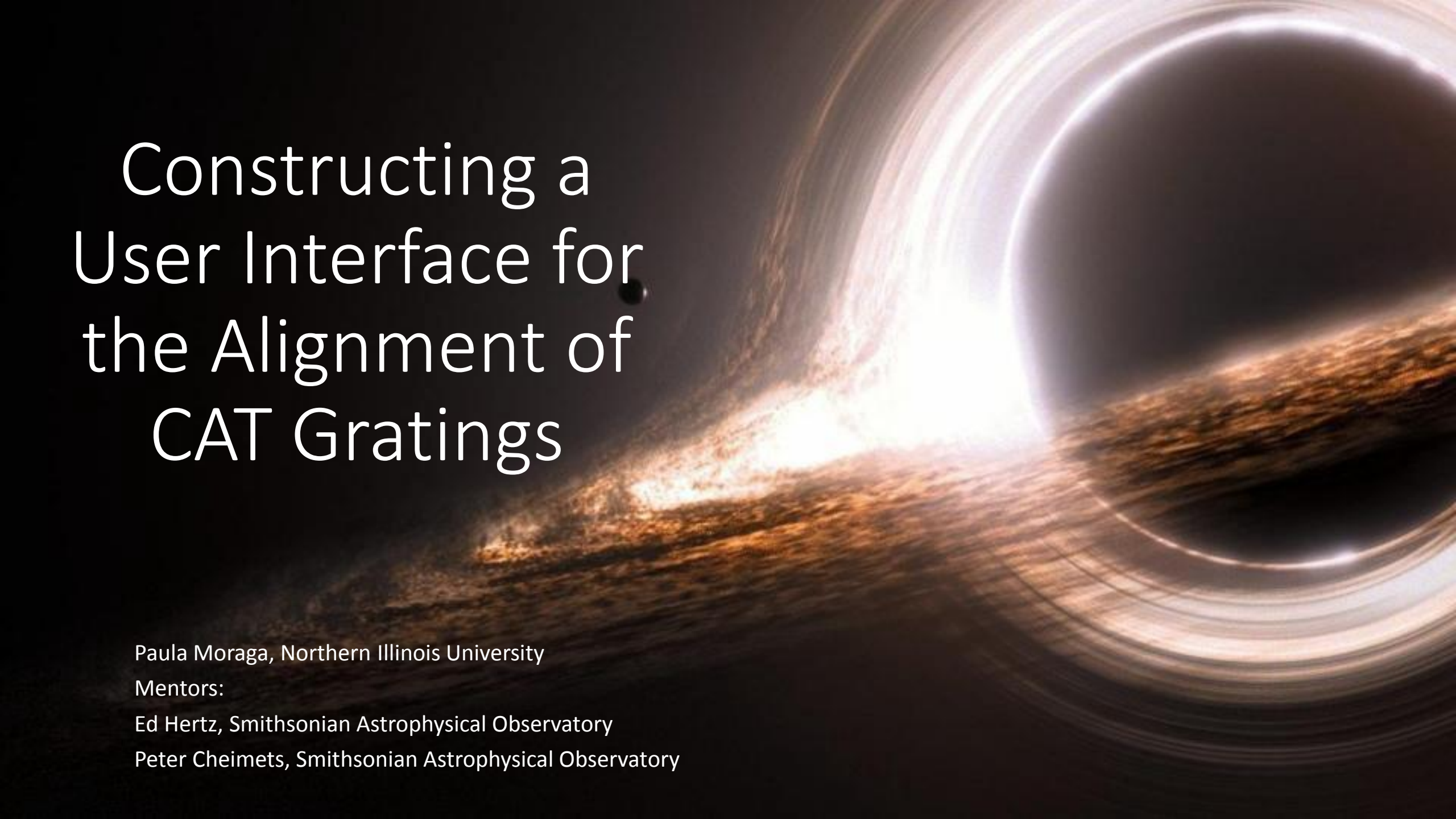
Constructing a User Interface for the Alignment of CAT Gratings



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Overview

- Project Overview
- CAT gratings
- Current alignment process
- The Problem
- Writing a software
- Future Work

Project Overview

- Writing a software for the simplification of an alignment process
- Arcus is an x-ray spectrometer that requires 704 critical angle transmission (CAT) gratings that each need to be aligned

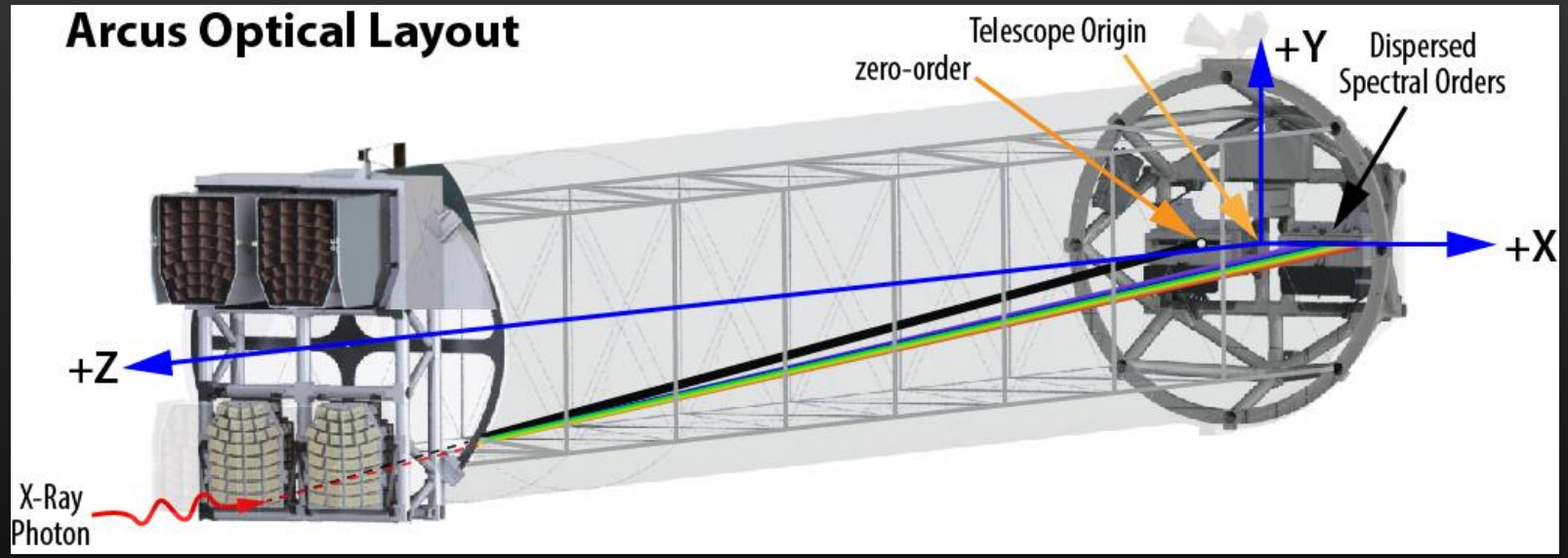


Image of Arcus Optical Layout retrieved from Arcus Proposal.

Big Picture

- Arcus is an x-ray spectrometer that is being built to answer three big questions:
  - How do baryons cycle in and out of galaxies?
  - How do emissions from black holes affect its surroundings?
  - How do stellar environments form and evolve?
- Flight projected for 2023

Image of molecular cloud Rho Oph.

CAT gratings

- Critical angle transmission (CAT) gratings allow for x-ray photons to pass at a grazing angle through the parent material.
- Developed for high resolving power soft x-ray spectrometers[1].
  - Advantages of blazed reflection gratings
  - Advantages of conventional transmission gratings
- Arcus will be using 704 of these gratings that must be interchangeable with each other.

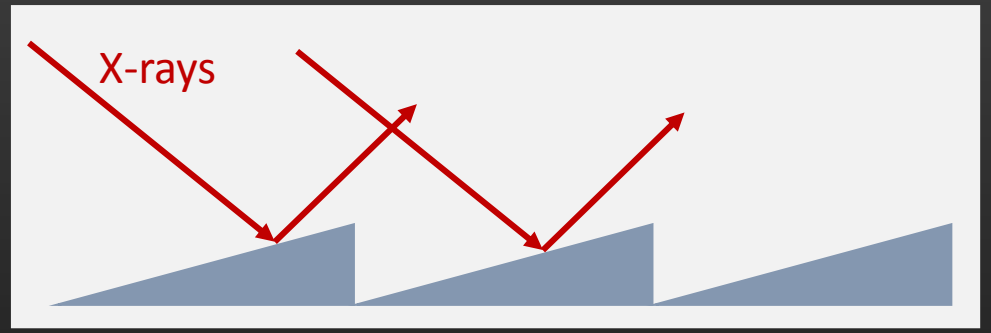


Diagram of a blazed reflection grating.

