UniHUB: Open Stack-based platform for integrated research, development and education

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Contents

- Introduction
- ISPRAS and web-laboratory UniHUB
- OpenFoam library, our solver and some cases
- Other research work
- Education
- Possible topics for collaboration
- Conclusions

ISP RAS

www.ispras.ru/en

- Compiler Technologies
  - Web-laboratory UniHUB
  - Compiler Optimizations
    Static & Dynamic Analysis
    Parallel Programming
- System Programming
  - Reverse Engineering
    Analysis of Binary
- Information Systems
  - Databases
    Natural Language Processing
    Semantic Analysis
- Software Engineering
  - Compliance
    and Functional Verification
    Testing
- Theoretical Computer Science
  - Discrete Mathematics
    Numerical Analysis
- Computing Systems Architecture
  - HPC, BigData Clusters

- Research
- Education
- Industry

ISP RAS was founded on January 25, 1994

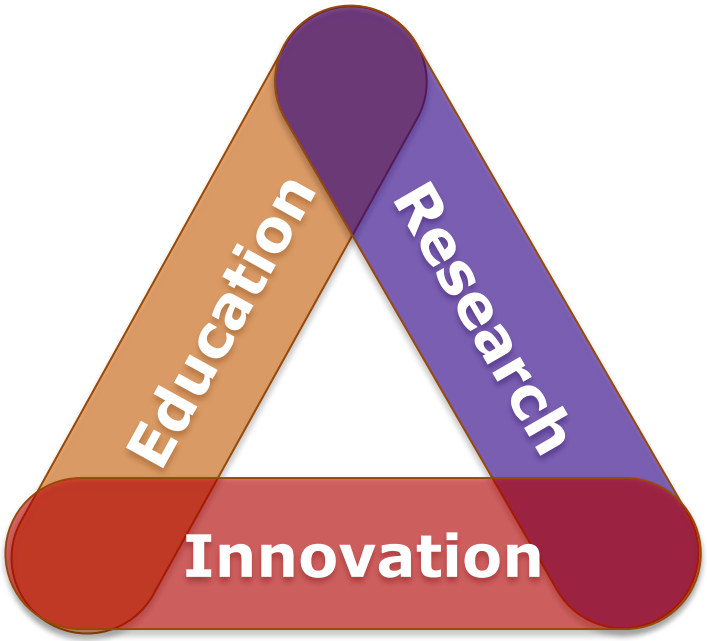
240 employeers: 60 Ph.D. and 15 Professors
3 departments of MSU, MIPT,HSE

Ecosystem of ISP RAS is based on the knowledge triangle

Research-oriented education

Academician & Industrial Advanced Research

Innovation via companies



Long term cooperation with industrial partners:
HPE, Samsung, Dell, Nvidia, Klocwork (now – RogueWave), etc.

ISPRAS: compilers and HPC direction

- GCC optimizations:
  - ✓ New aggressive scheduler with register renaming/speculation/predication support and software pipelining support (4% improvement on SPEC FP 2000 on IA-64)
  - ✓ GCC Modulo Scheduling improvements
  - ✓ Propagating alias information to the machine dependent optimizations (jointly with Richard Guenther from SuSE)
- Natural language processing tools for Taming Information Explosion (Texterra) and Semi-automatic data extraction from tables
- HPC direction and cluster's installations:
  - ✓ National Academy of Sciences of the Republic of Armenia (the most powerful on Caucasian region) ;
  - ✓ Oil company «LUKOIL»;
  - ✓ Moscow Institute of Physics and Technology (29 edition Top500);
  - ✓ Vyatka State University (30 edition Top500);
  - ✓ North-Eastern Federal University in Yakutsk (the most powerful on Far East region of Russia)
- We represented RAS in global technical communities initiated by HPE: Gelato, OpenCirrus

University Cluster program

Founders:

- Founded in 2008
- ISP RAS is Competence Center
- Technologies and education in parallel and distributed programming
- Creating technology specific web-laboratories
- Transfer of knowledge into Russian industry

Partners:

Technological platform of "University Cluster" program

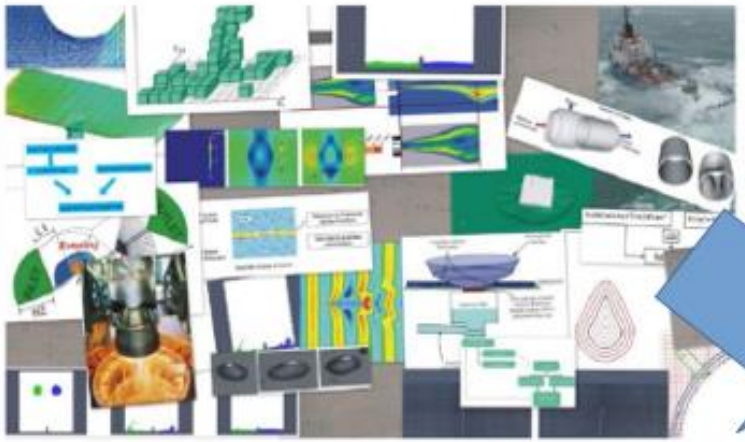
UniHUB* – OpenStack-based platform for creating problem-oriented web-labs:

- Users collaboration (webinars, wiki, trainings, forum, animated presentations, uploading and sharing materials, statistics and user feedback)
- Simulation tools delivered to browser
- Software development (IDE, source code control, bug tracking)

OpenStack, SPICE, Apache, Joomla, MediaWiki, FUDforum, Openqwaq, MOOC, Eclipse, Git, Bugzilla, MongoDB, RabbitMQ, Globus Toolkit, Slurm, Python.

*Availability – 24/7 (Data Center of CC RAS – former Yandex)

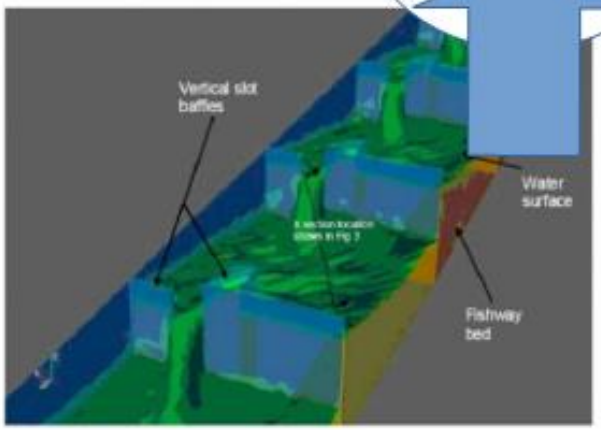
OpenSource: OpenFOAM



Research

Education

Open Source (OpenFOAM



Дамба. H=80 м. 200 Австралия. 2009. Сетка 200 блоков.

Audi A6. 2009. Сетка 47 М. 128-192 ядер.

Industry

Web-laboratory UniHUB

Start: 15 march 2011 г.

The goal: Building of Russian scientific community, users of Open Source software

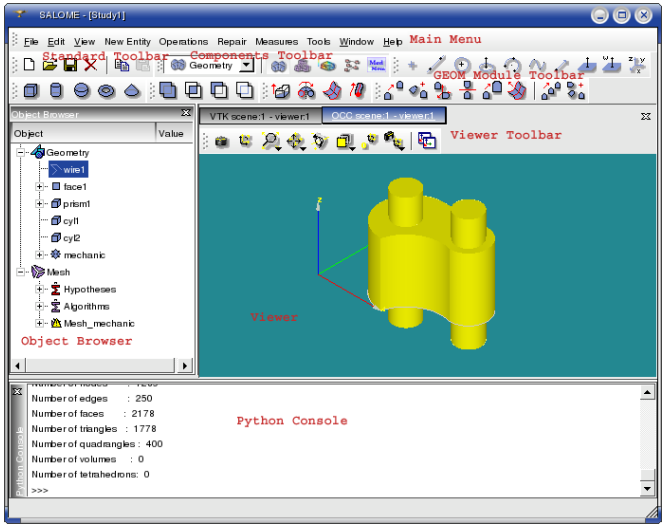
Specialization:

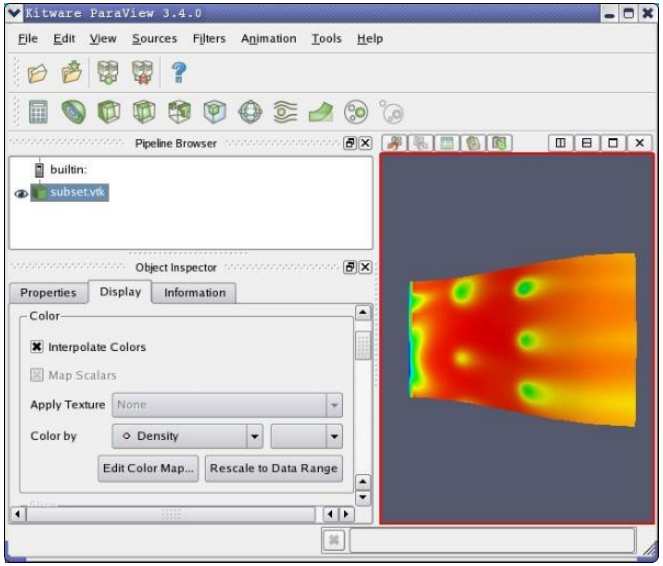
1) High-temperature gas dynamics and plasma;
2) Multiphase flows and coupled problems of mechanics;
3) Projects in the field of space technologies;
4) Methods of processing and analysis of Big Data;

Software: SALOME (***pre-processor***), OpenFOAM (solvers), ParaView (***post-processor***), Dakota, Calculix, Elmer, Incompact3D, NEK5000, BEM++ etc.

More then 3000 users are registered on 01.09.2015 in Web-Lab UniHUB.

