Experimental comparision of ^{7}Li neutron capture to ^{8}Li Coulomb breakup at 70 MeV/nucleon

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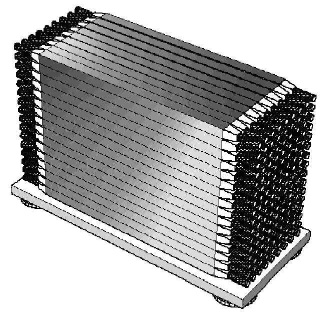
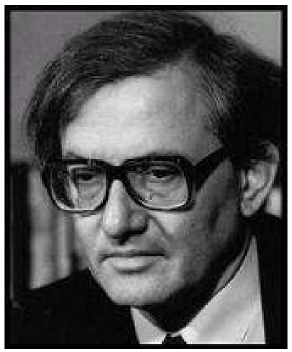
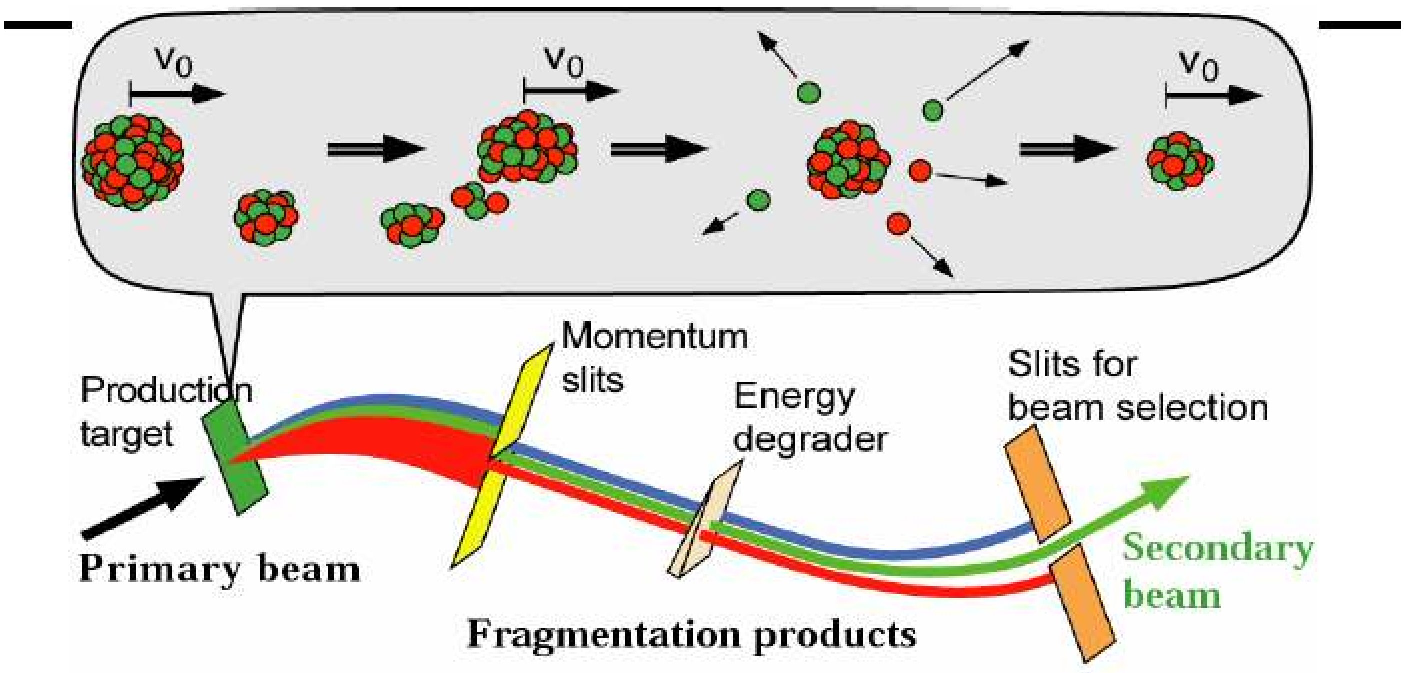




Zimányi School, 5. Dec. 2013

Overview

- IM energy nuclear physics 70 MeV/nucleon
- Coupled Cyclotron Facility, NSCL
- Radioactive Beam Physics



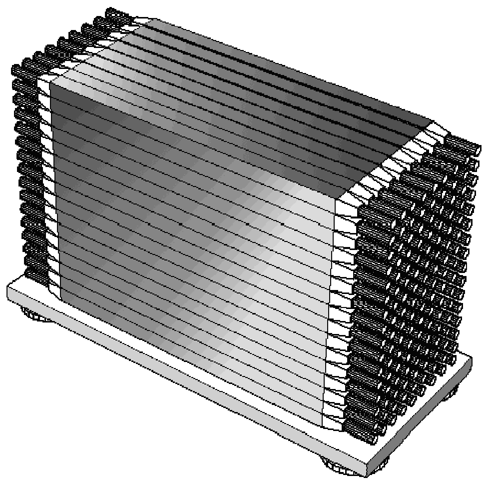
Specific topic

Experiment

- Coulomb breakup experiment
- Neutron capture determination
- ^{8}Li beam at 70 MeV/nucleon

