

REU 2009 Career Day

Radiation Effects Testing

Henry L. Clark, Ph D

Accelerator Physicist /

SEE Line Project Manager / Upgrade Project Manager

Cyclotron Institute, Texas A&M University

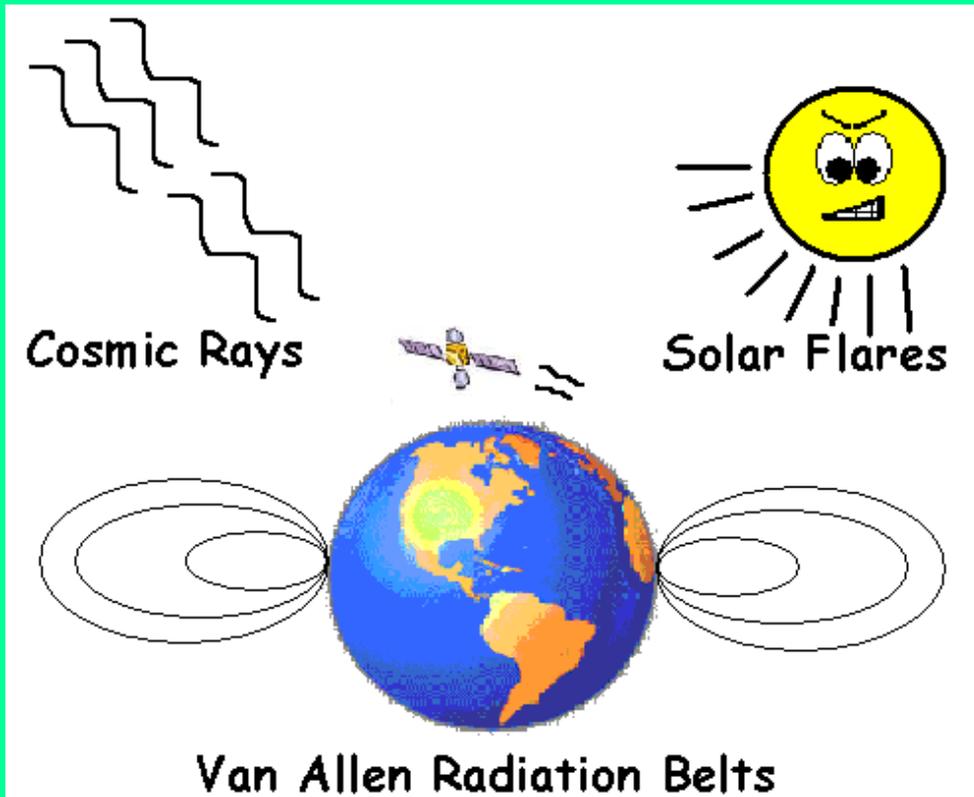
Education

- 1988 B.S. in Physics, Ohio University
 - Undergraduate thesis/research nuclear physics
- 1993 Ph.D. in Nuclear Physics, Ohio University
 - High Energy Physics at Fermi Nat Lab, Batavia, Ill
 - Summer positions at Los Alamos Nat Lab, Brookhaven Nat Lab
 - Experiments at Indiana U and Oak Ridge Nat Lab

Cyclotron Institute

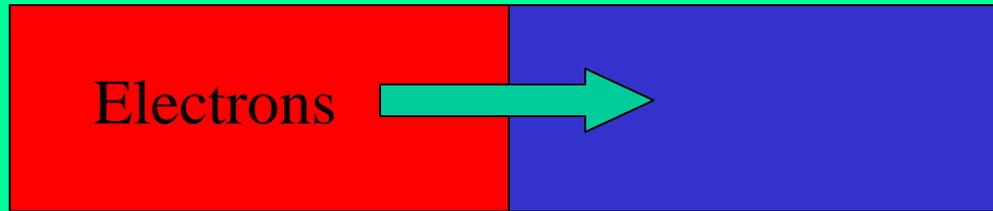
- 1993 Research Associate (Dr. Youngblood)
 - Giant resonance studies (GMR, ISGDR...)
 - Designed and built MDM focal plane detector
- 1998 Accelerator Physicist / SEE Line Project
 - Upgraded capabilities / Improvements
 - Built large customer base
- 2005 Upgrade Project Manager
 - Recommissioning of 88” (K150) cyclotron
 - Funding DOE, State, Welch Foundation, SEE Line
 - Restoration & utility improvements
 - Beam lines to existing K500 experiments
 - Ion Guides for reaccelerating radioactive ions

Radiation Effects



- Aerospace computer equipment receives radiation from cosmic rays, solar flares and the Earth's Van Allen radiation Belts.
- This radiation can harm or destroy space bound materials.

