



Precise measurement of the gamma decay probability of the 3- state of ^{12}C

G. Cardella¹, I. Dekhissi^{2,3}, J.D. Frankland³,
D. Gruyer^{2,3}, N. Le Neindre², N. S. Martorana¹
(FAZIA and CHIMERA Collaborations)

¹ INFN Catania, Italy

² LPCC, Caen, France

³ GANIL, Caen, France

April 2025 - $^{12}\text{C} + ^{12}\text{C}$ @ 105 MeV (e881)
 - $^{12}\text{C} + \text{CH}_2$ @ 105 MeV (e881)

June 2025 - $^{12}\text{C} + ^{12}\text{C}$ @ 165 MeV (e884)

Oct. 2025 - INDRA CsIs gamma calibration

Dec. 2025 - Rumors about CSS2 availability

Jan. 2026 - call for internal proposal at GANIL

Jan. 2026 - experiment proposal sent to GANIL

Feb. 2026 - T26-01 ~officially scheduled

Mar. 2026 - $^{12}\text{C} + \text{CH}_2$ @ 138 MeV

	2h00		20Ne		
	6h00				
Tuesday	10h00			chgt salle	Mode Z
31-Mar	14h00		Standby	SME pilot	T26-01 D5 ??
	18h00			P1449	
	22h00			Jamal Mohammad S.	
	2h00			2 UT	
	6h00			P1469	4 UT
Wednesday	10h00			L. Goodwin	
1-Apr	14h00			1,5 UT	
	18h00				
	22h00	186W		20Ne	
	2h00	P1449		13.7 MeV/u	
	6h00	Shahid			
Thursday	10h00			D1	
2-Apr	14h00			Test	
	18h00	Irradiation		3 UT	
	22h00	plaques			
	2h00				
	6h00				
Friday	10h00	Changement			Mode Z
3-Apr	14h00	Chambre			
	18h00				
	22h00				
Saturday	2h00			SME	
4-Apr	6h00	Degazage		pilot	
	10h00				T26-01
	14h00				D5 ??
	18h00				
	22h00				
	2h00				
	6h00				
Sunday	10h00				
5-Apr	14h00				
	18h00				
	22h00				
	2h00				
	6h00				
Monday	10h00				
6-Apr	14h00				
	18h00				
	22h00				
	2h00				
	6h00				
Tuesday	10h00				
7-Apr	14h00				

High temperature nucleo-synthesis

In normal stars, ^{12}C is mostly produced by the three alpha process through the Hoyle state (7.65 MeV).

At higher temperature, the 3^- (9.64 MeV) state might contribute but the poor knowledge of the 3^- gamma decay branching ratio leads to very uncertain rates.

Partial width history

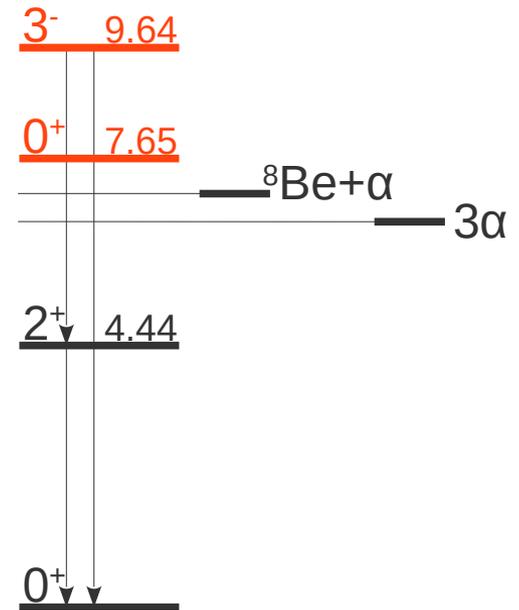
- $\Gamma_\gamma = 0.31 \text{ meV}$: Crannell et al. (1967) (e,e')
- $\Gamma_{\text{rad}}/\Gamma_{\text{tot}} < 10^{-7}$: Chamberlin (1974) (p,p') [$p\text{-}^{12}\text{C}$]
- $\Gamma_{\text{rad}}/\Gamma_{\text{tot}} = 1.3(1.2) 10^{-6}$: Tsumura (2021) (p,p') [$p\text{-}^{12}\text{C}$]
- $\Gamma_{2\gamma}/\Gamma_{\text{tot}} = 6.4(5.1) 10^{-5}$: Cardella (2021) (p,p') [$p\text{-}^{12}\text{C}\text{-}\gamma\text{-}\gamma$]

