Neutrino Nucleosynthesis of Exotic Nuclides ^{138}La and ^{180}Ta

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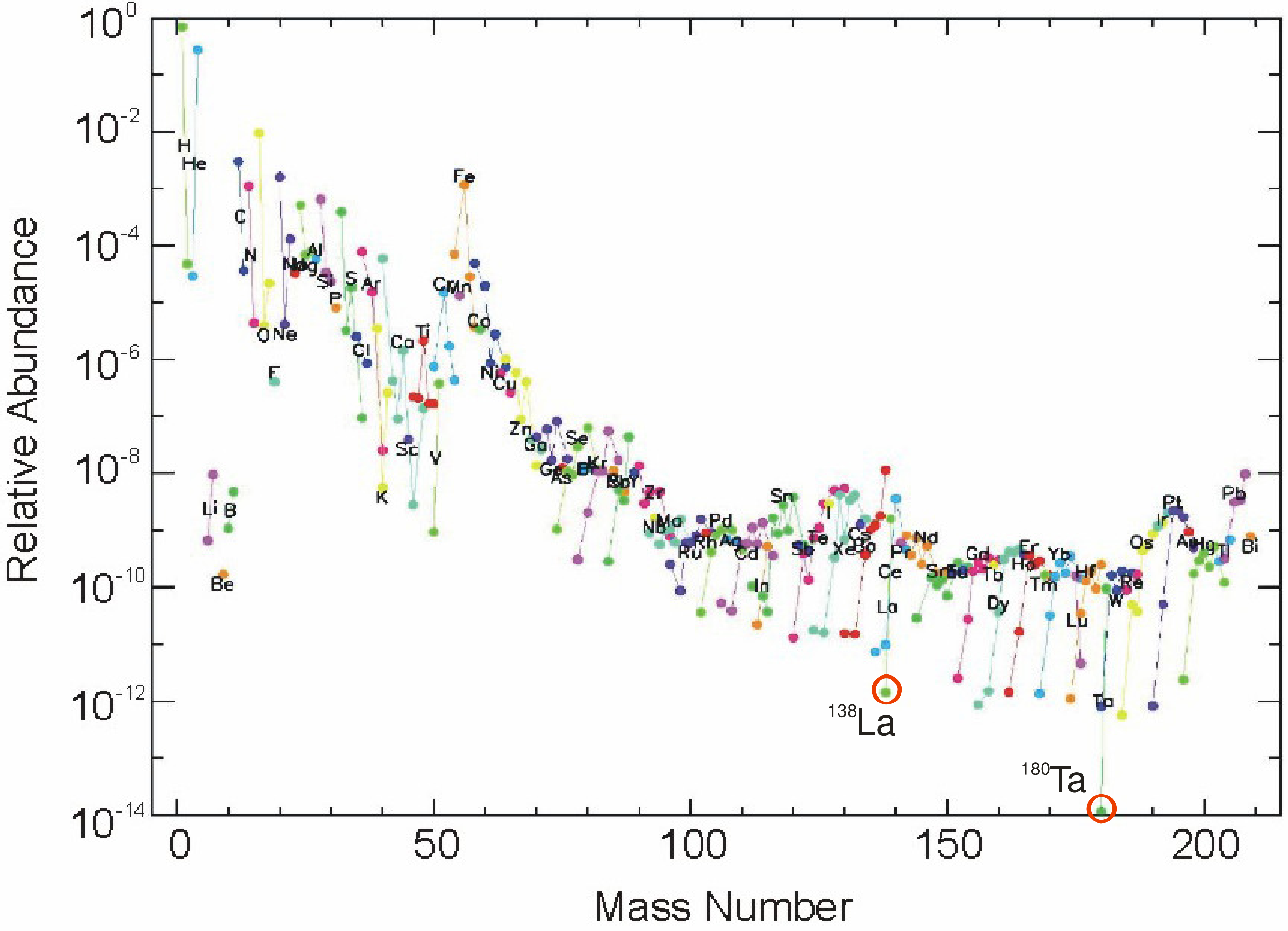
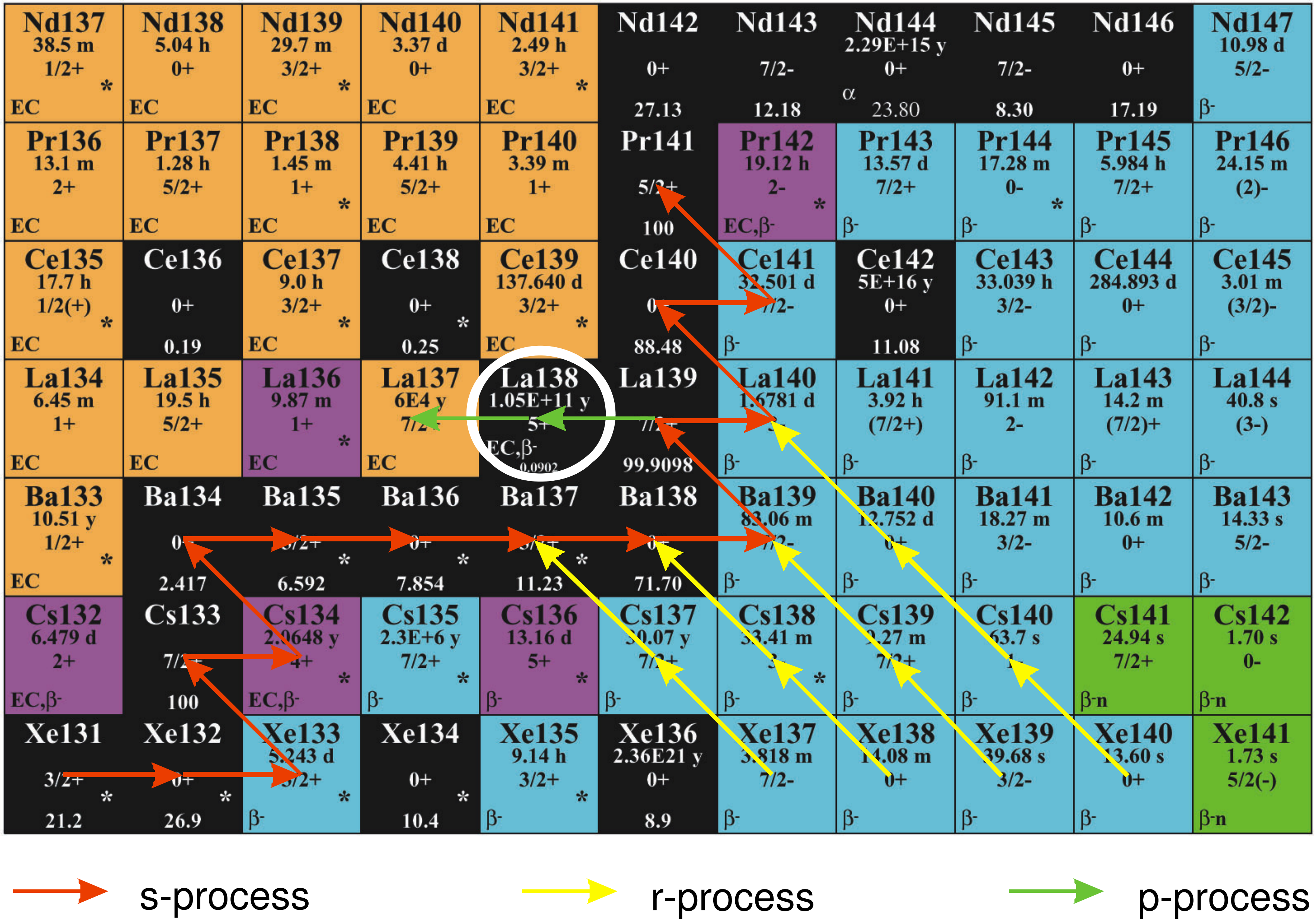
Outline

- Motivation
- Theoretical predictions
- Experimental requirements and setup
- Results vs. RPA calculations
- Summary and outlook

