Measurements for Reactor Decay Heat

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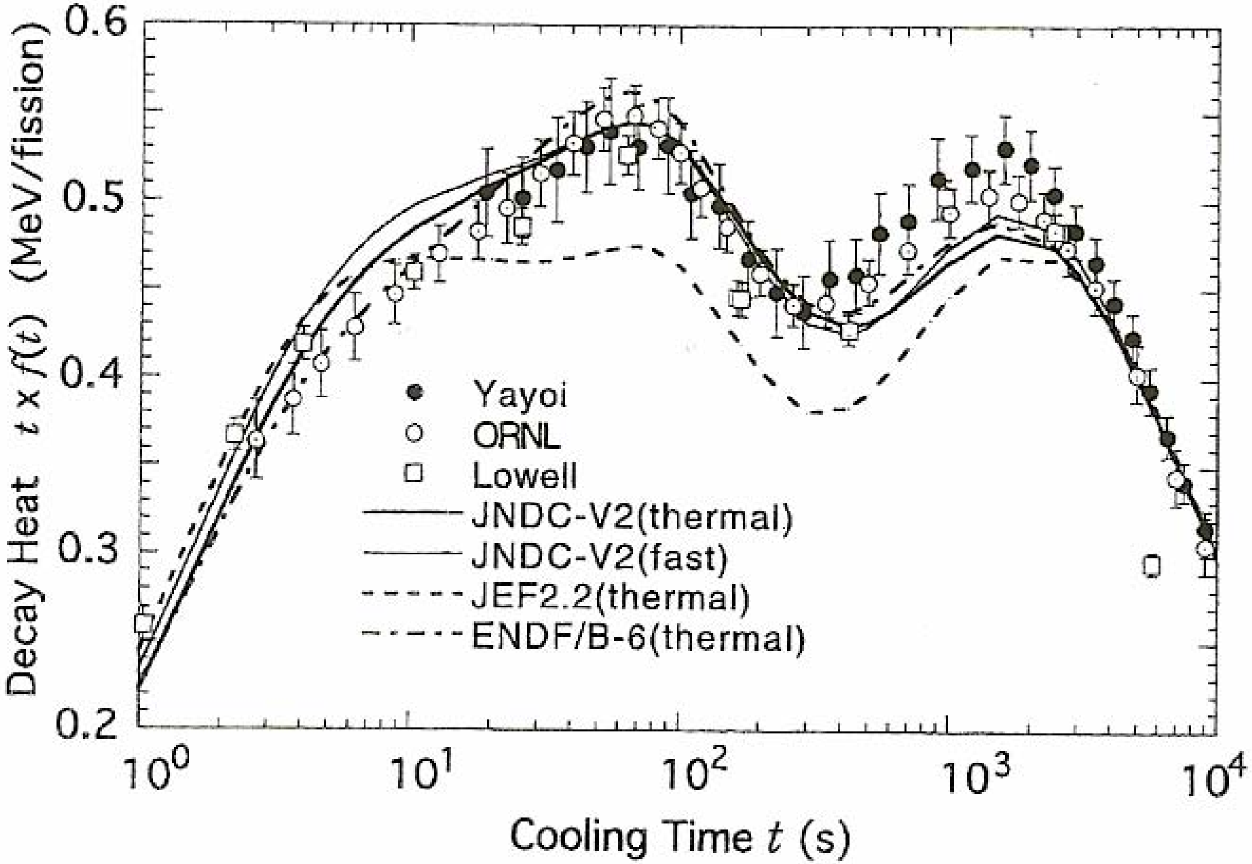
Example: measurement of the beta decay of $^{104,105}Tc$

The main motivation of this work was the study of Yoshida and coworkers (Journ. of Nucl. Sc. and Tech. 36 (1999) 135)

