



Structure of light nuclei at GANIL

In view of the 2026 GANIL PAC (December)

D. Gruyer^{1,2}, I. Dekhissi^{1,2}

¹ LPCC, Caen, France

² GANIL, Caen, France

+ Catania and Naples colleagues

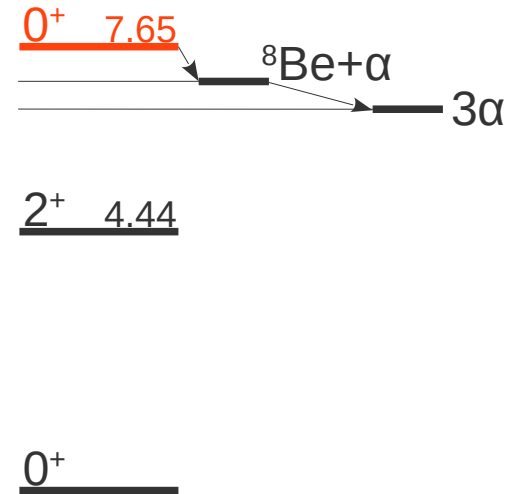


Quick overview of the recent campaign

Hoyle state radius (E881, 2025)

$^{12}\text{C}+^{12}\text{C}$ at 105 MeV with INDRA-FAZIA@GANIL

→ Differential cross-sections for all elastic and inelastic channels to measure the Hoyle state radius (analysis in progress)



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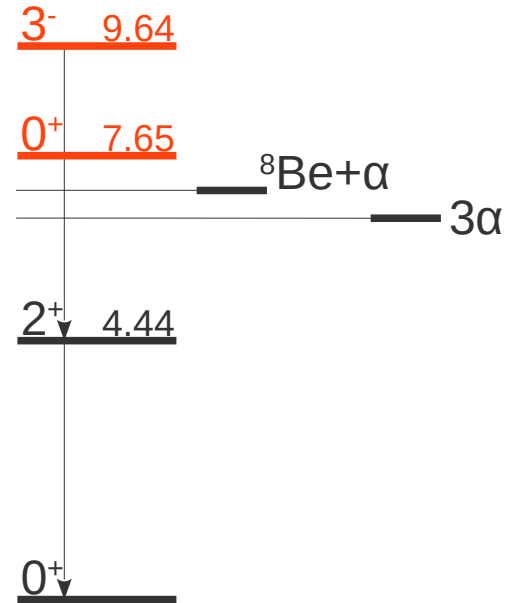
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3^- state gamma decay (T26-01, 2026)

$^{12}\text{C}+\text{CH}_2$ at 130 MeV with INDRA-FAZIA@GANIL

→ p- γ - γ coincidences to measure the gamma decay branching ratio of the 3^- state of interest for hot nucleosynthesis



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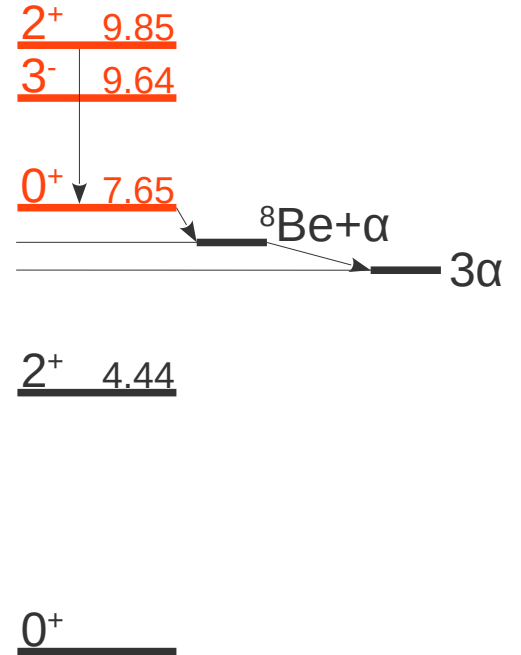
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Hoyle state rotationnal band

$^{12}\text{C}(p,p')^{12}\text{C}^*$ should populate the second 2^+ state that is tentatively associated to a rotationnal band of the Hoyle state. This could be confirmed by measuring the $B(E2; 2^+_2 \rightarrow 0^+_2)$!

→ p- α - α - α coincidences, to be investigated...



