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First measurement of the neutron capture cross section of ^{231}Pa in the keV region

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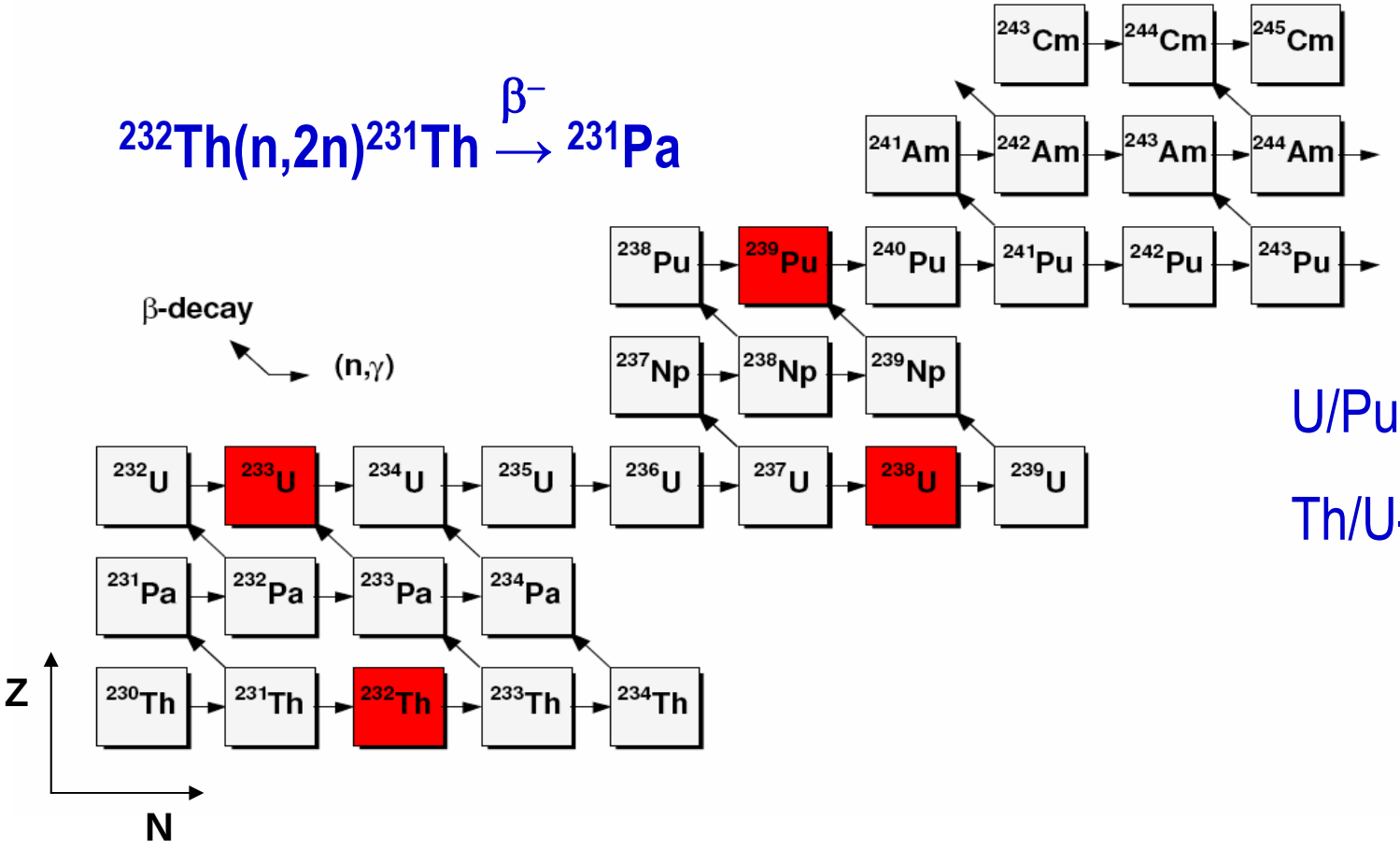
EFNUDAT laboratory: FZK VdG accelerator laboratory

Reducing nuclear waste: the thorium cycle

$$^{238}\mathrm{U} + \mathrm{n} \longrightarrow {}^{239}\mathrm{U} \xrightarrow{\beta^- \ (23\ min)} {}^{239}\mathrm{Np} \xrightarrow{\beta^- \ (2.4\ d)} {}^{239}\mathrm{Pu}$$

$$^{232}\mathrm{Th} + \mathrm{n} \longrightarrow {}^{233}\mathrm{Th} \xrightarrow{\beta^- \ (22\ min)} {}^{233}\mathrm{Pa} \xrightarrow{\beta^- \ (27\ d)} {}^{233}\mathrm{U}$$

