STE-QUEST
Electronics Thoughts

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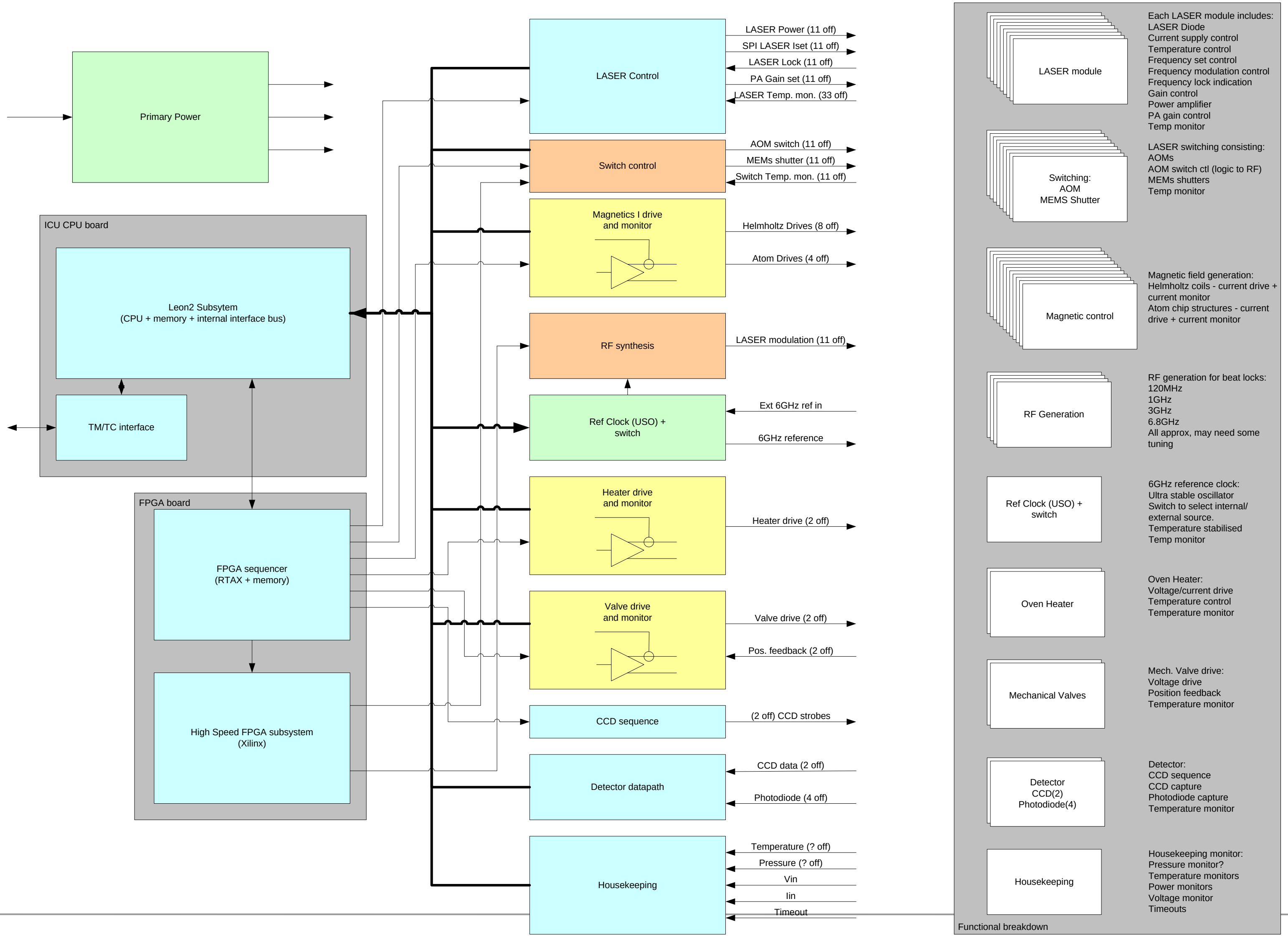
Electronics functions

- Provide stable low voltage/high current power for
  - Narrow band lasers
  - Coils/magnets (for controlling the BEC locations)
- Provide high power supplies for
  - Rb sources
  - Mechanical shutters on Rb source
  - [Pumps assumed controlled at spacecraft level]
- Control
  - AOMs, MEMS switches in laser paths
  - Overall thermal system
  - Precision thermal control of some components
- Read out
  - Housekeeping (temperatures, photodiodes, ...)
  - Science data (CCDs, photodiodes)
- Provide payload autonomy
  - Timeline control (microsecond accuracy over tens of seconds)
  - Implement laser tuning and locking algorithms
  - Safing
  - ...

