New developments of the GOSIA code

Paweł J. Napiorkowski, HIL UW

Town Meeting, Warsaw, 2013

What the GOSIA is?

- GOSIA is a powerful suite of semiclassical Coulomb excitation codes developed to both design and analyze multiple Coulomb excitation experiments.

- These codes were originally developed at the Nuclear Structure Research Laboratory of the University of Rochester in 1980 by Tomasz Czosnyka, Douglas Cline, and Ching- Yen Wu and development has continued at Rochester, Warsaw, and Köln.

- The scientific goals are to measure complete sets of electromagnetic transition strengths and static moments which provide a sensitive probe of nuclear structure for low-lying nuclear states.

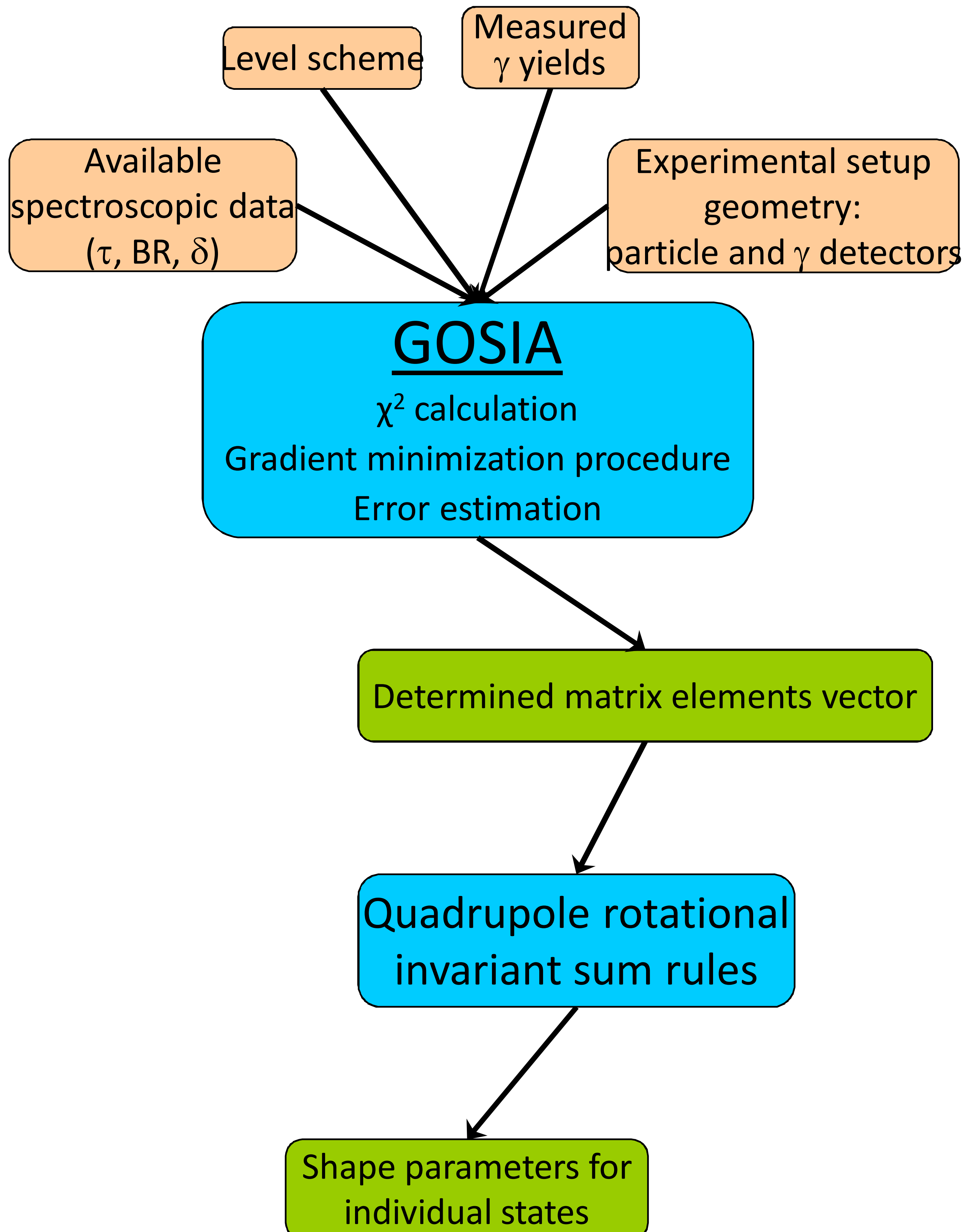
- GOSIA is specifically designed to handle heavy-ion induced Coulomb excitation where population of many excited states is measured using coincident detection of the scattered ions and the deexcitation gamma-ray decay.

- The code GOSIA is available free for users. However, all users must reference GOSIA
  [T. Czosnyka, D. Cline, C.Y. Wu - Am. Phys. Soc. 28:745 (1983)]
  in publications based on use of this code.

How does the GOSIA work?

Important features of the GOSIA code:

- χ2 fitting procedure to determine the best set of electromagnetic matrix elements
- extensive possibilities to take into account various geometries of experimental setup
- fast approximation method developed to speed up the analysis of the complex experiments



ARTICLE

doi:10.1038/nature12073

Studies of pear-shaped nuclei using accelerated radioactive beams

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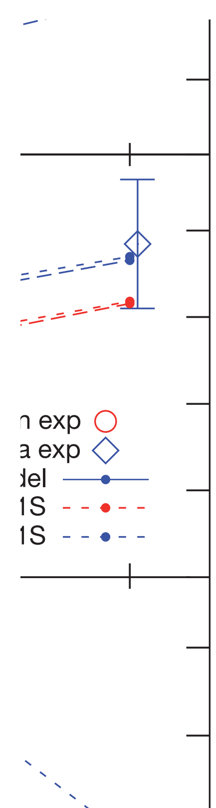
There is strong circumstantial evidence that certain heavy, unstable atomic nuclei are 'octupole deformed', that is, distorted into a pear shape. This contrasts with the more prevalent rugby-ball shape of nuclei with reflection-symmetric, quadrupole deformations. The elusive octupole deformed nuclei are of importance for nuclear structure theory, and also in searches for physics beyond the standard model; any measurable electric-dipole moment (a signature of the latter) is expected to be amplified in such nuclei. Here we determine electric octupole transition strengths (a direct measure of octupole correlations) for short-lived isotopes of radon and radium. Coulomb excitation experiments were performed using accelerated beams of heavy, radioactive ions. Our data on ^{220}Rn and ^{224}Ra show clear evidence for stronger octupole deformation in the latter. The results enable discrimination between differing theoretical approaches to octupole correlations, and help to constrain suitable candidates for experimental studies of atomic electric-dipole moments that might reveal extensions to the standard model.

The atomic nucleus is a many-body quantum system, and hence its   distribution weighted by radius squared[3]) is the lowest-order observ-



METHODS SUMMARY

In our experiments, the ^{220}Rn and ^{224}Ra produced by spallation diffused to the primary target surface and were then singly ionized ($q = 1^+$) in either an enhanced plasma ion-source[42] with a cooled transfer line (Rn) or a tungsten surface ion-source (Ra), accelerated to 30 keV, separated according to A/q, and delivered to a Penning trap, REXTRAP[43], at a rate of around 1.25×10^7 ions s^{-1} for ^{220}Rn and 4.4×10^7 ions s^{-1} for ^{224}Ra at the entrance. Inside the trap, the singly-charged ions were accumulated and cooled before allowing the ions to escape in bunches at 400 ms intervals into an electron-beam ion source, REXEBIS[43]. Here, the ions were confined for 400 ms in a high-density electron beam that stripped more electrons to produce a charge state of 52^+, extracted as 400 µs pulses before being mass-selected again according to A/q, and injected at 2.5 Hz into the REX linear post-accelerator. The level of isobaric impurity (for example, Fr) in the Ra beam was estimated to be below 1% by observing radio-active decays at the end of the beam line. For Rn, observation of contaminant decays was more difficult because of the small α-decay branching ratios to excited states, and only an upper limit of 5% could be obtained.

