ID Controls for Diamond-II

Ronaldo Mercado

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Contents

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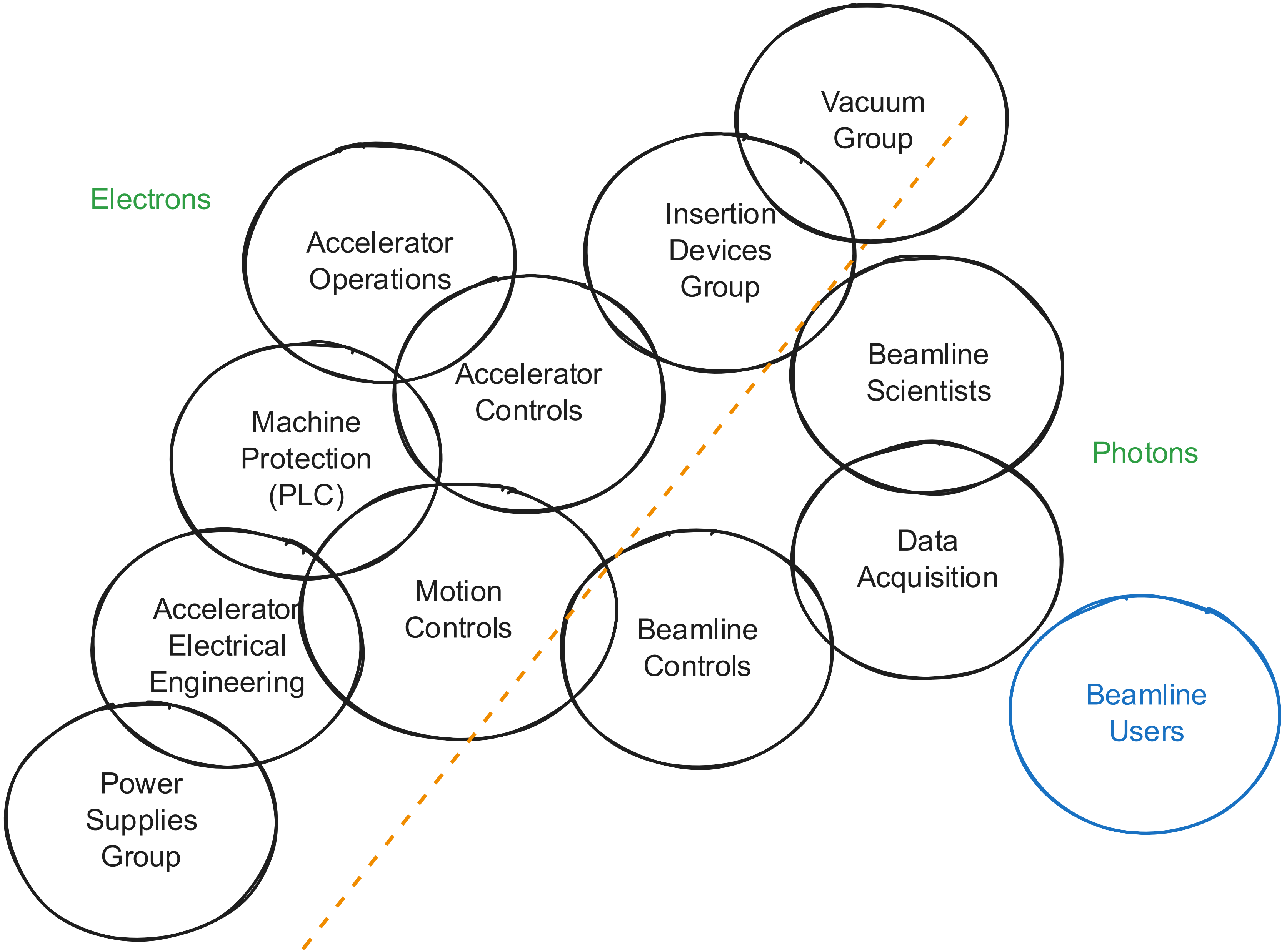
- Paul Amos
- Colin Stunnel
- Many others
  - Former colleagues
  - Current colleagues
  - External collaborators

diamond

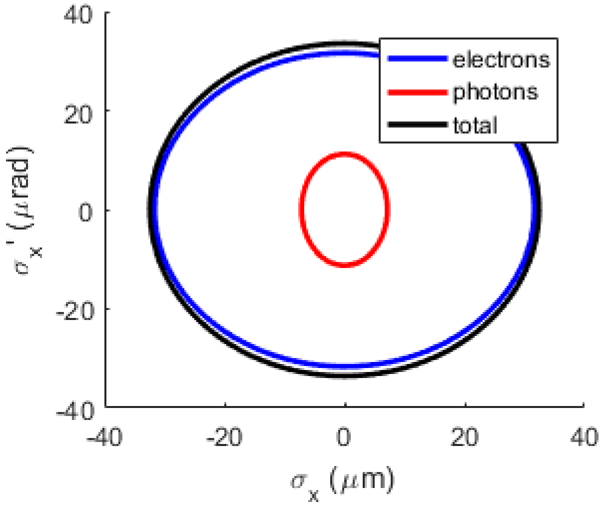

Electrons
Accelerator Operations
Accelerator Controls
Machine Protection (PLC)
Accelerator Electrical Engineering
Motion Controls
Power Supplies Group
Insertion Devices Group
Vacuum Group
Beamline Scientists
Beamline Controls
Data Acquisition
Photons
Beamline Users

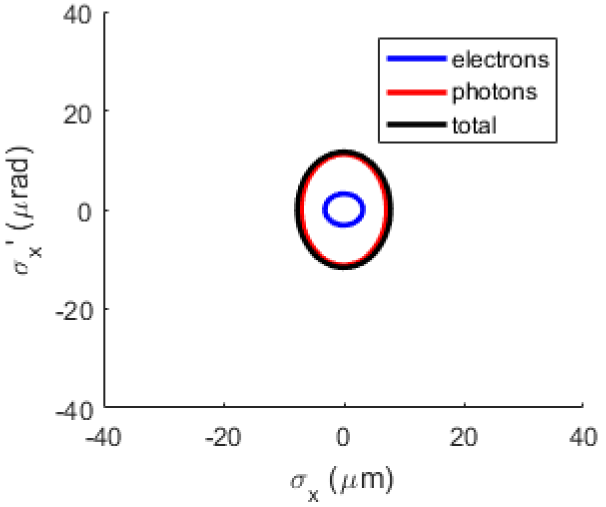
Contents

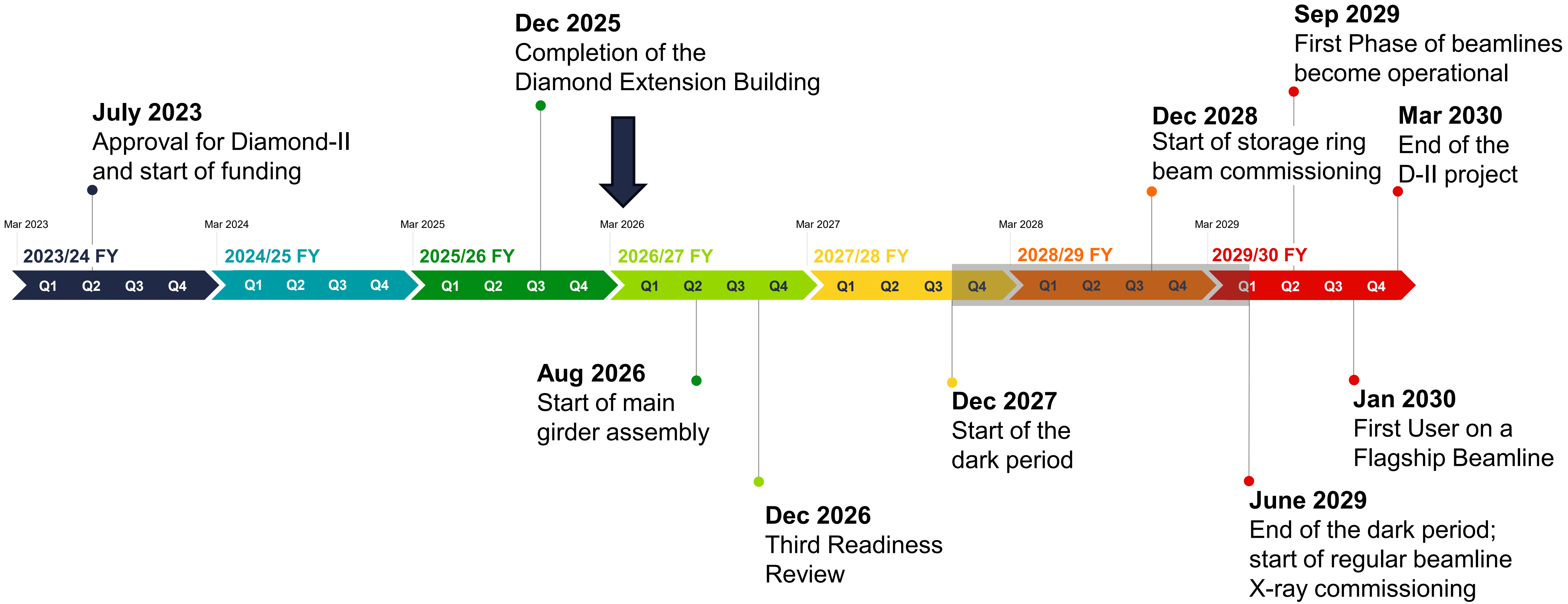
diamond

Diamond

- Diamond is a 3rd generation synchrotron light source
- Located at Rutherford Appleton Laboratory, Oxfordshire, UK
- Joint Venture between UK Government and Wellcome Trust
- Commissioned in 2006, first users in 2007
- Diamond-II upgrade






July 2023
Approval for Diamond-II and start of funding
Dec 2025
Completion of the Diamond Extension Building
Aug 2026
Start of main girder assembly
Dec 2026
Third Readiness Review
Dec 2027
Start of the dark period
Dec 2028
Start of storage ring beam commissioning
June 2029
End of the dark period; start of regular beamline X-ray commissioning
Sep 2029
First Phase of beamlines become operational
Jan 2030
First User on a Flagship Beamline
Mar 2030
End of the D-II project
Mar 2023
2023/24 FY
Mar 2024
2024/25 FY
Mar 2025
2025/26 FY
Mar 2026
2026/27 FY
Mar 2027
2027/28 FY
Mar 2028
2028/29 FY
Mar 2029
2029/30 FY
Q1 Q2 Q3 Q4

diamond

Motivation

- Refresh architecture of control system for an insertion device
- Context: Facility upgrade that includes build of 12 insertion devices.

diamond

Scope of work (ID group view)

