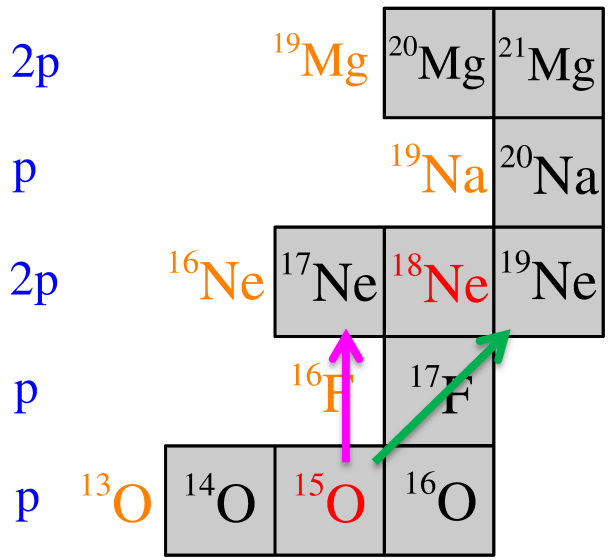
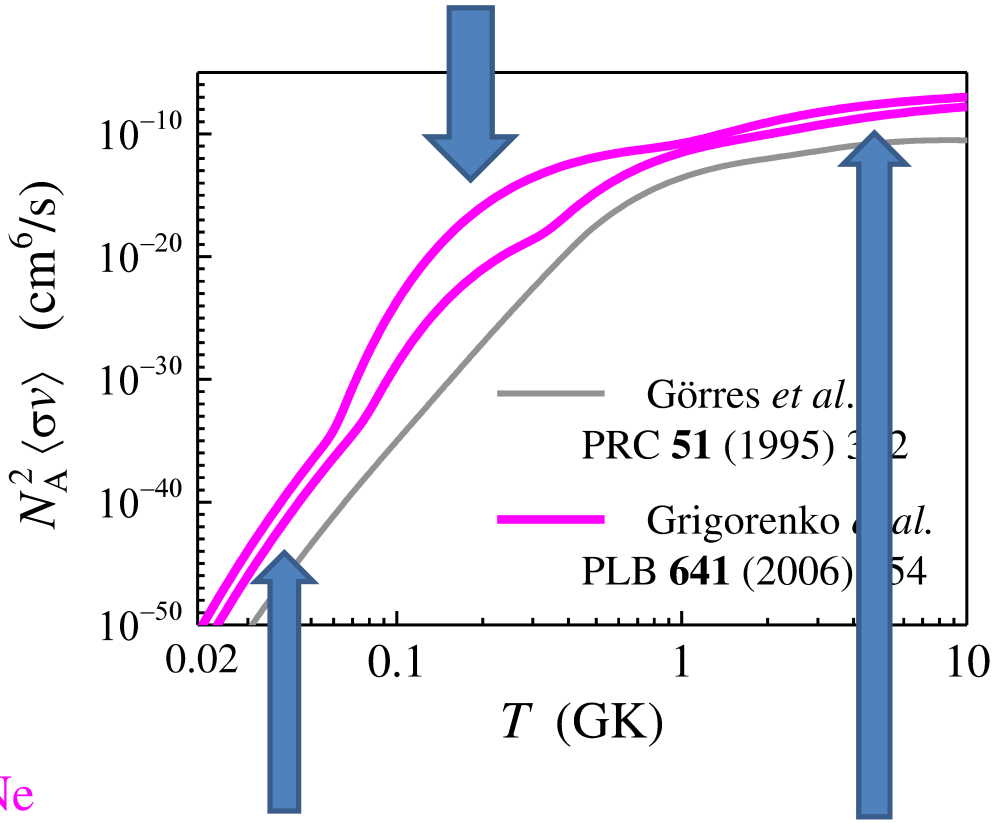
Application to nuclear astrophysics

