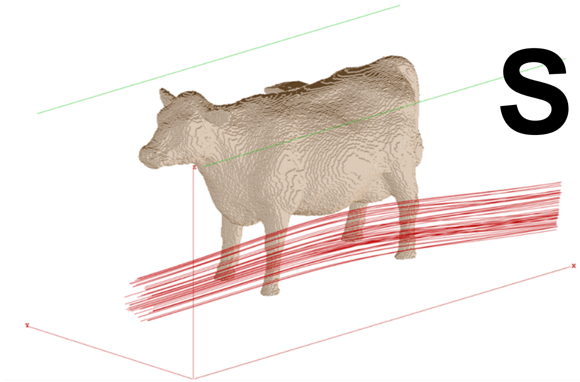
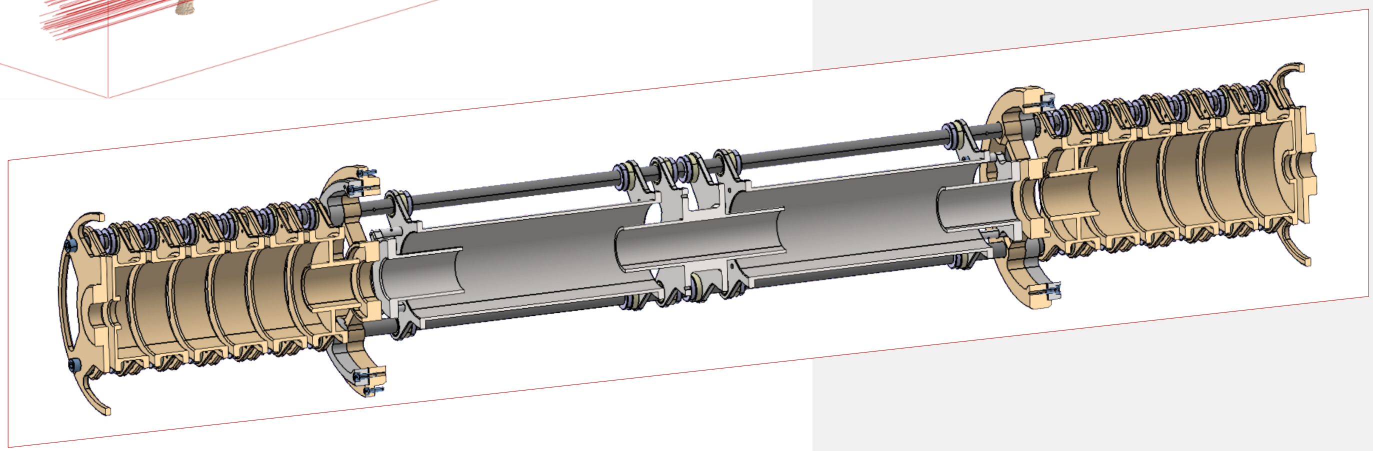
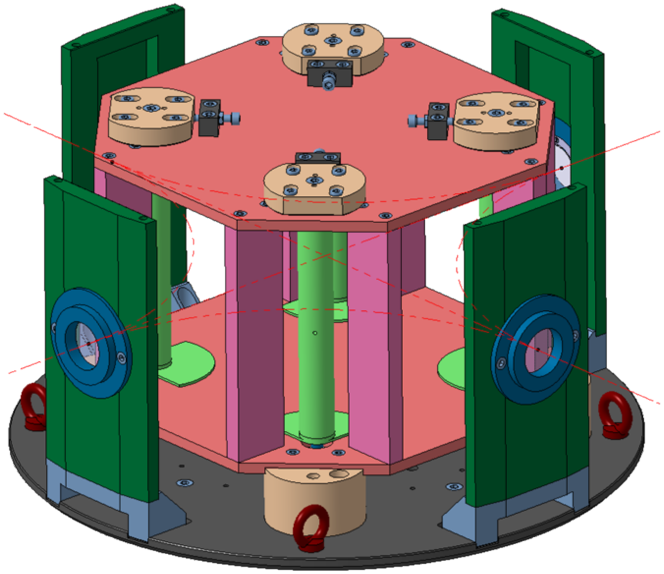
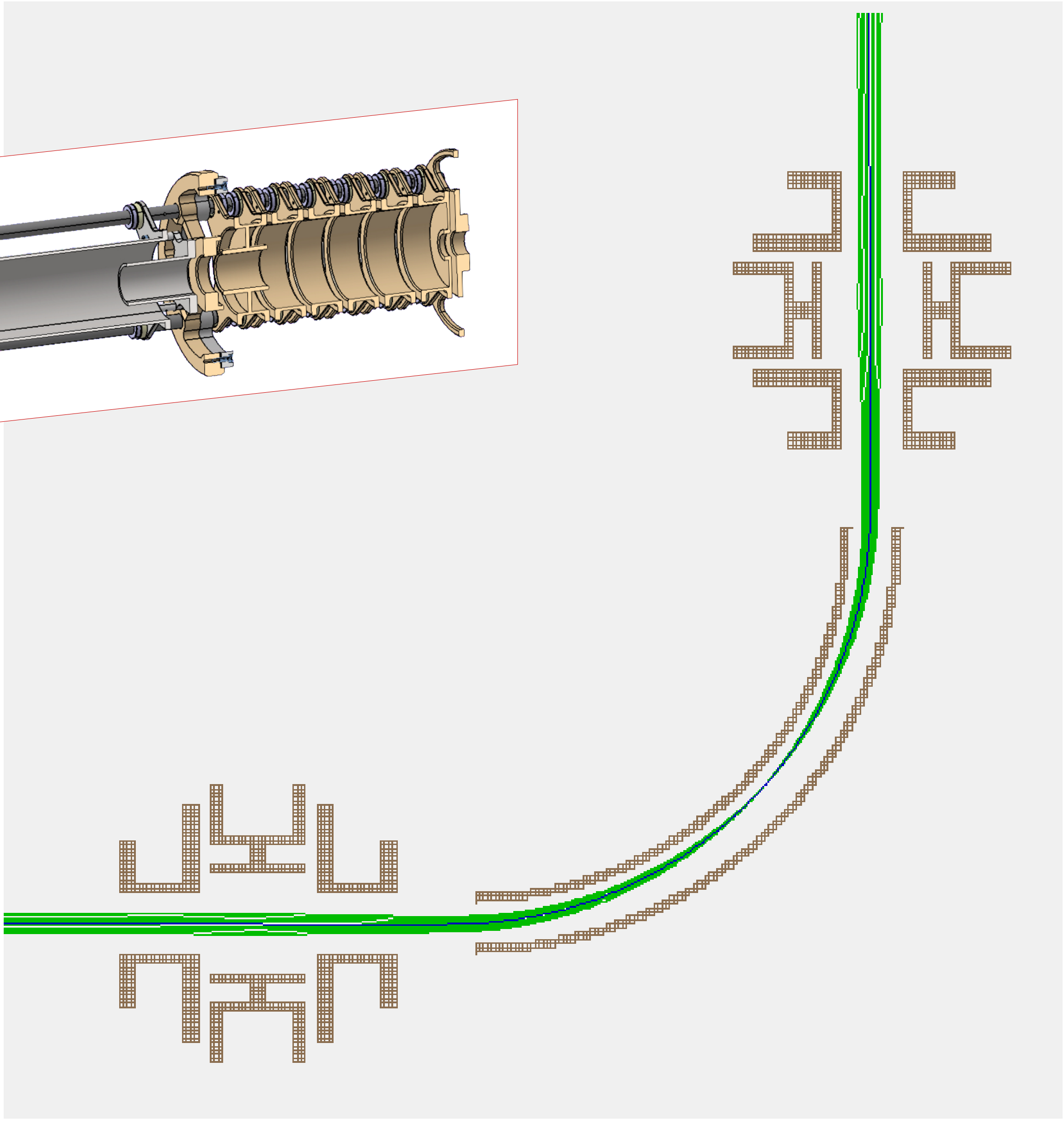
SIMION's Simplex optimizer









Introduction

- How to optimize an ion optics device ?

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- Built in Simplex optimizer in SIMION.

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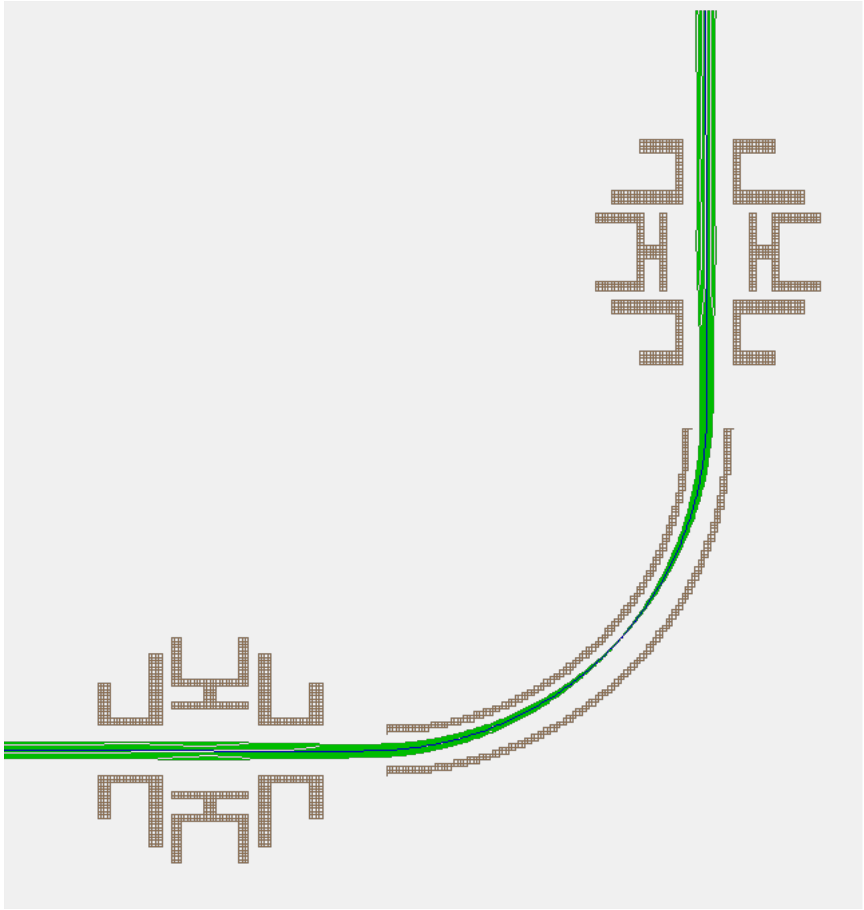
- Some limitations, no ion optics theory
- Example of a 90° blade deflector



Outline

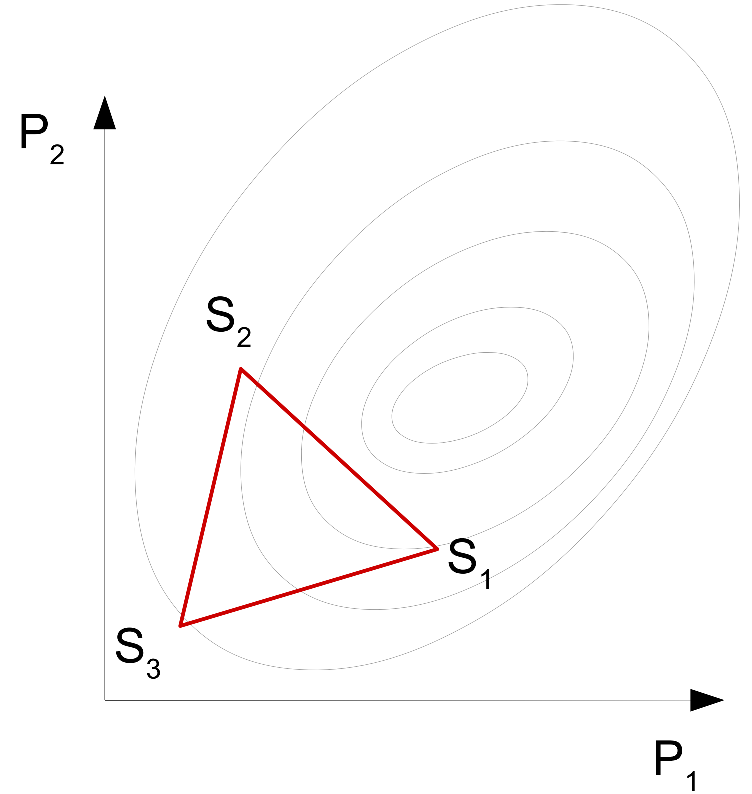
I. The Nelder-Mead Algorithm

II. Potential optimization

III. Geometric optimization

The Nelder-Mead algorithm

1. Sort the parameter sets S_1 , … , S_{n+1} so $f(S_1)$ < … < (S_{n+1})



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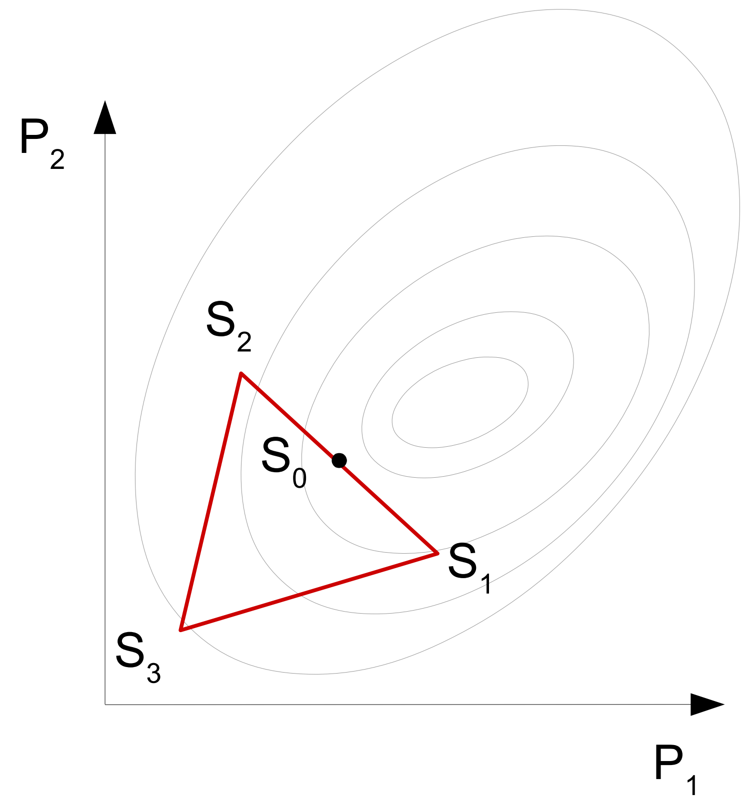

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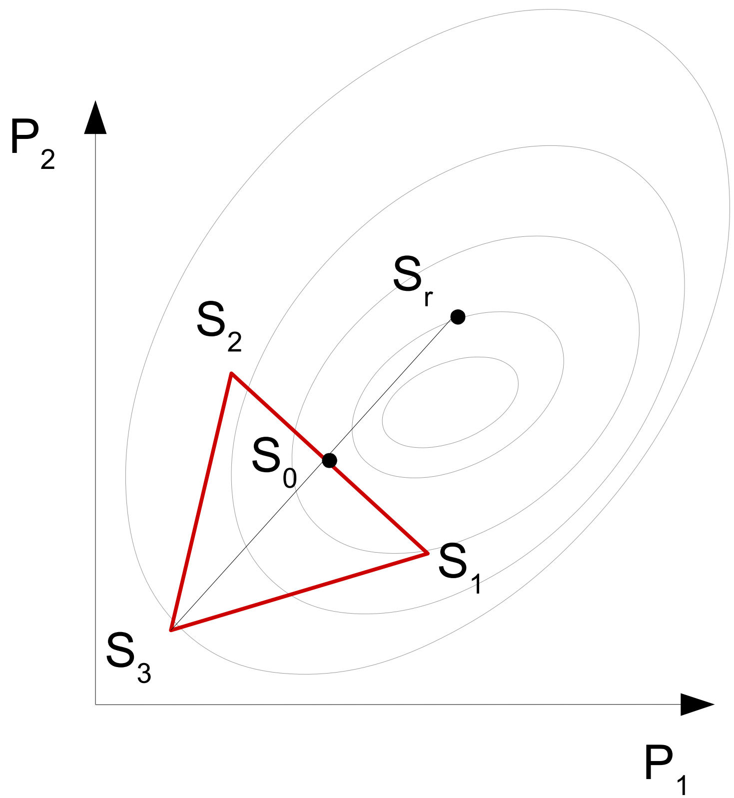

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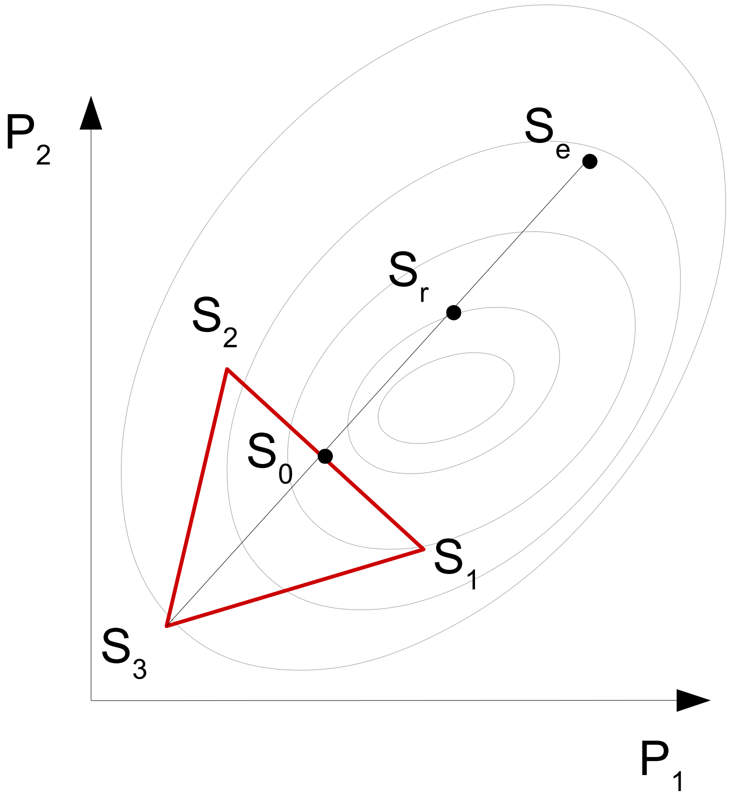

