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**ANOMALIES IN THE DECAY OF PARTICULAR NUCLEAR ISOTOPES**

**Juan Klein**  
**Comision Chilena De Enlgia Nuclea**

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**05/08/2014**  
**Final Report**

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**Air Force Research Laboratory**  
**AF Office Of Scientific Research (AFOSR)/ IOS**  
**Arlington, Virginia 22203**  
**Air Force Materiel Command**

# REPORT DOCUMENTATION PAGE

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<b>14. ABSTRACT</b>  It is extremely challenging to measure the half-life of long lived isotopes. A USAFA-Purdue-Stanford- CCHEN collaboration has documented experiments in which small, unexplained fluctuations were found in the half-lives of select radioisotopes. Since the fluctuation was small in each case (on the order of 0.5%), the effect usually had only a relatively minor impact on the determination of the half-life. A comparison of the periodic behavior of the data from several of the experiments indicated that the periods of the primary mode of oscillation are remarkably similar. While the systematic effects are certainly possible, the group notes the anomalies are similar in nature to some experimental Dark Matter searches that may indicate new physics. The group has gained access to daily calibration data for the IAEA's International Monitoring System. In a surprising turn of events, the group showed many of the IMS detectors are measuring small annual oscillations in many of the same isotopes as the aforementioned					
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# Precision Nuclear Decay Monitoring Experiment



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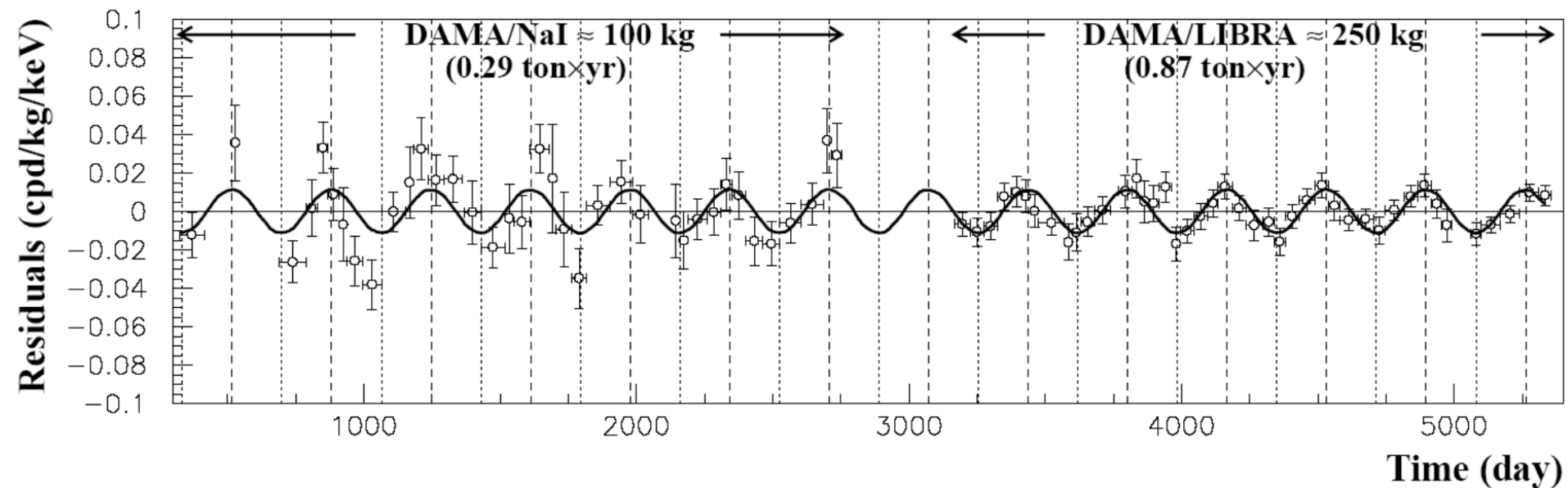
**AFOSR/SOARD Program Manager: Mr James Fillerup**

**FA9559-12-1-0027-DEF**

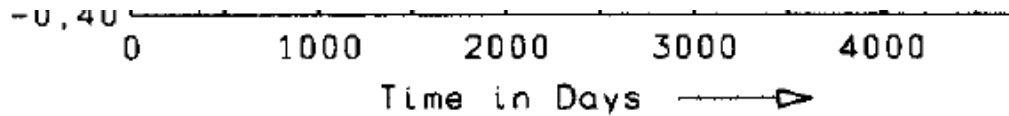


## THE HALF-LIFE OF <sup>137</sup>Cs - A CRITICAL REVIEW

2-6 keV



- Flynn et al. (a)
- Flynn et al. (b)
- Anspach et al.
- NBS
- Lagoutine et al.
- Ramthun
- Debertin
- Kochin et al.
- Schötzig et al.
- Martin et al.
- This work



- No
- No
- No
- No
- Yes
- Yes
- Yes

\* Where published values have been

of 365.25.

