Document	Project Proposal		
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Beamline:	FREIA	Project No.:	
Project Name:	Fast Slits	Sub Project:	[Sub Project]

1 Executive Summary

This is how we propose to deliver the fast slit system for the Freia beamline. We have broken the system down in to two separate projects. The first project is the delivery of fast three-slit system, which can accurately open a slit in 1second to an accuracy of 5 microns. The second project is development of a high-speed blocker system capable of opening and closing the slit aperture in a period of 15ms.

2 Introduction

The Freia beamline has developed a way of using three separate varying angles of incident beams on the sample. For the science case, this needs to happen very quickly with each slit opening or closing in 15ms to an accuracy of 5 microns. The science case requires packaging the three slit apertures in a single unit. Two of these slit units are spaced apart from each other by a 2m collimation tube that ensures there is no cross talk between each of the three angles.

Preliminary investigation work has identified that it is very difficult to achieve the preferred specification given the space envelope available. This is mainly due to the force needed to accelerate the slit blades into position and the accuracy needed.

3 Proposal

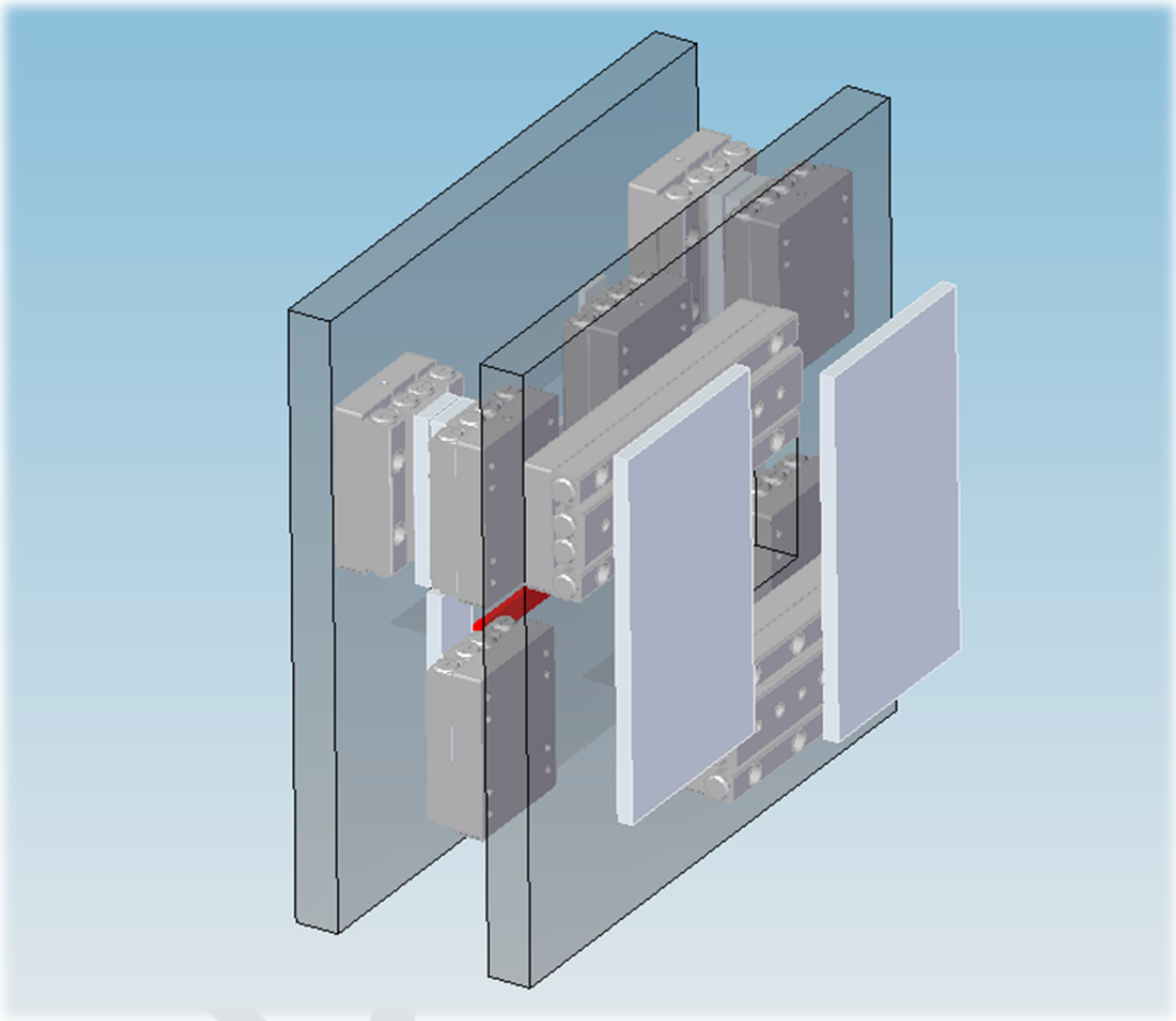
The IDD Mechatronics Automation Design team proposed to break this into two projects; the first being a set of slits that can open and close in 1 second and achieve an accuracy of 5 microns. After consulting with suppliers, this project looks to be achievable. The second project is the development of high-speed blockers. Due to the speed of these blockers, further development is required before assessing the feasibility of the project.

