



VALOR/TARGET Beamline Simulation: Building Models for Different Beamlines - Accelerator Division

Presenter Name: Bryan Mann, Giancarlo Ortega and Lianne Marrero Perez

Final Presentation

7/26/2024

About Giancarlo - VALOR Intern

- Incoming freshman at Marquette University
 - Major in Computer Engineering
 - Major Interests
 - Coding and Computer Hardware
 - STEM Research
 - Sports: Volleyball and Soccer



About Lianne - TARGET Intern



- Rising Senior at Geneva Community High School
- I am interested in majoring in Pharmaceutical Sciences or Chemical Engineering as a Pre-Pharmacy major.
- My favorite hobbies are crocheting, playing my flute and doing taekwondo

Why Fermilab?

I decided to apply to the TARGET internship because I have an interest in quantum physics theories like the wave particle duality theory. I also thought it would be a fantastic opportunity to gain some experience before going to college.



About Bryan - TARGET Intern

Rising Junior at Waubonsie Valley High School

Interests:

- Track & Field
- Games
- Aviation
- Space exploration

Extracurriculars:

- Track
- BSA (Black Student Alliance)
- ACT-SO (Science Olympiad)

Why Fermi?

- I was presented a great opportunity to work with like-minded individuals and expand my knowledge of STEM careers and topics.

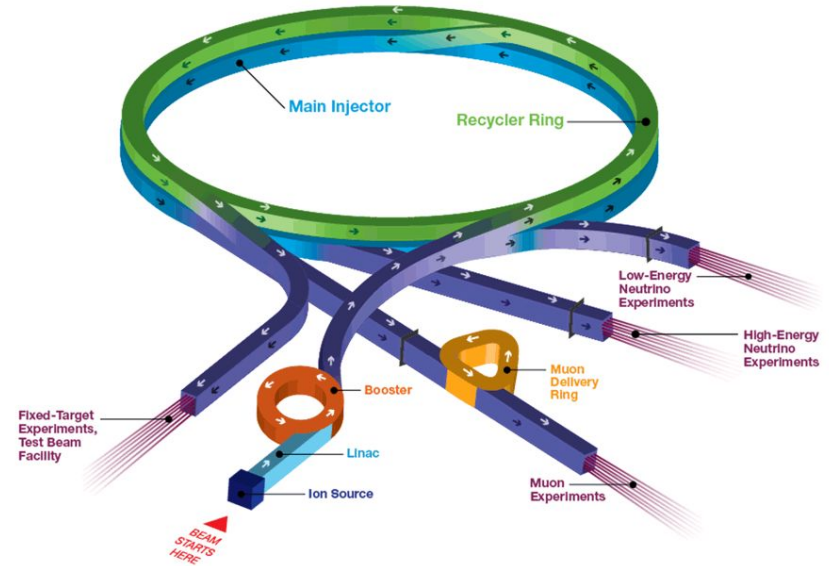


The Accelerator

- Step 1: Proton Ion source
- Step 2: Higher Energy
- Step 3: Directed to Experiment
 - Magnets



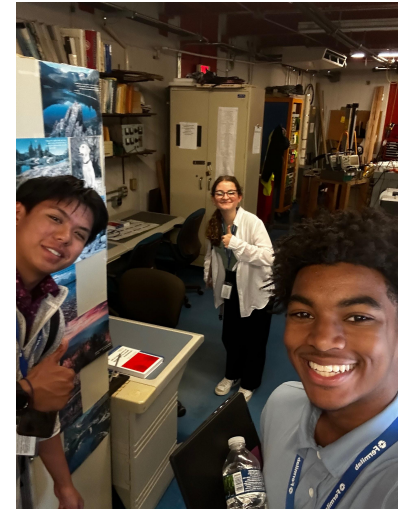
Fermilab Accelerator Complex



Our Project: Building Models for Several Beamlines



- Supervisor- Jason Crnkovic
 - Lessons
- Located in the LINAC with Geoffrey Donaldson
- Modeled and simulated beamlines with the use of JupyterHub Notebook and MadX program
 - Why?
 - Simple flat files
 - Supporting particle physics experiments
- NUMI beamline (Neutrinos at the Main Injector)
- BNB beamline (Booster Neutrino Beam)
- Switchyard (sends particles to three external beam areas)



What did it look like...

