Haeberli-fest June 10, 2005

Using nuclear physics techniques for materials analysis

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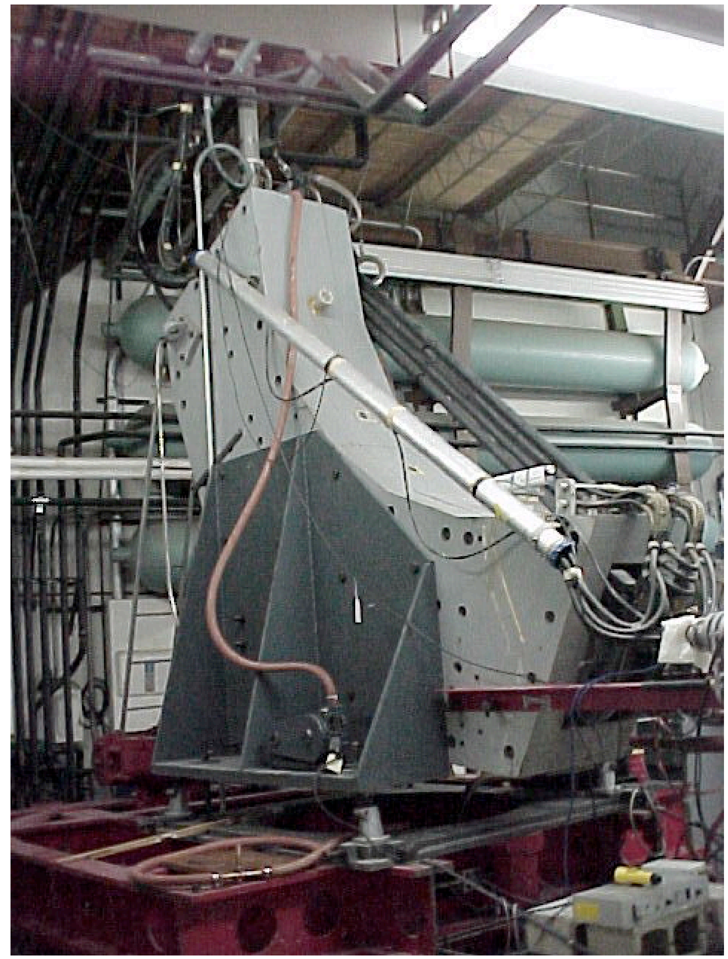
University of Arizona
Haeberli student 1960-1964

University of Arizona CN Van de Graaff
Installed 1966-67

The tank

The bending magnet



Rutherford

Backscattering

Through the years

(Arizona 1983-2000)

