MICE Target Status

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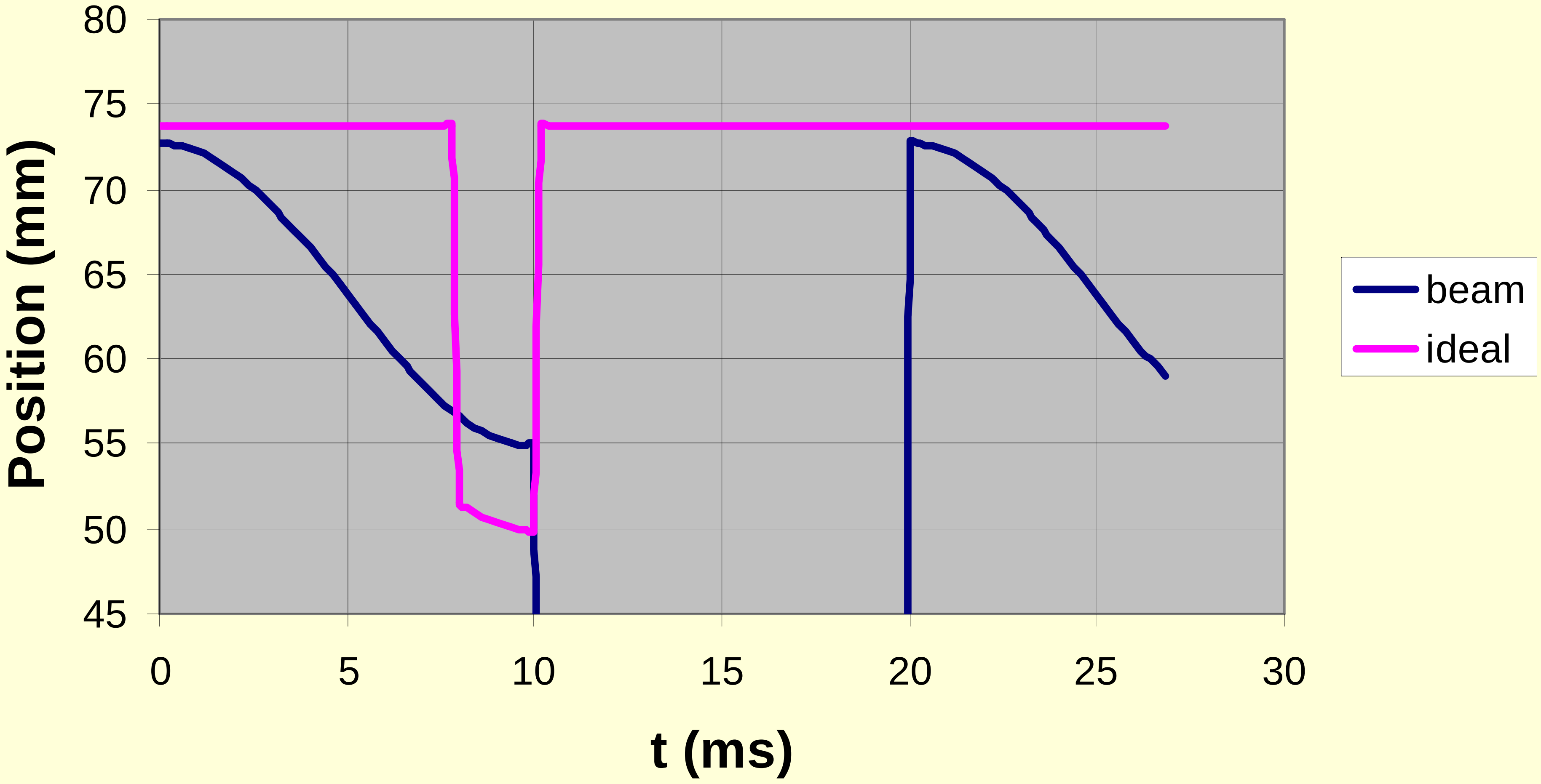
The challenge

- ISIS beam shrinks from 73 mm to 55 mm radius during acceleration
- Target must remain outside beam until 2 ms before extraction
- Then enters 5mm (into halo)
- Must be out of beam by next injection
- Beam cycle length 20 ms
- Target operation “on demand”, 1 to 10 (or 50) Hz

The challenge (continued)

