Task Force on the
Impact of Evaluated Nuclear Data on Society

- **Mission**:

  The goal of the Task Force on the Impact of Evaluated Nuclear Data on Society is to develop and maintain a broad registry of examples showing the direct impact of nuclear data on activities and applications that enhance specific research efforts and society in general.

Examples

Standards for half-life & decay rates

Identification of materials by nuclear decay signatures

Simulation Codes for Nuclear Reactions

Medical Applications

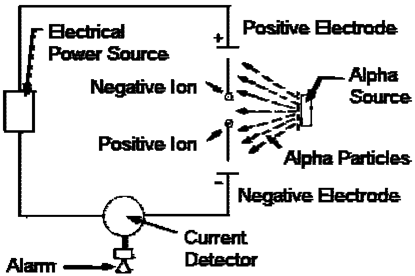
Homeland Security

Nuclear Physics In Society

People may be unaware Nuclear Physics applications that have changed various aspects of our lives

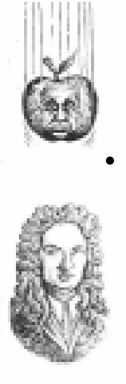
Smoke Detectors*

(Ionization Chamber)



We want to focus on applications which benefit society and require precise evaluated nuclear data

Impact of Precise Physics Data: Gravitational Physics



- **Space Exploration**

- **GPS**

  Boating

  OnStar – Find the nearest Restaurant

- **Military/Civilian “spy” satellites**

  Images – even on MapQuest

- **Astronomy/**

  Hubble Telescope

Standards for half-life & decay rates

(Nuclear Wallet Cards- ENSDF)

- Contain important nuclear data such as half-lives, decay modes, nuclear masses, and ground state spins and parities.
- Address concerns of accuracy and standardization
- Distribution by hard copy and web
- The Nuclear Material Management and Safeguards System (NMMSS), which monitors radioactive material inventories adopted the half-lives published in the NNDC's Nuclear Wallet Cards and mandated their use.

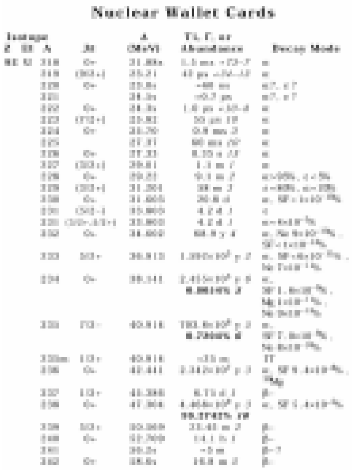


Figure: A page from the Nuclear Wallet Cards

Standards for half-life & decay rates

Mechanical Wear Studies Applications

- Estimates of obsolescence: systematic quantification of wear for high stress objects, for example ball bearings and polymer surfaces used in industrial applications.
- Overestimate gives unnecessary downtime and expense
- Underestimate could result in accidents or damage
- Implant radioactive isotopes in an object and monitor the rate at which the radiation activity is removed

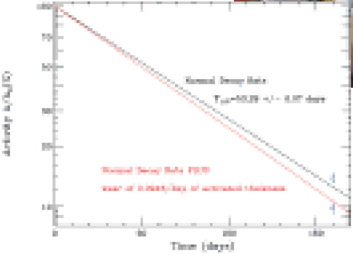


Figure: Simulation of a wear study using isotropically implanted ^{7}Be ions.

Radioactive Isotope Dating (ENSDF)

Archeological and geological studies used radioactive dating to characterize the age of artifacts and other samples. Methods are well established, represents a merging of biology and geology with history and nuclear physics.

Carbon dating is most familiar

judging the authenticity of various artworks

determining the age of artifacts

establish timeline for man's expansion through the world

^{14}C /^{12}C decreases after death

- **age determined by interpreting present-day $^{14}C/^{12}C$ ratio (vs historic atmospheric ratio)**
- **decay-rate of ^{14}C determines age**
- **quality of nuclear half-life presently superior to the quality of other parameters, such as uncertainties in the atmospheric $^{12}C/^{14}C$ ratio related to events like the Ice Age, active volcanic periods and atmospheric nuclear weapon testing.**

Geological dating/nuclear decay chains.

^{238}U to ^{206}Pb ratio, to date geological sites such as mineral deposits.

The ^{206}Pb is produced by a complex cycle of alpha- and beta-decays; and the accuracy of the age determination requires that all intermediate decays be well characterized

^{40}K to ^{40}Ar ratio, in igneous rocks to establish dates of volcanic activity.

Characterizing the $^{40}K/^{40}Ar$ composition near volcanoes, determines the chronological record of activity; i.e. determines dates of volcanic activity, distinguishing between volcanic events, and can establish if events have a regular cyclic pattern.

Identification of materials by nuclear decay signatures (ENSDF)

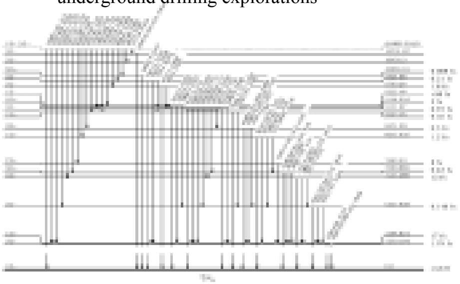
Measuring radiation permits detection of tiny traces of an element without requiring destruction of the sample

Identification of naturally radioactive material

- To identify a radioactive material, measure the characteristic γ-decay energies and compare them against the database of compiled γ-ray decay schemes that are present in the ENSDF database.
- This information is frequently referenced to identify radioactive materials that give rise to "background radiation". For example, thorium and uranium in concrete
- Presently: high-precision γ-ray detectors are used to identify radioactive waste that may be accidentally disposed of from medical, research or power plant applications.
- In addition, airports and other transportation related centers are beginning to use γ-ray systems to identify the presence of radioactive materials enhancing homeland security.

