KANT, THE ASNR PROBABILISTIC SOFTWARE FOR L2 PSA

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PREAMBLE

KANT

- Created in 2025, ASNR groups the French Safety Authority ASN and its technical support organization IRSN

- In France, 32 PWRs 900, 20 PWRs 1300, 4 PWRs 1450, 1 EPR are operated by EDF which develops all reference safety studies, for example PSA

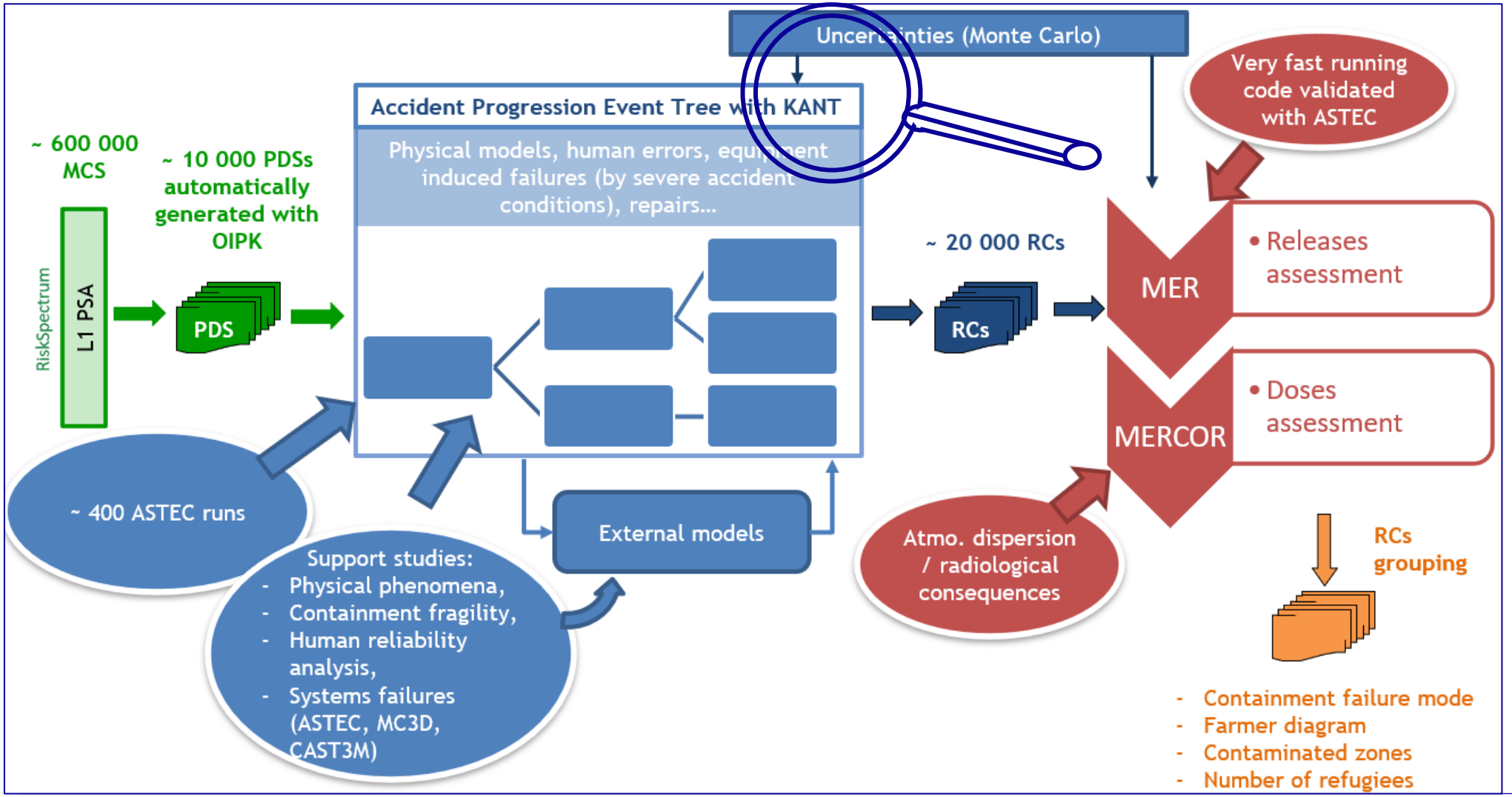
- ASNR maintains “detailed” L2 PSAs for the French PWRs 900 and 1300 that
  - include all knowledge from severe accident research program or accident simulations
  - reduce use of expert's judgments
  - provide containment failure modes frequencies and release categories frequencies associated to kinetic and amplitude of releases

