Decay of „stretched” states in the continuum

Natalia Cieplicka-Oryńczak

Institute of Nuclear Physics PAN, Kraków, Poland

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Outline

NEAREST FUTURE

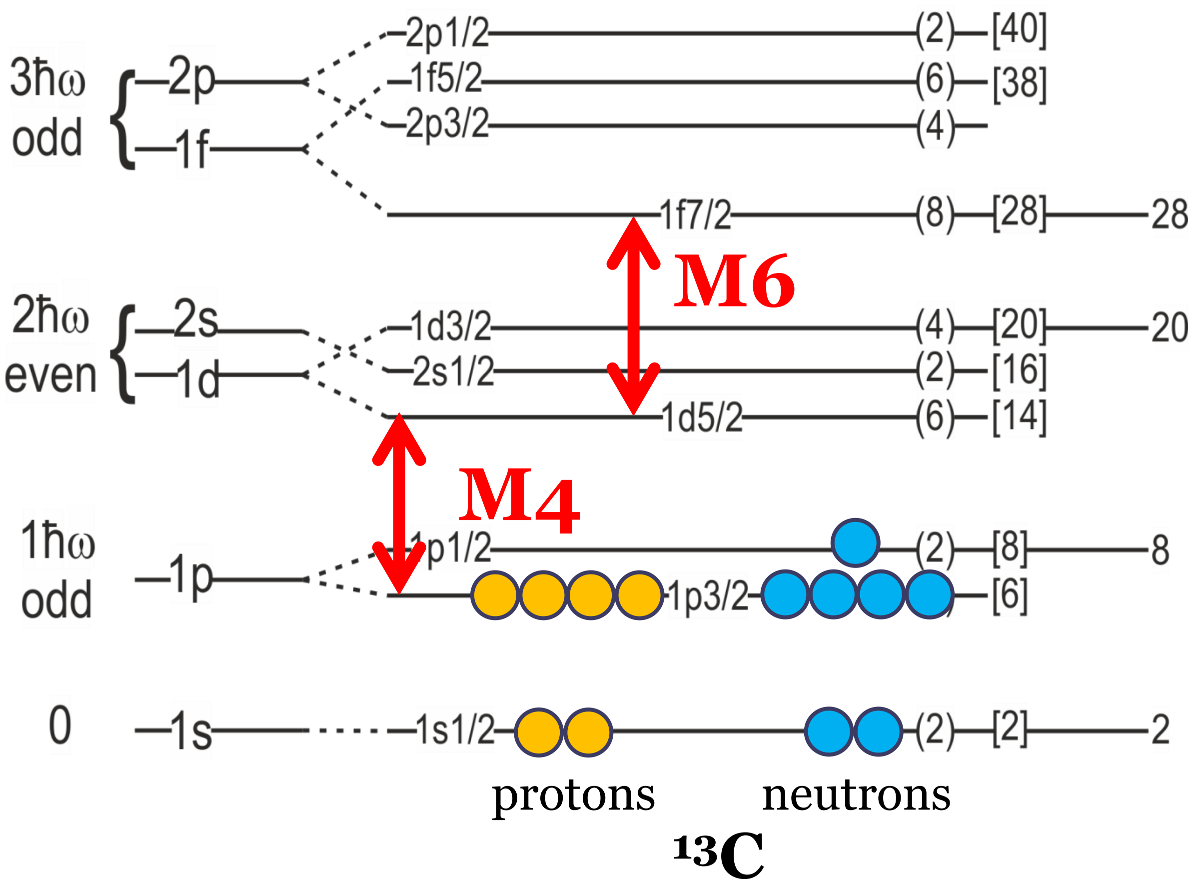
- What is a „stretched” state?
- The first case: ^{13}C

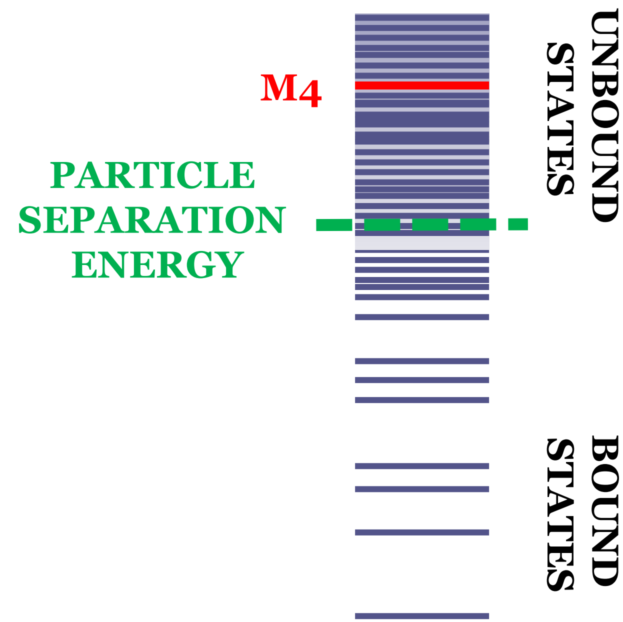
FUTHER FUTURE

- Developments at Cyclotron Centre Bronowice (Kraków)

Stretched states in the continuum

Such states are dominated by a single particle-hole component for which the excited particle and the residual hole couple to the maximal possible spin value: $J_{max} = j_p(\max) + j_h(\max)$





In 1p-shell nuclei they are reached by M4 transitions: $1p_{3/2} \rightarrow 1d_{5/2}$

Stretched states in the continuum

The configurational purity – ones of the simplest known nuclear excitations which should provide the most clean information on the details of nuclear force.

The M4 resonance, with its super-pure stretched coupling between the $p_{3/2}$ and the $d_{5/2}$ shells appears to be an ideal candidate to probe and constrain the spin-orbit and tensor components of the **Gamow Shell Model** interaction.

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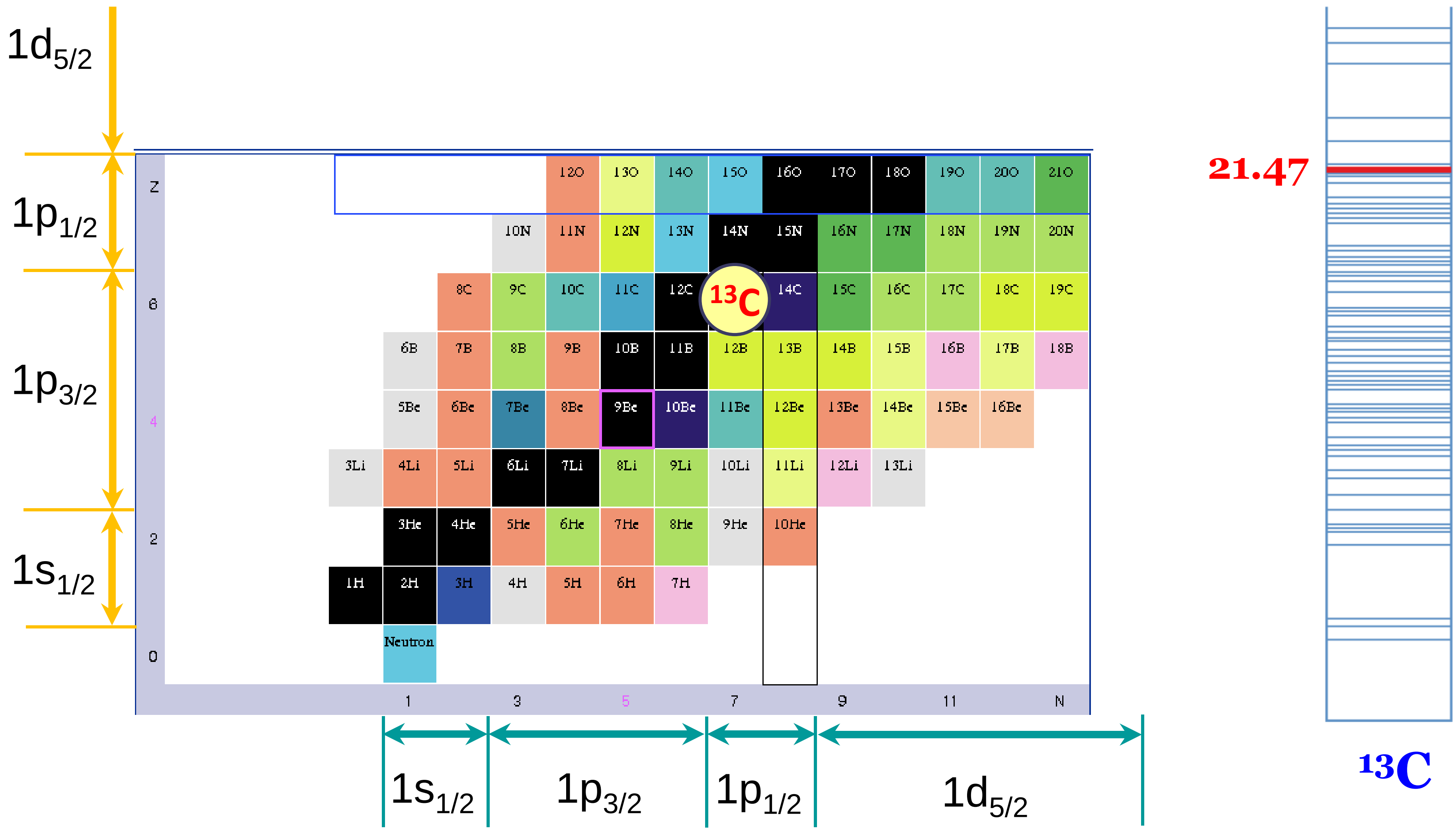
The talk of Y. Jaganathen

