Summary of P6 Problem: Iron Sphere Experiment

Presentation and Evaluation of Solutions with Conclusions for Future SINBAD Compilations

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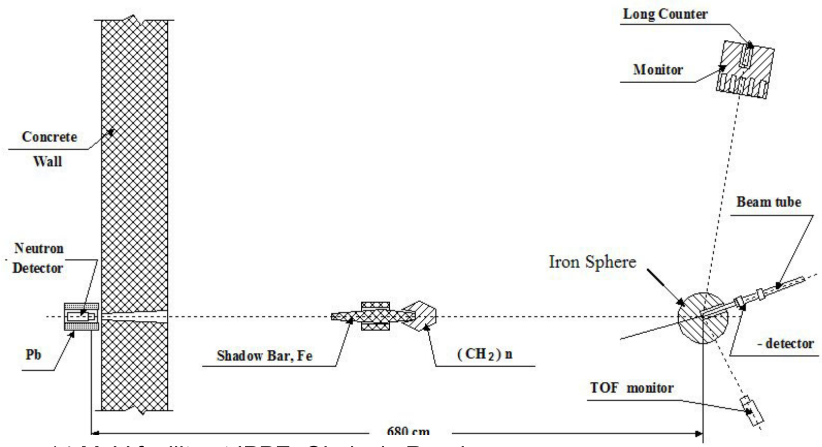
P6 - Neutron Spectra from Iron Spheres



14 MeV facility at IPPE, Obninsk, Russia

TOF experiments: detector time resolution, multiple scattering, flight path, neutron source from D-T reaction, conversion between time-of-arrival and energy spectra...

P6 - Iron Sphere Experiments

- Source: 280 keV deuterons injected to TiT target located in center of Fe spheres. ~14 MeV n produced by T(d,n).
- 5 iron spheres with wall thicknesses 2.5 – 28.0 cm.
- Energy and TOF spectra
- Uncertainties:
  – Statistics, equipment stability, Cf-252, TOF-E,
  – Detector time resolution (FWHM~4 ns): ion width (FWHM~2ns), detector resolution (FWHM=3.0 – 3.5 ns)
  – Geometry (collimator-detector system), background subtraction
  – Calculational uncertainties (MC statistics, approximations, cross sections)

Tasks

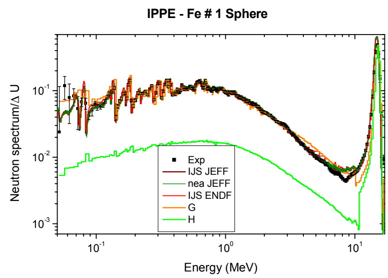
- Calculate **neutron leakage spectra** for the iron shells of different thicknesses.
- For larger shells compare the spectra obtained using **time independent and time dependent transport** calculations.
- Estimate the **uncertainties** in the calculated neutron spectra, caused by the method and nuclear data uncertainties (e.g. material density, cross sections).
- **Verify if the agreement** between the calculation and experiment is within the overall (computational and measurement) uncertainties.

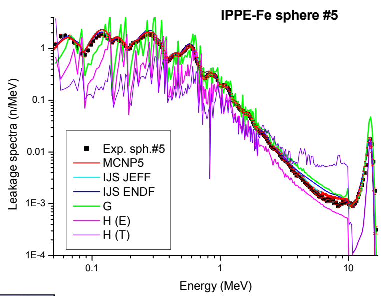
Objectives

- Test the skills of the participants in the use of the computer codes and the nuclear data;
- Obtain feedback information on how suitable the information contained in SINBAD is for the nowadays users and computer codes. Provide guidance for the future SINBAD compilations in order to facilitate the use of experimental data, and to deduce maximum information from the measurements.

