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Welcome

Image: ESO/P. Horálek

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MOONS Metrology System Calibration Tool

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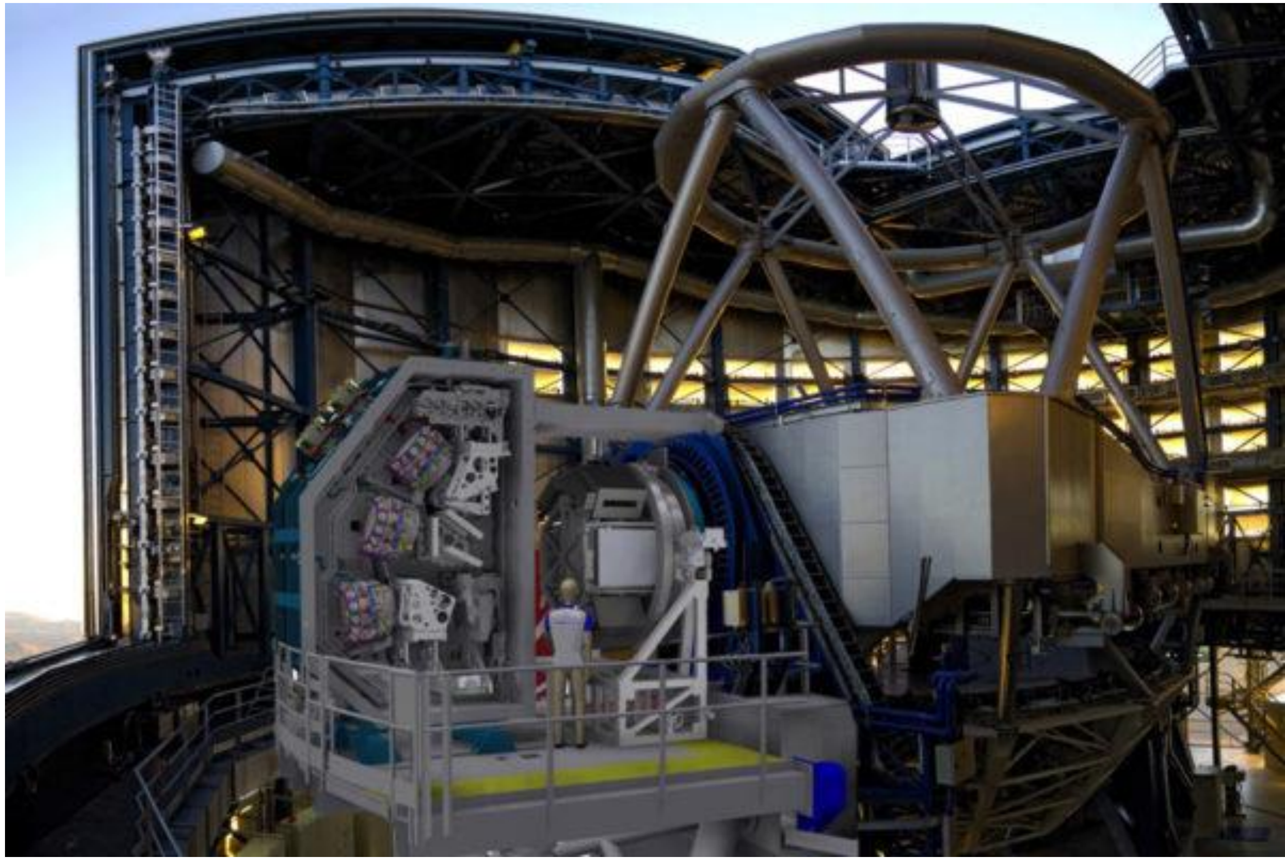
What is MOONS?