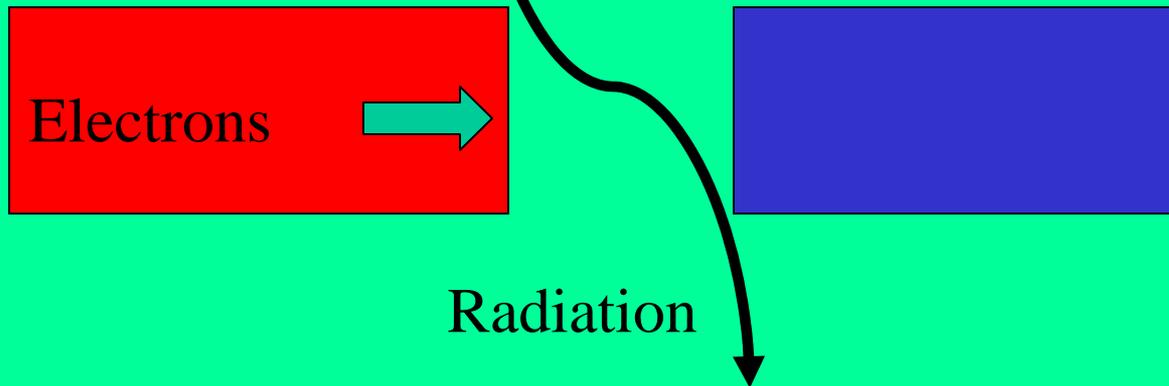
Normal Semiconductor Crystal



Electrical
Engineering

Physics

“Upset” Semiconductor Crystal



Testing Personnel

1/3 – Electrical Engineers

2/3 – Physicists

mainly Nuclear

Solid State

Various Effects

- Different forms of Radiation:
 - Light ions (protons, alphas),
 - Heavy ions (Ne, Ar, Fe.....Au, U),
 - Neutrons (nuclear reactions with space craft),
 - Electromagnetic (x-rays, gamma-rays)
- Total dose:
 - High intensity light ions and EM radiation
- Single Event Effects (SEE):
 - Heavy ions and light ions