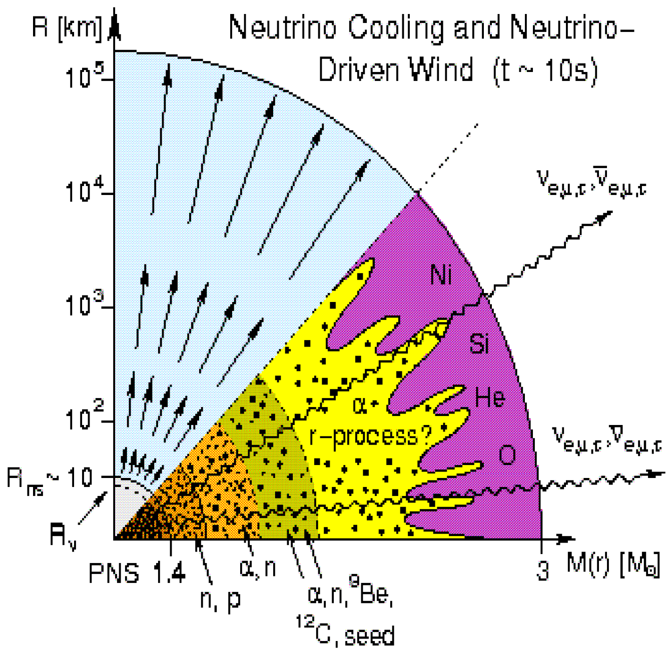
Motivation:

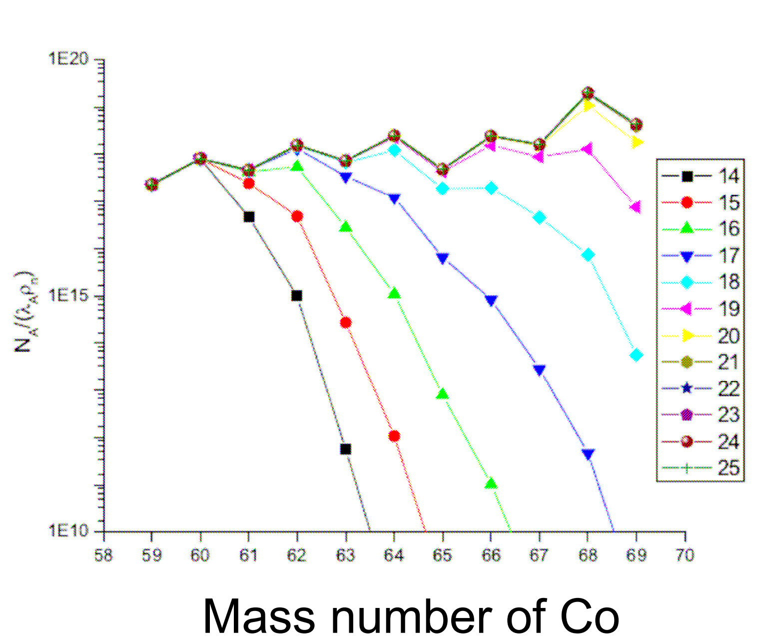
- Application for Nuclear Astrophysics



r-process for heavy element synthesis

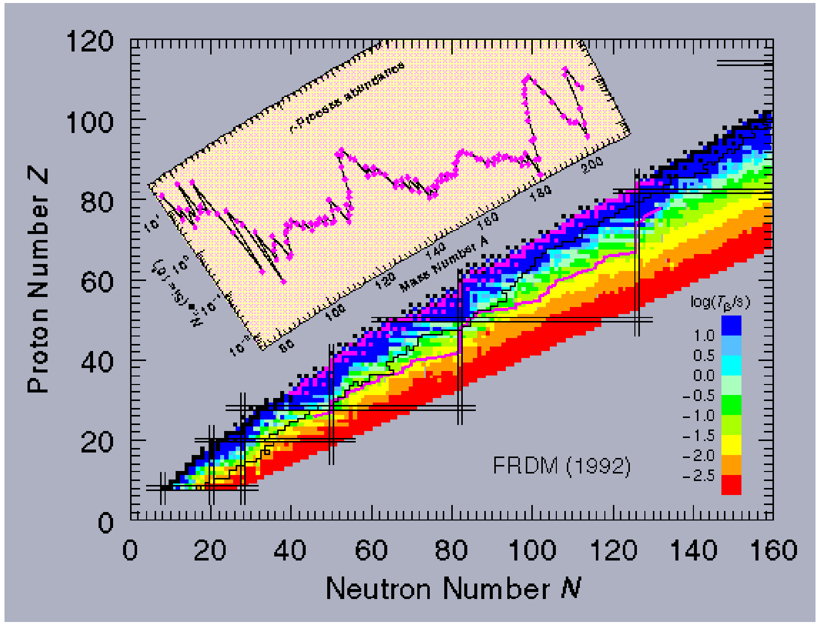
- r-process, explosive nucleosynthesis
- 1A supernovae
- High neutron flux, path of the r-process