File Home Insert Draw Page Layout Formulas Data Review View Automate Help

PROTECTED VIEW Be careful—files from the Internet can contain viruses. Unless you need to edit, it's safer to stay in Protected View. Enable Editing

H7 $=E7*constants!B59/1000$

name	statement	type	length	length2	K1	EPg	rho	a	B	U ^{1/2}	IG
						[cm]	[cm]	[cm]	[T]	[MeV]	[MeV]
B59P	FREED	SC	4160	4100	0.0000	1.86	81.007	4.64	0.20	0.0000	0.0000
VT80	WICKER	MCV	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
D80	ZJAO	SOB	1520	0.00	0.0022	0.00	0.00	0.00	0.00	0.8960	0.4800
HT80	WICKER	MCH	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
B801	FREED	F-1/2	3480	80.01	0.0000	2.32	30.94	3.04	0.78	0.0000	0.0000
B802	FREED	F-1/2	3480	80.01	0.0000	2.32	30.94	3.04	0.78	0.0000	0.0000
D81	ZJAO	SOB	1520	0.00	0.1074	0.00	0.00	0.00	0.00	0.1064	3.7247
B82	ZJAO	SOB	1520	0.00	0.1074	0.00	0.00	0.00	0.00	0.1074	3.4708
HT82	WICKER	MCH	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
VT82	WICKER	MCV	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
D84	ZJAO	SOB	1520	0.00	0.1275	0.00	0.00	0.00	0.00	0.1267	3.9787
B85	ZJAO	SOB	1520	0.00	0.1271	0.00	0.00	0.00	0.00	0.1269	3.9378
HT85	WICKER	MCH	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
VT85	WICKER	MCV	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
B801	FREED	F-1/2	3480	80.01	0.0000	2.32	30.94	3.04	0.78	0.0000	0.0000
B802	FREED	F-1/2	3480	80.01	0.0000	2.32	30.94	3.04	0.78	0.0000	0.0000
B803	FREED	F-1/2	3480	80.01	0.0000	2.32	30.94	3.04	0.78	0.0000	0.0000
B804	FREED	F-1/2	3480	80.01	0.0000	2.34	27.99	3.04	0.76	0.0000	0.0000
B805	FREED	F-1/2	3480	80.01	0.0000	2.34	27.99	3.04	0.76	0.0000	0.0000
D85	ZJAO	SOB	1520	0.00	0.0922	0.00	0.00	0.00	0.00	0.0916	2.9084
HT86	WICKER	MCH	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
B862	FREED	F-1/2	3480	80.01	0.0000	2.34	27.99	3.04	0.76	0.0000	0.0000
D87A	ZJAO	PNJ	0900	0.00	-0.0926	0.00	0.00	0.00	0.00	1.9068	2.7732
D87B	ZJAO	PNJ	0900	0.00	-0.0926	0.00	0.00	0.00	0.00	1.9068	2.7732
VT87	WICKER	MCV	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
B801	FREED	F-1/2	3480	80.01	0.0000	2.34	27.99	3.04	0.76	0.0000	0.0000
B802	FREED	F-1/2	3480	80.01	0.0000	2.34	27.99	3.04	0.76	0.0000	0.0000
B803	FREED	F-1/2	3480	80.01	0.0000	2.34	27.99	3.04	0.76	0.0000	0.0000
D88A	ZJAO	PNJ	0900	0.00	-0.0926	0.00	0.00	0.00	0.00	1.9068	2.7732
D88B	ZJAO	PNJ	0900	0.00	-0.0926	0.00	0.00	0.00	0.00	1.9068	2.7732
HT88	WICKER	MCH	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
B801	FREED	F-1/2	3480	80.01	0.0000	2.34	27.99	3.04	0.76	0.0000	0.0000
B802	FREED	F-1/2	3480	80.01	0.0000	2.34	27.99	3.04	0.76	0.0000	0.0000
B803	FREED	F-1/2	3480	80.01	0.0000	2.34	27.99	3.04	0.76	0.0000	0.0000
B804	FREED	F-1/2	3480	80.01	0.0000	2.34	27.99	3.04	0.76	0.0000	0.0000
D89A	ZJAO	PNJ	0900	0.00	-0.0926	0.00	0.00	0.00	0.00	1.9068	2.7732
D89B	ZJAO	PNJ	0900	0.00	-0.0926	0.00	0.00	0.00	0.00	1.9068	2.7732
HT89	WICKER	MCH	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
D90A	ZJAO	PNJ	0900	0.00	-0.0926	0.00	0.00	0.00	0.00	1.9068	2.7732
D90B	ZJAO	PNJ	0900	0.00	-0.0926	0.00	0.00	0.00	0.00	1.9068	2.7732
HT90	WICKER	MCV	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
VT90	WICKER	MCV	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
B871	FREED	F-1/2	3480	74.00	0.0000	2.28	40.75	3.04	0.78	0.0000	0.0000
B872	ZJAO	MJ	1500	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
HT87	WICKER	MCH	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000
VT87	WICKER	MCV	6400	0.00	0.0000	0.00	0.00	0.00	0.00	0.0000	0.0000

