Technologies for Cabled Fibre MOS & IFS

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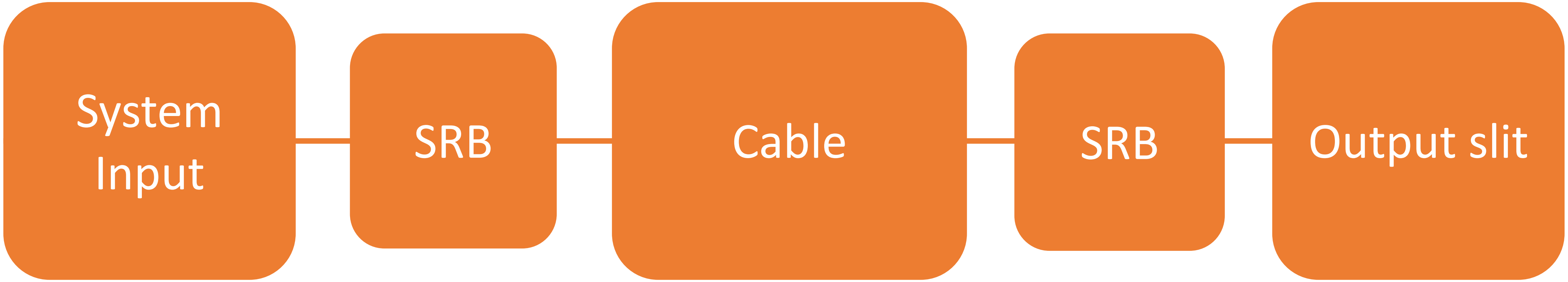
Fibre system fundamental requirements

- Flexible, ruggedised relay from focal plane to spectrographs
- High transmission over desired wavelength range
- F/# matched to both input (targets) and output (spectrograph F/in)
- Fibre size optimised to target scales and spectral R requirements
- Low system focal ratio degradation (FRD)
  - Minimal stress-induced FRD
  - Good quality control of end preparation
- High stability. Minimal variation in throughput & NF/FF stability → relates to FRD

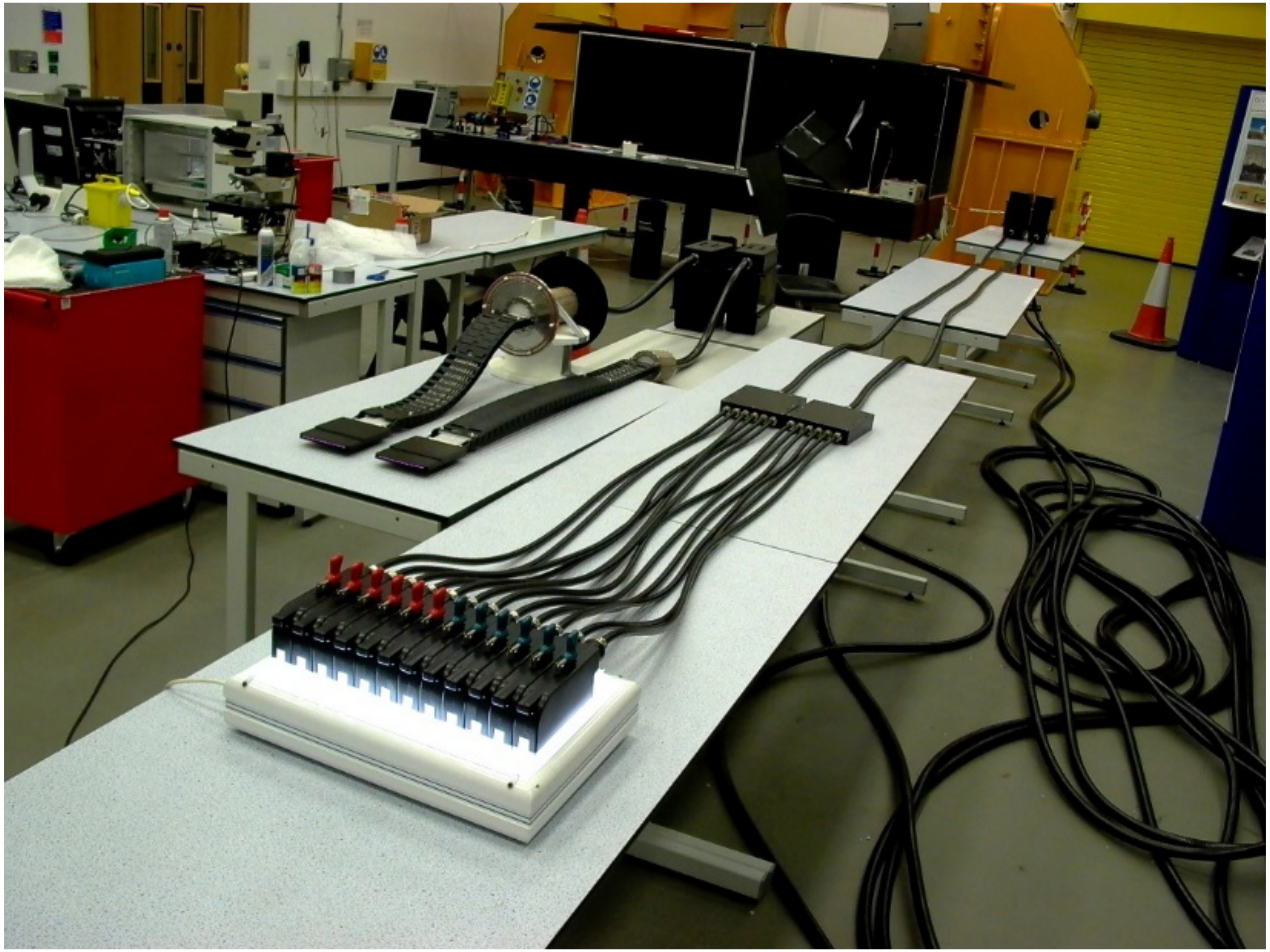
Generic fibre system schematic



F/in from telescope
Fore-optic,
microlens array?
→ F/cable

F/cable → F/out to
spectrograph,
microlens array?
Relay optic?

