WFIRST DRM2 candidate design – payload summary

- At SDT7 3/1-2/2012 consensus for concepts w/out overlap w/ other mission, aka "DRM2" was:
  - 1.1m aperture, unobscured three mirror anastigmat telescope
  - Single channel instrument
    - Imaging with filter wheel
    - Extend to 2.4um cutoff
    - Prisms with 1-2 prism assemblies for single or counter-dispersed galaxy redshift survey [1.7-2.4um bandpass] respectively, plus SN 1a spectroscopy prism assembly [goal of 0.6-2.4um bandpass]
    - H4RG focal plane
    - Requirement to fit on Falcon9 launch vehicle
  - ±36 degree pitch range [relative to 90 degrees from sun to center of FOV]
    - Same ±22.5° roll range as DRM1 & IDRM
- DRM2 design is based on a 7x2 layout of H4RG(-10) at 0.18"/pixel

WFIRST DRM candidate design summary – DRM2

- DRM2 is based on a 7x2 H4RG(-10) layout focal plane array
  - 0.18”/pixel, ie same focal length as ImC on IDRM1 and DRM1
  - 0.585 deg^2 active pixels
  - 0.387 IDRM ImC AΩ < this AΩ < 0.690 IDRM SpC AΩ [m^2deg^2]
  - Auxiliary fine guider for guiding during spectroscopy modes
  - Instead of outrigger fine guider, imaging mode fine guiding will be done using science focal plane using internal guide windowing function

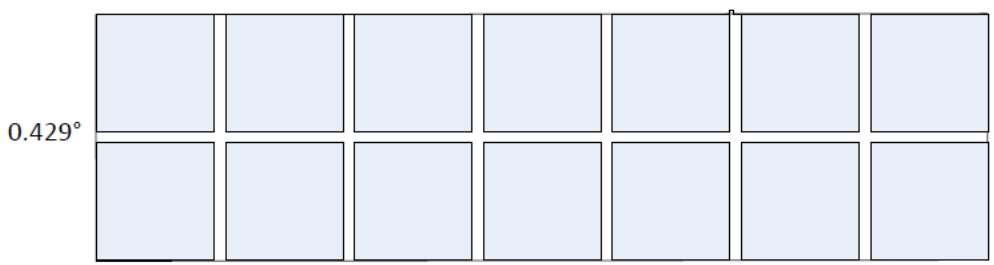
packed		ImC/SpC
npix [1 side of SCA]		4088
pixel size	mm	0.01
x gap size	mm	4.00
y gap size	mm	4.00
pixel scale	"/p	0.1800
nx		7
ny		2
active x	deg	1.431
active y	deg	0.409
total x	deg	1.551
total y	deg	0.429
active area	deg^2	0.585
total area/channel	deg^2	0.665
focal length	m	11.45924
aperture	m	1.1
system f/#		10.417
A - omega est.	m^2deg^2	0.556
Mpix		234.0

Field of view

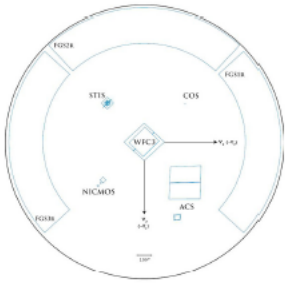
Channel field layout for WFIRST “DRM2”

The Field of view of the single channel which can be used in imaging (Im), BAO spectroscopy (Sp), or SN spectroscopy (SNSp) mode is shown to scale with the Moon, HST, and JWST. Each square is a 16Mpix vis-NIR sensor chip assembly (SCA), 10 um pixels

7x2 @ 0.18"/p, 0.585 sq.deg



1.551°

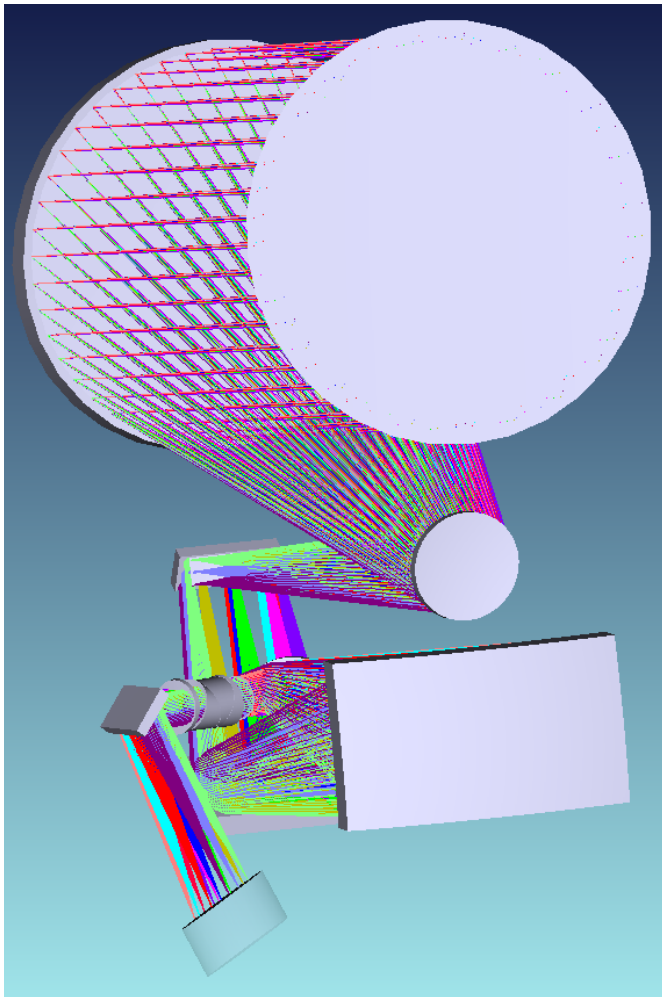


HST [all instruments]

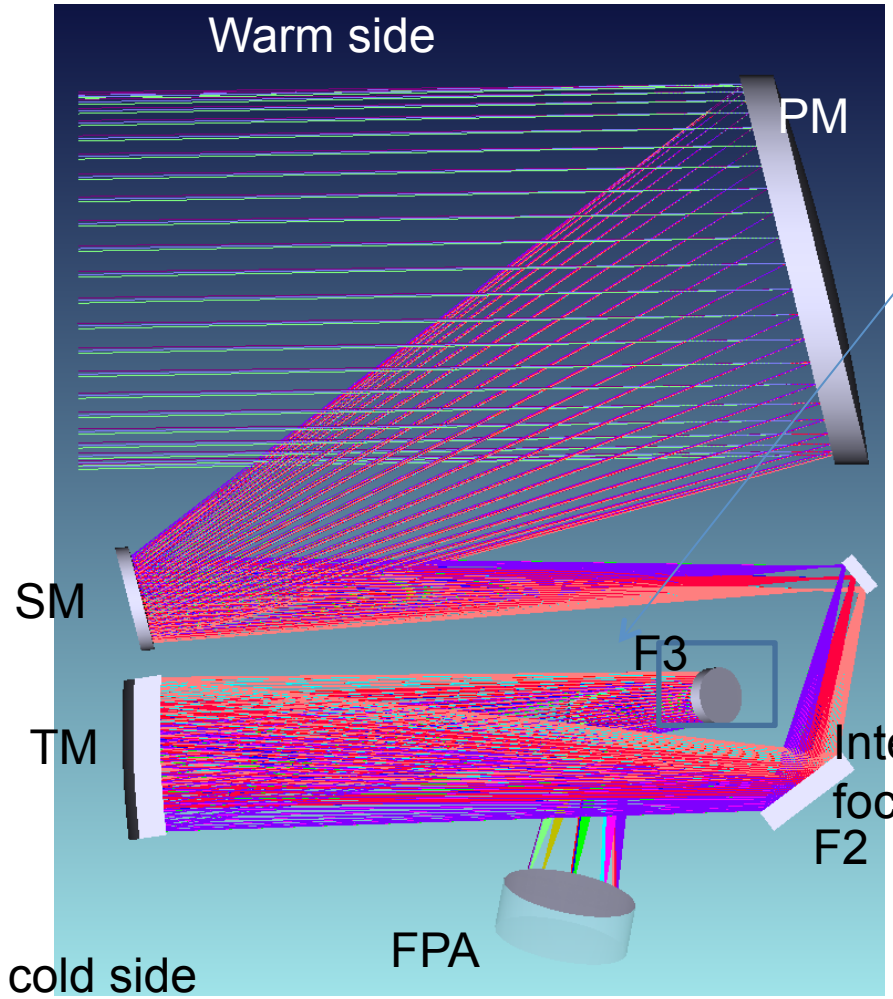
JWST [all instruments]

