European Commission

Description and usage of experimental data for evaluation in the resolved resonance region

Subgroup – 36

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Activities

The main task:

identify and quantify the metrological parameters involved in each step of the evaluation process, starting from the production of experimental data.

Activities:

(1) Identify the uncertainty components

(2) Identify methods for evaluating uncertainties in the resonance region using experimental covariance information

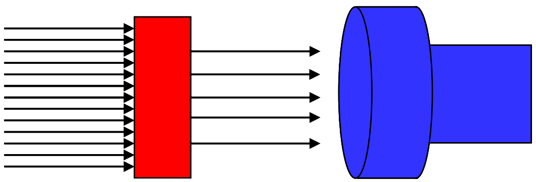
(3) Define and analyse case studies

(4) Provide recommendations for reporting and usage of experimental details and uncertainty components

1) Uncertainty components of experimental observables

Transmission

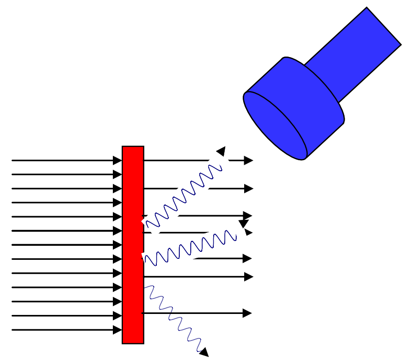
$$T_m \propto e^{-n_X \sigma_{tot}}$$



$$T_{exp} = N \frac{C'_{in} - B'_{in}}{C'_{out} - B'_{out}}$$

Reaction cross section

$$Y_m \propto \frac{\sigma_r}{\sigma_{tot}}(1 - e^{-n_x \sigma_{tot}}) + \ldots$$



$$C = \varepsilon_r \, \Omega_r \, F_r \, Y_r \, A_r \, \varphi$$

$$Y_{exp} = N \frac{\sigma_\varphi}{\varepsilon_r} \frac{C'_r - B'_r}{C'_\varphi - B'_\varphi}$$

Details in:
Nuclear data sheets, 113 (2012) 3054 - 3100

2) Evaluation methods

Methods to account for all uncertainty components and avoid PPP

- **Conventional uncertainty propagation (CUP)** Fröhner, NSE 126 (1997) 1 – 18
- **Monte Carlo (MC)** De Saint Jean et al., NSE 161 (2009) 363 - 370
- **Marginalization (MA)** Habert et al., NSE 166 (2010) 276 - 287

Differ in the way the uncertainty of experimental parameters are taken into account

Applications described in:

Nuclear data sheets, 113 (2012) 3054 – 3100
Becker et al. (ND2013)
Becker (this meeting, see case studies)

3) Define and analyse case studies

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Cases in RRR (transmission + capture)

- **Resonance parameters:**
  - Energy: 1 eV, 220 points from 0.7 eV to 1.3 eV
  - A) Γ_γ : 100 meV, Γ_n : 0.1, 1,10,100 meV
  - B) Γ_γ : 10 meV, Γ_n : 100 meV

- **Model parameters (experiment):**
  - Temperature: 300K ± 5K
  - Flight path: 10 m
  - Gaussian resolution: ΔL = 3.7 cm ± 0.74 cm (20%)
  - Areal density: (± 0.25%)

- **Experimental data simulated for different target thicknesses :**

Transmission (T_{exp} = 0.2 – 0.8)
Counting statistics : 0.71% for baseline
u_N = 0.5 %
u_B = 0.5 % with P/B=0.05

Capture (Y_{exp} = 0.2 – 0.8)
Counting statistics : peak yield 1%
u_N = 2.0 %
u_B (still to be done)

Used Models for Uncertainty Propagation

- <u>Only</u> **counting statistics (UU)**
- **Add uncertainties due to systematic effects:**

1. **Conventional Uncertainty Propagation (CUP)**

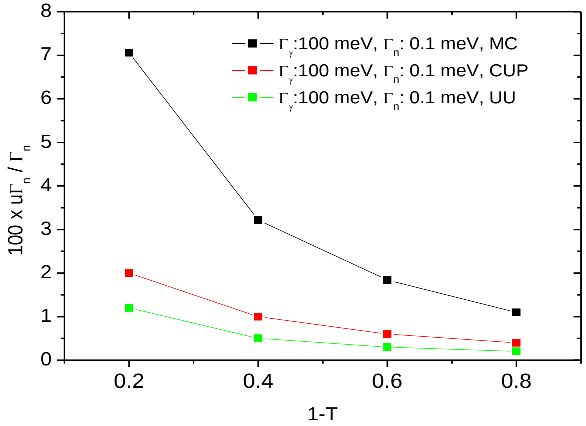
2. **Monte Carlo (MC) sampling of model parameters:**