T26-01

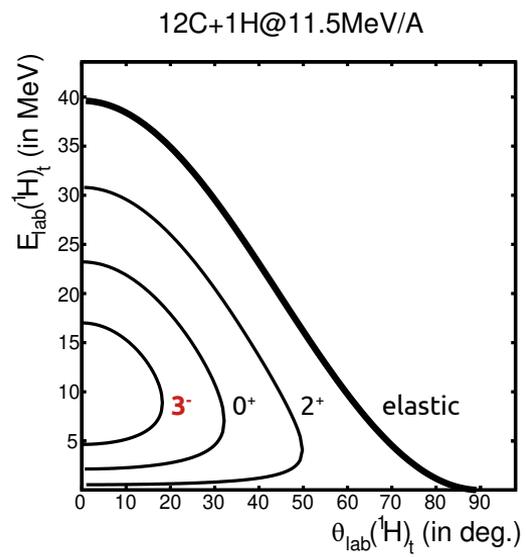
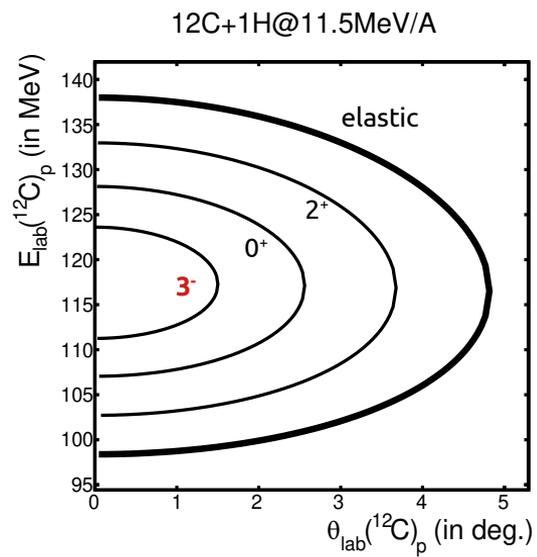
Measure $\Gamma_{2\gamma}/\Gamma_{\text{tot}}$ in (p,p') reaction with [$p\text{-}\gamma\text{-}\gamma$] coincidences benefiting from the good resolution of FAZIA for detecting the protons and the good efficiency of INDRA for the gamma rays.

→ 30% relative uncertainty on $\Gamma_{2\gamma}/\Gamma_{\text{tot}}$

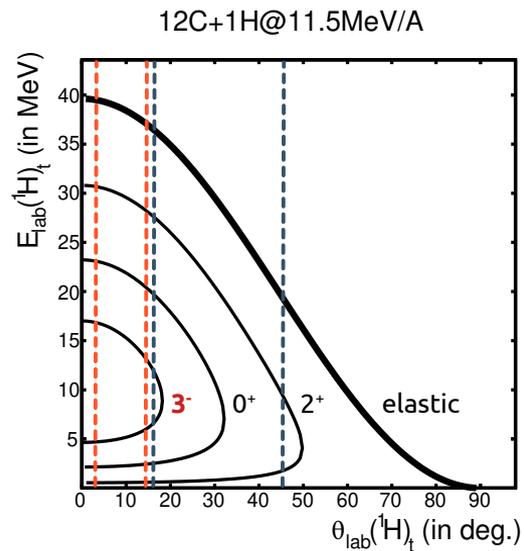
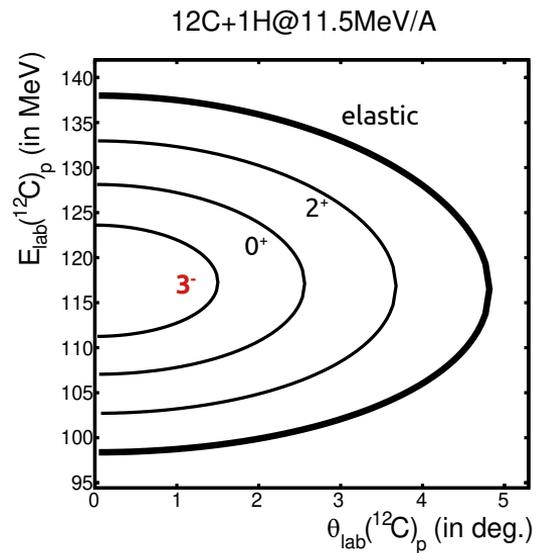
→ $^{12}\text{C} + \text{CH}_2$ @ 11.5 MeV/nuc.



