IRSN data processing tools in the resonance region

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Summary

- Why a nuclear data processing code at IRSN ?
- Overview
- The resolved resonance processing
- The unresolved resonance processing
- An object-oriented nuclear data handler
- Conclusions

Why a nuclear data processing tool

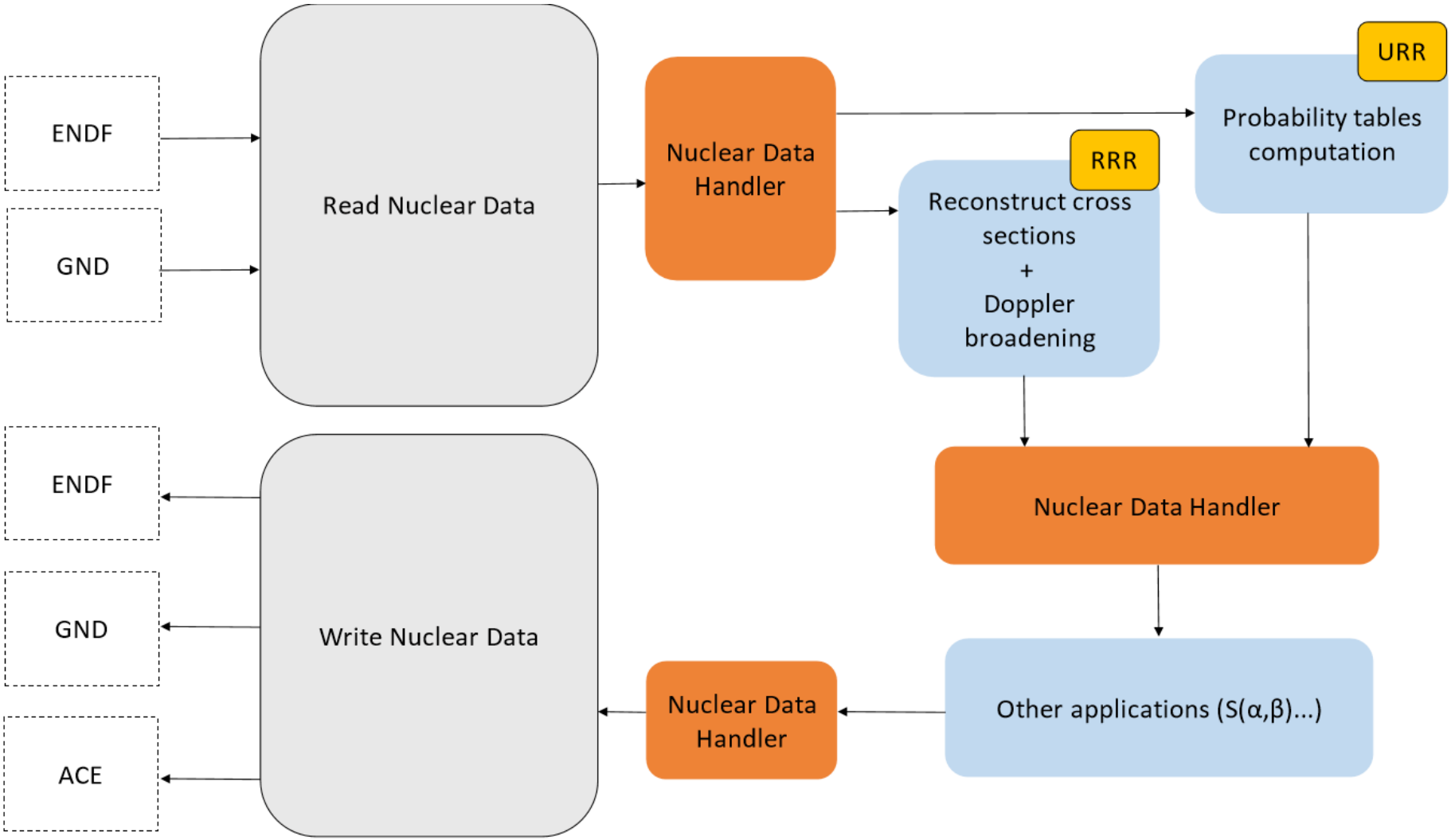
- IRSN = French Radioprotection and Safety Institute

- Need of quality nuclear data for safety applications :
  - criticality computations ;
  - reactor neutronics ;
  - uncertainties propagation quantification.