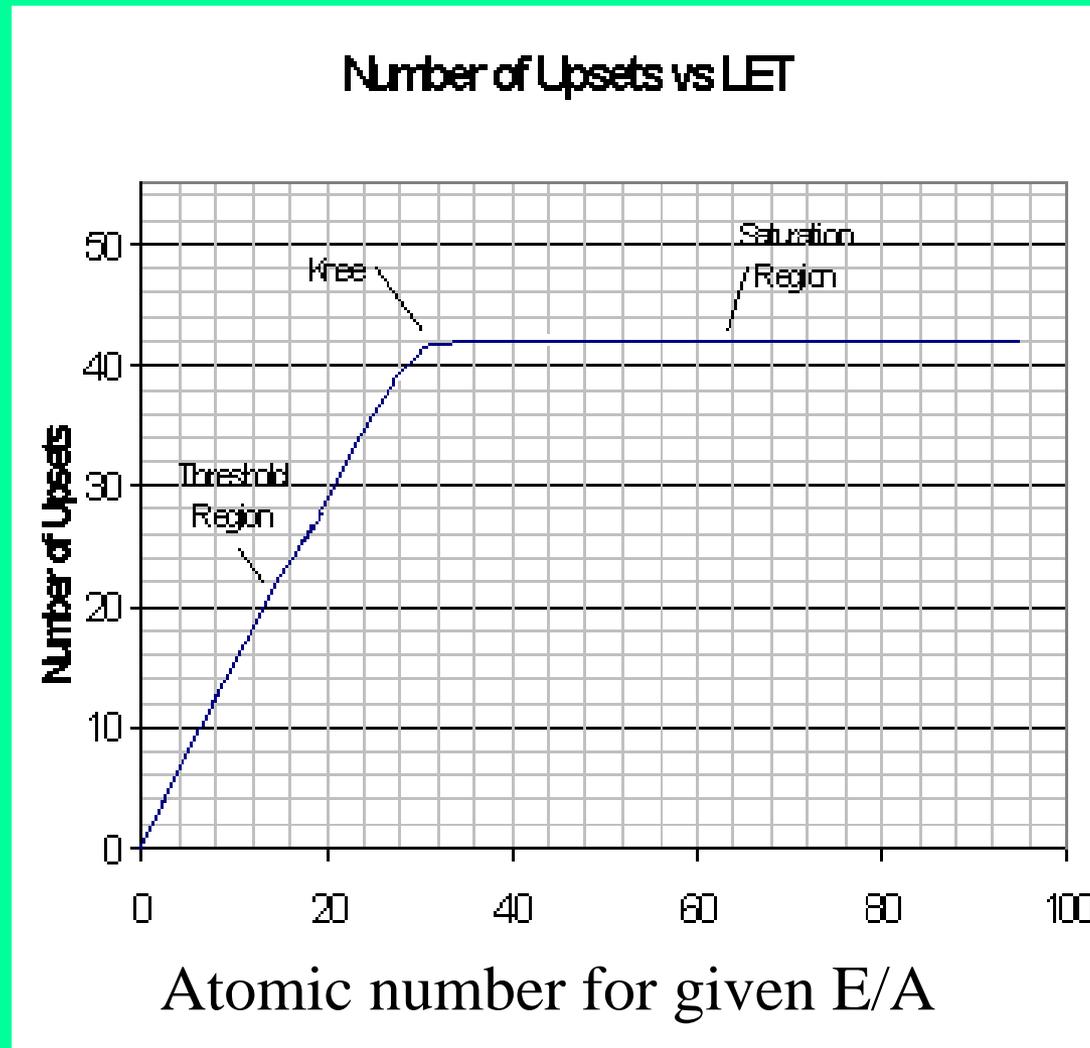
Total Dose Effect

- High intensity light-ions & EM radiation
- Complete failure of device
- Cannot be reset or repaired
- Testing is performed with
 - Protons (40 – 350 MeV), Indiana U, UC Davis, Berkeley Nat Lab, Massachusetts Gen Hosp...
 - Flash x-ray (Boeing-Seattle)
 - Gamma-ray (Co⁶⁰)

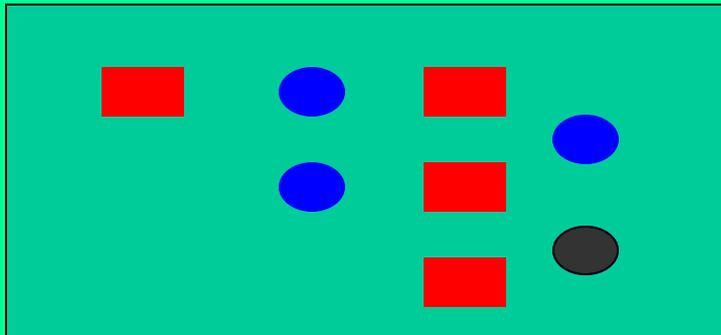
Single Event Effects

- Low intensity heavy ions ($\sim 10^8$ ions/s-cm²)
- Hard Errors
 - “Burn out” or “Latch up”
 - Cannot be reset or repaired
 - Generally caused by largest heavy-ions, Xe-Au
- Soft Errors
 - “Bit flip” from 1 to 0
 - Instantaneous de-synchronization or data loss
 - Rates measured over wide range of heavy-ions

Upset Cross Section



Part Size...



Circuit 20 years ago – “inches”

