US Nuclear Data Program

A.A. Sonzogni

National Nuclear Data Center

BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

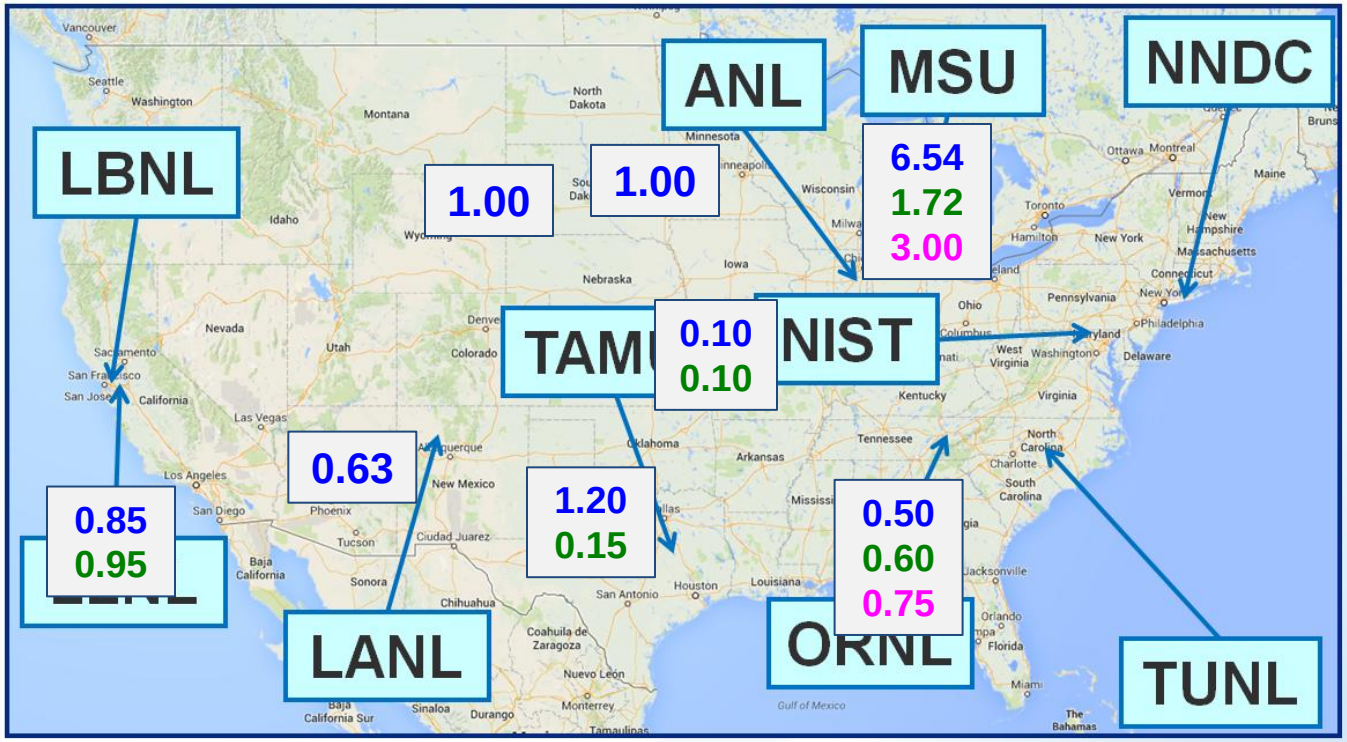
U.S. DEPARTMENT OF ENERGY | Office of Science

US Nuclear Data Program

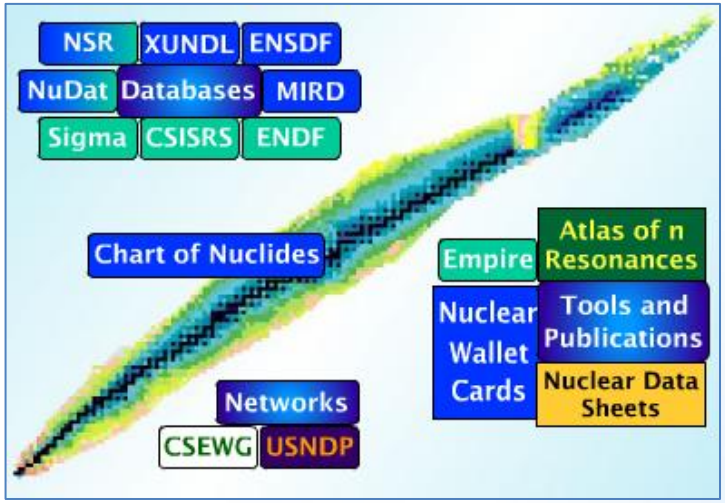
The mission of the United States Nuclear Data Program (USNDP) is to provide current, accurate, authoritative data for workers in pure and applied areas of nuclear science and engineering. This is accomplished primarily through the compilation, evaluation, dissemination, and archiving of extensive nuclear datasets. USNDP also addresses gaps in the data, through targeted experimental studies and the use of theoretical models.

FTEs
Sci Perm
Sci Temp
Tech/Admin

Current USNDP Groups



US Nuclear Data Program Main Products



Nuclear Science References (NSR)

All nuclear physics articles indexed according to content

EXFOR

Compiled nuclear reaction data

XUNDL

Compiled nuclear structure and decay data

ENSDF

Recommended nuclear structure and decay data

ENDF

Recommended particle transport and decay data, with a strong emphasis on neutron-induced reaction data

Nuclear Data Sheets

Journal devoted to the publication of nuclear data articles

Web dissemination

www.nndc.bnl.gov

Changes in the last two years

- Jag Tuli retired in 2016 and now under contract with LBNL.
- Libby McCutchan now ENSDF/XUNDL manager and Nuclear Data Sheets editor.
- New datacenters in Texas A&M University (Ninel Nica) and Michigan State University (Jun Chen).
- Mike Herman and Alejandro Sonzogni exchanged positions in September 2016.

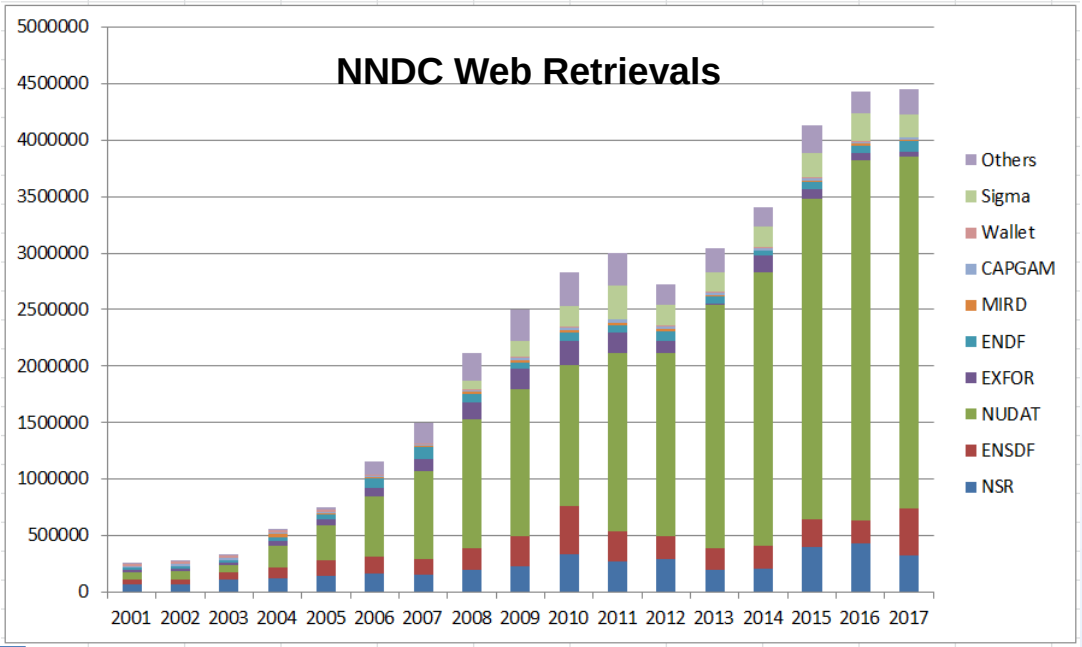
Current NNDC Staff

Staff Member	Jobs
Ramon Arcilla	System Administration / ENDF validation
David Brown	ENDF manager / EMPIRE
Mike Herman	ENDF / EMPIRE
Tim Johnson	WEB / ENSDF
Letty Krejci	Administrative / NDS assistant
Libby McCutchan	ENSDF/XUNDL manager, NDS editor, experiments
Gustavo Nobre	ENDF / EMPIRE
Boris Pritychenko	NSR / EXFOR / BE2 / BB / Astrophysics
Alejandro Sonzogni	Head / ENDF decay data / Web
Joann Totans	NSR / Library
Said Mughabghab (emeritus)	Neutron Resonances
Emil Betak (contract)	NSR
Stanislav Hlavac (contract)	EXFOR
Pavel Oblozinsky (contract)	NDS
Otto Schwerer (contract)	EXFOR
Balraj Singh (contract)	NSR / ENSDF / XUNDL / BE2 / BDN

