Evidence of Correlations Between Nuclear Decay Rates and Solar Activity

Jere Jenkins
Ephraim Fischbach

John Buncher
Tom Gruenwald
Dennis Krause
Josh Mattes
John Newport

References

- Perturbation of Nuclear Decay Rates During the Solar Flare of 13 December 2006 (Jere H. Jenkins, Ephraim Fischbach) http://arxiv.org/abs/0808.3986
- Evidence for Correlations Between Nuclear Decay Rates and Earth-Sun Distance (Jere H. Jenkins, Ephraim Fischbach, John B. Buncher, John T. Gruenwald, Dennis E. Krause, Joshua J. Mattes) http://arxiv.org/abs/0808.3283

Outline

- Brief history of radioactivity
- Brookhaven National Laboratory ^{32}Si data (Alburger, Harbottle, and Norton)
- PTB ^{226}Ra data (Siegert, Schrader, and Schötzig)
- BNL/PTB correlations
- 2006 December solar flare data
- Discrepancies in half-life measurements
- Possible mechanisms
- Spacecraft and other tests

RADIATIONS
FROM
RADIOACTIVE SUBSTANCES

by

SIR ERNEST RUTHERFORD, O.M., D.Sc., Ph.D., LL.D., F.R.S.
NOBEL LAUREATE
Cavendish Professor of Experimental Physics in the University of Cambridge

JAMES CHADWICK, Ph.D., F.R.S.
Fellow of Gonville and Caius College, Cambridge

and

C. D. ELLIS, Ph.D., F.R.S.
Fellow of Trinity College, Cambridge

Re-issue of the edition of 1930

CAMBRIDGE
AT THE UNIVERSITY PRESS
1951

CHAPTER VII

GENERAL PROPERTIES OF THE RADIATIONS

§ 34 a. Emission of α particles and probability variations. The rate of disintegration of all radioactive substances is expressed by a simple law, namely, that the number of atoms n breaking up per second is proportional to the number N of atoms present. Consequently $n = \lambda N$, where λ is a constant characteristic for a particular radioactive substance. The rate of transformation of an element has been found to be a constant under all conditions. It is unaltered by exposing the active matter to extremes of temperature or by change of its physical or chemical state. It is independent of the age of the active matter or its concentration. It is unaffected by exposure to strong magnetic fields. Hevesy has shown that the disintegration of the primary radioactive element uranium is unaltered by exposing it to the β and γ radiation from a strong source of radium, although these rays, of great individual energy, might be expected to penetrate the atomic nucleus.

Since the expulsion of an α or β particle results from an instability of the atomic nucleus, the failure to alter the rate of transformation shows that the stability of the atomic nucleus is not influenced to an appreciable extent by the forces at our command. This is not unexpected when we consider the enormous intensity of the forces, probably both electric and magnetic, which hold the charged parts of the nucleus together in such a minute volume.

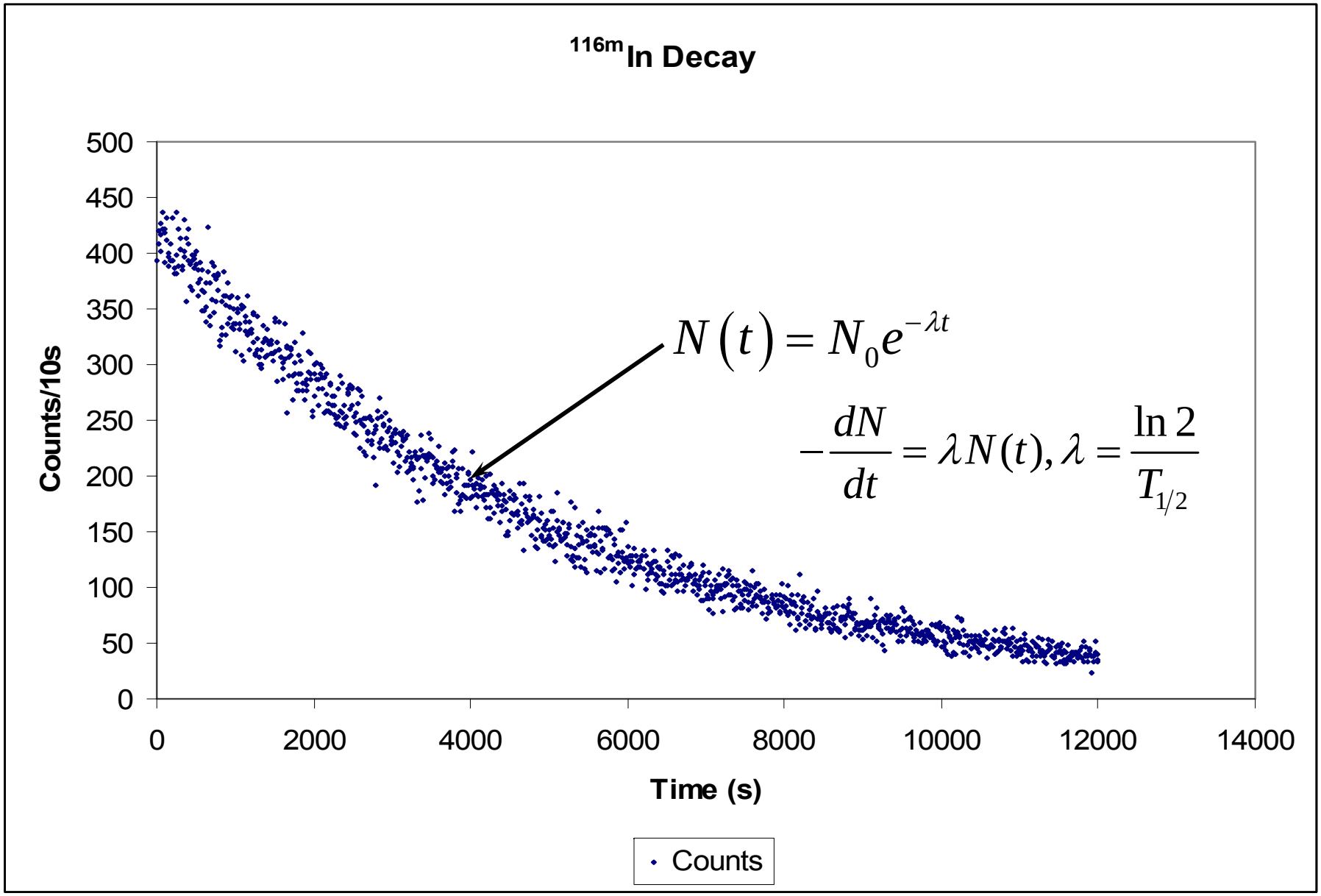
E. v. Schweidler* showed that the exponential law of decay of the radioactive bodies could be deduced without any special hypotheses of the structure of the radioactive nuclei or of the mechanism of disintegration. He assumed only that the disintegration of an atom is subject to the laws of chance, and that the probability p that an atom of a certain type shall be transformed within a given interval of time Δ is independent of the time which has elapsed since the formation of the atom and is a constant which is the same for all atoms of the same type or radioactive product.

For very small values of the time interval Δ, the chance p of transformation will be proportional to the length of the interval. There-

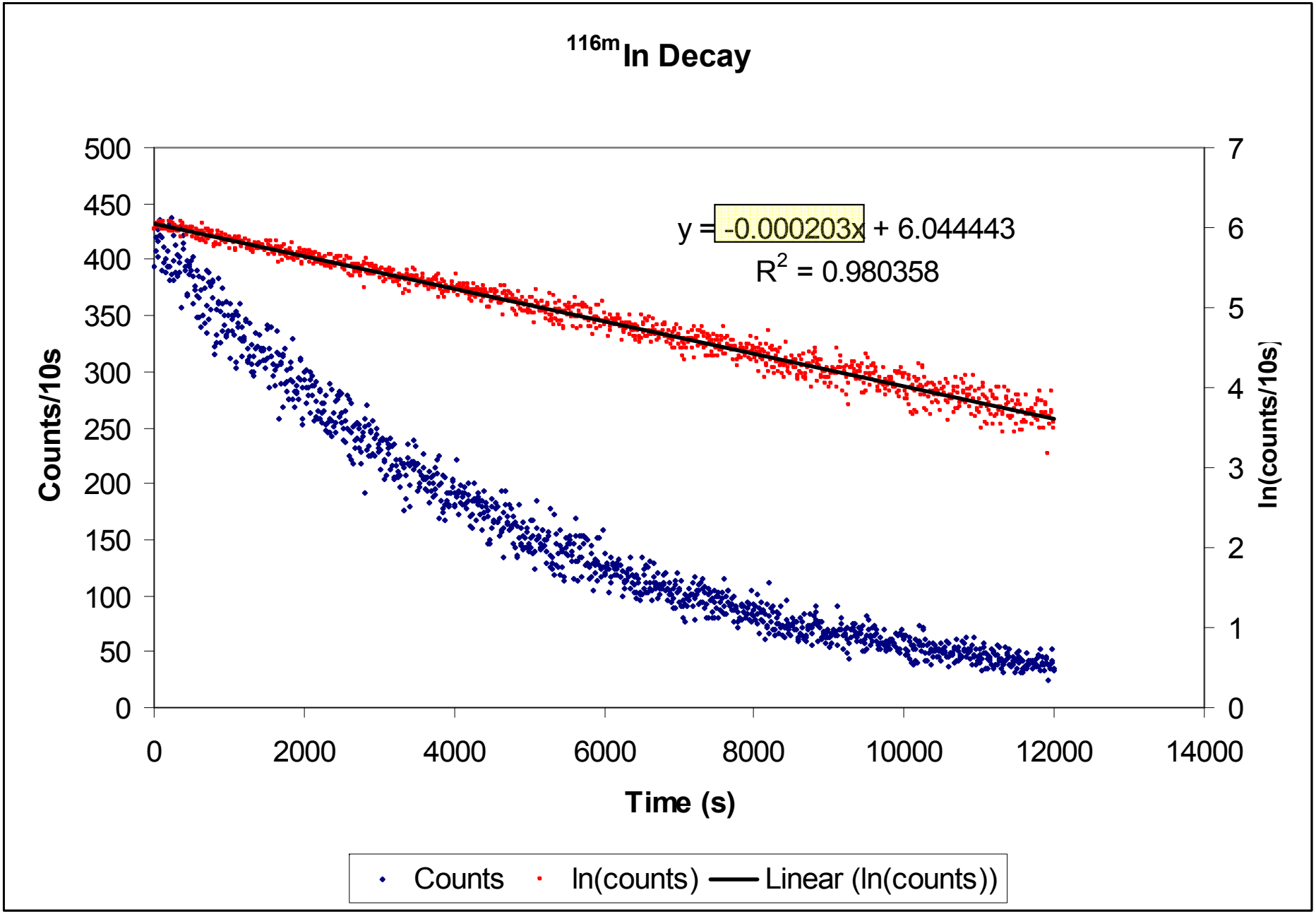
* Schweidler, *Congrès Internat. Radiologie*, Liège, 1905.

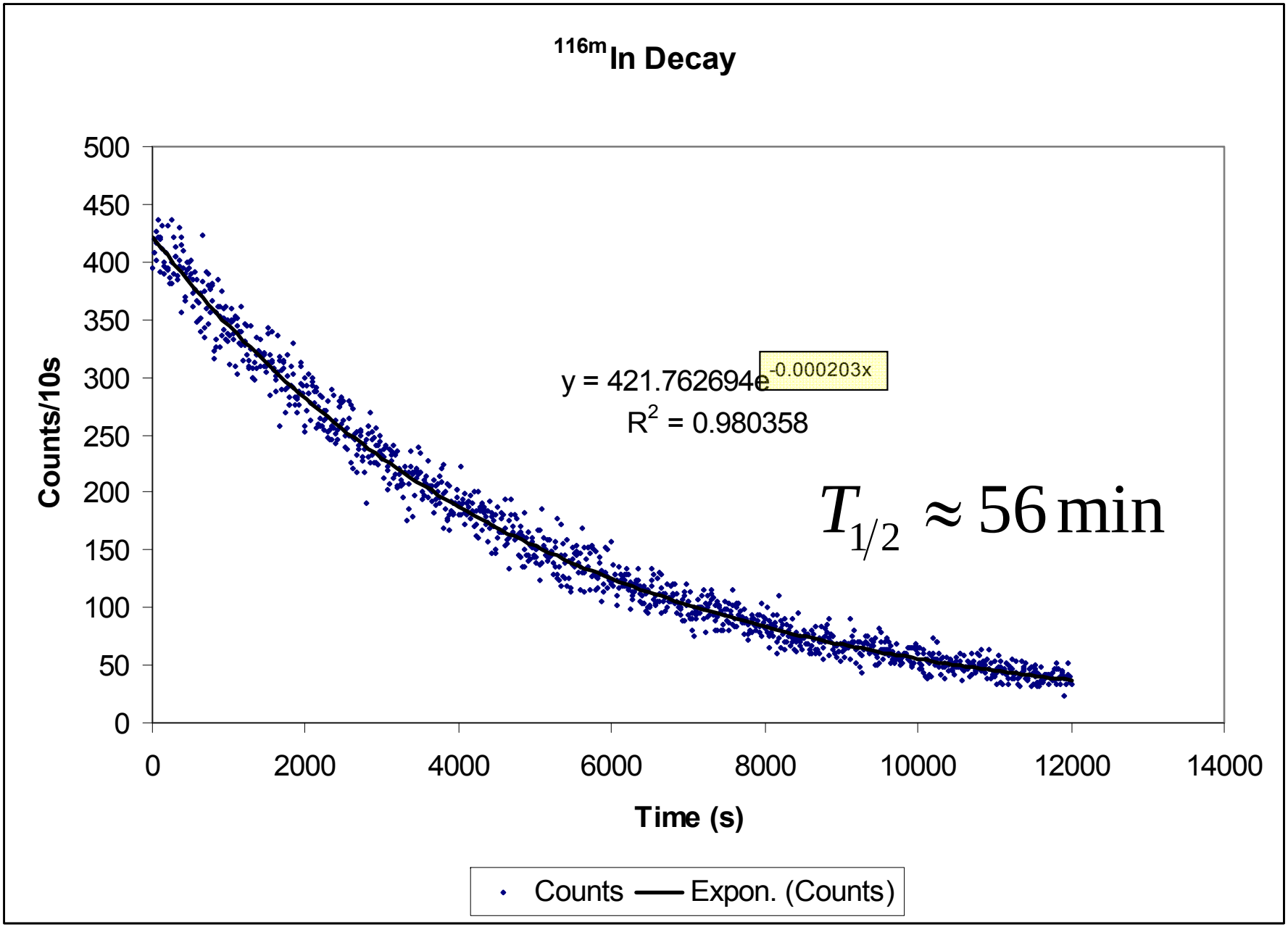
Rutherford and Petavel* introduced some radium emanation into a high pressure bomb in which cordite was exploded. The γ ray activity of the emanation was found not to be altered at the moment of the explosion although the maximum temperature was about 2500° and the corresponding pressure about 1000 atmospheres. Certain subsequent changes of the activity, which extended over some hours, were no doubt due to the difference in distribution of the active deposit brought about by the explosion. Schuster† showed that the γ ray activity of radium was not altered by exposure to a pressure of 2000 atmospheres. A similar result was obtained by Eve and Adams‡. It is thus seen that no evidence has been obtained that high temperatures or pressures have any influence in accelerating or retarding the rate of transformation of any radio-active substance. The rate of transformation proceeds at the same rate at a temperature of liquid air −186° as at a temperature of 1500°. Such a result brings out clearly

From: Radioactive Substances and Their Radiations, by Rutherford,



^{116m}In $T_{1/2}$=54.2 min


116m In Decay
y = -0.000203x + 6.044443
R2 = 0.980358
Counts/10s
ln(counts/10s)
Time (s)
500
450
400
350
300
250
200
150
100
50
0
7
6
5
4
3
2
1
0
0
2000
4000
6000
8000
10000
12000
14000
Counts
ln(counts)
Linear (ln(counts))


116m In Decay
Counts/10s
500
450
400
350
300
250
200
150
100
50
0
0
2000
4000
6000
8000
10000
12000
14000
Time (s)
y = 421.762694e-0.000203x
R2 = 0.980358
T1/2 ≈ 56 min
Counts
Expon. (Counts)

A New Test of Randomness

PHYSICAL REVIEW E **67**, 016113 (2003)

Geometric random inner products: A family of tests for random number generators

Shu-Ju Tu* and Ephraim Fischbach†
Department of Physics, Purdue University, West Lafayette, Indiana 47907-1396
(Received 4 October 2002; published 28 January 2003)

We present a computational scheme, GRIP (geometric random inner products), for testing the quality of random number generators. The GRIP formalism utilizes geometric probability techniques to calculate the average scalar products of random vectors distributed in geometric objects, such as circles and spheres. We show that these average scalar products define a family of geometric constants which can be used to evaluate the quality of random number generators. We explicitly apply the GRIP tests to several random number generators frequently used in Monte Carlo simulations, and demonstrate a statistical property for good random number generators.

DOI: 10.1103/PhysRevE.67.016113 PACS number(s): 02.50.Ng

Earth and Planetary Science Letters, 78 (1986) 168–176
Elsevier Science Publishers B.V., Amsterdam – Printed in The Netherlands

[6]

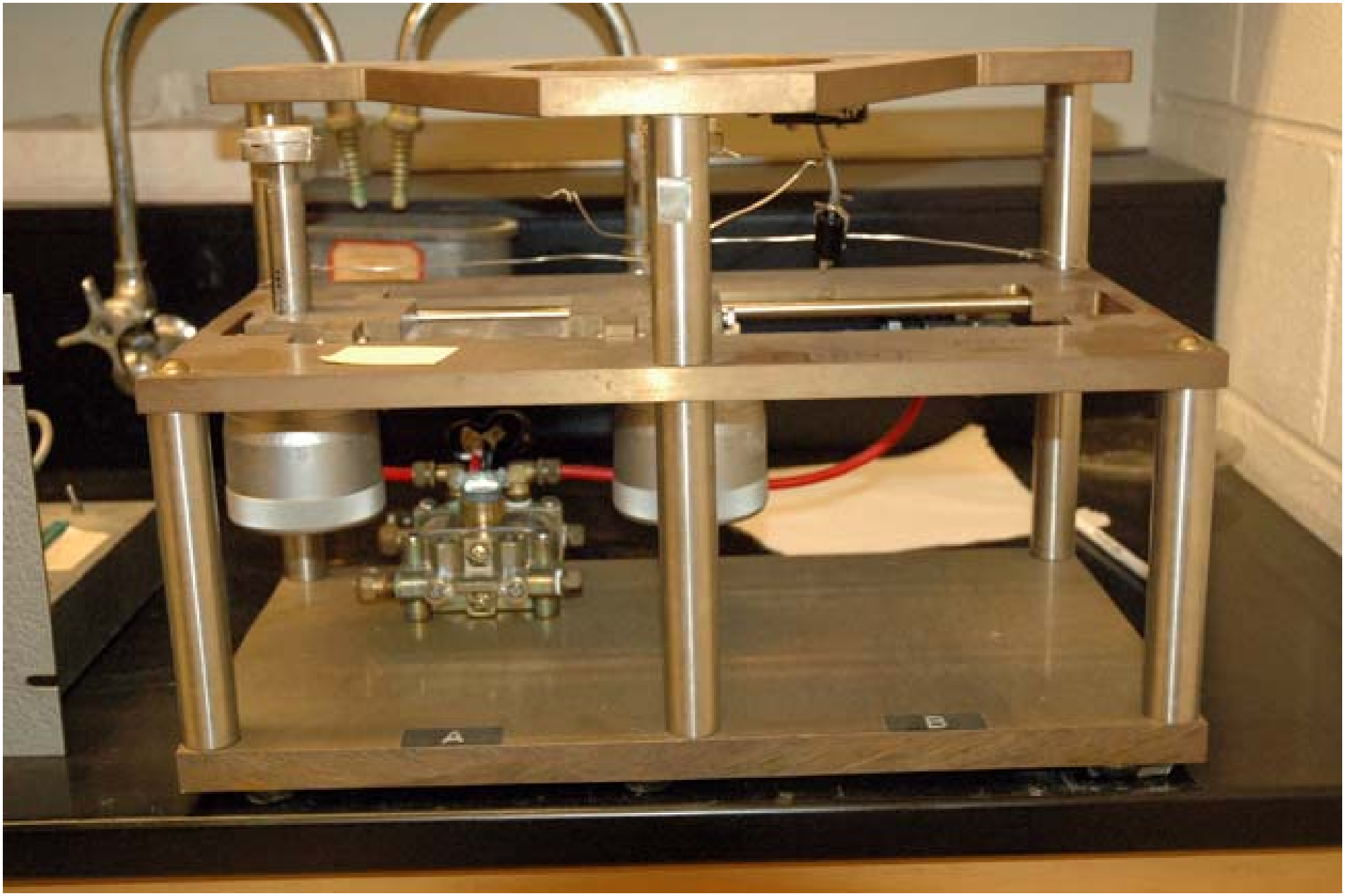
Half-life of ^{32}Si

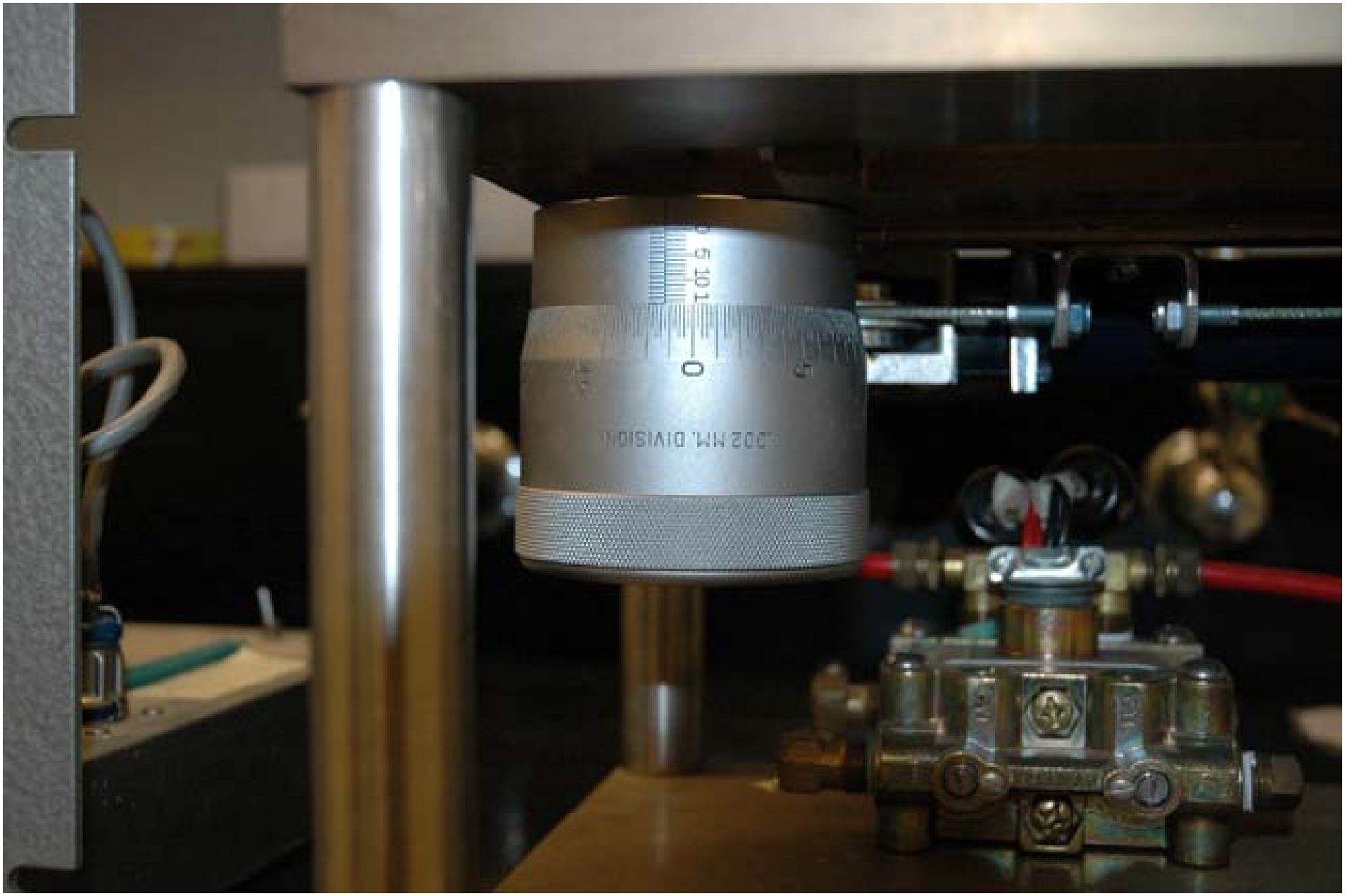
D.E. Alburger, G. Harbottle and E.F. Norton

Brookhaven National Laboratory, Upton, NY 11973 (U.S.A.)

