Stepping Up Precision:

Automated SiPM Characterization for nEXO Experiment

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McGill UNIVERSITY

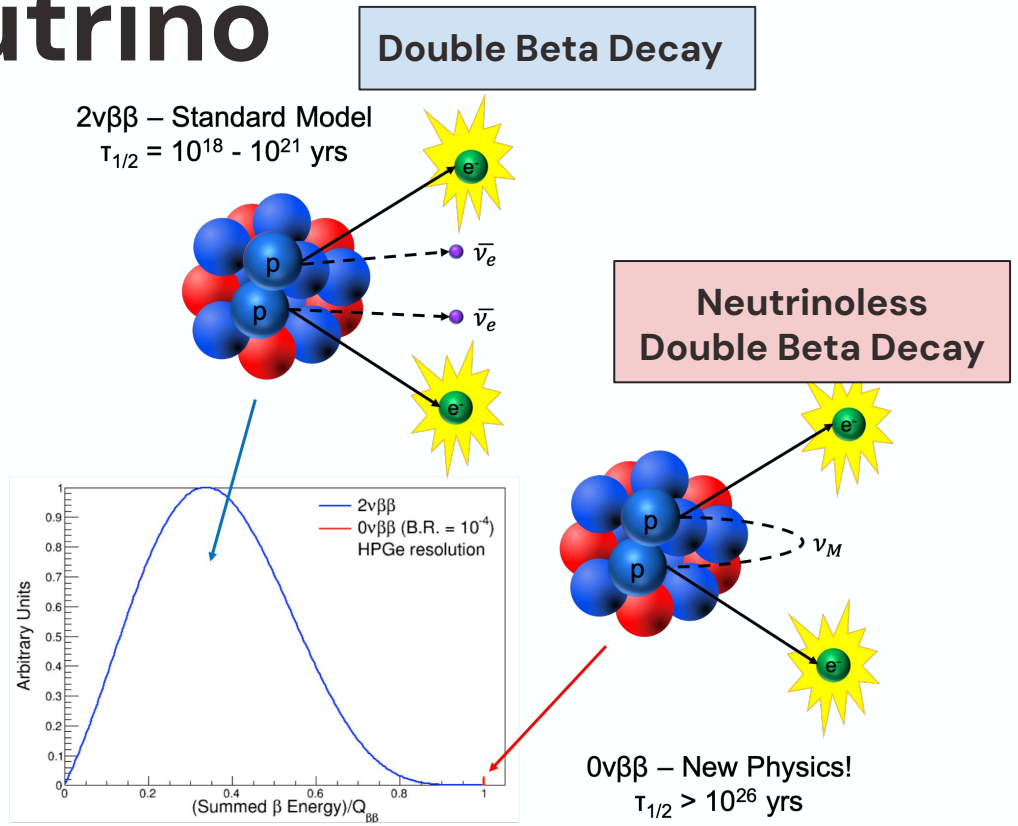
BNL

The Elusive Neutrino

The neutrino is one of the most aloof particles in the **Standard Model**.

