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# Physics and Physicists in Russia

Vladimir Shiltsev, Fermilab

APS April Meeting - 2016

April 19, 2016

# Content:

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- The Beginning : 1724 -1917
- Great Soviet Science
- *After Perestroika* :
  - Disaster
  - Diaspora
- Current Situation :
  - Facts and numbers
  - Institutes, Journals, Int'l Cooperation
  - Reforms
- Outlook

# History of Science in Russia

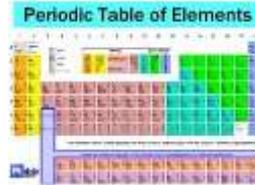
$e^{i\pi} + 1 = 0$



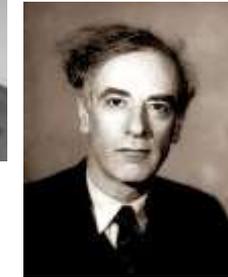
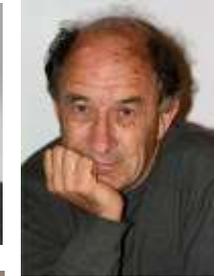
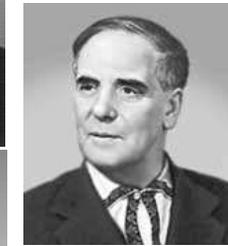
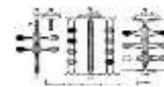
$\frac{\rho v^2}{2} + p = \text{const}$



Periodic Table of Elements



Дмитрий Иванович  
МЕНДЕЛЕЕВ



1700

1750

1800

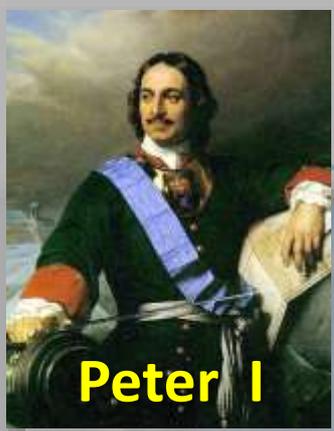
1850

1900

1950

2000

# Saint-Petersburg Academy



Peter I

fully state-sponsored (poll-taxes from 4 cities)

1724



First cohort from abroad - Bernoulli, Euler, Delisle, ...  
Lomonosov was the 1<sup>st</sup> Russian academician (1745)

- **Imperial Academy of Sciences** 1747
- **Russian Academy of Sciences** 1917
- **USSR Academy of Sciences** 1925
- **Russian Academy of Sciences** 1991

# Mikhail Lomonosov (1711-1765)

## “Father of Russian Science”

- Molecular theory of heat & colors
- Proved the law of conservation of matter in chemical reactions
- Discovered Venus’s atmosphere
- Built first helicopter
- Concept of atmospheric electricity
- Geodynamics and metal origins
- Proved organic origin of soil & oil
- Founded first University (Moscow)
- Formed Russian literary language
- Outstanding historian
- The best poet and courtier



# Dmitry Mendeleev (1834-1907)

Periodic Table of the Elements

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une	110 Unn								

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

■ hydrogen  
■ alkali metals  
■ alkali earth metals  
■ transition metals  
■ poor metals  
 nonmetals  
■ noble gases  
■ rare earth metals



- **Periodic law (1869)**

- Finalized equation for ideal gas (1874)

$$PV = nRT$$

beyond Clapeyron's

$$pV = BT \quad (1834)$$



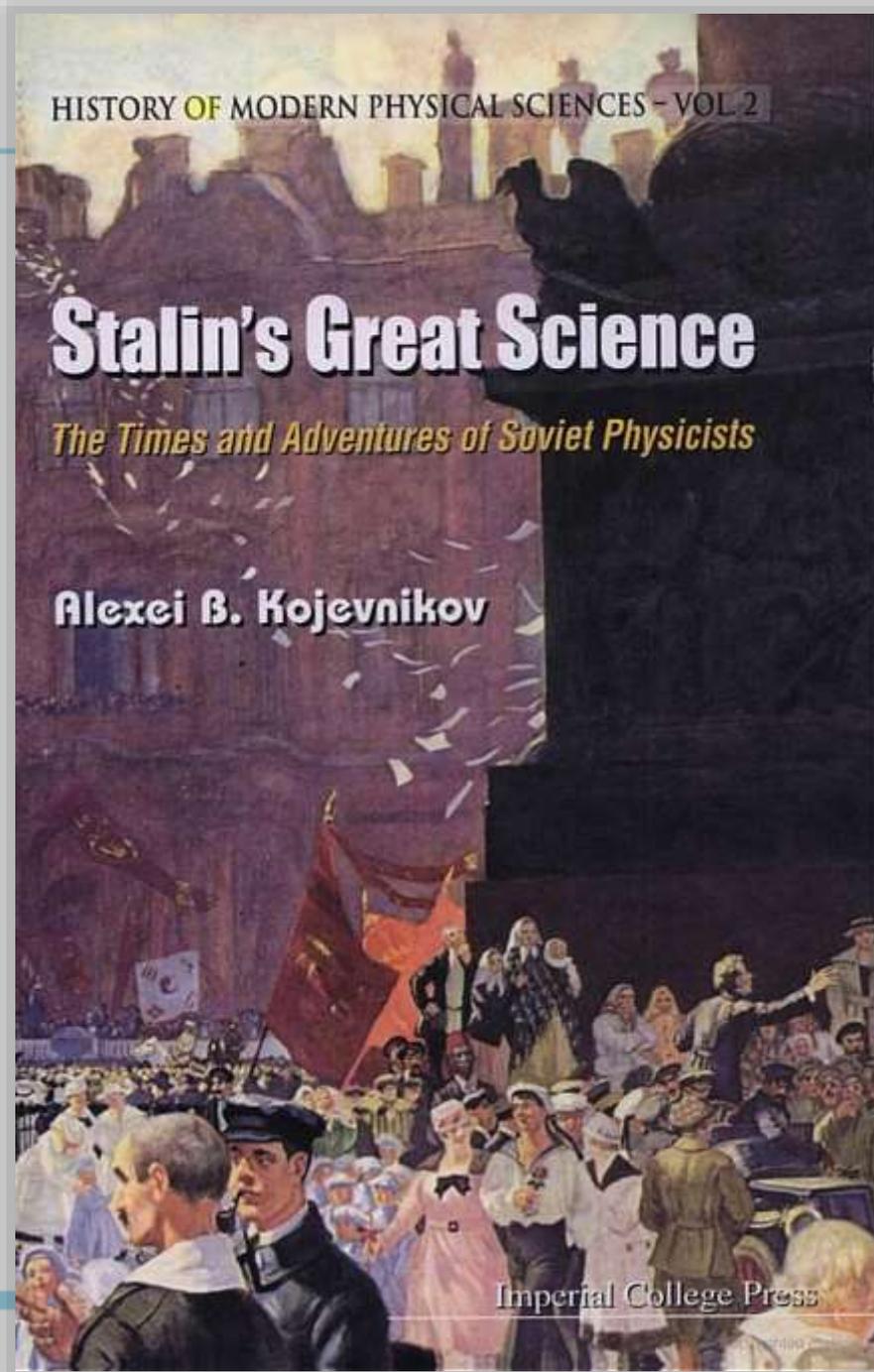
# 20<sup>th</sup> Century: USSR

## Physics Dominates!



**Nobel Prizes for  
Russia/USSR :  
19 total**

- 7 in Physics**
- 6 in Literature
- 2 in Physiology
- 2 Peace Prizes
- 1 in Economics
- 1 in Chemistry**



# Society's Call for Physics (100% State Support)

Berlin, 1945



MESM, 1948



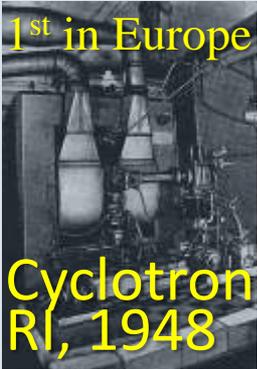
1<sup>st</sup> computer in Europe

BESM-1...6,  
Elbrus supercomputer, ...

