Common IT space for joint research in the field of Controlled Thermonuclear Fusion in Russian Federation - FusionSpace.ru

S. Portone, O. Semenov, A. Larionov, I. Semenov

E. Mironova, Z. Ezhova, L. Grigorian, D. Guzhev,

A. Mironov, N. Nagorniy, V. Nesterenko,

A. Nikolaev, E. Semenov

Project Center ITER
04 July 2023

Contents

Research and development of Fusionspace.ru

1. Existing tools of remote access to Fusion Facilities
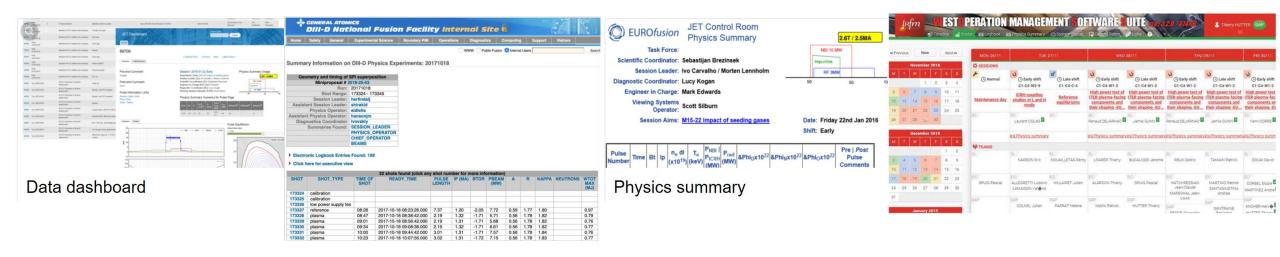2. Design and current status of Fusionspace.ru
3. Plans for future development

Existing tools of remote access to Fusion Facilities
(from large international projects and ITER
to joint fusion research in Russian Federation)

Existing tools of remote access to Fusion Facilities

1. JET   – data access;
        – scientific software for data processing and visualization;
1. DIII-D – remote access to IT services for data;
2. EAST – remote participation centers with access to infrastructure;
3. WEST – web-portal for experiment planning and data processing;
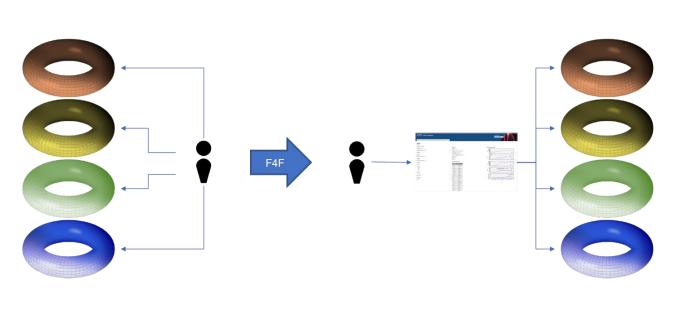   – distributed experiments with REC (Japan);

Fair for Fusion – concept of IT space in Europe

Objective: Centralize knowledge and ensure the availability of data from fusion research in Europe

Basic principles:

- Creation of a platform and software for the open exchange of fusion research data;
- ITER facility data policy of "open access to data" is being developed for the implementation of the current fusion research program;

