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Experimental Study on Negative-parity Linear-chain Rotational Bands in ^{16}C

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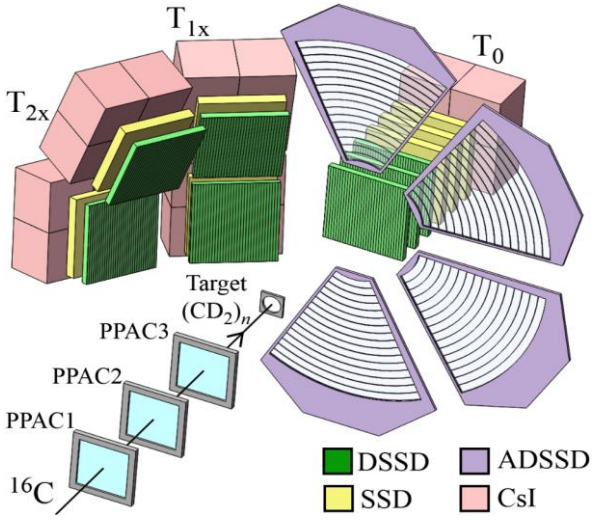
Catalogue

- Research Background
- Experiment in 2022 at RIBLL1@HIRFL,Lanzhou
- Data Analysis
- Result and Discussion
- Summary and Prospect

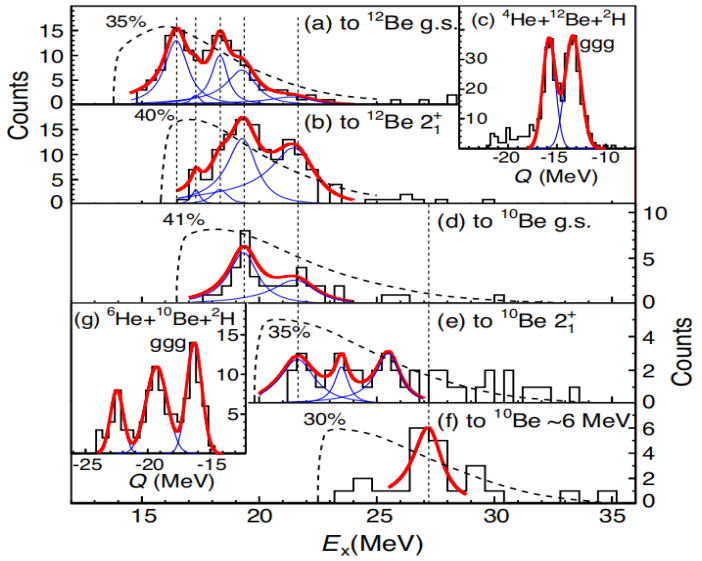
Research Background

Experiment on Positive-parity Linear-chain Rotational Bands in ^{16}C in 2018

Detectors setup



Excitation energy spectra

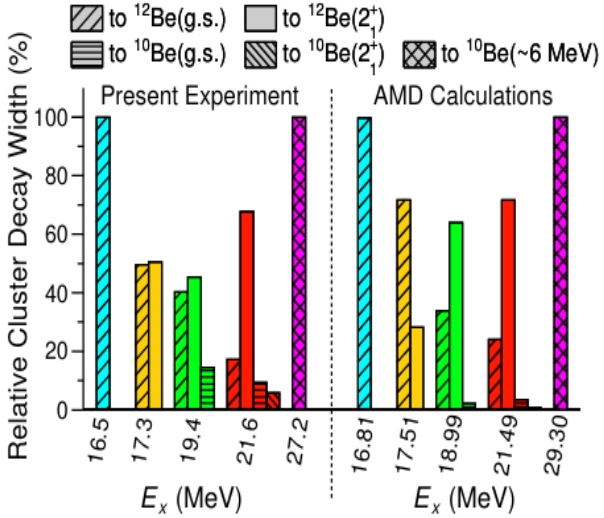


[1] Y. Liu, et. al., Phys. Rev. Lett, 124, 192501 (2020);
[2] 刘洋, 北京大学博士研究生学位论文, 2020;

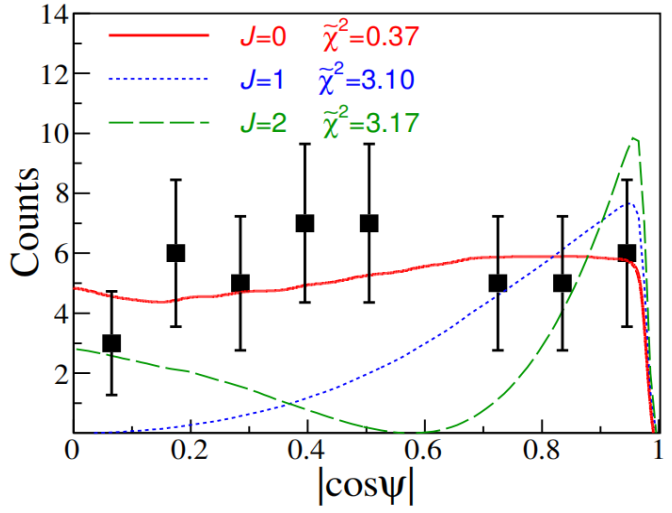
Present work			AMD calculations [21]	
E_x (MeV)	J^π	Γ_{tot} (keV)	E_x (MeV)	J^π
16.5(1)	0^+	1200(200)	16.81	0^+_6
17.3(2)		400(200)	17.51	2^+_9
18.3(1)		800(100)		
19.4(1)		1500(160)	18.99	4^+_{10}
21.6(2)		2200(200)	21.49	6^+_5
23.5(2)		680(200)		
25.5(2)		1230(200)		
27.2(1)		1460(200)	29.30	0^+_{14}

