

Systematic Study of Covariance Matrices as a Function of Resonance Characteristics

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Content

Systematic Study for the Resolved Resonance Range

- Case Definition: Transmission
- Case Definition: Capture
- Results

Unresolved Resonance Range

- Example: ^{179}Au

Transmission Test Cases

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:

- Temperature: 300K \pm 5K
- Flight path: 10 m
- Gaussian resolution: $\Delta L = 3.7 \text{ cm} \pm 0.74 \text{ cm}$ (20%)
- Areal density: depending on transmission ($\pm 0.25\%$)
- Normalization: 0.5%

Counting statistics uncertainty:

- C_{in} : 0.71% for baseline
- C_{out} : 0.71%
- B: 0.5 % with $P/B=0.05$
 $\approx 1\%$ for $T=1$

Dip transmission:

- $T=0.8, 0.6, 0.4, 0.2$

Capture Test Cases

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:

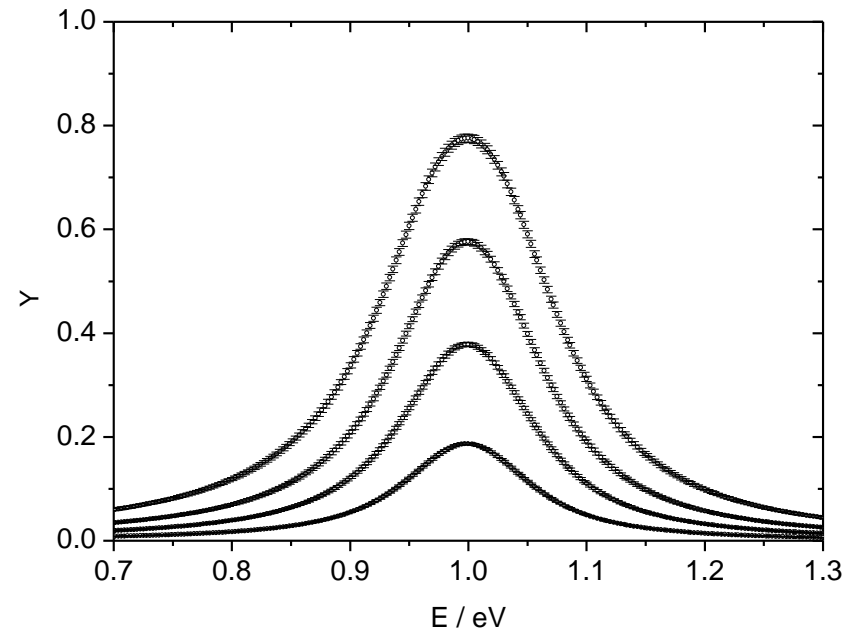
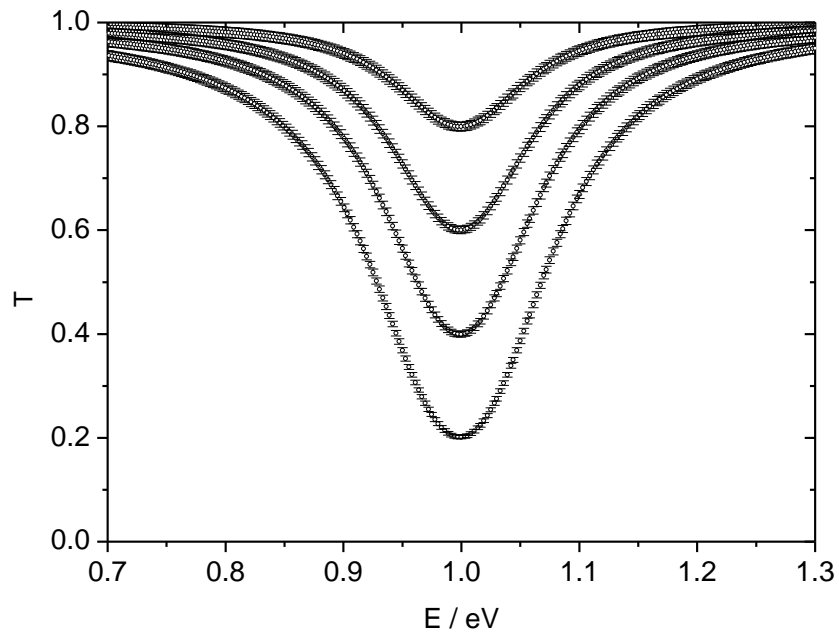
- Temperature: 300K \pm 5K
- Flight path: 10 m
- Gaussian resolution: $\Delta L = 3.7 \text{ cm} \pm 0.74 \text{ cm}$ ($\pm 20\%$)
- Areal density: same as for transmission ($\pm 0.25\%$)
- Normalization: 2%

Counting statistics uncertainty:

- 1% at peak yield

Transmission & Capture Examples

$\Gamma_\gamma : 100 \text{ meV}, \Gamma_n : 0.1 \text{ meV}$



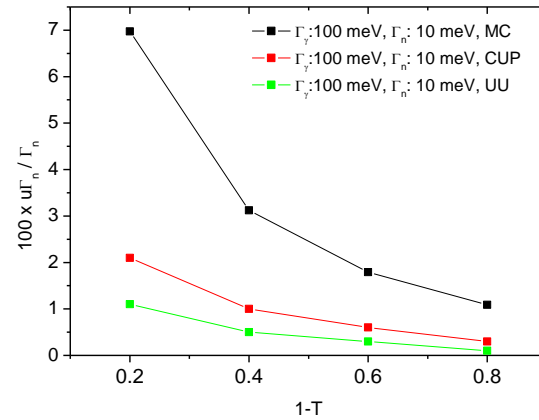
Used Models for Uncertainty Propagation

Uncertainty propagation towards the covariance matrix of the adjusted resonance parameters:

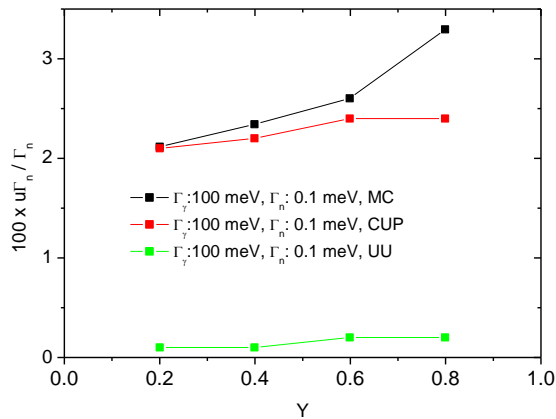
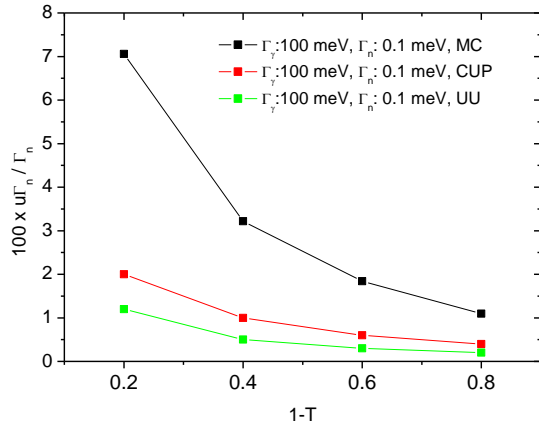
- Only counting statistics (UU)
- Add uncertainties due to systematic effects:
 1. Conventional Uncertainty Propagation (CUP) by adjusting resonance parameters and model parameters
 2. Monte Carlo (MC) sampling of model parameters:
 - 4000 different samplings
 - Total Covariance Theorem
- *Result: more than 100 covariance matrices*
- *Focus: $u\Gamma_{\gamma'}$, $u\Gamma_{n'}$, $\rho(\Gamma_{\gamma'}, \Gamma_{n'})$*

$$u\Gamma_n / \Gamma_n$$

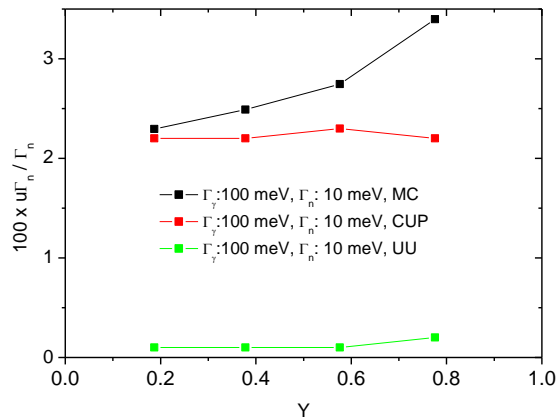
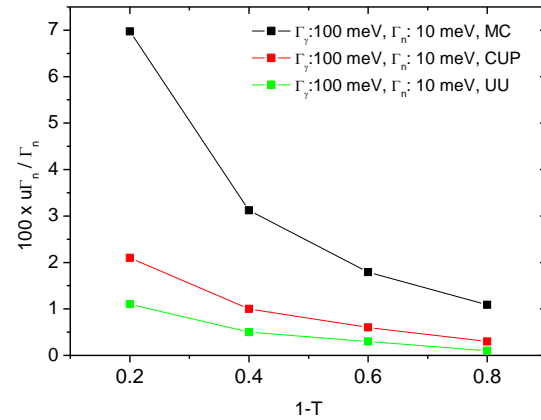
$\Gamma_\gamma : 100 \text{ meV}, \Gamma_n : 10 \text{ meV}$



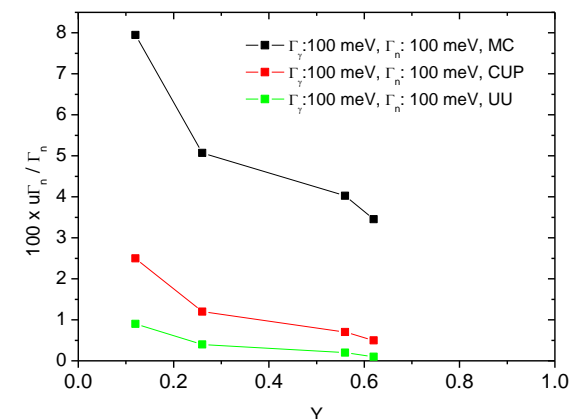
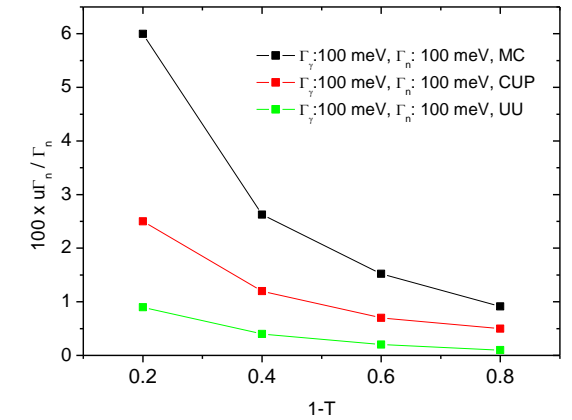
$\Gamma_\gamma : 100 \text{ meV}, \Gamma_n : 0.1 \text{ meV}$



