Automating the Sample Switching Process of the Prompt Gamma-Ray Activation Analysis (PGAA) Measurement Technique

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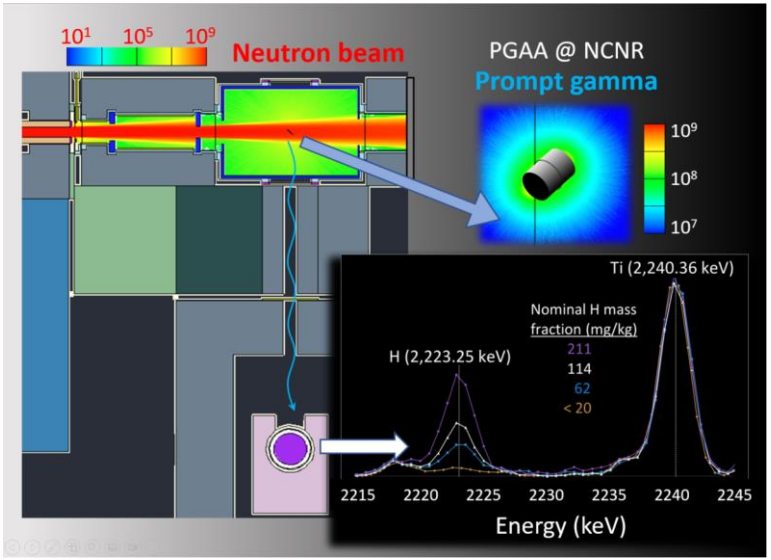
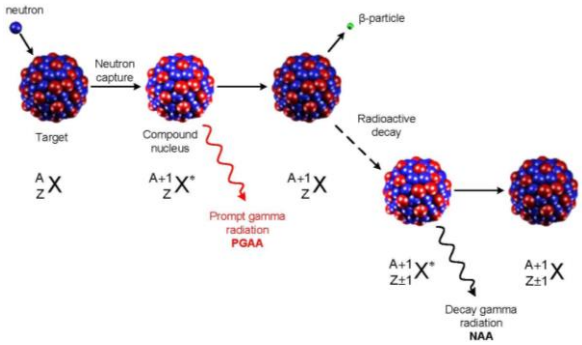
Background

Prompt Gamma-Ray Activation Analysis (PGAA)

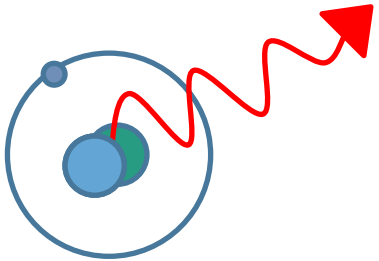
Used for determining the presence and amount of many elements simultaneously

1. **Neutron Bombardment**
2. **Neutron Capture**
3. **Gamma Ray Emission**
4. **Detection**
5. **Spectrum Analysis**
6. **Measurement**



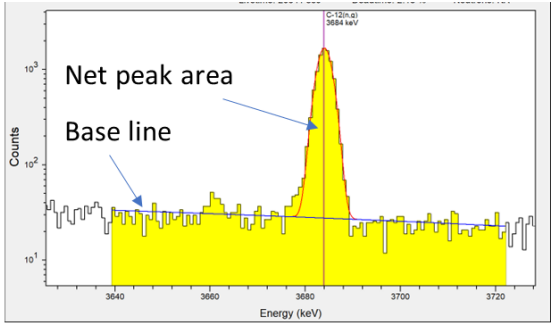


For chemical analysis: Neutron Activation Analysis. (2012). Sine2020. https://nmi3.eu/neutron-research/techniques-for-/chemical-analysis.html



$$A_x = \varphi_n n_x \varepsilon_x \sigma_{\gamma,x}$$

- $\sigma_{\gamma,X}$ gamma cross section (look up in library)
- ε_X detector efficiency at the peak x (measured)
- n_x Number of atoms of element x (unknown)
- φ_n neutron flux (cancels when taking ratios)
- A_x gamma count rate -- net area of peak (measured)

