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“Gamowian” Table Talk

Some “Big Science” Puzzles

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(FNAL, Chicago)

CERN Machine Advisory Committee

RASA-USA Conference, Nov. 7-8, 2015 r



Lunch table chats, stories...



Russian Dolls round table in cafeteria –
present of Soviet physicists to Fermilab, 1975

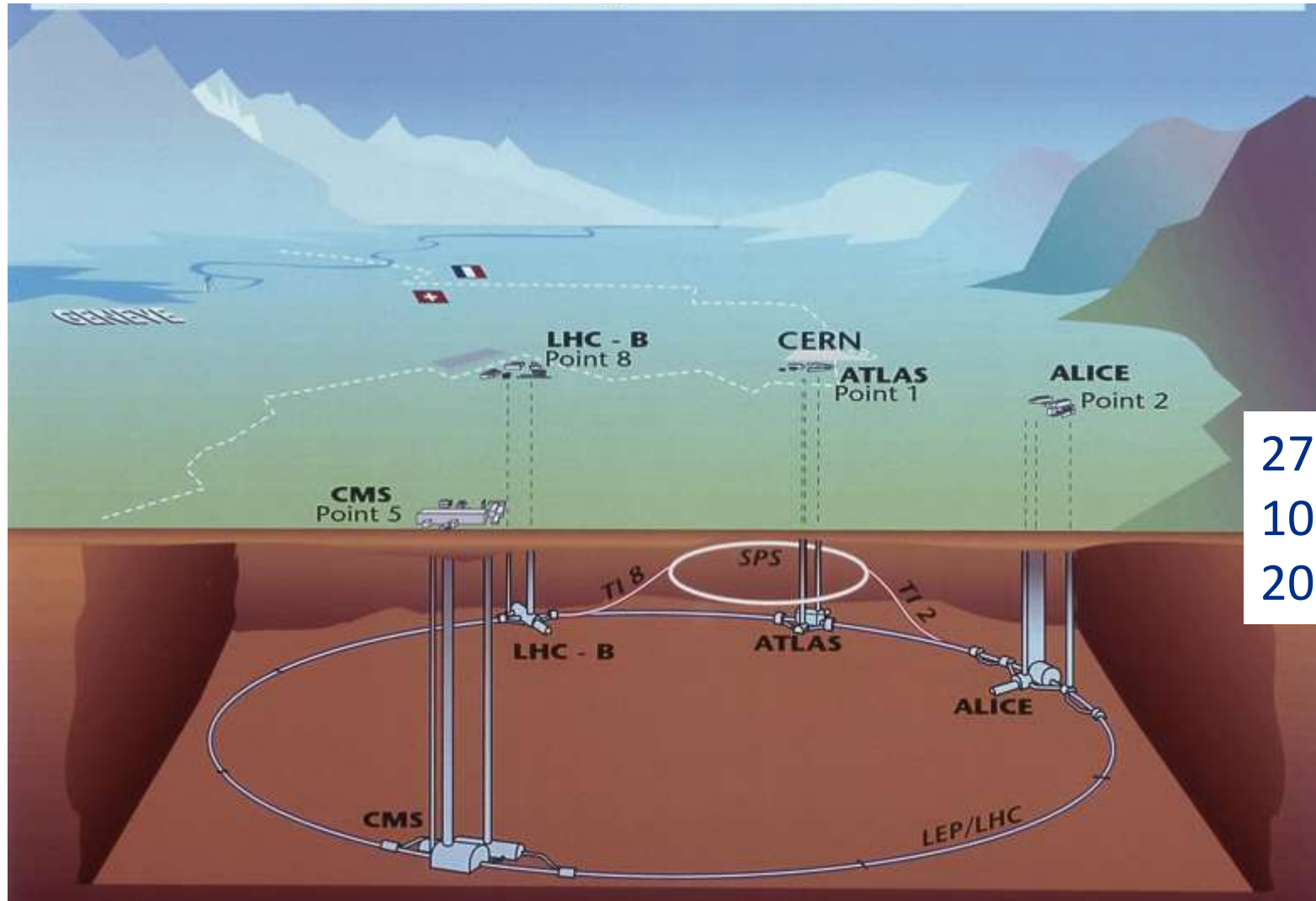
“Unproven and Controversial” - I

**Strange Bumps in the LHC
Data**

LHC=Large Hadron Collider

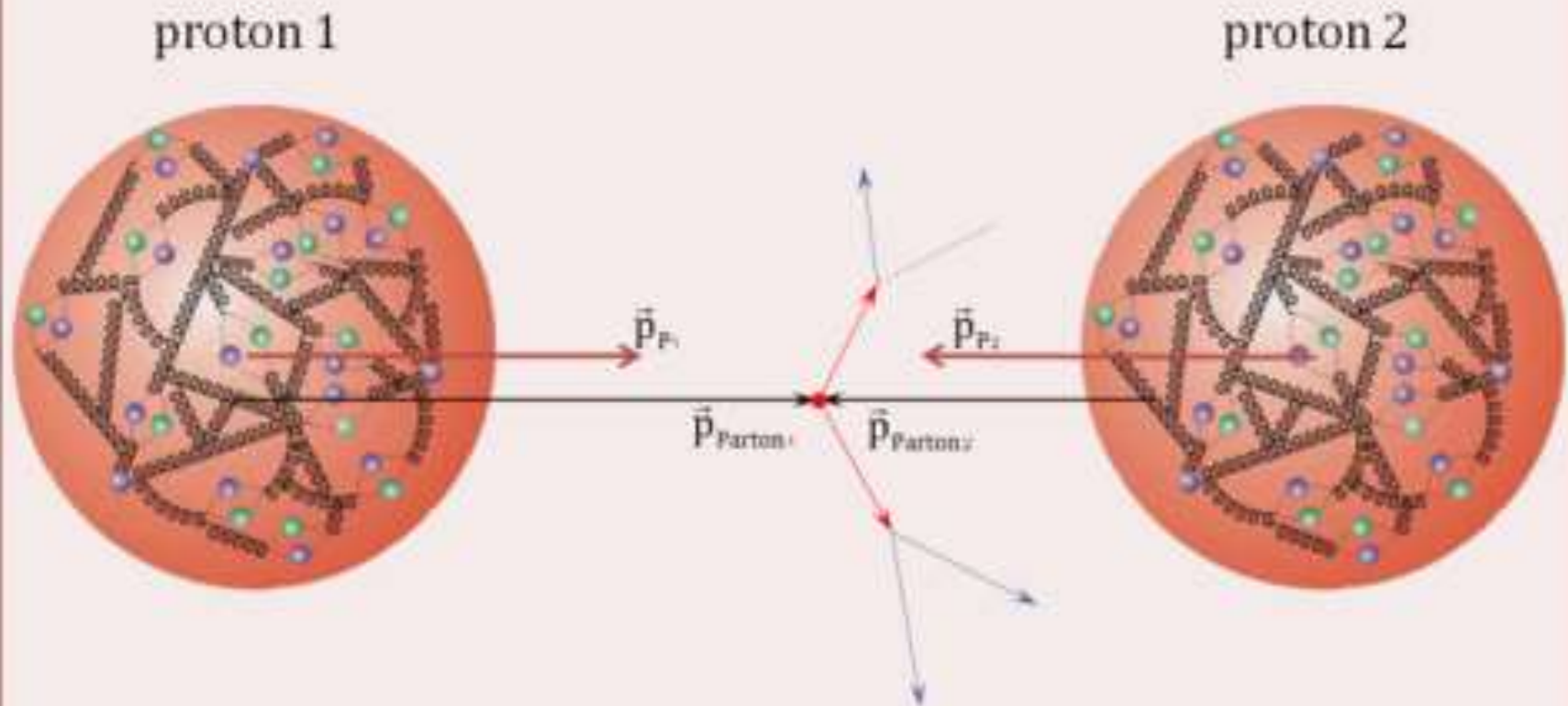
record high particle collision energy

13,000,000,000,000 electron-Volt=13 TeV



27 km circmf.
100 m deep
2008... -2035?

Interactions of constituents of the colliding protons, the so called partons (quarks, gluons)



$\vec{p}_{P_1}$... momentum proton 1

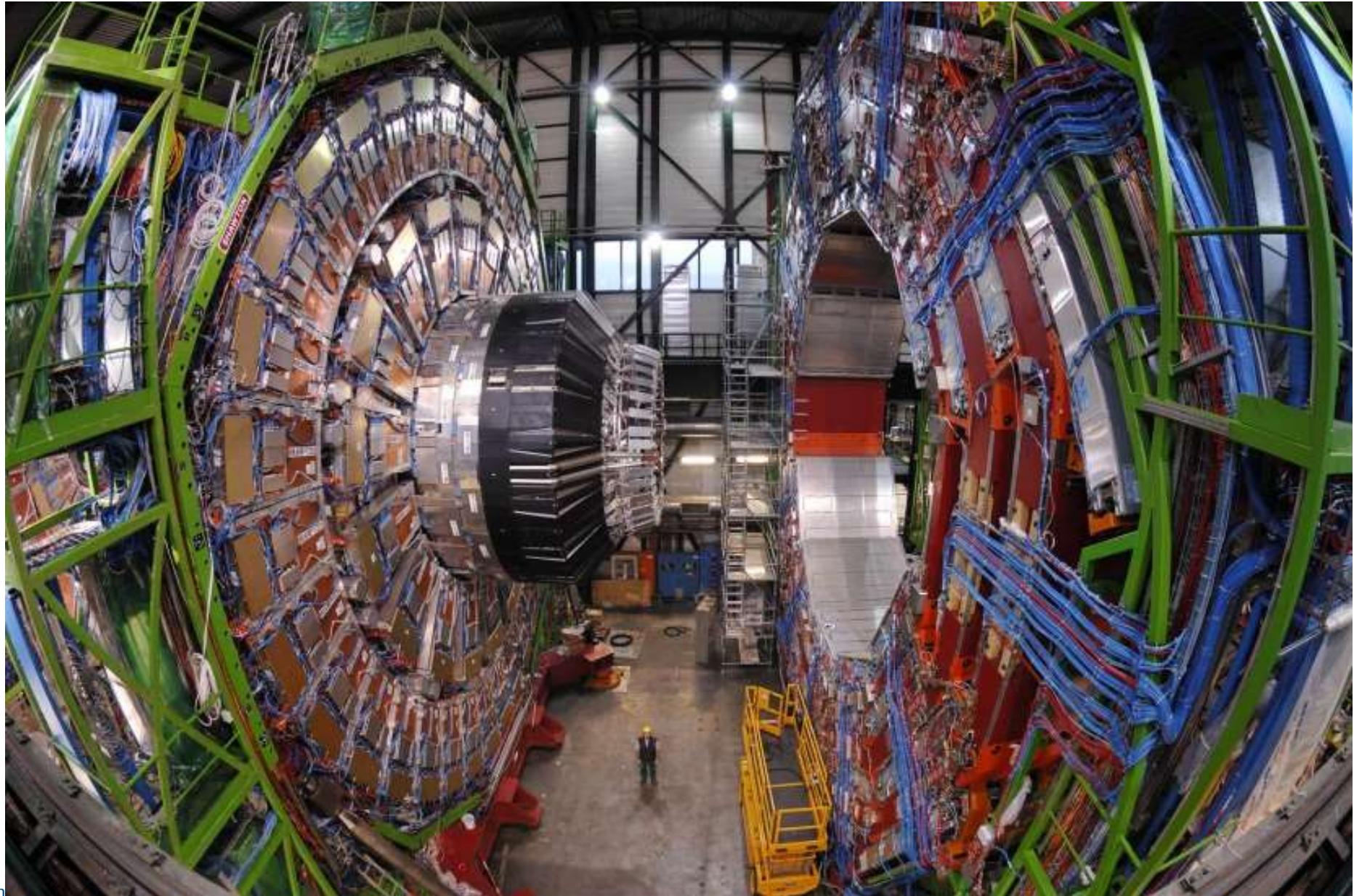
$\vec{p}_{P_2}$... momentum proton 2

• interaction vertex

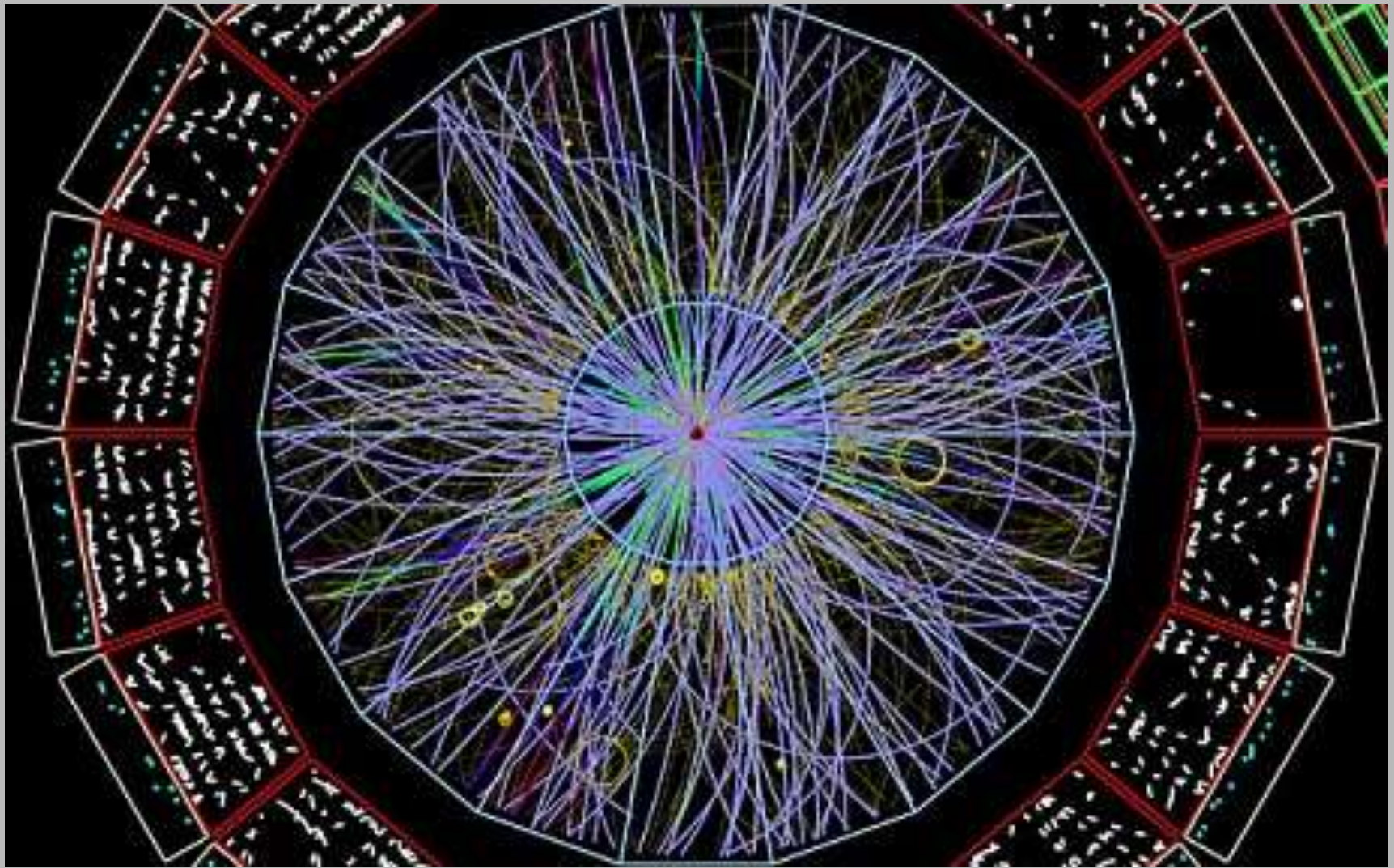
$\vec{p}_{Parton_1}$... momentum parton 1

$\vec{p}_{Parton_2}$... momentum parton 2

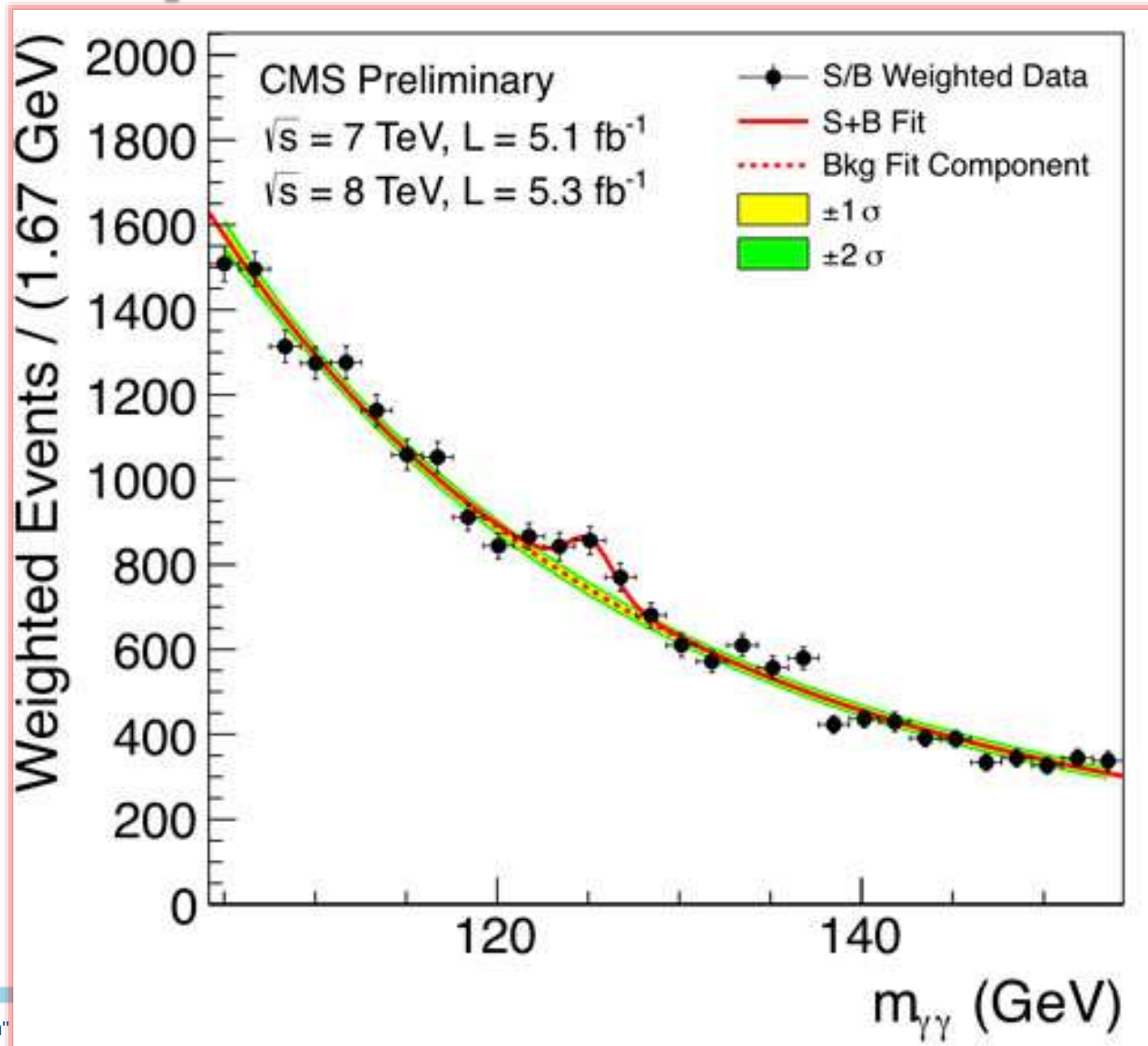
Particle Detectors: CMS & ATLAS



40,000,000 times a second



“Bumps” in Data ($\# \text{ events @ } E$)

