USNDP LBNL Isotopes Project Collaboration Report

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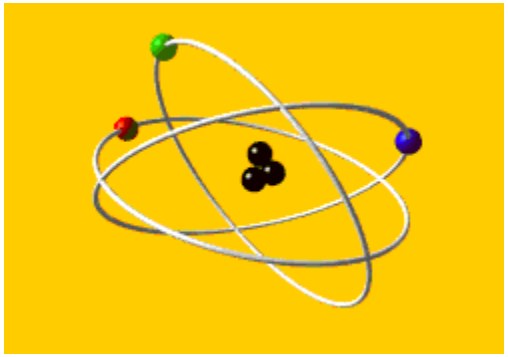


JÜLICH FORSCHUNGSZENTRUM

OCL Oslo Cyclotron Laboratory

FRM II Forschungs-Neutronenquelle Heinz Maier-Leibnitz

BERKELEY LAB

BNC Budapest Neutron Center

LLNL

NIF

THE UNIVERSITY OF CALIFORNIA 1868

Isotopes Project Group Members

Richard B. Firestone – Group Leader (USNDP, ANS&T)
Coral Baglin – Staff scientist (USNDP)
Shamsu Basunia – Staff scientist (ARRA)
Aaron Hurst – Staff scientist (ANS&T, USNDP)
Edgardo Browne – Emeritus staff scientist (NNDC)
Andrew Rogers – Postdoc (ANS&T, USNDP)

Funding sources:

USNDP – 1.9 FTE
ANS&T – 2 FTE
ARRA – 1 FTE
NNDC – 0.5 FTE

Isotope Project Collaborators

LLNL/LBNL ENDF γ-ray Library – B. Sleaford, N. Summers, J. Escher

LLNL National Ignition Facility – L. Bernstein

UC Berkeley Nuclear Engineering – K. van Bibber, K.-N. Leung

Budapest Reactor – T. Belgya, L. Szentmiklosi

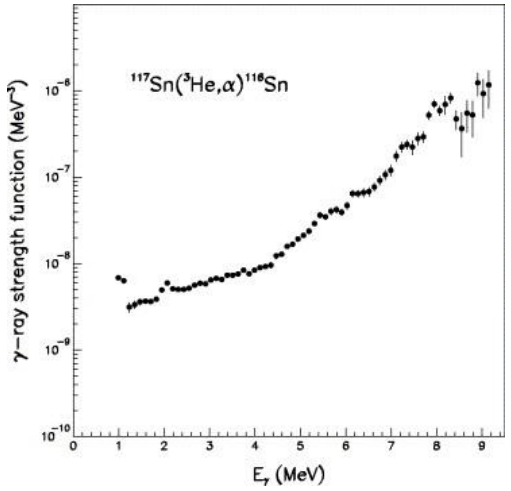
Garching FRM-II Reactor – Zs. Revay, P. Kudejova

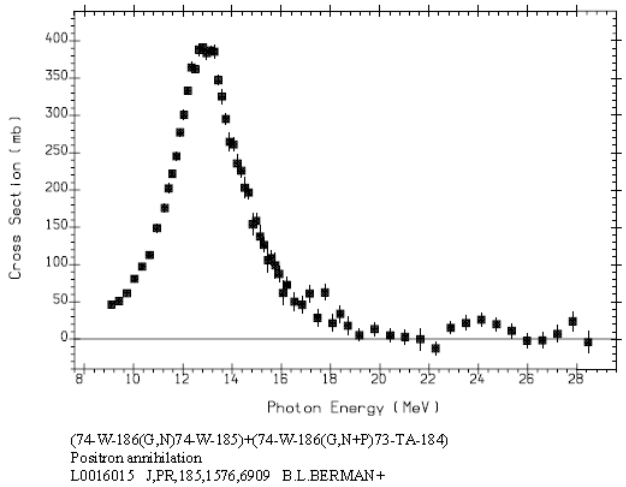
Charles University, Prague – M. Krticka, F. Becvar

