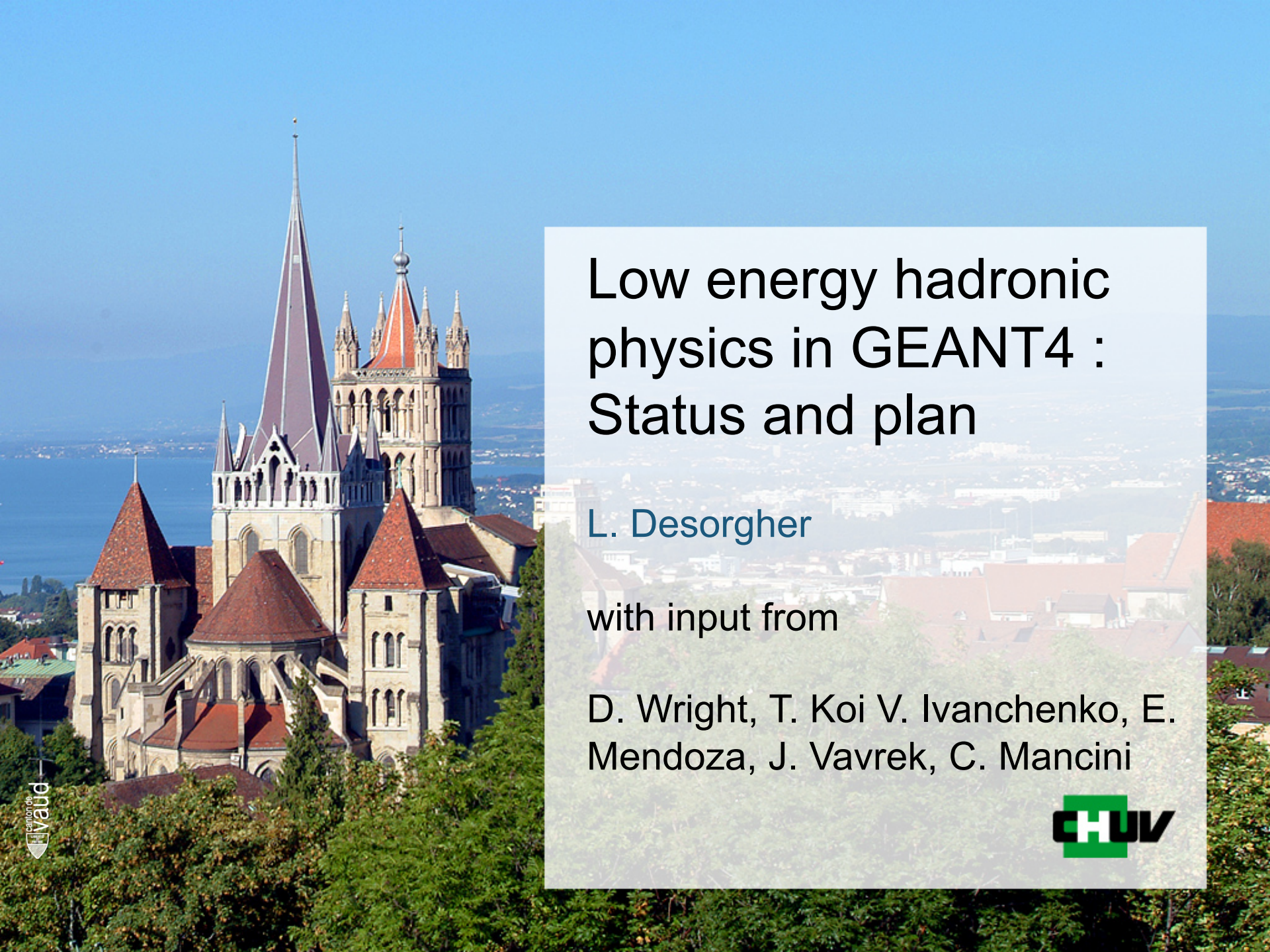


Low energy hadronic physics in GEANT4 : Status and plan

L. Desorgher

with input from

D. Wright, T. Koi V. Ivanchenko, E. Mendoza, J. Vavrek, C. Mancini

Outline

- De-excitation and Precompound
- Low Energy models for neutrons (and protons)
- Radioactive decay
- Gamma nuclear
- Ions-Ions

Pre-compound/de-excitation developments (V. Ivanchenko)

- Main developments for pre-compound/de-excitation were completed for Geant4 10.4
  - Migration to PRECO/DEEX parameters
  - Migration to new gamma data structure consistent with radioactive decay module
  - Provide long-lived isomere production
    - Added floating level states
  - Provide correlated gamma emission for radioactive decay
- For Geant4 10.5 mainly maintenance and bug fixes were performed
  - There are several items in the work plan for 10.5 to be added
- Essential for low energy hadron/ion transport are modifications in neutron and light ion cross sections