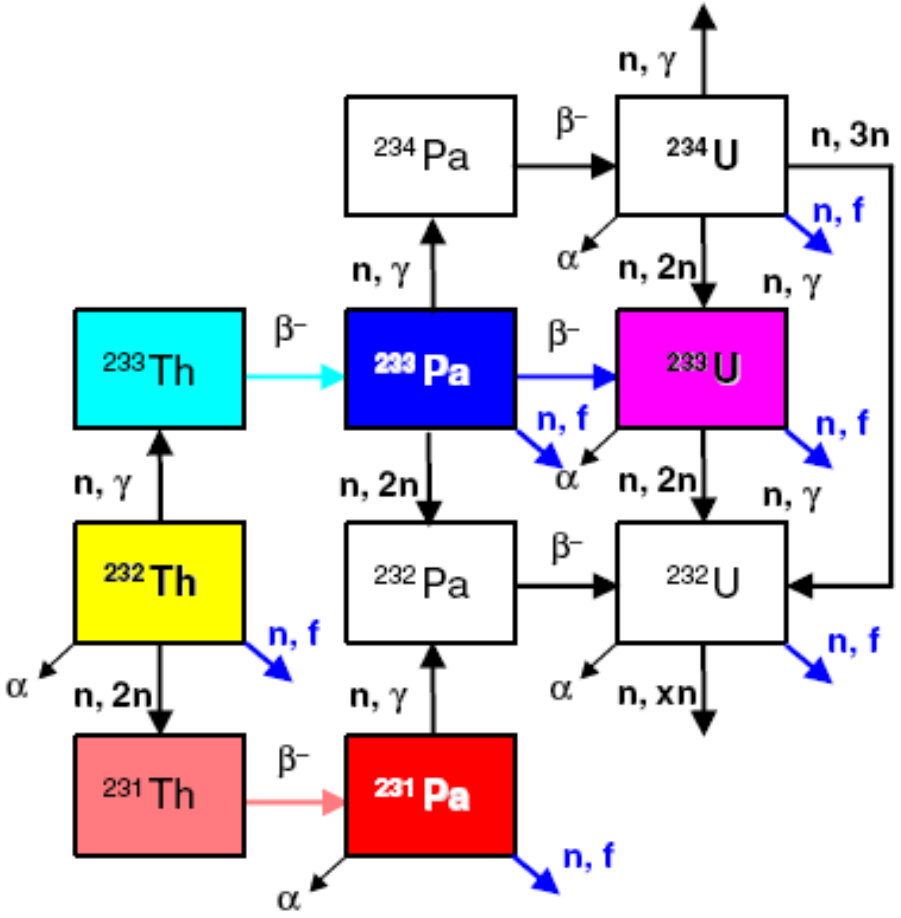
^{232}Th(n,2n)^{231}Th $\xrightarrow{\beta^-}$ ^{231}Pa

