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Multi-group Covariance Matrix for the Resolved Resonance Range of Np-237

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In the Resolved Resonance Range (RRR)…

1. Production of experimental covariance matrices

AGS method in CONRAD, a code to propagate uncertainty of cross section measurement data (see presentation of B. Habert)

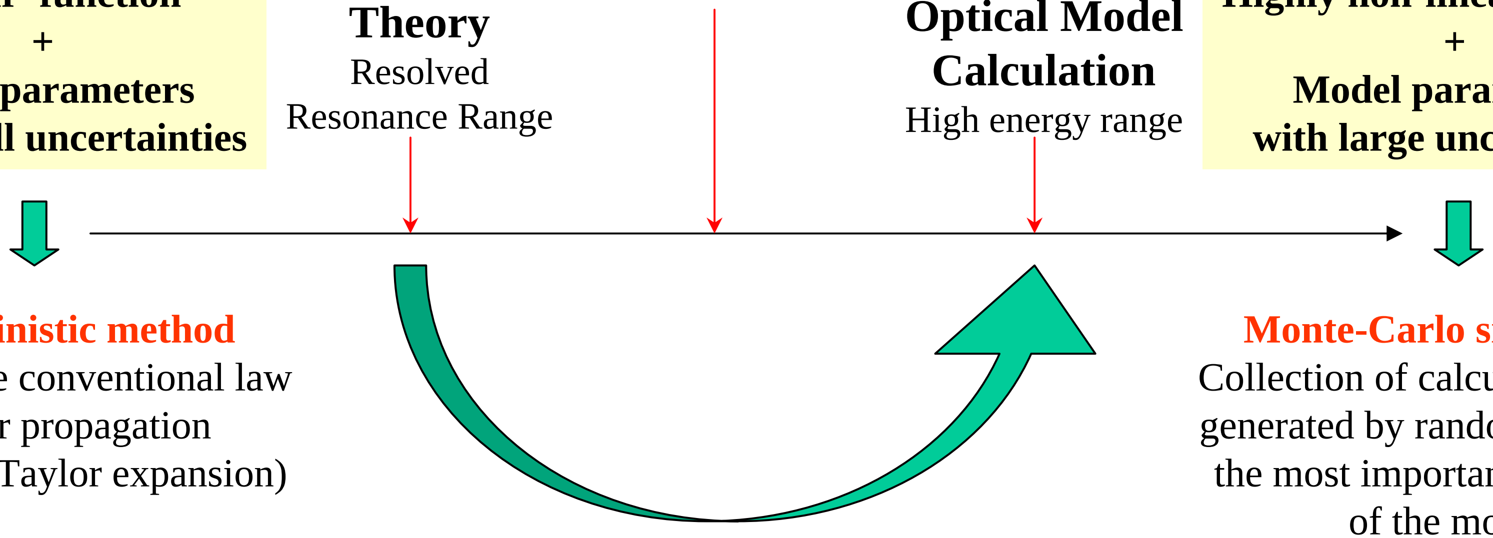
2. Production of correlations between the parameters of the model

Models in the Resolved Resonance Range :
Single-Level Breit Wigner, Multi-Level Breit Wigner, **Reich-Moore**, R-Matrix

3. Production of multi-group covariance matrices

Cross sections of interest (n,γ), (n,n), (n,f), (n,tot)

Generating covariance with nuclear model



Linear function
+
Model parameters
with small uncertainties

R-matrix
Theory
Resolved
Resonance Range

Averaged R-Matrix
+
Hauser-Feshbach
formalism
Unresolved
Resonance Range

Optical Model
Calculation
High energy range

Highly non-linear function
+
Model parameters
with large uncertainties

Deterministic method
based on the conventional law
of error propagation
(first order Taylor expansion)

Monte-Carlo simulation
Collection of calculated values
generated by randomly varying
the most important parameter
of the model

Experimental conditions
Sample composition
Resolution function
Doppler effect (FGM, CLM)
Prompt background
Multiple Scattering correction

Description of the method

$$\sigma(\vec{p}, \vec{x})$$

parameters adjusted on experimental data
+ covariance matrix ***P*** coming from the fit

non-adjusted parameters
+ Covariance Matrix ***X***

How to combine ***P*** and ***X*** to get consistent covariances ?

Monte-Carlo + Conditional Probabilities

Let us realize N Monte-Carlo simulation of $\vec{x}$. For each simulation k:

- we obtain $\vec{x_k}$
- we adjust the p_i parameters to obtain $\vec{p_k}$ (+ covariance matrix $\boldsymbol{P_k}$)