Preliminary Block Diagram



Budgets (current status – still evolving)

		DIMENSIONS		MASS		POWER*	
	size	length x width x height or length x diameter (mm x mm x mm)	volume (l)	without margin (kg)	with margin (kg)	average (W)	peak (W)
Physics Package	cylinder	800 x 600	226	101.83	122.08	55.19	135.60
Laser System* **	box****		42.7	46.15	55.38	156.64	156.64
Electronics	box	450 x 400 x 300	54	20.84	25.96	222.14	267.98
Ion Pump Control**	box	100 x 100 x 100	1	1.00	1.20	1.50	1.50
subtotal			**323.7**	**169.81**	**204.61**	**435.47**	**561.72**
additional system level margin (%)					20	20	20
TOTAL					**245.54**	**522.56**	**674.06**

- A kW-level payload requiring precision timing and sequencing of large numbers of components
- Stringent pointing requirements on the spacecraft
- Data volumes relatively low

Legacy

- STE-QUEST M3, M4
- German drop tower/sounding rocket, French parabolic flights, CAL
- Large-scale interferometers (Germany, France, UK, Italy?)
- Cold Atom in Space Community Roadmap
- …

→ in principle TRL9, but maybe really like TRL4 for STE-QUEST:

- STE-QUEST will fly higher and longer than other cold atom missions
  → Tougher requirements on radiation hardness
  → Can SWAP be improved?

Science and Technology Facilities Council

RAL Space

Space Electronics at RAL Space

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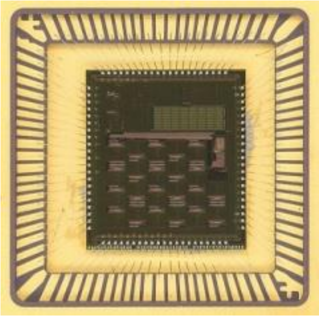
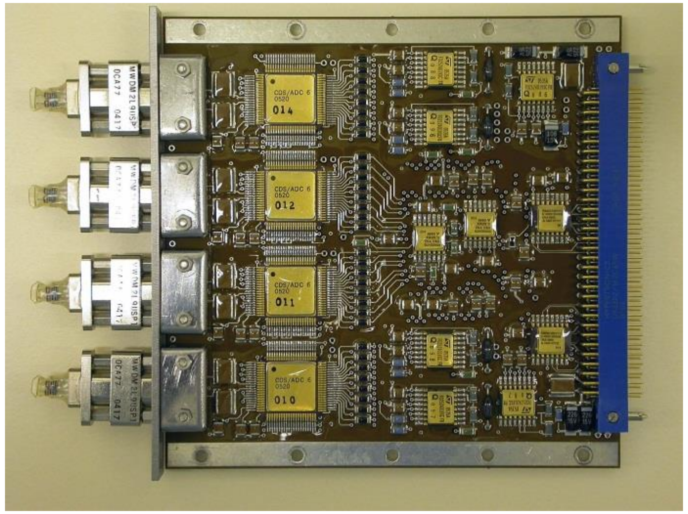
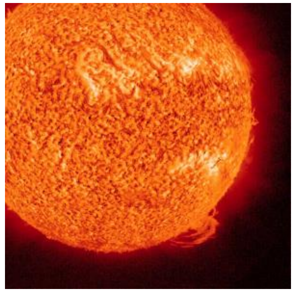
RAL Space Heritage







In-house mixed-signal ASIC design and qualification

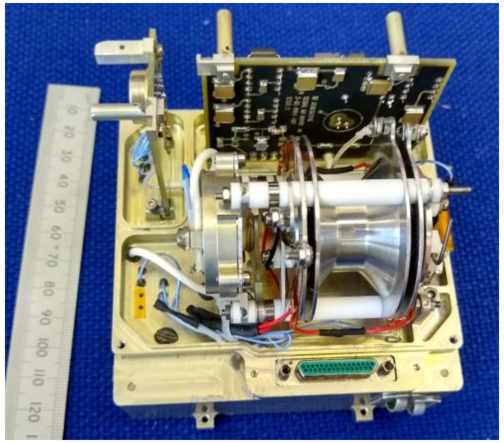
Eg: SDO CCD Camera Electronics

- Atmospheric Imaging Assembly (AIA), Lockheed Martin
- Helioseismic and Magnetic Imager (HMI), Stanford University
- SDO flight spares are being used on the LM IRIS SMEX mission

