Jet Propulsion Laboratory
California Institute of Technology

AFTA-WFIRST Coronagraph Instrument DRD Presentation

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AFTA Coronagraph Instrument Manager

11/18/2013

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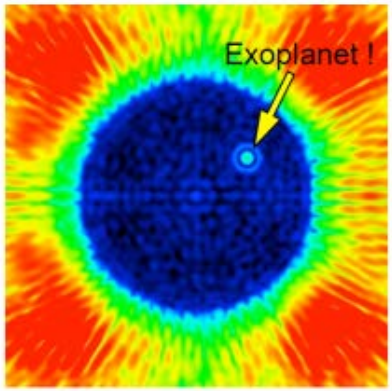
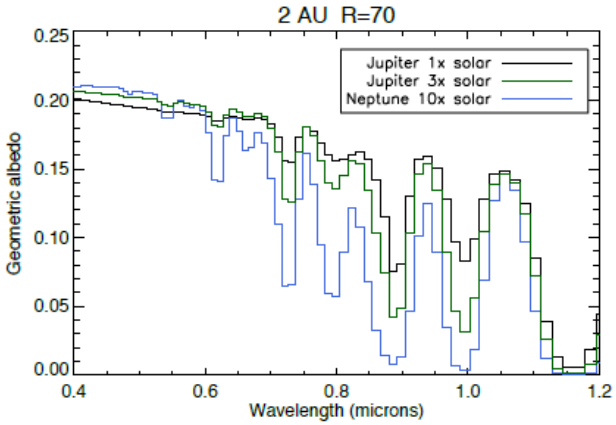
AFTA Coronagraph Instrument

Coronagraph Instrument



Exo-planet Direct imaging



Exo-planet Spectroscopy

Bandpass	430 – 980nm	Measured sequentially in five ~10% bands
Inner working angle	100 – 250 mas	3λ/D, driven by challenging pupil
Outer working angle	0.75 – 1.8 arcsec	By 48X48 DM
Detection Limit	Contrast = 10^{-9}	Cold Jupiters, not exo-earths. Deeper contrast looks unlikely due to pupil shape and extreme stability requirements
Spectral Resolution	70	With IFS, R~70 across 600 – 980 nm
IFS Spatial Sampling	17mas	This is Nyqust for λ~430nm

AFTA Coronagraph Instrument will:

- Characterize the spectra of over a dozen radial velocity planets.
- Discover and characterize up to a dozen more ice and gas giants.
- Provide crucial information on the physics of planetary atmospheres and clues to planet formation.
- Respond to decadal survey to mature coronagraph technologies, leading to first images of a nearby Earth.

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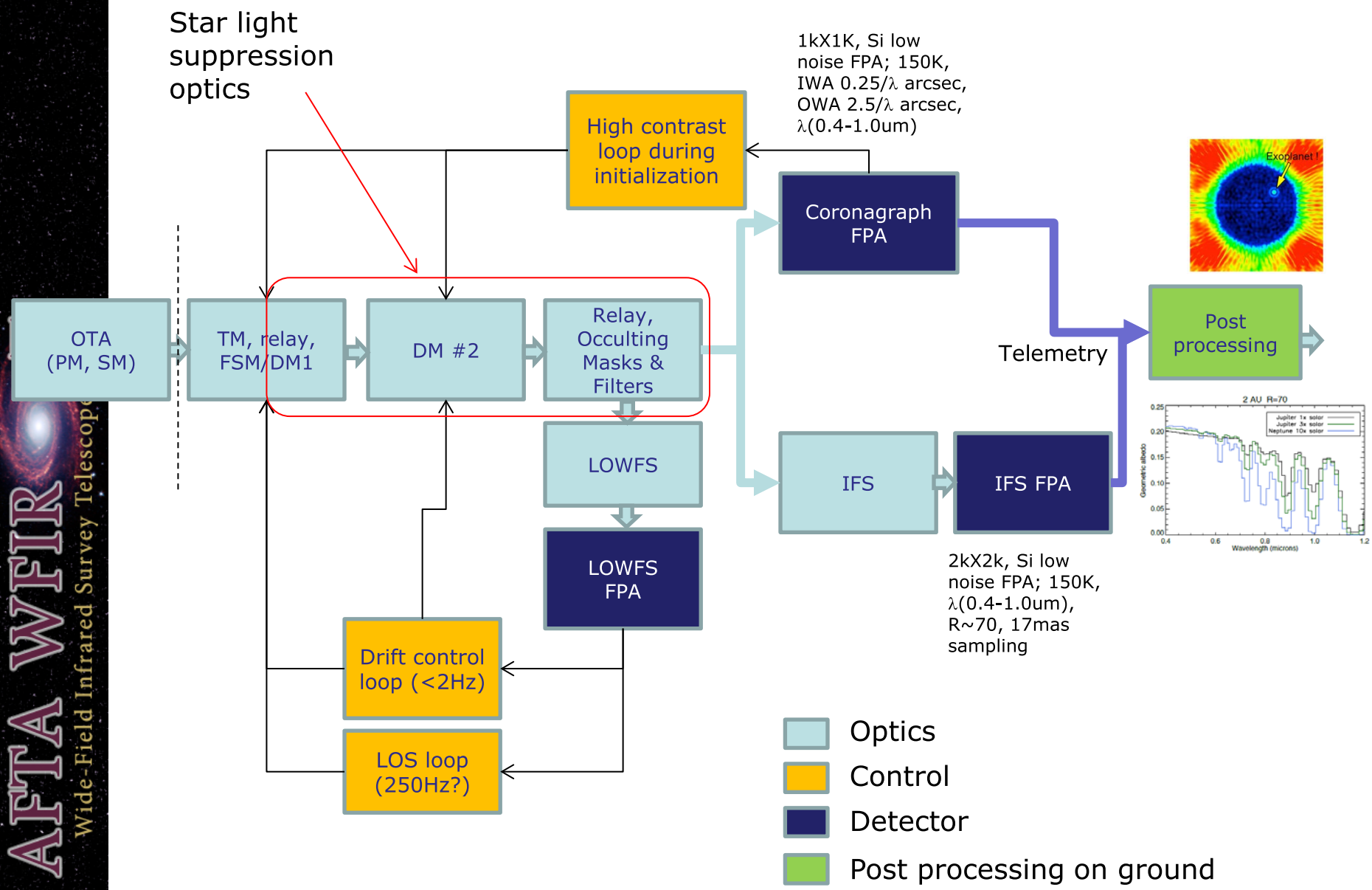
Functional Block Diagram



