Resonance Reactions Induced by Radioactive Beams.

(Studies of Exotic Nuclei and Applications to Nuclear Astrophysics)

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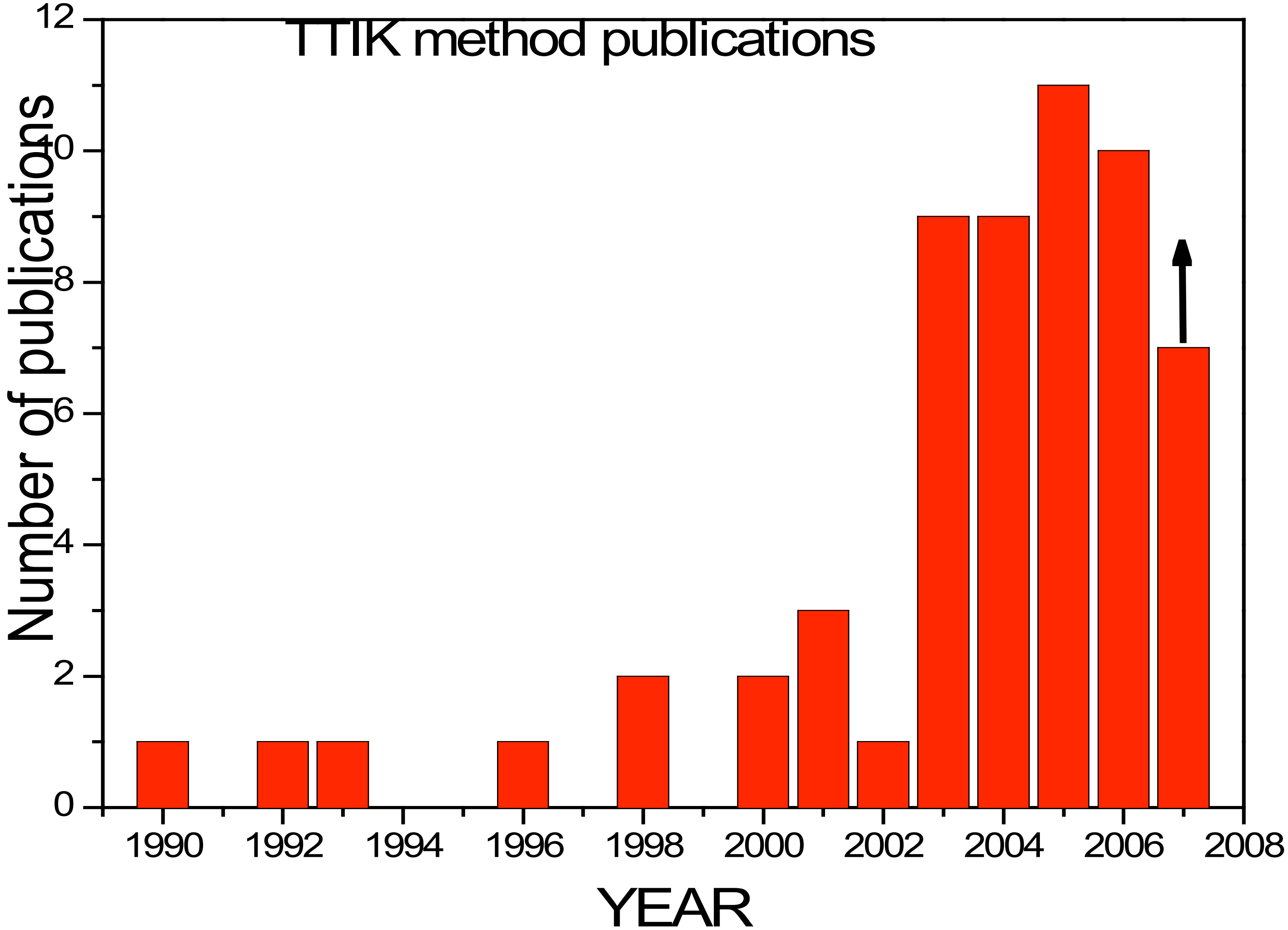
Texas A&M University, Cyclotron Institute & RRC Kurchatov Institute

CNR* 2007



TTIK method publications
Number of publications
YEAR
0
2
4
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1990
1992
1994
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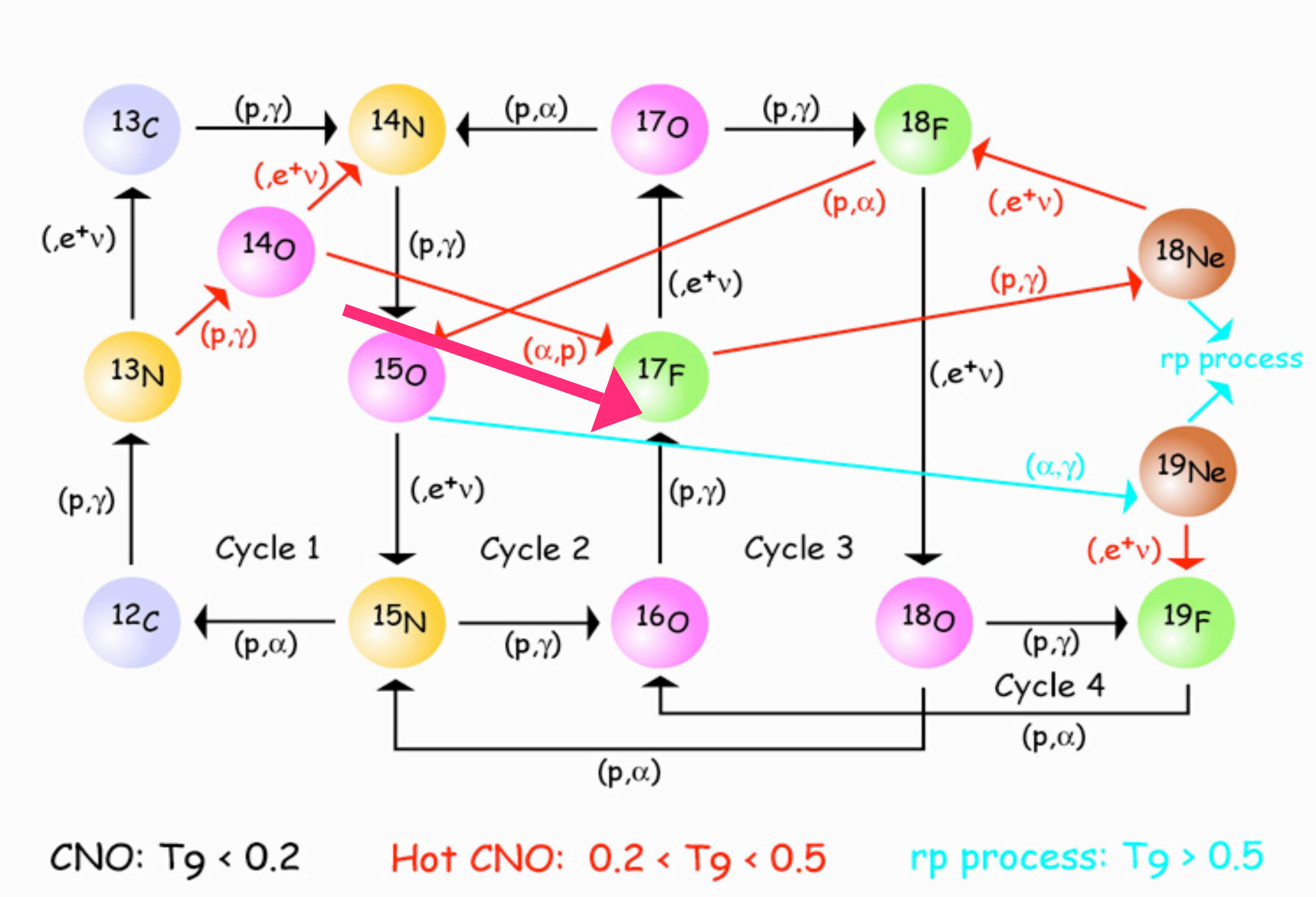
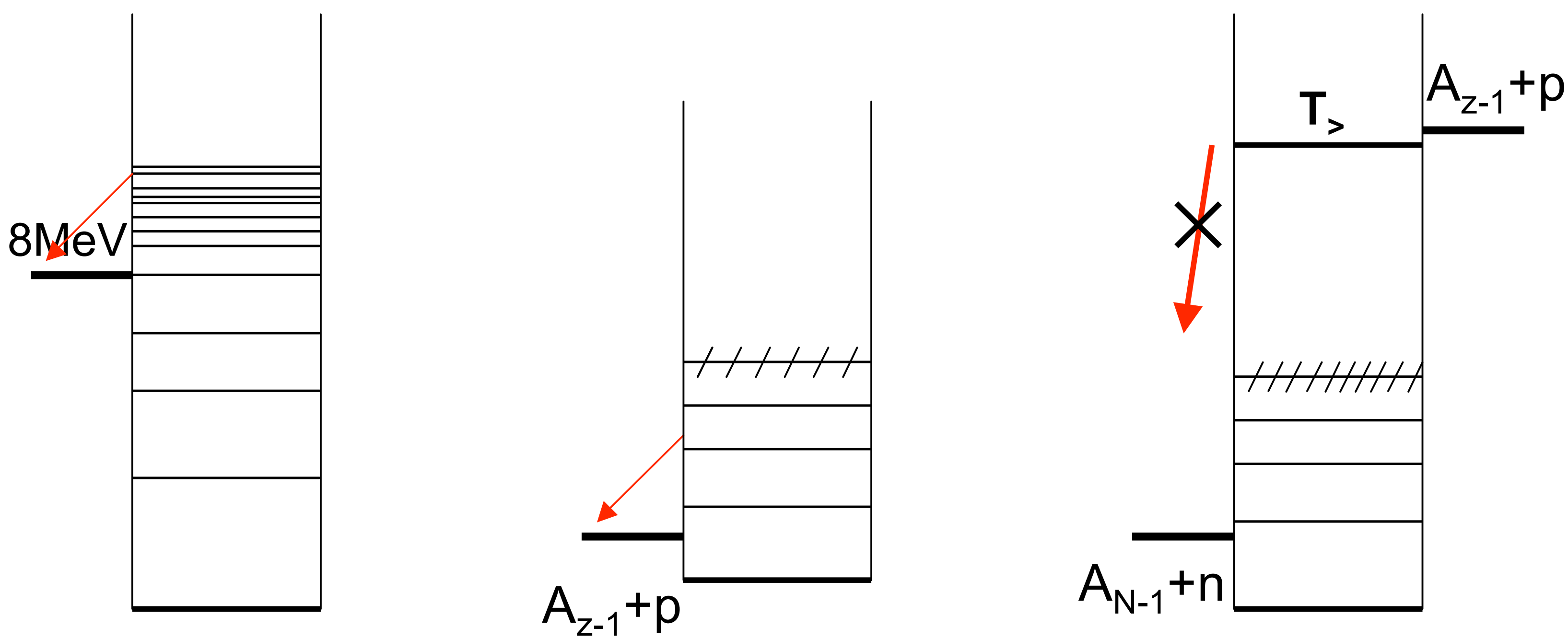
2004
2006
2008

