Report on USA Experimental Activities

Donald L. Smith

Argonne National Laboratory

WPEC 2006 – USA Experimental Activities
Introduction

• The material presented here is drawn from the 2005 annual CSEWG meeting (BNL, 8-10 Nov 2005)
• Reminder: Contributions to CSEWG are always voluntary
  --- This report represents only a portion of the total USA nuclear data effort
• The emphasis here is mainly on microscopic differential neutron reaction data relevant to various nuclear energy applications, however some instances of experiments that are also pertinent to astrophysics or fall in the realm of heavy-ion physics (e.g., properties of isomers) do appear in the included material
  --- It is often difficult to categorize the relevance of experimental activities
• Reactor and integral experiments are generally not included
• Contributors: ANL, BNL, INL, LANL, NIST, ORNL, and RPI
• An overview of each laboratory’s efforts is given followed by a Slide Show of material selected from their reports to CSEWG
  --- Most of the slides were prepared by the CSEWG meeting contributors

WPEC 2006 – USA Experimental Activities
• The main emphasis of the ANL nuclear data program is the evaluation of nuclear structure data for ENSDF
• However, some experimental work is carried out (as a sideline) with collaborators at the ANL ATLAS and Australian National University (Canberra) accelerator facilities
• Experiments during the past year focused on:
  --- Studies of K-Isomer properties in neutron-rich nuclei (near A ≈ 180)
  --- Spectroscopy of $^{237}U$ and $^{239}U$ using “Unsafe” Coulomb excitations
  --- Deformation studies on $^{171-175}$Hf and $^{170-171}$Ta
  --- Decay spectroscopy studies of the heavy-nuclei isotopes ($^{251,253}$Es, $^{255}$Fm, $^{245,246,249}$Cm, $^{251}$Cf, and $^{254}$No)
• The structure evaluation effort at ANL has benefited significantly from results produced by these experiments
Argonne National Laboratory
Slide Show
Experimental Activities
ANL Nuclear Data Program

Filip G. Kondev
Nuclear Engineering Division

2005 CSEWG Meeting
Brookhaven National Laboratory, November 8-10, 2005

Argonne National Laboratory

A U.S. Department of Energy
Office of Science Laboratory
Operated by The University of Chicago
Motivation: Why Studying Isomers?

- **Interesting physics phenomena**
  - The mapping of intrinsic orbitals in vicinity of the Fermi surfaces
  - The limits to the existence of high-K states
  - The question of the dilution of the K-quantum number
  - Seniority- and configuration-dependent probes of the major residual interactions in deformed nuclei, specifically pairing and spin-spin interactions.

- **Applications**
  - Astrophysics – stellar chronometers & thermometers
  - Detector calibration standards – high-multiplicity – tracking?
  - Gamma-ray lasers/batteries?
  - Transmutation of nuclear waste?
Deep Inelastic Experiments with GS

**Pulsed Beam Technique**
- well defined “clock”
- sensitive to in-beam and decay events

**Beam:** $^{136}$Xe @ 820 MeV

**Targets:**
- $^{176}$Lu (enriched up to 50%),
- $^{175}$Lu, $^{174}$Yb (gsfma112)
- $^{176}$Yb, $^{185}$Re (gsfma149)

**Beam:** $^{178}$Hf on Pb target (gsfma150)
Projectile-like nuclei

\[ ^{136}\text{Xe} \]
Target-like nuclei
### Studies of $^{186}$Re of relevance for astrophysics

$^{187}$Re-$^{187}$Os cosmochronometer can be used to date the r-process


The existence of long-lived isomeric state the production & destruction CS for the isomer are poorly known, but badly needed!

#### Activation Technique

- Difficult owing to the long $T_{1/2}$
- $T_{1/2}$ - only one measurement without uncertainty


Using prompt $\gamma$–ray technique following n-capture, as recently demonstrated for $^{239}$Pu(n,2n)$^{238}$Pu


What is needed – detailed knowledge of the $^{186}$Re levels above the isomer!