Moon (average size seen from Earth)

DRM2 ray trace



Oblique view view

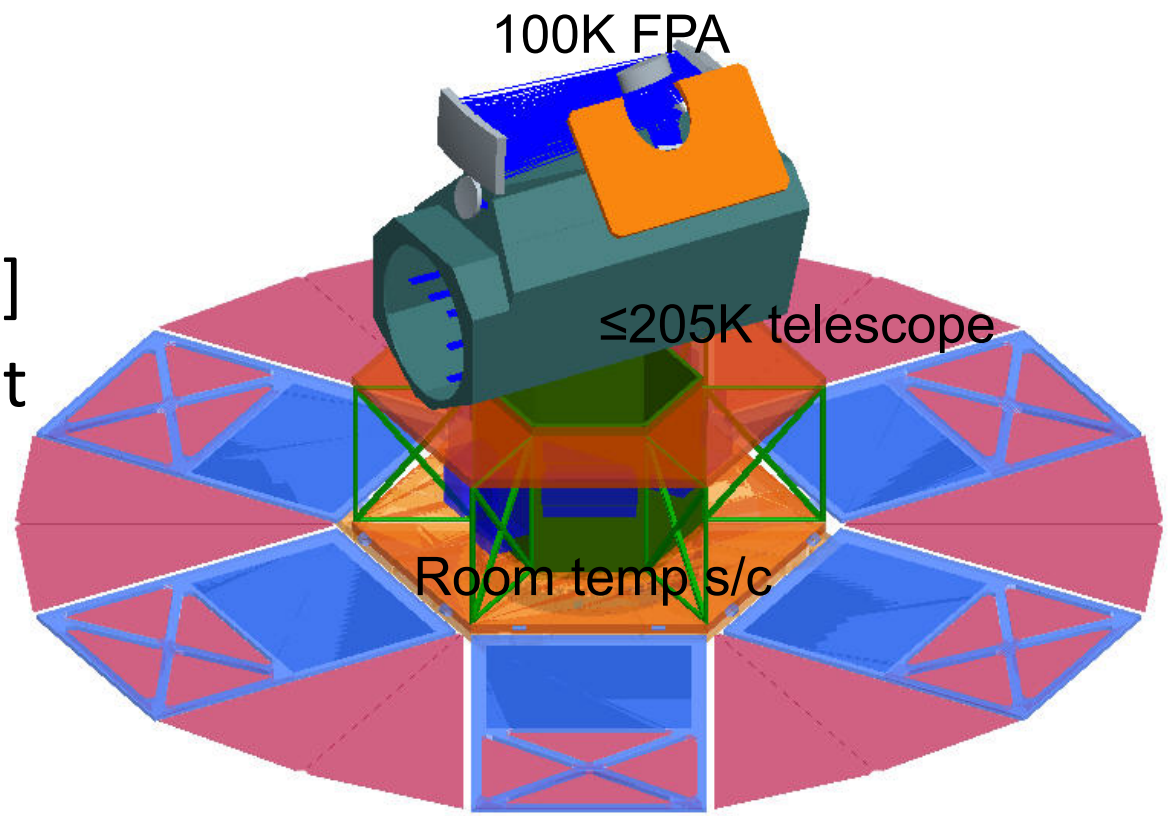


Cold stop & Filter wheel, Prism wheel, behind F3

Side view

Preliminary observatory view

- Deployable planar sunshade(purple) and solar array (blue) [WMAP-like]
- Hollow, lightweight s/c
- Side-viewing payload lowers center of gravity and aligns with center of pressure



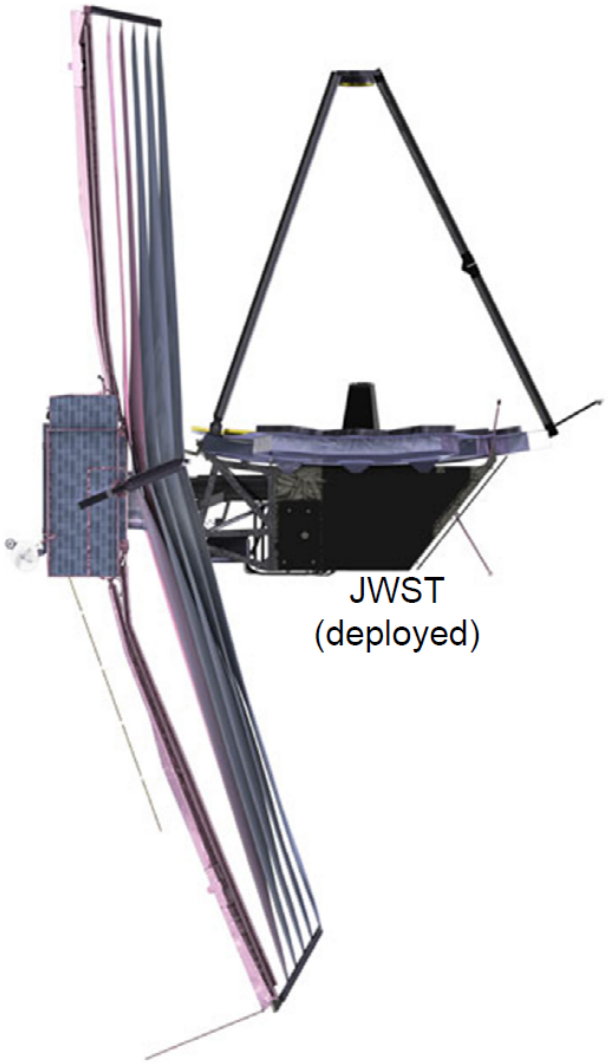
Sun side

Mass summary – now have robust margins on Falcon9

N. Armani 5/16/2012	DRM2 1.1m 1-Channel mass (kg)	% of SC
Payload Mass	563.2	38.54
SC Mass	786.0	53.79
Propellant Mass	112	7.66
Observatory Wet Mass Total (CBE)	1461.2	100.0
Falcon-9 LV to C3 Capability		
Falcon 9 LV mass margin (against wet CBE)		73.15
Atlas V to C3 Capability		
ATLAS V LV mass margin (against wet CBE)		109.76

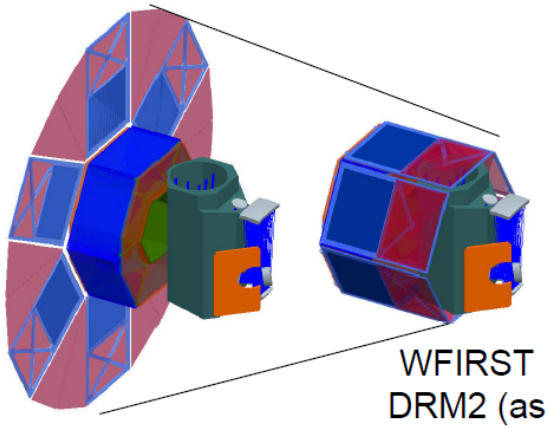
JWST, Kepler, WFIRST DRM2 to same scale

- All shown with field of view up and sun to left



JWST (deployed)

