Medical and Industrial Accelerators

(What I've done with my physics degrees)

Robert W. Hamm, PhD

CEO & President

R&M Technical Enterprises, Inc.

Pleasanton, CA

Presented at TAMU REU Career Day – July 10, 2009

My Education History

- **Loved math and science in high school (Lake Charles, LA). Attended Louisiana State University NSF science program summer before senior year.**
- **Worked one year in oilfields before starting college - completed BS in physics (1967) at University of Louisiana in Lafayette. (Worked in oilfields on week-ends, holidays & summers to pay for college.)**
- **Convinced by senior research professor to go to graduate school. Worked at Savannah River Lab for summer and then attended Florida State University in Tallahassee, working in nuclear physics lab. This is where I met Marianne.**
- **Completed MS degree in physics (1969) and went to work on accelerator staff, beginning 40 years in this field. Was turned down by university for doctorate work in accelerator physics, so Marianne also quit at her MS degree.**
- **Left FSU to take time off from school for our son to be born. Worked at Schlumberger in Houston as lab technician testing nuclear well logging tools.**
- **We were accepted by Texas A&M physics department to complete PhDs in physics. Department allowed my degree in accelerator physics (1977) and gave us assistance in many ways that enabled us to complete our degrees . (Studied in France to start PhD and visited USSR just before PhD completed.)**

(TAMU has Hamms' Endowed Scholarships and Florida State doesn't!)

Post Degree Work History

- **Worked at Los Alamos National Lab on LAMPF linac and in the newly formed Accelerator Technology Division, helping to develop the Radio Frequency Quadrupole (RFQ), a revolutionary new linac structure that now has widespread use worldwide. Worked as exchange scientist in Canada (CRNL) and Switzerland (CERN).**
- **Became Vice President of R&D at The Cyclotron Corporation (TCC) at age 37. (Company was going to commercialize RFQ technology)**
- **Became R&D Manager at Varian Medical Corp. after TCC went into bankruptcy. (Ran manufacturing group before leaving TCC.)**
- **Left Varian in 1985 to start AccSys Technology, Inc., an accelerator company based on the use of the RFQ linac for medical, industrial and research applications. (Designed and built 35 linac systems.)**
- **Completed the sale of AccSys in 2007 to Hitachi, Ltd. and "retired"! Started a consulting company, R&M Technical Enterprises, Inc., in 2008 to continue to have fun doing accelerator physics.**

