Mathematical modeling of physical problems and high-performance computing on the heterogeneous cluster HybriLit

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Invited Lecture at the RO-LCG 2014 conference, November 3-5, 2014

I. *General*

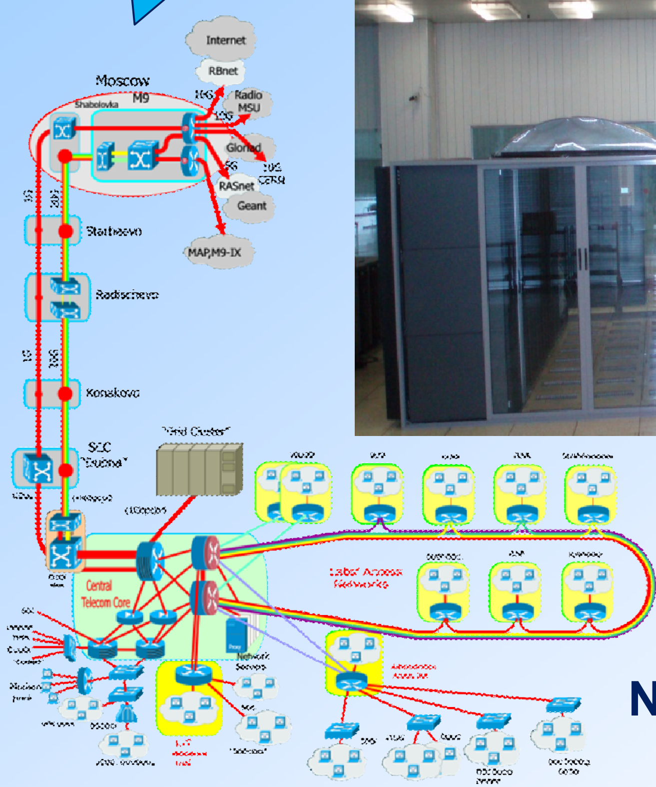
JINR Field of Research:

Networking, Computing, Computational Physics

LIT Topics in JINR Topical Plan:

05-6-1118-2014/2016 Information and Computing Infrastructure of JINR

05-6-1119-2014/2016 Methods, algorithms and software for modeling physical systems, mathematical processing and analysis of experimental data



Network

Resource

Mathematical simulation, methods, algorithms and software

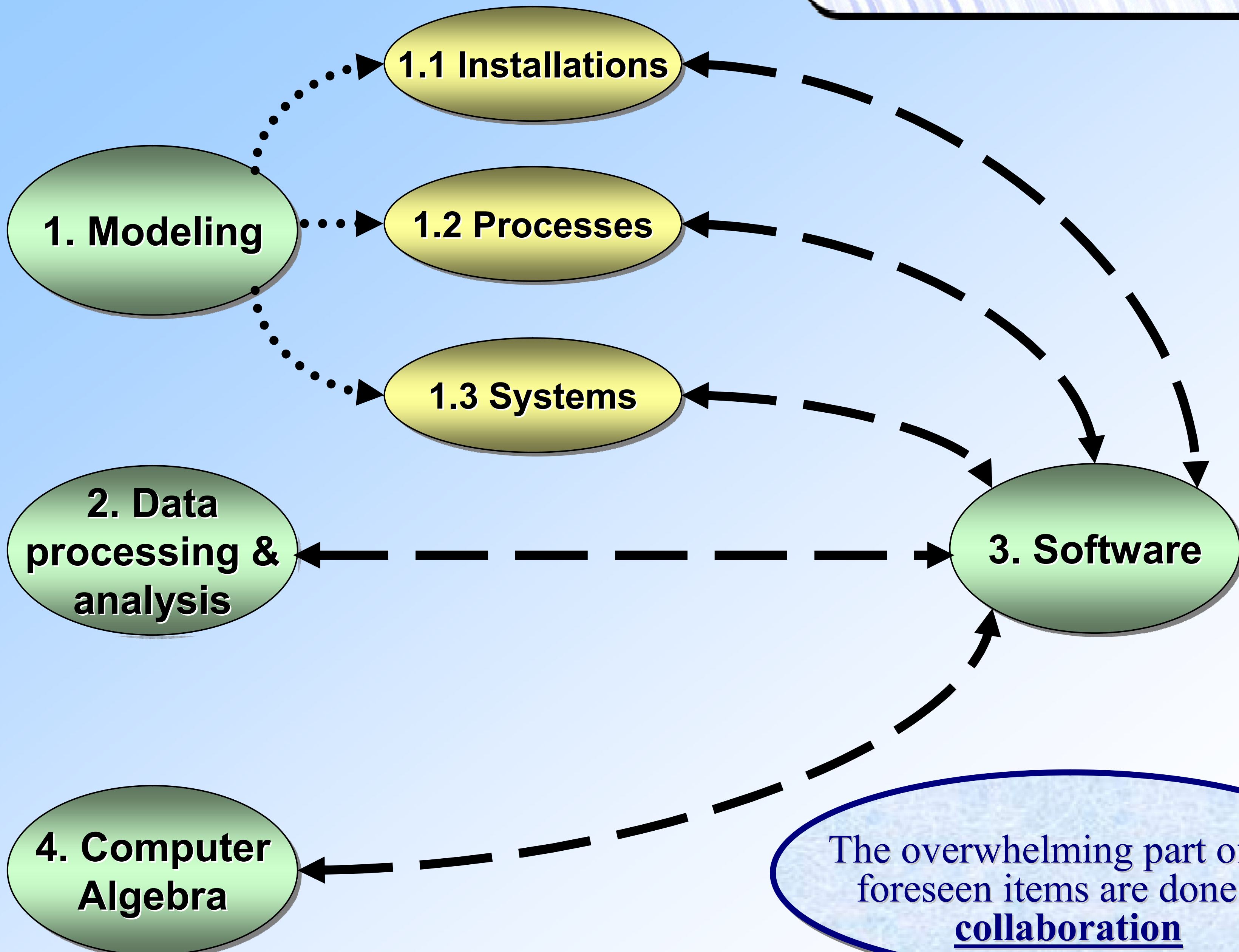
Information systems

Applied

The four main tasks of the topic 1119

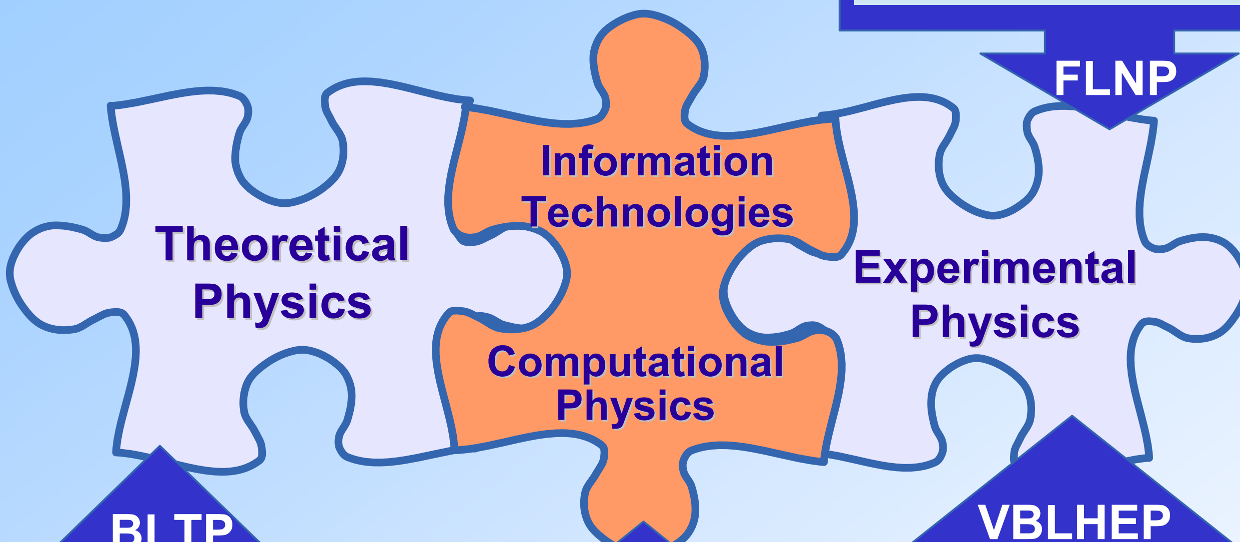
1. **Development of mathematical and computational methods for modeling**: new experimental facilities, accelerator complexes and their elements; nuclear-physical processes; complex physical systems.
2. **Mathematical methods for data processing and analysis**: development of new mathematical approaches for experimental data processing; algorithms and program complexes for solving topics in high energy physics, nuclear physics, condensed matter physics, including those at accelerator complexes LHC, NICA, FAIR, etc.
3. **Development of numerical methods, algorithms, and software, computationally adapted to many-core and hybrid architectures**, for solving physical models in high energy physics, nuclear physics, condensed matter physics, and nanotechnology.
4. **Development of methods, algorithms, and software of computer algebra** for modeling quantum systems and quantum informational processes, as well as for solving other applied mathematics topics.

Bird's-eye-view



The overwhelming part of the foreseen items are done **in collaboration**

LIT participates in 42 projects of 27 JINR topics of the 2014 Topical Plan of JINR



FLNP

04-4-1075-2009/2014
Leaders: S.A. Kulikov, V.I. Prikhodko

03-4-1104-2011/2016
Leader: V.N. Shvetsov, Deputies: Yu.N. Kopatch, E.V. Lychagin, P.V. Sedyshev

DLNP

02-2-1080-2009/2015
Leader: L.G. Afanasyev,
Sci. leader: L.L. Nemenov

02-2-1099-2010/2015
Leader: Yu.A. Gornushkin
Deputy: O.Yu. Smirnov

02-2-1109-2012/2014
Leader: L.G. Tkatchev

03-2-1101-2010/2015
Leaders: A.V. Kulikov

03-2-1102-2010/2015
Leaders: M.Yu. Kazarinov,
G.A. Karamysheva

BLTP

01-3-1113-2014/2018
Leaders: D.I. Kazakov,
O.V. Teryaev, A.B. Arbuzov

01-3-1114-2014/2018
Leaders: V.V. Voronov,
A.I. Vdovin, N.V. Antonenko

01-3-1116-2014/2018
Leaders: A.P. Isaev, A.S. Sorin
Deputy: S.O. Krivonos
Scientific leader: A.T. Filippov

LIT

Methods, Algorithms and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data

VBLHEP

02-1-1097-2010/2015
Leader: A.D. Kovalenko,
Deputies: N.M. Piskunov,
V.P. Ladygin, M. Finger (Jr.), R.A. Shindin

02-1-1088-2009/2016
Leader: A.S. Vodopyanov

02-1-1106-2011/2016
Leader: A. Malakhov,
V. Ivanov

02-0-1066-2007/2015
Leaders: R. Lednicky, Yu.A. Panebratsev

02-0-1081-2009/2016
Leaders: N.A. Russakovich,V.A. Bednyakov,
Deputy: A.P. Cheplakov

02-0-1065-2007/2014
Leaders: A.S. Sorin, V.D. Kekelidze Deputyies
G.V. Trubnikov, A.D. Kovalenko, I.N. Meshkov

02-0-1108-2011/2016
Leader: A.G. Olshevskiy,
Deputies: G.D. Alexeev, A.S. Vodopyanov

02-0-1082-2009/2014
Leaders: G.D. Alexeev, V.V. Glagolev,
Scientific leader: J.A. Budagov

02-0-1085-2009/2016
Leader: A.P. Nagaytsev,
Scientific leader: I.A. Savin

02-0-1083-2009/2016
Leader: A. Zarubin,
Scientific leader: I.A. Golutvin

II. *Large scale international collaborations*

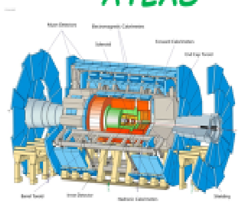
Significant participation in large scale international collaborations

Sizeable specific contributions to:

- **Magnetic field calculations** for new experimental facilities and elements of accelerator complexes
  - CBM dipole magnet;
  - SIS100 magnet elements at FAIR;
  - Profile optimization of the NICA collider dipole magnet;
  - Booster quadrupole magnet at NICA;
  - 3D-dipole magnet for BM@N
- **Software upgrade** for components of the improved **ATLAS** and **CMS** detectors, as part of JINR contribution
- Modeling, algorithm and software for **CBM@FAIR**
- Mathematical modeling of the hot and dense nuclear matter and spin physics phenomena within the flagman JINR **NICA/MPD** project
- Contributions to the upgrade of the **Geant4 package**

JINR participates in 3 experiments at LHC : ATLAS, CMS, ALICE

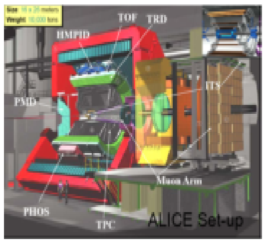
ATLAS



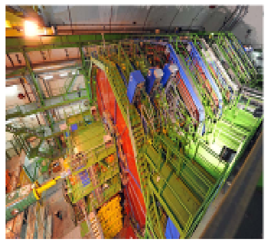
Physics:

- *Top-quark*
- *QCD @ Standard Model Physics*
- *Higgs Physics*
- *SUSY Physics*
- *Exotics Physics*
- *Heavy Ions Physics*

ALICE



CMS



LIT JINR, in particular, takes part in muon reconstruction studies in the CMS experiment

