

Neutron inelastic scattering on ^{238}U

Determination of neutron-induced gamma-production cross-sections resulting from inelastic scattering reactions on ^{238}U

Collaboration:

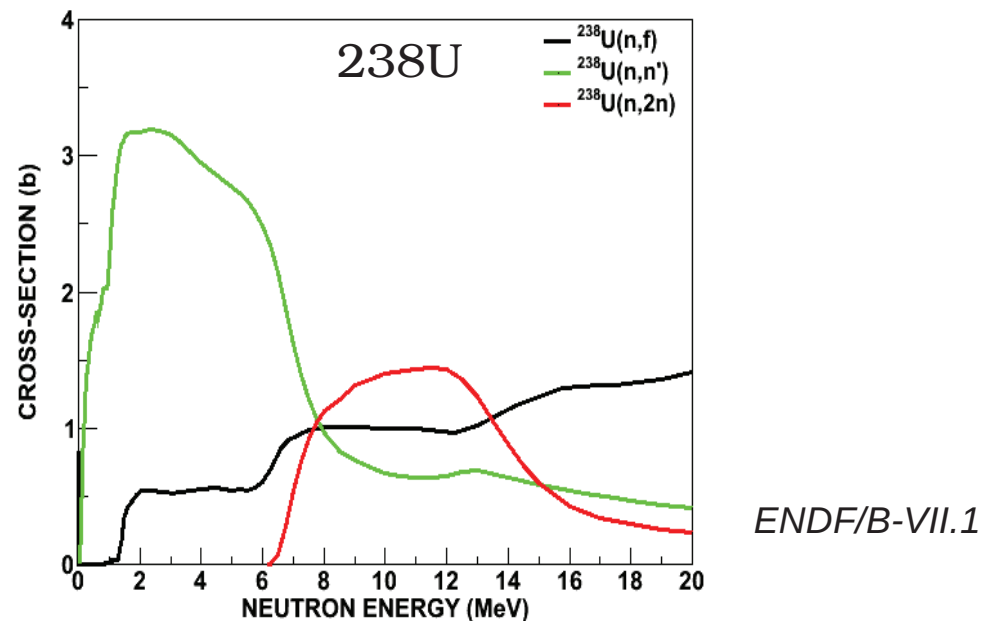
- CNRS-IPHC Strasbourg
- JRC-IRMM Geel
- CEA/DAM Bruyères-le-Châtel
- IFIN HH Bucharest

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Motivations

- Applications:
 - (n, xn) reactions important inside a reactor
 - studies for GEN-IV reactors (fuel, structure materials...)
 - need for data bases: precision (HPRL)

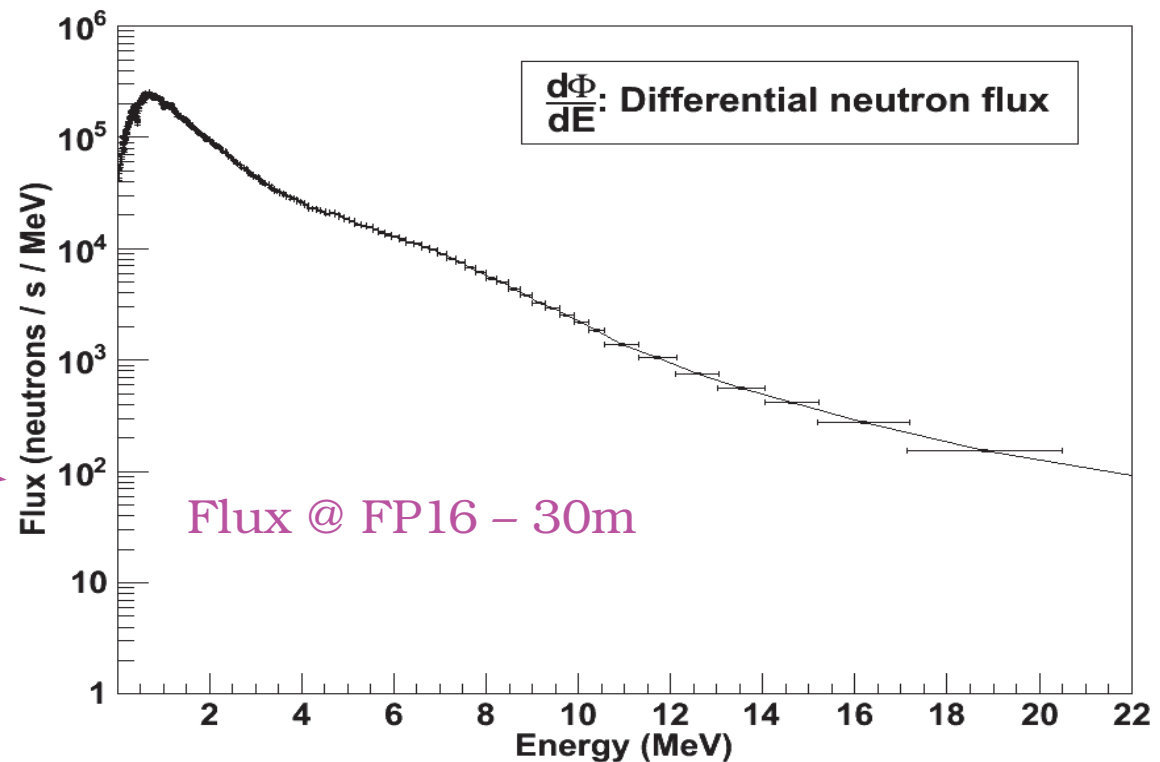
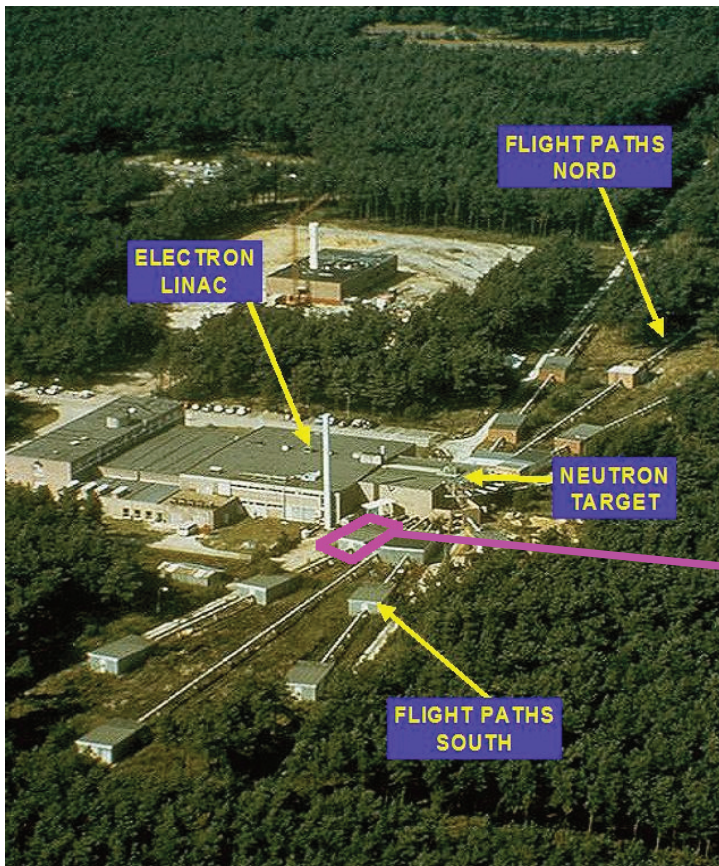


