

US Nuclear Data Program

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BROOKHAVEN
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a passion for discovery



U.S. DEPARTMENT OF
ENERGY

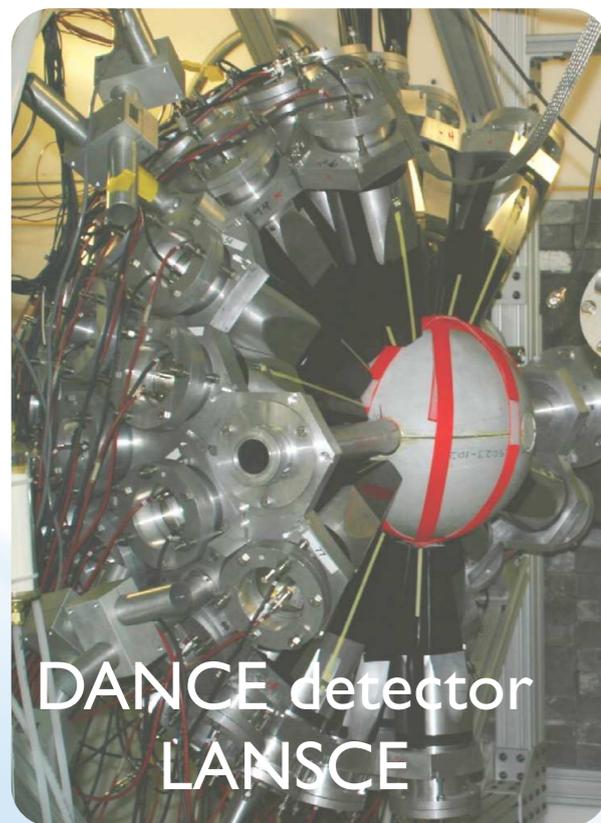
Office of
Science

Nuclear Data Program

Link between basic science and applications

Nuclear Science Community

- ♦ experiments
- ♦ theory



Brookhaven Science Associates

Mike Herman

Nuclear Data Community

- ♦ compilation
- ♦ evaluation
- ♦ dissemination
- ♦ archival



Application Community

needs data:

- ♦ complete
- ♦ organized
- ♦ traceable
- ♦ readable

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NSAC meeting, Sept. 21, 2012

Who needs nuclear data? and what for?

- **Basic science (physics)**

- testing theoretical models
- designing experiments
- analyzing experimental data

- **Astrophysics**

- origin of elements

- **Nuclear power**

- reactors R&D
- fuel cycle
- operation safety
- radiation shielding
- waste disposal and transmutation

- **Nuclear medicine**

- radioisotope production
- dose calculation
- radiotherapy
- diagnostics

- **National/homeland security**

- device R&D
- stockpile stewardship
- criticality safety
- nuclear forensics
- detecting illicit trafficking of nuclear materials

- **Industrial applications**

Nuclear Data

numerical values of nuclear physics quantities

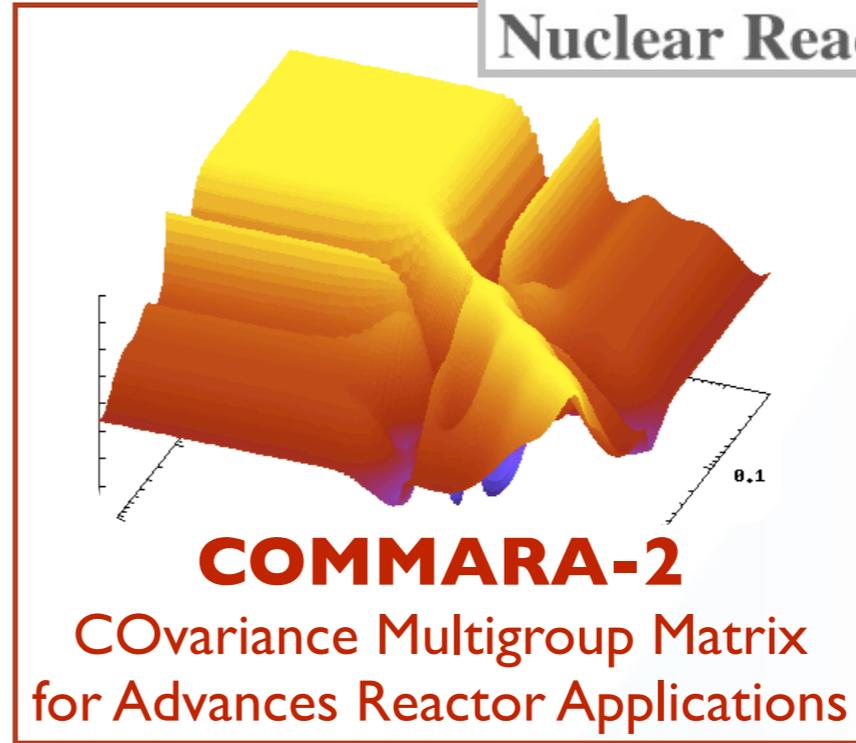
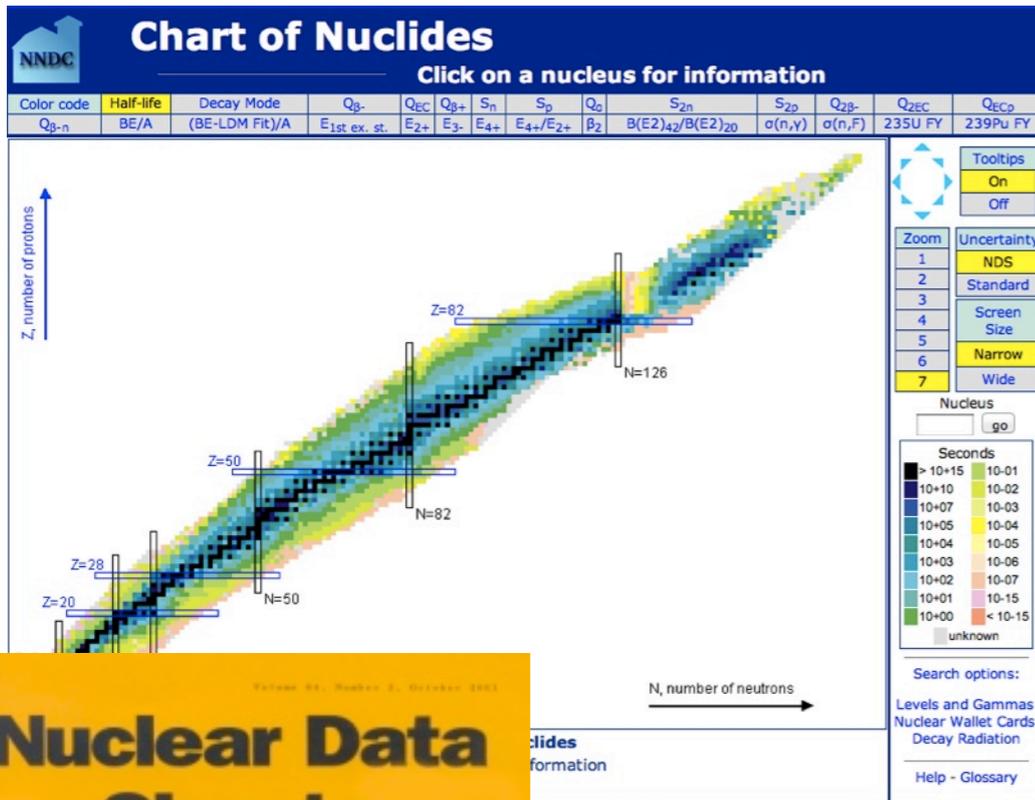
ND types:

- **Bibliographical** - index of publications (partially key-worded)
- **Compiled** - formatted and searchable collection of published results (typically experimental)
- **Evaluated** - recommended values obtained using all available knowledge (assessment of available experimental data combined with nuclear theory modeling, supported by experience and, if possible, validation against integral experiments)

