GALILEE: A nuclear data processing system for transport, depletion and shielding codes

Presented by M. COSTE-DELCLAUX

CEA Saclay/DEN/DANS/DM2S/SERMA/LLPR France

Contents

- Introduction
- GALILEE-V0
  - Description
  - Developments in progress
- GALILEE-Vn n ≥ 1
  - General description
  - Implementation
  - Validation/Qualification
- Conclusion

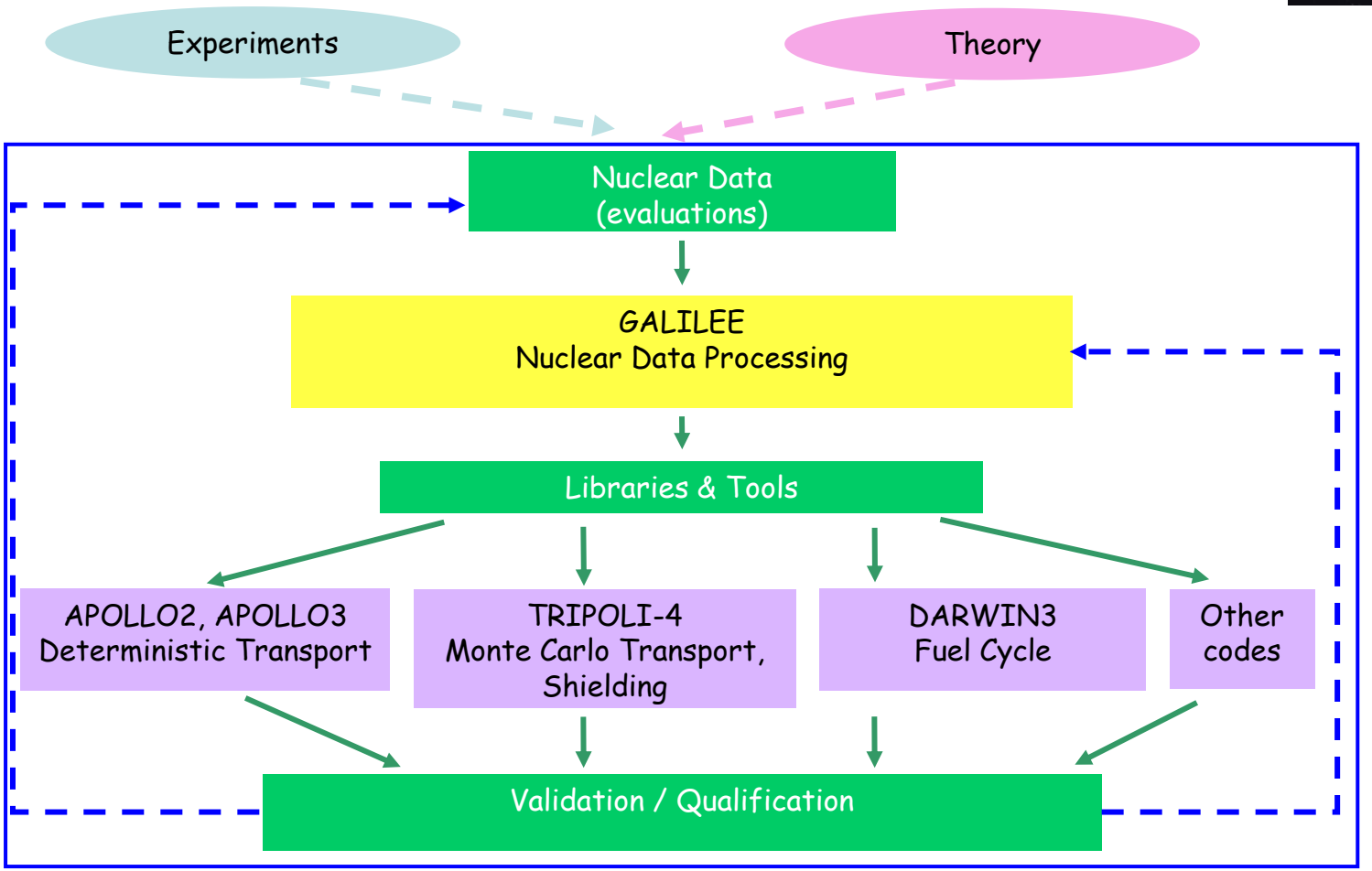
GALILEE Project

- CEA **Nuclear Data Processing System** for Transport, Depletion and Shielding Codes (application codes)