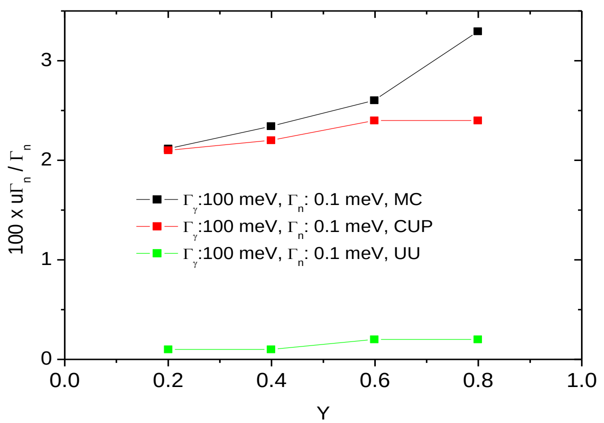
- **Only adjust reaction model parameters**
- **4000 different samplings**
- **Total Covariance Theorem**

Focus on : u_{Γ_γ}, u_{Γ_n}, $\rho(\Gamma_\gamma,\Gamma_n)$

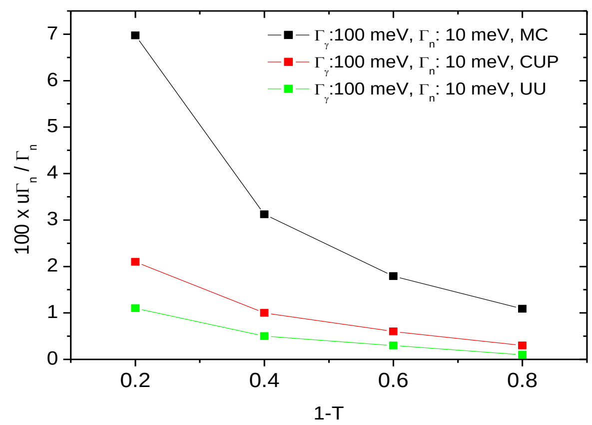
$u\Gamma_n / \Gamma_n$

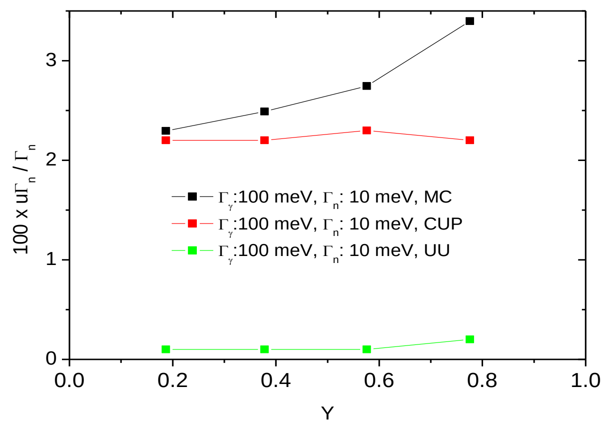
Γ_γ : 100 meV, Γ_n : 0.1 meV



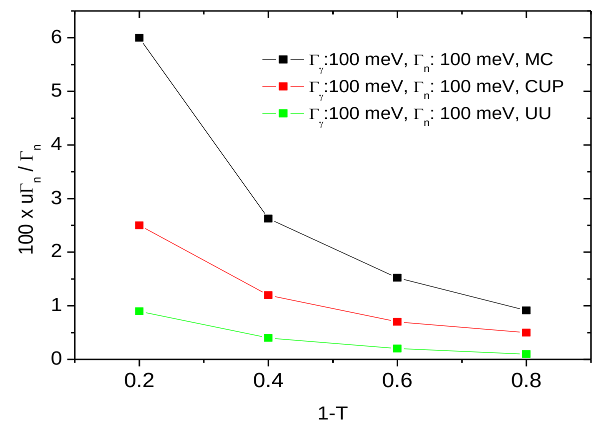