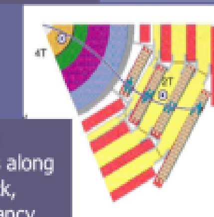
The CMS Original Concept

Guiding channels: $H \to ZZ \to \ell^+\ell^-\ell^+\ell^-$, $H \to \gamma\gamma$

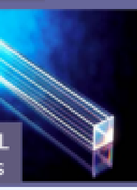
Optimized for high p_T leptons (and γ)

- Good momentum resolution with high B-field $\frac{\Delta p}{p} \sim p$ ⇒ 3.8T Solenoid

- Excellent and redundant muon identification ⇒ 4 muon stations along the track, redundancy



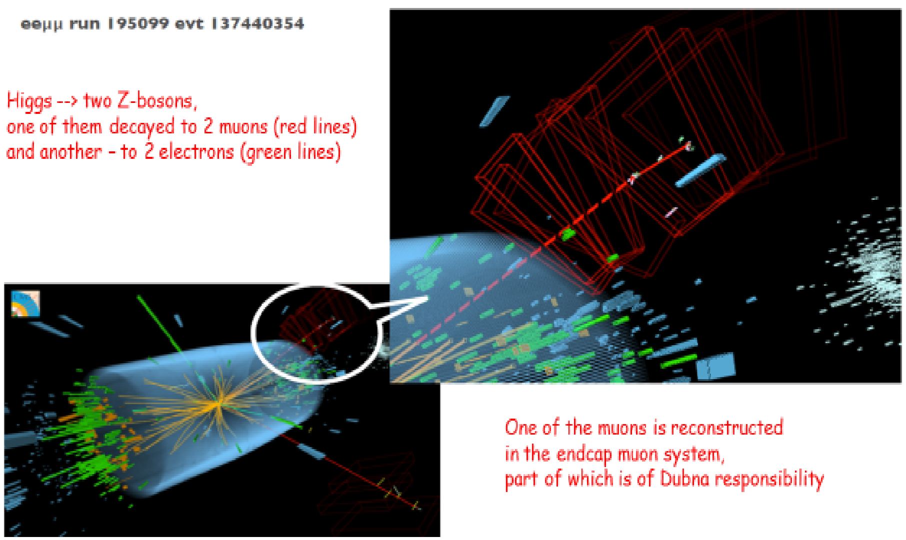
- Very high energy resolution for electrons and photons $\frac{\Delta E}{E} \sim \frac{1}{\sqrt{E}}$ ⇒ Fully active ECAL made of crystals



A HIGGS CANDIDATE 4-JUL-2012

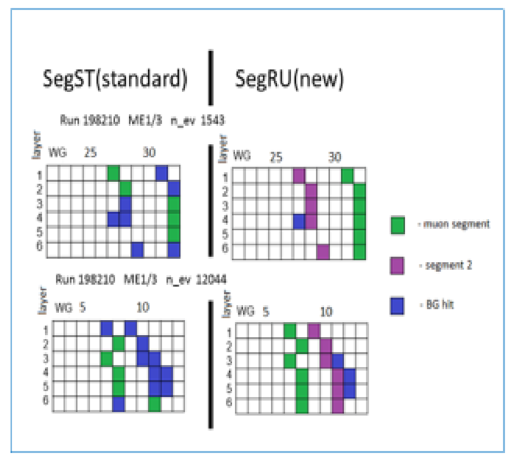
eeμμ run 195099 evt 137440354

Higgs --> two Z-bosons, one of them decayed to 2 muons (red lines) and another - to 2 electrons (green lines)



One of the muons is reconstructed in the endcap muon system, part of which is of Dubna responsibility

Current LIT activities: development of a new CMS muon segment builder



The new algorithm successfully decides the problems with background and multiplicity of hits, providing a correct muon segment building.

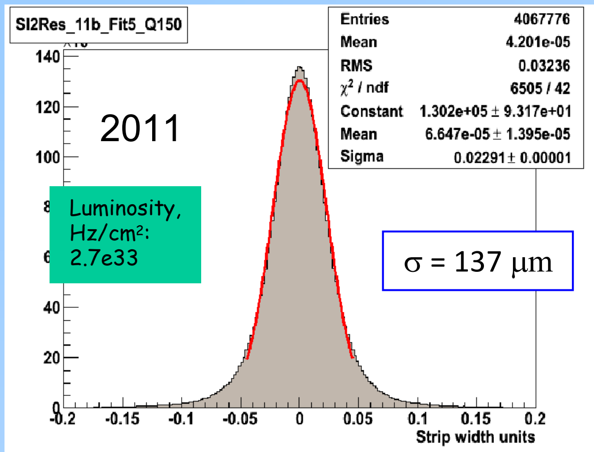
SegST – resulted from a current CMS code and
SegRU – resulted from the new algorithm;

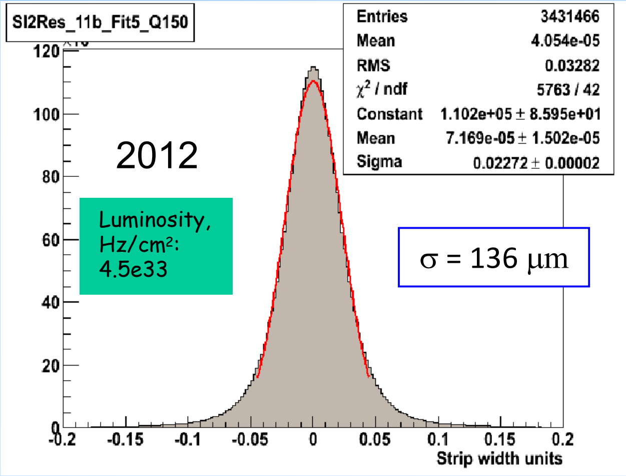
hitted Wire Groups are marked on the 6 Cathode Strip Chamber layers:
blue – background,
green – muon segment,
violet – electromagnetic secondaries

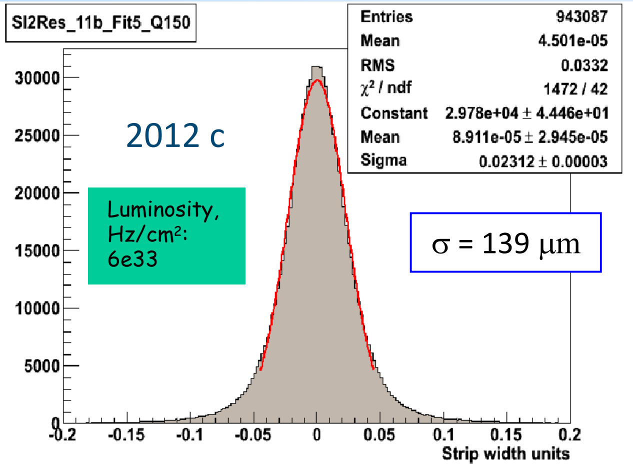
To be reported at CERN in November

By courtesy of V. Palichik and E. Tikhonenko (LIT)

CMS Cathode Strip Chambers Performance





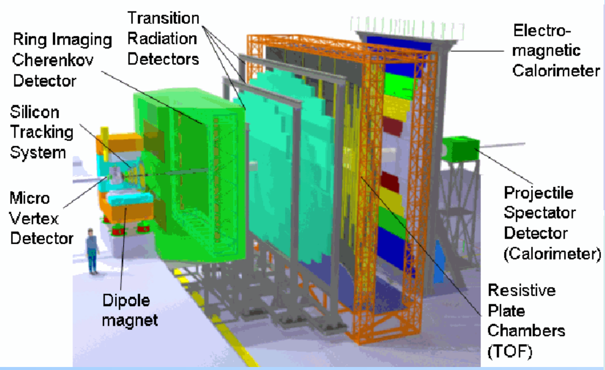


- Vladimir Palichik (LIT) is co-convenor of CMS CSC DPG (Detector Performance Group) since 2011.
- Outstanding contributions of LIT group to CMS during 2011-2013:
  - estimation of the cathode strip chambers spatial resolution and local reconstruction efficiency using 2012 collisions data;
  - ME1/1 chamber testing and troubleshooting;
  - offline validation of refurbished ME1/1 chambers with cosmic ray muons

Co-authorship to CMS Publications: **257** *during* 2011-2013 *in refereed journals (Phys.Lett.B. Phys.Rev.D, Phys.Rev.Letters, The European Phys.Journal C, Journal of High Energy Physics and others);*
\- **8** members of LIT staff *are among the* authors *of the* seminal CMS paper *"Observation of a new boson at a mass of 125 GeV with the CMS experiment at the LHC", Physics Letters B 716 (2012) 30-61.*

Left and Center: V.Palichik (LIT) report at CMS Run Coordination Workshop, Torino, Italy (Feb., 2013)
Right: V.Palichik et al., Journal of Instrumentation, 8 (2013) P11002.

CBM@GSI – Methods, Algorithms & Software for Fast Event Reconstruction



Fast parallel algorithms developed for event reconstruction

1)Tracking: Kalman filter and track following;

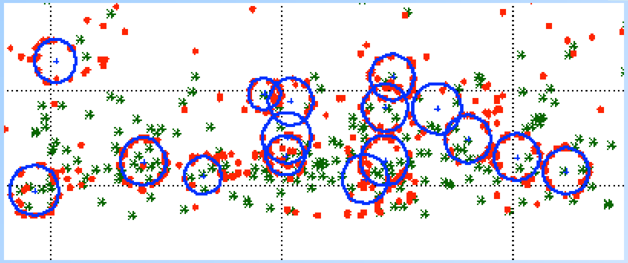
2) Ring reconstruction: Hough Transform, COP, ellipse fitting;

3) Electron identification in RICH: ANN and cuts

Modern technologies for parallelization:

1) Vectorization (SIMD - Single Instruction Multiple Data);

2) Multithreading (many cores CPU)



Results:

1) High efficiency of track and ring reconstruction (93-95%);

2) Very fast algorithms (few ms per event)

Task	Initial Time [ms/event]	Parallel Time [ms/event]	Speedup
Tracking	730	1.5	487
Ring reconstruction	375	2.5	143

TASKS:

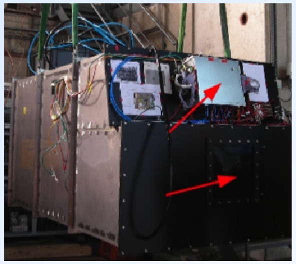
1) Development of methods, algorithms, and software for:
   - global track reconstruction;
   - event reconstruction in RICH;
   - electron identification in TRD;
   - momentum reconstruction;

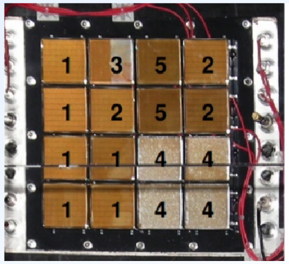
2) Magnetic field calculations;

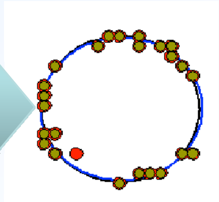
3) Beam time data analysis of the RICH and TRD prototypes;

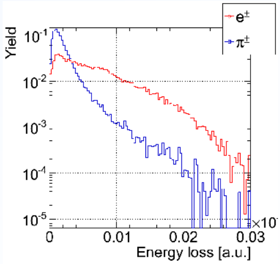
4) Tools for quality assurance of the CBMROOT software;

5) Contribution to the CBMROOT development







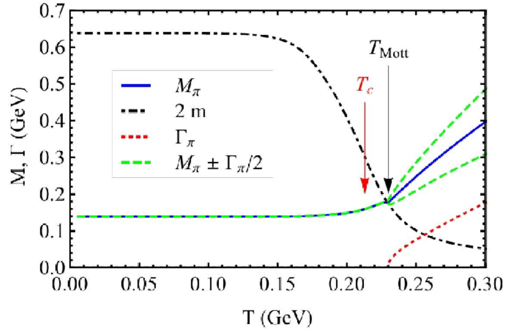


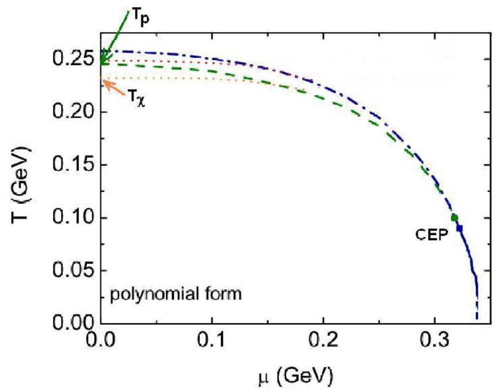
NICA/MPD: Development of a consistent QCD approach to the process modeling at finite temperature and density

☀ Consistent description of **chiral symmetry breaking** and its **restoration** at finite temperature

☀ Inclusion of the continuum state contribution to the scattering shift together with the Breit-Wigner ansatz for the resonance yields **computed phase shifts obeying the Levinson theorem**

Phase diagram:





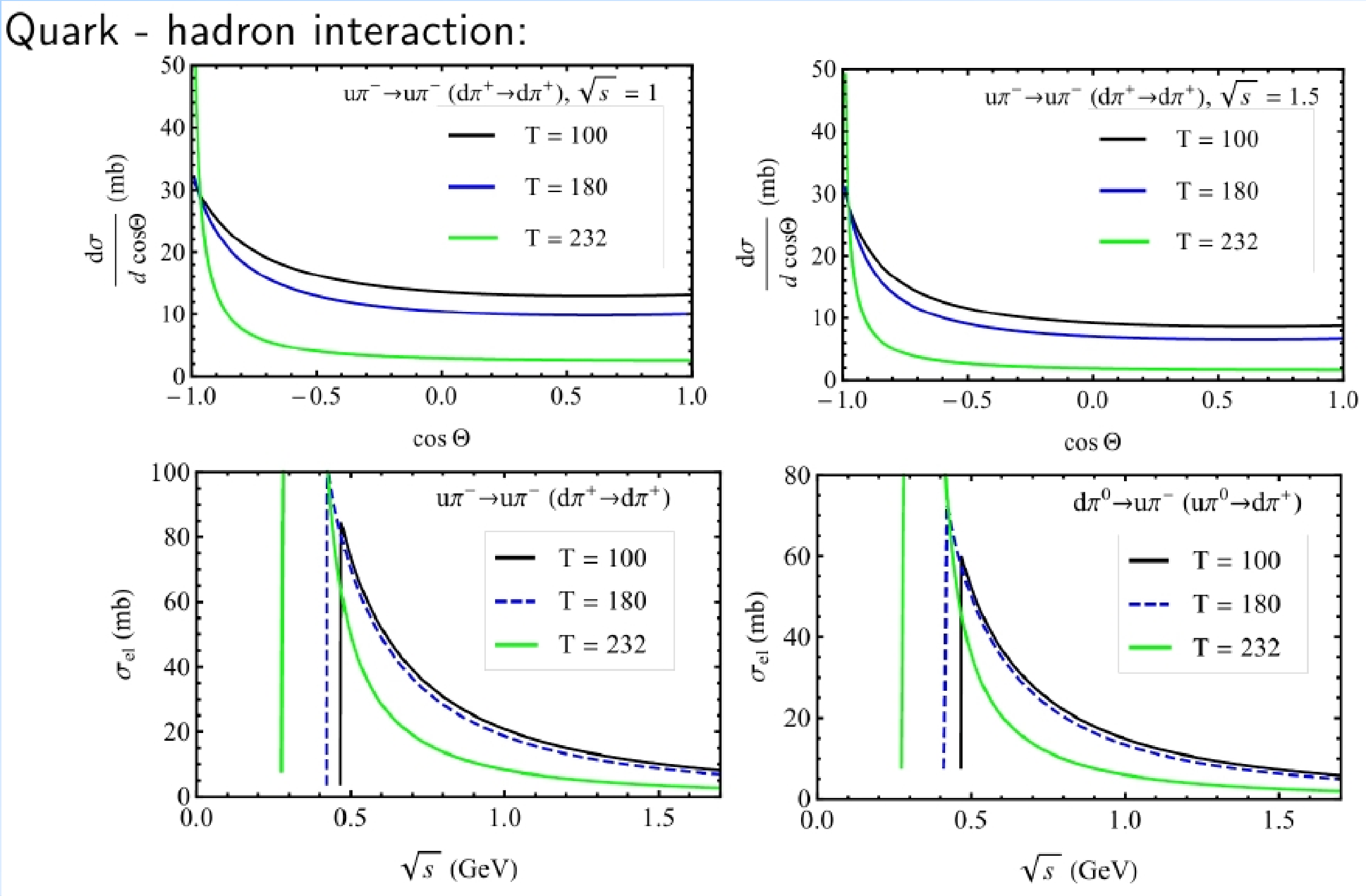
The characteristic temperatures:

- T_{Mott} - the pion dissociation temperature: $M_\pi = 2m_q$ ($T_{Mott} = 0.23$ GeV)
- T_χ - the crossover $\frac{\partial < q\bar{q} >}{\partial T}$ ($T_\chi = 0.245$ GeV)
- T_p - the deconfinement transition $\frac{\partial \Phi}{\partial T}$ (T_p =0.233 GeV)
- Critical temperature: $T_c = \frac{T_\chi + T_p}{2}$ ($T_c = 0.239$ GeV)
- Critical end piont: T_{CEP} ($T_{CEP} = 0.09$, $\mu_{CEP} = 0.322$ GeV)

Yu.L. Kalinovsky (LIT), V.D. Toneev, A.V. Friesen (BLTP), D. Blaschke, A. Wergieluk (Univ. Wroclaw), P. Costa (Coimbra Univ.) PRD 85 (2012), PEPAN Lett. 9 (2012), Int.J.Mod.Phys A27 (2012), arXiv:1212.5245 (subm. PRD), arXiv:1304.7150 (subm. Nucl.Phys. A)

NICA/MPD: Development of a consistent QCD approach to the process modeling at finite temperature and density

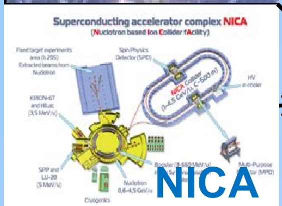
☀ Quark-meson interactions in a hot and dense medium can be confidently modeled to describe the **kinetics** of the processes



Yu.L. Kalinovsky (LIT), V.D. Toneev, A.V. Friesen (BLTP), D. Blaschke, A. Wergieluk (Univ. Wroclaw), P. Costa (Coimbra Univ.) PRD 85 (2012), PEPAN Lett. 9 (2012), Int.J.Mod.Phys A27 (2012), arXiv:1212.5245 (subm. PRD), arXiv:1304.7150 (subm. Nucl.Phys. A)

Hadronic interactions

FAIR
Facility for Antiproton and Ion Research in Europe GmbH



Geant 4 → **FTF model**

→ **Anti-proton, Anti-Nucleus + Nucleus**

→ **π, K, p, n, Λ, Nucleus + Nucleus**

Release Geant 4 9.6 patch-01/02 (2013)

Hadron-nucleon process cross section

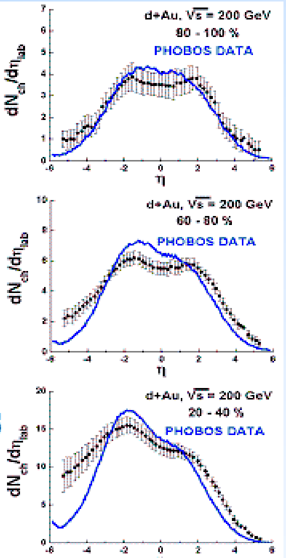
- Total, elastic and inelastic hadron-nucleon cross sections
- Cross sections of quark exchange processes
- Cross sections of anti-proton processes
- Cross sections of diffractive and non-diffractive processes

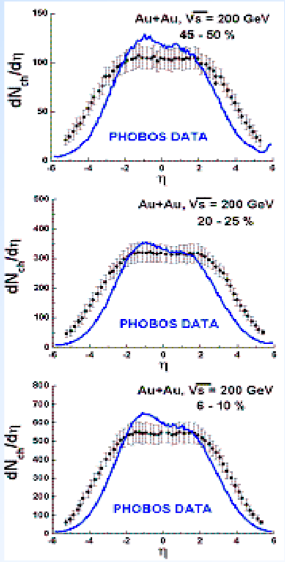
Simulation of hadron-nucleon interactions

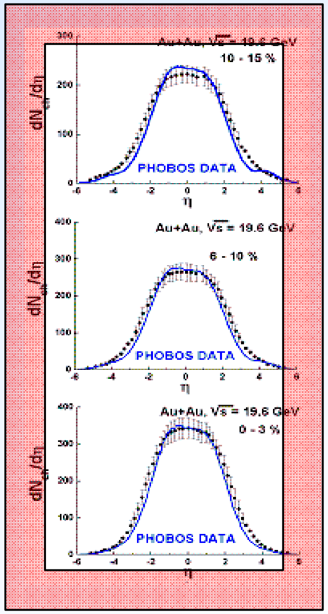
- Simulation of meson-nucleon and nucleon-nucleon interactions
- Simulation of anti-baryon-nucleon interactions

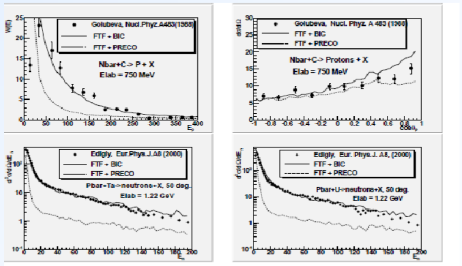
Simulation of nuclear interactions

- Sampling of intra-nuclear collisions
- Reggeon cascading
- "Fermi motion" of nuclear nucleons
- Excitation energy of nuclear residuals

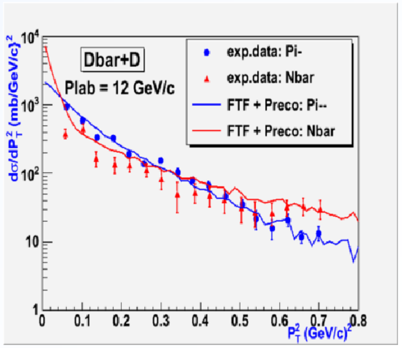








Inclusive π^+-meson, proton and neutron distributions in $\bar{p}A$- and $\bar{n}A$-interactions. The points are experimental data [21,22], the lines are our calculations.



A. Galoyan (VBLHEP), V. Uzhinsky (LIT)

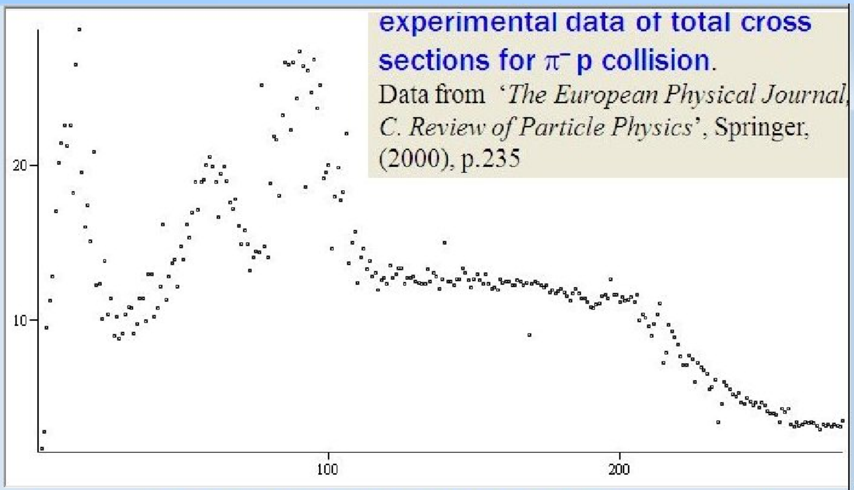
III. *Mathematical methods*

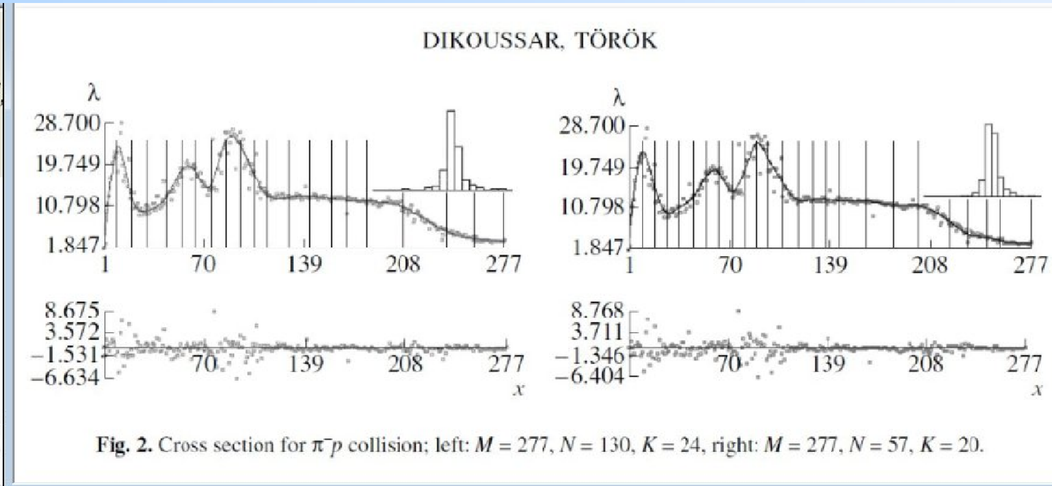
New mathematical method for experimental data processing and analysis

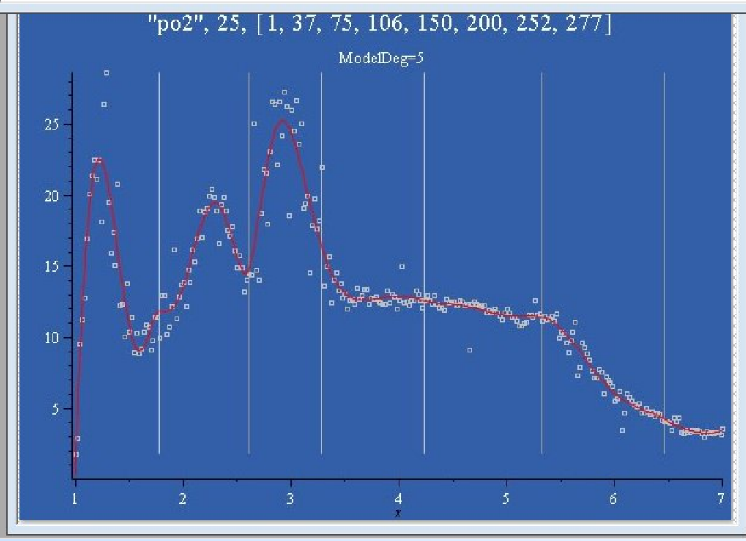
☀ **Polynomial approximation and robust data smoothing within the basic element method:** Previous research directed to the development of approximation methods, resulting in smoothing algorithms able to encompass features of the apparently irreconcilable **point-wise Taylor** and **interval-wise Chebyshev series expansions**, has resulted in a fundamentally new approach, called the **basic element method** (BEM) to the numerical solutions of the data smoothing problem.

