Milling plastic scintillator cells for calorimeter insert

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UC RIVERSIDE

Objective

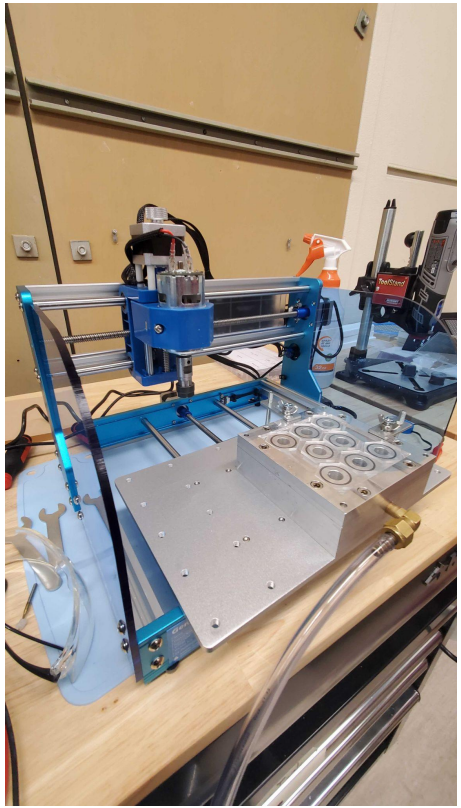
- Manufacture Plastic Scintillator cells to prototype Calorimeter insert
- Ultimately construct Calorimeter Insert using lab-manufactured Scintillator cells

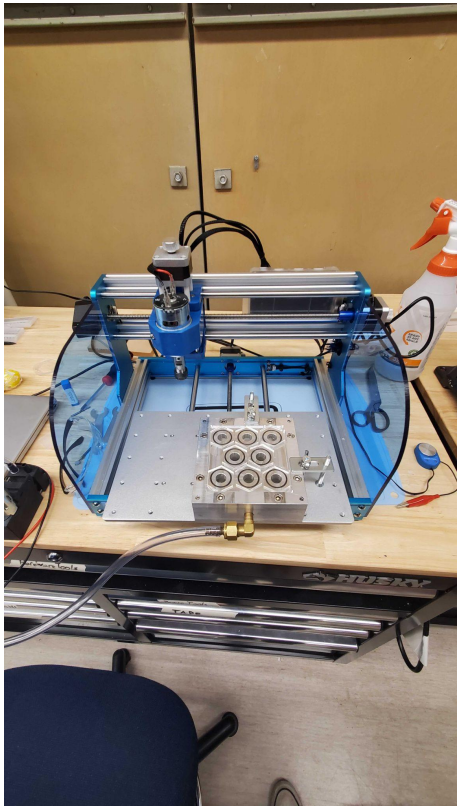
Prover 3018 V2 Desktop CNC

- Dimensions:
  - 290mm x 180mm x 40mm

- Affordable
  - Accessible

- Designed for Hobbyists
  - Relatively Straightforward

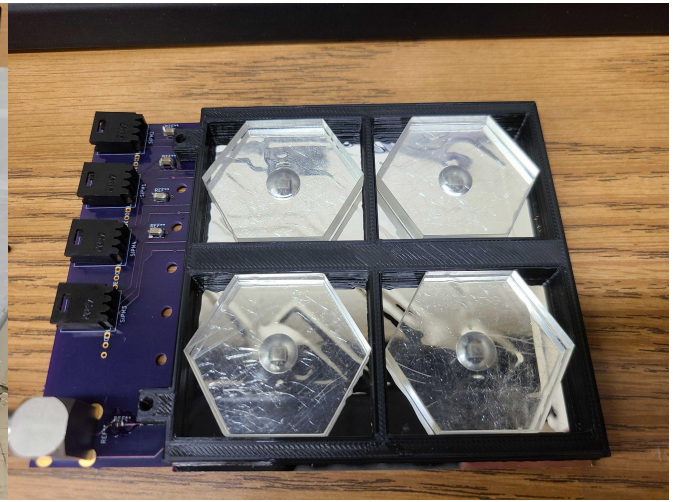




Prototype Calorimeter

Made and Assembled by the Arratia Group!