ITER

ITER - International Experimental Thermonuclear Reactor - worldwide scientific project - 35 nations are collaborating to build the world's largest tokamak, a magnetic fusion device that has been designed to prove the feasibility of fusion as a large-scale and carbon-free source of energy based on the same principle that powers our Sun and stars.
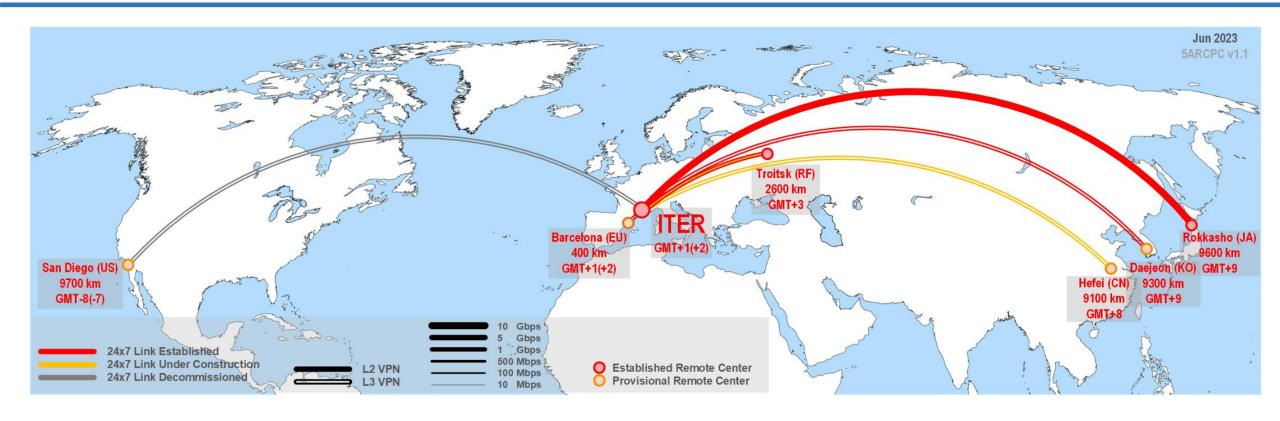
The ITER Members - China, the European Union, India, Japan, Korea, Russia and the United States - are now engaged in a 35-year collaboration to build and operate the ITER experimental device. Thousands of engineers and scientists have contributed to the design of ITER.

Possibility and functionality of remote participation in ITER is one of the most valuable questions.
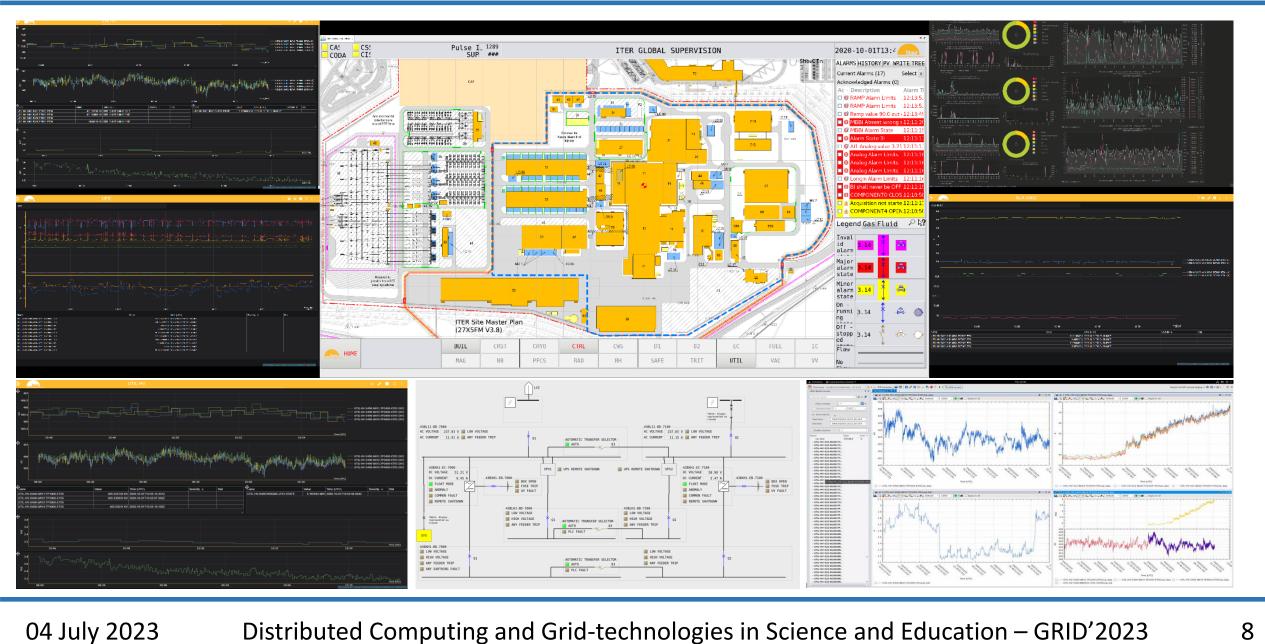
ITER – Remote Participation Centers

