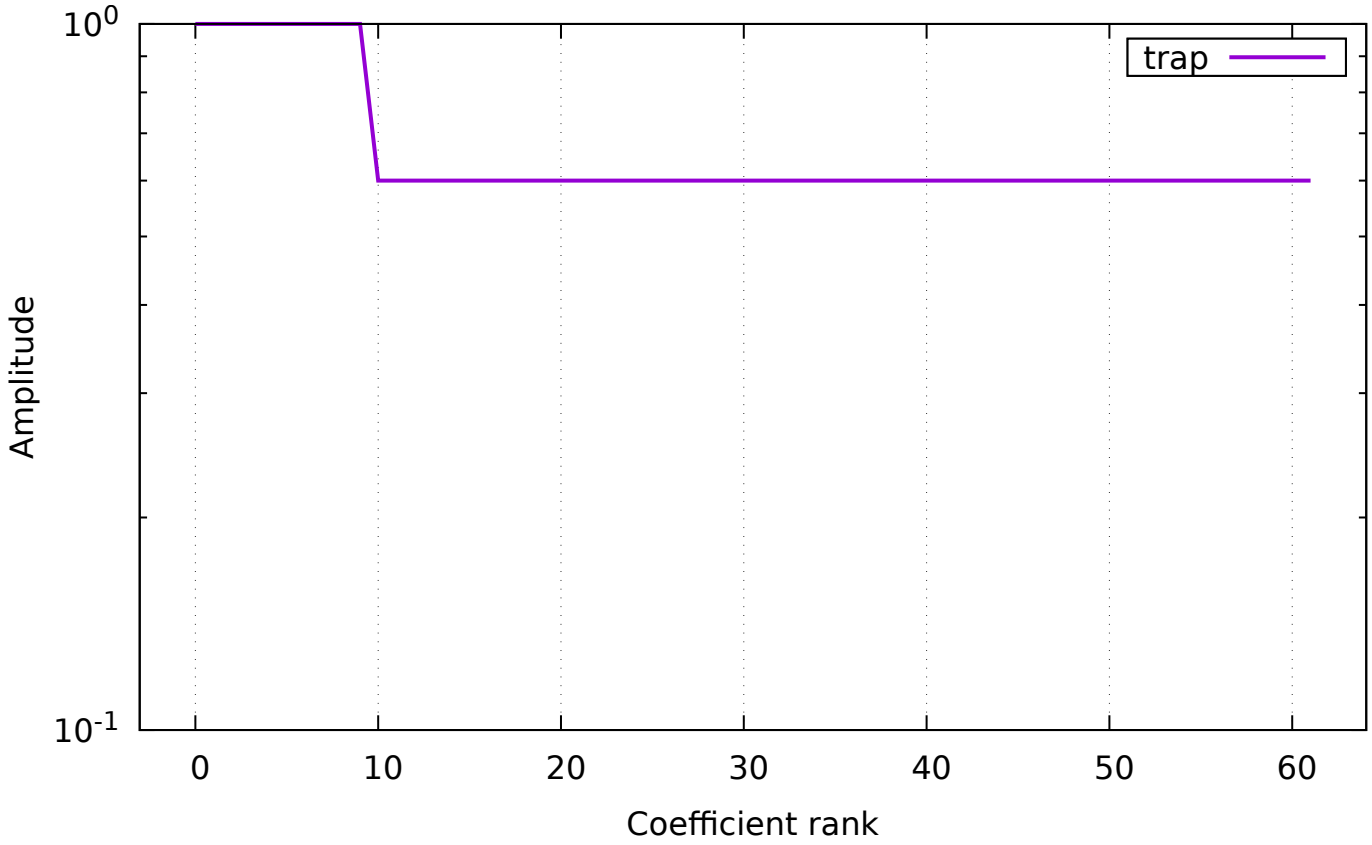

ep
Amplitude
Coefficient rank
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
$10^{-5}$
$10^{-6}$
0
100
200
300
400
500