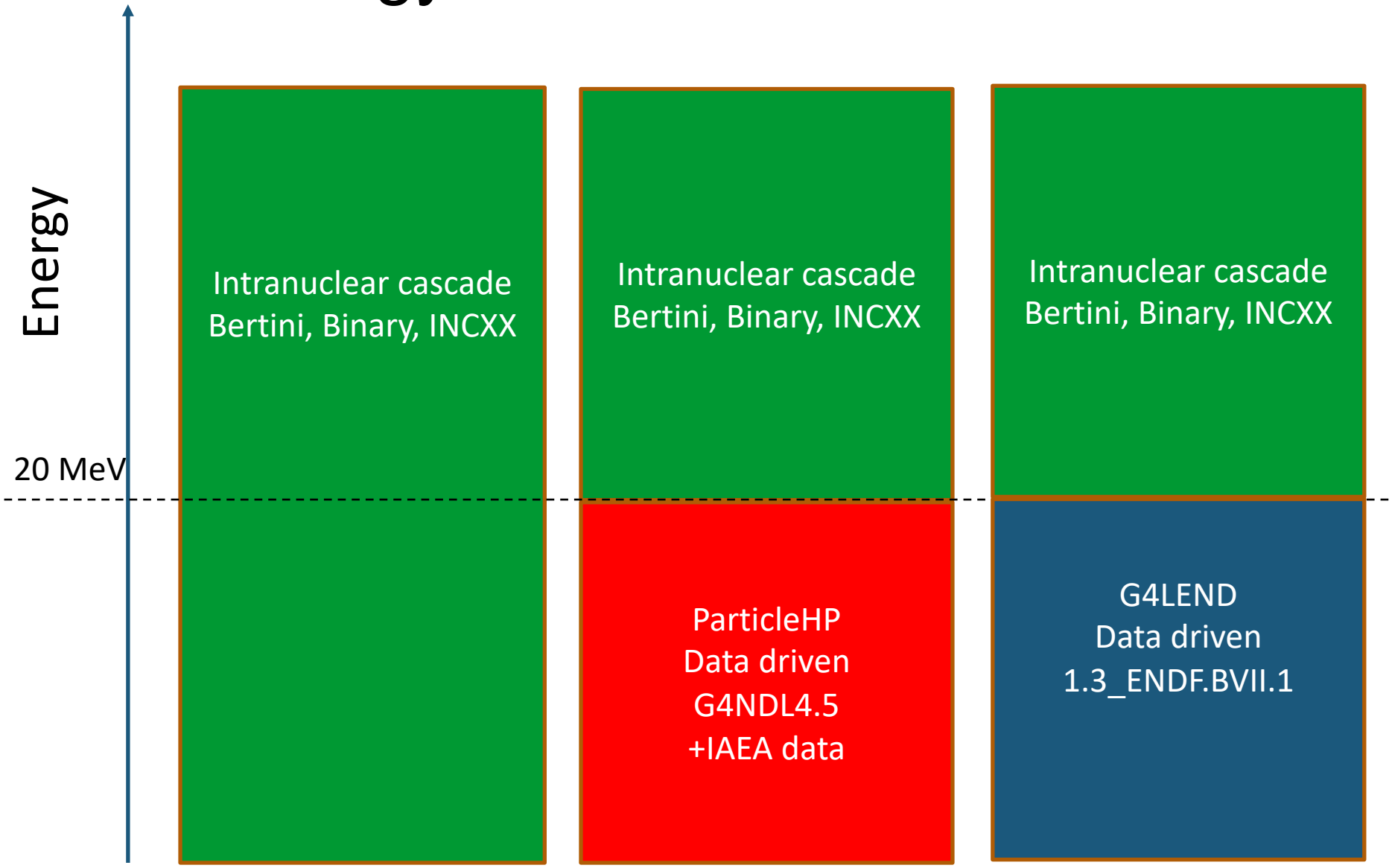
Photo Evaporation database

- Database is stable no changes in format for this year!
- Slight modification of few nuclei from 5.2 to 5.3
- Extension of internal conversion data to the N shell ???

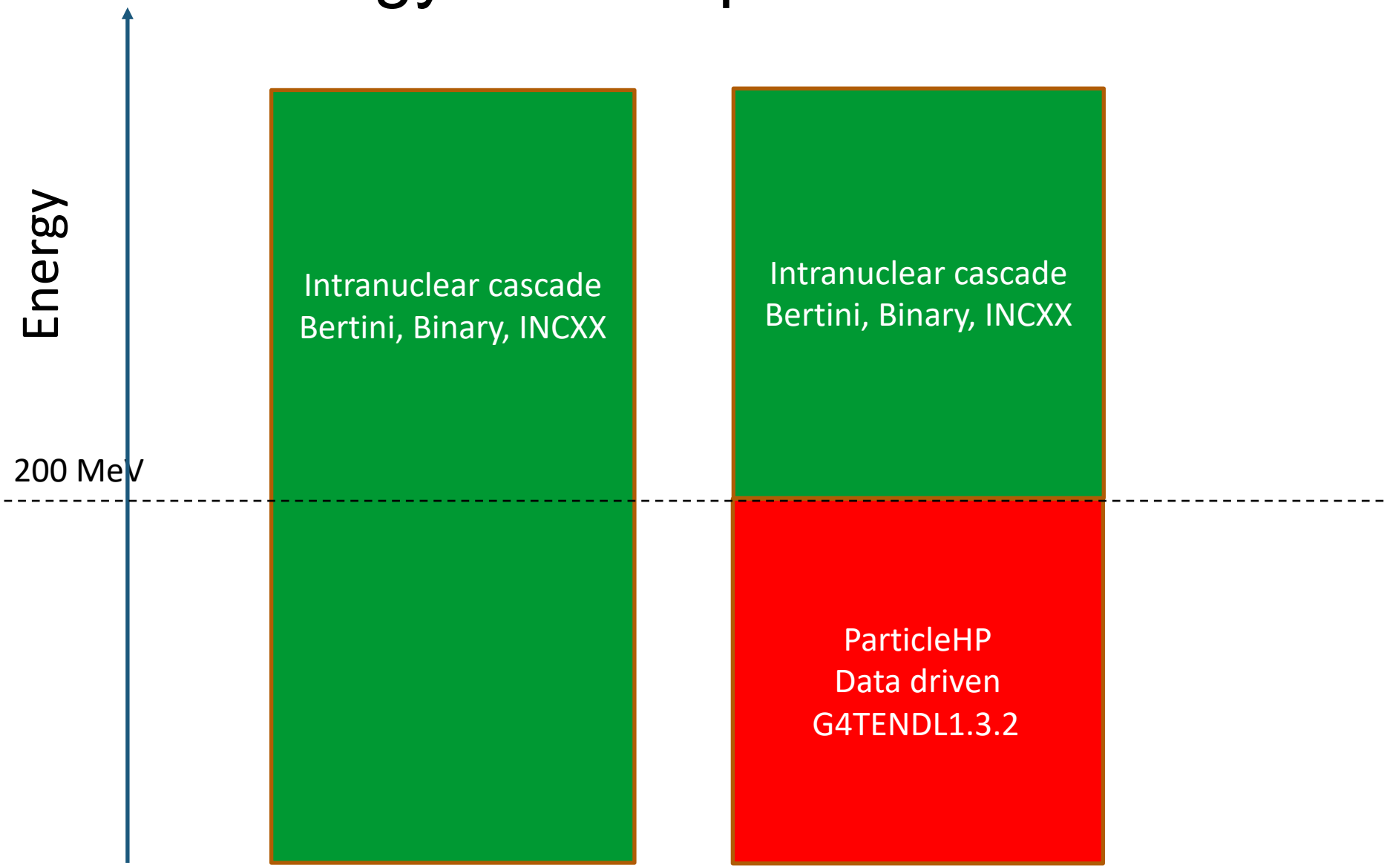
G4NEUTRONXS2.0 (V. Ivanchenko)