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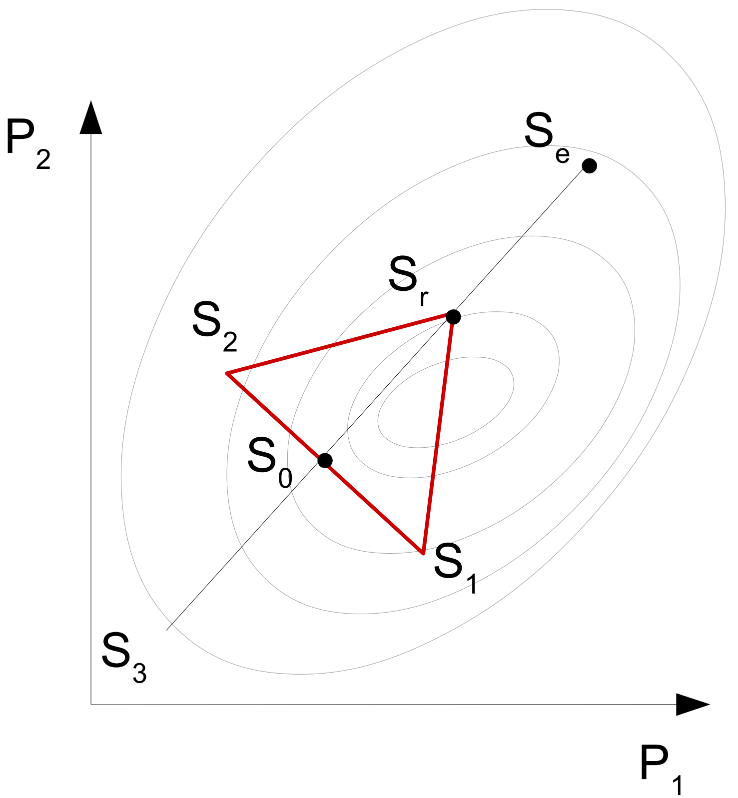

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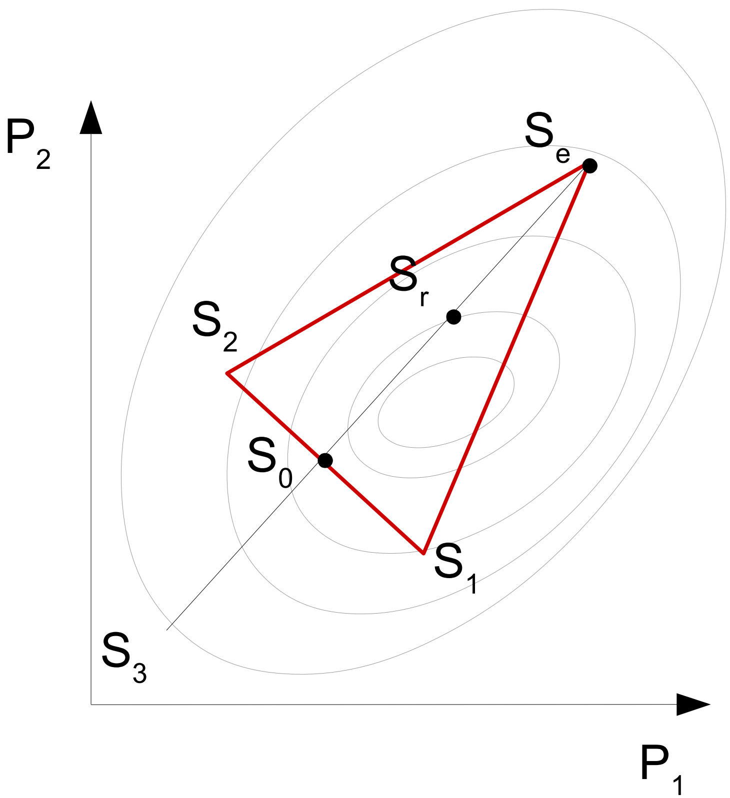

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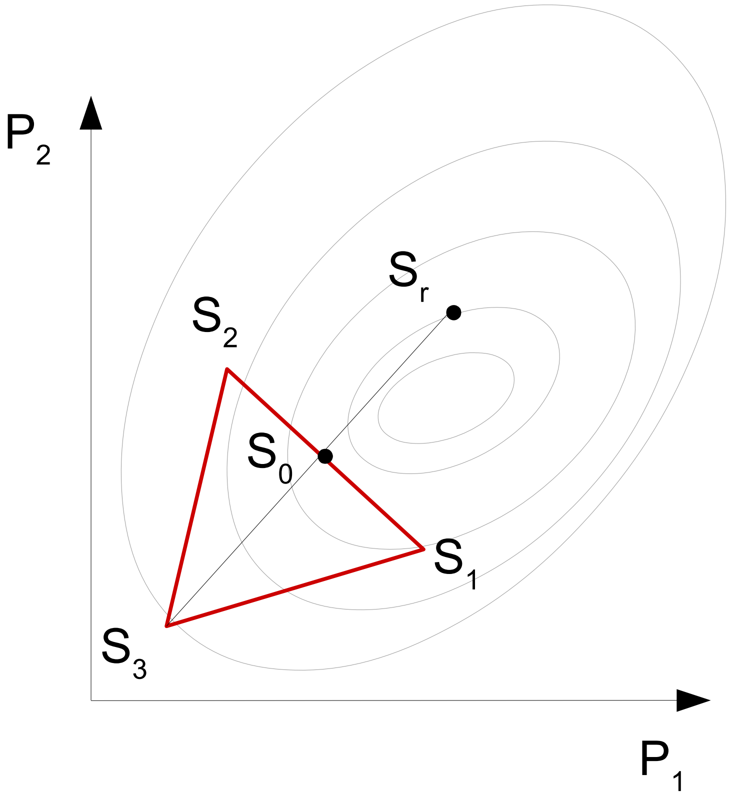

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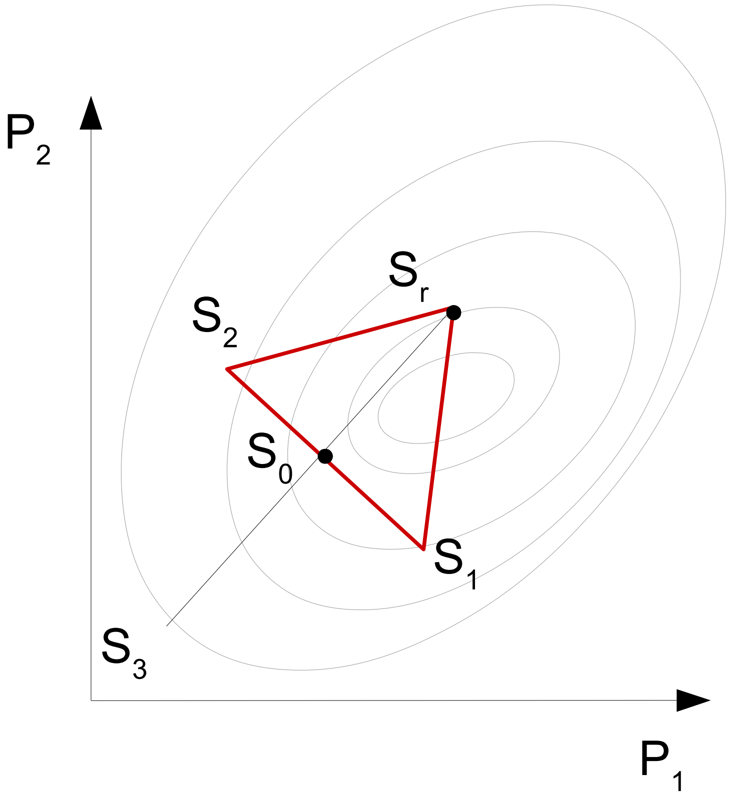

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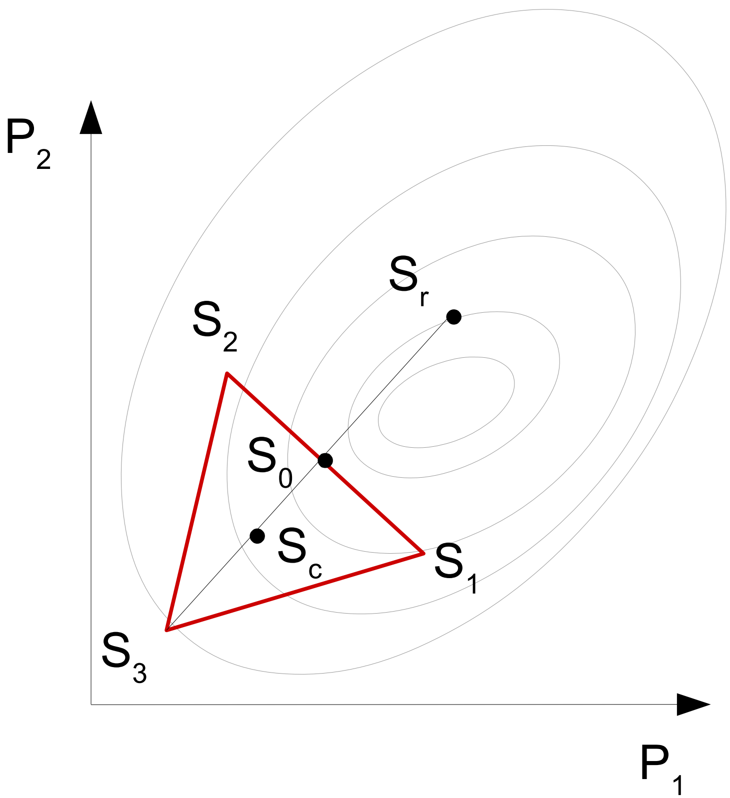

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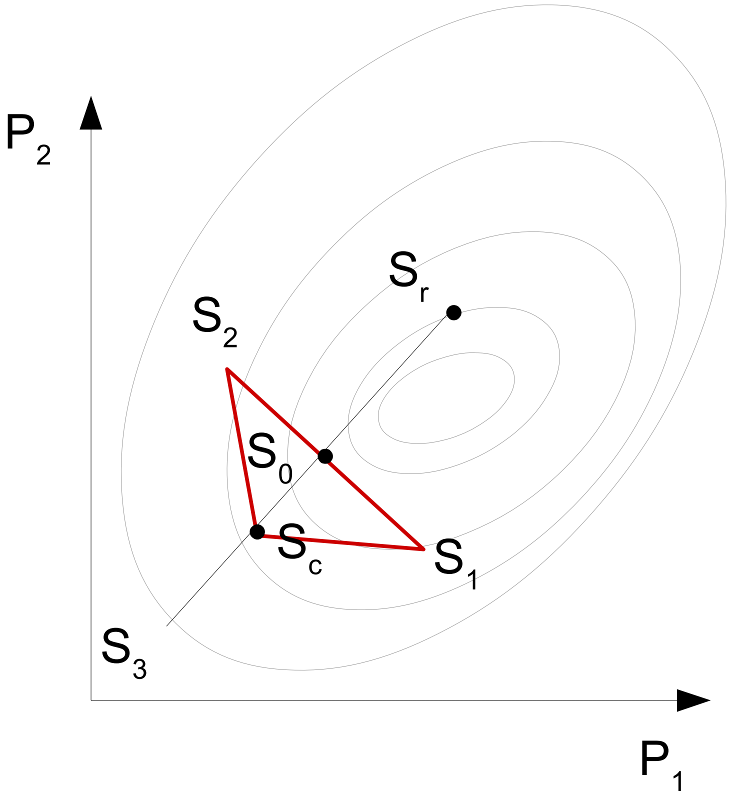

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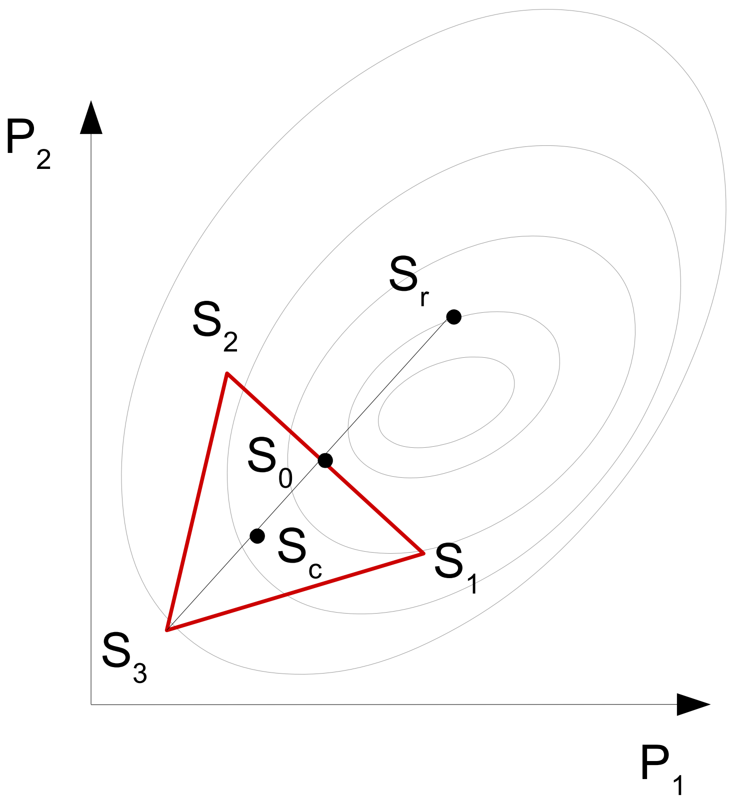

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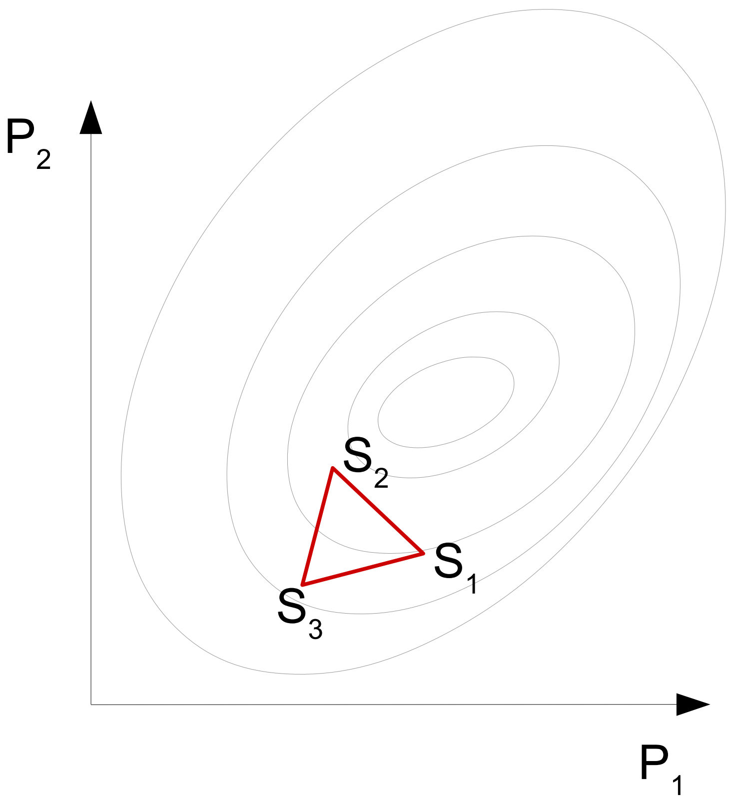

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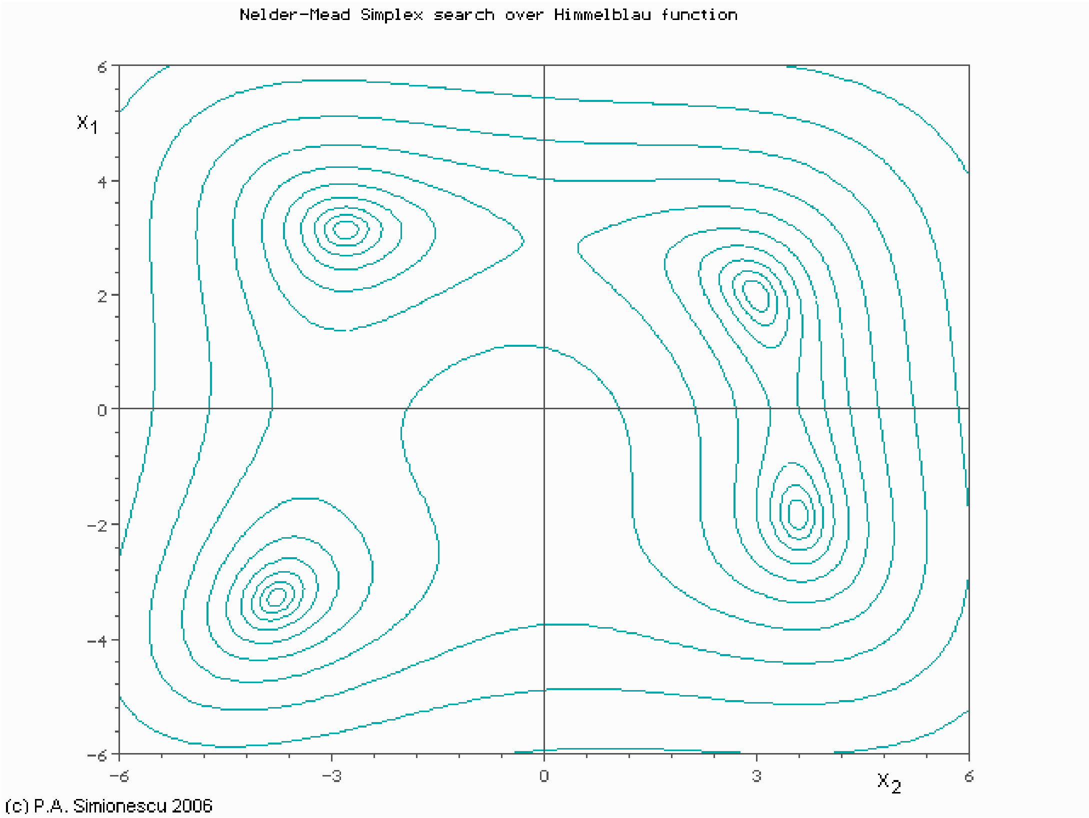

