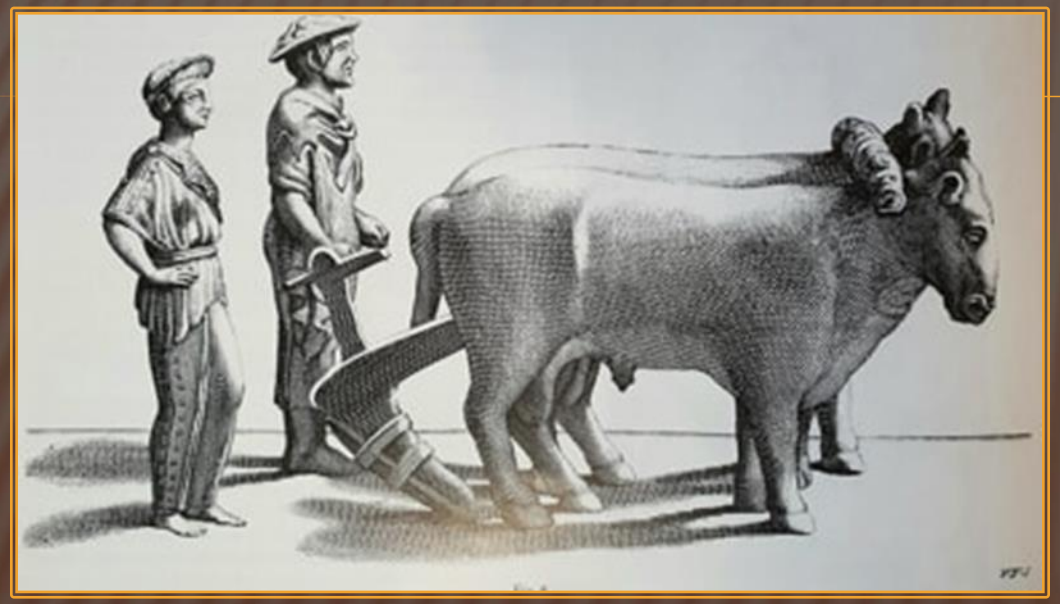
SYMPOSIUM FOR UGO's 90 YEARS
CERN Council Chamber, Friday 4 April 2025

QUASI-FREE ELECTRON SCATTERING ON NUCLEI AND ATOMS



Giovanni Stefani
Dipartimento di Scienze Università Roma Tre
CNR Istituto di Struttura della Materia

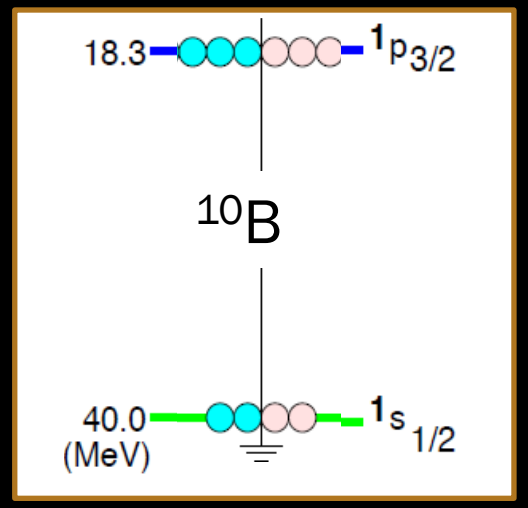
WHEN I MET UGO 1969

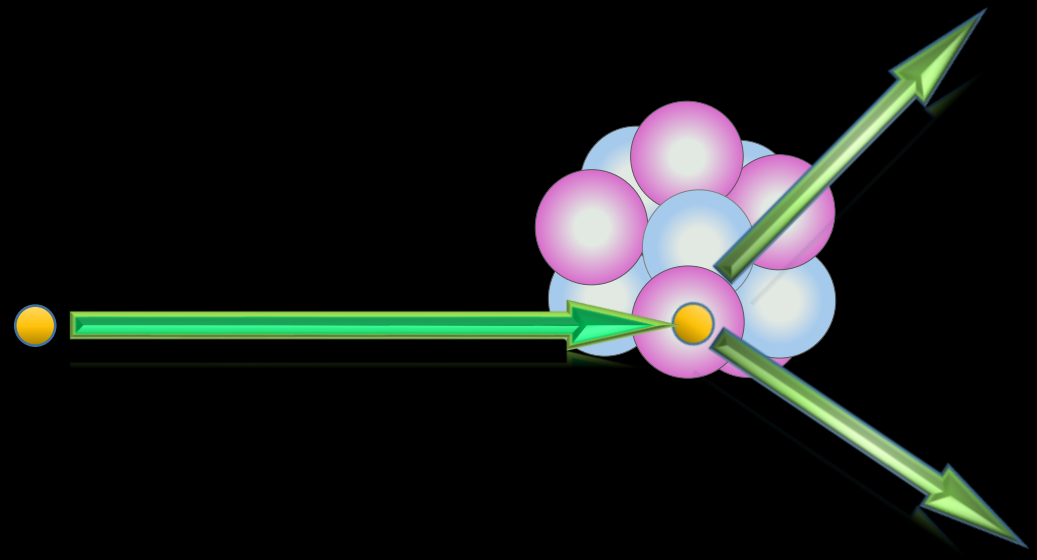
WHY QUASI-FREE SCATTERING?

Boron nucleus

5 protons+ 5 neutrons

Shell Model





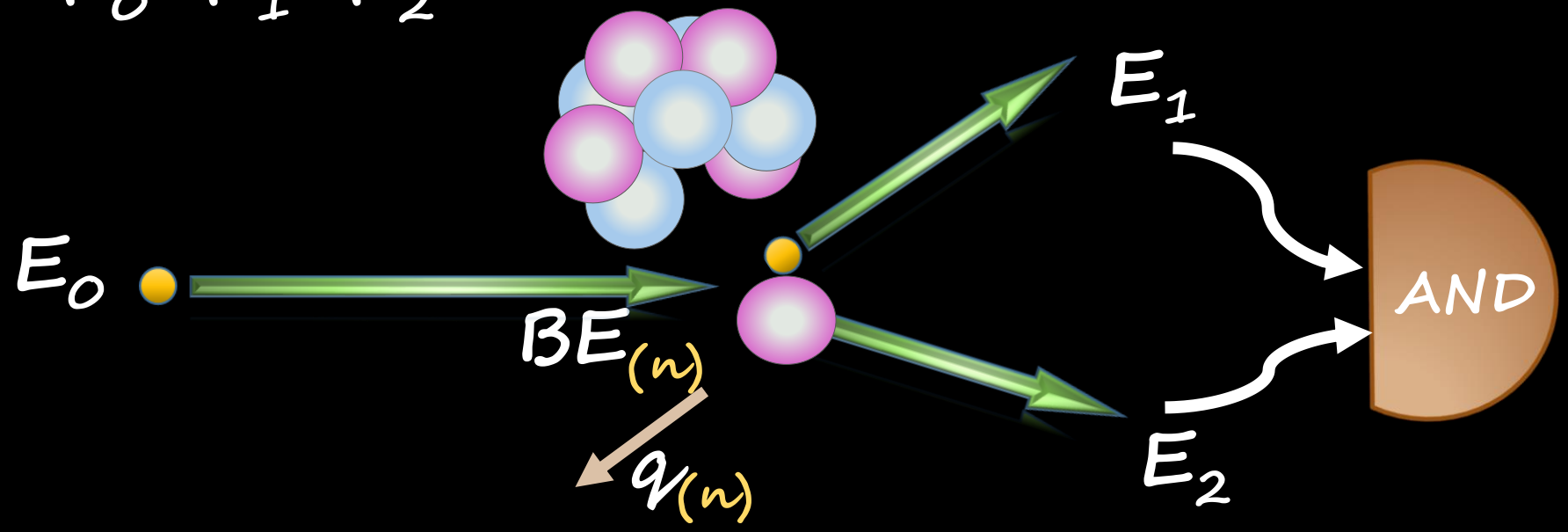
Binding energies and Momentum Distributions

