OzPoz for HRMOS?

Jon Lawrence
<jon.Lawrence@mq.edu.au>

AAO team: Dave Adams, Scott Case, Gayandhi De Silva, Tony Farrel, Peter Gillingham, Helen McGregor, David Robertson

HRMOS Requirements

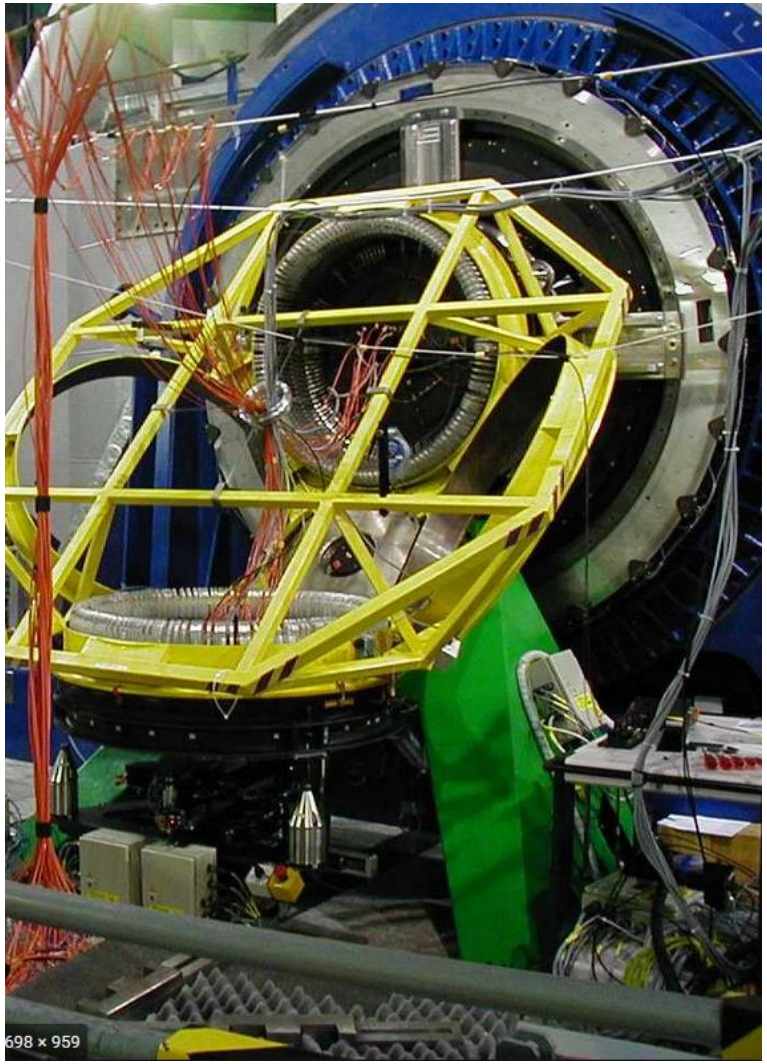
- Science requirements still under development:
- Key aspects for the fibre positioner:
  - Multiplex
  - Positioning accuracy
  - Field configuration time
  - Clustering capability
  - Fore-optics/fibre configuration

HRMOS preliminary science requirements

	Galactic Science	Satellite Galaxies	Exoplanets	Young Stars	Star Clusters
Resolution	80000	60000	80000	80000	>60000
Spectral range	Various windows 380-800nm	402nm [Th] 406nm [Pb] 481nm [Zn] Some flexibility	Simultaneous monitoring Ca II with a window at 500nm.	Halpha to Ca H&K, 100nm simultaneous	Various windows 380-800nm
Multiplex	20-100	100	100	50	>20
RV	100m/s	100m/s	10m/s	< 1km/s	1km/s
Efficiency	SNR > 100 G = 15 in 1 hr	SNR > 90 V = 16.5 in 2 hrs B = 17.5 in 5 hrs	Limiting mag V = 16.5 in 1hr	SNR = 10 V = 15 in 300s	SNR > 100 G = 15 in 1 hr

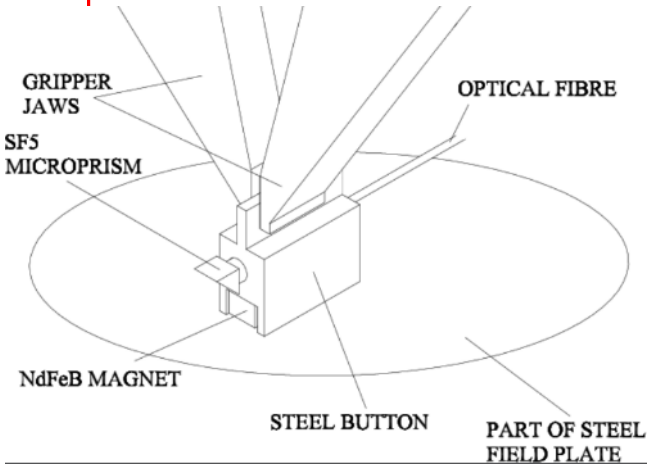
OzPoz overview

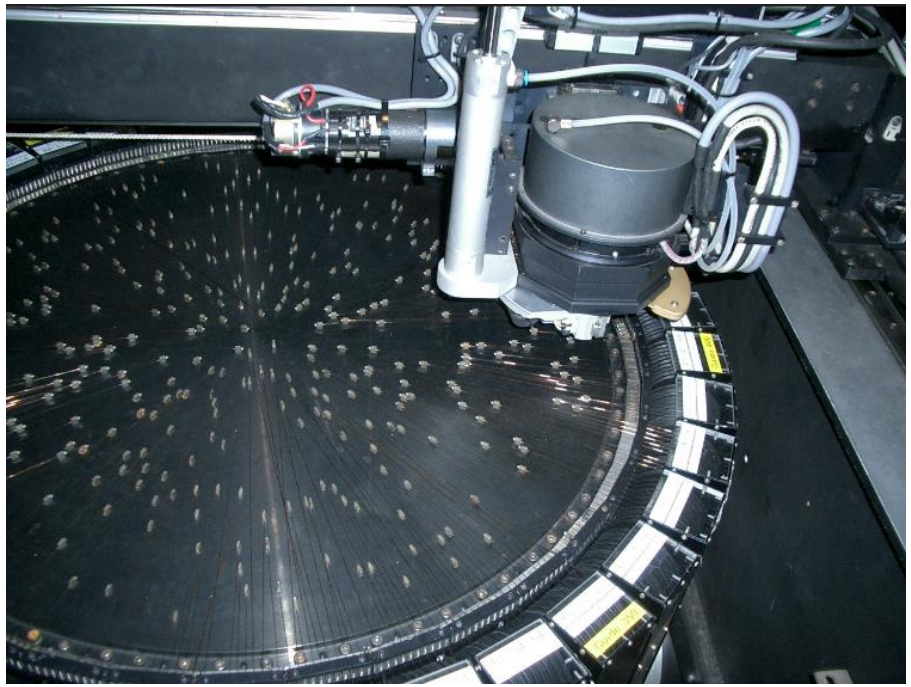
- OzPoz commissioned in 2003
- Up to 560 objects over 25 arcmin FOV for the 8 m VLT
- Developed by AAO
- Operates at UT2 on the Nasmyth platform
- As part of the FLAMES facility, feeds GIRAFFE with up to 130 single objects, or 15 IFU objects, or 1 IFU, and UVES with 8 objects
- >1000 papers
- Still in routine use!