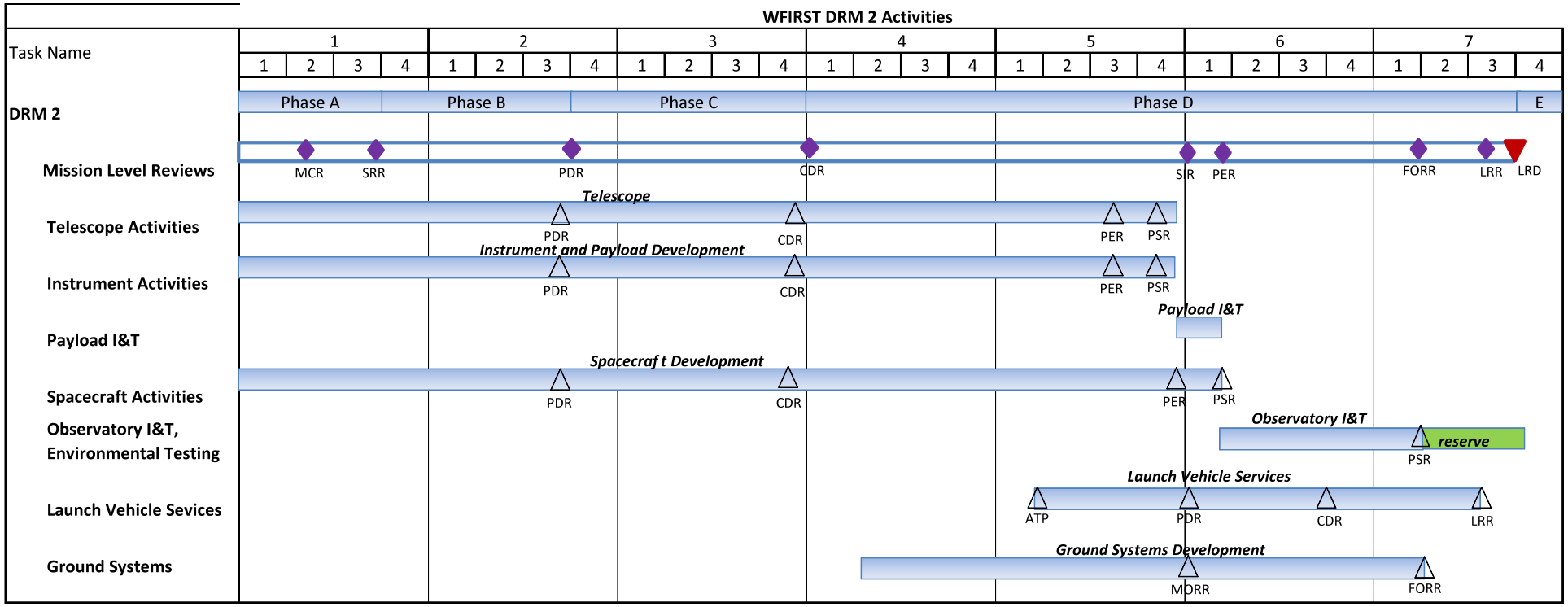
Kepler



WFIRST DRM2 (deployed)

WFIRST DRM2 (as launched)

DRM2 schedule



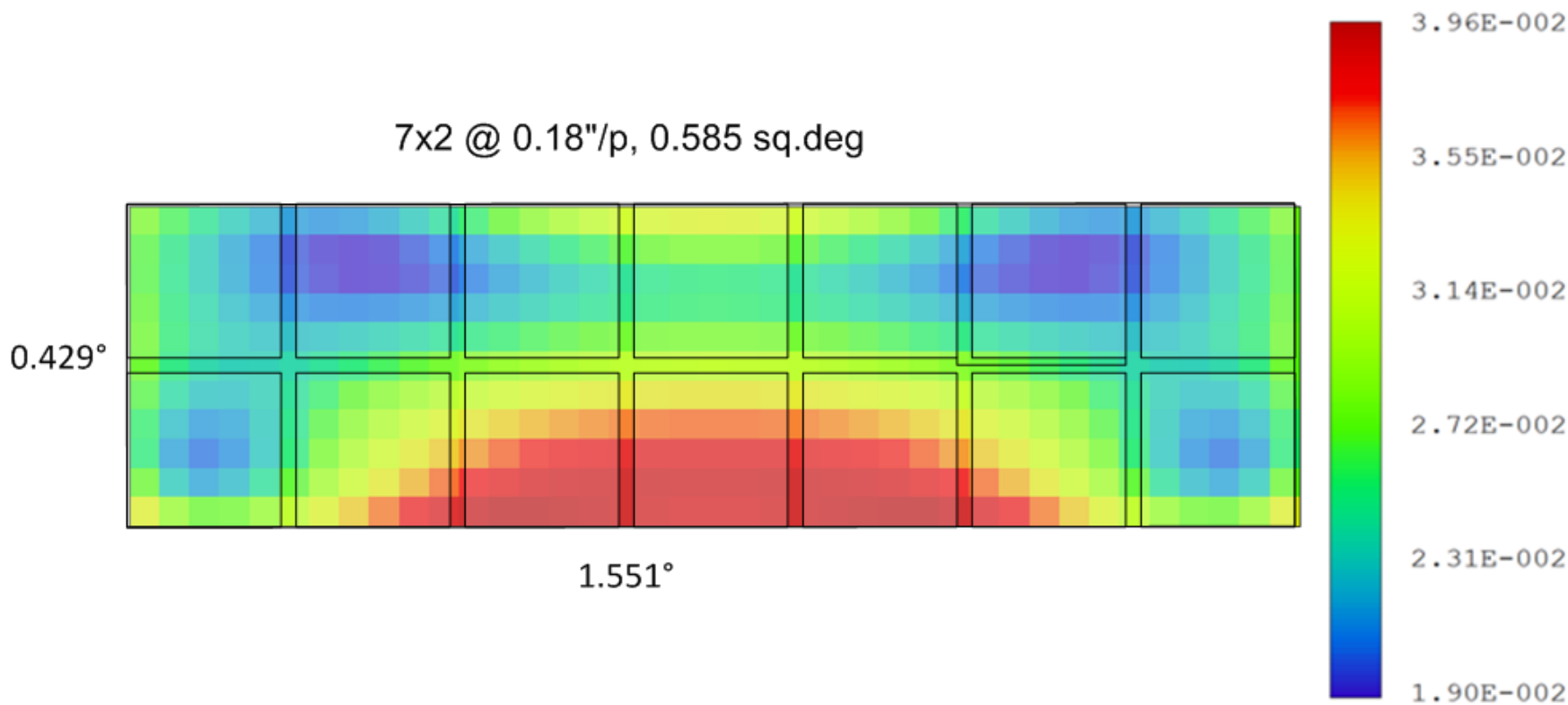
Costing process

- Contract in place
- Master equipment lists in work
- In-house “PriceH” parametric estimate {May-June}
- Aerospace “CATE” [cost and technical esimate] to follow