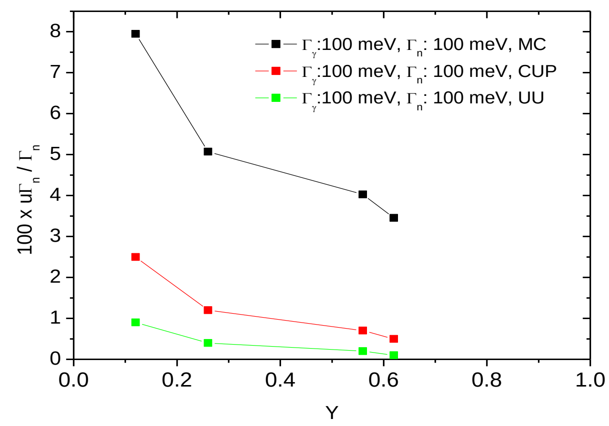
Γ_γ : 100 meV, Γ_n : 10 meV





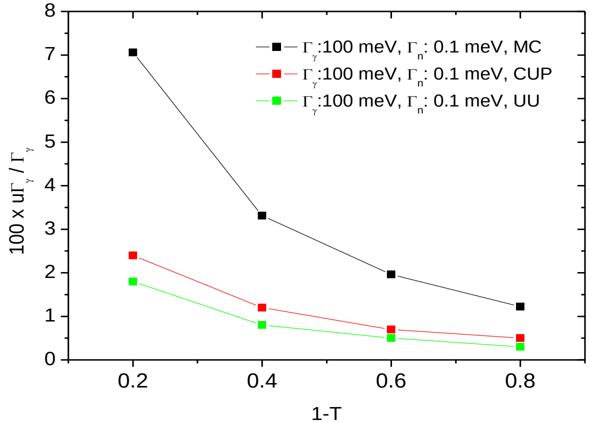
Γ_γ : 100 meV, Γ_n : 100 meV

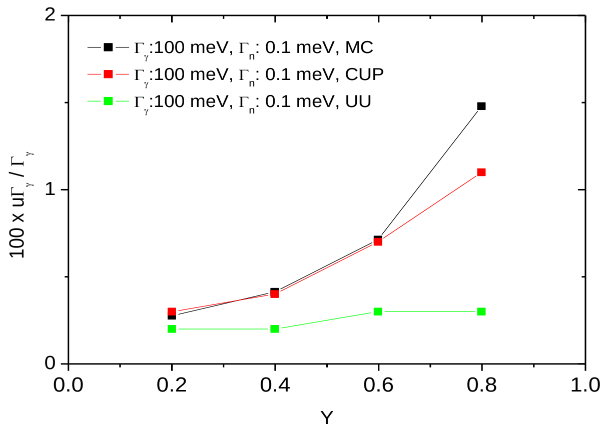




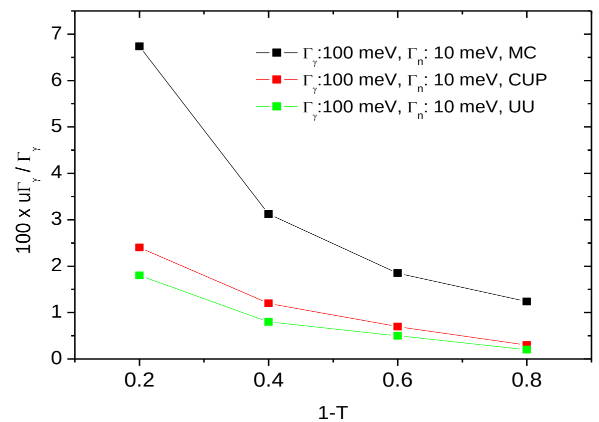
$u\Gamma_\gamma / \Gamma_\gamma$

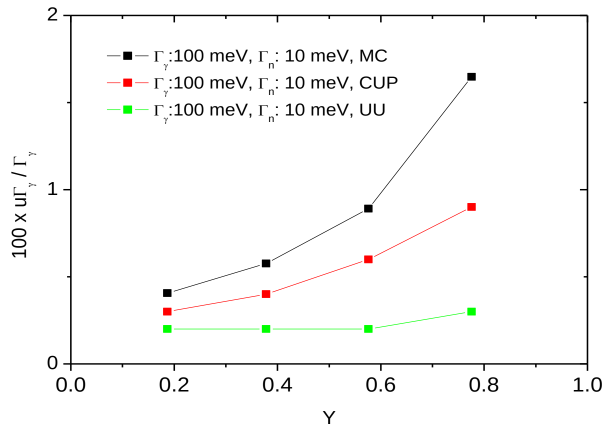
Γ_γ : 100 meV, Γ_n : 0.1 meV



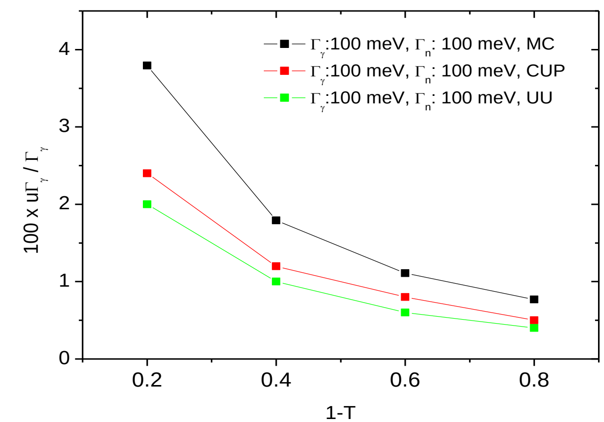