- ASNR develops L2 PSA for other types of facilities

- ASNR develops and uses **the probabilistic software KANT** for these L2 PSAs.

- **This presentation provides an overview of the status of KANT**

GLOBAL APPROACH FOR ASNR L2 PSA (PWR EXAMPLE)



PRESENTATION PLAN

KANT

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OVERVIEW OF KANT

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01

OVERVIEW OF KANT

OVERVIEW OF KANT

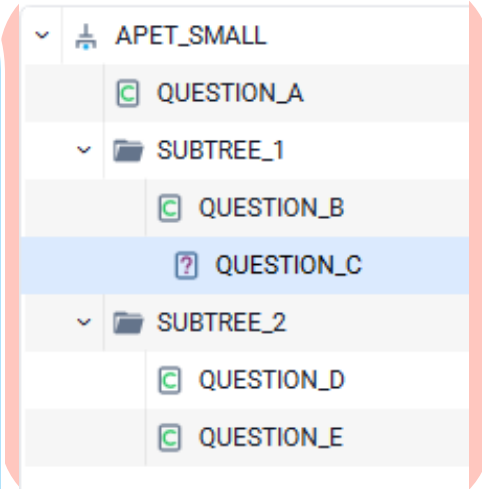
KANT

- KANT is a user-friendly tool able to
  - integrate all information from L1 PSA (initiating events, minimal cut-sets)
  - implement representative information about accident scenarios
  - reflect the chronology of the severe accident and integrate models for physics, human errors and systems → dynamic event trees can be modeled if needed
  - model all dependencies between events
  - integrate uncertainties and perform uncertainty analysis by Monte-Carlo simulations
  - consider all the containment failure modes
  - quantify the frequency and the radiological consequences of severe accident sequences

OVERVIEW OF KANT - WORKFLOW

- KANT represents the progression of a severe accident with a probabilistic tree : Accident Progression Event Tree or **APET**
- APET's entries are PDSs (Plant Damage States) coming from the L1-L2 interface process

- KANT explores the APET for every PDS and generates **L2 PSA sequences**
  - **series of events (or questions)** representing systems behaviour, physical phenomena, human actions
  - several answers per question, with conditional probability depending on the input variables
  - questions programmed in «KANT» language : flexible enough to cover all the reactor states and PDSs with a single APET
  - KANT groups similar L2 PSA sequences into **RCs** (Release Categories)



- KANT computes release and radiological consequences for each RC (with fast running codes)
- For Monte-Carlo quantification, KANT repeats the process

OVERVIEW OF KANT – SOME SPECIFICITIES

SEVERAL WAYS OF MODELING PHYSICAL PHENOMENA

- Grids of deterministic precomputed results
- Mathematical models written in the KANT language
- External libraries for more complex models

IMPLEMENTATIONS

- Supported systems : Windows, Linux
- Parallel processing : MPI* library
- For KANT language : Lua to improve performance / maintenance
- User interface framework : QT

