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Energy Levels of Light Nuclei, A = 3 - 20

Nuclear Data Evaluation Project
Triangular Universities Nuclear Laboratory

- TUNL Nuclear Data Evaluation Home Page

Information on mass chains and nuclides

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WWW TUNL

- TUNL Nuclear Data Group: Who we are and what we do.

Our publications on Energy Levels of Light Nuclei, A = 5 - 20:

- Publications: TUNL evaluations of A = 3 - 20, and modified versions of Fay Ajzenberg-Selove's publications of A = 5 - 20, are available here in PDF format. The most recent HTML documents of A = 3 - 20, and EL diagrams of A = 4 - 20 are also available here. Some reprints and preprints may be requested by mail.
- HTML for Nuclides: HTML documents are available for individual nuclides found within the TUNL or FAS evaluations.

Resources relating to our publications:

- Energy Level Diagrams are available for A = 4 - 20 nuclides.
- Tables of Energy Levels: a brief listing of tables of energy levels from the most recent publication for each nuclide A = 4 - 20.
- SiteMap and Complete List of Available TUNL Documents: Trying to find a specific TUNL evaluation or preliminary report, HTML document, General Table, Update List or Energy Level Diagram? Click here for a complete list of what's available on our website.

Applications and databases relating to the A = 3 - 20 nuclides:

- NSR Key Number Retrieval
- ENSDF: Information for A = 2 - 20 nuclides available through the National Nuclear Data Center (NNDC) site.
- Excitation Functions: Compilation of the excitation functions for various (p, X) and (α, X) reactions.
- Thermal Neutron Capture Data: Summary of level and branching intensity data measured in Thermal Neutron Capture.
- Ground-State Decay Data: Summary of half-life, branching intensity, and mass excess data measured in ground state beta- and charged-particle-decay.
- Half-Lives Table: List table of nuclear decay half-lives.
- NuDat at BNL: Allows to search and plot nuclear structure and nuclear decay data interactively.

Helpful links:

- TUNL Homepage
- TUNL Dissertations: Online access of TUNL dissertations collection. This site is in progress.
- Links: Important links to the National Nuclear Data Center, online nuclear physics journals, and other useful sites.
- Citation examples: A brief listing of examples of how to format your bibliography, references or citations from the information you obtain from our website.
- Directory
- Email us with problems, questions, suggestions, etc.

Disclaimer

Last modified: 20 September 2018

TUNL Nuclear Data Evaluation Home Page

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Ground State Beta-Decay and Particle Unbound Resonances Data for A = 3 - 20 Nuclei

Go to the Text Only section below if you prefer to view the nuclides in a text list.

Half-Lives Table

					^{18}Mg	^{19}Mg	^{20}Mg							
					^{17}Na	^{18}Na	^{19}Na	^{20}Na						
				^{15}Ne	^{16}Ne	^{17}Ne	^{18}Ne	^{19}Ne	^{20}Ne					
				^{14}F	^{15}F	^{16}F	^{17}F	^{18}F	^{19}F	^{20}F				
		^{11}O	^{12}O	^{13}O	^{14}O	^{15}O	^{16}O	^{17}O	^{18}O	^{19}O	^{20}O			
		^{10}N	^{11}N	^{12}N	^{13}N	^{14}N	^{15}N	^{16}N	^{17}N	^{18}N	^{19}N	^{20}N		
^{7}C	^{8}C	^{9}C	^{10}C	^{11}C	^{12}C	^{13}C	^{14}C	^{15}C	^{16}C	^{17}C	^{18}C	^{19}C	^{20}C	
^{6}B	^{7}B	^{8}B	^{9}B	^{10}B	^{11}B	^{12}B	^{13}B	^{14}B	^{15}B	^{16}B	^{17}B	^{18}B	^{19}B	^{20}B
^{5}Be	^{6}Be	^{7}Be	^{8}Be	^{9}Be	^{10}Be	^{11}Be	^{12}Be	^{13}Be	^{14}Be	^{15}Be	^{16}Be	^{17}Be	^{18}Be	
^{4}Li	^{5}Li	^{6}Li	^{7}Li	^{8}Li	^{9}Li	^{10}Li	^{11}Li	^{12}Li						
^{3}He	^{4}He	^{5}He	^{6}He	^{7}He	^{8}He	^{9}He	^{10}He	^{11}He	^{12}He					
	^{3}H	^{4}H		^{6}H	^{7}H									
			^{4}n		^{6}n									

3	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Color-code Key:

Stable	β^+ Decay	β^- Decay	Particle Unbound Resonances	Beta-Decays Diagram for Nuclei A = 3-20	Not Observed

Note: Comments, and corrections are welcome.
Please email us.

