Analysis of Time Correlation Measurements with the Active Well Coincidence Counter

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Outline

- MCNP-PoliMi main features
- Post-processing
    1. Shift register multiplicity
    2. Neutron generations
    3. Time interval analysis
- Results
- Conclusions
- Future work

MCNP-PoliMi (background)

- MCNP-PoliMi: a modification of MCNP-4C, originally developed to simulate correlation measurements with neutrons and gamma rays
- Monte Carlo output is a table, containing information on particle collisions in the detector cells
- Used to simulate detector response

MCNP Simulation

Simulation of induced fission: neutron multiplicity is restricted to integer less than and greater than $\bar{\nu}$

Mean values are correct, but not meant for the simulation of higher order moments

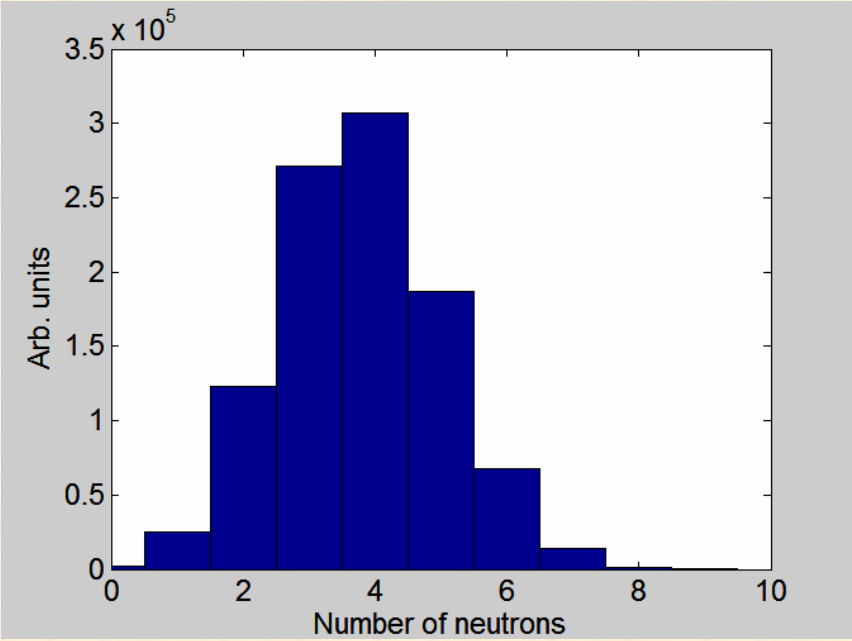
Main Features of MCNP-PoliMi Physics of particle transport

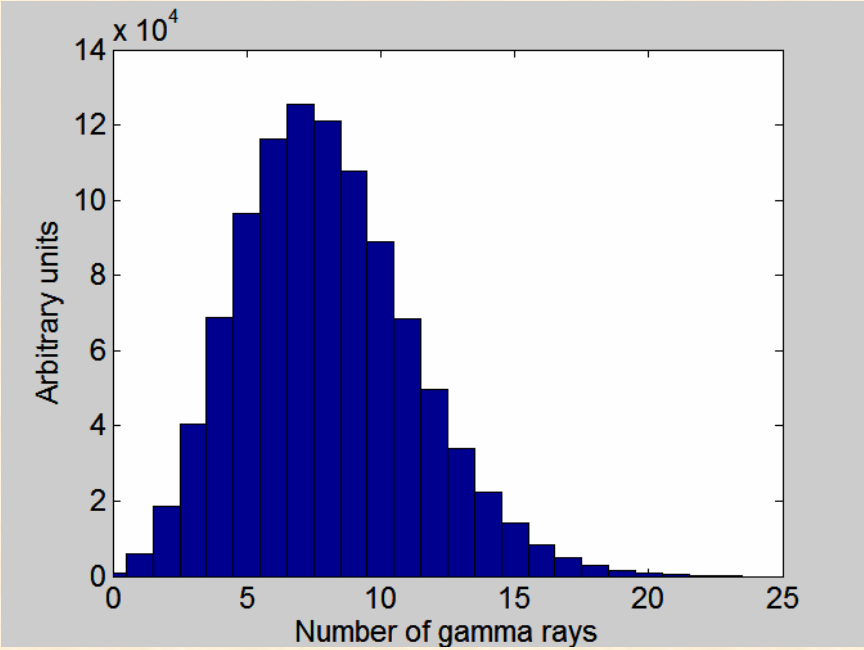
Correct neutron and gamma fission multiplicity distributions have been implemented

