CASE Instrument Overview

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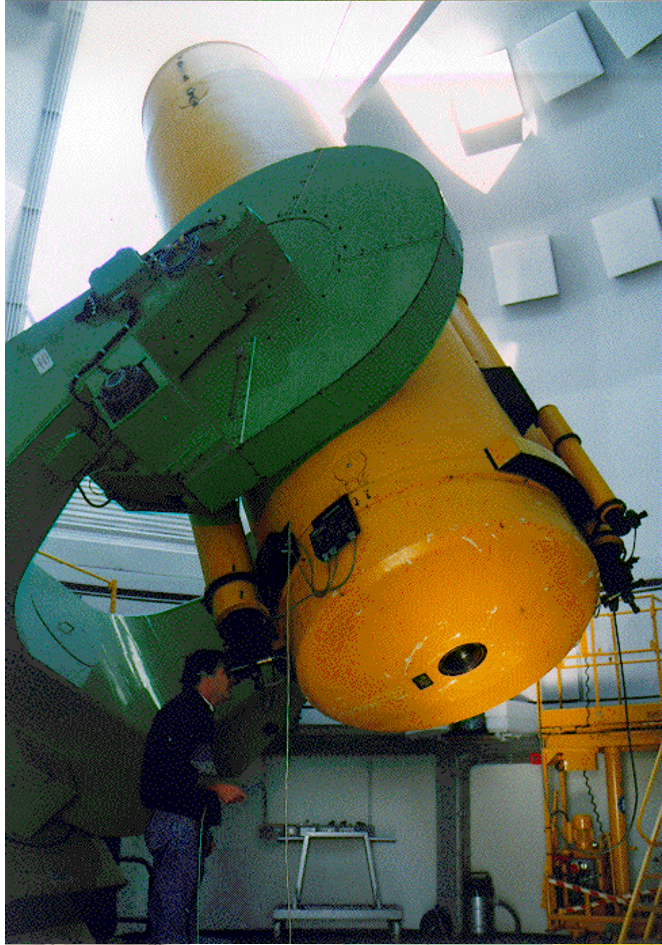
Calar Alto Schmidt Telescope

Schmidt corrector inside hinged lid

Aperture	**800 mm**
Focal Length	**2400 mm**
Focal Ratio	**f/3**
Field of View	**8 degrees**
	Ø 335 mm
Plate Format	**8” x 10”**
Plate Scale	**86.2 arcsec/mm**

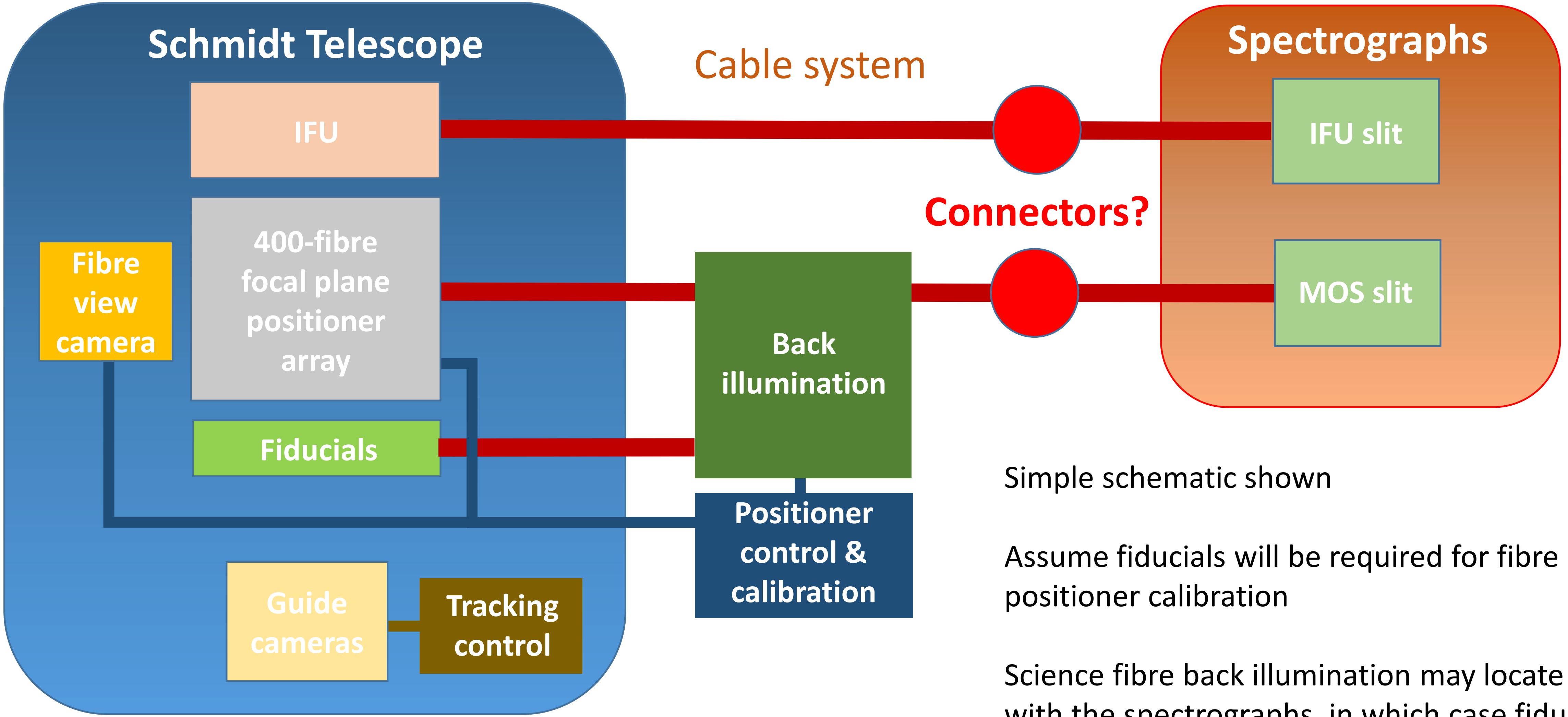
Primary mirror inside removable cell



Proposed CASE instrument system overview

- Fibre size (100 µm approx / ≈ 9 arcsec)
- Number of MOS fibres (300 – 500 TBD)
- Number of IFU fibres (300 – 500 TBD)
- Wavelength range from 360 nm to 950 nm
- R = 3000
- Spectrograph format, two arm (reflective collimator?)
- Detector 4K × 4K CCD, 15 µm pixels (similar to Teledyne type used in PFS cameras?)

System Overview



Simple schematic shown

Assume fiducials will be required for fibre positioner calibration

Science fibre back illumination may locate with the spectrographs, in which case fiducial back illumination will form a separate system