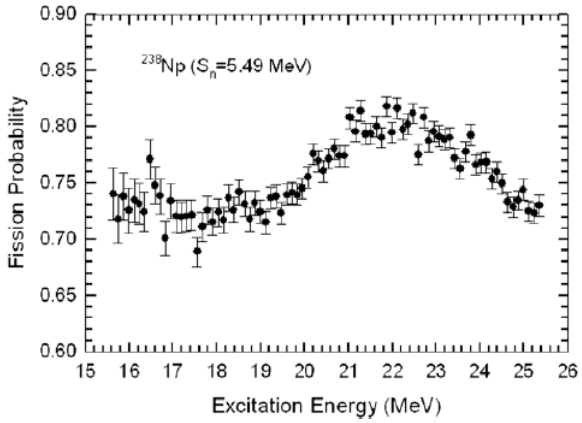
Evaluation of Particle/γ-ray Continuum Data – S. Siem, M. Guttormsen (Oslo Cyclotron)

TransActinide Nuclear Data Evaluation and Measurement (TANDEM) – M. Rossbach, C. Genreith (Jülich Forschungszentrum)

Evaluation of Particle/γ-ray Continuum Data







Oslo Cyclotron (CACTUS) **IAEA Photonuclear Data** **Texas A&M STARS/LiBeRACE Surrogate reactions**

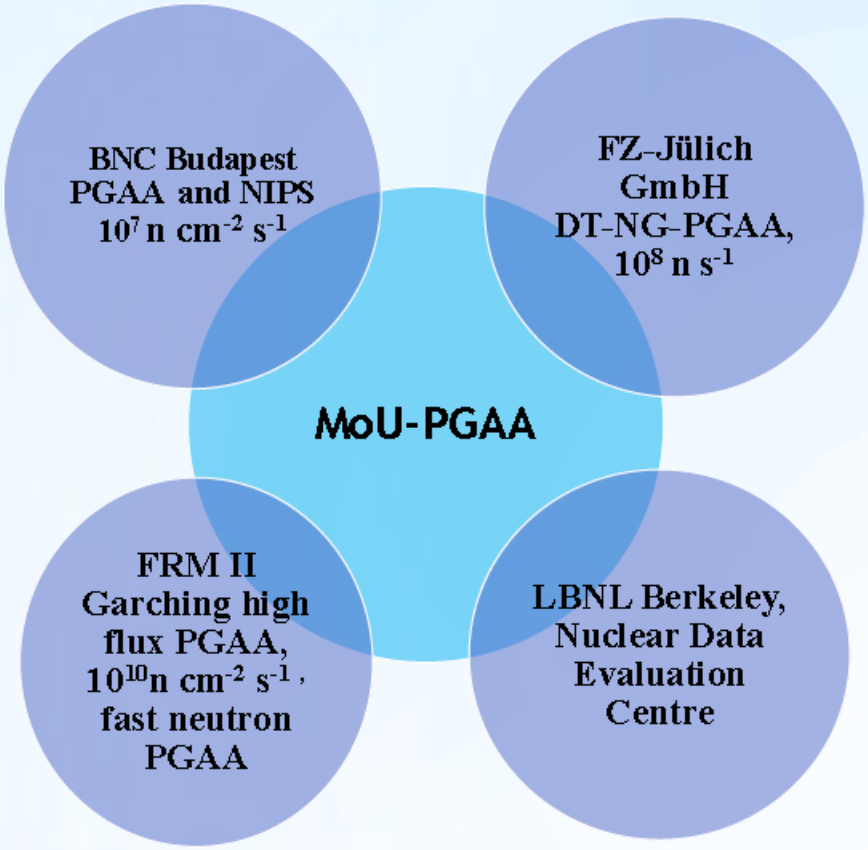
Continuum particle/γ-ray data are not in ENSDF

- **Statistical properties** of the nucleus at high level densities
- **Surrogate reaction** measurements of nuclear cross sections
- **Nuclear transport** calculations – RIPL
- **Nuclear astrophysics** calculations – nucleosynthesis

Proposed IAEA Consultants Meeting → IAEA CRP → Oslo led evaluation effort

Opportunity to bring new European collaborators to IAEA/NSDD!