Received August 15, 1985; revised version received March 3, 1986

Beta rays from a ^{32}Si-^{32}P source, produced in 1968-69 via the ^{30}Si(t,p)^{32}Si reaction using a Van de Graaff beam at $E_t = 3.4$ MeV, were counted with an end-window gas-flow proportional counter system including an automatic precision sample changer. Comparison counts were taken on the β rays from a ^{36}Cl source. Measurements beginning February, 1982 were made at approximately 4-week intervals, each consisting of a total of 40 hours of counting on each sample. The decay rate was determined from the ^{32}Si/^{36}Cl ratio of counts. Small periodic annual deviations of the data points from an exponential decay curve were observed, but are of uncertain origin and had no significant effect on the result. Based on the analysis of 53 points taken in 48 months, the value $T_{1/2} = 172(4)$ yr is adopted for the half-life of ^{32}Si. This result is substantially greater than two previously reported measurements of 108(18) yr and 101(18) yr but is lower than values based on geophysical evidence.


A
B


0
5
10
15
.002 MM. DIVISION

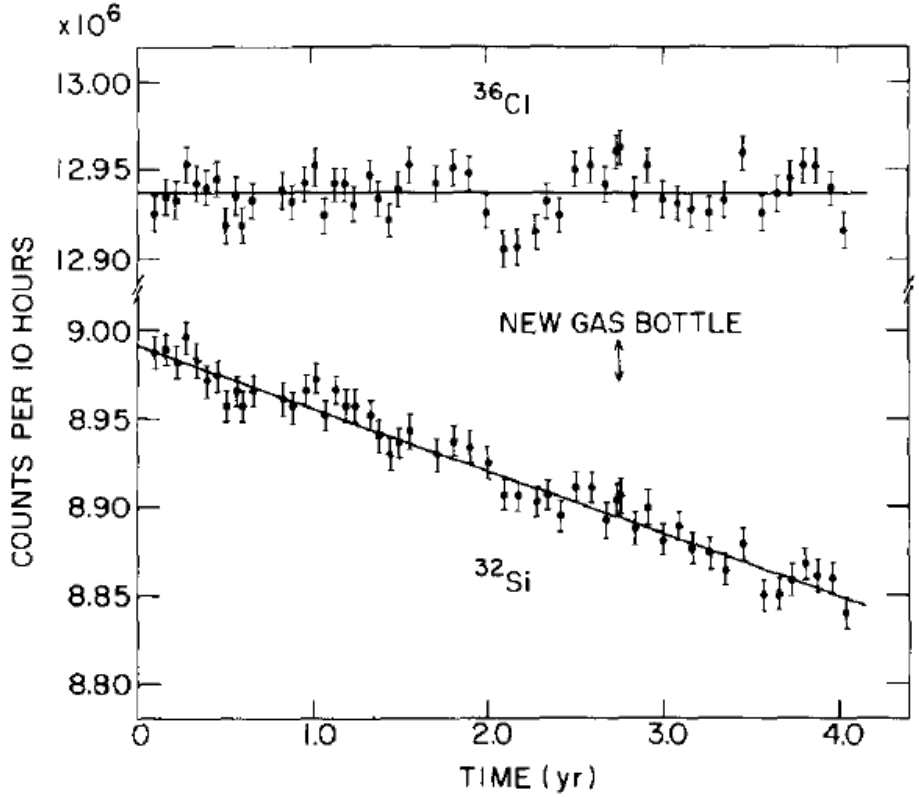


Fig. 3. Lower part, ^{32}Si singles counting rate measured over a period of 48 months; upper part, corresponding ^{36}Cl singles counting rate. Points are counts per 10 hr on each sample, averaged from 4 runs. Error bars are (arbitrarily) three times the statistical uncertainties. The solid curve shown for ^{32}Si is an exponential computer fit, although the ordinate is linear for convenience in plotting. The upper horizontal line is the average of all ^{36}Cl points. The results of the fit to the ^{32}Si data are $T_{1/2} = 173.8$ yr with an uncertainty of 4.8 yr and a standard deviation of 1.7 yr.

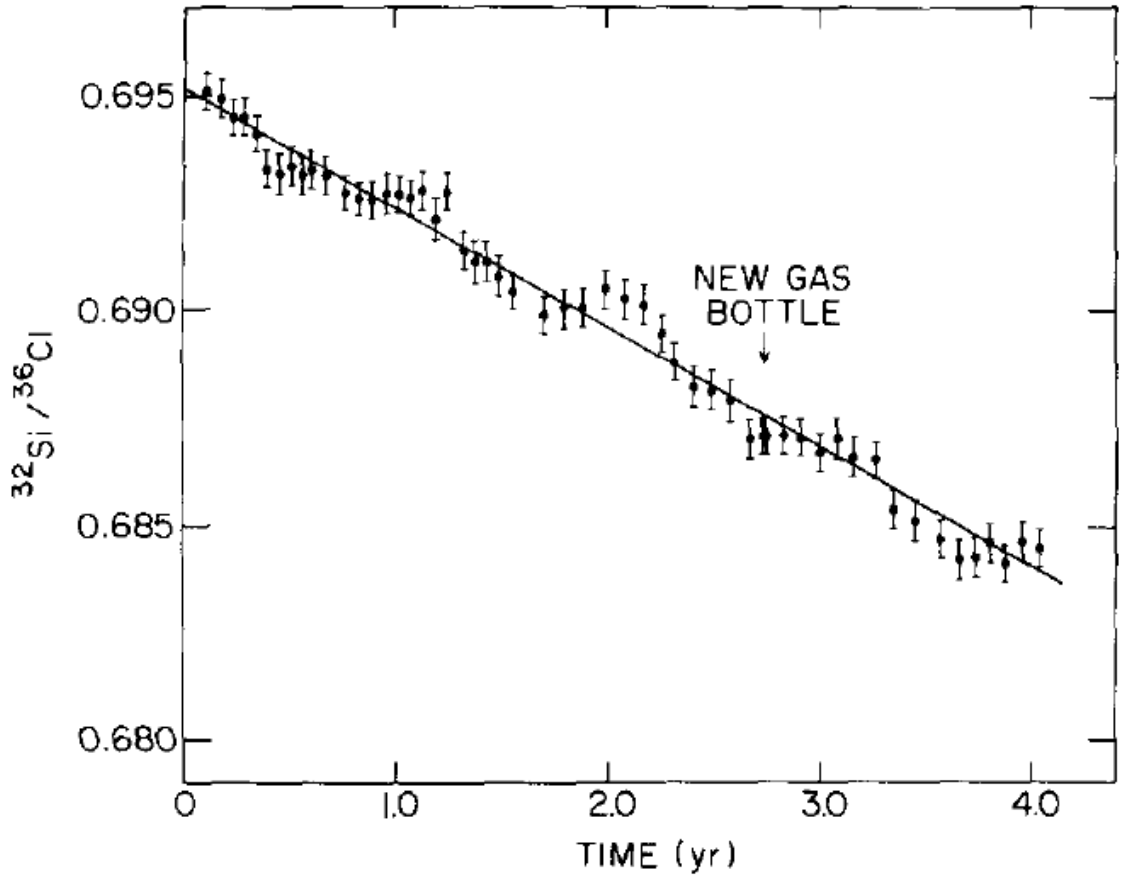


Fig. 2. Ratio of $^{32}Si/^{36}Cl$ counts measured for 53 points over a period of 48 months. Points are averages of 4 runs, each with 10 hr on each sample. Error bars are (arbitrarily) three times the statistical uncertainties and the solid line is an exponential computer fit, although the ordinate is linear for convenience in plotting. The results of the fit are $T_{1/2} = 171.6$ yr with an uncertainty of 3.3 yr and a standard deviation of 3.2 yr.

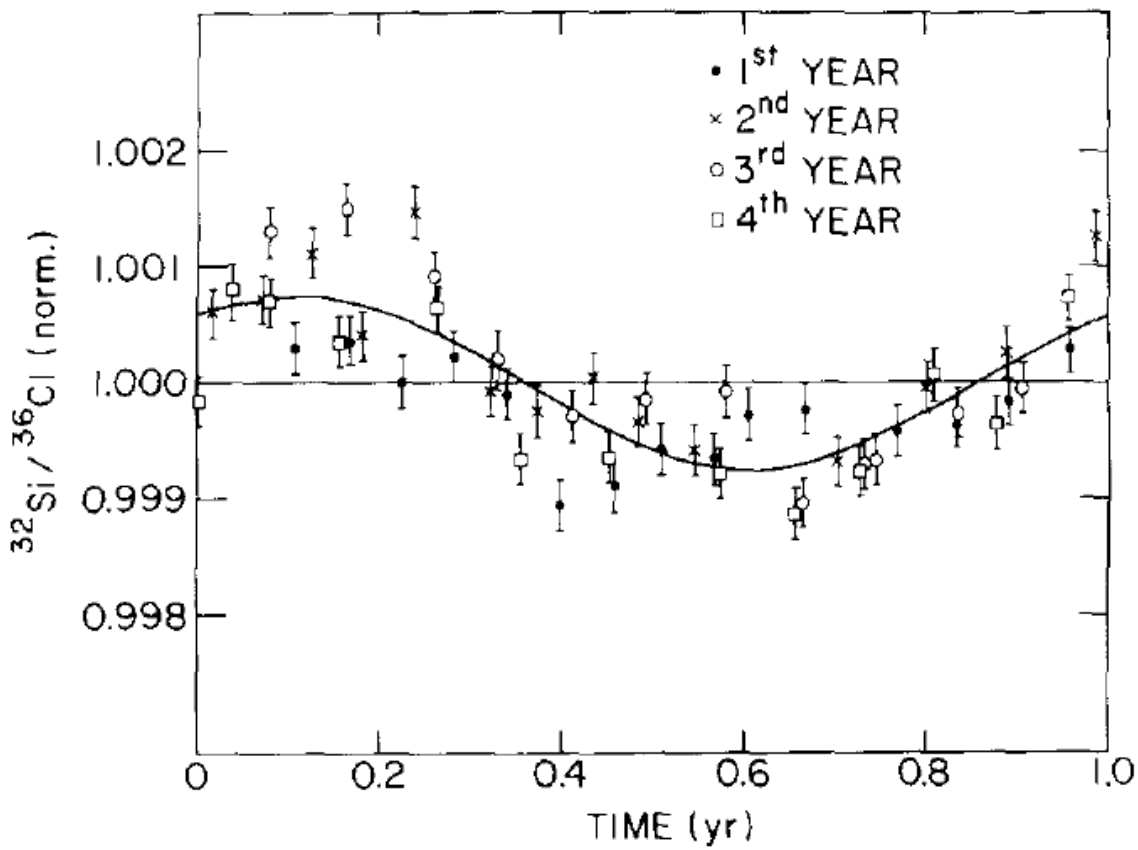
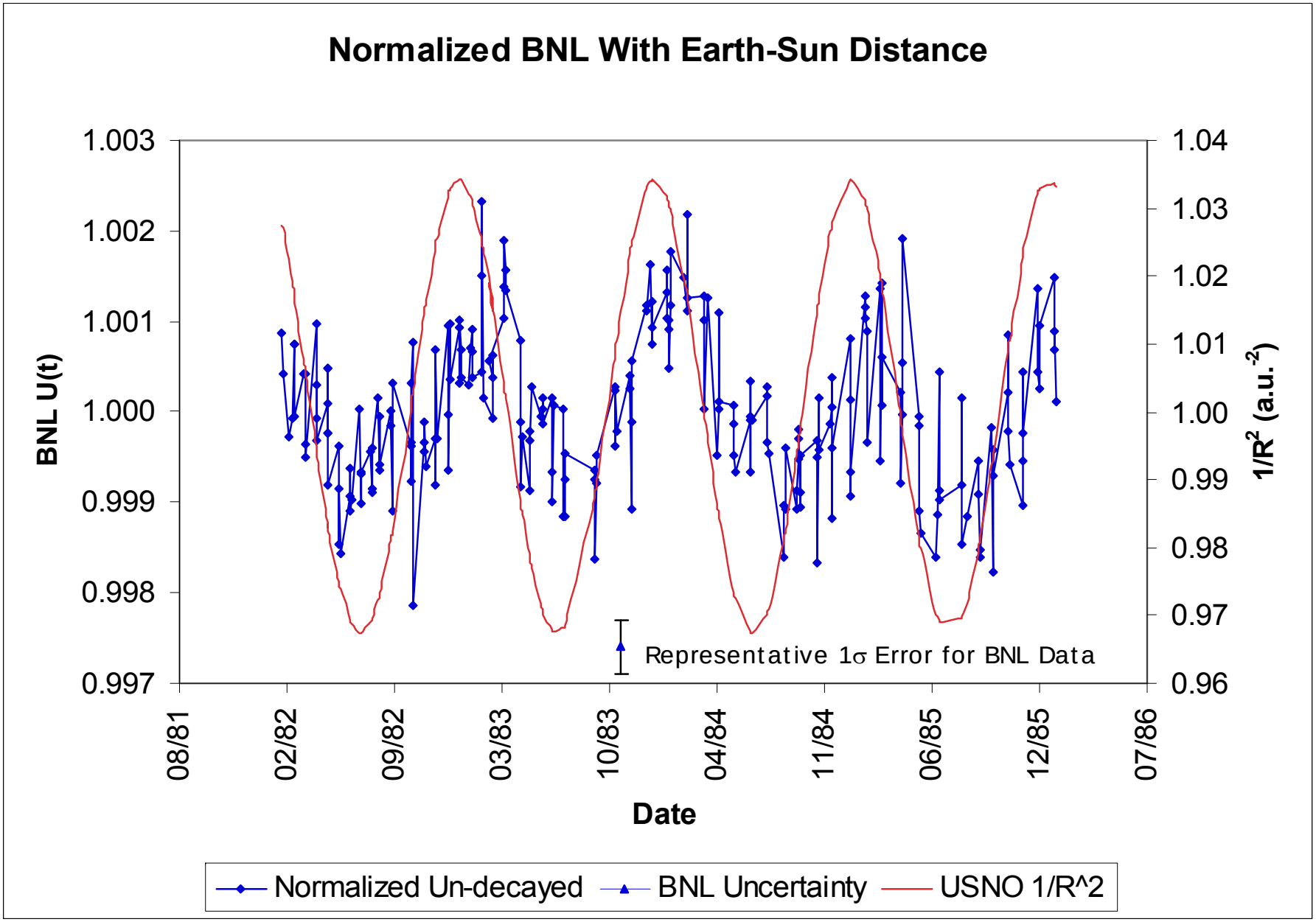


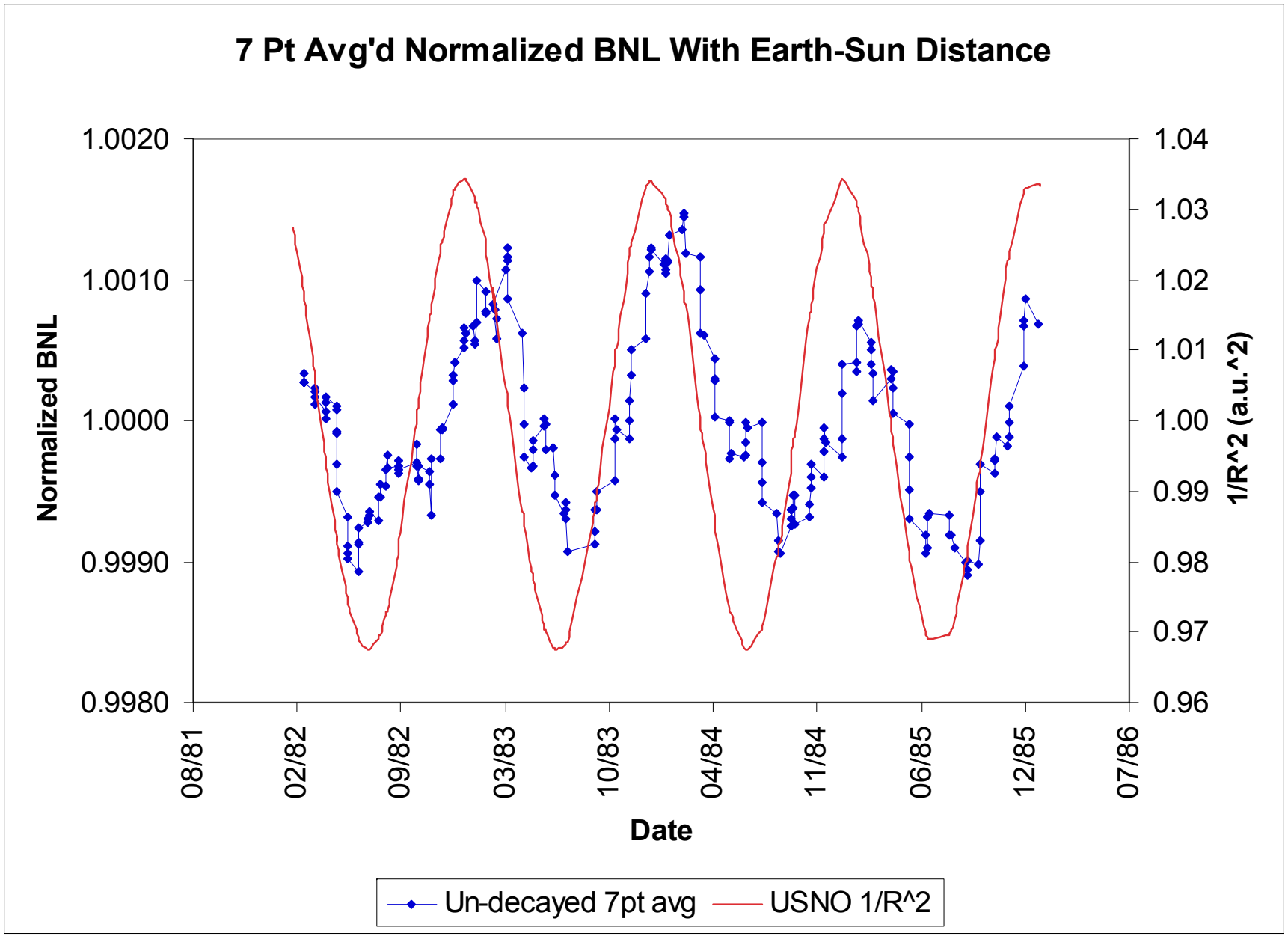
Fig. 4. Points from Fig. 2 corrected for decay using $T_{1/2} = 172$ yr, normalized to 1.000 for the average of all points, and plotted with four 12-month groups superposed. Error bars are statistical uncertainties and $T = 0$ is January 1. A clear annual effect is evident and an arbitrary sine function fit gives an amplitude of 3.4 standard deviations, a maximum on February 9, and a minimum on August 6.

bined with average temperature variations over a range of at least $\pm 5°F$, which is larger than the probable actual range. We therefore conclude that systematic periodic variations are present but that they cannot be fully accounted for by our tests or estimates.