- JA, RF: national program / financing / leading organization defined. 24x7 connection and deployment done
- EU, KO, CN: temporary model centers (T-RPC) proposed; links / infrastructure under construction
- US: T-RPC done under contract 2020-2021; defunct as of today pending internal discussion in the US
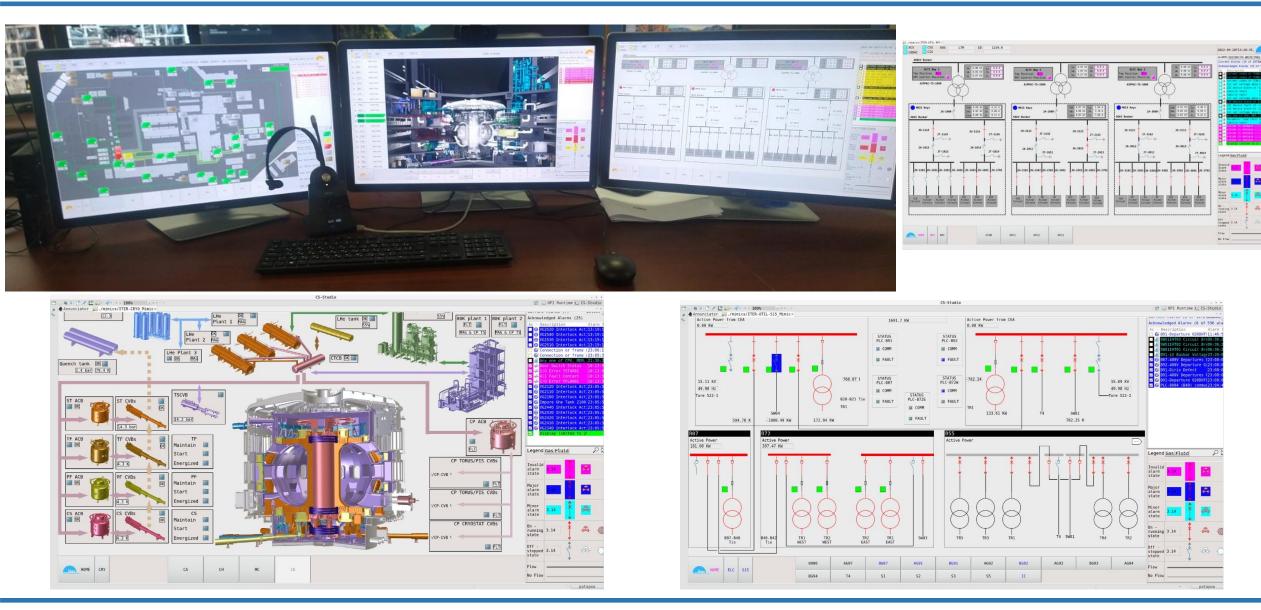- IN: expressed no interest so far.