TransActinide Nuclear Data Evaluation and Measurement (TANDEM)



Introduction:

A Memorandum of Understanding for close collaboration in the field of prompt gamma neutron activation analysis (PGAA) has been signed by several institutions for development of PGAA and their application in various fields. Generation and validation of nuclear data for actinides to update neutron capture cross sections, energies, and intensities for prompt and delayed gamma rays is priority. Improved nuclear data of actinides support calculation and experiments in reactor physics, transmutation, homeland security, safeguards and characterization of decommissioning and nuclear waste.

LLNL will join TANDEM

Initiative to bring Germany back into the IAEA/NSDD!

Isotopes Project Data Evaluations

Mass chain evaluation

- A=143, *Nuclear Data Sheets* **113**, 715-908 (2012)*
- A=29, *Nuclear Data Sheets* **113**, 909-972 (2012)
- A=192, *Nuclear Data Sheets* **113**, 1871-2111 (2012)
- A=230, *Nuclear Data Sheets* **113**, 2113-2185 (2012)*
- A=92, *Nuclear Data Sheets* **113**, 2187-2389 (2012)

*Evaluation supported by the NNDC

Capture γ-ray evaluation (EGAF)

- ^{39,40,41}K: completed, submitted to PRC.
- ^{182,183,184,186}W: completed, paper in final draft
- ^{151,153}Eu: completed pending check of cross section standardization.
- Z=1-17, ^{54,56,57,58}Fe, ^{61,63}Cu, ^{89}Y, ^{180}W, ^{237}Np, ^{235,238}U, ^{241}Pu in progress.

Isotopes Project Research

Thermal neutron beam measurements

- ^{70,72,73,74,76}Ge, ^{90,91,92,94,96}Zr(n,γ) approved at FRM-II
- Highly depleted ^{238}U(n,γ) planned at Budapest
- ^{239,240}Pu, ^{241,243}Am targets in preparation

UC Berkeley Nuclear Engineering Neutron Generator Laboratory

- Construction of 5×10^{11} n/s D+D generator completed
- Installation of neutron generator in progress
- Planned measurement of 2.5 MeV activation cross sections

Low-energy statistical photon strengths

- Determination of (n,γ) primary γ-ray photon strengths
- Increased low-energy photon strength

LBNL 88” Cyclotron High-Energy Neutron Beam

- Initial test run completed October, 2012 (with LLNL/NIF)

^{39,40,41}K(n,γ)

^{39}K(n,γ)

Author (Year)	$\sigma_0 \pm \Delta\sigma$ (mb)
Hansen (1949)	3.0±1.5
Pomerance (1952)	1.9±0.2
Gillette (1966)	1.4
Atlas	**2.1±0.2**
EGAF	**2.28±0.04**

^{40}K(n,γ)

Author (Year)	$\sigma_0 \pm \Delta\sigma$ (mb)
Pomerance (1952)	66±30
Gillette (1966)	≈70
Beckstrand (1971)	30±8
Atlas	**30±8**
EGAF	**90±7**

^{41}K(n,γ)

Author (Year)	$\sigma_0 \pm \Delta\sigma$ (mb)	σ_γ(1525)
Seren (1947)	1.0±0.2	
Pomerance (1952)	1.19±0.10	
Koehler (1967)	1.2±0.1	
Gryntakis (1976)	1.28±0.06	
De Corte (2003)	1.42±0.02	0.263(2)
Gleason (1975)	1.43±0.03	0.257(5)
Heft (1978)	1.43±0.03	0.252(5)
Lyon (1960)	1.45	
Ryves (1970)	1.46±0.03	
Kappe (1966)	1.49±0.03	0.266(8)
Kaminishi (1982)*	1.57±0.17	
Atlas	**1.46±0.03**	
EGAF	**1.62±0.03**	**0.269(5)**