List of available beta-decay data for A = 3 - 20 nuclei:

β^+ Decays:

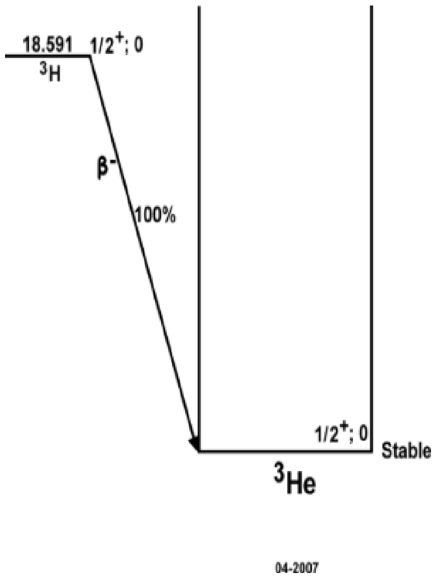
- Beryllium: ^{7}Be
- Boron: ^{8}B
- Carbon: ^{9}C, ^{10}C, ^{11}C
- Nitrogen: ^{12}N, ^{13}N
- Oxygen: ^{13}O, ^{14}O, ^{15}O
- Fluorine: ^{17}F, ^{18}F
- Neon: ^{17}Ne, ^{18}Ne, ^{19}Ne
- Sodium: ^{20}Na

β^- Decays:

- Hydrogen: ^{3}H
- Helium: ^{6}He, ^{8}He
- Lithium: ^{8}Li, ^{9}Li, ^{11}Li
- Beryllium: ^{10}Be, ^{11}Be, ^{12}Be, ^{14}Be
- Boron: ^{12}B, ^{13}B, ^{14}B, ^{15}B, ^{17}B, ^{19}B
- Carbon: ^{14}C, ^{15}C, ^{16}C, ^{17}C, ^{18}C, ^{19}C, ^{20}C
- Nitrogen: ^{16}N, ^{17}N, ^{18}N, ^{19}N, ^{20}N
- Oxygen: ^{19}O, ^{20}O

^{3}H

β^{-} Decay Evaluated Data



Measurements

1947NO01: ^{3}H; measured $T_{1/2}$.
1950JE60: ^{3}H; measured $T_{1/2}$.
1951JO15: ^{3}H; measured $T_{1/2}$.
1952LA19: ^{3}H.
1955JO20: ^{3}H; measured $T_{1/2}$.
1958FR50: ^{3}H.
1958GR93: ^{3}H.
1958PO64: ^{3}H.
1959PO78: ^{3}H.
1961JOZZ: ^{3}H.
1961PI01: ^{3}H; measured not abstracted; deduced nuclear properties.
1963EIZZ: ^{3}H; measured $T_{1/2}$.
1964MO29: ^{3}H; measured not abstracted; deduced nuclear properties.
1967JO09: ^{3}H; measured not abstracted; deduced nuclear properties.
1967JO10: ^{3}H; measured not abstracted; deduced nuclear properties.
1969DA18: ^{3}H; measured E_{β}; deduced Q_{β}, ν rest mass, *ft*.
1969SA21: ^{3}H; measured E_{β}; deduced ν rest mass, Gamow-Teller matrix element.