Selective decay properties

★ Structural link in population and decay

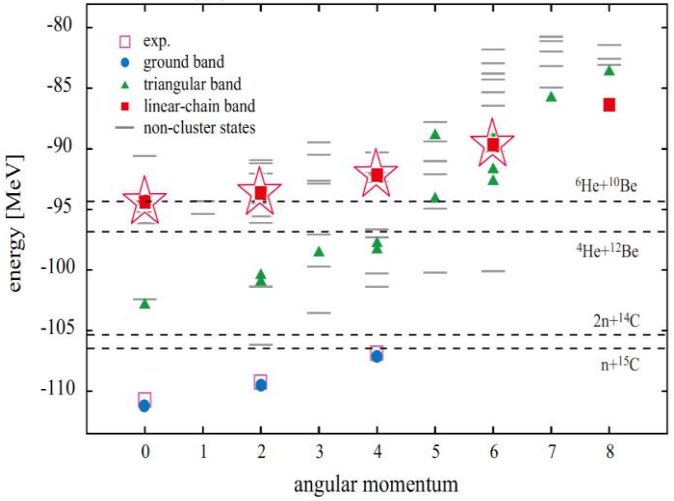


Spin determination in 16.5 MeV



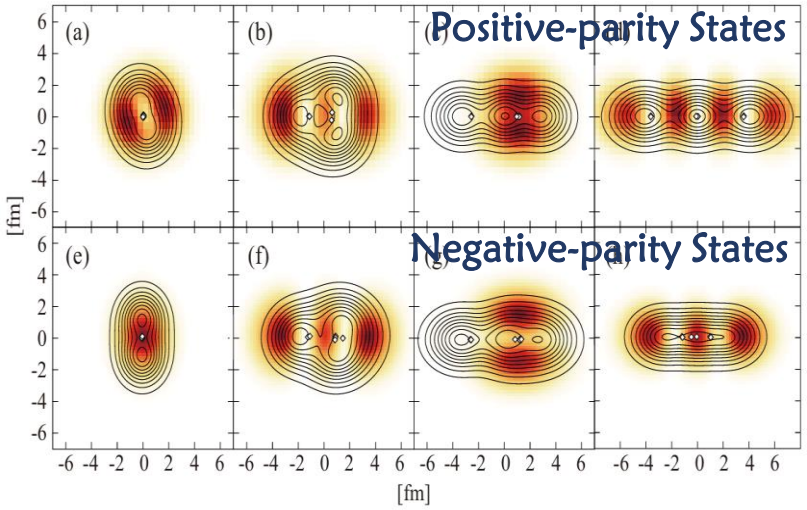
In comparison to theory predictions

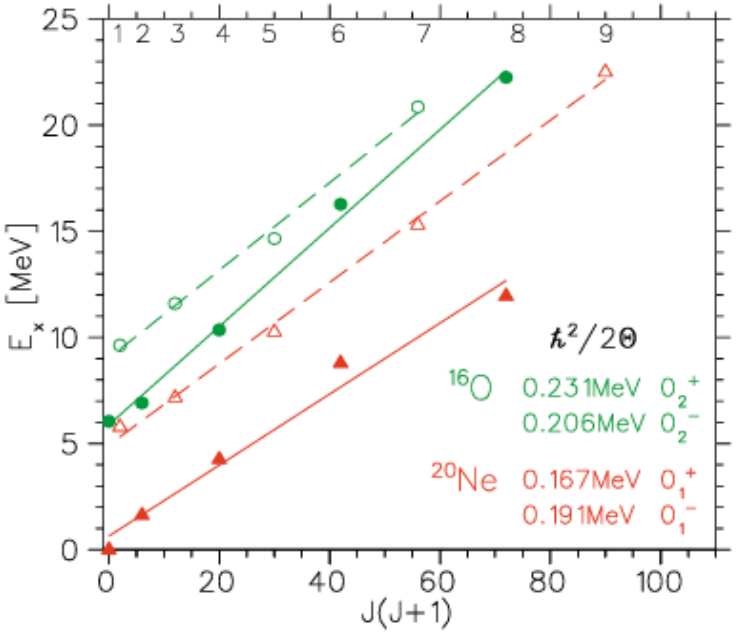
★ E_x–spin systematics



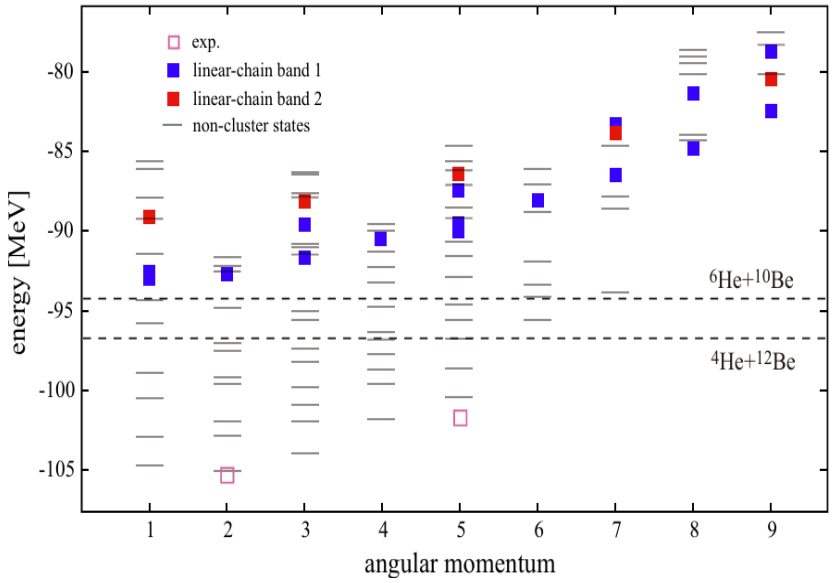
Research Background

Parity-inversion doublet





Theoretical Prediction



(a) Positive parity

J^π	E_x	$\Gamma_\alpha(^{12}\mathrm{Be}(0_1^+))$	$\Gamma_\alpha(^{12}\mathrm{Be}(2_1^+))$	$\Gamma_{^6\mathrm{He}}(^{10}\mathrm{Be}(0_1^+))$	$\Gamma_{^6\mathrm{He}}(^{10}\mathrm{Be}(2_1^+))$
0_6^+	16.81	335	1		
2_9^+	17.51	300	118	0	
4_{10}^+	18.99	505	954	33	
6_5^+	21.49	535	1591	78	18

(b) Negative parity

