Thoughts on reaching closure
on an
EIS optical configuration and wavelength bands

EIS-sci-torc

John Mariska
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Since the NRL EIS kickoff meeting, considerable additional study has gone into understanding the tradeoffs between the Cassegrain and the off axis paraboloid designs and among the different proposed wavelength bands. I believe we are now in a position to lay out all the issues that must be considered in making this decision. The purpose of this document is to outline what I consider to be those issues and to try to focus on the critical scientific and technical trades that should force the final decision.

1. Available configurations and wavelength bands

There are, of course, many spectral lines in each wavelength band under study. From a practical point of view, most of the science will be done with the stronger lines. On the other hand, it is useful to know in some detail what is available in each band. Based on discussions with others at NRL and with people involved in TRACE, I have decided that a minimum condition for a particular emission line being useful for playing a significant science role is that the line should be intense enough to accumulate 100 counts in 30 s. Rounding down, this translates into the condition that the count rate in the line must be 3.0 counts per second or greater. I have therefore used that criterion to select which lines are listed for quiet Sun observations. For active regions and flares, that results in too many lines. I have therefore limited the lines listed for those solar features to those that have 10.0 counts per second or greater. Even with those limitations, the tables are extensive. In making the tradeoffs we must make, though, they need to be referred to often to see the implications of each trade.

1.1 Cassegrain

1.1.1 Key instrument parameters (needs work)

- Pixel size: 1 arcsec
- Dispersion: 16.1 km/s per pixel
- Dispersion: 0.010 Angstroms/mm

1.1.2 Available wavelength bands and count rates

The following three tables list the available emission lines in each of the three wavelength bands under consideration for quite Sun, active regions and flares.

Cassegrain NRL1 Wavelength Band

Ion	Wave	Rate
Quiet Sun		
Fe XII	193.521	6.22
Fe XII	195.118	11.40
Active Region		
Fe XII	186.851	10.58
Fe XII	186.884	17.52
Fe XI	188.232	41.68
Fe XI	188.299	15.58
Fe X	190.043	16.15
Fe XXIV	192.042	10.06
Fe XII	192.393	62.35
Ca XVII	192.819	43.42
Fe XI	192.830	21.64
Fe XII	193.521	190.99
Ca XIV	193.866	12.94
Fe XII	195.118	349.72
Fe XII	195.131	22.49
Fe XIII	196.540	28.14
Fe XII	196.648	34.20
Fe XIII	197.433	13.79
Fe XIII	200.022	24.53
Fe XIII	201.128	18.65
Fe XIII	202.044	36.40
Fe XIII	203.828	17.56
Flare		
Fe X	184.543	18.61
Fe XI	184.803	13.72
Ca XIV	186.610	29.11
Fe XII	186.851	87.33
Fe XII	186.884	108.98
Fe XXI	187.892	335.18
Ar XIV	187.969	24.77
Fe XII	188.192	40.40
Fe XI	188.232	111.15
Fe XI	188.299	47.48
S XI	188.675	14.62
Fe XI	189.129	24.67
Fe XI	189.719	21.76
Fe X	190.043	38.84
Fe XI	190.143	11.38
Fe XII	190.489	21.55
Fe XII	191.053	121.21
S XI	191.266	44.14
Ar XIV	191.361	28.66
Fe XXIV	192.042	52994.56
Fe XII	192.393	162.47
O V	192.750	34.48
O V	192.797	74.49
O V	192.801	25.98
Ca XVII	192.819	2517.86
Fe XI	192.830	57.77
O V	192.904	157.49
O V	192.911	25.18
Fe XI	193.514	15.33
Fe XII	193.521	430.97
Fe X	193.715	10.76
Ca XIV	193.866	203.95
Ni XVI	194.024	29.66
Ar XIV	194.390	82.54
Fe XII	194.609	11.34
Fe XII	194.911	11.17
Fe XII	195.118	779.85
Fe XII	195.131	192.88
Ni XVI	195.275	10.10
Ni XV	195.536	10.37
Fe XIII	196.540	580.54
Fe XII	196.648	226.21
Fe XII	196.873	30.85
Fe XIII	197.433	64.42
Fe XI	198.545	35.04
S VIII	198.553	27.65
Fe XII	198.558	26.69
Fe XIII	200.022	141.09
Fe XII	200.355	24.95
Ca XV	200.977	66.01
Fe XX	201.010	17.28
Fe XII	201.116	29.28
Fe XIII	201.128	87.33
Fe XIII	202.044	84.65
Fe XII	202.089	14.55
Fe XIII	203.163	13.58
Fe XIII	203.797	33.38
Fe XIII	203.828	98.76
Fe XIII	204.263	16.40
Fe XVII	204.650	71.45