A few highlights of the last two years next

Web Disseminations

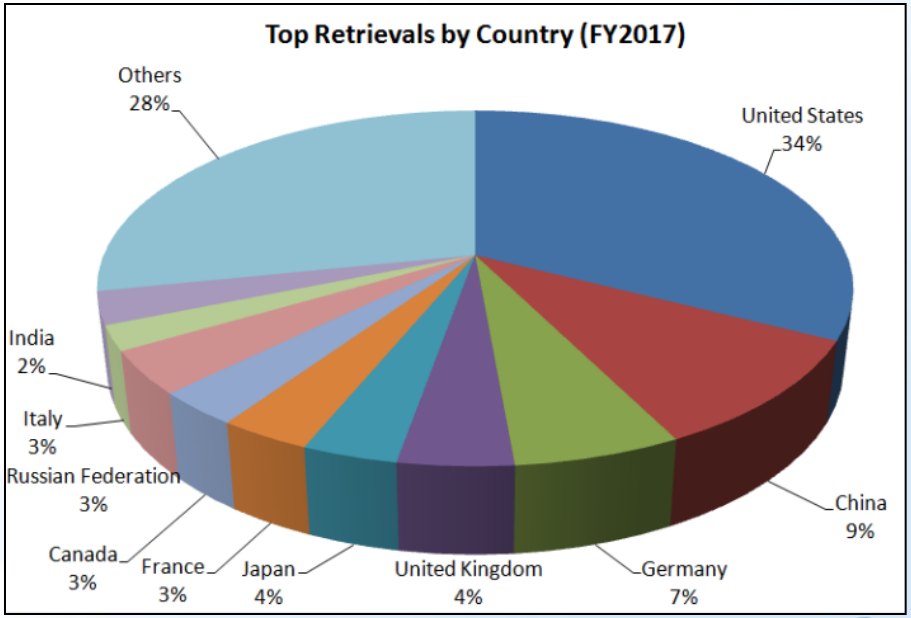
Lab	# FY17 retrievals (thousands)	Change relative to FY16
BNL	4,413	+1.1%
ORNL	200	+67%
TUNL	117	+13.6%



BNL Highlights

- We passed the cybersecurity audit with **ZERO** vulnerabilities.
- NuDat was expanded following Notre Dame meeting.
- New racks and servers
- New PDF output for ENSDF (Jun Chen, MSU)

More details on Tim Johnson's presentation.



FY17 Compilation metrics

- **NSR: 3,277 articles** relevant to nuclear science from around **80 journals** were incorporated and **1825** indexed according to content.

- **EXFOR:** low-energy nuclear reaction data from **98** articles were incorporated. Boris Prytichenko (Staff), Stanislav Hlavac (contractor) and Otto Schwerer (contractor) responsible for this effort. More details on Boris talk.

- **XUNDL**: nuclear structure and decay data from **314** articles were incorporated in the database. **Exciting development in collaboration with PRC.**

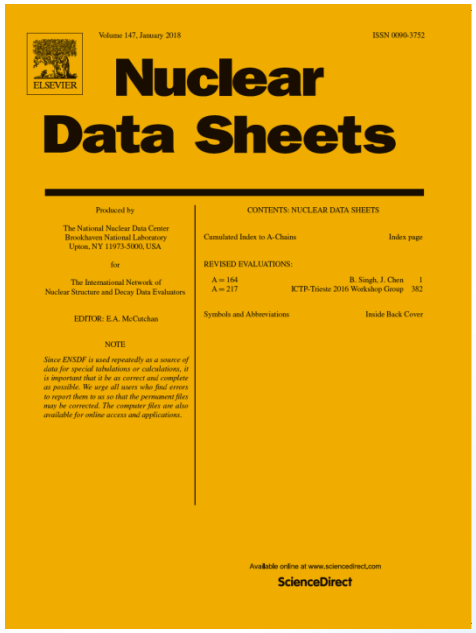
Compilation activities are in a healthy stage.

FY 17 ENDF/B Evaluations

- ENDF/B-VIII.0 was released on **February 2, 2018.** Will greatly impact nuclear science and technology applications in next 5-10 years.
- ENDF/B-VII.1 was released in 2011.
- ENDF/B-VII.0 was released in 2006.
- BNL, LANL, LLNL and NIST among USNDP-funded groups contributing to this multi-year effort
- ENDF/B is produced by the Cross Section Evaluation Working Group, an organization of nuclear science and technology scientist and engineers from national laboratories, universities and industry.
- ENDF/B-VIII.0 incorporates evaluation work from CIELO, the first international project of join nuclear reactions evaluations.

Nuclear Data Sheets

- Began in 1966, currently published by Elsevier.
- NNDC responsible for editorial role and management
- Original mission was to publish ENSDF evaluations and Recent References (NSR).
- Starting in 2006, one issue per year is devoted to nuclear reaction related articles.
- Unusual in that we publish ~20 manuscripts per year



Topic	Reference	# of Citations
ENDF/B-VII.0	NDS 107, 2931 (2006)	1147
ENDF/B-VII.1	NDS 112, 2887 (2011)	791
RIPL	NDS 110, 3107 (2009)	497
EMPIRE	NDS 108, 2655 (2007)	335
TALYS	NDS 113, 2841 (2012)	271
FLUKA	NDS 120, 211 (2014)	258
NuShellX@MSU	NDS 120, 115 (2014)	83

ENDF library

Reaction library

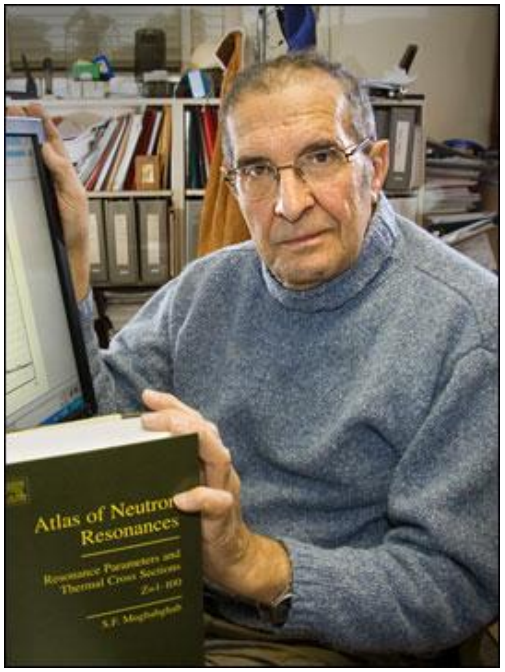
Reaction codes

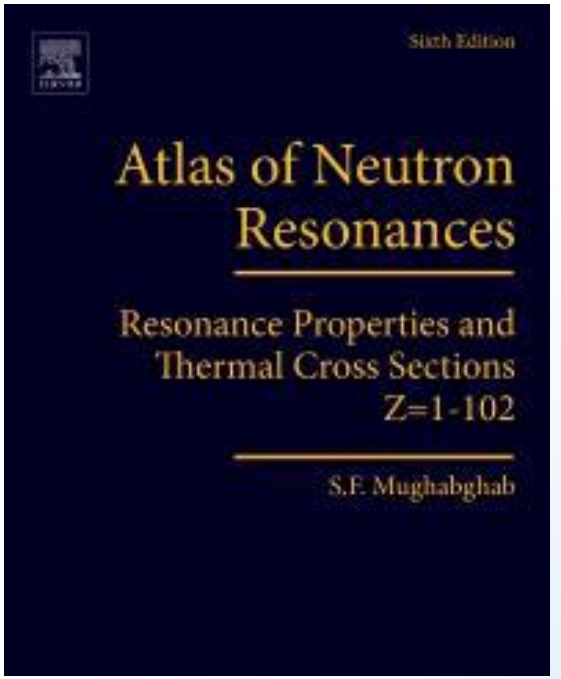
Application

Structure code

For perspective, most cited paper in PRC between 2006-2018: RHIC theory paper (2008) with 522 citations

6th Edition of the Atlas of Neutron Resonances by Said Mughabghab





Published in March 2018 by Elsevier, two volumes.