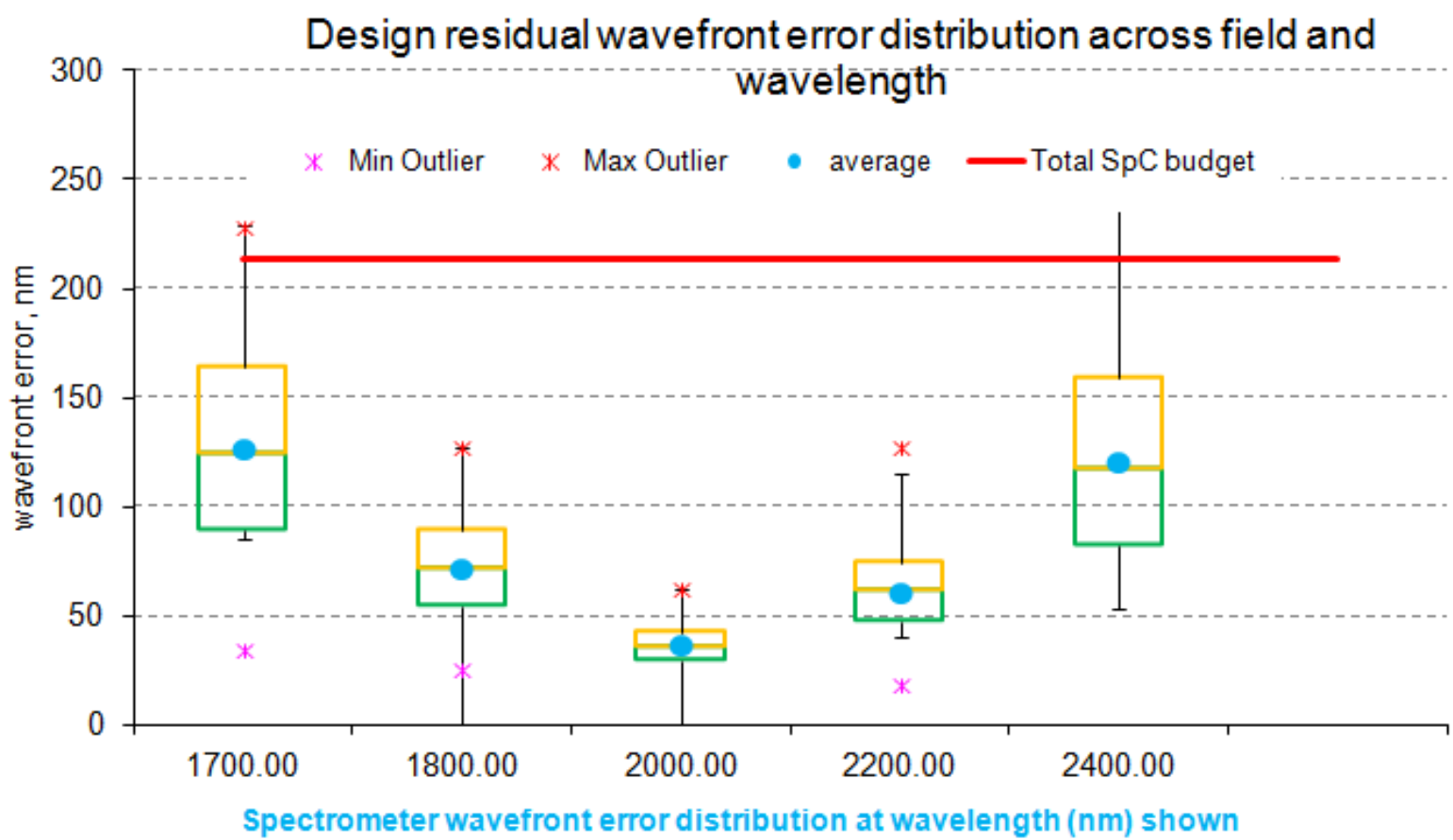
Payload design documentation

- Field of view graphic
- Ray trace & observatory views
- ImC mode design residual map
- SpC mode design residual box plot
- Spot diagrams
- Distortion plot
- SpC prism $D_\theta(\lambda)$ curves {preliminary}
- Throughput estimate

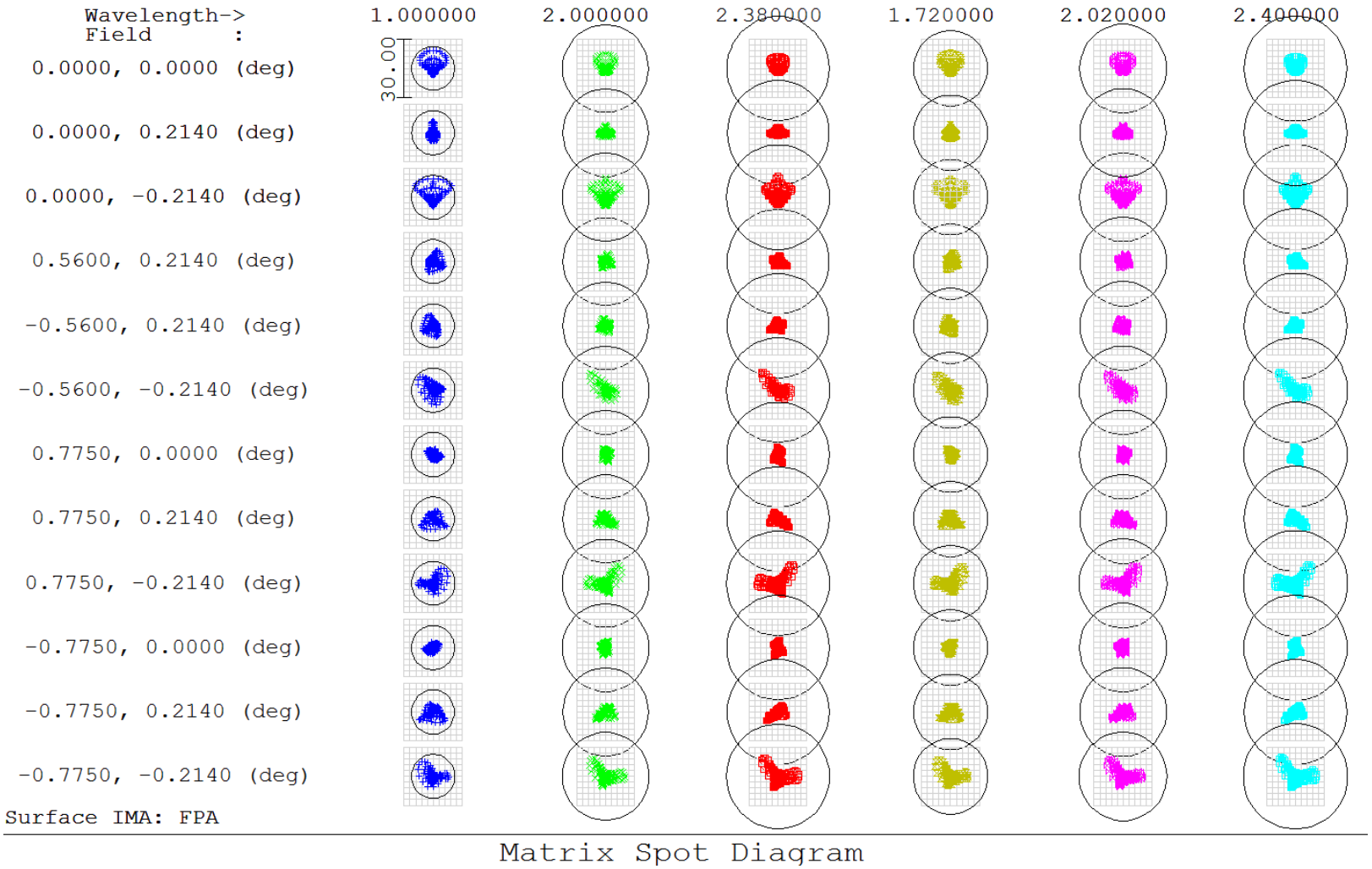
DRM2 ImC error residual wavefront error map, 1um