Unknown observables

Quasi free scattering

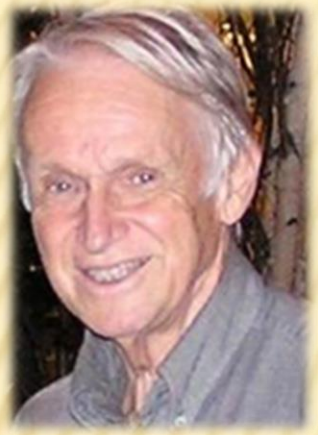
$$BE_{(n)} = E_0 - E_1 - E_2$$

$$q_{(n)} = P_0 - P_1 - P_2$$



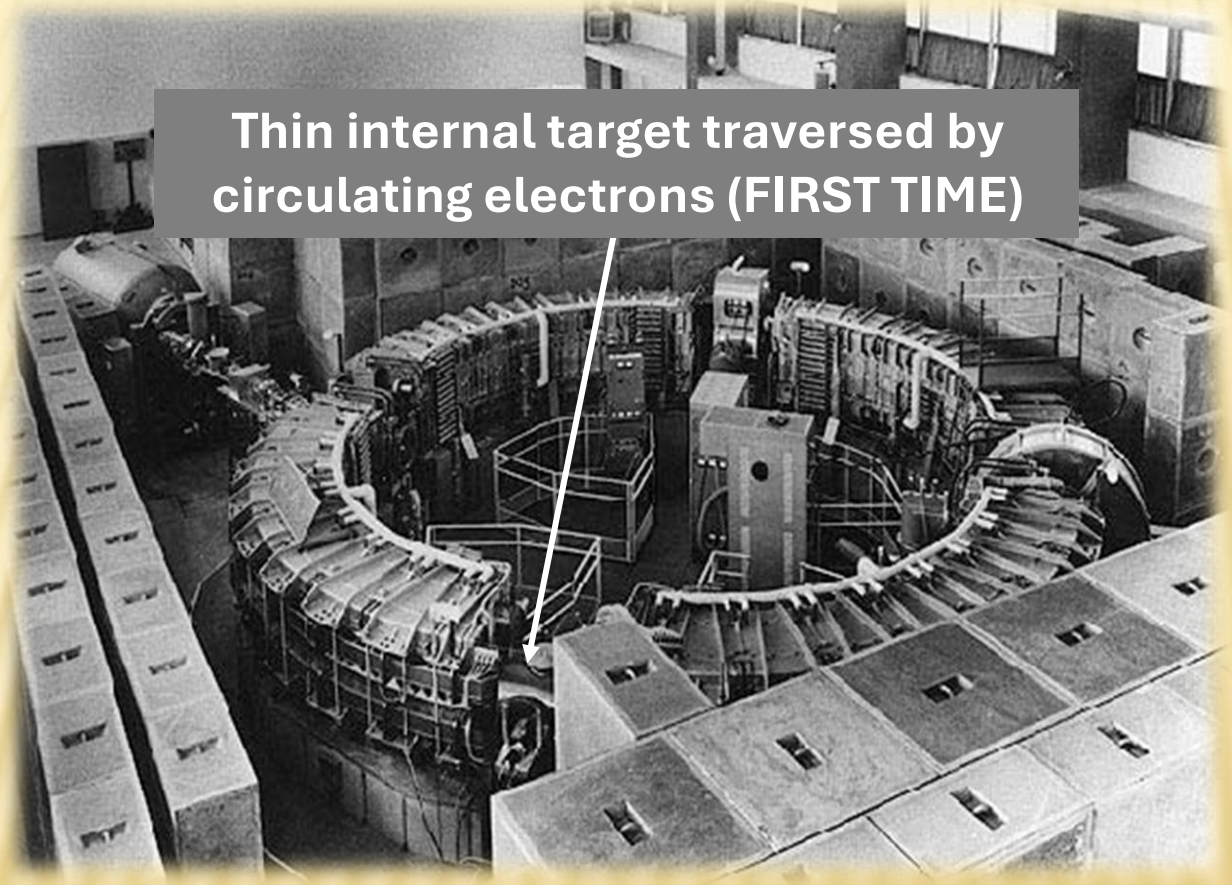
(e,e'p) INSTEAD OF (p,2p)