X-ray burst and novae



Resonances in exotic nuclei

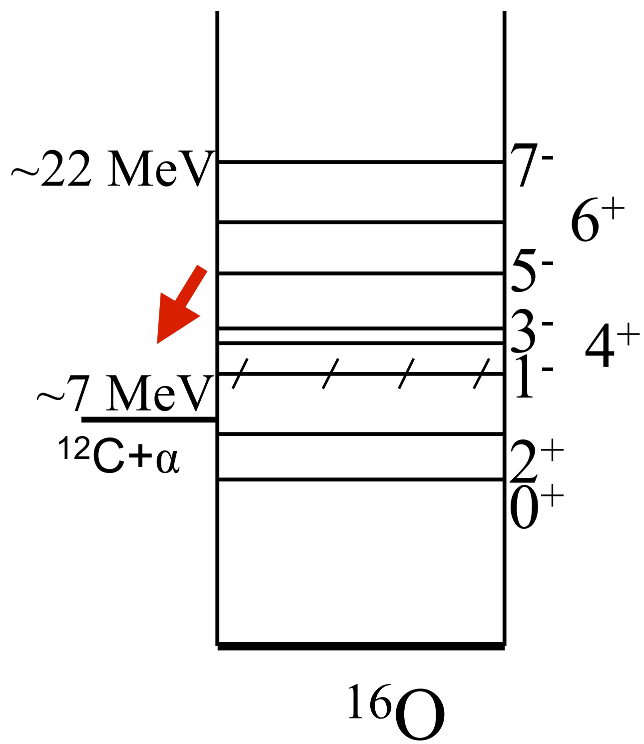
Conventional nucleus   Proton rich exotic   Neutron rich exotic



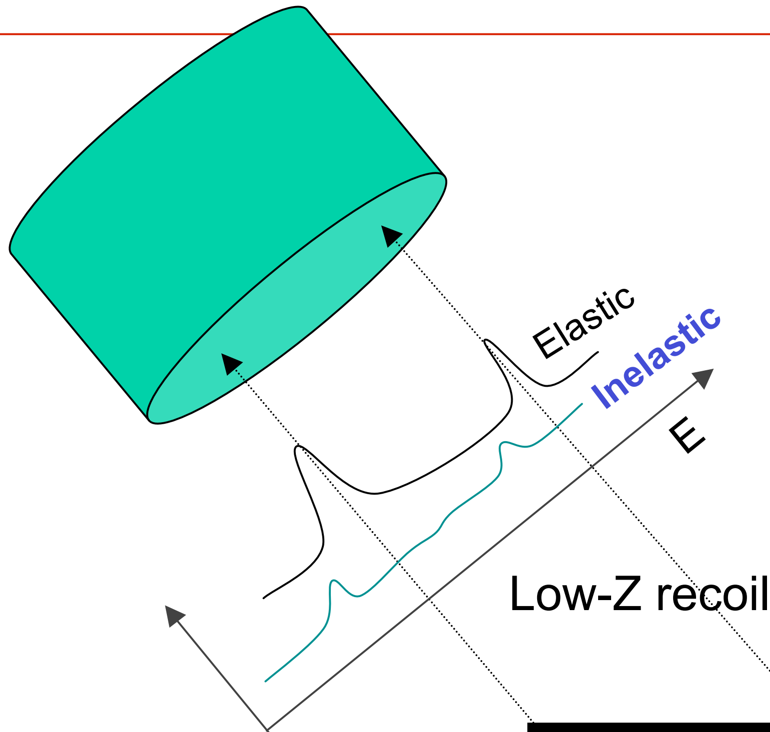
^{11}N ? ^{10}C+p

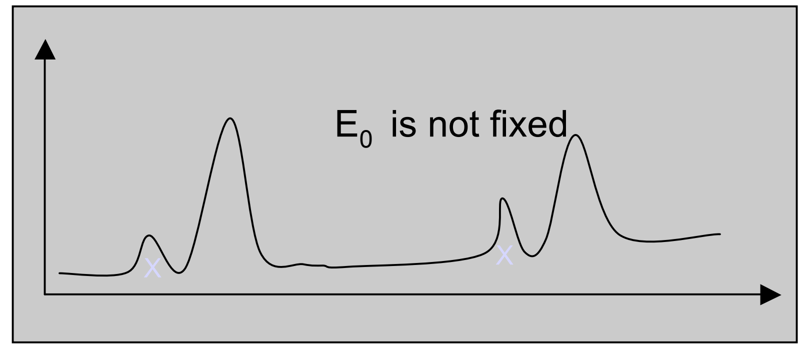
^{9}He? ^{8}He+p→^{9}Li (T=5/2)