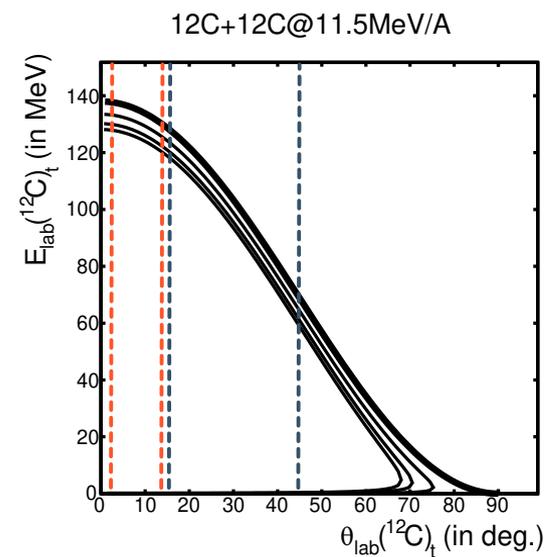
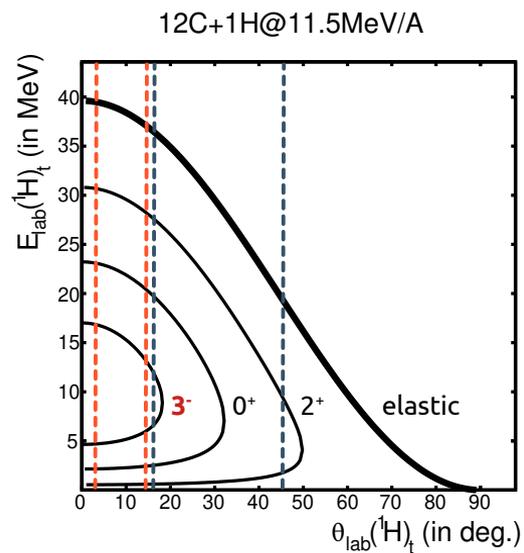
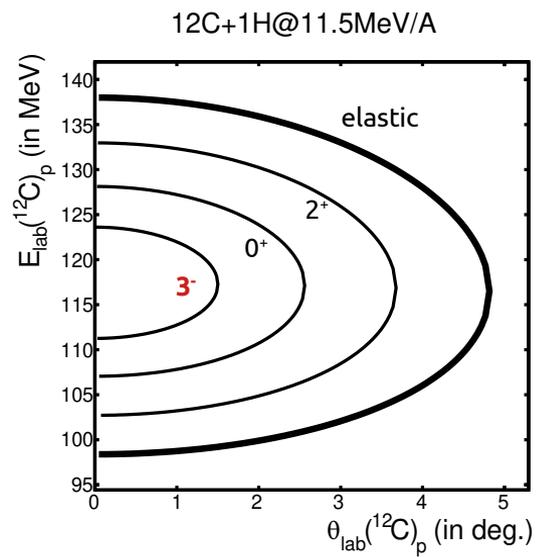
Kinematics and energy choice



