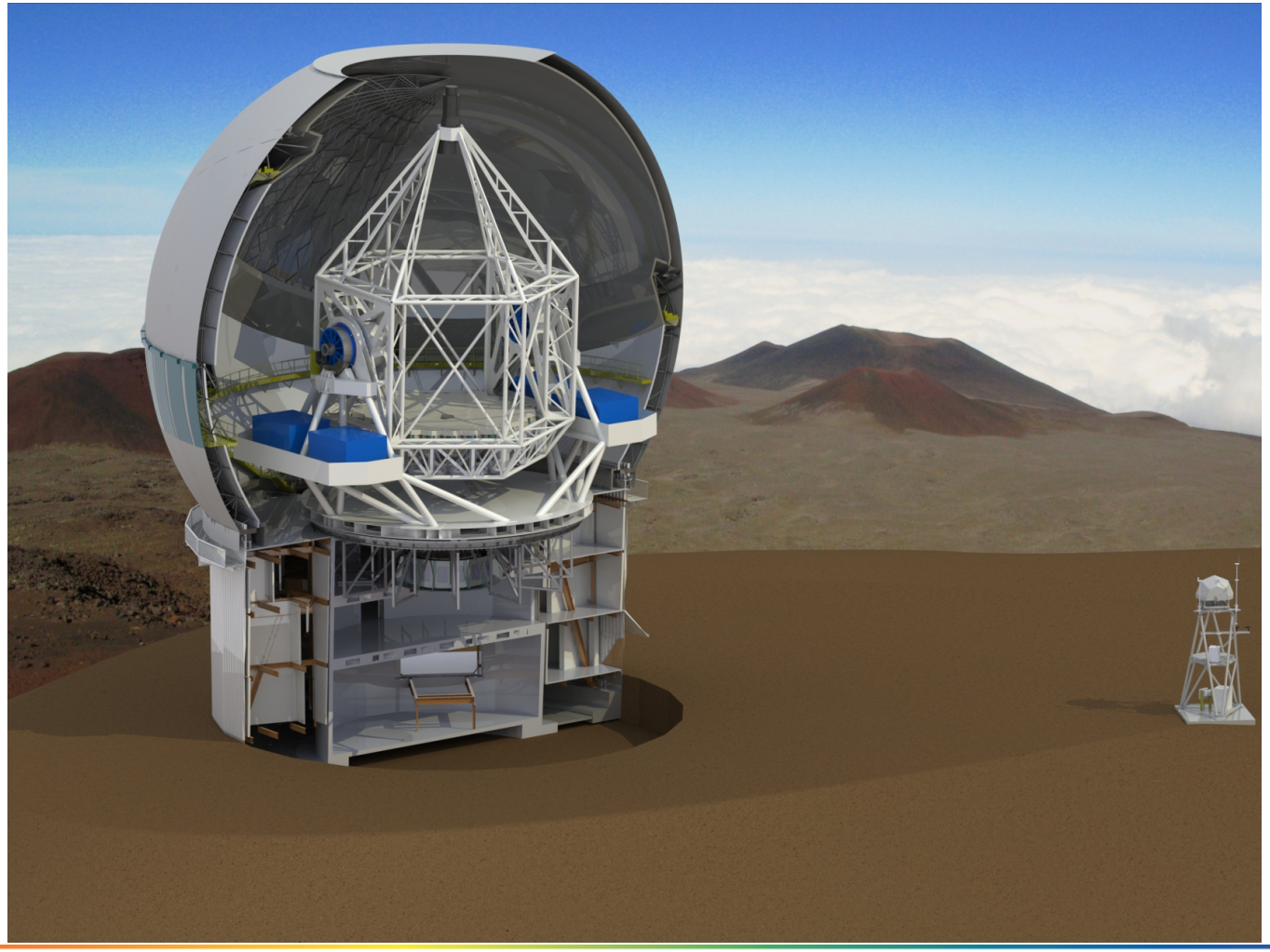
Maunakea Spectroscopic Explorer

# FiTS: Fibre Transmission System



# Overview

- Maunakea Spectroscopic Explorer (MSE)
  - Background
  - Science goals
- FiTS: The Fibre Transmission System
  - Requirements
  - Design and Analysis
  - Status and Future Work
- The UVic Fibre Test Facility
  - Goals of the facility
  - UVic / FTO Team
- Conclusions