Diamond

- CPMU-1 rework
- CPMU-2 rework
- Spare SCW

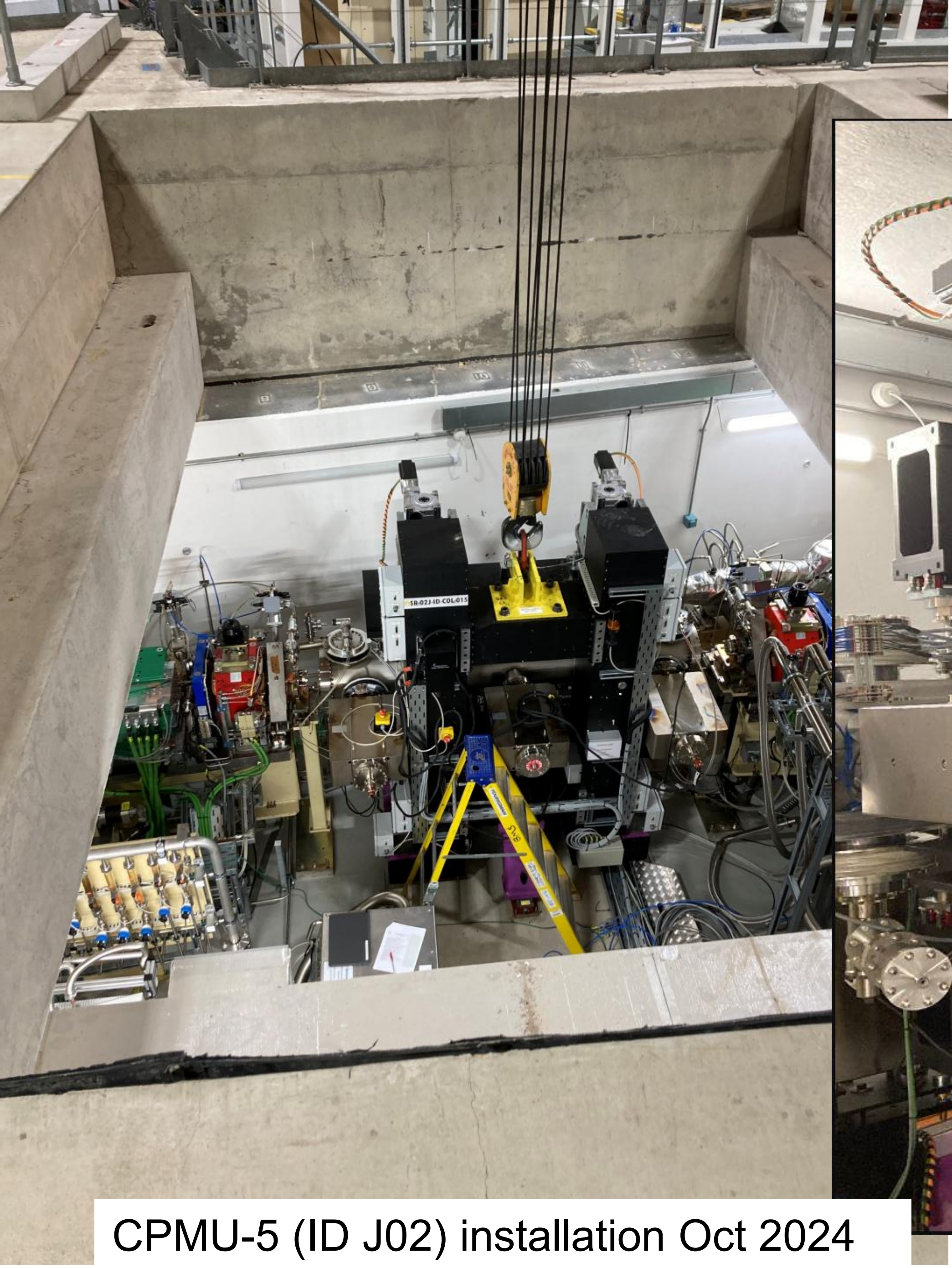
Diamond-II

In-house builds: 4

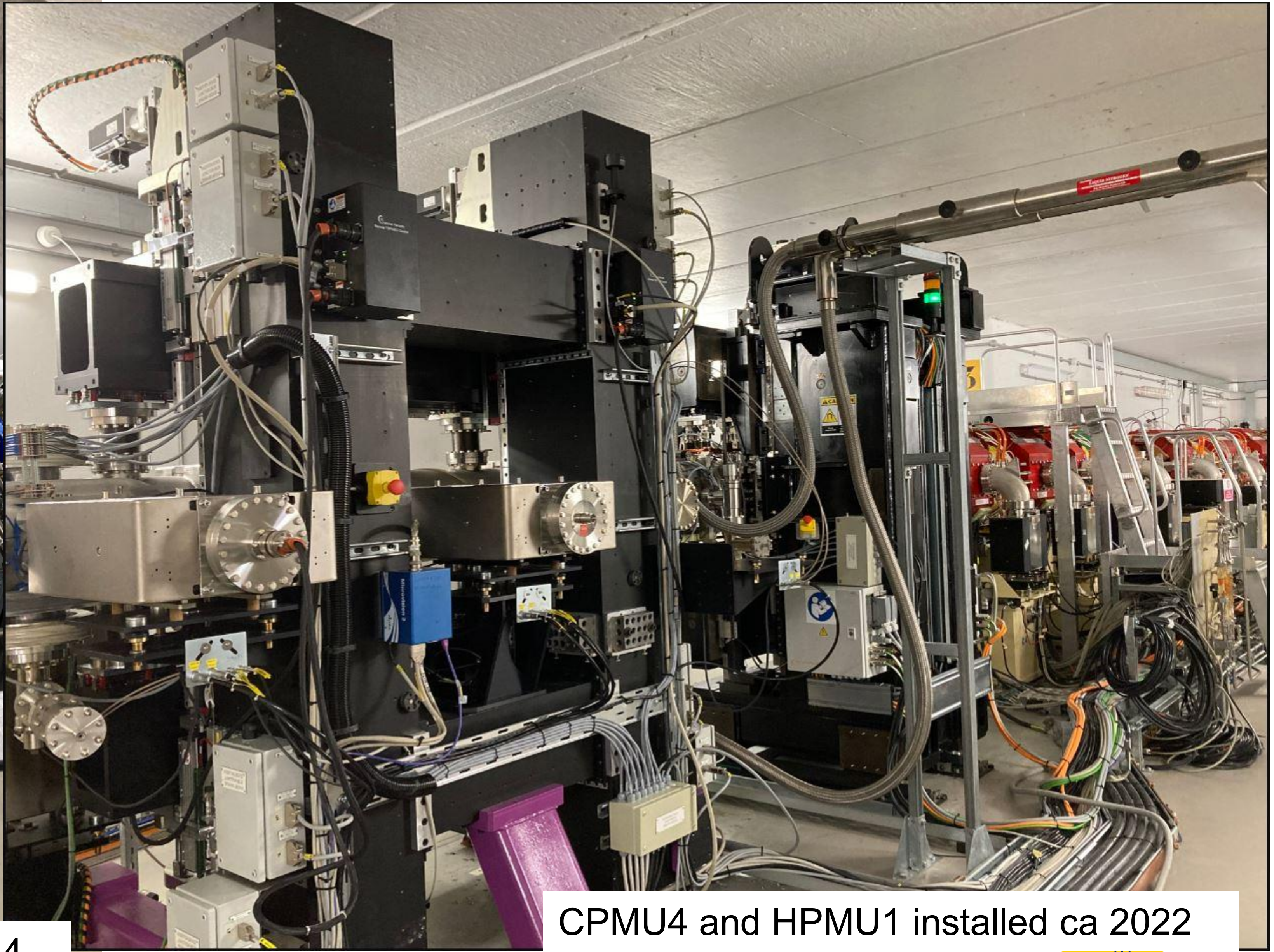
- K02 CPMU-6
- I05 APPLE-Knot
- I06 EMPHU
- I17 APPLE-II

Industry builds: 8

- K16 HPMU
- K21 HPMU
- I06 APPLE-II
- I08 APPLE-II
- I10 APPLE-II
- K18 3PW
- K14 MPW
- K07 APPLE-II



CPMU-5 (ID J02) installation Oct 2024



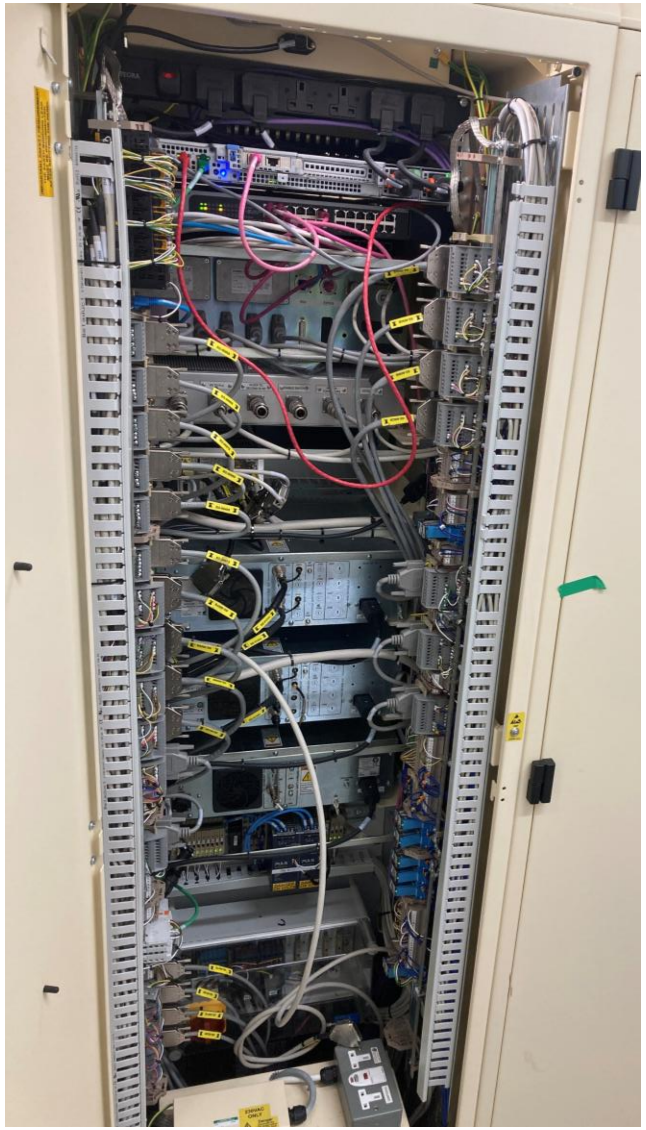
CPMU4 and HPMU1 installed ca 2022

Rack space considerations

VME crate

First generation of Control system takes up two racks

Shrunk to one rack for the latest two IDs installed (right)