Exotic Nuclides



Nucleosynthesis of ^{138}La



Production through Neutrino Process

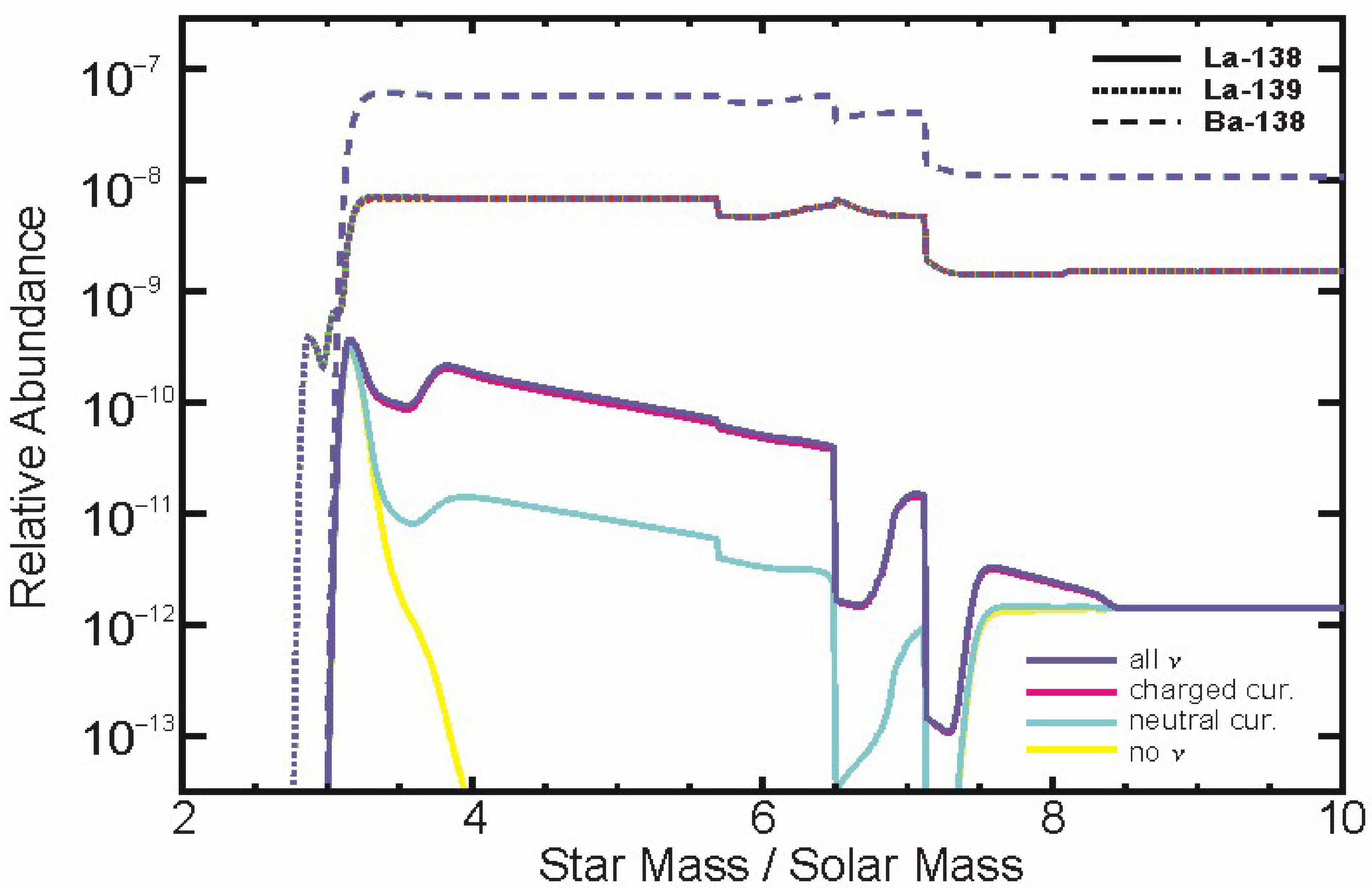
- Neutral current reactions: $^{139}La(\nu,\nu'n)^{138}La$
  $^{181}Ta(\nu,\nu'n)^{180}Ta$

- Charged current reactions: $^{138}Ba(\nu_e,e^-)^{138}La$
  $^{180}Hf(\nu_e,e^-)^{180}Ta$

- Complete stellar evolution in massive stars with the improved RPA calculations for ν-nucleus reactions

A. Heger et al., Phys. Lett. B 606 (2005) 258

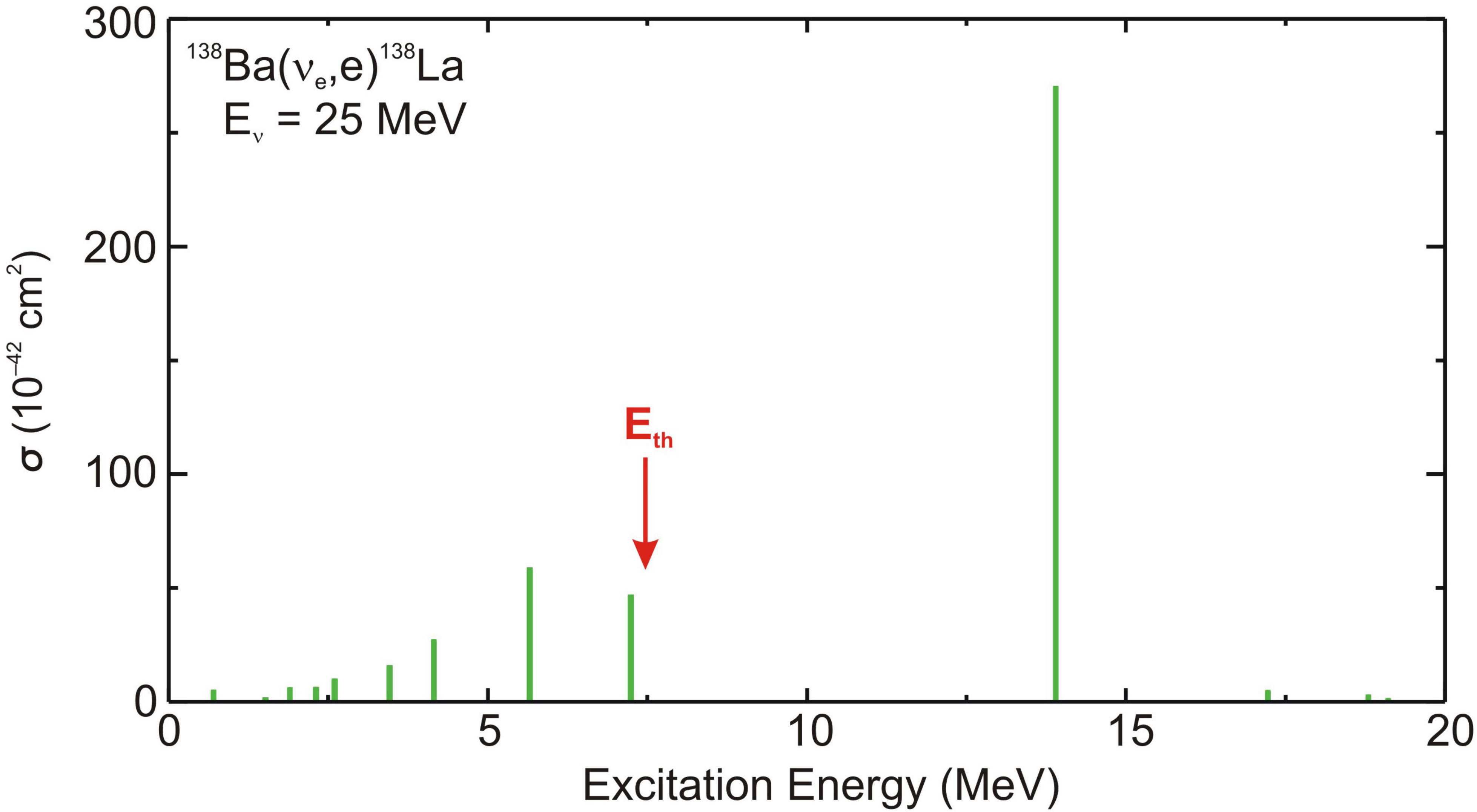
Different Production Processes of ^{138}La



- ^{138}La: pure ν process nucleus
- ^{180}Ta: 50% p process, 50% ν process (s process also not excluded)

Prediction

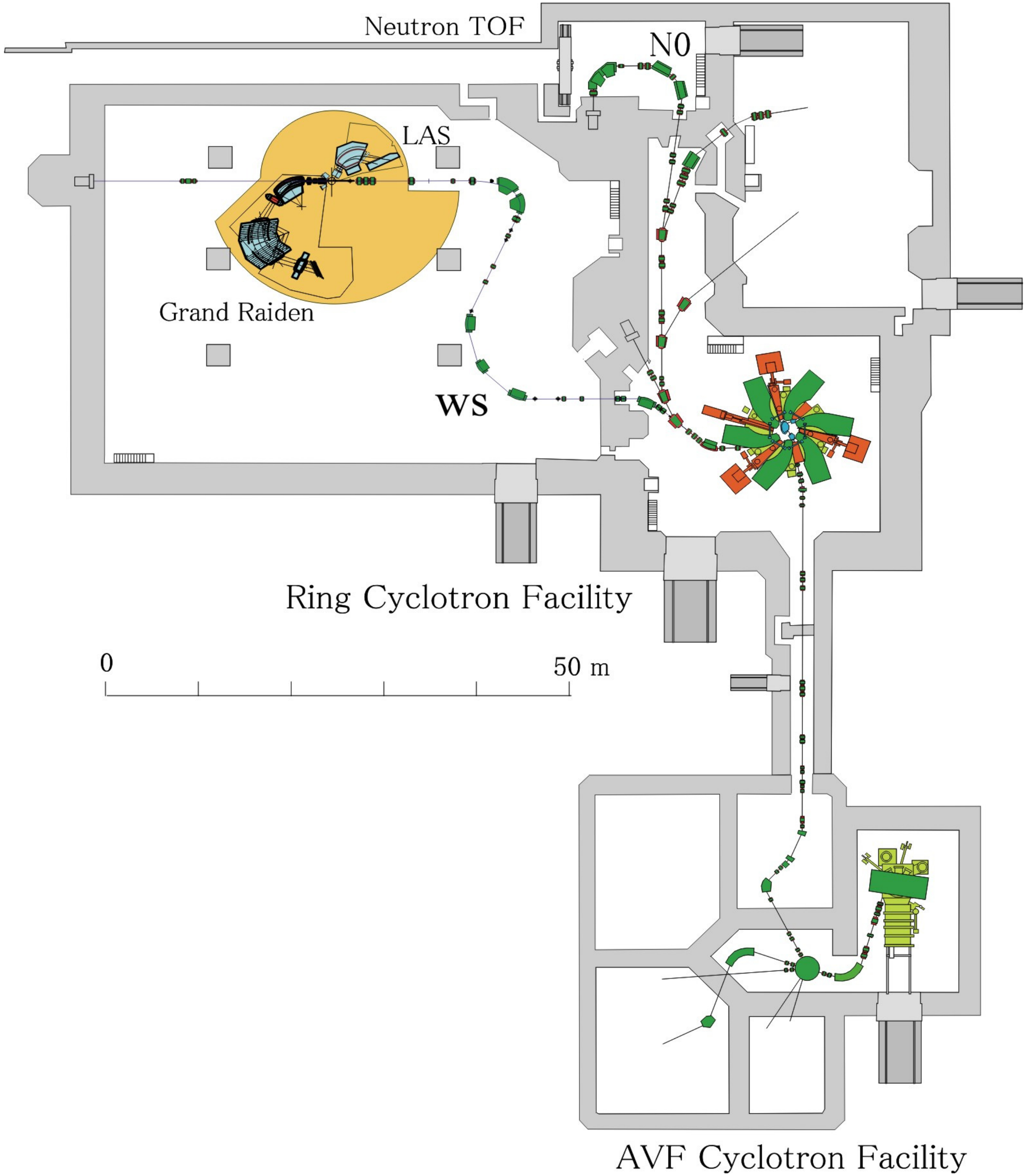
- Low neutrino energies ➡ small q ➡ $\Delta l = 0$ ➡ GT strength
- RPA predicts main GT resonance well above neutron threshold