Induced radiation for material identification

- We can induce radioactive decays from stable isotopes by either γ-ray or neutron bombardment.
- Thermal neutron and γ-ray activation yields can be deduced from the ENDF/ENSDF databases
- The induced decay signatures can identify anything from nitrogen in explosives to oil/mineral deposits in underground drilling explorations



Medical Applications (ENDF and ENSDF)

- **The field of nuclear medicine has provided a stunning array of techniques for the diagnosis and treatment of disease.**
- **Some of these applications require accurate information on nuclear reactions and/or structure such as are provided by the U.S. Nuclear Data Program.**

•Isotope tagging

complex molecules, tagged with radioactive isotopes, selectively attach to specific organs or features.

Imaging techniques such as positron emission tomography (PET) can map blood flow, tumors and other internal features or metabolic processes.

These advances are facilitated by:

- ability to produce radioactive isotopes cheeply
- accurate characterization of radioactive decay processes
- understanding of safe quantities of radiation
- much of this information is derived from the ENDF and ENSDF databases.

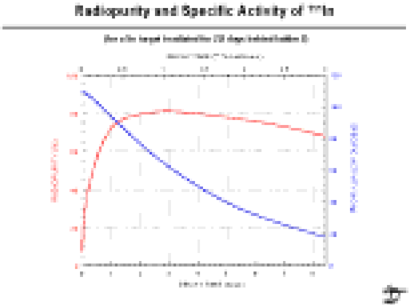


Figure: The isotope ^{111}In, produced by Sn(p,X)^{111}In. The ENDF data base provides $\sigma(E)$ to determine the optimum proton energy, the total quantity of ^{111}In produced, and what impurities are produced. (http://apt.lanl.gov/MIabstract.html)

Medical Applications (ENDF and ENSDF)

Radiation doses from external-beam radiotherapy

- For tumor irradiation, γ-ray attenuation lengths, or neutron or proton cross sections are used to simulate the distribution of energy deposition
- the most effective treatment irradiates the target zone while doing the least damage to surrounding tissue - relies on simulations using compiled data to optimize the effectiveness of treatment.
- At present, the International Commission on Radiation Units and Measurements has adopted relevant neutron- and proton-induced cross sections from the ENDF and has published them in ICRU Report 63 (2000), which has become the international standard.

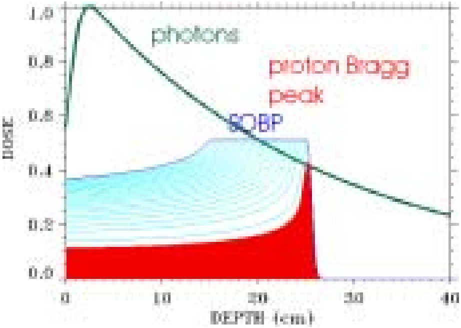


Figure: Calculated radiation doses from photon-beam therapy (green) and from proton-beam therapy (red). Treatment is optimized when dose is concentrated in the tumorous region. The technique of Spread Out Bragg Peak (SOBP - Blue), employs a range of proton energies in the treatment, and can irradiate a large volume of tissue while minimizing exposure to non-tumorous regions. (radmed.web.psi.ch/asm/gantry/why_p/n_why_p.html.)

Simulation Codes for Nuclear Reactions
(ENDF and Phenomenological reaction models)

- Monte Carlo Neutral Particle (MCNP), a nuclear reaction simulation code, is under continuous development at Los Alamos National Lab and traces its roots back to the Manhattan Project.
- "state-of-the-art" for simulating γ-ray, electron, neutron, hydrogen and heavy-ion (up to carbon) induced reactions for atomic and nuclear interaction processes.
- highest quality for two reasons: accurate reaction dynamics, and the reliability of the input data
- nuclear cross section data are transposed from the ENDF/B-VI library from the Cross Section Evaluation Working Group (CSEWG), which is coordinated by the US National Nuclear Data Center (NNDC) at Brookhaven.

<u>Among other uses the MCNP code is used to:</u>

- **Control/calculate radiation doses in various medical applications,**
- **Optimize designs for reactors/thermonuclear energy devices,**
- **Optimize shielding designs for high-radiation areas to create safe work environments in compliance with Nuclear Regulatory Guidelines without costly investment in unnecessary shielding**
- **Perform simulations of detector responses for complex γ-ray and charged-particle detectors that are used in a variety of applications.**
- **3-to-4 thousand active licenses of the current MCNP versions**

Homeland Security (ENDF and ENSDF)

Demand for new technologies that permit highly accurate and non-intrusive interrogation

- Decades of investment in fundamental research have provided a solid platform of evaluated nuclear data and experimental techniques that are relevant to homeland security initiatives.
- Existing databases of nuclear structure information (ENSDF) and nuclear reaction cross sections (ENDF) have provided vital input into many new efforts.
- New applications often involve the engineering of methods to "scale-up" research procedures that have long been applied in curiosity research
- Important to improve the quality of the nuclear data inputs (both cross sections and structure information) so that meaningful information about the distribution of materials in the sample can be deduced and so that occurrences of false positives can be minimized.

Summary

- Activities that create nuclear data, and activities that evaluate and organize nuclear data have proven to provide beneficial information that have broadened our understanding of the world around us.

- Derivative technologies that are based on the fundamental research have permitted the development of applications that benefit society.

- It is expected that continued support along these lines will continue to provide skilled leaders who will further develop new applications that will continue to benefit our society.