- Developing its own tool :
  - cross-checking ;
  - new numerical methods.

- GAIA-2.0 : a standalone C++-14 modular processing code :
  - library generation (ACE, PENDF) ;
  - reading from multiple evaluation formats (ENDF, GND) ;
  - reconstruction of resonances and Doppler broadening in a single step ;
  - generalized R-matrix formalism ;
  - Fourier transforms for the Doppler effect ;
  - not based on the ENDF-6 format.

Overview


ENDF
GND
Read Nuclear Data
Nuclear Data Handler
URR
Probability tables computation
RRR
Reconstruct cross sections + Doppler broadening
Nuclear Data Handler
Other applications (S(α,β)...)
Nuclear Data Handler
Write Nuclear Data
ENDF
GND
ACE

The resolved resonance range

- In the resolved resonance range :
  - full R-matrix formalism (no approximation) thanks to a *ST decomposition* of the R-matrix ;

$$R = S^{-1}T \qquad C = \left(\mathbb{1} - RL^0\right)^{-1} R = \left(S - TL^0\right)^{-1} T$$

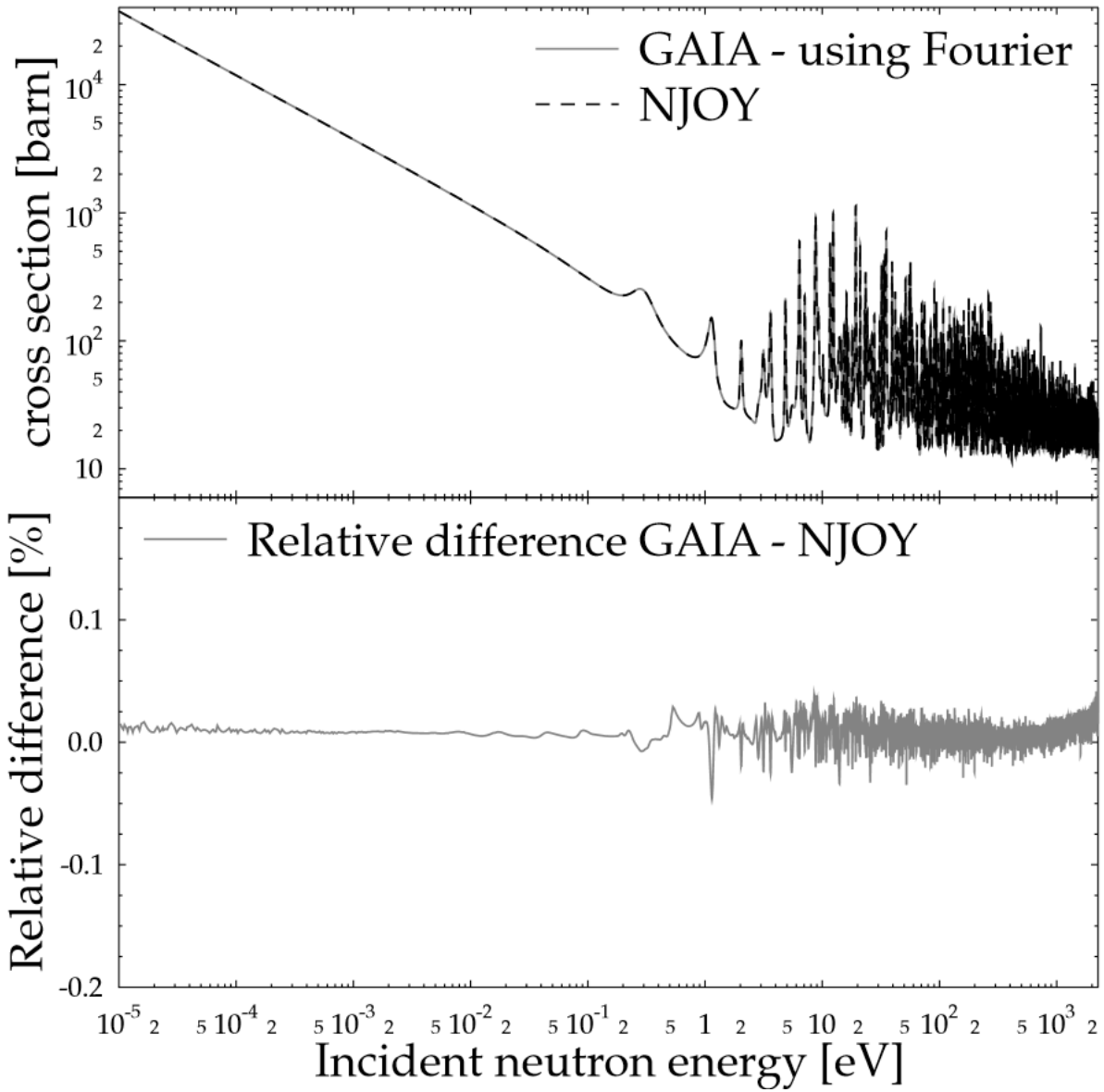
  - direct Doppler broadening of the Solbrig Kernel, without any linearisation (unlike SIGMA1), thanks to the use of Fourier transforms.