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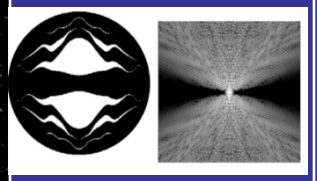
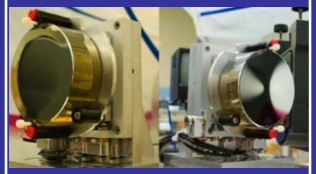
Star light suppression -- Technical Approach

Six different concepts

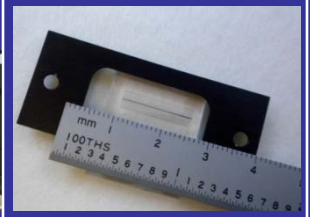


Shaped Pupil Mask Pupil Masking (Vanderbei & Kasdin, Princeton Univ.)

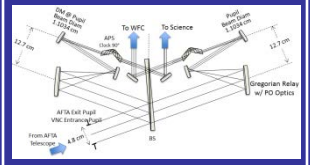
Vector Vortex Mask Image Plane (Serabyn, JPL)



Phase Induced Amplitude Apodization (PIAA) Pupil Re-Mapping (Guyon, Univ. Arizona)



Hybrid / Band-Limited Lyot Mask Image Plane Amplitude & Phase (Trauger, JPL)

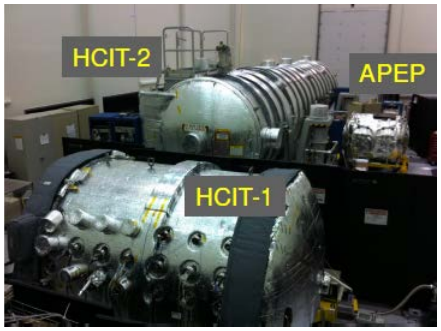


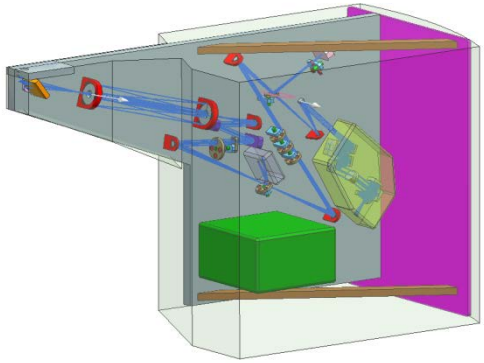
Visible Nuller Coronagraph: Phase-Occulting (Lyon, GSFC)

Visible Nuller Coronagraph: DaVinci (Shao, JPL)

Down select 1/6/2014

Primary approach	Back-up approach





TRL-5 @ start of Phase A (10/2016)

TRL-6 @ PDR (10/2018)

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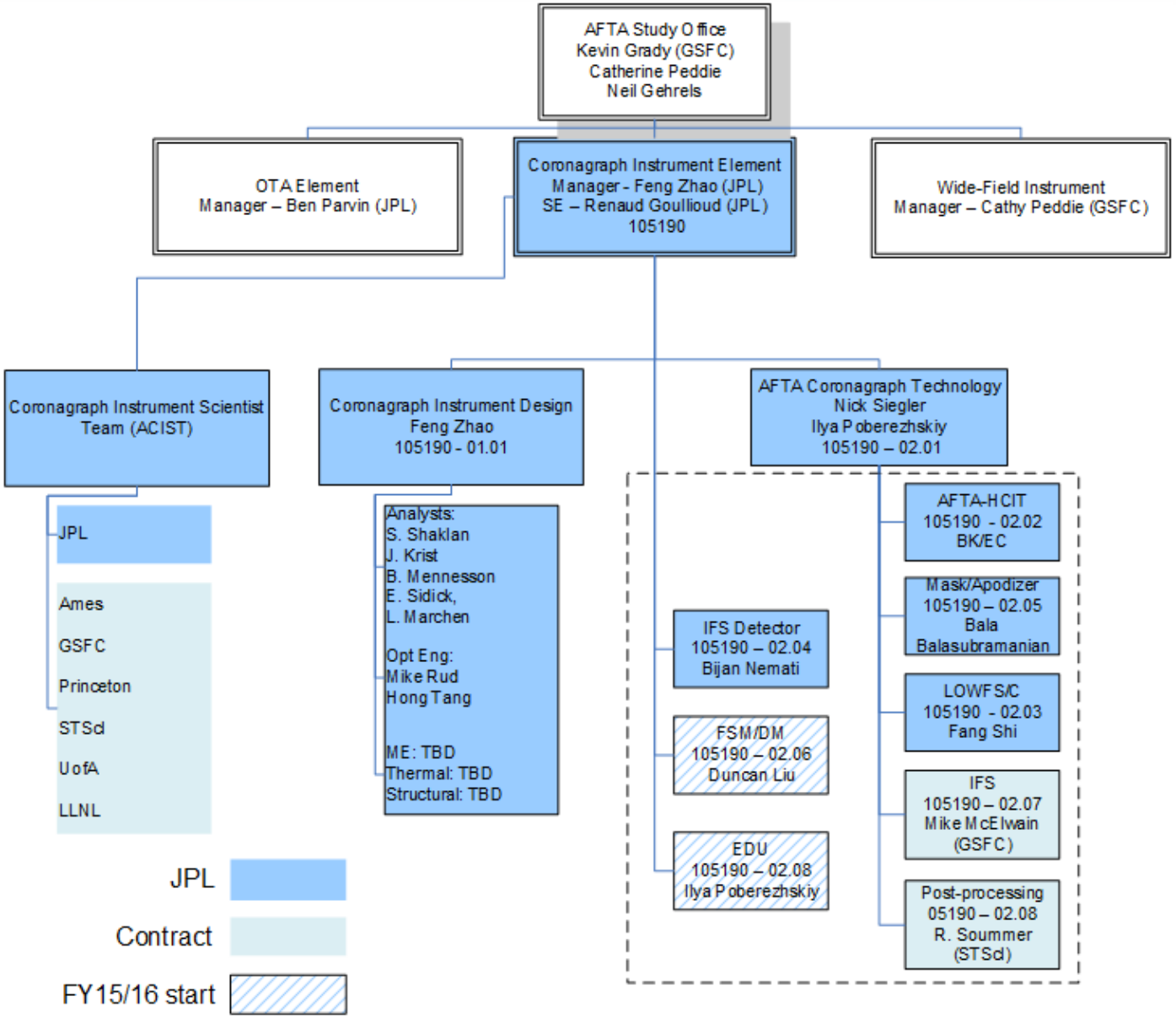
Org Chart