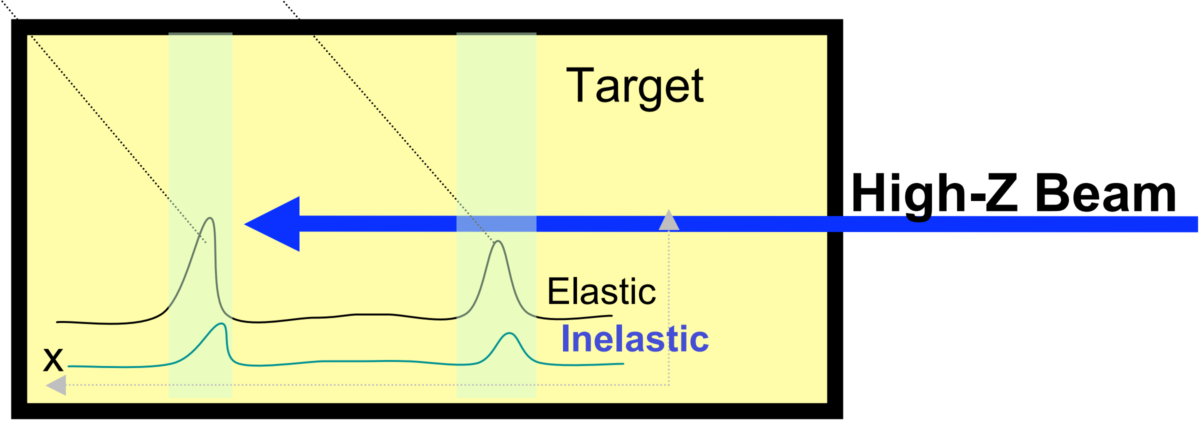
α cluster states in ^{16}O



Thick Target Inverse Kinematics Method





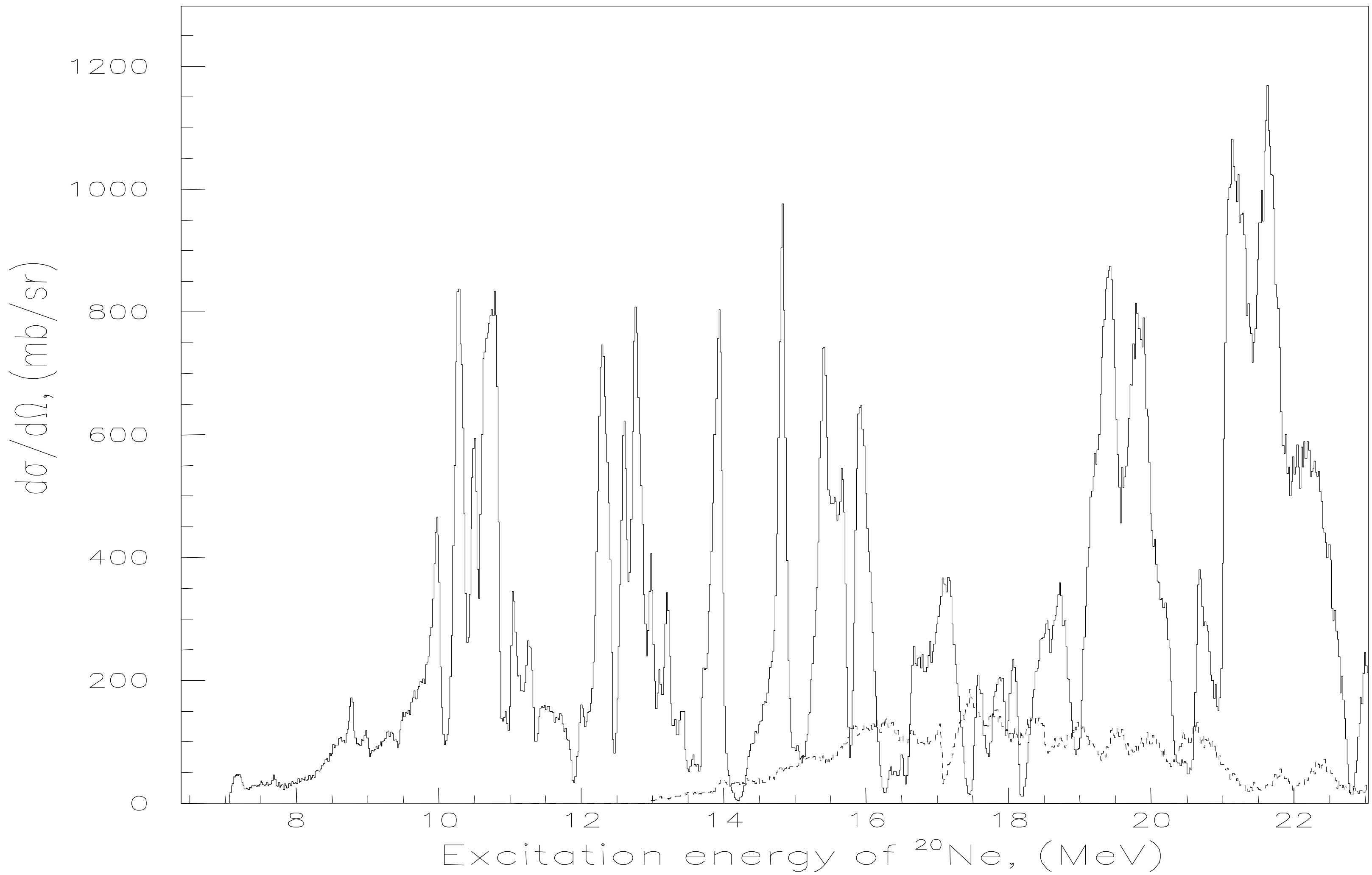


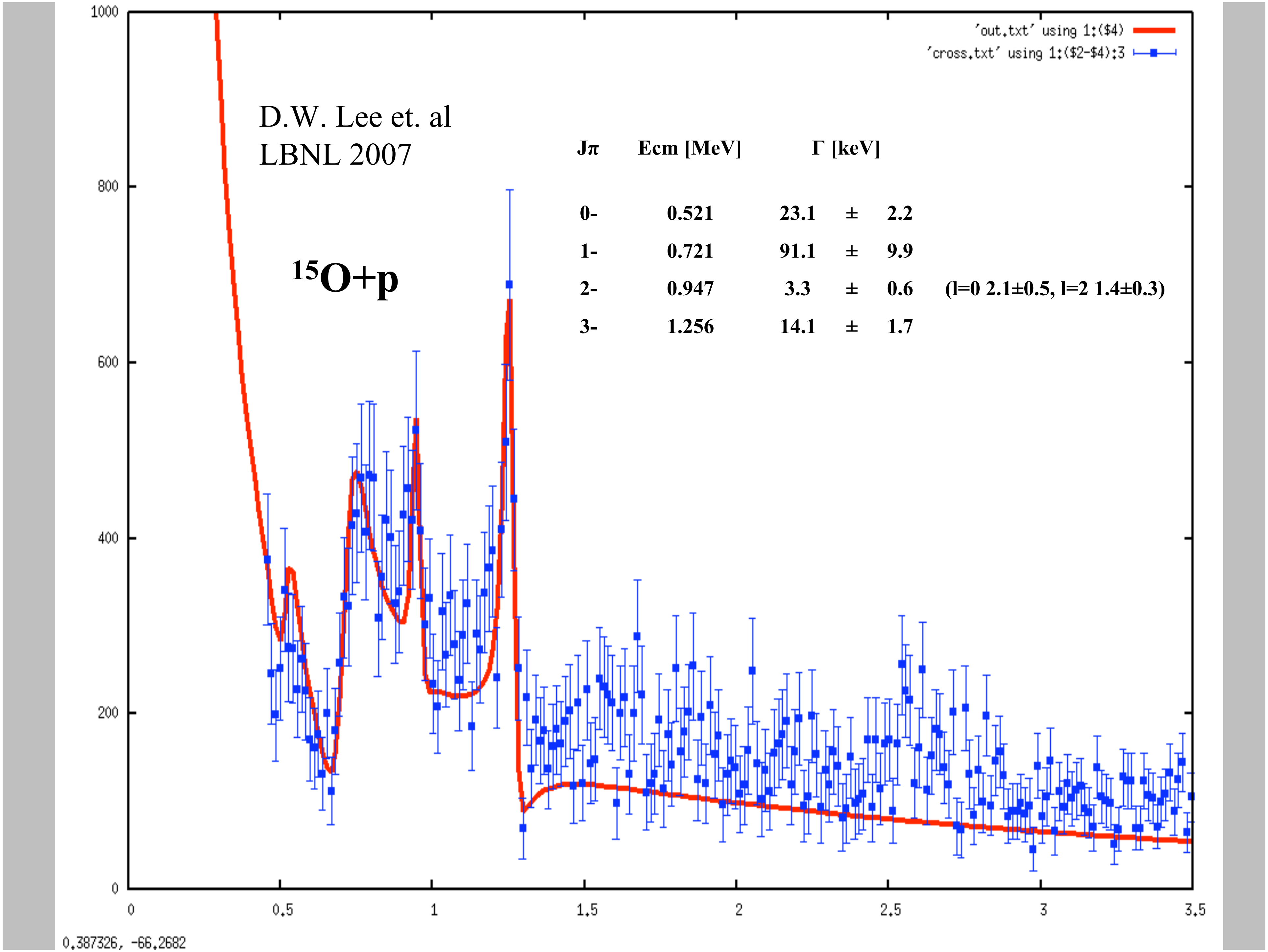
Good energy resolution
180 degree (c.m.) measurements
Excitation function is continuous
Low excitation energies can be measured

K. P. Artemov, M. S. Golovkov, **V. Z. Goldberg et al**, Sov. J. Nucl. Phys. 52, 480 (1990).

Resonance states in ^{20}Ne

^{16}O+He




D.W. Lee et. al
LBNL 2007
$^{15}O+p$
'out.txt' using 1:($4)
'cross.txt' using 1:($2-$4):3
Jπ Ecm [MeV] Γ [keV]
0- 0.521 23.1 ± 2.2
1- 0.721 91.1 ± 9.9
2- 0.947 3.3 ± 0.6 (l=0 2.1±0.5, l=2 1.4±0.3)
3- 1.256 14.1 ± 1.7
1000
800
600
400
200
0
0
0.5
1
1.5
2
2.5
3
3.5
0.387326, -66.2682

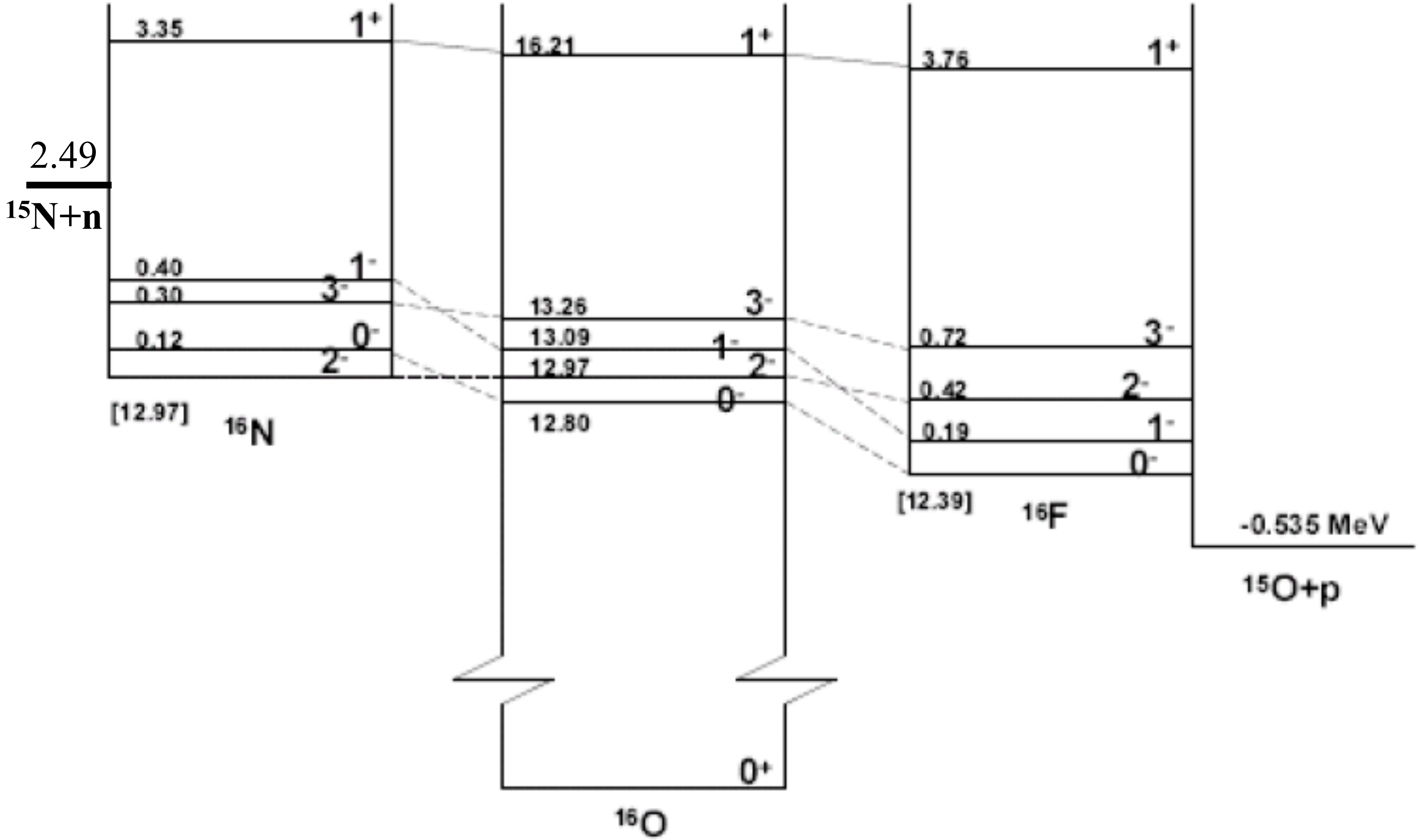


FIG. 1. An isobaric energy level diagram for the A=16, T=1 nuclear states

Table II. Comparison of ^{16}F experimental results with the isobaric analog states in ^{16}N and with theoretical calculations in the framework of the potential model.