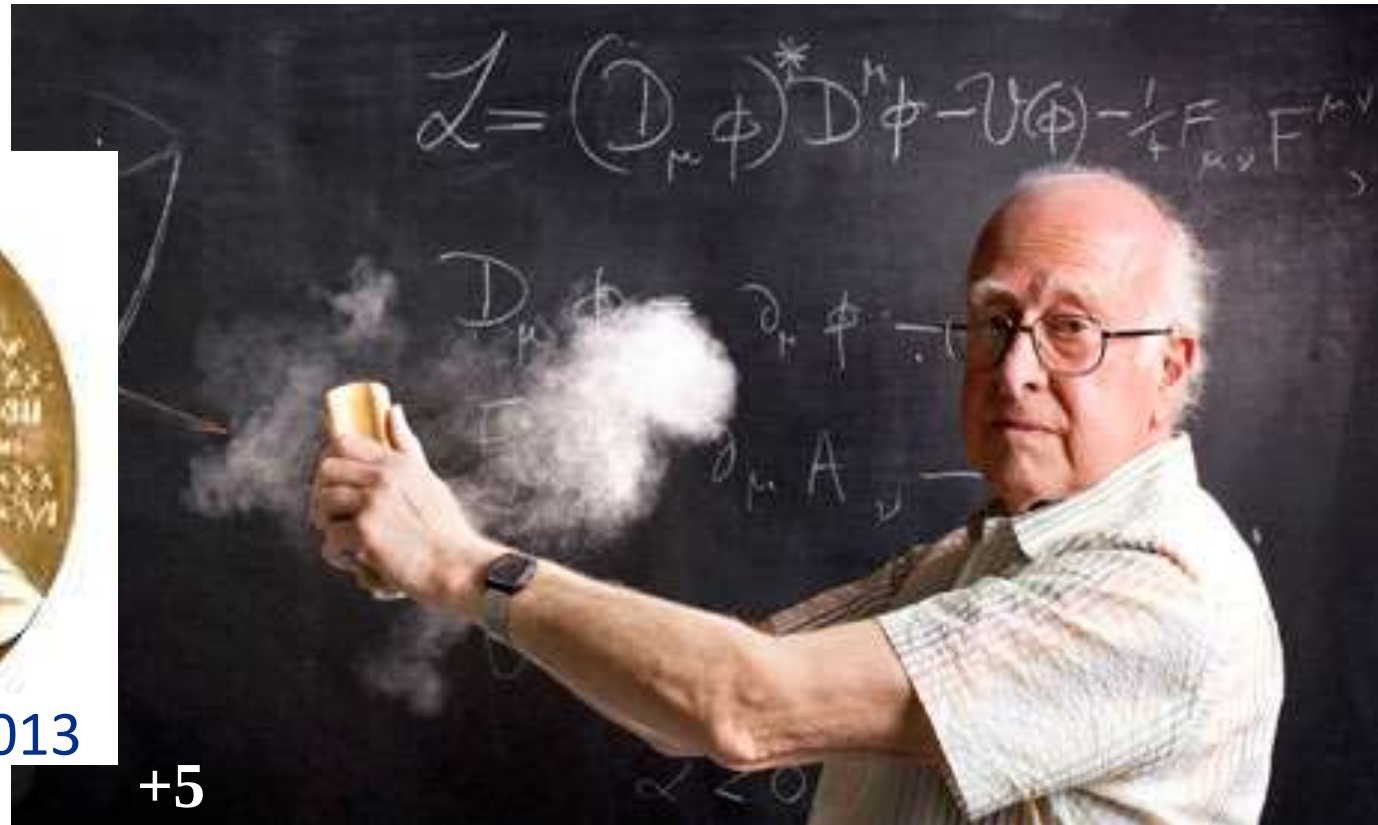


Recent important discovery: Higgs Boson, $m=125$ GeV (2012)



2013

+5



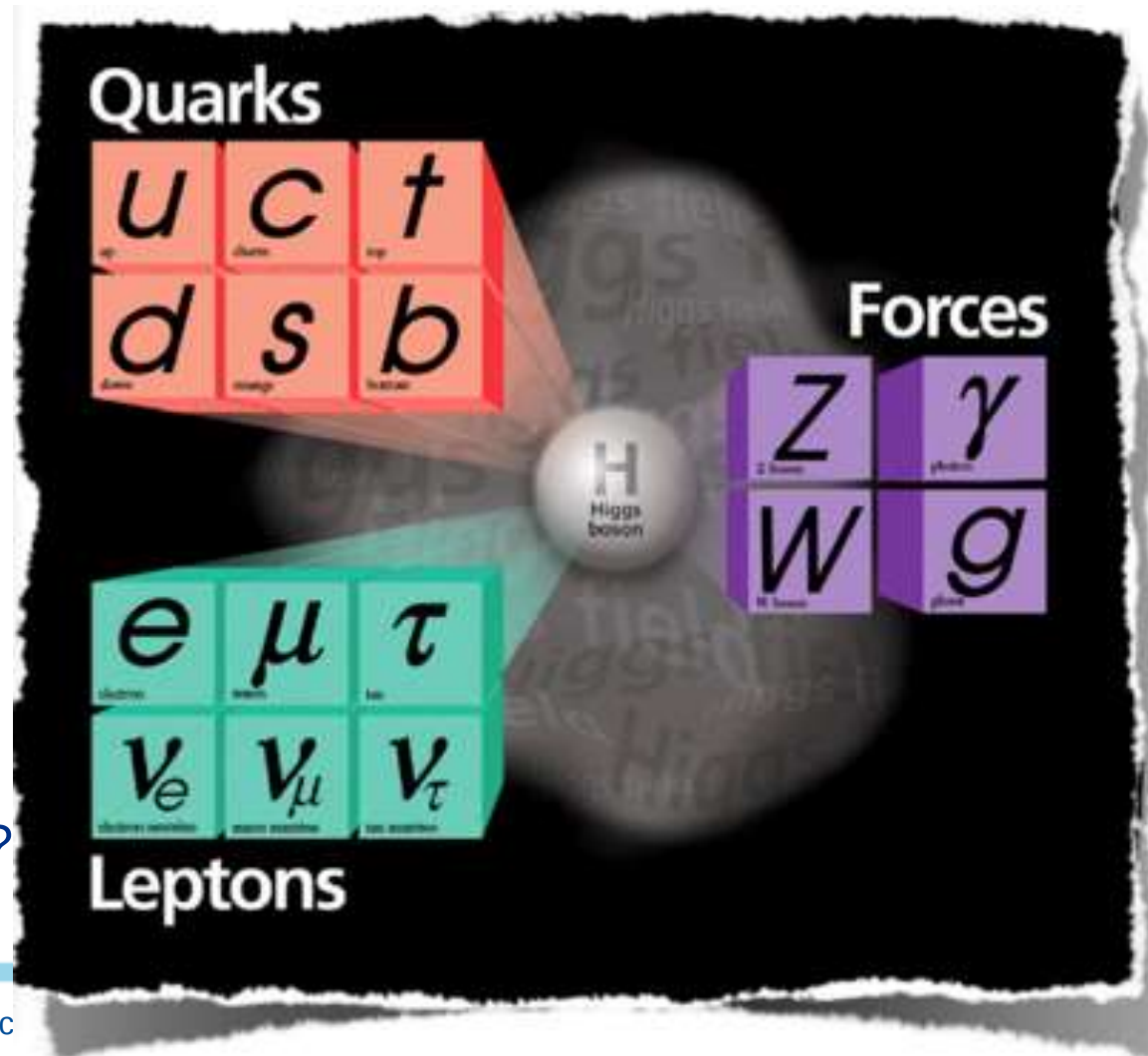
The “Higgs” – Last Missing Piece of The Standard Model of Particle Physics

The **Standard Model** describes the fundamental particles that we know about and the forces that govern their interactions.

The SM has been extraordinarily successful in describing nature. **HAPPY?**

NO! WHY?:

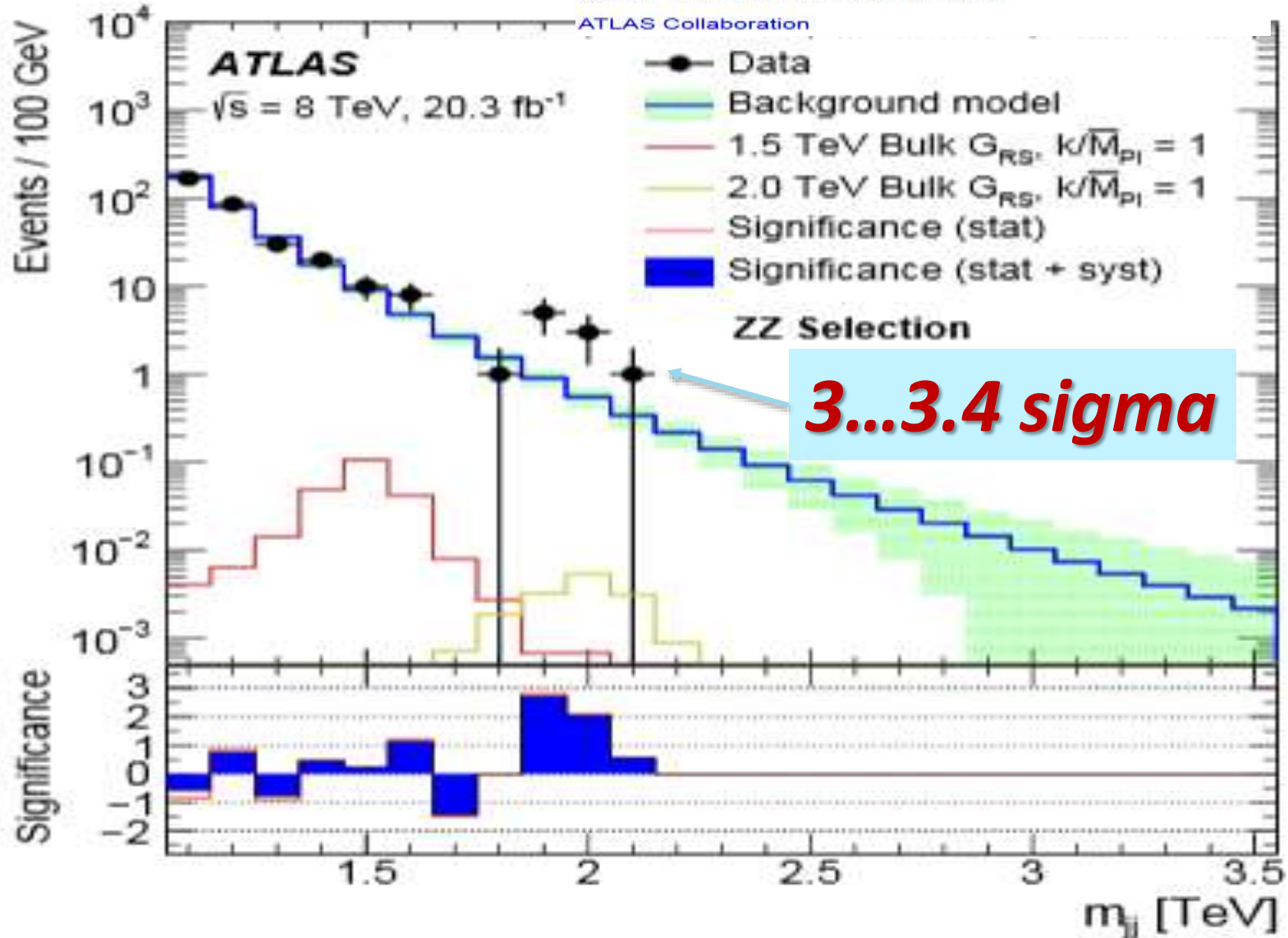
- Too many - 17 - elementary particles - !??
- Dark energy? Dark matter?
- Gravitation ?



Summer 2015: “Fuss” on LHC bumps

- arXiv:1506.00962

Search for high-mass diboson resonances with boson-tagged jets in proton-proton collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector



“3/4/5 Sigma”

In physics – *probability of mistake*

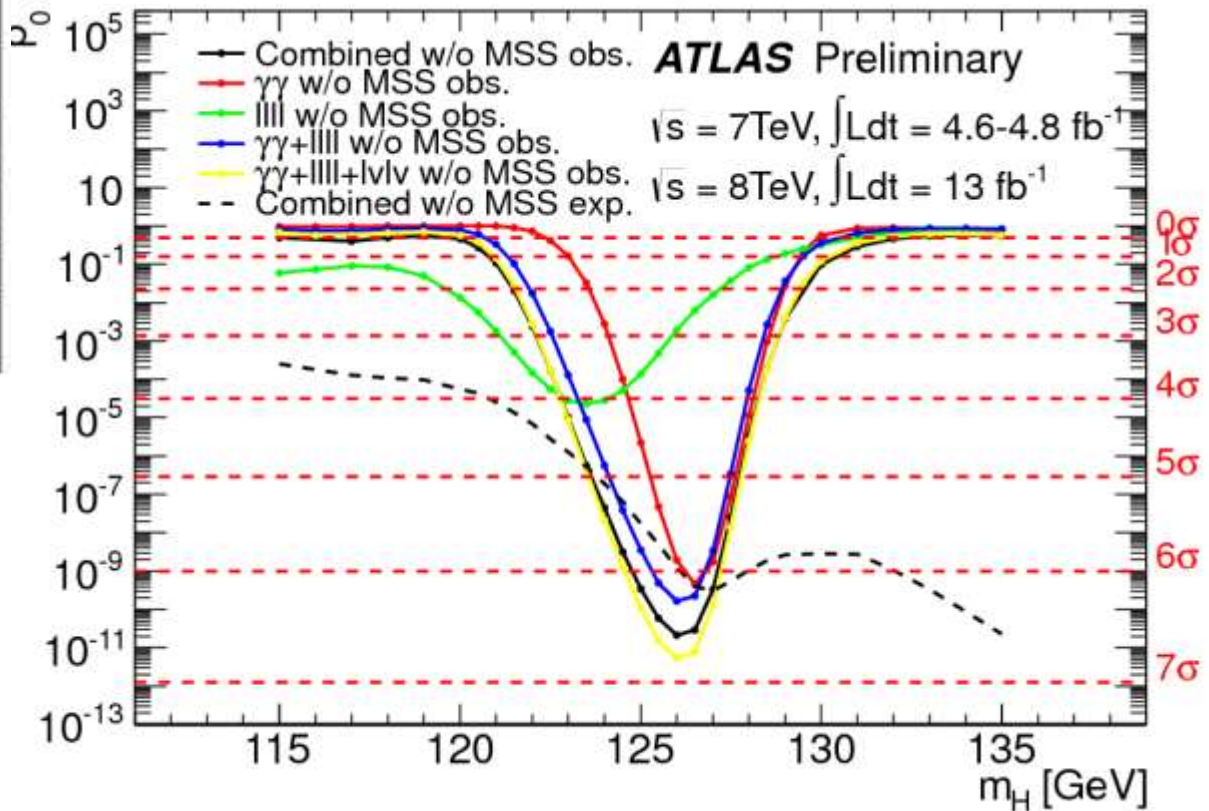
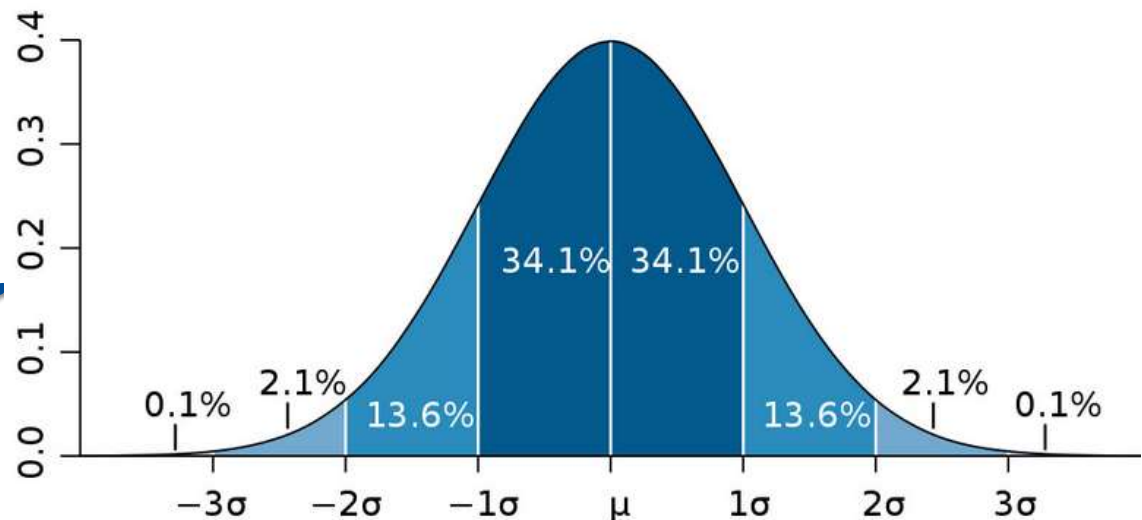
Sigma-Level	Alpha-Level
1	0.3174
2	0.0455
3	0.0027
4	0.0000633
5	0.00000057

3 σ – “*observation*”

5 σ – “*discovery*”

- Example

Higgs Boson $\sim 7 \sigma$



Are these “bumps” real?

Need more data to improve statistics (from 3 sigma $\rightarrow$ 5 sigma)

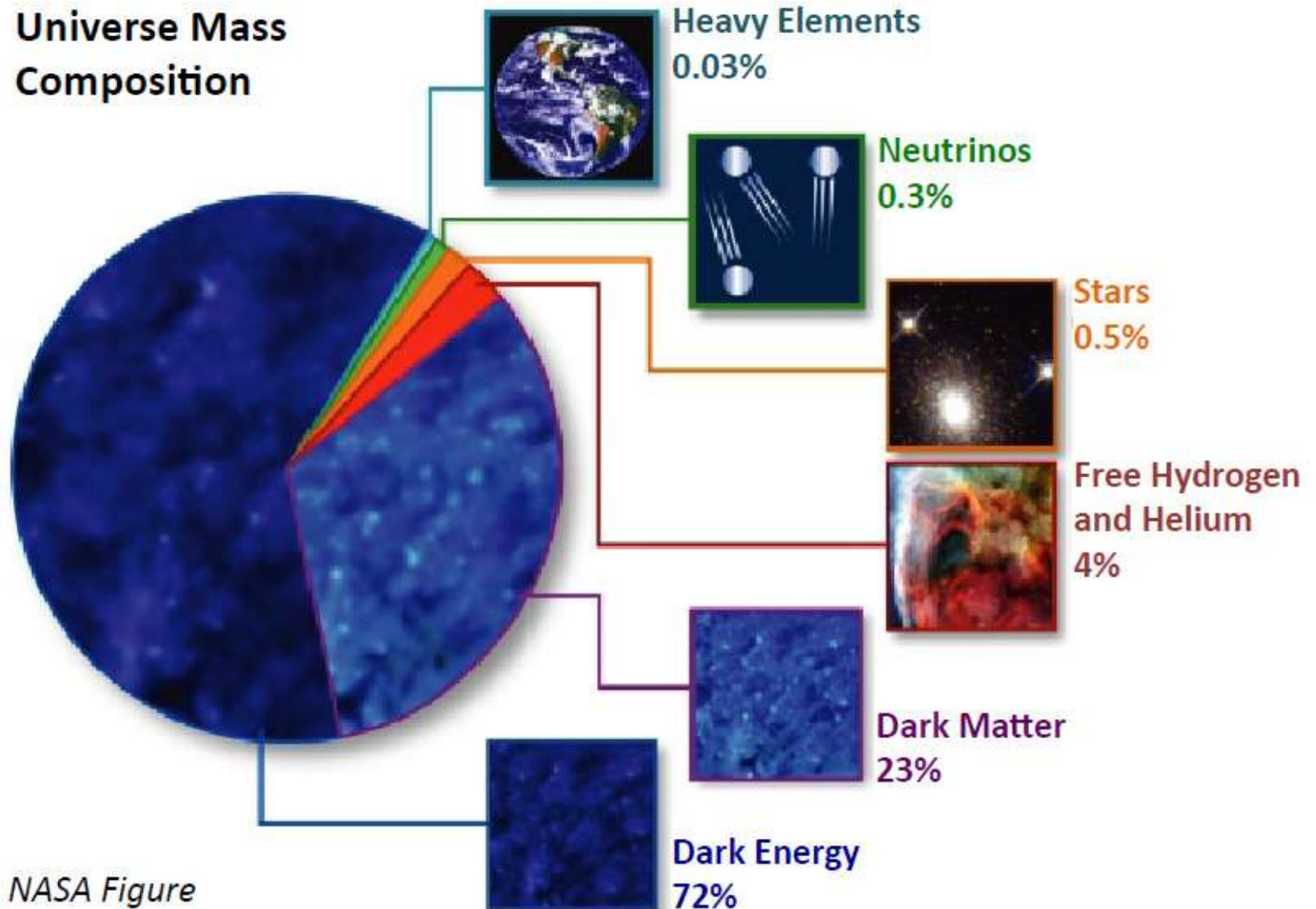
About 2 more years of data taking?