- PCBS designed and Soldered in lab
- Scintillators from repurposed material - Polished in lab.



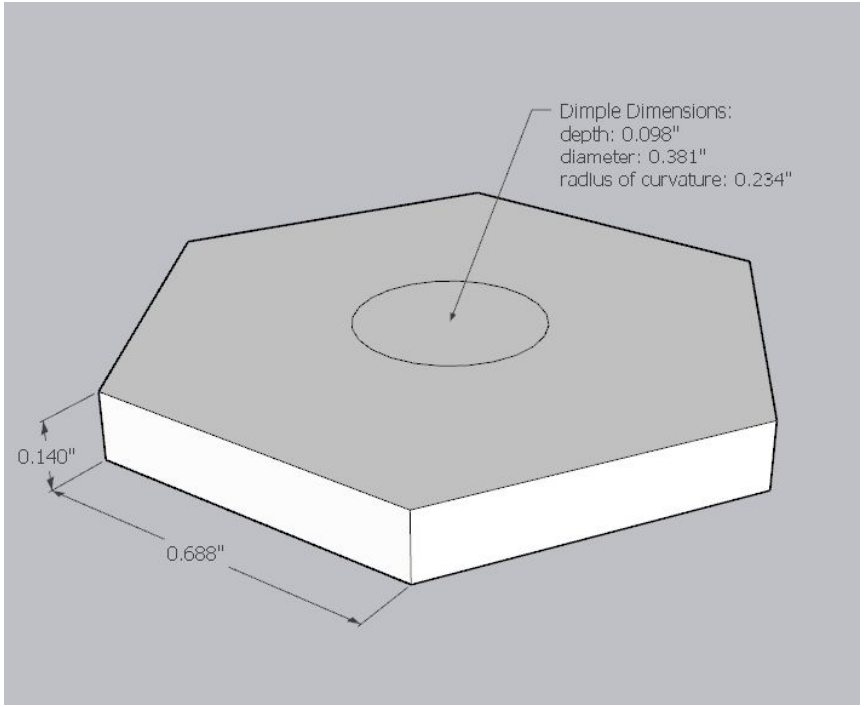
Scintillator Cells

Current Dimensions:

- Long Diameter ~ 34mm
- Thickness ~ 3.5mm
- Dimple Diameter ~ 9mm

Future Cell Variations:

- Different cell sizes
- Different dimple geometries and sizes



General Process

CAD → CAM → CNC Machine Software → Cutting

Model Design:
- Dimensions of desired piece

Softwares:
- Fusion 360
- Solidworks
- Sketchup

Manufacturing:
- Defines how the model is cut
- Specify milling bit, cut process, stock material