3.1 Fast slits

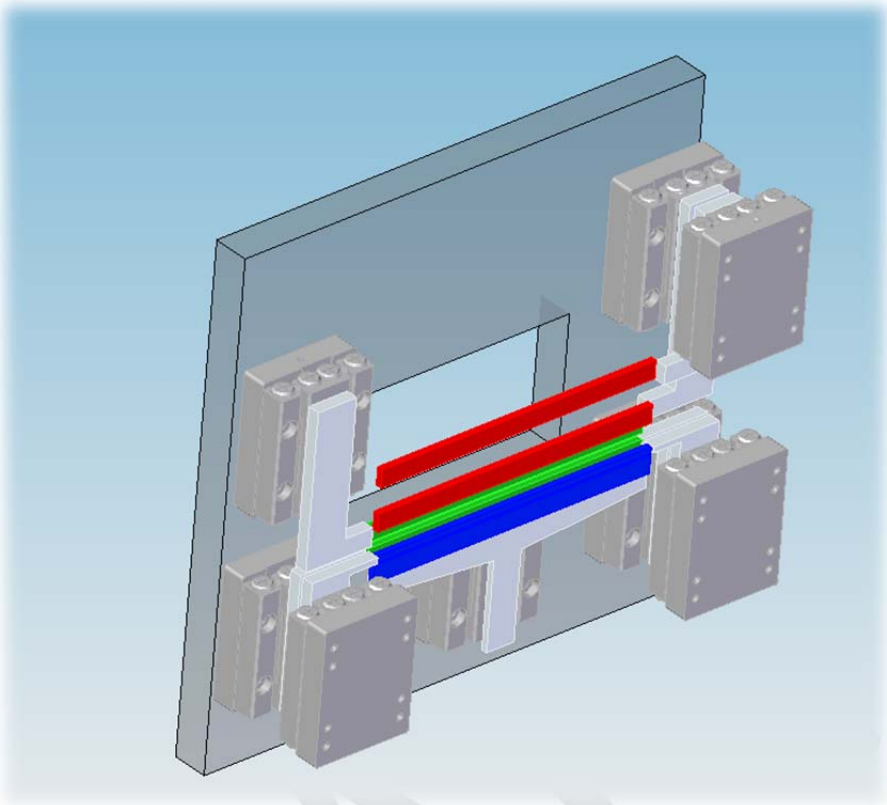
The fast slits will consist of a large number of SmarAct piezo linear stages. These stages are the ESS' preferred piezo stage. The Freia beamline has very tight space constraints; these stages have the benefit of being very small and micron accurate and have a maximum speed of 20 mm/s. After speaking to the supplier running them at this speed for the sort of duty cycles that Freia needs would result in them failing in a matter of days due to overheating. To be able to deliver a reliable, repeatable motion and to take in to account acceleration and deceleration, the fastest run speed would be to be able open and close a 15mm gap in 1 second using two stages; each stage moves 7.5mm in 1 second. To mitigate against the build-up of heat, excess heat may be removed from the

stages through passive heat sinks to the cave's air conditioning system. If further cooling is required, this could be achieved through water-cooling via the mounting plate of the slit unit.

