Single Event Effect Microchip Testing

at the Texas A&M University Cyclotron Institute

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and

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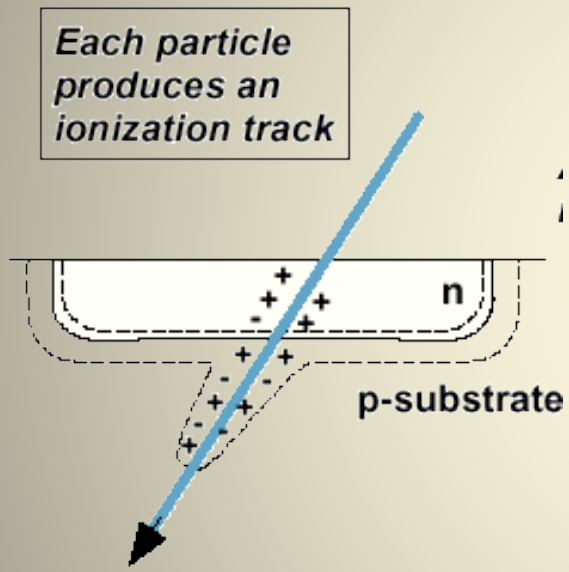
http://cyclotron.tamu.edu/ref/

Some definitions

- A single event upset (SEU) is a change of state caused by one single ionizing particle (ions, electrons, photons...) striking a sensitive node in a micro-electronic device.
- Soft errors are non-destructive and normally appear as transient pulses in logic or support circuitry, or as bit flips in memory cells or registers.
- Hard errors usually result in a high operating current, above device specifications, and must be cleared by a power reset. Burnout errors are so destructive that the device becomes operationally dead.

Example of Hard Error

- Gate rupture of MOSFET device.



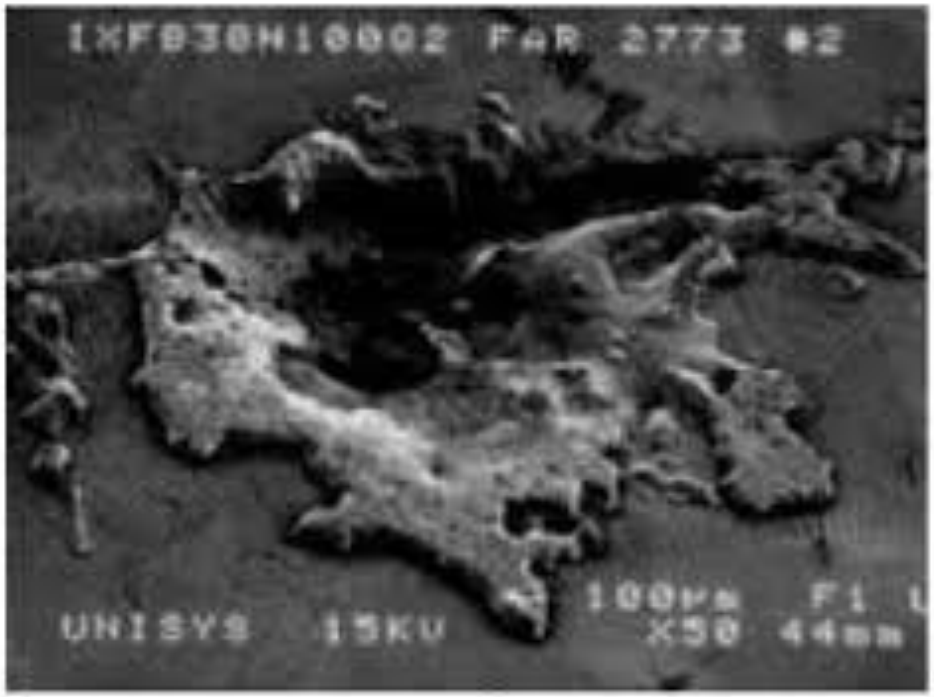
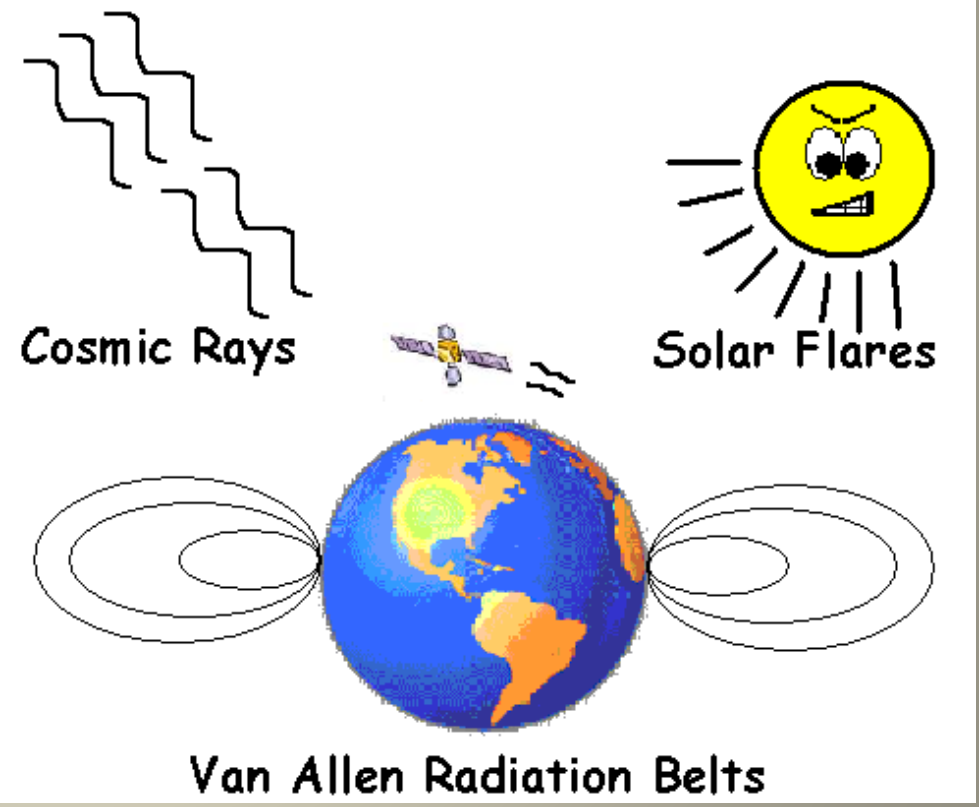