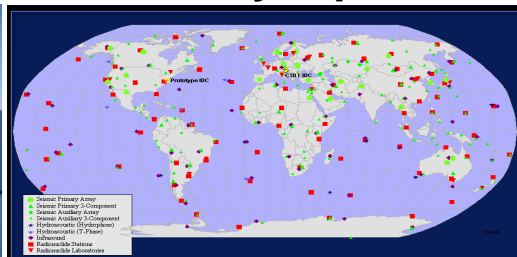
## Measured Half-lives for <sup>134</sup>Cs and <sup>109</sup>Cd



# CCHEN Decay Experiment: Unraveling Reports of Anomalous Decay



- **Periodic Variations Reported in 25 Long-term Nuclear Decay Experiments**
  - **Select  $\beta$  & E.C. Decay Affected**
  - **Wide variety of detectors types**
  - **Few experiments run for many years; independent confirmation difficult**
- **Periodic Variations found in IAEA's International Monitoring System (IMS) of precision radioisotope detectors**
  - **System monitors nuclear prolifer**
  - **Anomalies confirmed in calibration sources across network**
  - **Matches some anomaly reports**



Isotope	Effect Observed
$^3\text{H}$	Periodicity: $1 \text{ yr}^{-1}$
$^3\text{H}$	Periodicity: $1/d, 12.1 \text{ yr}^{-1}, 1 \text{ yr}^{-1}$
$^3\text{H}$	Periodicity: $\sim 12.5 \text{ yr}^{-1}$
$^3\text{H}$	Periodicity: $\sim 2 \text{ yr}^{-1}$
$^{22}\text{Na}/^{44}\text{Ti}^{[a]}$	Periodicity: $1 \text{ yr}^{-1}$
$^{36}\text{Cl}$	Periodicity: $1 \text{ yr}^{-1}, 11.7 \text{ yr}^{-1}, 2.1 \text{ yr}^{-1}$
$^{36}\text{Cl}$	Periodicity: $1 \text{ yr}^{-1}$
$^{54}\text{Mn}$	Periodicity: $1 \text{ yr}^{-1}$
$^{56}\text{Mn}$	Periodicity: $1 \text{ yr}^{-1}$
$^{60}\text{Co}$	Periodicity: $1 \text{ yr}^{-1}$
$^{60}\text{Co}$	Periodicity: $1/d, 12.1 \text{ yr}^{-1}$
$^{85}\text{Kr}$	Periodicity: $1 \text{ yr}^{-1}$
$^{90}\text{Sr}/^{90}\text{Y}$	Periodicity: $1 \text{ yr}^{-1}, 11.7 \text{ yr}^{-1}$
$^{108m}\text{Ag}$	Periodicity: $1 \text{ yr}^{-1}$
$^{133}\text{Ba}$	Periodicity: $1 \text{ yr}^{-1}$
$^{137}\text{Cs}$	Periodicity: $1 \text{ yr}^{-1}$
$^{152}\text{Eu}$	Periodicity: $1 \text{ yr}^{-1}$
$^{152}\text{Eu}$	Periodicity: $1 \text{ yr}^{-1}$
$^{154}\text{Eu}$	Periodicity: $1 \text{ yr}^{-1}$
$^{222}\text{Rn}^{[c]}$	Periodicity: $1 \text{ yr}^{-1}, 11.7 \text{ yr}^{-1}, 2.1 \text{ yr}^{-1}$
$^{226}\text{Ra}^{[c]}$	Periodicity: $1 \text{ yr}^{-1}, 11.7 \text{ yr}^{-1}, 2.1 \text{ yr}^{-1}$
$^{239}\text{Pu}$	Periodicity: $1/d, 13.5 \text{ yr}^{-1}, 1 \text{ yr}^{-1}$