See ^{239}Pu example, similar situation for $^{235,238}U$

^{239}Pu example

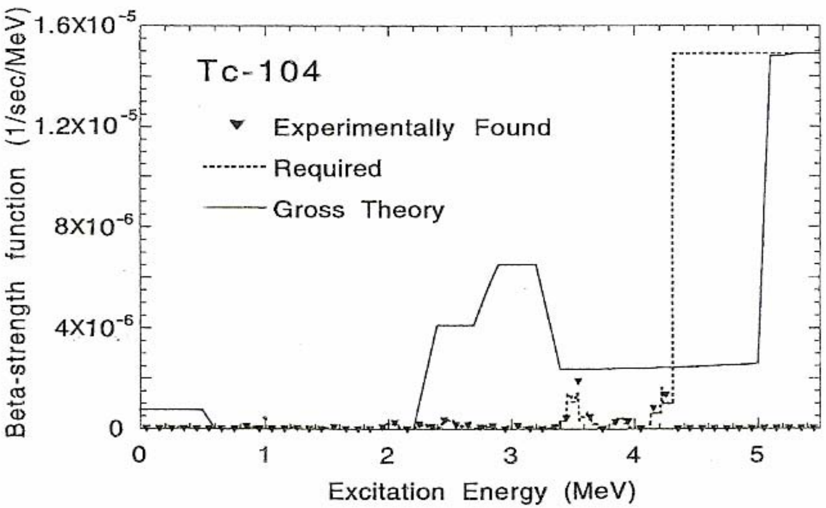


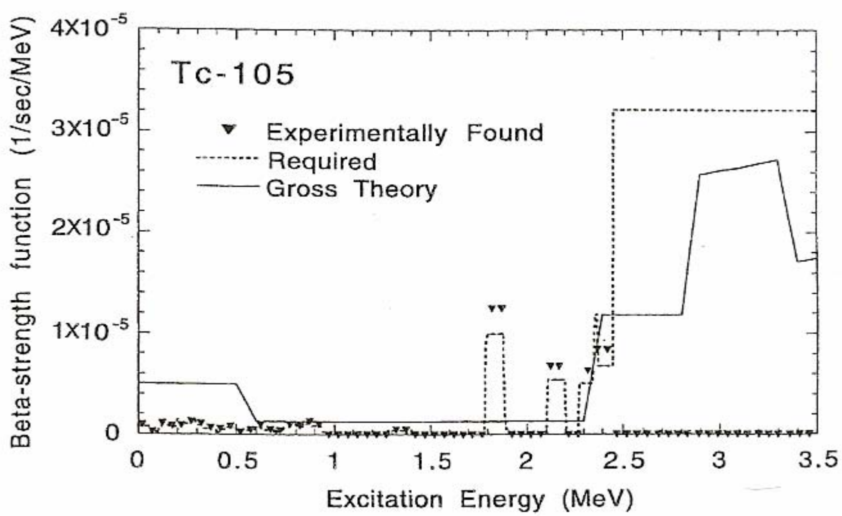
Motivations, original plans

In their work (detective work) Yoshida *et al*. identified some nuclei that may be responsible for the under-estimation of the E_ν component.

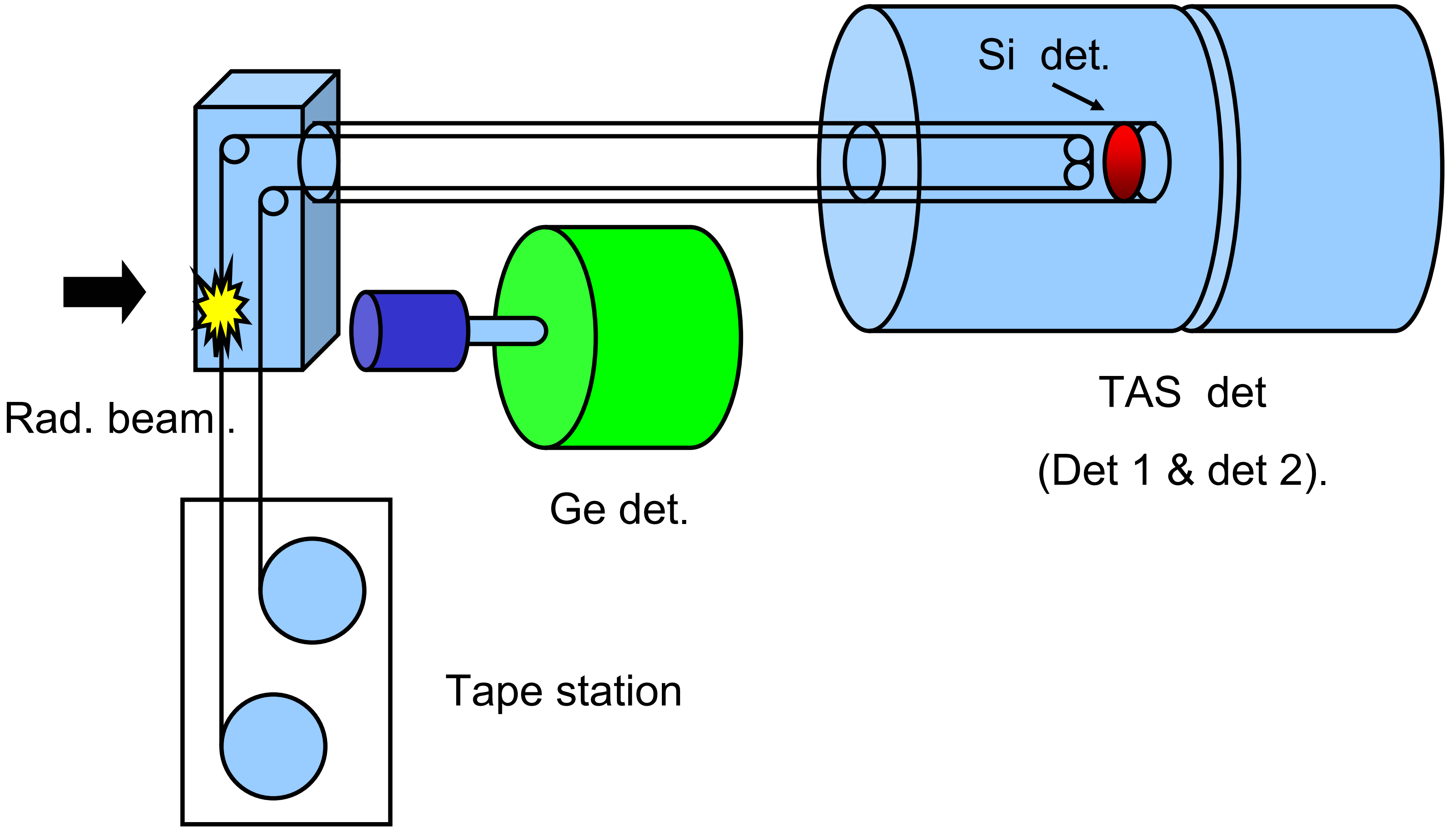
Possible nuclei that may be blamed for the anomaly were $^{102,104,105}Tc$

