

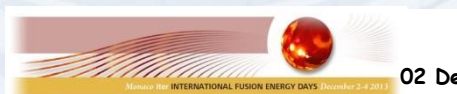


КРИОГЕНМАШ

Development of fusion technology in Russia

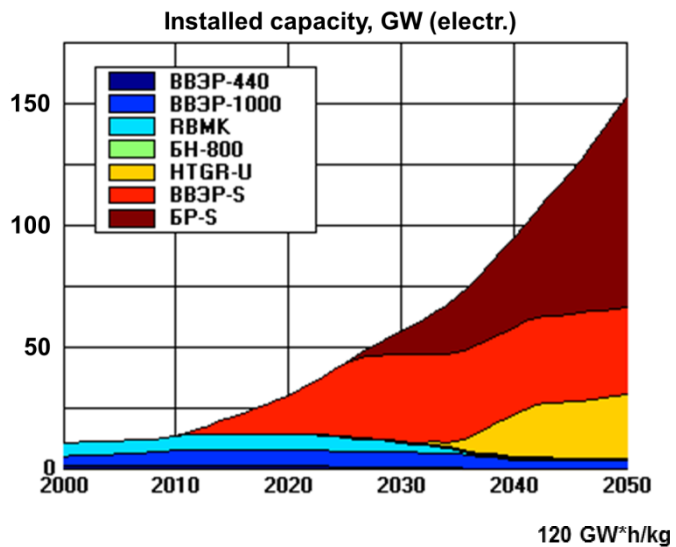
Vyacheslav Pershukov
State Atomic Energy Corporation «Rosatom»

THE GLOBAL ENERGY LANDSCAPE / Fusion and energy policies in the 7 ITER Members and France: presentations and round table discussion



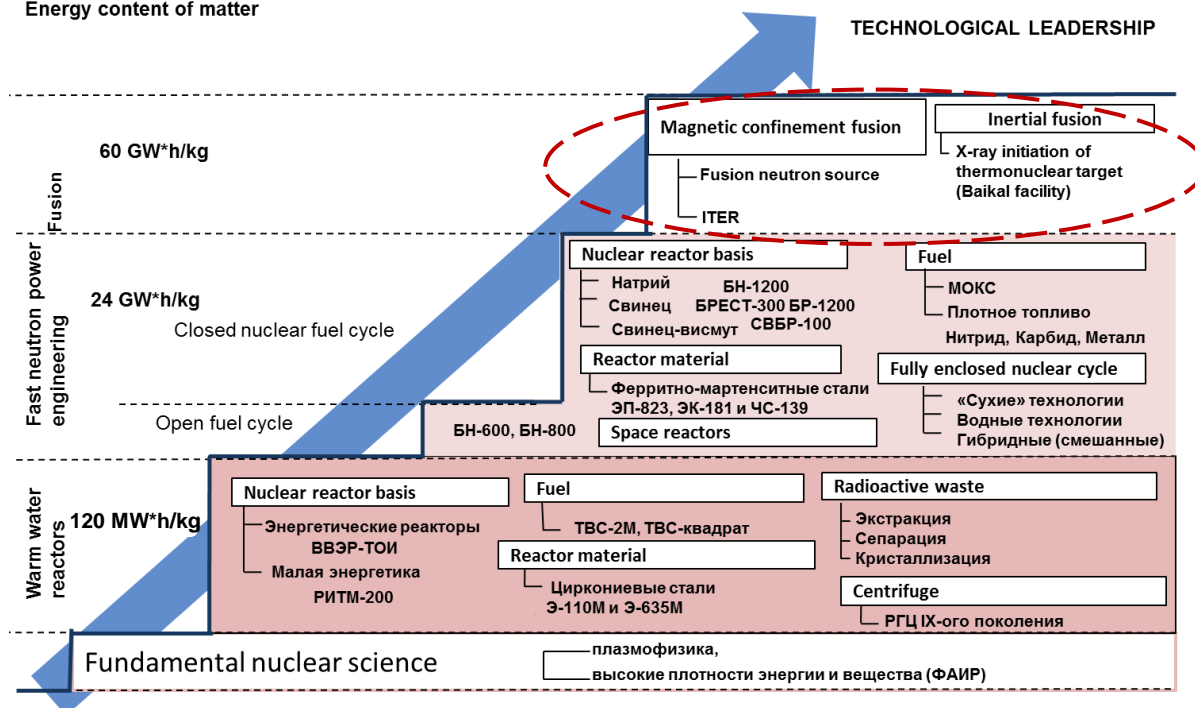
02 Dec. MIFED-2013, Monaco

RF nuclear reactor power basis



Nuclear power engineering Chart of innovative projects

Energy content of matter



Percentage of nuclear power engineering in RF, as well as in the world, ~ 17%

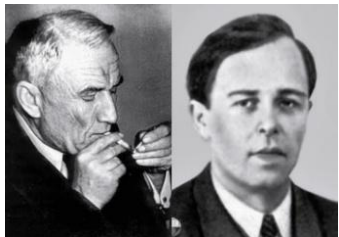
Unalternativity of nuclear power engineering - the basis of the energy policy of Russia for a long period.