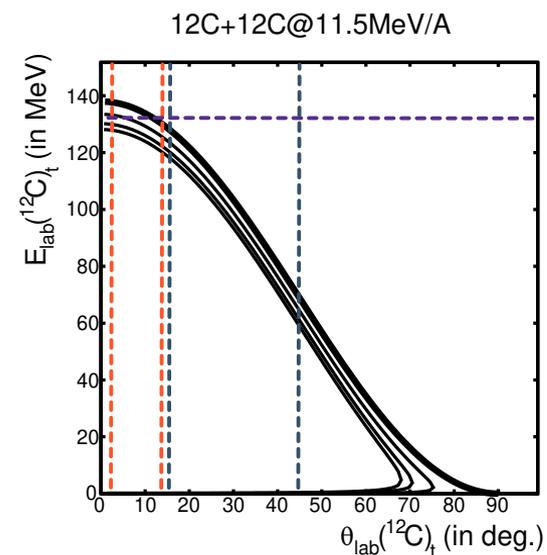
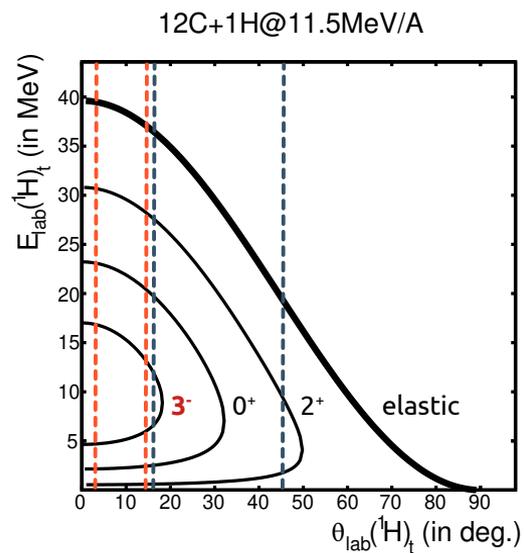
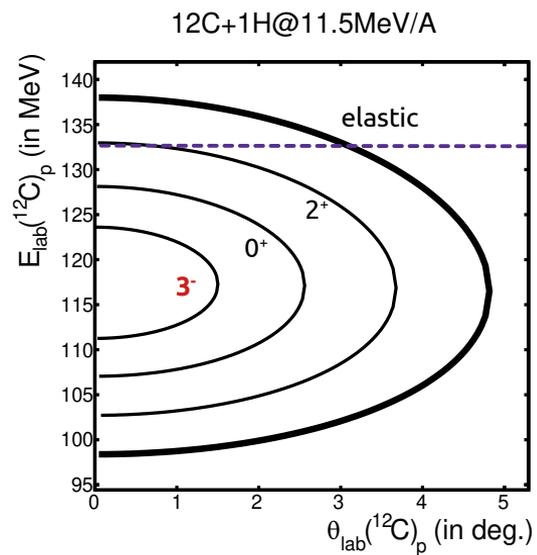
Kinematics and energy choice



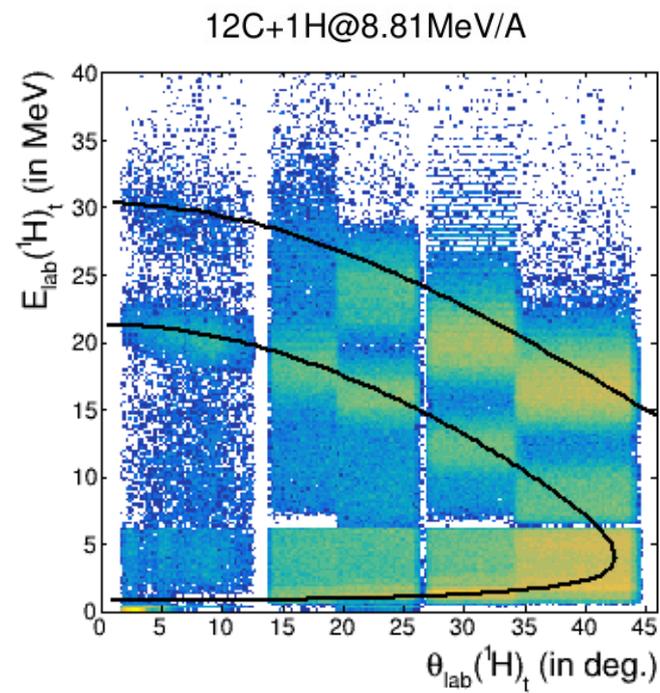
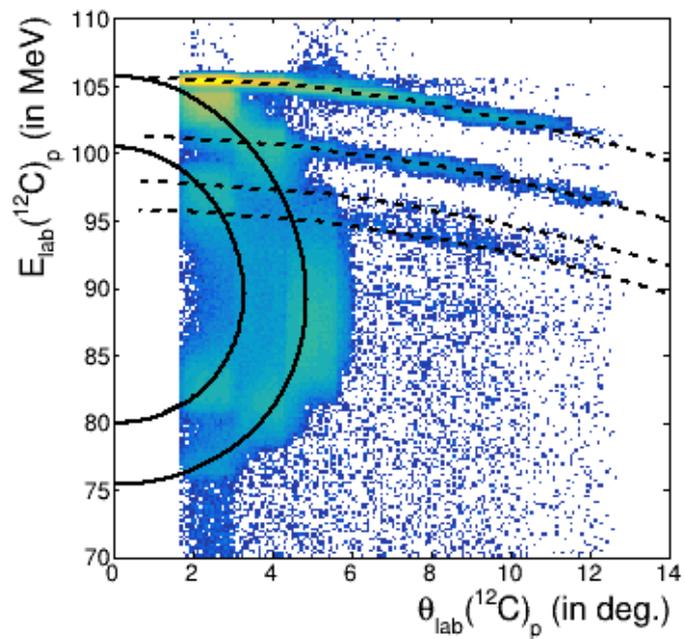
Kinematics and energy choice