FMOS example

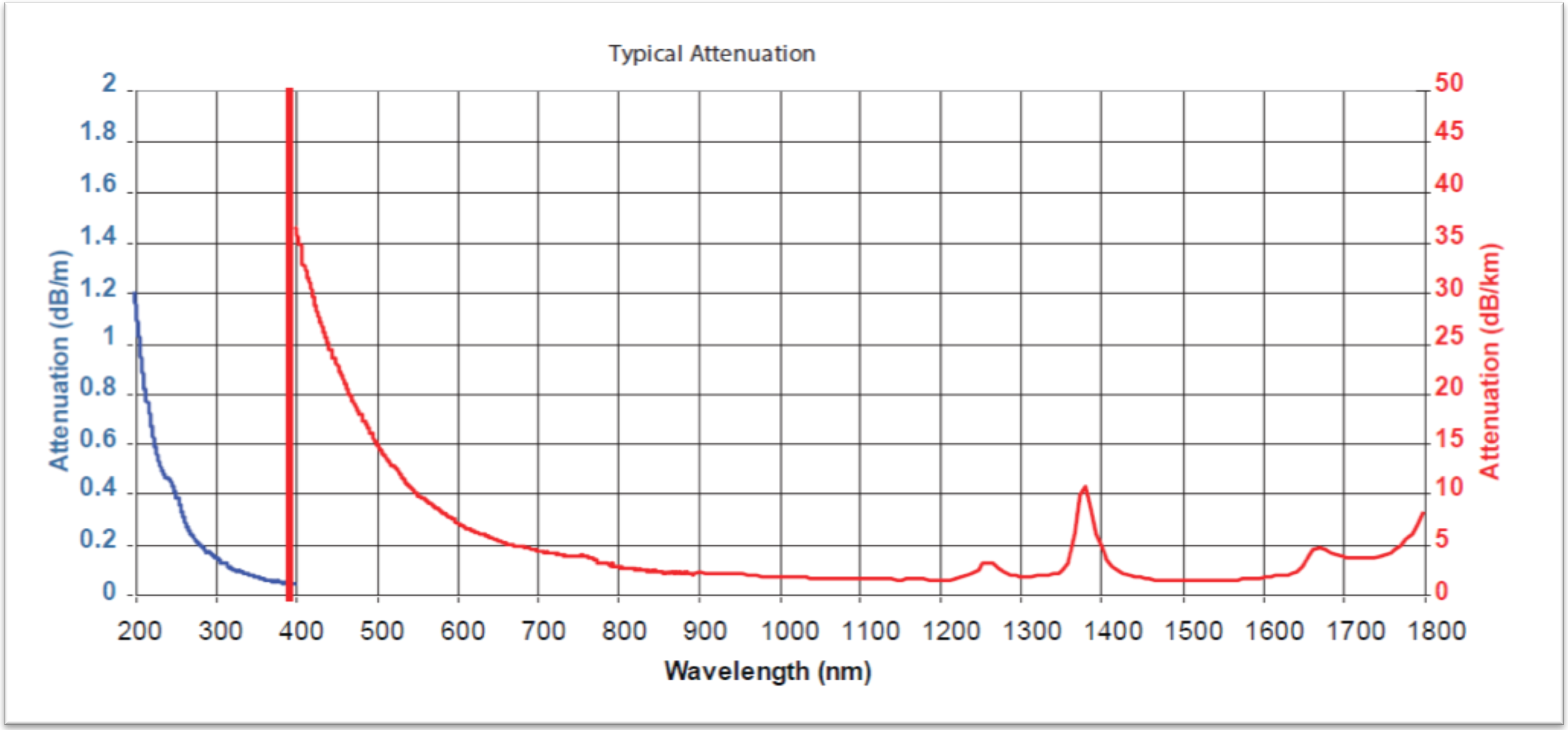


Fibre type considerations

- Minimal optical loss in the glass (varieties of fused silica employed typically, for long λ UV to H-band)
- Default fibre profile is circular core (square, octagonal for high res…)
- Appropriate N.A.for application
- Low inherent FRD
- Cost – custom core size versus off-the-shelf
- Clad thickness (evanescent wave loss considerations)
- Buffer material? Acrylate? Polyimide?

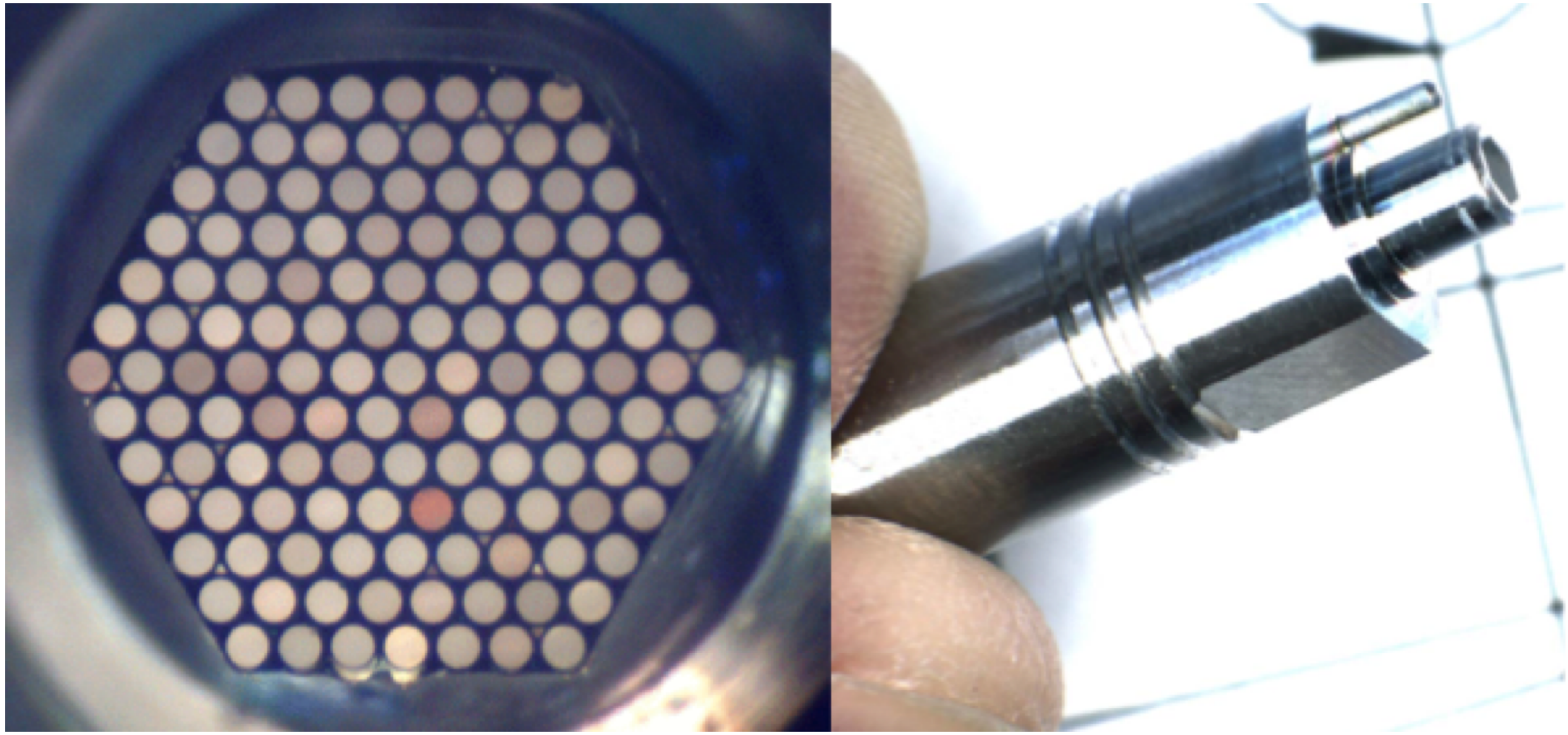
Usual providers Polymicro, Ceramoptec, Fibercore, Fujikura…