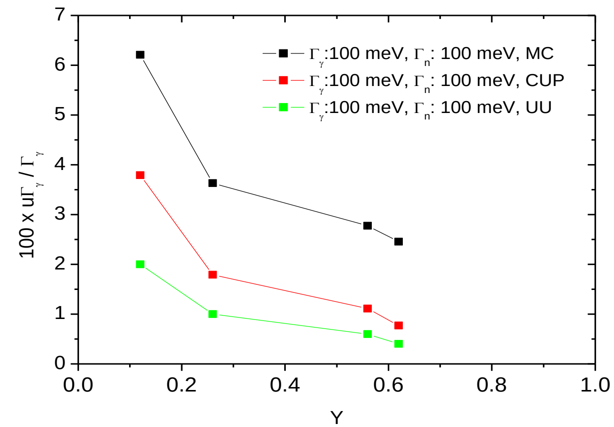
Γ_γ : 100 meV, Γ_n : 10 meV





Γ_γ : 100 meV, Γ_n : 100 meV





Dependence on Counting Statistics

Γ_γ : 100 meV
Γ_n : 0.1 meV

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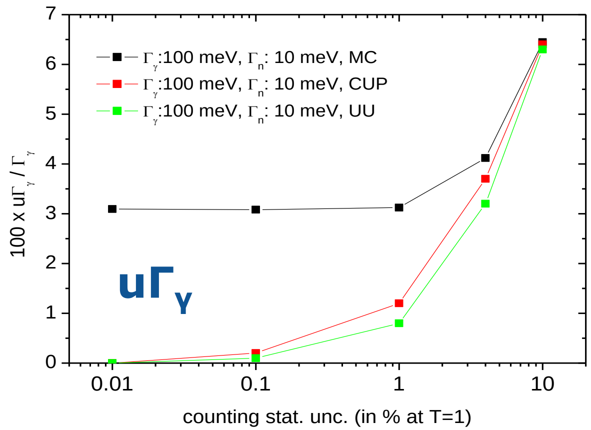
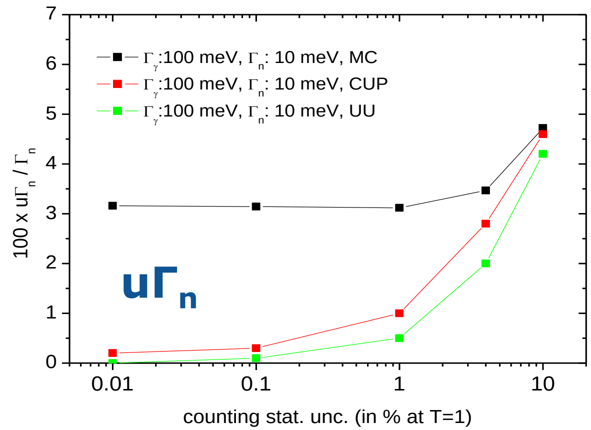
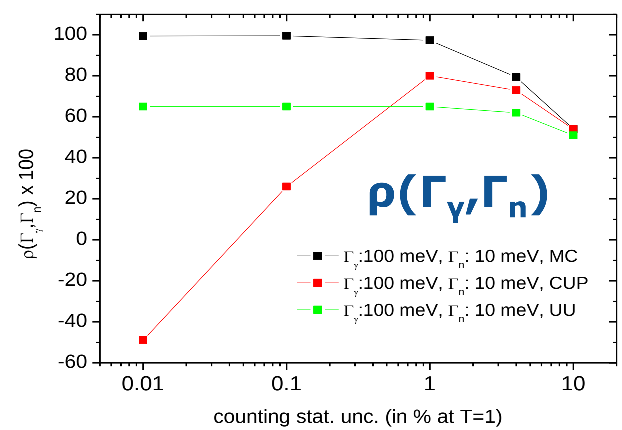
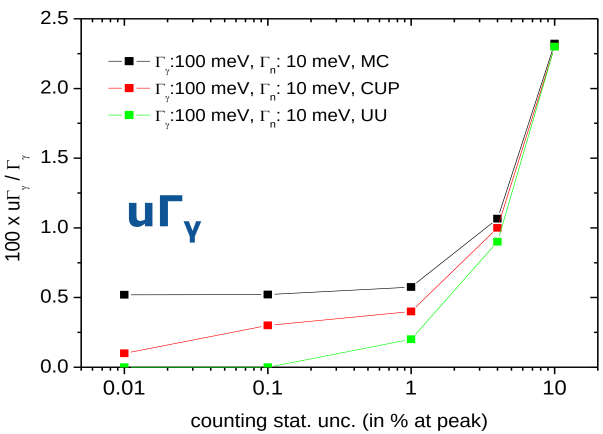
Transmission