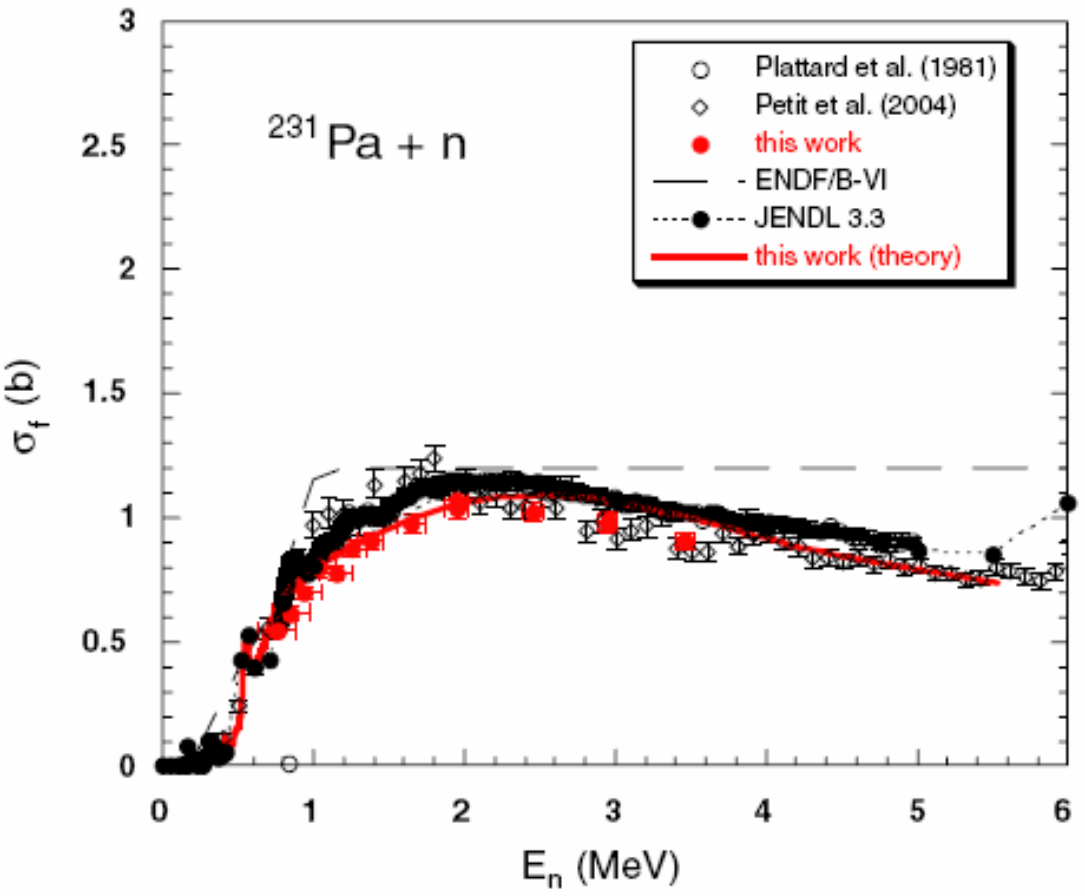


U/Pu-cycle: ^{237}Np

Th/U-cycle: ^{231}Pa

Elimination of ^{231}Pa



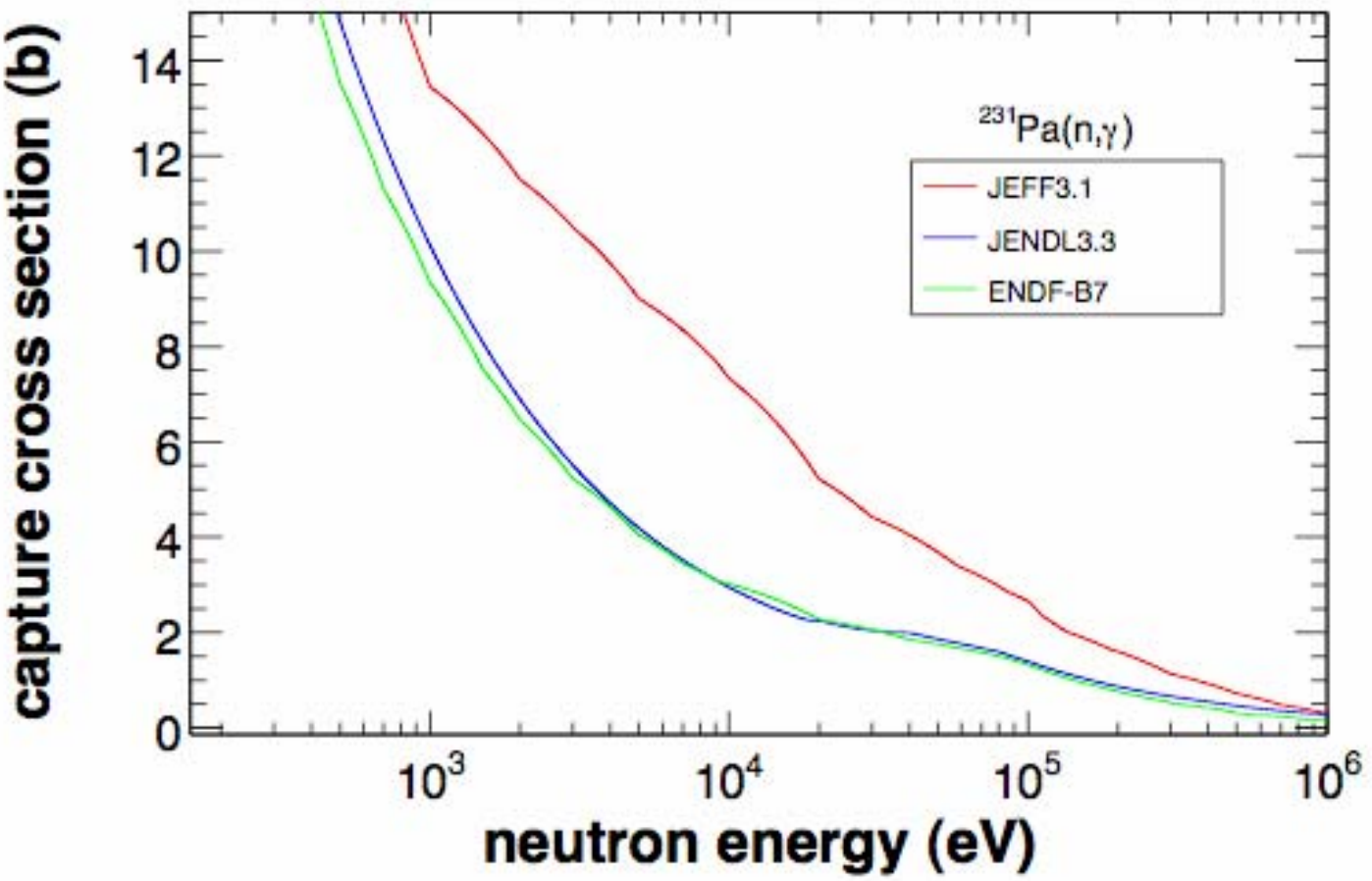


Fission

S. Oberstedt et al., ANE32(2005)1867

$^{231}Pa(n,\gamma)^{232}Pa$

No experimental data outside the thermal domain



