MICE Target Development

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Sheffield

8th June 2006

- Progress since last Collaboration Mtg.
  - Review of components
  - Assembly tests at RAL in April
  - Developments resulting from tests
  - Increased effort for target
- Plans & schedule June to November

Components

- Stator body
- Ceramic tube
- Glass readout tube
- Target shuttle
- Ceramic bearings
- Electronics
- Frame, jack, bellows, gate-valve

Stator (1)

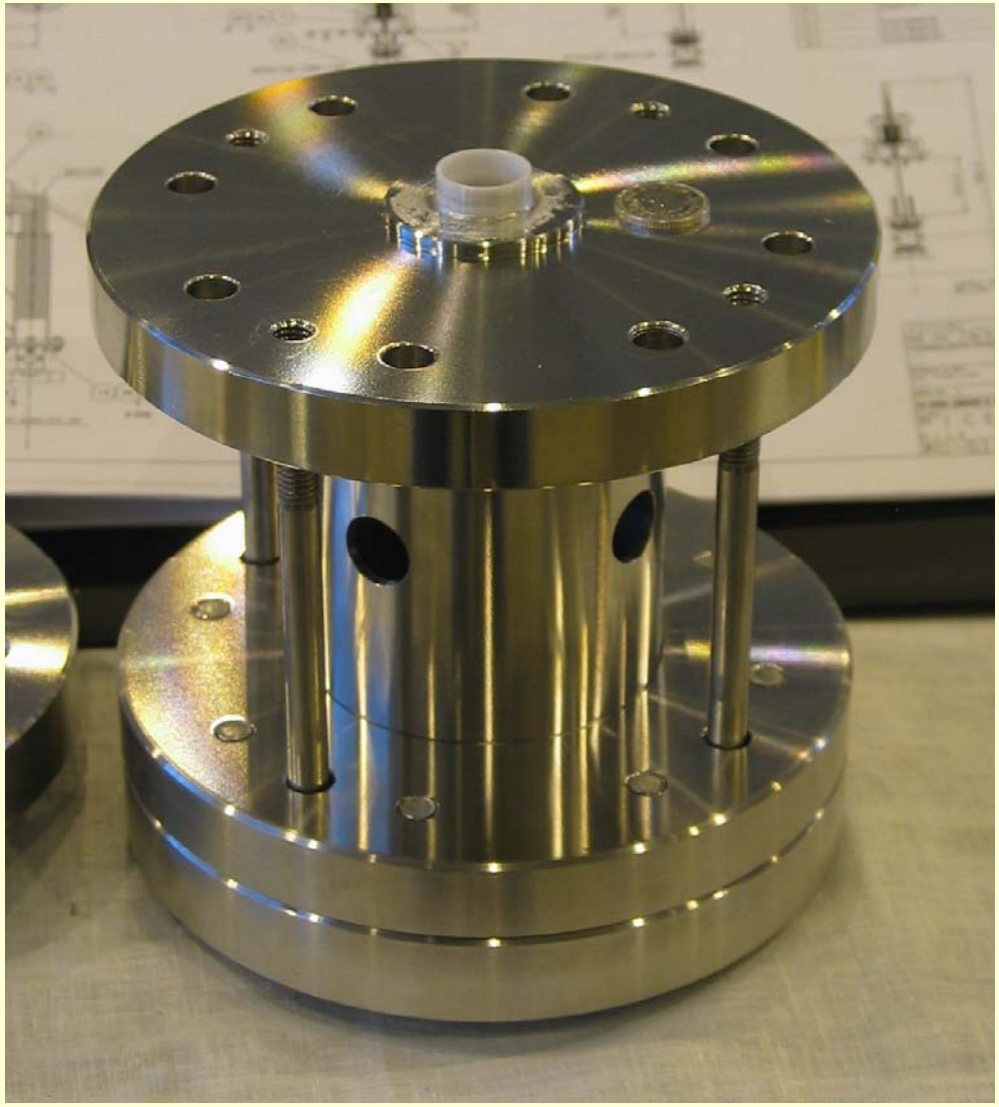
- Stator body from Manchester not built to specs.
- Micro-surgery allowed insertion of ceramic tube!
- We have learned how to make all components for future stators in house.