The GOSIA code performs a least-squares fit to the matrix elements between all known states coupled by electromagnetic operators, which are treated as free parameters. Although the fit is sensitive to the relative E1/E2 decay rates, E1 (and M1) excitation is negligible at the beam energies used and can be ignored. The magnitudes of the values of the starting parameters were chosen to be ran-

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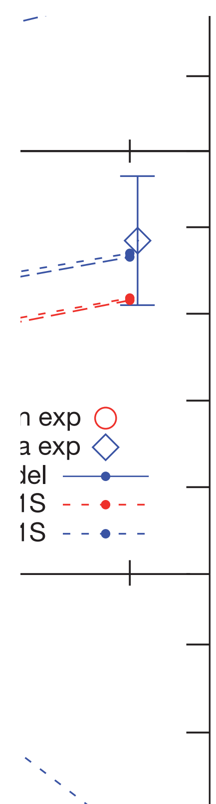

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2nd GOSIA WORKSHOP

9-11 April, 2013

GOSIA Workshop, HIL, Warsaw

1st GOSIA Workshop 2008 - EURONS

2nd GOSIA Workshop 2013 - ENSAR

- 27 participants
  form 15 institutes

Program

- 12 presentations:
  examples of COULEX analysis
- 3 working groups for hands-on session:
  practice with the GOSIA code
- round-table discussion:
  users needs to GOSIA development.

GOSIA updates

by Nigel Warr (Univ. of Cologne) for GOSIA Workshop 2013

- Manual improved. Doug Cline has also made a huge effort to improve the GOSIA manual/book.
- A code called “select” was mentioned, that could create the correlation matrix used by OP,ERRO. This has now been integrated into GOSIA as OP,SELE.
- There was a big problem with OP,INTG in inverse kinematics. For this a new OP,INTI has now been written and implemented.
- Spline code has been added as an alternative to the lagrangian method in the interpolation.
- The Band-Raman Internal Conversion Coefficients database (BrIcc): the fortran code for the BrIcc program is actually pretty simple, so I implemented it within GOSIA as OP,BRIC using spline. So now one can just download the BrIcc database from http://www.nndc.bnl.gov/nndcscr/ensdf_pgm/analysis/BrIcc and tell GOSIA where the database is. GOSIA then performs the interpolation for each transition that you use. You actually only need the .icc and .idx files. Use FO version normally, NH for Z > 110.
- Some experiments with Gammasphere ran into the limits on the number of levels, transitions and matrix elements. These arrays have been increased, which was not trivial due to the way GOSIA manages memory. However, there is an intrinsic limit of 999 matrix elements.
- There was a request for the Leuven and the RADWARE efficiency calibration parameterization parameterization was requested and implemented. There is now an EFF option in CONT, which selects the efficiency parameterization.
- RACHEL. Adam Hayes has made a huge effort to develop a GUI which can help the user to set up the input files and run GOSIA.
- And many others...

GOSIA Users needs

- **Calculating polarizations with GOSIA**
  GOSIA can easily give the statistical tensors, immediately after the excitation, but these are modified by the decay. To calculate the polarization, we need the statistical tensor for each level, just before the decay of that level. Actually, this is what is needed to calculate the angular distribution.

- **Comparison with other codes:**
  CLX (H. Ower), ECIS (Jacques Raynal), RELEX (C.A. Bertulani),
  DWEJKO (C.A. Bertulani, C.M. Campbell, T. Glasmacher).

- **Slowed down beams**
  Hans-Juergen Wollersheim (GSI) presented in his talk the issue with beams slowed down with a degrader. There is a broad spread in the energies of the beam and a broad angular spread too. The idea is to replace the stopping powers with some sort of convolution of the stopping power and the energy distribution in the beam.