- Part of a CEA global development program dedicated to fine modelling of nuclear systems.
  - Other projects contributing to this aim:
    - APOLLO3 (deterministic transport)
    - TRIPOLI-4 (Monte Carlo transport)
    - DARWIN3 (all fuel cycle problems)

- GALILEE aims:
  - To provide to application codes a **tool-box** allowing a consistent processing for nuclear data coming from any evaluation given in ENDF/B6 format,
  - To carry out an **automatic chain** for creating application libraries,
  - To provide **consistent application libraries** for modelling a nuclear system.

GALILEE project context



GALILEE project must be carried out in synergy

- **with application codes in order to be able to share "data" but also "tools"**
- **with codes creating evaluations (CONRAD) in order to be able to share physical models**

Why a processing system

- Nuclear Data stored in evaluations cannot be directly used in application codes
  - Cross-Sections given by resonance parameters in Resonance Range
  - Angular transfer laws given by Legendre polynomials decomposition (max. P64) at various incident energies
  - …
- Processing step requires
  - Physics: cross-section reconstruction thanks to **nuclear formalisms**
  - Numerical methods: Multigroup parameters calculations thanks to integration techniques
  - Computing: Library creation with a given format
- Process depends on:
  - Kind of information stored in an evaluation
  - Physical problem studied
  - Models used in application codes

GALILEE Project Steps

- GALILEE-V0
  - Reinforce our experience in Nuclear Data Treatment
    - ~20 know-how years
  - Perpetuate our specific processing tools

- GALILEE-Vn, n≥1
  - Carry out a **new** Nuclear Data processing system
  - Ensure consistency with evaluation data production
  - Insert Nuclear Data processing as one of the major components of a nuclear system modelling
  - Have a processing system at the same "Quality Level" as the new Physics Core or Criticality Codes
    - APOLLO3 (CEA)
    - TRIPOLI-4 (CEA)
    - DARWIN3 (CEA)
  - Introduce a « modularity » between nuclear data treatment and application codes