DRM2 SpC residual error distribution

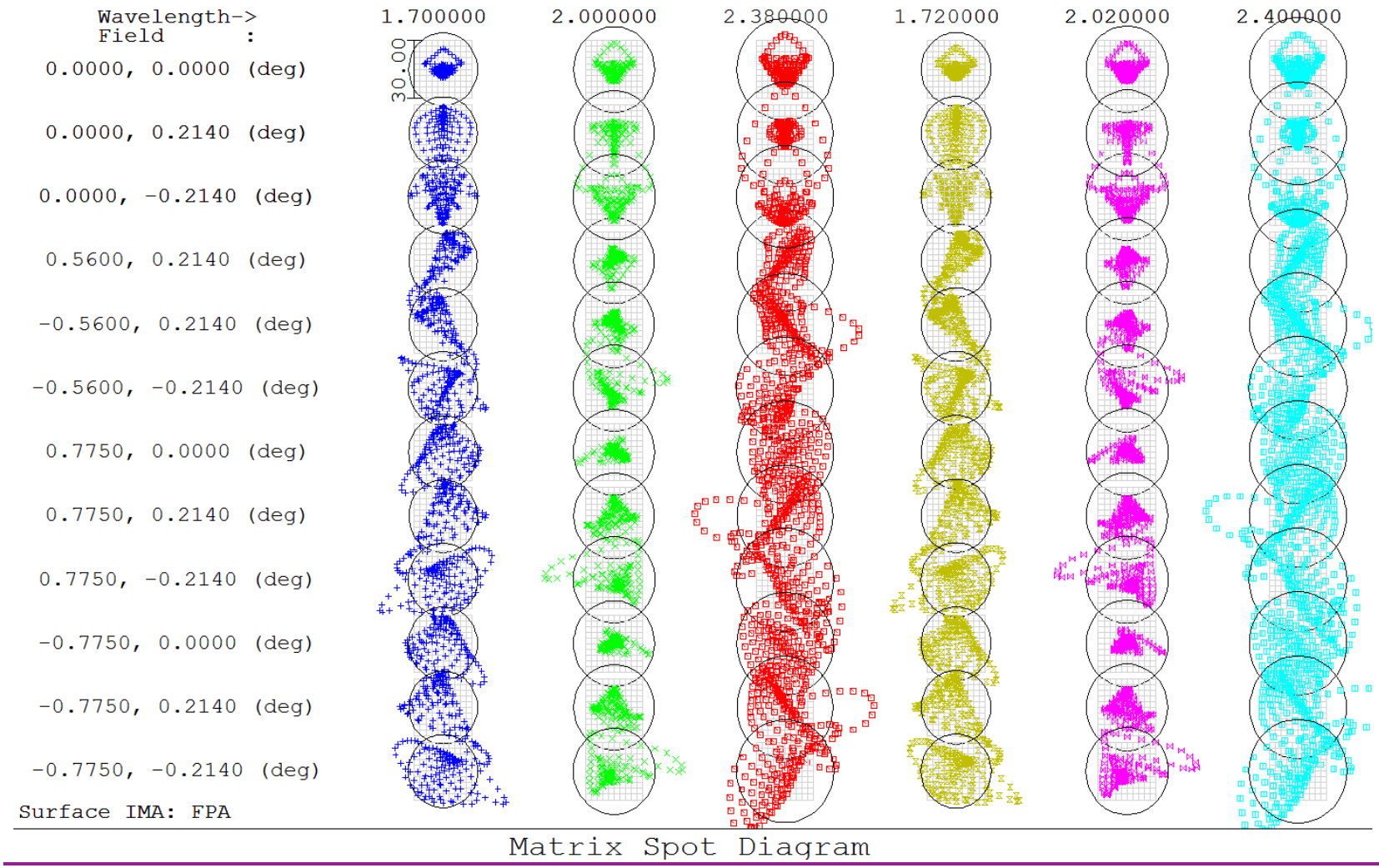


DRM2 Imaging spot diagram



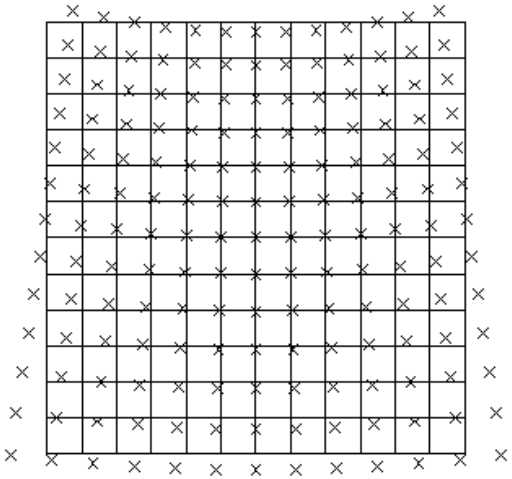
Matrix Spot Diagram

DRM2 GRS prism matrix spot diagram

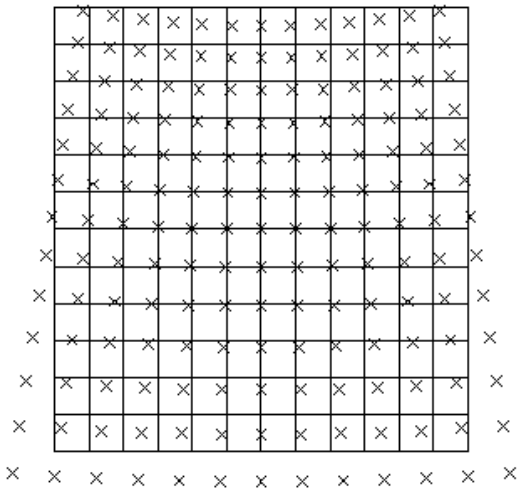


DRM2 Grid distortion

- L Imaging; R galaxy redshift spectroscopy prism



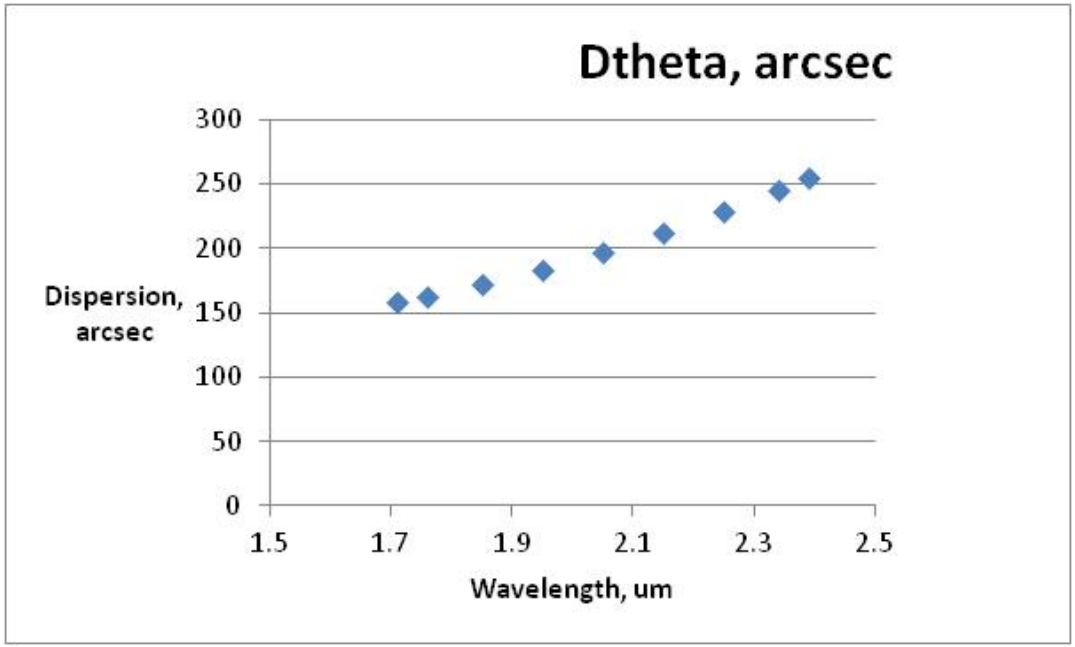
Grid Distortion	
DRM2 3/30/2012 Field: 1.1371 w 1.1371 h Degrees Image: 199.05 w 206.19 h Millimeters Maximum distortion: 1.2342% Scale: 10.000X, Wavelength: 1.0000 µm	D. Content/NASA GSFC drm2_120330a.zmx Configuration 1 of 2



Grid Distortion	
DRM2 3/30/2012 Field: 1.1371 w 1.1371 h Degrees Image: 189.09 w 203.24 h Millimeters Maximum distortion: 1.5573% Scale: 10.000X, Wavelength: 1.7000 µm	D. Content/NASA GSFC drm2_120330a.zmx Configuration 2 of 2

DRM2 D_θ – preliminary dispersion

- Bandpass (TBR) is 1.3-2.4um [z range 1-2.6]
- ADEPT requirement on D_θ == $\lambda/\{d\lambda/d\theta\}$ where θ is sky angle was range 200-240 over 1.3-2.0um
- ISWG requirement was D_θ >100 λ
- New materials being investigated