Improved simulation of time-correlation measurements
Analog simulation

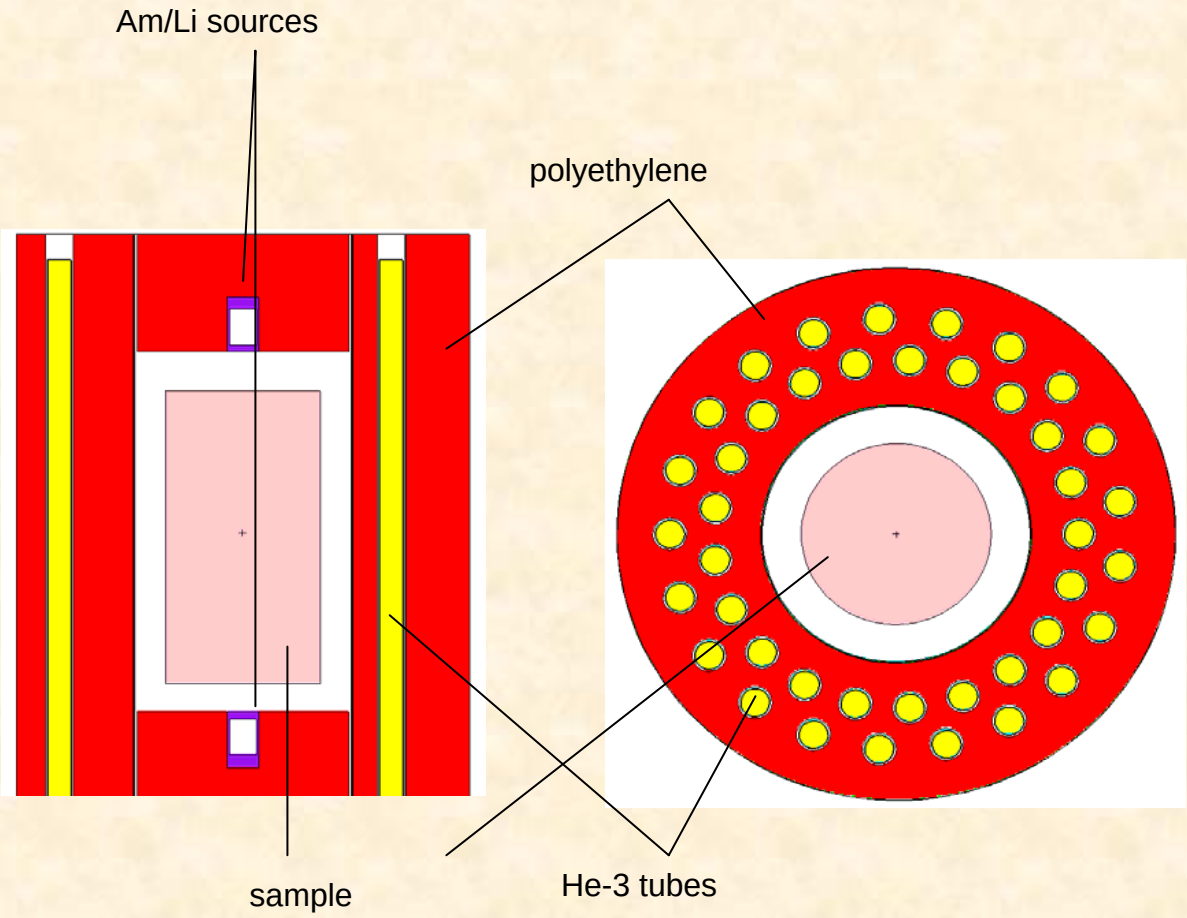
MCNP-PoliMi

Multiplicity of Neutron and Gamma rays from Fission: Cf-252





Geometry of MCNP-PoliMi Simulation



Active well

- **Detectors 42 He-3 tubes**
  - **IR 30.8 cm**
  - **OR 38.1 cm**
  - **4 atm;**
  - **Active length 55.8 cm**
- **Sample cavity has a diameter of 22.9 cm**

Collision Output File from MCNP-PoliMi (excerpt)

History number	Particle number	Projectile type*	Interaction type$^{\Delta}$	Target nucleus•	Cell number of collision event	Time (shakes)	Generation number	Number of scatterings	Energy (MeV)
1	6	1	0	2003	1	32401.6	3	221	8.15E-09
3	1	1	0	2003	1	18052.97	0	156	7.61E-08
7	1	1	0	2003	1	11250.02	0	107	3.34E-08
9	4	1	0	2003	1	1894.416	1	17	5.72E-06
10	1	1	0	2003	1	5845.552	0	62	9.25E-08
16	3	1	0	2003	1	4388.813	1	73	4.58E-08
18	7	1	0	2003	1	19023.05	2	153	8.27E-08
18	4	1	0	2003	1	8990.743	2	81	4.27E-08
32	1	1	0	2003	1	7732.952	0	67	1.31E-08
35	1	1	0	2003	1	6319.3	0	49	1.53E-08
...									

* 1 = neutron
Δ 0 = absorption
• 2003=helium-3

Post-Processing Code for MCNP-PoliMi Collision Output File

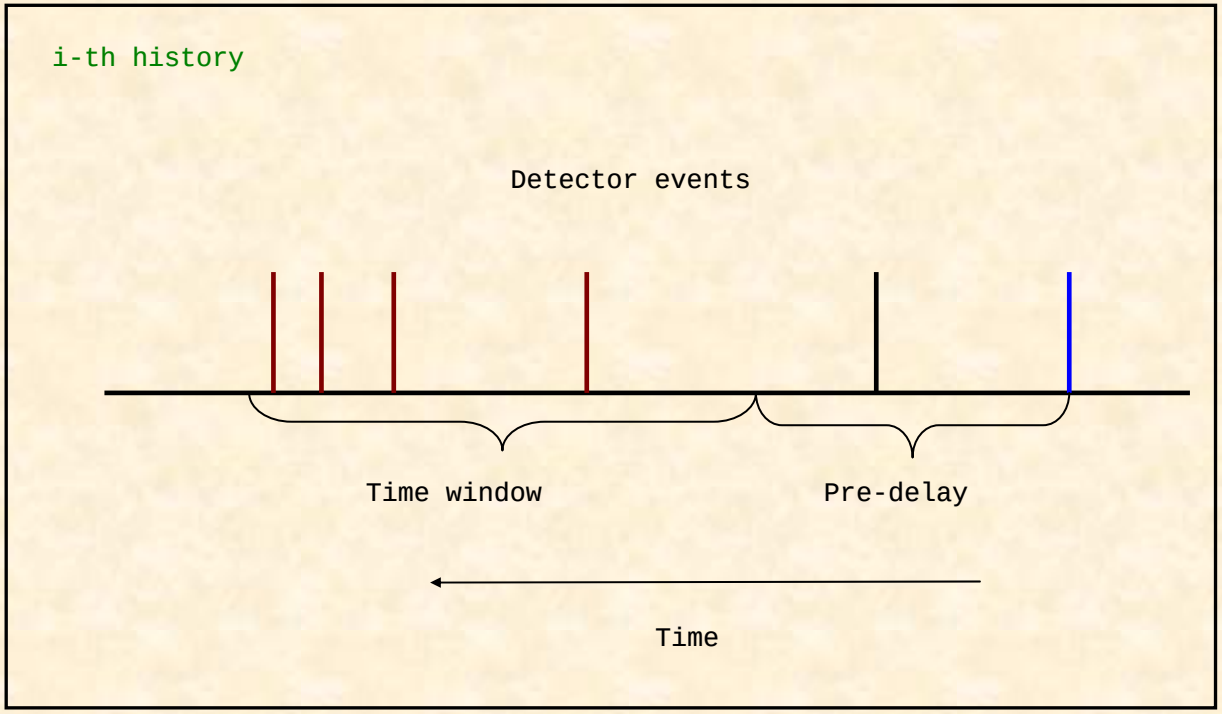
Takes into account:

- **Time of detection**
- **History number of detection**
- **Energy of neutron**
- **Generation number of neutron**

Calculates:

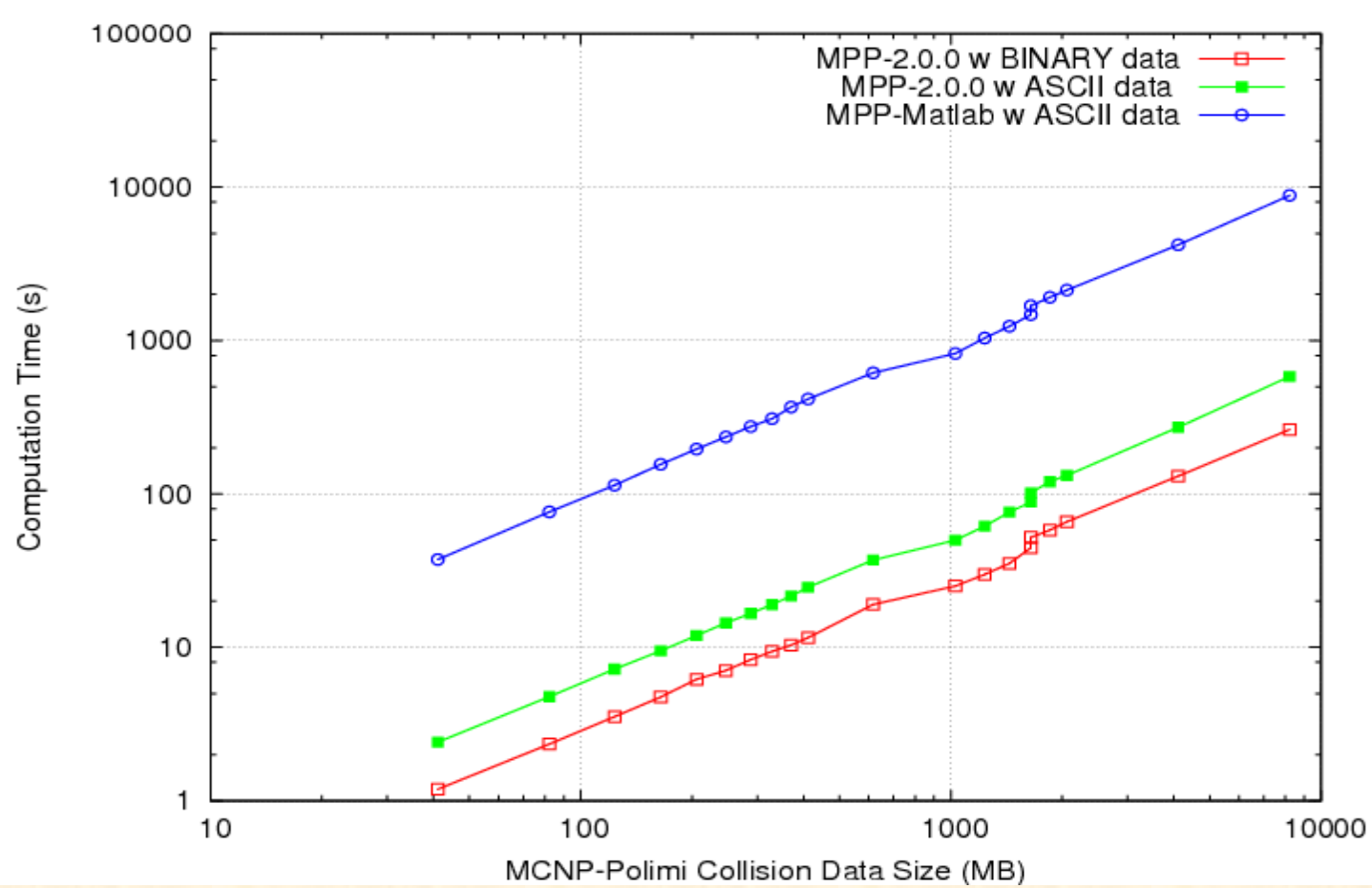
- **Multiplicity distributions**
- **Number of scatterings prior to capture**
- **Efficiency of detection system**
- **Detected neutrons as a function of the generation number**

Simulation of the Shift Register



MCNP-PoliMi Post-Processing

New code speed-up

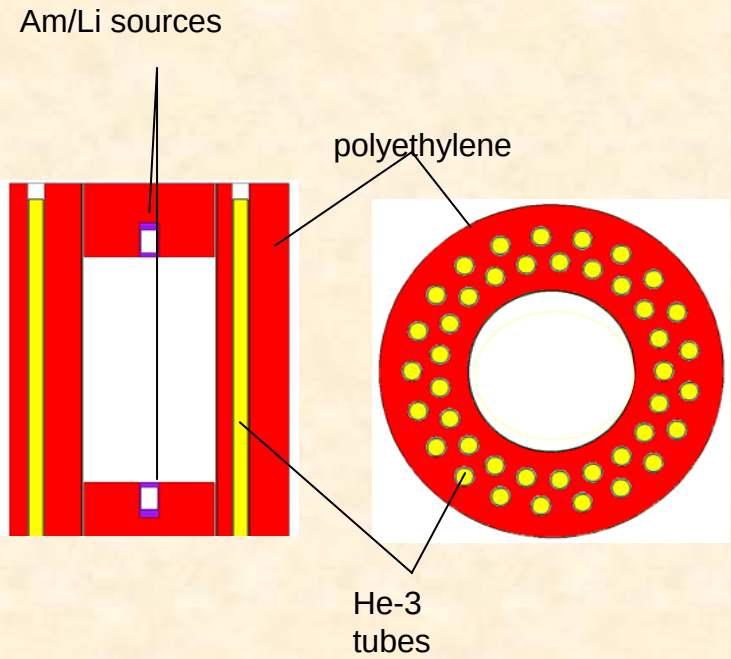


Uranium Metal Sample Characteristics

Composition: 92 wt% U-235 and 8 wt% U-238
Density: 18.9 g/cc
Radius: 5.08 cm

Name	Mass (g)	Height (cm)
u0	0	0
u1	3.06457E+03	2
u2	4.59685E+03	3
u3	6.12913E+03	4
u4	7.66142E+03	5