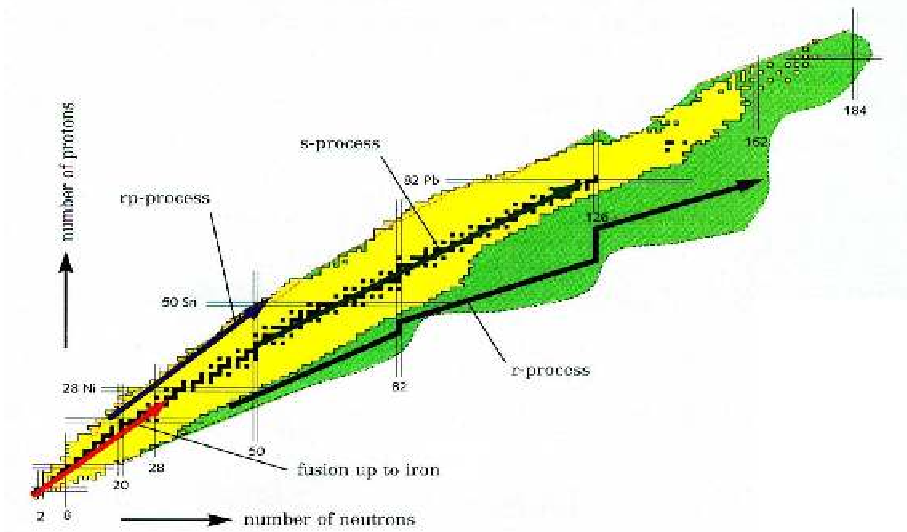




Importance of neutron capture experiments

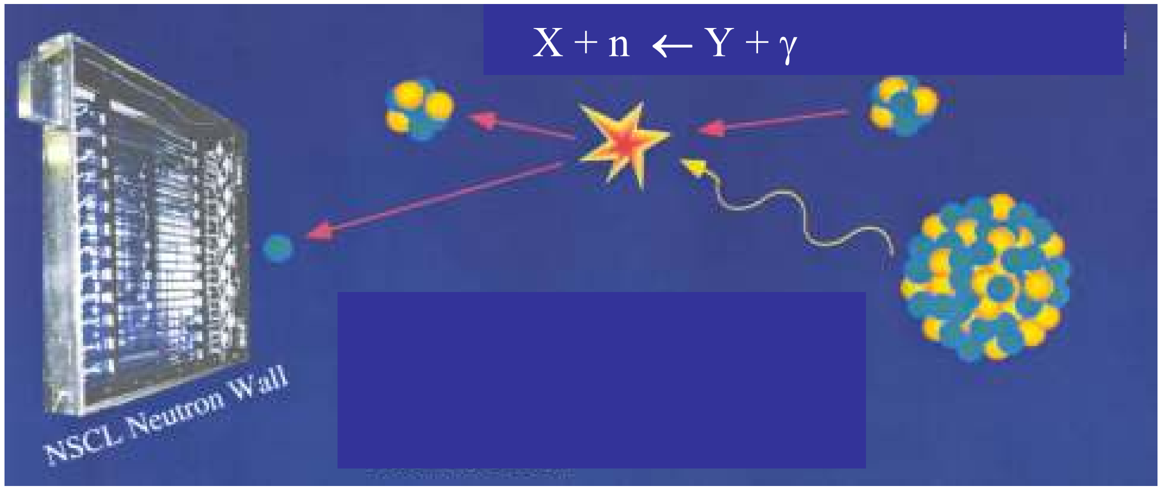
- Neutron capture on short half lives nuclei
- Statistical model calculations
- Verification measurement for further aims





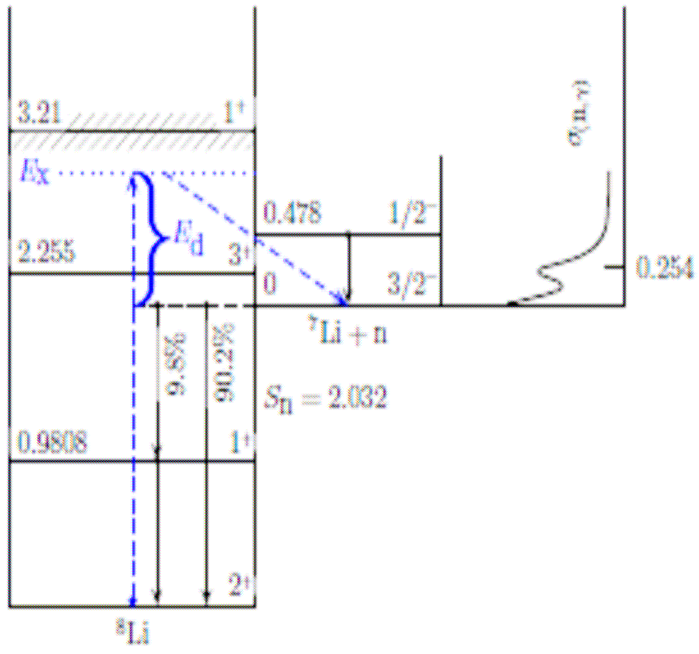
How can we measure an r-process neutron capture?