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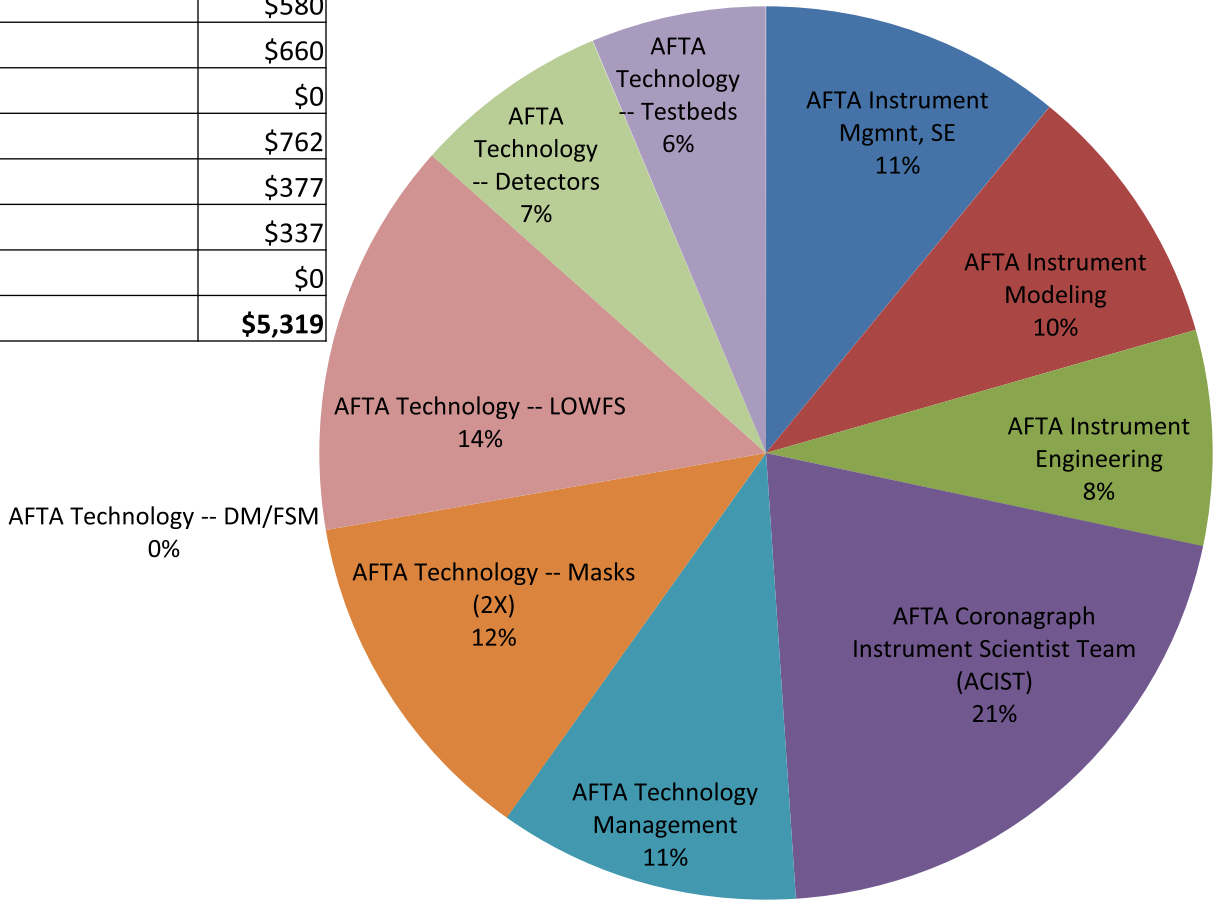
Draft FY14 Funding Distribution

Work Package	FY14 ($k)
AFTA Instrument Mgmnt, SE	$581
AFTA Instrument Modeling	$513
AFTA Instrument Engineering	$414
AFTA Coronagraph Instrument Scientist Team (ACIST)	$1,095
AFTA Technology Management	$580
AFTA Technology -- Masks (2X)	$660
AFTA Technology -- DM/FSM	$0
AFTA Technology -- LOWFS	$762
AFTA Technology -- Detectors	$377
AFTA Technology -- Testbeds	$337
AFTA Technology -- EDU (TRL-6)	$0
TOTAL	**$5,319**