A-bomb  
1949



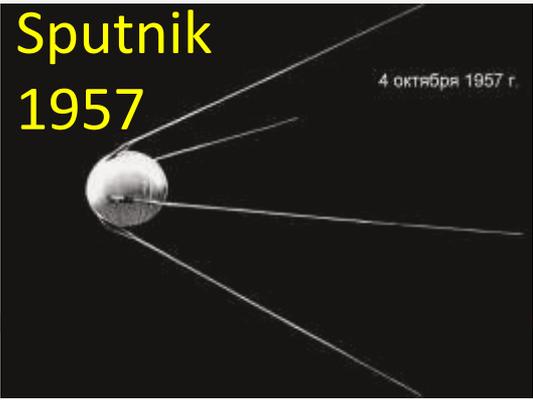
1<sup>st</sup> in Europe



Cyclotron  
RI, 1948

1<sup>st</sup> Nuclear Plant, Tokamak,  
Dubna, Serpukhov, Novosibirsk...

Sputnik  
1957



BTA-6m  
1975



world's largest  
till 1993

Exploration of Moon, Venus,  
1<sup>st</sup> space-radiotelescope, ...



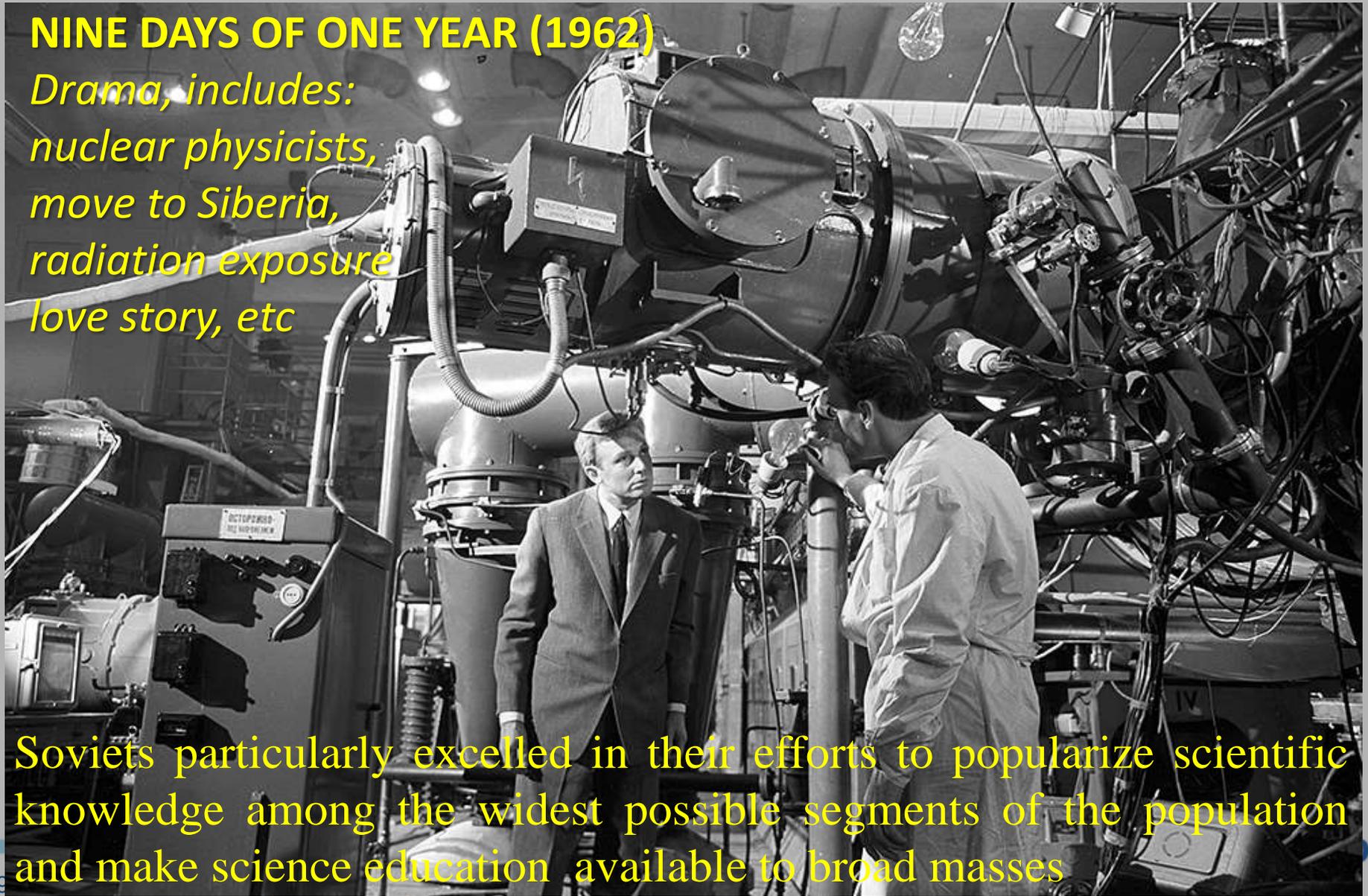
milab

# Physicists *EXTREMELY* Popular! (e.g. movies)

## **NINE DAYS OF ONE YEAR (1962)**

*Drama, includes:  
nuclear physicists,  
move to Siberia,  
radiation exposure  
love story, etc*

**Soviets particularly excelled in their efforts to popularize scientific knowledge among the widest possible segments of the population and make science education available to broad masses**

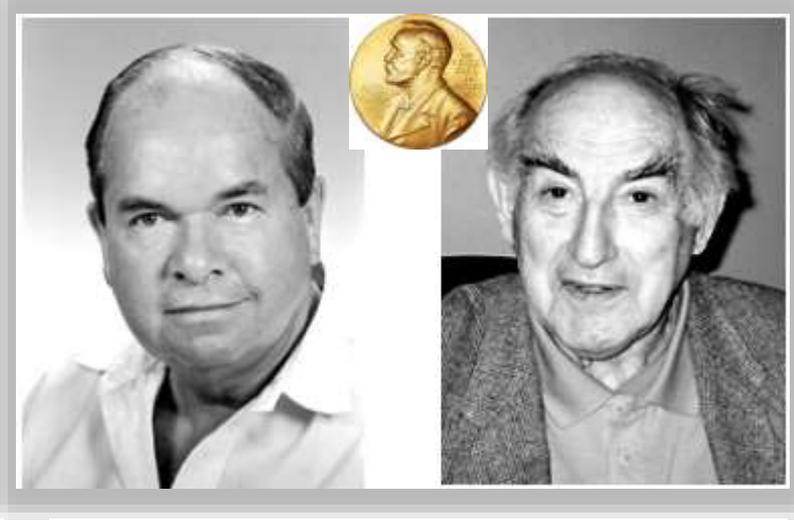




1958 Cherenkov,  
Tamm and Frank  
*Cherenkov radiation*

1962 Lev Landau  
*Theory of superfluid He*

1964 Basov, Prokhorov  
*Laser*



1978 Petr Kapitsa  
*Superfluid He*

2000 Zhores Alferov  
*Semiconductor laser*

2003 Abrikosov, Ginzburg  
*Theory of superconductors*

# PERESTROIKA



(THE RESTRUCTURING)

