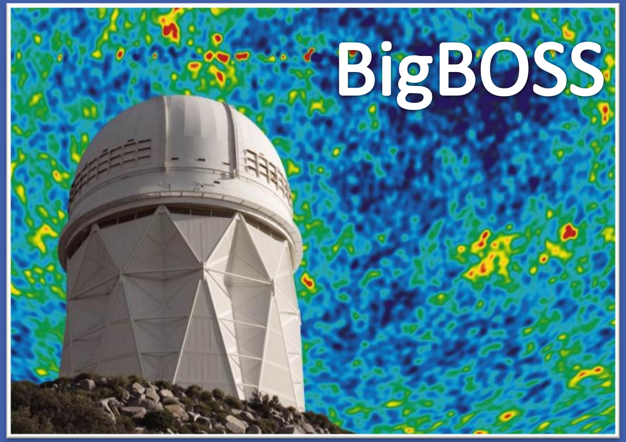


R-θ Fiber Positioner for the BigBOSS Instrument

J.Silber, C.Schenk, R.Besuner, P.Perry, R.LaFever, R.Post, M.Cepeda, F.Becker, M.Sholl, A.Karcher

Lawrence Berkeley National Laboratory

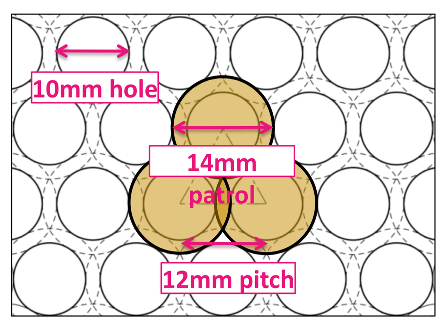
BERKELEY LAB

GOALS

The BigBOSS instrument is a multi-object spectrograph for a massively parallel survey of deep sky objects. It will rely on 5000 miniature robotic fiber positioners to dynamically target thousands of unique galaxies on every observation, with reconfiguration of the field to new targets every 20 minutes.

Can we build robotic positioners that are sufficiently…

1. Small — 12mm pitch
2. Precise — < 5 µm
3. Fast — < 45 sec repositioning
4. Well-aligned — < 0.15° tilt error
5. Well-located — < 5 µm axial error
6. Straight-moving — < 20 µm defocus error
7. Low cost — < $1k each
8. Long-lived — > 40k repositions