$$\sigma_T(E) = \frac{1}{E}\sqrt{\frac{\alpha}{4\pi}}\int_0^{+\infty}\sqrt{E_r}\,\sigma_0(E_r)\left[e^{-\alpha\left(\sqrt{E}-\sqrt{E_r}\right)^2} - e^{-\alpha\left(\sqrt{E}+\sqrt{E_r}\right)^2}\right]dE_r$$

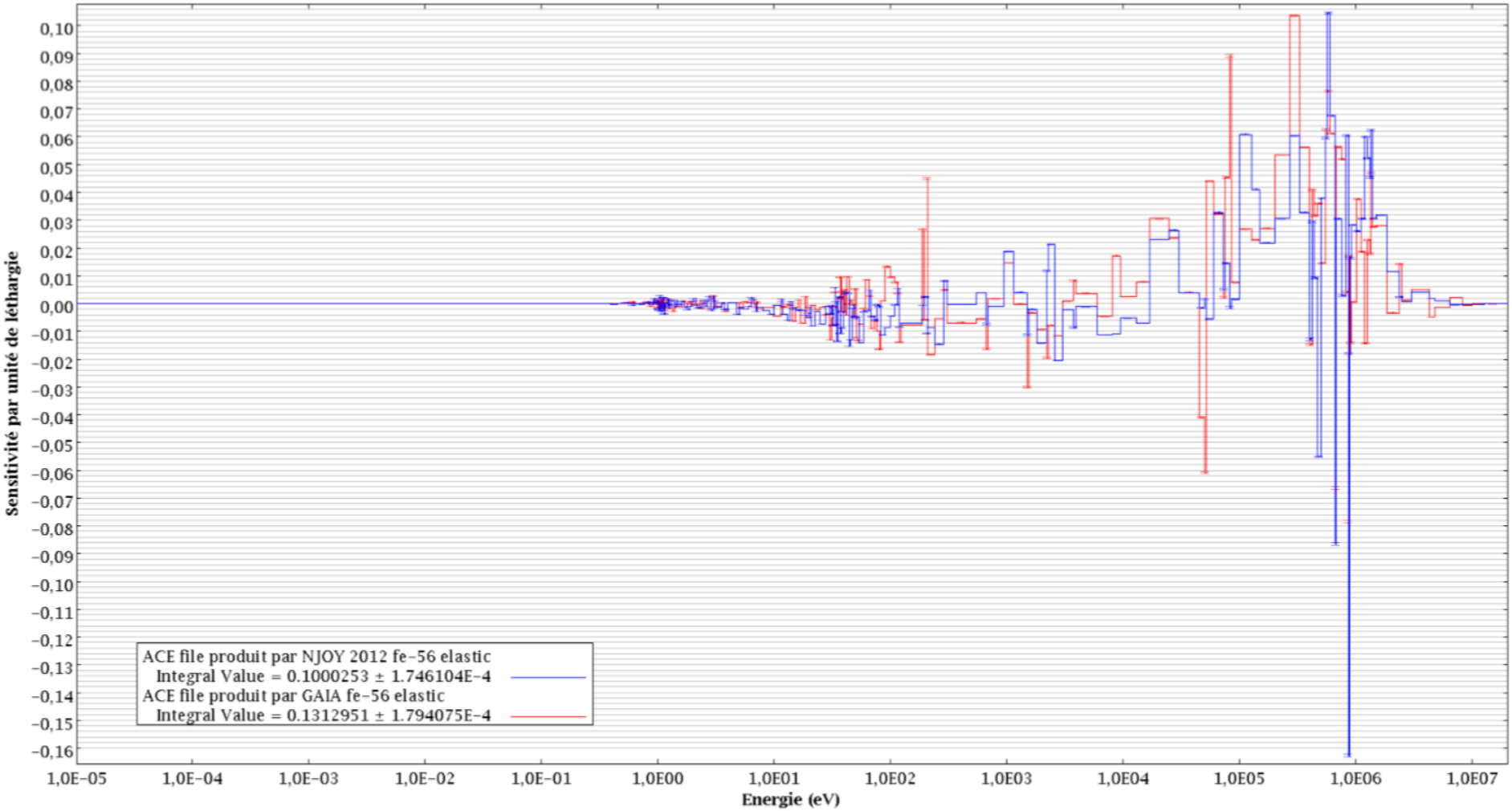
- Results compared to NJOY, PREPRO, SAMMY, and benchmarks.