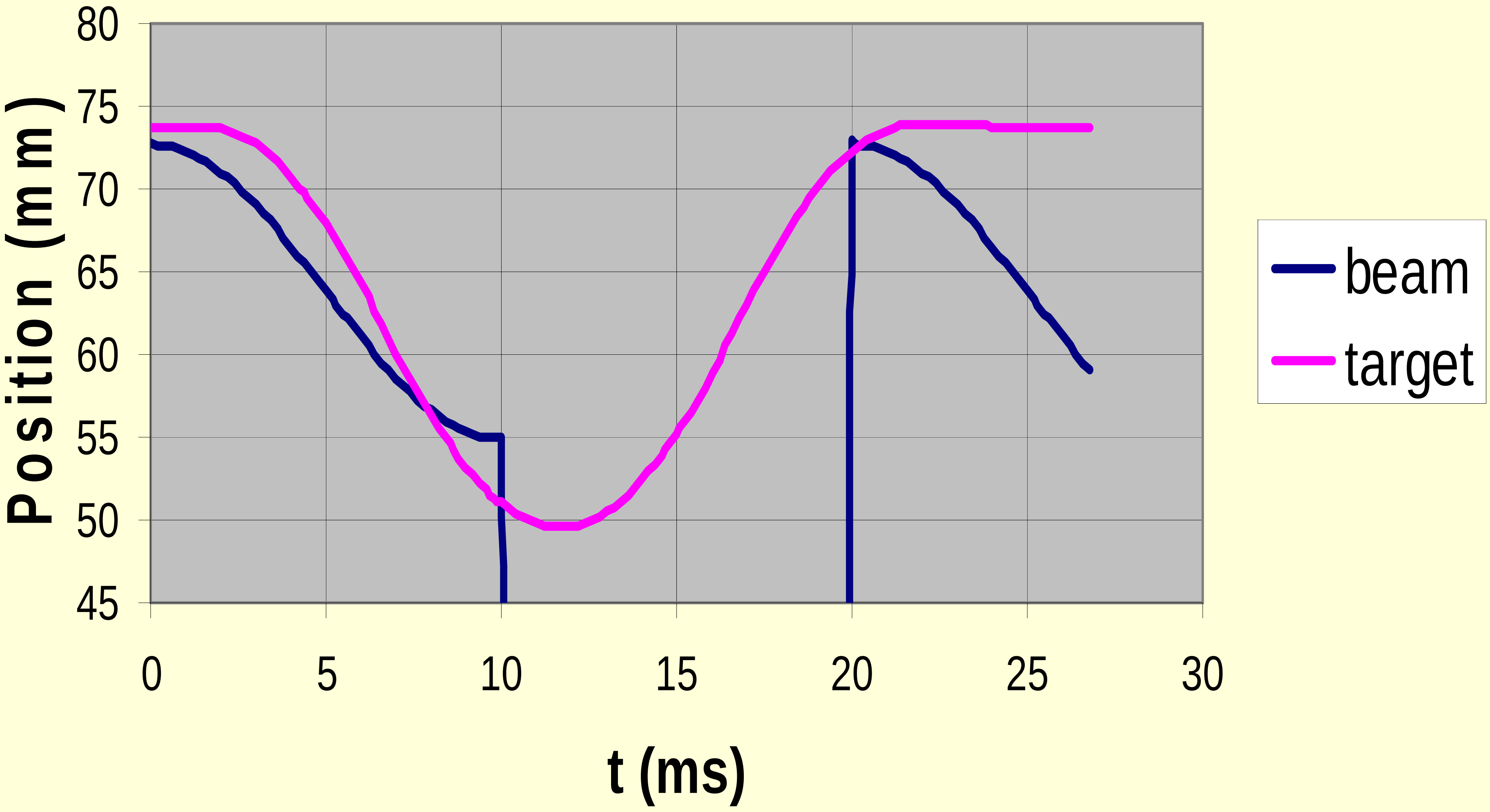
- Operation in vacuum
  - No lubricated bearings
  - No convective cooling
- Operation in radiation environment
- Must cause minimal vibration
- Must be completely reliable and maintenance-free

Ideal target motion



- Infinite acceleration!