Pearson Correlation Coefficient *r*=0.52, *N*=239, Prob=4.17x10^{-18}

Data from: Alburger, et al., Earth and Planet. Sci. Lett., **78**, (1986) 168-176



Pearson Correlation Coefficient *r*=0.66, *N*=233, Prob=1.0x10^{-31}

Data from: Alburger, et al., Earth and Planet. Sci. Lett., **78**, (1986) 168-176

Pergamon

Appl. Radiat. Isot. Vol. 49, No. 9–11, pp. 1397–1401, 1998
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PII: S0969-8043(97)10082-3

Half-life Measurements of Europium Radionuclides and the Long-term Stability of Detectors

HELMUT SIEGERT, HEINRICH SCHRADER* and ULRICH SCHÖTZIG

Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, D-38116 Braunschweig, Germany

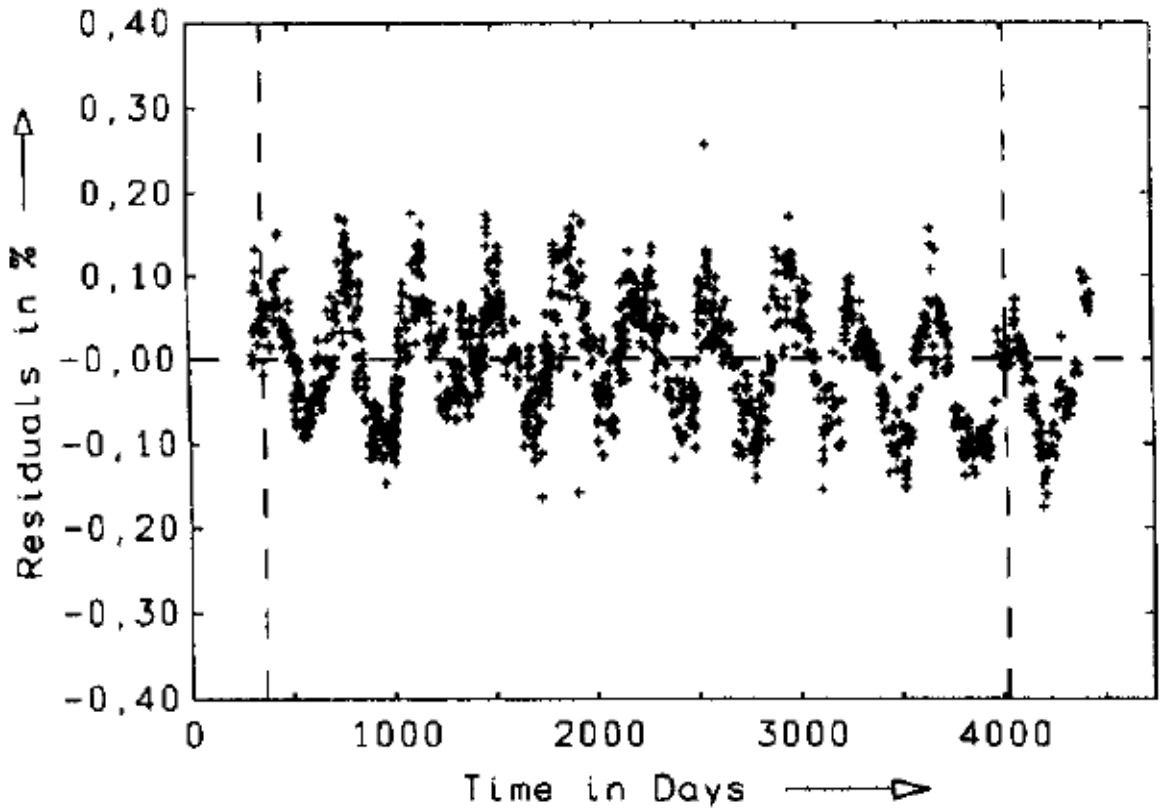
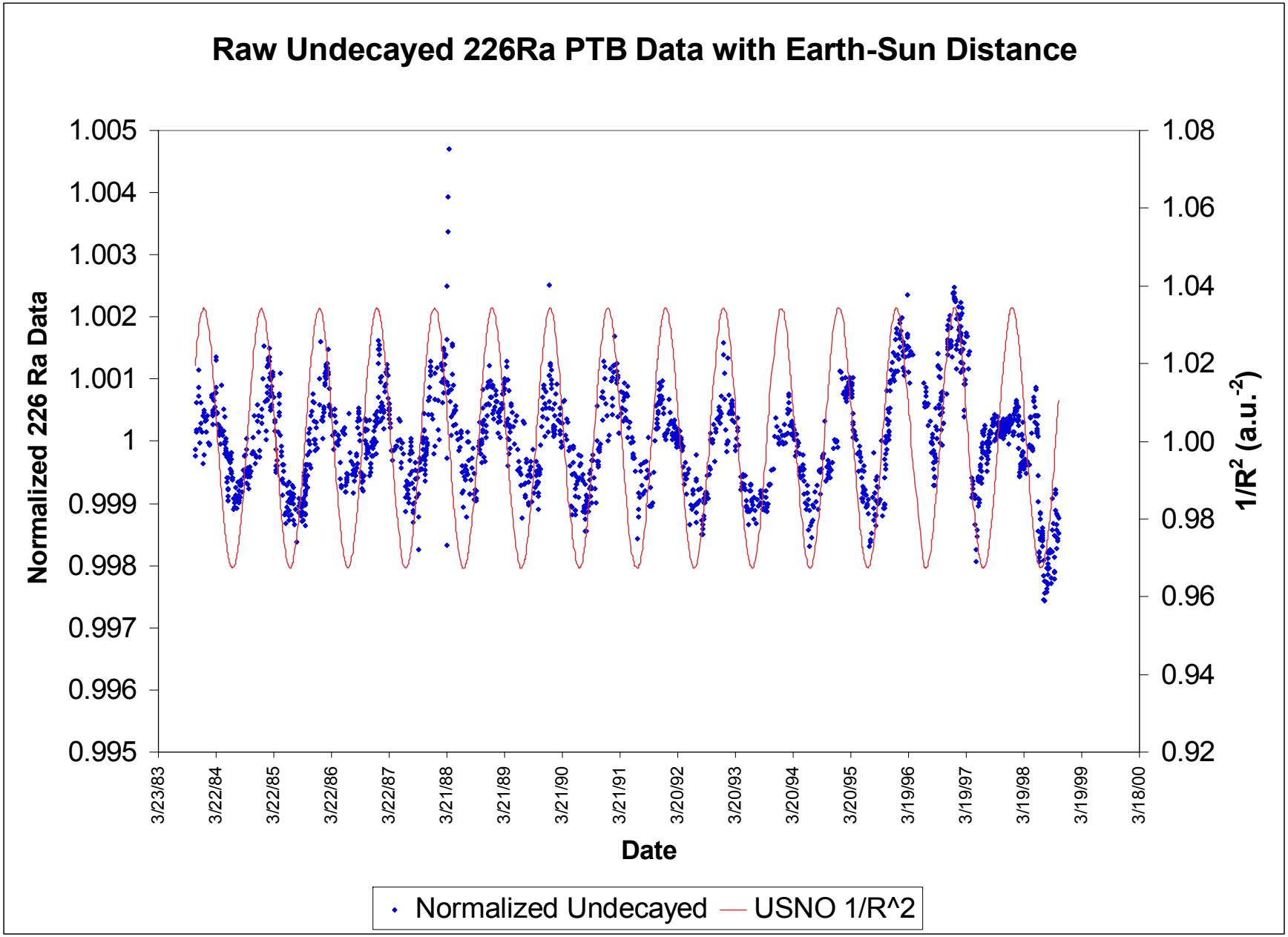
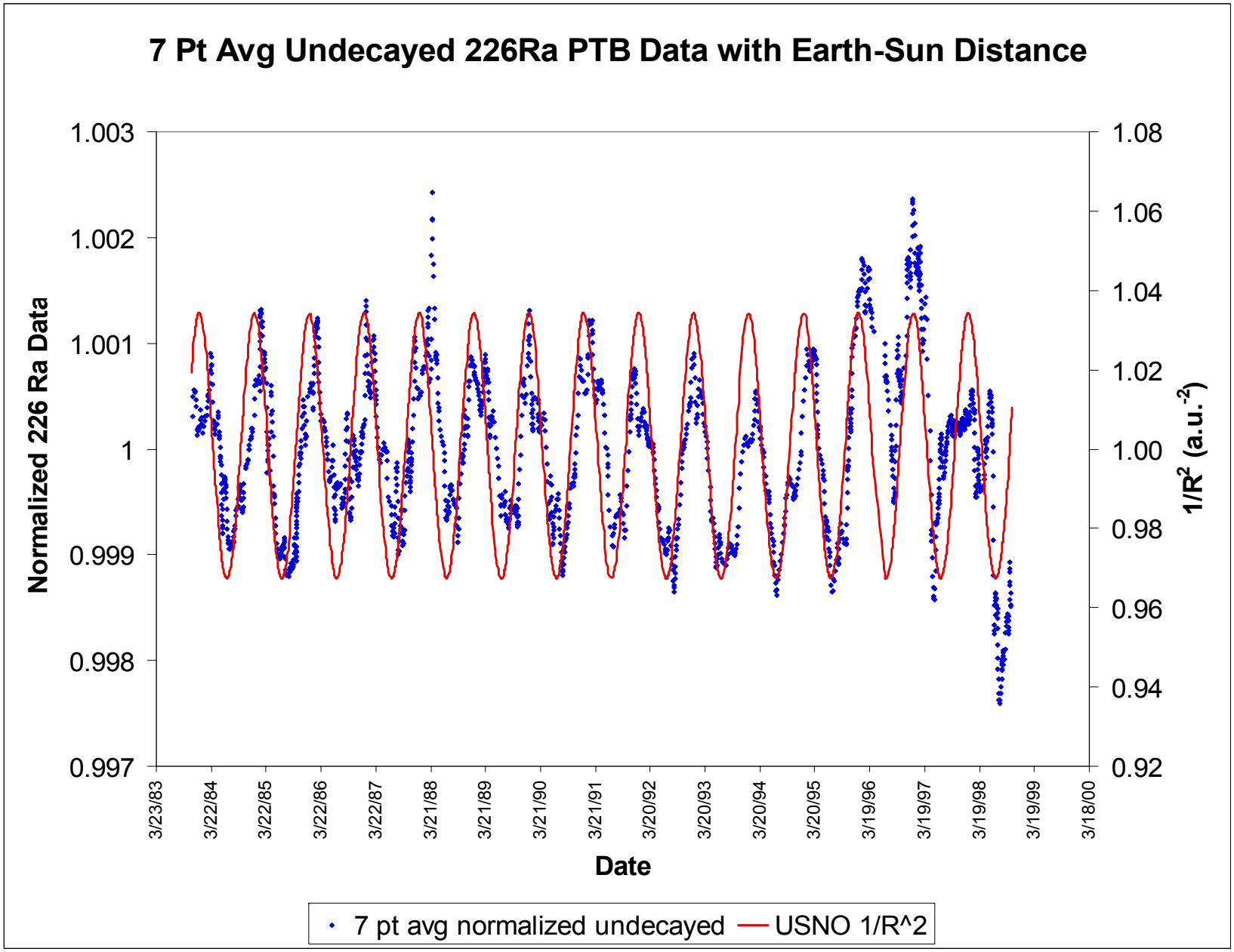


Fig. 1. Residuals of the ionization chamber measurement data of ^{226}Ra as a function of time from a fit with an exponential decay function. A datum point is an average value and contains about 30 individual measurements of current taken over about 3 days and corrected for background. The vertical dotted lines are positioned at 1st January at an interval of 10 years.



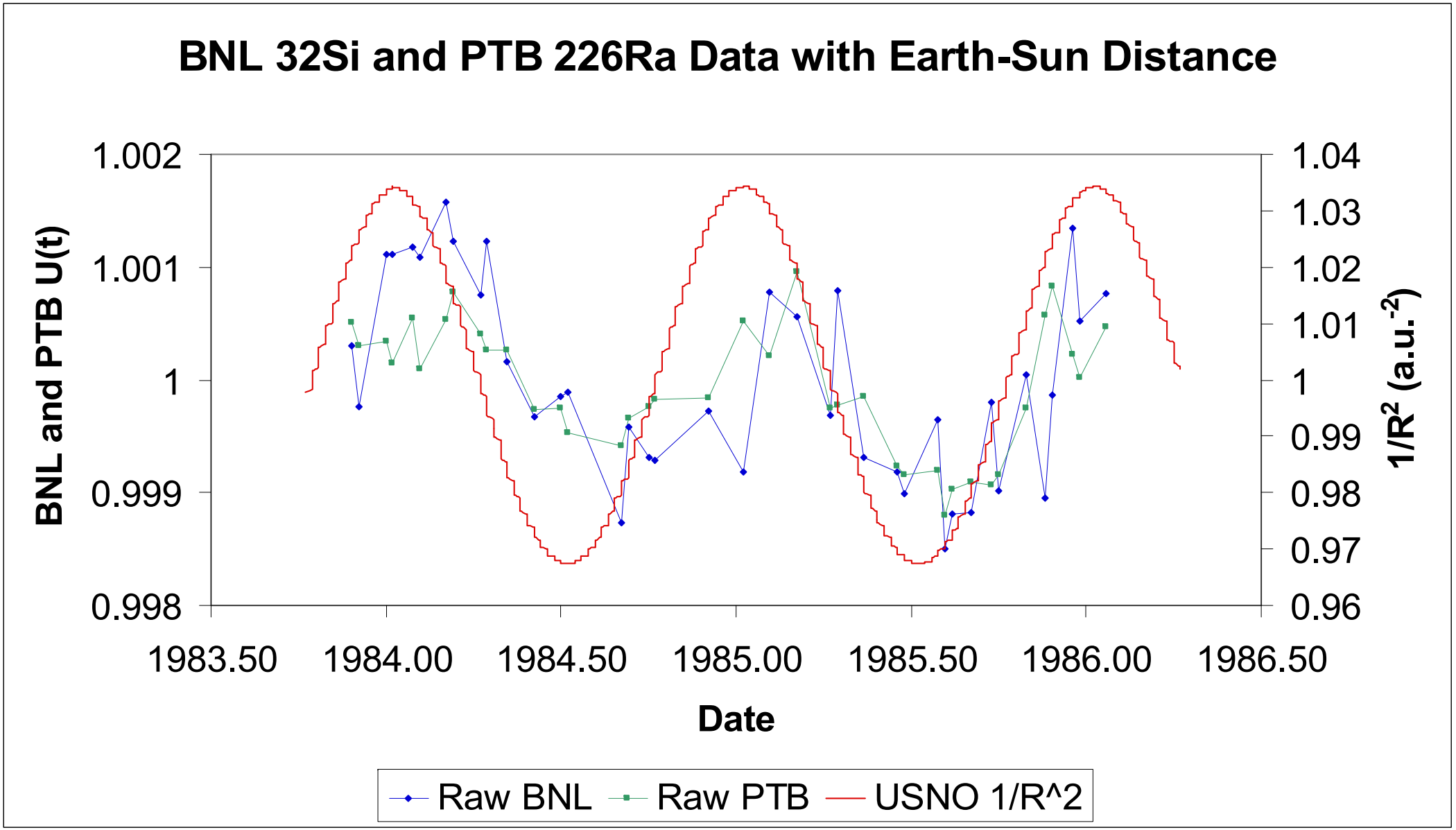
Pearson Correlation Coefficient r=0.62, N=1974, Prob=5.13x10^{-210}

Data from Siegert, et al., Appl. Radiat. Isot. **49**, 1397 (1998) Fig. 1

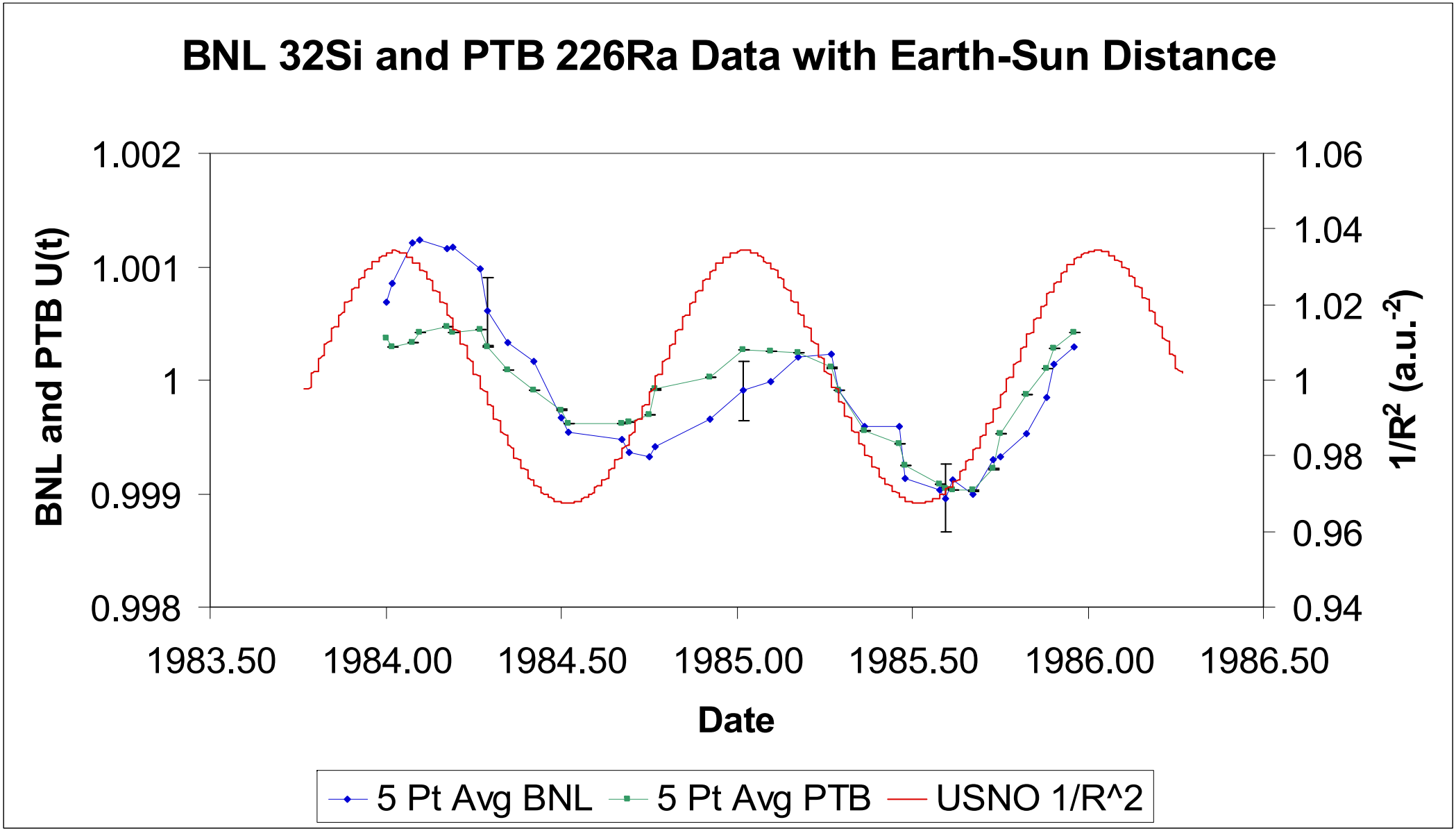


Pearson Correlation Coefficient *r*=0.65, *N*=1968, Prob=3.12x10^{-246}

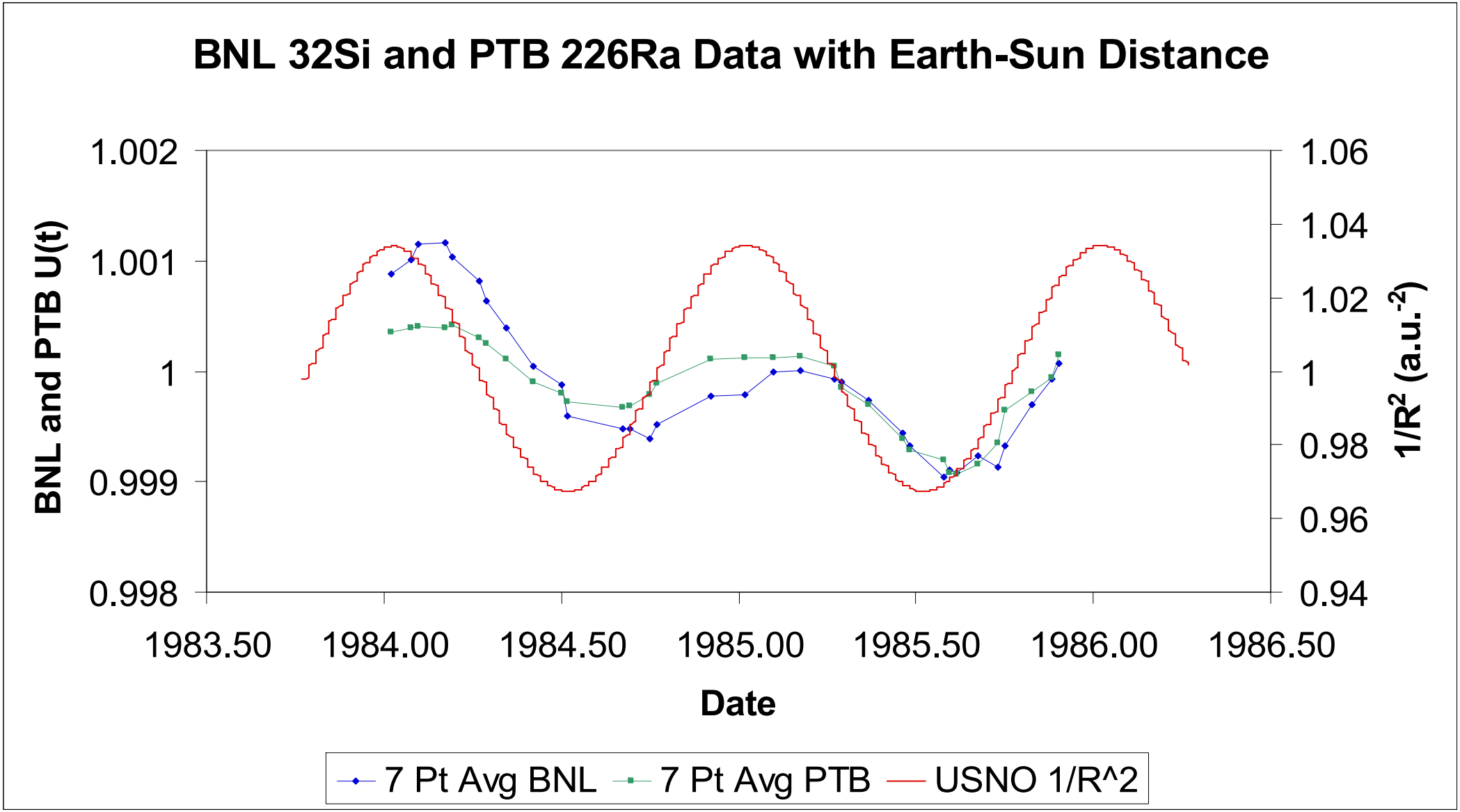
Data from Siegert, et al., Appl. Radiat. Isot. 49, 1397 (1998) Fig. 1