- G.Ferran, W.Haeck, M. Gonin, “Development Progress of the GAIA Nuclear Data Processing Software”, *Nuclear Data Sheet*, April 2014

The resolved resonance range



The resolved resonance range

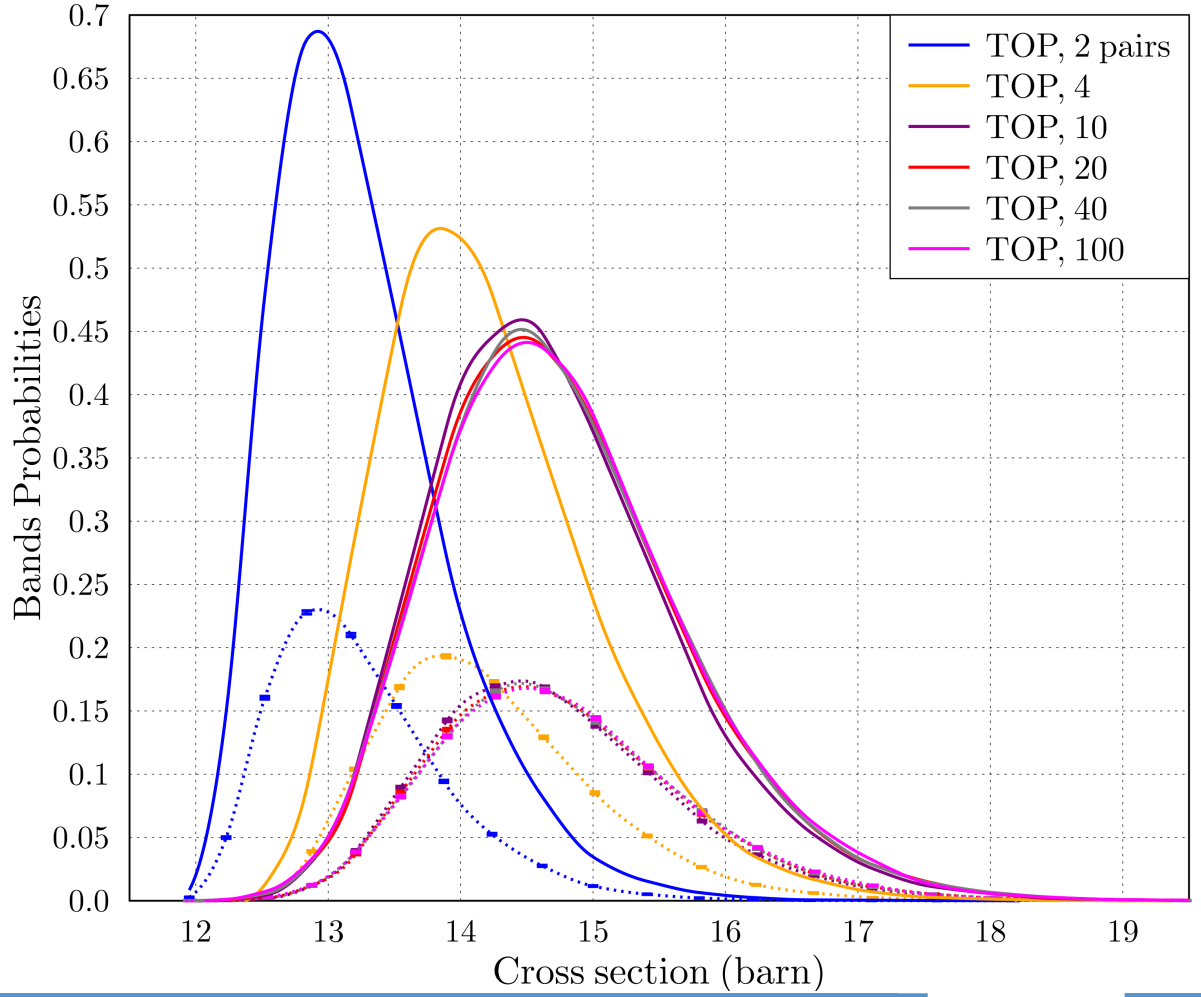