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**187Re-187Os Cosmochronometer**

- Can be used to date the r-process

**Activation Technique**

- Difficult owing to the long $T_{1/2}$
- $T_{1/2}$ - only one measurement without uncertainty


Using prompt $\gamma$–ray technique following n-capture, as recently demonstrated for $^{239}$Pu(n,2n)$^{238}$Pu


What is needed – detailed knowledge of the $^{186}$Re levels above the isomer!
Brookhaven National Laboratory

• The experimental data activities at BNL are compilation for the CSISRS (EXFOR) database and the maintenance and improvement of related on-line interactive software

  --- *Productivity is growing in all these categories*

• Upgrades to the EXFOR retrieval system software are being made steadily in collaboration with IAEA-NDS

  --- *e.g., improved data plotting capabilities (including on-line)*

• The key programmatic objectives are timeliness of the compilations and streamlining of communication between users, compilers, and the database itself

  --- *A new information feedback option is under development*
Status of CSISRS/EXFOR compilation

Dimitri Rochman
National Nuclear Data Center
Brookhaven National Laboratory
drochman@bnl.gov
Compilation Effort

- Total
- Neutron-induced reactions
- Charged particles-
- Gamma-

Number of compilations vs. Year

Brookhaven Science Associates
U.S. Department of Energy
EXFOR Improvements!

- Be closer to the experimental community
- Use EXFOR to publish on today’s knowledge
- Create an easy-to-read format
- System of retrieving specific data
- Simplify compilation rules

Idea?
EXFOR Plotting interface

EXFOR Request #1159

Format: Text (446Kb) ZIP (66Kb)

Bibliography: HTML (5Kb)

Data for plotting: ZVD (427Kb), ZIP (62Kb), send to ZVView
Idaho National Laboratory

- A project initiated by INL … with collaborators from ANL, Vanderbilt University, and Russia … has been initiated at ANL-IPNS to measure differential cross sections and resonance parameters for actinide isotopes
- Use is made of pulsed white-source neutrons, multiple detector types (Si SSD’s, BGO’s, HPGe’s, and Liquid Scintillators), timing criteria, and coincidence methods
- Preliminary measurements have been made using $^{235}\text{U}$ and $^{239}\text{Pu}$ samples to explore the approach
- If the technique proves to be viable, the emphasis will be on minor actinides using available Russian samples

--- This method is unlikely to prove competitive with conventional experiments for most precision measurements on the major actinides
IPNS - a spallation neutron source

A usable neutron energy from
~1 meV to ~1 MeV.

An integrated flux of ~5.3 x 10^6
n-cm-2-s-1 at 12 m.

Beam is available ~23 weeks
per year.

Neutron beam is moderated with
a cryogenic methane
moderator.

The incident proton pulse width,
~70 nanoseconds.

IPNS is a user facility, versus a
cost recovery facility.

Gram quantities of most
actinides can be used in
IPNS.
Event Triggers

n

T1

T3

n-γ

T4

Fission

n-n

T2

Stop

Start

TDC

T_Detector

n

HPGe

BGO

Liquid Scintillator

Si stack

Master Event

Neutron Time-of-Flight n=100 ms

Neutron Time-of-Flight n=100 ms

INL Idaho National Laboratory

12 November, 2005
Resonance Resolution

239Pu Cross section

Neutron Events

INL TOF 239Pu

Neutron Time-of-Flight (*10 ns)

INL TDC TOF
γ-ray Gated No Si-Detector

Neutron Events

Neutron Time-of-Flight (*100 ns)

Energy Range ~5-20 eV
Los Alamos National Laboratory

- Experimental nuclear data program at LANL continues to be the largest in the USA (facilities, effort, productivity)
- Proton- and neutron-induced reaction experiments are carried out at LANSCE using three target stations: Lujan Center (low-energy neutrons) and WNR Targets 2 & 4 (protons and fast neutrons)
- Extensive detector systems coupled with sophisticated instrumentation allow for a wide variety of experiments
- Nuclear reaction processes studied include \((p,x)\), \((n,\gamma)\), \((n,\text{inel})\), \((n,\text{xy})\), \((n,\text{CP})\), \((n,\text{nx+\gamma})\), \((n,\text{fission})\), nu-bar, etc.
- Emphasis is on both applications (e.g., nuclear energy, defense) and basic nuclear science (e.g., astrophysics)
Los Alamos National Laboratory

Slide Show

WPEC 2006 – USA Experimental Activities
Nuclear Data Experiments at LANSCE: Highlights 2005

Robert C. Haight
Los Alamos National Laboratory

WITH CONTRIBUTIONS FROM RENE REIFARTH

Cross Section Evaluation Working Group Meeting
US Nuclear Data Program Meeting
Brookhaven National Laboratory
November 8-11, 2005

LA-UR-05-8366
Nuclear data measurements at LANSCE are made with several instruments.

