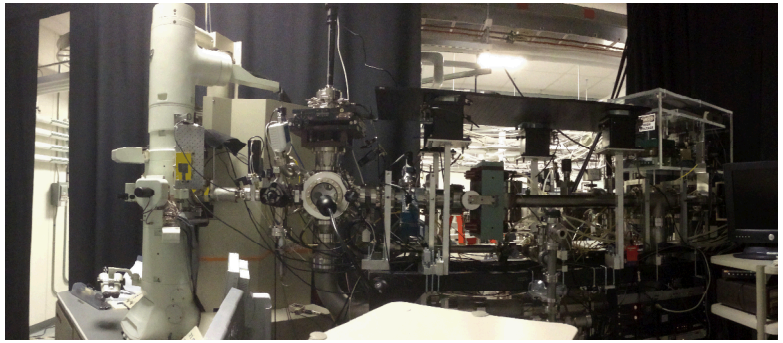
SAND2015-8526C

Exceptional service in the national interest

Sandia National Laboratories



Sandia's Ion Beam Laboratory

Jon Custer

Radiation-Solid Interactions

ion beam lab

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND NO. 2011-XXXXP

Overview

Sandia National Laboratories

- History of accelerators at Sandia
- The New Ion Beam Laboratory
- Preview of the Tour (Wednesday)

History of Accelerators at Sandia:

Sandia National Laboratories

- Use of accelerators at Sandia predates the 'Ion Beam Laboratory' as we know it today.
- They continue to be used because of the problems that they can solve.
- Those problems have been a continuous thread at SNL

- A short tour through history:

Sandia National Laboratories

RADIATION EFFECTS IN SEMICONDUCTORS

Proceedings of the Santa Fe Conference on Radiation Effects in Semiconductors, held October 3-5, 1967

Edited by F. L. Vook

Sandia Laboratories, Albuquerque, New Mexico

The field of radiation effects in semiconductors has rapidly advanced in recent years and substantial amounts of applicable evidence have been amassed.

Volume 13, Number 1 **APPLIED PHYSICS LETTERS** **1 July 1968**

ANISOTROPIC THERMAL CONDUCTIVITY OF ELECTRON-IRRADIATED CdS*

Frederick L. Vook
Sandia Laboratories
Albuquerque, New Mexico 87115
(Received 26 April 1968)

PHYSICAL REVIEW VOLUME 183, NUMBER 3 15 JULY 1969

Luminescence in Intrinsic and Annealed Electron-Irradiated GaAs:Cd†

GEORGE W. ARNOLD
Sandia Laboratories, Albuquerque, New Mexico 87115
(Received 17 March 1969)

Volume 14, Number 10 APPLIED PHYSICS LETTERS 15 May 1969

DIRECT EVIDENCE OF DIVACANCY FORMATION IN SILICON BY ION IMPLANTATION*

H. J. Stein, F. L. Vook, and *J. A. Borders*
Sandia Laboratories
Albuquerque, New Mexico 87115
(Received 21 March 1969)

ELECTRON PARAMAGNETIC RESONANCE OF DEFECTS IN ION-IMPLANTED SILICON*

K. L. Brower, F. L. Vook, and *J. A. Borders*
Sandia Laboratories
Albuquerque, New Mexico 87115
(Received 4 August 1969)
Appl. Phys. Lett. 15, 208 (1969)

VOLUME 16, NUMBER 3 APPLIED PHYSICS LETTERS 1 FEBRUARY 1970

ION IMPLANTATION DEPTH DISTRIBUTIONS:
ENERGY DEPOSITION INTO ATOMIC PROCESSES AND ION LOCATIONS*

David K. Brice
Sandia Laboratories, Albuquerque, New Mexico 87115
(Received 20 October 1969; in final form 11 December 1969)

A Simplified Technique for Crystal Alignment during Channeling Effect Measurements*

J. A. Borders and S. T. Picraux
Sandia Laboratories, Albuquerque, New Mexico 87115
(Received 6 April 1970)
Rev. Sci. Instrum. 41 1230 (1970)