Sensitivity of HEU-MET-INTER-001,
elastic scattering of 56Fe (LRU=1, LRF =7)

The unresolved resonance range

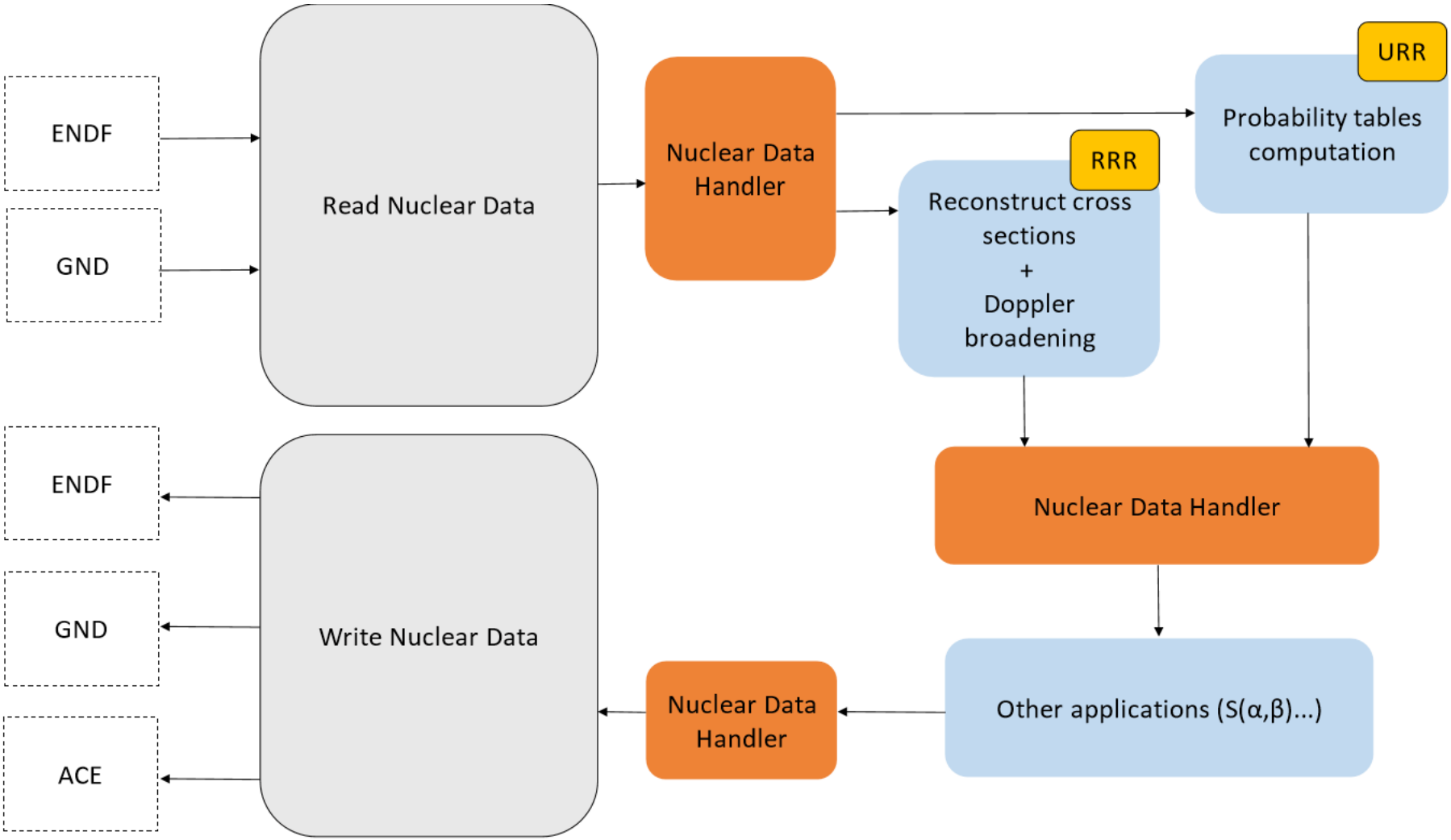
- Probability tables generation, thanks to a method similar to PURM (AMPX)