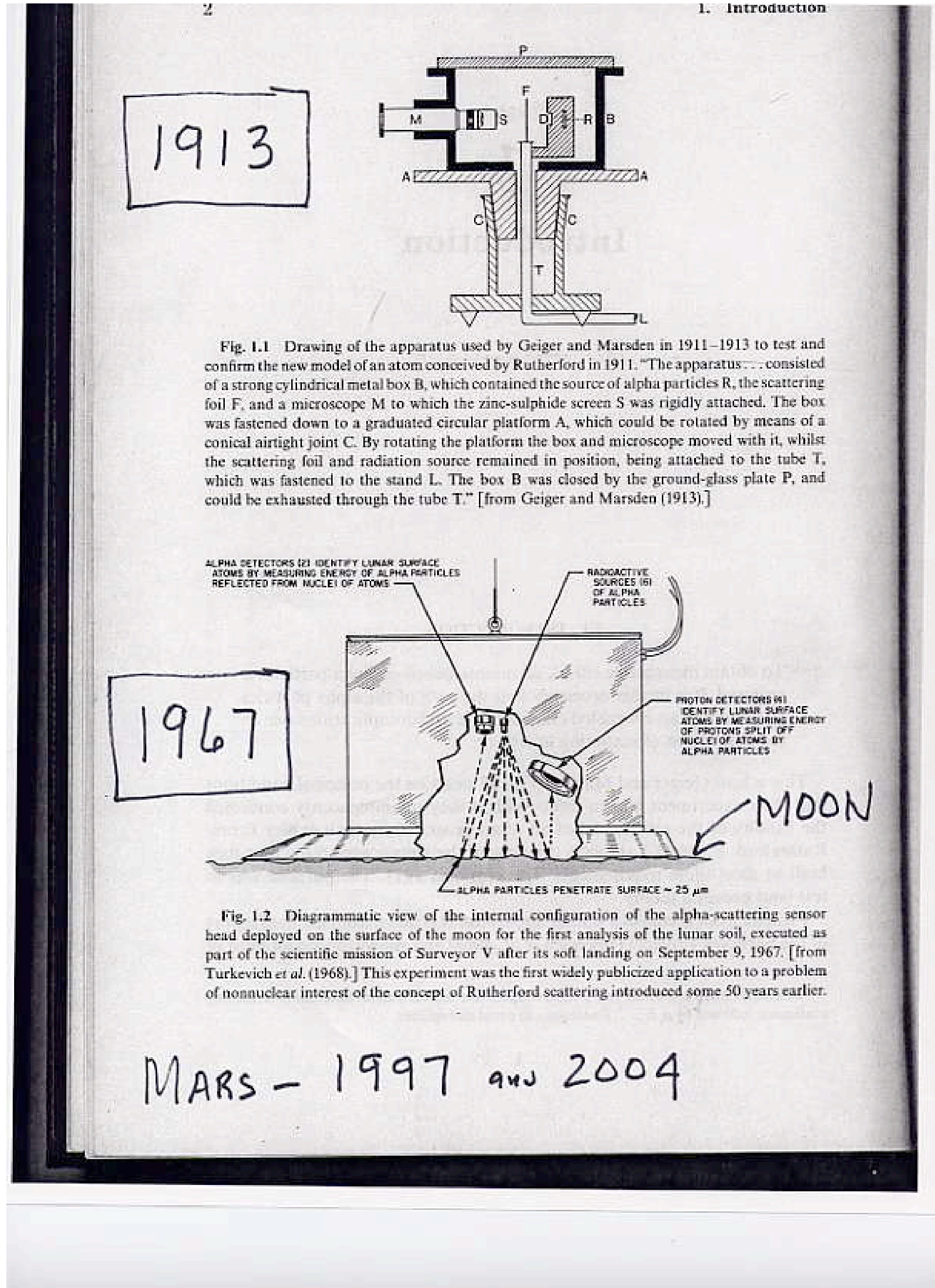
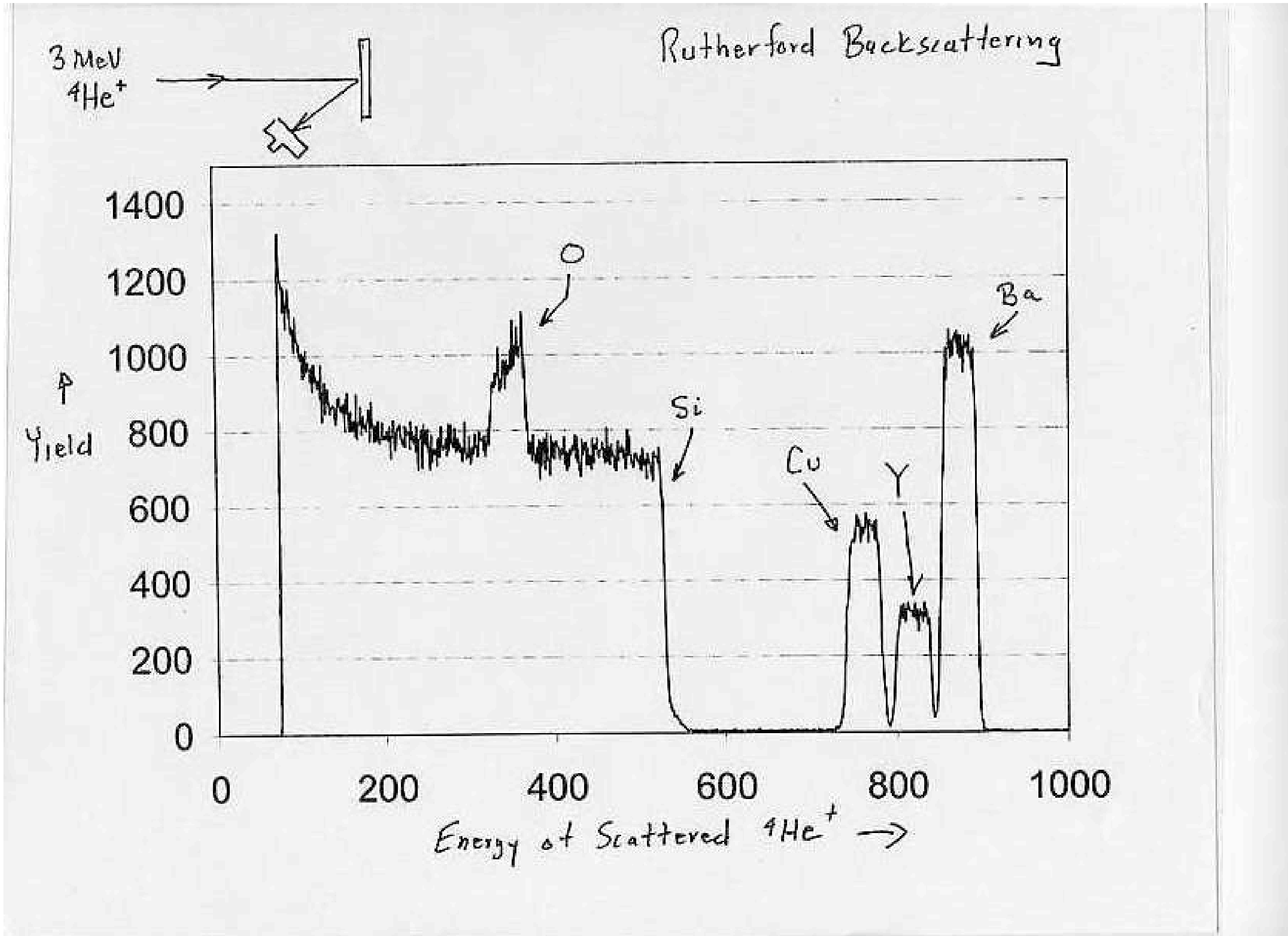


Fig. 1.1 Drawing of the apparatus used by Geiger and Marsden in 1911–1913 to test and confirm the new model of an atom conceived by Rutherford in 1911. "The apparatus . . . consisted of a strong cylindrical metal box B, which contained the source of alpha particles R, the scattering foil F, and a microscope M to which the zinc-sulphide screen S was rigidly attached. The box was fastened down to a graduated circular platform A, which could be rotated by means of a conical airtight joint C. By rotating the platform the box and microscope moved with it, whilst the scattering foil and radiation source remained in position, being attached to the tube T, which was fastened to the stand L. The box B was closed by the ground-glass plate P, and could be exhausted through the tube T." [from Geiger and Marsden (1913).]

