# SEA activities on the the evaluation of integral experimental measurements compiled in SINBAD, ICSBEP and SFCOMPO

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# *Historical introduction (1/2)*

- Naturally the first activity of a scientific team entering the world of the numerical simulation of reactor physics, criticality safety, material damage or radiological dose is to benchmark the calculation tools
- That was not the international practice in the 80`s. The usual method for people using the Monte Carlo method was adding 3xσ to the calculated keff, somehow assuming that the accuracy of the calculation code was related with the power of the computer or the user`s patience.
- That was somehow justified by the fact that, with the computers available at that time (CYBER 830 of ENUSA with a cost of 100 Mpta or 1 million €, equivalent to the Intel 80386) the sigma was a few%
- On the other side the people of the “deterministic codes” shouted proudly that they had “no uncertainties”
- My first real need of benchmarking the criticality code system SCALE0 was for the licensing of the Juzbado fuel manufacturing facility in 1985.

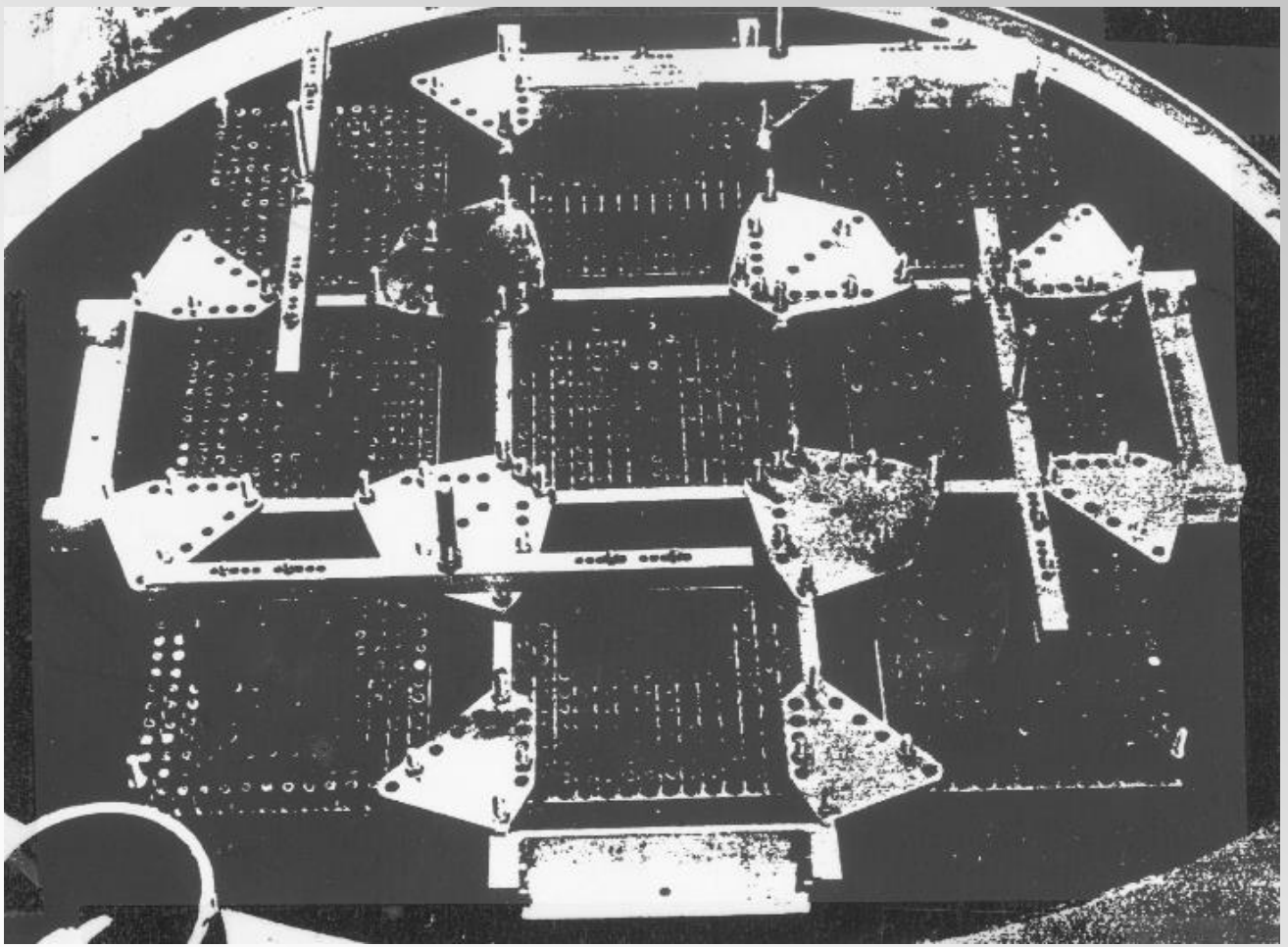
# *Historical introduction (2/2)*

- Then the natural process was to look for in the technical literature for critical experiments which were similar to the problems we were dealing with, i.e. low enriched uranium rods in water.
- The Bierman experiments performed by Batelle in Hanford, the B&W experiments made in Lynchburg, the Thomas high enriched cubes in ORNL, etc became familiar words in the criticality group at ENUSA
- Starting in 1998 as an independent company the first contact with Blair Briggs in the ICNC99 conference in Versailles introduced us to ICSBEP
- Later in 2008 we were contacted by Enrico Sartori to perform the compilation of some experiments for SINBAD database. We overperformed the compilation by discussing the validity of the data and comparing the calculated results and the measured values.
- Finally the efforts of Jose Manuel Conde at CSN created the first activity of evaluating the fuel depletion measurements existing in SFCOMPO by evaluating the F3F6 experiment and starting the Evaluation Guide

