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Glasgow 10m: Future ISC challenges

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Best laid plans…

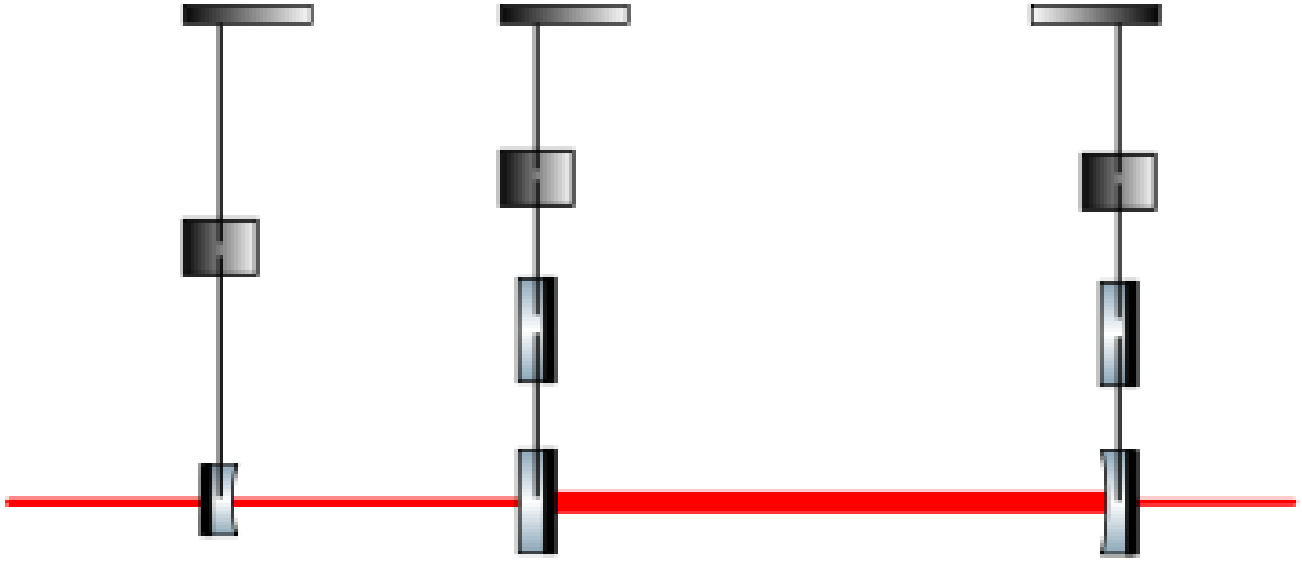
Current aim of the Glasgow 10m prototype:

- Set up a 3 mirror coupled cavity optical spring
  - Effectively a power recycled, detuned Fabry Perot cavity
- Investigate sensing and control schemes
  - First set up orthogonal sensing for the cavities
  - Then control the spring – circulating power, offset detuning, etc
- Investigate readout schemes/methods
  - Light coupling/end mirror + optical spring = ideal test platform for QND readout

Current JIF lab layout

Current set up is with heavy mirrors

- Arm cavity with triple-suspended fused silica mirrors
- Power recycling cavity with double-suspended composite optic
- Coupling mirror is a heavy mirror (flat, high reflectivity)