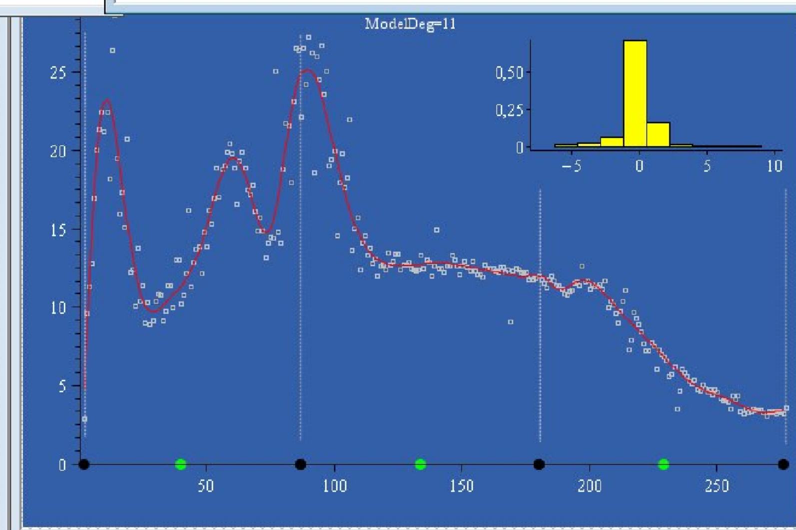
The BEM is characterized by exceptional **flexibility** and **robustness**, as well as by a remarkably **low computational complexity** (orders of magnitude lower than that of the well-known spline function method). The time is ripe for building **proper interfaces of the BEM to actual data smoothing problems** asked by various experiments.

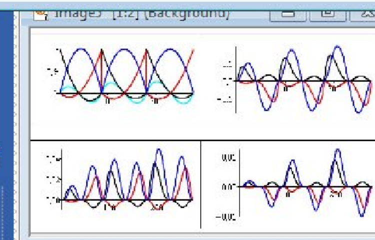
BEM vs. Splines for solving a typical smoothing problem





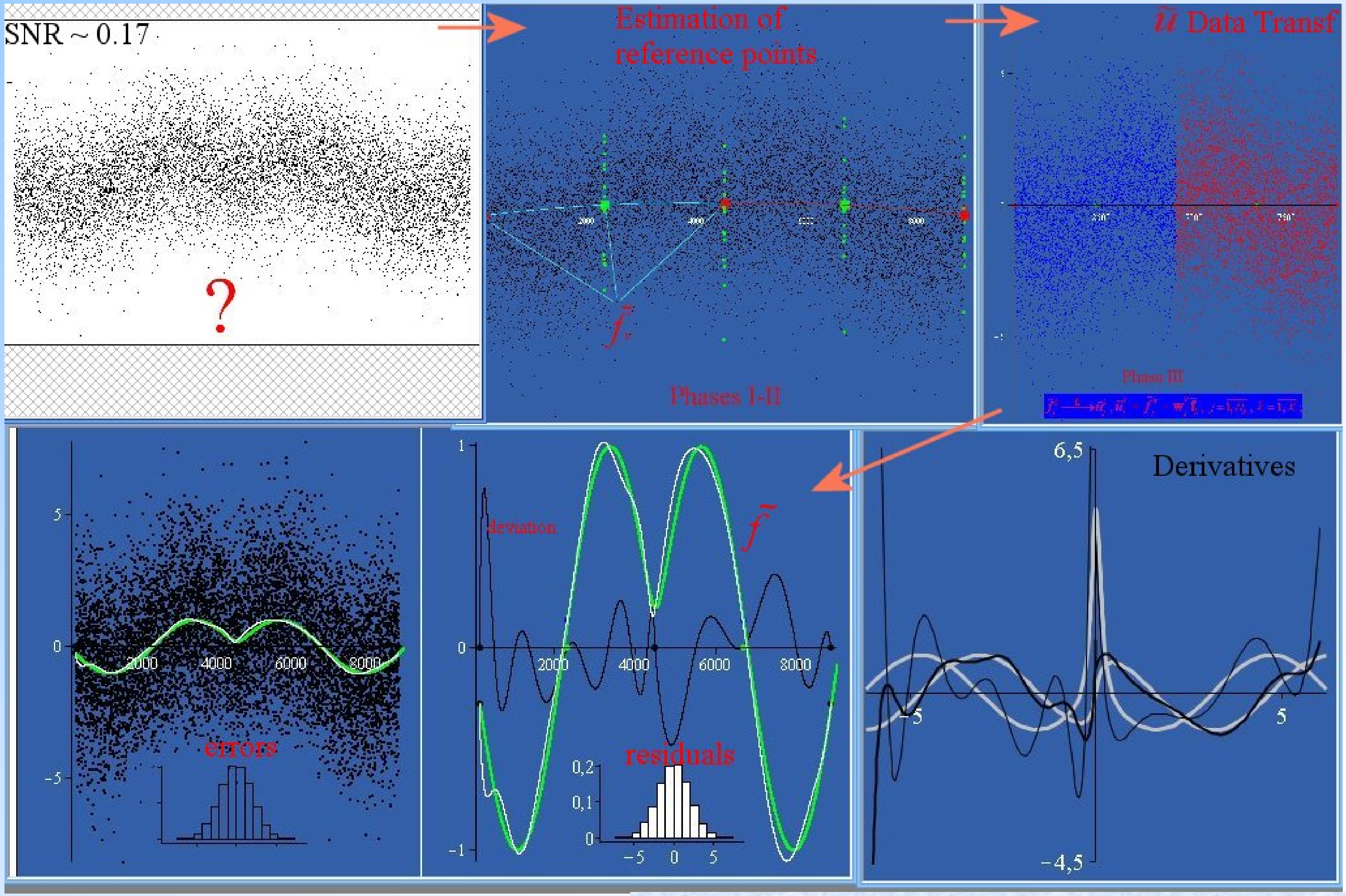






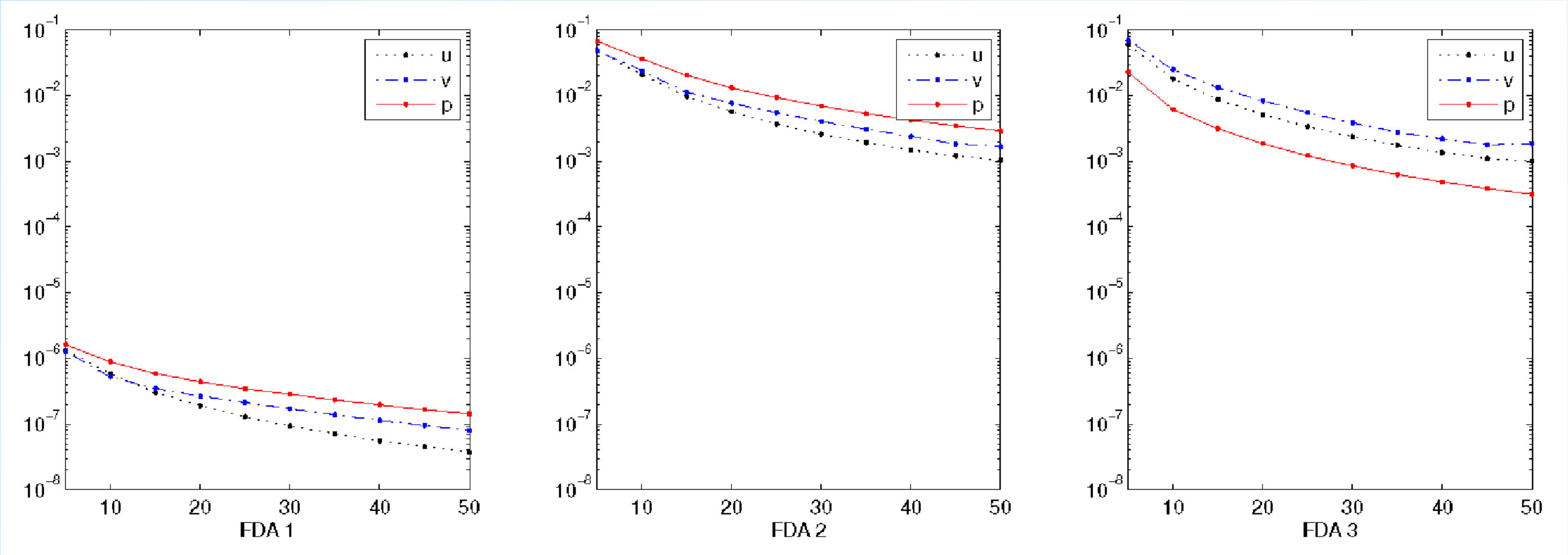
N.D. Dikousar, Matematicheskoe Modelirovanie (2014)

BEM solution of "Mexican Hat" smoothing problem for a low signal to noise ratio



Consistent discretization of non-linear PDE by finite-difference approximations

We prove that the ***inheritance of the algebraic properties*** of differential equations by the finite-difference approximation (FDA) discretization ***is of fundamental importance for consistent numerical solution***.

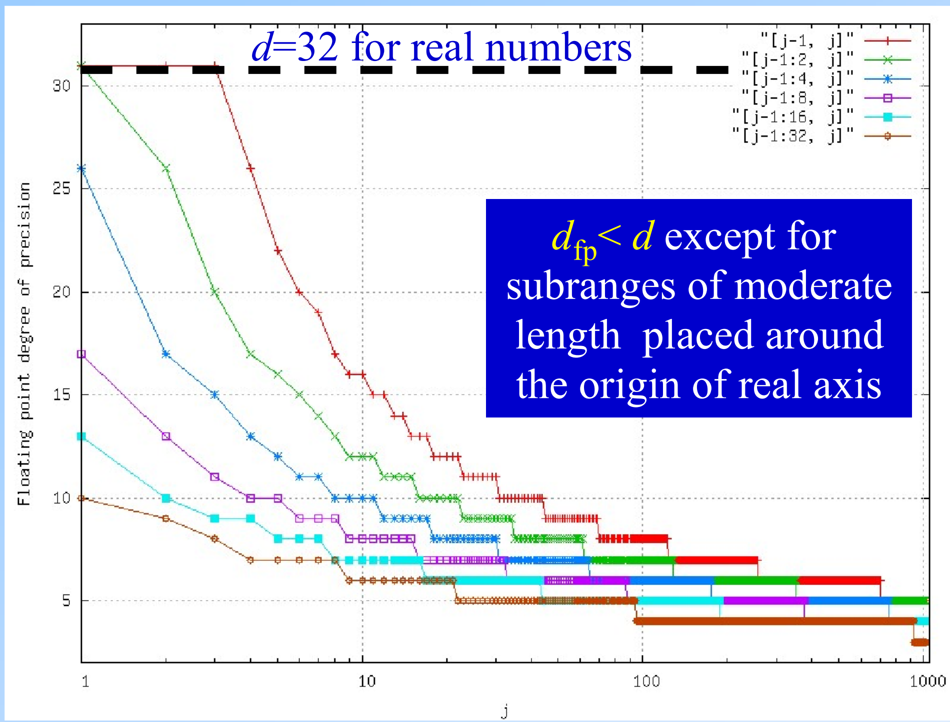


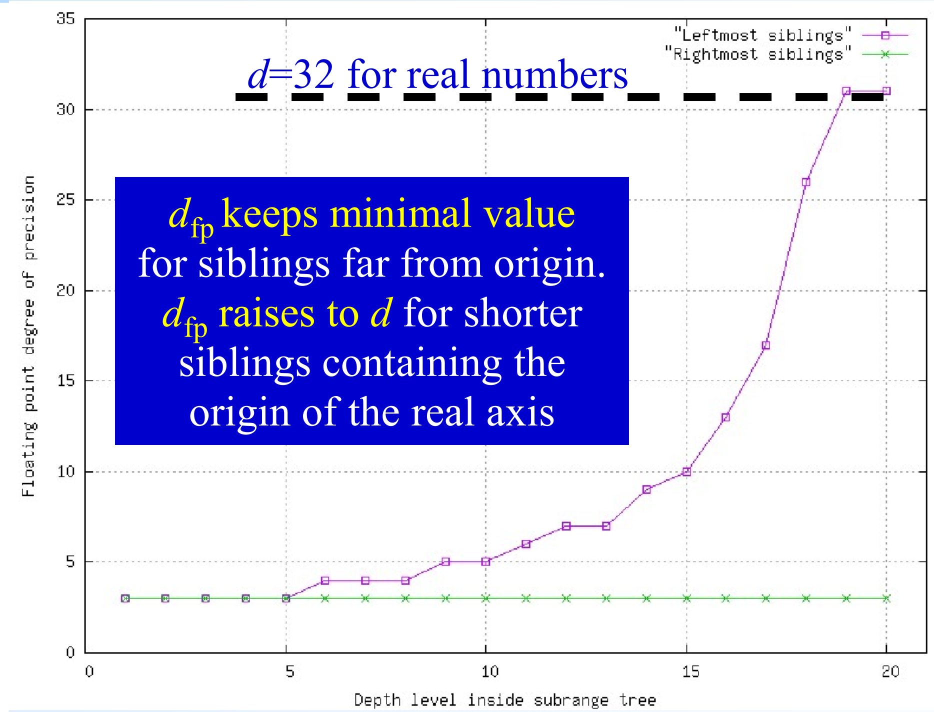
Computer experiment demonstration is provided for the two-dimensional Navier-Stokes equations (NSE) describing an incompressible viscous fluid.

