Experimental Validation of Surrogate Ratio Method for the (n,xp) cross sections

Presented by

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Outline

- Introduction
- Validity of Surrogate Ratio Method
- Experimental Details and data analysis
- Results
- Conclusion

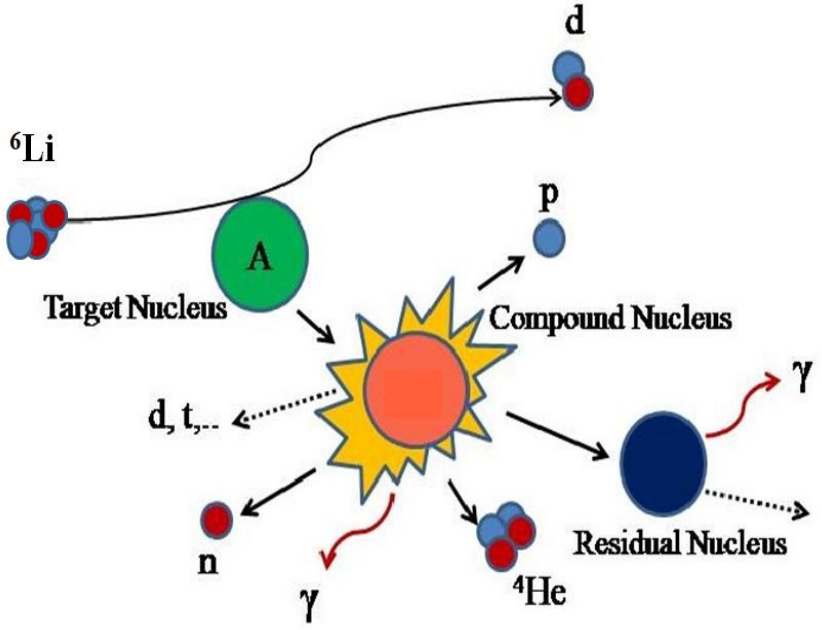
Surrogate Reaction Technique

➢ Surrogate reaction technique is an indirect method for cross section determination used for short lived nuclei.