«waiting point»
^{15}O $T_{1/2} = 122$ s



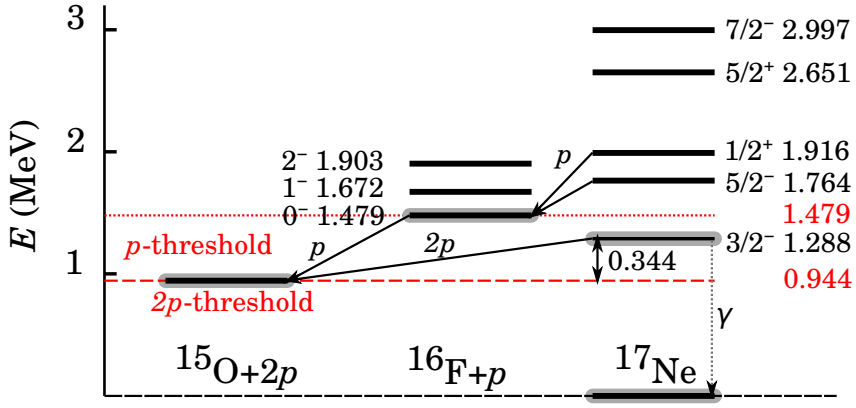
2p radiative capture competes with $^{15}O(2p,\gamma)^{17}Ne$ $^{15}O(\alpha,\gamma)^{19}Ne$

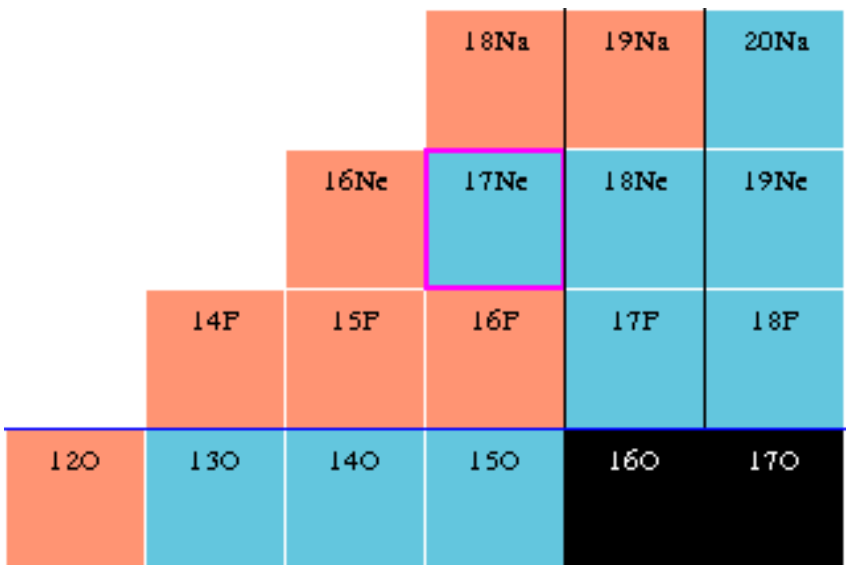
Resonant radiative capture on $3/2^-$



Nonresonant radiative capture on $1/2^+$, $3/2^+$

^{17}Ne nuclear system





$$\langle \sigma_{2p,\gamma} \rangle (T) \sim \frac{1}{T^{3/2}} \exp\left(-\frac{E_r}{kT}\right) \frac{\Gamma_\gamma \Gamma_{2p}}{\Gamma_{\rm tot}},$$

$$\Gamma_{2p}/\Gamma_\gamma = N_{2p}/N_\gamma \approx N_{2p}/N_{\rm tot}$$

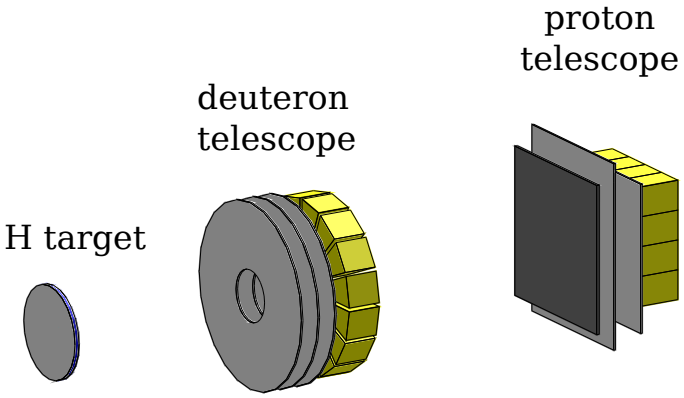
- theoretical predictions: $\Gamma_{2p}/\Gamma_\gamma = 0.9 - 2.5 \times 10^{-6}$ [L. V. Grigorenko and M. V. Zhukov, PRC76 2007]
- exp. limit $\Gamma_{2p}/\Gamma_\gamma \leq 7.7 \times 10^{-3}$ [M. J. Chromic, et. al., PRC66 2002]