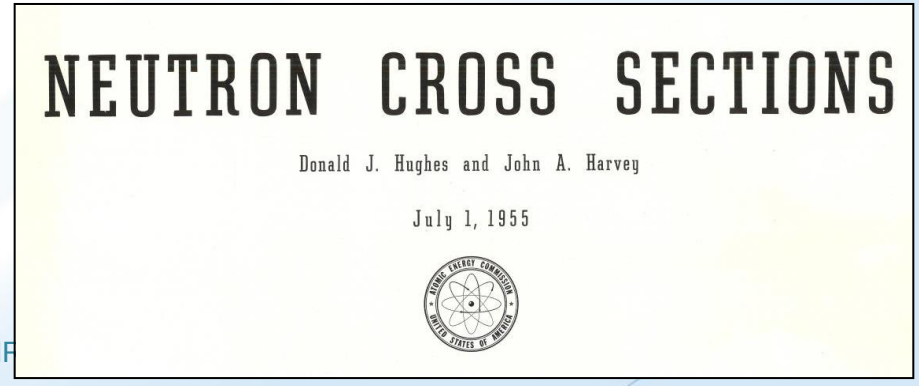
Said is scientist emeritus in BNL. Technical support provided by R. Arcilla, D. Brown, T. Johnson and A. Sonzogni.

2006 version has 1,200 citations!

60+ years of expertise, that started with Don Hughes, Jack Harvey and Charles Porter.

About 7 years of work to complete at no cost. No royalties will be received.

Will be used extensively in future ENDF/B.

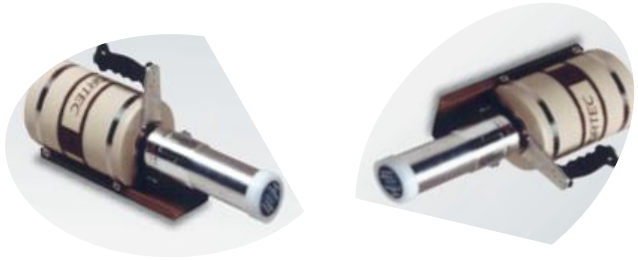

NEUTRON CROSS SECTIONS

Donald J. Hughes and John A. Harvey

July 1, 1955

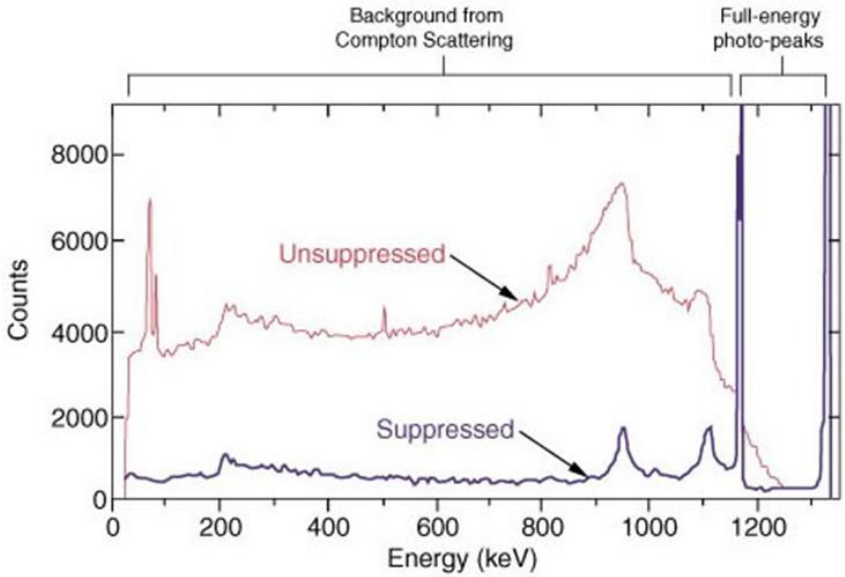
Capitalizing on advances in γ-ray spectroscopy

30 Years ago: 1-2 small detectors

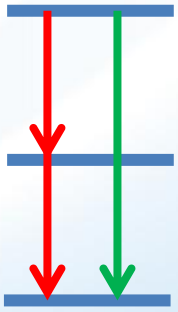


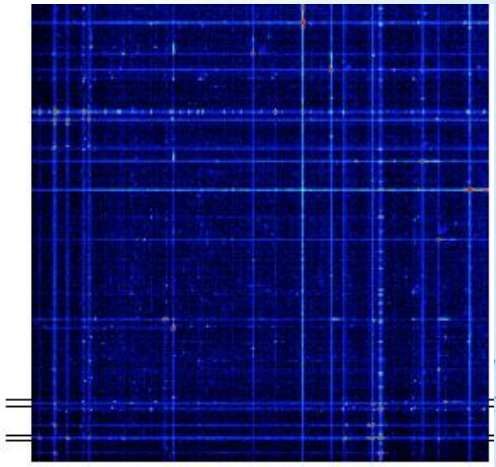
Present: 10-100 detectors

Compton suppression



γγ coincidences





Non-conventional PET agents : ^{86}Y

IOP Publishing | Institute of Physics and Engineering in Medicine
Physics in Medicine & Biology
Phys. Med. Biol. 60 (2015) 3479–3497
doi:10.1088/0031-9155/60/9/3479

PET imaging with the non-pure positron

PHYSICAL REVIEW C VOLUME 2, NUMBER 6 DECEMBER 1970

Energy Levels in ^{86}Sr from the Decay of 14.6-h ^{86}Y

A. V. Ramayya, B. Van Nooijen,* J. W. Ford, D. Krmpotić,† and J. H. Hamilton
Physics Department,‡ Vanderbilt University, Nashville, Tennessee 37203

and

J. J. Pinajian and Noah R. Johnson
Oak Ridge National Laboratory,§ Oak Ridge, Tennessee 37803
(Received 20 April 1970)

ELSEVIER
Contents lists available at ScienceDirect
Applied Radiation and Isotopes
journal homepage: www.elsevier.com/locate/apradiso

Tailoring medium energy proton beam to induce low energy nuclear reactions in $^{86}SrCl_2$ for production of PET radioisotope ^{86}Y☆