Accelerator Technology

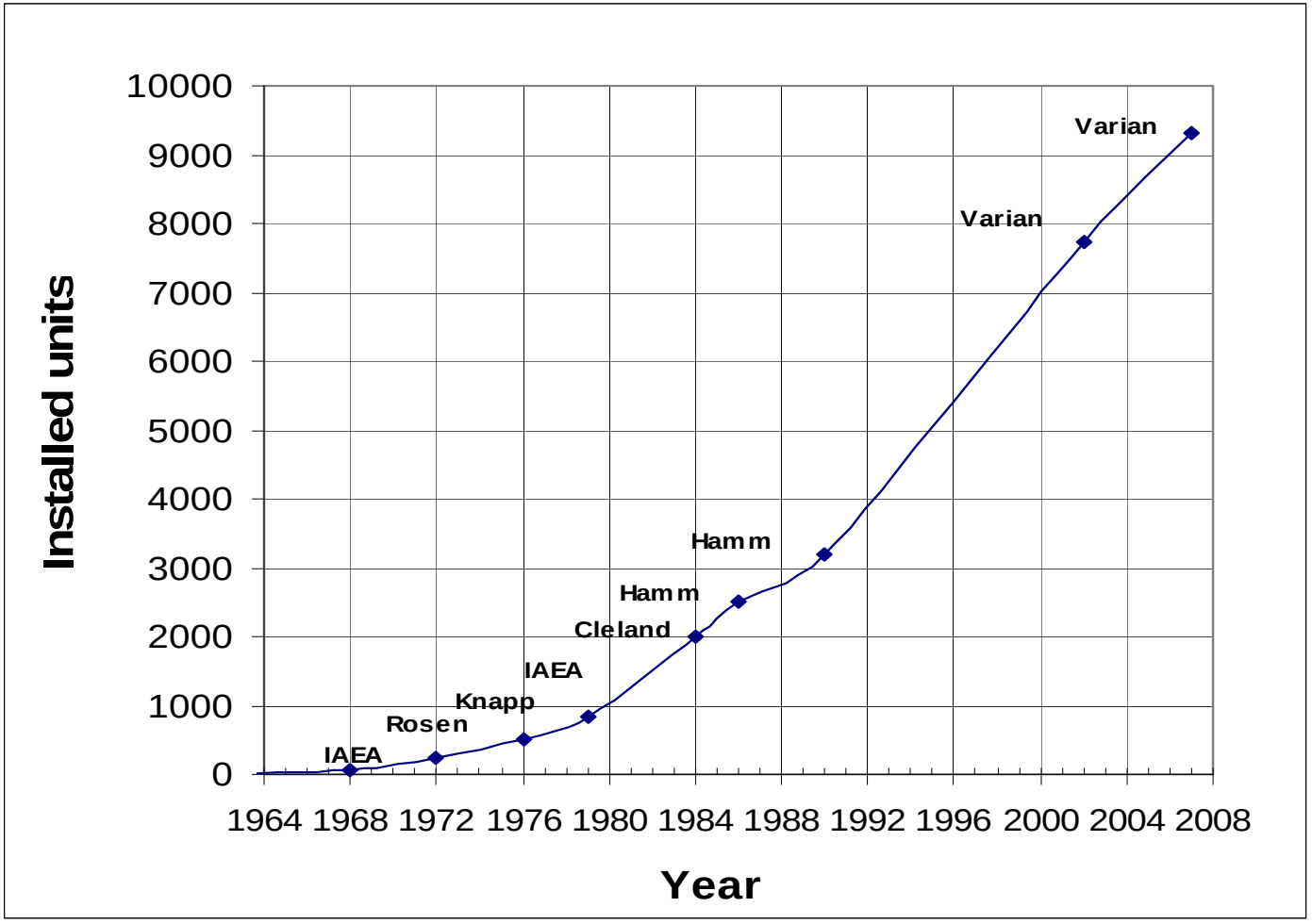
- Techniques originally developed for physics research in 1930's:
  - **Direct Voltage** – voltage gradient to accelerate charged particles (either electrons or ions)
    - Van de Graaff – charge carrying belt or "chain". Energies from 1 to 15 MeV at currents from nA to mA.
    - Dynamitron & Cockcroft Walton generator – voltage multiplier circuits. Energies to 5 MeV at currents up to 100 mA.
    - Inductive Core Transformer (ICT) – transformer charging circuit. Energies to 3 MeV at currents to 50 mA.
  - **RF Linacs** – RF generated voltage to accelerate "bunches" of charged particles
    - Electron linacs – standing wave cavities from 0.8 to 9 GHz. Energies from 1 to 16 MeV at beam power to 50 kW.
    - Ion linacs – all use RFQs at 100 to 600 MHz. Energies from 1 to 70 MeV at beam currents up to mA.
  - **Circular** – Magnetic field to maintain circular orbit.
    - Cyclotrons – ion energies from 10 to 70 MeV at beam currents to several mA.
    - Betatrons – electron energies to 15 MeV at few kW beam power.
    - Rhodotron – electron energies from 5 to 10 MeV at beam power up to 700 kW.
    - Synchrotron – electron energies up to 3 GeV and ion energies up to 300 MeV/amu.

Medical and Industrial Applications of Accelerators

- **Cancer therapy** – 250,000 treatments per day
- **Ion Implantation** – All modern electronics depends on it
- **Electron beam cutting and welding** – Cars, spacecraft and mass produced parts
- **Electron beam irradiators** – Processing, sterilization and curing
- **Radioisotope production** – Mostly for medical diagnostics.
- **Ion Beam Analysis** – A lot of QA and environmental testing
- **Non-destructive testing** – Cargo inspection is largest application
- **Neutron generators** – More QA and inspection tasks.
- **Synchrotron radiation** – Medical and industrial “inspection” on atomic scale.

We are currently putting together a book on these topics, so I want to briefly review the largest of these industrial applications.

Cancer Therapy



It has taken many years for this treatment technique to become widespread.