Links to nndc(national nuclear data center, Brookhaven laboratory) site(page 7) or directly to journal homepage(page 8)

1993WE03: ^{3}H(β^-); measured β-spectrum endpoint energy; deduced electron-antineutrino mass upper limit. ^{3}H, ^{3}He deduced atomic mass difference.
1994GR04: ^{3}H(β^-); measured β-counting rates, spectra
1994GR22: ^{3}H(β^-); measured activity vs quench values.
1994HO11: ^{3}H(β^-); measured integral β-counting rates, high accuracy modifield integral counting method.
1994WA35: ^{3}H(β^-); measured β-spectra, E_β distributions.
1995BA82: ^{3}H(β^-); measured direct limit on heavy neutrino.
1995BE35: ^{3}H(β^-); measured β-spectrum in end-point region; deduced ν rest mass, 95% confidence limit.
1995GR04: ^{3}H(β^-); measured spectra, β-distributions maximum points.
1995ST26: ^{3}H; measured β end point energy spectra; deduced anomalous structure, ν-mass implications.
1996SZ04: ^{3}H(β^-); measured βγ-, (e)γ-, (X-ray)γ-coin.
1997KA29: ^{3}H(β^-); analyzed, reviewed neutrino mass estimates from β-decay data analyses.
1997ZI03: ^{3}H(β^-); compiled, reviewed data; deduced consistency of national ^{3}H standard disseminated by several laboratories.
1998AK06: ^{3}H(β^-); measured $T_{1/2}$ difference for atomic, molecular tritium.
1998LO14: ^{3}H(β^-); measured β-spectrum in end-point region; deduced origin of spectrum anomaly, neutrino mass upper limit.
1998LO21: ^{3}H(β^-); measured β spectra; deduced neutrino rest mass upper limit.
1998VA22: ^{3}H(β^-); measured E_β, I_β(H, θ); deduced asymmetry coefficient.
1999BB29: ^{3}H(β^-); analyzed β spectrum; deduced neutrino mass limit.
1999HA46: ^{3}H(β^-); measured β spectra; deduced electron screening potential.
1999LO09, 1999LO10, 1999LO23: ^{3}H(β^-); measured β spectra; deduced endpoint energy, neutrino mass limit.
1999WE13: ^{3}H(β^-); measured β spectra; deduced endpoint energy, neutrino mass limit.
2000AK09: ^{3}H(β^-); analyzed $T_{1/2}$ for atomic, molecular tritium, related data.
2000BO26, 2000BO32: ^{3}H(β^-); measured E_β, I_β; deduced ν mass upper limit.
2000DE16, 2000ER02: ^{3}H(β^-); measured E_β, I_β.
2000DE20: ^{3}H(β^-); measured E_β; deduced neutrino mass limit.
2000LO08: ^{3}H(β^-); analyzed β-spectra anomalies; neutrino mass upper limit.
2000LO09: ^{3}H(β^-); measured E_β, I_β; deduced ν mass upper limit.
2000LU17: ^{3}H(β^-); compiled, evaluated $T_{1/2}$.
2001BO06: ^{3}H(β^-); measured E_β, I_β; deduced neutrino mass limits.
2001LO02: ^{3}H(β^-); measured E_β, I_β; deduced neutrino mass limits.
2002BO27, 2002BO31: ^{3}H(β^-); analyzed E_β; deduced neutrino mass.
2003KR17: ^{3}H(β^-); measured E_β; deduced neutrino mass limits.
2004AK16: ^{3}H(β^-); measured chemical shift in decay constant between atomic and molecular tritium; deduced atomic tritium $T_{1/2}$.
2005AK04: ^{3}H(β^-); analyzed data; deduced bare triton decay $T_{1/2}$, coupling constants ratio.
2005DO15: ^{3}H(β^-); calculated E_β, effect of external electromagnetic wave field. Implications for neutrino mass determination discussed.
2005KR03: ^{3}H(β^-); measured E_β; deduced neutrino mass limit.
2006BI13: ^{3}H(β^-); analysed data; deduced neutrino mass limit and spectrum shapes.
2006WE03: ^{3}H(β^-); compiled, analyzed decay data, neutrino mass limits.
2010OT02: ^{3}H(β^-); measured I_e, E_e; deduced β-spectrum, neutrino mass.
2011AS10: measured ^{3}H decay; deduced anti-neutrino mass.
2013BI07: ^{3}H(β^-); measured decay products, E_β, I_β.
2016PO08: ^{3}H(β^-); measured decay products; deduced exponential nature of nuclear decay.
2017AB05: ^{3}H(β^-); measured decay products, E_β, I_β; deduced β-spectrum.