CN Formation cross section

$$\sigma_{A(a,c)C} = \sigma^{CN}_{a+A}(E_x)P_c(E_x)$$

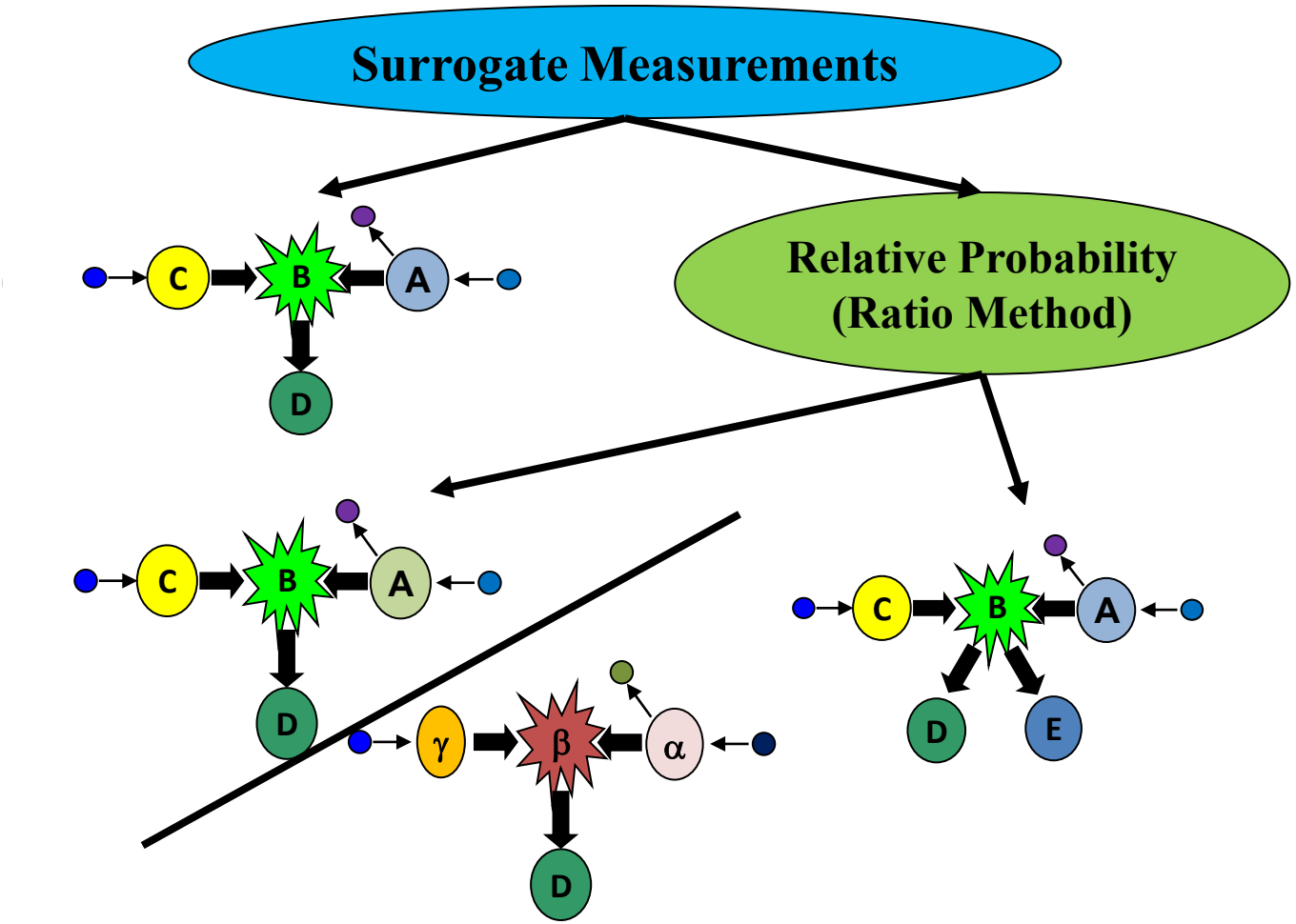
Measured experimentally



➢Surrogate reaction method is well established for (n,f) and (n,γ) reactions.

➢Cross sections for (n,p), (n,xp) and (n,xα) reactions of radio-nuclides are important for upcoming fusion reactor technology.