Softwares:
- MasterCAM
- Fusion 360

Controls CNC:
- Takes nc file from CAD - Interprets G-code

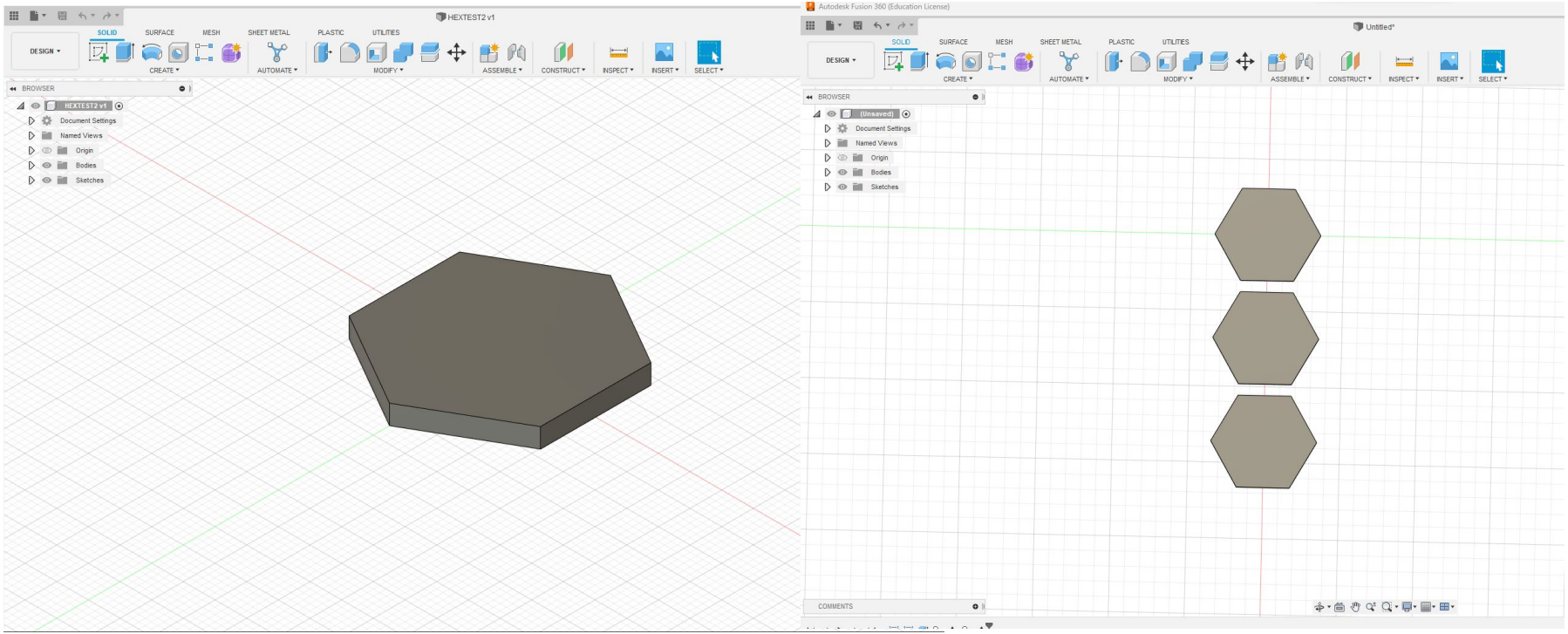
Softwares:
- Candle

Milling Bits:
- Bit size
- Flute Number
- Bit type

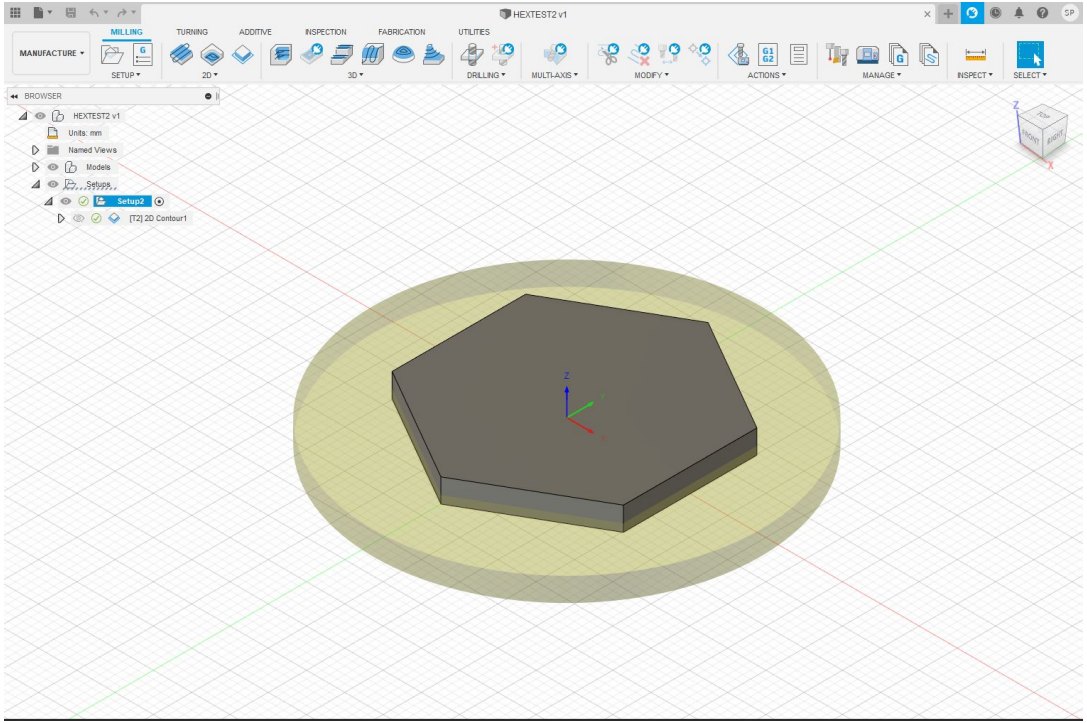
Material Fixing:
- Vacuum fixed
- clamped