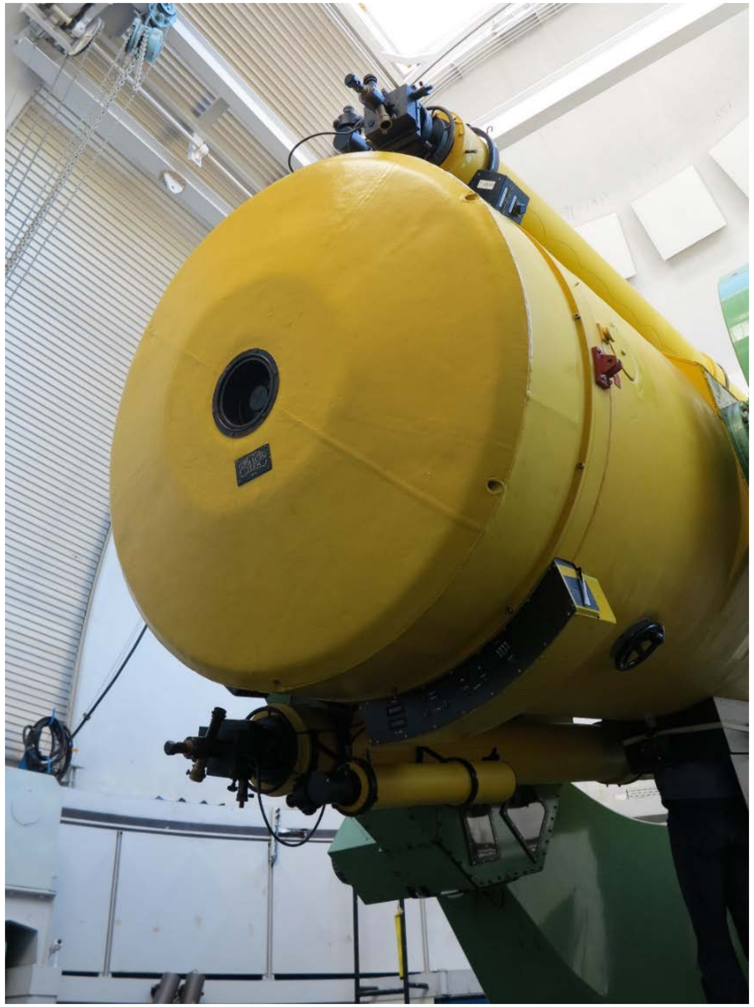
Risks

System element	Risks, challenges and issues	Risk level	Mitigation strategies /explanations
Telescope main structure	Work required to install a new focal plane is considerable, risk of damage to optics	Moderate	Devise an installation sequence that involves first removing the main telescope optics
Focal plane support structure	Is a mechanical design feasible? Can it be packaged in such a small space?	Moderate to high	DESI heritage for focal plane plate; a pre-existing support structure for the Schmidt plate cassette has been demonstrated, however packaging a complete positioner system in such a small unit has not
Positioners	Is a positioner of the right size feasible?	Low	The positioner technology is mature, although positioner length may need to be reduced. Thermal issues?
IFU	Feasibility	Low	A variety of effective, tried and tested technologies exist constructing the IFU input head
Guide cameras	Feasibility, packaging	Low	Small footprint cameras demonstrated for MOS guiding
Fibre view camera	Integrating camera support / positioning mechanism in such a small space is a challenge.	Moderate	'Swing arm' structure will be investigated

Risks (2)

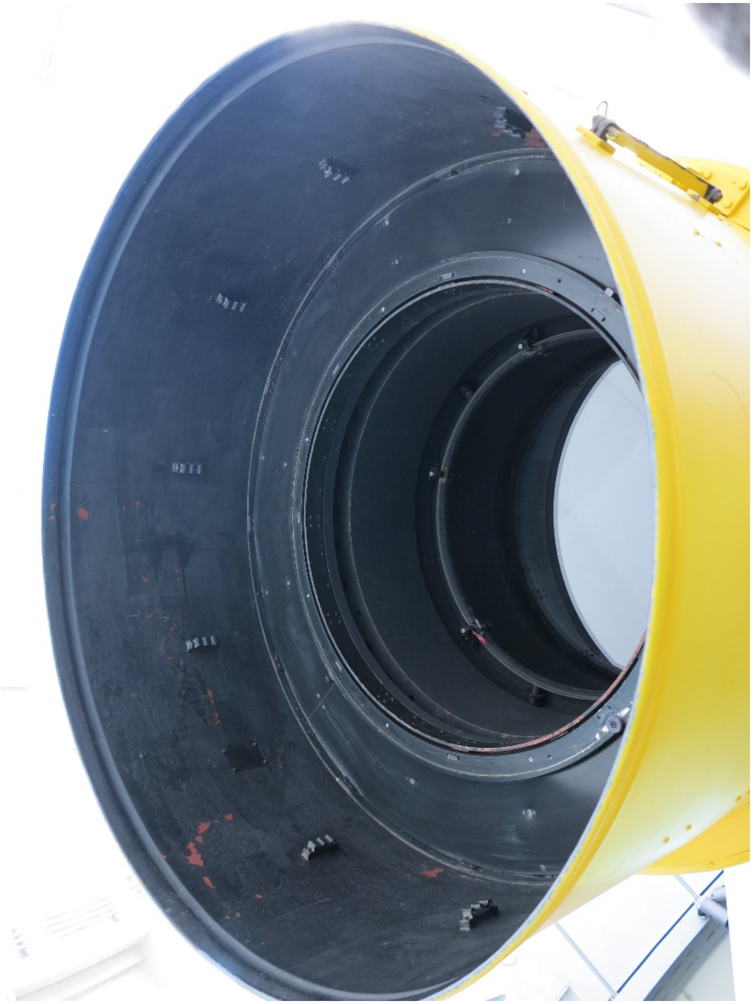
System element	Risks, challenges and issues	Risk level	Mitigation strategies /explanations
Fibre cables	Routing from the telescope to the spectrographs	Low to moderate	Although the fibre technology is mature for this wavelength range, and effective low-stress cable management schemes exist, there will need to be a careful assessment of potential routing paths to minimise cable length and small radius bends
Fibre connectors	Are connectors required? If yes, are they a practical proposition?	Moderate to high	Multi-fibre connectors exist for MOS projects, however they always have some impact on throughput. (a few percent for FMOS, 10% for Apogee. No IFU connector has been demonstrated
Pseudo-slits	Feasibility?	Low	Mature technologies exist for constructing slits in a range of complex geometries (thin, curved, non-parallel, non-telecentric)
Spectrographs	Feasibility? Location?	Low	The wavelength range is not excessive and well within the capabilities of commercial manufacturers such as Winlight There is a suitable room available adjacent to the dome where the spectrograph could be installed.