ITER RPC in Troitsk – mirroring of main experiment videowall

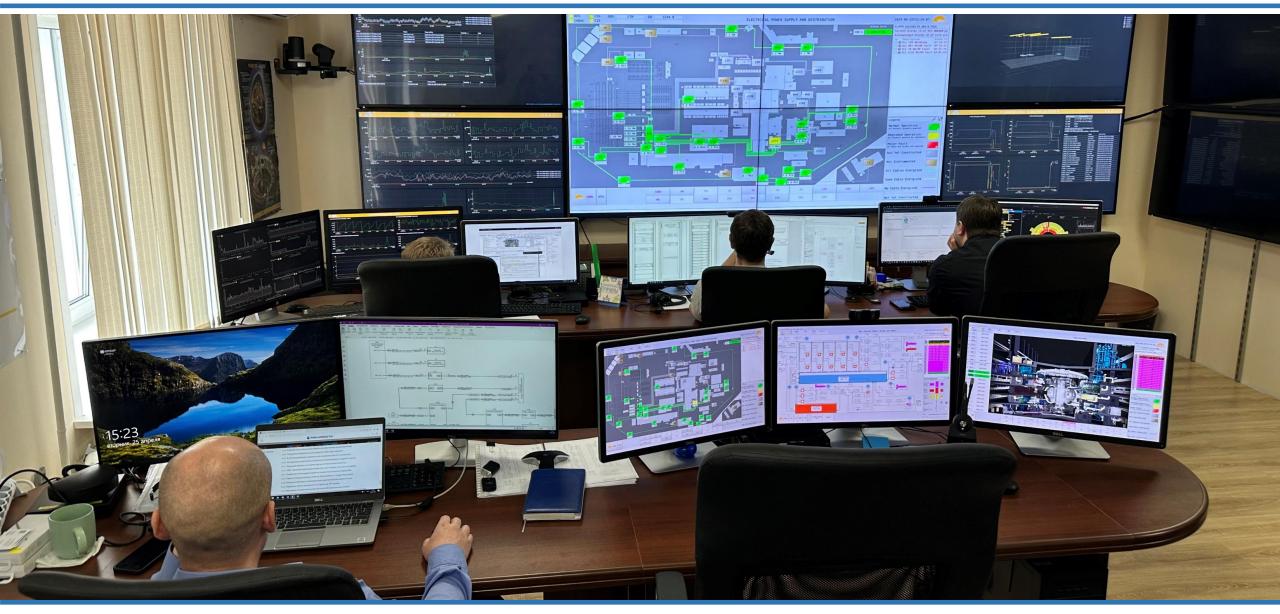# ITER RPC in Troitsk – Operation terminals and HMIs

Design and current status of Fusionspace.ru

Research and development of Fusionspace.ru

Aim: creation of Common IT space for joint Fusion research.

Main goals:
- access to accumulated knowledge;
- delivery of instruments and services for joint research in fusion;
- modern, reliable and comfortable information access for scientific results in Russia and, through ITER project, access to international fusion society;
- Web-portal for science information exchange (scientific data, software repositories, codes and standards).
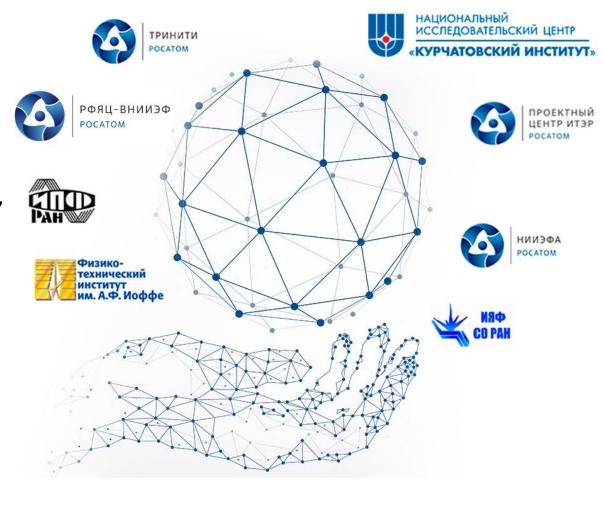
What we look after:

EUROfusion   ITER   Fair4Fusion

T-10
GLOBUS
TUMAN
T-11
GDT and etc.

Prototype creation in 2021

In 2021 prototype of common IT space was created on the basis of Rosatom enterprises (TRINITI, NIIEFA, Project Center ITER, RFNC-VNIIEF) and Russian Academy of Science institutes (FTI, IAP, BINP).

Outcomes:

1. In process of prototyping following infrastructure was created:

   - 8 Remote Participation Centers;

   - 6 Joint Laboratories;

   - Central Node.

2. Software, Hardware and Infrastructure approaches were approved;

3. First applications were performed:

   - Scientific workshop;

   - Distributed experiments,

   - Data Exchange.

