

M4 Signal-to-Noise Requirements and Goals

The following table summarizes the required photometric signal-to-noise which must be achieved to measure polarization position angles with uncertainties below fixed values. The table lists as columns various polarization position angle uncertainties, ranging from 1 to 15 degrees. As rows, the table lists mean linear polarization percentage values, ranging from 0.55 to 10 percent. The table values list the photometric S/N which must be achieved in order to reach the target angular uncertainties. The formula use to compute photometric S/N is:

$$S/N = (2)^{0.5} P^{-1} \cotangent(2 * \sigma_{\theta})$$

where P is the mean polarization percentage, and σ_{θ} is the target polarization position angle uncertainty. The factor of root-two comes from the relation between photometric measurements and the development of Stokes U and Q parameters.

Photometric Signal-to-Noise Required to Achieve Position Angle Knowledge							
Polariz. P [%]	Distrib. Percentile	Position Angle Uncertainty [in degrees]					
		1	3	5	7	10	15
0.55	5th	7364	2447	1458	1031	707	445
0.79	10th	5127	1703	1015	718	492	310
1.0		4050	1346	802	567	389	245
1.5		2700	897	535	378	259	163
2.0		2025	673	401	284	194	122
2.6	50th	1534	510	304	215	147	93
3.0		1350	449	267	189	130	82
3.5		1157	384	229	162	111	70
4.0		1013	336	201	142	97	61
4.5		900	299	178	126	86	54
5.0		810	269	160	113	78	49
5.5		736	245	146	103	71	45
6.0		675	224	134	95	65	41
6.8	90th	599	199	119	84	57	36
7.0		579	192	115	81	56	35
7.5		540	179	107	76	52	33
8.0		506	168	100	71	49	31
8.5	95th	476	158	94	67	46	29
9.0		450	150	89	63	43	27
9.5		426	142	84	60	41	26
10.0		405	135	80	57	39	24

S/N > 600:1 - exceeds M4/1997 goal - risk, credibility, calibration problems increased

150 < S/N < 600 - M4/1997 goal - mission hardware designed to meet this level

S/N < 150 - M4/1997 requirement - minimum value needed to ensure mission success.

The green colored cells identify combinations with S/N under 150:1, which is the M4 photometric *requirement*. The yellow colored cells identify combinations with S/N under 600:1 but

more than 150:1, which meet the M4 photometric *goal*. The red colored cells identify combinations with S/N values in excess of the M4 goal. Many of these may be achieved, however the data collection system is only guaranteed to not degrade values of S/N under 600:1.

The second column identifies the 100mm polarization percentage distribution percentiles, as measured by the Chicago group on the KAO. The 10th percentile occurs at a polarization of just under 0.8%, while 50% is at 2.6%.

Note that M4 will be able to meet the Science Team consensus goal of 3 degree position angle uncertainties only for the brightest half of the polarization distribution.

I believe this goal is excessive for conducting our science, and I'd like to argue for the following requirements and goals:

Requirement: 10 degrees position angle uncertainty for 90% of all positions showing
P > 2.5% (that is, 50% of the KAO distribution)
[This requirement leads to our photometric S/N requirement of 150:1]

Goals: 10 degrees position angle uncertainty for 90% of all positions showing
P > 0.8% (90% of all KAO measurements)
3 degrees position angle uncertainty for 90% of all positions showing
P > 2.5%
[These goals lead to our photometric S/N goal of 600:1]

We were able to sell these levels (150:1 & 600:1) in the M4/1997 proposal pretty well. If we try to push M4/1999 beyond 600:1, I don't think we will get through the science panel.

11/2/99 DC