Polymicro FBPI broadband fibre



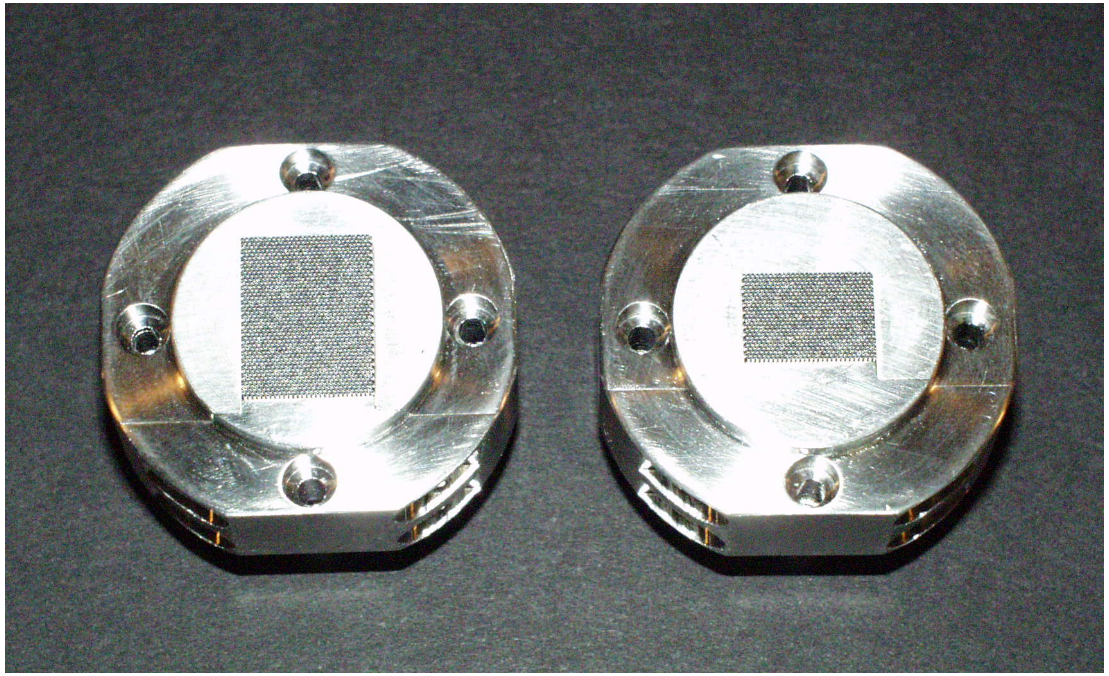
Developed primarily for astronomical applications. Fused silica, ultra low OH, polyimide buffer.

IFU Inputs – close packed

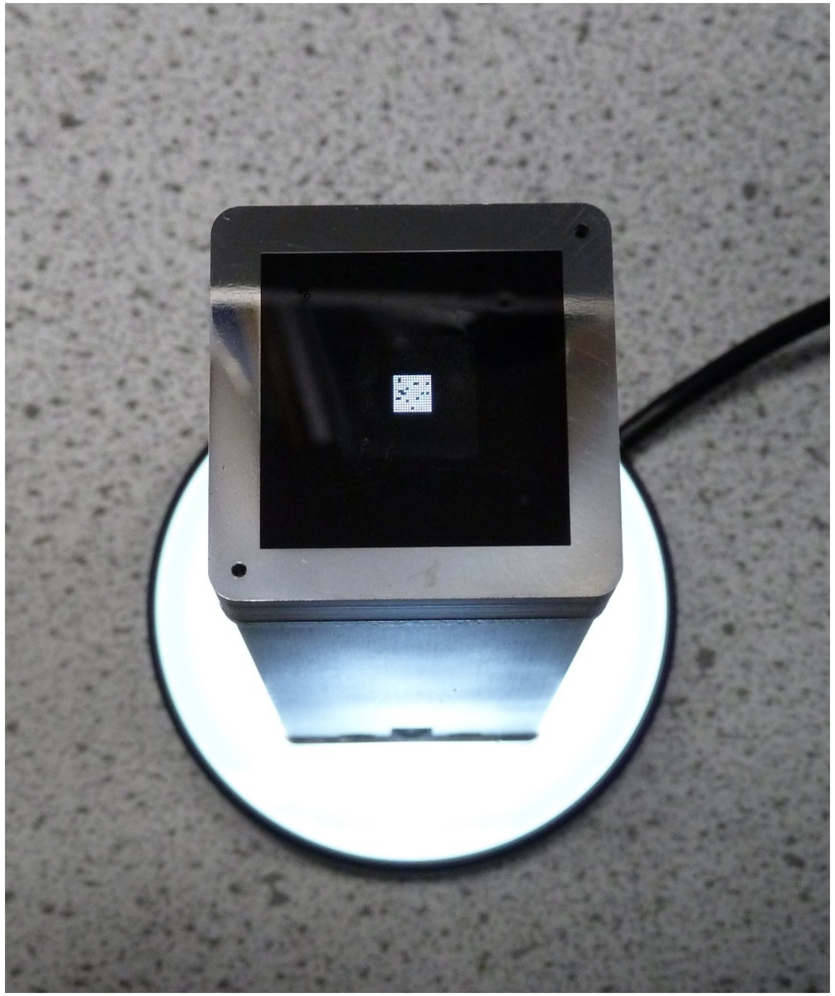


MANGA-style input, pitch = fibre OD.

IFU Inputs – custom pitch



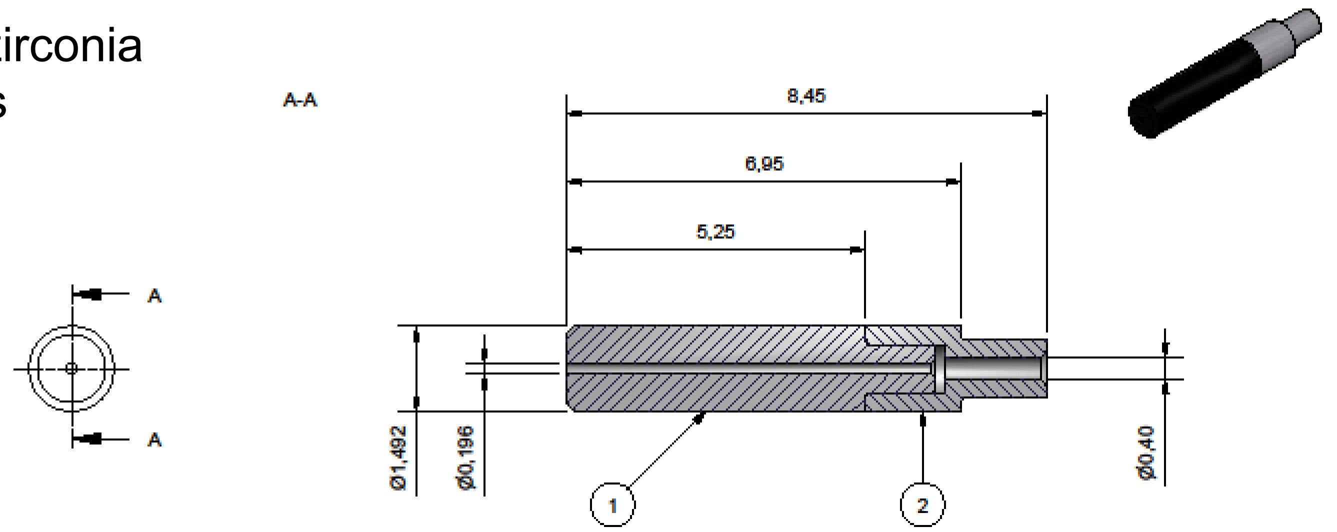
GMOS-IFU Fields – capillary tube arrays – RMS errors increase with fibre count