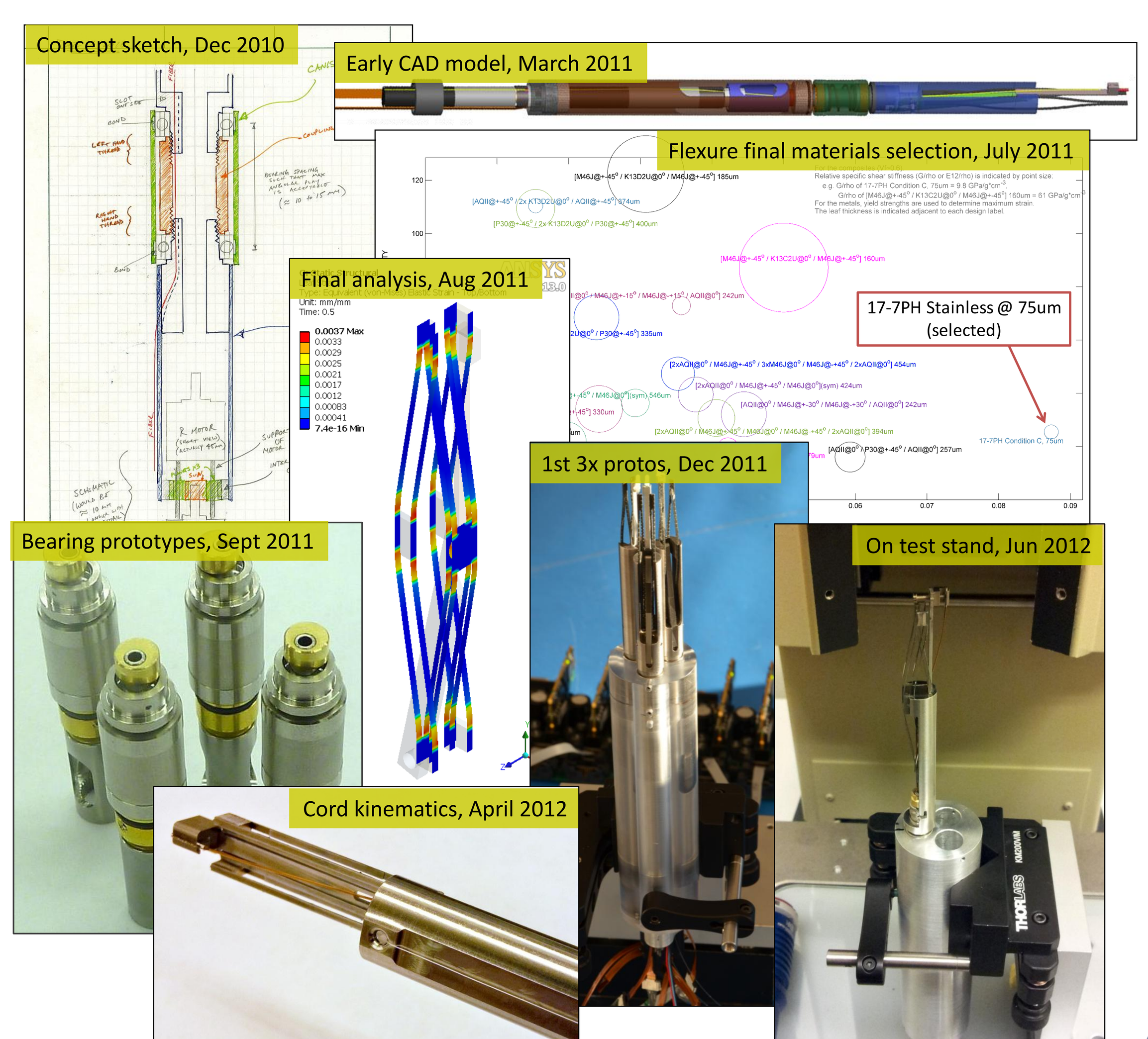


DEVELOPMENT APPROACH

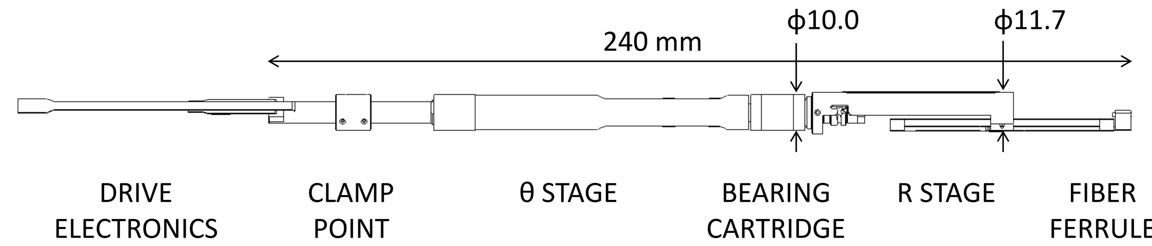
The development schedule was:

1. Concept map: Sketch options, back-of-envelope calcs
2. Select kinematics: Flexural R-θ chosen
3. Structural analysis: Flexure and housing design geometries
4. Rough prototyping: Early flexure concept built for feel / feasibility
5. Materials selection: Chose a precipitation-hardened steel (17-7PH)
6. Structural analysis: Re-analyze with final mat'ls, geometry
7. CAD model: Full positioner modeled
8. Sub prototypes: Careful build / test of key sub-assemblies
9. Full prototype 1: Whole positioner built for fits, feel, assembly, electronics integration
10. Cost estimate: Whole positioner cost @ 5000x qty
11. Full prototype 2: Immediate revision of CAD, then 2nd round of full prototypes
12. Testing 1: In-depth testing of full positioner
13. Full prototype 3: Commit revisions necessary from Testing 1
14. Testing 2: (In-progress)