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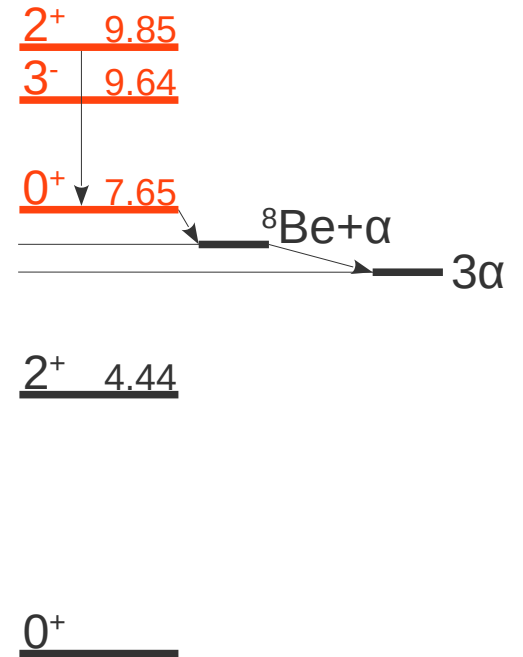
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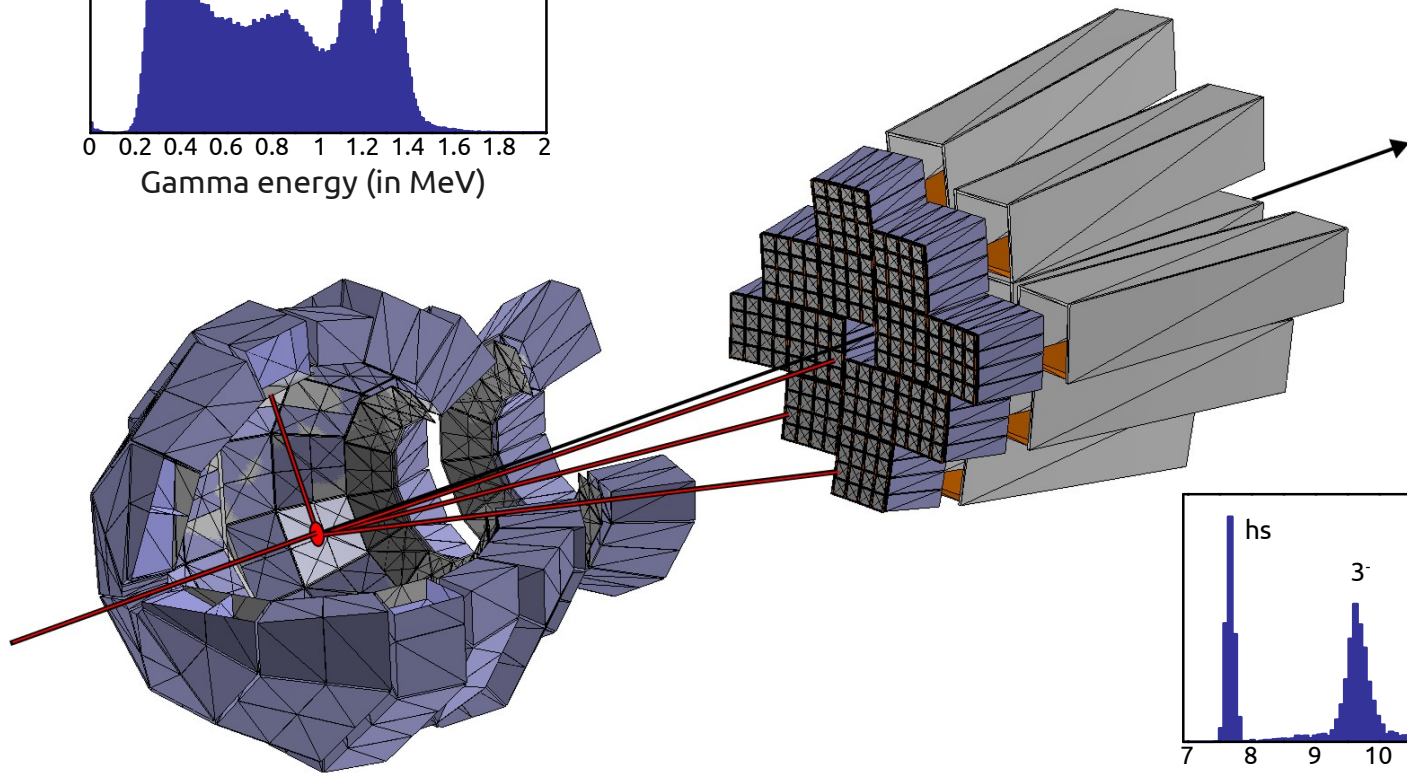