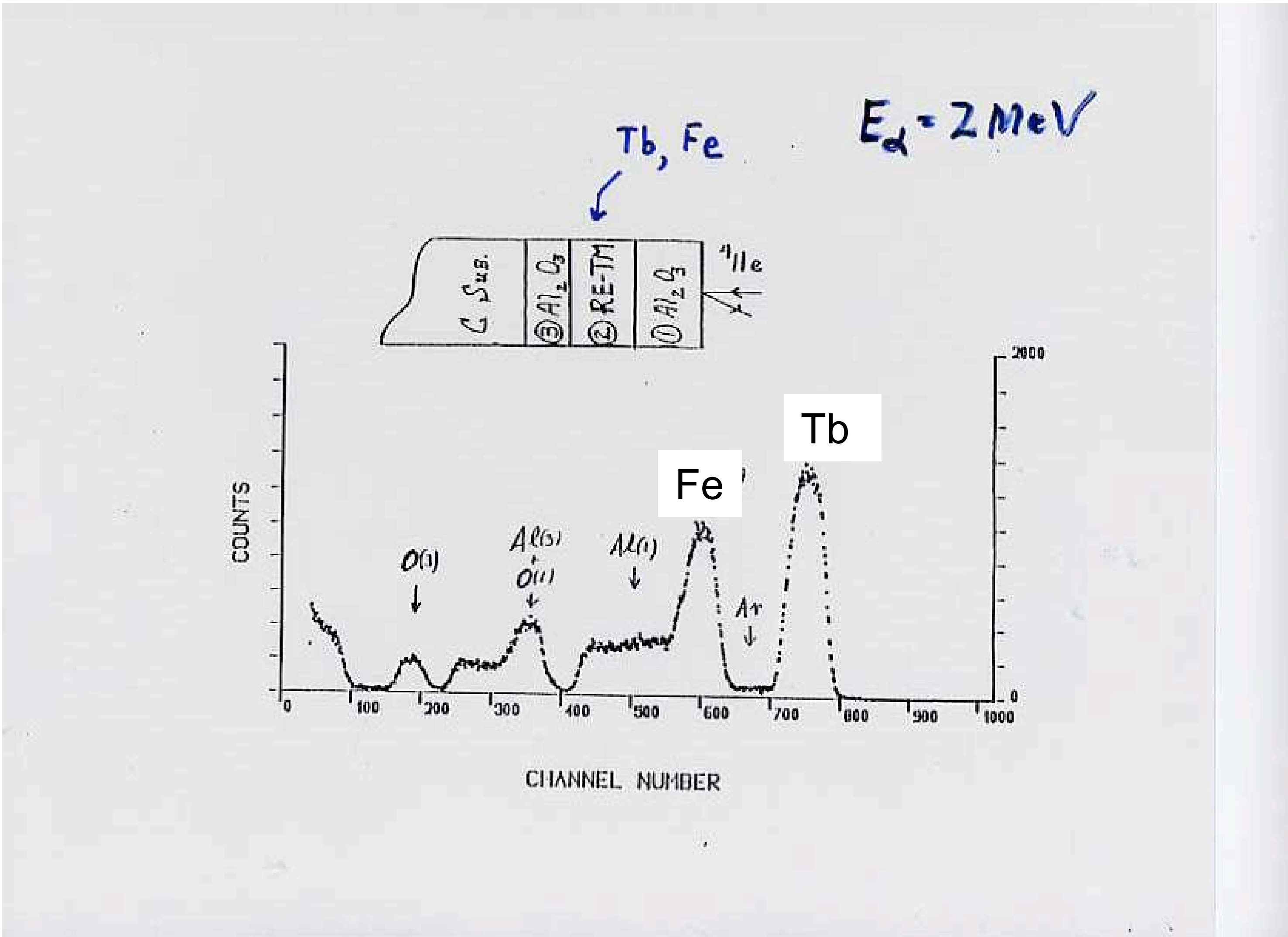
Fig. 1.2 Diagrammatic view of the internal configuration of the alpha-scattering sensor head deployed on the surface of the moon for the first analysis of the lunar soil, executed as part of the scientific mission of Surveyor V after its soft landing on September 9, 1967. [from Turkevich *et al.* (1968).] This experiment was the first widely publicized application to a problem of nonnuclear interest of the concept of Rutherford scattering introduced some 50 years earlier.