Stator (2)

- Coil winding company provided satisfactory sample.
- 30 coils purchased, to construct new stator.
- Coils wound in-house also satisfactory.
- Will try new cooling and potting techniques in near future.

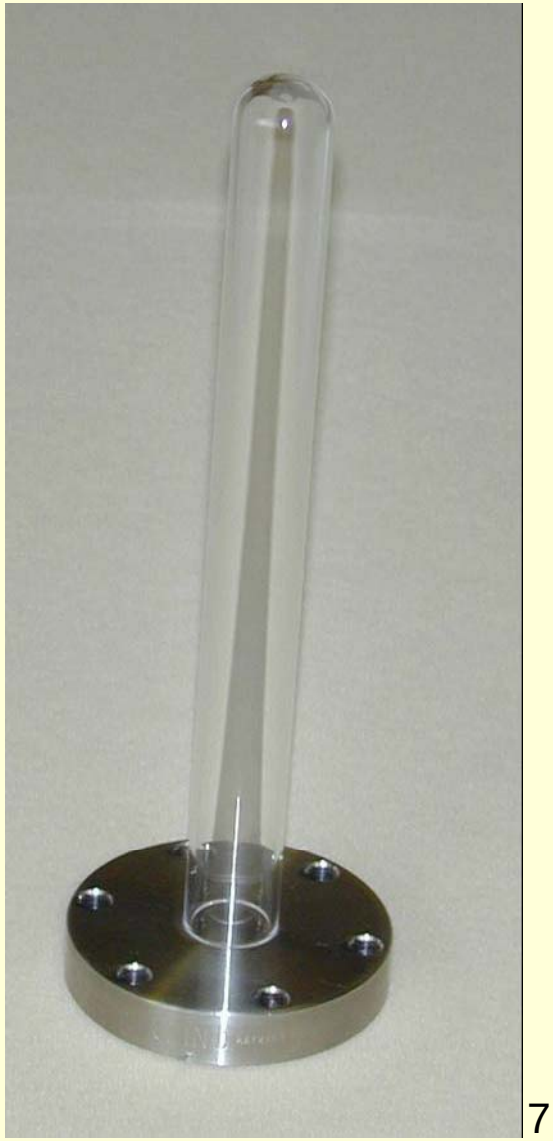
Ceramic tube

- Test flanges & dummy stator built at RAL.
- Indium vacuum seals tested.
- Pronounced satisfactory!



Optical readout enclosure

- Quartz glass tube and flange procured.
- Flange machined, tube fixed with cryostat cement.