Cross section for thermal neutrons (~200 b)

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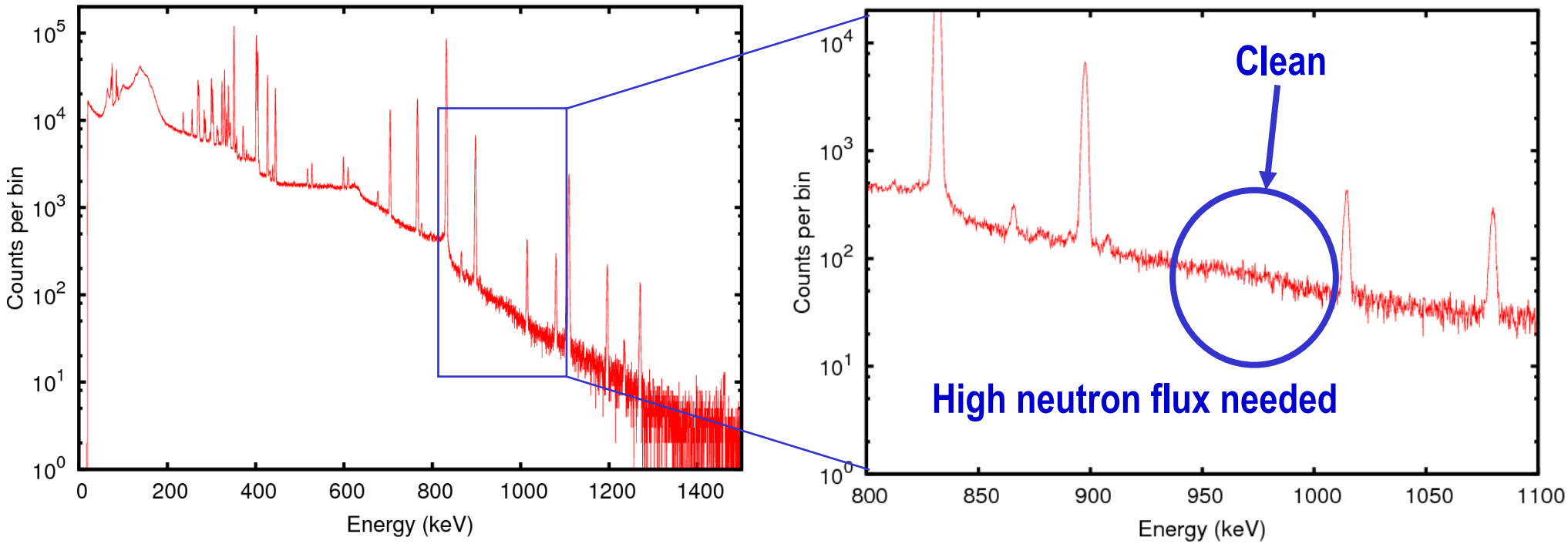
^{231}Pa sample



3.16 mg
28 mm diameter
Al-backing 0.25mm, 70 mm Ø
5.5 MBq ^{231}Pa
22 MBq activity daughters
Huge dead time
→ Pb and Cu shielding