UniCFD group has 930 users

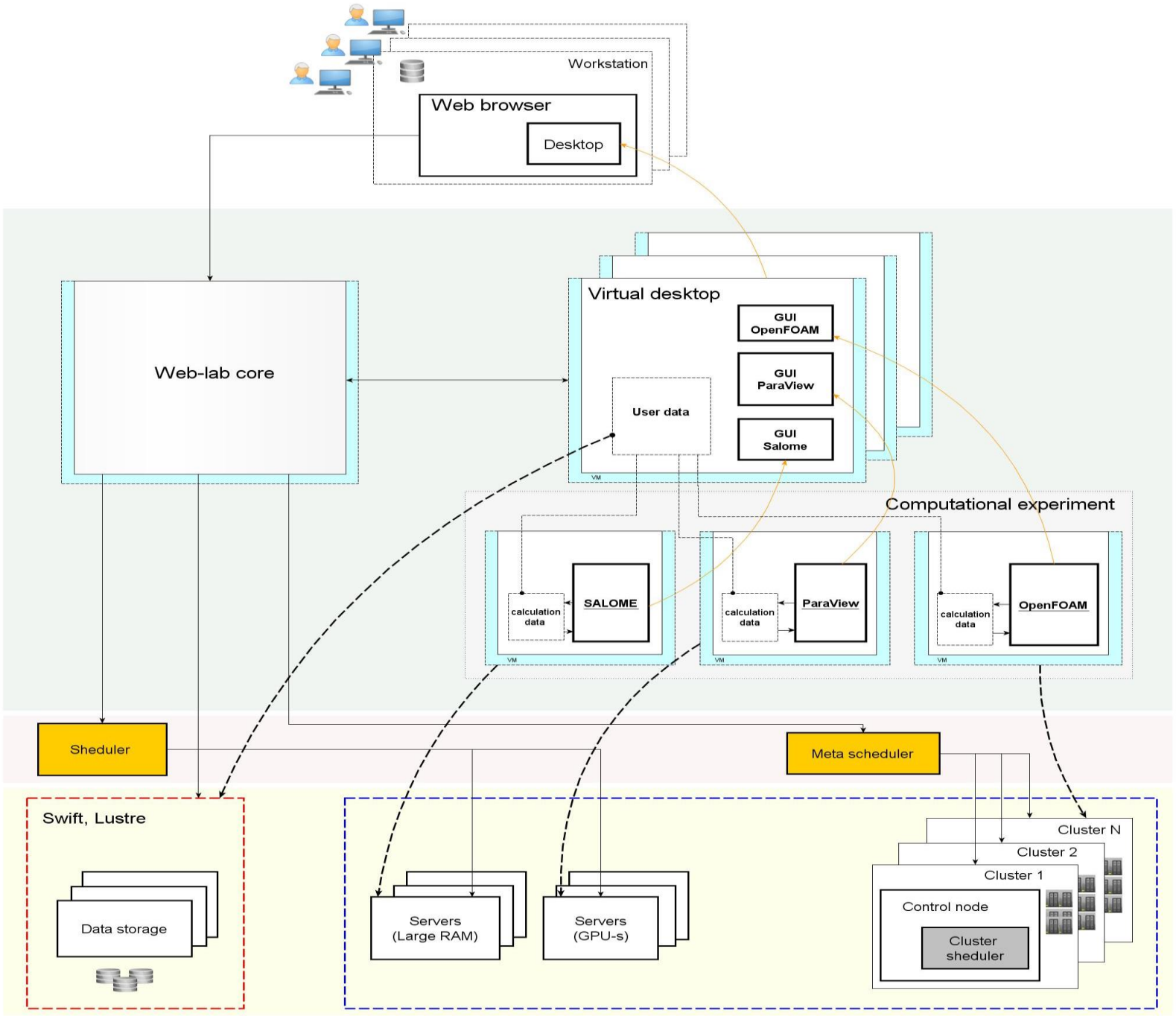




SALOME The Open Source Integration Platform for Numerical Simulation

OpenFOAM

ParaView


Workstation
Web browser
Desktop
Web-lab core
Virtual desktop
GUI OpenFOAM
GUI ParaView
GUI Salome
User data
VM
Computational experiment
calculation data
SALOME
ParaView
OpenFOAM
Sheduler
Meta scheduler
Swift, Lustre
Data storage
Servers (Large RAM)
Servers (GPU-s)
Cluster N
Cluster 2
Cluster 1
Control node
Cluster sheduler
Web-Lab
IaaS

ISP RAS

UniHUB.ru
проект ИСП РАН

Технологическая платформа программы
"Университетский кластер"

Поиск
Выйти | Настройки
Oleg Samovarov (oleg.samovarov)

Главная | Личный кабинет | Ресурсы | Пользователи | О проекте | Техническая поддержка

Наши ресурсы доступн
Ваших задач в режиме

Однако нам удается экономить энерги
разработанным алгоритмам динамичес
неиспользуемых вычислительных узло
уверены в том, что в любой момент вр
ровно столько узлов, сколько необход

РЕСУРСЫ

Найти

Популярные теги: UniCFDc1 | Open | SALOME | WebDAV | System | W | ParaView | tool:salome | CUDA | G | unihub usage | MPI | MapReduce | "University Cluster" program | Uniclu | HDFS | Open CAD-CAE | tool:js3co | PBS | aerogasdynamics | Office | e

Учебные курсы, Файлы, Публикации ресурсов, Обучающие материалы, Конференции... Все категории ›

