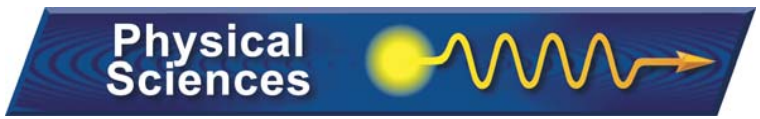
Overview of LLNL experimental program



Ching-Yen Wu

Lawrence Livermore National Laboratory

Nov 5, 2008

S&T Principal Directorate – Physical Sciences / N Division
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CSEWG 2008 at BNL

Outline

1. Tailored to the need of Stockpile Stewardship Program, relevant to GNEP
2. Highlights of FY08
3. Current and planned activities
4. New capabilities under development
   - Time Projection Chamber
   - ALEXIS
5. Summary

^{241}Am(n,2n) cross section

PHYSICAL REVIEW C 77, 054610 (2008)

Measurement of the ^{241}Am(n, $2n$) reaction cross section from 7.6 MeV to 14.5 MeV

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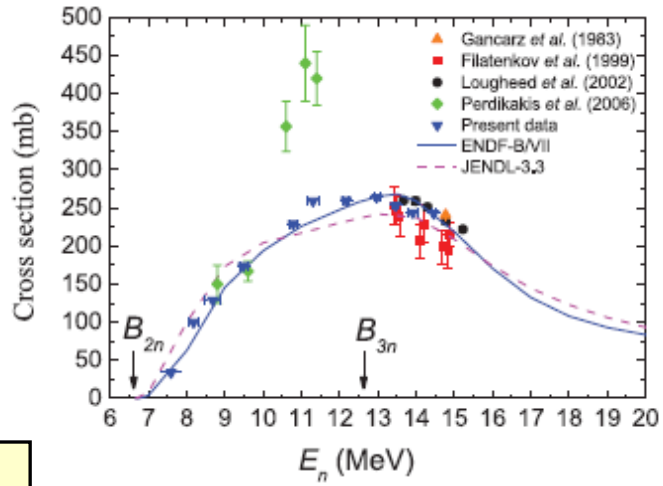

For monitoring the high-energy neutron-flux

^{241}Am(n,γ) cross section

PHYSICAL REVIEW C **78**, 034609 (2008)

Neutron capture cross section of ^{241}Am

M. Jandel,[1,*] T. A. Bredeweg,[1] E. M. Bond,[1] M. B. Chadwick,[1] R. R. Clement,[1] A. Couture,[1] J. M. O'Donnell,[1] R. C. Haight,[1] T. Kawano,[1] R. Reifarth,[1,†] R. S. Rundberg,[1] J. L. Ullmann,[1] D. J. Vieira,[1] J. B. Wilhelmy,[1] J. M. Wouters,[1] U. Agvaanluvsan,[2] W. E. Parker,[2] C. Y. Wu,[2] and J. A. Becker[2]

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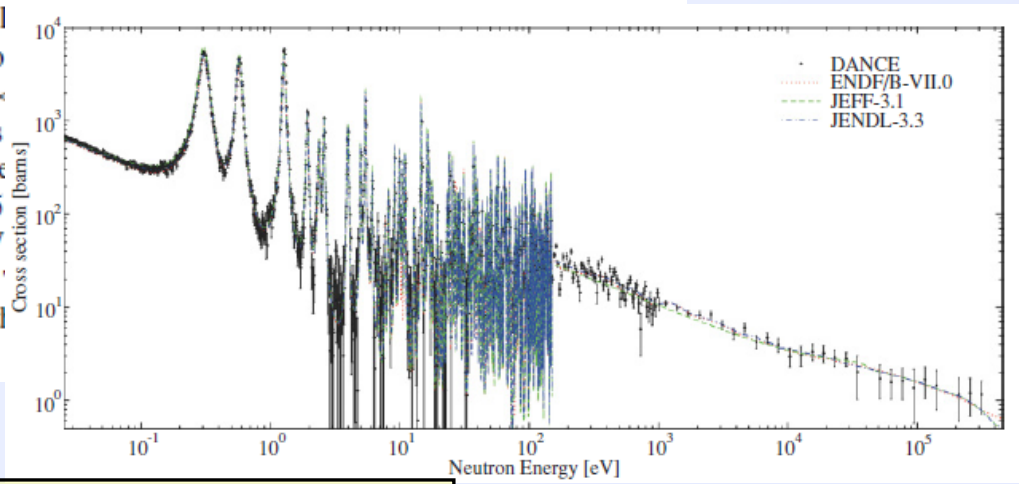
(Received 27 May 2008; published 24 September 2008)

The neutron capture cross section of ^{241}Am for incident neutrons from 0.02 eV to 320 keV has been measured with the detector for advanced neutron capture experiments (l
The thermal neutron capture cross section was determined to
other recent measurements. Resonance parameters for E_n <
measured cross section. The results are compared with values
and JEFF-3.1 evaluations. Γ_n neutron widths for the first three
the ENDF/B-VII.0 values. The resonance integral above 0.5
in the resolved and unresolved energy regions above 12 eV
incorporating the width-fluctuation correction of Moldauer.
data, and the extracted averaged resonance parameters in tl
those for the resolved resonances.