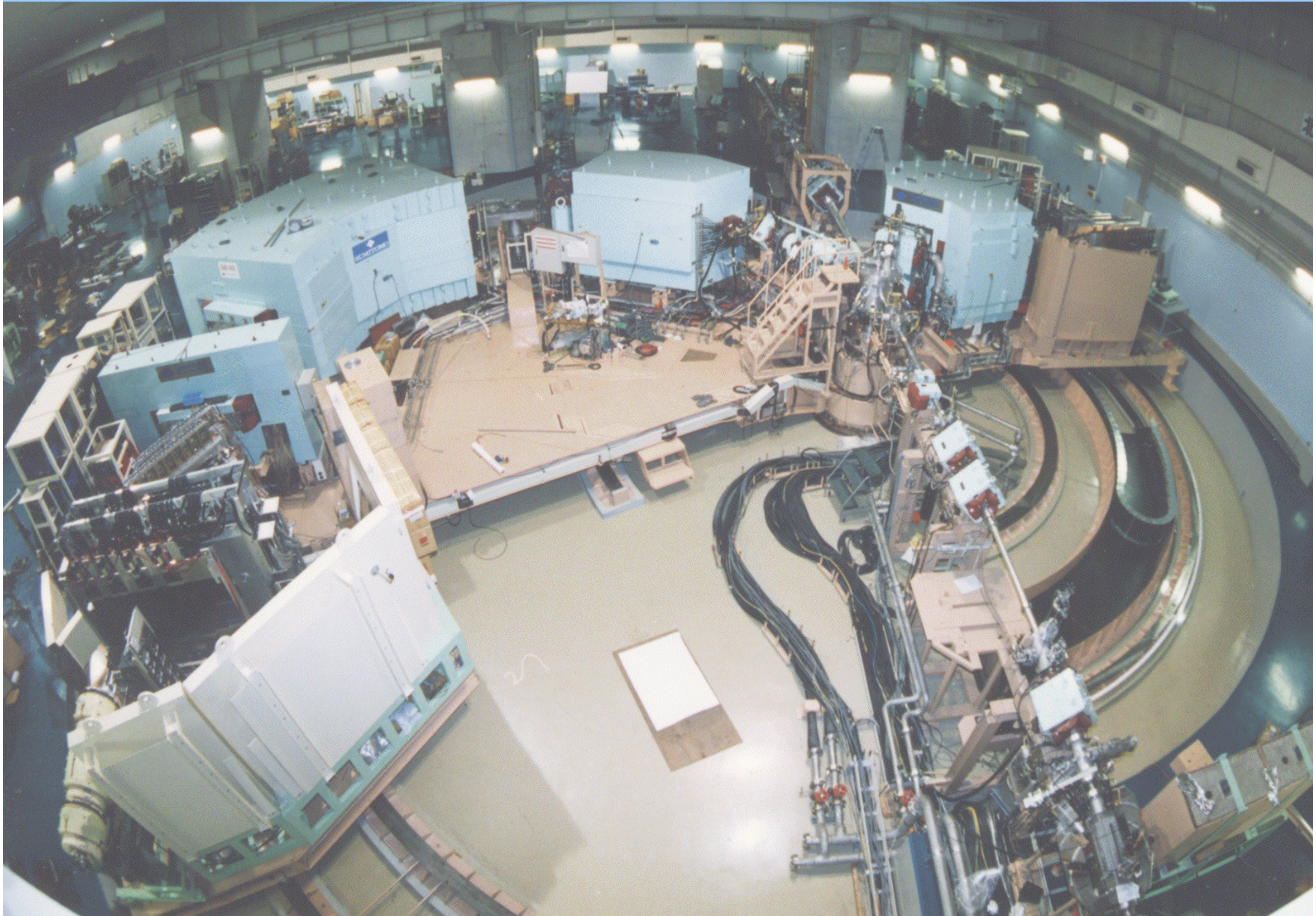
Experimental Requirements

- (ν_e,e) ➡ Gamow-Teller strength ⬅ (p,n) or (^{3}He,t)
- Gamow-Teller part ➡ Narrow angle cut around 0°
- Simple one step reaction mechanism ➡
  ➡ Intermediate energies