$\Gamma_\gamma : 100 \text{ meV}, \Gamma_n : 10 \text{ meV}$



$\Gamma_\gamma : 100 \text{ meV}, \Gamma_n : 100 \text{ meV}$

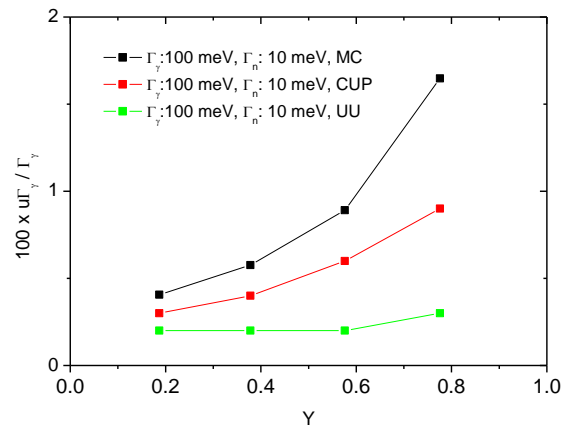
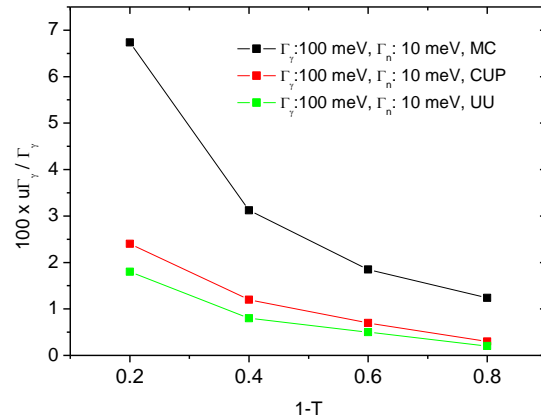




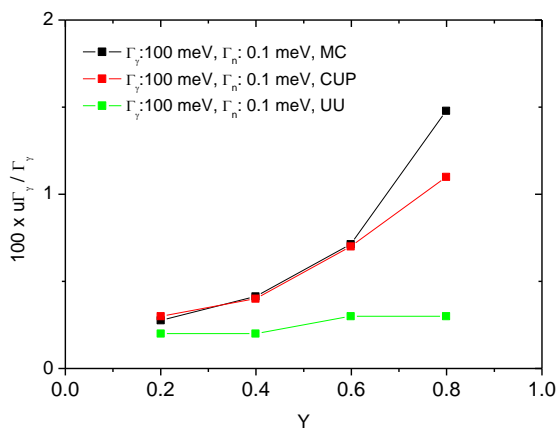
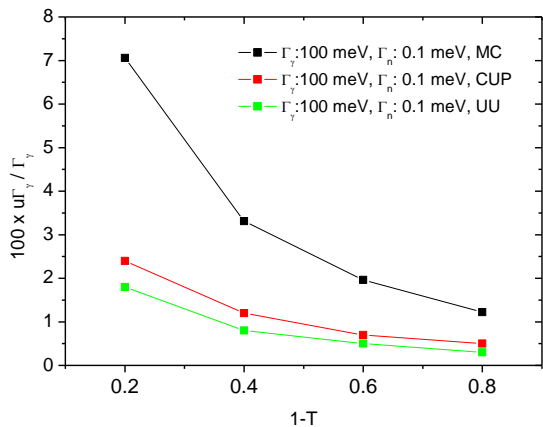
European
Commission

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

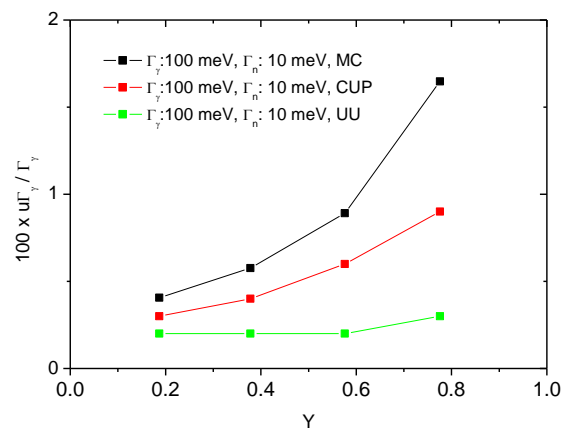
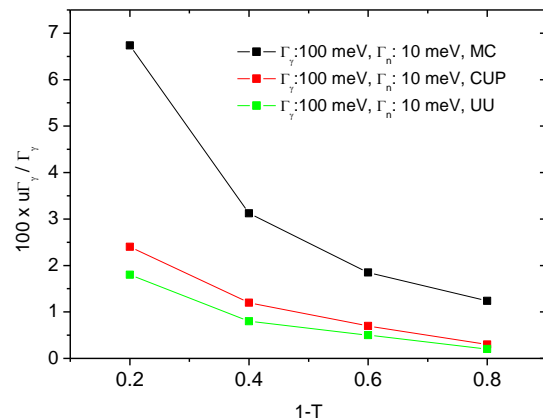
$\Gamma_\gamma : 100 \text{ meV}, \Gamma_n : 10 \text{ meV}$



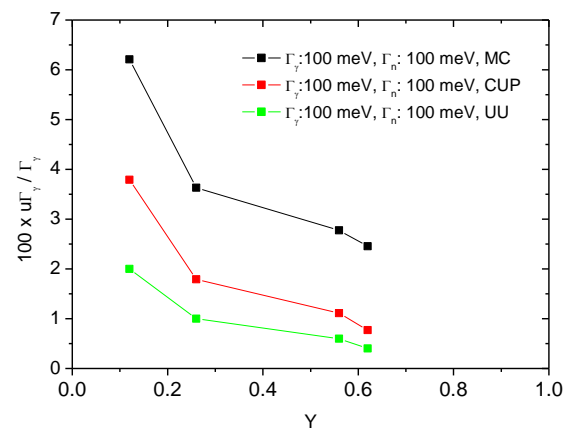
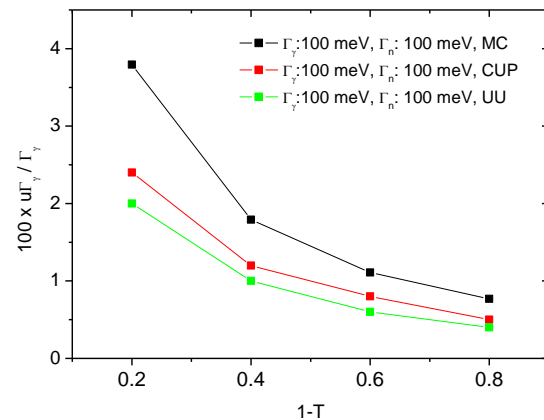
$\Gamma_\gamma : 100 \text{ meV}, \Gamma_n : 0.1 \text{ meV}$