Pick-and-place robot heritage

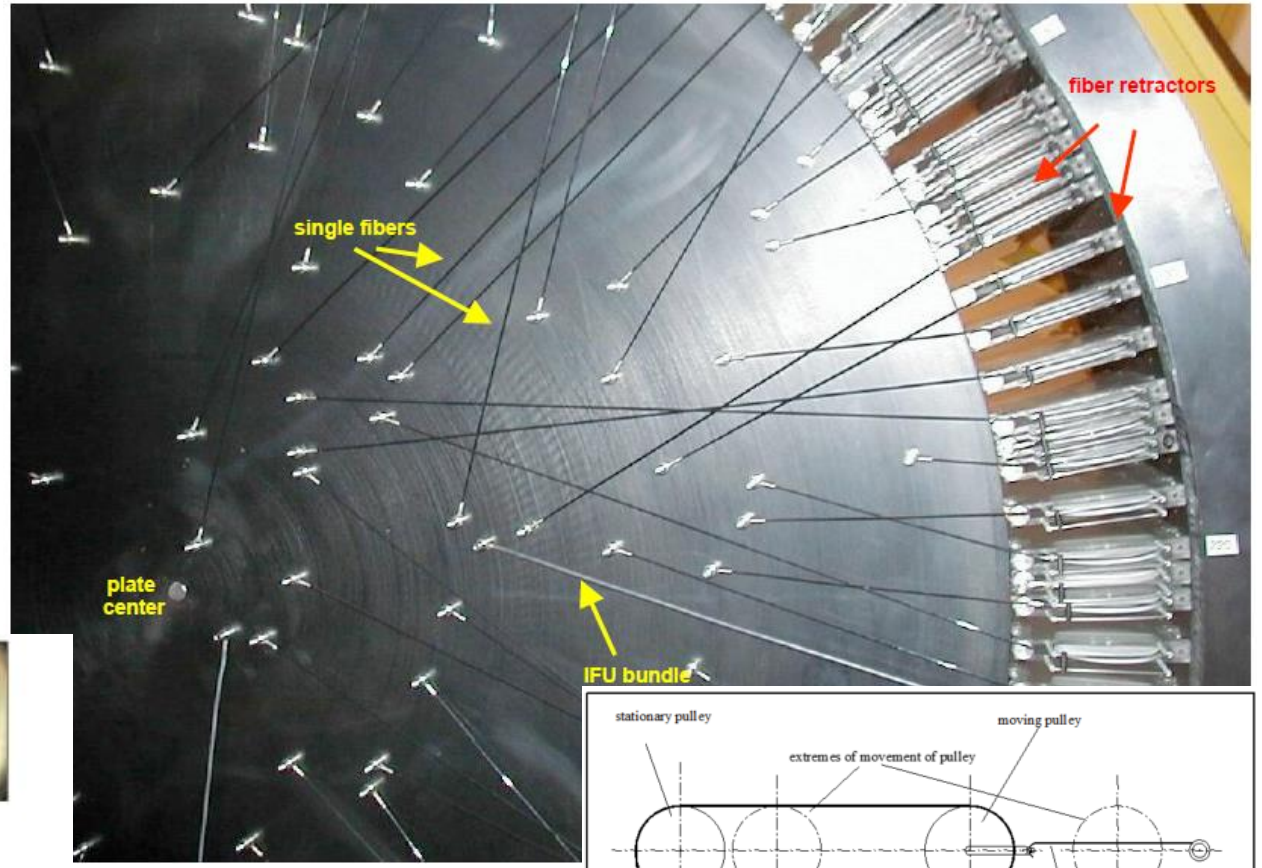
- AAO: 6df from 2001, 150 objects over 6 degree FOV for the 2 m UKST
- AAO: 2df from 1995, 400 objects over 2 degree FOV for the 4 m AAT
- Also Hydra (NOAO) and autofib (AA) earlier, Hectospec (Harvard SAO) later
- Currently WEAVE (Oxford) and Hector (USyd) in progress