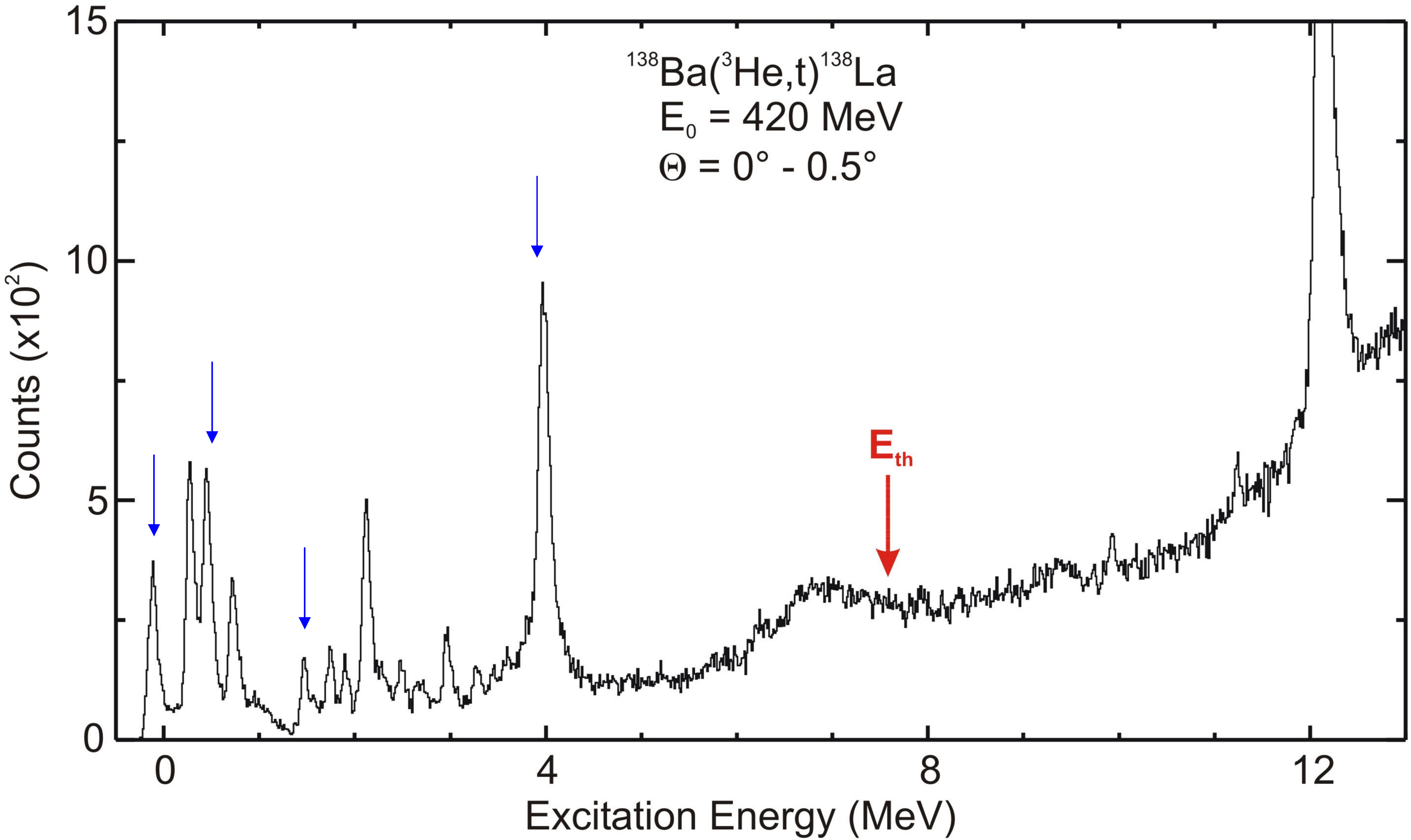
Experimental Facility at RCNP



Grand Raiden



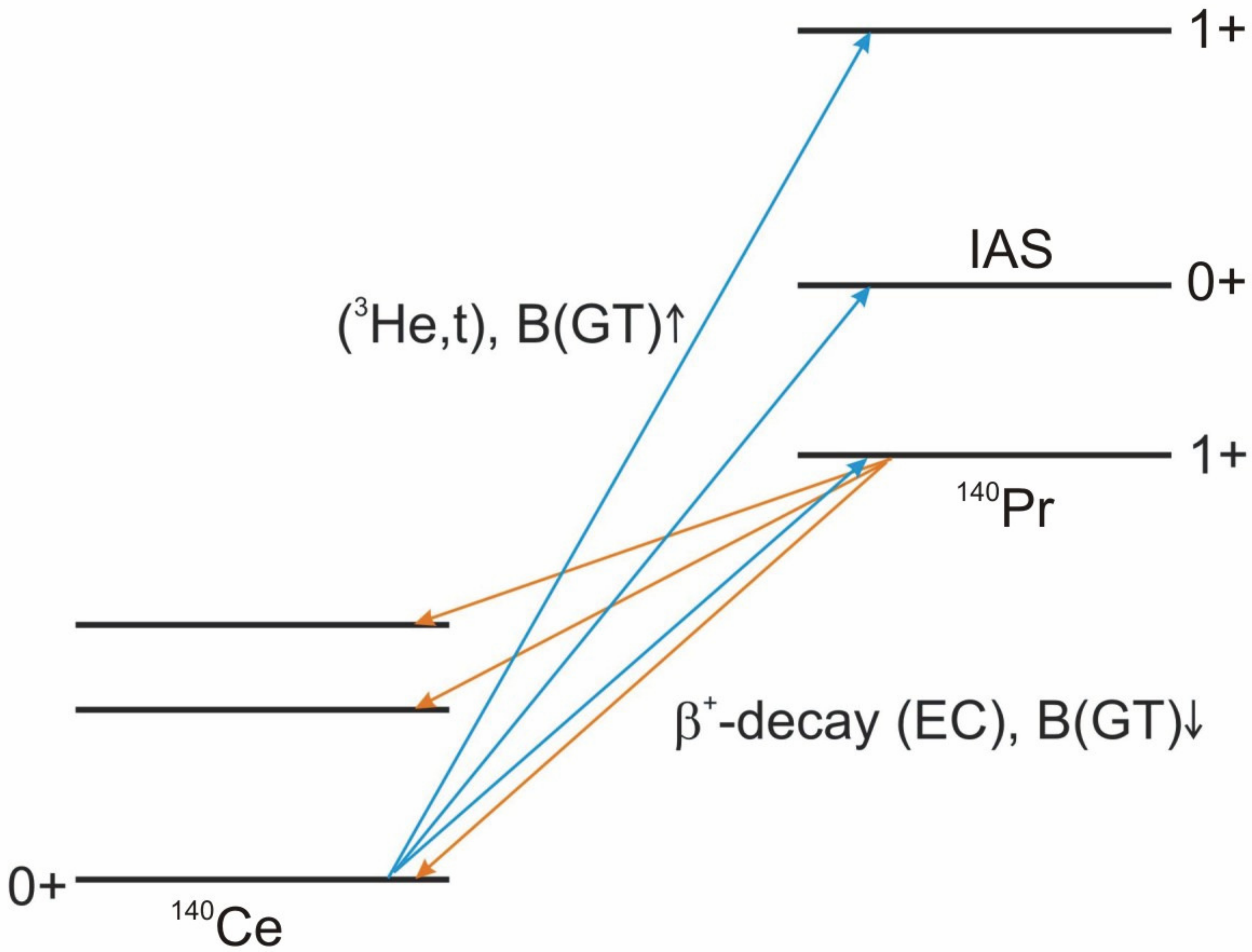
^{138}La Spectrum



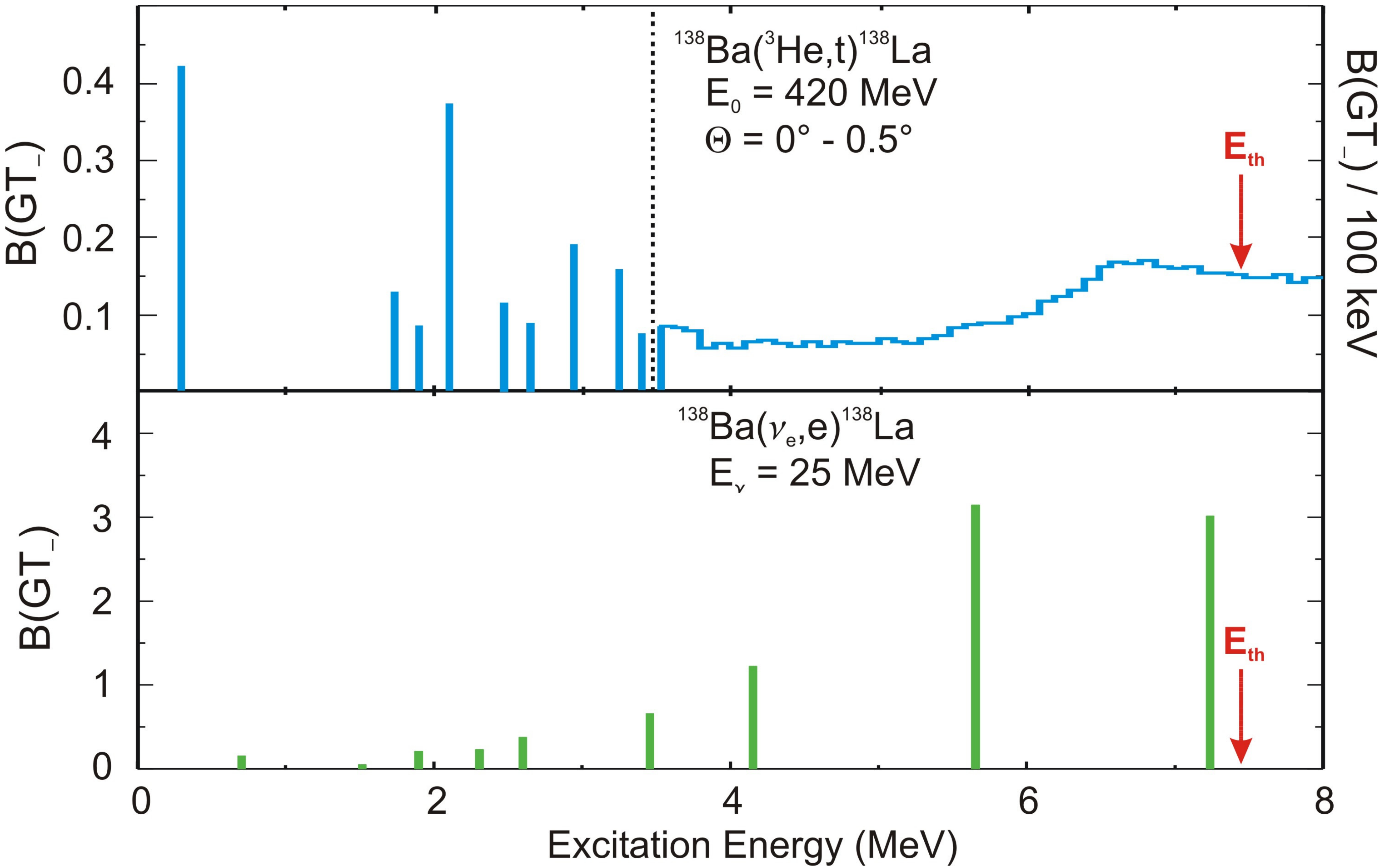
- Target: $^{138}BaCO_4$ embedded in polyvinylalcohol

B(GT) extraction

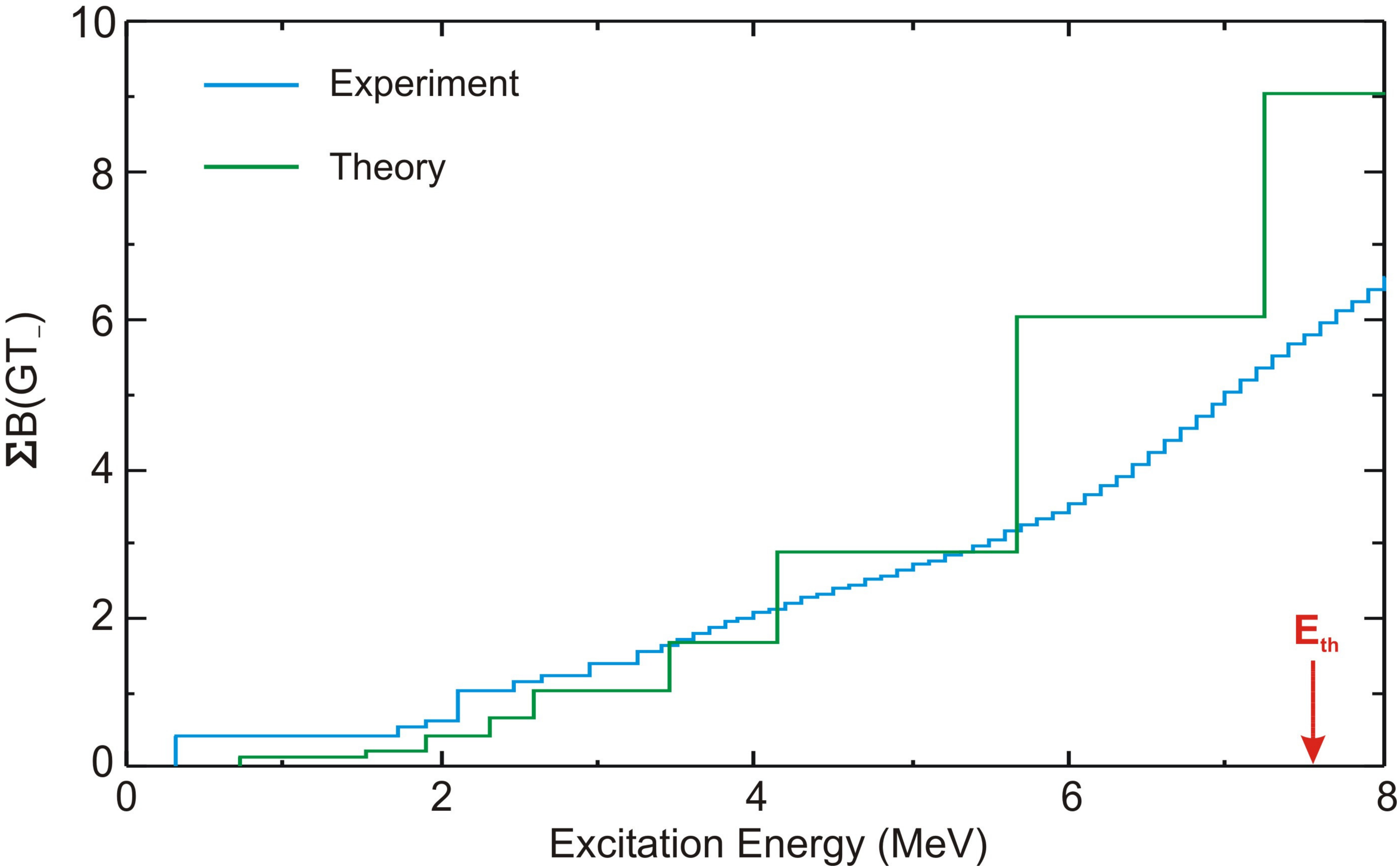
$$\sigma(0°) = K \cdot N_{\sigma\tau} \left| J_{\sigma\tau}(0°) \right|^2 B(GT)$$



