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Title: AN ENERGY SPREAD CORRECTION FOR ERDA HYDROGEN DEPTH PROFILING

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An Energy Spread Correction for ERDA Hydrogen Depth Profiling.*

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A technique for hydrogen depth profiling by reflection elastic recoil detection analysis called the *channel-depth conversion* was introduced by Verda, et al.[1] However, the energy spread in elastic recoil detection analysis spectra, which causes a broadening in the energy range and leads to errors in depth profiling, was not addressed by this technique. Here we introduce a technique to addresses this problem, called the *energy spread correction*. Together, the energy spread correction and the channel-depth conversion techniques comprise the depth profiling method presented in this work.

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[1] R.D. Verda, C.J. Maggiore, J.R. Tesmer,A. Misra, T. Hoechbauer, M. Nastasi, R.W. Bower, Nucl. Instr. and Meth. B, **183**, (2001), 401.

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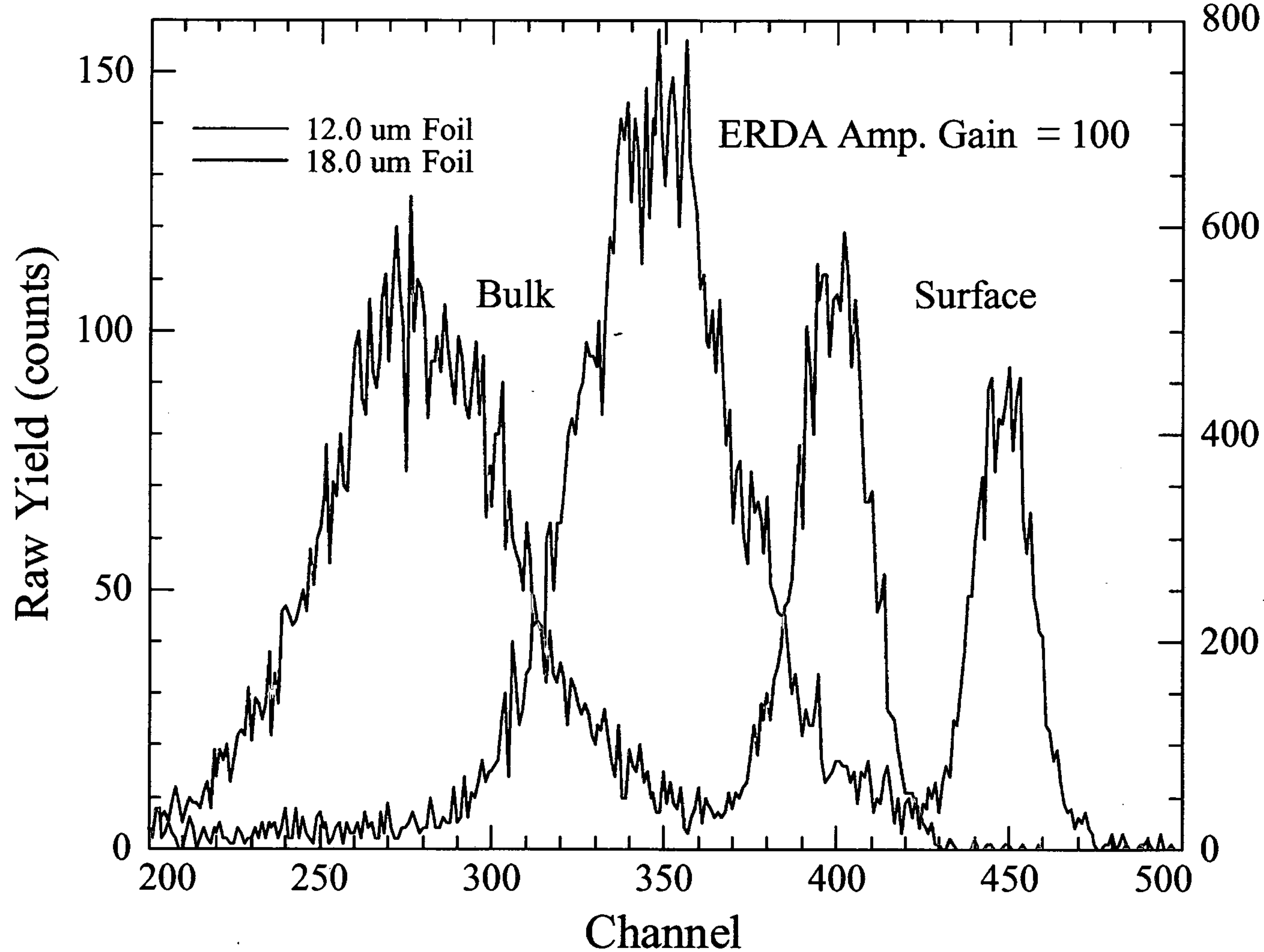
Introduction

Technique for hydrogen depth profiling by reflection ERDA called the *channel-depth conversion* introduced by Verda, et al.