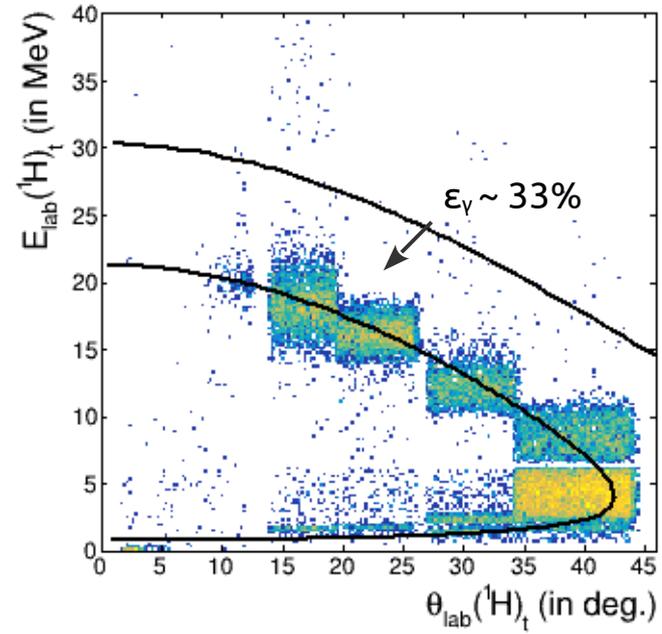
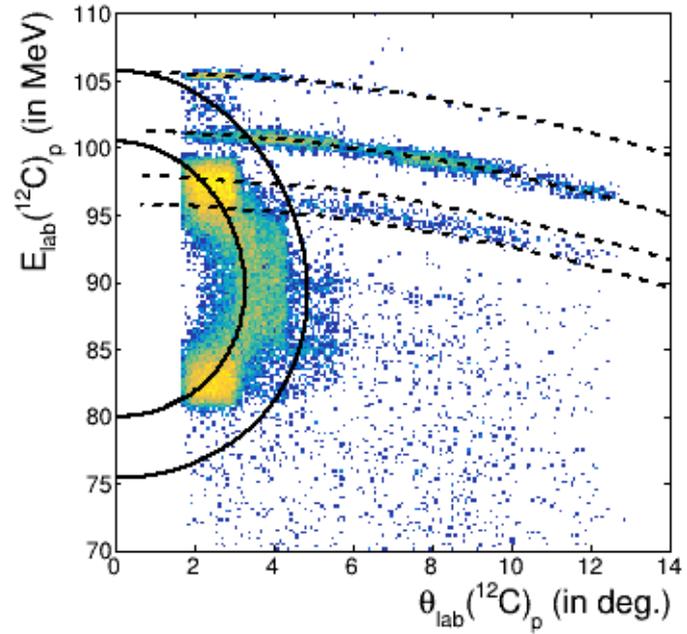
Kinematics and energy choice



CH₂ data from E881 (~20min)



$E > 3\text{MeV}$ gamma coincidences



Beam time estimate

Beam intensity of 1nA (10^9 pps)