Coolant:
- Water
- air

CAD - Fusion 360



CAM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MANUFACTURE
MILLING
TURNING
ADDITIVE
INSPECTION
FABRICATION
UTILITIES
SETUP
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DRILLING
MULTI-AXIS
MODIFY
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MANAGE
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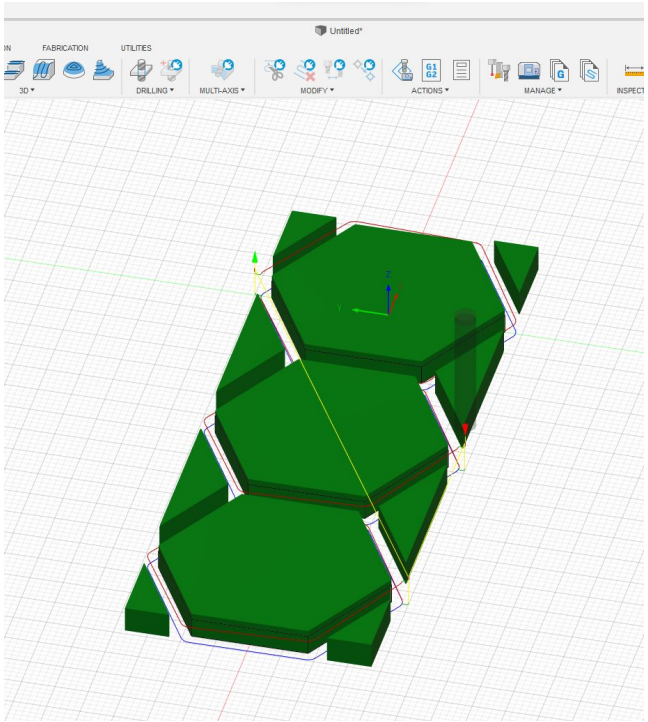
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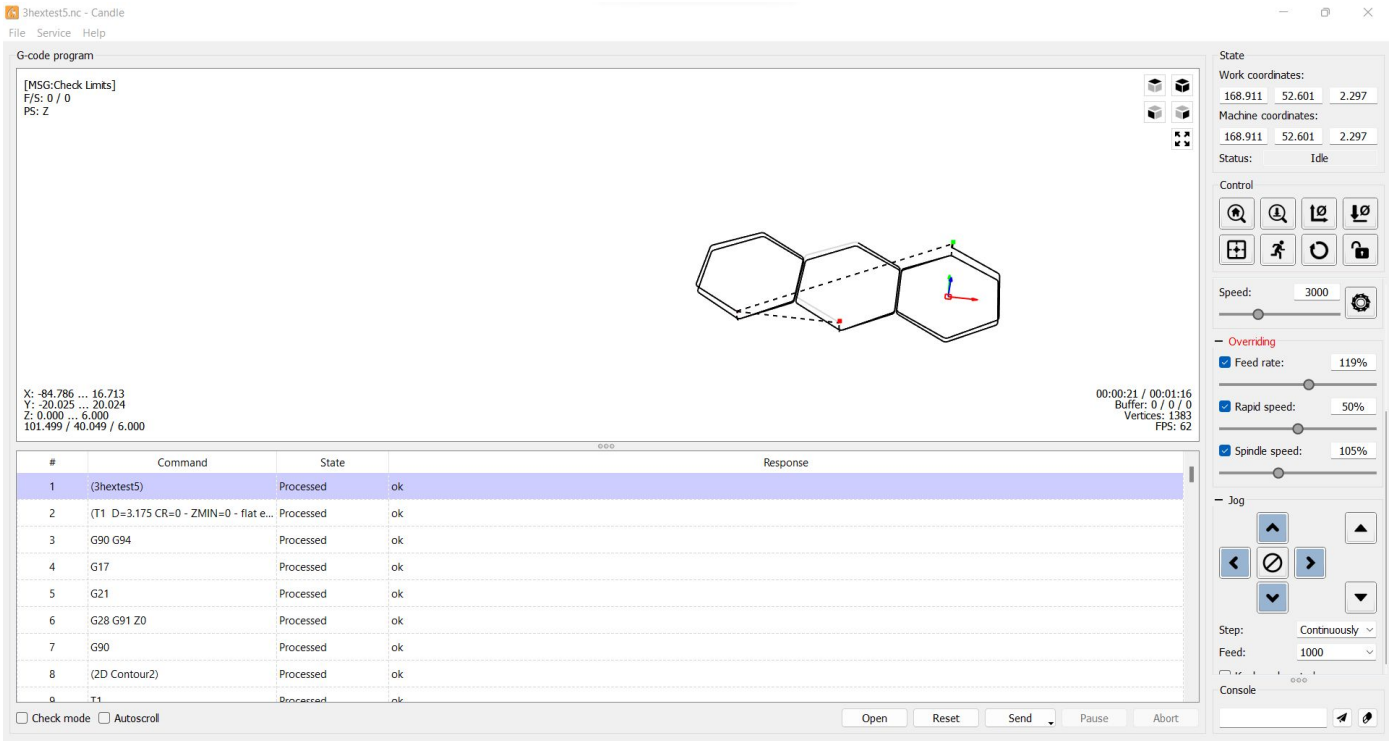
MANAGE

