Balancing handover areas among neighbouring cells in 3G networks

Evolutionary Algorithms

Multiobjective optimization and design

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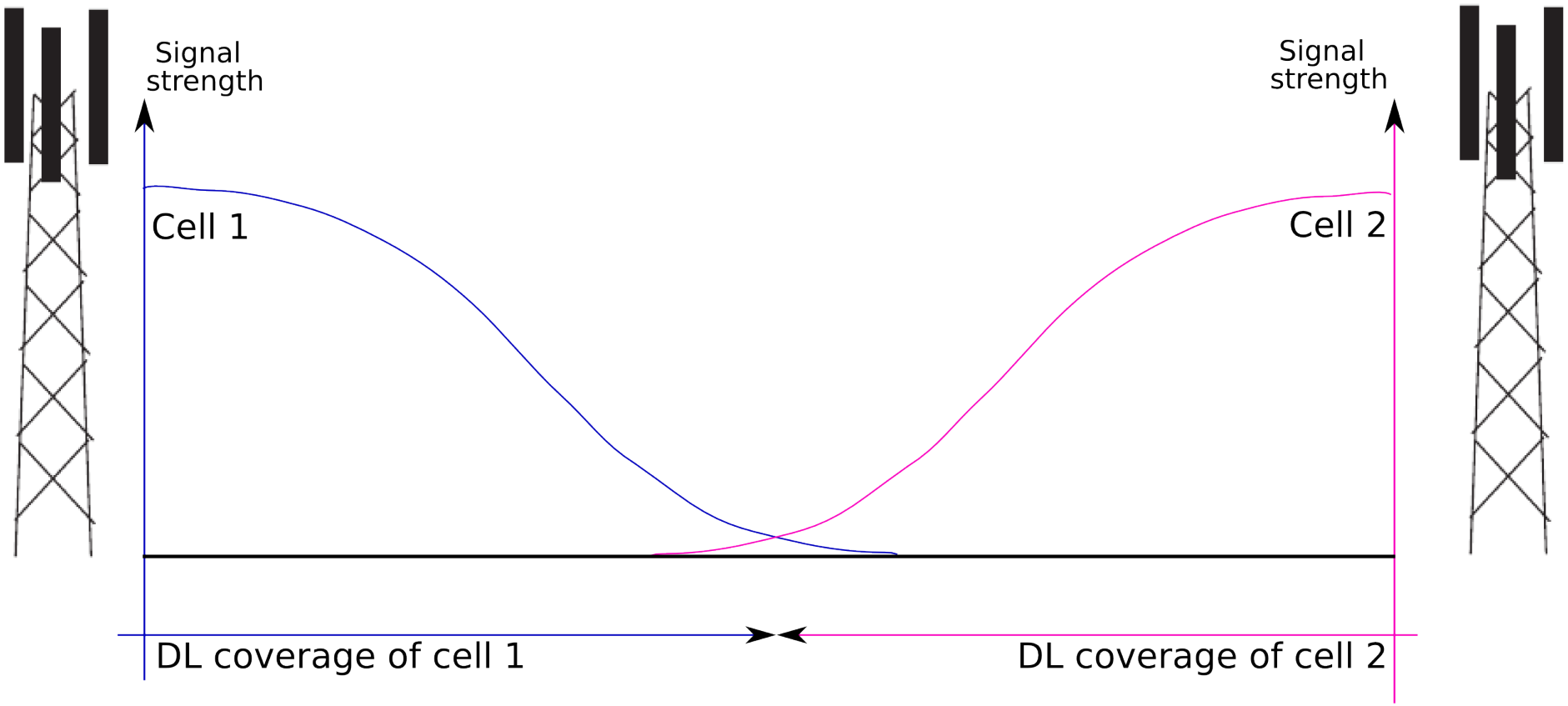
Jožef Stefan International Postgraduate School

May 2010

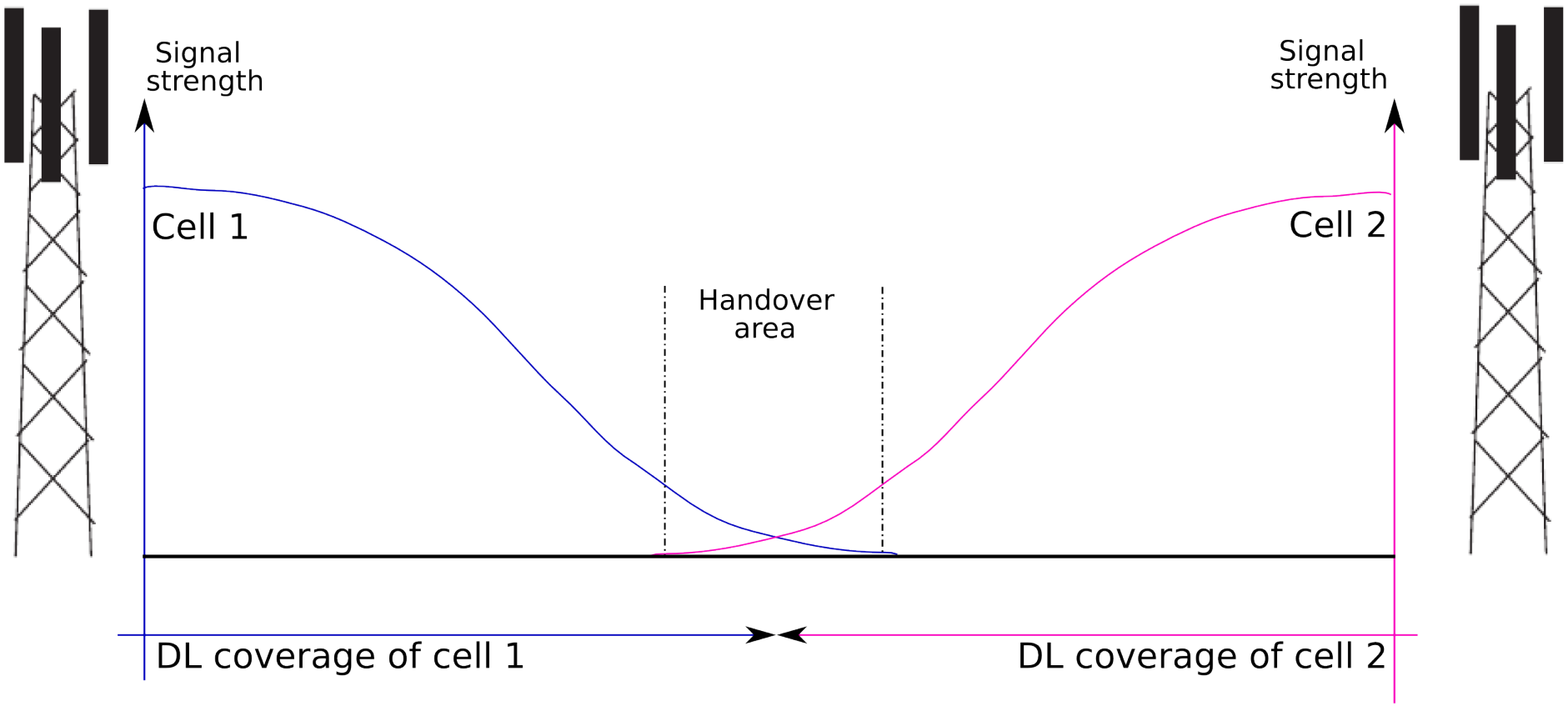
Outline

Outline

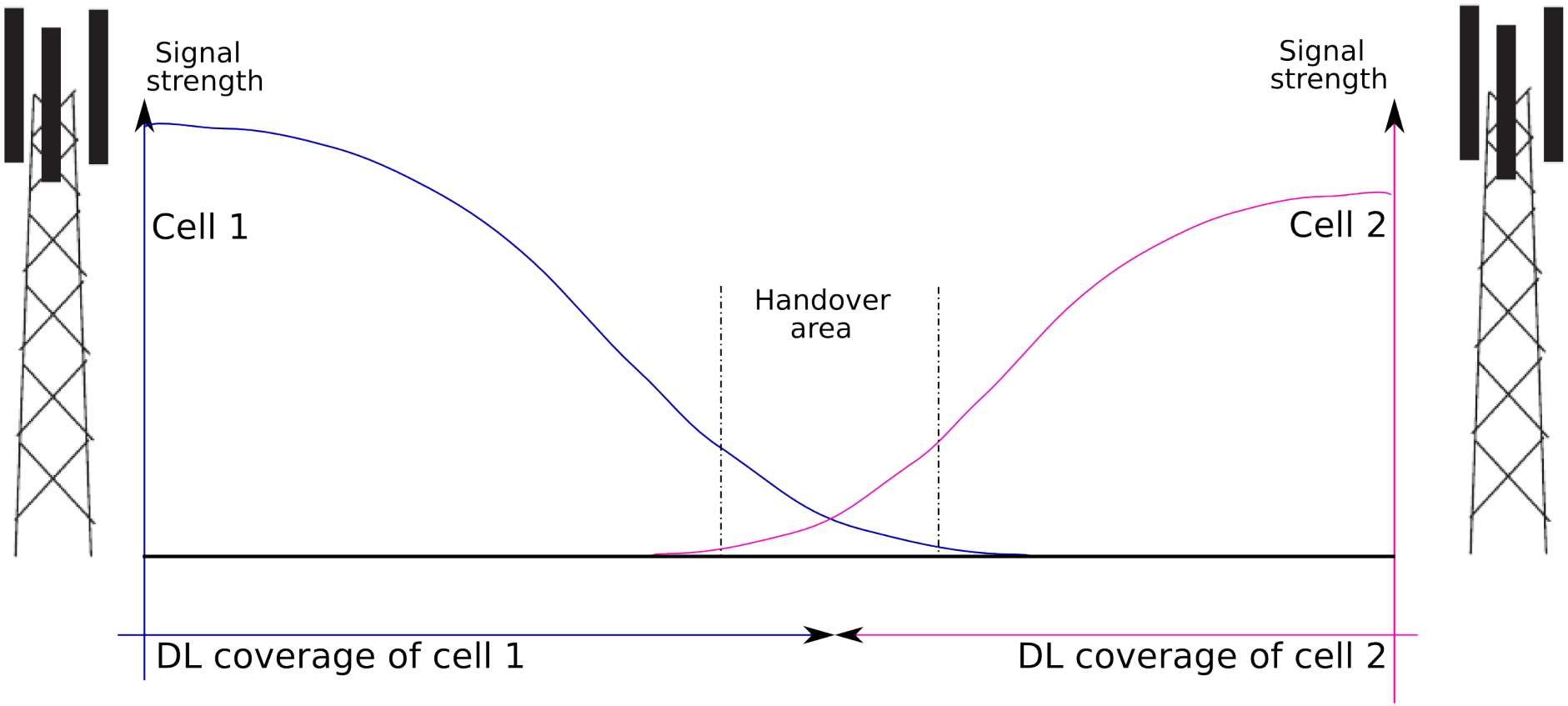
Neighbour cells



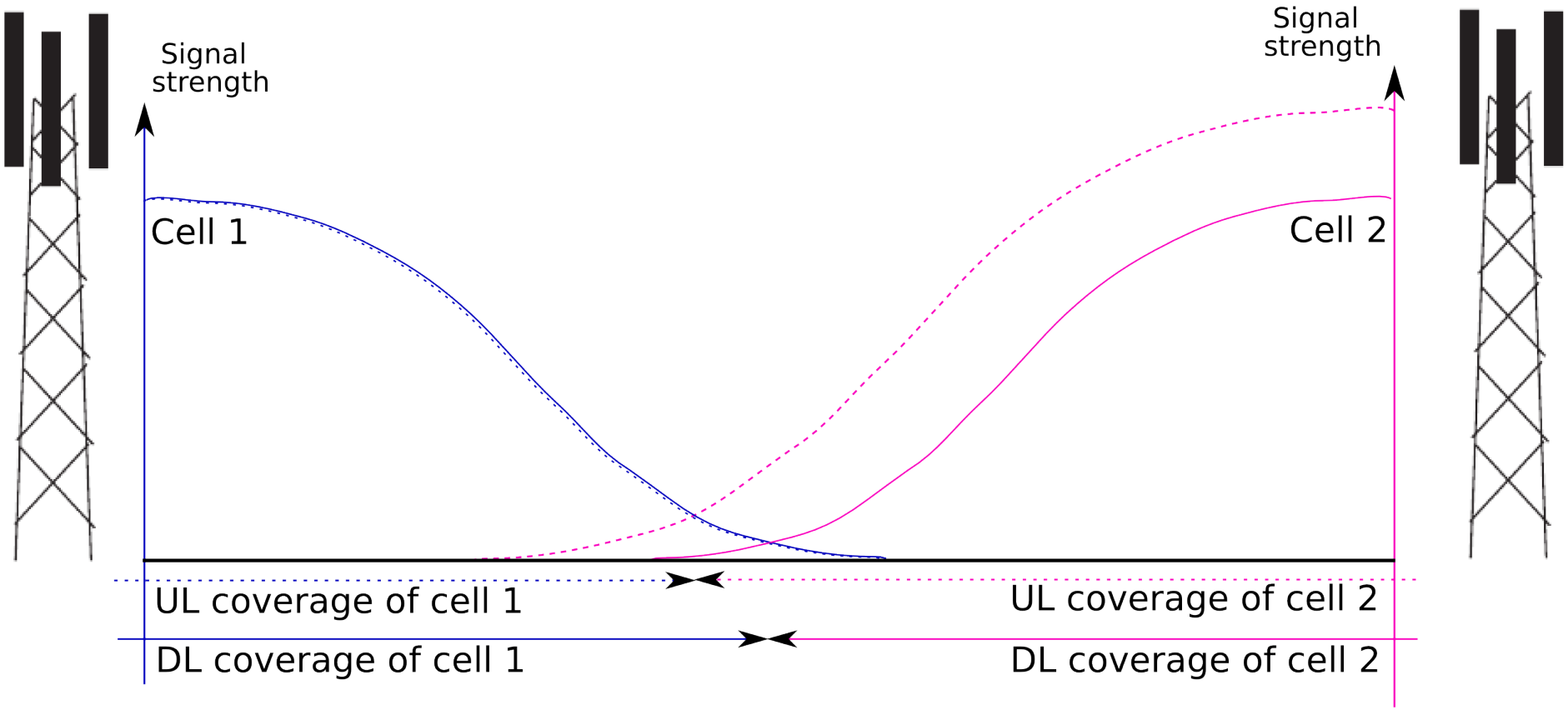
Handover area



Balancing handover area



Balancing UL-DL handover areas



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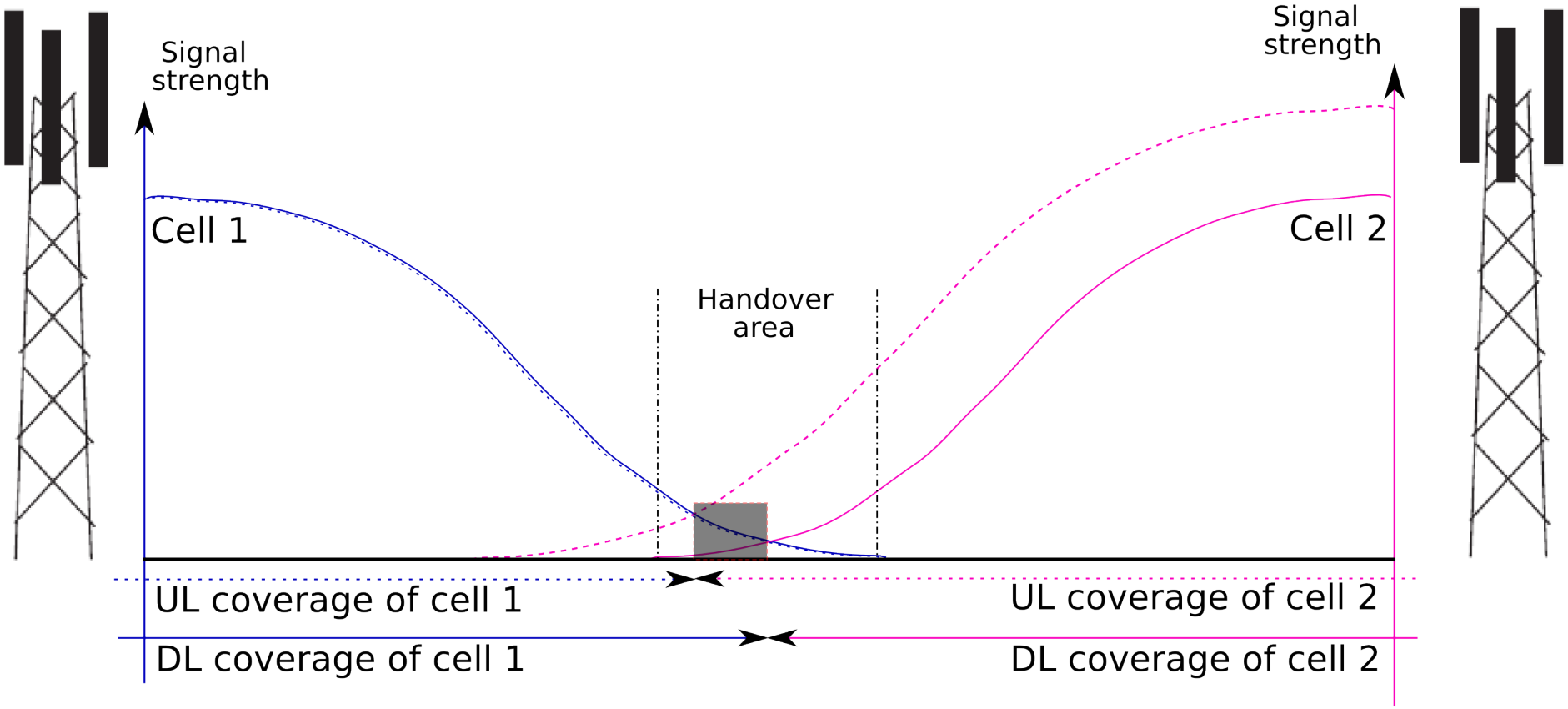

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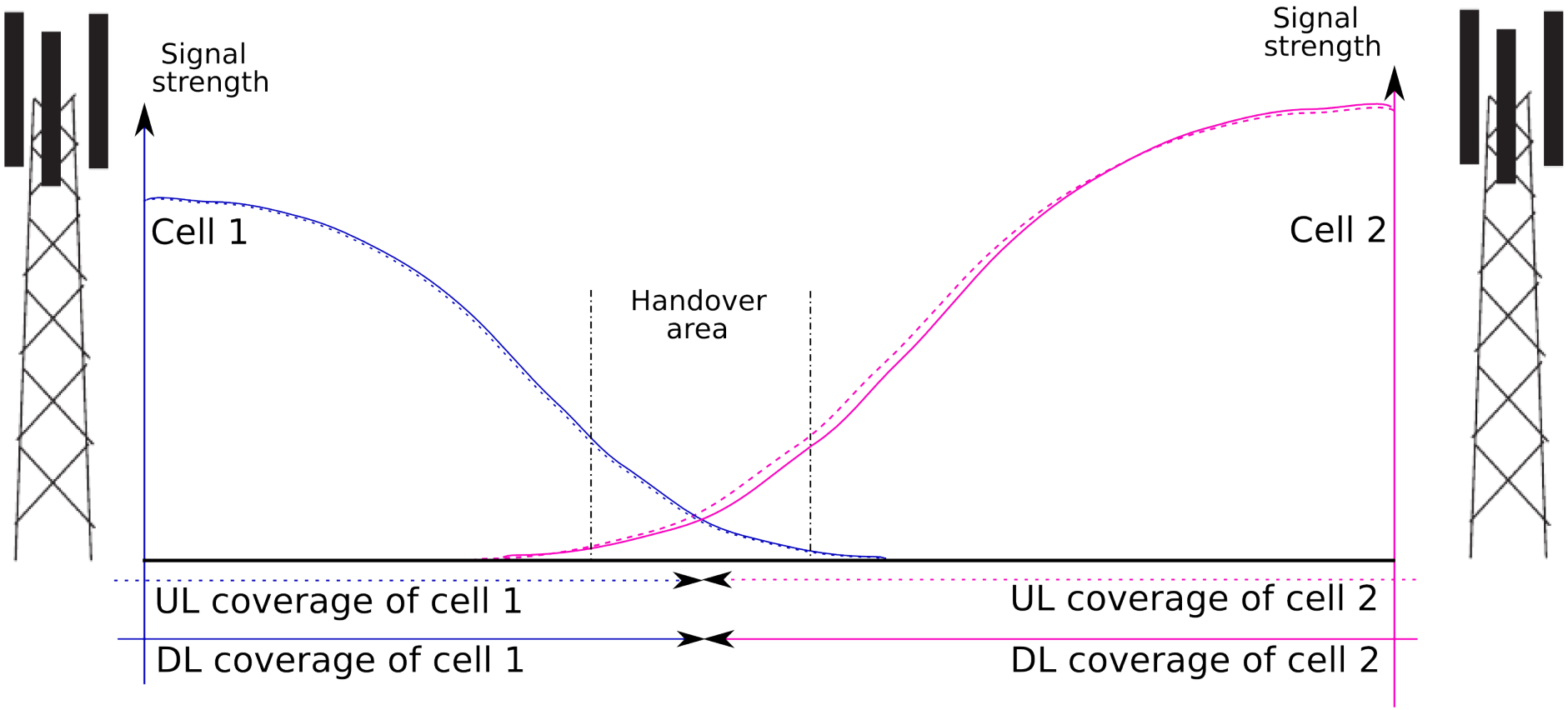

Outline

Adjacency Matrix

	CELL 1	CELL 2	CELL 3	CELL 4	CELL 5
CELL 1					
CELL 2					
CELL 3					
CELL 4					
CELL 5					

Adjacency Matrix

	CELL 1	CELL 2	CELL 3	CELL 4	CELL 5
CELL 1	0	0	1	0	1
CELL 2	0	0	0	1	0
CELL 3	1	0	0	0	1
CELL 4	0	1	0	0	0
CELL 5	1	0	1	0	0

Adjacency Matrix - simmetry

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Problem elements

- **Candidate solutions:** DL power setting for every cell.
- **Constraints:** solutions within $[-2dB, +2dB]$ of current setting.
- Static problem.