LATTICE EXPANSION AND STRAIN IN ION-BOMBARDED GaAs AND SI†

R. E. Whan and G. W. Arnold
Sandia Laboratories, Albuquerque, New Mexico 87115
(Received 9 July 1970; in final form 12 August 1970)
Appl. Phys. Lett. 17, 378 (1970)

Sandia National Laboratories

Technique for profiling ^{1}H with 2.5-MeV Van de Graaff accelerators[a)]

B. L. Doyle and P. S. Peercy
Sandia Laboratories,[b)] Albuquerque, New Mexico 87185

(Received 12 February 1979; accepted for publication 21 March 1979)

We describe an elastic recoil detection (ERD) analysis technique for profiling ^{1}H in the near-surface regions of solids using a 2.5-MeV Van de Graaff accelerator commonly used for ion-backscattering analysis. Energy analysis of ^{1}H forward scattered by 2.4-MeV ^{4}He incident on the target tilted at an angle of $\sim 75°$ yields a depth resolution of $\lesssim 700$ Å and a sensitivity of better than 0.1 at.% for ^{1}H to depths of $\lesssim 0.6$ μm in solids.

Appl. Phys. Lett. 34, 811 (1979)

Electron beam annealing of ion implanted Al

W. R. Wampler, D. M. Follstaedt, and S. T. Picraux
Sandia Laboratories, Albuquerque, New Mexico 87185

(Received 12 October 1979; accepted for publication 14 December 1979)

Appl. Phys. Lett 36 366 (1980)

Sandia National Laboratories

IEEE Transactions on Nuclear Science, Vol. NS-26, No. 1, February 1979

ION MICROANALYSIS AND IMPLANTATION APPLIED TO FUSION SURFACE RESEARCH*

F. L. Vook, B. L. Doyle, and S. T. Picraux†

SATURATION AND ISOTOPIC REPLACEMENT OF DEUTERIUM IN LOW-*Z* MATERIALS*

B.L. DOYLE, W.R. WAMPLER, D.K. BRICE and S.T. PICRAUX

Sandia National Laboratories†, Albuquerque, New Mexico 87185, USA

J. Nucl. Materials 93&94, 551 (1980)

PHYSICAL REVIEW B VOLUME 9, NUMBER 10 15 MAY 1974

Study of Cu diffusion in Be using ion backscattering*

S. M. Myers, S. T. Picraux, and T. S. Prevender
Sandia Laboratories, Albuquerque, New Mexico 87115
(Received 28 September 1973)

PHYSICAL REVIEW B VOLUME 38, NUMBER 10 1 OCTOBER 1988

Measurement of the oxygen content in high-T_c superconductors: Enhanced resonant ion-scattering analysis

J. C. Barbour, B. L. Doyle, and S. M. Myers
Sandia National Laboratories, Albuquerque, New Mexico 87185-5800
(Received 28 March 1988)

IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 39, NO. 1, FEBRUARY 1992

Nuclear Microprobe Imaging of Single-Event Upsets

K. M. Horn, B. L. Doyle, and Fred W. Sexton, *Member, IEEE*

A new approach to nuclear microscopy: the ion–electron emission microscope

B.L. Doyle [a,*], G. Vizkelethy [a,1], D.S. Walsh [a], B. Senftinger [b], M. Mellon [c]

[a] *Radiation–Solid Interactions and Processing Department 1111, MS1056, Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM 87185-1056, USA*

[b] *Staib Instrumente GmbH, Langenbach, Germany*

[c] *Quantar Technology Inc., Santa Cruz, CA, USA*

Nucl. Instr. Meth. B158, 6 (1999)

IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 53, NO. 6, DECEMBER 2006

Damage Equivalence of Heavy Ions in Silicon Bipolar Junction Transistors

E. Bielejec, G. Vizkelethy, N. R. Kolb, D. B. King, and B. L. Doyle

APPLIED PHYSICS LETTERS 98, 231901 (2011)