Figure 2: SEM image of failed MOSFET chip

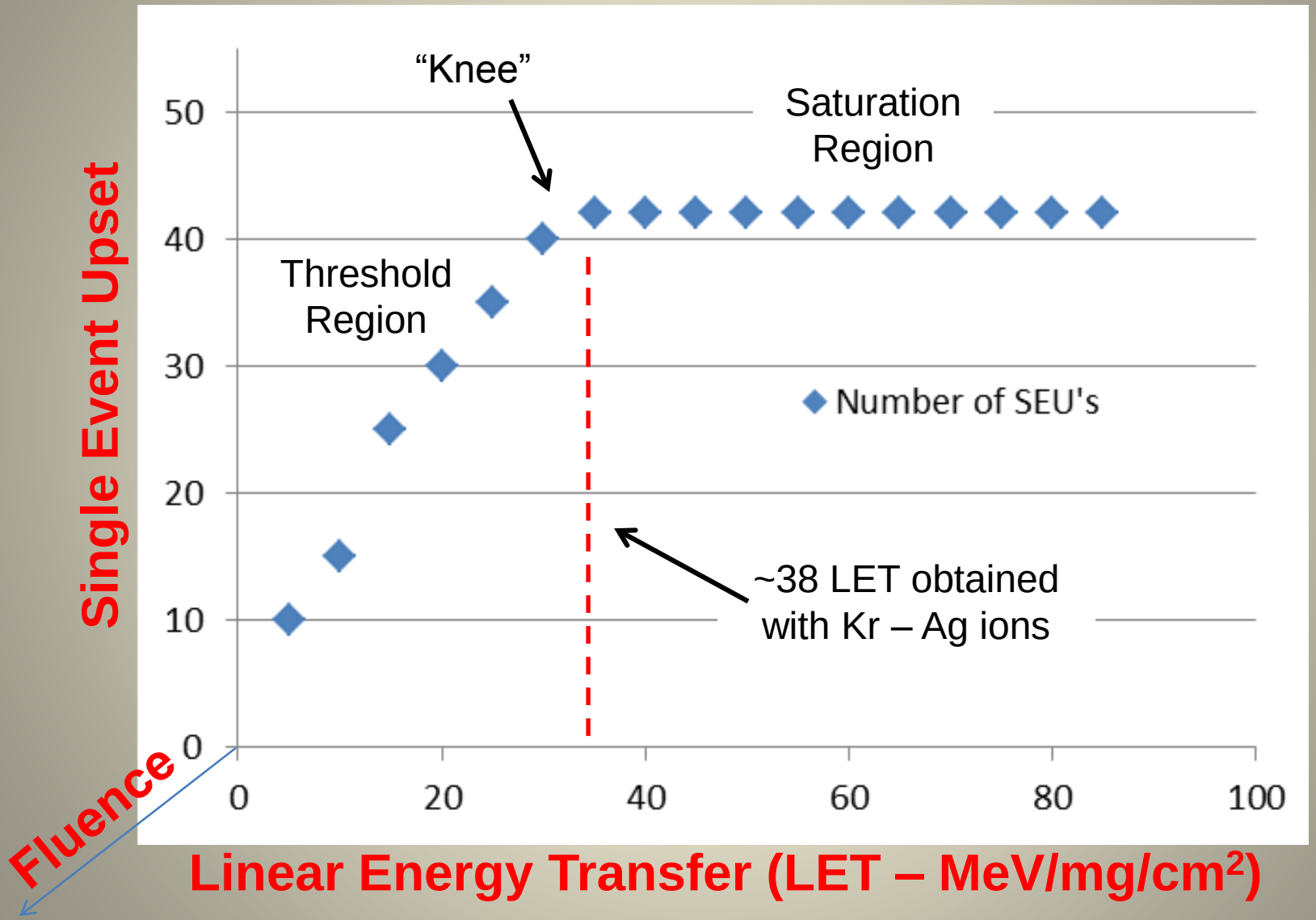
- Re-routes the flow of electrons of the device – causing charge and voltage changes