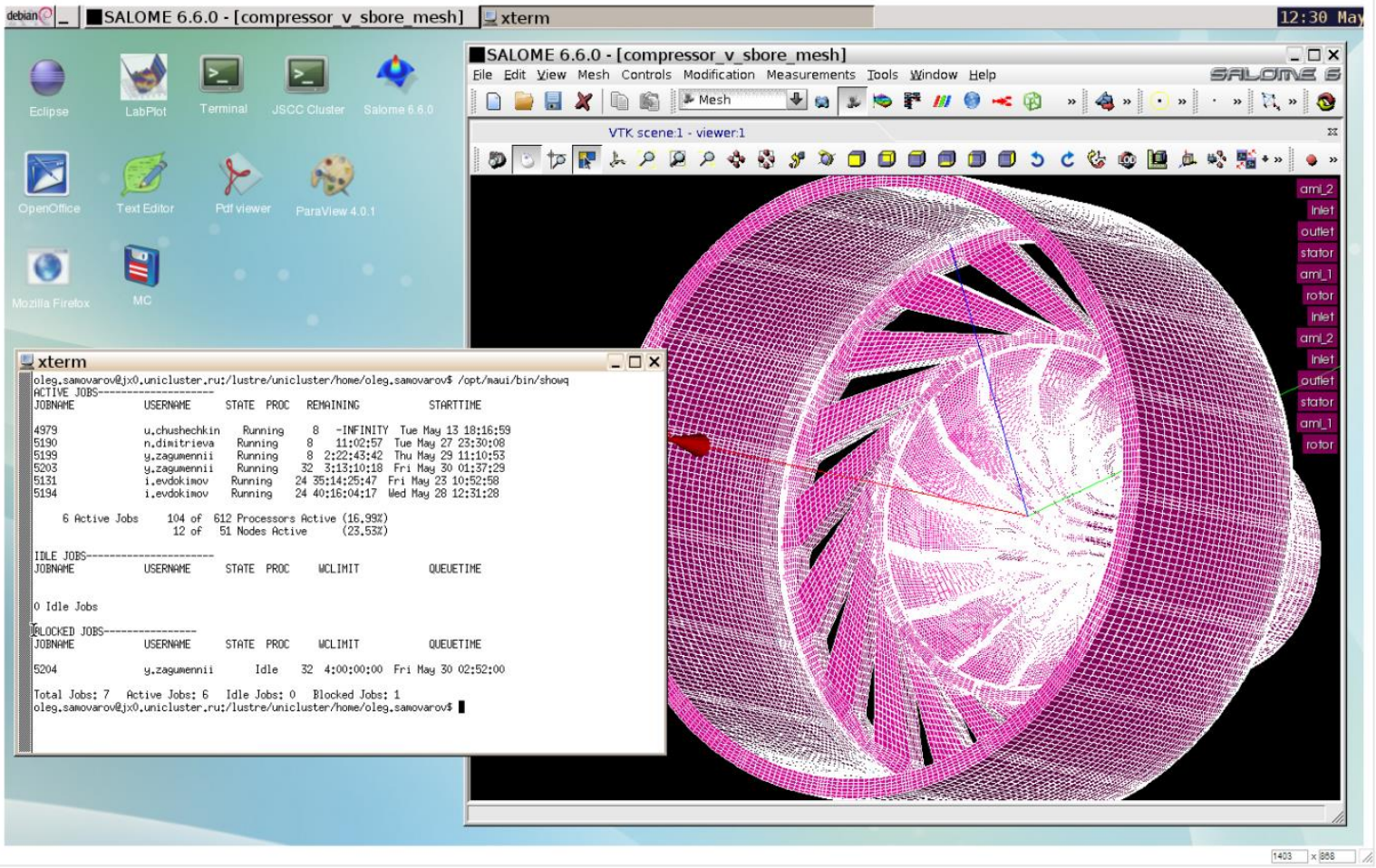
Добавить свой материал: приступ

Помощь
База знаний
Сообщить об ошибке
Связаться с нами

Virtual Desktop

Приложение | Вопросы | О приложении

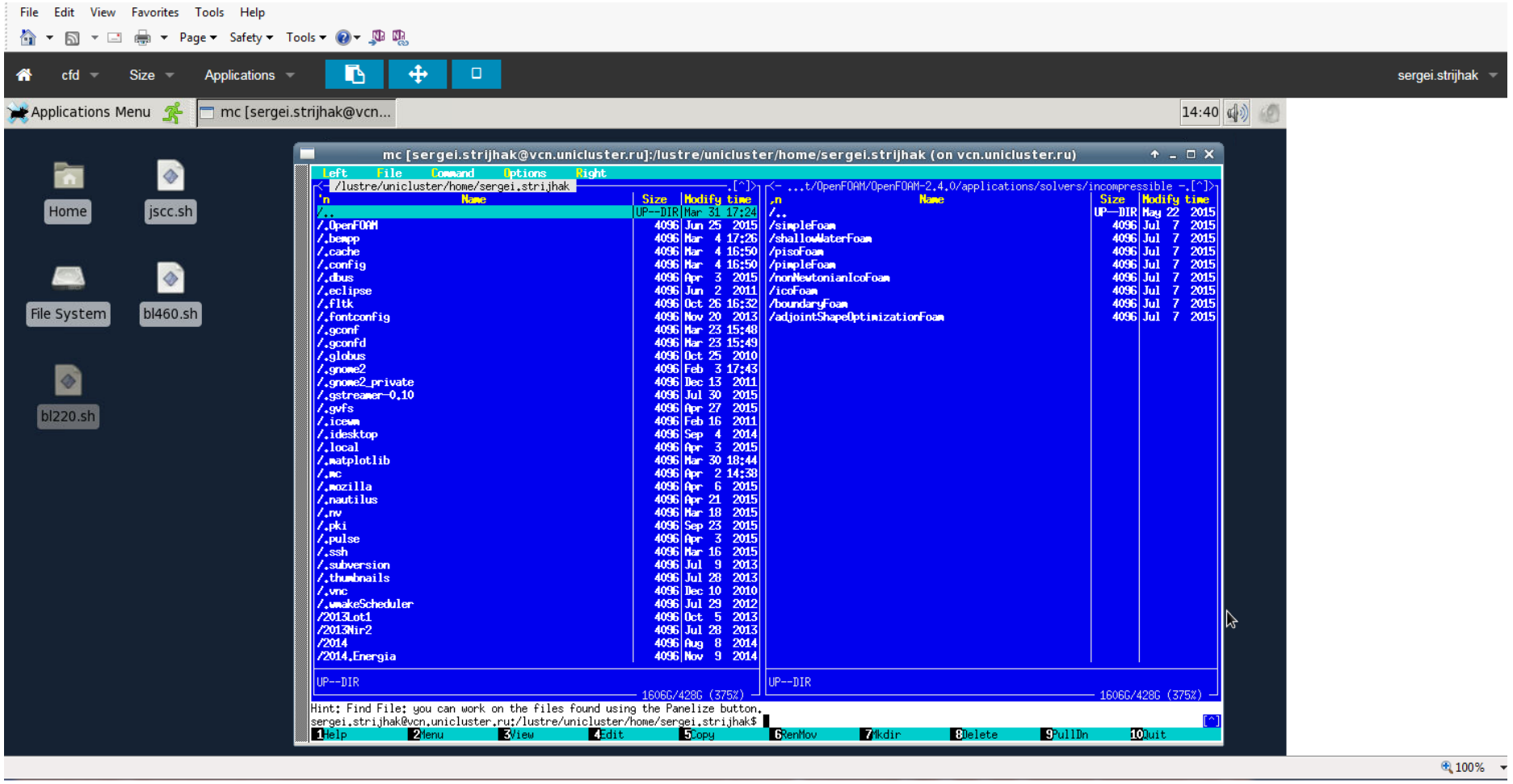
Обновить | В отдельном окне | Закрыть



Разделить сессию с пользователями (введите их имена через запятую): | Только для просмотра? | Разделить | (В данные момент сессия не разделена)

Что значит разделить сессию?

UniHUB 2.0: http://desktop.weblab.cloud.unihub.ru/login



Different solvers in OpenFOAM

$FOAM_APP/solvers

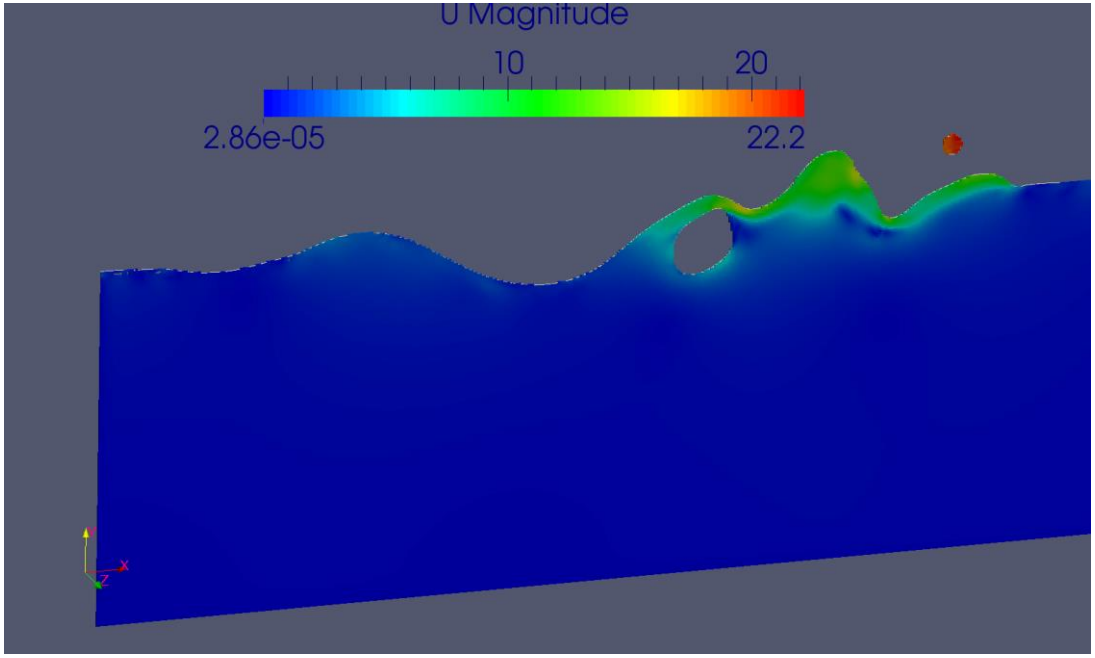
DNS	basic	combustion
dnsFoam	laplacianFoam, scalarTransportFoam	reactingFoam, fireFoam
compressible	discreteMethods	electromagnetics
sonicFoam, rhoCentralFoam	dsmcFoam	electrostaticFoam
financial	heatTransfer	incompressible
financialFoam	buoyantPimpleFoam, chtMultiRegionFoam	icoFoam, pisoFoam
lagrangian	multiphase	stressAnalysis
reactingParcelFilmFoam	interFoam, cavitatingFoam	solidDisplacementFoam

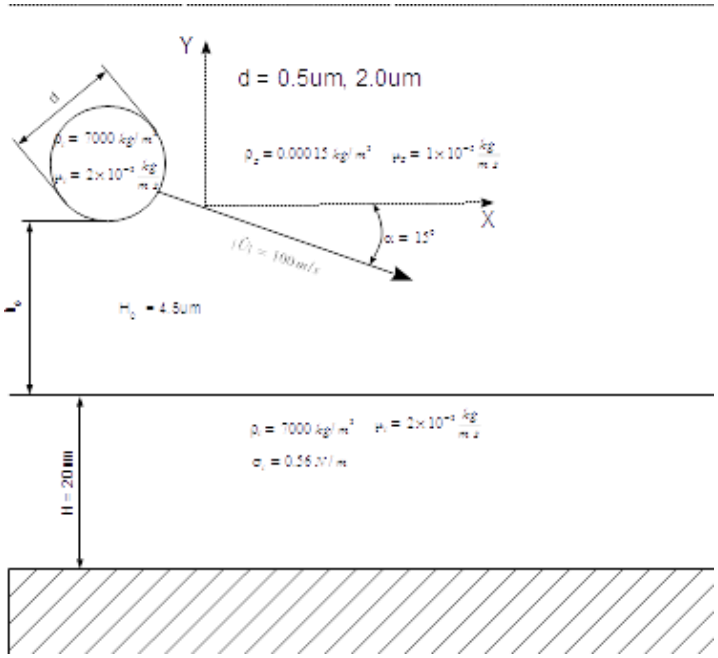
Solver — numerical model for integration of partial differential equations, which is based on finite volume method, written on C++ language

Two different versions of OpenFOAM: ***www.openfoam.org*** *and* ***www.extend-project.de***

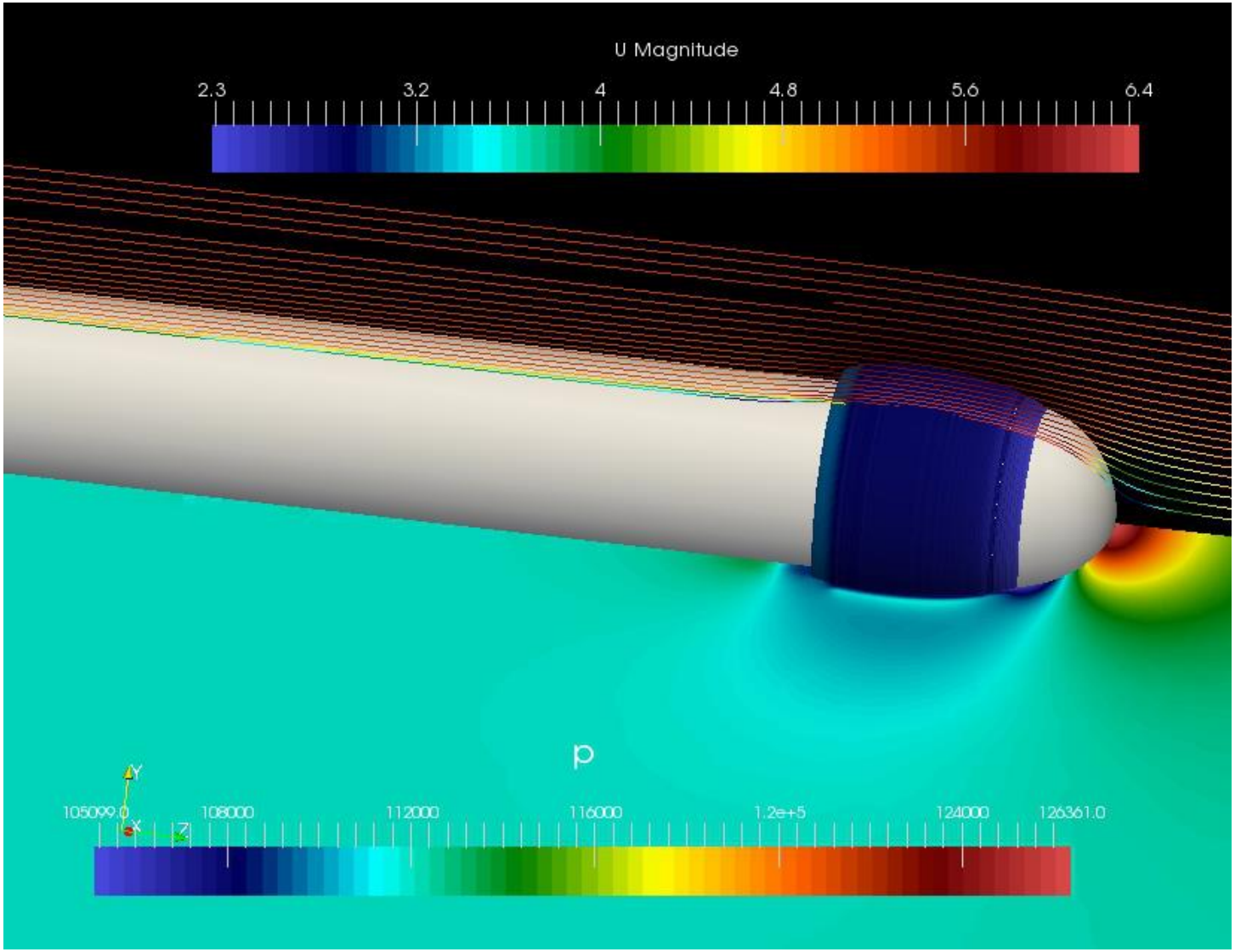
Interaction of liquid metal droplets with liquid layer