$\Gamma_\gamma : 100 \text{ meV}, \Gamma_n : 10 \text{ meV}$

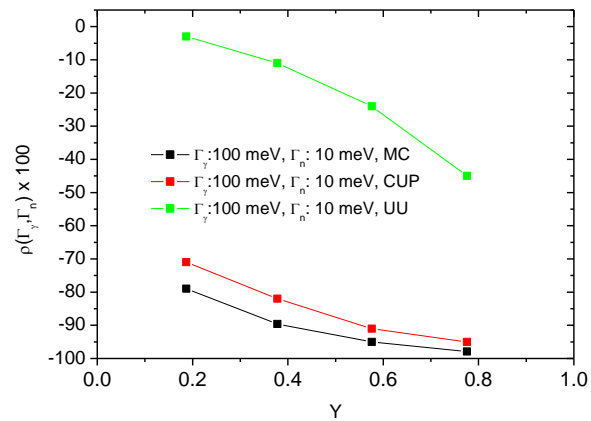
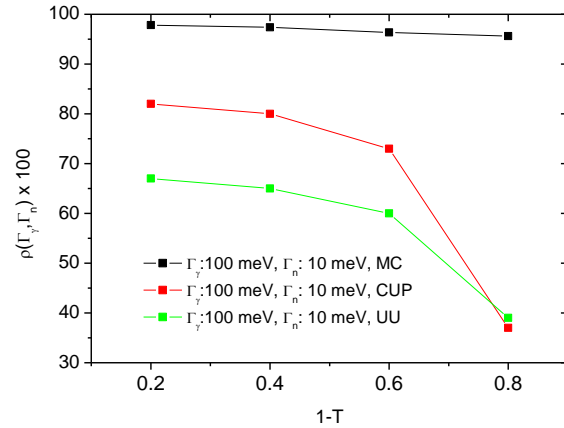


$\Gamma_\gamma : 100 \text{ meV}, \Gamma_n : 100 \text{ meV}$



$\rho(\Gamma_\gamma, \Gamma_n)$

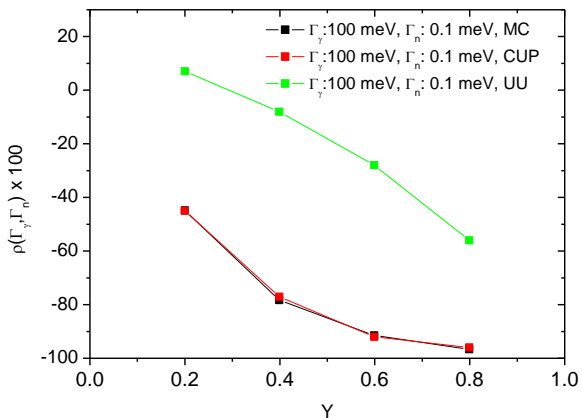
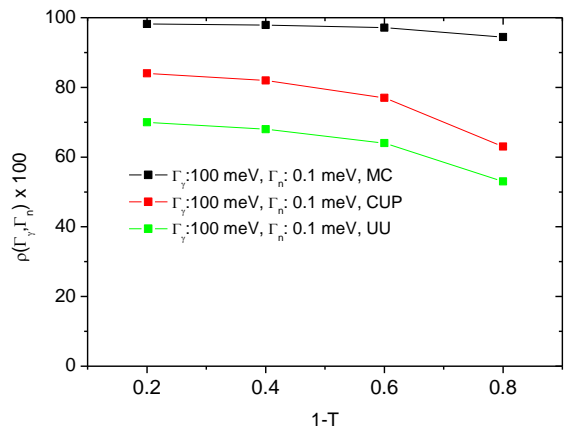
$\Gamma_\gamma : 100 \text{ meV}, \Gamma_n : 10 \text{ meV}$



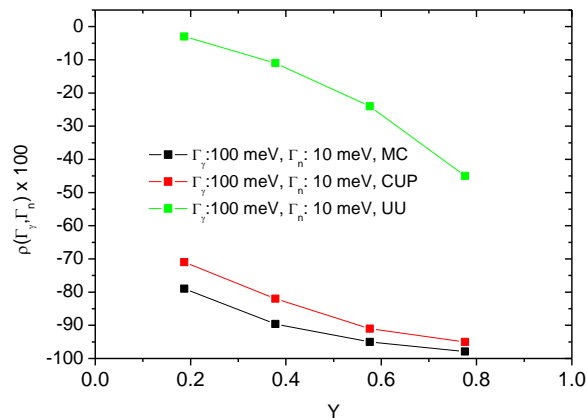
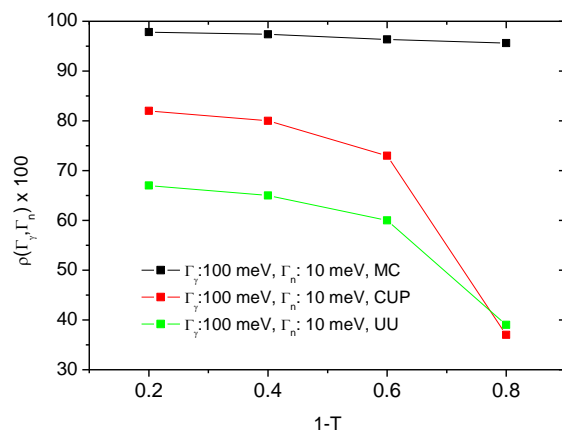
$$\rho(\Gamma_\gamma, \Gamma_n)$$