- **What is needed in GOSIA for AGATA?**

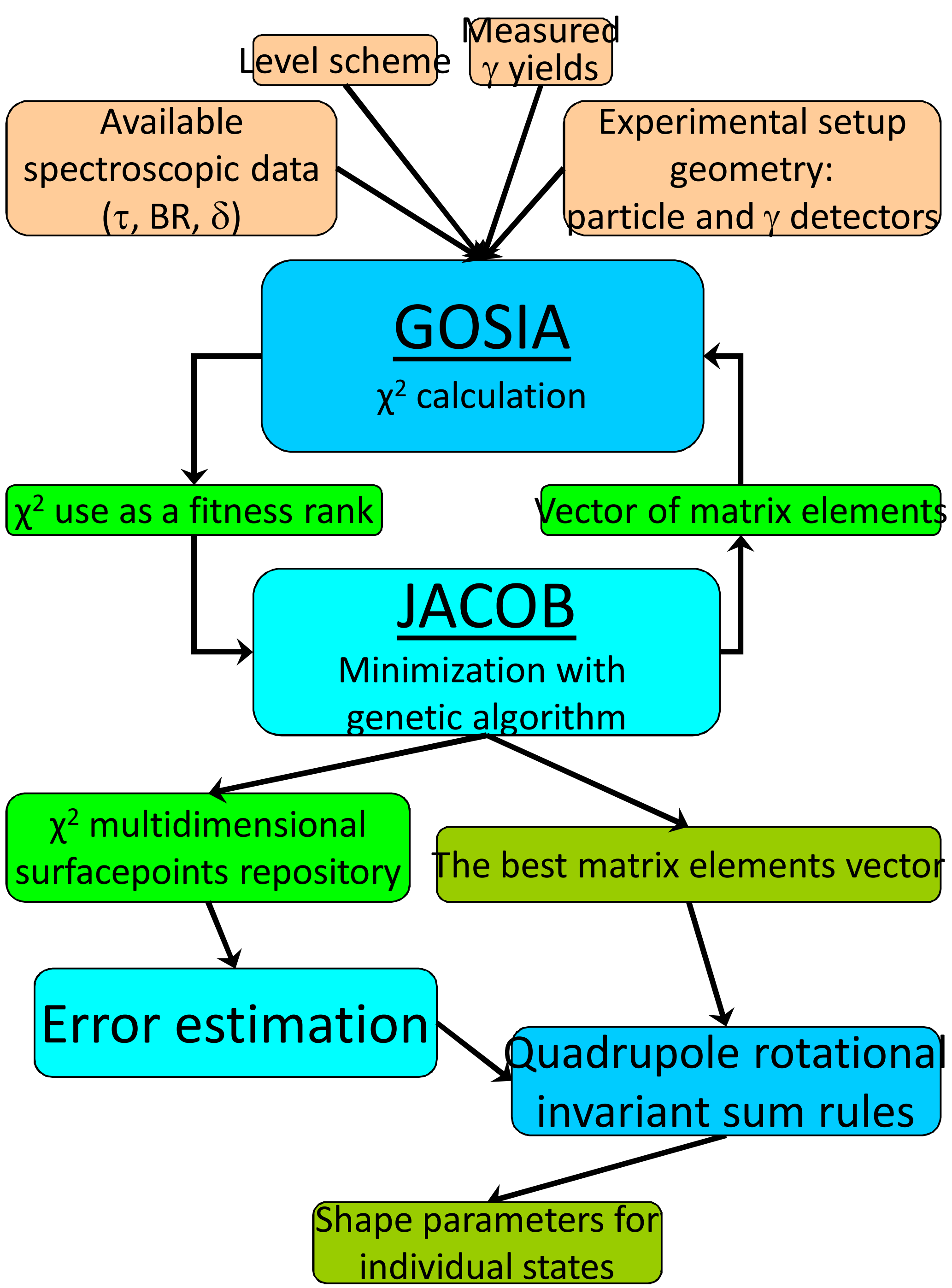
GOSIA in future

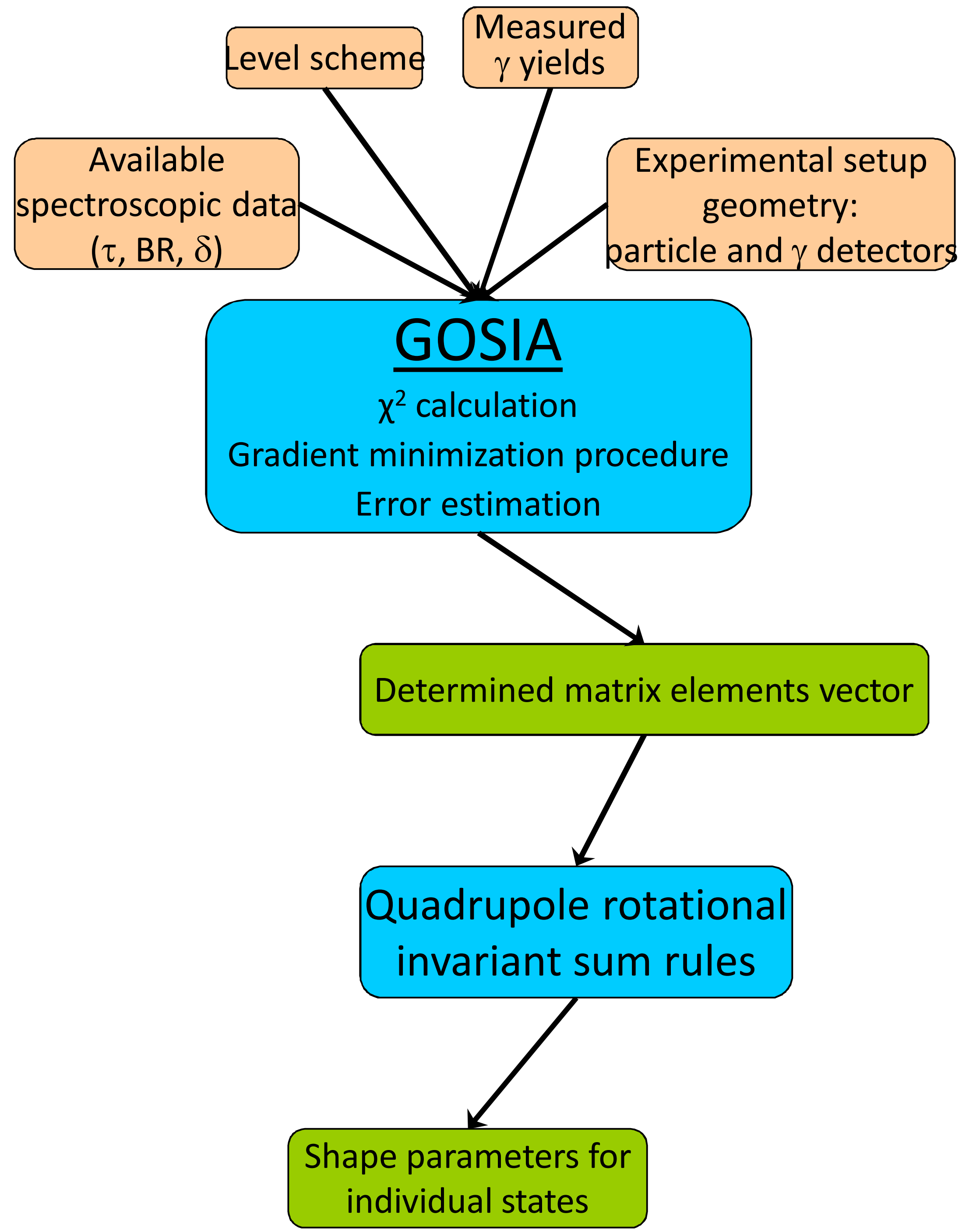
A new code should be extensible to allow new features:

- arbitrary particle- and γ–detector shapes
- alternative excitation codes (e.g. for intermediate energy)
- alternative de-excitation codes (e.g. to couple to geant4)
- alternative fit methods (e.g. genetic approach)

There are lots of ideas . . . but we need manpower to implement them!

Jacob - Genetic GOSIA





Jacob - Genetic GOSIA

The idea behind genetic algorithms is to do what nature does. Let us take rabbits as an example: at any given time there is a population of rabbits. Some of them are faster and smarter than other rabbits. These faster, smarter rabbits are less likely to be eaten by foxes, and therefore more of them survive to do what rabbits do best: make more rabbits. Of course, some of the slower, dumber rabbits will survive just because they are lucky. This surviving population of rabbits starts breeding. The breeding results in a good mixture of rabbit genetic material: some slow rabbits breed with fast rabbits, some fast with fast, some smart rabbits with dumb rabbits, and so on. And on the top of that, nature throws in a 'wild hare' every once in a while by mutating some of the rabbit genetic material. The resulting baby rabbits will (on average) be faster and smarter than these in the original population because more faster, smarter parents survived the foxes. (It is a good thing that the foxes are undergoing similar process — otherwise the rabbits might become too fast and smart for the foxes to catch any of them).

A genetic algorithm follows a step-by-step procedure that closely matches the story of the rabbits. Before we take a closer look at the structure of a genetic algorithm, let us have a quick look at the history of genetics (from [380]):

> "The fundamental principle of natural selection as the main evolutionary principle has been formulated by C. Darwin long before the discovery of genetic mechanisms. Ignorant of the basic heredity principles, Darwin hypothesized fusion or blending inheritance, supposing that parental qualities mix together like fluids in the offspring

Zbigniew Michalewicz
Genetic Algorithms + Data Structures = Evolution Programs
Springer-Verlag Berlin and Heidelberg GmbH & Co. K, 2013

Jacob - Genetic GOSIA

14 1. GAs: What Are They?

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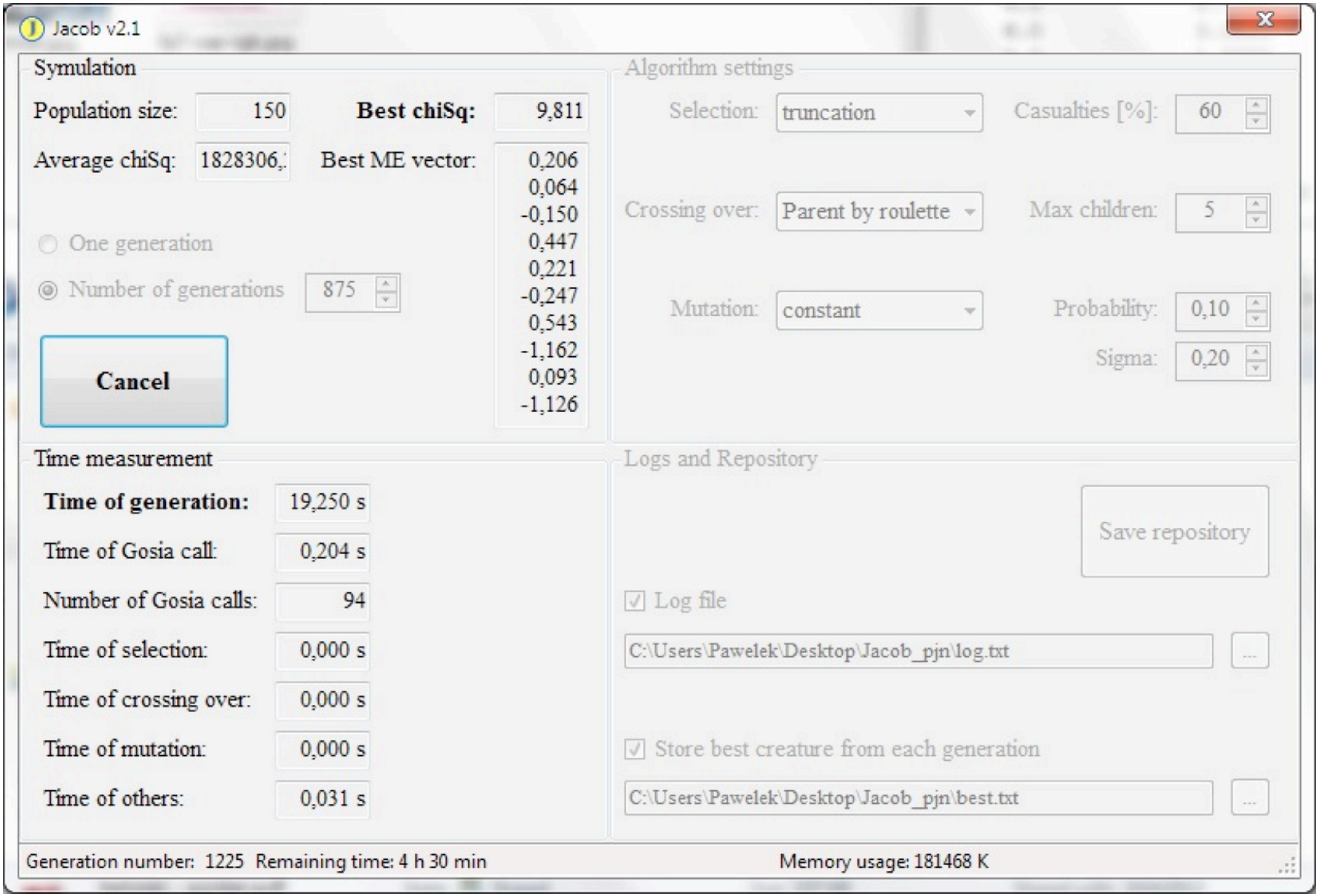
JACOB - Genetic algorithm implementation:

- the same data input scheme as in GOSIA
- resistance to the local minimum problem
- automatic scan for alternative solutions and expected better convergence to the global minimum
- error estimation based on the scan of the surface. χ2 surface
- parallel processing on several clustered computers connected into a network.