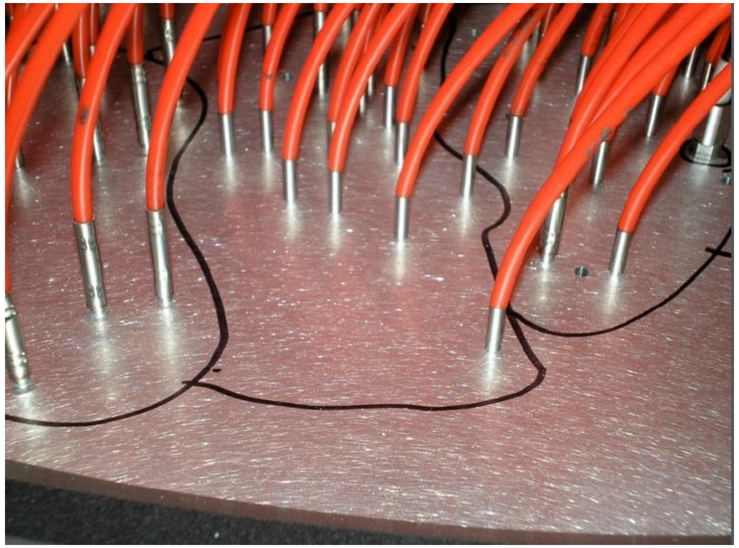
Multi-Object Optical and Near-infrared Spectrograph.

- Spectrograph = takes spectra, not photos.
- Optical and Near-infrared = visible light and IR wavelengths.
- Multi-Object = ability to look at many objects at the same time.



Why?

Because doing it by hand takes 30 minutes per observation…



… and feeding all the fibre optics by hand is ‘a little tiresome’.