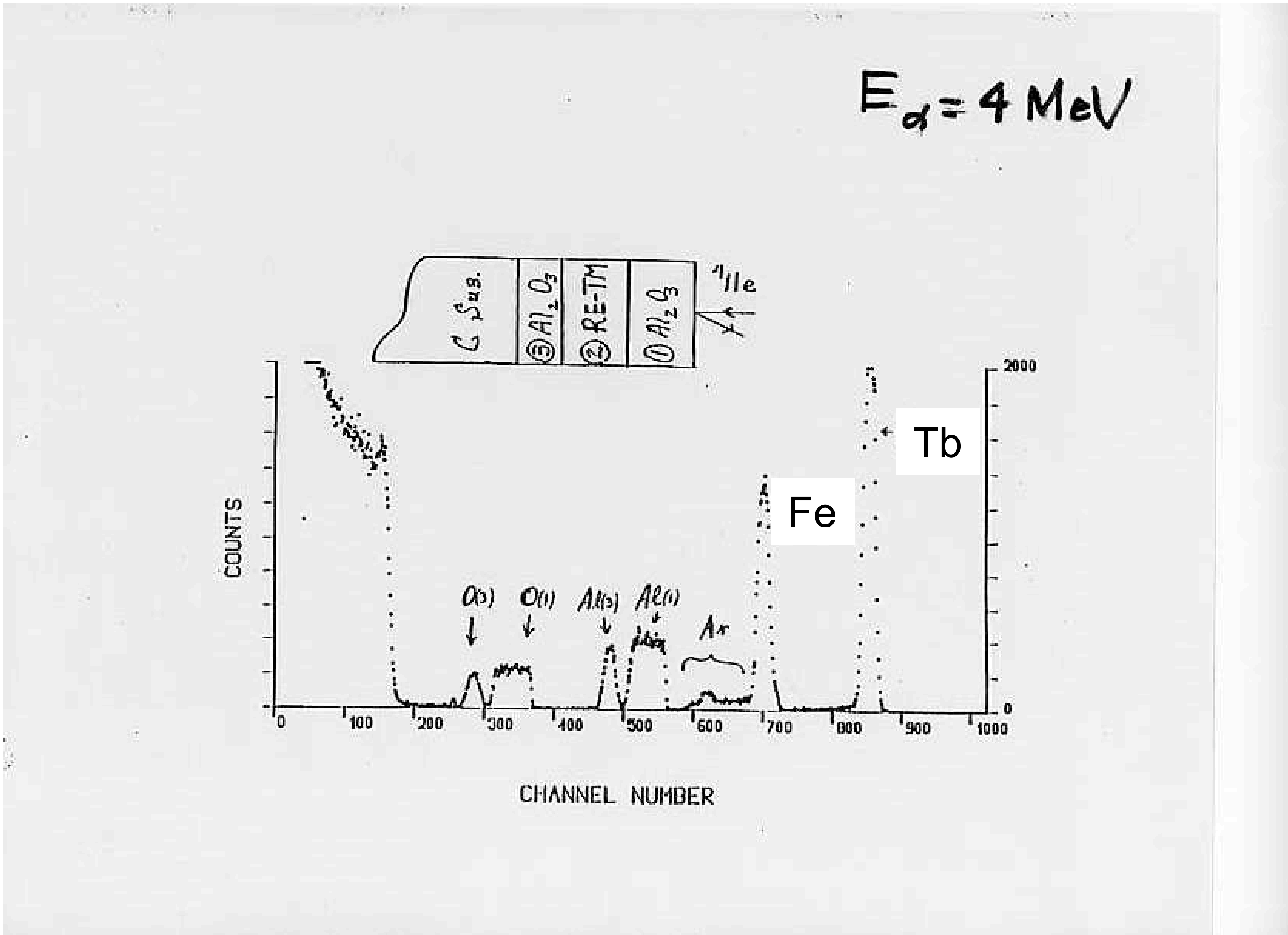


Areal density (atoms/cm2) accuracy ~ 4%

Stoichiometry accuracy < 1%

Multilayer thin film sample – advantage of high energy incident alpha particles





E_α = 4 MeV
C Sus.
③ Al2O3
② RE-TM
① Al2O3
4He
Tb
Fe
COUNTS
O(3)
O(1)
Al(3)
Al(1)
Ar
2000
0
0
100
200
300
400
500
600
700
800
900
1000
CHANNEL NUMBER