1962



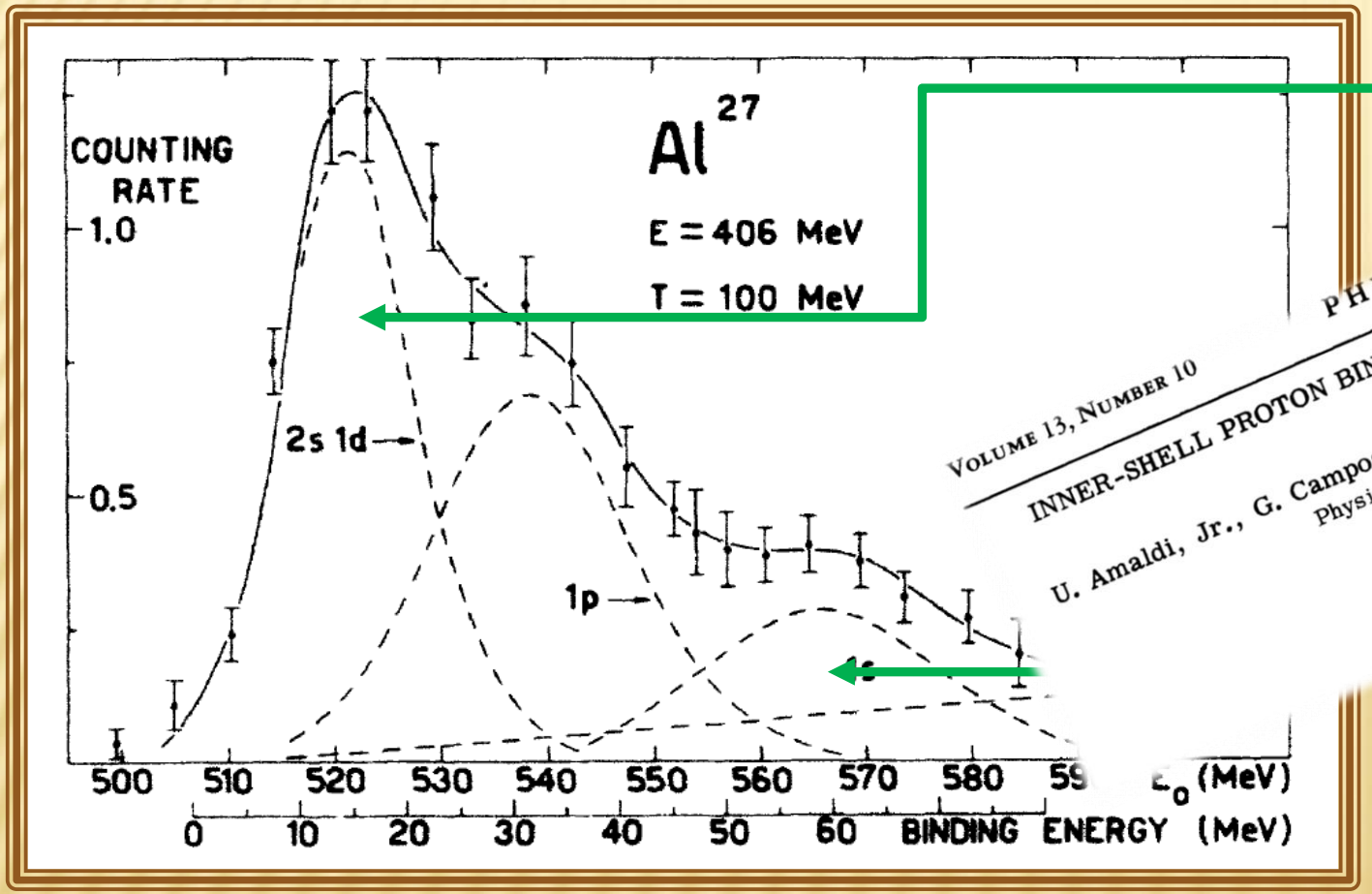
Torleif Erikson

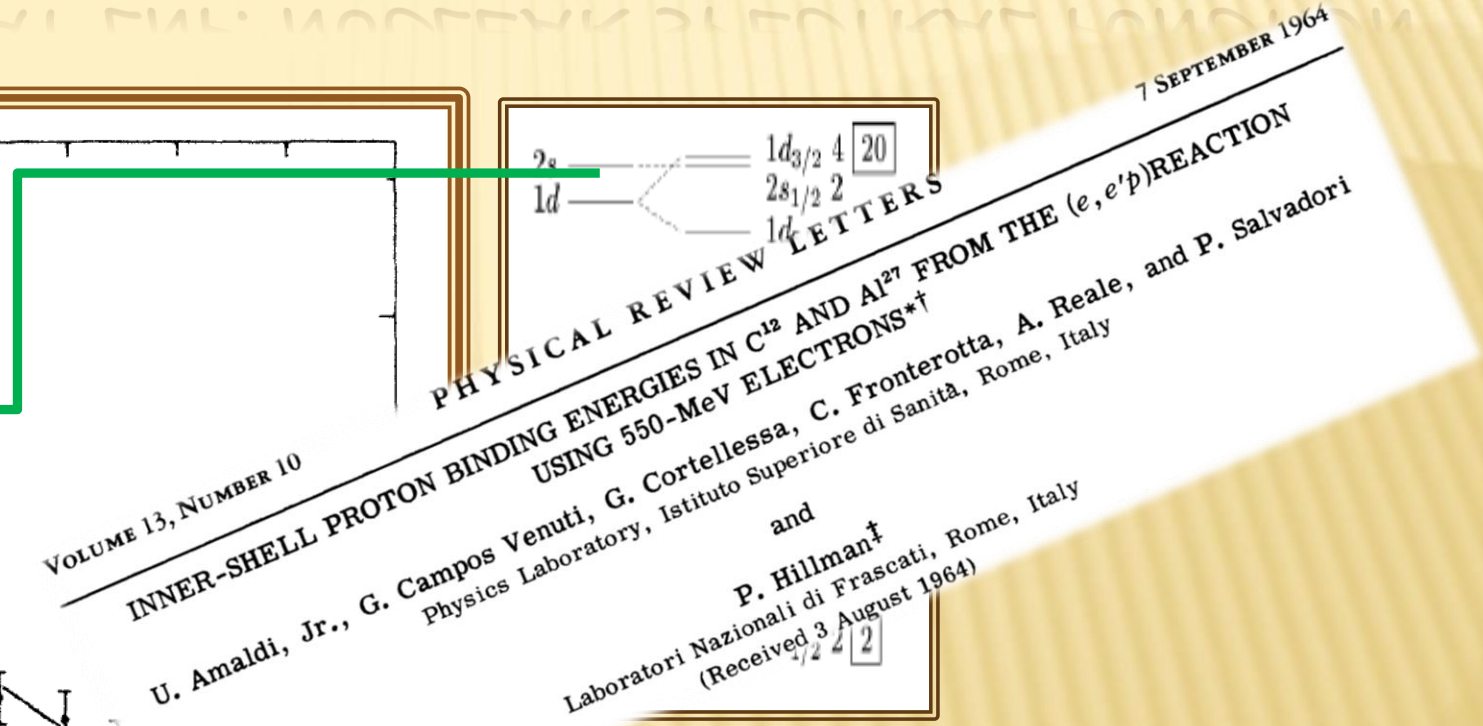
ELECTRON SYNCHROTRON
INFN LABORATORY @ FRASCATI - 1963