Jacob application



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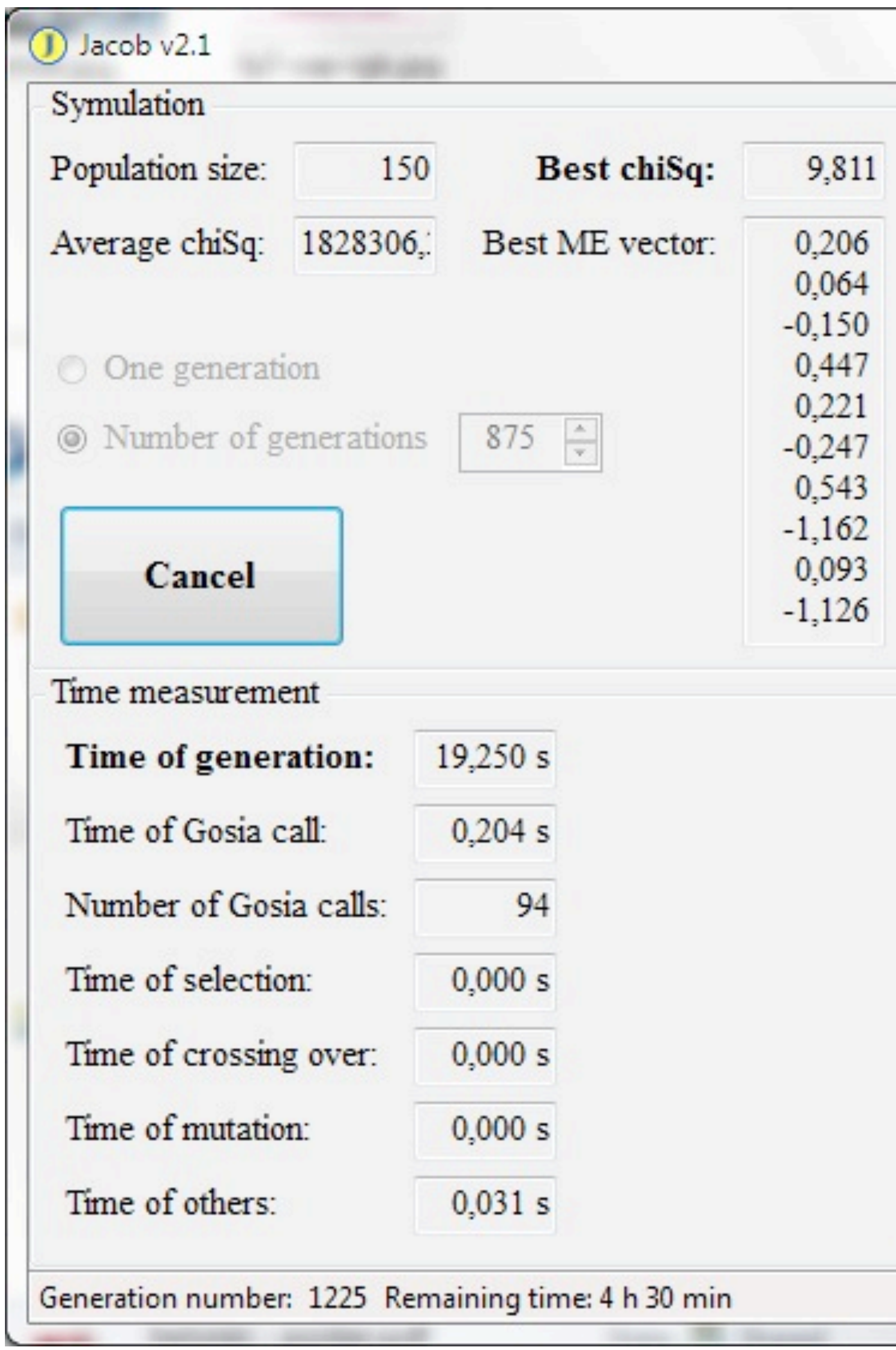