Studies of the M4 resonances in ^{13}C

The aim is to identify decay from the M4 $1p_{3/2} \rightarrow 1d_{5/2}$ resonance in ^{13}C



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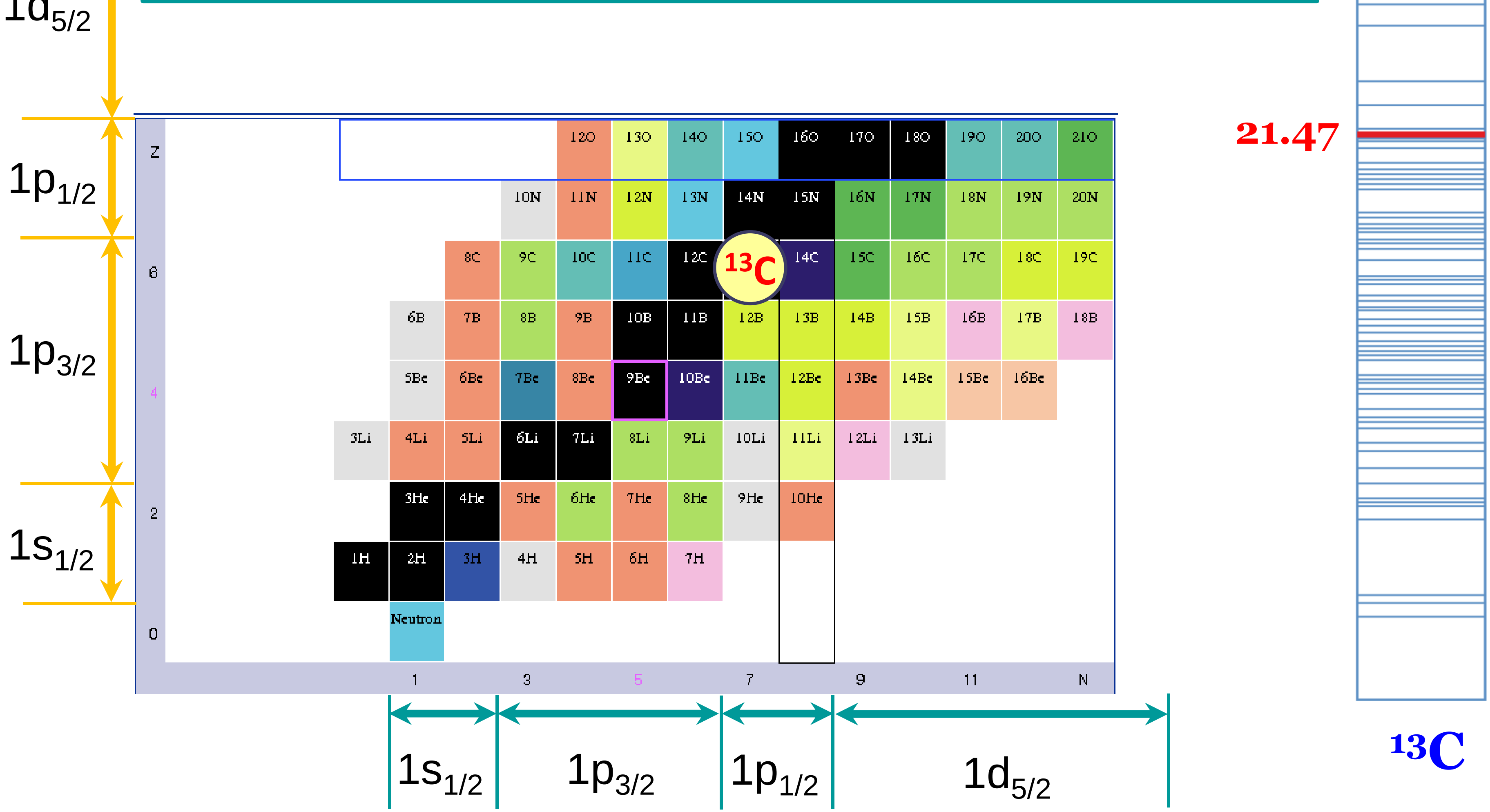
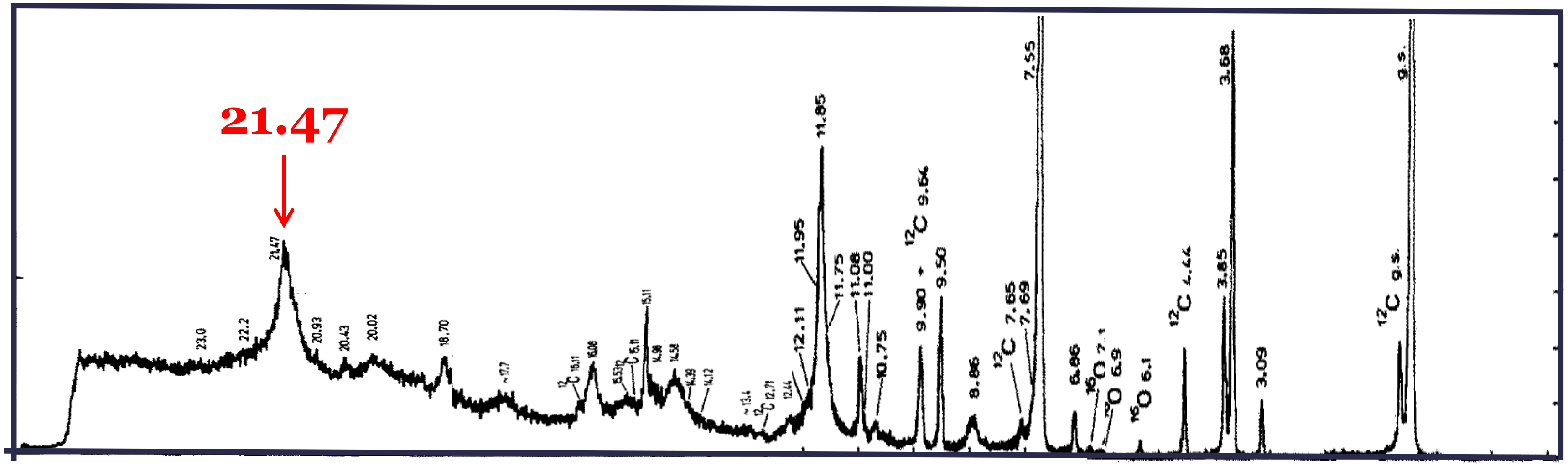
Populated in: **inelastic scattering of protons**, electrons or pions



Studies of the M4 resonances in ^{13}C

Inelastic proton scattering on ^{13}C
E_p = 135 MeV



E (MeV)

Indiana University Cyclotron Facility Magnetic Spectrograph , S.F. Collins et al., Nuc. Phys. A481, 494(1988)

From (π, π') scattering: **21.47 MeV** is (7/2$^+$,9/2$^+$) p and n excitations

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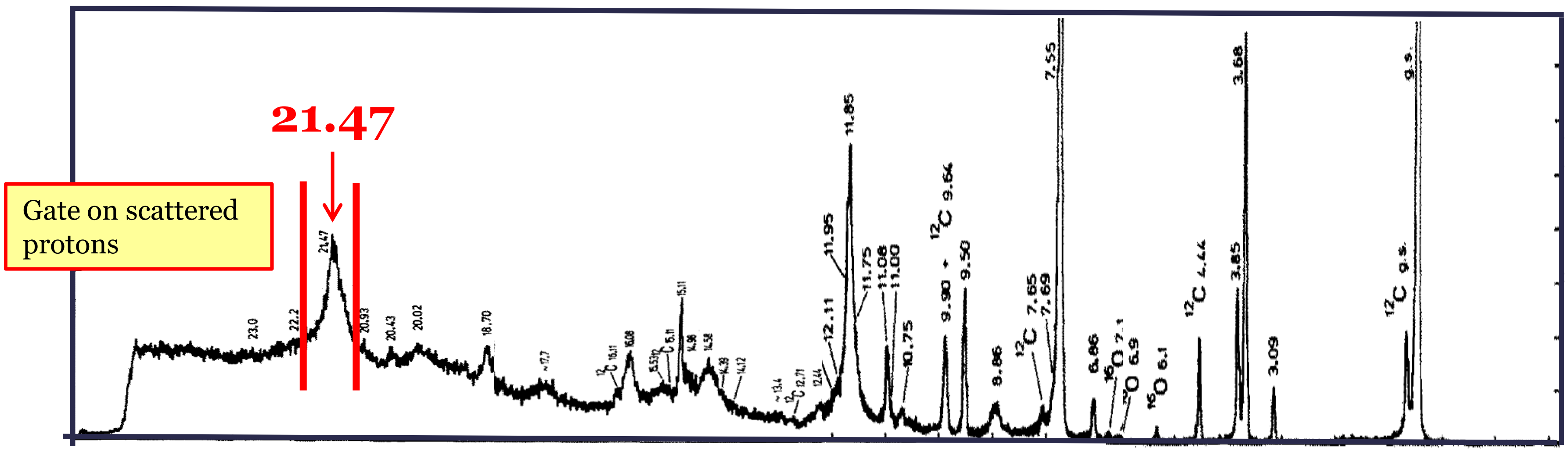