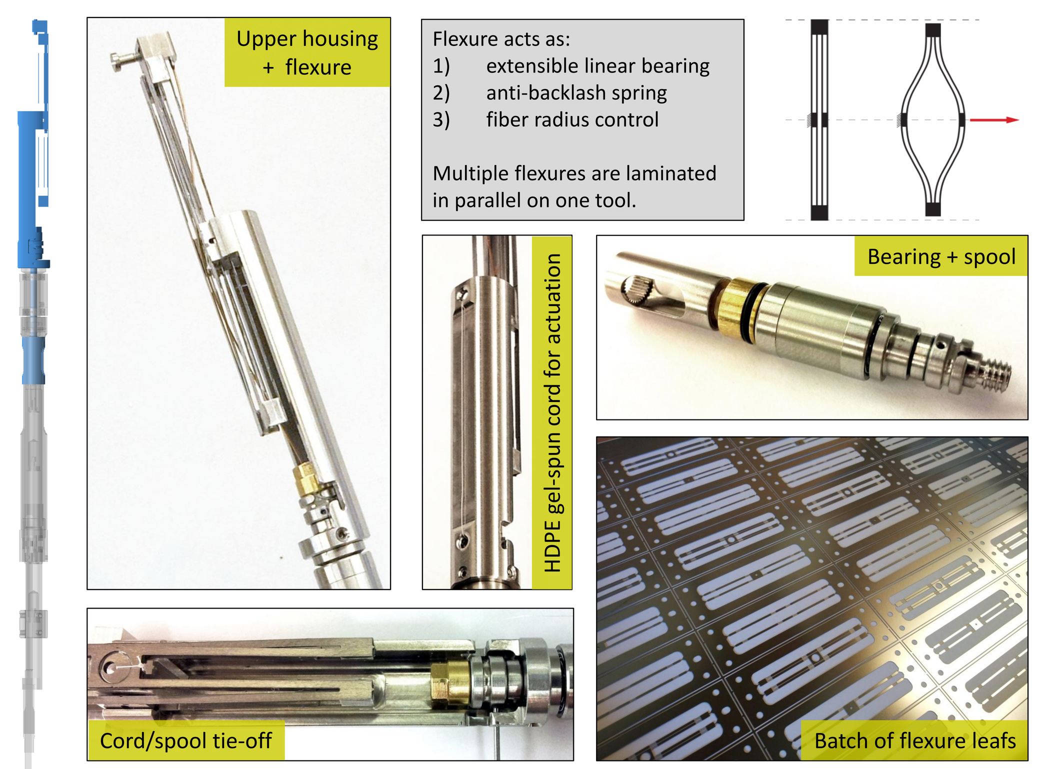
Key kinematics get analyzed; everything gets prototyped!