Dmitri G. Medvedev*, Leonard F. Mausner, Philip Pile

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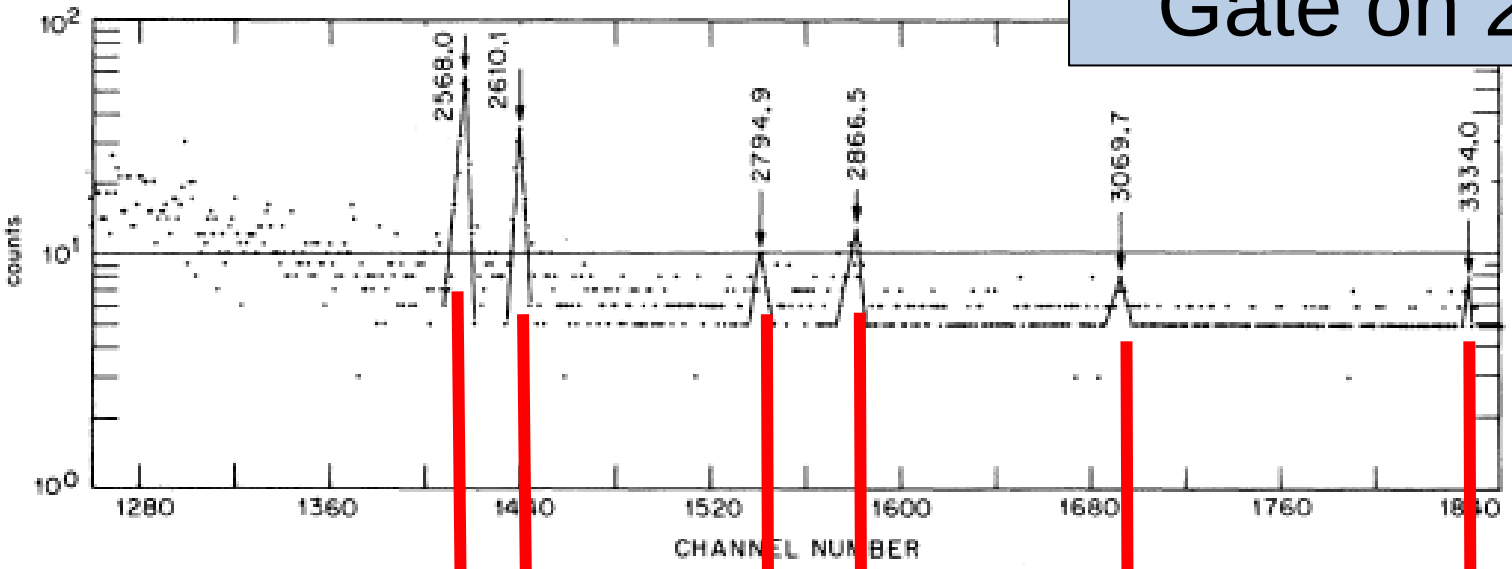
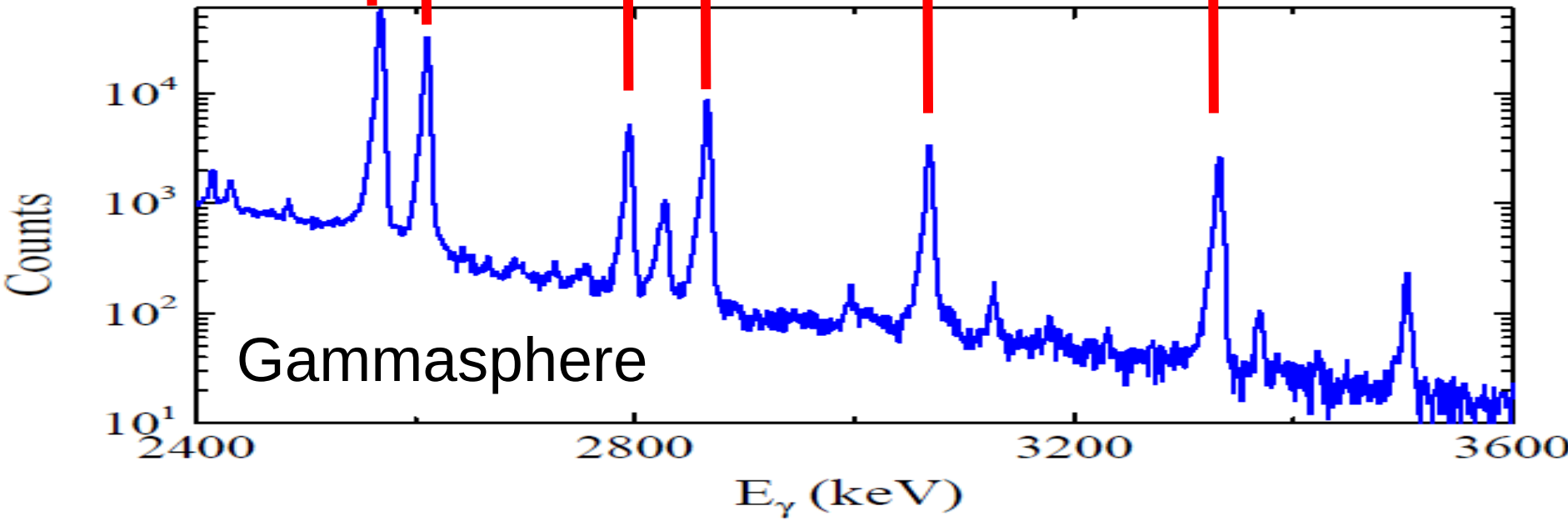
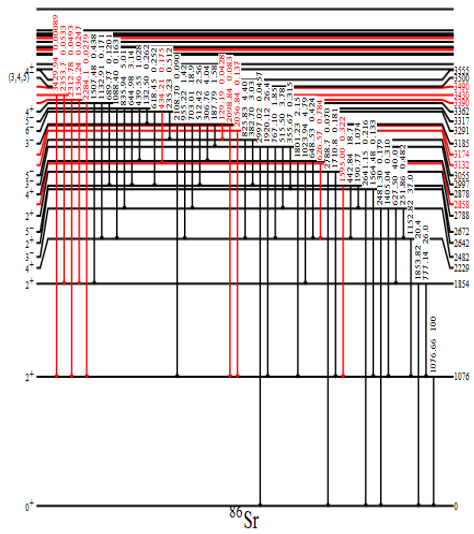
Results on ^{86}Y

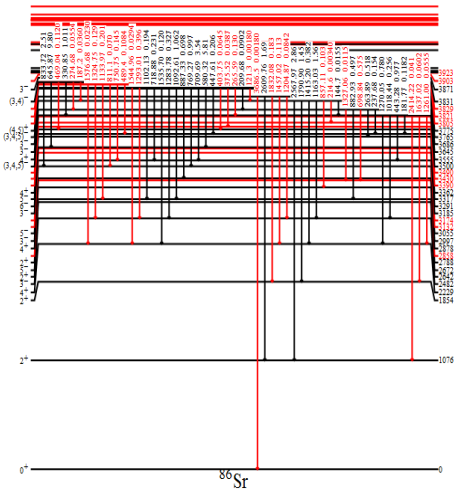
Gate on $2^+ \rightarrow 0^+$

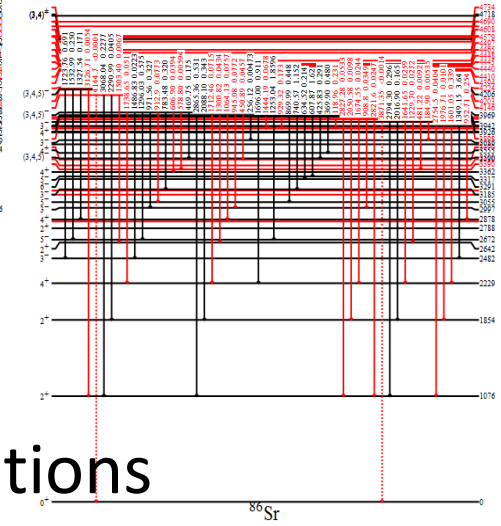


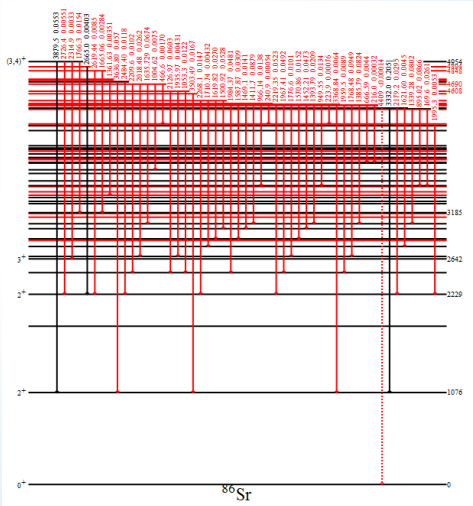


Revised Decay Scheme for ^{86}Y









Identified over 100 new transitions

511-keV intensity decreases by 20% !

^{86}Y source produced at UW Madison cyclotron, measurement in ANL, summer student analyzed data, article in preparation, contact: E.A. McCutchan (BNL).
Earlier experiment on ^{82}Rb has been published, M. Nino, E.A. McCutchan et al, PRC **93**, 024301 (2016).

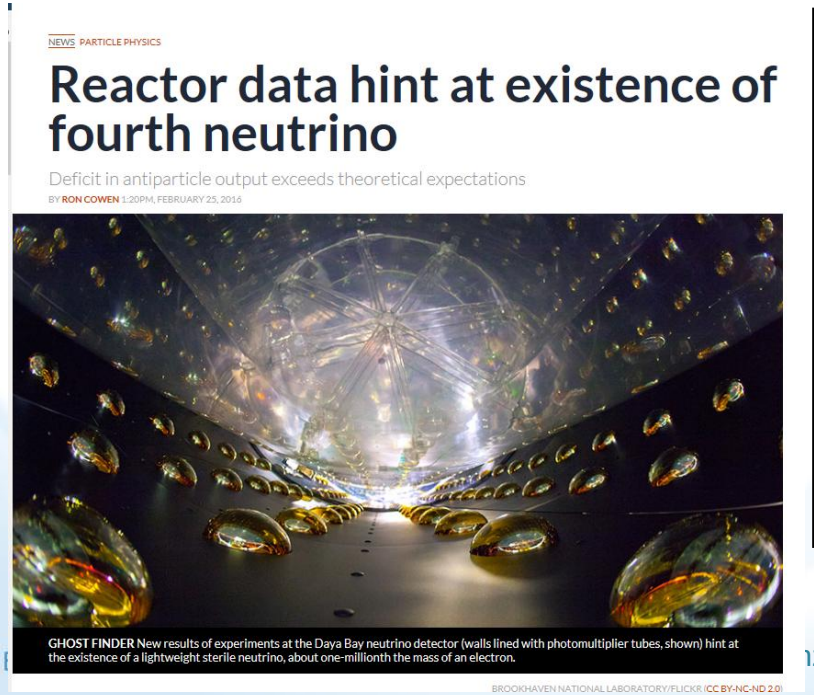
Reactor Antineutrino Anomaly

About 6 electron antineutrinos per fission from the beta-minus decay of the neutron rich fission products.