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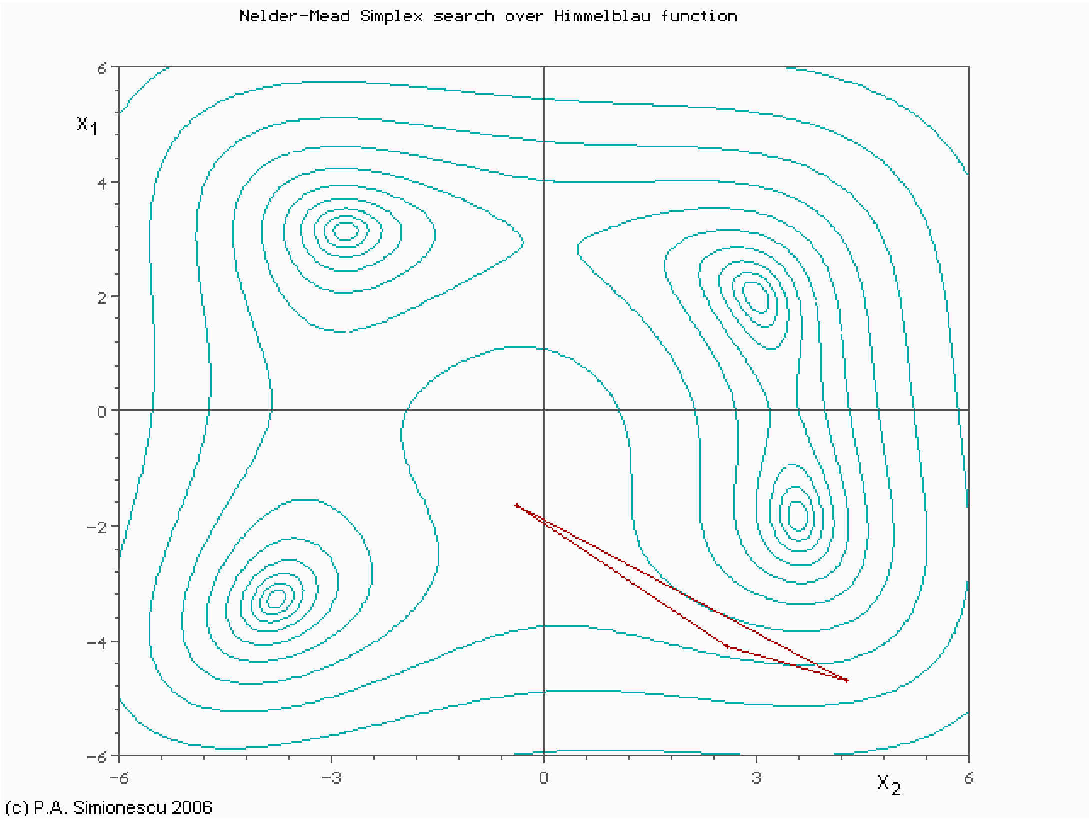

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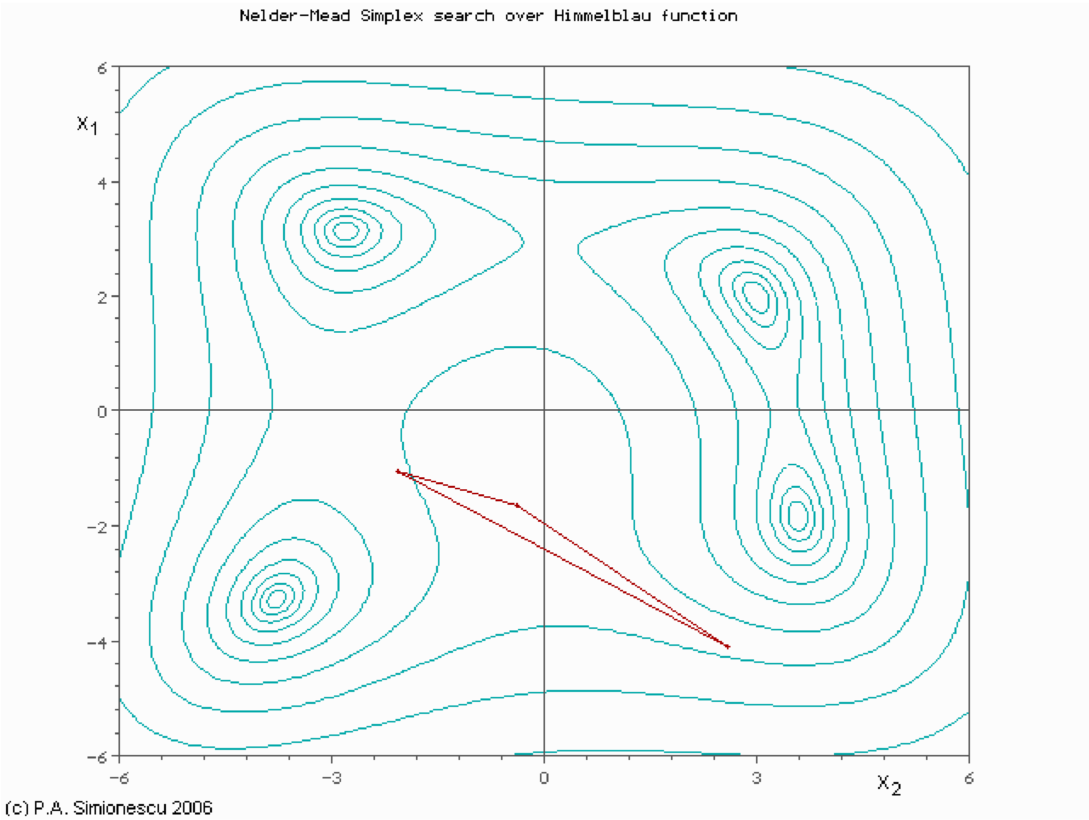

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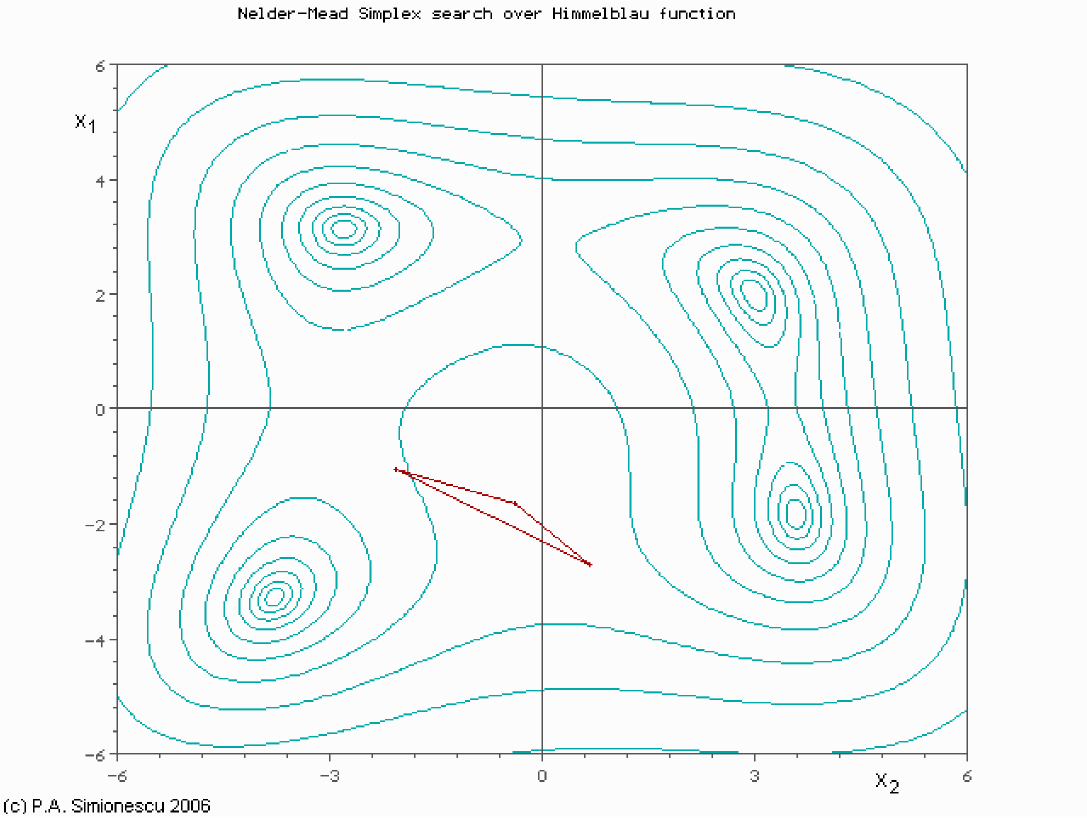

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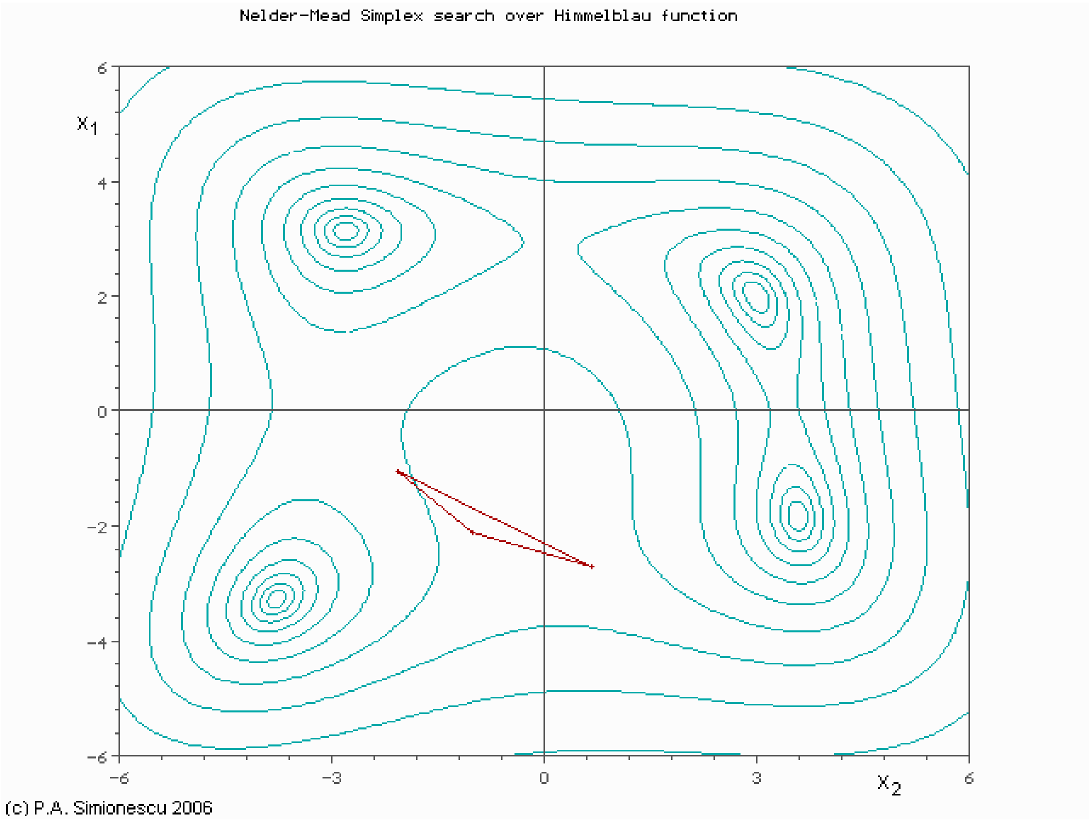

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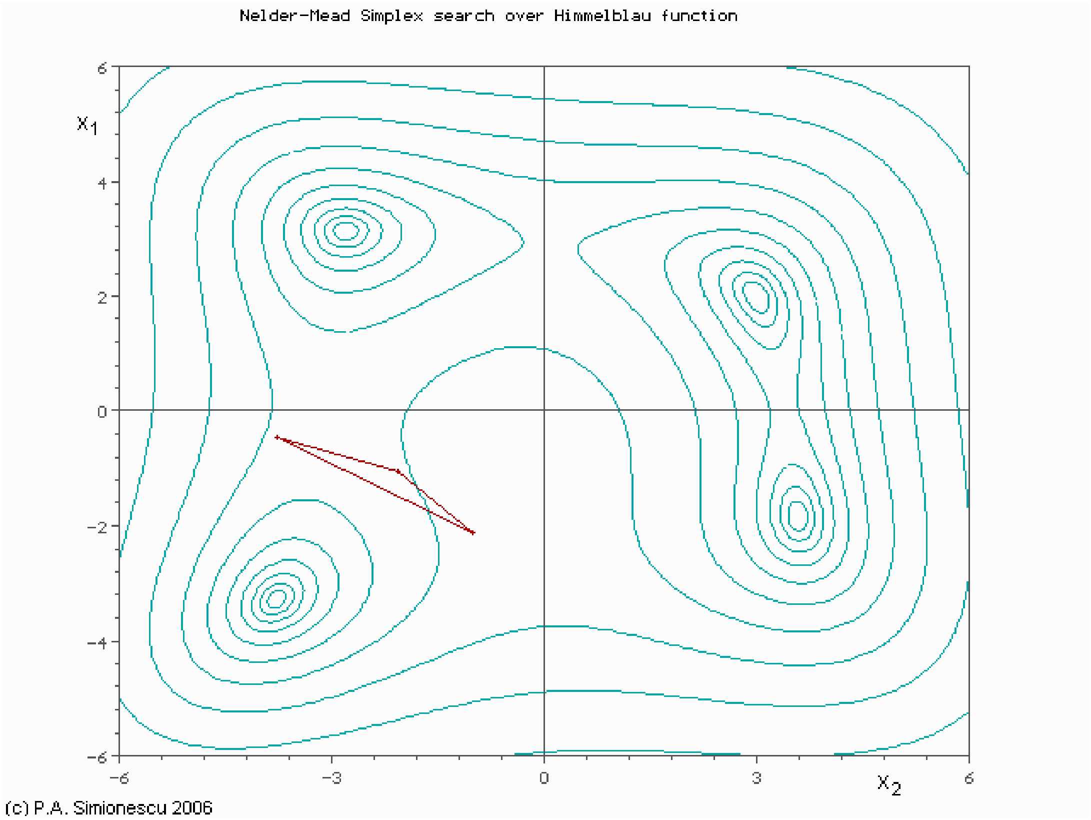

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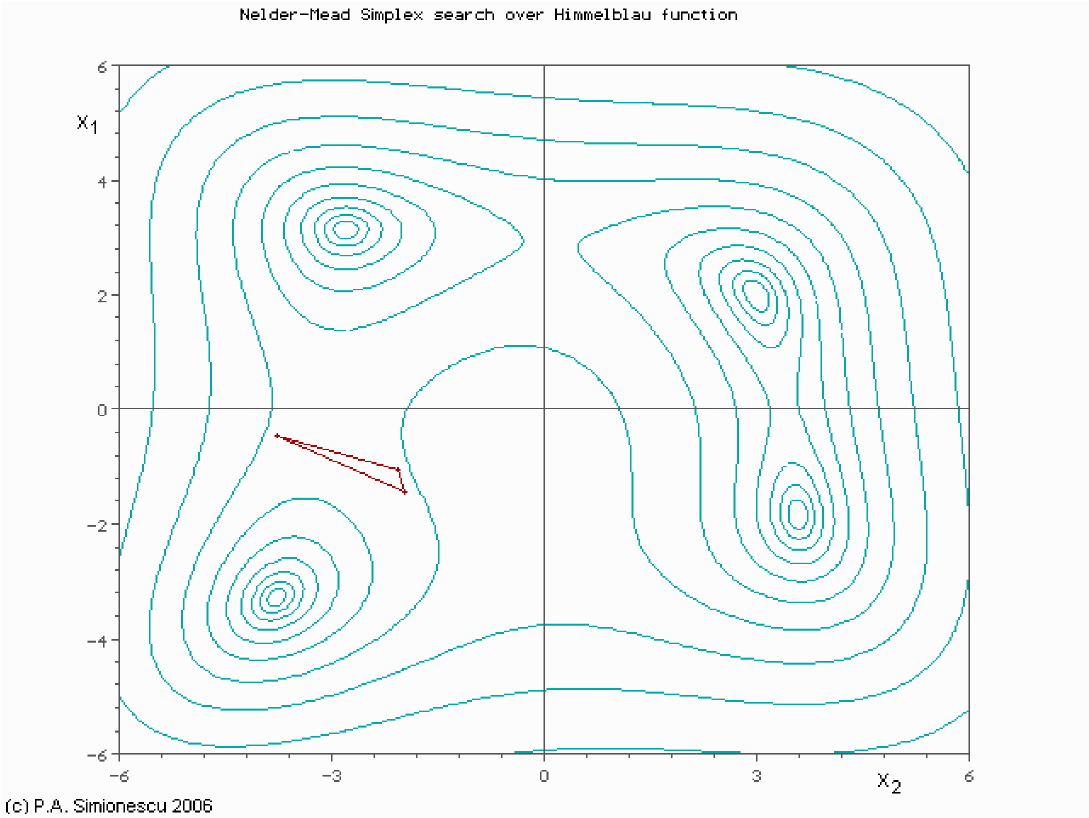