Channel-depth conversion does not address energy spread in forward recoil spectra. Energy spread causes broadening in the spectrum, and lead to errors in depth profiling.

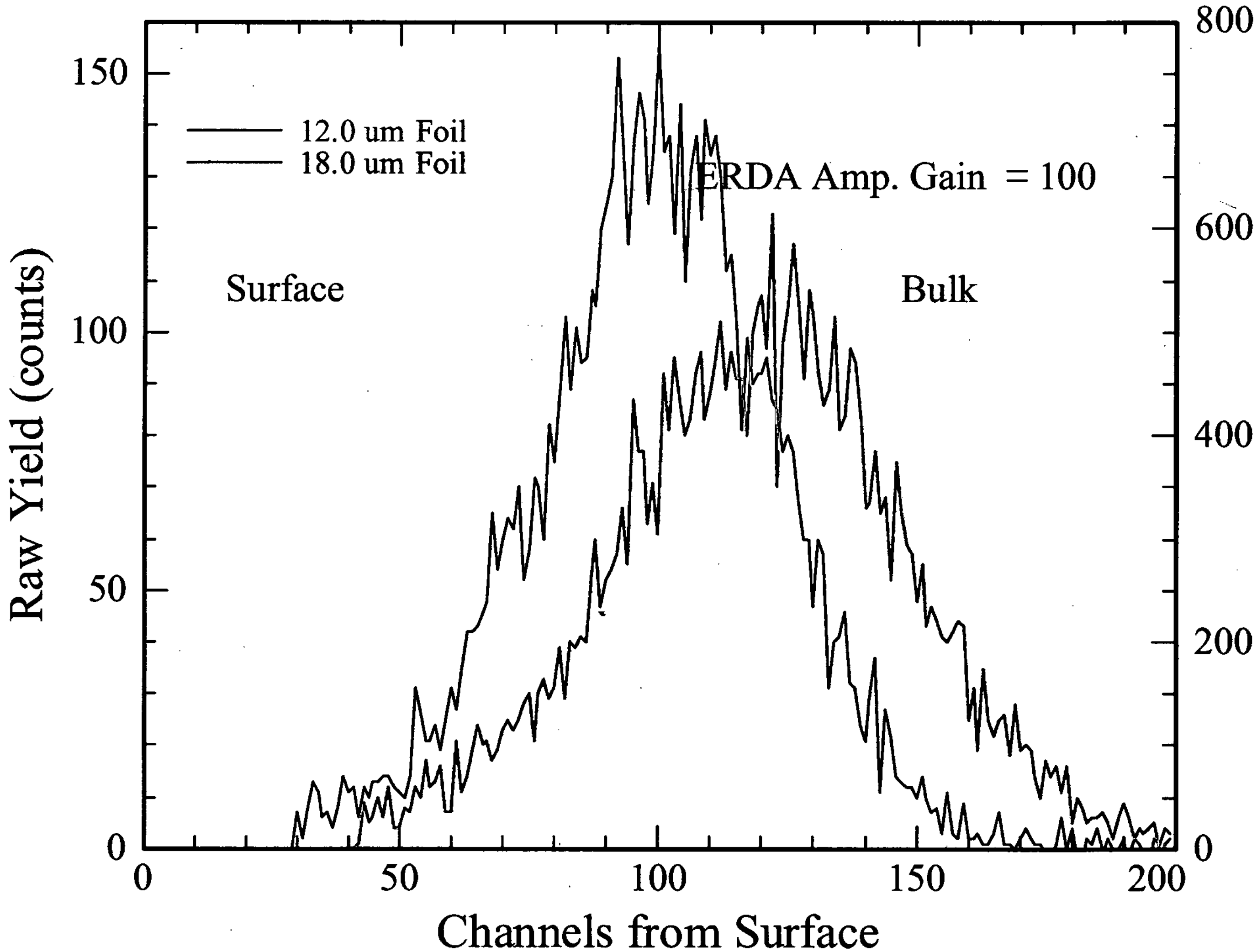
The *energy spread correction*, addresses this broadening of the spectrum. The energy spread correction in conjunction with the channel-depth conversion comprises an accurate hydrogen depth profiling method.

ERDA Spectra with Different Absorber Foils



Spectra are of the same sample, taken with different absorber foils.
Data for 18.0 μm absorber foil demonstrates the increase in energy spread.