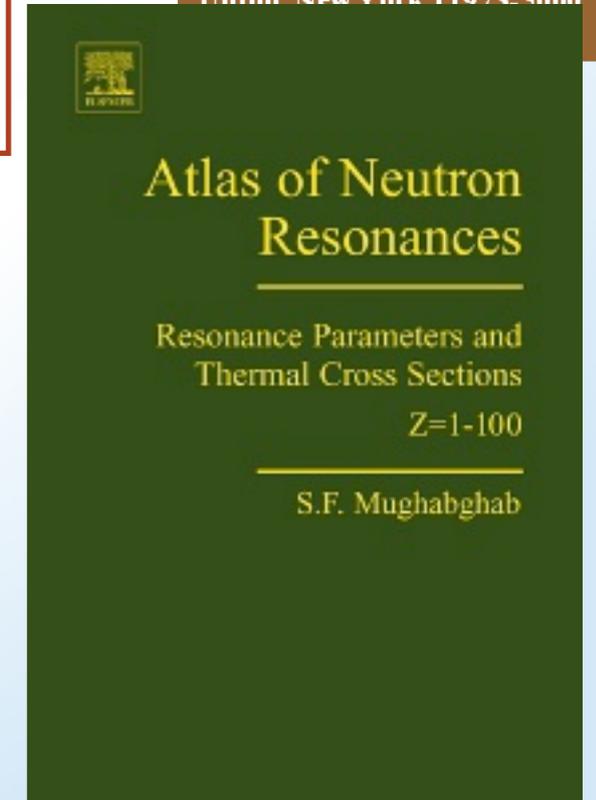
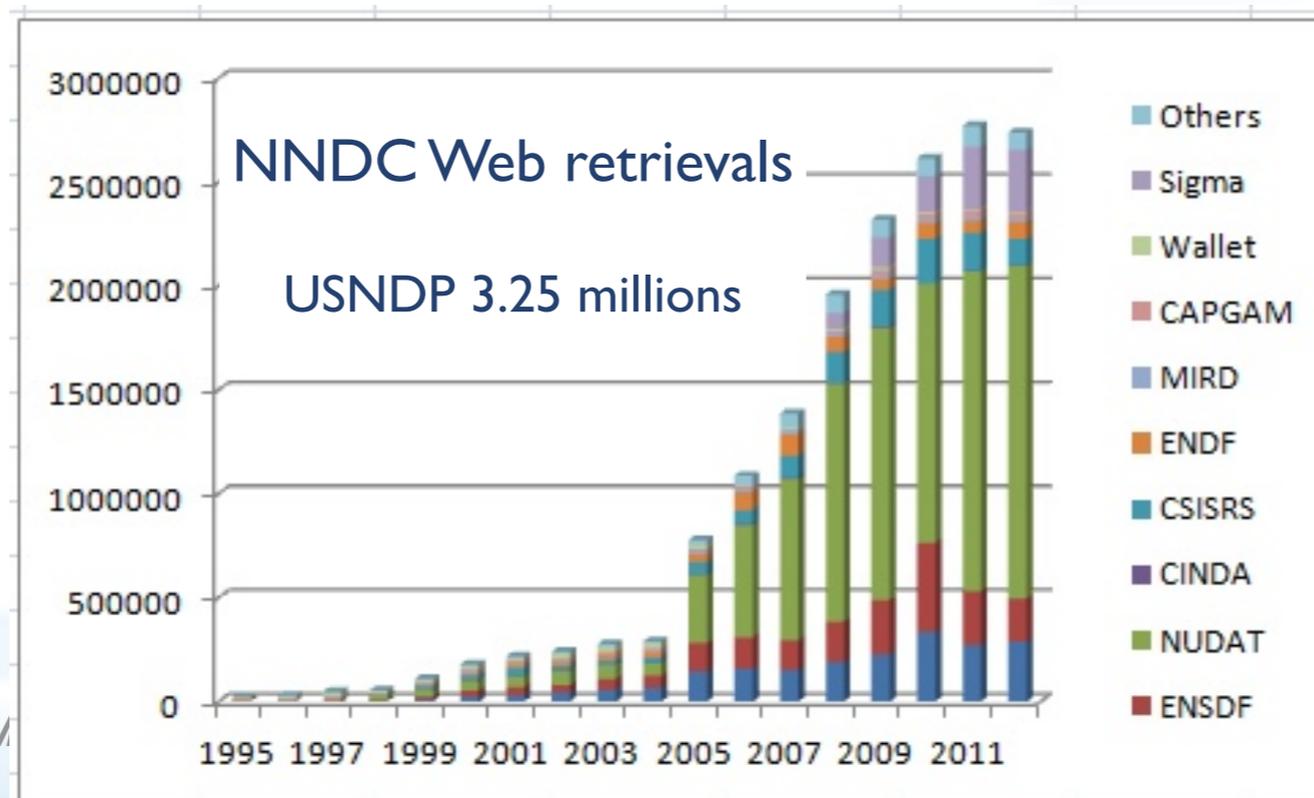
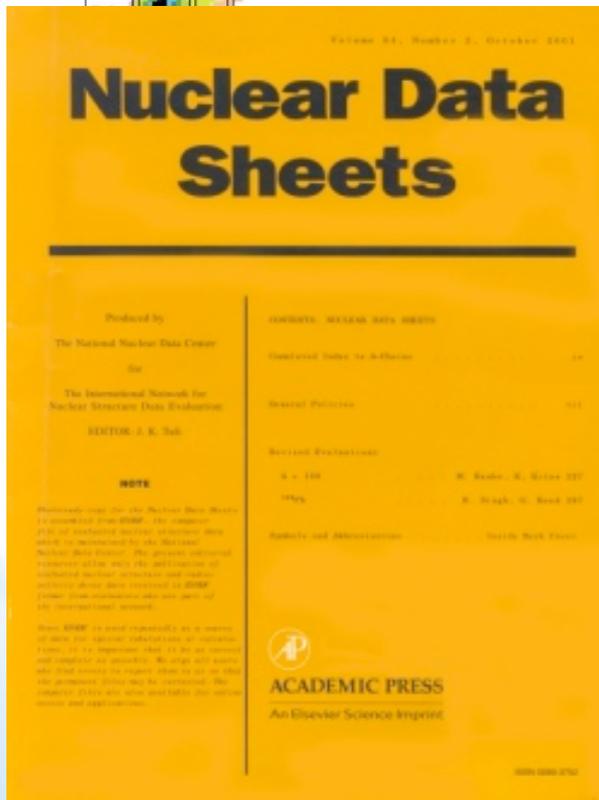
USNDP objective is to provide, in a timely manner, the highest quality nuclear data responding to the users' needs in order to ensure safety, reliability, efficacy, and sustainability of nuclear technologies.

	Structure & Decay	Reactions
Bibliographical database	NSR >208,000 publications	
Compilation databases	XUNDL >3,000 publications	EXFOR/CSISRS ~20,000 experiments
Evaluated libraries	ENSDF >3,000 isotopes	ENDF/B-VII.1 14 sub-libraries

Other popular products



NUCLEAR WALLET CARDS
October 2011
Jagdish K. Tuli
National Nuclear Data Center
www.nndc.bnl.gov
Brookhaven National Laboratory
P.O. Box 500
Upton, New York 11973-5000



US Nuclear Data Program (USNDP)

FY2011	FTE	Heads		2012
Scientific staff	19.9	54	Budget	\$6,485k



USNDP
 coordinated by NNDC
 Annual ND week, ND2013

Brookhaven Science Associates

International collaboration

JAEA Japan Atomic Energy Agency

CJD Institute for Physics and Power Engineering

KAERI KOREAN ATOMIC ENERGY RESEARCH INSTITUTE

International organizations

AEN NEA

IAEA
International Atomic Energy Agency

International networks

NSDD

NRDC



Application of Nuclear Data

Nearly-missed reactor accident in India

3/10/2004

Kakrapar Atomic Power Station 1



- Failure of regulation system
- Power increased from 73% to nearly 100%.
- Automatic shut down - accident avoided!
- However, according to the Design Manual power rise should **NOT HAPPEN!**
- Atomic Energy Regulatory Board shut down KAPS until incident is understood.
- **The newly released nuclear data library provided explanation and brought the plant into operation**