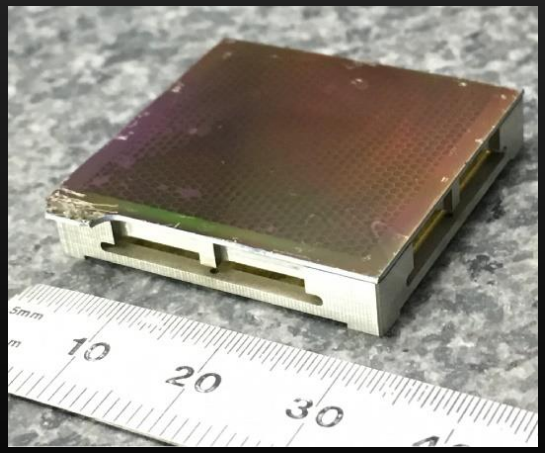
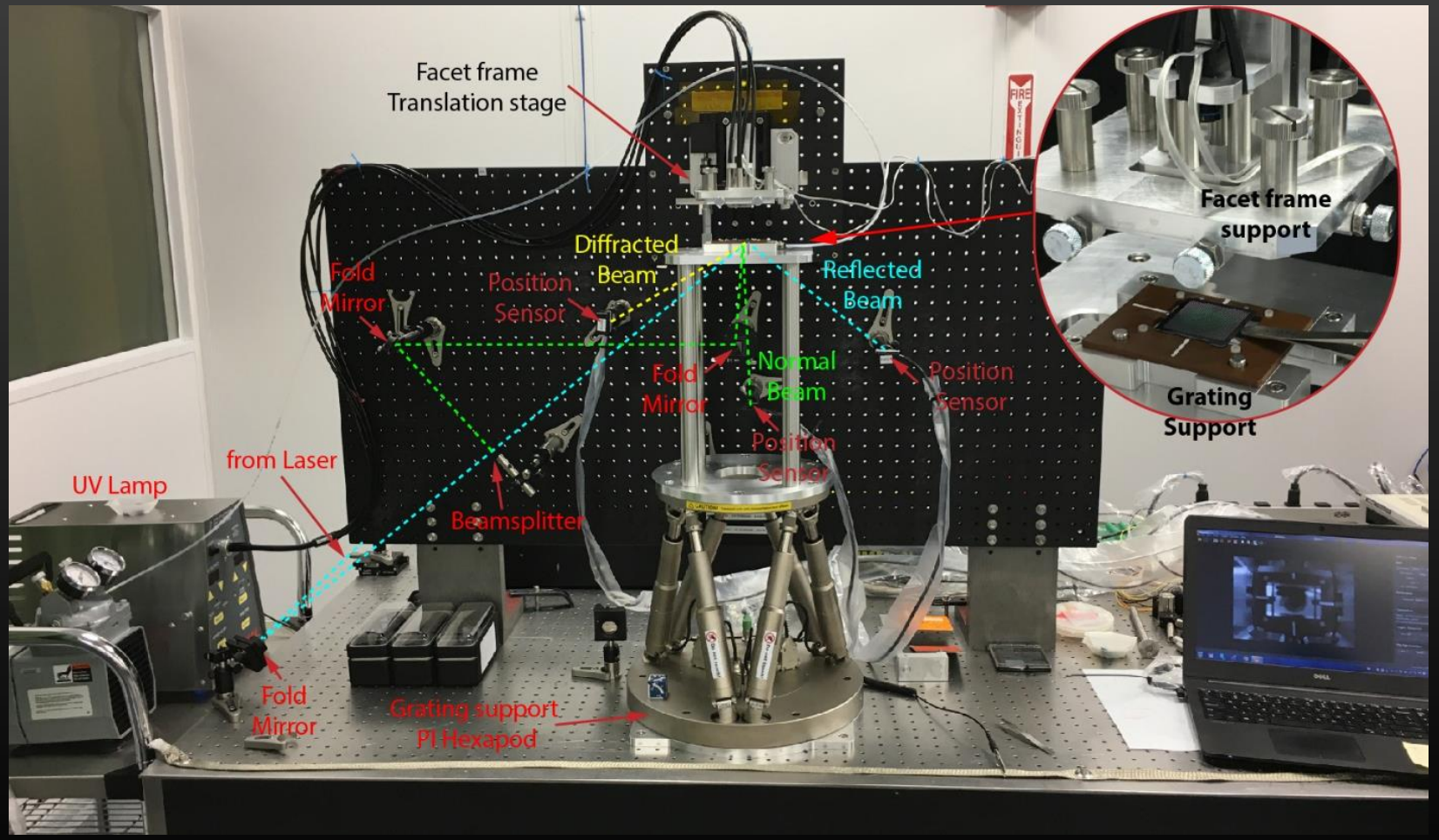


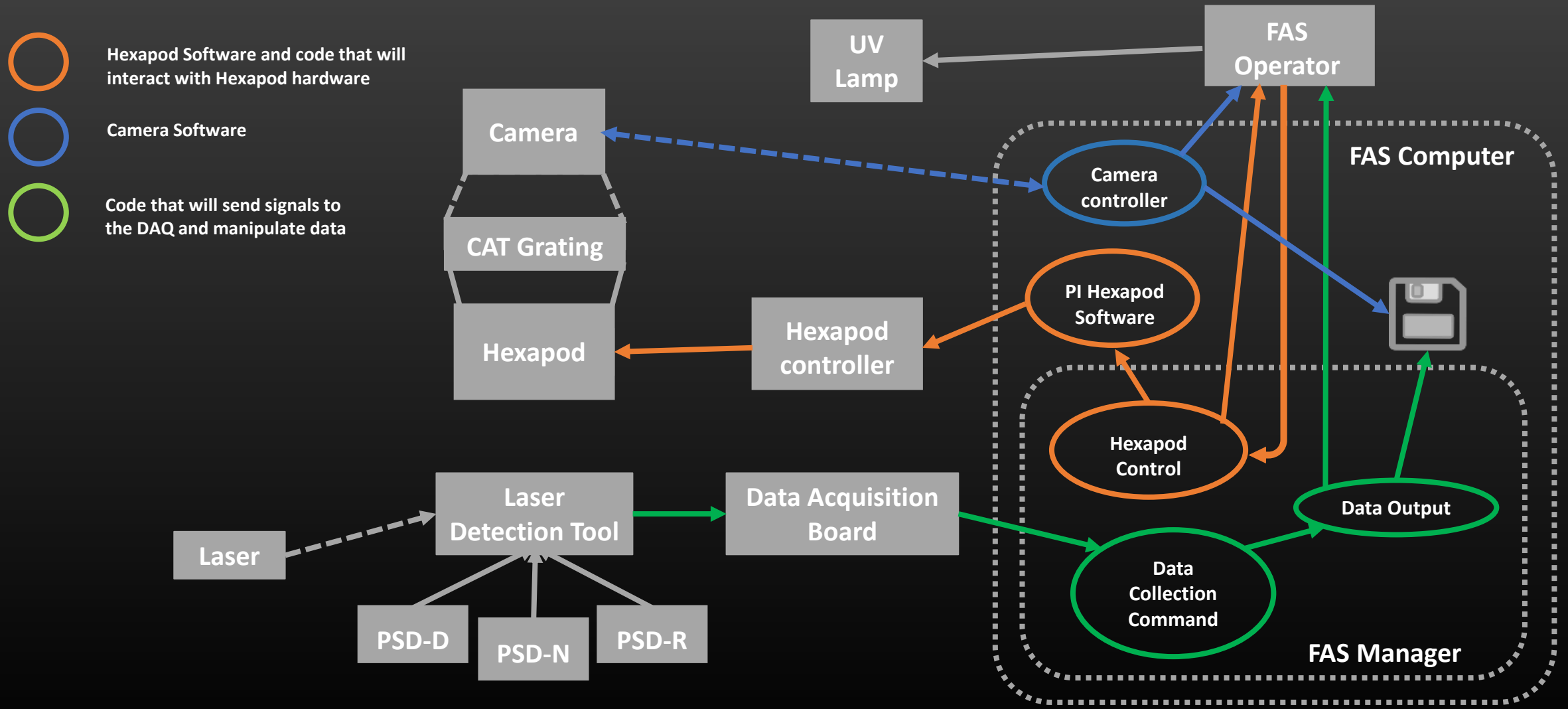
Image of CAT grating and its facet frame.