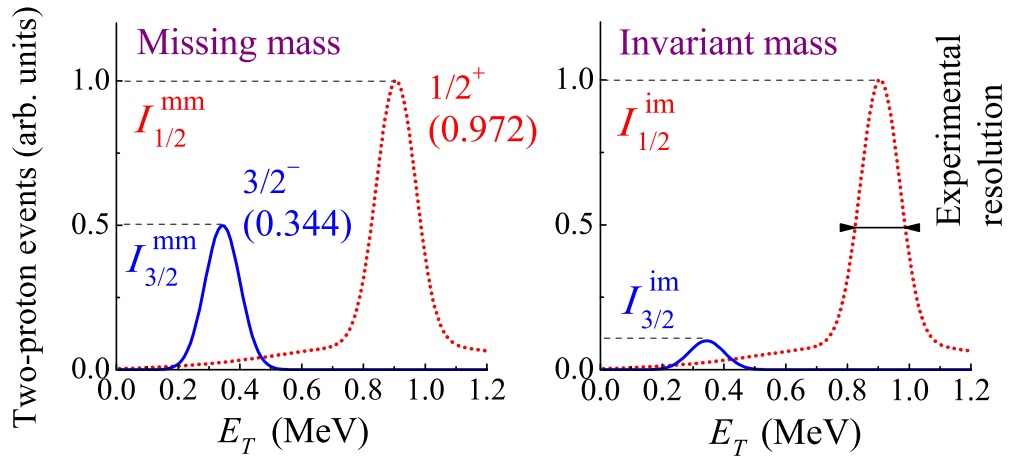
Method

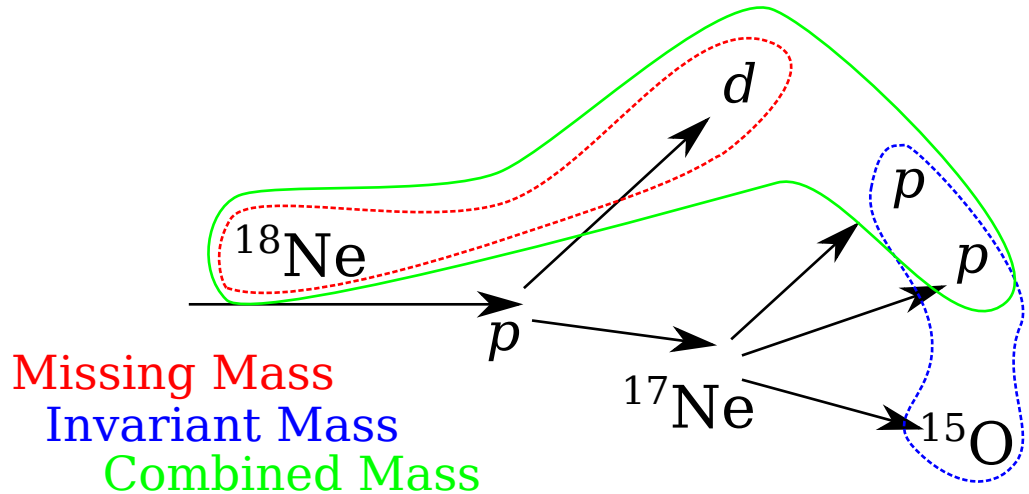
Requirement

- High statistic
- High resolution

- One neutron transfer reaction: ${}^{1}\mathrm{H}({}^{18}\mathrm{Ne}, d){}^{17}\mathrm{Ne}^{*}$
- $d - p - p$ gives full kinematics