- Two-way interaction with theory

Experimental area

GELINA @ IRMM, Geel, Belgium

- Pulsed electron beam on neutron production target (Uranium)
- Bremsstrahlung (photofission; gamma flash)
- Wide energy-range neutron beam (few eV to 20MeV)



Experimental set-up

Fission chamber (neutron flux determination)

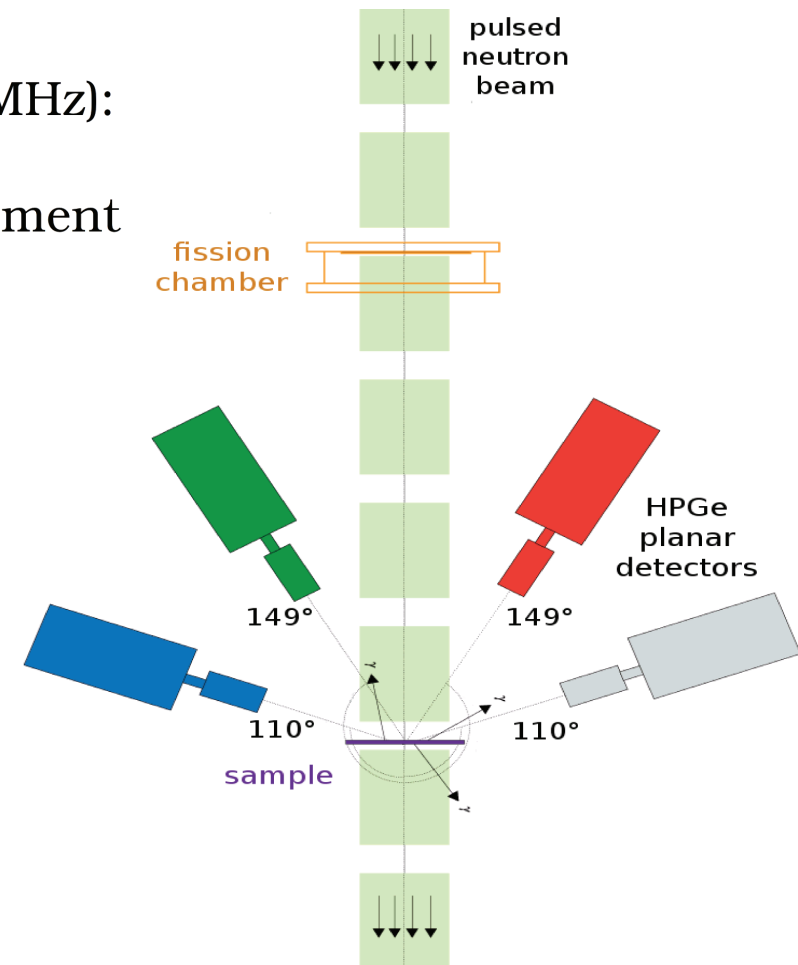
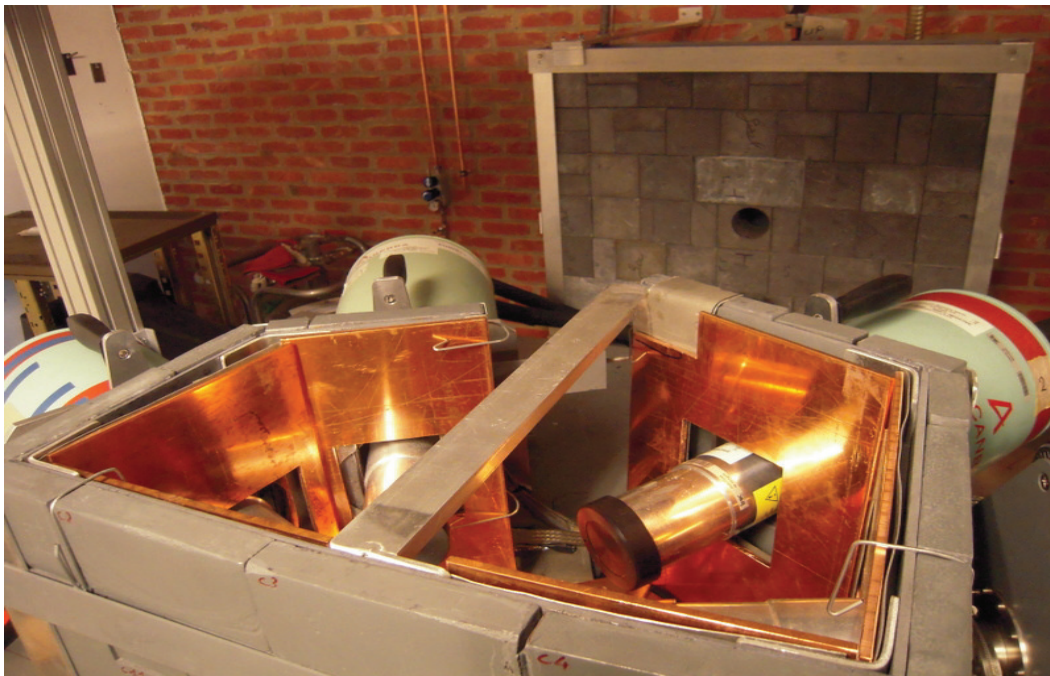
Sample (nucleus of interest)

Germanium detectors (prompt gamma spectroscopy)

Pulsed beam (800 Hz)