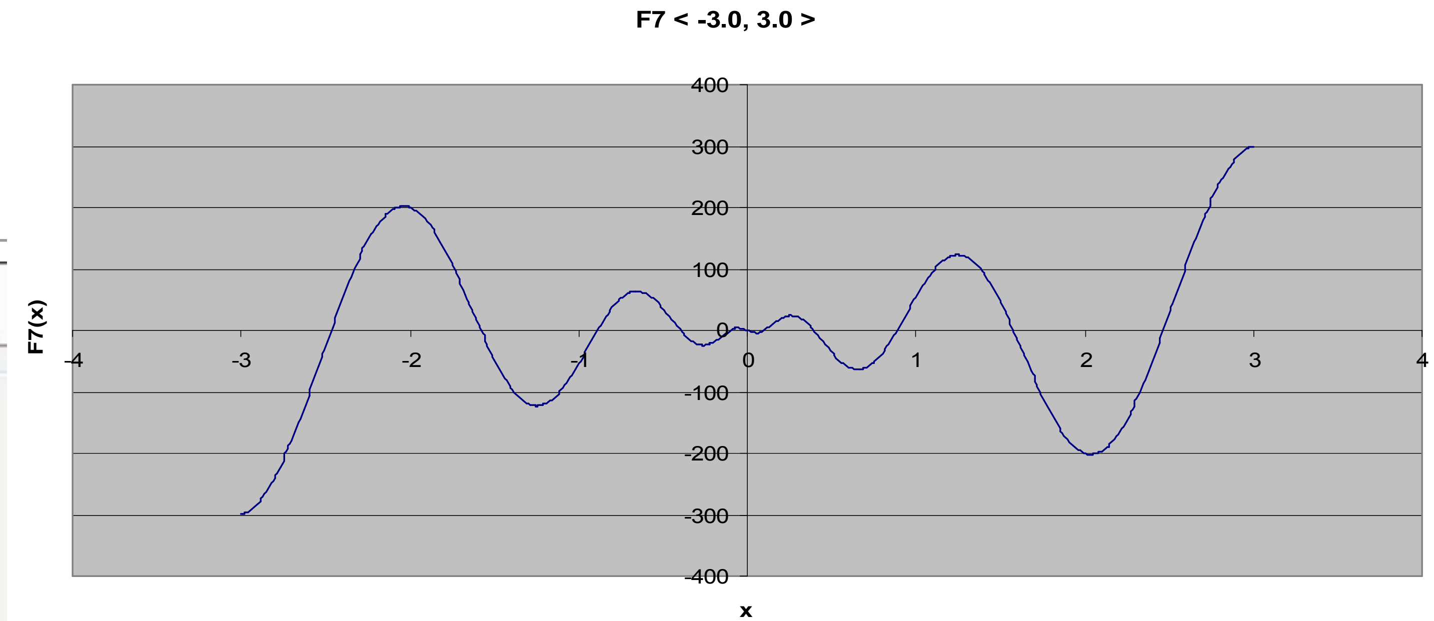
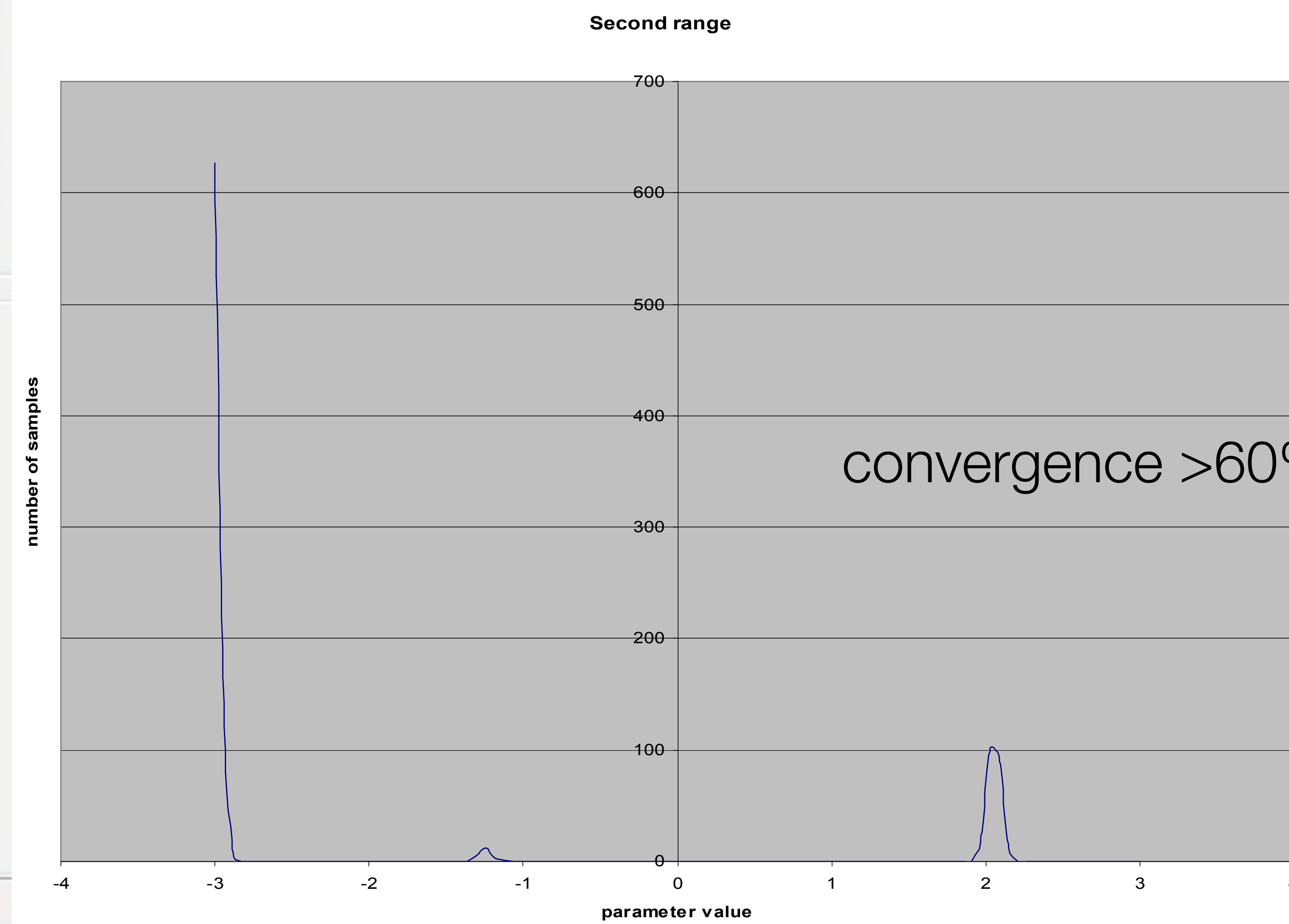
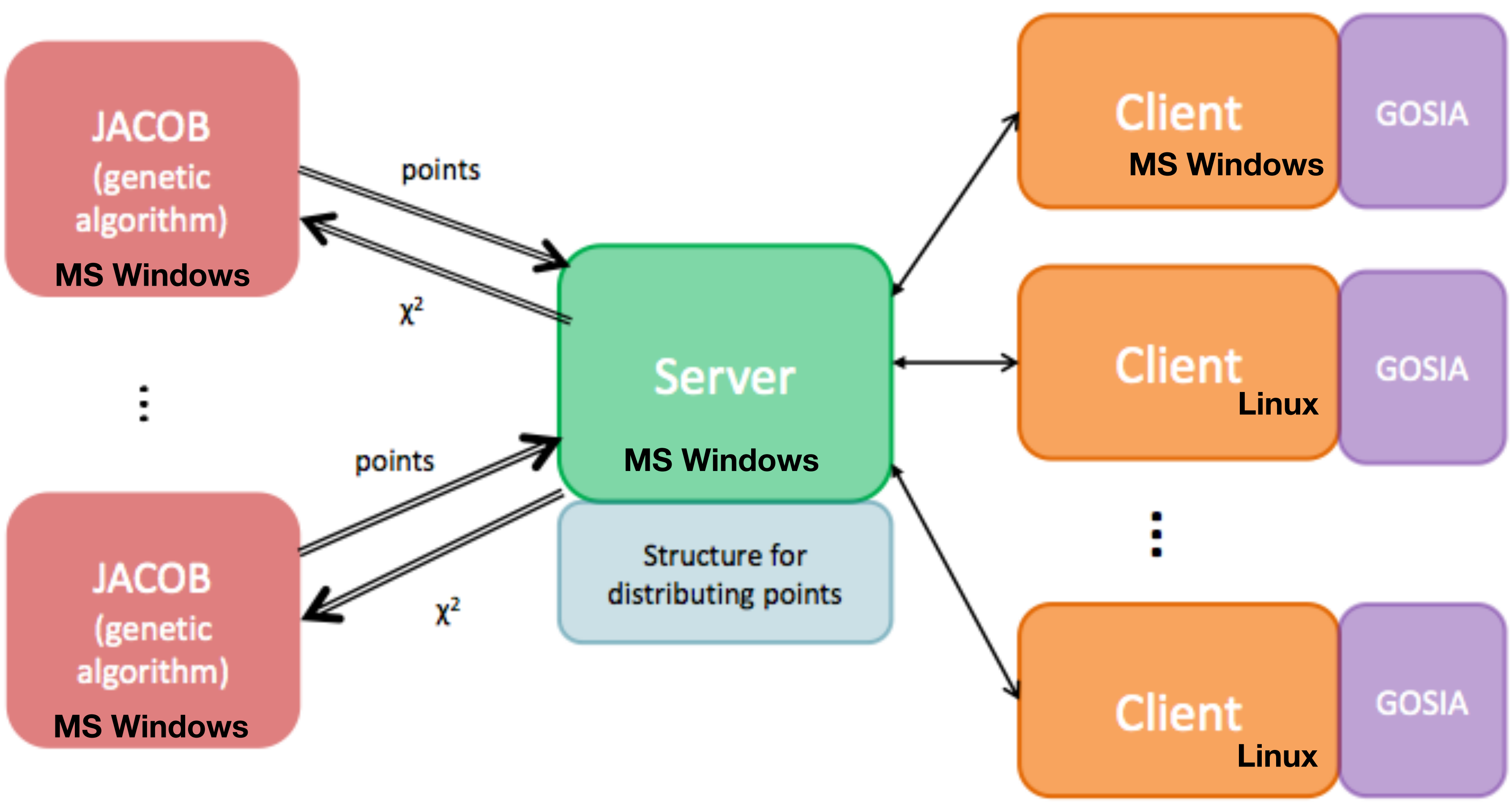




