Reflections on the Nature of Genius on Occasion of 300th Anniversary of

Mikhail Lomonosov

(1711-1765)

Which are the most complex sciences of nowadays? How the Chinook-47D helicopter came out of atmospheric electricity studies? What is the difference between "Type A" and "Type B" geniuses? How mosaics and the finest European porcelains are related to the law of conservation of matter? Whom does Benjamin Franklin meet in the downtown Batavia? Why observation of the Venus's atmosphere during its transit over Sun's disc on June 5, 2012 will be as hard as in May 26, 1761 when it was discovered? How many people are needed to reform a grammar, to invent a new type of reflector telescope, to estimate the age of the Earth to be at least 399,000 years on base of scientific evidences, a perform more than 4000 chemical tests in the Russia's first national laboratory, organize unprecedented Arctic exploration expedition and win a public completion among three best national poets? What is in common between Bob Wilson and Michelangelo Buonarotti? All that and much more in the lecture on the occasion of the 300th anniversary of the titanic figure of Russian Enlightenment – Mikhail Lomonosov (1711-1765). You are welcome to attend for a chance in just under 60 minutes to become one of only a few hundred Americans most knowledgeable in the achievements of a true Russian genius.

Tercentennial Anniversary of
LOMONOSOV

Lomonosov - 300

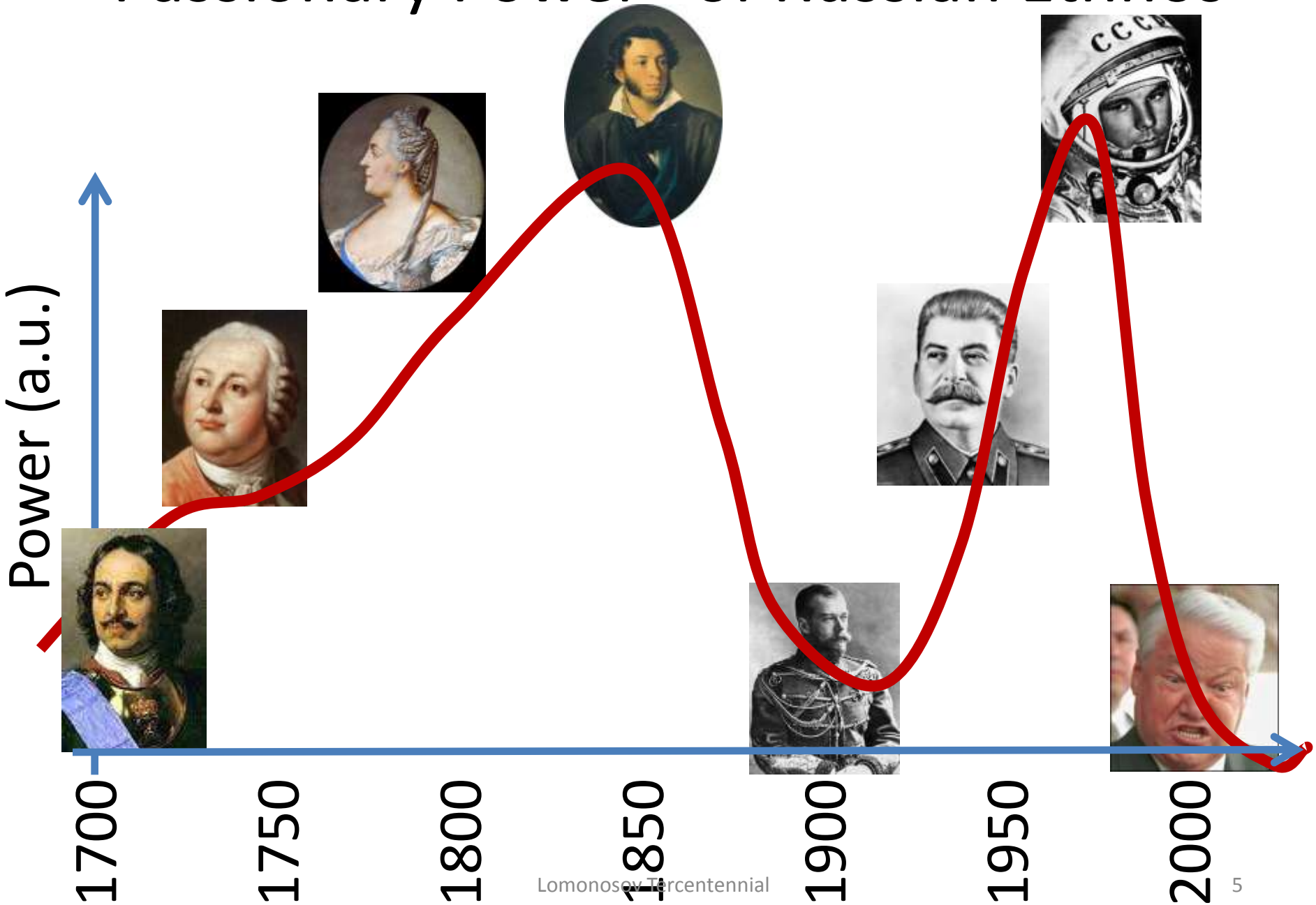
- Who is he
- Life
- Science
- Complexity of Science
- What does make a genius?
- Anecdotes
- Then and Now

Mikhail Vasil'evich
LOMONOSOV

Nov 19, 1711 – Apr 15, 1765

- **Physicist** and **Chemist**
- Poet and **Artist**
- **Engineer and Entrepreneur**
- Courtier and Administrator
- Philologist and **Astronomer**
- Geologist and Mineralogist

“Passionary Power” of Russian Ethnos



Pushkin on Lomonosov

1755

«…между Петром I и Екатериною II
он один является самобытным
сподвижником просвещения.
Он создал первый университет;
он, лучше сказать, сам был
первым нашим университетом”

А.С.Пушкин 1835

“…between Peter I and Catherine II, he (Lomonosov) was the original champion of the Enlightenment. He founded the first University: better to say, he himself was our first University…”

Named After Lomonosov

- Moscow State University – the top one in Russia
- Town (near St. Petersburg), home village in the North
- Range in Arctic ocean, ocean stream, peninsula, Moon crater, mineral, crayfish species
- Three other Universities
- One Theater
- Russian State Porcelain Factory
- 8 Schools
- 54 streets and squares
- Russian State-wide Tercentennial celebration in 2011

“…What's in my name for you?”

Pushkin

- ***Mikhail*** (1st name)
  - Very typical Russian/Slavic
  - Michael
  - Of choice for Nov. 19 DOB
- ***Vasil’evich*** (2nd name)
  - Father’s name - Vasily
  - “State-peasant” → fisherman
- ***Lomonosov*** (family name)
  - Two possible meanings →

“Ломонос” = Clematis

“Ломоносов” = breaking noses

Roots & Early Life

School & Scientific Tradition

Gottfried Wilhelm von Leibniz

1646 – 1716

Christian Wolff

1679 - 1754

Mikhail Lomonosov

1711 - 1765

In Germany
1737-1741

Lomonosov: 23 years in St.P's Academy

- **Adjunct** Professor of Physics St.Petersburg Academy 1742
- Dissertation "On origins of heat and cold" 1745
  (refereed and strongly supported by Leonhard Euler)
- **Academician** (Professor) of St.Petersburg Academy 1745
- Formulation and experimental proof of law of 1748
  conservation of matter and movements
- Physical Chemistry 1752
- *Measurements* of atmospheric electricity and 1753
  theory of electricity (with G.Richmann)
- First working model of helicopter 1754
- Novel concept of Reflector telescope 1756
- Theoretical concept of Earthquakes' origin 1757
  of minerals, review of geological observations
- Solid mercury obtained & studied (with I.Braun) 1759
- Discovery of Venus atmosphere 1761
- Theoretical justification of the Arctic path expedition 1763-65

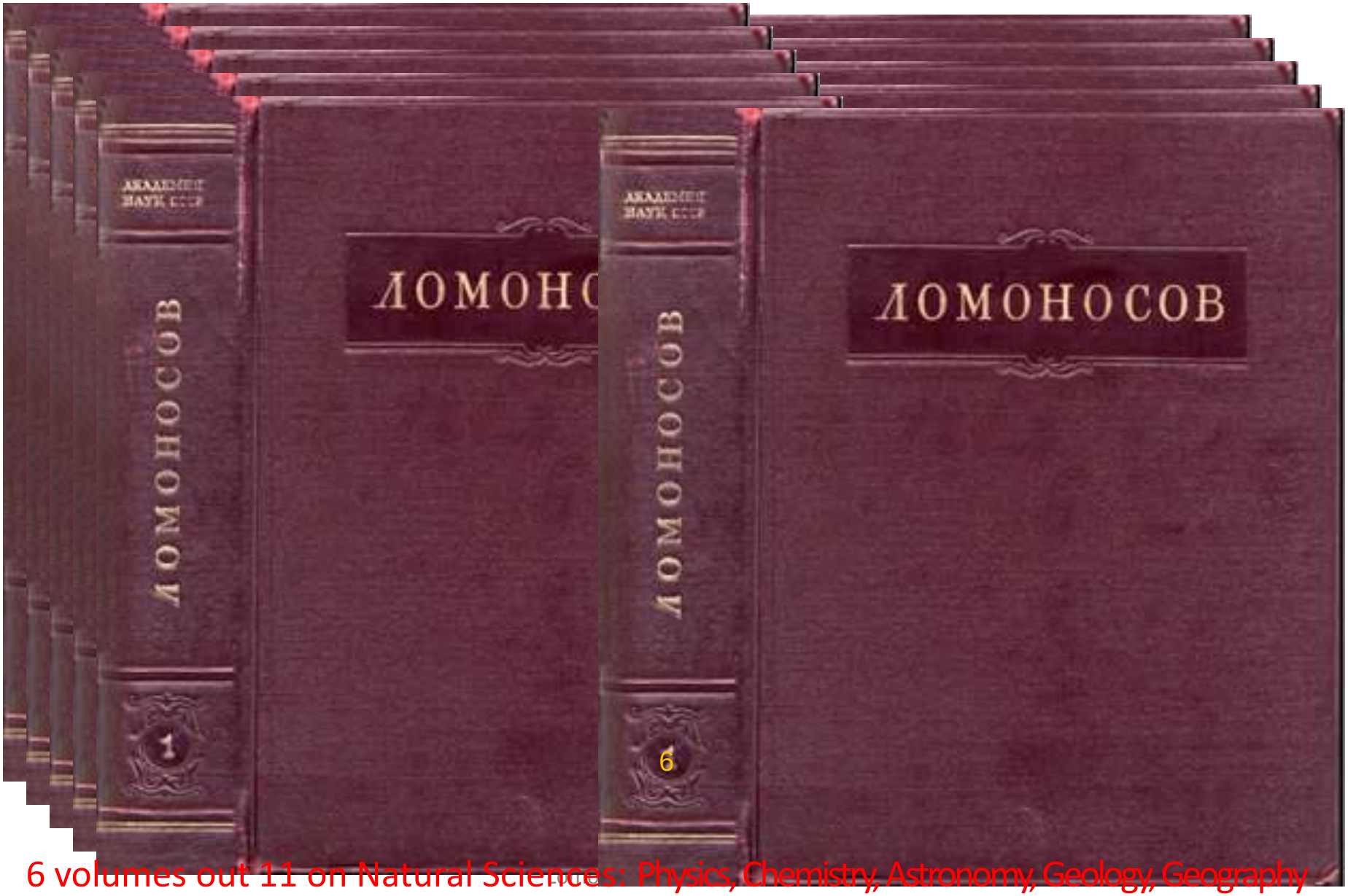
Scientific Academies

• Platonic Academy in Athems	~380's BC
• Accademia dei Lincei	1603
• Royal Society of London	1660
• German Academy of Sciences Leopoldina	1662
• French Academy of Sciences	1666
• Prussia Academy of Sciences Berlin	1700
• St-Petersburg Academy of Sciences	1724
• Royal Swedish Academy of Sciences	1739
• American Philosophical Society	1743
• Göttingen Academy of Sciences	1751
• Dutch Academy of Arts and Sciences	1806
• Academie Des Sciences Wien	1847
• National Academy of Sciences USA	1863

Saint-Petersburg Academy

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

Lomonosov *Complete Works* 1950-83



6 volumes out 11 on Natural Sciences: Physics, Chemistry, Astronomy, Geology, Geography

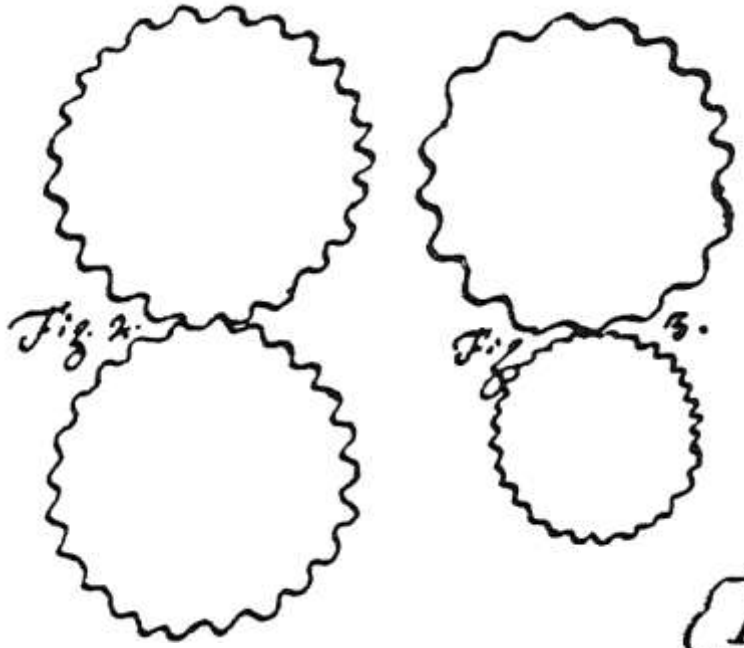
Lomonosov's Method

- He was [a Thinker + an Experimenter] :
  - His theories and hypotheses were based on tests and experiments, which he planned, prepared and carried out himself.
- He used to work on each of his many research topics for many years if not decades
- Always tried to turn his scientific discoveries into practice or inventions

Lomonosov's Major Results (1)

- New science of *Physical Chemistry* (1752)
  - on base of corpuscular-mechanical view
  - theory of light and color
  - the concept of ***absolute cold***
- Experimental proof of the law of conservation of matter:
  - the amendment to R.Boyle
- Experiments on the freezing of mercury
  - with I. Brown

His Corpuscular-Mechanical Views

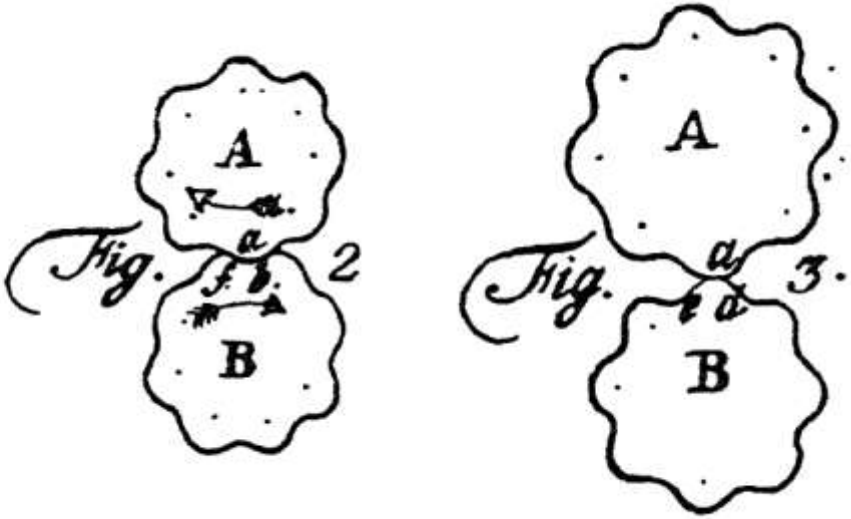


- Heat is not a liquid, it is a measure of rotation and motion of molecules
- Concept of ***absolute cold*** – no rotation or motion
- (out of fashion 1760-1840)

R=8.3 J/(mole K)

$$P=RT/(V-b)$$

R.Clausius 1850's



Figs. 1-3

Chemical-Physical Laboratory

- Russia's first national research lab
- Senate granted 1500 rubles
- >4000 tests by himself!
- Famous test in 1756
  - Repeated by Lavoisier 1773

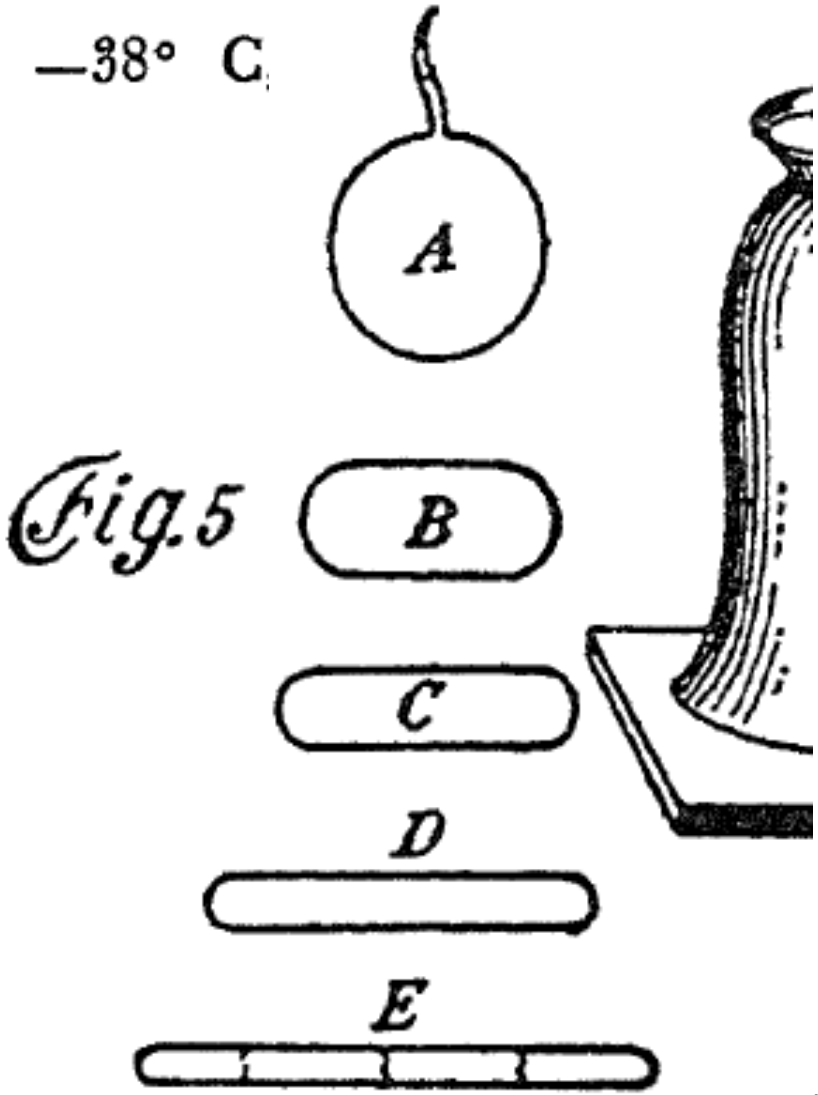
Matter & Motion Conservation

R.Boyle 1673: lead weight increased after heating (vessel opened) → "caloric particles penetrated glass"