Current Process



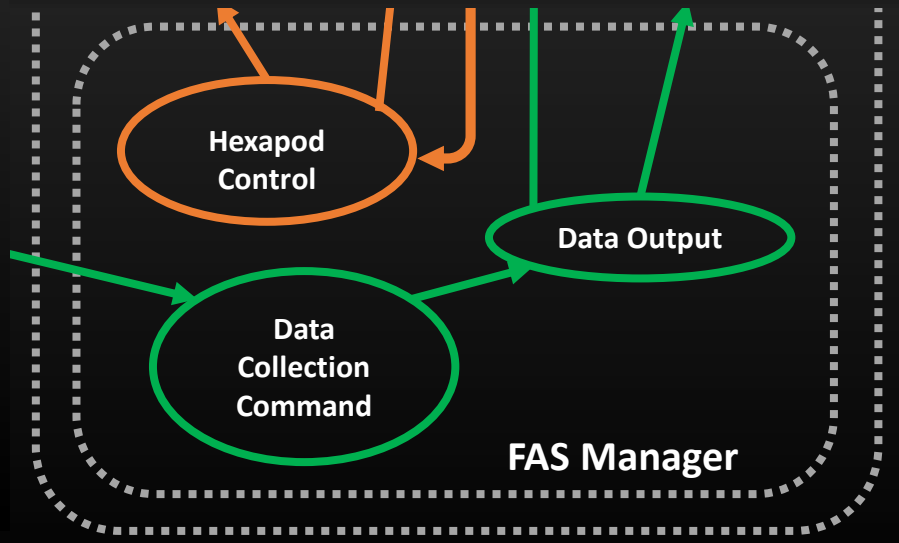
- Alignment is necessary due to fabrication error
- Two computers monitored by two people
- Not very practical, we need something simpler

Proposed New Process

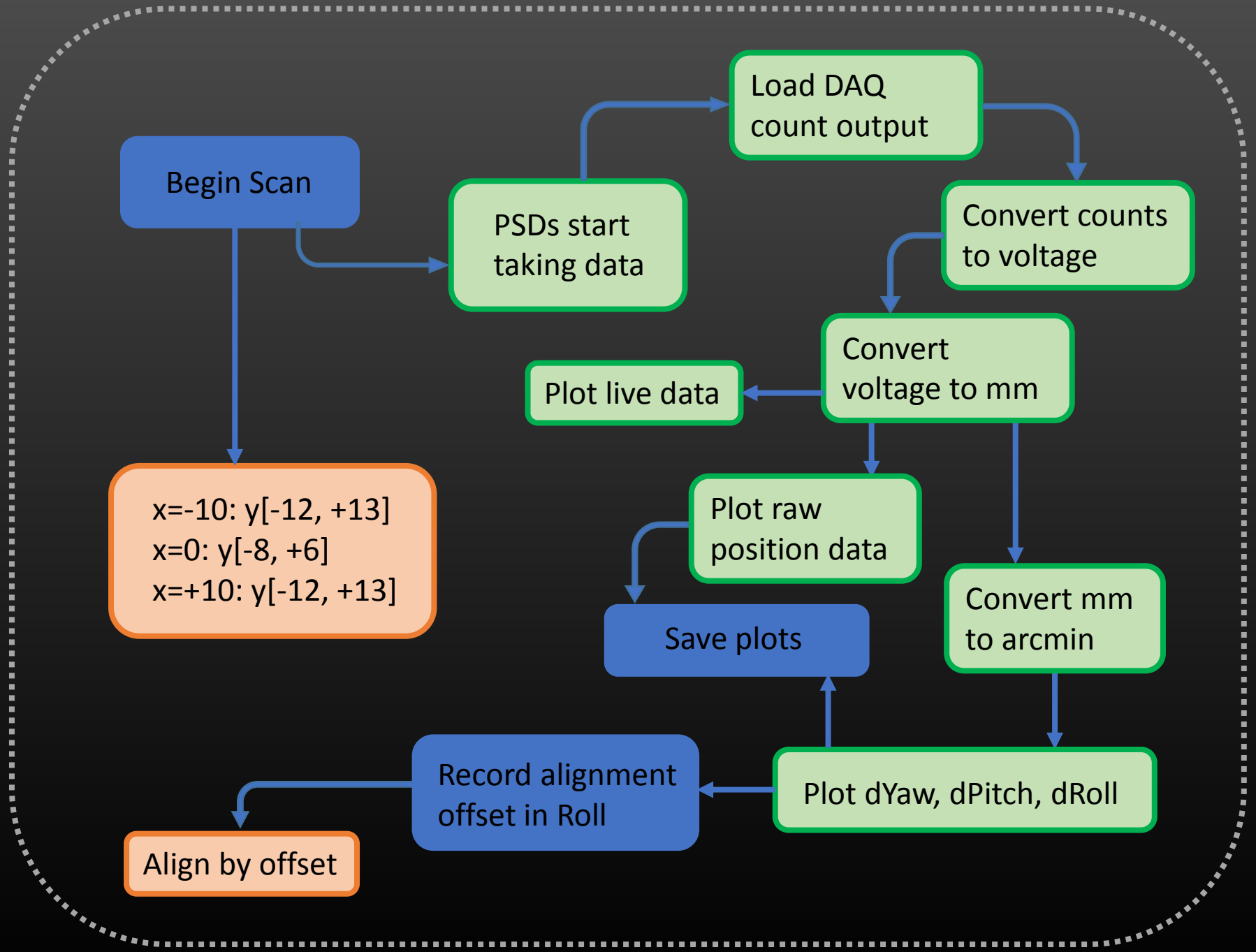


Project Specifics

- Focusing on data collection and manipulation for misalignment calculation
  - Translating code in C# and Matlab into Python
  - Creating missing functions
  - Writing algorithms that take into account the Hexapod's movement