Each fission ~200 MeV, or

~5 x 10^{20} antineutrinos/second for a 1 GWe reactor.

We observe 6% fewer electron antineutrinos from nuclear reactors at short distances, not accounted for the standard 3-flavor oscillation.



NEWS PARTICLE PHYSICS

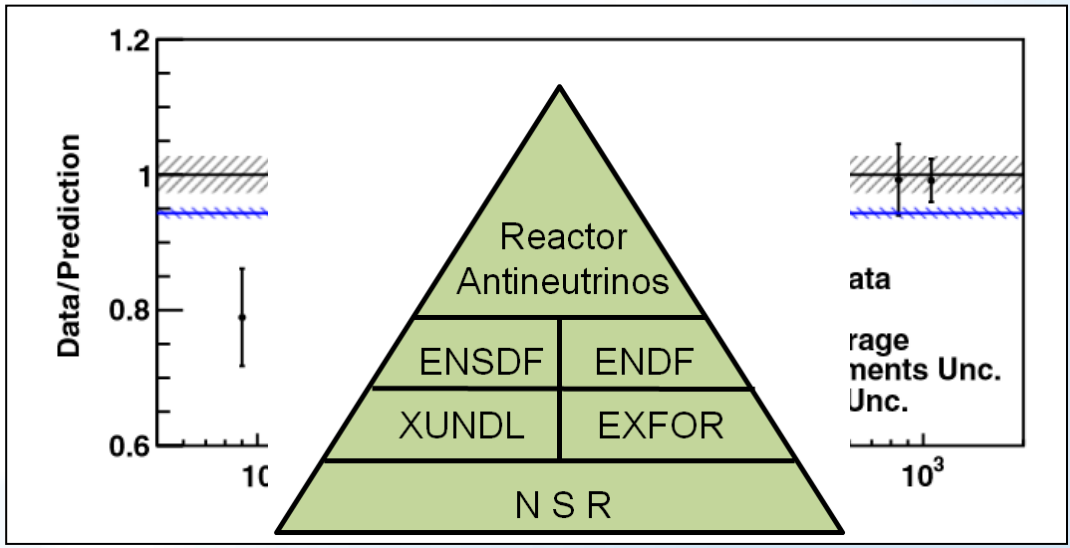
Reactor data hint at existence of fourth neutrino

Deficit in antiparticle output exceeds theoretical expectations

BY RON COWEN 1:20PM, FEBRUARY 25, 2016

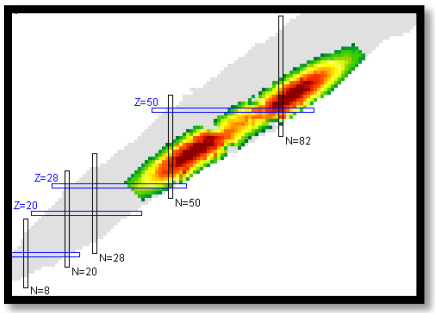
GHOST FINDER New results of experiments at the Daya Bay neutrino detector (walls lined with photomultiplier tubes, shown) hint at the existence of a lightweight sterile neutrino, about one-millionth the mass of an electron.

BROOKHAVEN NATIONAL LABORATORY/FLICKR (CC BY-NC-ND 2.0)



A problem at the top of the nuclear data pyramid.

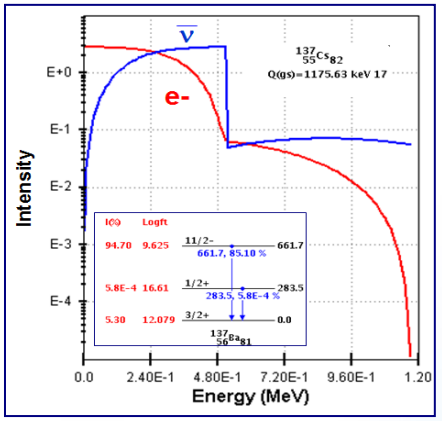
Using Our Databases

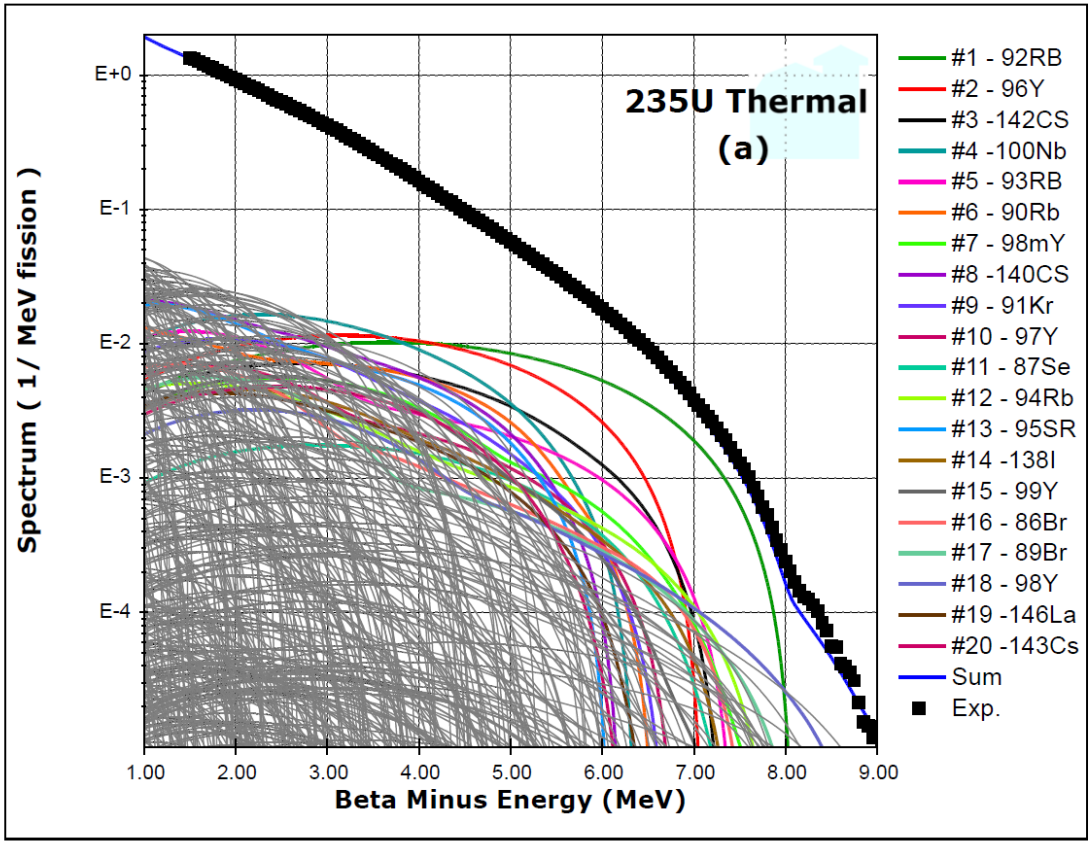


$$S(E) = \sum CFY_i S_i(E)$$

Cumulative Fission Yields

Individual Spectra





Comparison with the measured electron spectra.

Surprisingly, fewer contributors at high energy.

Results spurred a number of new measurements

First calculation of this type performed by P. Vogel et al in 1981 using ENDF/B-V.