Stay tuned...

“Unproven and Controversial” - II

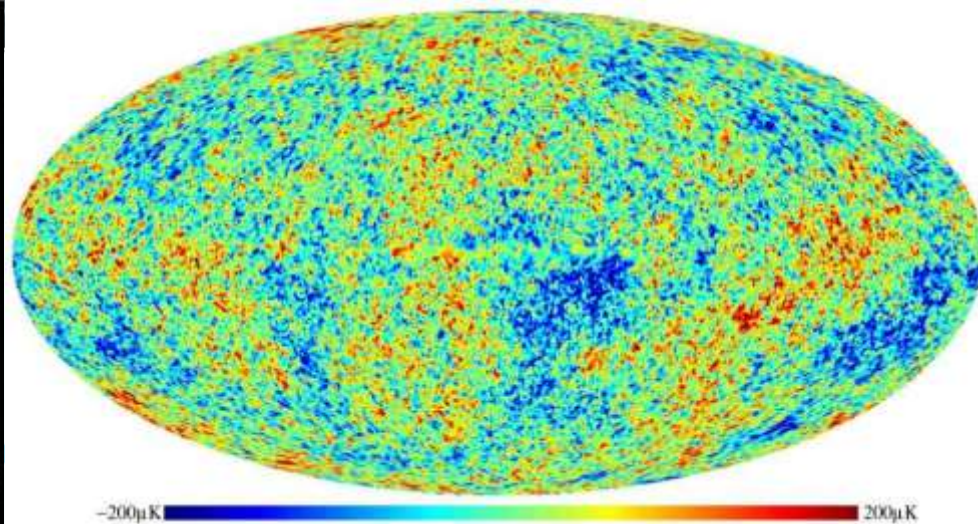
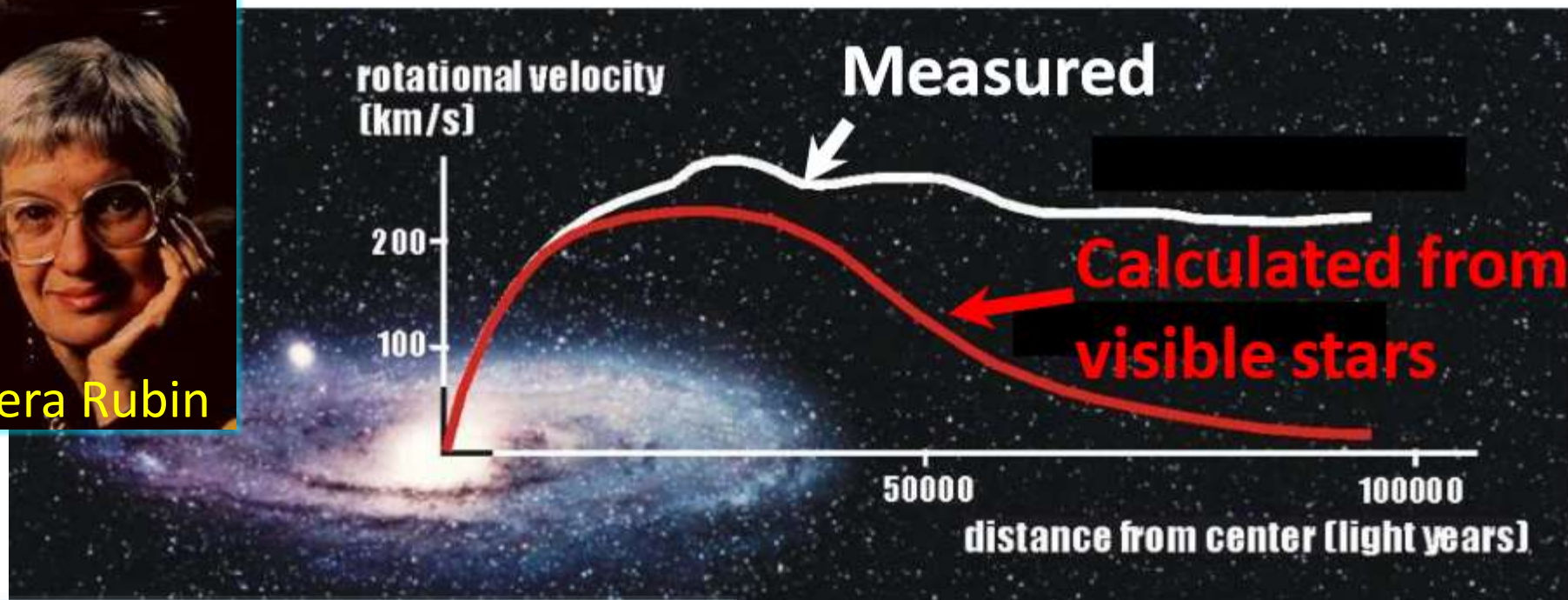
Dark Matter Search

Universe Mass Composition



NASA Figure

DARK MATTER : #1 “It Exists”

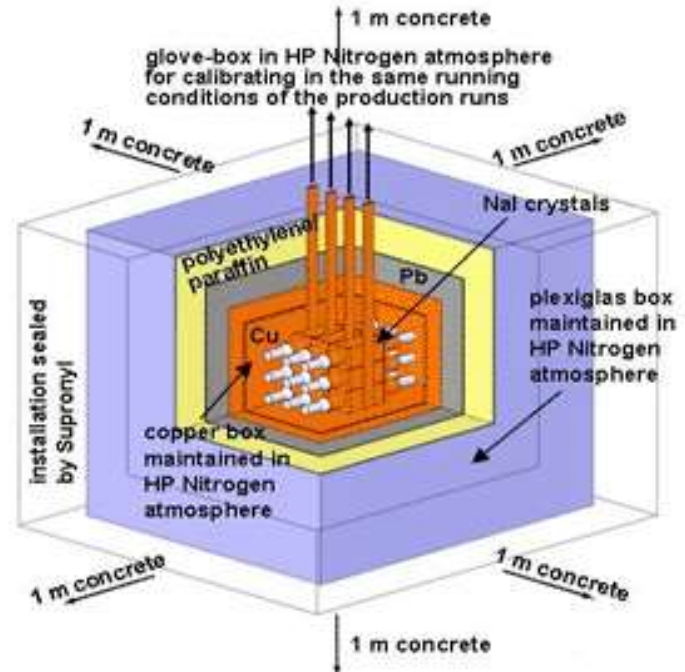
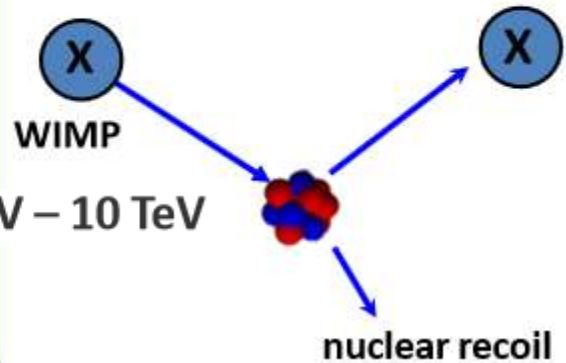


DAMA/LIBRA

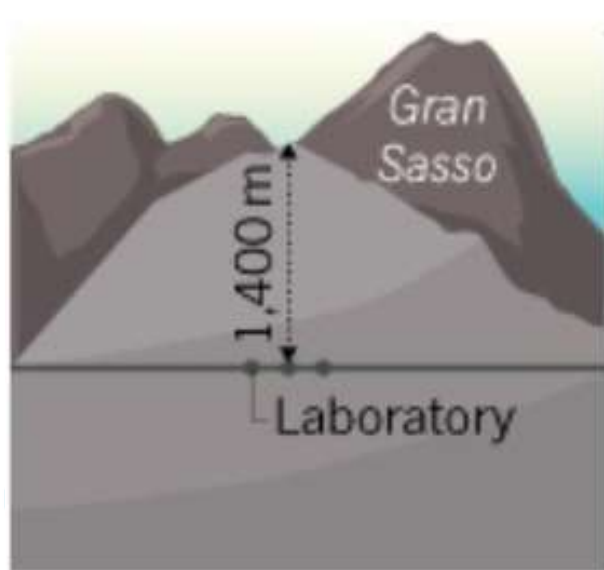
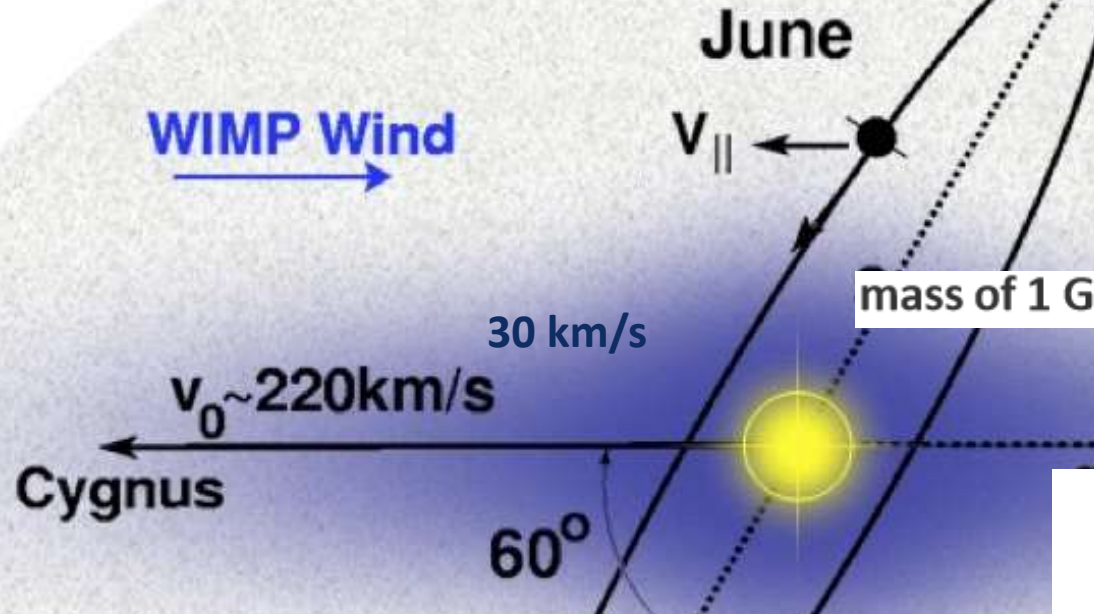
Direct Searches

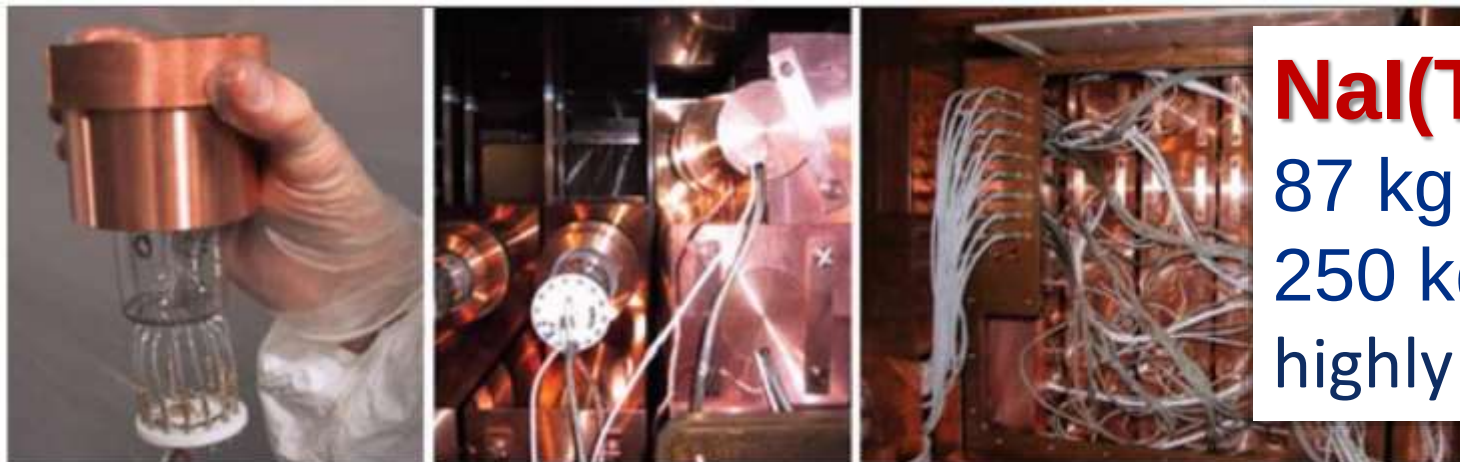
WIMP-nucleon scattering

Look for nuclear recoil



Simplified schema of ~ 100 kg NaI(Tl) set-up

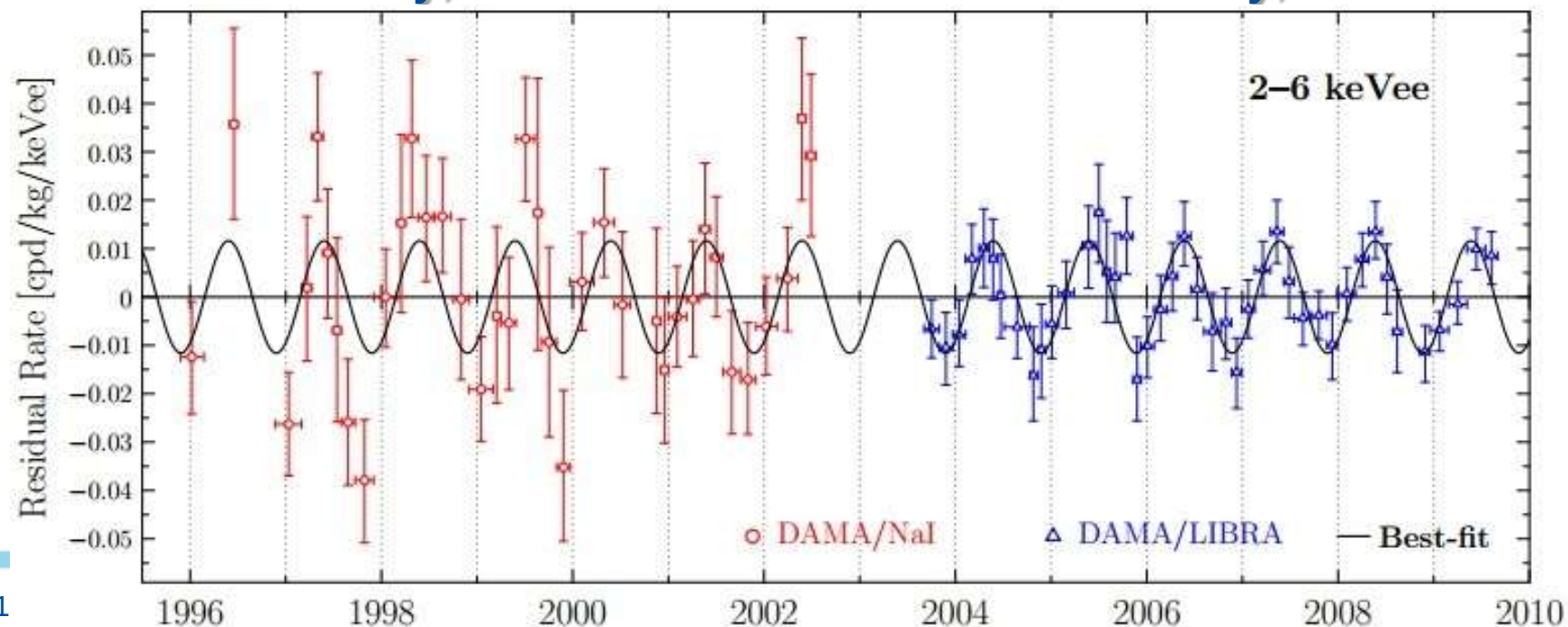




NaI(Tl) target:
 87 kg 1996-2003
 250 kg 2003-now
 highly radiopure

DAMA/LIBRA Results 1996-2013

~2000 hits/day, **annual modulation** ~10 hits/day, **9.3 σ** effect



CONTROVERSY (other detectors)

CoGeNT (Ge detector) ... **YES**

XMASS (LXe) **NO**

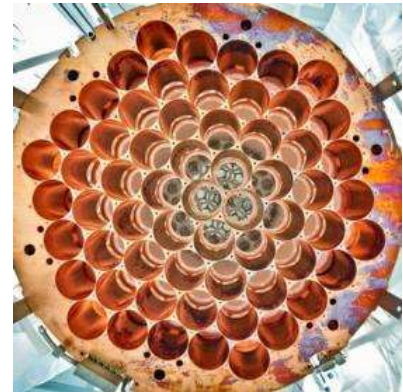
COUPP (Xe) **NO**

CDMS (Ge/Si) **NO**

Xenon100 (LXe) **NO**

LUX (Xe) **NO**

DAMIC (CCD) **mb?**



TWENTY THINGS PEOPLE SAY DARK MATTER IS MADE OF

WIRED

Weakly Interacting Massive Particles (WIMPS)

Massive Compact Halo Objects (MaCHOs)

Robust Associations of Massive Baryonic Objects (RAMBOs)

Macroscopic objects (macros)

Brown dwarf stars

White dwarf stars

Neutron stars

Black holes

Axions

Neutrinos

Neutralinos

Sterile neutrinos

Gravitinos

Photinos

Extradimensional mass

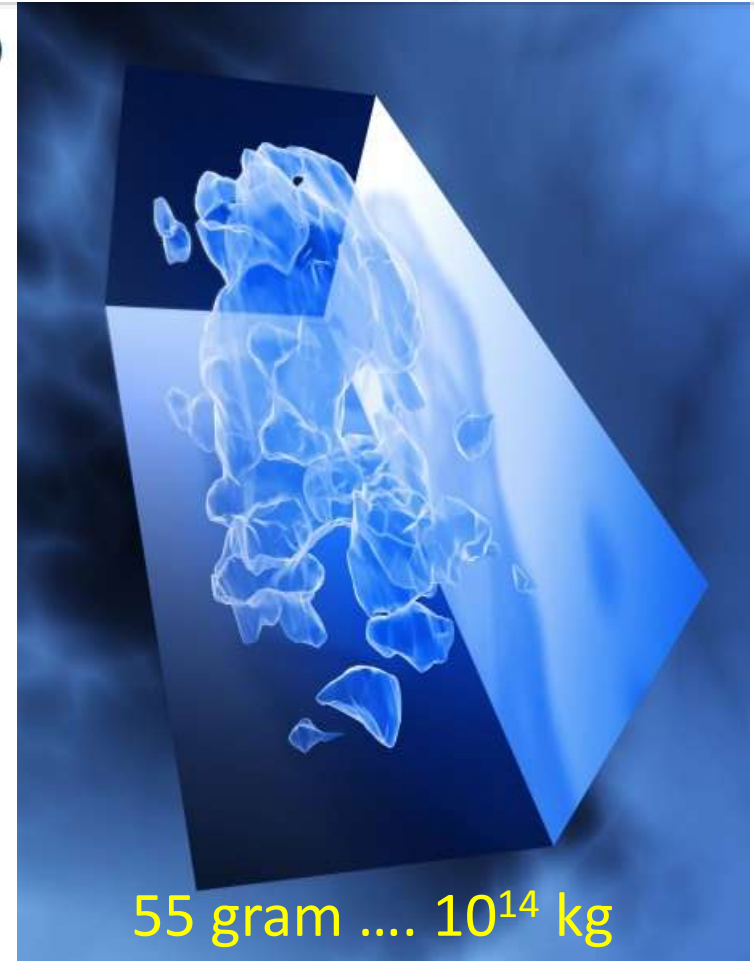
Defects in the quantum-field topology of the universe

Non-Newtonian, non-Einsteinian gravity

A “hidden valley” parallel dark-matter universe

Cat photos*

Not Particles, But Chunks: Dark Matter Gets Stranger



55 gram ... 10^{14} kg

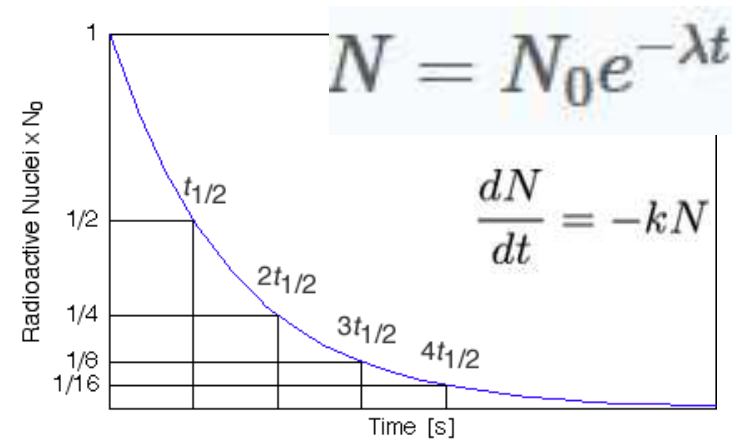
Fermilab

“Unproven and Controversial” - III

**Radioactive Decay
Periodically Varies in Time ?**

Radioactive decay

- Always exponential:



Zeitschrift
für
Physik
52

1929

Zur Quantentheorie des Atomkernes.