CNC Control Software - Candle



A little on G-code

A programming language designed for controlling CNCs (used also in 3d printing)

A series of commands from 0 to 99

Softwares built with GRBL firmware do not recognize all of these commands

G-Code Reference List

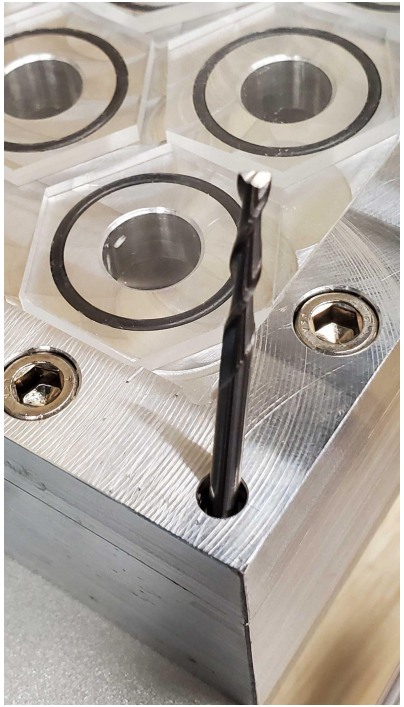
G Code	Function
G00	Positioning at rapid travel;
G01	Linear interpolation using a feed rate;
G02	Circular interpolation clockwise;
G03	Circular interpolation, counterclockwise;
G04	Dwell
G17	Select X-Y plane;
G18	Select Z-X plane;
G19	Select Z-Y plane;
G20	Imperial units;
G21	Metric units;
G27	Reference return check;
G28	Automatic return through reference point;
G29	Move to a location through reference point;
G31	Skip function;
G32	Thread cutting operation on a Lathe;
G33	Thread cutting operation on a Mill;
G40	Cancel cutter compensation;
G41	Cutter compensation left;
G42	Cutter compensation right;
G43	Tool length compensation;
G44	Tool length compensation;
G50	Set coordinate system (Mill);
G50	Maximum RPM (Lathe);
G52	Local coordinate system setting;
G53	Machine coordinate system setting;
G54	Set Datum;
G55	Set Datum;
G56	Set Datum;
G57	Set Datum;