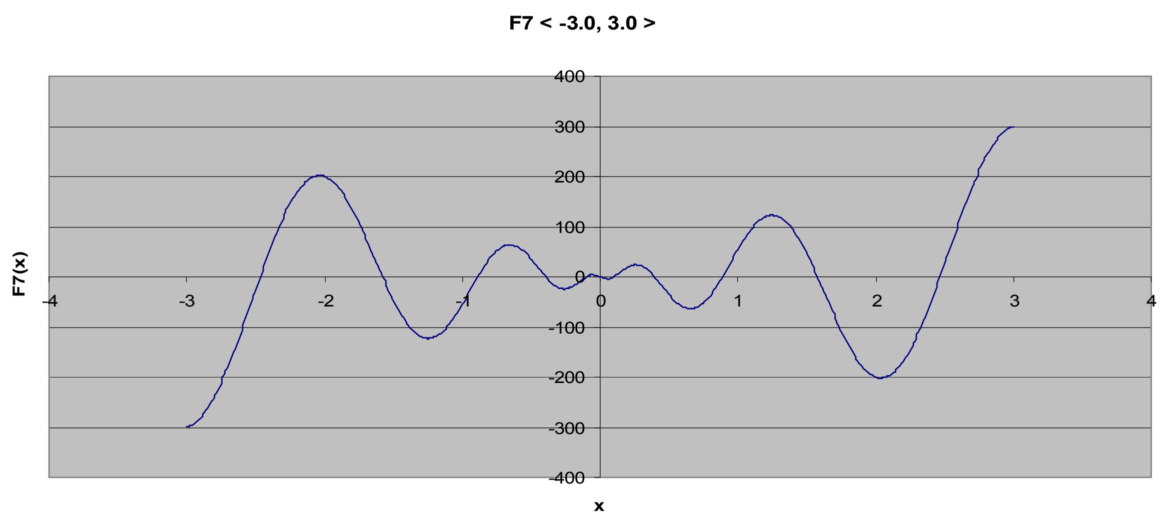


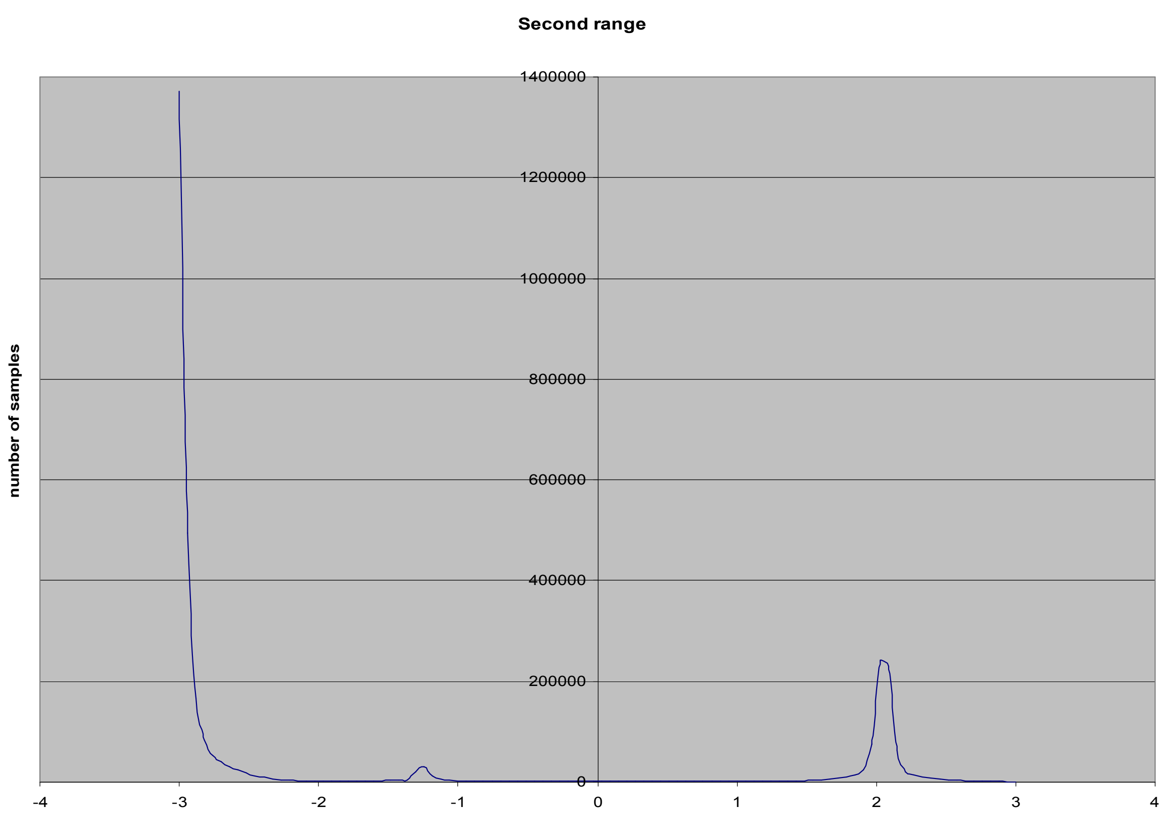
convergence >60%

Parallel processing



Chi-square landscape scan





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