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Objective function

Minimize ...

... the difference between UL and DL areas among neighbour cells.

Objective function

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$$\min \left| \sum_{i=1}^{|V|} \sum_{j=i}^{|V|} a_{ij} \left((UL(c_i) - UL(c_j)) - (DL(c_i) - DL(c_j)) \right) \right|$$

- c_i i-th cell of the network,
- $DL(c_i)$ downlink power of the i-th cell,
- $UL(c_i)$ uplink power of the i-the cell.

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Simulated annealing

- Discrete search space
  - changes of $0.1dBm$.
- Key parameters
  - initial temperature,
  - number of iterations.

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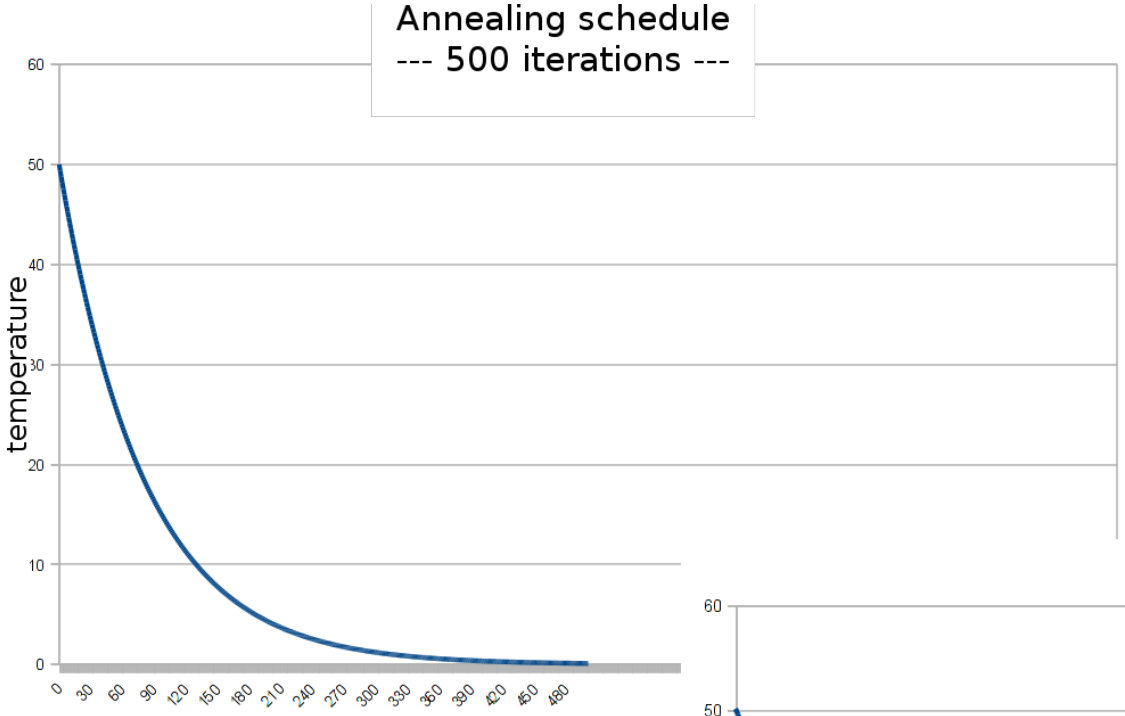
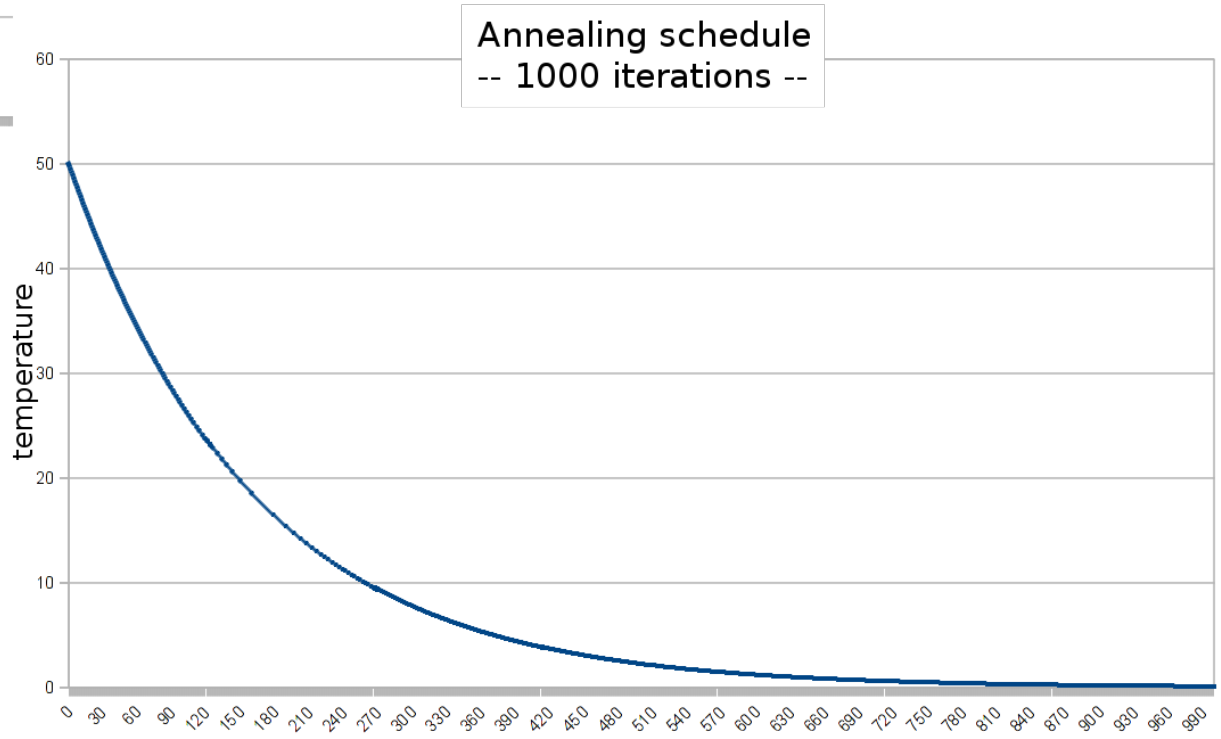
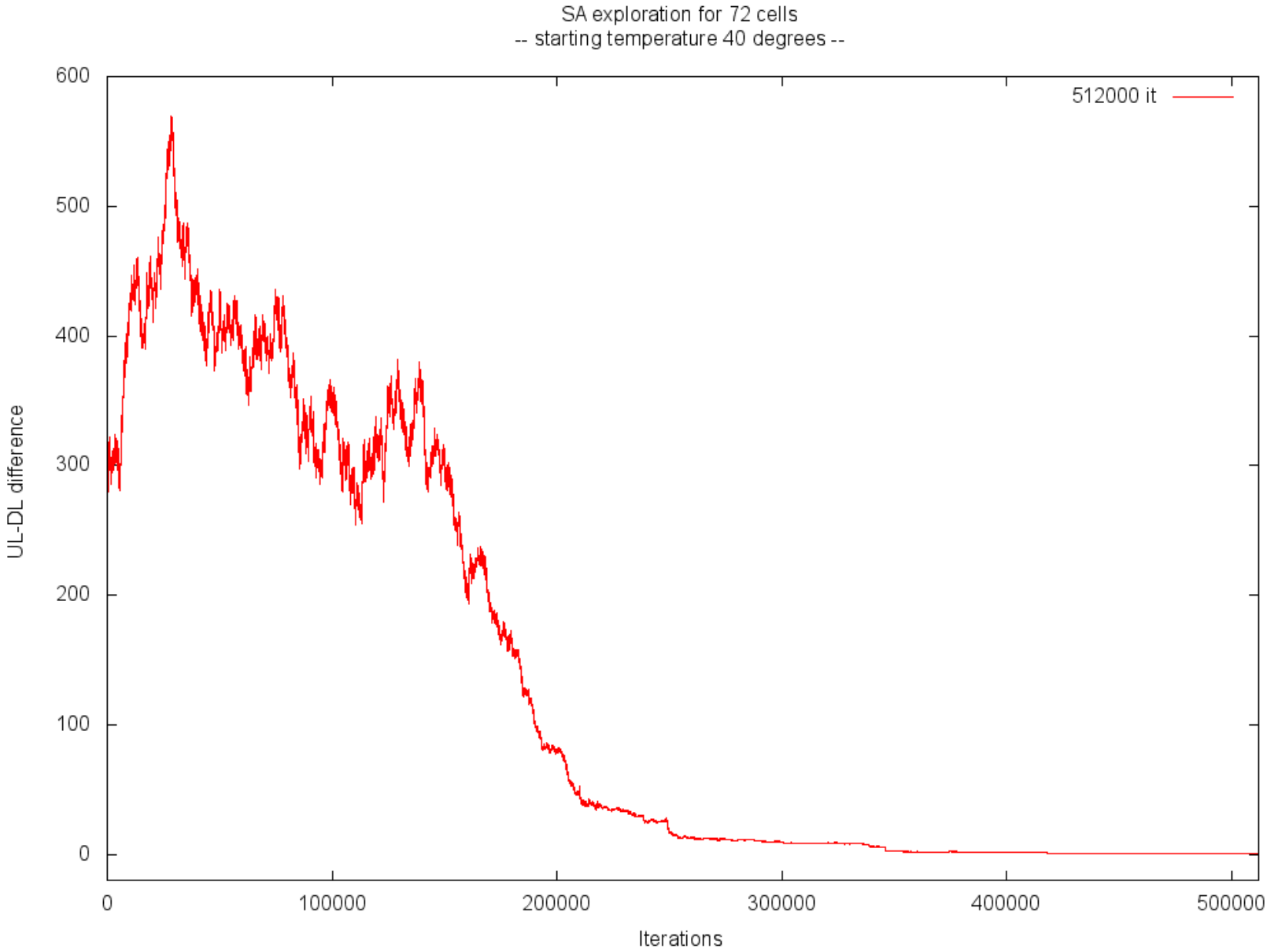

Annealing schedule
--- 500 iterations ---
temperature
60
50
40
30
20
10
0
0 30 60 90 120 150 180 210 240 270 300 330 360 390 420 450 480


Annealing schedule
-- 1000 iterations --
temperature
60
50
40
30
20
10
0
0 30 60 90 120 150 180 210 240 270 300 330 360 390 420 450 480 510 540 570 600 630 660 690 720 750 780 810 840 870 900 930 960 990

SA: Results


SA exploration for 72 cells
-- starting temperature 40 degrees --
512000 it
UL-DL difference
Iterations
0
100
200
300
400
500
600
0
100000
200000
300000
400000
500000

Objective functions

Minimize ...

... the difference between UL and DL areas among neighbour cells.

Minimize ...

... the total DL power used.

Objective functions

1 - Objective function

$$\min \left| \sum_{i=1}^{|V|} \sum_{j=i}^{|V|} a_{ij} \left((UL(c_i) - UL(c_j)) - (DL(c_i) - DL(c_j)) \right) \right|$$

2 - Objective function

$$\min \sum_{i=1}^{|V|} DL(c_i)$$

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- Continous search space.
- Key parameters
  - population size,
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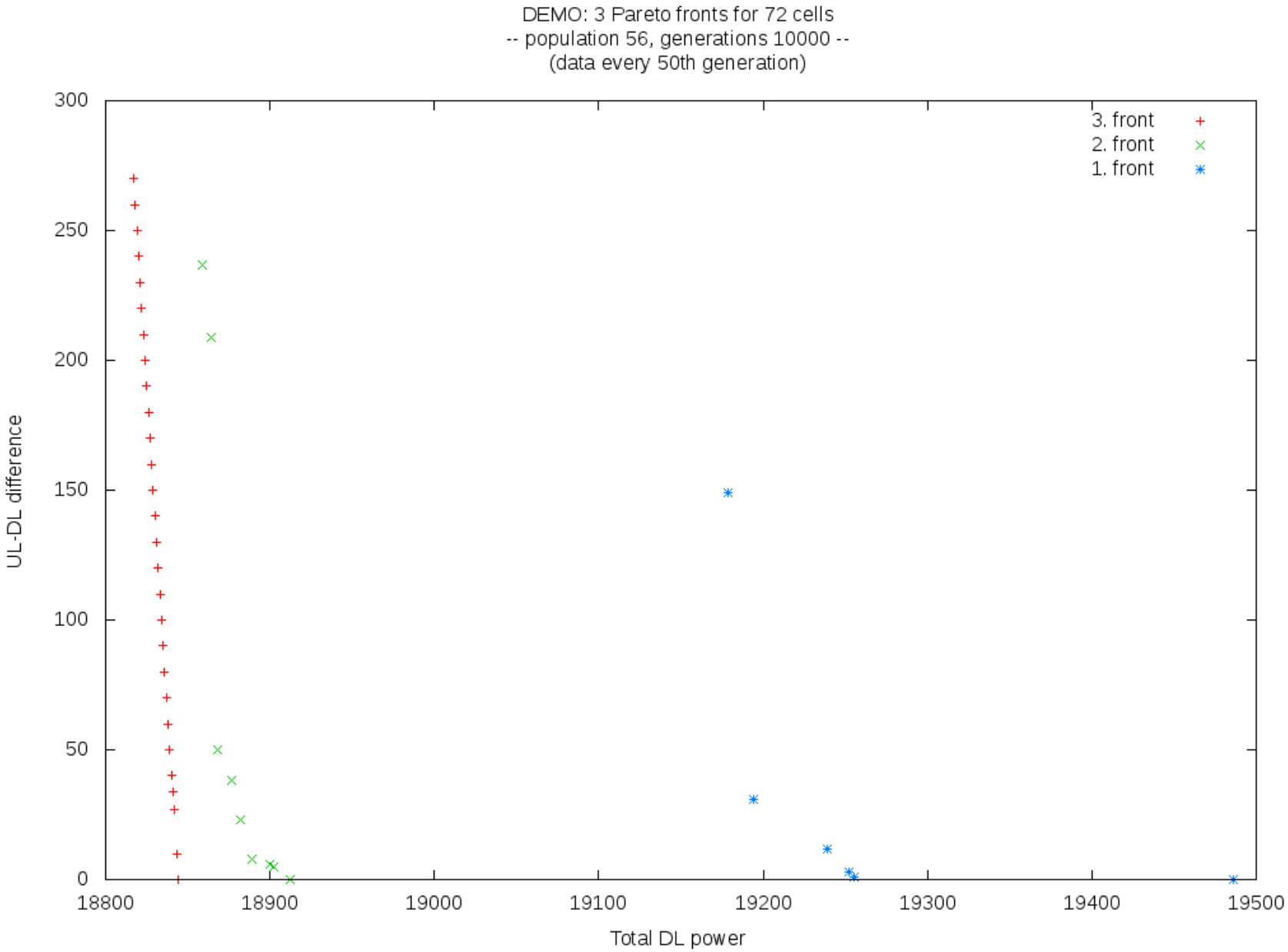

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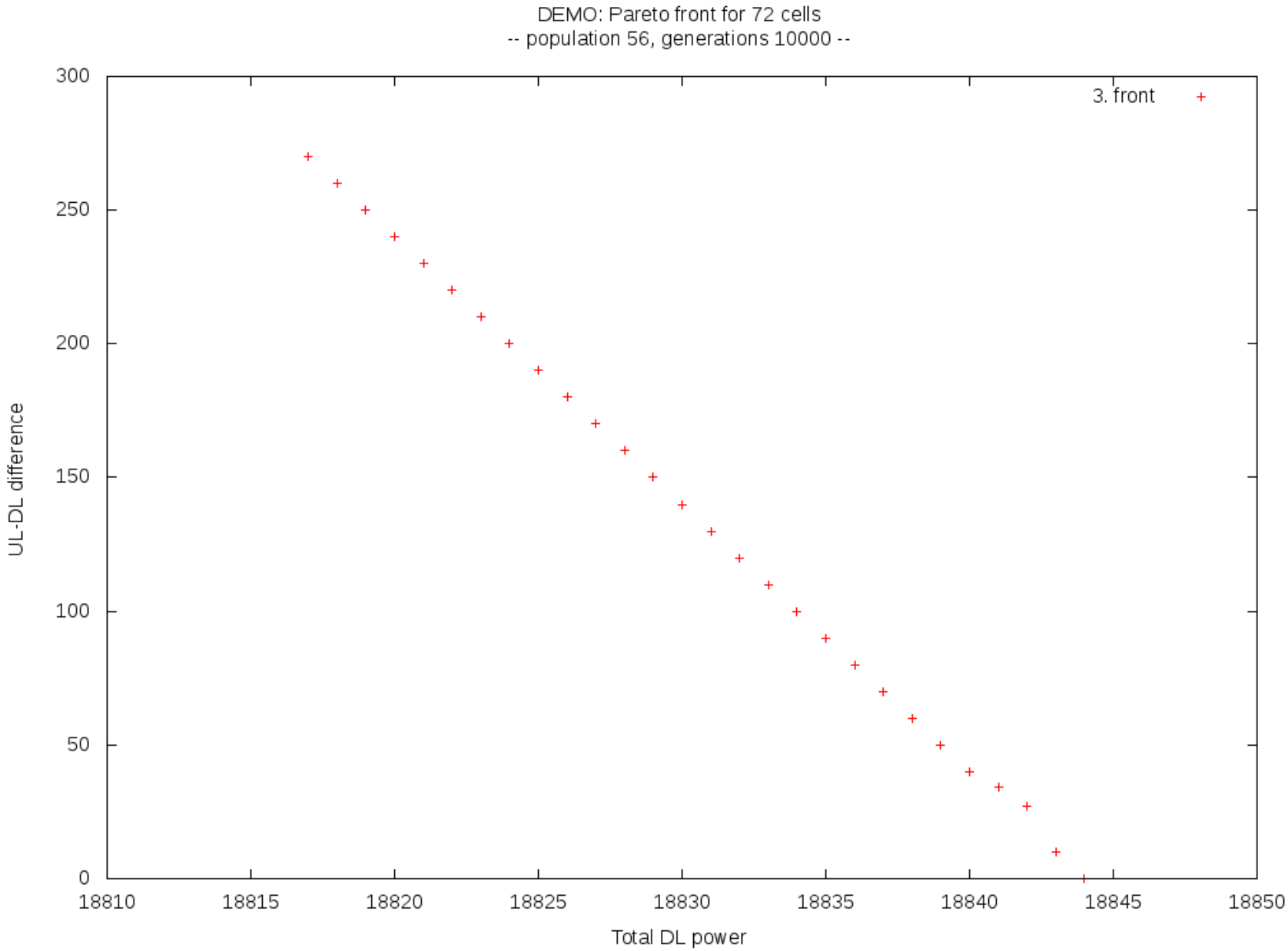

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- Both algorithms solved the balancing problem to optimality.
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- DEMO analysis included 2 parameters only (lots of other parameters left as default).
- DEMO was much faster (minutes $\longleftrightarrow$ hours).
- DEMO also lowered the total power used (2^{nd} objective).
- DEMO couldn't find good solutions in a discretized search space.