Measured half-life for $^{3}H(\beta^{-})^{3}He$

Recommended value (September, 2015):	12.323 ± 0.020 years	(Weighted Average Method: uncertainties of (1955JO20) and (1977RUZZ) adjusted to 12.262 ± 0.030 and 12.3232 ± 0.0246 as suggested in (2000LU17).)
Summary Table of Uncertainty Analysis:	Table Prev. (PDF)	
Measured values:	12.33 ± 0.02 years	(2000Unterweger: see also 12.43 ± 0.05 years in (1980UN01).)
	12.31 ± 0.03 years	(1991BU13: see also 12.29 ± 0.15 years in (1987BU28).)
	12.279 ± 0.033 years	(1988Akulov; Akulov et al, Zh. Tekh. Fiz. 14 (1988) 940; Sov. Tech. Phys. Lett. 14 (1988) 416. See discussion on a comparison of the molecular lifetime vs. the atomic lifetime in (2004AK16), where $T_{1/2}$(atomic) ≈ 12.264 ± 0.018 years is obtained.)
	12.38 ± 0.03 / 0.04 years	(1987OL04 / 1989Oliver)
	12.32 ± 0.03 years	(1987SI01)
	12.3232 ± 0.0043 years	(1977RUZZ: see also 12.346 ± 0.002 years in (1967JO09) and 12.355 ± 0.010 years in (1963EIZZ).)
	12.25 ± 0.08 years	(1967JO10)
	12.31 ± 0.13 years	(1966Merritt; Merritt and Taylor, Chalk River Rept. AECL-2510 (1966))
	12.58 ± 0.18 years	(1958PO64)
	12.262 ± 0.004 years	(1955JO20)
	$12.41^{+0.15}_{-0.25}$ years	(1951JO15)
	12.46 ± 0.1 years	(1950JE60)
	12.1 ± 0.5 years	(1947NO01)
	10.7 ± 2.0 years	(1947GO08)
Other Reviews:	12.312 ± 0.025 years	(DDEP)
	12.312 ± 0.011 years	(2006MA57)
	12.320 ± 0.022 years	(2000LU17)

Previous Measurements

Reference	Method or forms of ^{3}H sources	End Point Energy (keV)	Heat Output (W/g)	
(1952LA19)	magnetic	17.95 ± 0.1	(1950JE60)	0.321 ± 0.003
(1958FR50)	mass	18.65 ± 0.2 [a]	(1958GR93)	0.319 ± 0.001
(1959PO78)	magnetic	18.61 ± 0.1	(1958PO64)	0.312 ± 0.001
(1964MO29)	mass	18.47 ± 0.17 [a]	(1961JOZZ)	0.3244 ± 0.0013
(1969SA21)	electrostatic	18.70 ± 0.06 [b]	(1961PI01)	0.3240 ± 0.0009
(1969DA18)	magnetic	18.570 ± 0.075	**Average E_β (keV)**	
(1970LE15)	^{3}H implanation	18.540 ± 0.095	(1950JE60)	5.69 ± 0.04; calorimetry
(1972BE11)	magnetic-electrostatic	18.610 ± 0.016	(1958GR93)	5.57 ± 0.01; calorimetry
(1973PI01)	magnetic	18.578 ± 0.040	(1961PI01)	5.73 ± 0.03; calorimetry
(1974RO08)	magnetic	18.648 ± 0.026		
(1975SM02)	mass difference	18.559 ± 0.007		
(1976TR07)	magnetic	18.575 ± 0.013		
(1981LU07)	magnetic	18.577 ± 0.013		
(1983DE47)	thermal diffuse	18.562 ± 0.006		
(1985SI07)	^{3}H implanation	18.577 ± 0.007		
(1985BO34)	magnetic	18.5842 ± 0.0016		
(1987BO07)	valine	18.5794 ± 0.004		
(1993BA08)	moleculare tritium	18.5748 ± 0.0006		
(1993SU32)	$C_{14}H_{15}T_6O_2N_3$	18.5783 ± 0.0051		
(1995ST26)	gaseous tritium	18.5685 ± 0.002		
(2003KR17)	gaseous tritium	18.5705		

[a] Assumes anti-neutrino mass to be zero.

