# Group Meeting 11.08

Reading Nature. 2022 Oct;610(7933):656-660.

**Measurement of $^{19}F(p, \gamma)^{20}Ne$ reaction suggests CNO breakout in first stars**

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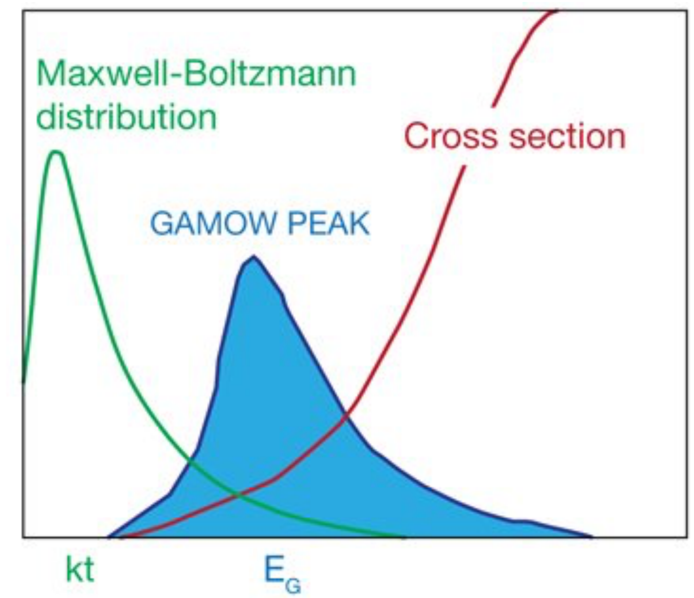
# Overview

The nuclear reactions in the stable nuclear burning stars are placed in the Gamow window (70 to 350 keV)



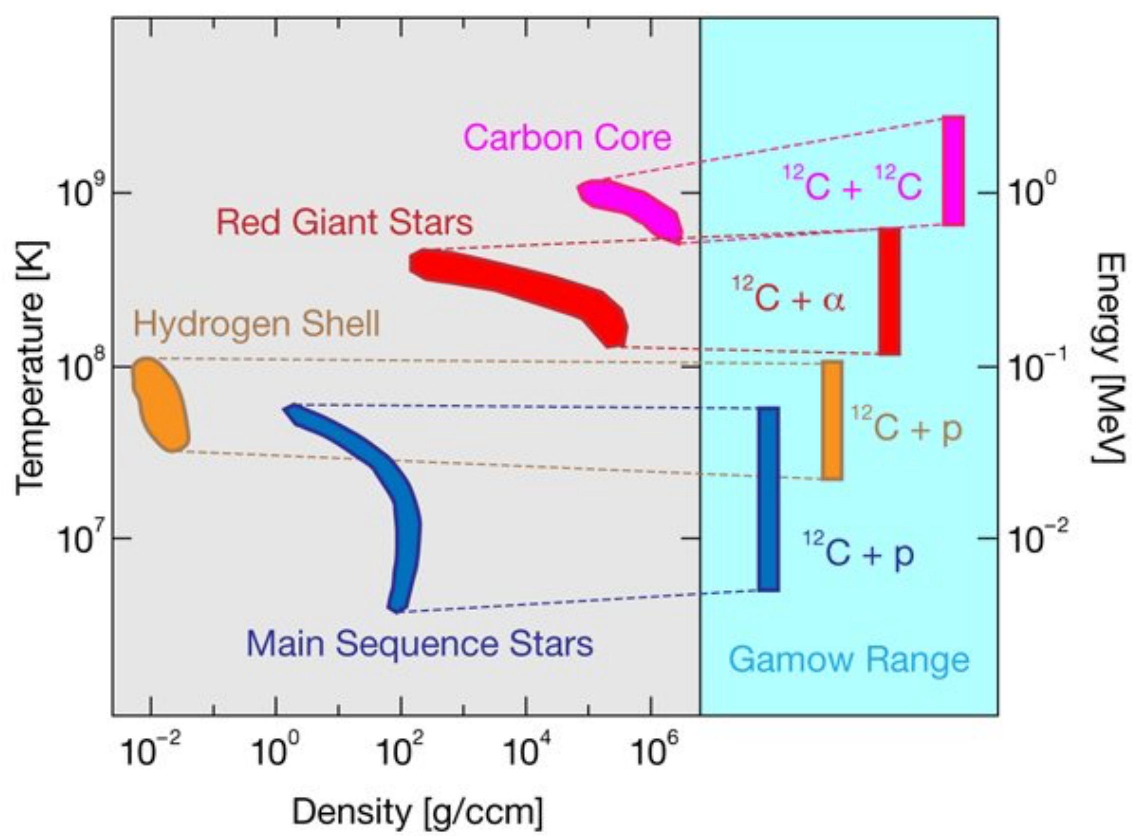




FIG1: Gamow window is the range of energies where nuclear reactions occur in stars. But the cross-section is too low to detect.[1]


[1]. Courtin, Sandrine (2016). proposal andromede. 10.13140/RG.2.1.4403.3526.