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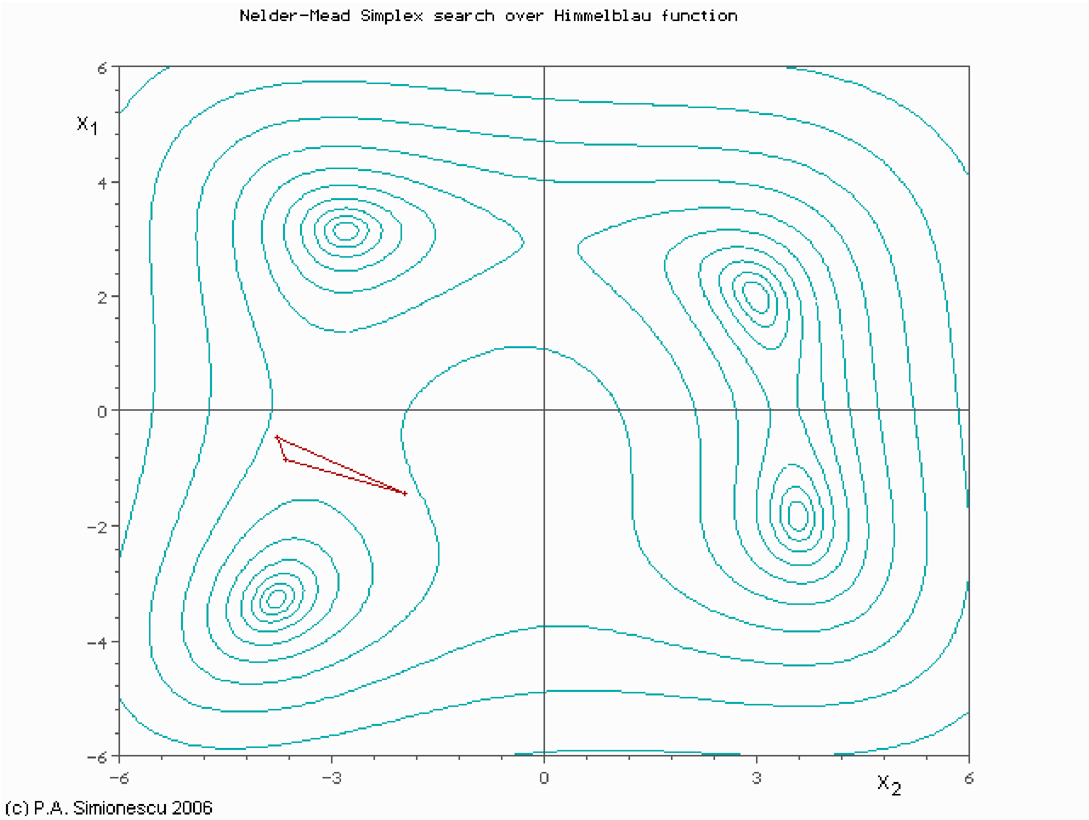

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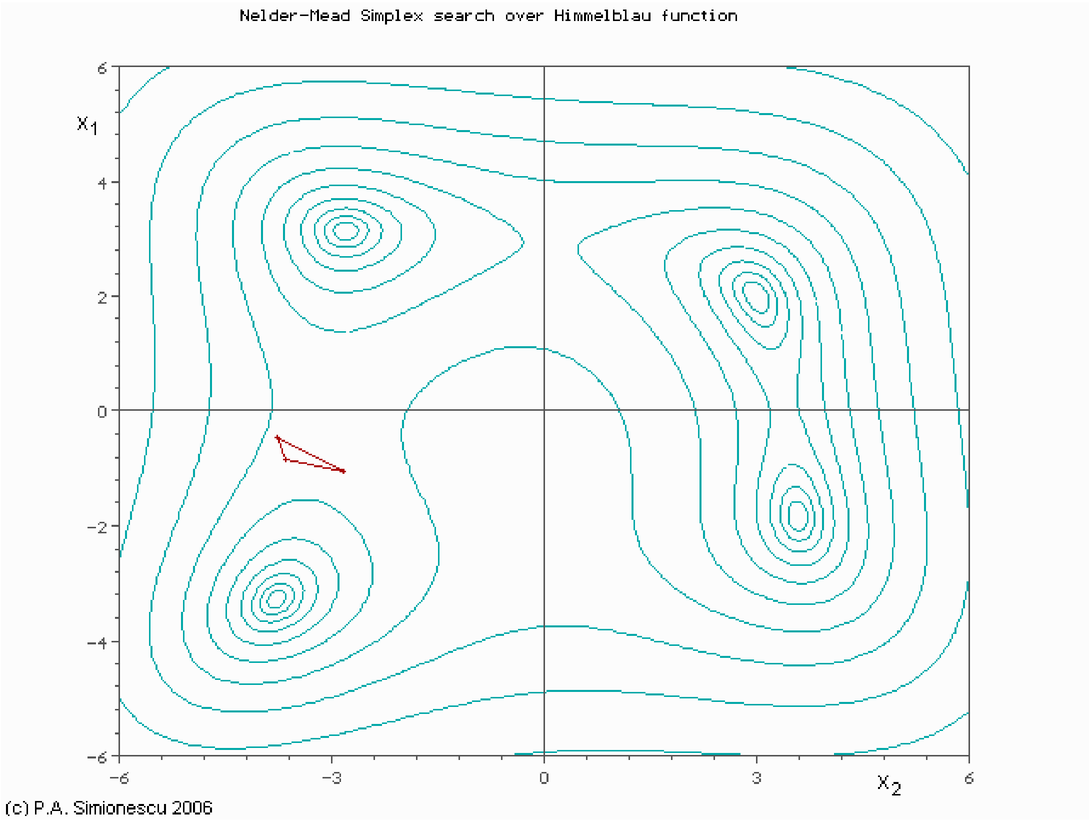

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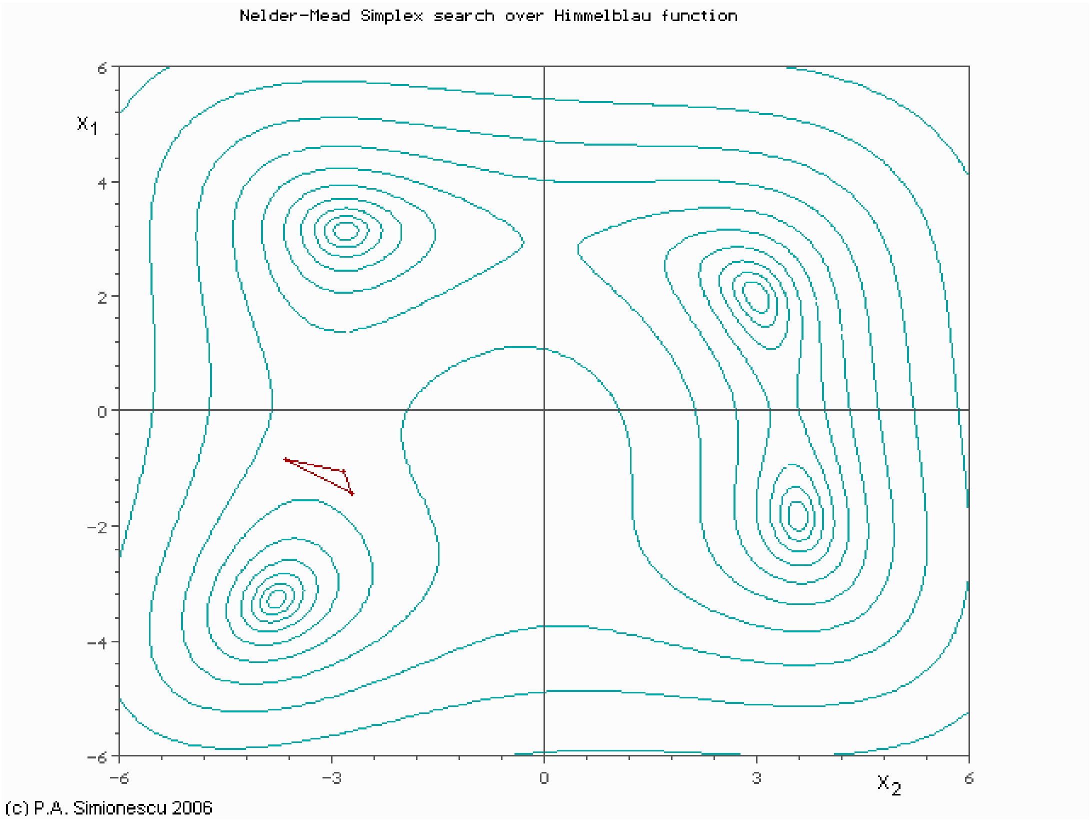

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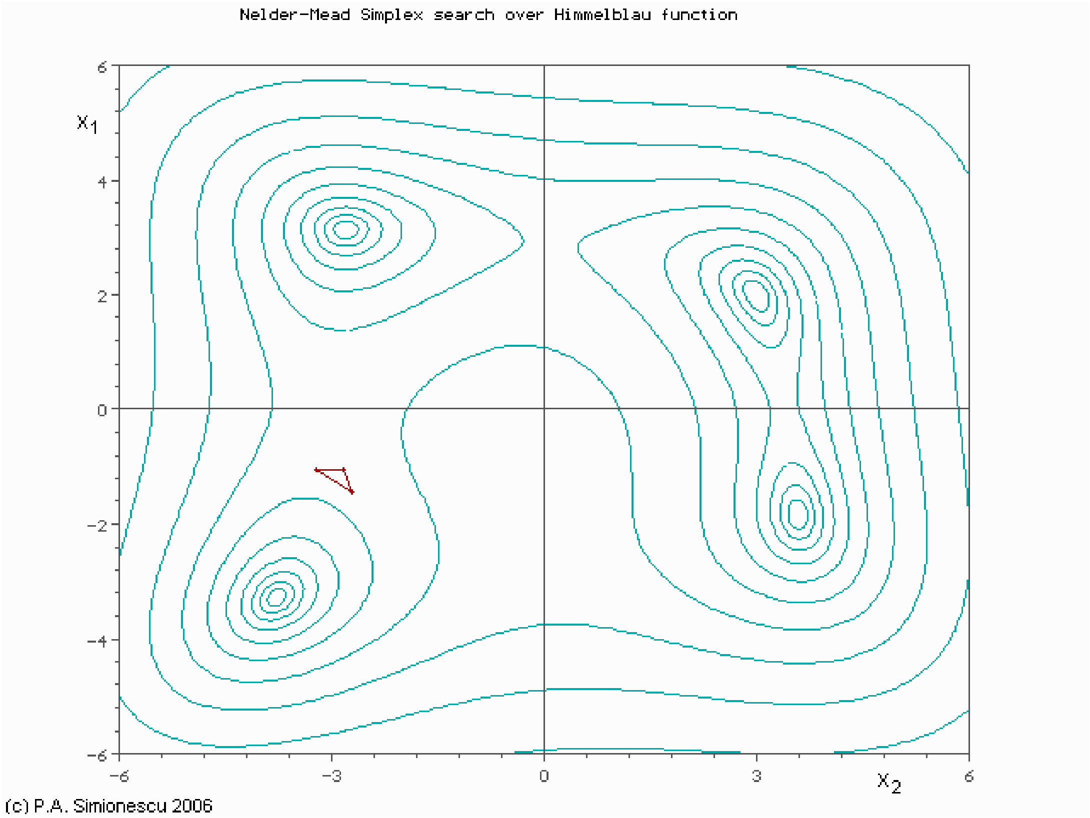

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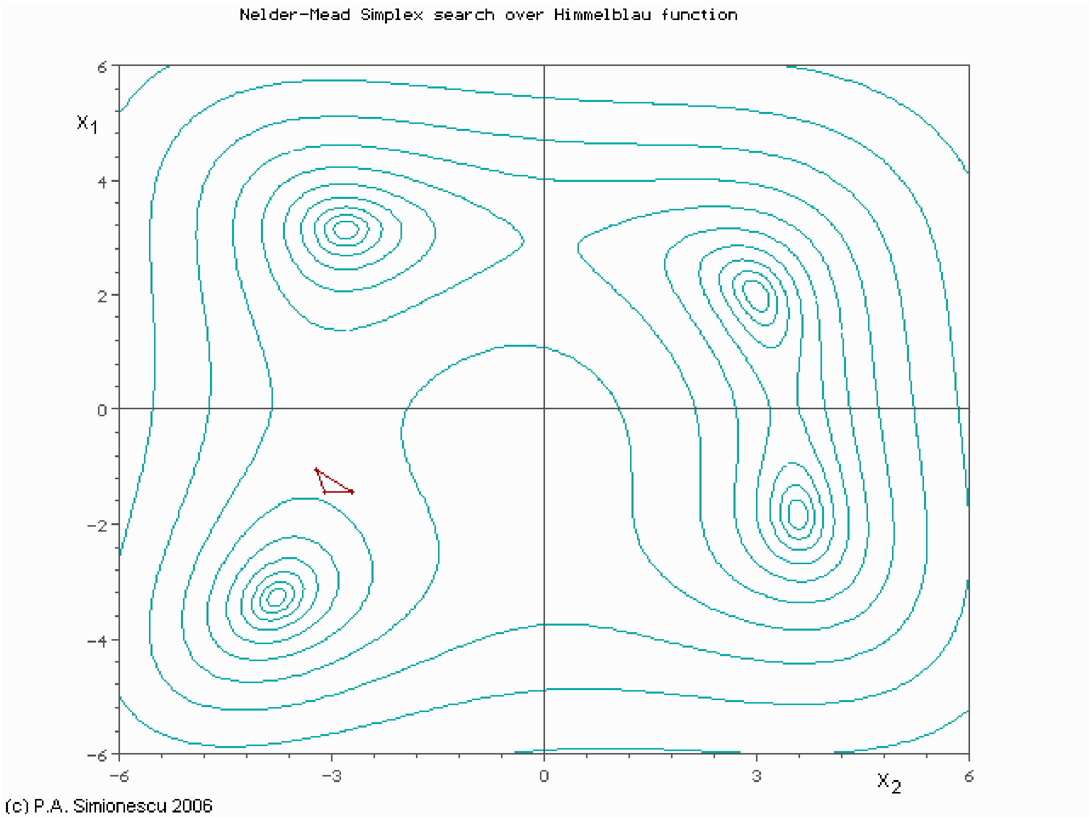

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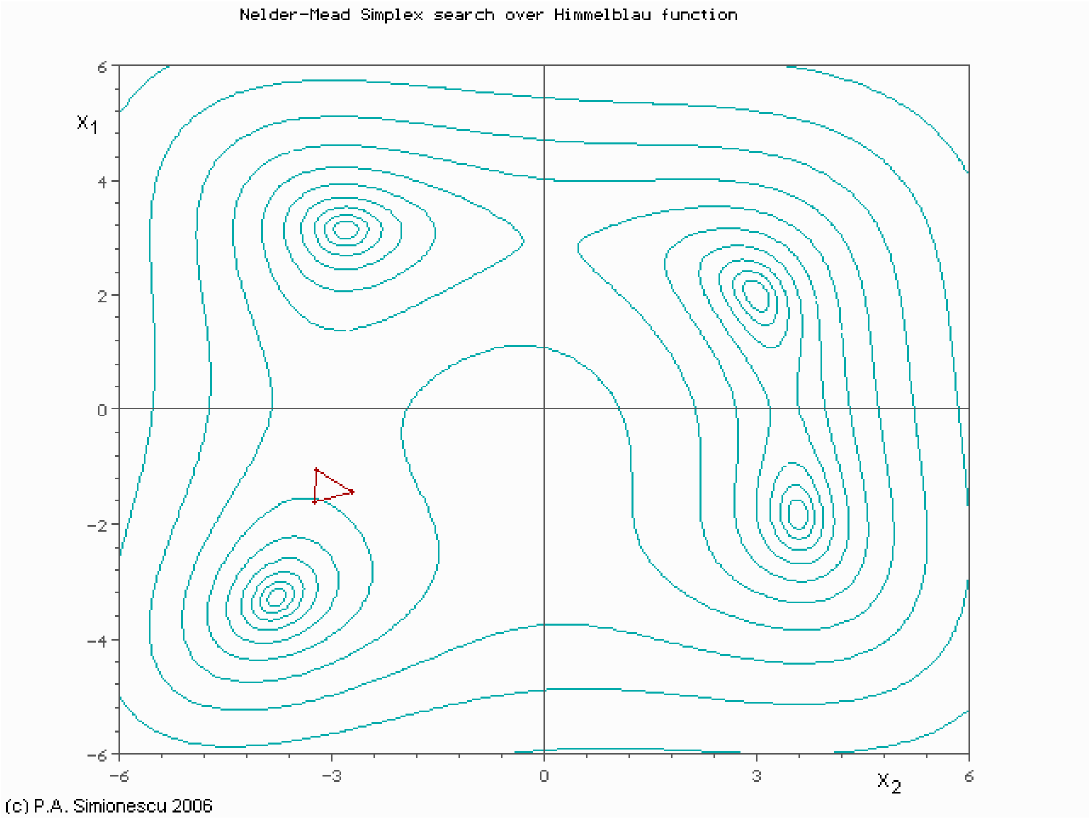