Telescope dis-assembly



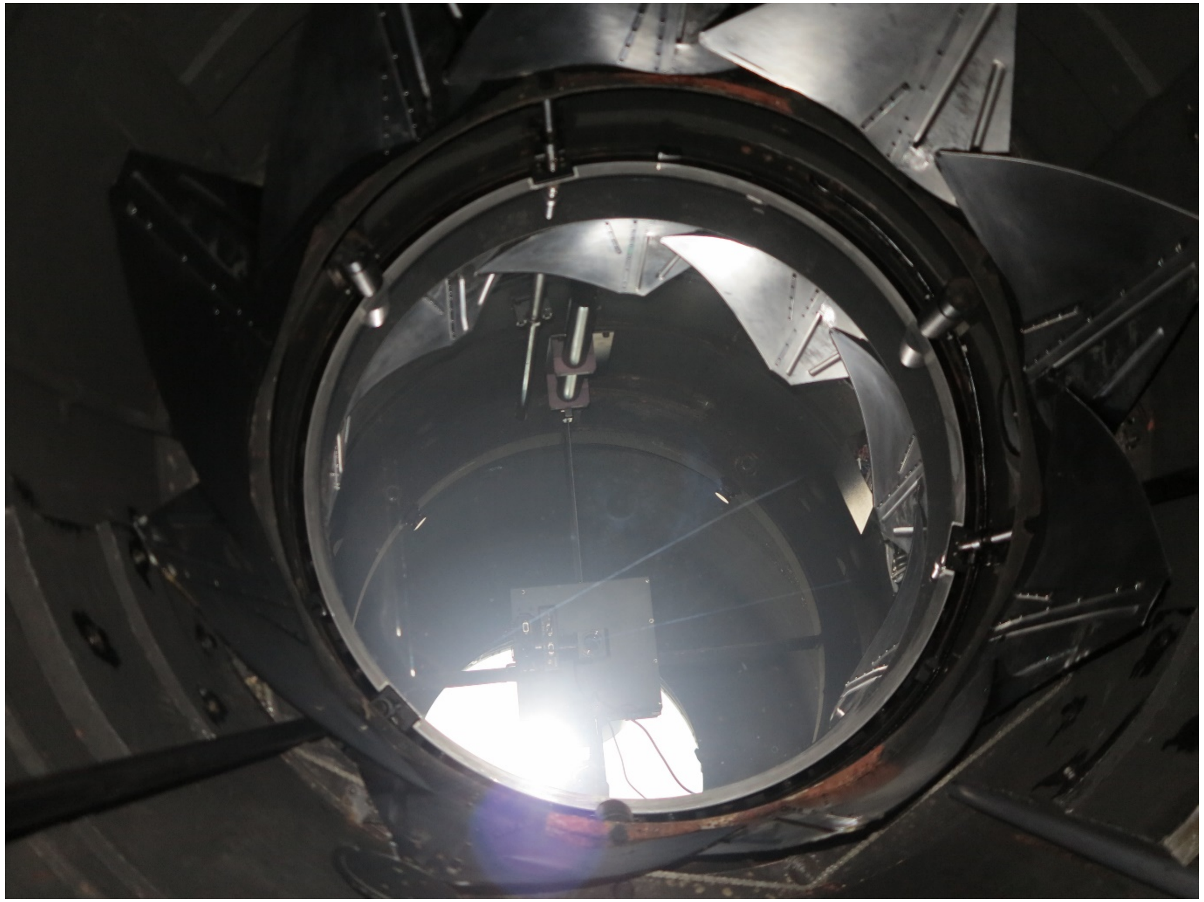
Mirror cell showing central pickup

Mirror cell handling mechanism

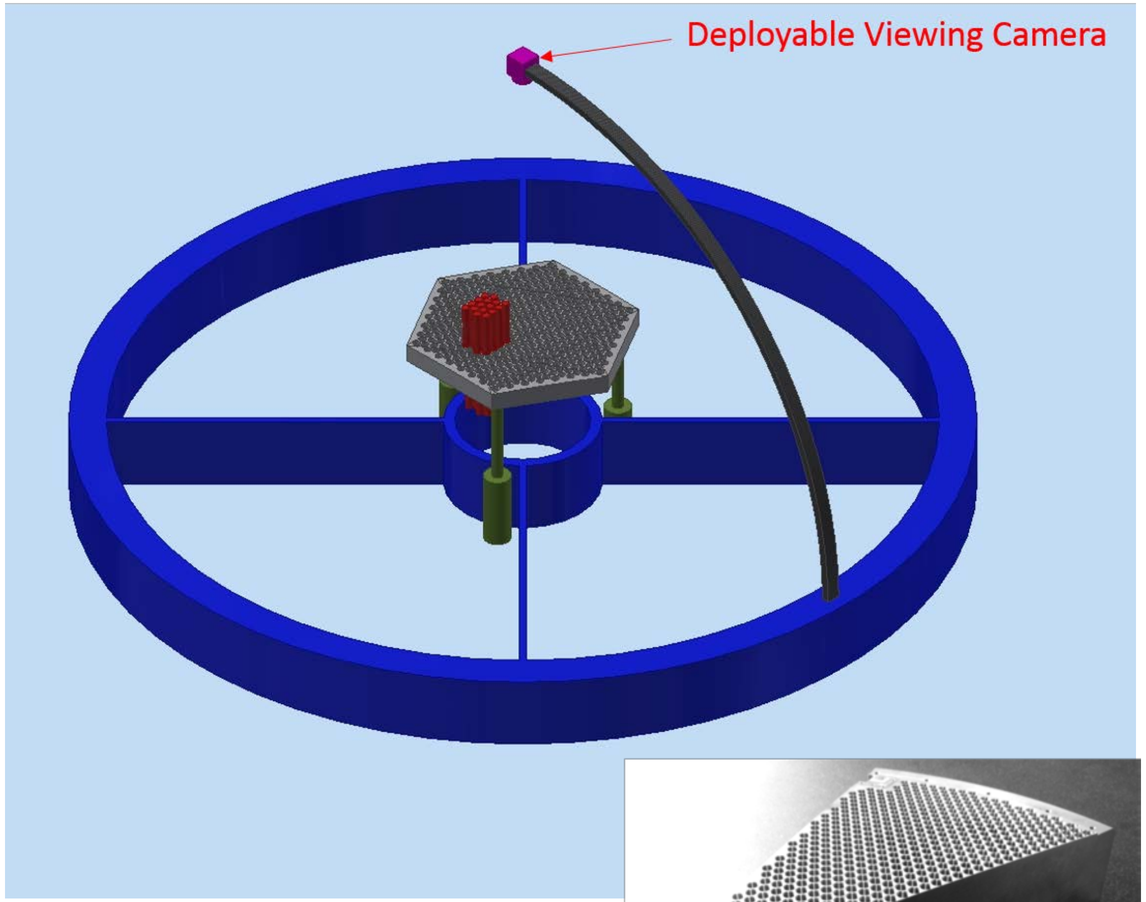


Hinged corrector plate

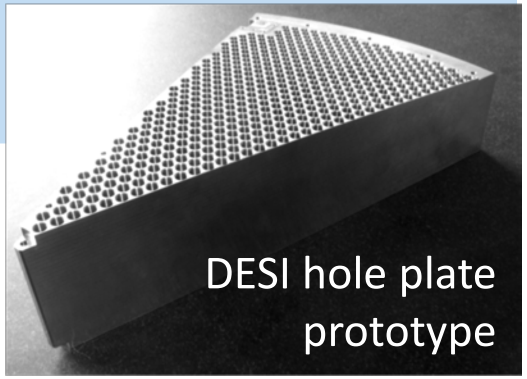
Focal plane structure