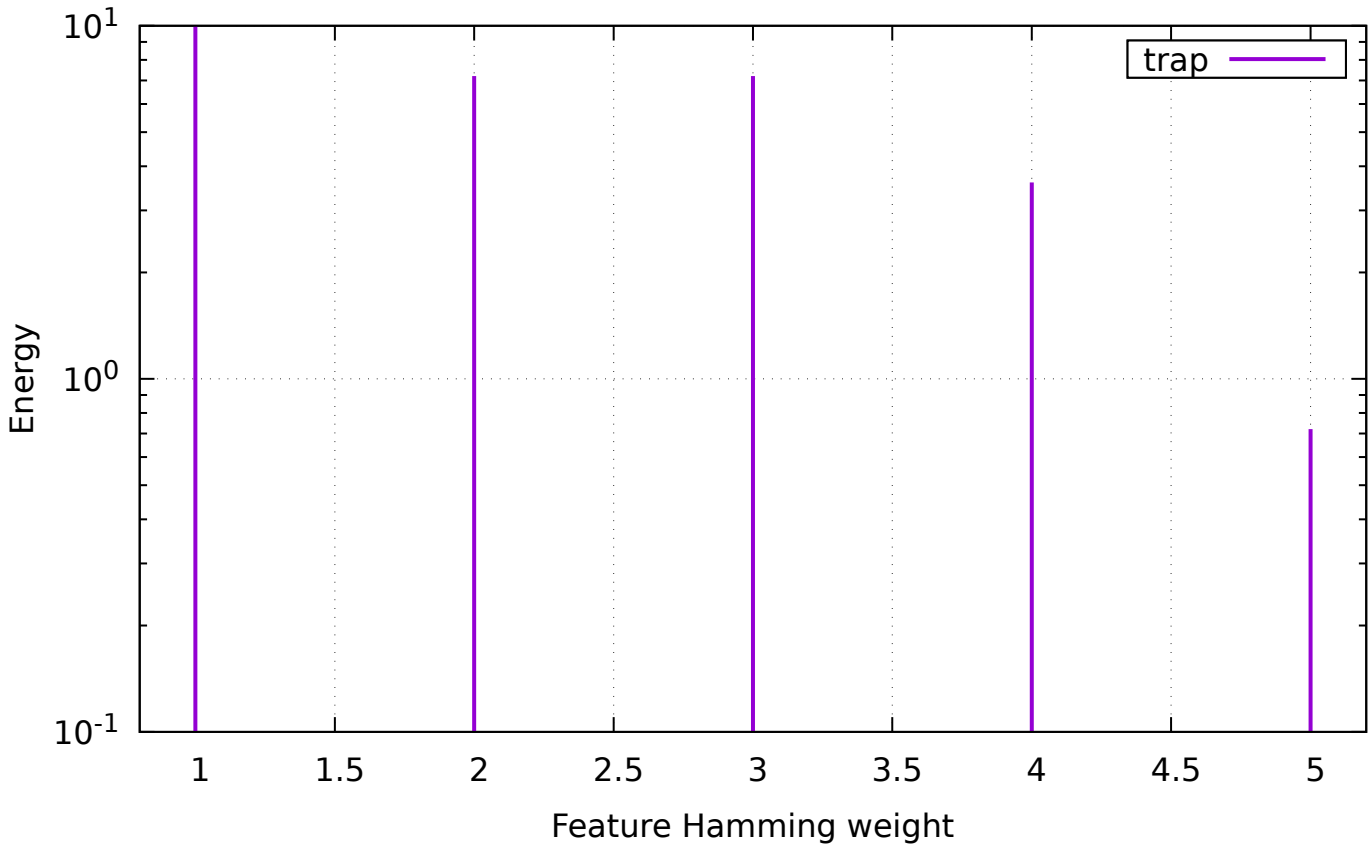

ep
Energy
Feature Hamming weight
$10^{1}$
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
$10^{-5}$
$10^{-6}$
2
3
4
5
6
7
8
9
10

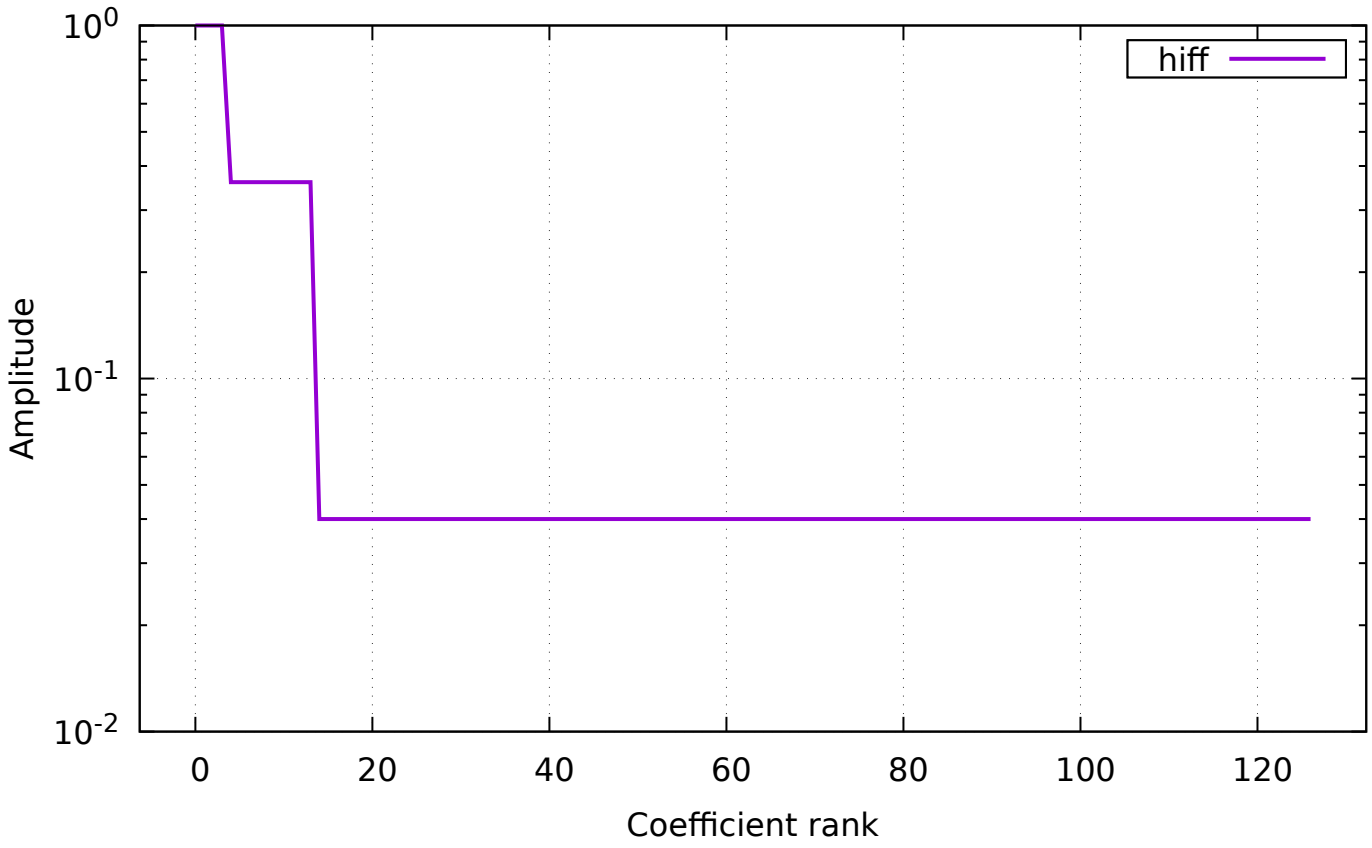

cancel
Amplitude
Coefficient rank
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
0
1
2
3
4
5
6
7
8