John Cameron's resonance elastic scattering of alphas from 16O

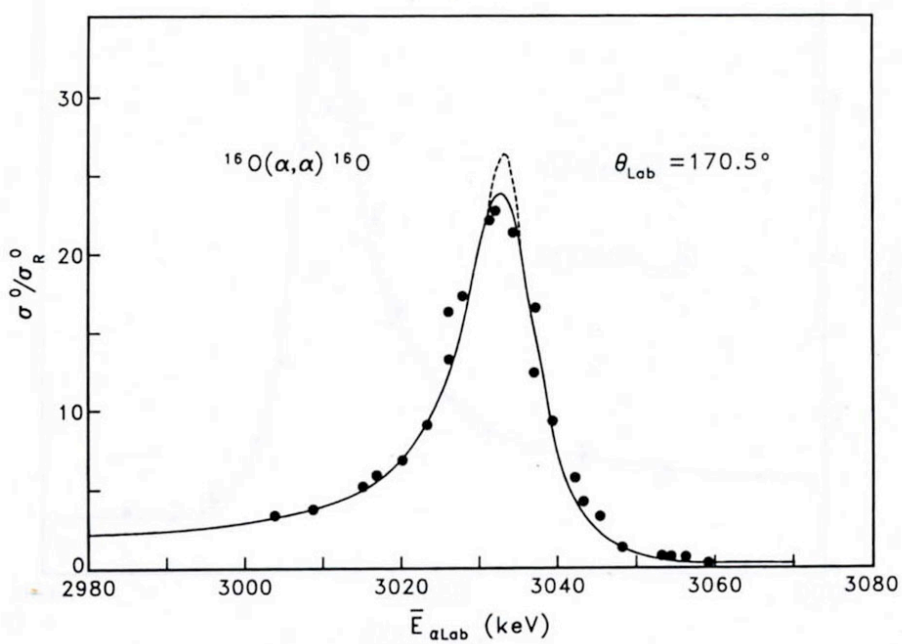


Fig. 2. Measured ^{4}He–O laboratory cross sections near the strong "3045" keV resonance are compared with values (solid line) calculated using Cameron's procedures [3] and our resonance parameters listed in table 3, including the effect of target thickness. The dashed curve is the result of the calculation for infinitesimal target thickness. The data points shown were taken with the thin (6 keV) target. We obtain the resonance energy of (3034 ± 4) keV.

Using the (_,p) nuclear reaction to determine boron in a thin film

Elastic scattering spectrum

Reaction proton spectrum

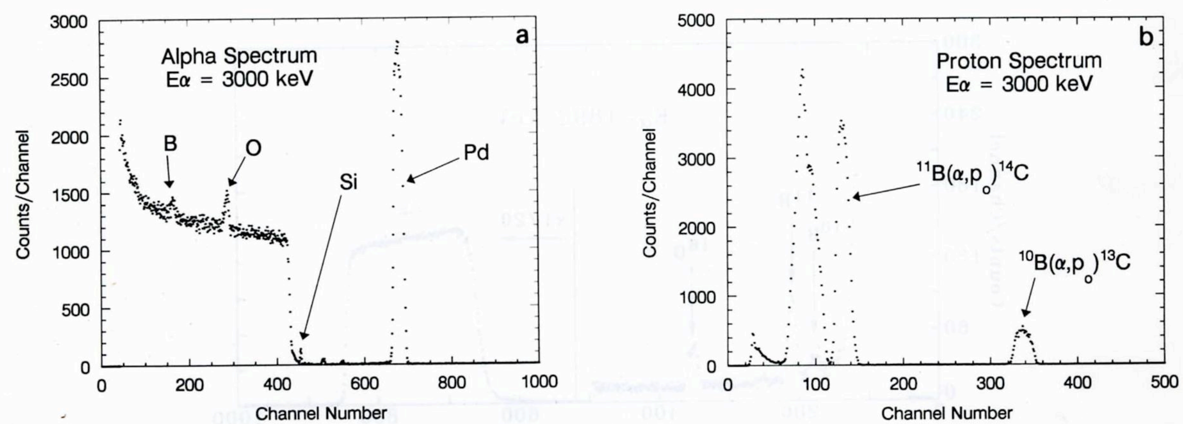


Fig. 6. (a) Energy spectrum of backscattered (170.5° lab angle) 3000 keV $^4He^+$ ions from a Pd(32 nm)/B(96 nm) thin film with a Si(4 nm) cap on a Si substrate. The collected charge was 50 μC. (b) Energy spectrum of protons (135° lab angle) taken simultaneously with the alpha spectrum of fig. 6a.