J^π	E_x	$\Gamma_\alpha(^{12}\mathrm{Be}(0_1^+))$	$\Gamma_\alpha(^{12}\mathrm{Be}(2_1^+))$	$\Gamma_{^6\mathrm{He}}(^{10}\mathrm{Be}(0_1^+))$	$\Gamma_{^6\mathrm{He}}(^{10}\mathrm{Be}(2_1^+))$
1_{11}^-	22.05	198	567	77	63
3_{14}^-	23.00	196	597	84	115
5_{15}^-	24.76	181	615	92	173
7_6^-	27.35	224	763	100	225

J^π	E_x	$\Gamma_\alpha(^{12}\mathrm{Be}(\mathrm{g.s.}))$	$\Gamma_\alpha(^{12}\mathrm{Be}(0^+;13.6\,\mathrm{MeV}))$	$\Gamma_{^6\mathrm{He}}(^{10}\mathrm{Be}(\mathrm{g.s.}))$	$\Gamma_{^6\mathrm{He}}(^{10}\mathrm{Be}(0_2^+))$
0^+	31.72	1	90	4	175
2^+	31.98	0	75	1	187
4^+	32.71	2	68	2	178

Positive-parity $(3/2_\pi^-)^2\,(1/2_\sigma^-)^2$–bond

Negative-parity mixed bond

Positive-parity $(1/2_\sigma^-)^2\,(1/2_\sigma^+)^2$–bond

[1] T. Baba, et al., Phys. Rev. C, 94, 044303 (2016) ;
[2] W. von Oertzen, et al., Eur. Phys. J. A, 43: 17 (2010);
[3] T. Baba, et al., Phys. Rev. C, 97, 054315 (2018) ;