Adjusted Spectra

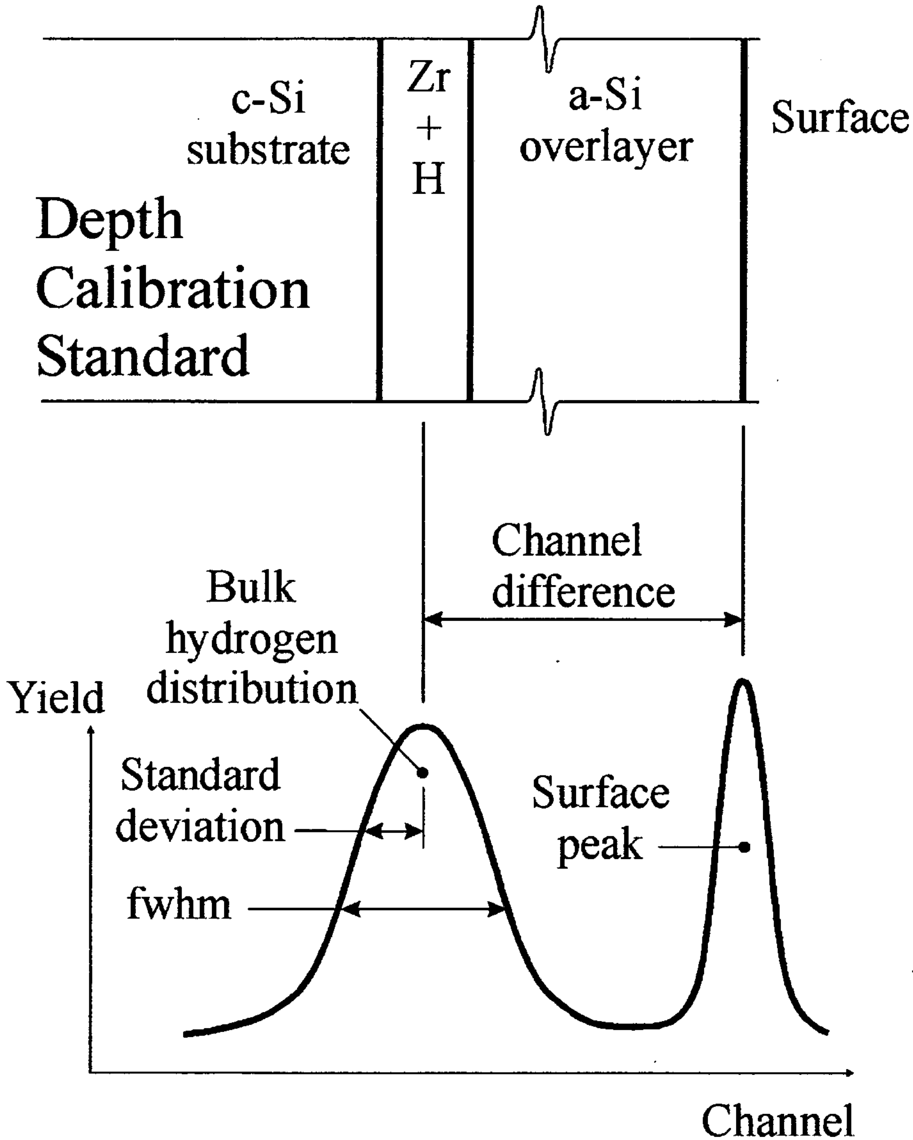


Adjusted spectra are obtained from the original spectra using

$$x_{ADJS} = s - x \, ,$$

where s is the channel of the surface peak.