Relative errors for the velocity components (u,v) and pressure (p) are plotted vs. the number of discretization knots. FDA1 preserves NSE algebraic properties, whereas FDA2 and FDA3 do not.

V.Gerdt et al., On Consistency of Finite Difference Approximations to the Navier-Stokes Equations, Lecture Notes in Computer Science 8136, 2013, pp. 46—60.

Floating point degree of precision of a quadrature sum





Computations done over the ***machine floating point number set*** need a fundamentally different characterization of the integrand properties.

The plots point to the property of the ***floating point degree of precision*** *of a quadrature sum* (d_{fp}) of showing significant deviation from the ***algebraic degree of precision*** (d) which holds over the field of the real numbers.

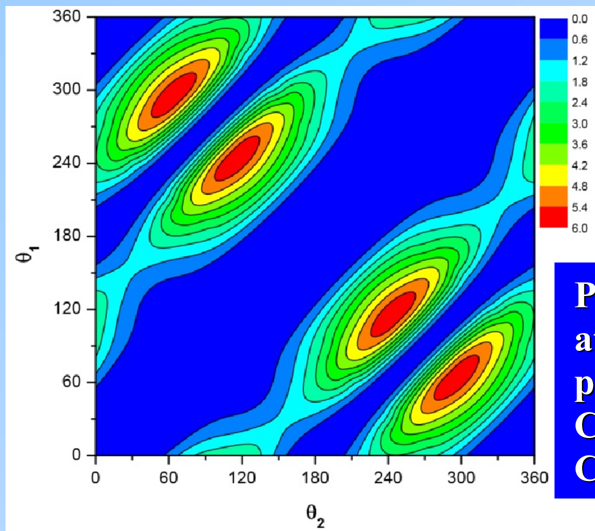
This entails substantial modifications of the implementation of ***Bayesian automatic adaptive quadrature.***

S. Adam, Gh. Adam, LNCS 7125, Springer (2012)

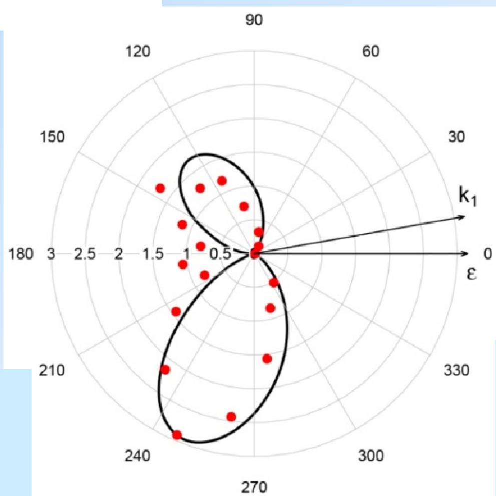
IV. *Early parallel computations*

Early codes adapted to multi-core and hybrid architectures

☀ Differential cross section (FDCS) for photo-double ionization of nitrogen molecule



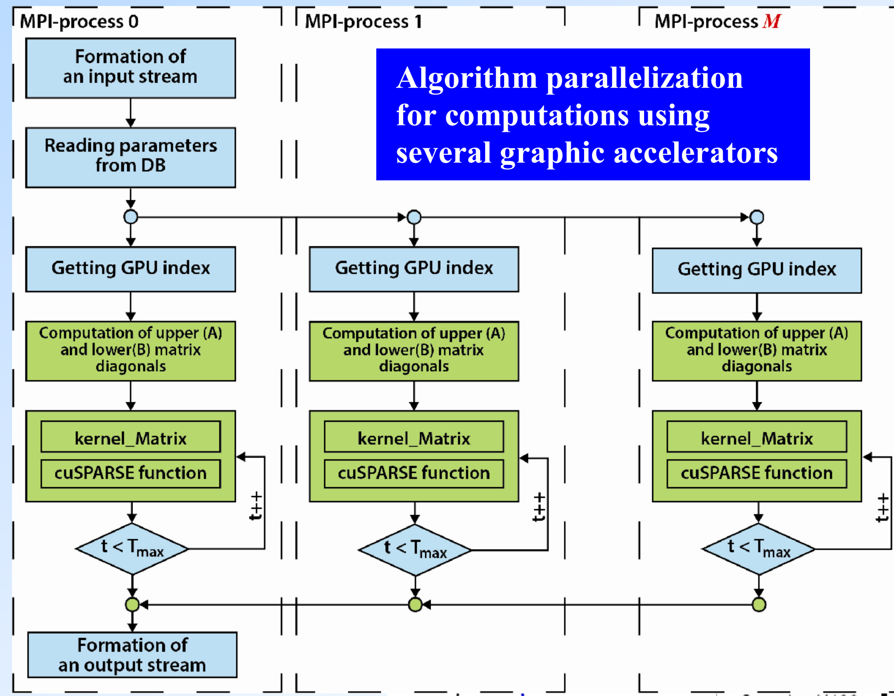
Parallel code run at the JINR CICC parallel cluster
CPU cores ≈ 100
CPU time ≈ 100 *h*



- Variation of the FDCS in terms of the two ejection angles θ_1 and θ_2 (top)
- Comparison of theoretical electron ejection angle θ_2 with experimental data (red dots) (right)

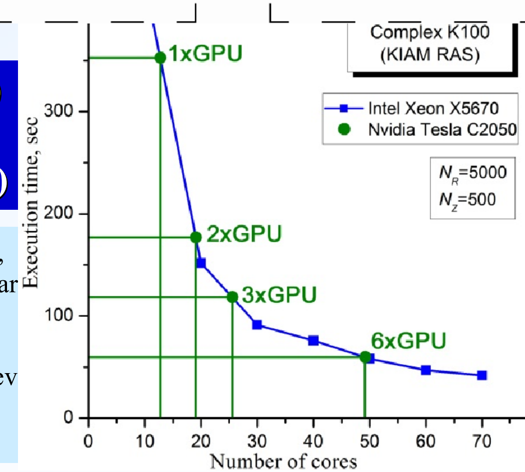
Bulychev A.A., Chuluunbaatar O., Gusev A.A. and Joulakian B. (γ,2e) photo-double ionization of N_2 molecules for equal energy sharing, J. Phys. B: At. Mol. Opt. Phys. 46 185203 (2013)

☀ Modeling thermal processes in materials irradiated by ion beams



Algorithm parallelization for computations using several graphic accelerators

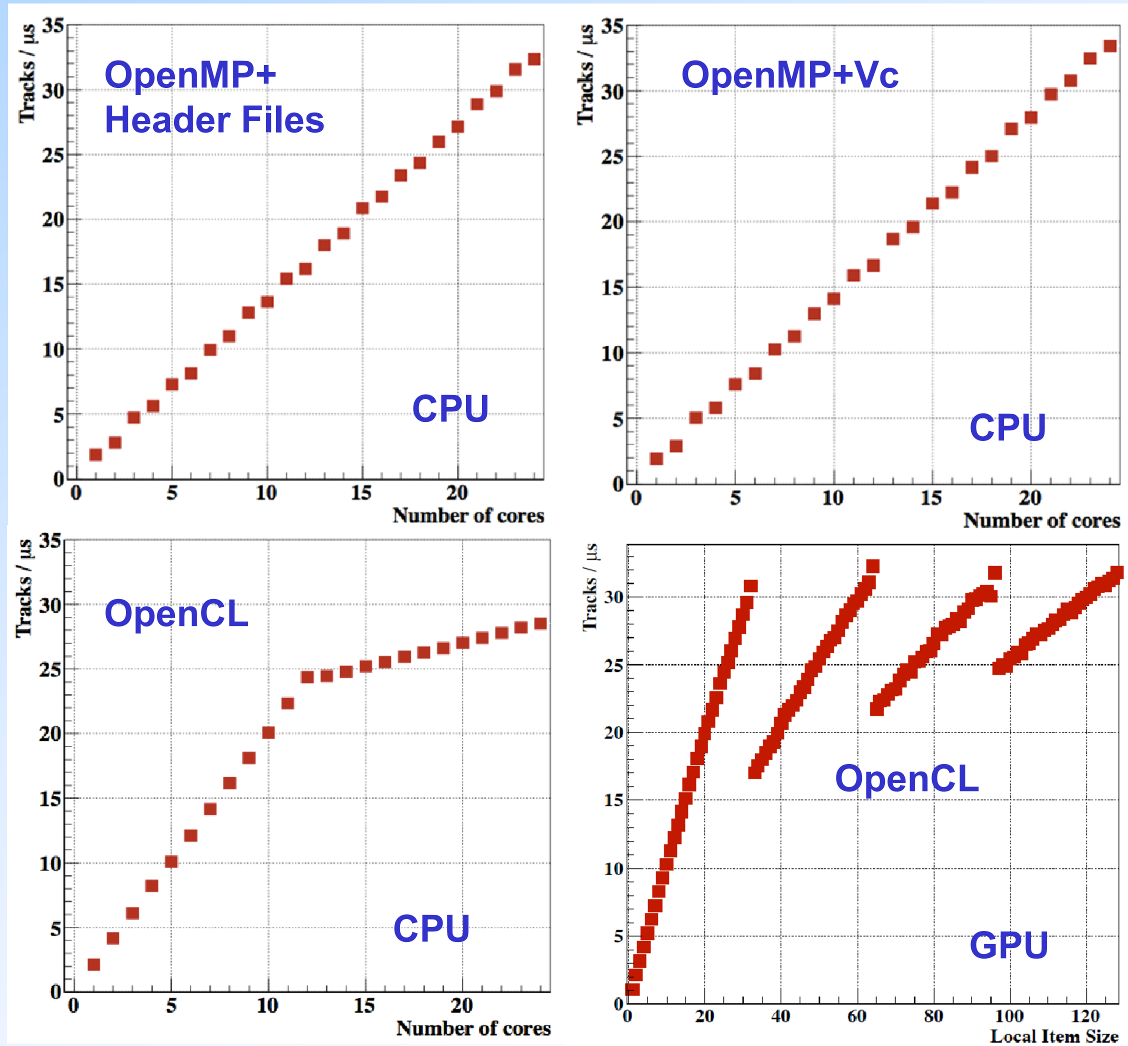
Code run at the K100 hybrid computer complex (KIAM RAS)



Alexandrov E.I., Amirkhanov I.V., Ivanov V.V., Podgainy D.V., Sarkar N.R.,Sarkhadov I., Sharipov Z.A., Streltsova O.I., Tukhliev Z.K., Zemlyanaya E.V.,Zrelov P.V., Zuev M.I.: Bulletin of PFUR, № 2(2) (2014)

Many-core computer experiments on Kalman filter based track reconstruction algorithm

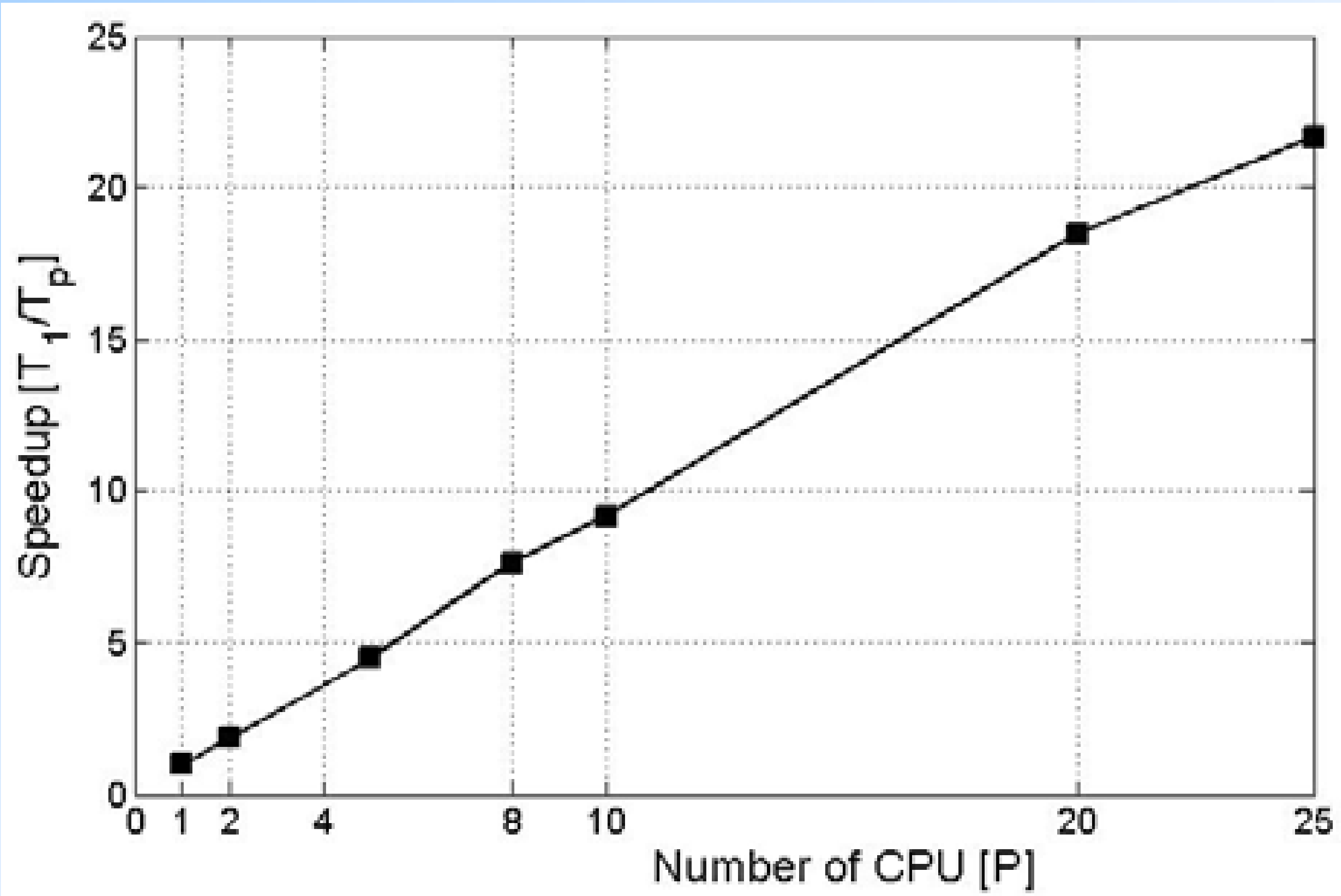
LIT implementations have reached ***strong scalability*** of four Kalman filter based ***track reconstruction algorithms*** *for* **CBM** ***experiment***, under different computing paradigms.