3-D Biospec randomiser – laser cut hole arrays in Cirlex - field size is unlimited. Also silicon, glass options

Focal plane terminations - PFS

Black zirconia ferrules



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	DUR-DWG-PFS-100101-0002	FERRULE
2	1	DUR-DWG-PFS-100101-0005	CAP

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ISSUE	RELEASE	INITIALS	DATE
B	STRAIN RELIEF BOOT DELETED	CMD	08/12/2014
A	FIRST ISSUE	CMD	15/10/2014

THIRD ANGLE PROJECTION

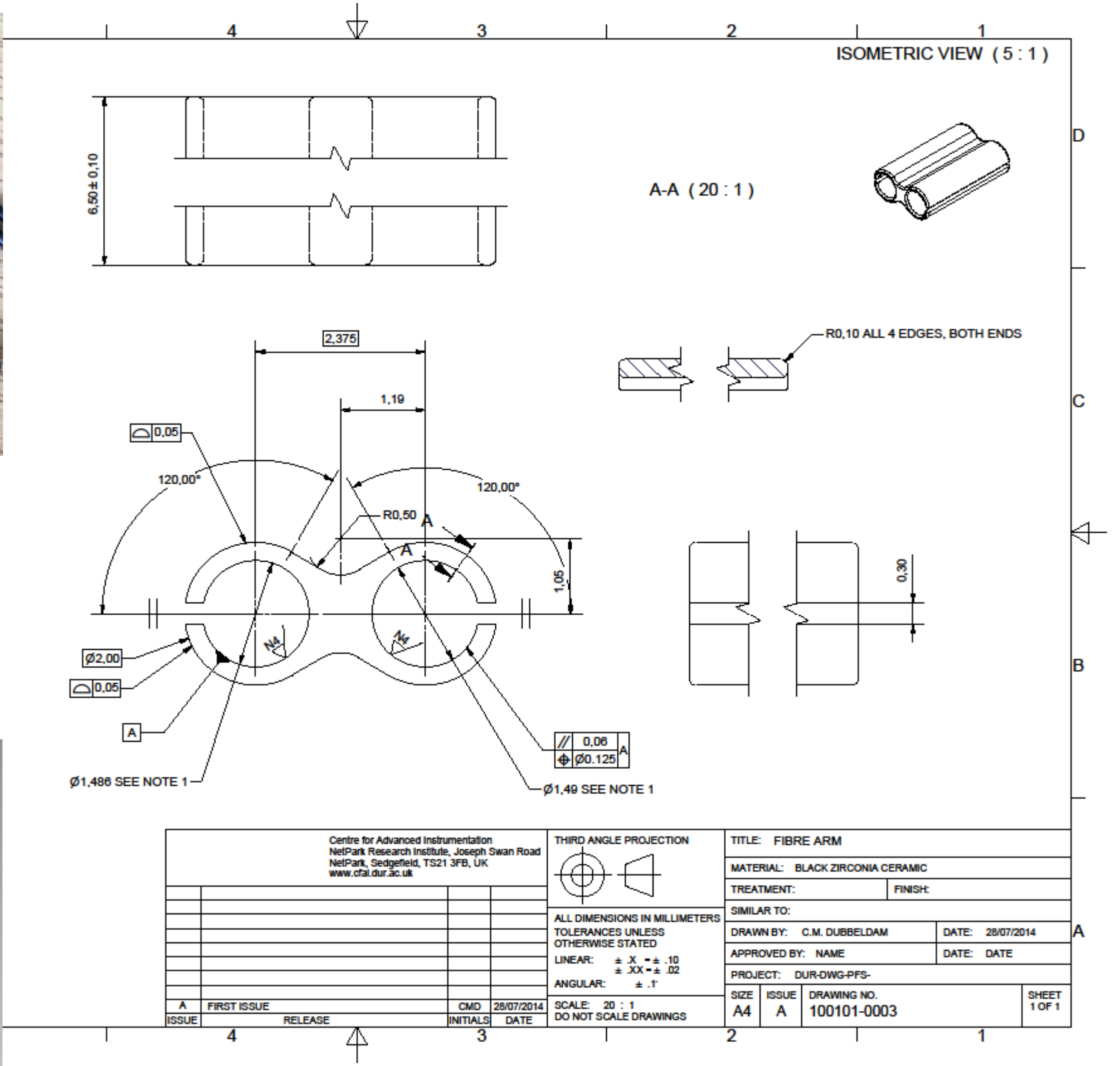
ALL DIMENSIONS IN MILLIMETERS
TOLERANCES UNLESS OTHERWISE STATED
LINEAR: ± .X = ± .10
± .XX = ± .02
ANGULAR: ± .1°

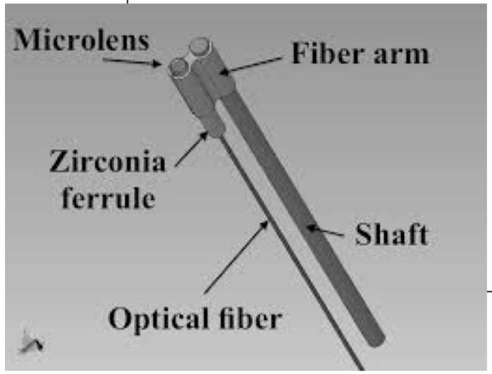
SCALE: 10 : 1
DO NOT SCALE DRAWINGS

TITLE: PFS FERRULE
MATERIAL:
TREATMENT: FINISH:
SIMILAR TO:
DRAWN BY: C.M. DUBBELDAM DATE: 15/10/2014
APPROVED BY: NAME DATE: DATE
PROJECT: DUR-DWG-PFS-

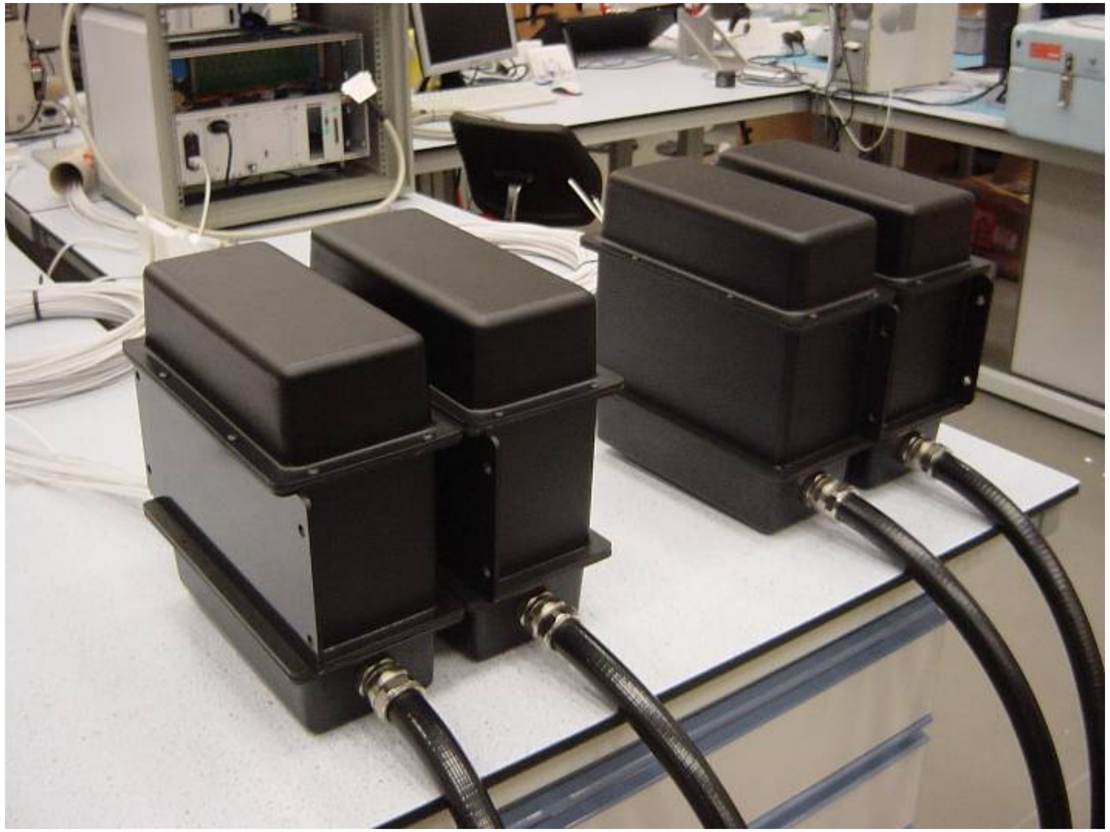
SIZE	ISSUE	DRAWING NO.	SHEET
A4	B	100101	1 OF 1