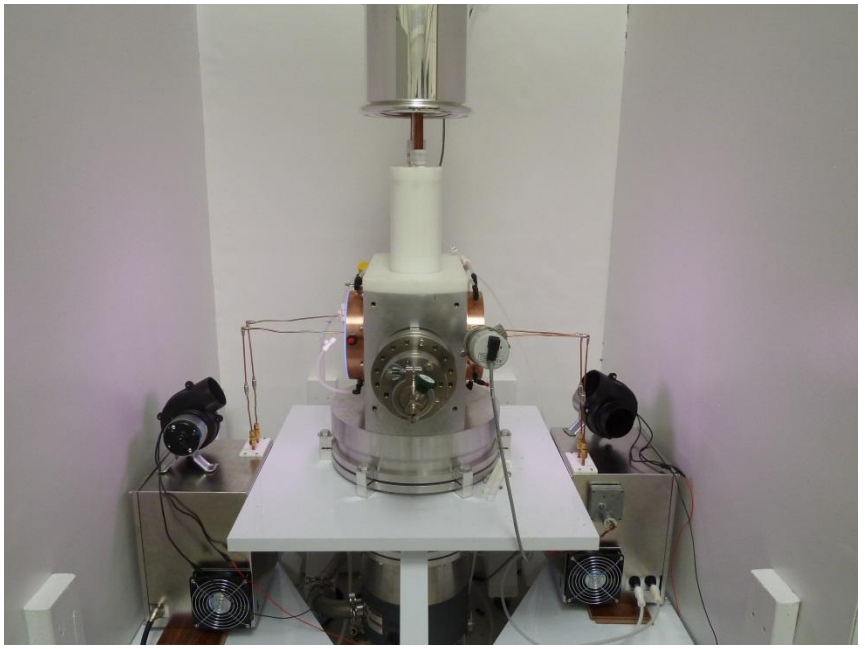
$P_\gamma = \sigma_\gamma/\sigma_0$ "precise ^{42}K β^- decay scheme normalization was found to be incorrect.

Submitted to Phys. Rev. C

Author (Year)	P_γ (1525)
Miyahara (1990)*	0.1808(9)
Simoes (2001)*	0.1813(14)
Kaminishi (1982)#	0.171(12)
EGAF	**0.166(4)**

UC Berkeley Neutron Generator Laboratory

5×10^{11} n/s D+D neutron generator is being installed at Etcheverry Hall on the UC Berkeley campus.

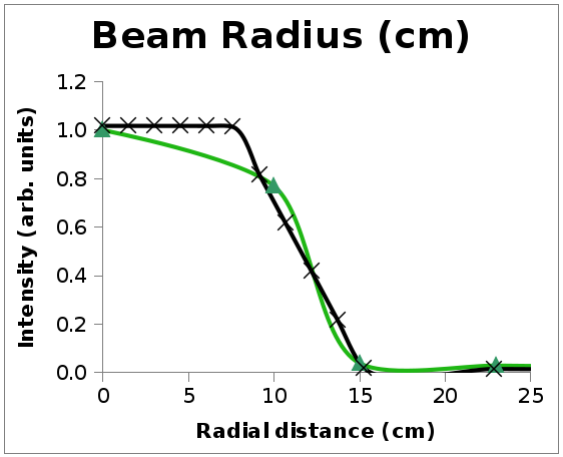


- 10^{10} n/cm^{2}s at the target area
- Built by NSF for Ar-Ar dating
- Available for $\leq$2.5 MeV cross section measurement

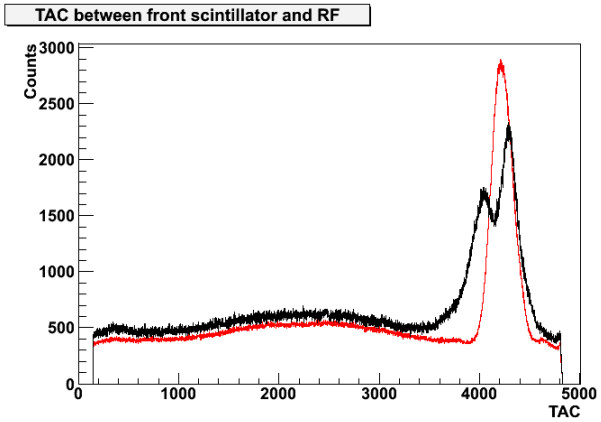
Neutron Beams at the 88” Cyclotron

The facility can supply a tunable, monoenergetic neutron beams in the range of 8-33 MeV, up to >10^8 n/cm^{2}s, by deuteron break up. 5-10 m flight path. Flux is 100× WNR 60R flux at these energies.