[b] Not correct for resolution effects.

Nuclear Science References (NSR)

NSR Reference Paper NIM **A 640**, 213 (2011)
Database version of March 29, 2019

1985BO53

Pisma Zh.Eksp.Teor.Fiz. 42, 107 (1985); JETP Lett.(USSR) 42, 130 (1985)

S.D.Boris, A.I.Golutvin, L.P.Laptin, V.A.Lyubimov, V.V.Nagovitsyn, E.G.Novikov, V.Z.Nozik, V.A.Soloshchenko, I.N.Tikhomirov, E.F.Tretyakov, N.F.Myasoedov

The Neutrino Mass Determination from the β Spectrum of Tritium in Valine (ITEP-84)

RADIOACTIVITY ^{3}H(β^{-}); measured Eβ, Iβ; deduced β-endpoint energy, neutrino mass lower limit. ^{3}He, ^{3}H deduced mass difference.

BibTex output.

JETP Letters

June 2017, Volume 105, Issue 12, pp 753–757 | Cite as

First measurements in search for keV sterile neutrino in tritium beta-decay in the Troitsk nu-mass experiment

Authors Authors and affiliations

J. N. Abdurashitov, A. I. Belesev, V. G. Chernov, E. V. Geraskin, A. A. Golubev, P. V. Grigorieva, G. A. Koroteev, N. A. Likhovid, A. A. Nozik, V. S. Pantuev, V. I. Parfenov, A. K. Skasyrskaya, I. I. Tkachev, S. V. Zadorozhny