Space Radiation Effects:

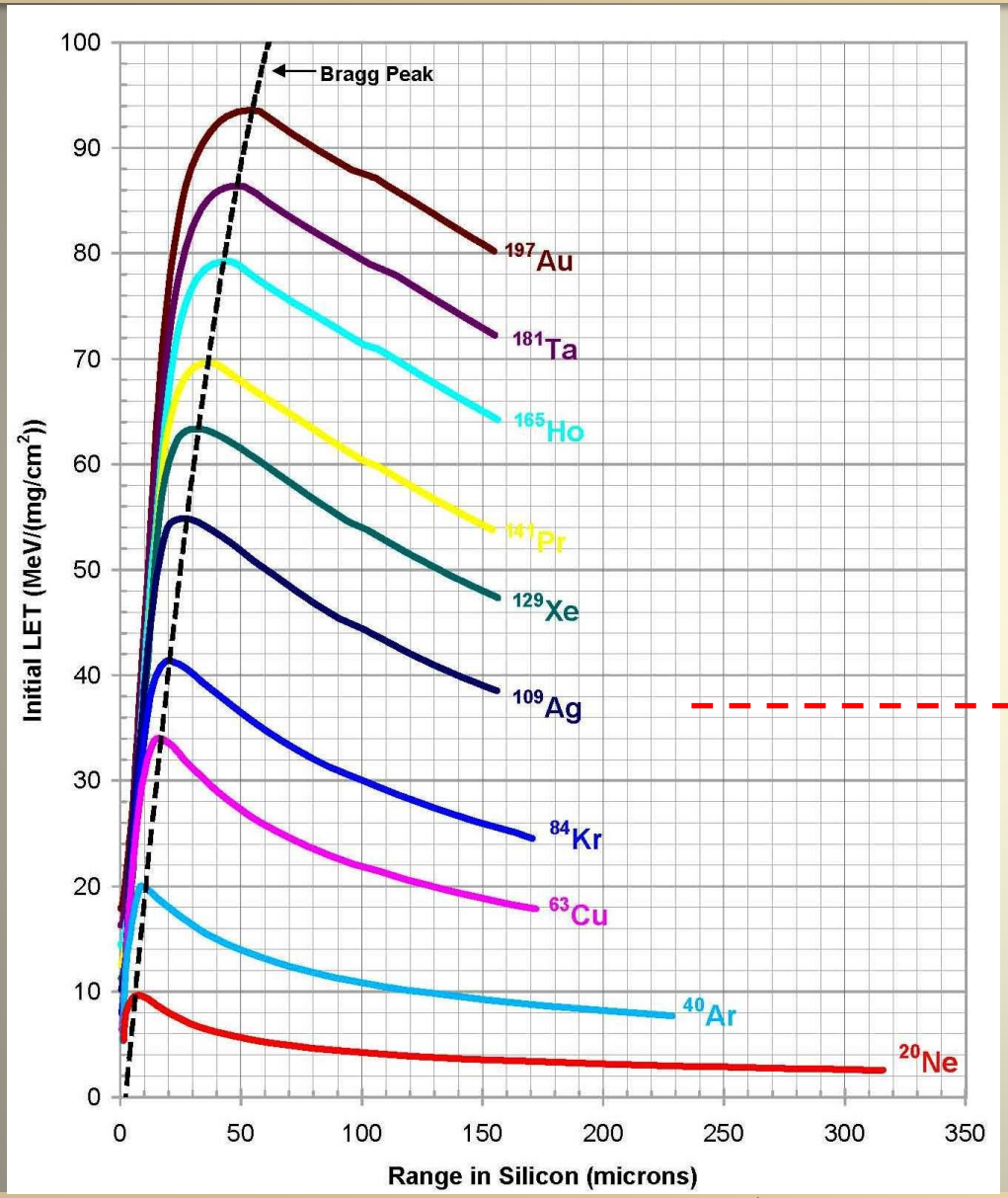
- Aerospace computer equipment receives radiation from cosmic rays, solar flares and the Earth's Van Allen radiation Belts - **causing SEUs**.
- Engineers must test the resilience of their computer chips in accelerated beams here on Earth to simulate the effects that will happen in space.