Cassegrain NRL2 Wavelength Band

Ion	Wave	Rate
Quiet Sun		
He II	303.780	18.32
Active Region		
He II	303.780	115.55
He II	303.786	59.24
Mg VIII	315.039	20.48
Si VIII	316.205	14.24
Mg VII	319.027	10.41
Si VIII	319.826	28.27
Fe XIII	320.809	11.19
Fe XVI	335.410	84.16
Flare		
Fe XV	284.160	27.81
Ca XVIII	302.190	312.70
Si XI	303.324	70.07
He II	303.780	28464.88
Fe XV	304.999	14.76
O III	305.657	13.38
O III	305.769	24.04
O IV	306.621	12.86
Fe XX	309.270	10.32
C IV	312.420	30.32
C IV	312.451	15.22
Fe XV	312.539	16.04
Mg VIII	313.754	21.81
Si VIII	314.327	14.04
Mg VI	314.647	11.68
Mg VIII	315.039	72.56
Si VIII	316.205	32.11
Mg VIII	317.039	21.49
Fe XIII	318.128	43.33
Mg VII	319.027	64.20
Si VIII	319.826	62.88
Ni XVIII	320.565	109.34
Fe XIII	320.809	59.90
O III	320.976	91.98
Mg IV	320.994	83.86
Fe XIII	321.400	10.62
Fe XV	321.802	22.53
N IV	322.568	14.84
N IV	322.718	24.72
Mg IV	323.306	42.13
Fe XVII	323.583	69.38
Fe XV	327.011	49.10
O III	328.447	45.58
Fe XIV	334.172	19.82
Fe XVI	335.410	2353.63
Fe XXI	335.514	37.35
Ca XVIII	344.760	49.78
Ar XVI	353.920	19.53
Fe XVI	360.761	50.53

Cassegrain Baseline Band

Ion	Wave	Rate
Quiet Sun		
He II	256.317	3.46
Active Region		
Fe XIII	251.956	14.99
He II	256.317	17.99
S XIII	256.684	11.23
Fe XIV	257.381	12.25
Si X	258.372	24.02
Fe XVI	262.984	26.96
S X	264.230	10.05
Fe XIV	264.780	34.70
Fe XIV	270.507	26.36
Fe XIV	274.200	16.51
Si VII	275.353	10.00
Fe XV	284.160	75.58
He II	303.780	24.32
He II	303.786	12.45
Flare		
Fe XV	233.869	10.24
Ni XXVI	234.093	56.87
He II	237.331	14.14
He II	237.331	28.24
O IV	238.360	15.85
O IV	238.570	28.73
Ni XXV	238.823	15.27
Fe XXI	242.072	22.64
He II	243.026	83.96
He II	243.027	41.81
Fe XV	243.790	57.02
Si VI	246.004	23.89
Fe XIII	246.211	21.75
Fe XXI	246.987	18.84
Fe XXII	247.160	151.62
O V	248.461	12.80
Si VI	249.124	14.56
Ni XVII	249.177	27.23
Fe XVI	251.074	192.97
Fe XIII	251.956	66.51
Fe XIV	252.191	39.19
Fe XXII	253.156	121.34
Si X	253.788	14.47
Fe XVII	254.530	20.40
Fe XVII	254.868	185.23
Fe XXIV	255.102	5564.74
He II	256.317	6168.44
Si X	256.384	29.45
Fe XIII	256.422	48.31
S XIII	256.684	205.93

Ion	Wave	Rate
Fe XIV	257.381	73.64
Si IX	258.080	30.67
Si X	258.372	107.14
S X	259.496	16.56
Fe XVII	259.711	14.32
O IV	260.389	14.99
O IV	260.556	10.44
Si X	261.063	35.72
Fe XVII	262.681	15.92
Fe XVI	262.984	768.74
Fe XXIII	263.762	2021.76
S X	264.230	32.35
Fe XIV	264.780	380.10
Ni XXIV	264.831	12.89
Fe XVI	265.014	81.48
Fe XVII	266.420	38.32
O IV	266.931	11.48
Mg VI	268.991	33.05
Fe XVII	269.410	74.90
Fe XVII	269.880	18.48
Mg VI	270.390	61.97
Fe XIV	270.507	157.98
Fe XXI	270.565	109.43
Si X	271.983	32.80
Si VII	272.638	16.23
Si VII	274.174	12.26
Fe XIV	274.200	91.99
Si VII	275.353	42.34
Fe XVII	275.543	20.90
Mg V	276.582	41.29
Fe XVII	276.797	22.74
Si VIII	276.838	19.81
Mg VII	277.000	13.78
Si VIII	277.054	25.88
Si X	277.255	15.55
Mg VII	278.402	19.27
Fe XVII	279.213	32.86
Fe XVII	280.143	22.82
Mg VII	280.737	13.20
Fe XV	284.160	1009.22
Fe XVII	284.172	15.40
Ni XVIII	291.984	19.44
Fe XXII	292.453	32.16
Ca XVIII	302.190	96.85
Si XI	303.324	16.45
He II	303.780	5990.60
Fe XVI	335.410	25.24

1.1

1.2 Off axis paraboloid

1.2.1 Key instrument parameters (needs work)

- Pixel size: 1.86 arcsec
- Dispersion: ? km/s per pixel
- Dispersion: ? Angstroms/mm

1.2.2 Available wavelength bands and count rates

The following three tables list the available emission lines in each of the three wavelength bands under consideration for quite Sun, active regions and flares. It is important to keep in mind the 2 arcsec pixel size used in computing these tables. The numbers assume that the region being observed by the 2 arcsec pixel is filled with emitting material. TRACE observations suggest that it would be prudent to think in terms of a 2 arcsec pixel observing a 1 arcsec feature. Thus, one should seriously consider reducing the rates in the tables by a factor of 4.