Lomonosov 1756: lead weight remained the same when vessel sealed → no caloric particles, matter conserved (in chemical reaction):

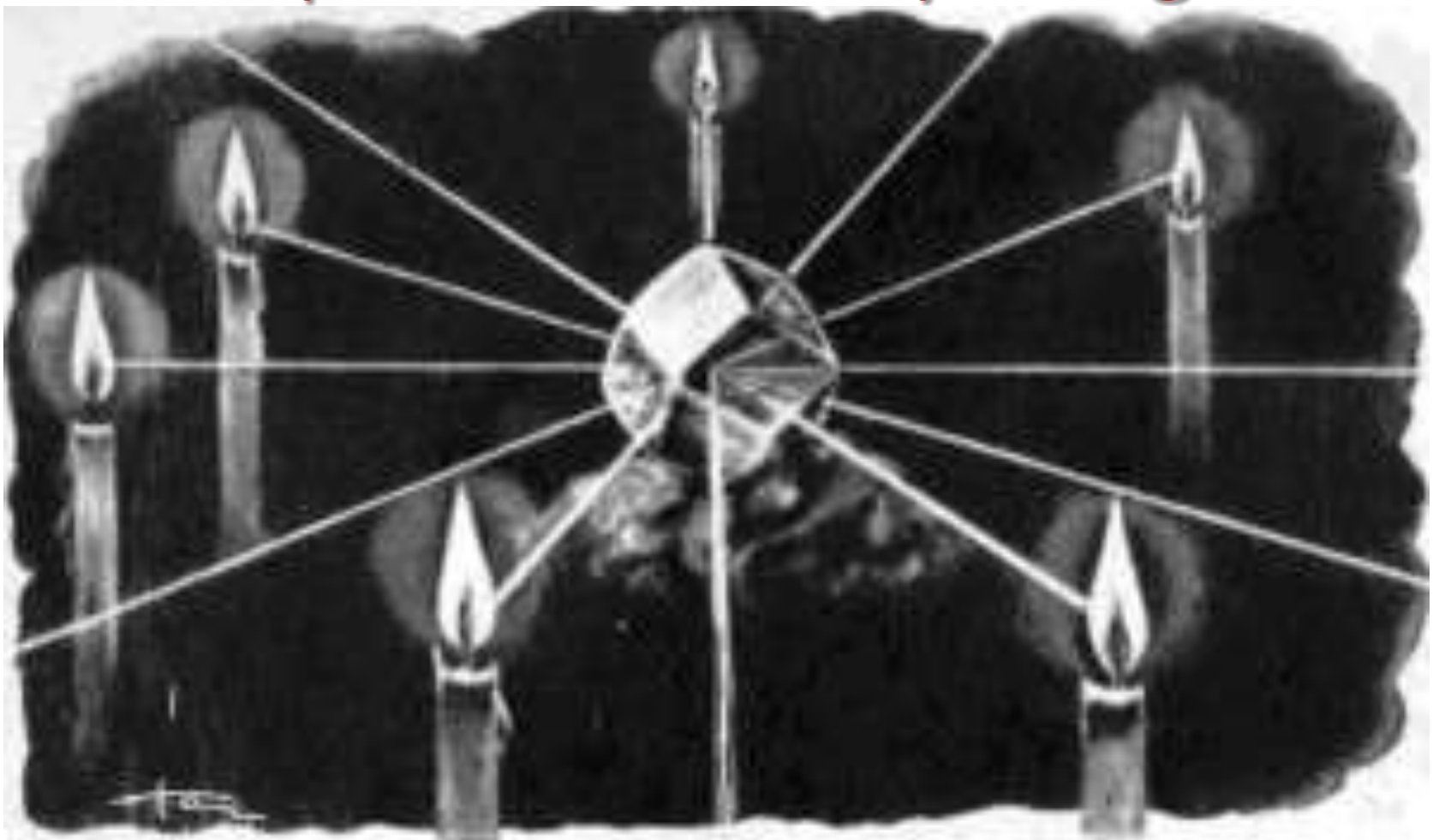
"...all changes that we encounter in nature proceed so that… however much matter is added to a body, as much is taken away from another … since this is the general law of nature, it is also found in the rules of motion: a body loses as much motion as it gives to another body". letter to Leonhard Euler

Mercury is Metal ! January 1759



- Cold weather -26 C
- Used mix of snow and concentrated nitric acid
- Together with I.Braun
  - Report Royal Society
  - Priority battle with F.U.T.Epinus

Against Newton's Corpuscular Theory of Light



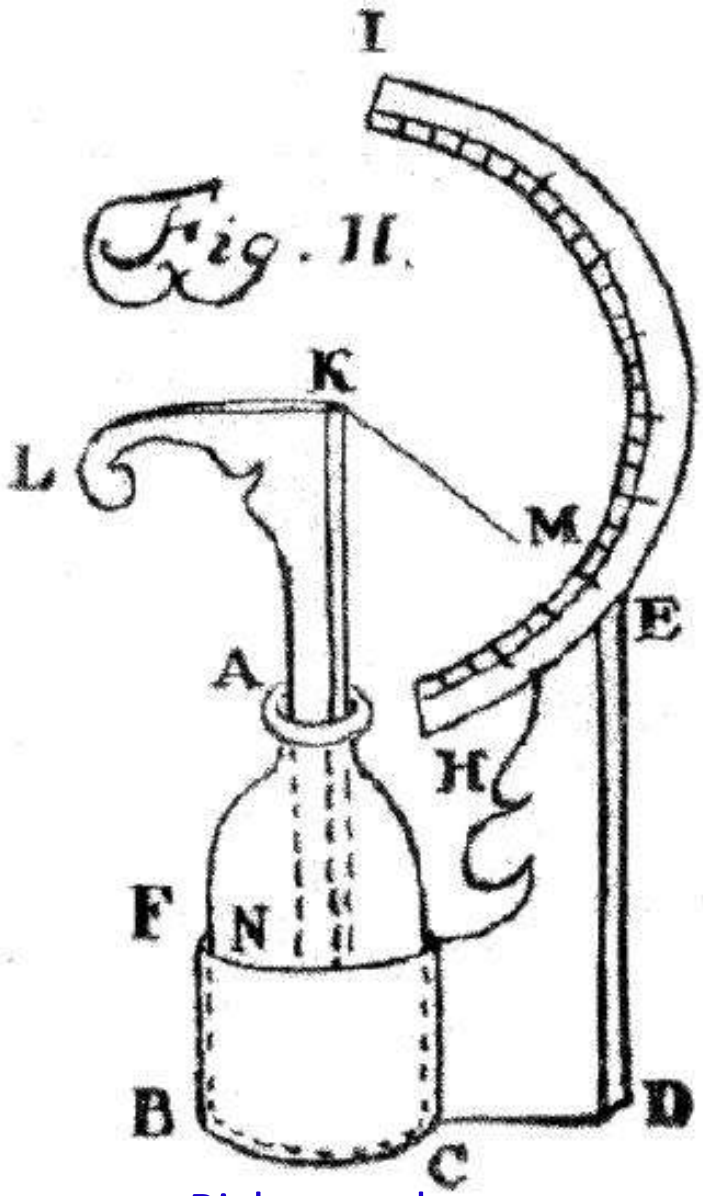
Многие современники Ломоносова считали свет потоками очень тонкой материи. «Но если это так, — спрашивал Ломоносов, — то каким образом световые лучи от многих свечей, не сталкиваясь, проходят сквозь алмаз?»

Mosaics “Battle of Poltava” (1764)

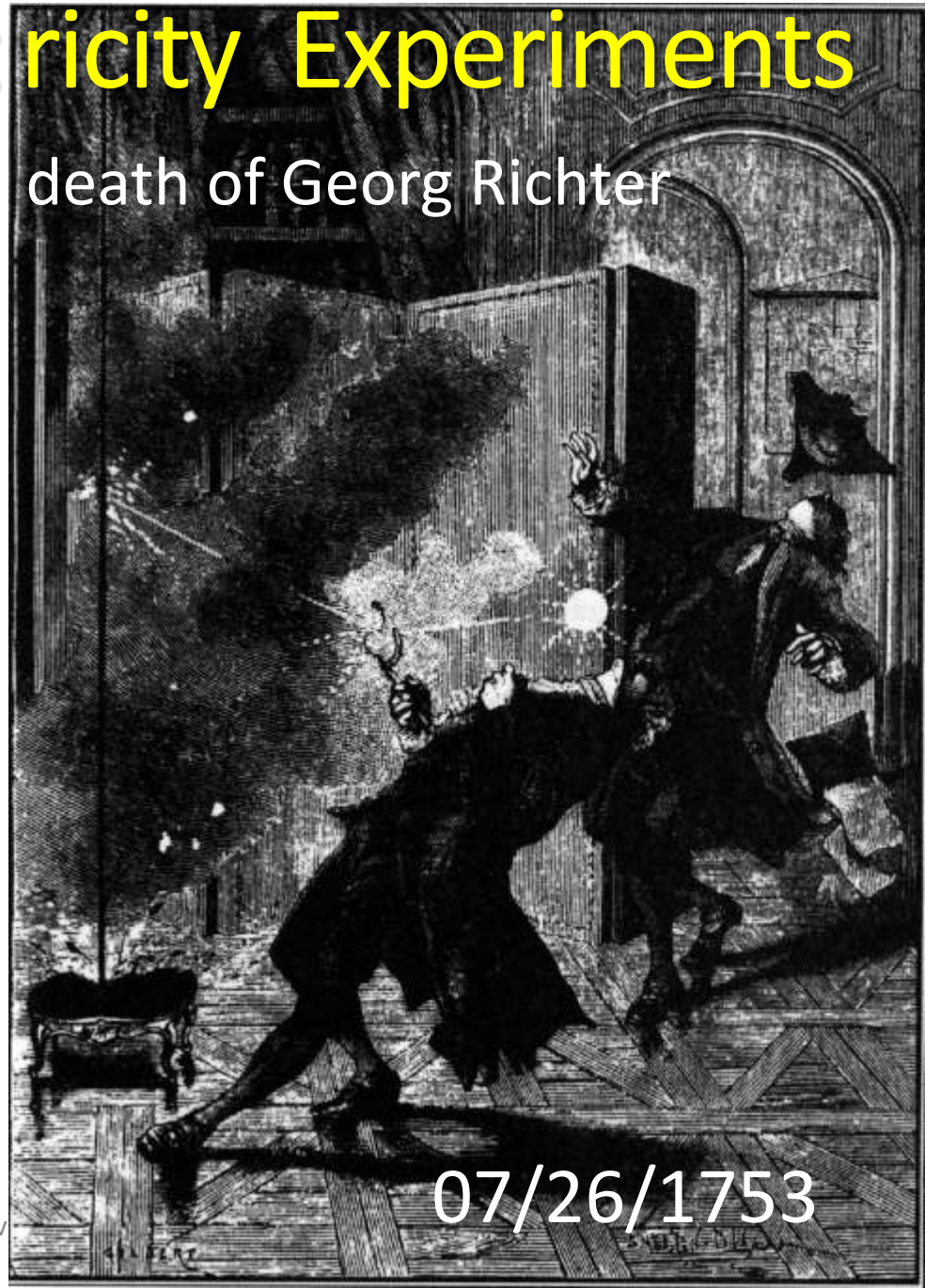
Lomonosov's Major Results (2)

- Electricity studies 1745-1760's
  - first quantitative measurement of electricity
  - Two measuring instruments (scales and electrometer) - with G. Richman
  - Automatic "lightning-meter" proposal
  - helicopter for atmospheric research
- The theory of air electricity
  - The friction in the vertical air currents
  - Applied to Northern Lights/ auroras
- Color theory in electric discharge

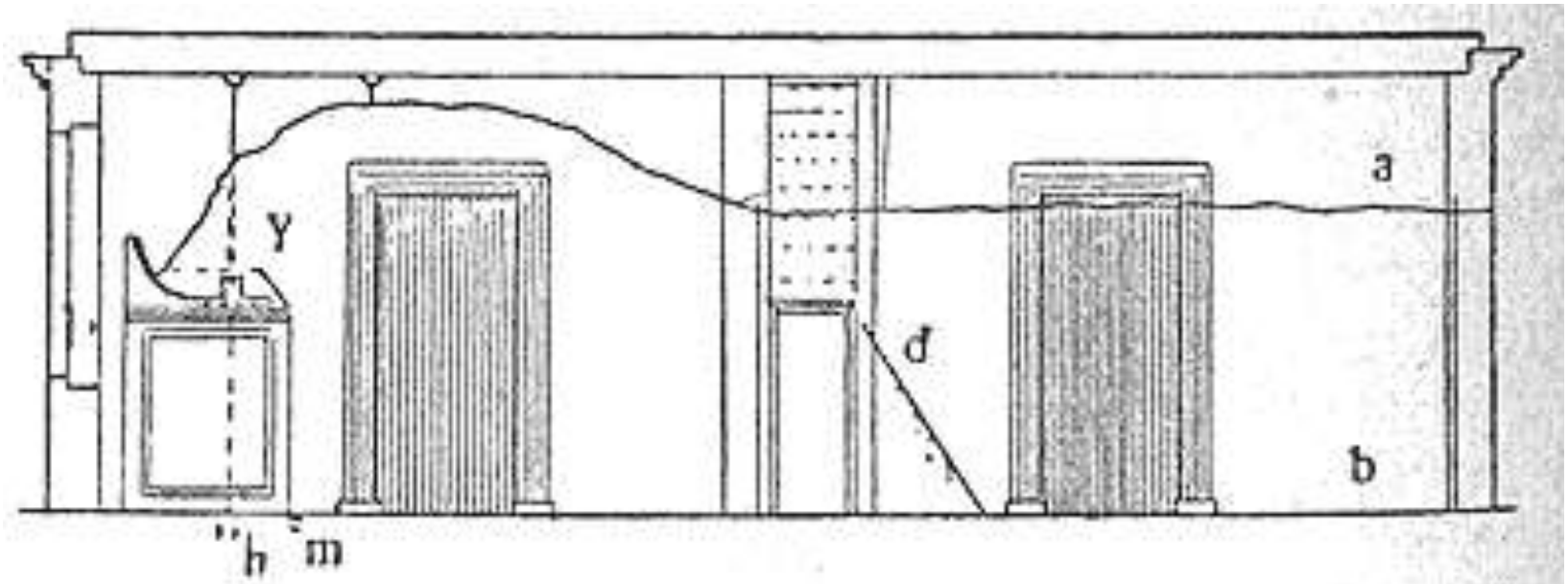
Lomonosov's Electricity Experiments



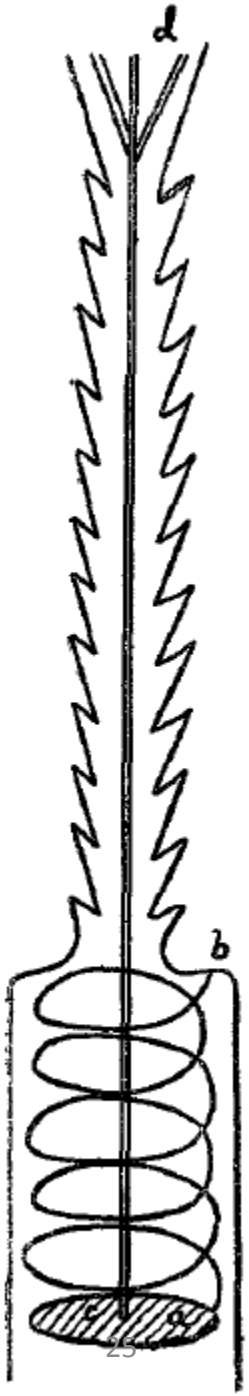
Richman electrometer



Georg Richman and Lomonosov



«Громовая машина» в доме Г. В. Рихмана в 1753 г. (*h* — место, где стоял Рихман в момент удара молнии).