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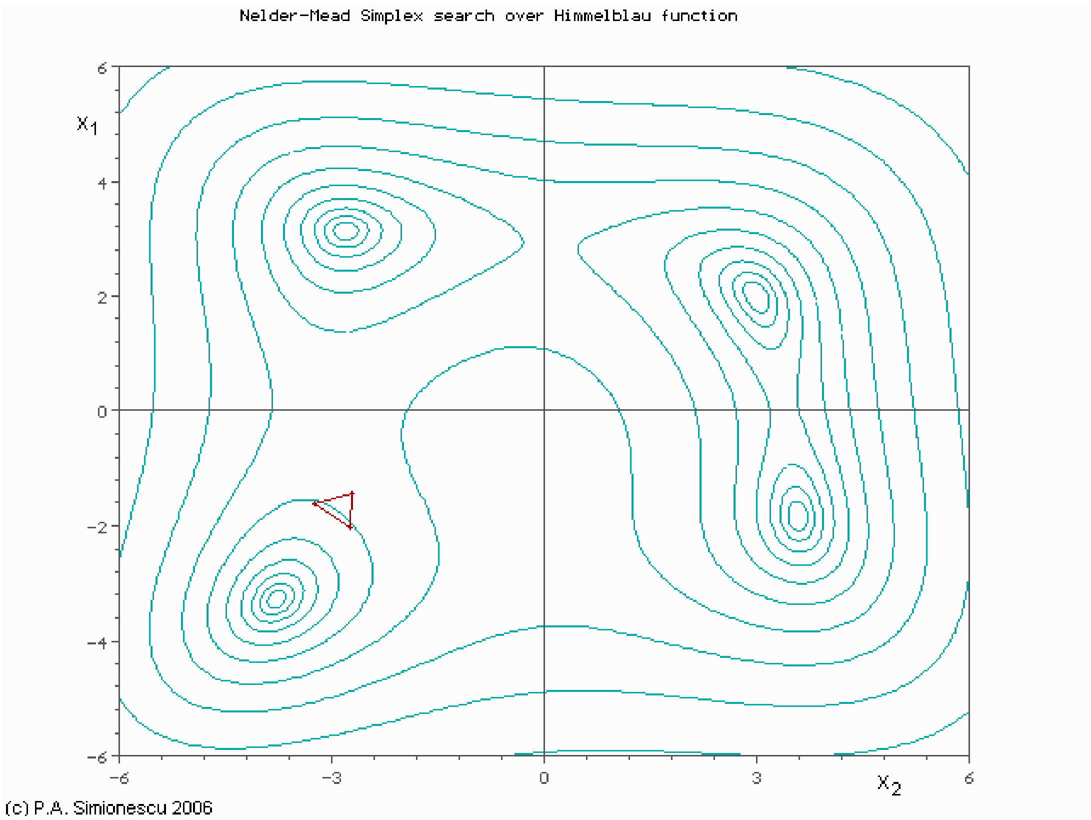

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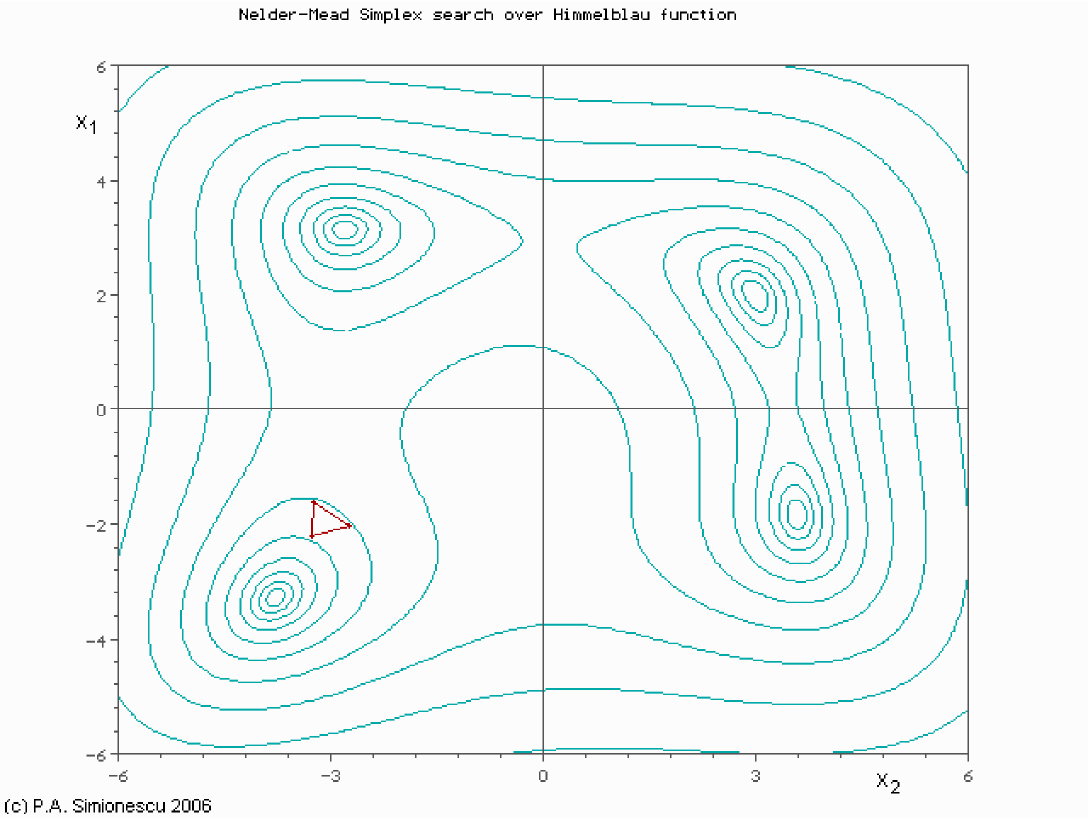

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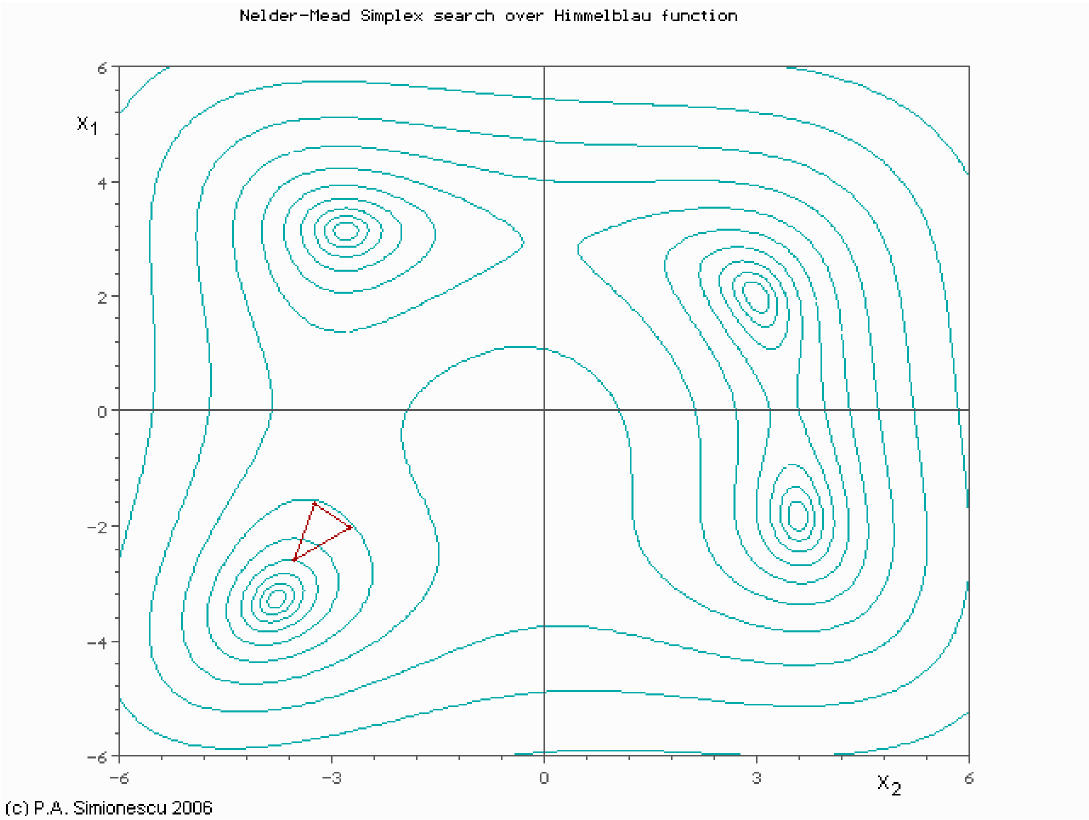

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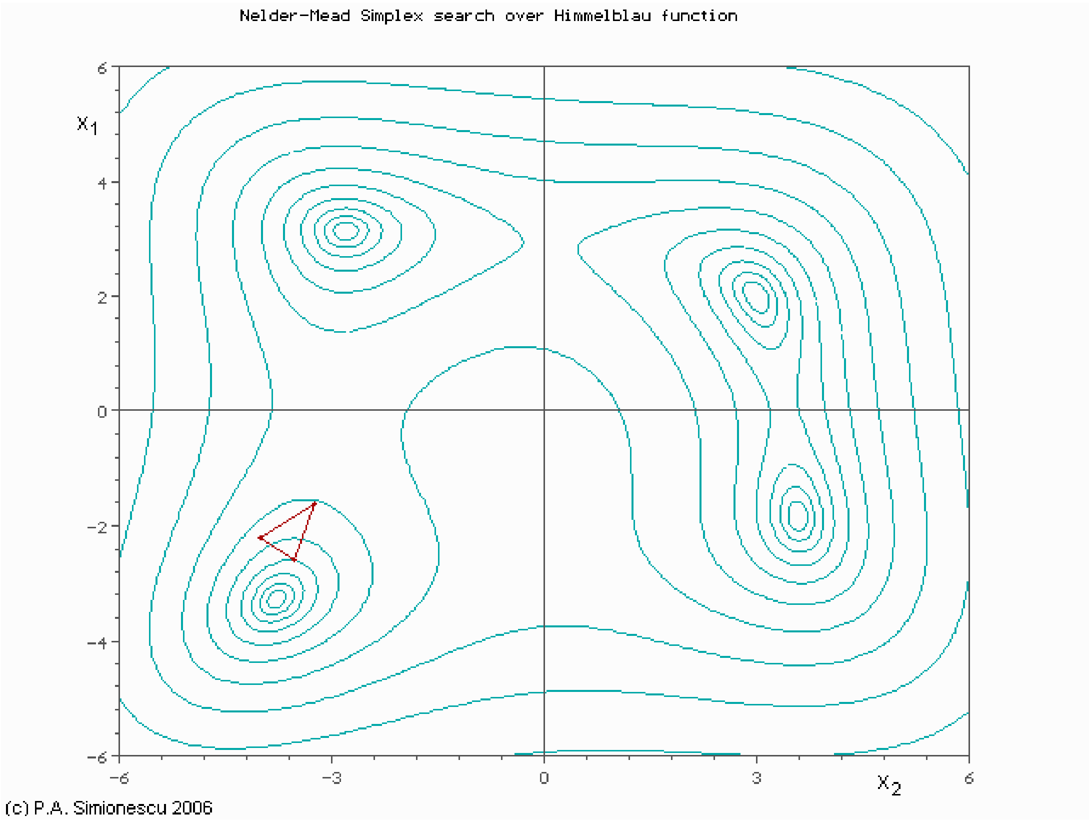

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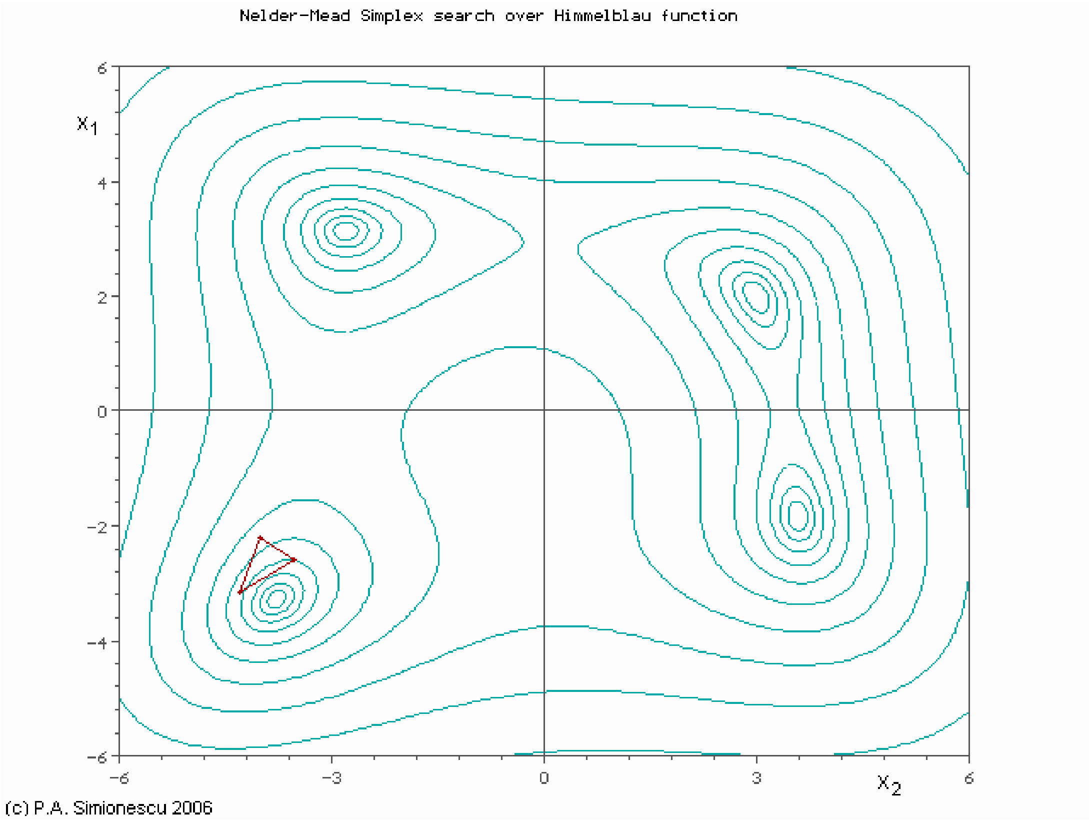

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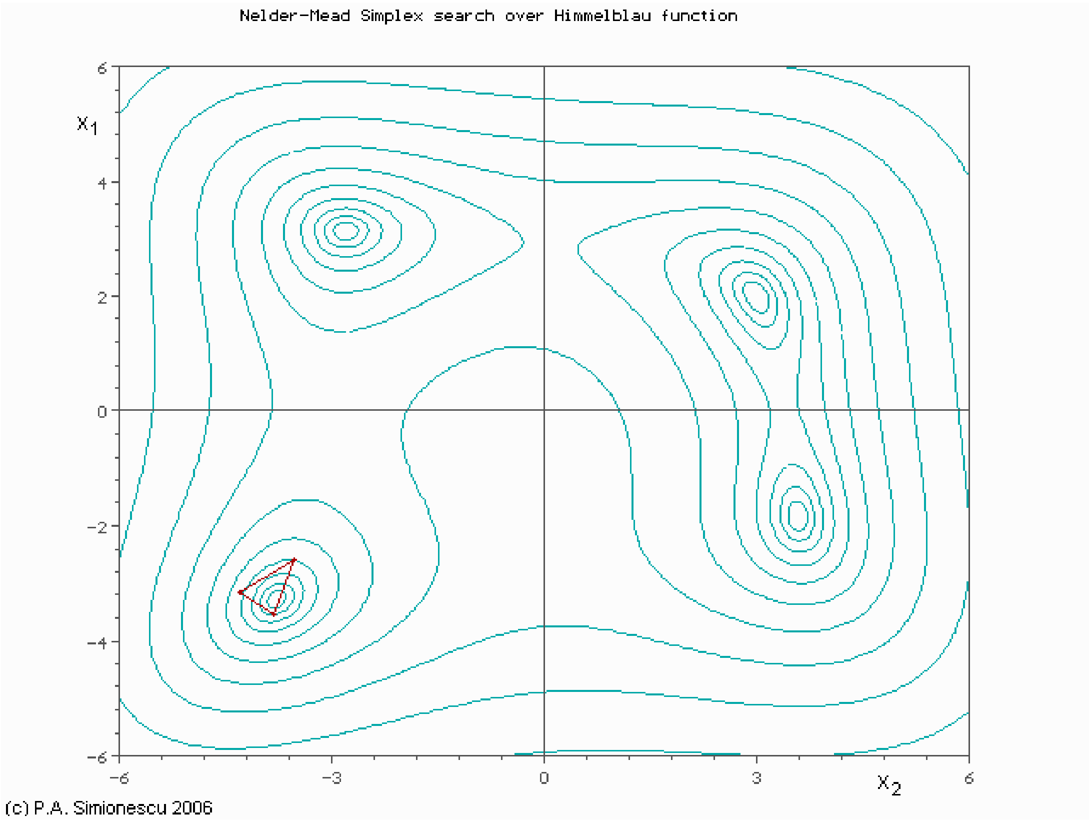