A.A. Sonzogni, T.D. Johnson, E.A. McCutchan, PRC91, 011301(R) (2015)

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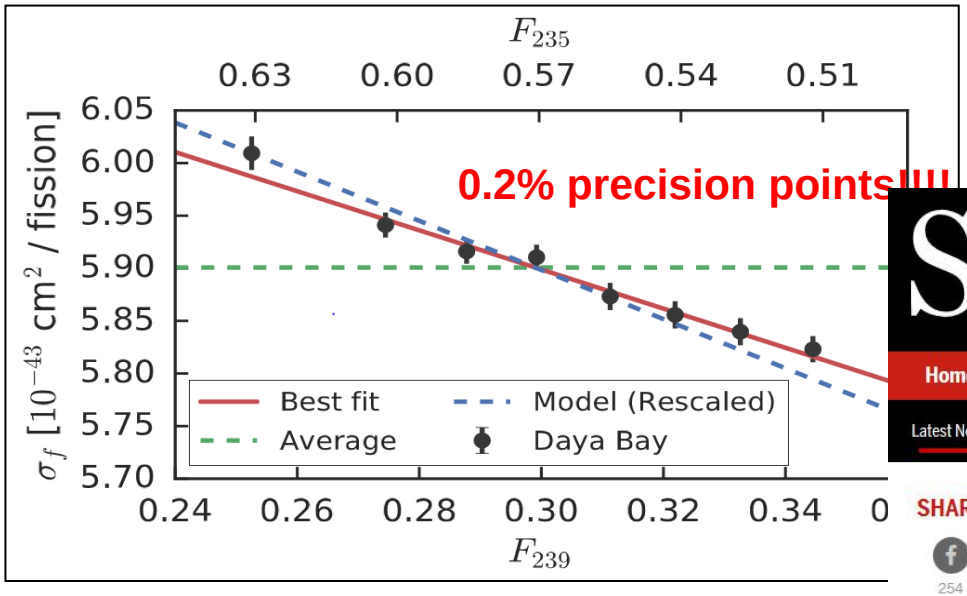
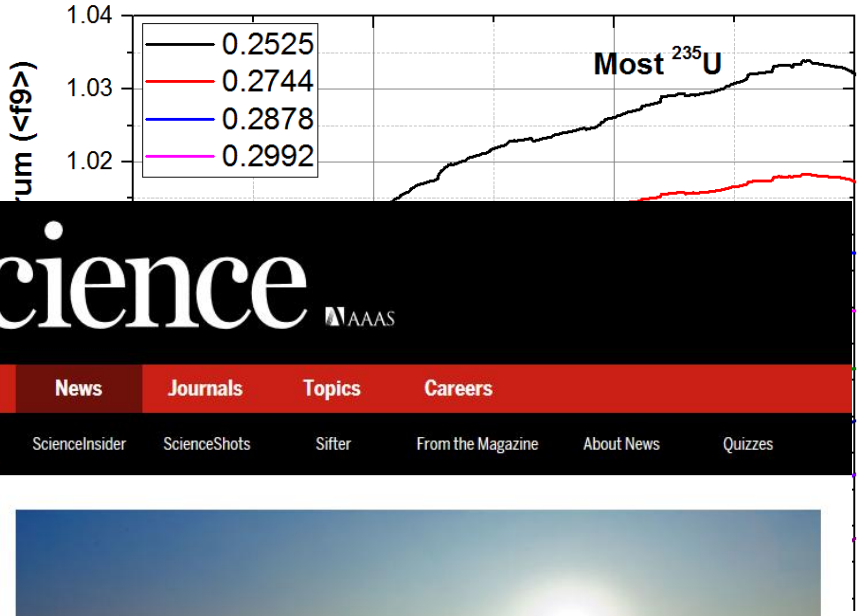
The anomaly, or not?





F.P. An *et al*, PRL **118**, 251801 (2017).

- Daya Bay measured the antineutrino yield as function of ^{239}Pu in the reactors
- ^{239}Pu agrees with measurement
- ^{235}U does not
- If anomaly, should be present in both

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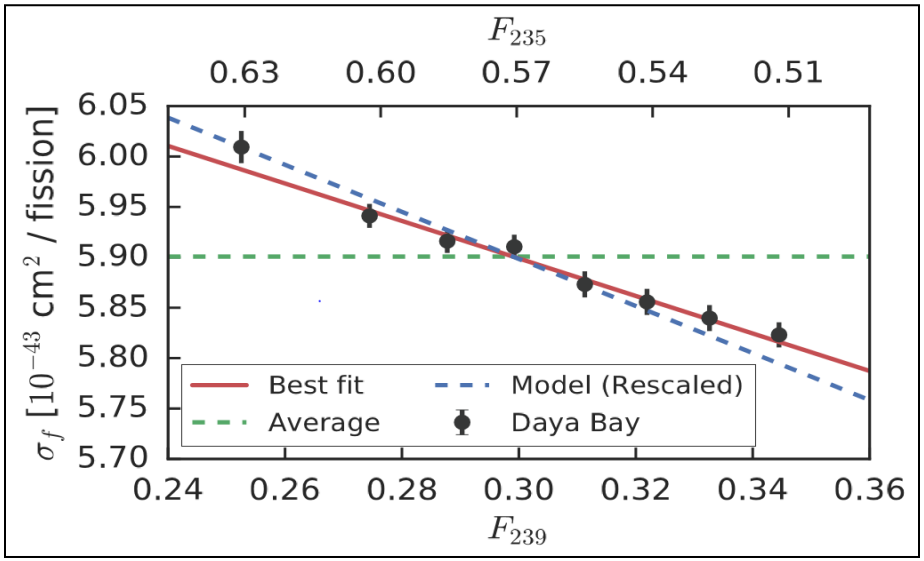
The Daya Bay Reactor Neutrino Experiment studies antineutrinos from six reactors near Shenzhen, China.
Photo courtesy of Lawrence Berkeley National Laboratory/Roy Kaltschmidt © 2010 The Regents of the University of California, through the Lawrence Berkeley National Laborator

Weird sterile neutrinos may not exist, suggest new data from nuclear reactors

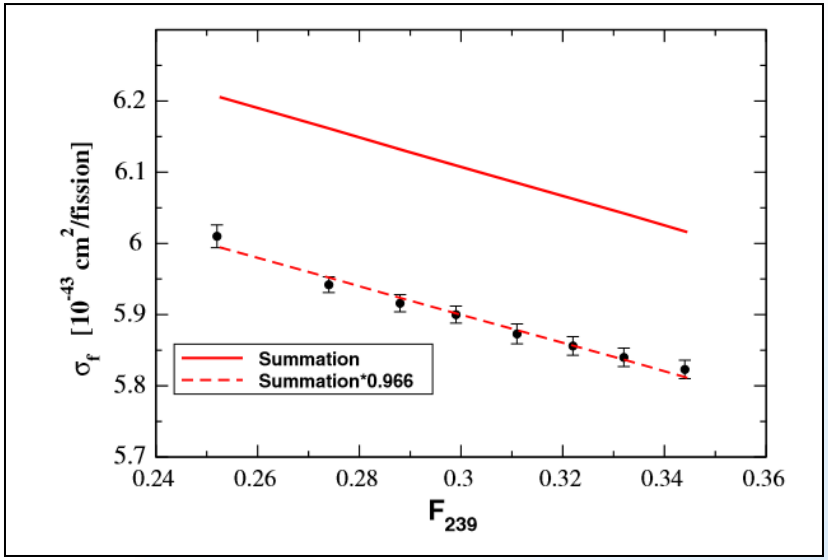
By Adrian Cho | Apr. 6, 2017 , 5:30 PM

Nuclear data to answer major science question

Daya Bay Analysis
(conversion of ILL data)



Our analysis
(Incorporates vast knowledge of decay data of fission fragments)
NNDC calculations using ENDF decay