CPMU-6 rack

First system using a powerbrick

October 2025

Motion Control

MAXv Family

c processor
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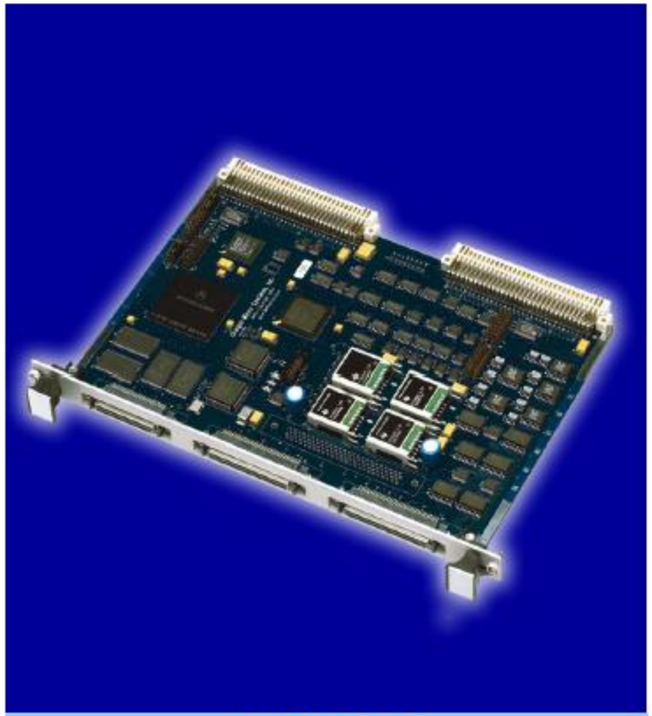
' interface.
ophisticated



FEATURES

- Backwards Compatible with VME58 controller
- System update rate of 122 µs includes PID on all 8 axes
- VME64 bus Specification ISO/IEC 15776:2001 (E)
- 266 MHz, 32-bit RISC processor
- Additional I/O includes: 2 analog outputs, 2 encoder inputs, 6 analog inputs, and 16 digital I/O.
- One 50 pin SCSI and Two 68 pin SCSI connectors for high density signal connection.
- Compatible with the IOvMAX


Sun
microsystems


DELL

Contents

Insertion devices development project

- Digital communication instead of analogue
  - EtherCAT
  - Step and direction
- Alternatives for encoders
- Trial a standard beamline controller
  - Use internal amplifiers
- Check structure deformation
  - Fit encoders across the beam and verify reading against encoders in structure

Motor controllers

- ACCELERATOR SYSTEMS
- OMS 58 Obsolete
- OMS MaxV Obsolete
- Delta Tau Brick Controller Obsolete

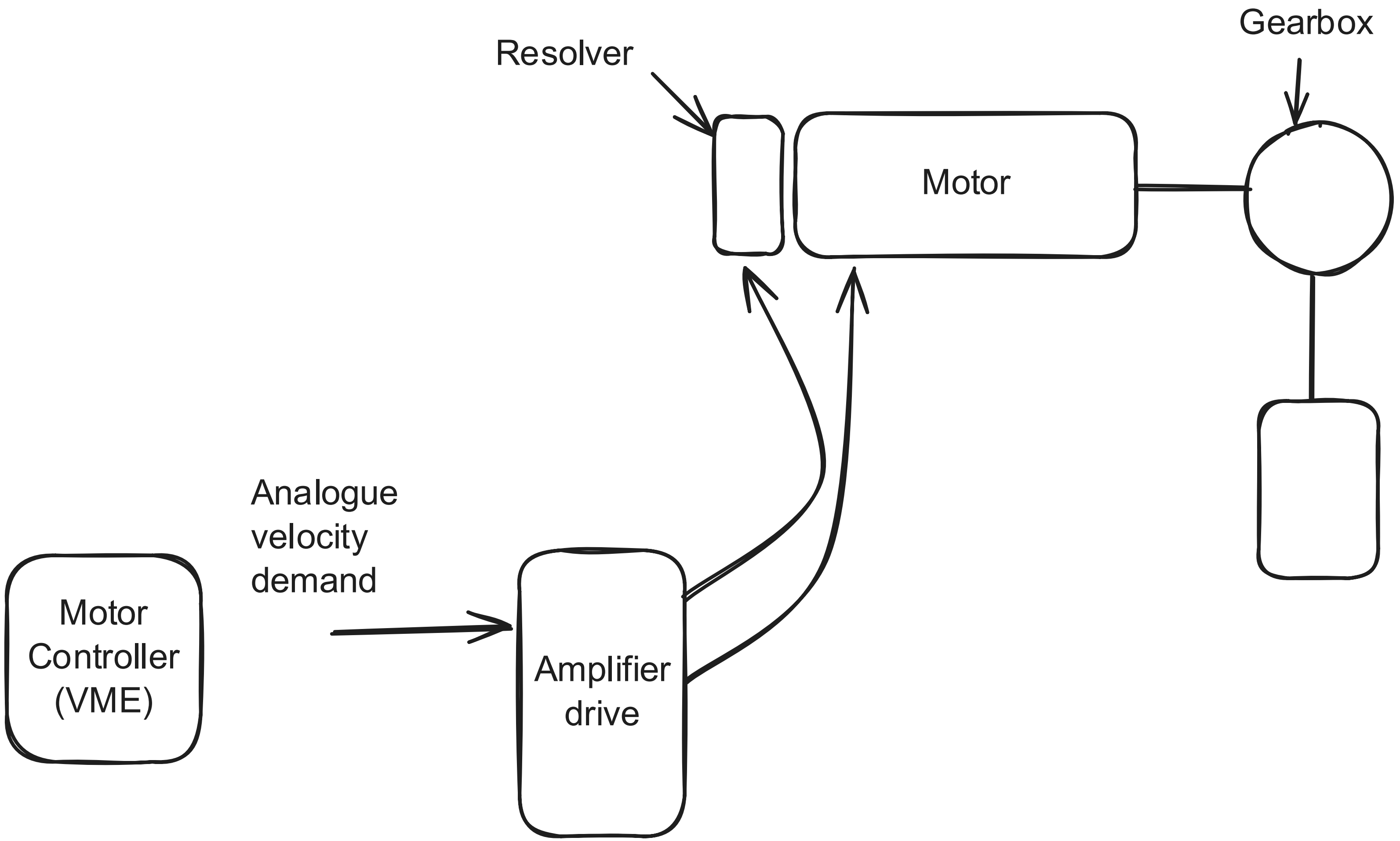
- DeltaTau/Omron CK3M (PowerPMAC)
- DeltaTau/Omron PowerBrick

- BEAMLINE SYSTEMS
- TWO systems
- -
- Not used in beamlines
- Delta Tau Geobrick (internal amplifiers, hundreds of systems)