180 Years failure-free operation in space

Full instrument build and assembly

Eg: Ptolemy (part of Rosetta mission)



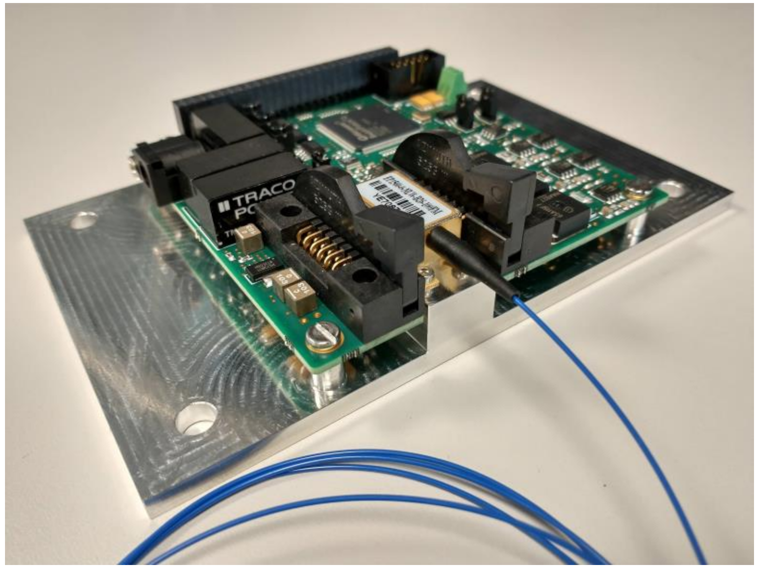
Ion Trap MS at the heart of Ptolemy

Ptolemy before assembly in Philae lander

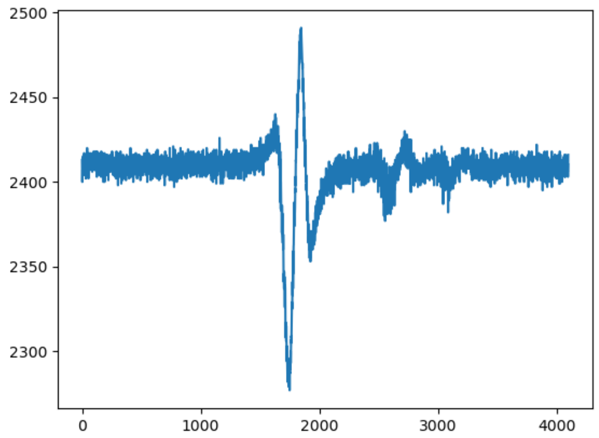
Cold Atoms Electronics

Laser Drive and stabilisation using space qualified* components

- Function:
  - Provides a variable laser current drive of few 100s mA
  - Provides a variable TEC current drive of few A
  - Spectroscopy lock (optimized to MTS)
  - Frequency offset lock (beat note detected up to 10GHz offset)
- Successfully tested
  - Laser Temperature stabilization
  - Free running laser linewidth <50kHz @ 1ms (using RIO planex laser diode)
  - MTS Lock with long term stability <<1MHz



Lab testing laser drive module (in PC104 form factor)