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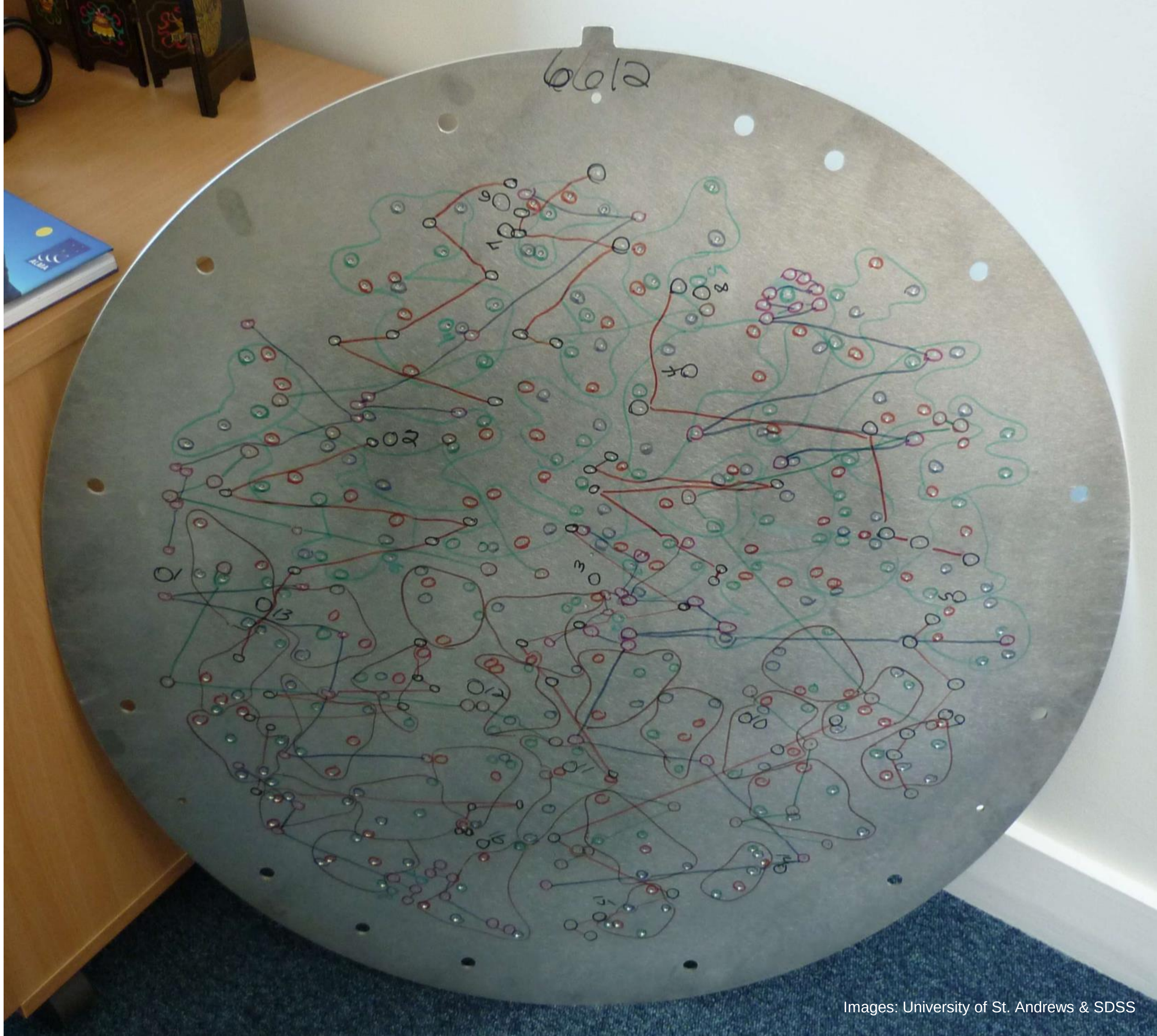