Project with ASML company

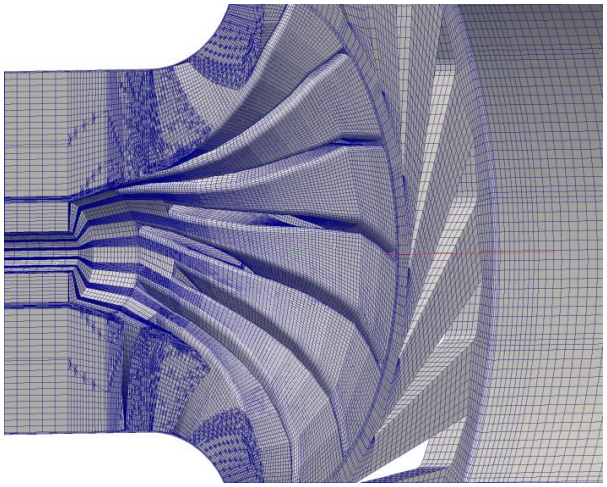


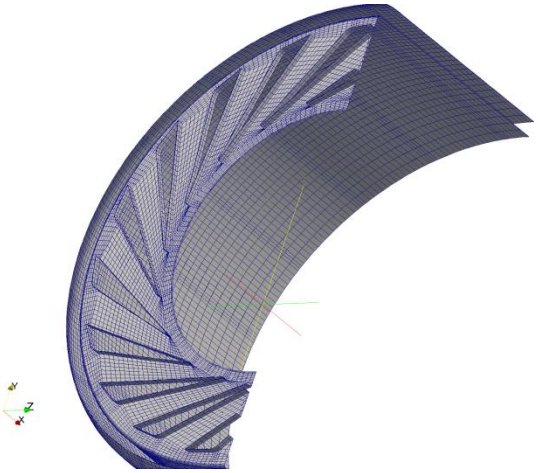


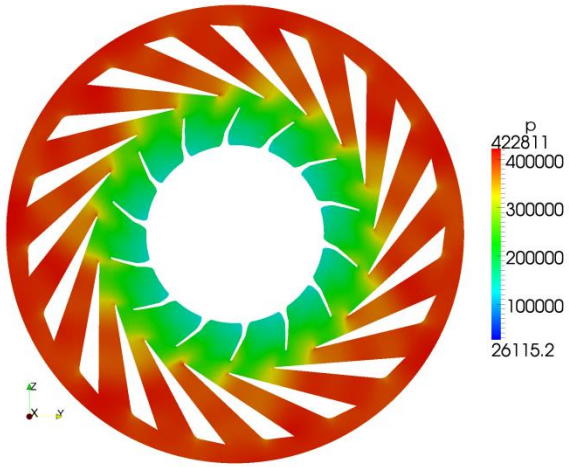
Cavitation with external flow.
Blue color shows cavitation cavity.

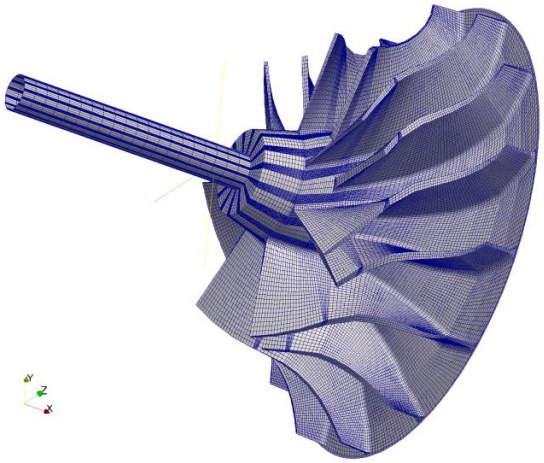


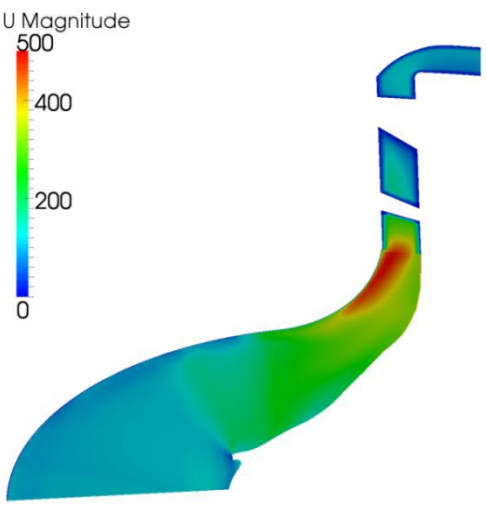
Turbomachinery Flows: Simulation of Supersonic Radial Compressor

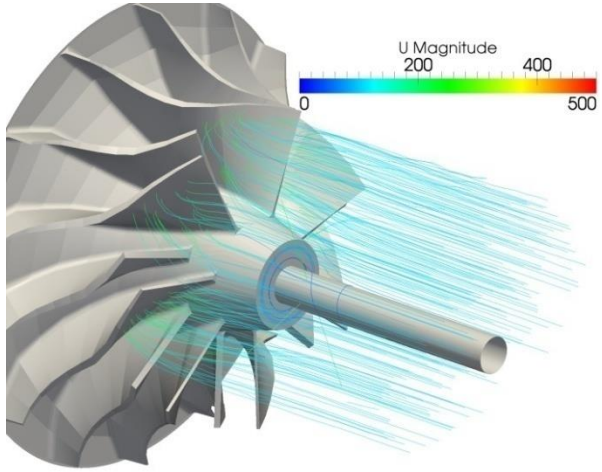






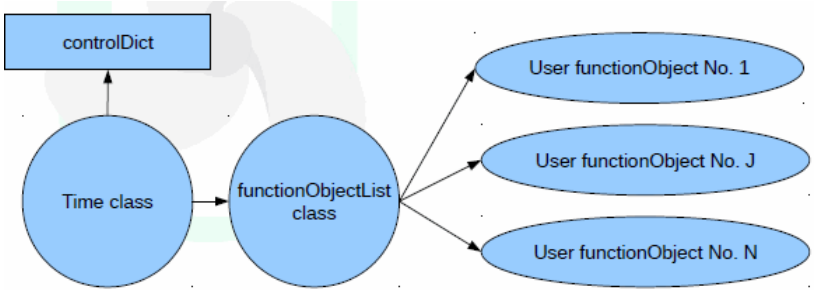




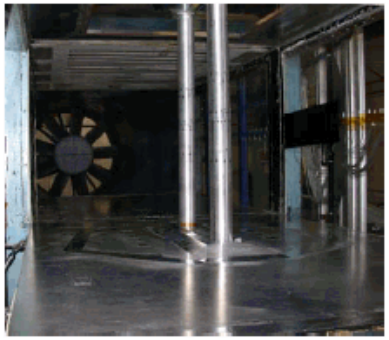


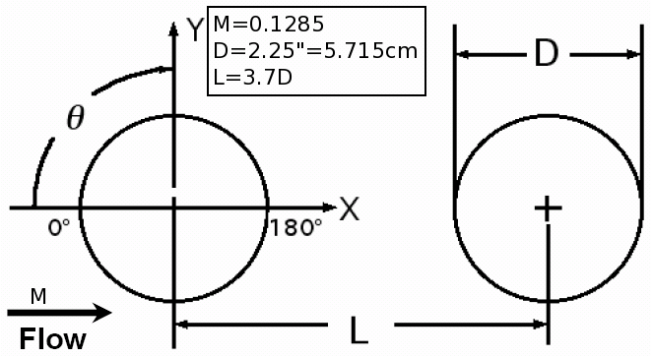
Turbulent Flow with LES model. Solver in OpenFOAM: mySonicDyMfoam. Number of cells: 26 111 120

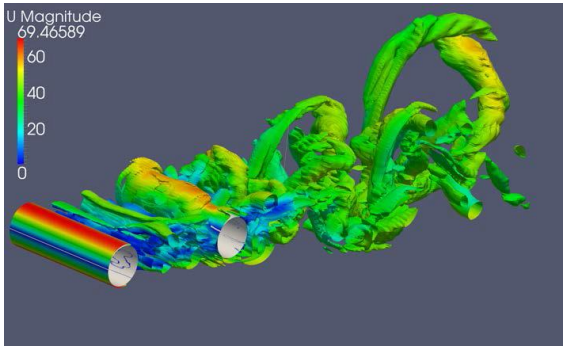
External aerodynamics and computational aeracoustics



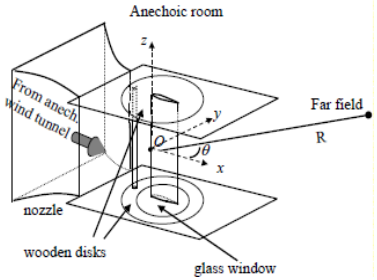
$$p'(\tilde{x},t) = \frac{1}{4\pi c_0}\frac{x_i}{r^2}\left[\frac{\partial F_i}{\partial t} + \frac{c_0 F_i}{r}\right]$$