SINBAD Benchmarks using TOF technique

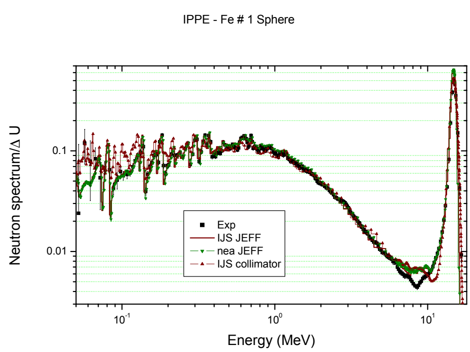
- ***Reactor Shielding***
  IPPE Th shell with 14 MeV and Cf-252 source neutrons
- ***Fusion Neutronics Shielding***
  Nickel Sphere (OKTAVIAN)
  Iron Sphere (OKTAVIAN)
  Aluminium Sphere (OKTAVIAN)
  Silicon Sphere (OKTAVIAN)
  Tungsten Sphere (OKTAVIAN)
  FNS Liquid Oxygen
  FNS Skyshine
  FNS Dogleg Duct Streaming
  IPPE Vanadium Shells
  IPPE Iron Shells
- ***Accelerator Shielding***
  RIKEN Quasi-monoenergetic Neutron Field in 70-210 MeV Energy Range
  HIMAC High energy Neutron (<800 MeV) Measurements in Iron
  HIMAC High energy Neutron (<800 MeV) Measurements in Concrete
  MSU experiment with He & C ions on Al target
  Neutron Spectra Generated by 590-MeV Protons on a Thick Pb Target



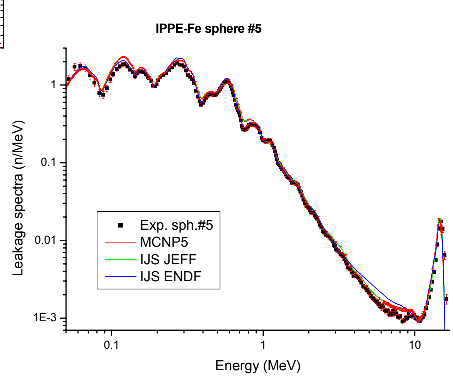


Returned Solutions

Altogether three solutions were received from the participants, all using MCNP codes. Although the modelling of the geometry and the transport calculations themselves seemed not to cause problems to the participants, the whole problem was found rather demanding, posing difficulties in the physical interpretation of the measurements and the computational results. Two of the received solutions were not complete since many physical effects were not addressed properly or not at all.



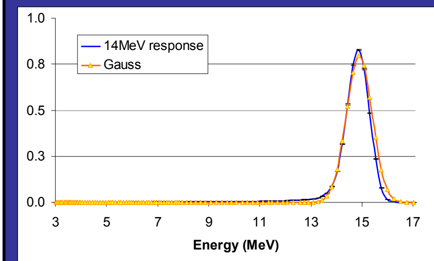
Solutions

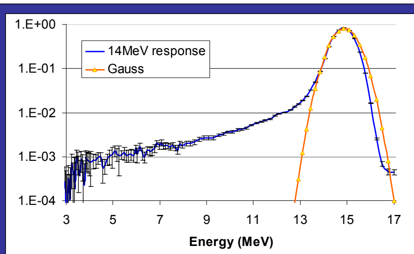


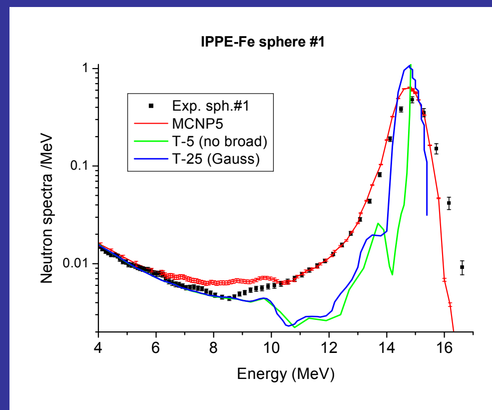
On the other hand, one solution received is very complete, with detailed study of major effects and some uncertainties involved in the measurements and the interpretation.

Response function (E= 14 MeV)