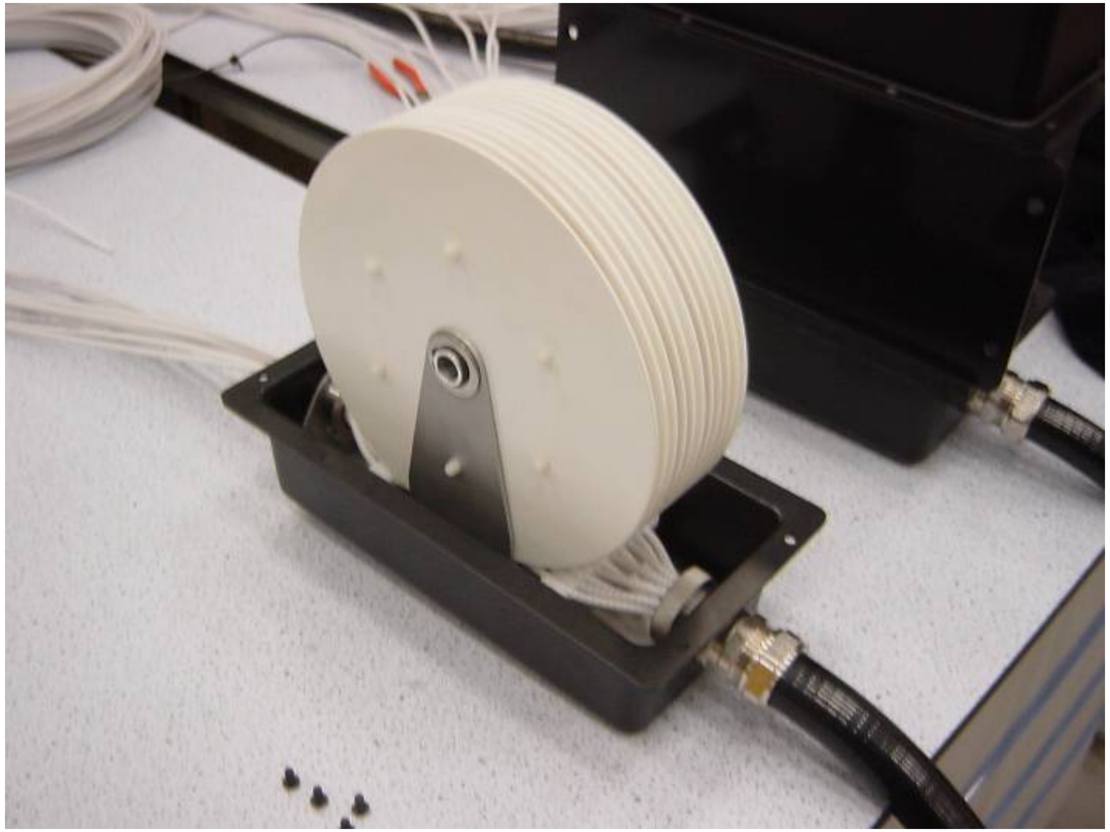
Focal plane terminations – PFS fibre arms