Reduction in thermal boundary conductance due to proton implantation in silicon and sapphire

Patrick E. Hopkins,[1,2,a)] Khalid Hattar,[1] Thomas Beechem,[1] Jon F. Ihlefeld,[1] Douglas L. Medlin,[3] and Edward S. Piekos[1]
[1]*Sandia National Laboratories, Albuquerque, New Mexico 87123, USA*
[2]*Department of Mechanical and Aerospace Engineering, University of Virginia, Charlottesville, Virginia 22904, USA*
[3]*Sandia National Laboratories, Livermore, California 87123, USA*

We've now come full circle back to:

Volume 13, Number 1 **APPLIED PHYSICS LETTERS** **1 July 1968**

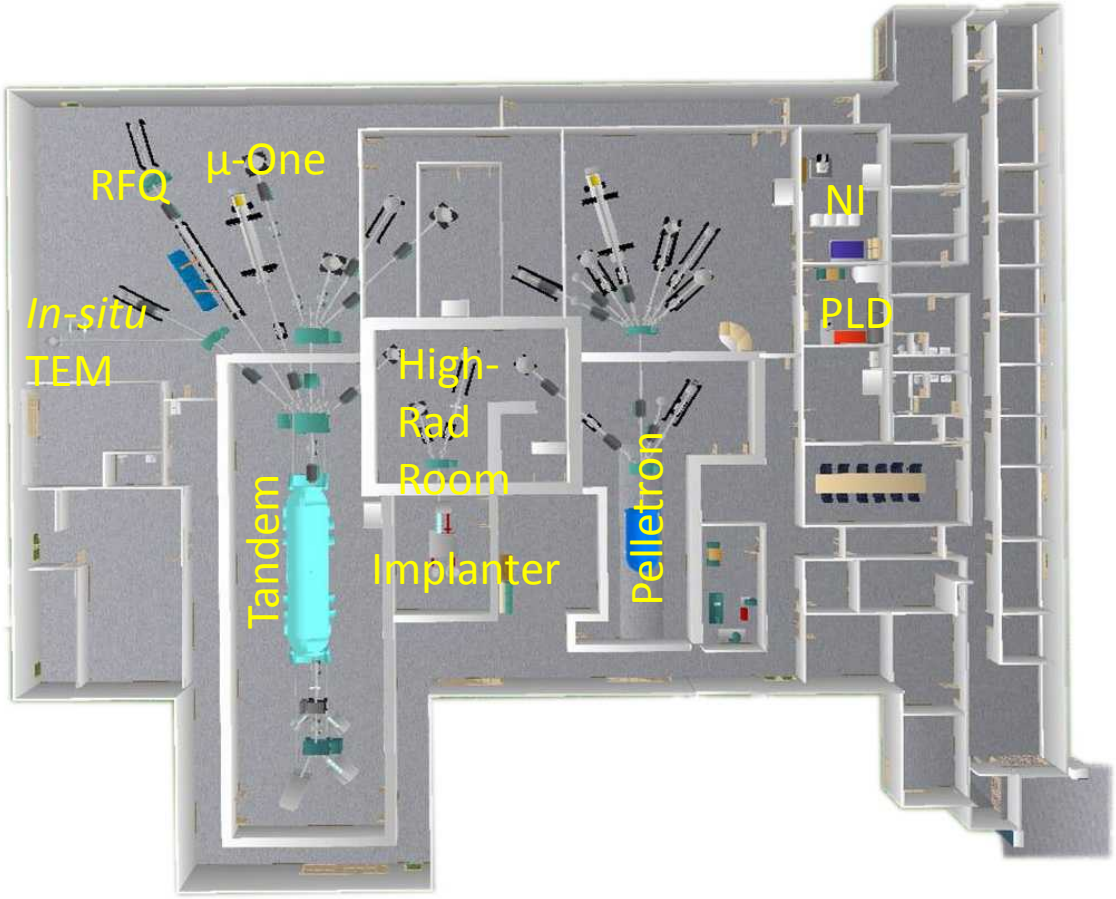
ANISOTROPIC THERMAL CONDUCTIVITY OF ELECTRON-IRRADIATED CdS*

Frederick L. Vook
Sandia Laboratories
Albuquerque, New Mexico 87115
(Received 26 April 1968)