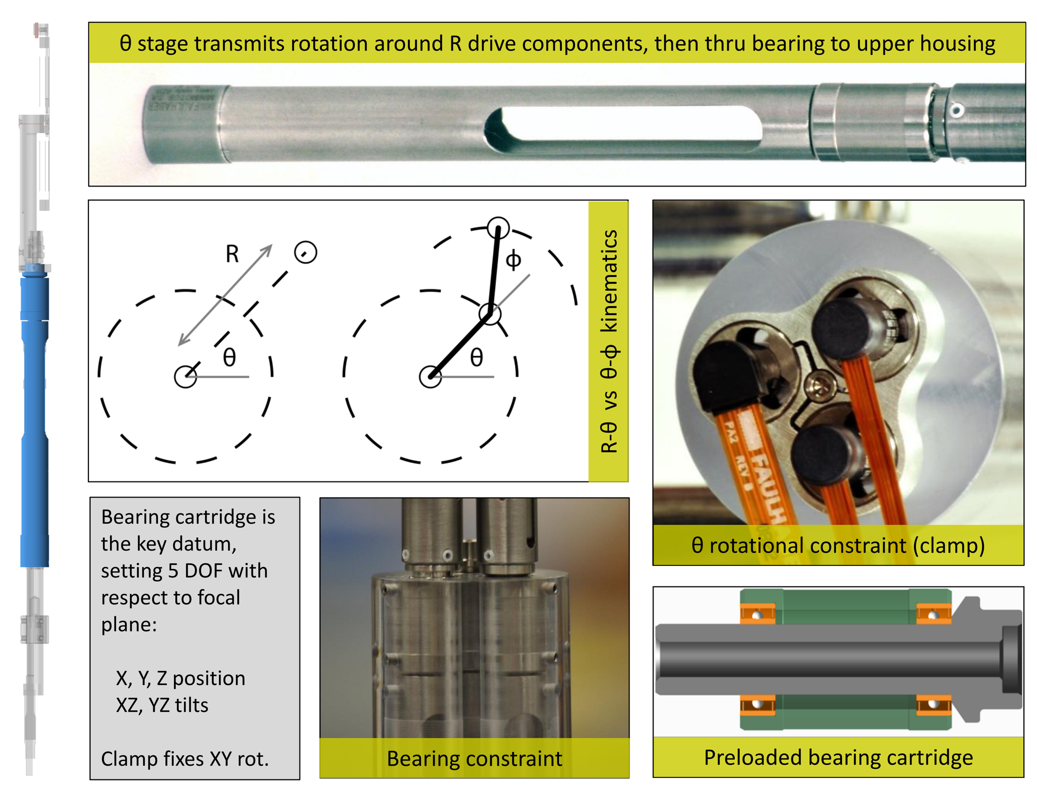
DESIGN



R STAGE (radial kinematics)



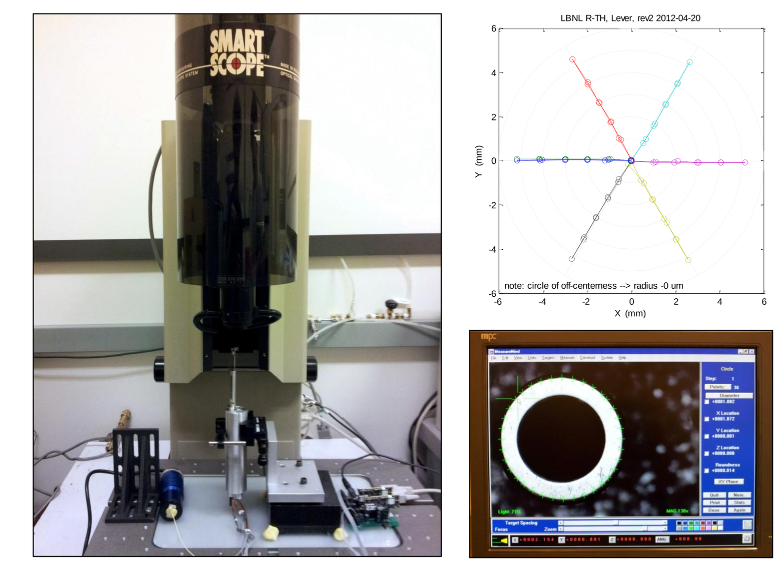
θ STAGE (angular kinematics)



MOTOR ASSEMBLY (drives R,θ)

TESTING

Full positioner accuracy, precision, repeatability (in progress)