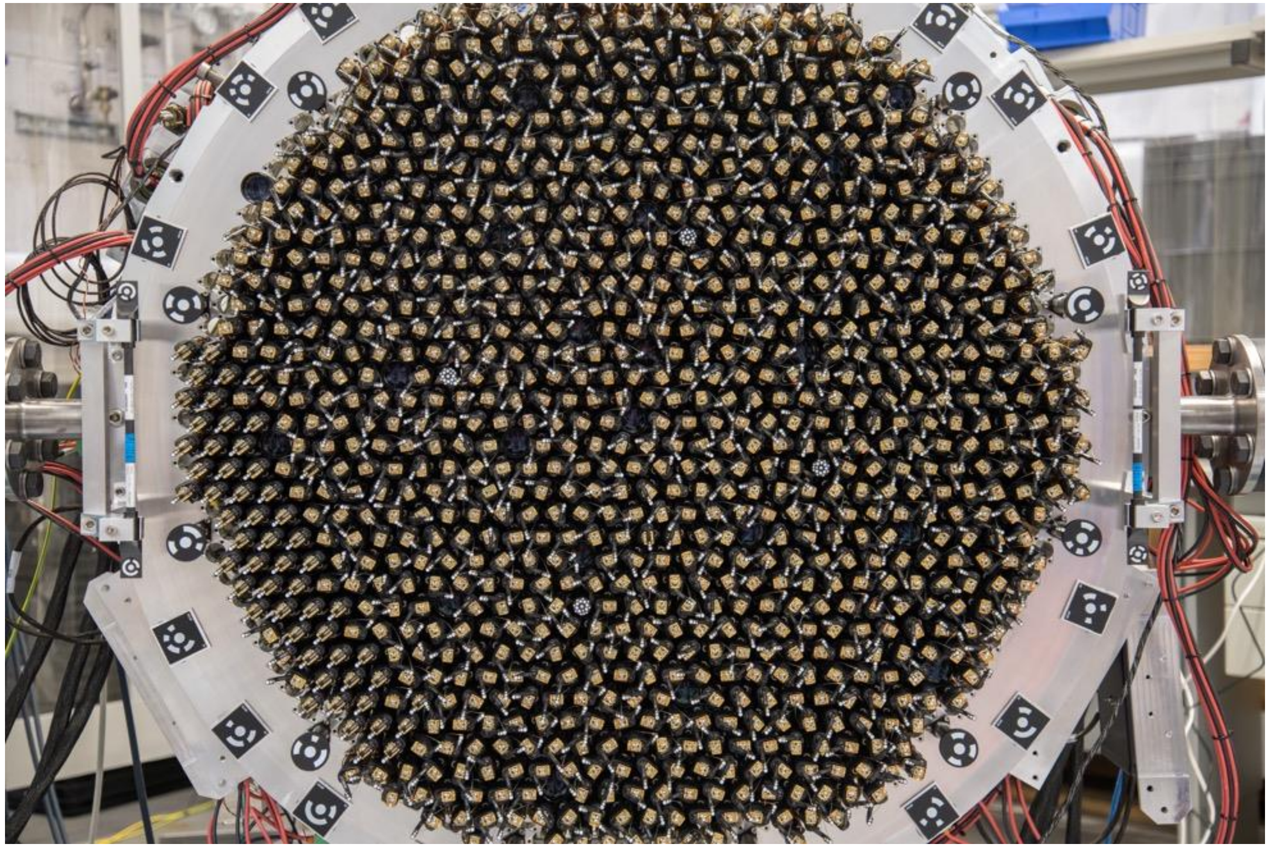
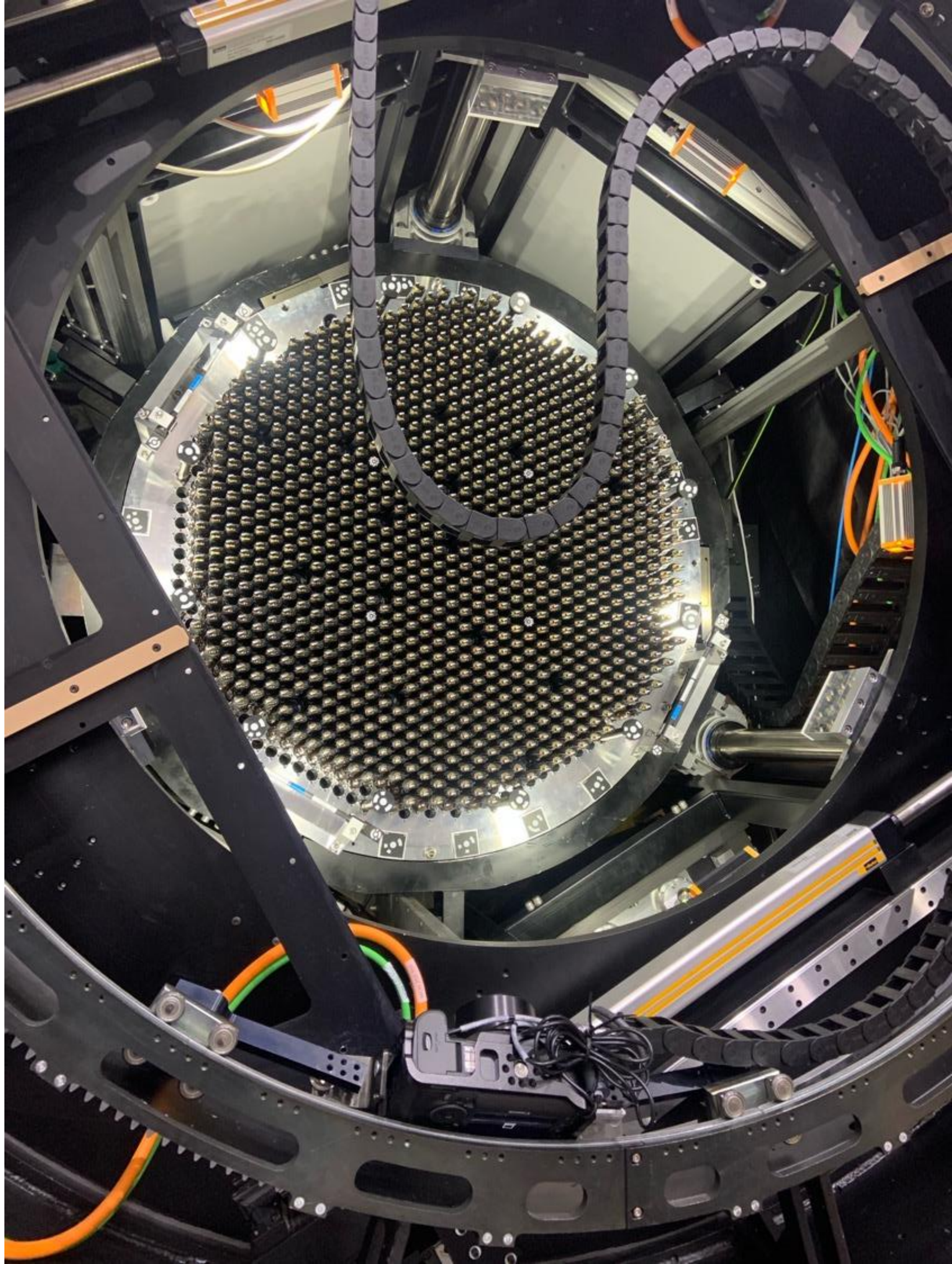