1.1.1

OAP NRL1 Wavelength Band

Ion	Wave	Rate
Quiet Sun		
Fe XI	180.408	5.34
Fe X	184.543	9.85
Fe XII	186.851	4.51
Fe XII	186.884	8.51
Fe XI	188.232	29.75
Fe XI	188.299	11.02
Fe X	190.043	11.00
Fe XII	192.393	22.17
Fe XI	192.830	11.53
Fe XII	193.521	65.86
Fe XII	195.118	117.31
Fe XII	195.131	5.85
Fe XIII	196.540	4.40
Fe XII	196.648	10.22
Fe XI	198.545	3.08
S VIII	198.553	7.07
Fe XIII	200.022	5.95
Fe XIII	201.128	5.67
Fe XIII	202.044	15.61
Fe XIII	203.828	7.48
Active Region		
Fe X	174.534	21.92
Fe X	177.243	29.92
Fe X	180.407	19.59
Fe XI	180.408	107.50
Fe XI	181.137	13.03
Fe XI	182.169	45.35
Fe X	184.543	181.50
Fe XI	184.803	23.04
Ca XIV	186.610	32.02
Fe XII	186.851	178.22
Fe XII	186.884	294.01
Fe XXI	187.892	10.32
Ar XIV	187.969	15.71
Fe XII	188.192	19.71
Fe XI	188.232	605.22
Fe XI	188.299	224.75
Fe XII	188.447	13.92
S XI	188.675	32.57
Ar XI	188.811	25.05
Fe XI	189.129	60.25
Fe XI	189.719	50.73
Fe X	190.043	202.40
Fe XII	190.071	40.00
Fe XI	190.143	23.21
Fe XII	191.053	39.49
S XI	191.266	81.65
Ar XIV	191.361	17.56
Fe XXIV	192.042	112.46
Fe XII	192.393	686.66
Ca XVII	192.819	470.24
Fe XI	192.830	234.25
Fe XI	192.900	19.95
O V	192.904	28.89
Fe XI	193.514	53.35
Fe XII	193.521	2022.33
Fe X	193.715	19.93
Ca XIV	193.866	135.77
Ar XI	194.109	13.82
Ar XIV	194.390	56.53
Fe XII	194.609	34.00
Fe XII	194.911	17.36
Fe XII	195.118	3599.51
Fe XII	195.131	231.45
Fe X	195.389	21.21
Fe XIII	196.540	291.93
Fe XII	196.648	355.55
Fe XII	196.873	37.67
Fe XIII	197.433	146.97
Fe XI	198.545	72.12
S VIII	198.553	81.28
Fe XII	198.558	12.88
Fe XI	199.175	15.10
Fe XIII	200.022	323.78
Fe XII	200.355	11.80
Ca XV	200.977	63.94
Fe XII	201.116	19.16
Fe XIII	201.128	288.71
Fe XI	201.576	36.73
Fe XIII	202.044	654.53
Fe XI	202.448	20.30
S VIII	202.610	12.43
Fe XI	202.706	46.27
Fe XIII	203.163	60.47
Fe XII	203.272	40.75
Fe XIII	203.797	135.94
Fe XIII	203.828	412.65
Fe XIII	204.263	53.88
Fe XVII	204.650	32.38
Fe XI	204.759	30.04
Fe XIII	204.945	28.78
Fe XII	206.371	19.25

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Ion	Wave	Rate
Fe XI	207.777	14.03
Fe XIII	209.621	24.67
Fe XIII	209.919	21.06
Fe XIV	211.320	86.88
Fe XII	211.732	14.65
Fe XIII	213.771	13.20
Fe XIV	219.136	11.55
Flare		
Fe X	174.534	51.64
Fe X	177.243	66.59
Fe XI	179.764	98.08
Fe XXIII	180.044	95.19
Fe X	180.407	66.89
Fe XI	180.408	265.46
Fe XI	181.137	56.38
Fe XI	182.169	185.29
Ca XIV	183.460	96.31
O VI	183.937	51.47
O VI	184.117	110.20
Fe XXII	184.182	151.23
Fe XI	184.412	54.65
Fe X	184.543	435.90
Fe XI	184.803	308.28
Ni XVI	185.230	97.01
Fe XIII	185.769	73.24
Ca XIV	186.610	505.16
Fe XII	186.851	1471.48
Fe XII	186.884	1829.07
Fe XXI	187.892	5031.92
Ar XIV	187.969	369.01
Fe XII	188.192	588.83
Fe XI	188.232	1613.92
Fe XI	188.299	685.08
Fe XII	188.447	114.90
S XI	188.675	203.86
Ar XI	188.811	130.10
Fe XI	189.129	330.92
Ni XV	189.243	65.13
Fe XI	189.719	279.00
Fe X	190.043	486.61
Fe XII	190.071	122.66
Fe XI	190.143	141.64
S XI	190.355	66.48
Fe XII	190.489	262.11
Fe XII	191.053	1424.99
S XI	191.266	512.77
Ar XIV	191.361	331.26
Fe XV	191.408	54.91
Fe XXIV	192.042	592435.94