constants Geometry Magnets - fields Magnets - currents Magnets - sn Vacuum Power Supplies

File Edit View Run Kernel Git Diagram Tabs Settings Help

testmaxd BeamlineNB.mxd boone.mxd fake.mxd

```

103 B871:FBEND,L=3.0480,K1=0.0000;
104 VT80:WICKER,L=0.4000,K1CX=0.0000;
105 VT82:WICKER,L=0.4000,K1CX=0.0000;
106 VT85:WICKER,L=0.4000,K1CX=0.0000;
107 VT87:WICKER,L=0.4000,K1CX=0.0000;
108 VT86:WICKER,L=0.4000,K1CX=0.0000;
109 VT81:WICKER,L=0.4000,K1CX=0.0000;
110 VK872:WICKER,L=0.3050,K1CX=0.0000;
111 VT83:WICKER,L=0.4000,K1CX=0.0000;
112 HT86:WICKER,L=0.4000,K1CX=0.0000;
113 HT82:WICKER,L=0.4000,K1CX=0.0000;
114 HT85:WICKER,L=0.4000,K1CX=0.0000;
115 HT86:WICKER,L=0.4000,K1CX=0.0000;
116 HT88:WICKER,L=0.4000,K1CX=0.0000;
117 HT87:WICKER,L=0.4000,K1CX=0.0000;
118 HT82:WICKER,L=0.4000,K1CX=0.0000;
119 HT83:WICKER,L=0.7620,K1CX=0.0000;
120
121
122
123 FOOD: LINE=
(MARKER,H051,D1,MARKER,B511P,D2,MARKER,VT800,D3,MARKER,MARKER,Q860,D4,HT860,D5,MARKER,MARKER,B8601,D6,B8607,D7,MARKER,MARKER,MARKER,Q81,D8,Q862,D9,MARKER,HT862,D10,VT862,D11,MARKER,MARKER,MARKER,MARKER,MARKER,MARKER,Q864,D12,Q865,D13,MARKER,HT865,D14,VT865,D15,B8661,D16,B8662,D17,B8663,D18,MARKER,B8661,D19,MARKER,B8662,D20,MARKER,B8663,D21,MARKER,HT866,D22,B8663,D23,MARKER,Q867A,D24,Q867B,D25,MARKER,VT867,D26,MARKER,B8671,D27,B8672,D28,B8673,D29,MARKER,Q868A,D30,Q868B,D31,MARKER,HT868,D32,B8681,D33,B8682,D34,B8683,D35,MARKER,Q869A,D36,Q869B,D37,MARKER,VT869,D38,B8691,D39,B8692,D40,B8693,D41,MARKER,MARKER,Q870A,D42,Q870B,D43,MARKER,HT870,D44,MARKER,MARKER,MARKER,Q871A,D45,Q871B,D46,MARKER,VT871,D47,MARKER,B8711,D48,MARKER,MARKER,MARKER,Q872,D49,HT872,D50,VK872,D51,B8721,D52,M
ARKER,MARKER,MARKER,HT873,D53,VT873,D54,MARKER,Q873,D55,MARKER,Q874,D56,Q875,D57,MARKER,MARKER,MARKER,MARKER,MARKER,MARKER,MARKER,MARKER,MARKER,MARKER,MARKER,MARKER,MARKER,MARKER,MARKER,MARKER);
124
125
126 USE, PERIOD=FOOD;
127 THISS,SAVE,BETA=15.0,BETHY=5.0;
128 PLOT,HAXIS=S,VAXIS=BETH,BETH;
129
130 HATCH, SEQUENCE=FOOD;
131
132 THISS, SAVE;
133 PLOT,HAXIS=S,VAXIS=BETH,BETH;
134
135 Value, TABLE(SUMM,Q1);
136 Value, TABLE(SUMM,Q2);
137 WRITE, TABLE(SUMM,FILL=FOOD.txt;

