K150 Cyclotron Beam Development & MS Physics in Radiation Effects

at the Texas A&M University Cyclotron Institute

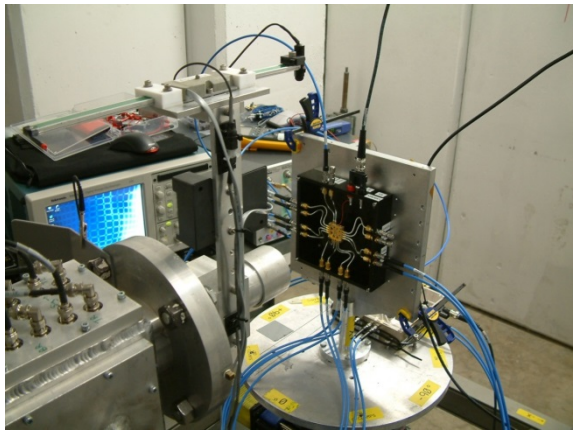
Henry L Clark, PhD

Accelerator Physicist / Project Manager

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

1967 - 2017 50 YEARS OF BEAM exploring the nuclear frontier

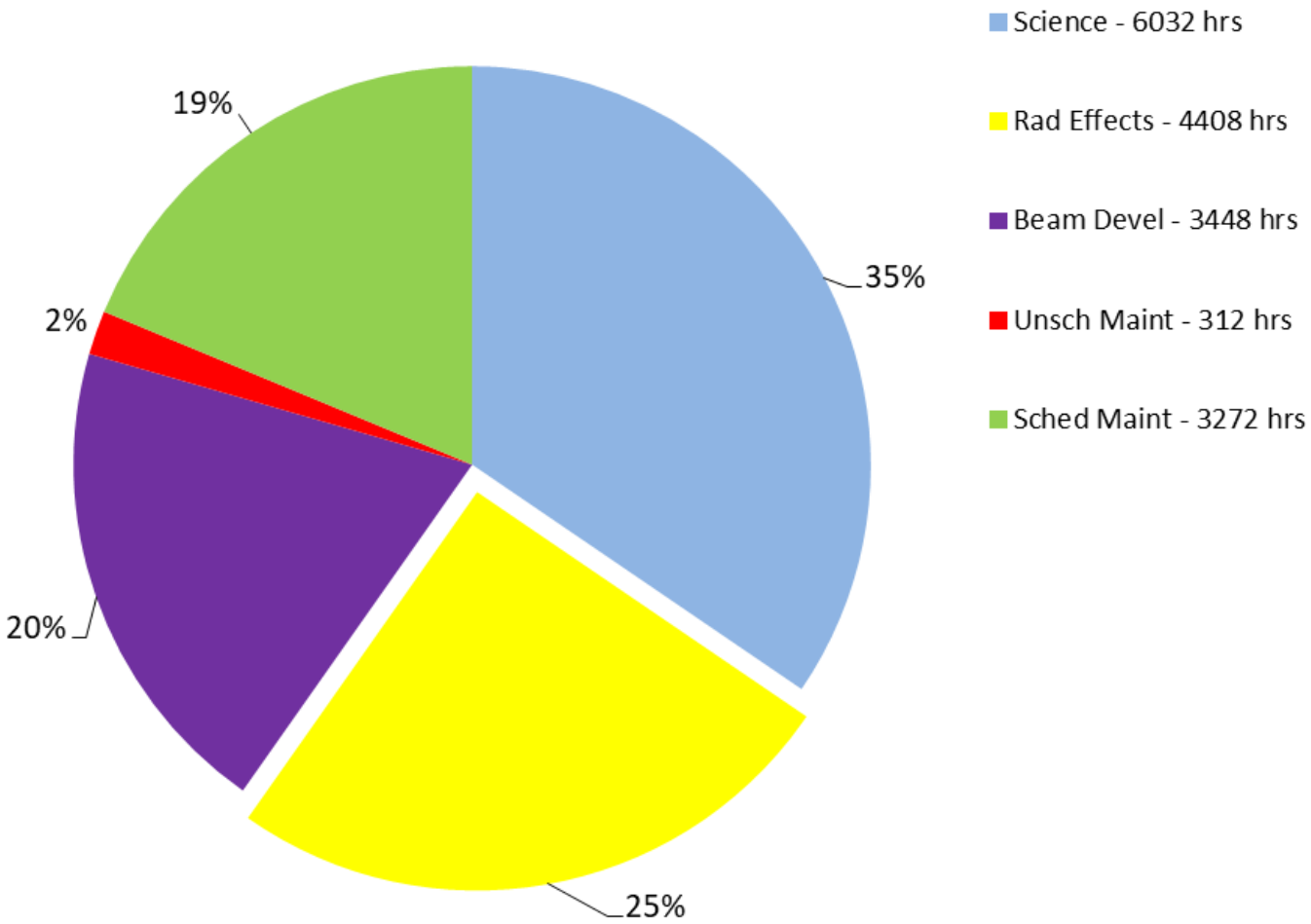
TEXAS A&M UNIVERSITY



Heavy ions – K500 Cyclotron

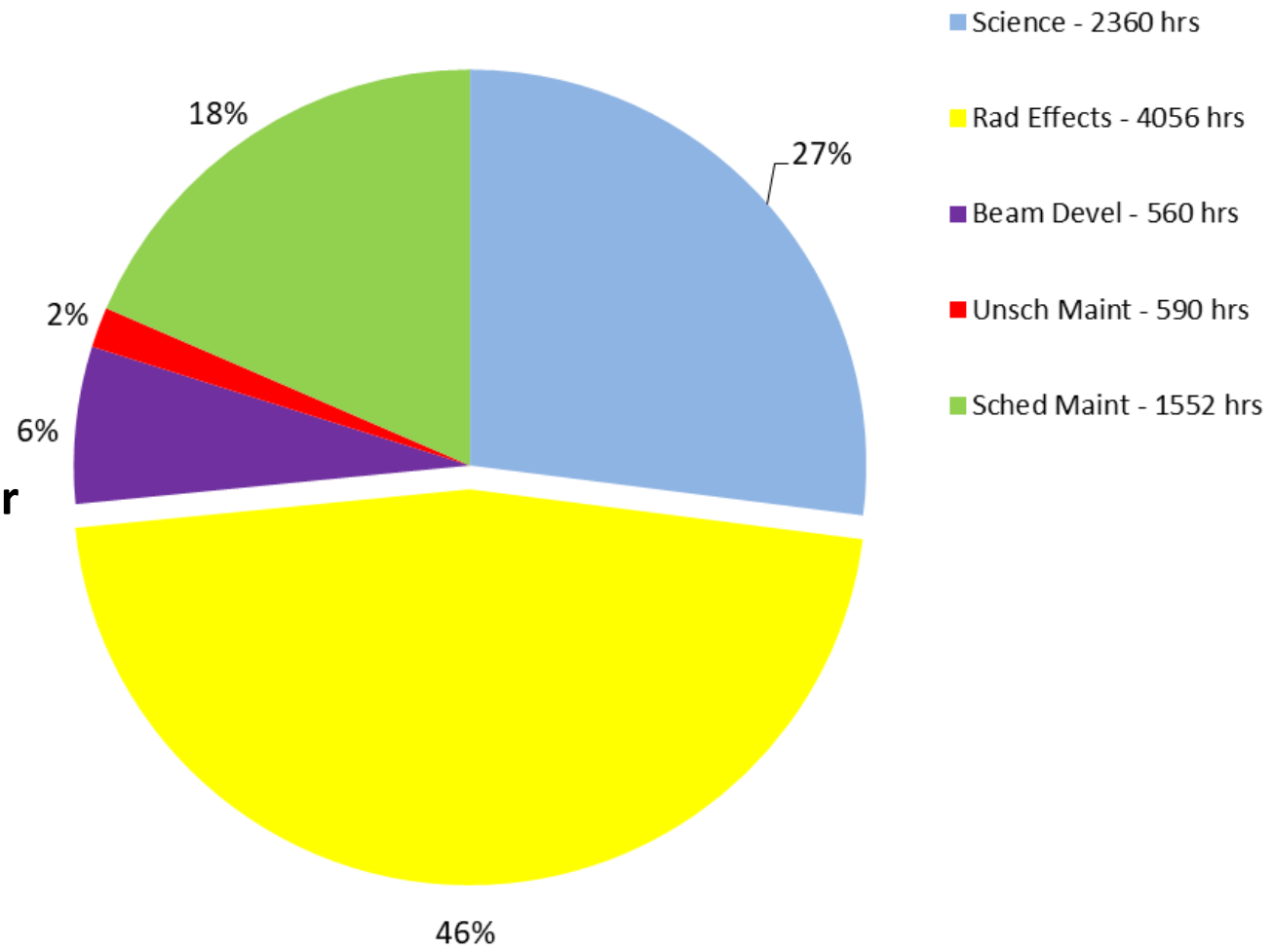
Protons & Heavy ions (new) – K150 Cyclotron

Year 2019
K500 + K150 Operational Hours
(8,736 hrs/cyclotron x 2 cyclotron = 17,472 hrs)