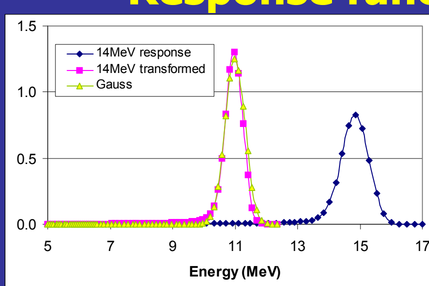
conrad-ivo.xls

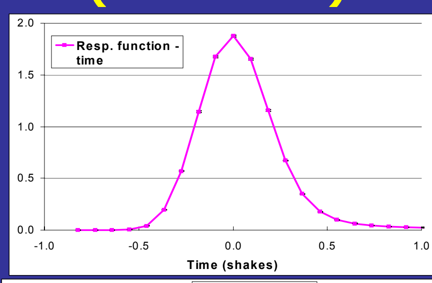


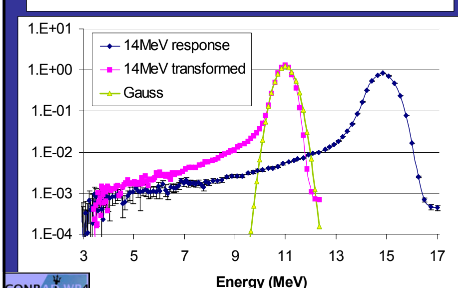


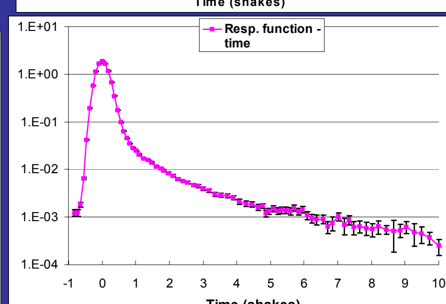


Response function (E<14 MeV)

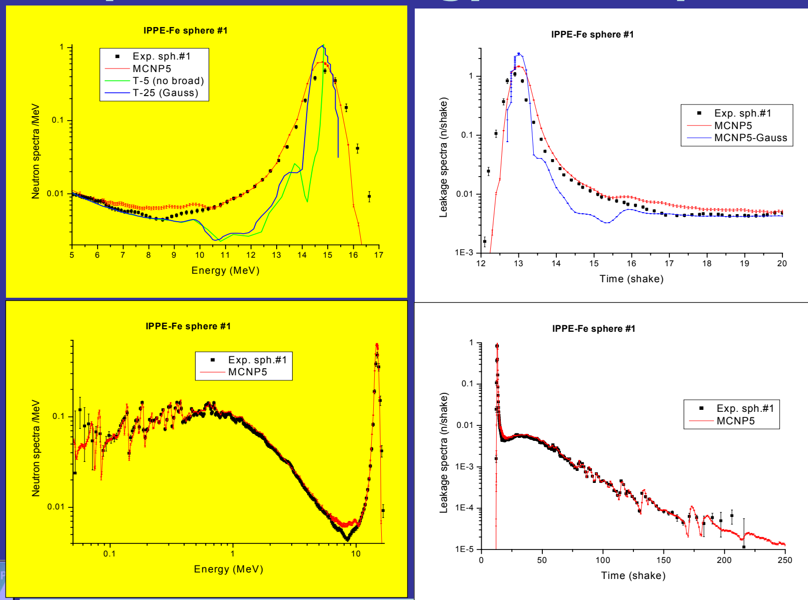




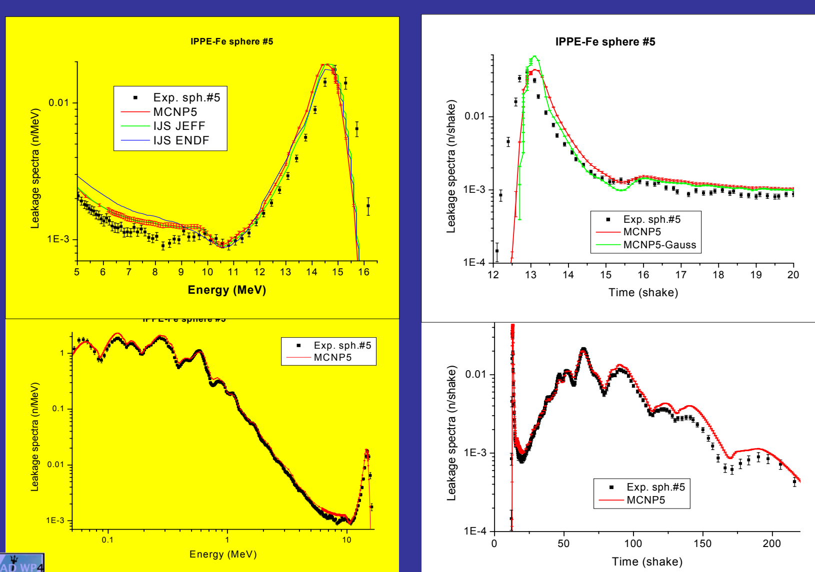




Fe sphere # 1: Energy – time spectra

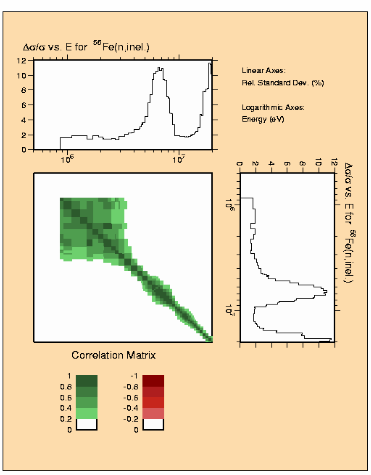


Fe sphere # 5: Energy – time spectra



Can the benchmark be useful to further improve today's high quality cross section evaluations?