# Overview

## The background noise in JUNA is much lower.

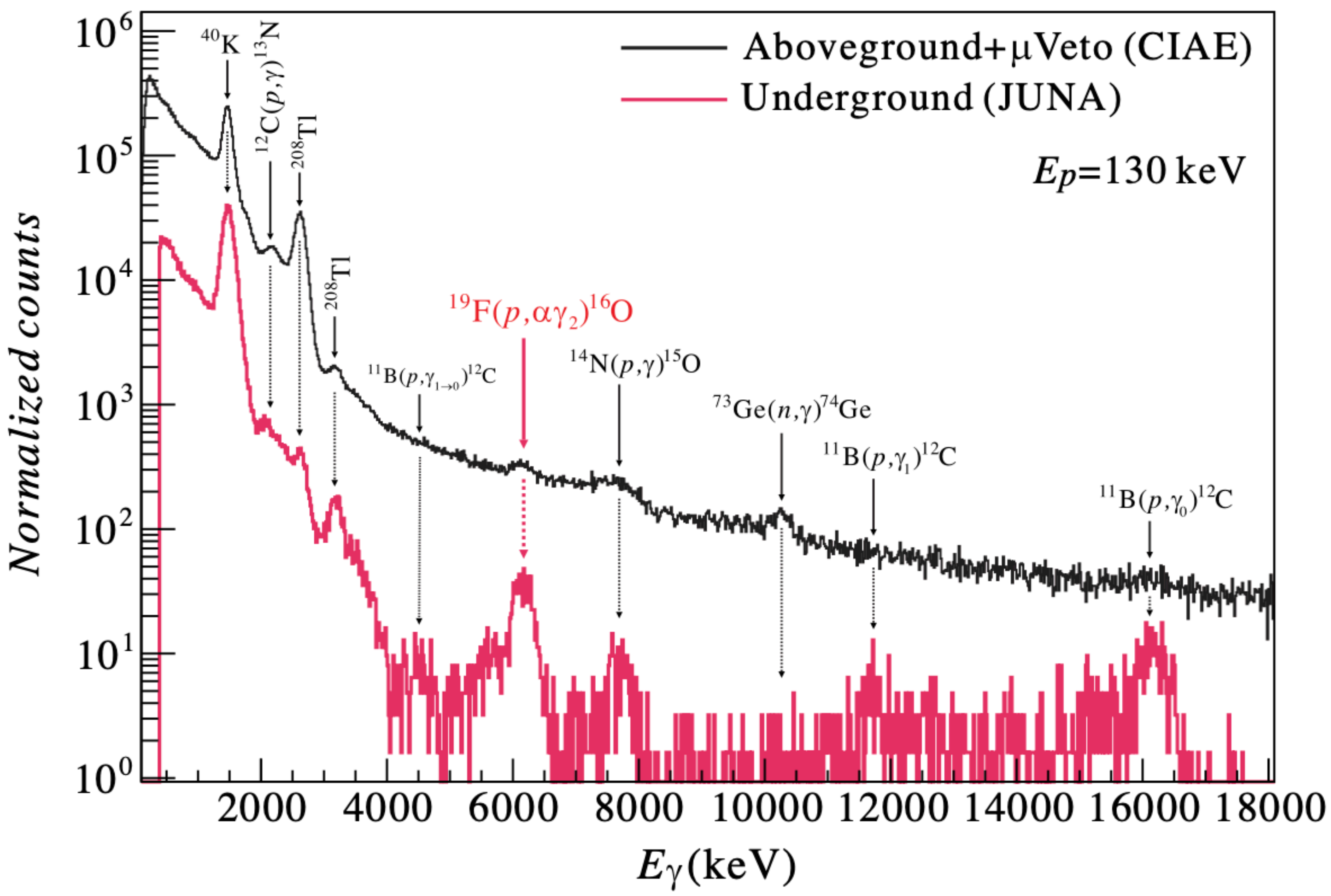
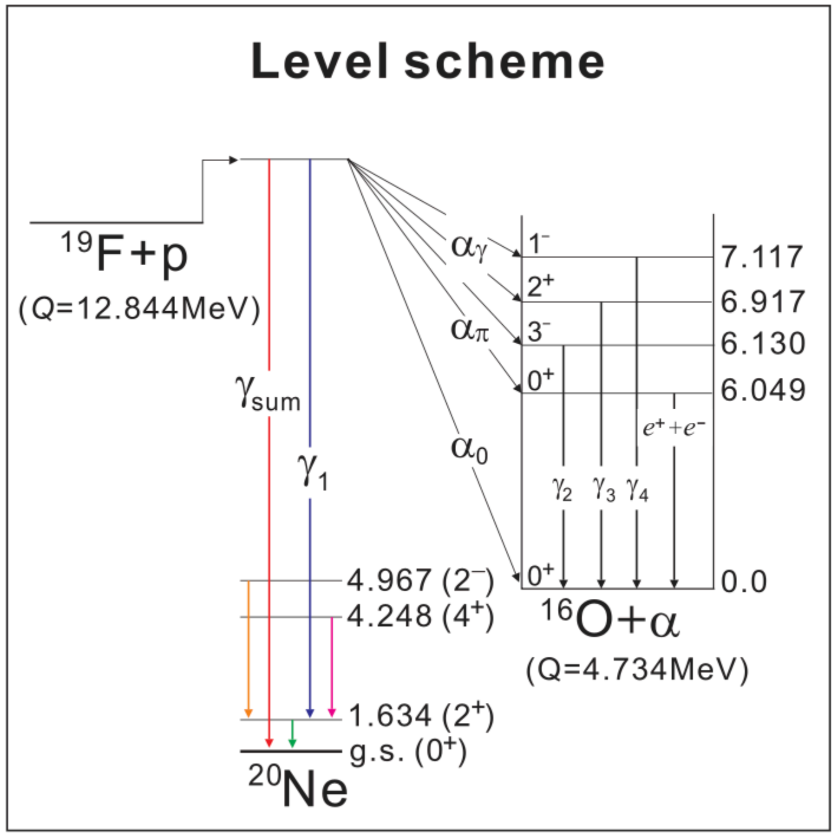