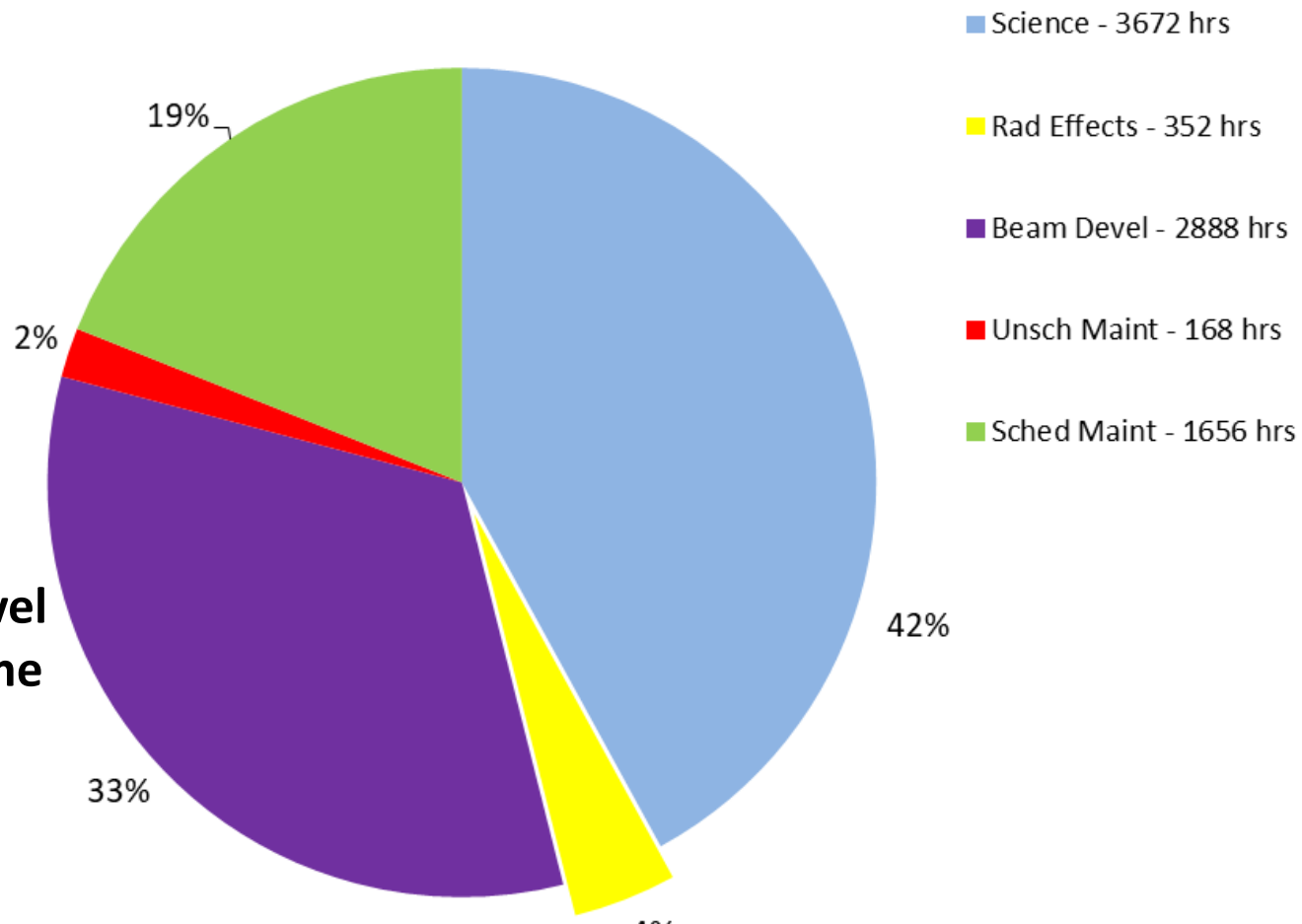


Year 2019
K500 Operational Hours
(8,736 hrs/year)

ECR Ion Source Change Over



Year 2019
K150 Operational Hours
(8,736 hrs/year)



½ Beam Devel & ½ Idle Time

Protons (E = 1 – 45 MeV)