- **GEANIE** ($n,x_\gamma$)
- **FIGARO** ($n,x_{n+\gamma}$)
- **DANCE** ($n,\gamma$)

- **N,Z** ($n$, charged particle)
  - **LSDS**
  - Fission
  - Double Frisch-grid fission chamber; also standard fission ion chamber
Nuclear data experiments at LANSCE use neutrons at three locations: Lujan Center, Target 2 and Target 4.
Recent & planned GEANIE neutron-induced gamma-ray cross-section measurements at LANSCE/WNR

\(~1 \text{ MeV} < E_n < 200 \text{ MeV}\)

- $^{191,193}\text{Ir}(n,n'\gamma), (n,xn\gamma), \text{ and } (n,pxn\gamma)$ – results ND2004
- $^{197}\text{Au}(n,n'\gamma), (n,xn\gamma), \text{ and } (n,pxn\gamma)$ – results APS DNP 10/2004
  - New levels and $\gamma$’s obtained for $^{191,193}\text{Ir}$ and $^{197}\text{Au}$
- $^{nat}\text{Cr} + ^{nat}\text{V}$ – relative, for secondary cross section standards
- $^{48}\text{Ti}(n,x\gamma)$ – dissertation - D. Dashdorj (NCSU/LLNL)
- $^{150}\text{Sm}(n,2n\gamma)$ – reported (UCRL-TR-205760)
- Planned analysis:
  - $^{100}\text{Mo}(n,x\gamma), ^{130}\text{Te}(n,x\gamma), ^{19}\text{F}(n,x\gamma)$
  - $^{70,72,74}\text{Ge}(n,x\gamma)$ – INL
- Planned measurements: $^{124}\text{Sn}, ^{138}\text{Ba}, ^{169}\text{Tm}, ^{186}\text{W}, ^{203}\text{Tl}, ^{233}\text{U}$
New GEANIE data significantly improve the $^{193}\text{Ir}(n,n')^{193m}\text{Ir}$ cross section database.
Present and future experiments at FIGARO/WNR: neutron-emission spectra and $\nu$-bar in fission

$1 \text{ MeV} < E_n < 200 \text{ MeV}$

**Fission Chamber in beam**
- $^{235,238}\text{U}(n,f): \ E_{fn}, \ \nu$-bar  
- $^{235}\text{U}(n,f): \ E_{fgamma}$  
  R. Nelson, in progress
- $^{237}\text{Np}(n,f): \ E_{fn}, \ \nu$-bar  
  Data being analyzed
- 2.3 m flight path at 20-deg  
  Pre-equilibrium preceding fission

**Gamma-ray trigger (HPGe or BaF$_2$)**
- $^{99}\text{Tc}, \ 208\text{Pb}, \ \text{Ba}$  
  In progress
Model-Measurement Comparison for Ni(n,n'γ)
We measure proton, deuteron and alpha-particle production cross sections for the Advanced Fuel Cycle Initiative

1 MeV < En < 100 MeV

- Ta(n,xp) and (n,x_α)
- Cr(n,xp) and (n,x_α)

Planned:
- Zr(n,xp) + (n,x_α)

Goal is to determine, e.g. helium production / dpa for accelerated radiation damage analysis
New LANSCE data differentiate among evaluations

Iron(n,helium)

Cross Section (b)

Neutron Energy (MeV)

LANSCE-2004 (preliminary)

FZK/INPE

JENDL-HE

IEAF-2001

LA-150

NRG-2003

TSL-Uppsala-2004

Los Alamos
New data are for Tantalum and Chromium

Future measurements: Zr and Mo
DANCE Progress 2004 - 2005

**Stable Targets:**
- $^{197}$Au (well-studied standard)
- $^{139}$La, $^{45}$Sc, $^{55}$Mn, $^{59}$Co, $^{60}$Cu, $^{76}$V, $^{78}$Rb, $^{80}$Sr (gaps in s-process)
- $^{102}$Pd (p process)
- $^{62}$Ni ("weak" s-process puzzle)
- $^{76,77,78,80}$Se (s-process)
- $^{54,57,58}$Fe (s-process)
- $^{94,95}$Mo ($\gamma$-ray strength function)
- $^{152,154}$Gd (radchem and s-process)
- $^{151,153}$Eu (radchem)
- $^{147}$Sm (spin assignments for resonances via multiplicities)

**Radioactive Targets**
- $^{237}$Np -- AFCI
- $^{234,235,236,238}$U -- known standards and defense programs
- $^{242}$Pu -- AFCI and defense
- $^{151}$Sm -- key s-process branch (largely completed)
- $^{241,242,243}$Am (planned) -- AFCI and defense

**Capture-fission ratio**
- $^{235}$U
$^{237}$Np Status: Final results, statistical uncertainties
0.7 mg of $^{242}$Pu
A Lead Slowing-Down Spectrometer is under development, driven by 800 MeV protons from the PSR.