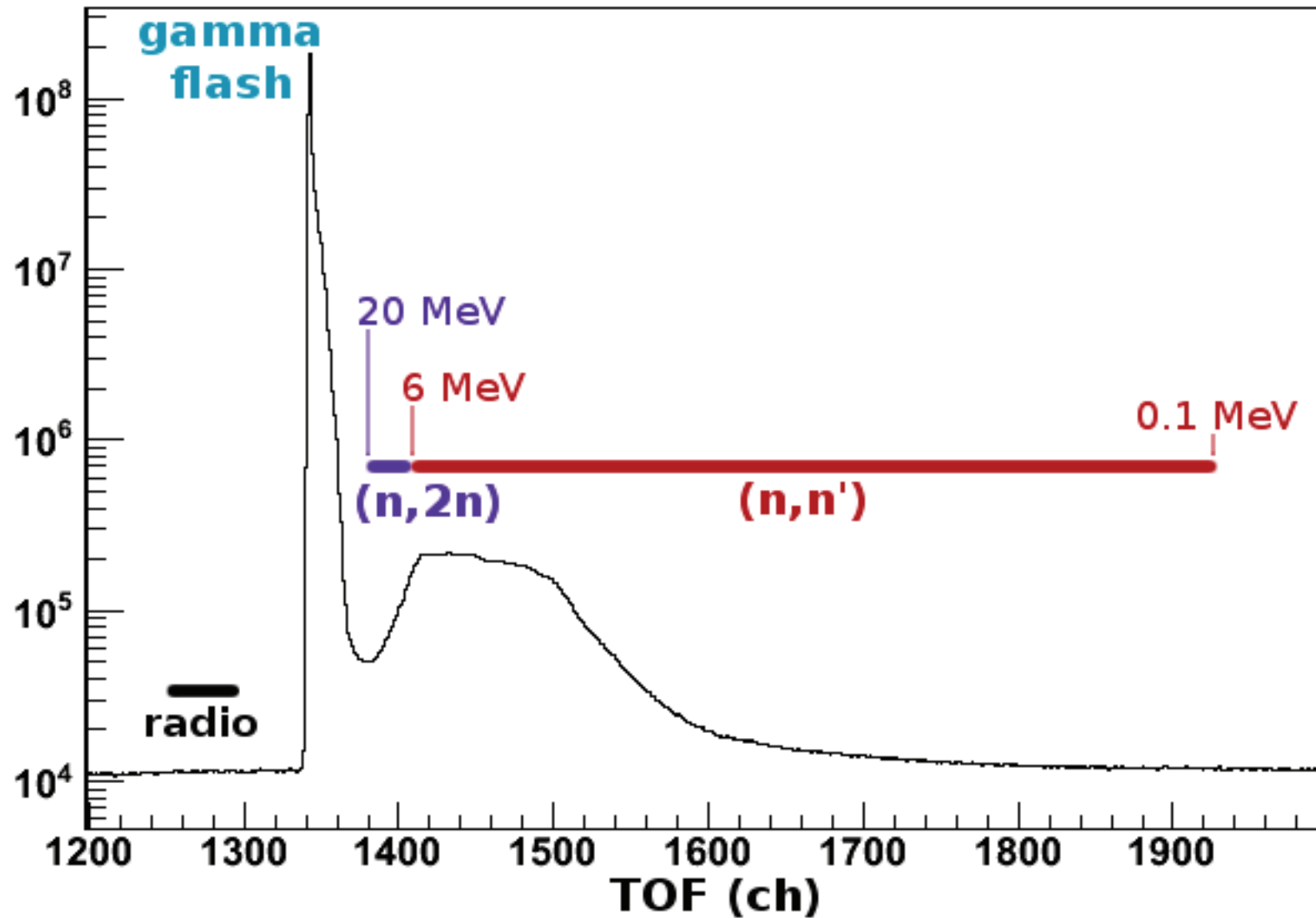
Digital data acquisition (100 MHz):

- gamma energy
- Time of Flight (ToF) measurement



Data analysis

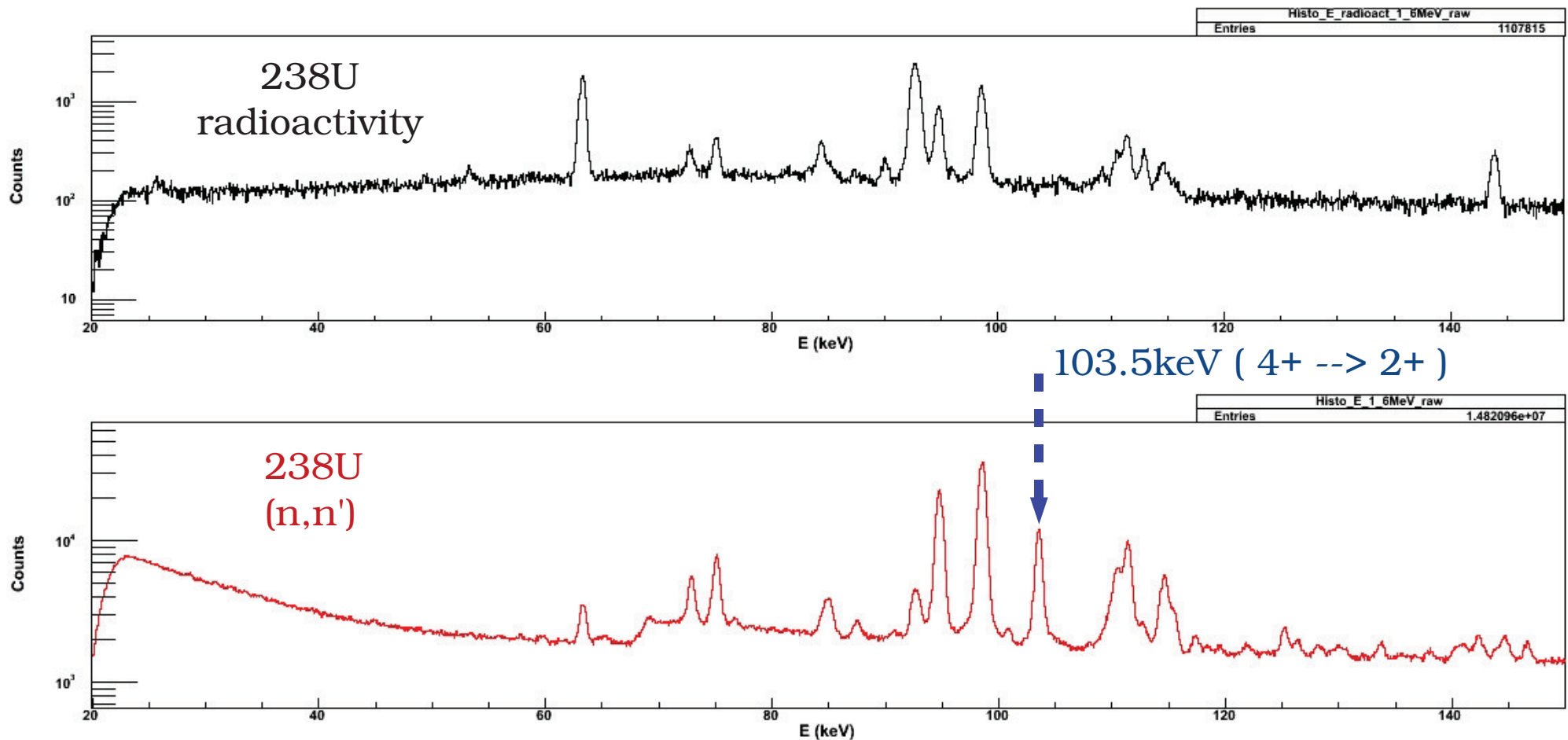
Time distribution of gamma events for different processes



Data analysis

Energy spectra with time-window condition (i.e. incident neutron energy)