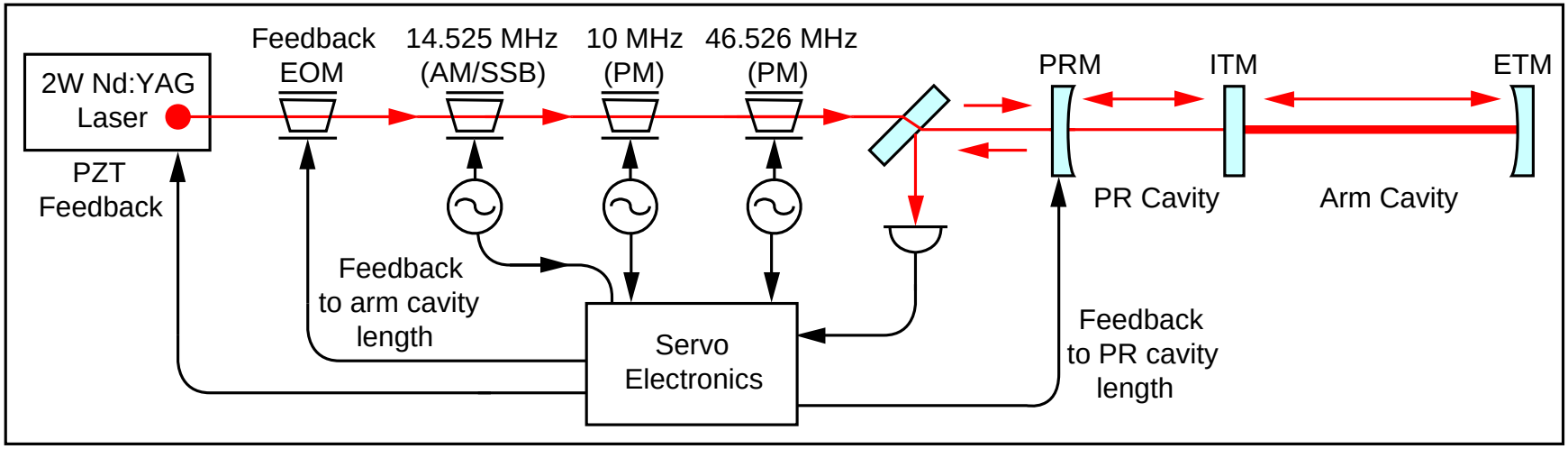


- PRC finesse ~50, AC finesse ~600
- Incident power ~200mW – can be increased quite easily – particularly if we tweak some parameters in the modulation arrangement…

Initial control scheme

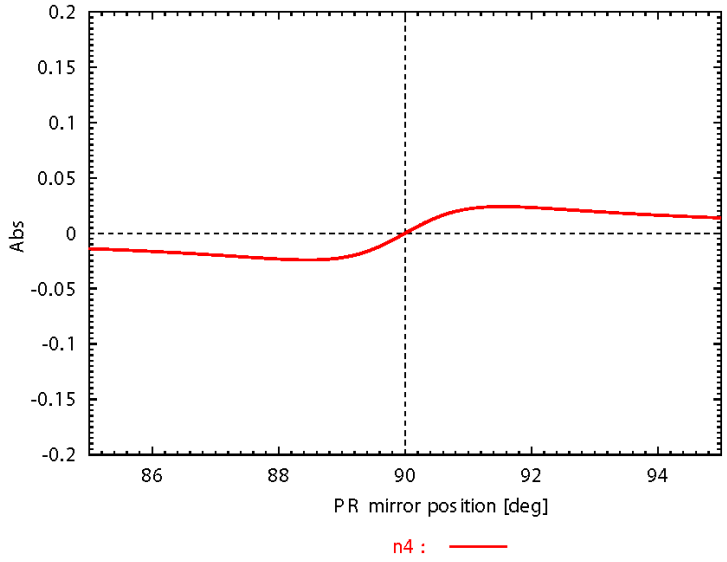
At the simplest level the control scheme is straight forward

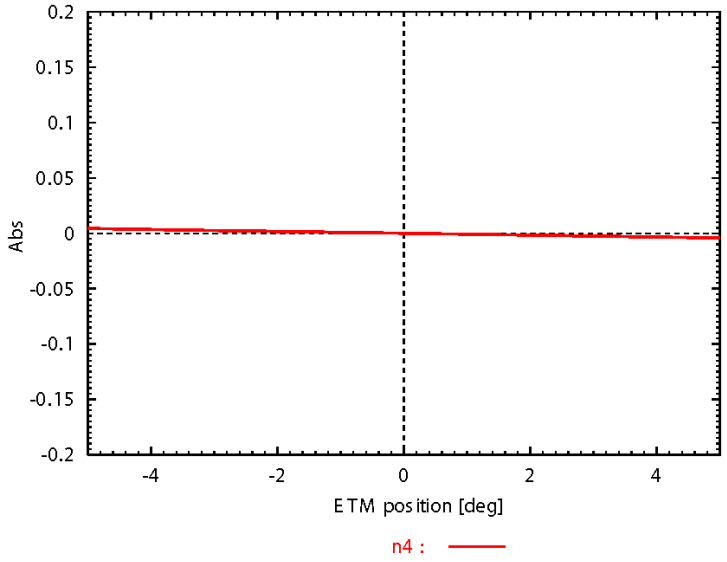
- 3 sets of RF sidebands
- PRC controlled by beat between AM sidebands at half PRC FSR and 10MHz PM sidebands
- AC controlled by beat between carrier and extra set of phase sidebands