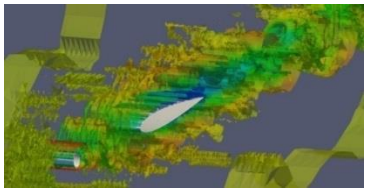


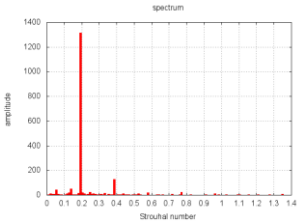




Test case : tandem cylinders





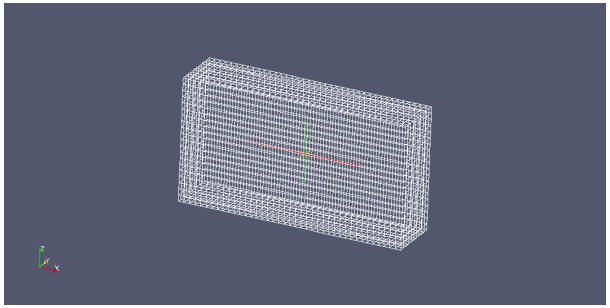


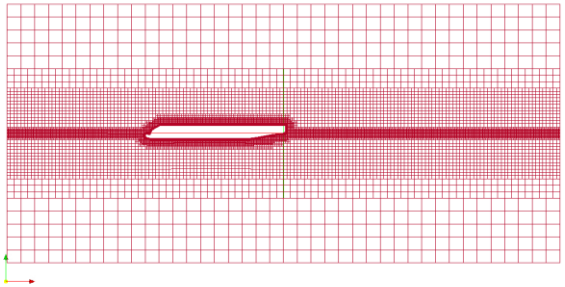
Solver : pisoFoam + LES model + Libacoustics.so library
New Project for 2016: Hybrid CAA solver with lagrangianCentralFoam and BEM++

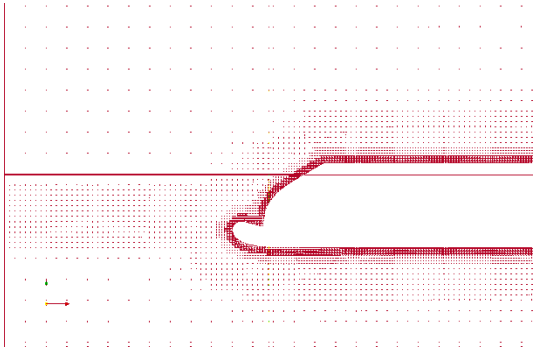
Ship Hydrodynamics

Different Re (Reynolds) and Fr (Froude) numbers.

Solver in OpenFOAM: interFoam + k-omega SST turbulence model



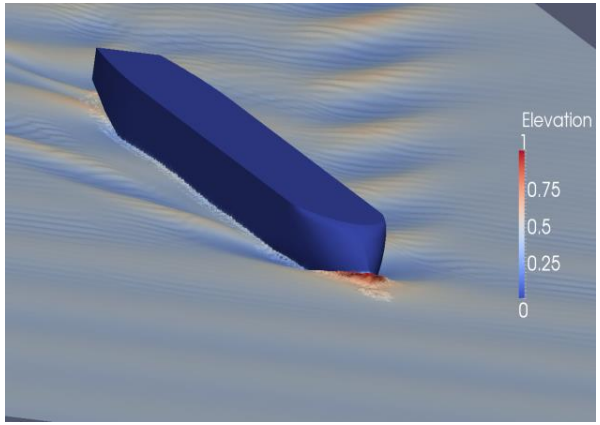


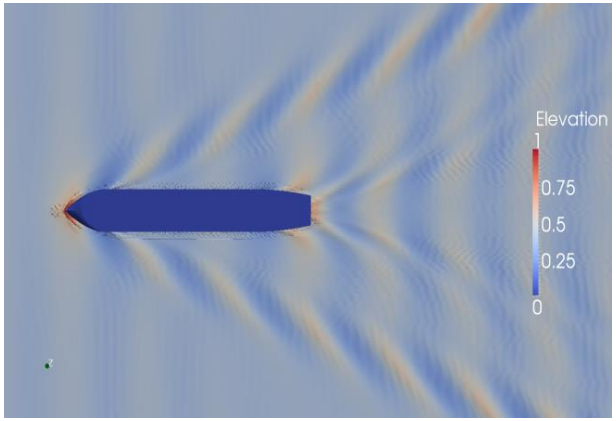


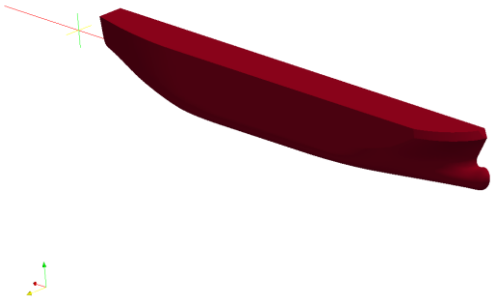
Domain: 1000 m*250 m* 510 m. Lship=6 м.

Number of cells: ~ 4 000 000 – 96 000 000

Definition of forces and moments







Ph.D. Student: N.Tryaskin. Supervisor: Prof. I.V. Tkachenko

Research of droplet impacts on the large Froude numbers

Main goals of research:

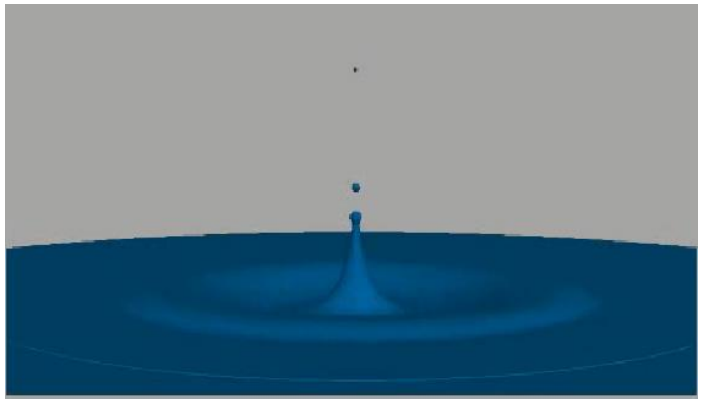
- to investigate the possibility of different open-source packages to solve problems of droplet impact;
- to make a numerical research of different regimes of droplet impact to the deep pool or to solid surface with different contact angles.

Parts of research:

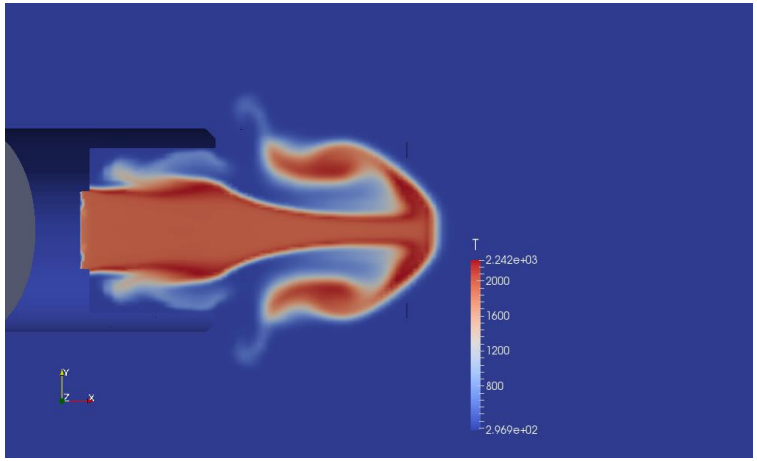
- investigation of droplet impact to the deep pool;
- investigation of droplet impact to the solid surface with different values of contact angle;
- study of heat transfer effects when droplet falls onto the solid surface.

Range of dimensionless criteria:

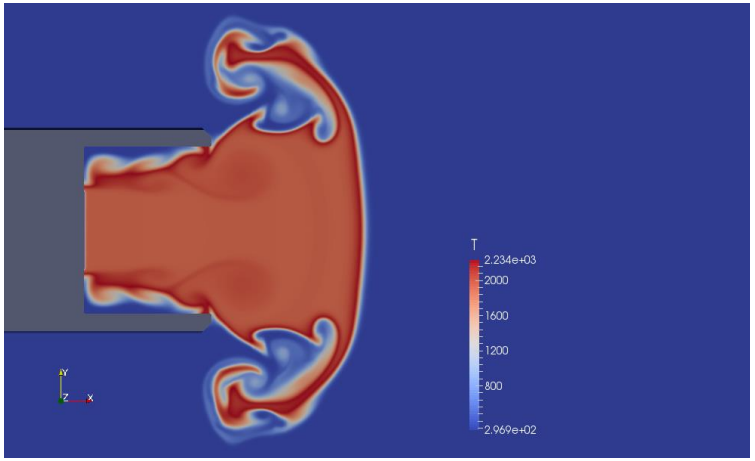
- $\mathrm{Fr} = \dfrac{U^2}{gd} > 10^5$
- $\mathrm{Re} = \dfrac{\rho U d}{\mu} = 400 \ldots 3000$
- $\mathrm{We} = \dfrac{\rho U^2 d}{\sigma} = 10^2 \ldots 10^4$