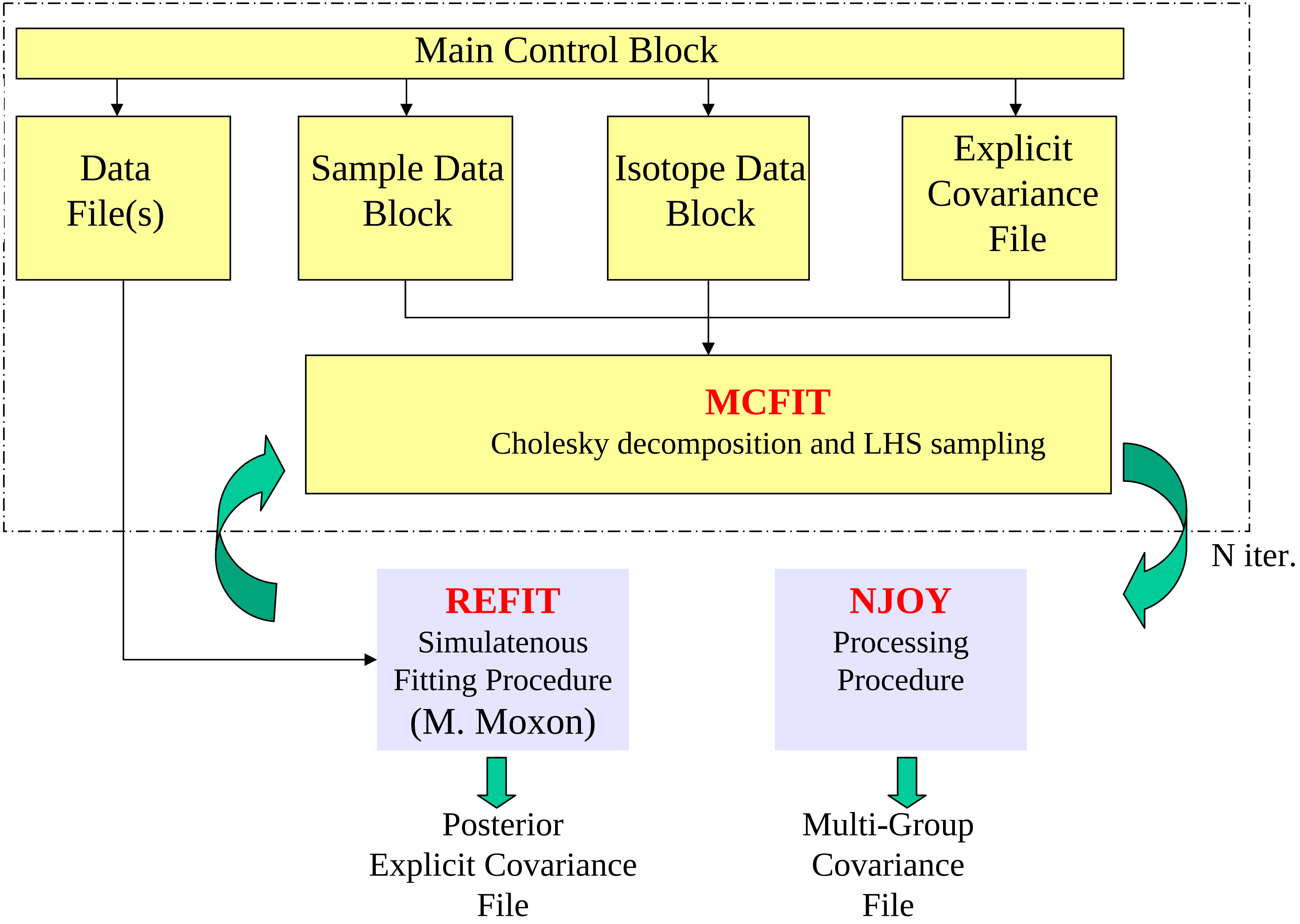
$$\vec{p_k} = \mathbb{E}(\vec{p} \,|\vec{x} = \vec{x_k})$$

$$P_k = cov(p_i, p_j \,|\vec{x} = \vec{x_k})$$

- the final covariance is given by :

$$cov(p_i, p_j) = cov(p_{k,i}, p_{k,j}) + \mathbb{E}(P_k)$$

The MCFIT interface



Main Control Block

Data File(s)

Sample Data Block

Isotope Data Block

Explicit Covariance File

MCFIT
Cholesky decomposition and LHS sampling

N iter.

REFIT
Simulatenous Fitting Procedure
(M. Moxon)

NJOY
Processing Procedure

Posterior Explicit Covariance File

Multi-Group Covariance File

Experimental data

Integral Trend :

2006 - D. Bernard et al. (OSMOSE) ⇒ **JEF/DOC-1144**

Thermal capture cross section :

2004 - A. Letourneau et al. (Mini-INCA) ⇒ **180 ± 5 b**

Capture cross section:

1981 - L.W Weston and J.H. Todd (ORELA)
2005 - O. Scherbakov et al. (KURRI)
2005 - E.I. Esch et al. (LANSCE) ⇒ **New normalisation of 1.07 ± 0.03 !!!**