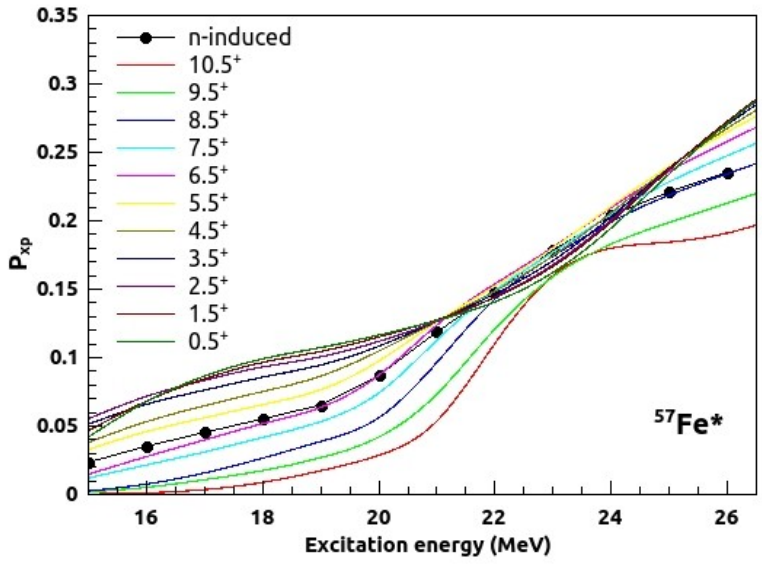
Variants Surrogate Method

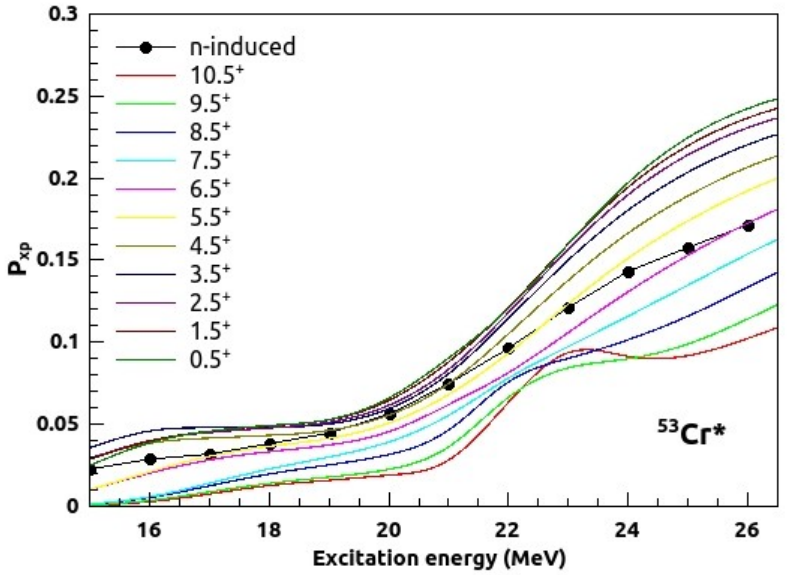


❖Surrogate ratio method are more robust in presence of spin dependence of decay probabilities and pre-equilibrium contributions.

Weisskopf-Ewing approximation

Weisskopf-Ewing approximation states that the decay probabilities of a compound nucleus are independent to the spin and parity state of the compound nucleus.