FAS Manager

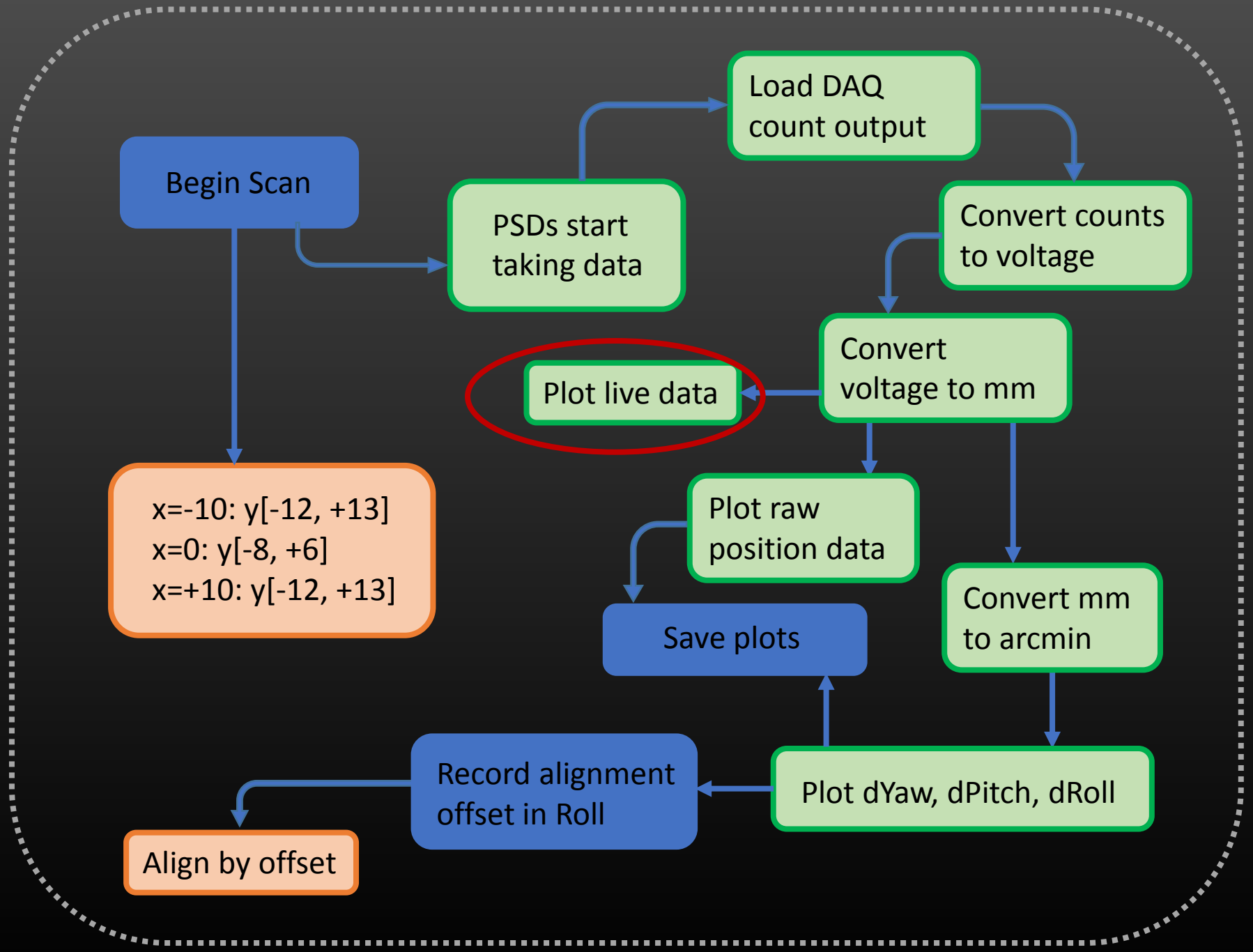


Executed by code pertaining to movement of Hexapod

Executed by code pertaining to data collection and manipulation

Involves user interaction

FAS Manager



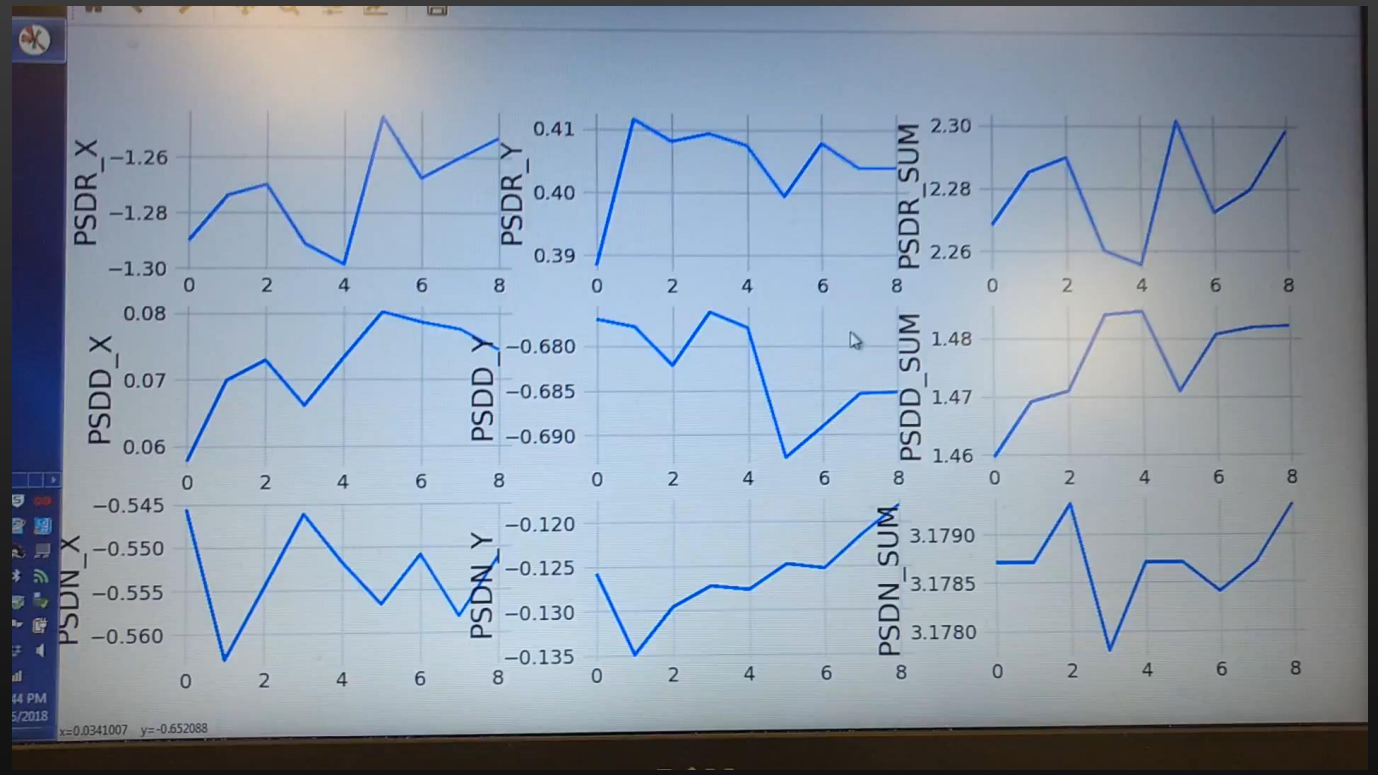
Executed by code pertaining to movement of Hexapod

Executed by code pertaining to data collection and manipulation

Involves user interaction

Live plotter

- Data is only collected while the Hexapod's y-axis is moving in the positive direction
- Translated C# code



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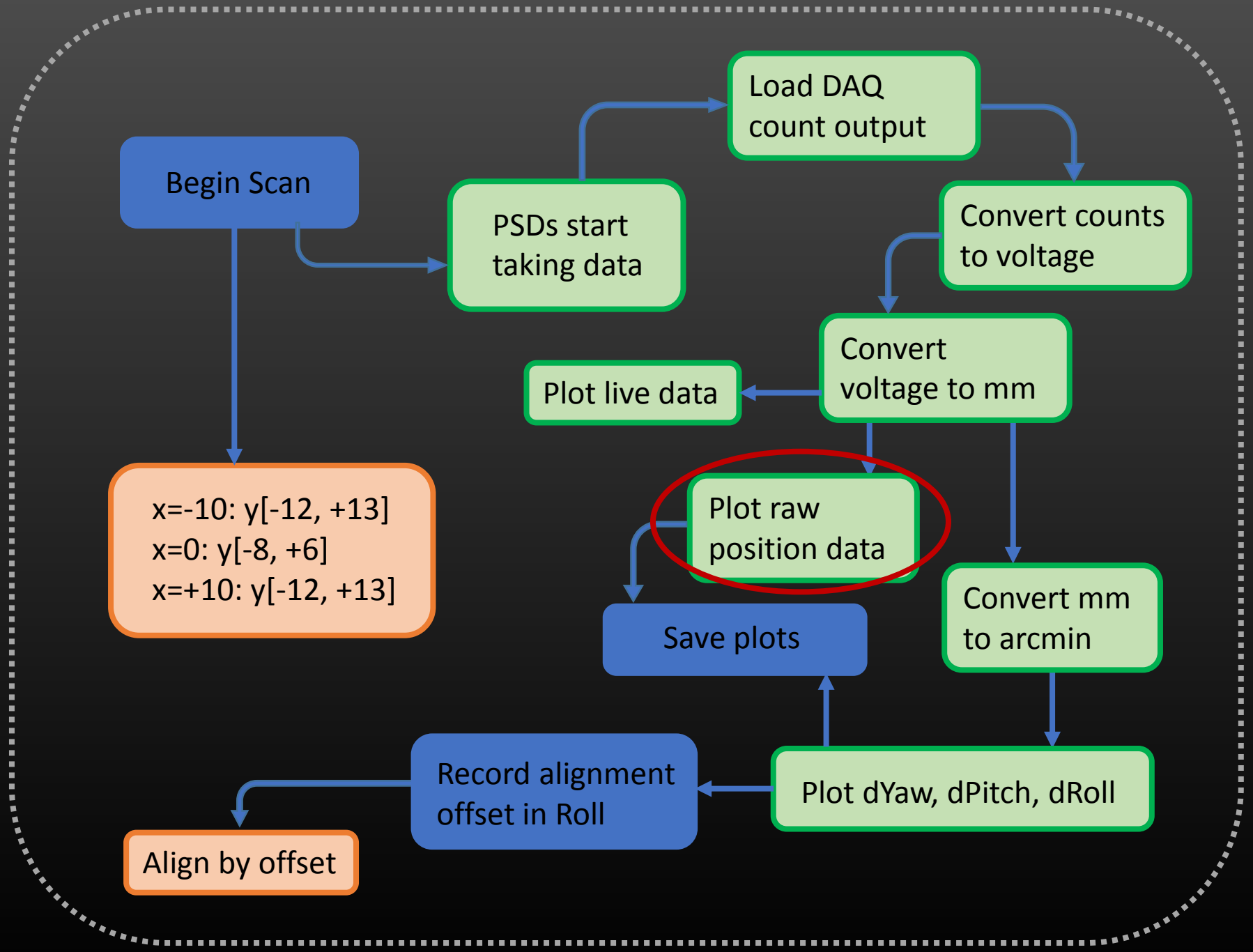