Neutron Detection Efficiency
Am/Li source, no sample



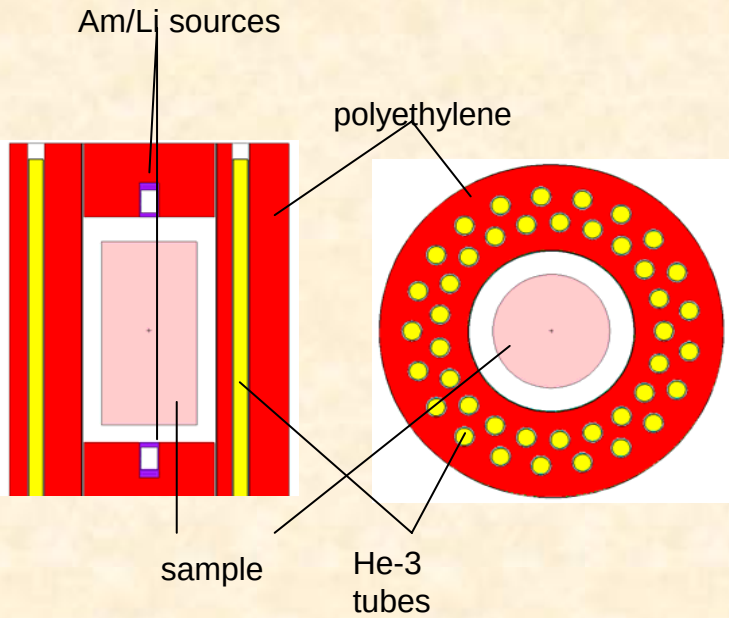
Number of Am/Li neutrons: 1e6

Total counts: 129,579

Am/Li neutrons counted: 129,579

Efficiency for Am/Li n: ~13 %

Neutron Detection Efficiency
7.6 kg Sample



For the 7.6 kg uranium metal sample