For monitoring the low-energy neutron-flux

Benchmark of the surrogate ratio method for (n,f) reaction

The Surrogate Ratio Method in the Actinide Region Using the $(\alpha, \alpha' f)$ Reaction

S.R. Lesher,[1,2,*] J.T. Burke,[1] L.A. Bernstein,[1] H. Ai,[3] C.W. Beausang,[2] D.L. Bleuel,[1,4] R.M. Clark,[4] F.S. Dietrich,[1] J.E. Escher,[1] P. Fallon,[4] J. Gibelin,[4] B.L. Goldblum,[1,5] I.Y. Lee,[4] A.O. Macchiavelli,[4] M.A. McMahan,[4] K.J. Moody,[1] E.B. Norman,[1,5] L. Phair,[4] E. Rodriguez-Vieitez,[4] N.D. Scielzo,[1] and M. Wiedeking[1,4]

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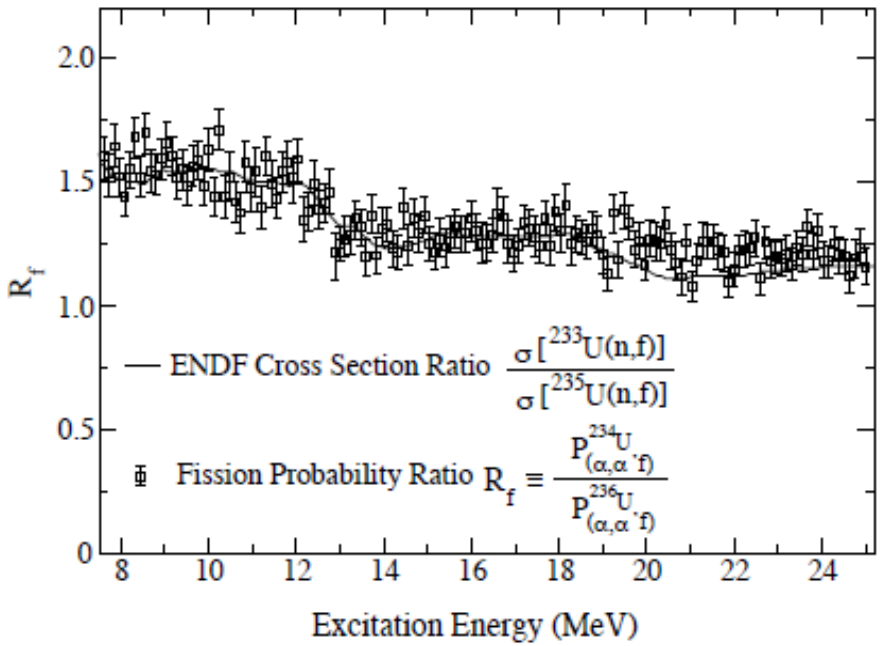
(Dated: August 28, 2008)



- **Submitted to PRC**
- **Good agreement achieved with the direct measurements**

Benchmark of the surrogate ratio method for (n,γ) reaction

Benchmarking the Internal Surrogate Ratio Method: 21 MeV ^{235}U(d,p) by p-γ and p-f

J.M. Allmond,[1,*] C.W. Beausang,[1] L.A. Bernstein,[2] L. Phair,[3] D.L. Bleuel,[2] J.T. Burke,[2] S.R. Lesher,[2] N.D. Scielzo,[2] M. Wiedeking,[2] B.F. Lyles,[4] R. Hatarik,[5] H.B. Jeppesen,[3] and M.A. McMahan[3]