GT Strength Distribution in ^{138}La

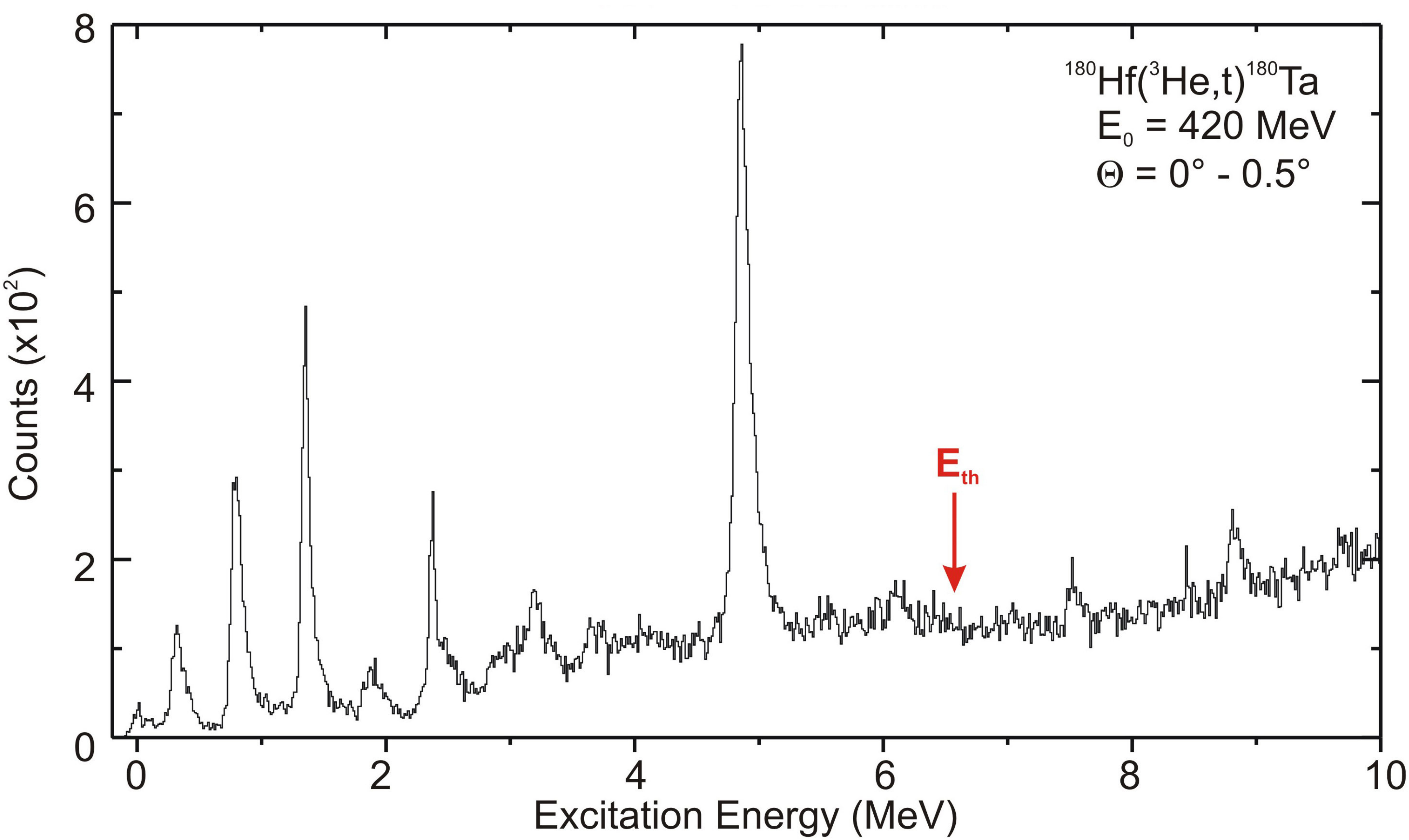


Comparison Experiment/RPA



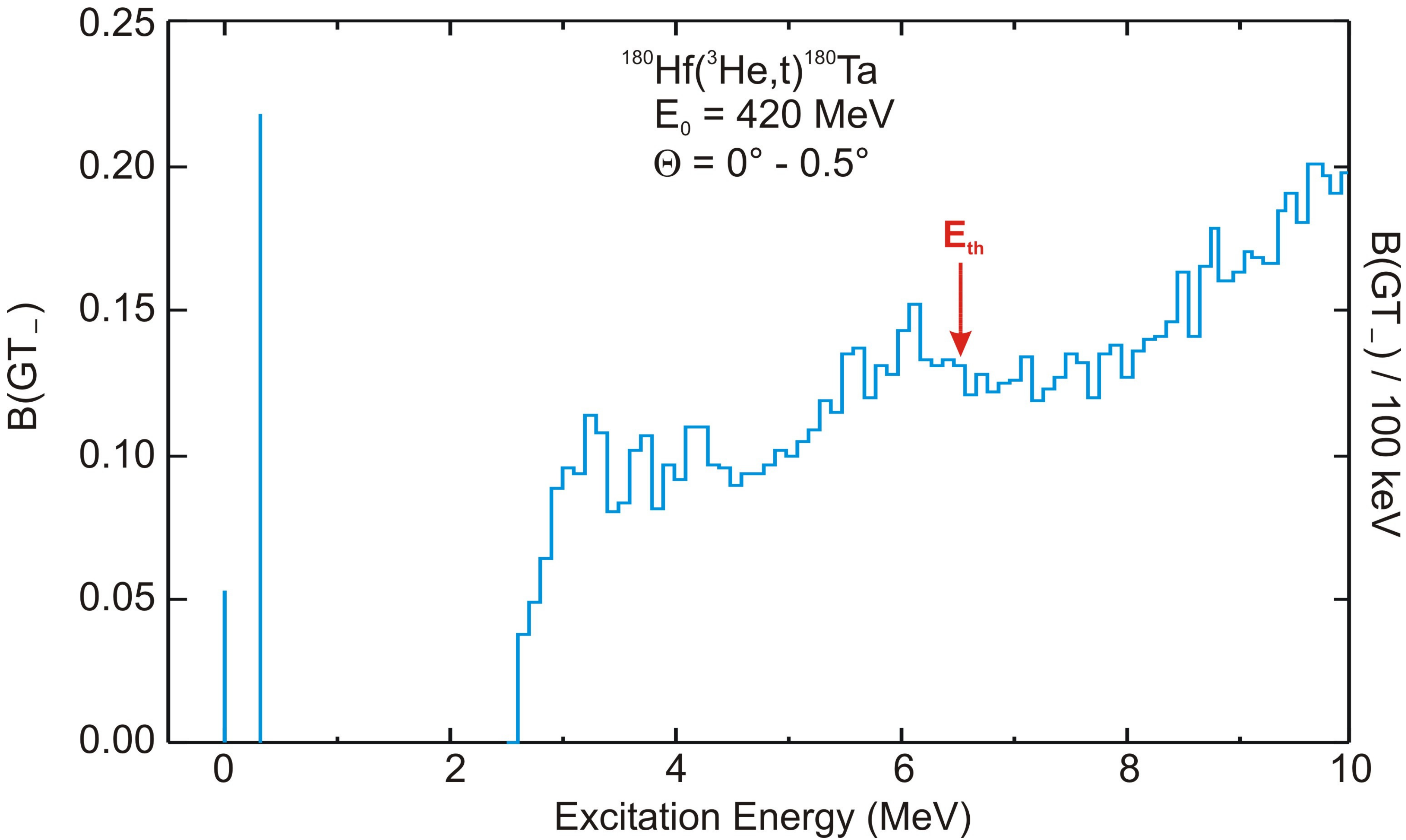
- $B(GT_-)_{exp} \approx 64\%\ B(GT_-)_{th}$ at 7.47 MeV