- Structure of the data set is changed because of particle HP
  - Separate directories for n, p, d, t, he3, he4 cross sections
  - Element x-sections from threshold to max hadronic energy (100 TeV)
    - Physics data tables shared between threads extracted from ParticleHP
    - Glauber Gribov cross section above 20 GeV
- Added extra isotope data for 11 more elements (was 17 before)
  - Ne, Mg, S, Cl, K, Sc, Ti, Ga, Pd, In, Pt
  - Limit on isotope abundance is reduced to 0.001 (was 0.01)
- Fixed discontinues in last bins
  - Isotope data only for E < 20 MeV
- Fixed G4CrossSectionDataStore code
  - Isotope selection
  - Integral approach
  - Added possibility to remove unused data sets
    - Problem #2057
- New proton and light ion inelastic x-section is tested in QBBC Physics List

Low energy models neutrons



Low energy models proton



ParticleHP status

- Maintained and developed by T.Koi till GEANT4 10.4
  - Added NREPS71 model to accurate n+C reactions
  - New TENDL data for p, alpha, triton, up to 200 MeV
- Maintenance and bug reports taken over by
  D. Wright, E.Mendoza, D. Cano-Ott, P. Arce
- Some fixes by V. Ivantchenko and A. Ribon
- Update and validation of the IAEA Geant4 neutron data
  E. Mendoza, D. Cano

New NeutronHP IAEA data

E. Mendoza , D. Cano -Ott
CIEMAT

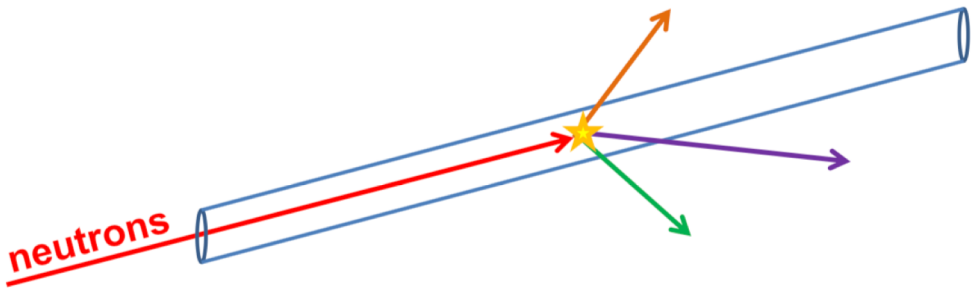
Update and validation of the IAEA Geant4 neutron data

JEFF-3.1, JEFF-3.0, ENDF/B-VII.0, ENDF/B-VI.8, CENDL-3.1, BROND-2.2, JENDL-4.0, JENDL-3.3.

JEFF-3.3, JEFF-3.2, ENDF/B-VIII.0, ENDF/B-VII.1, BROND-3.1 and JENDL-4.0u (version 2016/1/6).

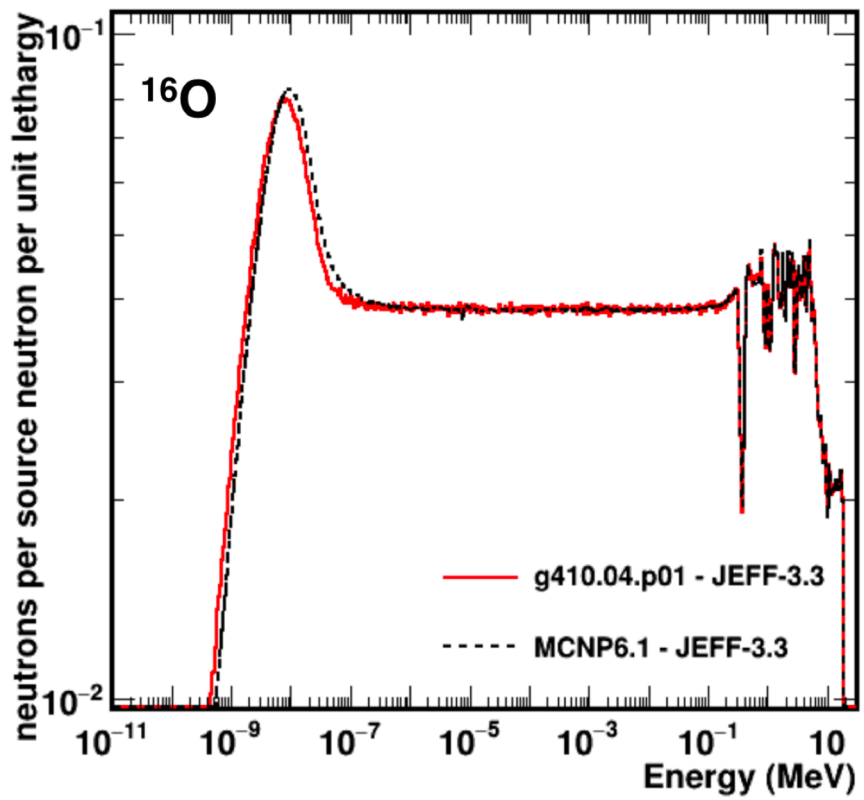
Validation of IAEA data G4 vs MCNP6

E. Mendoza and D. Cano-Ott, IAEA report, June 2018



Neutrons

- Neutrons 10^{-10} – 20 MeV
- Isotope Target



ParticleHP plan for 10.5

- Maintenance of ParticleHP
  P. Arce, E. Mendoza & D. Cano Ott, T. Koi, Dennis Wright

- Maintenance and update of the IAEA Geant4 neutron data
  E. Mendoza & D. Cano Ott