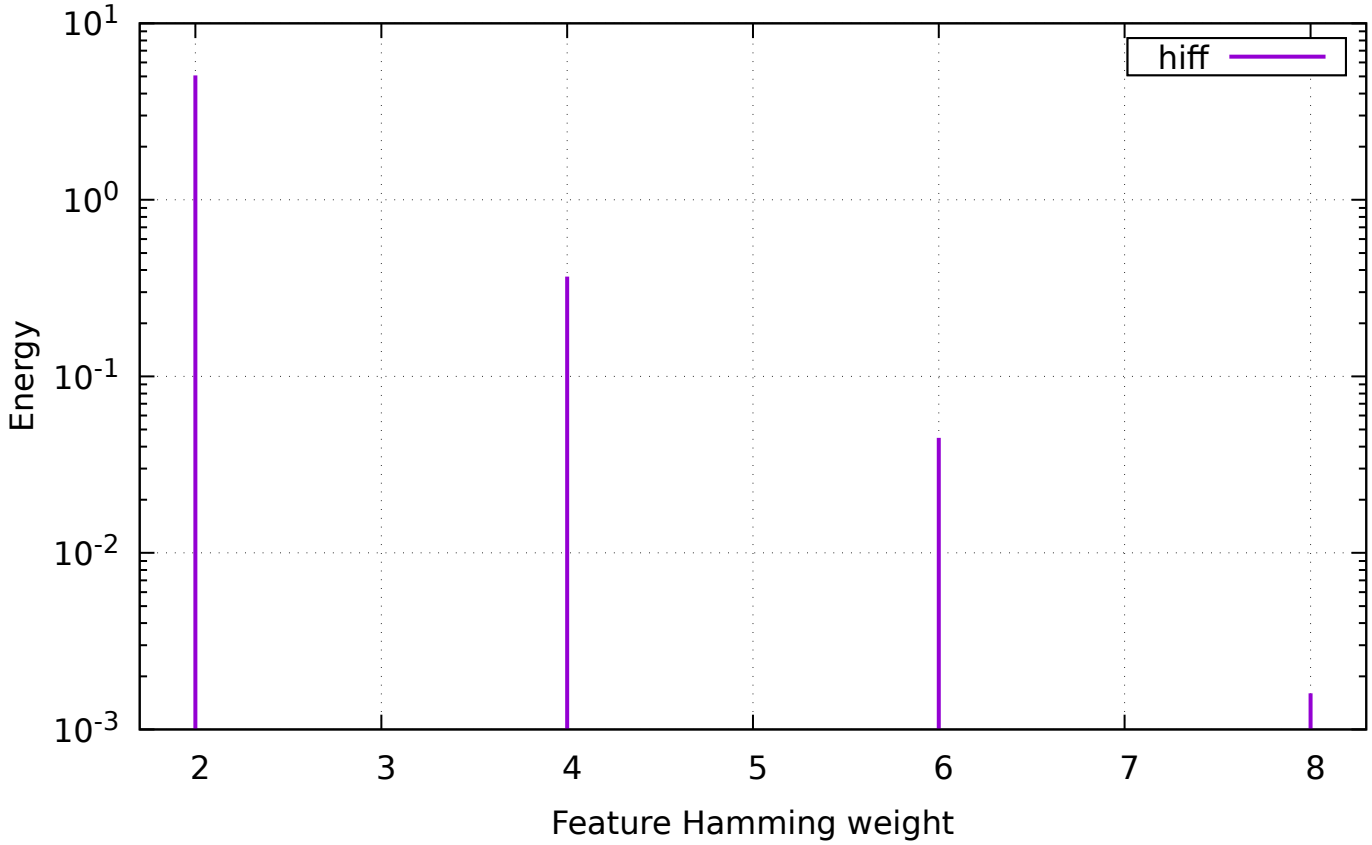

cancel
Energy
Feature Hamming weight
$10^{1}$
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
$10^{-5}$
1
1.2
1.4
1.6
1.8
2