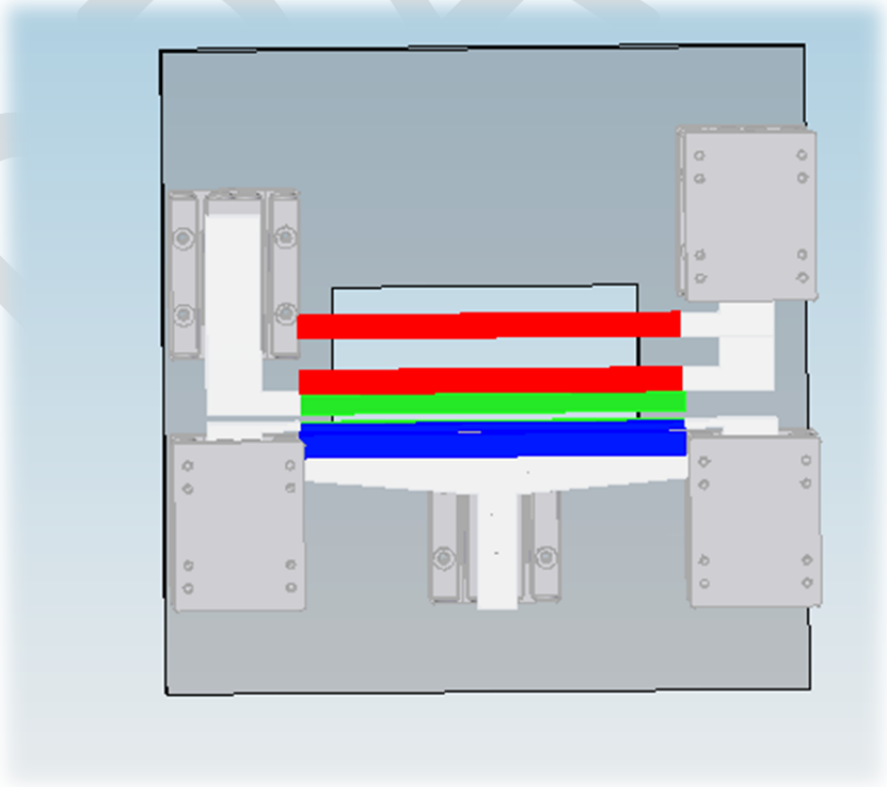
At the anticipated duty cycle of 10 minutes/hour, 8 hours/day, 50/days per year, the slit system would last 1 year before needing replacement. Replacing the stages could take up to 1 week. If a high-speed blocker system was developed and used this would mean that the slits were not moving so often, and the lifespan would be greatly increased.



This shows the horizontal blades at the front and blades stacked up on multiple stages behind



The horizontal blades and back plate have been removed in this view



This is an initial concept of the small set of slit that is closest to the sample. The space envelope this would take up would be between. 100mm (h) x 100mm (w) x 50mm (t) minimum size and a maximum size of 200mm (h) x 200mm (w) x 100mm (t)