Von G. Gamow, z. Zt. in Göttingen.

Mit 5 Abbildungen. (Eingegangen am 2. August 1928.)

Es wird der Versuch gemacht, die Prozesse der α -Zerfälle nach der Wellenmechanik näher zu untersuchen und den Zusammenhang zwischen Zerfallskonstante und Energie der α -Strahlen zu erhalten.

§ 1. Es ist schon öfters* die Vermutung geäußert worden, daß im Atomkern die nichtcoulombschen Kräfte eine wichtige Rolle spielen. Über die Natur dieser Kräfte sind Hypothesen gemacht worden. Es können die Anziehungen zwischen den einzelnen Kernbauelementen oder die Anziehungen zwischen einem Kernbauelement und dem Kern als Ganzem in Betracht kommen.

Kräfte mit wachsender Entfernung vom Kern sehr schnell ab, und nur in unmittelbarer Nähe des Kernes überwiegen sie den Einfluß der Coulombschen Kraft.

Aus Experimenten über die Zerstreuung der α -Strahlen können wir schließen, daß, für schwere Elemente, die Anziehungen in der Entfernung $\sim 10^{-13}$ cm noch nicht merklich abnehmen. Auf Fig. 1 gezeichnete Bild für den Verlauf der Coulombkraft $U(r)$ und der Anziehungskraft $V(r)$ ist unbekannt und vielleicht viel kleiner als die Coulombkraft.



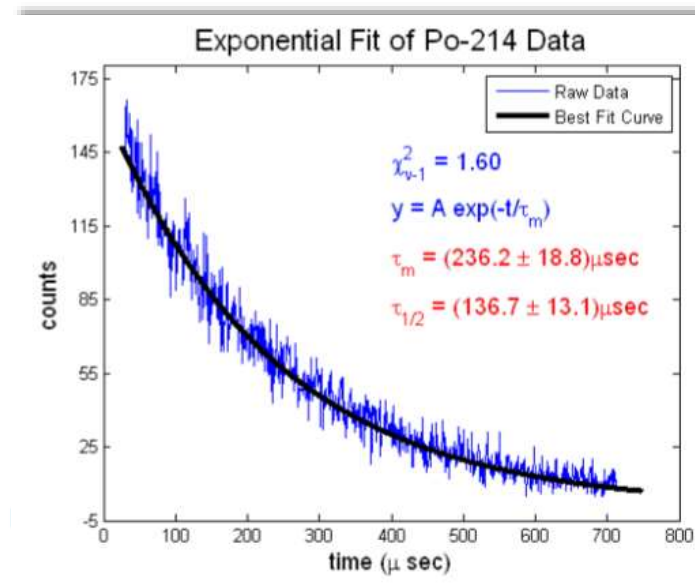
Fig. 1.

Barrier Penetration

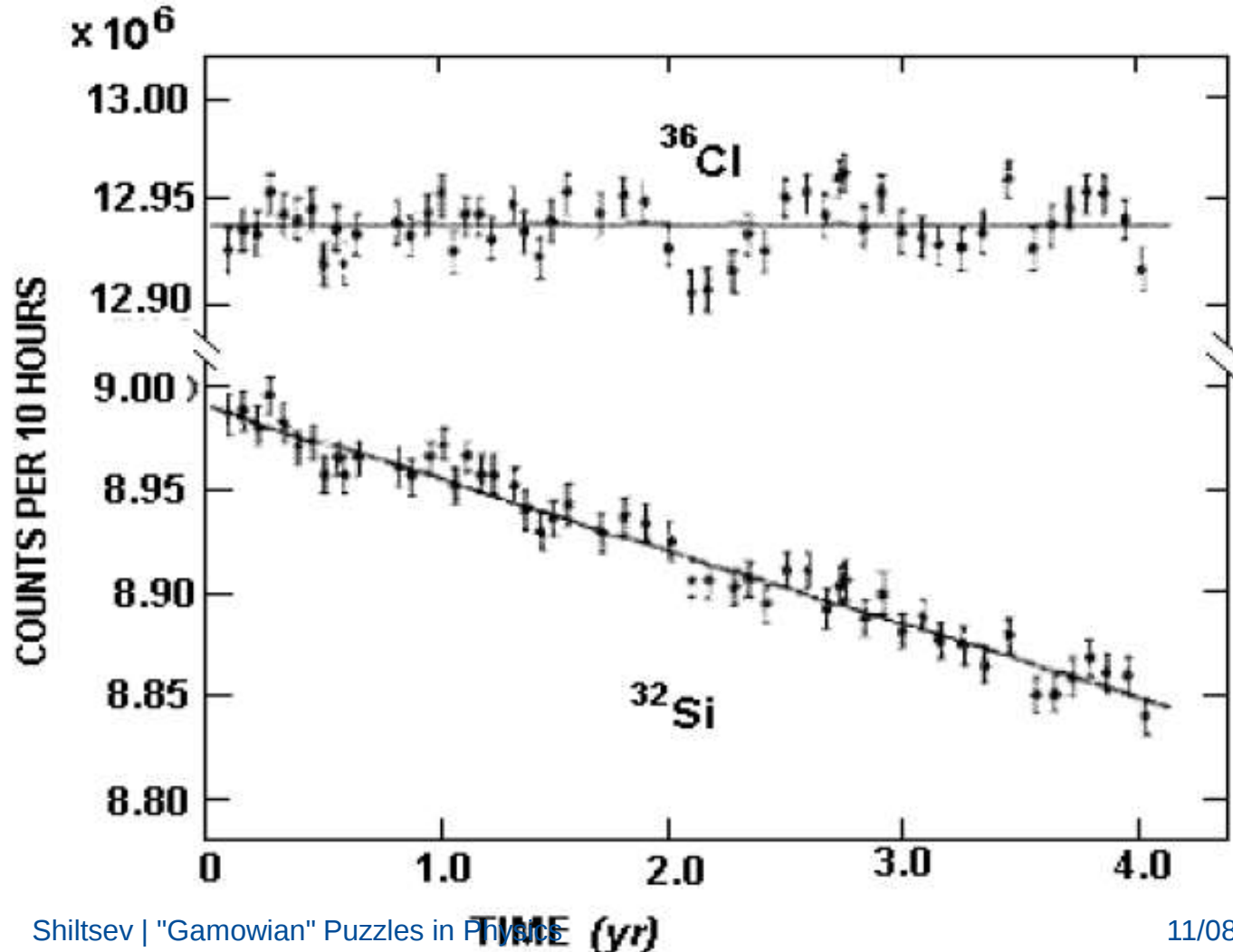
alpha decay

$$\ln(1/\tau_{1/2}) = a_1 \frac{Z_n}{\sqrt{E}} + a_2$$

The Geiger-Nuttall Law



Si-32 ($T_{1/2}$ =300,000 years) and Cl-36 **in Brookhaven National Lab** **0.2-0.3% annually ...4 years**



D.E. Alburger, G. Harbottle, E.F. Norton,
Earth and Planetary Science Letters 78
(1986) 168

Ra-226 in Berlin... 0.1% annually

15 years

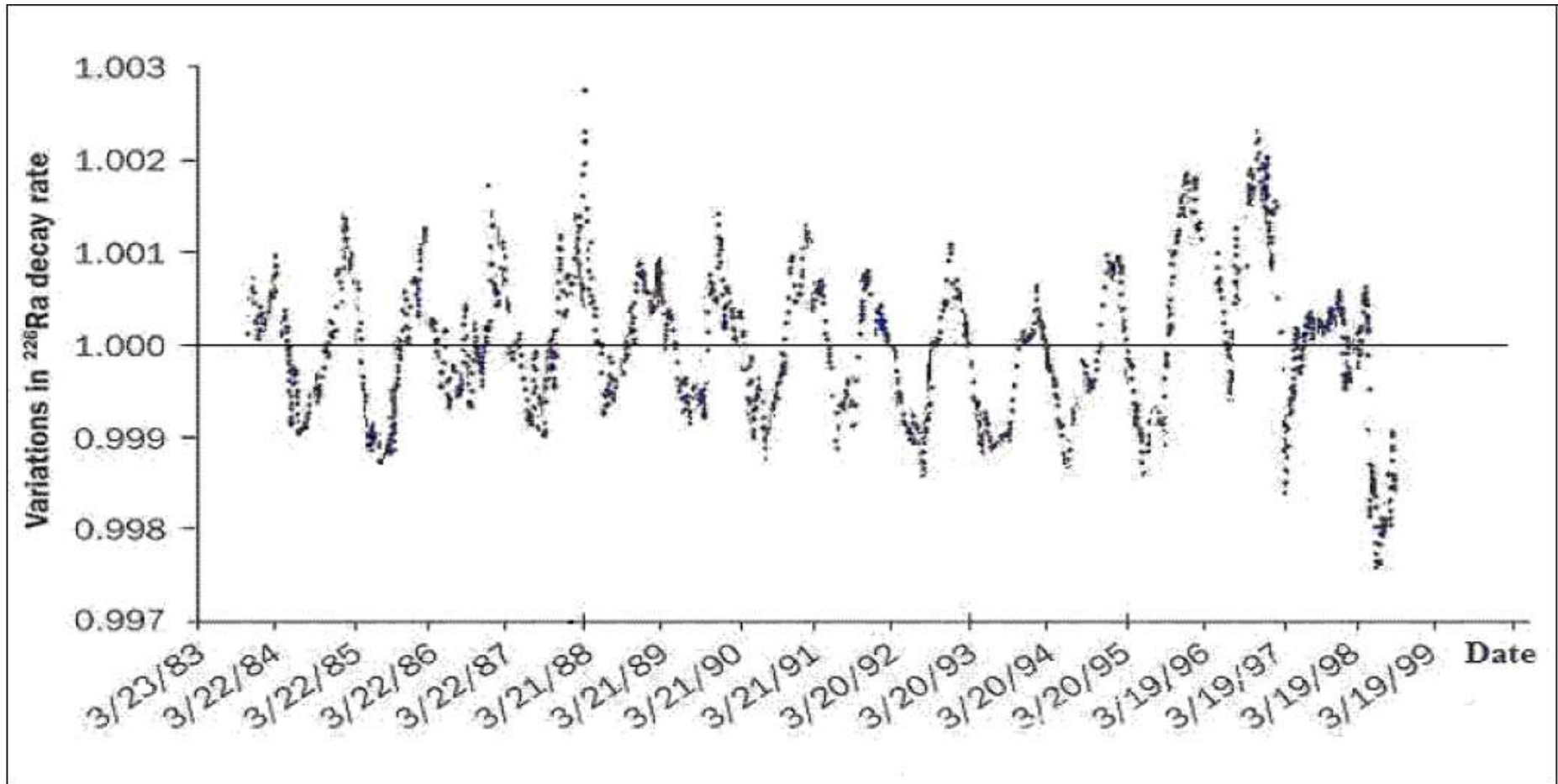
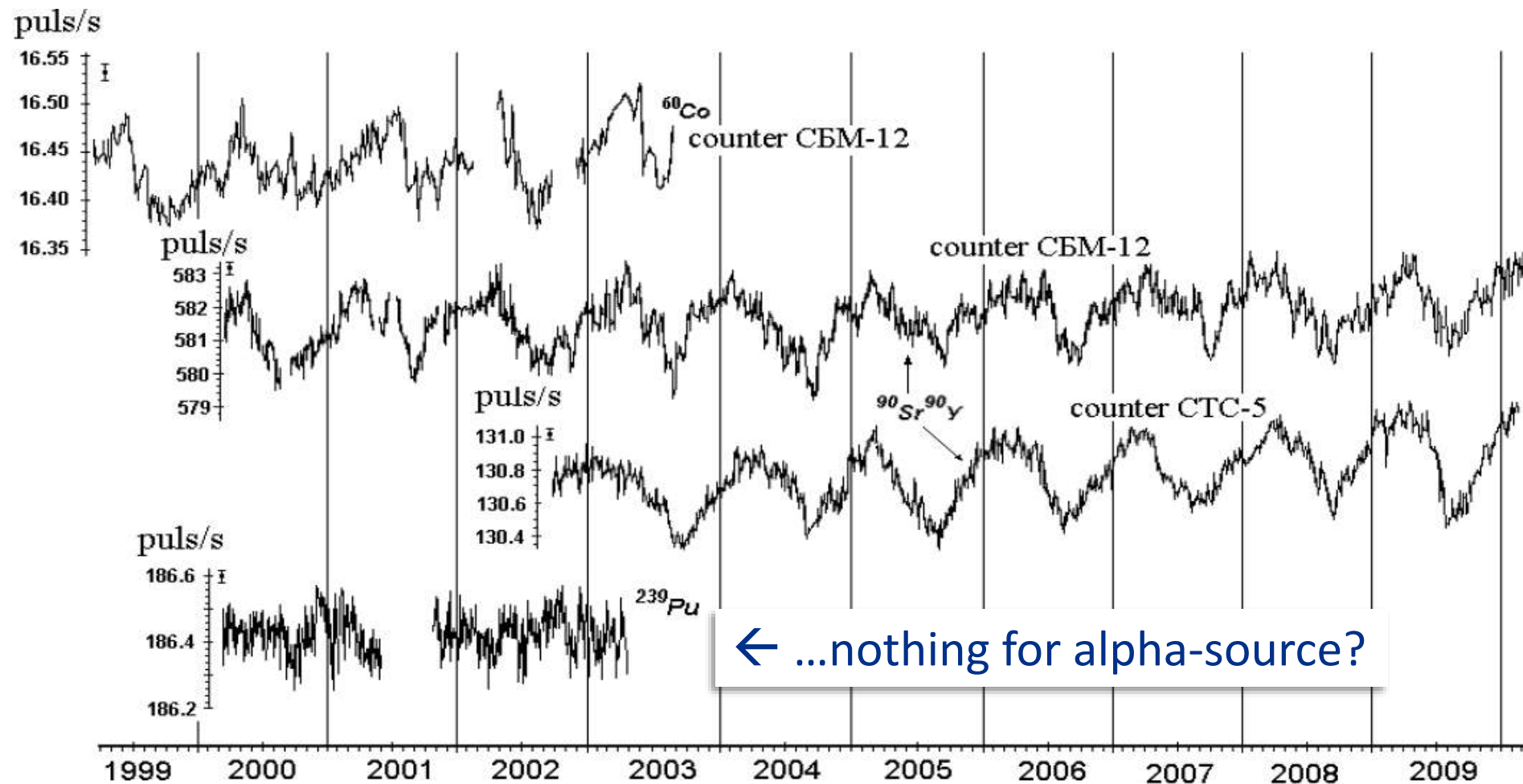


Fig.8. Deviations of ^{226}Ra radioactivity measurements from average value [11].

Co-60 (5.3 yrs) & Sr-90/Y-90 (29 yrs) in Moscow State University 10 years 0.3% annually, 0.02% monthly



← ...nothing for alpha-source?

VARIABILITY OF NUCLEAR DECAY RATES

PLEASE NOTE: *The Net Advance of Physics* does not take a position on the existence and/or explanation of the reported phenomena. To add papers, please write to the editor (redingtn at mit dot edu). Last update: 07/30/15 TOTAL=87papers

• Research papers: General:

- [Is Radioactive Decay Really Exponential?](#) by Philip J. Aston [*Europhysic*]
- [Sensitivity of astrophysical reaction rates to nuclear uncertainties](#) by Thor

• Research papers: PERIODIC VARIATIONS: SCALE OF SECONDS:

◦ GSI K-Capture Anomaly:

- [Measurement of the beta+ and orbital electron-capture decay rates i](#)
- [Observation of Non-Exponential Orbital Electron Capture Decays c](#)
- [On the time-modulation of the K-shell electron capture decay of H-](#)
 - [Oscillations in the GSI electron capture experiment](#) by H. Bu
- [Kinematics and Quantum Field Theory of the Neutrino Oscillations](#)
- [New method for studying neutrino mixing and mass differences by](#)
 - [Comment on the Neutrino-Mixing Interpretation of the GSI T](#)
 - [Reply \[to Giunti\]](#) by A. N. Ivanov et al. [2008/03]
 - [Comment](#) by Murray Peshkin [2008/04] Meant to refute Lipk
 - [The GSI method for studying neutrino mass differences - For](#)
 - [Comment](#) by Murray Peshkin [2008/11] "Quantum mechanic
 - [The GSI Time Anomaly: Facts and Fiction](#) by Carlo Giunti [
 - [Comment](#) by V. V. Flambaum [2009/08] Disagrees with Lipk
- [Neutrino-Pulsating Vacuum and Neutrino Mass Difference](#) by H. K
- [Neutrino masses from the Darmstadt oscillations](#) by A. N. Ivanov e
 - [GSI Oscillations as Laboratory for Testing of New Physics by](#)
- [Rates of Processes with Coherent Production of Different Particles](#) quantum beats between energy levels of decaying ion instead.
 - [Comment](#) by A. N. Ivanov et al. [2008/07]
 - [The GSI anomaly](#) by Hendrik Kienert et al. [2008/08] Agains
 - [The GSI Time Anomaly: Facts and Fiction](#) by Carlo Giunti [
 - [Can the "Darmstadt oscillations" be treated as two closely sp](#)
 - [The GSI Time Anomaly: Facts and Fiction](#) by Carlo Giunti [
- [New interactions: past and future experiments](#) by Michele Maltoni |
- [On the Time-Modulation of the Beta-Decay Rate of H-like 140Pz58](#)
- [Search for Oscillation of the Electron-Capture Decay Probability of](#)
 - [Comment](#) by Yu. A. Litvinov et al. [2008/07]
- [Could the GSI Oscillations be Observed in a Standard Electron Cap](#) reporting that a conventional (as opposed to storage-ring) K-capture
- [Theoretical Overview of Neutrino Properties](#) by Zhi-Zhong Xing [2