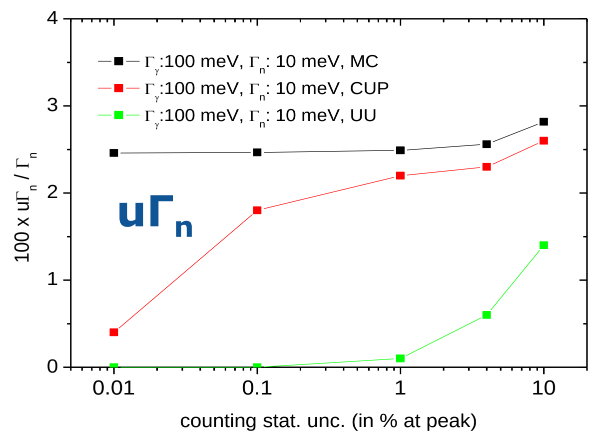


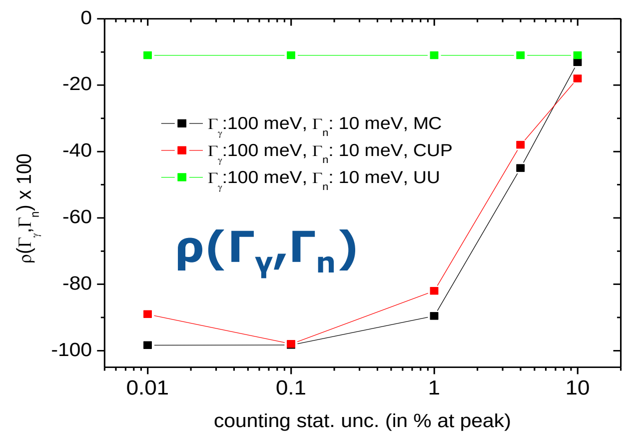




Capture







Conclusions from case studies

- **Resolved resonance region** (from case studies presented at SG-36 by Becker (IRMM))
  - **Conventional uncertainty propagation**

$$V_p = \left(G^T V_{exp}{}^{-1} G\right)^{-1}$$ (similar for Bayes equation)

including the uncertainty on the normalization in V_{exp} is similar as including the normalization as an adjustable parameter in the fit. Consequently, the uncertainty is not fully propagated. The propagation of the normalization uncertainty to V_p strongly depends on the experimental details: target thickness, number of data points, counting statistics,…

It supposes a perfect model.

  - The normalization uncertainty can be fully propagated by MC-sampling as proposed by De Saint Jean et al. (or marginalization, however, this method is not yet full-proved)

- **Unresolved resonance region**

4) Recommendations to report experimental data

- **Facility/ Neutron production TOF-response functions**
  - **No feedback from last meeting**
  - **Importance : see CIELO correspondence**
  - **IAEA initiative : meeting October 2013**

- **Target characteristics**

- **Experimental data uncertainties**
  - **Report TOF**
  - **Ideally : AGS-concept**
  - **In any case report separately**
    - **Uncorrelated component (due to counting statistics)**
    - **Normalization uncertainty**

Details described in:

Otuka et al., JKPS 59 (2011) 1314

Becker et al., JINST 7 (2012) P11002

Actions :

- Prepare report

  (1) Uncertainty components of experimental observables
  (2) Methods to propagate uncertainties in the resonance region
  (3) Case studies
  (4) Recommendations for reporting experimental data
  (5) Summary

- Prepare manual for AGS and distribute (NEA)