Energy Spread from Depth Calibration Standards



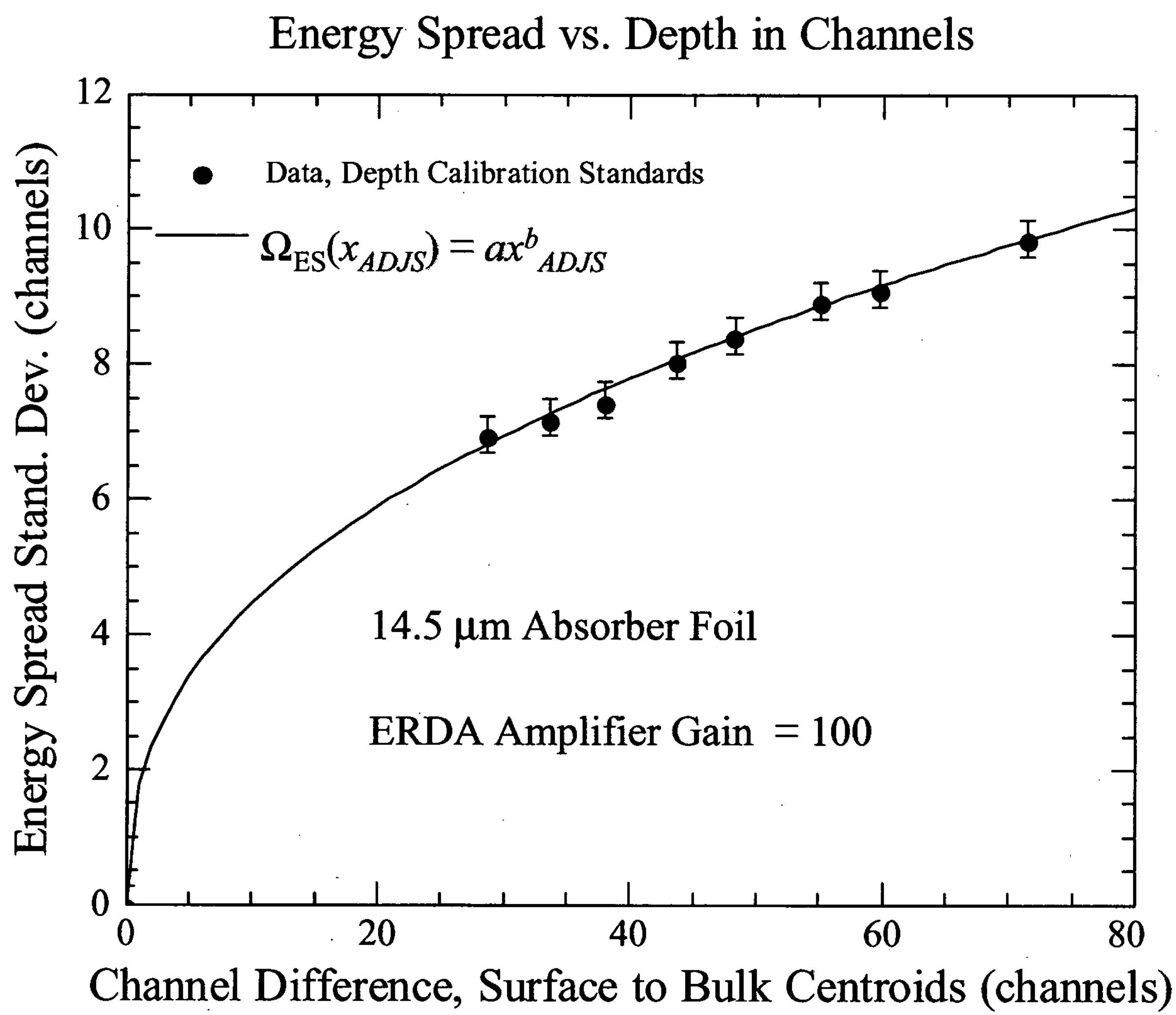
ERDA spectrum

ERDA spectra are taken of the depth calibration standards.

The standard deviations are plotted against the channel differences.

Result is the total energy spread (in channels) as a function of depth (also in channels).

~Infinitesimal Zr + H Layer



For accuracy, energy spread correction technique manipulates data in terms of channels, because ERDA data were taken in channels.

Mathematical Model: Energy Spread Correction

$$\Omega^2_{ENERGY\ SPREAD} = \Omega^2_{BEAM} + \Omega^2_{GEOMETRY} + \Omega^2_{DETECTOR} + \ldots \quad (1)$$

Szilagyi E., Nucl. Instr. and Meth. B, **161-163**, 2000, 37

$$\Omega^2_{TOTAL} = \Omega^2_{ES} + \Omega^2_{ACTUAL} \quad (2)$$

Rauhala, E., Handbook of Modern Ion Beam Materials Analysis (Tesmer J. R., Nastasi. M., eds.),p.15

$$\Omega^2_{ACTUAL} = \Omega^2_{TOTAL} - \Omega^2_{ES} \quad (3)$$

Follows from Eq. (2)

$$\Omega^{(i)}_{ES} \approx \Omega^{(i)}_{STANDARD} \quad (4)$$

Energy Spread from Standards

$$\Omega_{\mathrm{ES}}(x_{ADJS}) = a x^b_{ADJS} \quad (5)$$

Fit of data of Standards

$$\Omega^2_{ACTUAL}(x_{ADJS}) = \Omega^2_{TOTAL} - \Omega^2_{ES}(x_{ADJS}) \quad (6)$$

Substitute Eq. (5) into Eq. (3)