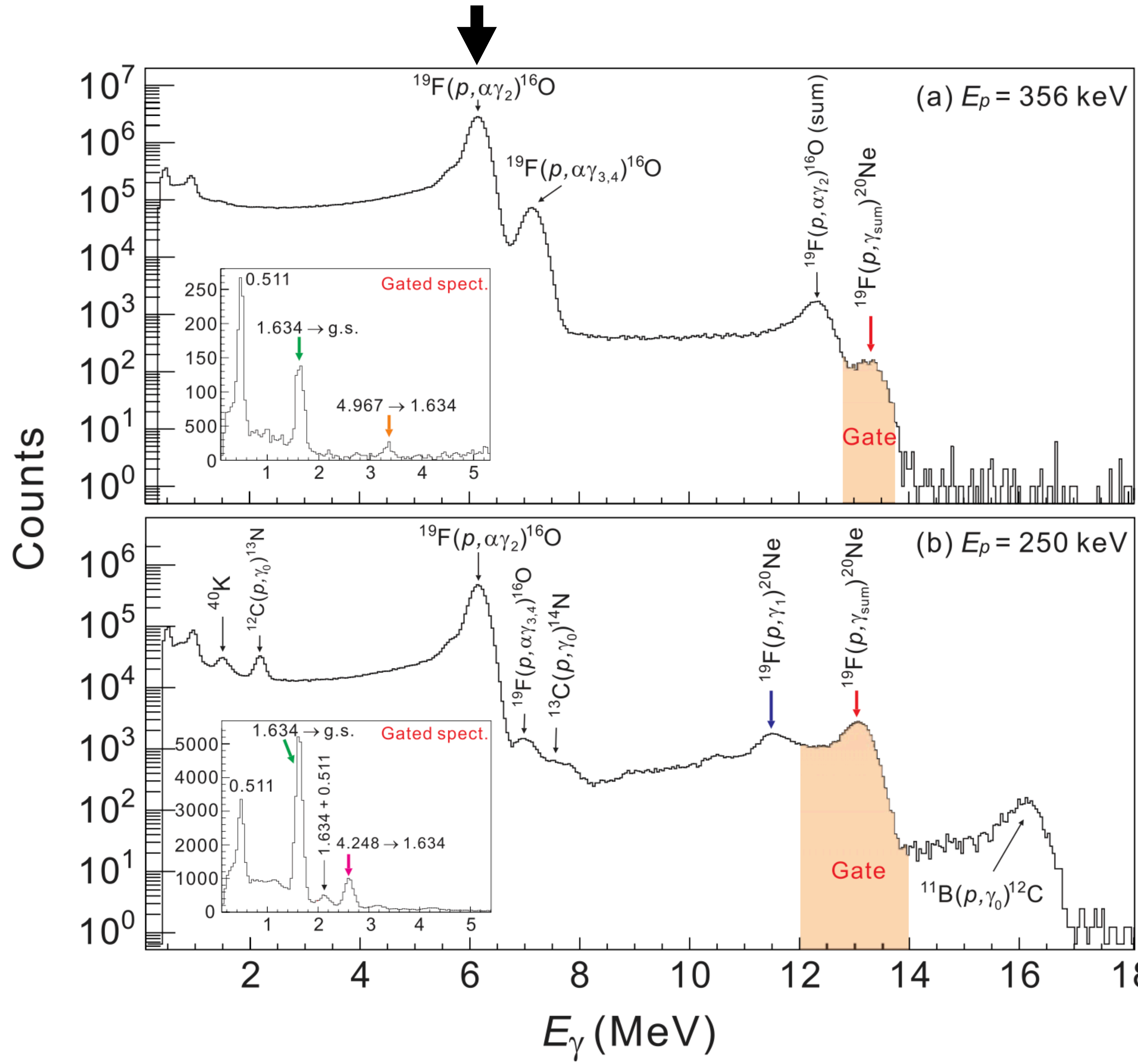

FIG2: γ-ray spectra of the $^{19}F + p$ experiments.[2]


[2]. L. Y. Zhang, J. Su, J. J. He et al., Phys. Rev. Lett 127, 152702 (2021).

# Result




Competing Chanls



# Result

Find a resonance at $E_{com} = 225.2keV$, below the known $E_{com} = 323.9keV$