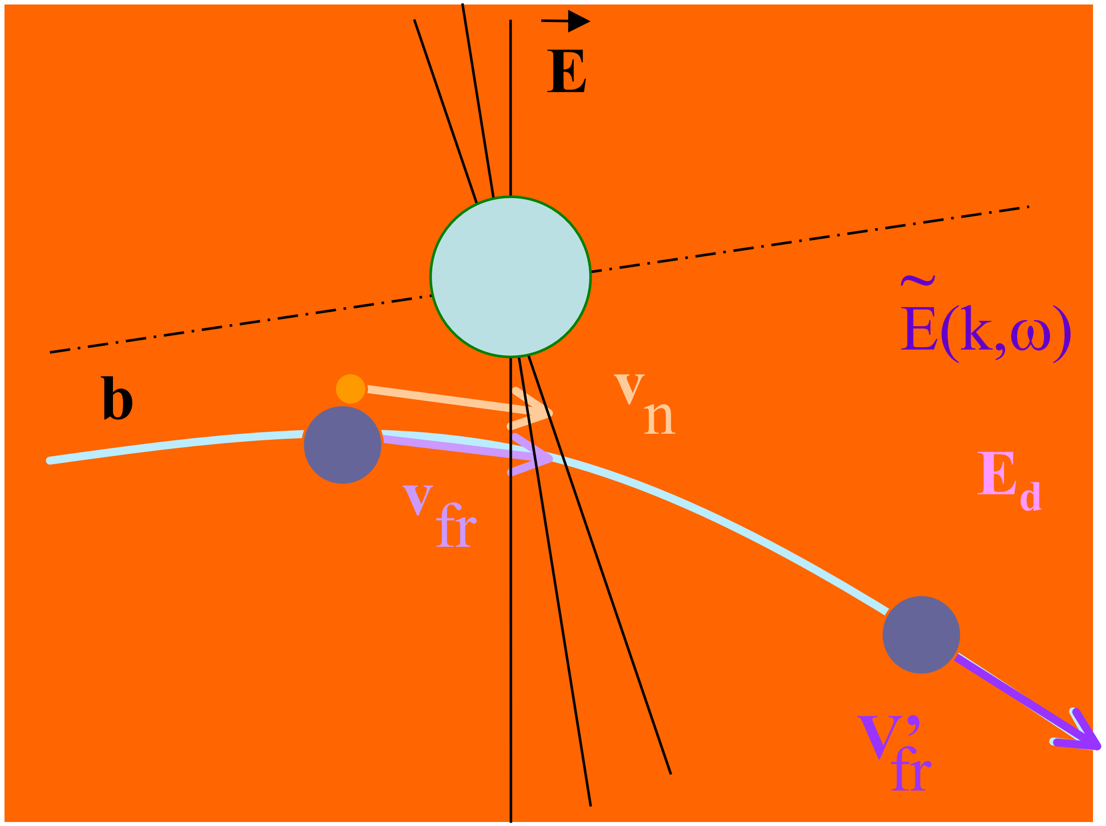
- direct reaction ($X+n \rightarrow Y+\gamma$)
  - – bombarding with neutrons (target half-life)
  - – Deuteron target + X=RIB
  - – Trojan Horse and ANC methods
- inverse reaction ($Y+\gamma \rightarrow X+n$):
  - – Coulomb dissocation of Y=RIB
  + neutron detector



The description of Coulomb-breakup

^{8}Li + lead





The steps to get capture cross section

- Neutron capture

  from detailed balance

$$\sigma(n,\gamma)=\frac{(2j_Y+1)2}{(2j_X+1)(2j_n+1)}\frac{E_\gamma^2}{2\mu c^2 E_n}\cdot\sigma(\gamma,n)$$

- Dissociation:

$$\sigma(\gamma,n)=\boxed{\frac{d\sigma_{Coulomb}}{dE}}\frac{E_\gamma}{n_{E1}(E_\gamma)}$$

- virtual photon method:

$$n_{E1}(E_\gamma)=\int_{b_{\min}}^{\infty}\frac{n_{E1}(E_\gamma)}{db}db$$

- Measured cross section on several target:

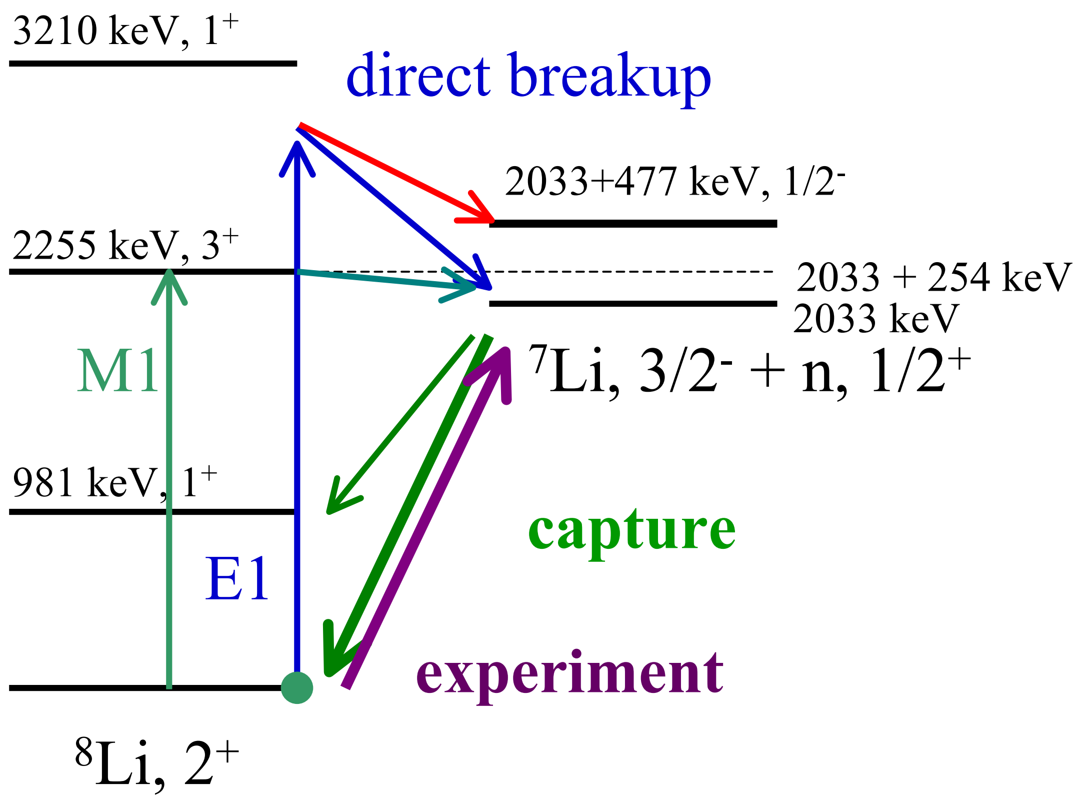
$$\frac{d\sigma}{dE}=\frac{d\sigma_{Coulomb}}{dE}+\frac{d\sigma_{nuclear}}{dE}$$