GALILEE-V0 Description

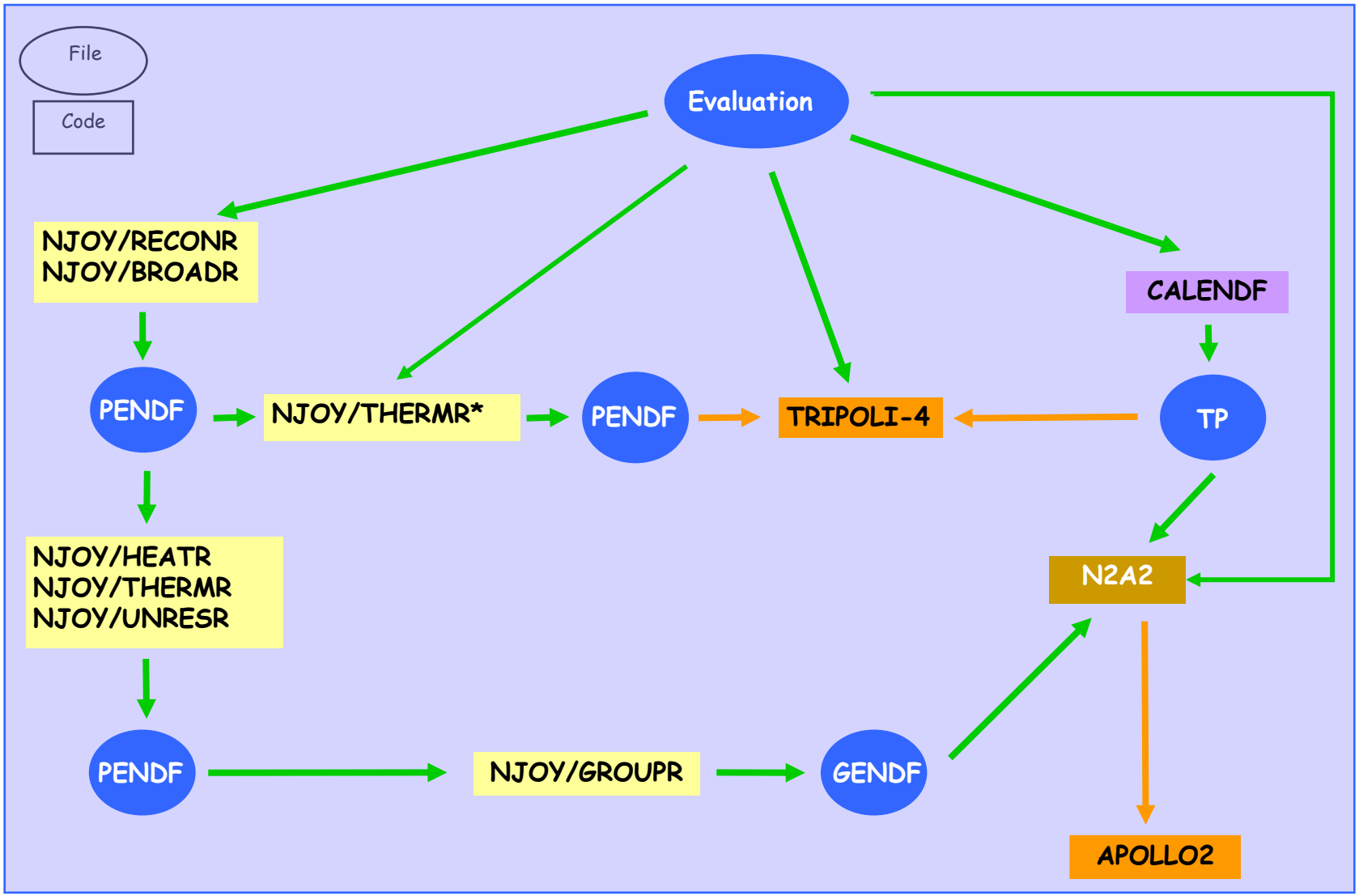
- Elaboration of an integrated chain producing automatically consistent libraries for APOLLO2 and TRIPOLI-4
  - Processing chain GALILEE-V0-1
  - In β-tests at CEA/SPRC since January 2008

- Based on:
  - NJOY99: Los Alamos Nuclear Data processing system (USA)
  - CALENDF-2005: CEA Nuclear Data processing code
    - Probability Tables
  - PREPANJ99
    - data for NJOY and CALENDF
  - LIBNJ90
    - Convivial access to ENDF, PENDF and GENDF NJOY formats
  - N2A2
    - interface between NJOY and CALENDF output files and APOLLO2 libraries
  - Scripts written in PERL