^{16}N			^{16}F			^{16}F Theory			
						Parameter set #1 (a=0.65 fm)	Parameter set #2 (a=0.75 fm)		
Ex [MeV]	J^π	C^2S [a]	E_x [MeV±keV]	J^π	Γ_p[keV] [b]	Γ_{sp}[keV]	Γ_{sp} [keV]	C^2S (Exp.)	C^2S (Shift)
0.120	0^-	0.95	0	0^-	23.1±2.2	21.8	22	1.05	0.91
0.397	1^-	0.96	0.190±20	1^-	91.1±9.9	89.5	96	0.95	0.88
0	2^-	0.93	0.422±19	2^-	3.3±0.6	3.6	4.3	0.77	
0.296	3^-	0.87	0.721±17	3^-	14.1±1.7	12.7	15.0	0.94	

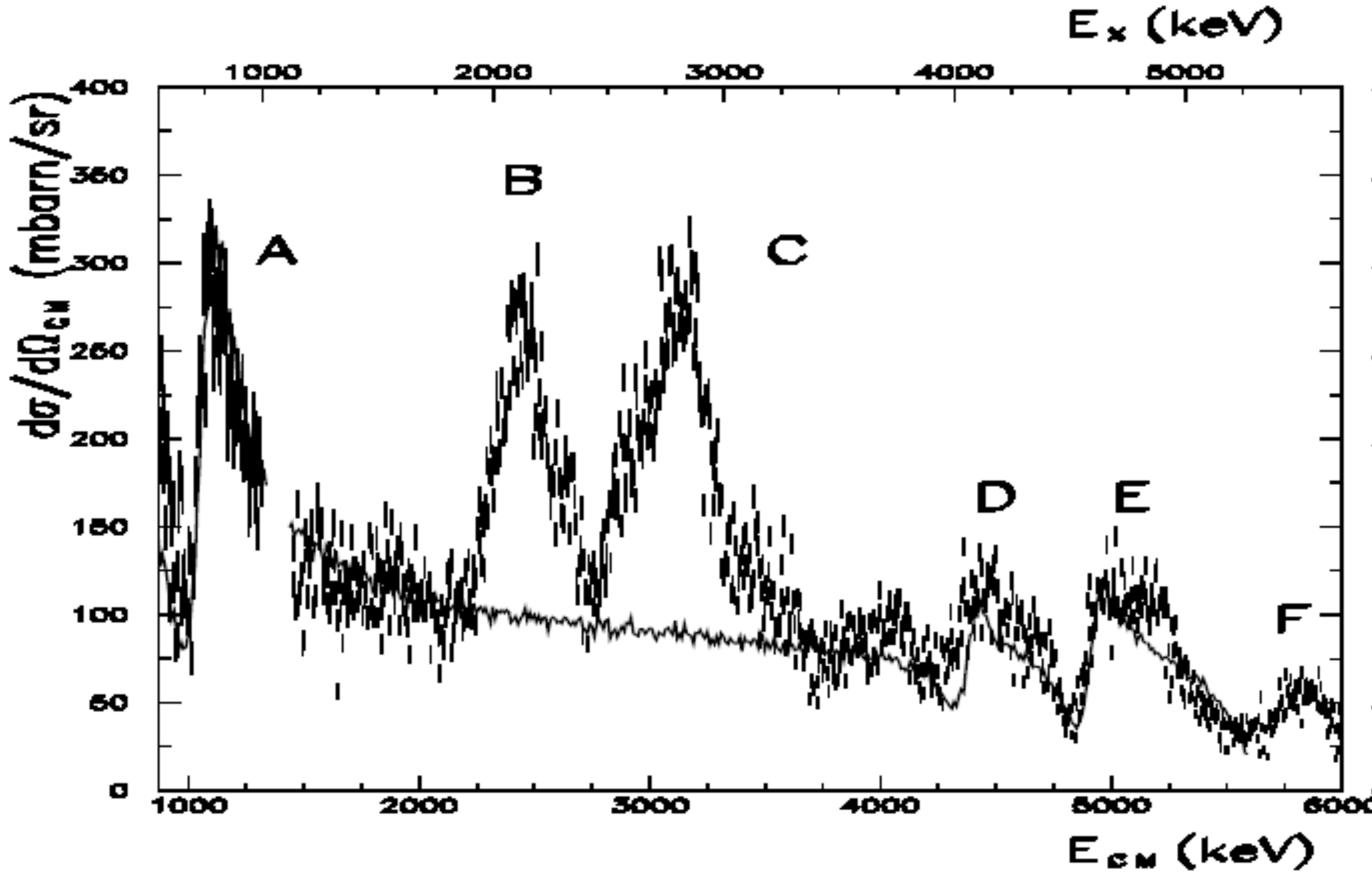
[a] OXBASH calculation reported in Ref. [36].

[b] This work.

^{18}Ne+p, θ=180^0 c.m.

Eur. Phys. J. A **24, 237 (2005)**

F. de Oliveira Santos *et al.*: Study of ^{19}Na at SPIRAL



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Nuclear Physics A 746 (2004) 113c–117c

Direct measurement of the astrophysical reaction $^{14}O(\alpha,p)^{17}F$

M. Notani[a], S. Kubono[a], T. Teranishi[a], Y. Yanagisawa[b], S. Michimasa[a], K. Ue[a], J.J. He[a], H. Iwasaki[c], H. Baba[d], M. Tamaki[a], T. Minemura[b], S. Shimoura[a], N. Hokoiwa[e], Y. Wakabayashi[e], T. Sasaki[e], T. Fukuchi[e], A. Odahara[f], Y. Gono[e], Zs. Fülöp[g], E.K. Lee[h], K.I. Hahn[h], J.Y. Moon[i], C.C. Yun[i], J.H. Lee[i], C.S. Lee[i] and S. Kato[j]

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4. SUMMARY

In summary, the astrophysical $^{14}O(\alpha,p)^{17}F$ reaction, which is important in various steller environments such as X-ray bursts, has been measured directly for the first time, by using a radioactive ^{14}O beam. The present experiment has shown that the combination of a low-energy RI beam and cold helium gas target can be used for the study of (α,p) reactions. The measured cross section was found to differ from a prediction based on an indirect measurement, and a direct measurement with time-inverse reaction since the observed channel was limited to the branch to the ^{17}F ground state alone. A proton decay from the ^{18}Ne levels at $E_x = 7.05$ and 7.12 MeV to the first-excited state in ^{17}F has been measured. This result would suggest an increase of 50% for the $^{14}O(\alpha,p)^{17}F$ reaction rate and might affect the scenario of ignition phase of X-ray burst.

$^{14}O(\alpha,p)$

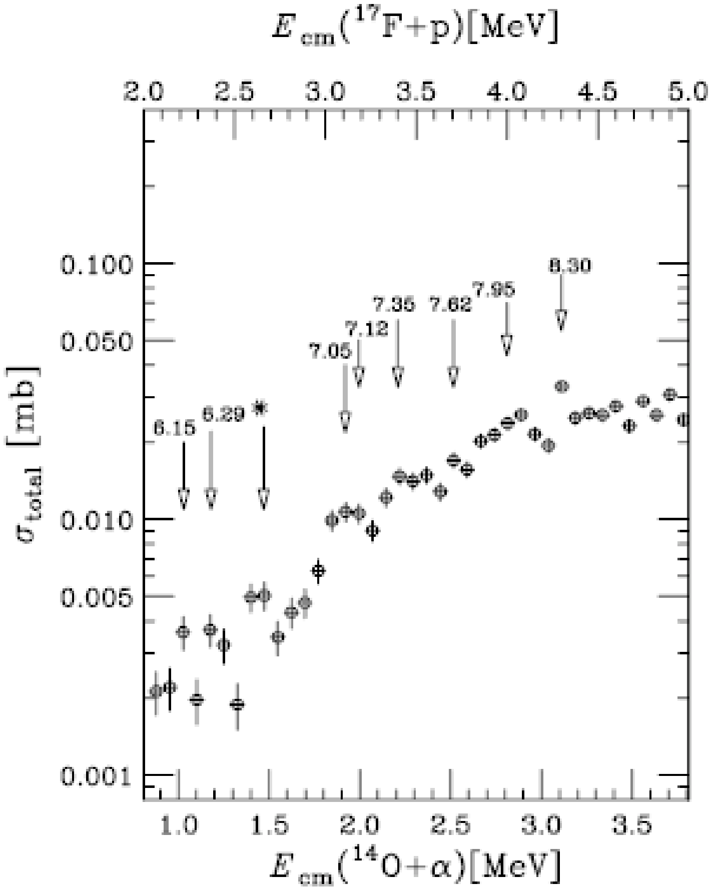


Figure 2. Measured cross sections for tl $^{14}O(\alpha,p)^{17}F$ reaction. The asterisk mark is the new observation.

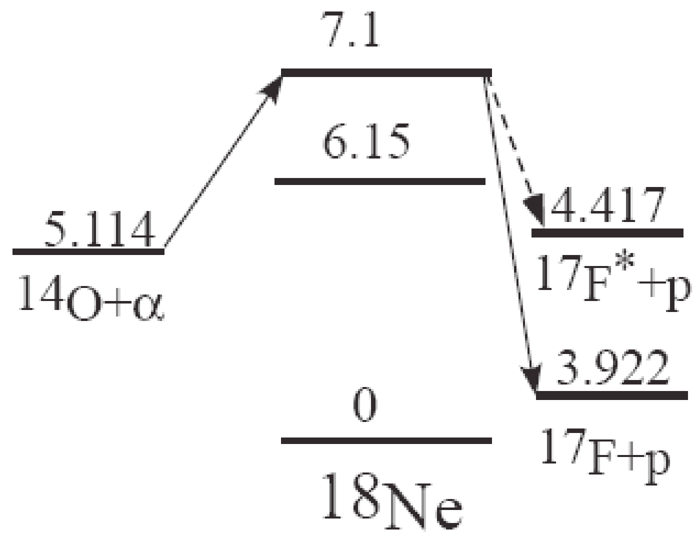
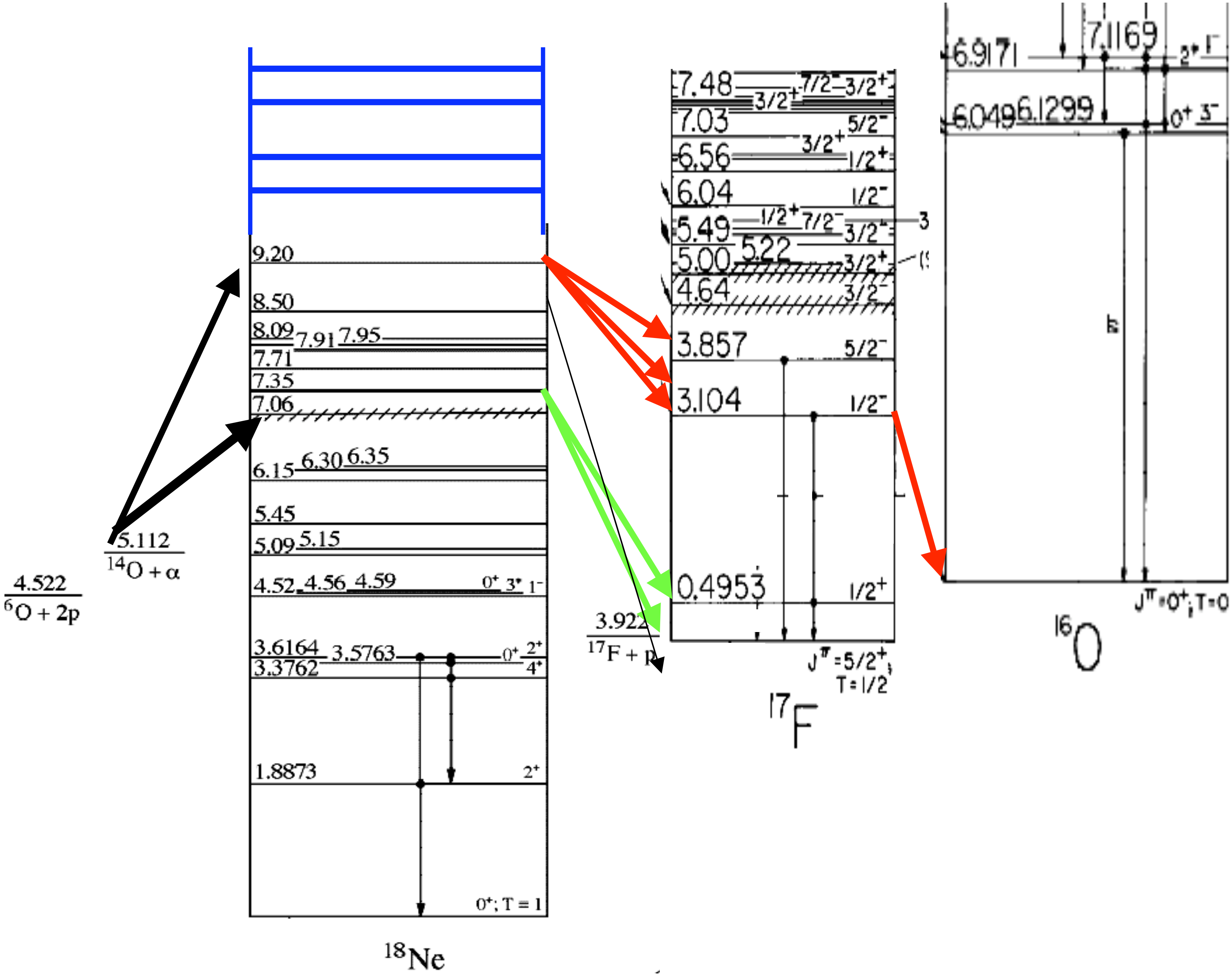