180 μ g/cm² CH₂ target

Cross section to excite the ¹²C 3⁻ state ~70mb

proton detection efficiency ~70%

Gamma decay branching ratio ~10⁻⁶ (worst case)

Gamma detection efficiency ~30%

Beam/detector availability during the run ~70%

→ 60 total p- γ coincidences (for 21 BTU)

→ 20 total p- γ - γ coincidences (for 21 BTU)

Hoyle state decay

With similar hypothesis but for the Hoyle state:

→ 1700 total p- γ coincidences (for 21 BTU)

→ 500 total p- γ - γ coincidences (for 21 BTU)

T26-01

We have requested 23 BTU, we obtained 17 BTU, but for free !

→ Test the new MDPP firmware (digital signal traces)

→ ¹²C + ¹²C can also be analyzed (inelastic+transfert+gammas)

→ High statistics to search for the Efimov state

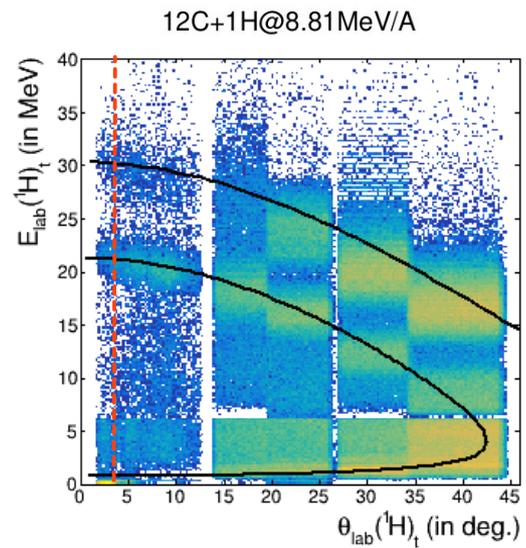
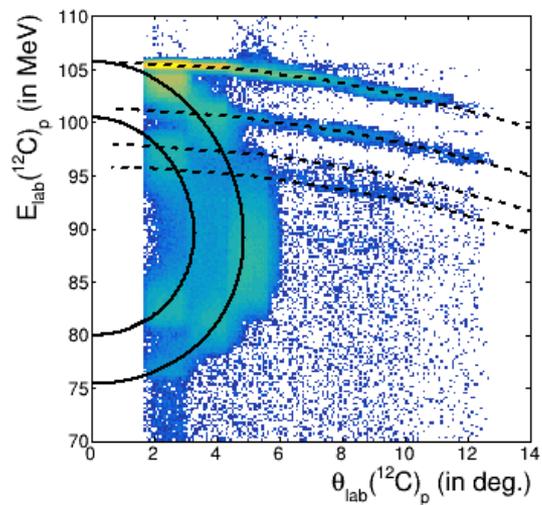
M. Harada, et al., J of NUC. SCI. and TECH. 36, 313 (1999).

Table 3 Experimental partial and total reaction cross sections of the $p+^{12}\text{C}$ reaction (unit:mb)
Relative contributions (%) of various reaction channels in the total $p+3\alpha$ cross sections are given in the parenthesis.