1987-91



1989

A. Sakharov



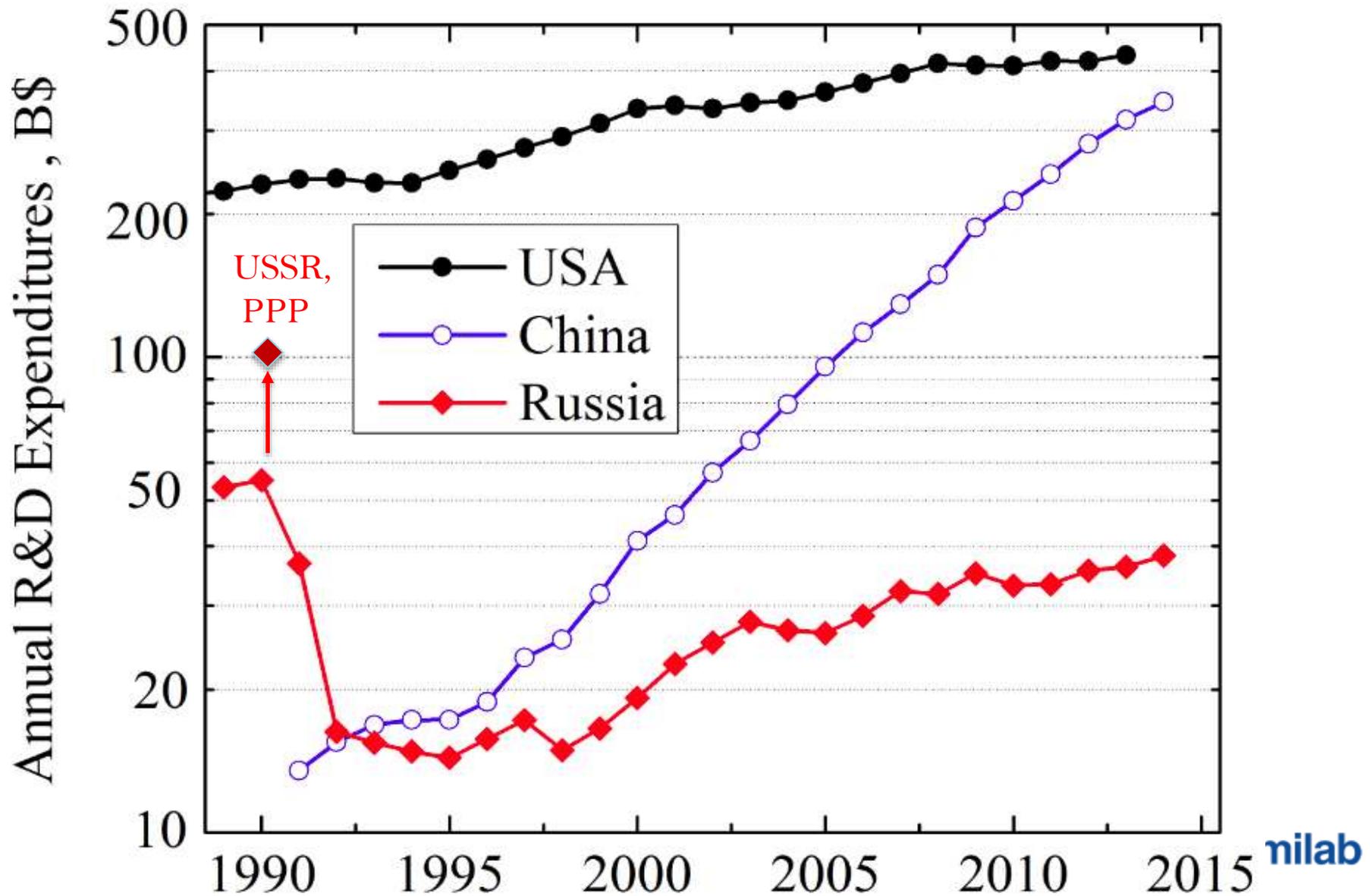
1993



1994

"Pauper Professors  
- Russia's Shame!"

# OECD Research & Development Data



# Results of Science's Extremity in 90's

1. Left Science (~60%)
2. Suffer (~1/3) 
3. Emigration (<5%):
  - > 15,000 (?) scientists
  - > 6,000 in the US
  - ~40% Physicists



George Soros  
*Open Society  
Foundation*  
(1995-2013)

>1B\$ total  
support for  
~65,000  
teachers,  
professors &  
students

# Russian Scientific Diaspora: **RASA-USA**

## 7-th Russian-American Sci Association Conference



GWU, Washington, DC, Nov 7-9, 2015



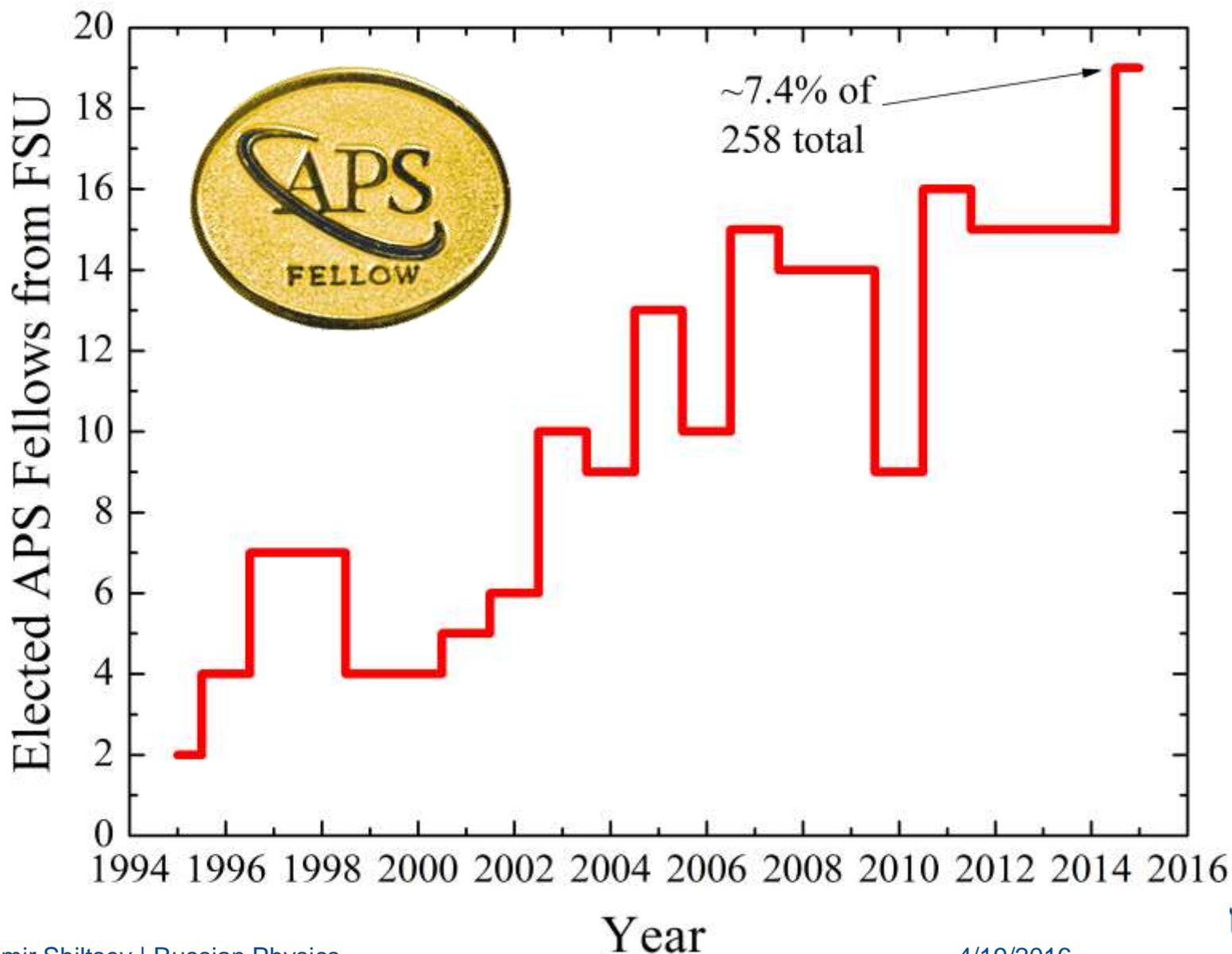
- Over 160 participants from US and Russia; 26 presentations by world leading scientists; attended by Minister of Education and Science D.Livanov and Ambassador of