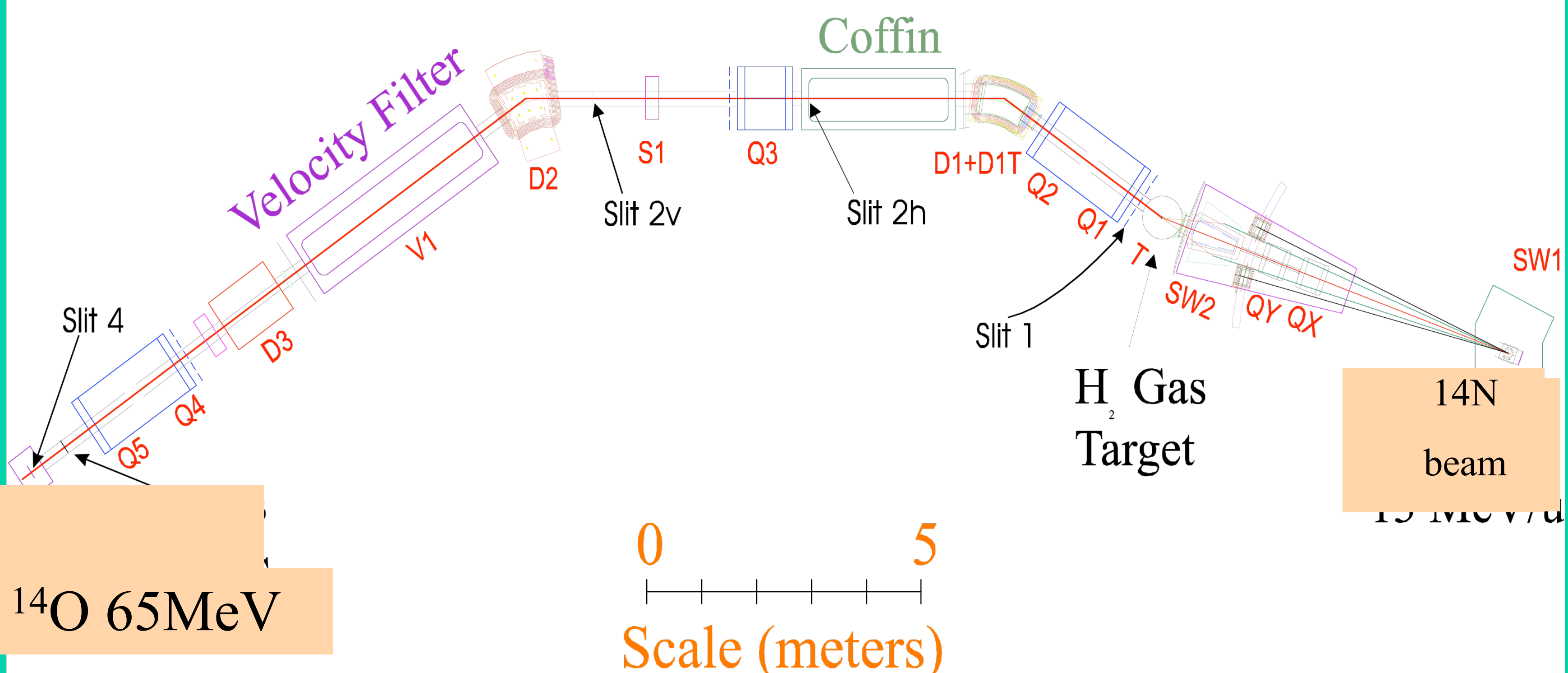
Figure 3. Level Scheme of ^{18}Ne. The dashed line arrow shows a transition to the excited state of ^{17}F.



9.20
8.50
8.09
7.91
7.95
7.71
7.35
7.06
6.15
6.30
6.35
5.45
5.09
5.15
4.52
4.56
4.59
0+ 3+ 1−
3.6164
3.5763
0+ 2+
3.3762
4+
1.8873
2+
0+; T = 1
18Ne
5.112
14O + α
4.522
16O + 2p
3.922
17F + p
7.48
7.03
6.56
6.04
5.49
5.00
5.22
4.64
3.857
5/2−
3.104
1/2−
0.4953
1/2+
Jπ=5/2+; T=1/2
17F
6.9171
7.1169
6.049
6.1299
0+ 3−
2+ 1−
Jπ=0+; T=0
16O