The (new) Ion Beam Laboratory

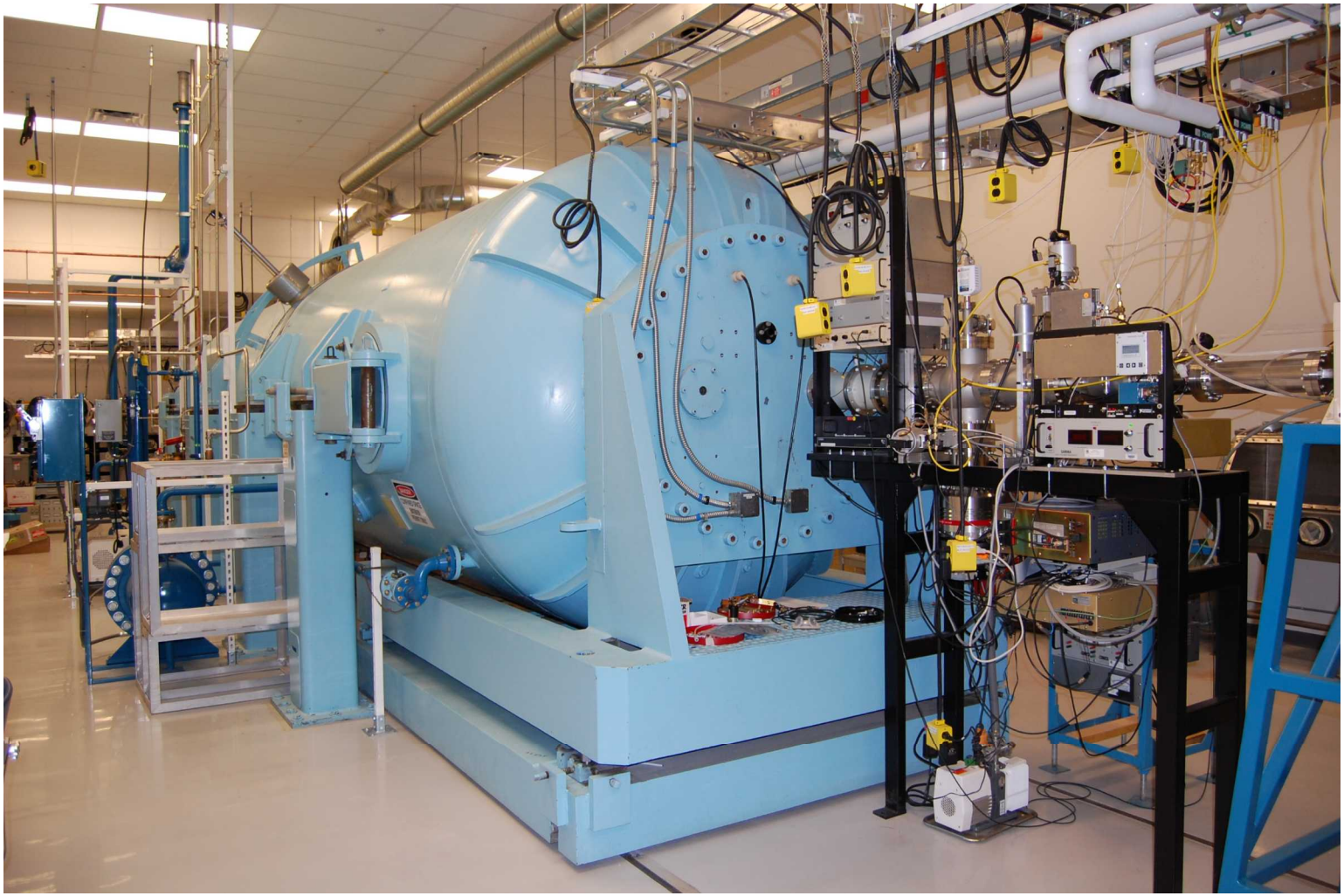
Sandia National Laboratories

General Overview of Interior



6MV HVE EN Tandem

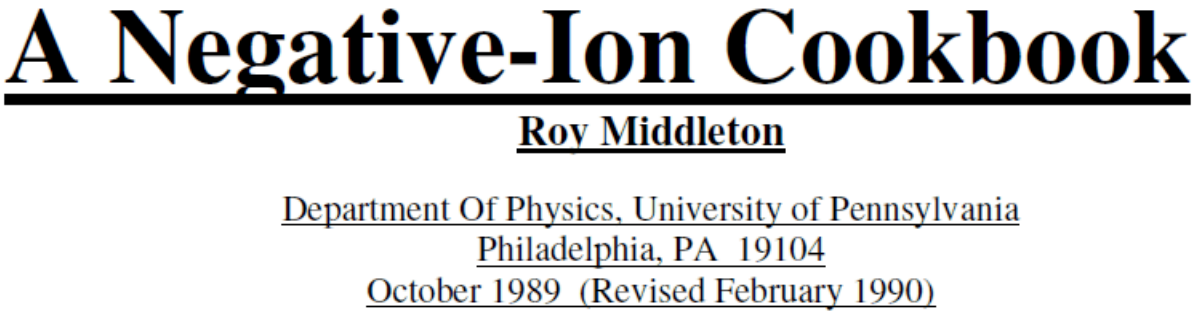
Sandia National Laboratories



ion beam lab

History

- Originally HV EN-14 (no EN-13)
- Installed at U. Penn in February 1962



A Negative-Ion Cookbook

Roy Middleton

Department Of Physics, University of Pennsylvania
Philadelphia, PA 19104
October 1989 (Revised February 1990)

- Replaced with an FN Tandem ~1975
- Bought by SNL and installed in the (old) IBL in 1976
- Upgraded to Pelletron charging system in 1992
- Move 3/2010 to the (new) IBL