Images: University of St. Andrews & SDSS

Rotating Front End





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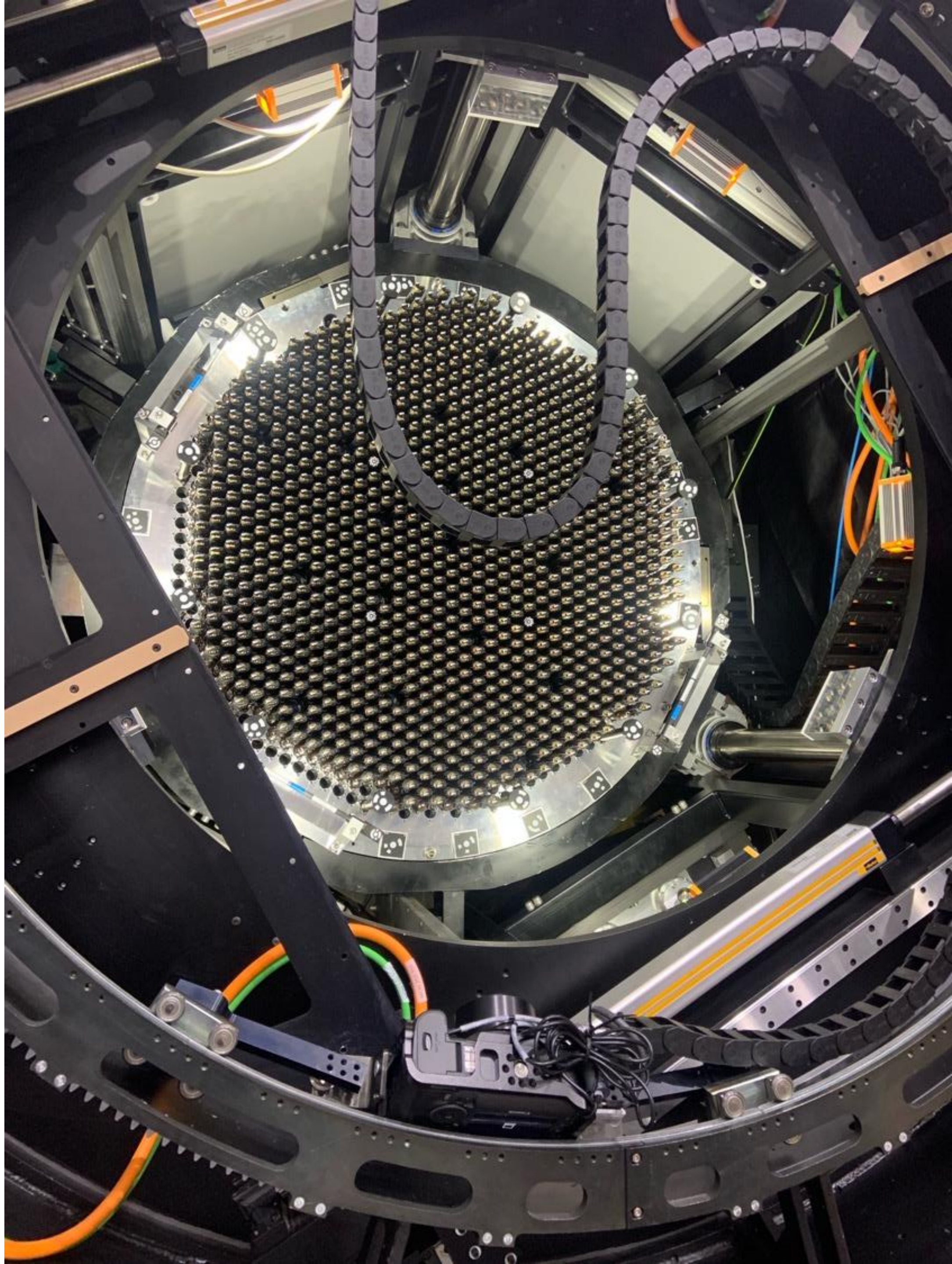
FPU Movement

Each FPU moves to look at a target. To cover as much of the focal plate as possible, with at least two FPUs, they need to reach the centre of their neighbour – this means they can (and do) collide with each other.

Positioning accuracy of approx. 20 microns is required.

We need to know where the FPUs are to work out how to move them to where we want them to be.