Cargo screening for nuclear materials

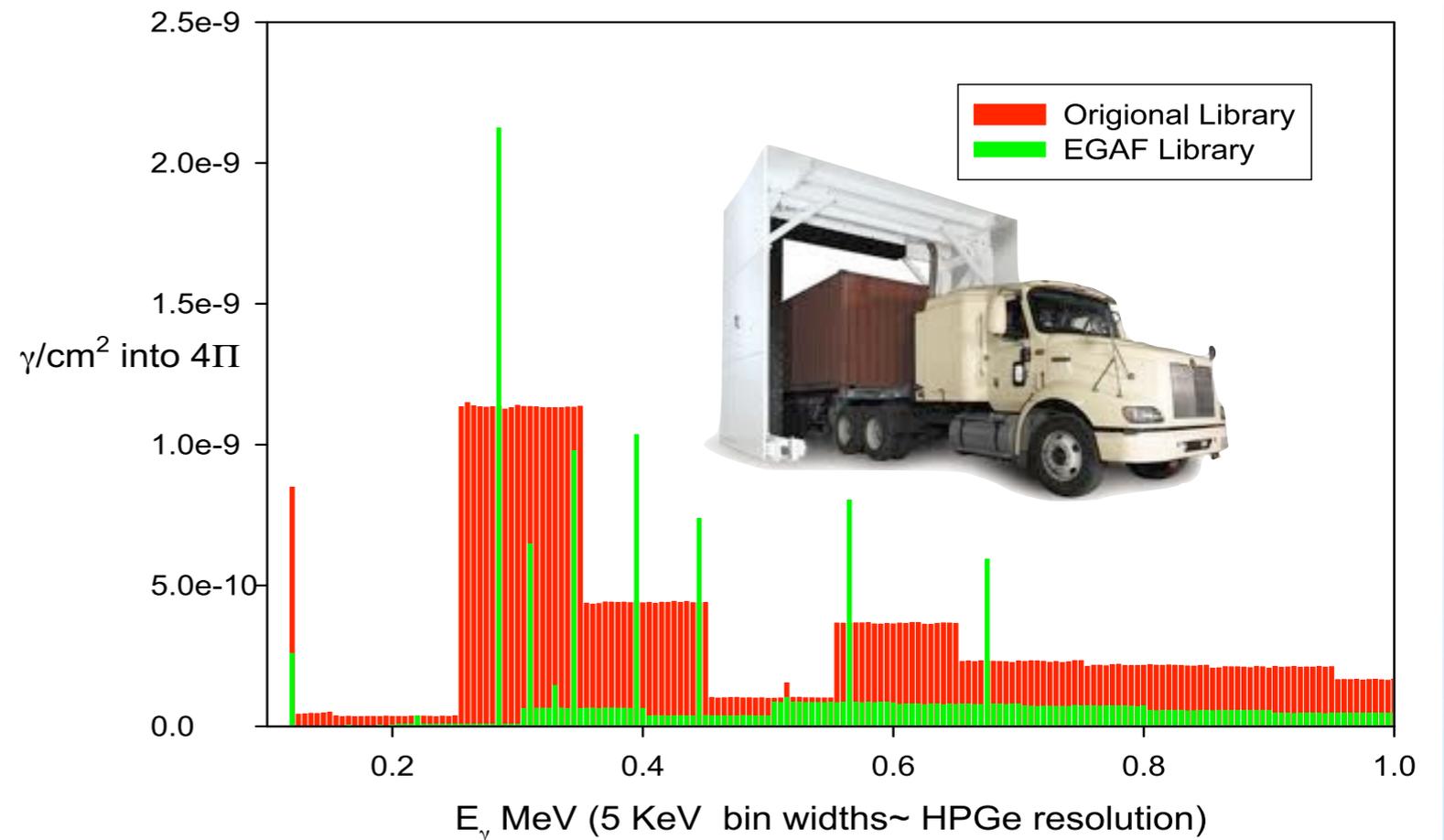
Evaluated Gamma Activation File

- Capture primary γ 's easy to separate from background and difficult to shield (6-12 MeV)



fingerprint for the capturing isotope

- Presence of fission products is a clear indicator of actinides being present (neutrons from spontaneous fission)



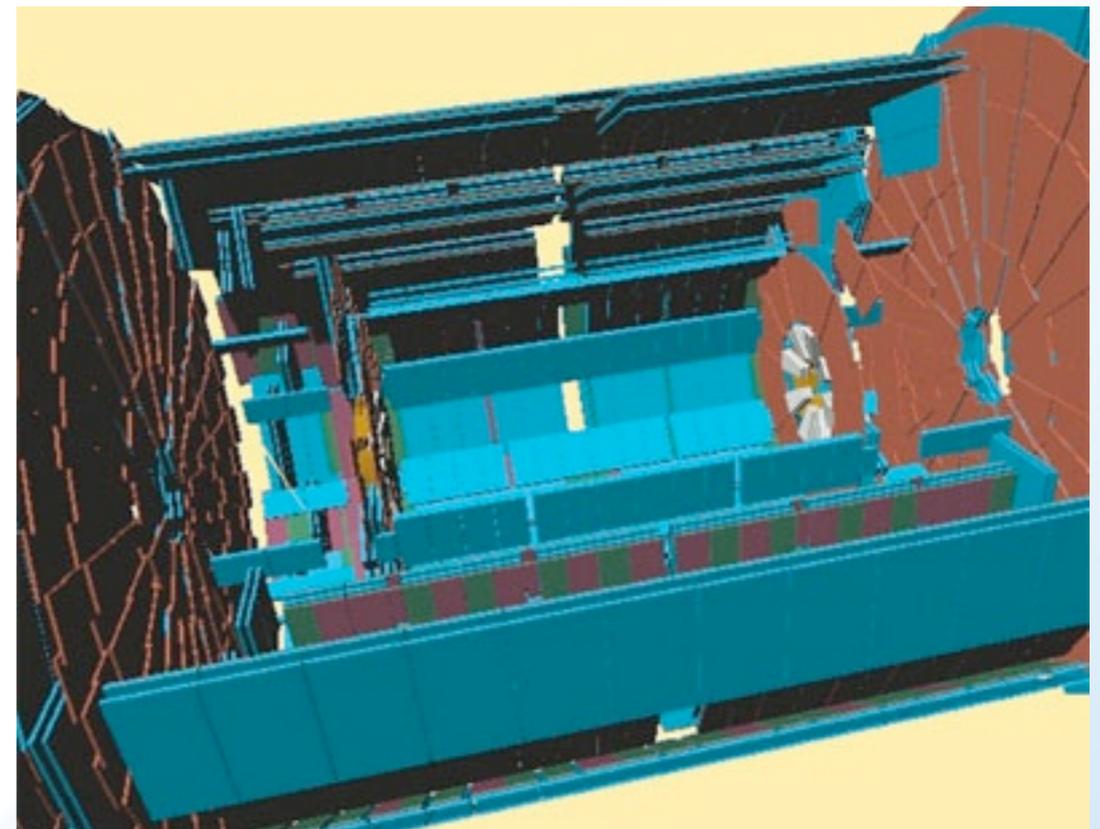
EGAF library allows identification of γ -lines from $^{104}\text{Pd}(n_{\text{th}}, \gamma)$