```

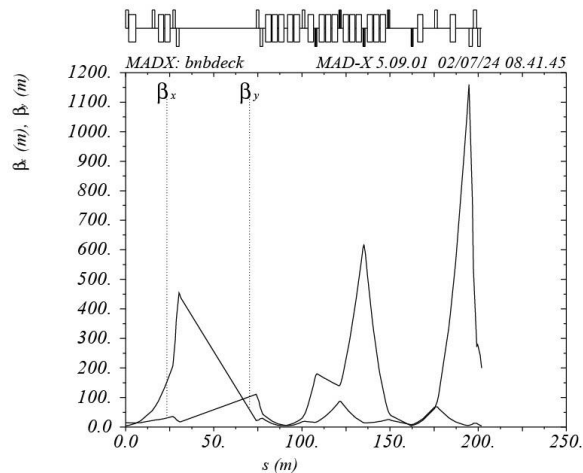
Simple C 1 Plain Text Mem: 120.96 / 6553600 MB Disk Usage: 0.0 / 24689061952.00 B Lr: 123 Col: 300 Scaes: 1 BeamlineNB.mxd

Detailed View of Code

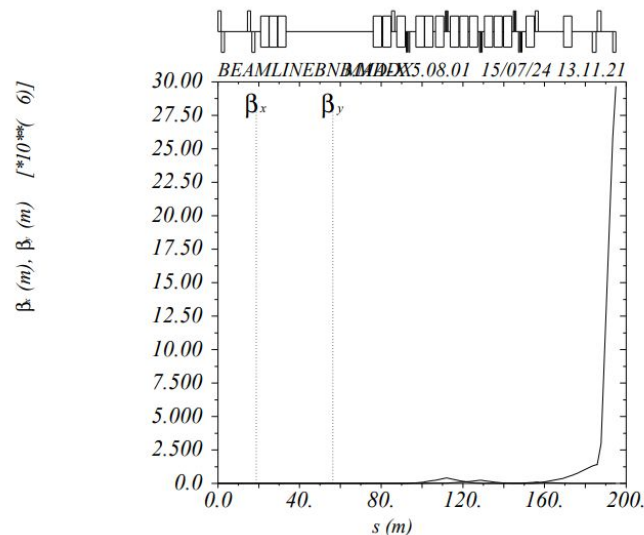
```
14
15 DZERO:    MARKER;
16 Q701:    QUAD,      L=3.048000,    K1=K1P1Q1;
17 Q60_END:  DRIFT,    L=0.152400;
18 VP701:    MONITOR,  L=0.203200;
19 DCQ1A:    DRIFT,    L=0.106830;
20 MRVC_END: DRIFT,    L=0.068260;
21 VT701:    VKICK,    L=0.152400,    ANGLE=0.000000;
22 MRVC_END: DRIFT,    L=0.068260;
23 DCQ1B:    DRIFT,    L=0.038490;
24 MRVC_END: DRIFT,    L=0.068260;
25 VT701:    VKICK,    L=0.152400,    ANGLE=0.000000;
26 MRVC_END: DRIFT,    L=0.068260;
27 DCQ1C:    DRIFT,    L=0.027740;
28 MRVC_END: DRIFT,    L=0.011270;
```


Our Project: What did it look like

Examples :