- [Theoretical Overview of Neutrino Properties](#) by Zhi-Zhong Xing [2008/07] With re
- [Neutrinos do not oscillate yet at GSI](#) by Avraham Gal [2008/08] ... and when they d
 - [Time Modulation of Orbital Electron Capture Decays of H-like Heavy Ions b](#)
 - [Neutrino magnetic moment effects in electron-capture measurements at GSI](#)
- [Spin-rotation coupling in non-exponential decay of hydrogenlike heavy ions](#) by Gu
 - [Comment](#) by V. V. Flambaum [2009/08] Disagrees.
- [Why a splitting in the final state cannot explain the GSI-Oscillations](#) by Alexander I
- [On the time modulation of the K-shell electron capture decay rates of H-like heavy](#) data can be explained in terms of the interference of two massive neutrino mass-eig
 - [Comment](#) by V. V. Flambaum [2009/08] Disagrees.
 - [Reply](#) by A. N. Ivanov and P. Kienle [2009/09]
- [Quantum-Mechanics of nu and GSI oscillations for pedestrians: Relativistic quantu](#)
- [The GSI oscillation mystery](#) by Alexander Merle [*Progress in Particle and Nuclear* observed oscillations cannot be caused by standard neutrino mixing."
- [Is the GSI anomaly due to neutrino oscillations? - A real time perspective](#) by Jun W
- [Oscillations in the decay law: a possible quantum mechanical explanation of the GS](#) (Oscillating) non-exponential decays of unstable states by Francesco Giacosa and G
- [GSI anomaly and spin-rotation coupling](#) by Gaetano Lambiase et al. [2012/05]
 - [Comment on a recent attempt to explain the 'GSI anomaly' by initial-state e.e.r](#)
- [Decay Oscillations in Electron Capture and the Neutrino Mass Difference](#) by Murra
 - [GSI Oscillations as Interference of Neutrino Flavour Mass-Eigenstates and](#)
- [Neutrino signals in GSI two-body EC rates](#) by Avraham Gal [2014/07]
- [Decay Law of Relativistic Particles: Quantum Theory Meets Special Relativity](#) by I
- [Oscillating Decay Rate in Electron Capture and the Neutrino Mass Difference](#) by M
- [Properties of decaying particles: "GSI anomaly" like effects](#) by Krzysztof Urbanow

• Research papers: PERIODIC VARIATIONS: SCALE OF DAYS OR YEARS:

- [Evidence for Solar Influences on Nuclear Decay Rates](#) by Ephraim Fischbach et al. [2010
- [Half-life of 125I](#) by D. E. Alburger et al. [*Earth Planet. Sci. Lett.* 78, 168 (1986)] Observe
- [Evidence for Correlations Between Nuclear Decay Rates and Earth-Sun Distance](#) by Jer
- [Searching for modifications to the exponential radioactive decay law with the Cassini spo](#)
- [Evidence against correlations between nuclear decay rates and Earth-Sun distance](#) by Eric
- [Analysis of environmental influences in nuclear half-life measurements exhibiting time-d](#) effects are too large to be explained by variations in sensitivity of detectors.
- [Variations of decay rates of radio-active elements and their connections with global aniso](#) the same authors.
- [Researches of alpha and beta radioactivity at long-term observations](#) by A. V. Parkhomov

- [Additional experimental evidence for a solar influence on nuclear decay rates](#)
- [The Case for a Solar Influence on Certain Nuclear Decay Rates](#) by Peter Stur
- [Additional experimental evidence against a solar influence on nuclear decay](#) artifacts ..."
- [Concerning the Phase of the Time-Variation in the Cl-36 Decay Rate by model".](#)
- [Time-Varying Nuclear Decay Parameters and Dark Matter](#) by Jonathan Nistor instead?
- [Disproof of solar influence on the decay rates of 90Sr/90Y](#) by Karsten Kosse
- [Analysis of Beta-Decay Rates for Ag108, Ba133, Eu152, Eu154, Kr85, Ra22](#)
- [Results of a search for daily and annual variations of the Po-214 half-life at tl](#)

• Research papers: NON-PERIODIC VARIATIONS:

◦ General:

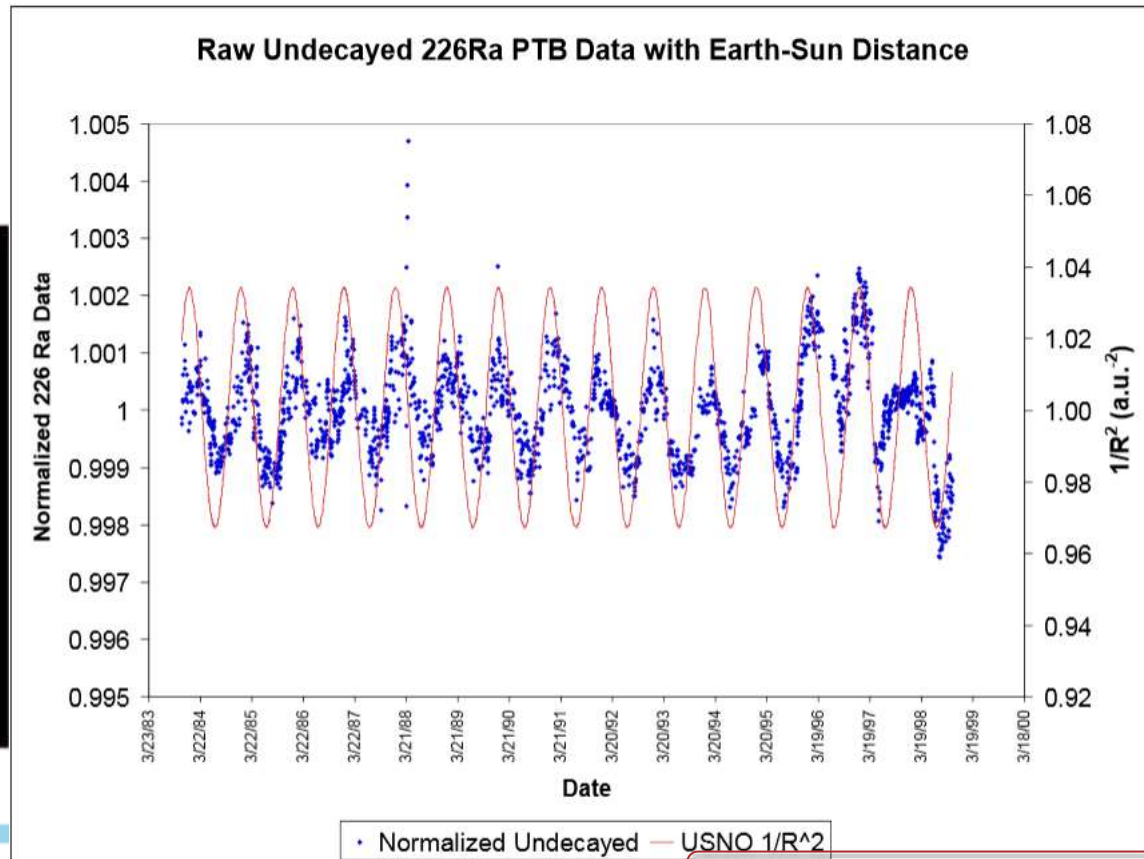
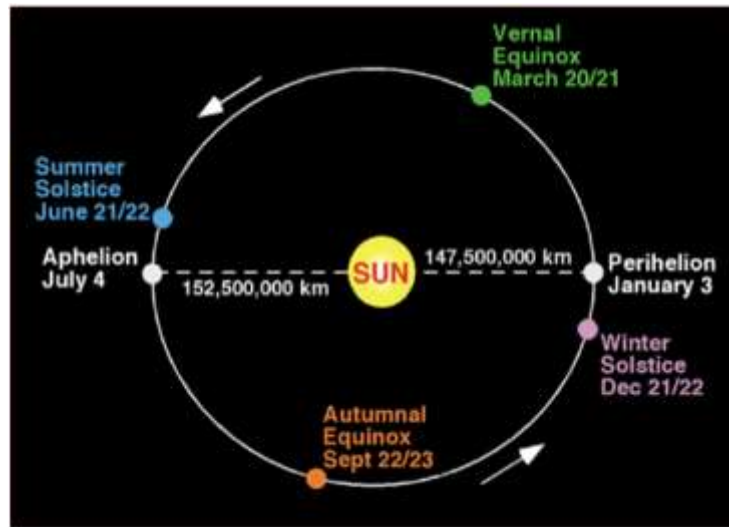
- [Non-Poisson distributions observed during counting of certain carbon-](#)
- [Is it possible to stimulate nuclear alpha decay by superfluid helium?](#) by
- [Search for the time dependence of the 137Cs decay constant](#) by E. Bell
- [Constraining spacetime variations of nuclear decay rates from light cur](#)
- [Neutrino induced decoherence and variation in nuclear decay rates](#) by I
- [Signature of nonexponential nuclear decay](#) by R. N. Manchester [2015]

◦ Of Cosmic Origin:

- [Interpretation of cold nuclear fusion by means of erzion catalysis](#) by Yi resembling muons.
- [New interactions: past and future experiments](#) by Michele Maltoni [20
- [Perturbation of Nuclear Decay Rates During the Solar Flare of 13 Dec](#)
 - [Implications for C-14 Dating of the Jenkins-Fischbach Effect an](#)
 - [Effect of radioactivity decrease. Is there a link with solar flares?](#)
 - [Study of the dependence of 198Au half-life on source geometry](#) matter. Paper reports an experiment to set limits on this effect. [A
 - [Search for correlations between solar flares and decay rate of rad](#)

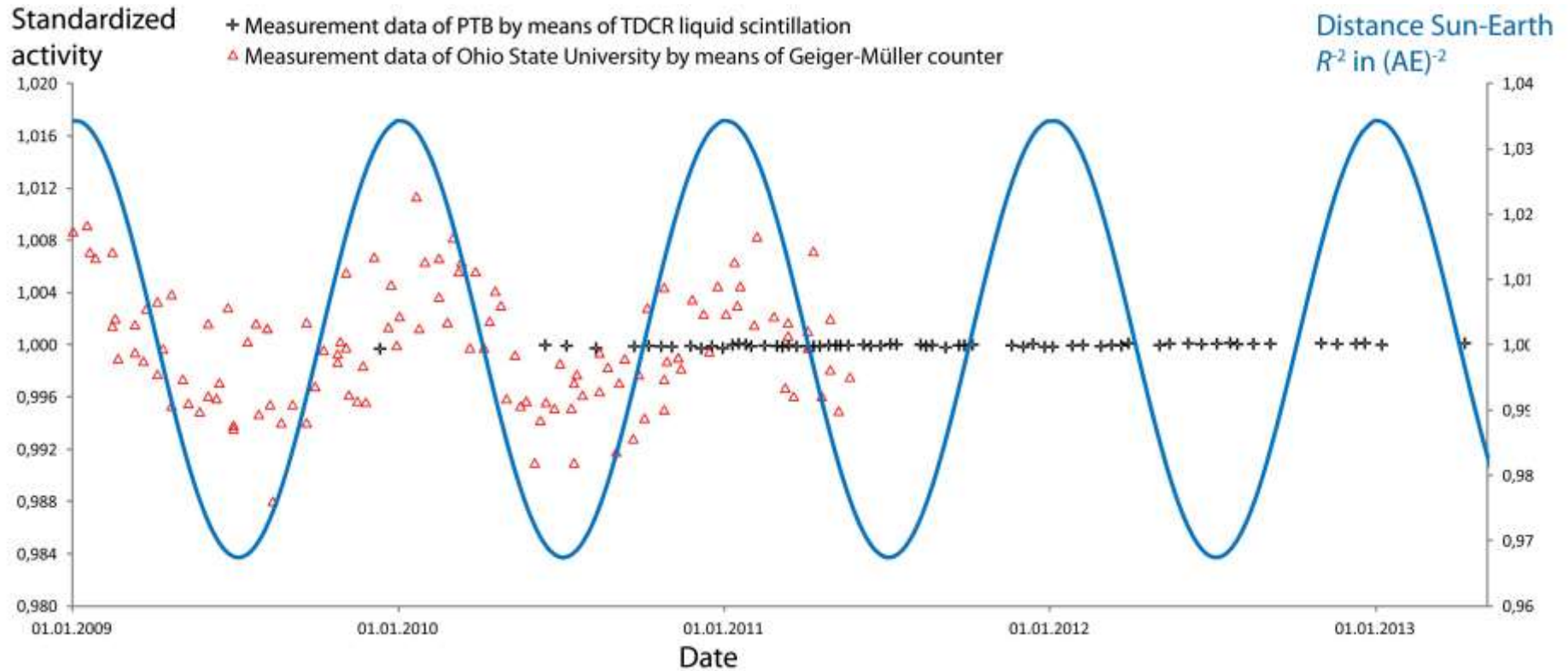
Jenkins, Jere H., et al. "Evidence of correlations between nuclear decay rates and Earth–Sun distance." *Astroparticle Physics* 32.1 (2009): 42-46.

Eccentricity of Earth's Orbit



Cross-checks (2009-2013)

CI-36 – Ohio State vs PTB (Berlin)

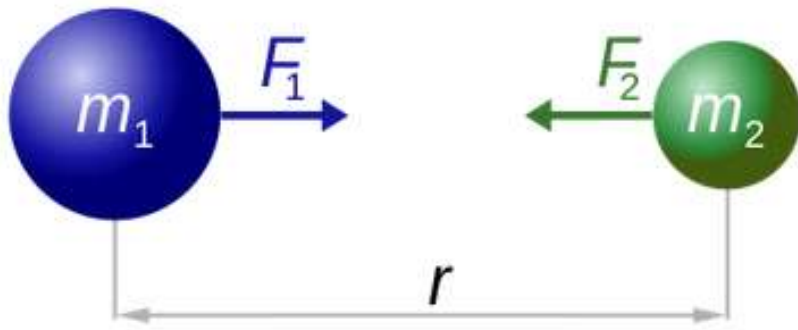


The issue not resolved... stay tuned

“Unproven and Controversial”- IV

Gravitational Constant
is Not a Constant ?

Gravitational Constant G



$$F_1 = F_2 = G \frac{m_1 \times m_2}{r^2}$$

Measured many
times with relative
standard uncertainty
 1.2×10^{-4}

$$G = 6.673\,84(80) \times 10^{-11} \text{ m}^3 \text{ kg}^{-1}$$

Henry Cavendish
experiment 1797-1798
(2 balls on strings 1.6 lbs + 2
heavy ball 350 pounds)

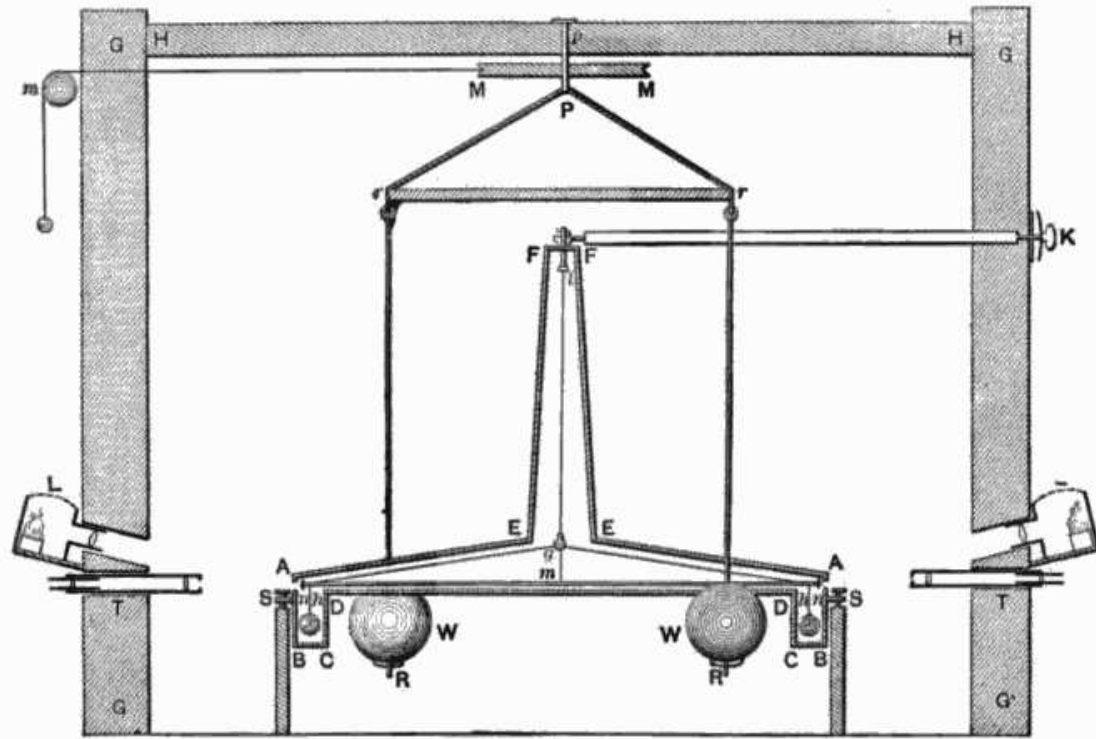
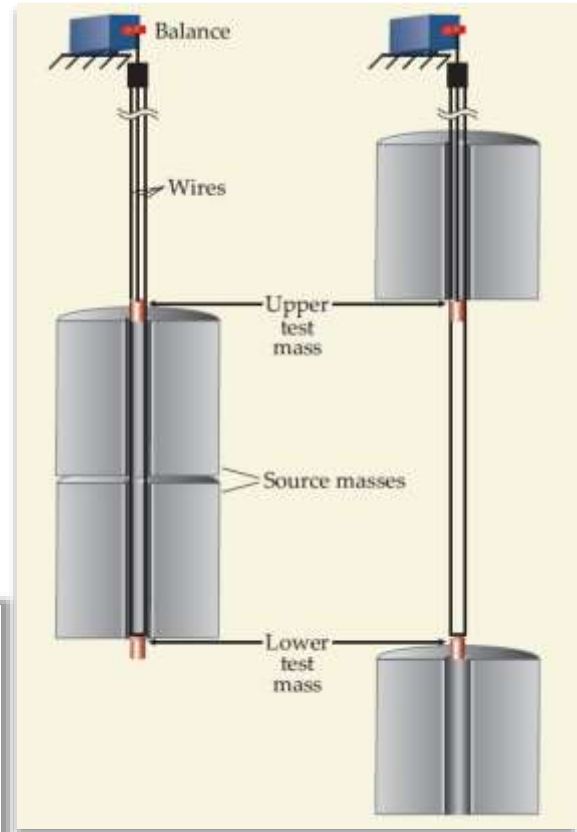
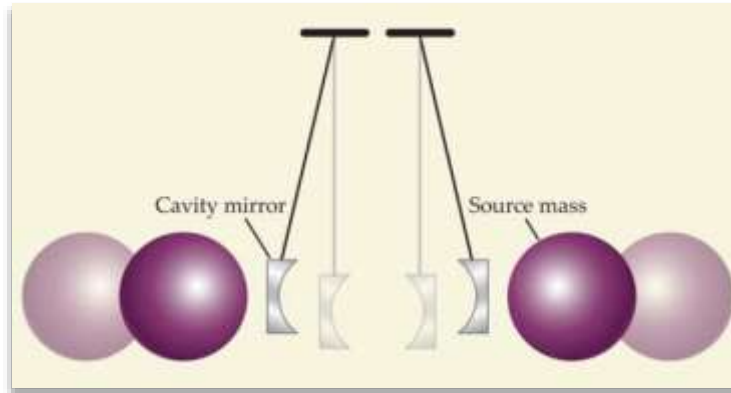
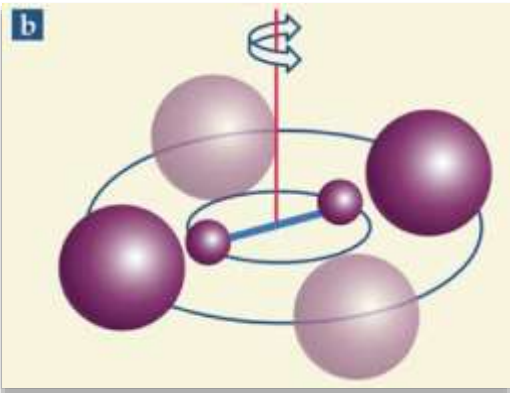
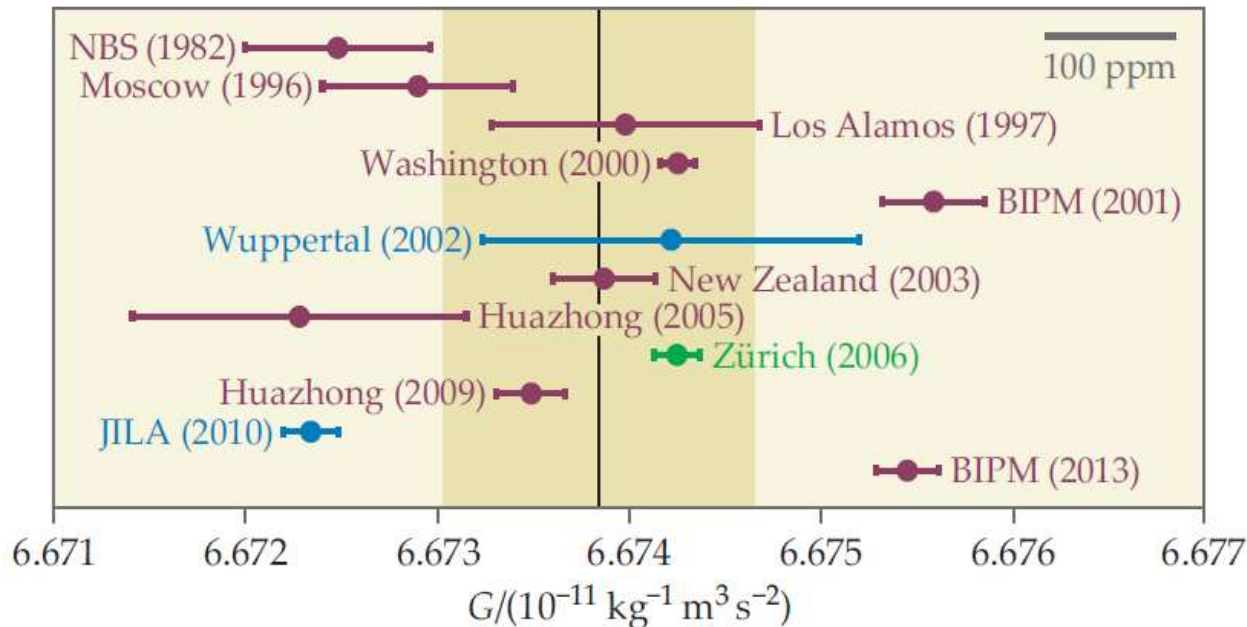