Brad Steagford

High energy physics

GEANT4 and FLUKA adopt USNDP libraries

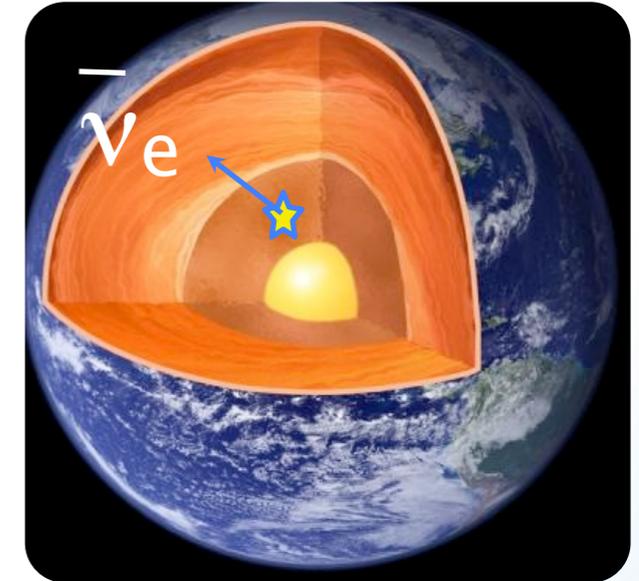
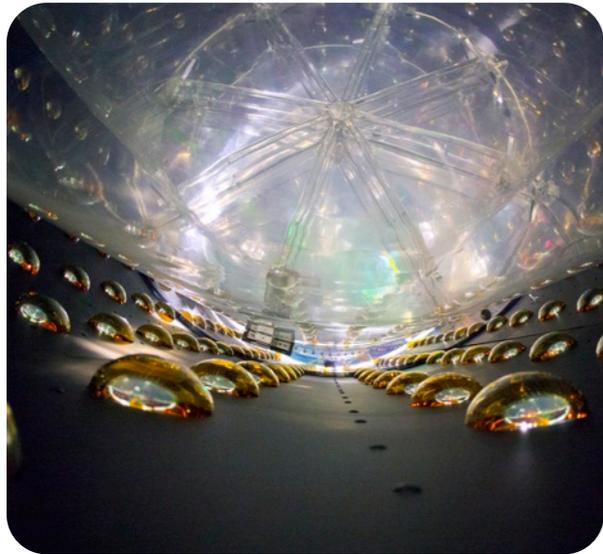
- Geant4 Neutron Data Library (G4NDL) based on ENDF/B-VII.0
- Thermal scattering in the 'High Precision' neutron models uses ENDF/B-VII.0
- The radioactive decay data from the Evaluated Nuclear Structure Data File (ENSDF)
- Also FLUKA uses ENDF/B data



ATLAS detector muon system, simulated in Geant4

State of the art antineutrino spectrum modeling

antineutrinos are the ultimate probe



Basic Science:

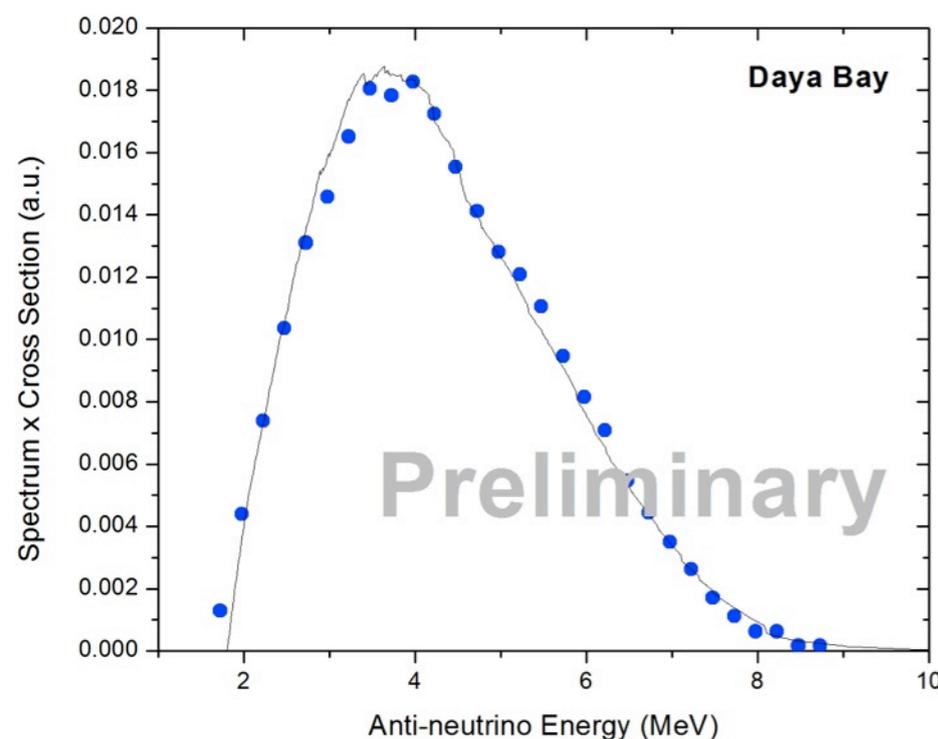
Study of neutrino oscillations in Daya Bay

Non-proliferation:

safeguards and reactor monitoring

Geophysics:

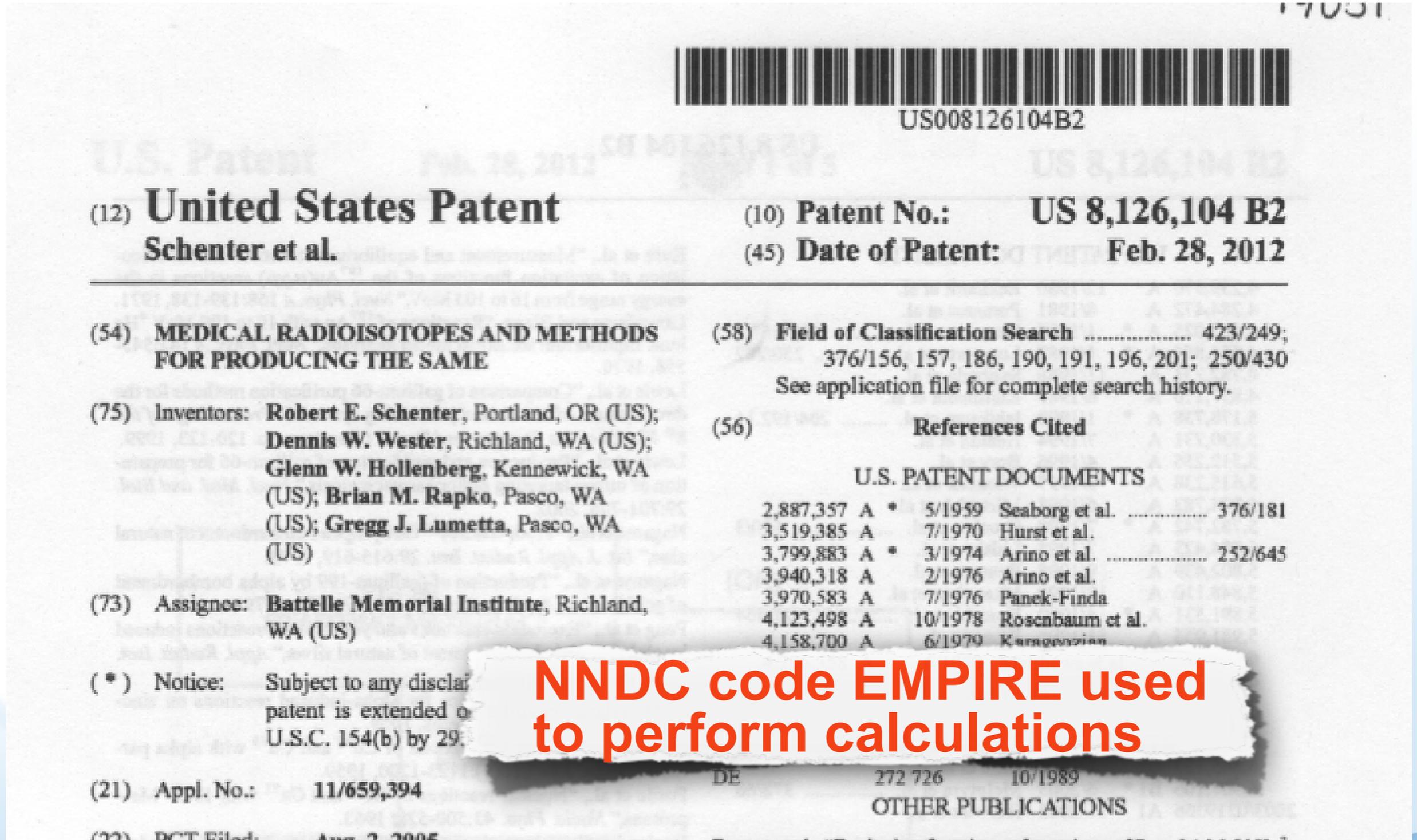
Earth tomography from long lived radioisotopes