Pearson Correlation Coefficient *r*=0.66, *N*=39, Prob=5.8x10^{-6}



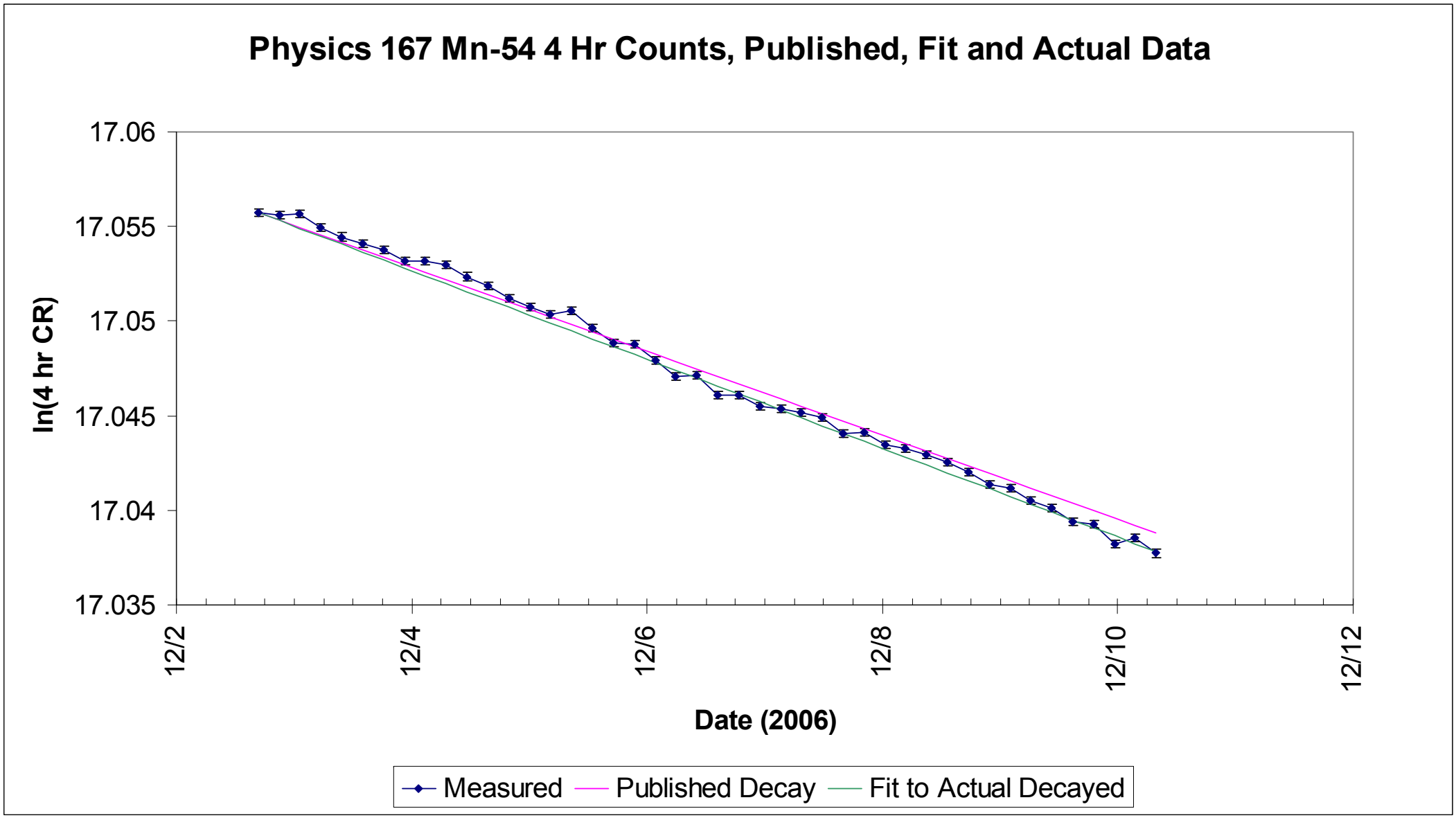
Pearson Correlation Coefficient r=0.87, N=35, Prob=3.78x10^{-12}



Pearson Correlation Coefficient *r*=0.89, *N*=33, Prob=1.85x10^{-12}

Motivation for Purdue Experiments

- Correlation between BNL and PTB data
- Correlation of these data with $1/R^2$ Earth-Sun distance


Physics 167 Mn-54 4 Hr Counts, Published, Fit and Actual Data
17.06
17.055
17.05
17.045
17.04
17.035
ln(4 hr CR)
12/2
12/4
12/6
12/8
12/10
12/12
Date (2006)
Measured
Published Decay
Fit to Actual Decayed

Solar Flare Forces Shuttle Astronauts to Seek Shelter From Radiation

Wednesday, December 13, 2006

FOX NEWS

Astronauts scampered to shielded areas of the international space station and space shuttle Discovery Tuesday night to protect themselves from possibly being exposed to high levels of radiation from an unusually large solar flare, NASA said.

ADVERTISEMENT

Activity aboard Discovery and the space station was interrupted when the solar flare erupted late Tuesday, as two astronauts were finishing the first spacewalk of the current shuttle mission.

Space.com categorized it as an X-3 flare, in the most dangerous category. Such storms are fairly common when the Sun is at its most active, but they are rare during the current low point in the 11-year cycle of solar activity.

• Click here to visit FOXNews.com's Space Center.

NASA spokesman Bill Jeffs told FOXNews.com that crew members slept overnight in "heavily shielded areas" of their respective craft — such as airlocks and the Destiny science lab aboard the space station — as a precautionary measure.

"That move was made to avoid having to wake the crew during their sleep period," NASA spokesman John Ira Petty told Space.com. "It was never a danger to the crew."

Astronauts Rewire the Space Station

Thursday, December 14, 2006

By MIKE SCHNEIDER, Associated Press Writer

CAPE CANAVERAL, Fla. — Two spacewalking astronauts

Severe Geomagnetic Storm Expected From Tuesday's Solar Flare

Thursday , December 14, 2006

By Robert Roy Britt

Space weather forecasters revised their predictions for storminess Wednesday after a major flare erupted on the Sun overnight, threatening damage to communication systems and power grids while offering up the wonder of the Northern Lights.

ADVERTISEMENT

"We're looking for very strong, severe geomagnetic storming" to begin probably around mid-day Thursday, Joe Kunches, lead forecaster at the NOAA Space Environment Center, told SPACE.com.

The storm is expected to generate aurora or Northern Lights as far south as the northern United States Thursday night.

• Click here to visit FOXNews.com's Space Center.

Astronauts aboard the International Space Station are not expected to be put at additional risk, Kunches said.

esa News

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31-May-2008

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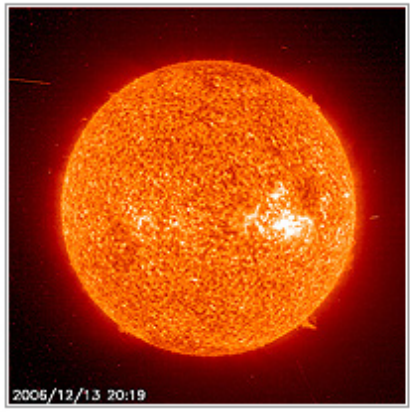


SOHO image of storm on Sun, 13 December 2006

ESA mission controllers react to solar flare

15 December 2006

An energetic storm on the Sun has forced ESA mission controllers to react to anomalies or take action to avoid damage to spacecraft. Several missions, including Integral, Cluster and Envisat, felt the storm's effects, highlighting the need for ESA's ongoing development of space weather forecasting tools.

The joint ESA/NASA spacecraft SOHO (Solar & Heliospheric Observatory) imaged a large solar flare on 13 December that led to an energetic solar radiation storm.

The LASCO (Large Angle and Spectrometric Coronagraph Experiment) instrument on board SOHO detected a powerful coronal mass ejection (CME) generated by the storm; the CME - a stream of fast-moving atomic particles - was directed towards Earth. The flare also generated X-rays.

The ejection arrived at Earth 14 December between 13:00-19:00 CET (12:00-18:00 UTC), where it gave rise to a strong geomagnetic storm; initial edges of the ejection were detected as early as 04:00 CET (03:00 UTC) on 13 December.

Artist's impression of the SOHO spacecraft

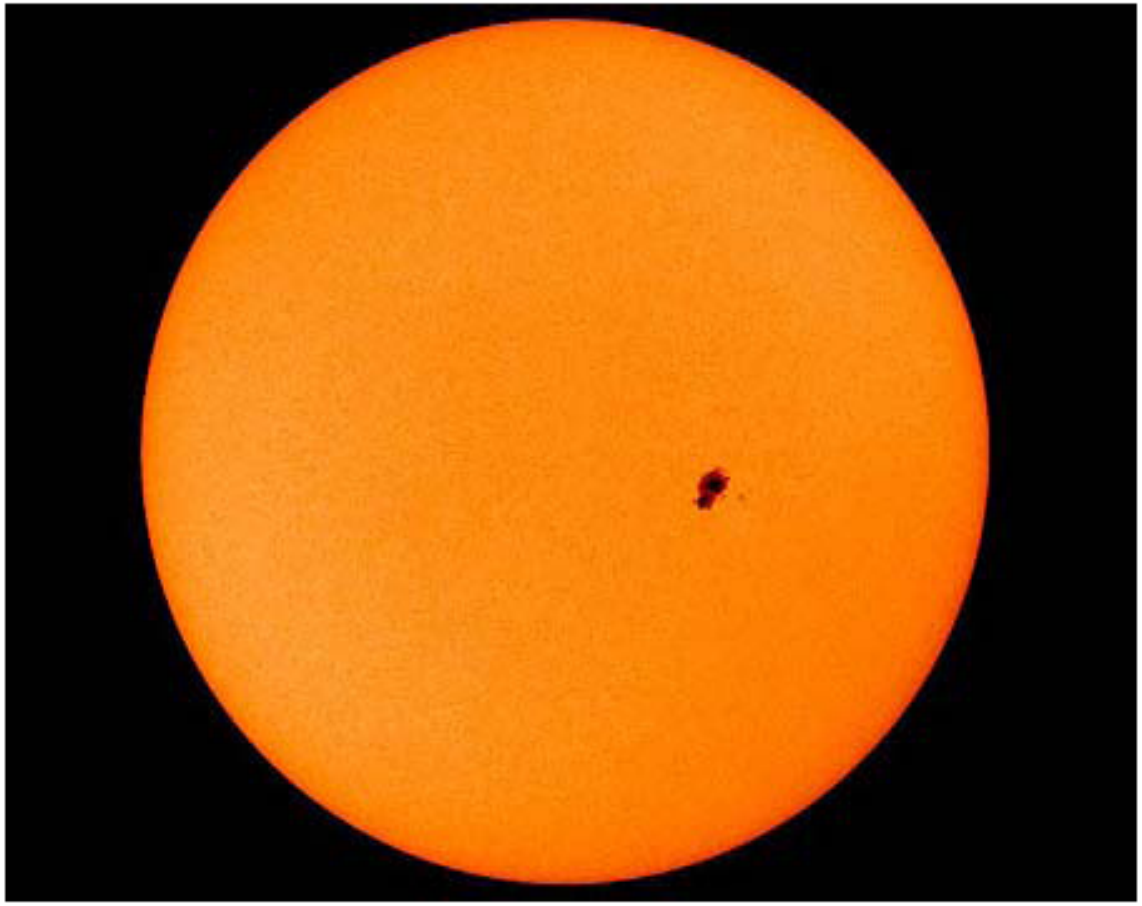
The coronal mass ejection came during a week of intense solar activity that is not yet over. An additional peak event occurred during the night of 14 December, and ground controllers on several ESA missions have reported varying effects on their spacecraft.

Spacecraft Operations

More news
- NOAA tracking space weather event
- See Mercury's silhouette with SOHO
- European expertise helps to view the Sun in a new way

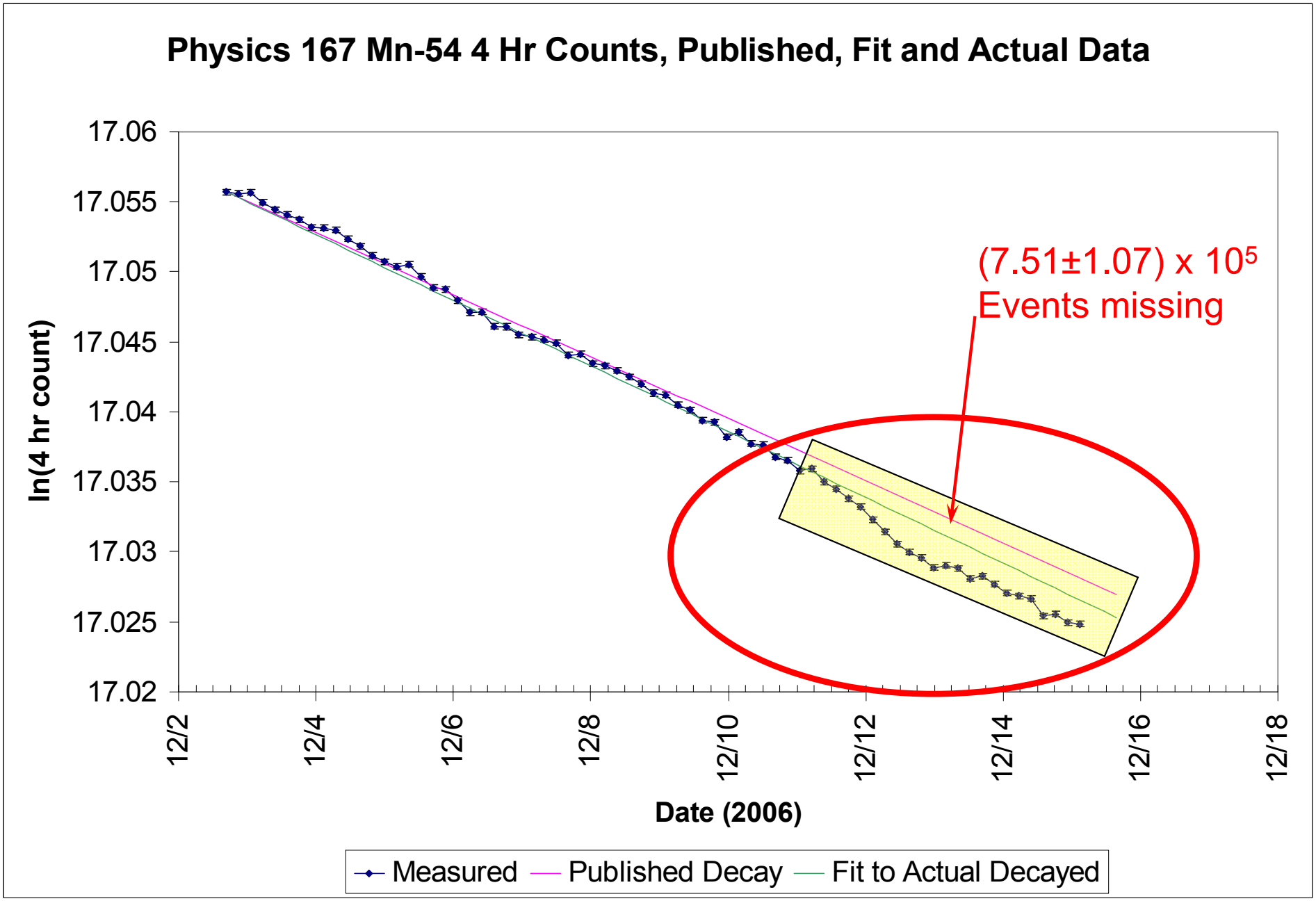
Related links
- SOHO and space weather
- ESA Space Weather
- Coronal Mass Ejections
- Envisat overview
- Cluster overview
- Integral
- SEISOP Fact Sheet (PDF)