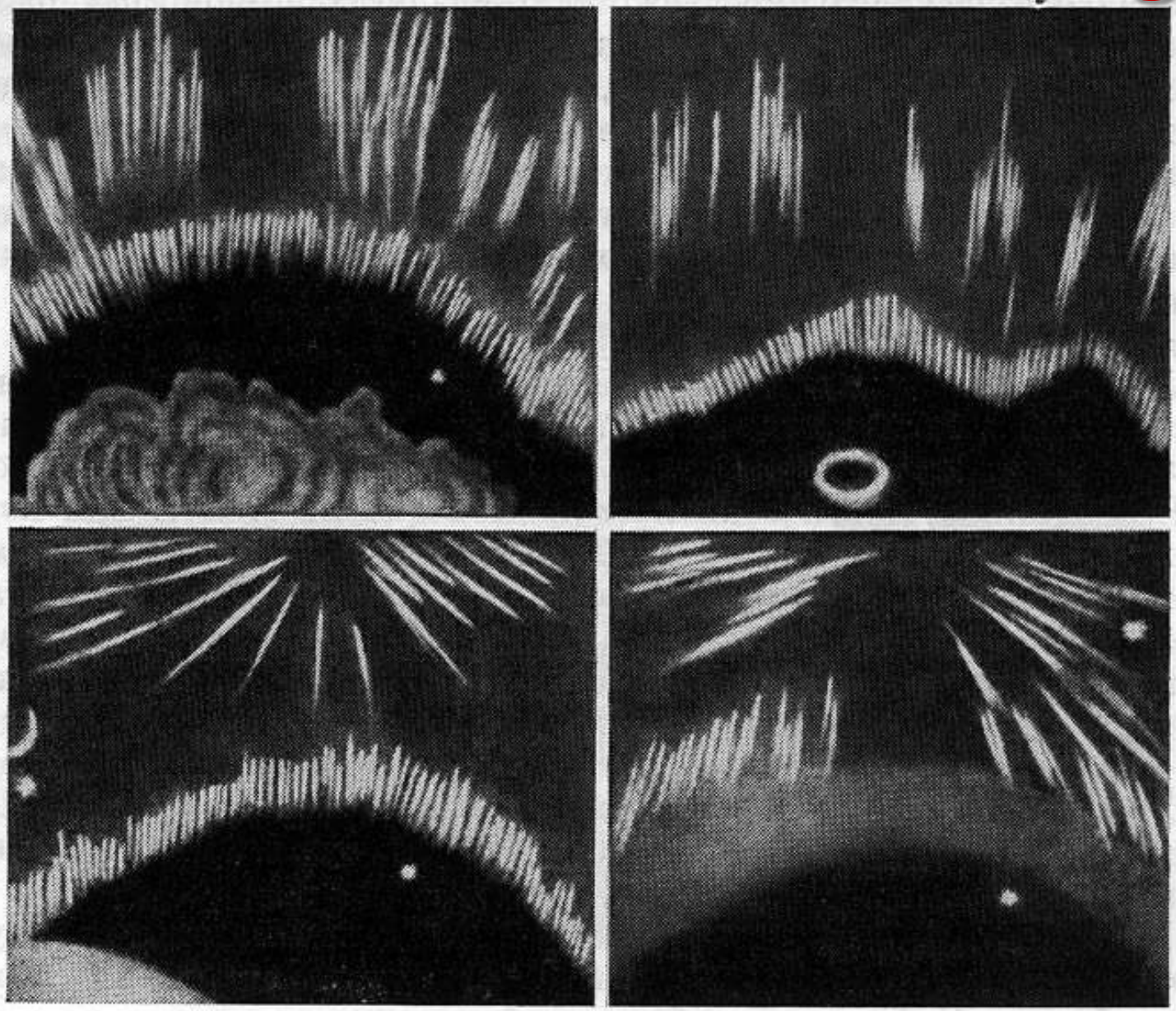
Lomonosov response – device for automatic detection of max charge →

Theory of Atmospheric Electricity

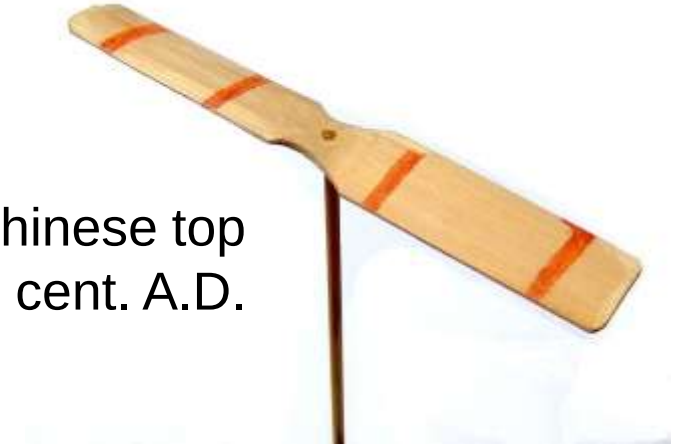
Air density increase due to lower temperature in upper atmosphere is ~2.5 times stronger than density decrease due to high elevation

1753

Explanation of Northern Lights

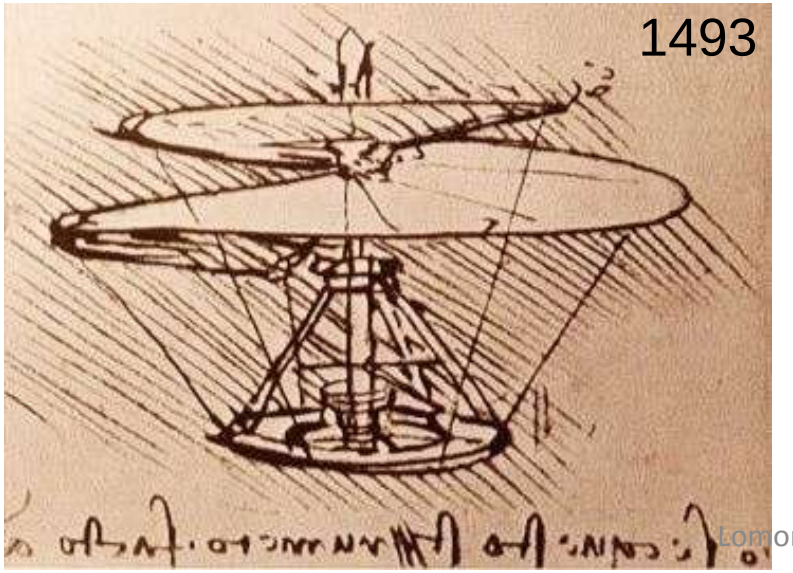


1754 Lomonosov's "Aerodynamic Machine"



Chinese top
4th cent. A.D.

Leonardo's "airscrew"
1493



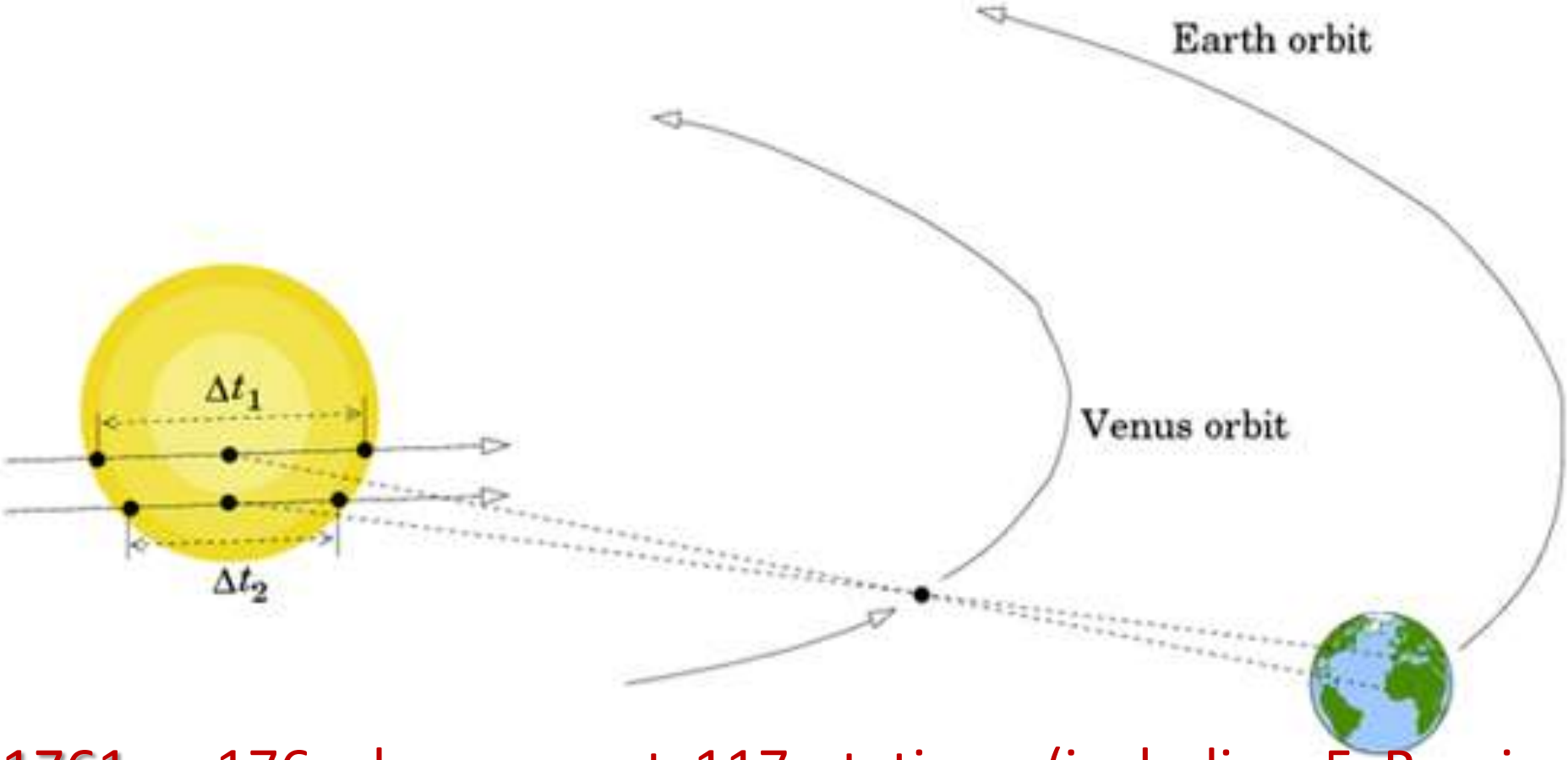
* counter-rotating blades
**for atmospheric research

also in *Yak*-24, *Piasecki* H-21, all *Kamov*'s helicopters

Lomonosov's Major Results (3)

- Discovery of atmosphere of Venus
  - during the 1761 Transit of Venus
- Inventions
  - A telescope with one lens ("Herschellian")
  - Sideroscope
  - "Night-vision tube"
  - Method to determine the position of the sun on the ship
  - Automatic course recorder of a ship
  - Many others

Transit of Venus June 1761



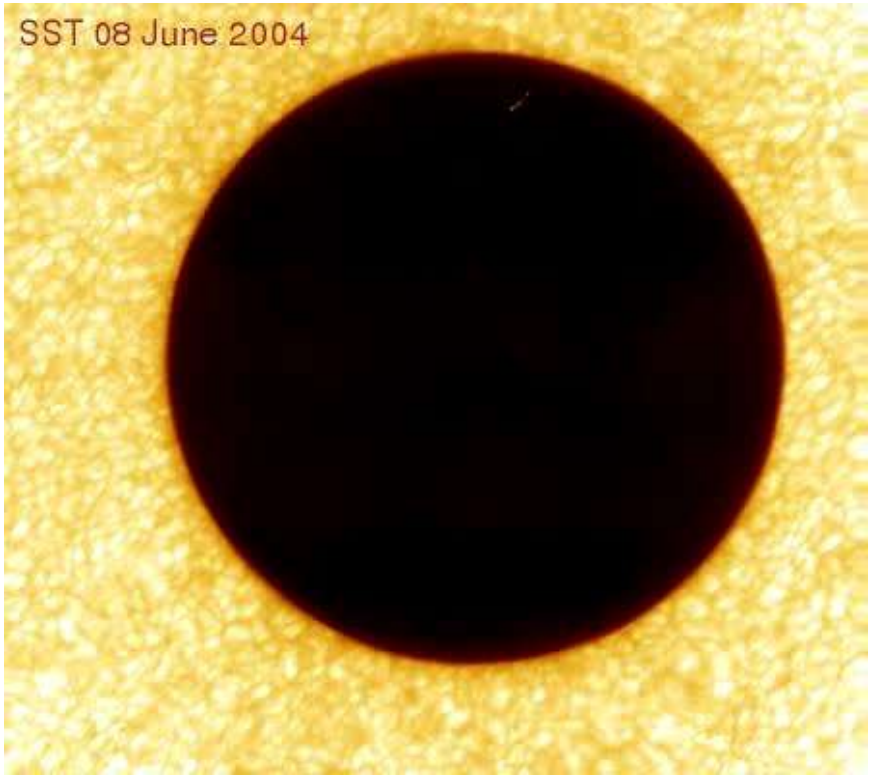
1761 – 176 observers at 117 stations (including 5 Russian astronomers in 3 cities all over Russia); major goal – determine distance to the Sun; very rare event – ToV in 1769, 1876, 1884 and 2004 …

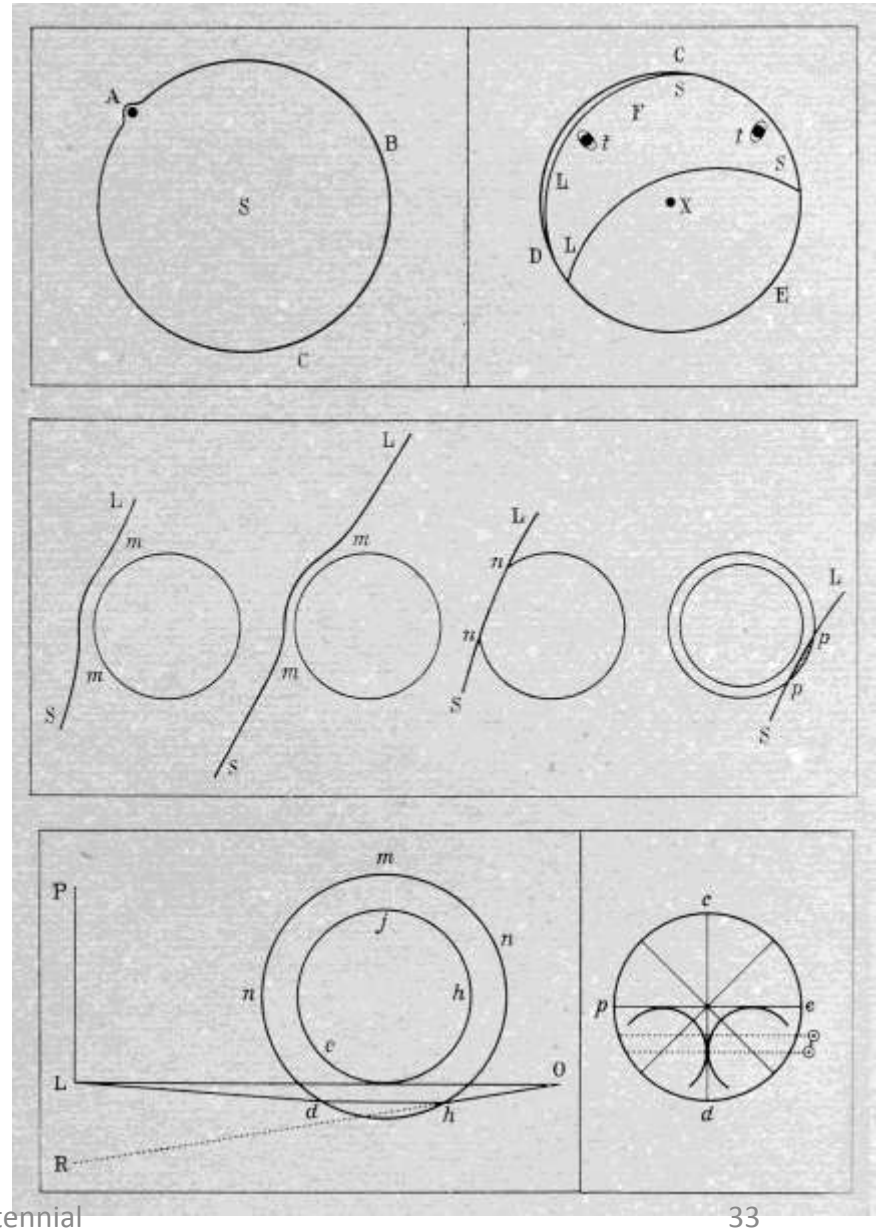
Lomonosov's Actions in 1761

Important! – he used lightly smoked glass

ercenter

Lomonosov Discovery of Atmosphere of Venus





Transit of Venus June 5-6, 2012

You can see it, your kids can see it, your neighbor kids can see it!