Central node infrastructure

- Hyper-convergent failover cluster of virtual machines;
- Convergent failover cluster of virtual machines;
- Data storage system;
- GPU stations for data processing and scientific computing;
- Network infrastructure:

Top-of-Rack Architecture

Core level

100GbE 100GbE 100GbE 100GbE 100GbE

Access level

25GbE 25GbE 25GbE 25GbE 25GbE

Endpoint devices

Central node resources

Hyper-convergent failover cluster of virtual machines
16 servers:
- 640 cores CPU 2.5GHz@3.9GHz
- 4TB RAM
- 15TB SSD
- Network interlinks - 25 Gb/s

Data storage system - vSAN:
- 15TB SSD Tier of cache
- 90TB SSD Tier of storage

Convergent failover cluster of virtual machines
16 servers:
- 640 cores CPU 2.5GHz@3.9GHz
- 4TB RAM
- 15TB SSD
- Network interlinks - 25 Gb/s
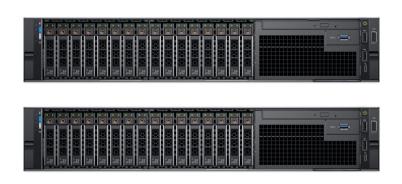
Data storage system - SAN:
- 68TB SSD
- 230TB 15K SAS HDD

GPU stations for data processing and scientific computing

High-performance GPU:

- 64 core CPU 2.3GHz@3.3GHz
- 512GB RAM
- 20TB SSD
- 49536 GPU cores, 640 GB video memory

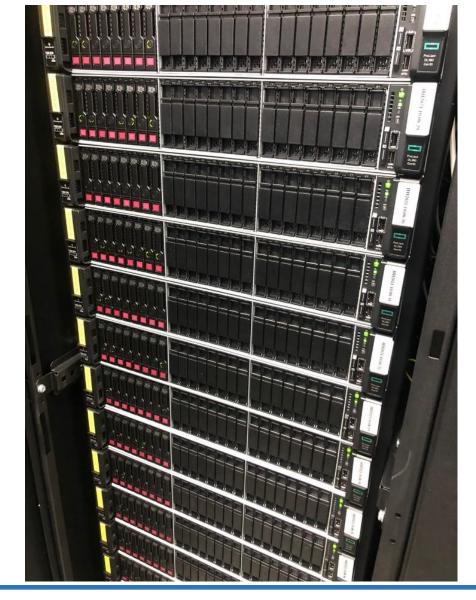## GPU-servers:

- 96 cores CPU 2.4GHz@4GHz
- 1TB RAM
- 4TB SSD
- 10Тб 15K SAS HDD
- 21504 GPU cores, 96 GB video memory