$E_p$ denotes the proton beam energy delivered from the accelerator.

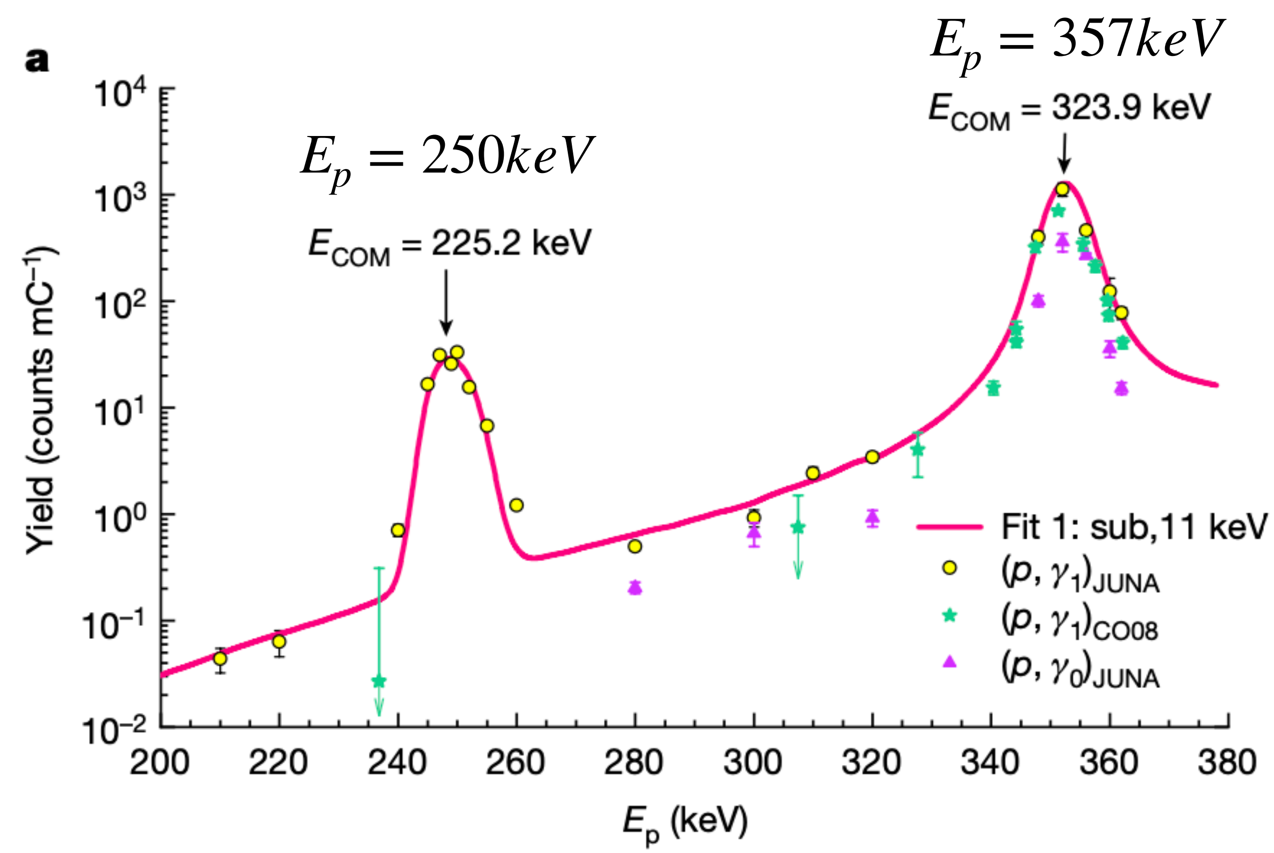



FIG2: Experimental yields of the $^{19}F(p, \gamma_{0,1})^{20}Ne$ reaction measured at JUNA. The red line is depicted using the *R*-matrix fit. Here,