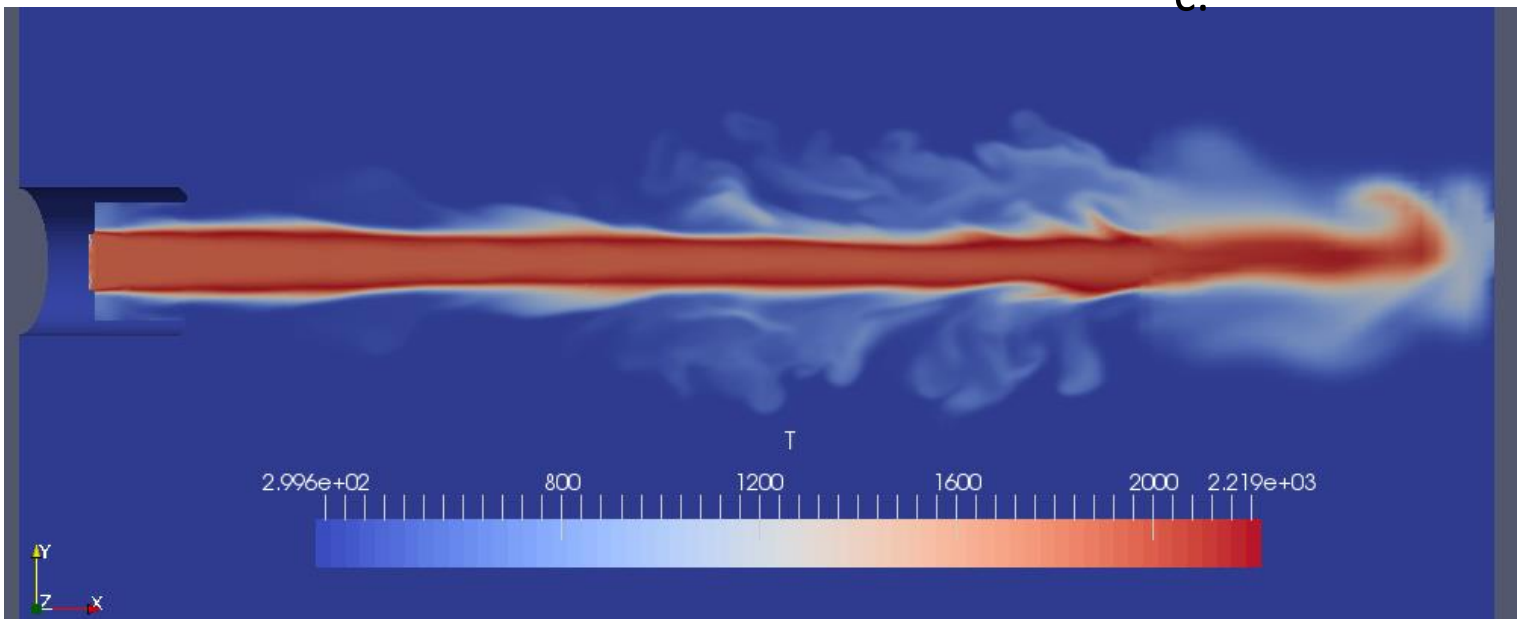
Fields of temperature for solder torch V=10 м/с.



Grid - 8mln. cells. Time T1= 0,001 c.



Grid — 5 mln. cells. Time T1= 0,001 c.



Grid — 8 mln. cells. Time T1= 0,01 c.

Project: Cluster for analysis of Big Data

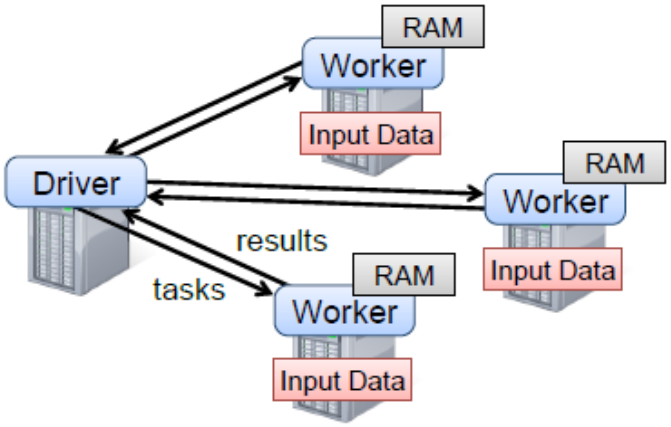
1) Algorithm POD (Lumley 1970; Sirovich 1987) Proper Ortogonal Decomposition:

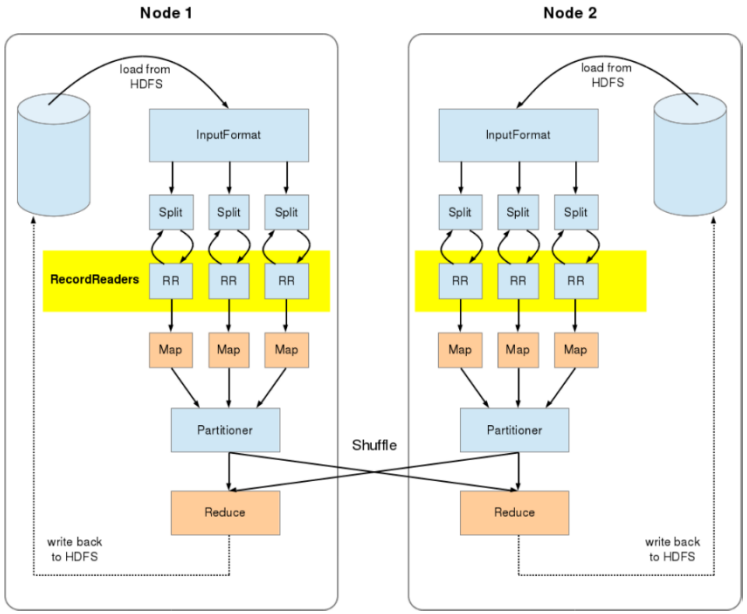
- Simple algorithm which depends from snapshots.
- SVD decomposition.
- Orthogonalization in space

2) Algorithm DMD (Rowley 2009; Schmid 2010) Dynamic mode decomposition:

- Time snapshorts.
- Orthogonalization in time.

3) Search and group of data





Deployment of Apache Spark cluster in ISP RAS Hadoop/Mapreduce cluster

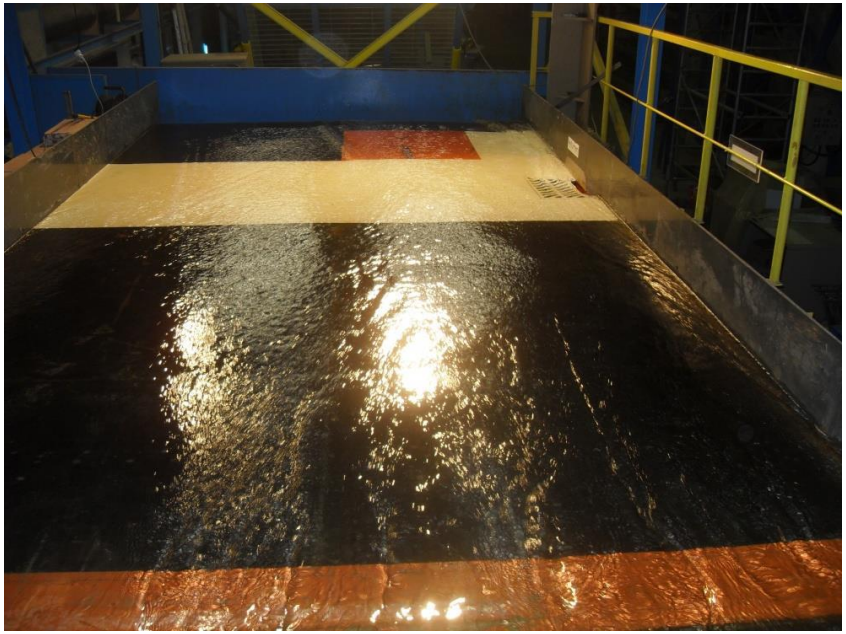
Ph.D. student: M. Kalugin Supervisors: Prof. A, Avetisyan, Ph.D. S.Strijhak

Web-laboratory UniCFD=Community

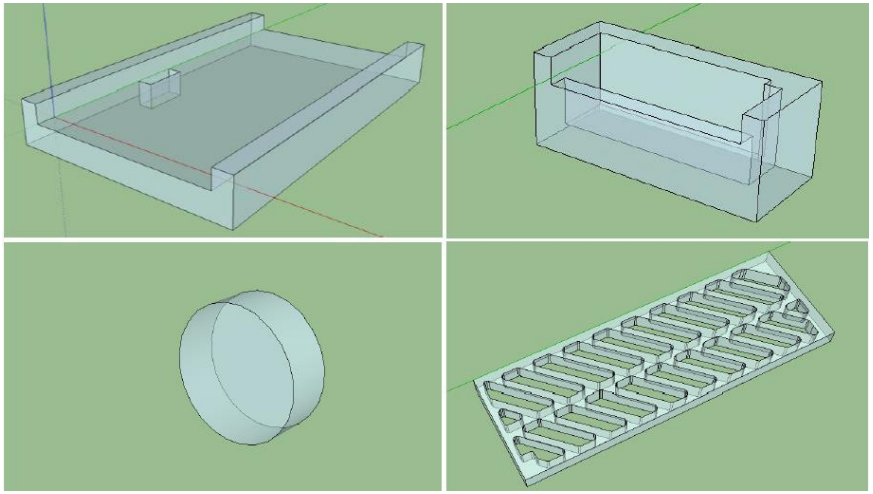
The main goal – creating the community of users and developers

2011-2015: Workshops, Users' trainings, Conferences, Summer schools in Moscow State University (MSU supercomputer Academy)

UPC: cfd for urban drainage



Urban Drainage platform - Hydraulics Laboratory in UPC



Ph.D student : Jackson Tellez
Platform Dim: 5.5m x 3m. Flow rate: 100 l/s.
Different conventional Grates
OpenFOAM: interFoam, porousinterFoam
The goal: 3D turbulent flow simulation, definition of velocity fields, pressure drop, flow rate, particle trajectories

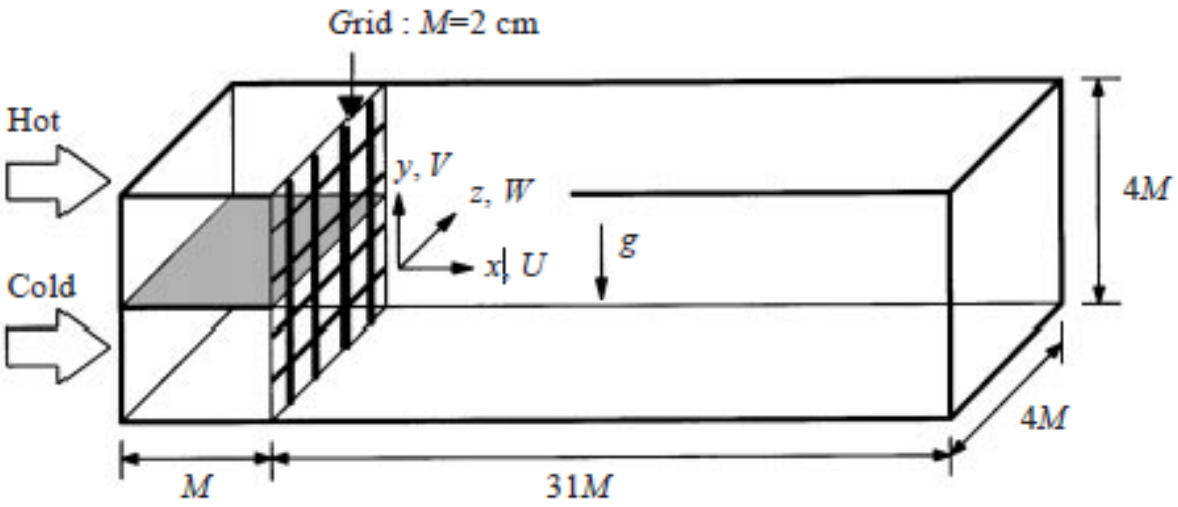
New: Possible implementation of PANS (Partially-averaged Navier Stokes) model in OpenFOAM