^{180}Ta Spectrum



- Target: $^{180}TaO_2$ embedded in polyvinylalcohol

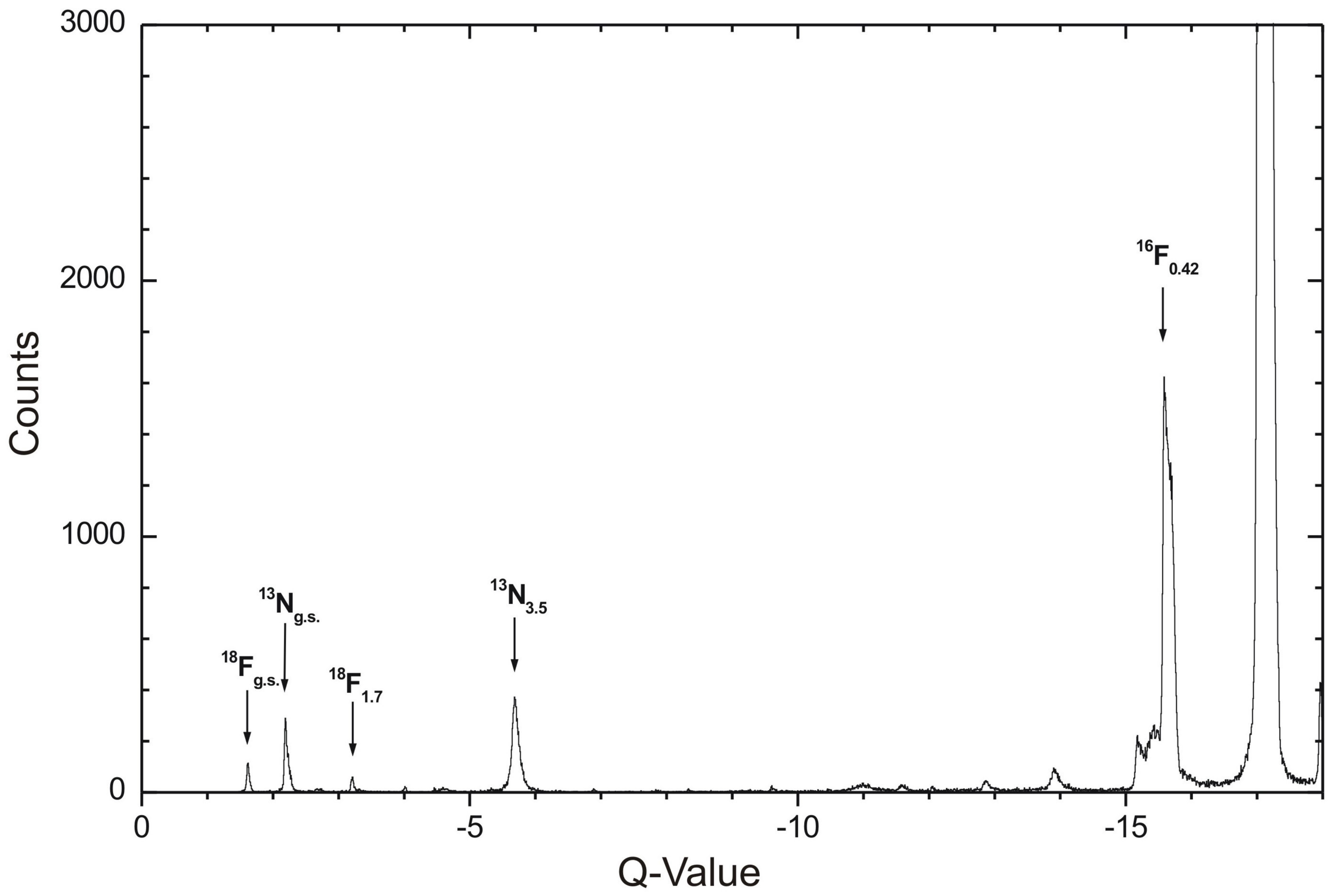
GT Strength Distribution in ^{180}Ta



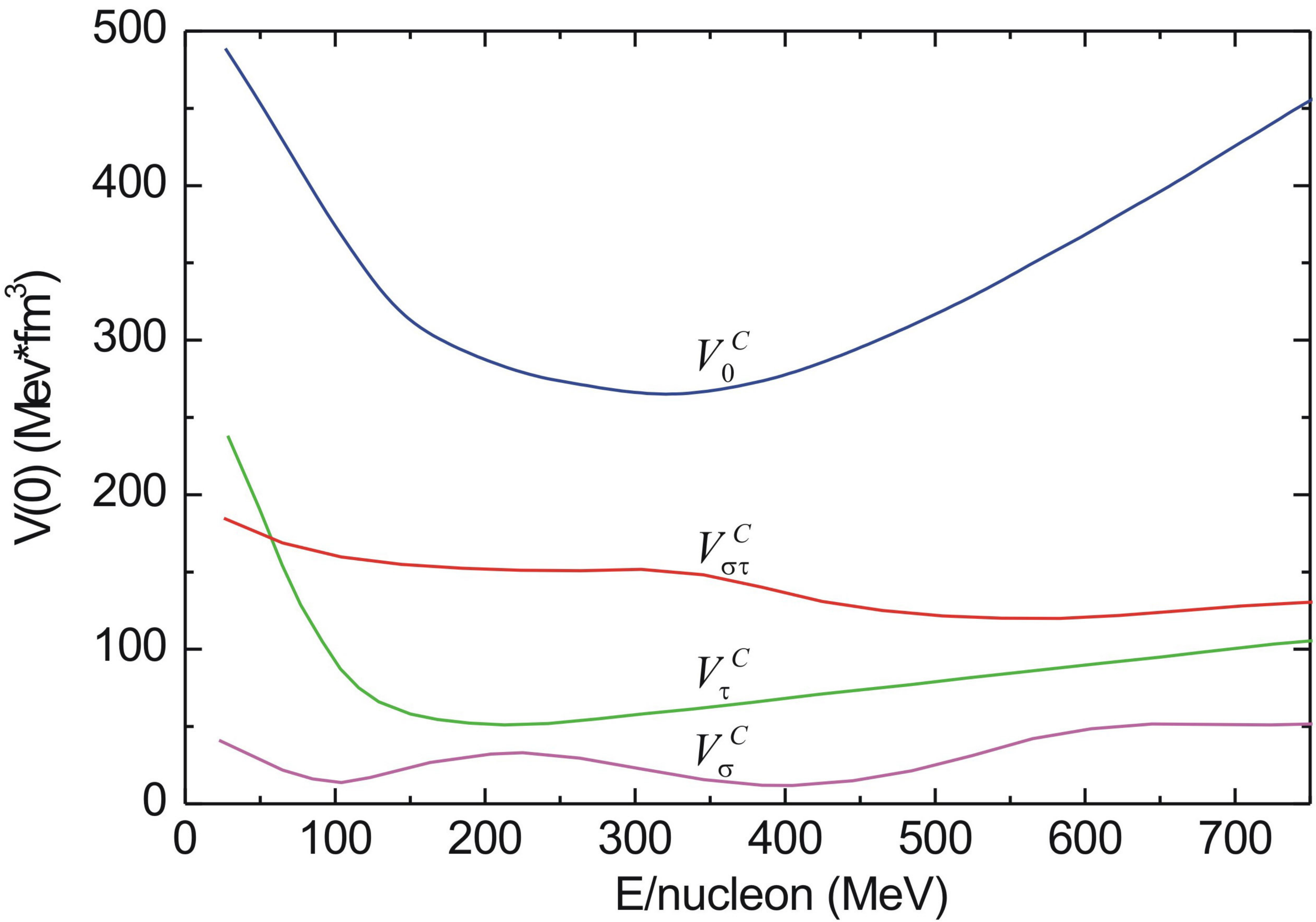
Summary and Outlook

- Analysis of ^{138}La and ^{180}Ta data completed
- Good agreement found for ^{138}La
- Comparison with the theory for ^{180}Ta underway
- Integration into network calculations underway