Then, we calculate a path to move each FPU onto a target (hopefully…) and start moving…



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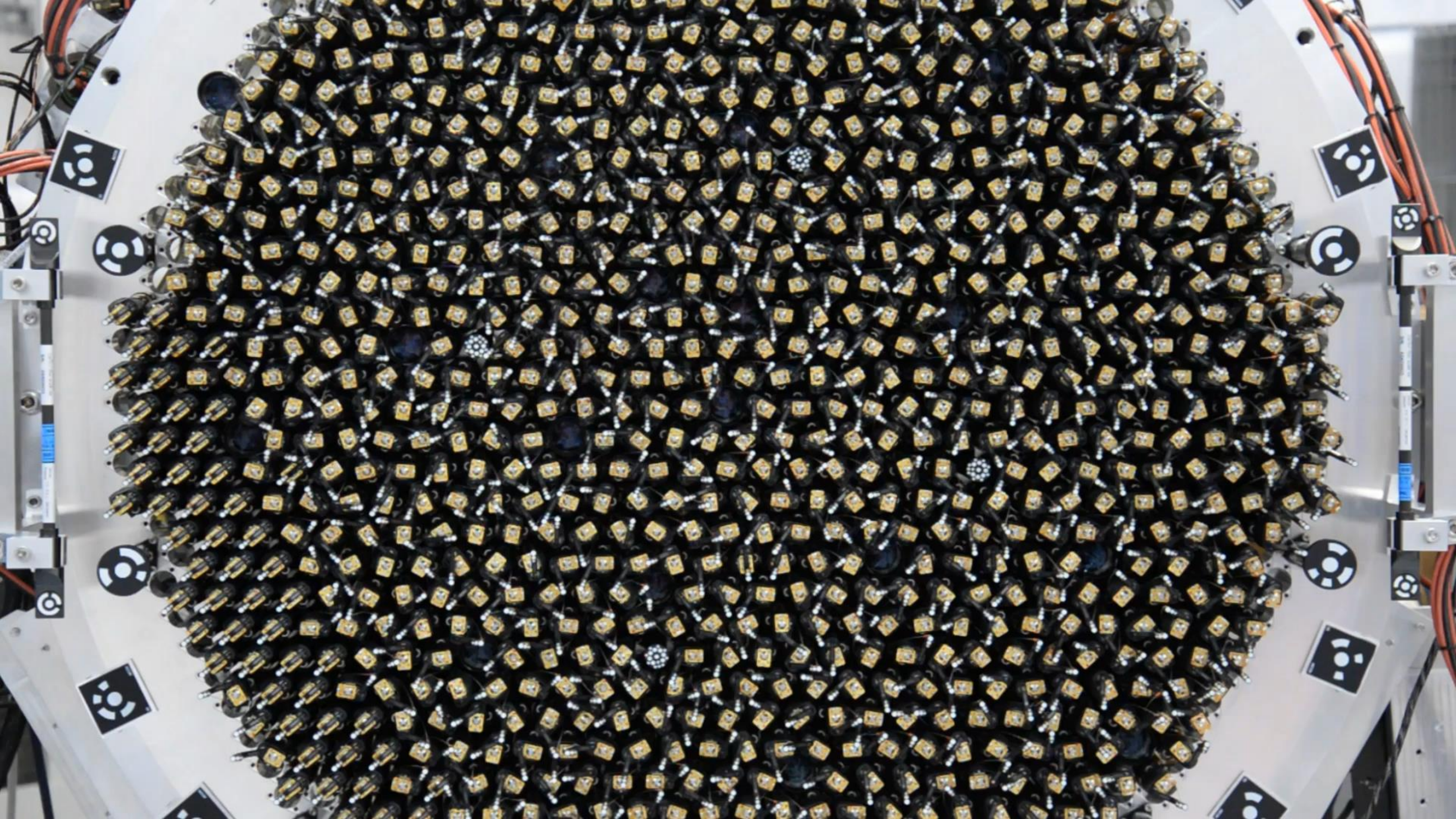


Optical Metrology System

Are the FPUs in the right place?

Installation error? Earthquake? Maintenance?

1. Take metrology measurements (at least 4, preferably 10+) at varying rotations of the alpha arms. Gives us approx. 12,000 coordinates.
2. Allocate those coordinates to an FPU ID (we know the length of the arms, so given a tolerance we can check 12,000 coordinates against 1,000 FPUs and decide which is the best match, or bin any errors.
3. Then, find the centre of each circle of the resulting coordinates. Thankfully, there's a Python library for this!