^{231}Pa
$T_{1/2}$ = 3.3 10^4 y

^{232}Pa
$T_{1/2}$ = 1.31 d
E_γ = 969.3 keV
I_γ = 0.43

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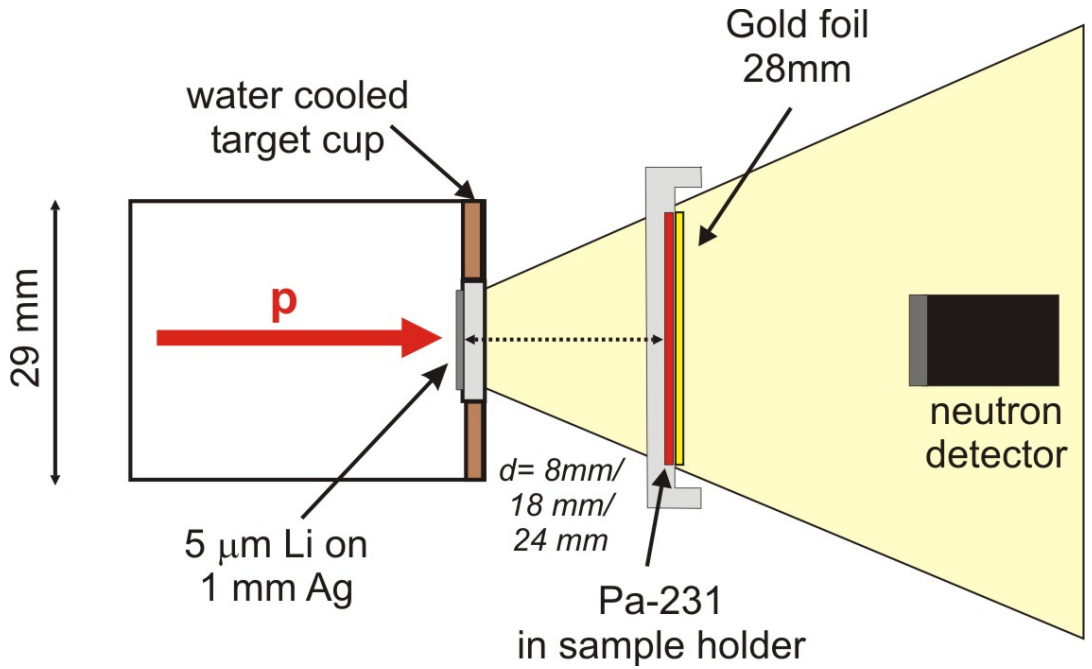
Irradiations at FZK

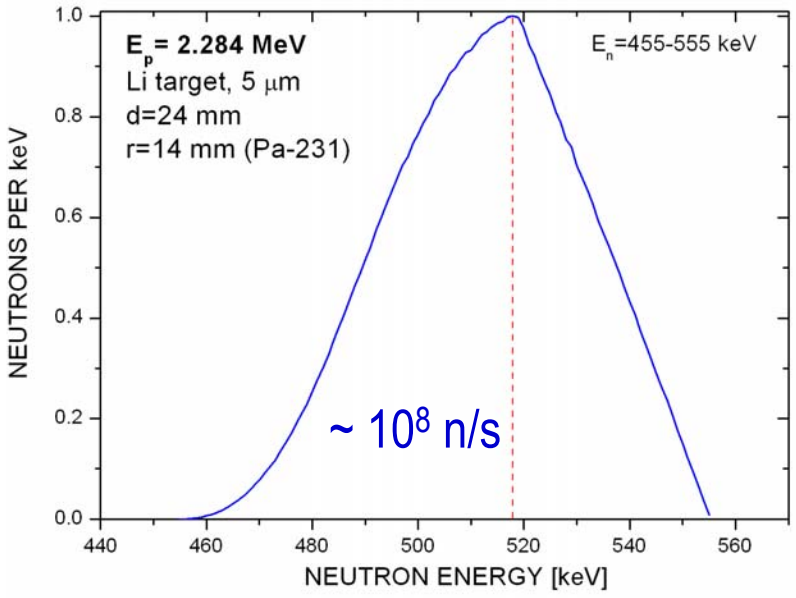


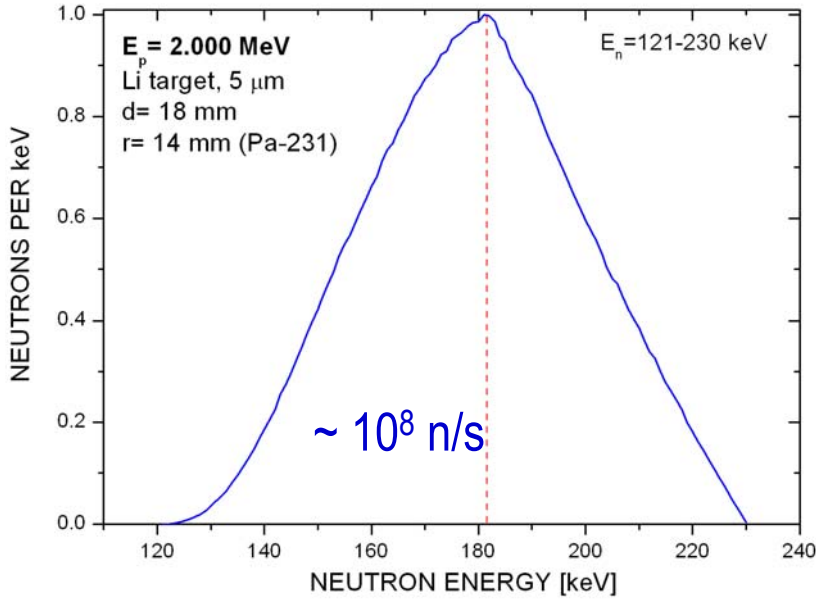
100 μA beam current
6 μm Li-metal target
48 hour irradiation
Three energies
optimized for fluence
21 Jan – 11 Feb 2008