**Prominent 1yr & 28da Periodicities**

*Studying this phenomena is of practical as well as scientific value...*





# CCHEN Decay Experiment: Present Status



**Mimic IMS Calibration  
Measurements but at Higher Data  
Rates & Longer Integration Times**

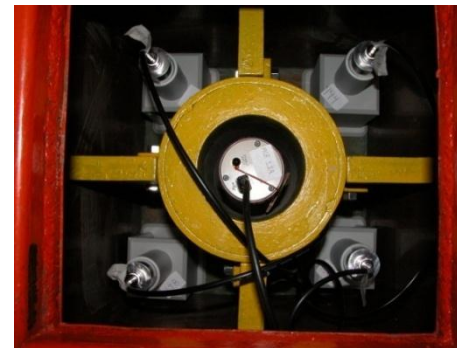
## Variety of Detectors & Sources

- $^{54}\text{Mn}$ ,  $^{36}\text{Cl}$ ,  $^{90}\text{Sr}$ ,  $^{32}\text{Si}$
- Empty Detectors as Control
- Monitor Environmental Variables (TPH)

## Coordinated w/ 4 Additional Sites

- CCHEN (Santiago, Chile)
- US Air Force Academy
- Purdue University
- Brigham Young University

**Now Completing Final Report**

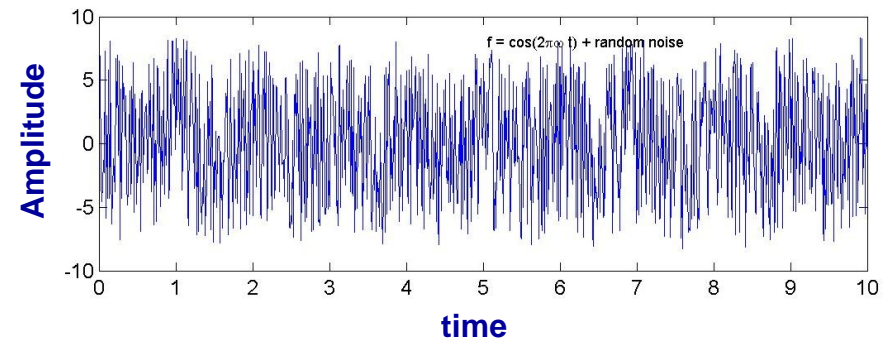
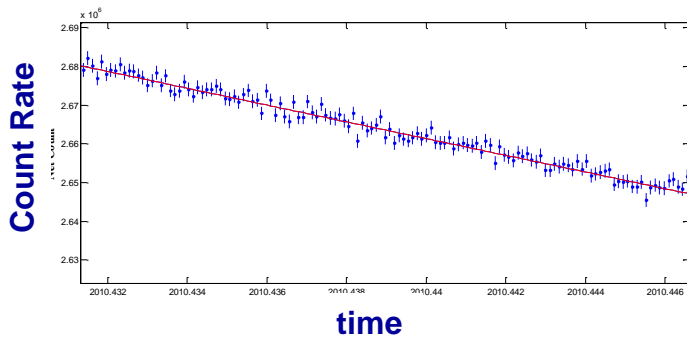


View of Test Chamber (top), Gieger Mueller and NaI Detectors (bottom right), and empty NaI detector in separate chamber,

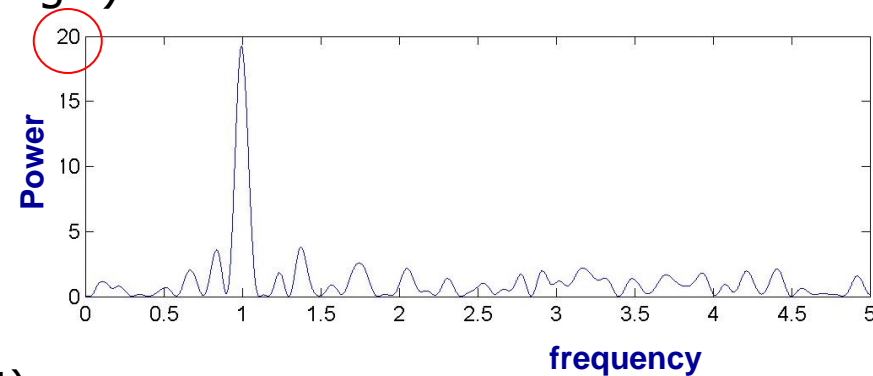
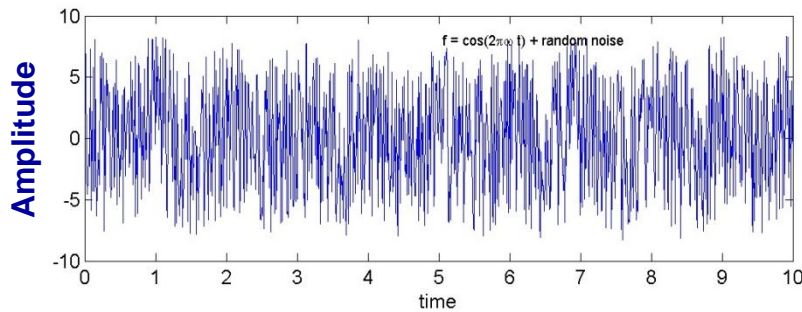
**Six Detector Array: 4 Isotopes + 2 Empty**