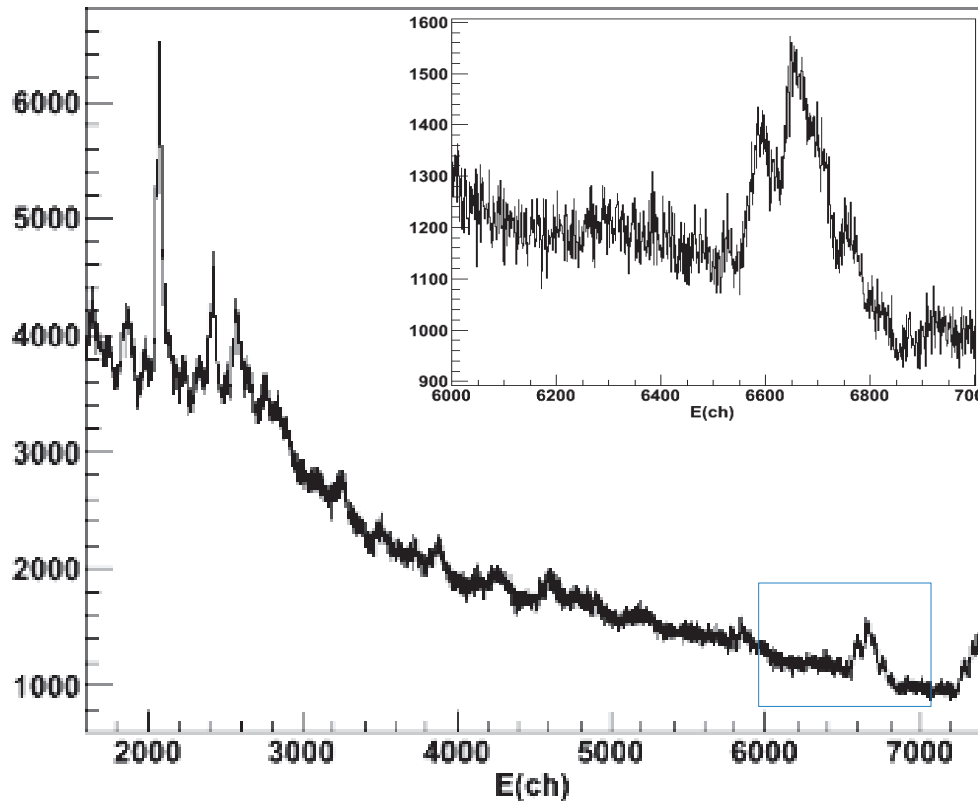
- equivalent time windows for radioactivity (before gamma flash)
→ spot typical (n,xn gamma) rays



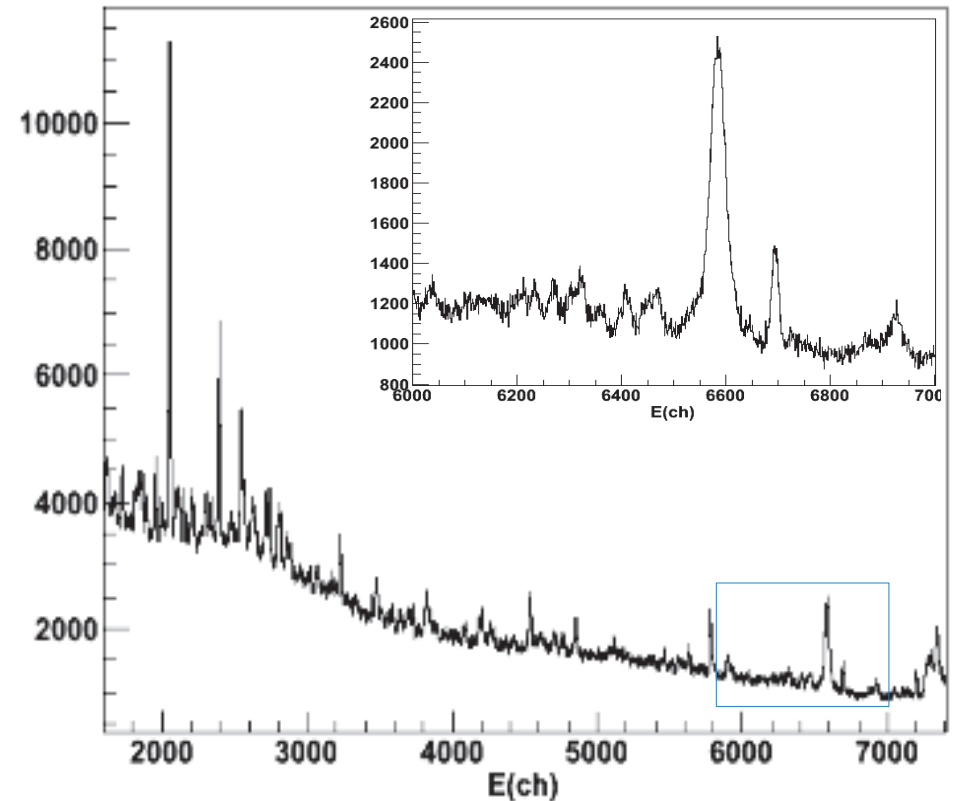
Towards $\sigma(n, xn \gamma)$

Long acquisition times: ~ 1200 hours
→ permanent recalibration needed

“raw data”



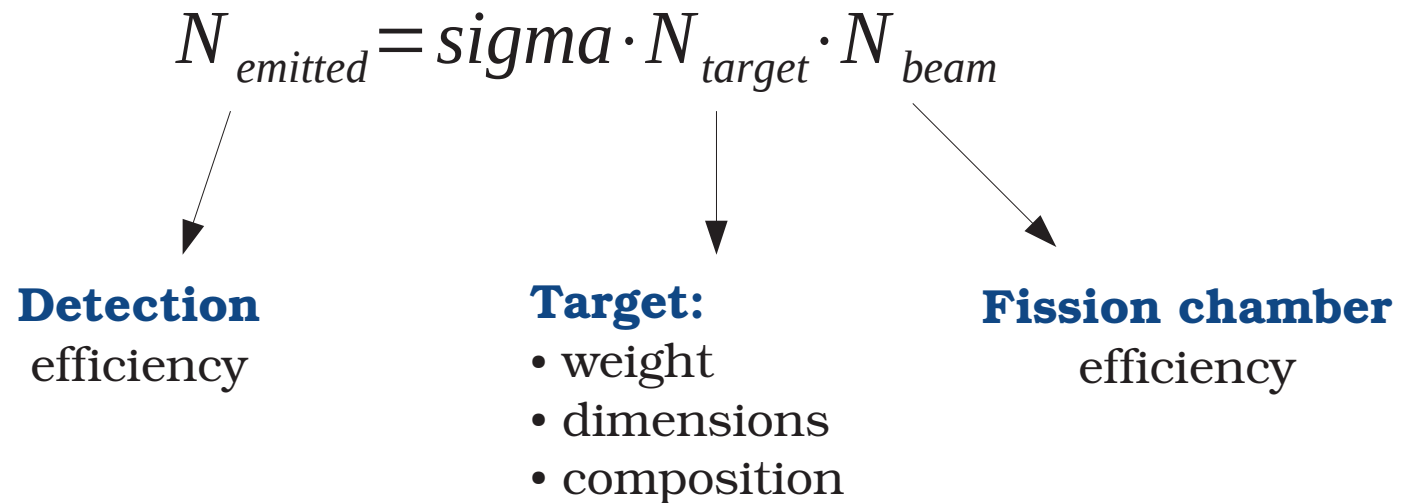
“aligned data”



→ **Weak reaction rays become visible**

Towards $\sigma(n, xn \gamma)$

Cross-section vs incident neutron E for ONE gamma and ONE detector



Combination of multiple detectors information:

Gauss quadrature (2 det.@ 110° , 2 det.@ 150°)