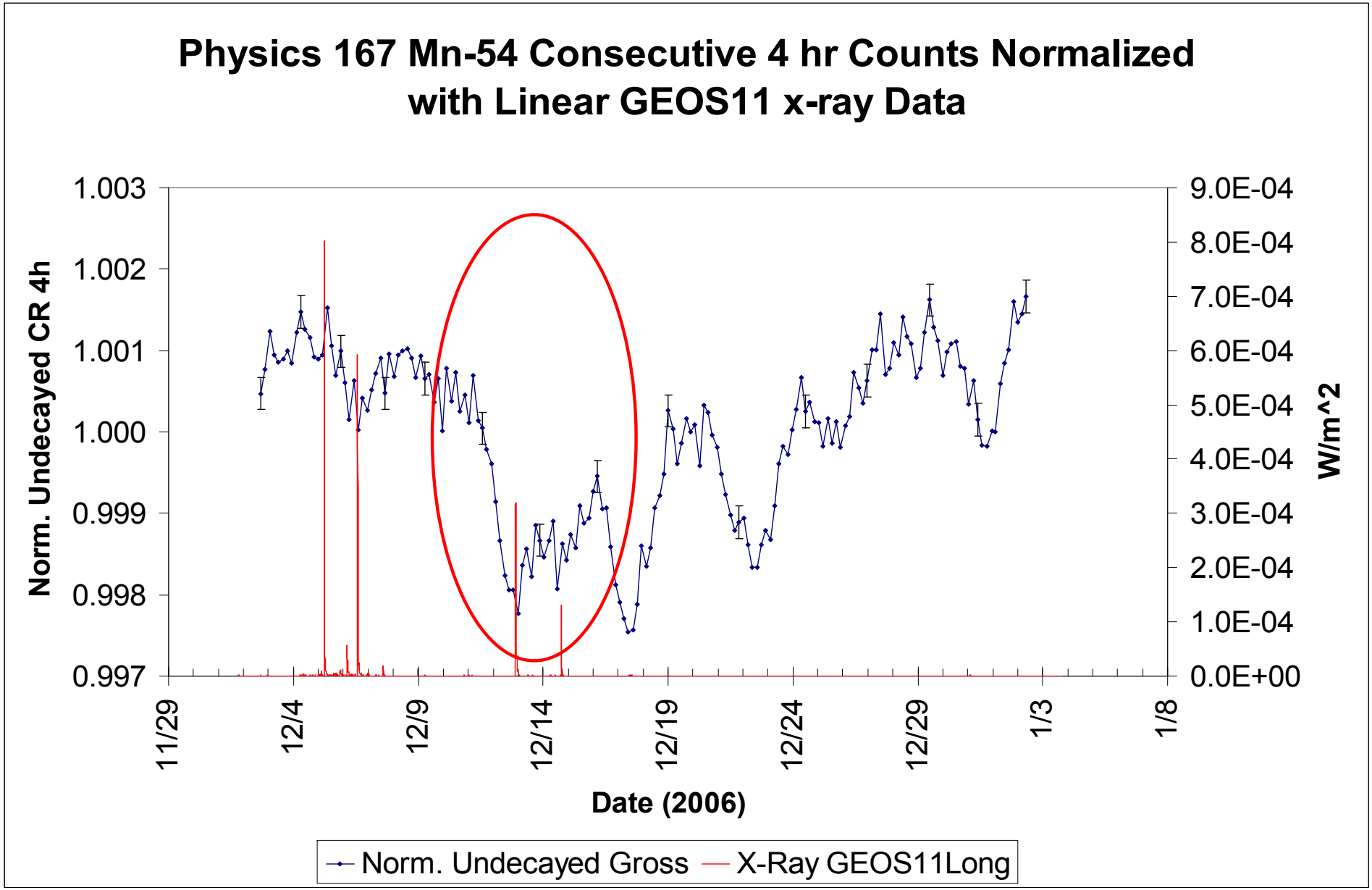
Sunspot 930 Source of Dec 06 Flares

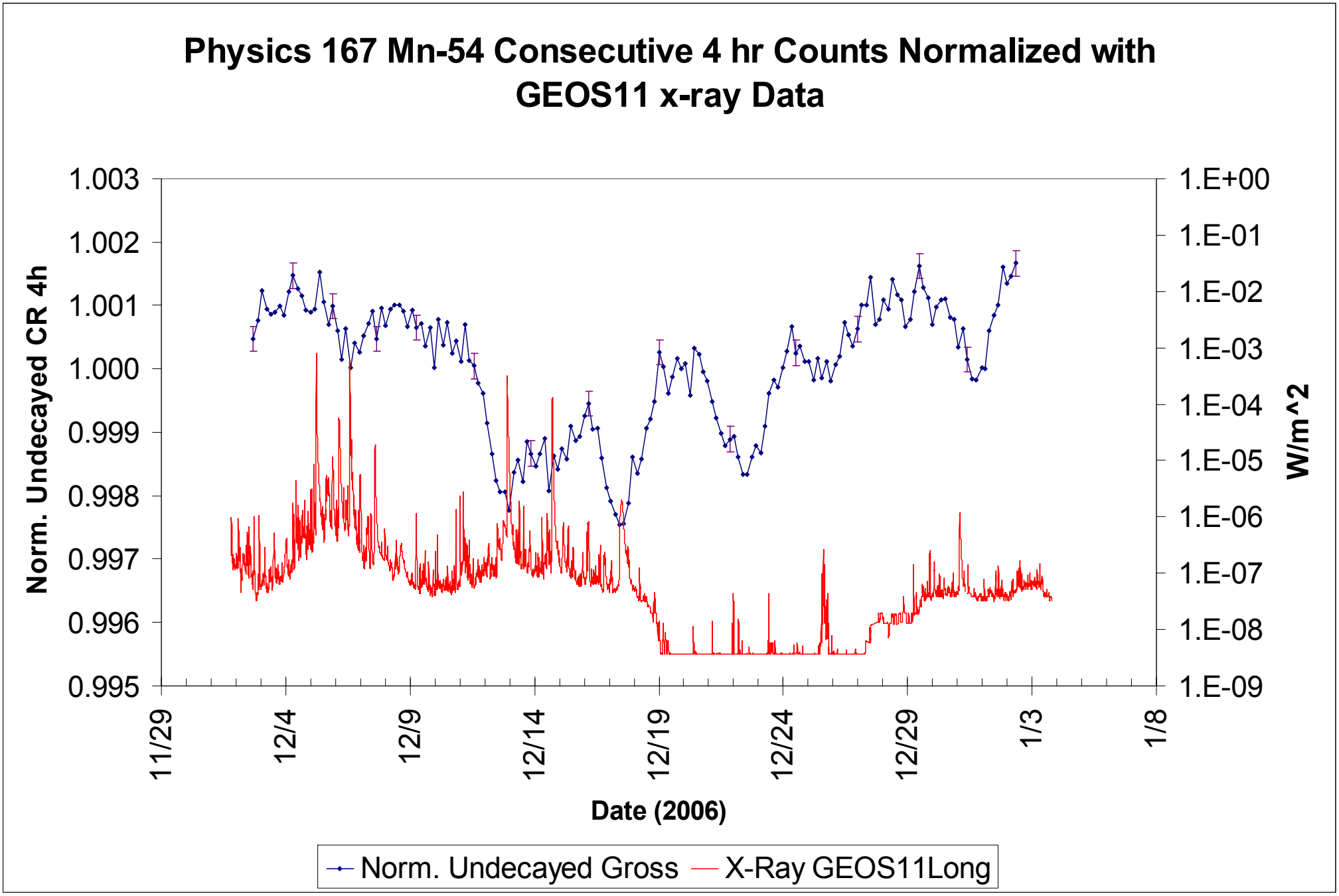


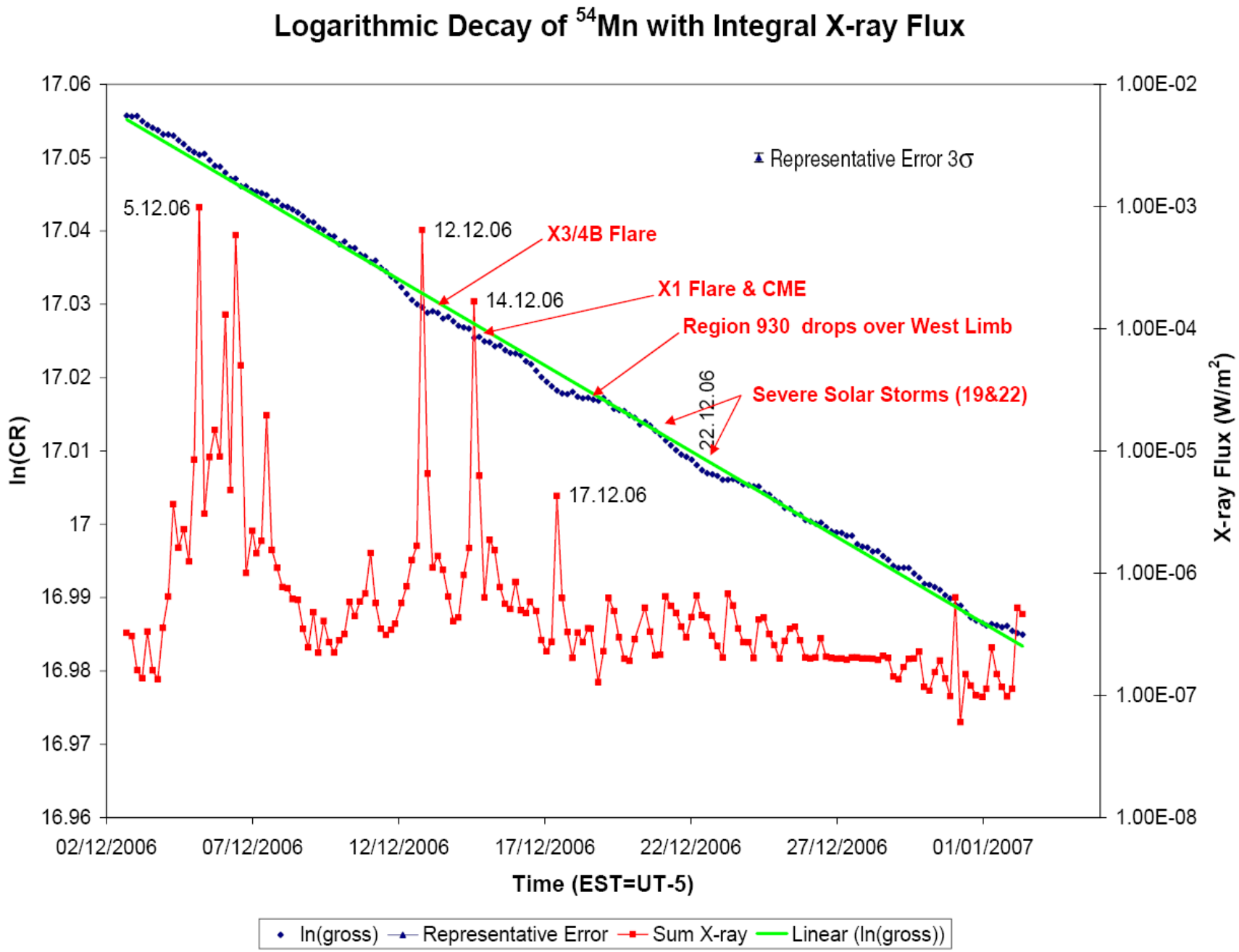
SOHO/MD

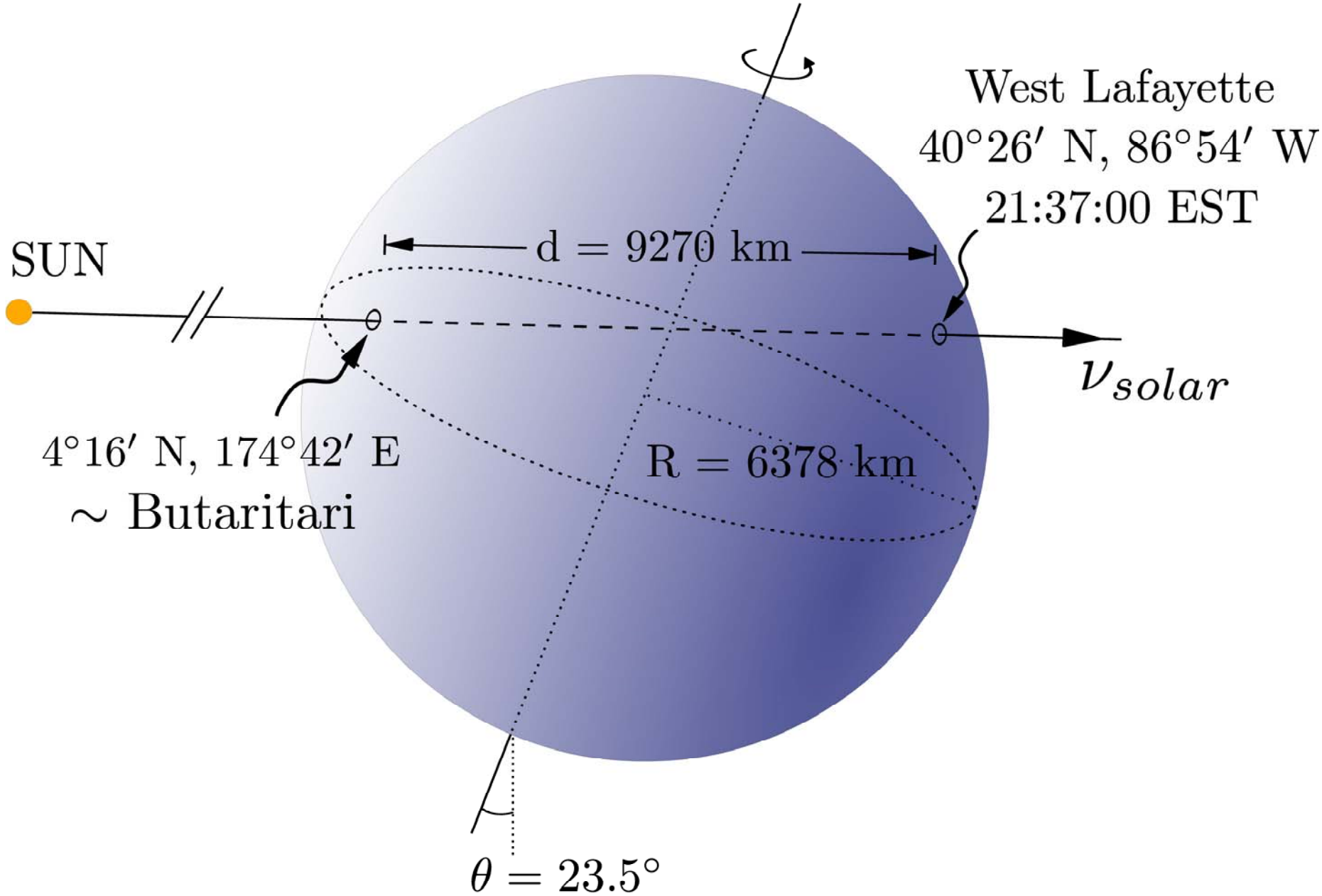
Sunspot 930, responsible for the solar flare that had astronauts sleeping in protected areas aboard the space shuttle and international space station

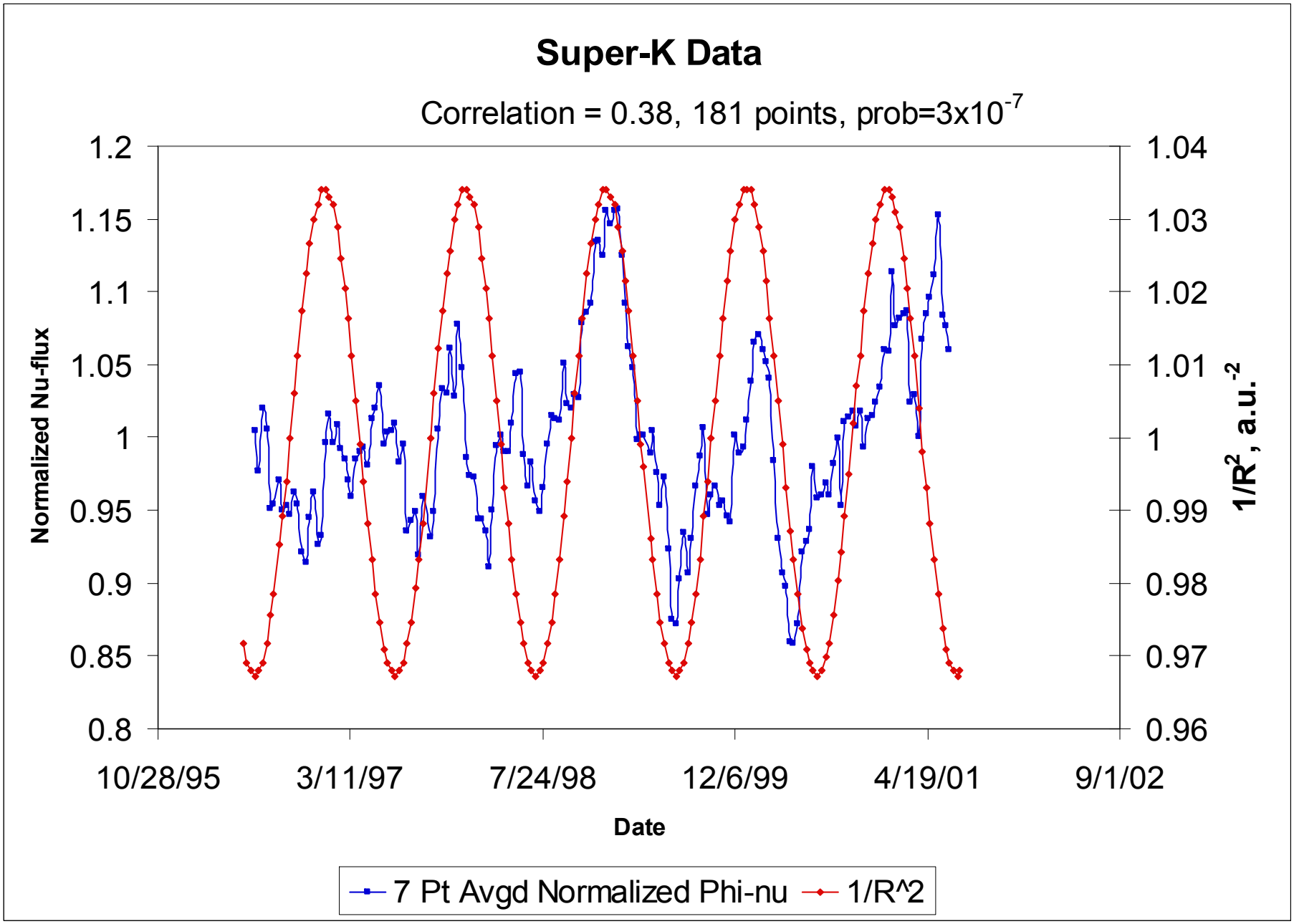

Physics 167 Mn-54 4 Hr Counts, Published, Fit and Actual Data
ln(4 hr count)
17.06
17.055
17.05
17.045
17.04
17.035
17.03
17.025
17.02
12/2
12/4
12/6
12/8
12/10
12/12
12/14
12/16
12/18
Date (2006)
(7.51±1.07) x 10^5
Events missing
Measured
Published Decay
Fit to Actual Decayed


Physics 167 Mn-54 Consecutive 4 hr Counts Normalized with Linear GEOS11 x-ray Data
Norm. Undecayed CR 4h
1.003
1.002
1.001
1.000
0.999
0.998
0.997
W/m^2
9.0E-04
8.0E-04
7.0E-04
6.0E-04
5.0E-04
4.0E-04
3.0E-04
2.0E-04
1.0E-04
0.0E+00
11/29
12/4
12/9
12/14
12/19
12/24
12/29
1/3
1/8
Date (2006)
Norm. Undecayed Gross
X-Ray GEOS11Long

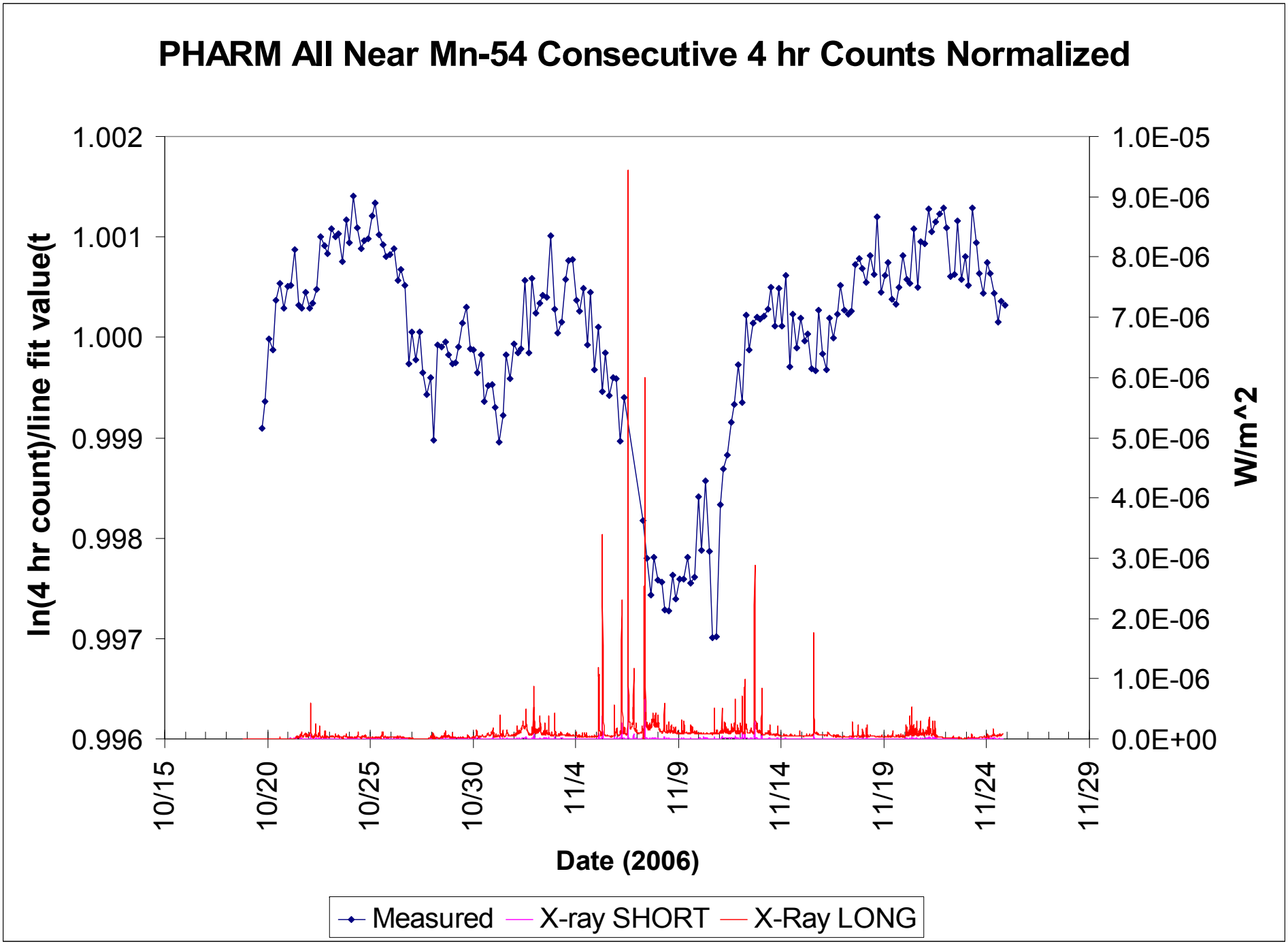

Physics 167 Mn-54 Consecutive 4 hr Counts Normalized with GEOS11 x-ray Data
Norm. Undecayed CR 4h
1.003
1.002
1.001
1.000
0.999
0.998
0.997
0.996
0.995
W/m^2
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
11/29
12/4
12/9
12/14
12/19
12/24
12/29
1/3
1/8
Date (2006)
Norm. Undecayed Gross
X-Ray GEOS11Long


Logarithmic Decay of 54Mn with Integral X-ray Flux
Representative Error 3σ
5.12.06
12.12.06
14.12.06
17.12.06
22.12.06
X3/4B Flare
X1 Flare & CME
Region 930 drops over West Limb
Severe Solar Storms (19&22)
ln(CR)
X-ray Flux (W/m2)
Time (EST=UT-5)
17.06
17.05
17.04
17.03
17.02
17.01
17
16.99
16.98
16.97
16.96
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
02/12/2006
07/12/2006
12/12/2006
17/12/2006
22/12/2006
27/12/2006
01/01/2007
ln(gross)
Representative Error
Sum X-ray
Linear (ln(gross))


West Lafayette
40°26′ N, 86°54′ W
21:37:00 EST
SUN
d = 9270 km
ν_{solar}
4°16′ N, 174°42′ E
∼ Butaritari
R = 6378 km
$\theta = 23.5°$



Data from Yoo, et al., Phys Rev D **68**, 092002 (2003)


PHARM All Near Mn-54 Consecutive 4 hr Counts Normalized
ln(4 hr count)/line fit value(t
W/m^2
1.002
1.001
1.000
0.999
0.998
0.997
0.996
1.0E-05
9.0E-06
8.0E-06
7.0E-06
6.0E-06
5.0E-06
4.0E-06
3.0E-06
2.0E-06
1.0E-06
0.0E+00
10/15
10/20
10/25
10/30
11/4
11/9
11/14
11/19
11/24
11/29
Date (2006)
Measured
X-ray SHORT
X-Ray LONG