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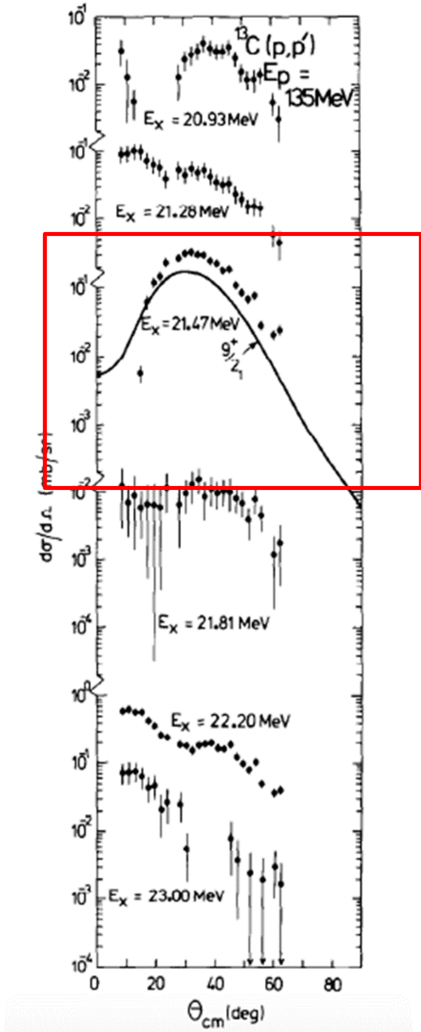
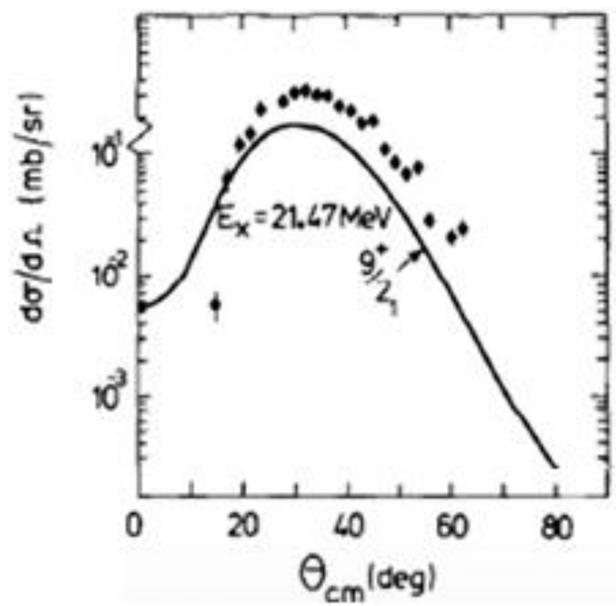
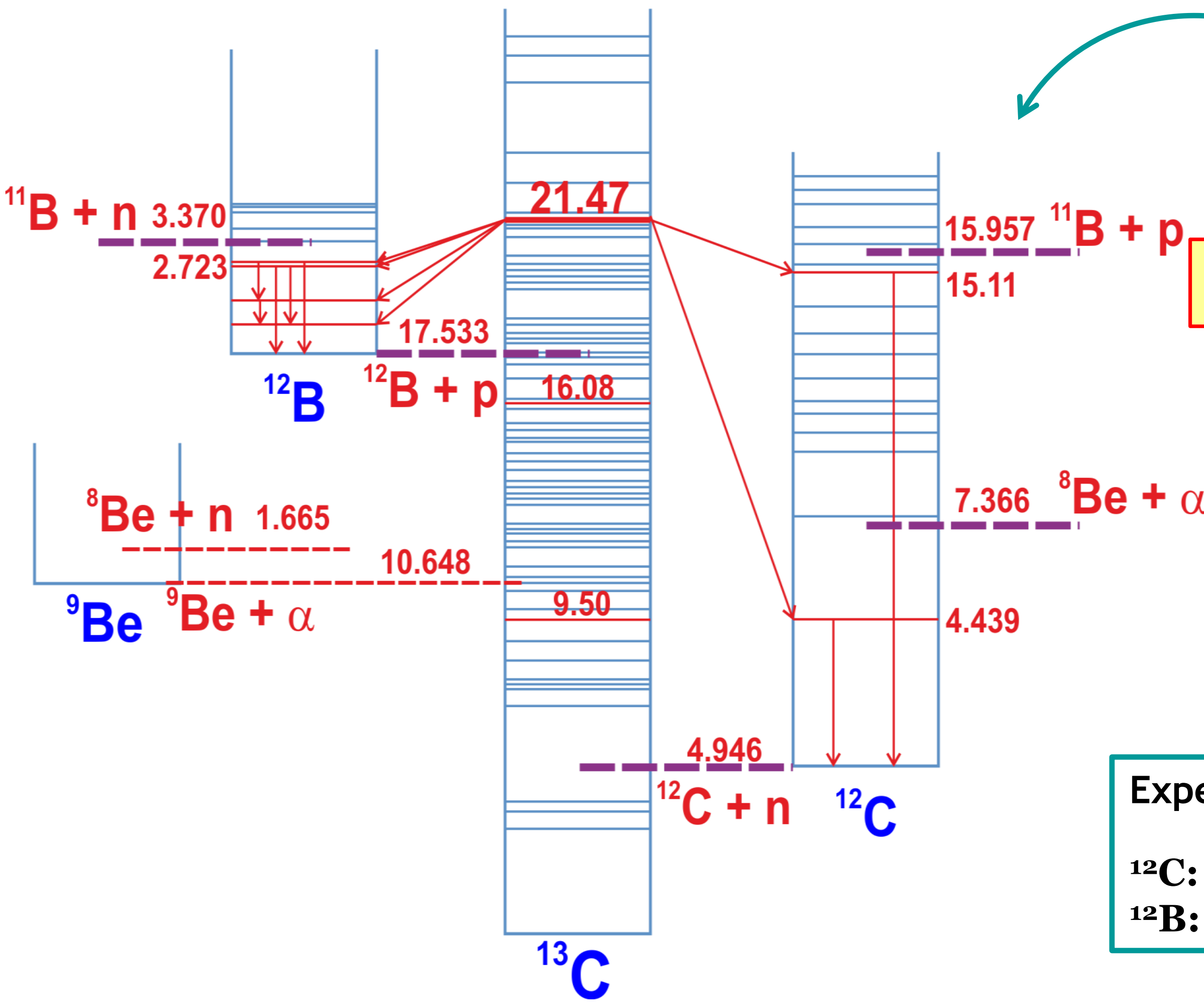


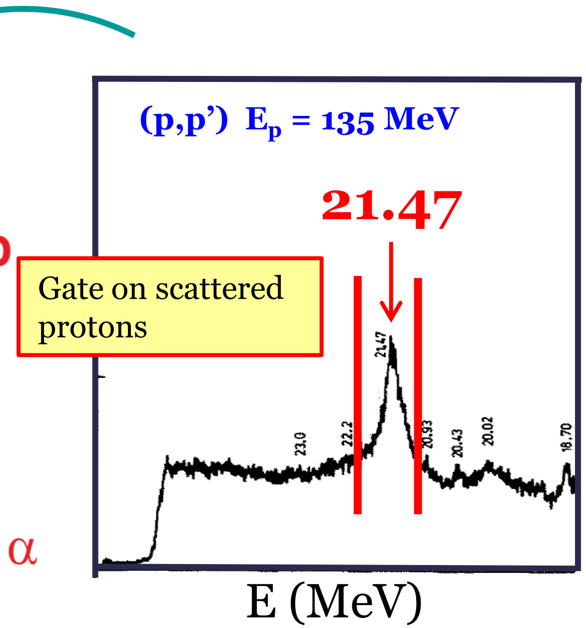


The M4 resonance at 21.47 MeV
is peaked at 30°

S.F. Collins et al., Nuc. Phys. A481, 494(1988)

Studies of the M4 resonances in ^{13}C





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Expected γ-rays:

^{12}C: 4434, 15110 keV
^{12}B: 953, 1668, 1674, 2723 keV

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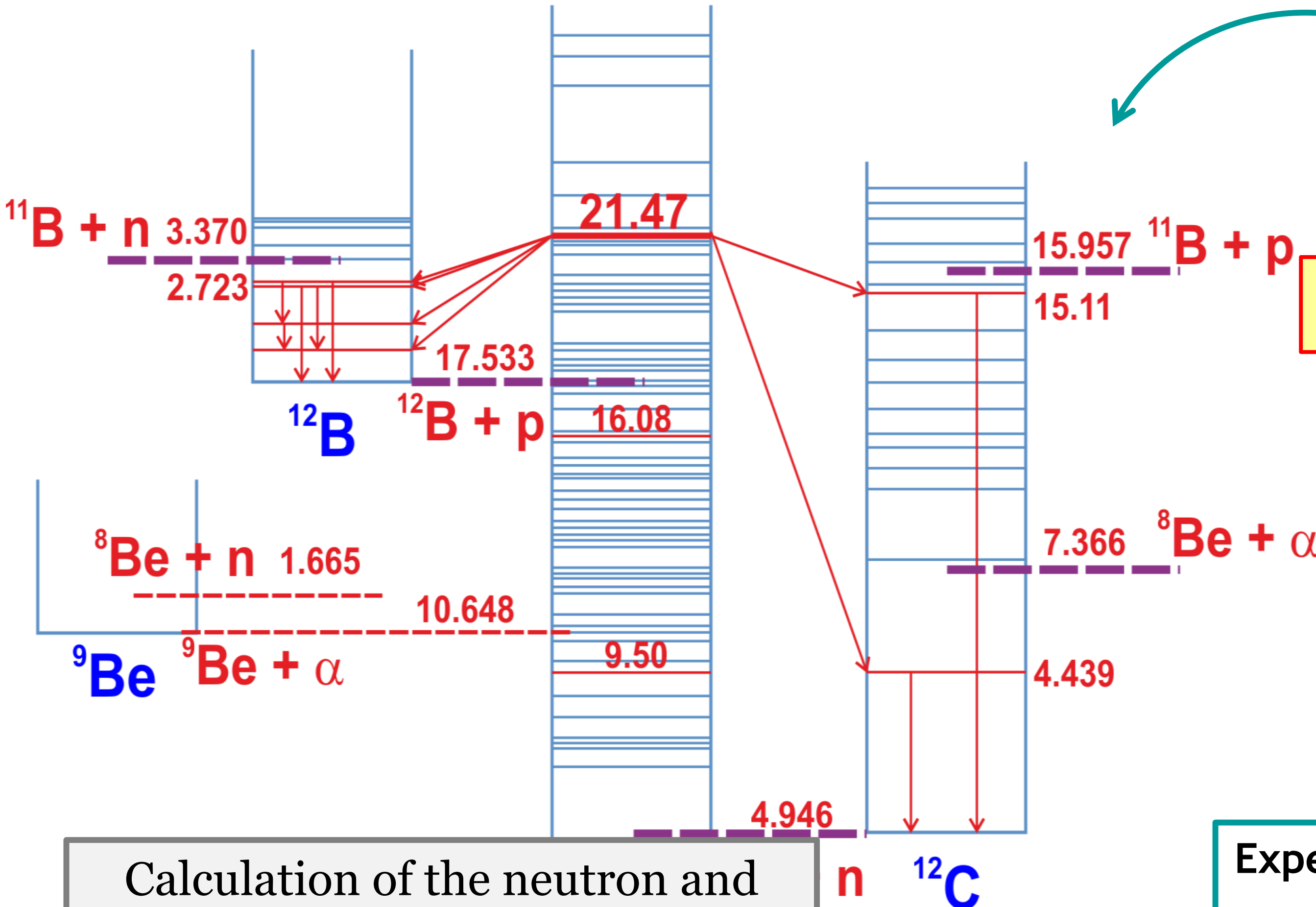

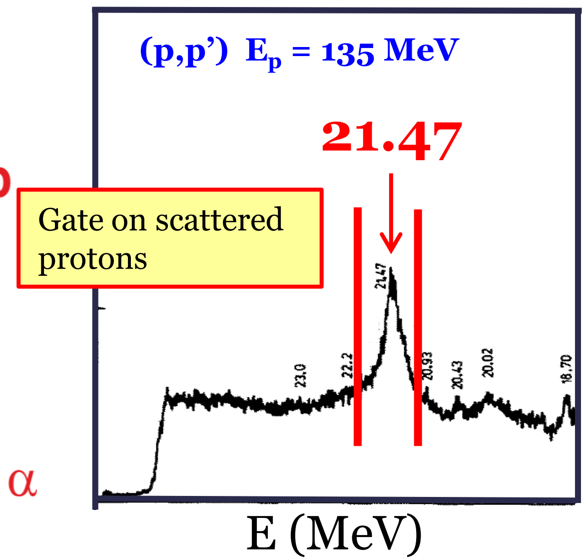

S.F. Collins et al., Nucl. Phys. A481, 494(1988)

Calculation of the neutron and proton branching ratios from Gamow Shell Model - the talk of **Y. Jaganathen**

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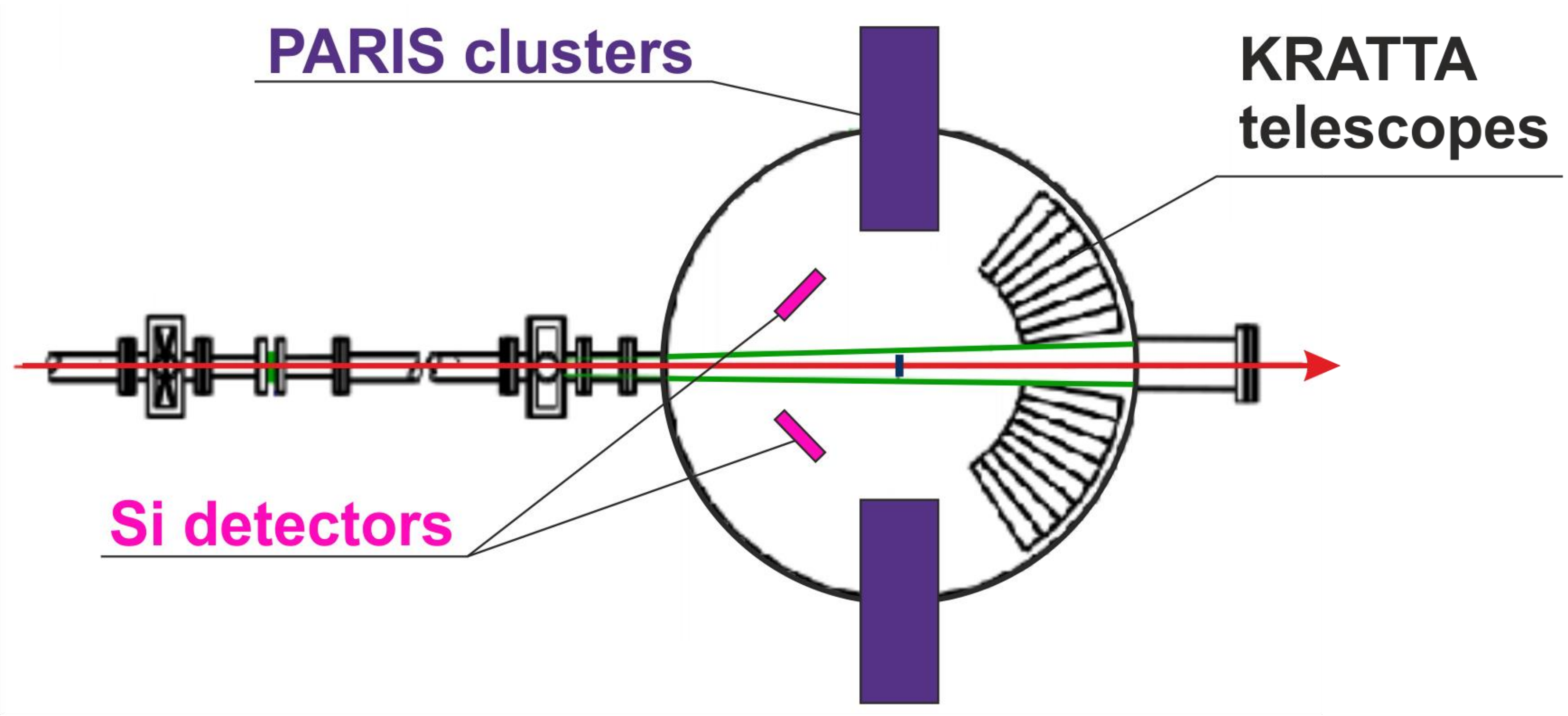
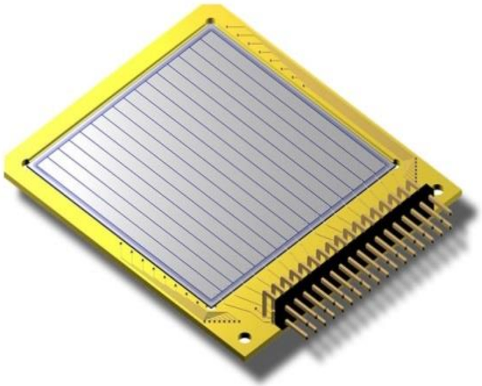
Experimental setup – presently available