→ for each gamma, (n,xn gamma) cross-section

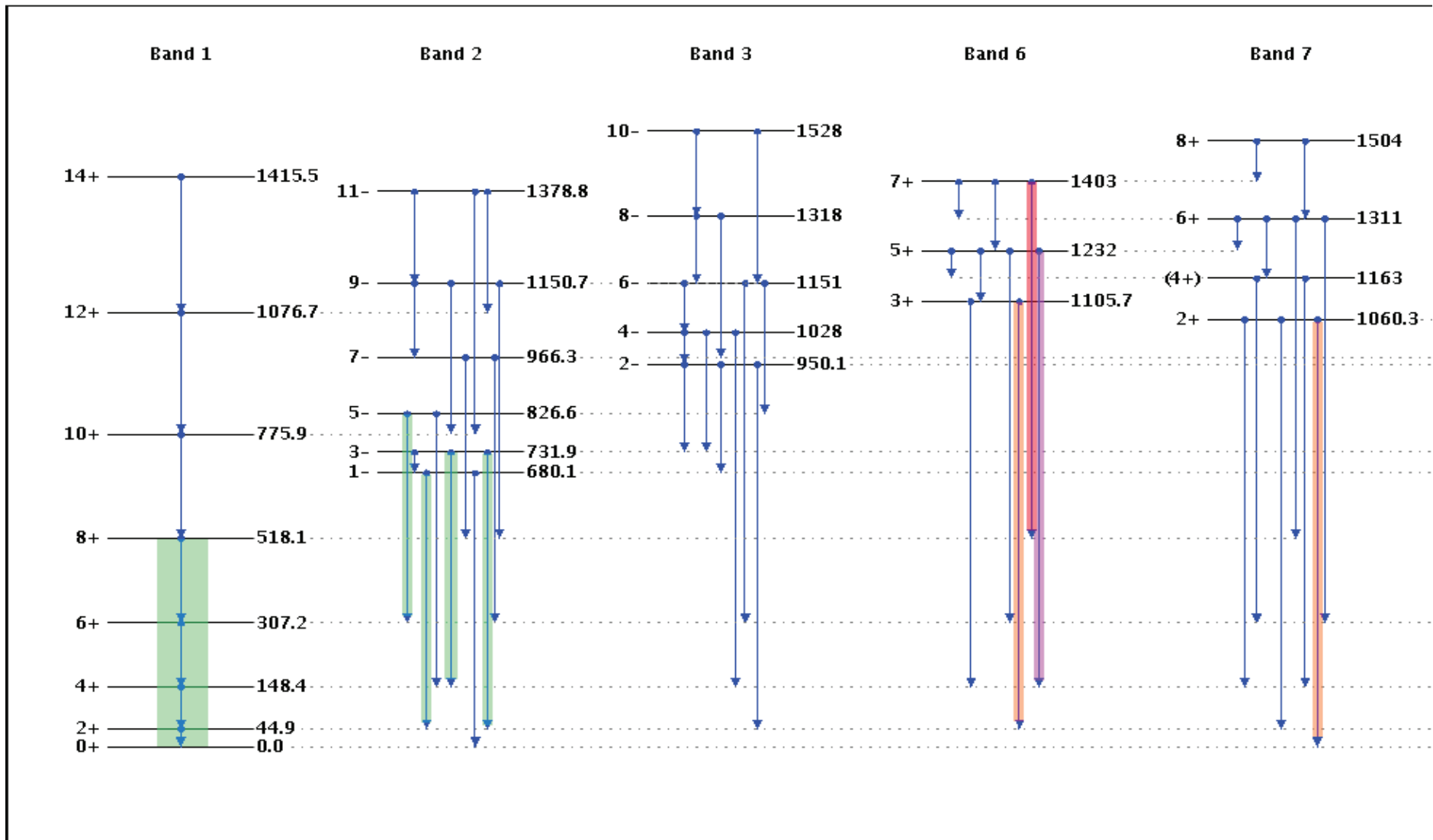
Results

- ^{238}U (Sample of natural Uranium 99.3% ^{238}U)
 - over 1200 hours of beam time
 - about 30 (n,xn gamma) “spotted”
 - 20 preliminary (n,n' gamma) cross-sections

Neutron inelastic scattering on ^{238}U

Results

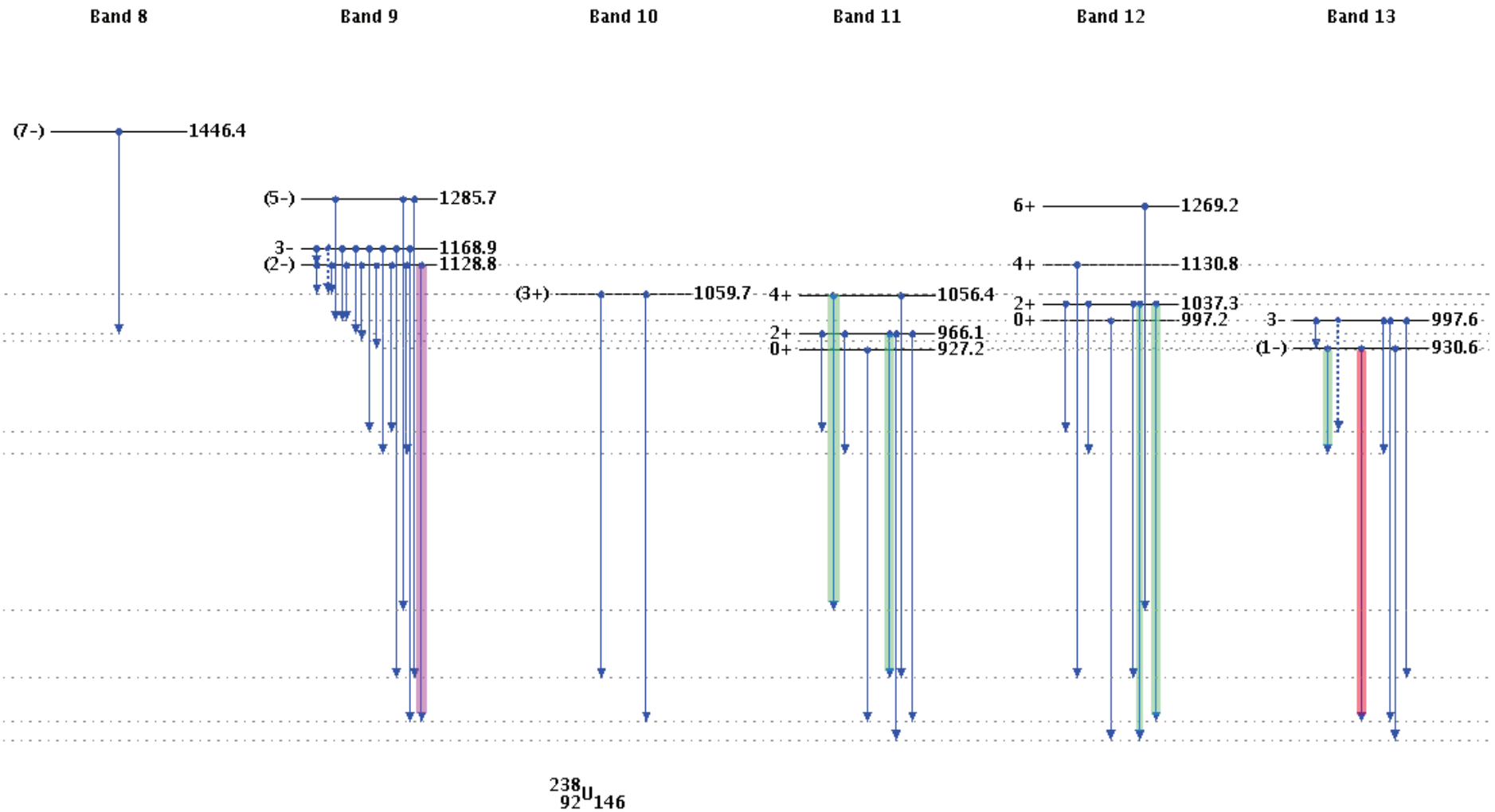
- reference (NNDC)
- Analyzed transition
- Multi-occurring gamma energy