Ion	Wave	Rate
Fe XII	192.393	1789.19
O V	192.750	374.41
O V	192.797	807.37
O V	192.801	281.60
Ca XVII	192.819	27269.64
Fe XI	192.830	625.38
Fe XI	192.900	60.72
O V	192.904	1700.41
O V	192.911	271.78
S X	193.477	54.28
Fe XI	193.514	162.32
Fe XII	193.521	4563.41
Ar XII	193.680	95.64
Fe X	193.715	113.33
Ca XIV	193.866	2140.17
Ni XVI	194.024	310.15
Ar XI	194.109	71.84
Ar XIV	194.390	856.93
Fe XII	194.609	117.30
Fe XII	194.911	115.18
Fe XII	195.118	8026.59
Fe XII	195.131	1985.02
Ni XVI	195.275	103.90
Fe X	195.389	94.36
Ni XV	195.536	106.58
Fe XIII	196.540	6021.52
Fe XII	196.648	2351.87
S X	196.814	67.24
Fe XII	196.873	322.63
Fe XIII	197.433	686.61
Fe XI	198.545	398.29
S VIII	198.553	314.55
Fe XII	198.558	303.74
Fe XI	199.175	67.53
Fe XIII	200.022	1862.70
Fe XII	200.355	344.32
Ca XV	200.977	997.88
Fe XX	201.010	262.59
Fe XII	201.116	452.42
Fe XIII	201.128	1351.99
Fe XI	201.576	108.67
Fe XIII	202.044	1522.04
Fe XII	202.089	263.56
Fe XI	202.448	53.88
Fe XI	202.706	140.91
Fe XIII	203.163	291.40
Fe XII	203.272	204.63
Fe XIII	203.797	781.38
Fe XIII	203.828	2321.14
Fe XIII	204.263	406.52

Ion	Wave	Rate
Fe XVII	204.650	1850.07
Fe XI	204.759	144.11
Fe XIII	204.945	135.10
Fe XII	206.371	59.10
Ca XV	208.329	50.85
Ca XVI	208.585	304.33
Ca XV	208.716	50.01
Fe XIII	209.621	162.94
Fe XIV	211.320	421.45
Fe XII	211.732	50.56
Fe XIII	213.771	86.95
Fe XXII	217.293	70.80
Fe XIV	219.136	226.25
Ar XV	221.151	124.47
Fe XIII	221.827	69.41

OAP NRL2 Wavelength Band

Ion	Wave	Rate
Quiet Sun		
Si XI	303.324	4.84
He II	303.780	485.59
Mg VIII	311.796	4.11
Mg VIII	313.754	8.69
Si VIII	314.327	8.41
Mg VIII	315.039	27.35
Si VIII	316.205	18.08
Mg VIII	317.039	7.66
Mg VII	319.027	12.94
Si VIII	319.826	33.06
Active Region		
Fe XV	284.160	161.08
Si IX	296.117	27.65
Ca XVIII	302.190	57.31
Fe XIII	303.301	14.37
Si XI	303.324	268.89
He II	303.780	3062.98
He II	303.786	1569.79
Fe XV	304.999	10.04
Fe XI	308.548	10.25
Fe XIII	311.552	12.03
Mg VIII	311.796	48.37
Fe XIII	312.109	47.53
Fe XV	312.539	18.61
Fe XIII	312.872	27.30
Mg VIII	313.754	101.54
Si VIII	314.327	99.78
Mg VI	314.562	10.71
Mg VI	314.669	19.00
Mg VIII	315.039	320.38
Si VIII	316.205	214.48
Mg VIII	317.039	89.42
Fe XIII	318.128	32.94
Mg VII	319.027	145.90
Si VIII	319.826	390.66
Mg VII	320.512	16.54
Ni XVIII	320.565	60.94
Fe XIII	320.809	152.53
Mg IV	320.994	13.35
Fe XIII	321.400	40.44
Fe XVII	323.583	16.63
Fe X	324.763	27.42
Fe XV	327.011	47.47
Fe X	331.472	12.19