Existing scheme, seen reflected in the primary mirror

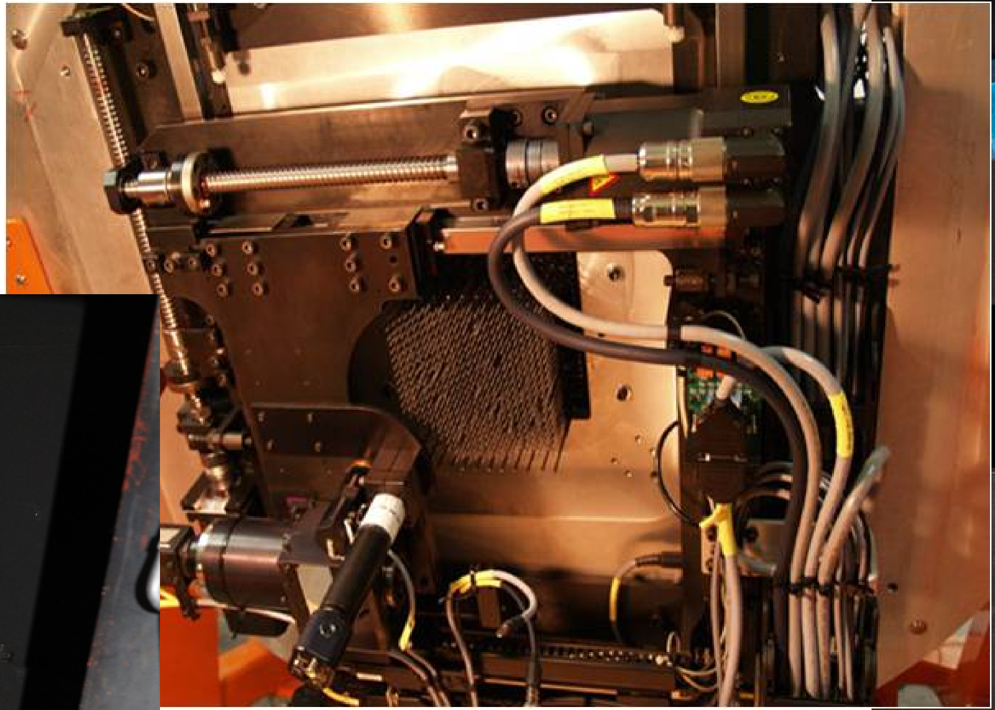


Proposed new scheme

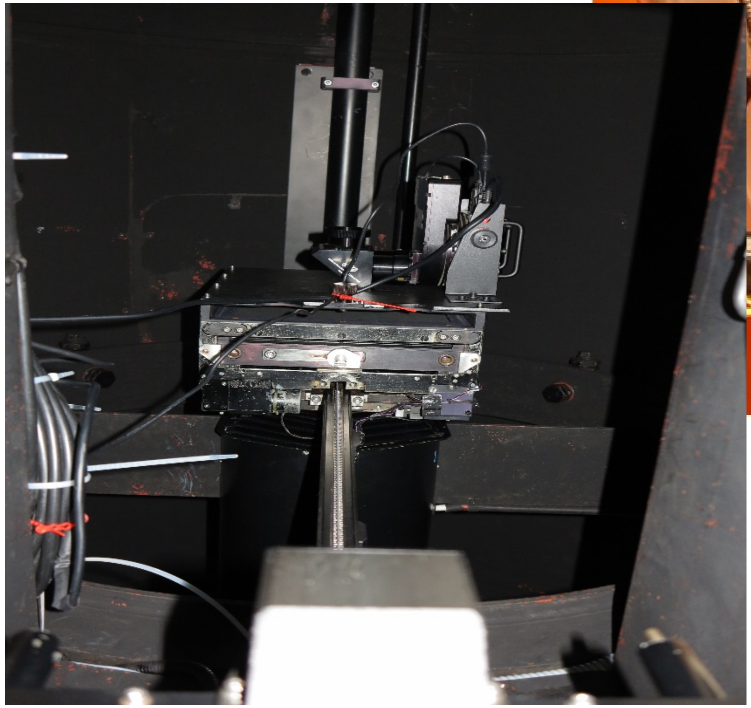


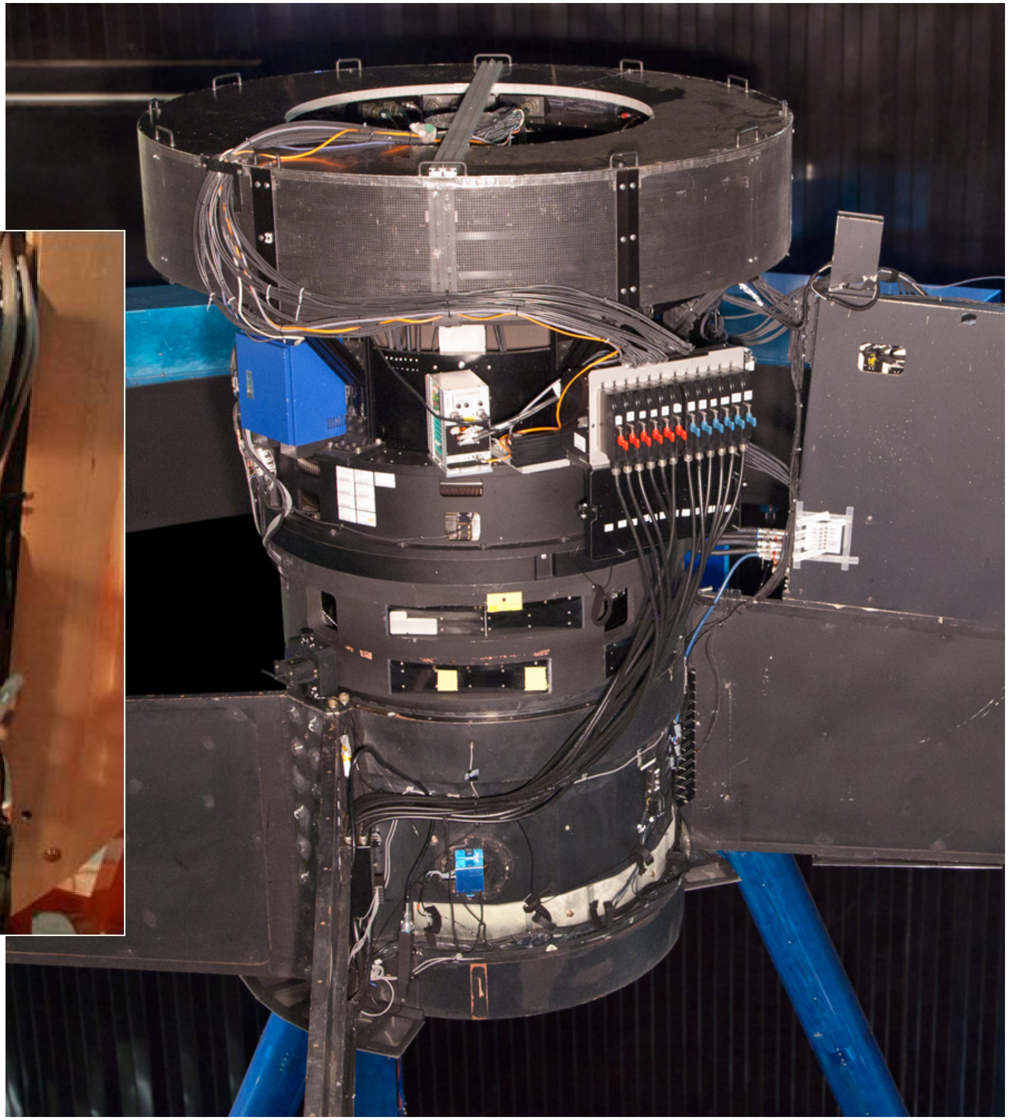
Focal plane structure

Echidna focal plane