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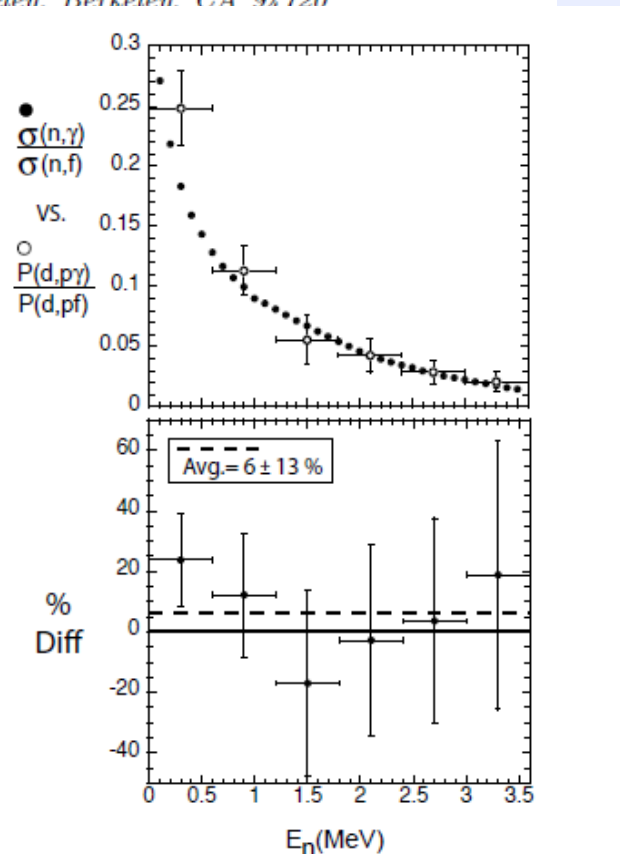
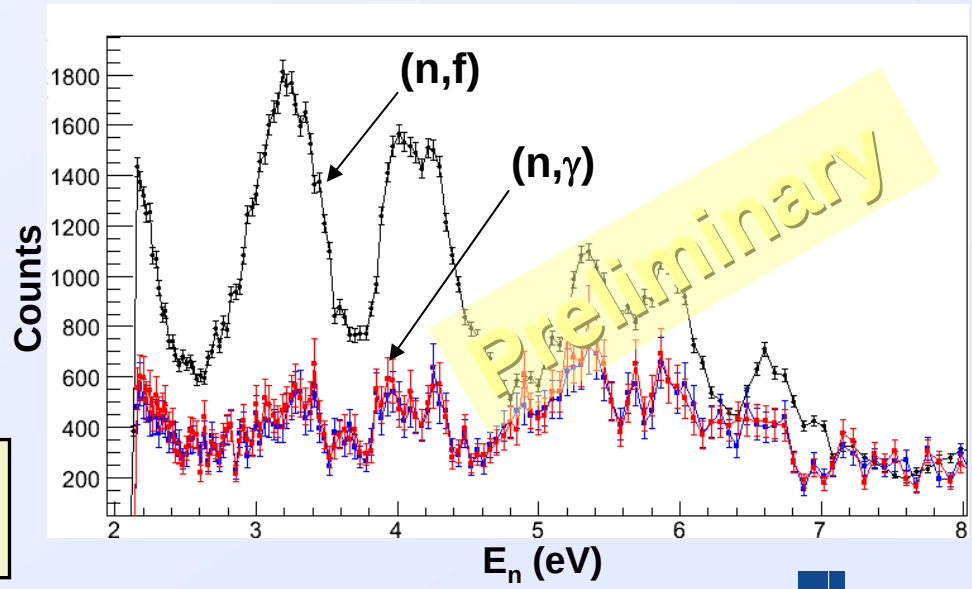
(Dated: October 17, 2008)



- **Ready for submission**
- **Reasonable agreement achieved with the direct measurements**

^{242m}Am(n,f)(n,γ) cross sections

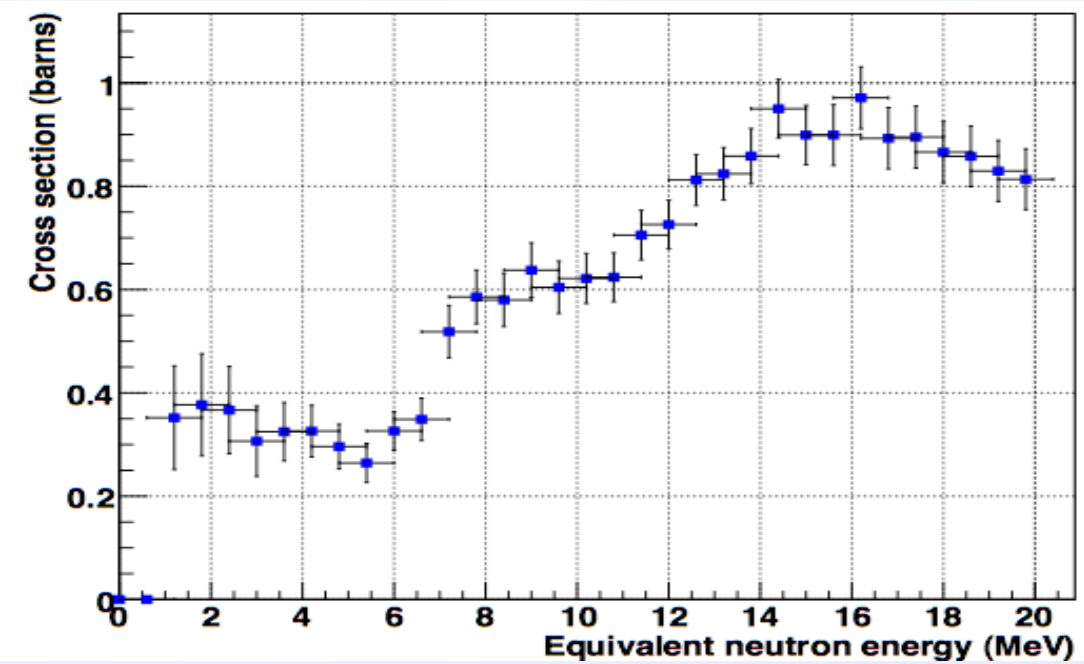
1. Two measurements were fielded at LANL using the DANCE array in FY07 and FY08 with ~98% enriched ^{242m}Am sample
2. Targets were fabricated at LLNL using both 0.5 mil Be and 2 μm Ti foils
3. (n,f) cross section for E_n up to ~100 keV was determined in the first measurement (~47 μg total mass on Be foil)
4. (n,γ) cross section for E_n between 2 and 9 eV was measurement in the second measurement (~154 μg total mass on Ti foil). (M. Jandel of LANL)