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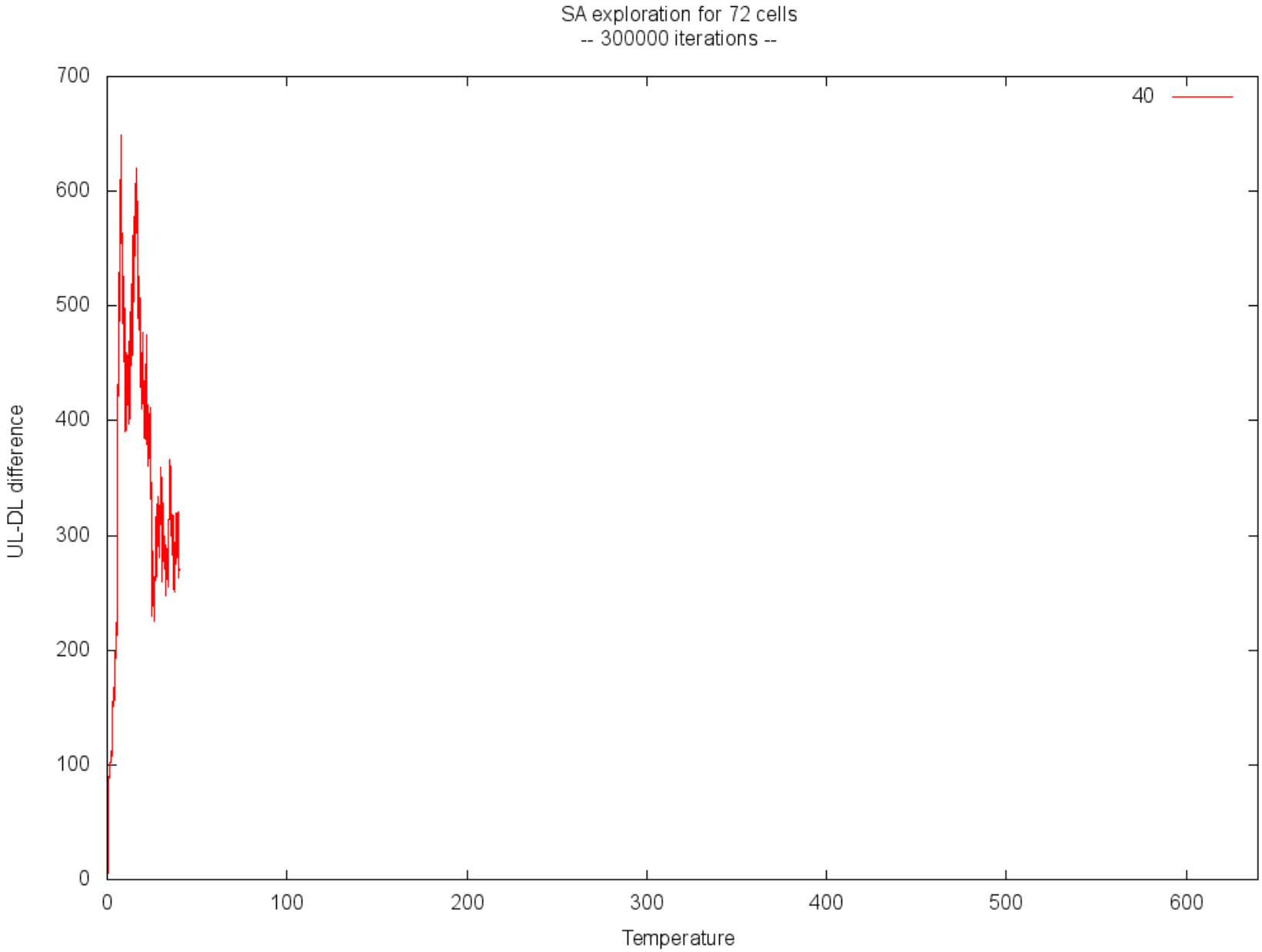
SA: Starting temperature



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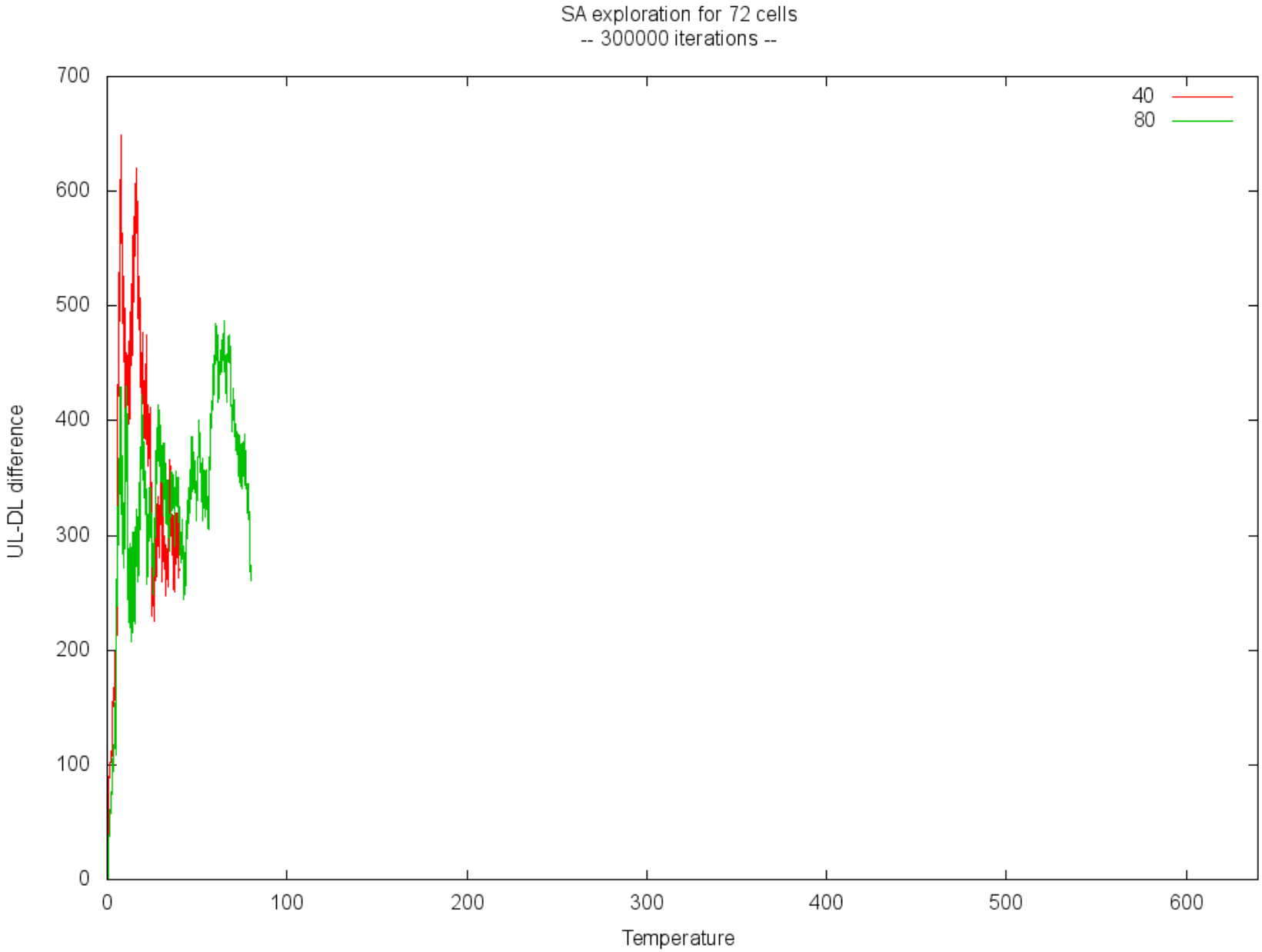

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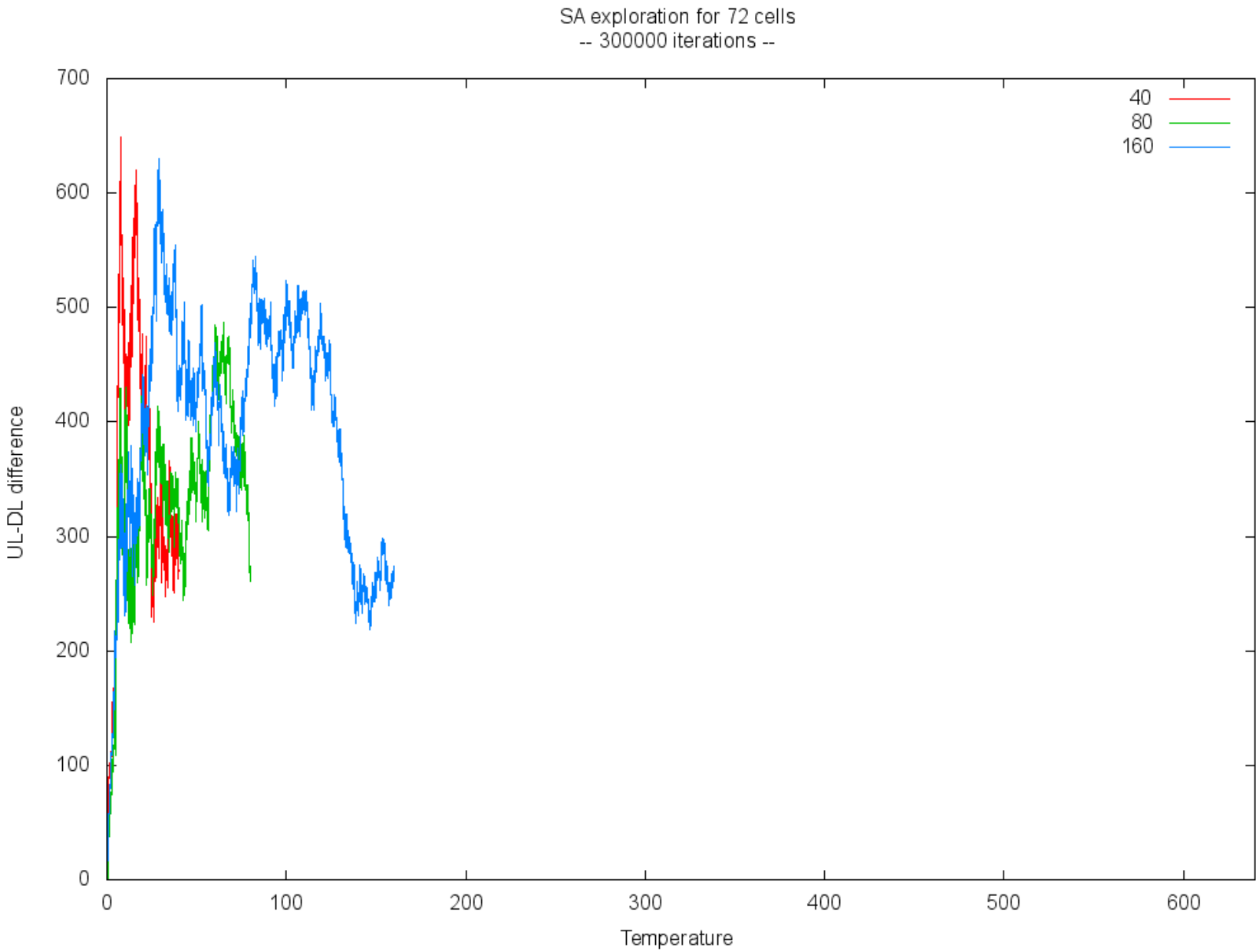

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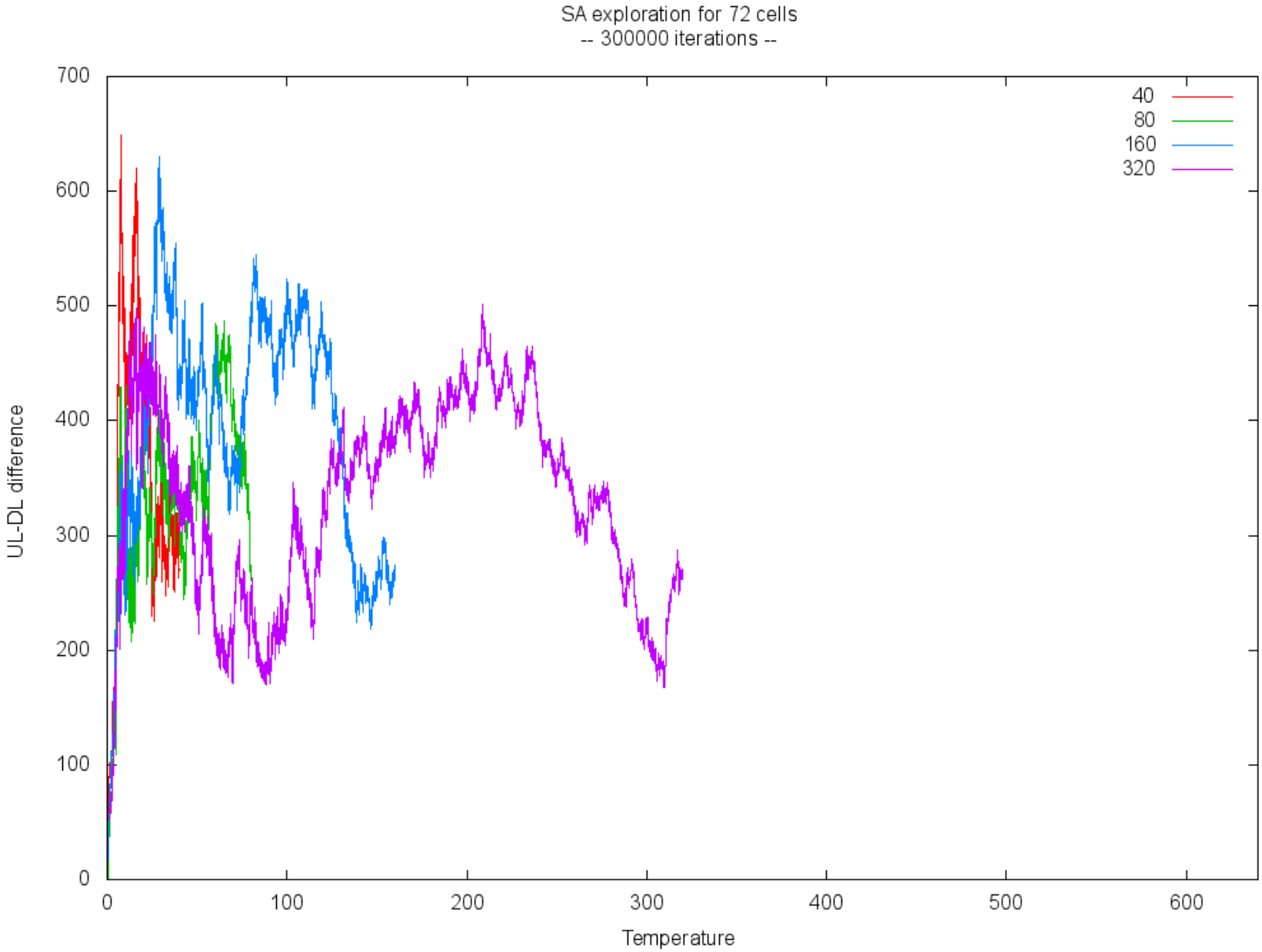