- Maintenance of the Wendt Fission Fragment module
  B. Wendt

G4LEND status and plan

- Maintained and developed by T.Koi till GEANT4 10.4

- Maintenance and further development
  Douglas Wright, Jerome Verbeke LLNL

- data **ftp://gdo142.ucllnl.org/LEND_GND1.3/** 2014

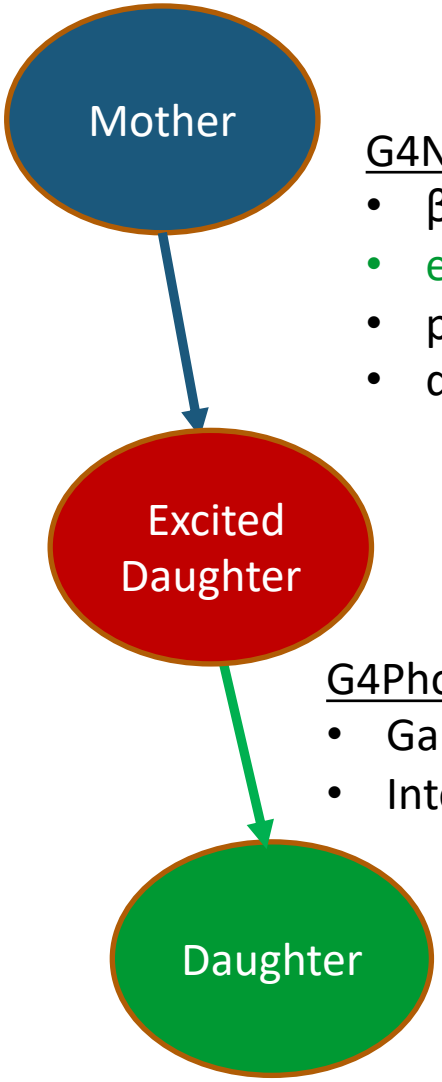
Plan

- Development for neutron- and gamma-induced reactions J. Verbeke

- New version of LEND/GIDI Douglas Wright

- Maintenance and support of physics lists for LEND J. Verbeke & Douglas Wright

Radioactive module in Geant4



G4NuclearDecay

- β^-,β^+, α
- e^- capture K,L, M, + N
- p,n emission
- discrete β^- n delayed

G4PhotoEvaporation

- Gamma transition
- Internal conversion

G4AtomicRelaxation

- Xrays emission
- Auger emission

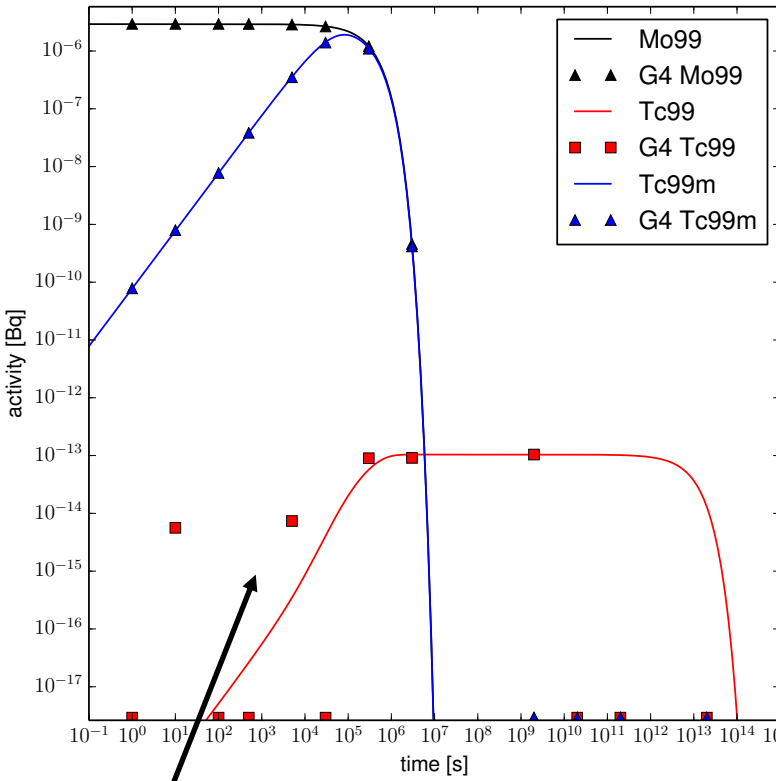
Two simulation modes

- Analog
- Biased

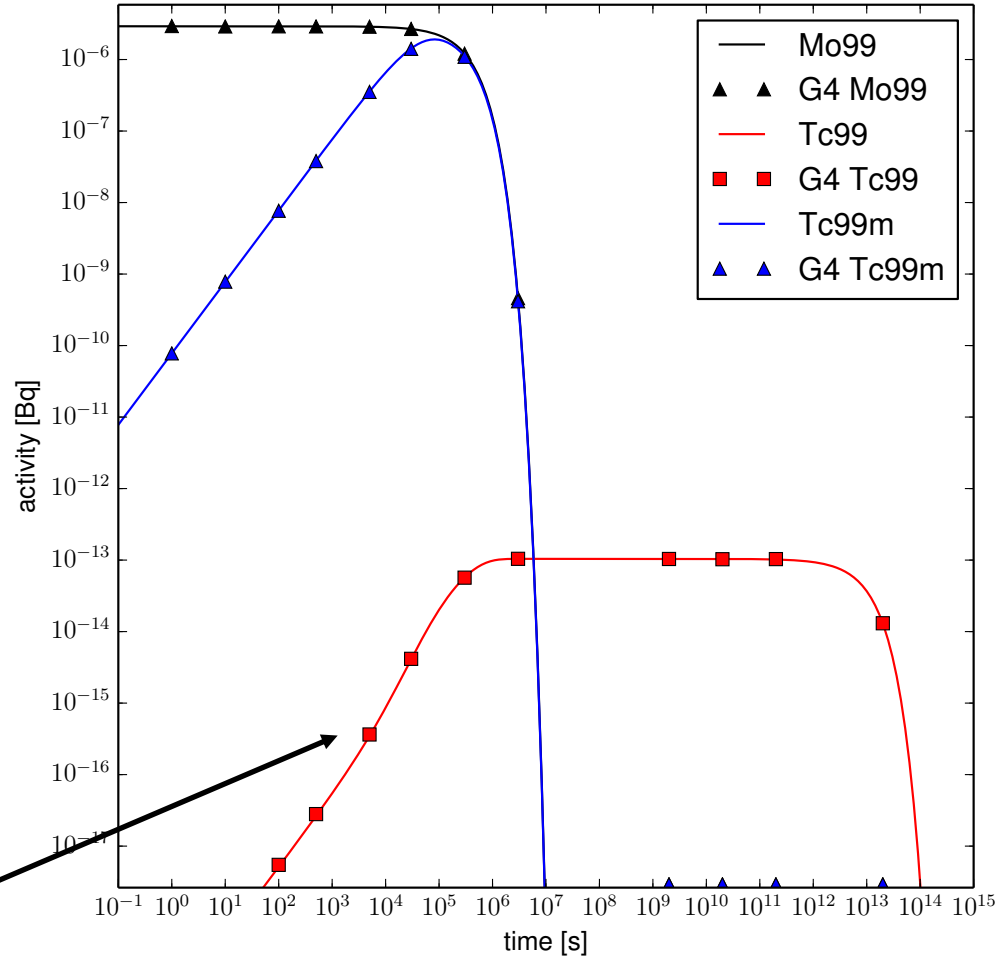
Code and database are stable now!