Typical SEU "Soft Error" Cross Section



LET vs Range in Silicon 15 MeV/u ions

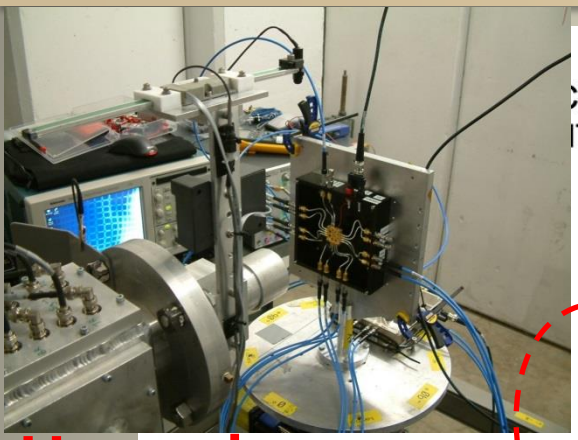


Saturation Region

"Knee"

Threshold Region

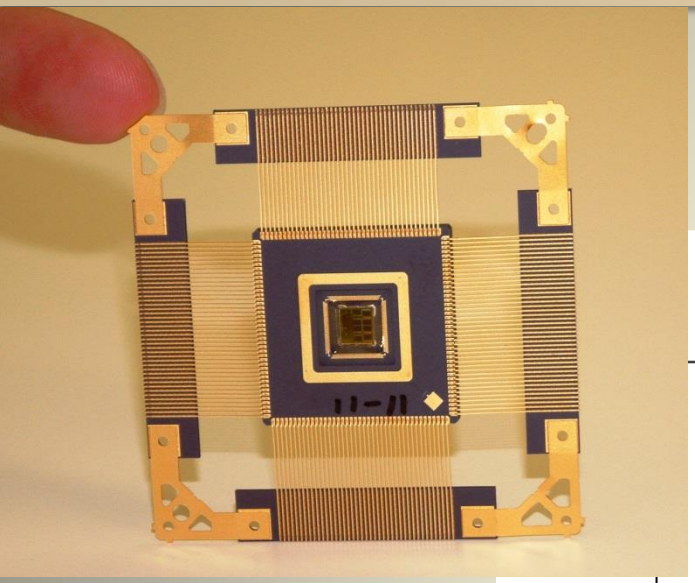
Two SEU Testing Stations at Texas A&M



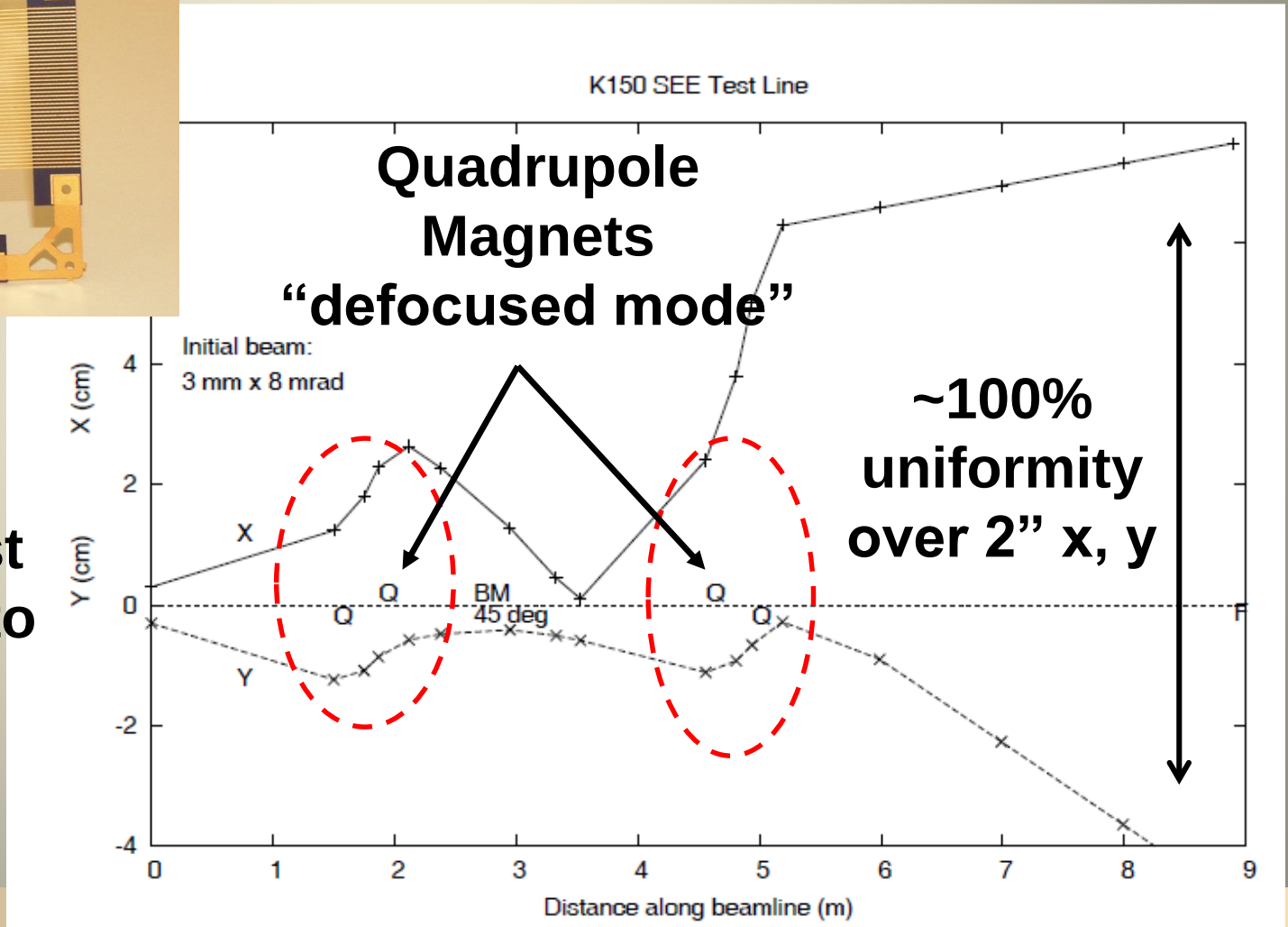
Heavy ions – K500 Cyclotron

Protons – K150 Cyclotron

Large & Uniform Beam Spot Technique



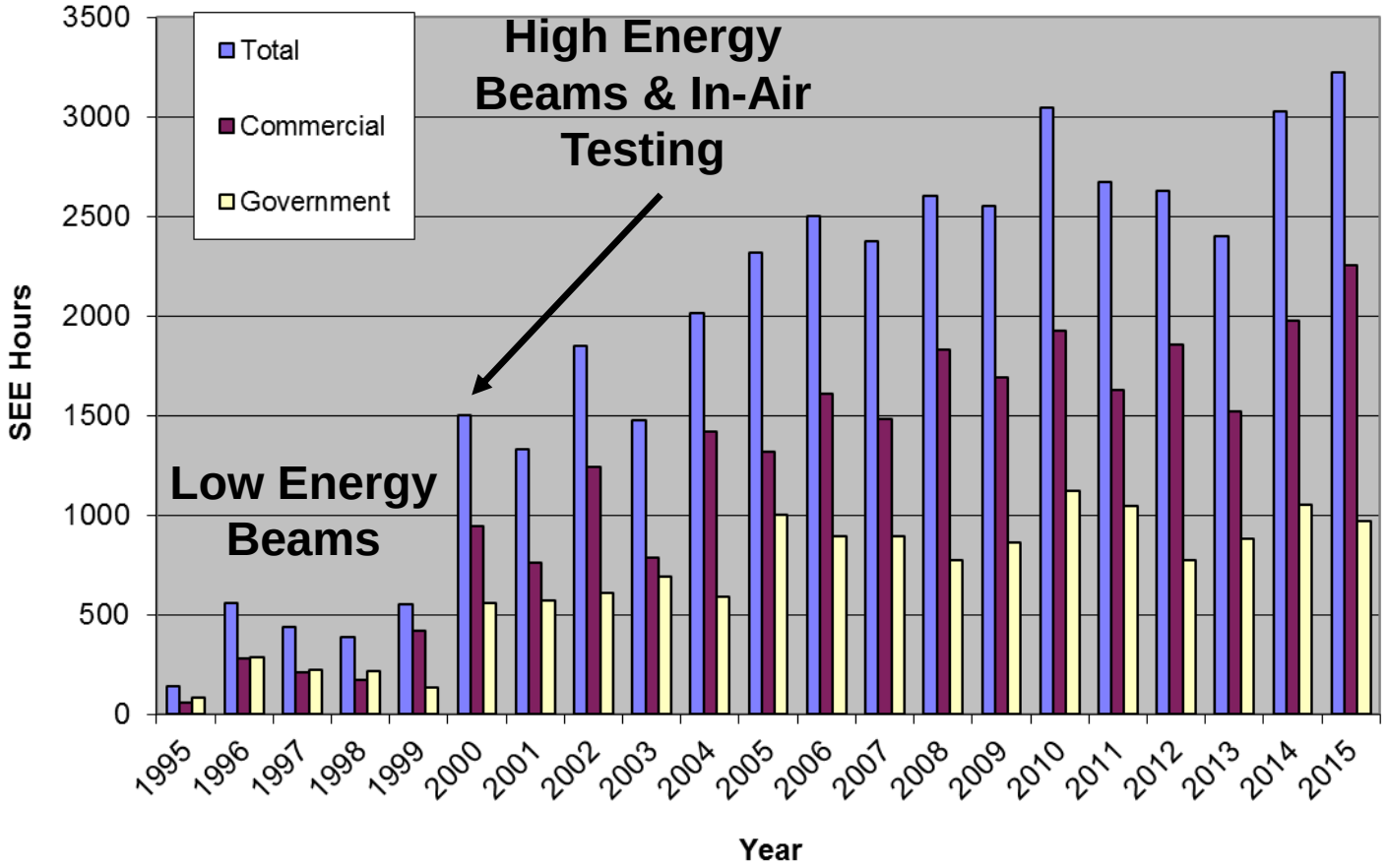
Beam spot (intensity) must be uniform up to 3” diameter



History of SEU Testing at Texas A&M

- **Began in 1995 with 10 MeV/u heavy ions, but with a limited list of beams**
- **Added high energy series (15, 25, 40 & 55 MeV/u) over years 1997-2005 (15 MeV/u is offered from ^{4}He to ^{197}Au)**
- **Offered "in-air" testing in year 2000 - usage hours increased from ~500/yr to ~2500/yr**
- **Usage hours have remained steady at ~2500 hours since year 2006**
- **Usage by 1/3 Government/University and 2/3 Commercial agencies has remained consistent**
- **Usage by international agencies continues to increase (France, Japan, Italy, Korea, Singapore, Canada)**
- **In 2015, added K150 proton testing beam line (30 – 50 MeV)**