1967 - 2017 50 YEARS OF BEAM exploring the nuclear frontier

TEXAS A&M UNIVERSITY

K500 Beam List

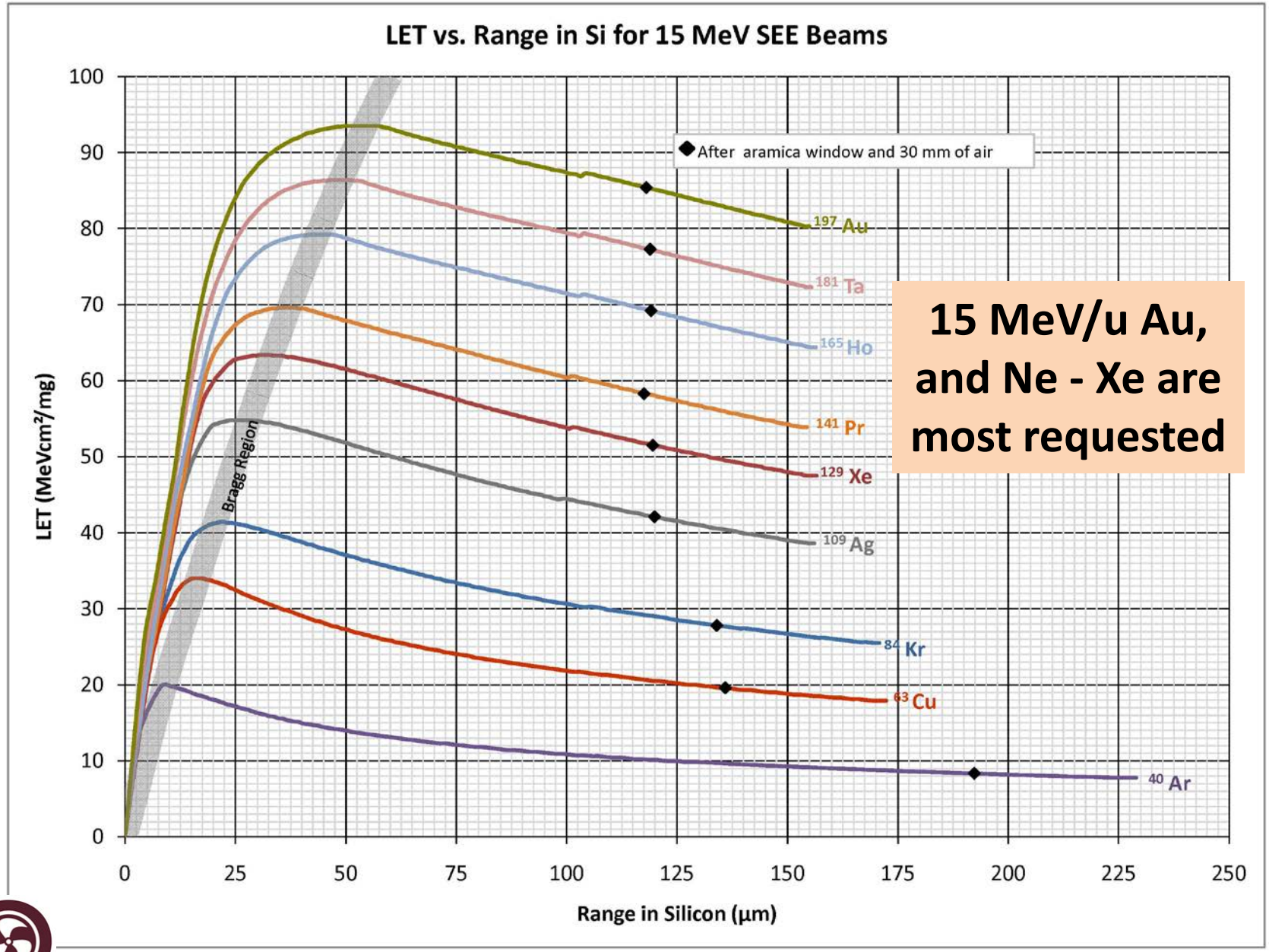
95% - 15 MeV/u ions

4% - 25 MeV/u ions

1% - 40 MeV/u ions

	Ion	Mass (amu)	A MeV	Total Energy (MeV)	Energy at Bragg Peak (MeV)	Range in Si (μm)	Range at Bragg (μm)	Range to Bragg Peak (μm)	Initial LET (vacuum)	Initial LET (air)	LET at Bragg Peak
15 A MeV	^{4}He	4.003	15	60	0.4	1423	2	1421	0.11	0.11	1.5
	^{14}N	14.003	15	210	7	428	7	421	1.3	1.3	6.7
	^{20}Ne	19.992	15	300	14	316	8	308	2.5	2.6	9.6
	^{40}Ar	39.962	15	599	29	229	9	220	7.7	8.0	20.1
	^{63}Cu	62.930	15	944	90	172	16	156	17.8	18.7	34.0
	^{84}Kr	83.912	15	1259	152	170	21	149	25.4	26.6	41.4
	^{109}Ag	108.905	15	1634	248	156	26	130	38.5	40.3	54.8
	^{129}Xe	128.905	15	1934	339	156	31	124	47.3	49.3	63.4
	^{141}Pr	140.908	15	2114	441	154	37	117	53.8	56.0	69.6
	^{165}Ho	164.930	15	2474	608	156	44	112	64.3	66.7	79.2
	^{181}Ta	180.948	15	2714	702	155	46	109	72.2	74.8	86.4
	^{197}Au	196.967	15	2954	902	155	53	102	80.2	82.8	93.5
25 A MeV	^{4}He	4.003	24.8	99	0.4	3449	2	3447	0.07	0.07	1.5
	^{14}N	14.003	24.8	347	7	1009	7	1002	0.9	0.9	6.7
	^{22}Ne	21.991	24.8	545	14	799	8	791	1.7	1.8	9.7
	^{40}Ar	39.962	24.8	991	29	493	9	484	5.4	5.5	20.1
	^{84}Kr	83.912	24.8	2081	152	332	21	311	19.3	19.8	41.4
	^{107}Ag	106.905	24.8	2651	246	287	26	260	30.3	31.1	54.8
	^{129}Xe	128.905	24.8	3197	335	286	31	255	37.9	38.9	63.4
40 A MeV	^{14}N	14.003	40	560	7	2334	7	2327	0.6	0.6	6.7
	^{20}Ne	19.992	40	800	14	1655	8	1647	1.2	1.2	9.7
	^{40}Ar	39.962	40	1598	29	1079	9	1070	3.8	3.8	20.1
	^{78}Kr	77.920	40	3117	140	622	20	602	14.2	14.4	41.4