Excitation energy

Lower

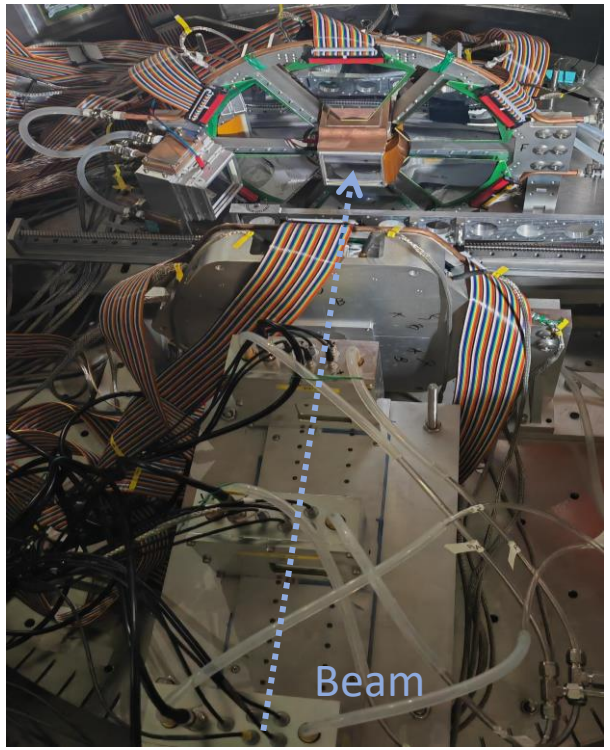
Higher

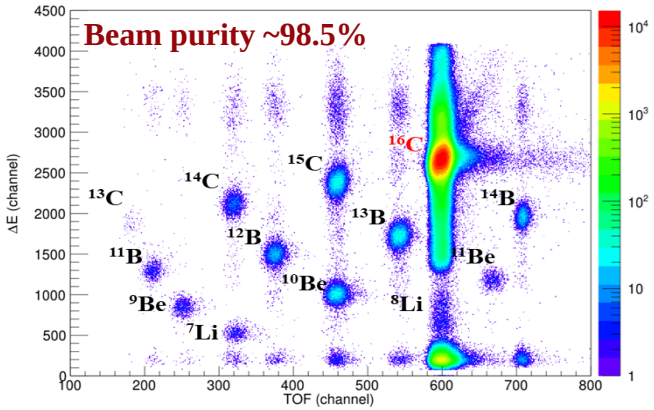
Experiment in 2022

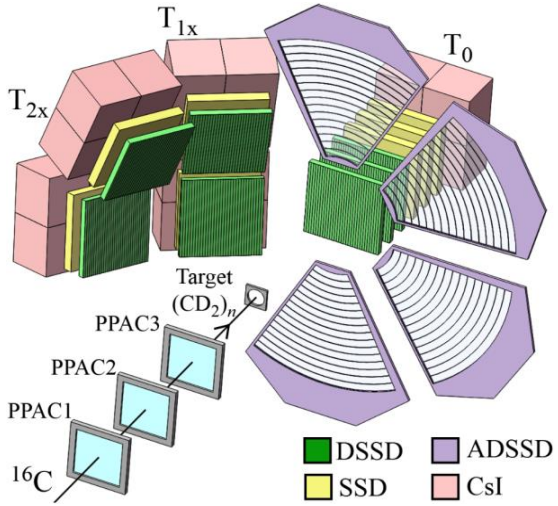
At RIBLL1@HIRFL, Lanzhou

Experiment in 2022

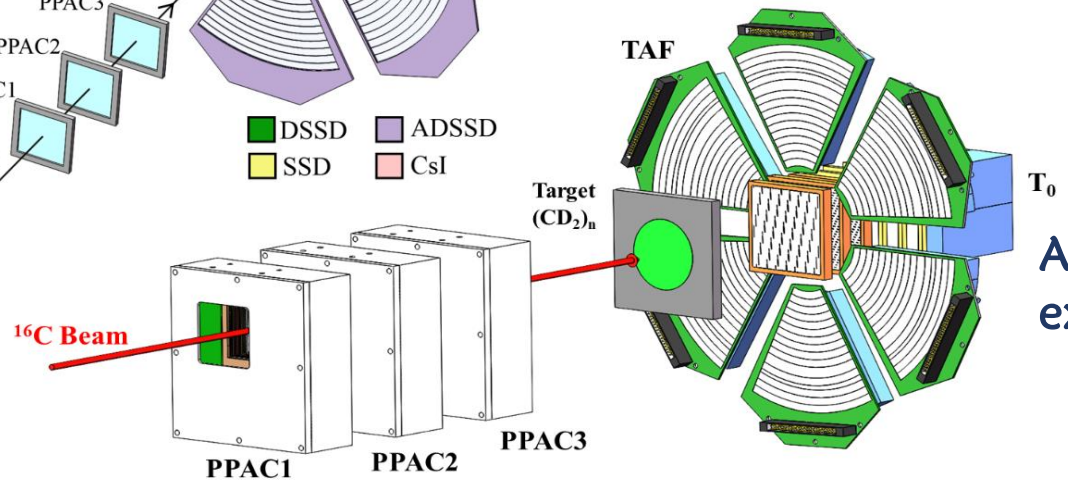
Detectors setup





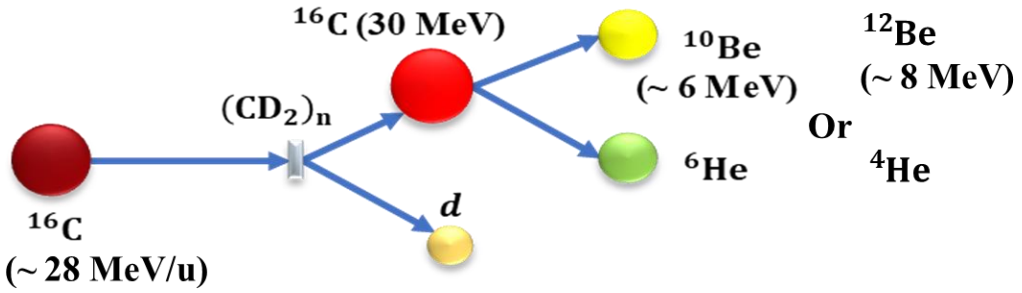


A schematic view of the experimental setup in 2018