Strain relief boxes

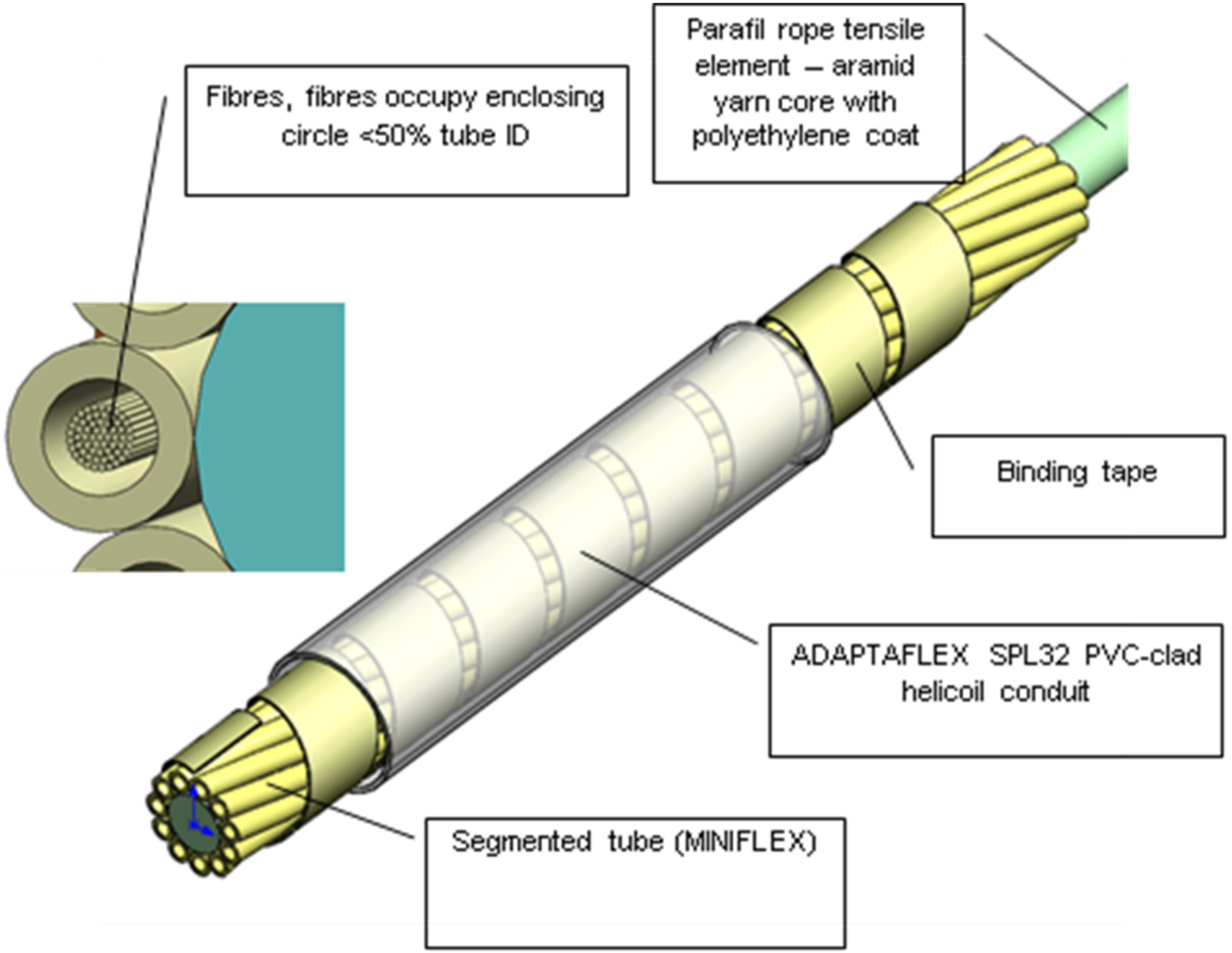




Allow tensions to dissipate due to differential movements / “settling” in the fibre cable, Decouples the main cable from the end termination, serve as a reservoir of fibre during manufacturing

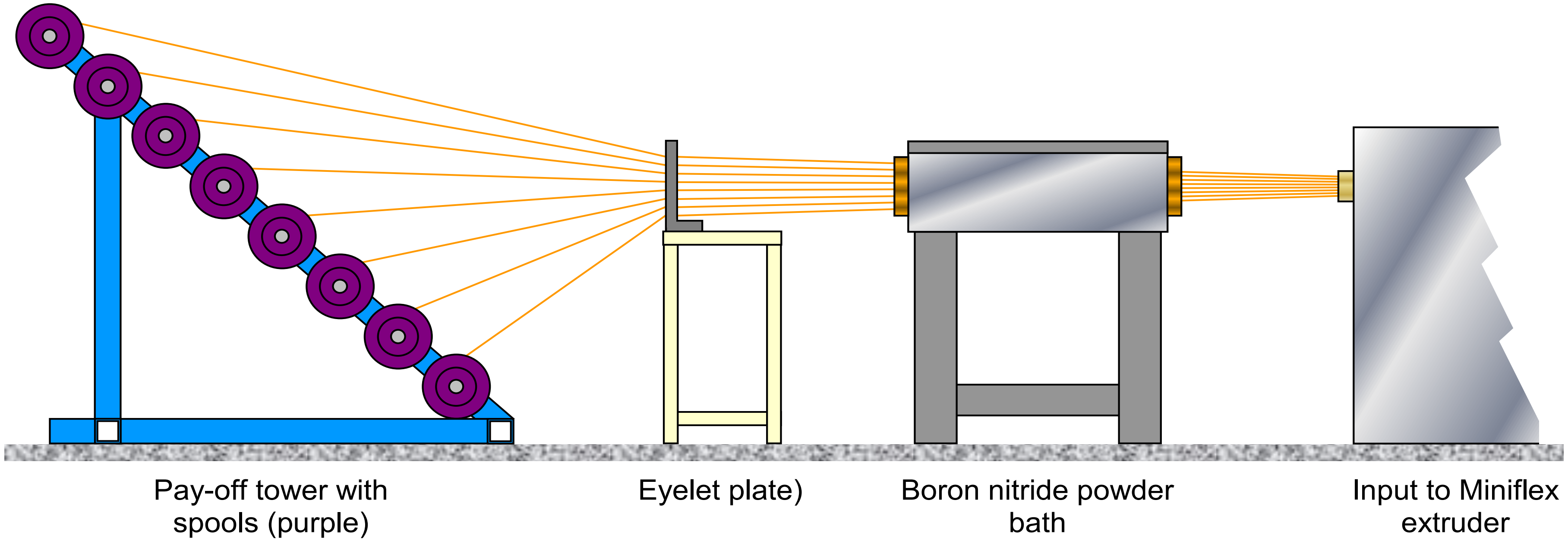
Stranded cable design

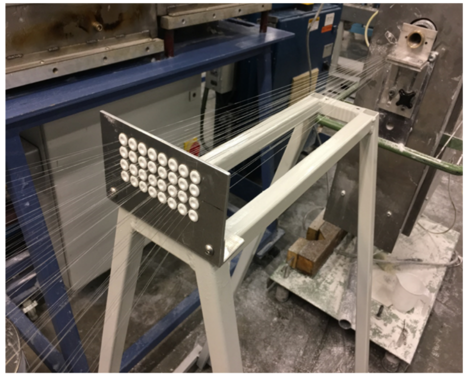
- As used for FMOS, PFS, DESI
- Tensile load supported by high strength core
- Additional fibre per unit length (~2%) ensures minimal stress due to cable bending -‘racetracking’.



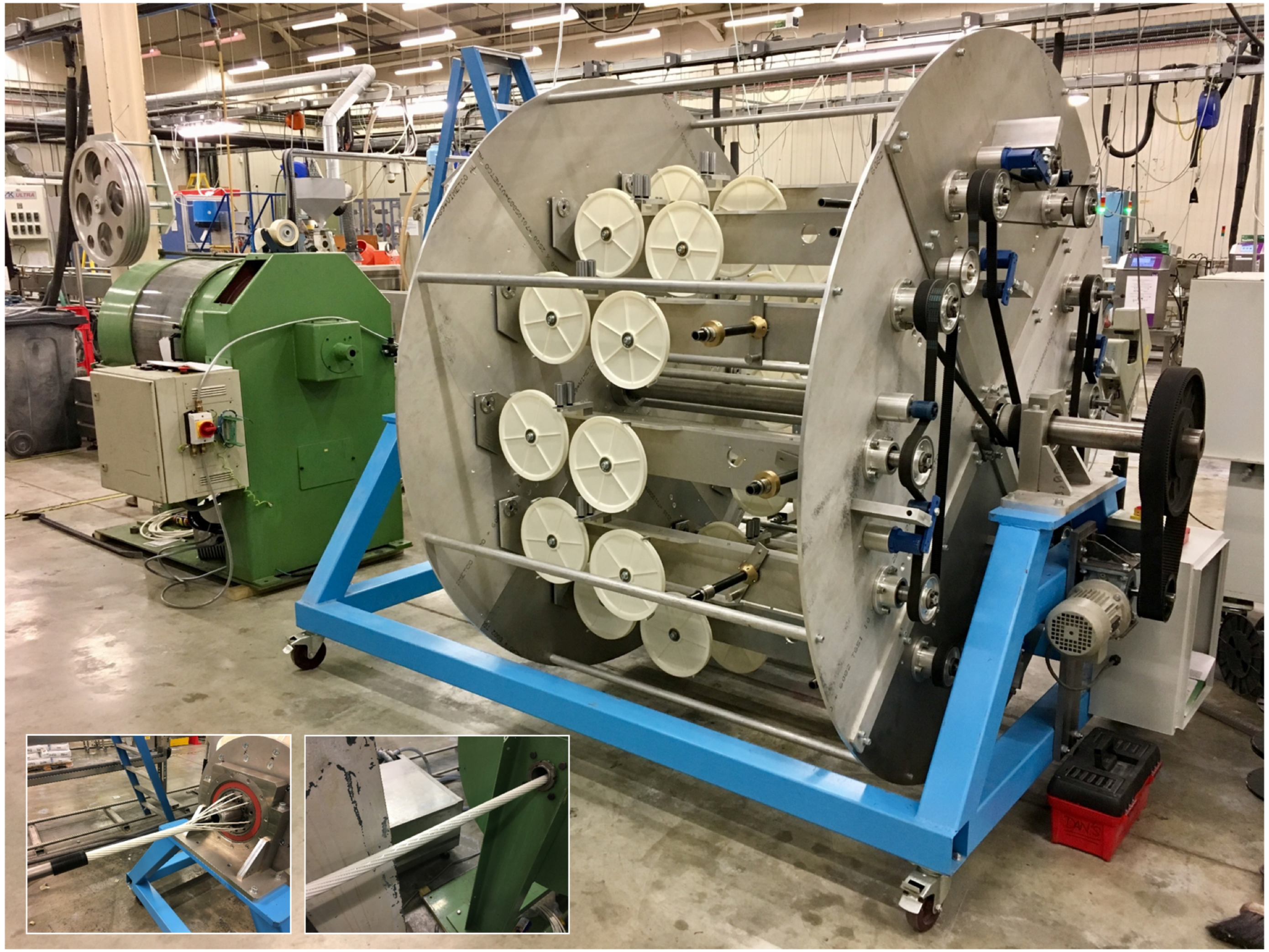
Collaborative R&D with PPC Broadband Fiber Ltd. Formerly m2fx