$b\cdot Z^2$ + $a\cdot(1.2fm\ A^{1/3}+r_0)$

Or a little more complicated?

Possible complications

- E2, M1 photons
- nuclear component scaling law…
- Excited states

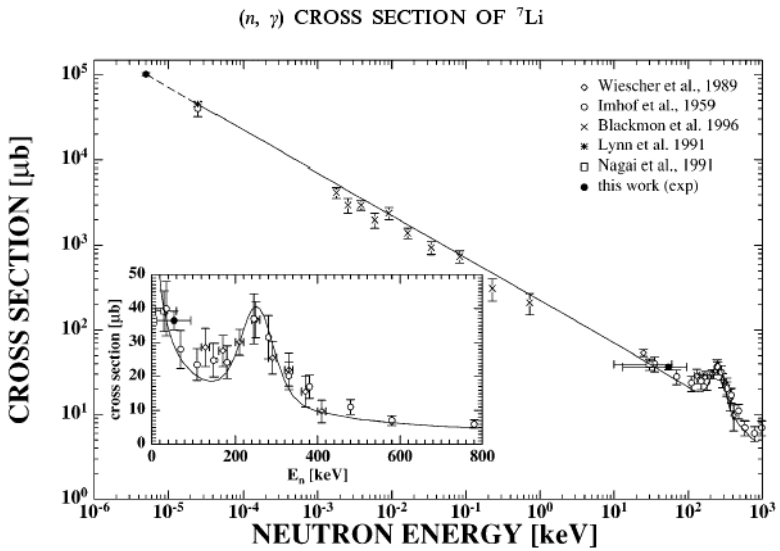


$2^+ \otimes E1 \rightarrow 1^-, 2^-, 3^-$

$2^+ \otimes M1 \rightarrow 1^+, 2^+, 3^+$

The ^{8}Li Coulomb breakup

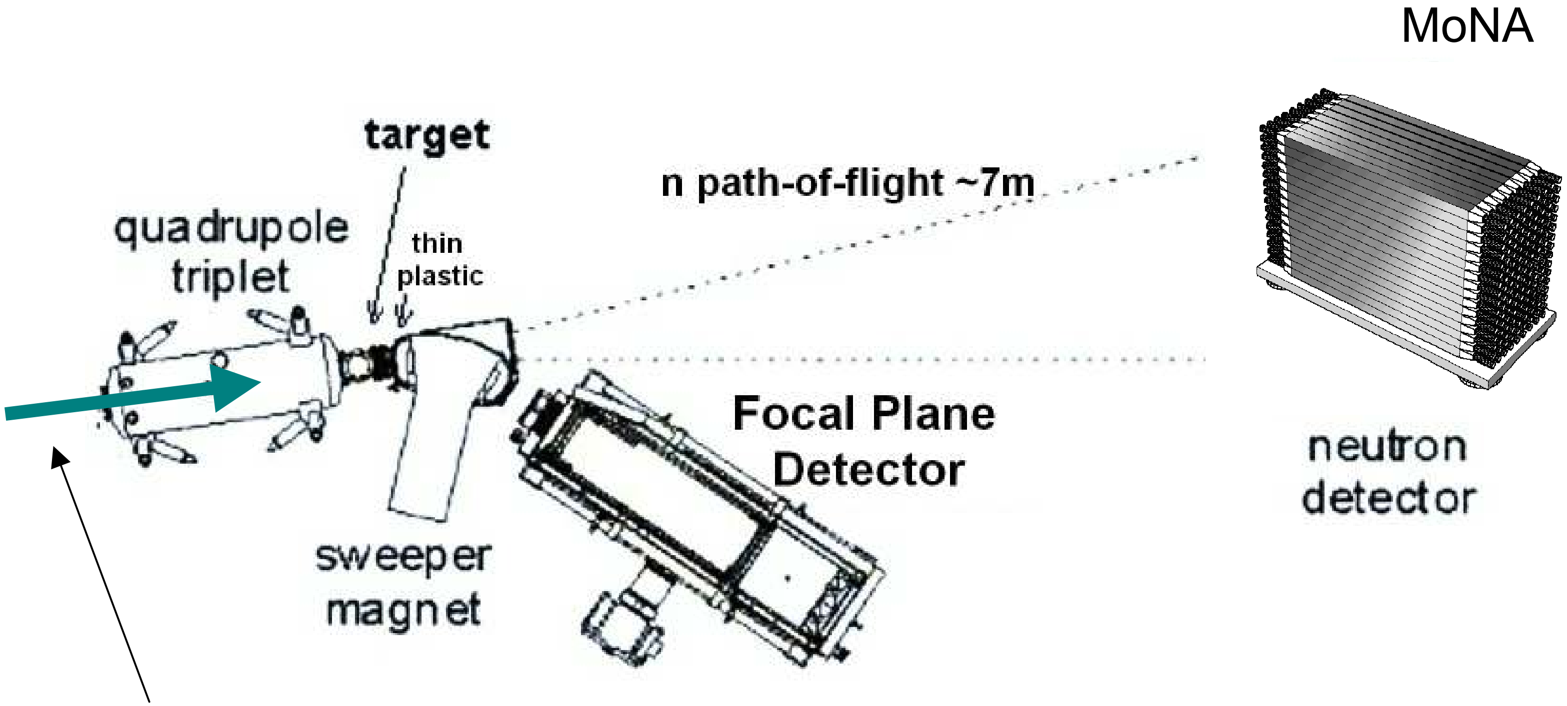
- Low binding energy neutron
- Stabil final state nucleus
- Wide energy range for experiments on ^{7}Li(n,γ)
- Comparision is possible