SEU Testing Hours at Texas A&M



Single Event Upset Testing Agencies…

Actel Corporation
Aeroflex Corporation
Aerospace Corporation
Air Force
AMTEC Corporation
ASTRUM - France
ATK Mission Research
BAE Systems
Ball Aerospace
Boeing Corporation
Boeing Research & Technology
Boeing Satellite Systems
Broadcom Communications
CAMBR / University of Idaho
CEA - France
Cisco Systems
Data Device Corporation
Full Circle Research
General Dynamics
Georgia Tech University
Harris Semiconductor
HIREX - France
Honeywell
Hughes Space Communications
IBM Corporation
ICS Radiation
Innovative Concepts, Incorporated
Intel Corporation
International Rectifier
Intersil Corporation
ITT Aerospace
ITT Communications
JD Instruments
Johns Hopkins
Lockheed Martin
Los Alamos National Laboratory
Makel Engineering
Maxwell Engineering
McDonnell-Douglas
MD Robotics
MDA Corporation
Michigan State University-NSCL
Micro RDC
MicroSemi Corporation
Mitsubishi Heavy Industries
Motorola Corporation
NASA Goddard Space Flight Center
NASA Jet Propulsion Laboratory
NASA Johnson Space Center
NASA-Goddard Space Flight Center
National Semiconductor
Naval Research Laboratory
Naval Surface Warfare Center
Northrop Grumman
Novous Technologies
OptiComp Corporation
Peregrine Semiconductor
Prairie View A&M Center For Applied Radiation Research
Radiation Assured Devices
Raytheon Corporation
SAIC
Sandia National Laboratory
Save Incorporated
SEAKR Engineering
Silicon Space Technologies
Silicon Turnkey Solutions
SOREQ - Israel
Southwest Research Institute
Stapor Research
Star Vision
Sun Tronics
Texas Instruments
Thales Alenia-France
TRAD-France
United Space Alliance
University of Colorado
University of Idaho
University of Texas - El Paso
Vanderbilt University
VPT Incorporated
White Sands Army Research Laboratory
Xilinx Corporation