Moving the Tandem

Sandia National Laboratories

3MV Pelletron for Ion Beam Analysis

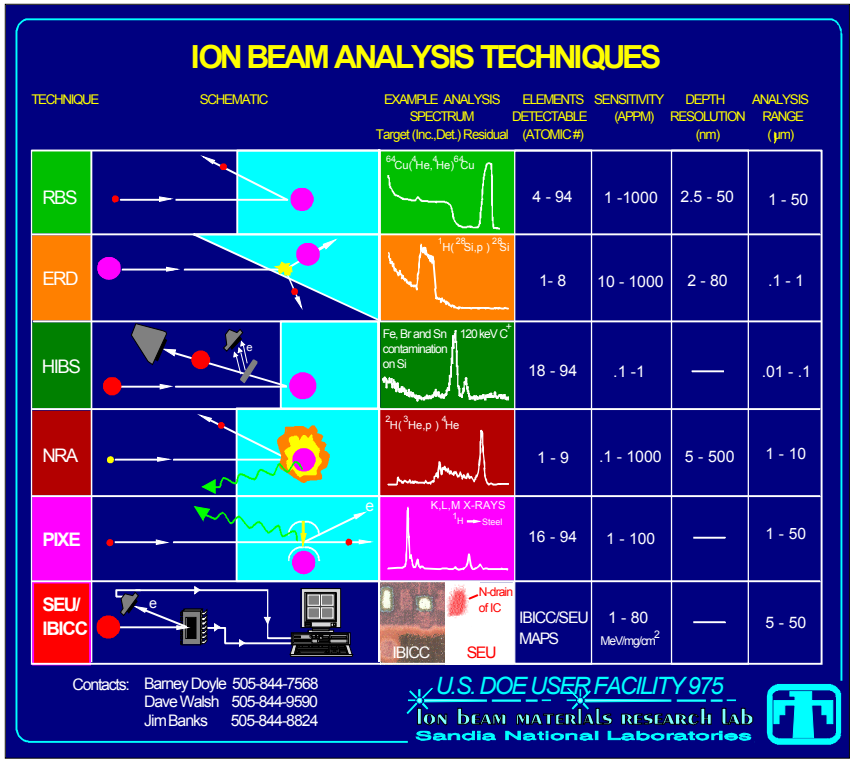
Sandia National Laboratories

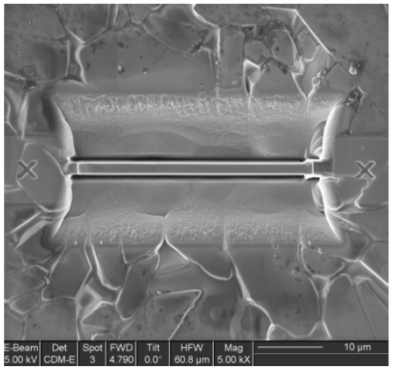
3MV single-ended NEC Pelletron being installed. Can maintain ±100V on terminal

uBEAM line – 1μm spot for IBA, 200nm spot for SEU, nm resolution stage.

All of the major IBA techniques are available on the uBEAM

- RBS - Rutherford BackScattering
- ERD - Elastic Recoil Detection
- HIBS – Heavy Ion BackScattering
- NRA - Nuclear Reaction Analysis
- PIXE - Proton Induced X-ray Emission
- SEU/IBIC – Single Event Upset and Ion Beam Induced Current Imaging





Microbeam IBA experiments in the IBL

- Elemental concentration distributions in 3D
- TEM samples can be analyzed
- H profiling using uERD
  - Sintered Ceramics
    - H_2O well known to modify voltilization behavior of common commercial glasses
    - Where is H_2O (i.e. H) localized?
  - microERD used to map H
  - microRFS performed at same time to measure sample thickness variations