# Result

Find a resonance at $E_{com} = 225.2keV$, below the known $E_{com} = 323.9keV$

$$S(E) = \frac{E}{\exp(-2\pi\eta)}\sigma(E)$$

$$\eta = \frac{Z_1 Z_2 e^2}{4\pi\epsilon_0 \hbar\nu}$$

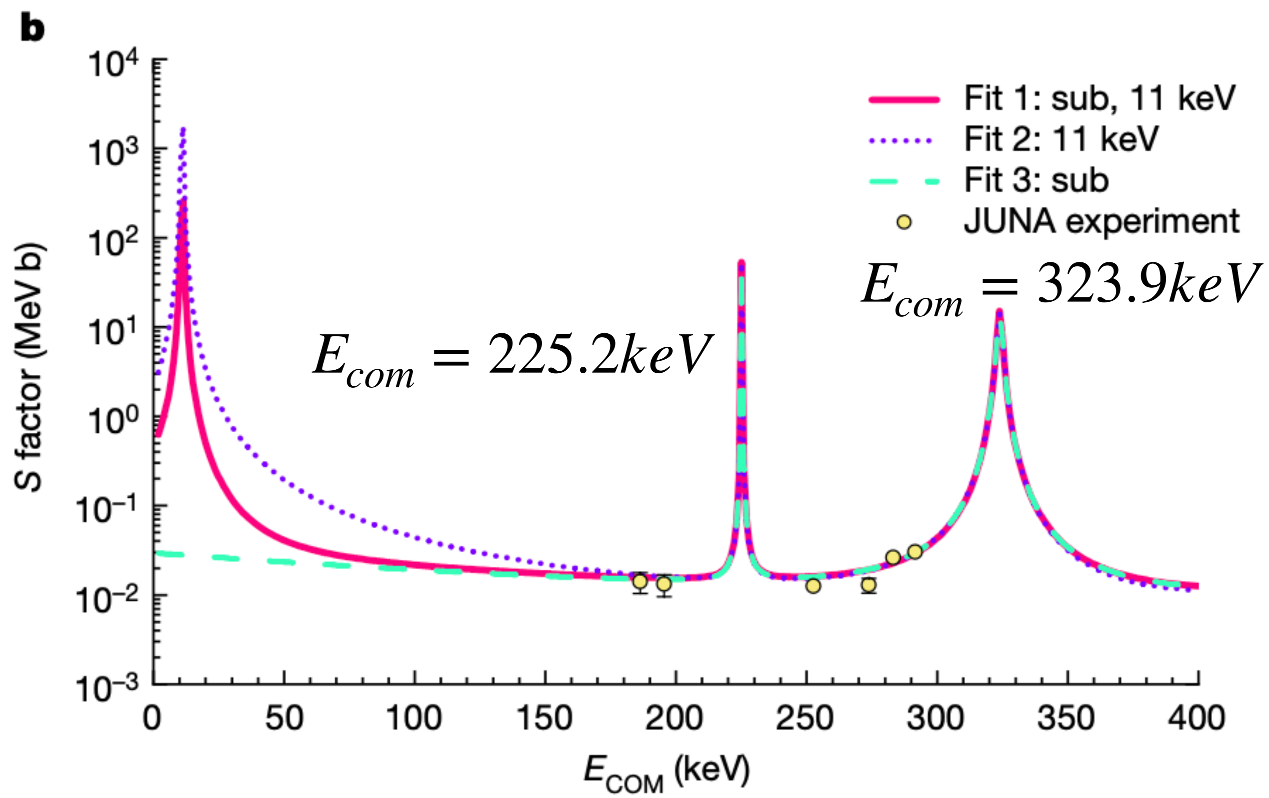
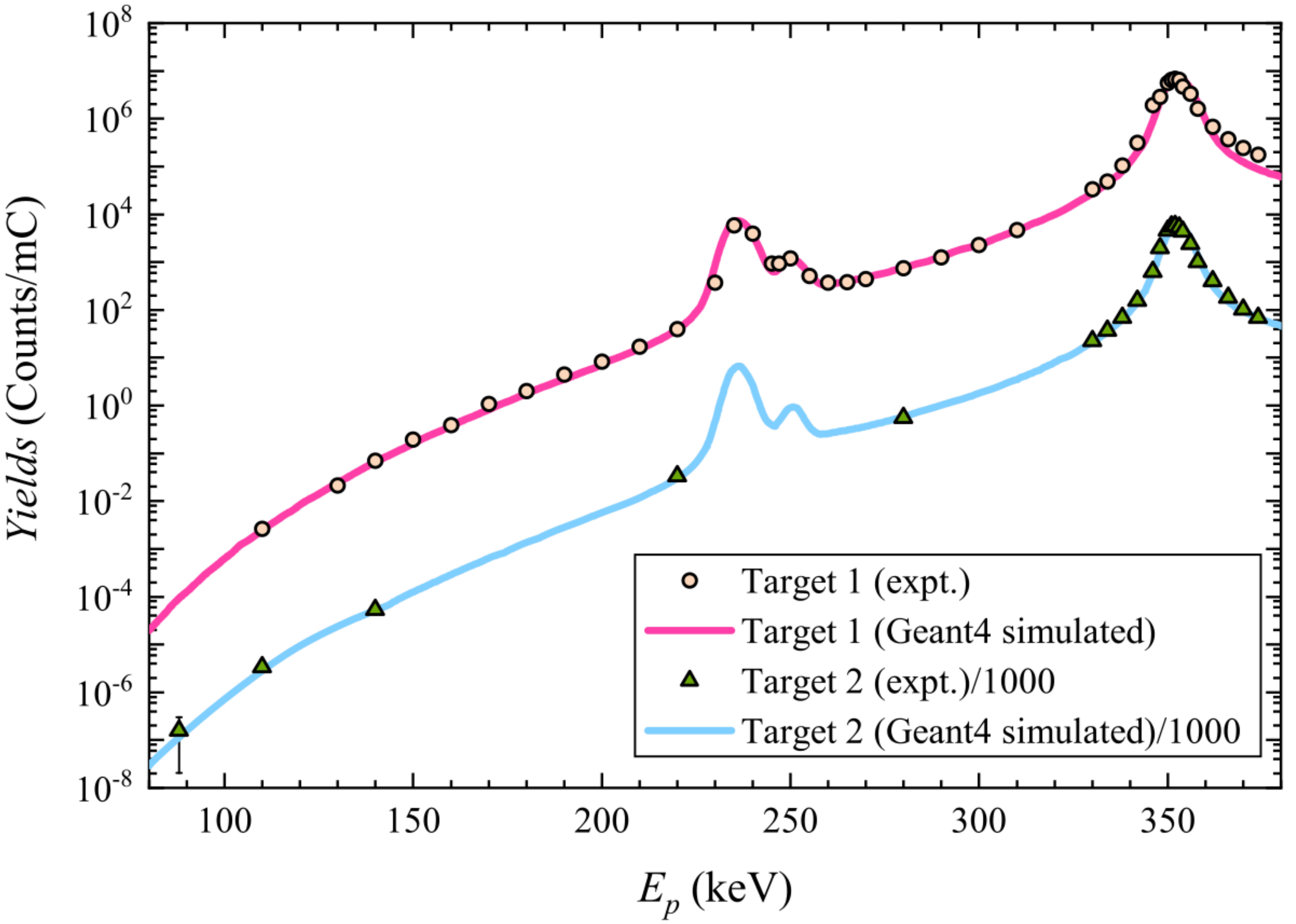