*First 12 Months of Data Show Oscillations in Several Detectors*

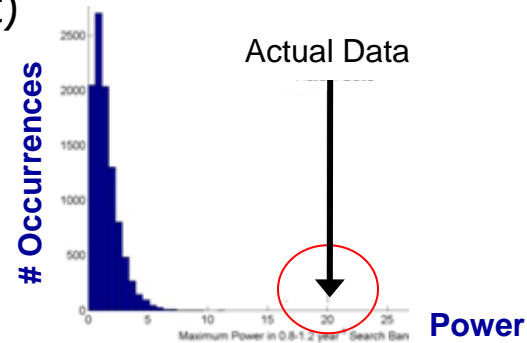
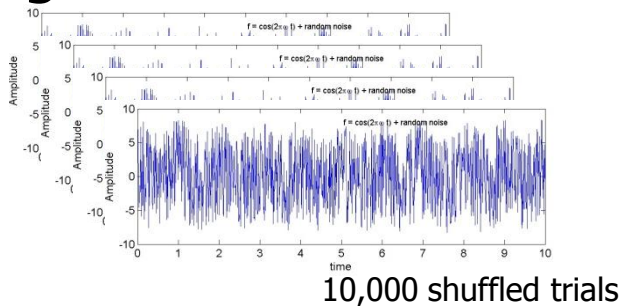
## 1) Determination of Residuals from Fit