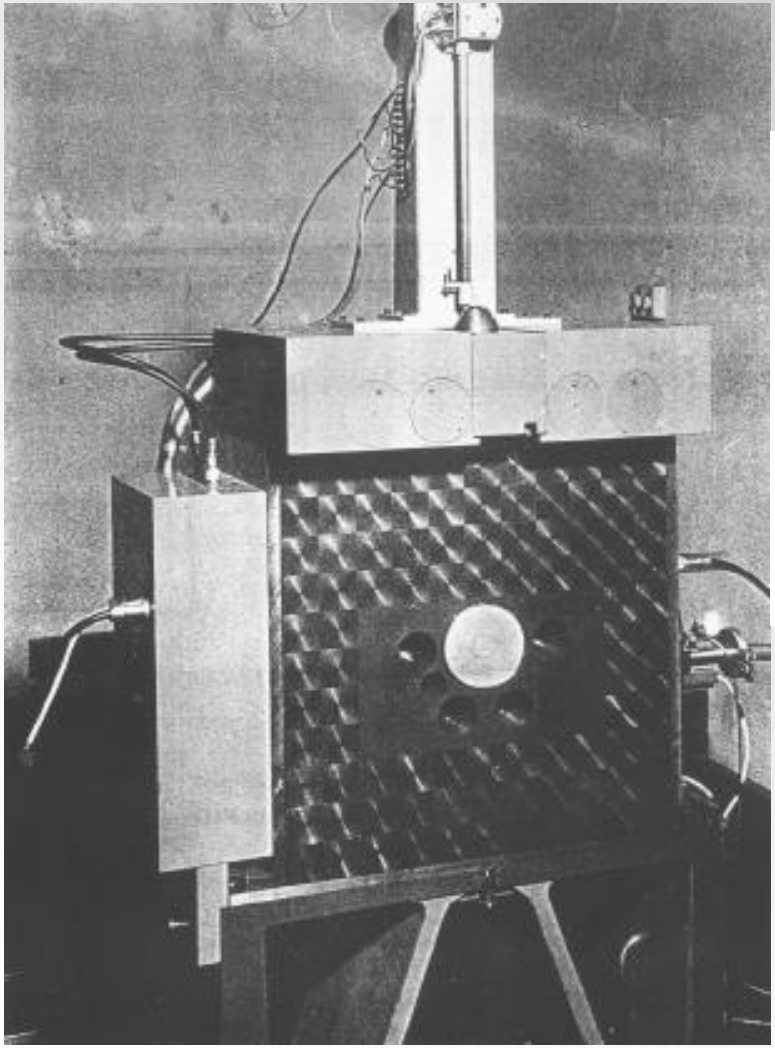
# *SEA experience with ICSBEP*

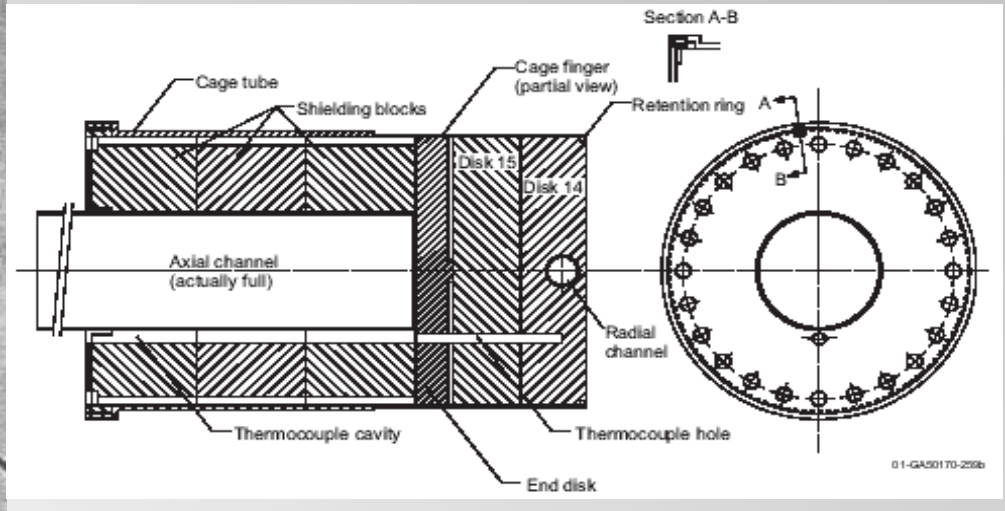
- The first two evaluations we performed were coincidentally the two sets of B&W experiments (a single array with absorber rods and 9 assemblies with absorber plates). We received the logbooks and could access one person at the lab. They were presented at St. Pertersburg meeting in 2000.
- Next year we perform the evaluation of our own Spanish criticality experiment, the first criticality of CORAL-I reactor in 1968. People in ANS conference in Milwaukee were astonished by the fact that there was a fast reactor in Spain at that time. Keff=1.0018 with σ(exp.)=0.10
- All those efforts made by SEA with our own funding were very productive in terms of learning on uncertainties, on the concept of "evaluation" and especially on the personal contacts with criticality experts worldwide.
- ICSBEP has established a very high landmark in the quality, in the description details of an experiment and in the format itself.
- The thousands of critical configurations described in this database cover not only light water reactor systems but also those related with the early weapon manufacturing process and the very last need with individual nuclides such as Np-237.