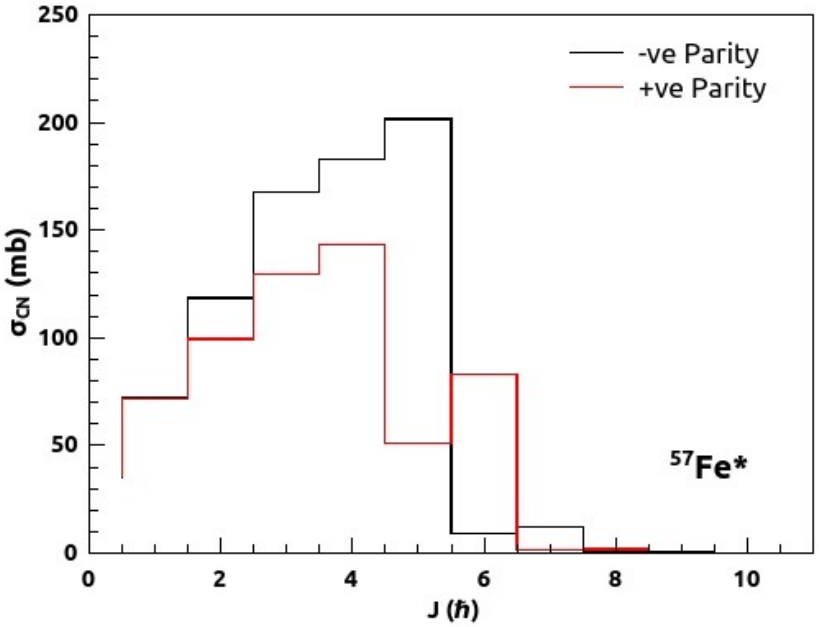


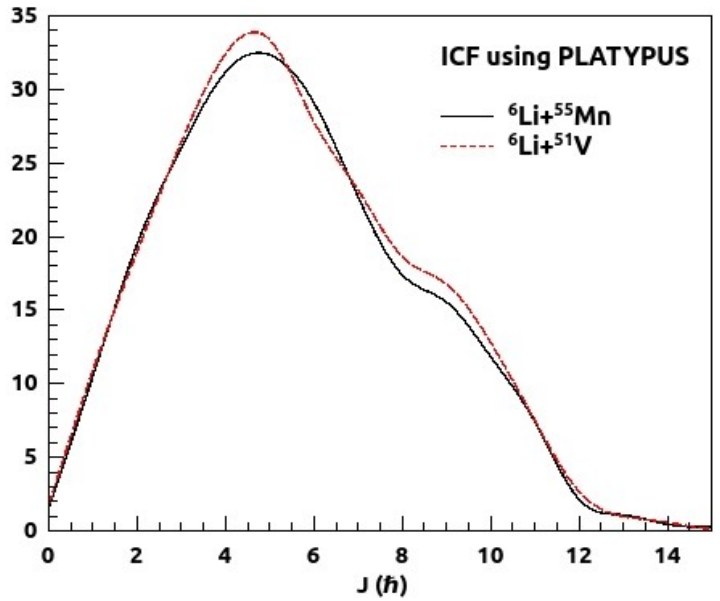


- Spin-parity dependent proton emission probabilities of the compound nuclei $^{57}Fe^*$ and $^{53}Cr^*$..

Weak Weisskopf-Ewing approximation

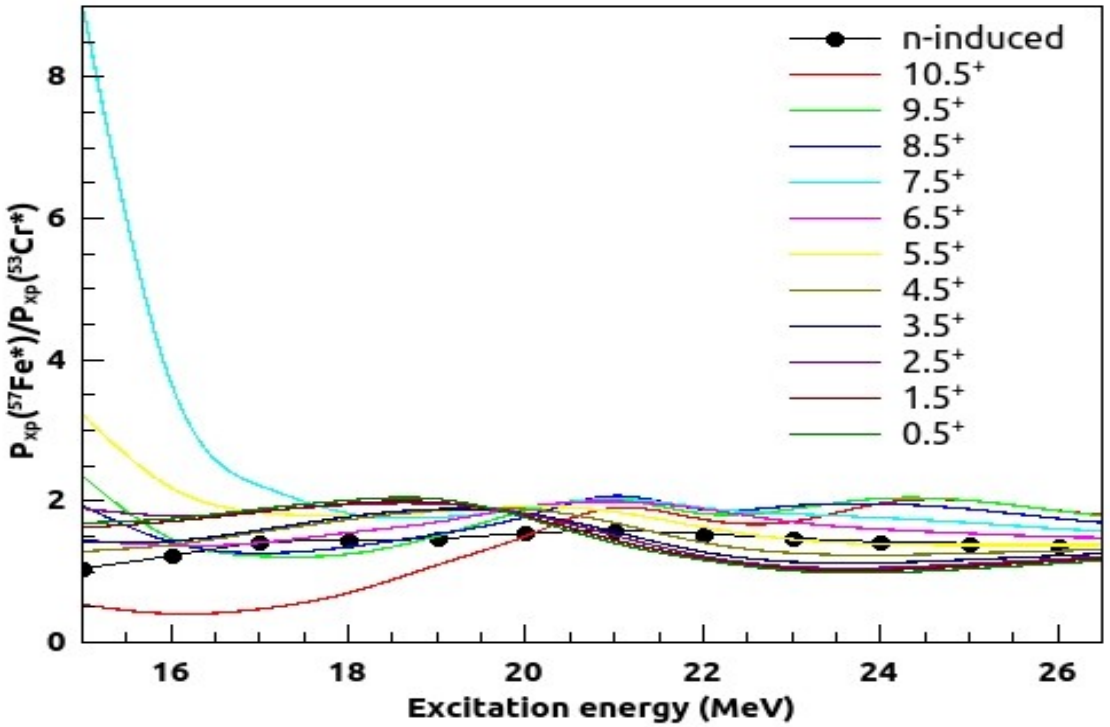
- Two surrogate reactions populating compound nuclei in similar spin distribution.
- Spin difference between compound nuclei populated through neutron induced and surrogate reactions less than 10ħ.
- J^{π}-by-J^{π} convergence of the decay probabilities.





- Spin distribution of compound systems populated in neutron induced and surrogate reactions.

Weak Weisskopf-Ewing approximation



- It is observed that the average root mean square deviation of the spin dependent ratios to the ratio calculated from the evaluated data from JENDLE is ≈26%.
- This means that we can determine (n,xp) cross sections with accuracies 26% and less.