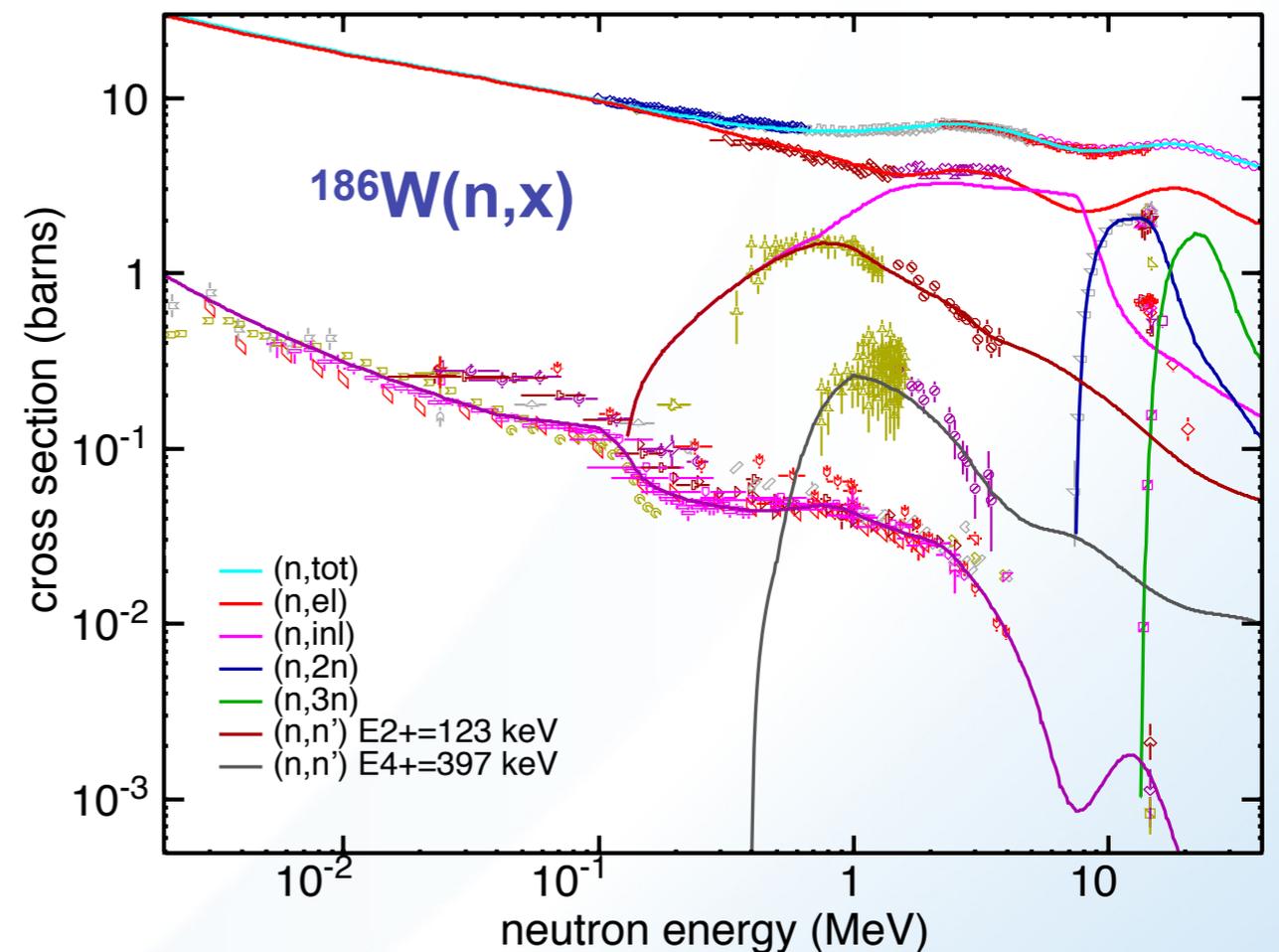
Evaluate, with uncertainties, the anti-neutrino spectrum from β decays of actinides and their fission products and archive them in ENDF/B-VII.2 for applications

NSAC meeting, Sept. 21, 2012

Isotope production: $^{96}\text{Zr}(\alpha,n)^{99}\text{Mo}$ alternative (non-reactor) way of producing ^{99}Mo