# *Babcock Willcox critical experiments (LCT-011 & 051)*



# *CORAL-I first criticality (HMF-062)*





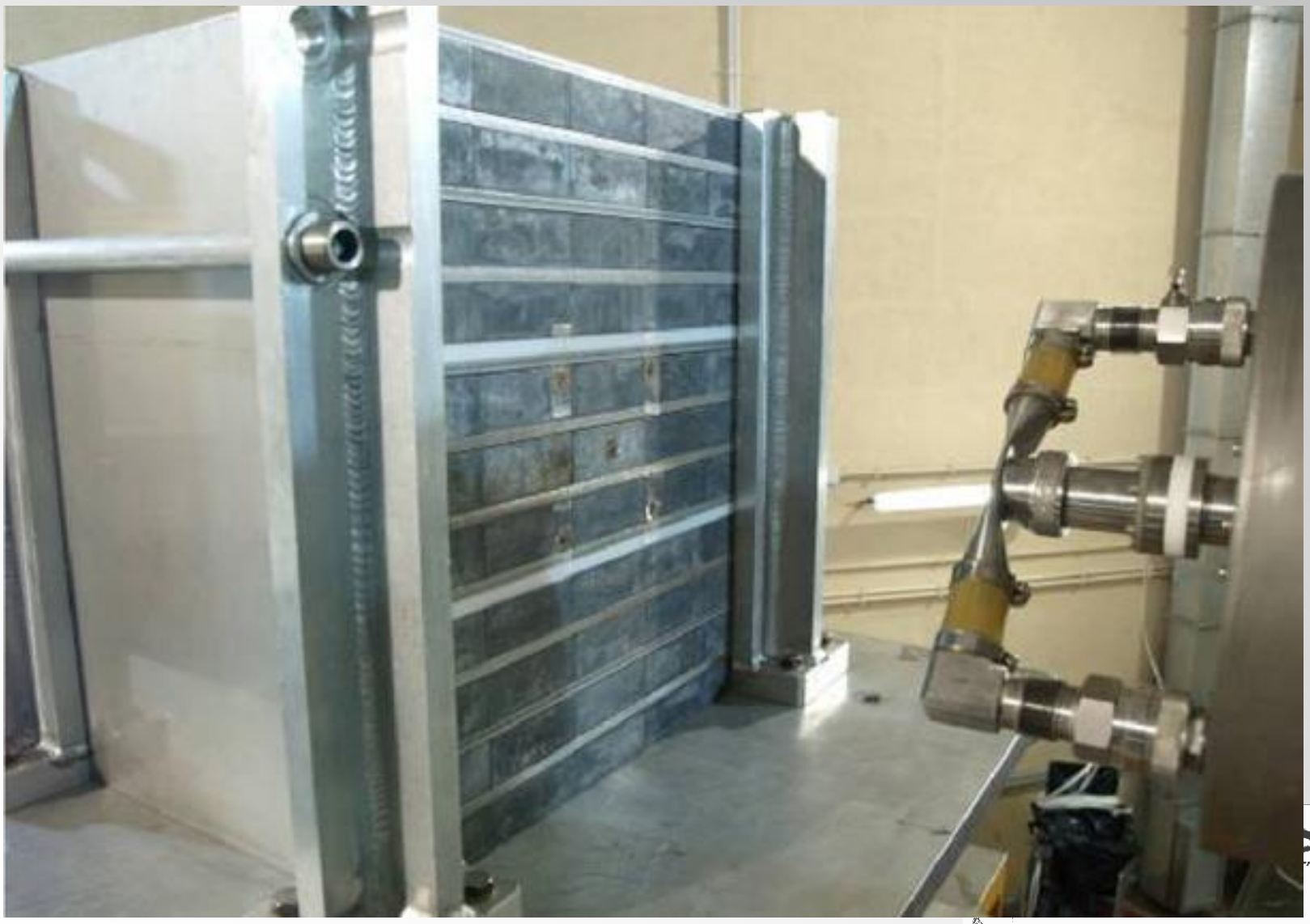
# *SEA experience with SINBAD*

- Shielding is not the same type of problem than criticality safety. When licensing a new facility you can take your gamma REM-meter or your set of Bonner spheres to measure neutron dose rate. Unlike that, in criticality when you see the “blue flash” it is too late, at least for you!
- Shielding benchmark is essential for performing a reasonable design in a stationary facility, hence saving money and space but hardly there is risk for human dose. This makes much lower the interest of the institutions.
- From 1996 the SINBAD database is managed by NEA & RSICC
- Presently 102 experiments included, only 4 in the last 10 years.
- Attention!! No one of them is fully evaluated, they are "as is"
- In 2019 the Evaluation Guide authored by this author was approved!
- In 2021 an effort has started to evaluate these experiments by voluntary contribution with the support of NEA secretariat, ORNL and the "old people" present in this project, i.e. Ivo Kodeli and myself
- No funding mechanism established yet