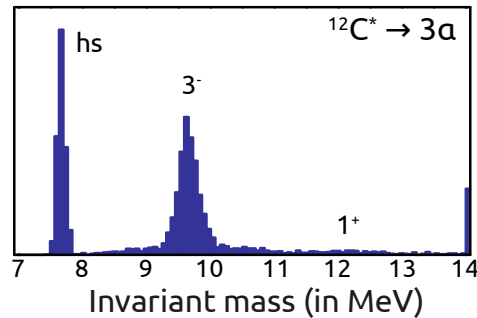
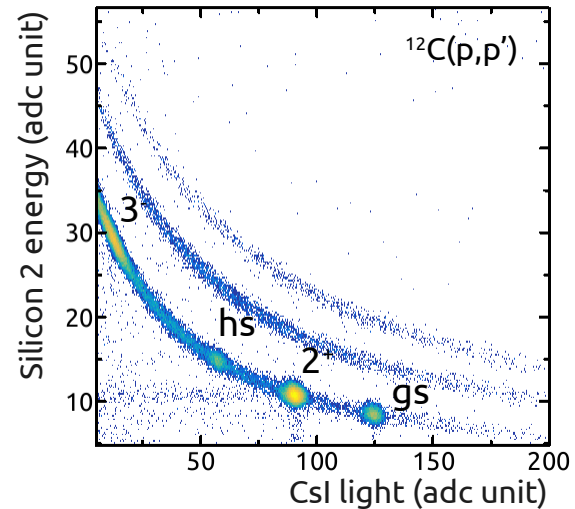
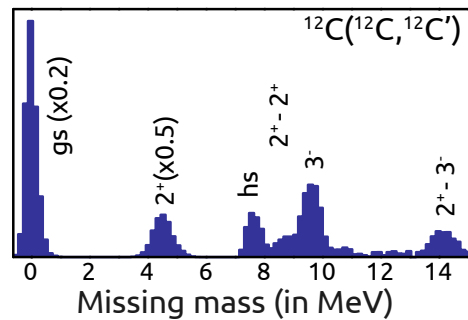
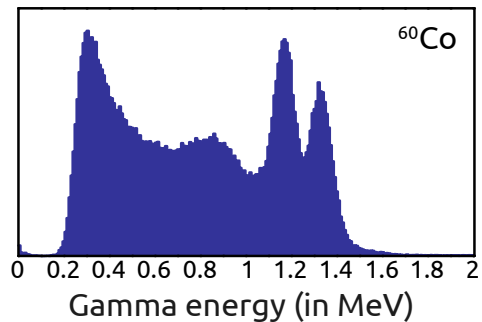
Alpha-clustering in n-rich Oxygens (E894, 2027)