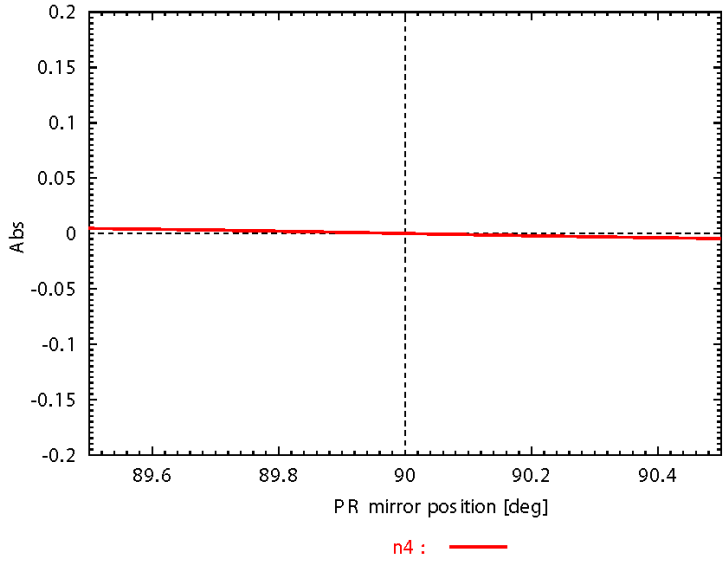


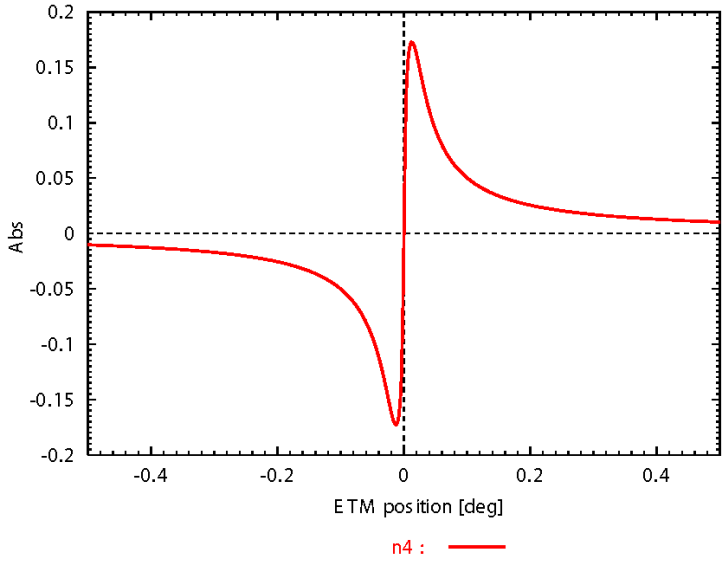
- Highly decoupled near the operating point – unlike conventional PRC control schemes, the PRC doesn't become unstable when the AC is detuned