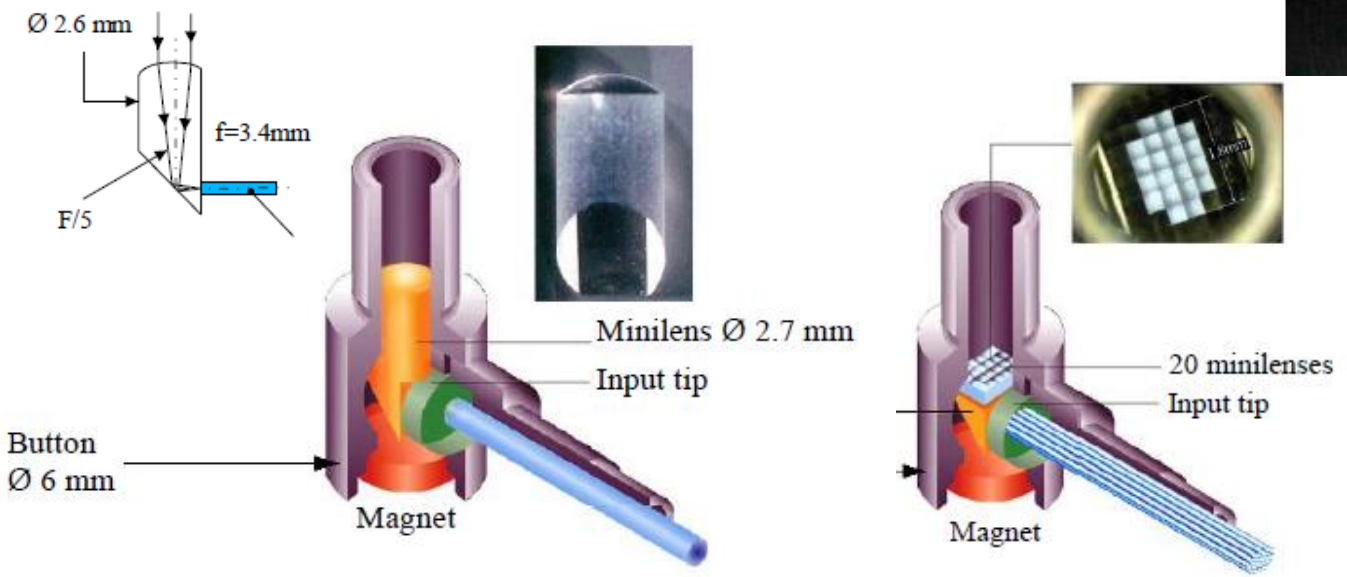


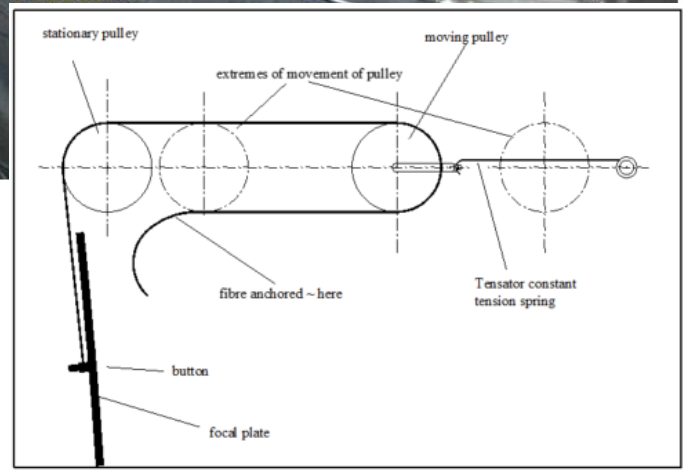


OzPoz operation: fibres and field plate

- Fibres installed on magnetically attached buttons to a curved steel field plate
- Buttons include optics for f/ratio conversion
- Both single fibre and IFU configurations
- Back illumination system inside spectrograph
- Includes button-mounted field acquisition coherent bundles (for scale factor, offsets, guiding)
- Fibre retractors deal with fibre cable management