First experiment 10/7/2012 (LLNL/LBNL)

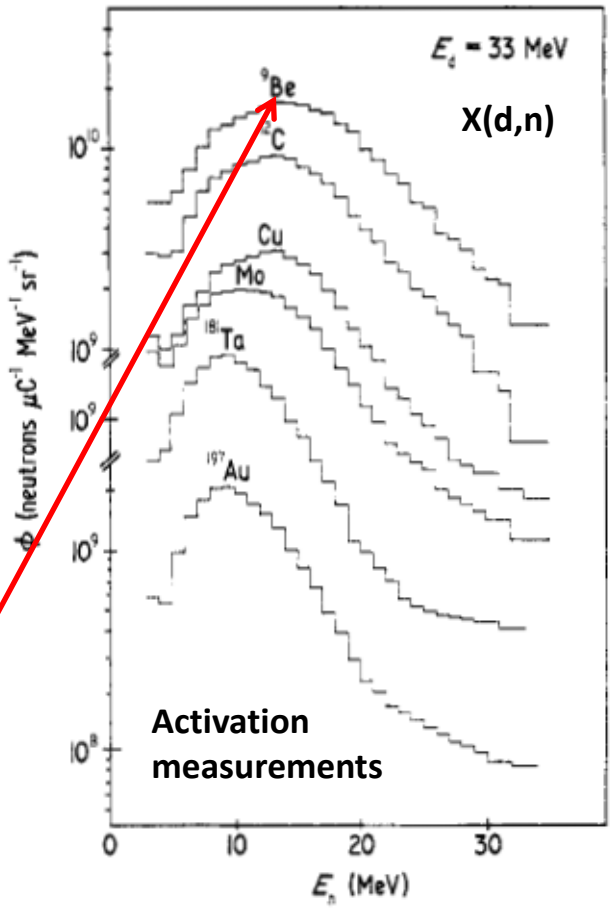


Beam profile from different scintillator positions. R=12 cm for 7 m flight path.