Russia in the US S.Kislyak

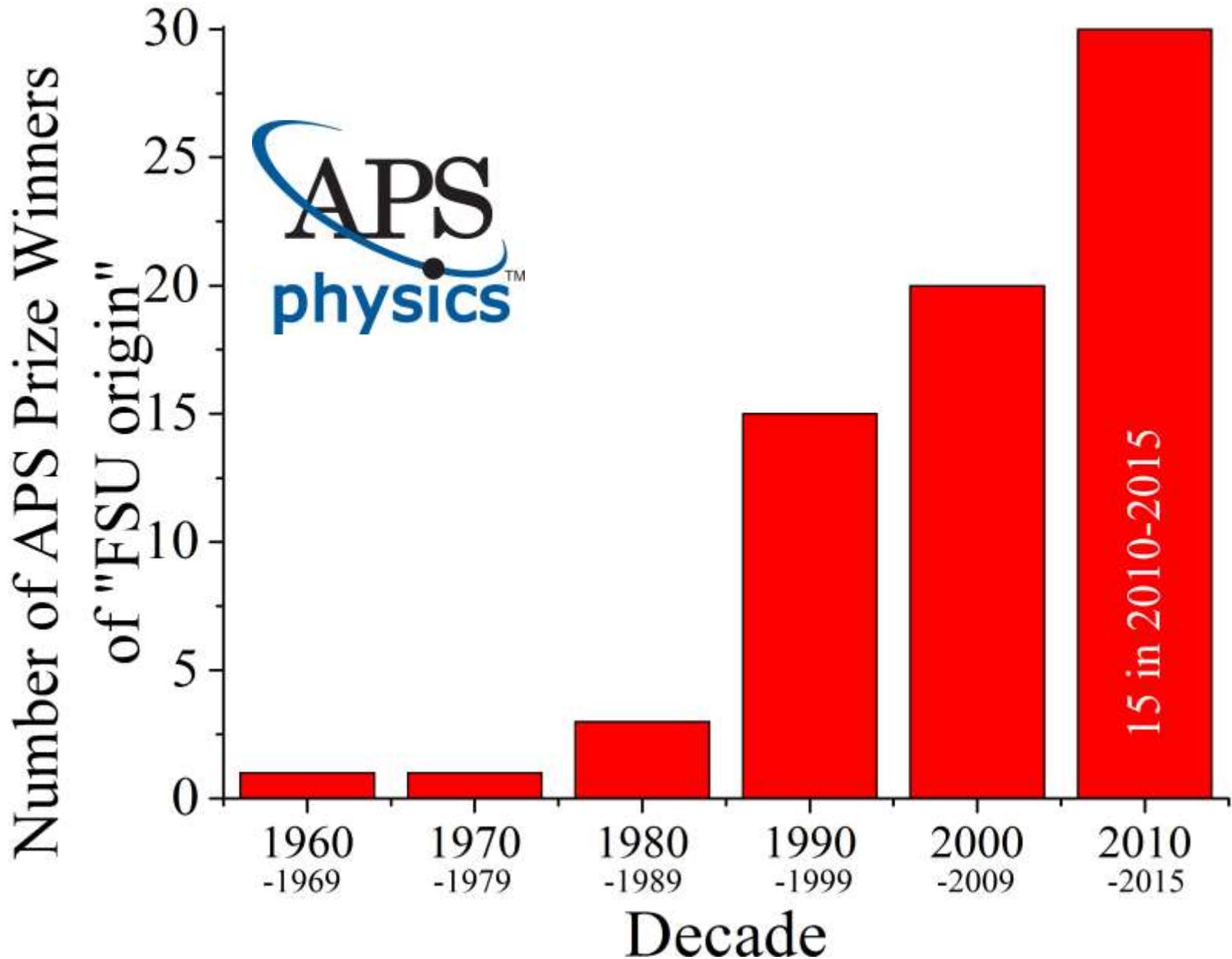
- Joint **APS-RASA George GAMOW session & Awards**
- attended by *Igor Gamow*, GWU Professors, historians, students, APS/CISA/FIP, policy makers



# APS and Russian Physics Diaspora



# APS and Russian Diaspora (2)



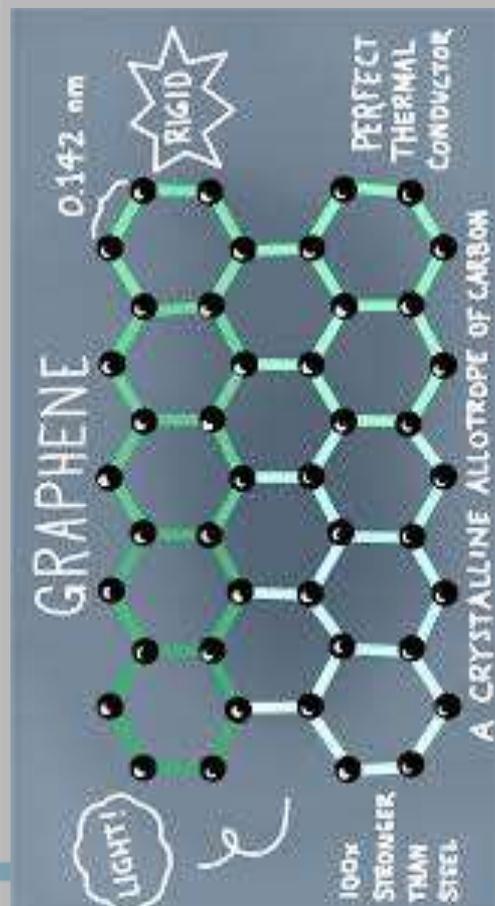


# 2010 Andrei Geim and Konstantin Novoselov

## Graphene



*Moscow Physics and Technology Institute →  
University of Manchester*



# Russian Physics Now:

- 78 Research Institutes doing fundamental (49) and applied physics research (29) - some 35,000 staff

## St.Petersburg (8)

Ioffe Phys. Tech. Inst.  
SPb Institute Nucl.Phys.  
Pulkovo Observatory

## Nizhny Novgorod (2)

Inst. Applied Physics  
Physics of Microstructures

## Tomsk (5)

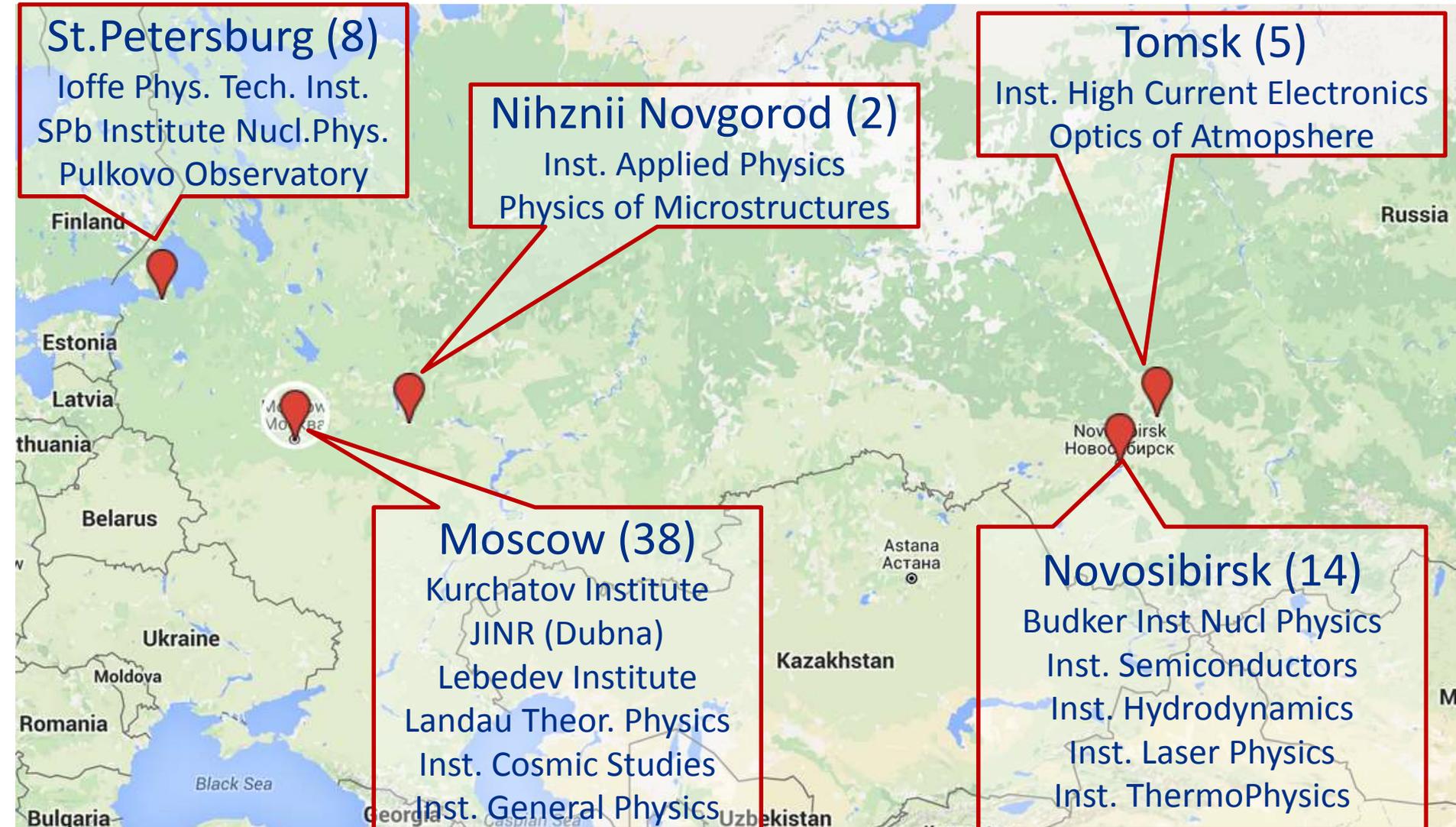
Inst. High Current Electronics  
Optics of Atmosphere

## Moscow (38)

Kurchatov Institute  
JINR (Dubna)  
Lebedev Institute  
Landau Theor. Physics  
Inst. Cosmic Studies  
Inst. General Physics