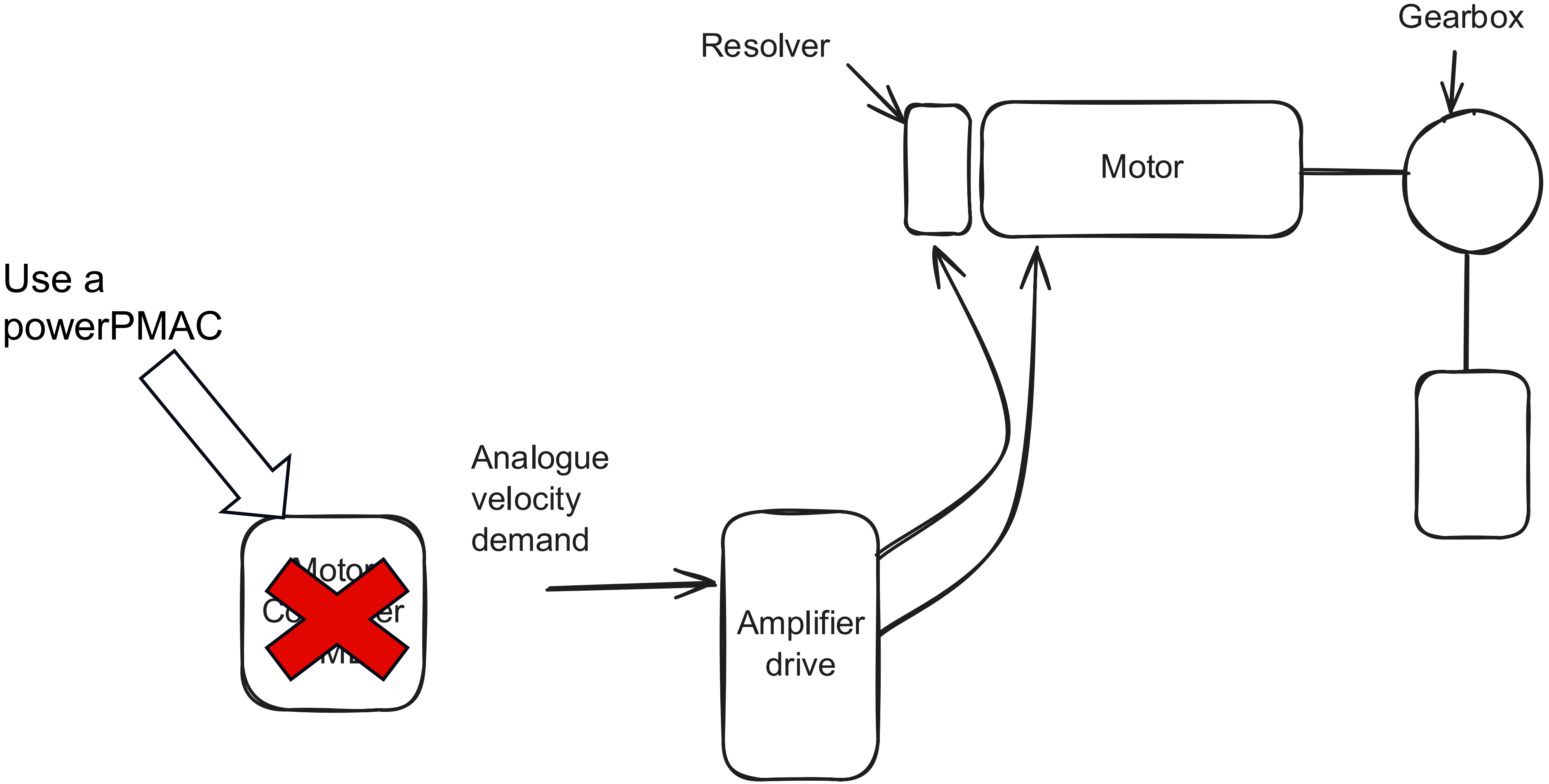
- All upgrades and new systems

diamond

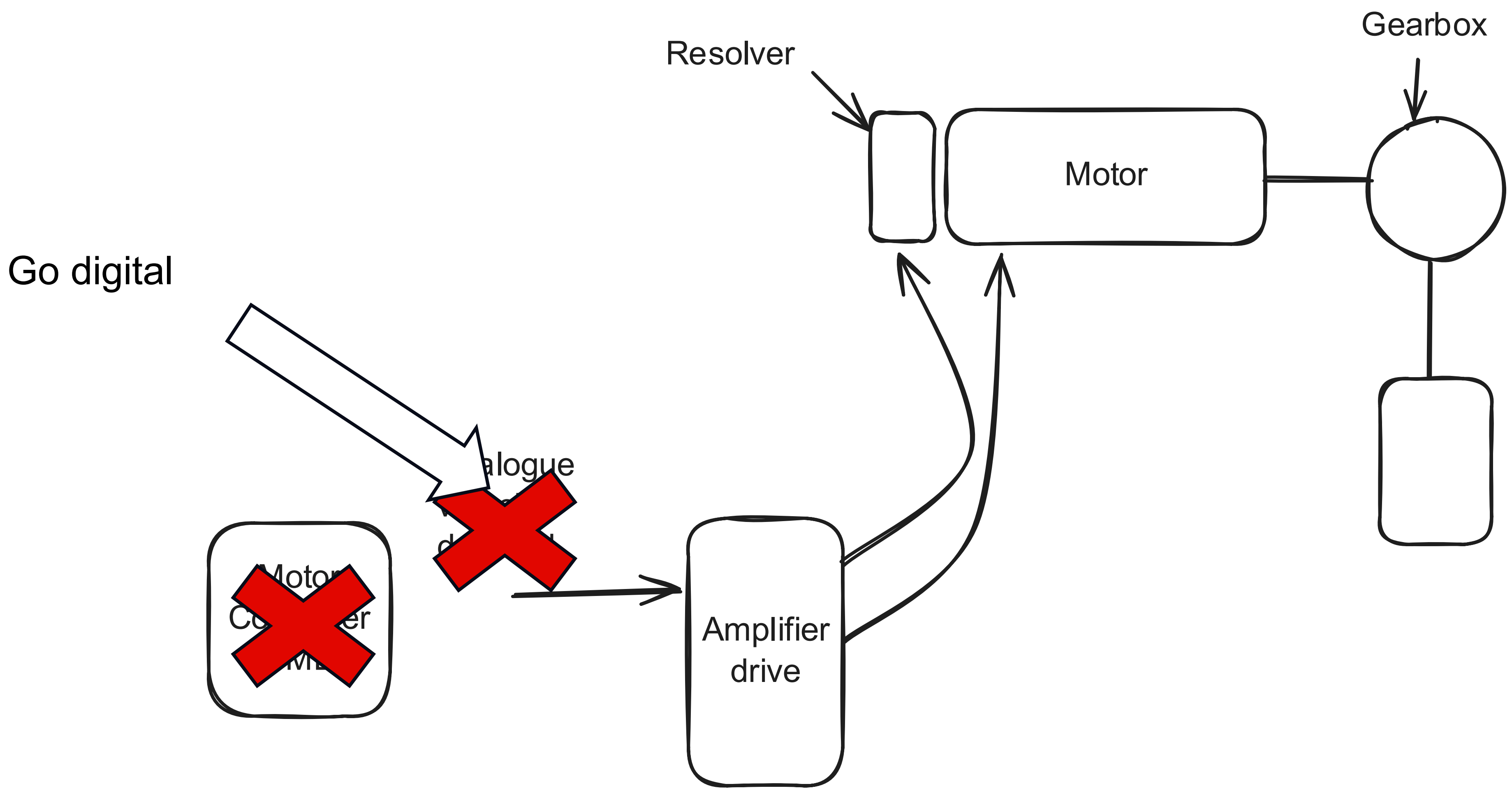
Analogue velocity demand



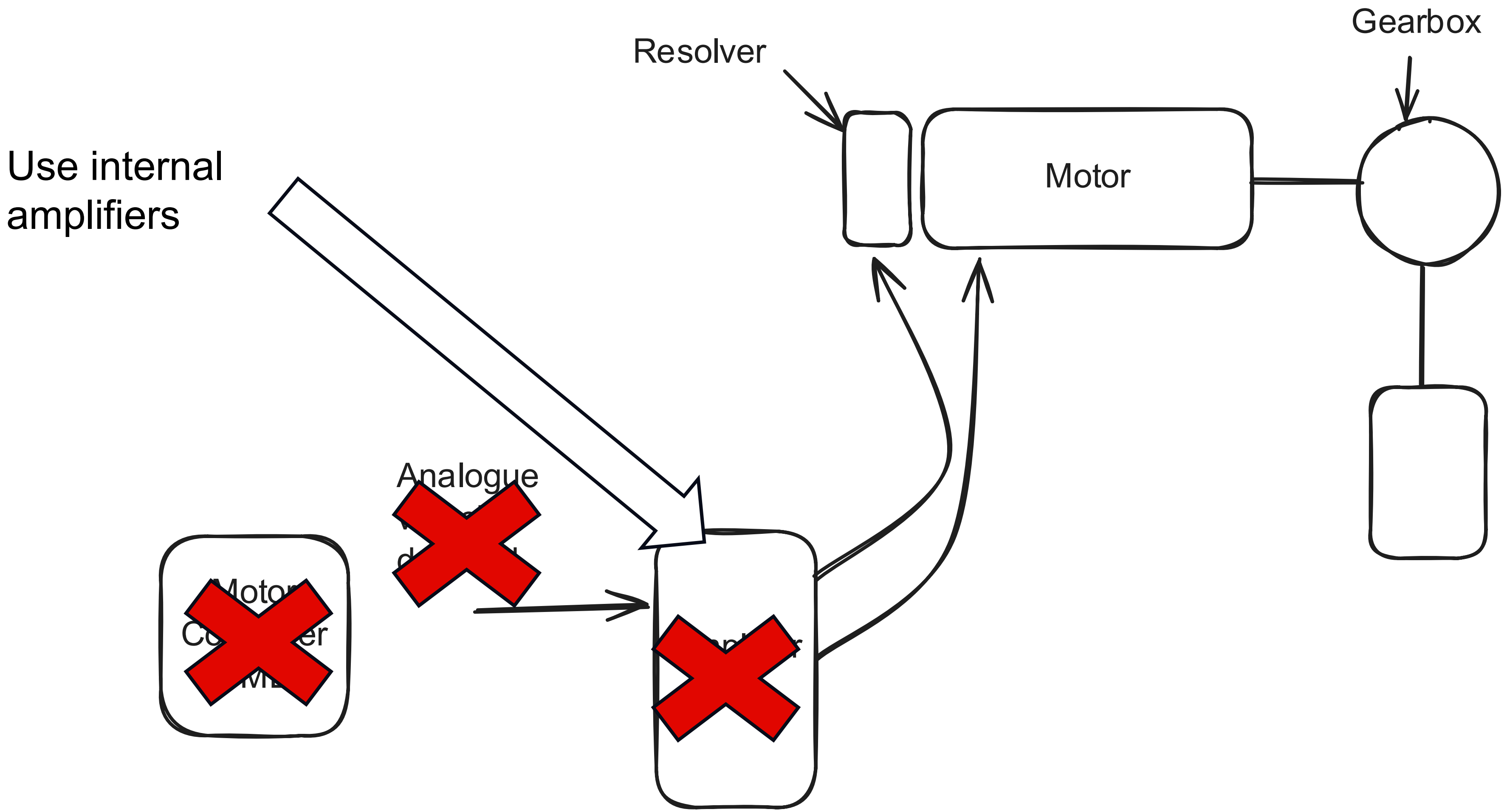
Analogue velocity demand



Analogue velocity demand

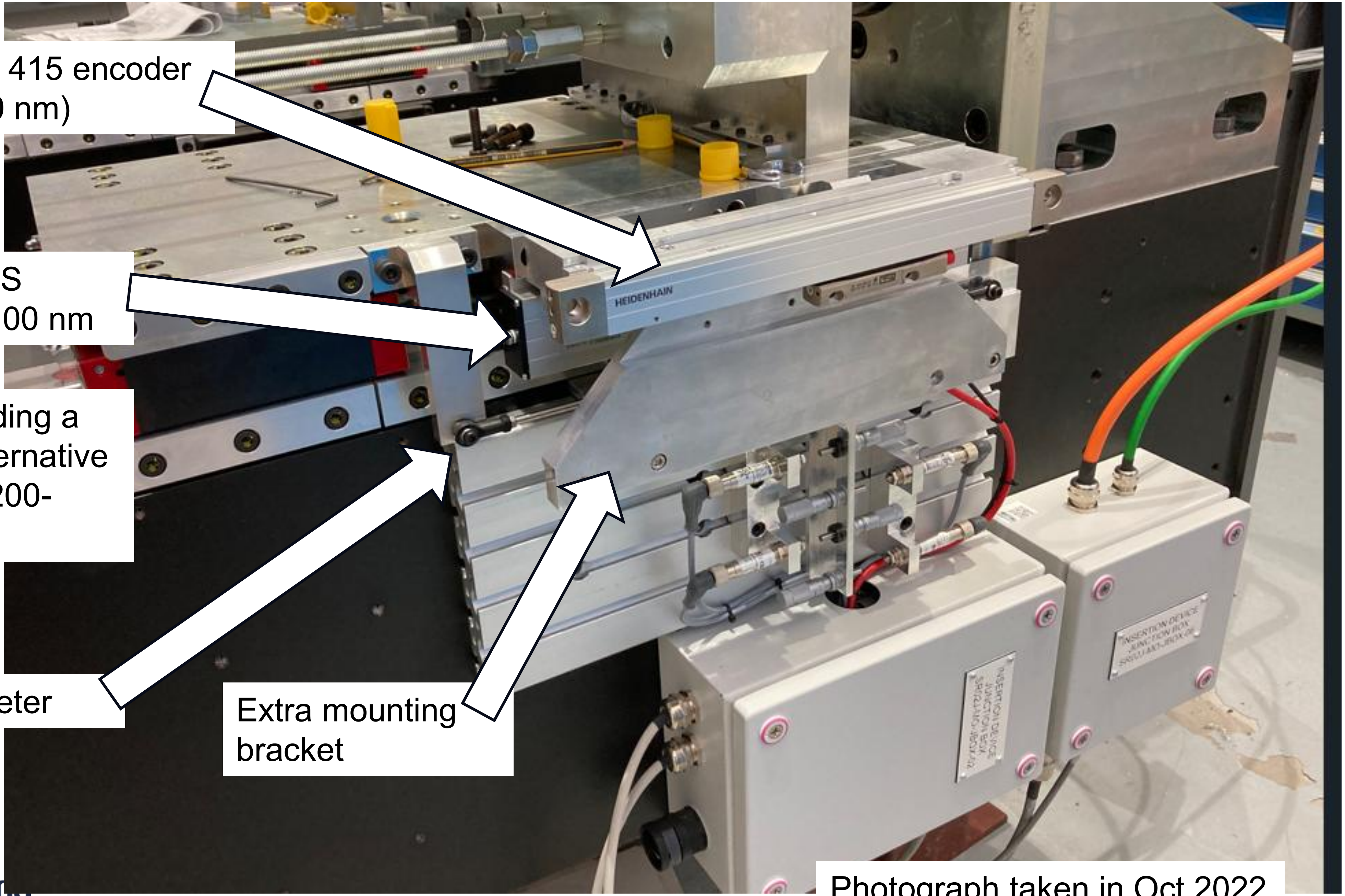


Analogue velocity demand




TRelectronic GmbH
Eglishalde 6 D-78647 Trossingen
Art.No: 3200-00058
SN: 00080
Measuring length: 240 mm
Interface: SSI PRESET + V/R TRWINPRO
Resolution: 0,1 µm
Databits, Code: 24 Bit BINAER
Supply Voltage: 8-27 VDC
SW/Pinout: 6042.01 / 2862
Manuf. No.
Made in Germany
CE