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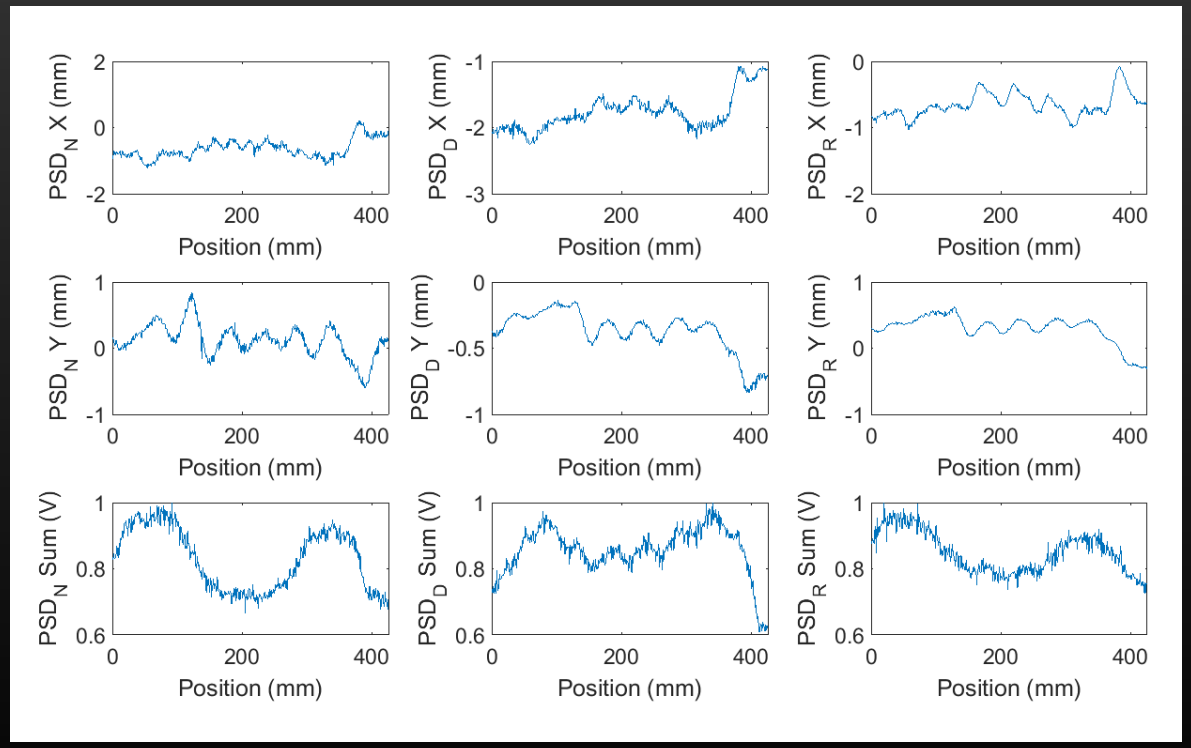
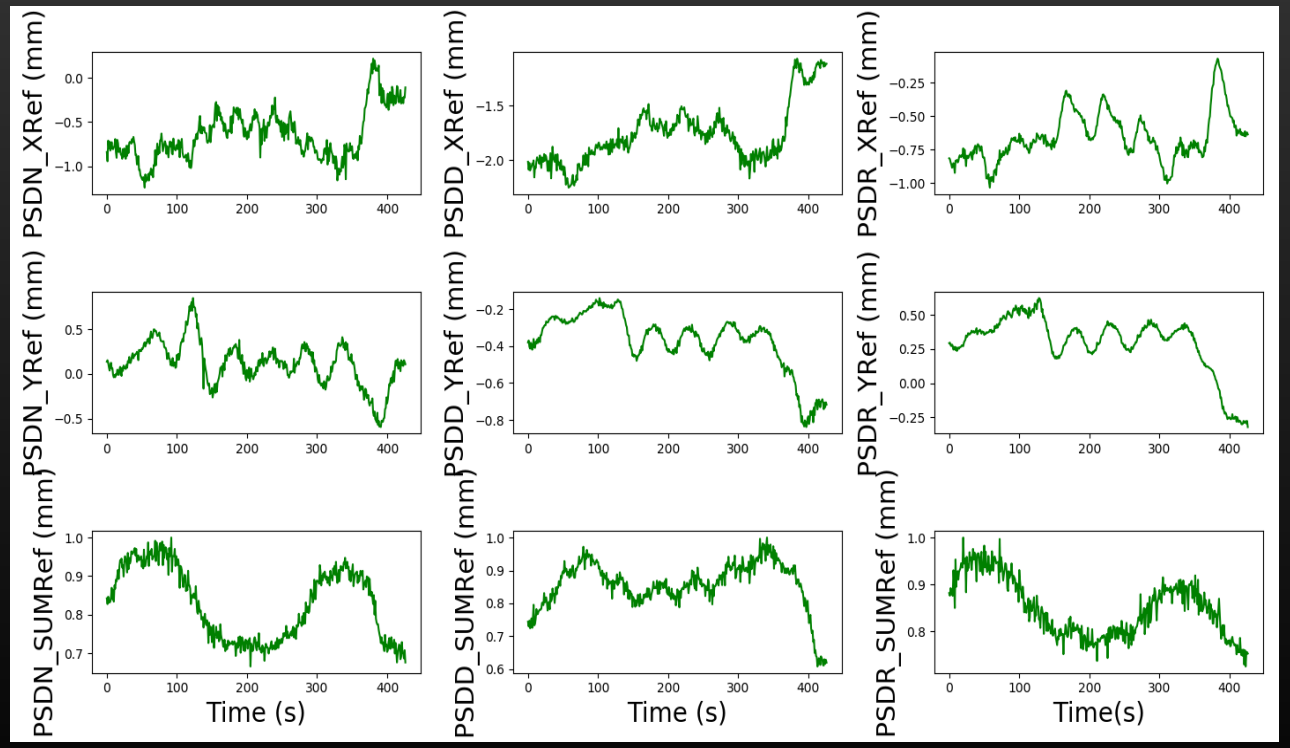
Data manipulation

Matlab plot: Reference Grating (X19)

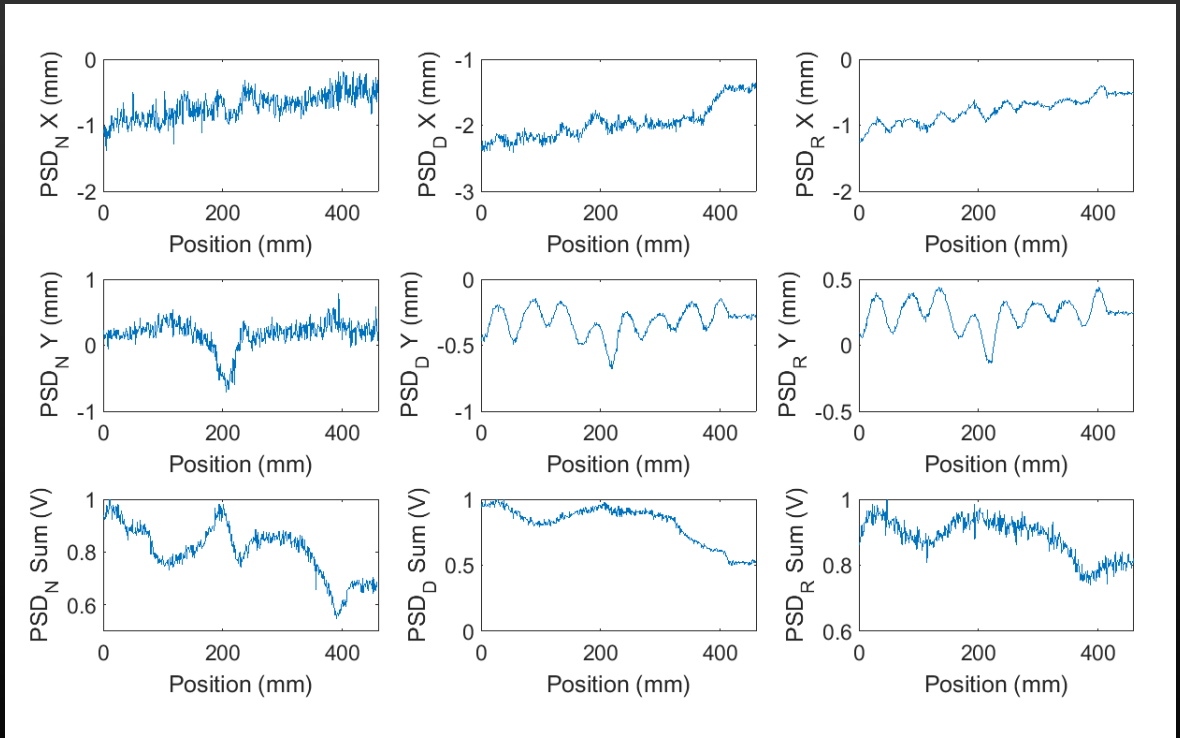


Python plot: Reference Grating (X19)