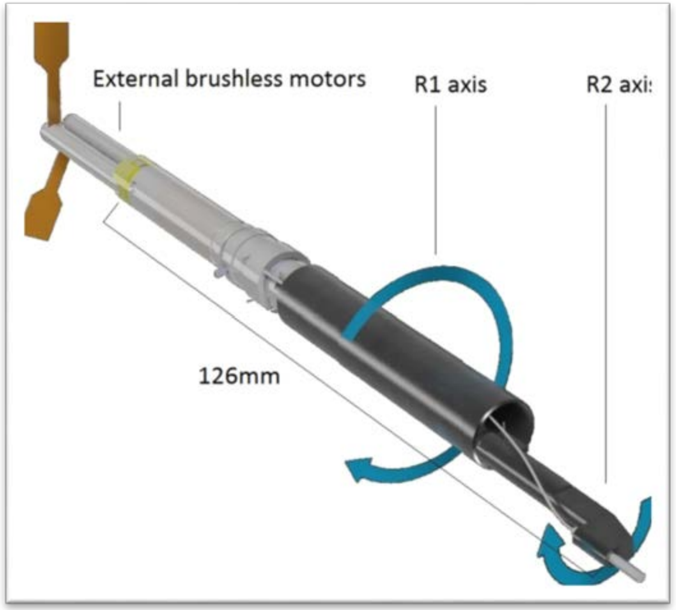
Schmidt cassette





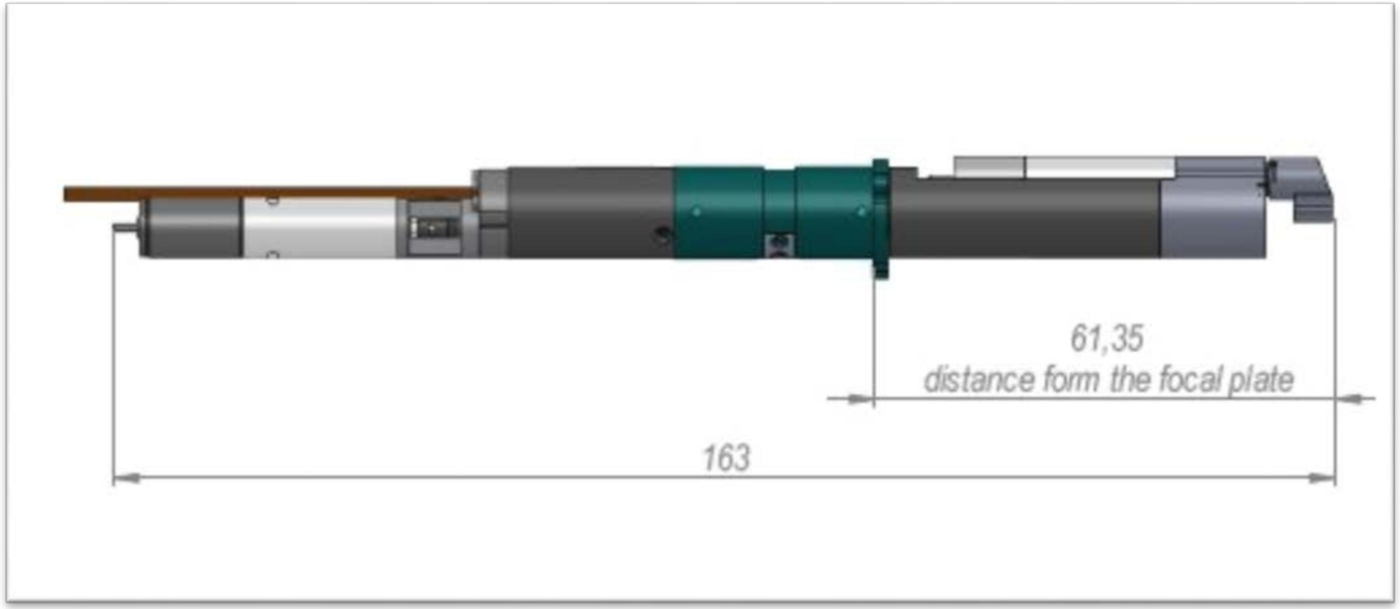
FMOS-Echidna Prime Focus Unit

Positioners



DESI

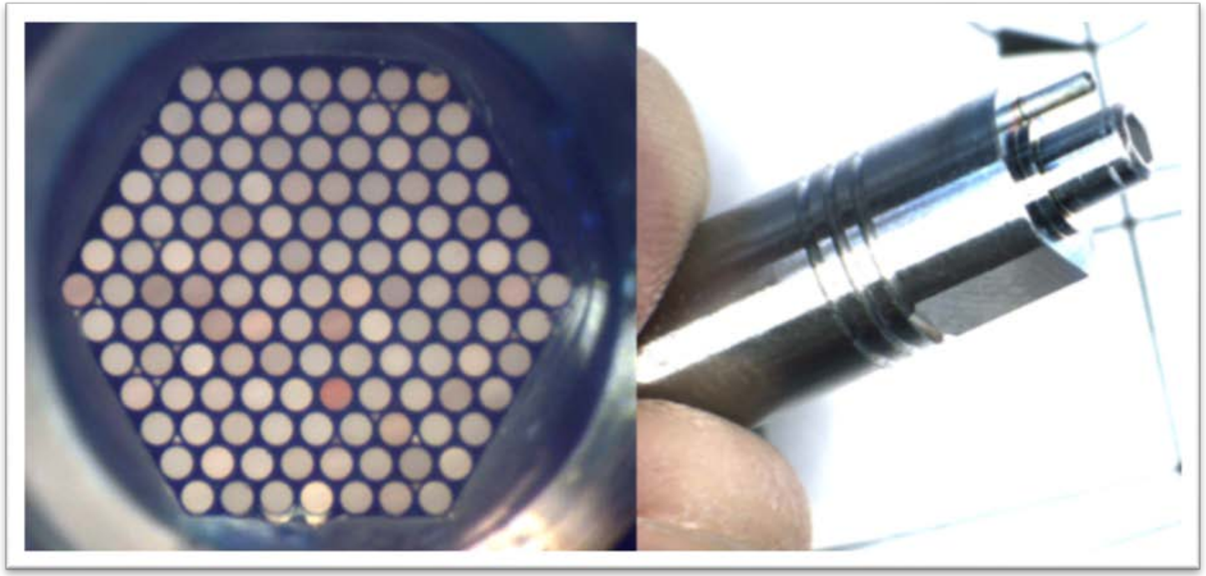
Centre to centre pitch: 10.4
Patrol field diameter: 12.008