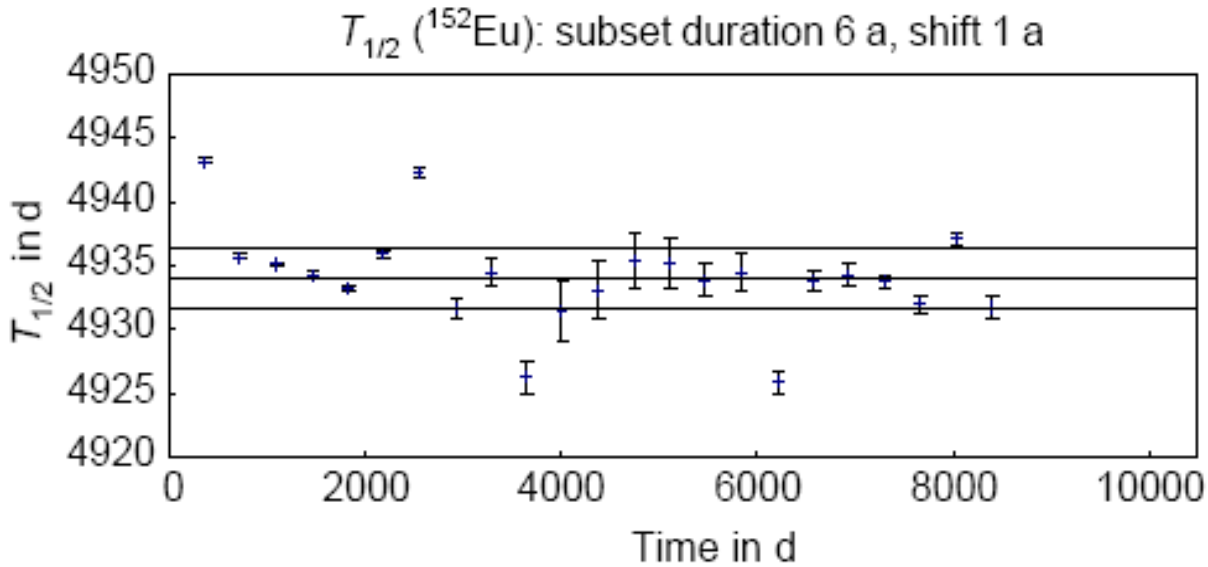
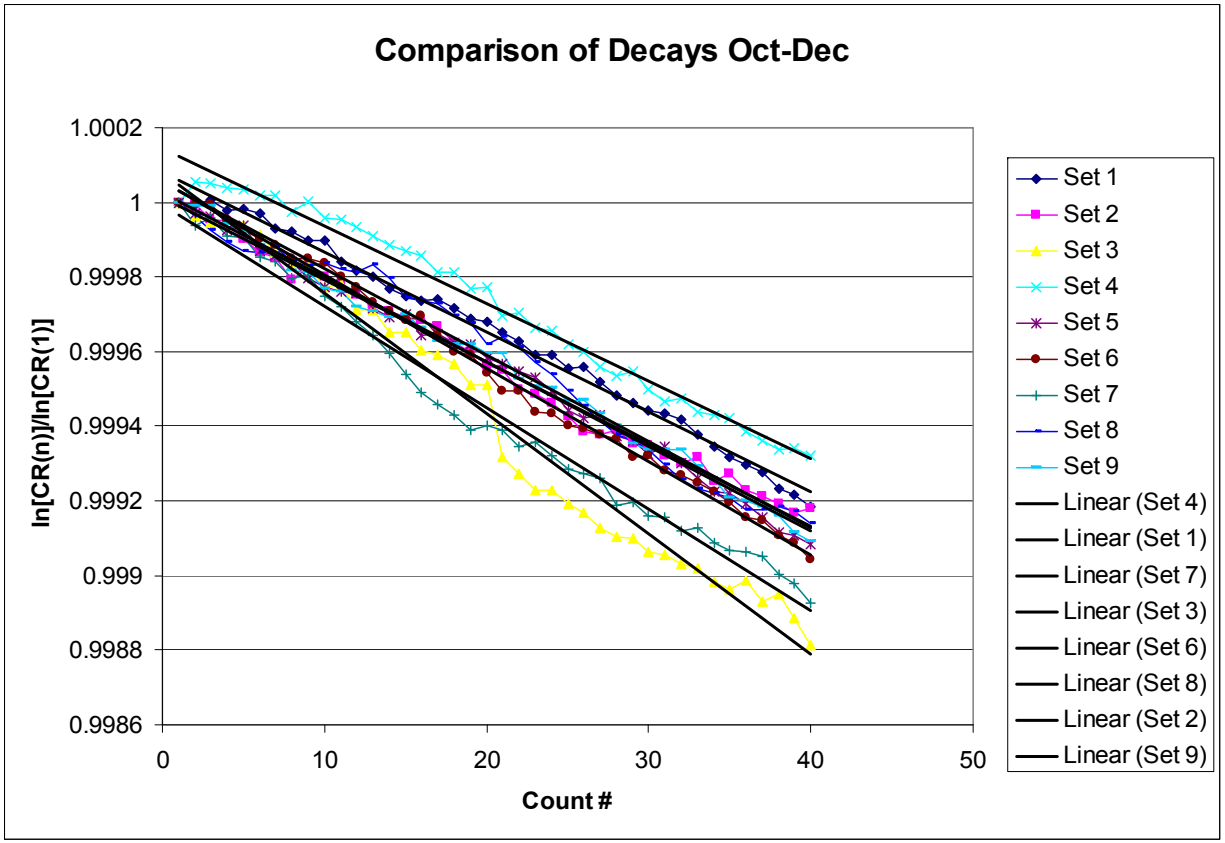
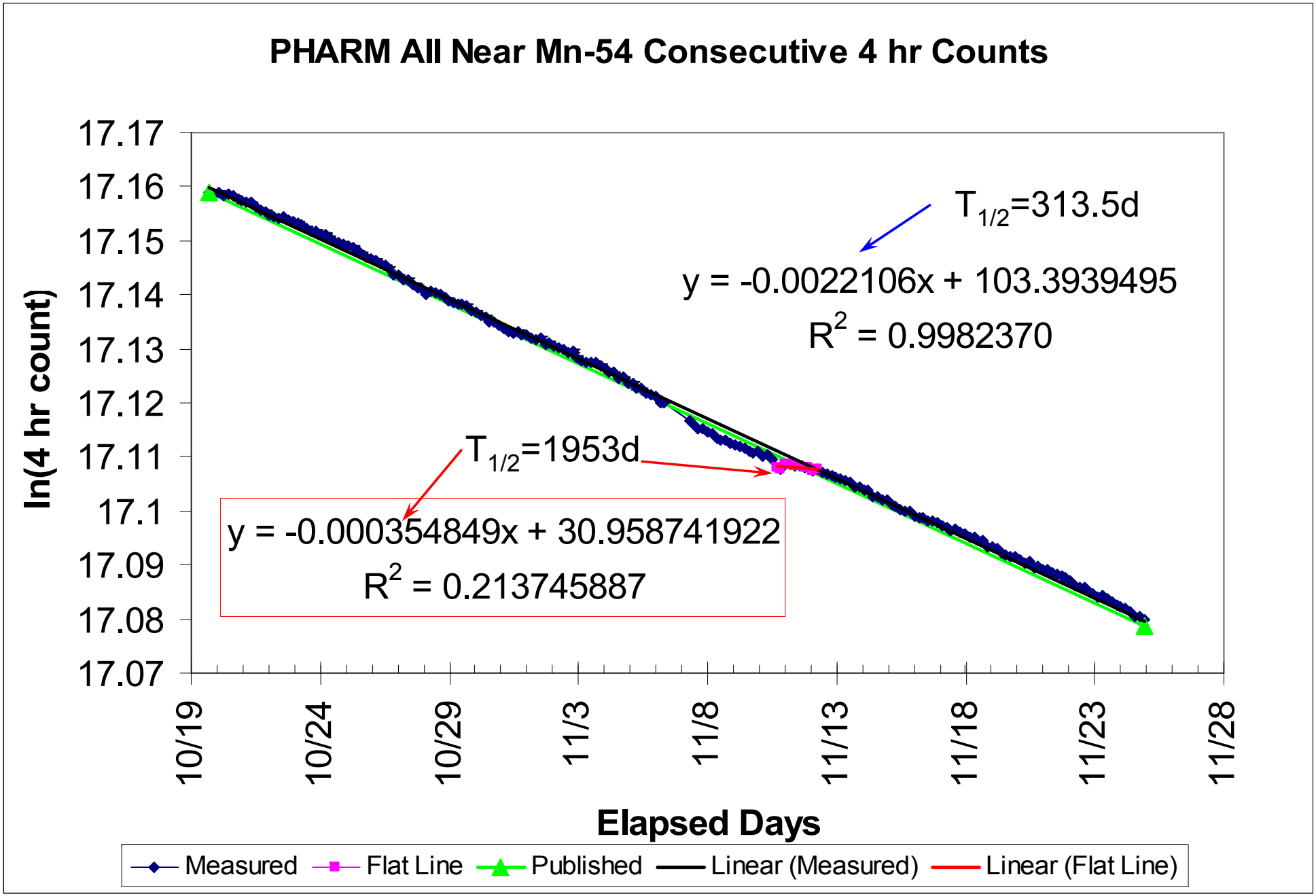


Fig. 2. Least-squares fits of data subsets of half-life measurements of ^{152}Eu as presented in Fig. 1. The subset results are plotted at the starting time of a subset with a duration of 6 years, and shifted by 1 year per subset starting point. The bars associated with the points represent the individual uncertainty of the corresponding subset fit. The horizontal line across the centre of the diagram is positioned on the final half-life value, with a line above and below that represent the positive and negative uncertainty value, respectively.

H. Schrader, Appl. Rad. & Iso., **60** (2004) 317-323



	Start	Stop	Total events	slope (a)=	σa=	T1/2	Significance
PHARM 0-39	10/19/06 17:10	10/26/06 16:18	1,125,533,997	-0.002057562	1.45E-05	**336.878**	**-11.28**
PHARM 40-79	10/26/06 20:35	11/02/06 18:33	1,107,115,186	-0.002137321	1.48E-05	**324.307**	**-5.65**
PHARM 80-119	11/02/06 22:50	11/10/06 16:04	1,087,799,523	-0.002684431	1.27E-05	**258.210**	**36.59**
PHARM 120-159	11/10/06 20:20	11/17/06 18:55	1,070,959,137	-0.002001981	1.49E-05	**346.230**	**-14.69**
PHARM 160-199	11/17/06 23:11	11/24/06 21:36	1,055,144,190	-0.002228968	1.5E-05	**310.972**	**0.55**
PHYS 167 0-39	12/2/06 16:40	12/09/06 14:47	1,013,691,320	-0.002403516	1.54E-05	**288.389**	**11.89**
PHYS 167 40-79	12/09/06 19:02	12/16/06 17:00	995,311,701	-0.002616834	1.55E-05	**264.880**	**25.55**
PHYS 167 80-119	12/16/06 21:15	12/23/06 19:05	978,797,865	-0.00222234	1.56E-05	**311.890**	**0.10**
PHYS 167 120-159	12/23/06 23:20	12/30/06 20:59	964,155,029	-0.002181871	1.58E-05	**317.685**	**-2.46**


PHARM All Near Mn-54 Consecutive 4 hr Counts
ln(4 hr count)
17.17
17.16
17.15
17.14
17.13
17.12
17.11
17.1
17.09
17.08
17.07
10/19
10/24
10/29
11/3
11/8
11/13
11/18
11/23
11/28
Elapsed Days
T1/2=313.5d
y = -0.0022106x + 103.3939495
R2 = 0.9982370
T1/2=1953d
y = -0.000354849x + 30.958741922
R2 = 0.213745887
Measured
Flat Line
Published
Linear (Measured)
Linear (Flat Line)

Possible Mechanisms

- Spatial Variation of the Fine Structure Constant α

Spatial Variation of the Fine Structure Constant α

For alpha decay (e.g., $^{226}Ra \rightarrow {}^{222}Rn + {}^{4}He$)

$$\frac{\delta\alpha}{\alpha} \approx \frac{\delta\Gamma}{\Gamma}\left(\frac{1}{4\pi Z\alpha}\frac{v}{c}\right) \rightarrow 6.3\times10^{-3}\left(\frac{\delta\Gamma}{\Gamma}\right)$$

From our ^{226}Ra data,

$$\frac{\delta\Gamma}{\Gamma} \approx 3\times10^{-3} \quad \Rightarrow \quad \boxed{\frac{\delta\alpha}{\alpha} \approx 2\times10^{-5}}$$

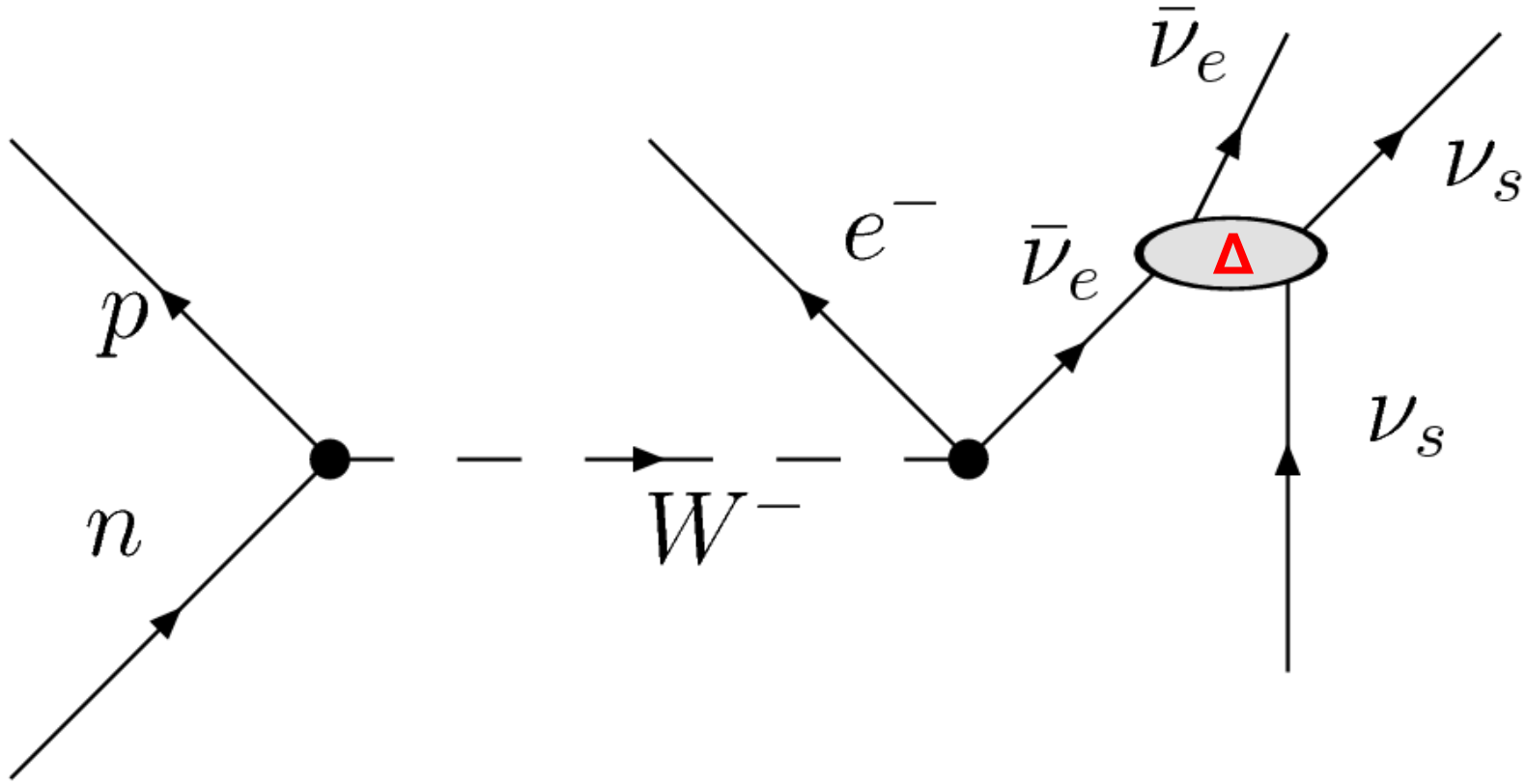
This *may* be incompatible with existing WEP and 5th force constraints.

References: D. J. Shaw, gr-qc/0702090; J.D. Barrow and D. J. Shaw, arXiv:0806:4317; J.-P. Uzan, Rev. Mod. Phys. **75**, 403 (2003)

Possible Mechanisms

- Spatial variation of the fine structure constant α
- Spin-dependent long range force coupling to neutrinos

Spin-dependent long range force coupling to neutrinos



Variation in Solar Neutrino Flux

1. For β-decay, $\frac{d\Gamma}{dE} \propto E\sqrt{E^2 - m_e^2}(E_0 - E)^2$
   where Γ is extremely sensitive to small shifts in E_0

2. Assume $E_0 \rightarrow E_0 + \Delta$, where Δ arises from solar neutrinos, then
   $$(E_0 - E)^2 \rightarrow (E_0 - E)^2 + 2\Delta(E_0 - E) + \Delta^2$$

3. Next, assume $\Delta = \left\langle \frac{A}{r^3}[3(\vec{\sigma}_1 \cdot \hat{r})(\vec{\sigma}_2 \cdot \hat{r}) - \vec{\sigma}_1 \cdot \vec{\sigma}_2 \right\rangle$
   where $1 = \nu_e$, $2 = p, e, n, \nu_e$

4. For an unpolarized sample,
   $$(E_0 - E)^2 \rightarrow (E_0 - E)^2 + \Delta^2$$

Variation in Solar Neutrino Flux (cont'd)

5. Compare this to the change induced by $m_\nu^2 \neq 0$

$$(E_0 - E)^2 \rightarrow (E_0 - E)\sqrt{(E_0 - E)^2 - m_\nu^2}$$

$$For\ (E_0 - E)^2 \gg m_\nu^2, \Delta^2 \Rightarrow \boxed{\Delta^2 \approx -\frac{1}{2} m_\nu^2}$$

$$m_\nu^2 = -100\ \mathrm{eV}^2 \text{ to } -10\ \mathrm{eV}^2.$$

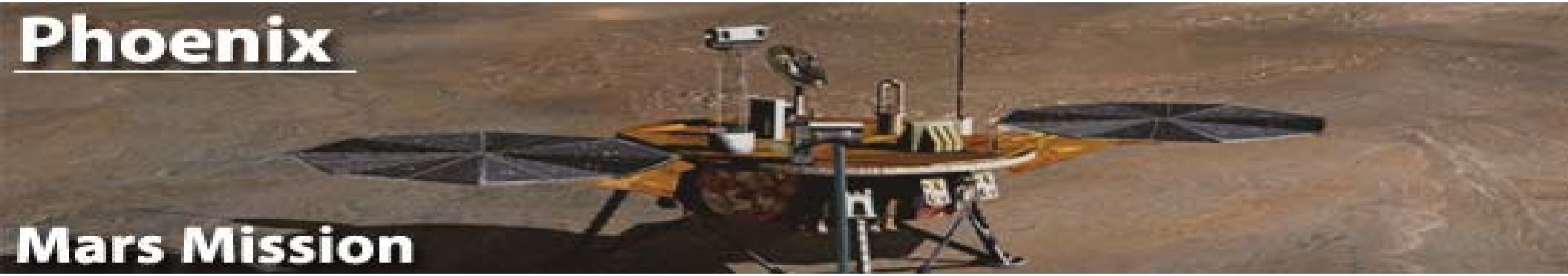
$$\Rightarrow \boxed{\Delta^2 = 50\ \mathrm{eV}^2 \text{ to } 5\ \mathrm{eV}^2}$$

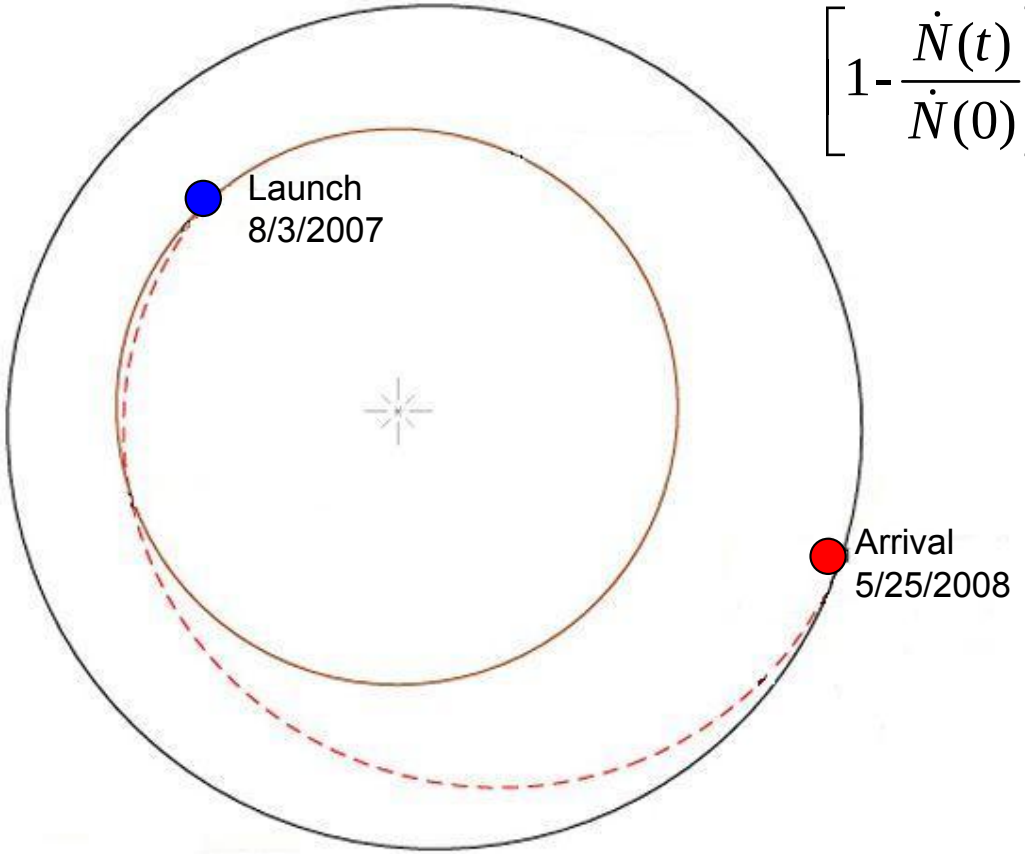
This *may* be compatible with current limits on neutrino magnetic dipole moments.

$\overline{\nu}$ MASS SQUARED (electron based)

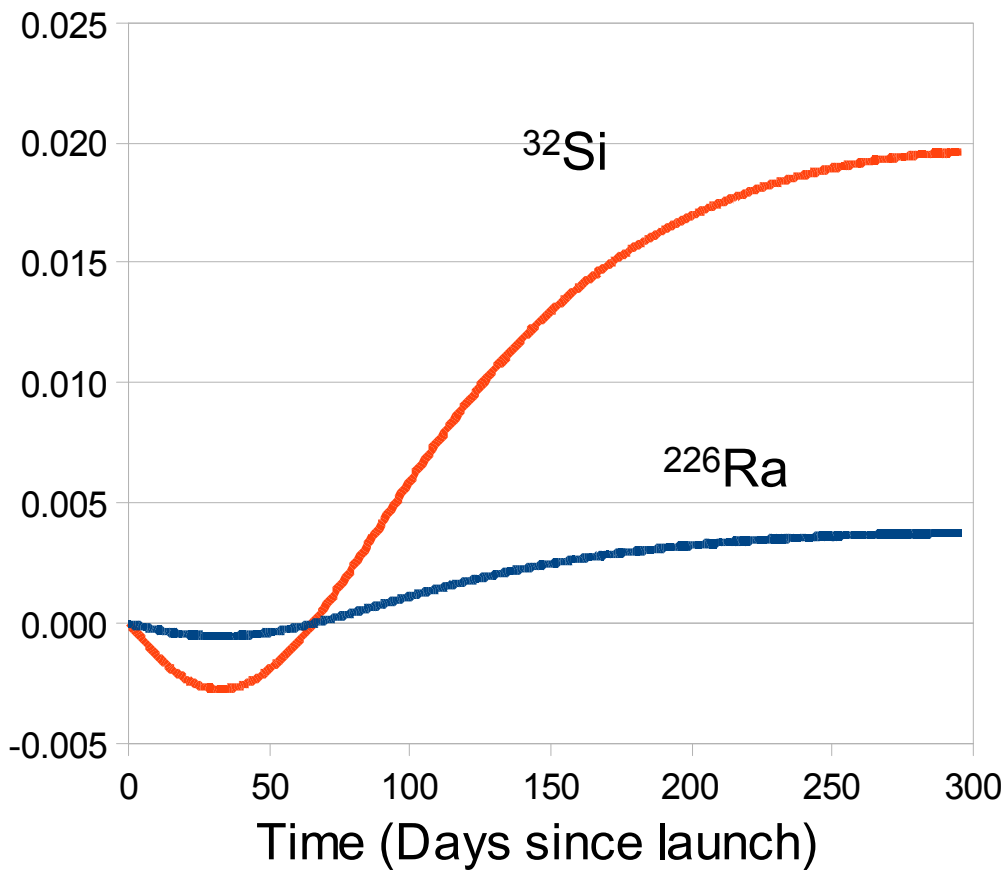
Given troubling systematics which result in improbably negative estimators of $m^{2(\mathrm{eff})}_{\nu_e} \equiv \sum_i |U_{ei}|^2 \; m^2_{\nu_i}$, in many experiments, we use only KRAUS 05 and LOBASHEV 99 for our average.