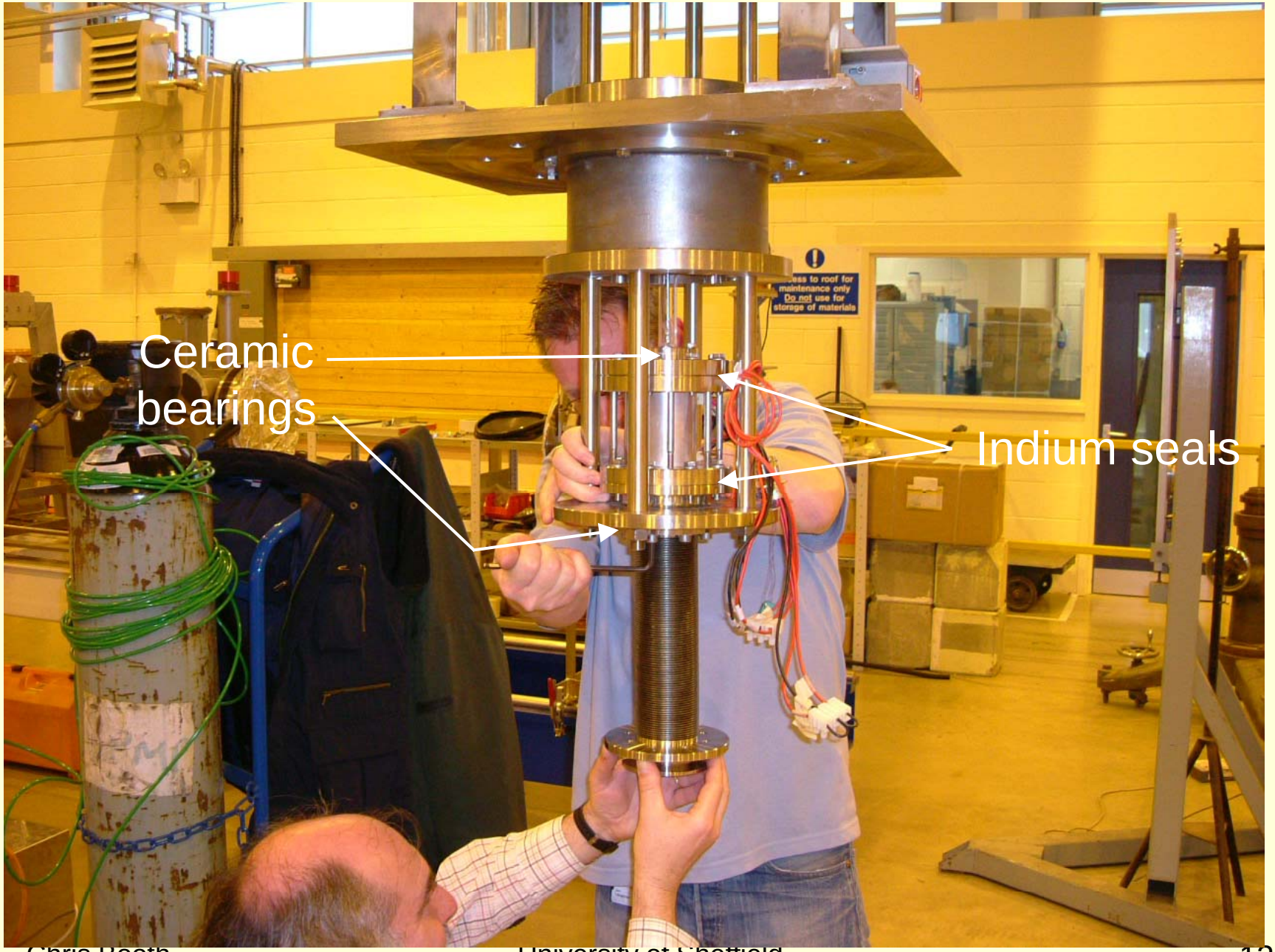
Shuttle

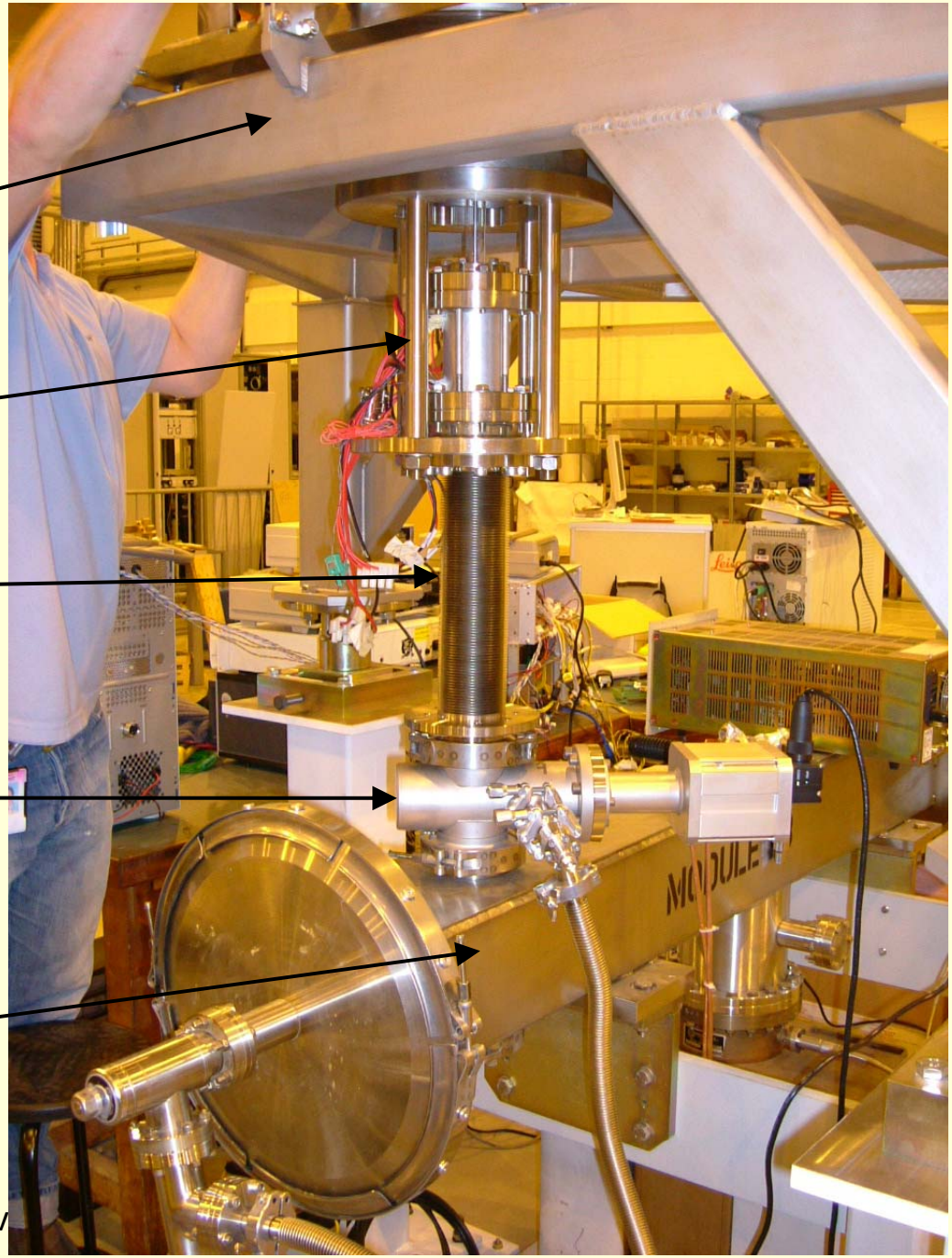
- Oxford assembled shaft, target, alignment fin, stop, magnets, readout vane (see picture) – many thanks!
- Magnets, readout vane supplied by Sheffield.
- For prototype, shaft produced from steel tube rather than titanium.
- Assembly cleaned in Oxford, delivered direct to RAL.

Control electronics

- Cards now rack-mounted.
- Extensive tests with prototype drive. Several hours pulsing at 0.3 Hz (10 A).