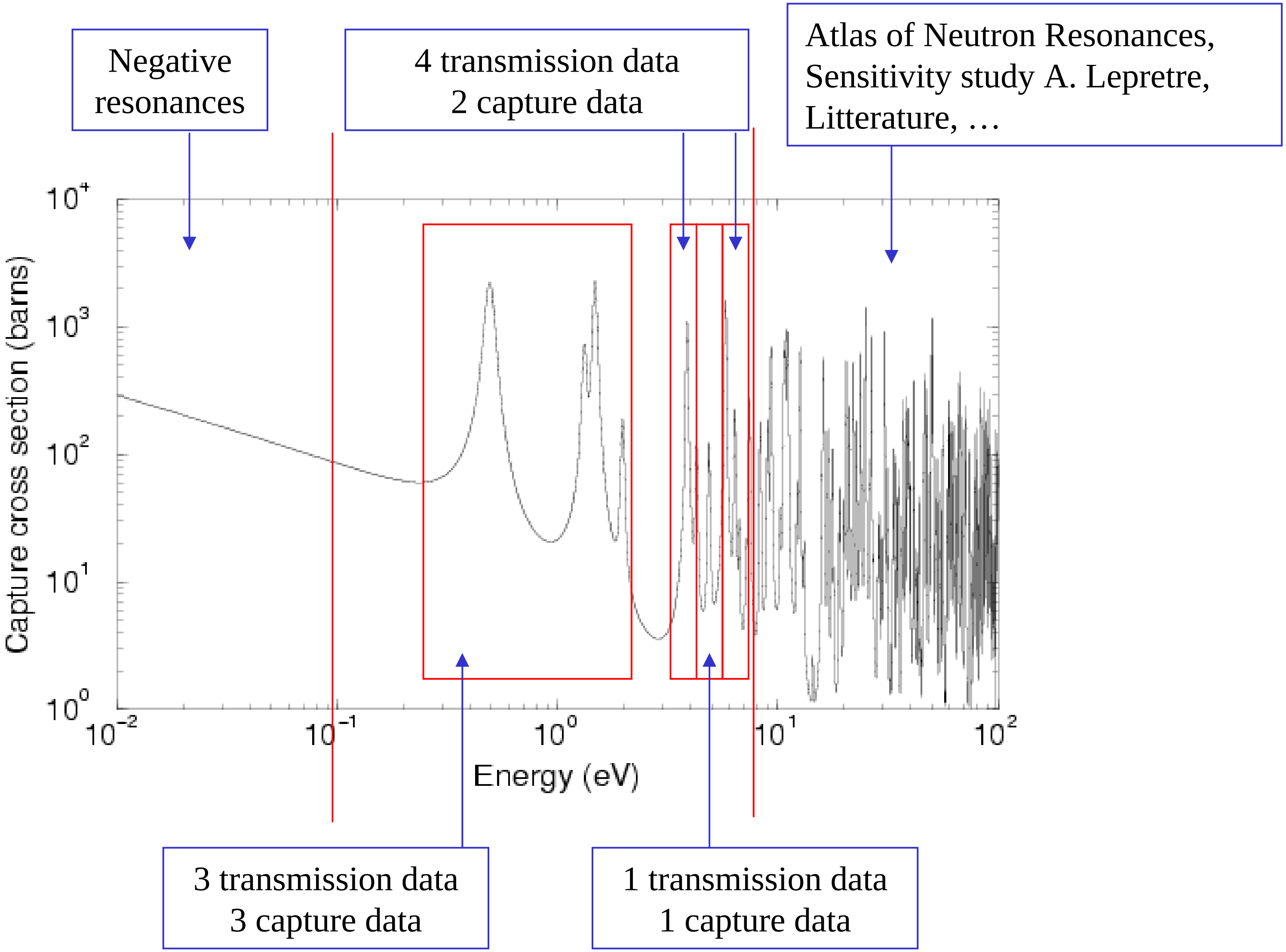
Total cross section :

1999 - V.Gressier et al. (GELINA) ⇒ **$<\Gamma_\gamma> = 40 \pm 2$ meV**

Fission widths (+ variance) :

1984 - S.F. Mughabhab (BNL)
1993 - E. Dermendjiev et al. (JINR)
1998 - S.B. Borzakov et al. (JINR)

Resonance analysis and error propagation



Negative resonances

4 transmission data
2 capture data

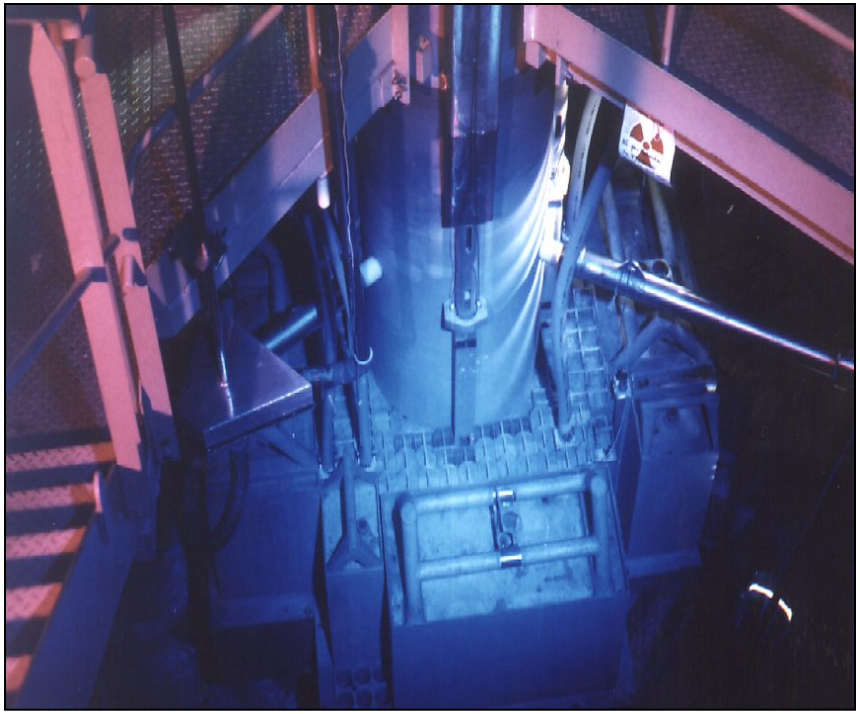
Atlas of Neutron Resonances,
Sensitivity study A. Lepretre,
Litterature, …