With spring



Position (mm)
80
75
70
65
60
55
50
45
0
5
10
15
20
25
30
t (ms)
beam
target

Basic drive specifications

- Travel >25 mm
- Peak acceleration (min.) ~1 mm ms^{-2}

  $=1000\ ms^{-2} = 100\ g$
- Rep. reate
  - On demand 1 Hz → 10 Hz (→ 50Hz?)
  - (Machine cycle length 20 ms)

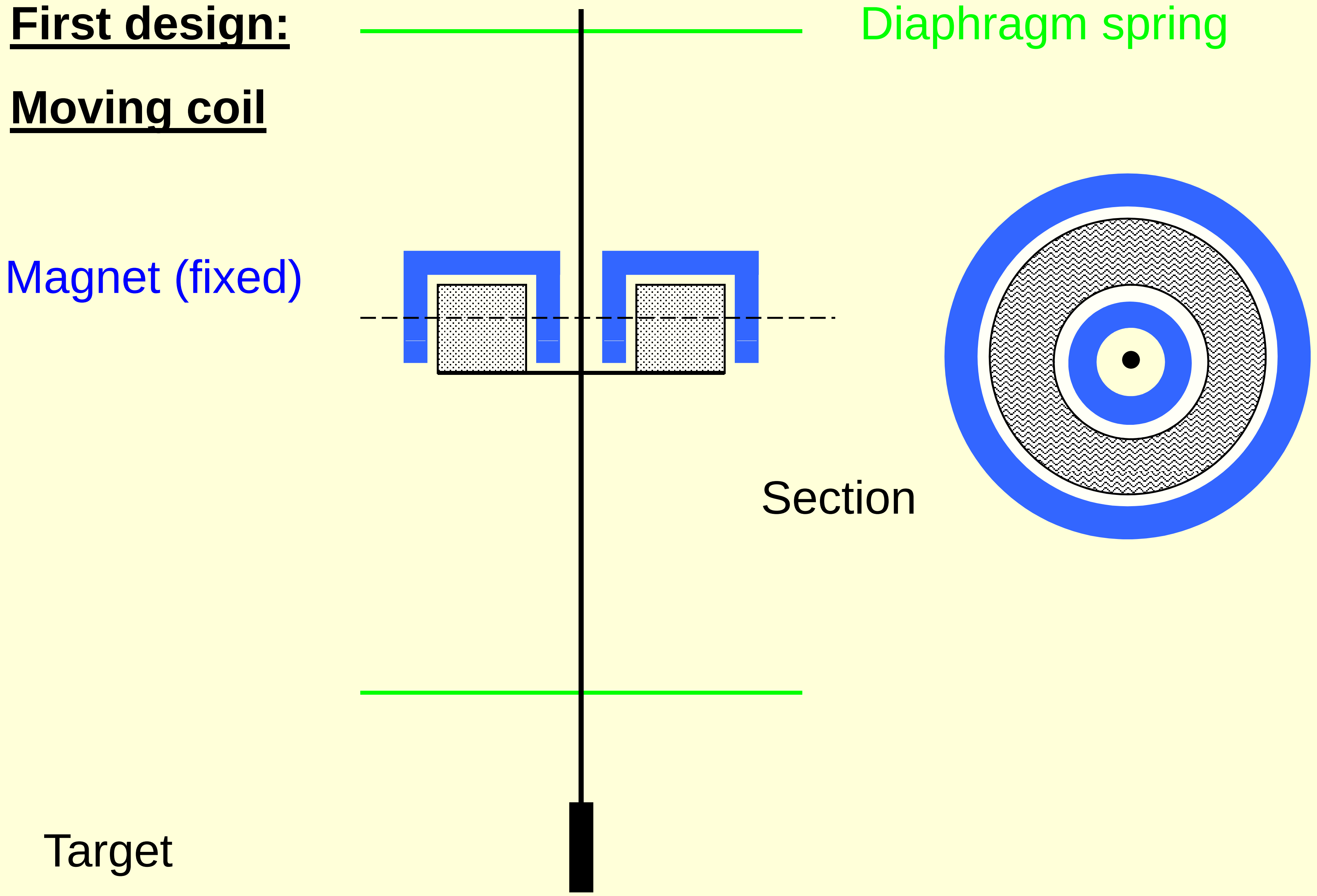
Components (or tasks)

- Diaphragm springs: 25 mm travel
  (±12.5 or …?)
- Magnet & coil assembly
- Position sensing
- Power supply & control, feedback etc.
- Cooling?
- …

[What buy, what make?]

First design:

Moving coil



Problems!