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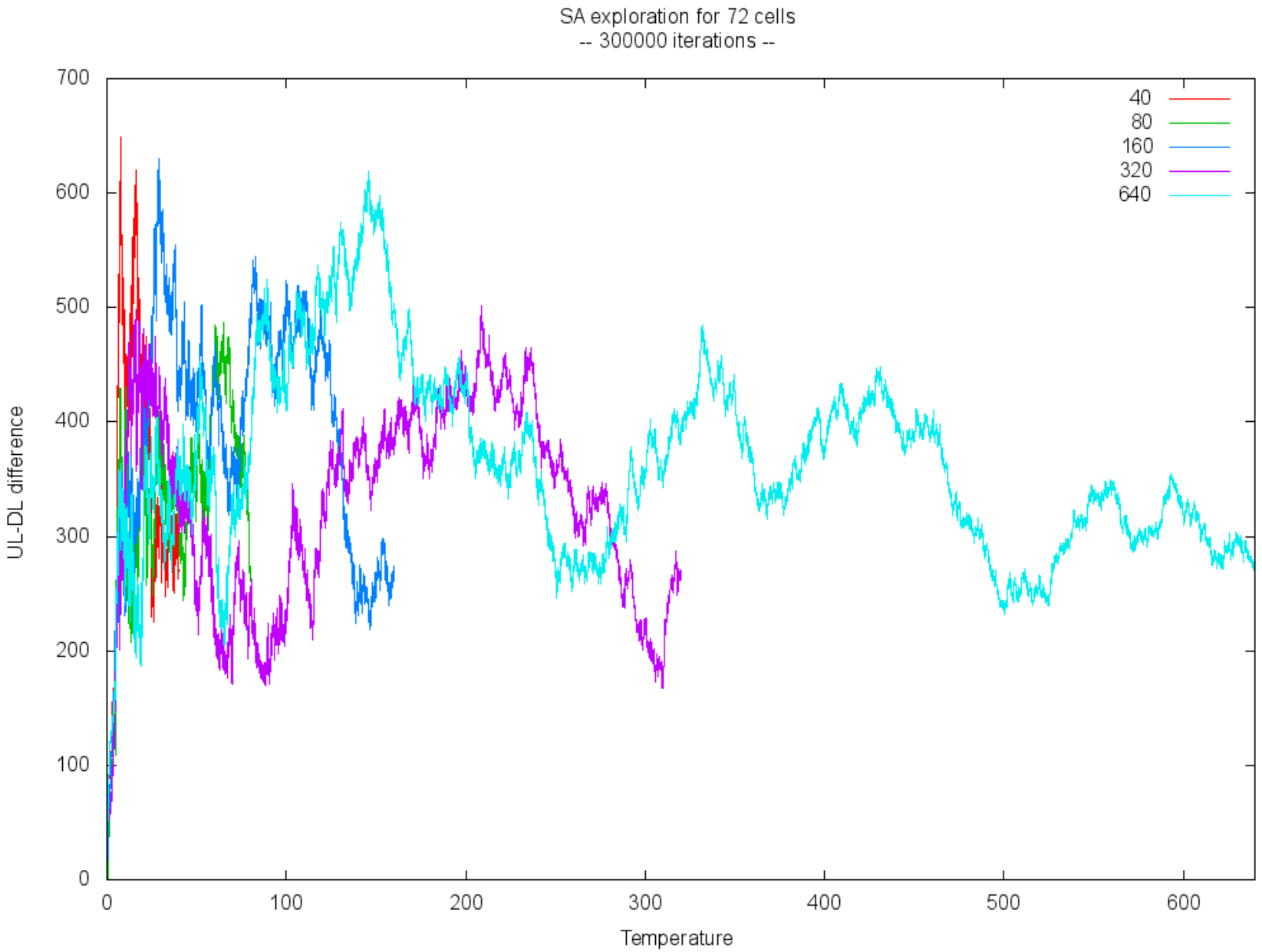
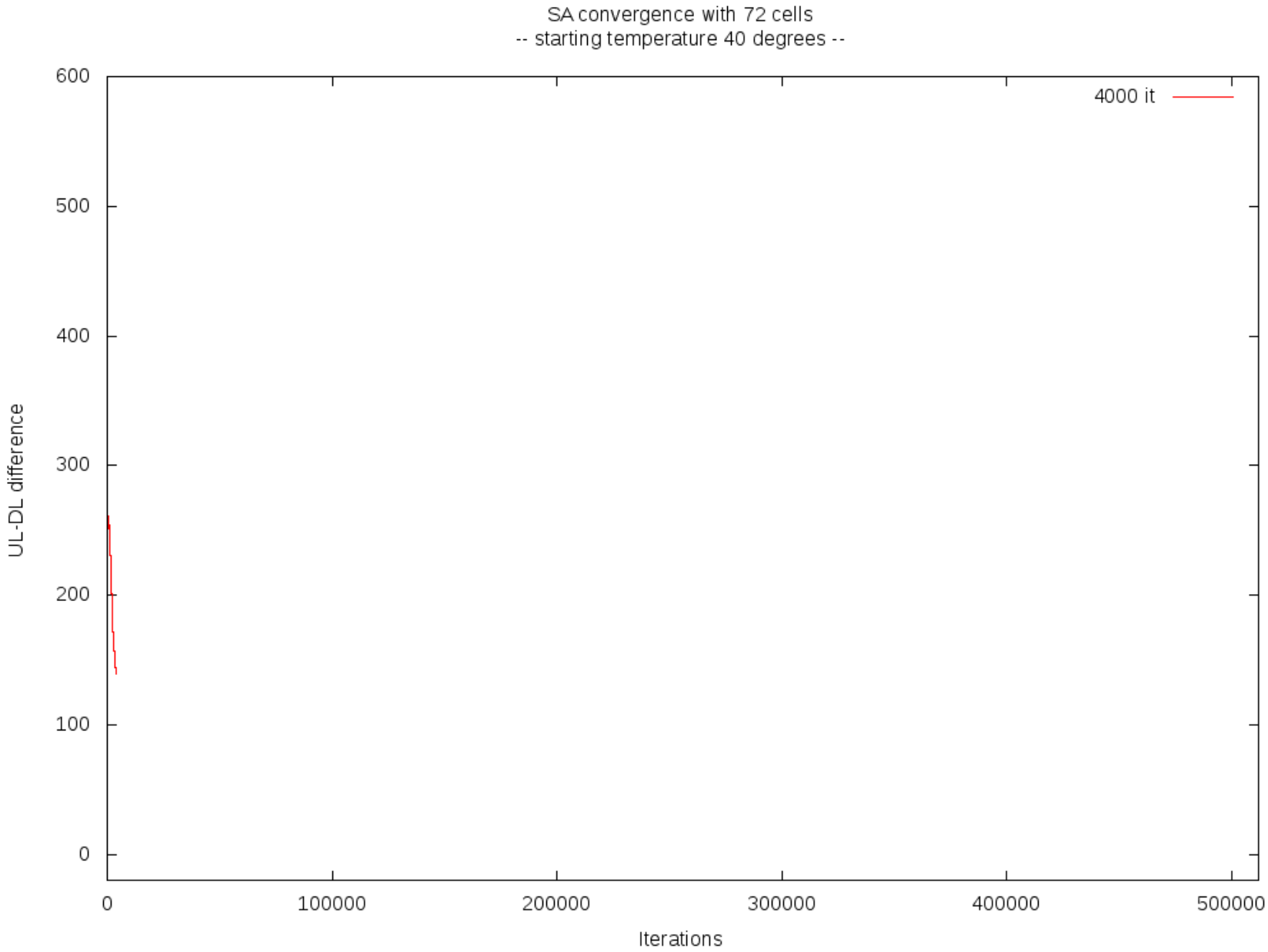


SA: Number of iterations



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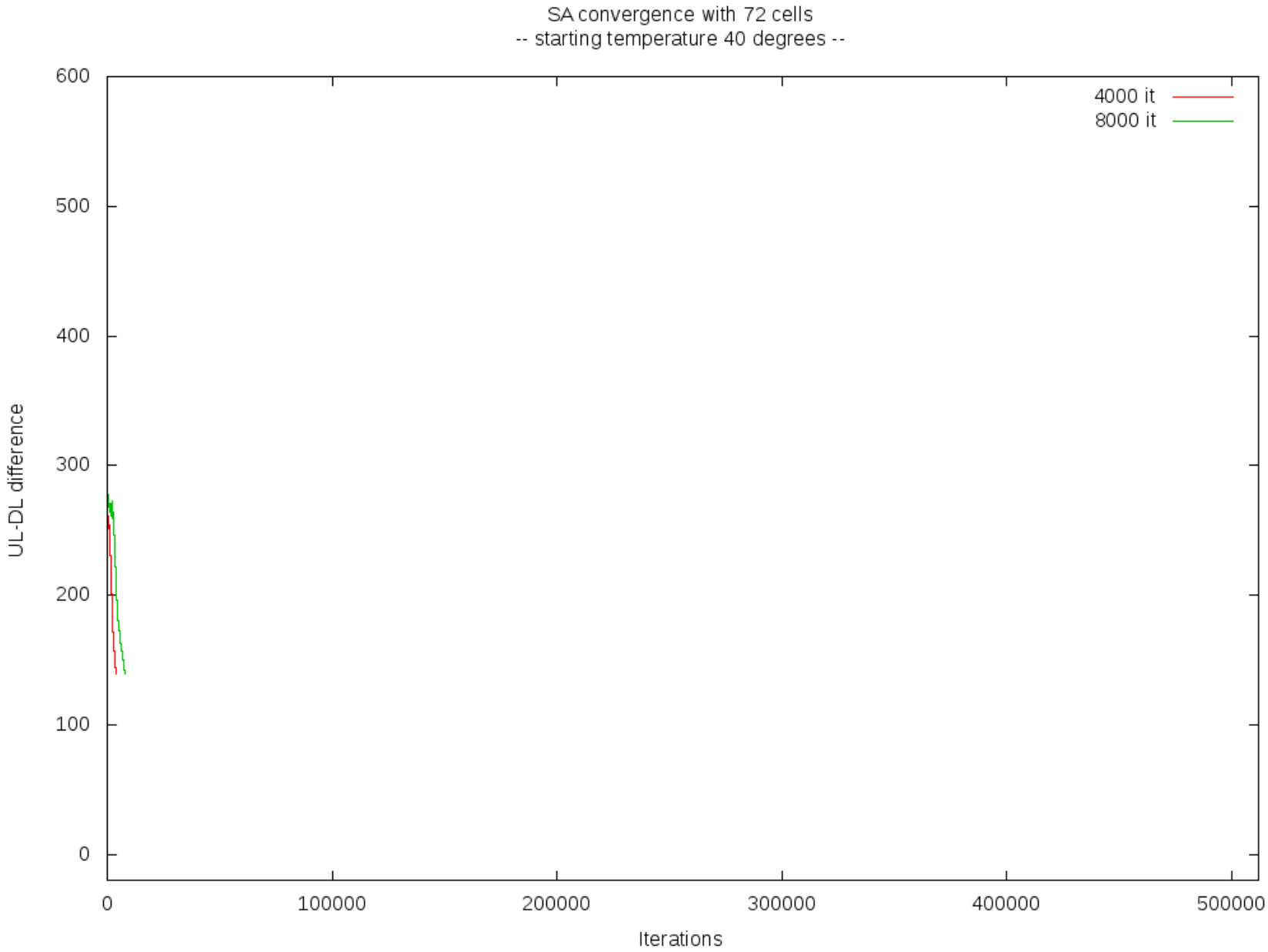

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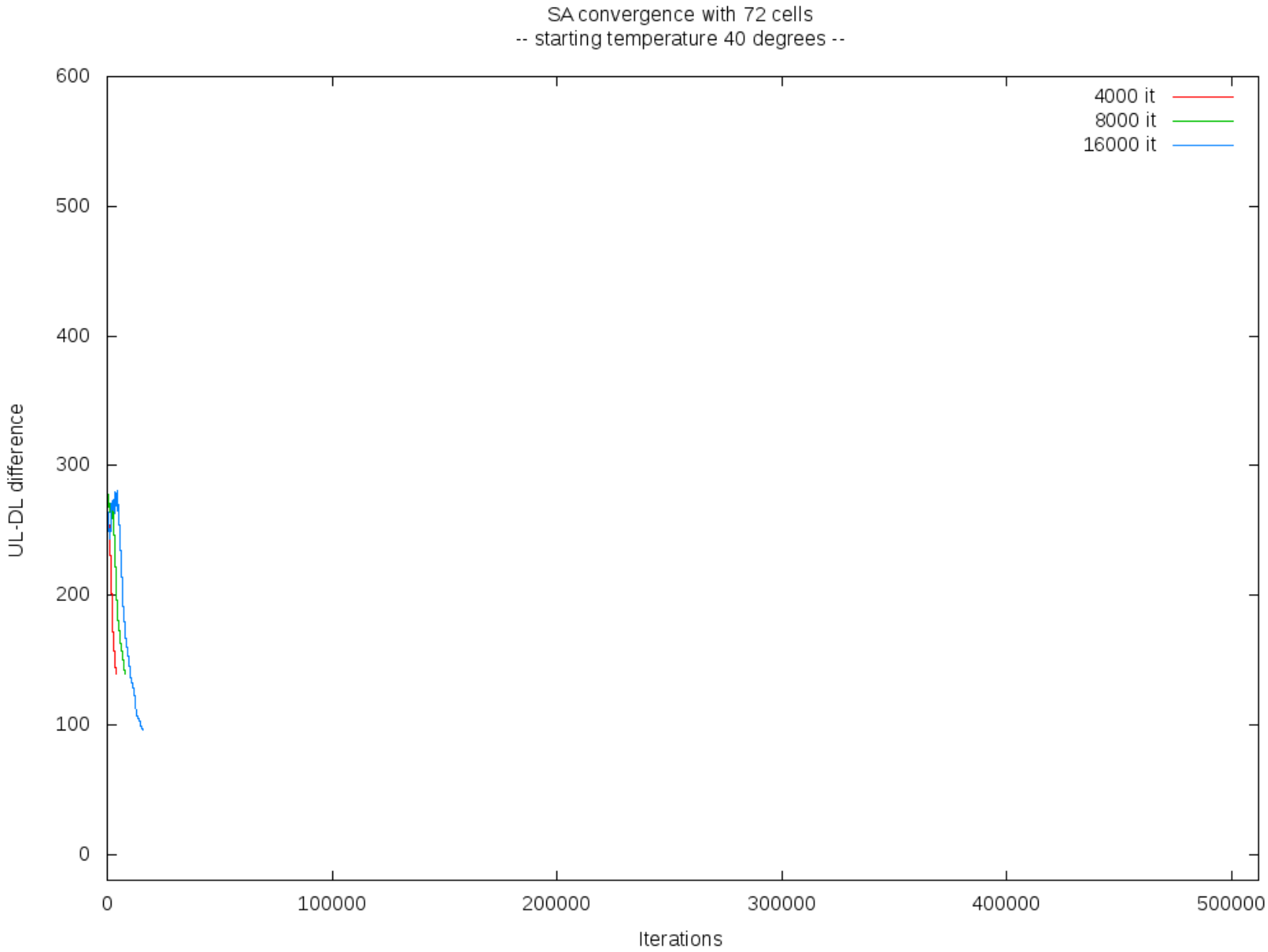

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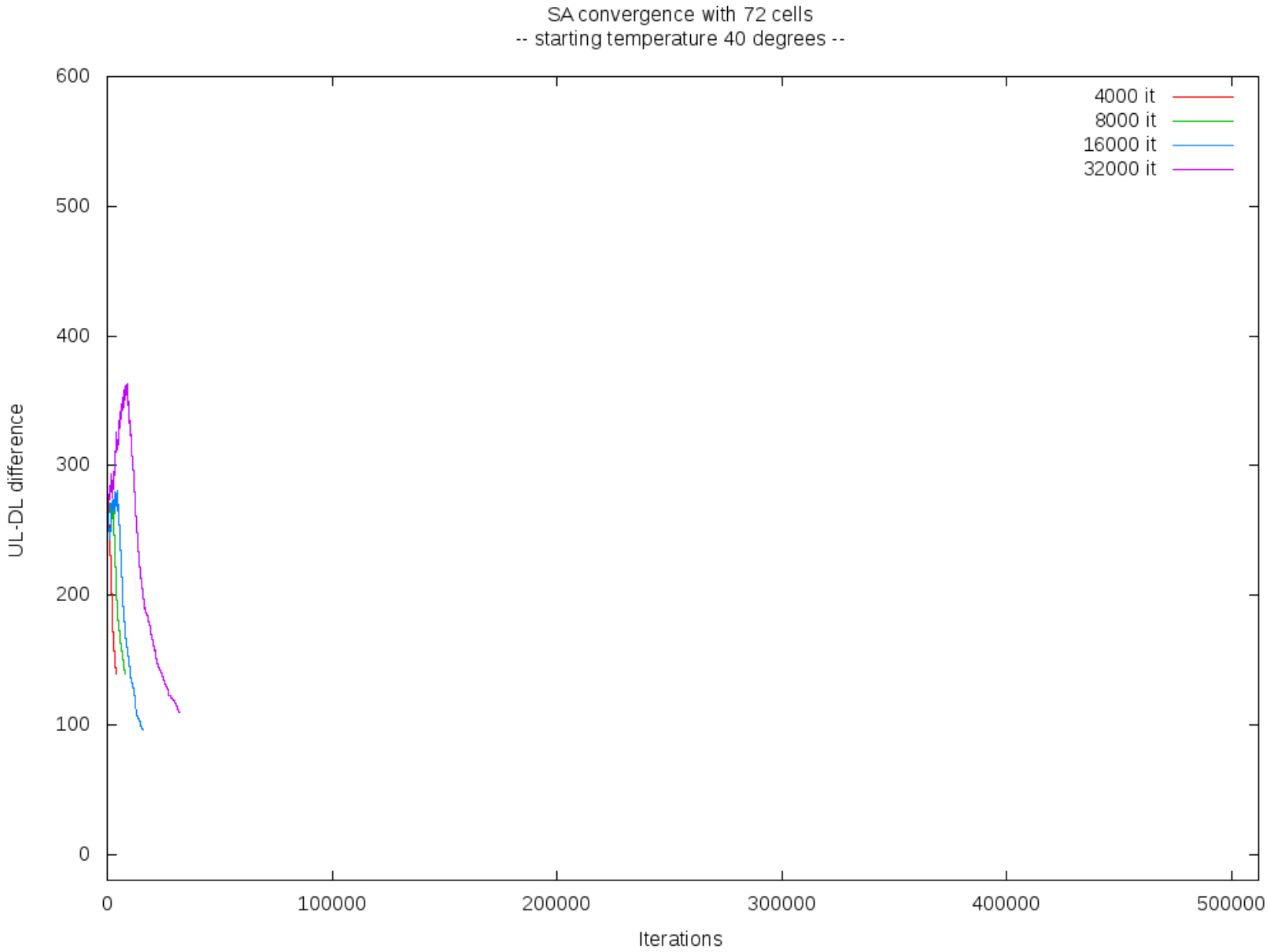

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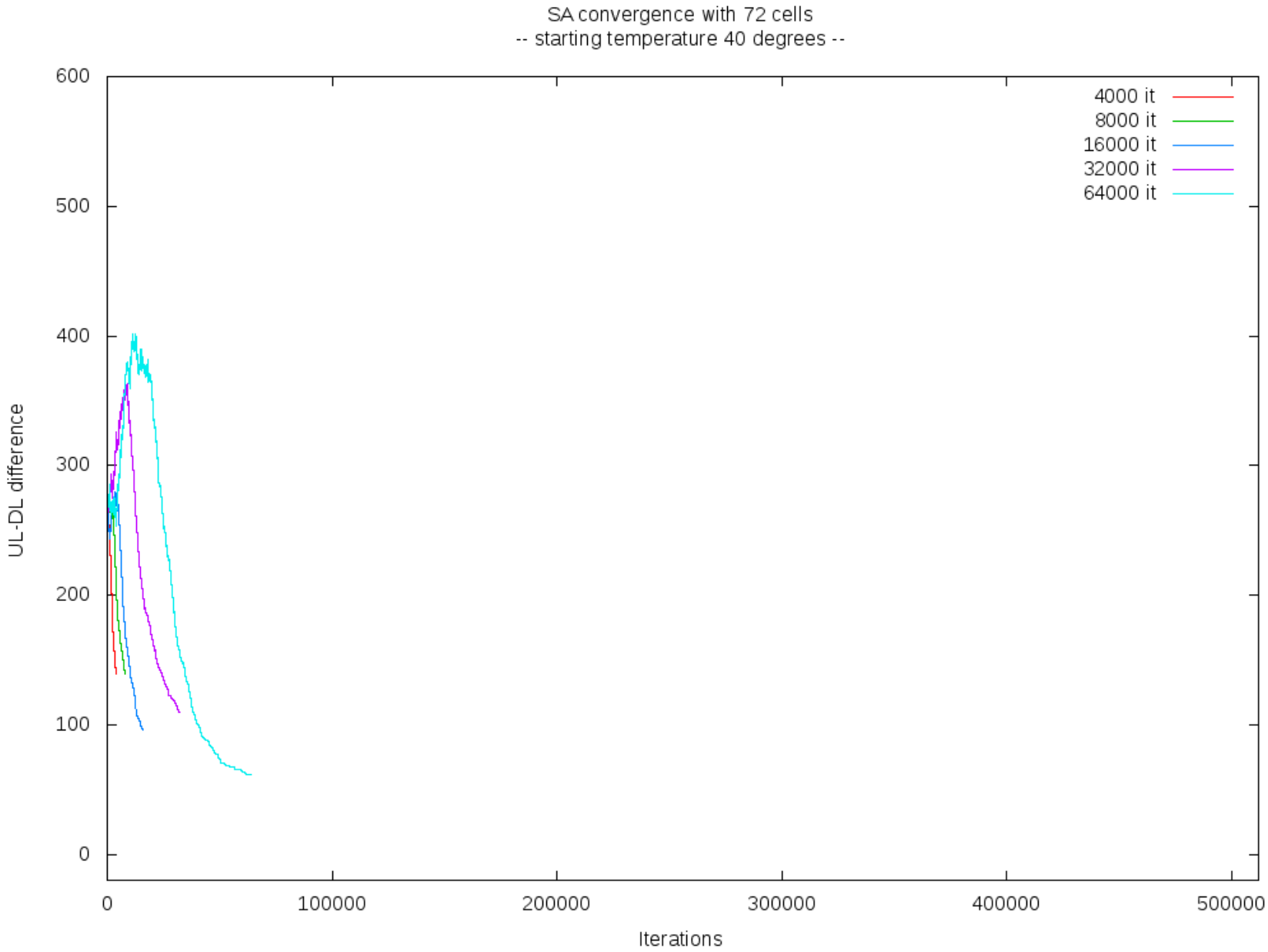