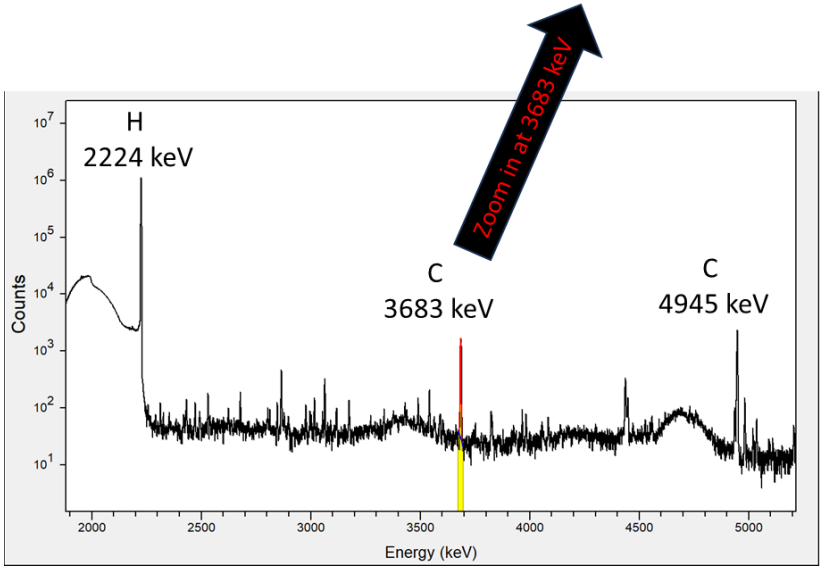


PGAA for composition analysis:

Area Ratio $\frac{A_x}{A_y} \propto$ Atom Ratio $\frac{n_x}{n_y}$

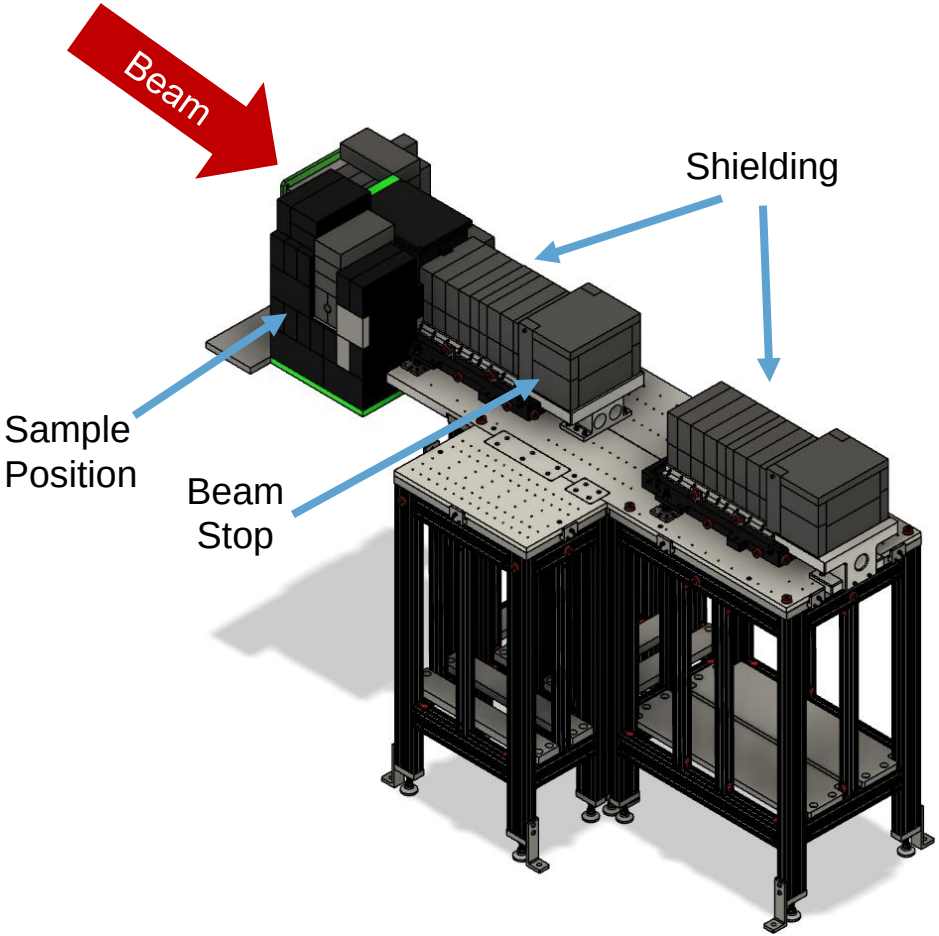
Atom ratio ←→ Mass ratios

Cancellation of Factors



PG spectrum of PLA (3D printing material)

Current PGAA setup



Project Description

Why?