MARS

Momentum Achromat Recoil Separator

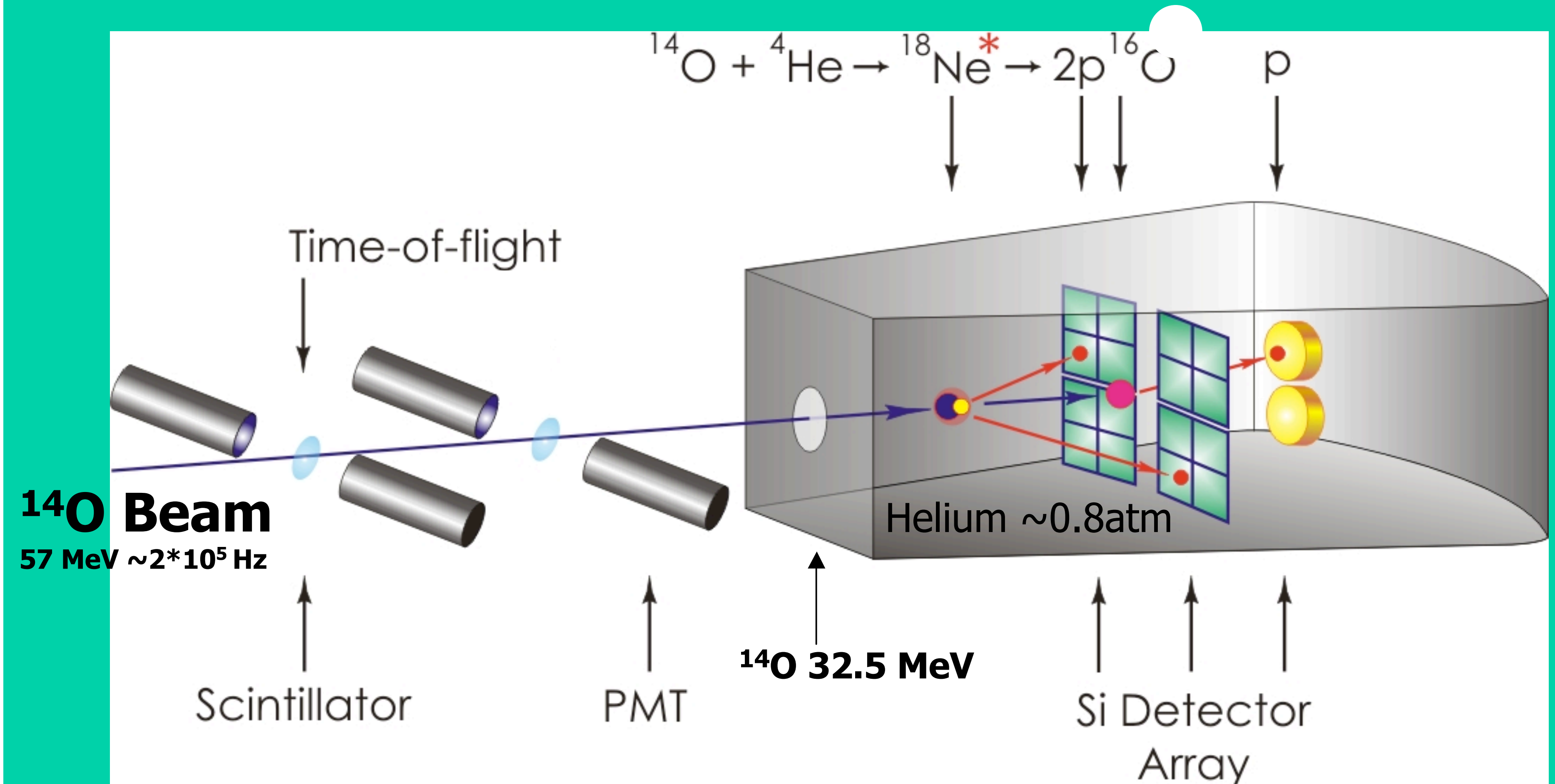


rimary beam ^{14}N@ 12 MeV/A – K500 Cyclotron

rimary target LN_2 cooled gas target H_2 p=3.0 atm

Purity: >99%
Intensity: ~10^6pps

Scattering Chamber/Target



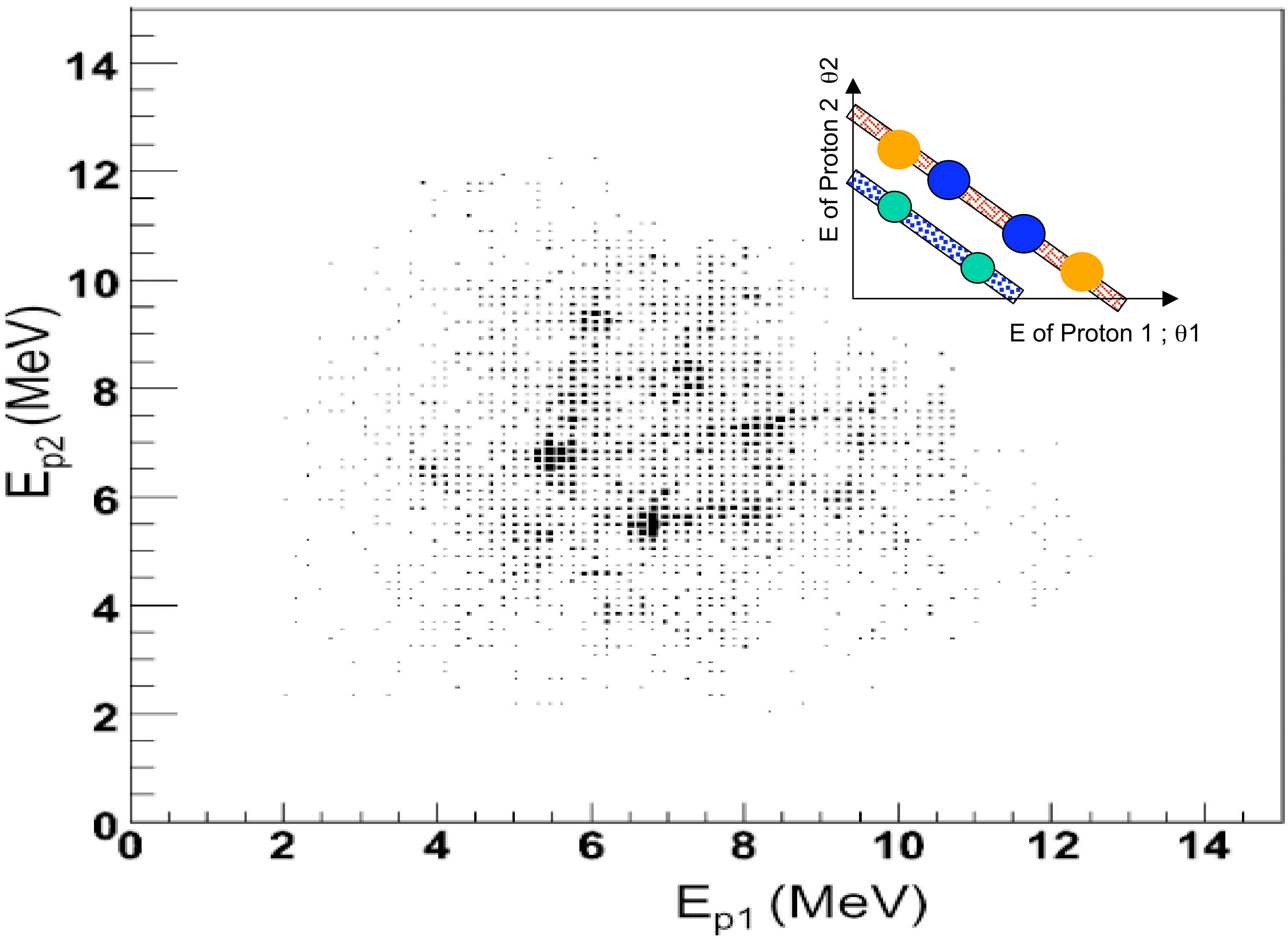
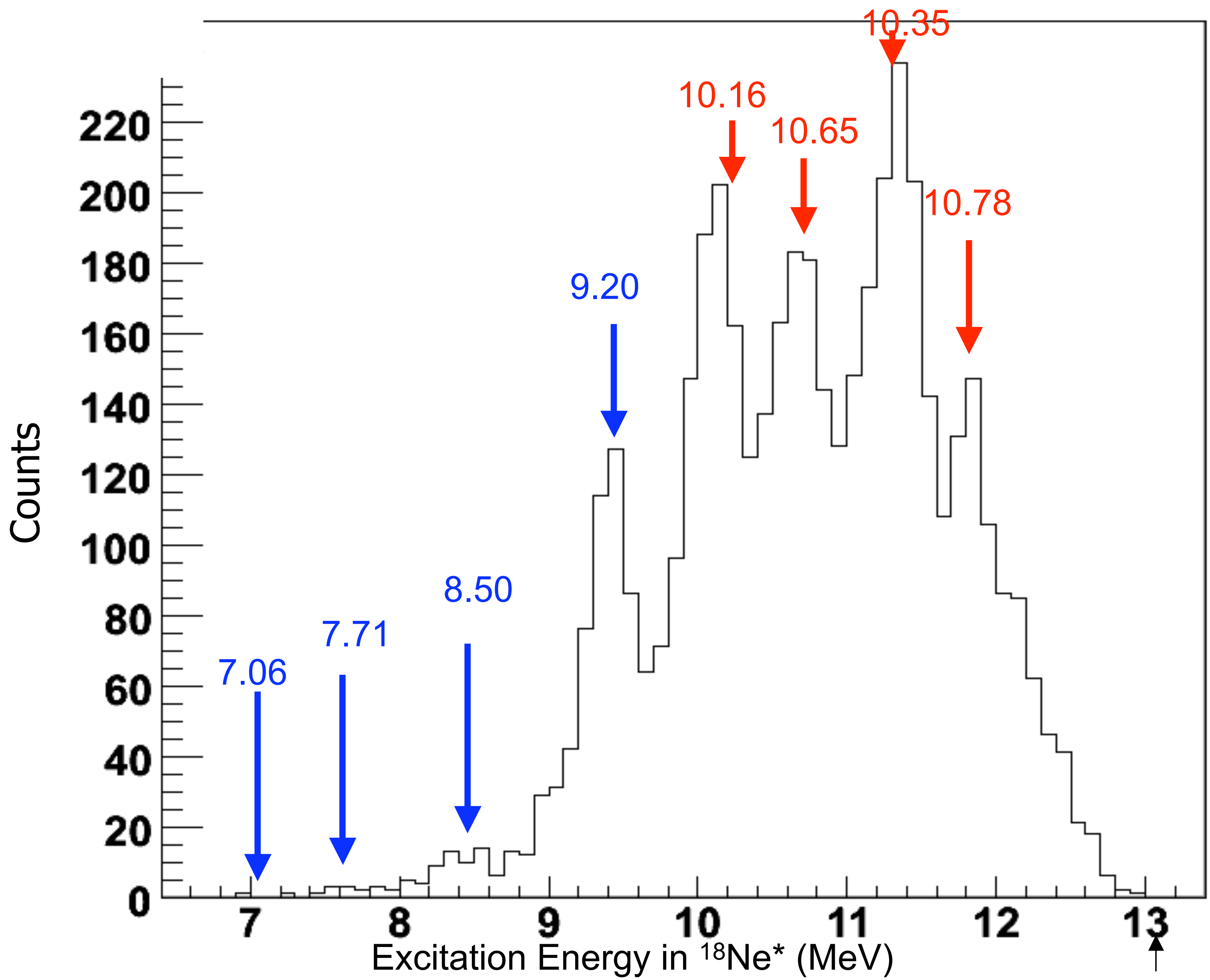
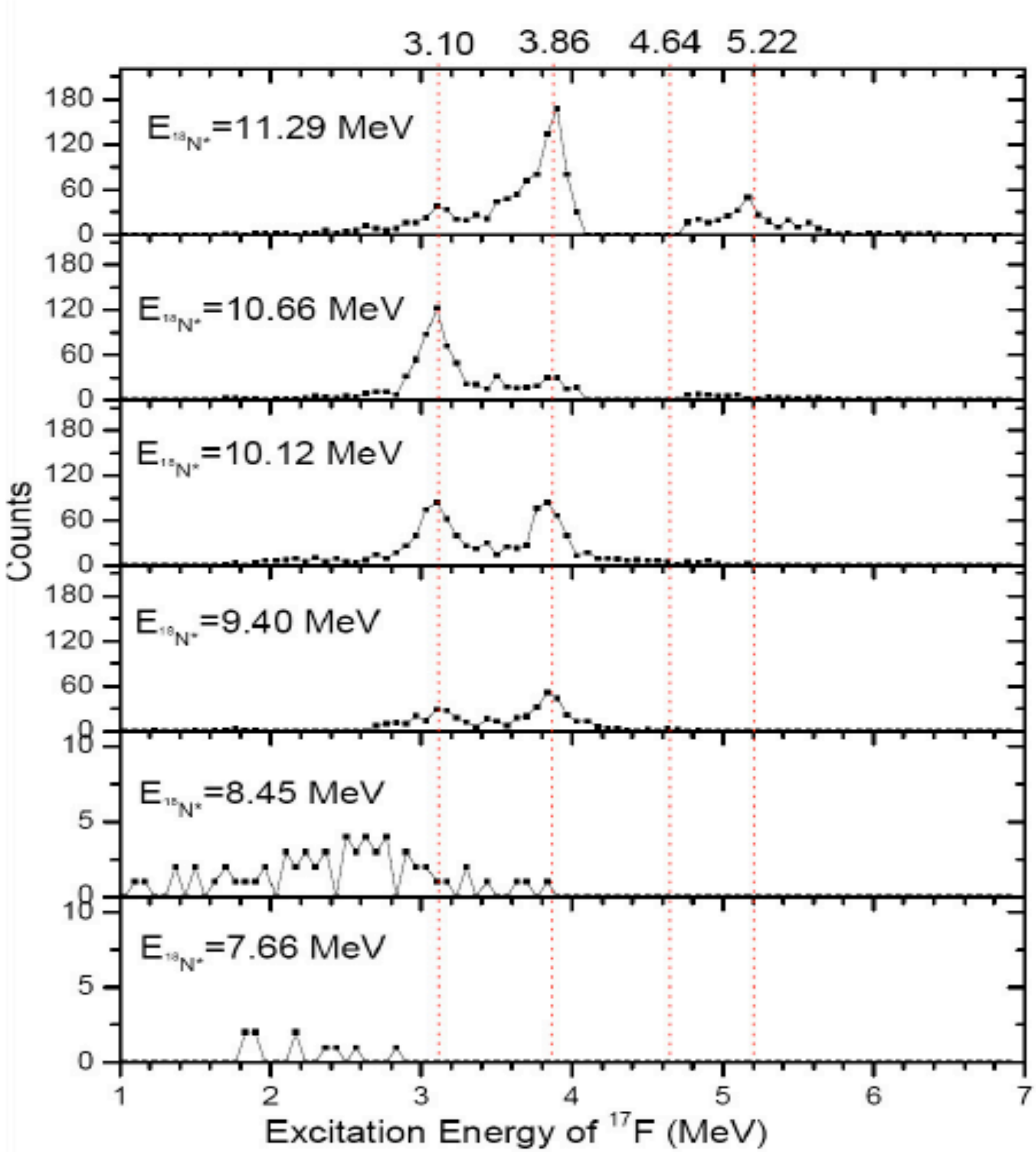
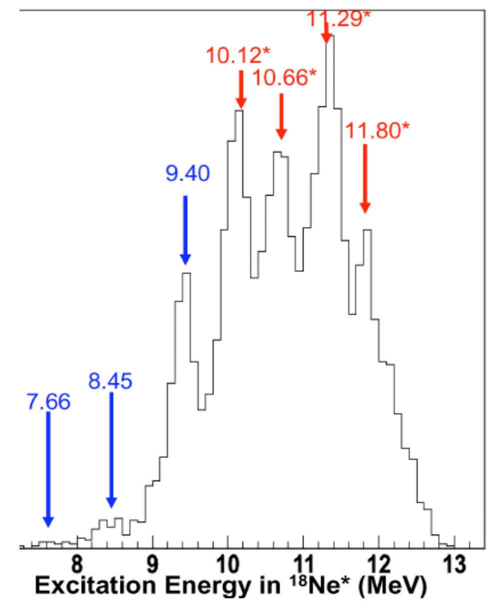