Remote Participation Centers
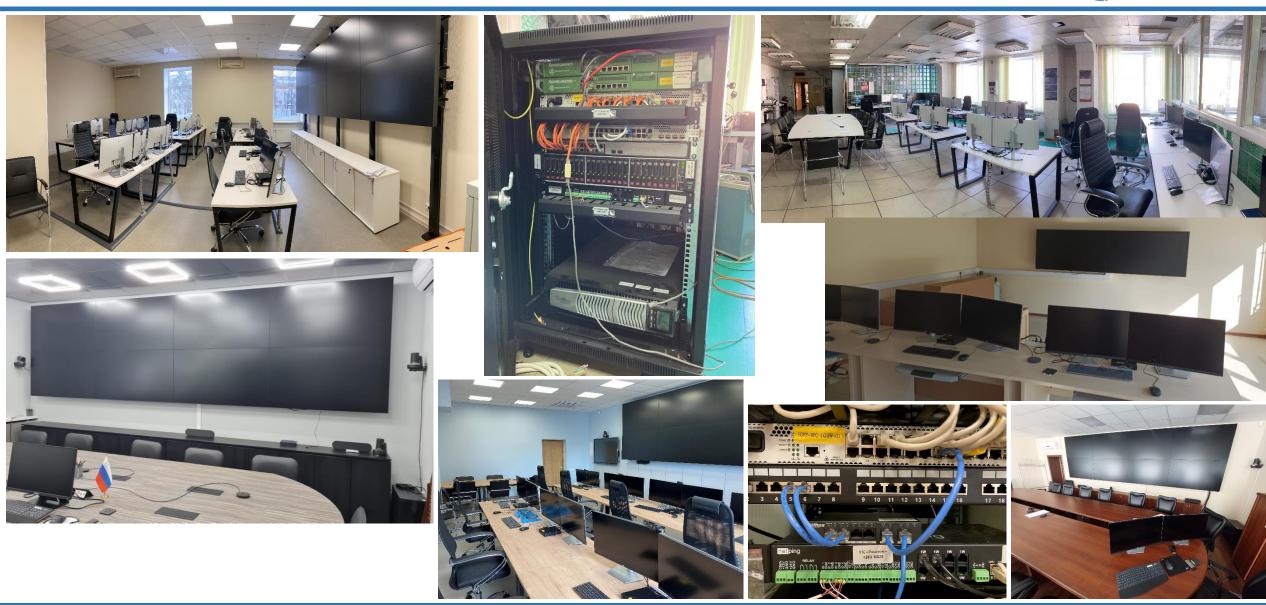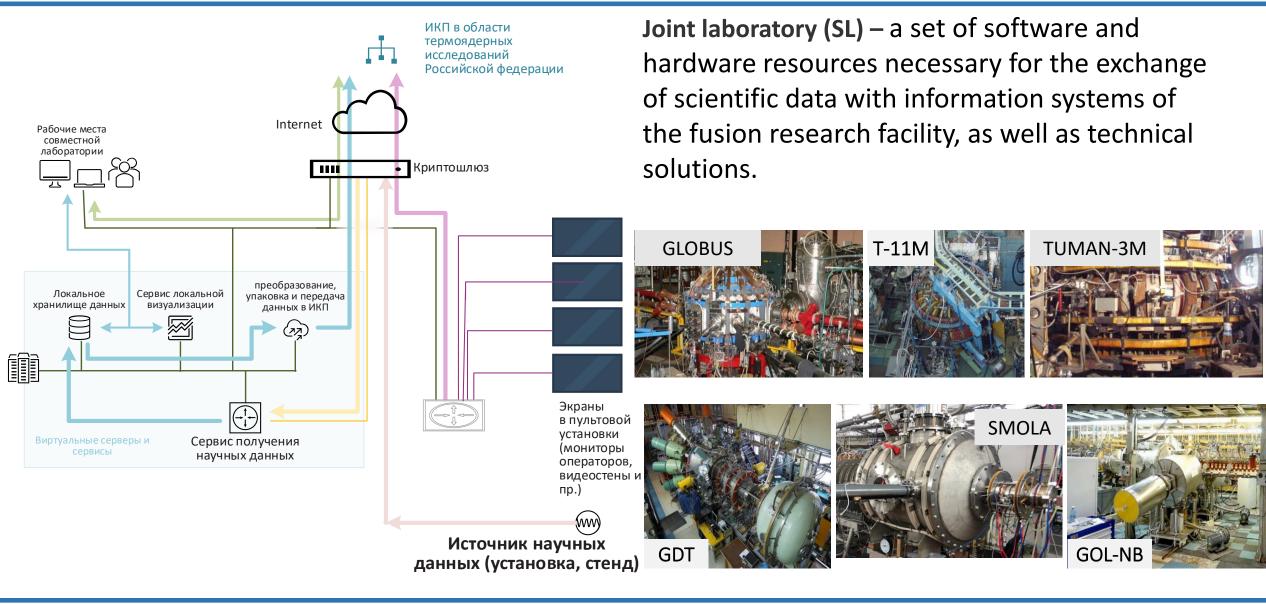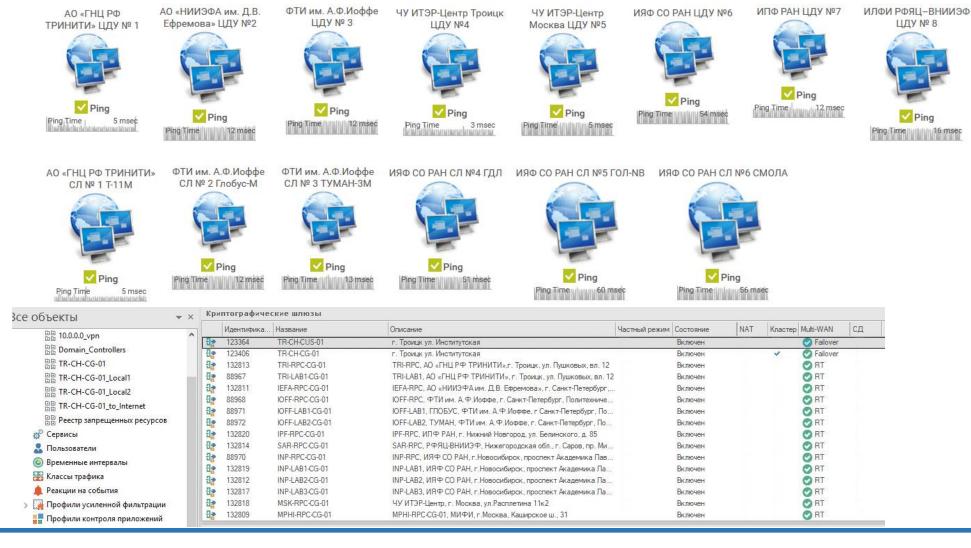
Joint laboratories