This concept uses 8 x 1720 piezo stages and 2 x 2475 piezo stages

The large set of slits would be a similar thickness and width but 300mm tall

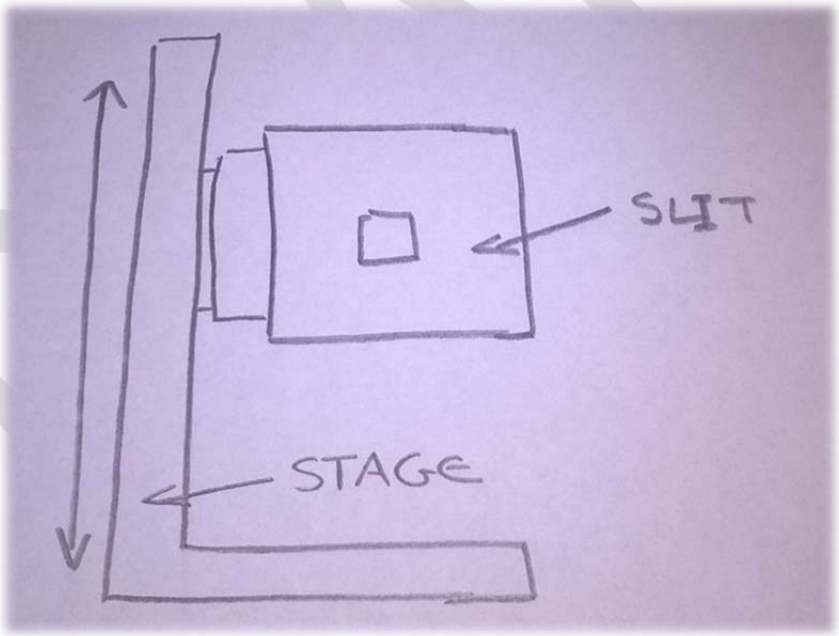
It would consist of 2 x 24105, 4 x 1750 and 2 x 2475 piezo stage

4 Alternatives Considered

A group of eight engineers and brainstormed ideas to identify possible solutions for the slit and blocker problems. Of the 20+ solutions brainstormed, none could fully cover the specification of the slits and blockers together.

4.1 Off-the-shelf Slit + Translation Stage

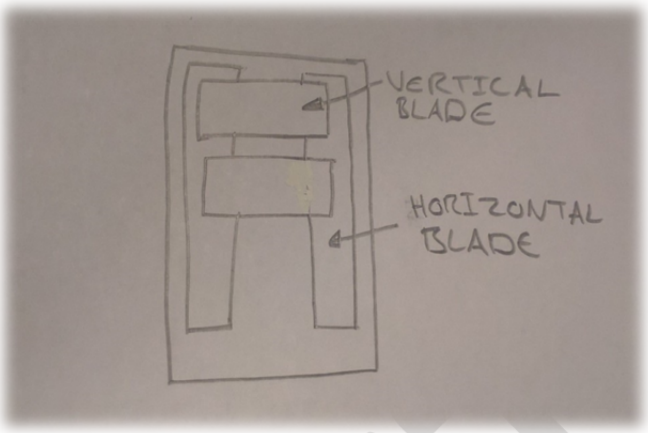
An off the shelf slit package, mounted on a vertical translation stage to translate between the three positions.



Pros	Cons
• Low cost • Minimal development time (off the shelf) • Accuracy meets requirements • Tried and tested on ISIS reflectometers	• Speed insufficient • Not compatible with high-speed blockers

4.2 Single Large-aperture slit

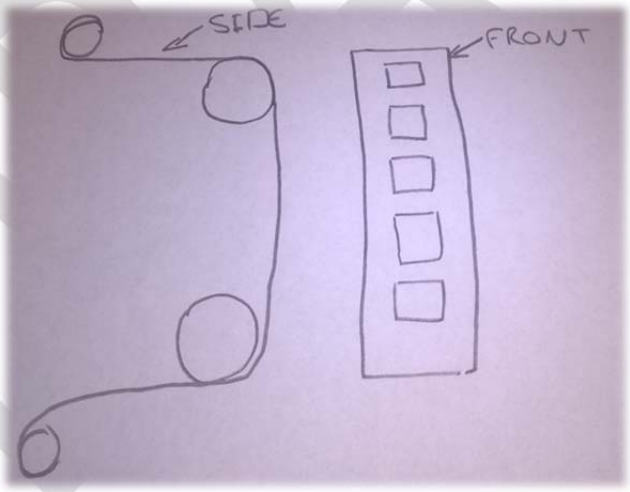
A large set of jaws covering all slit apertures over its range of travel.