K500 Beams



15 MeV/u Au, and Ne - Xe are most requested

1967 - 2017 50 YEARS OF BEAM exploring the nuclear frontier

TEXAS A&M UNIVERSITY

K150 Beams

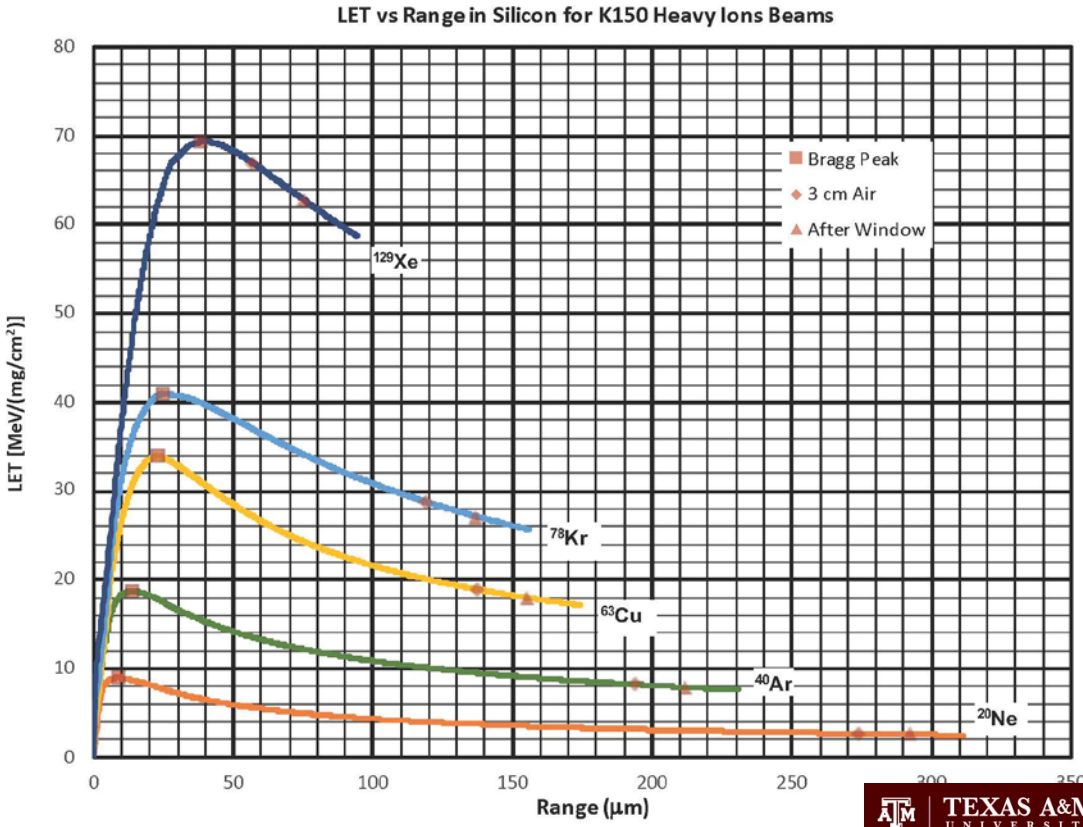
Ion	Mass (amu)	A MeV	Total Energy (MeV)	Range in Si (μm)	Range to Bragg Peak (μm)	Initial LET (vac)	Initial LET (air)	LET at Bragg Peak
^{20}Ne	19.992	15	300	311	302	2.5	2.6	9.0
^{40}Ar	39.962	15	599	231	217	7.6	7.9	18.7
^{63}Cu	62.930	15	944	174	151	17.1	18.0	34.0
^{78}Kr	77.920	15	1169	156	135	25.7	27.1	41.0
^{129}Xe	128.905	10	1289	94	55	58.7	62.8	69.3

Protons, He, N also available

First users start today! June 16, 2020

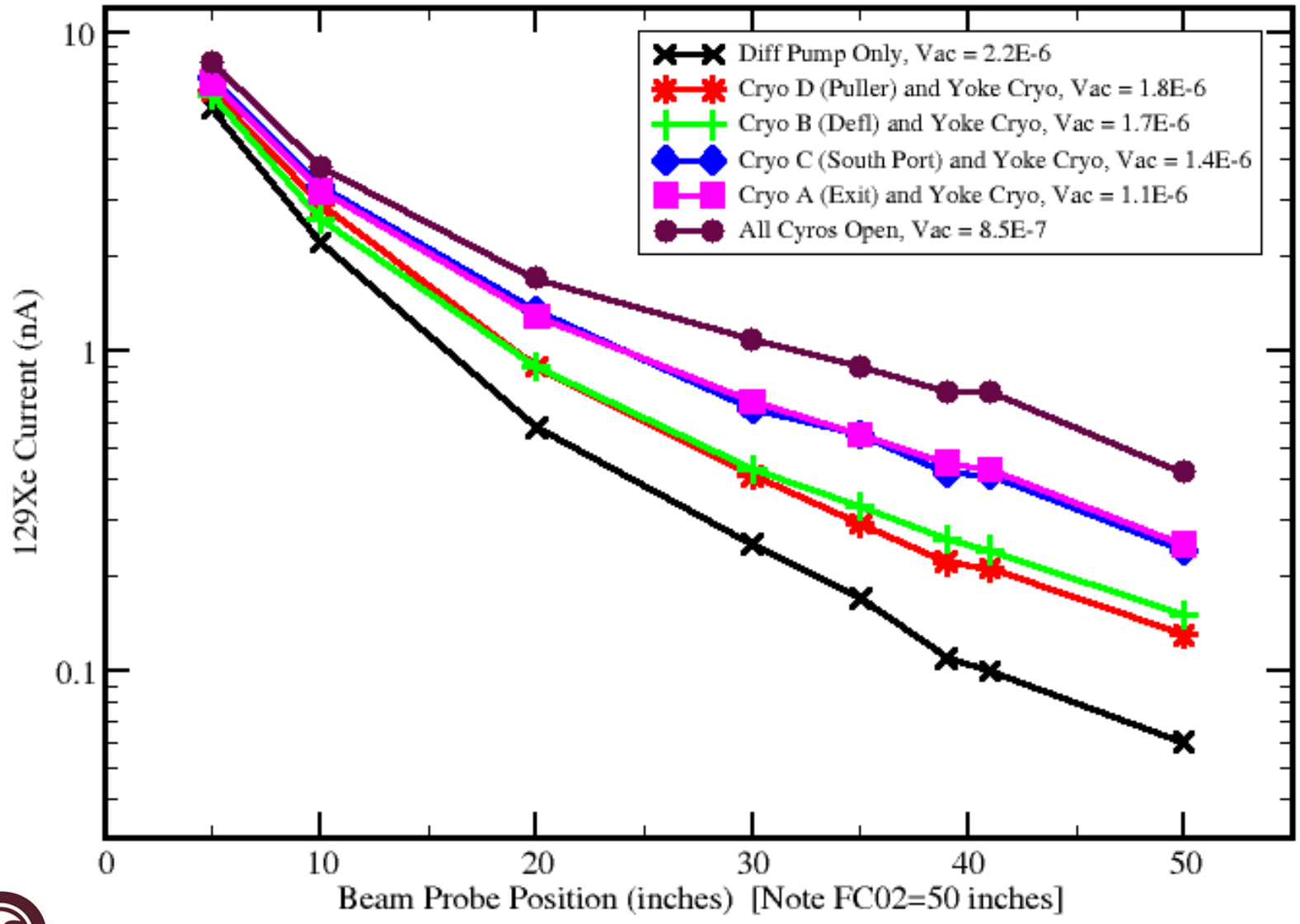
Continued Development:

- Gas system
- Metal ions between Kr & Xe at or above 10 MeV/u
- Xe at 15 MeV/u (requires improved vacuum and ECR performance)

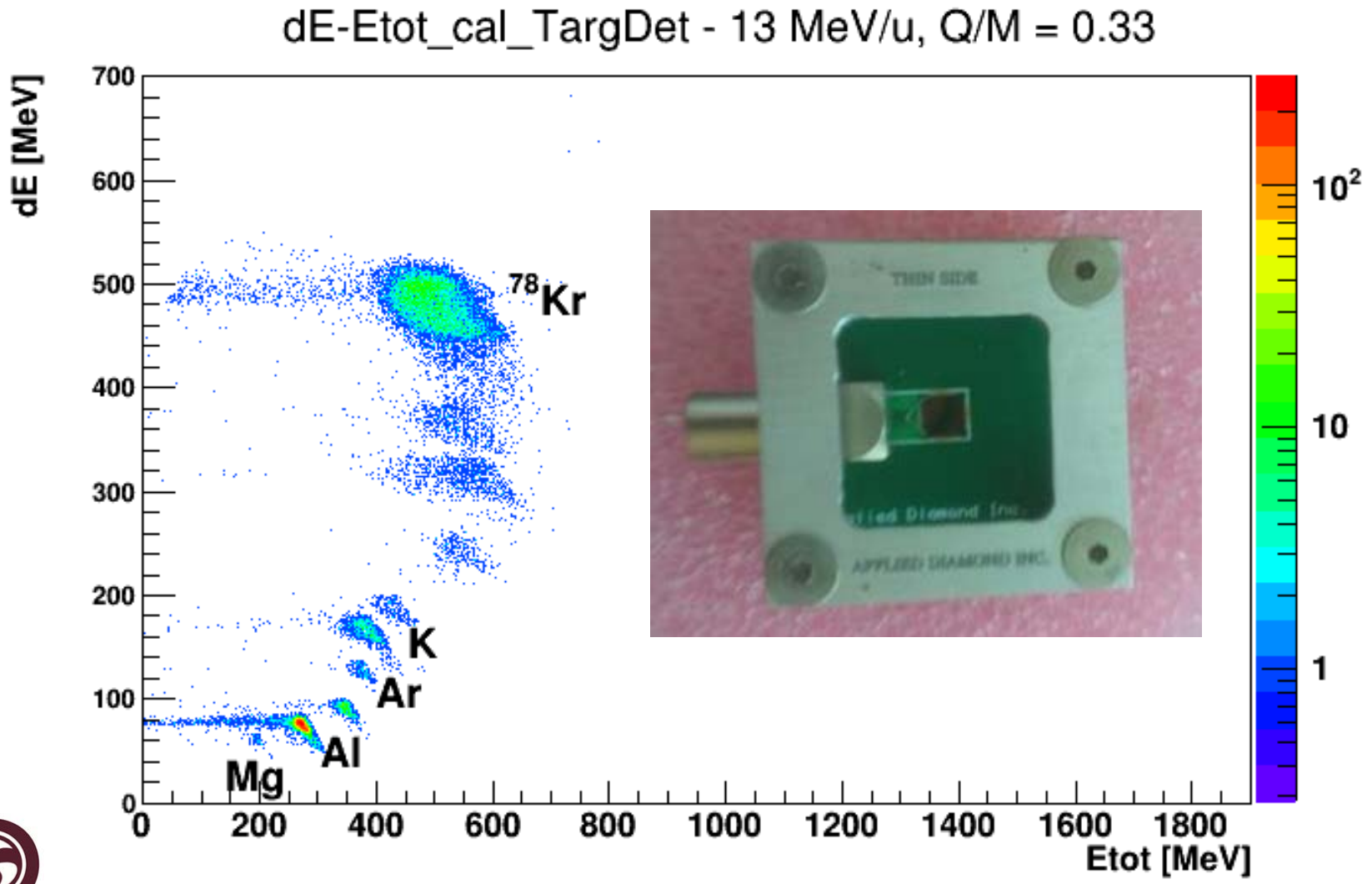


K150 Beam Transmission Test vs. vacuum (5/7/2020)