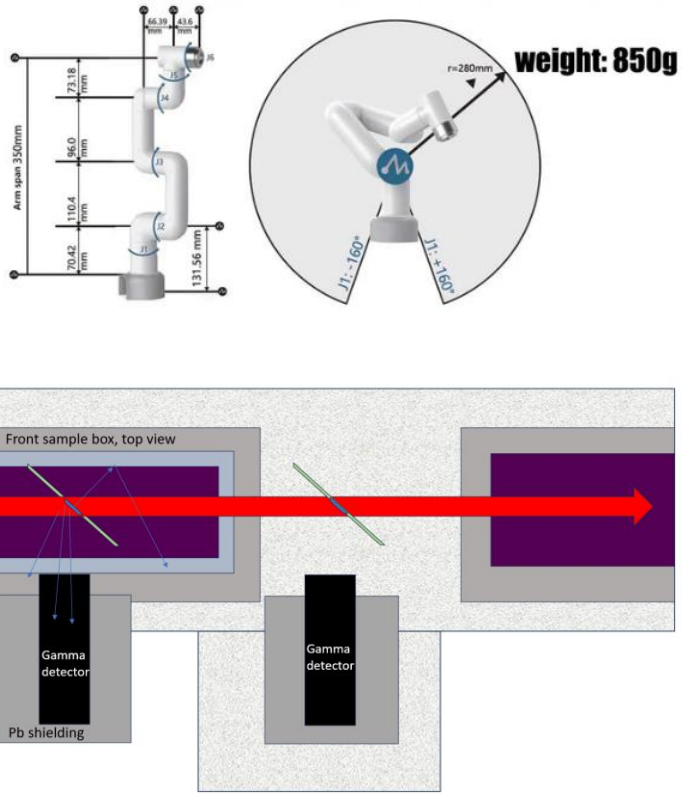
Problem

- Manual sample switching
- Potential residual radiation exposure
- Limited efficiency

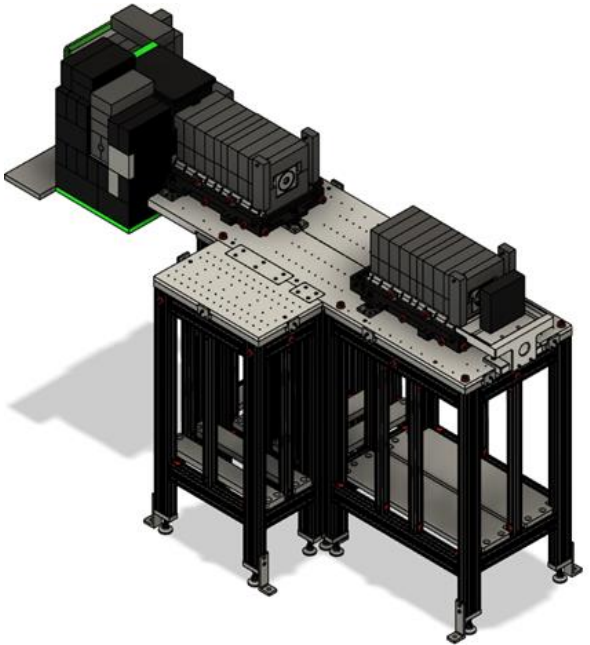
Goals

- Automate sample switching
  → redesign frame and rack
  →Evaluate a robot arm as a solution
- Ensure consistency by achieving precise and repeatable positioning of sample

Constrains



- Work envelope of robotic arm
- Space limitations of open space
- Does not obstruct existing equipment



MyCobot

Characteristics

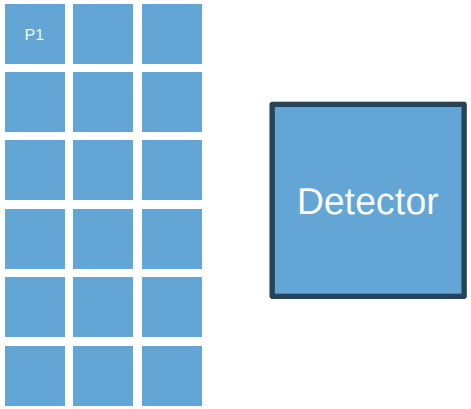
- Raspberry Pi configuration
- 6 Joints
- Claw mechanism
- Reads joint angles for movement
- Education Device (not industrial)