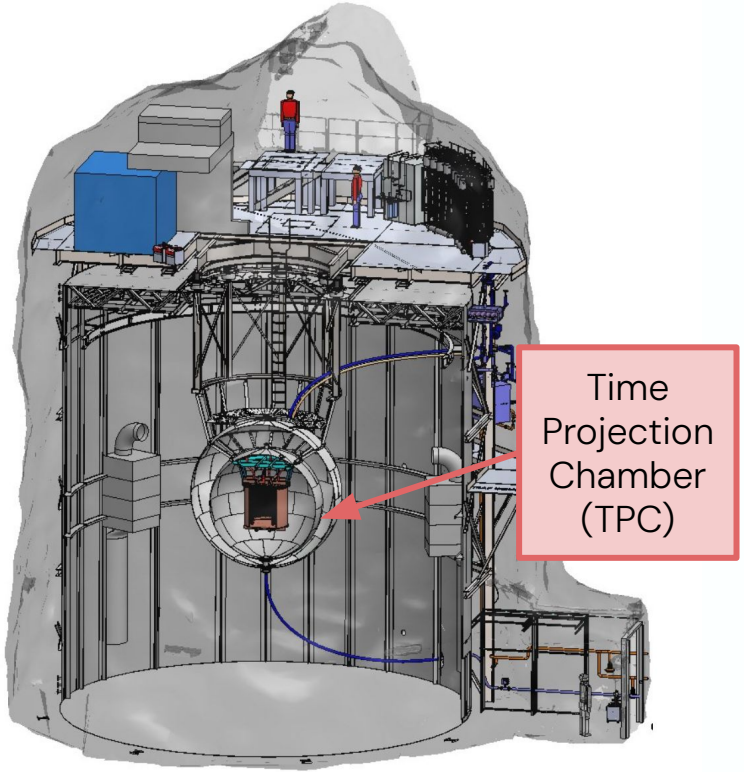
Neutrinos are **tiny, nearly massless particles** with **no charge**.

Neutrinoless double beta decay is **beyond the standard model**



Double beta decay and neutrinoless beta decay diagram (Gruszko, n.d.)

The nEXO Experiment



nEXO detector in SNOLAB Cryopit (*nEXO 2024 June Pictures*, n.d.)

nEXO is a proposed detector searching for a hypothetical rare nuclear decay called **neutrinoless double beta decay** (0νββ).

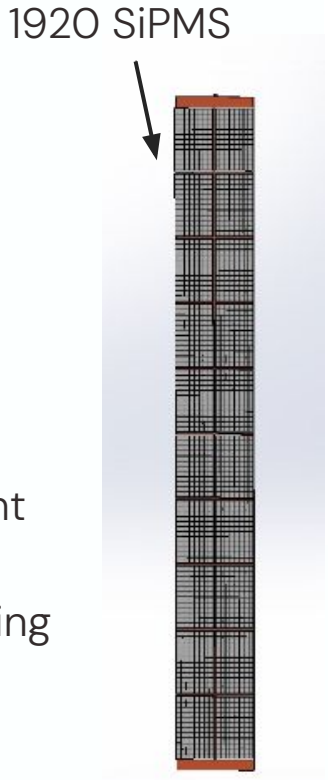
- We are using **~50 000 silicon photomultipliers** (SiPMs) in our TPC

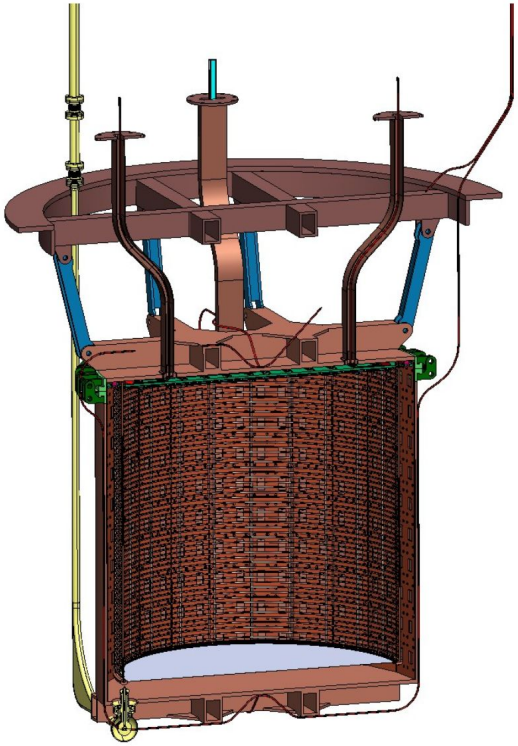
SiPM Characterization

Why Use SiPMs?