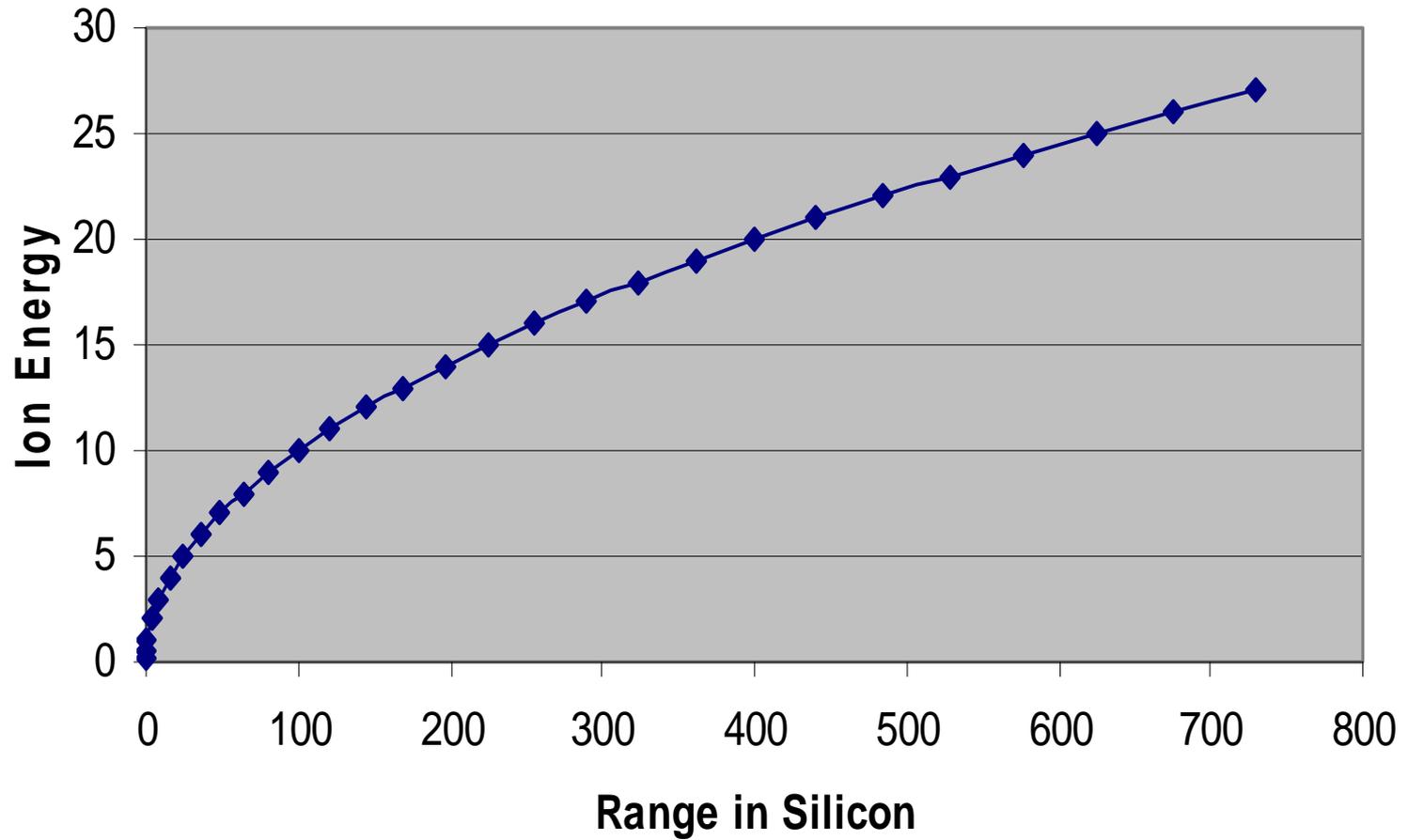


Integrated Circuit
Today – “microns”