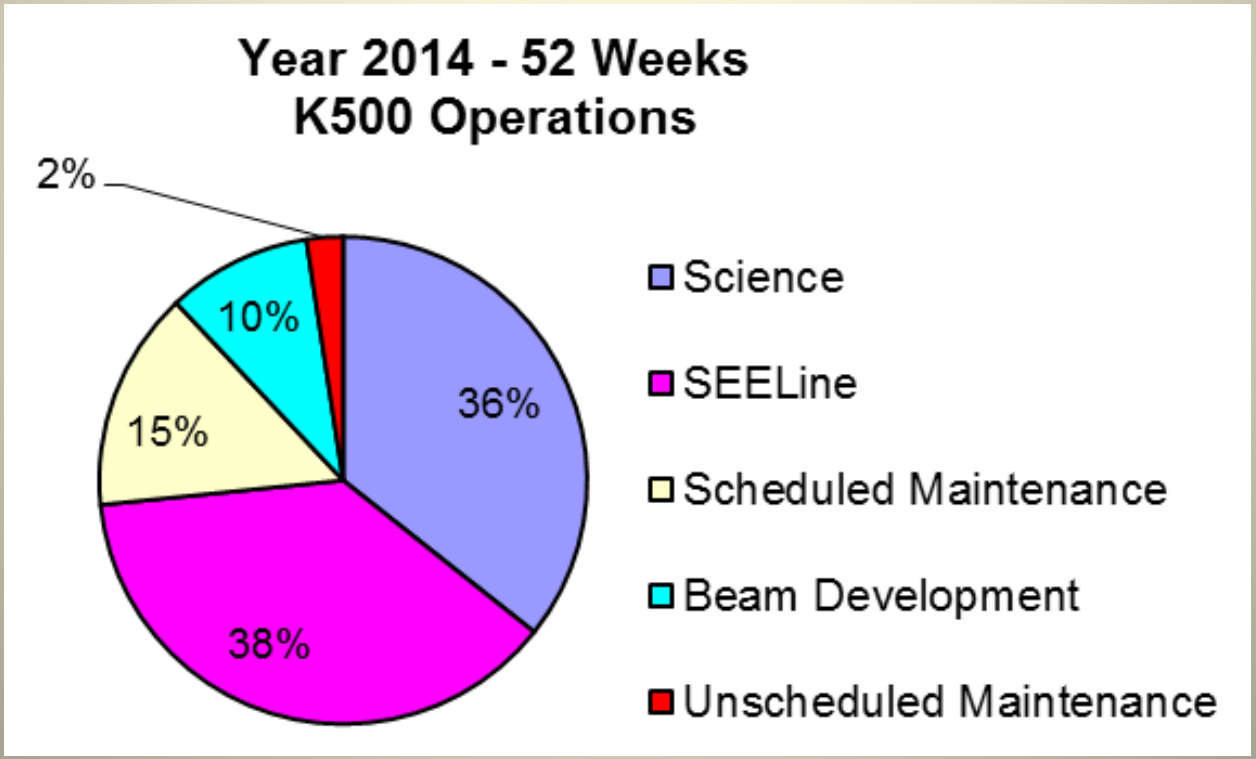
K500 Operational Hours – Year 2014

52 weeks

	Total Hours	% Total
Science	3,117.00	36%
SEELine	3,295.00	38%
Scheduled Maintenance	1,275.00	15%
Beam Development	838.00	10%
Unscheduled Maintenance	211.00	2%
	8,736.00	100.0%

Annual K500 Operation:
February – December

Scheduled Maintenance:
January



Typical Beam Schedule:

		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
		12-Sep-16 D-LF N-JJ	**13-Sep-16** D-LF N-JJ	**14-Sep-16** D-LF N-JJ	**15-Sep-16** D-JP N-JJ	**16-Sep-16** D-JP N-LF	**17-Sep-16** D-JP N-LF	**18-Sep-16** D-JP N-LF
0000	K500	IRCOS Cont.	↓	↓	↓	Beam Development	Beam Development	Beam Development
0800	K500	Innoflight SEE Beams	Innoflight SEE Beams	Beam Development	Boeing SEE Beams	Texas Instruments SEE Beams	Boeing SEE Beams	Ryoei SEE Beams
1600	K500	SEAKR SEE Beams	Boeing SEE Beams	SEAKR SEE Beams	↓	↓	↓	↓
0000	K150	LIG Cont.	↓	↓	↓	↓	↓	↓
0800	K150	↓	↓	↓	ECR/Cyclotorn Conditioning	Rogachev 8 MeV/u ^{10}B	↓	↓
1600	K150	↓	↓	↓	↓	↓	↓	↓
		19-Sep-16 D-JJ N-JC	**20-Sep-16** D-JJ N-JC	**21-Sep-16** D-JJ N-JC	**22-Sep-16** D-LF N-JC	**23-Sep-16** D-LF N-JJ	**24-Sep-16** D-LF N-JJ	**25-Sep-16** D-LF N-JJ