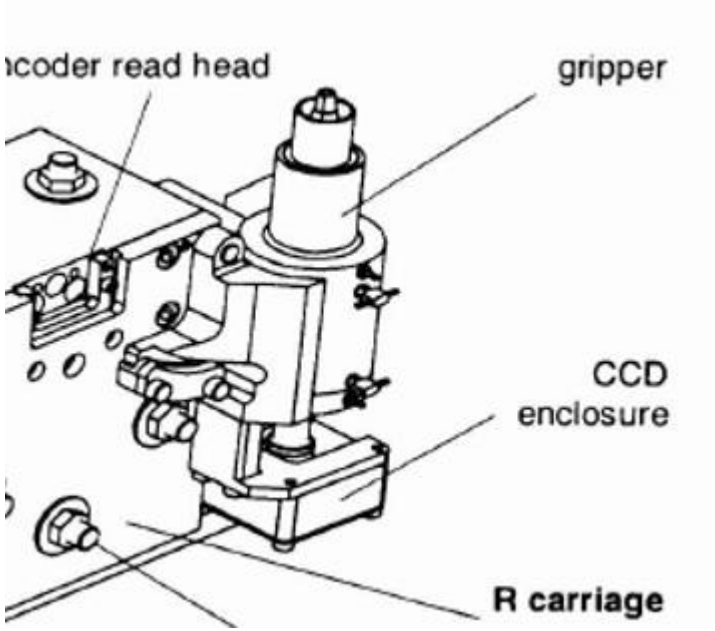


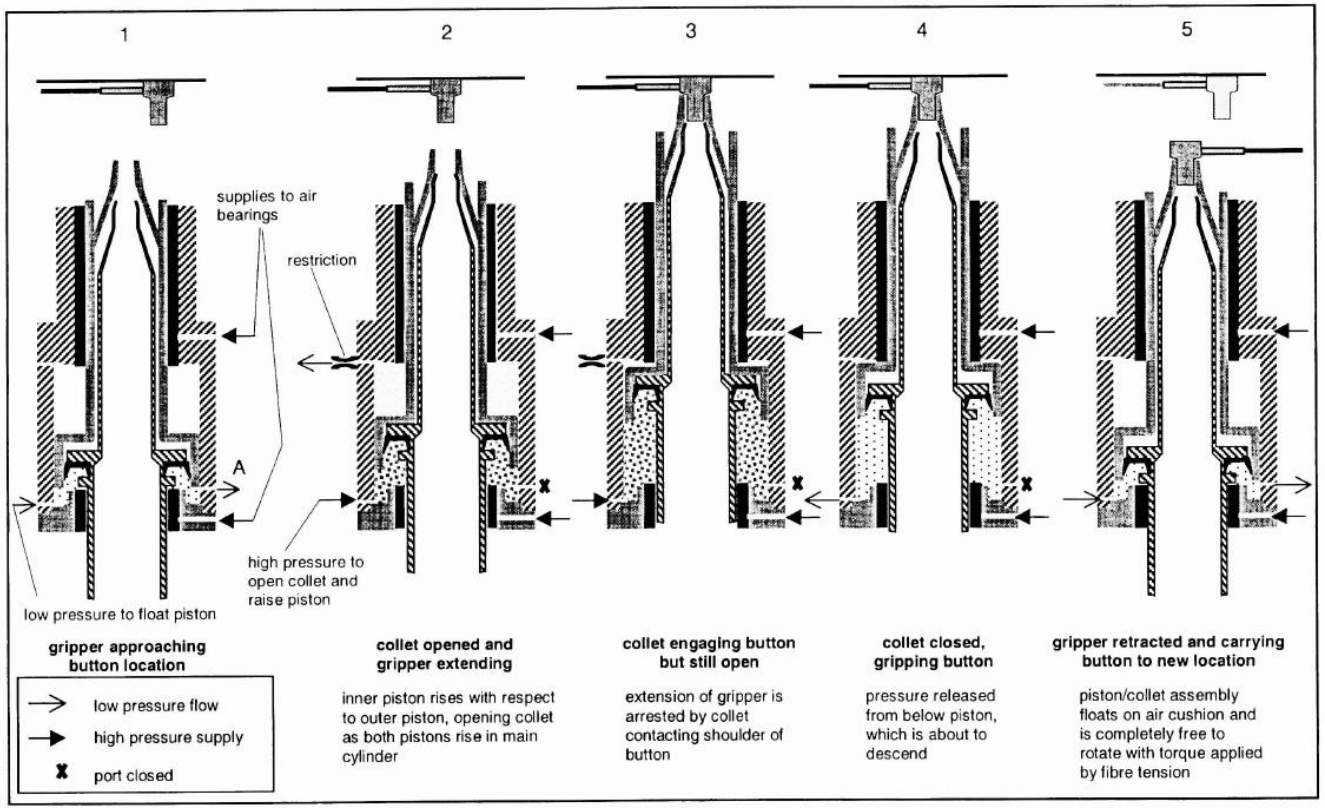




OzPoz operation: gripper

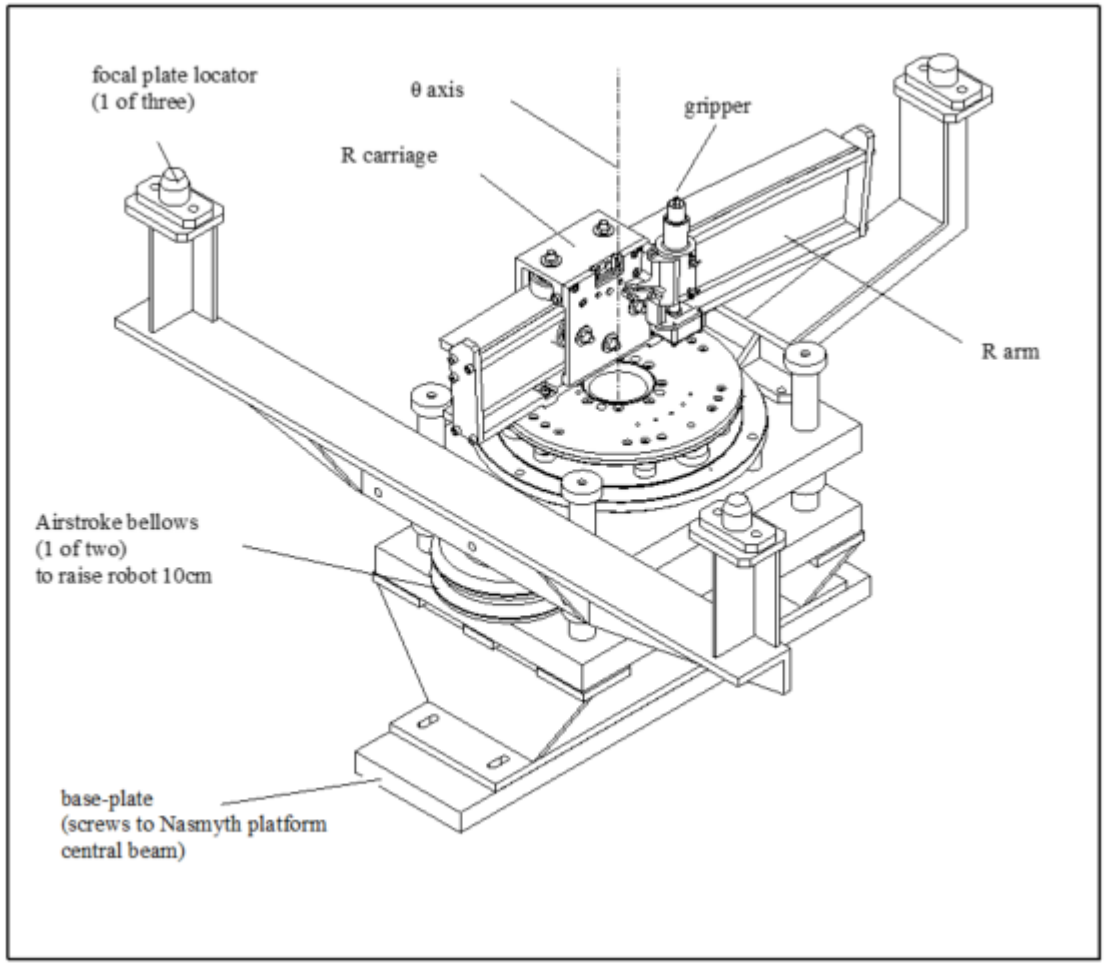
- Gripper design needs to meet specifications on
  - Force to withdraw at lower button diameter
  - Force to withdraw at upper button diameter
  - Torque to rotate collect
  - 50000 pick and place cycles
- Gripper has 3 jaw collet that is pneumatically actuated via a hollow shaft
- Gripper is hollow allowing rear mounted CCD to view an image of the back illuminated fibre