## Novosibirsk (14)

Budker Inst Nucl Physics  
Inst. Semiconductors  
Inst. Hydrodynamics  
Inst. Laser Physics  
Inst. ThermoPhysics



# “Radio-Astron” (SPEKTR-R) 2011-now

## 10 m, $\lambda=1.2-92\text{cm}$ Lebedev Physics Institute

### 20 Earth dia base $\rightarrow$ 27 $\mu$ arc sec (record)

#### Russia's RadioAstron space observatory

The RadioAstron observatory with an unprecedented high resolution capability will make it possible to observe remote objects in space

**Parabolic antenna**

- Diameter: 10 meters
- Comprises 27 carbon-plastic "petals"

**Broad-beam antennas**

**Focal module**

#### This is the first Russian orbital radio telescope

It will study:

- Galaxy nuclei
- Black holes
- Neutron stars
- Interstellar plasma clouds
- The Earth's gravitational field
- And many other objects and phenomena in the Universe

Ordered by: **Federal Space Agency**

Chief contractor: **Lavochkin Research and Production Association**

Scientific equipment developed by: **Astro Space Center of the Russian Academy of Sciences' Lebedev Physics Institute**

The RadioAstron observatory was launched on July 18, 2011.

Active service life: At least five years

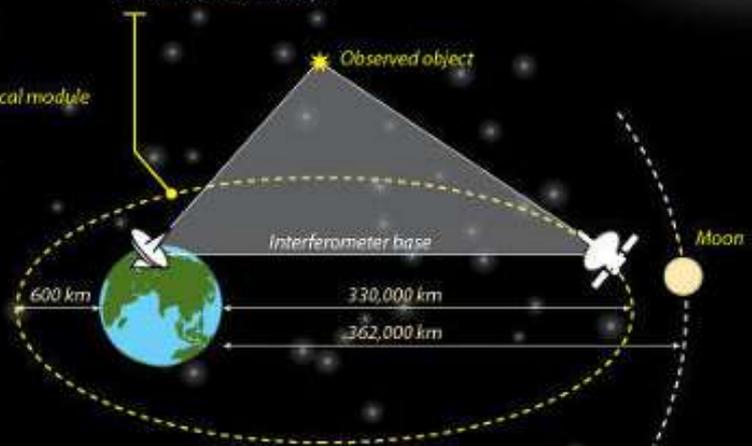
**Navigator service module**

**High-capacity radio facility**

**Solar batteries**

**Highly elliptical orbit**

- Apogee: 330,000 kilometers
- Perigee: 600 km
- Orbital period: 8.2 days



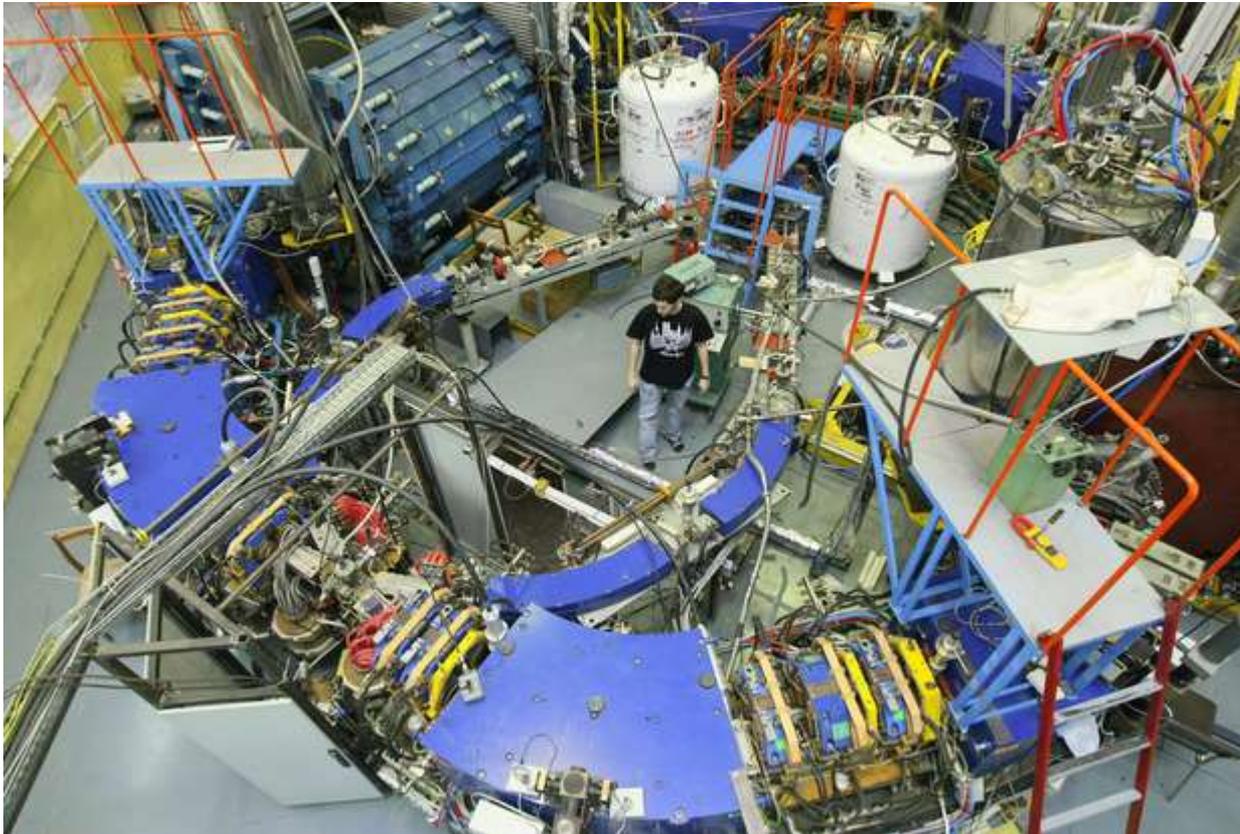
The RadioAstron observatory will operate with an international network of ground-based radio telescopes. This huge ground- and space-based telescope system, also called an interferometer, will provide the finest angular resolution.

This will make it possible to obtain images of remote objects with a resolution exceeding that of NASA's Hubble orbital telescope a thousand times over

# Colliding Beams 1-6 GeV cme

## Budker Institute of Nuclear Physics (Novosibirsk)

- “Round Beams” technique for **record** high beam-beam tune shift  $\xi=0.25$
- “resonant depolarization” **record** energy precision  $\delta E/E \sim 1e-7$