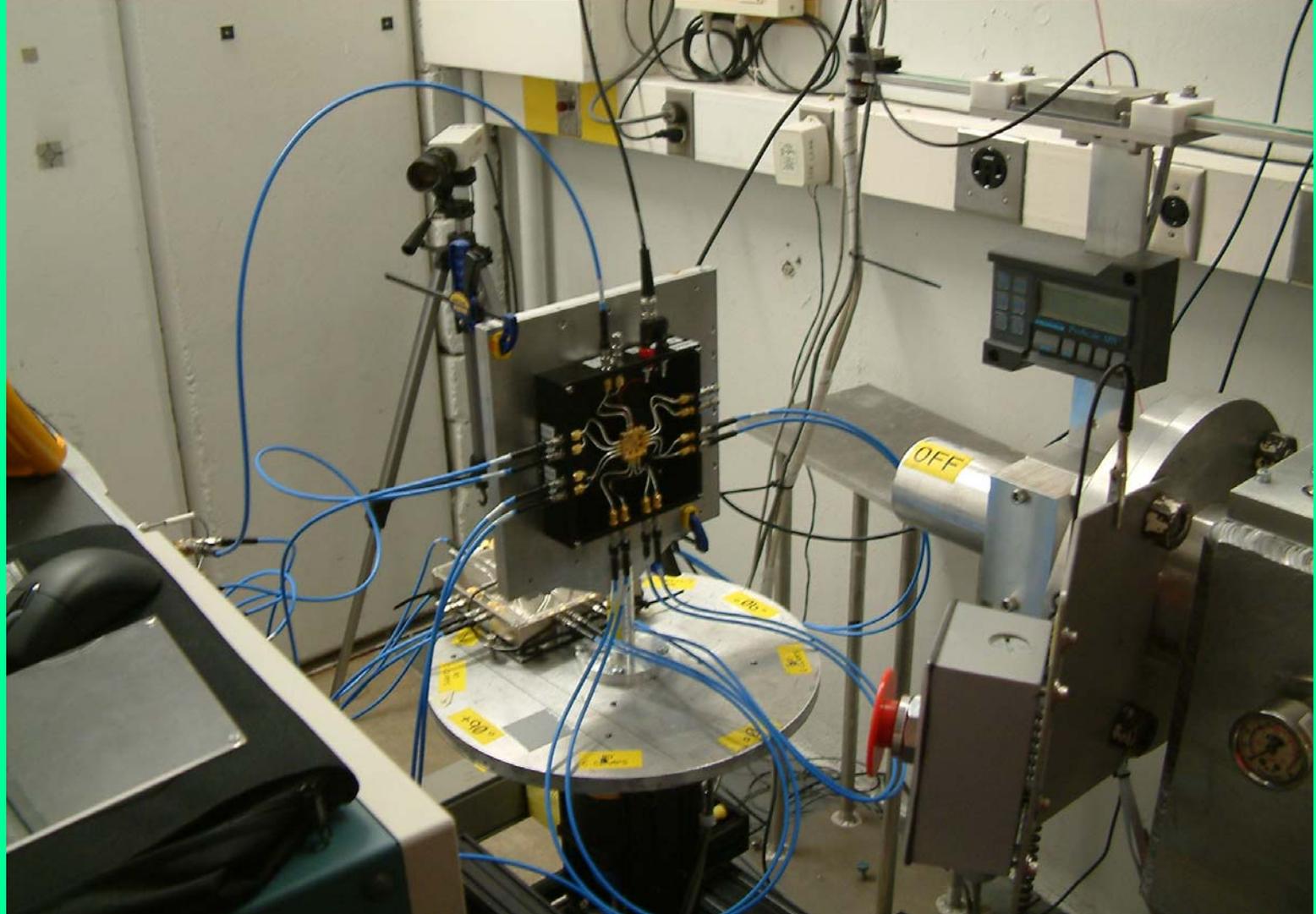
Radiation Effects

- Particle energy matters!
- Most heavy ions 15-100 MeV/nucleon
 - Test at space energies
 - TAMU Cyclotron
 - 15 MeV/u He, N, Ne, Ar, Cu, Kr, Ag, Xe, Pr, Ho, Ta, Au (Z=2-79)
 - 25 MeV/u He, N, Ne, Ar, Kr, Xe (Z=2-54)
 - 40 MeV/u He, N, Ne, Ar, Kr (Z=2-36)
 - 55 MeV/u O, Ar (Z=8-18)