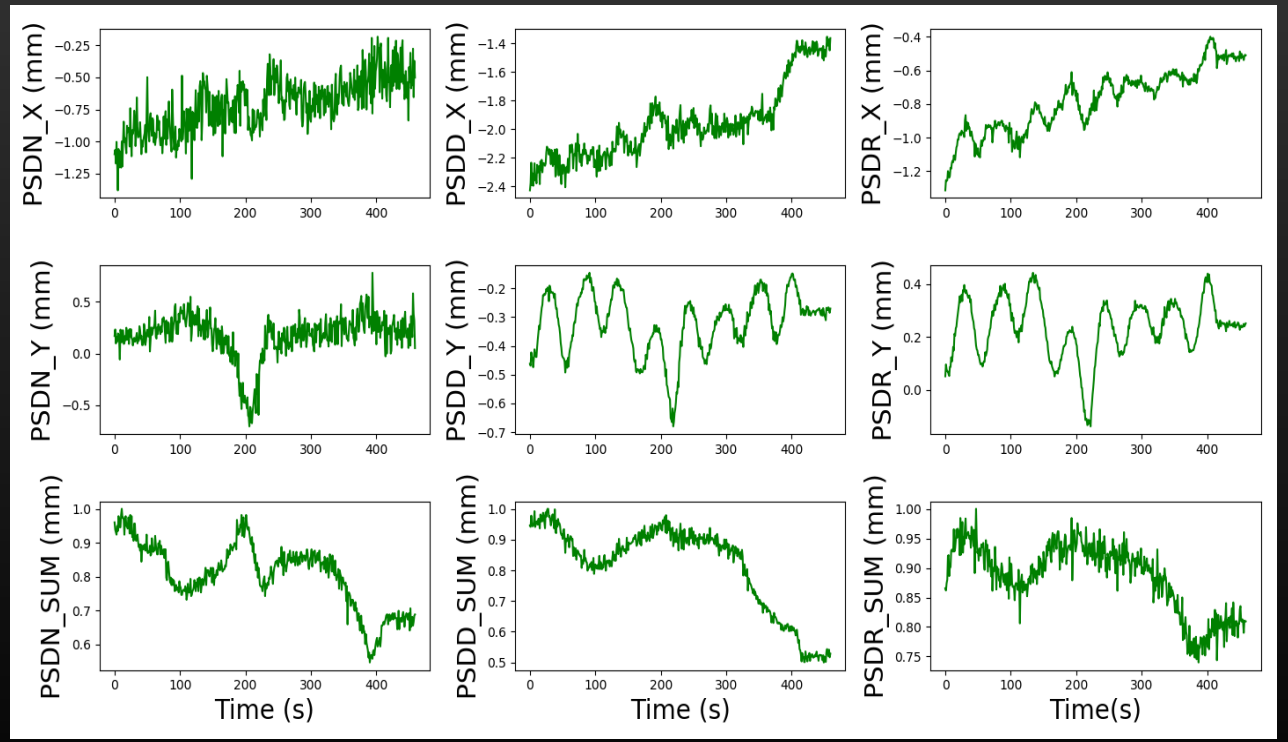


Data manipulation

Matlab plots: Scanned Grating (X21)

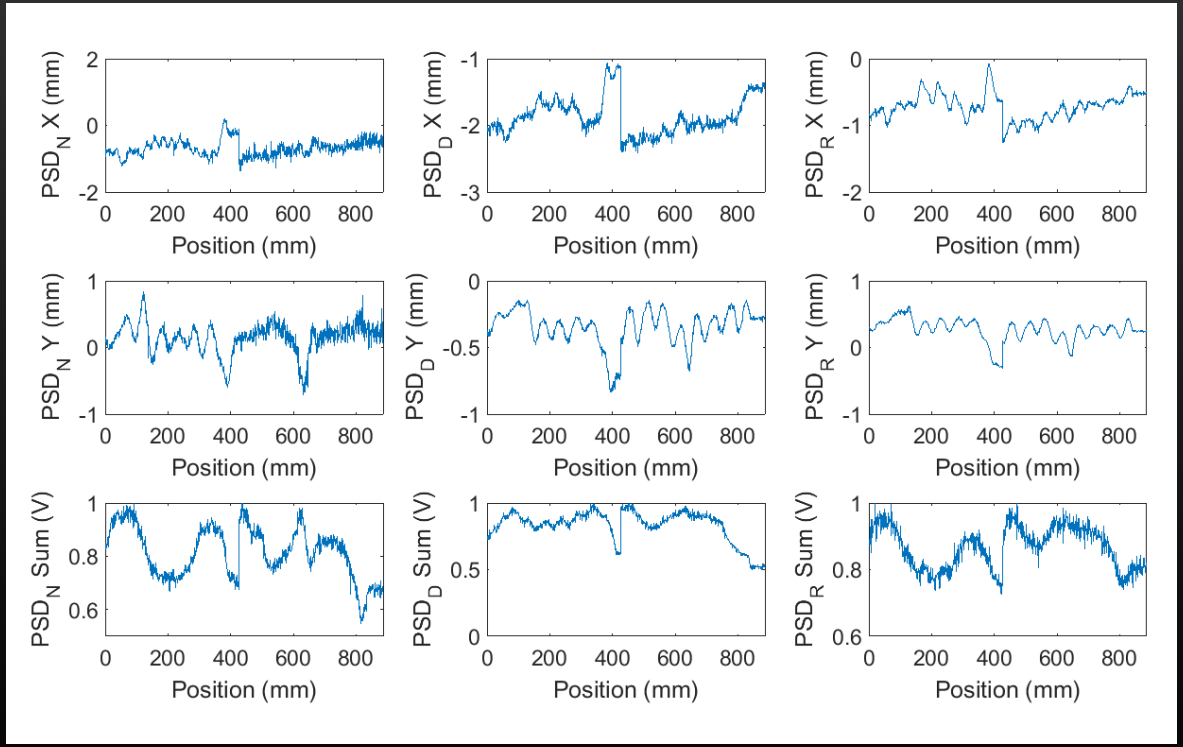


Matlab plots: Scanned Grating (X21)