FIG3: S factor of the $^{19}F(p,\gamma_{0,1})^{20}Ne$ reaction measured at JUNA.

# Result

They also got the yield of $^{19}_{9}F(p, \alpha\gamma)^{16}_{8}O$.

FIG5: Experimental yields of the $^{19}_{9}F(p, \alpha\gamma)^{16}_{8}O$ reaction measured at JUNA. The red line is depicted using the *R*-matrix fit.[2]





[2]. L. Y. Zhang, J. Su, J. J. He et al., Phys. Rev. Lett 127, 152702 (2021).

# Result

$(p,\alpha)/(p,\gamma)$ rate is an invaluable tool with which to diagnose how the first stars evolved and died, and has far-reaching implications on stellar modeling.

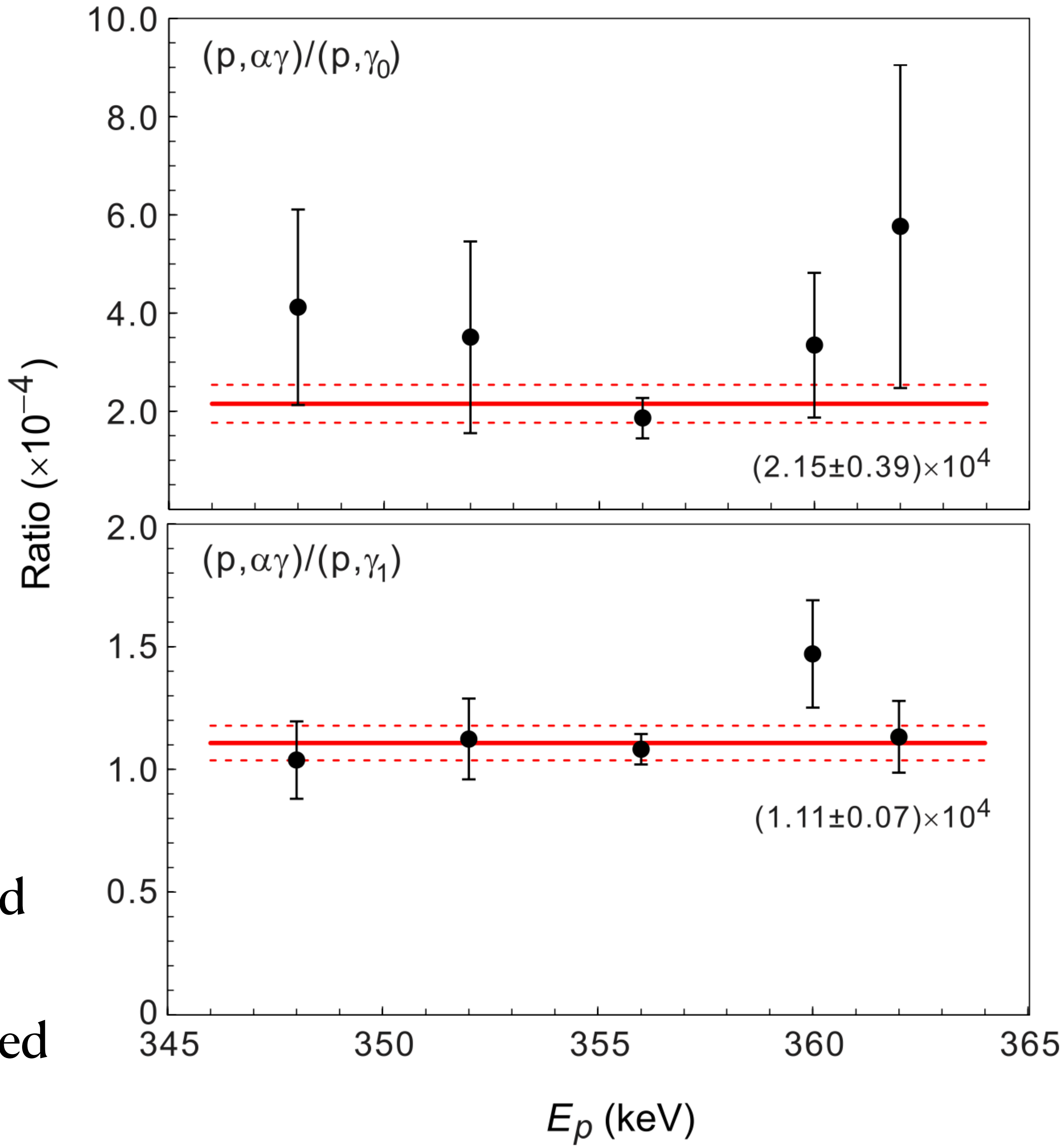
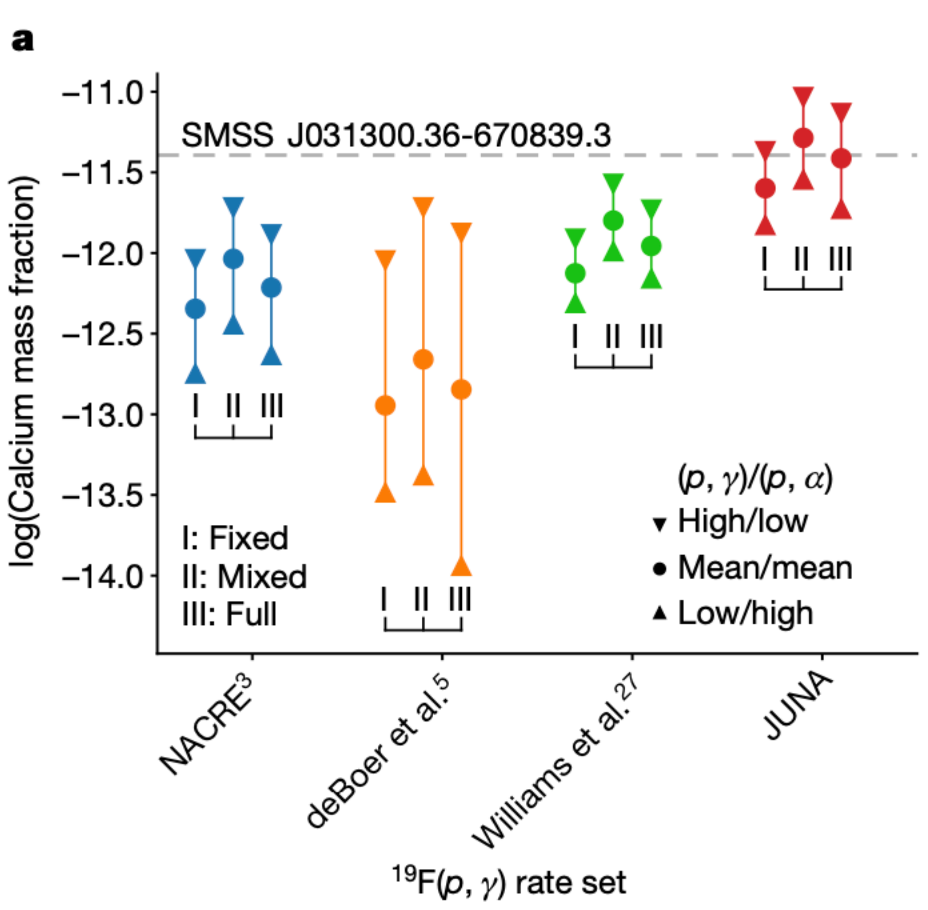