Pros	Cons
• Simplicity • Accuracy meets requirements	• Speed insufficient • Not compatible with high-speed blockers

4.3 Film Blocker

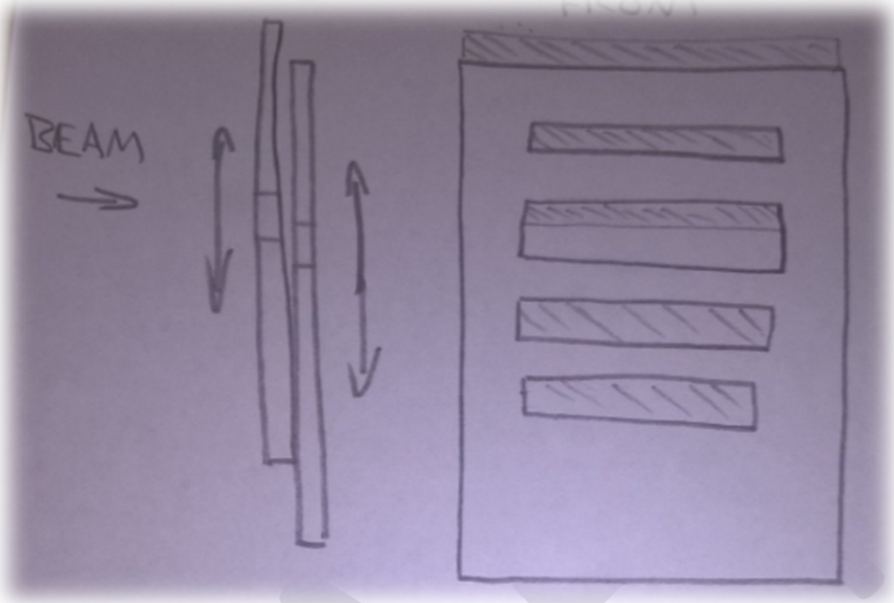
A film coated with a neutron-absorbing material passes over two rollers. Gaps in the blocking material define the apertures.



Pros	Cons
• Low cost • Simplicity • Compact	• Cannot vary aperture size • Bonding blocking material to film requires development

4.4 Oscillating Plates

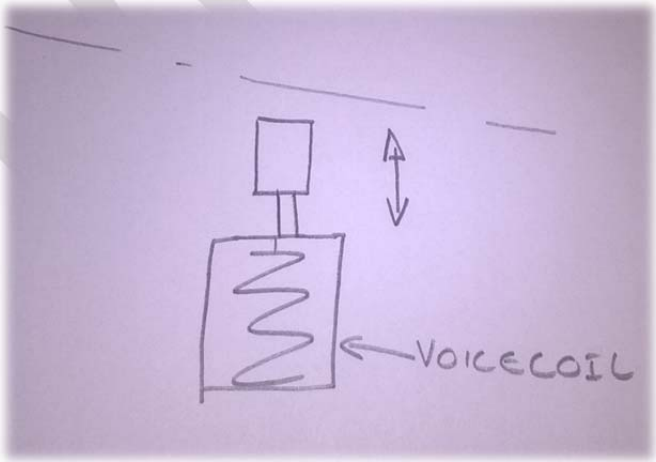
An oscillating plate with slit apertures, which oscillates to each slit position. A series of replaceable plate cartridges gives different aperture spacing.



Pros	Cons
• Simplicity • Aperture size variable • Motion feasible	• Cartridges need to be changed between experiments