Modelled responses



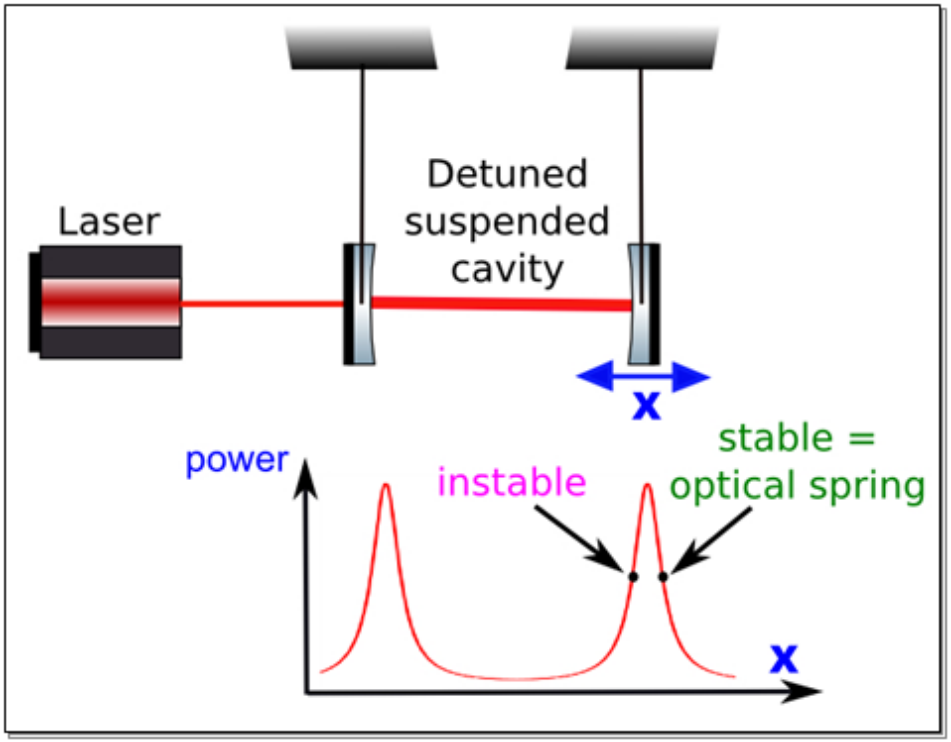






Why detuning?

Put simply – detuning a cavity is how we generate an optical spring…



- The spring resonance parameters depend on the degree of detuning and the power incident on the mirror

Where do we go from here?

Current status

- Control scheme exists and can be used to lock the 3 mirror coupled cavity (3MCC) at centre of resonance
- All heavy mirrors
- Analogue controls – robust, but not very adaptable

Coming soon

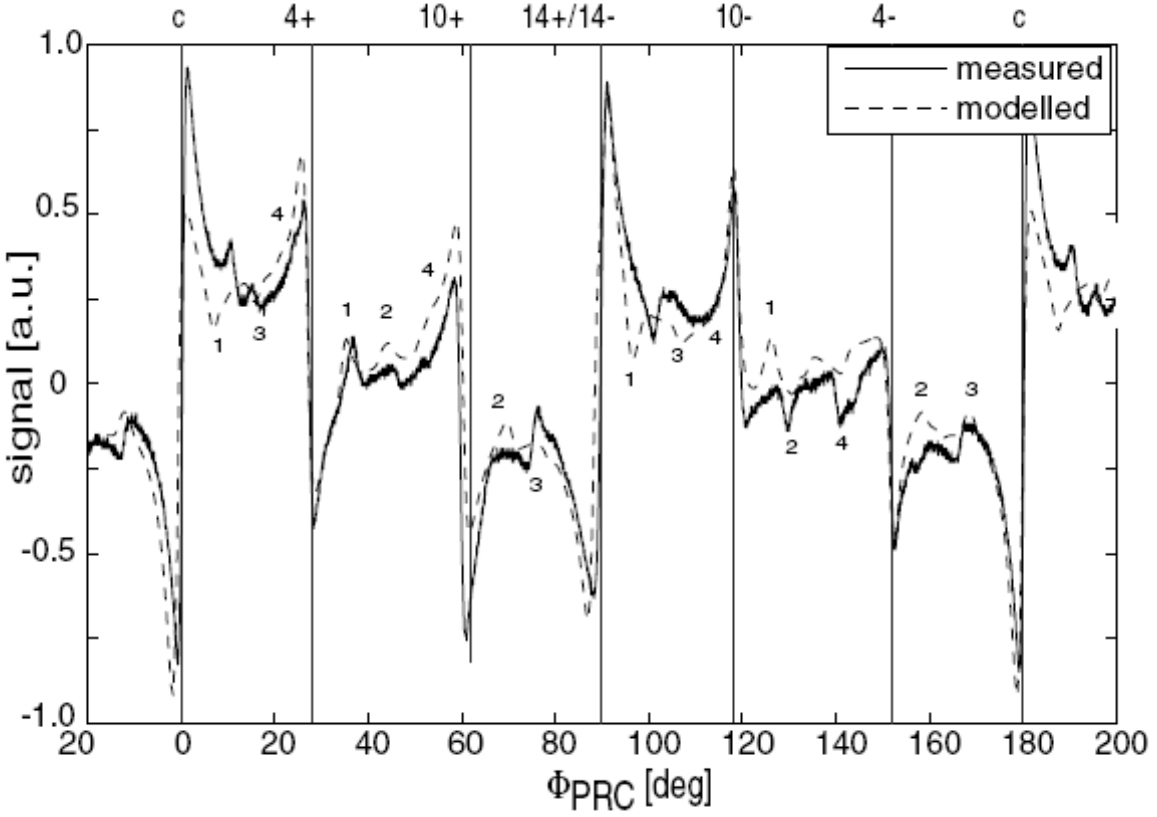
- Digital controls – flexible control structure
- More power! The more we have, the higher we can push the optical spring and the more information we can glean from the system
- Light (100g) mirror
  - Initially – replace the end mirror with a light mass to accentuate the optical spring
  - Later – can replace the intermediate mass (coupling mirror) – more like an optical bar