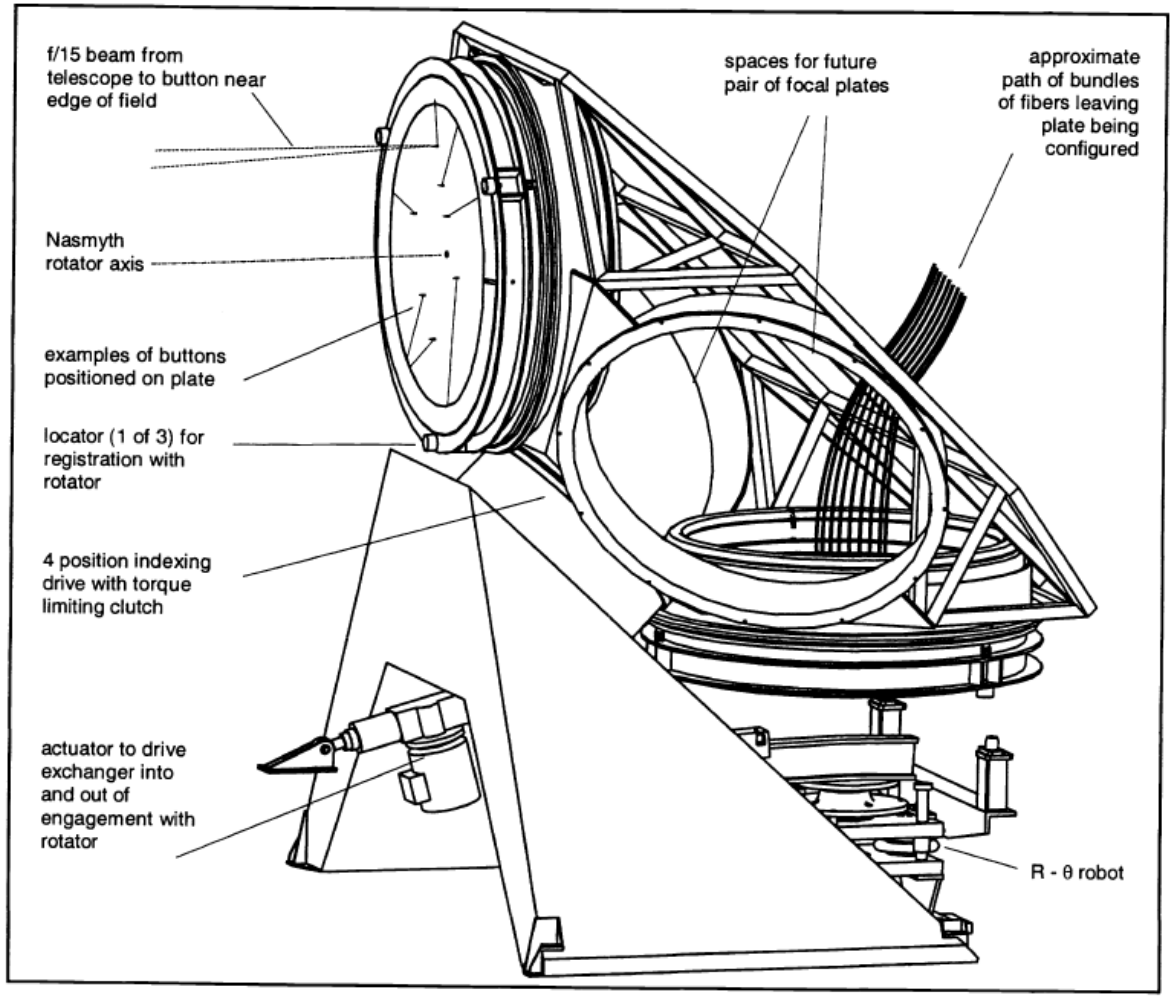
OzPoz operation: robot

- OzPoz uses R-theta robot to match the curvature of the field plate
- The button has to rotate in phi so as not to bend the tensioned fibre where it attaches to the prism
- Linear motor drives the gripper along the radial arm with cylindrical top surface using air bearings
- Encoder tape is mounted along the top of the arm
- Theta drive uses a brushless servo torque motor with clear centre path for cables with encoder tape around perimeter
- The plate includes fiducial marks used for transformation between the field plate and the robot encoders with the thermal expansion of the plate taken into account.



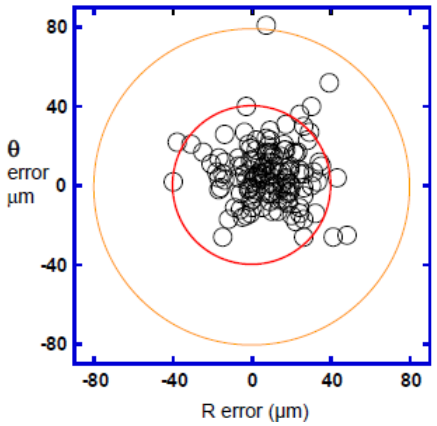
OzPoz operation: plate exchange

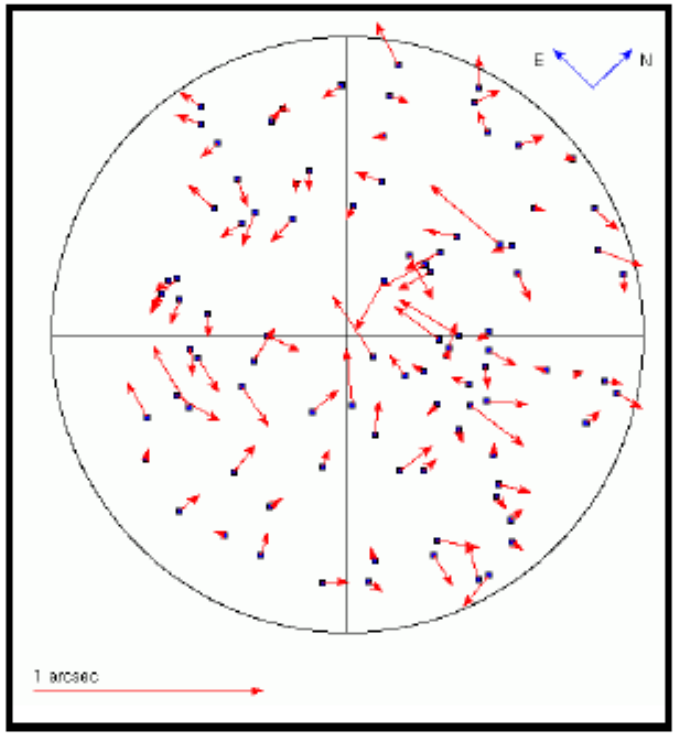
- Two field plates: with robot configuring on off-telescope plate while observing with the on-telescope plate
- Plate interchange involves lowering of robot translation of field plate from Nasmyth rotator
- Two locations for spare plates
- System includes a calibration unit for flat field and multi-line sources injection into fibres – nominally a day time operation

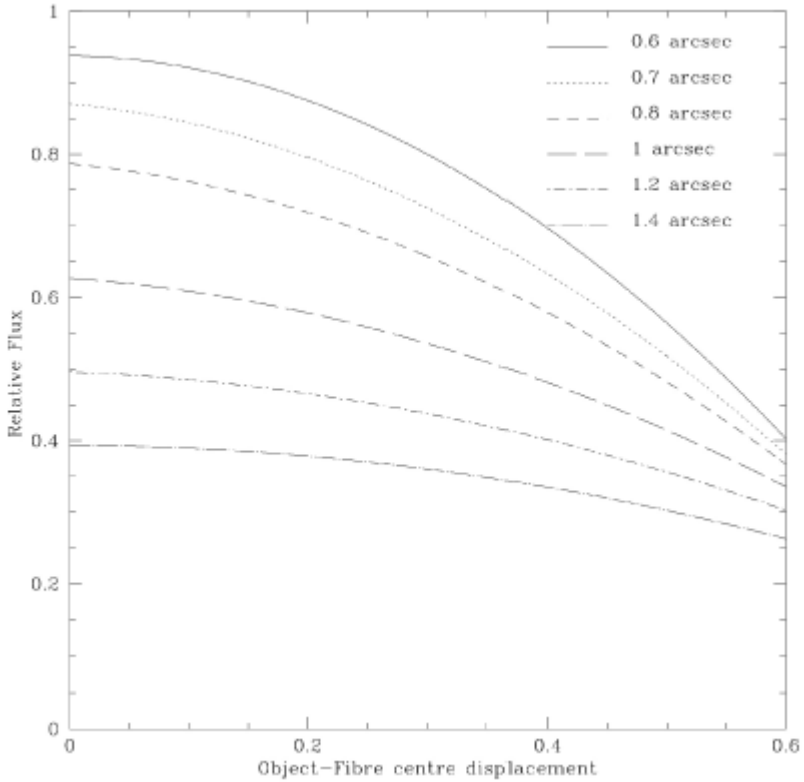


OzPoz positioning accuracy

- Measurement error:
  - Image centroid measurements
  - Encoding intervals
  - Scale non-linearities
  - Temperature
  - Path stability
- Positioning error:
  - Eccentricity correction
  - Gripper collet
  - Focal plane irregularity
  - Foreign particles
- Location error
- Optical distortion