Correction of biased mode of G4RadioactiveDecay

Dennis wright



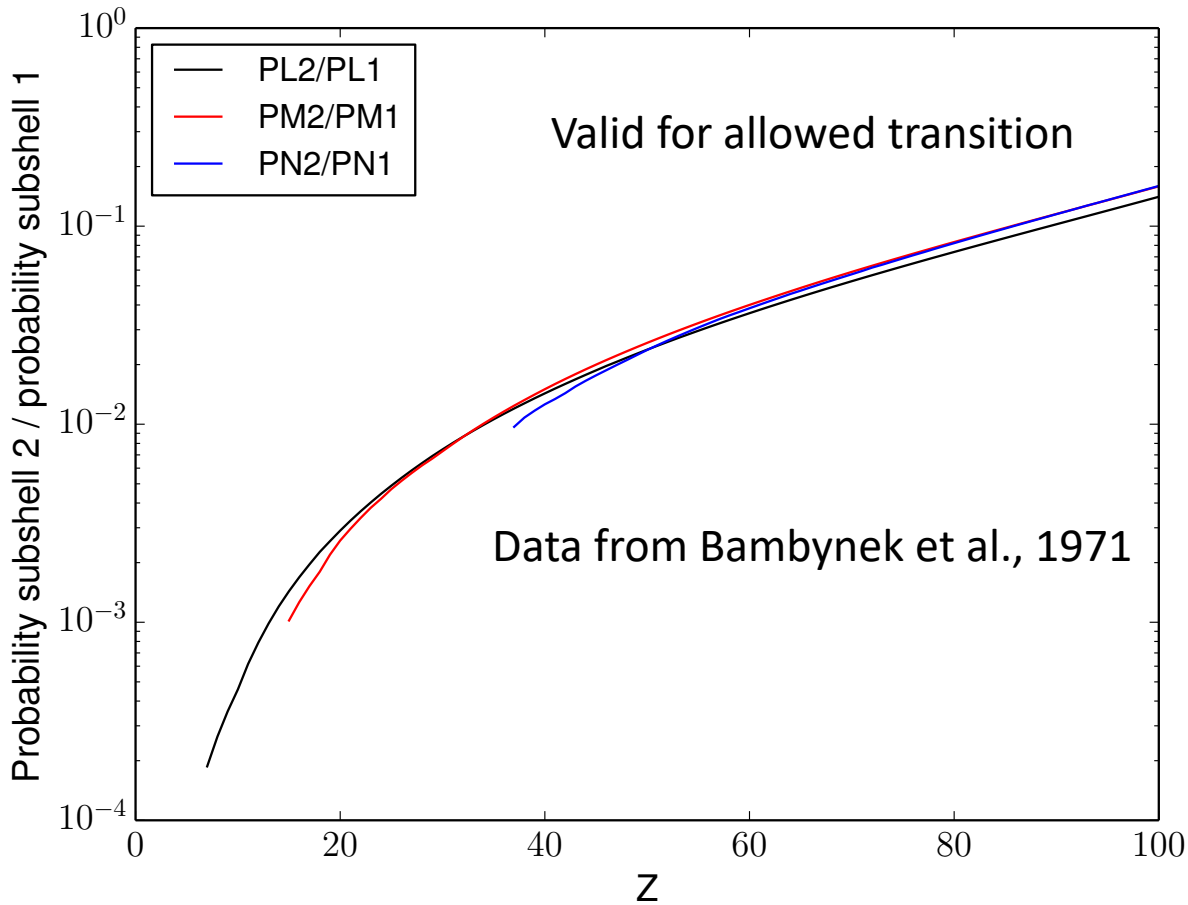
After correction



Improvment of electron capture

L. Desorgher

- Extend G4ECapture to the N Shell : ^{54}Mn data in G4Database
- Improve the probability of partial probability of capture from subshell