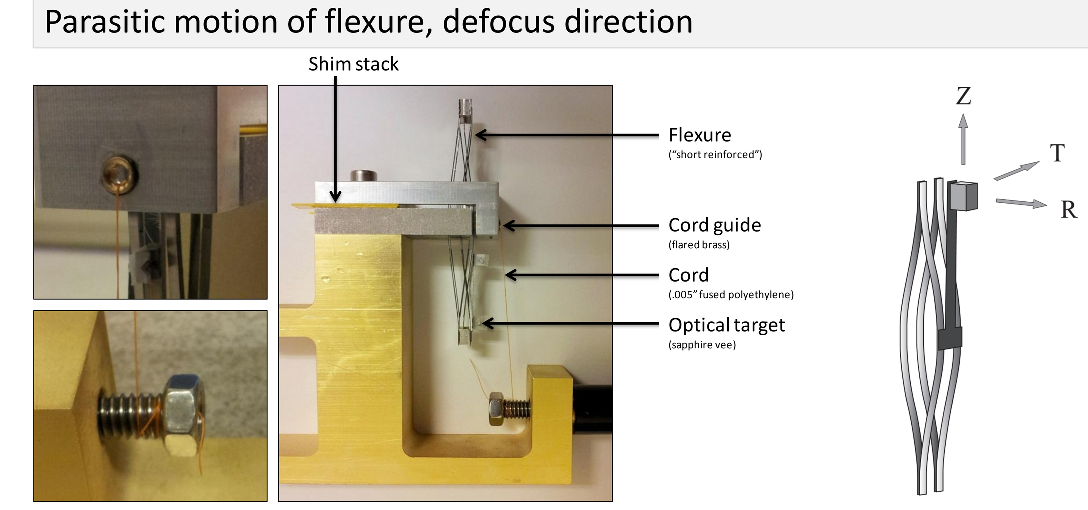


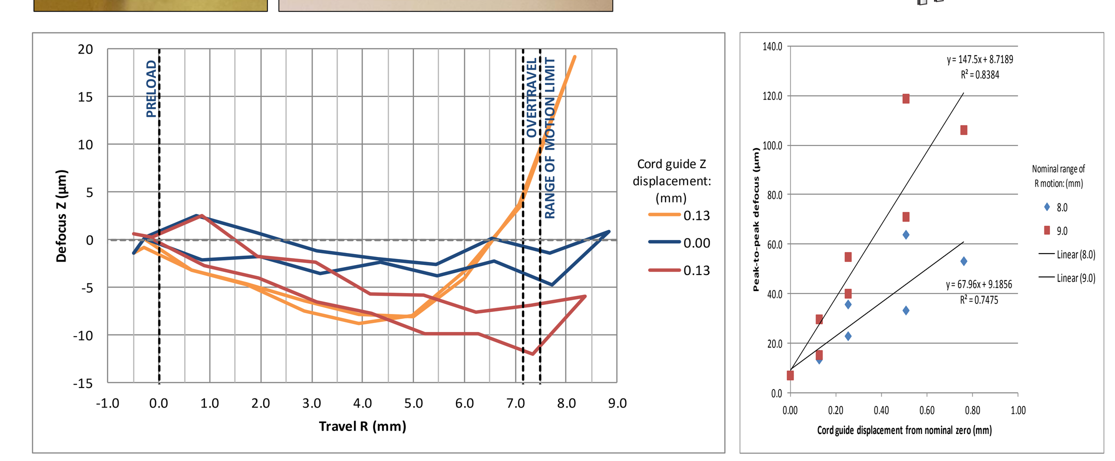
Video coordinate measuring machine is primary tool for measuring positioner performance.

Originally, manual point taking. Recently, we've fully automated, with feedback to positioner; allows thousands of points and strong statistics.

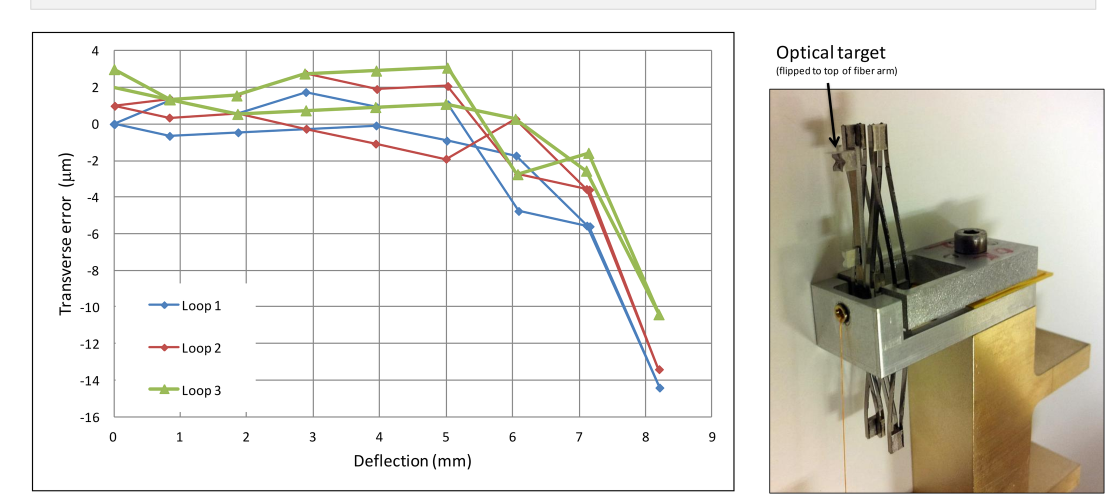
Also in development is an automated system centroids light of a backlit fiber: even faster, allows parallel measurement of multiple positioners; replicates the actual feedback loop that will be on the BigBOSS corrector.