Fig. 1

Gravitational Constant G

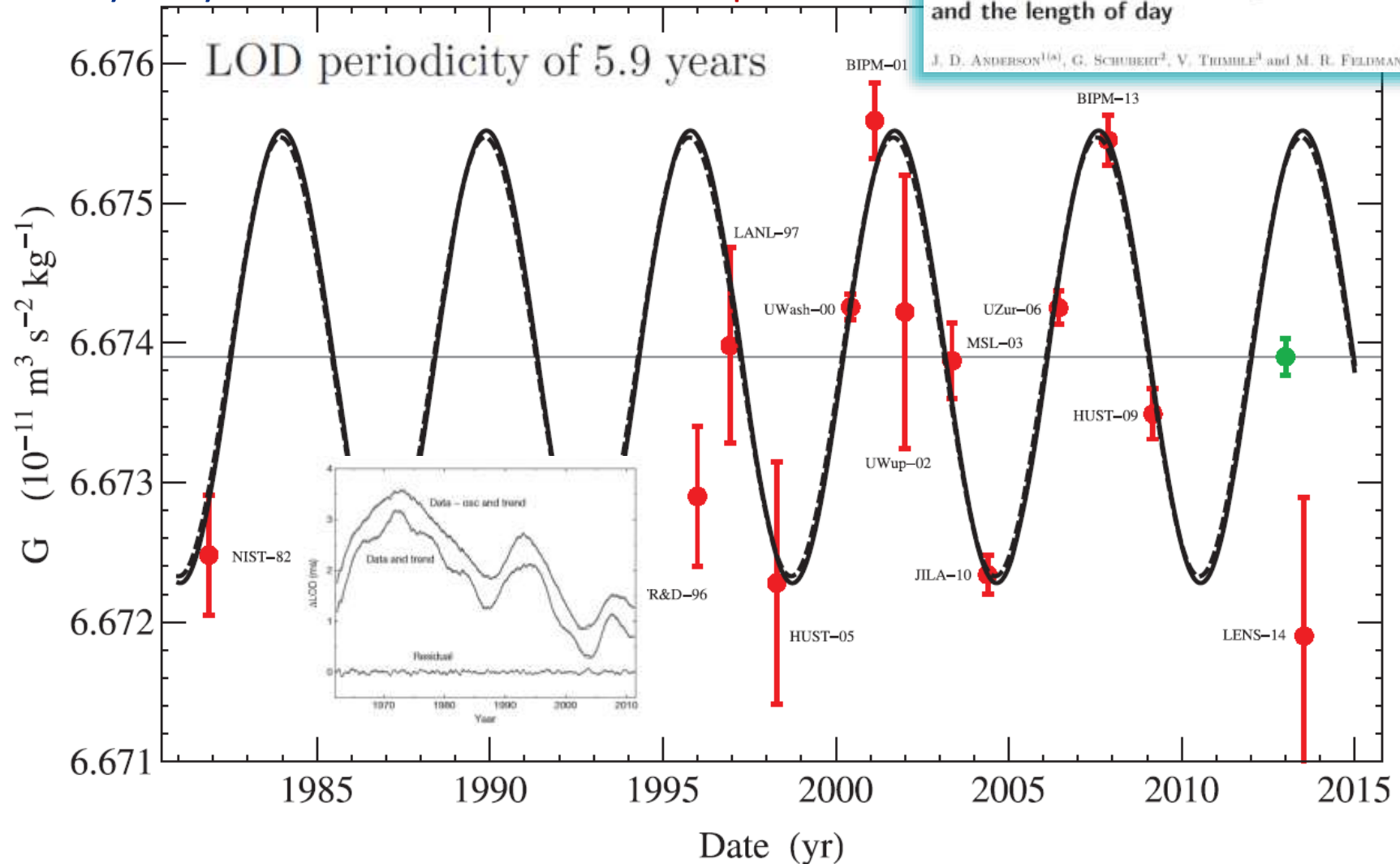


Inconsistency of results
“Разброд и Шатания”



G is not a constant ?

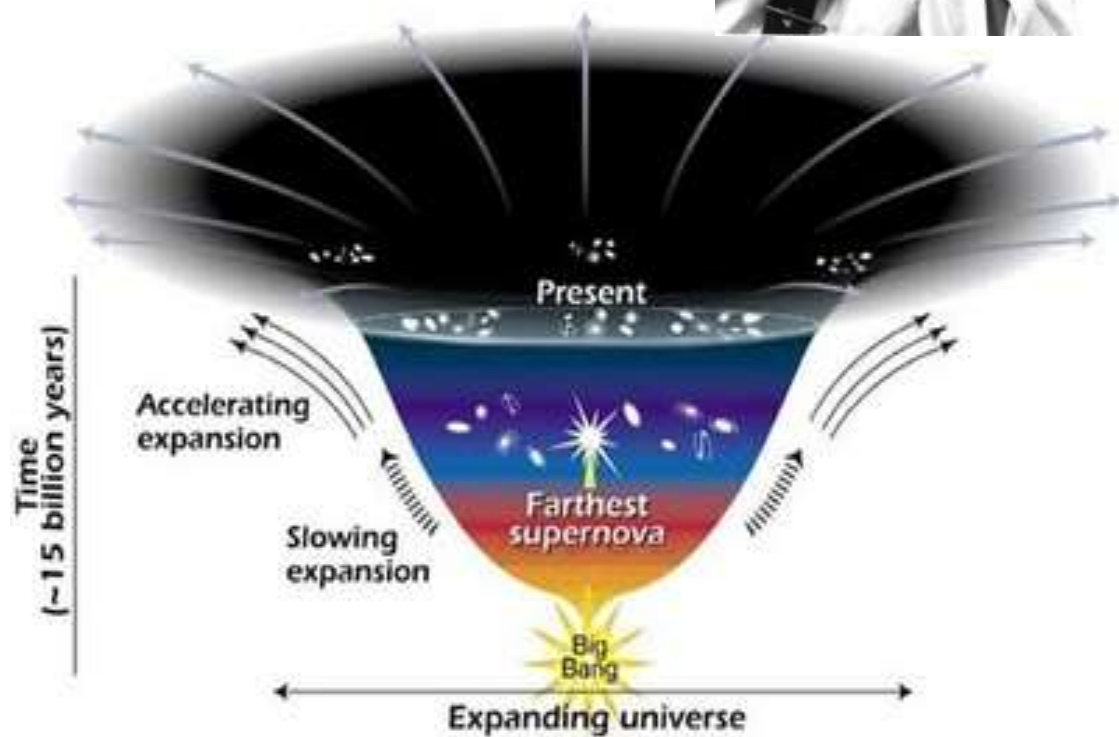
Length of the day (24 hours) varies by ~ 0.002 sec over decades and periodically by 0.00013 sec every 5.9 year $\rightarrow$ **G correlates with that period ?**



“Unproven and Controversial”- V

**“Penrouse Circles” –
Signals from
“Before the Big Bang”?**

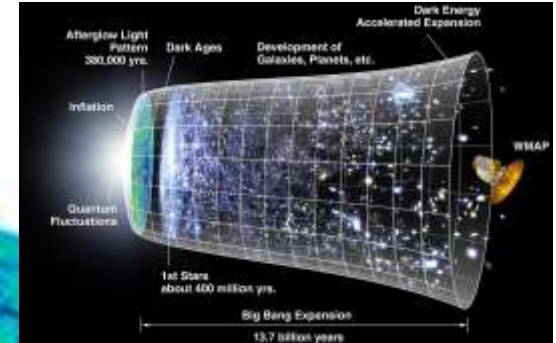
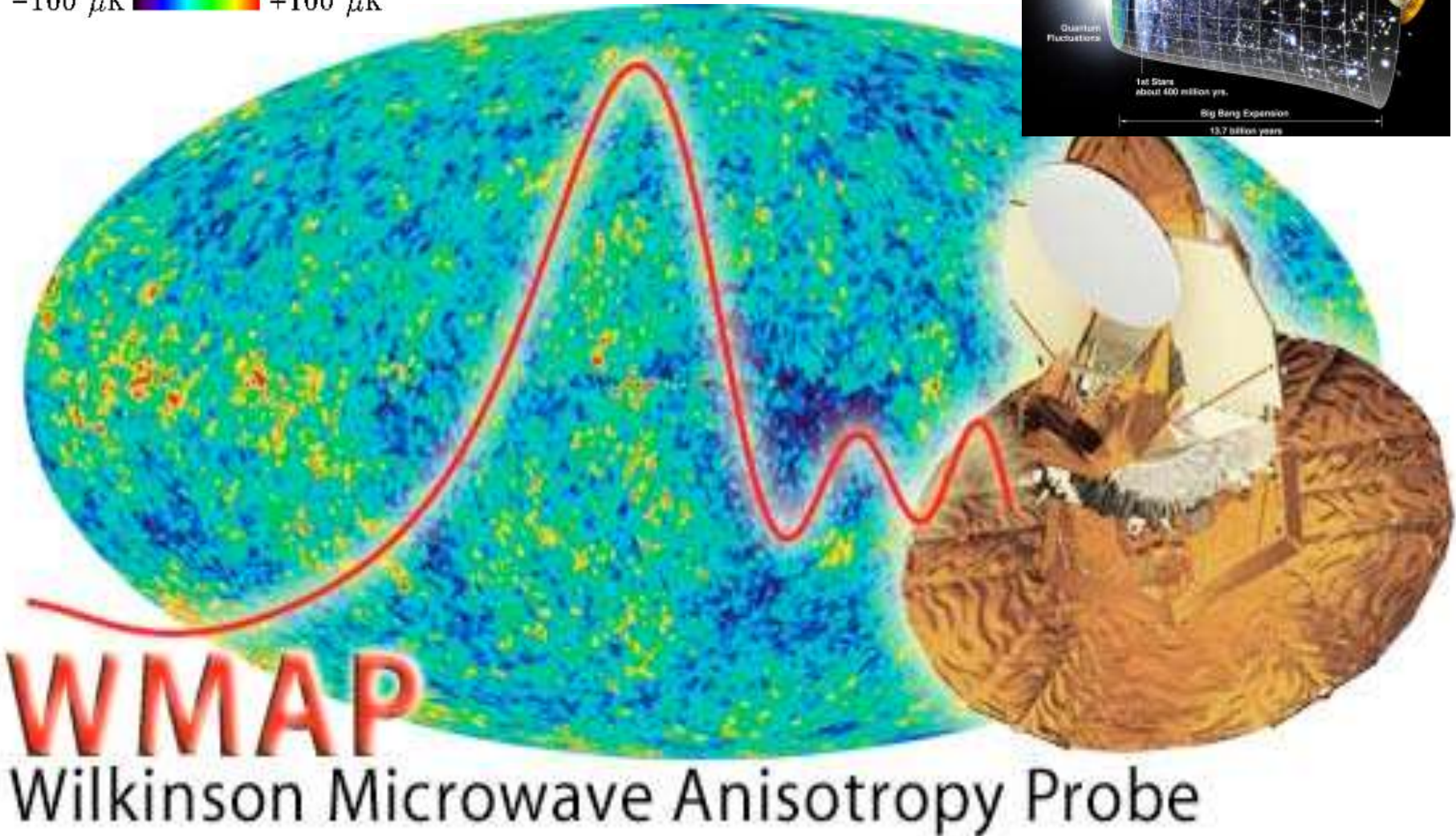
What was before Big Bang?



Cosmic Microwave Background

$$T = 2.72548 \pm 0.00057 \text{ K}$$

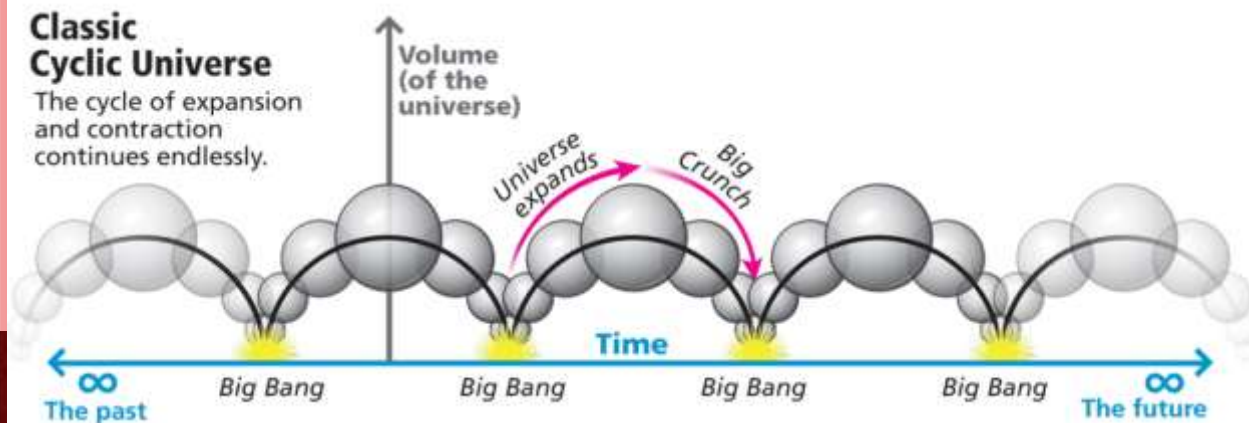
$-100 \mu\text{K}$  $+100 \mu\text{K}$



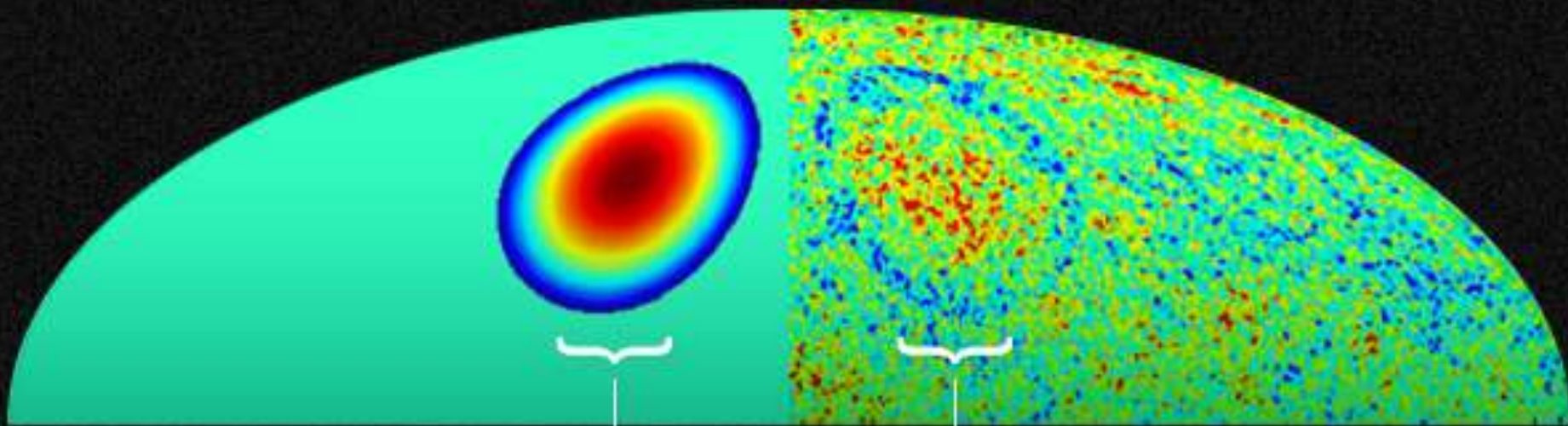
Hypothesis: Cyclic Cosmology



Roger
Penrose



WHAT A BUBBLE COLLISION WOULD LOOK LIKE

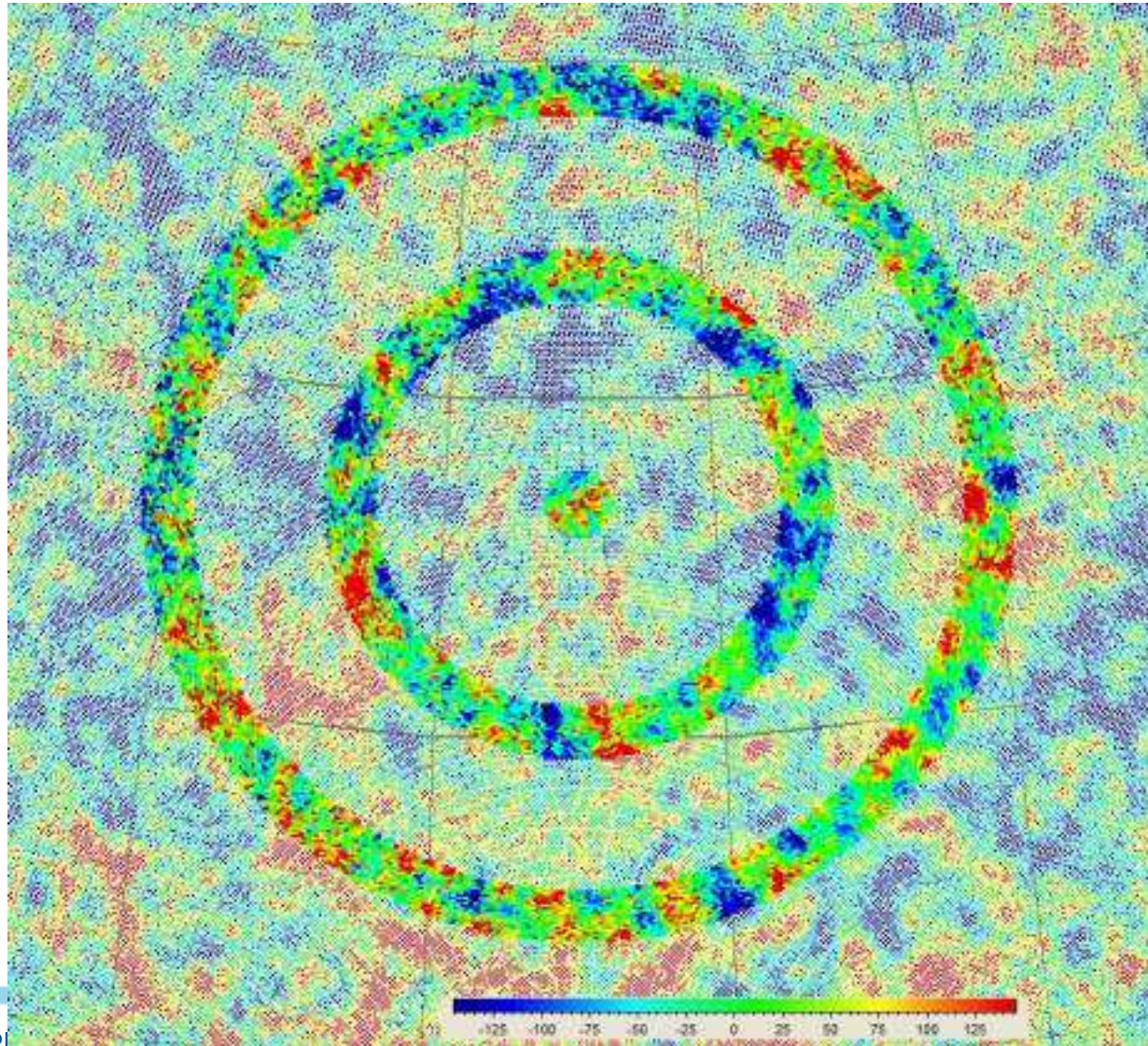


Temperature change

Effect on the CMB

“Penrose Circles” – discovered?