- Statistic resonances are obtained across the unresolved resonance range by *pairs*.



U235, E=2,5 keV, p(σ_{tot}) for different numbers of resonances

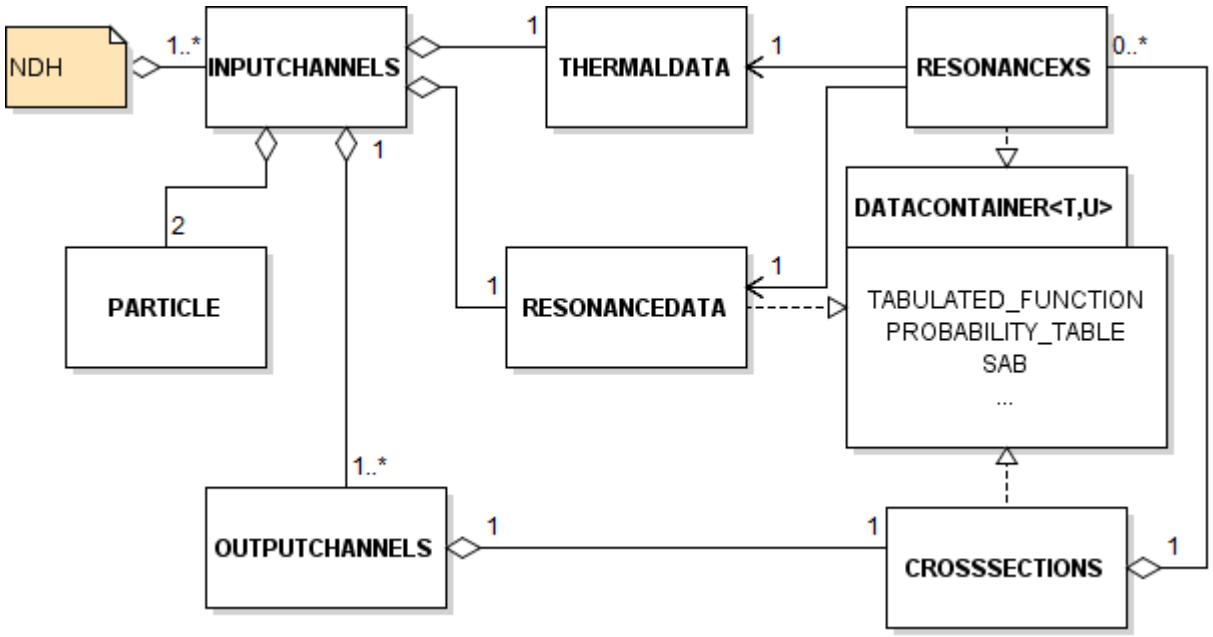
An object-oriented nuclear data handler



An object-oriented nuclear data handler

- Shall be independent from the ENDF format
- Shall contain hierarchised and organized nuclear data, without redundency
- Be able to pass and keep relevant information between the modules

→ A serialized set of C++ classes



Conclusions

- It is possible to open a 'restaurant' → a nuclear data processing tool
  - GAIA is still a R&D code,
  - not all of a full processing code's features are implemented,
  - it is a focus on some points.

- First results from GAIA correspond to NJOY's, with fully different numerical methods.

- An effort is made to push the code forwards :
  - preparation for the GND format
  - structure allowing the independence of modules
  - compatibility with other codes because of the modularity

  → Treatment of the thermal range (S(α,ß))

  → Treatment of the unresolved resonance range : Phd starting now

  → IRSN will more closely work with the CEA (CALENDF)