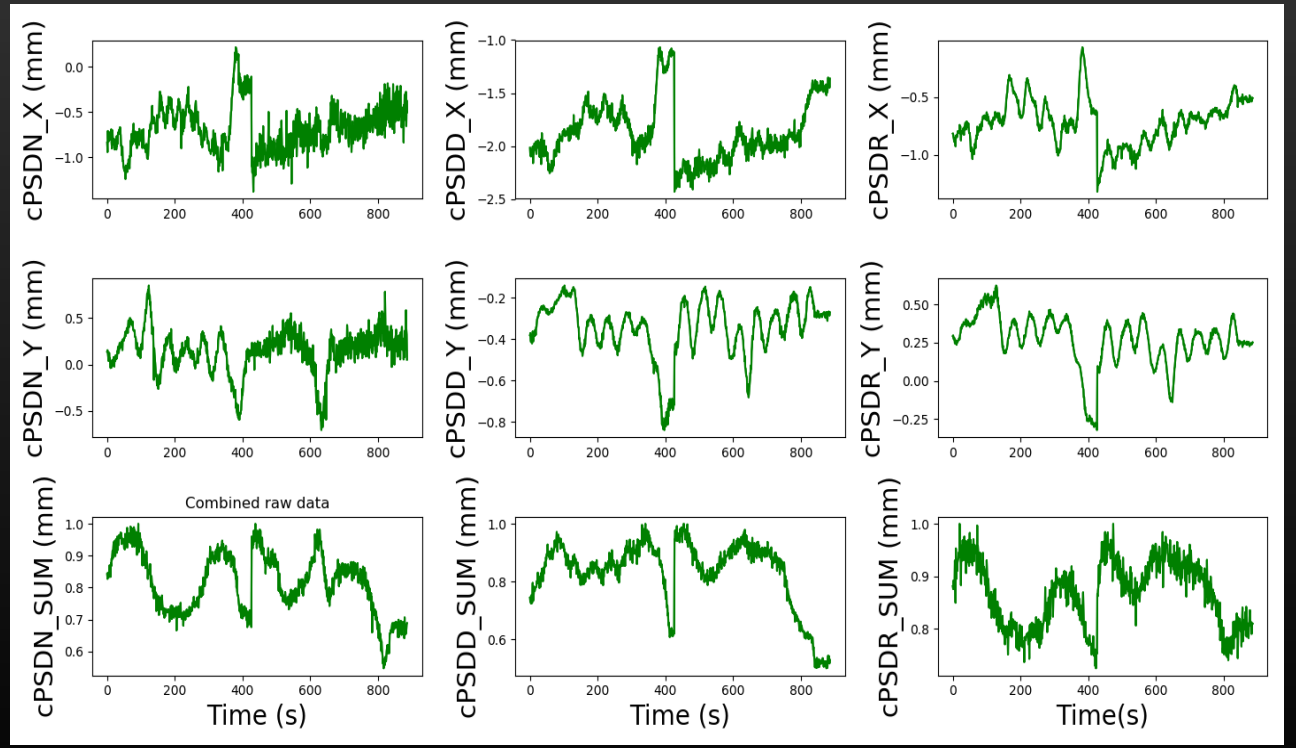


Data manipulation

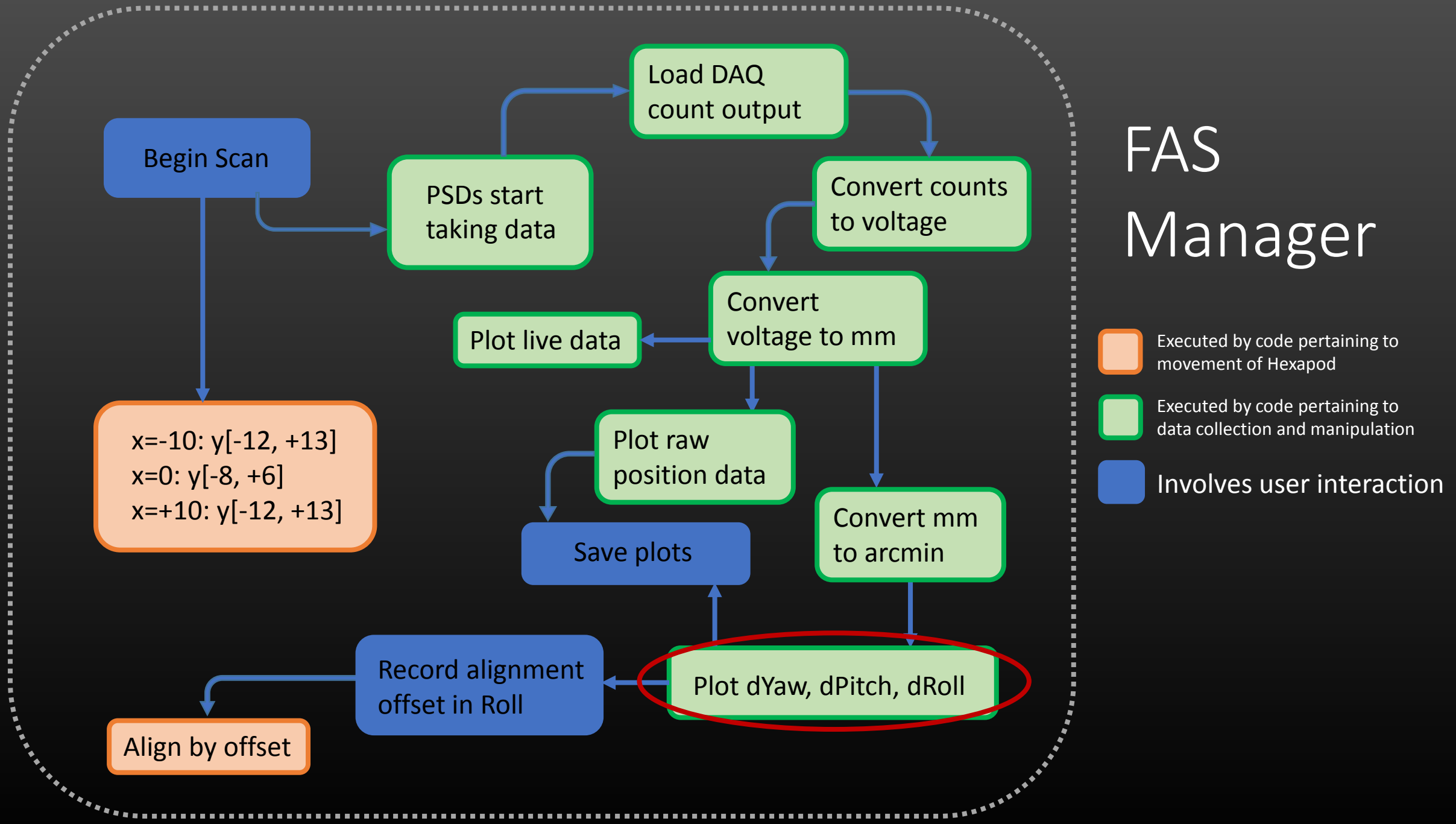
Matlab: Combined Data (X19, X21)



Python plot: Combined Data (X19, X21)

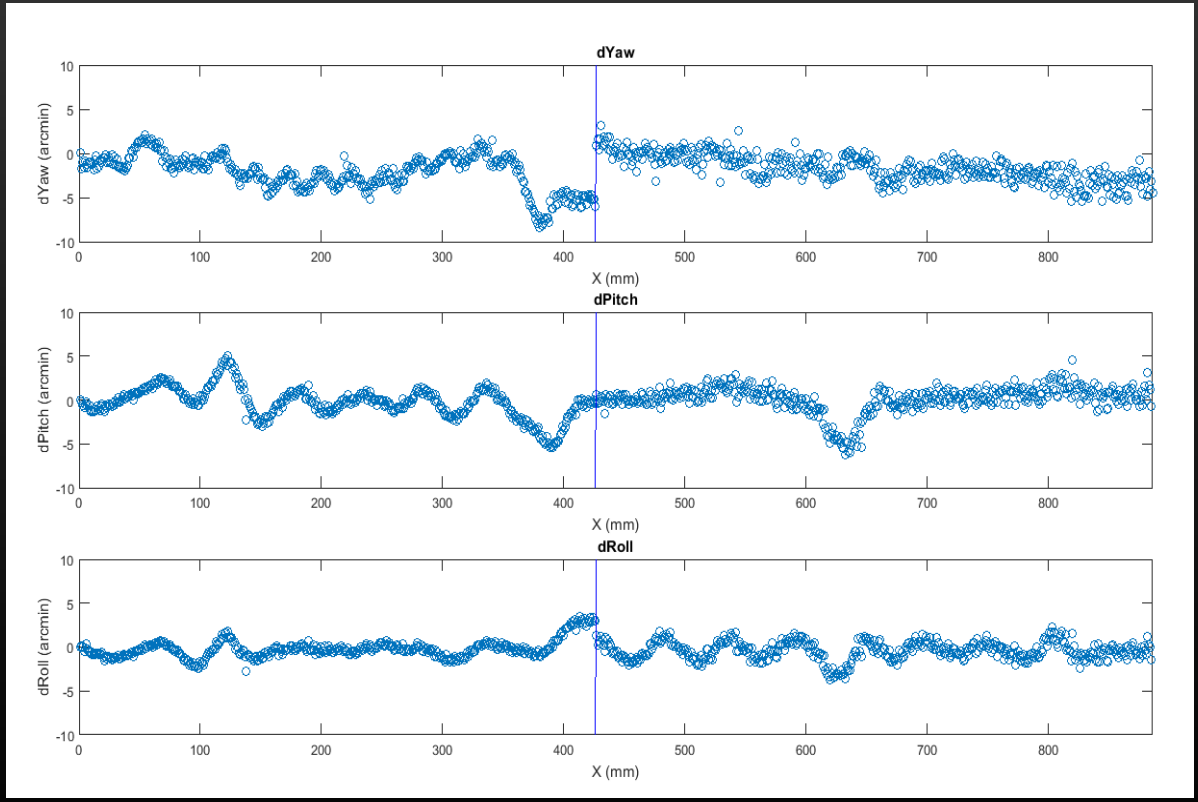


FAS Manager

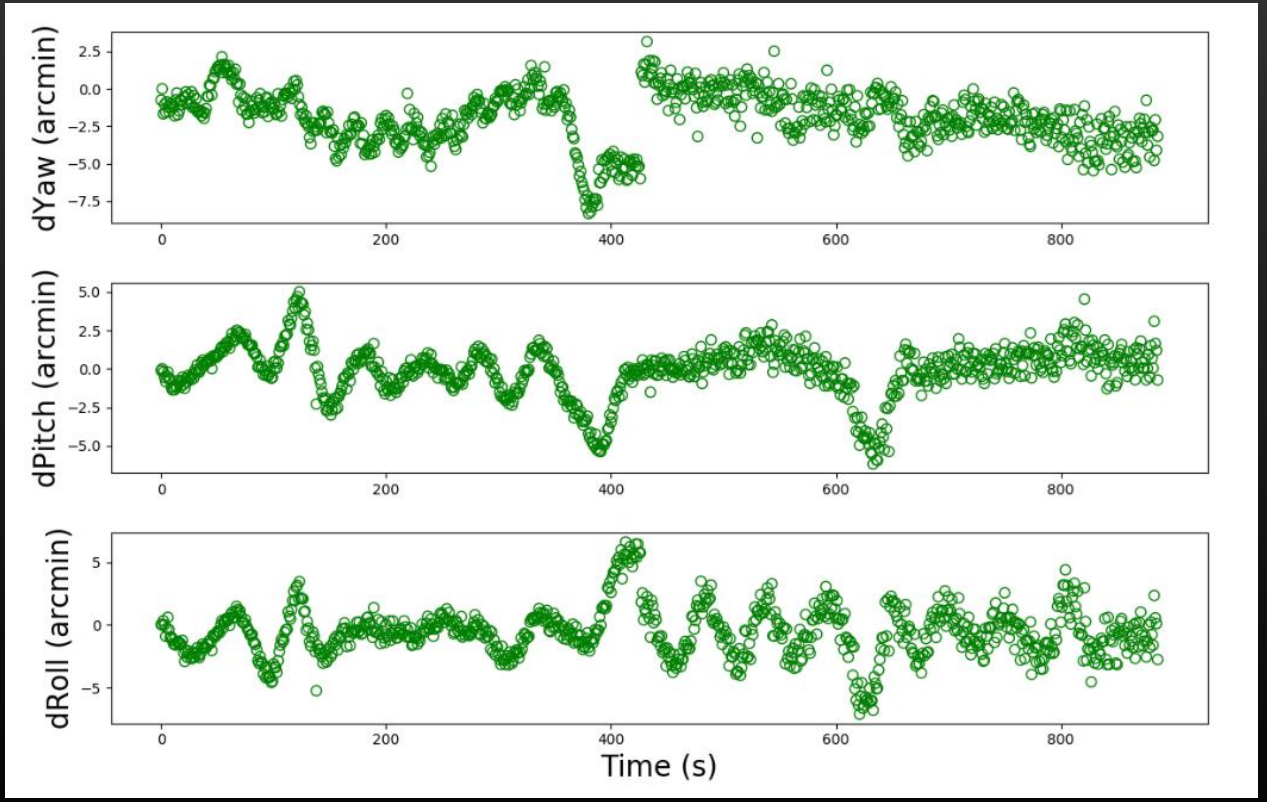

Begin Scan
Load DAQ count output
PSDs start taking data
Convert counts to voltage
Convert voltage to mm
Plot live data
x=-10: y[-12, +13]
x=0: y[-8, +6]
x=+10: y[-12, +13]
Plot raw position data
Save plots
Convert mm to arcmin
Record alignment offset in Roll
Plot dYaw, dPitch, dRoll
Align by offset
Executed by code pertaining to movement of Hexapod
Executed by code pertaining to data collection and manipulation
Involves user interaction