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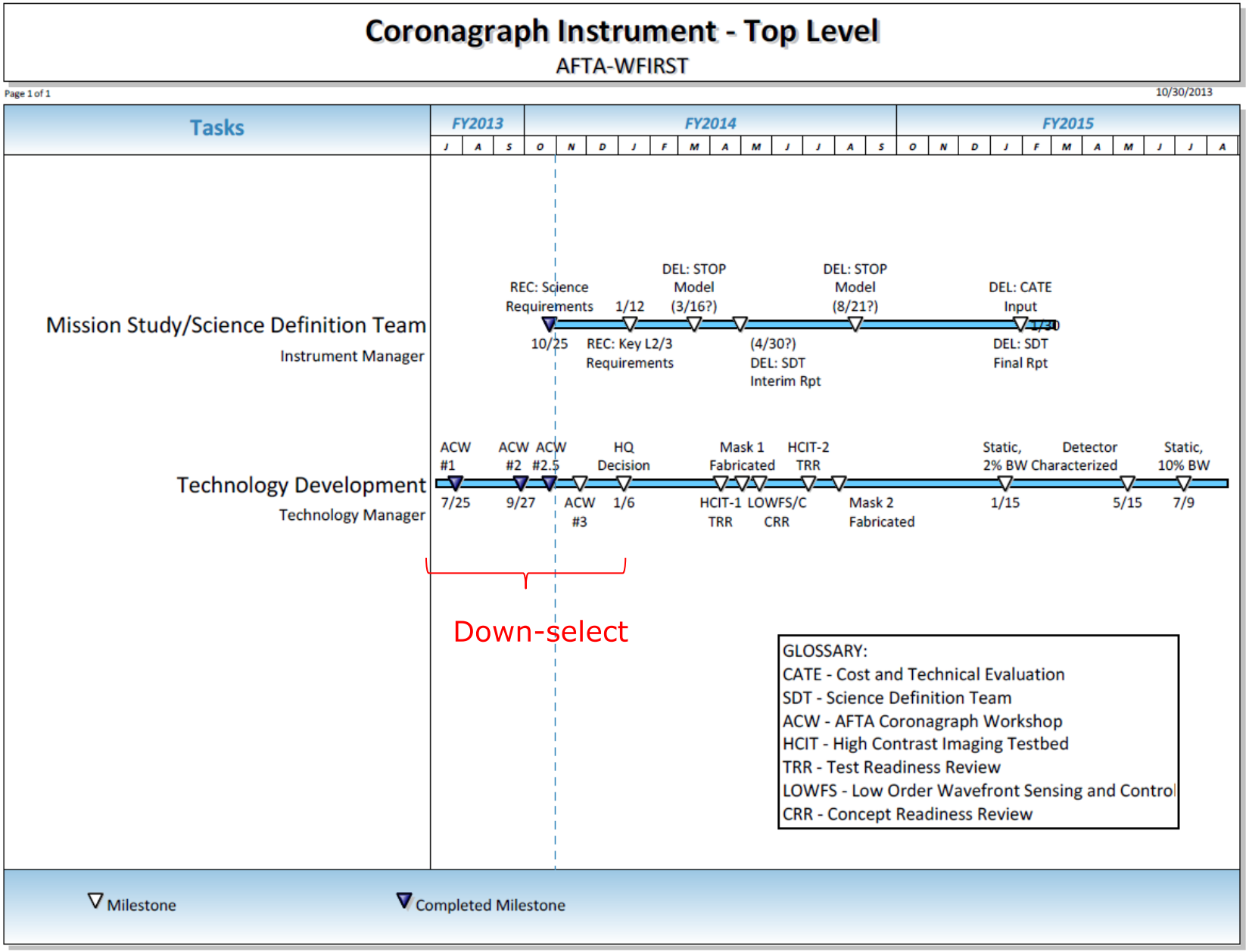
Top Level Schedule (shown up to 2015)



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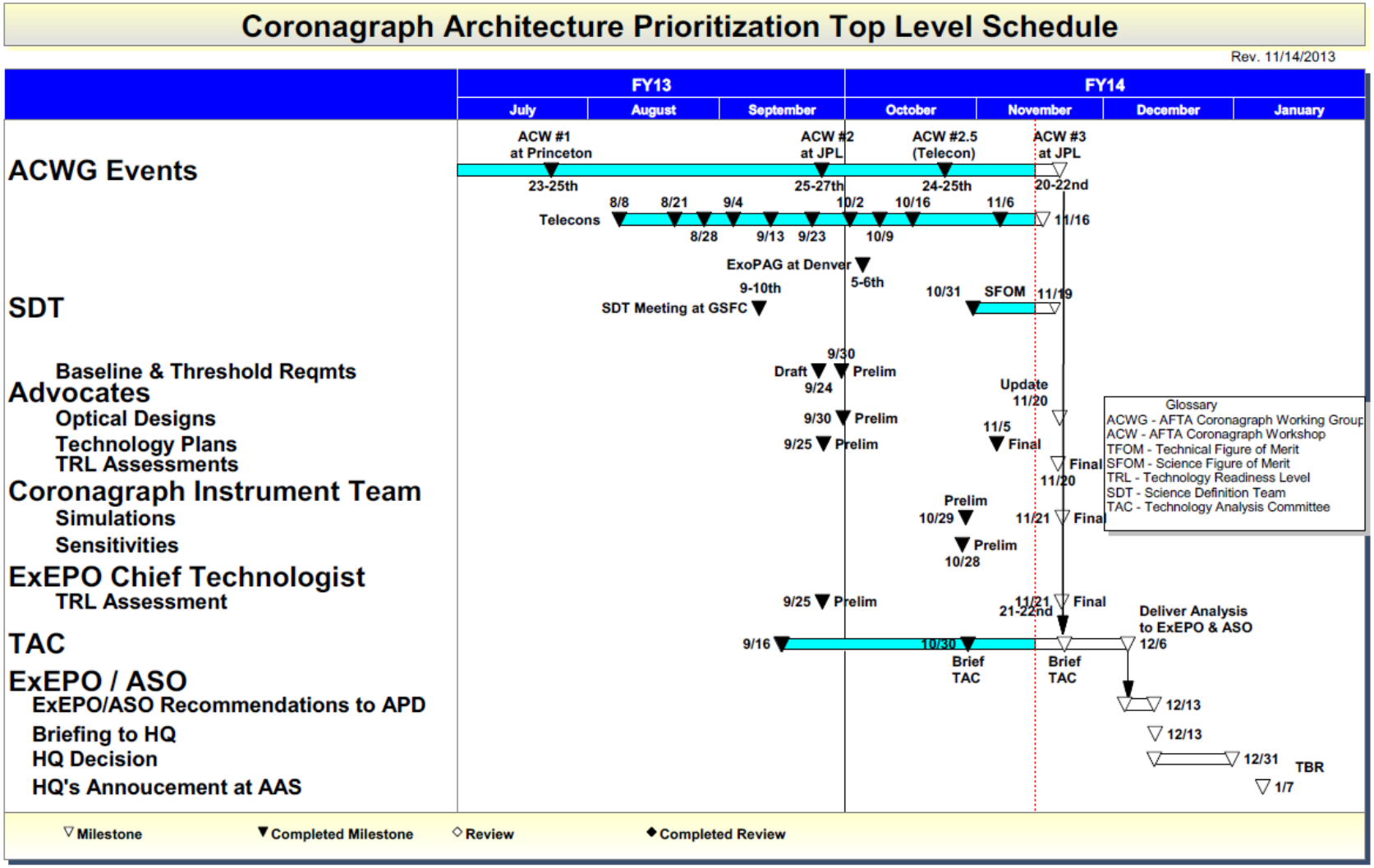
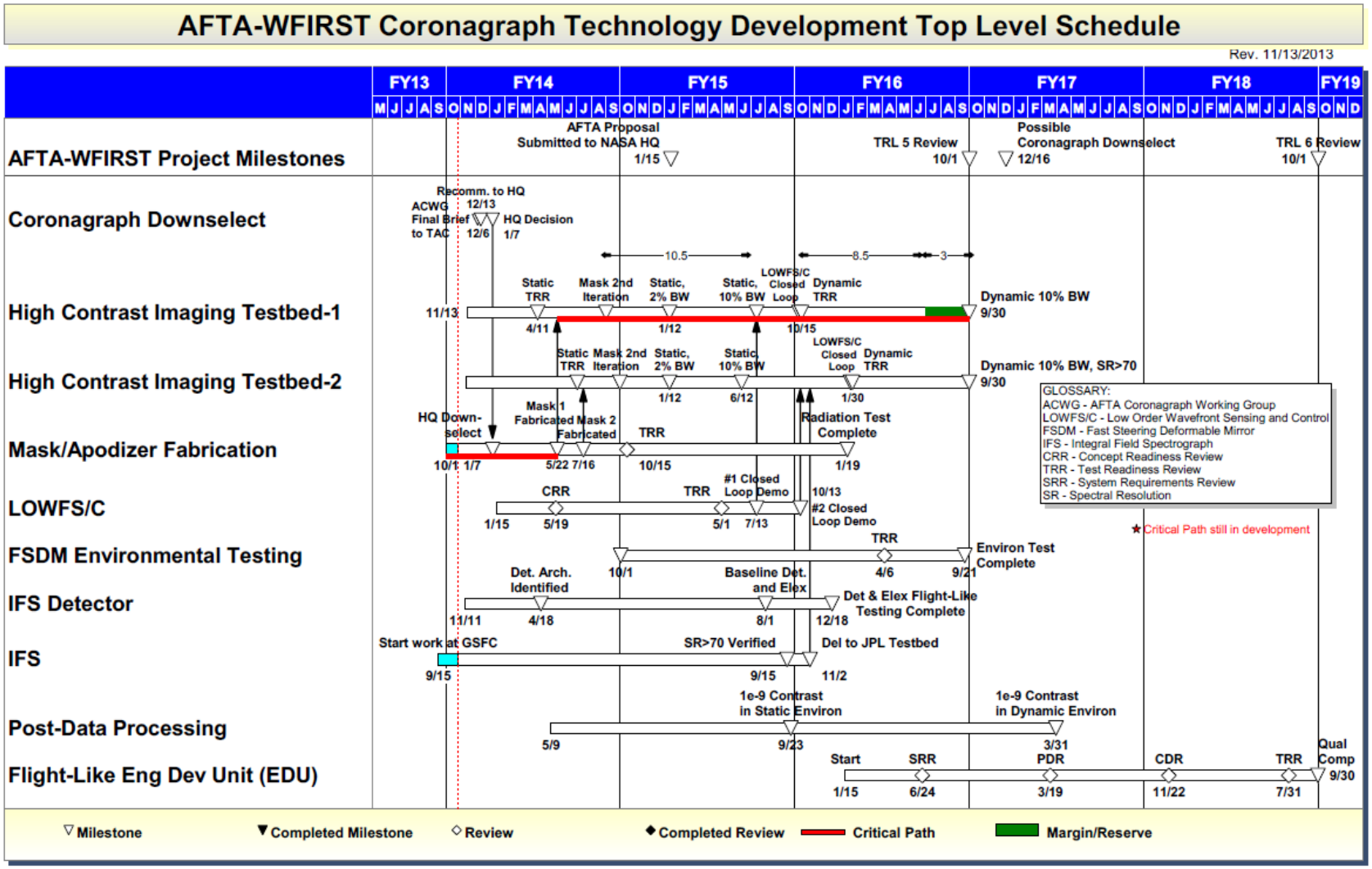
Down-select detailed schedule