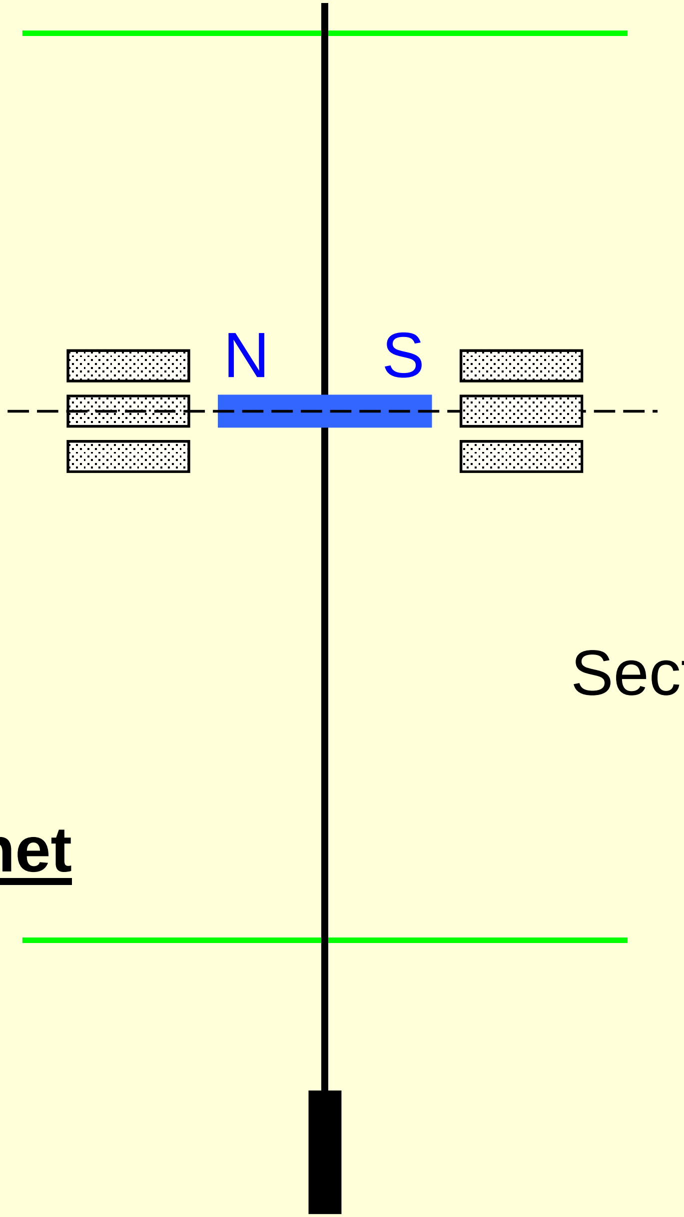
- Large volume of permanent magnetic field
- Large current, hence mass (hence power) of coils
- Difficulty of cooling

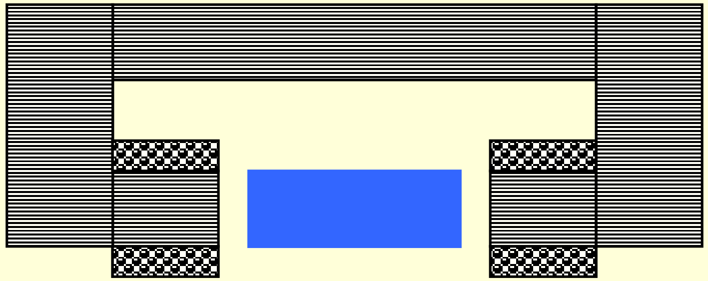
Discussions with Electrical and Electronic Engineering (EEE) in Sheffield:

- Modified idea for linear motor drive

Alternative design:

Moving magnet





Advantages

- Lower mass – light moving magnet (sintered neodymium-iron-boron)
- Stationary windings – more power, many cooling options
- Larger travel possible

Disadvantage

- Multiple coils
- More sophisticated power supply & commutator required
- Phase and amplitude control required

Control ideas

- 2 levels
  - Rapid hardware position feedback to control phase & ensure stability and reproducibility
  - Pulse-to-pulse monitoring (software) of position, timing, etc. to provide slow adjustments to drive waveform

Position monitoring requirements

- For monitoring
  - Precision 0.2 mm, sampled every 0.1 ms
- For drive phase control
  - Precision ~ mm, timing ~ 0.2 ms ?

Position monitoring method?