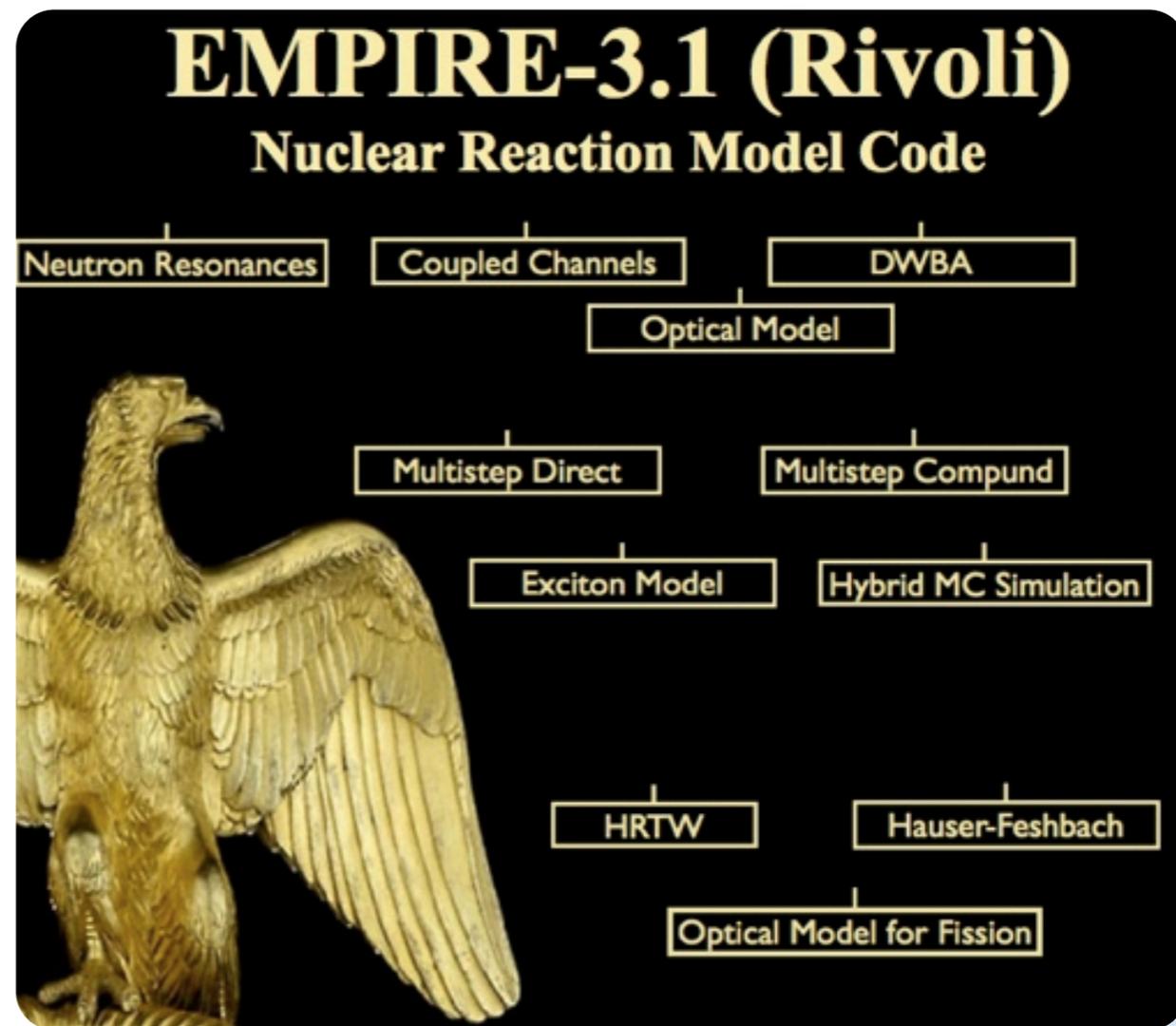
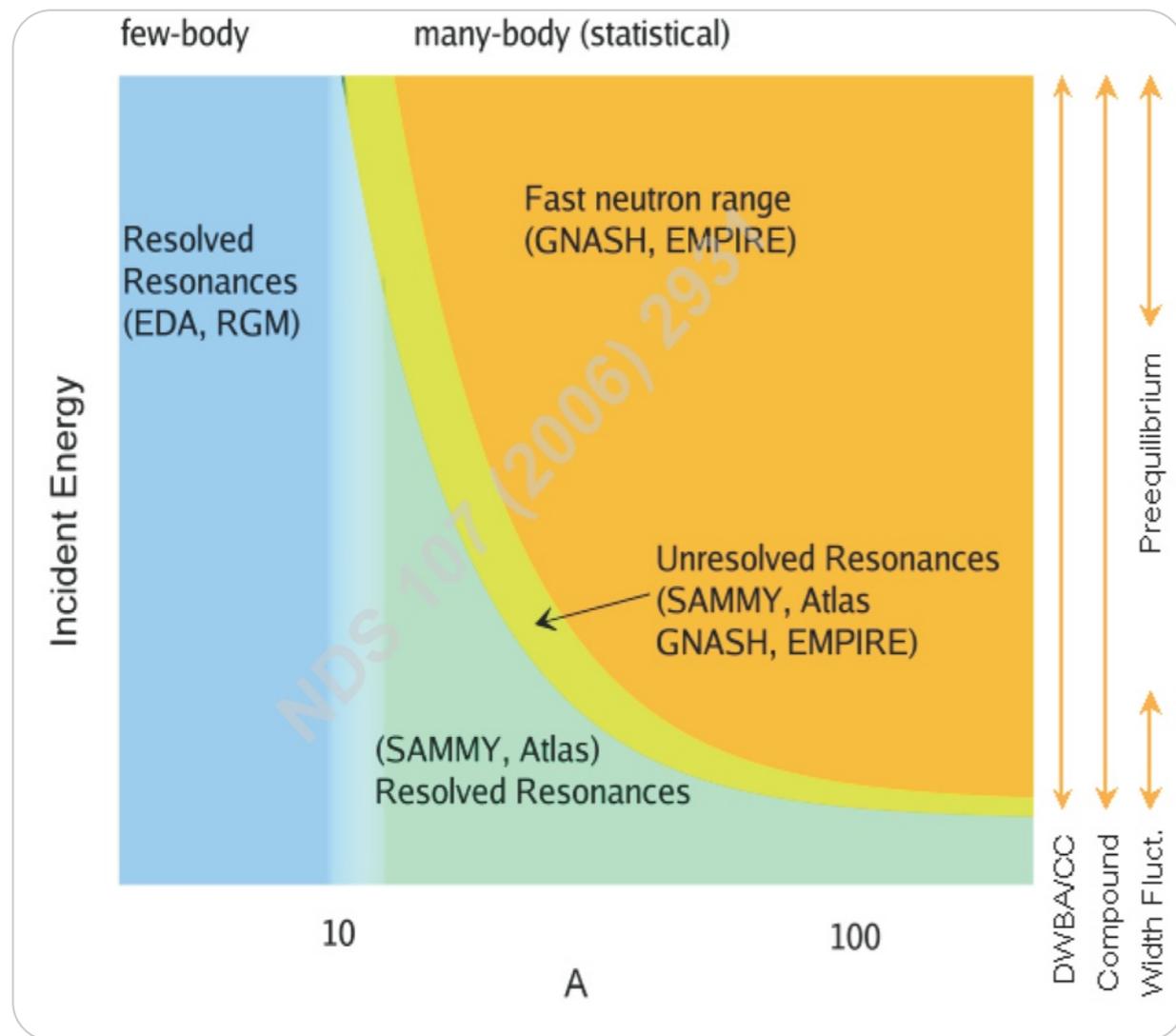
Nuclear Reaction Theory in Nuclear Data Evaluation



Experiments never cover whole
energy range and all reaction
channels

Nuclear theory

ND is the major user and developer of nuclear modeling



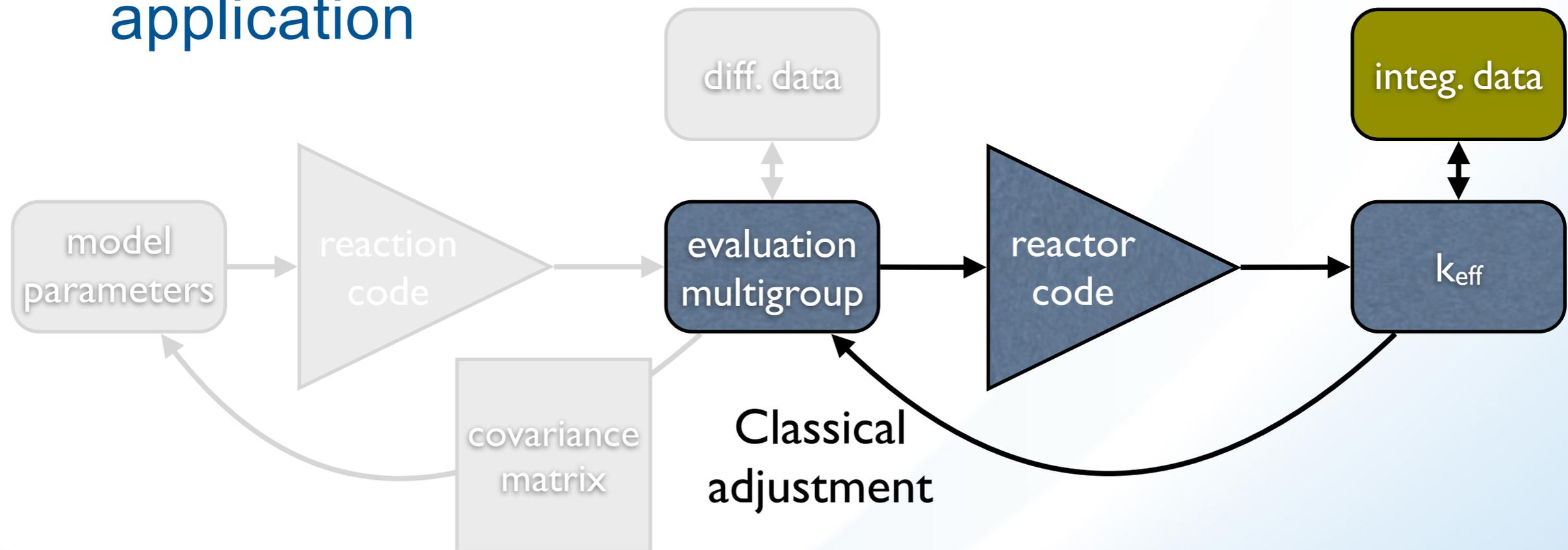
- Fills gaps in experimental data
- Provides full set of observables

- Helps to choose among discrepant measurements
- Ensures consistency of the evaluation