4.5 Voice Coil/Magnetic Levitation

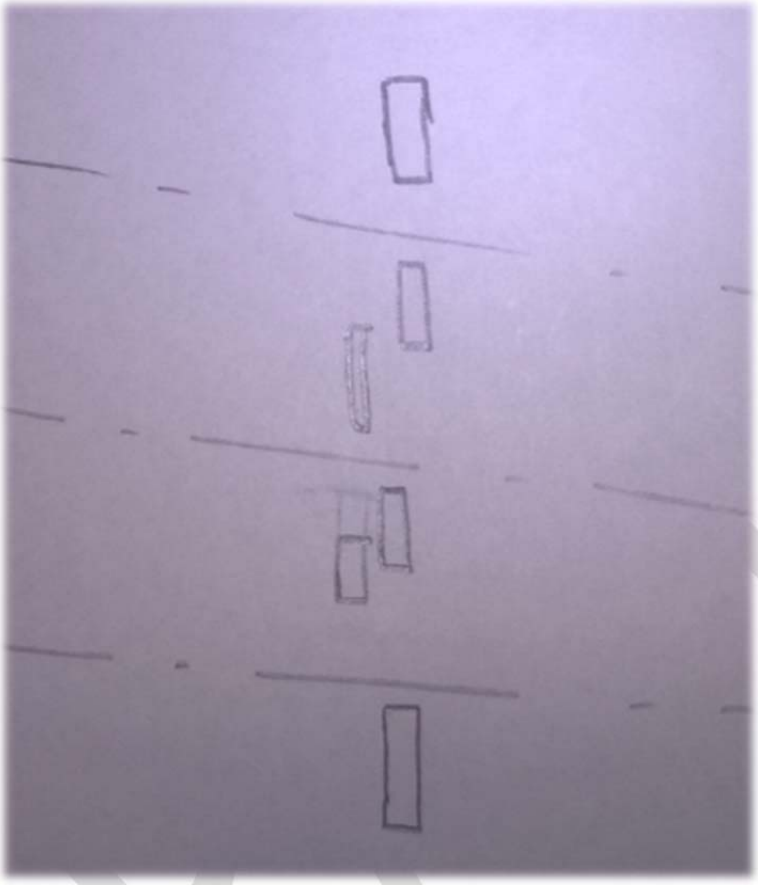
An oscillating plate magnetically levitated between coils at either end. A voice coil drives the plate to the required positions.



Pros	Cons
• Accuracy meets requirements • Aperture size variable	• Voice coils unproven - require further development before assessing feasibility

4.6 Staggered Blades

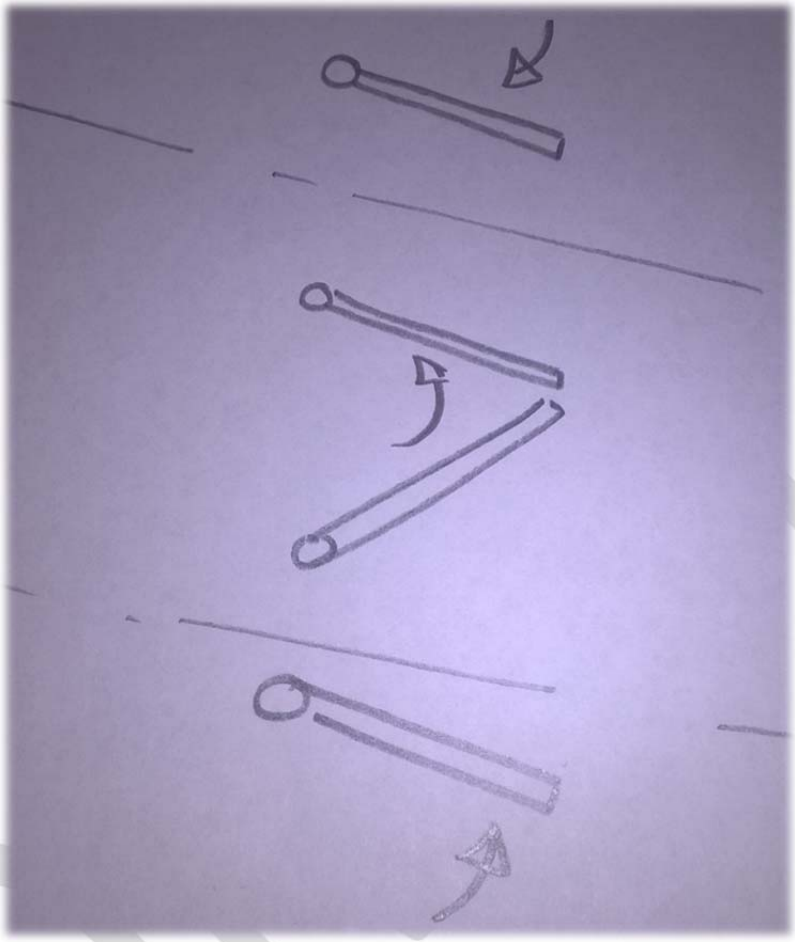
A series of staggered blades to define the apertures, preventing clashes between blades. Telescoping blades where space envelope is insufficient for rigid blades.