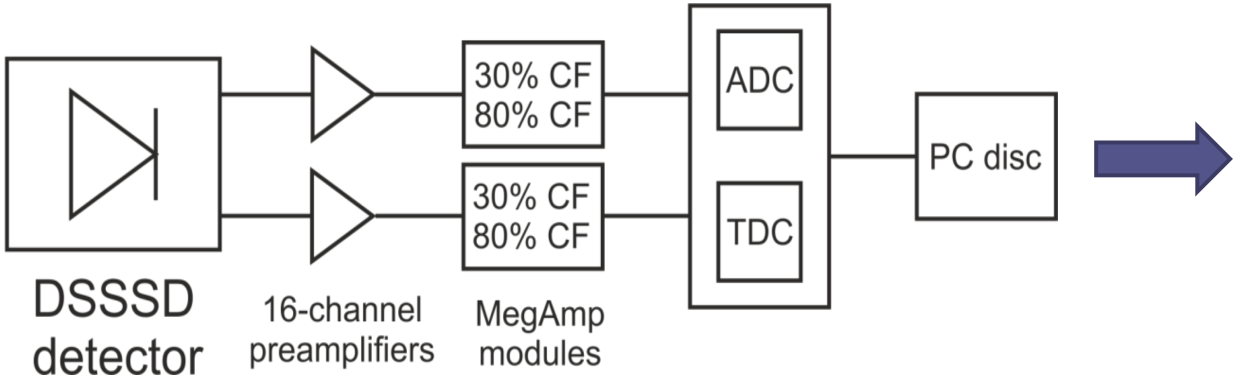
Experimental setup – presently available

Double Sided Silicon Strip Detector (Micron Semiconductor Ltd)

Active area:	50mm x 50mm
No. of channels:	32 (16 per side)
Thickness:	1.5 mm
Full depletion:	200V

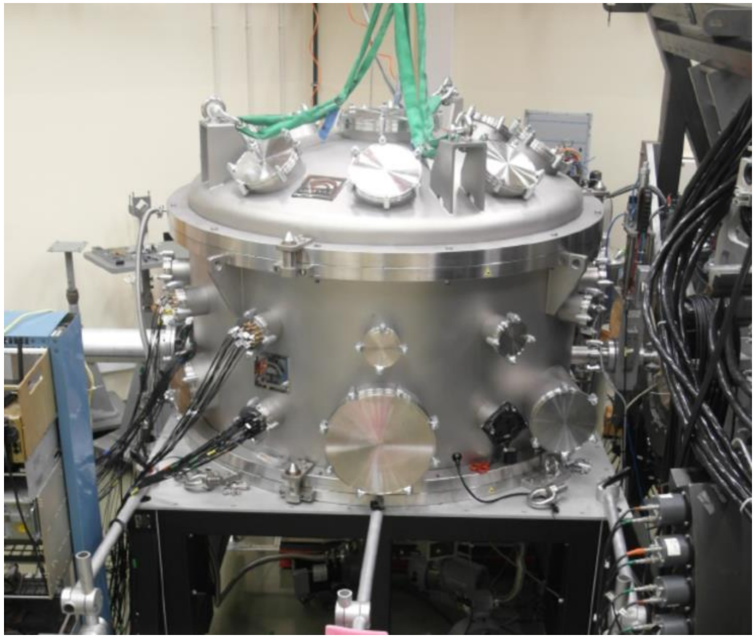


Single side view (www.micronsemiconductor.co.uk)

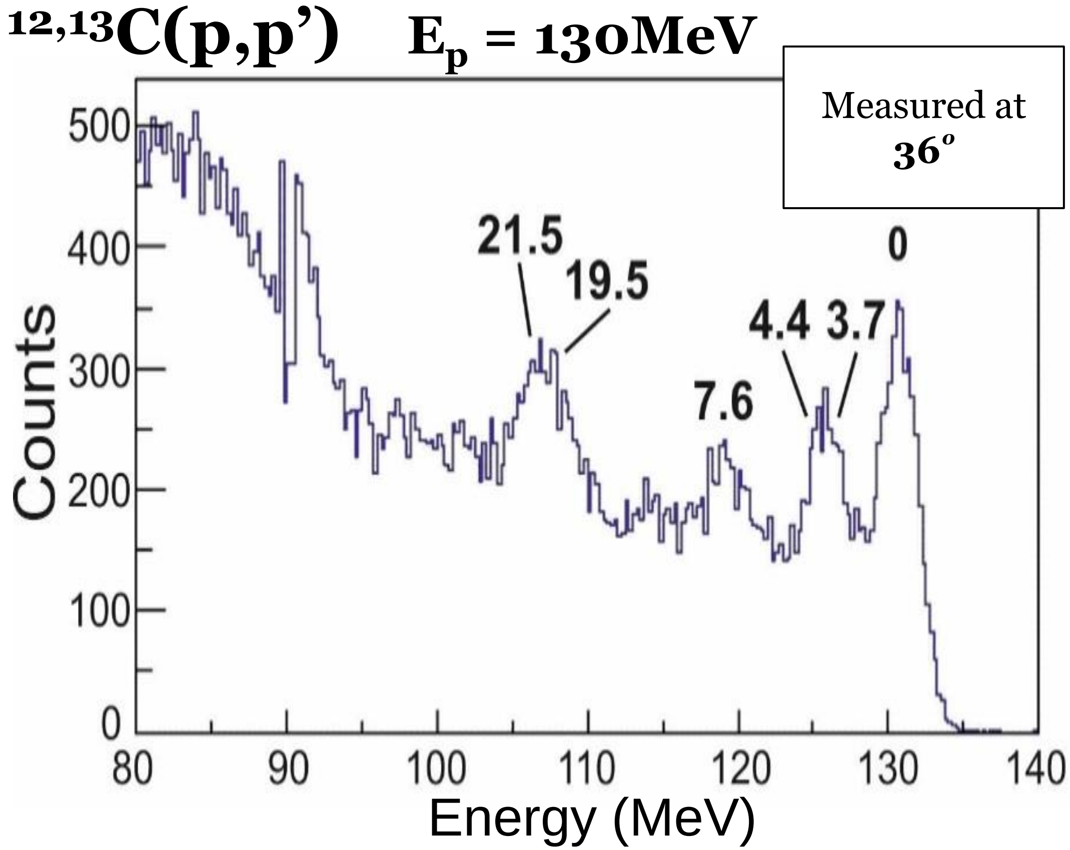


Information on the energy and rise time allowing for **light particle identification**

Experimental setup – presently available



Big vacuum chamber at CCB



The results from a recent test experiment performed at CCB – the proton energy spectrum

Future developments at CCB

More complex cases and heavier nuclei, where the density of states is larger, may be studied only if the **energy resolution will be improved**

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1) New experimental hall at CCB:
Magnetic spectrometer - precise measurement of the excitation energy of the resonance

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The talks of B. Wasilewska and M. Krzysiek

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1) New experimental hall at CCB:
Magnetic spectrometer -

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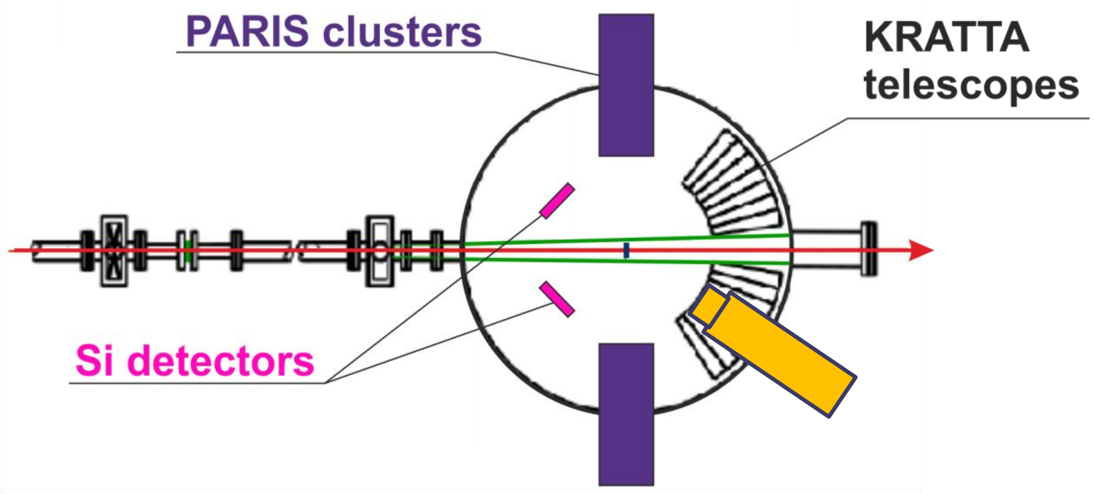
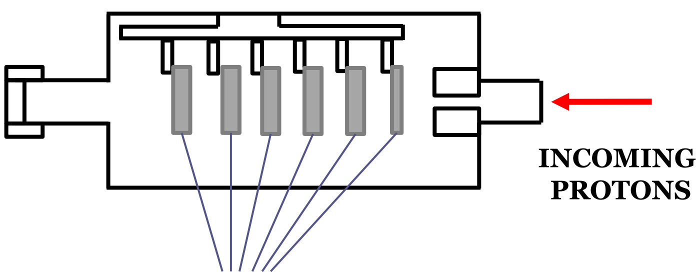
2) Another possibility: **Ge detector for proton energy measurements**