(n,γ) cross section a factor of 2 to 10 larger than NDF evaluation

Current activities for the surrogate work

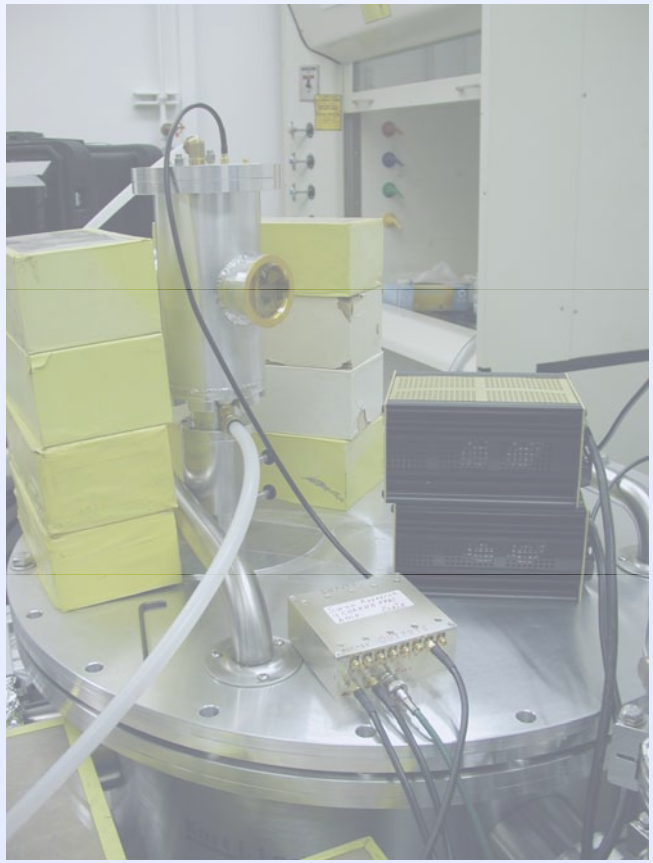
1. ^{239}U(n,f) cross section using ^{238}U(^{18}O,^{16}O)^{240}U*



2. ^{239}U(n,2n) cross section using ^{238}U(^{18}O,^{16}O)^{240}U*
3. ^{153,155,157}Gd(n,γ) cross section using ^{154,156,158}Gd(p,p′)
   - *s*-process nucleosynthesis

^{239}Pu(n,2n) cross section

1. Deduced from the reaction modeling of measured (n,2nγ) cross section
2. Cross section for E_n from threshold to <20 MeV deduced from the $6^+ \rightarrow 4^+$ transition of ^{238}Pu in an earlier work (PRC 65, 02160(R), 2002)
3. Deduce the cross section from the $4^+ \rightarrow 2^+$ transition to minimize the uncertainty introduced by modeling
4. Enhance the sensitivity by excluding the γ rays of fission fragments using a fission counter
5. Experiments scheduled at TUNL in FY08 and FY09



Improve the accuracy of ^{239}Pu(n,2n) cross section by a factor of two for E_n near the threshold