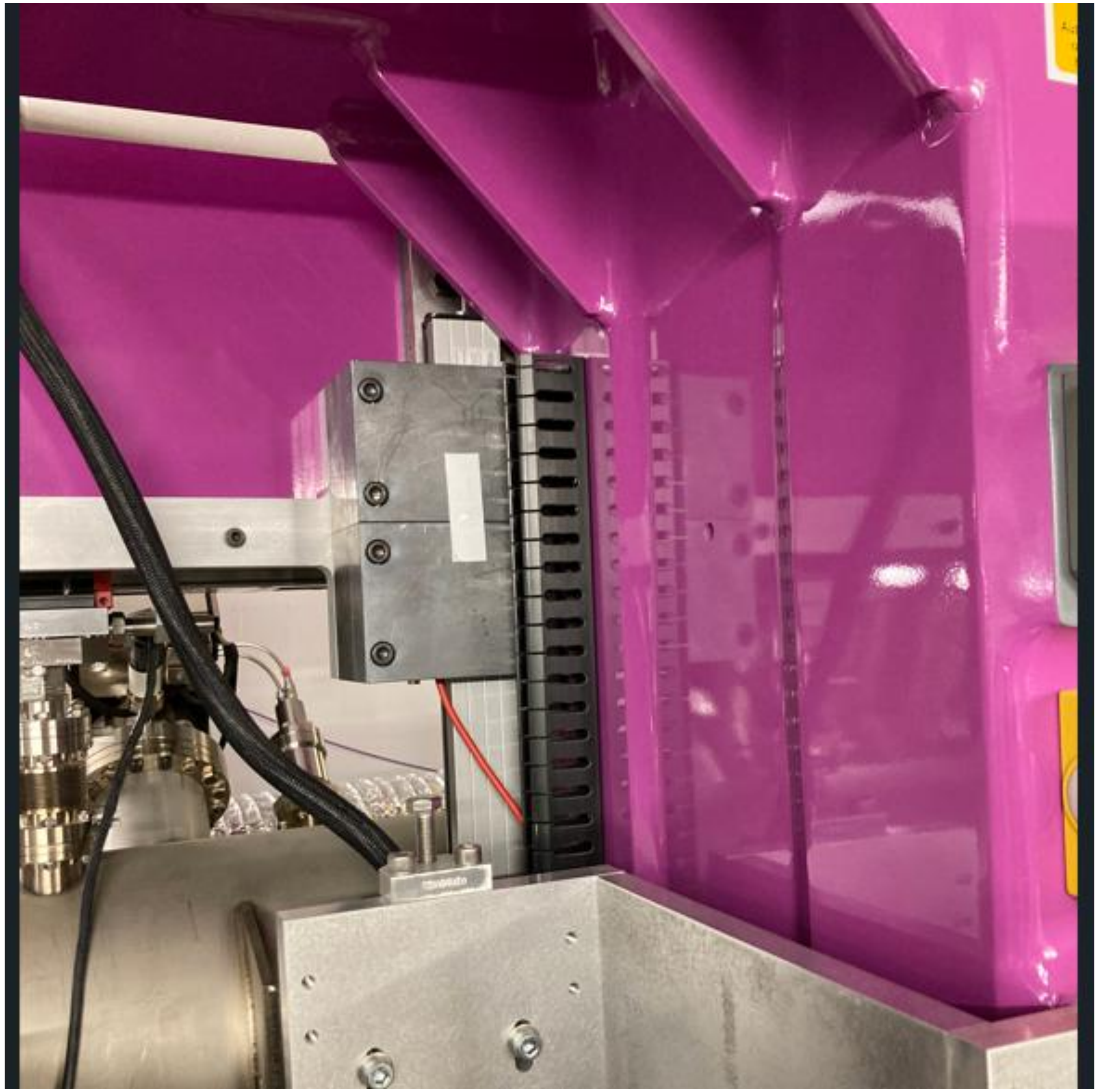
diamond



Photograph taken in Oct 2022

Radiation damage

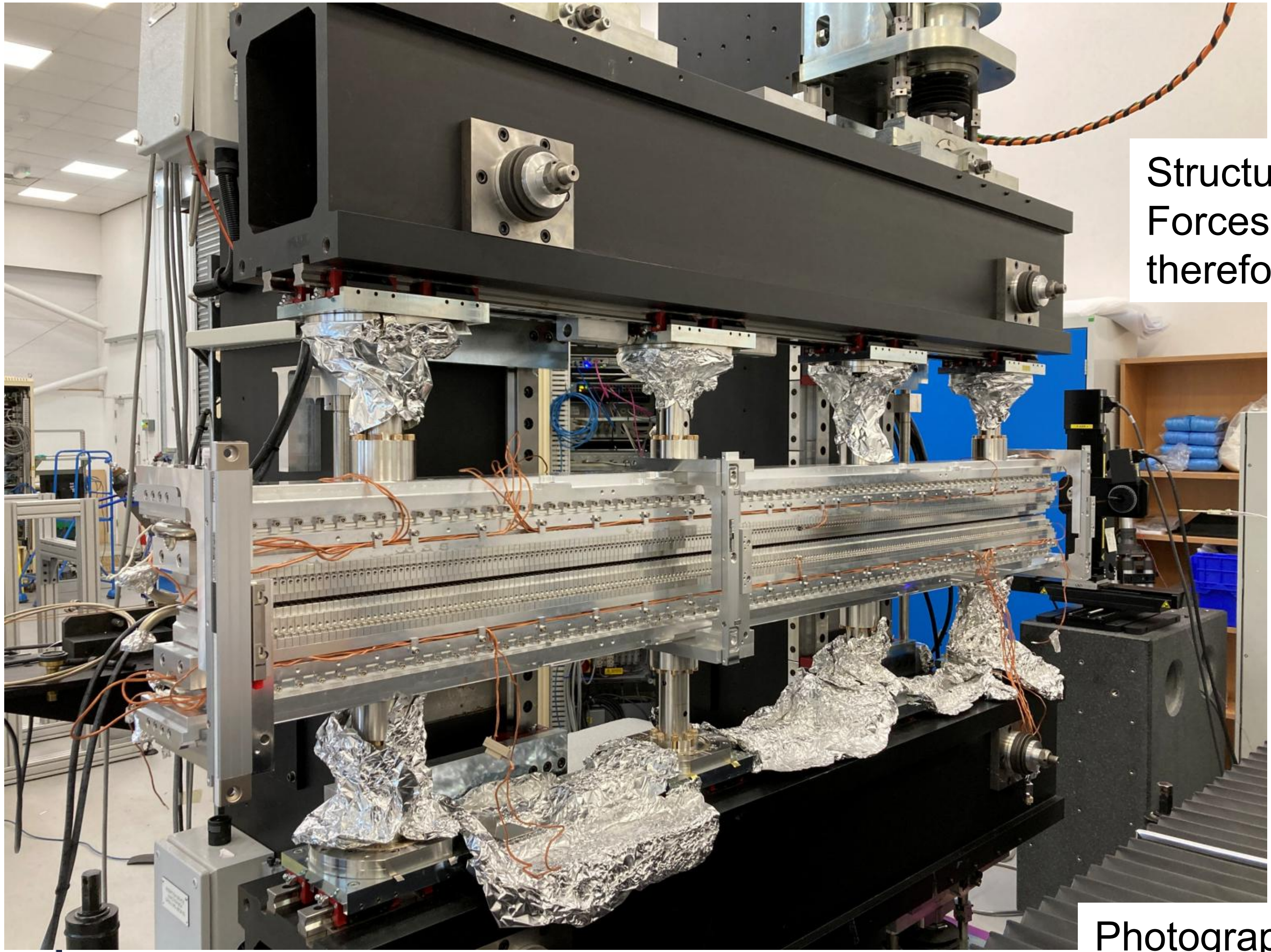
- Has been a problem since the early days.
- Attempts to mitigate using lead shielding
- Mechanism in place to power-cycle encoders to recover.
- Affects most IDs directly after the collimator
- Regular encoder swapping



Contents

- Self introduction and organisation of groups involved
- Diamond and Diamond-II upgrade
- Insertion Devices Controls Development Project
- Torque tests and apple knot ID
- Optics synchronisation for Diamond-II
- Conclusions

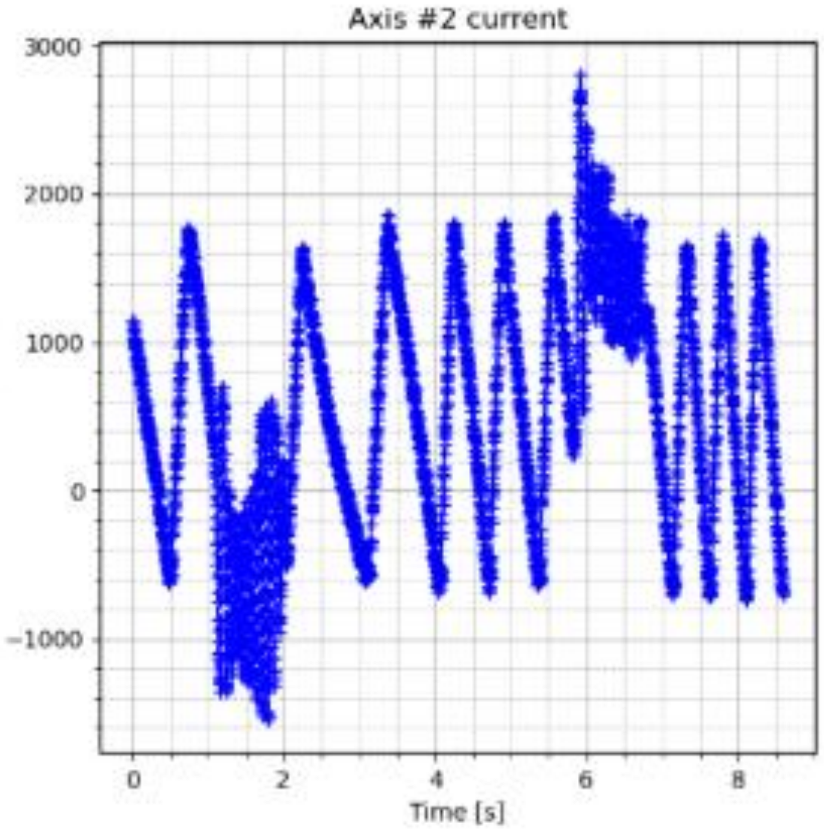
CPMU-1 structure



Structure will be used at 4 mm gap
Forces increase when cold, therefore tested at gap 3.4