Technology Development Schedule



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Accomplishment in the past quarter

- Formed an AFTA Coronagraph Instrument team!
- Negotiated FY14 scope and budget with AFTA Study Office
- Supported AFTA coronagraph down select
  - PROPER analysis, Sensitivity analysis,Optical layout and engineering evaluations
  - Organized workshops, telecons with the community
- Developed technology maturation plans in response to HQ request
- Survived government shut-down
  - Slight delay in ACWG analysis, but able to keep original final evaluation date 11/21/2013 (ACW #3)
  - Able to fund some technology critical path items such as mask risk mitigations (thanks to Kevin for some technology money advance before the shut-down!)
  - Minor impact to design team – slower ramp up

Issues and Concerns

- No major issues and concerns

Plan for next quarter

- Support final ACWG evaluation and down select recommendation
- TRL 5 and 6 coronagraph definitions vetted and concurred
- Key technology milestones concurred
- Continue Instrument Design Team, start including “ACIST”

Back-up charts

The Science Path Towards the New Worlds Mission

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Complete the census

Kepler (warm)
WFIRST μ-lensing (cool)

Find nearby transiting planets

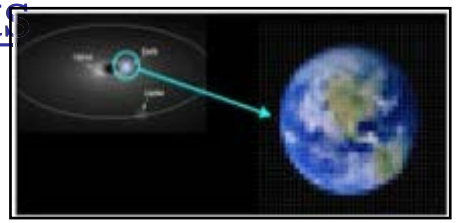
TESS

Characterize super-earth/mini-Neptunes

JWST

Imaging and Spectroscopy of planets

WFIRST-AFTA coronagraph (Jupiters, Neptunes, Super-Earths)
New Worlds Mission (Earth 2.0)