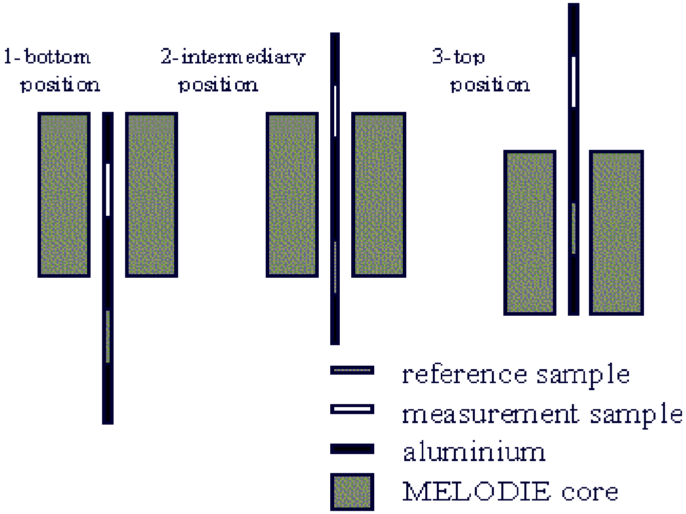
3 transmission data
3 capture data

1 transmission data
1 capture data

MINERVE integral trends

⇒ **OSMOSE** experiment performed in the **MINERVE** facility of CEA/Cadarache

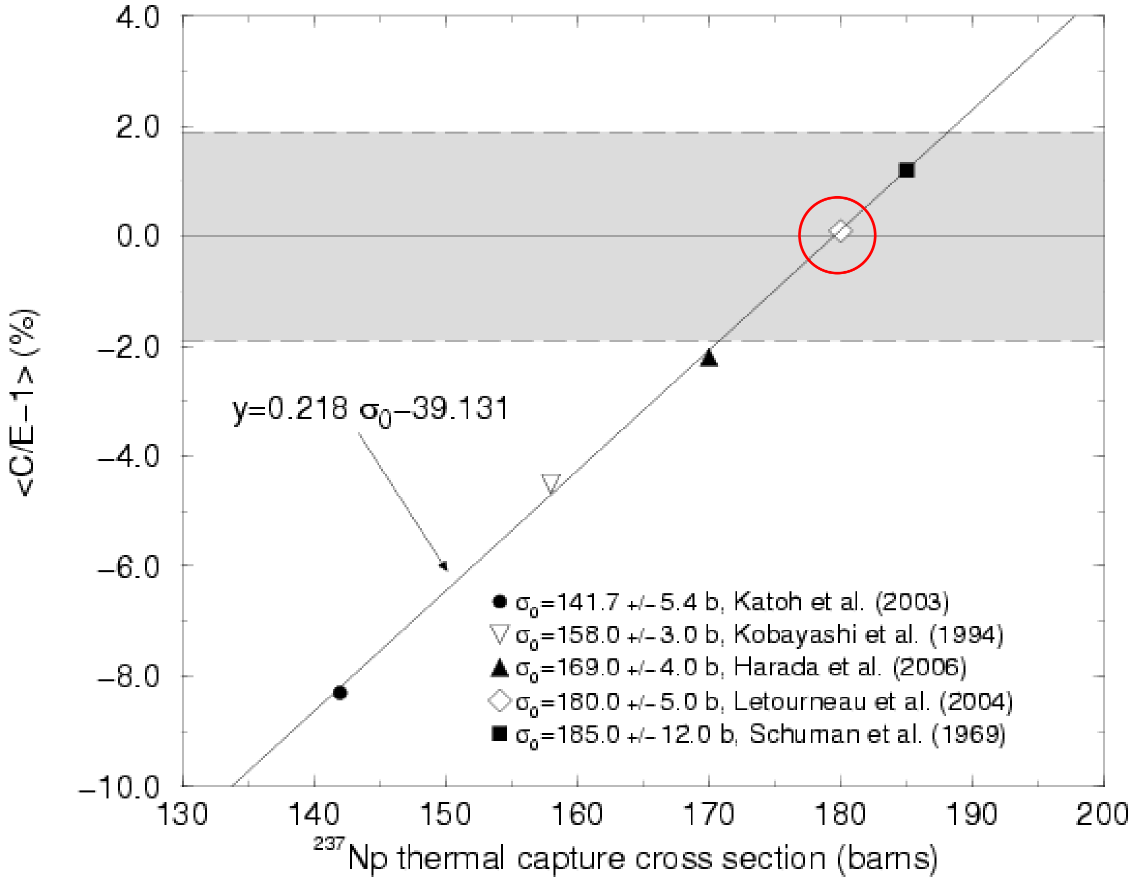




MINERVE is a low-power (<100W) pool reactor. Several lattices orresponding to different neutron spectra can be loaded in the central experimental cavity (800 pins), such as LWR UOx and MOx lattices.