## 17 trap

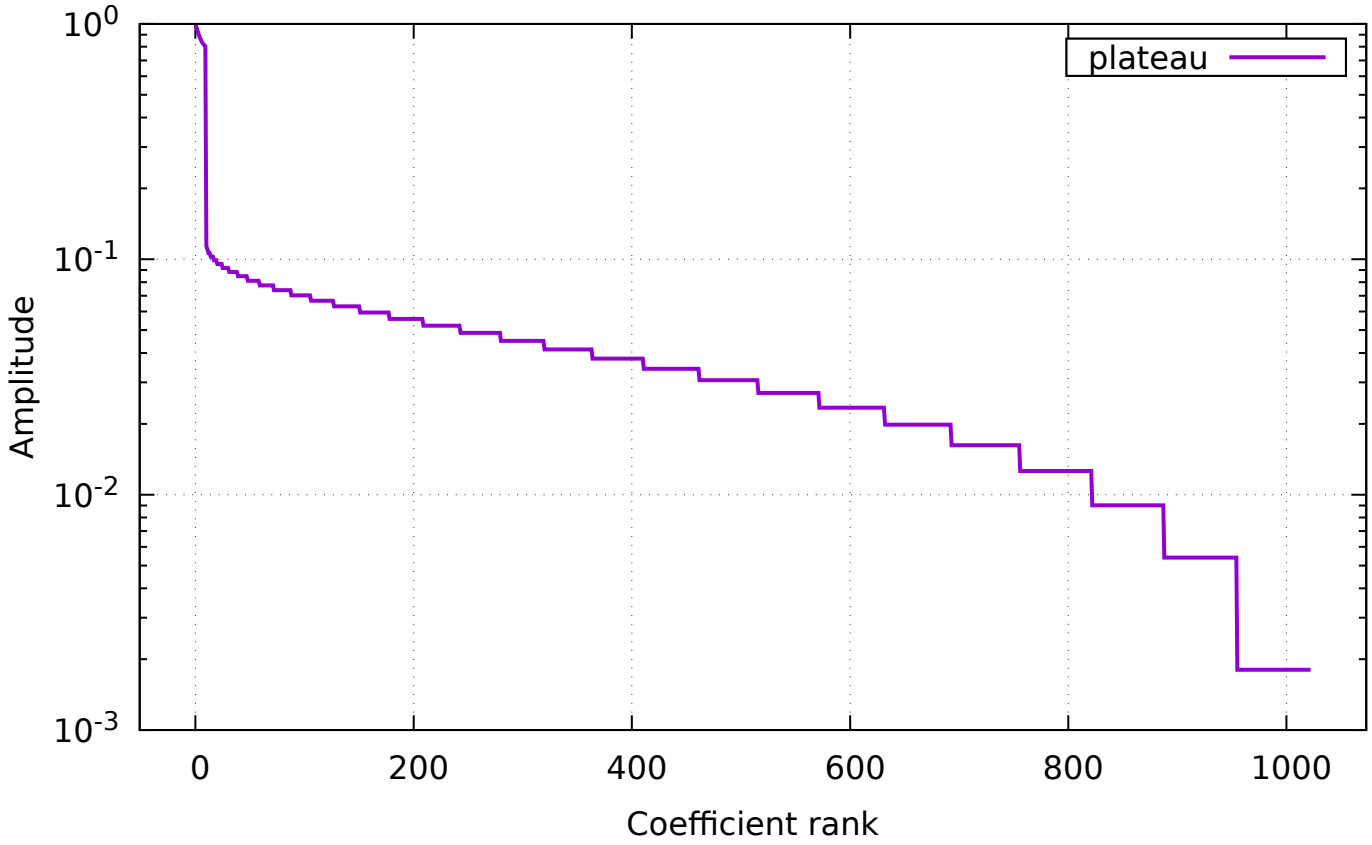

trap
Amplitude
Coefficient rank
$10^0$
$10^{-1}$
0
10
20
30
40
50
60

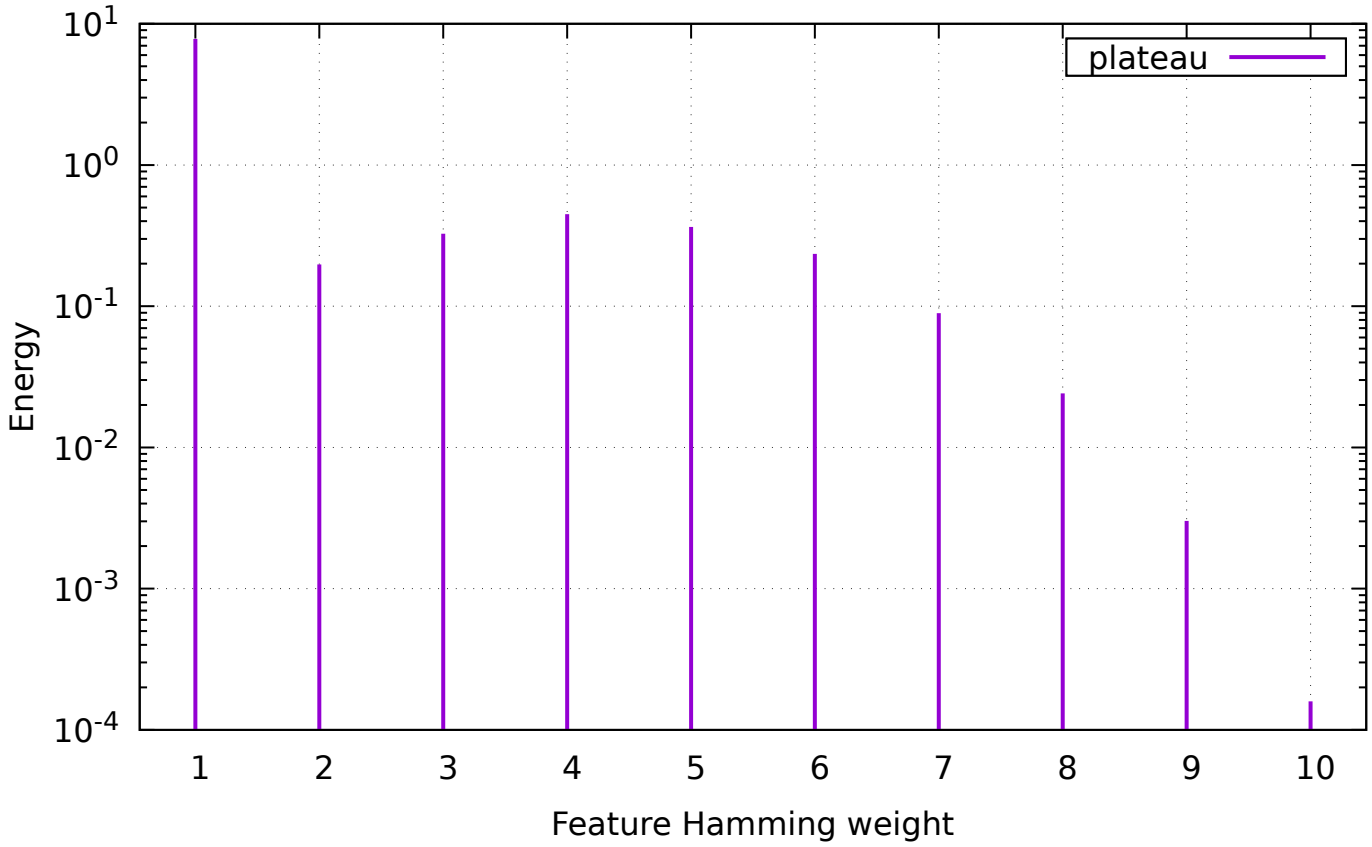

trap
Energy
Feature Hamming weight
$10^1$
$10^0$
$10^{-1}$
1
1.5
2
2.5
3
3.5
4
4.5
5