# *Working groups to evaluate SINBAD experiments*

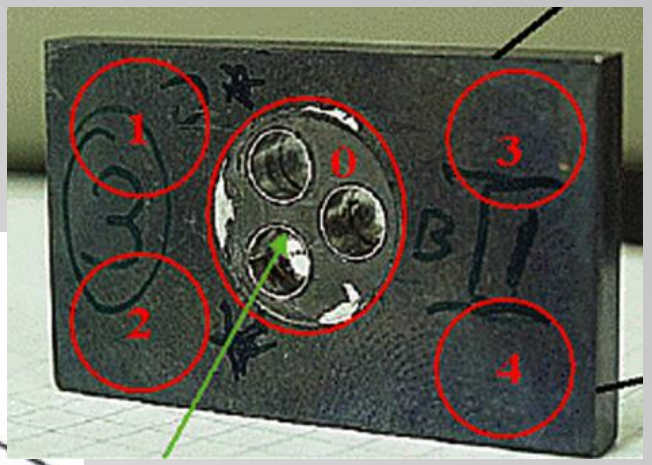
| ID | Subgroups | Lead | Participants | |
|---|---|---|---|---|
| 1 | FNG Copper | I. Kodeli | G. Zerovnik, J. Haverkamp, P. Ortego, Y. Celik, D. Leichtle | |
| 2 | Broomstick: O16 | S. Simakov | P. Ortego, I. Kodeli, M. Zerkle, A. Vasiliev | |
| 3 | KFK - n gamma | S. Simakov | P. Ortego, I. Kodeli, T. Watson | |
| 4 | FNG Tritium prod | P . Ortego | D. Leichtle, G. Zerovnik | |
| 5 | CERF | R. Froeschl | CERN team + T. Miller contact | |
| 6 | WCLL | D. Leichtle (prelim.) | P. Ortego, G. Zerovnik | |
| 7 | HIMAC | Proposal: S. Tsuda (to be confirmed!) | | |
| 8 | PCA Replica | | A. Vasiliev | |
| 9 | Oktavian | | A. Milocca ?, C. Celik | |
| 10 | LLNL Spheres | S. Kim | C. Celik, P. Ortego, T. Watson, J. Haverkamp | |
| 11 | SFR specific benchmarks: JAS | Terrapower (J. Hader, J. Brogan) | | |
| 12 | Vessel fluence | A. Alpan | O. Buss, A. Vasiliev, P. Ortego, J. Hader, J. Brogan + Terrapower team | |