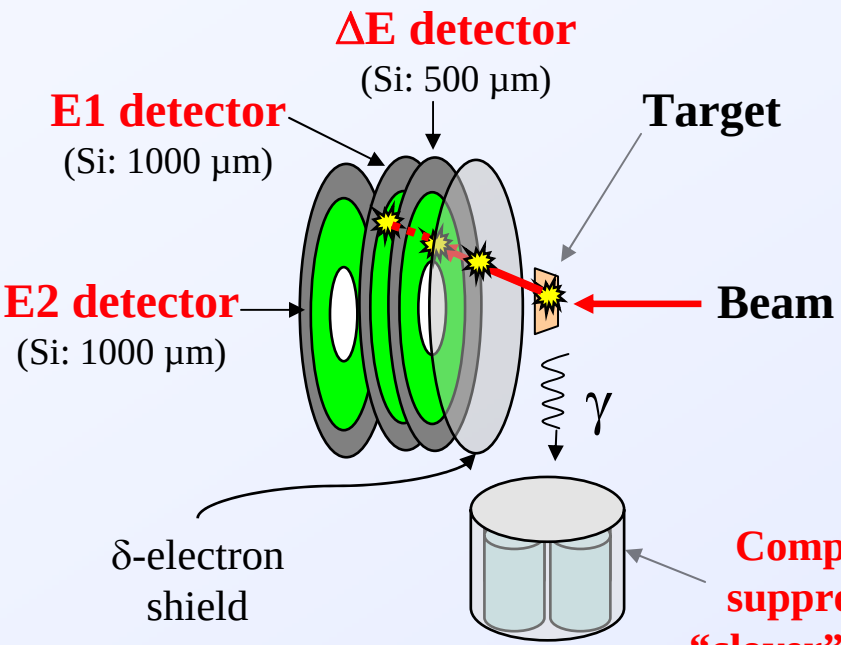
Fission initiative

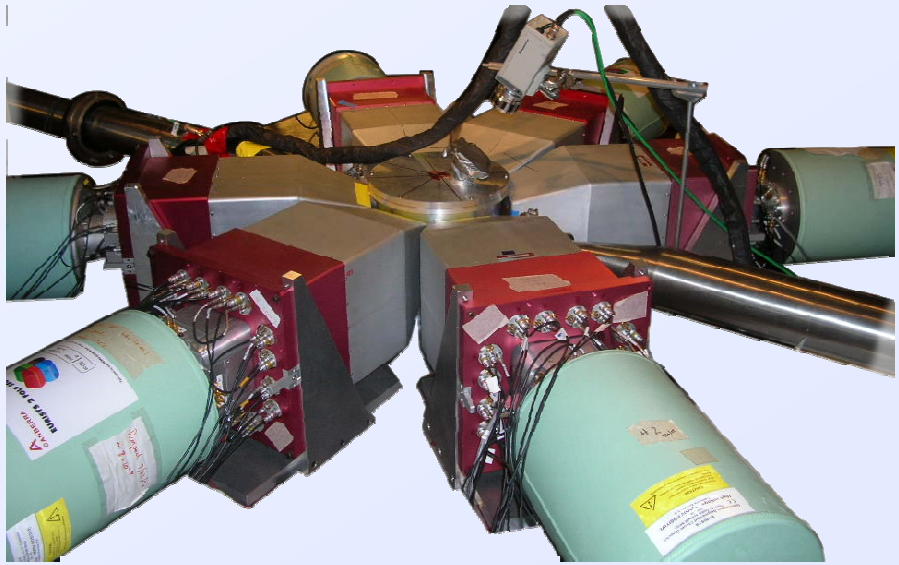
1. Improve the fission cross section to 1% accuracy
   - Develop the Time Projection Chamber
2. Improve the fission-neutron spectrum for E_n below 1 MeV and above 8 MeV
   - Neutron detectors
     - A large detector array with a solid-angle coverage ~10%
     - ^{6}Li doped plastic scintillator or alternatives for the detection of neutrons with energy between 0.1 and 1 MeV
   - A new fission trigger detector with a sub-nanosecond time resolution

FIGARO array for the fission-neutron spectrum measurement (R. Haight of LANL)

Planned activities for the surrogate work

1. **Precision study of (d,p) reaction on ^{239}Pu**
   - **Provide the data needed for modeling the fission cross section on the first excited state in ^{239}Pu**
2. **Review article on the surrogate work**



