Neutron Capture Measurements on Radioactive Targets

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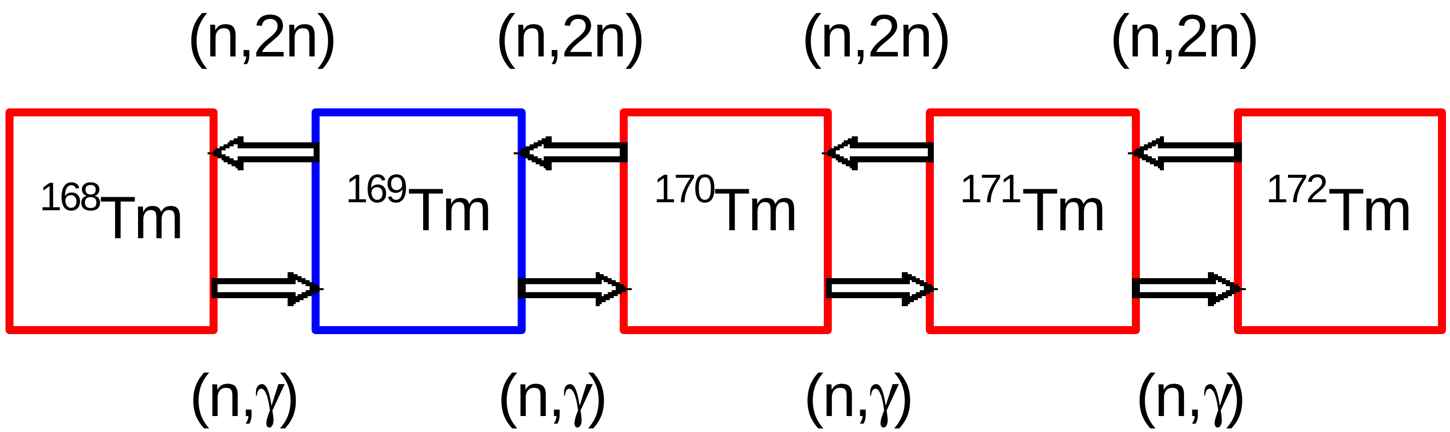
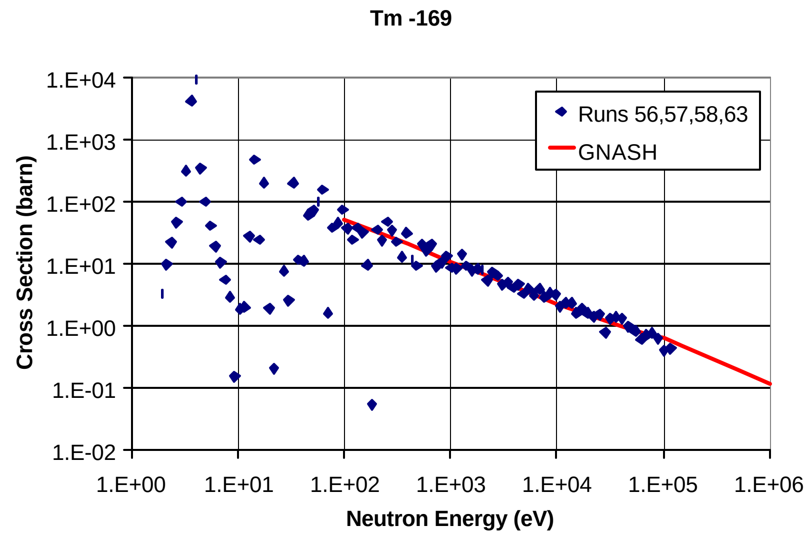
Neutron Capture on Unstable Nuclei



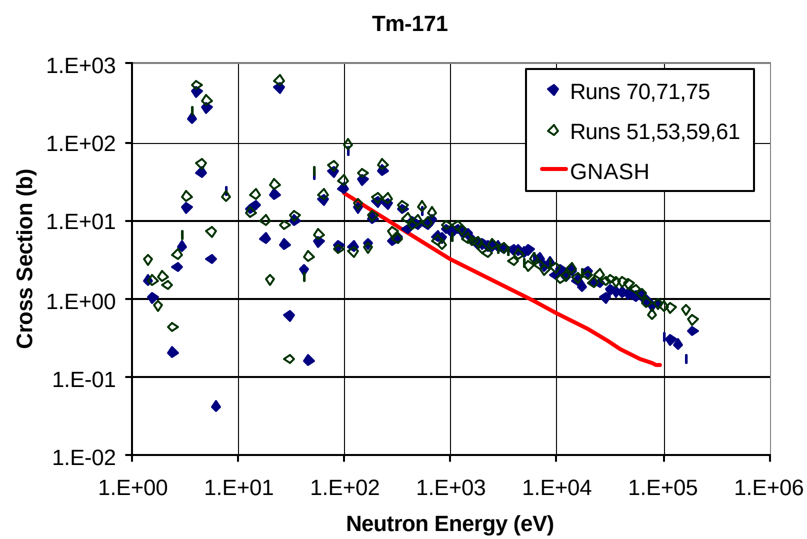
- Stable isotopes were inserted in weapons tests as diagnostics
- Accurate cross sections needed to infer device performance
- Cross sections for unstable isotopes mostly obtained from calculation- neutron capture has large uncertainties