Limitations

- Speed
- Grip
- Has a mind of its own yet not very smart

Prototyping & Development

“Typical” Sample Changer

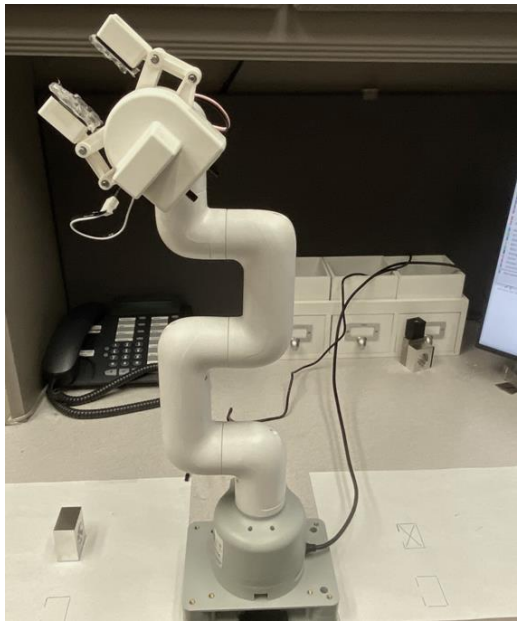


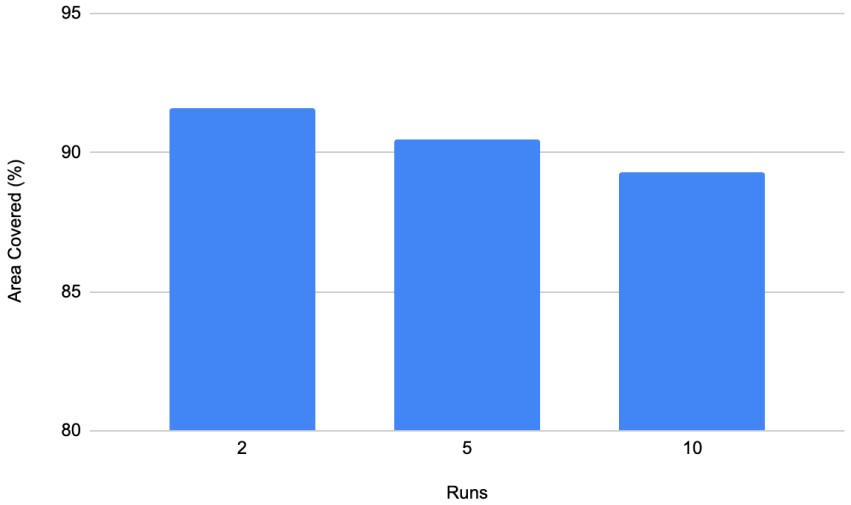
PGAA Specific:

→ Develop a more adaptable solution tailored to the specific needs of Prompt Gamma-Ray Activation Analysis (PGAA)

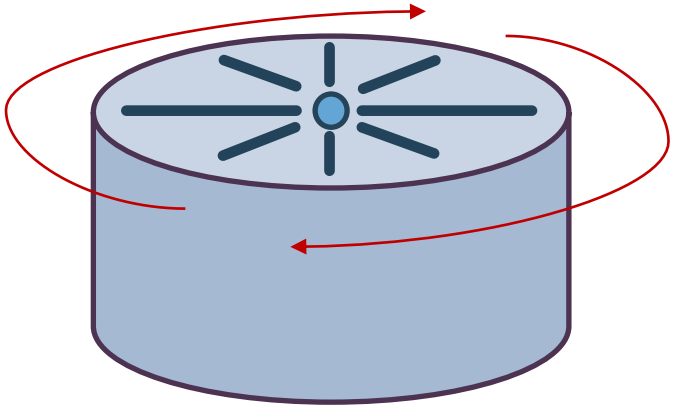
→ Design solution centers around the use of a robotic arm to automate the handling of sample frames.

Testing

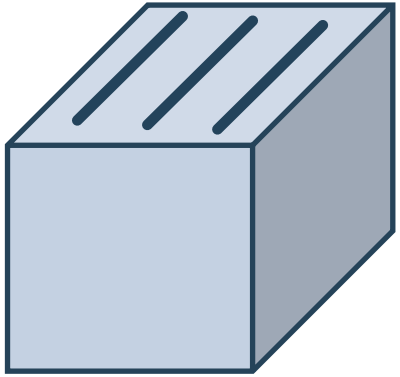


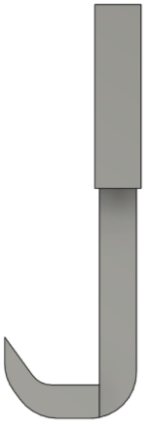


Considerations



VS.



