

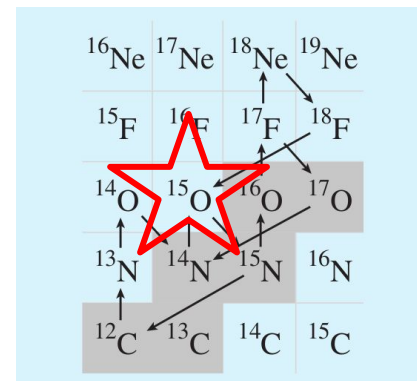
# Determining the $\alpha + {}^{15}\text{O}$ radiative capture rate by measurement of the ${}^7\text{Li}({}^{15}\text{O}, t){}^{19}\text{Ne}$ reaction

AUTHOR: Jennifer Sanchez Rojo  
SUPERVISOR: Christian Aa. Diget

# $\alpha$ - CAPTURE ON $^{19}\text{Ne}$

Highest ranked recent experiment at GANIL (July 2019).

- ★ 150  $\alpha$ -capture on neutron stars in binary systems (X-ray bursts): Breakout from the Hot CNO cycle into r-process nucleosynthesis.
- ★ Key Breakout Points  $^{15}\text{O}$  and  $^{18}\text{Ne}$ .
- ★ Long-standing challenge of measuring the rate through the 4.033 MeV state in  $^{19}\text{Ne}$ .
- ★ Combined gamma-ray, light ion, heavy ion coincidences in 150  $\alpha$ -transfer measurement.



Hot CNO cycle  
[Frost-Schenk, J. W. et al. *Phys. Educ.* **53**, 024001 (2017)]



Separate publication of nucleosynthesis in the related scenario where the neutron star enters the companion star envelope

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## Nucleosynthetic yields from neutron stars accreting in binary common envelopes

J Keegans ✉, C L Fryer, S W Jones, B Côté, K Belczynski, F Herwig, M Pignatari, A M Laird, C Aa Diget

Monthly Notices of the Royal Astronomical Society, Volume 485, Issue 1, May 2019, Pages 620–639,  
<https://doi.org/10.1093/mnras/stz368>

# REACTION

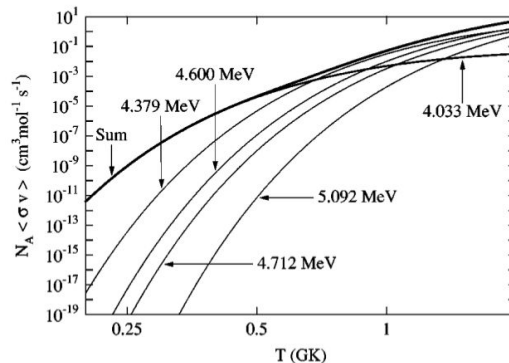
- ★  $^{19}\text{Ne}$  state at 4.033 MeV expected to be the biggest contribution to reaction rate.
- ★ Indirect  $\alpha$  transfer reaction in inverse kinematics.



[Davids, B. *et al.*  
Phys. Rev. C **67**, 012801 (2003).]