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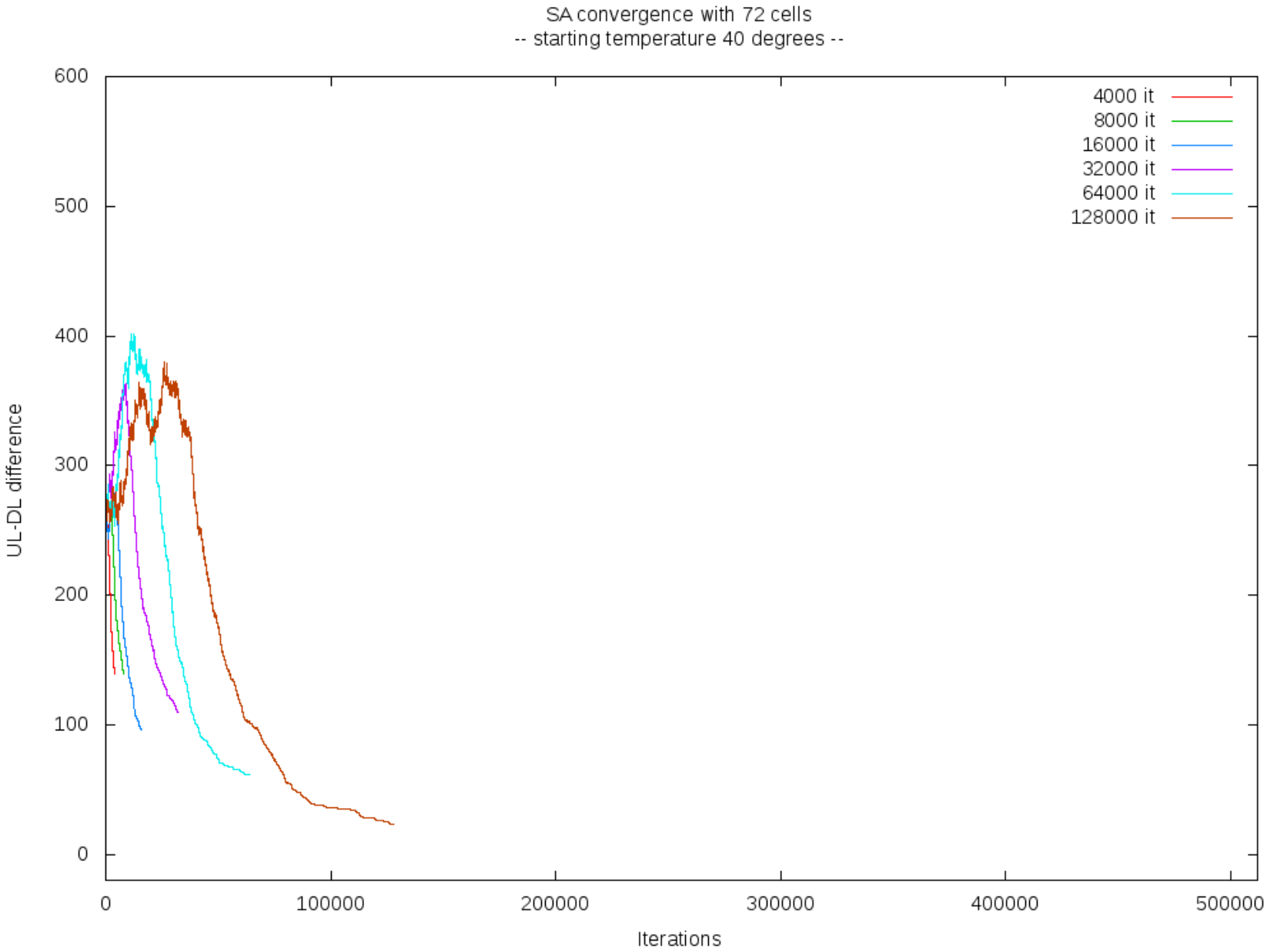

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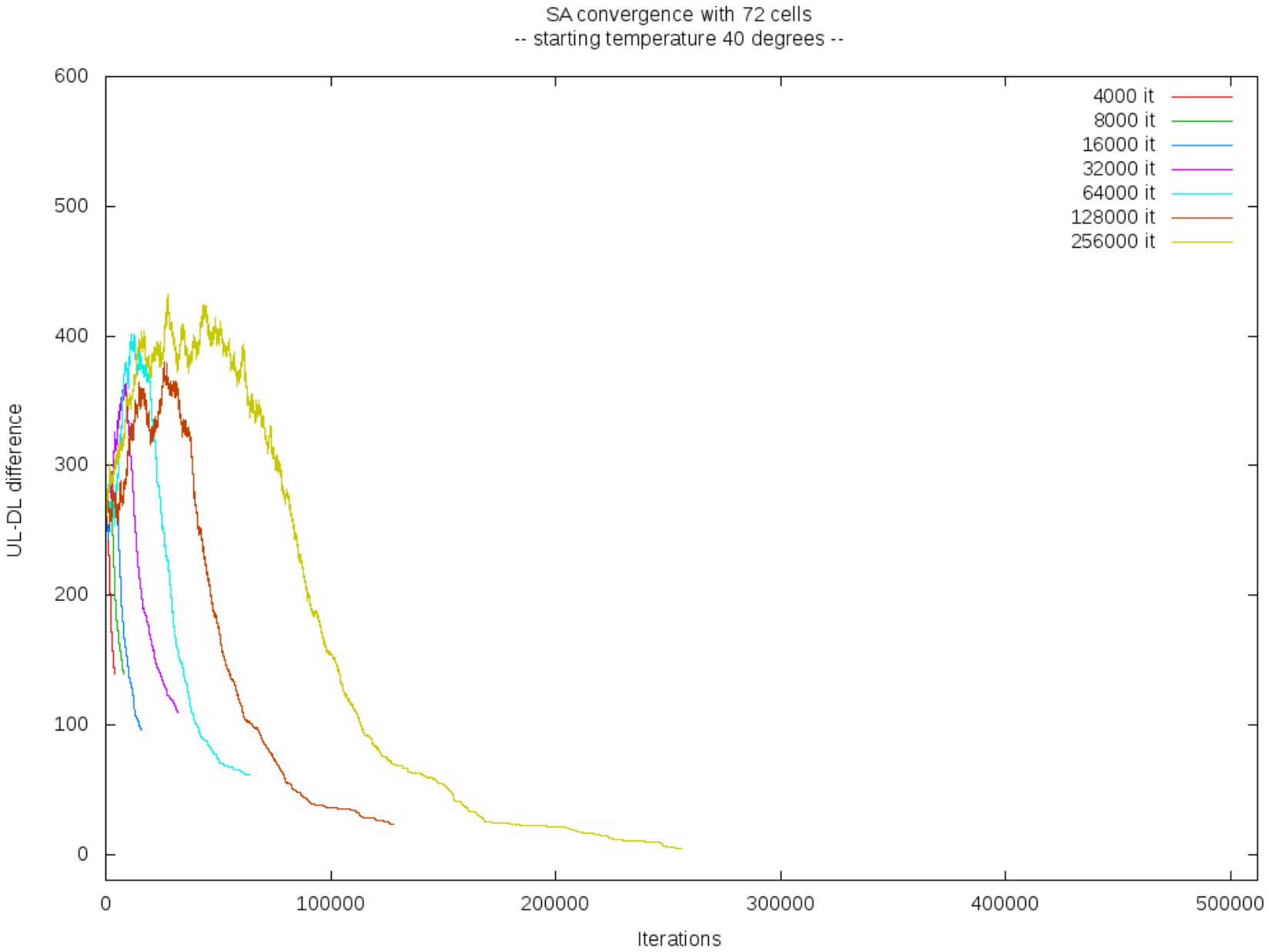

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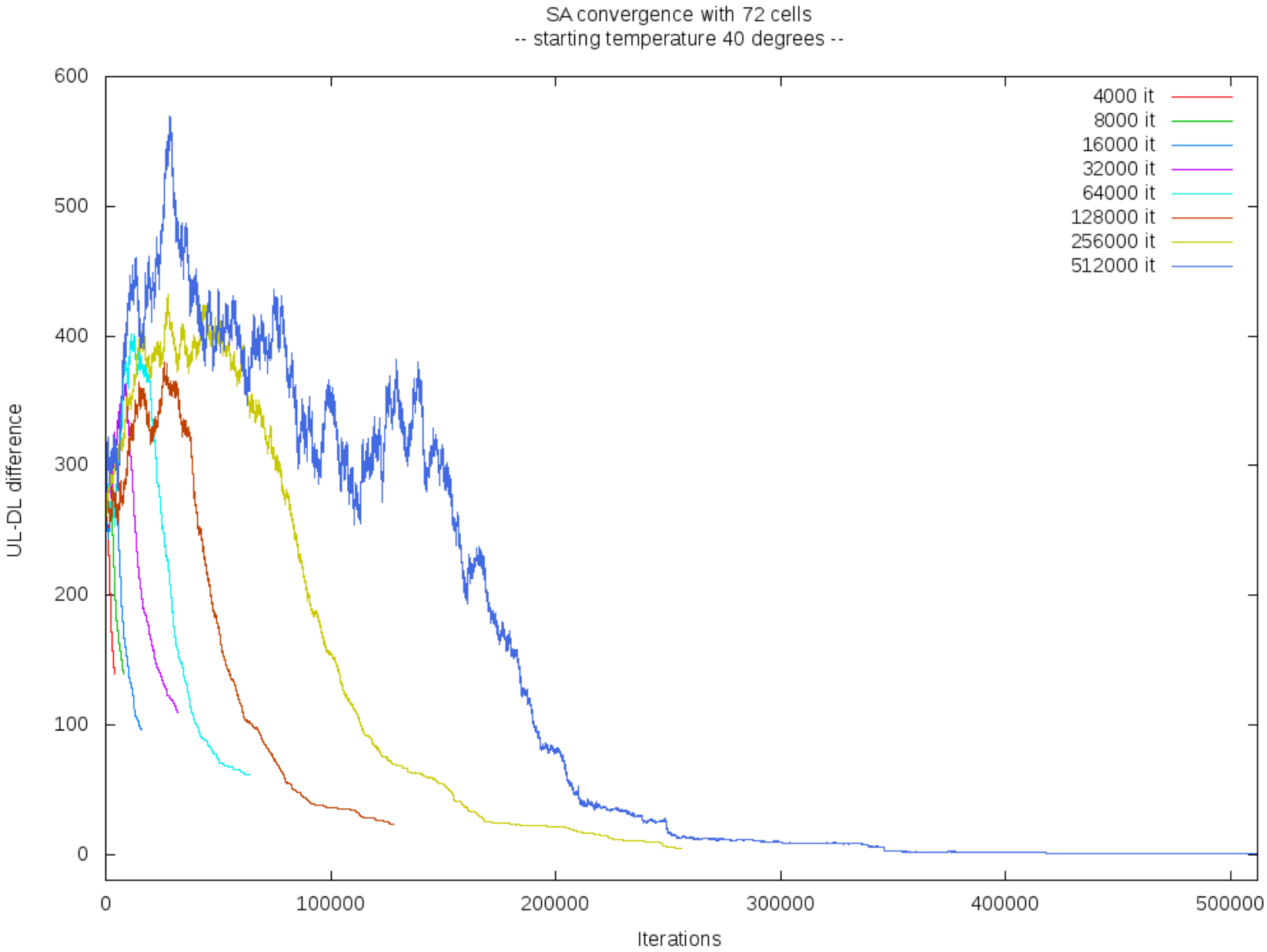
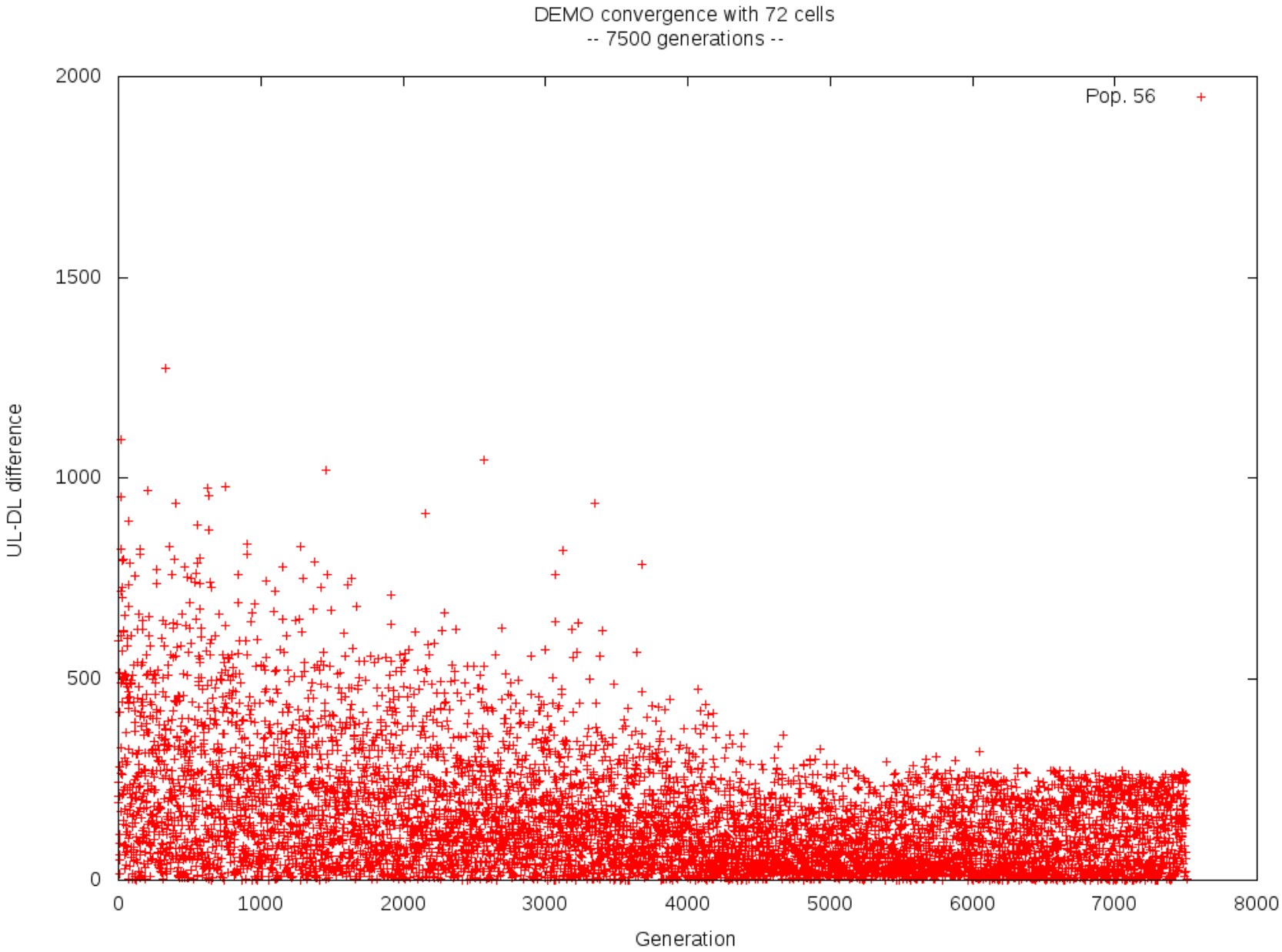


DEMO: Population size



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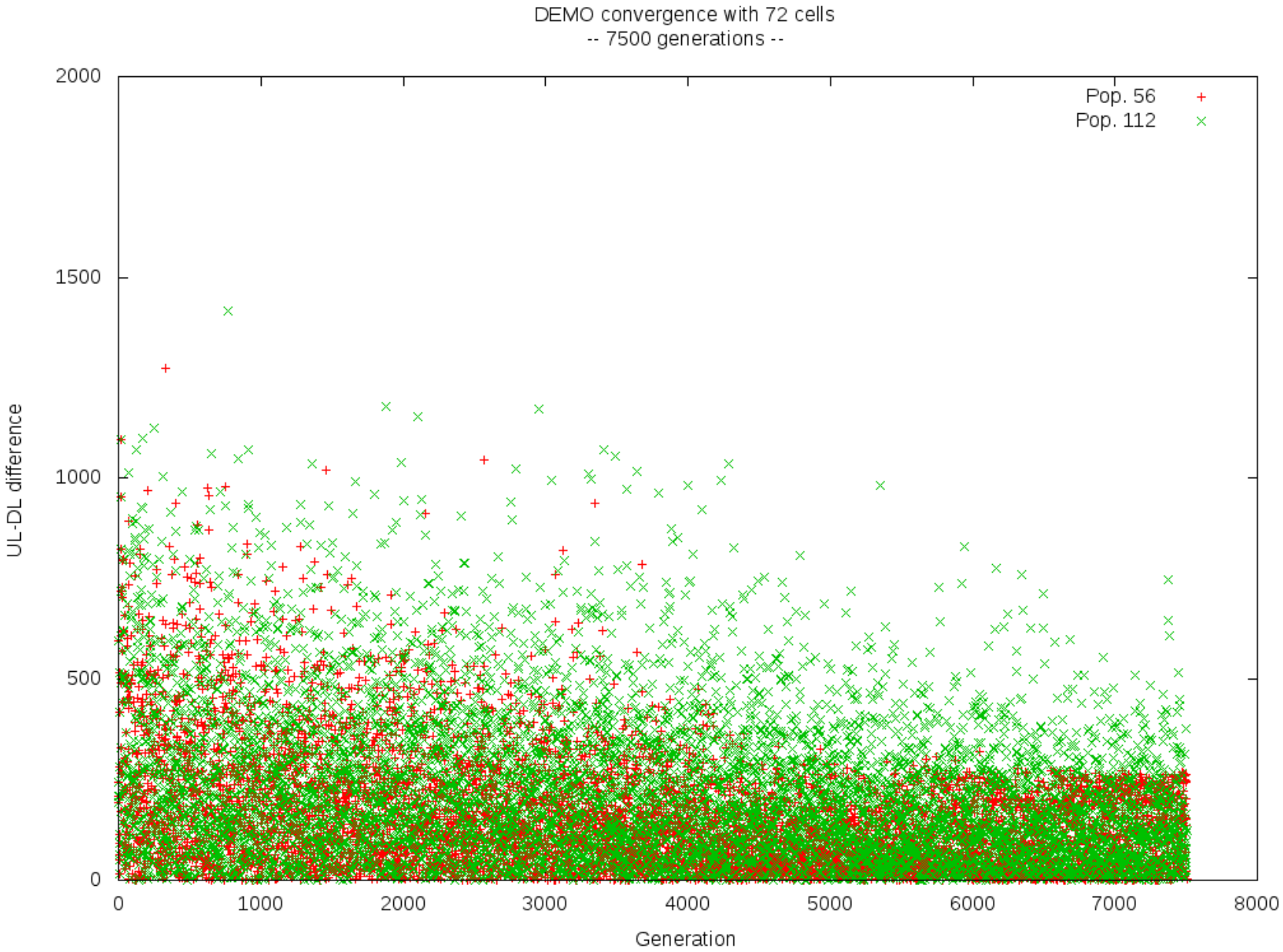