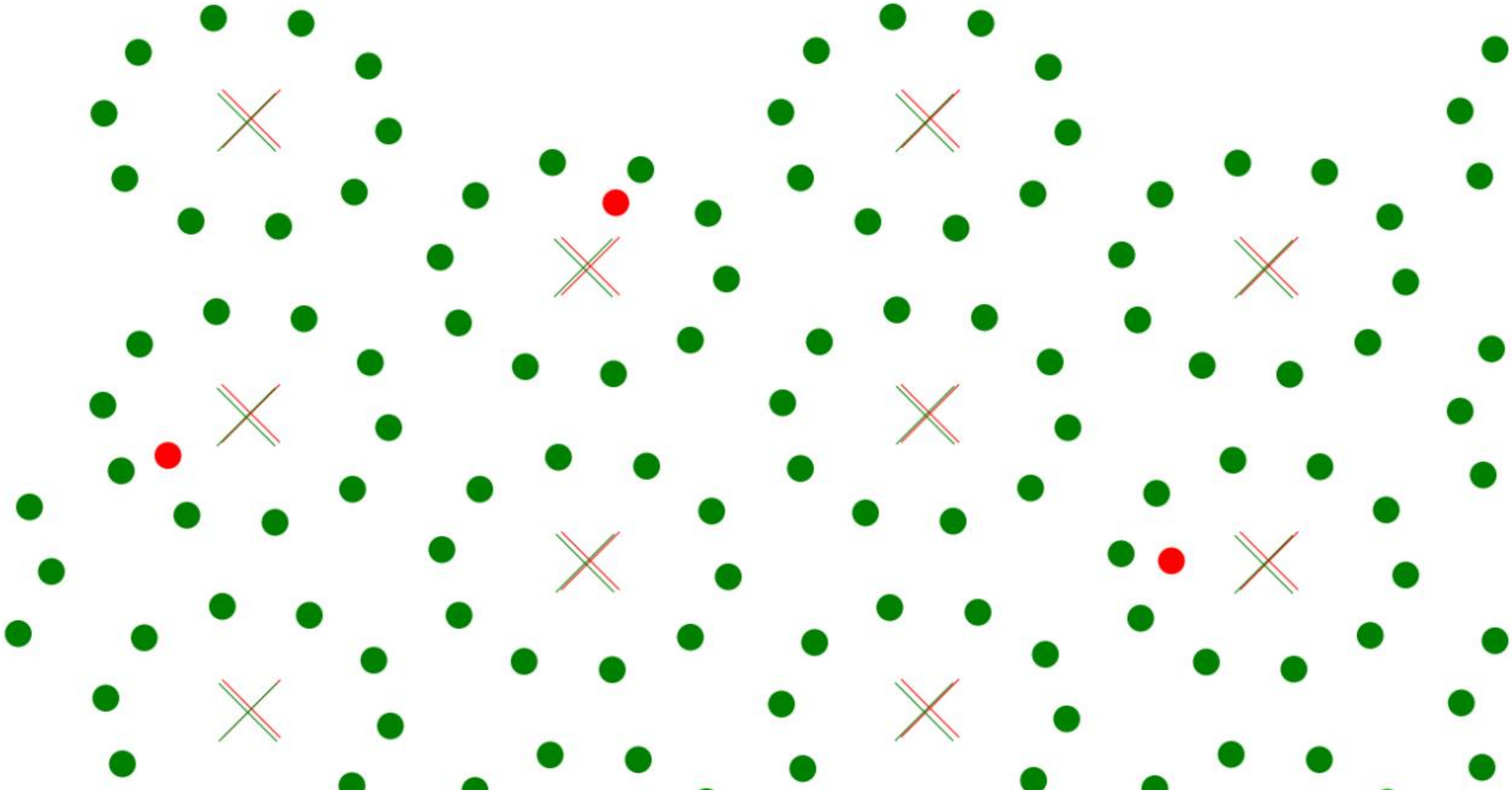
Circle Fitting

https://github.com/AlliedToasters/circle-fit

Test several different algorithms, varying from conventional least squares methods to gradient descent. Performance ranging from > 2 hours (not acceptable) to approx. 10 minutes with little difference in precision (20 – 100 microns). So, let’s go with the fastest:

Levenberg–Marquardt algorithm – iterative numeric minimisation

Can we multi-thread? Yes, but 10 minutes is fine so let’s not overcomplicate.