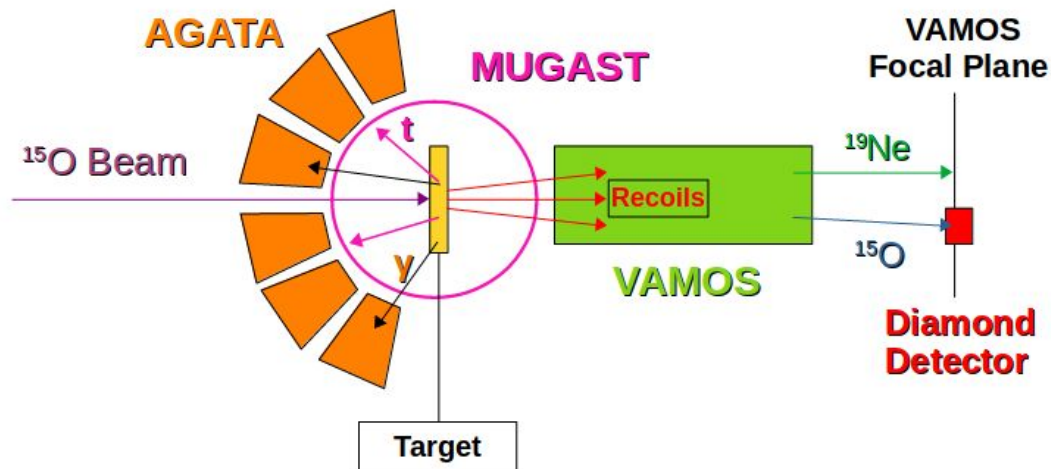


UNIVERSITY  
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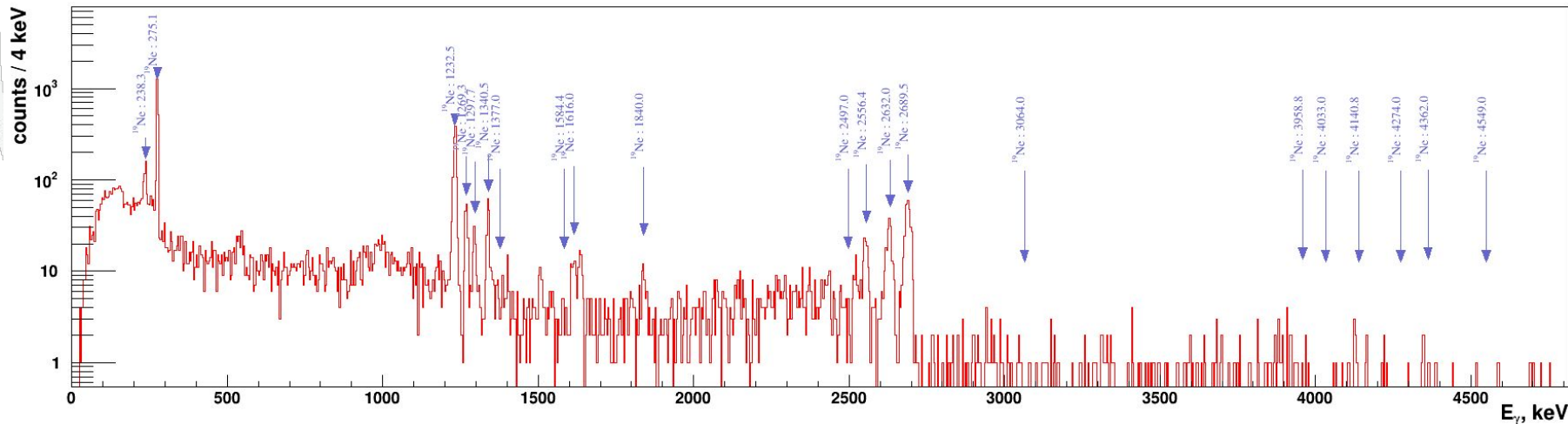
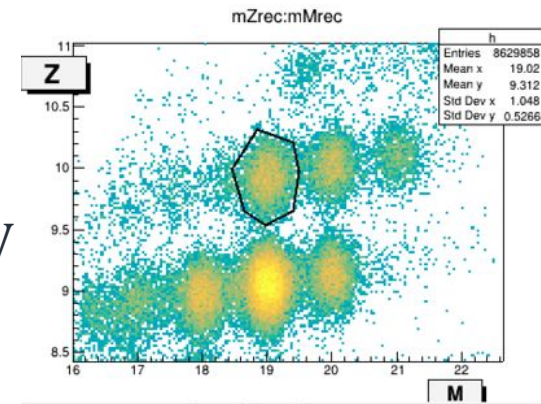
# SET-UP

- ★  $^{19}\text{Ne}$  prompt- $\gamma$ : AGATA
- ★ Triton ejectile: MUGAST
- ★  $^{19}\text{Ne}$  recoil: VAMOS
- ★  $^{15}\text{O}$  unreacted beam: Diamond detector.