Cross section sensitivity / uncertainty analysis



Fe-56(n,inel) from JEFF-3.1

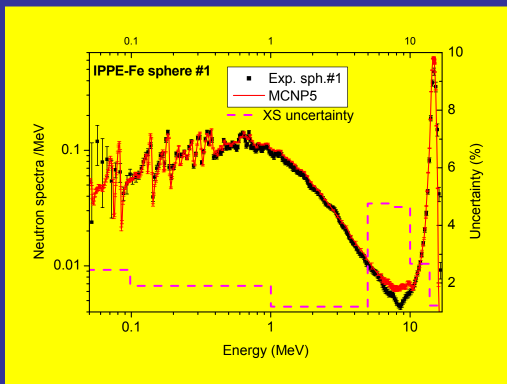
Code system
- ANISN – n transport
- SUSD3D – XS sensitivity & uncertainty

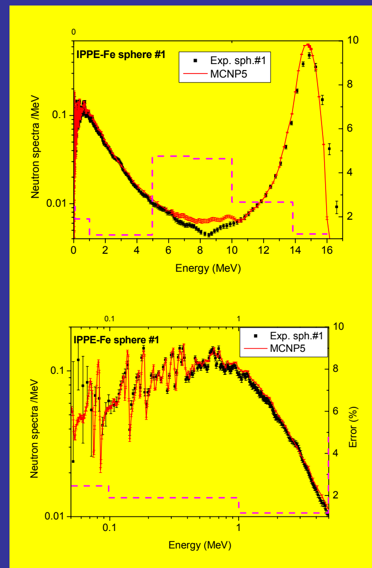
Main sensitivities
-elastic cross section
-(n,2n)
-Inelastic
-(n,p)

Total sensitivity
-Sphere # 1: +0.06
-Sphere # 5: +0.01

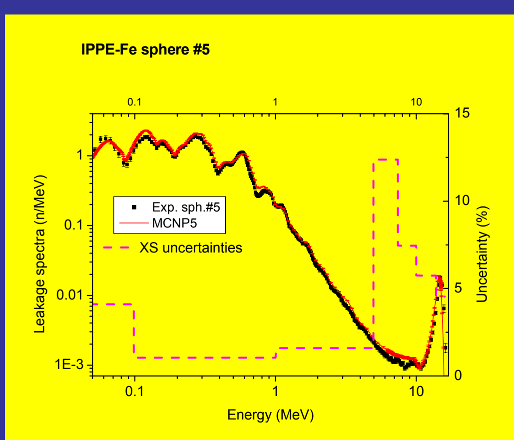
Fusion Eng. Design 70 (2004) 221-232

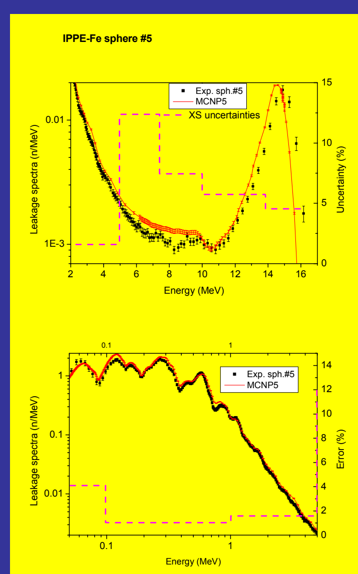
Fe sphere # 1: C/E compared to XS uncertainties





Fe sphere # 5: C/E compared to XS uncertainties





Conclusions

- Several participants found the physical interpretation of the exercise difficult, particularly the detector response function was not used properly in 2 cases;;
- Modification (simplification of physics) in the SINBAD benchmark description would facilitate the use of the data;
- Explicit modelisation of the collimator and providing TOF spectra in addition to the energy spectra could make the life of the users much easier. If the collimator is included in the computational model, the MCNP results (using 4-ns Gaussian broadening), could be compared directly with the measured TOA spectra, without needing any response function, nor TOA-Energy transformation.

  Detailed information on collimator and detector system would be required in the latter case.