Photograph taken July 2023

Test results



Maximum current 3.3 Amp
Motor rating 4.9 Amp

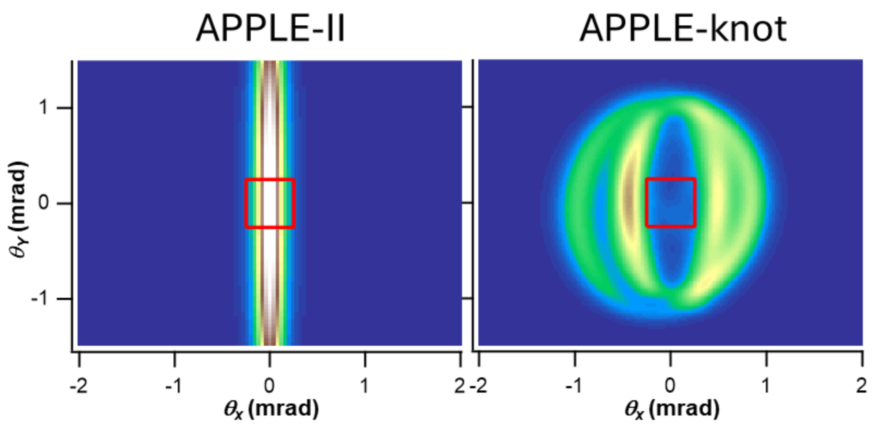
32 % headroom

Internal Report TDI-ID-CTRL-020

Torque tests for Apple-Knot

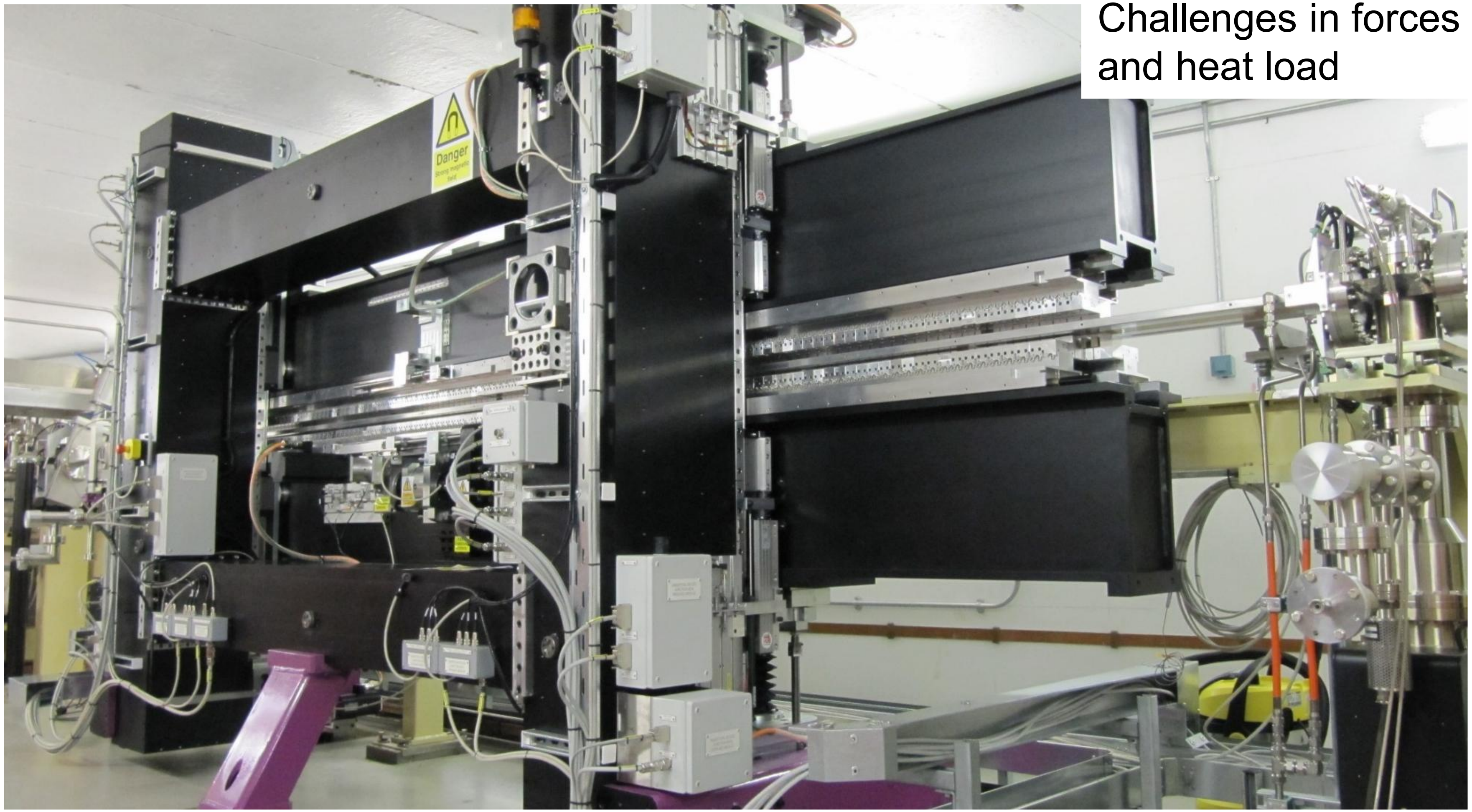
Motivation
Provide low photon energies
Variable polarisation: vertical, horizontal and circular
Reduce on-axis heat load – damage to optical components

Designed and built in SSRF (Shanghai)
Visit by Prof Shan Qiao April 2019

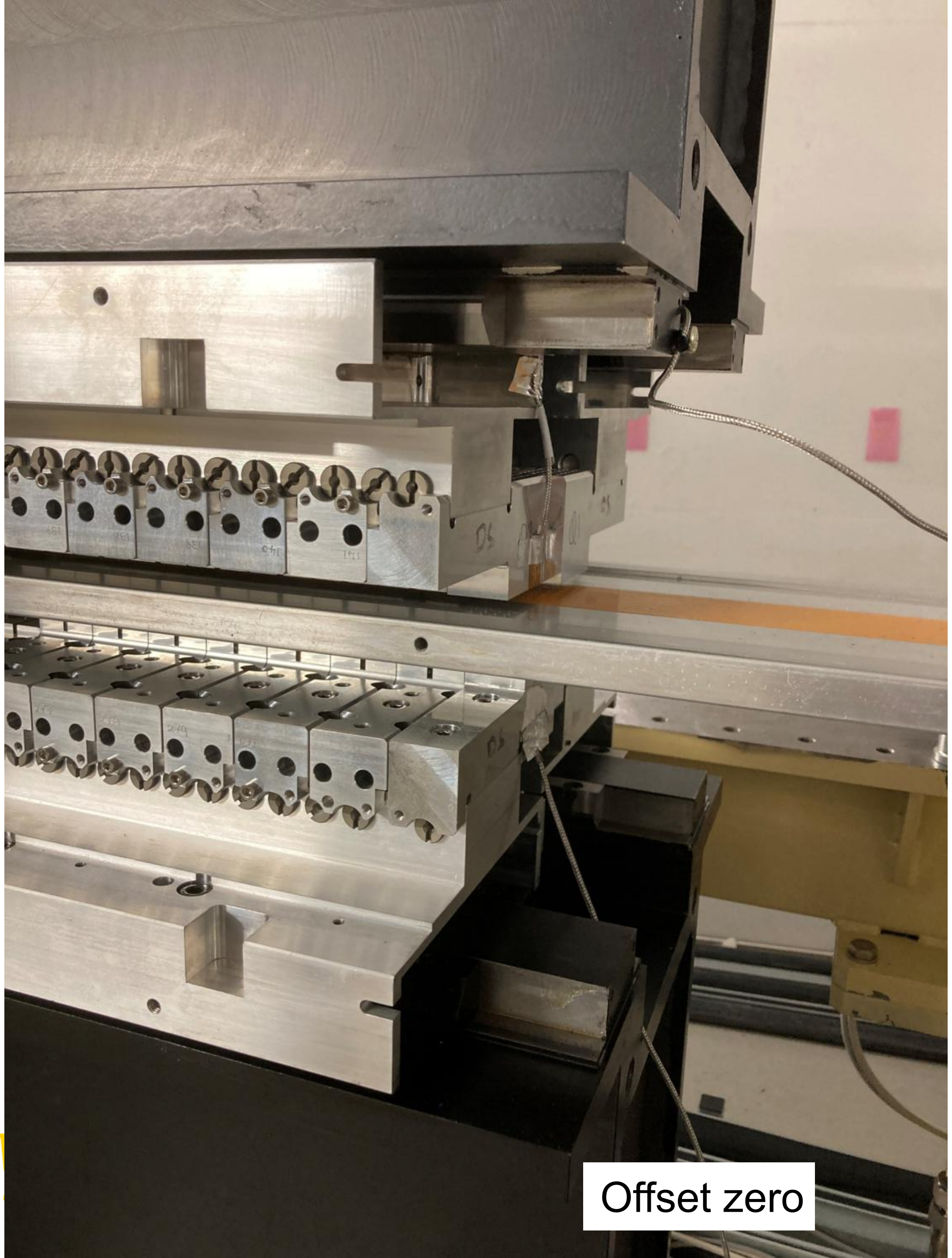


Ref.: e.g. S. Qiao, D. Ma, D. Feng, S. Marks, R. Schlueter, S. Prestemon, and Z. Hussain, “Knot undulator to generate linearly polarized photons with low on axis power density,” Review of Scientific Instruments 80, 085108 (2009).