Opportunities for enhancing the Nuclear Data Program

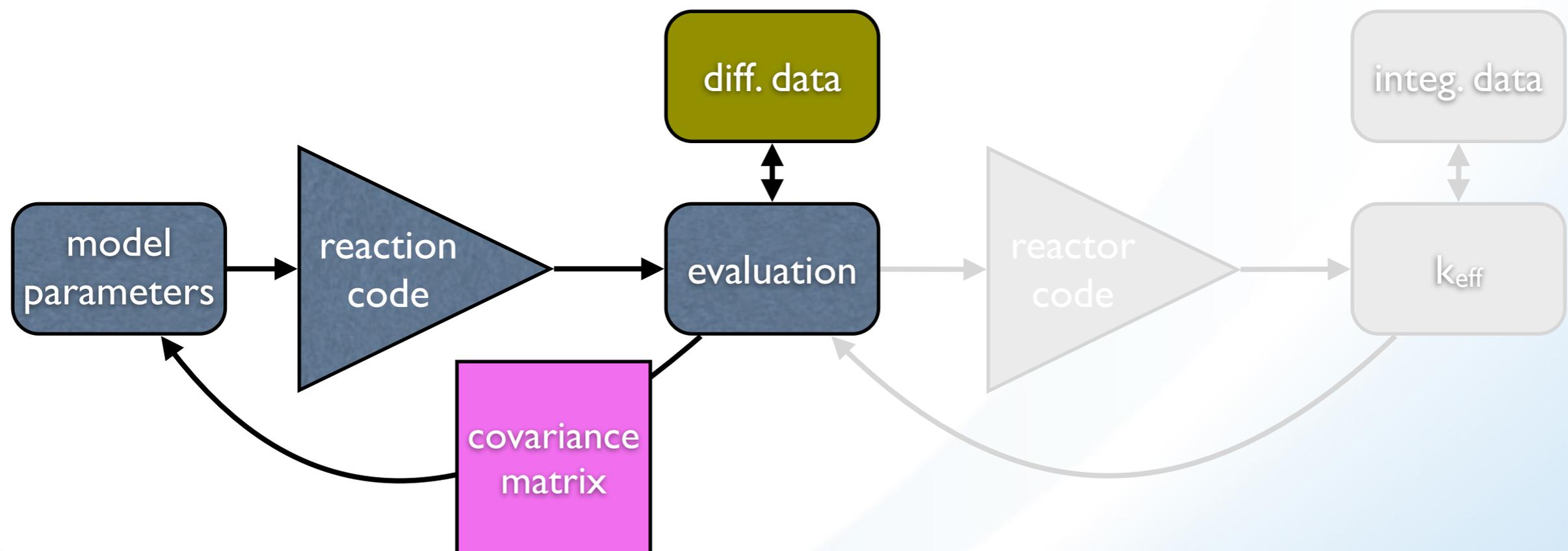
Consistent adjustment (assimilation) linking reaction theory and integral experiments

- Users often tune multi-group evaluated files to a certain type of integral experiments
- Such adjusted file is only valid for a specific application



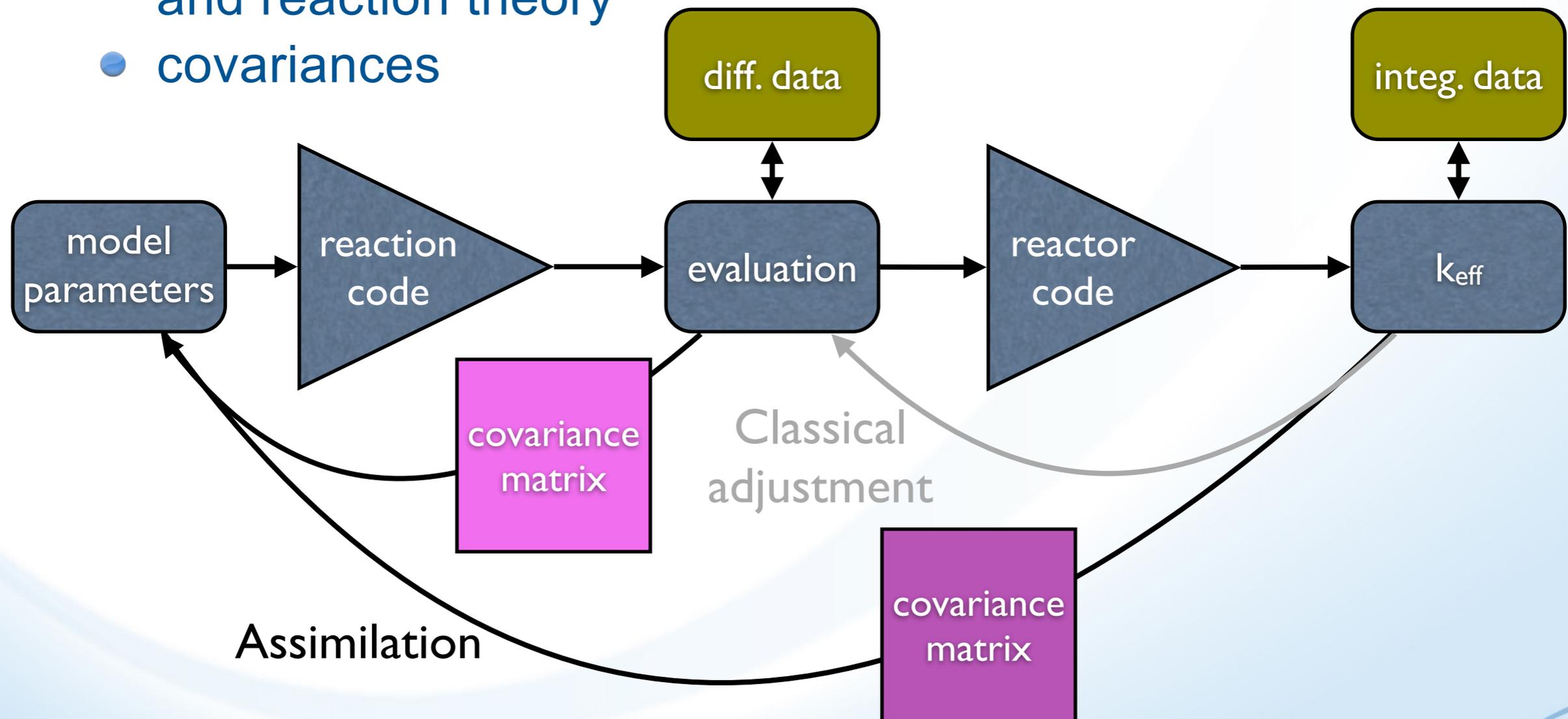
Consistent adjustment (assimilation) linking reaction theory and integral experiments

- Modern practice is to use nuclear reaction code constrained by experimental data to produce evaluation and covariances



Consistent adjustment (assimilation) linking reaction theory and integral experiments

- Tuning is moved from multi-group file to reaction model parameters providing
 - evaluation constrained by differential and integral data and reaction theory
 - covariances