Courtesy of Ugo Amaldi

FIRST (e,e'p) EXPERIMENT AT LNF: NUCLEAR SPECTRAL FUNCTION

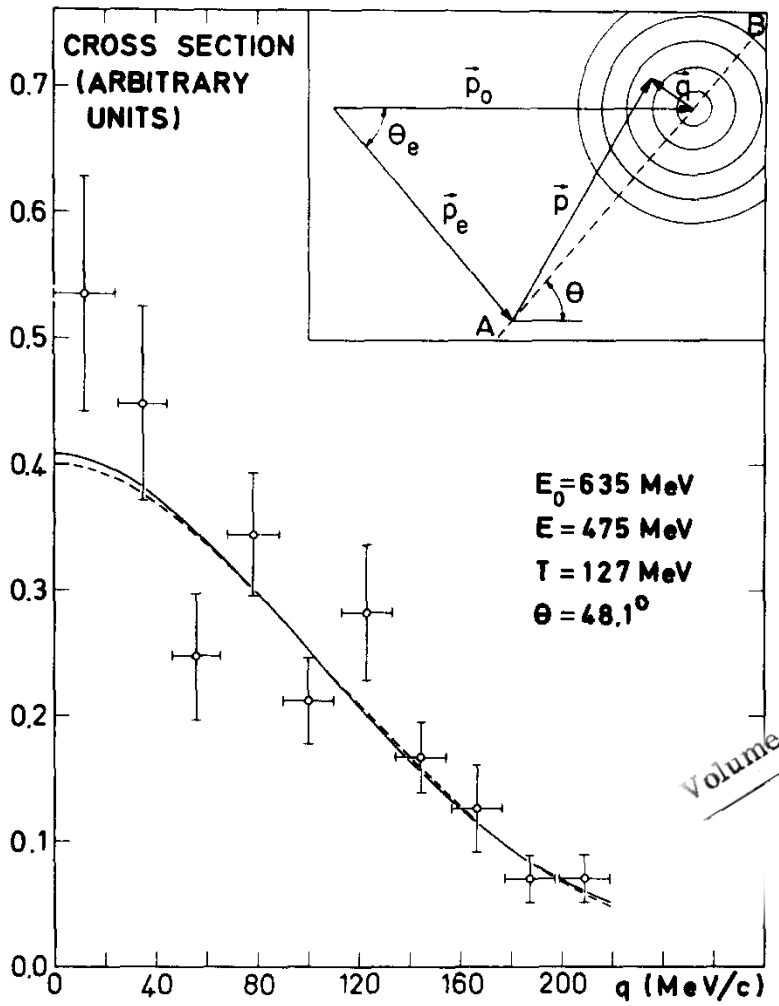


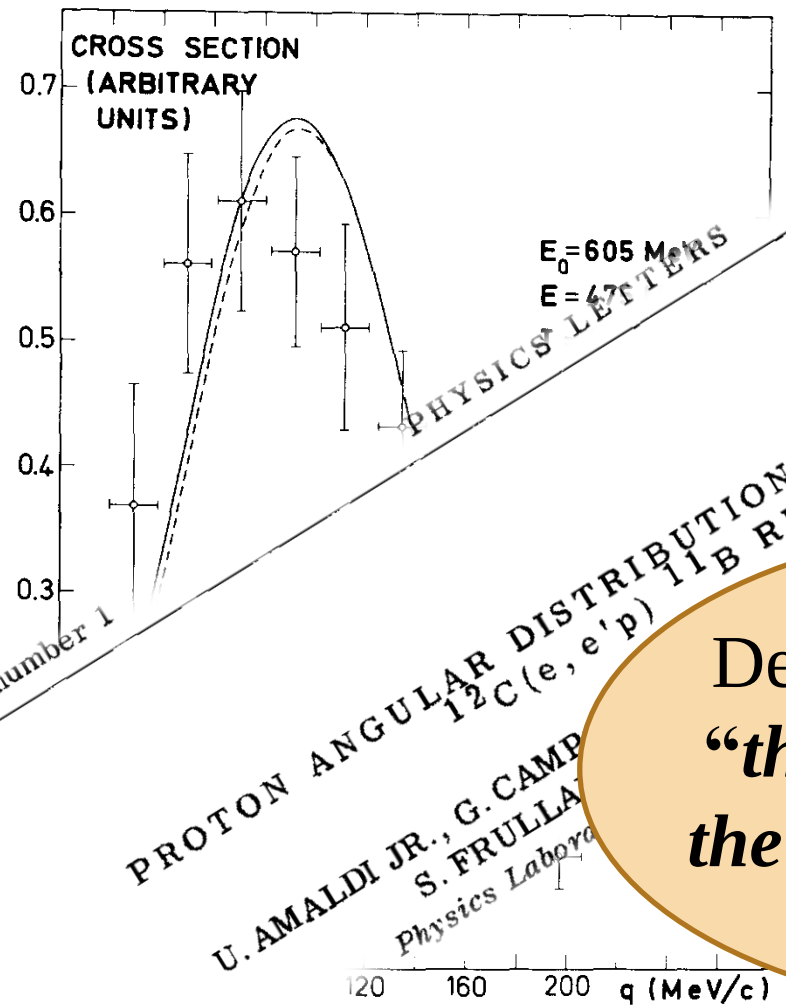


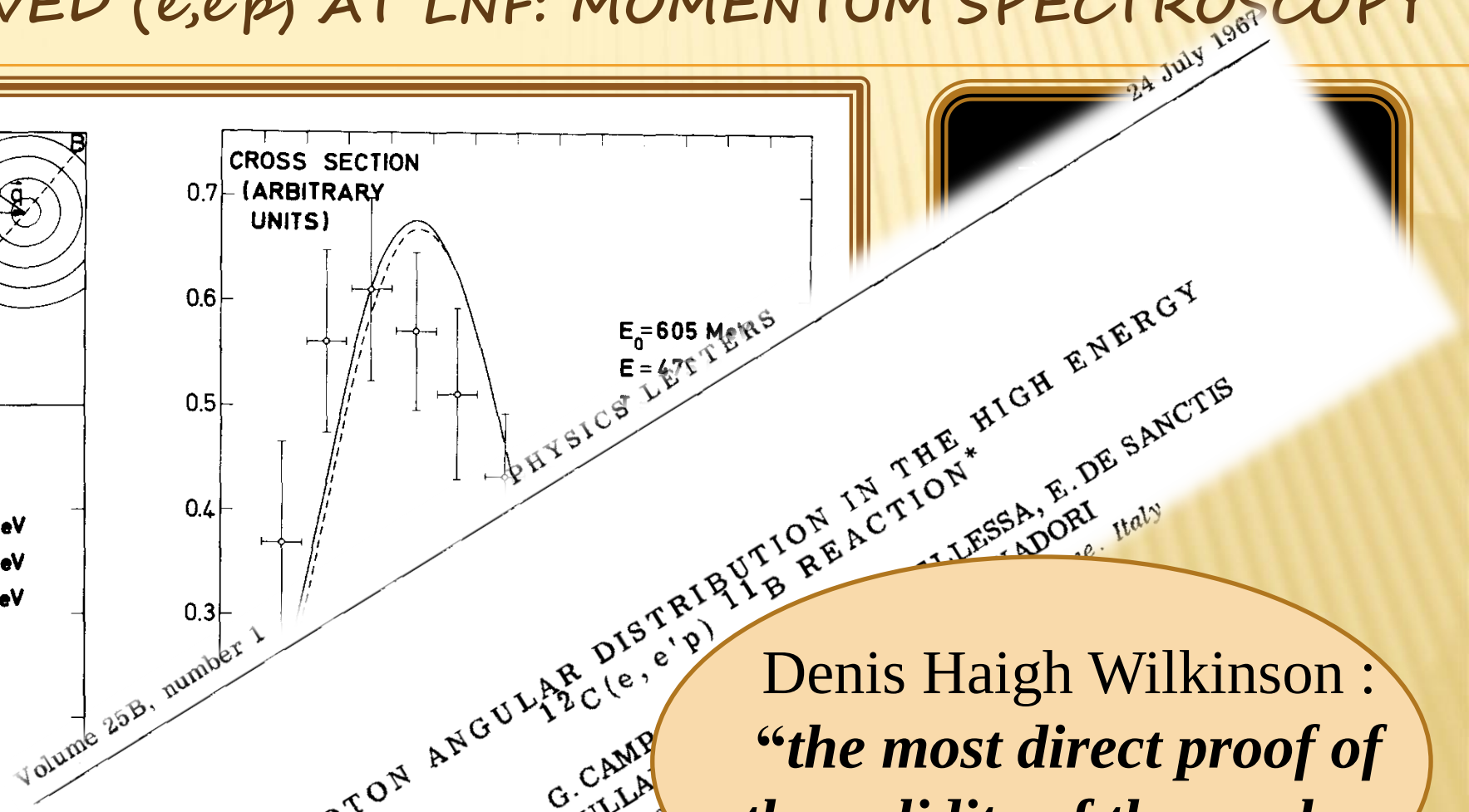
$$E_0 + A_{(N)} = E_1 + E_2 + A_{(N-1)}$$