FRIDAY, APRIL 24, 1964

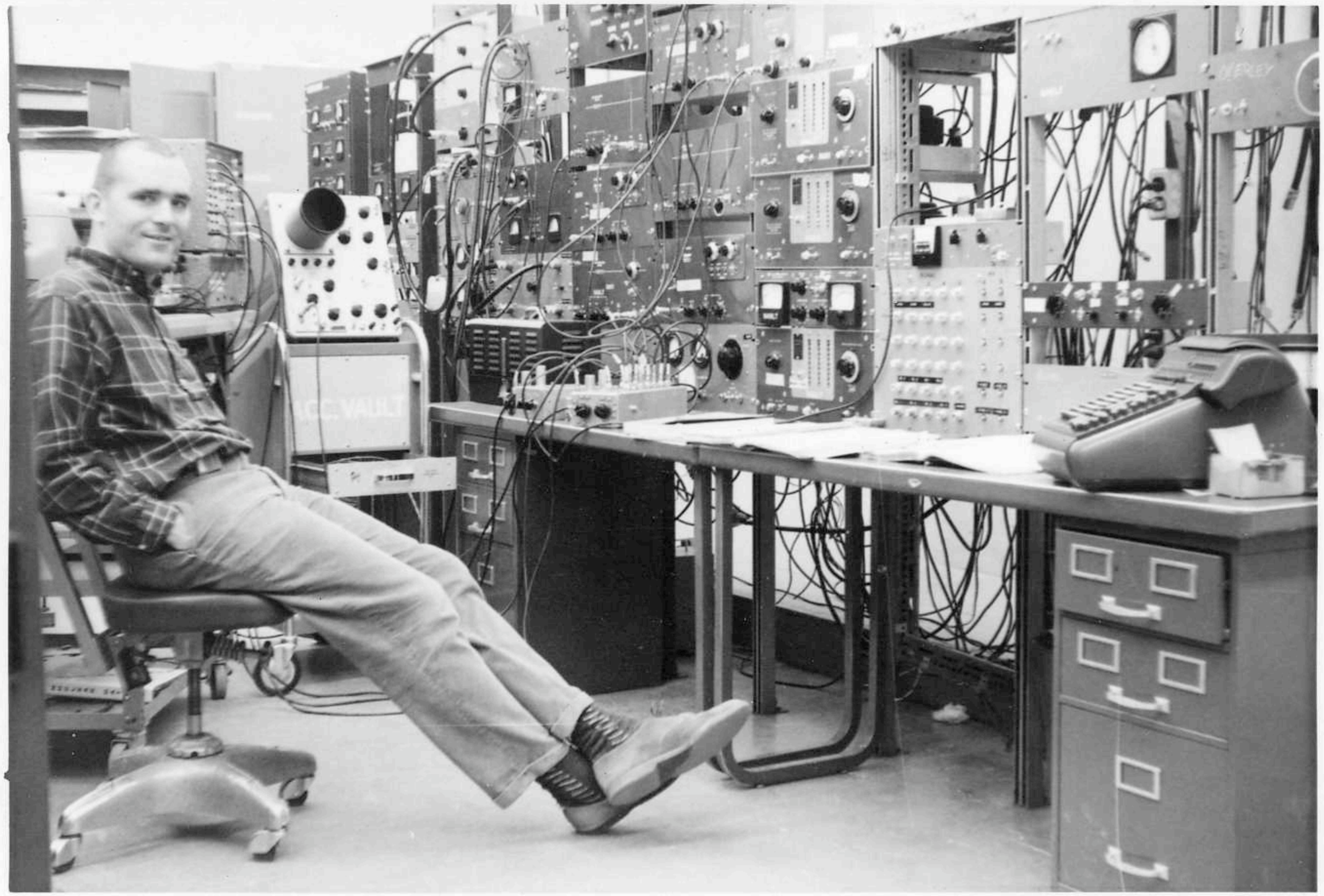
It Spews Ionized Atoms

The new $40,000 Van de Graaff accelerator is shown to University of Arizona President Richard A. Harvill, left, by physicists Douglas J. Donahue, center, and Stanley Bashkin. The machine spews ionized atoms with an energy of 2 million electron volts. Its installation this week at the university will enable the scientists to continue here their research on star-like light. (Sheaffer photo by Mark Godfrey)