Russia. Main historical milestones

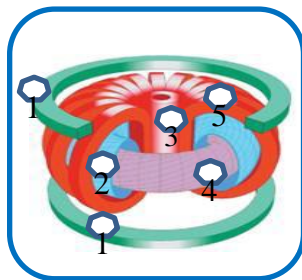
1951 - 1960

1971 - 1990

TOKAMAK (TOroidal CAmera MAgnetic Coil)



I.E. Tamm A.D. Sakharov



In 1972 the tokamak concept with elongated cross-section and poloidal divertor was proposed by L.A. Artsimovich and V.D. Shafranov.

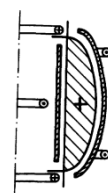


Рис. 2
Finger-ring tokamak T-9

T-9 Elongated cross-section
↓
T-12 Poloidal divertor
TVD

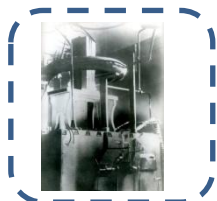


L.A. Artsimovich V.D. Shafranov

Prototype Termonuclear Reactor – OTR (1988)

**Fusion in Russia.
History**

1961 – 1995



Tokamak TMP - 1953 г.

T-3a

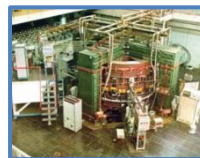


T-7

NbTi



T-10



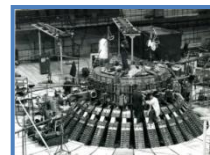
T-15 (Nb₃Sn)



KTM

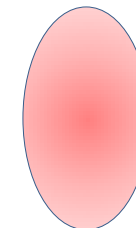


T-14



INTOR (1980)

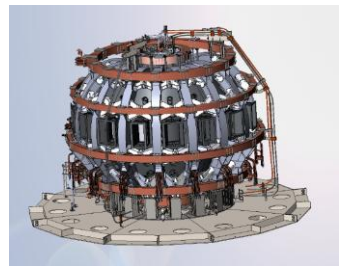
ITER



Tokamak mainstream



T-15 Upgrade with poloidal divertor and warm magnetic coil



Globus-M (poloidal divertor, low aspect ratio)



Multi mirror magnetic trap, GDL



Z-pinches – Angara-5



Inertial laser fusion – UVL-2M



Fusion in Russia today

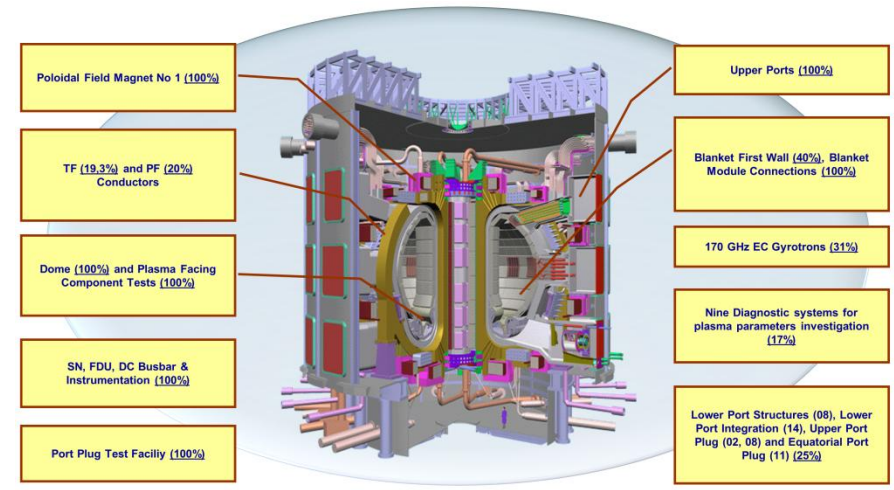
ITER – mainstream of international scientific cooperation

Proposition of Eugeny Velikhov to Mikhail Gorbachev at first, and then to Ronald Reagan of the creation the international fusion reactor project.



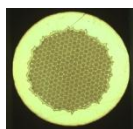
Geneva, 1985

Russian participation in ITER

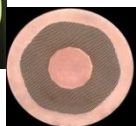


Superconductors

Nb₃Sn strend



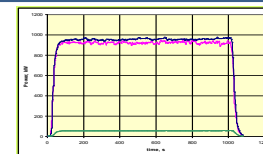
NbTi strend



120 tons of NbTi and ~97 tons of Nb₃Sn strends will be made in 2014.