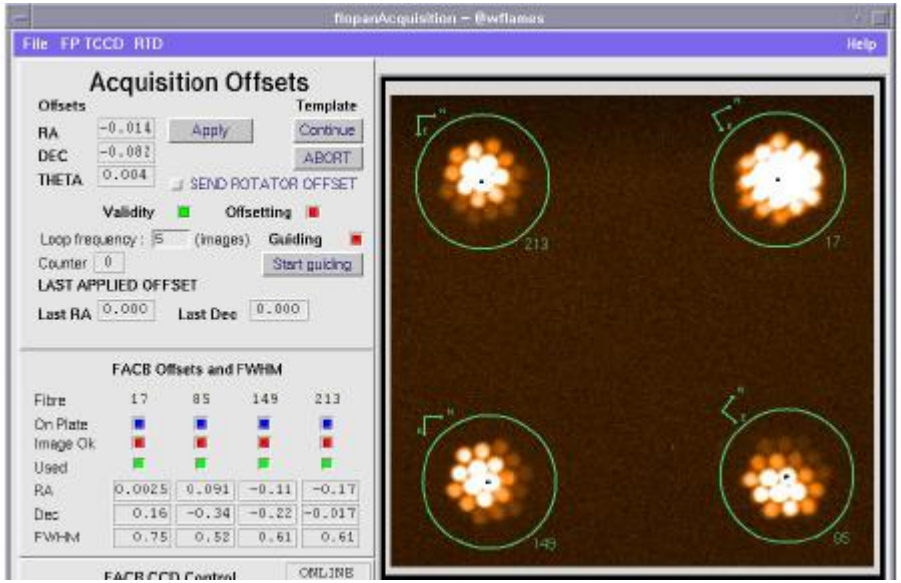


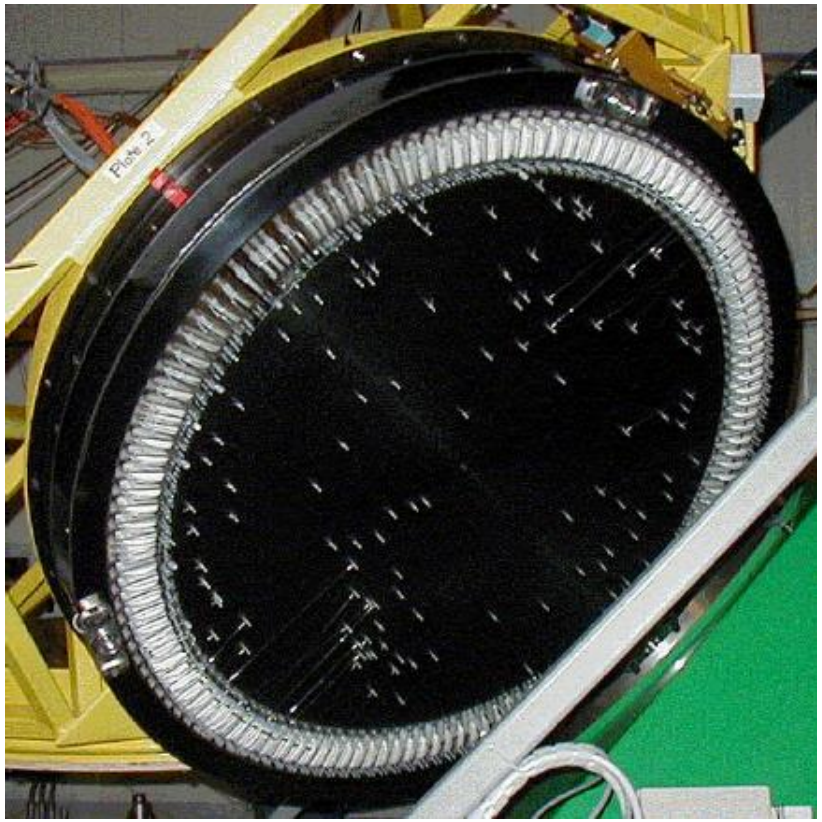


The Fibre Positioner is able to position the fibres with an accuracy better than +/-0.1 arc (peak-to-peak)

OzPoz configuration and exchange time

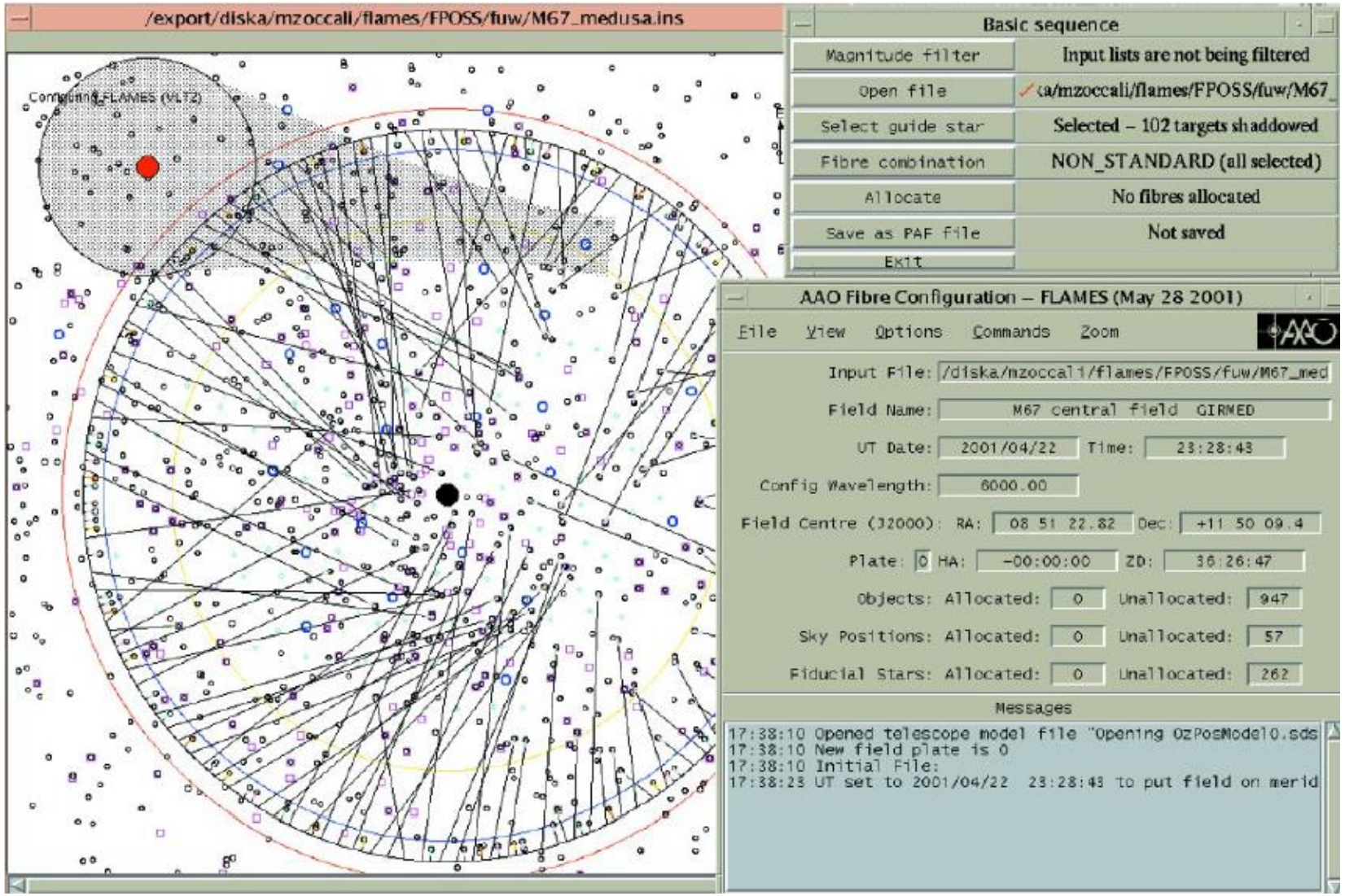
- Average time to re-position a button is ~6 seconds giving 15 minutes for full field of 130 GIRAFFE fibres
- Note specification is 10 seconds per fibre giving 20 mins for GIRAFFE
- Switching time between field plate: 3 minutes (specification was 5 minutes)
- Set up for observations is 12 minutes:
  - Point the telescope
  - Apply active optics
  - Acquire the acquisition bundles