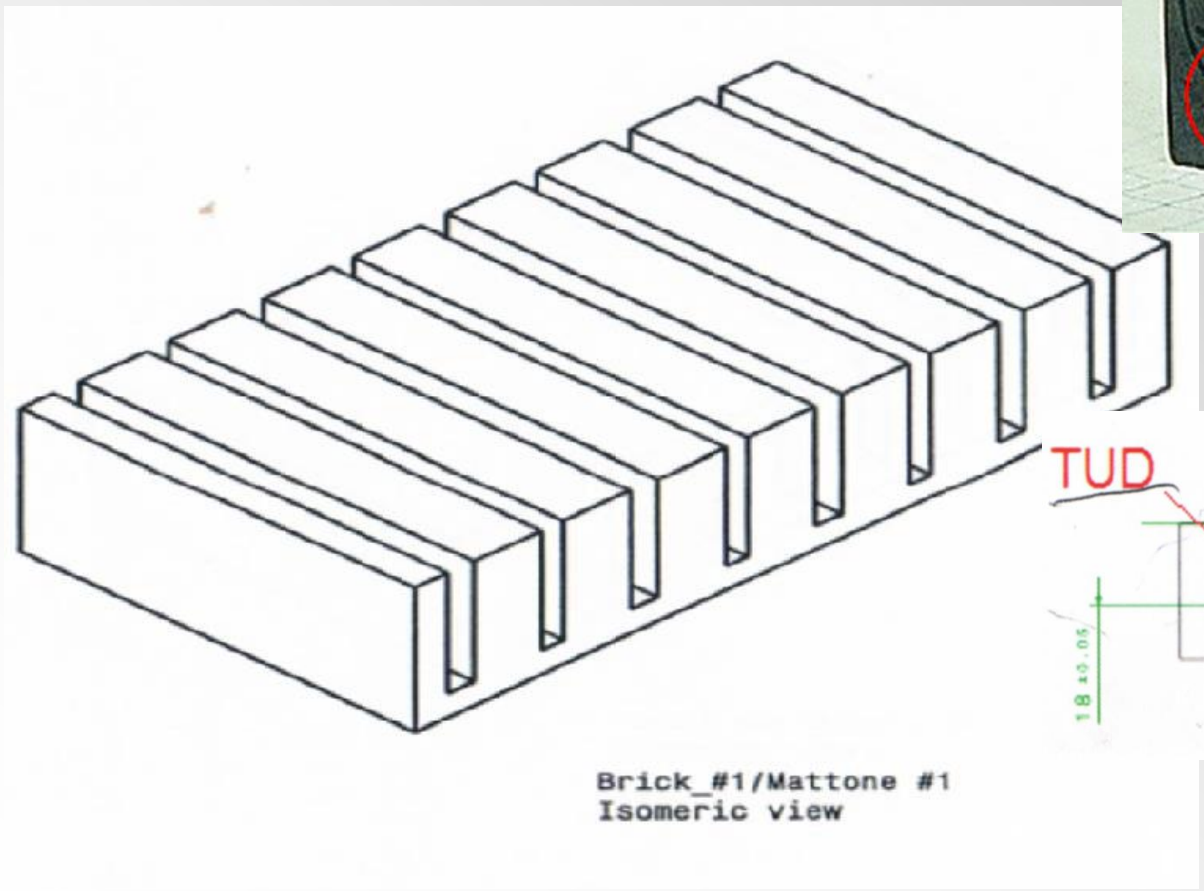
# *HCLL experiment description*

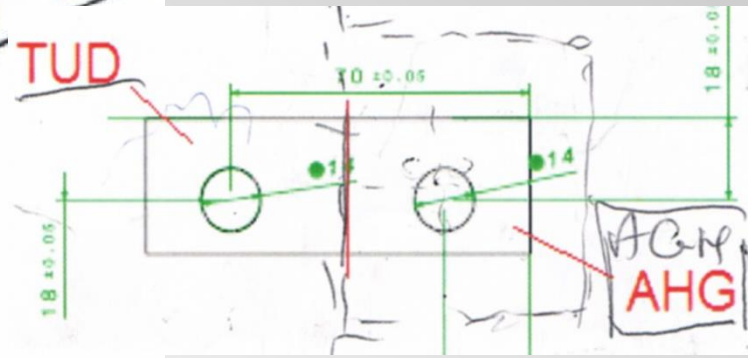


# *HCLL measurement techniques (2/2)*

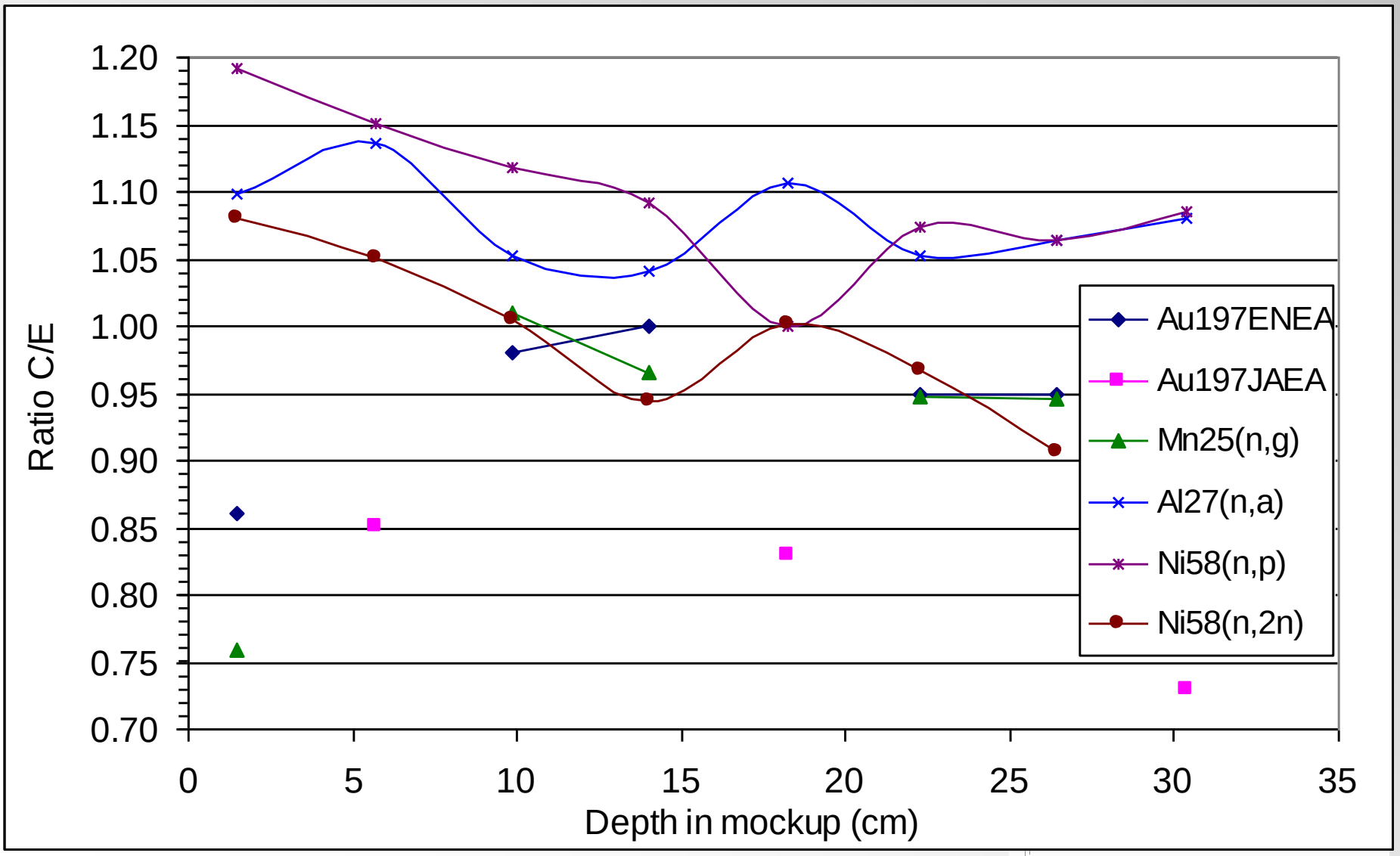
Two central Lead-Li bricks with 8 & 7 cut slots allocating two semiholders (4.5x3cm2) each with reentrant holes containing stacks of CO3LI2 pellets and TLDs or foils



# *Sample calculation results: C/E ratio for activation foils*



# *SEA experience with SFCOMPO (1/2)*

- Started as japanese database of measuments of nuclides in spent fuel
- In 2009 and with a voluntary contribution of CSN the evaluation effort started with the preparation of the Evaluation Guide and the evaluation of the Forsmark F3F6 measurements