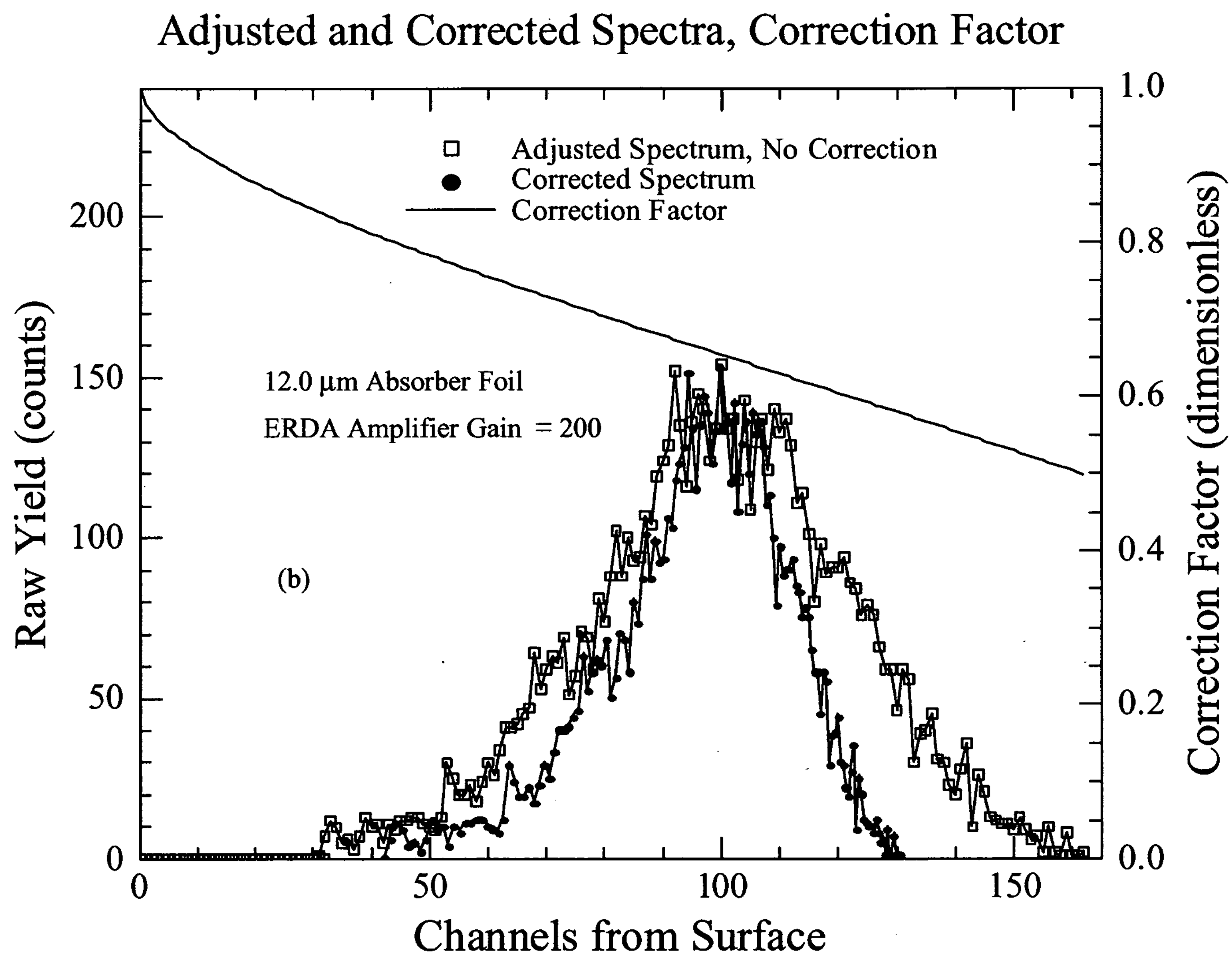
$$x_{CORRECTED} = (x_{ADJS} - c)\frac{\Omega_{ACTUAL}(x_{ADJS})}{\Omega_{TOTAL}} + c \quad (7)$$

Model for correction to channels; $c \equiv$ centroid of adjusted spectrum

$$\text{Correction Factor} \equiv \frac{\Omega_{ACTUAL}(x_{ADJS})}{\Omega_{TOTAL}} \quad (8)$$