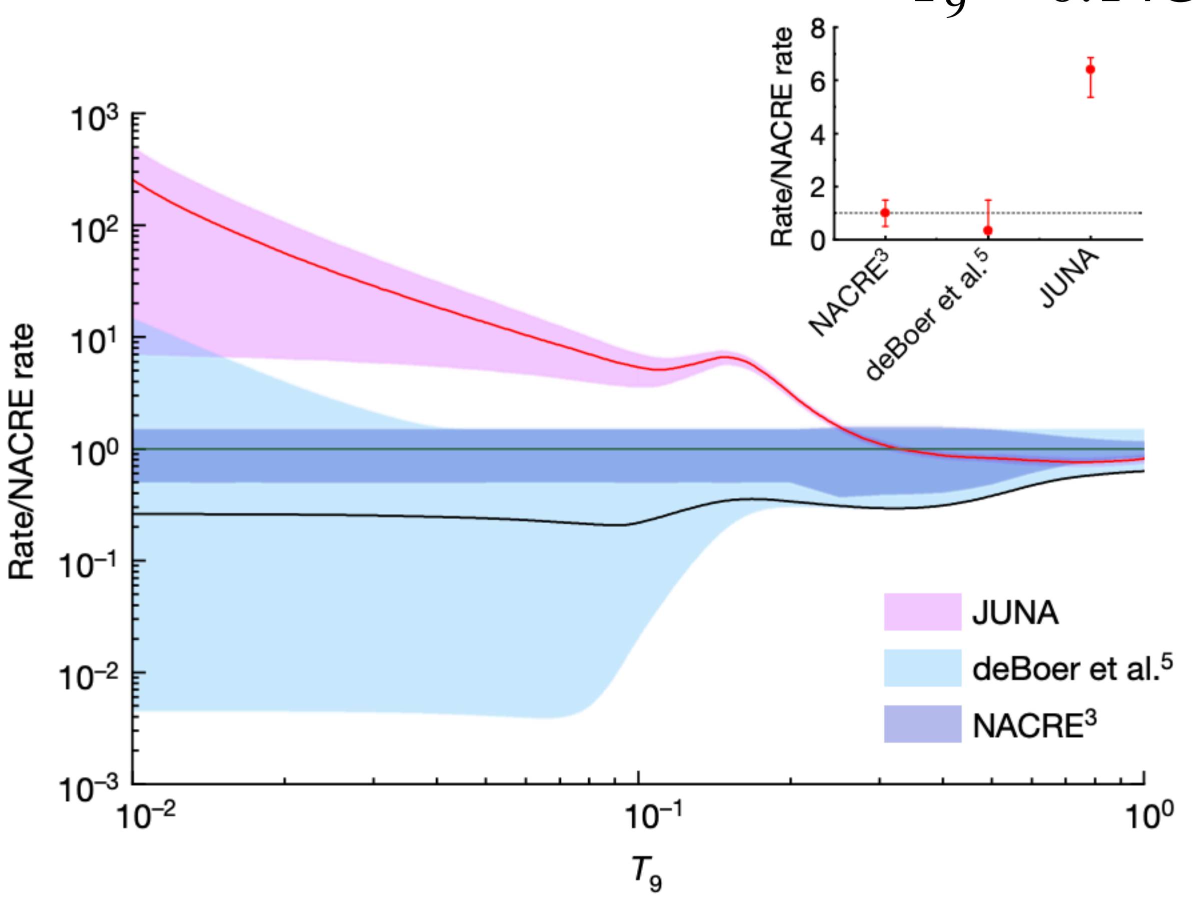

FIG6: Yield ratios of $(p,\alpha\gamma)/(p,\gamma_1)$ and $(p,\alpha\gamma)/(p,\gamma_0)$ over the 323-keV resonance. The red line is the weighted average ratio.

# Calculation

The $^{19}F(p,\gamma)^{20}Ne$ reaction rate as a function of temperature is calculated by numerical integration of the *S* factors. About 5.4-7.4 times larger than NACRE.




$T_9 = 0.14GK$




(I)indicates trajectories of fixed temperature and density;

(II) is for time-dependent trajectories that include the effect of mixing due to convection;

(III) is for yields from full stellar models.