AVS-NEW-V1

Centre to centre pitch: 14.4
Patrol field diameter: 16.64

IFUs



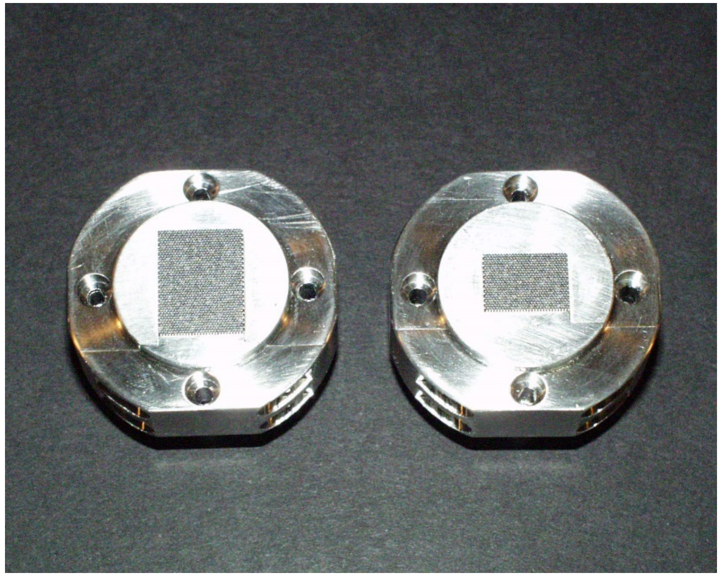
MaNGA IFU

Buffered fibers with 120 micron core diameters

Close-packed hexagonal fibers IFUs, 54% live-core fill factor

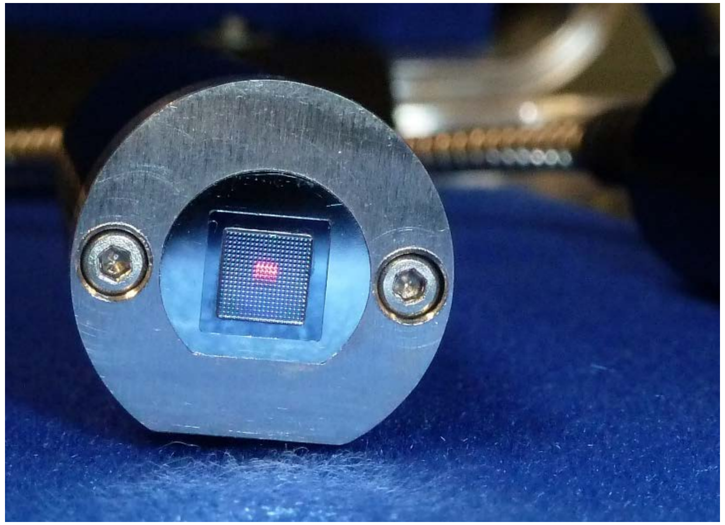
IFU size from 19 to 127 fibers

Planned to use the same technology for WEAVE; 547 fibres



GMOS IFU inputs; 1000 fibre & 500 fibre respectively

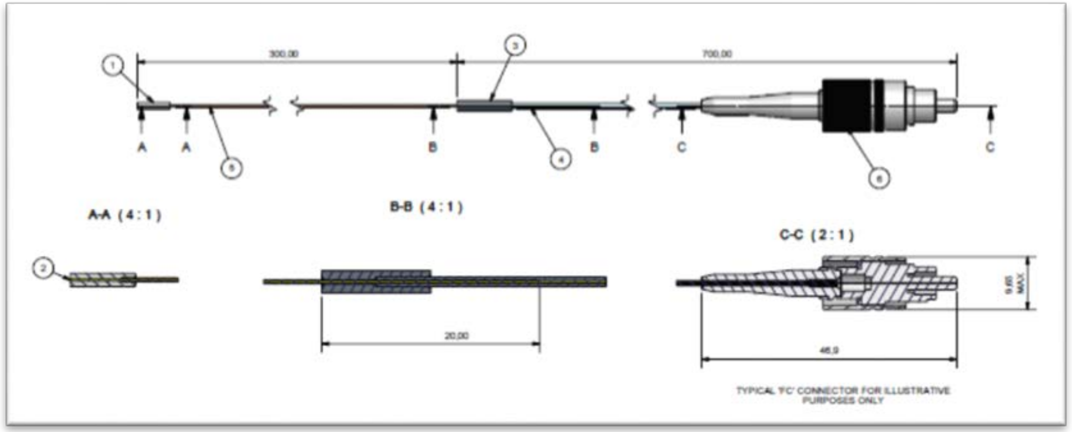
Suitable for microlensed IFUs



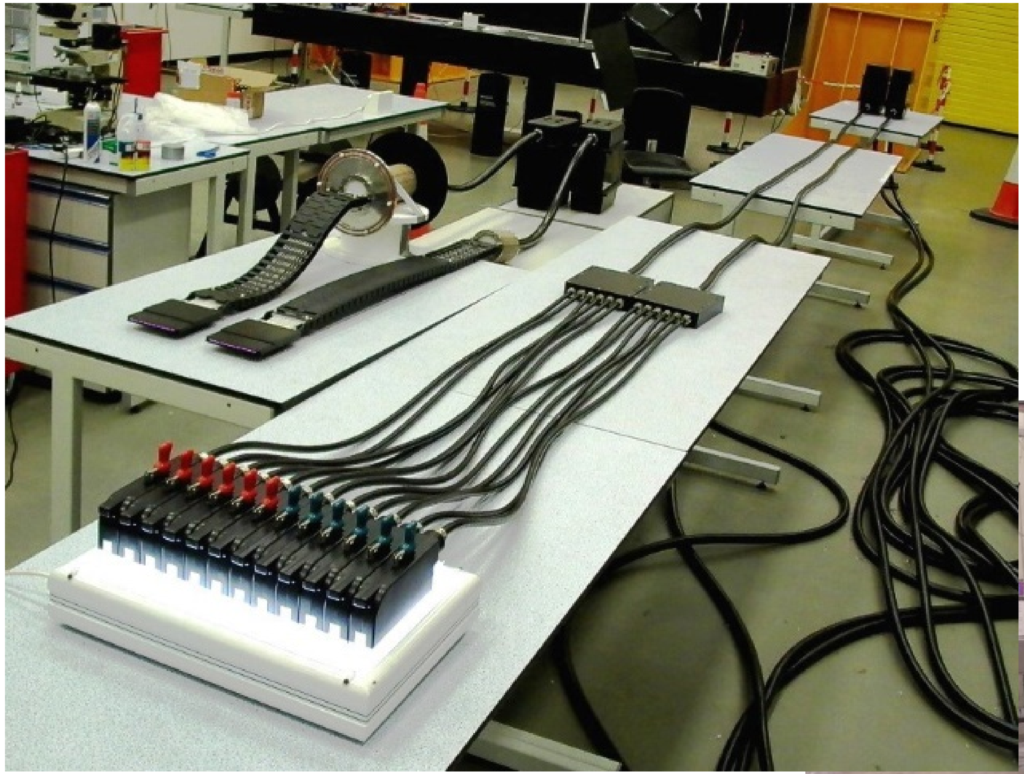
New technology developed in Durham – laser machined silicon