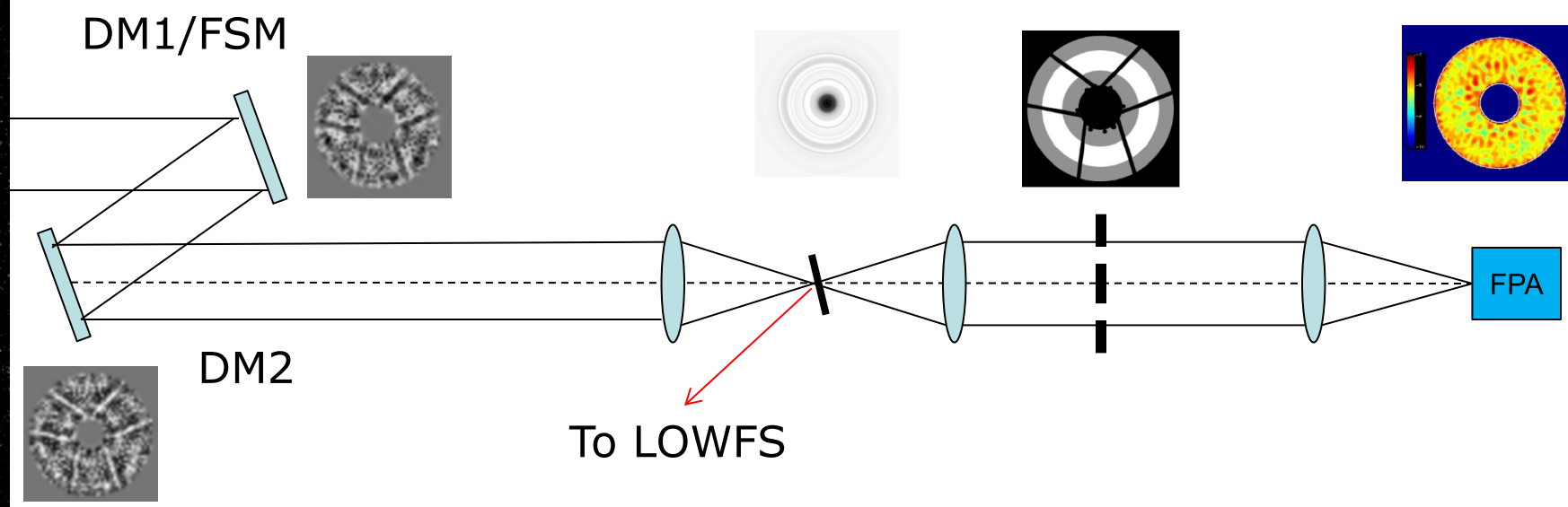


Coronagraph on Key NASA Flagship Missions

	HST			JWST			WFIRST
Instrument name	NICMOS	STIS	ACS	NIRCam	TFI	MIRI	? (HCCI)
Wavelength	H (1.6um), for NIC2	0.2 – 1.0um	0.2 – 1.0um for HRC	1 – 5um	1.5 – 2.5um; 3.1 – 5.0um	10.65um, 11.4um, 15.5um (5%); 23um (20%)	0.4 – 1.0um
Coronagraph type	Lyot			Lyot, with Gaussian apodization	Lyot, with Gaussian apodization	1) QPM= Quadrant phase mask; 2) Lyot	TBD
Contrast (raw)				1E-5	1E-5	1E-5	1E-8
Contrast (post processing)				8E-7	1E-6		1E-9
IWA (arcsec)	0.5	0.7	0.9	1.7	2	0.5	0.1
OWA (arcsec)							1.0
Throughput							
Key Exo-planet science example							

* J. Krist, "Coronagraph on the Hubble Space Telescope", http://exep.jpl.nasa.gov/TPF/Coronagraph_PDFs/CWP2006_15_Krist_pp83-85.pdf
** M. Clampin, "Coronagraphic detection of exosolar planets with the James Webb Space Telescope", http://www.stsci.edu/jwst/doc-archive/white-papers/JWST_Coronagraph_WP.pdf

Hybrid Lyot



DM1, DM2	Pupil mapping	Apodizer mask	Occulting mask	Lyot stop	Inverse pupil mapping
Mild ACAD on both DMs			Complex transmission, on filter wheel	Transmission, grey, fixed	

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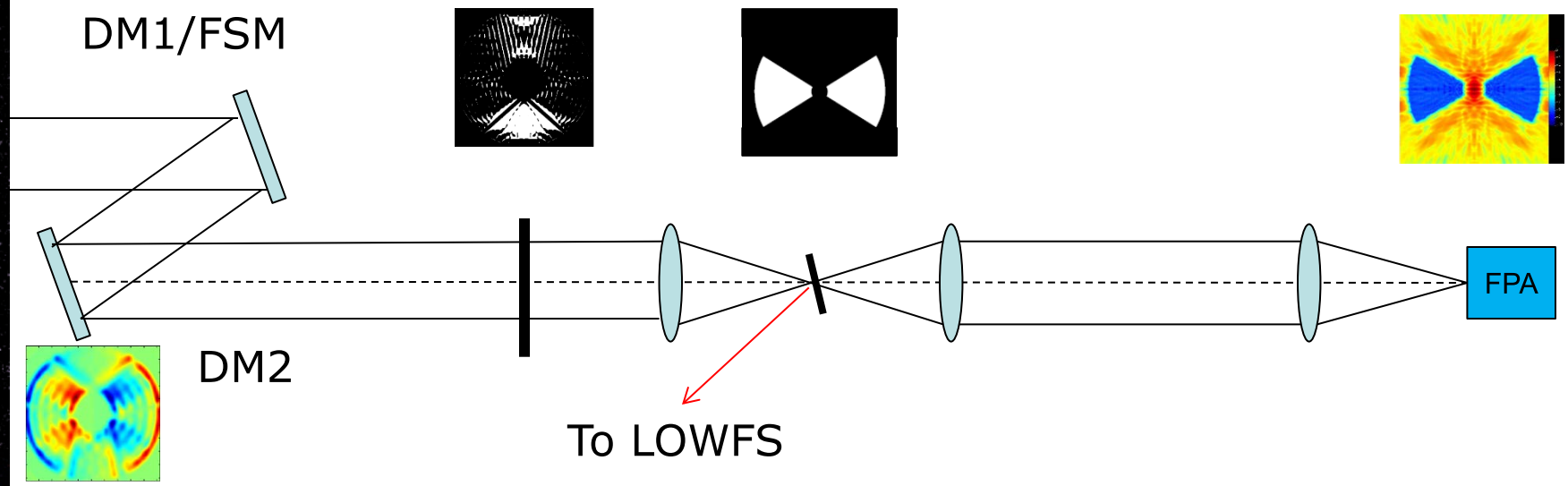
Shaped Pupil



DM1, DM2	Pupil mapping	Apodizer mask	Focal plane mask	Lyot stop	Inverse pupil mapping
Mild ACAD on both DMs		Binary reflection on filter wheels	Binary transmission, on filter wheel		