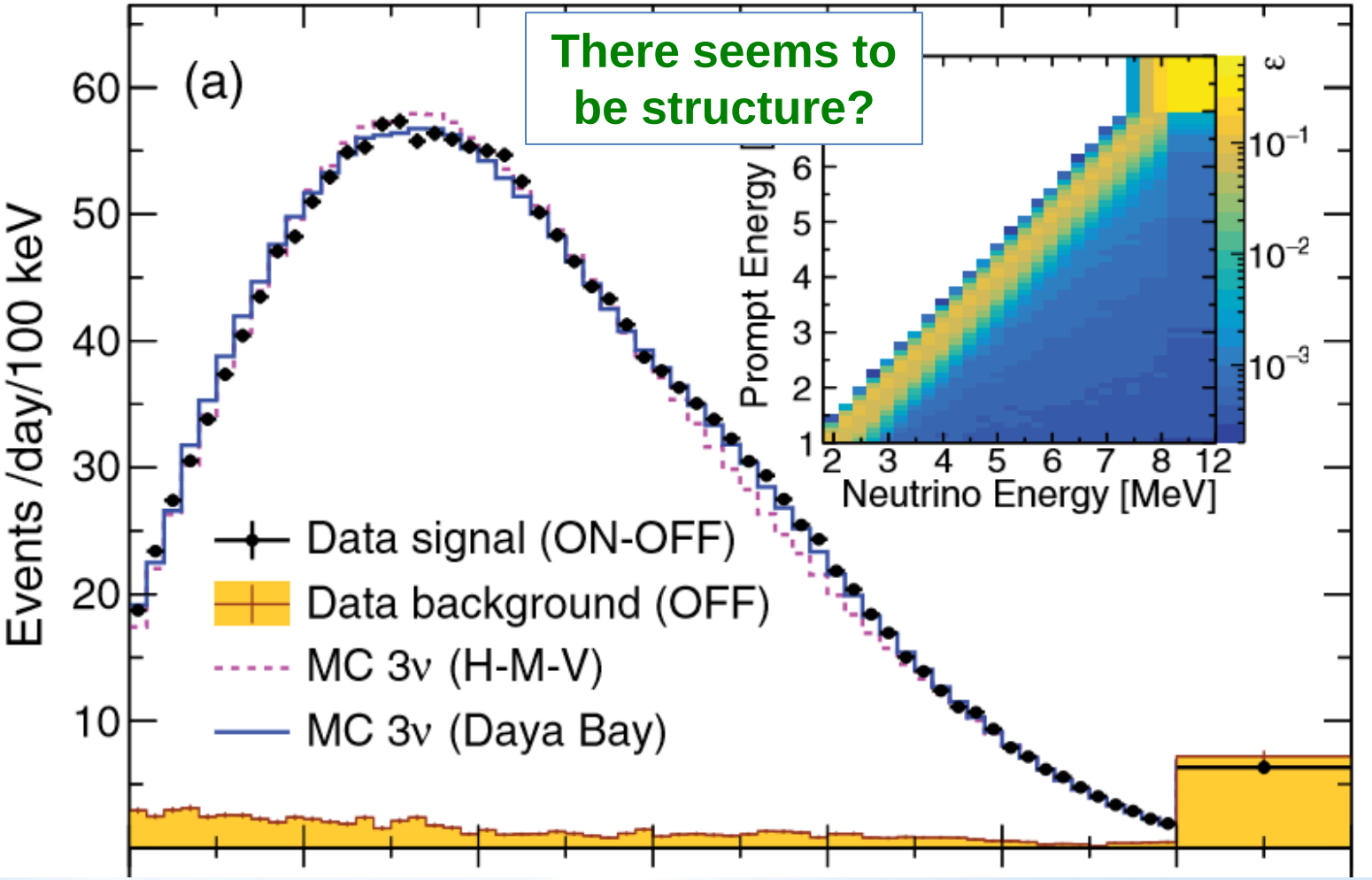


Abstract ends with:

'An analysis of the antineutrino spectra that is based on a summation over all fission fragment β decays, using nuclear database input, explains all of the features seen in the Daya Bay evolution data. However, this summation method still allows for an anomaly. We conclude that there is currently not enough information to use the antineutrino flux changes to rule out the possible existence of sterile neutrinos.'

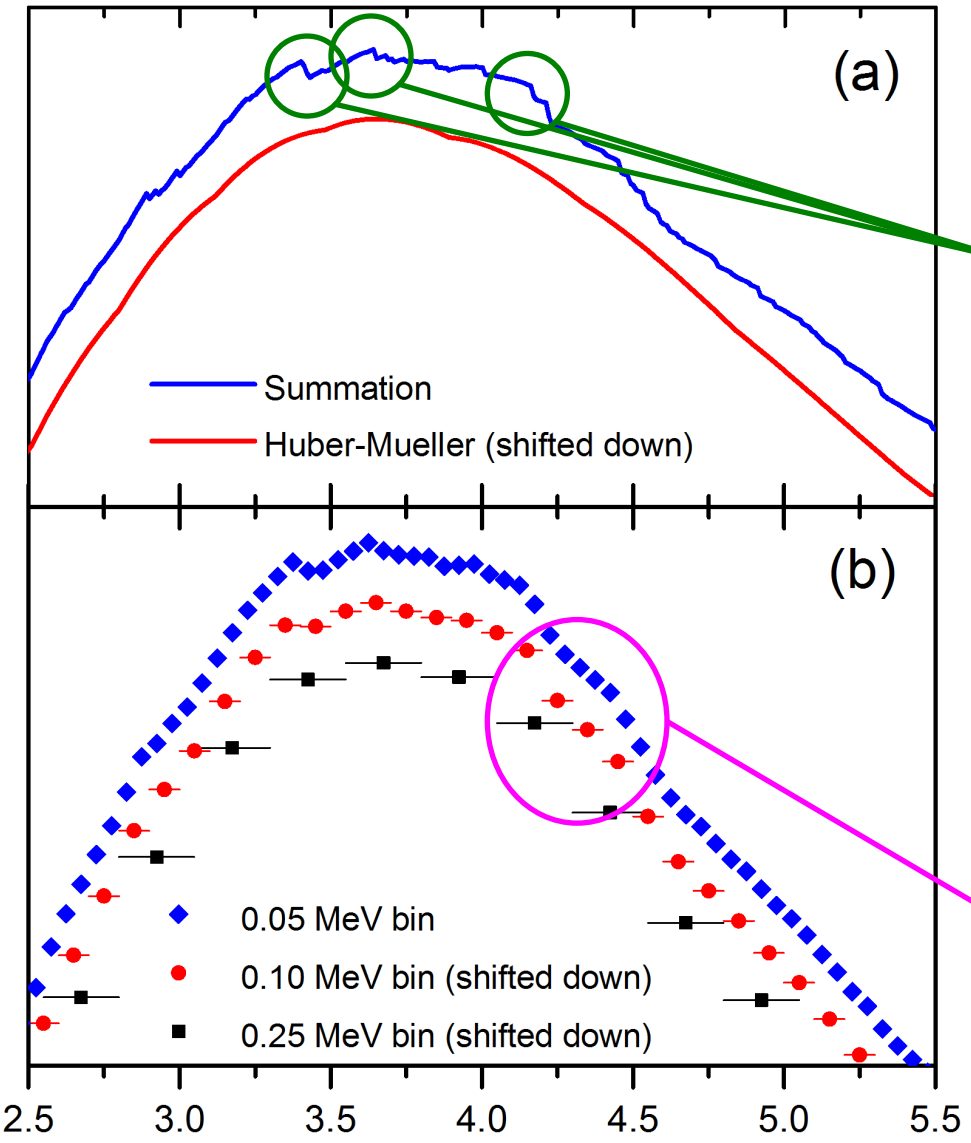
Fine Structure

NEOS data, 30 m from a power reactor



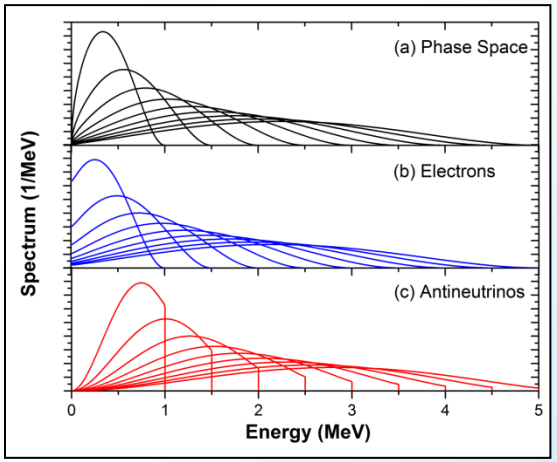
A. Ko et al, PRL **118**, 121802 (2017)

Fine Structure



As the reactor spectrum is the sum of ~800 individual spectra, can we seen individual effects?