Suitable for microlensed IFUs

Cable manufacture



MOS fibre prototyping

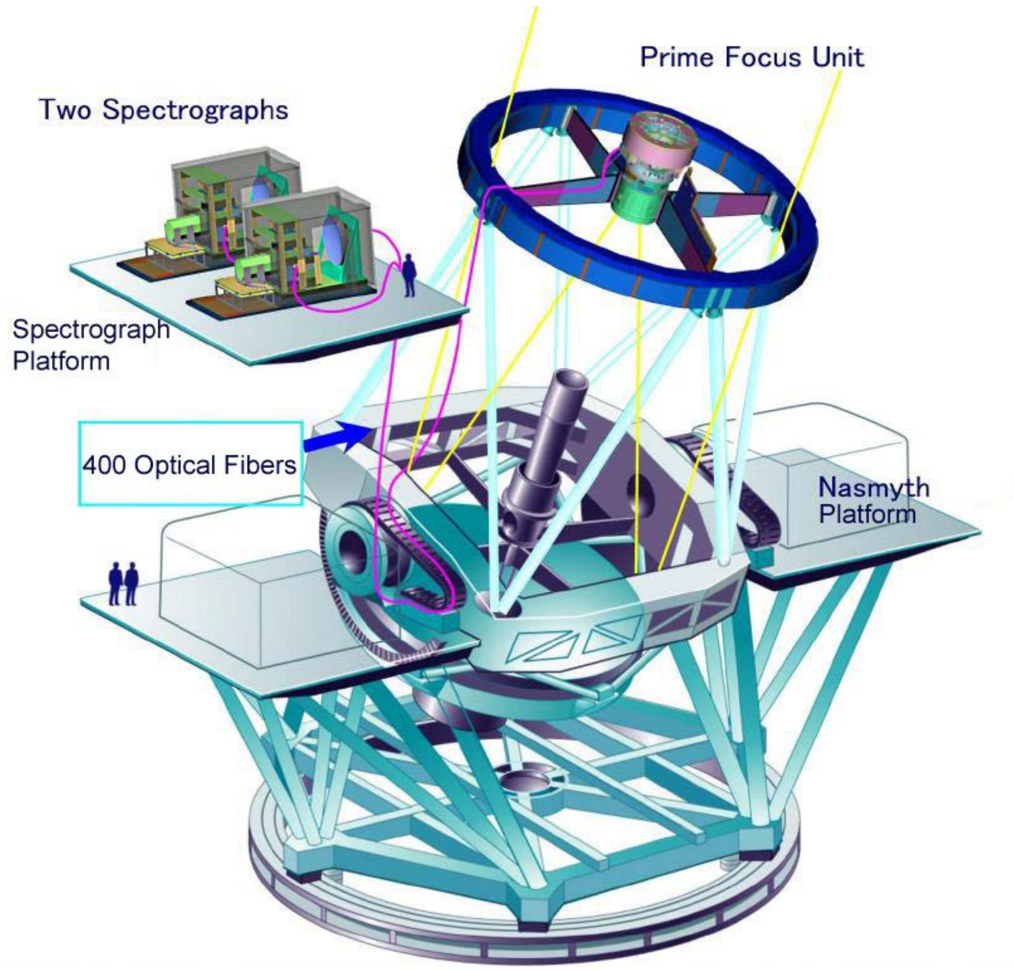


FMOS fibre system

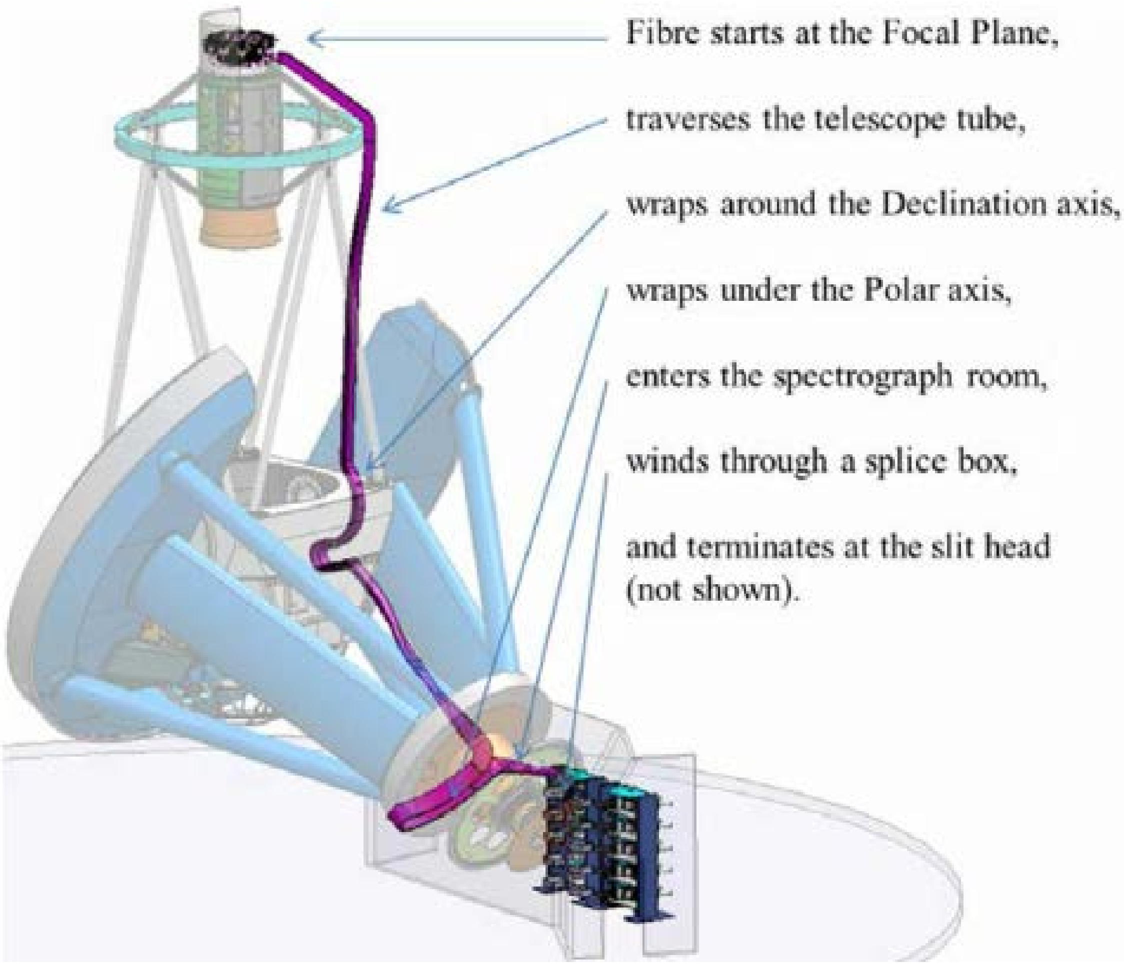
Durham/m2fx constructed planetary cable winding machine

FMOS cable, form replicated in PFS, DESI, and others

Cable routing



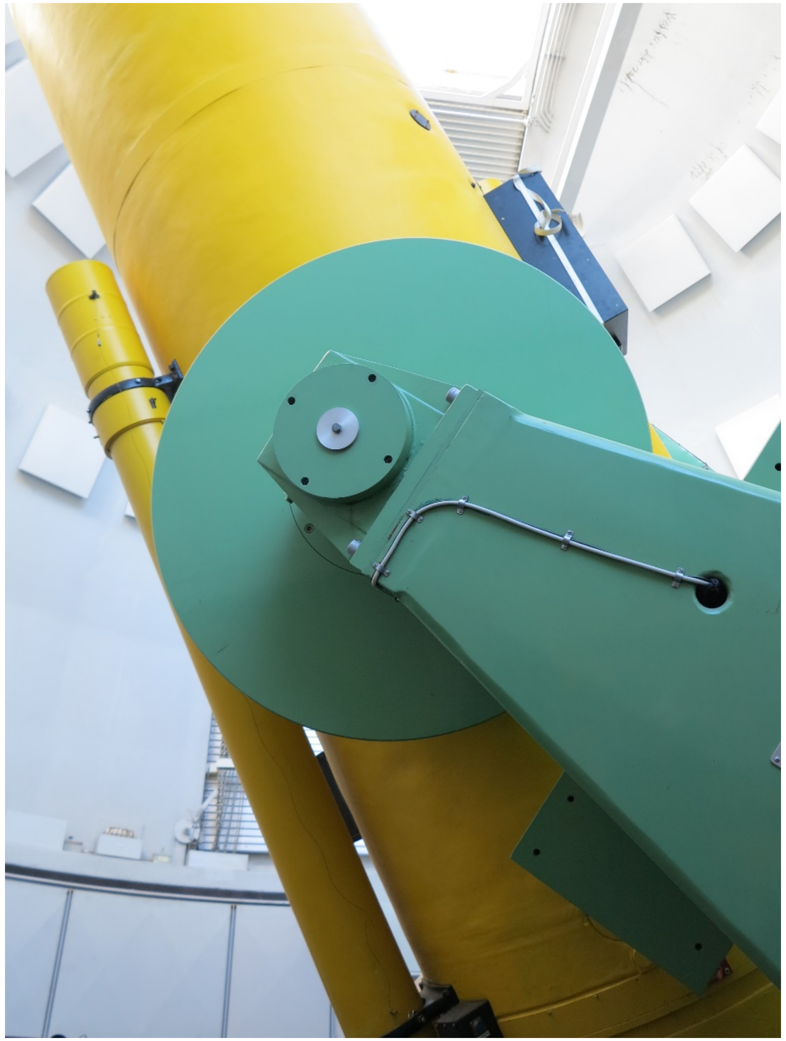
Subaru FMOS / PFS – alt-azimuth = simple



Mayall DESI – equatorial = challenging

Cable routing (2)

Declination axis

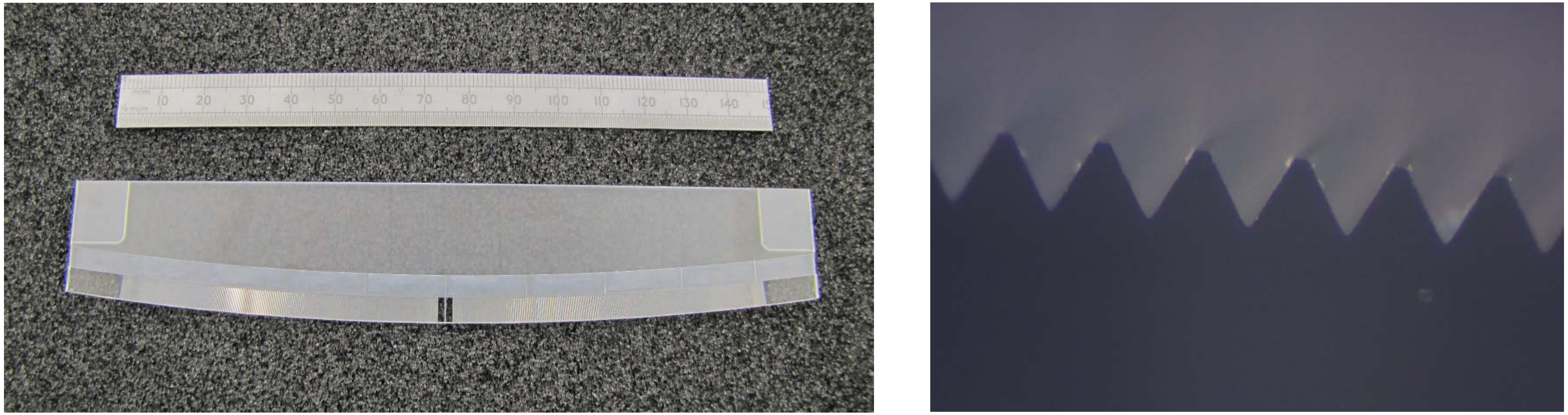


Declination axis

Cassette access port

Pseudo slits

FMOS pseudo slits – non parallel, non-telecentric, low profile, antireflection coated