Neutron inelastic scattering on ^{238}U

Results

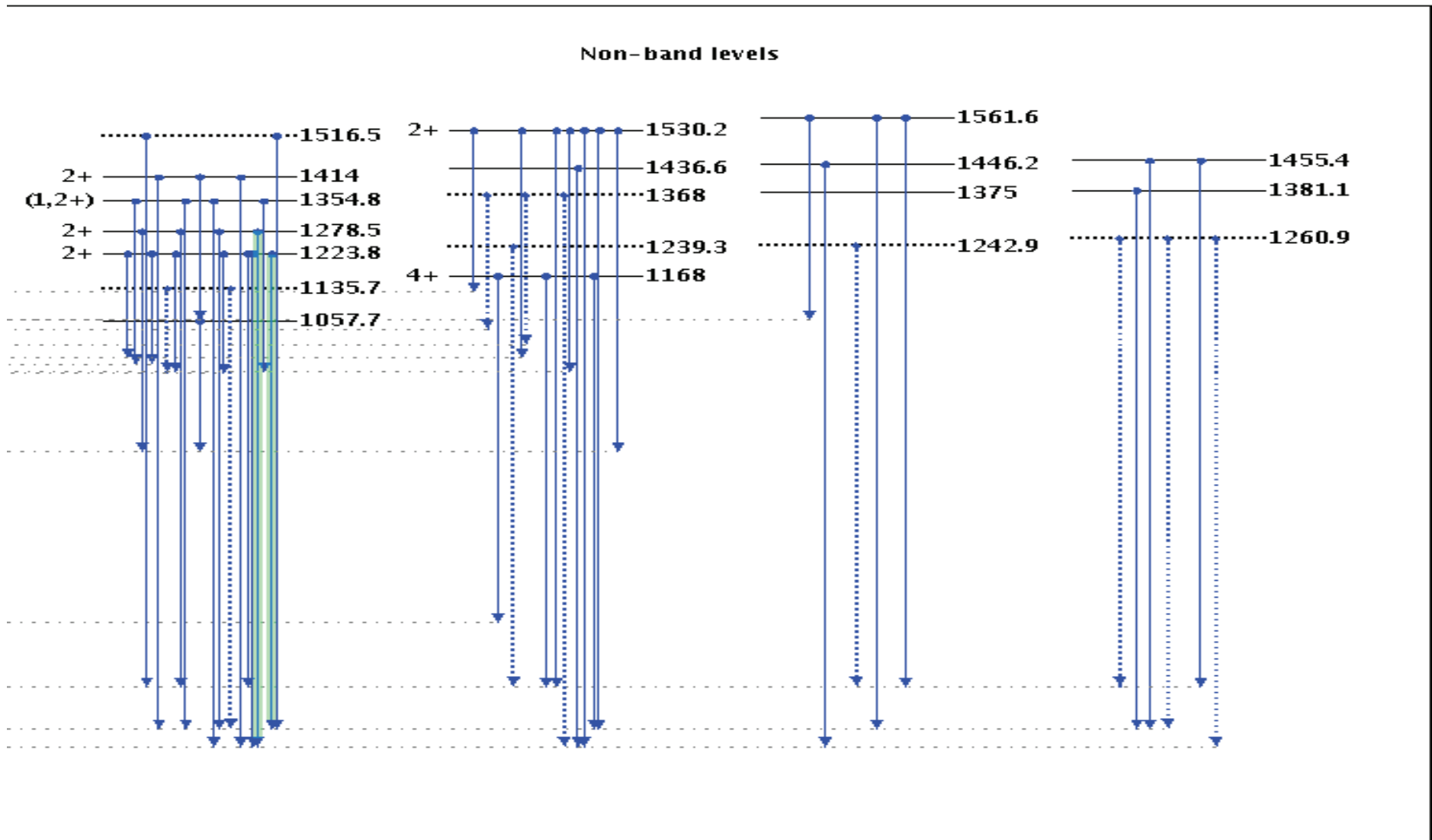
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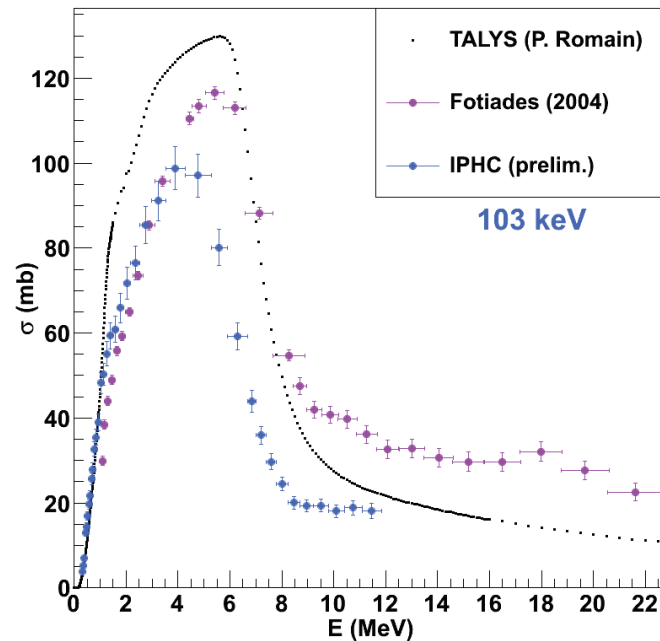
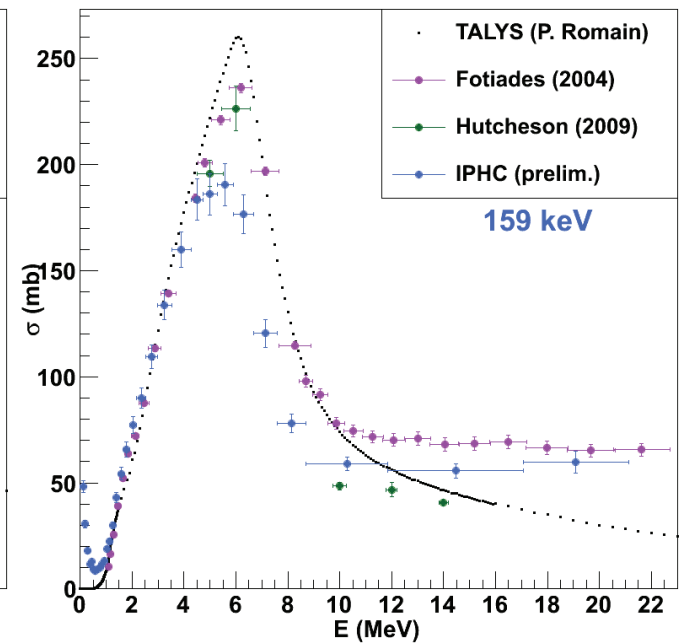
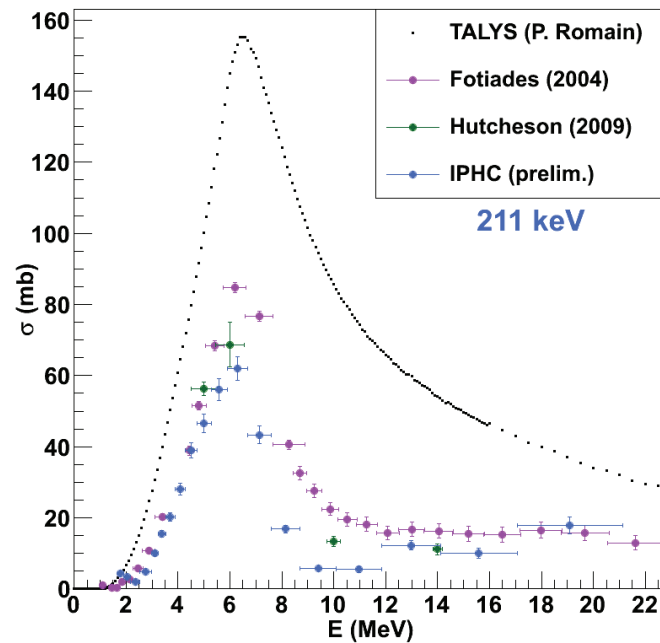
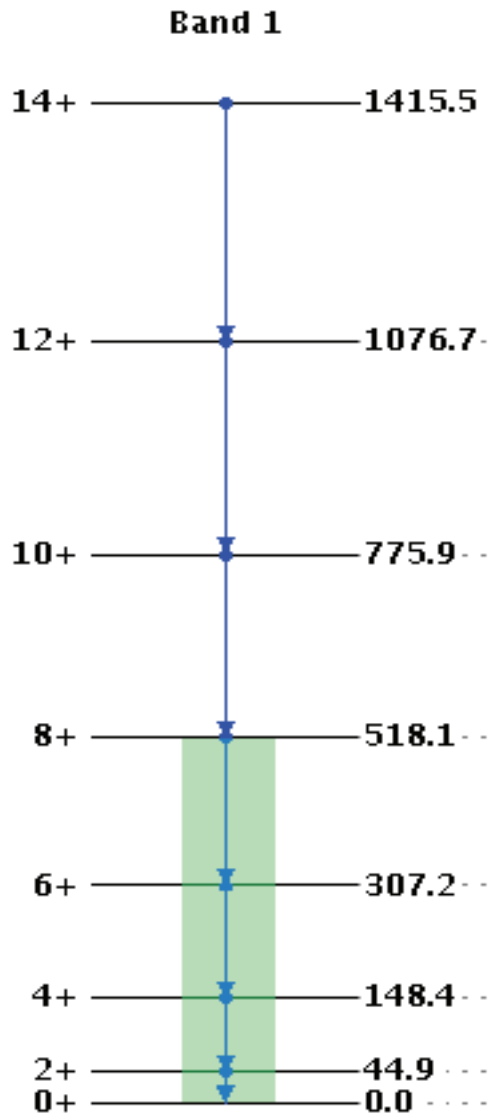
Neutron inelastic scattering on ^{238}U