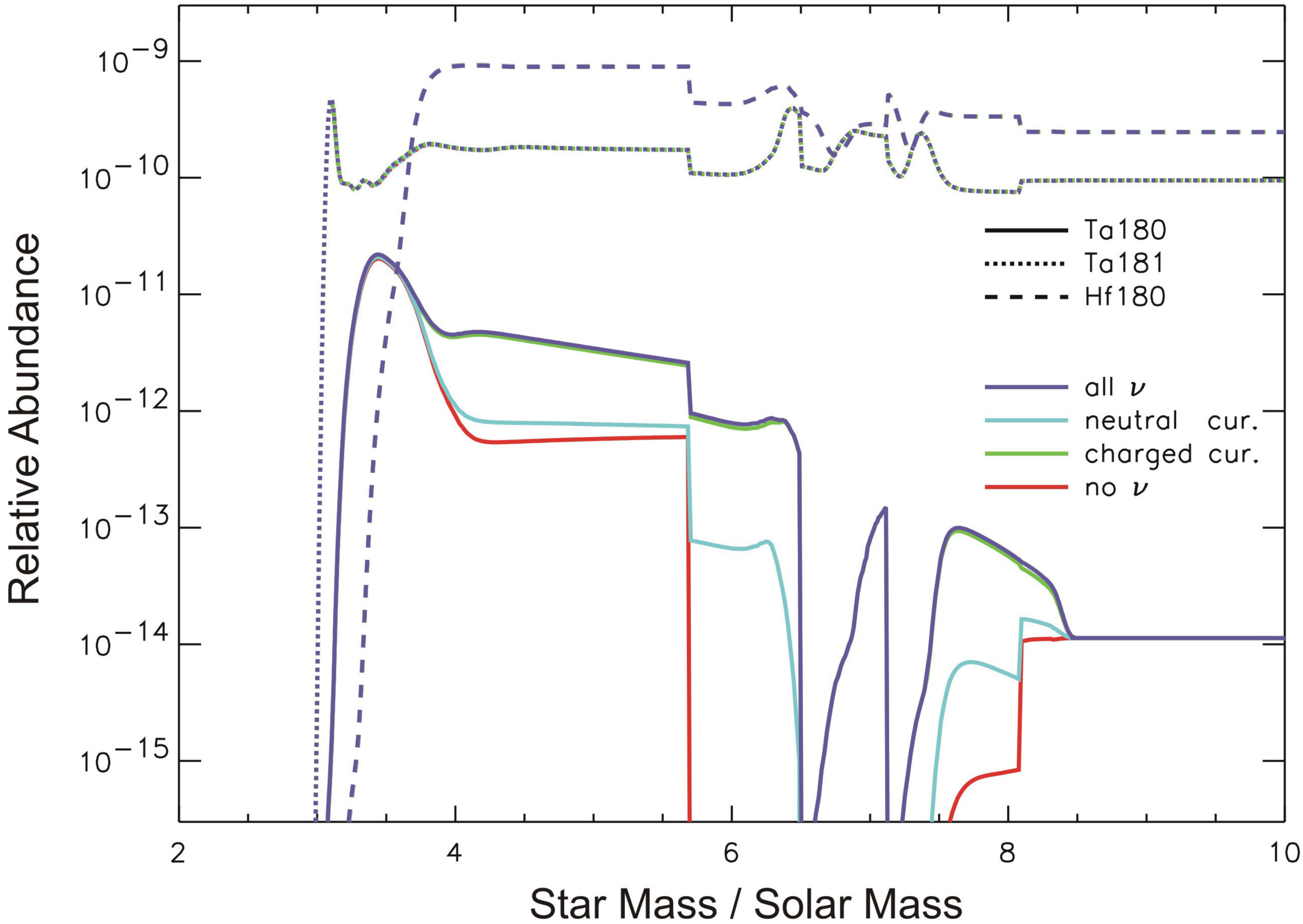
PVA Spectrum



Nucleon-Nucleon Interaction: E_{in} Dependence at q = 0

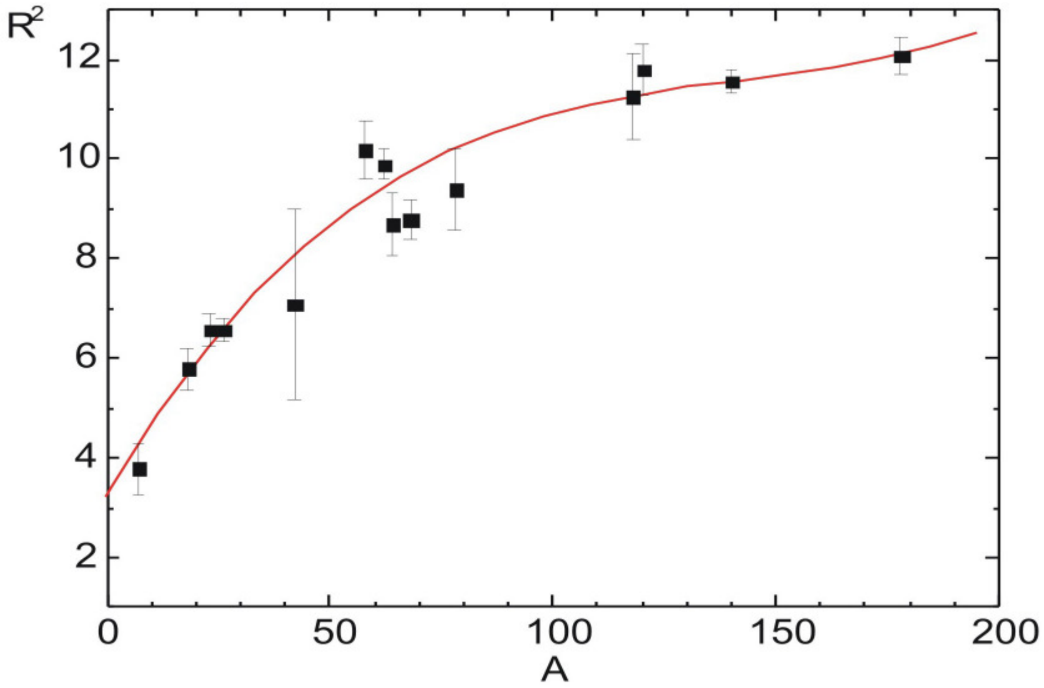


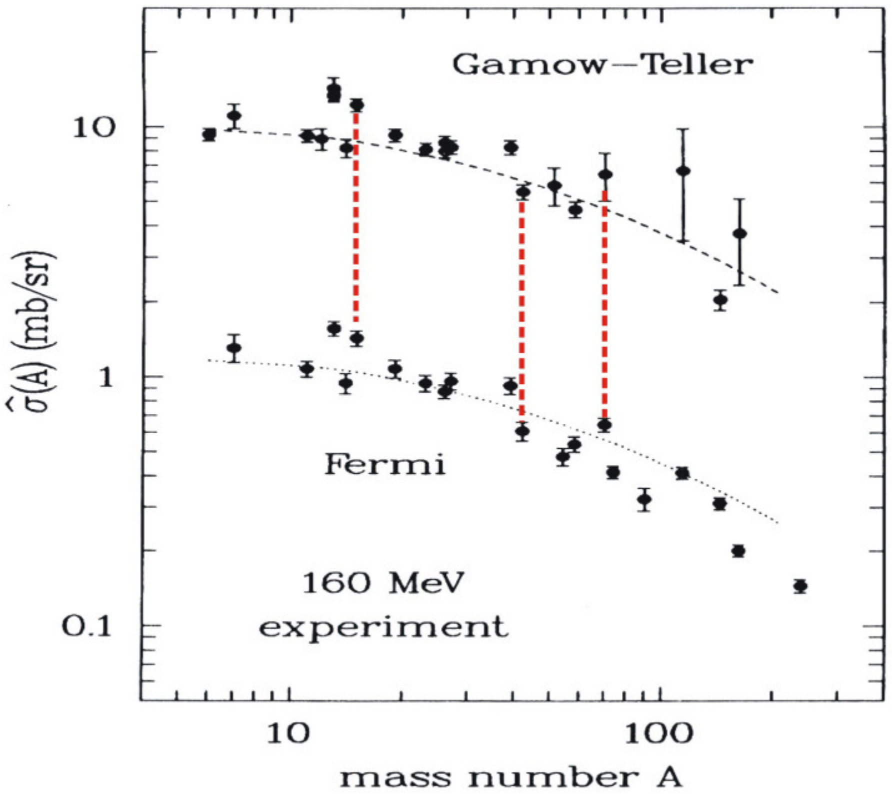
Production of ^{180}Ta



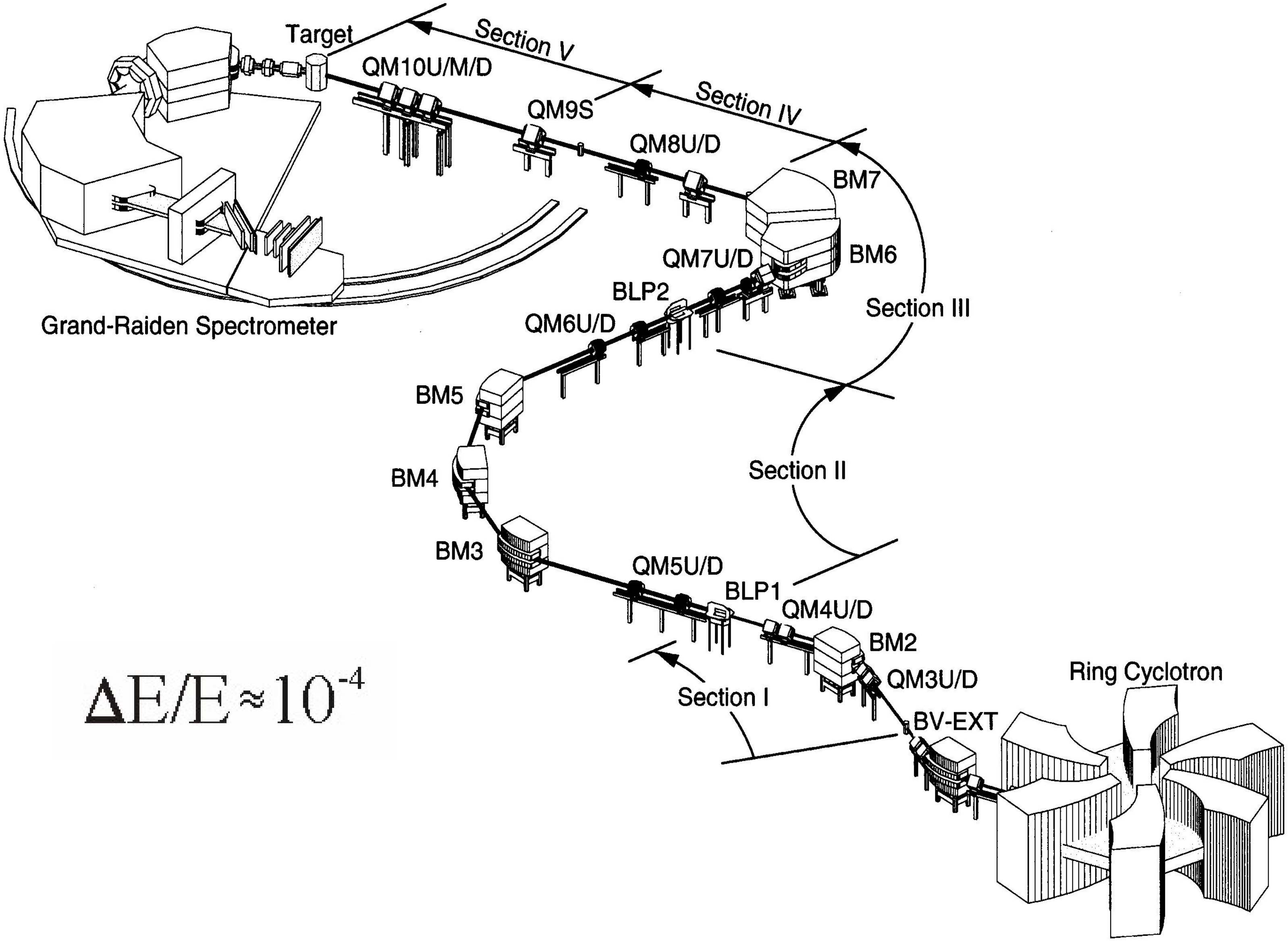
R^2 Value

- GT unit cross section: unit $\sigma_{GT} = \sigma_{GT}(0°)/B(GT)$
- Fermi unit cross section: unit $\sigma_F = \sigma_F(0°)/B(F)$