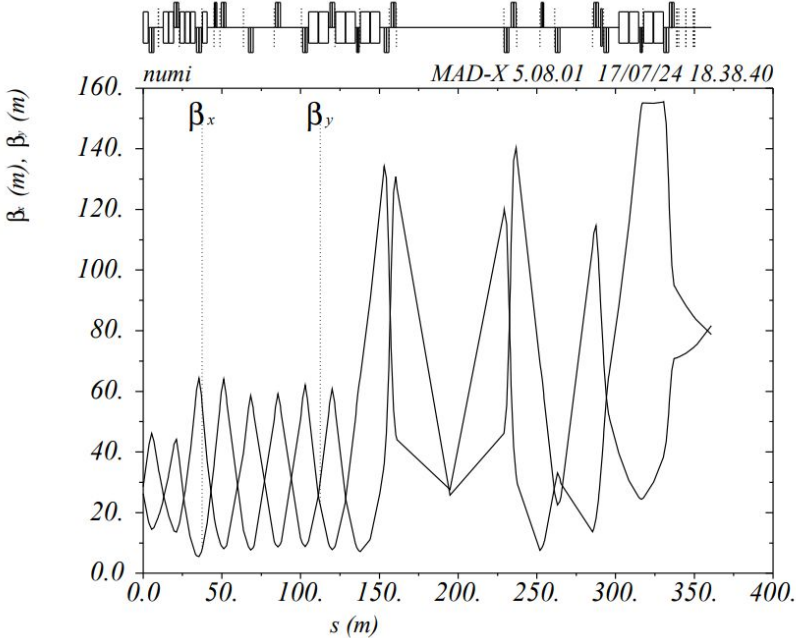


Our first time running the code.
(for the BNB line)