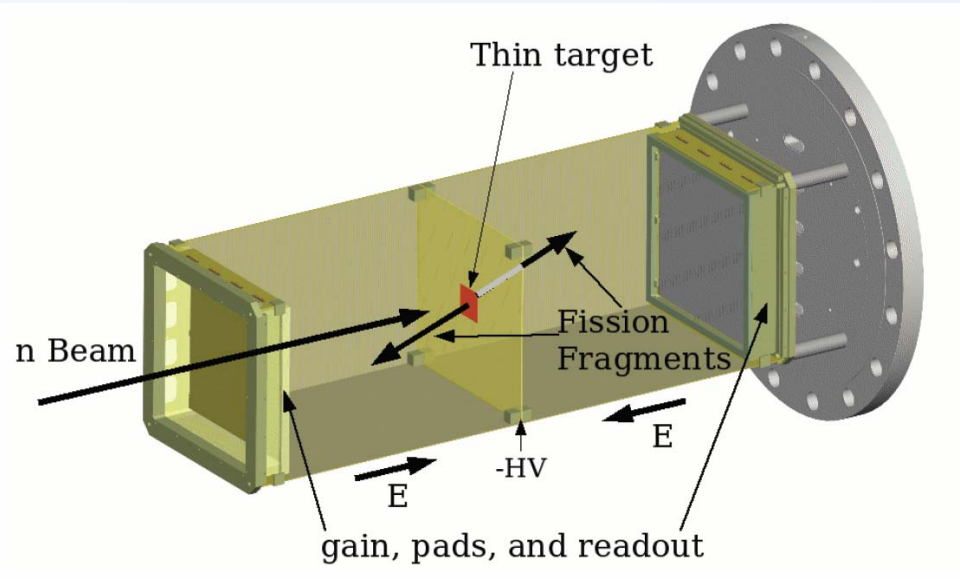


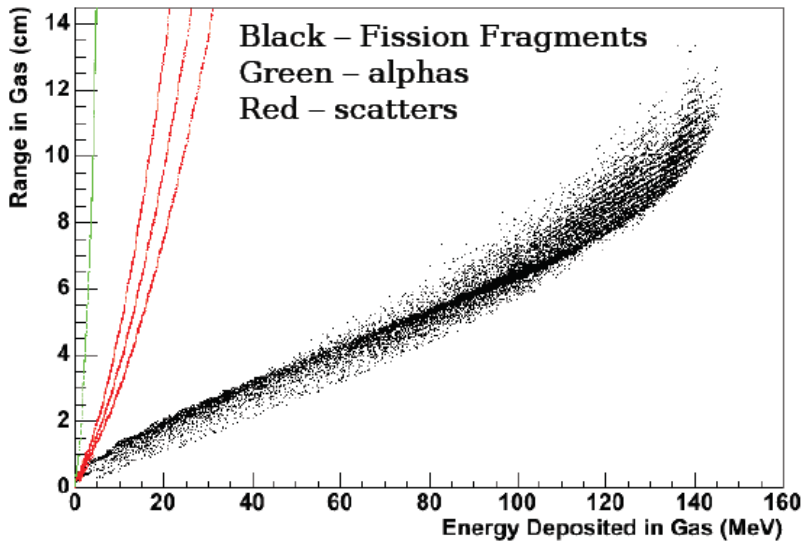
Fission cross section measurement using TPC

Improve the precision of measured ^{239}Pu(n,f) cross section to ~1%

Capability:

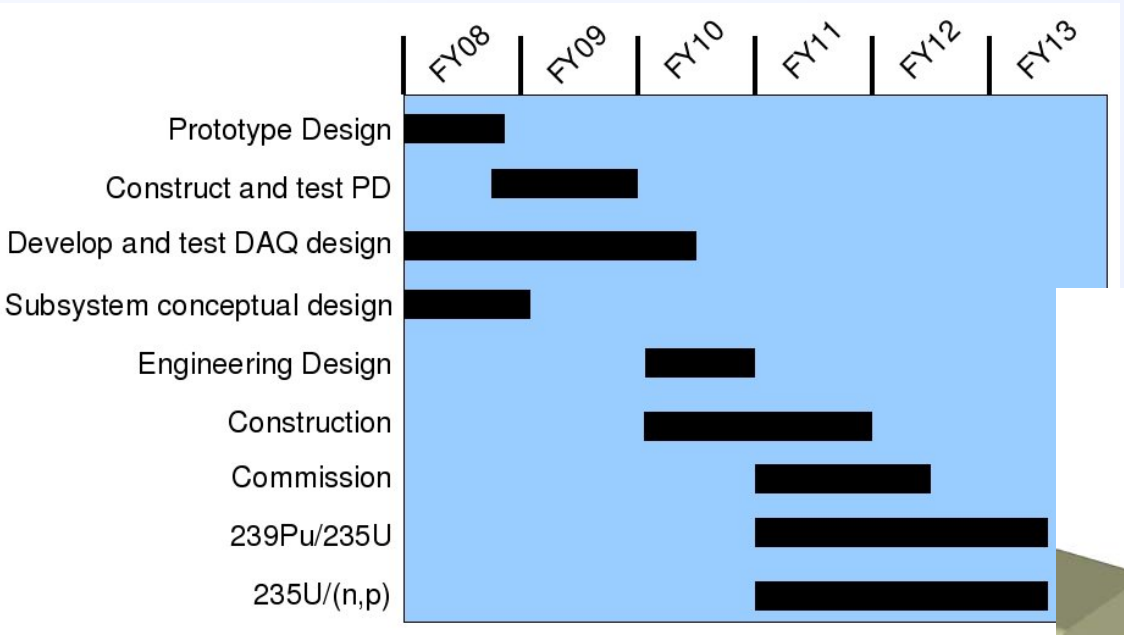
1. **Trajectory reconstruction**
2. **High background-event rejection**
3. **Charged-particle identification**
4. **Standalone or in conjunction with other detectors**