Throughput 1 of 3 ; imaging mode

Effective Area Analysis

configuration title: **ImC [sngl chnl image]**

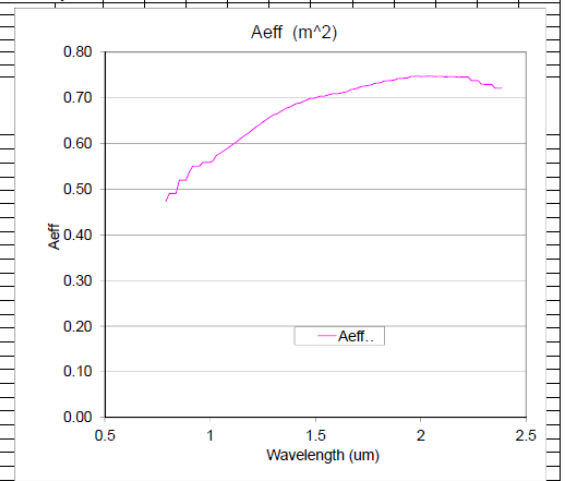
D. Content

Min wavelength	um	0.79	Mirror diameter	m	1.1
Max wavelength	um	2.4	# mirrors		7
Mirror coating	pAg or pAu	pAu	# refractive elements (lens/prism)		1
filter name			linear obscuration ratio (HST=0.33)		0
3/30/2012 revising DRM1	um	n/a	area fraction lost to SM vanes		0
fraction width of bandpass, R		n/a	area fraction lost to pupil mask		0.040
wavelength spacing	um	0.0159400	Contamination loss at EOL		0.02
Rel. bandpass		1.0094	Dichroic T/R, #	R	0
assumed max bandpass efficiency		0.9500			

mirror geometric area

Area (m^2)	0.950	m^2
illuminatated aperture	0.912	

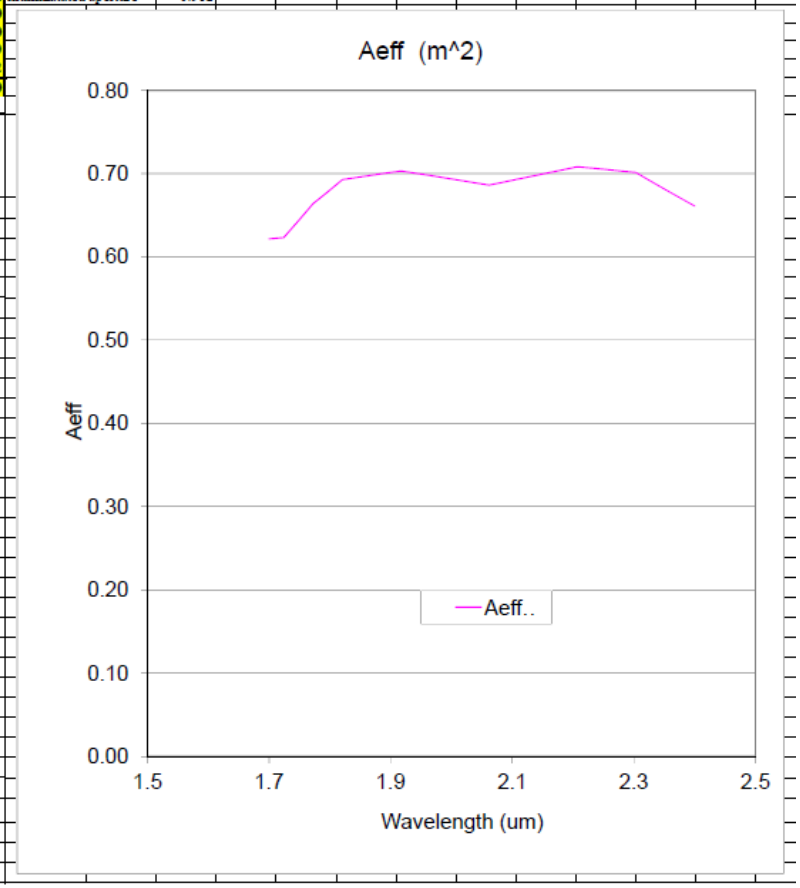
wavelength (um)	Mirror reflectivity (Protected Au)	Lens Antireflection coating transmission, per surface	Bandpass filter trans-mission	Dichroic	Optical Through-put	combined reflectivity of mirrors	combined transmission of lenses & prisms	Contami-nation loss	detector QE	Aeff (m^2)
0.79	0.9750	0.9500	1	1.0000	0.7560	0.8376	0.9026	0.98	0.701	0.473
0.8059	0.9800	0.9500	1	1.0000	0.7835	0.8681	0.9026	0.98	0.700	0.490
0.8219	0.9800	0.9500	1	1.0000	0.7835	0.8681	0.9026	0.98	0.700	0.490
0.8378	0.9800	0.9500	1	1.0000	0.7835	0.8681	0.9026	0.98	0.700	0.490
0.8538	0.9850	0.9607	1	1.0000	0.8304	0.8996	0.9230	0.98	0.700	0.520
0.8697	0.9850	0.9607	1	1.0000	0.8304	0.8996	0.9230	0.98	0.700	0.520
0.8856	0.9850	0.9607	1	1.0000	0.8304	0.8996	0.9230	0.98	0.700	0.520
0.9016	0.9900	0.9607	1	1.0000	0.8603	0.9321	0.9230	0.98	0.700	0.538
0.9175	0.9900	0.9714	1	1.0000	0.8796	0.9321	0.9437	0.98	0.700	0.550
0.9335	0.9900	0.9714	1	1.0000	0.8796	0.9321	0.9437	0.98	0.700	0.550
0.9494	0.9900	0.9714	1	1.0000	0.8796	0.9321	0.9437	0.98	0.700	0.550
0.9653	0.9900	0.9786	1	1.0000	0.8926	0.9321	0.9576	0.98	0.700	0.559
0.9813	0.9900	0.9786	1	1.0000	0.8926	0.9321	0.9576	0.98	0.700	0.559
0.9972	0.9900	0.9786	1	1.0000	0.8926	0.9321	0.9576	0.98	0.700	0.559
1.0132	0.9900	0.9786	1	1.0000	0.8926	0.9321	0.9576	0.98	0.704	0.562
1.0291	0.9900	0.9857	1	1.0000	0.9056	0.9321	0.9717	0.98	0.709	0.574
1.0450	0.9900	0.9857	1	1.0000	0.9056	0.9321	0.9717	0.98	0.714	0.578
1.0610	0.9900	0.9857	1	1.0000	0.9056	0.9321	0.9717	0.98	0.720	0.583
1.0769	0.9900	0.9857	1	1.0000	0.9056	0.9321	0.9717	0.98	0.725	0.587
1.0929	0.9900	0.9866	1	1.0000	0.9073	0.9321	0.9734	0.98	0.731	0.593
1.1088	0.9900	0.9866	1	1.0000	0.9073	0.9321	0.9734	0.98	0.738	0.598
1.1248	0.9900	0.9866	1	1.0000	0.9073	0.9321	0.9734	0.98	0.744	0.603
1.1407	0.9900	0.9875	1	1.0000	0.9089	0.9321	0.9752	0.98	0.750	0.610
1.1566	0.9900	0.9875	1	1.0000	0.9089	0.9321	0.9752	0.98	0.757	0.615
1.1726	0.9900	0.9875	1	1.0000	0.9089	0.9321	0.9752	0.98	0.763	0.620
1.1885	0.9900	0.9875	1	1.0000	0.9089	0.9321	0.9752	0.98	0.769	0.625
1.2045	0.9900	0.9884	1	1.0000	0.9106	0.9321	0.9769	0.98	0.776	0.632
1.2204	0.9900	0.9884	1	1.0000	0.9106	0.9321	0.9769	0.98	0.782	0.637
1.2363	0.9900	0.9884	1	1.0000	0.9106	0.9321	0.9769	0.98	0.788	0.642
1.2523	0.9900	0.9893	1	1.0000	0.9122	0.9321	0.9787	0.98	0.794	0.648
1.2682	0.9900	0.9893	1	1.0000	0.9122	0.9321	0.9787	0.98	0.801	0.653
1.2842	0.9900	0.9893	1	1.0000	0.9122	0.9321	0.9787	0.98	0.806	0.658
1.3001	0.9900	0.9893	1	1.0000	0.9122	0.9321	0.9787	0.98	0.812	0.662
1.3160	0.9900	0.9875	1	1.0000	0.9089	0.9321	0.9752	0.98	0.818	0.665
1.3320	0.9900	0.9875	1	1.0000	0.9089	0.9321	0.9752	0.98	0.823	0.669
1.3479	0.9900	0.9875	1	1.0000	0.9089	0.9321	0.9752	0.98	0.829	0.674
1.3639	0.9900	0.9875	1	1.0000	0.9089	0.9321	0.9752	0.98	0.834	0.678
1.3798	0.9900	0.9857	1	1.0000	0.9056	0.9321	0.9717	0.98	0.840	0.680
1.3957	0.9900	0.9857	1	1.0000	0.9056	0.9321	0.9717	0.98	0.845	0.684
1.4117	0.9900	0.9857	1	1.0000	0.9056	0.9321	0.9717	0.98	0.849	0.688
1.4276	0.9900	0.9839	1	1.0000	0.9024	0.9321	0.9681	0.98	0.854	0.689
1.4436	0.9900	0.9839	1	1.0000	0.9024	0.9321	0.9681	0.98	0.858	0.692
1.4595	0.9900	0.9839	1	1.0000	0.9024	0.9321	0.9681	0.98	0.862	0.696
1.4754	0.9900	0.9839	1	1.0000	0.9024	0.9321	0.9681	0.98	0.866	0.698
1.4914	0.9900	0.9822	1	1.0000	0.8991	0.9321	0.9646	0.98	0.869	0.699
2.2884	0.9900	0.9750	1	1.0000	0.8861	0.9321	0.9507	0.98	0.921	0.729
2.3044	0.9900	0.9750	1	1.0000	0.8861	0.9321	0.9507	0.98	0.921	0.729
2.3203	0.9900	0.9750	1	1.0000	0.8861	0.9321	0.9507	0.98	0.921	0.729
2.3362	0.9900	0.9750	1	1.0000	0.8861	0.9321	0.9507	0.98	0.920	0.729
2.3522	0.9900	0.9697	1	1.0000	0.8764	0.9321	0.9402	0.98	0.920	0.721
2.3681	0.9900	0.9697	1	1.0000	0.8764	0.9321	0.9402	0.98	0.920	0.721
2.3841	0.9900	0.9697	1	1.0000	0.8764	0.9321	0.9402	0.98	0.920	0.721
2.4000	0.9900	0.9697	1	1.0000	0.8764	0.9321	0.9402	0.98	0.920	0.721
average	0.9894	0.9812	1.0000		0.8940	0.9283	0.9628	0.9800	0.8447	0.6761
RMS	0.0024	0.0092	0.0000		0.0286	0.0151	0.0179	0.0000	0.0840	0.0773
min	0.9750	0.9500	1.0000		0.7560	0.8376	0.9026	0.9800	0.7000	0.4735
max	0.9900	0.9893	1.0000		0.9122	0.9321	0.9787	0.9800	0.9209	0.7475