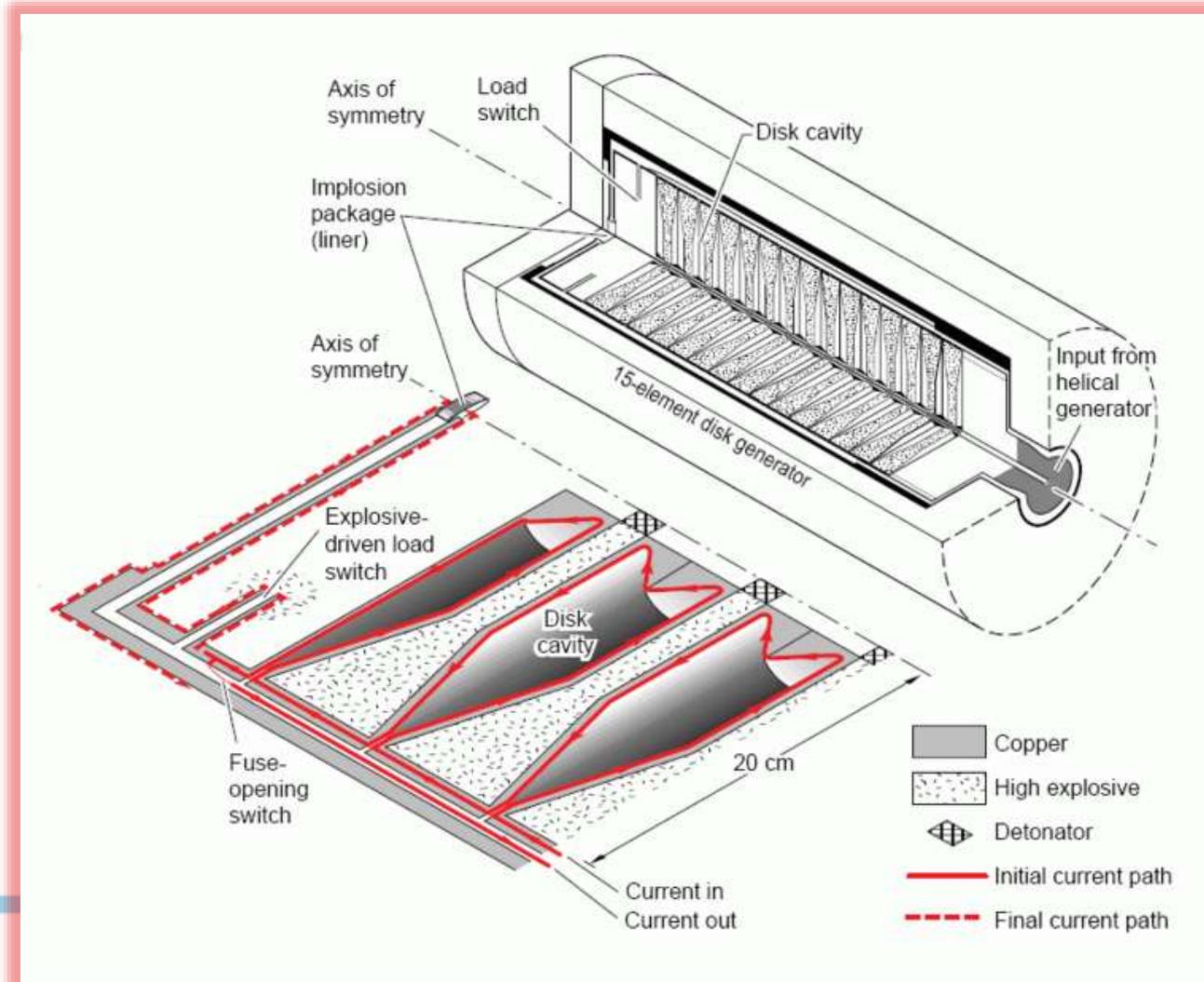
## Russia: 2 out of 7 Colliders

- VEPP-2000
- VEPP-4M
- DAFNE (Italy)
- BEPC (China)
- Super-B (Japan)
- RHIC (USA)
- LHC (Europe)
- (NICA – constr'n)



# Record High Magnetic Field 2,400 T VNIITEF (Sarov)

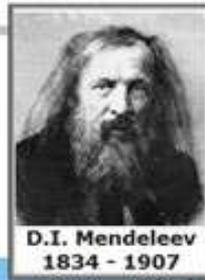
## Explosively pumped flux compression generator



# New Elements 113-118

## Joint Institute for Nuclear Research (Dubna)

группы элементов																													
периоды	I	II	III	IV	V	VI	VII	VIII										VIII	IX	X	XI								
1	H																He												
2	Li																Ne												
3	Na																Ar												
4	K																Fe												
5	Rb																Ru												
6	Cs																Os												
7	Fr																Db												
8	Lanthanides																												
9	Actinides																												



**IUPAP:**

December 30, 2015

#113 RIKEN

#115 JINR, LLNR, ORNL

#117 JINR, LLNR, ORNL

#118 JINR, LLNL

#114 Flerovium  
(JINR, 2012)

#116 Livermorium  
(JINR, LLNL, 2012)

113

Discovered  
at JINR in 2003

114

Discovered  
at JINR in 1999

115

Discovered  
at JINR in 2003

116

Discovered  
at JINR in 2000

117

Discovered  
at JINR in 2009

118

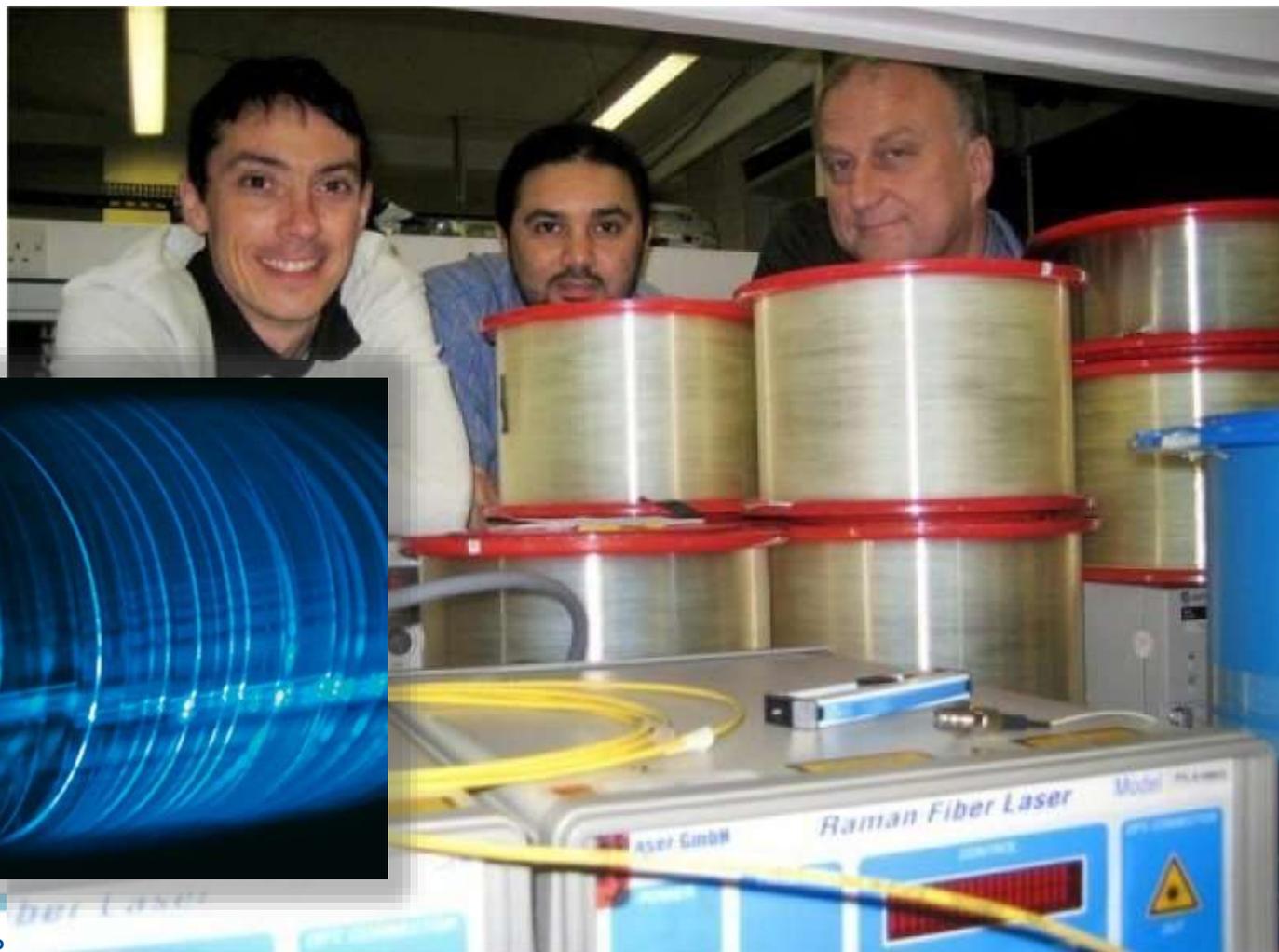
Discovered  
at JINR in 2001



# World's Longest Laser 270 km

## Novosibirsk IAE & Aston (UK)

Raman  
fiber  
laser



# Russia Supports Int'l Megascience



FAIR  
(Darmstadt)  
17%



European  
XFEL (Hamburg)  
25%



Grenoble, 11%

# Large Hadron Collider



## Russia-CERN:

**TOTAL LHC  
USERS**

**~12500**

**USA** (non-member)

**1730**

**ITALY**

**1500**

**GERMANY**

**1200**

**RUSSIA** (non-member)

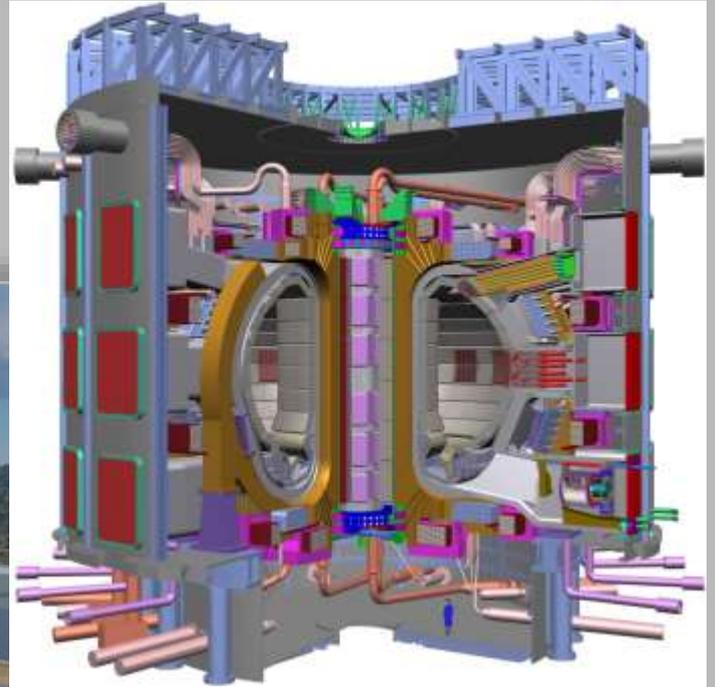
**920**

**UK**

**900**

- In-kind contribution  
~150 M\$ to LHC constr.  
(beamlines)
- Support of many groups  
in 4 major experiments
- Considering joining CERN  
as *Associate Member*

# Russia-ITER: 9% (2B\$?) (EU & RU, US, CH, RK, IN, JP)



29 m dia x 29 m  
2020... -2022?