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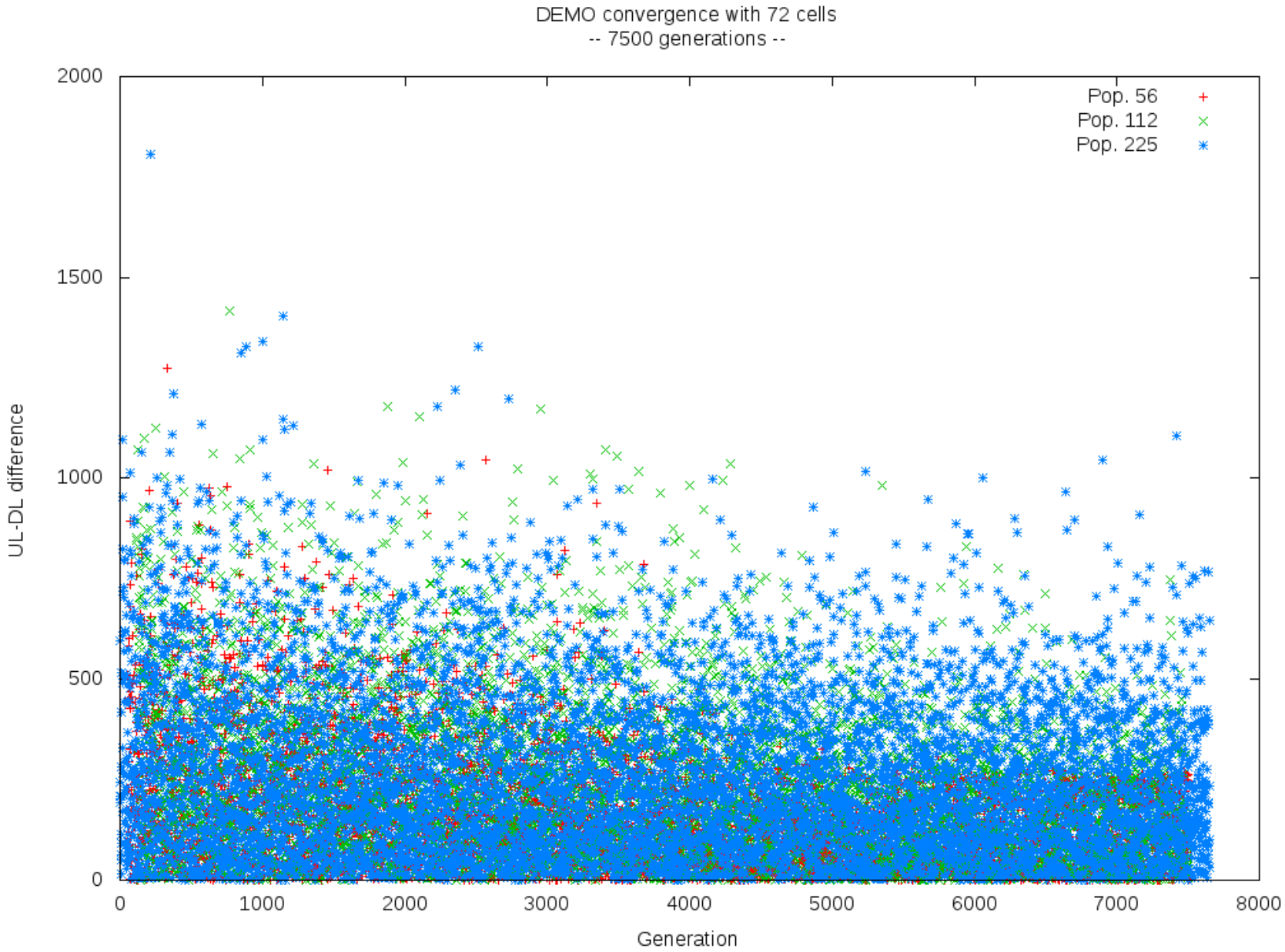

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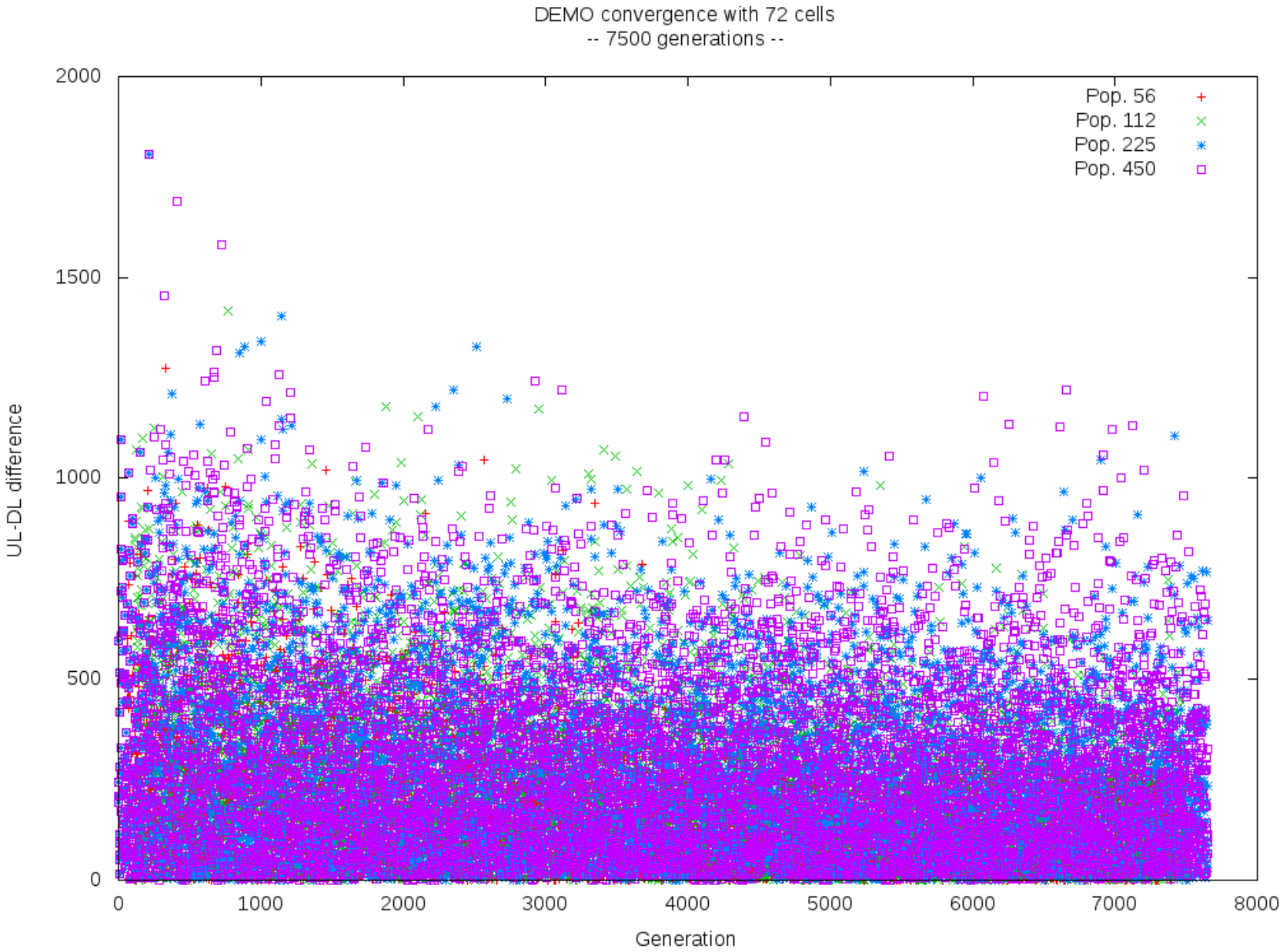

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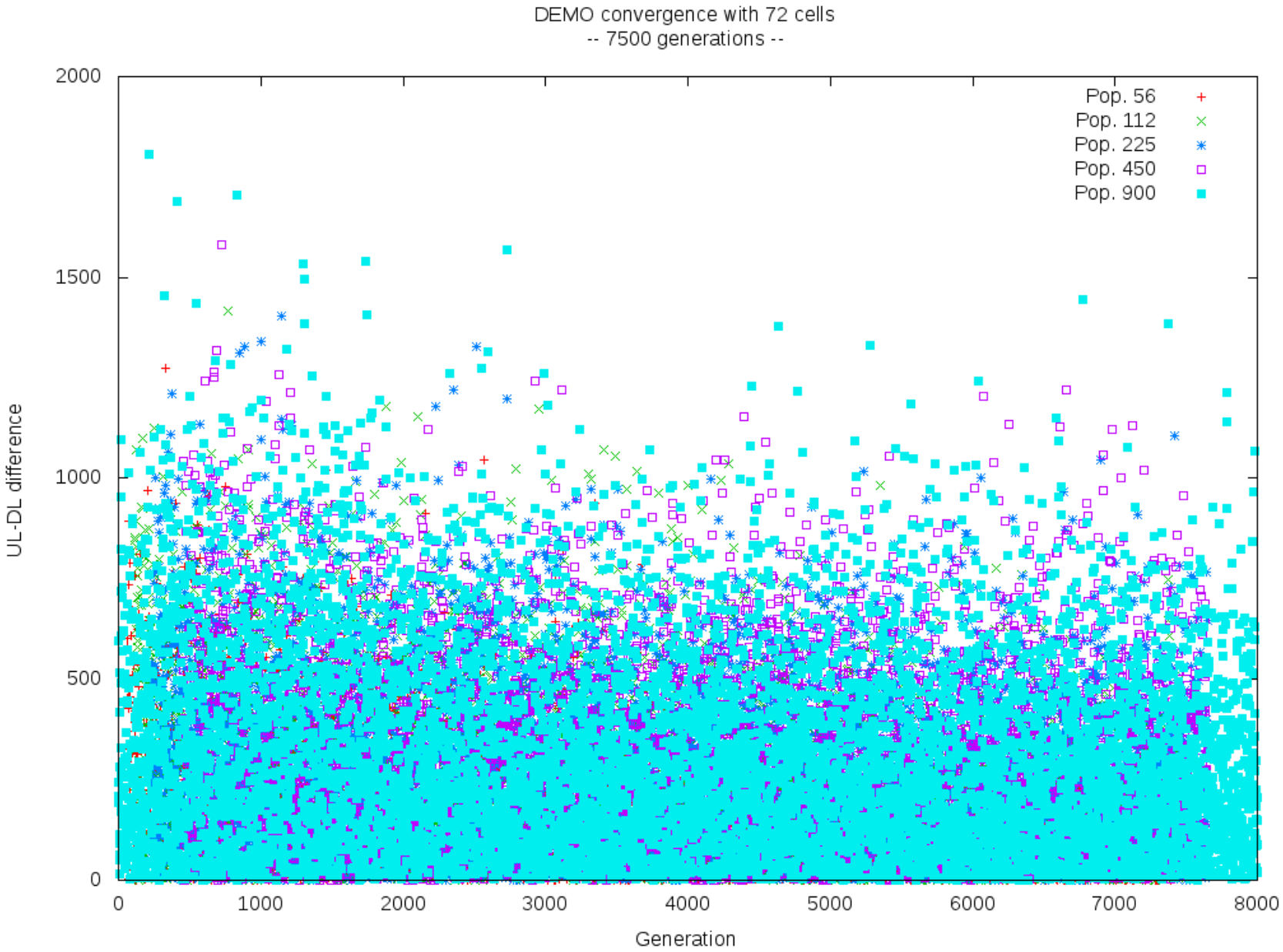

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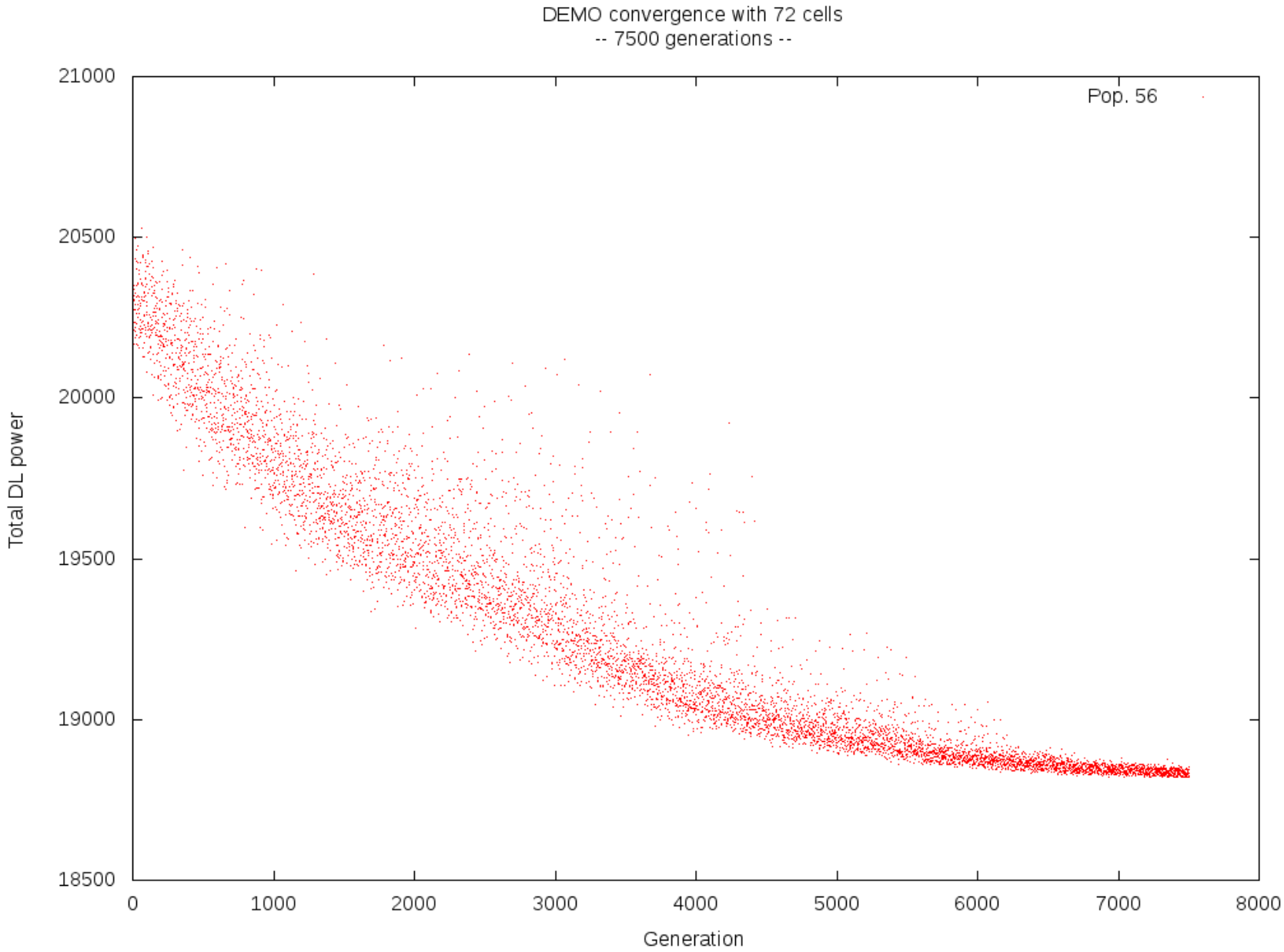

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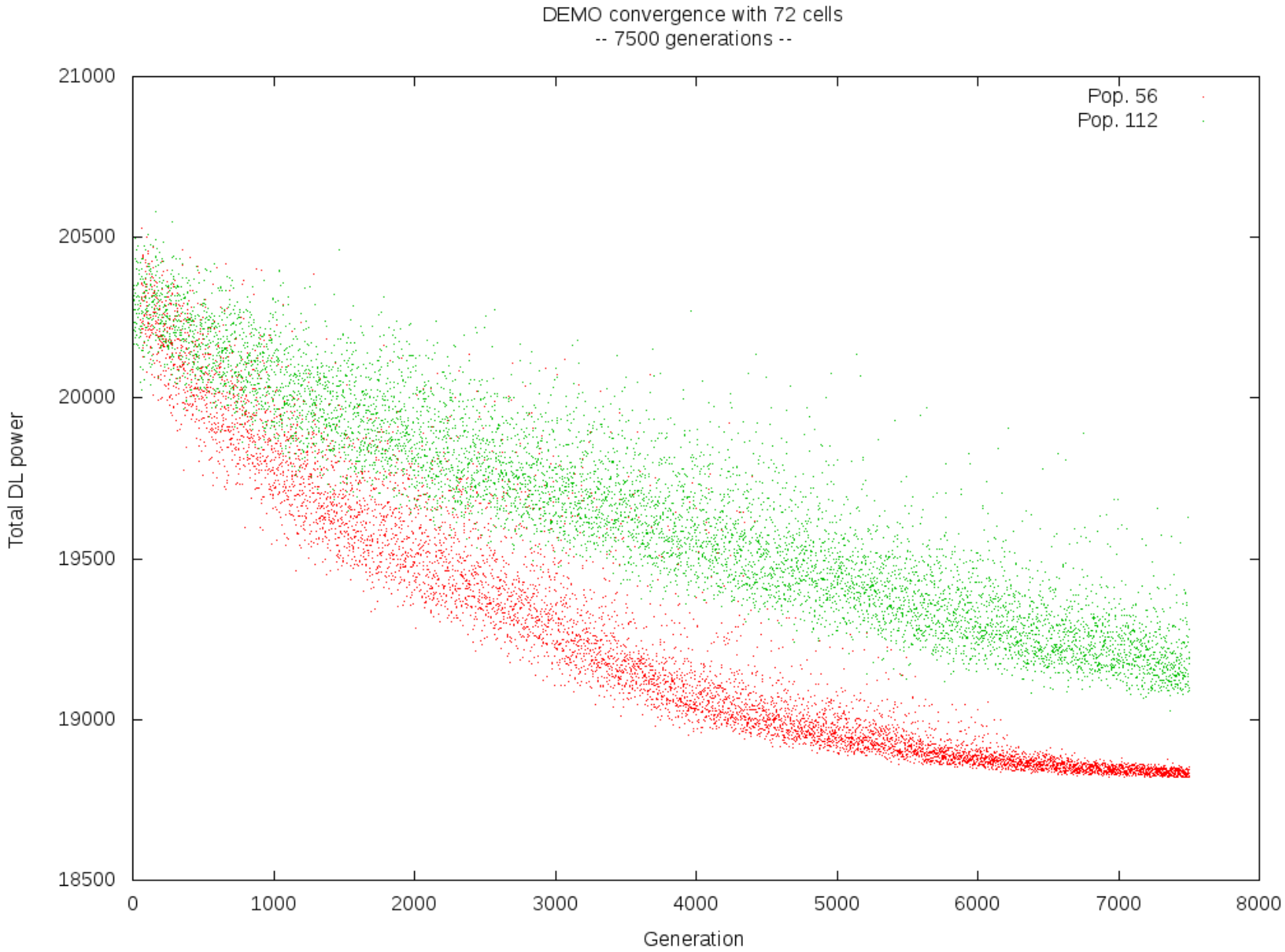

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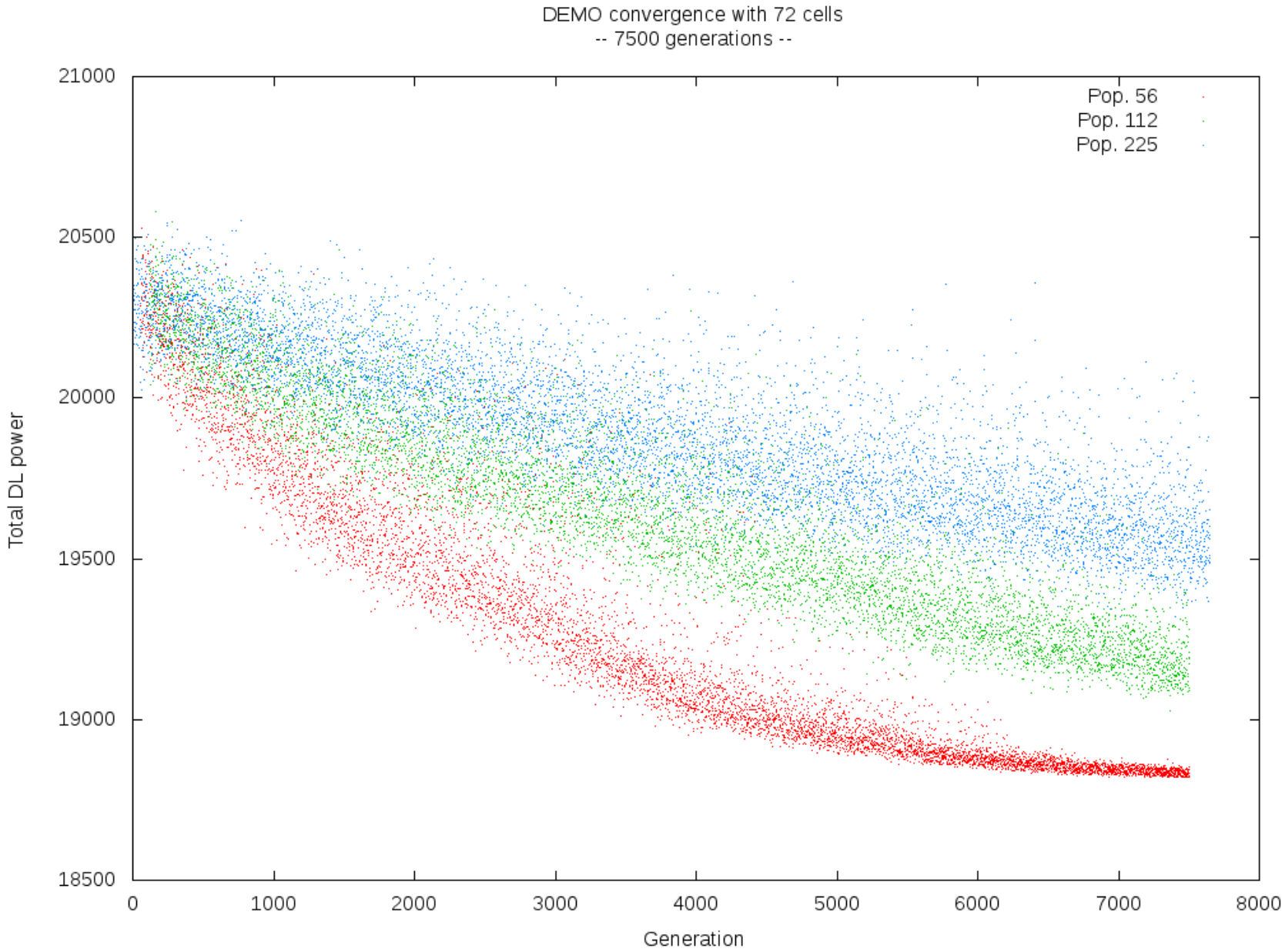