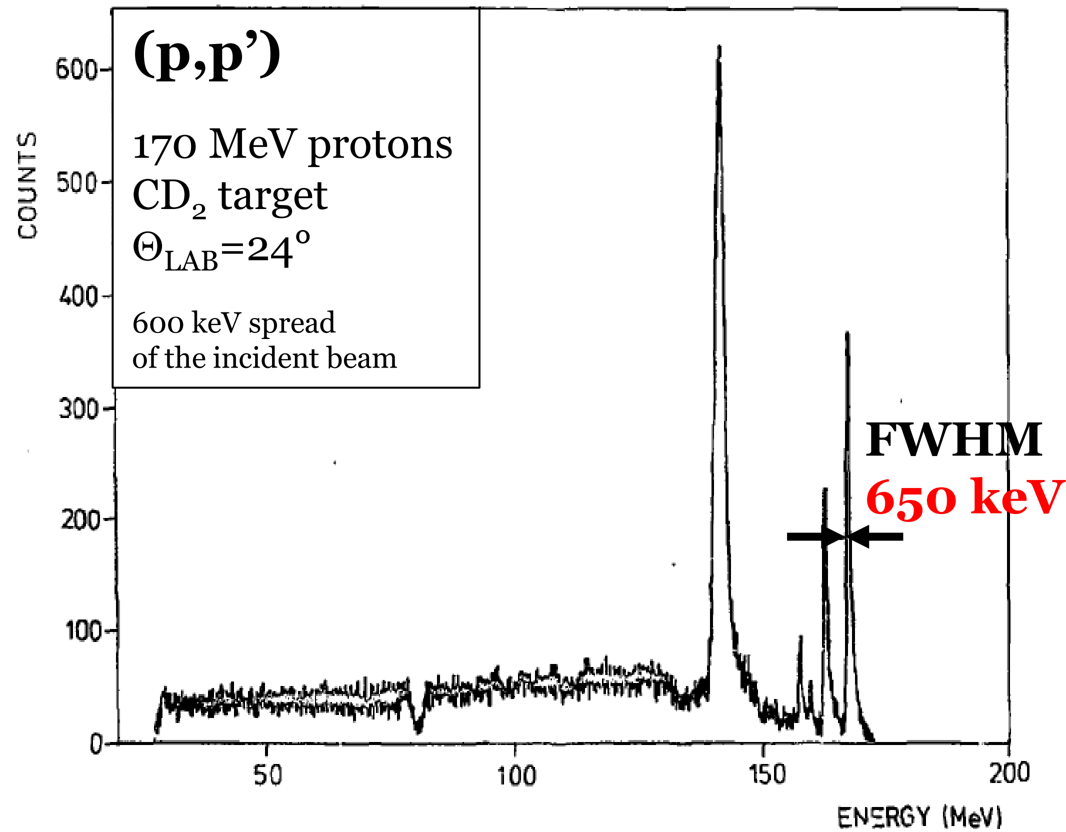
Future developments at CCB

Ge detector for scattered protons energy measurement



6 HPGe DETECTORS
(66 mm Ge in total)

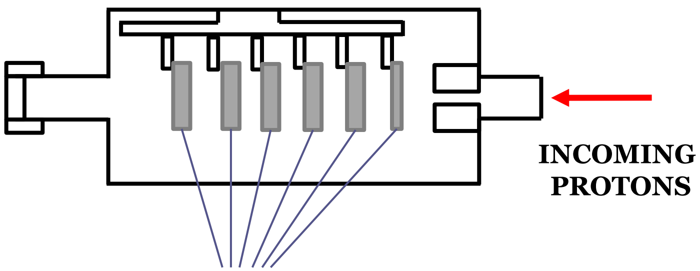
Energy (MeV)	Range (mm)	Stopped in Detector No.	ΔE(fwhm) (keV)	$\frac{\Delta E}{E}$ x10^3	Efficiency (%)
95.6	21	3	240±20	2.51	91.53*
113.2	28	4	300±20	2.65	89±2
130.6	37	4	320±20	2.45	86±1.5
144	43	5	370±20	2.57	81±2
150.4	46	5	380±20	2.53	79±2
156.5	50	5	380±20	2.43	74±3
162.4	54	>5	-	-	-



G. Riepe et al., Nucl. Inst. And Meth. 177, 361 (1980)

Future developments at CCB

Ge detector for scattered protons energy measurement



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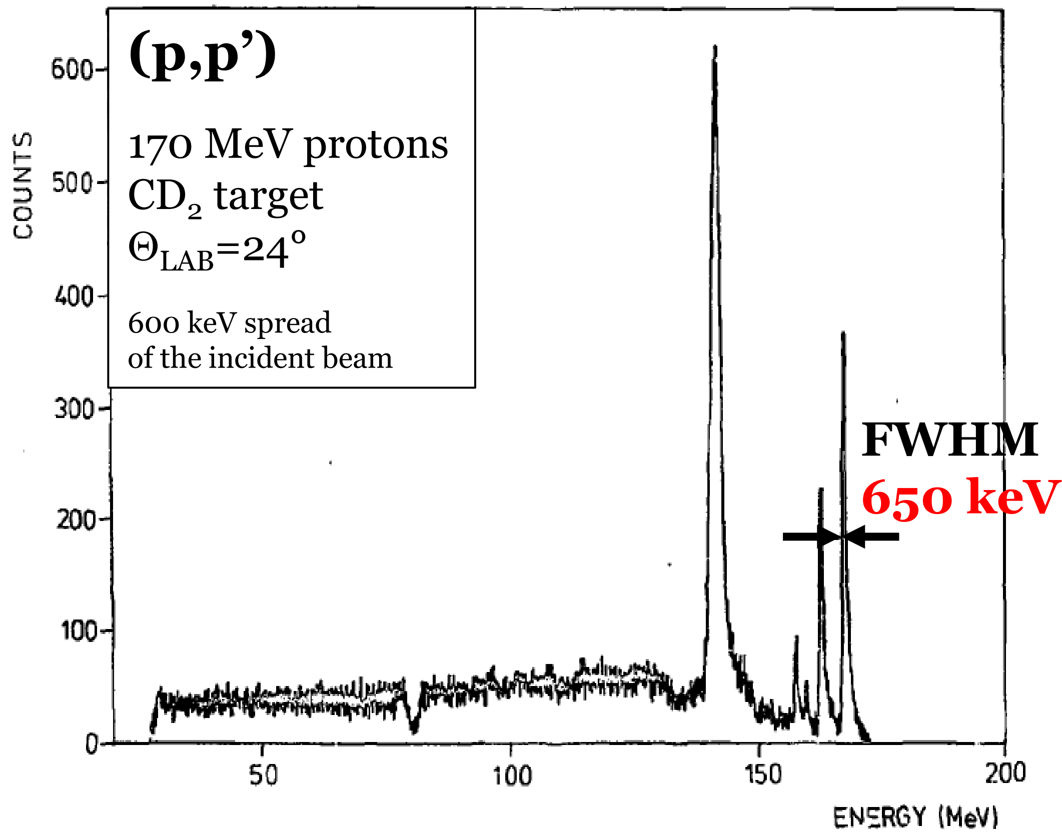
Energy (MeV)	Range (mm)	Stopped in Detector No.	ΔE(fwhm) (keV)	$\frac{\Delta E}{E}$ x10^3	Efficiency (%)
150.4	46	5	380±20	2.53	79±2
156.5	50	5	380±20	2.43	74±3
162.4	54	>5	-	-	-

E (MeV)	FWHM(keV)
130.6	320



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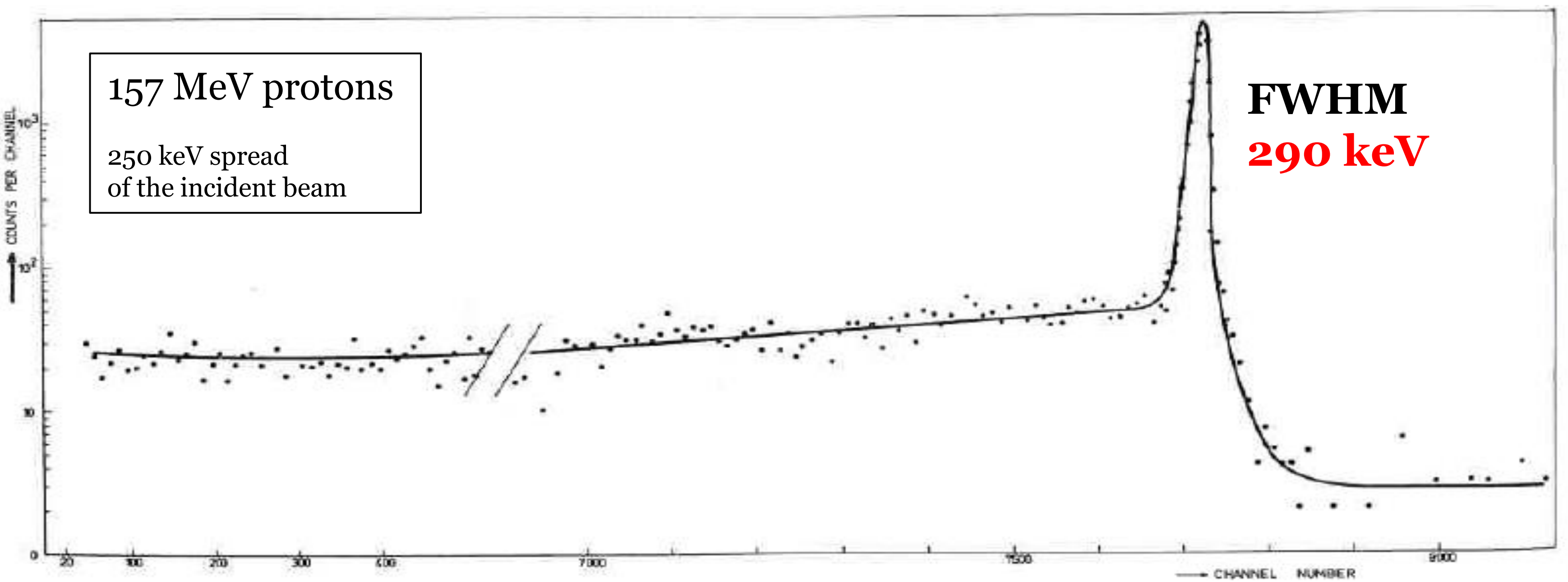