$^{16,18,20}\text{O}(d,^6\text{Li})$ at 120-150 MeV with INDRAFAZIA@GANIL

→ Probe the probability of alpha-cluster formation in the surface of oxygen isotopes with increasing neutron content

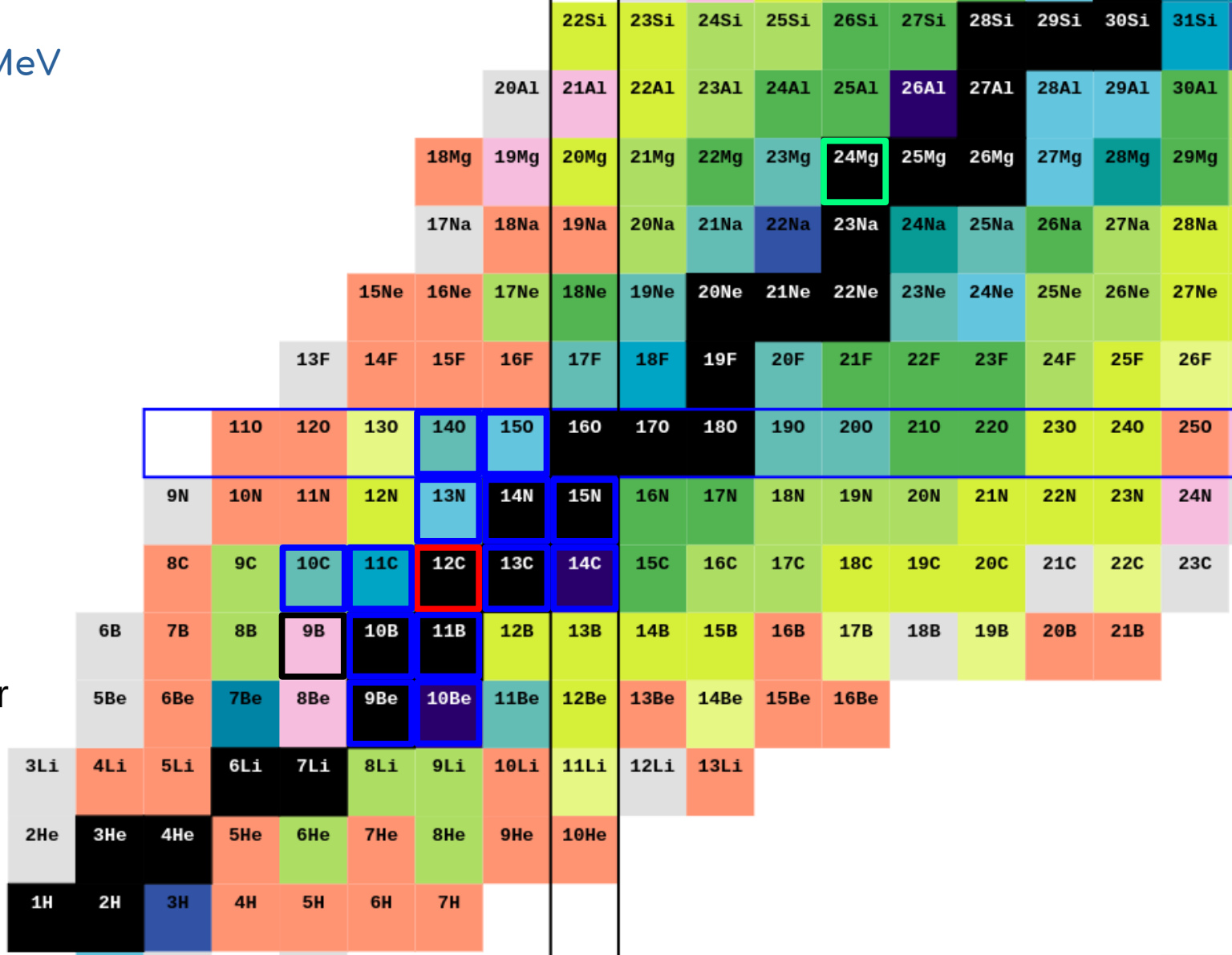


INDRAFAZIA for direct reactions