Ion	Wave	Rate
Al X	332.789	34.72
Fe XIV	334.172	91.51
Mg VIII	335.253	25.69
Fe XII	335.339	10.20
Fe XVI	335.410	1942.29
Mg VIII	339.006	19.62
Ca XVIII	344.760	12.30
Si IX	345.124	16.85
Si X	347.403	19.90
Fe XIII	348.183	10.41
Si IX	349.873	18.68
Fe XII	352.106	10.76
Fe XI	352.662	10.08
Si X	356.012	15.26
Fe XVI	360.761	115.33
Mg IX	368.070	25.66
Flare		
Fe XV	284.160	2150.82
Ni XVIII	291.984	231.08
Fe XXII	292.453	421.86
Ca XVIII	302.190	9055.46
Si XI	303.324	1904.35
He II	303.780	754538.31
O III	303.802	194.67
Fe XV	304.999	366.12
O III	305.597	143.14
O III	305.657	320.35
O III	305.769	572.17
O IV	306.621	292.65
O IV	306.884	166.57
Fe XI	308.548	101.92
Fe XX	309.270	205.84
Mg VIII	311.796	171.00
Fe XIII	312.109	168.96
C IV	312.420	524.17
C IV	312.451	262.72
Fe XV	312.539	275.94
Fe XIII	312.872	129.97
Mg VIII	313.754	357.53
Si VIII	314.327	225.25
Mg VI	314.540	103.90
Mg VI	314.647	185.16
Mg VIII	315.039	1135.01
Si VIII	316.205	483.63
Mg VIII	317.039	315.74
Fe XIII	318.128	619.08
Mg VII	319.027	899.69
Si VIII	319.826	868.96
Mg VII	320.512	109.43

Ion	Wave	Rate
Ni XVIII	320.565	1495.31
Fe XIII	320.809	816.76
O III	320.976	1251.96
Mg IV	320.994	1141.20
Fe XIII	321.400	144.03
Fe XV	321.802	304.60
N IV	322.568	200.12
N IV	322.718	333.27
Mg IV	323.306	568.40
Fe XVII	323.583	936.96
Fe XV	327.011	702.60
O III	328.447	685.98
O III	328.740	137.88
Al X	332.789	151.52
Fe XIV	334.172	418.20
Fe XVI	335.410	54316.77
Fe XXI	335.514	868.39
Fe XVII	340.402	104.36
Ca XVIII	344.760	1942.53
Fe XVII	347.850	127.95
Fe XVII	350.496	140.89
Ar XVI	353.920	1006.92
Fe XVI	360.761	3217.66

OAP Baseline Wavelength Band

Ion	Wave	Rate
Quiet Sun		
Fe IX	241.739	5.62
Fe IX	244.909	3.91
Si VI	246.004	4.42
Fe XIII	251.956	5.82
He II	256.317	59.01
Si X	256.384	4.29
Fe X	257.239	3.98
Si X	258.372	12.70
Si X	261.063	4.69
S X	264.230	4.77
Fe XIV	264.780	5.36
Mg VI	268.991	4.91
Mg VI	270.390	9.04
Fe XIV	270.507	4.42
Si X	271.983	4.06
Si VII	272.638	5.49
Si VII	274.174	4.19
Si VII	275.353	16.89
Si VIII	276.838	5.72
Si VII	276.839	3.06
Mg VII	277.000	5.78
Si VIII	277.054	7.22
Mg VII	278.402	8.60
Si VII	278.443	4.17
Mg VII	280.737	3.48
Fe XV	284.160	8.80
He II	303.780	171.81
Active Region		
Fe XIV	211.320	13.92
Fe XIV	219.136	11.27
Fe XIII	221.827	15.59
Si IX	225.024	12.18
Si IX	227.000	25.37
Fe XIII	228.159	16.46
O IV	238.570	11.65
Fe XIII	240.696	33.84
Fe IX	241.739	52.95
He II	243.026	15.14
Fe XV	243.790	100.94
Fe IX	244.909	41.61
Si VI	246.004	42.92
Fe XIII	246.211	110.99
S XI	246.895	15.64
Si VI	249.124	23.92

Ion	Wave	Rate
Ni XVII	249.177	38.37
Fe XVI	251.074	133.09
Fe XIII	251.956	288.32
Fe XIV	252.191	68.51
Si X	253.788	59.66
Fe XVII	254.868	57.38
Fe XXIV	255.102	18.64
Fe X	256.197	61.94
He II	256.317	307.09
He II	256.318	153.55
Si X	256.384	126.75
Fe XIII	256.422	74.07
S XIII	256.684	189.90
S X	257.146	38.49
Fe X	257.285	30.69
Fe XIV	257.381	203.50
Fe XI	257.547	19.56
Si IX	258.080	44.20
Si X	258.372	389.70
S X	259.496	81.23
Si X	261.063	138.04
Fe XVI	262.984	396.02
Fe XXIII	263.762	13.50
S X	264.230	144.51
Fe XIV	264.780	495.16
Fe XVI	265.014	40.31
Mg VI	268.989	54.65
Fe XVII	269.410	18.38
Mg VI	270.391	100.96
Mg VI	270.404	13.80
Fe XIV	270.507	372.49
Si X	271.983	119.48
Si VII	272.638	53.81
Si VII	274.174	41.88
Fe XIV	274.200	256.30
Si VII	275.353	162.07
Si VII	275.667	25.34
Mg VII	276.154	20.22
Mg V	276.582	26.78
Si VIII	276.838	74.77
Si VII	276.839	30.23
Mg VII	277.000	56.43
Si VIII	277.054	92.55
Si X	277.255	68.19
Mg VII	278.402	83.90
Si VII	278.443	39.96
Fe XVII	279.213	10.76
Mg VII	280.737	40.41
S XI	281.401	13.48
Al IX	284.042	12.07