$$BE_{(n)} = -E_0 + E_1 + E_2$$

FIRST ANGLE RESOLVED (e,e'p) AT LNF: MOMENTUM SPECTROSCOPY

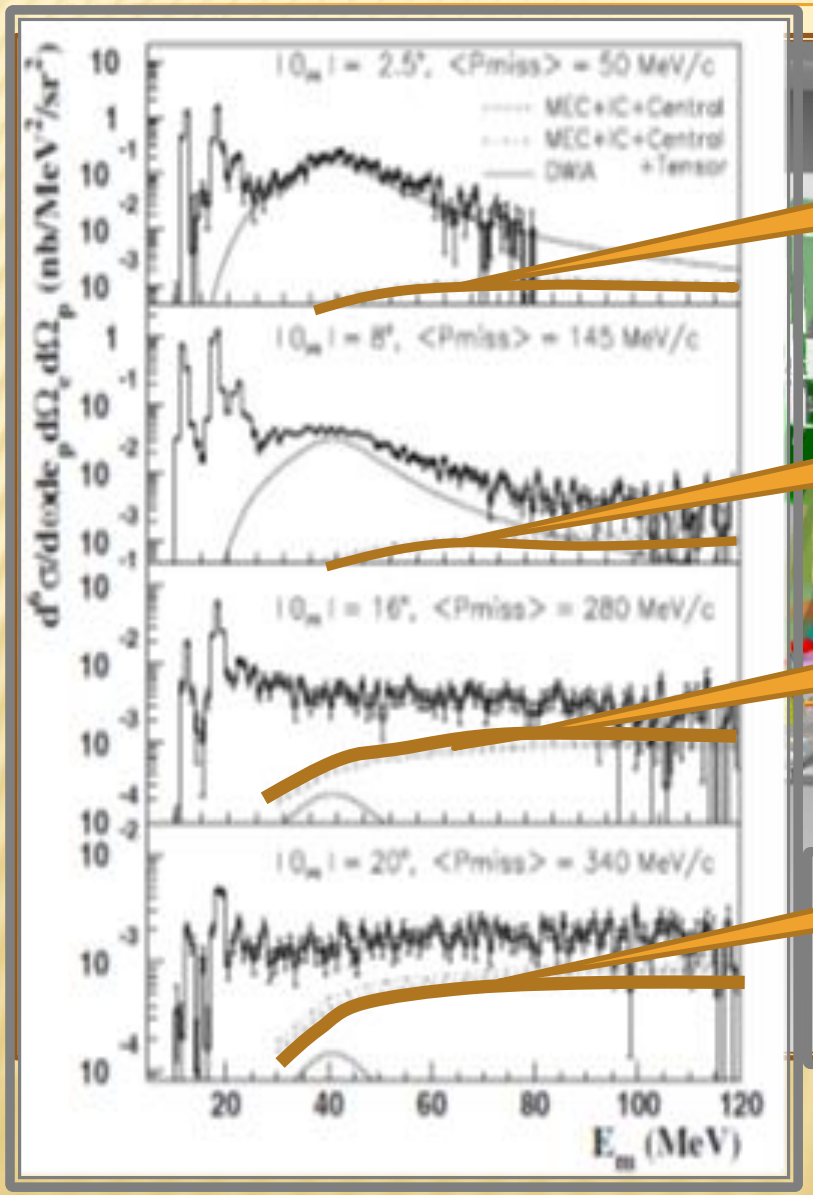


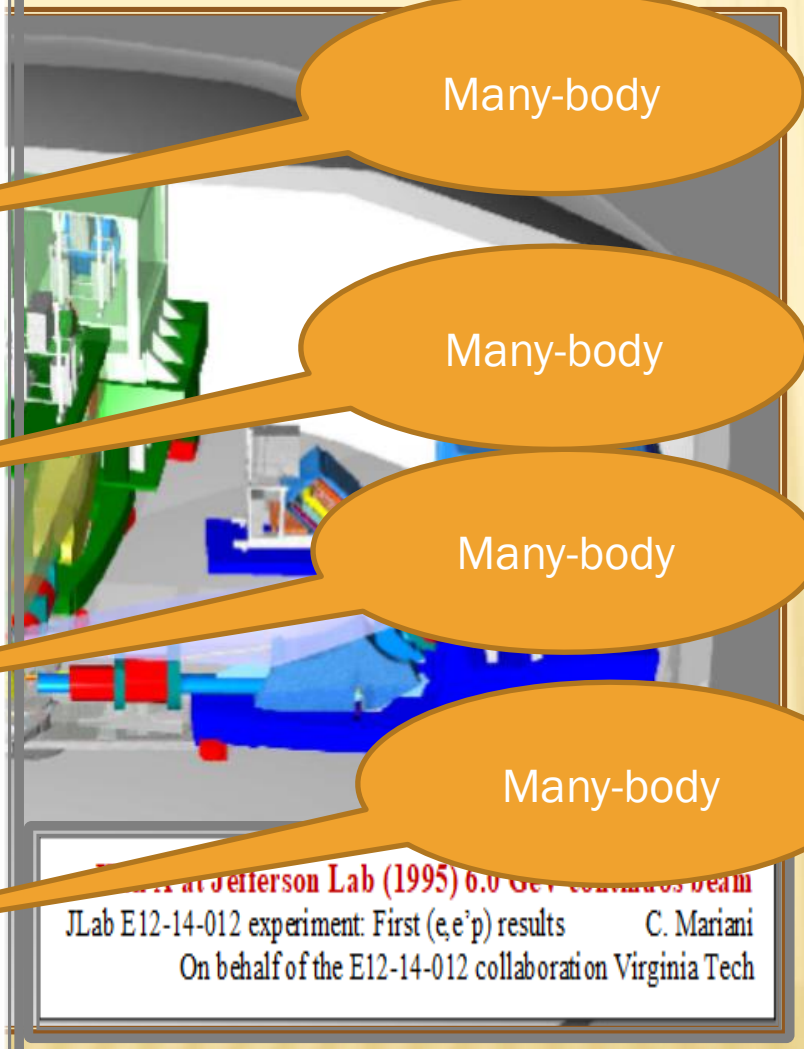




Denis Haigh Wilkinson :
"the most direct proof of the validity of the nuclear shell model".