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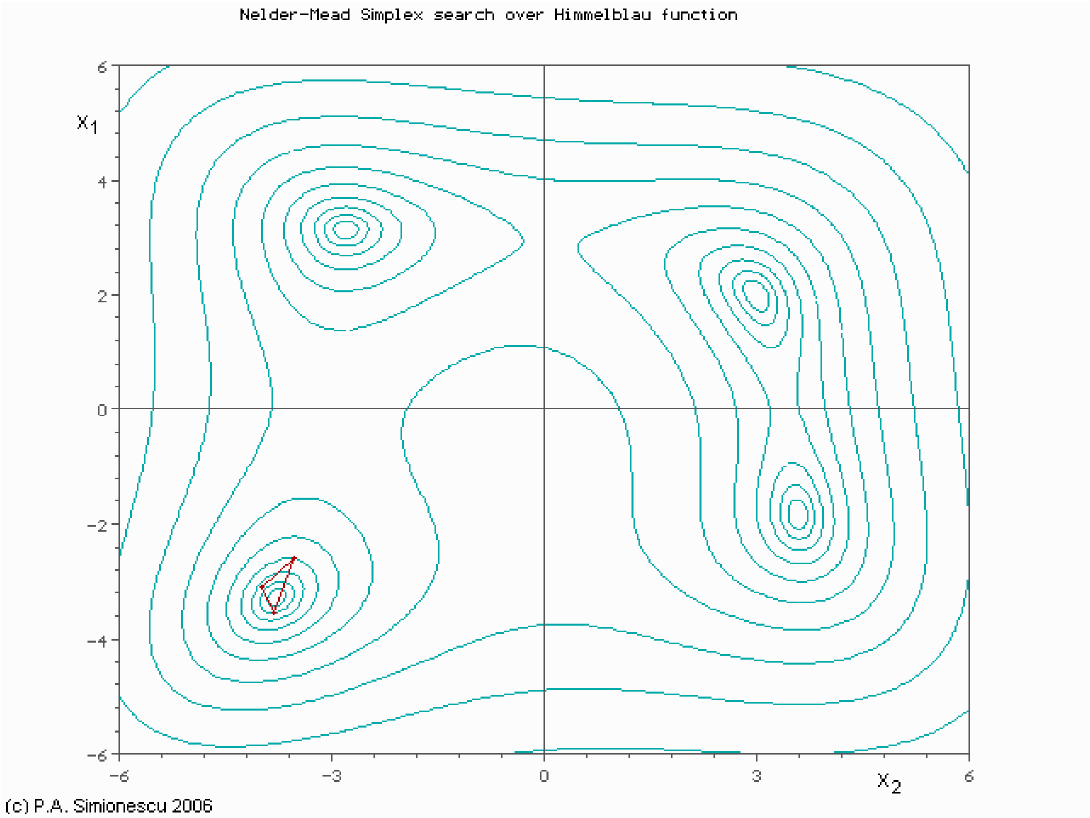

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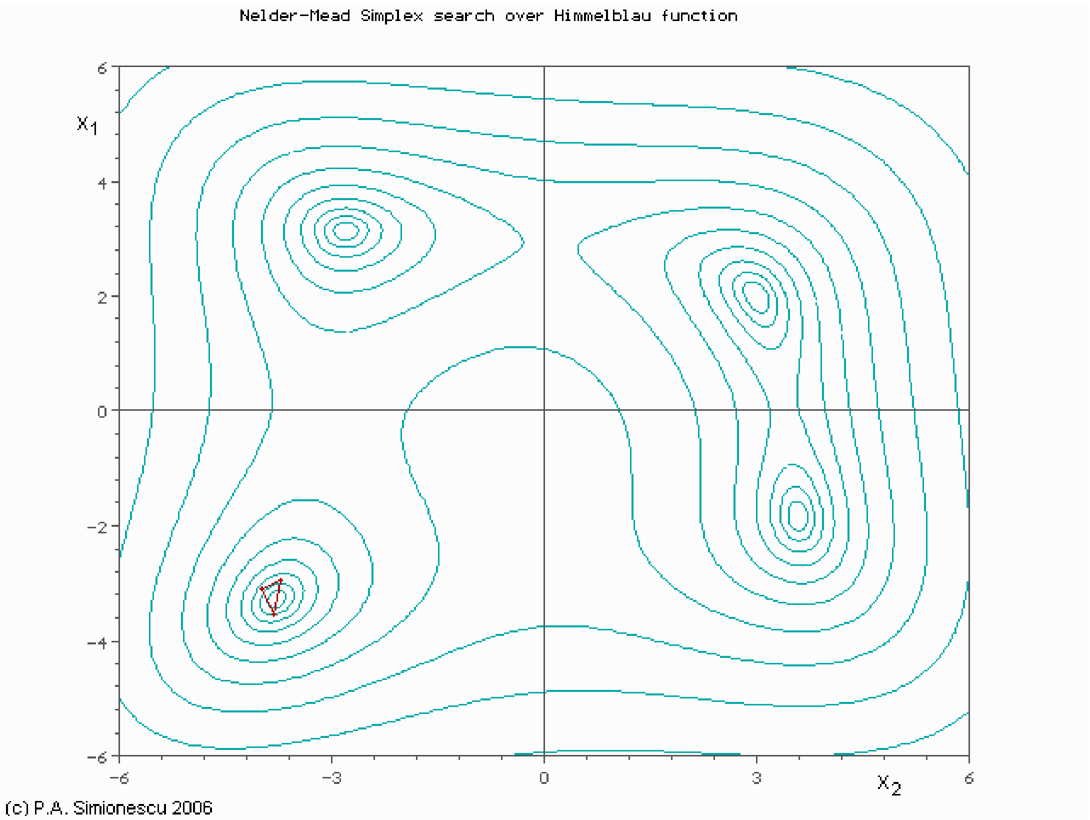

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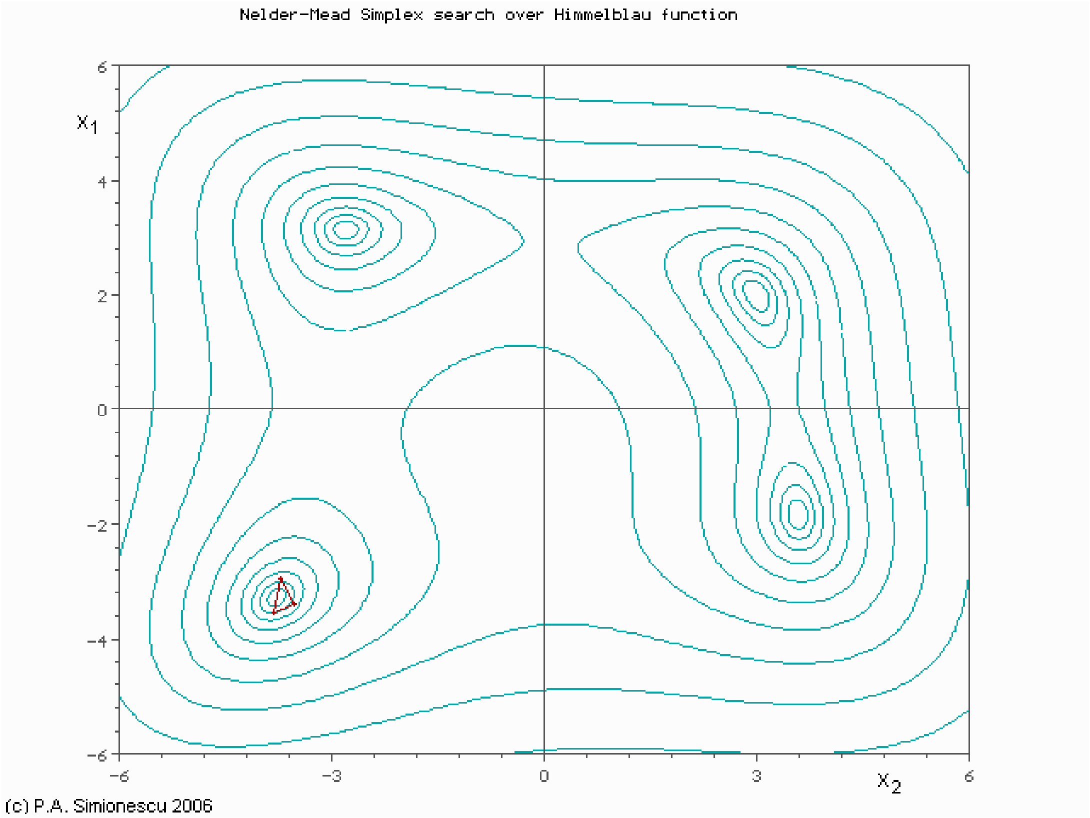

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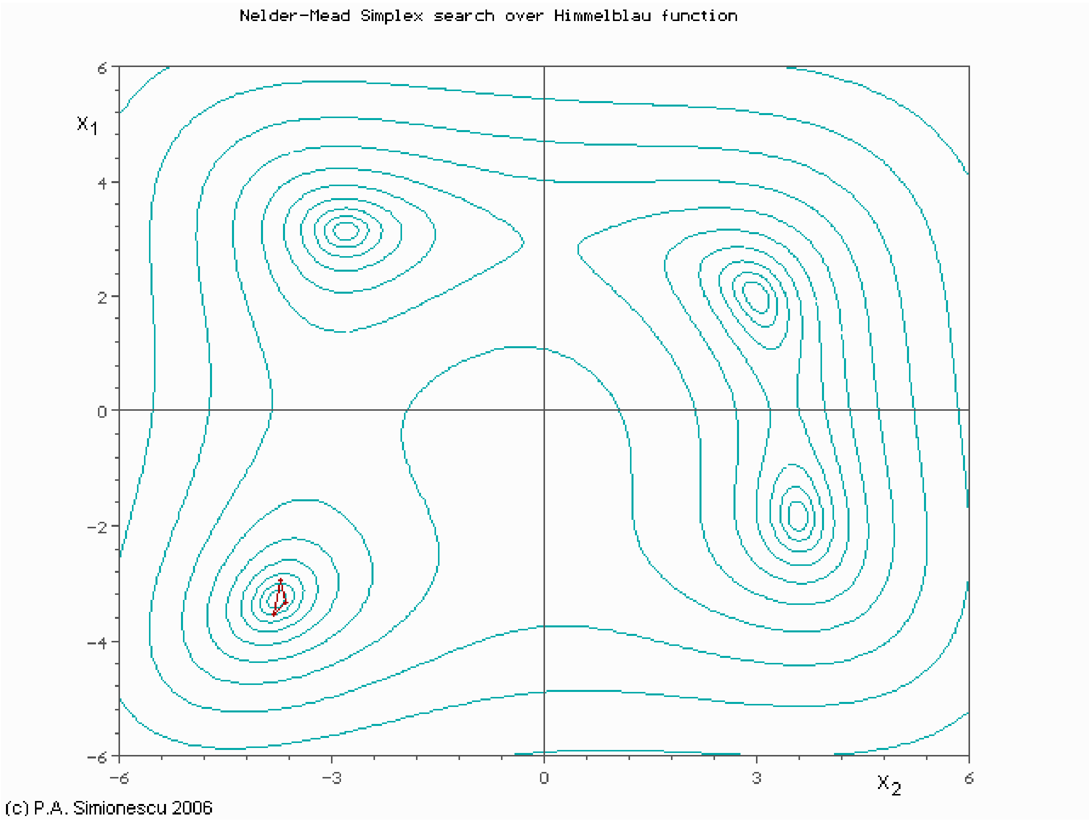

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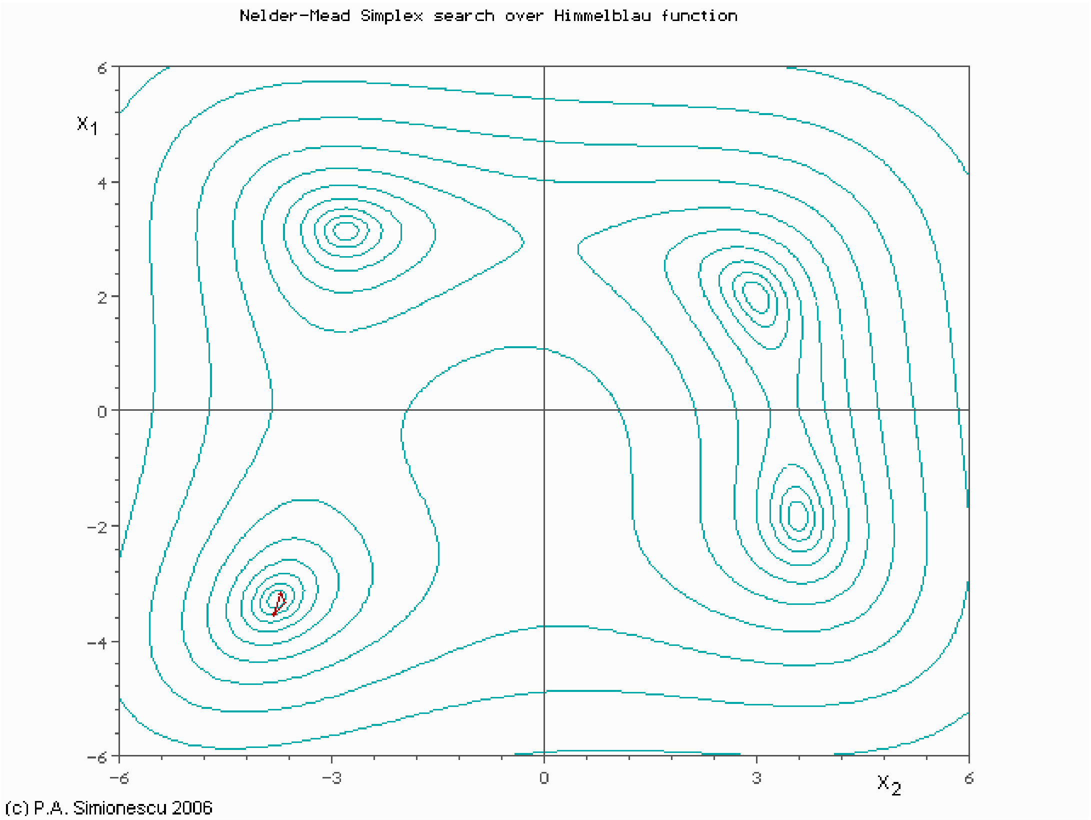

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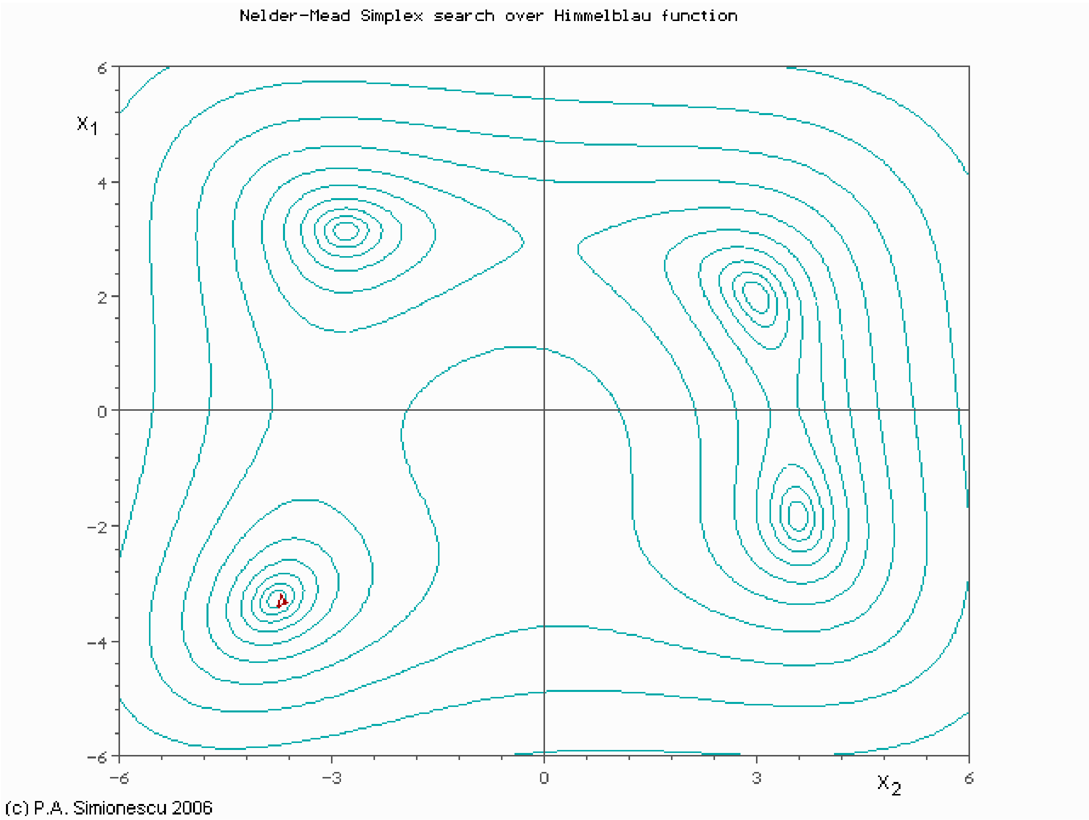