Neutron trajectories following the interaction of 1 proton with the tungsten target in the lead cube.
We have characterized the time-energy correlation and measured the resolution in capture resonances. 

Simulation: $<E_n> = \frac{K}{(t + \text{to})^2}$

with resolution, $\Delta E/E \sim 30\%$
Lead Slowing-Down Spectrometer: To measure fission cross sections of ultra-small samples

- Effort motivated by interest in measuring the fission cross section of isomers and small samples of actinides
- Calculations show that cross section for $^{235\text{m}}\text{U}$ is significantly different than for ground state
- Experiments are in collaboration with LLNL, RPI and CEA/DAM
With the LSDS, we have measured the neutron-induced fission cross section on $^{239}$Pu section with sub-$\mu$g samples.

- Last year 27 ng
- This year 9.87 ng with higher current & higher rep-rate of PSR
- Good results up to 100 keV
- First planned $^{235m}$U measurement 12/05

![Graph showing $^{239}$Pu(n,f) cross-sections](image)
First excited state of $^{235}\text{U}$ is produced in decay of $^{239}\text{Pu}$

- $^{235}\text{mU}$
  - 26 min half-life
  - 73eV
  - Decays by internal conversion
  - 99% of 239Pu decays populate $^{235}\text{mU}$
  - 5 gm of Pu will produce 10ng of $^{235}\text{mU}$

- Fast extraction of $^{235}\text{mU}$ will be required

- To measure this small cross section, it is necessary to increase the neutron flux by using a lead-slowing down spectrometer (LSDS)
Fission cross section measurements are being renewed at LANSCE

- Data for the Advanced Fuel Cycle Initiative
- New data $^{237}$Np (standard fission chamber)
- FY-06: $^{237}$Np, $^{240}$, $^{242}$Pu with Frisch-grid chamber
- FY-06-07: Precise $^{239}$Pu fission cross section
- People:
  - Tony Hill
  - Fredrik Tovesson
  - F.-J. Hambsch
  - others
Initiative on the Horizon – more neutrons in fast reactor energy region

- Need to improve flux in 1 keV – 5 MeV range
- Need a short pulse with better repetition rate
  - Lujan pulse is too long ~ 250 ns
  - WNR: 1.8 to 5 µs spacing is too small
Fast reactors emphasize 1 keV – 5 MeV neutron energy range
Initiative on the Horizon – Materials Test Station for DOE/NE

- Peak fast (>0.1 MeV) neutron flux of $\geq 1 \times 10^{15}$ n.cm$^{-2}$.s$^{-1}$
- At least 1 kW/cm$^3$ volumetric heating in at least 30 fuel pellets
- Burnup rate of 3% per year in the peak flux region
- Displacement rate in iron of at least 10 dpa/y
MTS will be located in the 32,000-ft² LANSCE “Area A” experiment hall

Existing assets include:
800-MeV proton linac
30-T crane
Secondary cooling loops
Back-up generator
Shield blocks
Utilities

MTS will provide the first fast neutron irradiation capability in the USA since the shutdown of the FFTF and EBR-II
The damage rates for the MTS are similar to that predicted in IFMIF and roughly twice ITER.

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*FPY = full power year; MTS expected operation is 4400 hrs per year.
National Institute for Standards and Technology

• Emphasis is on high precision standards measurements
• Recent experimental projects include:
  --- $H(n,n)H$ angular distribution measurements at 15 MeV in collaboration with LANL and Ohio University
  --- High precision scattering length measurements for $H(n,n)H$ and $3He(n,p)$
  --- Ultracold ($\approx 3$ meV) neutron cross section measurements for $6Li(n,t)$ using a novel calorimetry technique
• NIST has been a leader in the development of a new neutron standards file (it will be included in ENDF/B-VII)
National Institute for Standards and Technology

Slide Show

WPEC 2006 – USA Experimental Activities
Recent Work to Improve the Database for the Neutron Cross Section Standards
Including Recent Work at NIST

Allan D. Carlson
Ionizing Radiation Division
National Institute of Standards & Technology

Presented at
The CSEWG meeting
Brookhaven National Laboratory
November 8, 2005
H(n,n)H Recent Work