(e,e'p) 50 YEARS LATER





Many-body

Many-body

Many-body

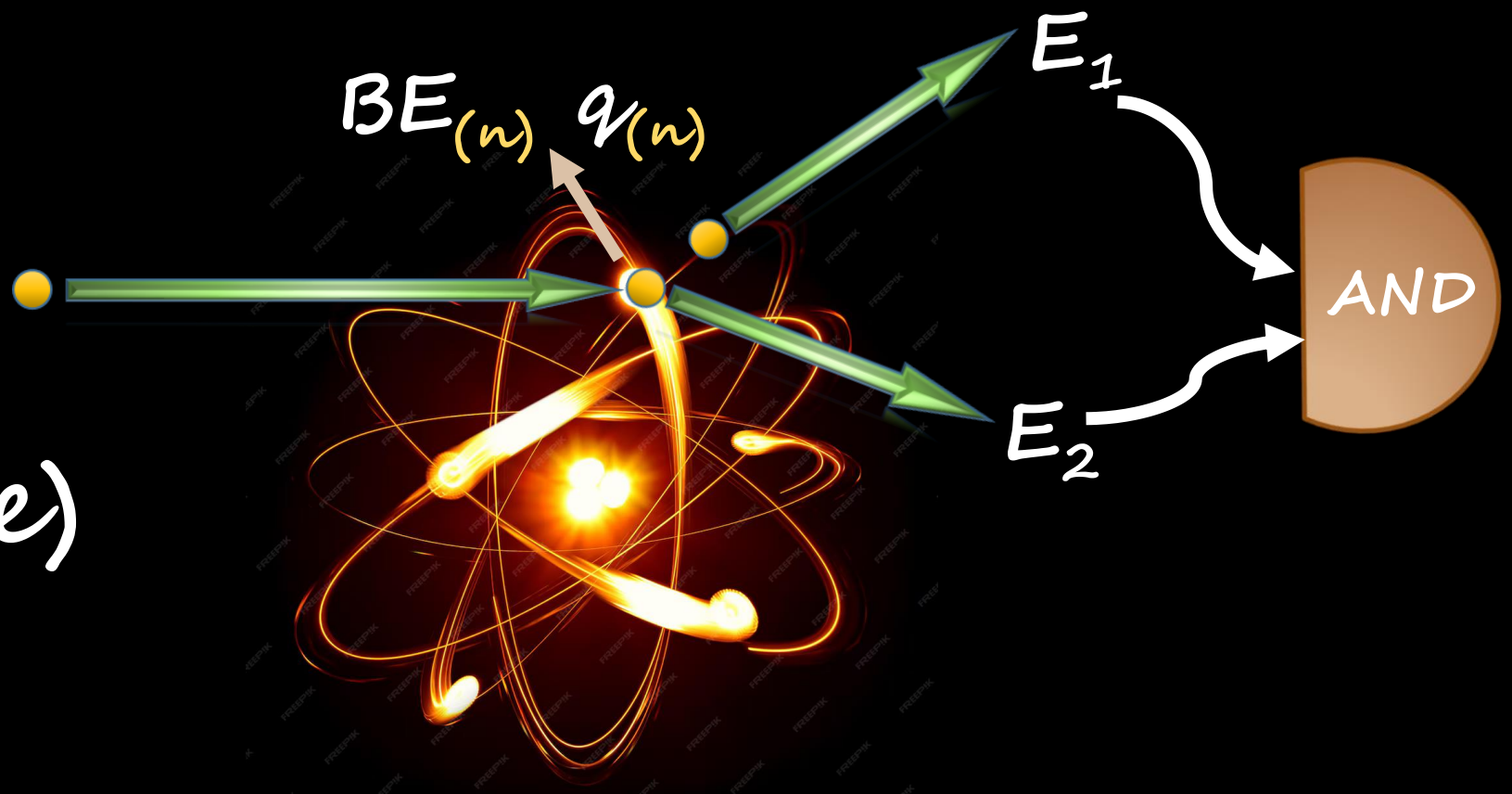
Many-body

Frascati I	*(1963)*	*500MeV*
Tokyo	*(1970)*	*750 MeV*
Frascati II	*(1972)*	*700MeV*
SCLAY	*(1971-)*	*500MeV*
Karkov	*(1972)*	*1.2 GeV*
Desy	*(1973)*	*2.7 GeV*
NIKHEF-K	*(1984)*	*500MeV*
Jefferson Lab	*(1989)*	*2.2 GeV*

Quasi free scattering On Atoms

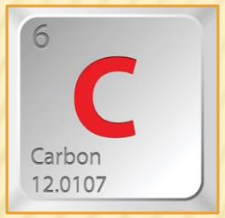
$$BE_{(n)} = E_0 - E_1 - E_2$$

$$q_{(n)} = P_0 - P_1 - P_2$$



(e,2e)

FIRST (e,2e) SPECTRAL FUNCTION ON ATOM



THE REVIEW OF SCIENTIFIC INSTRUMENTS VOLUME 40, NUMBER 8 AUGUST 1969

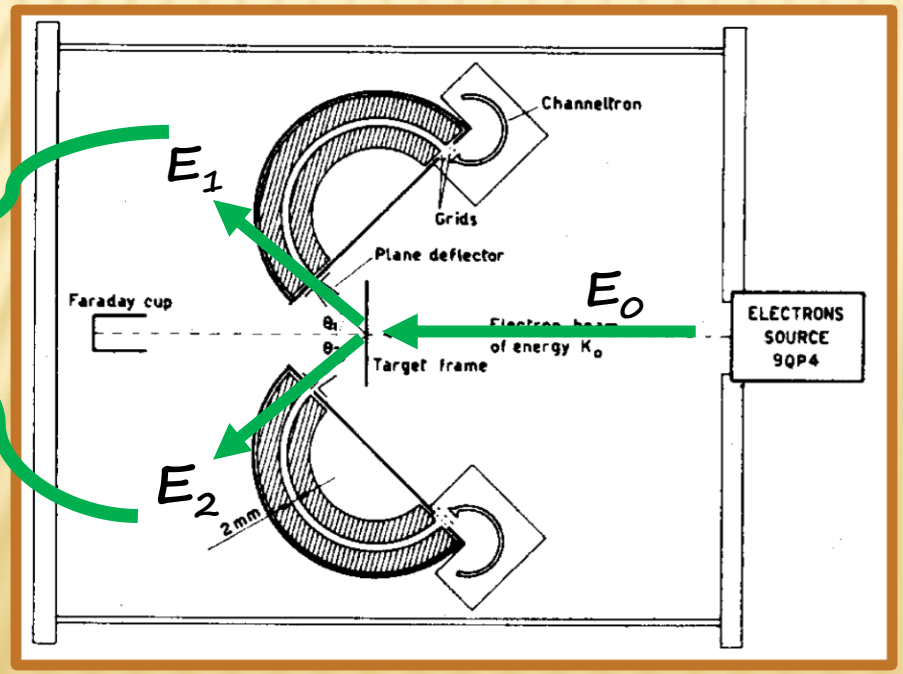
Use of a Two Channeltron Coincidence in a New Line of Research in Atomic Physics