Spectrum from **1 coaxial Ge detector** (90 mm length, 37 mm diameter)

D. Dorcioman et al., Nucl. Inst. And Meth. 101, 91 (1972)

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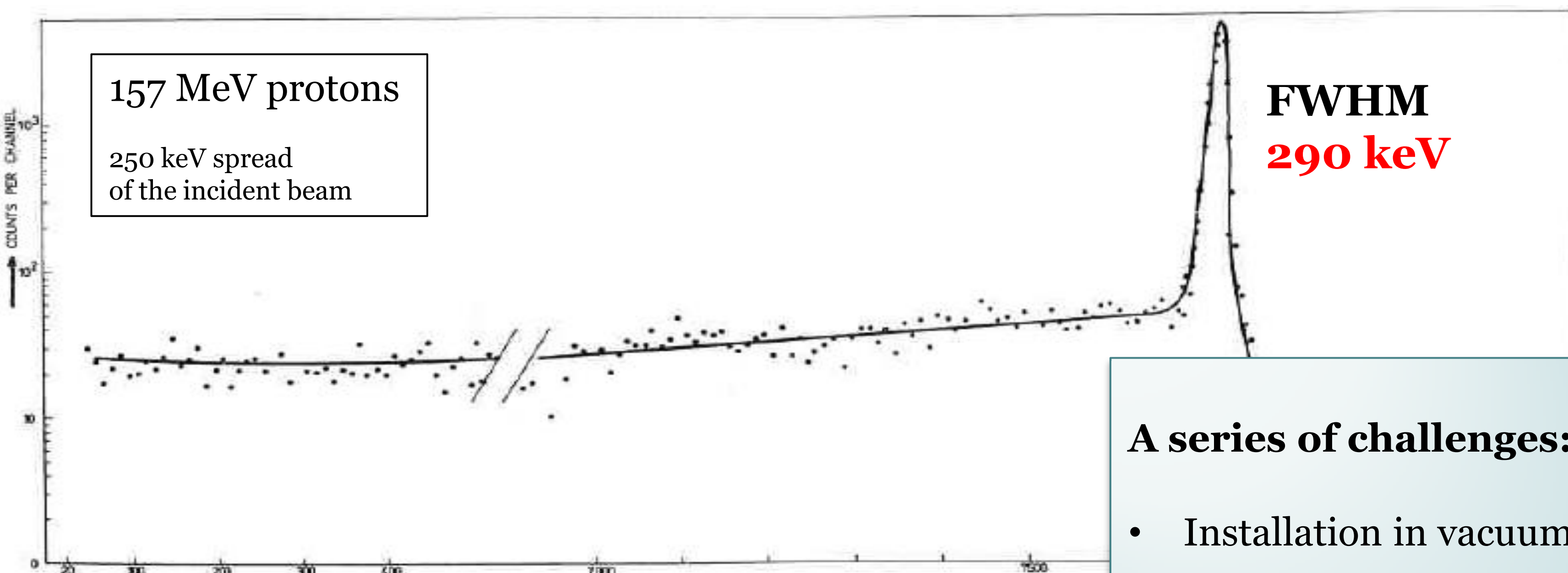


Spectrum from **1 coaxial Ge detector** (90 mm length, 37 m

A series of challenges:

- Installation in vacuum
- Radiation damages
- ....

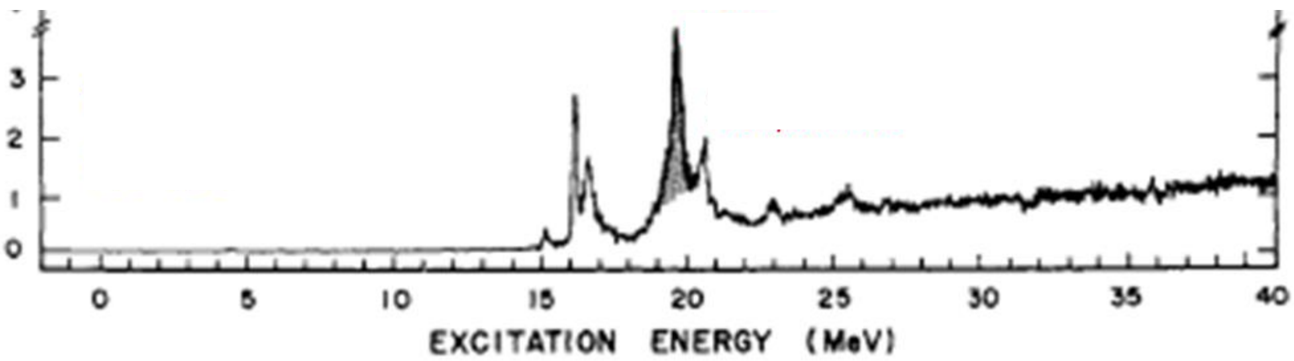
D. Dorcioman et al., Nucl. Inst. And Meth. 101, 91 (1972)

Interesting cases for future studies

- **^{12}C**: excited states having strong single-particle-hole component appear in ^{12}C at energies above 16 MeV
- broad, overlapping nature of M4 excitations in ^{12}C – better energy resolution needed
- in particular, a resonance with sizable M4 and 2^- components has been observed at the 19.5-MeV excitation energy, in measurements at high momentum transfer.

(e,e') scattering

19.5 – strong M4 component



R.S. Hicks et al., Pys. Rev. C34, 1161 (1986)

Two states with T=1 and T=0 predicted

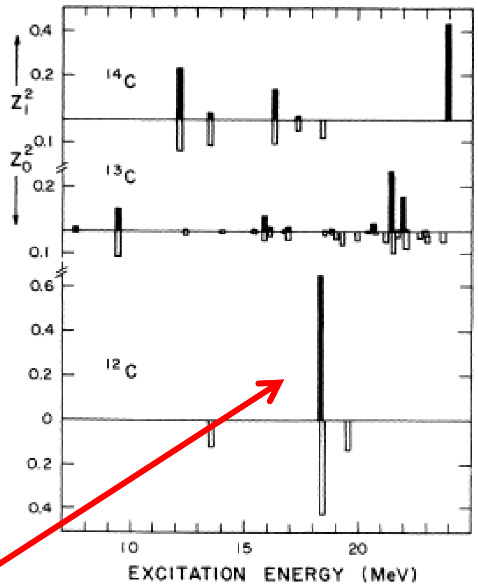
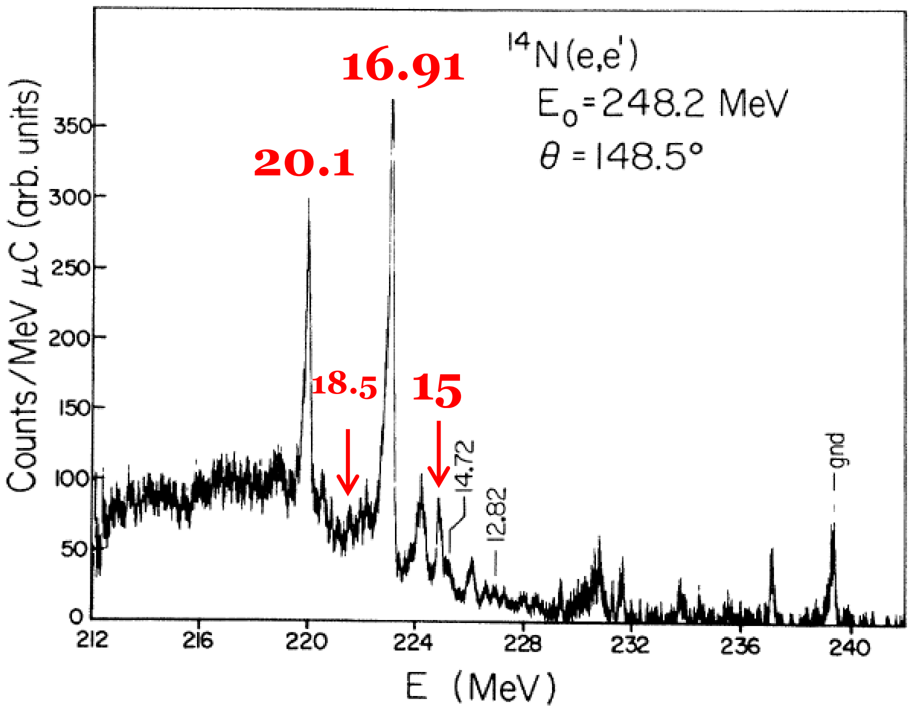


FIG. 2. Squared shell model transition amplitudes obtained for *M4* excitations in carbon isotopes. Isovector amplitudes are represented by solid bars and read upward. Isoscalar amplitudes are represented by open bars and read downward.