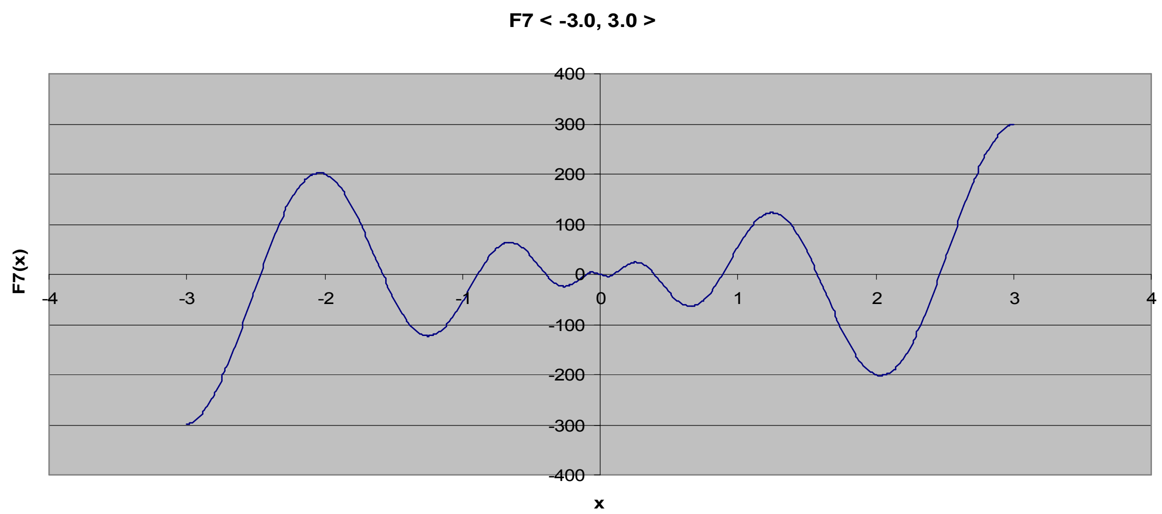
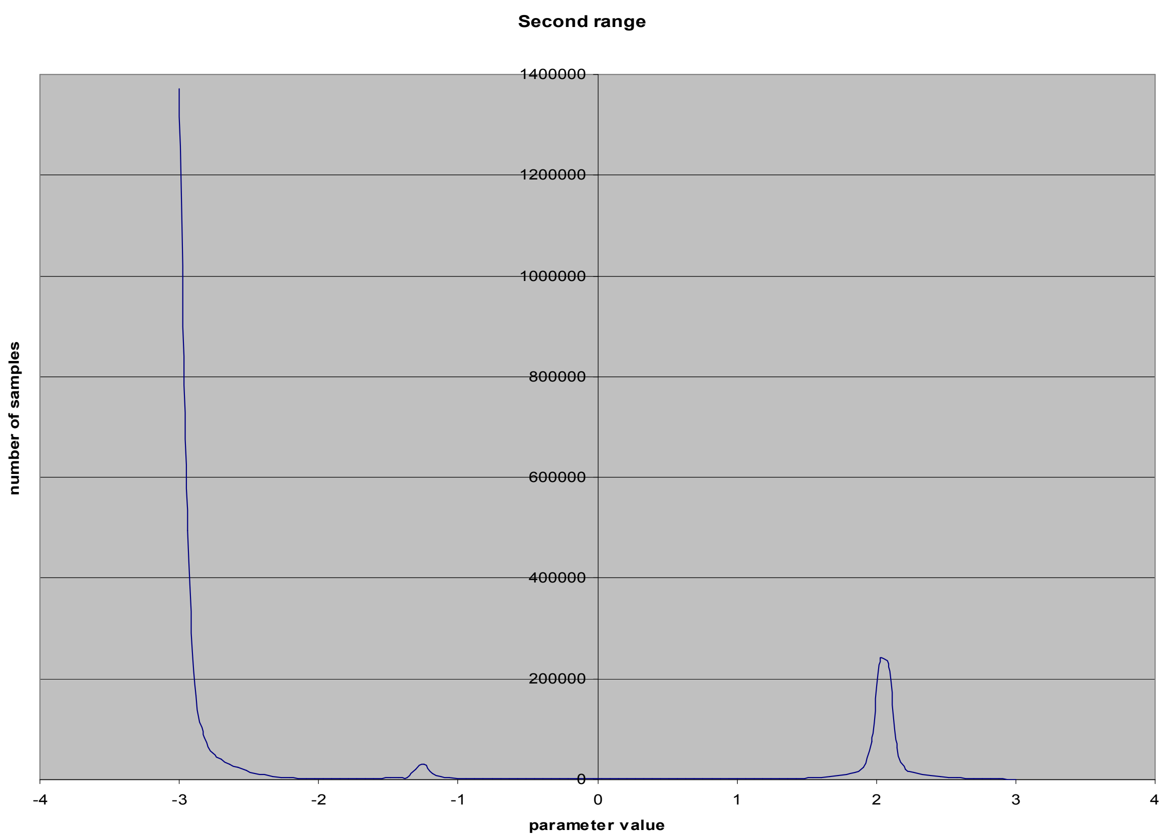
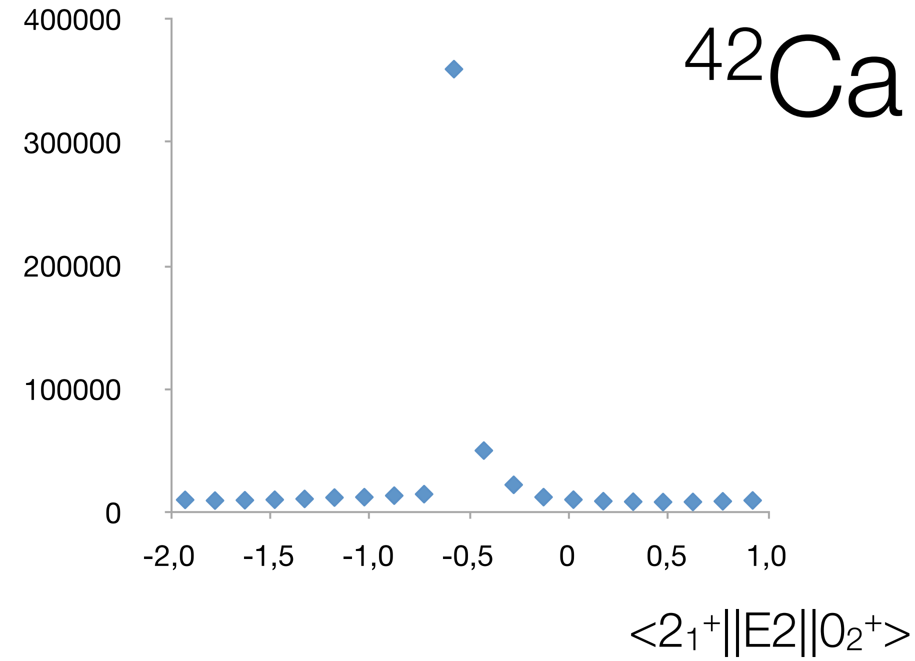
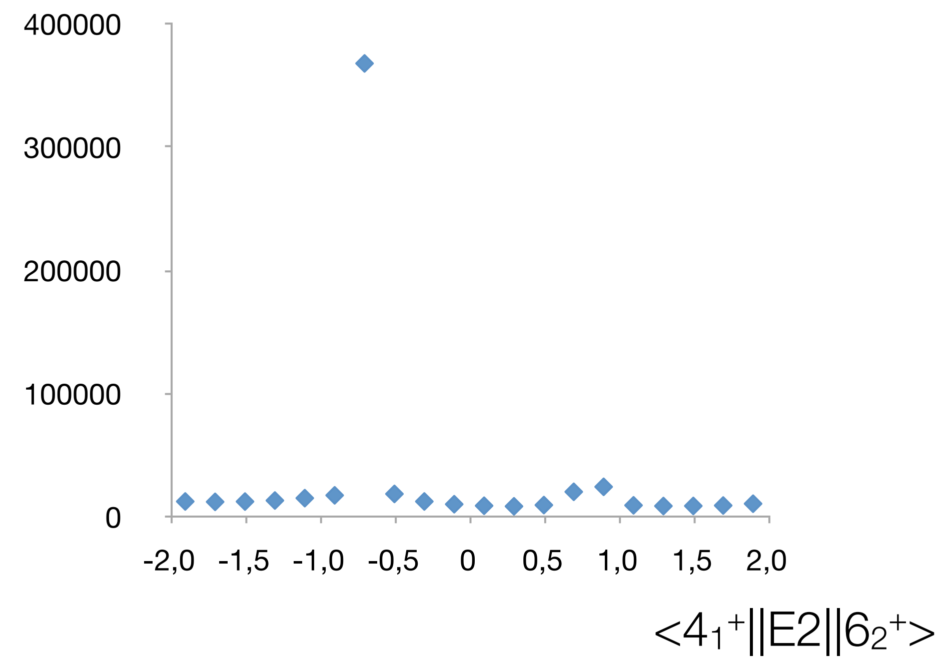
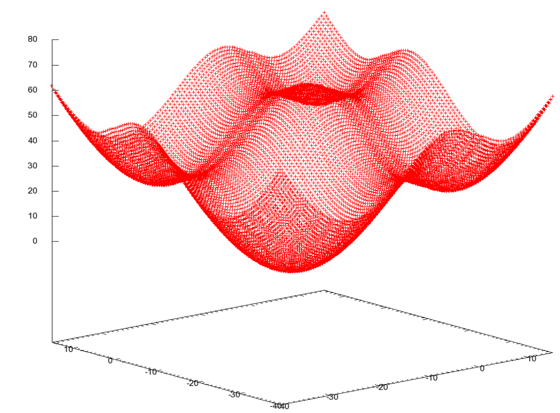