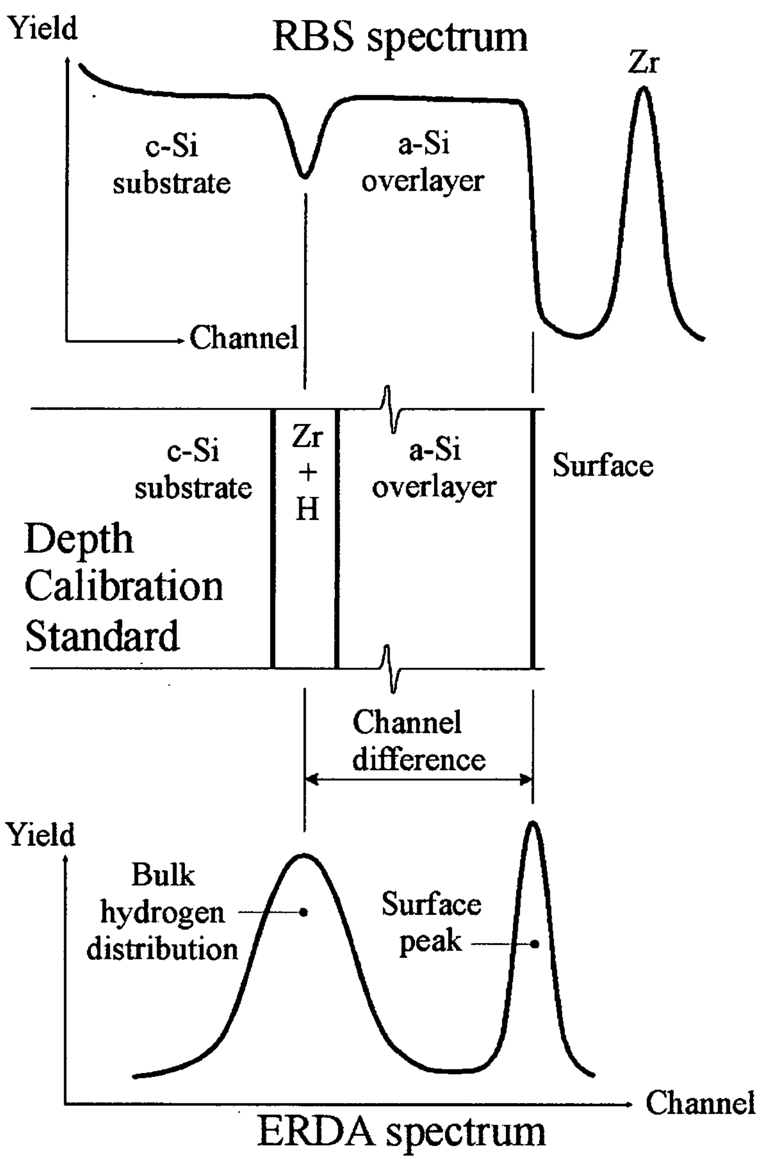
Definition

Model Corrects for Energy Spread in FRES



Correction is function of depth because
Energy spread is function of depth

Channel-depth Conversion from Depth Calibration Standards

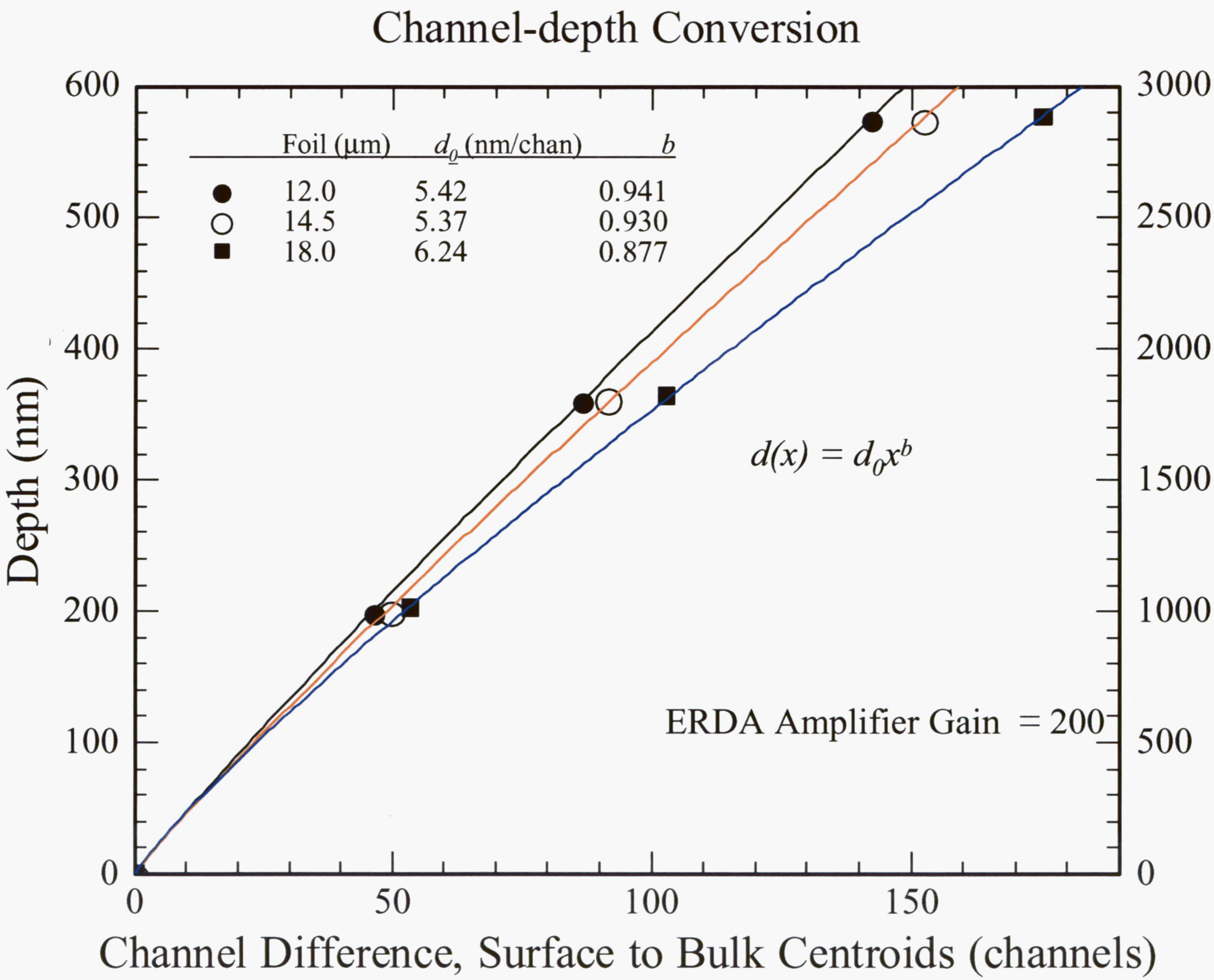