(M. Heil, F. Käppeler, M. Wiescher, A. Mengoni. 1998)

Experimental setup

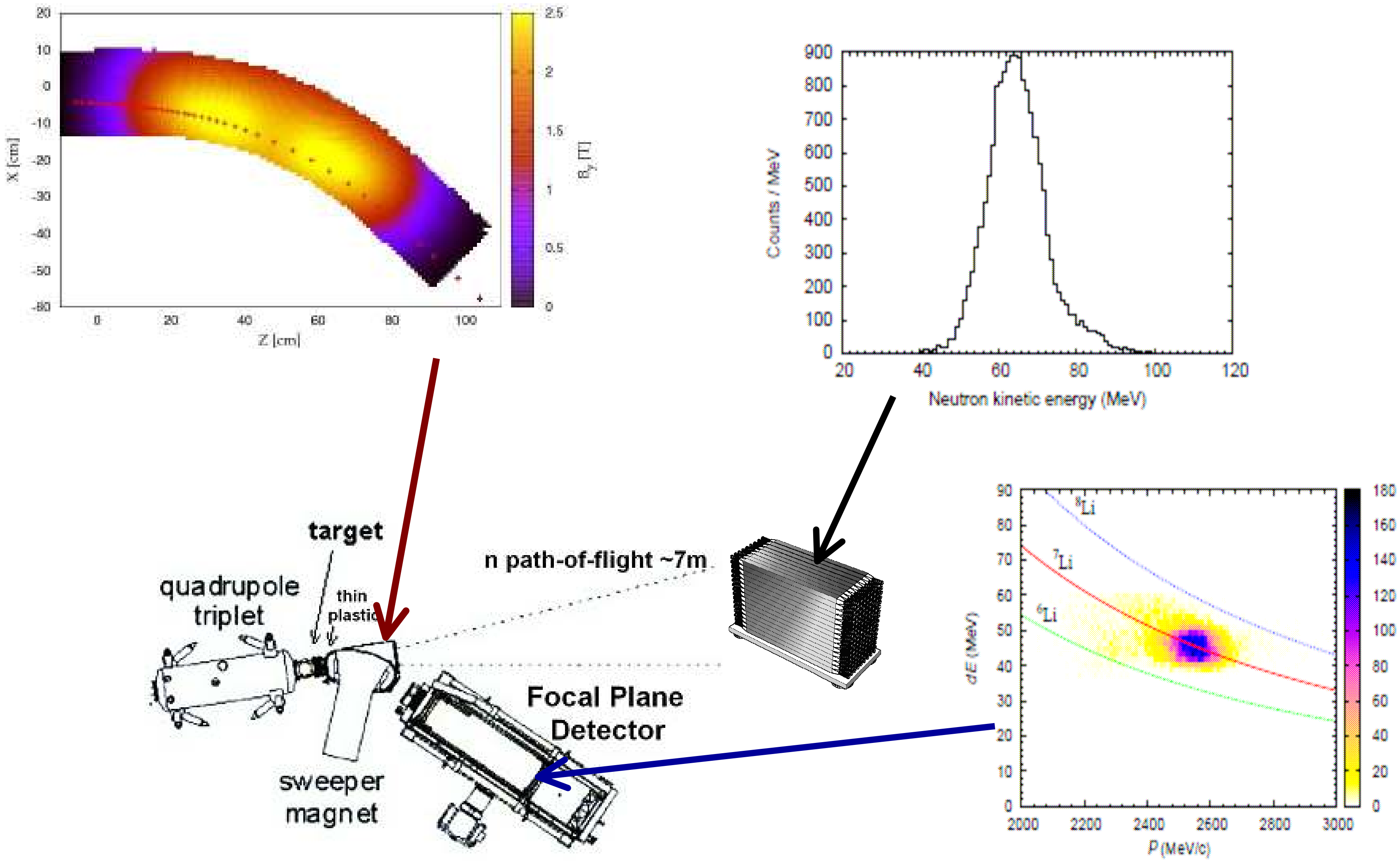
- MONA neutrondetector at NSCL



^{8}Li at 70 MeV/nucleon

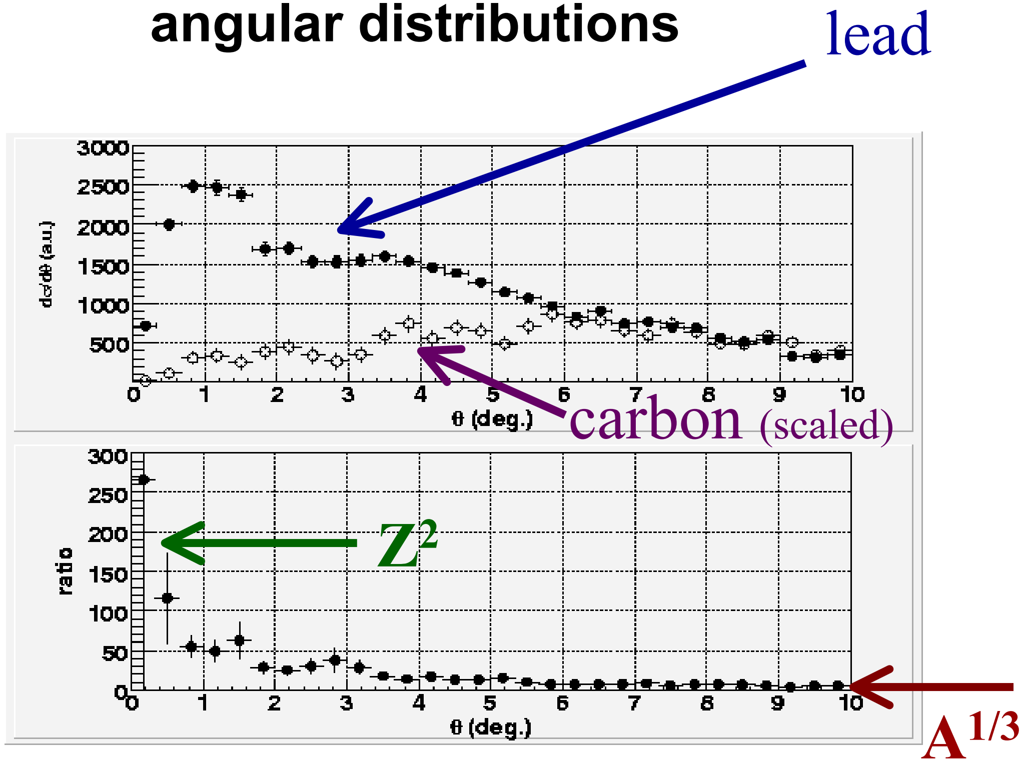
momentum vectors of fragment + neutron

Measured parameters

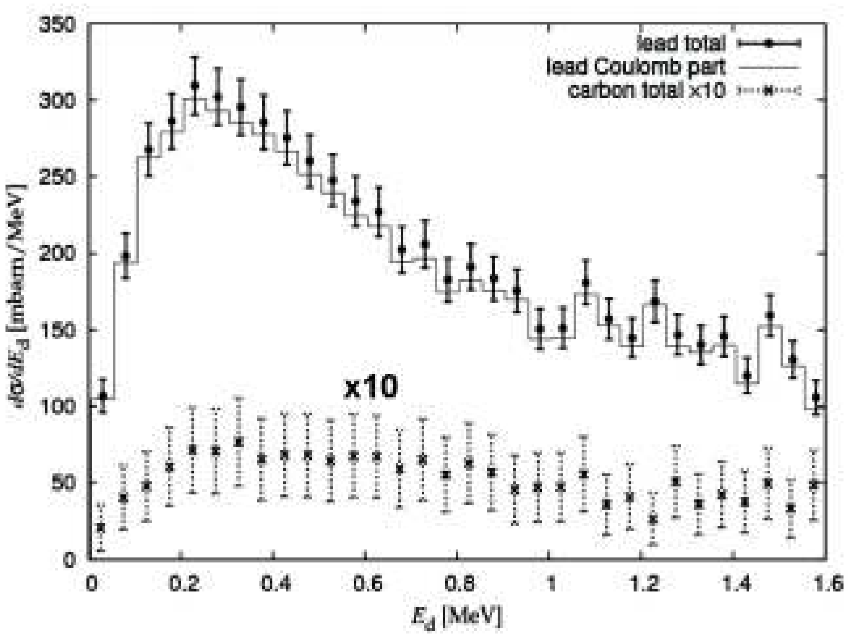