# PRELIMINARY RESULTS

- ★ Online results show transfer reaction
- ★ Detected triple coincidence VAMOS+AGATA+MUGAST
- ★ PID in VAMOS: identification of  $^{19}\text{Ne}$  - highly selective
- ★ AGATA gated on VAMOS and MUGAST: show expected gamma-ray transitions, except 4.033 MeV
- ★ Reaction rate may prove significantly lower than currently assumed

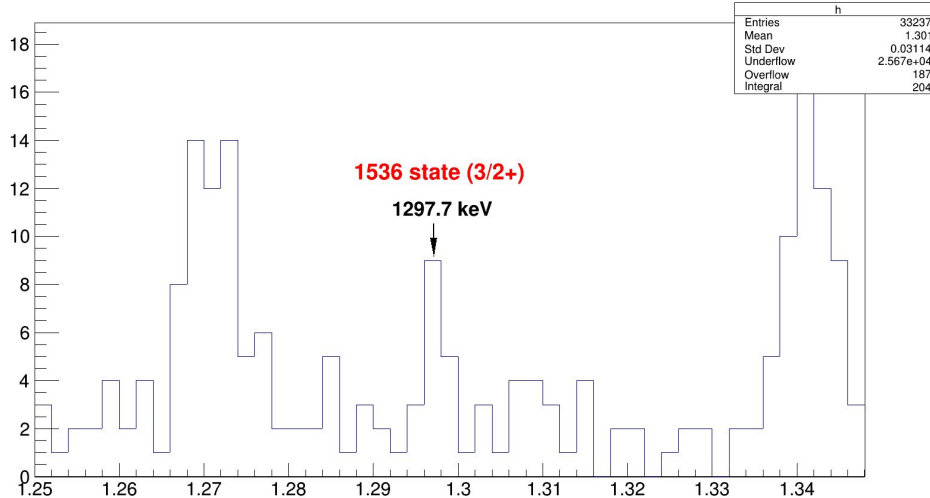


# PRELIMINARY RESULTS: RUN 112-126

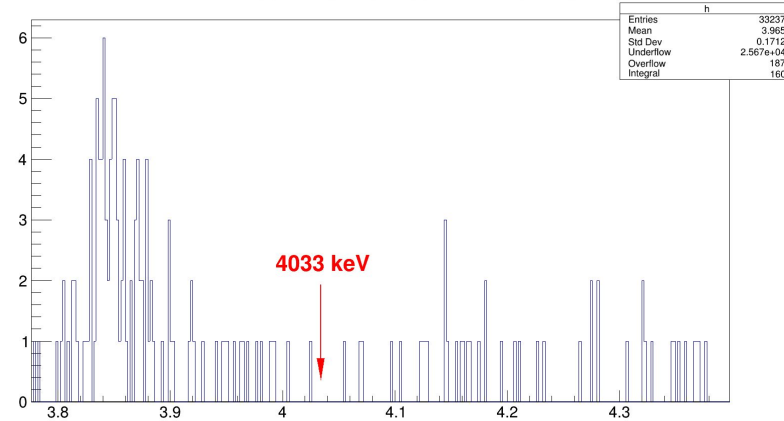


- Observed state **1536 (3/2+)** gamma ray at 1297.7keV
- Zero counts on region of interest at 4033 keV