A schematic view of this experimental setup

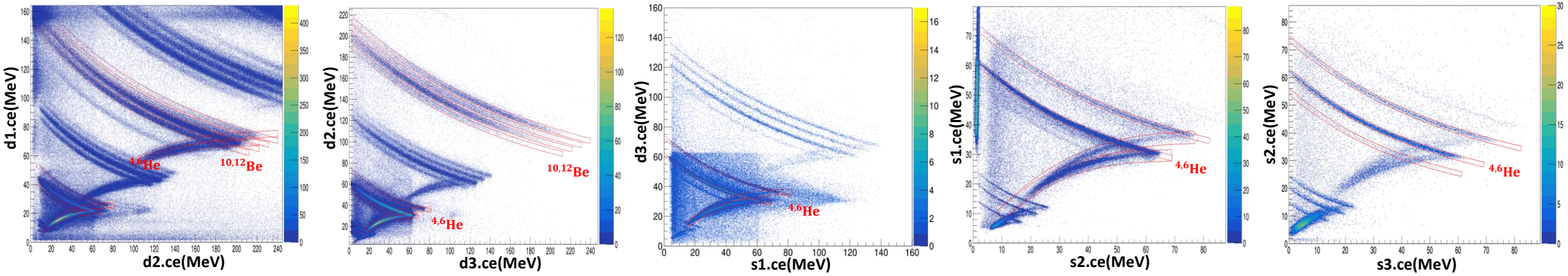
Targeted reaction channels



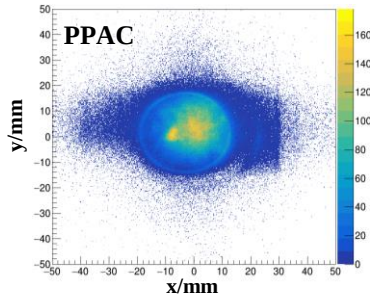
Data Analysis

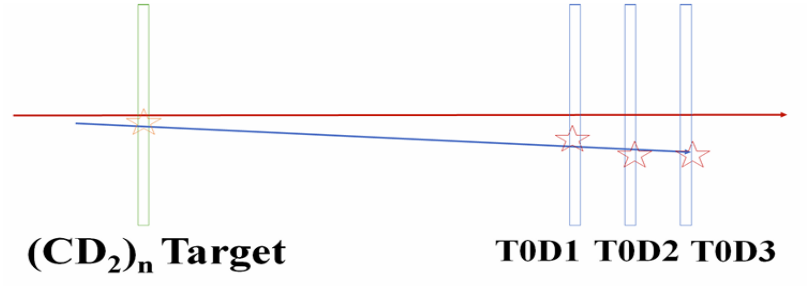
Data Analysis

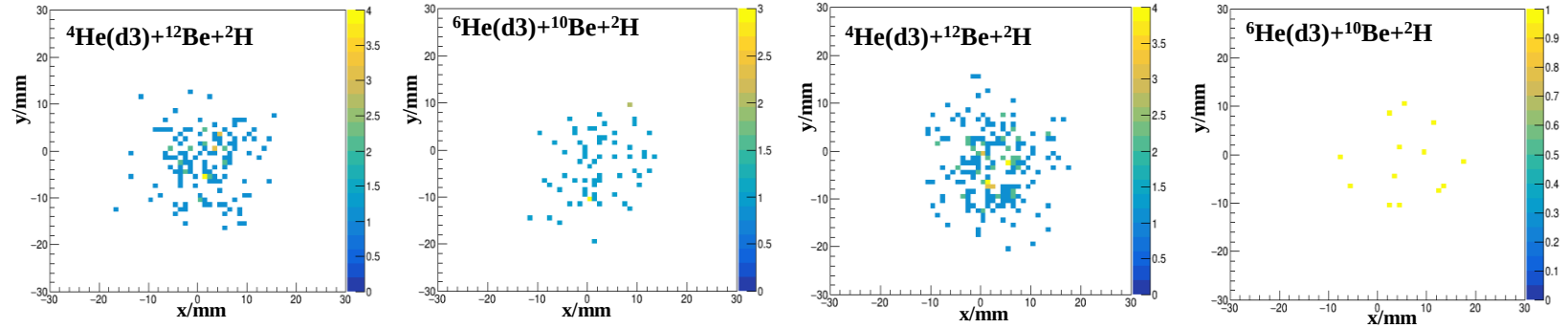
Particle identification(PID) spectrum



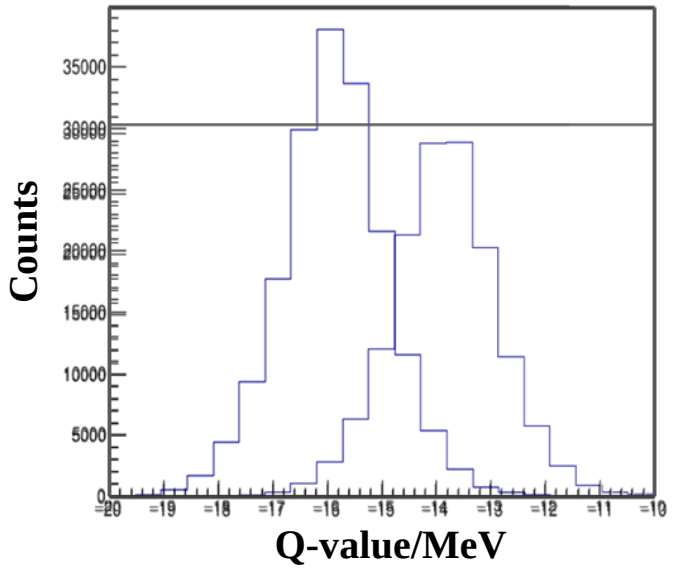
Reaction point