Explanation: not correctly measured, certainly suffer from the Pandemonium effect, their half lives are in the range, and their fission yields are also the required to solve the discrepancy



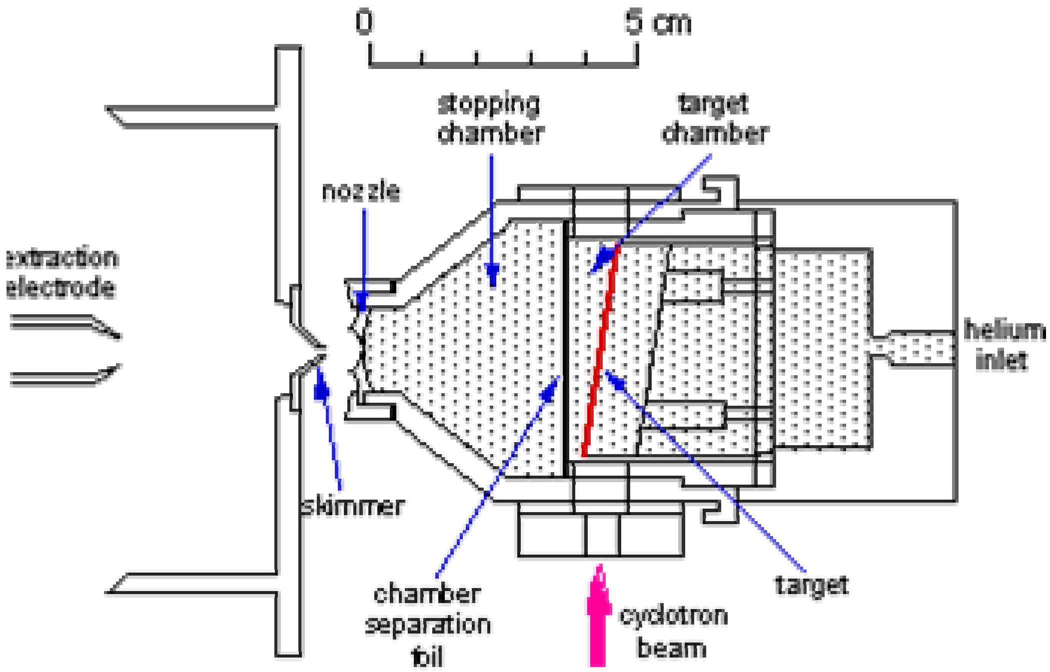


Experimental setup



The IGISOL technique

Fission ion guide: 2700 ions/s per mb, eff. of 1.6×10^{-4} relative to the production in the target