Anticipating problems…

Alignment

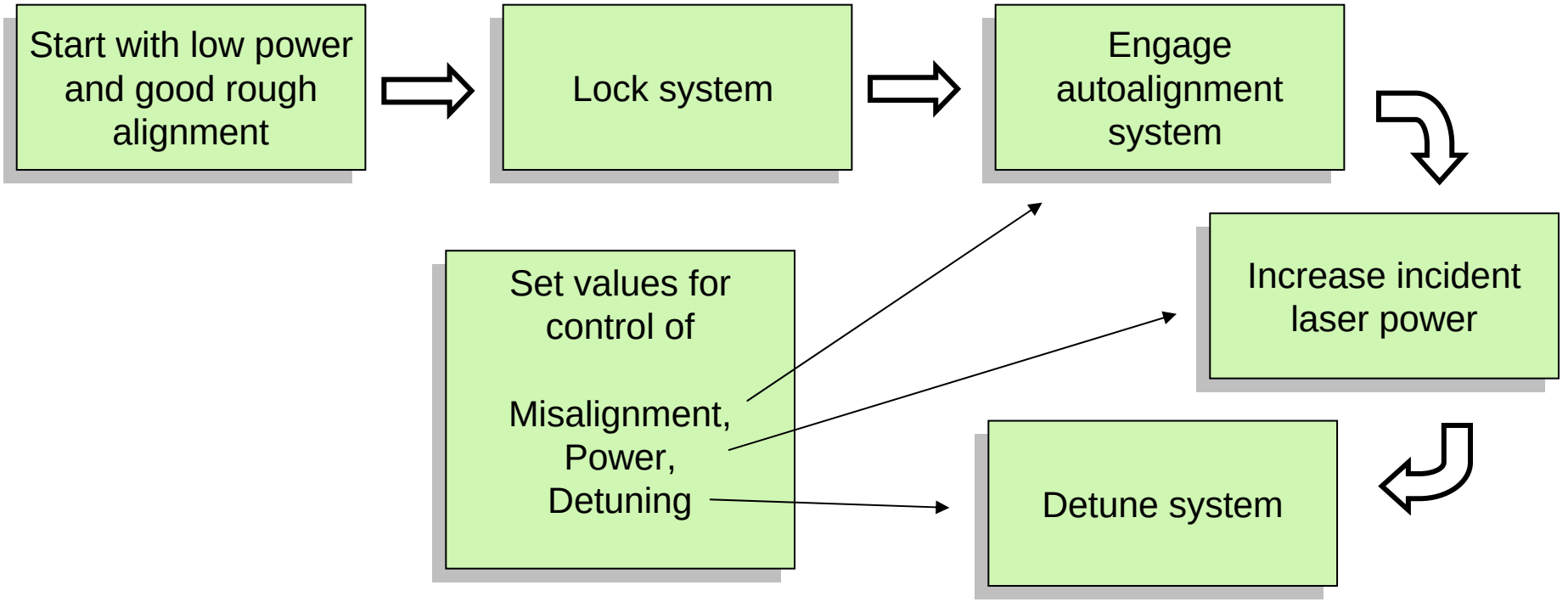
- While characterising the cavity control scheme we noticed that alignment played a large part in coupling between the cavities and lock stability