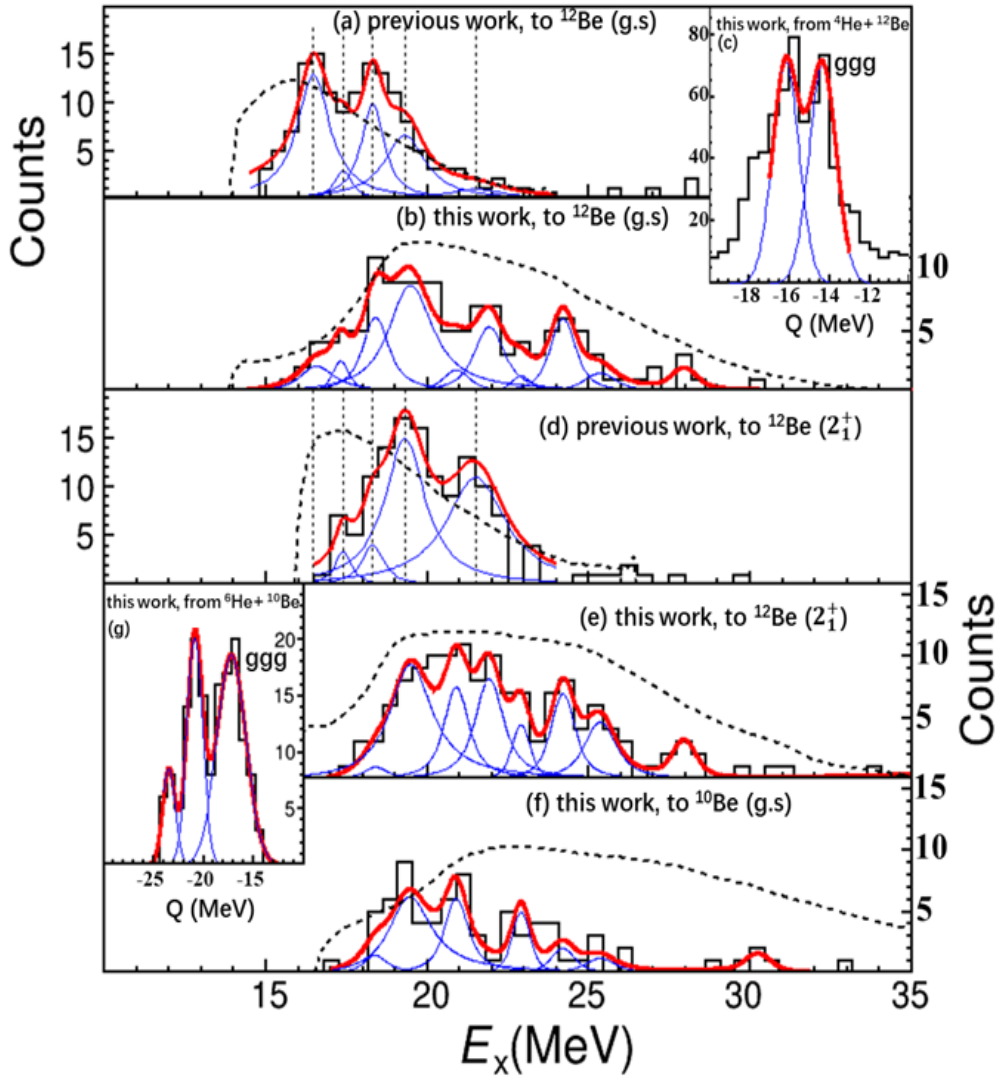
Simulation result



Result and Discussion

Result and Discussion

Excitation energy spectra

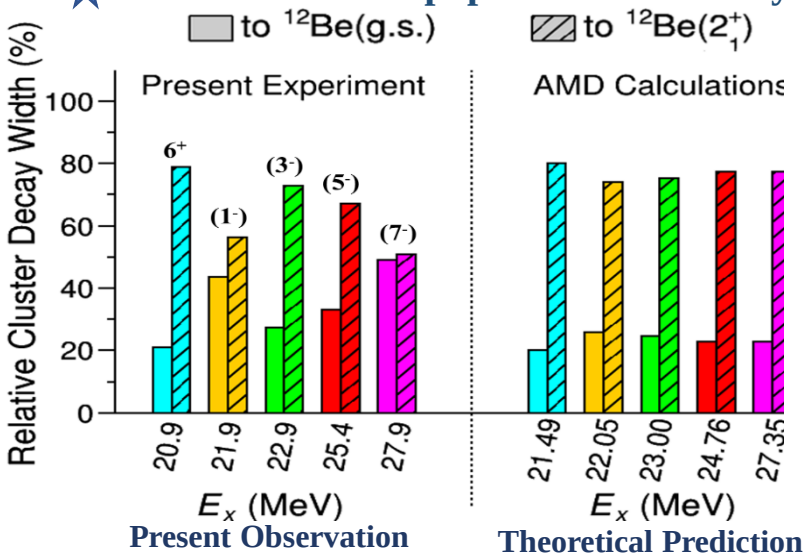


present observation			predicted[51, 52, 59]		previous observation [50, 135, 138]		
E_x(MeV)	J^π	Γ_{tot}(keV)	E_x	J^π	E_x(MeV)	J^π	Γ_{tot}(keV)
16.6(1)		1225(200)	16.81	0^+_6	16.5(1)	0^+	1200(200)
17.3(1)		401(200)	17.51	2^+_9	17.3(2)	2^+	400(200)
18.4(1)		811(100)			18.3(1)		800(100)
19.4(1)		1521(160)	18.99	4^+_{10}	19.4(1)	4^+	1500(160)
20.9(2)		704(70)	21.49	6^+_5	21.6(2)	6^+	2200(200)
21.9(2)	(1^-)	843(50)	22.05	1^-_{11}			
22.9(2)	(3^-)	302(120)	23.00	3^-_{14}			
24.2(2)	(8^+)	561(50)			23.5(2)[c]		680(200)
25.4(2)	(5^-)	865(70)	24.76	5^-_{15}	25.5(2)[c]		1230(200)
27.9(2)	(7^-)	376(50)	27.35	7^-_6			