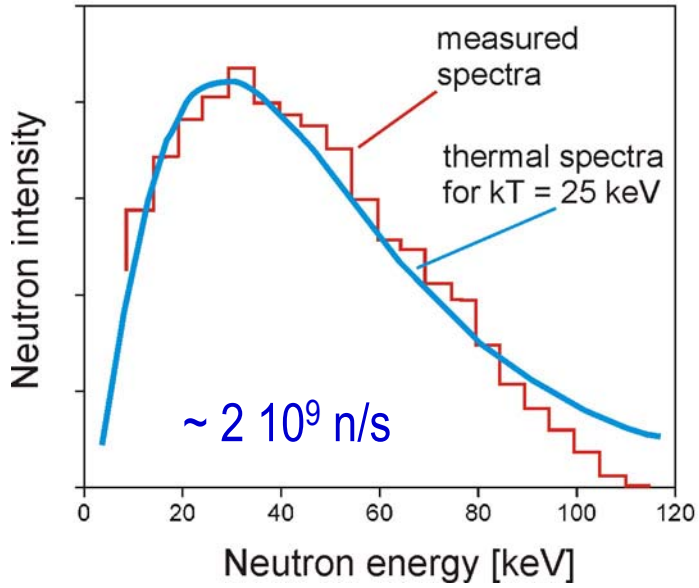
Spectral shape
- Measured with TOF
- Estimated with MC simulation

Fluence
- Au-foil, back-to-back w. ^{231}Pa

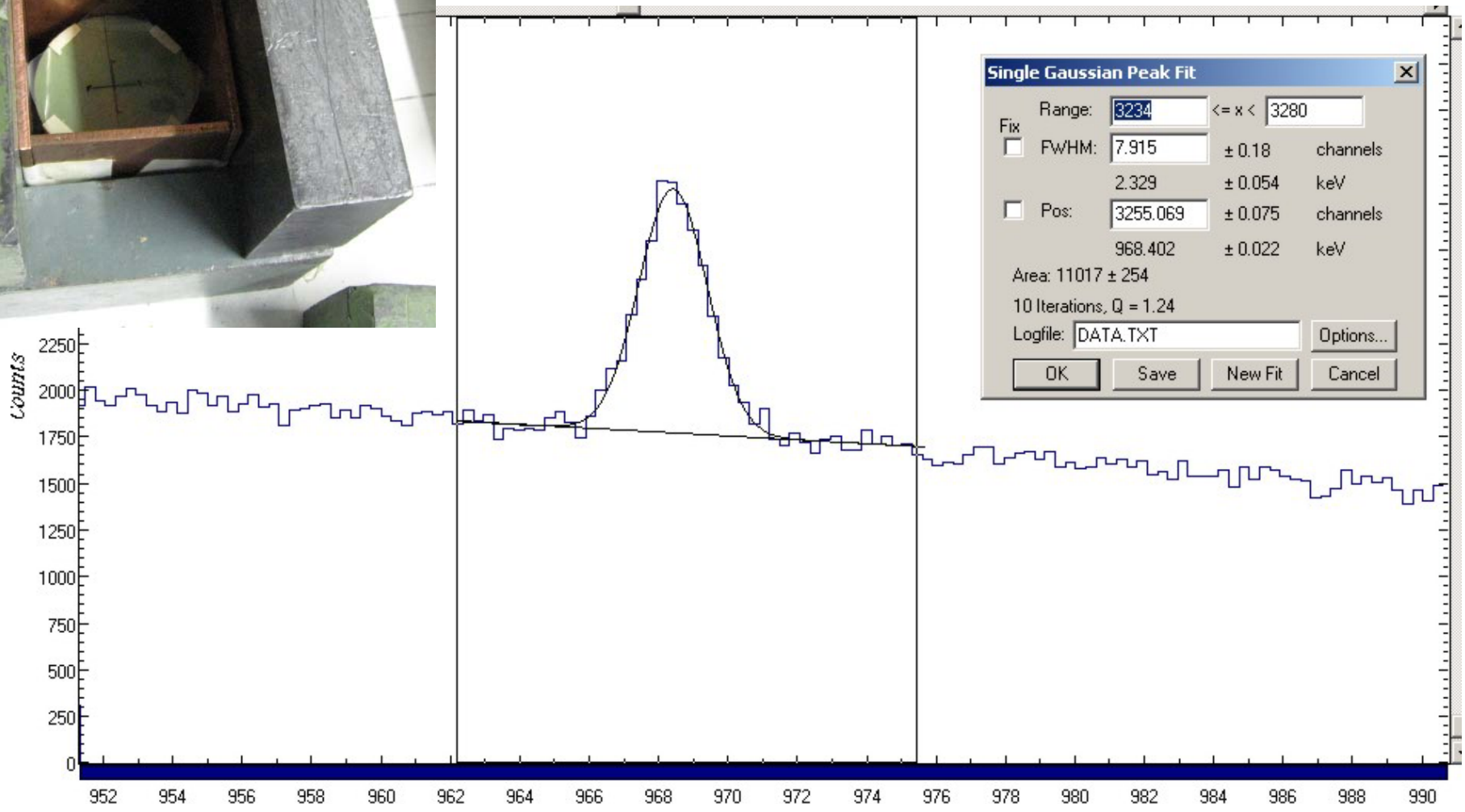
Estimated fluence distributions (MC)