G Code	Function
G58	Set Datum;
G59	Set Datum;
G70	Finish cycle (Lathe);
G71	Rough turning cycle (Lathe);
G72	Rough facing cycle (Lathe);
G73	Chip break drilling cycle;
G74	Left hand tapping (Mill);
G74	Face grooving cycle;
G75	OD groove pecking cycle (Lathe);
G76	Boring cycle (Mill);
G76	Screw cutting cycle (Lathe);
G80	Cancel cycles;
G81	Drill cycle;
G82	Drill cycle with dwell;
G83	Peck drilling cycle;
G84	Tapping cycle;
G85	Bore in, bore out;
G86	Bore in, rapid out;
G87	Back boring cycle;
G90	Absolute programming;
G91	Incremental programming;
G92	Reposition origin point (Mill);
G92	Screw thread cutting cycle (Lathe);
G94	Per minute feed;
G95	Per revolution feed;
G96	Constant surface speed (Lathe);
G97	Constant surface speed cancel;
G98	Feed per minute (Lathe);
G99	Feed per revolution (Lathe);

GCodeTutor.com

Milling Bits

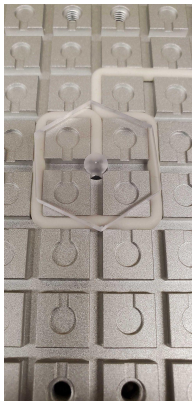
- Different Bit types for different cuts:
  - Edge Cuts: 2-flute Flat End
  - Dimple: Ball End
- Chip Evacuation and Heating:
  - Flute number