- NIST Coherent Scattering Length data published.
  - $b_{np} = -3.7384 \pm 0.0020$ fm
- Ohio University-NIST-LANL 15 MeV angular distribution experiment.
  - Data taking has begun.
Experimental setup for the Ohio U.-NIST-LANL measurement of the n-p scattering angular distribution at 15 MeV.
Two dimensional plot (sum of the pulse heights in the E +DE detectors vs the pulse height in the DE detector) for a telescope at 12 degrees from the neutron beam direction. The colors indicate the number of events. The region “2” shows the two dimensional gate used to select the region of interest.
$^3\text{He}(n,p)$ Recent Work

- NIST Coherent Scattering Length data has been published.
  - $b=5.872 \pm 0.0072$ fm
- An NIST experiment is beginning on measurements of the spin-dependent portion of the $n-^3\text{He}$ coherent scattering length.
$^6$Li(n,t) Recent Work

• Improvements continue on an NIST measurement of the $^6$Li(n,t) cross section standard at ~ 4 meV neutron energy. The emphasis is on improved fluence determinations using methods based on:

  • calorimetry, by measuring the heat produced by the $^6$Li(n,t) reaction in a thick Li target.

  • The well known nu-bar of $^{252}$Cf and counting fissions events in a $^{252}$Cf fission chamber. A Mn bath is used as a means of comparing the ~4 meV neutron fluence with the $^{252}$Cf neutron fluence.

  • $\alpha$-$\gamma$ coincidences using the $^{10}$B(n,$\alpha\gamma$) reaction.

• Zhang et al. have re-measured the $^6$Li(n,t) cross section in the MeV energy region since “particle leaking” effects were present in their original data. The data are now being analyzed.
• ORELA has not been fully operational so scientists at ORNL have been involved in measurements elsewhere

• A collaboration with IRMM at GELINA under a DOE-EURATOM agreement is focusing on two areas:
  
  --- Fission product total and capture cross section data for burnup credit applications (\(^{103}\)Rh, \(^{133}\)Cs, \(^{143}\)Nd, \(^{149}\)Sm, \(^{151}\)Sm, and \(^{155}\)Gd)
  
  --- \(^{55}\)Mn total and capture cross section data for criticality safety applications

• A collaboration with LANL at WNR is undertaking inelastic scattering measurements on \(^{19}\)F for criticality safety applications (to resolve an existing discrepancy)
Oak Ridge National Laboratory

Slide Show
2005 COLLABORATIVE MEASUREMENTS: ORNL & IRMM
ORNL & LANL

Klaus Guber (ORNL)
Ron Nelson (LANL)
Peter Schillebeeckx & Peter Siegler (IRMM)

CSEWG Meeting
Brookhaven National Laboratory
November 8-10, 2005
$^{103}$Rh Experiments at GELINA

- **Experimental Conditions:**
  - Due to cooling problem not full power: 400 Hz Rep Rate instead of 800 Hz.
  - Pulse width of the neutron beam 1nsec.

- **Two experiments were performed:**
  - Total cross section (transmission) at 26.45 m flight path with a $^6$Li glass detector using a $^{103}$Rh sample with 0.00187 at/b.
  - Neutron capture using the pulse height weighting technique with two C$_6$D$_6$ detectors at a distance of 28.1m. Sample thickness for $^{103}$Rh was 0.000337at/b.

- **Additional run with background filter were performed, as well as sample out runs.**

- **Despite the short flight path the resolved energy range is up to several keV.**
$^{103}$Rh Capture Data

![Graph showing $^{103}$Rh capture data with counts on the y-axis and TOF/nsec on the x-axis. The graph includes lines for background from sample scattered neutrons, sample out, and $^{103}$Rh.]

Background from sample scattered neutrons
Sample out
$^{103}$Rh

Counts

TOF / nsec

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY
$^{55}\text{Mn}$ Experiments at GELINA

- **Experimental Conditions:**
  - Due to cooling problem not full power: 400 Hz Rep Rate instead of 800 Hz.
  - Pulse width of the neutron beam 1nsec.

- **Two experiments were performed:**
  - Total cross section (transmission) at 26.45 m flight path with a $^6\text{Li}$ glass detector using a $^{55}\text{Mn}$ sample with 0.118 at/b.
  - Neutron capture using the pulse height weighting technique with two $^{6}\text{CD}_6$ detectors at a distance of 28.1m. Sample thickness for $^{55}\text{Mn}$ was 0.019 at/b.