New in 2026

**Message Passing Interface*

02

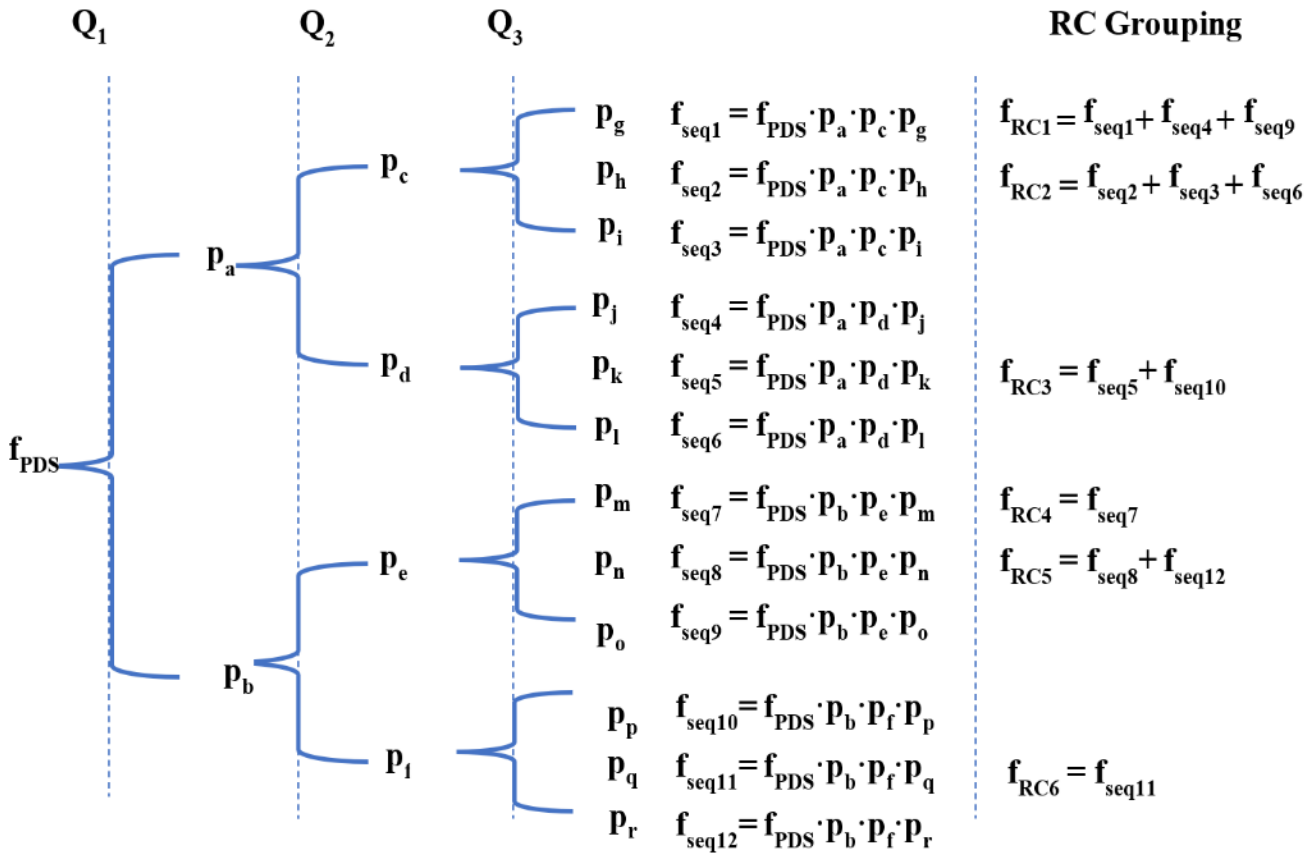
ALGORITHM AND LANGUAGE

APET EXPLORATION ALGORITHM

KANT

Principle:

- KANT explores the questions and their possible answers recursively
- After each question, the frequency is updated
- Explored branches are discarded when frequency < cutoff value
- This is repeated for each PDS
- This is repeated for each sample in Monte-Carlo mode