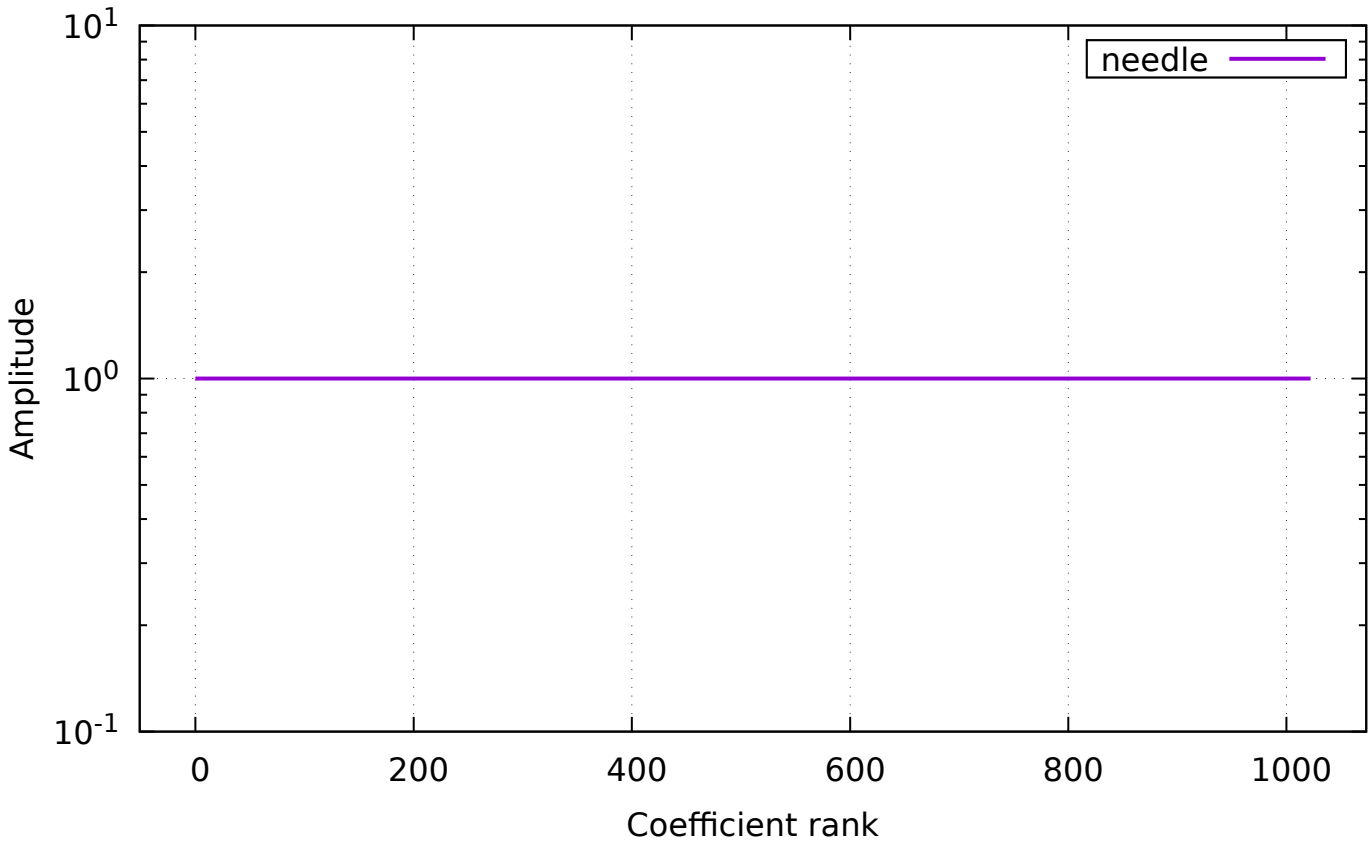

hiff
Amplitude
Coefficient rank
$10^0$
$10^{-1}$
$10^{-2}$
0
20
40
60
80
100
120

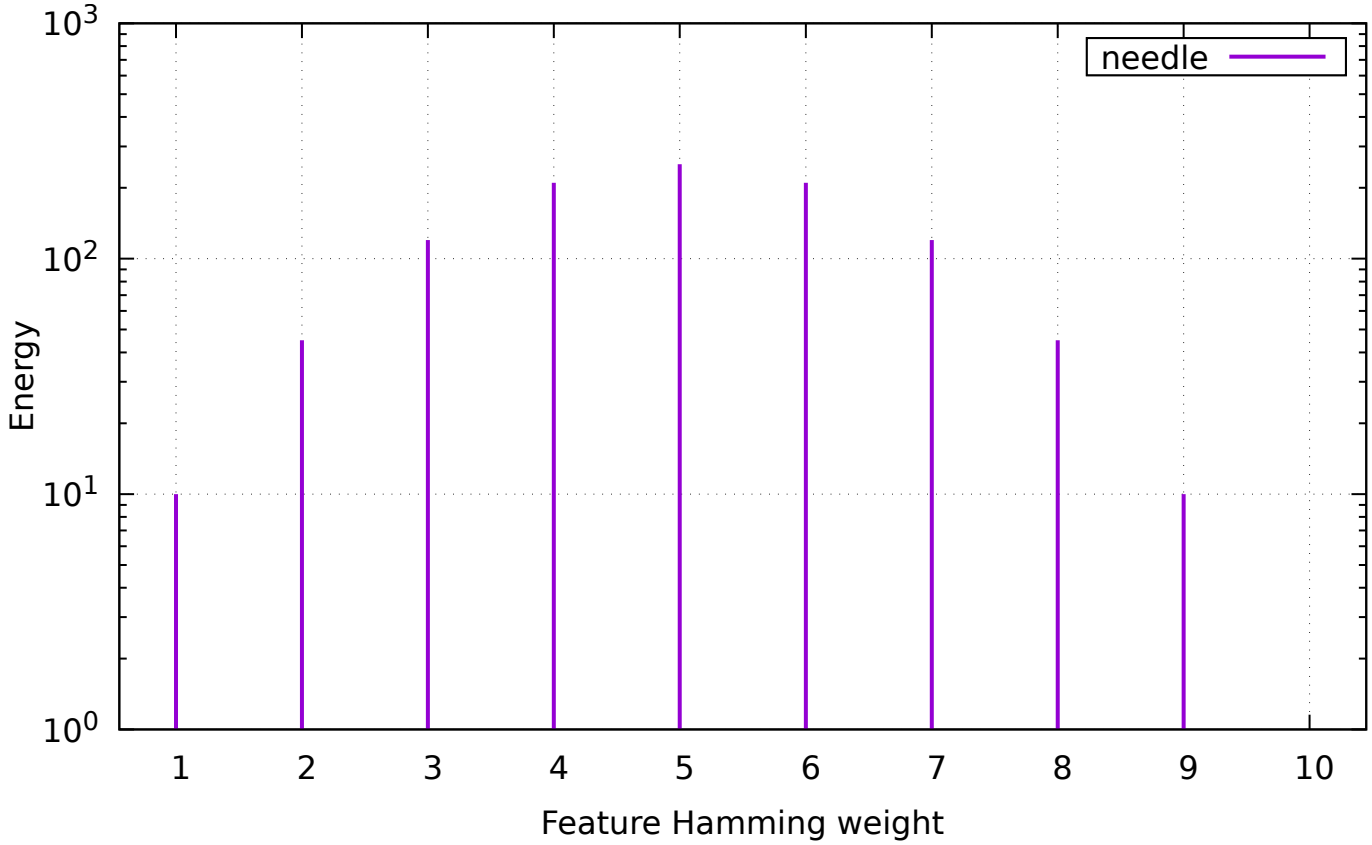

hiff
Energy
Feature Hamming weight
$10^1$
$10^0$
$10^{-1}$
$10^{-2}$
$10^{-3}$
2
3
4
5
6
7
8