Ceramic Samples

#1

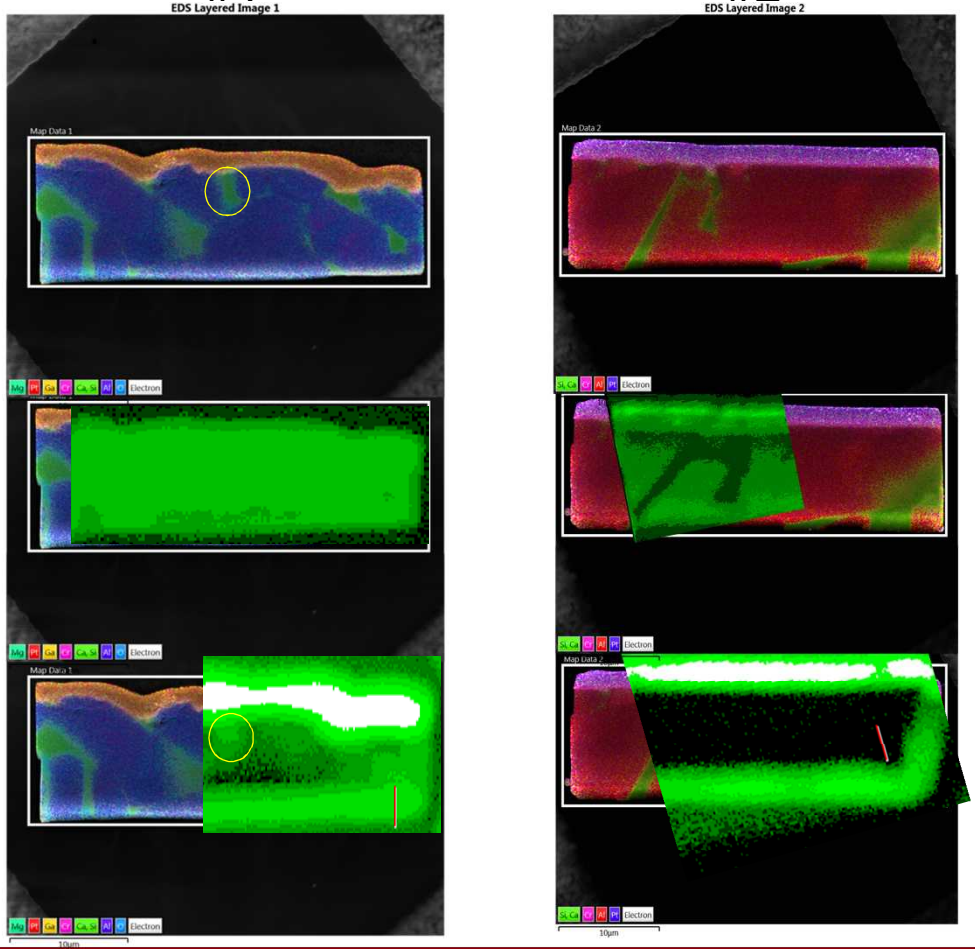
#2

Sample prep by Gary Bryant 1819

SEM

RFS

ERD



HVEE Ion Implanter

Sandia National Laboratories

- Research ion implant system
  - Cockroft-Walton type voltage supply
- 400kV at sea level