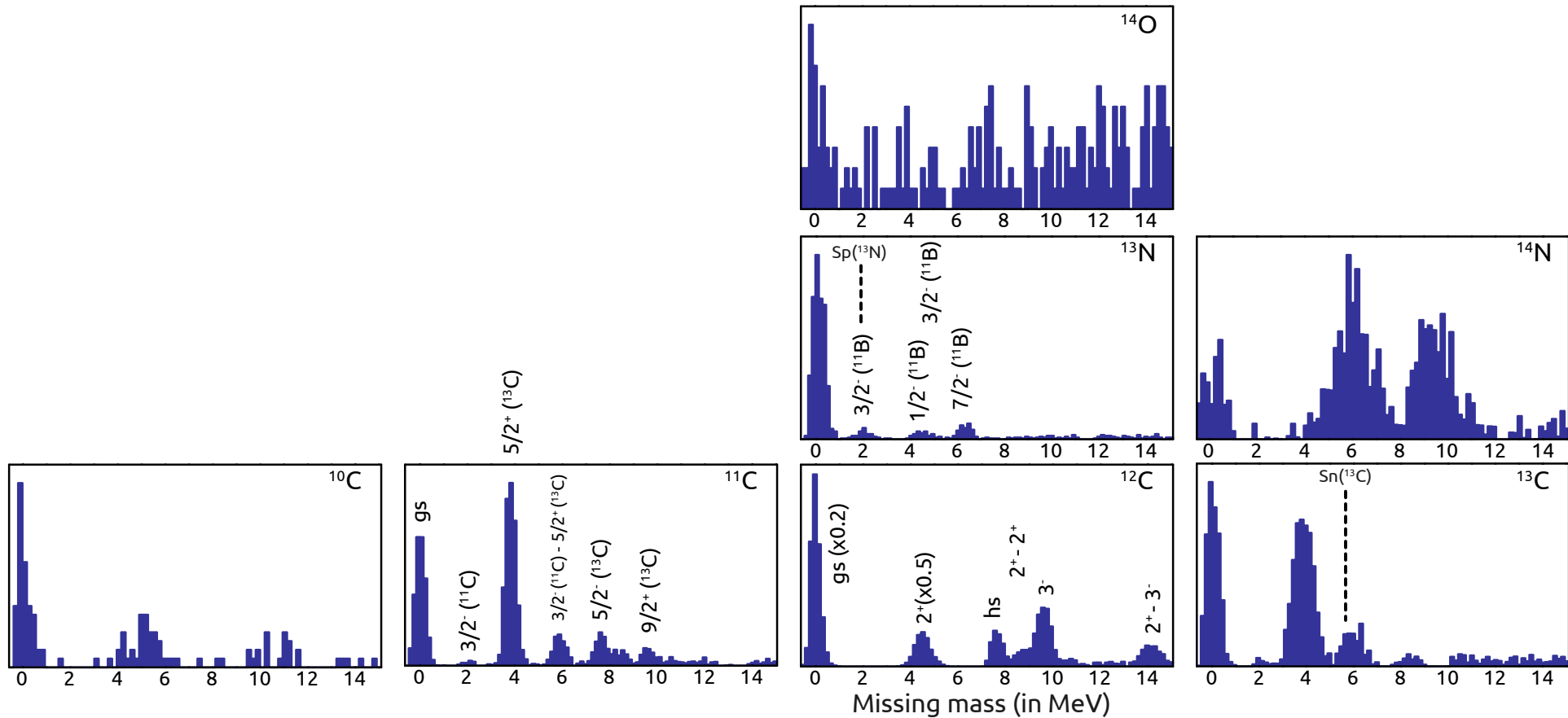


$^{12}\text{C} + \text{C}/\text{CH}_2 \sim 100\text{-}150 \text{ MeV}$

- (p,p') and ($^{12}\text{C}, ^{12}\text{C}'$)
- p, n, d, ^3He transfer
- (p, α)
- fusion



12C + C/CH2 ~ 100-150 MeV





Opportunities with SPIRAL1 beams

Neon-18 beam ($\sim 10^6$ pps)