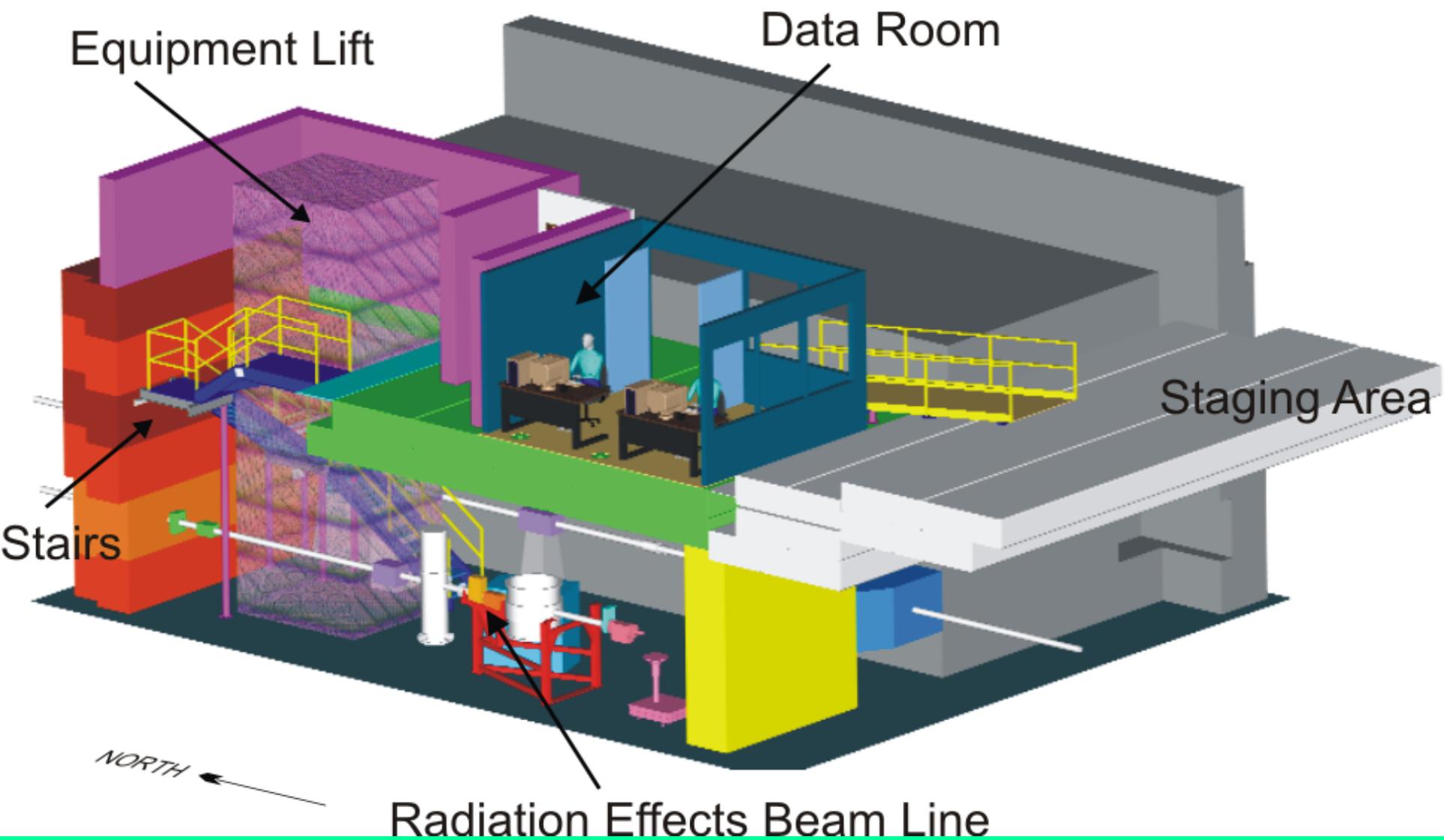
Ion Range



In-air Testing!



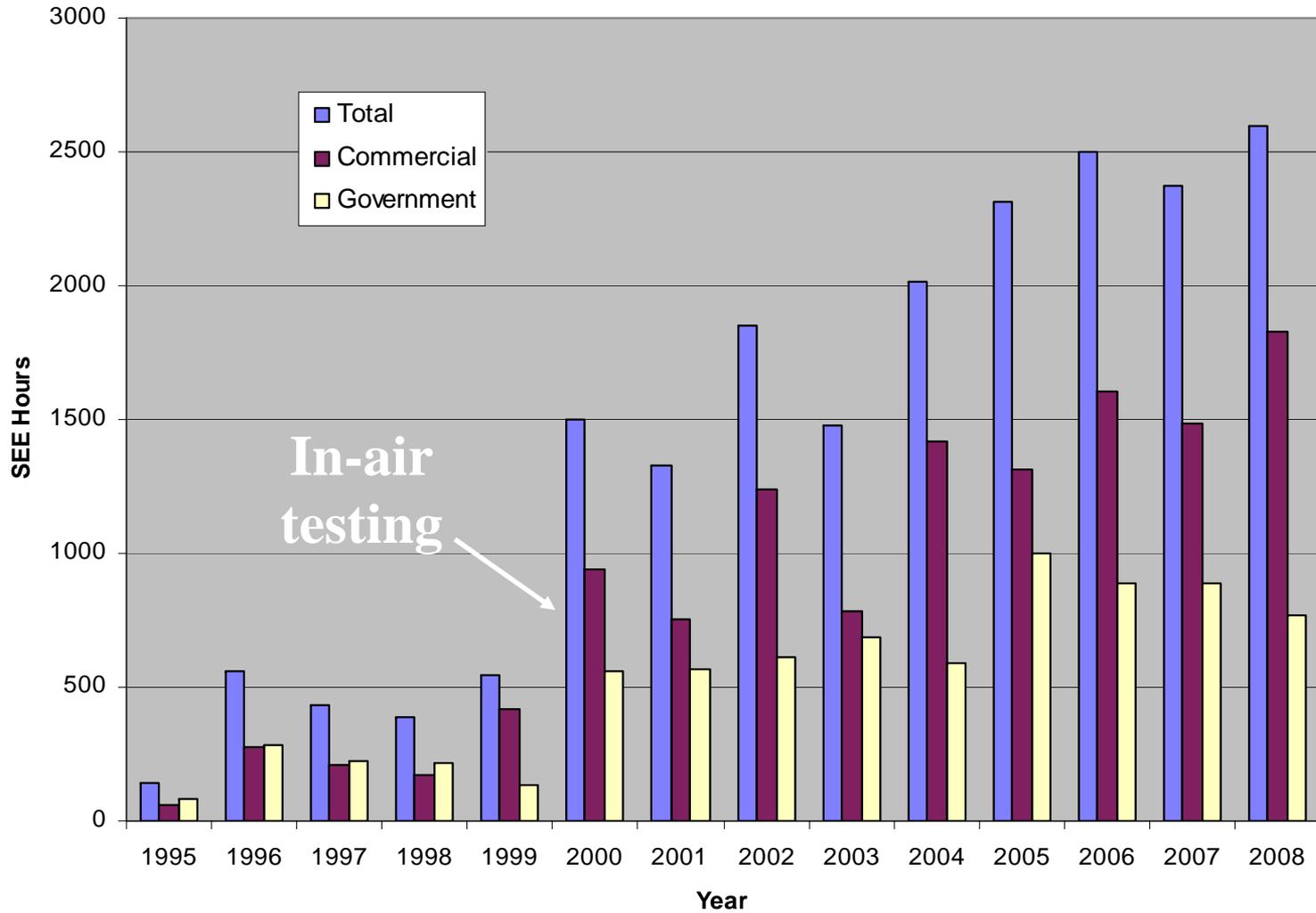
3D View of New Radiation Effects Line Location