OzPoz configuration

- Typical to pick and place positioners, overall clustering is good.
- Minimum object separation is 11 arcsec (set by size of the magnetic buttons)



OzPoz reliability

- Original specification called for operational lifetime of 10 years
- Limits on MTBF of system components
- After 16 months of operation:
  - Less than 1% time lost to instrument issues, with <0.1% in the last 6 months
- In 18 years of operation:
  - Gripper camera has been replaced
  - 1 problem in an electronics card
  - A few problems with position sensors with some swapped out
  - No major hardware upgrades
  - No systematic failures
  - Some fibre breakages and damages
  - Generally low number of events

Start Date (UT)	End Date (UT)	Ongoing ?	Event Types	Instrument Modes	KPI Parameters	Non-KPI Parameters	Calibration Raw Types	Calibration Breakpoint ?	Comment	History
2021-08-24 15:00		false	• INTERVENTION	• MEDUSA		• flux	• SIMLAMP	false	Tal Lamp power source was adjusted from 8 to 6mA	[show]
2021-01-13 14:00	2021-01-14 14:00	false	• ELEMENT_FAILURE Controler of the Tungsten lamp failed. Consequently, calibrations stopped and resumed after it was fixed.	• ALL			• FFLAT	false		[show]

Month	time lost h:mm	Description	time lost for month h:mm	time available for month h:mm	% lost
Apr 2003	1:00	Fiber 201 slip	3:50	42:15	9.1
	0:30	Retractor problem			
	2:20	Tumbler does not move			
May	1:05	Button stuck in gripper	4:12	135:38	3.1
	0:30	GIRAFFE CCD readout failure			
	0:15	UVES fiber not in porch position			
	0:26	Fiber 37 no image seen on plate			
	0:31	OzPoz Robot interlock triggered			
	0:25	OzPoz Robot interlock triggered			
	0:45	Fiber 214 manual intervention needed			
	0:15	Robot grabbed 3 fibers placing 213			
Jun	0:25	FACB 85 won't place	4:39	126:51`	3.7
	1:05	FACB 85 won't place			
	0:43	FCAB 213 won't place			
	0:16	Button 125 can't be found			
	0:30	UVES fiber 37 failed to place			
	1:40	Plate configuration failed			
Jul	0:10	UVES fiber 103	0:40	150:41	0.4
	0:10	FACB 149 not on porch			
	0:15	FP hung after switch from UVES			
	0:05	FLAMES technical CCD problem			
Aug	0:00	FACB 149 could not be placed	0:00	114:41	0.0
Sep	0:30	Fiber 52 broken	0:30	77:36	0.6
Oct	0:55	GIRAFFE back illumination problem	0:55	138:18	0.7
Nov	2:12	Gripper cannot place fibers	2:12	130:36	1.7
Dec	0:00		0:00	146:17	0.0
Jan 2004	0:00		0:00	128:07	0.0
Feb	0:00		0:00	124:57	0.0
Mar	0:00		0:00	113:40	0.0
Apr	0:10	Trolley did not attach properly	0:10	71:33	0.2
		Totals	**17:08**	**1501:10**	**1.1%**

OzPoz refurbishment

- Lifetime:
  - with operations target of 10 years and start date ~3032 then need to last until 3042 (ie 40 years of lifetime for parts)
- First step:
  - Thorough evaluation of event logs, quality assurance statistics
  - Detailed mechanical inspection
  - Review of all project components, failure modes analysis
- Key items for replacement likely to include:
  - Electronics: with lifetime and spare parts considerations (potentially bring up to new ESO standard)
  - Cameras: acquisition and button monitoring camera
  - Fibres: likely new requirements for size and number of fibres, also worthwhile to improve transmission
  - Buttons: likely need new lenses, buttons replacement depends on inspection
  - Moving parts, ie gripper collet, retractor springs, etc
  - Plastics, ie, retractor housings, cabling and cable management
  - Software: to be evaluated, may involve low level for eg., new electronics sensors, motors

OzPoz enhancement

- Increase to accuracy:
  - Likely possible with careful analysis of error budgets
  - Difficult to get substantial improvements
  - **Probably not required (0.1 arcsec is already good) but science input needed**