Fibre pull into tubing – Miniflex production line



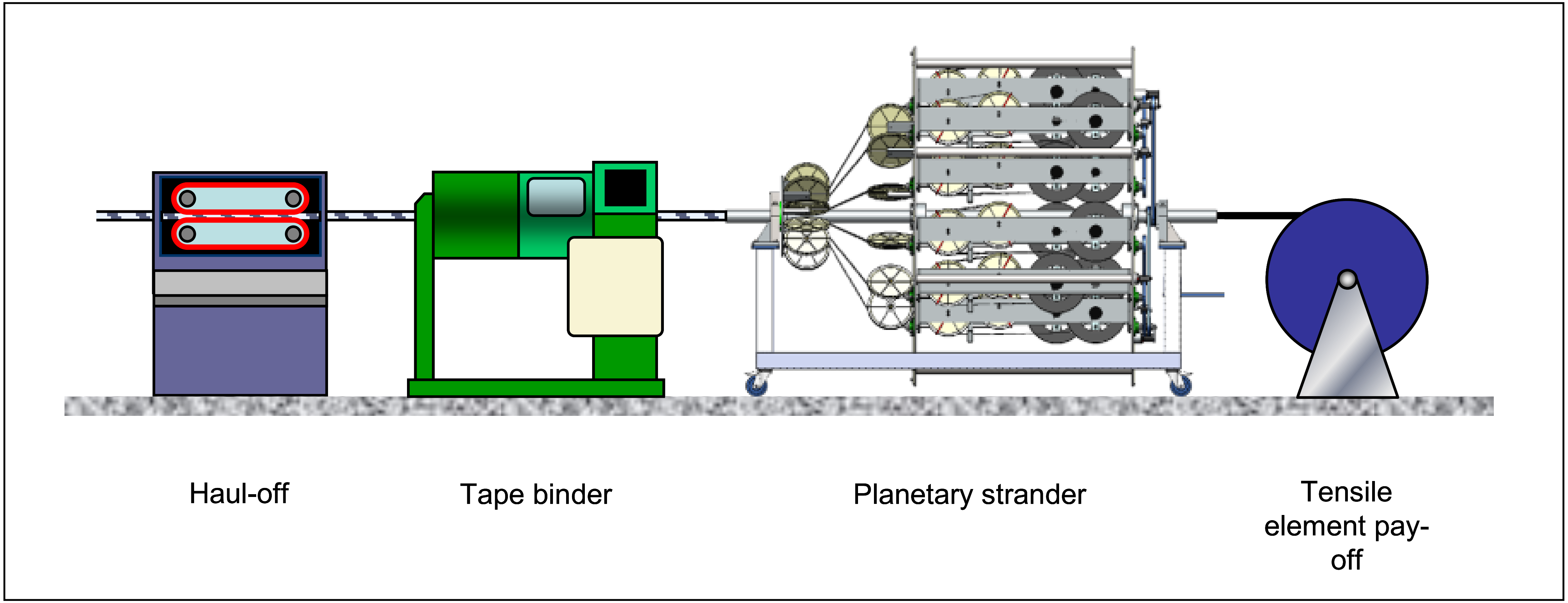


The planetary strander



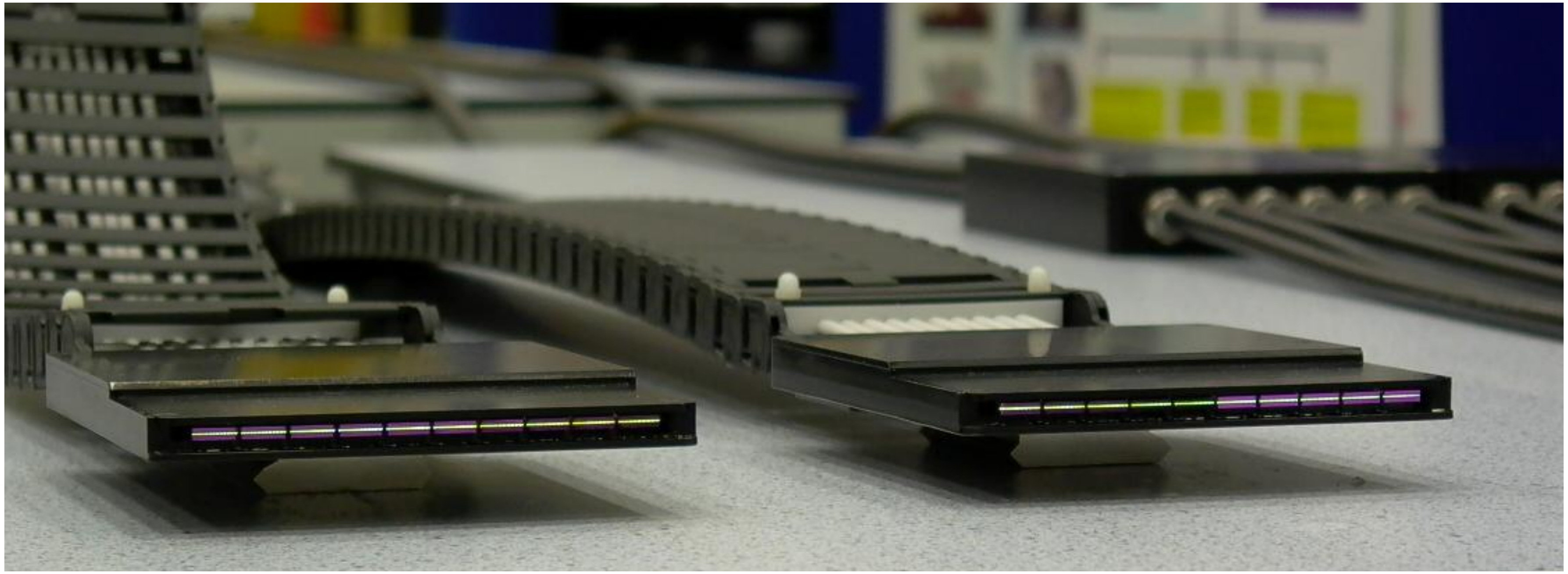
The completed strander, minus the fibre in Miniflex tubing. The motor and drive belt can be seen on the far right. The inset photos bottom left show stranded cable coming off the line; (left) the cable emerges from the machine, (right) the cable after tape binding.