Results

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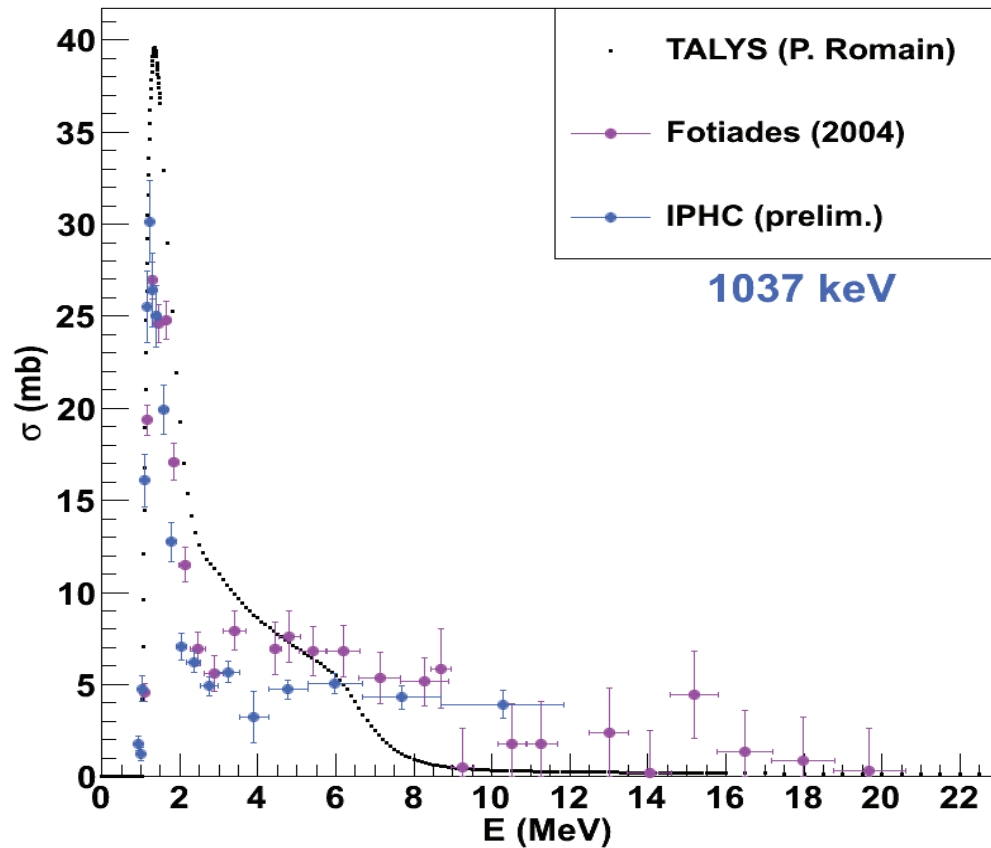
Results



Ongoing analysis on the 45keV...