Maunakea Spectroscopic Explorer

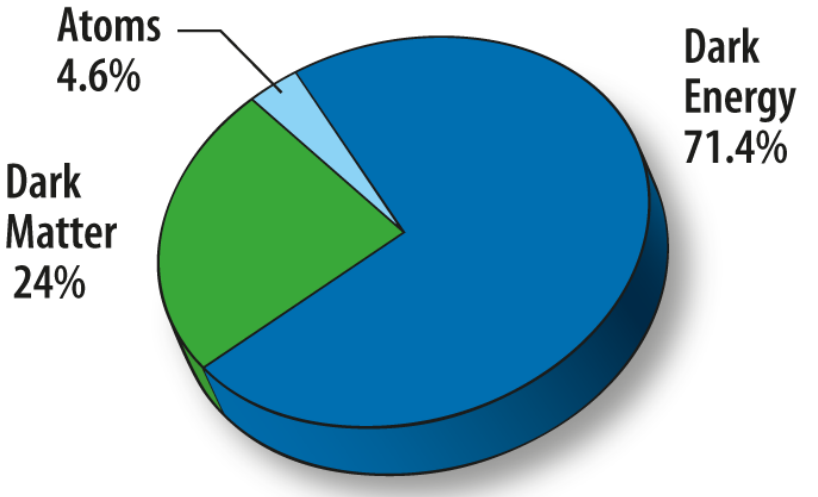
# Background on MSE

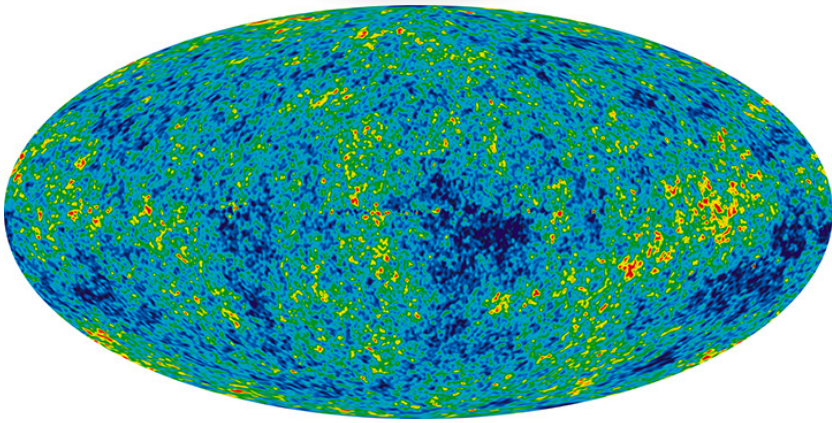
- Wide field, highly multiplexed spectroscopic facilities are urgently needed, especially to complement wide field imaging facilities
- It is relatively straightforward to upgrade 3.6 m CFHT to a wide field 11 m telescope in existing building on MaunaKea (in a “dome” with a larger aperture)
- Formal conceptual design study has just been completed by international partnership that includes Canada, France, Hawaii, China, India, Australia, Spain
- http://mse.cfht.hawaii.edu/

Maunakea Spectroscopic Explorer

# BIG Science questions

- The Universe is composed of Dark Matter and Dark Energy both of which are challenging for observations
- Dark Matter perhaps best explored by studying very large samples of stars in the Milky Way
- Dark Energy perhaps best explored by studying very large samples of galaxies at different distances over the whole sky
- => **Need precision spectroscopy of tens to hundreds of millions of faint stars and galaxies over whole sky**



WMAP 9yr

**See MSE Detailed Science case:**
**http://mse.cfht.hawaii.edu/science/mse-science-docs/DSC/MSE_DSC_ExpDraft_27May2016.pdf**