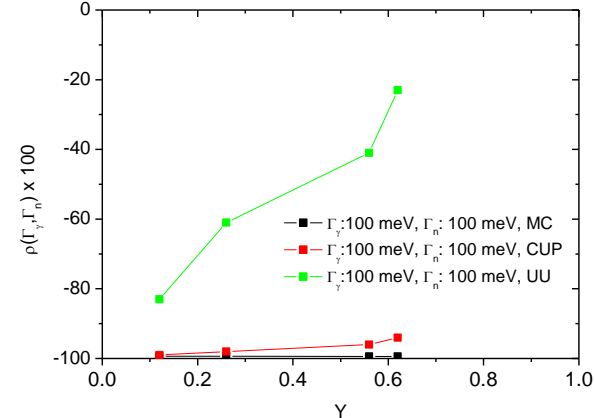
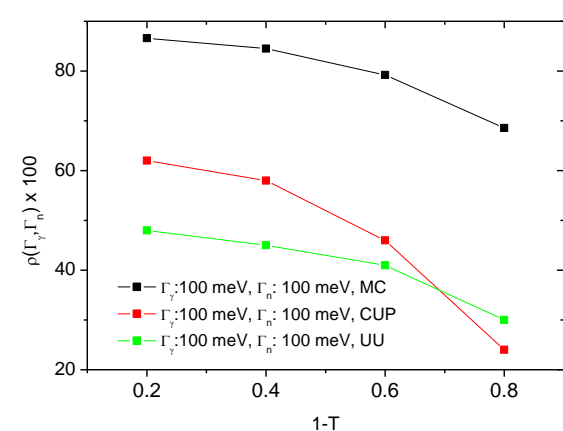
$\Gamma_\gamma : 100 \text{ meV}, \Gamma_n : 0.1 \text{ meV}$



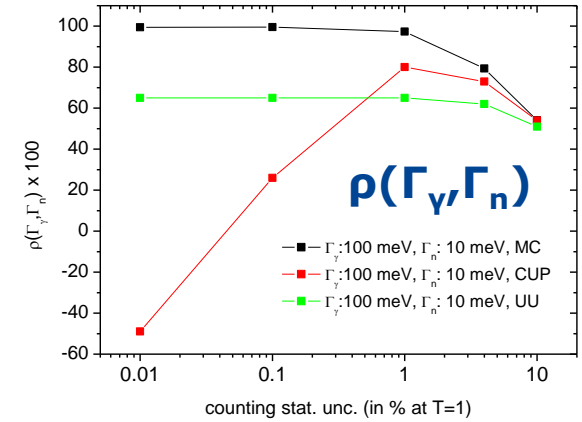
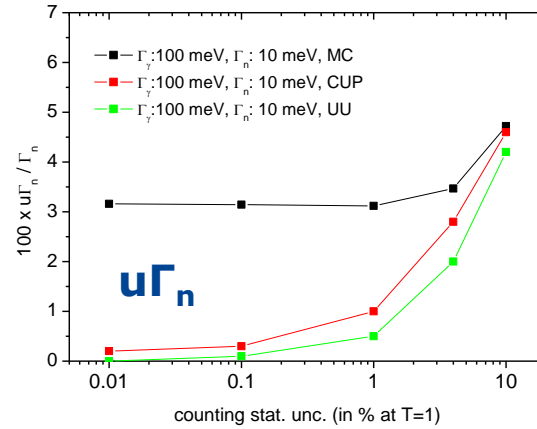
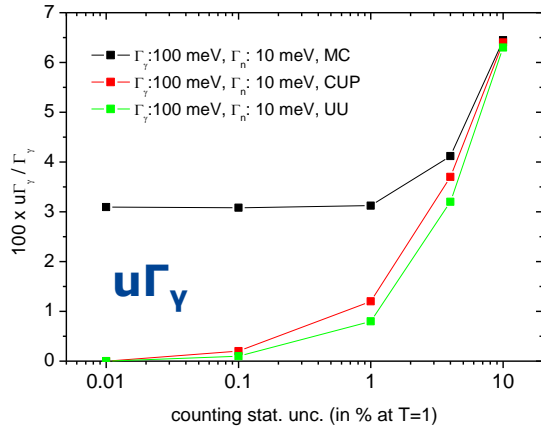
$\Gamma_\gamma : 100 \text{ meV}, \Gamma_n : 10 \text{ meV}$



$\Gamma_\gamma : 100 \text{ meV}, \Gamma_n : 100 \text{ meV}$



Transmission

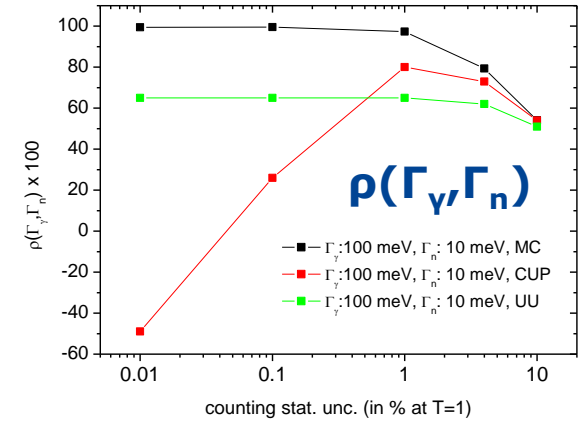
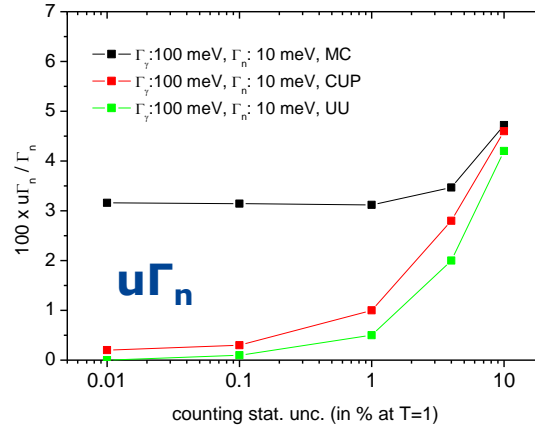
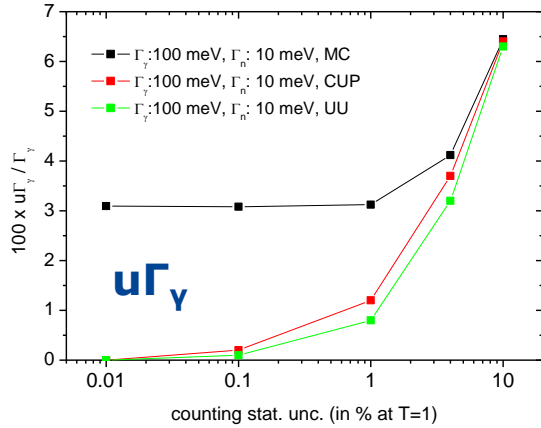