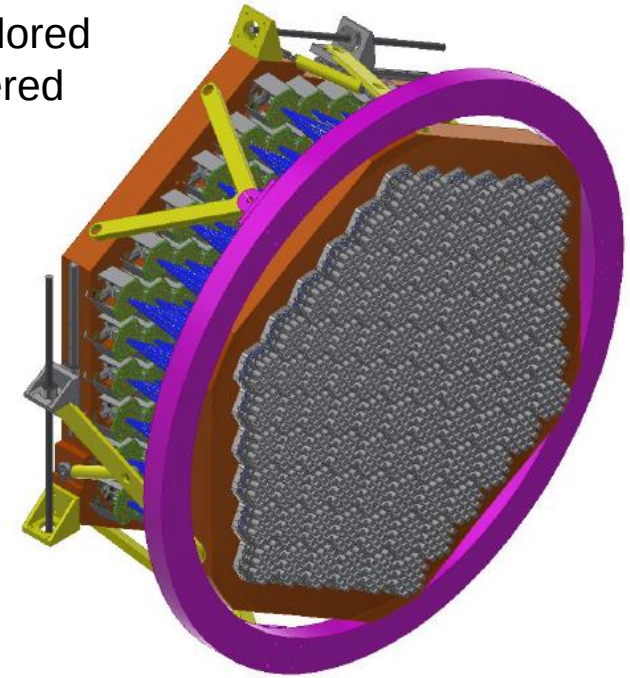
- Reduction in reconfiguration time:
  - Multiple robot arms
  - Alternative robot choices
  - Improvements to field acquisition sequence
  - Improved plate swapping system (redesign, higher torque motors, etc)
  - Consider operation with only one plate
  - **Need to look at full field configuration error budget and science modeling**

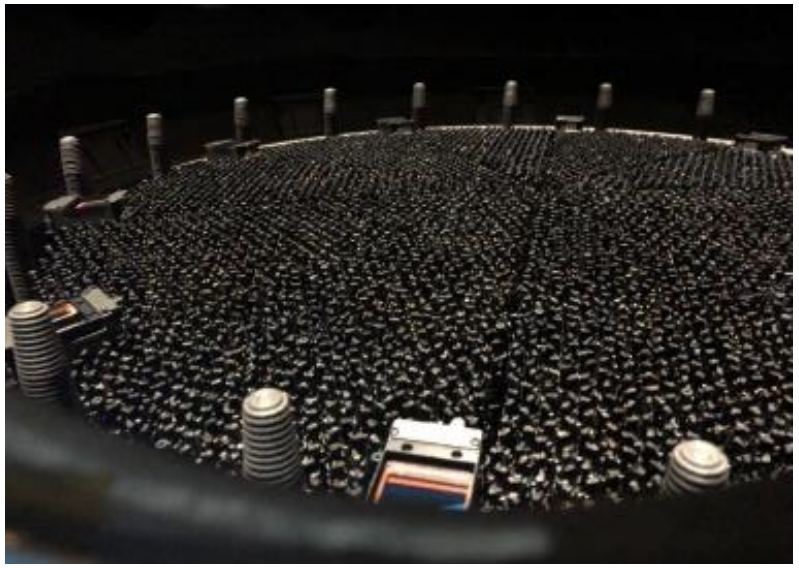
- Improvements to clustering:
  - Button redesign
  - Tiers of retractors
  - **Probably difficult to achieve**

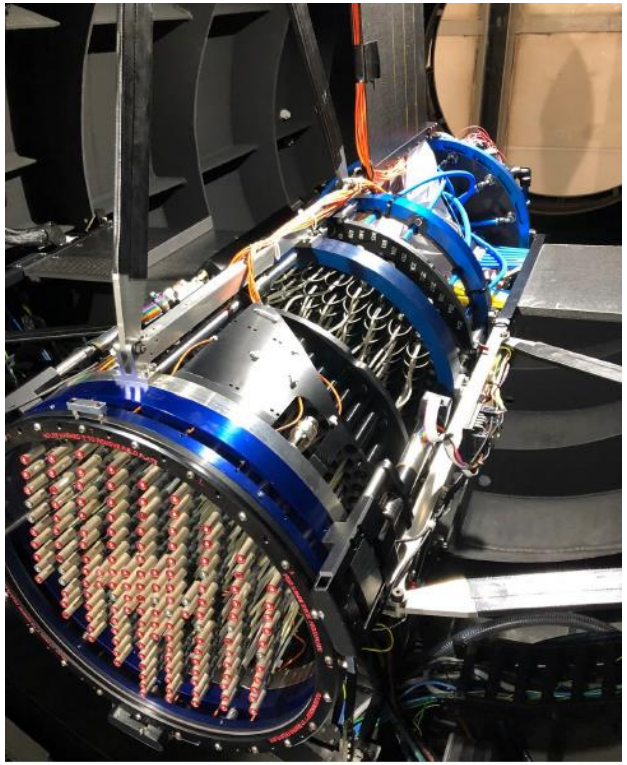
- Increase in multiplex:
  - Retractor redesign
  - **Likely limited by slit length (ie size of spectrograph) so may enough already**

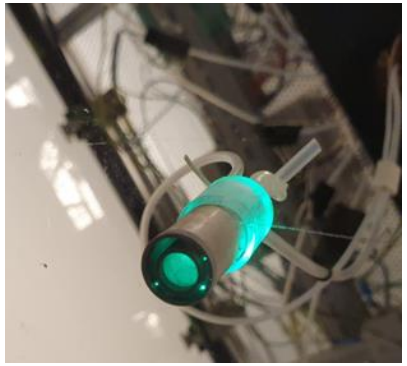
Alternative concepts

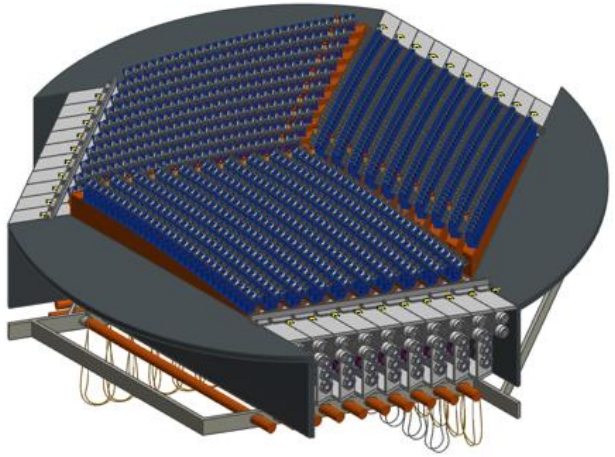
- Starbugs are an option to be explored
- Theta-phi also should be considered











Summary

- OzPoz is a reliable instrument at the VLT
- Seems to be a good match to the requirements of HRMOS
- Trade-off of needed to determine:
  - Cost, schedule, and specification of refurbished OzPoz
  - Cost, schedule, and specification of enhanced OzPoz (various options)
  - Cost, schedule, and specification of alternative concepts (likely a few)
- To be informed by science benefit