diamond

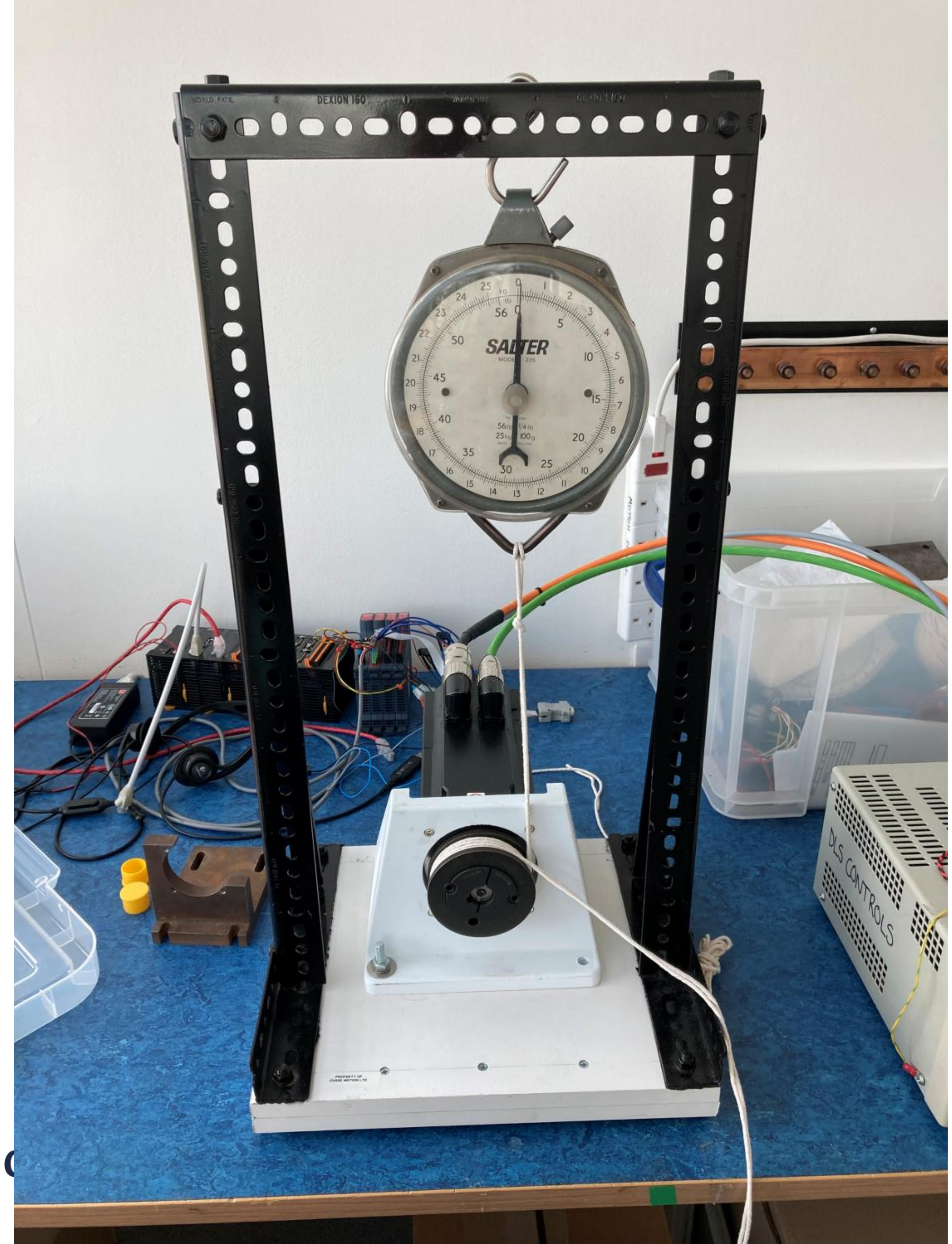


5 metre device
Challenges in forces and heat load



Offset zero

Offset ½ period



Test setup in motion control lab

Support from ID group to build rig and evaluate results

Requirement from the beamline:

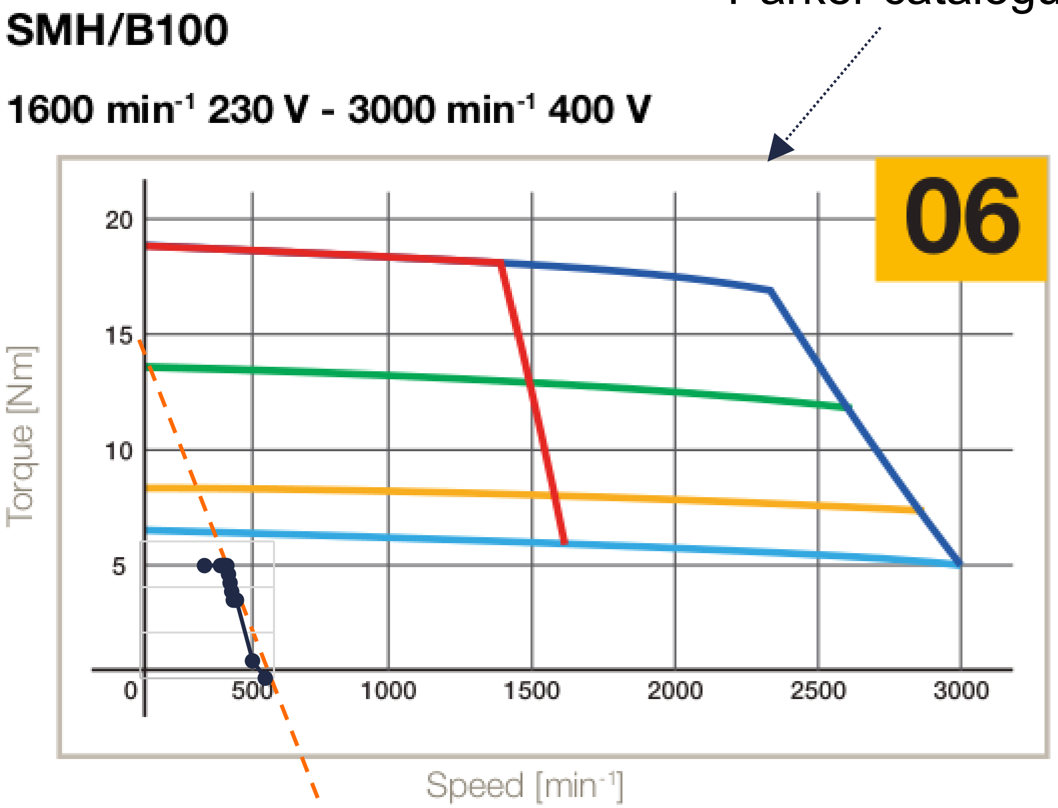
Drive the phase motor at 1 mm/sec

Conclusion from test:

Maximum rotation speed is ~7.9

Torque curves

Torque curves from Parker catalogue



Speed [min^-1]	Torque [Nm]
240	4.94
300	4.94
306	4.94
312	4.94
318	4.94
324	4.94
330	4.56
336	4.18
342	3.8
348	3.42
354	3.42
360	3.42
420	0.76
467.4	0

Reported by X Tran ca. July 2025

Maximum rpms much smaller at 48 V voltages

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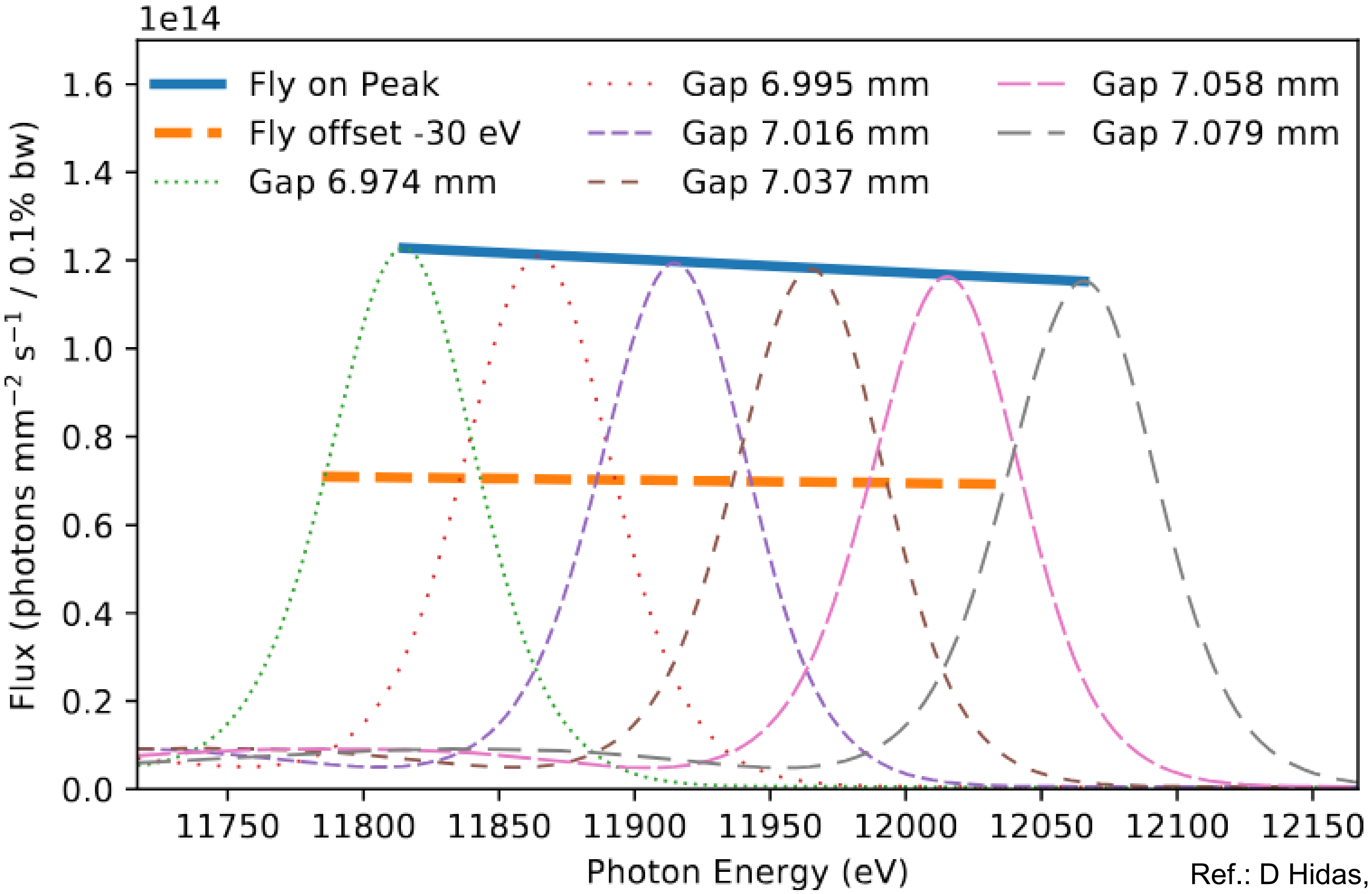
diamond

Optics synchronisation



20 times speed-up compared to step-scan at the SRX beamline

Ref.: D Hidas, AM Kiss, M Rakitin, J Sinsheimer, T Tanabe, M Musardo High precision real-time insertion device and monochromator synchronization at NSLS-II Nuclear Instruments and Methods in Physics A **1031** 166505 (2022).