Computer simulations of the RBS spectra give the areal density of the a-Si overlayers.

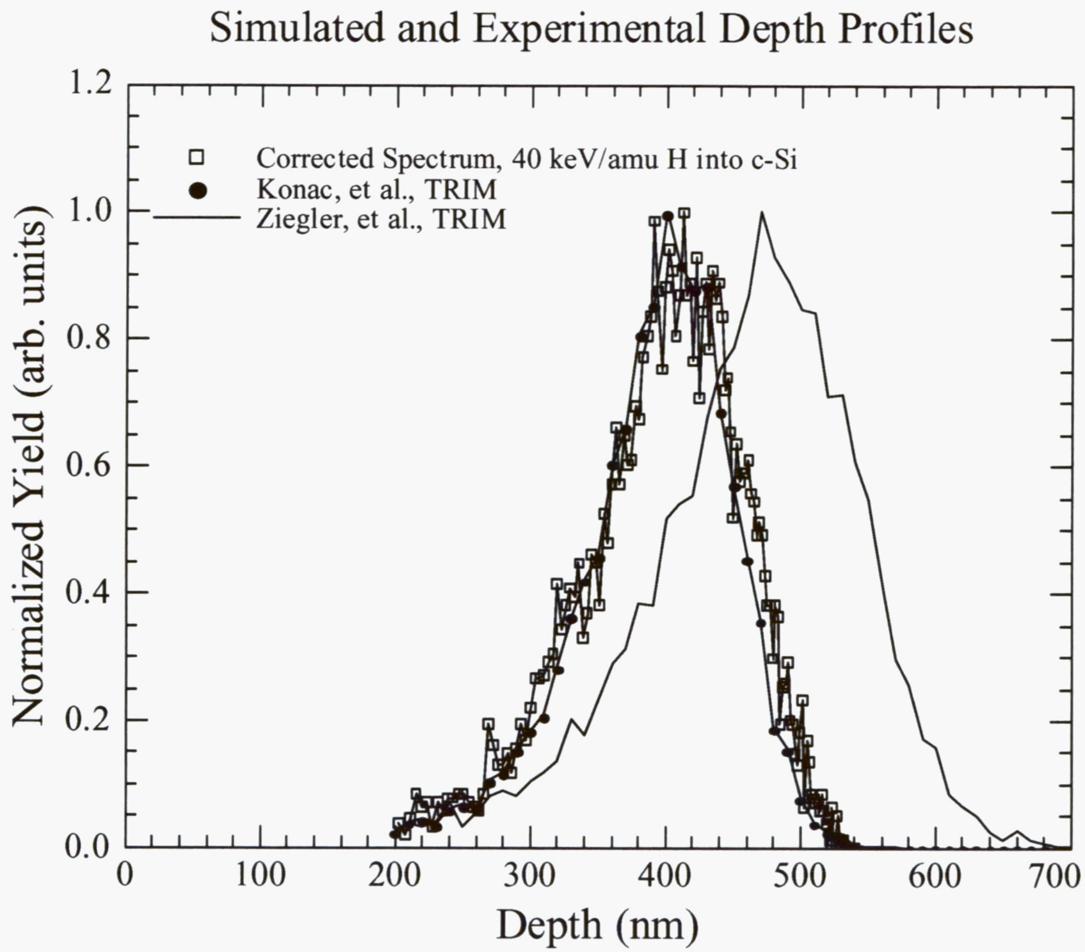
The a-Si areal density is expressed as c-Si thickness, because the depth profile is used for c-Si samples.