Ion	Wave	Rate
Fe XV	284.160	1765.50
S XI	285.822	13.08
S XII	288.434	15.41
Si IX	290.690	12.41
Fe XII	291.053	11.01
Ni XVIII	291.984	24.74
Si IX	292.763	11.38
Si IX	292.800	12.02
Si IX	292.856	10.14
Si IX	296.117	35.51
Si IX	296.213	10.40
Ca XVIII	302.190	26.23
Si XI	303.324	102.32
He II	303.780	1083.72
He II	303.786	554.88
Mg VIII	315.039	22.68
Si VIII	316.205	13.24
Si VIII	319.826	16.64
Fe XVI	335.410	94.44
Flare		
Fe XIV	219.136	220.72
Ar XV	221.151	184.48
Fe XIII	221.827	117.58
Fe XIII	228.159	108.43
O IV	233.562	145.44
Fe XV	233.869	352.07
Ni XXVI	234.093	1937.73
He II	237.331	427.87
He II	237.331	854.13
O IV	238.360	462.84
O IV	238.570	833.19
Ni XXV	238.823	438.89
Fe XIII	240.696	150.08
Fe XXI	242.072	583.94
He II	243.026	2100.36
He II	243.027	1045.81
Ar XIV	243.740	139.90
Fe XV	243.790	1391.11
Fe IX	244.909	195.89
Si VI	246.004	544.50
Fe XIII	246.211	492.87
S XI	246.895	128.02
Fe XXI	246.987	417.46
Fe XXII	247.160	3343.79
O V	248.461	271.75
Si VI	249.124	303.47
Ni XVII	249.177	566.60
Fe XVI	251.074	3804.89
Fe XIII	251.956	1279.09

Ion	Wave	Rate
Fe XIV	252.191	748.85
Fe XXII	253.156	2257.53
Si X	253.788	264.52
Fe XVII	254.530	365.32
Fe XVII	254.868	3287.60
Fe XXIV	255.102	98143.82
He II	256.317	105288.88
Si X	256.384	501.72
Fe XIII	256.422	822.28
S XIII	256.684	3481.22
S X	257.146	124.34
Fe XIV	257.381	1223.32
Si IX	258.080	501.11
Si X	258.372	1738.10
S X	259.496	261.63
Fe XVII	259.711	225.19
O IV	260.389	232.18
O IV	260.556	161.15
Si X	261.063	545.32
Fe XVII	262.681	235.14
Fe XVI	262.984	11290.64
Fe XXIII	263.762	29294.44
S X	264.230	465.23
Fe XIV	264.780	5423.19
Ni XXIV	264.831	183.85
Fe XVI	265.014	1158.84
Fe XVII	266.420	536.43
O IV	266.931	160.14
O IV	266.981	102.21
Mg VI	268.991	460.01
Fe XVII	269.410	1045.21
Fe XVII	269.880	259.00
Mg VI	270.390	874.03
Mg VI	270.400	118.72
Fe XIV	270.507	2231.93
Fe XXI	270.565	1547.39
Si X	271.983	476.80
O IV	272.127	111.90
Si VII	272.638	239.97
Si VII	274.174	190.21
Fe XIV	274.200	1428.29
Si VII	275.353	686.13
Fe XVII	275.543	341.26
Si VII	275.667	112.69
Mg V	276.582	702.49
Fe XVII	276.797	390.33
Si VIII	276.838	340.58
Si VII	276.839	134.41
Mg VII	277.000	238.44
Si VIII	277.054	448.92

Ion	Wave	Rate
Si X	277.255	271.99
Mg VII	278.402	353.83
Si VII	278.443	169.45
Fe XVII	279.213	624.32
Fe XVII	280.143	451.25
Mg VII	280.737	267.51
N IV	283.574	138.04
Fe XV	284.160	23573.98
Fe XVII	284.172	359.84
Ni XVIII	291.984	610.29
Fe XXII	292.453	1025.70
Si IX	296.117	108.80
Ca XVIII	302.190	4145.32
Si XI	303.324	724.67
He II	303.780	266965.47
Fe XV	304.999	106.91
O III	305.769	148.24
Fe XVI	335.410	2641.13
Ca XVIII	344.760	155.18

2. Scientific considerations

2.1 Overview

With the exception of the He II 304 Angstrom line, none of the proposed wavelength bands contains strong transition region lines. Thus, EIS is by definition an instrument whose primary goal is coronal science. Moreover, based on the counting rates tabulated above, EIS will be at its best in active regions and flares. I believe that active region science should be the primary science driver in selecting an optical configuration and wavelength bands. Flares should be the secondary science driver—mostly because they will be relatively infrequent at the time Solar-B flies. Quiet region science, including coronal holes, is then the tertiary science driver. Here I summarize what I think should be the primary science capabilities for each science driver.