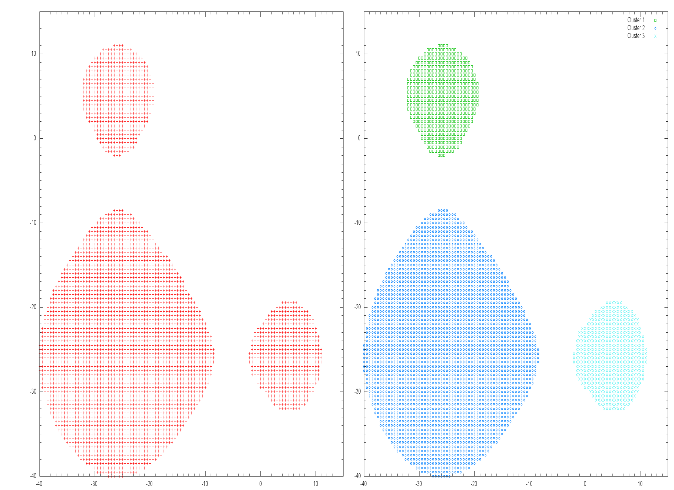


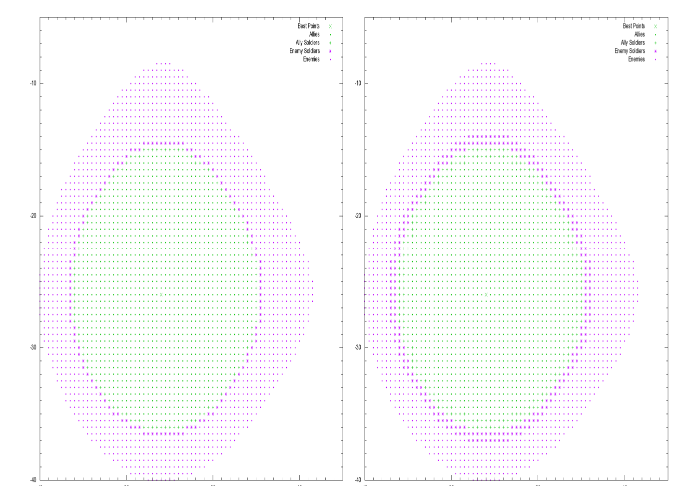




Front Line Algorithm for error estimation







D.A.Piętak, J. Wojciechowski, P. J.Napiorkowski
A Front Line Algorithm For Error Estimation In Data Sets With Nonuniform Sampling Distribution
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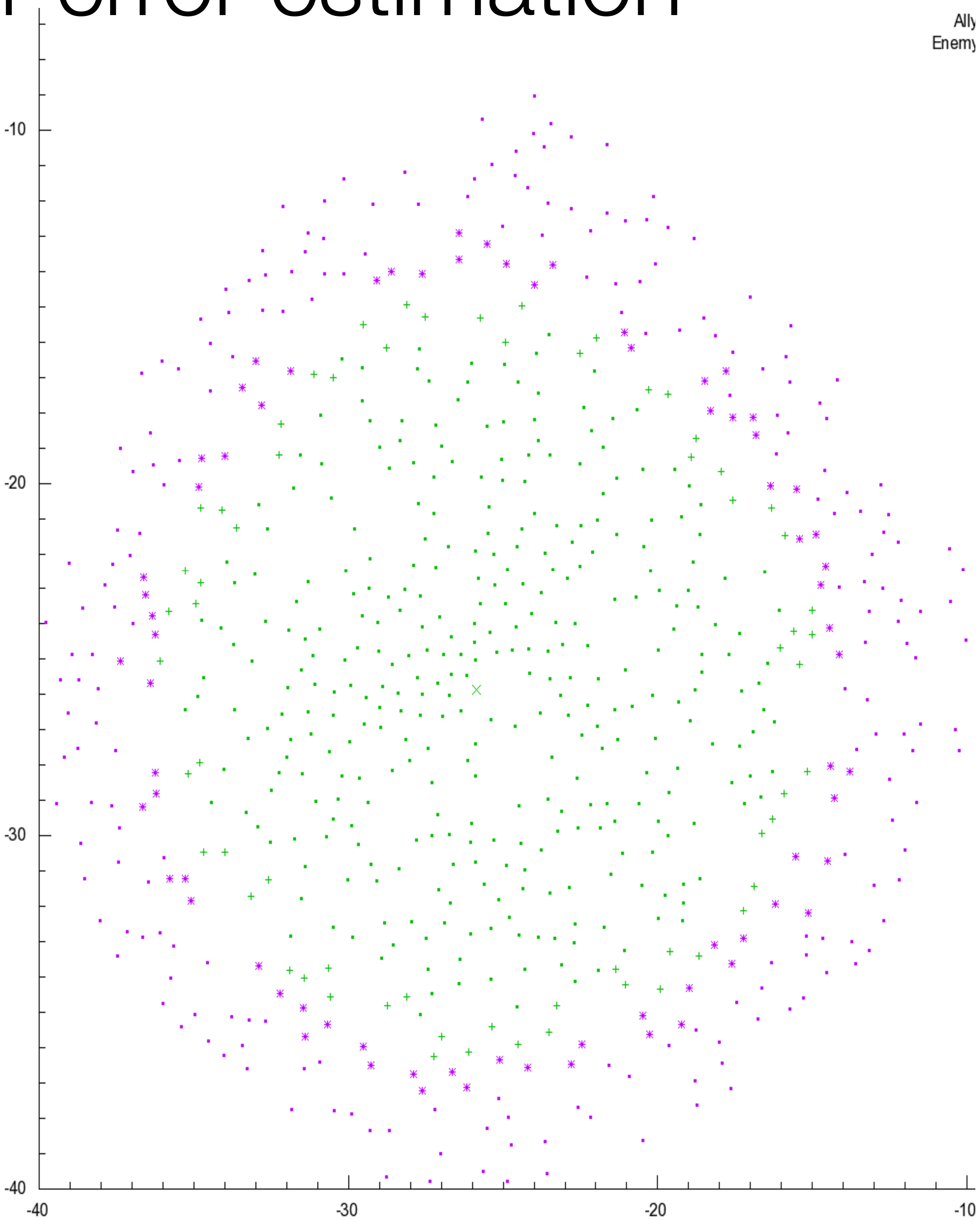

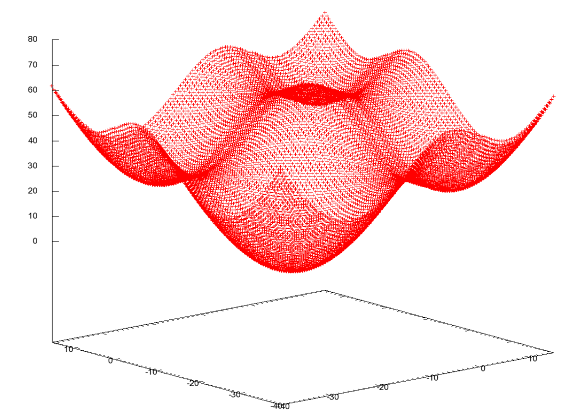

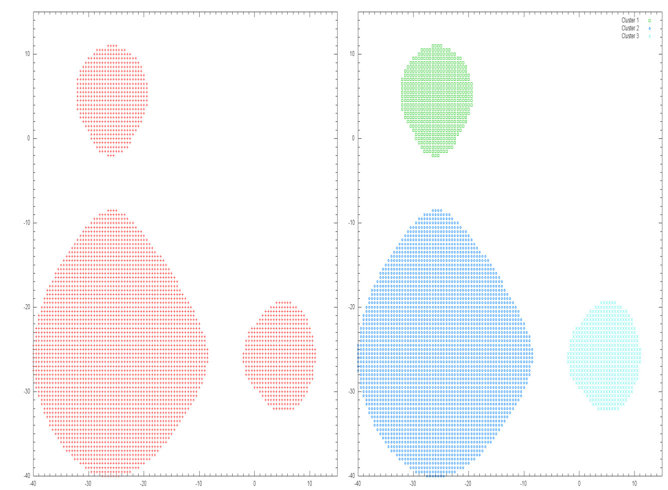

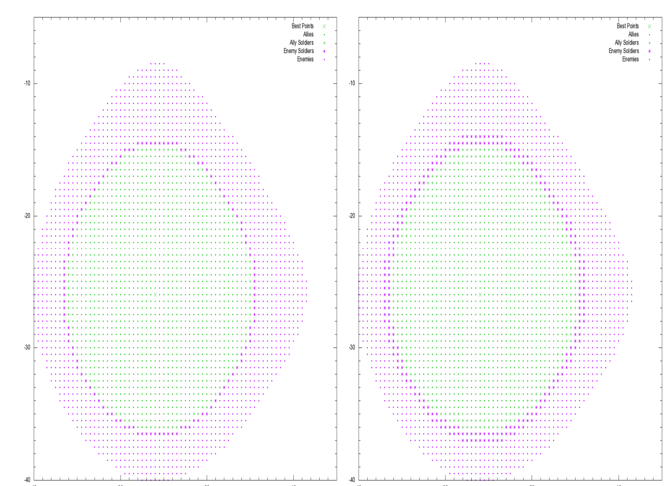

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Summary

- GOSIA is in a good shape.
- GOSIA Users Group keeps the GOSIA code updated.
- Development of genetic approach is going on.
- Look forward to the 3rd GOSIA Workshop

DOUG CLINE awarded the Marian Smoluchowski medal

The Founding Father of Multiple Coulomb Excitations Douglas Cline has been awarded Marian Smoluchowski Medal by Polish Physical Society. It is the highest honor offered by the Polish Physical Society.

The official ceremony will take place
September 9, 2013 in Poznan
at Polish Physicist Congress

The award is conferred upon Douglas Cline in recognition of his part in development of nuclear structure studies as well as his outstanding contribution to the work and progress of the Warsaw centre of nuclear spectroscopy.

The Marian Smoluchowski Medal is awarded annually for exceptional research in the field of physical science and role in promoting physics and physics education in Poland.

see:http://www.42zfp.put.poznan.pl

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XLII Zjazd Fizyków Polskich
Poznań 8-13.09.2013

- Zaproszenie
- Komitety
- Sesje specjalistyczne
- Wystąpienia plenarne
- Terminy i opłaty
- Kontakt
- Rejestracja
- Materiały

Wykład inauguracyjny

prof. Klaus von Klitzing laureat Nagrody Nobla 1985	**Max Planck Institute for Solid State Research, Stuttgart**	**Fundamental constants: A new basis for our international system of units!?**

Wykłady plenarne zaproszone (50 min + 10 min)

prof. D. Cline Laureat nagrody Smoluchowskiego - 2013	University of Rochester	Coulomb excitation as a probe of nuclear structure

Wystawcy

WYDAWNICTWO NAUKOWE PWN

Visit to Heavy Ion Laboratory

Thursday (20.06) after lunch
please contact
the registration desk