- Fermi strength is totally concentrated in IAS: $B(F) = N - Z$
- R^2 definition: R^2 = unit σ_{GT} / unit σ_F



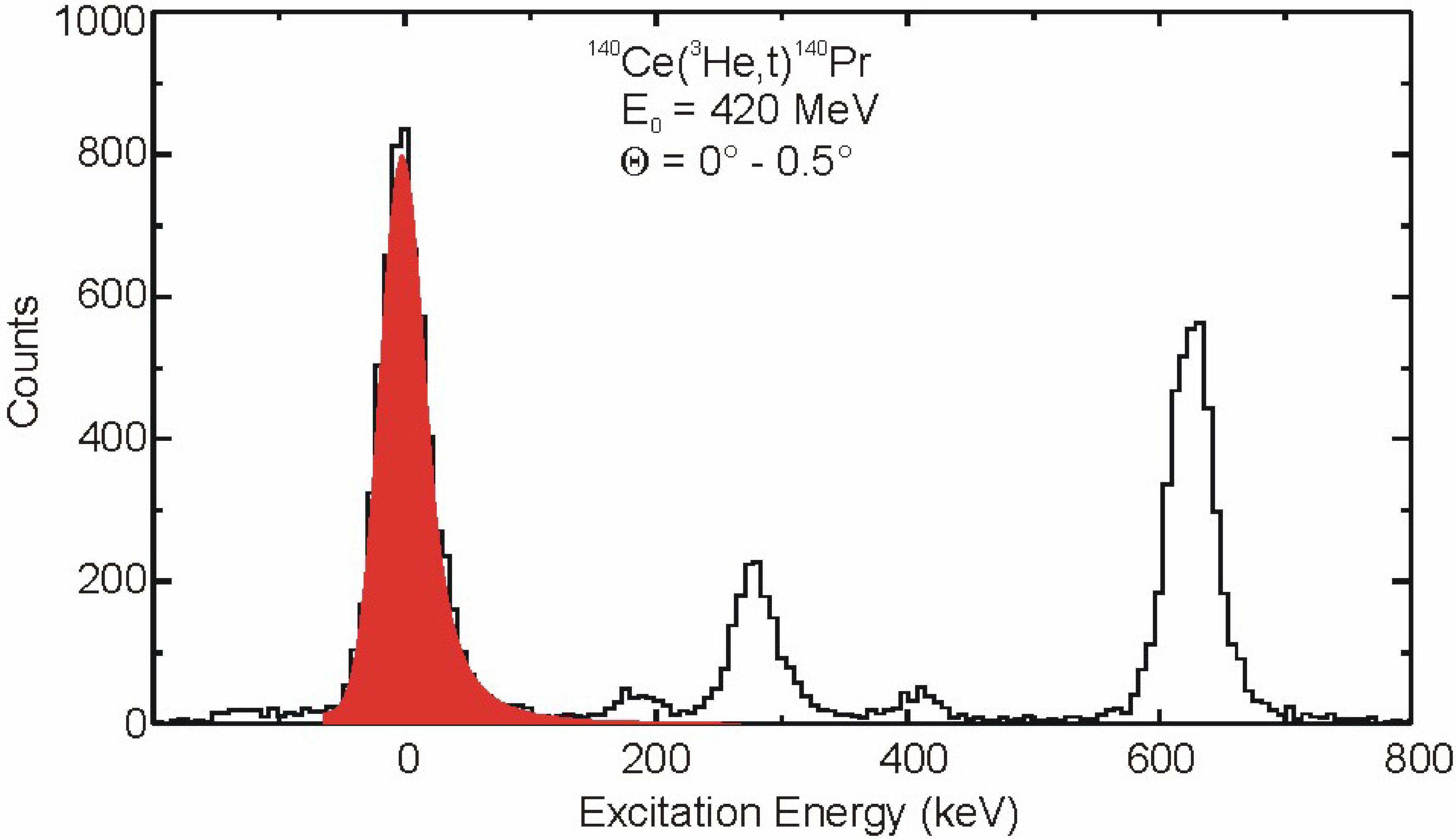


High Resolution WS Course

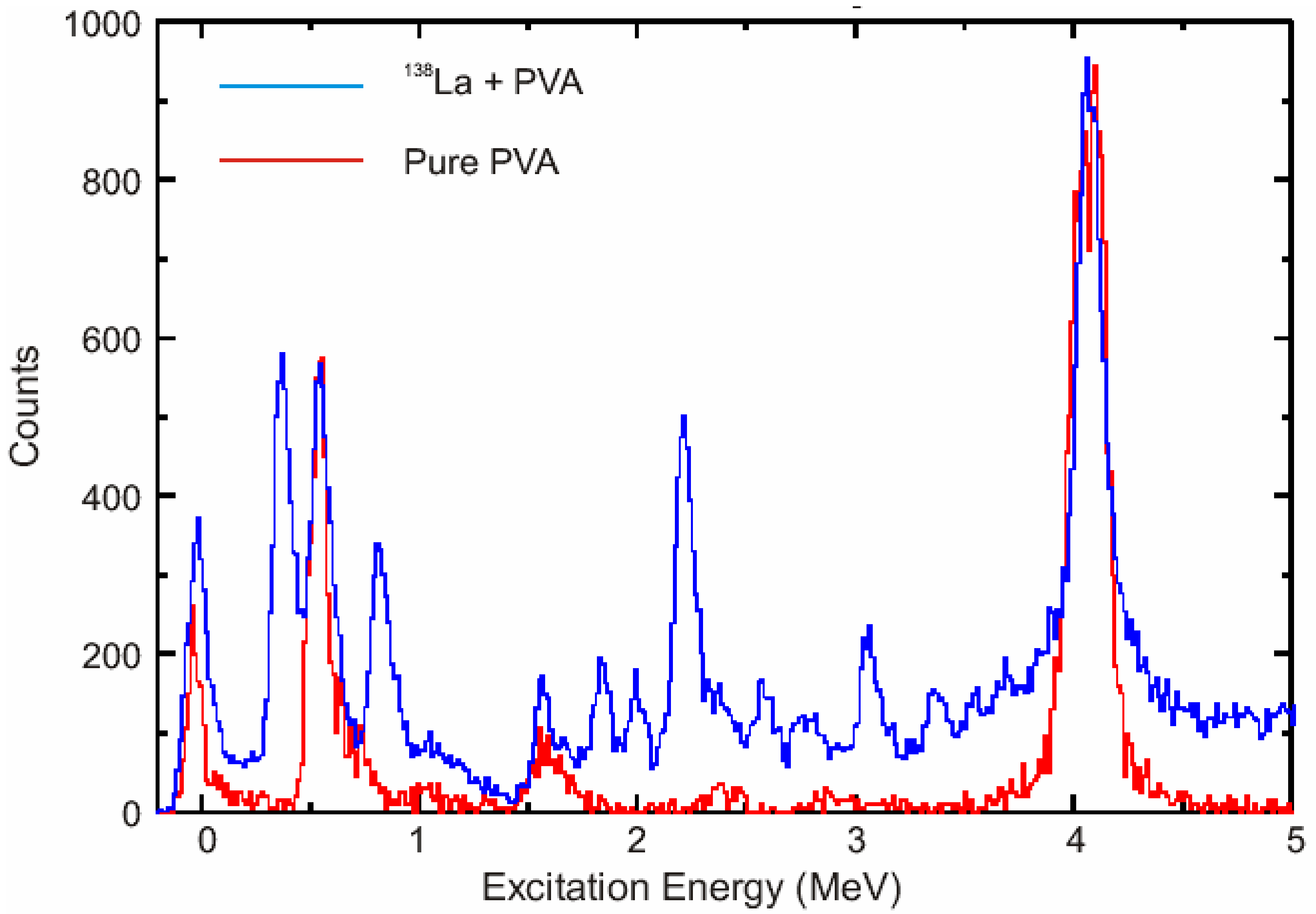


$$\Delta E/E \approx 10^{-4}$$

Conversion to B(GT)



^{140}Pr(g.s., 1^{+}) ➡ ^{140}Ce(g.s.,0^{+}) β-decay B(GT) = 0.245



1000
800
600
400
200
0
Counts
138La + PVA
Pure PVA
0
1
2
3
4
5
Excitation Energy (MeV)