Development of fusion technology in Russia

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

TOKAMAK (TORoidal CAmera MAGnetic Coil)

I.E.Tamm  A.D.Sakharov

1961 – 1995

Tokamak TMP - 1953 г.

T-9

Elongated cross-section

TVD  Poloidal divertor

L.A.Artsimovich  V.D.Shafranov

Fusion in Russia. History

T-3a

NbTi

T-7

T-10

T-14

Hybrid Fusion/Fision Reactor (1978)

T-15 (Nb₃Sn)

KTM

1971 - 1990

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

INTOR (1980)

ITER

Prototype Termonuclear Reactor – OTR (1988)
**Russia. Main milestones**

**T-15 Upgrade** with poloidal divertor and warm magnetic coil

**Globus-M**
( poloidal divertor, low aspect ratio)

**Multi mirror magnetic trap, GDL**

**Z-pinchs – Angara-5**

**Inertial laser fusion – UVL-2M**

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** 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

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**Fusion in Russia today**

**Russian participation in ITER**
Superconductors

120 tons of NbTi and ~97 tons of Nb$_3$Sn strends will be made in 2014.
Made Unit length: $1 \times 760m + 1 \times 100m + 5 \times 415m + 12 \times 760m$

Gyrotrons, Injectors

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

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

ITER technology & infrastructure

Switching network, Magnet PF-1

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

Winding area of magnet PF-1

Parameters of gyrotron prototype fully satisfied the ITER requirements

1 MeV, 5 MW, 1000 s neutral beam injector

15-65 keV, 0.1-2.5 MW, 0.01-100s diagnostic NBI
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
- Laser 2J / 100Hz

**Spectral Analytical Equipment**
- Filter polychromator 5-200 eV
- Grating polychromator 0.3-200 eV

**Laser system:**
- Nd:YAG 1.0645μm (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)

**Neutral Particle Analyzer**
- Two neutral particle analyzers: HENPA (0.2 – 2 Mev) and LENPA (10 – 200 keV)

**ITER diagnostic**

**Optics**
- CXRS
- H-Alpha Spectroscopy

**Neutrals**

**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
- Lover 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
- MIPT
- Bauman MSTU
- SPbSU
- MEPHI
- SPbSPU
- LobachevskySU
- NovosibirskySU
- MPEI

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.
Fusion in RF.

- **Thermonuclear energy plant**: 2050 +
- **Hybrid Fusion/Fission**: 2040 - 2050
- **Fusion Neutron Source**: ~ 2030
- **T-15 UVL-2M Globus-M**: 2020
- **ITER**: 2023

**Fusion development**
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