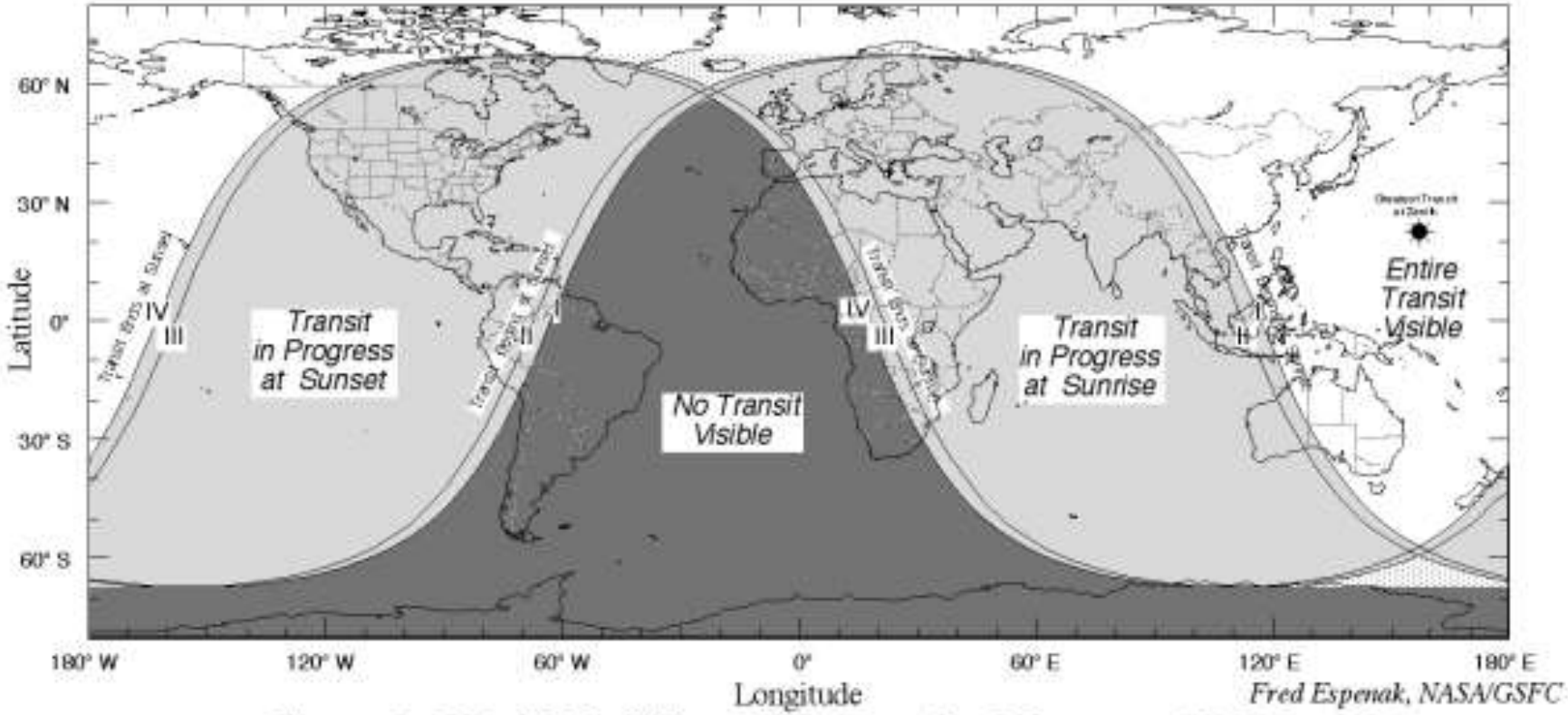
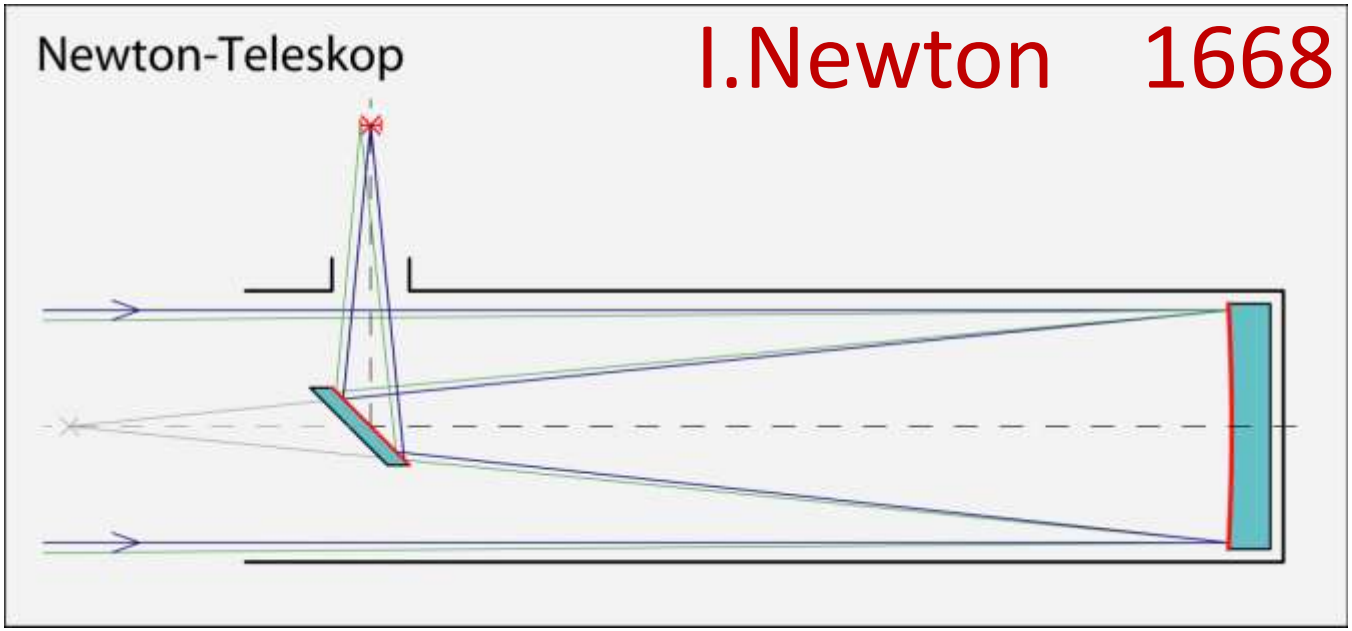
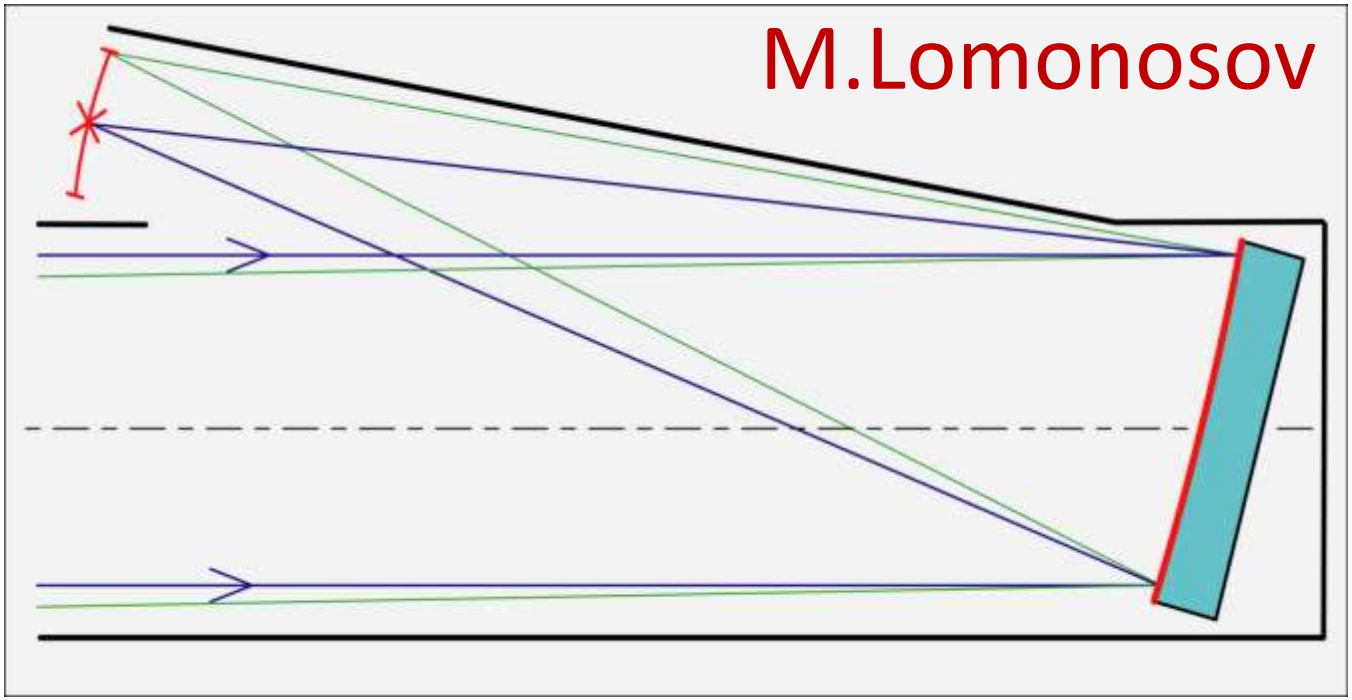


Figure 3 - World Visibility of the Transit of Venus — 2012 June 06

250th Anniversary of the Discovery of Venus Atmosphere by Lomonosov



I.Newton 1668

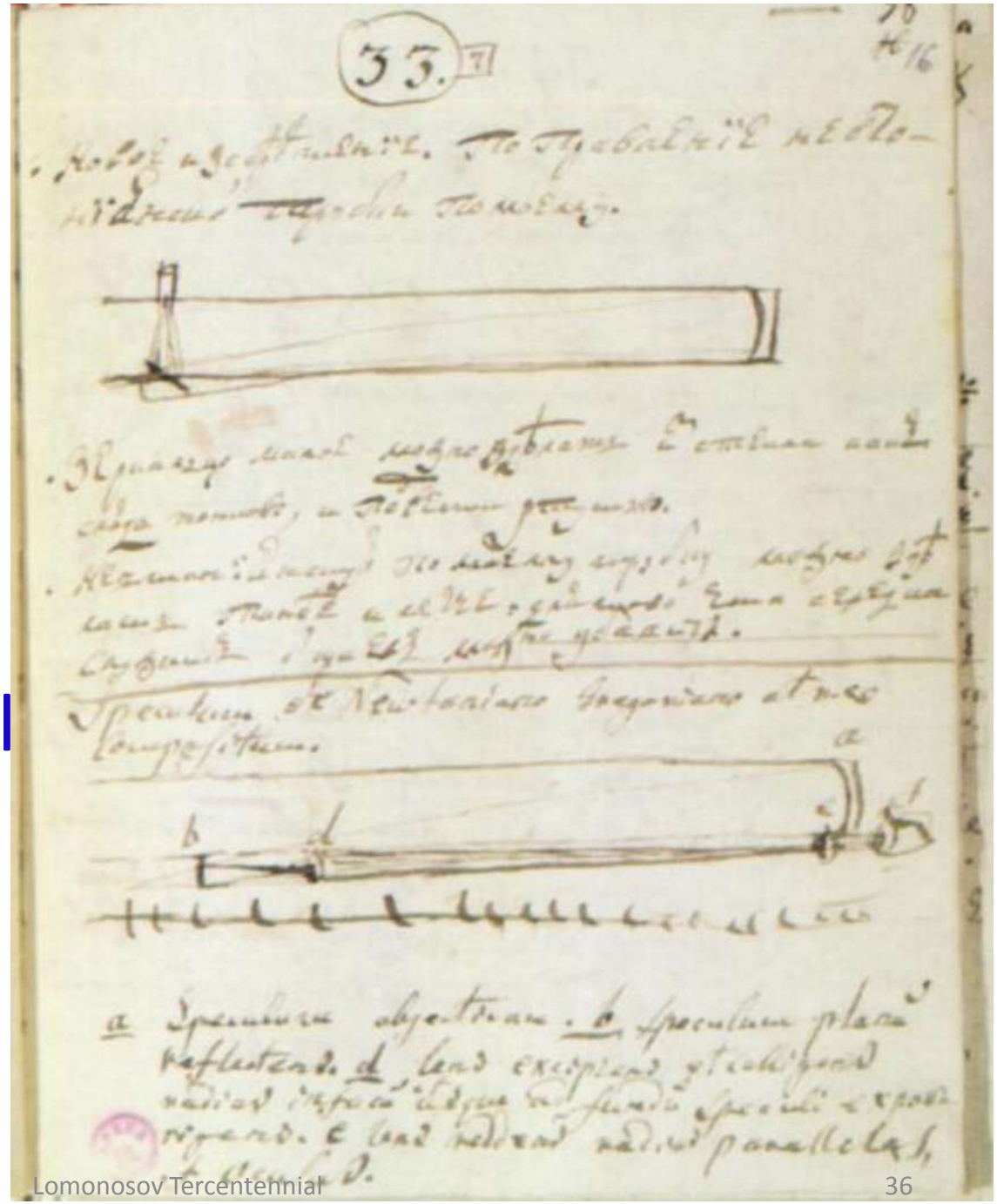


M.Lomonosov 1756

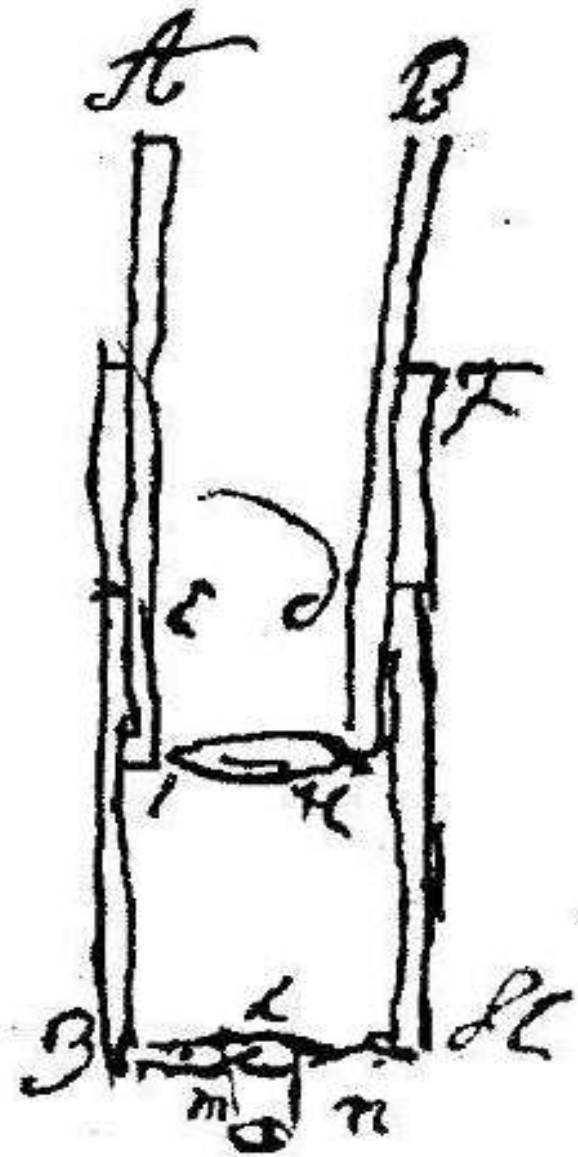
Lomonosov Reflector Telescope

- Lomonosov's concept 1756
  successful model 1762

- William Hershel 1789



Night-Vision Tube 1756

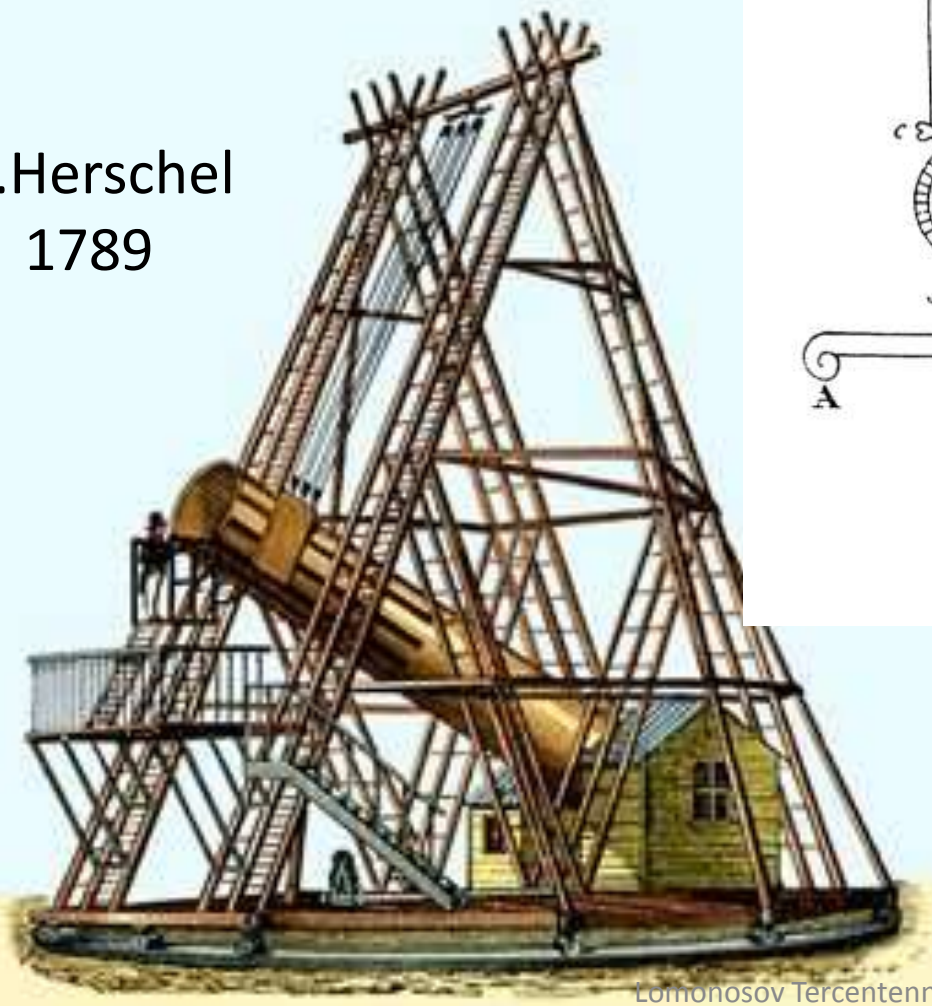


- Large objective + 8mm eye-piece
- MVL's explanations denied
  - by Epinus, Rumobvsky, Grishow
  - *Ricco's law* 1877: **B_{min}=const/Area**
- 3 built for Arctic expedition 1765

“Siderostat”

flat mirror

W.Herschel
1789



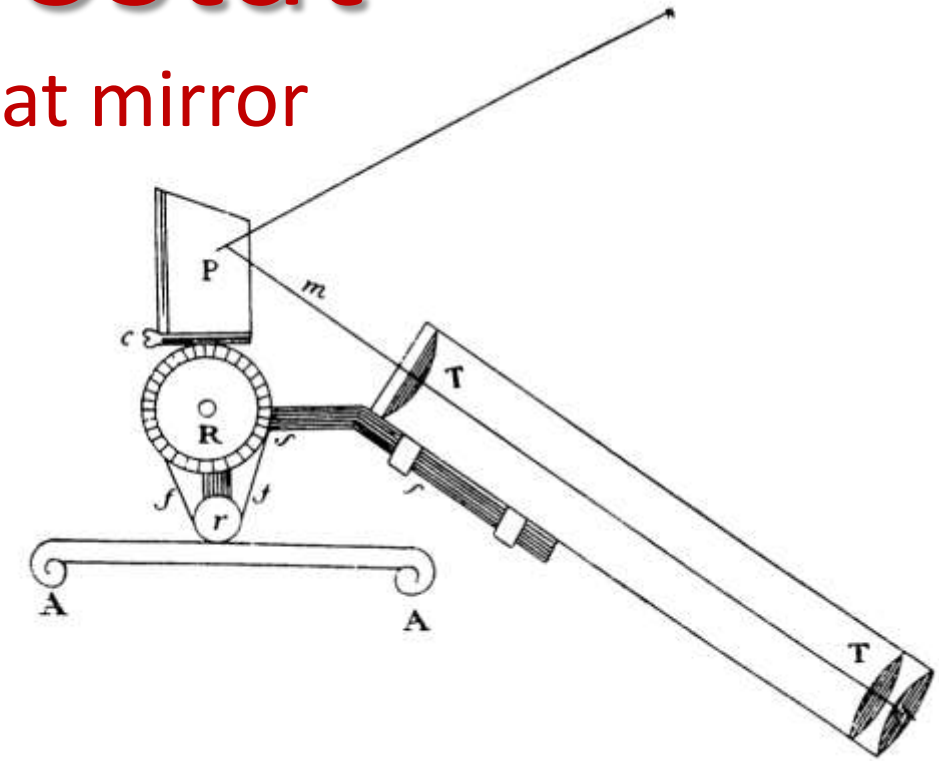


Fig. XII.