G4RadioactiveDecay Plan

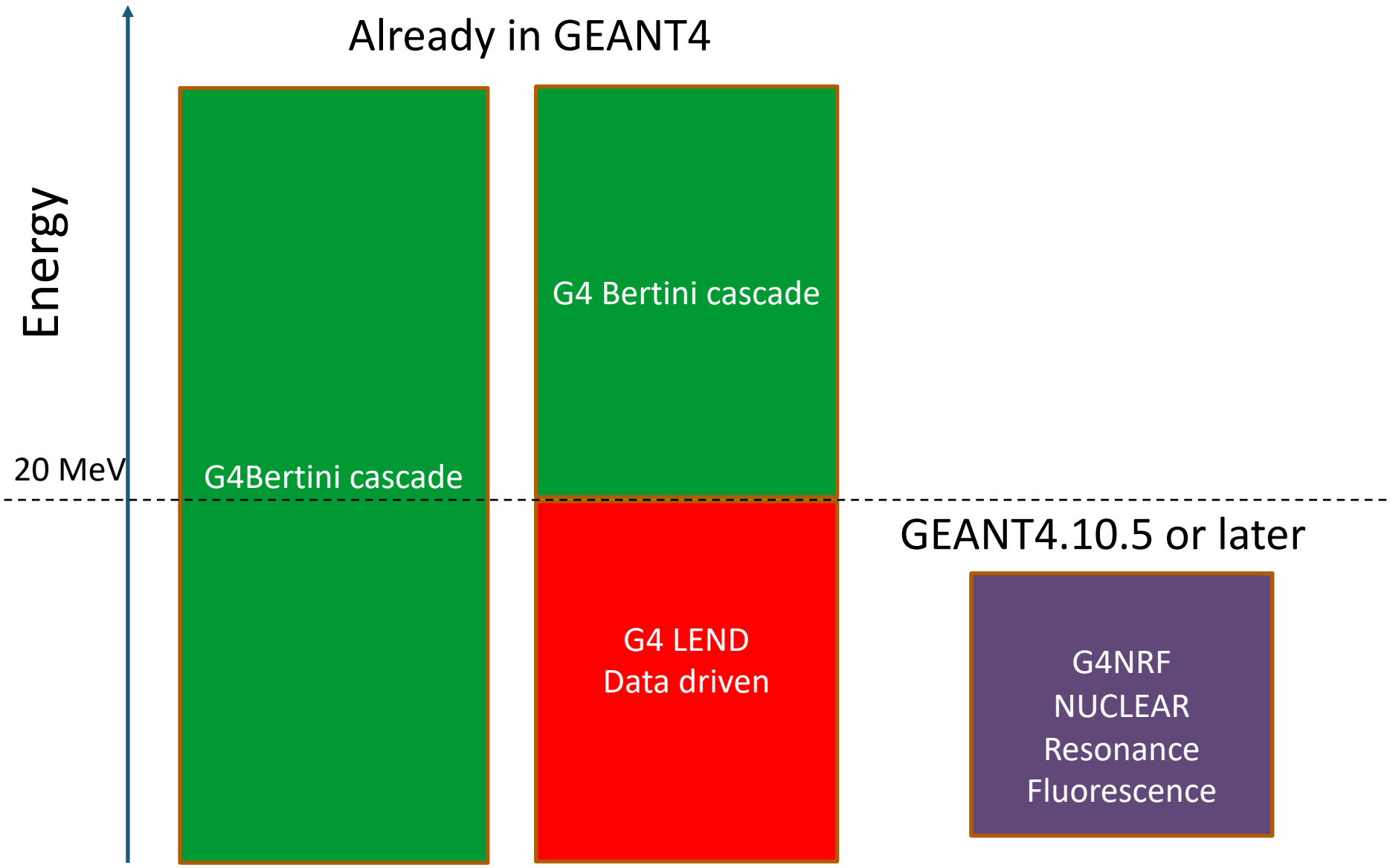
GEANT4.10.5

- RDM biasing improvements D. Wright
- Improvments Electron Capture L. Desorgher
- Maintenance of the RDM & PhotoEvaporation data-sets L. Desorgher
- Declare Radecay Mode as Creator Model Index to secondary Track

FUTURE

- Beta-delayed neutron emission, Super Heavy Elements L. Sarmiento
- Publication
- Validation plots D. Wright, L.Desorgher

Gamma nuclear interaction models



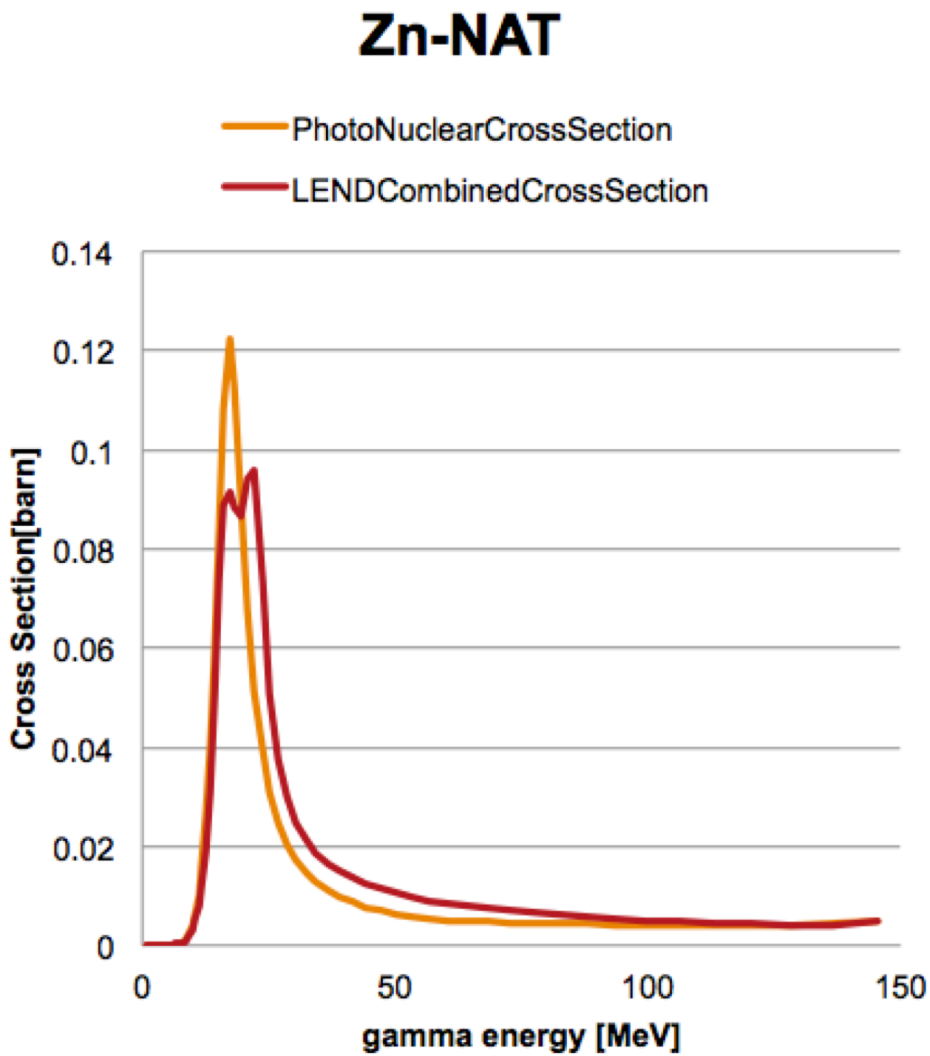
Gamma nuclear
G4LENDOrBertModel since G4.10.4