- [V.G.Gurzadyan](#),
[R.Penrose](#) (2010)
 - arXiv:1011.3706
 - 6σ effect! $15 \mu\text{K}/2.5$
 - arXiv:1012.1486
 - arXiv:1302.5162
 - In agreement with CCC
- Critics:
 - Moss A, Scott D., Zibin J.P., arXiv:1012.1305
 - Wehus I.K., Eriksen H.K., arXiv:1012.1268
 - A.Hajian, arXiv:1012.1656
 - 3σ – noise!
- Confirmation
K.Meissner et al,
arXiv:1207.2498



Summary:

Physics is fun !

George Gamow was great !

**There are many interesting
discoveries ahead of us !**

Thank you for your attention!



Few More Comments on George Gamow

GWU – Concoran Hall

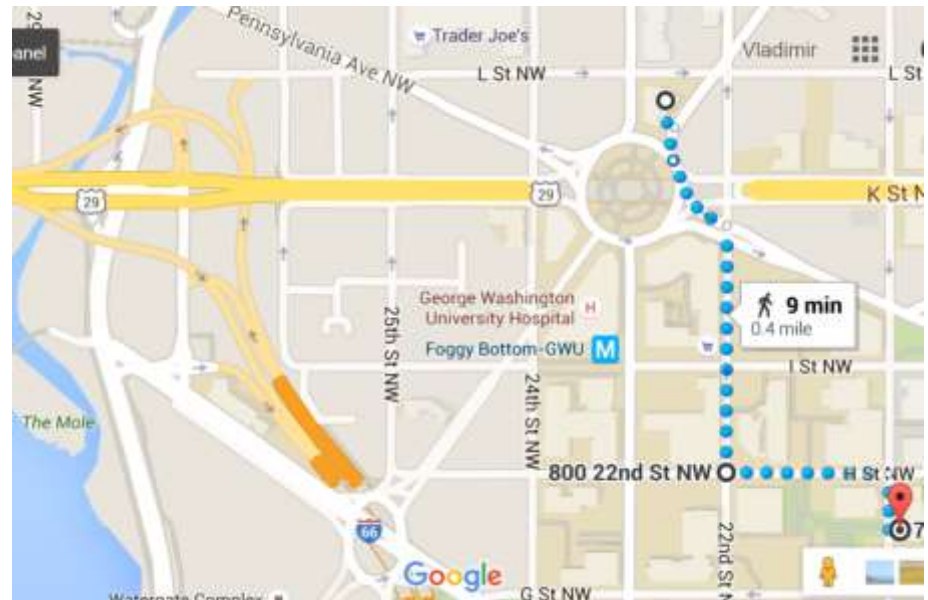


George Gamow
Professor Of Physics
at The George Washington University
from 1934 to 1956

Gamow (1904-1968) is renowned for developing the "Big Bang Theory" of the universe (1948); explaining nuclear alpha decay by quantum tunneling (1928); describing, with Edward Teller, spin-induced nuclear beta decay (1936); pioneering the liquid-drop model in nuclear physics (1928); introducing the "Gamow" factor in stellar reaction rates and element formation (1938); modeling red giants, supernovae, and neutron stars (1939); first suggesting how the genetic code might be transcribed (1954); and popularizing science through a long series of books, including the adventures of "Mr. Tompkins" (1939-1967)

This plaque is placed in honor of their colleague George Gamow
by the
Physics Department
of
The George Washington University

April 2000



Gamow in English “literary world”

Google books Ngram Viewer

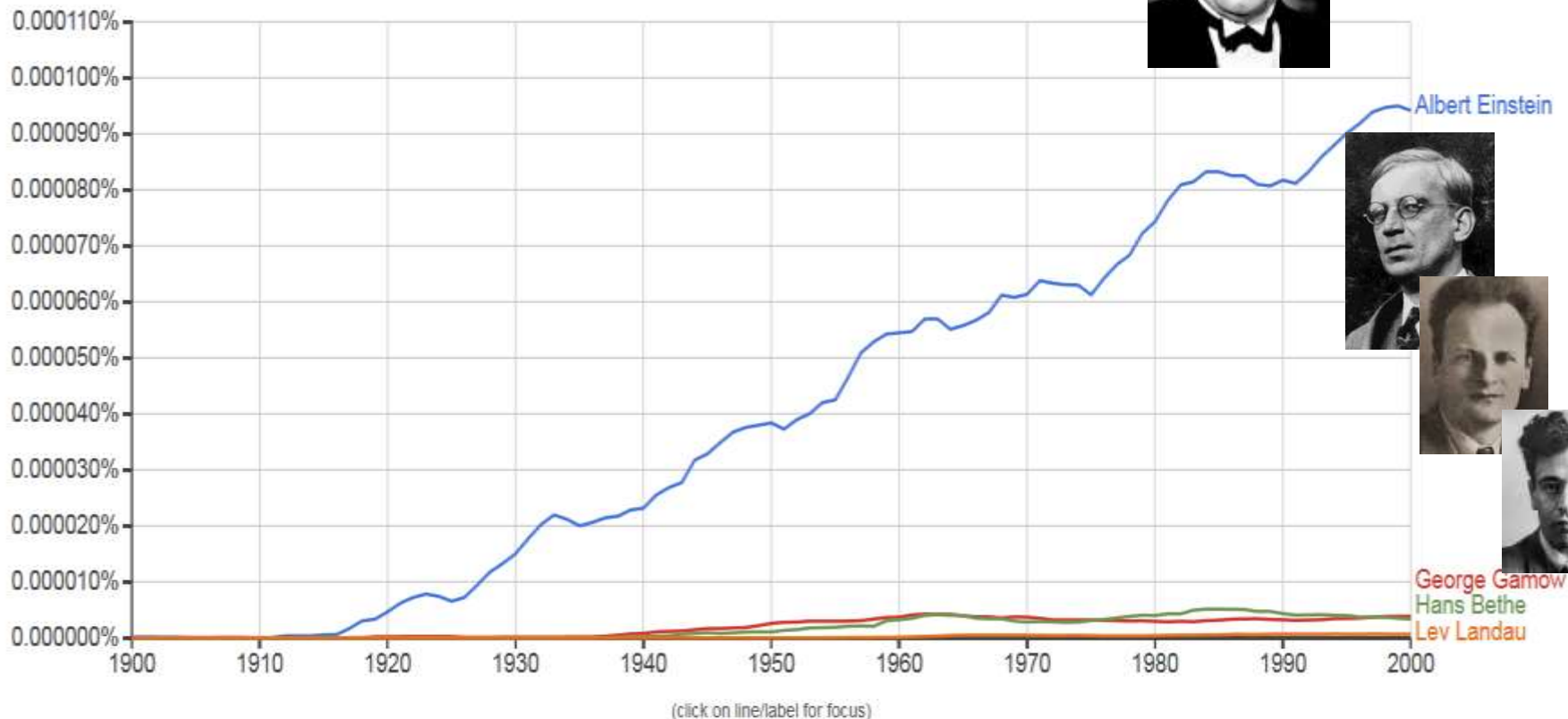
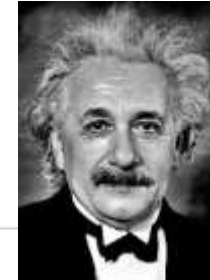
Graph these comma-separated phrases: Albert Einstein, George Gamow, Hans Bethe, Lev Landau

☐ case-insensitive

between 1900 and 2000 from the corpus English

with smoothing of 3

Search lots of books



George Gamow
Hans Bethe
Lev Landau

Gamow in Russian

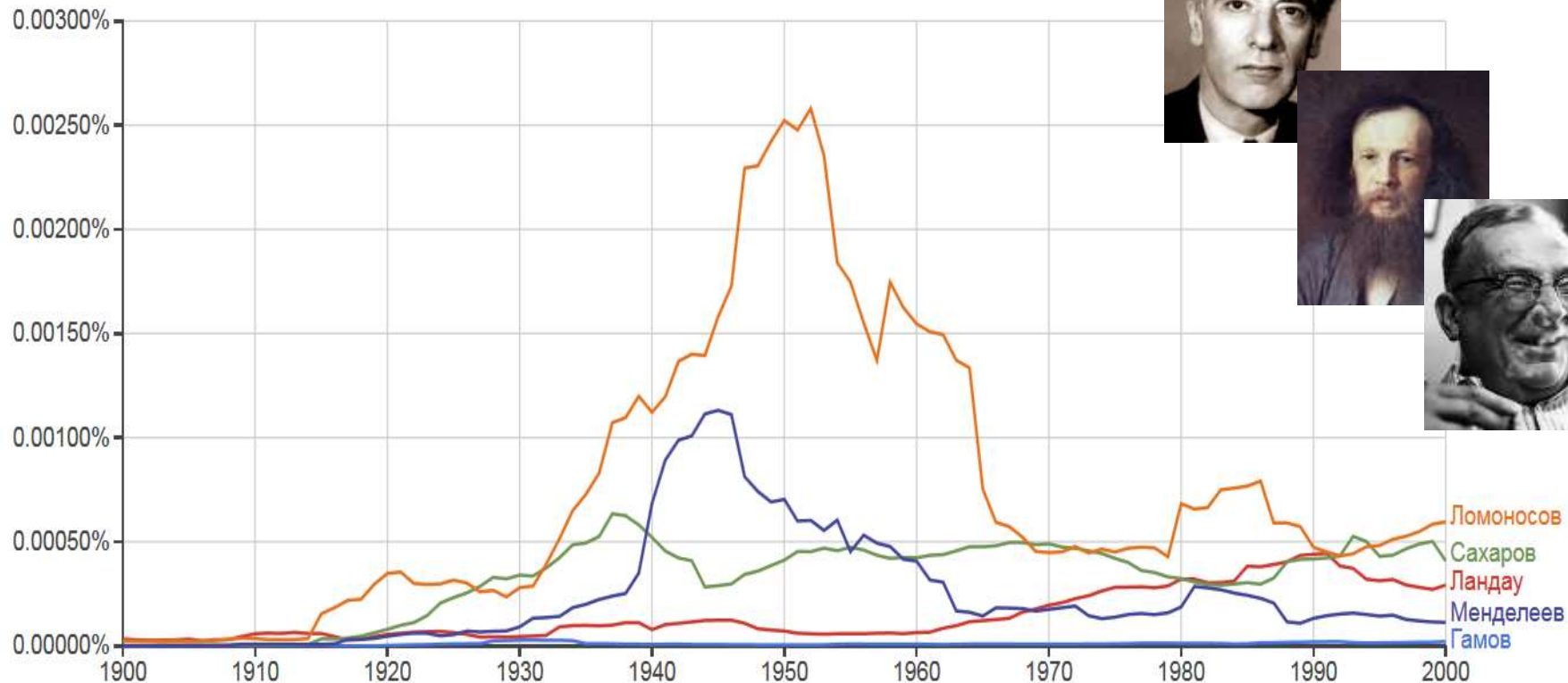
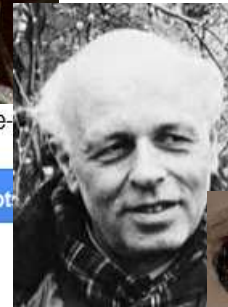
Google books Ngram Viewer

Graph these comma-separated phrases:

between and from the corpus

with smoothing of

[Search books](#)



(click on line/label for focus)

Google search: “формула Гамова”

Екатерина Гамова, team Russia
World Champion (2006, 2010)
202 см (6'8")
upto George Gamow (204 cm)



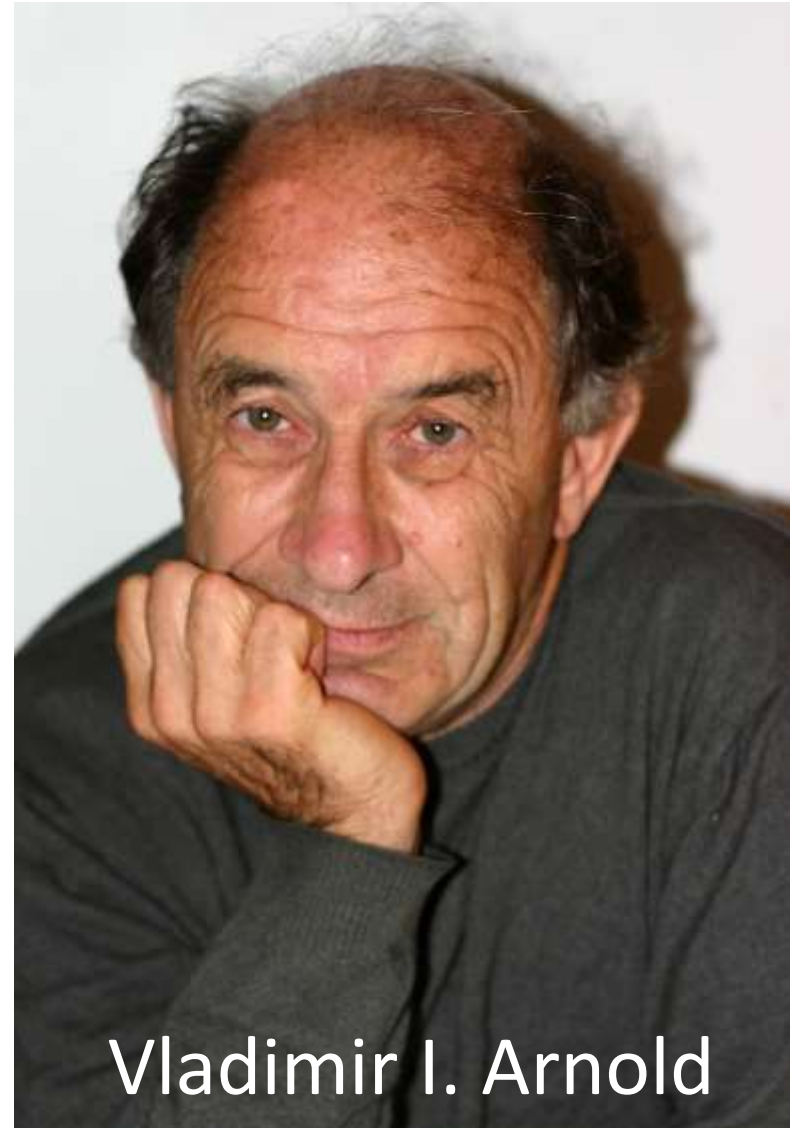
Why **111** ?

- A1: because of 1904 (GG's B-day)
- A2: *Vladimir Arnold* (1937-2010),
in Russian State Duma 06.12.2002:
 - *G. Seabord* (Nobel Physics, 1951)
 - California State Board of Education/
Academic Standards Commission

111 : 3

without calculator

- Senate
- “anti-constitutional” & “racist”
- declined



Но у Гамова были, как можно догадываться, весьма личные отношения с теоретической физикой. Он смотрел на нее как на вольное, слегка даже легкомысленное искусство — и время от времени получал в ответ большие и маленькие подарки. Такие, как эти 3 К из "Physics Today", доставшиеся без трудов и усилий и точно совпавшие с первыми измерениями Пензиаса и Вилсона. Очевидно, что и 7 К из статьи 1953 г. — это тоже приз из тех, что выпадают на долю "избранных, счастливых праздных, единого прекрасного жрецов".

Август 1994 г.

УСПЕХИ ФИЗИЧЕСКИХ НАУК

Том 164, № 8

ИЗ ИСТОРИИ ФИЗИКИ

**Как Гамов вычислил температуру реликтового излучения,
или немного об искусстве теоретической физики**

А.Д. Чернин

DM? X-ray signal from outer space points to dark matter

Alexey Boyarsky of Leiden University (Netherlands)

Compare spectra of X-rays from Galaxies with models - see excess!