Experimentas of fractal grates and oscillation grates (UPC, Barcelona, Prof. J.M. Redondo)

Two scale grate

Sierpinski grate

Numerical Domain



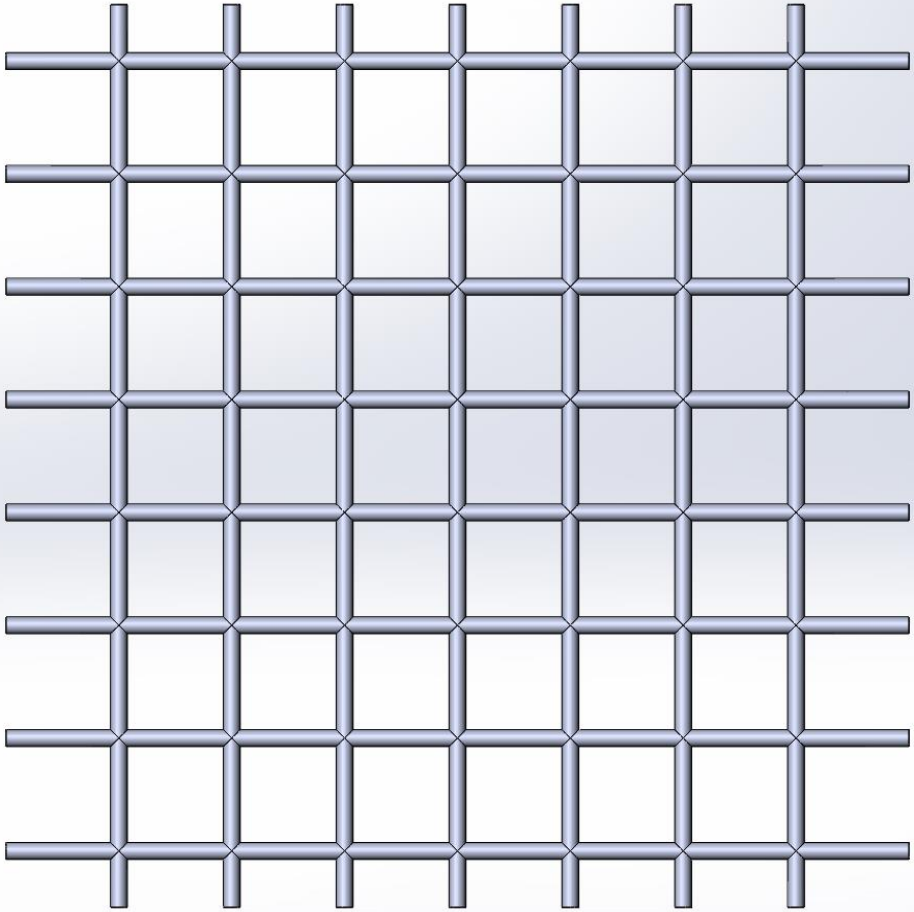
The mesh size of grid:
***M* = 2.0 x 10e−2 m**
Diameter of the rod
***d* = 3.0 x 10e−3 m**

The computational domain was 640x80x80 mm (32*M X* 4*M X* 4*M*) in the streamwise, vertical and spanwise directions

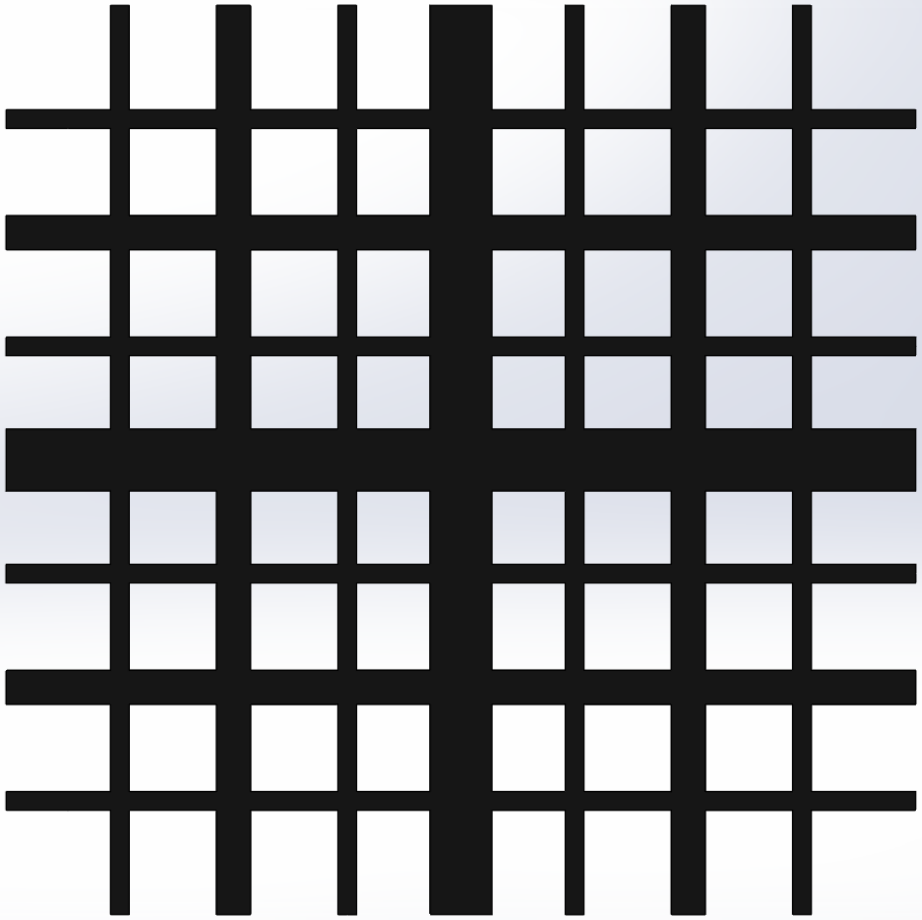
The numbers of grid points used here were 640 x160 x 160 in the streamwise, vertical and spanwise directions and therefore the grid spacings were 1.0 x 10e−3 m in the streamwise direction and 5.0 x 10e−4 m in the vertical and spanwise directions

A square turbulence-generating grid, on which the velocity components are set to zero, was located 2.0 X 10e−2 m downstream from the entrance

Biplane grid



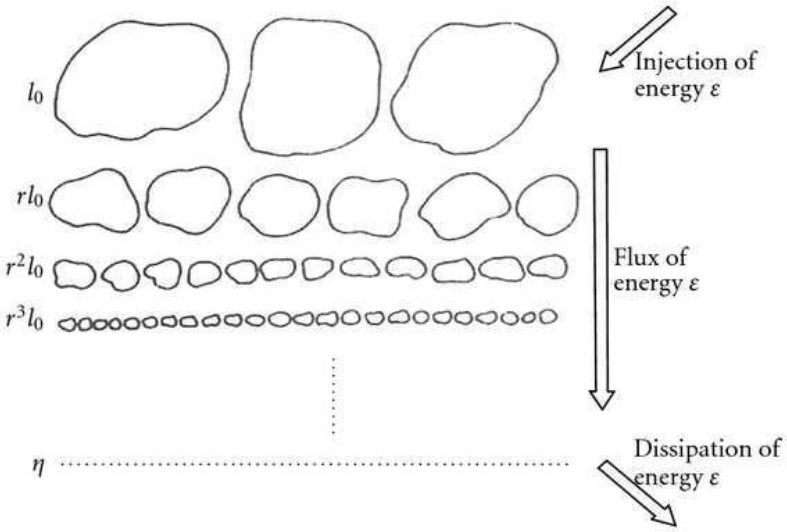
Fractal Cross grid (T=0.91 м, tmax=62 мм,tmin=18.78мм, w=5 мм)



Turbulence modeling

RANS, LES, DNS

The Kolmogorov (1941) -5/3 Law



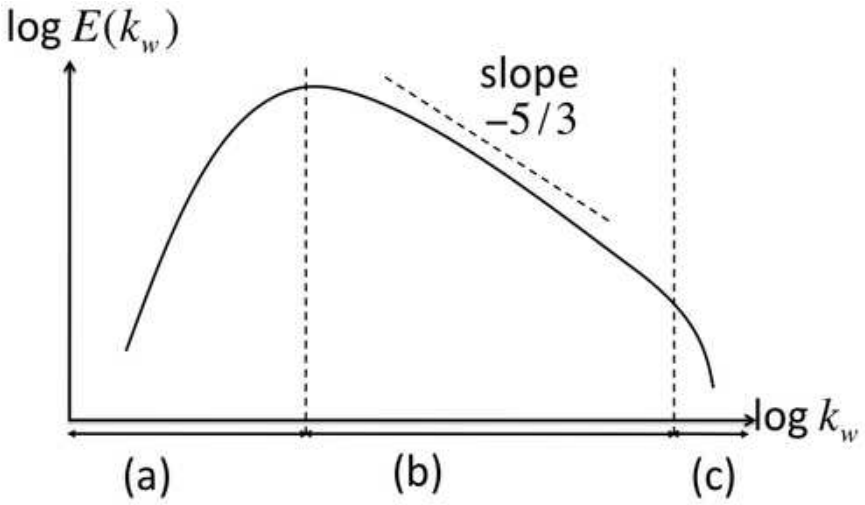


Fig. : Energy cascade and spectrum

- DES is a hybrid LES/RANS approach.
- Zonal approaches, switch the solving equations during the simulation or inside the domain.
- Fixed zonal approach, the RANS zones are defined a priori (close to wall)
- PANS is a hybrid DNS/RANS approach.