# Science to Requirements

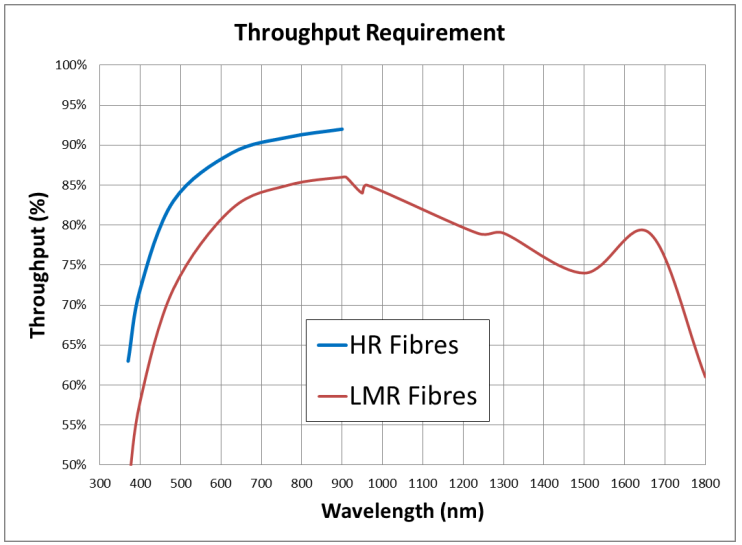
- Faint targets => large collecting area, very efficient optical system
- Large area => large field (effectively limited by physical sizes of lenses)
- Typical target densities => thousands of spectra
- Target selection => fibers are only practical solution
- Precision spectroscopy requires extremely well characterized, stable spectra

Therefore, MSE top-level requirements are:

- Telescope: 11 m aperture, 1.5 sq. deg field
- Wavelength range: 0.37 – 1.8 um
- > 3200 low/medium resolution spectra, > 1000 high res spectra per field
- Spectral resolution from R=2,500 to R=40,000
- Sensitivity: 24 magnitude objects (@SNR=2)
- Spectro-photometric accuracy < 3%
- Velocity precision of 20 km/s (@SNR=5)

# FiTS Requirements

- Science requirements flow down into key FiTS requirements
  - Throughput
    - > 90% @ 900 nm (HR fibres)
    - > 85% @ 900 nm (LMR fibres)
  - Focal Ratio Degradation (FRD) < 5%
  - Spectral and photometric stability
    - Requirements still TBD