April 24, 1964

Still Spewing Ionized Atoms - Feb 9, 2000

MAR. 1963



$^{19}F(\alpha,p)^{22}Ne$

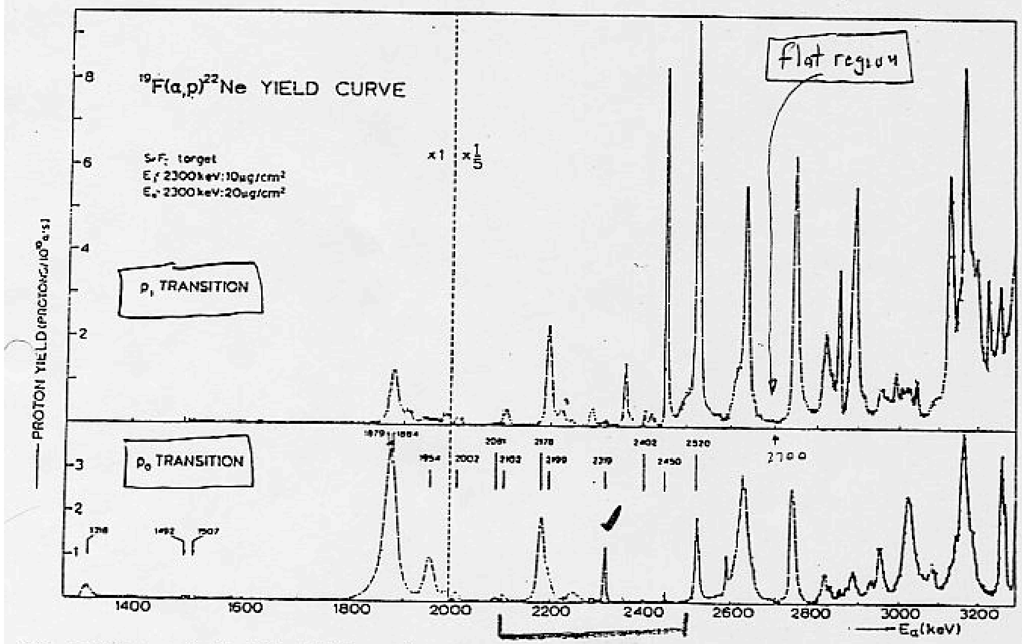
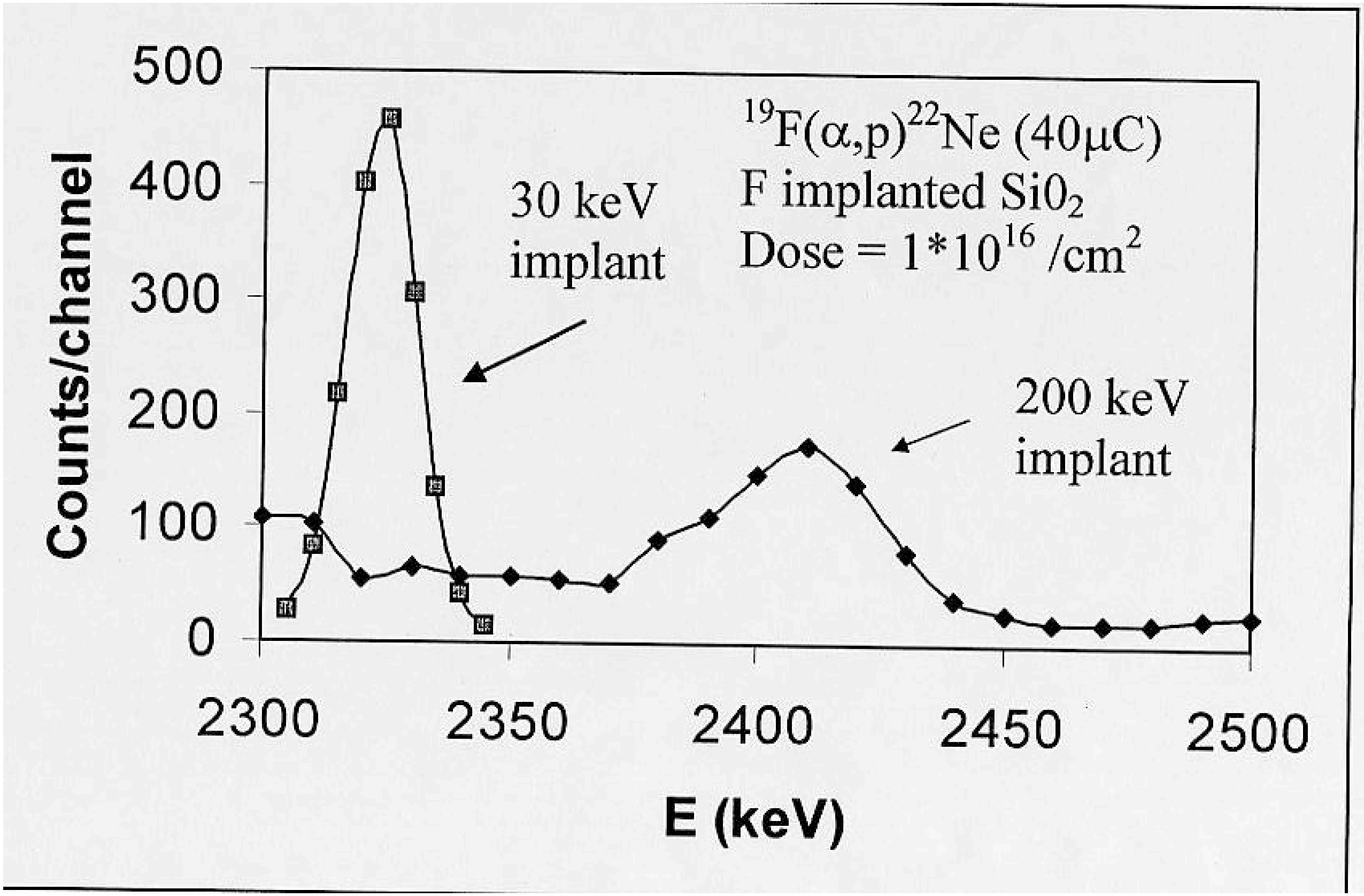


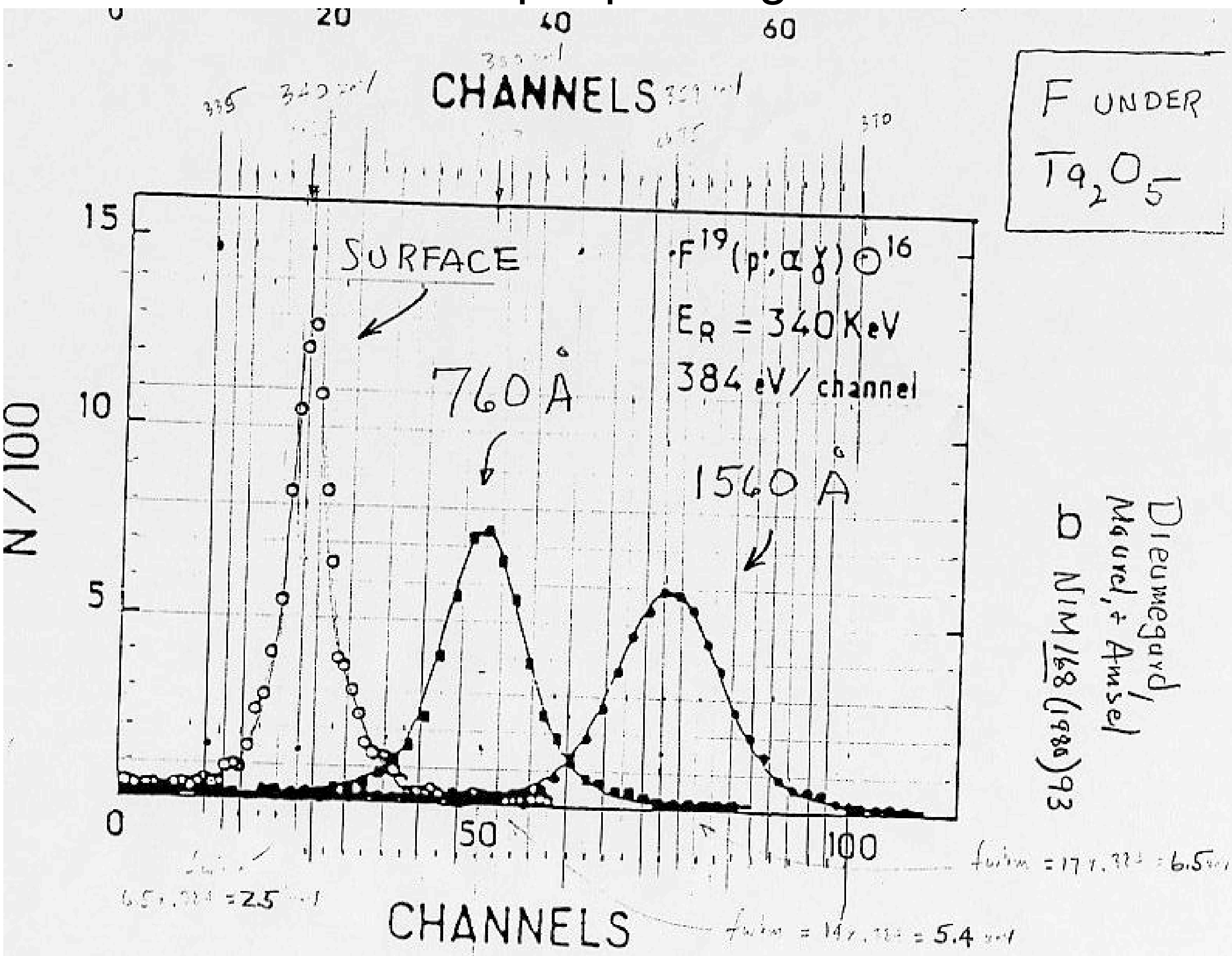
Fig. 1. Yield curve for the $^{19}F(\alpha, p)^{22}Ne$ reaction, observed at a laboratory angle $\theta = 120°$. Ground-st: *e proton angular distributions are investigated at resonances, indicated with an arrow.