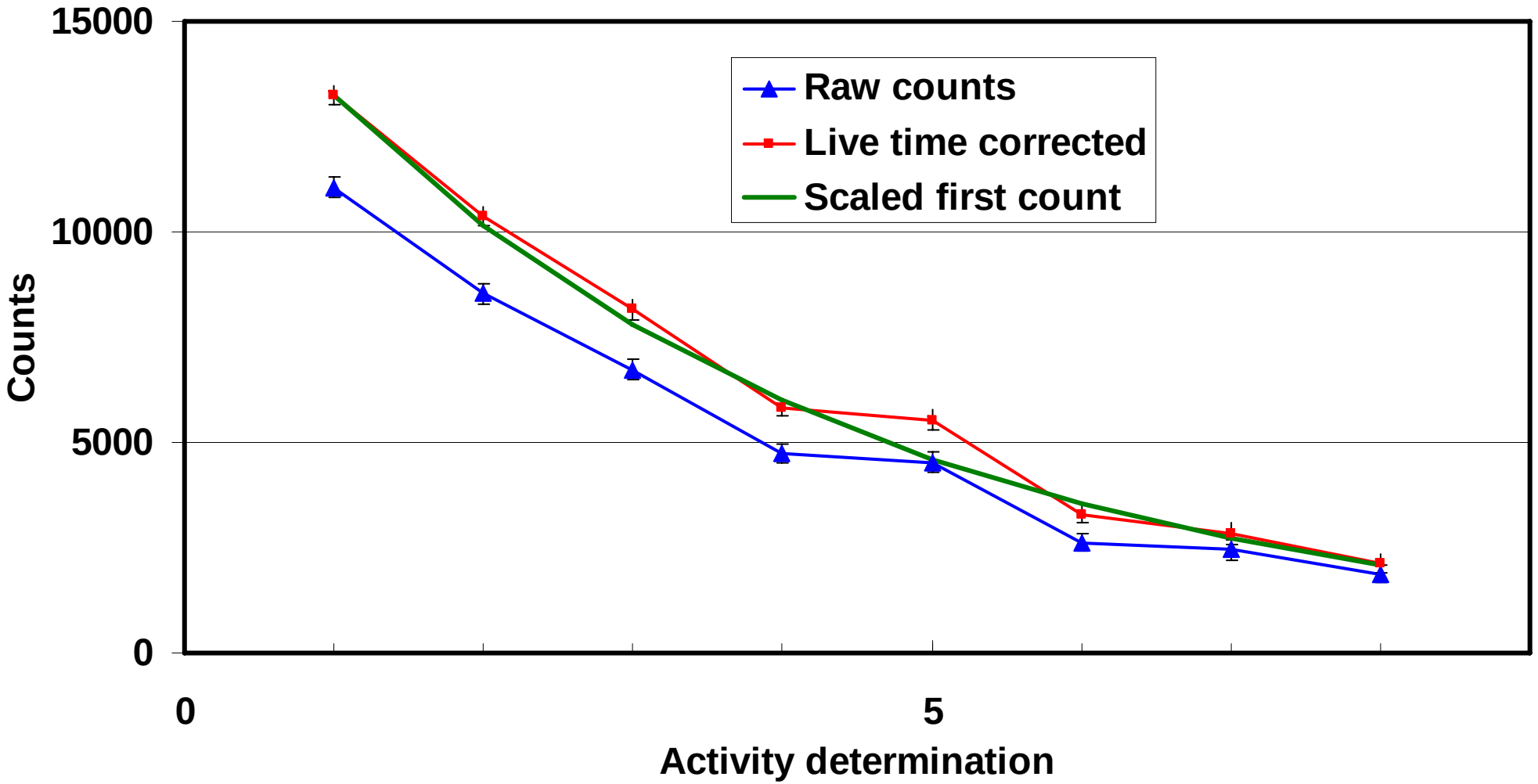




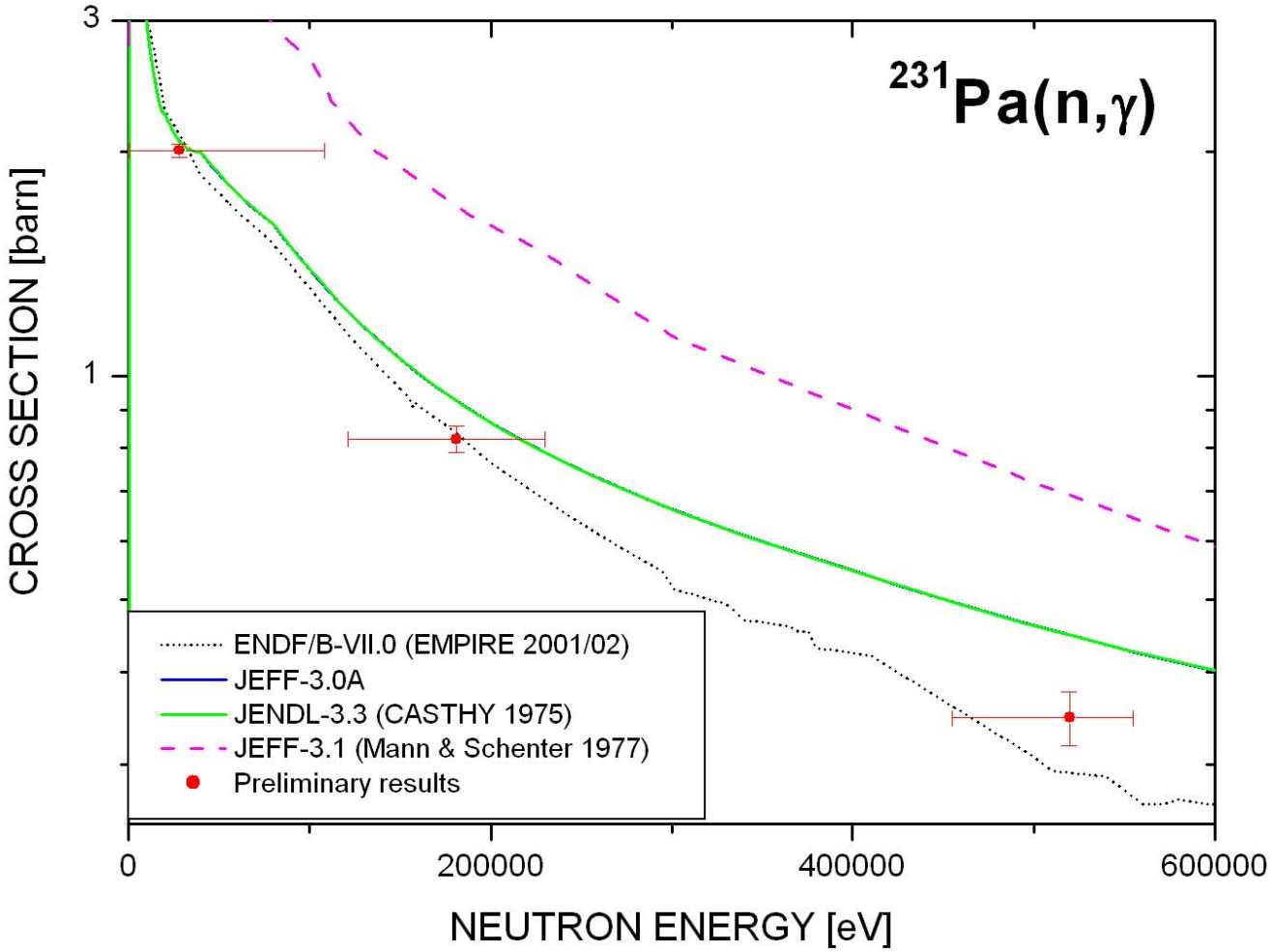
First measured activity (12h)



Confirmation of the half life ^{232}Pa



Preliminary results



- The preliminary results agree best with the latest modeling efforts of ENDF/B-VII with the EMPIRE code.