AddBack\_EDC {abs(mM\_Q2\*9 - 19)<0.3}



AddBack\_EDC {abs(mM\_Q2\*9 - 19)<0.3}

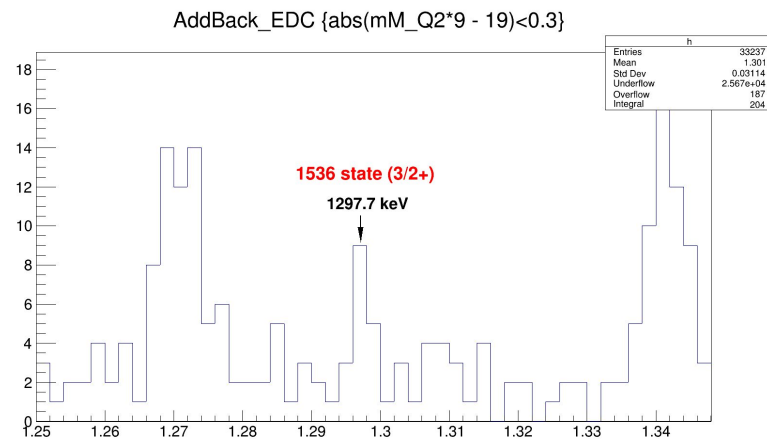


# PRELIMINARY RESULTS: RUN 112-126

## ★ Estimation of the cross section for (3/2<sup>+</sup>) state

- Yield:  $Y = N_{\text{react}} / t = 0.000046 \text{ r/s}$
- $N_{\text{Li}} = 2.895 \text{ e}19 \text{ at/cm}^2$
- Beam Intensity  $I_B = \sim 10^7$
- Efficiency correction:  $= 0.0126$ 
  - MUGAST = 50%
  - AGATA = ~ 7%
  - VAMOS = ~70%
- Branching Ratio correction: 95%
- Charge State correction: 0.40 for 9+

$$\sigma = \frac{Y}{I_B N_{\text{Li}} \epsilon} \longrightarrow \sigma = 17.07 \mu\text{barn}$$





# PRELIMINARY RESULTS: RUN 112-126



★ Comparing ratio between (3/2+) states

- 1536 keV state
- 4033 keV state

★ Upper limit on 4033 keV state

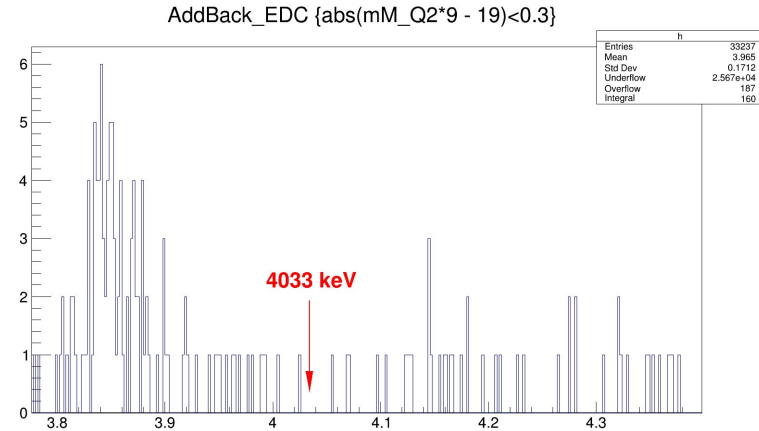
$$R = \frac{Y_1}{Y_2} = \frac{\sigma_1}{\sigma_2} \longrightarrow \sigma_2 = \frac{\sigma_1 N_2}{N_1}$$

★ Assuming  $N_2 = 1$  count on the 4033 keV level.

★  $N_1 = 19$  counts on these runs.

$$\sigma_2 \leq 0.90 \mu\text{barn}$$

★ Cross section within the VAMOS acceptance.



# CONCLUSIONS

- ★ X-ray Bursts consequence of breakout of HCNO cycle in neutron star surfaces.
- ★ Study of  $\alpha + {}^{15}\text{O}$  reaction for understanding X-ray Burst mechanism.
- ★ 4.033 MeV excited state main component of reaction rate at given temperatures.
- ★ Better selectivity with current set up: VAMOS + AGATA + MUGAST
- ★ **PRELIMINARY** estimation of  $\sigma < 0.90 \mu\text{barn}$
- ★ Analysis to be done!