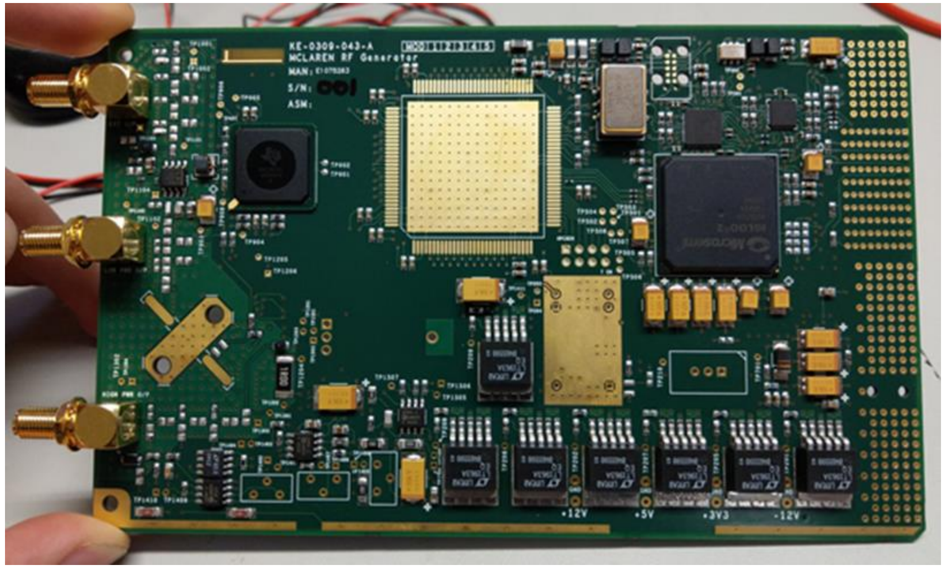
Sample MTS error signal

*Some times using equivalent components for the lab demonstrators, with space counterpart identified

Cold Atoms Electronics

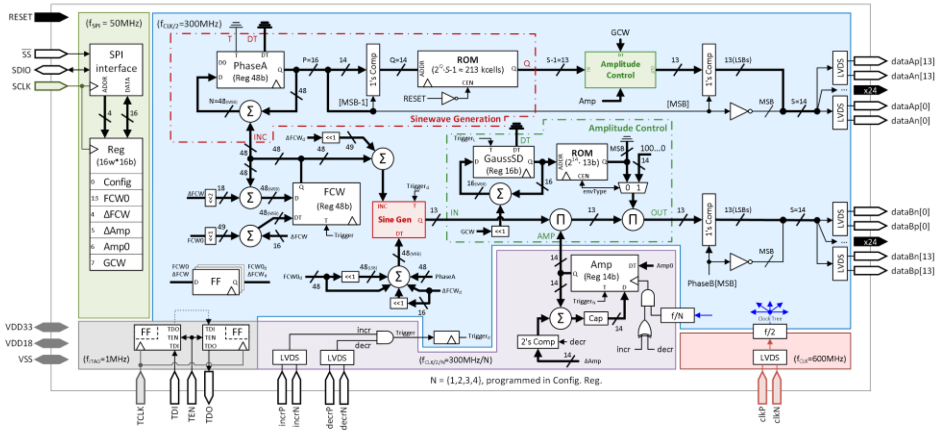
In-house DDS ASIC using space tested xxx

- Function:
  - Provides a variable RF signal (100 – 150 MHz) with <100kHz
  - 2 watts of electrical power to drive the AOM devices.
- Successfully output a waveform and able to obtain:
  - Different pulse shapes (square and gaussian amplitude envelopes)
  - Pulse width <1µs and time jitter <10ns
  - Frequency chirps with frequency resolution 0.1Hz



McLaren DDS ASIC
Blocks Diagram

Version 4.2
29/11/2017



Lab prototypes

- Function:
  - Magnetic Coil Drive
  - Digital pulse generator
- Successfully tested
  - Currents up to 5A with fast switch off (<1ms)
  - TTL pulses with jitter <10ns