Made Unit length: 1×760m + 1×100m + 5×415m + 12×760m

Gyrotrons, Injectors



Parameters of gyrotron prototype fully satisfied the ITER requirements

Procurement of nine gyrotron: 170 GHz/1MW/1000s



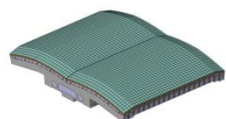
1 MeV, 5 MW, 1000 s neutral beam injector



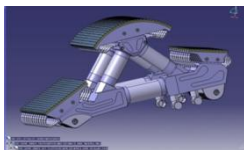
15-65 keV, 0.1-2.5 MW, 0.01-100s diagnostic NBI

ITER technology & infrastructure

First Wall, Divertors, HHFTest



Delivery of 179 first wall panels (EHF type), start manufacturing of RF beryllium for FW



Delivery of 60 Domes of divertor



Performing of heat flux acceptance tests of divertor components at 800 keV e-beam IDTF testing facility

Switching network, Magnet PF-1



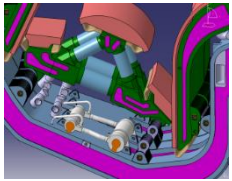
Winding area of magnet PF-1

Highly reliable switches for superconducting coil protection and more than 4 km of water cooled bus bars

Russia. Contribution to plasma diagnostics development

Neutrons

Divertor Neutron Flux Monitor

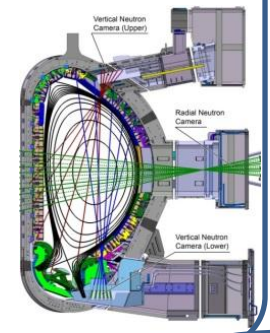


U-235 and U-238 fission chamber detectors

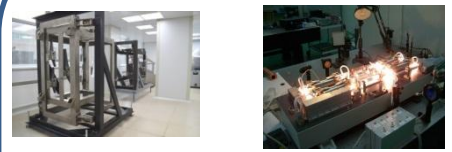
Diamond fast atoms and neutron spectrometer



Vertical Neutron Camera for fusion source tomography



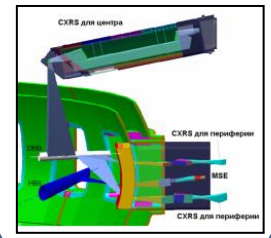
Divertor Thomson scattering



Full-scale prototype of in-vessel optics
 Spectral Analytical Equipment
 Filter polychromator 5-200 eV
 Grating polychromator 0.3-200 eV
 • Laser system:
 Nd:YAG 1.0645 μm (2 J, 3 ns, 50Hz)
 Nd:YLF laser 1.047 μm (2 J, 10 ns, 5Hz)
 Nd:YAG laser 0.946 μm (0.1 J, 10 ns, 100 Hz)

Optics

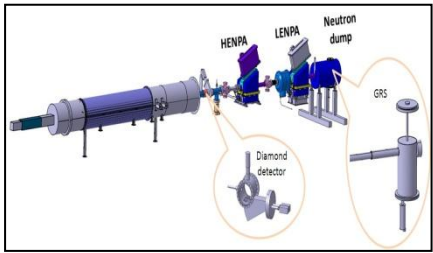
CXRS



H-Alpha Spectroscopy

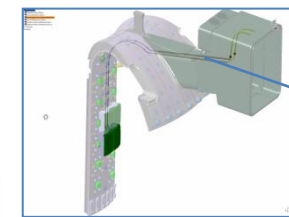
ITER diagnostic

Neutral Particle Analyzer



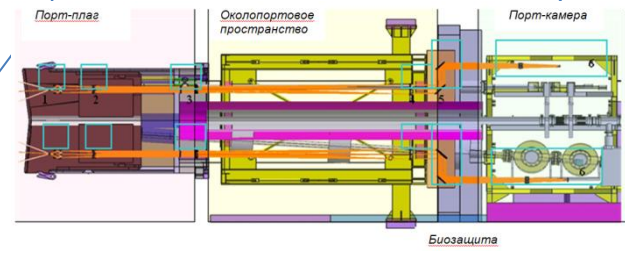
Two neutral particle analyzers: HENPA (0.2 – 2 Mev) and LENPA (10 – 200 keV)

HFS Reflectometry



Extremely wide band of transmitted microwaves from 12 to 140 GHz with several oversized bends and vacuum windows

Port-plugs



Upper port 02, 08, 14
 Lower port 08
 Equatorial port 11

ITER is a platform for international scientific activity and professional level of specialist grow