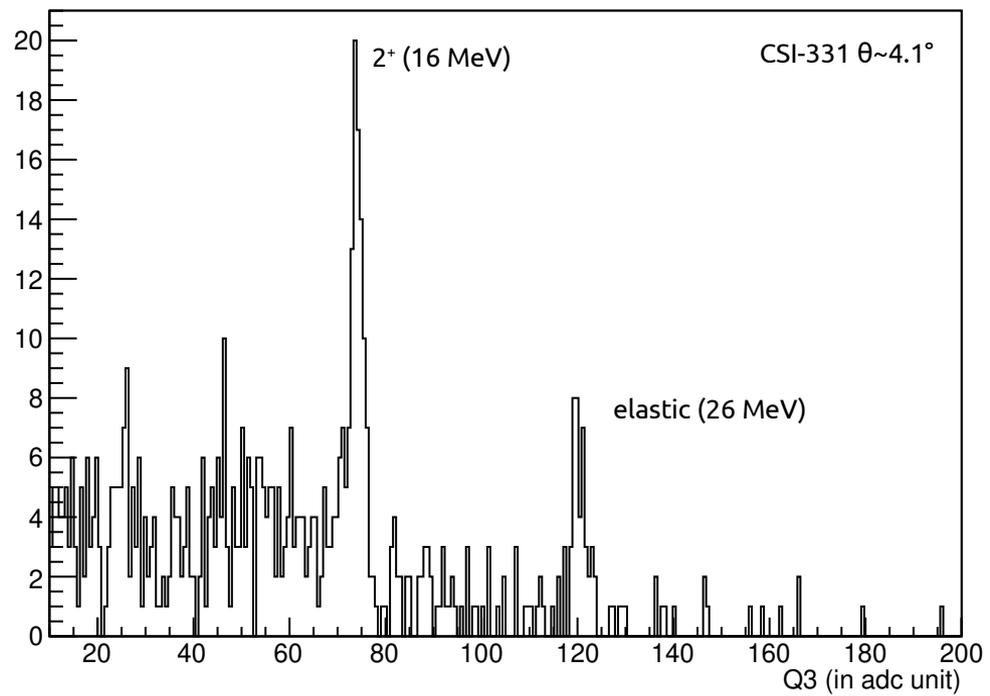
Reaction channel	14 MeV	18 MeV	26 MeV
(1) $p+^{12}\text{C}^*$ (0^+ , $E_x=7.7$ MeV)	5.7 \pm 0.1 (2.9)	4.7 \pm 0.1 (1.5)	3.1 \pm 0.1 (1.3)
(2) $p+^{12}\text{C}^*$ (3^- , $E_x=9.6$ MeV)	70.0 \pm 0.2(35.8)	59.9 \pm 0.3(19.4)	30.9 \pm 0.3(12.5)
(3) $p+^{12}\text{C}^*$ (1^- , $E_x=10.8$ MeV)	23.8 \pm 0.3(12.2)	2.6 \pm 0.2 (0.8)	4.0 \pm 0.1 (1.6)
(4) $p+^{12}\text{C}^*$ (2^- , $E_x=11.8$ MeV)		3.5 \pm 0.2 (1.1)	2.6 \pm 0.1 (1.0)
(5) $p+^{12}\text{C}^*$ (1^+ , $E_x=12.7$ MeV)		15.1 \pm 0.1 (4.9)	5.2 \pm 0.1 (2.1)
(6) $p+^{12}\text{C}^*$ (4^+ , $E_x=14.1$ MeV)		11.1 \pm 0.6 (3.6)	5.9 \pm 0.2 (2.4)
(7) $p+^{12}\text{C}^*$ (1^+ , $E_x=15.1$ MeV)			4.6 \pm 0.1 (1.9)
(8) $p+^{12}\text{C}^*$ (2^+ , $E_x=16.1$ MeV)			4.9 \pm 0.1 (2.0)
(9) $\alpha+^9\text{B}_{g.s.}$	40.8 \pm 0.8(20.8)	43.1 \pm 0.3(14.0)	12.4 \pm 0.1 (5.0)
(10) $\alpha+^9\text{B}^*$ ($5/2^-$, $E_x=2.3$ MeV)	25.1 \pm 0.1(12.8)	19.0 \pm 0.2 (6.2)	12.2 \pm 0.1 (4.9)
(11) $\alpha+^9\text{B}^*$ ($7/2^-$, $E_x=7.0$ MeV)			19.8 \pm 0.4 (8.0)
(12) 3BSB	30.2 \pm 0.1(15.4)	149.4 \pm 1.0(48.5)	142.3 \pm 1.0(57.4)
Total $p+3\alpha$	195.7 \pm 1.6	308.3 \pm 3.0	248.0 \pm 2.7
$p+^{12}\text{C}^*$ (2^+ , $E_x=4.4$ MeV)	225.8 \pm 6.3	129.5 \pm 1.2	86.0 \pm 0.1
Total reaction cross section [†]	421.5 \pm 7.9	437.0 \pm 4.2	334.1 \pm 2.8

[†]Summation of cross sections of $p+3\alpha$ and $p+^{12}\text{C}^*$ (2^+ , $E_x=4.4$ MeV).

CsI calibration with elastic protons



CsI calibration with elastic protons





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other Easter in GANIL!**
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