Result and Discussion

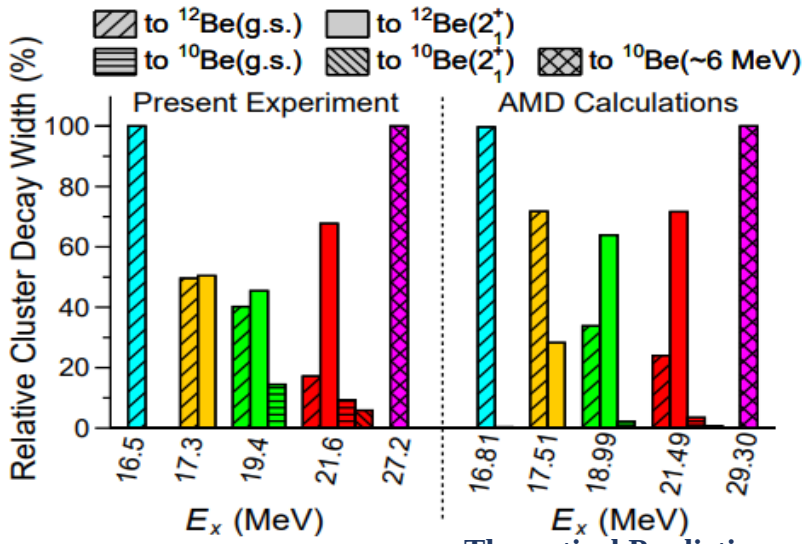
Selective decay properties

★ Structural link in population and decay



Present Observation

Theoretical Prediction of Negative-parity

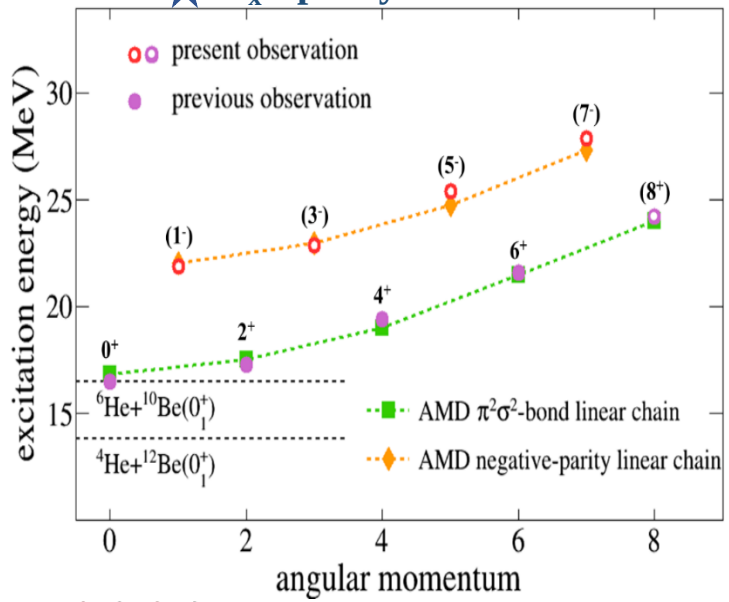


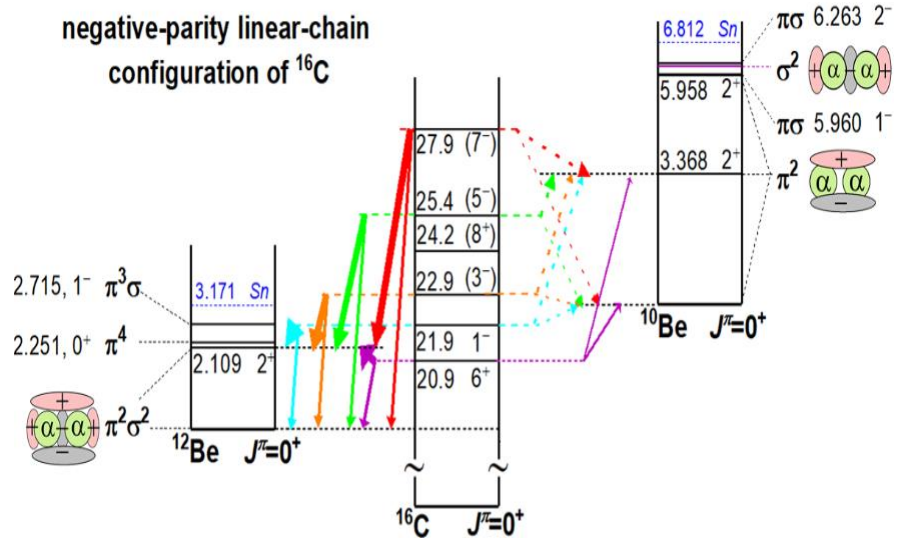
Previous Observation

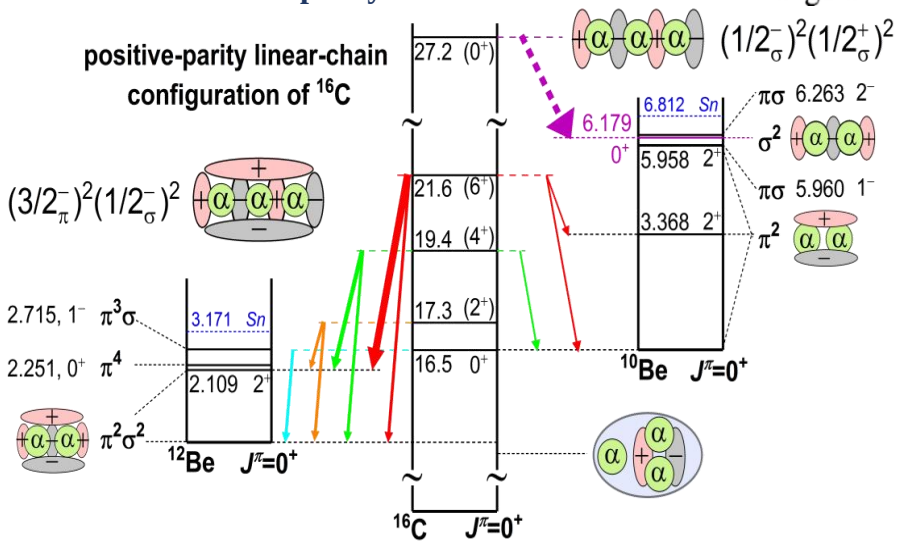
Theoretical Prediction of Positive-parity

Extension of positive-parity band

★ E_x–spin systematics







Summary and Prospect

Summary and Prospect

- Search for the negative-parity linear-chain molecular band would be a necessary supplement to the existence of exotic molecular structure and the previous work on the positive-parity states.
- A new inelastic excitation and cluster decay experiment was conducted with ^{16}C beam at 28 MeV/nucleon and a $(CD_2)_n$ target.
- Owing to the developed detector setup and data analysis methods, several new resonant states have been observed:

  (1) agree with previously reported positive-parity states;

  (2) modify the previous observation of 6^+ member state, and extend positive-parity linear chain rotational band to the 8^+ member state;

  (3) assign the newly observed states at 21.9, 22.9, 25.4 and 27.9 MeV as the 1^-, 3^-, 5^- and 7^- members of the negative-parity linear chain molecular rotational band.

Thank you for your listening !