- Some reliability & noise problems are being addressed.

Bellows


Ceramic bearings
Indium seals

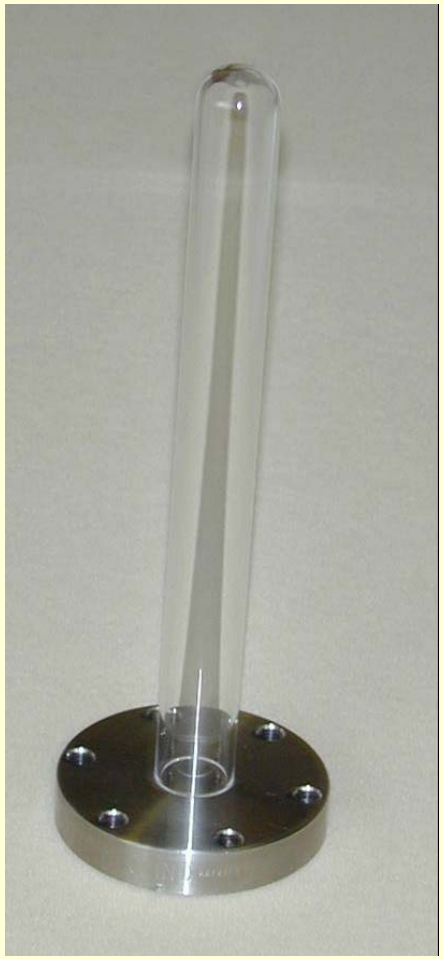

Support frame
Drive mechanism
Bellows
Gate valve
Beam pipe

Assembly test: 24-28 April

- First time many parts came together:
  - Stator first connected to electronics 20th
  - Glass readout tube assembled 21st
  - Target shuttle finished morning of 24th
  - Some RAL parts and flanges not previously assembled.