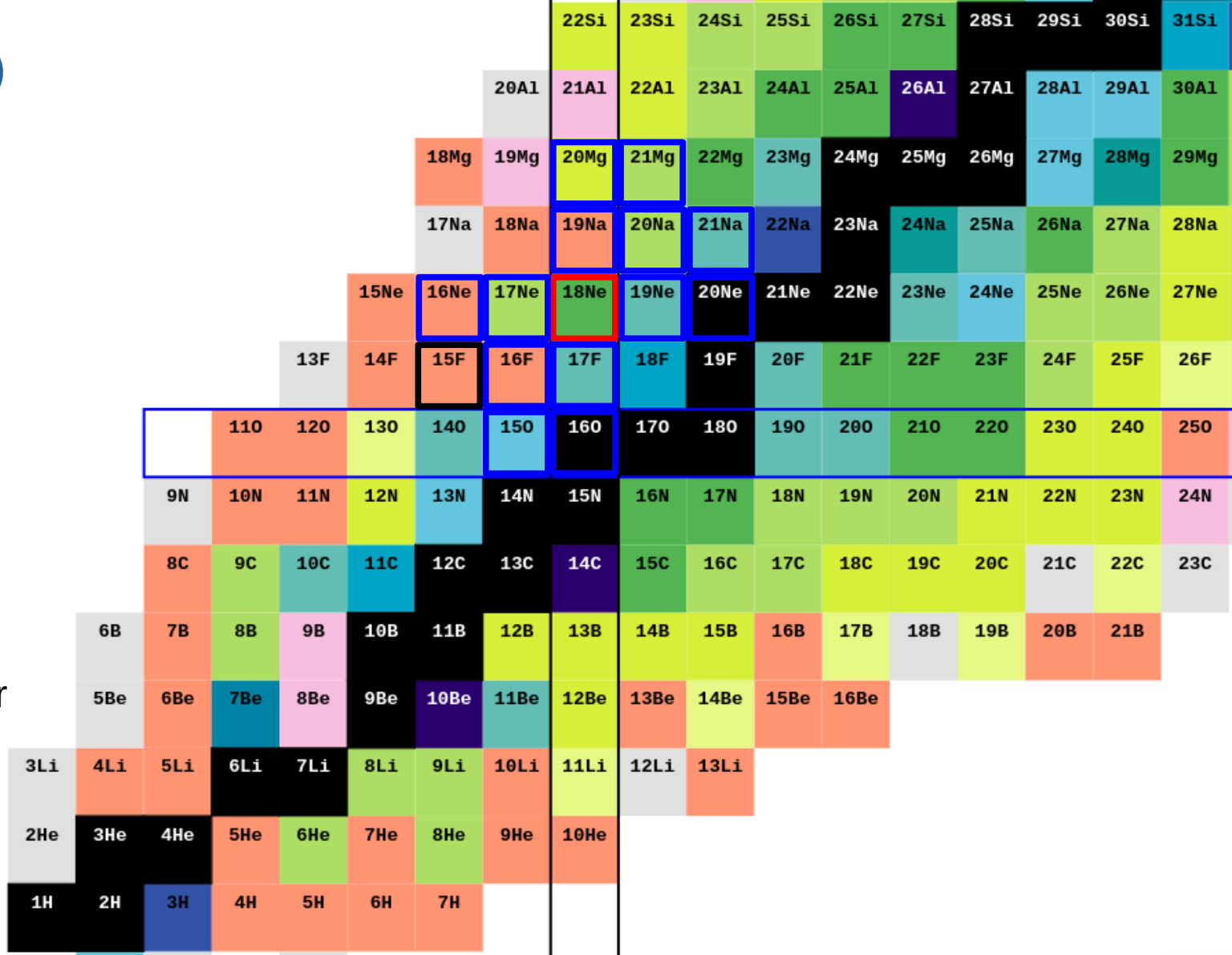
^{18}Ne (p,a) ^{15}F

^{16}Ne , ^{17}Ne

^{19}Na , ^{21}Mg

(...)

- (p,p') and (^{12}C , $^{12}\text{C}'$)
- p, n, d, ^3He transfer
- (p,a)
- fusion