Reactions on Unstable Nuclei

- ^{169}Tm
  - Tm was an important radchem diagnostic
  - Stable Tm was chosen for an initial test
  - 1 mg sample
  - Data agrees with previous data and with calculation



- ^{171}Tm
  - $\tau_{1/2}$ ~ 1.9 year
  - Sample prepared by reactor irradiation of ^{170}Er and chemically separated
  - 1 mg (1 Ci) sample
  - Above 1 keV measurements and calculations diverge.



171Tm (n,g) Cross Section

(Averaged over Maxwell Distribution)

	30 keV (mb)	25 keV (mb)
Activation Measurement:		
Rundberg at FZK		291 ± 10
Calculations:		
Holmes (1976)	917	
Bao, Beer, Kaeppeler, Voss Wisshak, and Rauscher (2000)	486	539
Rauscher and Thielemann (1999)	399	
P.G. Young	292	335

Calculations cannot provide accurate cross sections

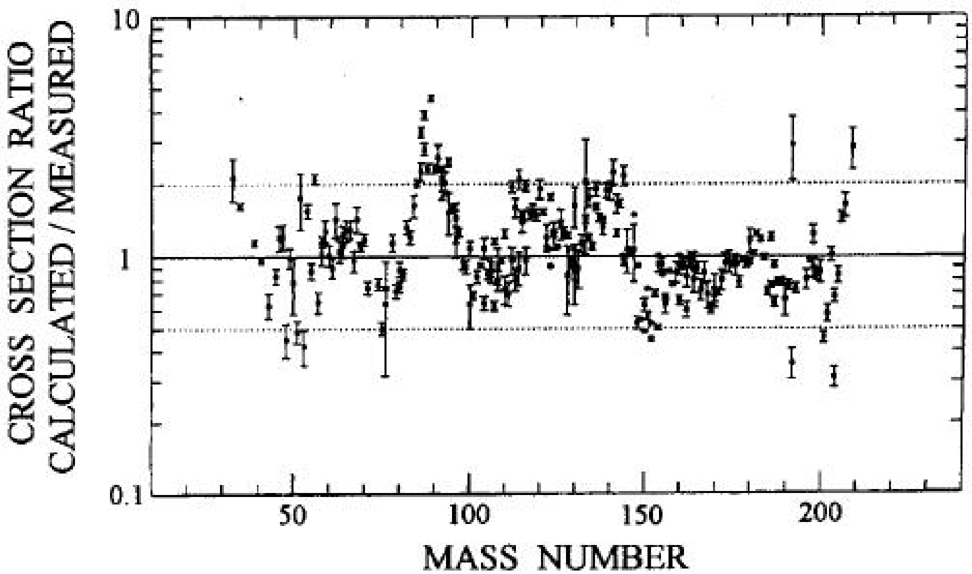
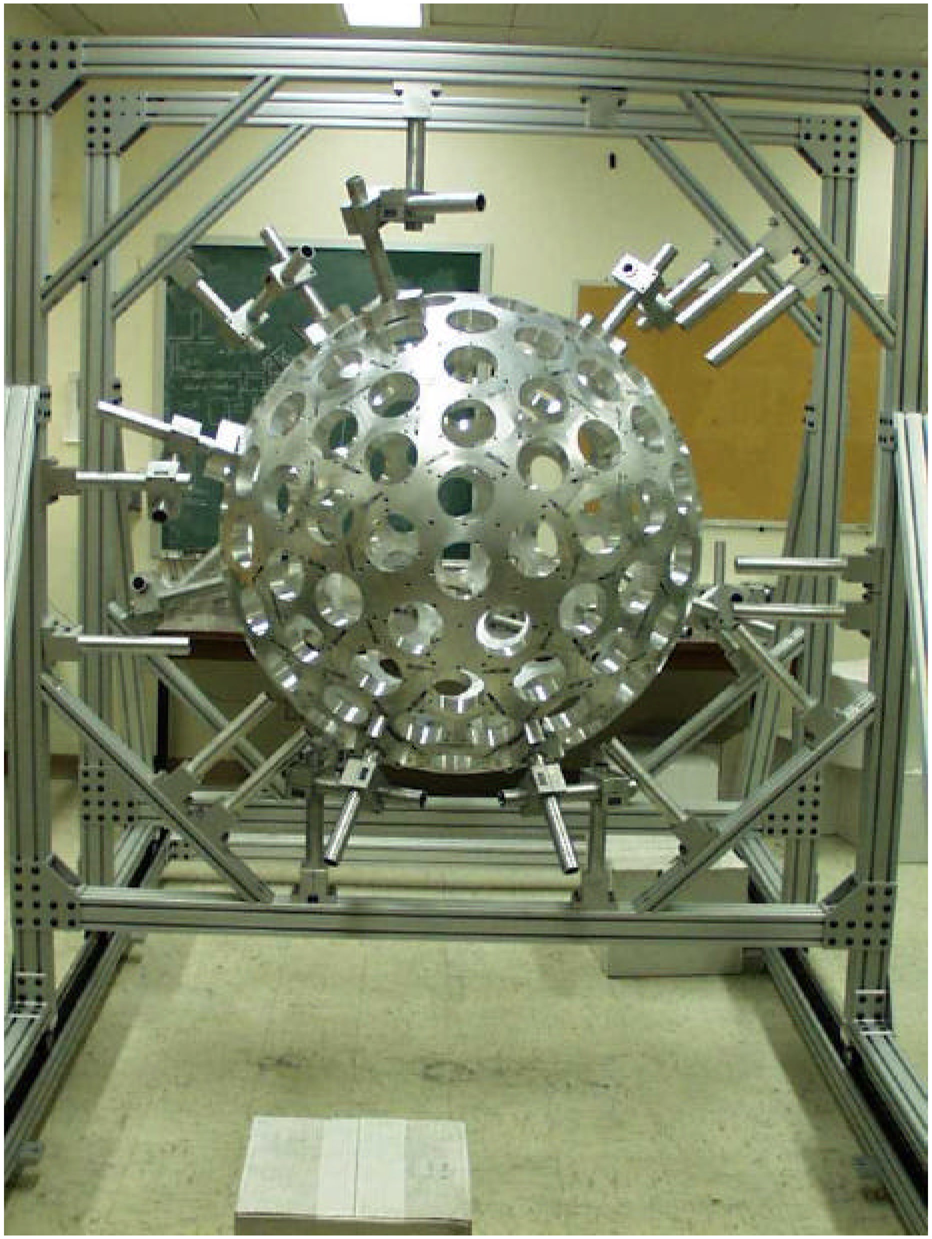