## 19 plateau

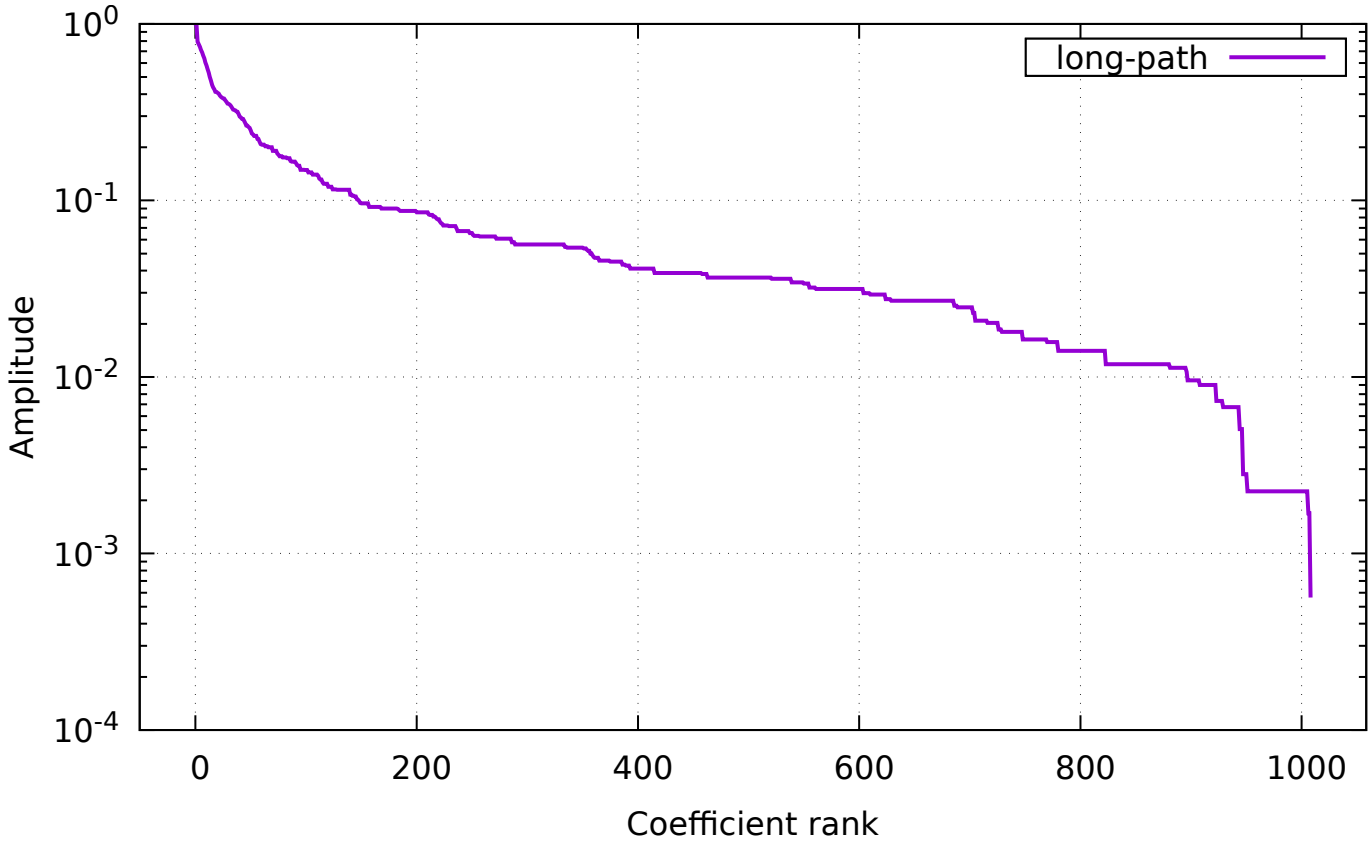

plateau
Amplitude
Coefficient rank
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
0
200
400
600
800
1000