ИКП в области термоядерных исследований Российской федерации

Internet

Криптошлюз

Рабочие места совместной лаборатории

Локальное хранилище данных

Сервис локальной визуализации

преобразование, упаковка и передача данных в ИКП

Виртуальные серверы и сервисы

Сервис получения научных данных

Экраны в пультовой установки (мониторы операторов, видеостены и пр.)

Источник научных данных (установка, стенд)

Joint laboratory (SL) – a set of software and hardware resources necessary for the exchange of scientific data with information systems of the fusion research facility, as well as technical solutions.

GLOBUS

T-11M

TUMAN-3M

GDT

SMOLA

GOL-NB

Connection quality monitoring system
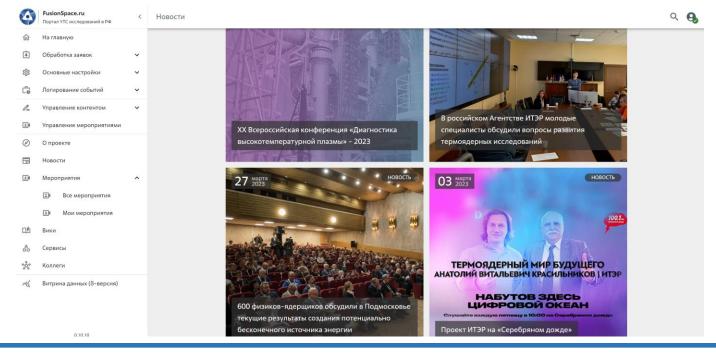
Web-portal for information exchange

FusionSpace.ru is a common environment for data and knowledge exchange among Russian fusion society.

Web portal is a front-end of the common IT space. Now it is under construction, but basic functionality has been created in the previous year:

- Users and roles management:

- Wiki, competency and knowledge management:

- Event management:

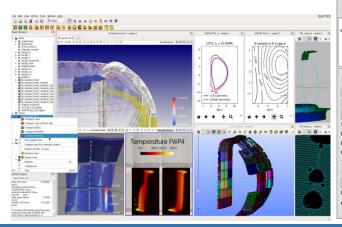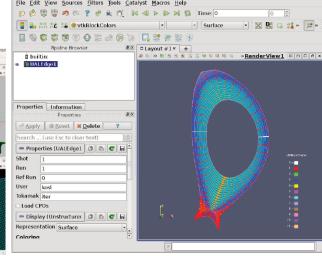- System events and user actions logging.