## 2) Spectral Analysis (modified Lomb-Scargle)

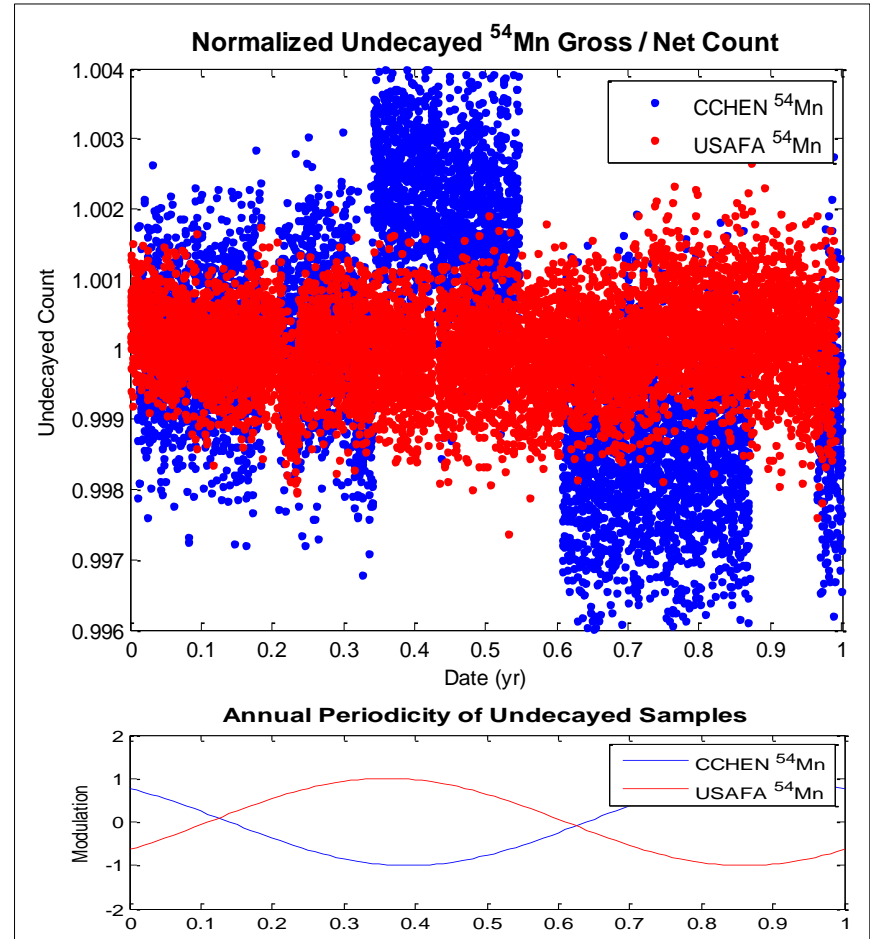
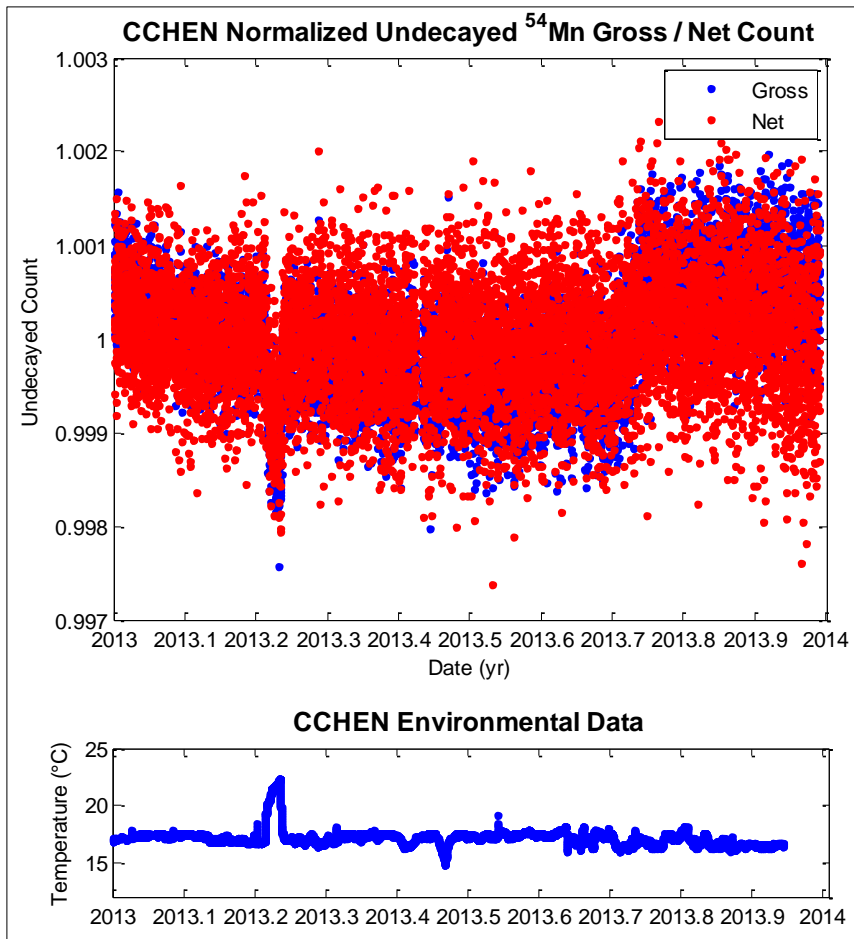


## 3) Significance Estimates (Shuffle Test)





# Recent Results



**Analysis is well underway with focus on cross-comparisons between locations and autocorrelation with environmental factors (phase is complicated!)**