Planetary stranding



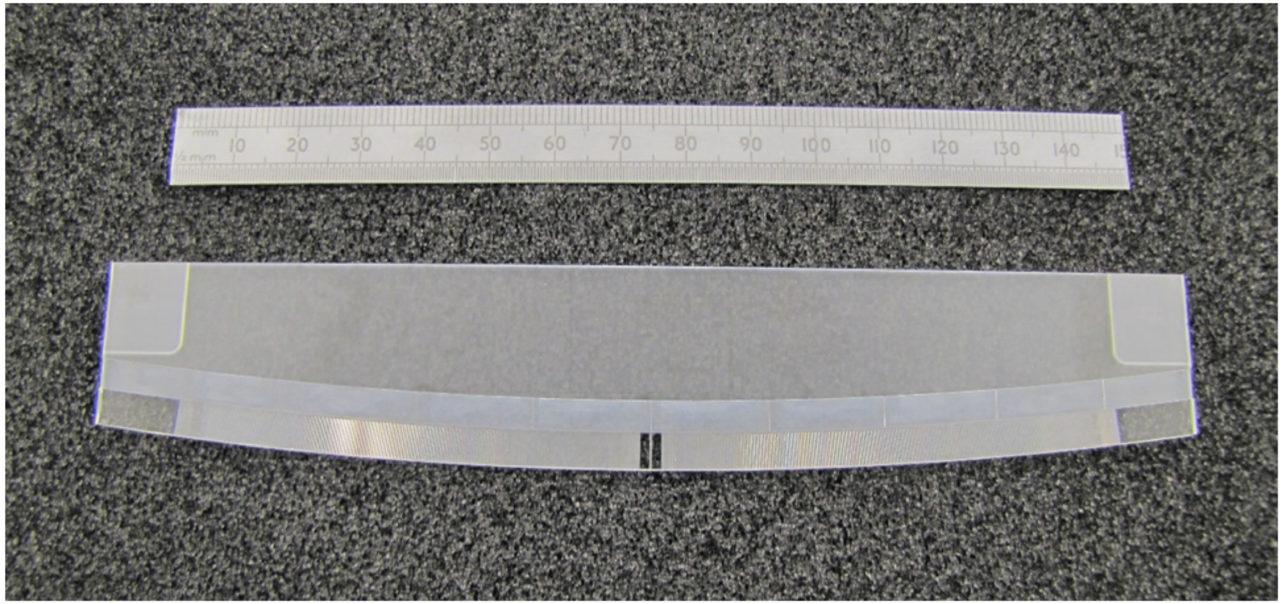
The production line, starting with the tensile element on the right, leading through to a finished stranded and tape-bound cable core on the left.

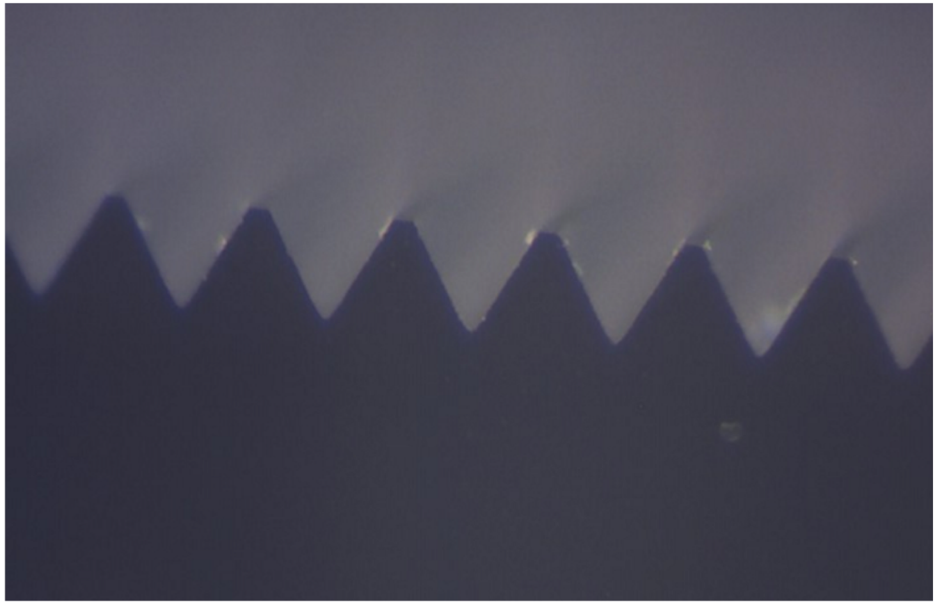
Slit units – v-groove arrays



- Slit formed from sub-blocks
- Low FRD
- In each block pointing is parallel, blocks arranged to approximate curvature
- AR coat carried on windows / field lenses / microlenses
- Large gaps

Monolithic v-groove array





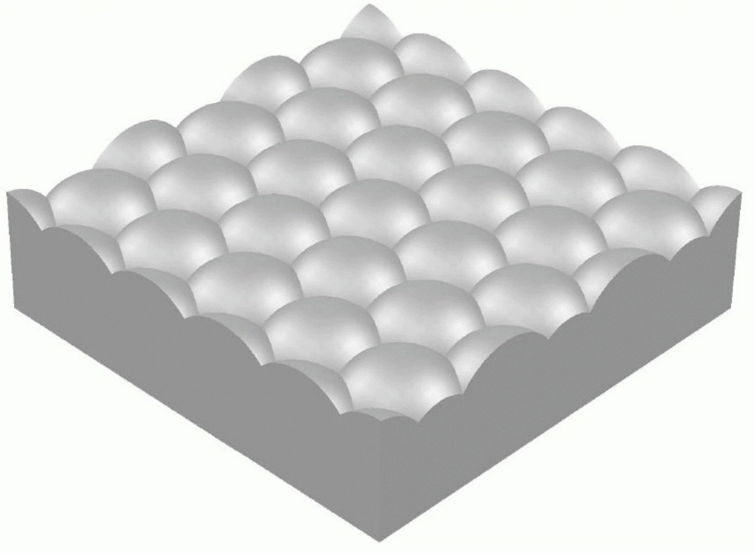
New slit technology – monolithic v-groove arrays. Borofloat 33 glass. Lid not shown.

- Transparent – enables novel bonding strategies
- True pointing
- Curved slits – two axes?!
- Extremely high tolerance
- Low FRD
- AR coat

- Thin
- Both surfaces can carry v-grooves
- No gaps – best for IFUs

R&D supported by NAOJ Subaru & Kavli IPMU.

Microlenses



Current manufacturing techniques enable both positive and negative arrays → doublets, even triplets are possible in a variety of glasses → HiRES
Can be AR coated.

Summary

- A variety of established and new technologies can be deployed for MOS & IFS fibre systems
- Trade-off can be undertaken of cost versus efficiency
  - Off the shelf approach versus custom, highly optimised “custom component” approach