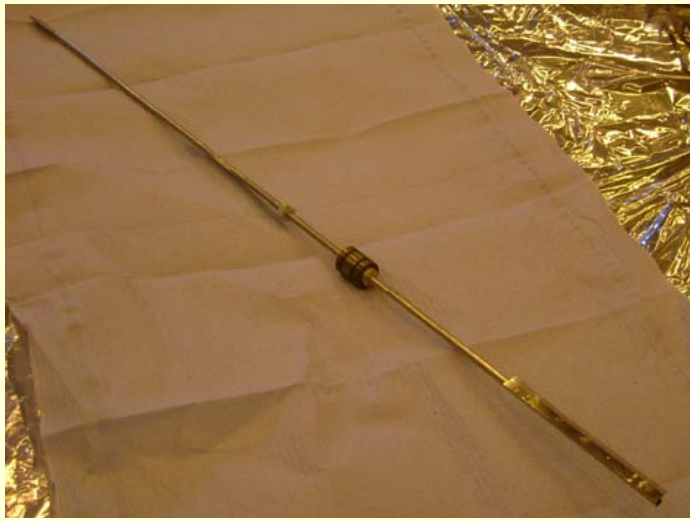
What did we learn?

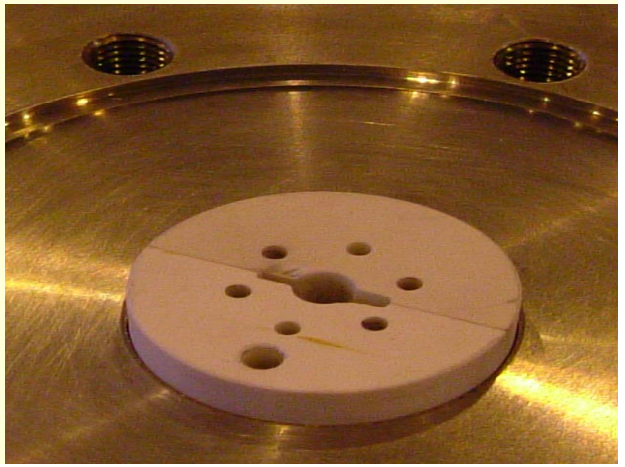
1. Glass tube was very fragile!
   - Broken near metal flange.
   - Ground down and re-glued – vacuum tested ok.
   - New crack when tightened down onto full assembly.
   - Covered in epoxy! Amazingly, this appeared to seal ok!