Theoretical activities

Collaboration with the theory community

- **Improve theory based modeling**

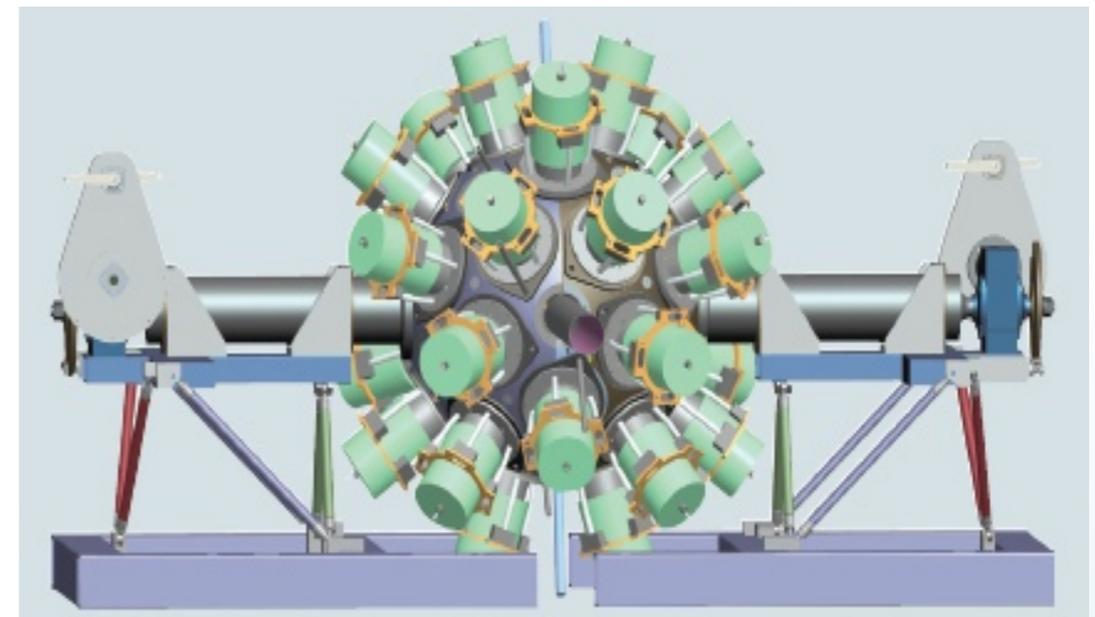
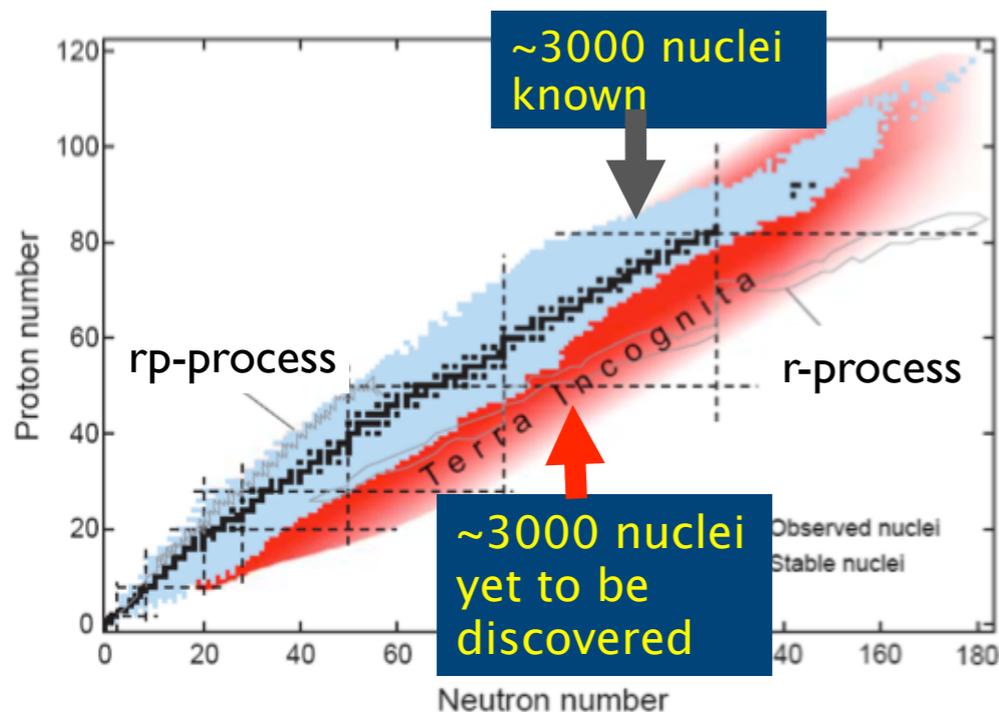
- further improvement of fission channel
- advance covariance methodology
- more microscopic input parameters in reaction calculations
- explore possibility of using results of the SciDAC Universal Nuclear Energy Density Functional (UNEDF)

- **Archive and disseminate results of (UNEDF)**



- codes: feasible with NNDC-GForge server
- results: a challenge - terabytes of data per year

Challenge of new, high quality data from FRIB(MSU), CARIBU(ANL), RIKEN, TRIUMF, GANIL, CERN, GSI



GRETINA-AGATA γ -ray tracking arrays

F. Kondev

- New data foreseen for nuclear structure & reactions involving nuclei far from the stability line
- data need to be promptly compiled, evaluated & disseminated to support scientific discoveries and preserve investment
- development of new evaluation methodologies, strategies & dissemination tools that are tailored to the specific needs

Experimental activities

preserve skills, make program more attractive

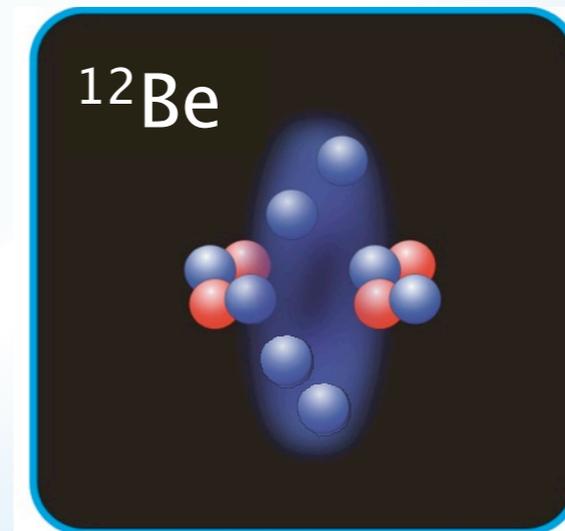
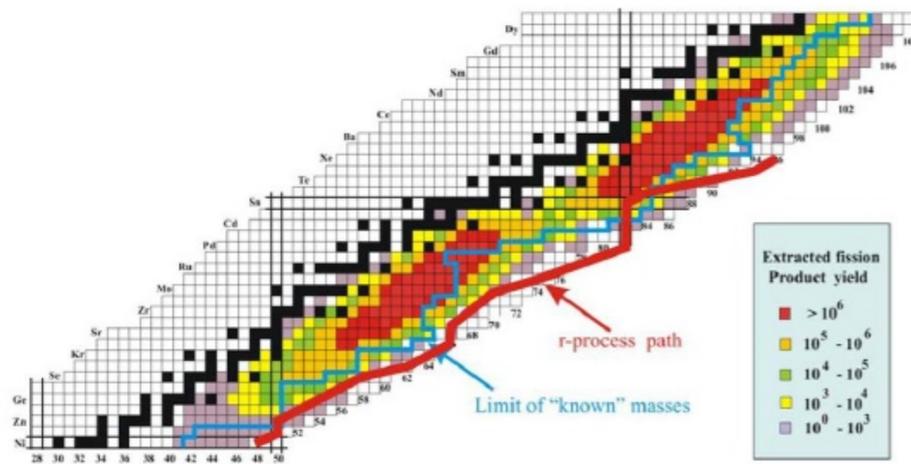
- Accepted NNDC proposals at major facilities

Precision β -delayed neutron emission in ^{138}I
(CARIBU, ANL)

- Reactor control, shut down, post-processing of fuel
- r-process nucleosynthesis

Precise measurement of the $B(E2; 2 \rightarrow 0)$ in ^{12}Be
(GRETINA, MSU)

- Confirmation and guidance of new ab-initio theories
- Influence of loosely-bound neutrons



- In planning: measurement of β spectra at Yale

Employ modern IT technology collaboration, dissemination and formats

- **Use modern IT tools for coordinated data development**
 - GForge collaboration system, SVN versioning system, automatic data verification.
- **Upgrade data dissemination**
 - applications for mobile devices
 - physics calculations on demand (on ND center servers)
- **New XML format (moving into XXI century)**
 - take advantage of XML flexibility and existing software



Conclusions

- Nuclear Data Program
 - provides essential support for basic science and applications
 - preserves knowledge by archiving experimental and evaluated data
 - develops state of the art modeling of reactions
- Future opportunities
 - advance evaluation methodology
 - unification of structure and reaction data
 - enhancing experimental program
 - modernization of formats and data retrievals
 - CIELO: world-wide reaction data file