Interesting cases for future studies

M4 resonances in ^{14}N

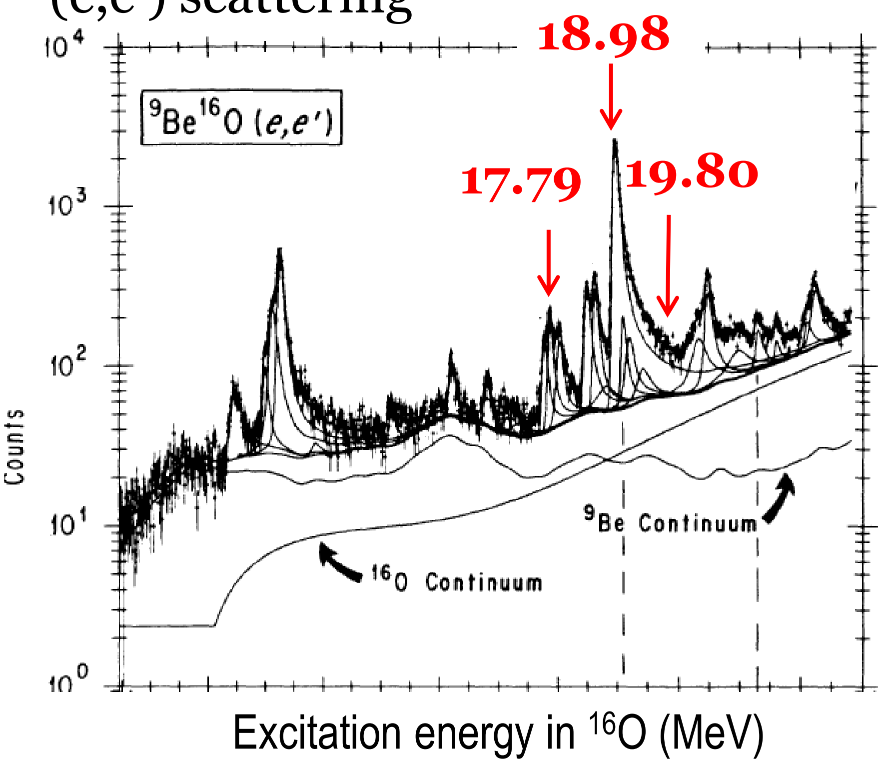
(e,e') scattering



J.C. Bergstrom et al., Pys. Rev. C29, 1168 (1984)

M4 resonances in ^{16}O

(e,e') scattering



C.E. Hyde-Wright et al., Pys. Rev. C35, 880 (1987)

Interesting cases for future studies

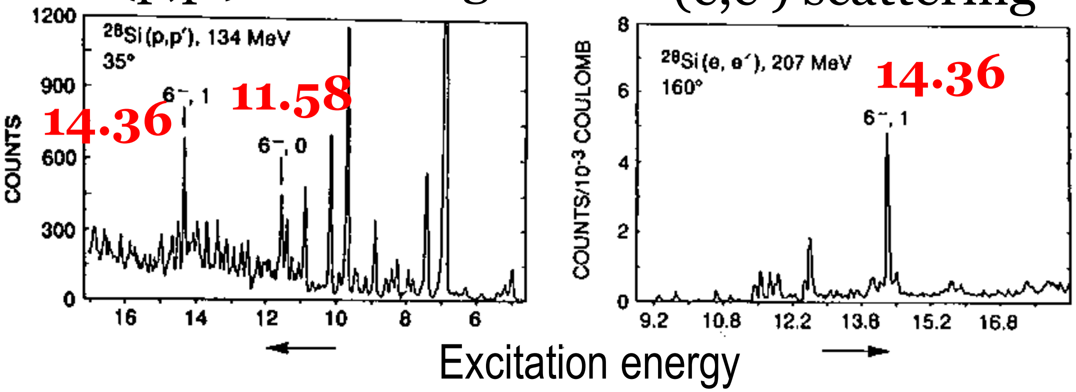
M6 transitions in 2s1d-shell nuclei

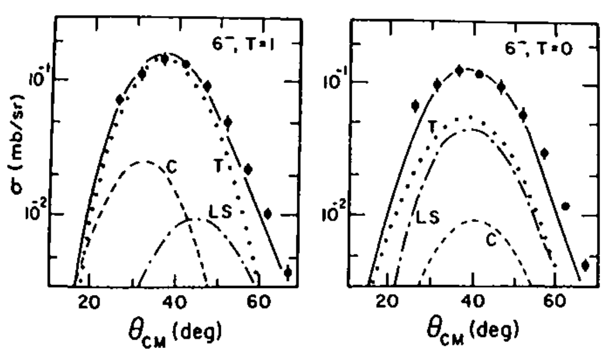
$1f_{7/2}1d_{5/2}^{-1}$ particle-hole coupling to $J^{\pi}=6^{-}$

(^{24}Mg, ^{28}Si)

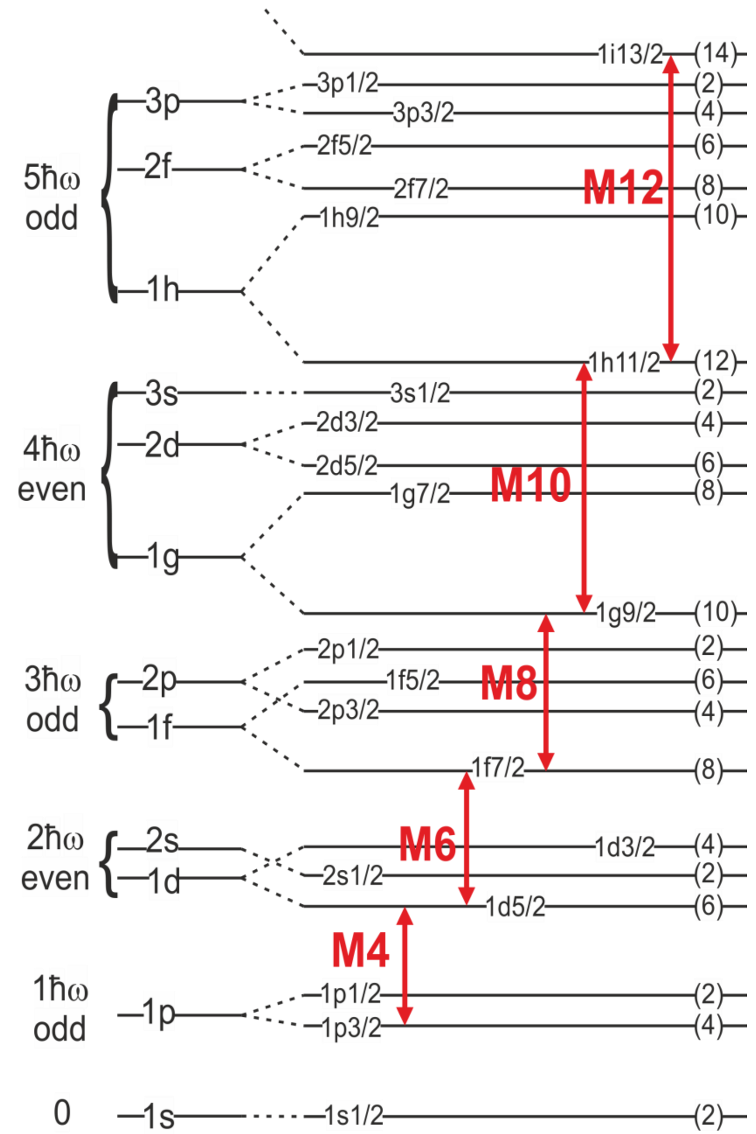
^{28}Si

(p,p') scattering (e,e') scattering





R.O. Nelson et al., Pys. Rev. C30, 755 (1984)



Summary

- The precise information will obtained on the **decay of the stretched states** in p-shell nuclei
- **^{13}C, ^{12}C, ^{14}N, ^{16}O** will be studied with presently available and completed devices, as well as with the equipment planned to be developed in future.
- Such information will provide a unique opportunity to constrain the parameters of the **Gamow Shell Model** which can greatly improve its predictive power.

Collaboration

N. Cieplicka-Oryńczak, B. Fornal, M. Kmiecik, A. Maj,
M. Ciemała, B. Wasilewska, M. Krzysiek, Ł. Iskra,
M. Ziębliński, J. Łukasik, P. Pawłowski, et al.
Institute of Nuclear Physics Polish Academy of Sciences, Kraków, Poland

S. Leoni, A. Bracco, G. Benzoni, S. Brambilla,
C. Boiano, F. Camera, F. Crespi, et al.
University of Milan and INFN Sezione di Milano, Milan, Italy

Thank you for your attention!