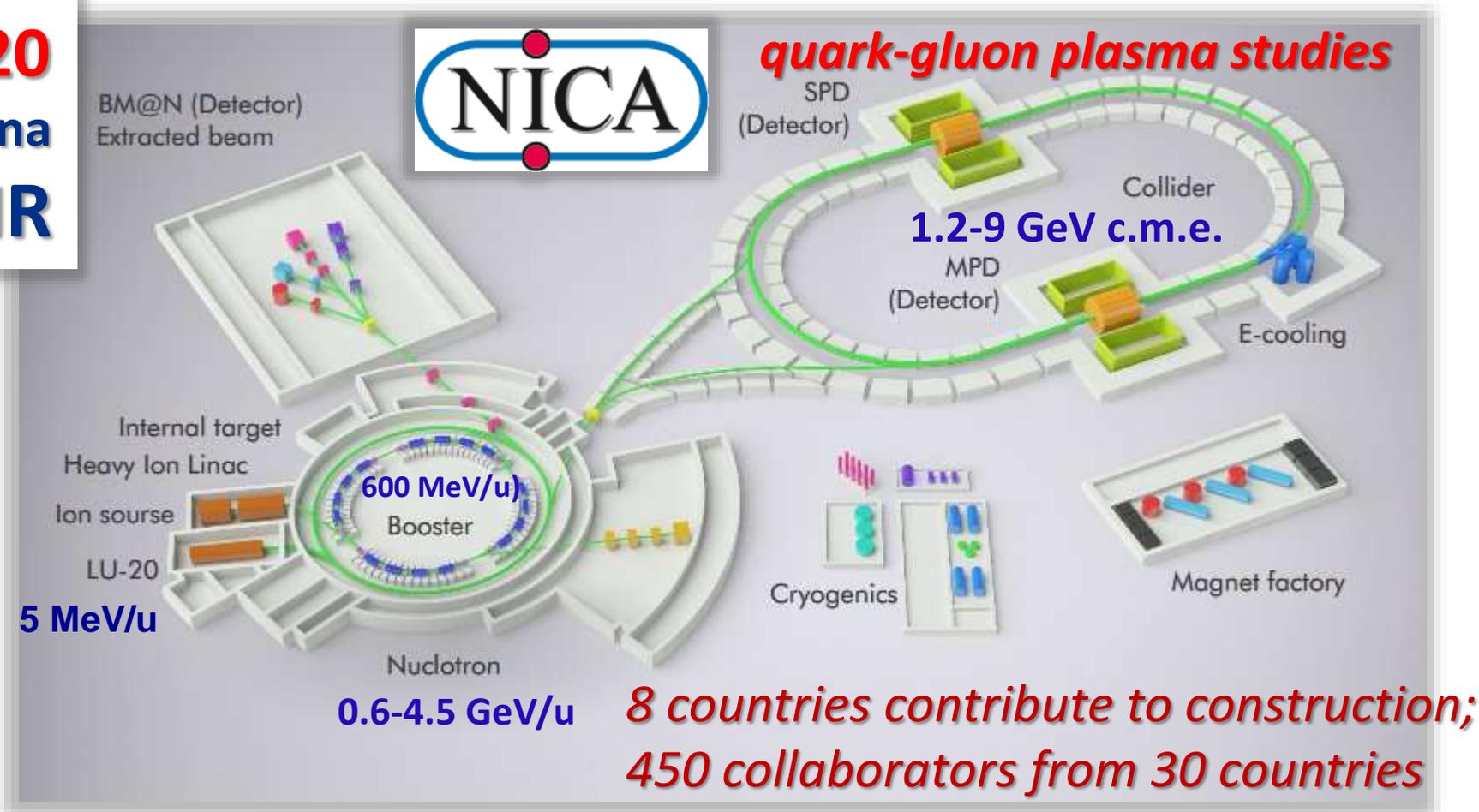
*the idea of  
tokamak (1951 -  
Lavrentiev, Sak-  
harov, Tamm)*



**Construction at Cadarache, France, site of the ITER nuclear-fusion experiment**

# Russia's Megascience: *Ion-Ion Collider NICA*

**2020**  
**Dubna**  
**JINR**



**Other Megascience Projects:** *Research Reactor PIK* (St.Petersburg – under constr.), *4-Gen FEL ISSI-4* , *Tokamak IGNITOR* (both – Kurchatov Inst.), *200 PW EXELS Laser* (N.Novgorod), *e+e- Collider Tau-C Factory* (Novosibirsk)

# Physics research in Russian Universities started to grow only recently, # publications on the rise

~40% of total, ~half – in collaboration with RAS

## 2015-2016 *Times Higher Education* World University Rankings- Physical Sciences

36	<b>National Research Nuclear University MePhI</b> Russian Federation
59	<b>Lomonosov Moscow State University</b> Russian Federation
=86	<b>Novosibirsk State University</b> Russian Federation

3 others in Top-300 (QS): Moscow Institute of Physics&Technology ;  
Saint-Petersburg State University, Saint-Petersburg Polytechnic

Russia's Physics Papers **16,000/yr** (4.1%, 7<sup>th</sup>)

Russia's Total Sci Papers **50,000/yr** (1.7%, 15<sup>th</sup>)

## IFs' of Top-10 Russian Physics Journals

2.964	LASER PHYSICS LETTERS	(out of ~40)
1.892	PHYSICS-USPEKHI	
1.409	RUSSIAN GEOLOGY AND GEOPHYSICS	
1.364	JETP LETTERS	
1.297	ASTRON LETT+	
1.287	REVIEWS ON ADV MATERIALS SCI	
1.156	HIGH TEMPERATURE	
1.049	RUSSIAN J. OF MATHEMATICAL PHYS	
1.025	LASER PHYSICS	
0.931	J EXP THEOR PHYS+	

# GDP and Science Indicators

	GDP (PPP, WB'14) B\$	Incl. Goods B\$	Total Research B\$	Basic Research (State) B\$
USA 	17,400 #2	3,600 #2	470 #1	<b>75</b> #1
China 	18,000 #1	9,000 #1	370 #2	<b>17</b> #4
Russia 	3,700 #5	1,500 #4	42 #9	<b>4.5</b> #9

# 2013 Reform of Russian Academy

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- Government: “..RAS is ineffective and outdated, too many functions”:
  - expertise
  - finances, organization, legal, information, etc
  - (too independent, politically unsupportive, estate-rich)
- Reform:
  - RAS’s only function is now only **expertise**; RAS combined with Medical and Agriculture Academies
  - Special Agency to control finances, organiz’n, etc
  - Focus on science in Universities, rather than Institutes
  - More of grant support, less “base” support (1:3 now)

# 2013

- *Federal Agency for Scientific Organizations (FASO)* to control finances for academy research org's, appoint directors of institutes, etc

## A Hard, Fast Fall for Russian Academy

SCIENCE VOL 342 6 DECEMBER 2013



Physicist, 67

29 May

Vladimir Fortov  
elected RAS  
president



27 June

RAS reform  
legislation  
unveiled

27 September

Reform legislation  
signed into law



Bureaucrat, 36

25 October

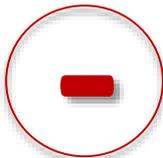
Mikhail Kotyukov  
appointed head of  
academy oversight  
agency