Nuclear – Coulomb mechanisms

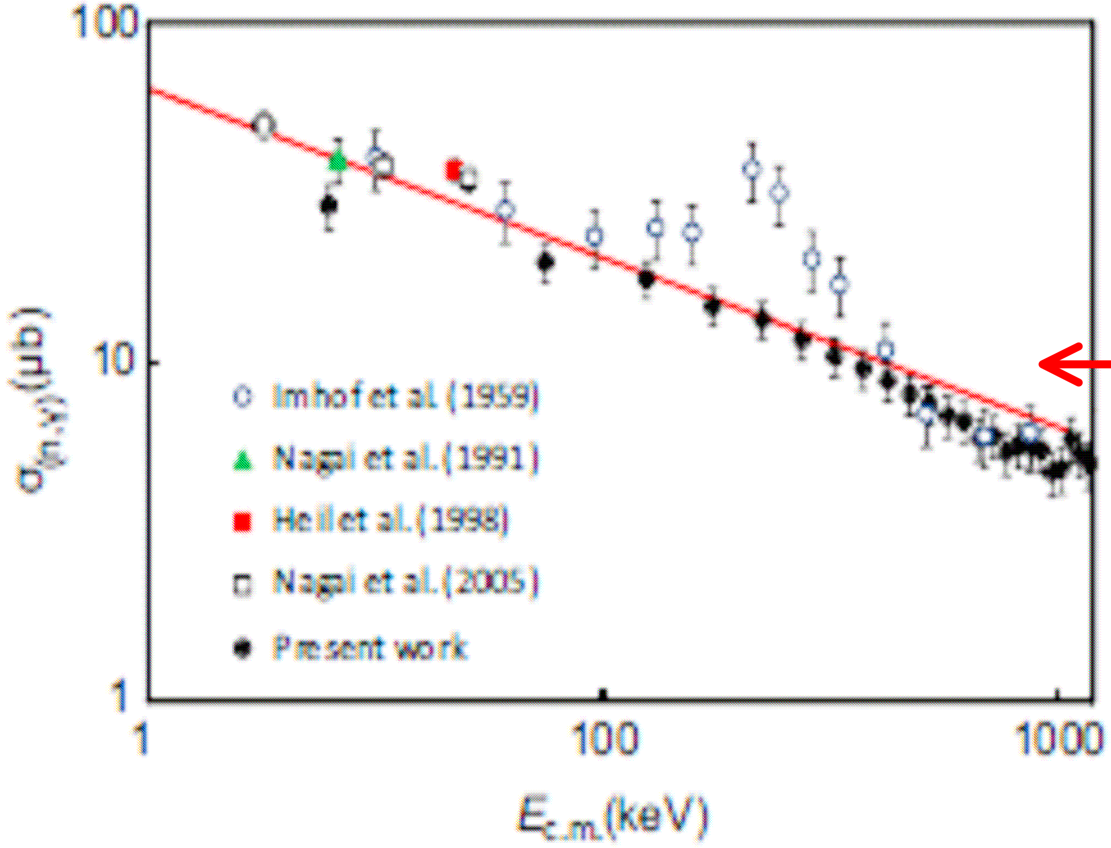
angular distributions



breakup cross sections



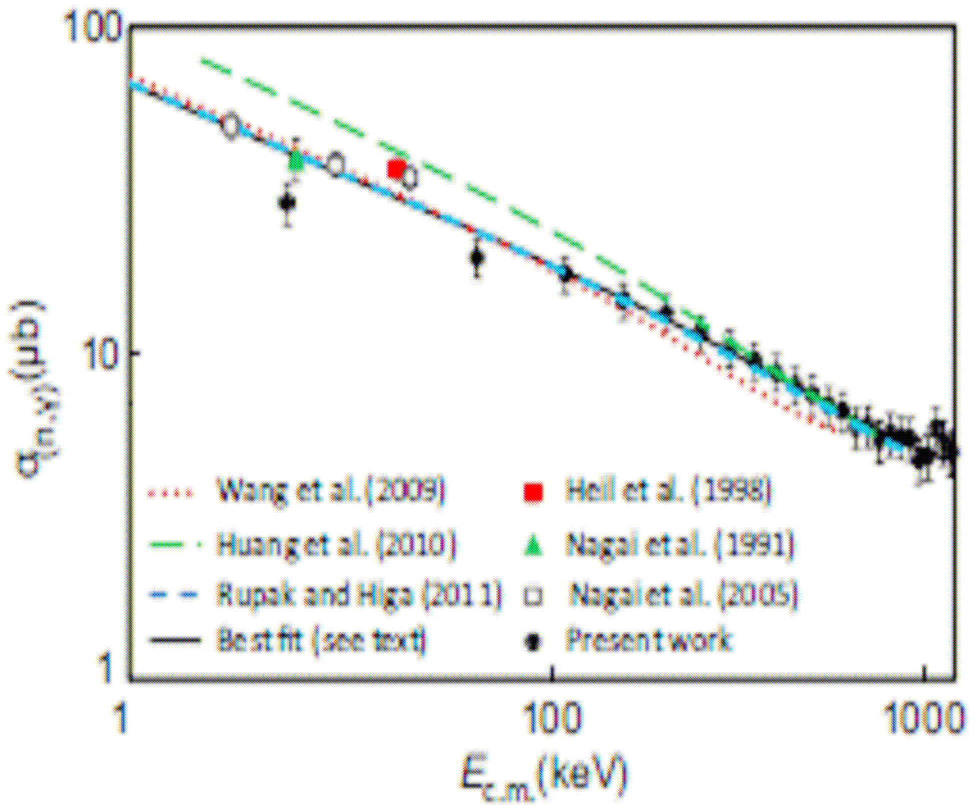
Neutron capture cross section



$$\sigma_{n,\gamma} = A \big/ \sqrt{E_{\mathrm{n}}}$$

Neutron capture cross section

$$\sigma v = S_0 E^{l_i}(1 + s_1 E + s_2 E^2)$$



R. Izsák, Physical Review C, 88 (2013) 065808 [online]

Conclusions

- The Coulomb dissociation is a good tool for nuclear astrophysics
- There are issues to investigate in any given cases
- In a verifying experiment we found that the concept works