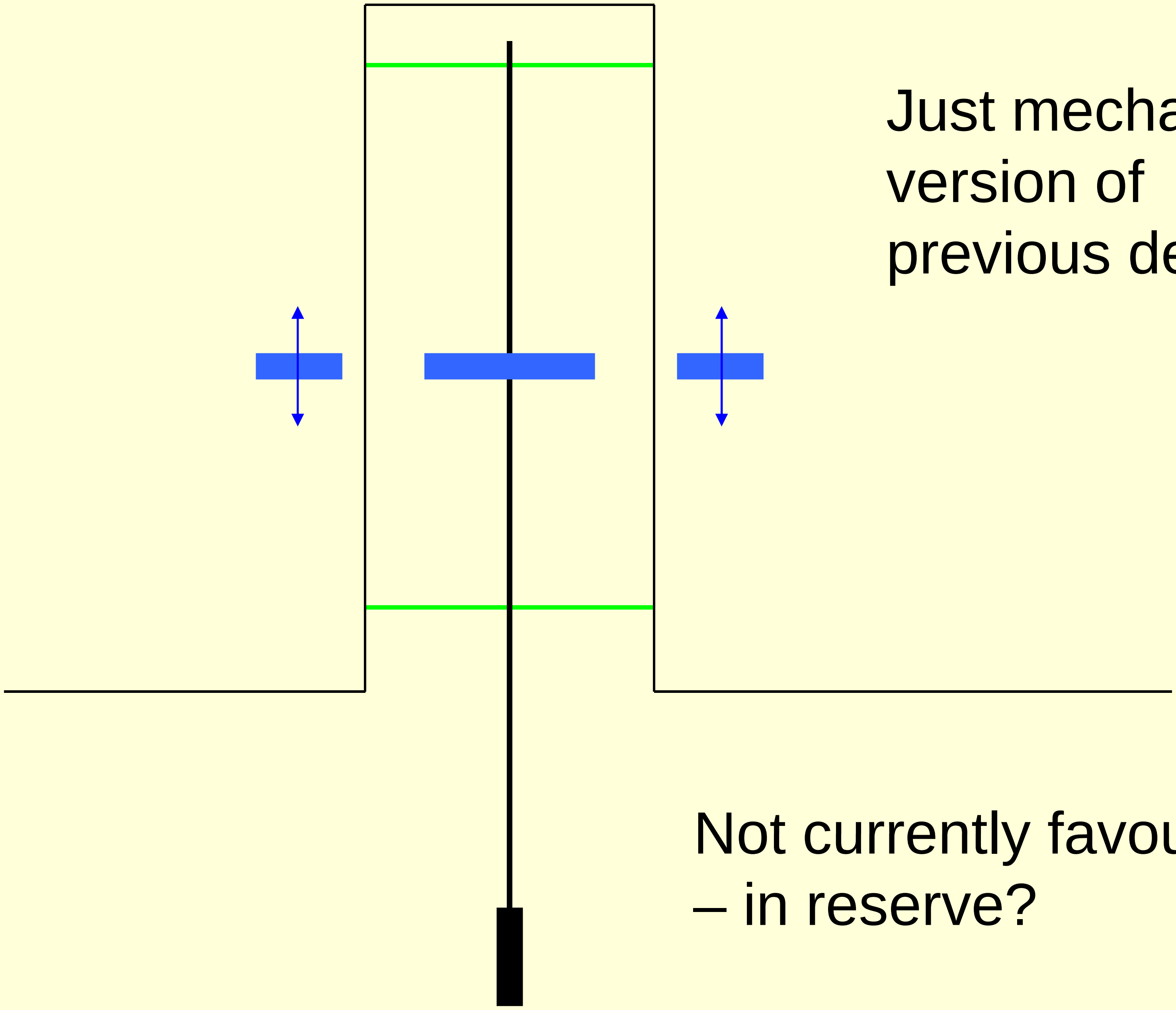
- LVDT (Linear Variable Differential Transformer)
  - Good precision, but not fast enough
- Optical encoder
  - Excellent precision, probably not fast enough, not radiation hard
- *Capacitive sensor?*
  - *Precision, stability, speed not yet clear!*
- *Magnetic sensor?*
  - *Is electronics rad hard?*

Parallel studies – with Caburn Ltd

- ~~Bellows, with solenoid/cam outside vacuum?~~

Fatigue!!

- Magnetic coupling through vacuum chamber?



Just mechanical version of previous design?

Not currently favoured – in reserve?

Next steps

- Continue design studies with EEE
  - Build prototype magnet/coil system
- Design/make/acquire diaphragm springs with sufficient travel
- Develop fast position sensing
- Interface to power supply/driver
- Implement 2-stage feedback
- Test and characterise

Future

- Radiation-hard position sensing?
- Improved control and feedback
- Operation in vacuum
- Cooling?
- Long term stability (fatigue of springs?)
- …

Timetable??

• First prototype	Summer 04
• Develop control	Autumn 04
• System tests	Winter 04-05
• Cooling, stability tests	Spring-Summer 05
• Rad-hard components	Spring-Summer 05
• Interfaces with ISIS	Spring-Summer 05
• Implement improvements	Summer 05
• Final device construct/test	Autumn-Winter 05
• Install	Winter-Spring 06