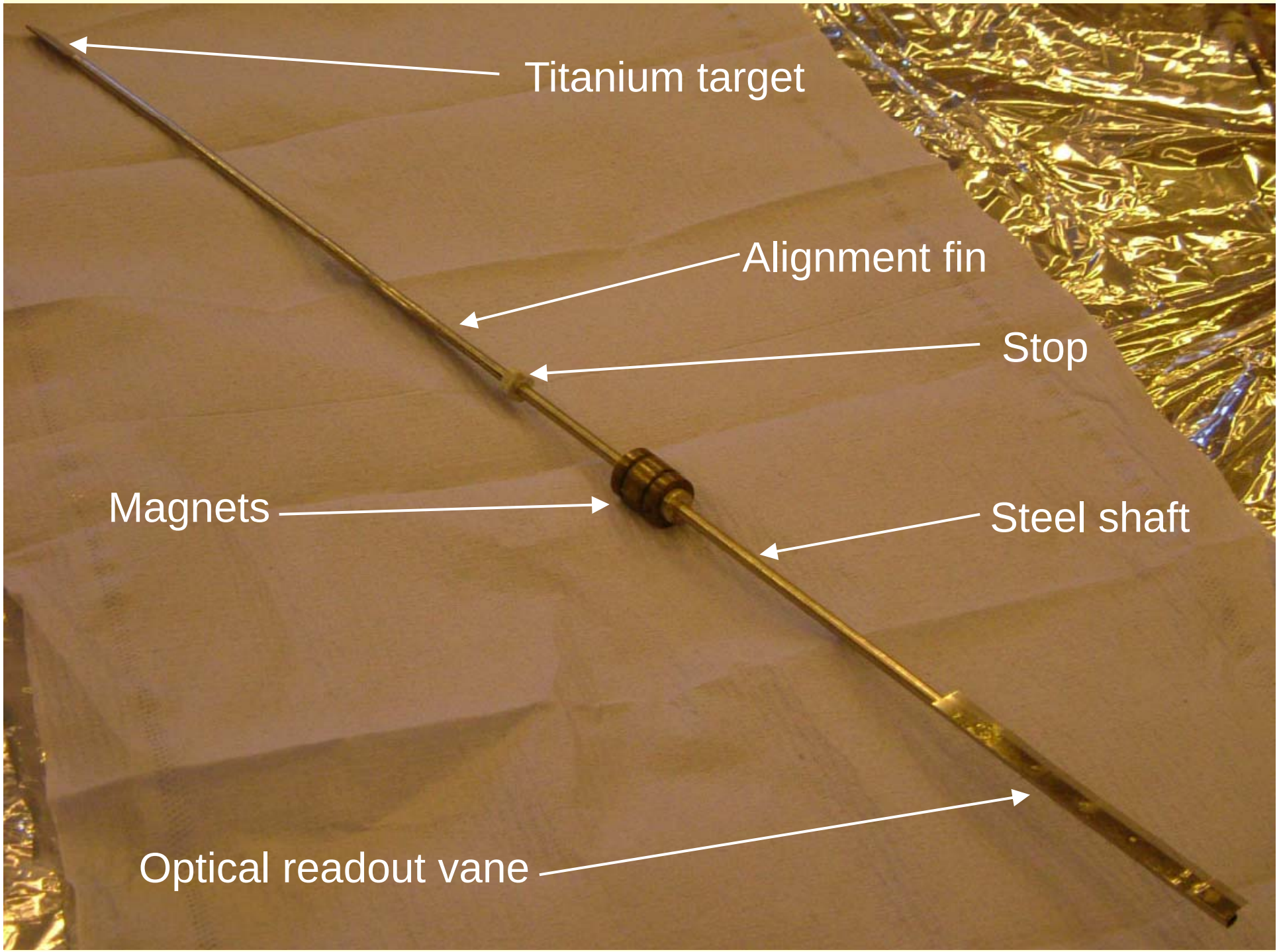


2. Target shuttle was distorted

- Slot cut along thin-walled tube to take alignment vane caused shaft to distort.
- Vane was twisted and slightly off-axis at one end.
- Would not pass through ceramic bearing.
- Slot & hole in bearing machined out to allow shaft and vane to pass.
- Some play and roughness, but movement satisfactory.






Titanium target
Alignment fin
Stop
Magnets
Steel shaft
Optical readout vane

3. Indium seals did not work!

- Despite success with test pieces, could not pump down below 3×10^{-3} mbar.
- Flanges found to have too large diameter and chamfer; rebates incorrect so inadequate closure of seal.
- Attempts to seal with extra indium.
- Only partial improvement.
- Prevented vacuum quality checks with mass spectrometer.

4. Temperature sensitivity

- Operation of drive (power-off to hold position) caused deterioration in vacuum. (Only 10-15°C temperature rise.)
- Chilled water cooling (12°C) also worsened vacuum.
- Partial recovery on return to ambient temperature.
- Movement of ceramic tube disturbing (imperfect) seal?

5. Optical readout block did not fit

- Insufficient space for readout block around glass tube when drive in raised position.
- Large guide flange removed – appears not to be necessary.
- Flange could also be machined down to allow space.


Large flange

6. Extremely difficult to align optics
   - Higher refractive index of quartz tube?
   - RAL restrictions on use of laser in hall.
   - Adjustment system not suitable for 3D alignment in both position and angle
7. Shaft length checked - OK
   - relative positions of target (raised) & gate valve, target (lowered) & beam-pipe, readout vane & top of tube etc were all correct.

Solutions to problems

1 & 6 Delicate glass tube, difficult alignment

- Replace glass tube with steel plus flat glass windows
  - Robust, much simpler optics.
  - Redesign optical mounts to allow off-line alignment and accurate relocation.
  - Involve RAL engineer in design (in conjunction with Richard Nicholson).
  - Meeting yesterday in Sheffield.