Path Planning

Need for:

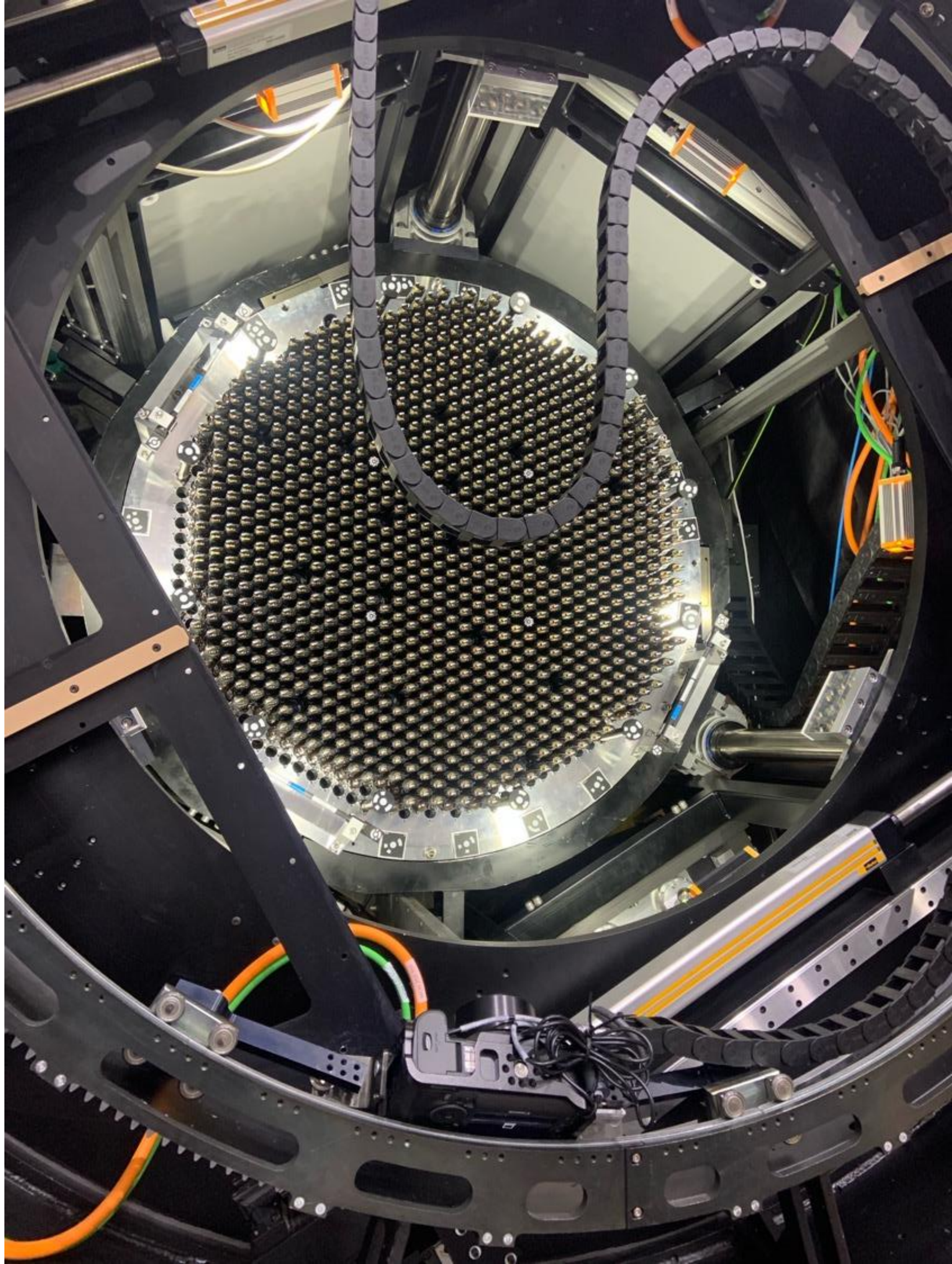
- Waveforms for the stepper motors.
- Computational efficiency – observation every two minutes means path calculations must keep up.
- Precision, collisions require to be recovered from, taking time
- Reduce wear on the motors – minimise oscillation.
- Btw, the next generation of MOS could have 20,000 FPUs, so scalability would be ideal!

Currently:

- Decision three, but depth only 2 or 3 for each ‘turn’.
- Modelling of attractive and repellent forces.
- The FPUs still collide with each other... why?

Solutions?

- Is this a variant of TSP, do similar solutions help?
- 3D CAD modelling to simulate the whole system?
  (But VLT uses 1990s hardware – there is no supercomputer in the basement.)
- Distributed computing using the FPUs themselves?



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Questions?

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Thank you

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