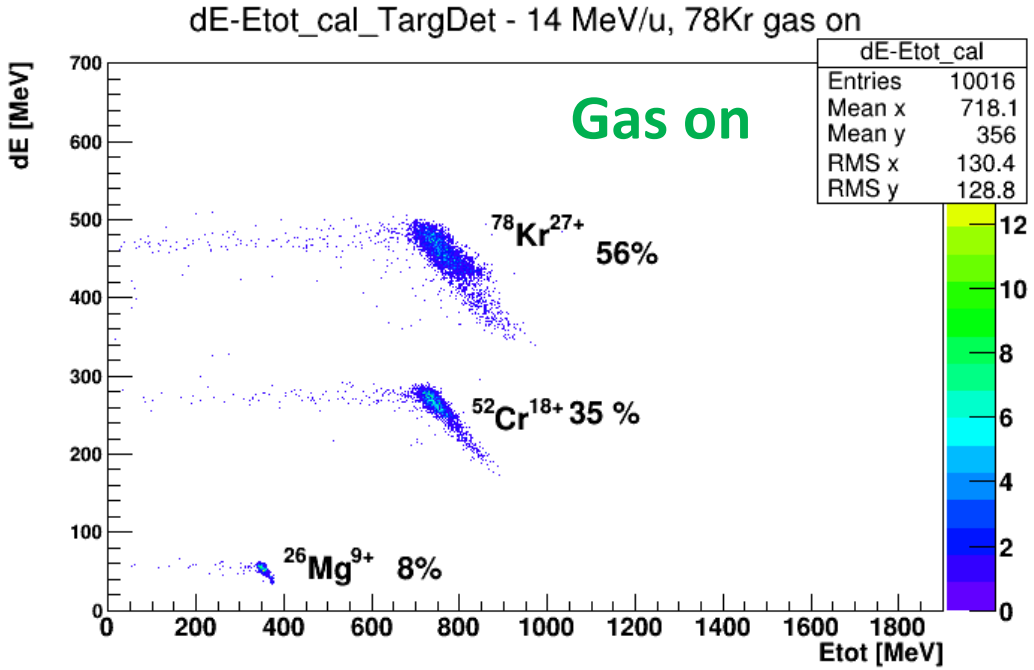
Beam = 129Xe 31+ at 6.3 MeV/u

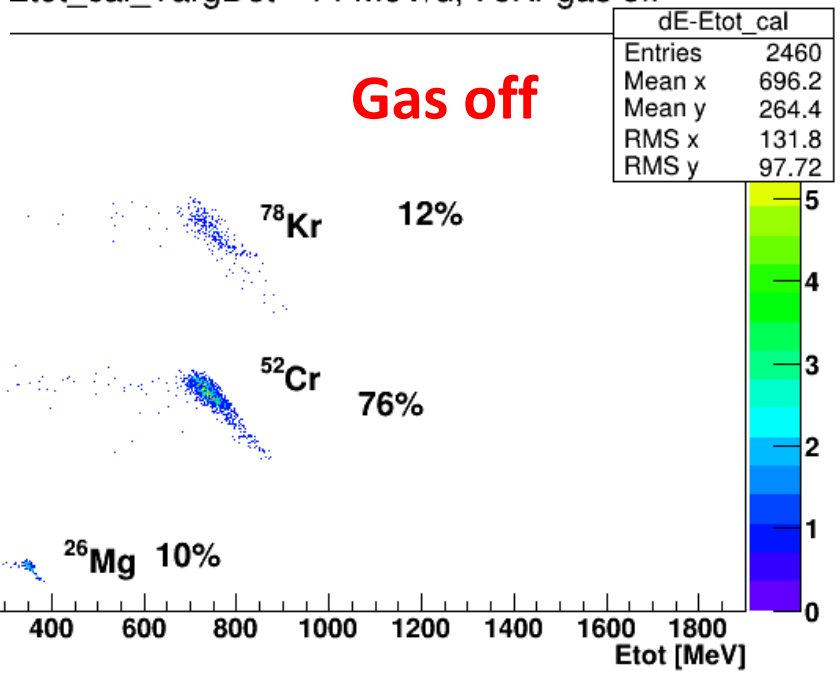


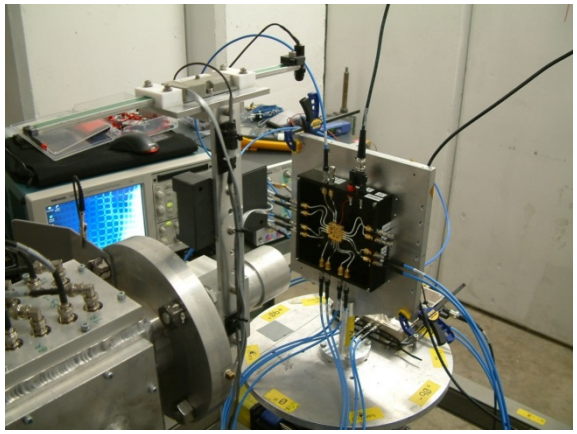
Diamond Detector Development for verifying beam purity



Diamond Detector Development for verifying beam purity







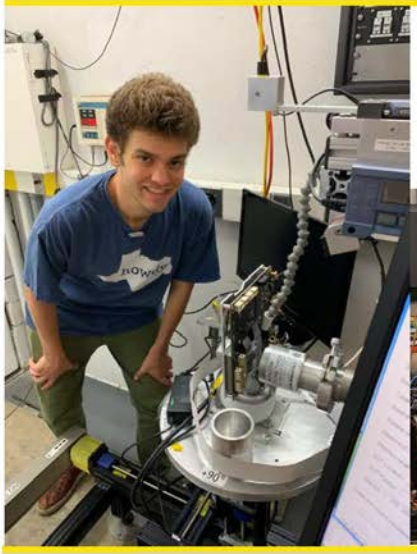
Test Plan Needs: K500, K150 or K500 + K150?

Heavy ions – K500 Cyclotron

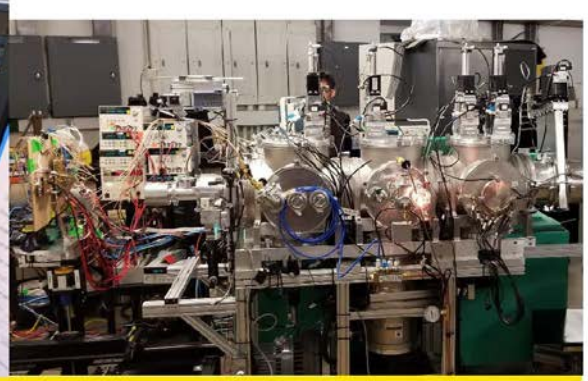
Protons & Heavy ions (new) – K150 Cyclotron

TEXAS A&M UNIVERSITY
Science

Mesmerized by space exploration?