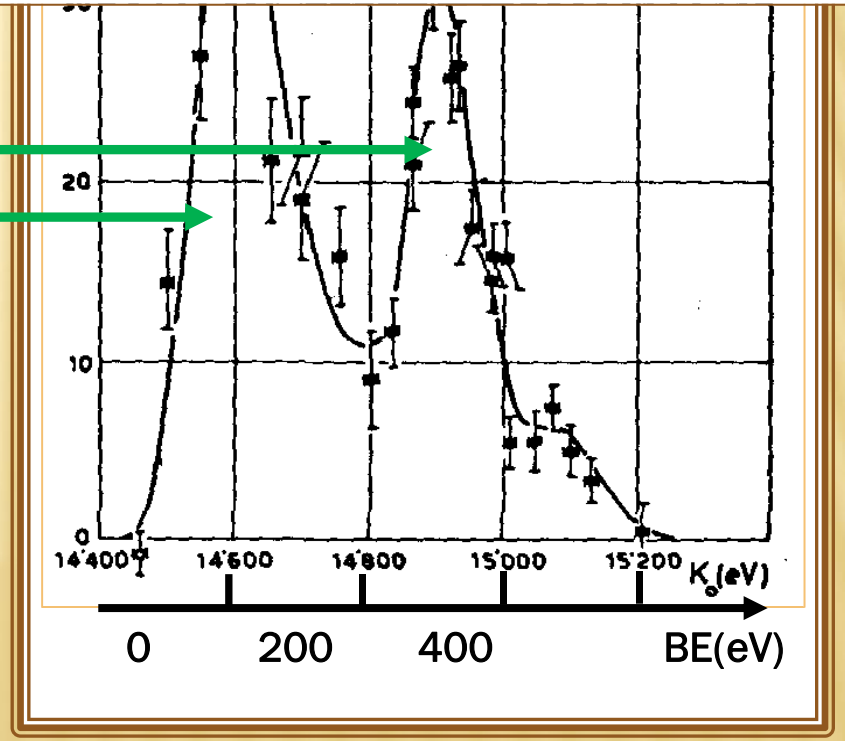
U. AMALDI, JR.
Laboratori di Fisica, Istituto Superiore di Sanità, Roma
AND
A. EGIDI, R. MARCONERO, AND G. PIZZELLA
Gruppo di Fisica Cosmica del Consiglio Nazionale delle Ricerche, Istituto di Fisica dell'Università, Roma, Italy

(Received 20 December 1968)