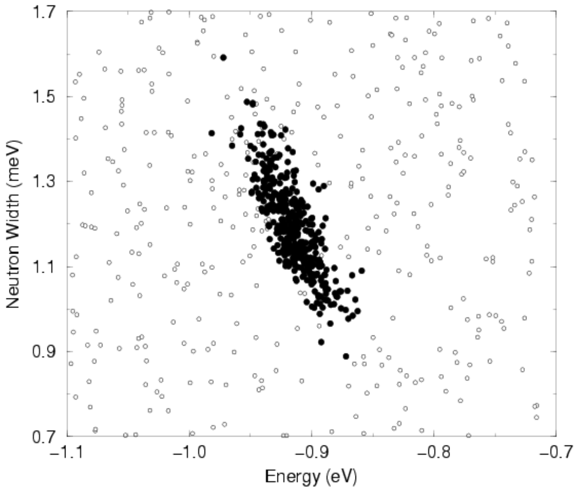
- Reactivity variation due to sample oscillations in a thermal $U0_2$ spectrum.
- Cylindrical column of UO_2 pellets (ϕ=8.1 mm, h=95 mm) doped with Actinide.
- **Admixed masses of the two ^{237}Np samples: 0.1g and 0.6 g**

APOLLO2 calculations

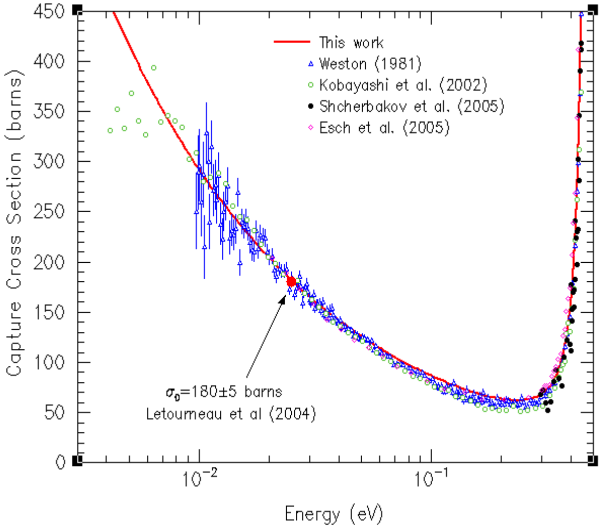


Reactivity worth proportional to the thermal capture cross section

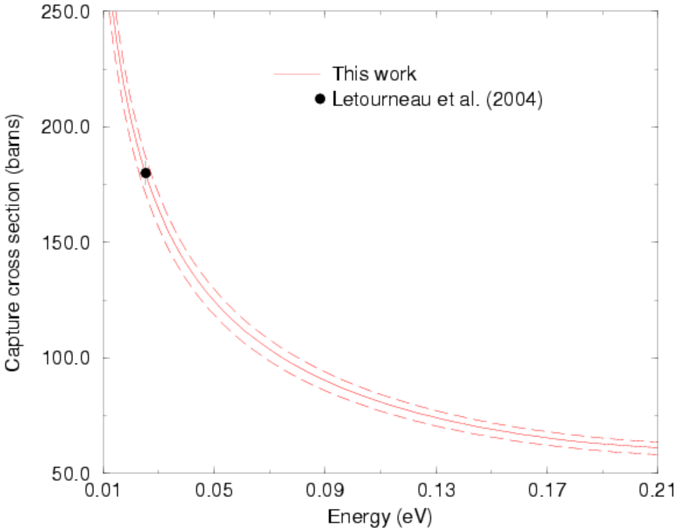
Determination of the negative resonances