Actel Corporation
Aeroflex UTMC
Aerospace Corporation
Air Force
BAE Systems
Ball Aerospace
Boeing (Seattle)
Boeing Satellite Systems
Full Circle Research
General Dynamics
Harris Semiconductor
Honeywell
Hughes Space Communications
IBM
Innovative Concepts Inc.
International Rectifier
Intersil Corporation
Johns Hopkins
Lockheed-Martin
Los Alamos National Laboratory
Makel Engineering
Maxwell Technologies

McDonnell-Douglas
Michigan State University-NSCL
Mission Research Corporation
Mitsubishi Heavy Industries
Motorola
NASA-Goddard Space Flight Center
NASA-Jet Propulsion Laboratory
NASA-Johnson Space Center
Naval Research Laboratory
Naval Surface Warfare Center
Navy-Crane
Northrop Grumman
Novus Technologies
Prairie View A&M CARR
Radiation Assured Devices
Raytheon Corporation
Sandia National Laboratory
SEAKR Engineering
Texas Instruments
United Space Alliance
Xilinx

Hours / Year



~2,500 Hours of SEE Line

52 weeks/year

x (5 days/week)

x (8 hours/days)

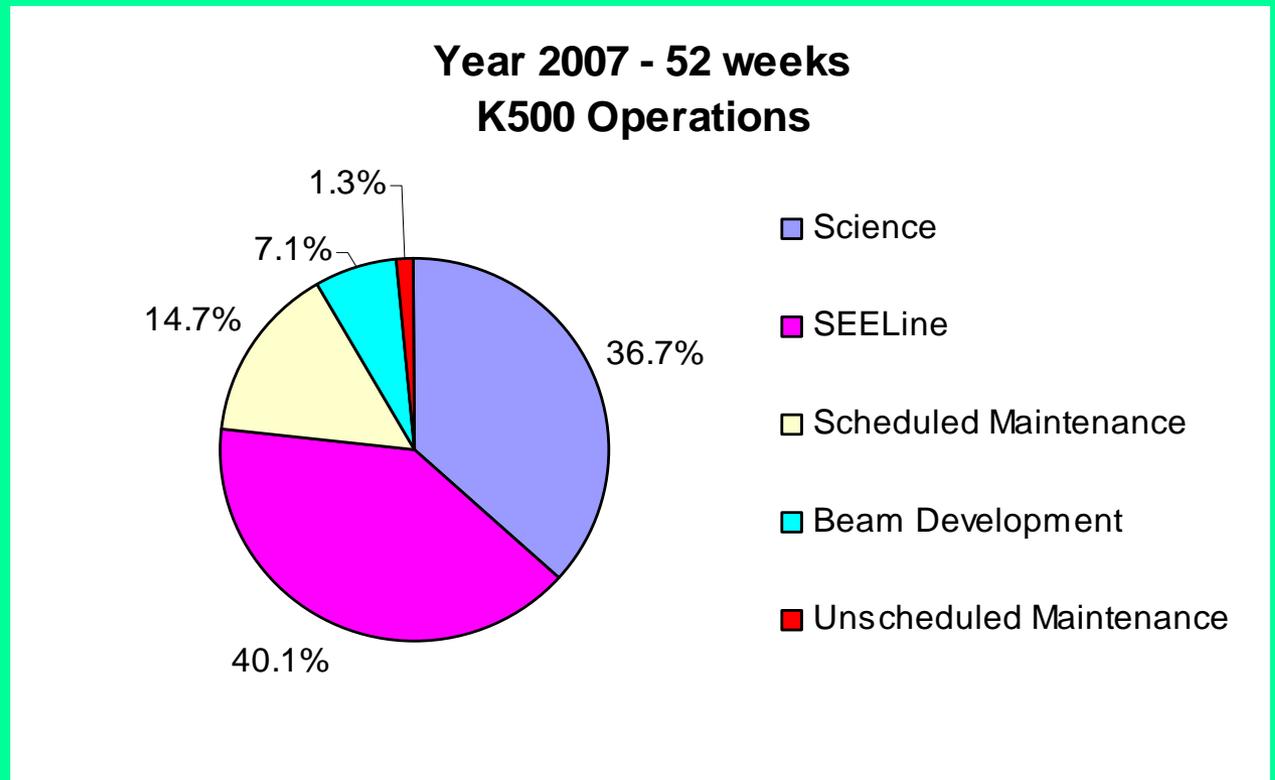
= 2,080 hours (80%)