Fields, Particles, and Nuclei

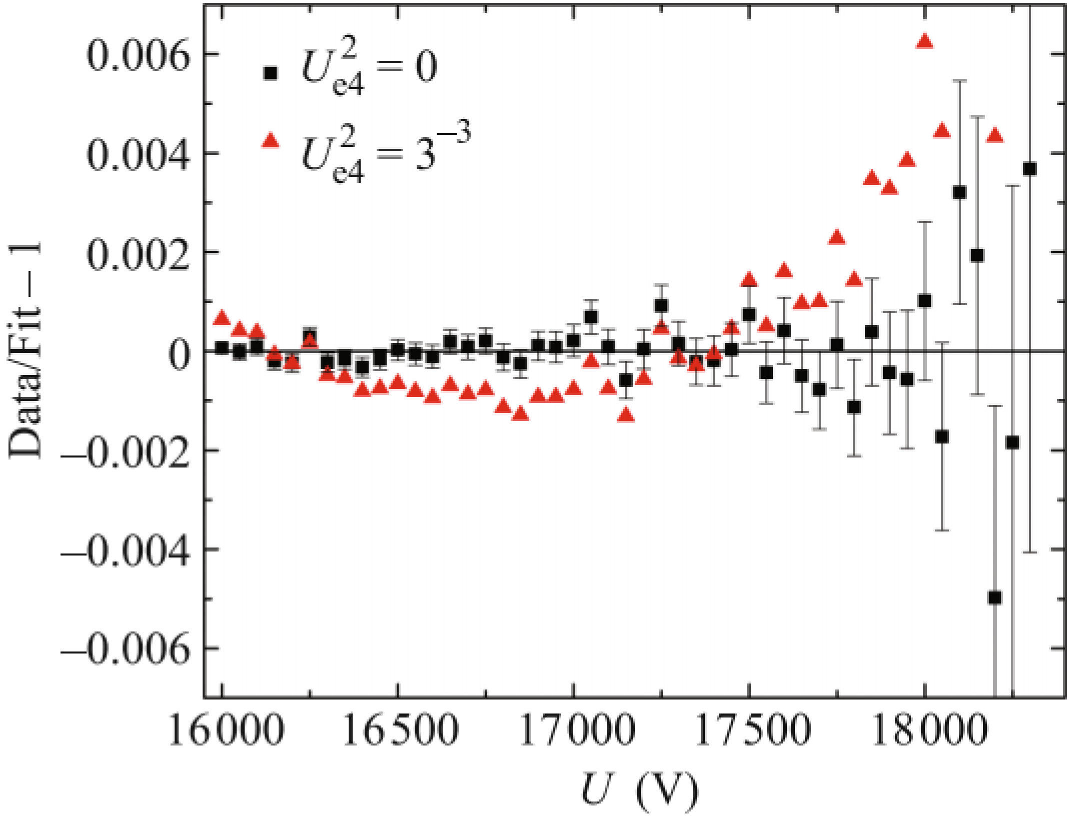
First Online: 13 June 2017

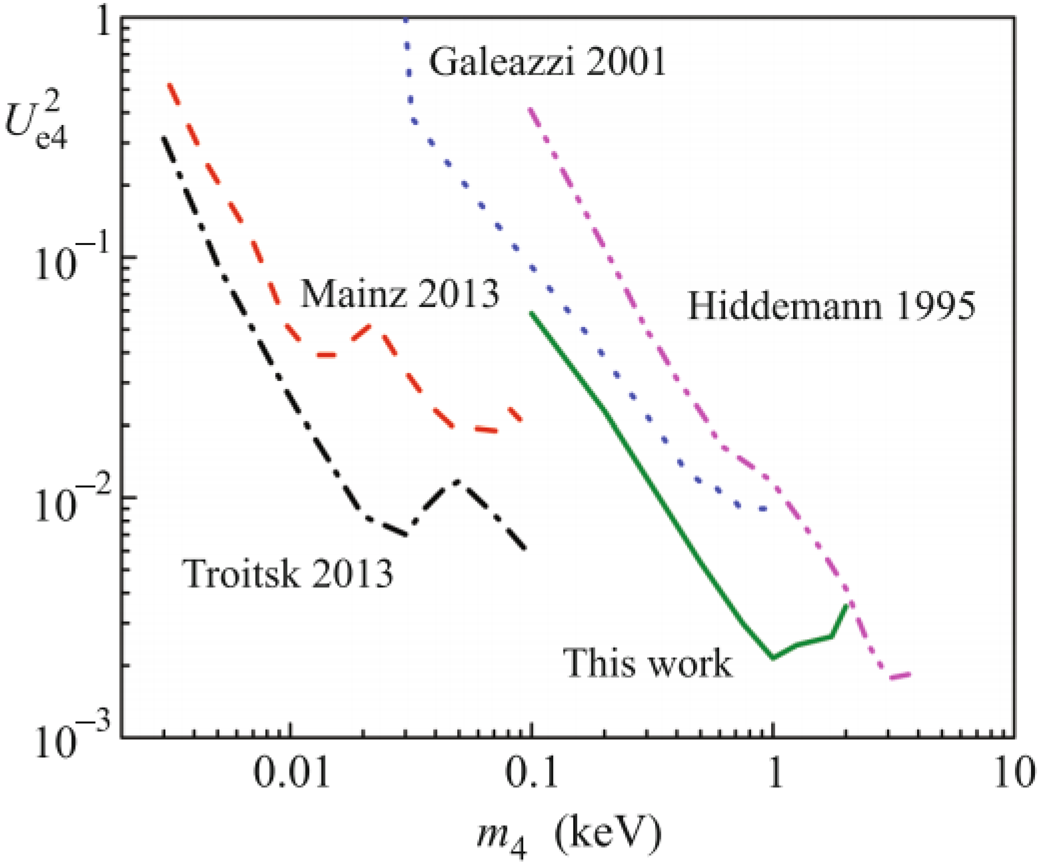
Abstract

We present the first results of precision measurements of tritium -decay spectrum in the electron energy range 16–18.6 keV by the Troitsk nu-mass experiment. The goal is to find distortions that may be caused by the existence of heavy sterile neutrinos. A signature would correspond to a kink in the spectrum with characteristic shape and end point shifted by the value of a heavy neutrino mass. We set new upper limits to the neutrino mixing matrix element $U_{e4}{}^2$, which improve existing limits by a factor of 2 to 5 in the mass range of 0.1–2 keV.