Sharp cutoffs that can be seen with 0.1 MeV binning or less



Shoulder spanning several 100s keV

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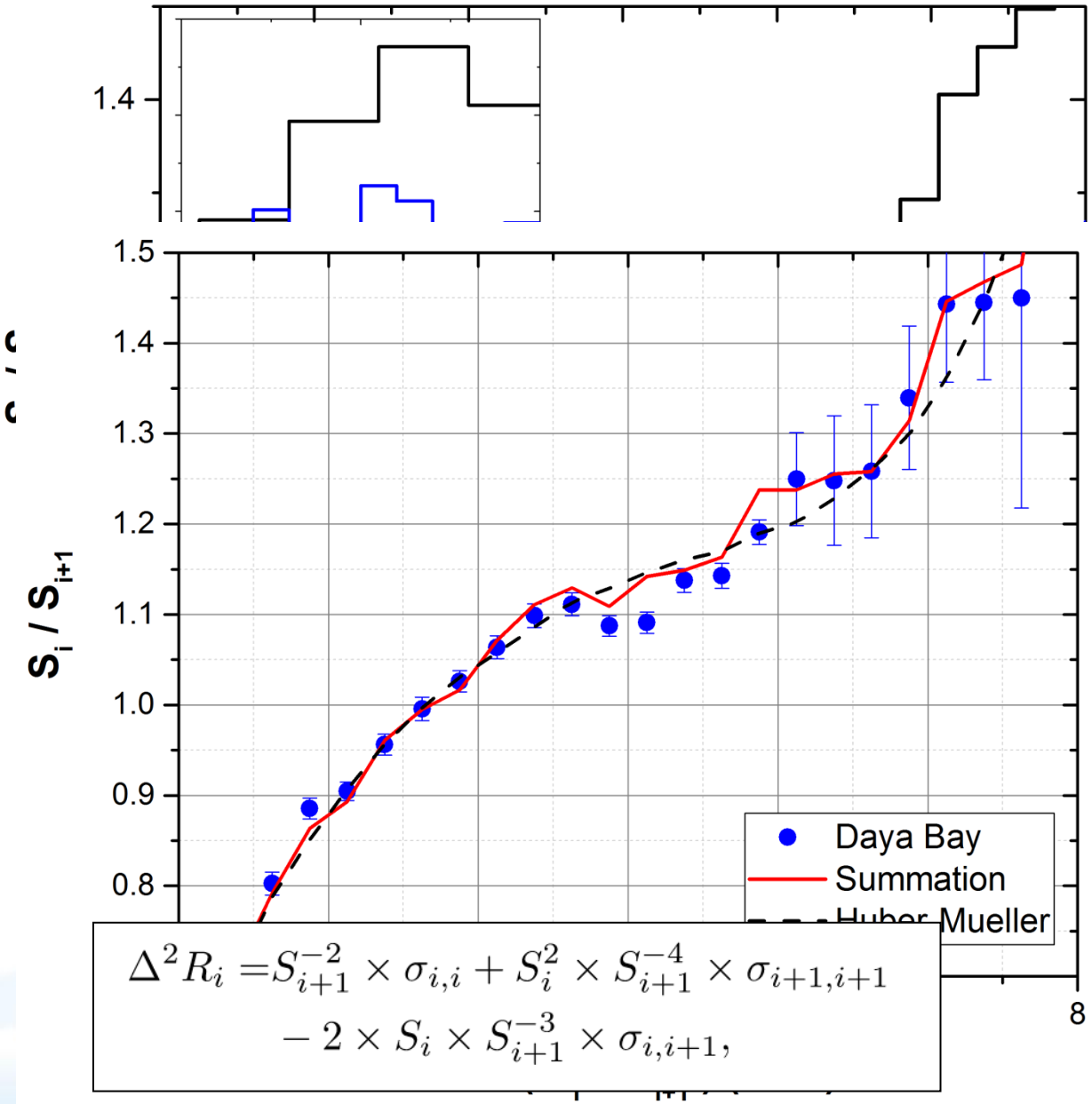
How to reveal Fine Structure?

Ratio of adjacent points:

$$R_i = S_i / S_{i+1}$$

Surprisingly, even with a 0.25 MeV binning a structure can be seen.

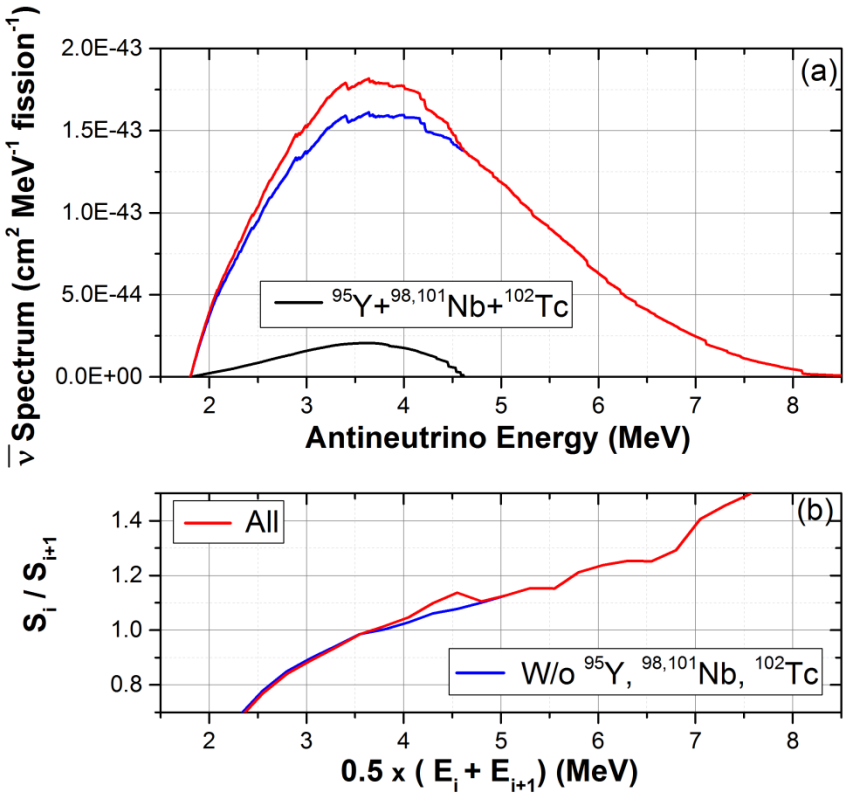
Structure observed in Daya Bay data, covariance matrix crucial for analysis.



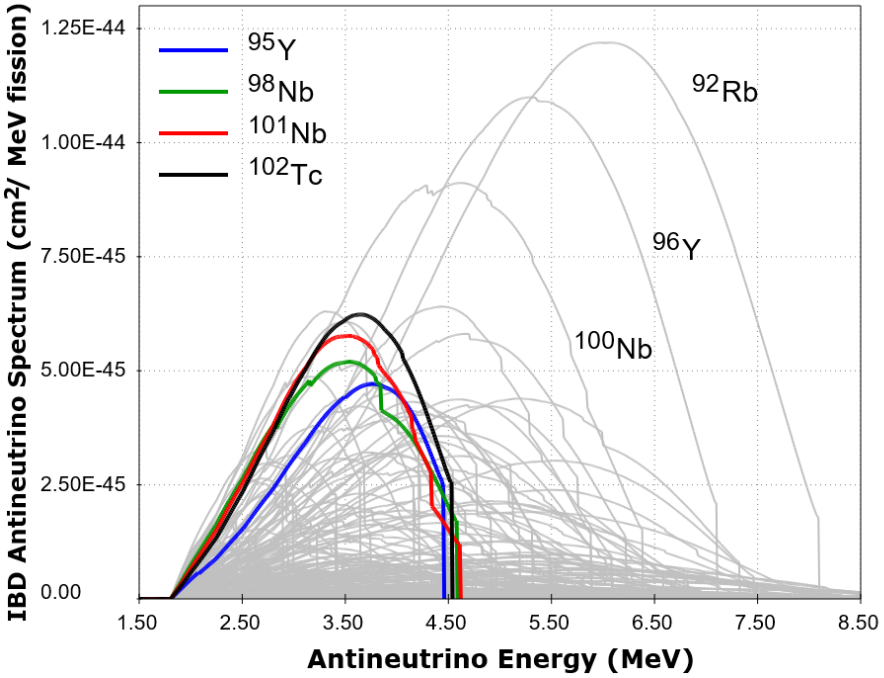
$$\Delta^2 R_i = S_{i+1}^{-2} \times \sigma_{i,i} + S_i^2 \times S_{i+1}^{-4} \times \sigma_{i+1,i+1} - 2 \times S_i \times S_{i+1}^{-3} \times \sigma_{i,i+1},$$

Nuclides behind fine structure

Looking for trees in the forest



This “Fine structure” can be attributed to just 4 nuclides



For more details, see:
A.A. Sonzogni, M. Nino, E.A. McCutchan arXiv:1710.00092

Eagerly awaiting PROSPECT data to perform similar analysis