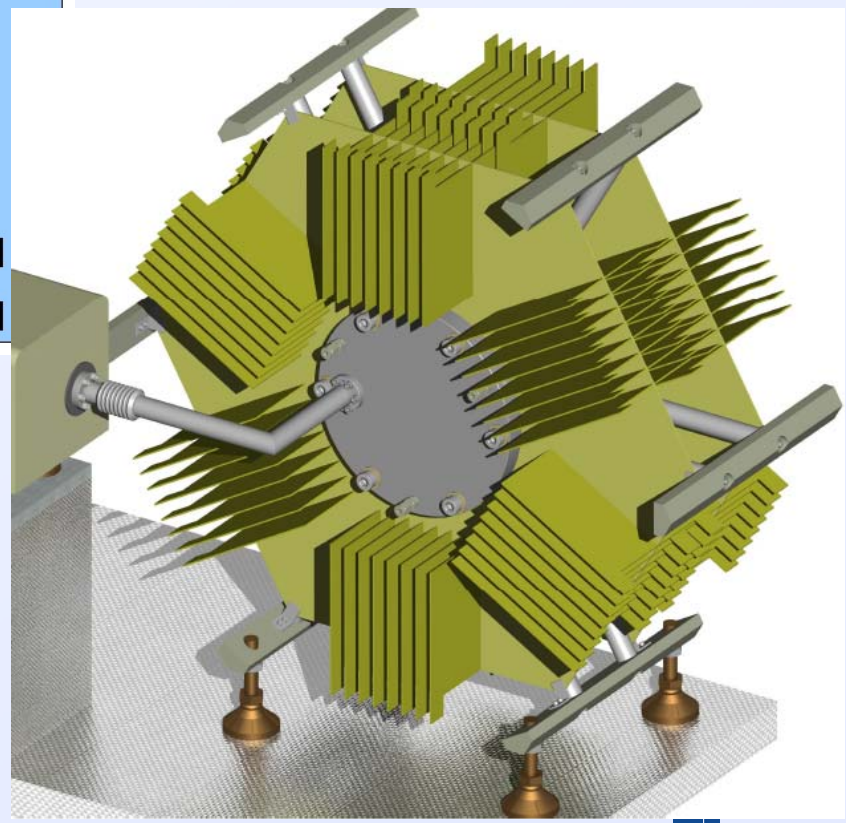




LLNL/LANL/INL/Georgia Inst Tech/Ohio U/Oregon St U/Cal Poly St U/Col Sch Mines/Abilene Chris U

TPC: update


FY08
FY09
FY10
FY11
FY12
FY13
Prototype Design
Construct and test PD
Develop and test DAQ design
Subsystem conceptual design
Engineering Design
Construction
Commission
239Pu/235U
235U/(n,p)



ALEXIS: an intense, tunable neutron source at LLNL

Pelletron accelerates *light ions* (p, d, He) which impinge on various isotopic targets to produce neutron beams with specified intensities and energy spectrum