M.Lomonosov
1759

Lomonosov: Beyond Natural Sciences

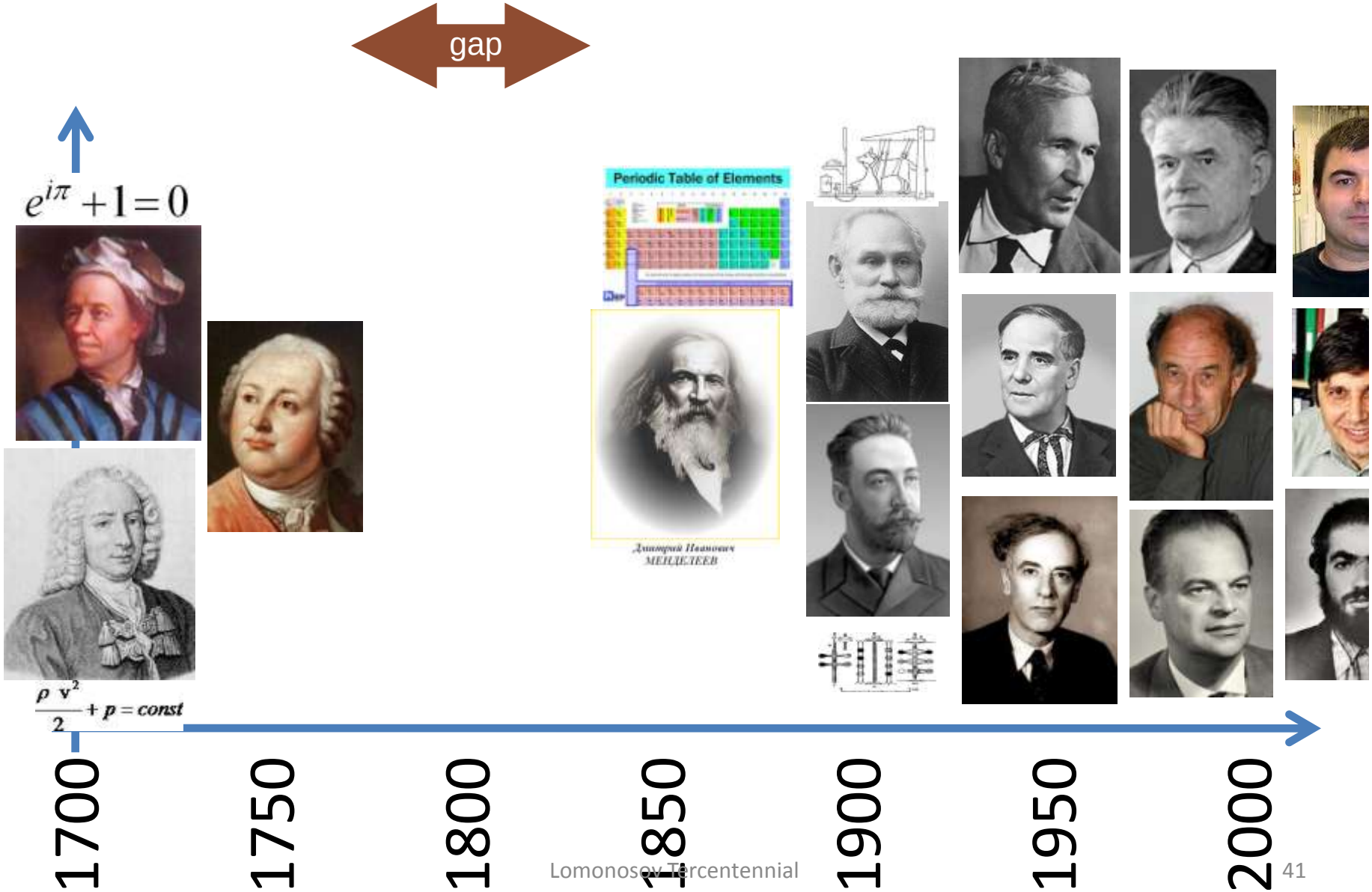
- Odes to Empresses 1739, 1746, 1763
- Founded Moscow University 1755
- Arctic Sea Expedition 1763
- Russian Grammar 1754
- Mosaics Factory 1752-1764
- Academy Management (top 3) 1757-1765
- Russian History 1765
- Demography Analysis 1761
  - Age difference (15/2), no forced marriages, 3rd time widowers, monks age limit, baptism in warm water, move holydays, pharmacies, birth assistance → 10 million/20 yrs (pop. 22 million in 1750) double the rate

POLL #1

- How many non-Russian speakers are in the audience? (raise your hand, please)
- How many of you HAVE heard of Lomonosov?

- How many Russian-speakers are in the audience?
- How many of you have NOT heard of Lomonosov?

History of Science in Russia



Batavia, Lomonosov and Franklin

Self-Made Man by Bobby Carlyle

Lomonosov and Ben Franklin

Similar legacies in Russia and US: Key figures of Enlightenment & 1st orig. scientists

Britannica 1954	¼ page	5 pages
БСЭ (Sov.Encicl.1978)	6 pages	2 pages
Wiki Eng	4 pages	20 pages
Wiki Rus	35 pages	5 pages

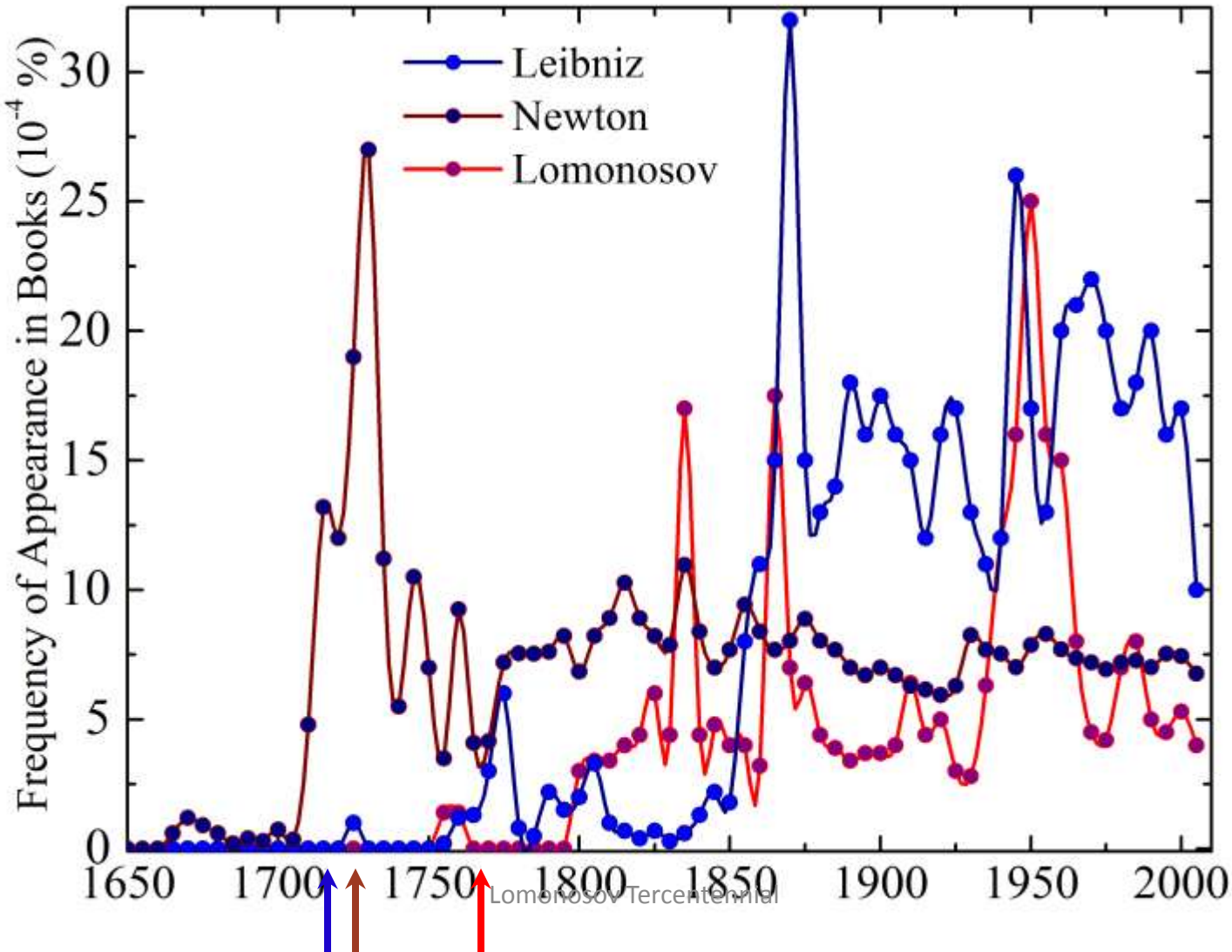
Google books Ngram Viewer

- New culturonomics tool:
  - http://books.google.com/ngrams

  - Frequency of appearance of the word or combination of words in the published books vs year
  - >5M digitized books (5%), 500B words,7 languages

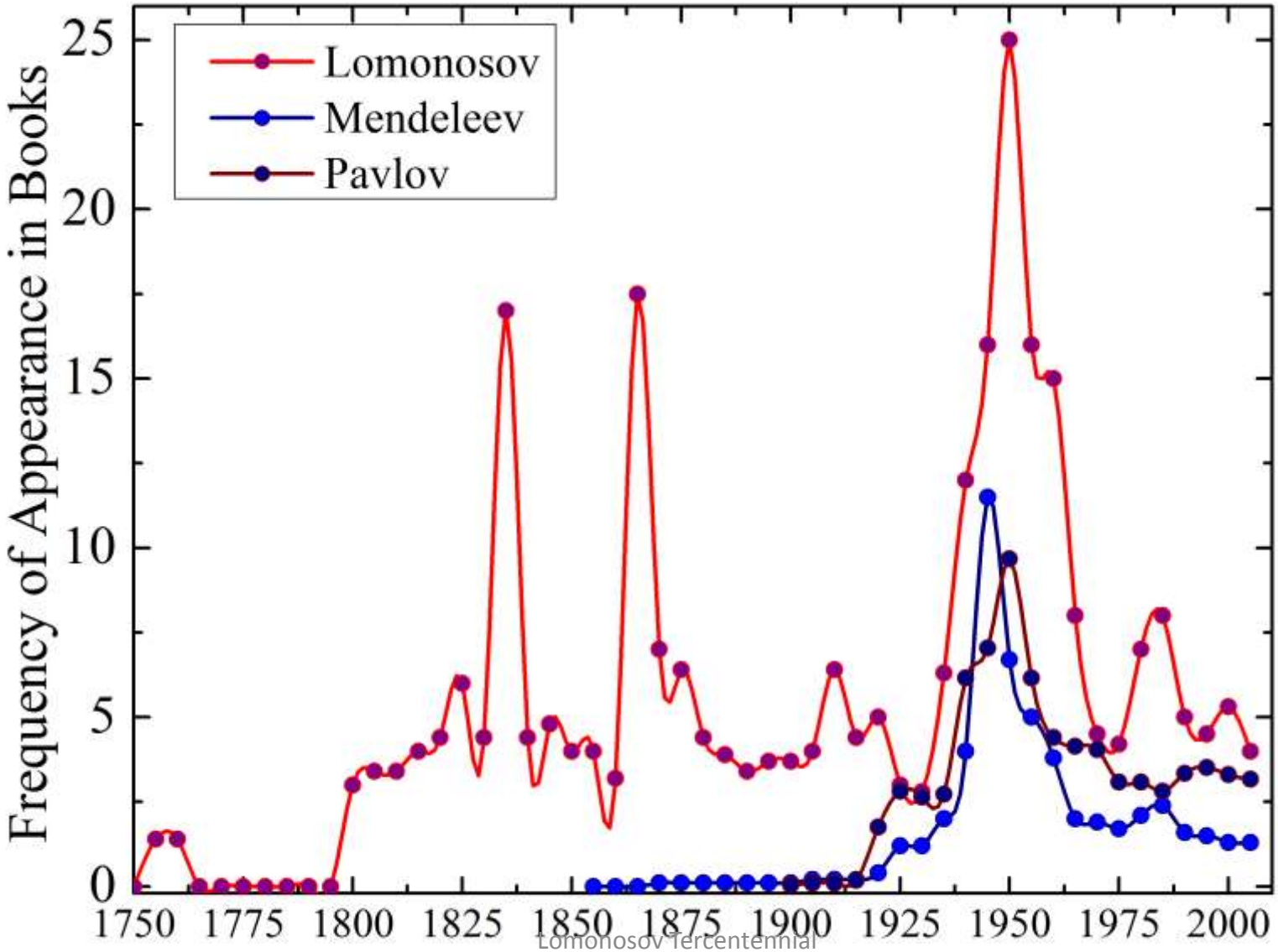
Three Scientific Geniuses:

English, German, Russian book collections



Most Prominent Russian Scientists

Russian book collection



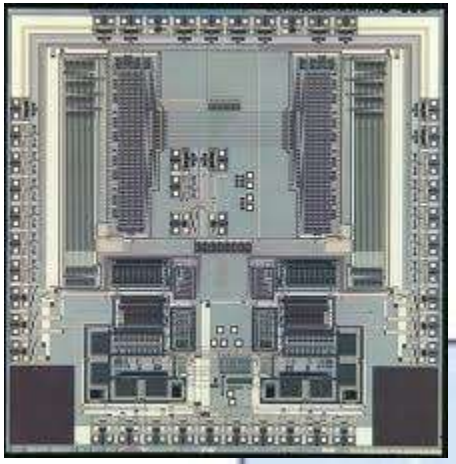
Lomonosov’s Tercentennial 2011

- Lomonosov's 2011 celebration is state-wide in Russia - preparations started in 2006 per Russian President's order
- The plan of celebration lists 36 actions for Russian Ministries of Foreign Affairs, Education and Science, Postal Office, Russian Academy of Sciences, Arkahangelsk Governor and includes:
  - All-Russian "scientific competition" of young scientists
  - "Lomonosov classes" in every Russian school
  - Postal stamps, medals, UN and UNESCO events
  - Russian Chemistry Olympiad in Arkhangelsk
  - "Lomonosovskie Chteniya" (Lomonosov's Seminars) in Russia and abroad
  - Number of Russian and Int'l conferences on subjects of chemistry, physics, fleet, geography, etc
  - Books on Lomonosov including new popular biography
  - Movie on his life
  - New edition of Lomonosov's works
  - Expositions in Russia and abroad
- City of Arkhangelsk (birthplace of Lomonosov) has their own list of celebration events and actions (some 100 items long).

On the Nature of Scientific Genius

- I will need to guide you through a concept of complexity of sciences and a little bit of math

An Example of Complex System



“Moore‘s Law”

number of transistors on one chip

doubles every ~2 years

Theorem of Complex Systems

The system is complex → many problems and parameters → one can not solve all the problems at once → address them step by step

$$Fractional\ \ Gain\ \ per\ steps\ 1 \rightarrow (1+F)$$

$$after\ \ M\ \ steps\ (1+F)^M \approx e^{FM}, \text{etc.}$$

...or in time →

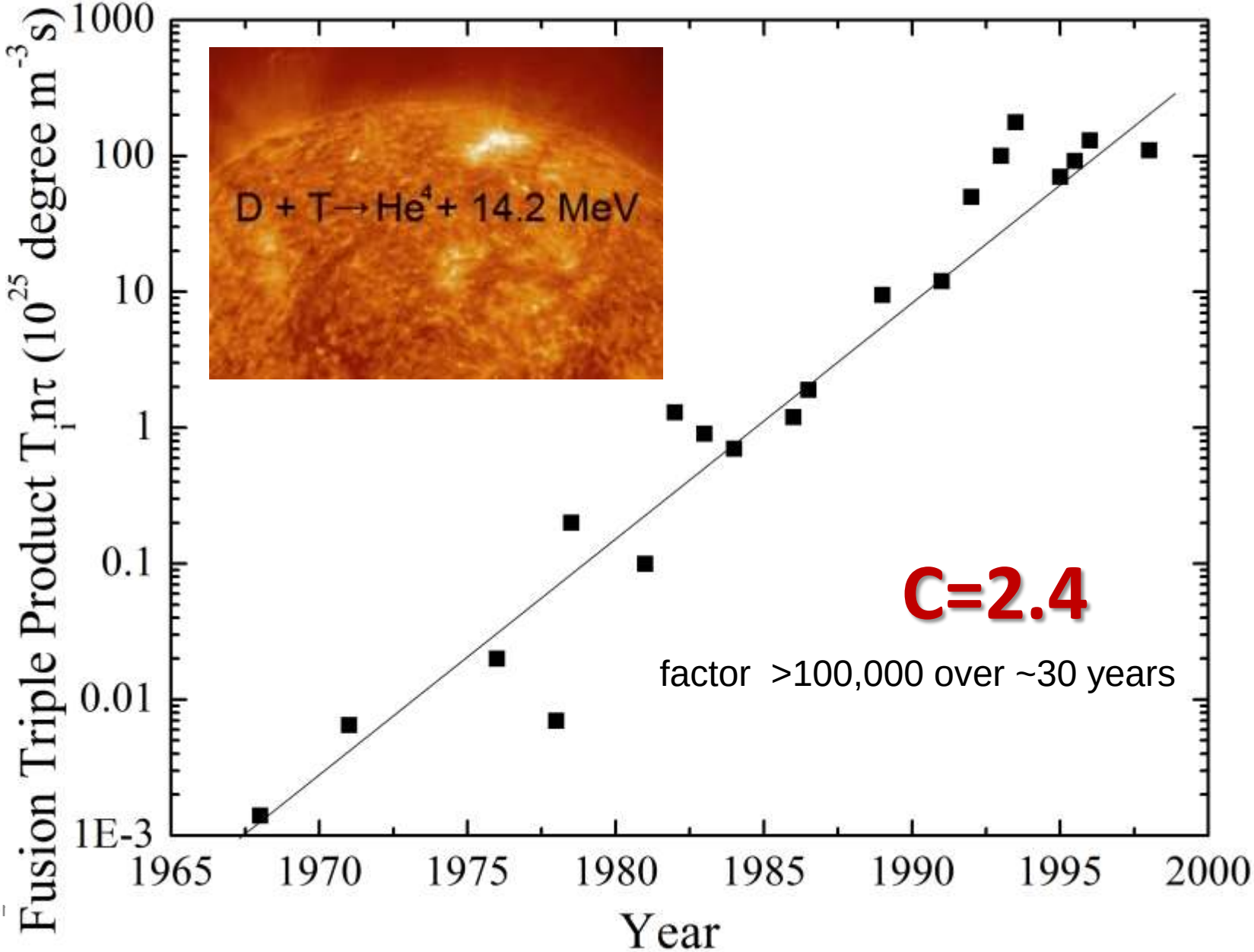
$$L(after\ \ time\ T) = L_0 \times \exp(T/C)$$