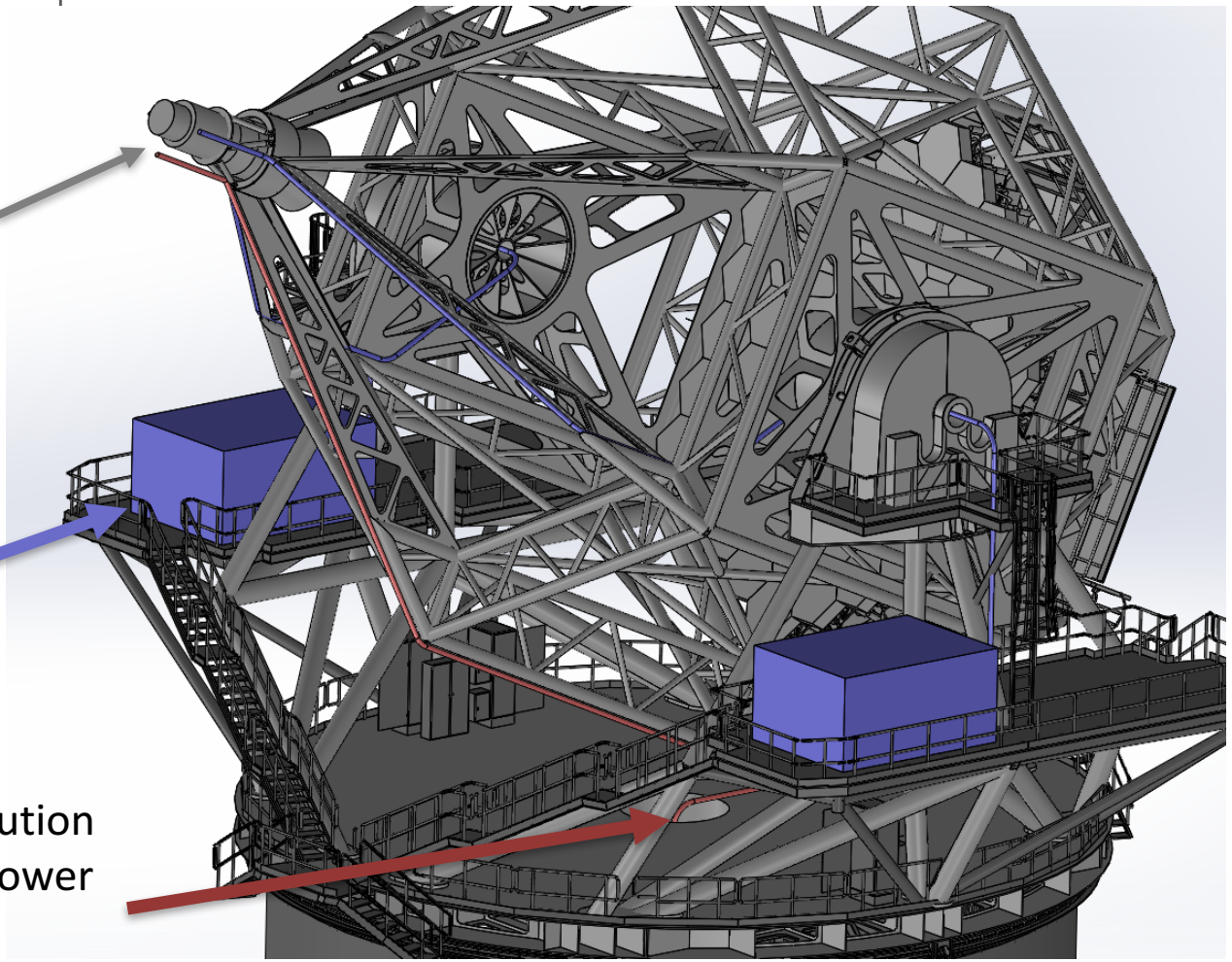

- However fiber transport *usually* produces significant light losses, variable transmission and variable image quality
  - Need to pay careful attention to details of design of FiTS, including extensive testing of all options and components

# FiTS Design

Fibre optic cables carry light from MSE prime-focus…

To 2 High-Resolution Spectrographs…

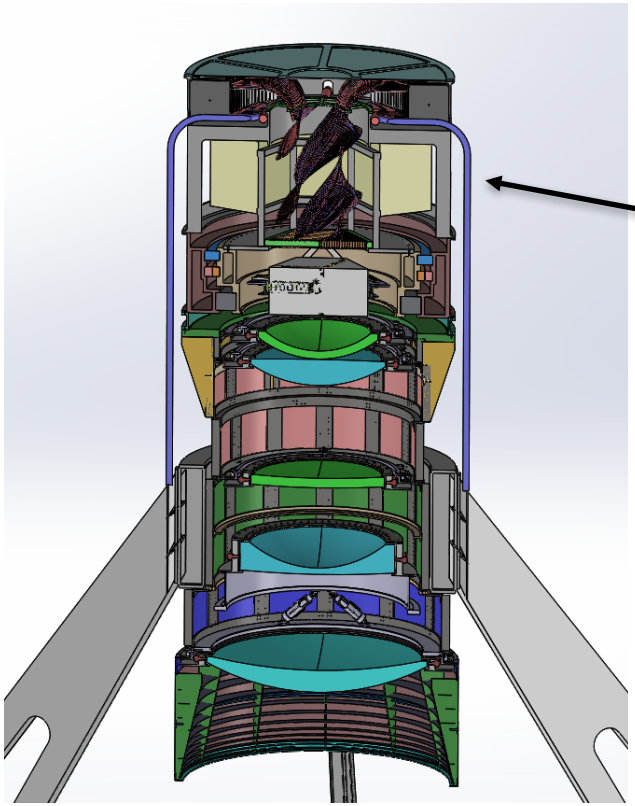
and 6 Low/Med -Resolution Spectrographs (in the lower Coudé room)