V.V. Ivanov et al., (2013)

Parallel solution of the heat flow simulation inside a cylindrical cryogenic cell subject to millisecond electric discharges: algorithm scalability

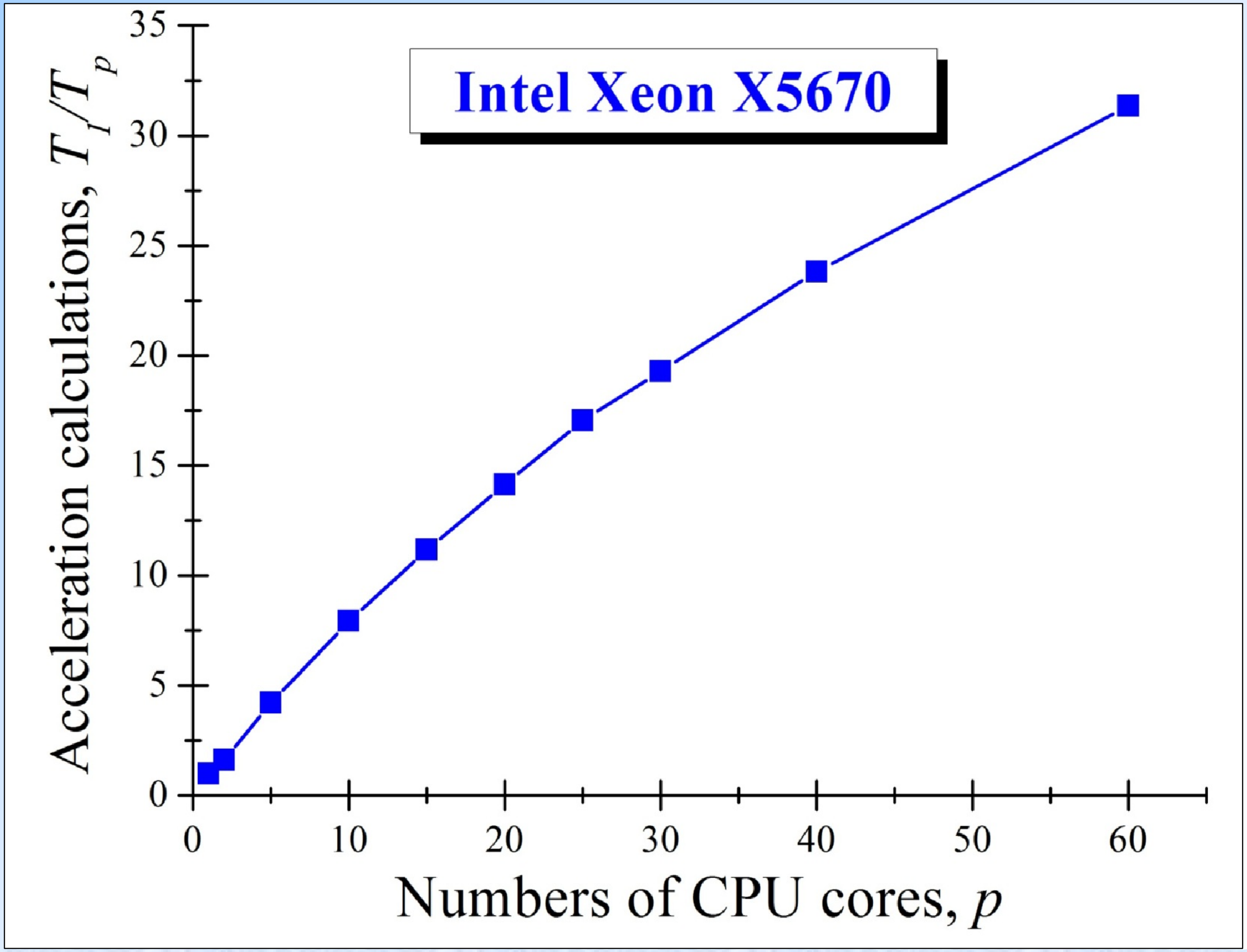
Computations done at the LIT-JINR CICC show that ***inter-processor communication*** becomes sizeable at P>20



A. Ayriyan, E. Ayryan, E. Donets, J. Pribis, in Math. Modeling and Comp. Sci., Springer, LNCS 7125 (2012);
A. Ayriyan, E. Donets, J. Pribis, poster to the 39-th Session of PP-PAC, June 2013.

Parallel solution of the simulation of thermal processes in materials irradiated by heavy ion beams : algorithm scalability

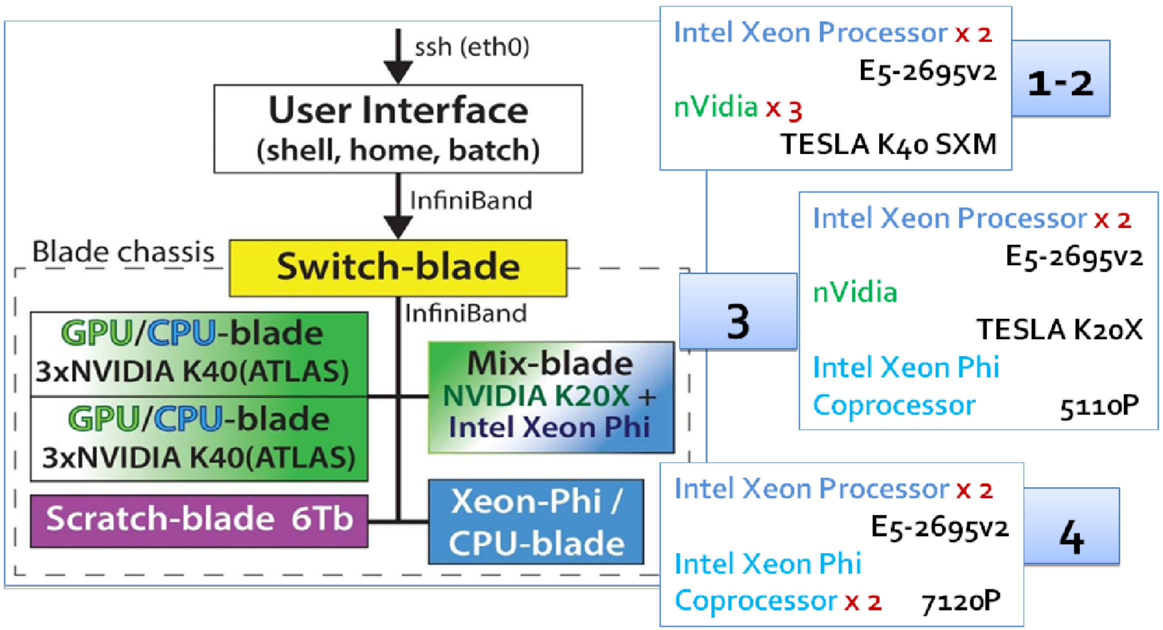
Computations done at the LIT-JINR CICC show ***sizeable inter-processor communications***



E.I. Alexandrov, I.V. Amirkhanov, V.V. Ivanov, D.V. Podgainy, N.R. Sarkar, I. Sarkhadov, Z.A. Sharipov, O.I. Streltsova, Z.K. Tukhliev, E.V. Zemlyanaya, P.V. Zrelov, M.I. Zuev, poster to the 39-th Session of PP-PAC, June 2013.

V. *Parallel computing on* HybriLIT

The heterogeneous computing cluster HybriLIT



http://hybrilit.jinr.ru/

Resources

CPU 96 cores
GPU 19968 cuda cores
PHI 182 cores

RAM 512 Gb
EOS storage 14 Tb
Ethernet
InfiniBand 40 Gb/s

Performance

Max. single-precision	46,914 Tflops
Max. double-precision	17,979 Tflops

Power consumption: 10 KW

Software installed:

Scientific Linux 6.5.
CUDA Toolkit 5.5, CUDA Toolkit 6.0
OpenMPI 1.6.5, 1.8.1
OpenMP GCC, ICC
Intel Cluster Studio 2013
JDK-1.7.0, JDK-1.8.0

Compilers used:

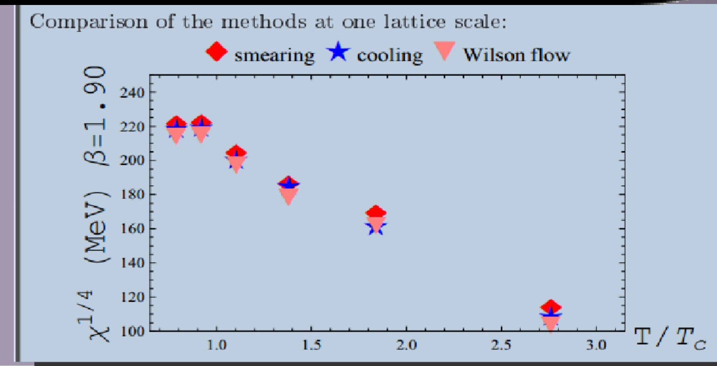
nvcc
mpic++, mpicc, mpicxx, mpif77, mpif90,
mpifort, icc, ifrort
mpiicc, mpiifort

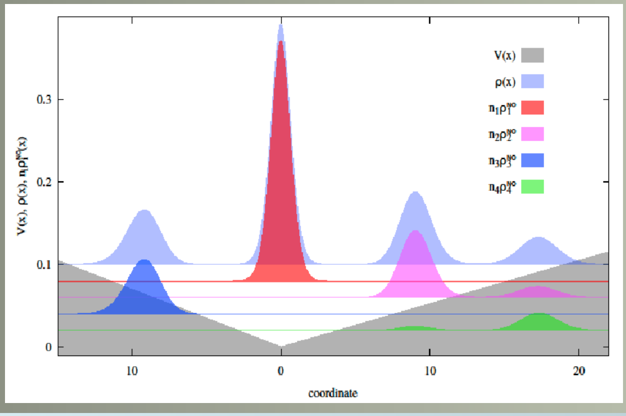
First parallel runs on HybriLIT

Smearing techniques in lattice QCD:

F. Burger (IP HU, Berlin, Germany),
M. Müller-Preussker (IP HU, Berlin, Germany),
E.-M. Ilgenfritz (BLTP&VBLHEP JINR),
A. M. Trunin (BLTP JINR)

http://theor.jinr.ru/~diastp/summer14/program.html#posters





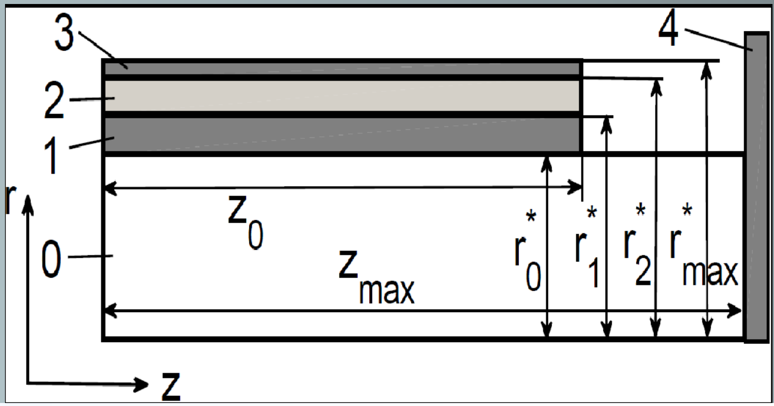
Investigation of Bose-systems:

Alexej I. Streltsov ("Many-Body Theory of Bosons" group at CQD, Heidelberg University, Germany),
Oksana I. Streltsova (LIT JINR)

http://MCTDHB.org

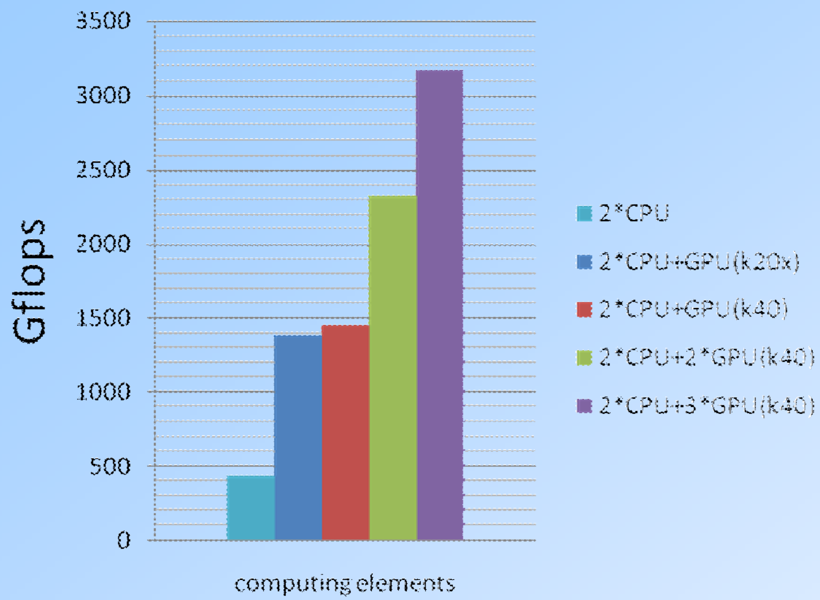
Optimized temperature work cycle of a multilayer cylindrical object (source of multiply charged ions)

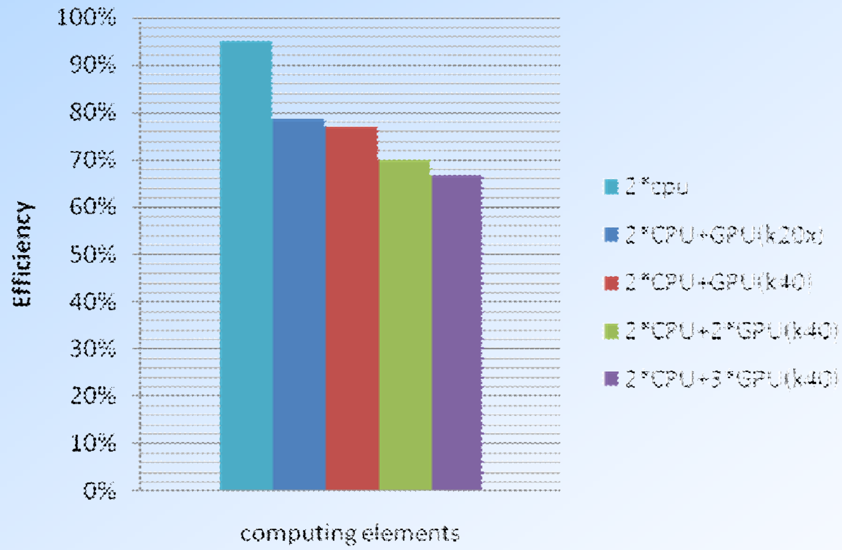
A. Ayriyan (LIT JINR), J. Busa Jr. (TU of Kŏsice, Slovakia),
E.E. Donets (VBLHEP, JINR),
H. Grigorian (LIT JINR,;Yerevan State University, Armenia),
J. Pribis (LIT JINR; TU of Kŏsice, Slovakia)



arXiv:1408.5853v2 [physics.comp-ph] 7 Sep 2014

Linpack benchmark of HybriLIT (preliminary)





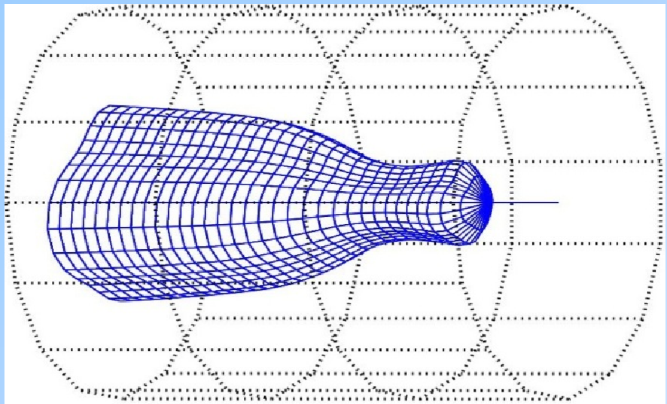
Linpack testing parameters corresponding to the data reported in figures:

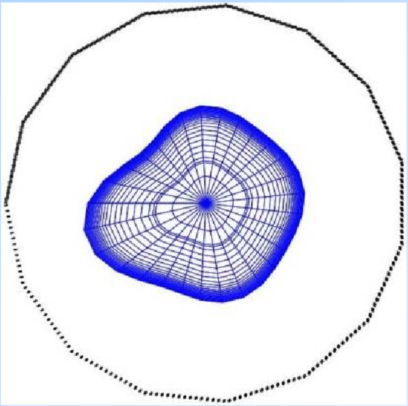
- For **CPU**, the default version defined on the **intel studio (composer_xe_2013_sp1.2.144)**, with the CPU frequency = **2.4 GHz** of the **E5-2695 v2** Intel processor
- For **GPU**, the version **hpl-2.0_FERMI_v15**, downloaded from the official NVIDIA site
- The data correspond to:

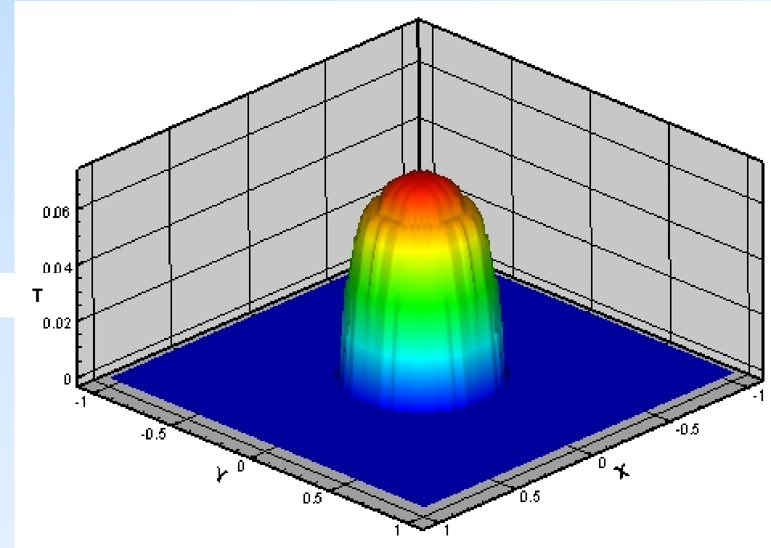
    the order of the coefficient matrix A, **N = 120 000**,
    the block partitioning factor **NB = 1 024**,
    24 CPU per 1 GPU for a single **K20x** or **K40**,
    6 CPU per 1 GPU for **2*K40**, and
    4 CPU per 1 GPU for **3*K40**

VI. *Testing* HybriLIT *vs.* K100 *hybrid cluster at* KIAM RAS

GIMM FPEIP : package for simulation of thermal processes in materials irradiated by heavy ion beams







Alexandrov E.I., Amirkhanov I.V., Zemlyanaya E.V., Zrelov P.V., Zuev M.I., Ivanov V.V., Podgainy D.V., Sarker N.R., Sarkhadov I.S., Streltsova O.I., Tukhliev Z. K., Sharipov Z.A. (LIT)
Principles of Software Construction for Simulation of Physical Processes on Hybrid Computing Systems (on the Example of GIMM_FPEIP Complex) // Bulletin of Peoples' Friendship University of Russia. Series "Mathematics. Information Sciences. Physics". — 2014. — No 2. — Pp. 197-205.

Computational Task

Solve a system of coupled PDE describing heat conduction within the thermal spike model in cylindrical coordinates (z axis is perpendicular to the ion momentum hitting the surface)

$$C_e(T_e)\frac{\partial T_e}{\partial t} = \nabla(\lambda_e(T_e)\nabla(T_e)) - g(T_e - T_i) + A_e(\mathbf{r},t)$$

$$C_i(T_i)\frac{\partial T_i}{\partial t} = \nabla(\lambda_i(T_i)\nabla(T_i)) - g(T_e - T_i) + A_i(\mathbf{r},t)$$

Here e and i label the electron gas and ion lattice subsystems, characterized by the unknown temperature fields $T_e(\mathbf{r}, t)$ and $T_i(\mathbf{r}, t)$, respectively.

$C_e(T_e)$, $C_i(T_i)$ & $\lambda_e(T_e)$, $\lambda_i(T_i)$ denote the specific heat capacity and thermal conductivity coefficients of the electron gas and respectively the lattice;

g denotes the electron-phonon interaction;

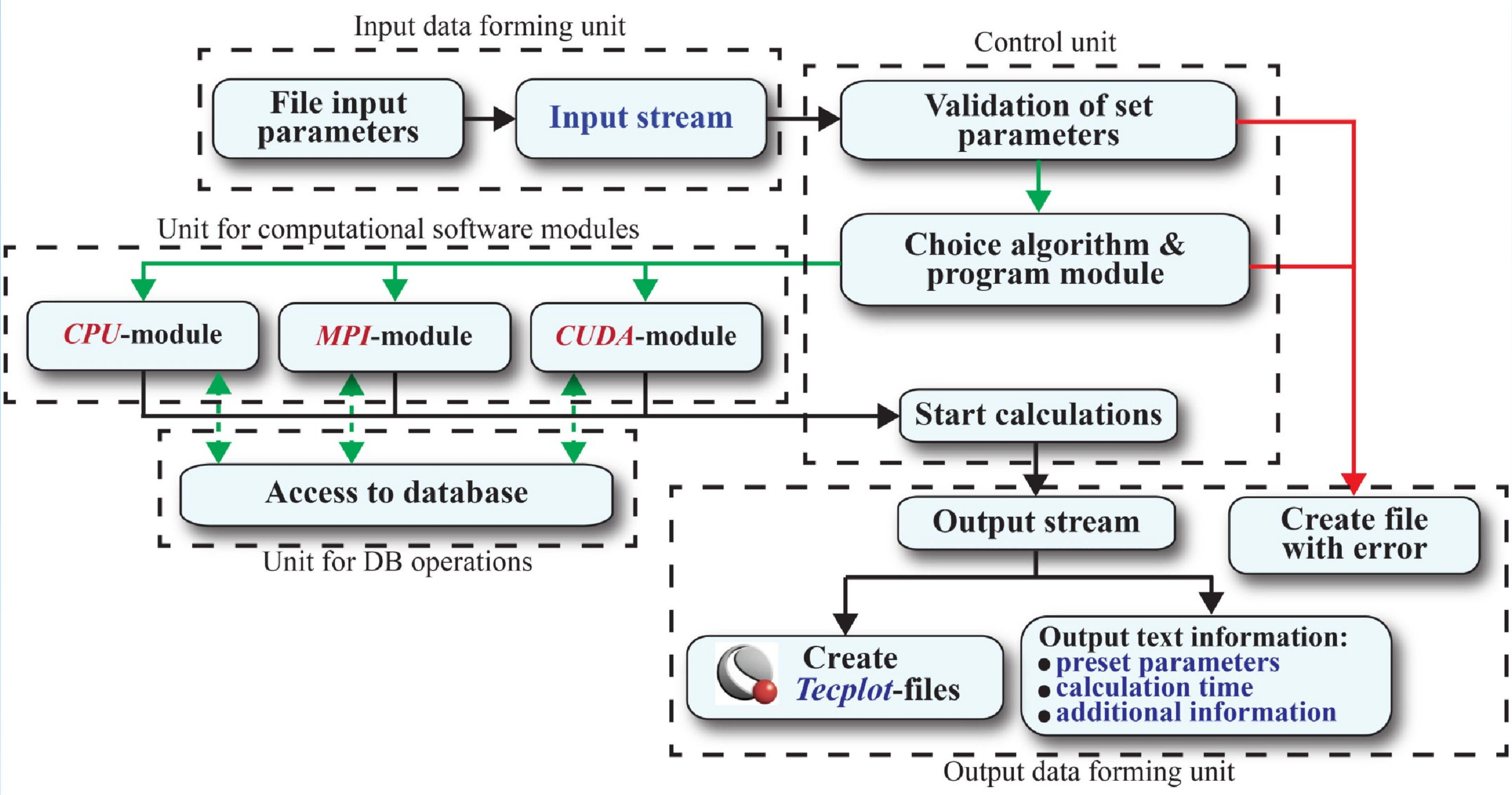
$A_e(\mathbf{r}, t)$ and $A_i(\mathbf{r}, t)$ denote the volumetric energy densities induced by the incident ion flux into the electron gas and ion lattice subsystems.

$$T_{e,i}(r,\varphi,z,t) = T_{0,e,i}(r,z,t) + \sum_{m=1}^{M} T_{m,e,i}(r,z,t)\left(c_{1m}\cos m\varphi + c_{2m}\sin m\varphi\right)$$