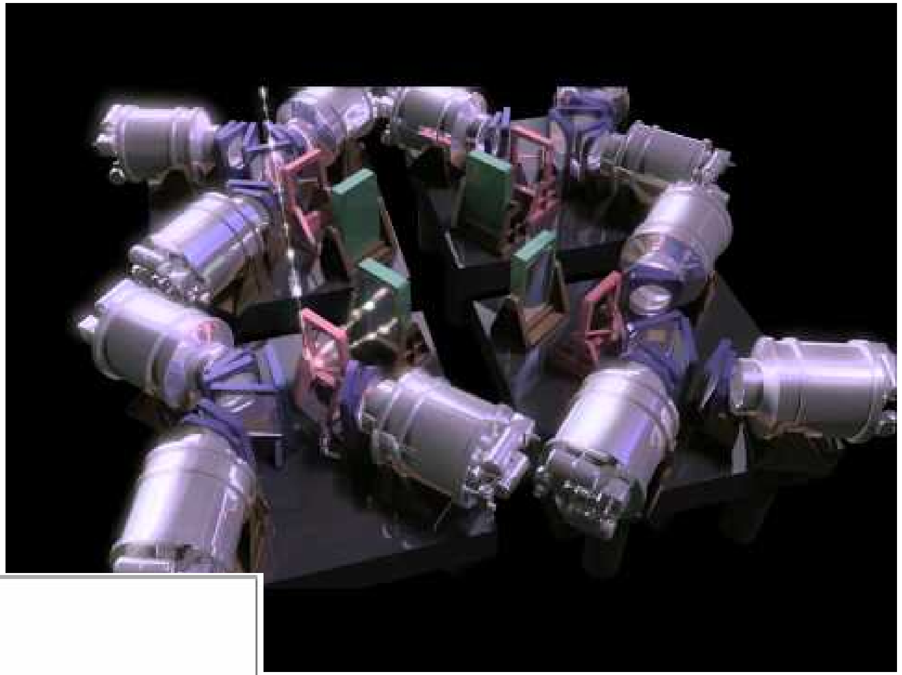


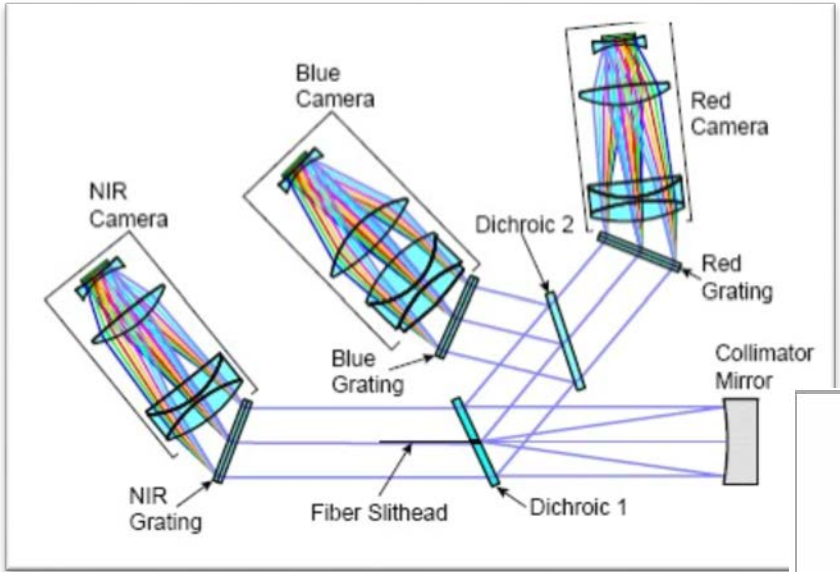
New slit technology

Spectrograph

PFS SuMIRE spectrographs

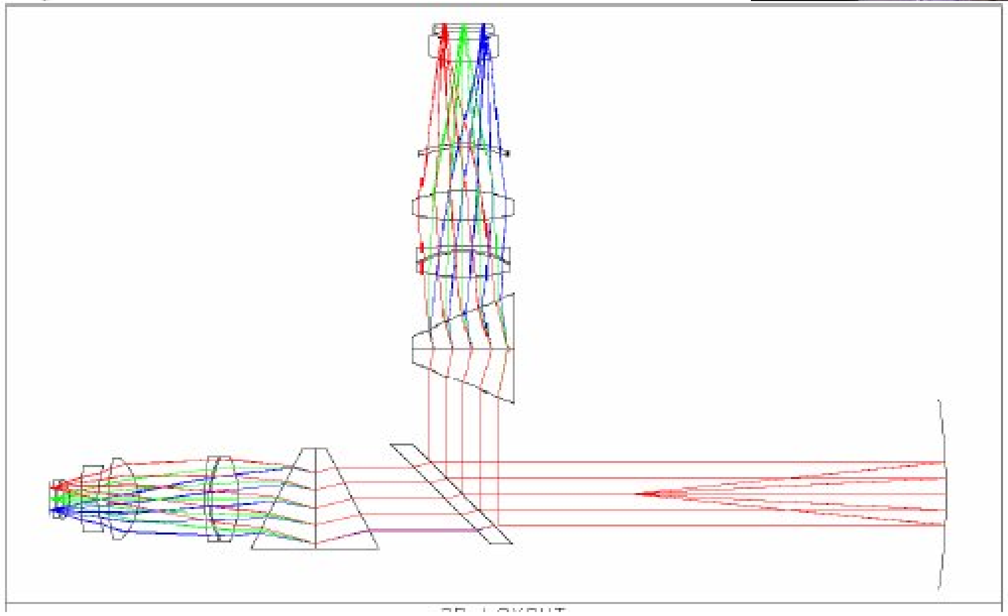
Wavelength 380 nm to 1300 nm
(split into 3 arms)
R (typical) = 3000





DESI Spectrograph

Wavelength 360 nm to 980 nm
(split into 3 arms)
R = 1500 to 4000 depending on λ



LoRCA 2 arm concept
Wavelength 360 nm to 950 nm
R = 3000

Trade-off studies

- Multiplex - observing efficiency vs. cost.
- Actuator control - open loop vs. closed loop:-
  - Open loop using stepper motors: can the required accuracy be achieved?
  - Closed loop using servo motors: requires encoders (costly?) or focal plane viewing camera.
    - Viewing camera cannot achieve required resolution in single exposure - scanning mechanism required.
    - Fibres have to be back-illuminated.
    - Reference points (fiducial fibres?) required in focal plane.

- Acquisition and guiding:-
  - Telescope has auxiliary guide scopes. **! FLEXURE !**
  - Auxiliary cameras in focal plane: how many needed to provide sky coverage?

- Active focal plane (tip/tilt, focus) required?

Trade-off studies (2)

- Mechanical interface with telescope:-
  - Interface with existing spider:
    - Severe space restrictions (depth) necessitate new pick-off design and may lead to more expensive, sub-optimal focal plane design.
    - “Messy” interface: mounting provisions may be in awkward locations, fibres and electrical harness needs to be routed in-situ, etc.
    - Restricted working space inside optical tube would make installation extremely challenging.
  - Replace existing spider with new support structure:
    - Flexibility w.r.t. accommodating existing pick-off design.
    - Nice “clean” interface: fibres and harness can be pre-routed with connectors in convenient locations.
    - However:
      - ! Implementation requires removal of primary mirror !
      - ! New structure needs to be lifted into optical tube - access required through hinged corrector assembly !
      - ! Work to be carried out at approx. 6 m height above floor - Health and Safety !

!!! Need mechanical drawings for Schmidt optical tube assembly !!!

Interface issues

- Optical:-
  - Telescope focal plane: convex, spherical surface, 2400 mm radius, 8 deg. (Ø 335 mm) corrected Field of View;
    - Stability, distortion, atmospheric refraction / dispersion, etc.
  - Acquisition and guide cameras;
    - Field of View, optimum location, etc.
  - Fibre output.
    - Break-out panel with connectors on side wall of telescope.

- Mechanical:-
  - Interface with telescope: need drawings for Schmidt optical tube assembly.

- Electrical:-
  - Actuators;
  - Acquisition and guide cameras;
  - Tip/tilt & focus mechanism.

- Software
  - Focal plane configuration;
  - Acquisition and guiding;
  - Focal plane control (tip-tilt & focus).

! Need to define interfaces as soon as possible !