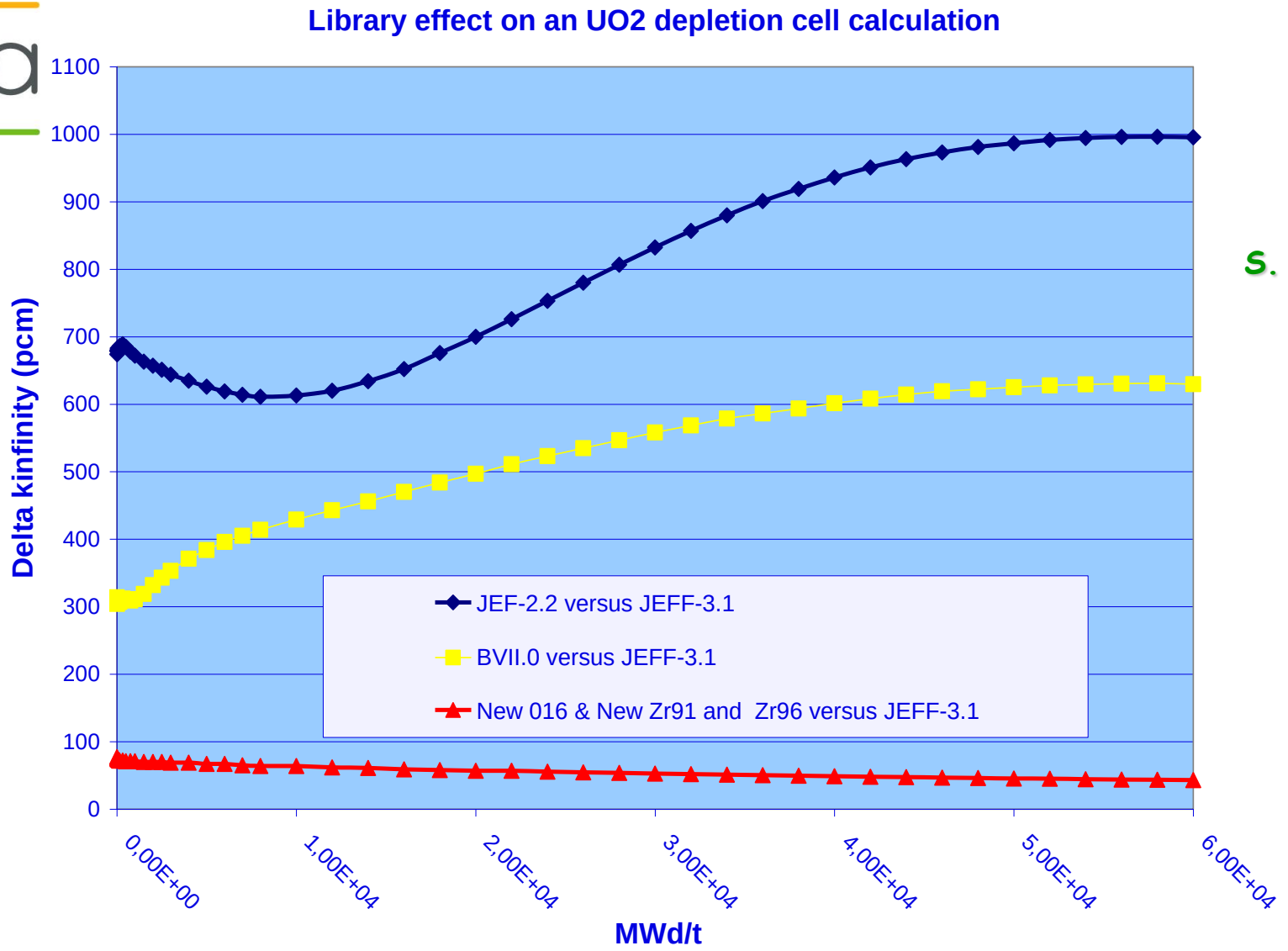
GALILEE-V0 Developments

- 2008 planned developments
  - Introduce ECCO/ERANOS-2 library creation in GALILEE-V0 chain
  - Create a verification tool allowing us, when a new library coming from a new evaluation is produced, to test
    - Data consistency and completeness
    - The impact of the new evaluation on a set of calculations
      - Core Physics
      - Criticality
      - Depletion
      - Shielding
      - …

GALILEE-V0-1 Chain



GALILEE-VO verification tool



From S. MENGELLE

GALILEE-V1: Why a new Nuclear Data Processing System? (1)

Nuclear Data Processing activity (capability & skill) is essential at CEA

- GALILEE-V1 aims:
  - Provide fully **mastered tools**
    - Renewed and standardised
    - That can be parameterised
    - Able to create **all** the application code libraries
  - Provide a **processing system** with two complementary running ways
    - An **integrated** way to create, with a convivial and automatic chain, consistent libraries for all the application codes
      - consistent global modelling of a nuclear system.
    - An **open** way to provide processing tools for application codes

GALILEE-V1: Why a new Nuclear Data Processing System? (2)

Nuclear Data Processing activity (capability & skill) is essential at CEA

- GALILEE-V1 could provide a shared platform for nuclear data treatment
  - CEA/IRSN
    - R&D
    - Use of a common tool
    - Possible co-developments if an agreement is found for property/diffusion rights
  - Interest shown by OCDE for a European nuclear data processing system, open , linked to JEFF3 (IRSN proposal at November 2007 JEFF meeting)
  - Durable teams involved in GALILEE
    - Associated to new code development sustained by industrials or by safety authority

GALILEE-V1 - Tool Box (1)

- To develop our own nuclear data processing tools allows us to master the modelling carried out in application codes
  - Nuclear data processing depends on the use of the data in the application codes

- Full mastering of processing tools allows to choice:
  - What kind of nuclear data a given application takes into account
    - Scattering reaction
      - total
      - elastic & total inelastic
      - elastic & each inelastic level
  - Processing accuracy and interpolation laws (reconstruction)
  - Nuclear Data Representation
    - Standard ones (PENDF, GENDF, PT)
  - Data format