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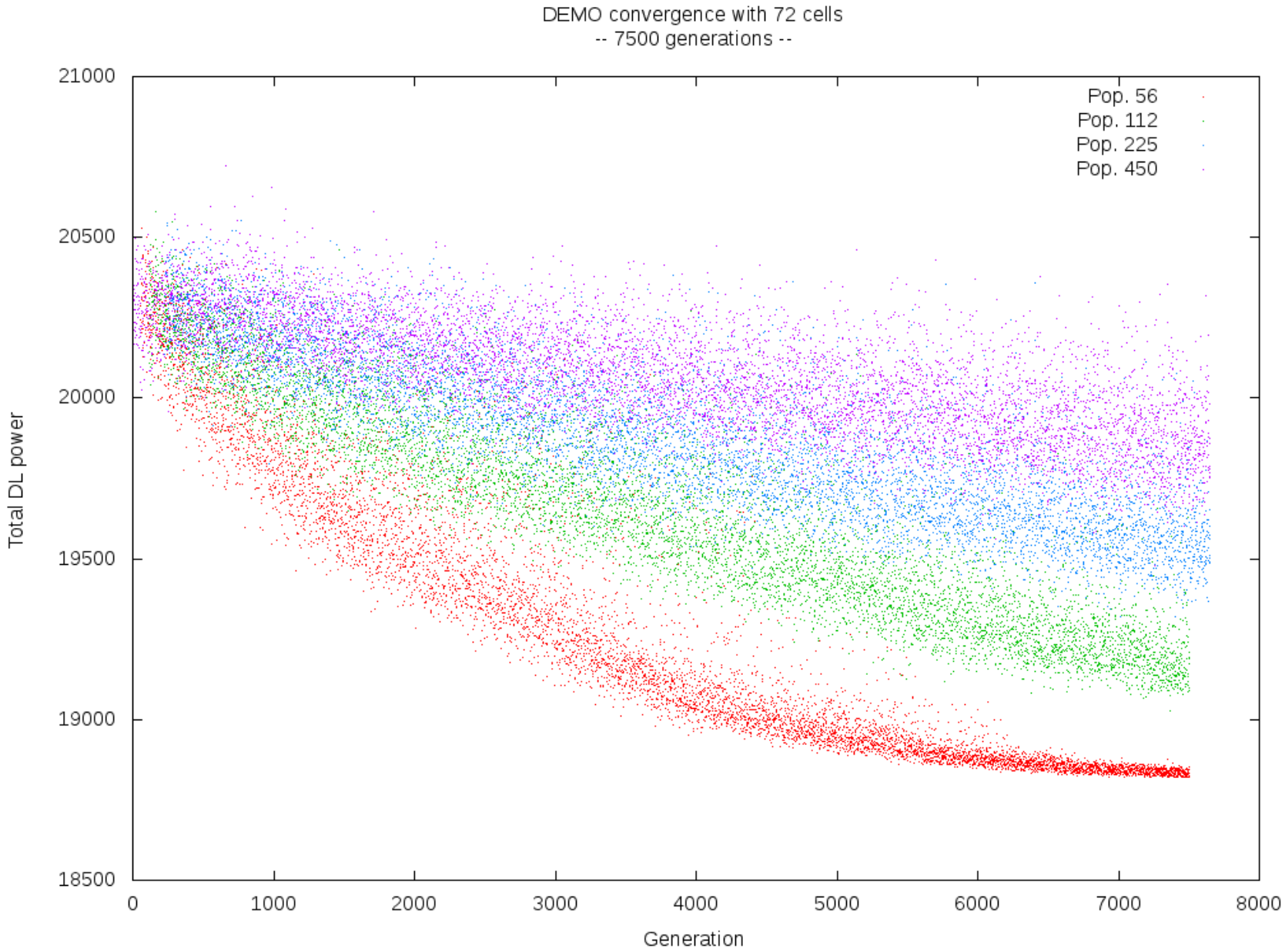

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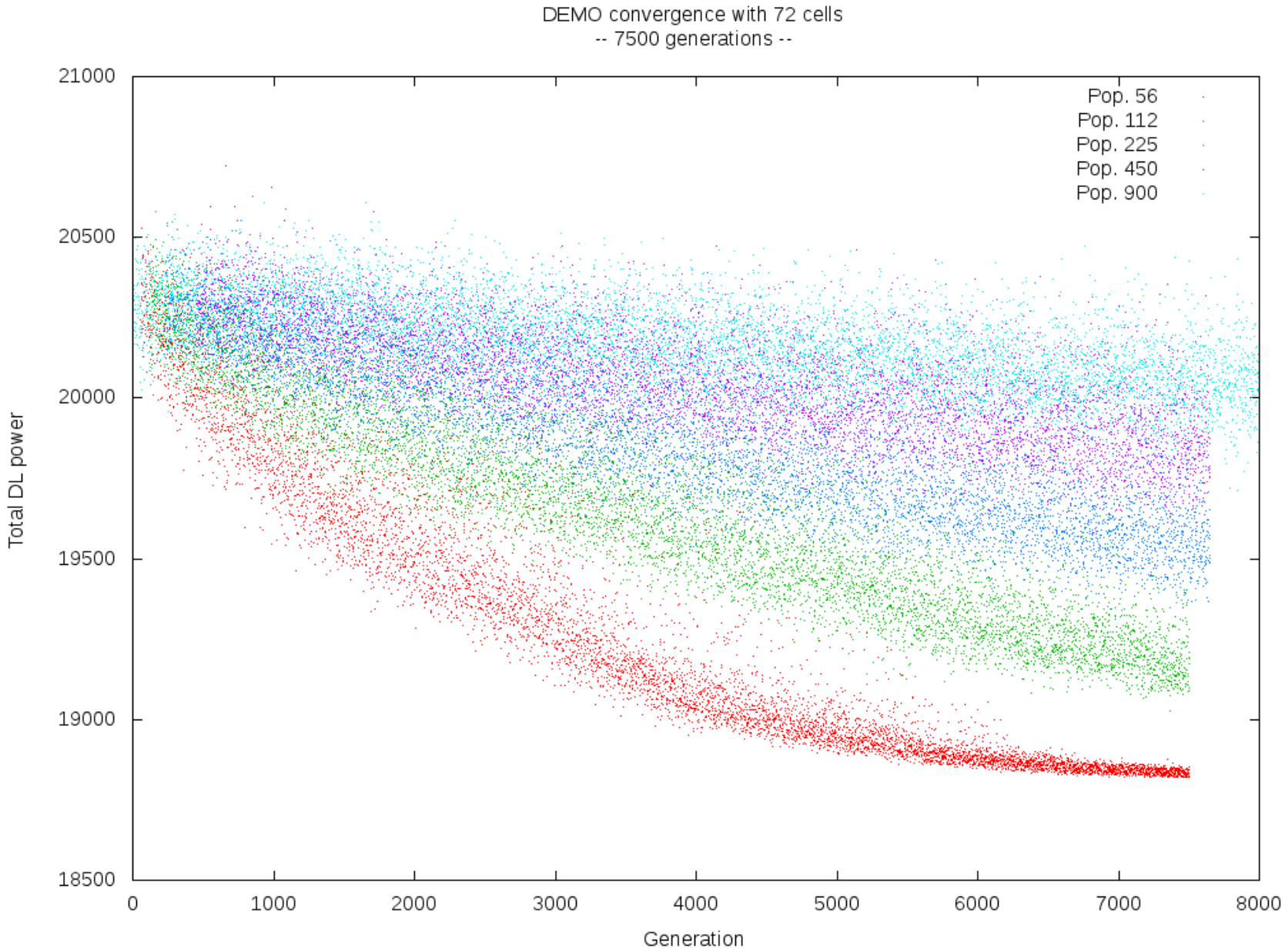
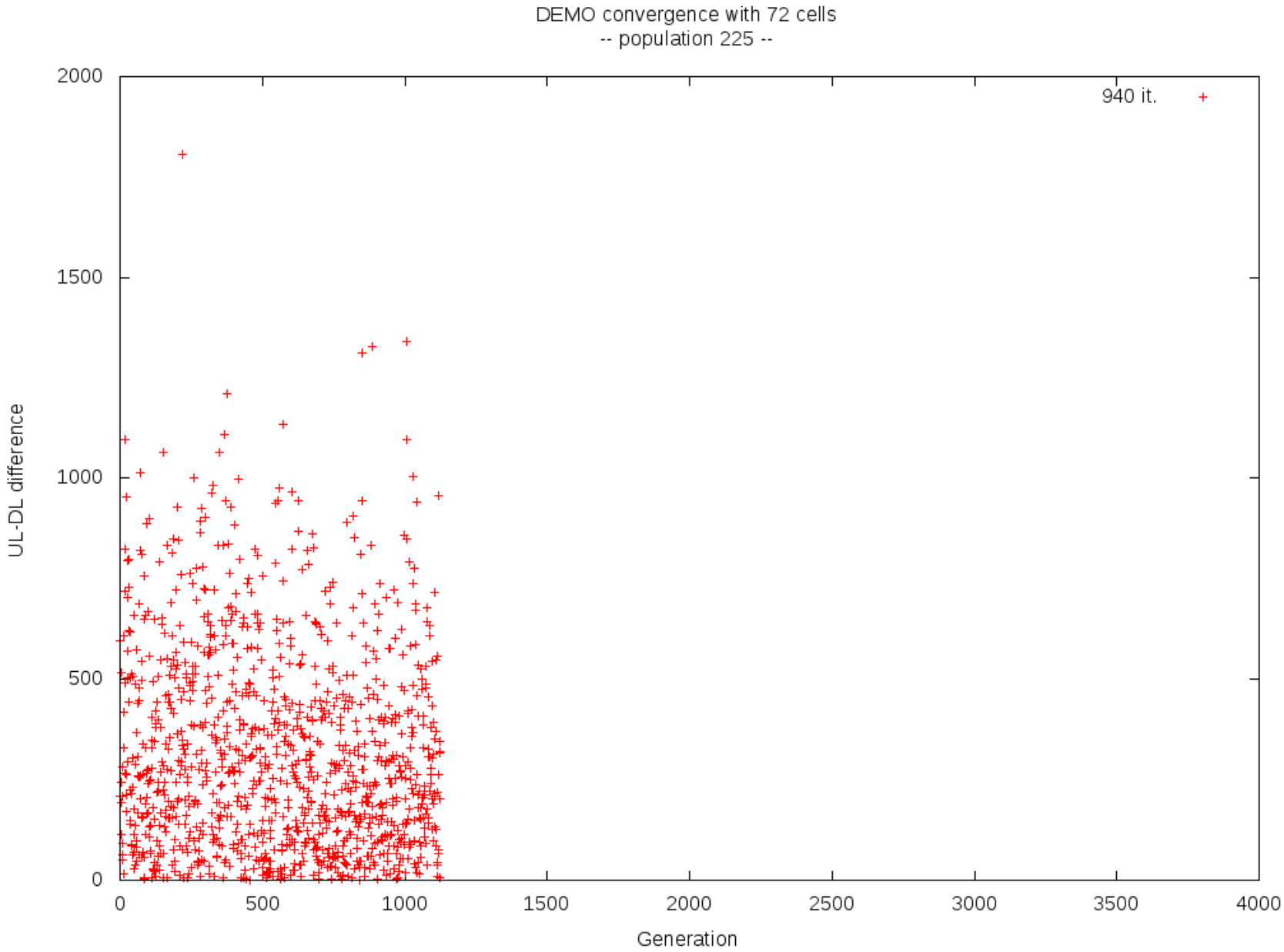


DEMO: Number of generations



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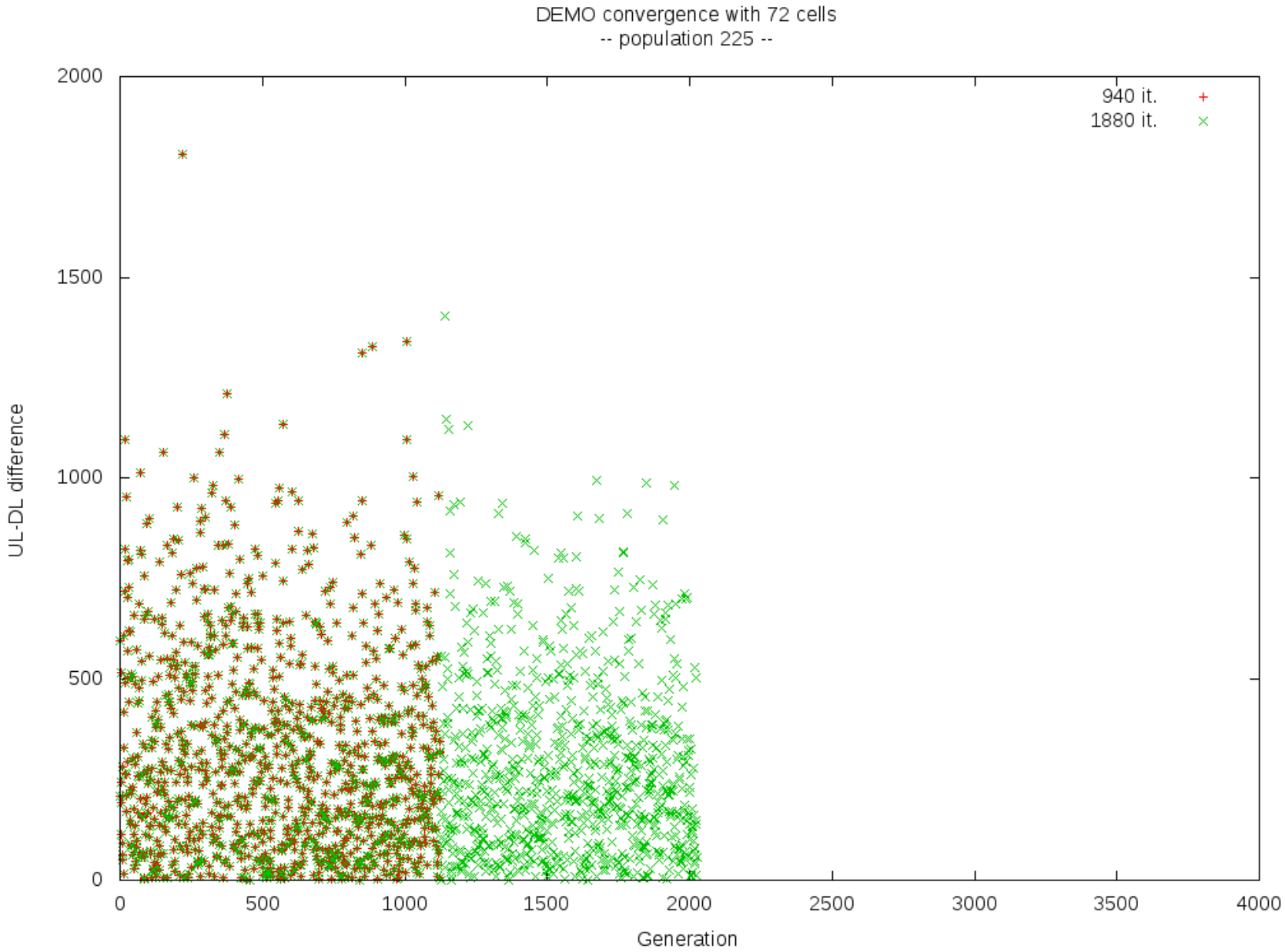

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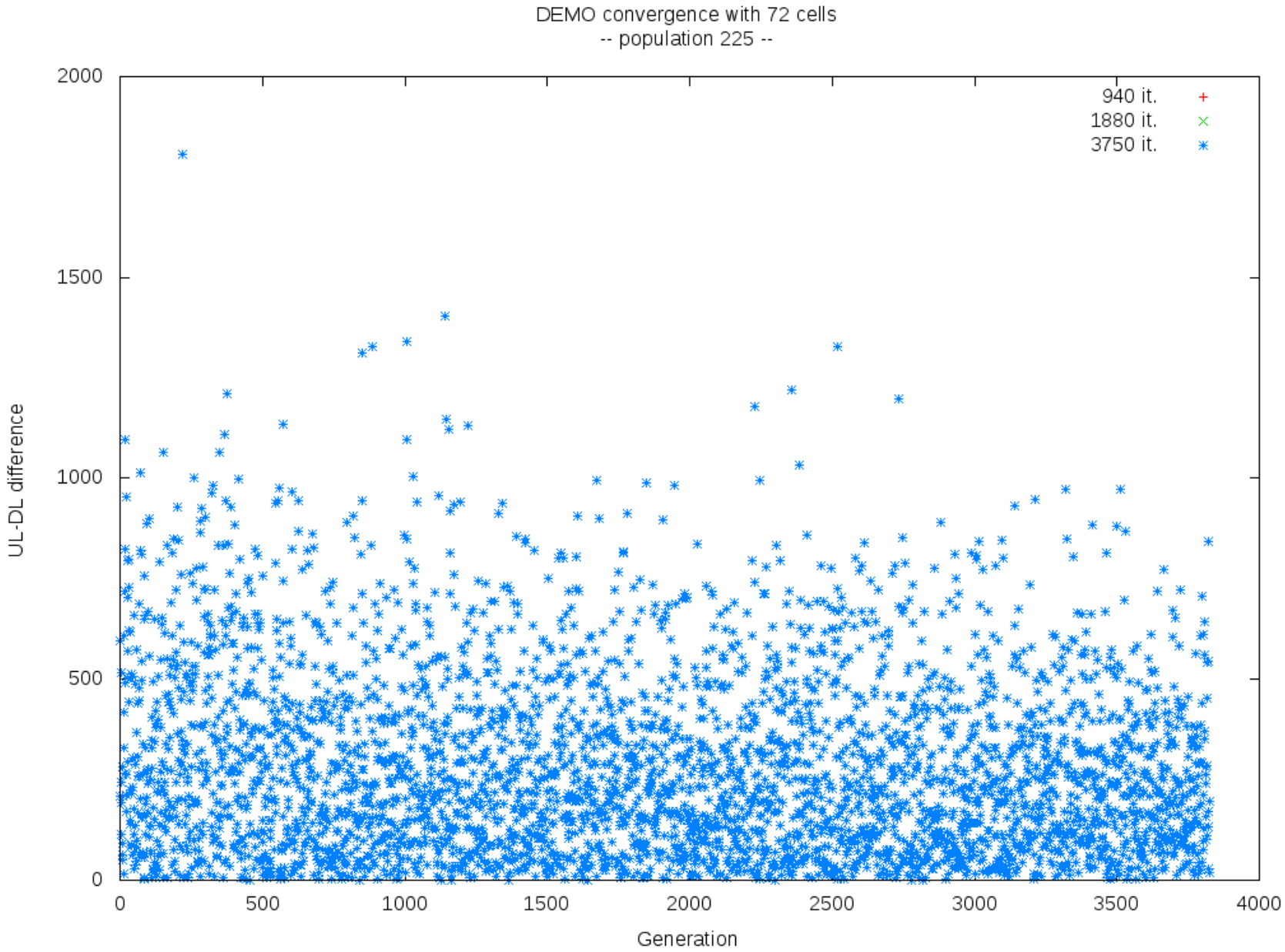