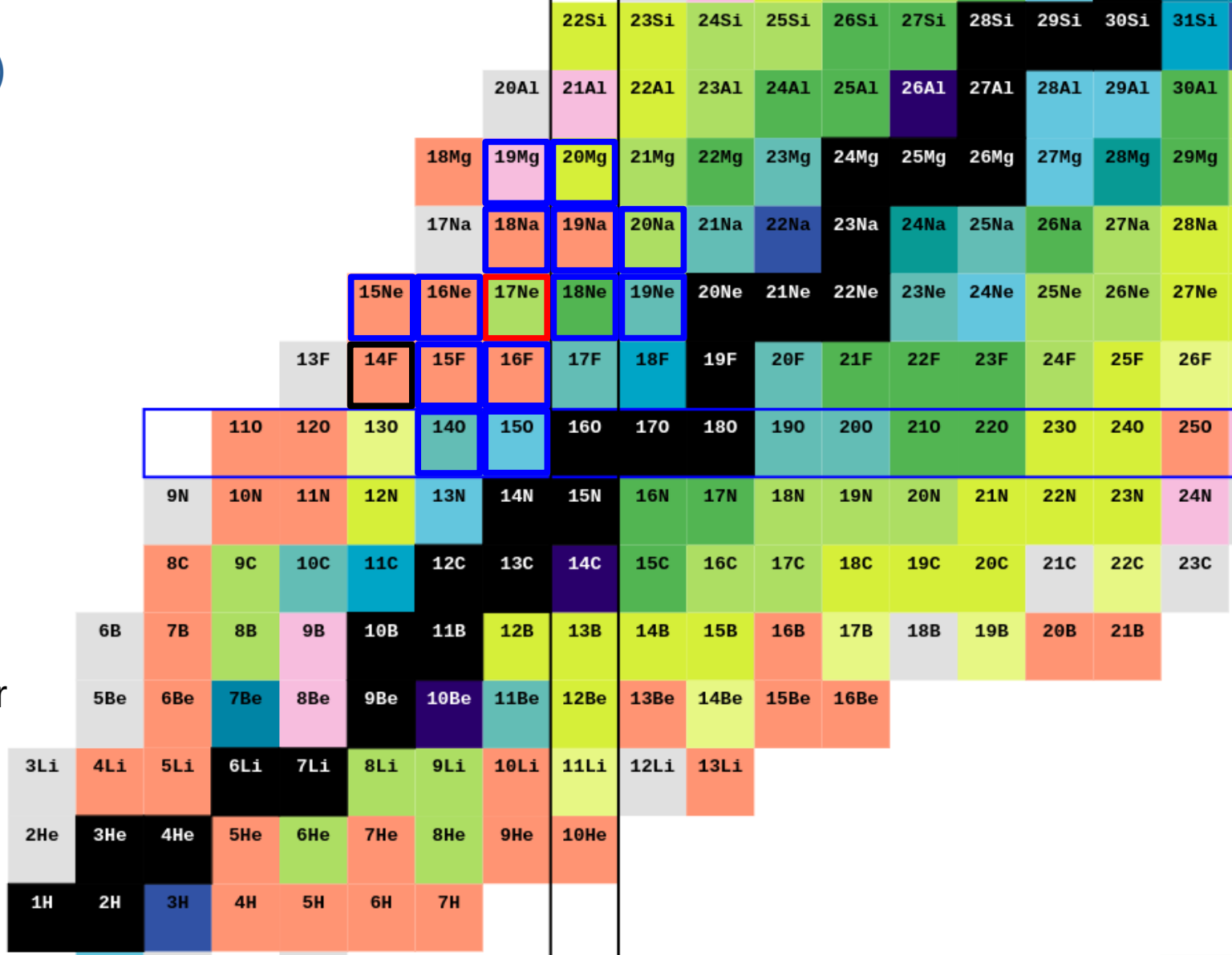
Neon-17 beam ($\sim 10^4$ pps)

^{17}Ne (p,a) ^{14}F

^{15}Ne , ^{16}Ne

^{18}Na , ^{19}Mg

- (p,p') and (^{12}C , $^{12}\text{C}'$)
- p, n, d, ^3He transfer
- (p,a)
- fusion





Possible proposal ?

Hoyle-analog state in ^{13}N

Ying-Yu Cao (曹颖瑜)

Key Laboratory of Nuclear Physics and Ion-beam Application (MOE), Institute of Modern Physics,

Fudan University, Shanghai 200433, China

and Center for Fundamental Physics and School of Mathematics and Physics, Hubei Polytechnic University, Huangshi 435003, China

We investigate the cluster structure of ^{13}N using a microscopic $\alpha + \alpha + \alpha + p$ four-body cluster model. The calculated spectra reasonably agree with the observed spectra in the low-lying states. We calculate the reduced width amplitudes and spectroscopic factors to investigate the Hoyle-analog state in ^{13}N . Our calculations show that the $3/2^-$ state at $E_x = 10.8$ MeV is primarily composed of $^{12}\text{C}(0_2^+) + p$ and $^9\text{B}(3/2^-) + \alpha$ components. This finding is generally consistent with the newly observed $3/2^-$ state at $E_x = 11.3$ MeV via the $3\alpha + p$ decay channel. Moreover, considering the calculated root-mean-square radius and isoscalar monopole transition strength, the $3/2^-$ state emerges as a candidate for the Hoyle-analog state with the $^{12}\text{C}(0_2^+) + p$ cluster structure.