date	comment
2/9/2012	initial release, revised from WIDRM1_throughput_111103
2/13/2012	QE model updated with internal trap inefficiency and 70% floor
3/30/2012	revising DRM1 to DRM2 - aperture & 2 more fold flats. SpC blue edge

Throughput, 2 of 3: galaxy redshift spectroscopy

Effective Area Analysis					configuration title:		SpC															
D. Content																						
Min wavelength		um	1.7				Mirror diameter		m	1.1	mirror geometric area											
Max wavelength		um	2.4				# mirrors			7		Area (m^2)	0.950									
Mirror coating		pAg or pAu	pAu				# refractive elements (lens/prism/dichroic))			4	illuminatated aperture		0.912									
	filter name						linear obscuration ratio (HST=0.33)			0												
3/30/2012	revising DRMI	um	2.05				area fraction lost to SM vanes			0												
fraction width of bandpass, R			0.3415				area fraction lost to pupil mask			0.040												
wavelength spacing		um	0.0241				Contamination loss at EOL			0.02												
Rel. bandpass			0.3415				Dichroic T/R, #		T	0												
assumed max bandpass efficiency			0.9500							m^2												
wavelength (um)	Mirror reflectivity (Protected Au)	Lens Antireflection coating transmission, per surface	Bandpass filter trans-mission	Dichroic	Optical Through-put	combined reflectivity of mirrors	combined transmission of lenses & prisms	Contami-nation loss	detector QE	Aeff (m^2)												
1.7	0.9900	0.9831	0.95	1.0000	0.7726	0.9321	0.8289	0.98	0.900	0.622												
1.7241	0.9900	0.9831	0.95	1.0000	0.7726	0.9321	0.8289	0.98	0.902	0.623												
1.7483	0.9900	0.9867	0.95	1.0000	0.7956	0.9321	0.8536	0.98	0.904	0.643												
1.7724	0.9900	0.9903	0.95	1.0000	0.8193	0.9321	0.8790	0.98	0.906	0.664												
1.7966	0.9900	0.9928	0.95	1.0000	0.8354	0.9321	0.8963	0.98	0.908	0.678												
1.8207	0.9900	0.9952	0.95	1.0000	0.8518	0.9321	0.9139	0.98	0.909	0.693												
1.8448	0.9900	0.9955	0.95	1.0000	0.8539	0.9321	0.9161	0.98	0.911	0.695												
1.8690	0.9900	0.9958	0.95	1.0000	0.8560	0.9321	0.9184	0.98	0.912	0.698												
1.8931	0.9900	0.9961	0.95	1.0000	0.8580	0.9321	0.9206	0.98	0.913	0.701												
1.9172	0.9900	0.9964	0.95	1.0000	0.8601	0.9321	0.9228	0.98	0.914	0.703												
1.9414	0.9900	0.9958	0.95	1.0000	0.8560	0.9321	0.9184	0.98	0.915	0.700												
1.9655	0.9900	0.9952	0.95	1.0000	0.8518	0.9321	0.9139	0.98	0.916	0.698												
1.9897	0.9900	0.9946	0.95	1.0000	0.8477	0.9321	0.9095	0.98	0.917	0.695												
2.0138	0.9900	0.9940	0.95	1.0000	0.8436	0.9321	0.9051	0.98	0.917	0.692												
2.0379	0.9900	0.9934	0.95	1.0000	0.8395	0.9321	0.9007	0.98	0.918	0.689												
2.0621	0.9900	0.9928	0.95	1.0000	0.8354	0.9321	0.8963	0.98	0.918	0.686												
2.0862	0.9900	0.9934	0.95	1.0000	0.8395	0.9321	0.9007	0.98	0.919	0.690												
2.1103	0.9900	0.9940	0.95	1.0000	0.8436	0.9321	0.9051	0.98	0.919	0.693												
2.1345	0.9900	0.9946	0.95	1.0000	0.8477	0.9321	0.9095	0.98	0.920	0.697												
2.1586	0.9900	0.9952	0.95	1.0000	0.8518	0.9321	0.9139	0.98	0.920	0.701												
2.1828	0.9900	0.9958	0.95	1.0000	0.8560	0.9321	0.9184	0.98	0.920	0.704												
2.2069	0.9900	0.9964	0.95	1.0000	0.8601	0.9321	0.9228	0.98	0.921	0.708												
2.2310	0.9900	0.9961	0.95	1.0000	0.8580	0.9321	0.9206	0.98	0.921	0.707												
2.2552	0.9900	0.9958	0.95	1.0000	0.8560	0.9321	0.9184	0.98	0.921	0.705												
2.2793	0.9900	0.9955	0.95	1.0000	0.8539	0.9321	0.9161	0.98	0.921	0.703												
2.3034	0.9900	0.9952	0.95	1.0000	0.8518	0.9321	0.9139	0.98	0.921	0.701												
2.3276	0.9900	0.9934	0.95	1.0000	0.8395	0.9321	0.9007	0.98	0.921	0.691												
2.3517	0.9900	0.9915	0.95	1.0000	0.8273	0.9321	0.8876	0.98	0.920	0.681												
2.3759	0.9900	0.9897	0.95	1.0000	0.8153	0.9321	0.8748	0.98	0.920	0.671												
2.4	0.9900	0.9879	0.95	1.0000	0.8035	0.9321	0.8620	0.98	0.920	0.661												
average	0.9900	0.9932	0.9500		0.8385	0.9321	0.8996	0.9800	0.9155	0.6864												
RMS	0.0000	0.0037	0.0000		0.0243	0.0000	0.0261	0.0000	0.0062	0.0229												
min	0.9900	0.9831	0.9500		0.7726	0.9321	0.8289	0.9800	0.8999	0.6216												
max	0.9900	0.9964	0.9500		0.8601	0.9321	0.9228	0.9800	0.9210	0.7080												