hours	Monday 6-Feb	Tuesday 7-Feb	Wednesday 8-Feb	Thursday 9-Feb	Friday 10-Feb	Saturday 11-Feb	Sunday 12-Feb
000	Shut Down Maintenance						
0800			NASA JPL SEE Line			SJY-FAUST MDM Line	
1600							
	Monday 13-Feb	Tuesday 14-Feb	Wednesday 15-Feb	Thursday 16-Feb	Friday 17-Feb	Saturday 18-Feb	Sunday 19-Feb
000							
0800							NASA GSFC SEE Line
1600							
	Monday 20-Feb	Tuesday 21-Feb	Wednesday 22-Feb	Thursday 23-Feb	Friday 24-Feb	Saturday 25-Feb	Sunday 26-Feb
000							
0800				NASA JSC SEE Line			
1600				NASA JPL SEE Line			Lock Mart SEE Line
	Monday 27-Feb	Tuesday 28-Feb	Wednesday 1-Mar	Thursday 2-Mar	Friday 3-Mar	Saturday 4-Mar	Sunday 5-Mar
000							
0800	SJY NIMROD			Aeroflex SEE Line			
1600		Raytheon SEE Line	Lock Mart SEE Line	NAVSEA SEE Line			
	Monday 6-Mar	Tuesday 7-Mar	Wednesday 8-Mar	Thursday 9-Mar	Friday 10-Mar	Saturday 11-Mar	Sunday 12-Mar
000							
0800					RET-Catania MDM Line		
1600	Maintenance		NAVSEA SEE Line				
	Monday 13-Mar	Tuesday 14-Mar	Wednesday 15-Mar	Thursday 16-Mar	Friday 17-Mar	Saturday 18-Mar	Sunday 19-Mar
000							
0800					RET MARS Line		
1600							
	Monday 20-Mar	Tuesday 21-Mar	Wednesday 22-Mar	Thursday 23-Mar	Friday 24-Mar	Saturday 25-Mar	Sunday 26-Mar
000							Beam Development
0800	Boeing Sat Sys SEE Line			Intern Rect SEE Line			SJY NIMROD
1600					BAE Systems SEE Line		
	Monday 27-Mar	Tuesday 28-Mar	Wednesday 29-Mar	Thursday 30-Mar	Friday 31-Mar	Saturday 1-Apr	Sunday 2-Apr
000						Beam Development	Beam Development
0800	Boeing Sat Sys SEE Line				PVAMU SEE Line	NASA JSC SEE Line	
1600		Raytheon SEE Line	Lock Mart SEE Line	Beam Development			

Year 2007 K500 Analysis

52 Weeks

	Total Hours	% Total
Science	3,208	37%
SEELine	3,500	40%
Scheduled Maintenance	1,288	15%
Beam Development	624	7%
Unscheduled Maintenance	116	1%
	8,736	100%



Accelerator Physics SEE Line Group

Don May / George Kim

Greg Chubarian / Gabriel Tabacaru

Vladimir Horvat,

Joe Brinkley and Bruce Hyman

All have MS or PhD
degrees in Physics

More Information

Nuclear Radiation Effects

Conference (NSREC)

www.nsrec.org