This section is very much a work in progress. Right now (28 February 1999) it represents only my thoughts, and I am sure there are errors that will need to be corrected. I have put nothing in the flare requirements table and know we need to converge on what goes in the other tables. The goal here is to help drive the discussion using agreed upon instrument information and agreed upon science requirements.

2.2 Active region science

2.2.1 Active region science requirements table

Requirement	Value	Science Drivers
Spatial Resolution		
Pixel Size	1 arcsec or less	Apparent diameter of many loops seen in TRACE is at resolution of 1 arcsec.
Field of View	5 arcmin, but could be as small as 2 for some observations	• TRACE observations show that heating in active region loops takes place in the first 10,000 to 20,000 km (14 to 30 arcsec). • Typical active region sizes are 5 arcmin.
Spectral Resolution		
Velocity Resolution	<2 km/s	• TRACE observations show features in long-lived loops with propagation speeds of up to 10 km/s. • Features in active region loops observed by TRACE show velocities of 55 to 80 km/s.
Line broadening	<5 km/s	Active region line profiles are know to show nonthermal line broadening of on the order of 20 km/s at coronal temperatures.
Complex line profiles		Not sure what to expect in active regions.
Temporal resolution		
Minimum time for spectrum	5 s (1 arcsec slit) 10 s (2 arcsec slit)	• A feature in a loop traveling at 100 km/s would travel 1 arcsec every 7.25 s. • Typical coronal sound speed 150 km/s. A feature traveling at this speed would cover 1 arcsec in about 5 s. • TRACE active region observations suggest that coronal heating is modulated on timescales of

		minutes or less.
Minimum time for spectroheliogram	<10 min	• TRACE observations seem to show heating lasts for tens of minutes and then cuts off, suggesting that a relatively long time for a spectroheliogram would be reasonable. • TRACE observations show loops evolve on timescales of tens of minutes. • Conductive timescale for a coronal loop is on the order of 15 min.
Temperature coverage	min below 600,000K max at least 5 MK	• Hot cores of active regions show temperatures of 3 to 5 MK • Active regions display large loops in the 1 to 2 MK temperature range. • Need at least one transition region line to connect with magnetograms. CDS observations suggest that any line formed below about 600,000 K is fine.

2.3 Flare science

2.3.1 Flare science requirements table

Requirement	Value	Science Drivers
Spatial Resolution		
Pixel Size		
Field of View		
Spectral Resolution		
Velocity Resolution		
Line broadening		
Complex line profiles		
Temporal resolution		
Minimum time for spectrum		
Minimum time for spectroheliogram		
Temperature coverage		

2.4 Quiet region science

2.4.1 Quiet region science requirements tableRequirement	Value	Science Drivers
Spatial Resolution		
Pixel Size	<2 arcsec	• Network elements seen in HRTS in C IV lines have FWHM of about 3.4 arcsec. Filling factor arguments suggest structures seen in C IV have sizes as small as 1% of this number. • Explosive events observed in the transition region have sizes average sizes of 1500 km (2 arcsec). • Apparent diameter of many loops seen in TRACE is at resolution of 1 arcsec. • Quiet Sun observations of transition region with SUMER and corona with TRACE suggest structures at 1 arcsec level are common.
Field of View	>1 arcmin	Need to image at least one supergranule cell.

		Typical size of supergranule cell is 35,000 km (about 60 arcsec).
Spectral Resolution		
Velocity Resolution	<2 km/s	• Transition region observations of explosive events from HRTS show peak velocities of around 100 km/s. • Steady downflows seen in quiet transition region lines have peak Doppler shift velocities of around 10 km/s.
Line broadening	<5 km/s	Nonthermal line broadening observations in the transition region and corona show a peak quiet Sun value of about 25 to 30 km/s, with a decrease toward the corona to values of 10 to 20 km/s.
Complex line profiles	<10 km/s	For a complex event, which is not simply Gaussian in shape, want enough velocity resolution to try to follow the detailed evolution of the emission as a function of position relative to the location of the rest wavelength. For a peak velocity of 100 km/s, would like say 10 velocity bins.
Temporal resolution		
Minimum time for spectrum	7.25 s (1 arcsec slit) 15 s (2 arcsec slit)	• Explosive event has typical velocity of 100 km/s. If motion orthogonal to line of sight, then feature would travel 1 arc sec every 7.25 s. If wish to follow such an event, then minimum time for spectrum would be at least time to get decent Doppler shift measurement (time to get 100 counts). • Coronal heating theories involving waves suggest would like to measure changes on the order of the time it takes a wave to transit the structure. Taking a supergranule cell as a characteristic size and a speed of 1000 km/s, gives a time of 35 s.
Minimum time for spectroheliogram	?	• Would like to cover a supergranule cell at a sufficient cadence to view relationship of evolving magnetic elements to upper transition region and coronal structure. Time scale for this is long. • Would like to see possible effects of explosive events on surroundings. Requires only small field of view, but am not sure what repetition time.
Temperature coverage	min below 600,000 K max ?	• Linking with SOT observations requires at least one line formed in the transition region. CDS data suggests that any line formed below a temperature of about 600,000 K will be fine. • Having a strong transition region line would provide extra science when the SOT is distant from active regions. • Quiet corona is not very interesting at higher temperatures. Thus need at least one strong line in low corona (near 1 MK).