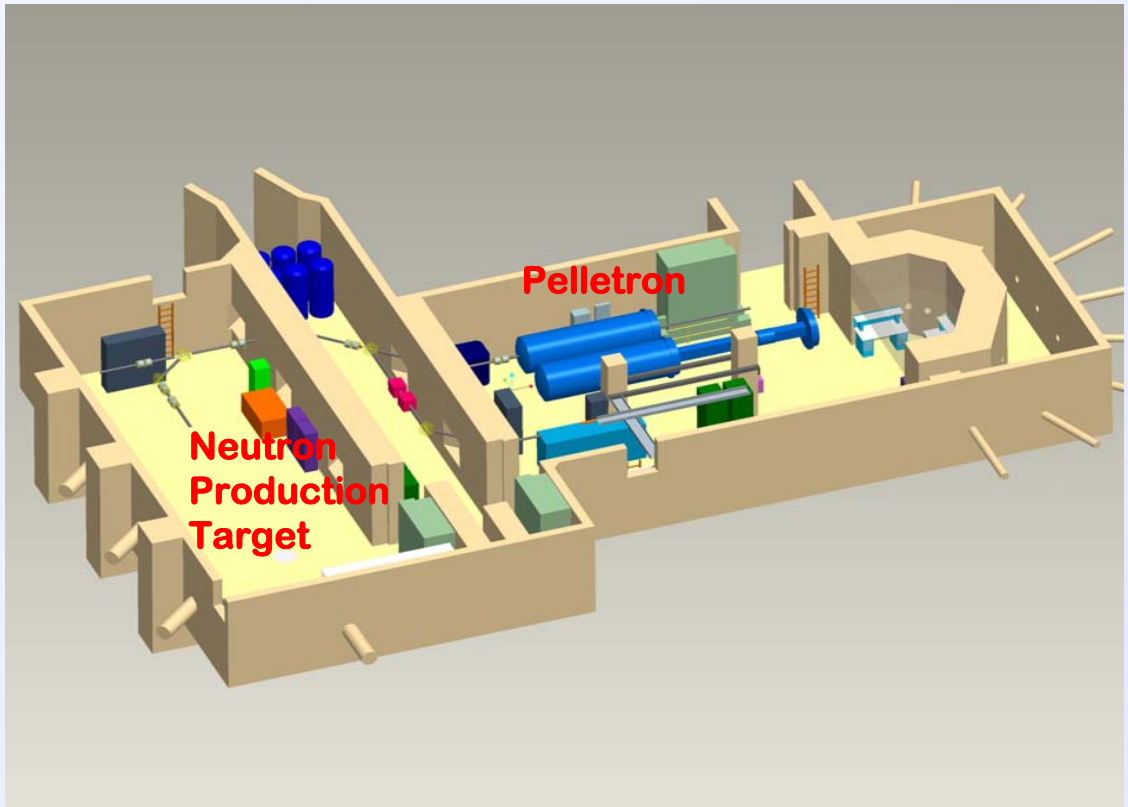
Neutron Production:

Production Reaction	Neutron Energy Range (MeV)	Neutron Energy Spread (FWHM)	Total Neutron Yield (n/s)	Neutron Flux at 10 cm from target ($n/cm^2/s$)	Notes
$^7Li(p,n)^7Be$	0.01-0.4	~30 keV	10^9	10^7	4
$t(p,n)^3He$	0.5-5.0	~400 keV	$>10^9$	$>10^7$	1,2
$d(d,n)^3He$	5.0-9.0	~400 keV	$>10^{10}$	$>10^8$	3
$t(d,n)^4He$	13.0-15.0	~100 keV	10^{10}	10^7	1,2

1. 5 mg/cm^2 titanium assumed for tritium target.
2. Same tritium target can be use for both (p,n) and (d,n) reactions.
3. ~0.5 MeV is assumed energy loss in deuteron target.
4. $^7Li(p,n)$ produces roughly 30 keV thermal spectra with beam energy of 1.918 MeV.

ALEXIS: update

1. All the beam optical and diagnostic components were installed
2. The accelerator tank is under the care of NEC Corp
3. Procurement and final installation has been delayed



Summary

1. Provide the cross section essential to the Stockpile Stewardship Program
2. Relevant to GNEP
3. Team with the university personnel funded under NNSA/SSAA, LANL, and LBNL in both experimental and theoretical efforts
4. TPC on schedule and ready by FY11
5. ALEXIS delayed
6. Continue to develop new direction and capability as needed

Acknowledgement

1. LLNL – U. Agvaanluvsan, L. Ahle, J.A. Becker, L. Bernstein, J. Burke, S. Lesher, R. Macri, K. Moody, E.B. Norman, W. Parker, N. Scielzo, M.A. Stoyer, P. Wilk, and C.Y. Wu
2. LANL – T.A. Bredeweg, R.R.C. Clement, A.J. Couture, J.M. O'Donnell, M.M. Fowler, R.C. Haight, M. Jandel, R. Reifarth, R.S. Rundberg, J.L. Ullmann, D.J. Vieira, J.B. Wilhelmy, and J.M. Wouters
3. LBNL – M.S. Basunia, R.M. Clark, M.A. Delaplanque-Stephens, P.Fallon, J.D. Gibelin, I.Y. Lee, B. F. Lyles, A.O. Macchiavelli, M.A. McMahan, L.W. Phair, E. Rodriguez-Vieitez, F.S. Stephens, and M. Wiedeking
4. TUNL – C. T. Angell, D. Dashdorj, B. Fallin, C.R. Howell, H.J. Karwowski, J.H. Kelley, A. Tonchev and W. Tornow
5. U. Richmond – C.W. Beausang
6. TPC – M. Heffner (LLNL)
7. ALEXIS – L. Ahle (LLNL)