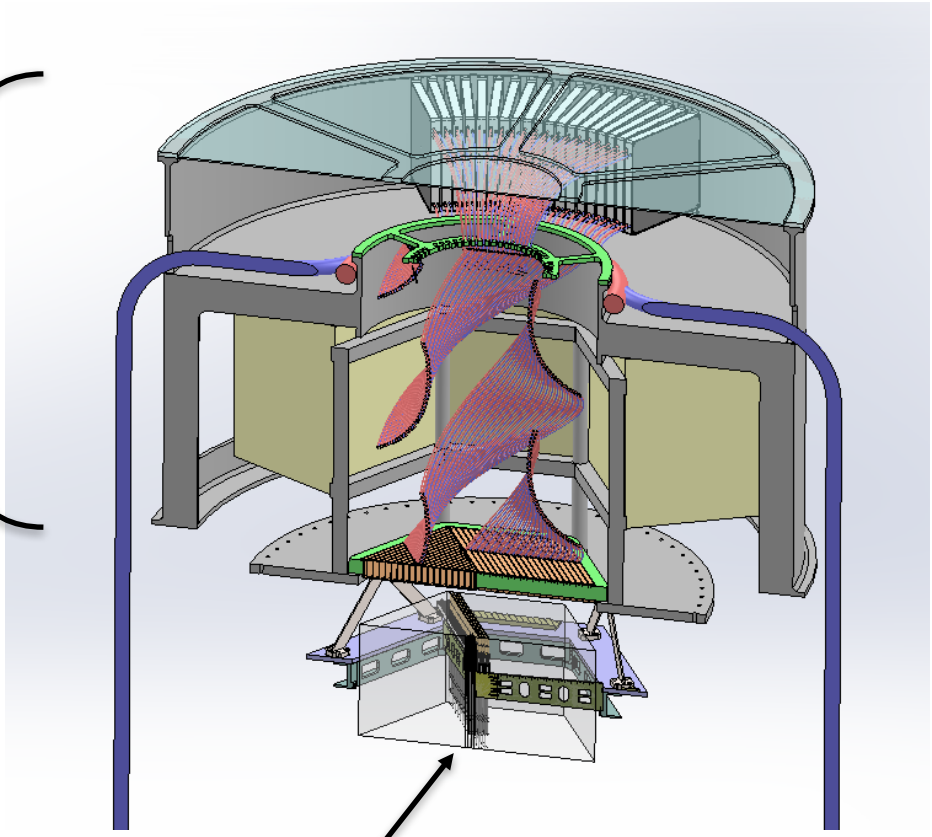


Distance: 35 m to HR
50 m to LMR

# FiTS Design

MSE Top-End Assembly (prime focus)