- Allow us to derive **timing information** of events in TPC
- Can **detect single photons**
- Can operate in **cryogenic temperatures** (165 Kelvin)

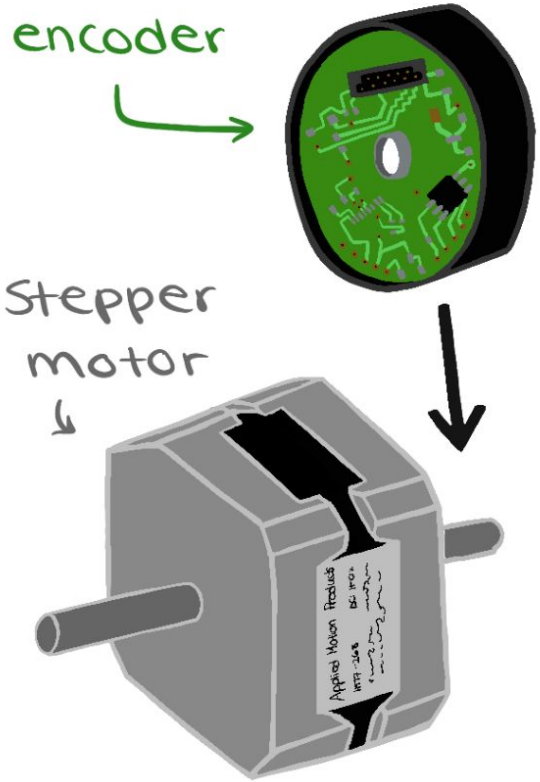
- We need to scan over the SiPMs with a light source to **calibrate** them
- We plan to use precision actuators consisting of **stepper motors and encoders**





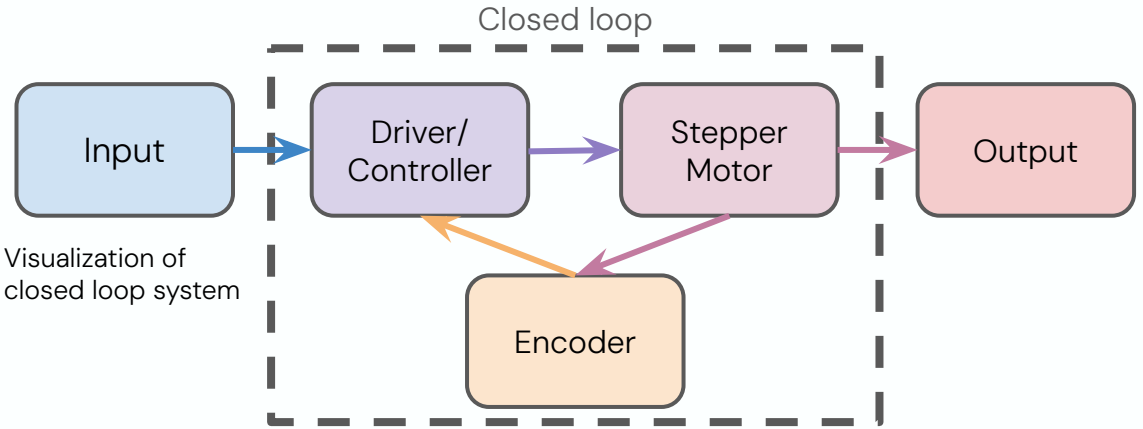
Time Projection Chamber (Right)
Stave (left)
(*nEXO 2024 June Pictures*, n.d.)

What is a Stepper Motor and Encoder?