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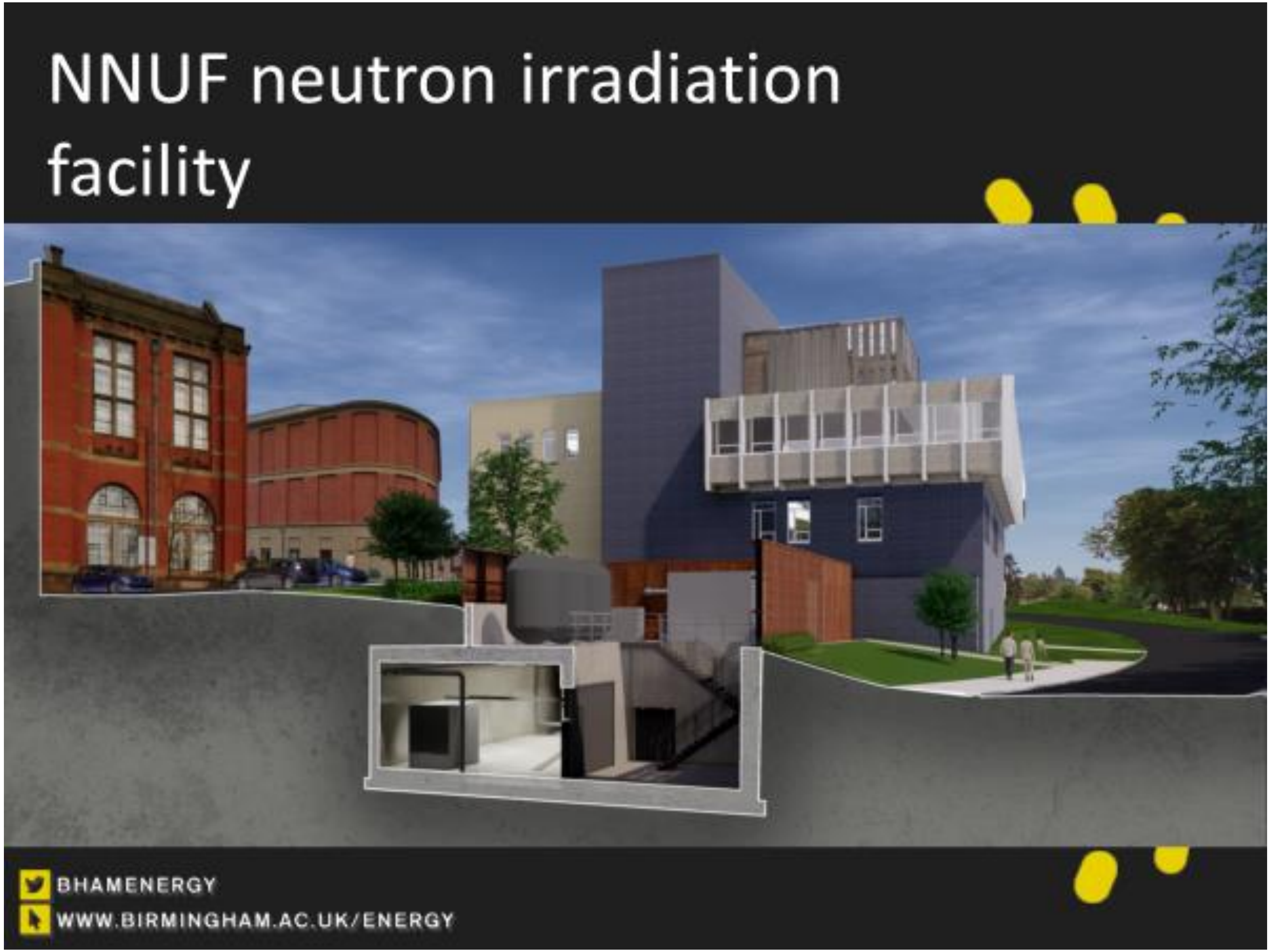
RAL Space


NNUF neutron irradiation facility
BHAMENERGY
WWW.BIRMINGHAM.AC.UK/ENERGY

Phase 1 (years 1 and 2)

- Building alteration and hardware procurement
- Accelerator delivery and installation

Phase 2 (year 3)

- Work-up to 30 mA protons [Q1-Q2 2022]
- Fast neutron fluence rate of 1.8×10^{11} n/cm^2/s
- Thermal fluence rate of 6×10^9 n/cm^2/s
- Develop modified target system for closer location of samples
- Develop associated fast neutron reflector configuration

Phase 2 (year 4)

- Fast neutron fluence of 1×10^{12} n/cm^2/s
- Achieving a 10^{18} integrated neutron fluence required operation for 11.5 days

Phase 3 (years 4+)

- Develop deuteron beam with enhancement of fluence to >3×10^{12} n/cm^2/s
- Achieving a 10^{18} integrated neutron fluence required operation for 4 days

Development of Dual Beam Facility 2023+

Thermal Management!