Pros	Cons
• Accuracy meets requirements • Aperture size variable	• Requires high-speed blockers

4.7 Venetian Blind Concepts

The blades defining the slit apertures are pivoted at one end, allowing for greater coverage without clashing with adjacent blades.



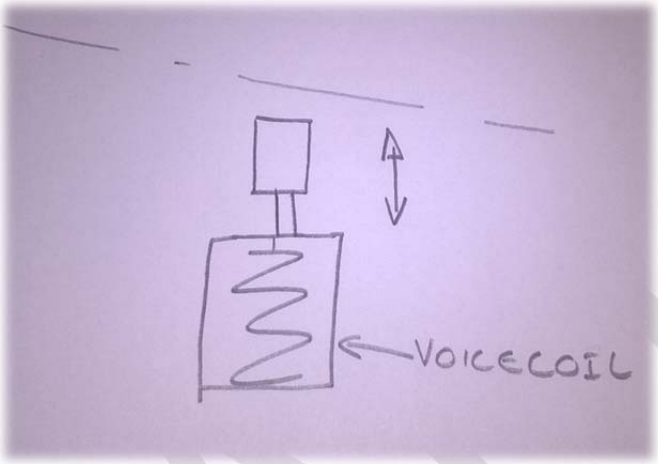
Pros	Cons
• Accuracy meets requirements • Aperture size variable	• Requires high-speed blockers • Reflections from blade surface at low angles

5 High Speed Blockers

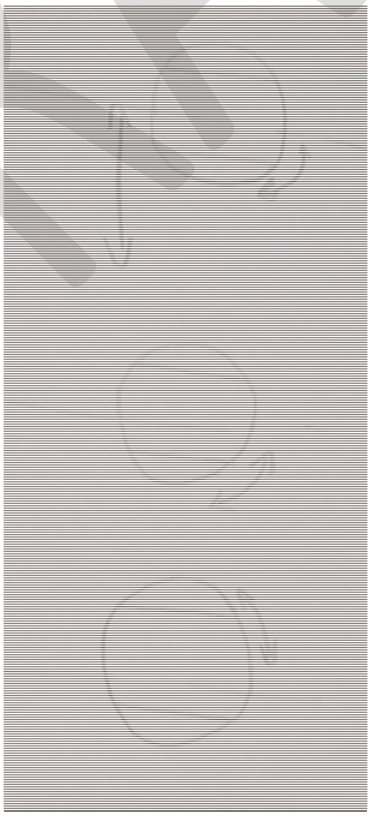
Having spoken to voice coil suppliers the high speed blockers are right at the end of achievable technology due to space restraints, heat dissipation, operation duty.

We would look to concept design and build up to 3 prototypes to test this technology

We are currently considering a voice coil design like below



We are also considering a rotary design using 3 rotating blockers with the top blocker fitted to a linear stage like below



6 Timescales

6.1 Fast slits

Specification – Jan 2018

Concept proven on test rig- May 2018

Full design – Oct 2018

6.2 High Speed Blocker

Develop up to 3 possible concepts- may 2018 to Feb

7 Milestones

TBC

8 Cost Review

TBC

8.1 Capital

8.2 Resource

- ISIS Project Estimate Template

9 Risks

9.1 Fast Slits

- The piezo stages use Linear Encoders in the stage- These may suffer Radiation damage and would stop stages working.

  Mitigation – test encoders in similar Radiation environment

- The blades for the slits are very small may be difficult to make may oscillate once moved.

  Mitigation – build concept.

9.2 High Speed Blocker

- Technology is un proven
- Heat dissipation of set up
- Vibration dissipation of blocking affecting samples
- Space restraints
- Reliability
- Operation Duty

  Mitigation – build concept