KANT PROGRAMMING LANGUAGE

- English and French keywords
- Usual language features
  - Control instructions : `if … switch … for … while …`
  - Operators : `+ - * / % and or not = < > <= >= <>`
  - Types and arrays : `integer, real, boolean, string [size]`
  - Debug : `break, stop`
- Domain-specific keywords and features
  - APET branching : `go_to, go_to_end_apet`
  - APET exploration information: `answer, answer(), write_sequence`
- Built-in functions : `MIN, MAX, power, log …`
- User functions, external function calls

03

GRAPHICAL USER INTERFACE

THE GRAPHICAL USER INTERFACE

The GUI is organized in pages, one page per step in development and quantification of an APET

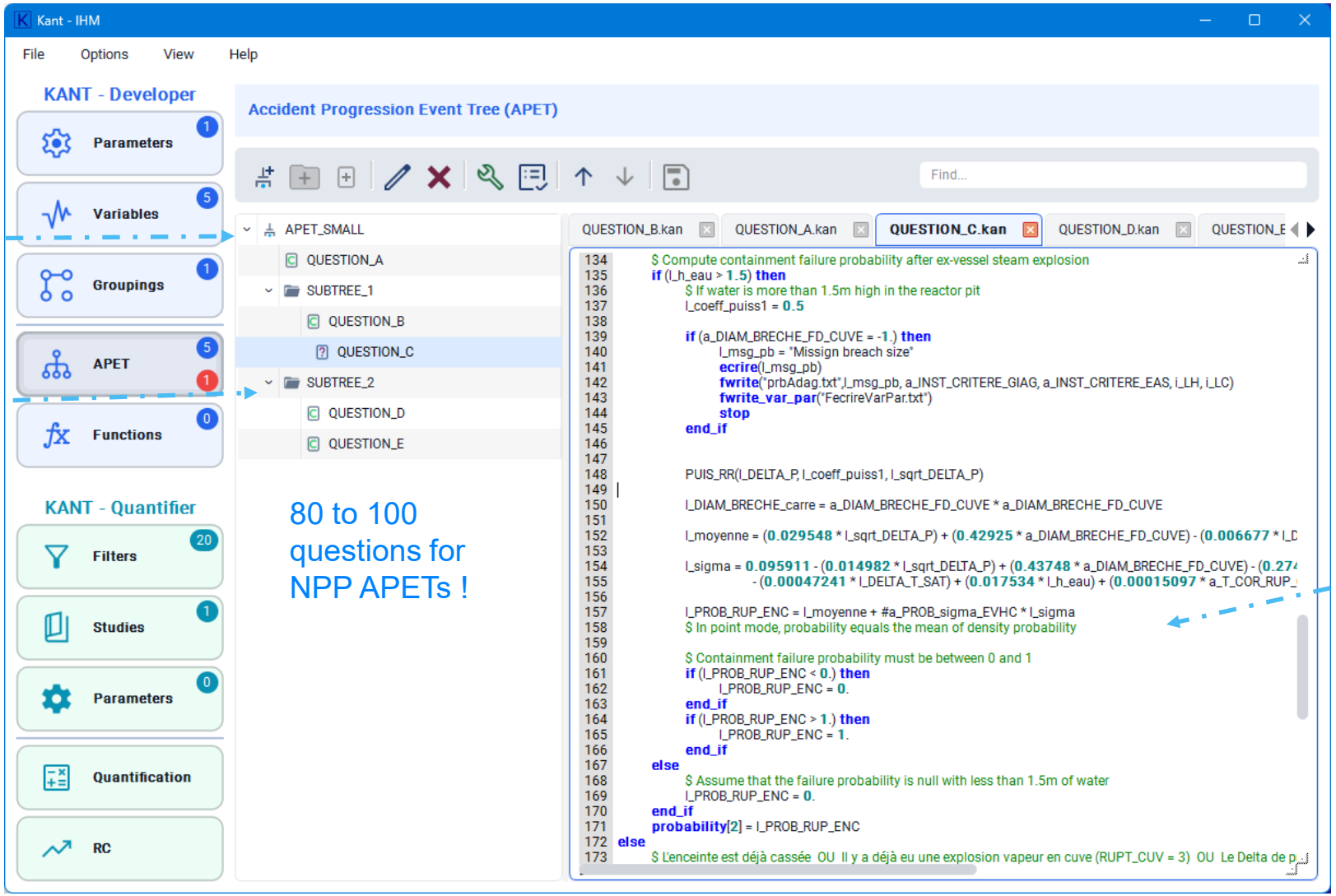
- KANT Developer pages:
  - Variables : type, name, attributes (PDS variables, release variables, others)
  - Parameters : type, name, unit, description
  - Groupings rules: variables considered, allowed values
  - APET : tree construction and programming in KANT language