2 Distorted shuttle shaft

- Oxford redesigned target shuttle
  - Target, shaft, stop, alignment fin machined out of single piece of titanium.
  - Cross-shaped (or square?) cross-section.
  - Strong, no tendency to twist.
  - Only magnets and readout fin to be added.
  - New (or modified) ceramic bearings will be required – design to allow insertion of shaft through lower bearing for easier assembly.
  - Some questions have just arisen as to whether the shaft can be machined to this design! The design is under review.

3 & 4 Leaks at indium seals

- Flanges for indium seals to be re-ground or re-made
  - Vacuum and temperature tests are being performed at RAL.
  - Importance of careful quality control
  - Vacuum & temperature cycling tests will also be performed in Sheffield
  - In longer term, consider need for bonded ceramic-metal.

Conclusions of Tests

Despite problems, a lot was learned.

- Practical details of assembly for first time.
- Improved design of major components.
- No proper vacuum tests.
- No reliability or vibration tests.
- Review held (with ISIS) 16th May.
- Will repeat assembly in hall in July, full mechanical & electrical test in September.
- Will not install in ISIS for June – perform thorough off-line checks for October access.

Increased Effort for Target Work

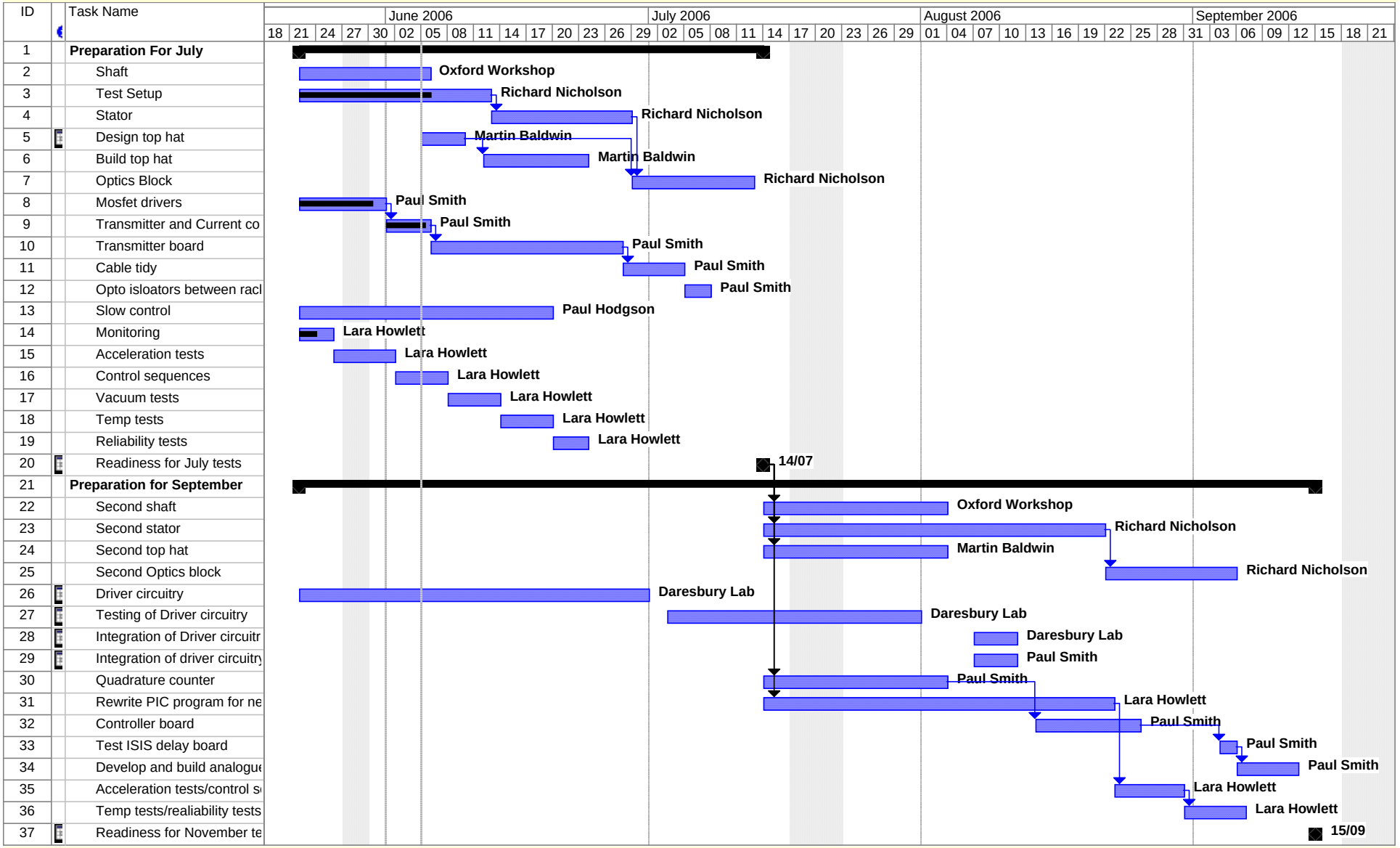
- Daresbury lab electronic engineer (Steve Griffiths)
  - High power driver electronics
    - Capacitor bank power supply
    - >100 A hex bridge using IGBTs
- Oxford workshop effort
  - Shuttle shaft construction
- Mechanical engineer (Martin Baldwin) (RAL)
  - Replacement chamber with optical windows
  - Readout alignment mounting (with RN at Sheff.)
- Sheffield Physicist/Engineer (advertise soon!)
  - Thermal modelling of stator – improved cooling
  - Electromagnetic modelling – more efficient drive?