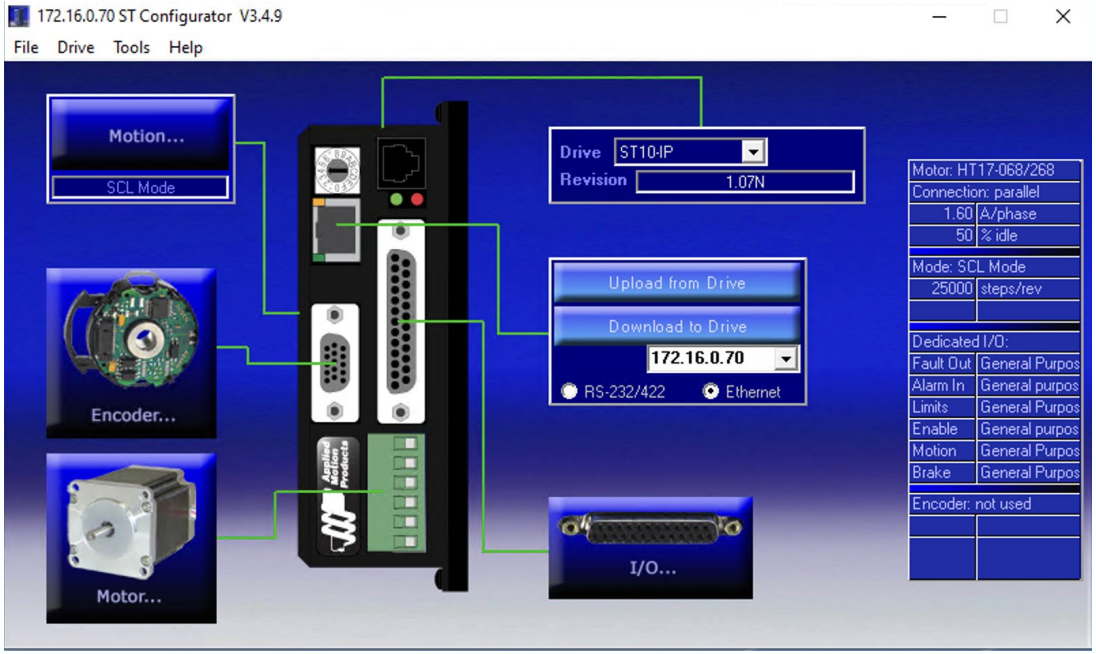
Stepper motor and encoder diagram

- The **stepper motor** rotation is controlled by discrete electrical signals that will move it a ‘step’
  - This stepper motor as **25000 steps**
- The **encoder** can measure rotation angle and speed of the motor and will enable **positioning as small as 0.0001 mm**



Visualization of closed loop system

Getting Started



Applied Motion Products software: ST Configurator

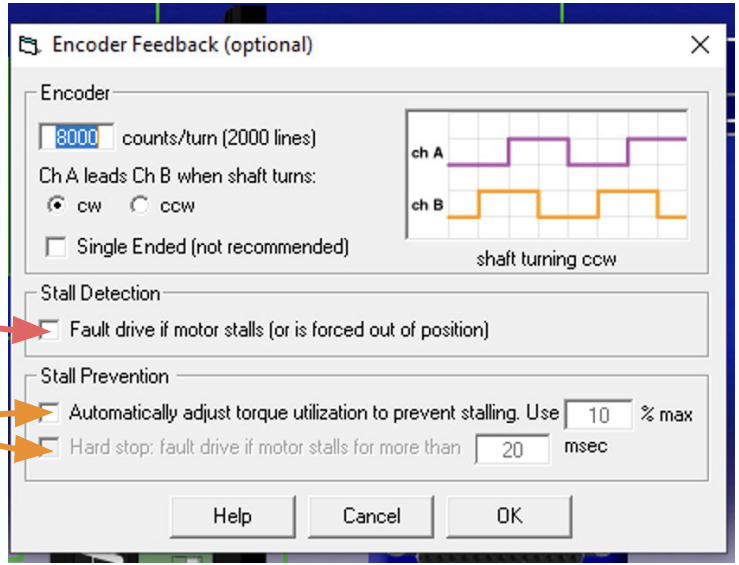
- The software used with Applied Motion Products is STF Configurator

Goal: Use the stepper motor and encoder to make precise scanning movements necessary to scan over the SiPMs