- The US effort (ORNL) has been focused on creating a complete database of easy access, SFCOMPO-2. Very important support from UPM (Oscar, Jesús Martínez, UPM students)
- The Spanish effort has been focused on the evaluation of experimental measurements (intense and continuous)
  - CSN Aid in 2010
  - SEA-CSN-ENRESA collaboration project (2012-2016)
  - SEA-CSN collaboration project (2020-2024)

# *SEA experience with SFCOMPO (2/2)*

- A total of 12 measurements have already been evaluated but yet pending formal approval of Technical Review Group because of non yet existing
  - ARIANE BM1, BM5 (MOX) DM1, DU1 (BWR) GU1, GU2, GU3, GU4 (PWR)
  - REBUS, Forsmark F3F6
  - MALIBU GGU1, GGU2
  - Fukushima Daini 2F2D1 (gadolinium, 1 cycle)
- Other 5 experiments are in the process of evaluation and approval
  - Fukushima Daini 2F2D2, 2F2D3, 2F2D5, MALIBU (?)
- A full presentation would be necessary for giving some insight but as a summary, main difficulties found in SFCOMPO (in relation to ICSBEP)
  - Large number of parameters measured (many nuclides)
  - The determination of the sample burnup
  - The magics of "chemical analysis"
  - The large uncertainty in void fraction (BWR)

MUCHAS GRACIAS

MANY THANKS