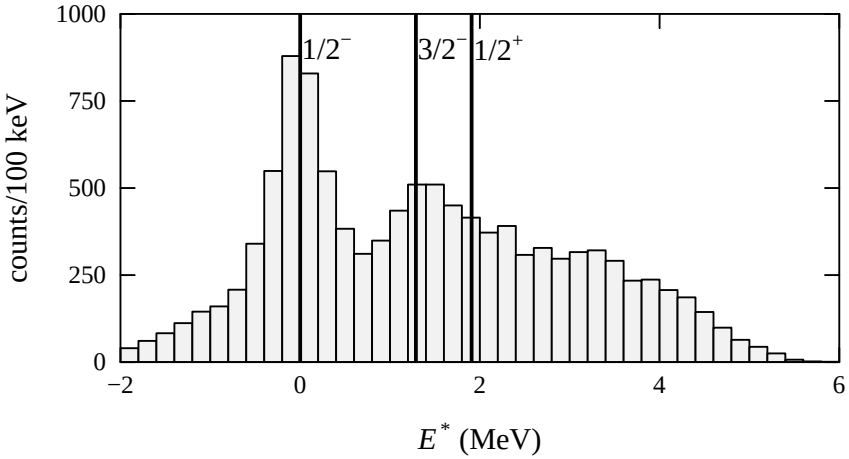






Results

missing mass on"Thin"-target

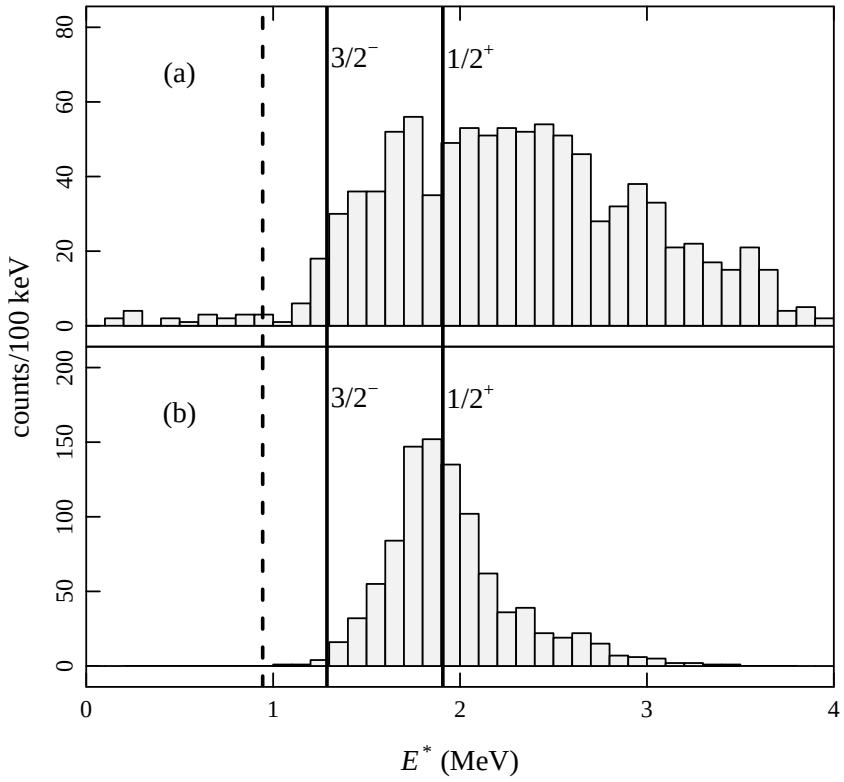


N_{tot} estimation

$N_{\mathrm{tot}} = 47500(5200)$

- combined mass spectrum shows no peak associated with $3/2^-$
- There are 13 events located at $1.2 < E^* < 1.37$

$2p$ coincidence



MSU: $\Gamma_{2p}/\Gamma_\gamma < 7.7 \times 10^{-3}$

JINR: $\Gamma_{2p}/\Gamma_\gamma < 7.8 \times 10^{-4}$

theor: $\Gamma_{2p}/\Gamma_\gamma < 2.5 \times 10^{-6}$