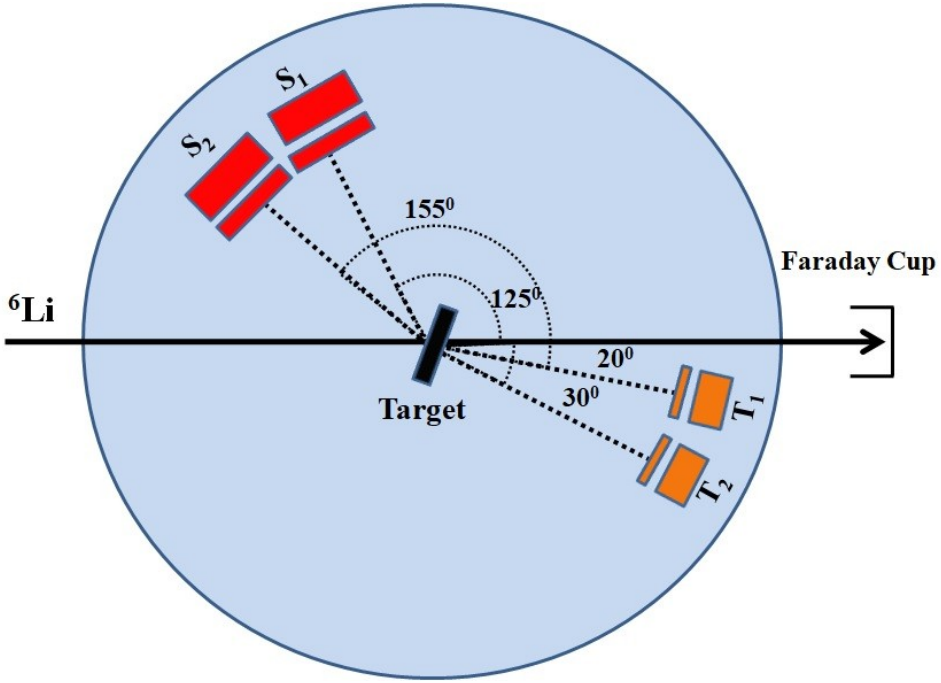
Validation of Surrogate ratio method

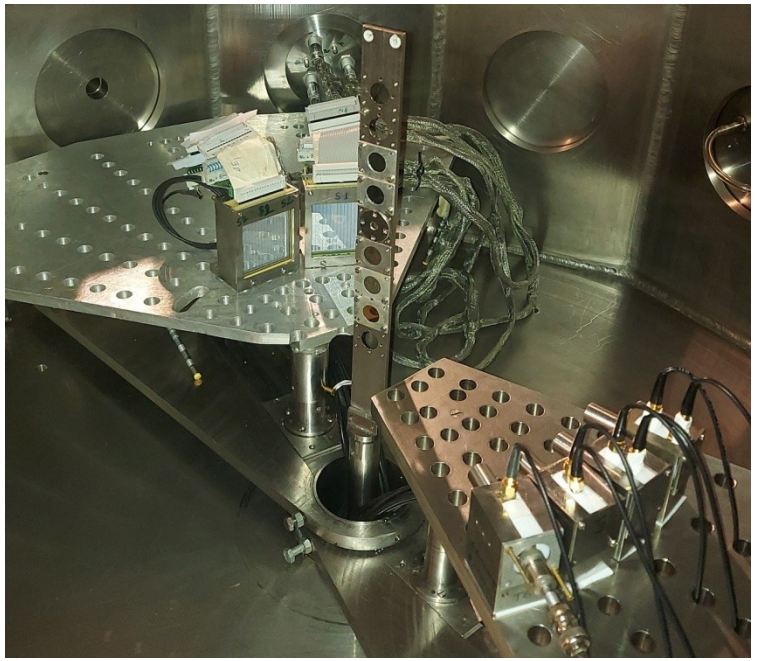
- The experiment was performed at BARC-TIFR Pelletron Accelerator Facility in Mumbai, India.