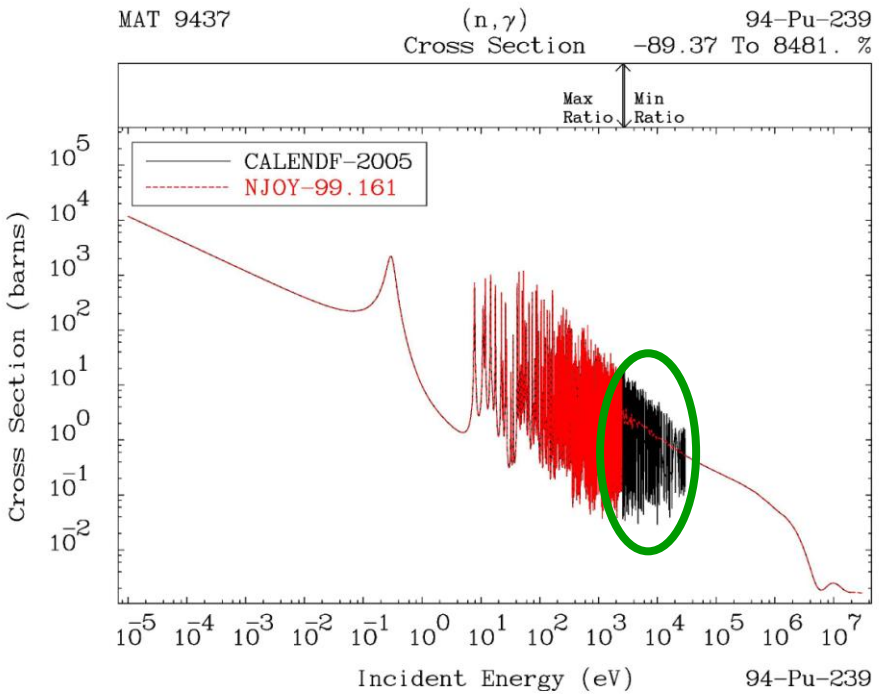
GALILEE-V1 - Tool Box (2)

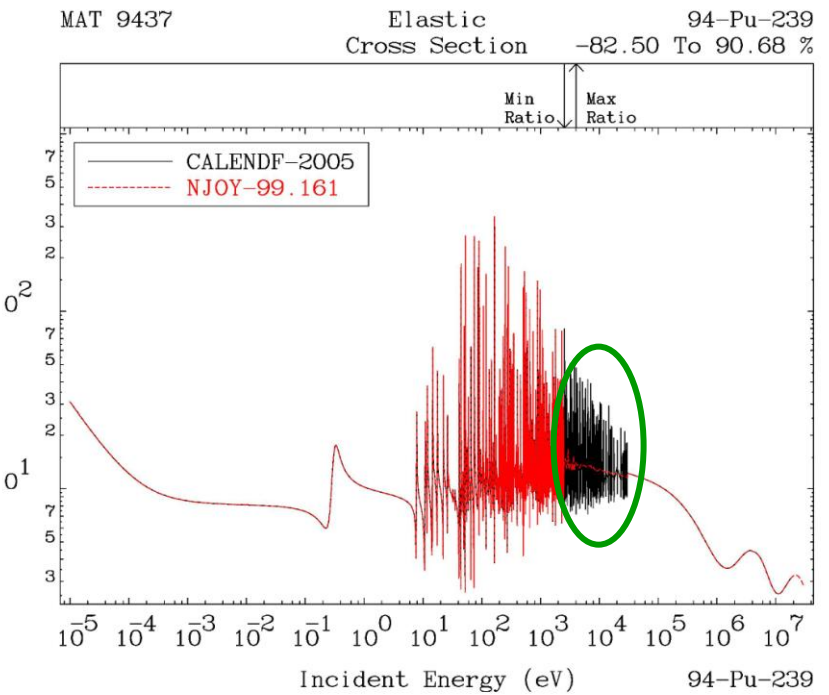
R&D Activities

- Improve some nuclear data process
  - Unresolved range
  - Anisotropy
  - Thermal range
  - Uncertainties
- Define new nuclear data representation
  - Anisotropy