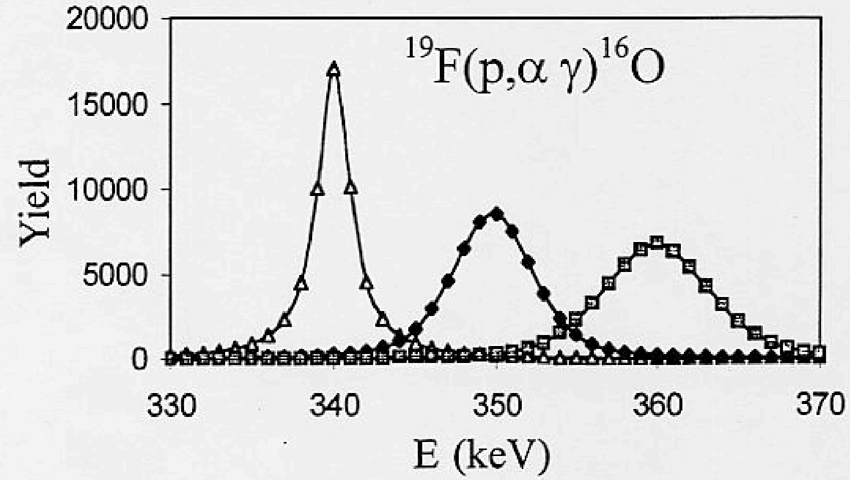
J. Kuperus, Physica 31 1603 (1965)



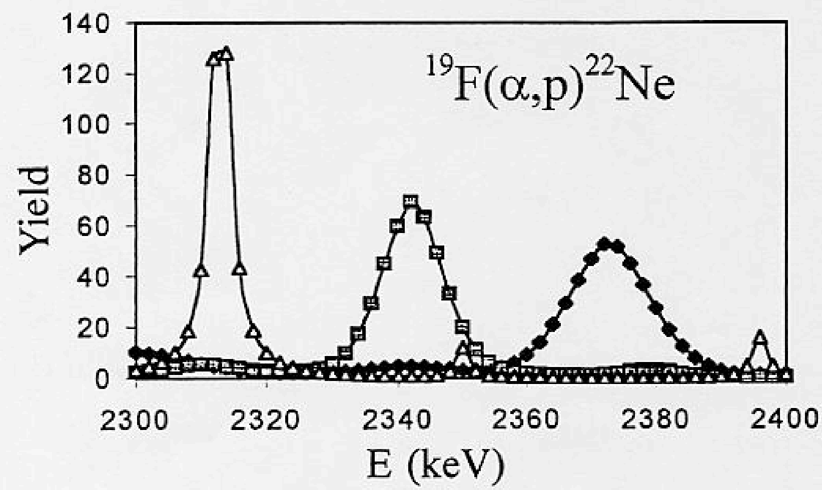
Counts/channel
500
400
300
200
100
0
2300
2350
2400
2450
2500
E (keV)
30 keV implant
200 keV implant
$^{19}F(\alpha,p)^{22}Ne$ (40μC)
F implanted SiO_2
Dose = $1*10^{16}$ /cm^2

Compare 340 keV (p,gamma) with 2313 keV (alpha,p) for depth profiling F





20000
15000
10000
5000
0
Yield
$^{19}F(p,\alpha\gamma)^{16}O$
330
340
350
360
370
E (keV)



140
120
100
80
60
40
20
0
Yield
$^{19}F(\alpha,p)^{22}Ne$
2300
2320
2340
2360
2380
2400
E (keV)