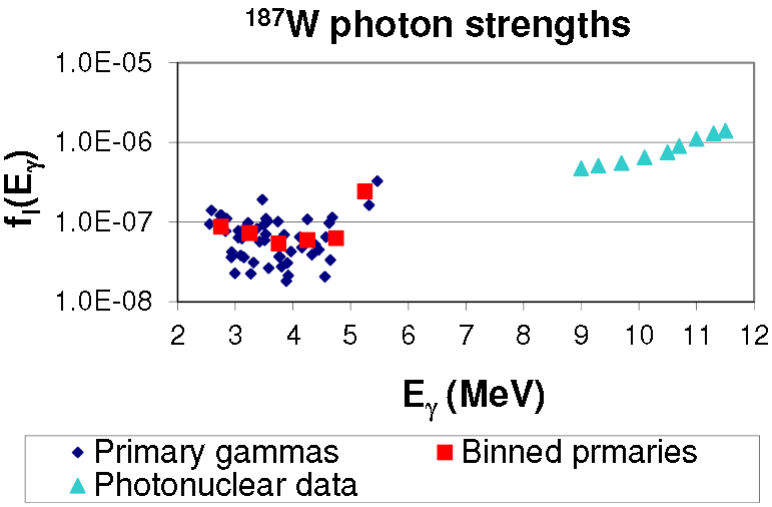


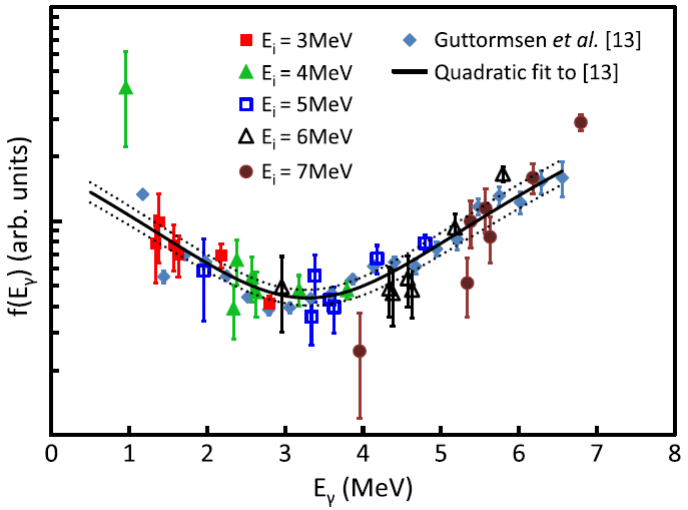
Retuning cyclotron eliminated double peak giving 1 ns fwhm timing.

6×10^8 n/s·cm^2, Be target 10 μA.



Statistical Photon Strengths





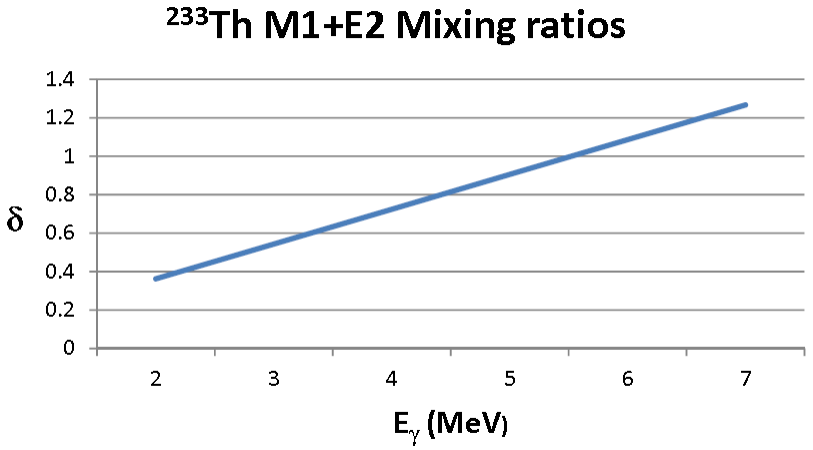
First determination of primary γ-ray E1 photon strengths from EGAF and resonance data.

$$f_\gamma = \frac{\sigma_\gamma \Gamma_\gamma}{\sigma_0 d_0 E^{2l+1}}$$

Mysterious upbend in the ^{95}Mo(d,p) photon strength measured at STARS/LiBeRACE

First determination of the contribution of M1+E2 mixing ratios to photon strengths.

$$\delta^2 = \frac{f_{E2}}{f_{M1}} E_\gamma^2$$



Isotope Project Future Plans

Mass chain evaluation

Primary responsibility for A=21-30

Capture γ-ray evaluation

Evaluate (n,γ) for 5-10 elements per year

- (n,γ) Adopted Levels, Gamma → EGAF, RIPL,(ENSDF)
- E_γ, σ_γ, σ_0 → EGAF, ENDF
- Activation data → EGAF, DDEP,(ENSDF)
- S_n → EGAF, Atomic mass evaluation

Capture γ-ray measurements

Thermal: All isotopes Z=1-60, 62-83, selected actinides

2.5-33 MeV: Prompt, delayed cross sections, all elements

Statistical studies

DICEBOX calculations

Primary γ-ray photon strength functions

Surrogate reactions

Isotopes Project Issues

- **Impending retirement of 2 FTE (RBF, CMB) by FY2014**

  Search for new staff is ongoing but slowed by LBNL NSD budget concerns. *Continuation at LBNL is in doubt.*