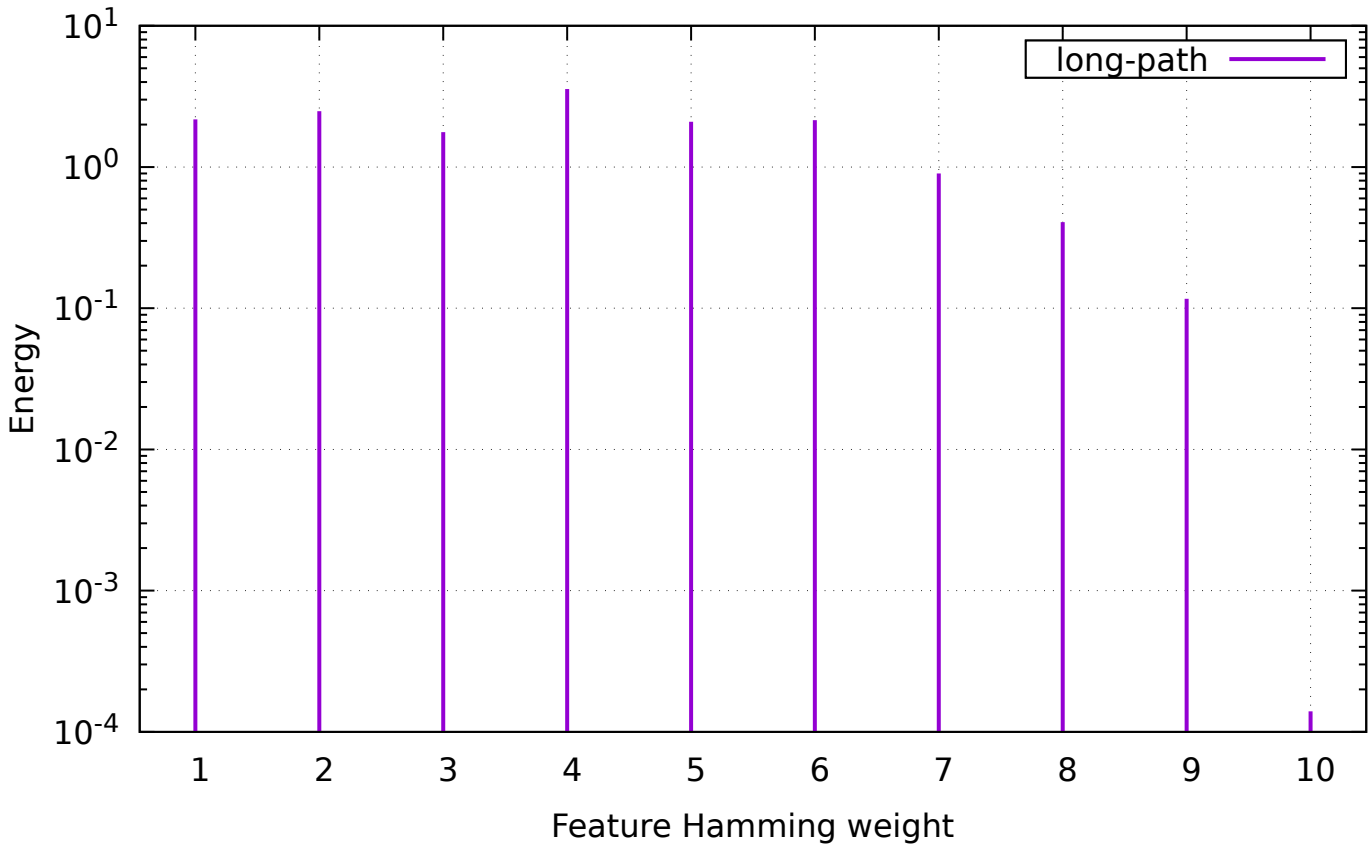

plateau
Energy
Feature Hamming weight
$10^{1}$
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
1
2
3
4
5
6
7
8
9
10


needle
Amplitude
Coefficient rank
$10^1$
$10^0$
$10^{-1}$
0
200
400
600
800
1000

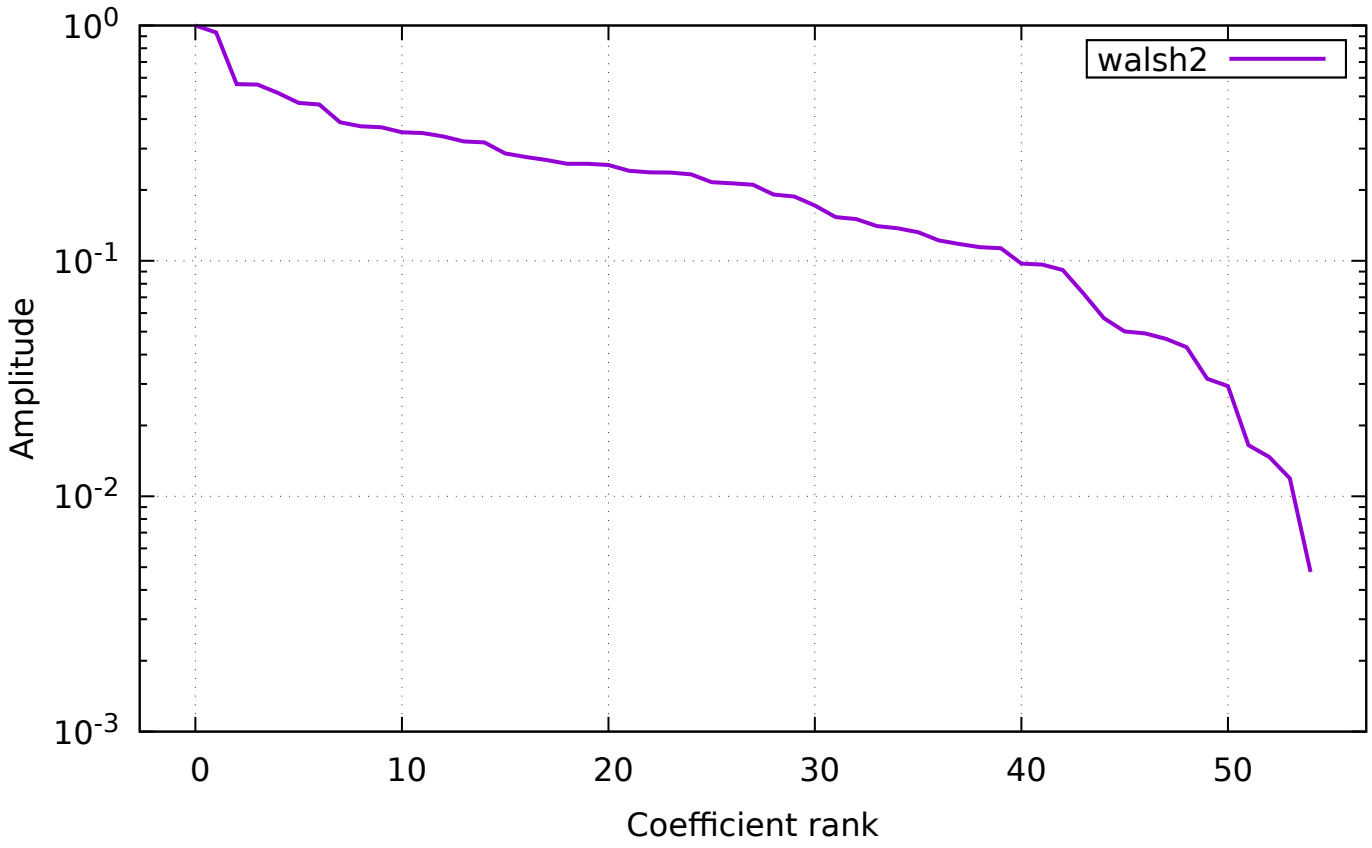

needle
Energy
Feature Hamming weight
$10^3$
$10^2$
$10^1$
$10^0$
1
2
3
4
5
6
7
8
9
10