Decay of the proton-unbound superradiant state in ^{13}N

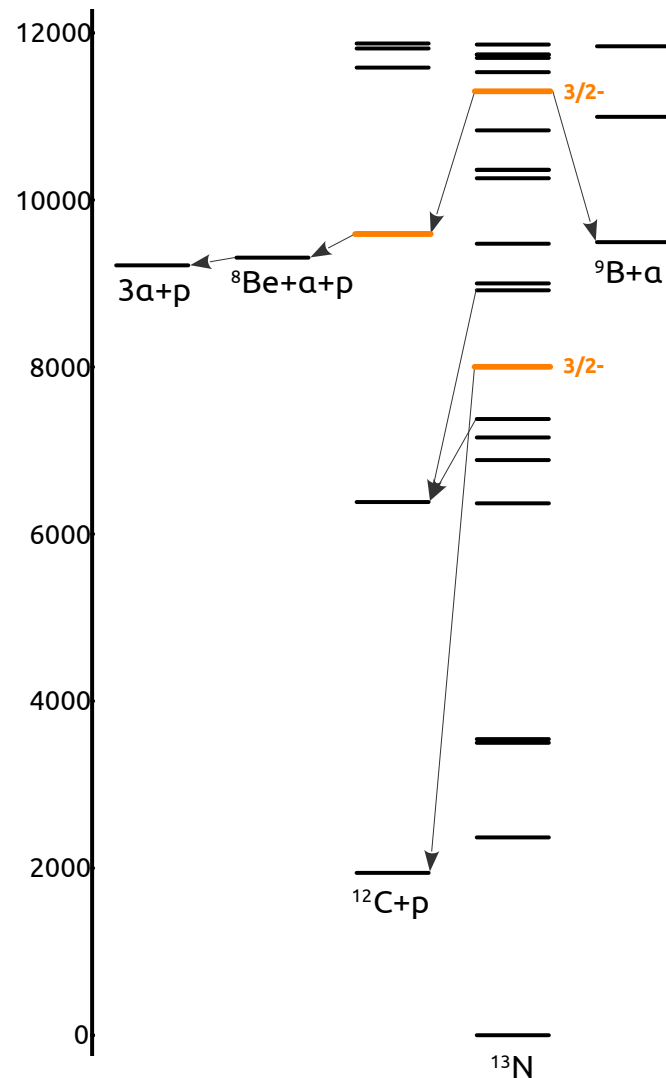
K. Hanselman^{1,*}, I. Wiedenhöver¹, A. Volya¹, L. T. Baby¹, G. W. McCann¹, K. T. Macon^{1,2}

E. C. Good², C. M. Deibel², B. Sudarsan² and J. C. Blackmon²

¹Department of Physics, Florida State University, Tallahassee, Florida 32301, USA

²Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana 70803, USA

The $^{12}\text{C}(^3\text{He}, d)^{13}\text{N}^*$ reaction is studied in an experiment with a high-resolution magnetic spectrograph, in coincidence with protons detected in silicon detectors near the target. This allows for the observation of angular correlation patterns between the proton transfer and proton decays from populated unbound resonances. A formalism describing the spin polarization of direct reactions is developed to analyze these correlations, and is verified on the known directionally asymmetric decay distributions arising from parity mixing in the $^{13}\text{N}(\frac{3}{2}^-, \frac{5}{2}^+)$ doublet. The same formalism is used to study the decays from the continuum-aligned, broad $3/2^+$ resonance at 7.9 MeV excitation energy, which arises from superradiant coupling. The observed asymmetric angular correlation patterns are approximately reproduced by adding an “artificial” $3/2^-$ resonance with strength equal to that of the reaction formalism. This parity-mixing approach serves as a first approximation to a more advanced reaction model of rapid reaction and decay sequences.



Nitrogen-13 continuum states

Study the Hoyle-analogue state, confirm the spin and decay properties...

Study the decay properties of the superradiant state (other cases?)

→ $^{13}\text{N} (p,p') ^{13}\text{N}^*$

By-products

Study ^{10}C populated by (p,a) reactions

Invariant mass and missing mass spectroscopy of all transfer products

But

The next PAC might not be open to SPIRAL1 proposals...

Can be also populated in proton transfer from ^{12}C , but beam already asked twice...

Other ideas with stable beams ? $^{15}\text{N} (p,a) ^{12}\text{C}^* (1^+ \text{ at } 15.1 \text{ MeV}) ?$

We should have a look at $^{12}\text{C} + \text{CD}_2$ data from T26-01 !

The Oxygen run (2027) might give new ideas...



Work in progress...