Thickness is plotted against channel difference, and the fit gives the *channel-depth* conversion, $d(x) = d_0 x^b$

Depth Profiling by Channel-depth Conversion

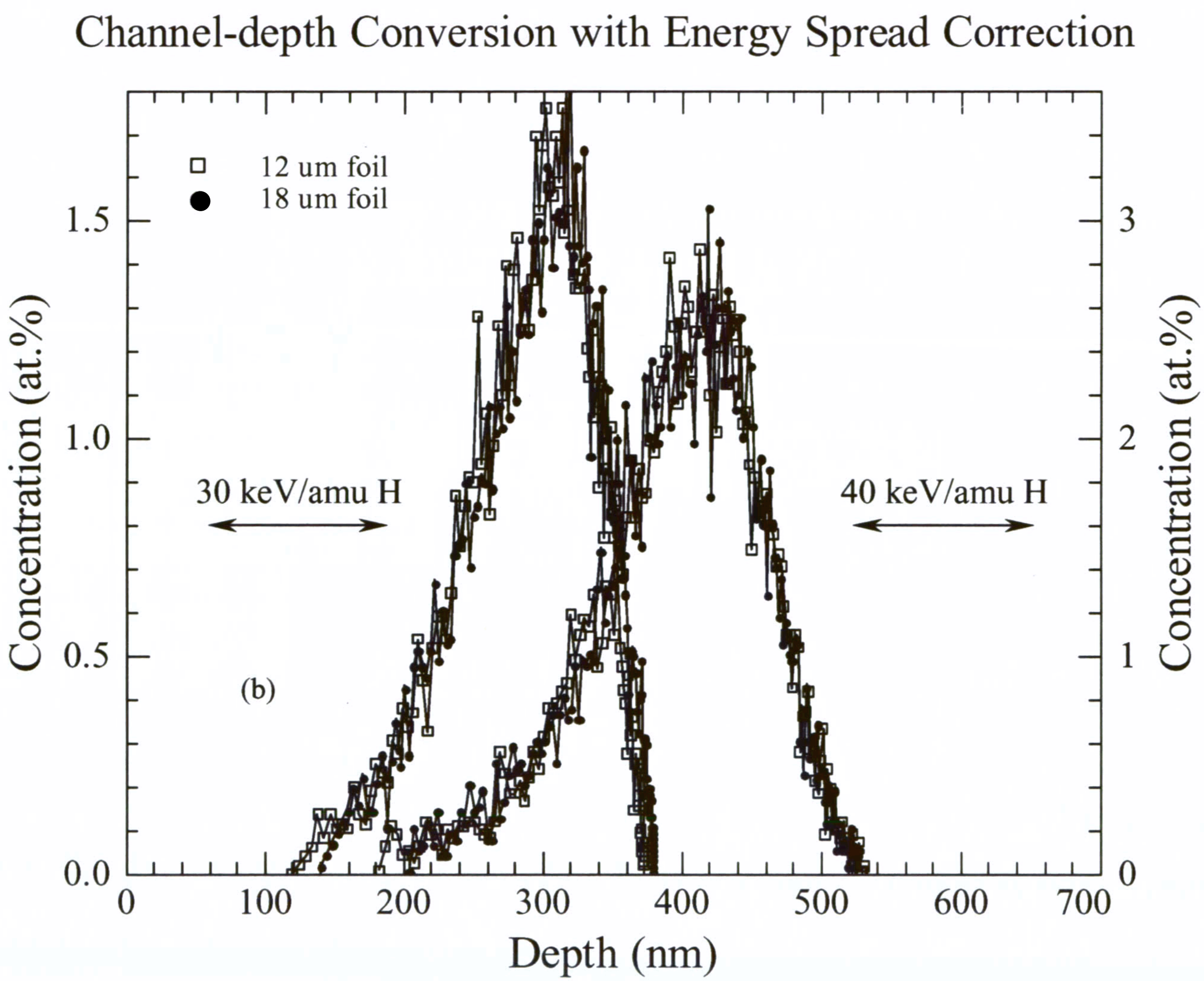


Depth Profiling Method Physically Accurate



	Centroid (nm)	St. Dev (nm)	Skewness (pure)	St. Dev ÷Centroid (%)
No Correction	406	85	-0.096	21
Correction	393	62	-0.60	16
Konac, TRIM	392	56	-0.60	14
Ziegler, TRIM	462	78	-0.53	17

Depth Profiling Method Independent of Foil



The depth profiling technique gives results that are independent of the absorber foil used, regardless of the energy or dose of the implant.

Conclusion

This work introduced a technique to correct for the energy spread in elastic recoil detection analysis called the *energy spread correction*.

The energy spread correction is determined from ion beam analysis of the same standards used to determine the *channel-depth conversion*.

Used in conjunction, the two techniques offer an accurate hydrogen depth profiling method.

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