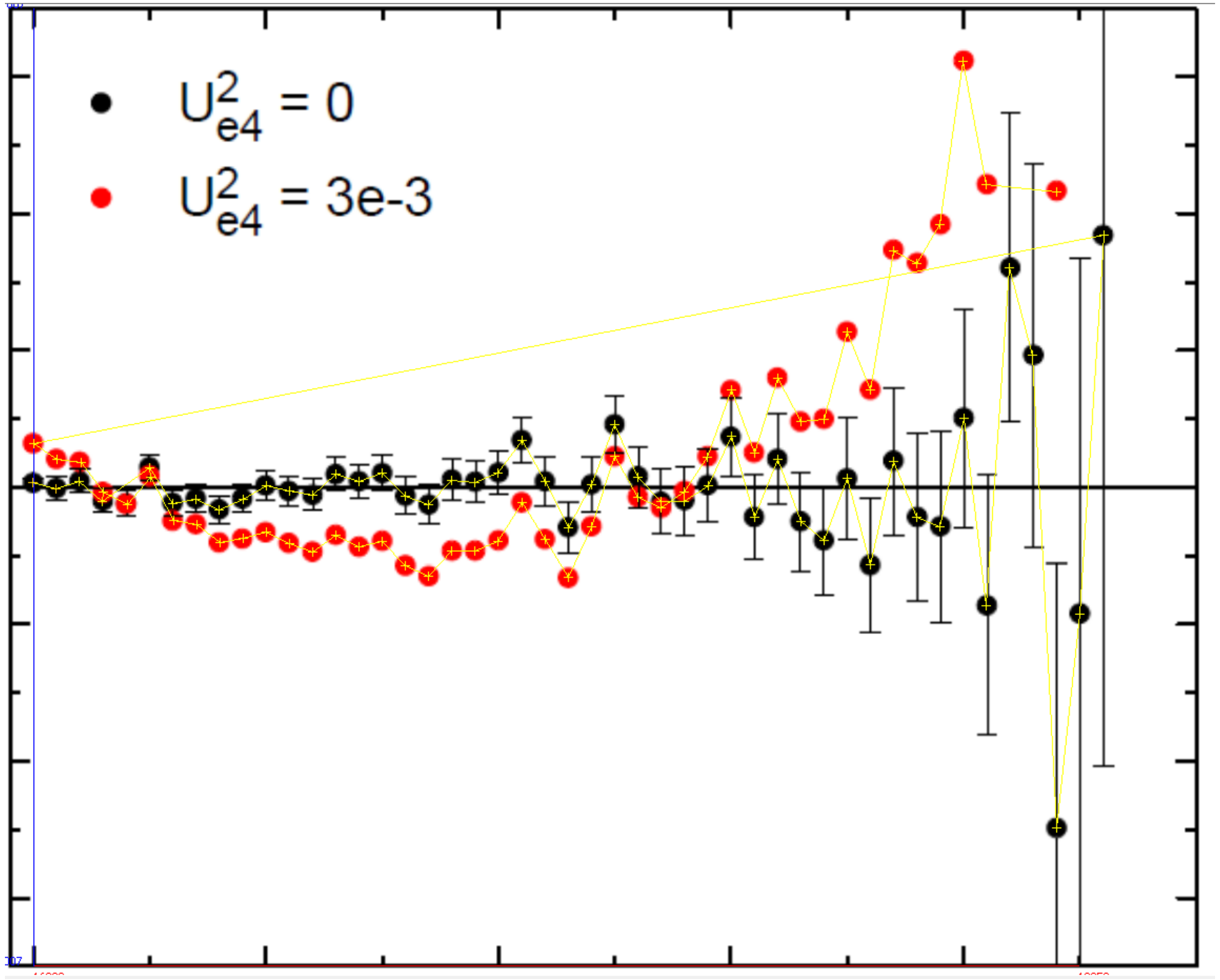
V.S. Pantuev et al. “First measurements in search for keV sterile neutrino in tritium beta-decay in the Troitsk nu-mass experiment”, June 2017, Volume 105, Issue 12, pp 753–757