Number of Am/Li neutrons: 1e6

Total counts: 176,733

Am/Li neutrons counted: 115,438

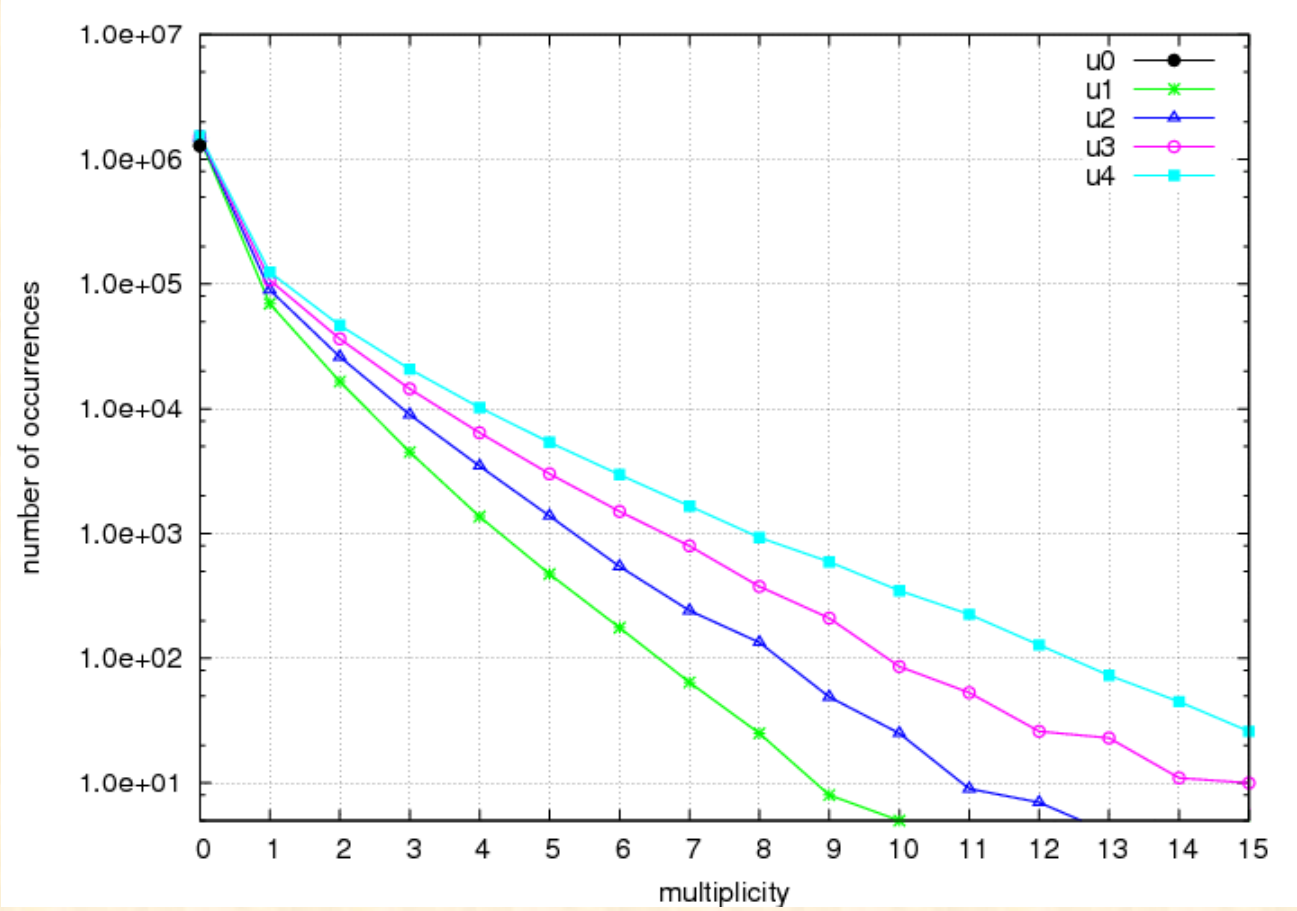
Number of induced fissions: 111,786

Induced fission neutrons: 281,336

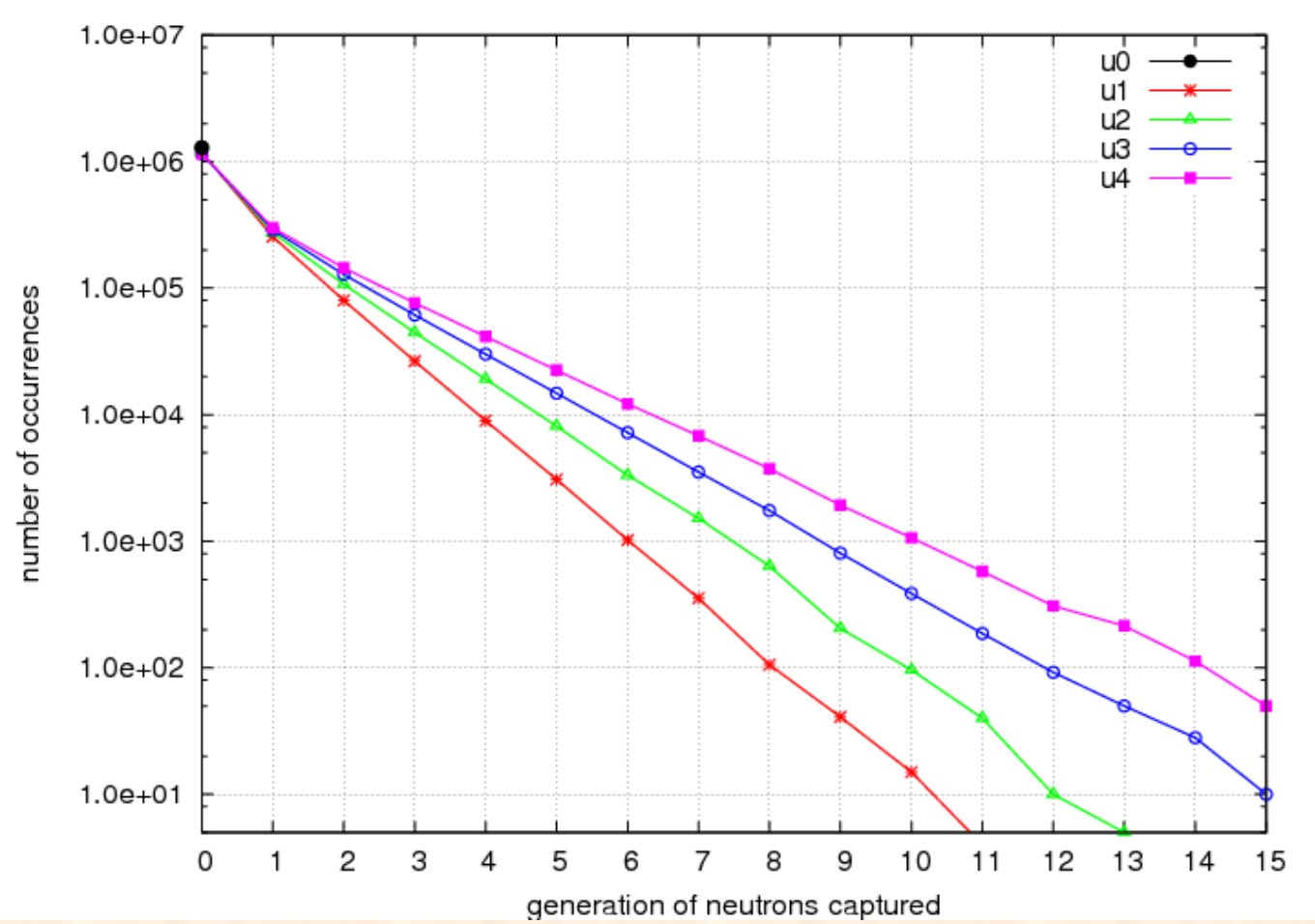
Induced fission neutrons counted: 61,295