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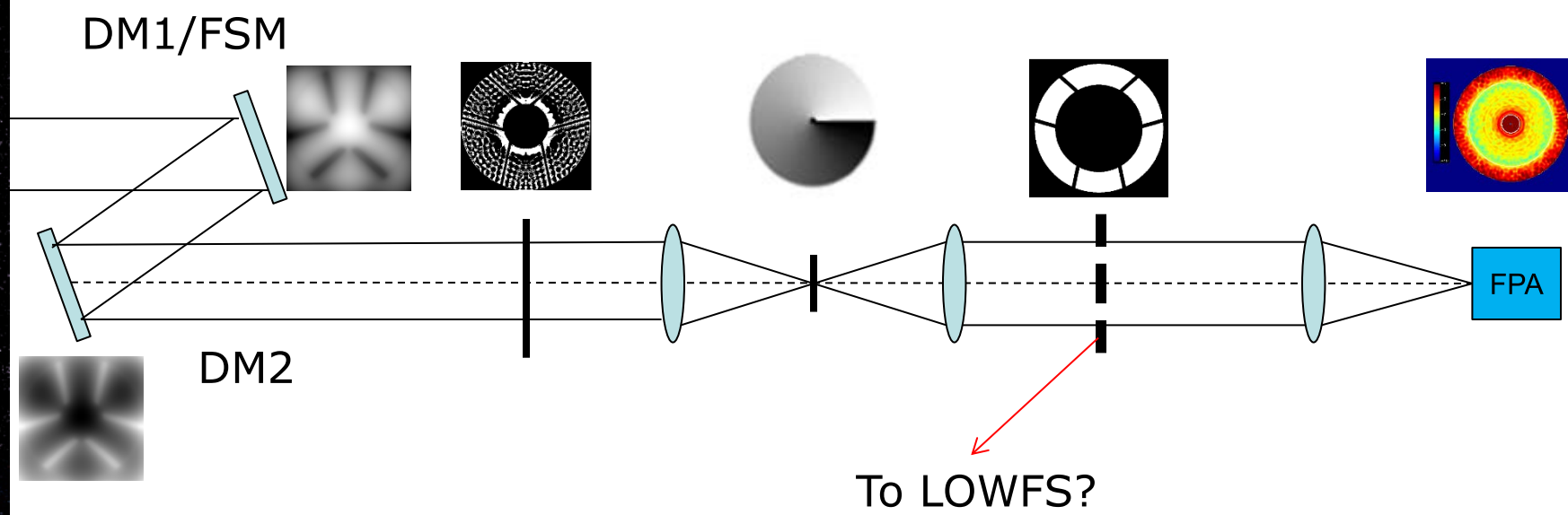
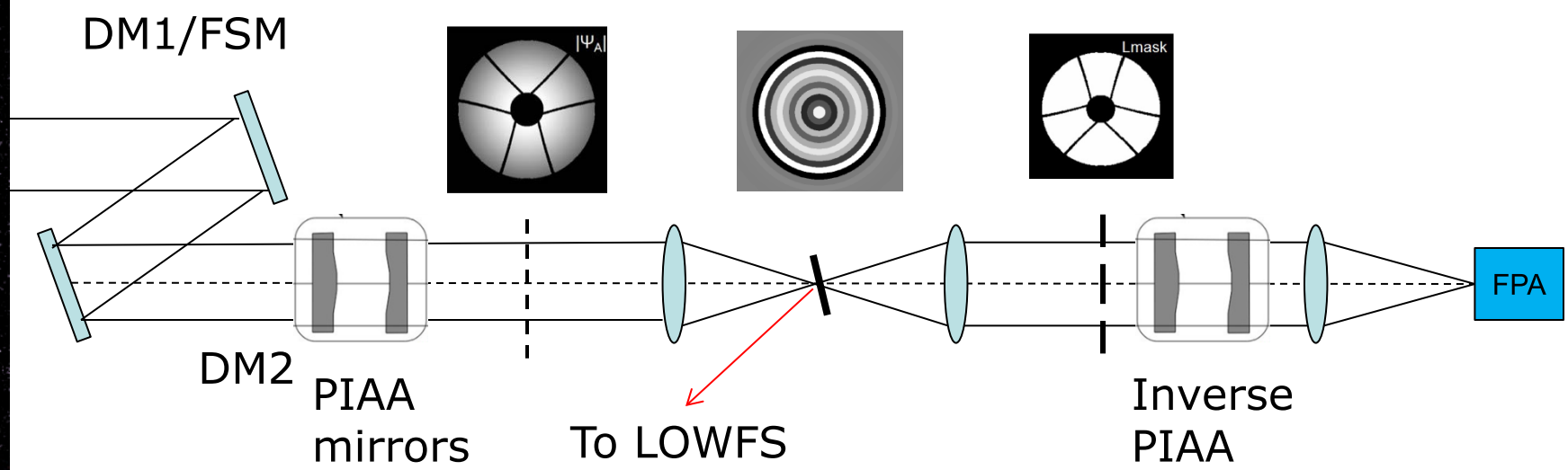
Vector Vortex



DM1, DM2	Pupil mapping	Apodizer mask	Focal plane mask	Lyot stop	Inverse pupil mapping
Strong ACAD on both DMs		Binary transmission, on filter wheel	Vortex transmission, on filter wheel	Transmission, binary, fixed	

PIAA - CMC



Final design deadline extended to 11/4/2013

DM1, DM2	Pupil mapping	Apodizer mask	Occulting mask	Lyot stop	Inverse pupil mapping
Medium ACAD on both DMs	PIAA mirrors	Gray scale, filer wheels?	Phase transmission, on filter wheel	Transmission, binary, fixed?	Inverse PIAA mirrors