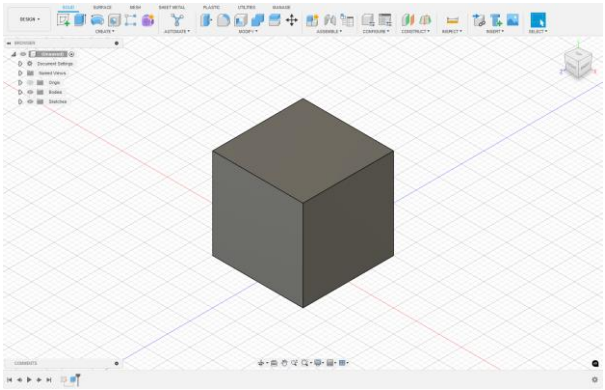


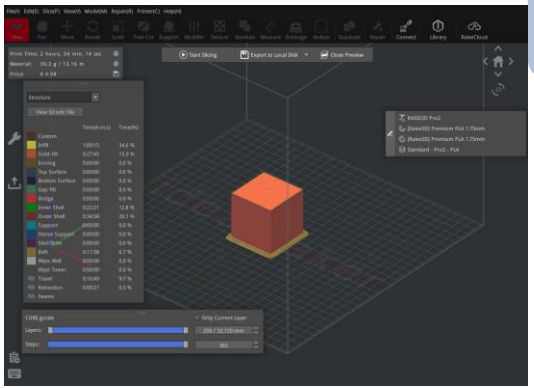
VS.