Details of our experiment:

Beam: 30 MeV proton (5microA)

Target: natural U

Target thickness: 15 mg/cm^2

Target dimensions: 10x50 mm, tilted 7 degrees

Yield of ^{112}Rh: 3500 atoms/microC

Tight collimation scheme to avoid contamination of neighbour mases (losses of 25%)

Analysis of $^{104,105}Tc$

Expectation Maximization (EM) method:

- modify knowledge on causes from effects

$$P\left(f_j \mid d_i\right) = \frac{P\left(d_i \mid f_j\right) P\left(f_j\right)}{\sum_j P\left(d_i \mid f_j\right) P\left(f_j\right)}$$

Algorithm:

$$f_j^{(s+1)} = \frac{1}{\sum_i R_{ij}} \sum_i \frac{R_{ij} f_j^{(s)} d_i}{\sum_k R_{ik} f_k^{(s)}}$$

Some details (d=Rf)

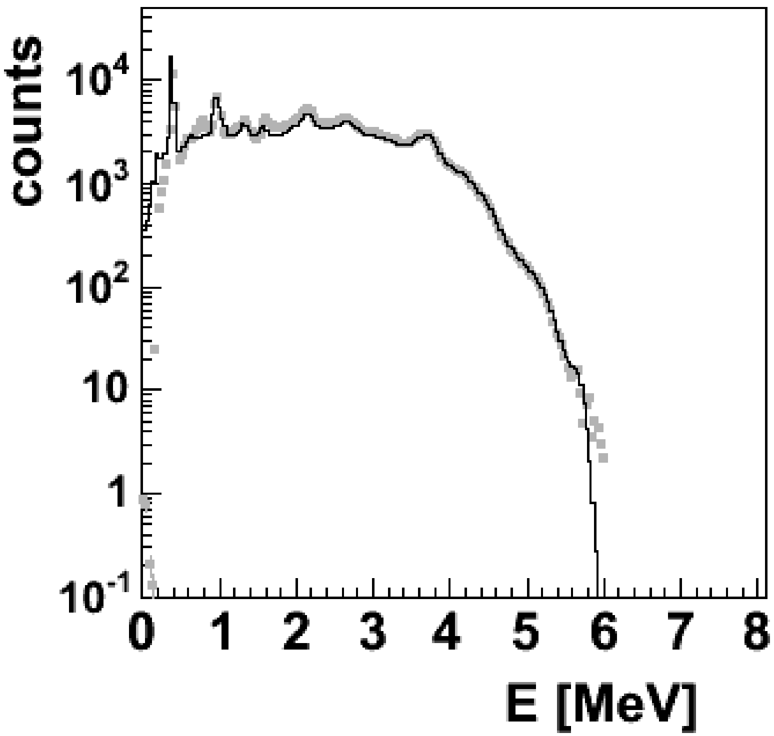
Known levels up to: 1515 keV excitation (104Tc case),
1340 keV (104Tc case)

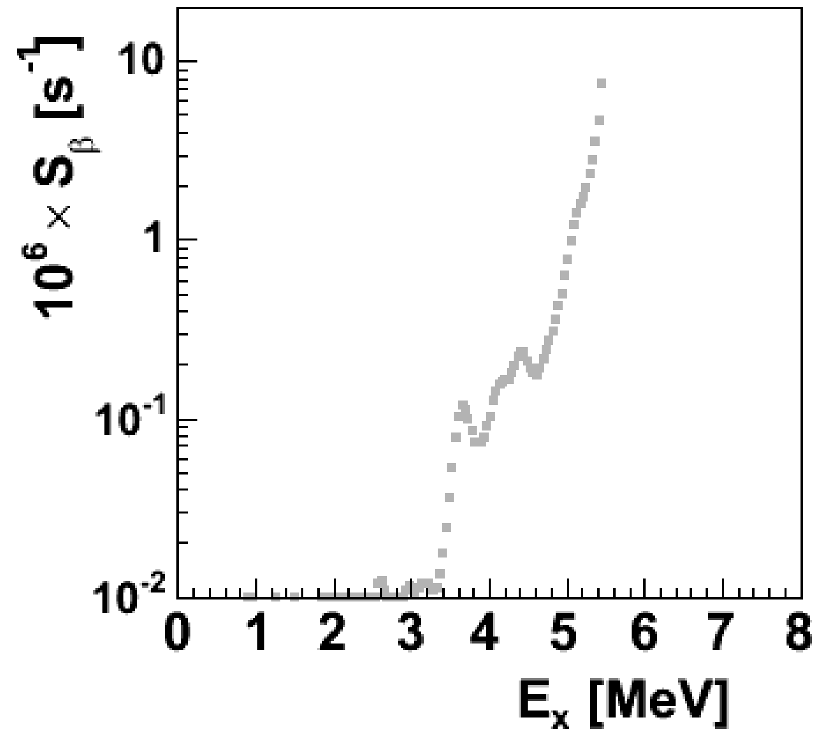
From that level up to the Q_β value we use an statistical model