AFTA: Phase-Occulted VNC Nulling Schematic

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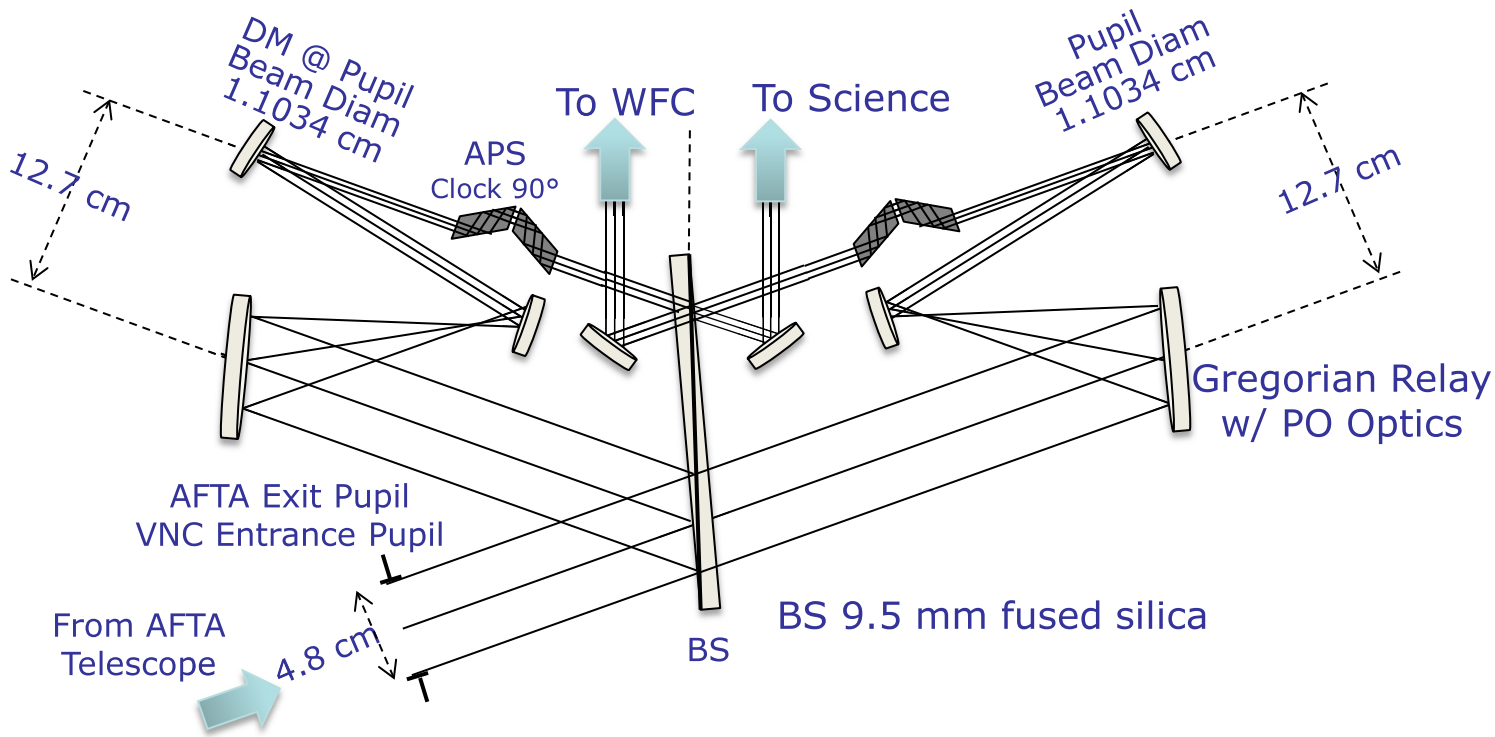

Interferometer	WFC
1 stage nulling interferometer	Two DMs for both phase and amp
Full aperture (radial shear)	Lyot stop?
Achromatic phase shifters*	
Delay line to adjust OPD	

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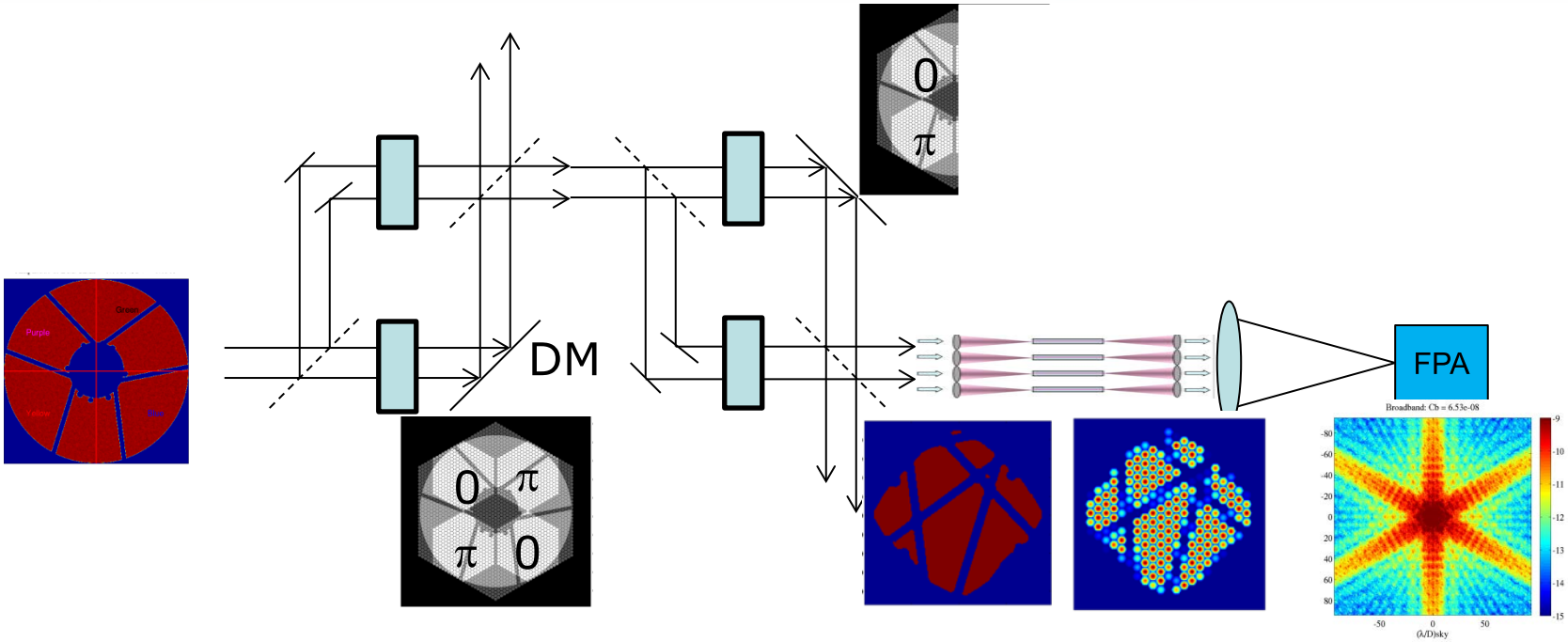
VNC-DaVinci



Interferometer	WFC
2 stage nulling interferometers	One DM (4 quadrants) for both phase and amplitude control
Diluted aperture (4X)	Lyot stop mask (binary, transmission, fixed)
Achromatic phase shifters	Fiber bundle spatial filters
Delay line to adjust OPD	

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