3D Printing

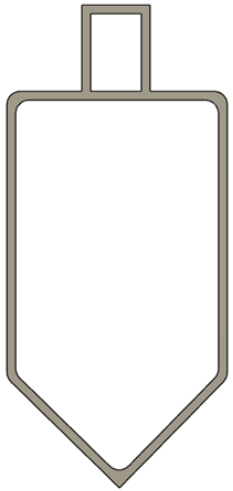
AUTODESK®
FUSION 360™

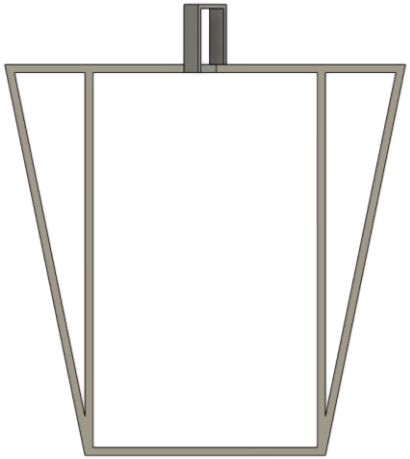
IdeaMaker

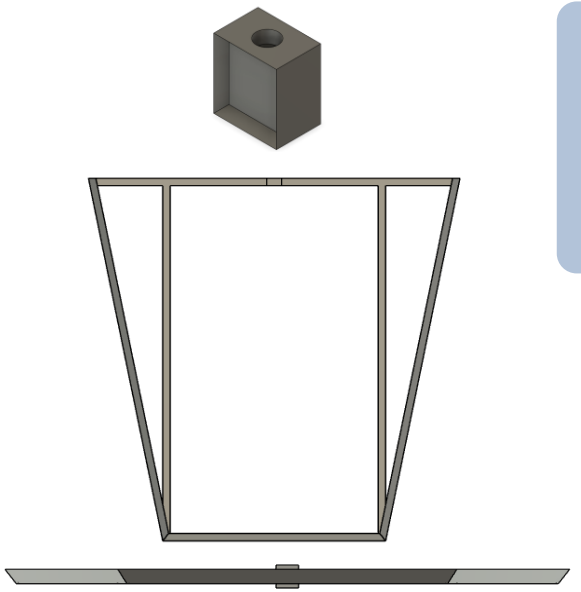




Frame Design Evolution

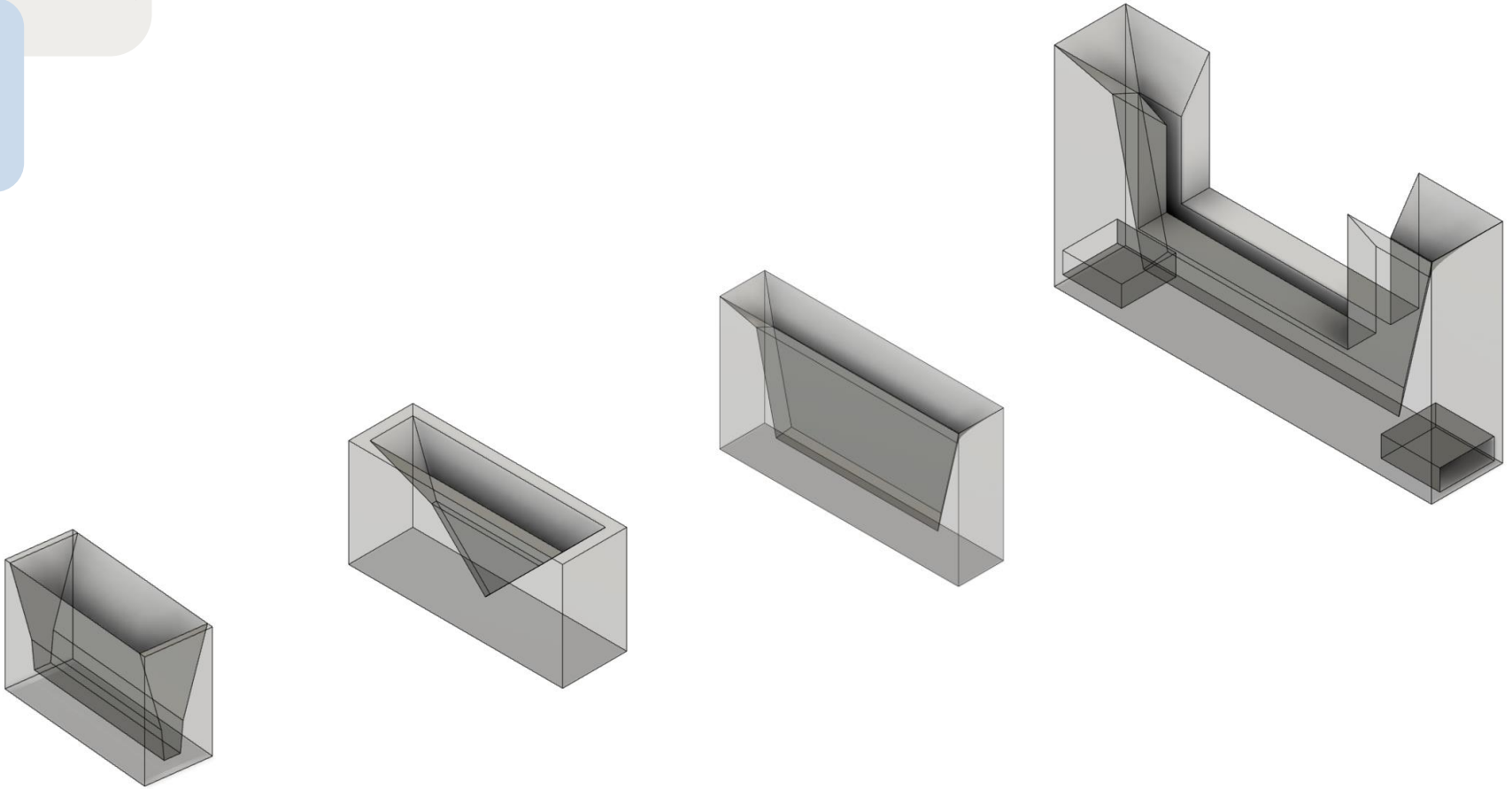




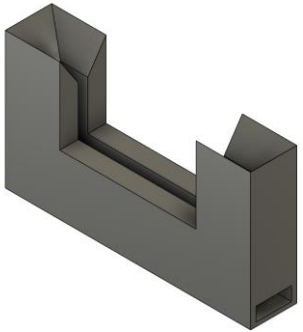


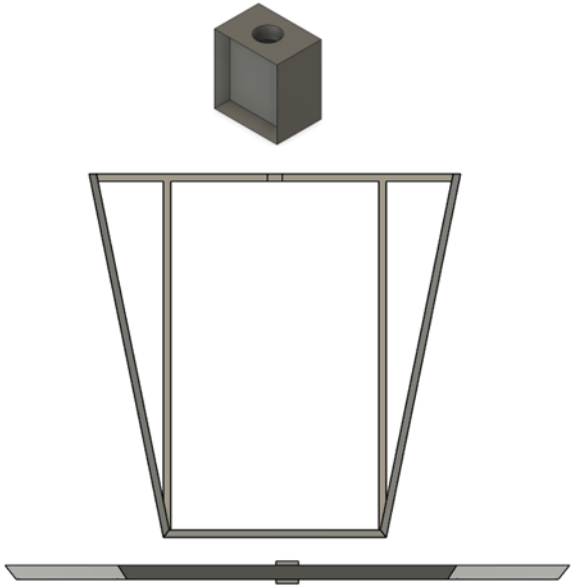
Fusion 360