*Preliminary Results Indicate Phase Shifts Between Locations ...*

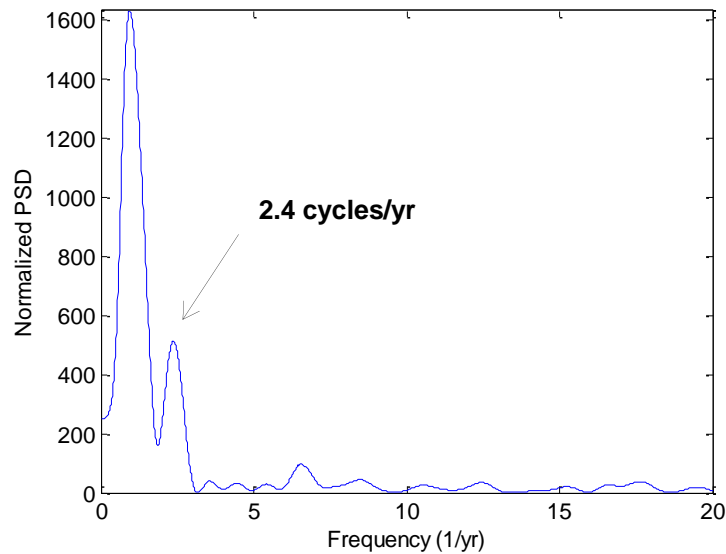




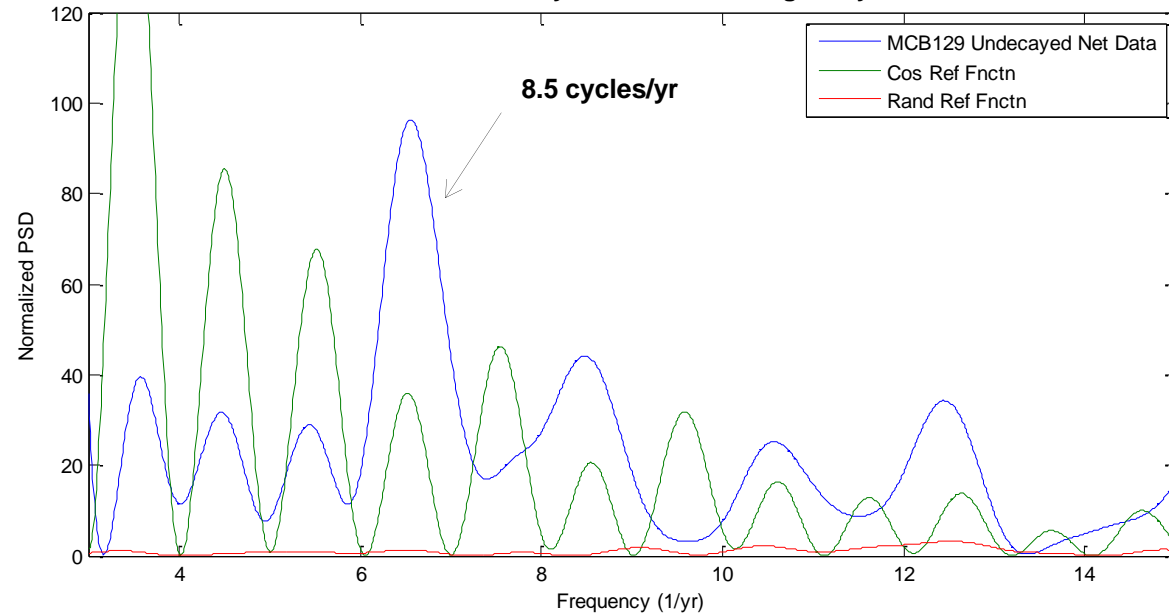
# Recent Results



MCB129 Undecayed Net



MCB129 Undecayed Net Anti-Aliasing Analysis



- **Oscillations have different phase than TPH measurements**
  - **Possibly a lag in NaI(d) response**
- **Empty detector shows null response**
- **No corresponding oscillations in GM Detectors**

*Preliminary Results Indicate Several Non-Random Secondary Peaks ...*



# Transition Approach



## Direct Beneficiaries

### Time-Series Analysis of Nuclear Decay Residuals Boosts Measurement Capabilities and Diagnostic Power

- **Comprehensive Test Ban Treaty Org. (CTBTO)**
- **AFTAC**
- **DTRA**
- **MDA**
- **Laboratori Nazionali del Gran Sasso**
- **Other Gov't Agencies**

## Papers / Presentations

### 10 Peer-Reviewed Papers (2012-14)

*Time-Varying Nuclear Decay Parameters and Dark Matter.* In Review. 2014.

*Power-Spectrum Analysis of Reconstructed DAMA Data.* In Review. 2014

*Concerning Time Dep. of Decay Rate...* Applied Rad & Isotopes. 2013.

*Stability of the IMS Radionuclide Detector Network.* CTBTO SnT Conference. 2013.

**+ 5 Recent Conference Presentations  
+ Invited Book Chapter**

*Adoption of Methodology and Approach Is Growing Rapidly!*