C (Complexity) = # years to ***e*-fold** progress

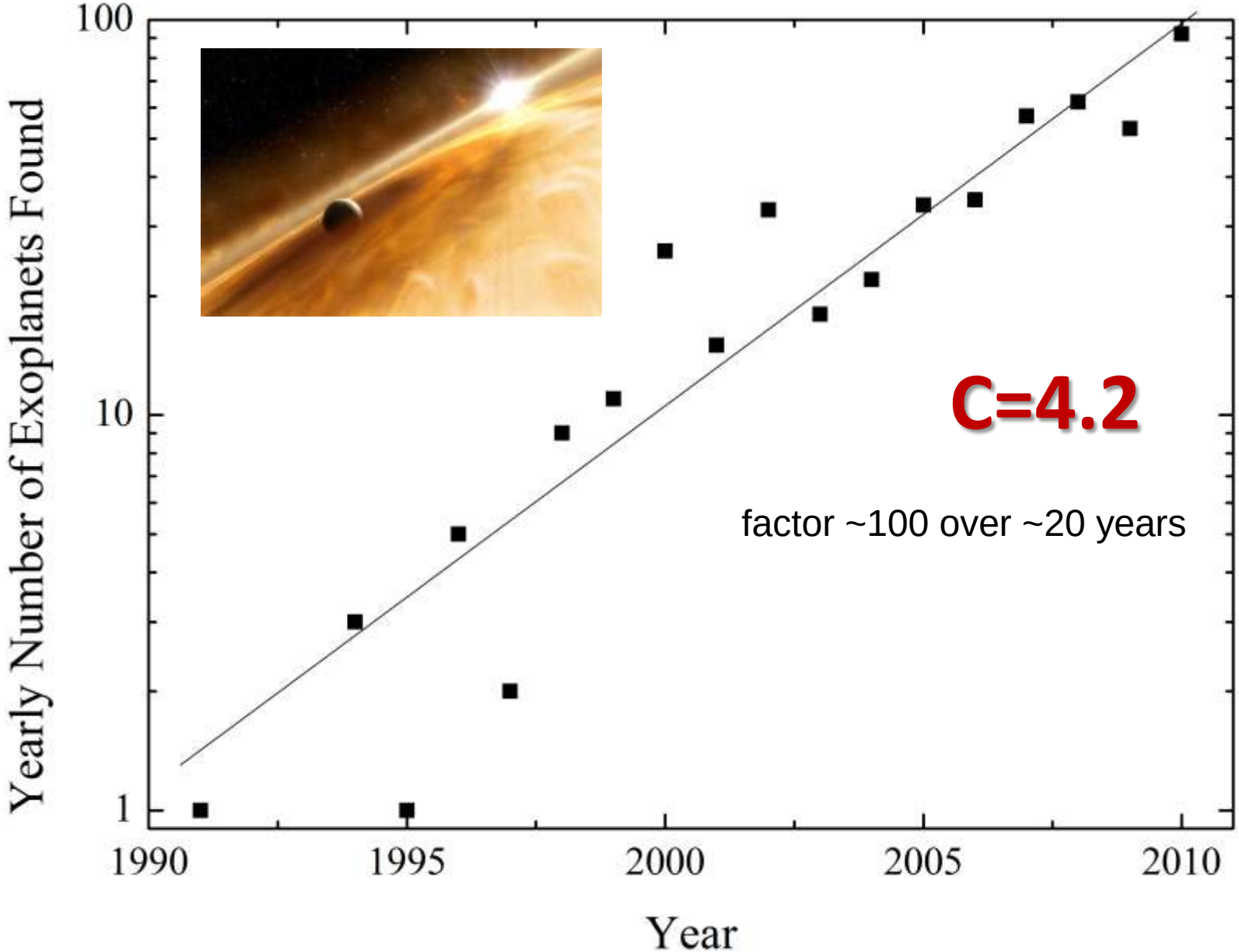
E.g. "Moore's Law" → ***C*=2**yrs***/ln(2*** factor***)=2.9***

V. Shiltsev Modern Physics Letters A
Vol. 26, No. 11 (2011) 761–772

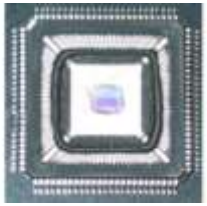
Thermonuclear Reactors

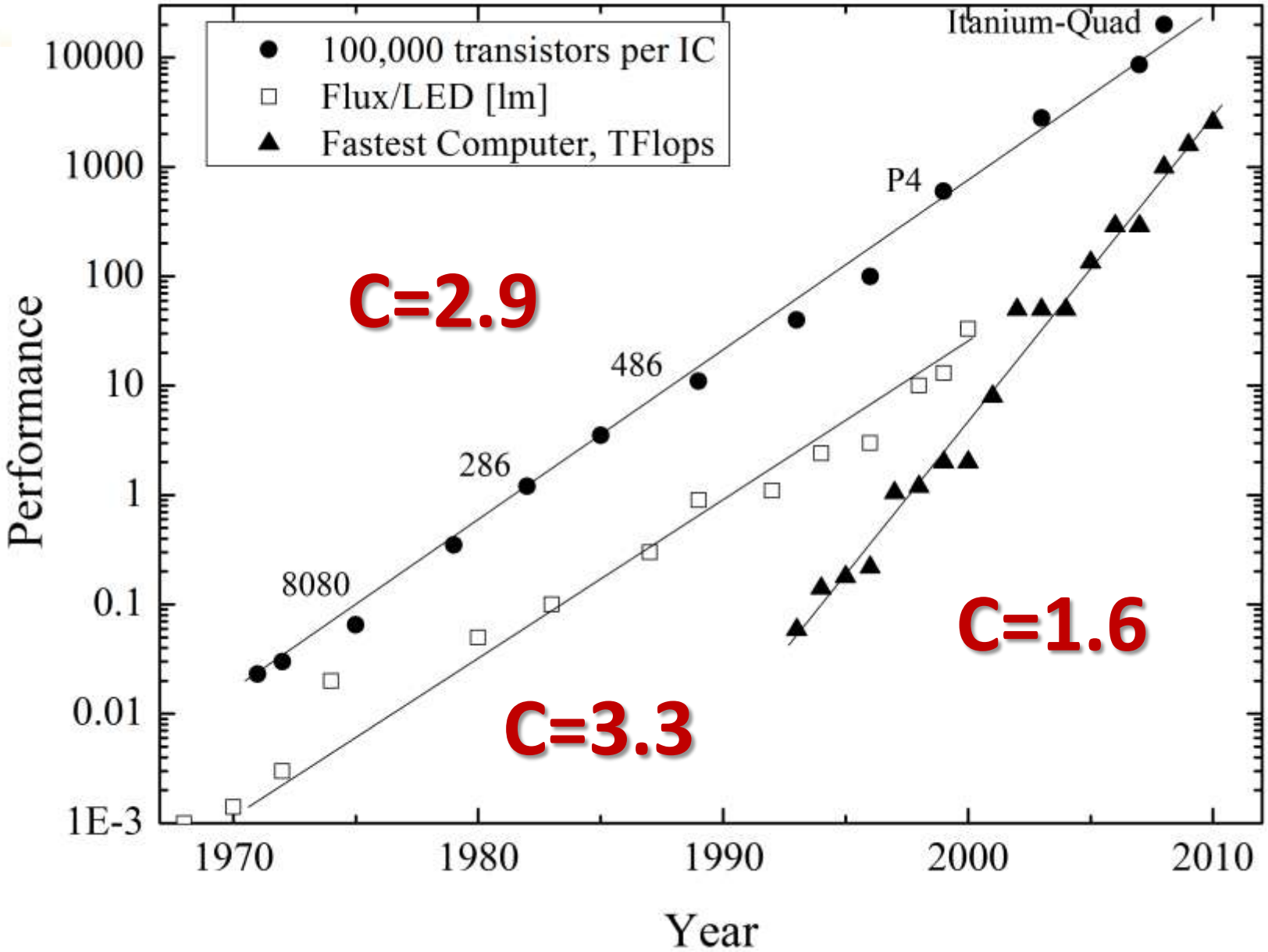


Exoplanets


100
10
1
Yearly Number of Exoplanets Found
1990
1995
2000
2005
2010
Year
C=4.2
factor ~100 over ~20 years

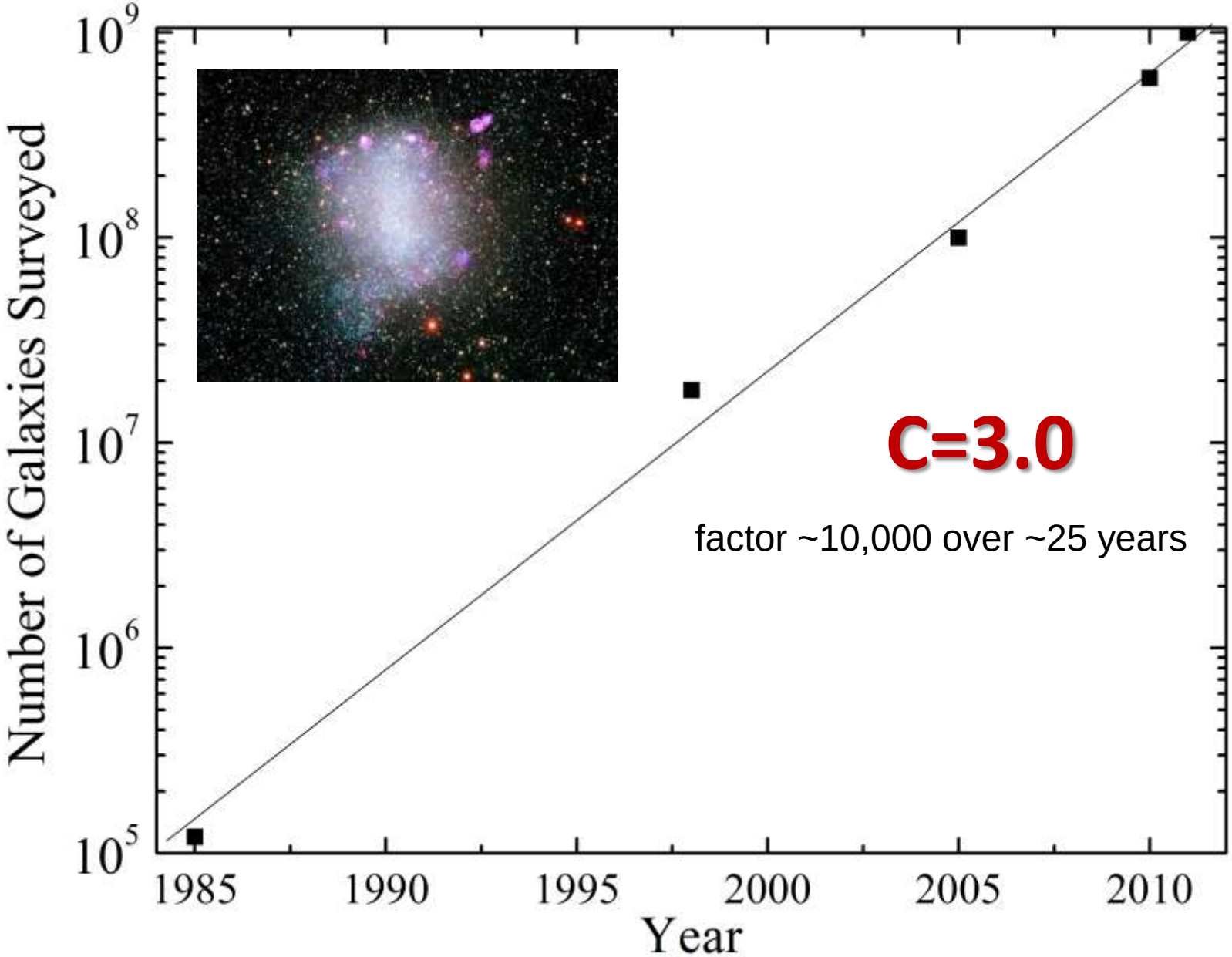
Moore's Law, LEDs, SuperComputers



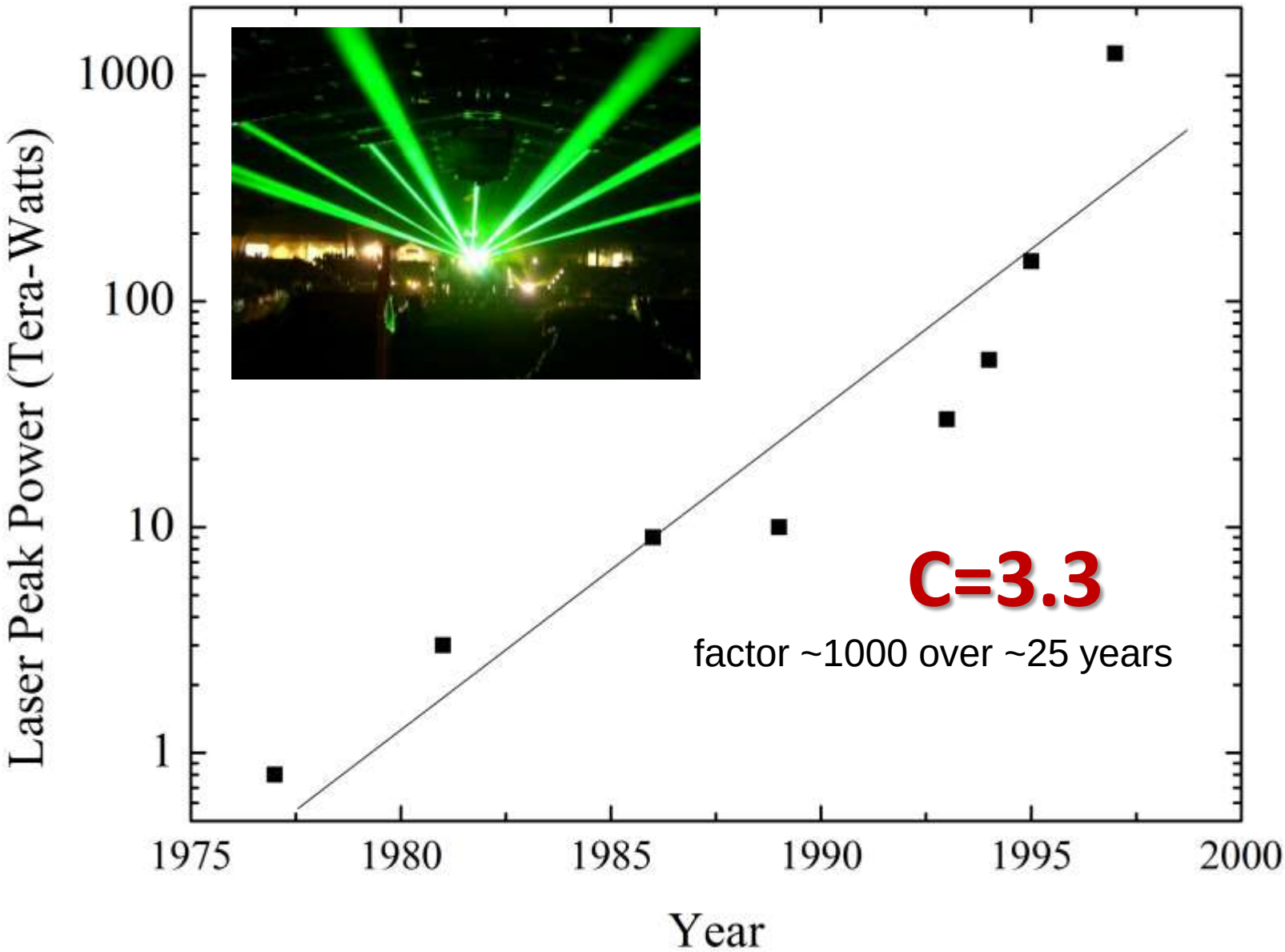


Lomonos

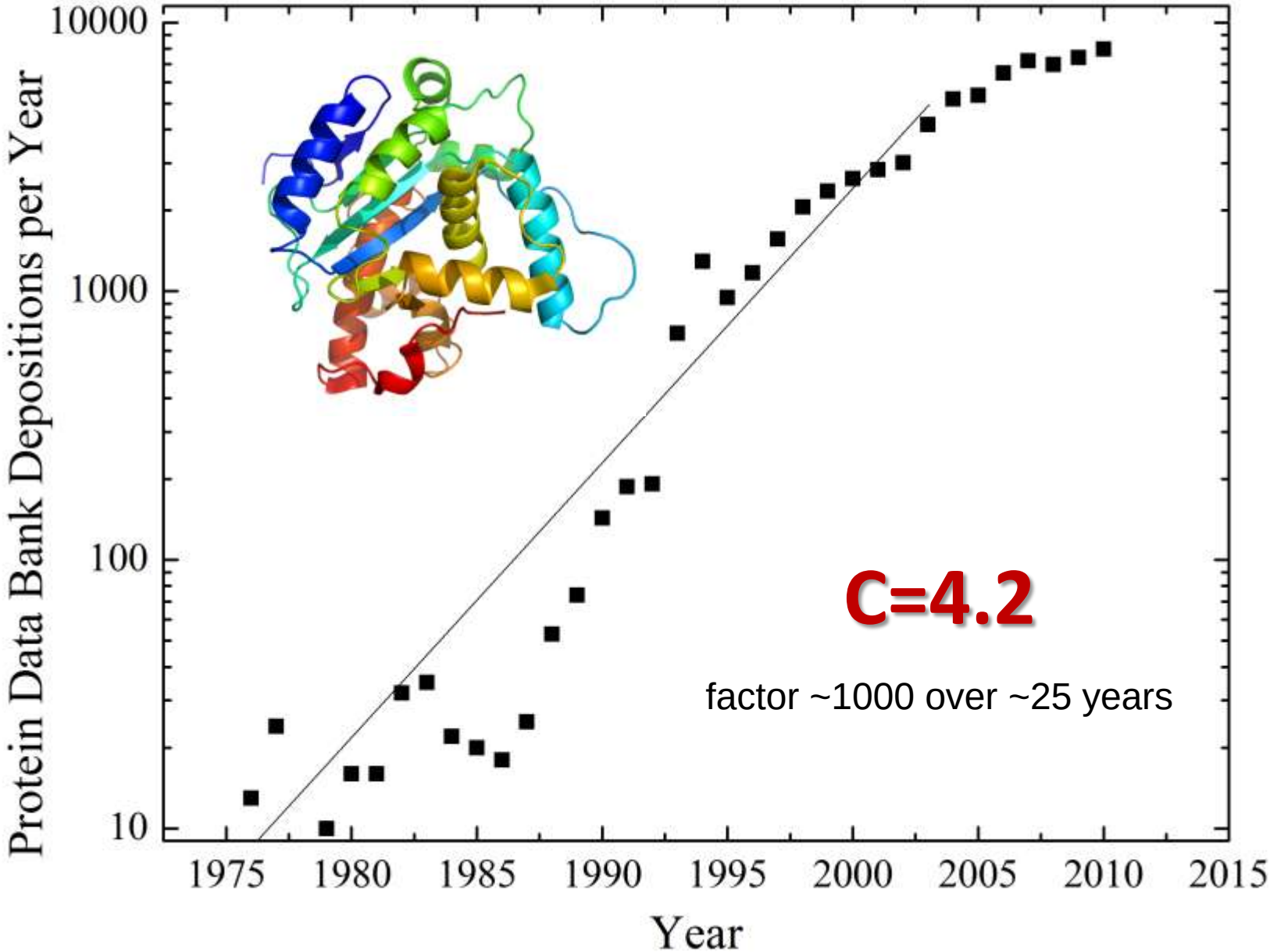
Number of Observed Galaxies



Ultra-High Power Lasers



Protein Structures deposited in PDB



Lon

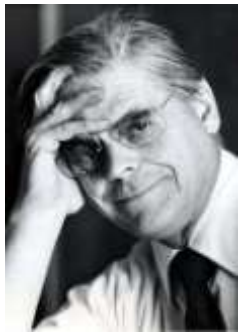
“Complexities” of Sciences

	c
Supercomputers	1.6
Fusion Reactors	2.4
Moore’s law	2.9
Galaxies Surveyed	3.0
LED light	3.3
Laser power	3.3
Protein structures	4.2
Exoplanets search	4.2