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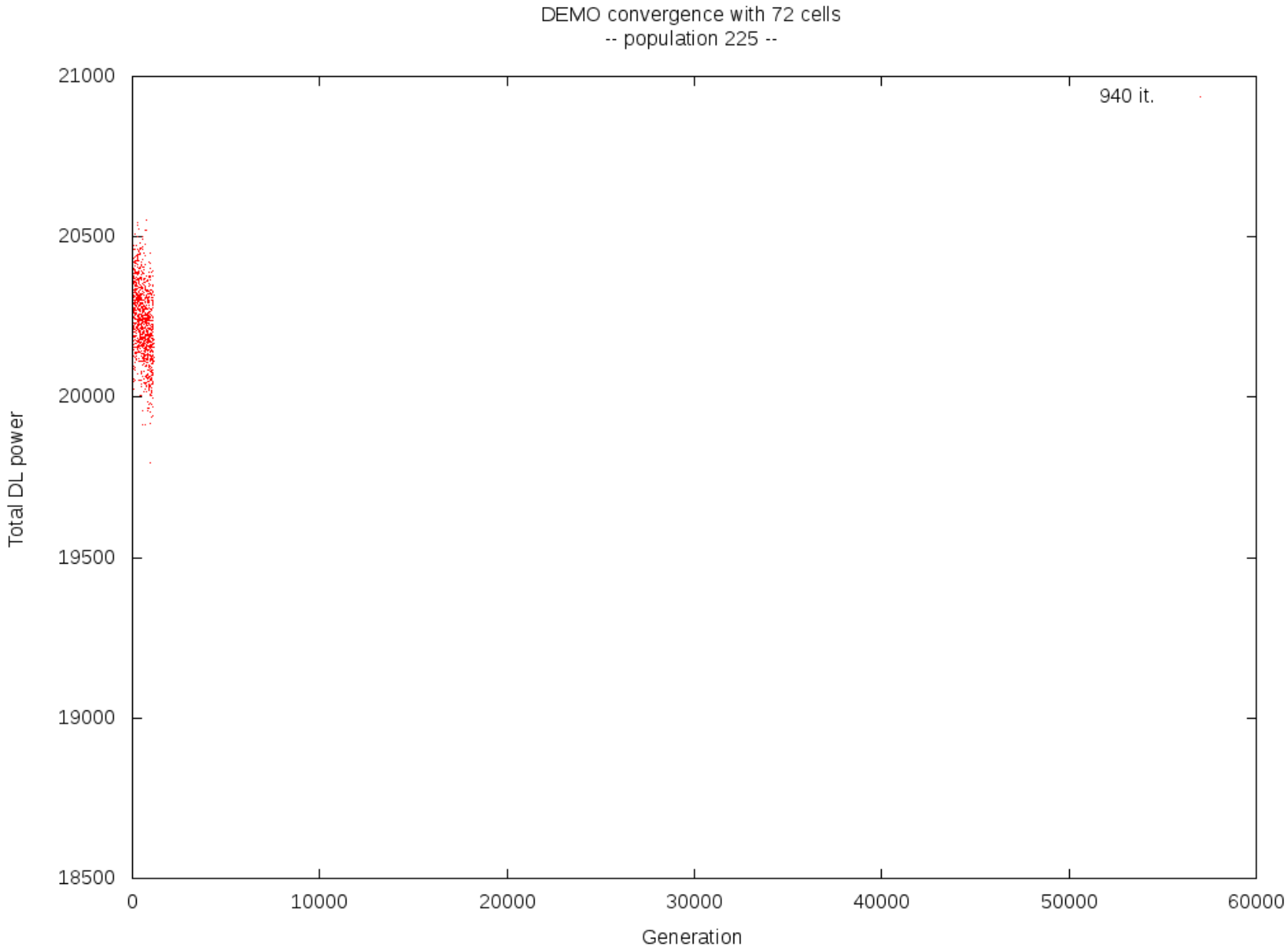
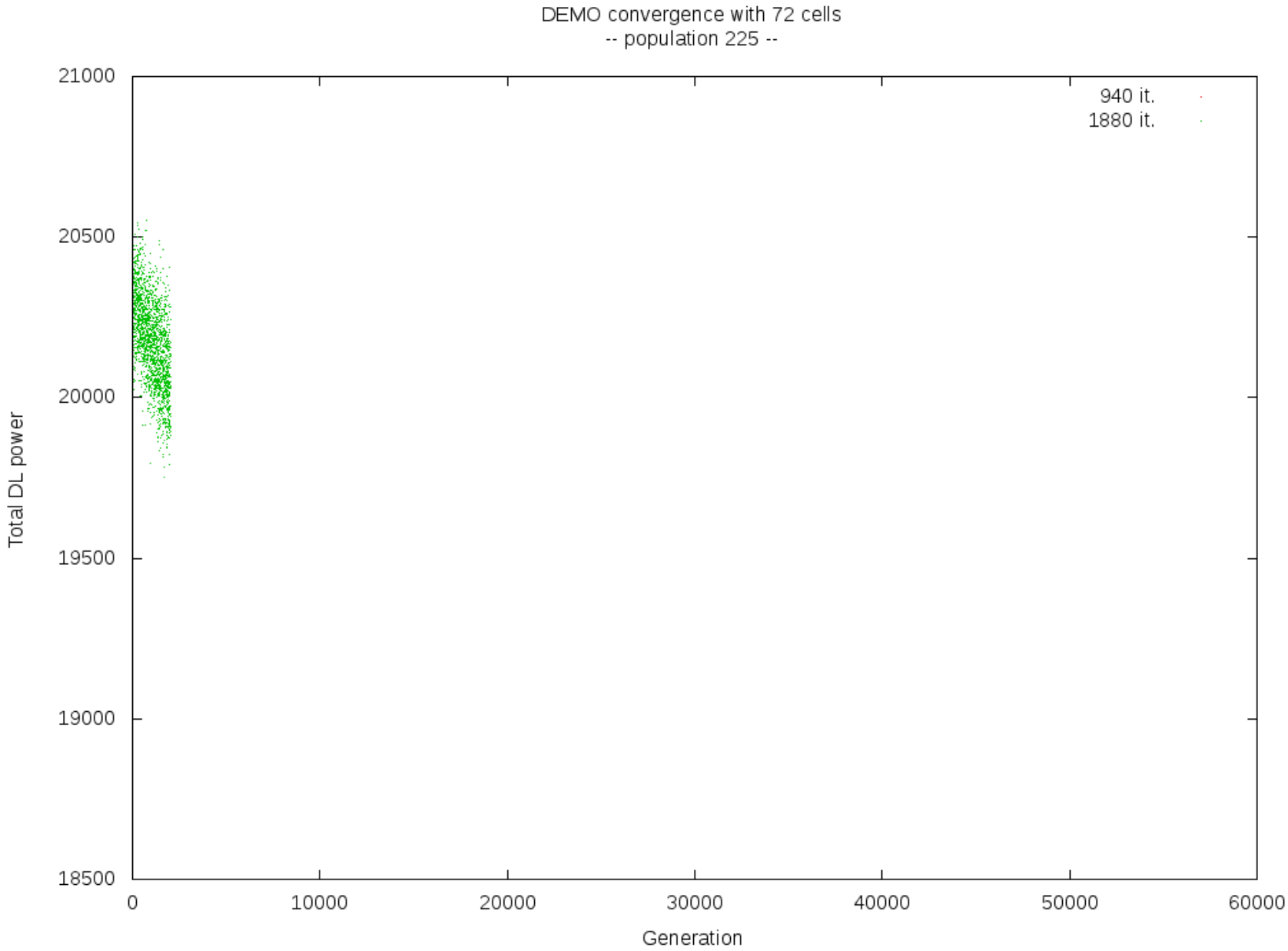
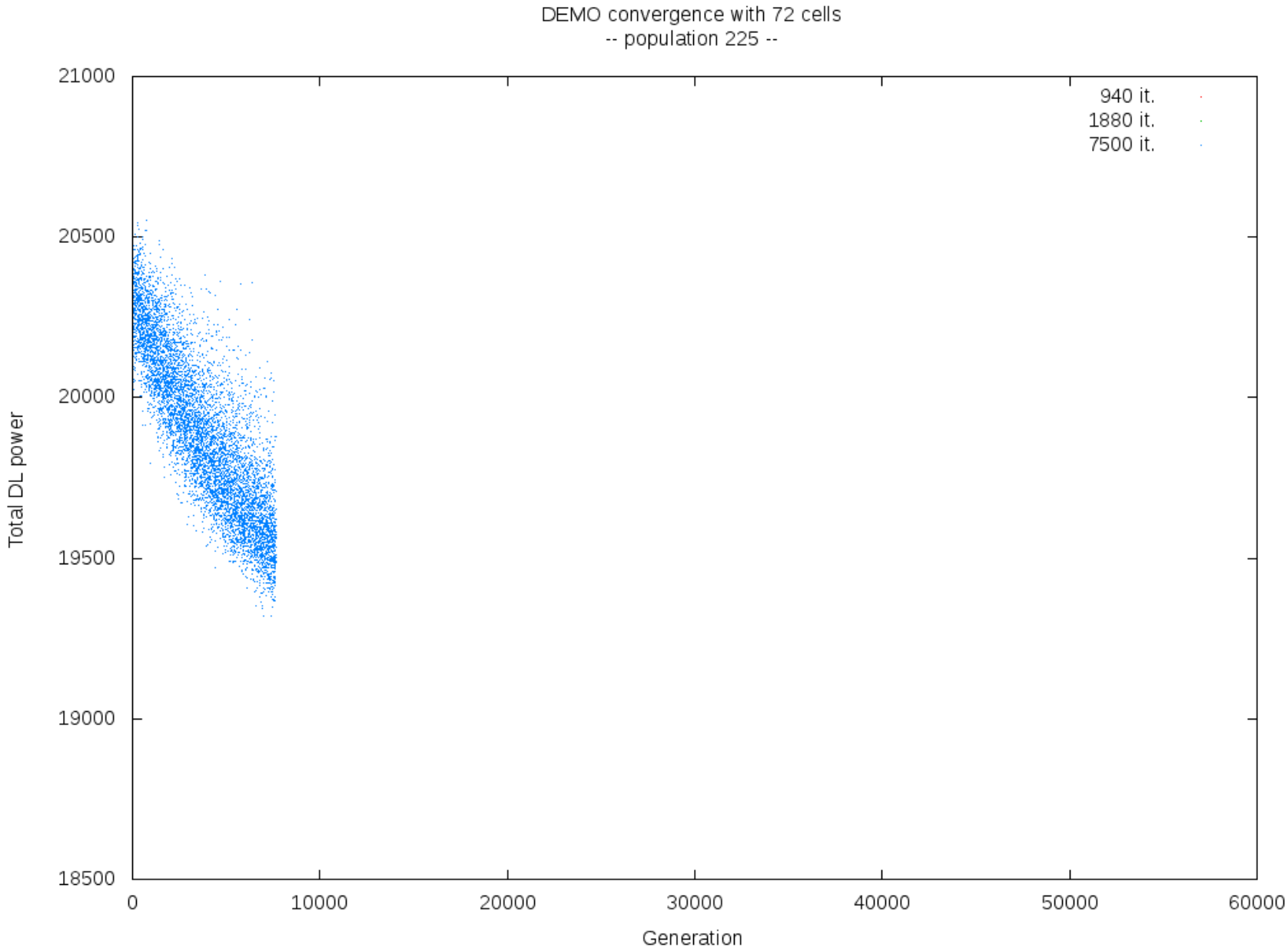


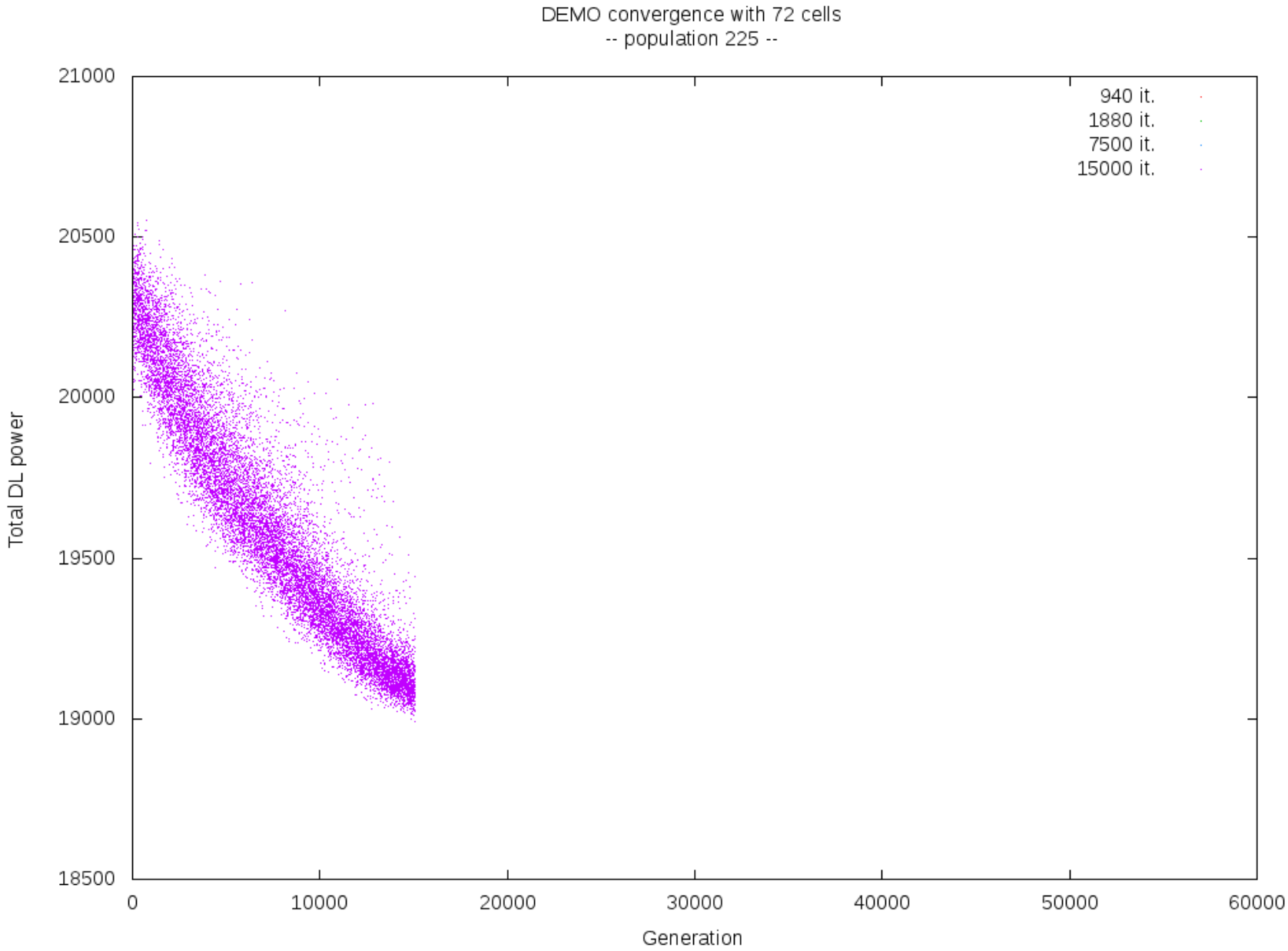
DEMO: Number of generations



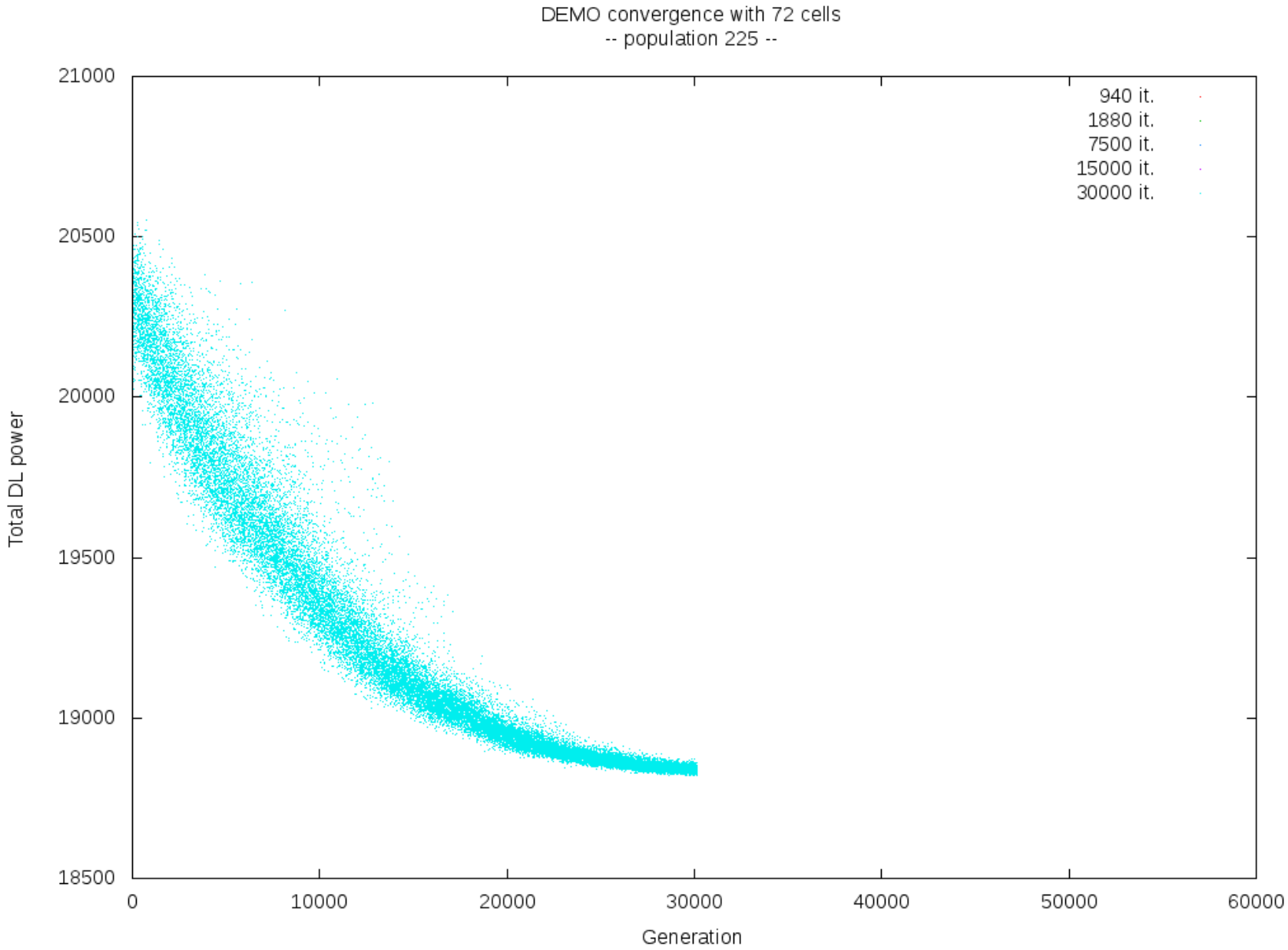
DEMO: Number of generations



DEMO: Number of generations



DEMO: Number of generations



DEMO: Number of generations