- KANT Quantifier pages:
  - PDS filters : boolean expressions to restrict the PDSs to consider, if needed
  - Study definition : APET, PDS file
  - Parameters values : fixed values or probability laws (for each study)
  - Quantification : running parameters (cutoff frequency …)

GUI : APET REPRESENTATION EXAMPLE

Questions

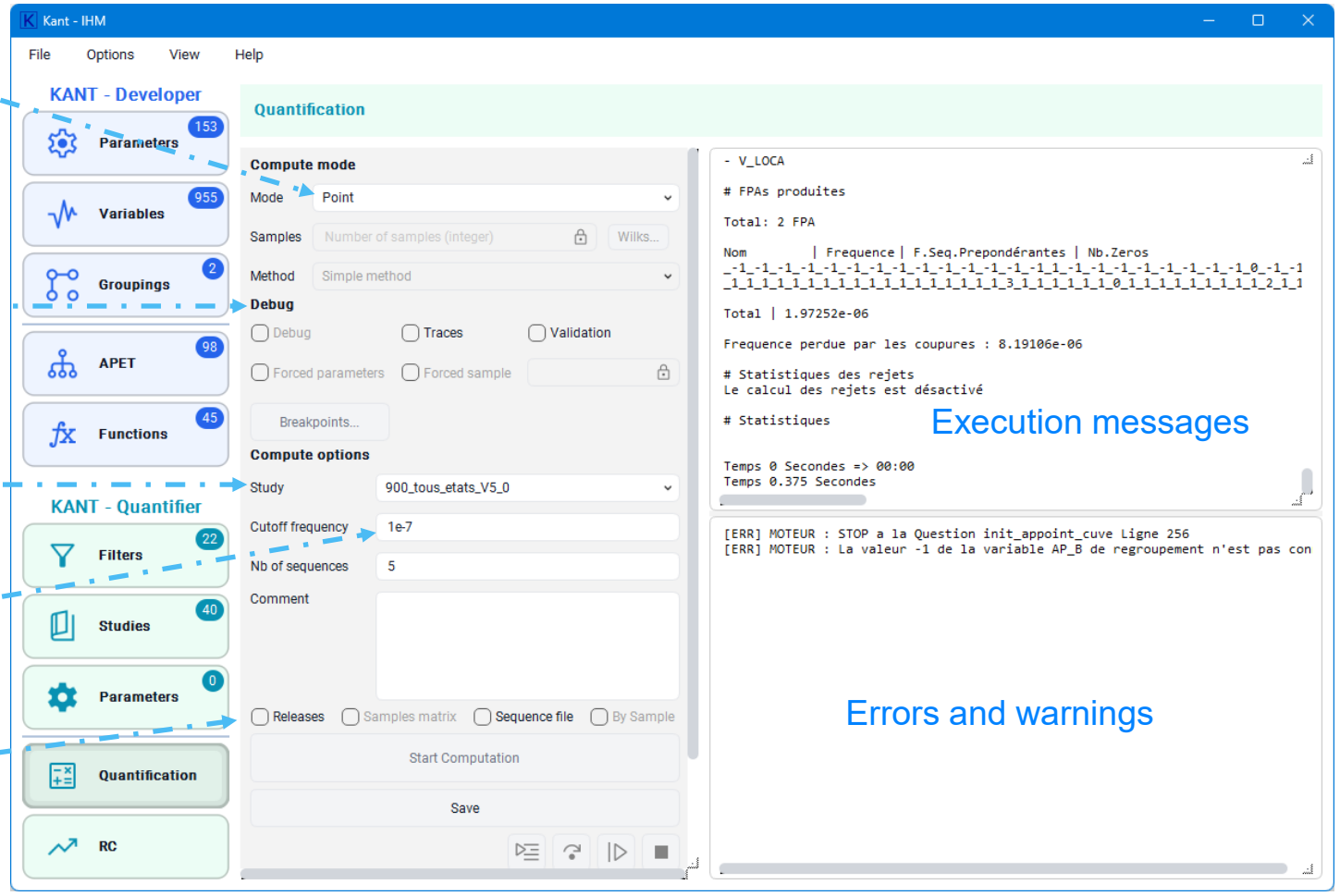
Subtrees for APET legibility



80 to 100 questions for NPP APETs !

Question code in KANT language

GUI : RUNNING A QUANTIFICATION



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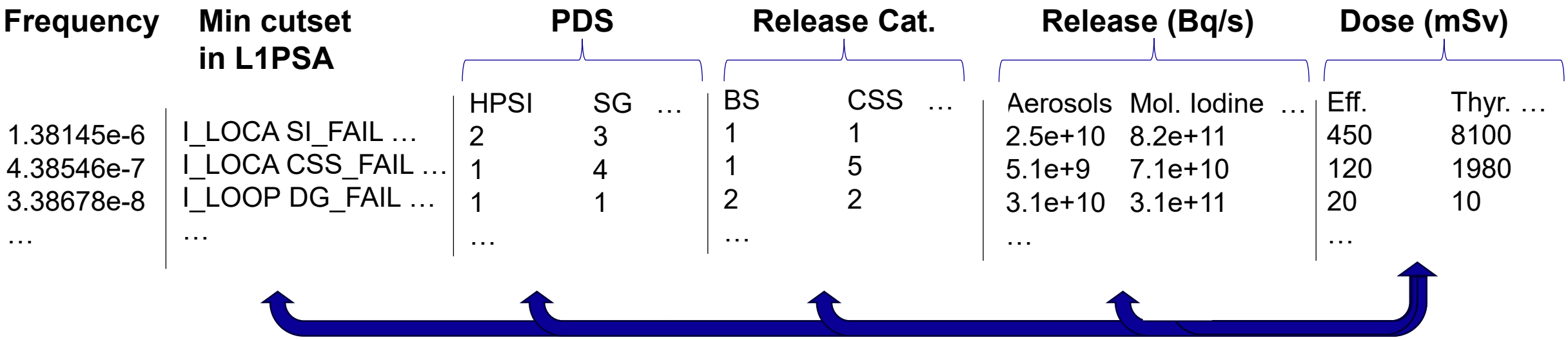
RESULTS

KANT RESULTS



- The results are post-processed with a dedicated ASNR tool : PEPS (**P**ost-proc**E**ssing for **PS**A)
- The analyst can examine results from L1 PSA to L2 PSA

HPSI : High Pressure Safety Injection
SG : Steam Generator status
BS : (Containment) Breach Size
CSS : Containment Spray System
Eff. : effective dose
Thyr. : Thyroid dose

05

CONCLUSION

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- KANT is a user-friendly software used to perform ASNR's L2 PSA
- KANT is continuously improved for calculation performances, user interface / functions and maintainability
- KANT allows users to trace the results (frequencies/releases/consequences) back to the root causes (initiating events, systems failures, human failures, severe accident phenomena …) modeled in L1 PSA and L2 PSA
- ASNR will continue to use KANT for NPPs PSAs and also other facilities like fuel cycle facilities or SMRs

THANK YOU FOR YOUR ATTENTION