Fig. 12. Stellar (n,γ) cross sections calculated with the statistical model code NON-SMOKER are compared with the available experimental data [108].

(From Rauscher and Thielemen, *Atomic and Nuclear Astrophysics*, IOP, 1998)



Detector for Advanced Neutron Capture Experiments (DANCE)

Capture targets and Experiments

- Amount of material for measurement
  - 1 mg for C6D6 at Lujan Center
  - 0.1 to 0.05 mg for full DANCE array at Lujan Center
  - 1 ng (?) For Lead slowing-down Spectrometer
- Target Production
  - Reactor + chemical separation
  - Reactor plus isotope separator
  - Spallation production plus isotope separator
  - RIA
- Neutron targets for inverse Kinematics?
  - Good Luck with deuteron

Tm Parameters

Properties	^{168}Tm	^{170}Tm	^{171}Tm
Half Life	93.1 d	129 d	1.92 y
γ energy	198,816 keV	85 keV	67 keV
β energy		968, 884 keV	30, 97 keV

Activity	^{168}Tm	^{170}Tm	^{171}Tm
1 mg	8.4 Ci	5.9 Ci	1.1 Ci
10 μg	84 mCi	59 mCi	11 mCi
1 ng	8.4 uCi	5.9 uCi	4.1 uCi

RIA Production

(“Bucket” Approach – 100 kW rates from web site)

	^{168}Tm	^{170}Tm	^{171}Tm
Production rate	7×10^{11} /sec	1×10^{11} /sec	8×10^{10} /sec
1 mg in	1400 hr (58 d)	10,000 hr (417 d)	12,500 hr (521 d)
10 μg in	14 hr	100 hr	125 hr

Bottom Line - Capture Studies and RIA

- RIA Wonderful isotope production/separation machine - Use in “Bucket Mode”
- Not Unique - but will produce isotopes reactors/separation can not
- Neutron capture studies - need neutron source
  - Targets of interest to SBSS - transport to LANSCE
  - RIA On-site source
    - Spallation on way to beam dump?
    - D + T with moderator?
- In beam studies- for neutron capture, not obvious
- Radioactive material handling, bucket-mode requires advanced detectors and intense neutron source