- 350kV in Albuquerque (less air)
- Many ion sources
  - gas, sputter, oven, …

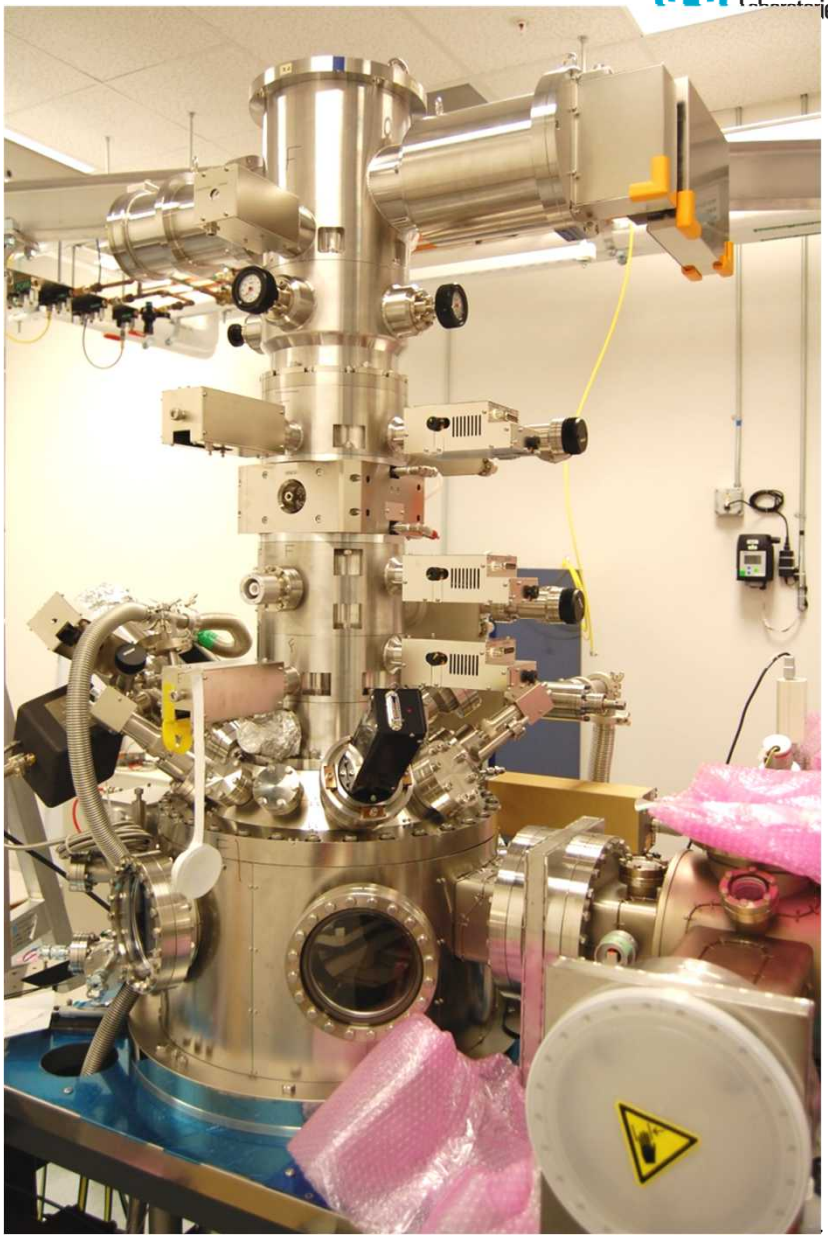
- The primary calibration standard in the US for pulsed neutron detectors
  - Accelerate D or D_2 into deuterated or tritated targets