Feature Failures

Would cause motor to stall

Would cause motor to move sporadically



Encoder features popup on ST Configurator

Initial Solutions

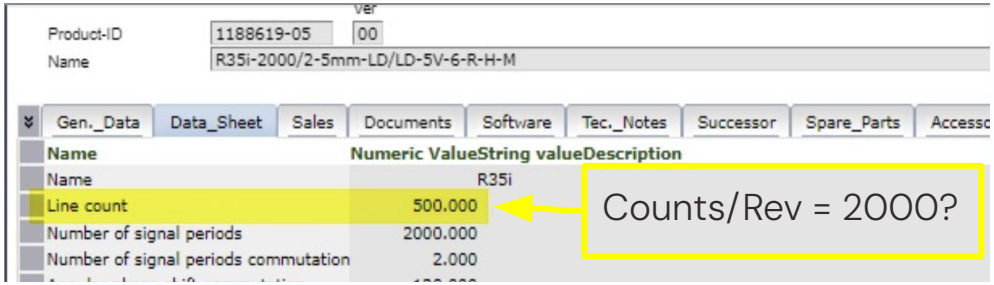
- Studied the **datasheets** and **manuals** for the driver, motor, and encoder
- **Disassembled** the encoder and reassembled using the driver manual

- Contacted encoder manufacturer for the **encoder count**

Decoding the Encoder

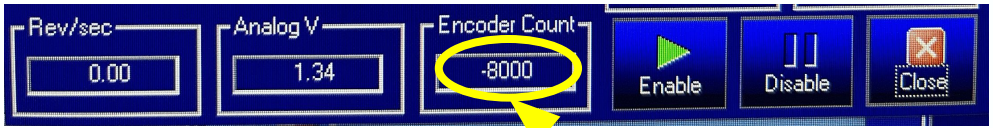
- Received the encoder count however features still did not work….

Counts/revolution = Line count * 4



Manual sent by encoder manufacturer

- After various tests, it was **verified that the encoder readout was correct** finally unlocking the next stage