NJOY/CALENDF

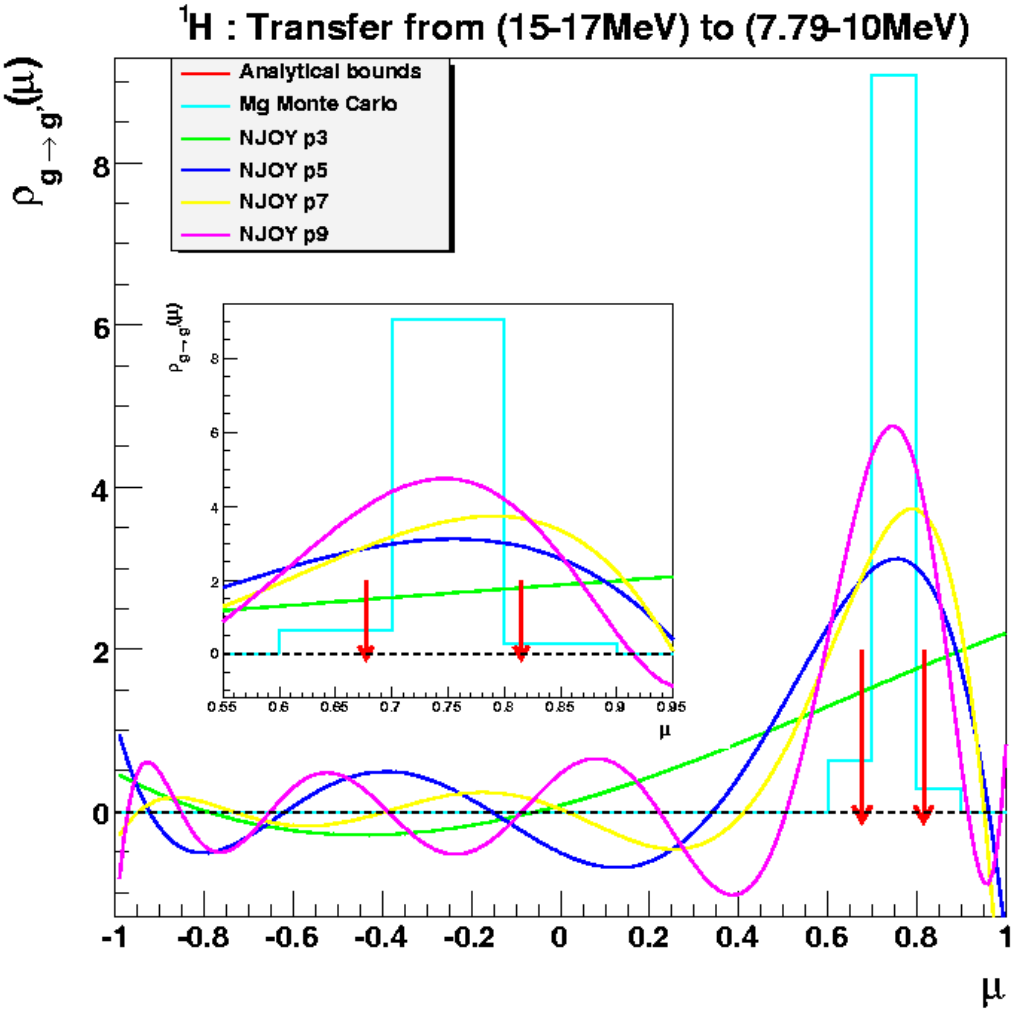
From J.C SUBLET





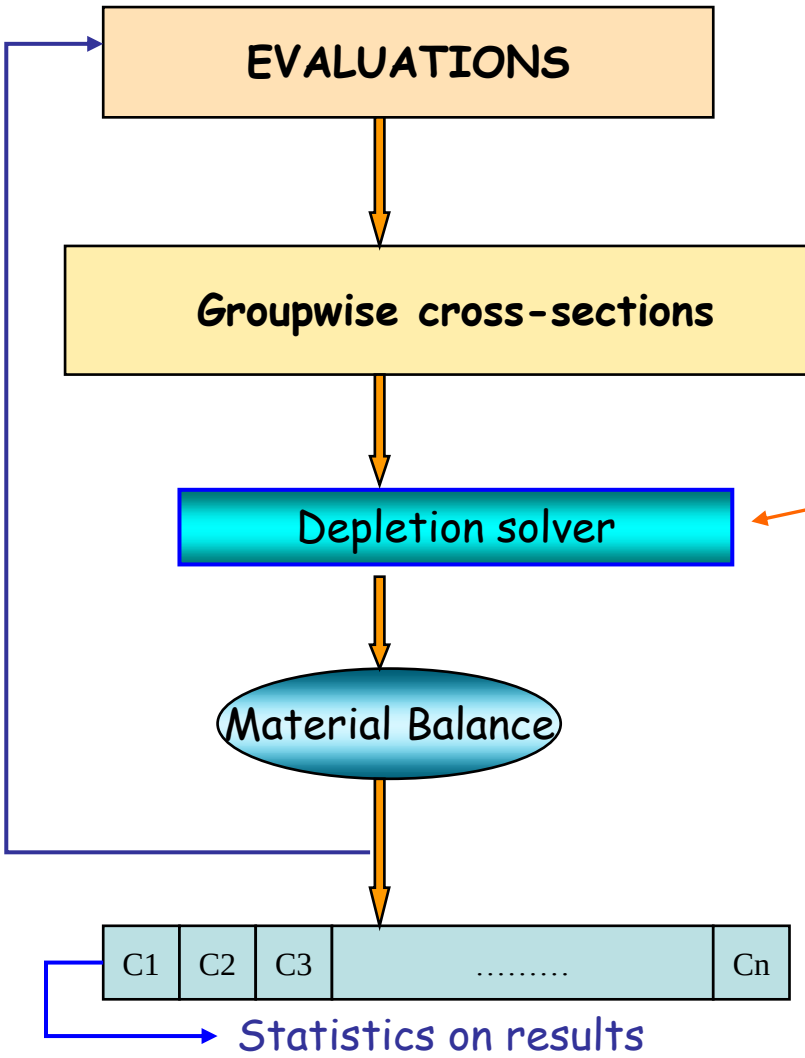
Cross-section reconstruction in unresolved resonance range

Groupwise Anisotropy calculation



From C. JOUANNE & C.M. DIOP

Uncertainty propagation



No intrusive method

GALILEE-V1 – Integrated processing system

- Global modelling of a nuclear system needs several application codes which data must be fully consistent

- Code to code comparisons are often used
  - To validate an industrial calculation scheme versus a reference calculation scheme
  - To validate a reduced depletion chain used in a transport code versus a complete one used in a depletion code

- Modelling effects in application codes begin smaller and smaller
  ➔ Process inconsistencies appear

GALILEE-V0 : Integrated system ensuring consistent libraries for TRIPOLI-4 and APOLLO2/CRONOS2

GALILEE-V1: Integrated system ensuring consistent libraries for all the codes used in the global modelling of a nuclear system

Neutronics, criticality, fuel cycle, shielding

GEN II, GEN III, GEN IV, ITER, …

GALILEE-V1 – Open and modular processing system (1)

- Application code libraries are no longer "static" ones
  - with a collection of given isotopes
  - processed once and for all
  - on a given temperature grid
  - on a given energy mesh

- Part of the processing can be done during a neutronics calculation
  - In a neutronics/thermo-hydraulics coupling, temperature distribution varies and cross-sections have to be broadened dynamically (already possible in TRIPOLI-4)
  - Cross-section description can be calculated on a refined energy mesh thanks to a specific tool creating a fitted energy mesh which is under progress at CEA