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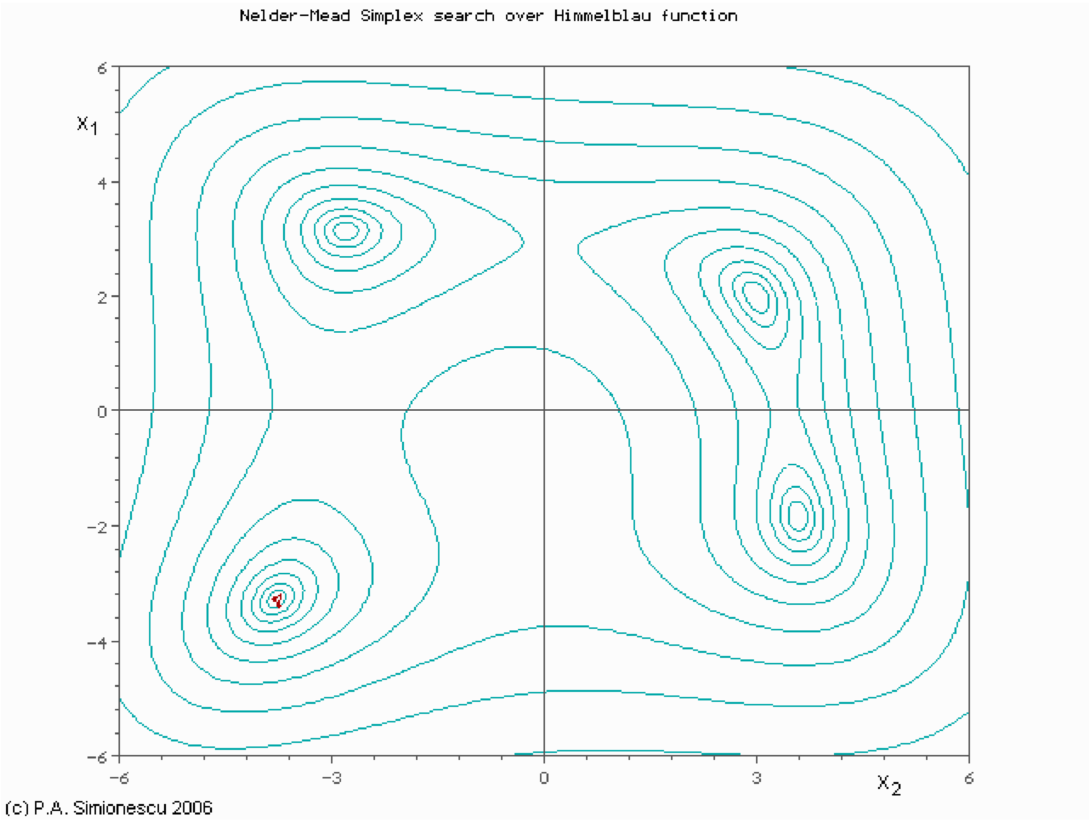

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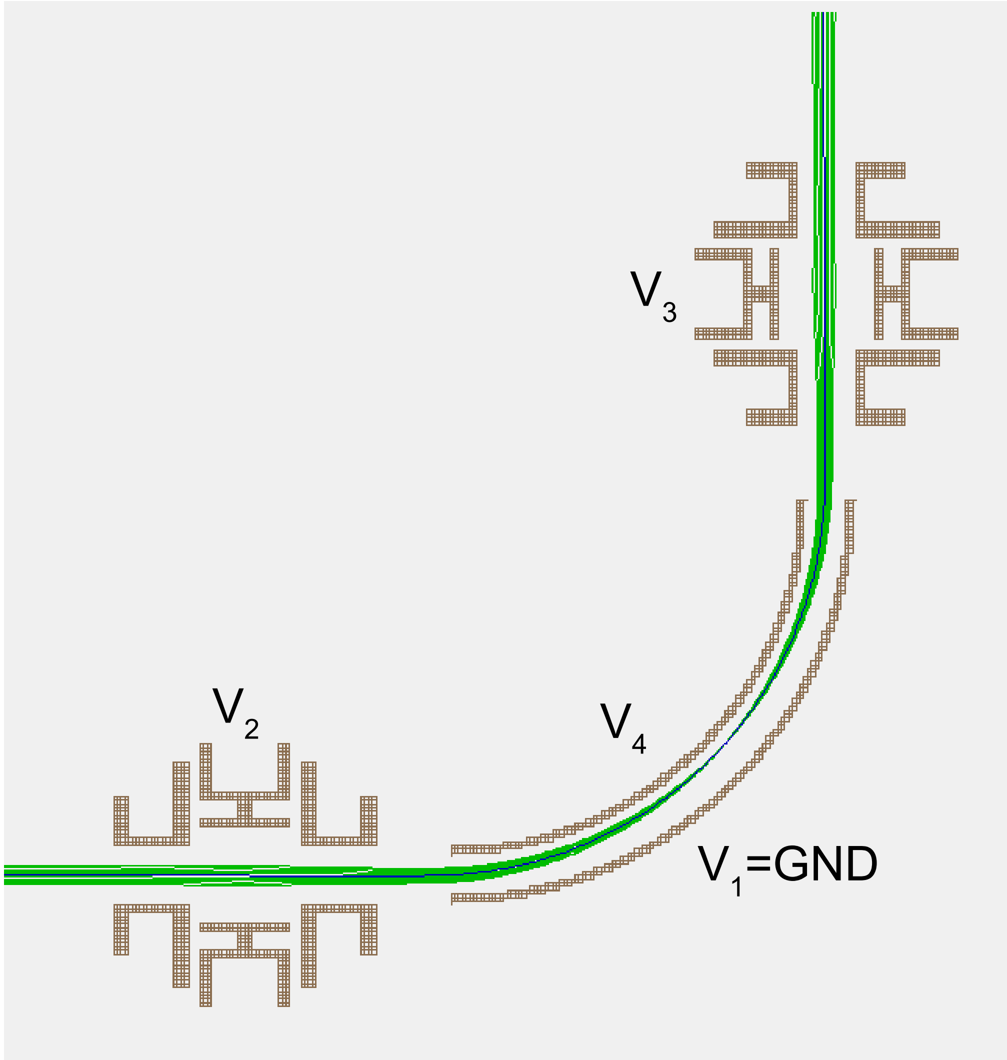
Potential optimization

Potentials:



Potential optimization

Goal function:

```
s = abs(means[2]-EL2x)*1E1 + abs(means[5])*1E1 + (bad_splat/number_of_ions)*1E2
```

position — angle — transmission

Potential optimization

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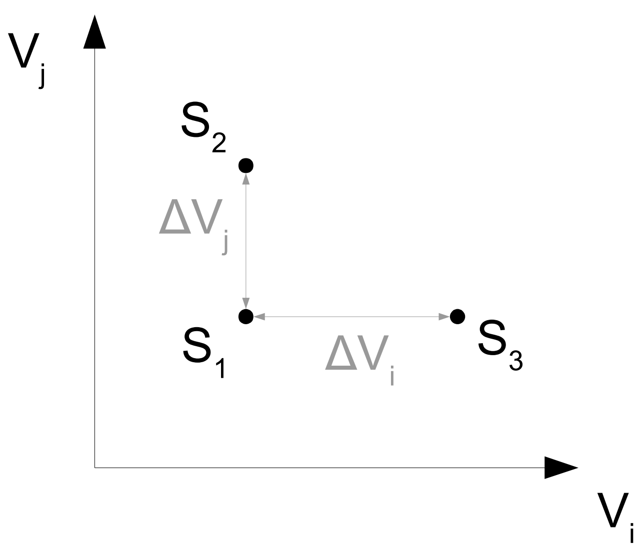
position — angle — transmission

Starting the optimizer:



Optimizer =

Starting point $(V_1, \ldots, V_n)$

+

Variations $(\Delta V_1, \ldots, \Delta v_n)$

+

Convergence radius

Potential optimization

Input beam:

Potential optimization

Input beam:

- Can be gaussian

Potential optimization

Input beam:

- Can be gaussian

or

- Can be made with arithmetic sequences

Potential optimization

Input beam:

- Can be gaussian

or

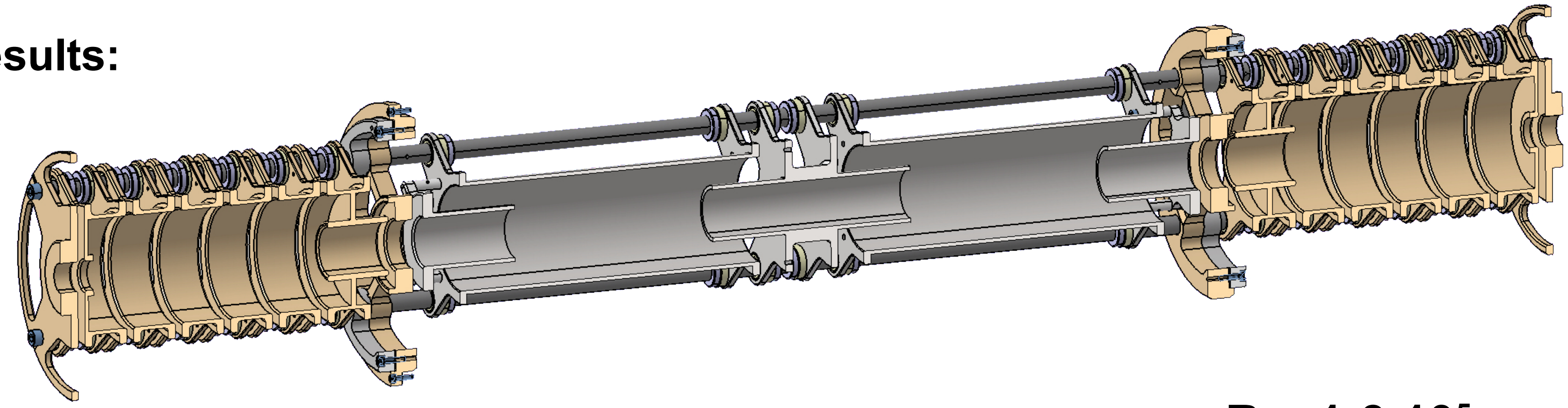
- Can be made with arithmetic sequences

but

It shouldn't be random !

Potential optimization

Results:



R = 1-3.10^5

Potential optimization

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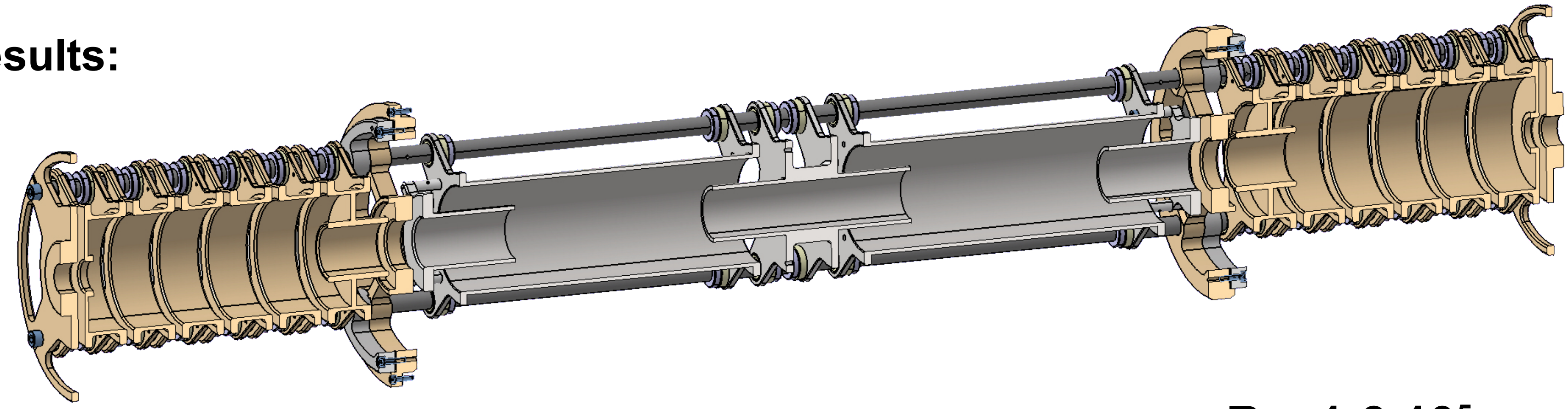

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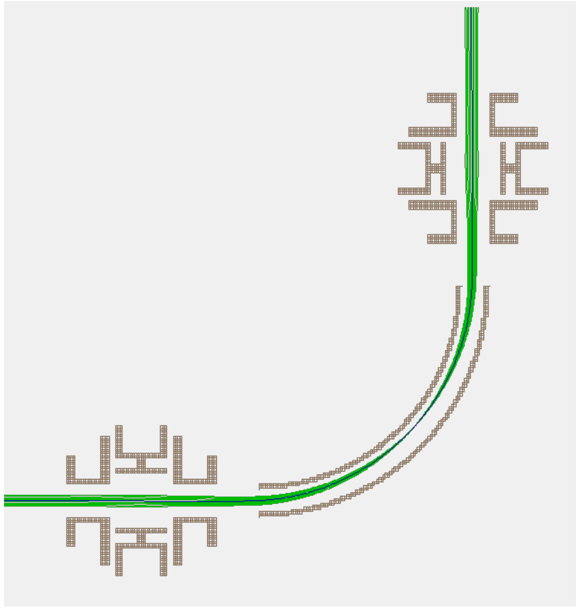

s=25.9411 ➡ s=0.8322

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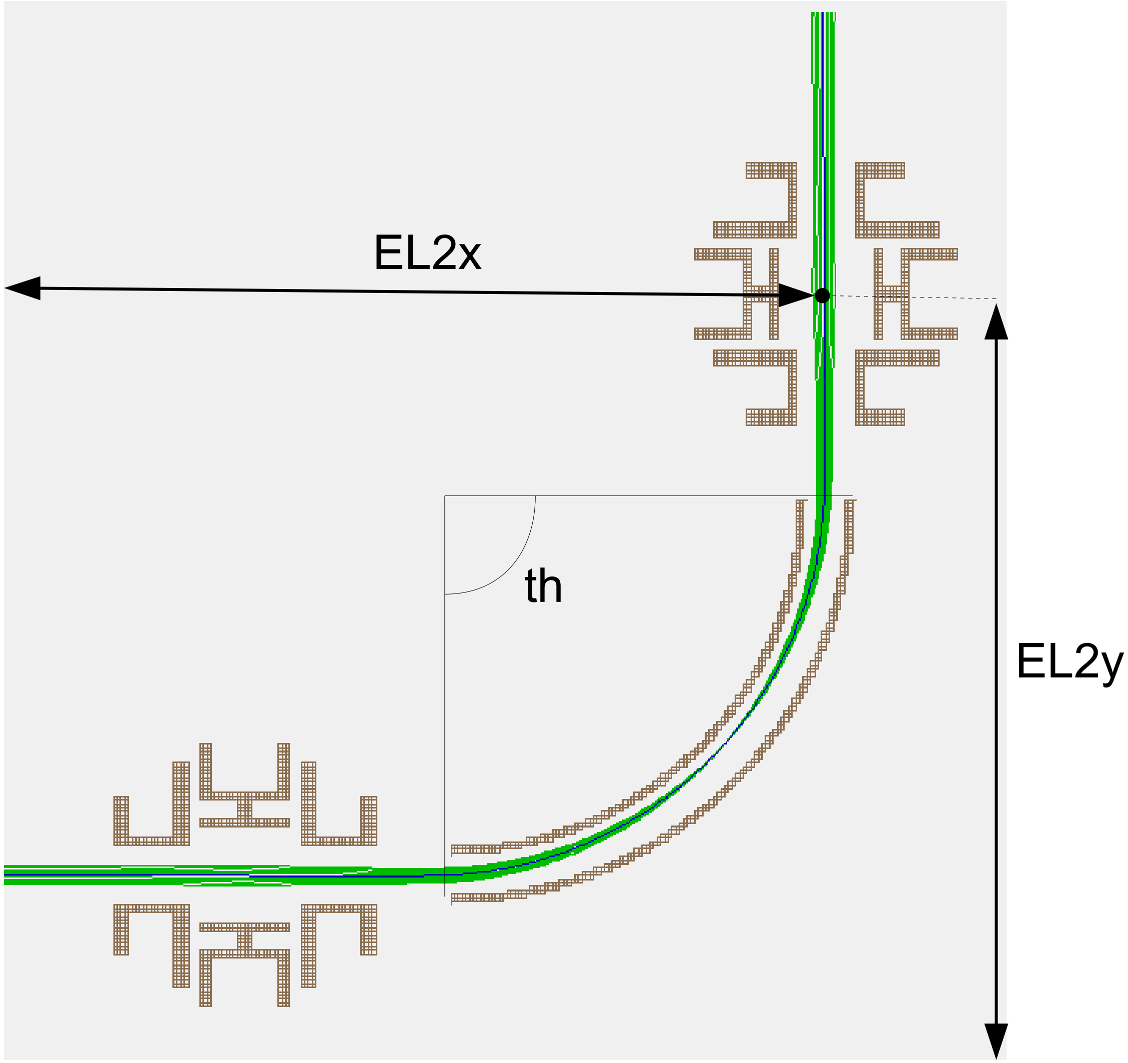
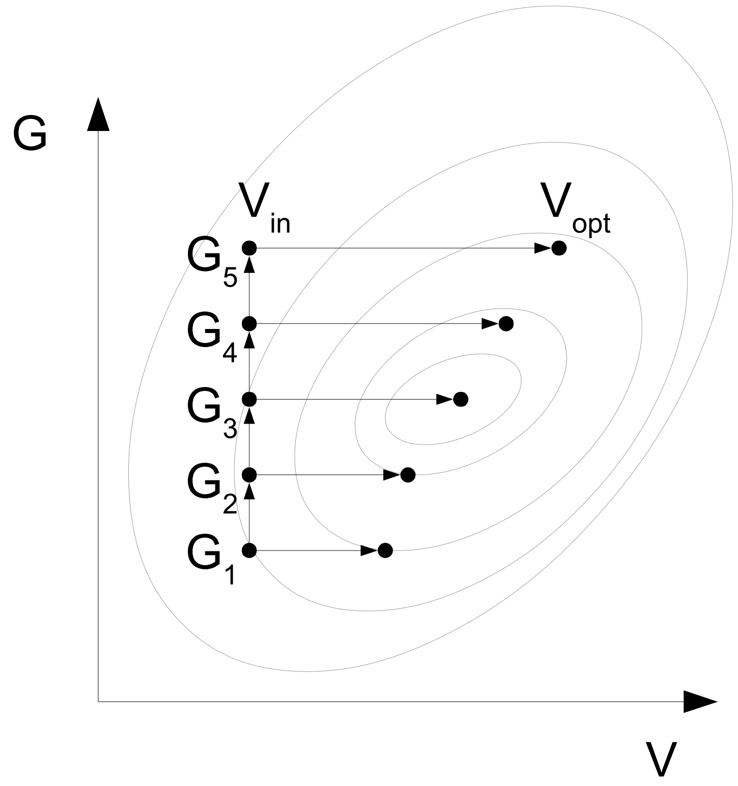