Desired Reaction	CN	Surrogate Reaction	^{6}Li Energy	Q_{gg}
^{56}Fe(n,xp)	^{57}Fe	^{6}Li(^{55}Mn, α)^{57}Fe	25 MeV	14.13 MeV
^{52}Cr(n,xp)	^{53}Cr	^{6}Li(^{51}V, α)^{53}Cr	25 MeV	14.74 MeV

- Freshly prepared self-supporting targets of ^{55}Mn and ^{51}V of thickness ~600 μg/cm^2 were used.

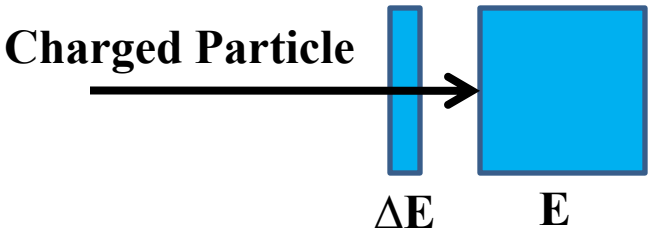
Experimental Details



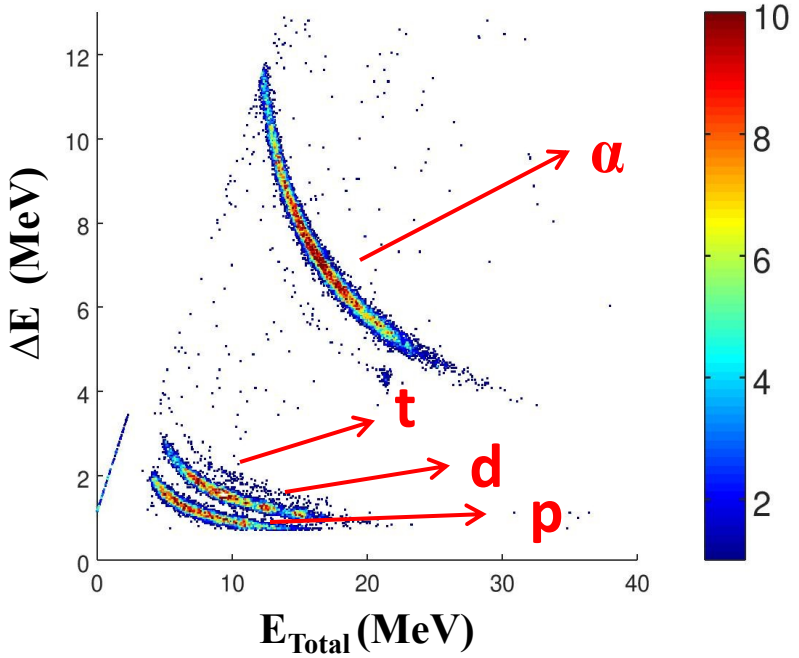


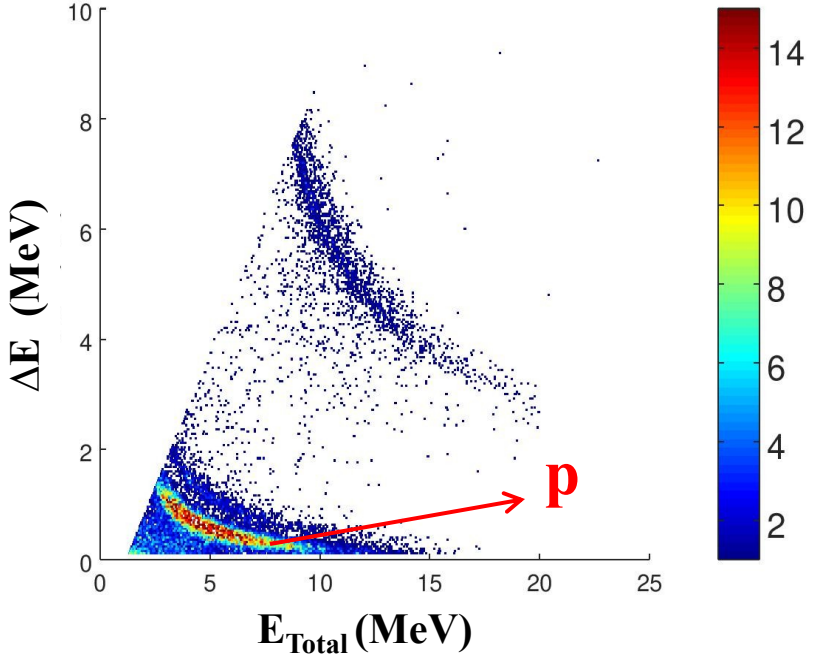
- Si strip telescope detectors (S1 and S2) (ΔE ~57 μm and E ~1550 μm) with strips of dimension 3.1x50 mm^2 and active area of 5x5 cm^2 .
- Si surface barrier telescope detector (T_1 and T_2) (ΔE ~100 μm and E ~1 mm).
- Detectors were calibrated using ^{229}Th α-source and $^{12}C(^{6}Li, \alpha)$ reaction.