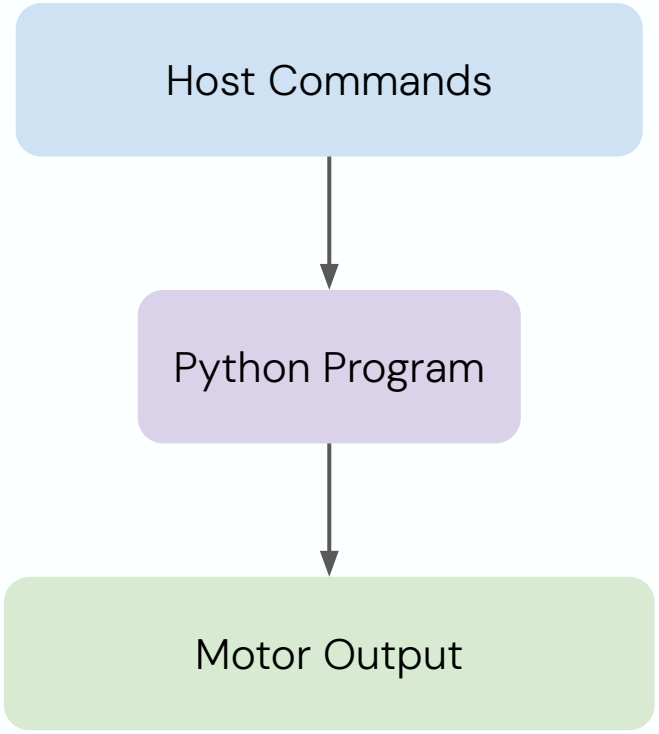
Readout on ST Configurator

After one revolution

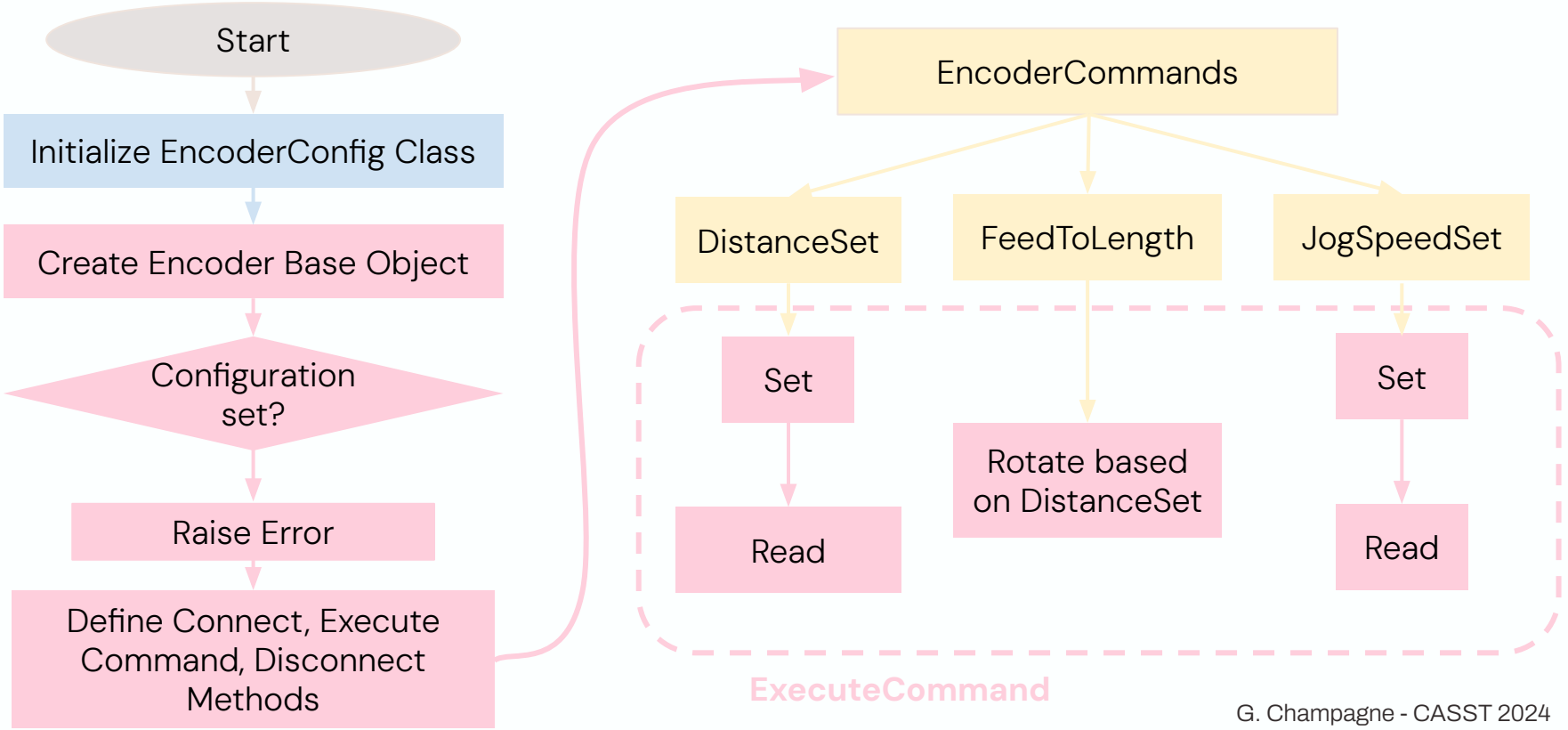
Stepper Motor Control Program

Goals:

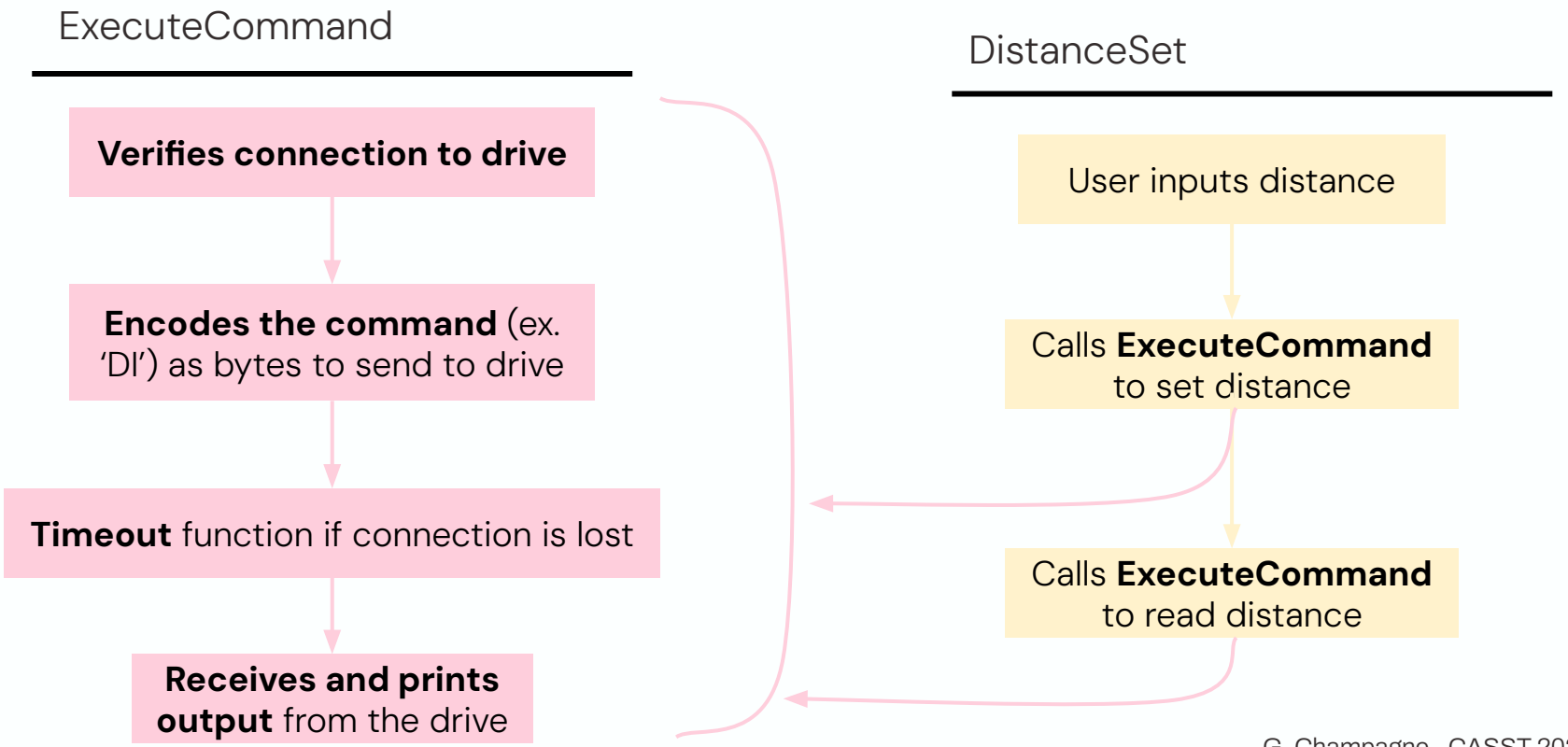
- To organize program into **classes**
- Include functions such as: **connect, reset device, home, go to position, read encoder, read back**
- Write short return time functions (<5sec)



Building Functional Code



Command Logic: DistanceSet



In Summary & Onward

Successes:

- Troubleshooting initial issues
- Code development
- It works!

Remaining Challenges:

- Occasional connection errors
- Temperature limits

Next Steps:

- Homing function
- Further refinement to program

Thank You!

Contact me!

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References

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** All figures created by author unless otherwise noted

Mastering Host Commands

- Built in programming software written in Applied Motion's **Serial Command Language (SCL)**

- Created a test to **ensure motor and driver communications**
- Initial test was **successful**