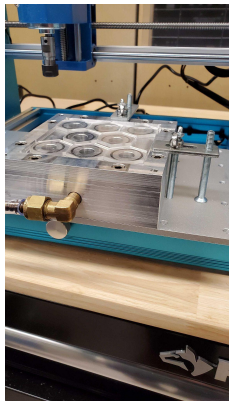


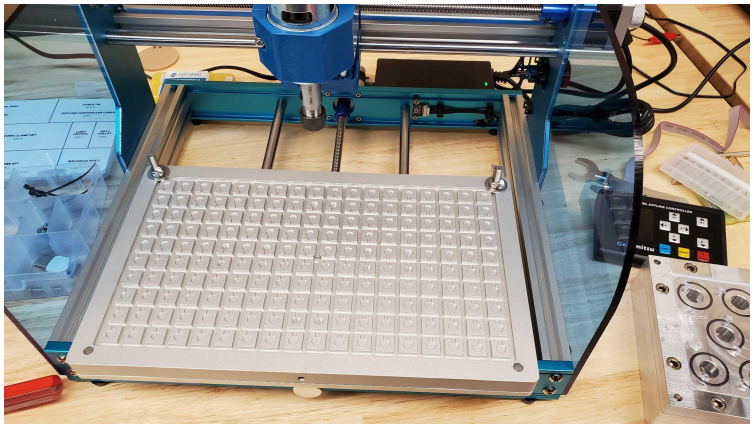
Cutting Setup

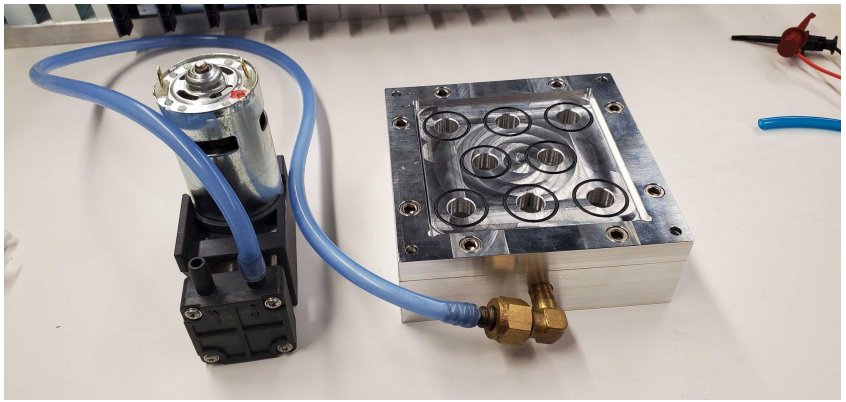
Vacuum Setup:

- Specialized Vacuum Chuck
  - Holds ~ 10cm^2 stock material
- Vacuum Table
- Small Vacuum





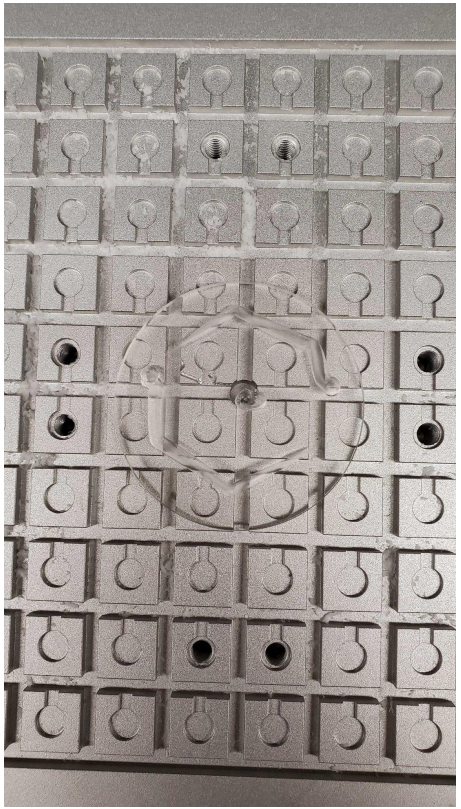


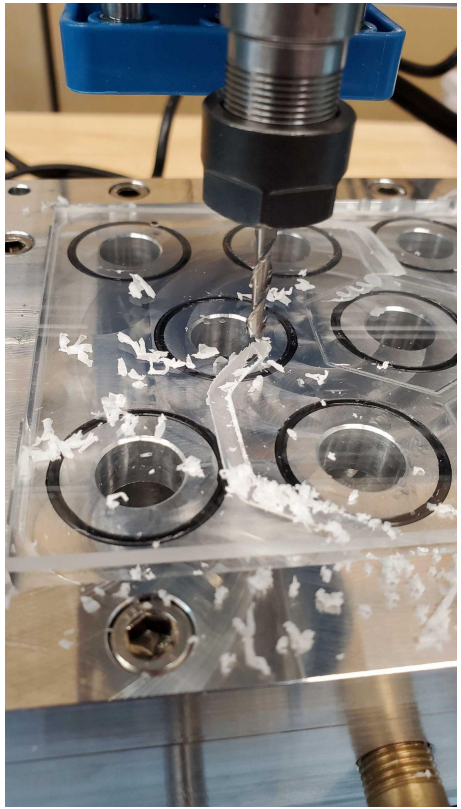


Cutting Tests

Main issues:

- Vacuum Breaks When Water Coolant is applied
- Heating
- Poor Defined CAM Height





Summary

- Fusion 360 for CAD and CAM
- Candle for CNC machine control
- ⅛” 2 flute bit for edge cuts
- Ball end mill bit

Future Goals

- Design and manufacture multiple variations of scintillator cells for testing
- Manufacture Scintillators for Calorimeter Inserts