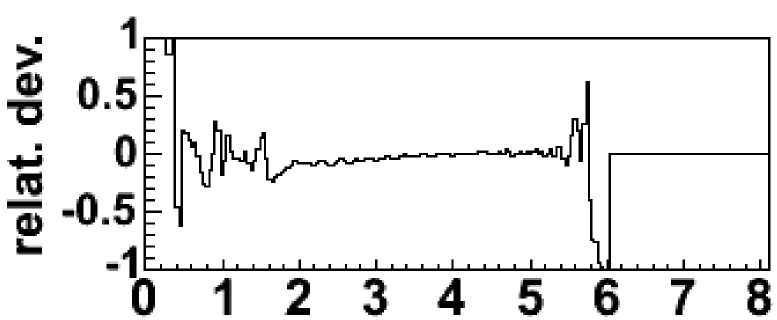
(Back Shifted Fermi formula for the level density with parameters taken from the RIPL dbase (^{102}Ru,^{106}Pd, 105Ru)

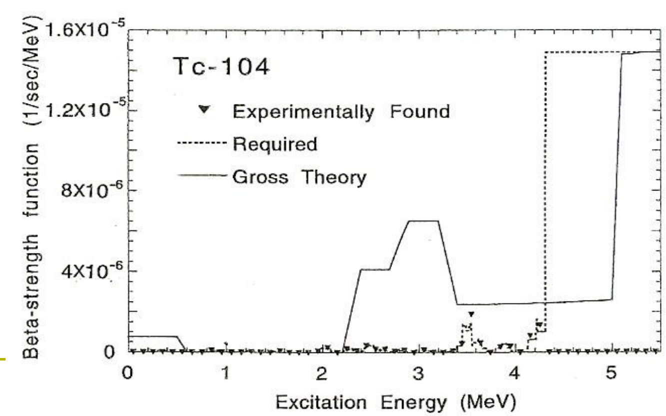
Branching ratios

Results of the analysis for ^{104}Tc

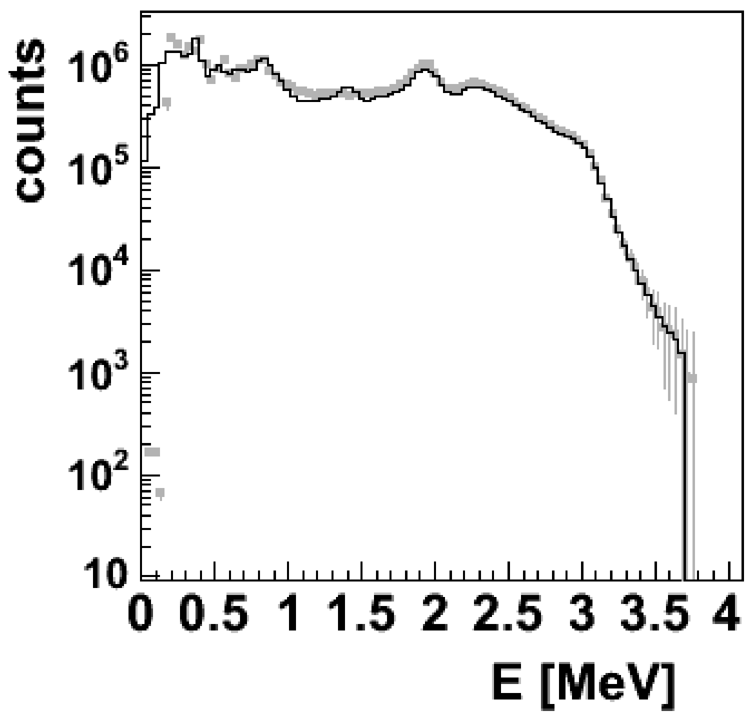


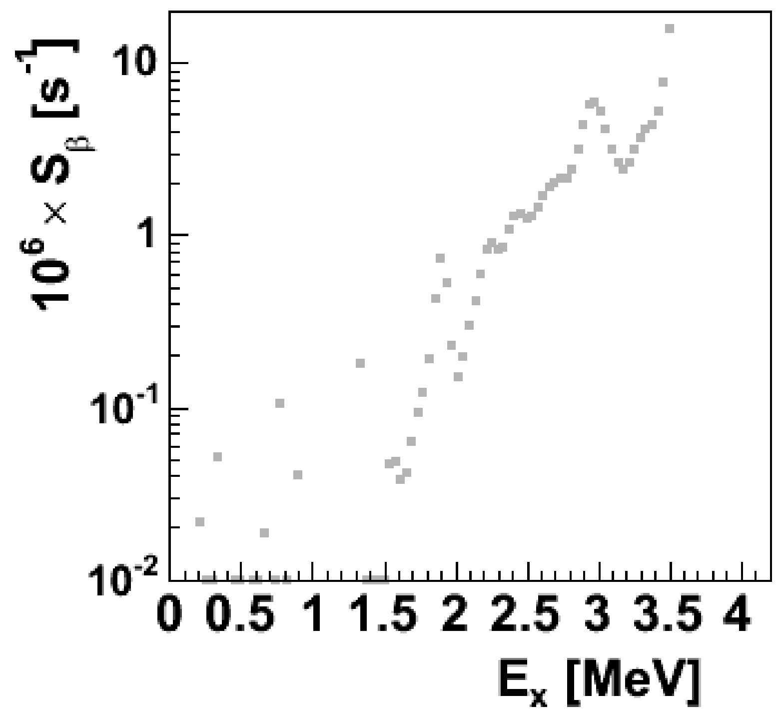


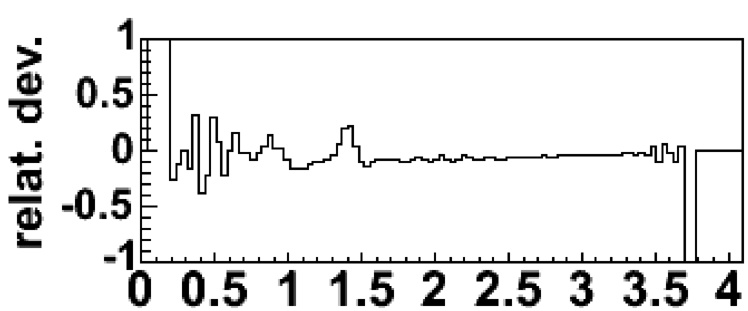


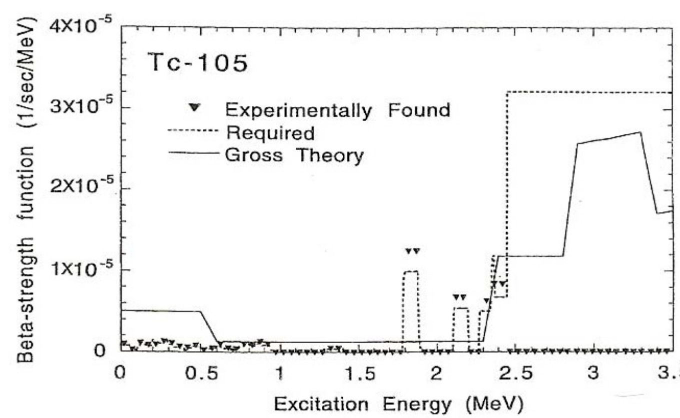


Results of the analysis for ^{105}Tc









New accepted proposal: some of the cases from the new Yoshida's list

We have 7 days (Jyväskylä Laboratory, Finland)

Decay	$T_{1/2}$	Q_β(keV)	Y_{trap}(at/s)	Shifts
$^{102}Tc \rightarrow {}^{102}Ru$	5.28s	4532	2	8
$^{103}Tc \rightarrow {}^{103}Ru$	54.2s	2662	2	6
$^{103}Mo \rightarrow {}^{103}Tc$	67.5s	3750	104	1
$^{105}Mo \rightarrow {}^{105}Tc$	35.6s	4950	104	1
$^{106}Tc \rightarrow {}^{106}Ru$	35.6s	6547	5	3

Conclusions

- From the available information (databases) it is clear that there is a huge amount of work to be done. It requires close collaboration with the experts of the field in order to determine priorities.

- There are specific issues that need to be addressed for each case of interest: purity of the beam, beta delayed neutron emission, etc.