Fig. 6. the Dalitz plot of the coincident protons from the reaction $^{14}O(^{4}He, 2p)^{16}O$. The energy of protons are given in lab system.

Excitation function for the $^{14}O(\alpha,2p)$ reaction



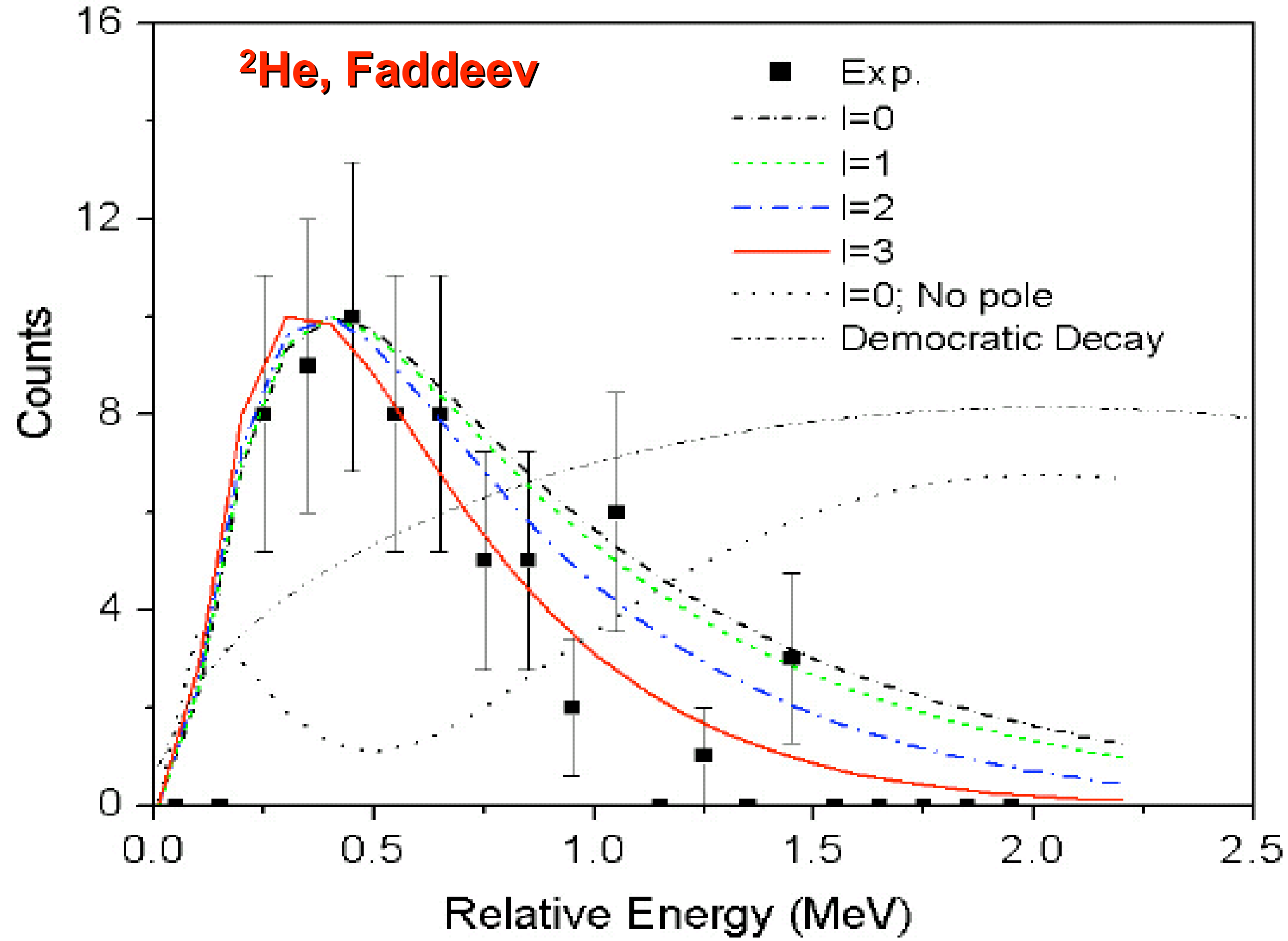




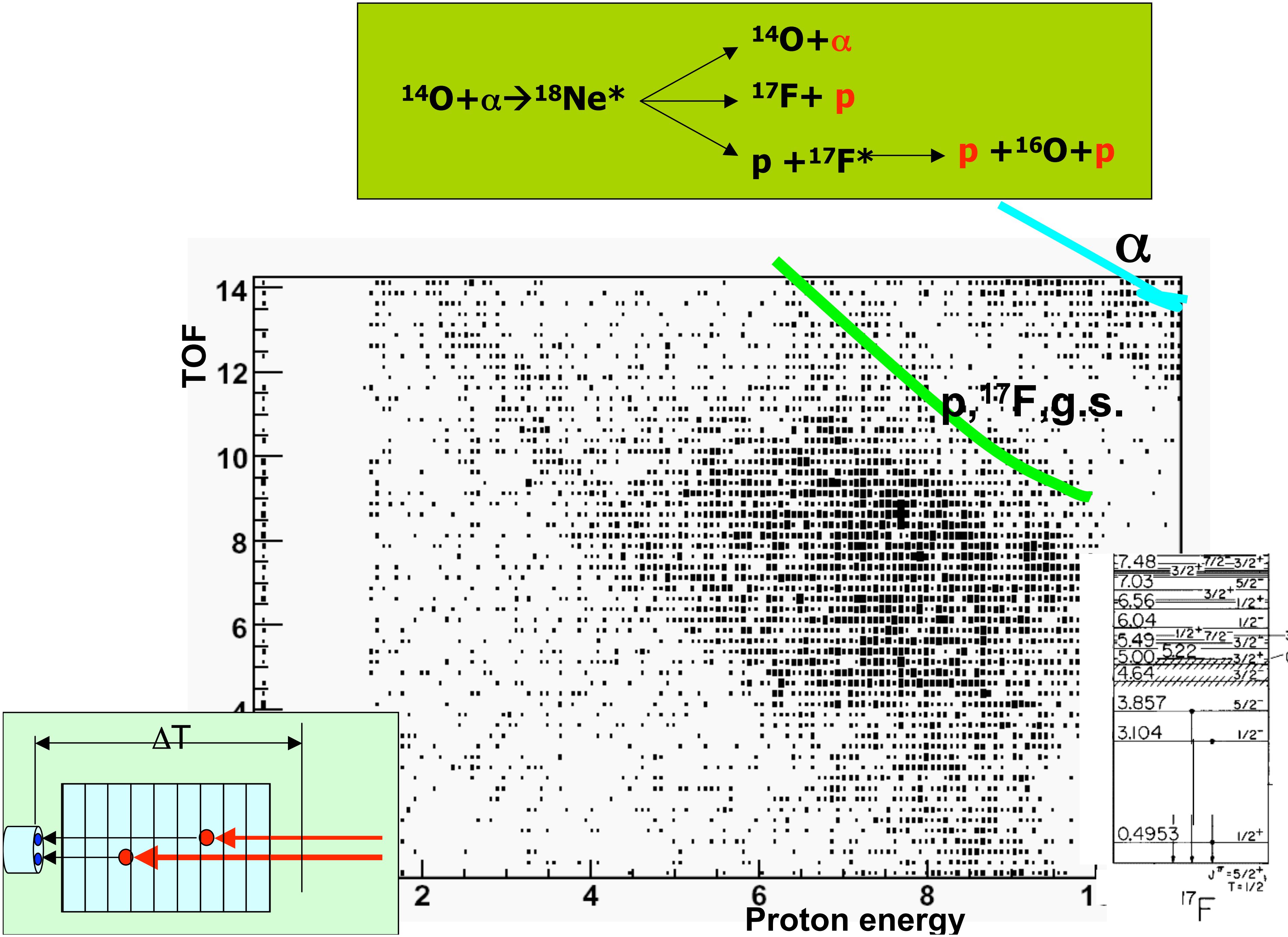
^{8}Ne* states which decay through 2-proton emission.The cross
MeV is about 0.045 mb, and 11.29 MeV peak is about 3.9 mb.

proton decay modes of the ^{18}Ne states

2p decay of 8.45 MeV state in ^{18}Ne



Changbo Fu, V.Z.Goldberg, A.Mukhamedzhanov et al,
Phys. Rev. C, 76, 021603(R) (2007)



14O+α→18Ne*
14O+α
17F+ p
p +17F*
p +16O+p
α
p,17F,g.s.
TOF
14
12
10
8
6
4
2
4
6
8
1
Proton energy
ΔT
7.48
7.03
6.56
6.04
5.49
5.22
5.00
4.64
3.857
3.104
0.4953
17F