Checking the dark matter origin of 3.53 keV line with the Milky Way center

A. Boyarsky¹, J. Franse^{1,2}, D. Iakubovskiy³, and O. Ruchayskiy⁴

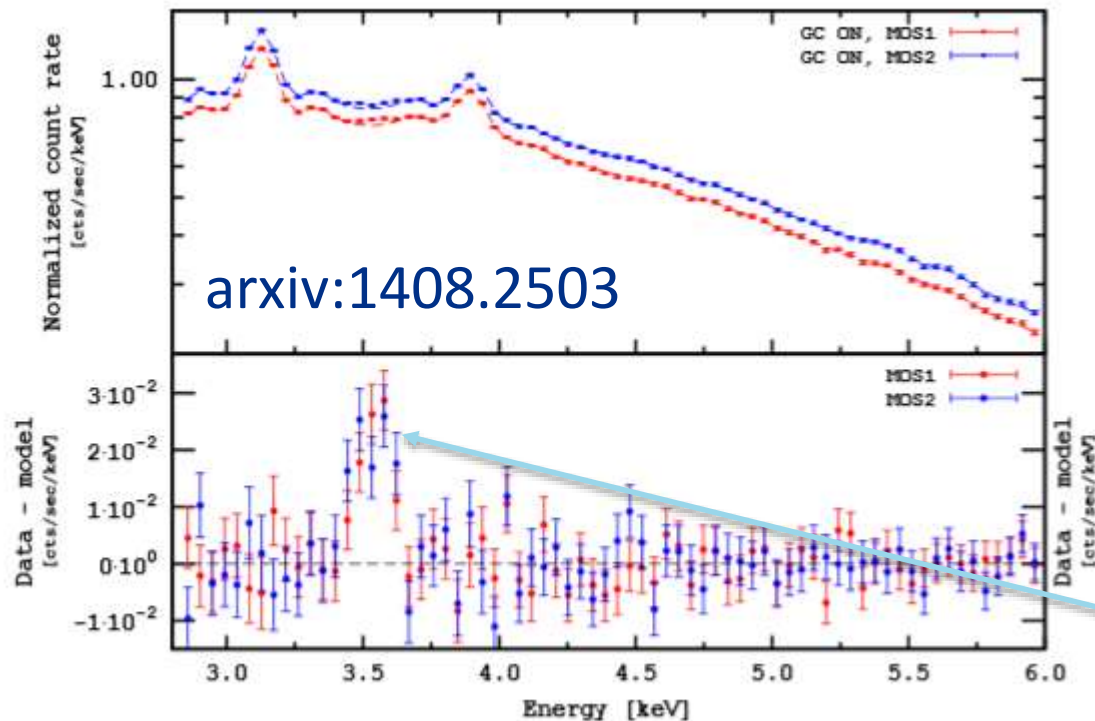
¹Instituut-Lorentz for Theoretical Physics, Universiteit Leiden, Niels Bohrweg 2, Leiden, The Netherlands

²Leiden Observatory, Leiden University, Niels Bohrweg 2, Leiden, The Netherlands

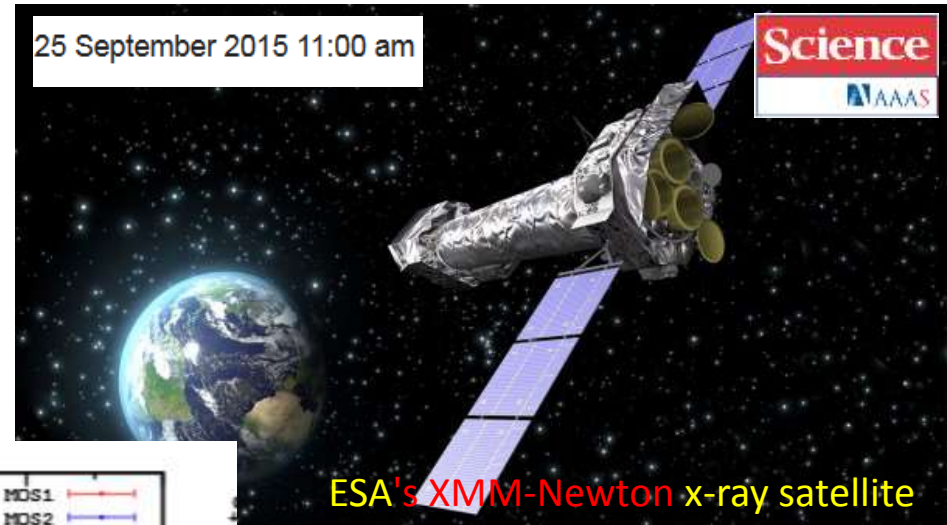
³Bogolyubov Institute of Theoretical Physics, Metrologichna Str. 14-b, 03680, Kyiv, Ukraine

⁴Ecole Polytechnique Fédérale de Lausanne, FSB/ITP/LPPC, BSP, CH-1015, Lausanne, Switzerland

(Dated: August 12, 2014)



arxiv:1408.2503



ESA's XMM-Newton x-ray satellite

Data from:

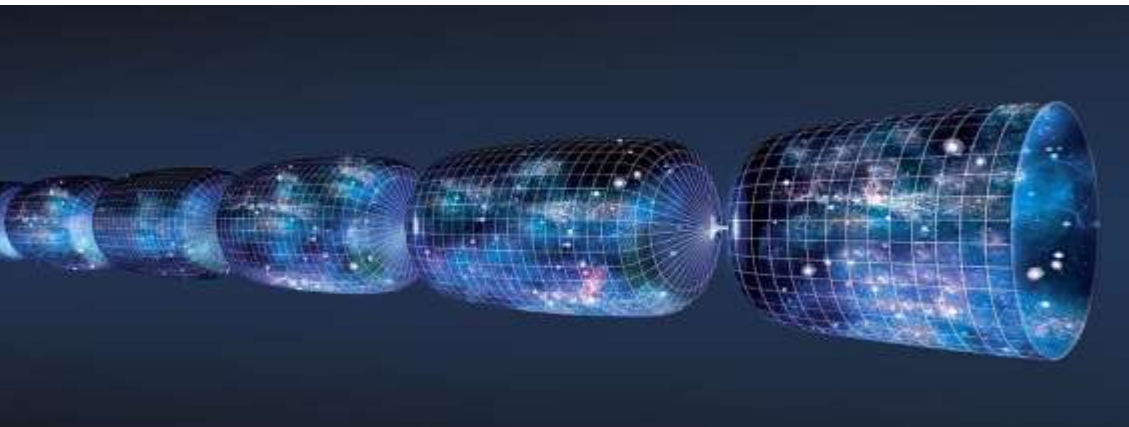
- Center of our Galaxies
- Pegasus cluster
- Andromeda Galaxy
- 73 other Galaxy clusters

Point to

3540 eV line ($m_e/150$)
with ~ 6 sigma significance

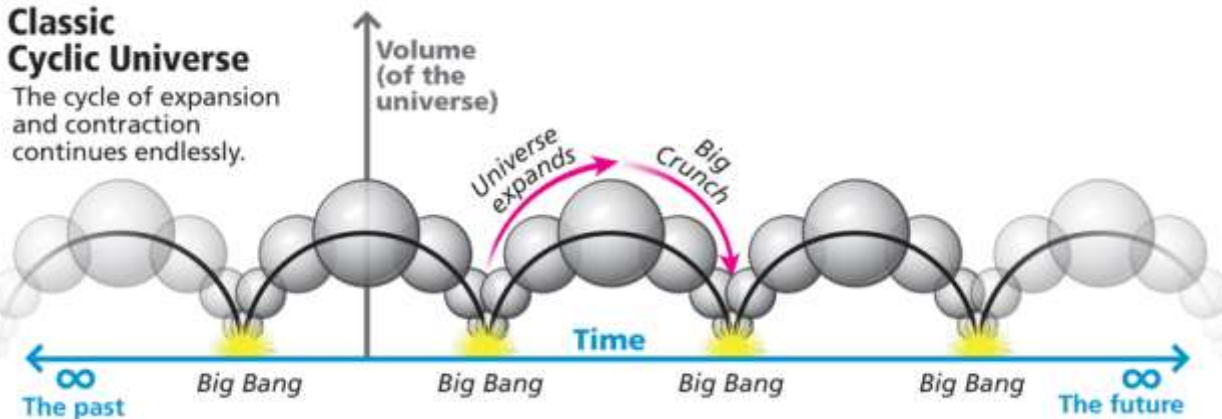
Поиски под фонарем и далее...





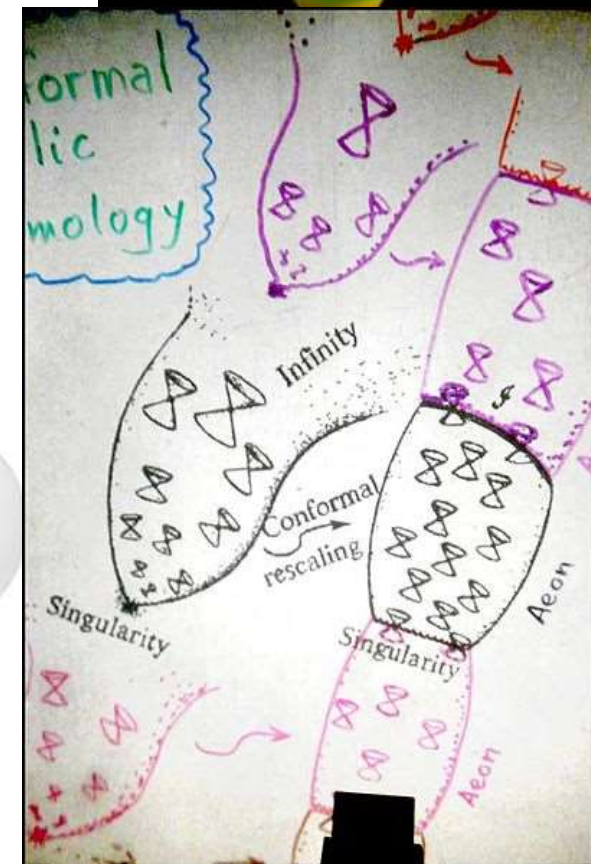
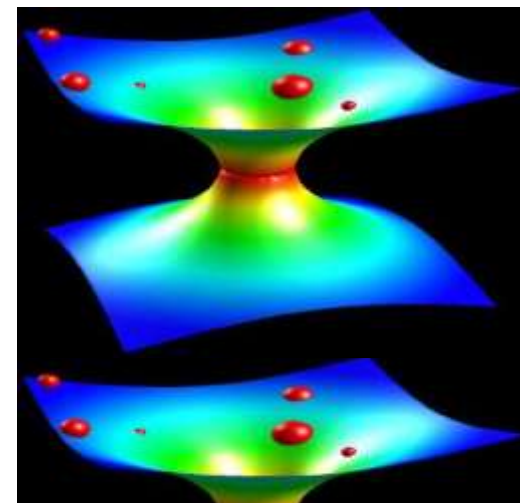
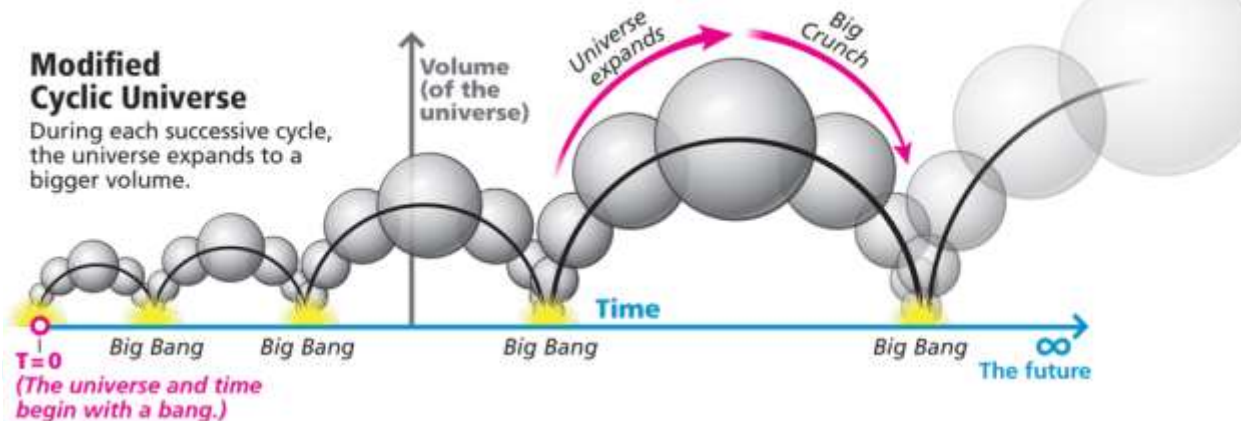
Classic Cyclic Universe

The cycle of expansion and contraction continues endlessly.



Modified Cyclic Universe

During each successive cycle, the universe expands to a bigger volume.



“Unproven and Controversial”- VI

Moon Origin Controversy

Our Moon (Луна) – “Impact Theory”

Theia – Hartmann, Davis (1975) and Cameron, Ward (1976)

T_0 = 4567 million
years ago: birth of
Solar system

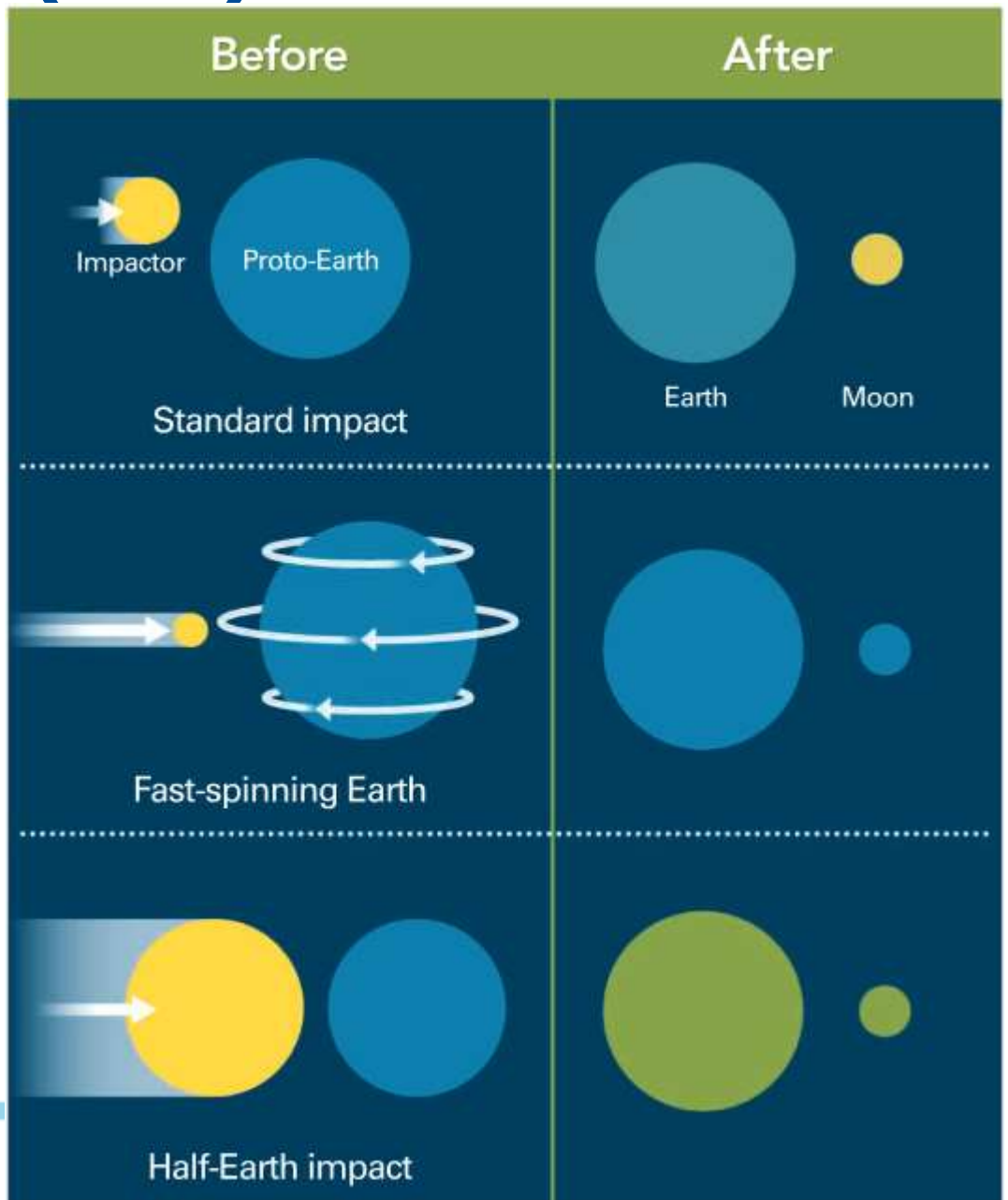
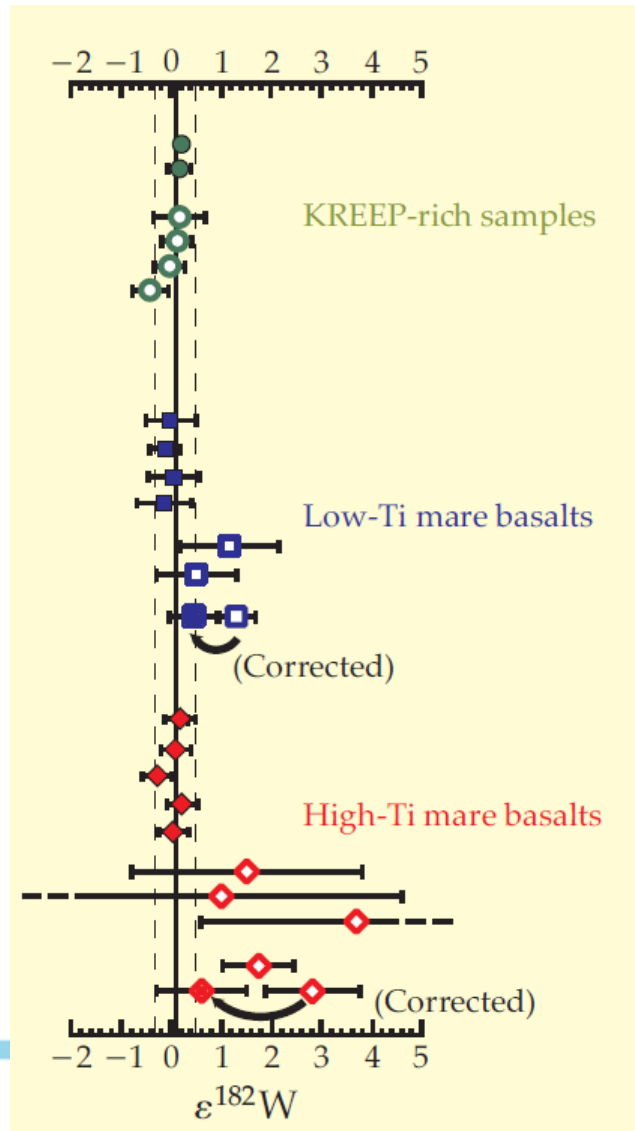
T_0 +(10-20) million
years
separation of iron
(core) and silicon
(outer layers)

T_0 +(60-120) million
Theia impact (~10%
of Earth weight and
~20 km/sec) and
Moon formation

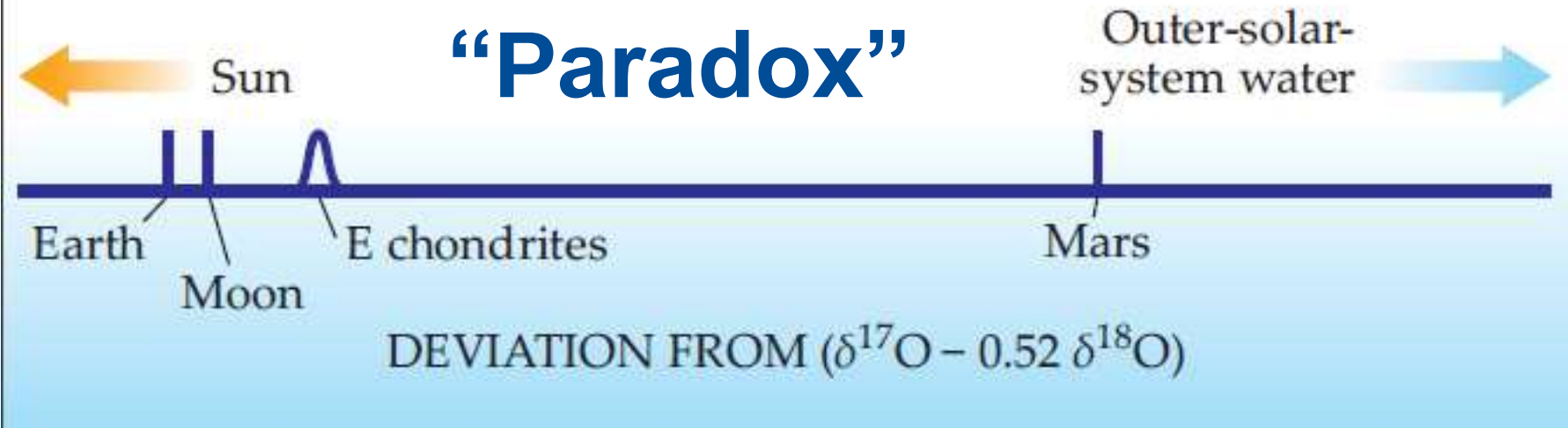


Theia can not be *a priory* of the same isotopic content as Earth – **but it is to <0.001% !?**

(Not) Our Moon ?



“Paradox”



The Earth–Mars difference in Δ is 300 times smaller than the difference between Earth and the Sun; the Earth–Moon difference in Δ is smaller still by an additional factor of about 25

No isotopic differences between Earth and the Moon have yet been recognized; for instance, for **O, Ti, Ca, Si, or W** – **why ???**

Next steps:

- Better measurements
- Better models
- “Better rocks” (Chang’e-5 03/05/2017)
- Check Venus