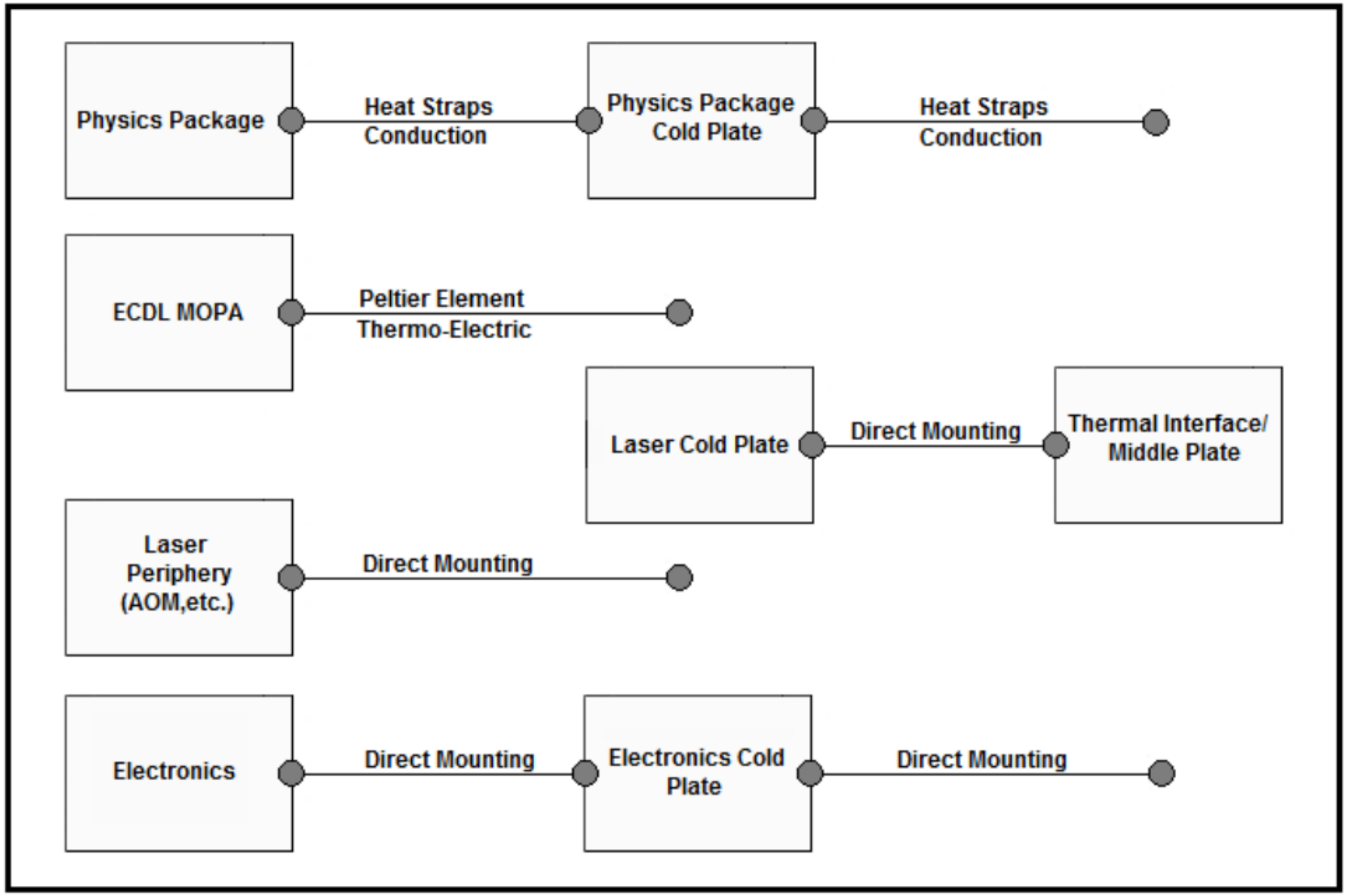


Figure 3-26: Thermal management approach for the STE-QUEST ATI.

TRL4→6
Potential Facilities and Companies Support

Science & Technology Facilities Council Rutherford Appleton Laboratory	Satellite Test Facilities Space Systems Engineering, Space Electronics
ThalesAlenia Space a Thales / Leonardo company	Satellite Platforms
TELEDYNE e2V Everywhereyoulook™	Sensor System Integration Vacuum Systems
Trym Systems Ltd	Consultancy
magnaparva	Mechanical and thermal design
STAR-Dundee	Space electronics, wiring and fibre for data handling
XCAM	Space and specialist CCD and CMOS imaging solutions
UNIVERSITY OF BIRMINGHAM	Neutron and Proton irradiation facility AI testbeds