Dependence on Counting Statistics

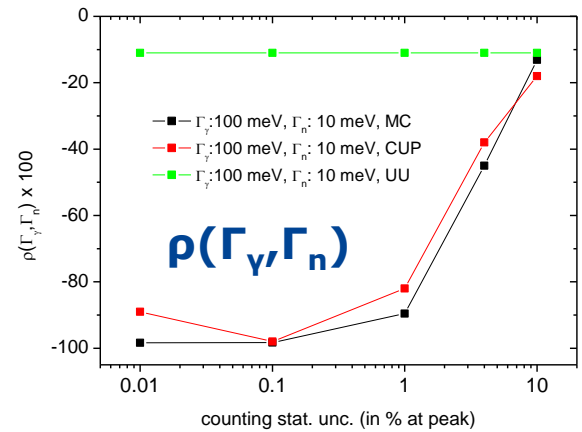
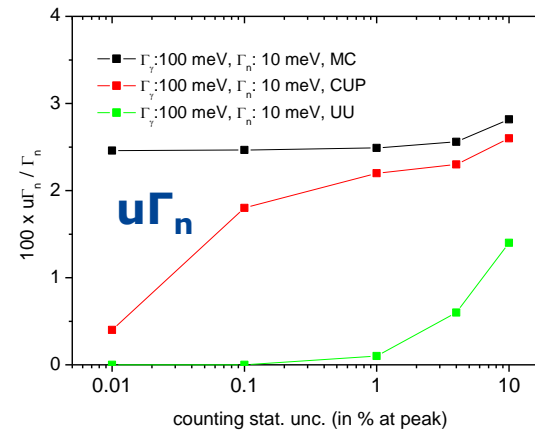
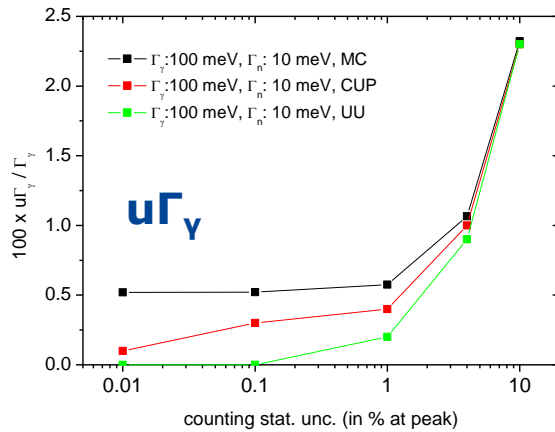


$\Gamma_\gamma : 100 \text{ meV}$
 $\Gamma_n : 0.1 \text{ meV}$

Transmission

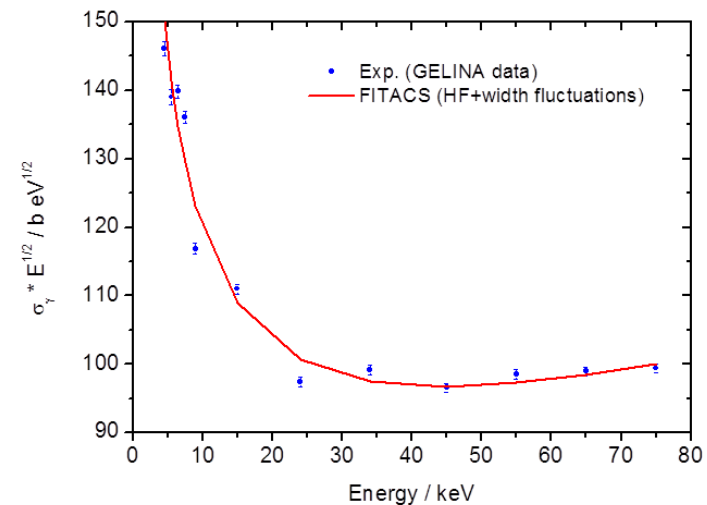
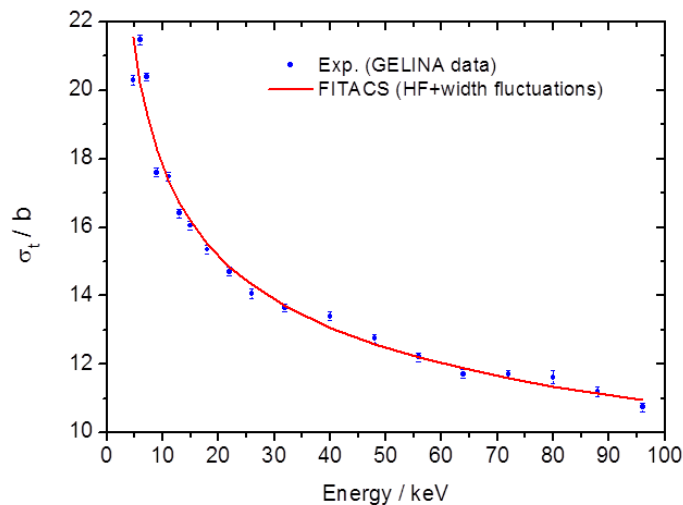


Capture



URR Example: ^{197}Au

URR capture yield and transmission measurement on ^{197}Au . Fitting was done with FITACS (HF+width fluctuations). Correlated uncertainties: capture: $uN_C/N_C=1.5\%$, transmission: $uN_T/N_T=2\%$.