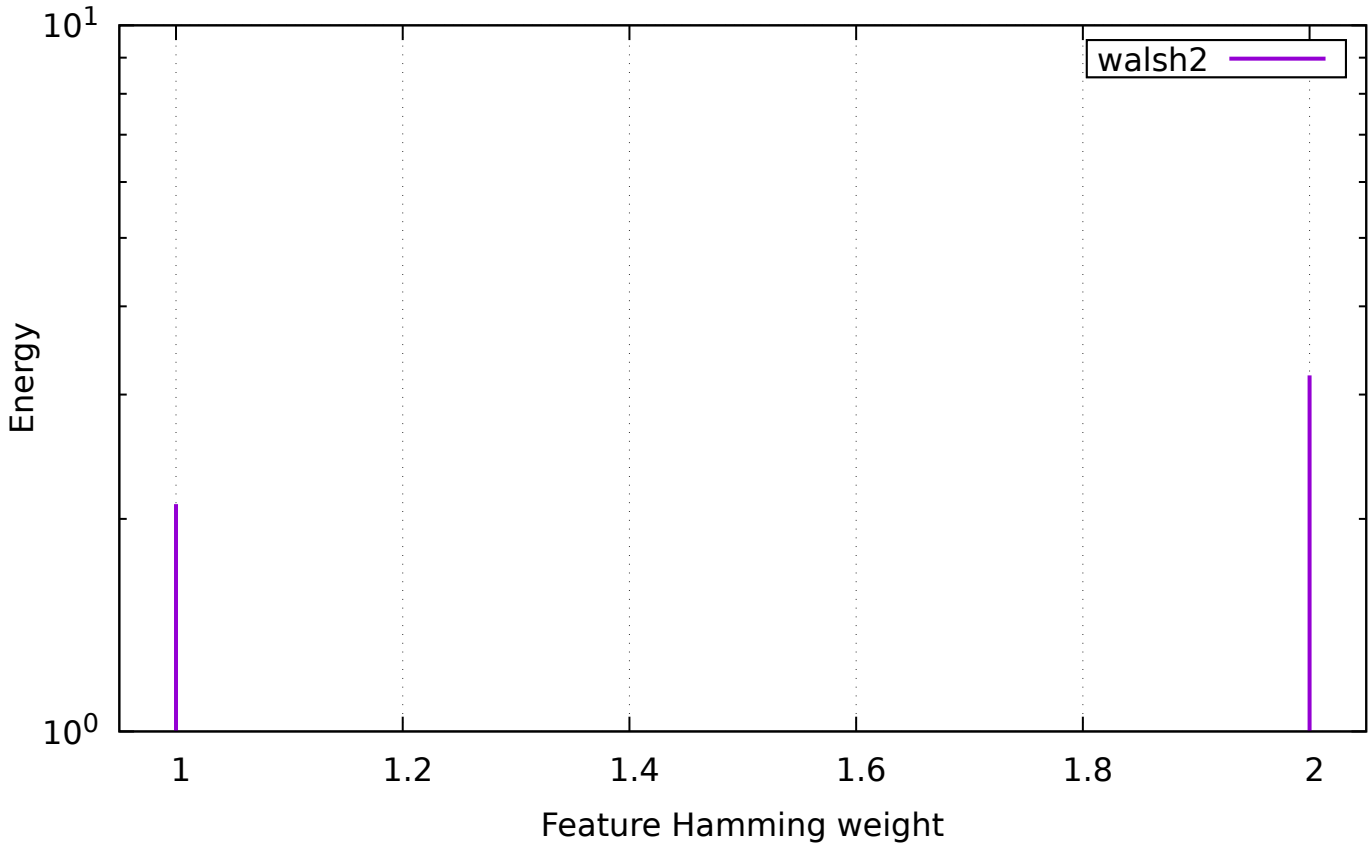
## 21 long-path


long-path
Amplitude
Coefficient rank
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
0
200
400
600
800
1000


long-path
Energy
Feature Hamming weight
$10^{1}$
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-4}$
1
2
3
4
5
6
7
8
9
10

## 22 walsh2




# A Plan

```
{
    "exec": "hnco",
    "opt": "--fn-walsh-transform -b 0 -s 10",
```

```
"parallel": true,
"results": "results",
"graphics": "graphics",
"report": "report",
"functions": [
    {
        "id": "one-max",
        "opt": "-F 0"
    },
    {
        "id": "lin",
        "opt": "-F 1 -p instances/lin.10"
    },
    {
        "id": "leading-ones",
        "opt": "-F 10"
    },
    {
        "id": "ridge",
        "opt": "-F 11"
    },
    {
        "id": "jmp-2",
        "opt": "-F 30 -t 2"
    },
    {
        "id": "jmp-4",
        "opt": "-F 30 -t 4"
    },
    {
        "id": "djmp-2",
        "opt": "-F 31 -t 2"
    },
    {
        "id": "djmp-4",
        "opt": "-F 31 -t 4"
    },
    {
        "id": "fp-2",
        "opt": "-F 40 -t 2"
    },
    {
        "id": "fp-4",
        "opt": "-F 40 -t 4"
    },
    {
        "id": "nk",
        "opt": "-F 60 -p instances/nk.10.2"
    },
    {
        "id": "max-sat",
        "opt": "-F 70 -p instances/ms.10.3.10"
    },
    {
        "id": "labs",
        "opt": "-F 80"
    },
    {
        "id": "ep",
        "opt": "-F 90 -p instances/ep.10"
    },
    {
        "id": "cancel",
```

```
            "opt": "-F 100 -s 9"
        },
        {
            "id": "trap",
            "opt": "-F 110 --fn-num-traps 2"
        },
        {
            "id": "hiff",
            "opt": "-F 120 -s 8"
        },
        {
            "id": "plateau",
            "opt": "-F 130"
        },
        {
            "id": "needle",
            "opt": "-F 20"
        },
        {
            "id": "long-path",
            "opt": "-F 140"
        },
        {
            "id": "walsh2",
            "opt": "-F 162 -p instances/walsh2.10"
        }
    ]
}
```

# B Default parameters

```
# algorithm = 100
# bm_mc_reset_strategy = 1
# bm_num_gs_cycles = 1
# bm_num_gs_steps = 100
# bm_sampling = 1
# budget = 10000
# bv_size = 100
# ea_lambda = 100
# ea_mu = 10
# fn_name = noname
# fn_num_traps = 10
# fn_prefix_length = 2
# fn_threshold = 10
# function = 0
# ga_crossover_bias = 0.5
# ga_crossover_probability = 0.5
# ga_tournament_size = 10
# hea_bit_herding = 0
# hea_num_seq_updates = 100
# hea_reset_period = 0
# hea_sampling_method = 0
# hea_weight = 1
# learning_rate = 0.001
# map = 0
# map_input_size = 100
# map_path = nopath
# mutation_probability = 1
# neighborhood = 0
# neighborhood_iterator = 0
# noise_stddev = 1
# num_iterations = 0
```

```
# num_threads = 1
# path = nopath
# pn_mutation_probability = 1
# pn_neighborhood = 0
# pn_radius = 2
# population_size = 10
# pv_log_num_components = 5
# radius = 2
# results_path = results.json
# rls_patience = 50
# sa_beta_ratio = 1.2
# sa_initial_acceptance_probability = 0.6
# sa_num_transitions = 50
# sa_num_trials = 100
# seed = 0
# selection_size = 1
# target = 100
# print_defaults
# last_parameter
# exec_name = hnco
# version = 0.12
# Generated from hnco.json
```