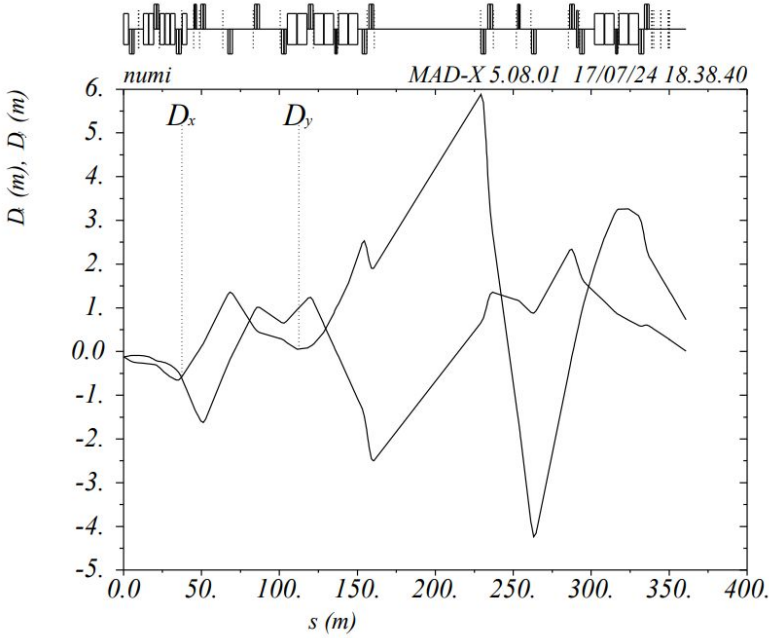


More attempts to reach an accurate beamline

Accurate Simulation of a Beamline

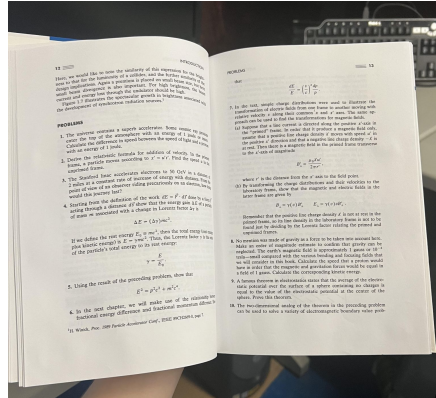
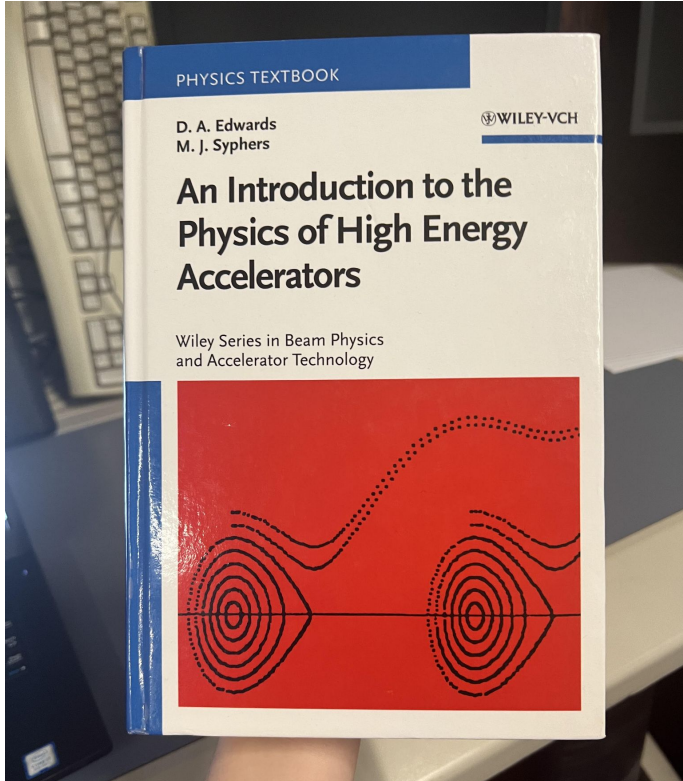


Beta Function



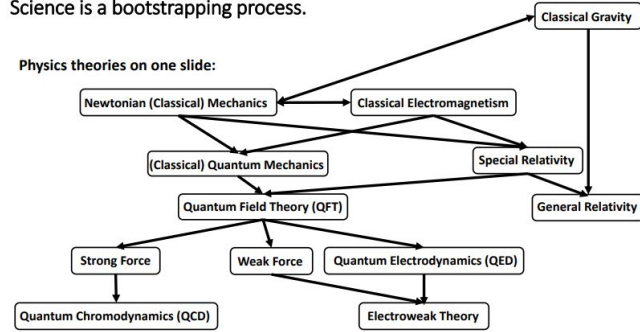
Dispersion Plot

Learning Accelerator and Particle Physics



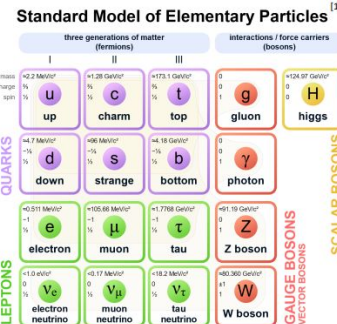
Science is a bootstrapping process.

Physics theories on one slide:



Standard Model:

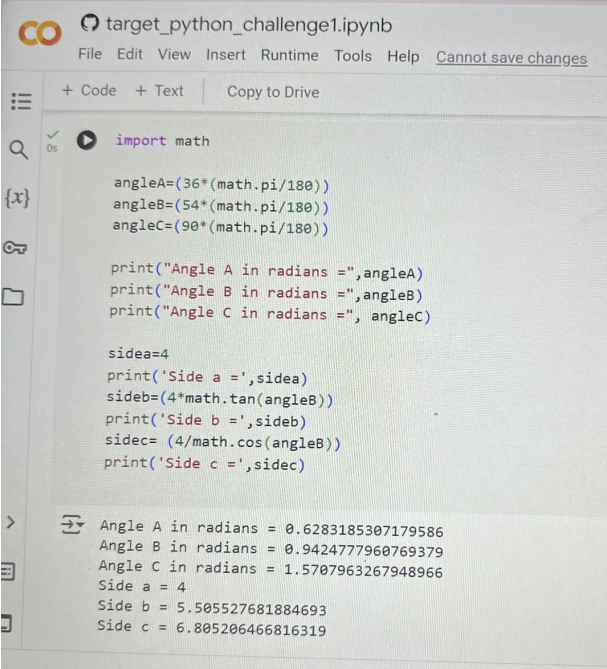
- SM explains the interaction of matter & forces at large energies & small distances.
- Matter & forces are both treated as particles in the SM.
- Particles can be created & destroyed.
- Fermions & bosons are the two basic types of quantum particles.



[1] MisM and Cuzh, "File:Standard Model of Elementary Particles.svg", https://en.wikipedia.org/wiki/File:Standard_Model_of_Elementary_Particles.svg, Accessed June 21, 2023.