Training of personnel for fusion
in Russia universities

MSU

SPbSPU

MIPT

LobachevskySU

Bauman MSTU

NovosibirskySU

SPbSU

MPEI

MEPHI

↑
Top level

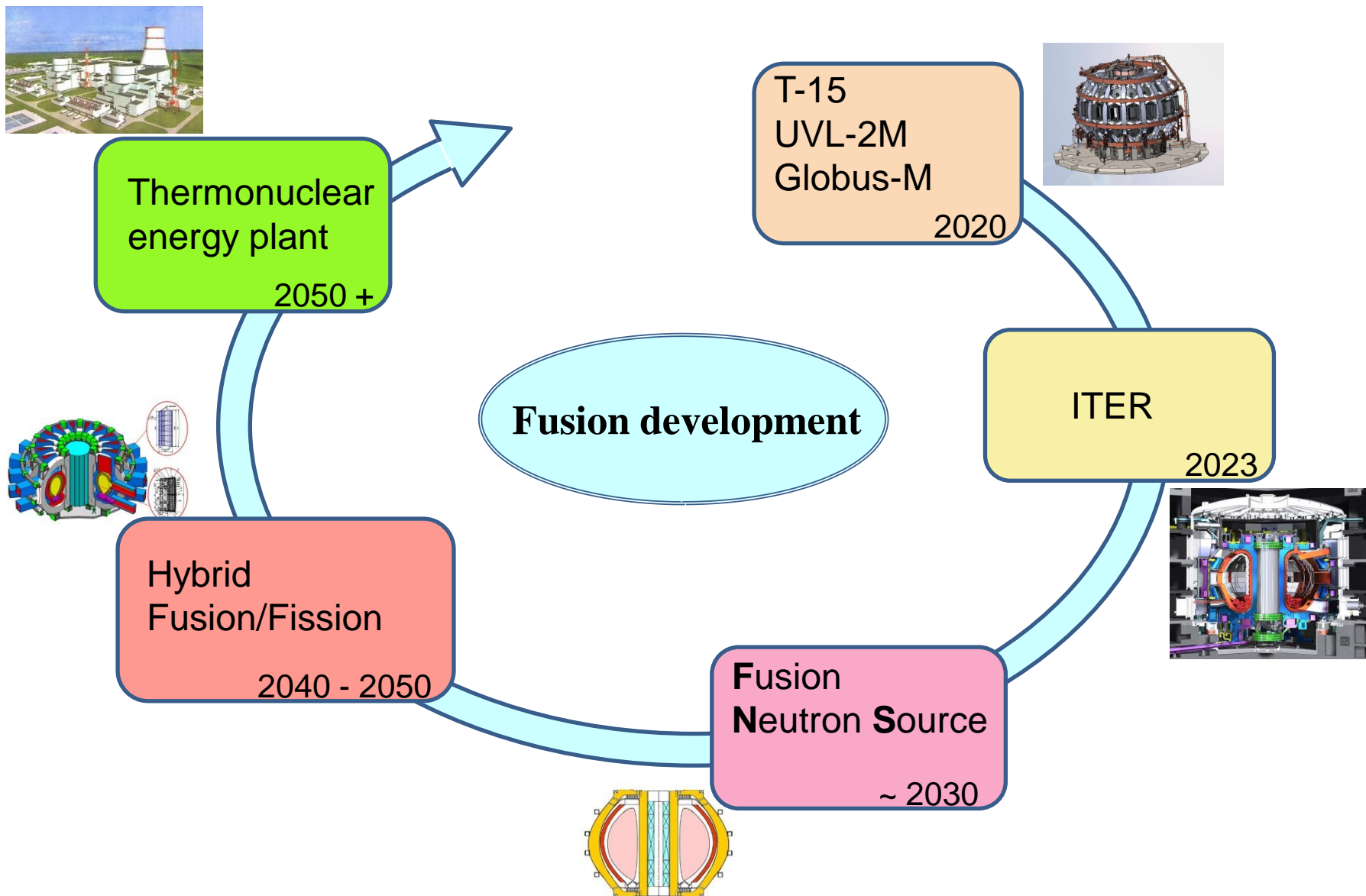
ITER internship

2012. Seven Russian researchers to
explore the ITER world



2014. Ten Russian researchers will
visit to Cadarache for 3 month

*The objective is to provide the right number of specialists for future work on ITER.
I.e. with the total participation of about 1,000 scientists in the ITER research
programme, RF plans to train about 100 researchers to work on the ITER site.*



Russia confirms the importance of the ITER project for the development peaceful use of nuclear energy

Due to the international ITER project, Russia is creating the industrial infrastructure and technologies for fusion energy and new high-tech industries

Russia continues the support of scientific centers and industry, as well as the specialists training, for the national fusion programm

Thank you for attention