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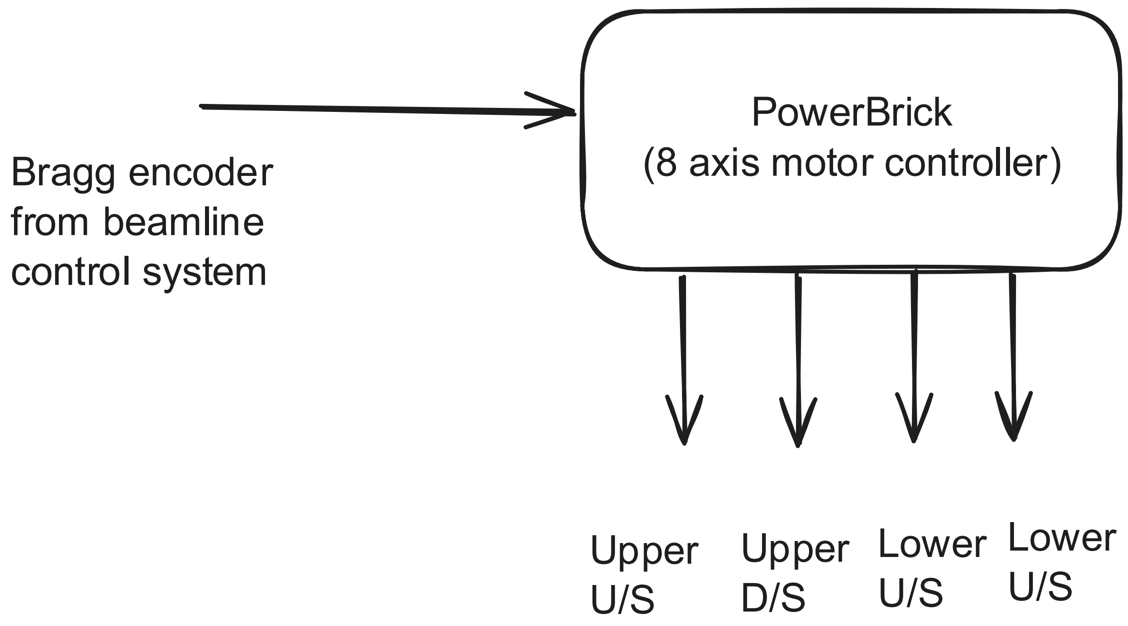
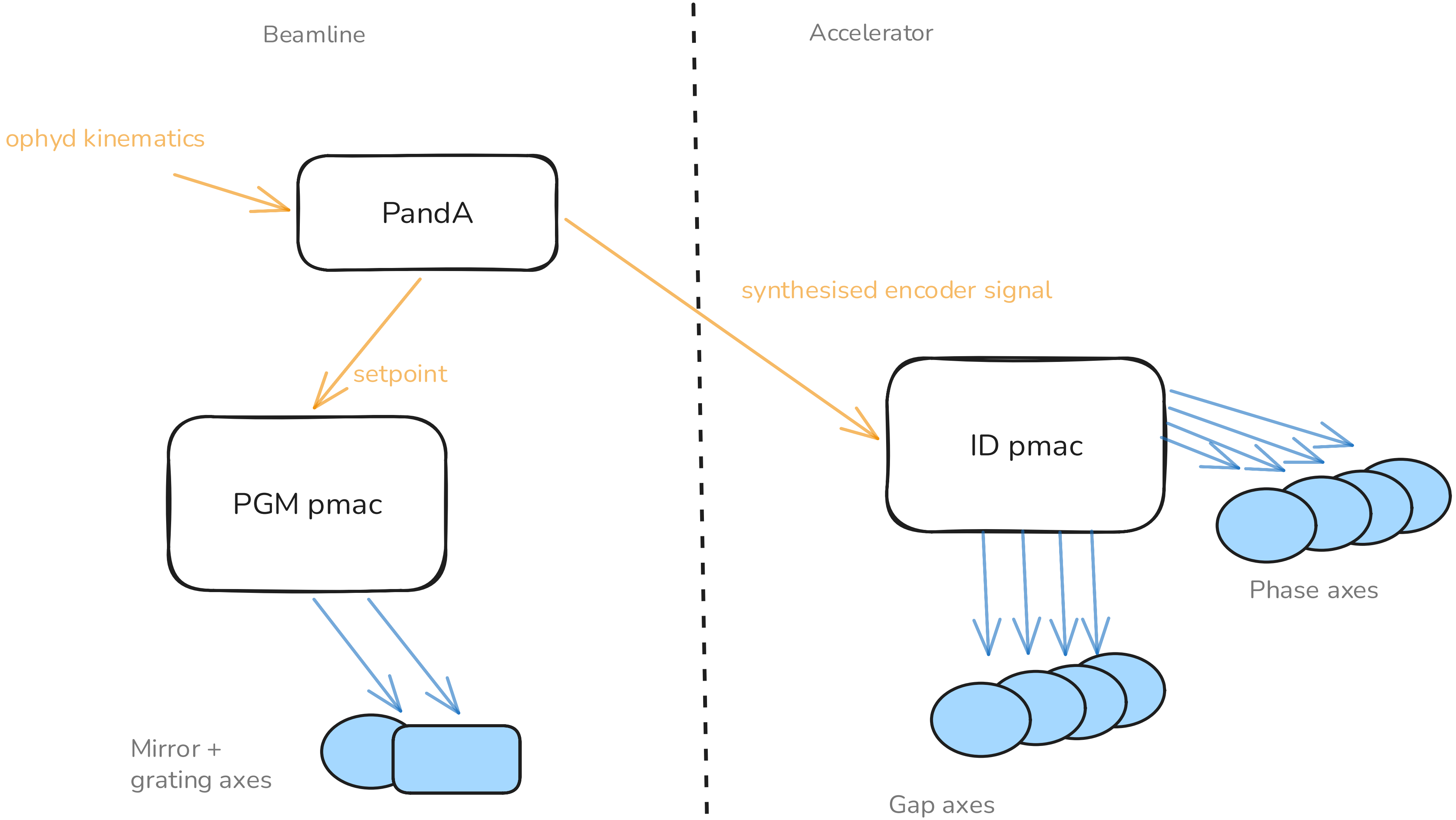
Synchronization scheme



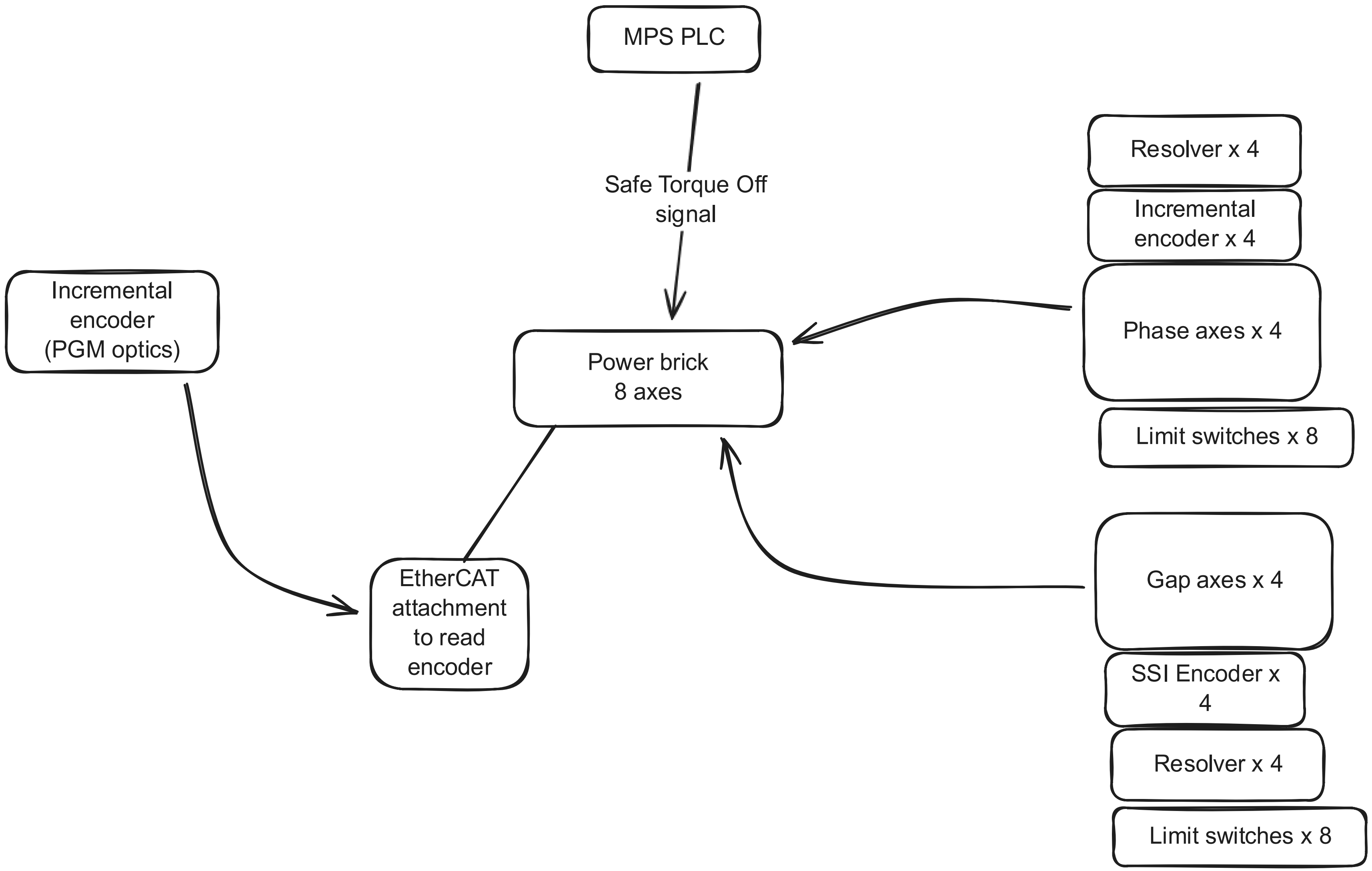
- Master/slave technique using compensation tables as hardware synchronisation method.
- Encoder signal from Mono Bragg axis is taken into ID motion controller
- Tests performed ID system (CK3M controller)

Synchronization scheme orchestrated externally



diamond

Agreed schematic control for Apple-Knot ID



Conclusions

- There are advantages to using a powerbrick
- There are alternatives if we can’t use a powerbrick
- We have validated the synchronization scheme when driving four axes
- We have done work to validate the motor controller
  - Torque verification
  - Selected method to synchronise when driving eight axes (gap and phase IDs)