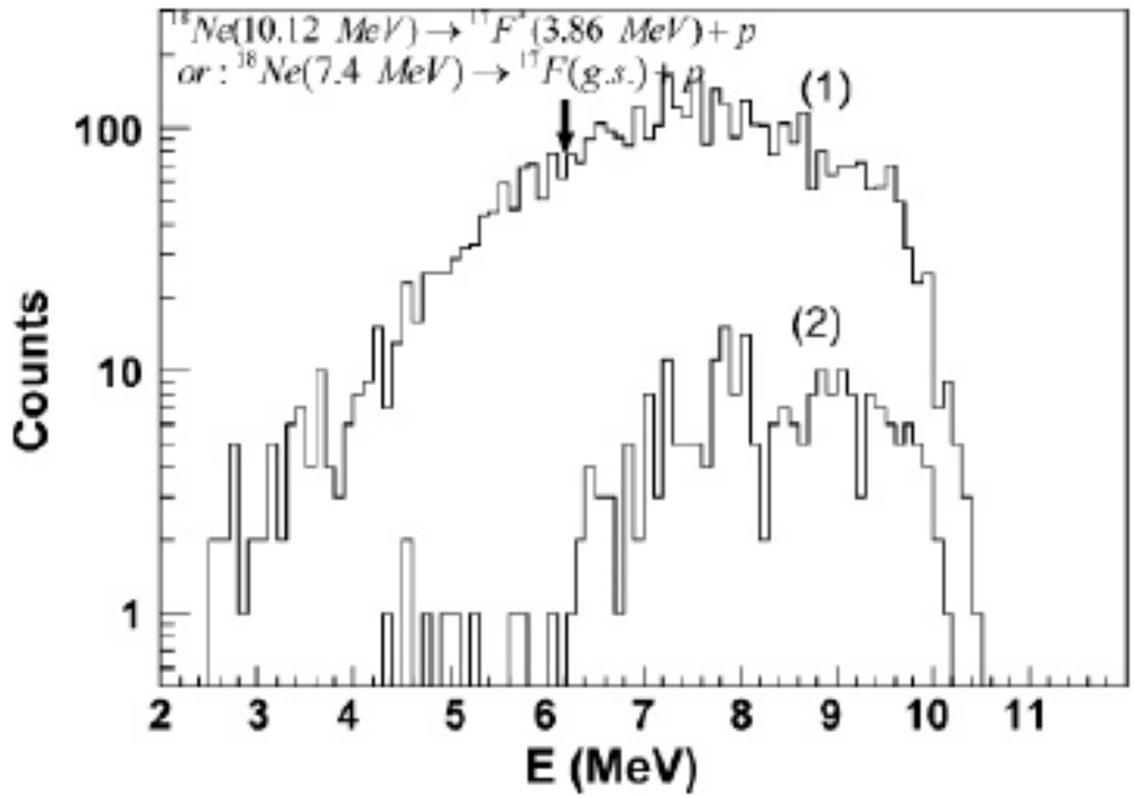
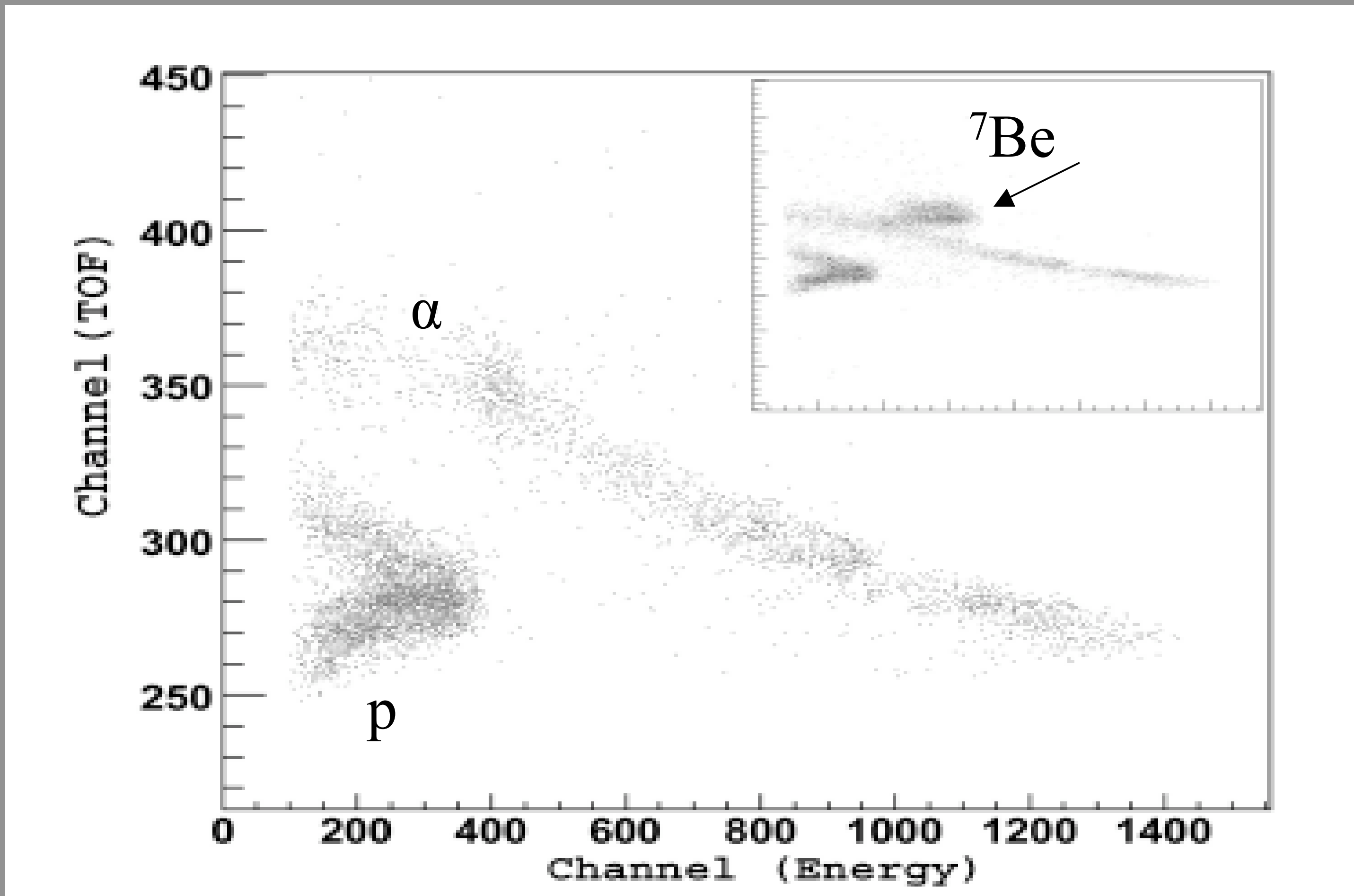
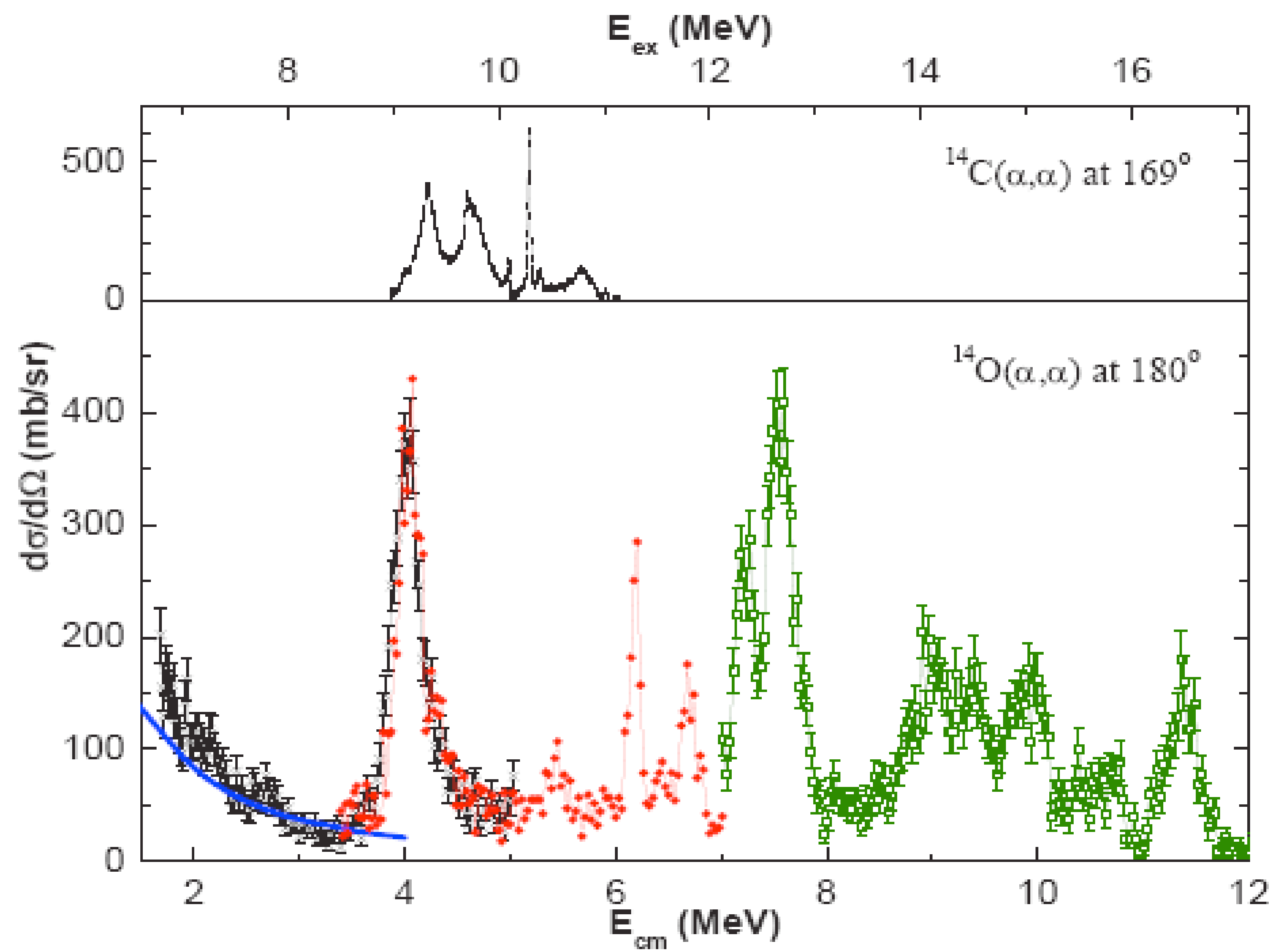


FIG. 7. Yield of protons at 0°. (1) Total proton yield; (2) yield of $p_0 + p_1$, see text for explanation.

$^{14}O+\alpha$ identification spectrum



Excitation functions



Thank ya'll