Forward Backward approach

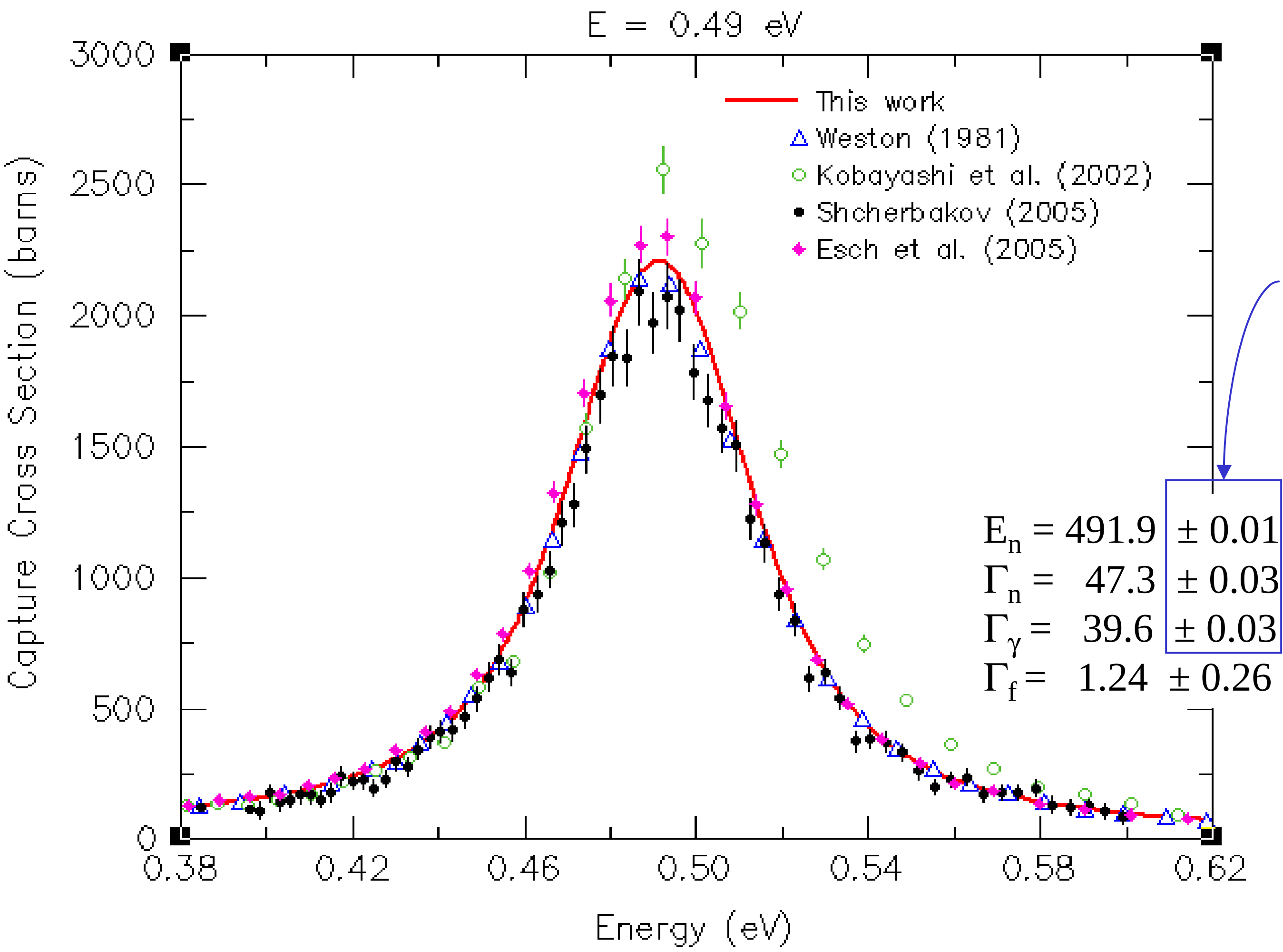


Processing



New χ^2 selection if needed

Capture Cross Section



Fitting procedure

total

E_n = 491.9 ± 0.01 ± 0.3 meV

Γ_n = 47.3 ± 0.03 ± 0.4 µeV

Γ_γ = 39.6 ± 0.03 ± 0.5 meV

Γ_f = 1.24 ± 0.26 µeV

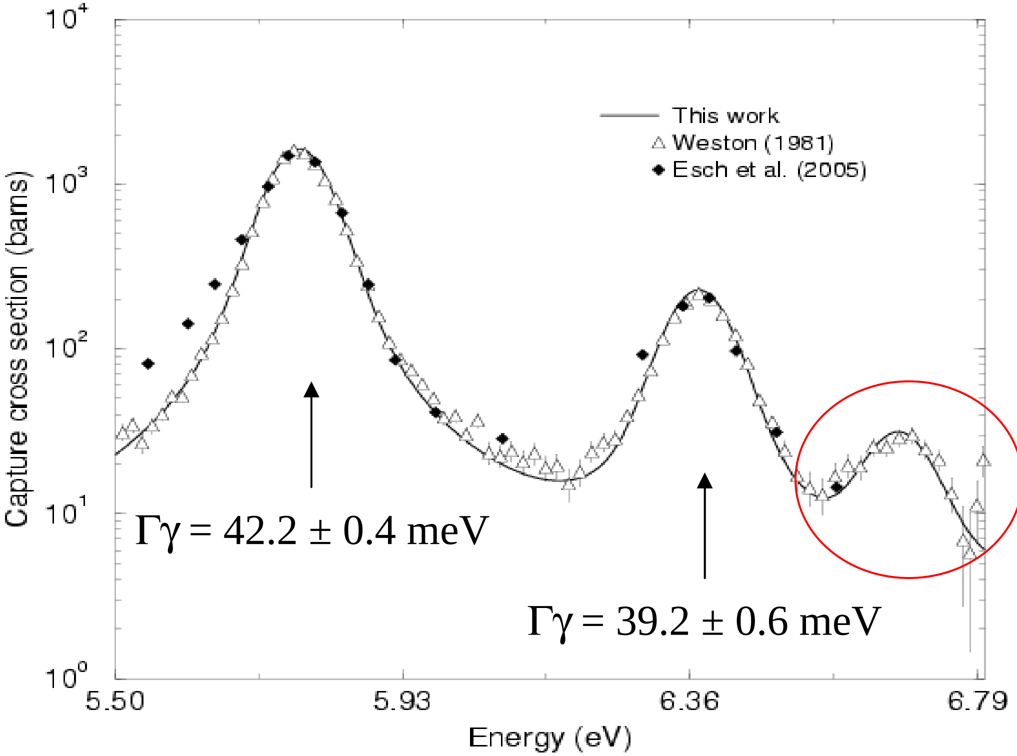
⇒ Large discrepencies between the various capture data sets