Data manipulation

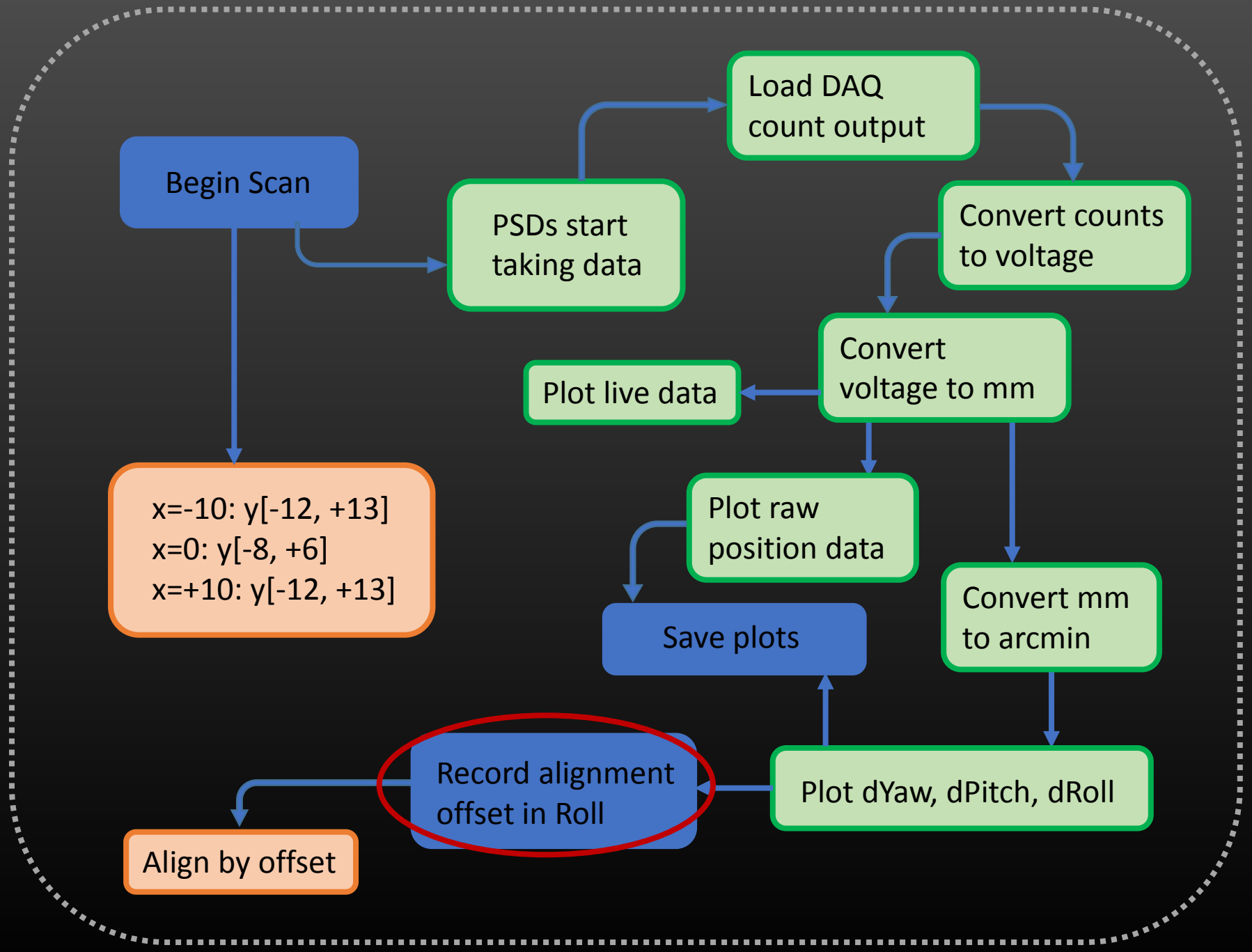
Matlab plot: dYaw, dPitch, dRoll



Python plot: dYaw, dPitch, dRoll



FAS Manager



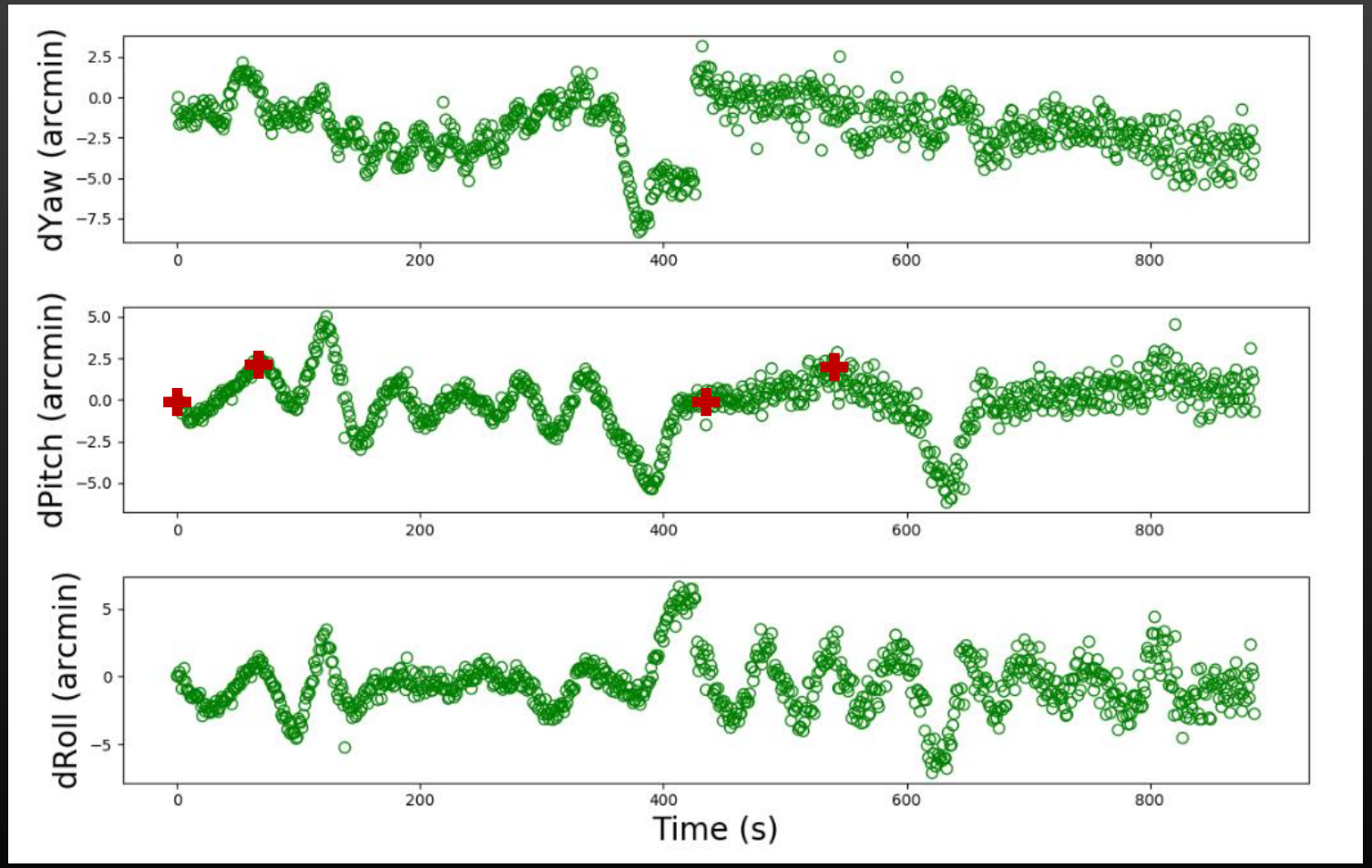
Executed by code pertaining to movement of Hexapod

Executed by code pertaining to data collection and manipulation

Involves user interaction

Misalignment calculation

- After data is collected and plotted, the grating's misalignment is calculated with user input
- Two ranges are selected and compared two each other



Conclusion

- A complex aligning process was simplified by creating a single software
- Data collection and manipulation were merged
- Movements of the Hexapod were incorporated
- GUI still needs to be built around it

Acknowledgements

A special thanks to Ed Hertz, Peter Cheimets, Jacob Hohl, and Jung Ki Song, who all played an important role in helping me with this project.

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Thank you!