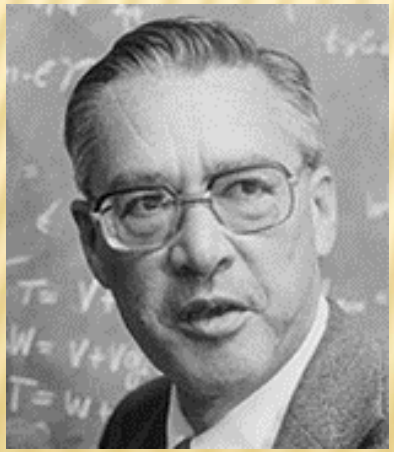
$\delta E = E_0 - (E_1 + E_2)$

AND

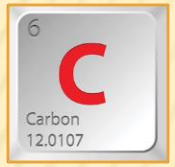


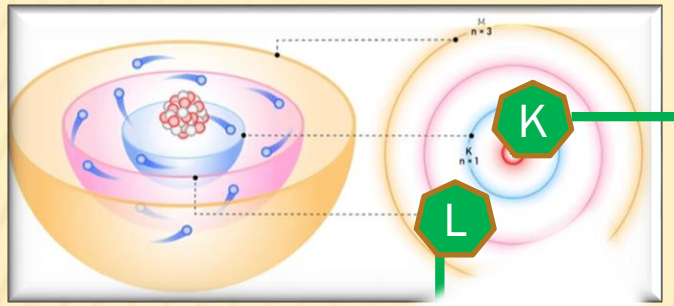


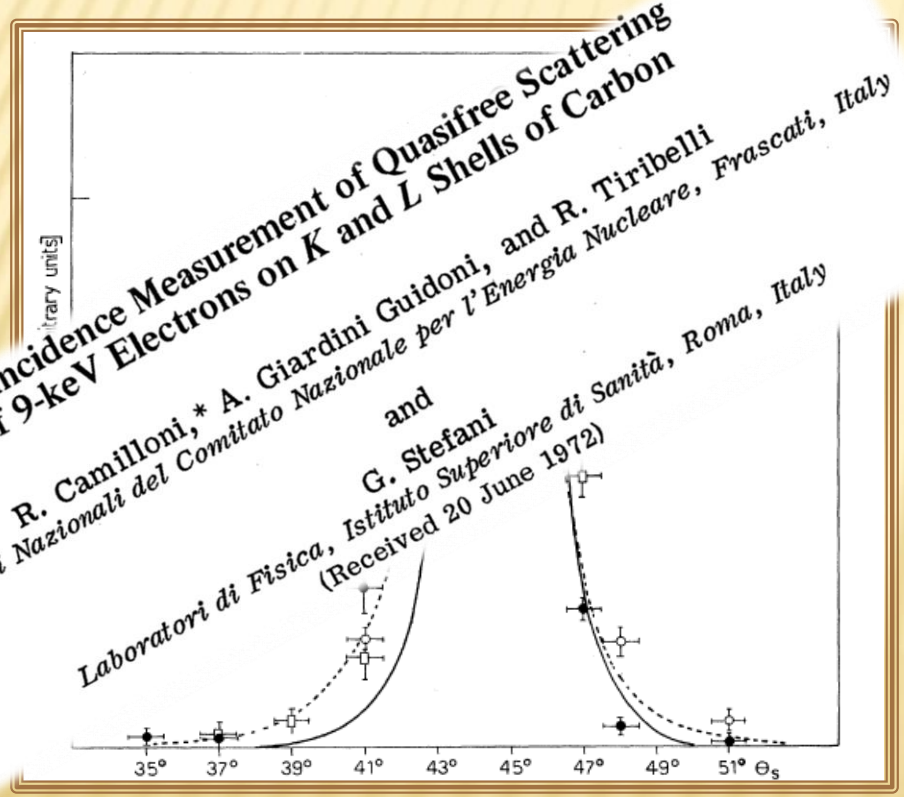
IN UGO'S FOOTSTEPS TOWARDS MOMENTUM SPECTROSCOPY

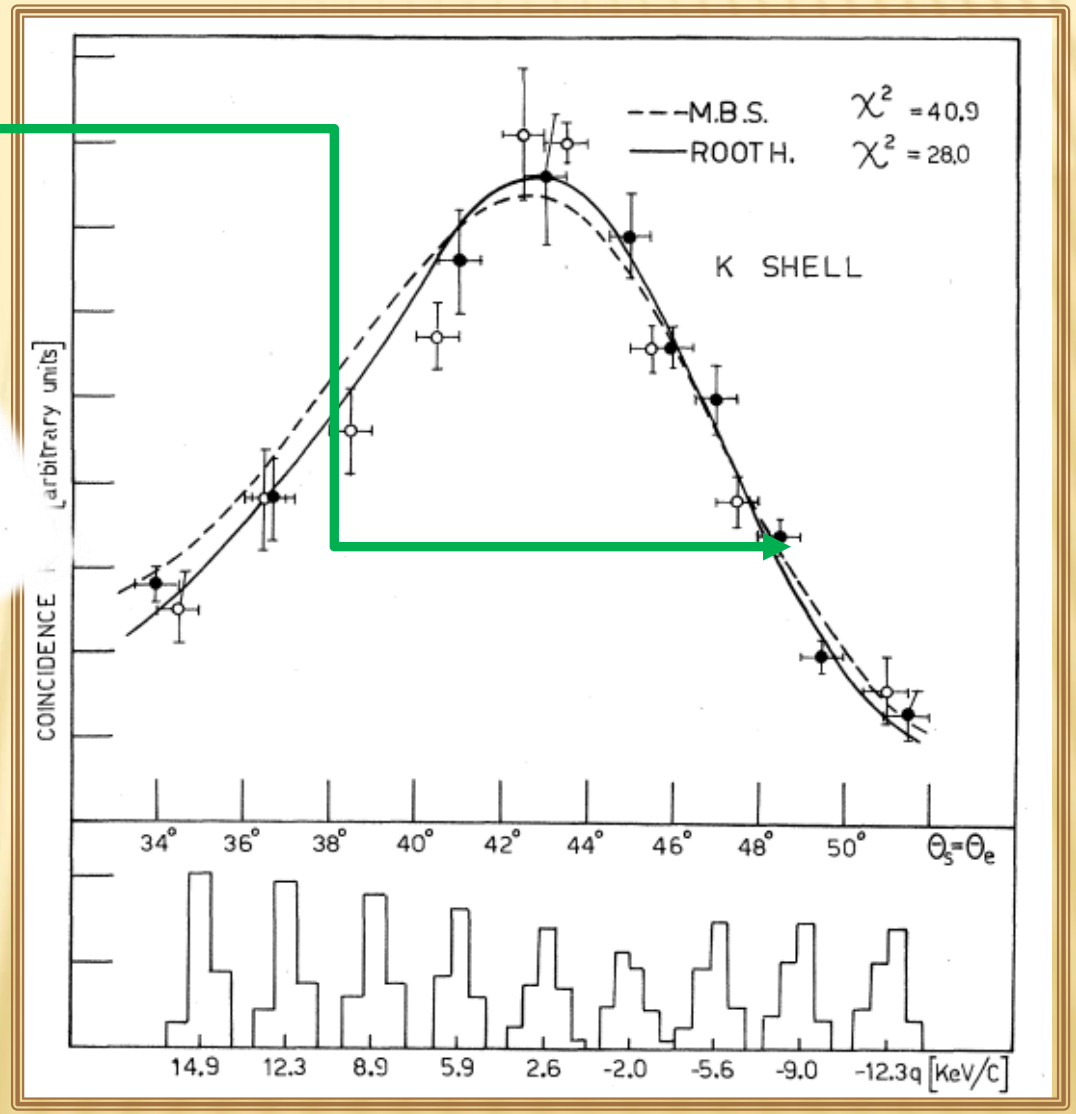


FIRST MOMENTUM SPECTROSCOPY ON ATOMS



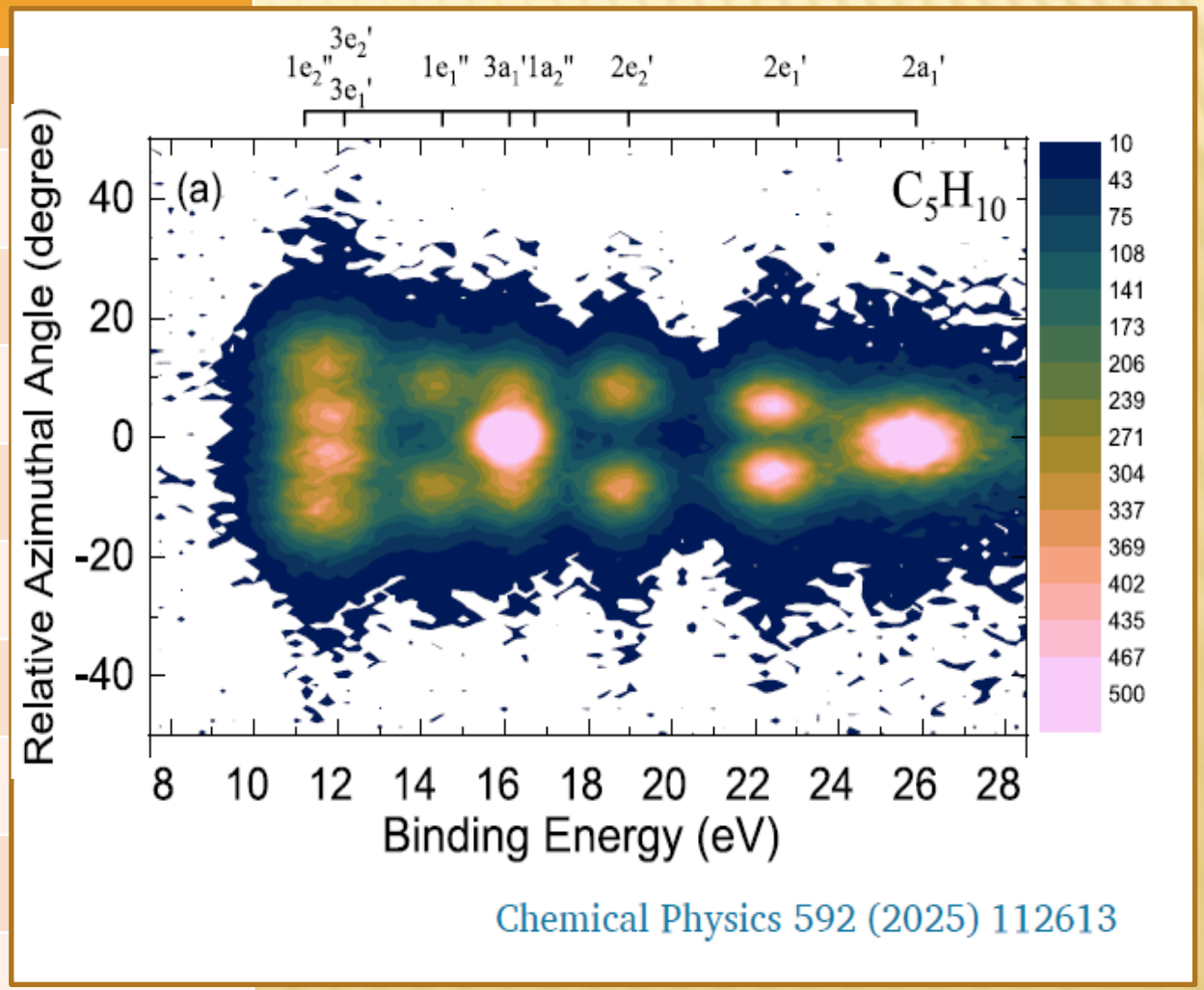






MOMENTUM SPECTROSCOPY: A VITAL AND EVOLVING LEGACY

1972	Frascati National Laboratory CNEN (Italy)
1973	Flinders University. Adelaide (South Australia)-.
1978	British Columbia University. Vancouver (Canada)
1978	University of Maryland. College Park (USA)
1981	IMAI-CNR, Montelibretti (Italy)
1983	Université Paris Sud. Orsay (France)
1983	Virginia Polytechnic Institute (USA)
1989	Tsing Hua University Peking (China)
1996	City University Osaka (Japan)
1996	University Science & Technology Hefei (China)
1997	Tohoku University Sendai (Japan)
2002	Tokio University of Agricolture and Technology Tokyo (Japan)



Chemical Physics 592 (2025) 112613

SYMPOSIUM FOR UGO's 90 YEARS
CERN Council Chamber, Friday 4 April 2025

FOR THE FERTILE FIELDS OF RESEARCH YOU HAVE PLOUGHED

Thank you Ugo !

CNR
Istituto di Struttura della Materia

ROMA TRE
UNIVERSITÀ DEGLI STUDI