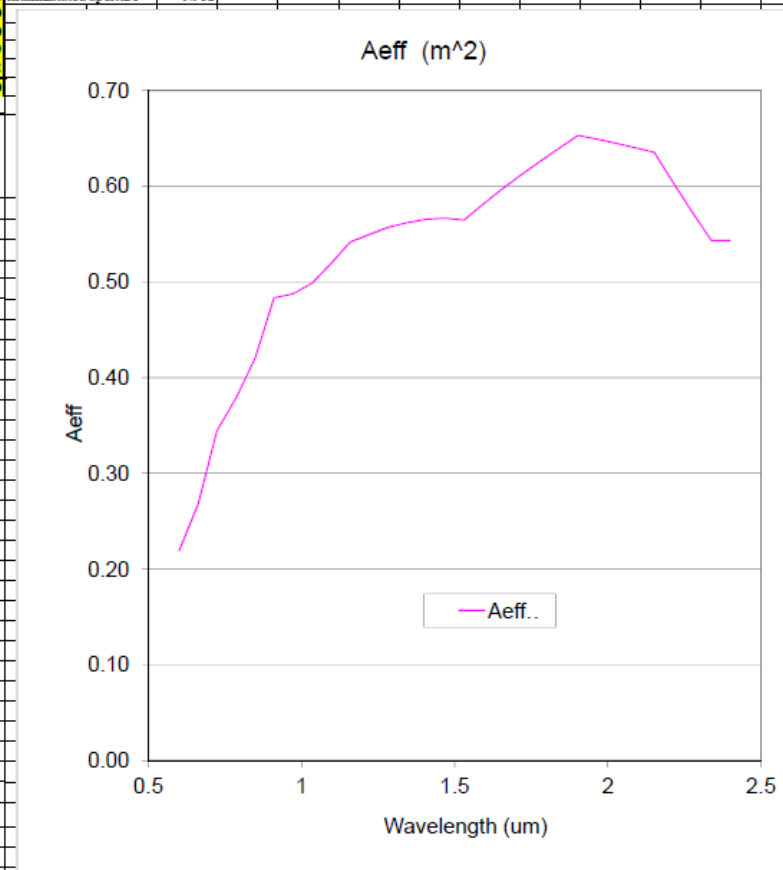
Throughput, 3 of 3: SN 1a spectroscopy

Effective Area Analysis

configuration title: SN spec

D. Content

Min wavelength	um	0.6	
Max wavelength	um	2.4	
Mirror coating	pAg or pAu	pAu	
filter name			
3/30/2012 revising DRM1	um	1.5	
fraction width of bandpass, R		1.2000	
wavelength spacing	um	0.0621	
Rel. bandpass		1.2000	
assumed max bandpass efficiency		0.9500	

Mirror diameter	m	1.1	mirror geometric area
# mirrors		7	Area (m^2) 0.950
# refractive elements (lens/prism/dichroic))		4	illuminatated aperture 0.912
linear obscuration ratio (HST=0.33)		0	
area fraction lost to SM vanes		0	
area fraction lost to pupil mask		0.040	
Contamination loss at EOL		0.02	
Dichroic T/R, #	T	0	
		m^2	

wavelength (um)	Mirror reflectivity (Protected Au)	Lens Antireflection coating transmission, per surface	Bandpass filter trans-mission	Dichroic	Optical Through-put	combined reflectivity of mirrors	combined transmission of lenses & prisms	Contami-nation loss	detector QE	Aeff (m^2)
0.6	0.9200	0.9406	0.95	1.0000	0.3247	0.5578	0.5821	0.98	0.755	0.219
0.6621	0.9450	0.9406	0.95	1.0000	0.3917	0.6730	0.5821	0.98	0.764	0.267
0.7241	0.9700	0.9533	0.95	1.0000	0.5237	0.8080	0.6481	0.98	0.736	0.344
0.7862	0.9750	0.9661	0.95	1.0000	0.6036	0.8376	0.7207	0.98	0.702	0.379
0.8483	0.9800	0.9745	0.95	1.0000	0.6710	0.8681	0.7729	0.98	0.700	0.420
0.9103	0.9900	0.9830	0.95	1.0000	0.7721	0.9321	0.8284	0.98	0.700	0.483
0.9724	0.9900	0.9841	0.95	1.0000	0.7788	0.9321	0.8356	0.98	0.700	0.487
1.0345	0.9900	0.9852	0.95	1.0000	0.7856	0.9321	0.8428	0.98	0.710	0.498
1.0966	0.9900	0.9862	0.95	1.0000	0.7924	0.9321	0.8501	0.98	0.733	0.519
1.1586	0.9900	0.9873	0.95	1.0000	0.7992	0.9321	0.8575	0.98	0.758	0.542
1.2207	0.9900	0.9852	0.95	1.0000	0.7856	0.9321	0.8428	0.98	0.782	0.549
1.2828	0.9900	0.9830	0.95	1.0000	0.7721	0.9321	0.8284	0.98	0.806	0.557
1.3448	0.9900	0.9809	0.95	1.0000	0.7589	0.9321	0.8142	0.98	0.828	0.562
1.4069	0.9900	0.9788	0.95	1.0000	0.7459	0.9321	0.8002	0.98	0.848	0.565
1.4690	0.9900	0.9767	0.95	1.0000	0.7330	0.9321	0.7865	0.98	0.864	0.567
1.5310	0.9900	0.9745	0.95	1.0000	0.7204	0.9321	0.7729	0.98	0.876	0.564
1.5931	0.9900	0.9767	0.95	1.0000	0.7330	0.9321	0.7865	0.98	0.887	0.581
1.6552	0.9900	0.9788	0.95	1.0000	0.7459	0.9321	0.8002	0.98	0.895	0.597
1.7172	0.9900	0.9809	0.95	1.0000	0.7589	0.9321	0.8142	0.98	0.901	0.612
1.7793	0.9900	0.9830	0.95	1.0000	0.7721	0.9321	0.8284	0.98	0.907	0.626
1.8414	0.9900	0.9852	0.95	1.0000	0.7856	0.9321	0.8428	0.98	0.911	0.640
1.9034	0.9900	0.9873	0.95	1.0000	0.7992	0.9321	0.8575	0.98	0.914	0.653
1.9655	0.9900	0.9862	0.95	1.0000	0.7924	0.9321	0.8501	0.98	0.916	0.649
2.0276	0.9900	0.9852	0.95	1.0000	0.7856	0.9321	0.8428	0.98	0.918	0.645
2.0897	0.9900	0.9841	0.95	1.0000	0.7788	0.9321	0.8356	0.98	0.919	0.640
2.1517	0.9900	0.9830	0.95	1.0000	0.7721	0.9321	0.8284	0.98	0.920	0.635
2.2138	0.9900	0.9767	0.95	1.0000	0.7330	0.9321	0.7865	0.98	0.921	0.603
2.2759	0.9900	0.9703	0.95	1.0000	0.6957	0.9321	0.7464	0.98	0.921	0.573
2.3379	0.9900	0.9639	0.95	1.0000	0.6600	0.9321	0.7081	0.98	0.920	0.543
2.4	0.9900	0.9639	0.95	1.0000	0.6600	0.9321	0.7081	0.98	0.920	0.543
average	0.9847	0.9762	0.9500		0.7144	0.9015	0.7867	0.9800	0.8343	0.5354
RMS	0.0153	0.0126	0.0000		0.1157	0.0846	0.0757	0.0000	0.0865	0.1103
min	0.9200	0.9406	0.9500		0.3247	0.5578	0.5821	0.9800	0.7000	0.2192
max	0.9900	0.9873	0.9500		0.7992	0.9321	0.8575	0.9800	0.9208	0.6528