Ion Implantation

Semiconductors

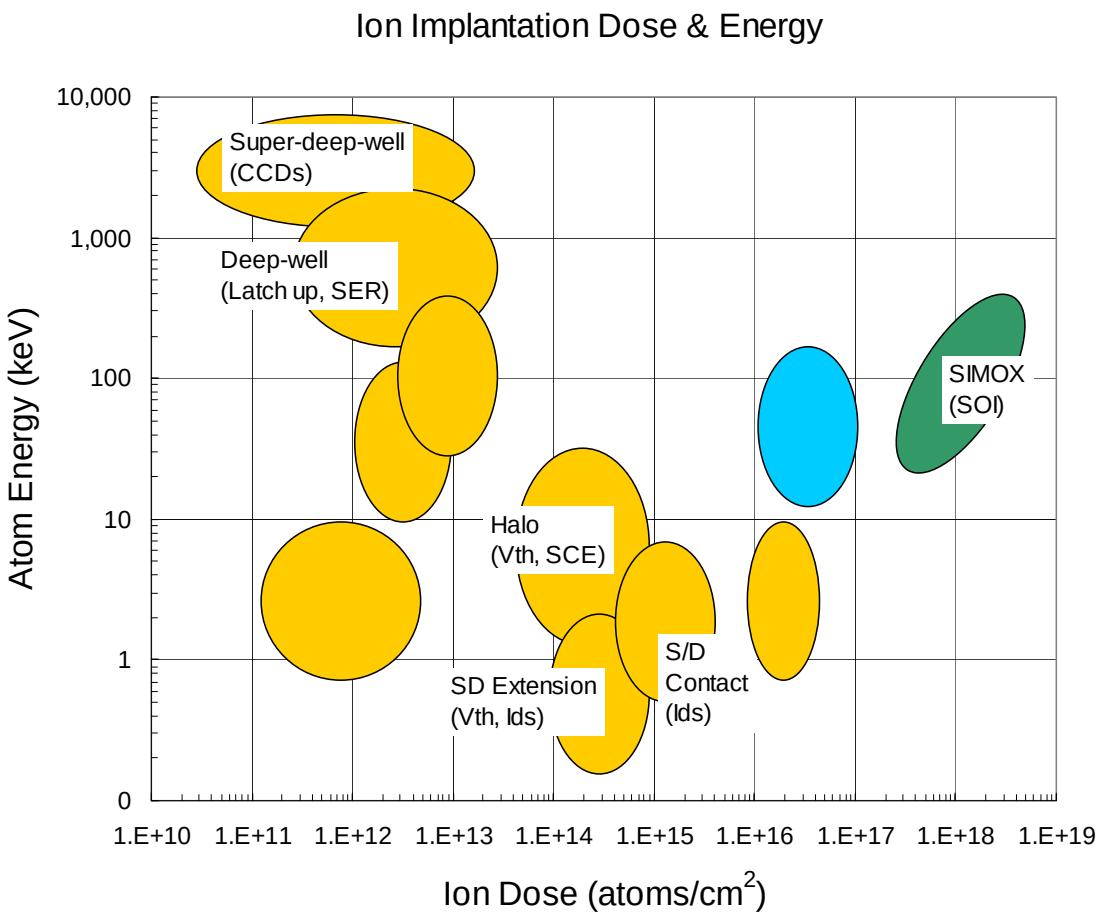
- CMOS fabrication
- SIMOX
- Cleaving silicon
- MEMS

Metals

- Harden cutting tools
- Artificial human joints

Ceramics & glasses

- Harden surfaces
- Modify optics



All digital electronics now dependent on ion implantation.

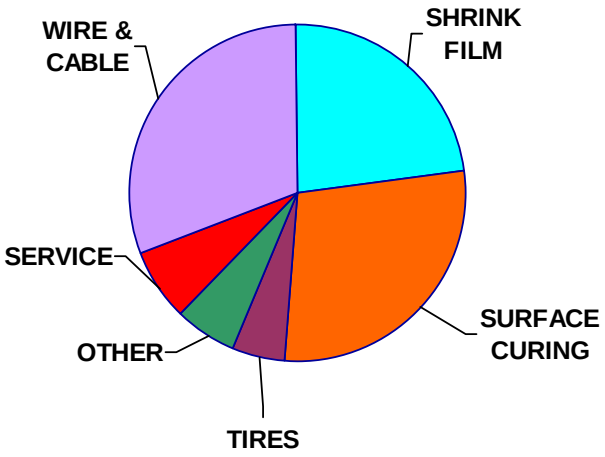
Electron Beam Irradiation

- Cross linking of materials (largest application)
- Sterilization of single-use disposable medical products – surgical gowns, surgical gloves, syringes, and sutures (growing applications)
- Food and waste irradiation (largest potential applications)

Cross linking applications

Product	Applications
Cross-linked polyethylene(PE) and PVC	Heat and chemical-resistant wire insulation; pipes for heating systems
Cross-linked foam polyethylene	Insulation, packing and flotation material
Cross-linked rubber sheet	High quality automobile tires
Cross-linked polyurethane	Cable insulation
Cross-linked nylon	Heat and chemical resistant auto parts
Heat resistant SiC fibers	Metal and ceramic composites
Vulcanized rubber latex	Surgical gloves and finger cots
Cross-linked hydrogel	Wound dressings
Acrylic acid grafted PE film	Battery separators
Grafted polyethylene fiber	Deodorants
Curing of paints and inks	Surface coating and printing

Cross linking by industry



Total of $50 billion per year

This physics application touches many people's lives..

Future Industrial Accelerators

- **Free Electron Laser (FEL)**
  - *Next generation of synchrotron light source.*
  - Uses electrons from linac with PM wiggler to create tunable light source for many applications now performed at electron synchrotron facilities.

- **Superconducting Linacs & Cyclotrons**
  - Improvements in cryogenic technology from widespread use in large research and medical accelerators
  - Increase in efficiency and size reduction of systems for cancer therapy, and radioisotope and neutron production.

- **Fixed Field Alternating Gradient (FFAG) Cyclotron**
  - Being developed for high energy physics research at national labs.
  - Also being developed as a neutron source for BNCT, and if proven, will be quickly adapted for other neutron beam applications.

Other R&D underway, but is kept secret for competitive reasons

Wisdom gained from my experience

- Find your passions & pursue your dreams.
  (*The more you want to do it, the less it seems like work*.)
- Go at your own pace, but “JUST DO IT”.
- The system isn’t always right, but you should not let that stop you.
- There are positions in industry that are as rewarding as those in research labs and universities.
- The work is more important than the pay.