⇒ Data reported by Kobayashi are left out from this analysis

Average radiation width

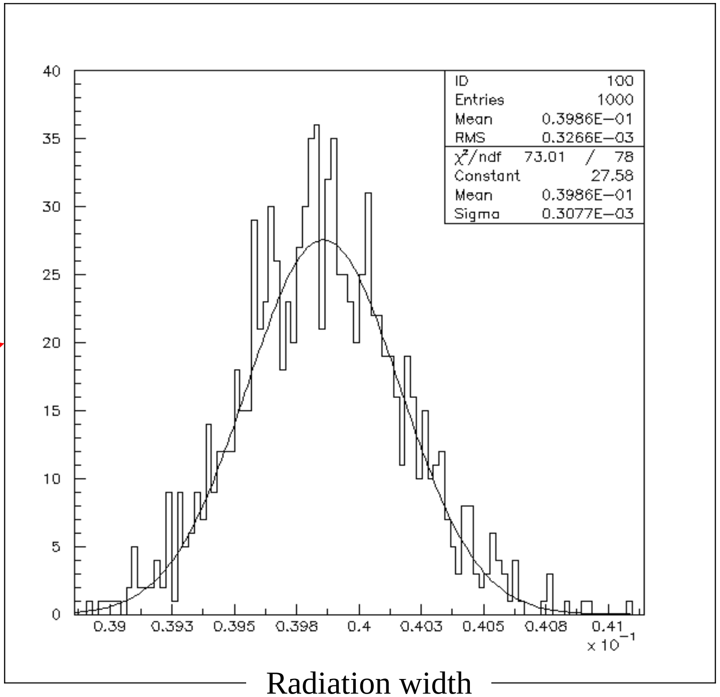
How to propagate the error on the radiation widths that are set to the average value ?

The average radiation width is calculated at each iteration.



Γγ = 42.2 ± 0.4 meV

Γγ = 39.2 ± 0.6 meV



Radiation width

Γγ = 39.8 ± 0.3 meV

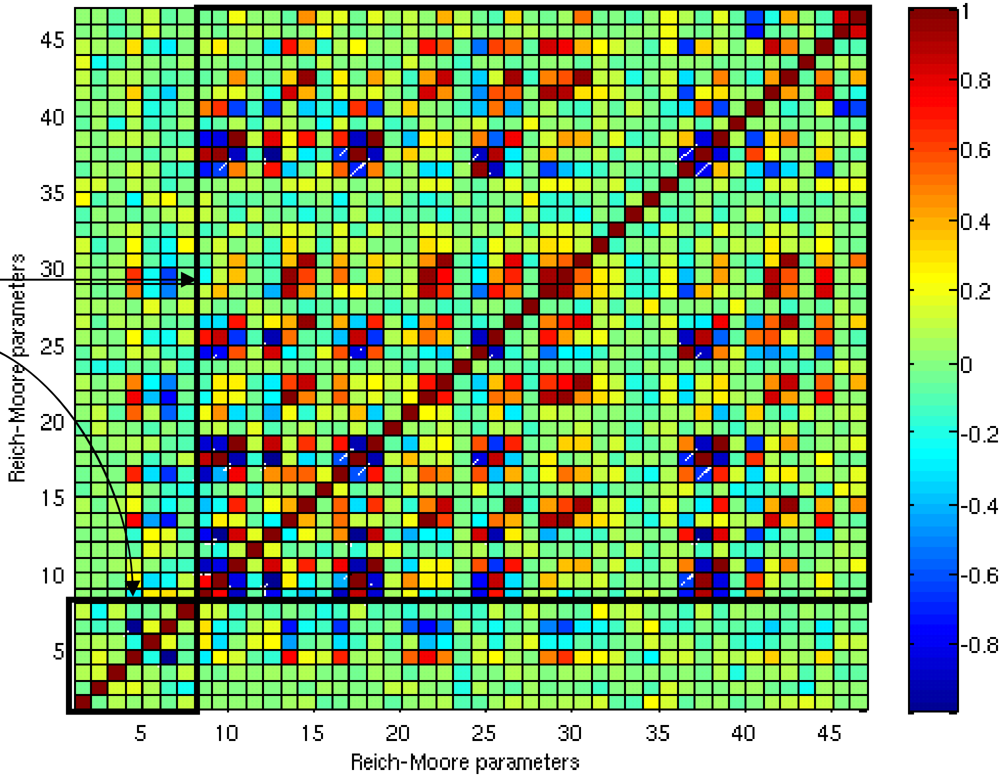
Correlations between the resonance parameters $\{E_o, \Gamma_\gamma, \Gamma_n, \Gamma_f \ldots\}$