URR: Parameter Correlation Matrix

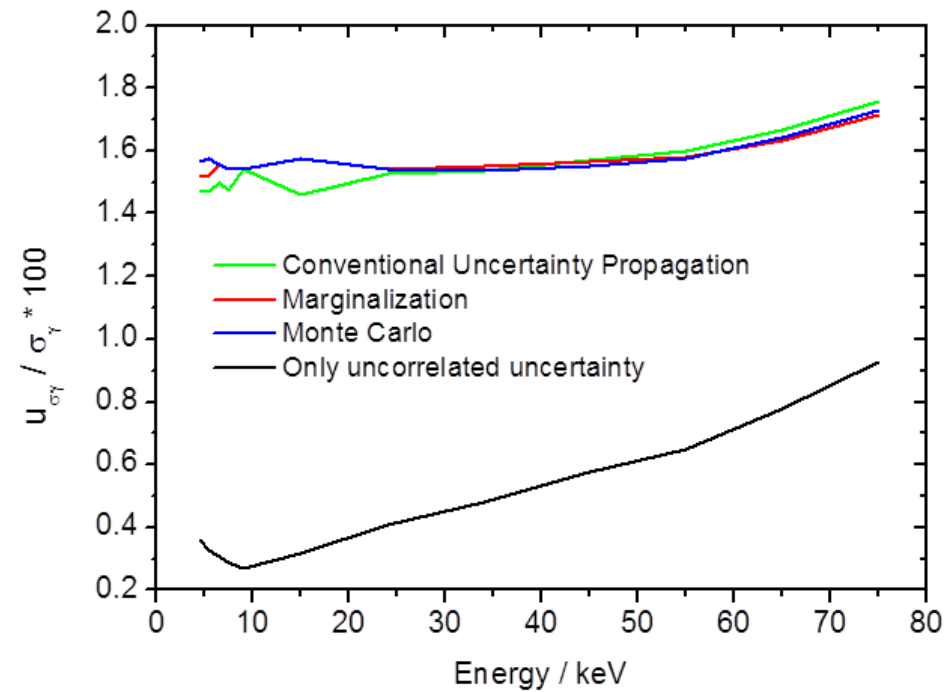
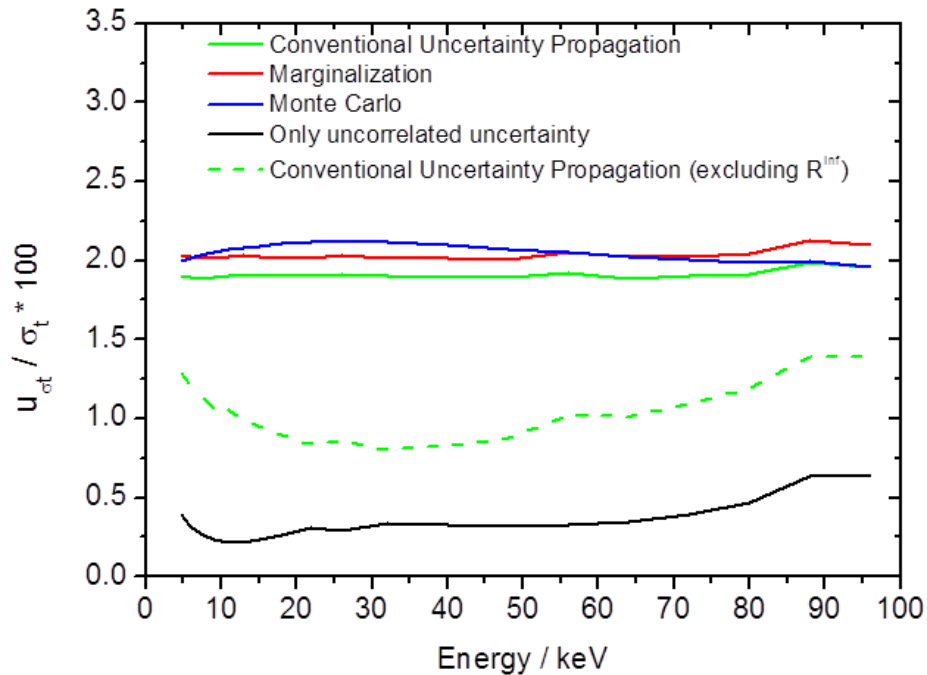
CUP

θ	$100 \times (u_\theta/\theta)$	$\rho(\theta, \theta') \times 100$								
		$S_{n,0}$	R_0^∞	$\langle \Gamma_\gamma^0 \rangle$	$S_{n,1}$	$\langle \Gamma_\gamma^1 \rangle$	$S_{n,2}$	N_T	N_C	
Including R_0^∞										
$S_{n,0}$	1.89×10^{-4}	2.6	100							
R_0^∞	-1.63×10^{-1}	9.2	-11.8	100						
$\langle \Gamma_\gamma^0 \rangle$	1.36×10^{-1}	2.7	-55.5	0.4	100					
$S_{n,1}$	2.80×10^{-5}	9.0	71.4	15.0	-50.9	100				
$\langle \Gamma_\gamma^1 \rangle$	1.18×10^{-1}	155	-76.5	-22.1	52.6	-85.1	100			
$S_{n,2}$	1.86×10^{-4}	133	76.0	22.0	-49.0	79.3	-99.4	100		
N_T	1.00	1.9	-63.2	83.3	31.3	-30.9	28.8	-28.5	100	
N_C	1.00	1.5	0.9	0.2	-79.2	-4.5	-4.4	2.4	-0.3	100
Excluding R_0^∞										
$S_{n,0}$	1.88×10^{-4}	2.6	100.0							
R_0^∞	-1.63×10^{-1}	-	-							
$\langle \Gamma_\gamma^0 \rangle$	1.37×10^{-1}	2.7	-55.9	-	100					
$S_{n,1}$	2.80×10^{-5}	8.9	74.6	-	-51.6	100				
$\langle \Gamma_\gamma^1 \rangle$	1.56×10^{-1}	197.8	-81.7	-	54.0	-84.8	100			
$S_{n,2}$	1.86×10^{-4}	130.8	81.1	-	-50.3	78.8	-99.3	100		
N_T	1.00	1.0	-97.2	-	56.0	-79.4	87.5	-86.7	100	
N_C	1.00	1.5	0.9	-	-79.2	-4.6	-4.5	2.5	-0.8	100