VALUE (eV^2)	CL%	DOCUMENT ID		TECN	COMMENT
− 1.1± 2.4 OUR AVERAGE					
− 0.6± 2.2± 2.1		[15] KRAUS	05	SPEC	^{3}H β decay
− 1.9± 3.4± 2.2		[16] LOBASHEV	99	SPEC	^{3}H β decay
• • • We do not use the following data for averages, fits, limits, etc. • • •					
− 3.7± 5.3± 2.1		[17] WEINHEIMER	99	SPEC	^{3}H β decay
− 22 ± 4.8		[18] BELESEV	95	SPEC	^{3}H β decay
129 ±6010		[19] HIDDEMANN	95	SPEC	^{3}H β decay
313 ±5994		[19] HIDDEMANN	95	SPEC	^{3}H β decay
−130 ± 20 ±15	95	[20] STOEFFL	95	SPEC	^{3}H β decay
− 31 ± 75 ±48		[21] SUN	93	SPEC	^{3}H β decay
− 39 ± 34 ±15		[22] WEINHEIMER	93	SPEC	^{3}H β decay
− 24 ± 48 ±61		[23] HOLZSCHUH	92B	SPEC	^{3}H β decay
− 65 ± 85 ±65		[24] KAWAKAMI	91	SPEC	^{3}H β decay
−147 ± 68 ±41		[25] ROBERTSON	91	SPEC	^{3}H β decay

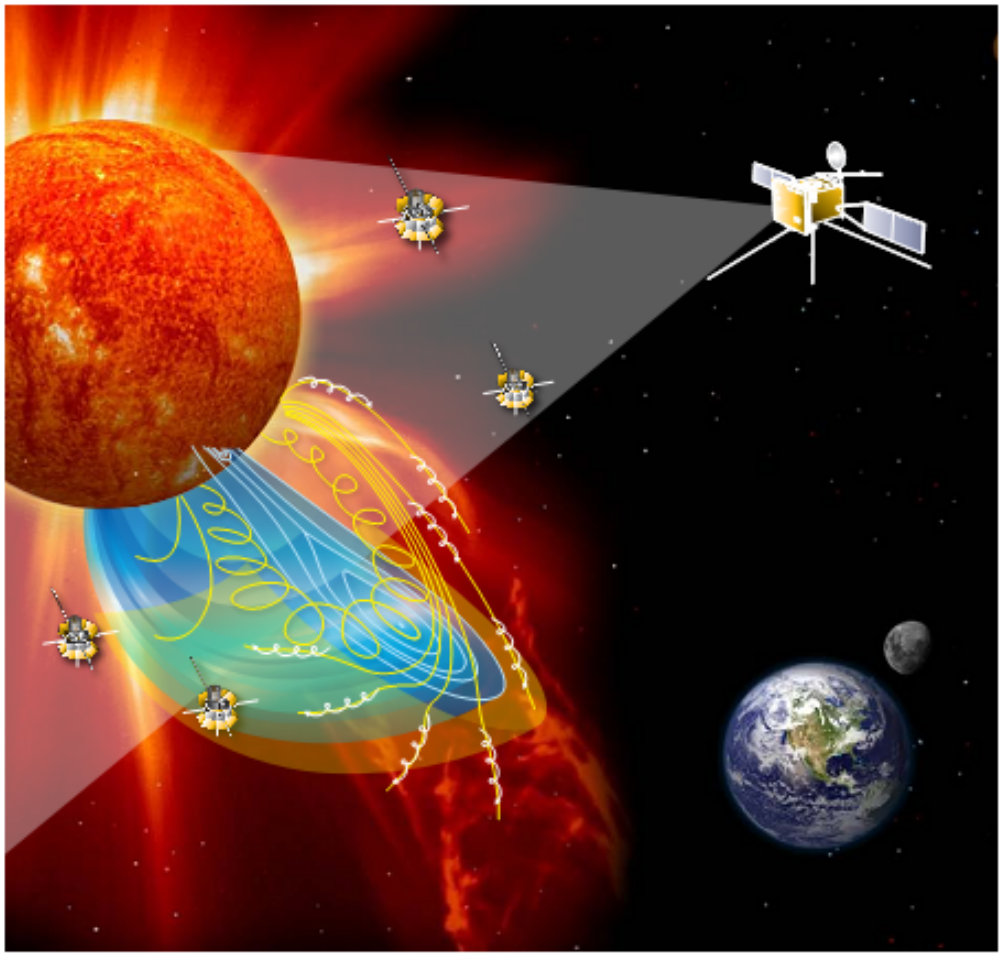


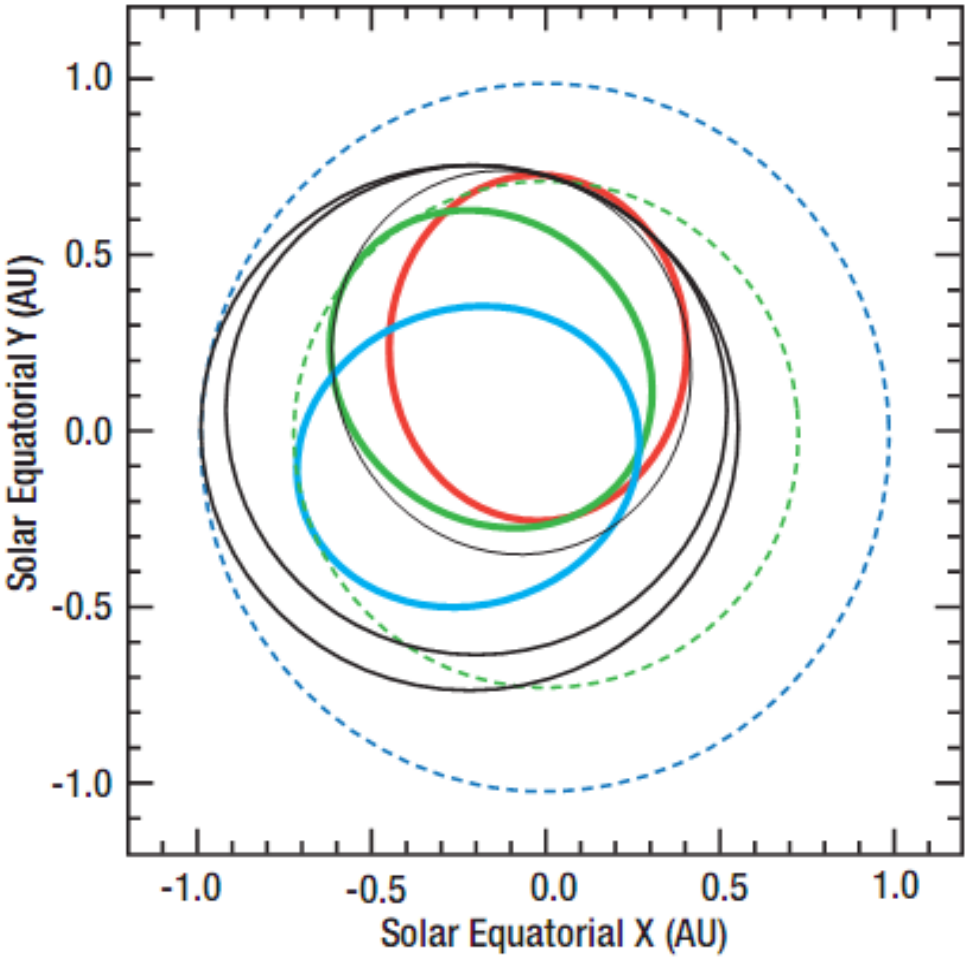


$$\left[1 - \frac{\dot{N}(t)}{\dot{N}(0)}\right]$$

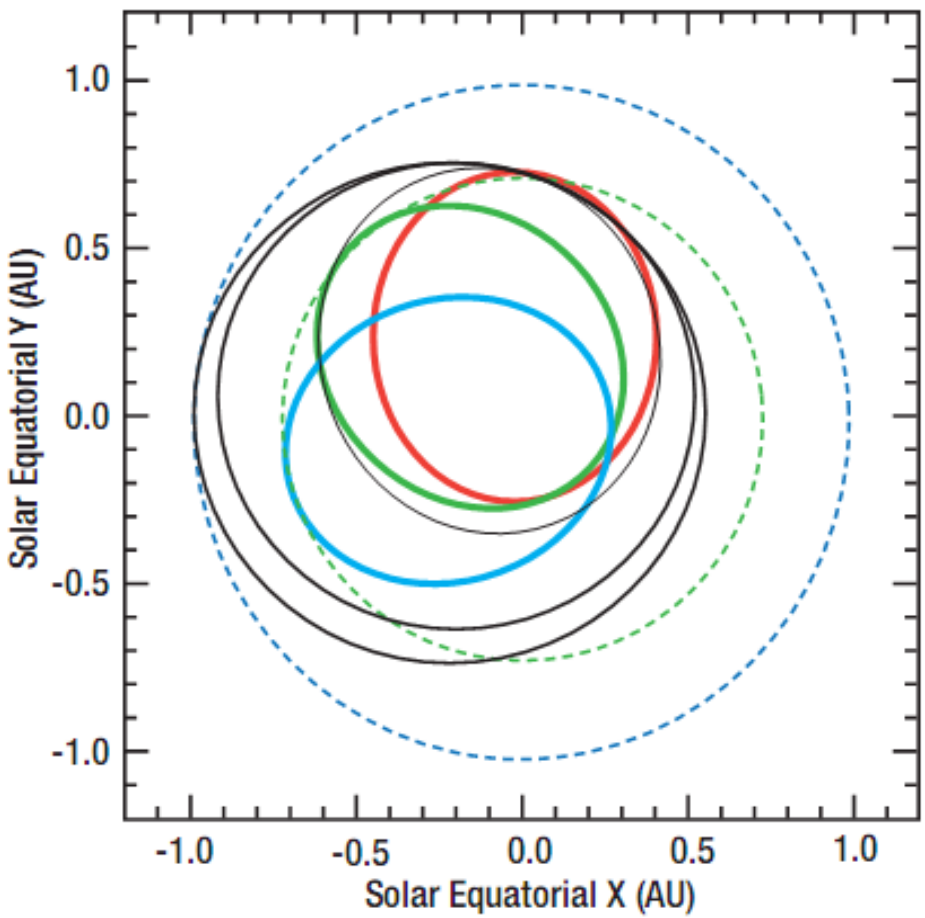


LWS Sentinels Mission

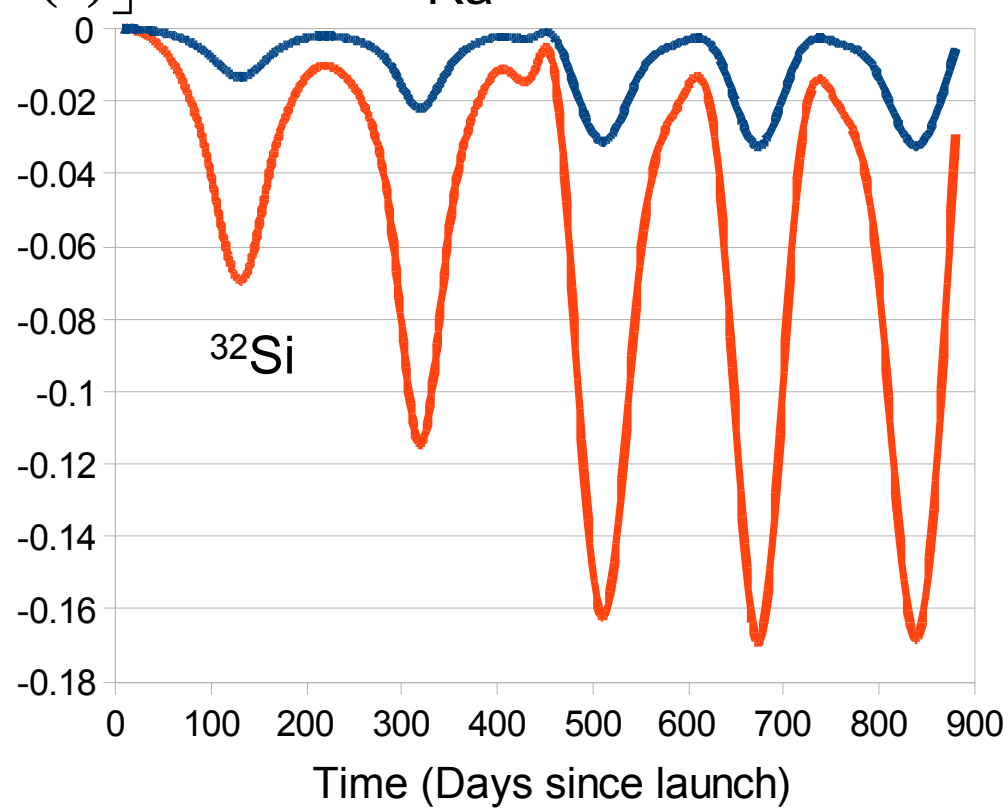




LWS Sentinels Mission



$$\left[1-\frac{\dot{N}(t)}{\dot{N}(0)}\right]$$



Potential Missions for Experiment

- Monitor decay rate on Earth.
  - Precisely measure variations in decay rates between periapsis and apoapsis.
- Stable orbit around stable Lagrange points.
  - May have significant difference between apoapsis and periapsis.
- Mars Science Laboratory.
  - Radioisotope power system for generation of electricity from the heat of radioactive decay.
- Jupiter Polar Orbiter (Juno).
  - Map Jupiter's gravitational and magnetic fields.
- Europa Jupiter System Mission.
  - Likely to have radioisotope thermoelectric generator (RTG) on board.
- Titan Saturn System Mission.
  - Likely presence of RTG onboard.
- Europa Astrobiology Lander.
  - Likely presence of RTG onboard.
- Solar Probe Plus
  - Spacecraft designed to plunge deep into the sun's atmosphere
- Heliophysical Explorers Solar Orbiters and Sentinels.
  - Multiple close approaches to the sun.

NASA's Upcoming Missions

Mars Science Laboratory

Launch: September 2009

• Can measure radiation produced by the interaction of space radiation with the Martian atmosphere and surface rocks and soils.

• Carries radioisotope power system to generate electricity from the heat of plutonium's radioactive decay.

Juno

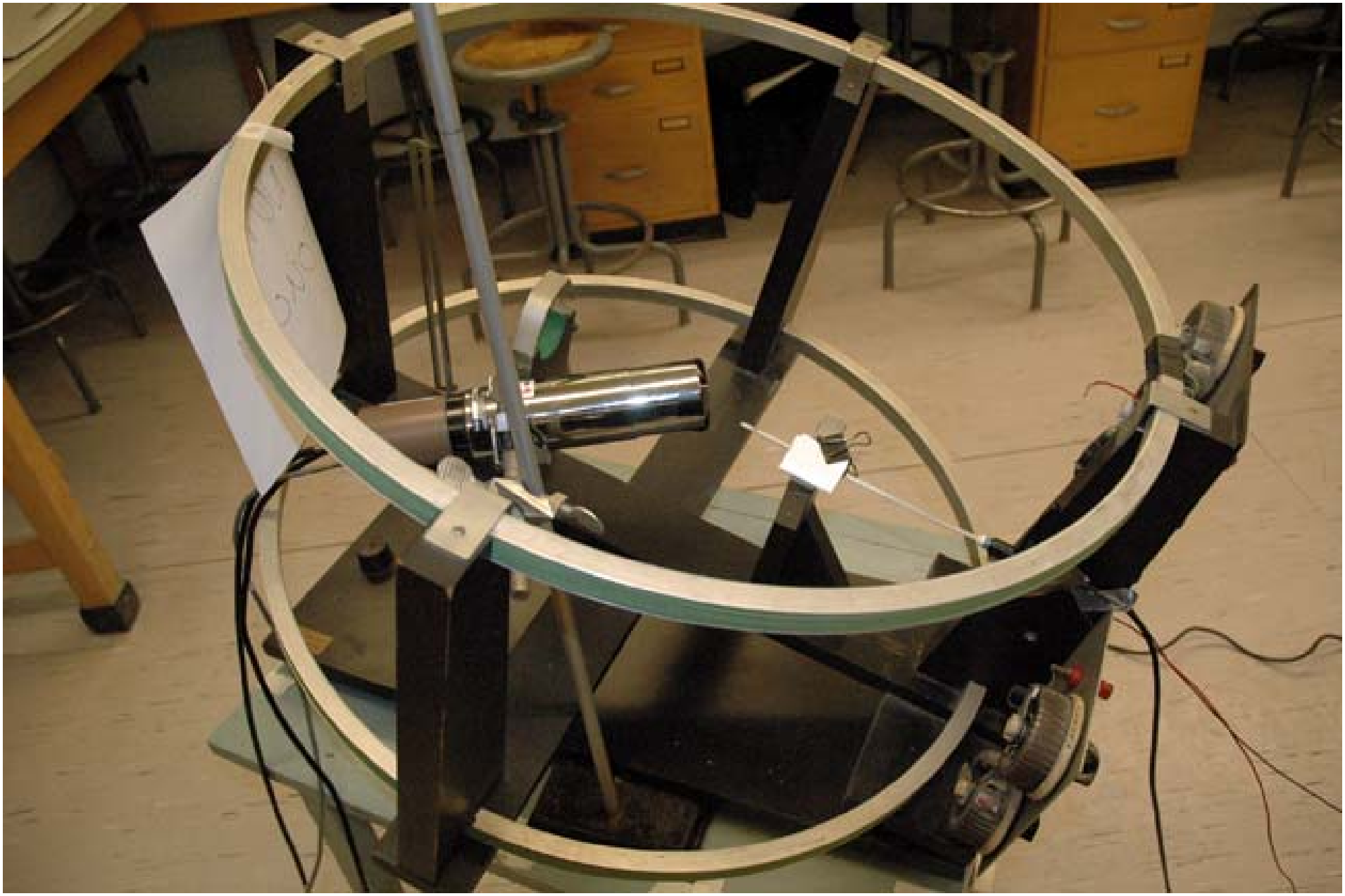
Launch: August 2011

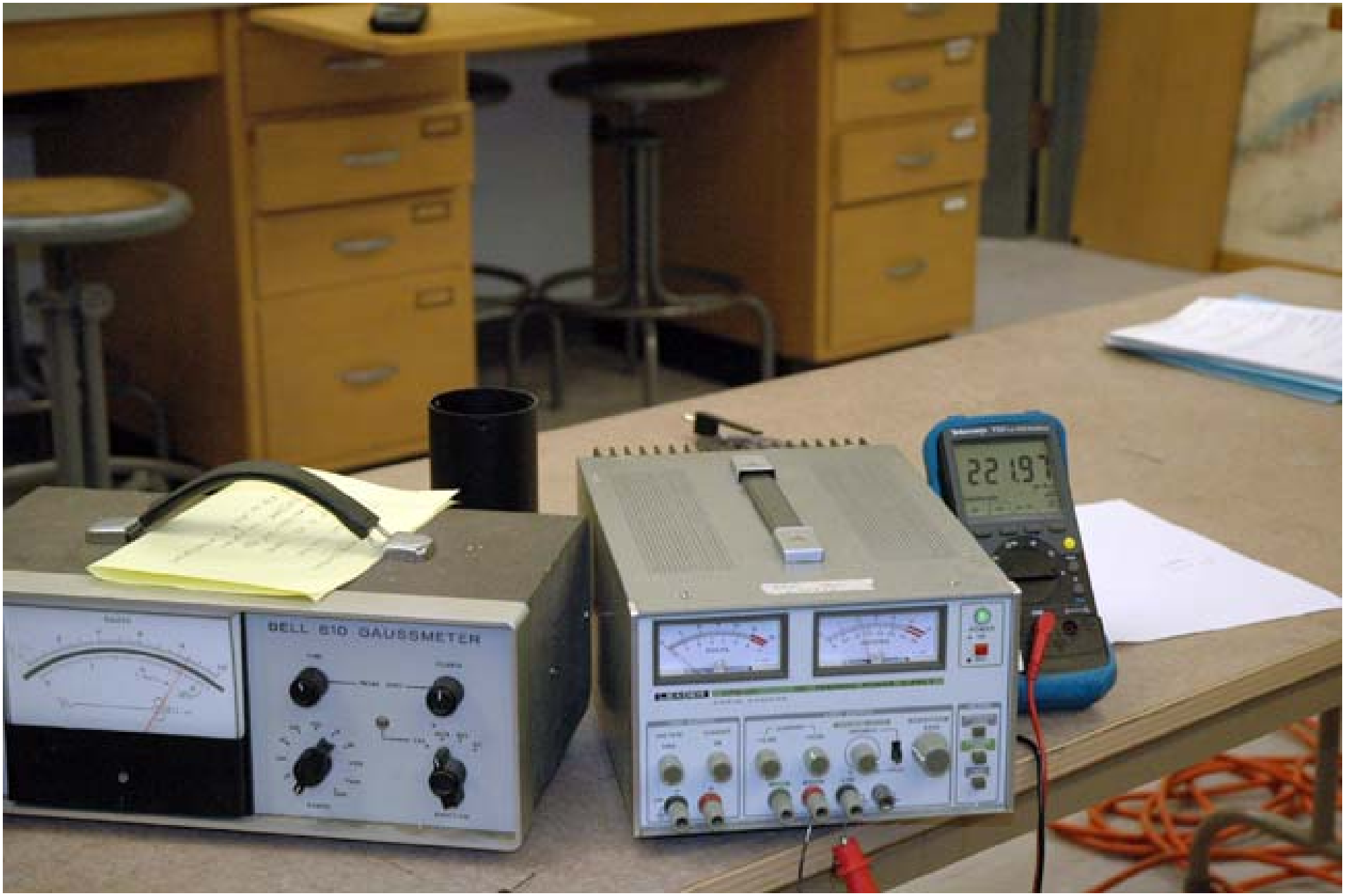
•Will precisely map Jupiter's gravitational and magnetic fields to assess the distribution of mass in Jupiter's interior, including properties of the planet's structure and dynamics.