Tatsumi Koi, Dennis wright

- G4LEND models below 20 MeV when data exist
  - database has γ interaction information on isotopes from D to ^{241}Pu
  - cross sections also come from LEND, unless no data, then use G4PhotoNuclearCrossSection as we do now
- Otherwise use Bertini
- Available in ShieldingLEND physics lists
- New test will be implemented

Cross Section Comparison, LEND vs. G4PhotoNuclearCrossSection

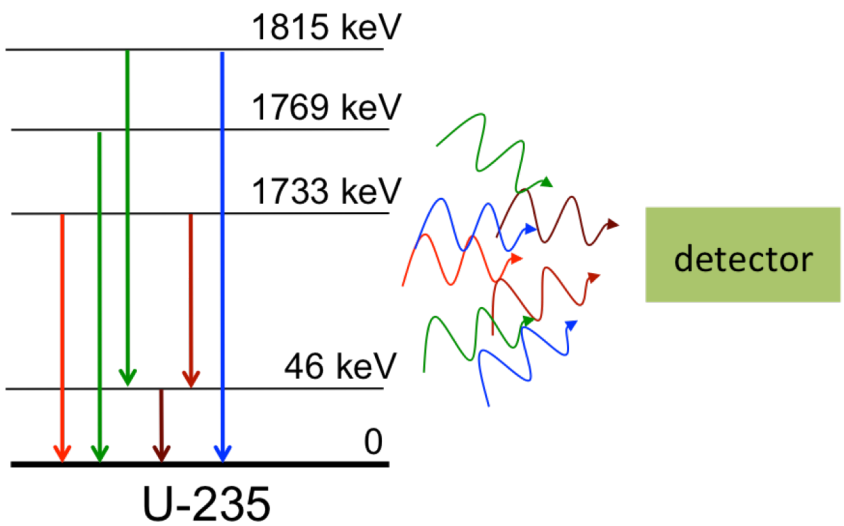
Tatsumi Koi, Dennis wright

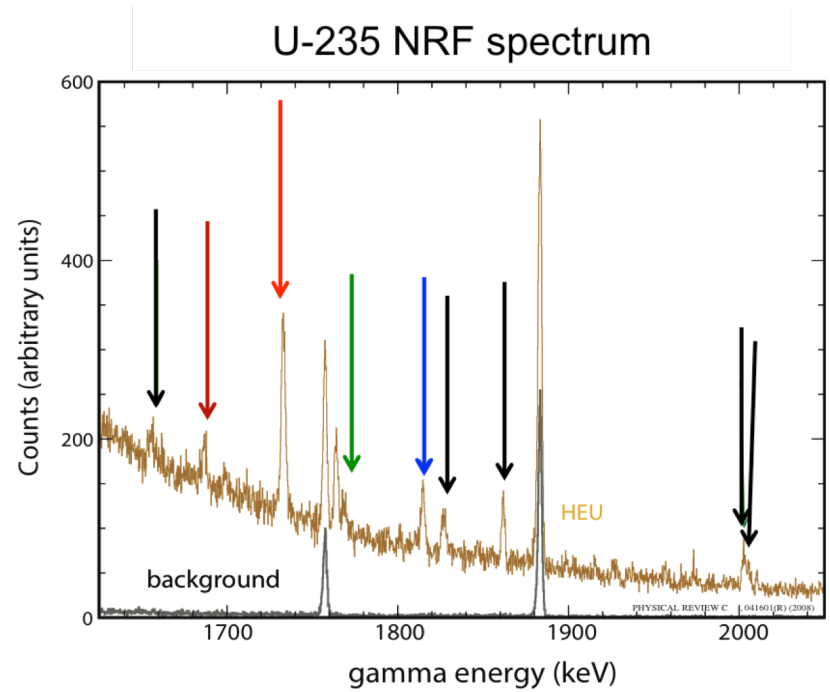


Gamma Nuclear Fluorescence G4NRF

Jayson Vavrek, MIT