Plans & Schedule (1)

- Indium seal tests (RAL)
- Build new shaft (Oxford)
- Design/build top chamber/readout (Sheff/RAL)
- Build new stator (Sheffield)
- Vacuum tests (Sheffield)
- Optical isolation of control boards (Sheffield)
- Optical drive of hex bridge (Sheffield)
- Improved control & monitoring (Sheffield)
- Acceleration & temperature tests (in vacuum) (Sheffield)
- Reliability tests (Sheffield)
- Mechanical test at RAL 17th-21st July

Plans & Schedule (2)

- Build & test IGBT hex bridge driver (Daresbury)
- Build second shaft (Oxford)
- Build second (improved?) stator (Sheffield)
- Build second top chamber/readout (Sheff/RAL)
- New quadrature board for optics (Sheffield)
- Improved controller hardware & software (Sheffield)
- ISIS interface boards (Sheffield)
- Temperature monitoring hardware & s/w (Sheffield)
- Acceleration tests (at 80 A) (Sheffield)
- Temperature, reliability tests (at 80 A) (Sheffield)
- Mechanical & electrical test at RAL 18th-22nd September
- Installation in ISIS October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Task Name
June 2006
July 2006
August 2006
September 2006
18 21 24 27 30 02 05 08 11 14 17 20 23 26 29 02 05 08 11 14 17 20 23 26 29 01 04 07 10 13 16 19 22 25 28 31 03 06 09 12 15 18 21
1 Preparation For July
2 Shaft
3 Test Setup
4 Stator
5 Design top hat
6 Build top hat
7 Optics Block
8 Mosfet drivers
9 Transmitter and Current co
10 Transmitter board
11 Cable tidy
12 Opto isloators between racl
13 Slow control
14 Monitoring
15 Acceleration tests
16 Control sequences
17 Vacuum tests
18 Temp tests
19 Reliability tests
20 Readiness for July tests
21 Preparation for September
22 Second shaft
23 Second stator
24 Second top hat
25 Second Optics block
26 Driver circuitry
27 Testing of Driver circuitry
28 Integration of Driver circuitr
29 Integration of driver circuitry
30 Quadrature counter
31 Rewrite PIC program for ne
32 Controller board
33 Test ISIS delay board
34 Develop and build analogue
35 Acceleration tests/control s
36 Temp tests/realiability tests
37 Readiness for November te
Oxford Workshop
Richard Nicholson
Richard Nicholson
Martin Baldwin
Martin Baldwin
Richard Nicholson
Paul Smith
Paul Smith
Paul Smith
Paul Smith
Paul Smith
Paul Hodgson
Lara Howlett
Lara Howlett
Lara Howlett
Lara Howlett
Lara Howlett
Lara Howlett
14/07
Oxford Workshop
Richard Nicholson
Martin Baldwin
Richard Nicholson
Daresbury Lab
Daresbury Lab
Daresbury Lab
Paul Smith
Paul Smith
Lara Howlett
Paul Smith
Paul Smith
Paul Smith
Lara Howlett
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15/09