POLL #2

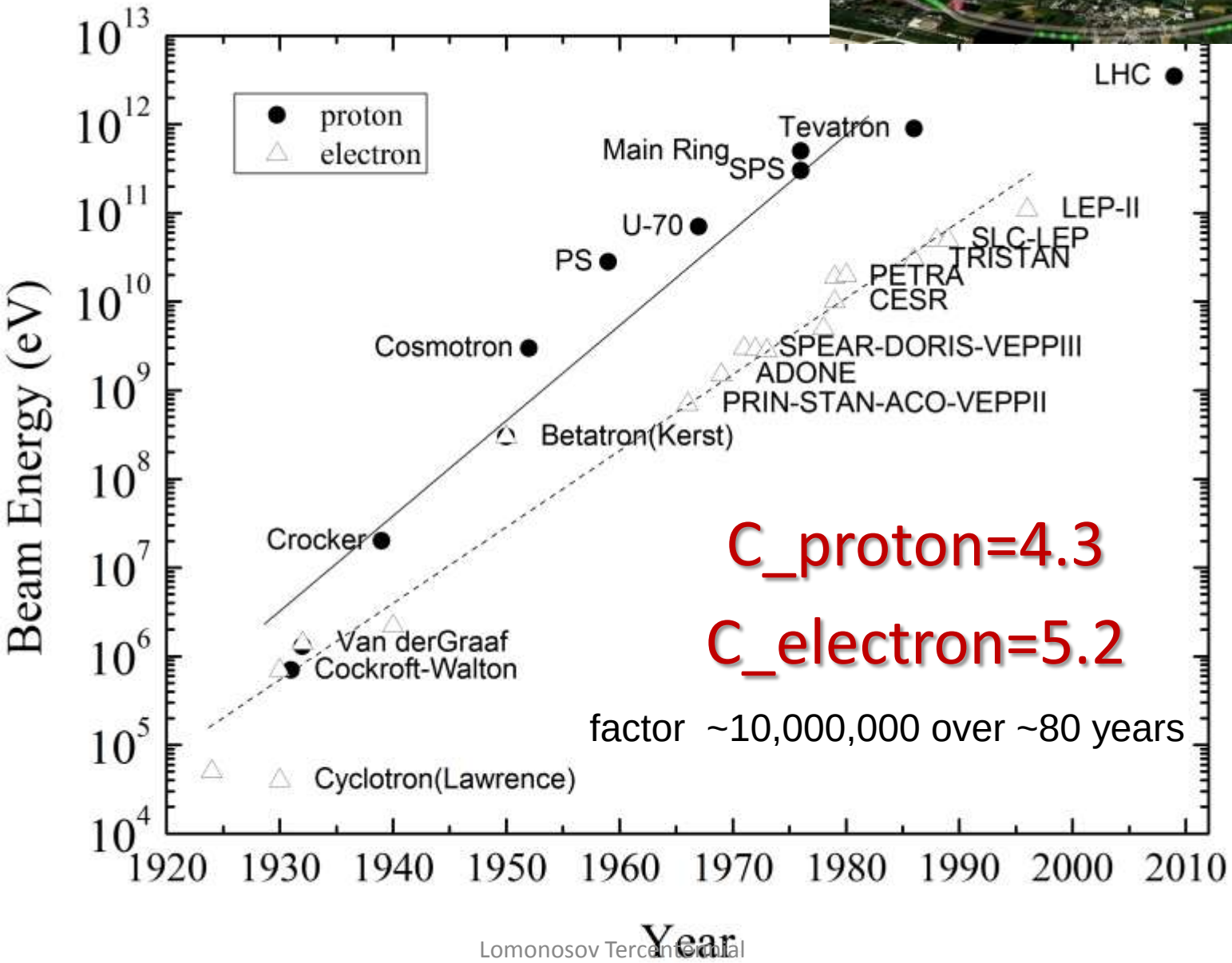
- How many of you think that accelerators are harder (more complex) than “Moore’s Law”?

- How many of you think that accelerators are easier (less complex) than “Moore’s Law”?

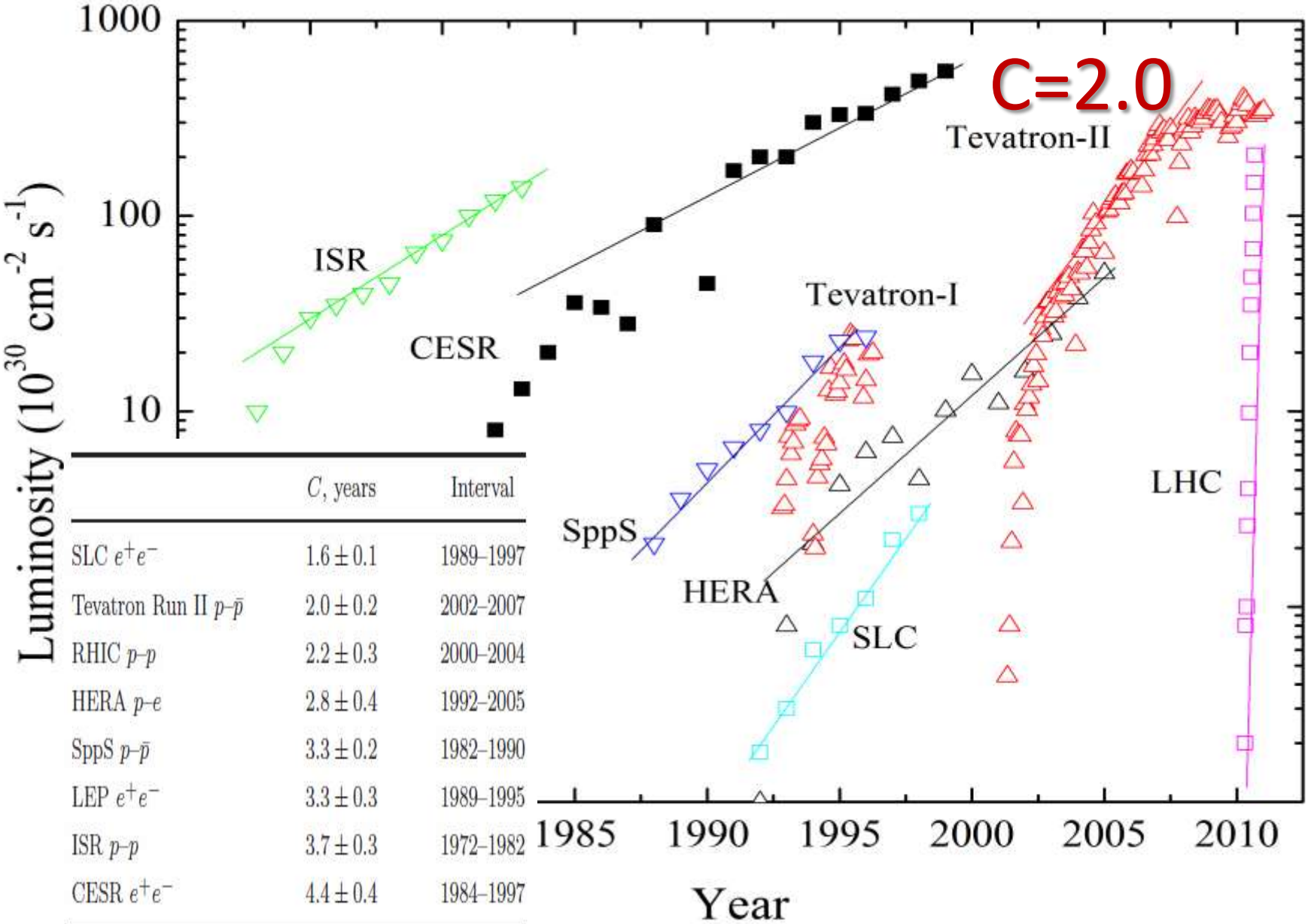


Beam Energy

ALICE
CMS
ATLAS
LHCb


Beam Energy (eV)
Year
proton
electron
LHC
Tevatron
Main Ring
SPS
U-70
PS
Cosmotron
Crocker
Van derGraaf
Cockroft-Walton
Cyclotron(Lawrence)
Betatron(Kerst)
PRIN-STAN-ACO-VEPPII
ADONE
SPEAR-DORIS-VEPPIII
CESR
PETRA
TRISTAN
SLC-LEP
LEP-II
C_proton=4.3
C_electron=5.2
factor ~10,000,000 over ~80 years

Record Luminosity of Colliders

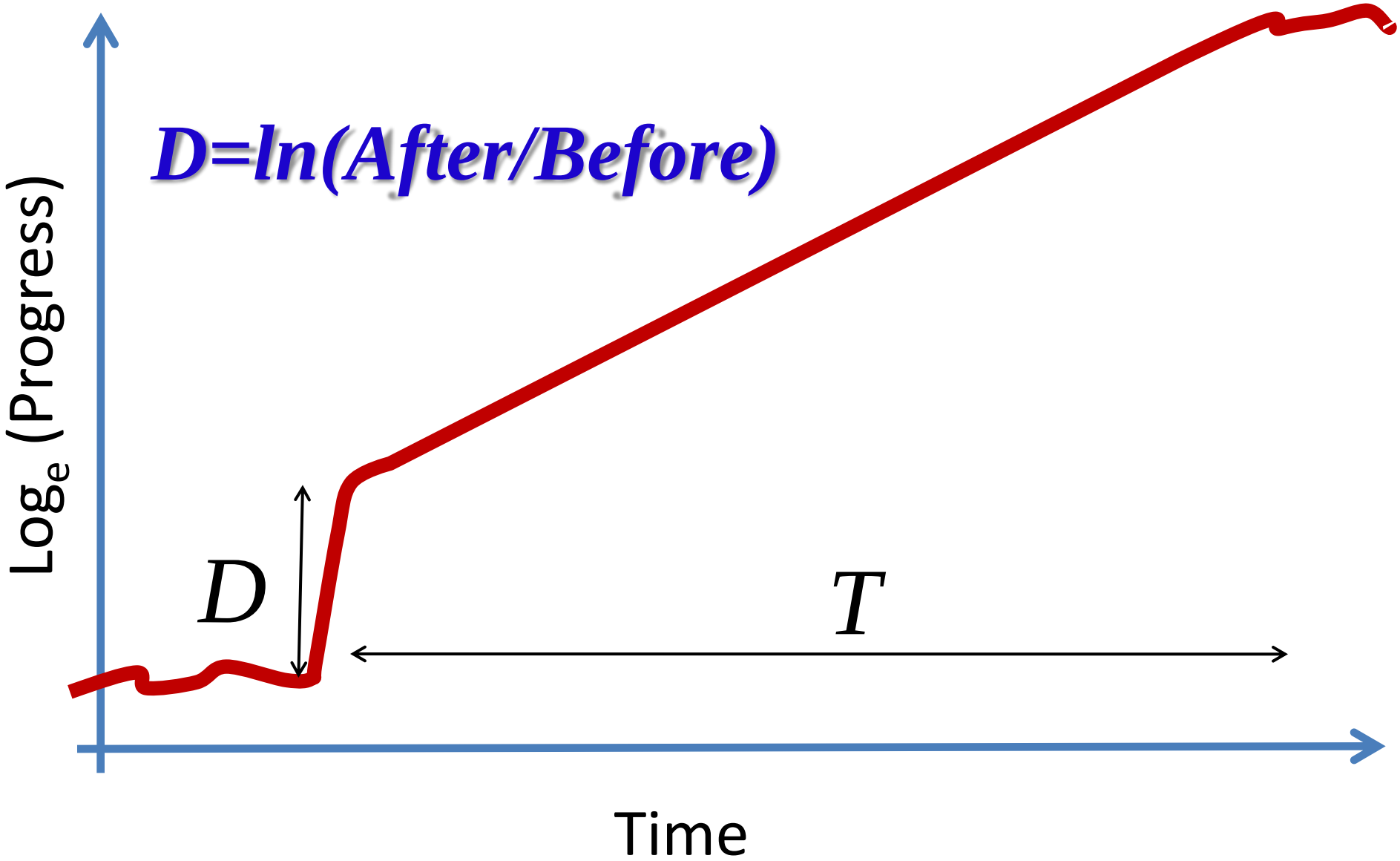


	C, years	Interval
SLC e^+e^-	1.6 ± 0.1	1989–1997
Tevatron Run II p–$\bar{p}$	2.0 ± 0.2	2002–2007
RHIC p–p	2.2 ± 0.3	2000–2004
HERA p–e	2.8 ± 0.4	1992–2005
SppS p–$\bar{p}$	3.3 ± 0.2	1982–1990
LEP e^+e^-	3.3 ± 0.3	1989–1995
ISR p–p	3.7 ± 0.3	1972–1982
CESR e^+e^-	4.4 ± 0.4	1984–1997

Back to Moore's Law – Who Started it?

1947 Bardeen, Brattain

"Genius Effect"



To be able to compare historical figures, more useful is:

"Genius Formula"

$$Genius = T \times B \times D$$

ln(Time)

duration of impact

Breadth

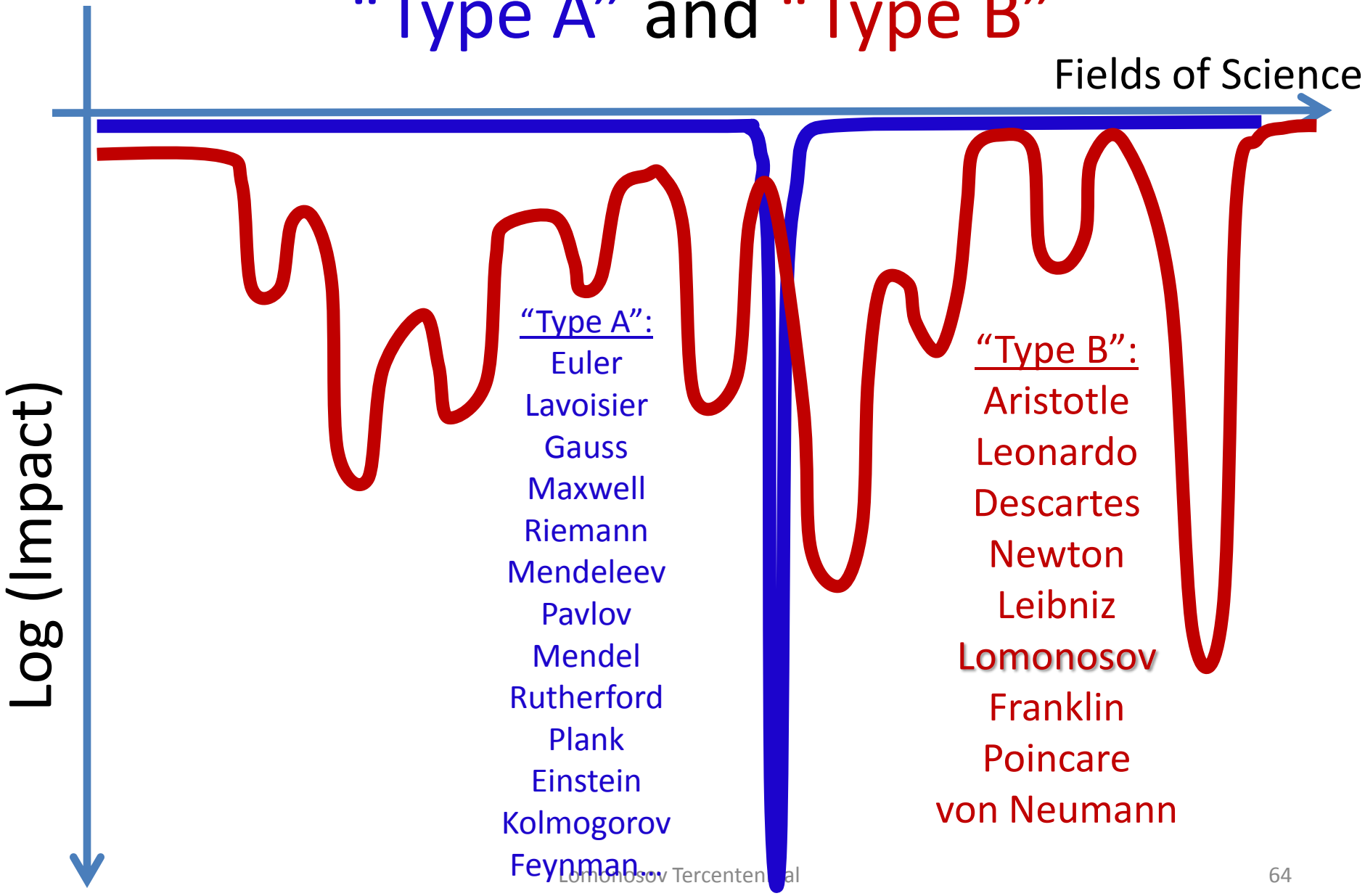
# of areas

Depth

of impact

=*ln*(After/Before)

"*B*-factor" Scientific Geniuses: "Type A" and "Type B"



Lomonosov's *G*:

- Grammar $\ln(100 \text{ yrs}) \times \ln(2) = 3$
- Poetry $\ln(60 \text{ yrs}) \times 1/3 = 1.3$
- Chemistry $\ln(20\text{yrs}) \times 0.1 = 0.3$
- Optics $\ln(100 \text{ yrs}) \times 1/20 = 0.2$
- Venus $\ln(60 \text{ yrs}) \times 1/5 = 0.8$
- Geography $\ln(60 \text{ yrs}) \times 1/4 = 0.9$
- History $\ln(250 \text{ yrs}) \times 1/10 = 0.5$

TOTAL $G = 7 \pm 2$

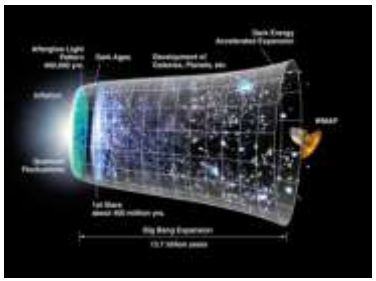
Genius Coefficients $G = T \times B \times D$

- Scientist(me) **~0.03**
- Inventors **0.1-2**
- Nobelists **0.3-4**

- Pithagoras, Aristotle, Newton,Lomonosov, Einstein **4-9**
- Sheakespeare, Pushkin **7-12**

$ln(7519yrs) \times 6 \times ln(10)$

- **Biblical God** **123**
- **Big Bang** **300-650**

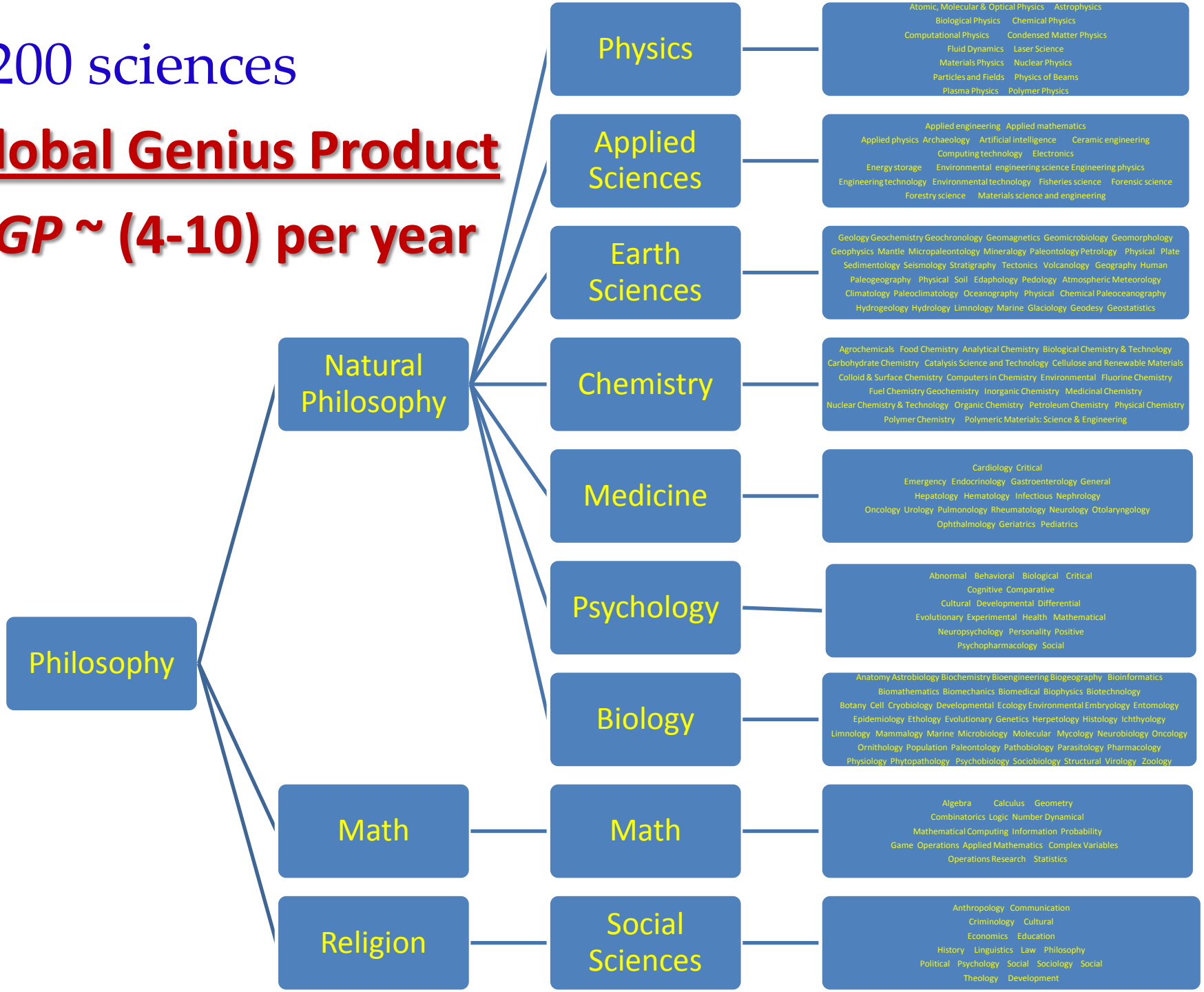


$ln(14\ BYrs) \times ln(10^6)$

~200 sciences

Global Genius Product

GGP ~ (4-10) per year



Limitations of the "Genius Formula"

$$ln(T) \times B \times ln(After/Before)$$

- how to account geniuses in art, music, etc?
- Baseline choice issue
  - eg (my) family of 4 with two kids
  - by my definition

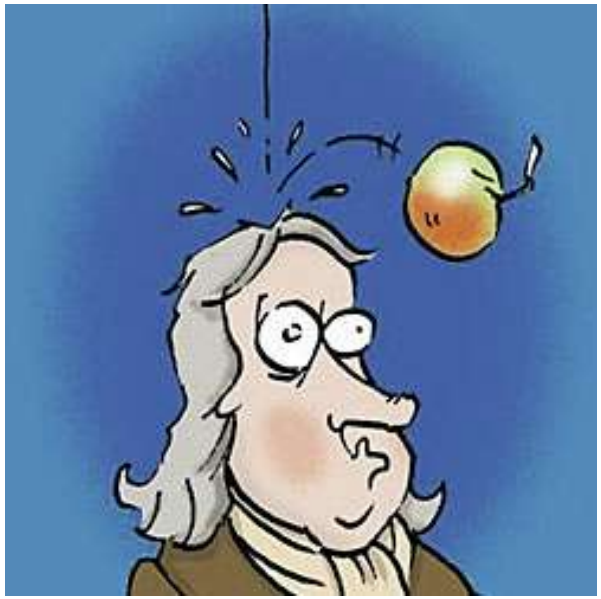
$G = ln(13yrs) \times 2kids \times ln([7B+1]/7B) = 1 \times 10^{-9}$

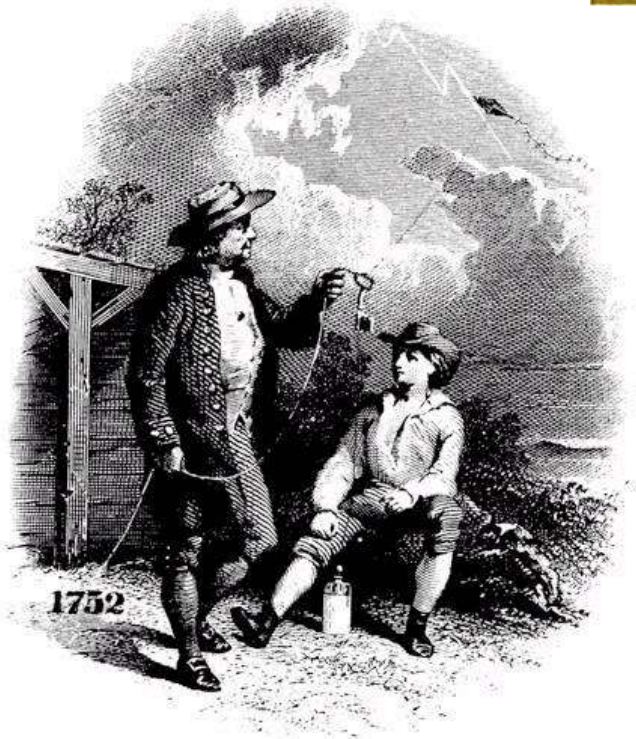
  - by (my wife's) definition

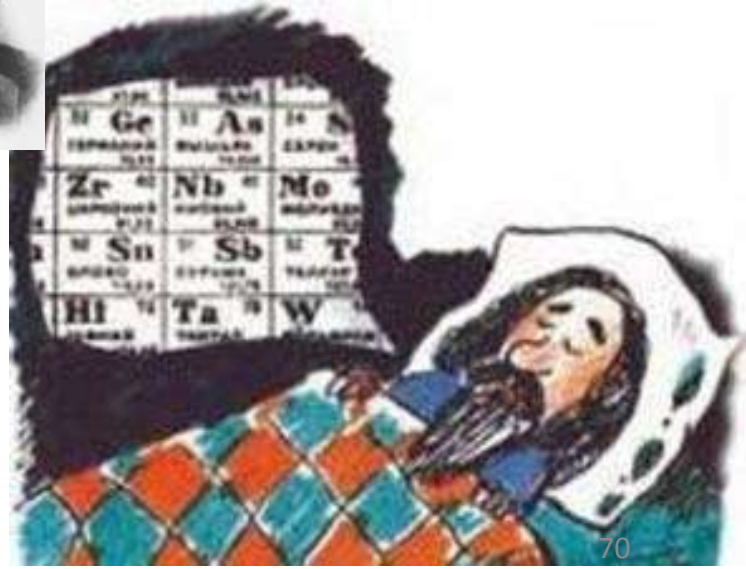
$G = ln(13yrs) \times 2kids \times ln(4/2) = 3.5$

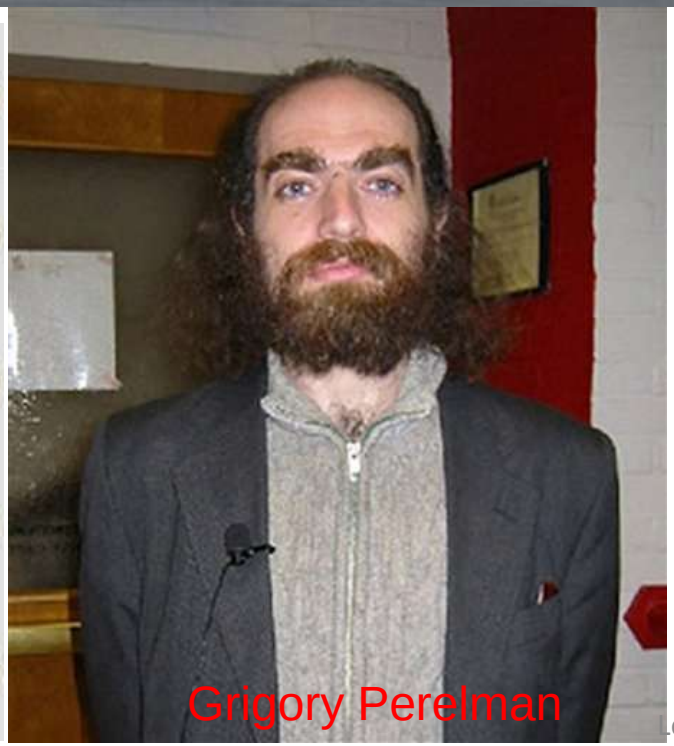
Other Characteristics of a Genius

Every Genius Has (Impressive) Story!









Grigory Perelman

Proved soul theory of manifolds 1994
Declined European Math Prize 1996
Solved Poincare Conjecture 2002
Declined Fields Medal 2004
Declined 1M$ Clay Prize 2010
Refused Academy Position 2011

German hussars enlist drunk Lomonosov to the service of the King of Prussia

Lomonosov's prophetic dream about his father

Three sailors' attempt to rob Lomonosov

Another Sign of Genius: Rebelliousness

Petr Kapitsa, USSR

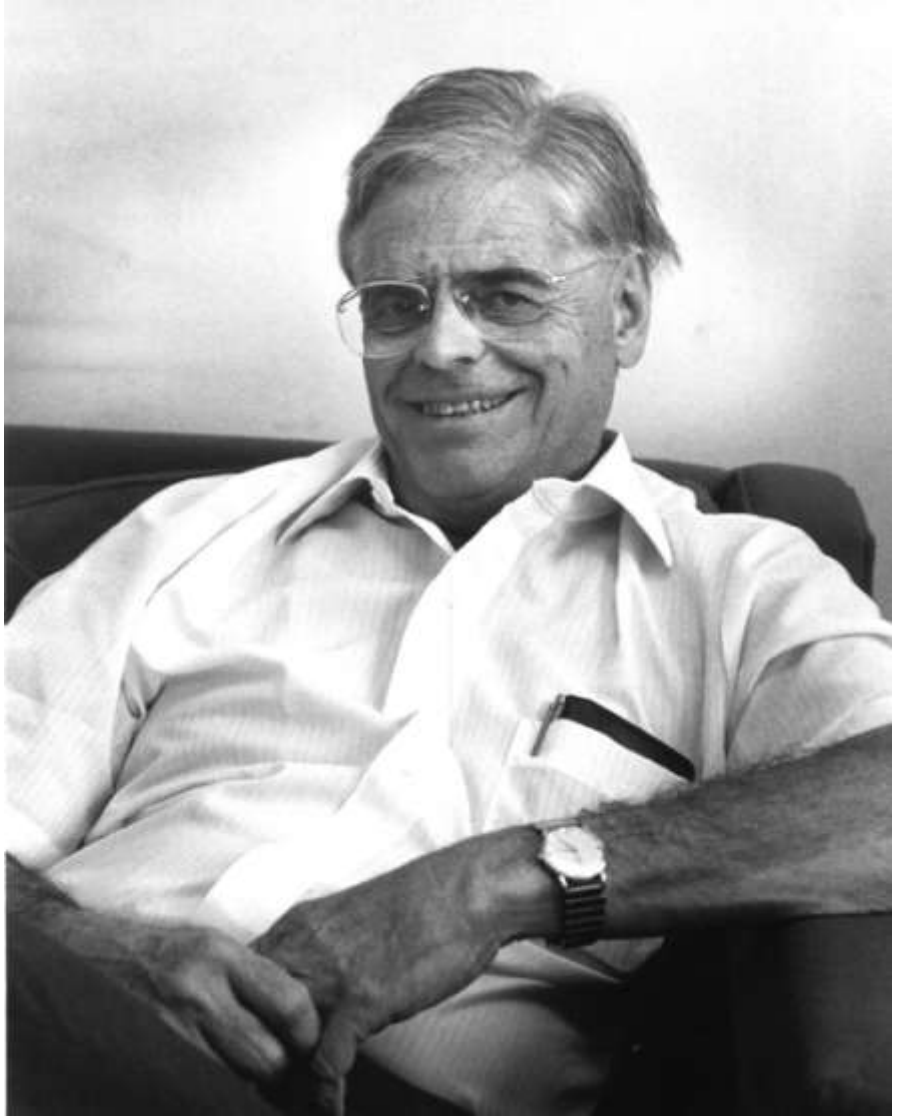
1978 Nobel Prize

Superfluid Helium

- Kapitsa On Geniuses:
  - Lomonosov vs Schumacher
  - Michelangelo and Medici
  - Kapitsa himself and Beriya

Robert R. Wilson

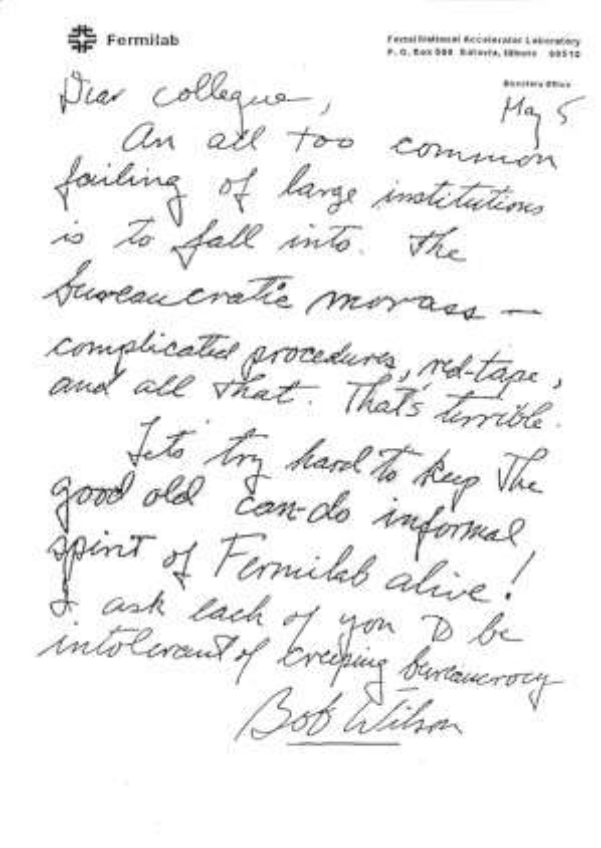
(1914–2000)



Accelerator director quits over cash shortage

The Universities Research Association, which runs the US Fermi National Accelerator Laboratory (Fermilab), has accepted the resignation of Dr Robert R. Wilson. Wilson, Fermilab's director, quit as a protest against the US government's refusal to fund the early completion of equipment to raise the proton beam energies at the accelerator.

New Scientist 2 March 1978



Fermilab

Fermi National Accelerator Laboratory
P. O. Box 500 Batavia, Illinois 60510

Director's Office

May 5

Dear colleague,

An all too common failing of large institutions is to fall into the bureaucratic morass — complicated procedures, red-tape, and all that. That's terrible.

Let's try hard to keep the good old can-do informal spirit of Fermilab alive! I ask each of you to be intolerant of creeping bureaucracy

Bob Wilson

Final Words…

- The system of entire humankind is very complex
  - Both in terms of hierarchy of connections and *C*-coefficients
- We see that it is progressing, moving somewhere
  - Generates new knowledge, ideas, arts, inventions, etc
- It's not fully clear yet how world's genius (GGP - global genius product) is created
  - it is hard to get there, so we should not lose positions
  - advanced society is needed for genius to appear
  - on the other hand, geniuses do transform the society
- To understand who we are, we must comprehend our geniuses of a type of Galileo, Newton, Einstein, Leibniz, Franklin, and Lomonosov

With that –

I congratulate all of us with 300th anniversary of **Mikhail Lomonosov !**

Thank you for your attention!