2016 Oct data

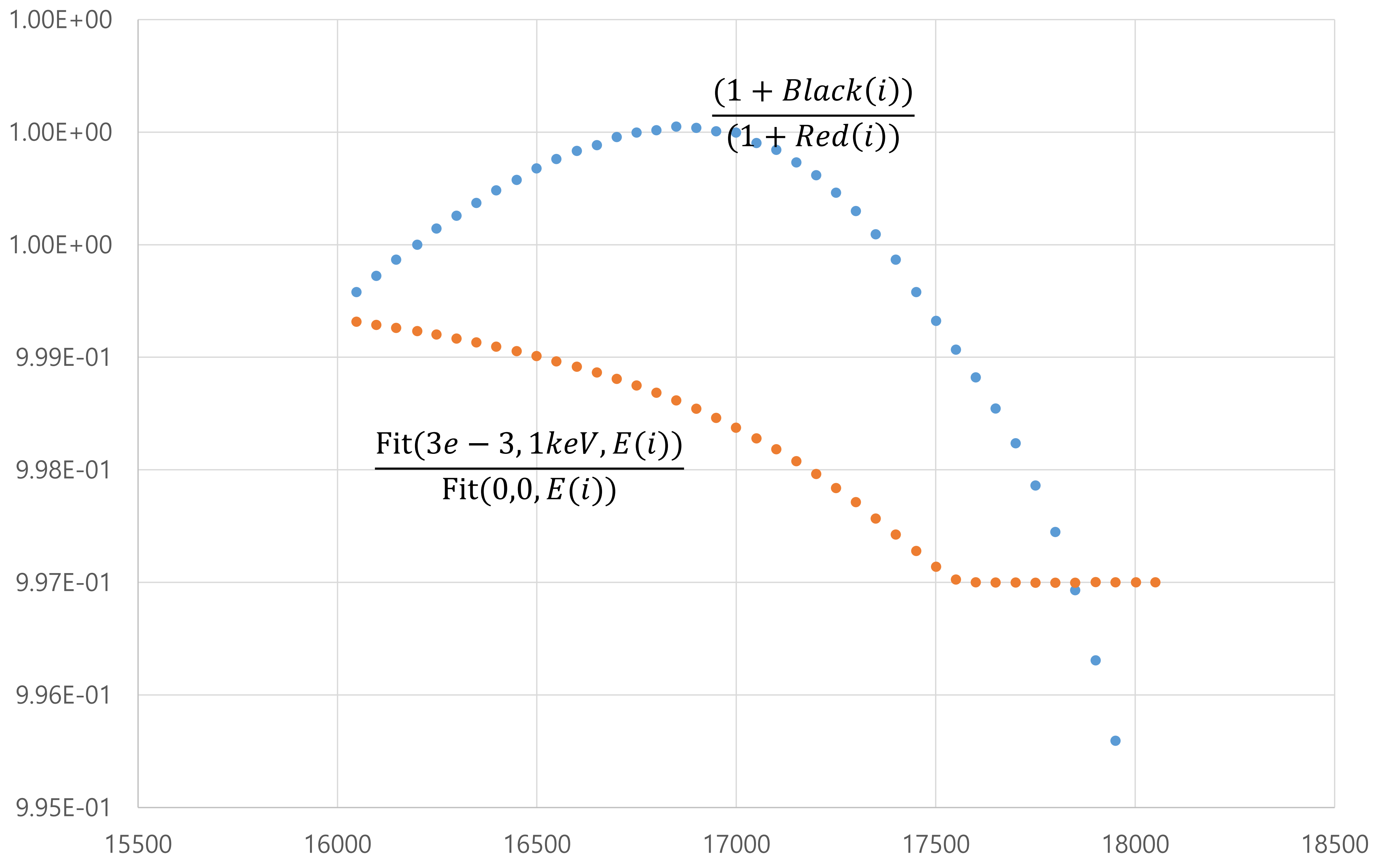




30sec(measurement time) at each point(15kHz at 16000V(16000eV)), acceptance = 2.1%(from source to detector)



$U^2_{e4} = 0$
$U^2_{e4} = 3e\text{-}3$



$\frac{(1 + Black(i))}{(1 + Red(i))}$
$\frac{\mathrm{Fit}(3e-3, 1keV, E(i))}{\mathrm{Fit}(0,0,E(i))}$
1.00E+00
1.00E+00
1.00E+00
9.99E-01
9.98E-01
9.97E-01
9.96E-01
9.95E-01
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