Workshops

- Python Workshop-
This workshop taught us the basics of coding on Python. There were challenges (practice problems) to apply the knowledge that was taught in the lectures.
- Resume Workshop-
Taught us how to make resumes that highlighted our best qualities and gave us tips on how to make our resume concise.
- College Admissions Workshop -
Helped us understand what it takes to be a competitive candidate for the college admission process



The screenshot shows a Jupyter Notebook titled 'target_python_challenge1.ipynb'. The code defines three angles in radians and calculates the corresponding sides of a triangle. The output shows the numerical values for each angle and side.

```
import math

angleA=(36*(math.pi/180))
angleB=(54*(math.pi/180))
angleC=(90*(math.pi/180))

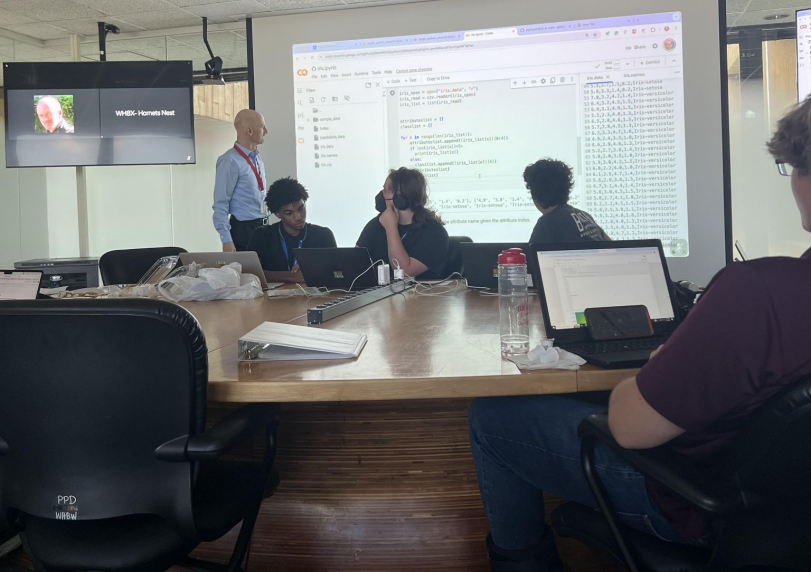
print("Angle A in radians =",angleA)
print("Angle B in radians =",angleB)
print("Angle C in radians =", angleC)

sidea=4
print('Side a =',sidea)
sideb=(4*math.tan(angleB))
print('Side b =',sideb)
sidec= (4/math.cos(angleB))
print('Side c =',sidec)
```

```
Angle A in radians = 0.6283185307179586
Angle B in radians = 0.9424777960769379
Angle C in radians = 1.5707963267948966
Side a = 4
Side b = 5.505527681884693
Side c = 6.805206466816319
```

This was one of the challenges in the Python Workshop. In this challenge we worked to find the missing sides and angles of a triangle.

Workshops



Python

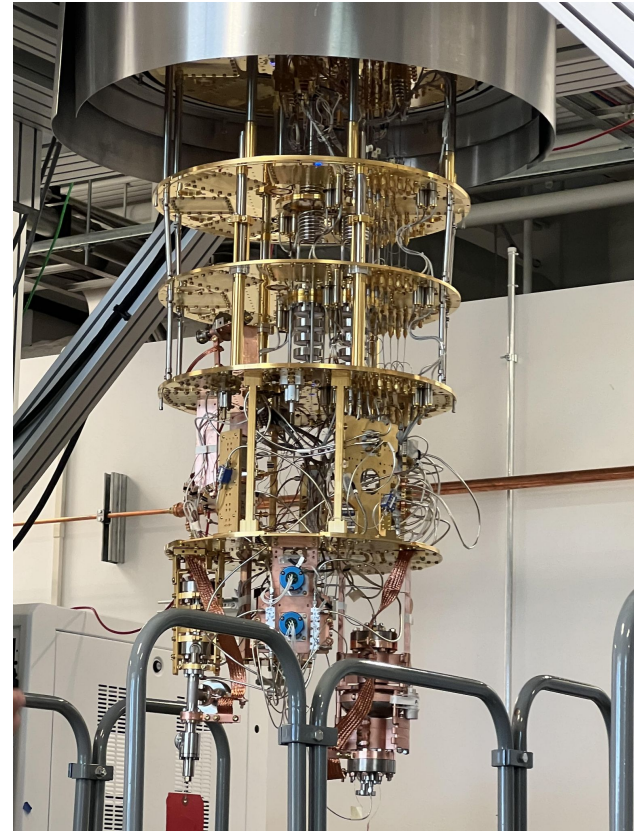


College Admission

Tours

We attended many tours during these internship. Some of these tours were:

- Integrated Engineering Research Center (IERC)
- Superconducting Quantum Materials and Systems Centers (SQMS)
- Fermilab Tour (Wilson Hall + driving tour)



Dilution fridge (part of the SQMS tour)

Tours



Reflection

Lianne

Takeaways:

- Narrowed down my career interests.
- Given me a deeper understanding of particle physics and particle accelerators.

Favorite Moments:

- Touring the LINAC building
- Going to the prairie
- Touring the rest of the site

Goals:

- Become a pharmacist
- Major in chemical engineering or pharmaceutical sciences.

Gian

Takeaways:

- Professional Environment within Fermilab
- Advice for my everyday life
 - Presenting yourself
 - Career advice
- Opportunities after the internship

Favorite Moments:

- Tours to different parts of the lab.
- Learning about the Main Control Room

Goals:

- Pursue Computer Engineering and work for reputable company

Bryan

Takeaways:

- Exposure to various fields of physics and engineering
- Realistic view of STEM jobs

Favorite Moments:

- Meeting the people here
- Learning what different people work on at the lab

Goals:

- Continue to pursue engineering interests

Acknowledgements

Thanks!

Anahi Ruiz Beltran : Program lead for the Target Internship

Cortez Watkins : Program lead for the Valor Internship

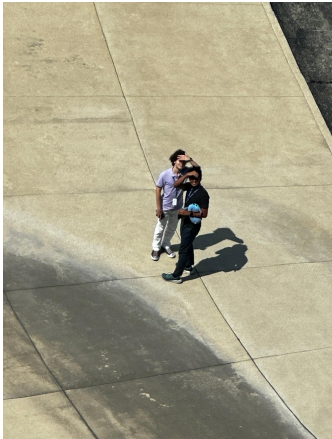
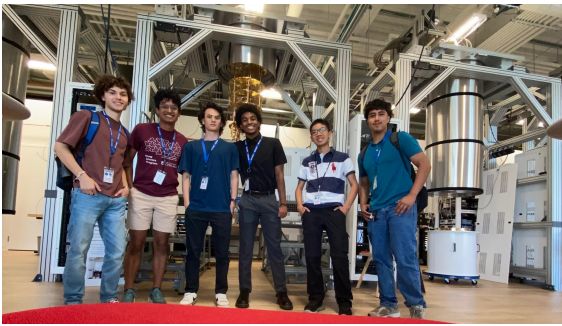
Jason Crnkovic : Beams Division, External Beam Delivery Department

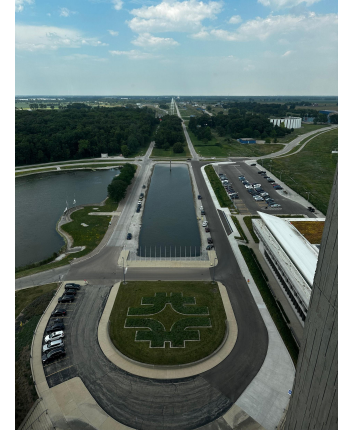
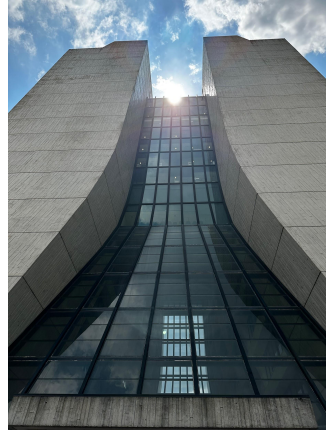
Susan McGimpsey : Beams Division, External Beam Delivery Department

Marco Mambelli : Scientific Computing Division

Geoffrey Donaldson: Technician in the Beams Division

Fermilab Friends







Thank you!