Geometry optimization

G sweep + V optimization



- Easy to find local minima
- Fast

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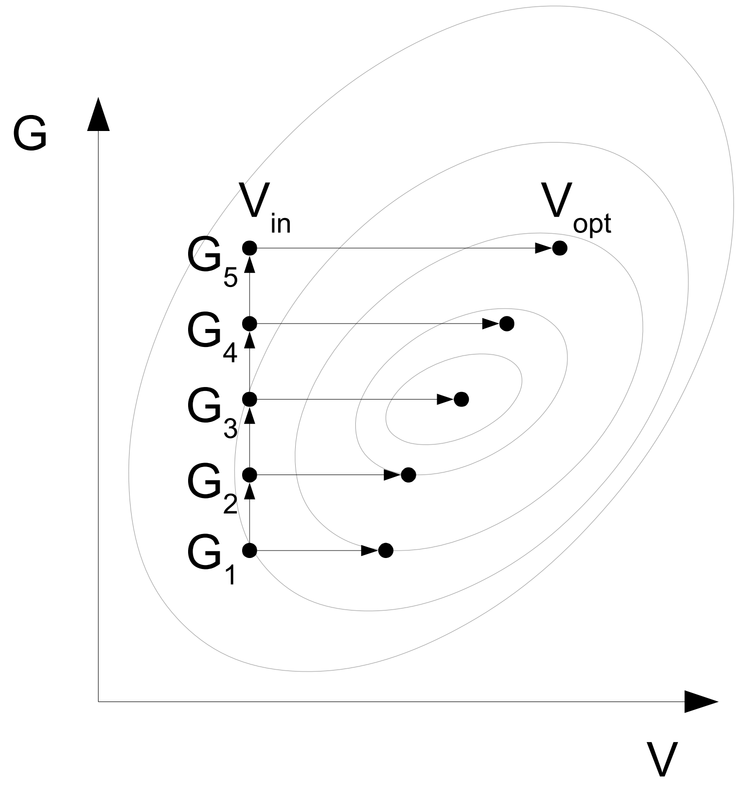

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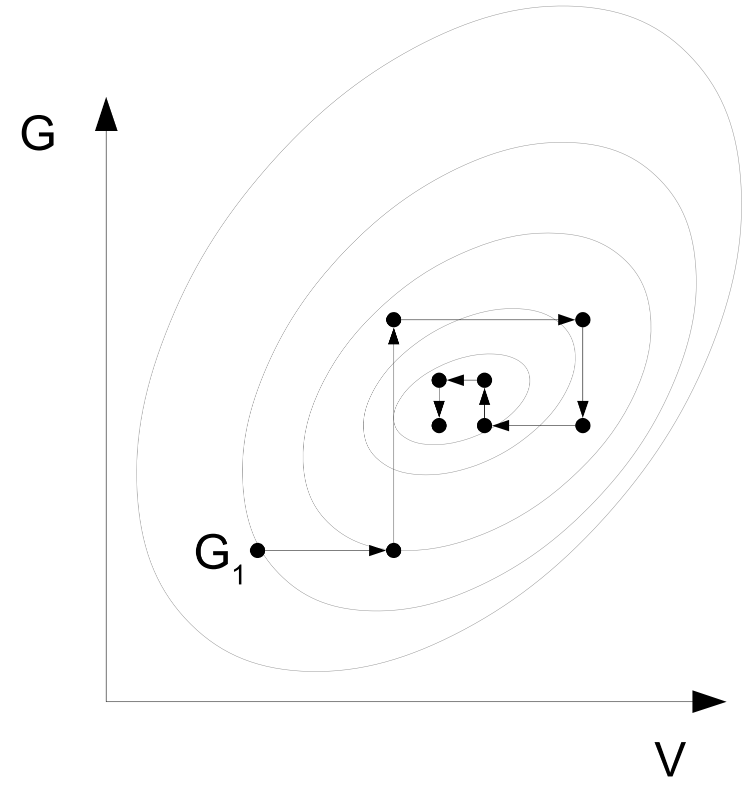
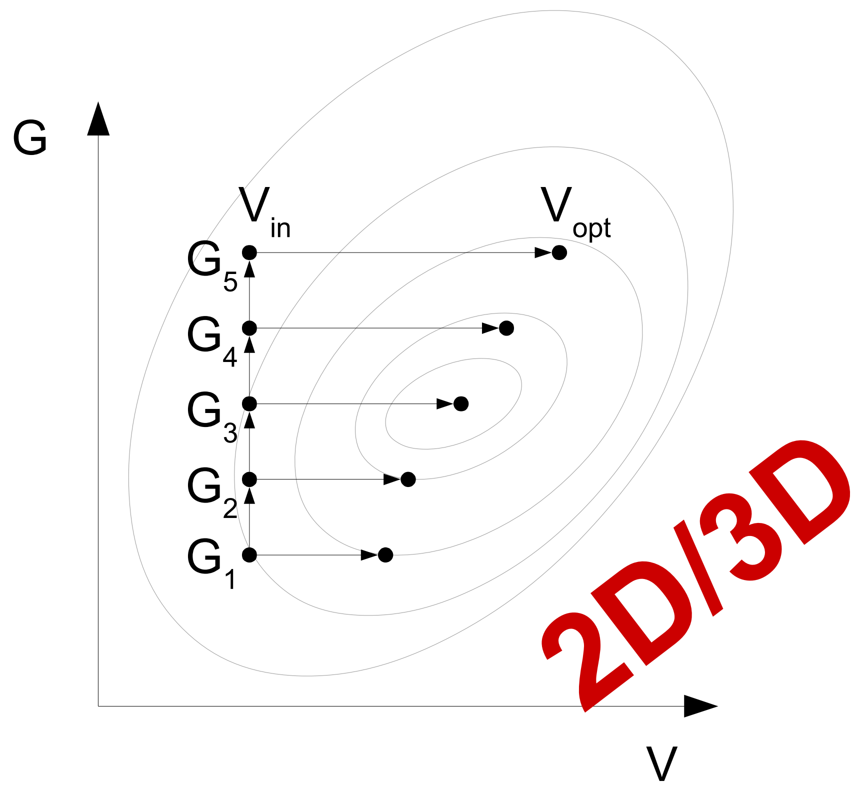
Intricated simplexes



- Finds better, close to absolute minimas
- Slow

Geometry optimization

G sweep + V optimization



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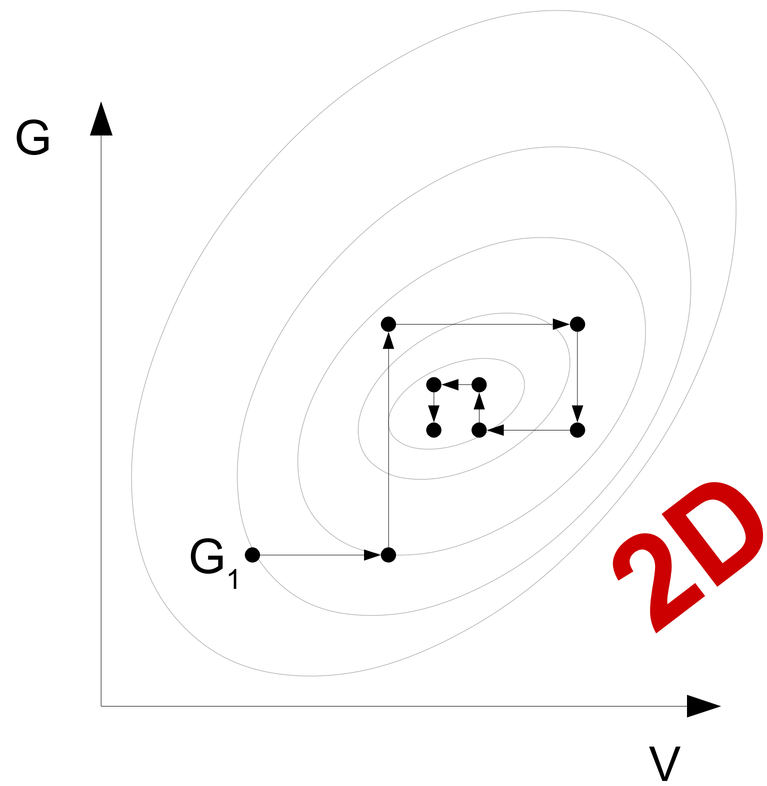

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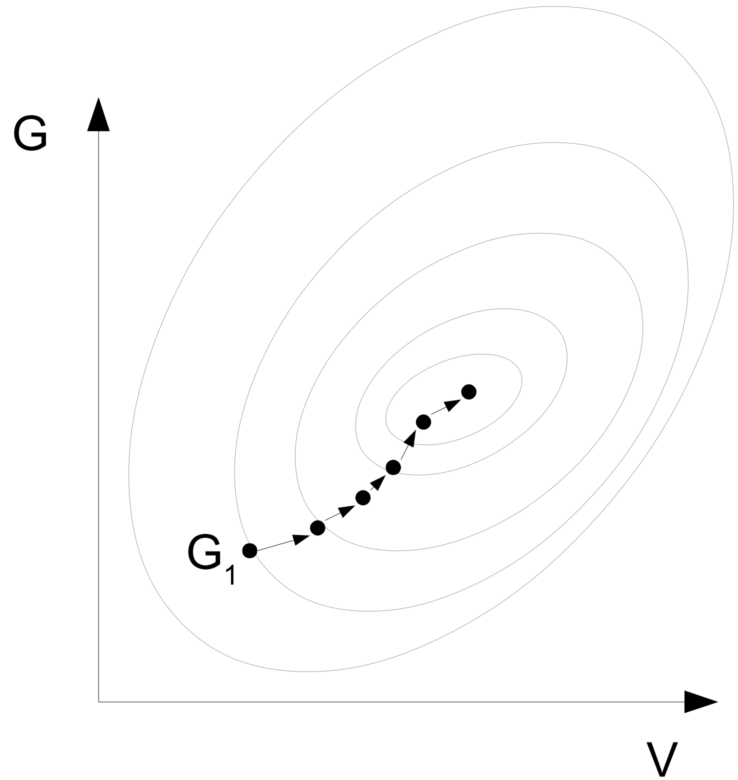
Geometry optimization

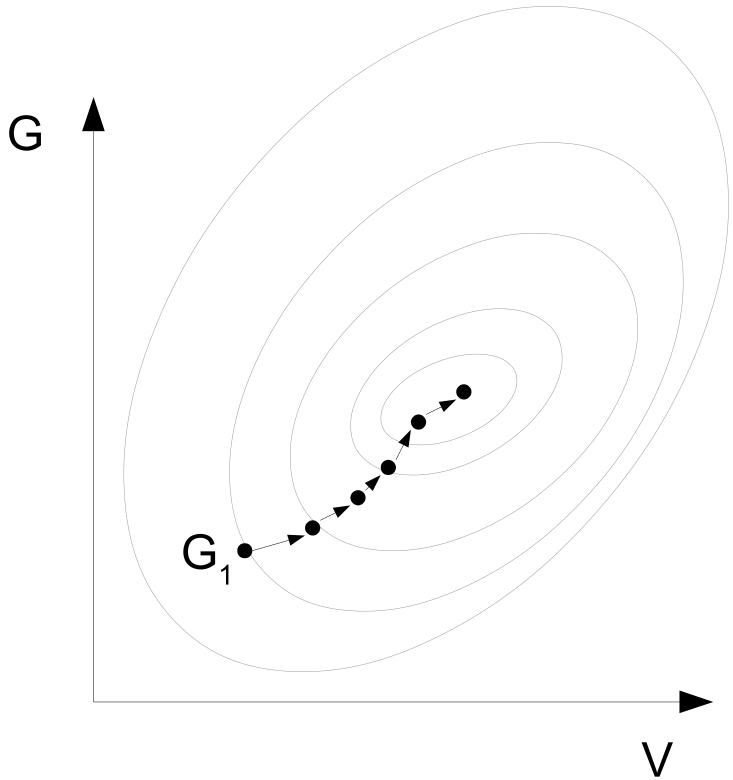
Simplex on G & V



- Can be faster or slower than intricated simplexes
- Still slow
- No feedback

Geometry optimization

Simplex on G & V



2D

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Geometry optimization

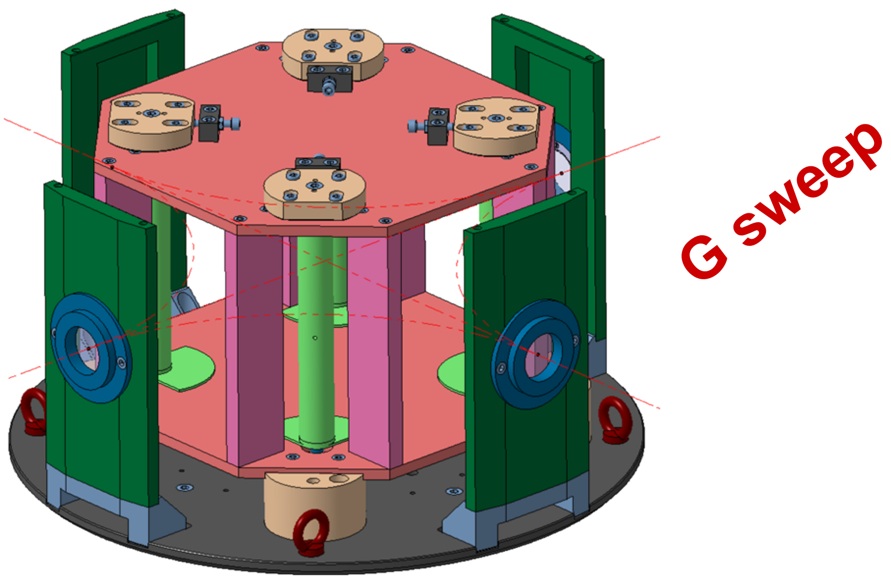
Results:

- Parallelism conservation :

$$\alpha = 0.0017°$$

- ToF spread conservation :

$$ToF_{FWHM} = 0.59\text{ns}$$



Geometry optimization

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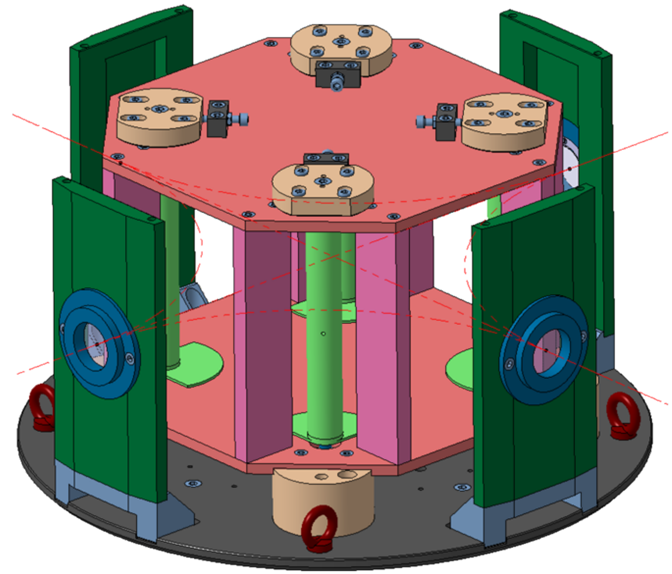

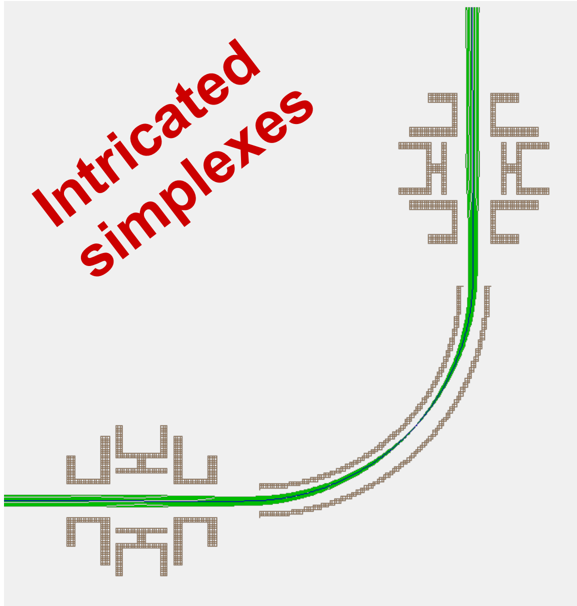

s=25.9411 → **s=0.8322**

→ **s=0.00001**

Conclusion

- The Simplex optimizer is a very powerfull tool

  → Easy V opt

  → Possible G opt / Beam opt

- Some of its drawbacks can be compensated (restart, randomize&restart, simulated annealing)

- Why is it working ? Not working ?