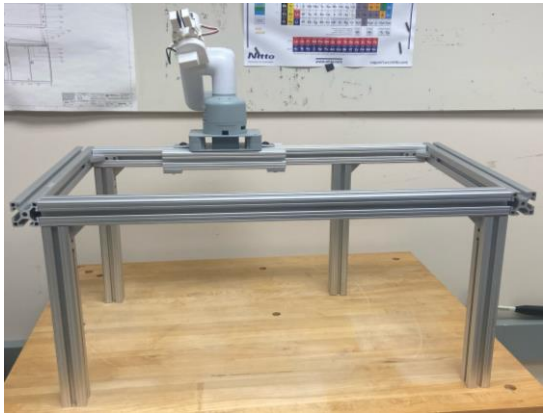
Rack Evolution



Putting it All Together



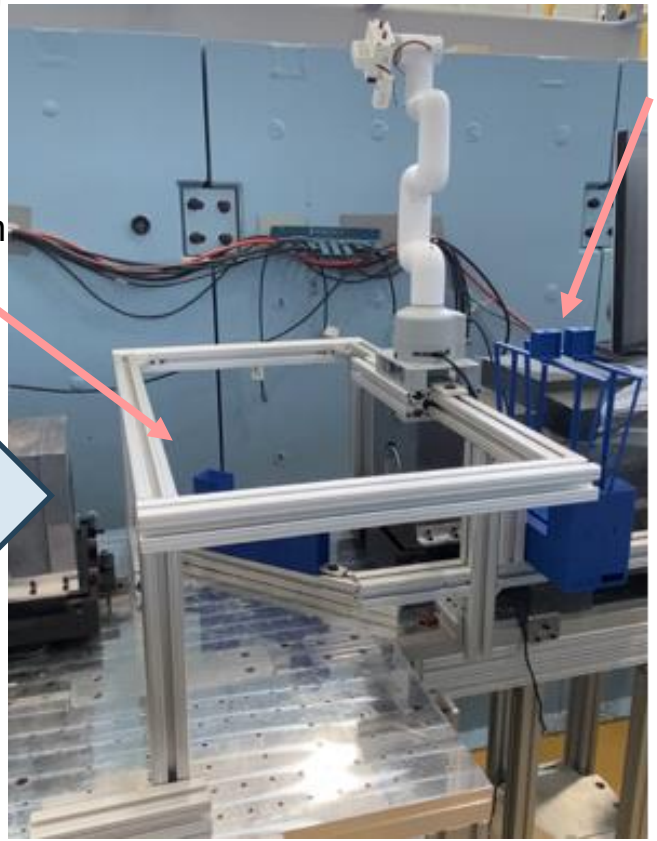


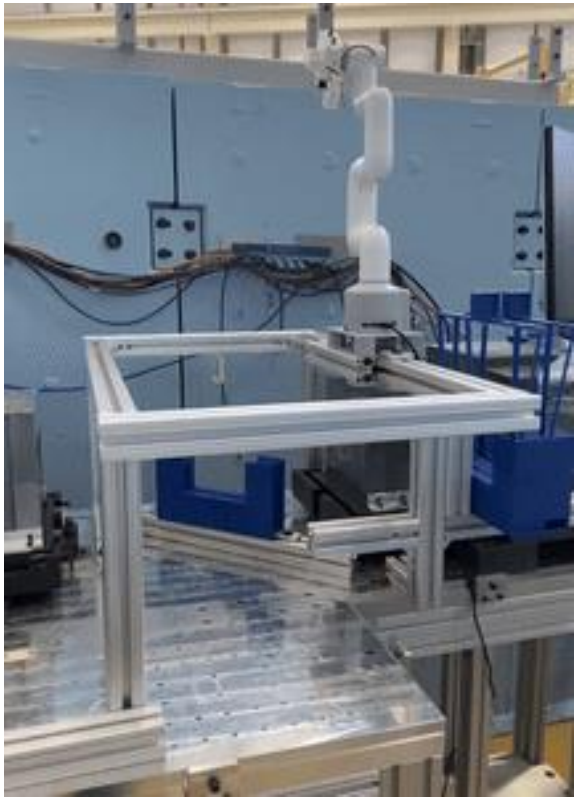


*Constructed using 80/20 aluminum pieces

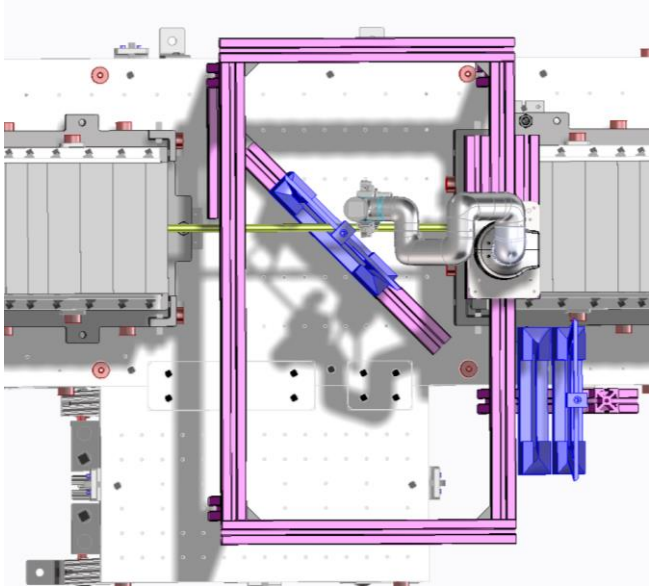
80/20 BUILD YOUR IDEA

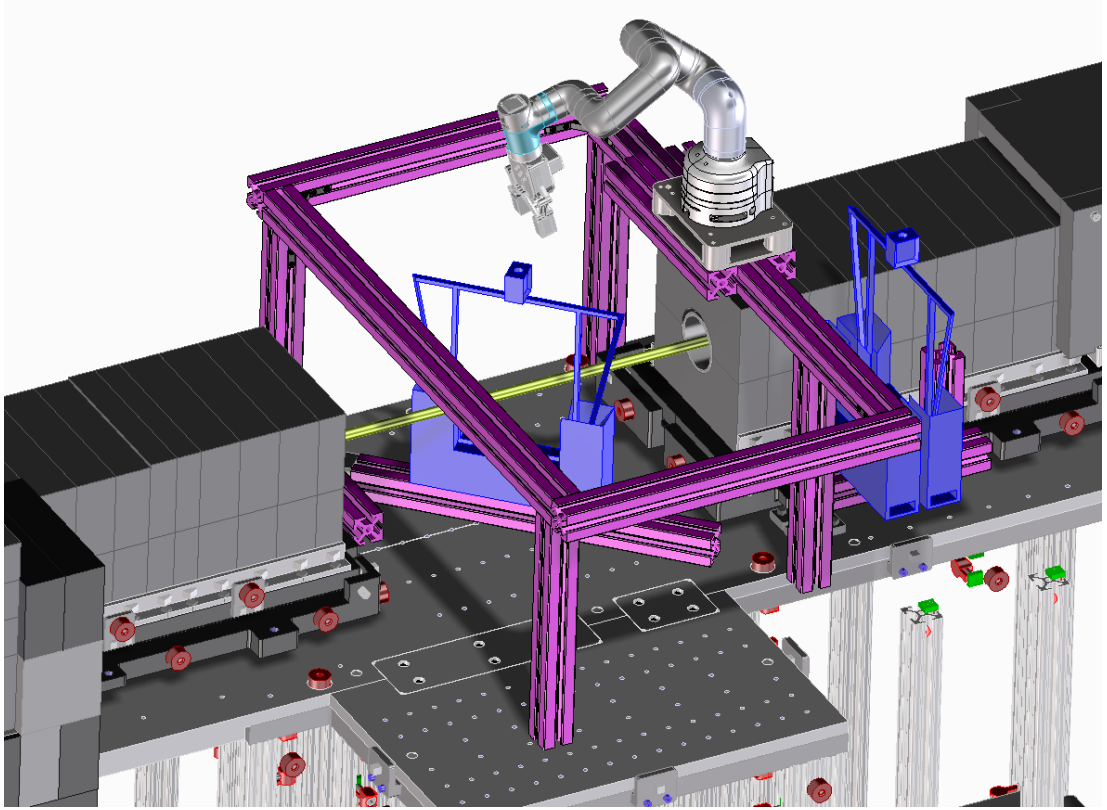
PGAA Adapted Sample Changer