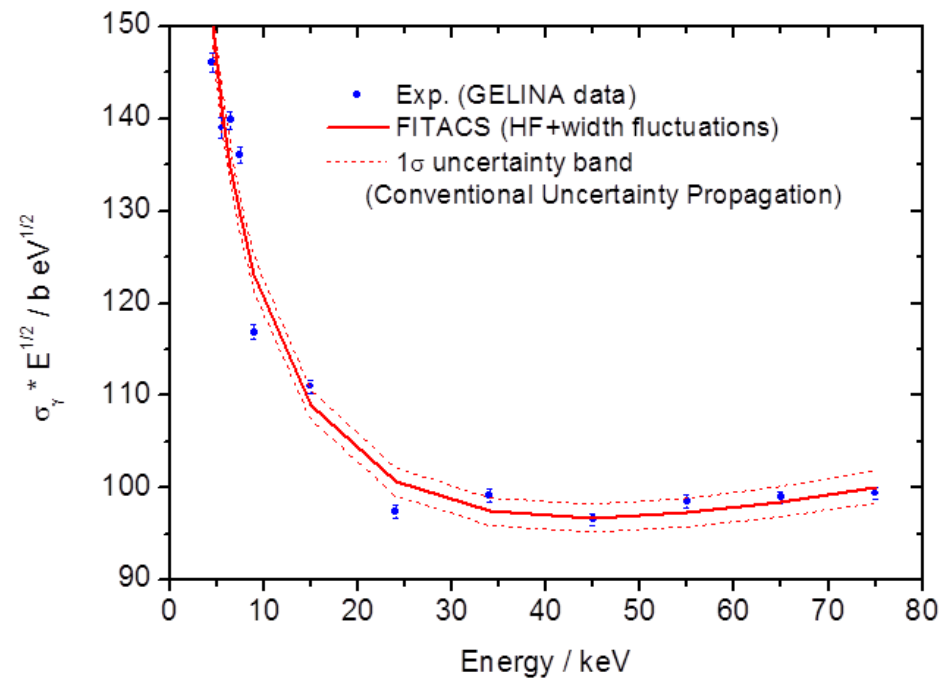
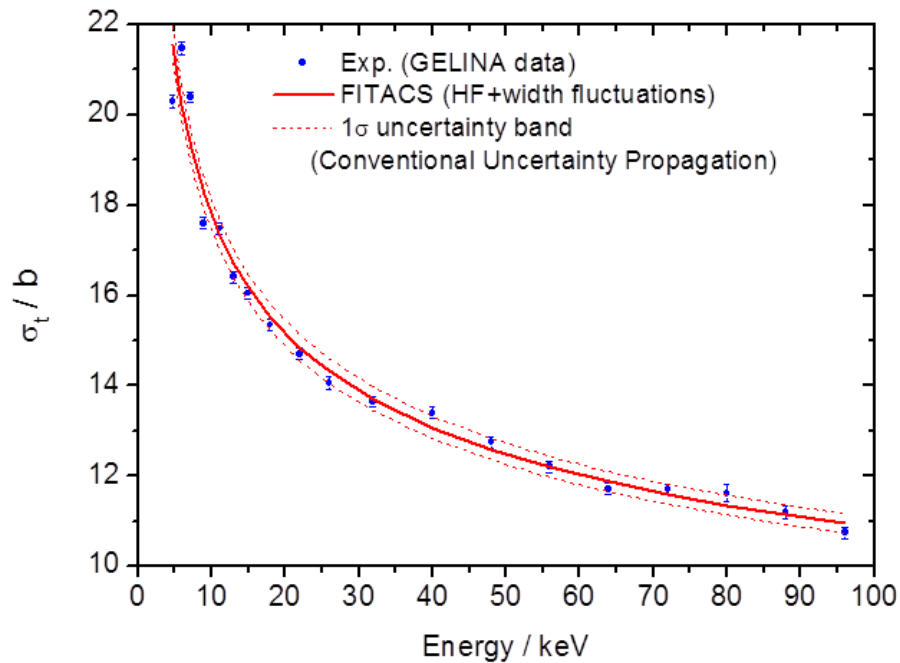
MC

θ	$100 \times (u_\theta/\theta)$	$\rho(\theta, \theta') \times 100$							
		$S_{n,0}$	R_0^∞	$\langle \Gamma_\gamma^0 \rangle$	$S_{n,1}$	$\langle \Gamma_\gamma^1 \rangle$	$S_{n,2}$	N_T	N_C
$S_{n,0}$	1.89×10^{-4}	2.4	100						
R_0^∞	-1.67×10^{-1}	10.6	-10.9	100					
$\langle \Gamma_\gamma^0 \rangle$	1.35×10^{-1}	2.8	68.9	0.1	100				
$S_{n,1}$	2.80×10^{-5}	8.8	68.9	17.9	-48.7	100			
$\langle \Gamma_\gamma^1 \rangle$	1.21×10^{-1}	192	-66.9	-38.7	43.4	-82.5	100		
$S_{n,2}$	1.82×10^{-4}	130	66.7	38.2	-39.8	76.5	-99.1	100	
N_T	1.00	-	-	-	-	-	-	-	-
N_C	1.00	-	-	-	-	-	-	-	-

Cross Section Uncertainty



Cross Section Uncertainty



Summary

Monte Carlo:

- Direct propagation of model parameter uncertainties
- conservative uncertainty estimation

CUP:

- Possible improvement of model parameters

Correlation coefficient:

Depends strongly on:

1. model (UU, CUP, MC)
2. resonance parameters
3. counting statistics
4. uncertainties of model parameter