Earn your MS in Physics in Radiation Effects!



Why Study Radiation Effects at Texas A&M University?

With a Physics Masters degree from Texas A&M University specializing in Radiation Effects, you can expect to line up a rewarding job – well before graduation day. Federal government aerospace organizations such as NASA and the Jet Propulsion Laboratory, contractors such as Boeing, Honeywell, Lockheed Martin, and SpaceX, and military services such as the Air Force, Navy, and Space Force are all looking for people with experience and education in Radiation Effects. In addition to space, the autonomous vehicle industry needs people able to build robust terrestrial systems that can tolerate these effects to navigate the millions of vehicles that will soon be in operation across the globe. With their growing workforce needs, organizations like these provide opportunities for Masters students to do internships as an integral component of their career development. Collectively, government agencies and independent companies conduct hundreds of Radiation Effects experiments annually at the Cyclotron Institute. You'll get to rub shoulders with the very people that you may eventually work for!

For Enrollment Information Contact:
Prof. Carl Gagliardi
cggroup@comp.tamu.edu
979-845-1411

Gain in class and hands on experience, from studying topics such as:

PHYS 603 Electromagnetic Theory I
ECEN 714 Digital Integrated Circuit Design
NUEN 604 Radiation Interactions and Shielding

Intern with companies and agencies such as:
Boeing, Space X and NASA

CYCLOTRON INSTITUTE

cyclotron.tamu.edu

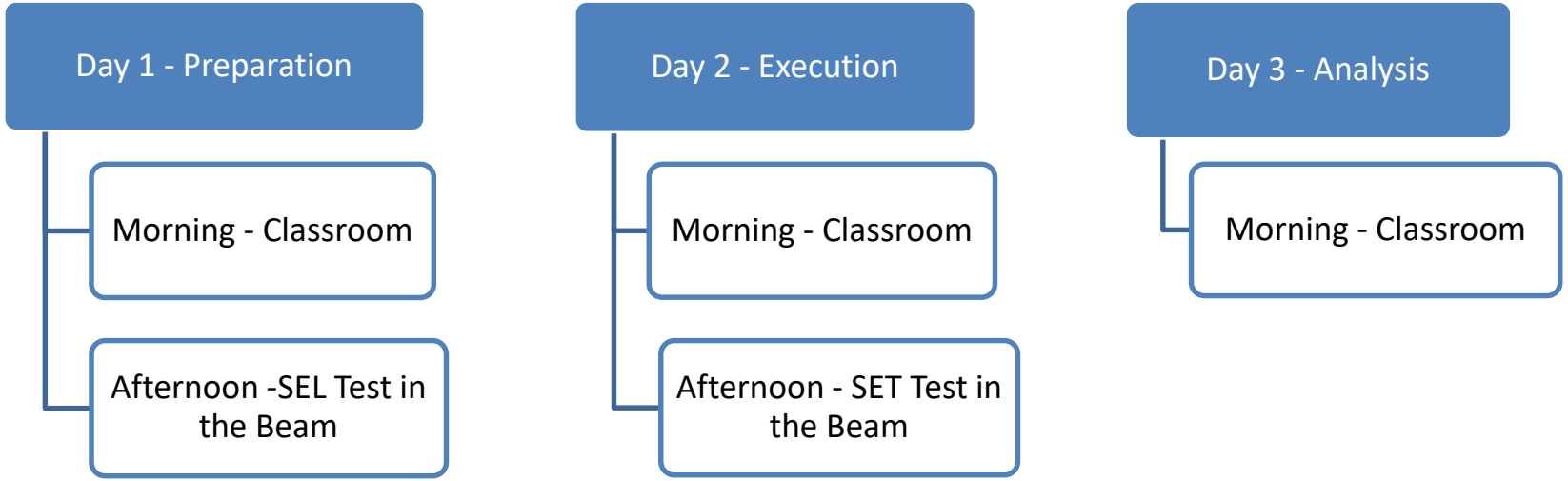
1967 - 2017 50 YEARS OF BEAM exploring the nuclear frontier

TEXAS A&M UNIVERSITY

Fall 2020 - Masters in Radiation Effects at TAMU:

- Two year MS program Physics/Cyclotron Institute:
  - Coursework on relevant Physics/EE/ME topics
  - Lab work training – conduct SEE testing on well known parts (setup, take data, analyze)
  - Masters project – new part type, new technology, new testing procedure….TBD
- Masters Project(s) – collaborative effort with NASA
- Masters Students would graduate with:
  - General knowledge in Radiation Effects
  - Hands on testing/laboratory experience
- Application Deadline – July 17, 2020 for Fall 2020
- **Financial Assistance for US citizens – Tuition, Fees & Stipend**

Spring 2021 – Radiation Effects Bootcamp at TAMU in collaboration with NASA



- **Overview of SEE testing, environments, terminology and testing facilities.**
- **How to build a test plan and choosing support equipment for the test session**
- **Execution, data taking, efficiency & common mistakes**
- **Analysis and examples of Project Saves…..and more**

Visit our website at

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

Questions, contracting, scheduling contact Henry Clark at

clark@comp.tamu.edu

1967 - 2017 50 YEARS OF BEAM exploring the nuclear frontier

TEXAS A&M UNIVERSITY