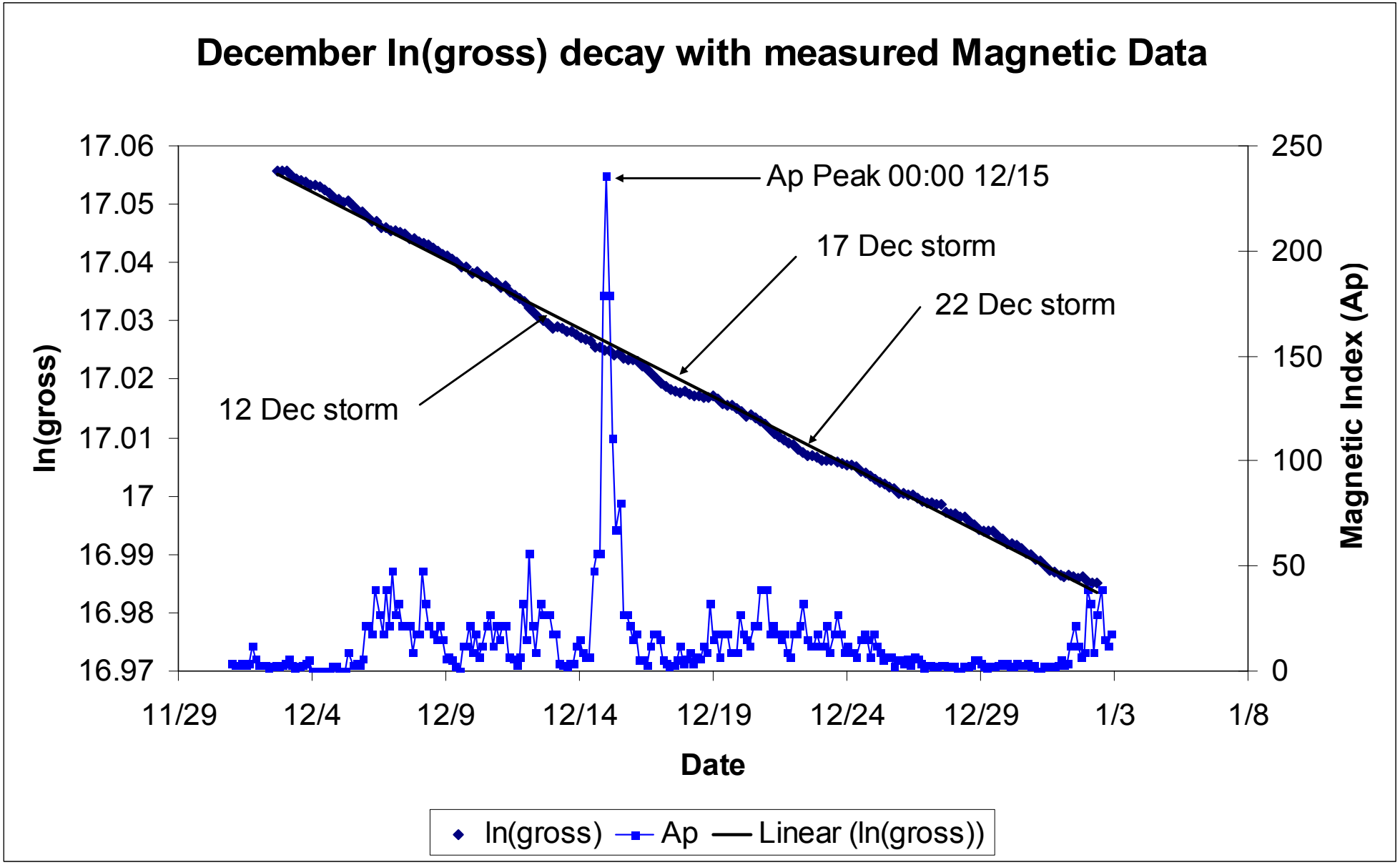
Summary

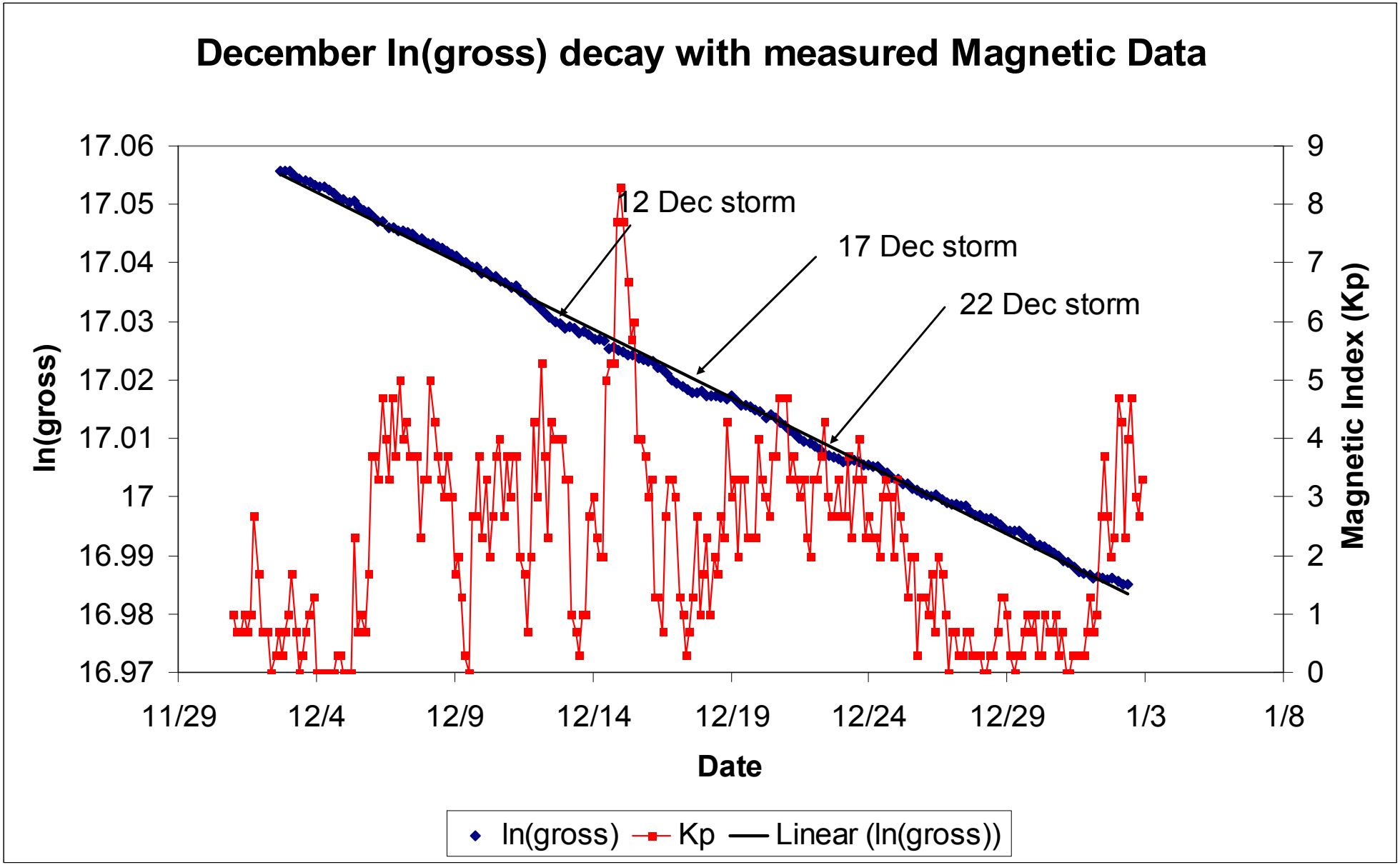
1. BNL and PTB data indicate an annual modulation of ^{32}Si and ^{226}Ra decay rates strongly correlated with $1/R^2$
2. Data taken during the 12-Dec 2006 solar flare on ^{54}Mn also showed a response of the decay rate to solar activity.
3. These data are consistent with a modulation of nuclear decay rates by solar neutrinos and, perhaps, by some other field which modifies the fine structure constant, α, and/or some other fundamental constants.
4. Detailed mechanisms to account for these data can be tested in upcoming NASA Mars missions and the NASA Sentinels mission.

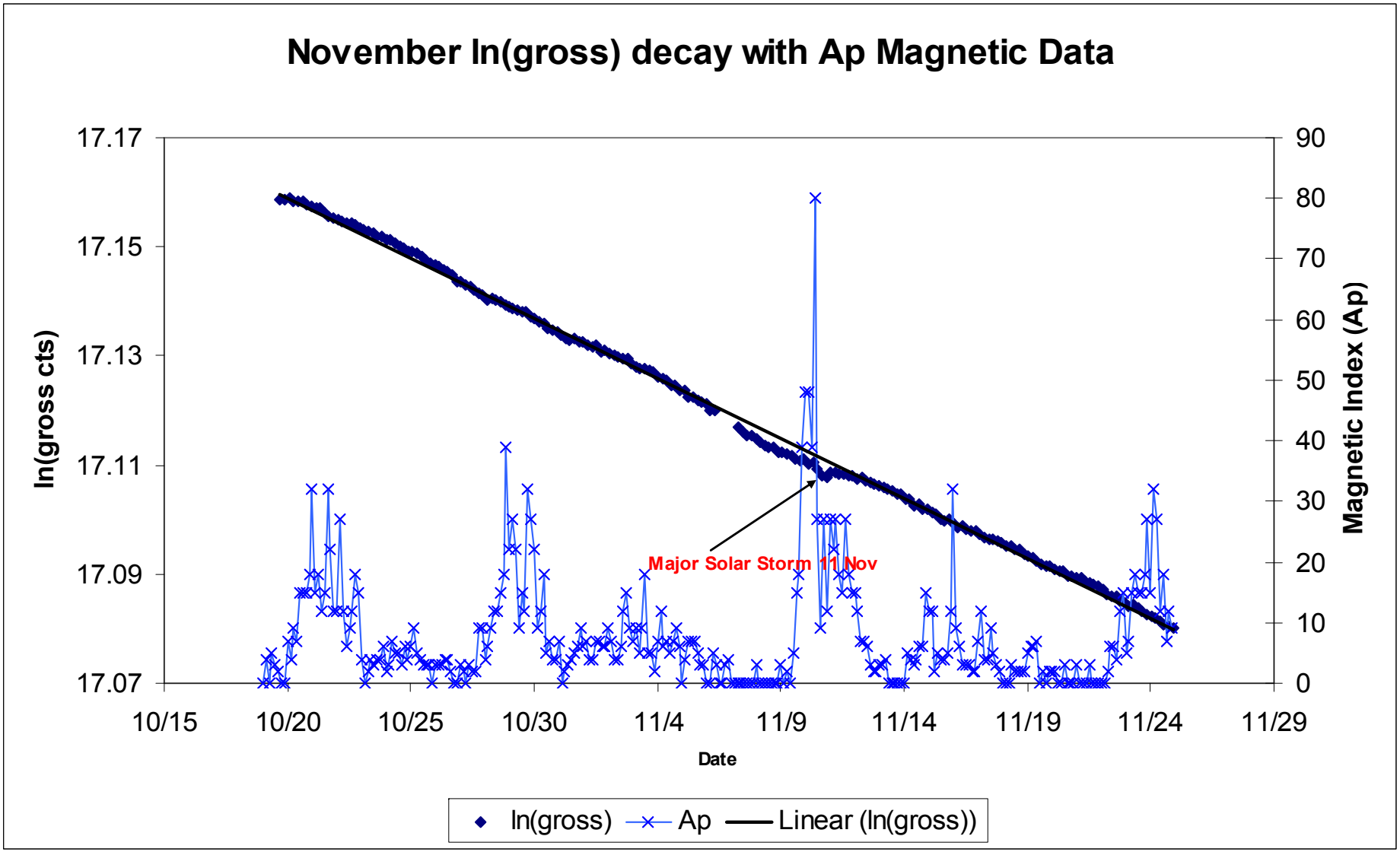
END

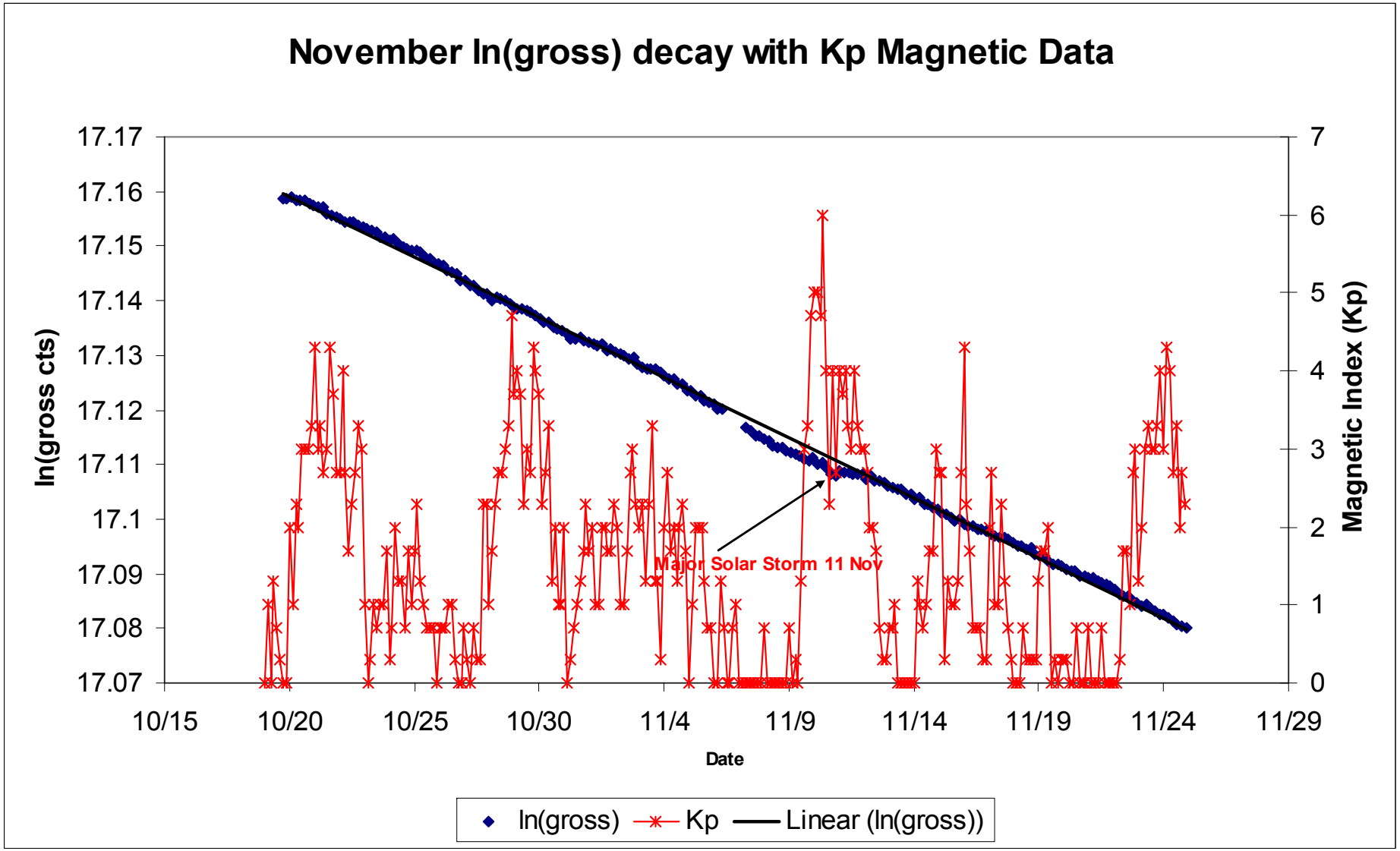


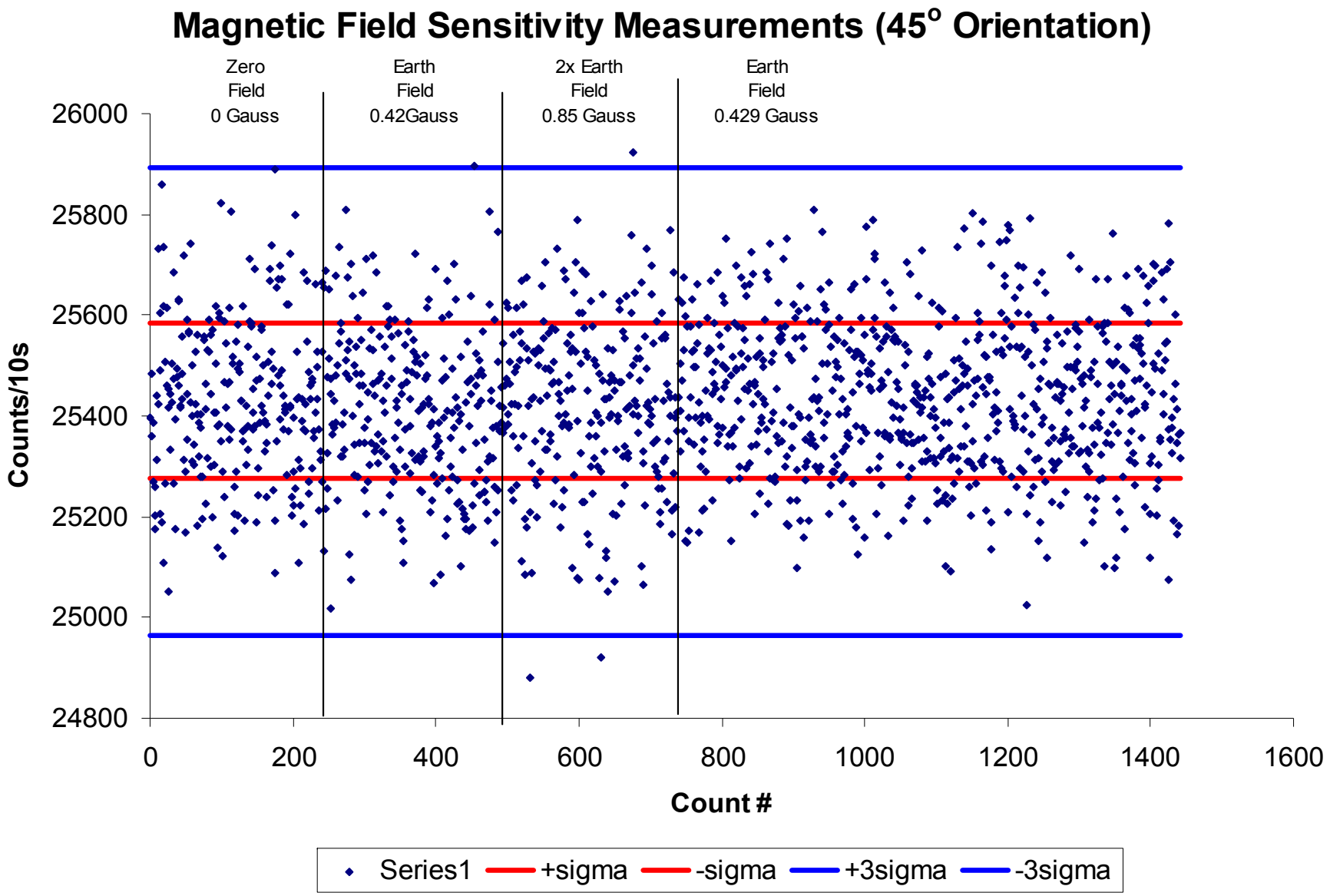

BELL 610 GAUSSMETER


December ln(gross) decay with measured Magnetic Data
17.06
17.05
17.04
17.03
17.02
17.01
17
16.99
16.98
16.97
ln(gross)
250
200
150
100
50
0
Magnetic Index (Ap)
Ap Peak 00:00 12/15
17 Dec storm
22 Dec storm
12 Dec storm
11/29
12/4
12/9
12/14
12/19
12/24
12/29
1/3
1/8
Date
ln(gross)
Ap
Linear (ln(gross))


December ln(gross) decay with measured Magnetic Data
17.06
17.05
17.04
17.03
17.02
17.01
17
16.99
16.98
16.97
ln(gross)
9
8
7
6
5
4
3
2
1
0
Magnetic Index (Kp)
12 Dec storm
17 Dec storm
22 Dec storm
11/29
12/4
12/9
12/14
12/19
12/24
12/29
1/3
1/8
Date
ln(gross)
Kp
Linear (ln(gross))


November ln(gross) decay with Ap Magnetic Data
ln(gross cts)
17.17
17.15
17.13
17.11
17.09
17.07
Magnetic Index (Ap)
90
80
70
60
50
40
30
20
10
0
10/15
10/20
10/25
10/30
11/4
11/9
11/14
11/19
11/24
11/29
Date
Major Solar Storm 11 Nov
ln(gross)
Ap
Linear (ln(gross))


November ln(gross) decay with Kp Magnetic Data
ln(gross cts)
17.17
17.16
17.15
17.14
17.13
17.12
17.11
17.1
17.09
17.08
17.07
Magnetic Index (Kp)
7
6
5
4
3
2
1
0
10/15
10/20
10/25
10/30
11/4
11/9
11/14
11/19
11/24
11/29
Date
Major Solar Storm 11 Nov
ln(gross)
Kp
Linear (ln(gross))


Magnetic Field Sensitivity Measurements (45° Orientation)
Zero Field 0 Gauss
Earth Field 0.42Gauss
2x Earth Field 0.85 Gauss
Earth Field 0.429 Gauss
Counts/10s
26000
25800
25600
25400
25200
25000
24800
0
200
400
600
800
1000
1200
1400
1600
Count #
Series1
+sigma
-sigma
+3sigma
-3sigma