Efficiency for induced fission n: ~22 %

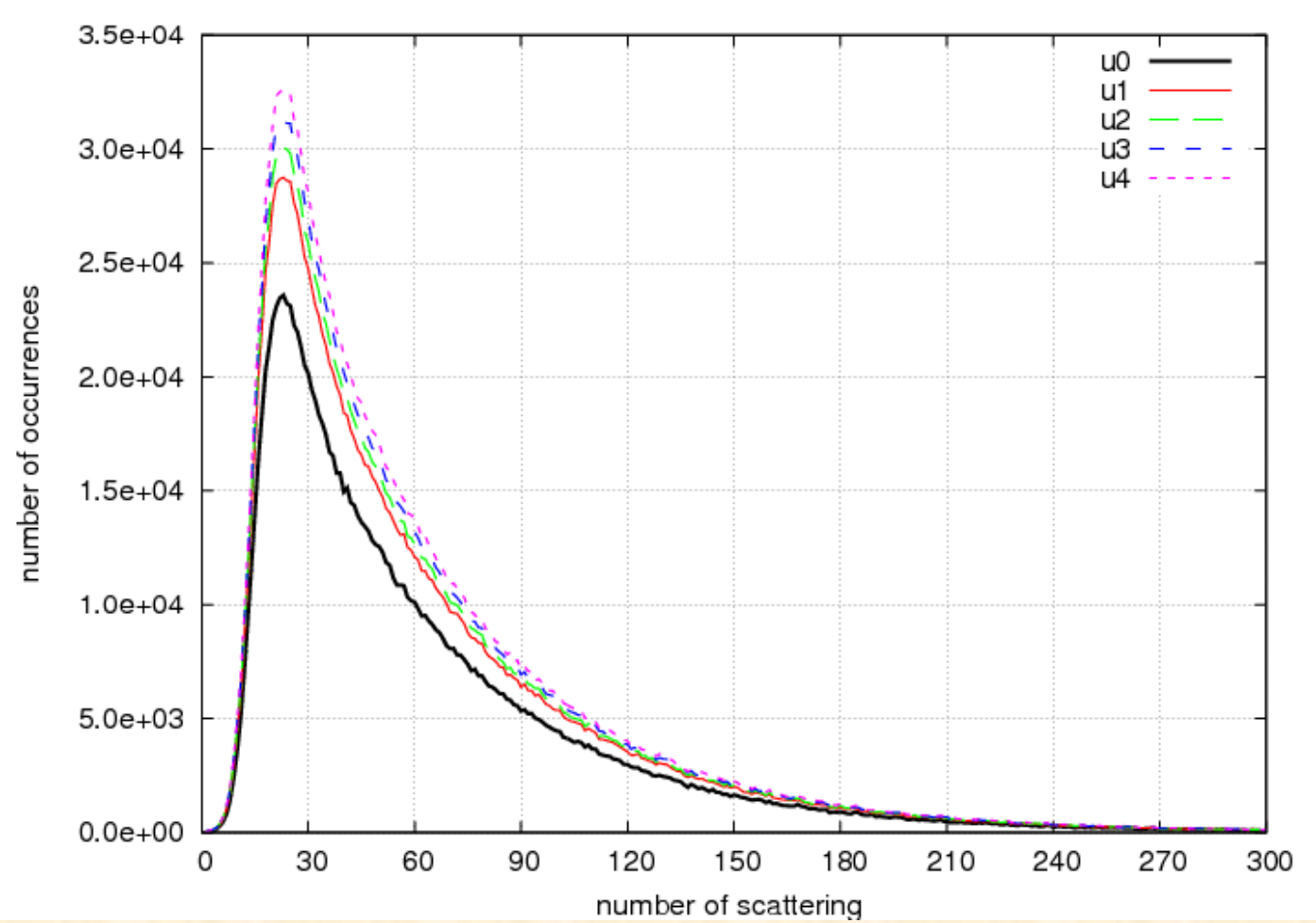
Multiplicity Distributions for Uranium Metal Samples



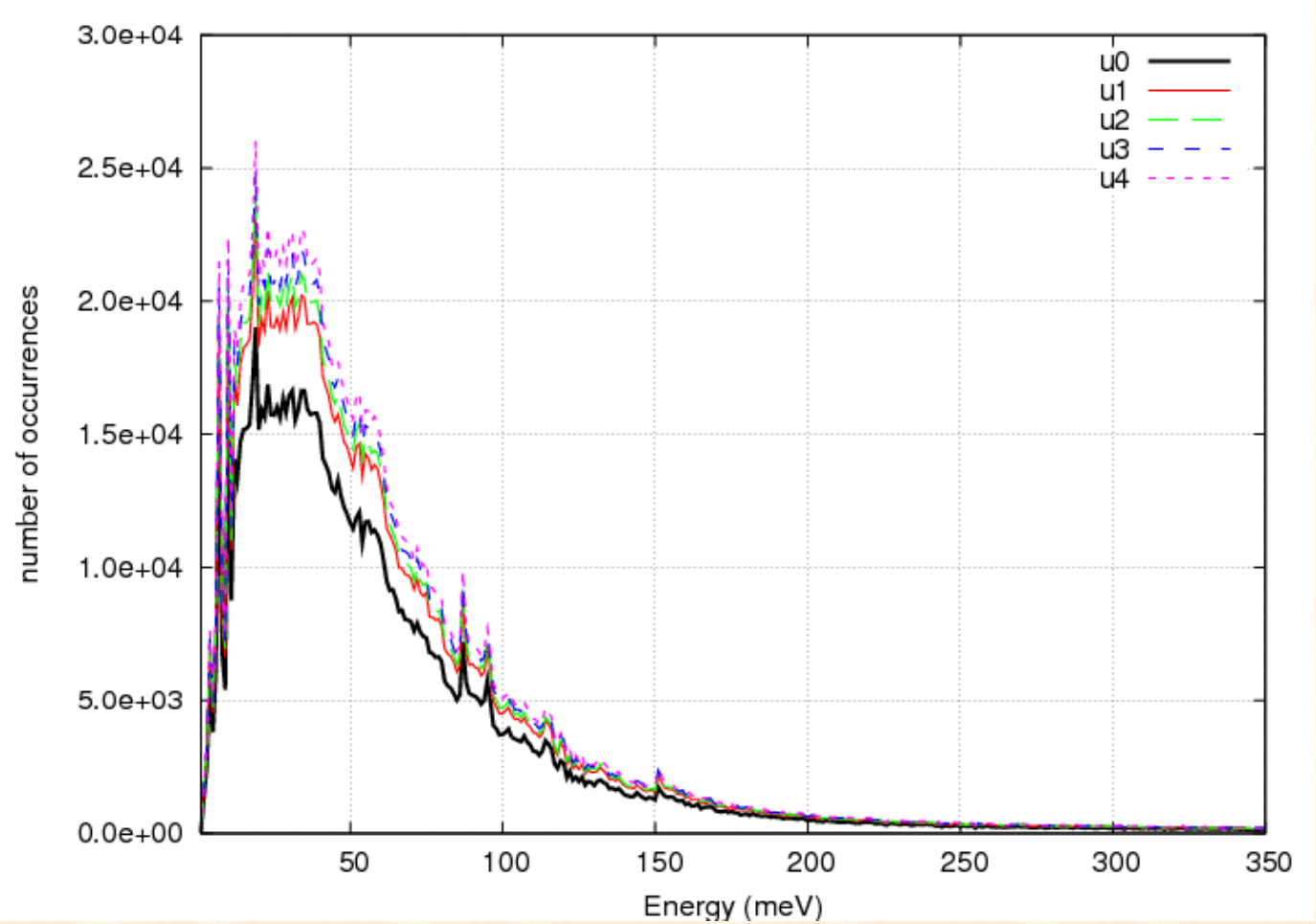
Neutron Generations for Various Uranium Metal Samples