2.5 Science tradeoffs

The tables below reproduce the first two columns of the science requirements tables and then list in the third column the tradeoff information between the two configurations and the three wavelength bands. Much more needs to be added here.

2.5.1 Active regions

Requirement	Value	Tradeoffs
Spatial Resolution		
Pixel Size	1 arcsec or less	Cassegrain only way to achieve this requirement.
Field of View	5 arcmin, but could be as small as 2 arcmin for some observations	Either instrument can achieve.
Spectral Resolution		
Velocity Resolution	<2 km/s	Either instrument can achieve with 100 counts/s or more.
Line broadening	<5 km/s	• Either instrument can achieve with 100 total counts or more. • Excellent line profiles at the 500 to 1000 total counts. • Issue is time to reach these numbers
Complex line profiles	?	• Analyzing complex line profiles will probably require 500 to 1000 or more counts in line. • Issue is time to reach these numbers.
Temporal resolution		
Minimum time for spectrum	5 s (1 arcsec slit) 10 s (2 arcsec slit)	• Cassegrain can achieve 100 count level in 5 s for any line with a count rate of 20 counts/s or more (11 lines in NRL1, 5 lines in NRL2, 6 lines in Baseline). • Cassegrain can achieve 500 count level in 5 s for any line with a count rate of 100 counts/s or more (2 lines in NRL1, 1 line in NRL2, 0 lines in Baseline. • OAP can achieve 100 count level in 10 s for any line with a count rate of 10 counts/s or more (all lines listed in wavelength band tables listed above). • OAP can achieve 500 count level in 10 s for any line with a count rate of 50 counts/s or more (34 lines in NRL1, 17 lines in NRL2, 38 lines in Baseline). • Caveat—OAP numbers are based on fully filled 2 arcsec pixels. If we assume fine structure is 1 arcsec, then count rates in the tables should be reduced by about a factor of 4 for the OAP. This then leads to a threshold of 40 counts/s for 100 count level and 200 counts/s for 1000 count level.
Minimum time for spectroheliogram	<10 min	• Cassegrain covers 5 arcmin in 300 1 arcsec steps. Achieving that at the 100 count level in a line in 10 min requires 2 s integrations, leading to a minimum count rate of 50 counts/s (3 lines in NRL1, 3 lines in NRL2, 1 line in Baseline) • OAP covers 5 arcmin in 150 2 arcsec steps. Achieving that at the 100 count level in 10 min requires 4 s integrations, leading to a minimum count rate of 25 counts/s (numerous lines in each wavelength band).
Temperature coverage	min below 600,000 K,	

	max at least 5 MK	

2.5.2 Flares

Requirement	Value	Tradeoffs
Spatial Resolution		
Pixel Size		
Field of View		
Spectral Resolution		
Velocity Resolution		
Line broadening		
Complex line profiles		
Temporal resolution		
Minimum time for spectrum		
Minimum time for spectroheliogram		
Temperature coverage		

2.5.3 Quite Sun

Requirement	Value	Tradeoffs
Spatial Resolution		
Pixel Size	<2 arcsec	
Field of View	>1 arcmin	
Spectral Resolution		
Velocity Resolution	<2 km/s	
Line broadening	<5 km/s	
Complex line profiles	<10 km/s	
Temporal resolution		
Minimum time for spectrum	7.25 s (1 arcsec slit) 15 s (2 arcsec slit)	
Minimum time for spectroheliogram	?	
Temperature coverage	?	

2.5.4 Conclusions

While both the science requirements tables and the science tradeoff tables are still incomplete, there are some conclusions that we can already reach.

1. Both instruments have adequate spectral resolution for doing coronal and transition region dynamics.

2. Both instruments can make spectroheliograms of reasonable sized regions of the solar corona.

3. The key science tradeoff is between spatial resolution and temporal resolution. We must somehow reach agreement on

- The shortest integration time required for active region, flare, and quiet Sun observations, both for individual spectra and for spectroheliograms,
- The required size of a spectroheliogram in active regions, flares, and quiet Sun, and
- Whether 1 arcsec spatial resolution is absolutely necessary or only desirable.

3. Technical considerations

I'm in over my head in this area, but someone has to fill in some details here.

3.1 Mass

3.2 Power

3.3 Telemetry

3.4 Grating fabrication