Parasitic motion of flexure, defocus direction



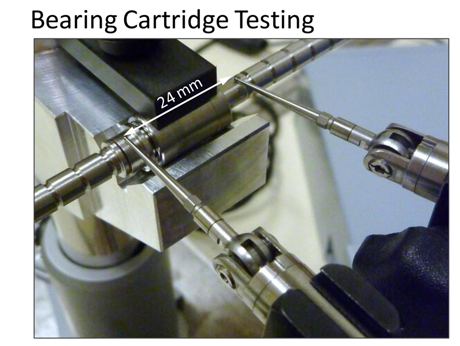


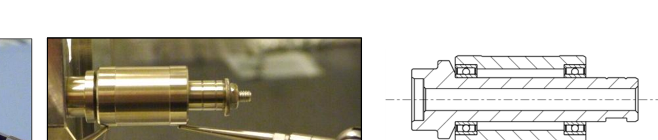
Parasitic motion of flexure, transverse direction



More sub-component testing

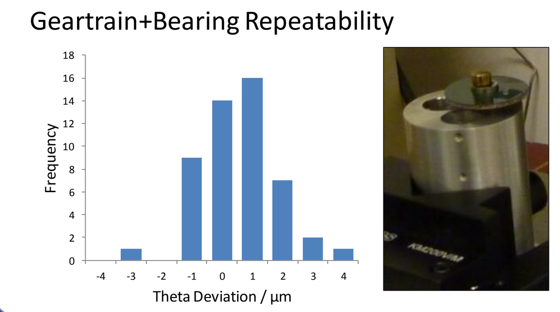
Bearing Cartridge Testing



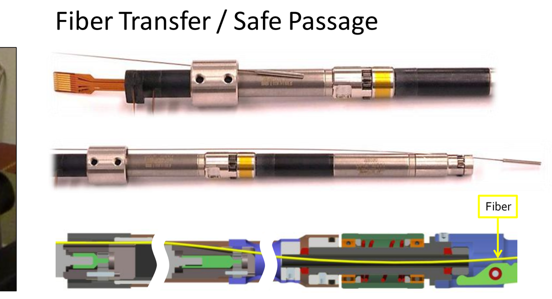


	Min	Max	Average	Unit	Notes
Axial Displacement	0.0	1.0	**0.4±0.2**	µm	0.5…3.5 N axial load
Tilt of nominal shaft axis	0.007	0.032	**0.019±0.007**	deg	roundness of sleeve included
Tilt due to radial run-out of shaft	0.006	0.018	**0.013±0.004**	deg	roundness of shaft included
Torque resistance	4.6E-05	5.8E-05	**5.0E-05±0.8E-05**	deg/Nmm	40…120 Nmm load
Radial stiffness			**>8**	N/µm	-4…+4 N radial load
Axial stiffness	measurements ongoing				