Software development

Following applied software for data exchange, processing and visualization:

1. Software for acquiring, transmission and storage of the scientific data of different formats and volumes. This data is received from joint laboratories and after standardization is stored in central storage in native and standardized formats.

2. Software for analyses and visualization of experimental data, aimed on data in standardized FusionSpace format:
   - User application integration;
   - Standard mathematical functions;
   - Multi-user operation regimes;
   - Data visualization tool with flexible settings.

3. E-Logbook.

Computing capabilities – first steps

Computing cluster consist 16 VM with 40 CPUs and 64Gb RAM (40Gb dedicated to SLURM) each. OS: Ubuntu 20.04.5

Installed packages: gcc, gfotran, icc, java,Python, Cmake, Julia, Lua, Go, Open MPI, Intel MPI, git, mc, vim, neovim, nano, SLEPc and PETSc.

Installed toolchains:

Foss:

- binutils (https://www.gnu.org/software/binutils/)
- the GNU Compiler Collection (GCC, https://gcc.gnu.org/), i.e. gcc (C), g++ (C++) and gfortran (Fortran)
- the Open MPI library (https://www.open-mpi.org/)
- the OpenBLAS (http://www.openblas.net/) + LAPACK (http://netlib.org/lapack)
- the FlexiBLAS library (https://www.mpi-magdeburg.mpg.de/projects/flexiblas), with OpenBLAS + LAPACK
- the ScaLAPACK (http://netlib.org/scalapack) library is also included
- the FFTW library (http://fftw.org/)

Intel:

- the Intel C/C++/Fortran compilers (https://software.intel.com/en-us/intel-compilers), i.e. icc, icpc and ifort,
- binutils and GCC, which serve as a base for the Intel compilers, are also included
- the Intel MPI library (https://software.intel.com/en-us/intel-mpi-library)
- the Intel Math Kernel Library (MKL, https://software.intel.com/en-us/intel-mkl) for BLAS/LAPACK/FFT functionality

First users – Project Center ITER (neutron calculations) и NRC KI (plasma calculations)

Plans for future
Perspective of development for 2025-2030
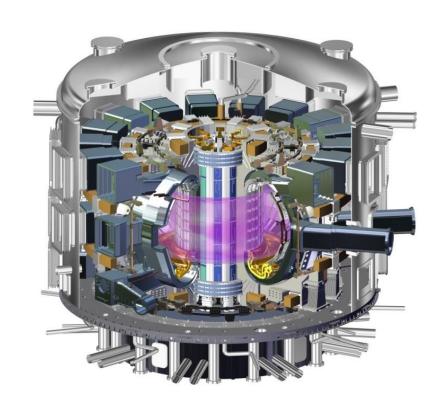
FusionSpace.ru evolution

- Development of new processing and analyses tools of experimental data in FusionSpace.ru, including elements of machine learning.

- Development and creation of a computing hardware platform for Fusion data experiment processing based on the developed tools.

- Development of a secure segment of FusionSpace.ru for data and information exchange during new Tokamak design.

- Modernization of the FusionSpace.ru software for working with accumulated Fusion data research (implementation of algorithms for mass processing of big data, modernization of the calculation module);

- Development of an isolated protected segment of FusionSpace.ru for foreign installations connection (e.g. ITER, EAST, KTM), ensuring information interaction and user access to their information.

Connection to ITER data

- ITER installation will have near 50 diagnostics;

- During ITER D-T operation:
    - **2,2 PB** each day of scientific program;
    - **0,45 EB** during the operation year;

- Data volume will increase with the development of systems;

- Simultaneous processing of interconnected data in real time is required;

- Development of a highly efficient data processing and analysis process;

- **Russian fusion society should have all the tools to work with ITER data.**

Thank you
for attention!

Portone Sergey
Head of Control System Section
Project Center ITER

Tel.: +7 (499) 281 72 21
Cell.: +7 (917) 512 97 73
E-mail: S.Portone@iterrf.ru
www.iterrf.ru