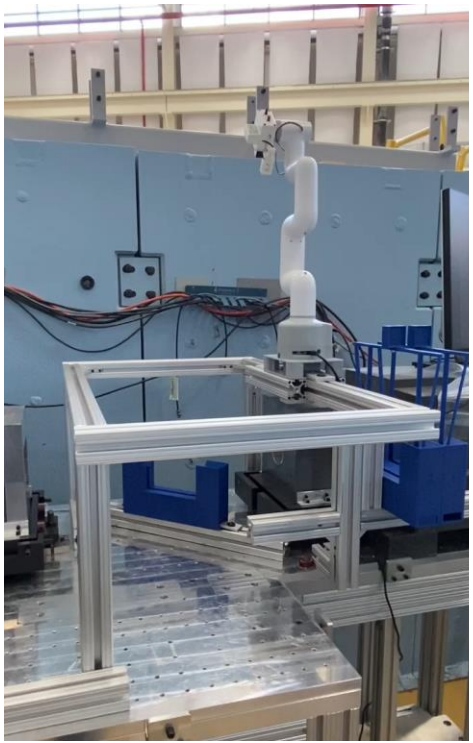
PGAA Adapted Sample Changer





Future Steps

- Interface with instrument control software
- Feedback control
- Fail sensors
- Shutter control
- Safety considerations
- Additional storage positions
- Versatile applications



Thank you!
Any Questions?

Acknowledgments

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