# Massive protests in Moscow, Novosibirsk, etc → cosmetic changes in the law, 1 year moratorium on RAS property deals



# Academy's Reform: Two Years Later

- Massive replacement of ~ 50% of Institute Directors over 65
- State law on “minimal secured” science funding support
- Resolved several legal issues on RAS property
- Some energization of research activities in Universities
- No serious hiccups in money flow
- No visible increase in scientific productivity
- No reduction of huge income gap btw executives-scientists
- Substantial increase of the paperwork and reporting
- Clogged collaborations between research institutes, int'l partners, local governments and Universities
- Scientists largely removed from decision making at all levels from Institute to State; internal democracy lost
- Moderate salary increase (now 0.5MRub=7k\$ /yr avg) at the expense of staff attrition; still far from Putin's goal of x2 region



# Life Under New Management: ITEP

## Institute for Theoretical and Experimental Physics (Moscow)

- Research on nuclear physics, accelerators, cosmic rays
- Created in 1945 under Academy of Sciences
- then under *RosAtom*, since 2011- part of "*Kurchatov Institute*" Center
- Poor sci management, reduced site access, move from HEP to nano-science, low salaries 200\$/mo while administration gets x20 more, etc

## Exodus of scientists

- BELLE group (De'15)



Prof. Mikhail Danilov  
(B-mesons, CERN) 2015



Prof. Alexander Gorsky  
(string theory, QCD) 2014

The screenshot shows the homepage of the 'saveITEP.org' website. At the top, the text 'ИТЕП ИТЭФ S.O.S.!' is displayed in large blue and red letters. Below this, contact information is provided: 'www.saveITEP.org', 'saveITEP@gmail.com', and 'saveITEP@yahoo.com'. A navigation menu includes links for 'СТАТЬЯ ШОК', 'ТРЕБОВАНИЯ', 'ОБРАЩЕНИЯ', 'ОБСУЖДЕНИЕ', 'НОВОСТИ', 'ДОСЬЕ', 'ИТЭФ без дураков', 'ПРОЕКТ', 'ИДЕЯ САЙТА', 'ДОРОЖНАЯ КАРТА', 'УСТАВ ИТЭФ', 'ИДЕИ БУДУЩЕГО', 'МИР ОБ ИТЭФ', and 'КОНТАКТЫ'. On the left, there are three boxes for petitions: 'ОБРАЩЕНИЕ К РУССКИМ ПОЛИТИКАМ' (650 signatures), 'APPEAL TO RUSSIAN POLITICIANS' (650 supporters), and 'ПИСЬМО УЧЕНЫХ ИТЭФ' (867 signatures). The central image shows a large white building with columns and the text 'SAVE and PROTECT ITEP' and 'Спаси ИТЭФ!'. On the right, there is a 'Dear Science-mag!' link and a 'Что такое ИТЭФ?' button.

# “*Russian Robin Hood of Science*”

Limited access to int’l periodic due to lack of funding



- <https://sci-hub.io>
- 48,000,000 papers for free
- “anything you want” directly from JSTOR, Springer, Sage, and Elsevier, etc
- PDF in a second
- using access keys donated by academics

\* sued by *Elsevier* → in response to the NY Court injunction - referred to article 27 of the *UN Declaration of Human Rights*: “...everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits”.



Alexandra Elbakyan



# Science as Victim of Strained US-Russia Relations

- U.S. government policy guidance issued in Spring'14 to agencies to clamp down on travel by government scientists to Russia. Based on that guidance, NASA and the Department of Energy (DOE) announced in April'14 that they would block most government travel to Russia



## Geopolitics disrupt scientific exchange with Russia

Tweet 23 Share 58 g+1 0



By Eli Kintisch | 1 August 2014 4:15 pm | 9 Comments

Tensions with Russia over the unrest in Ukraine are inflicting collateral damage on science. *ScienceInsider* has learned that several U.S. scientists have pulled out of upcoming conferences in Russia.

Some cancellations stem from policy guidance that the U.S. government issued to agencies this spring to clamp down on travel by

4/19/2016



Prof. Konstantin Severinov  
Rutgers (US), SkolTech(TU)

## US sanctions put research at risk

Scientific collaboration during the cold war was one of the few links between the United

University, New Jersey, USA; and Skolkovo Institute of Science and Technology, Russia.  
[severik@waksman.rutgers.edu](mailto:severik@waksman.rutgers.edu)

- “...Earlier this month, **the FBI warned universities in Boston, Massachusetts**, about venture-capital partnerships with Russia (see [go.nature.com/oyxpth](https://go.nature.com/oyxpth)). The US government is also severing scientific exchange by NASA and the Department of Energy with scientists in Russia. These moves are causing widespread consternation in the Russian research community....
- **...the new US policies are likely to be counterproductive.”**

# Push back: DPF to OSTP

*“...Inhibiting the interchanges among scientists is antithetical to the nature of science.”*

*“...We urge you to remove the ban on visits of Russian scientists to the US as well as to allow US laboratory scientists to travel to Russia”*

Sincerely,

The Executive Committee of the Division of Particles and Fields



Ian Shipsey, Chair, Purdue University

Nicholas Hadley, Chair-Elect, the University of Maryland  
JoAnne Hewett, Vice Chair, Stanford University  
Jonathan L. Rosner, Past Chair, the University of Chicago  
Howard Haber, Secretary/Treasurer, the University of California Santa Cruz  
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Nikos Varelas, the University of Illinois at Chicago  
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Particles and Fields

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shipsey@particle.purdue.edu

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rosner@hep.uchicago.edu

**JoAnne Hewett**  
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Dr. John P. Holdren  
Director, Office of Science and Technology Policy  
Executive Office of the President  
Eisenhower Executive Office Building  
1650 Pennsylvania Avenue  
Washington, DC 20504

Dear Dr. Holdren,

In early April 2014, the Department of Energy's National Laboratories were instructed by the Department of Energy to ban Russian scientists from visiting. At the same time the Department of Energy banned US laboratory scientists from travelling to Russia to participate in joint experiments, conferences, and meetings. The ban affects scientists on both sides, including young students and postdocs.

Inhibiting the interchanges among scientists is antithetical to the nature of science. We are cooperating closely with Russian scientists on many fundamental studies to the benefit of all. Never in the past have such strict bans been imposed, as travel provided an opportunity for cooperation and open scientific dialog even during the Cold War era. The US condemned the limits imposed on travel of the Soviet physicists at that time. We should continue to wisely differentiate between the government of Russia and its people.

Joint activities with Russian scientists benefit both countries. There are experiments at US particle accelerators where Russian scientists participate in designing and providing parts of the detectors by delivering them to the US. Data accumulated at US experiments are analyzed jointly; results are openly discussed, and the results are published and available to scientists from all over the world. As just one of many possible examples, at the Fermi National Accelerator Laboratory in Illinois, scientists from 26 countries are participating in the analysis of the Tevatron collider data. These scientists include groups from Russia and Ukraine, and, in many cases, Russian and Ukrainian scientists are working on the same activities productively and in close cooperation.

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# 2 years later: Counterproductive Indeed

- Exodus of Russian scientists from many US-led collaborations
  - Europe greatly benefited from that (CERN, XFEL, FAIR)
  - Adds to already existing issues of the US “decoupling” from the world’s science (since 9/11)
- Multi-fold reduction of US to Russia travel/exchanges
- Reduction of Russian \$\$ support (full... now partially back)
- “No-guarantee” of visa’s and visits of any kind
- In “positive” cases - greatly increased terms to get visitors/collaborators to the US
  - Extra layer of approval (eg DOE)
  - from 1-2 mos before to 3-4 mos now (was even longer)

# Summary and Outlook

- Russian physics and science in general was and is a visible part of world's culture:
  - over ~300 years – many great names and many ups & downs
  - particularly flourishing in Soviet times, 1950's to 80's
- Social changes and breakup of the Soviet Union in 1991 led to catastrophe for science as well:
  - x6 reduction of funding, x3 reduction in # of researchers
  - creation of significant scientific diaspora, very visible in APS
- **Certain progress occurred since early 2000's but still far from restoration of former Soviet scientific might :**
  - physics doing relatively well, due to strong base and int'l collab's
  - still, salaries and prestige are low, recent reforms not effective
  - the US measures against Russian scientists counterproductive and need to be revoked
- Russian physics (science) undergoing reforms which might take another 5-10 years ... possible outcomes not yet clear



**Thank You for Your Attention!**

Vladimir Shiltsev | Russian Physics