0000	K500	Ryoei Cont.	NASA JPL SEE Beams	NASA JPL SEE Beams	↓	↓	↓	↓
0800	K500	↓	Int. Rectifier SEE Beams	Ryoei SEE Beams	↓	NASA GSFC SEE Beams	↓	NASA GSFC SEE Beams
1600	K500	↓	↓	↓	Air Force SEE Beams	↓	Air Force SEE Beams	↓
0000	K150	Rogachev Cont.	↓	↓	↓	↓	↓	↓
0800	K150	ECR/Cyclotorn Conditioning	Light Ion Guide 15 MeV H-	↓	↓	↓	↓	↓
1600	K150	↓	↓	↓	↓	↓	↓	↓
		26-Sep-16 D-JC N-JP	**27-Sep-16** D-JC N-JP	**28-Sep-16** D-JC N-JP	**29-Sep-16** D-JJ N-JP	**30-Sep-16** D-JJ N-JC	**1-Oct-16** D-JJ N-JC	**2-Oct-16** D-JJ N-JC
0000	K500	NASA GSFC Cont.	↓	↓	↓	↓	↓	↓
0800	K500	Honeywell SEE Beams	NASA GSFC SEE Beams	↓	↓	↓	↓	↓
1600	K500	↓	↓	↓ Lockheed Martin	↓ Beam Dev.	↓	↓	↓
0000	K150	LIG Cont.	↓	↓	↓	↓	↓	↓
0800	K150	↓	↓	↓	↓	↓	↓	↓
1600	K150	↓	↓	↓	↓	↓	↓	↓

- 1 – 2 weeks SEU Testing (yellow)
- 1 – 2 weeks of Science Experiments (all other colors)
- Schedule 6 – 8 weeks in advance

Visit our website at

http://cyclotron.tamu.edu/ref/

Questions, contracting, scheduling contact Henry Clark at

clark@comp.tamu.edu