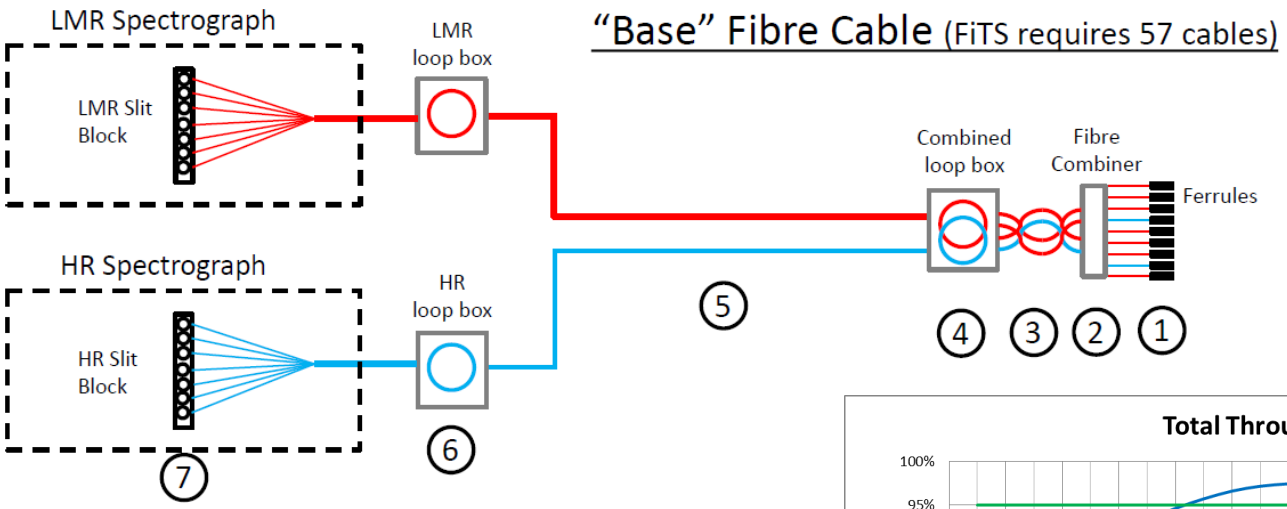




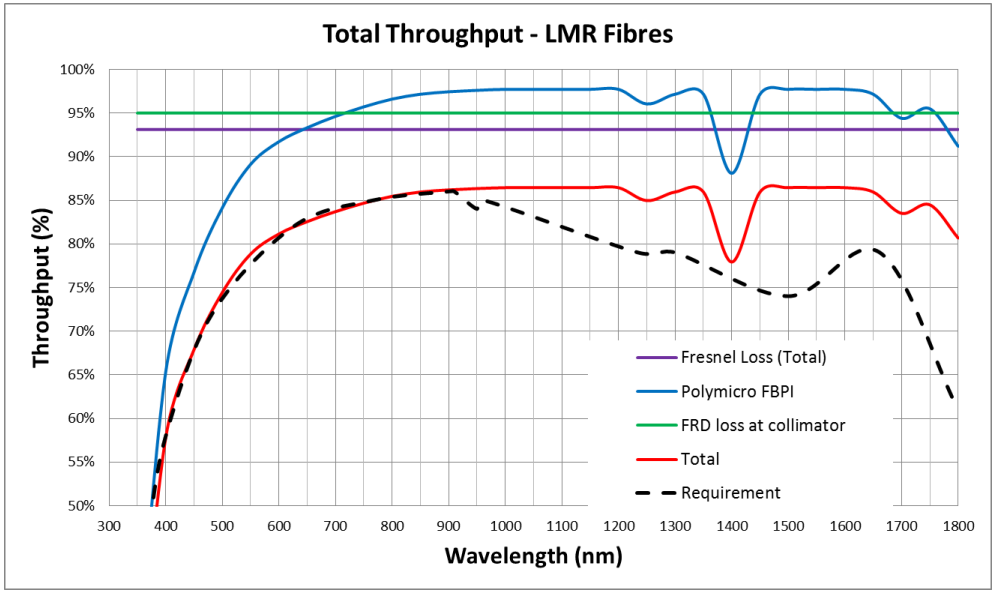
Fibre positioning system (supplied by others)

- Individually positions 4332 fibres w/in field
- De-rotates field motion during observation

# Cable Design and Analysis




FiberTech *Optica*




- Working with FibreTech Optica to develop modular fibre cables
- Need high throughput fibre materials and excellent AR coatings, over a very broad wavelength range

# Status and Future Work

- Preparing for Delta-CoDR in late winter/early spring
- Currently working to fully define requirements
- Project still needs:
  - Better definition of integration and test sequence with the positioning system and telescope
  - A plan for addressing stability requirements, through modelling or testing
  - Research into candidate fibre materials
  - Research into broadband AR coatings for fibres

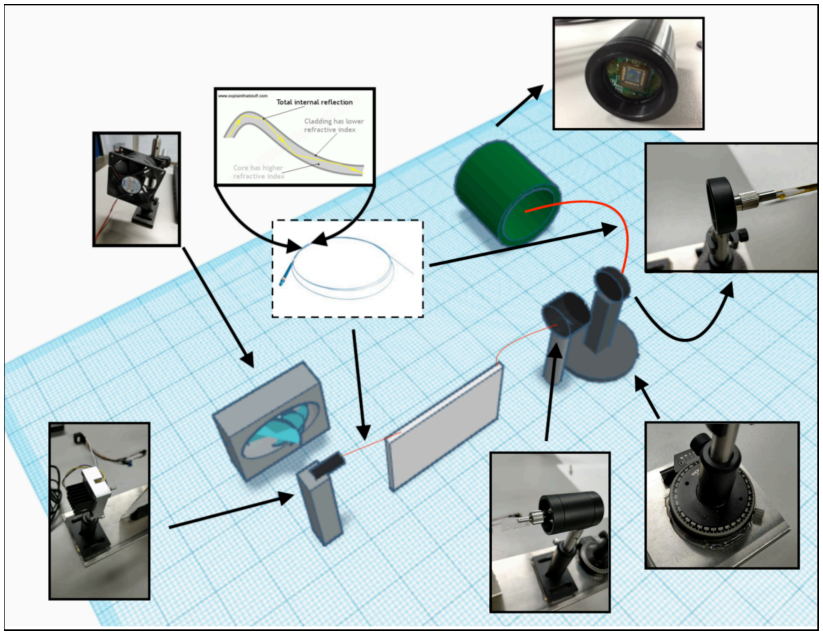
- Project will be a multi-million dollar effort
  - Testing of so many fibres is time consuming and expensive