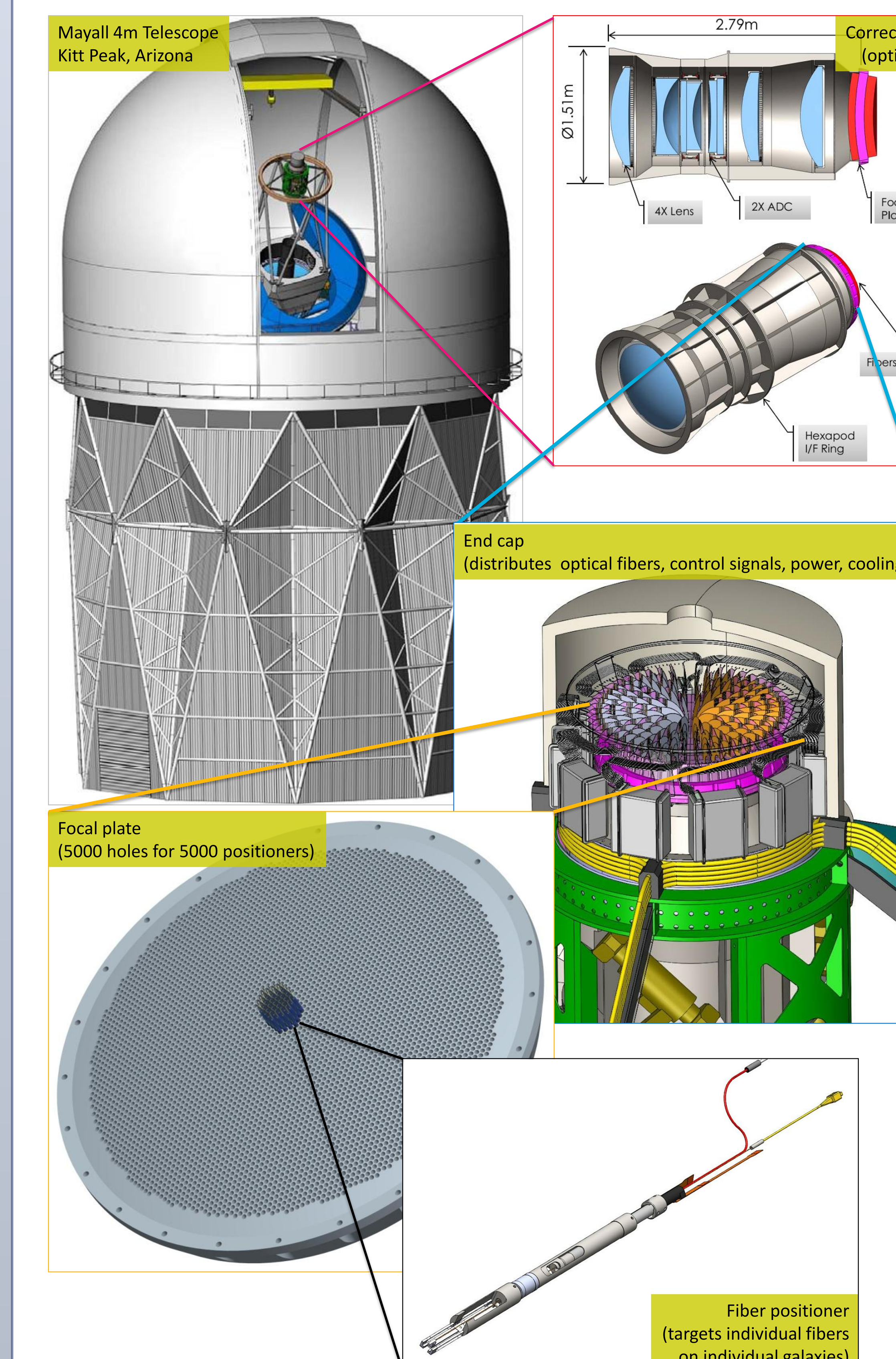
Geartrain+Bearing Repeatability



Fiber Transfer / Safe Passage



THE BIGGER PICTURE



CONCLUSIONS / CURRENT STATUS

A complete mechanical design for the BigBOSS fiber positioner is ~90% complete, and 100% operational for test purposes.

The feasibility is proven (by good results from sub-component testing).

The expertise gained through the prototyping process has helped drive interfaces and specifications for the larger engineering effort.

Cost estimate is currently rough (due to scaling of small batches), but looks reasonable at this point.

Testing of full positioner is in progress, completion in July.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support by the Director, Office of Science, U.S. Department of Energy under Contract No. DE-AC03-76SF00098.