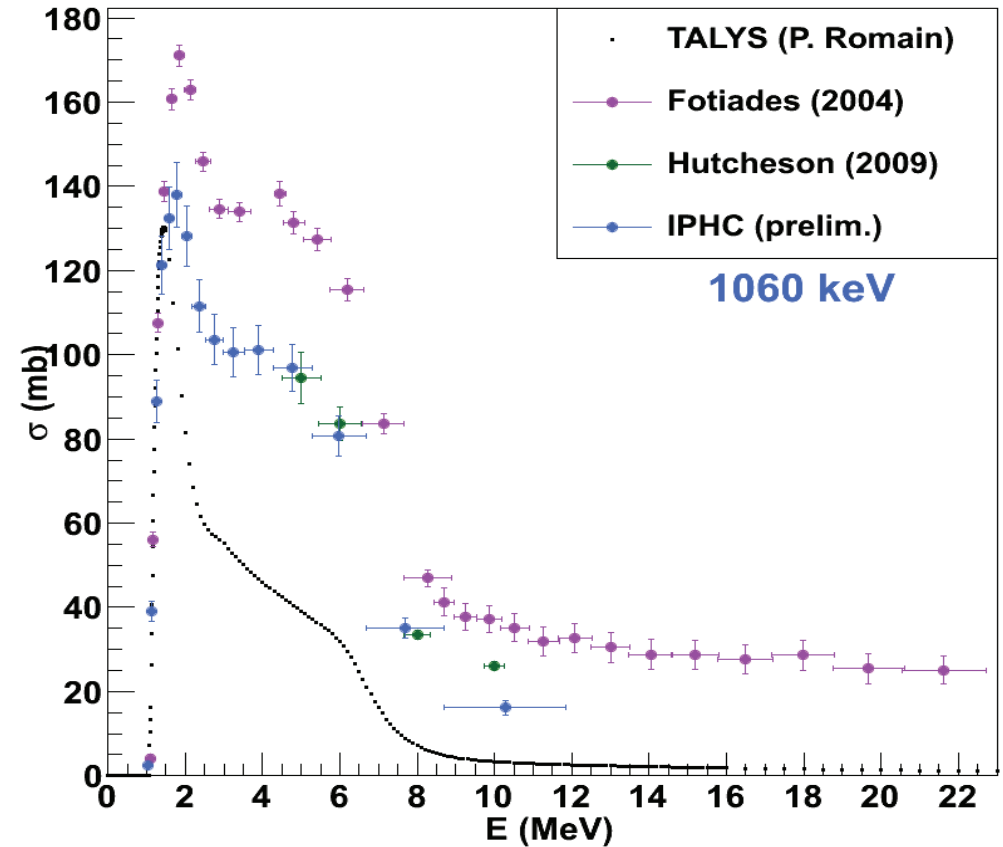
Results

Transitions down to Ground State (0^+)



$E_i = 1037.3 \text{ keV } (2^+)$
 $E_f = 0.0 \text{ keV } (0^+)$

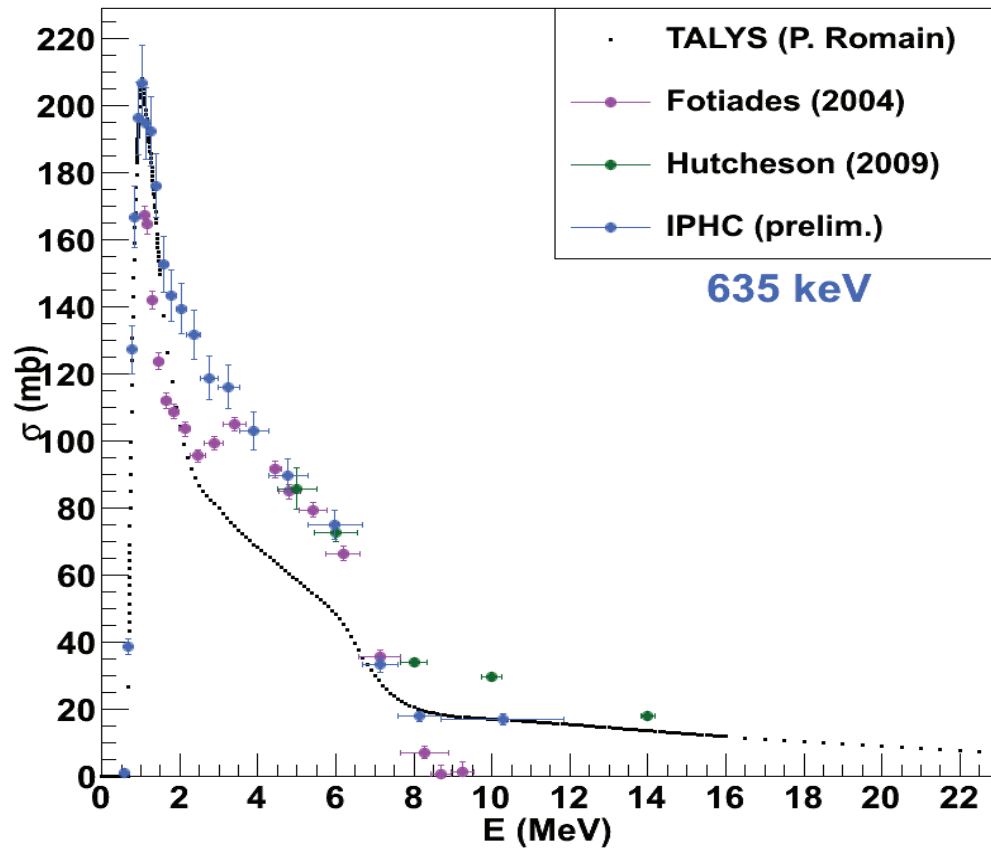
Agreement between data sets



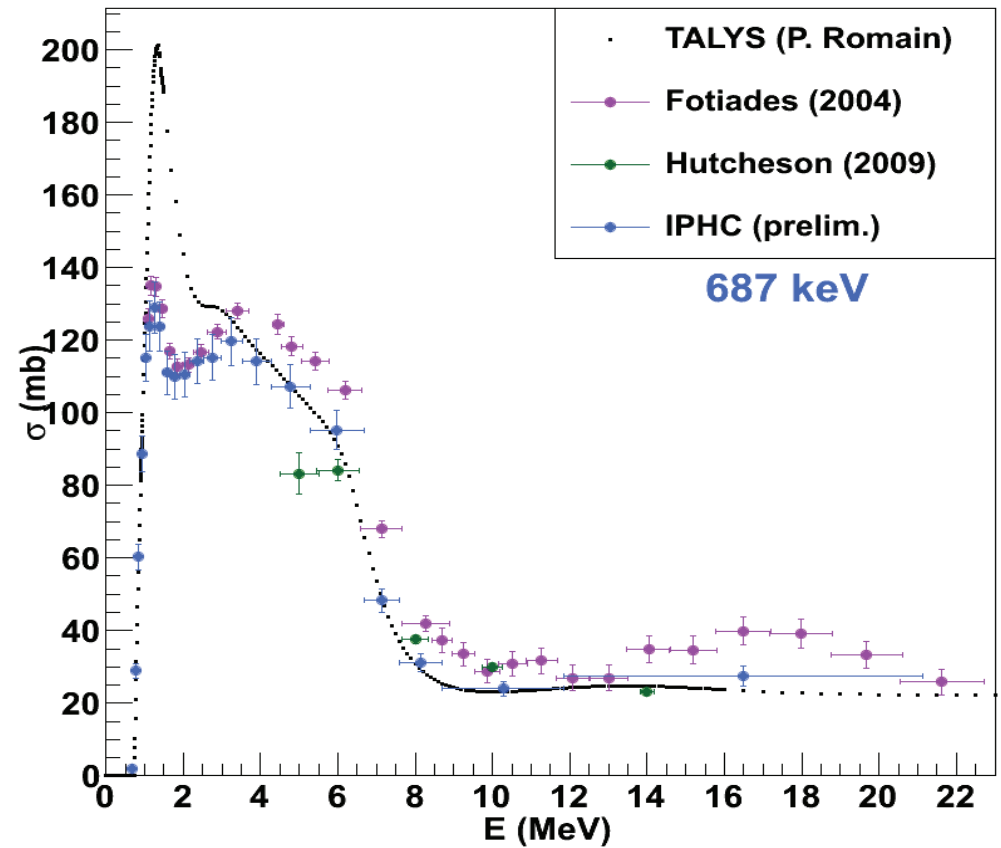
$E_i = 1060.3 \text{ keV } (2^+)$ $E_i = 1105.7 \text{ keV } (3^+)$
 $E_f = 0.0 \text{ keV } (0^+)$ $E_f = 44.9 \text{ keV } (2^+)$

Summed transitions...

Results



$E_i = 680.1$ keV (1-)
 $E_f = 44.9$ keV (2+)



$E_i = 731.9$ keV (3-)
 $E_f = 44.9$ keV (2+)

Support

Many thanks to IRMM staff