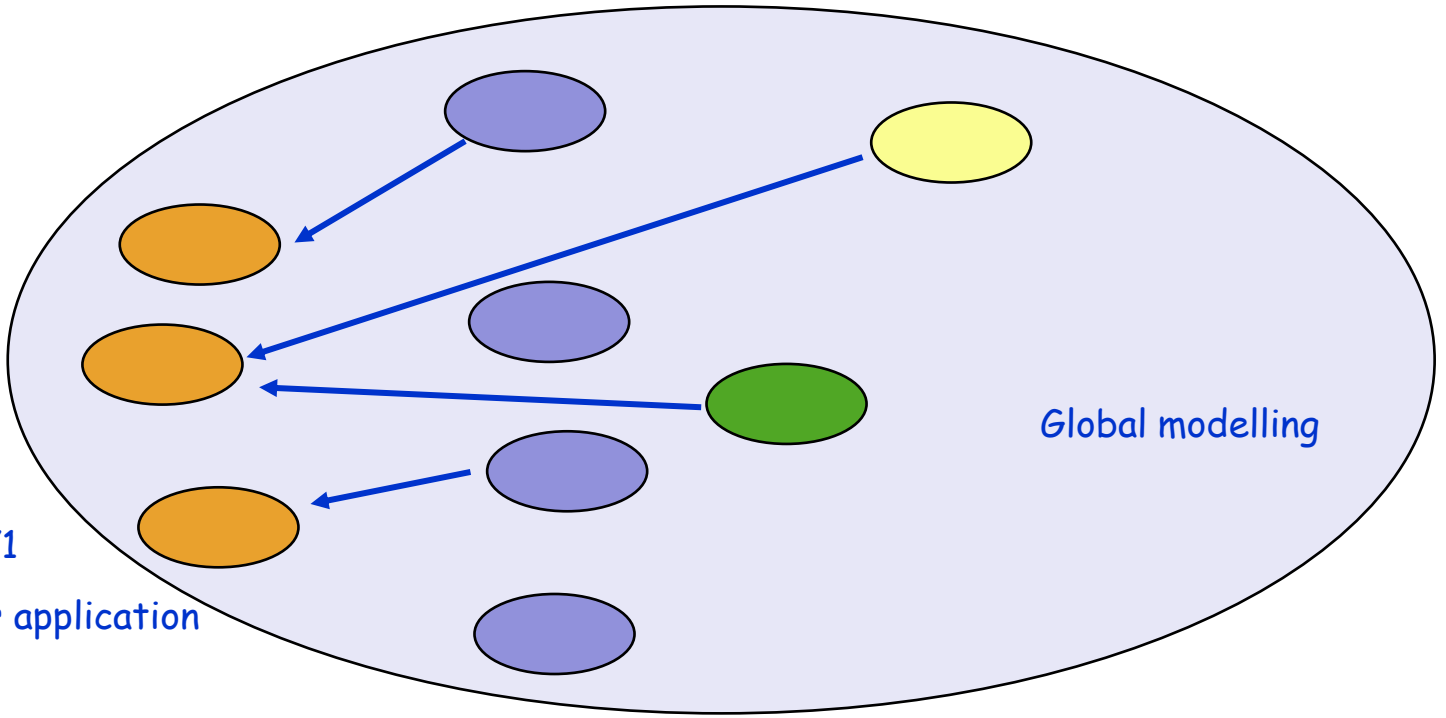
GALILEE-V1:

- will provide a dynamic interface with application codes

- will gather modular and parameterised tools

GALILEE-V1 – Open and modular processing system (2)

Aim : Global modelling of a nuclear system



GALILEE-V1

Tool box for application codes

APOLLO3

TRIPOLI-4

DARWIN3

GALILEE-V1 - Implementation

- New processing system
  - Conceived in a modular and parameterised way
  - With an automatic and integrated way of running

- Based on CALENDF-2005 for physical models
  - Renewed for all computational aspects
    - Modern computer language (C++)
  - Completed
    - Provide all NJOY functionalities needed for core physics
      - Comparison between several processing tools
      - Inter-Validation

- Ensuring consistent models with codes that create nuclear evaluations
  - CONRAD

GALILEE-V1 – Validation/Qualification

- Build a test collection
  - Ensuring the quality of the data provided to application codes
  - Ensuring that there is no regression when a component is changed
  - Allowing to measure the impact, on representative core physics situations, of changing an isotope evaluation, a model, …
- Benchmarks participation
  - ICSBEP (criticality)
  - SINBAD (shielding)
  - DICKENS, AKYIAMA (residual power)
  - Benchmarks AEN/OCDE (depletion)
  - …

Conclusion

Nuclear Data Processing at CEA

- Major activity
- One fundamental component of nuclear system global modelling
- Nuclear Data Processing System GALILEE
  - Is in phase with the new generation of reactor physics codes
  - Brings consistency and representation flexibility to nuclear data used in application codes
  - Is unified, integrated or open, and validated
  - Allows R&D activity
  - Ensures consistency with models used to create evaluations (CONRAD)