# UVic FiTS Facility

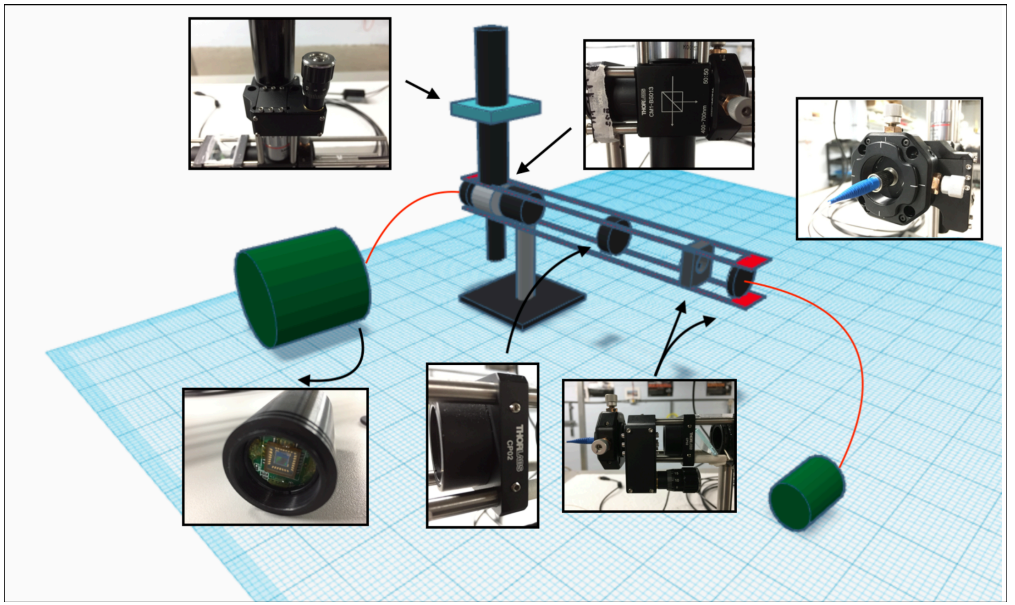
- Currently being built in Dr. Colin Bradley's lab within the Department of Mechanical Engineering
- Began construction in November following a visit to FiberTech Optica (FTO) by two team members (see poster!)
- Planned tests include:
  - **Ring test**
    - explore fibre focal ratio degradation (FRD), aiming to verify the FRD < 5% requirement
  - **Formed beam test**
    - study the effects of fibre cladding, joining procedures and dynamics on FRD (**simulating on-sky conditions**)
  - **Multi-fibre behaviour, cross-talk and throughput**
  - **Test automation**

# UVic FiTS Facility II

## Schematic of the Ring Test




## Schematic of the Formed Beam Test



# UVIC Team

- Stephanie Monty (BSc student, Astronomy)
  - Managing project, responsible for requirements definition
- Farbod Jahandar (MSc student, Astronomy) and Collin Kielty (PhD student, Astronomy)
  - Software development, image processing and motion control
- Jooyoung Lee (MASc student, Mech Engineering)
  - Opto-mechanical design, hardware development
- Supervision from Dr. Kim Venn (Physics and Astronomy) and Dr. Colin Bradley (Mech Engineering)

# Conclusions

- MSE is an exciting project, addressing the need for highly-multiplexed, wide-field spectroscopy
- FiTS Fibre Transmission System is an integral part of the facility design
  - Requirements and scale of project are challenging

- Challenges exist in the design, construction and testing
- Keys to success are a strong partnership between NRC-H, FTO and UVic, leveraging the capabilities of each organization