NanoImplanter

- FIB “on steroids”
- 100kV column
- Liquid metal source
- ExB filter to select ion/charge

- 20 nm spot size
- Li, Si, P, Cu, Pt, Au, Sb, … run

- High resolution lithography stage and electrical contacts

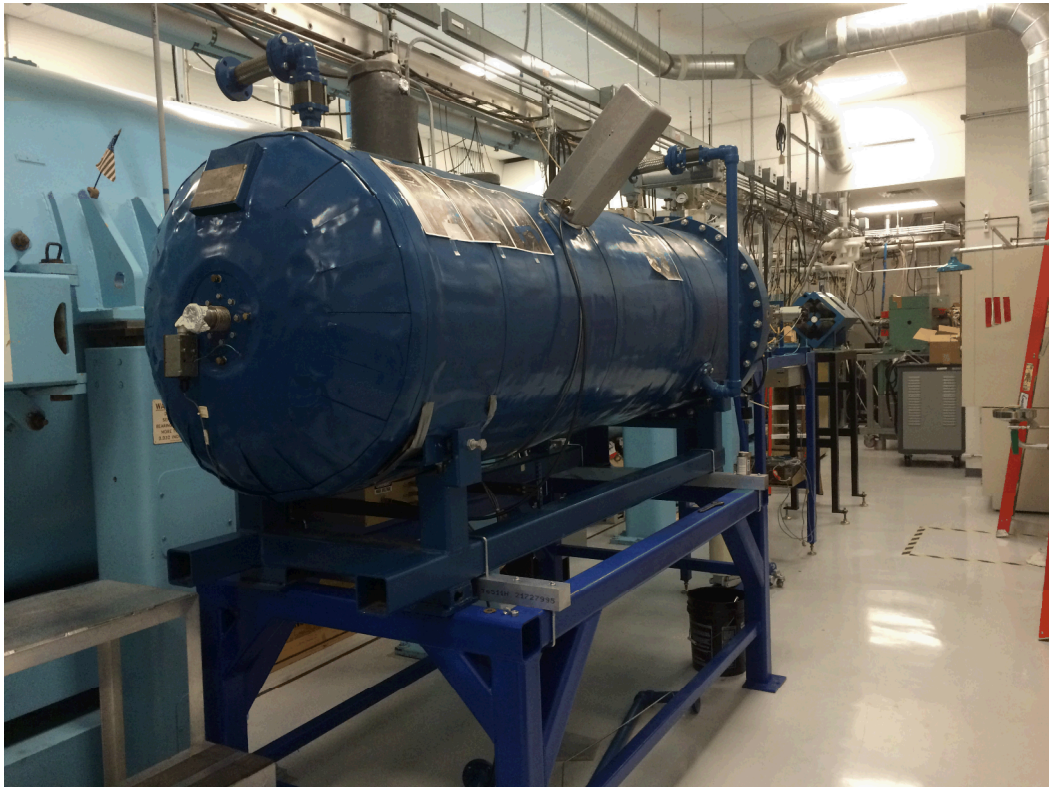


Sandia National Laboratories

ion beam lab

The ‘Baby’ Tandem

- Installing a new (to us) 1MV NEC Tandem



The New IBL

- Tour is on Wednesday afternoon!
- See most of the building, all of the accelerators
- See you then!