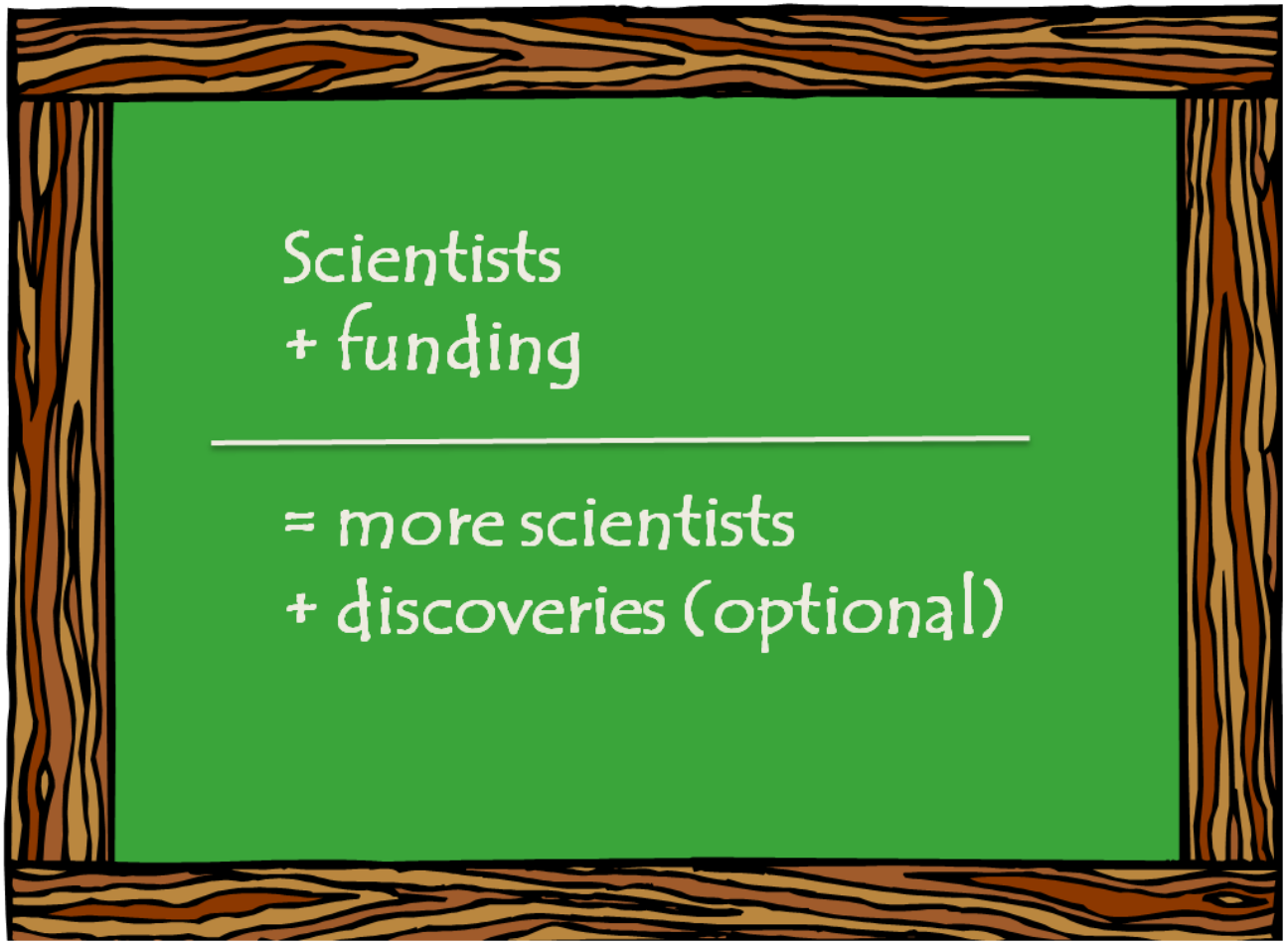
- **Possible move of Isotopes Project to UCB Campus**

  + Lower overhead would allow support of additional FTE
  + Better access to student participation (XUNDL)
  + Neutron Generator Laboratory
  – Impact to LBNL low energy program
  – Leadership on Berkeley campus

- **Left coast collaboration: LBNL/LLNL/UCB**

  Merge LBNL(Data/Low Energy), LLNL(NIF/Data), UCB(NE) groups into a joint “West Coast” collaboration.

  Exists in pieces but needs funding agency(s) blessing


Scientists
+ funding
= more scientists
+ discoveries (optional)