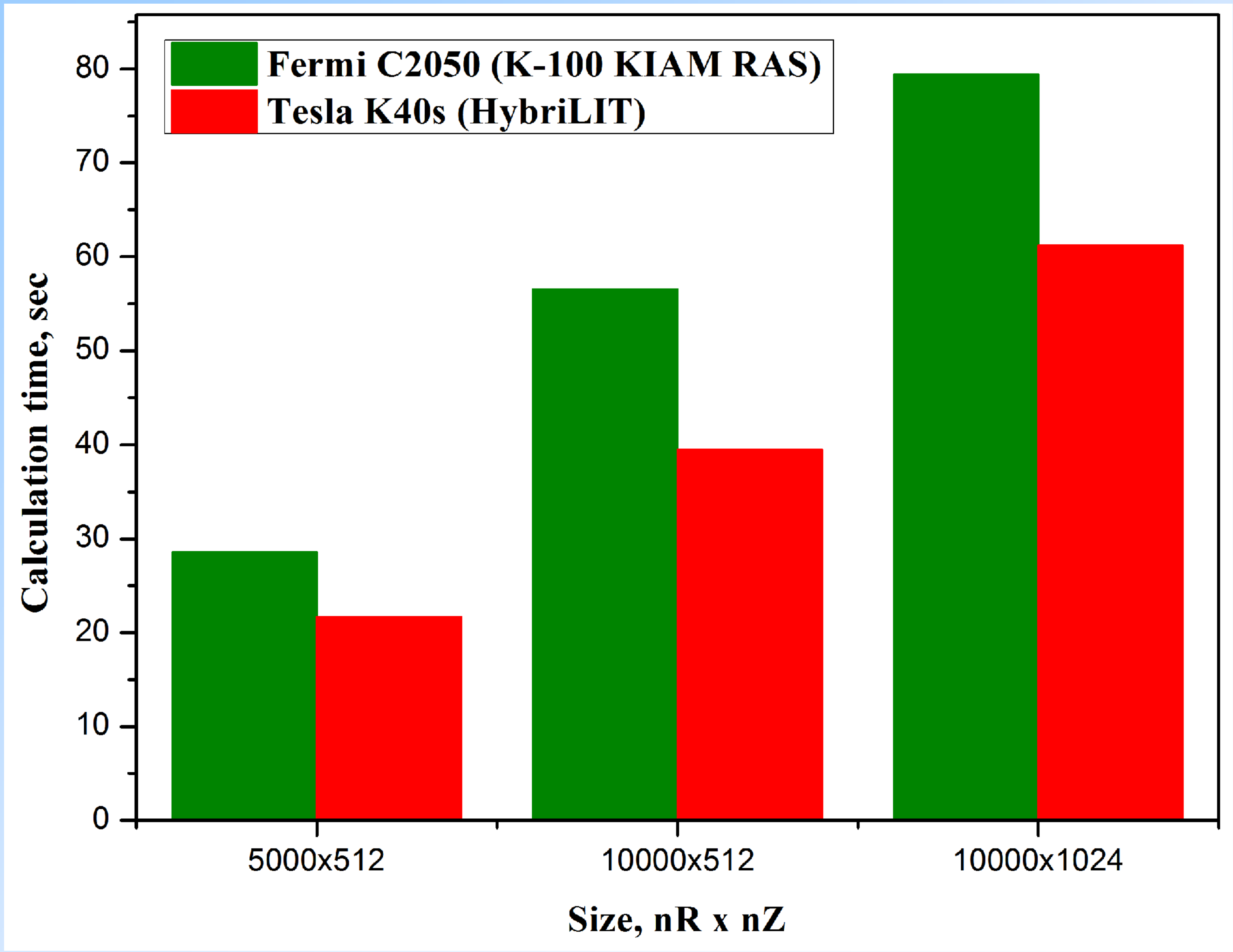
Size of problem: $N_R \times N_Z \times M$

Multi-GPU

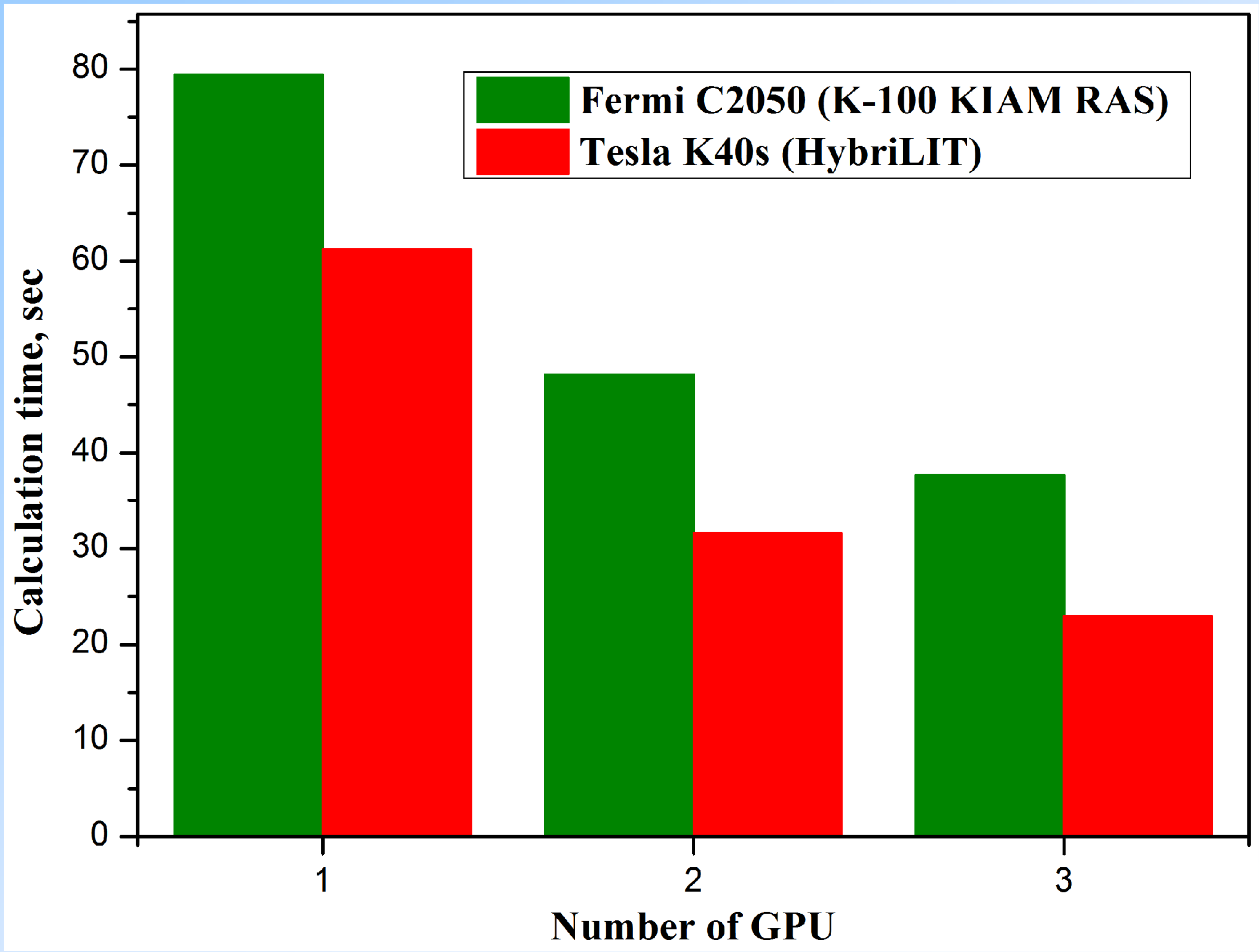
GIMM FPEIP: Logical scheme of the algorithm



GPU calculations



Multi-GPU calculations



VII. Invitation to MMCP 2015 (High Tatras, Slovakia)

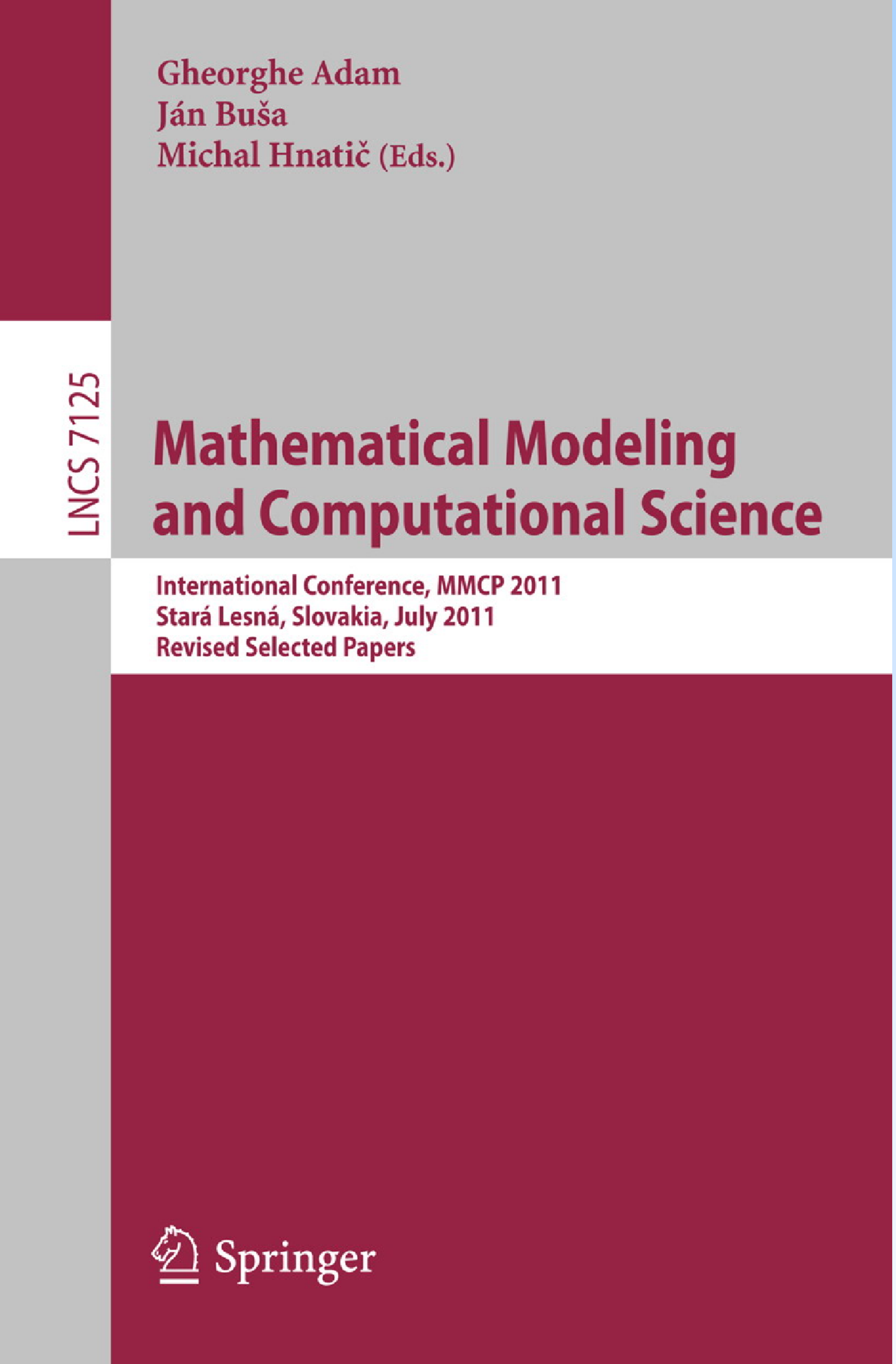
Mathematical Modeling and Computational Physics (MMCP'2011)
July 4 - July 8, 2011
Stará Lesná, Slovakia

Organizers:

- Laboratory of Information Technologies,
- Inst. Exp. Physics, SAS, Košice,
- Technical University, Košice,
- Pavol Jozef Šafárik University, Košice,
- Union of Slovak Mathematicians and Physicists, Košice, Slovakia

Topics:

-mathematical methods and tools for modeling complex physical and technical systems;
- methods, software and computer complexes for experimental data processing;
- methods, algorithms and software of computer algebra;
- computational chemistry, biology, and biophysics;
- distributed scientific computing;
- computing tools of a new generation.



Book Performance Report 2013

June 2014

Dear Gheorghe Adam,

We would like to provide you with an overview of how your book has been performing on the market. Because eBooks have become well established among academic and corporate scientists, this report concentrates on the electronic version of your publication.

Results for your eBook

Since its online publication on February 18, 2012, there has been **a total of 6006 chapter downloads** for your book on Springer Link. The table below shows the download figures for the last year(s).

This means your book was one of the **top 50% most downloaded eBooks** in the relevant Springer eBook Collection in 2013.

Year	Chapter Downloads
2013	4703
2012	1303

Mathematical Modeling and Computational Physics (MMCP'2015)

July 13 - July 17, 2015

High Tatra Mountains, Slovakia

Organizers:

- **LIT-JINR, Dubna, Russia,**
- **IFIN-HH, Bucharest, Romania,**
- **Technical University, Košice,**
- **Institute of Experimental Physics, SAS, Košice,**
- **Pavol Jozef Šafárik University, Košice, Slovakia**

Preliminary Topics:

-1. mathematical methods and tools for modeling complex physical and technical systems, computational chemistry, biology, and biophysics;

-2. methods, software and computer complexes for experimental data processing;

-3. methods, algorithms, and software of computer algebra (quantum and analytic computing);

-4. distributed scientific computing and big data;

-5. parallel and hybrid calculations, extra massive parallelism

Mathematical Modeling and Computational Physics (MMCP'2015)

July 13 - July 17, 2015

High Tatra Mountains, Slovakia

First announcement to be issued soon. You are kindly invited!

Organizers:

- **LIT-JINR, Dubna, Russia,**
- **IFIN-HH, Bucharest, Romania,**
- **Technical University, Košice,**
- **Institute of Experimental Physics, SA... ...e,**
- **Pavol Jozef Šafárik University, K... ...ovakia**

Preliminary Topics:

-1. mathematical m... ...and tools for modeling complex physical and technical syst... ...nputational chemistry, biology, and biophysics;

-2. metho... ...re and computer complexes for experimental data proc...

-3. ...s, algorithms, and software of computer algebra (...tum and analytic computing);

-... distributed scientific computing and big data;

-... parallel and hybrid calculations, extra massive parallelism

Thank you for your attention !