Data Analysis



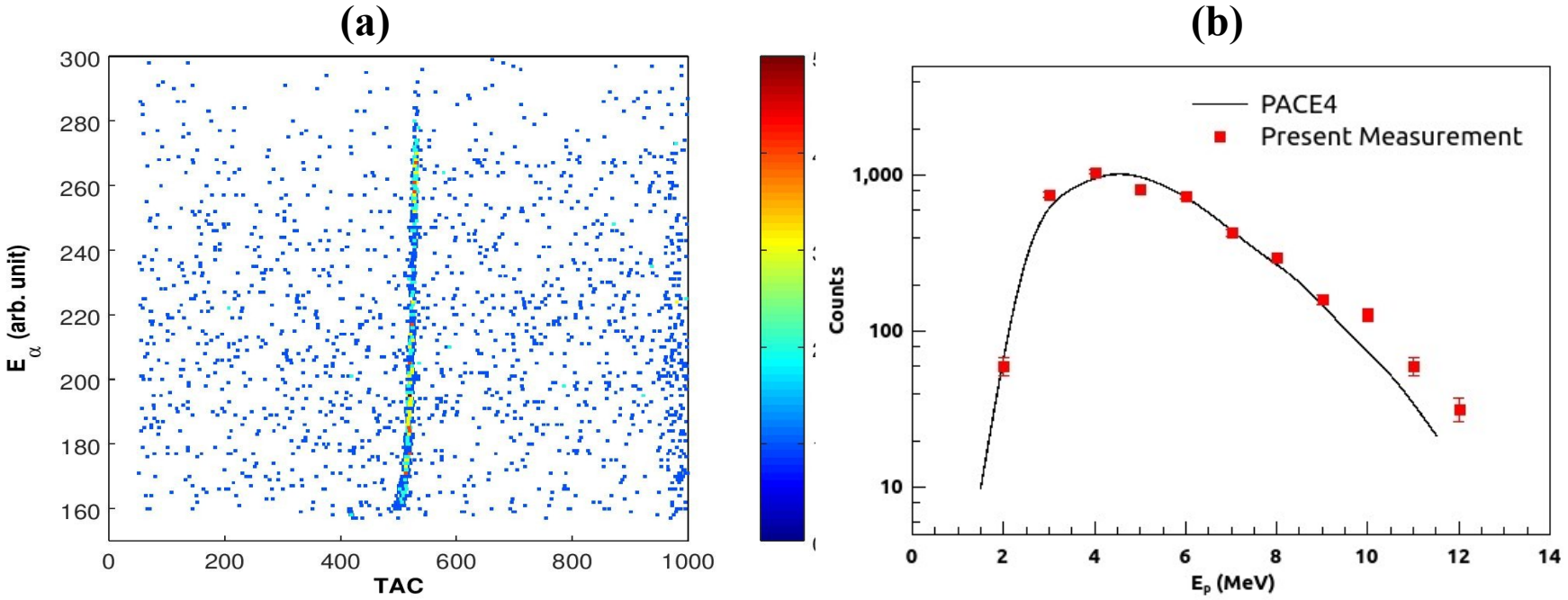
$E_{Total} = \Delta E + E_{residual}$





- A typical plot of ΔE versus E_{total} obtained from the telescope detector T_1 and one of the strips of S_1

Data Analysis



- (a) Time correlations between the detected particles in telescope detector telescope and decay particle recorded in strip detectors. (b) energy spectra of protons detected in strip detectors with PACE-4 calculations.