Number of Neutron Scatterings Prior to Detection in He-3 Detectors

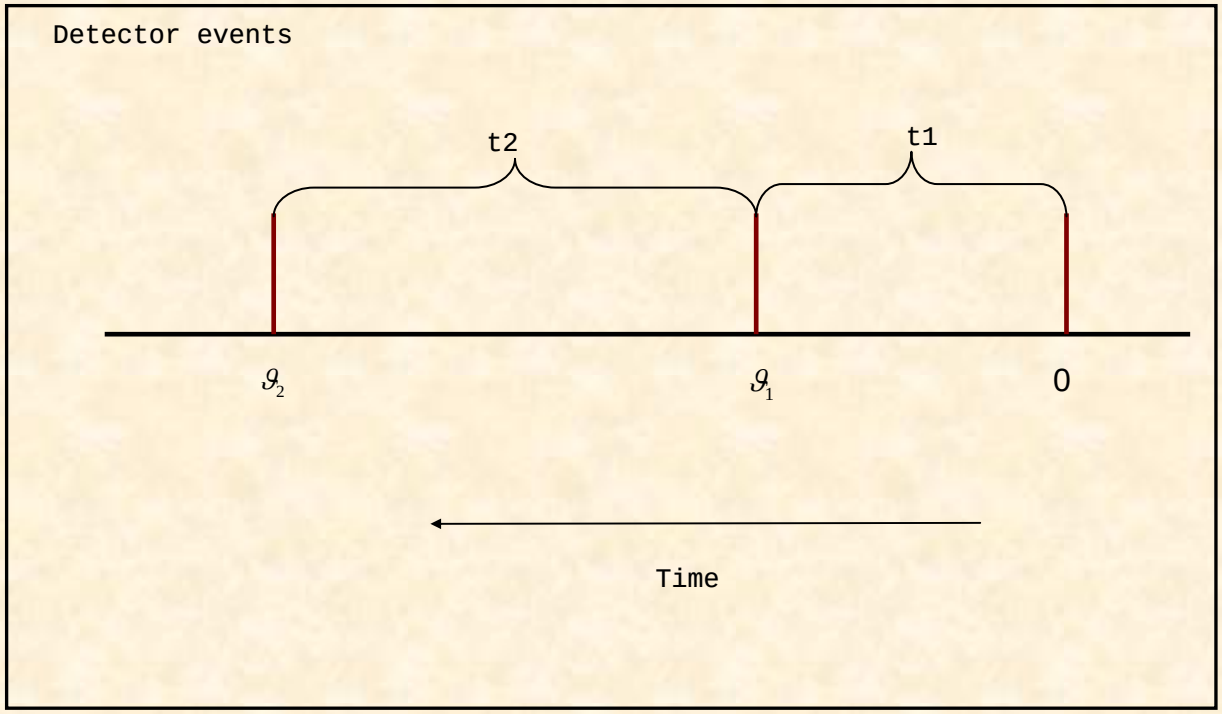


Neutron Energy Prior to Detection in He-3 Detectors



Time Interval Analysis

Two-Dimensional Rossi Alpha Distribution

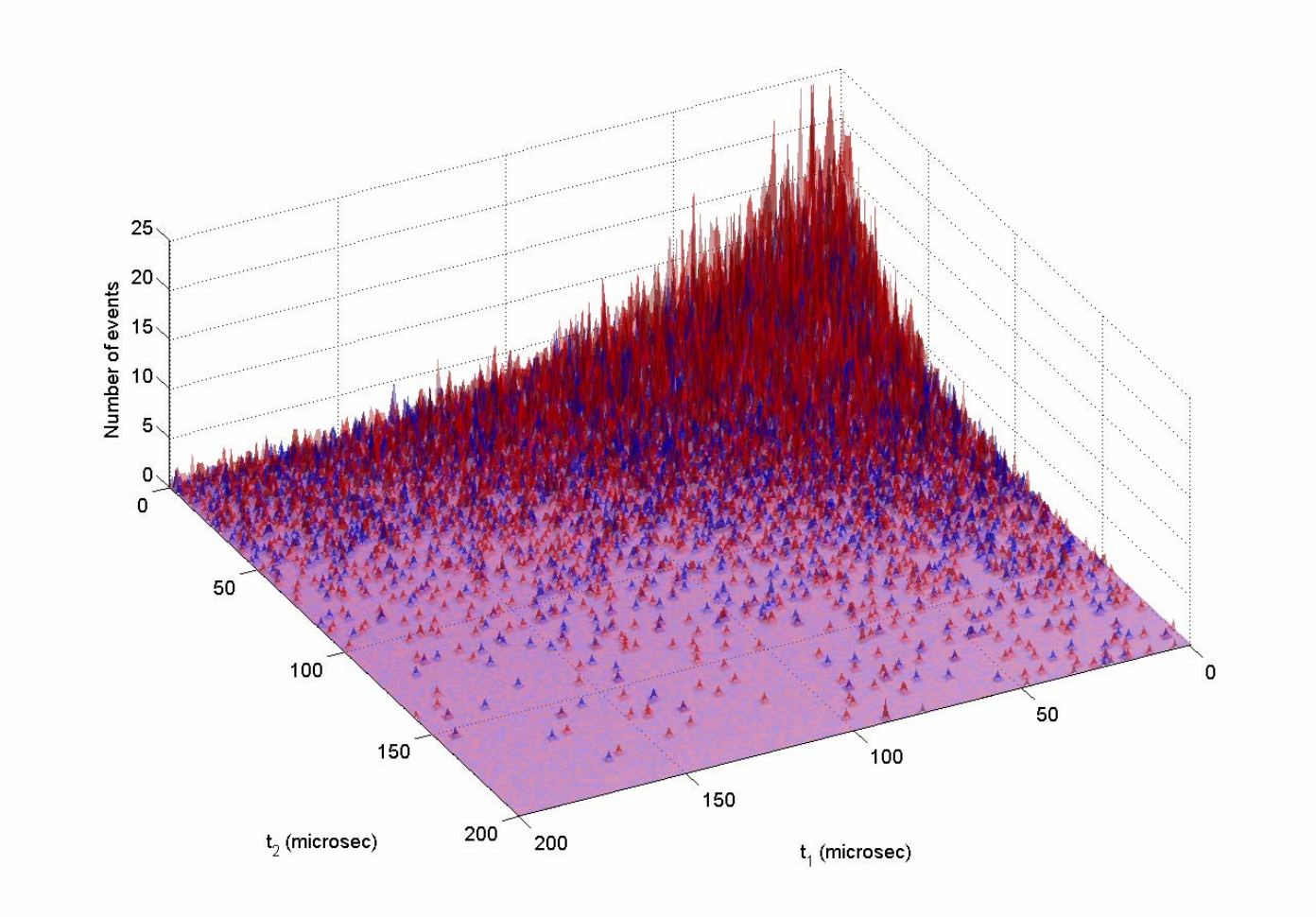


- Proposed by M. Bruggeman, P. Baeten, et al.
- Time between detector triplets.

$$R(\vartheta_1)R(\vartheta_2) \propto e^{-\vartheta_1/\tau}e^{-\vartheta_2/\tau} = e^{-2t_1/\tau}e^{-t_2/\tau} \propto R_2(t_1,t_2)$$

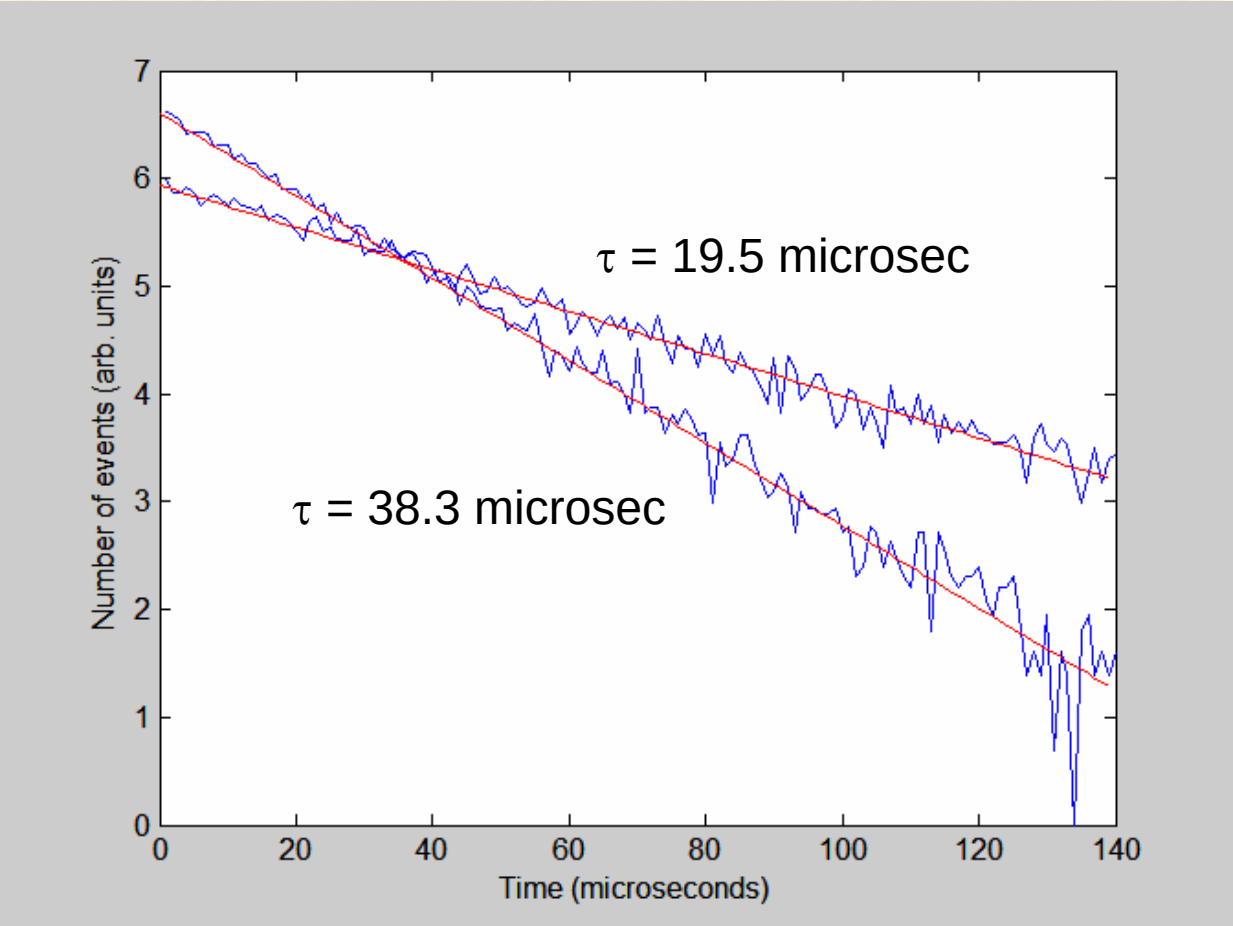
Time Interval Analysis

Results



Time Interval Analysis

Results



Conclusions

- **MCNP-PoliMi can be used to model the measurements performed with active well coincidence counters. Can also be used for modeling passive coincidence counters.**

- **Improved understanding of the physics of processes that occur in the counter: time and energy of detected neutrons, generation numbers, efficiency, and time interval analysis.**

Future Work

- **Analysis of accidental coincidences**
- **Comparisons of Monte Carlo predictions and experimental data acquired from fissile samples with active or passive coincidence counter.**

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