- In particular, mismatches in mode-matching and alignment contribute to offsets and can cause distortion of the error signals
- Numbers in the right hand plot indicate n+m of TEM_nm modes
- With a light mirror where the goal is radiation pressure dominance – the light mirror will twist in response to varying light power



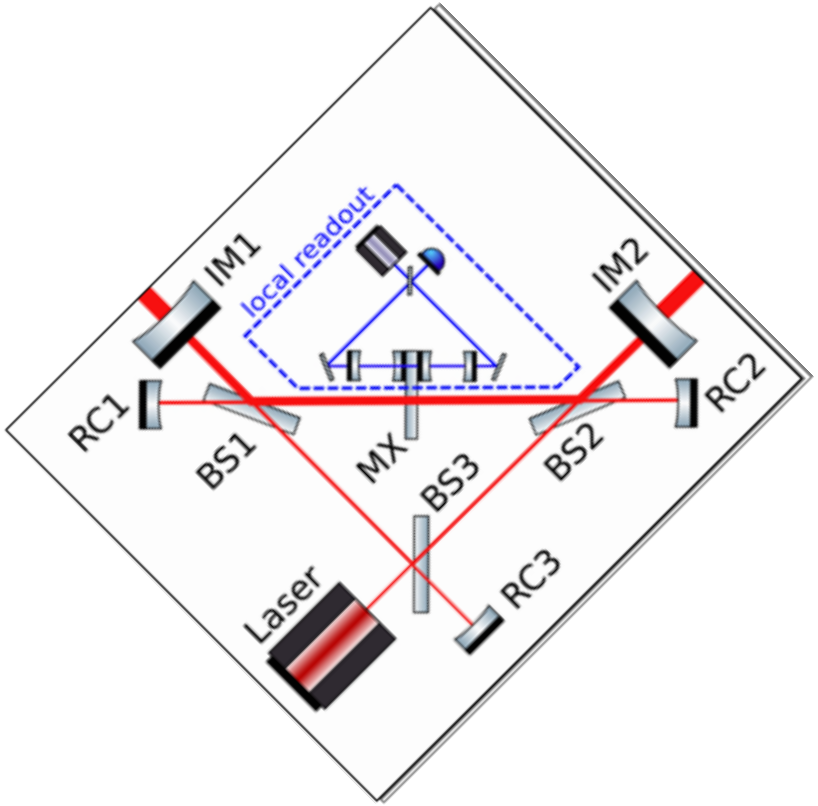
Light mirror + high circulating laser power

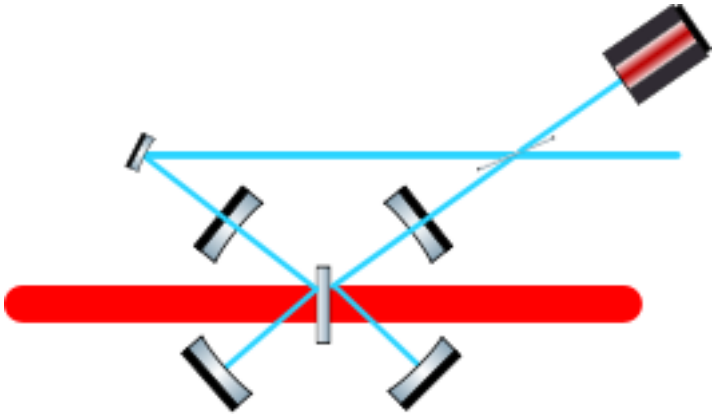
- Alignment will be a problem
  - Can fix with an autoalignment system
- Lock acquisition may also be difficult
  - Mirror gets knocked about while trying to lock
- Adaptable digital controls may be vital to operation…



Can we implement a local readout scheme?

- Challenging, but with a light mirror coupled cavity we have a good test system to build on…
- Methods are still under consideration - but whichever method is chosen, it will have to be controlled and operate within the existing framework





This has been an overview of 3MCC work in Glasgow

- Not much in the way of detail…

- If you want to know more – just ask! We're more than happy to talk about it.
- If you have any suggestions – we'd like to hear them!
- If you would like to get involved – we'd like to hear from you!