12 resonances ⇒ 47 resonance parameter (31 free and 16 sampled)

Three transmission data ⇒ thickness and temperature were sampled

Three capture data ⇒ **normalisation** and temperature were sampled

same σ_γ^{th} used as « reference » ⇒ **normalisation factors are correlated**



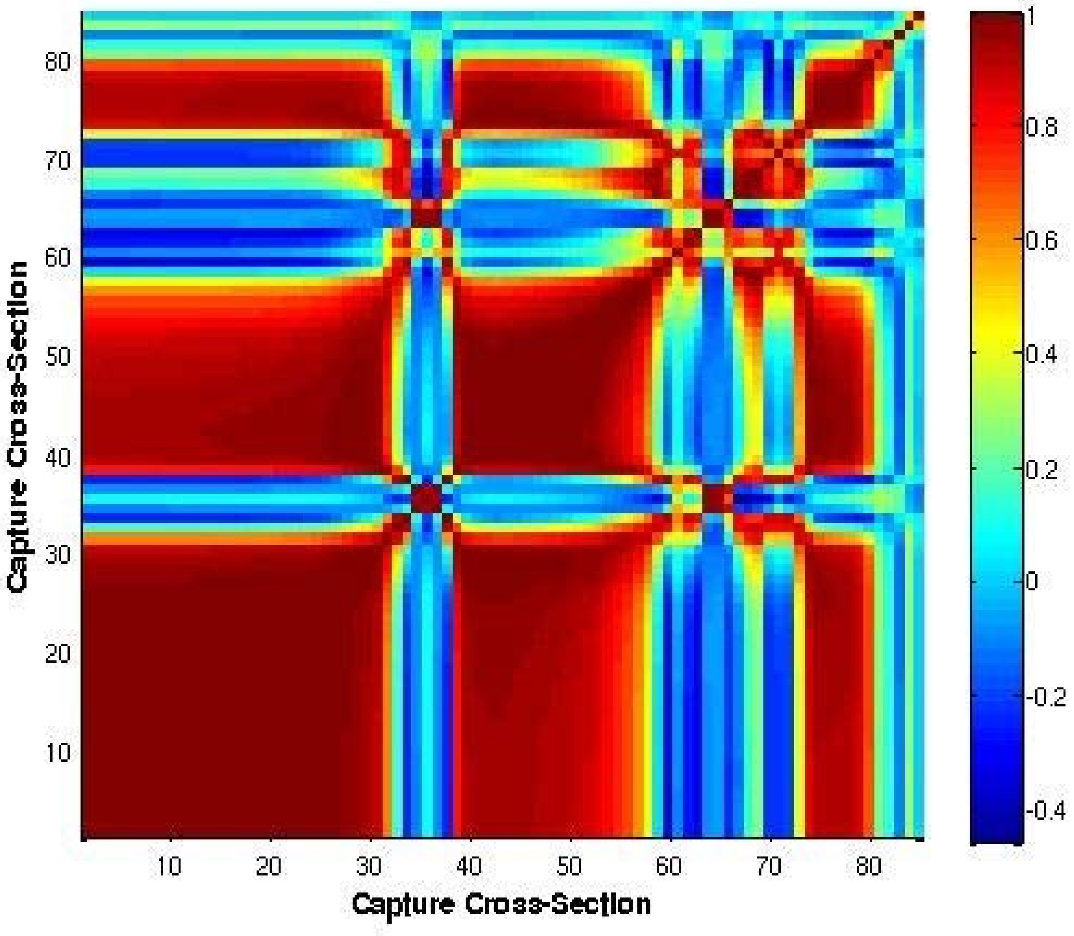
10 resonances

2 negative levels

Explicite Covariance File

Multigroup Covariance Matrix

Posterior « Explicite Covariance File » generated by the MCFIT interface can be used to produce Multigroupe Covariance Matrix (with **NJOY**)



Conclusions and Perspectives

- **Resonance Shape Analysis** coupled to **Monte-Carlo calculations** is able to produce realistic multigroup covariance matrices in the resolved resonance range with reasonable time calculations.

- Use the new resonance parameters from nTOF (**C. Guerrero, PhD Thesis**).

- Use the **Atlas of Neutron Resonances** in association with the sensitivity study performed by A. Lepretre.

- Need for new measurements of the thermal capture cross section ?
(**six NpO_2 samples available** for activation measurements in the MINERVE reactor, Cf. experimental work of P. Leconte, CEA-Cadarache)