- Additional run with background filter were performed, as well as sample out runs.

- Despite the short flight path the resolved energy range is up to 300 keV.
$^{55}$Mn Capture Data

$^{55}$Mn Capture

S Background filter
$^{55}\text{Mn} \text{ Capture Data Detail}$
$^{19}$F(n,n1γ) Experiments using WNR at LANL

- **Experimental Conditions:**
  - The GEANIE spectrometer consists of 26 Compton-suppressed, high-resolution germanium γ-ray detectors and is located on an approximately 20-m-long FP.
  - GEANIE is located at flight path 4, 60° right.

- Experiments were performed using a Teflon sample.

- (n,n1γ) cross section for the first two exited levels were measured.

- Additional sample out runs were performed.

- Experimental difficulty is the 90 nsec life time of the second level, which will smear out the neutron energy resolution.
Rensselaer Polytechnic Institute

- Experiments at RPI are performed using white-source neutrons produced at the Gaerttner LINAC facility
  - Emphasis is on neutron capture and transmission measurements in the resonance region
- Measurements and data analysis are being carried out for isotopes of Nd, Nb, Gd, Rh, Re, and Mo
- Efforts to upgrade the LINAC facility and develop improved measurement capabilities are on-going
  - A new large neutron detector (104 cm x 70 cm) is now installed
  - A new digital data acquisition system allows pulse-shape discrimination with no deadtime
  - Upgrade of LINAC injector (shorter pulses and better emittance)

WPEC 2006 – USA Experimental Activities
Rensselaer Polytechnic Institute

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WPEC 2006 – USA Experimental Activities
Cross Section Measurements and Analysis at Rensselaer

Report at CSEWG meeting 2005

R. C. Block, Y. Danon, N. Francis, M. Lubert, M. Rapp F. Saglime

Rensselaer Polytechnic Institute, Troy, NY, 12180

and

J.A. Burke, N.J. Drindak, J. Hoole, G. Leinweber

Lockheed Martin Corporation, Schenectady, NY 12301-1072
Measurements Completed This Year

• Re
  – Used 7 metallic samples, thickness range of 1-100 mils.
  – Completed thermal (0.005-20 eV) and epithermal (5-1000 eV) transmission and capture measurements.

• $^{164}$Dy
  – 7 liquid ($D_2O$) samples were prepared with 98% enriched $^{164}$Dy. Two metallic natural Dy samples also used.
  – Completed thermal (0.005-20 eV) and epithermal (5-1000 eV) transmission and capture measurements.
Data Analysis

<table>
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<th>Sample</th>
<th>Status</th>
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<tr>
<td>Nd</td>
<td>Paper was accepted for publication in NS&amp;E</td>
</tr>
<tr>
<td>Nb</td>
<td>Analysis completed, paper submitted to NS&amp;E</td>
</tr>
<tr>
<td>Gd</td>
<td>Analysis completed, paper submitted to NS&amp;E.</td>
</tr>
<tr>
<td>Rh</td>
<td>Transmission analysis started (using SAMMY)</td>
</tr>
<tr>
<td>Re</td>
<td>Data analysis started</td>
</tr>
<tr>
<td>Mo</td>
<td>Data analysis started</td>
</tr>
</tbody>
</table>
Recent Measurements on Gadolinium

![Graphs showing transmission and capture yield data for different energies.](image)

1.27-mm Data
SAMMY fit
0.127-mm Data
SAMMY fit
New Gd Resonances

Energy [eV] vs. Capture Yield and Transmission
Gd Thermal Region - Separated Isotopes

Capture Yield vs. Energy [eV]

Transmission vs. Energy [eV]

Capture Yield vs. Energy [eV]

RPI
ENDF
New Capabilities

• Transmission Measurements at 100m flight station with a large Neutron Detector (~104 cm x 70 cm)
  – Allows high energy transmission and spectra measurements in the energy range 0.2-20 MeV.

• Scattering detectors at ~30m flight path for the energy range 0.2-20 MeV
  – A digital data acquisition system allows pulse shape analysis with no dead time.

• LINAC Injector Upgrade
  – Provide shorter pulses (<5 ns), higher current (several amperes peak current), better emittance, commercially available spare parts
  – Installation under way – completion expected early next year.
LINAC Injector Upgrade

- The Injector system was assembled and tested outside the LINAC room.
- A 5 ns wide pulse was successfully demonstrated.
- In order to install the new system, the LINAC is shut down for 3 months until Jan 2006.
--- The End ---