Data Analysis

$$\frac{\sigma^{56}Fe(n,xp)(E_x)}{\sigma^{52}Cr(n,xp)(E_x)} = \frac{\sigma_{CN}^{57}Fe(E_x)P_{CN}^{57}Fe(E_x)}{\sigma_{CN}^{53}Cr(E_x)P_{CN}^{53}Cr(E_x)}$$

Experiment

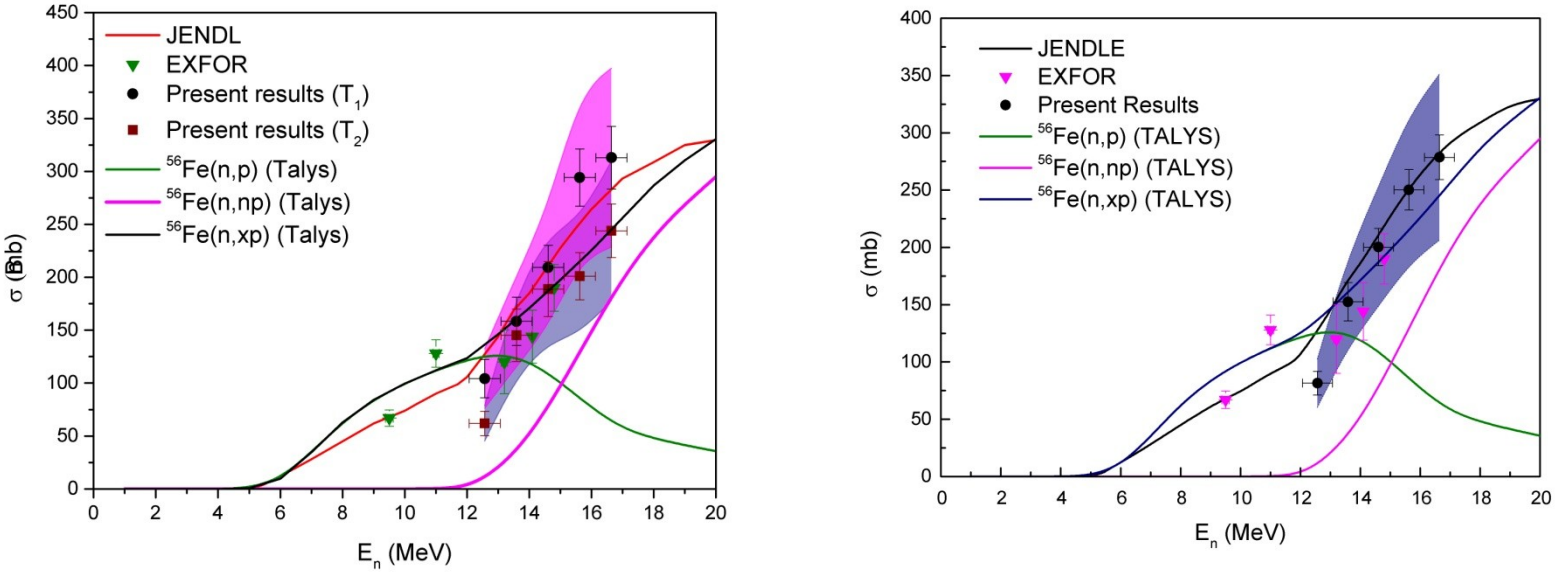
Evaluated data

$$P_{CN}(E_x) = \frac{N_{\alpha-p}^{coincidence}}{N_{\alpha}^{single}}$$

- σ_{CN} are compound nucleus formation cross sections and can be calculated using optical model calculations.

Results and Discussion

(a) **(b)**



- (a) ^{56}Fe(n,xp) cross sections measured using T_1 and T_2 (b) ^{56}Fe(n,xp) cross sections measured by adding counts corresponding to T_1 and T_2.

Acknowledgements

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Thank you

for

your kind

attention!