Wilcox, David C. Turbulence Modeling for CFD. Third Edition. 2006. 536 p.

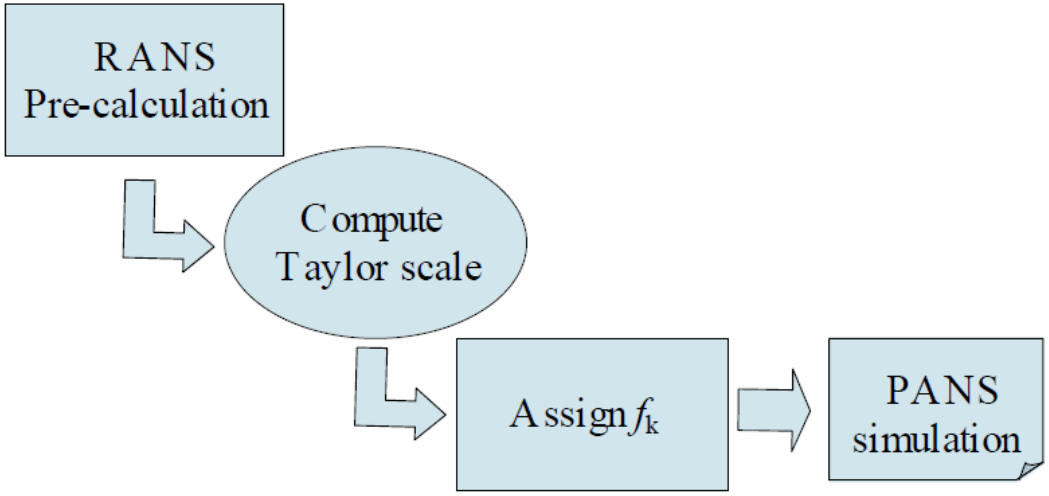
PANS model

Partially-averaged Navier Stokes (PANS) is a suite of turbulence closures of various modeled-to-resolved scale ratios ranging from Reynolds-averaged Navier Stokes (RANS) to Navier-Stokes (Direct Numerical Simulations).

The objective of PANS, like hybrid models, is to resolve large scale structures at reasonable computational expense.

The cut-off lengthscale in PANS is quantified by two parameters: the unresolved-tototal ratios of kinetic energy (fk) and dissipation (fe).

The unresolved stress is modeled with the Boussinessq approximation and modeled transport equations are solved for the unresolved kinetic energy and dissipation



$$f_k \gtrsim \frac{\Delta}{\Lambda}$$

grid-size Δ

Λ is the pertinent Taylor microscale.

Figure 1. Four-step implementation scheme.

Girimaji, S.S., 2006, Partially-Averaged Navier-Stokes Model for Turbulence: A Reynolds-Averaged Navier-Stokes to Direct Numerical Simulation Bridging Method ASME J. Appl. Mech., 73, 413–421

PANS is a hybrid RANS/DNS approach

URANS $k-\varepsilon$ closure equation system

$$\frac{\partial k}{\partial t} + U_j \frac{\partial k}{\partial x_j} = P_k - \varepsilon + \frac{\partial}{\partial x_j}\left[\left(\nu + \frac{\nu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right]$$

$$\frac{\partial \varepsilon}{\partial t} + U_j \frac{\partial \varepsilon}{\partial x_j} = C_{1\varepsilon}\frac{\varepsilon}{k}(P_k) - C_{2\varepsilon}\frac{\varepsilon^2}{k} + \frac{\partial}{\partial x_j}\left[\left(\nu + \frac{\nu_t}{\sigma_\varepsilon}\right)\frac{\partial \varepsilon}{\partial x_j}\right]$$

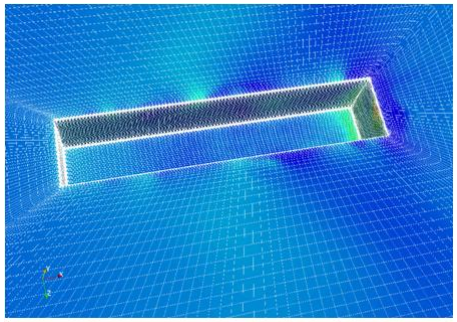
- $C_{1\varepsilon} = 1.44$, $C_{2\varepsilon} = 1.92$, $\sigma_\varepsilon = 1.3$ and $\sigma_k = 1$
- ν_t is updated every time step as

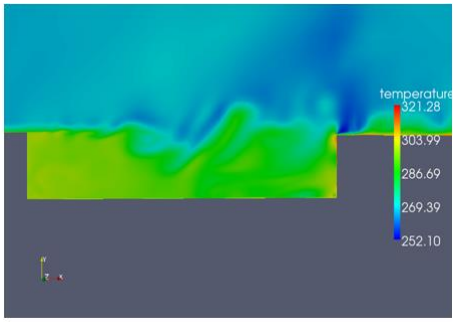
$$\nu_t = C_\mu \frac{k^2}{\varepsilon}; \quad C_\mu = 0.09$$

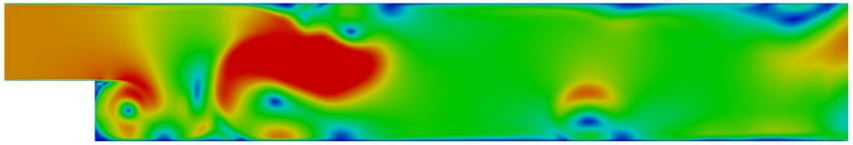
- The method can catch only large oscillation such as vortex shedding

Girimaji, S., Jeong, E., and Srinivasan, R., "Partially Averaged Navier–Stokes Method for Turbulence: Fixed Point Analysis and Comparison with Unsteady Partially Averaged Navier–Stokes," Journal of Applied Mechanics, Vol. 73, No. 3, 2006, pp. 422–429

PANS cfd examples
(Chalmers Technology University, Texas A&M University)

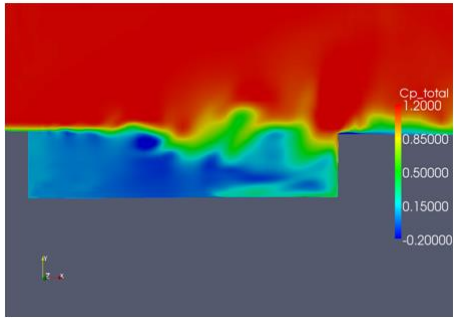


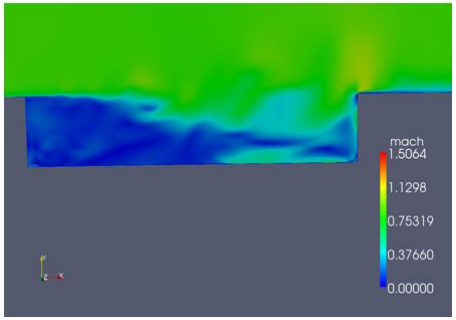




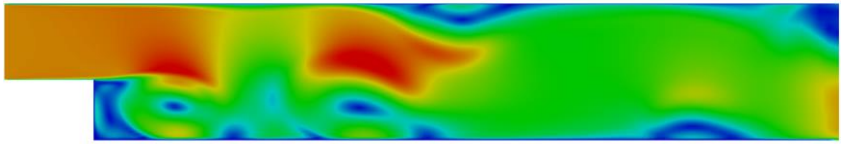
Instantaneous velocity field.

Fixed Fk PANS



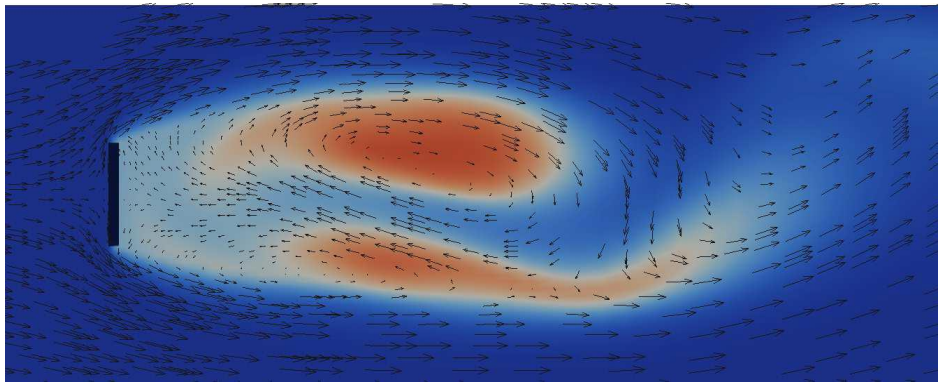


Transonic 3D cavity

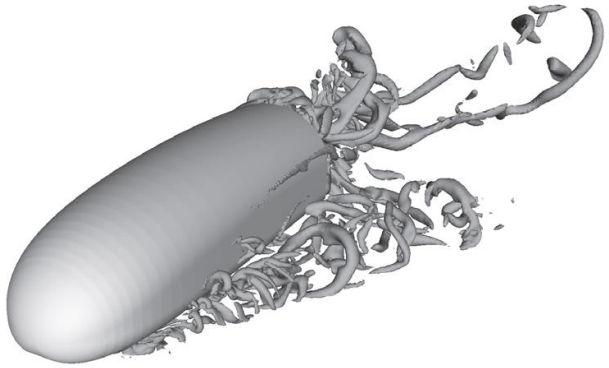


Instantaneous velocity field.

varying Fk PANS



simulation cavitation in 2d flat plate



flow around generic vehicle

Conclusions

- There is a web laboratory in ISP RAS and we use different Open Source software
- pisoCentralFoam with different modifications is available on github.com
- We try to do a research in fluid dynamics
- We prepared different courses and trainings with Salome/OpenFoam/Paraview
- Deployment of UniHUB in different organizations in Russia
- Our solver is a good start point for scientific collaboration with other different groups! ☺