Nuclear resonance fluorescence (NRF) to make isotope-specific measurements

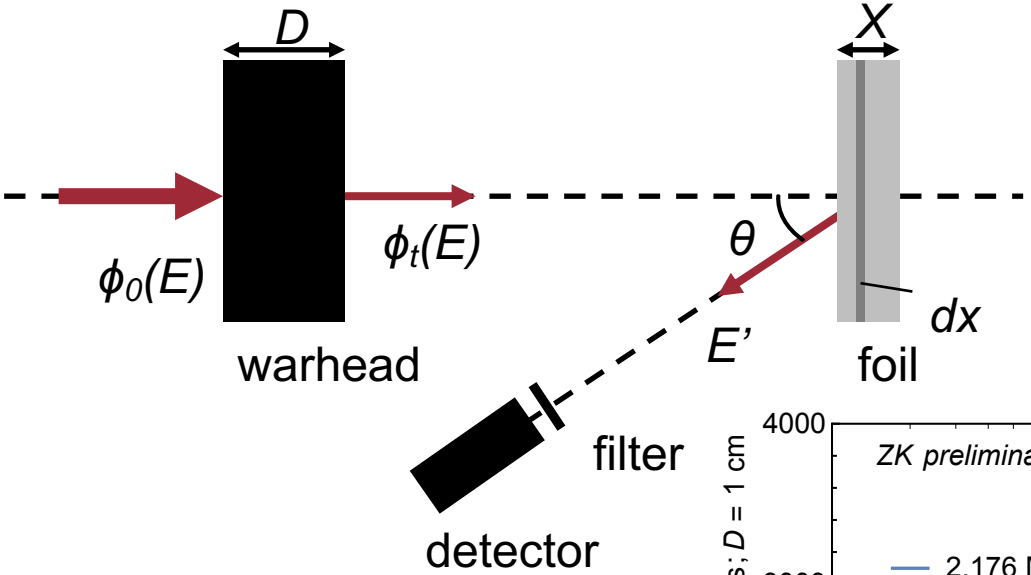


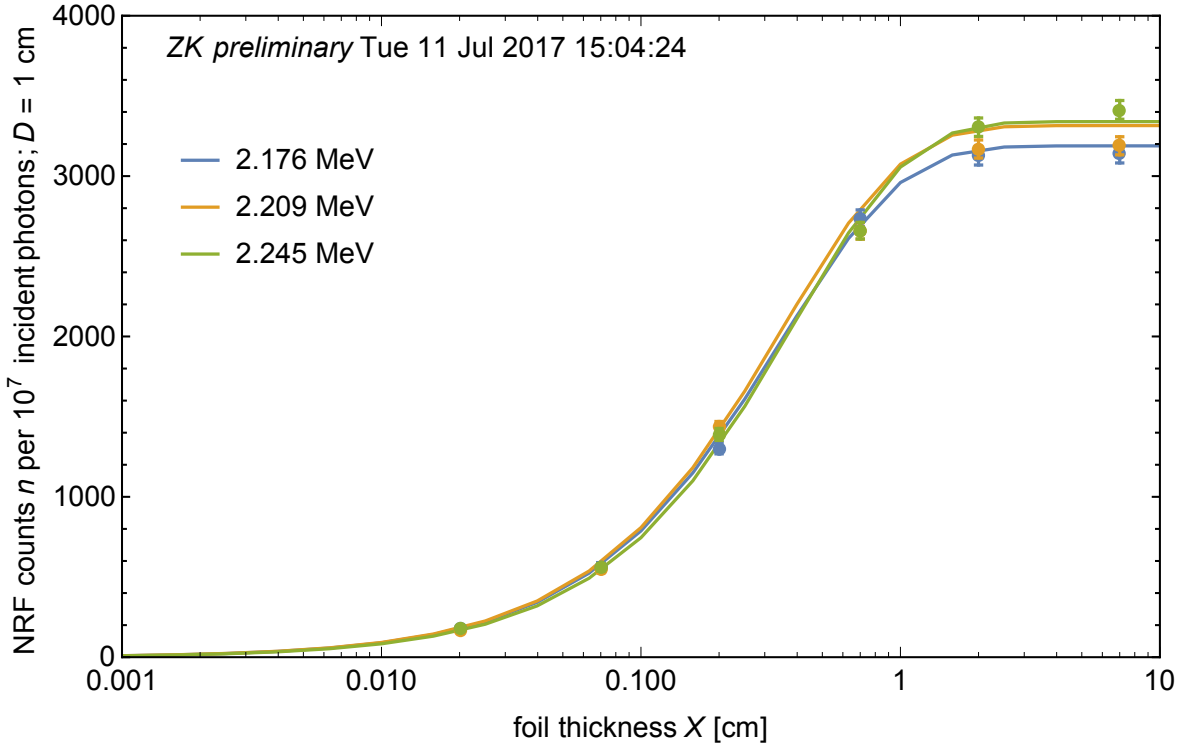


different line spectra for U-235, U-238, Pu-239, Pu-240…

Gamma Nuclear Fluorescence G4NRF

Vavrek et al., NIM B, 2018



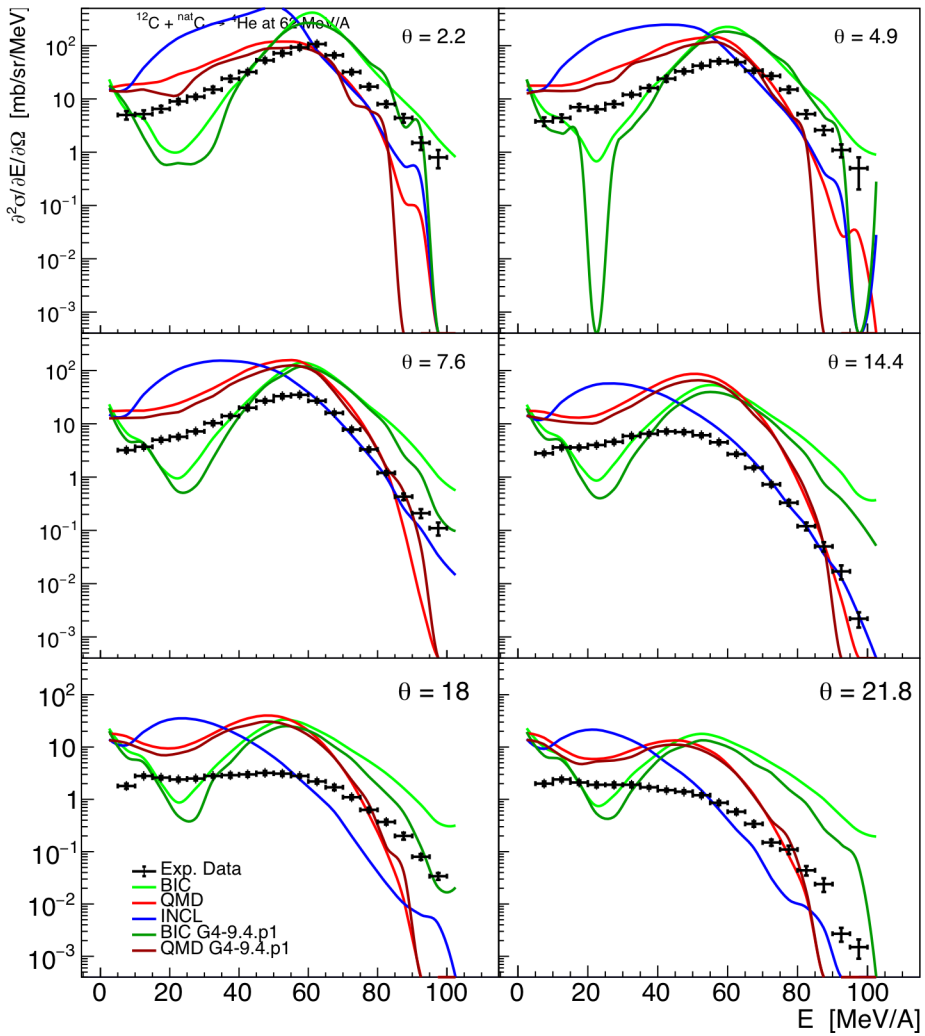


G4NRF status and plan

- G4NRF code and database completed
- Available on https://github.com/jvavrek/NIMB2018
- Discussion needed for inclusion into next release or later

Ions- Ions Carlo Mancini

- Update of the benchmark test with INCL model



- Development of G4 interface with SMB and BLOB