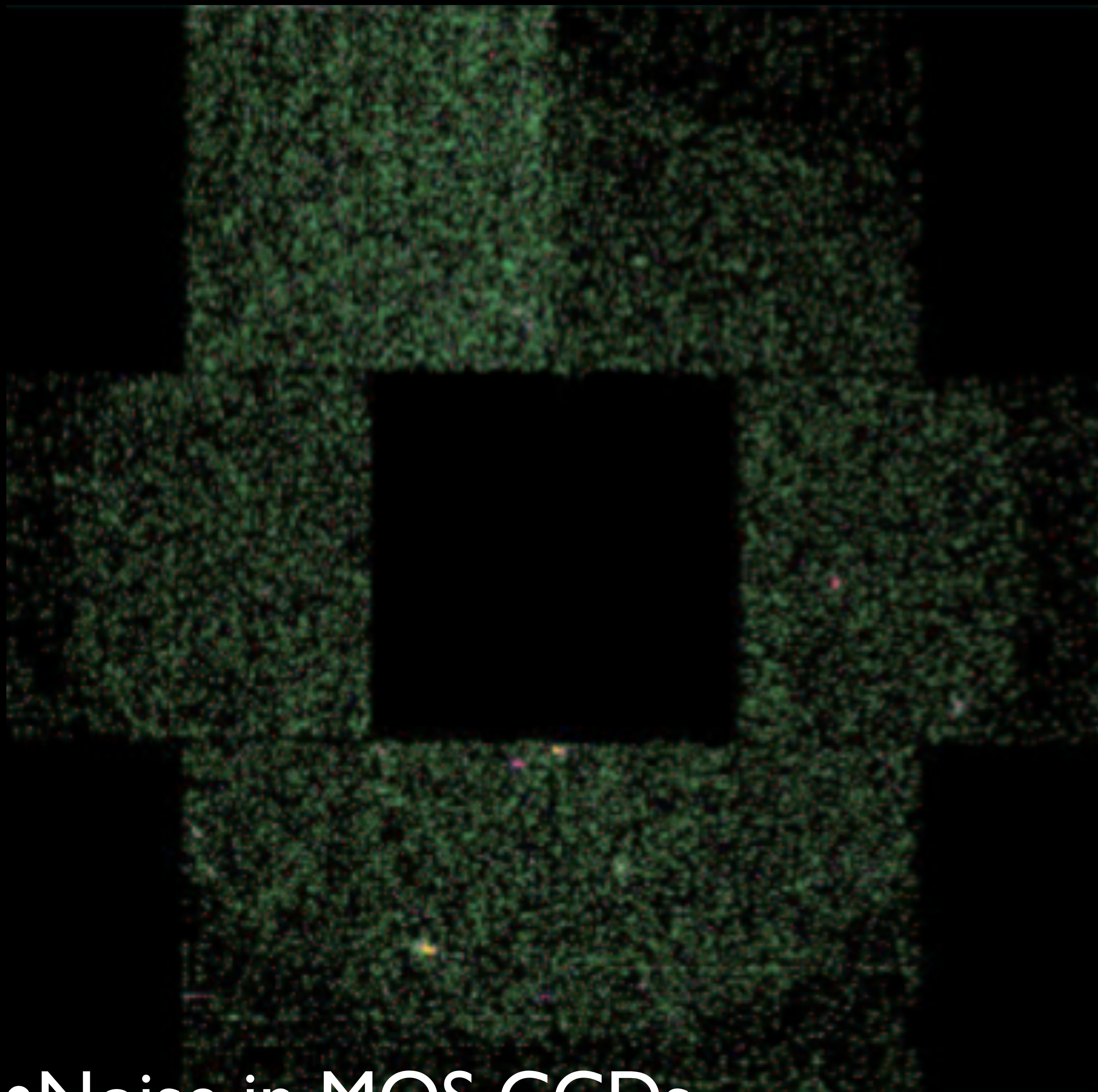
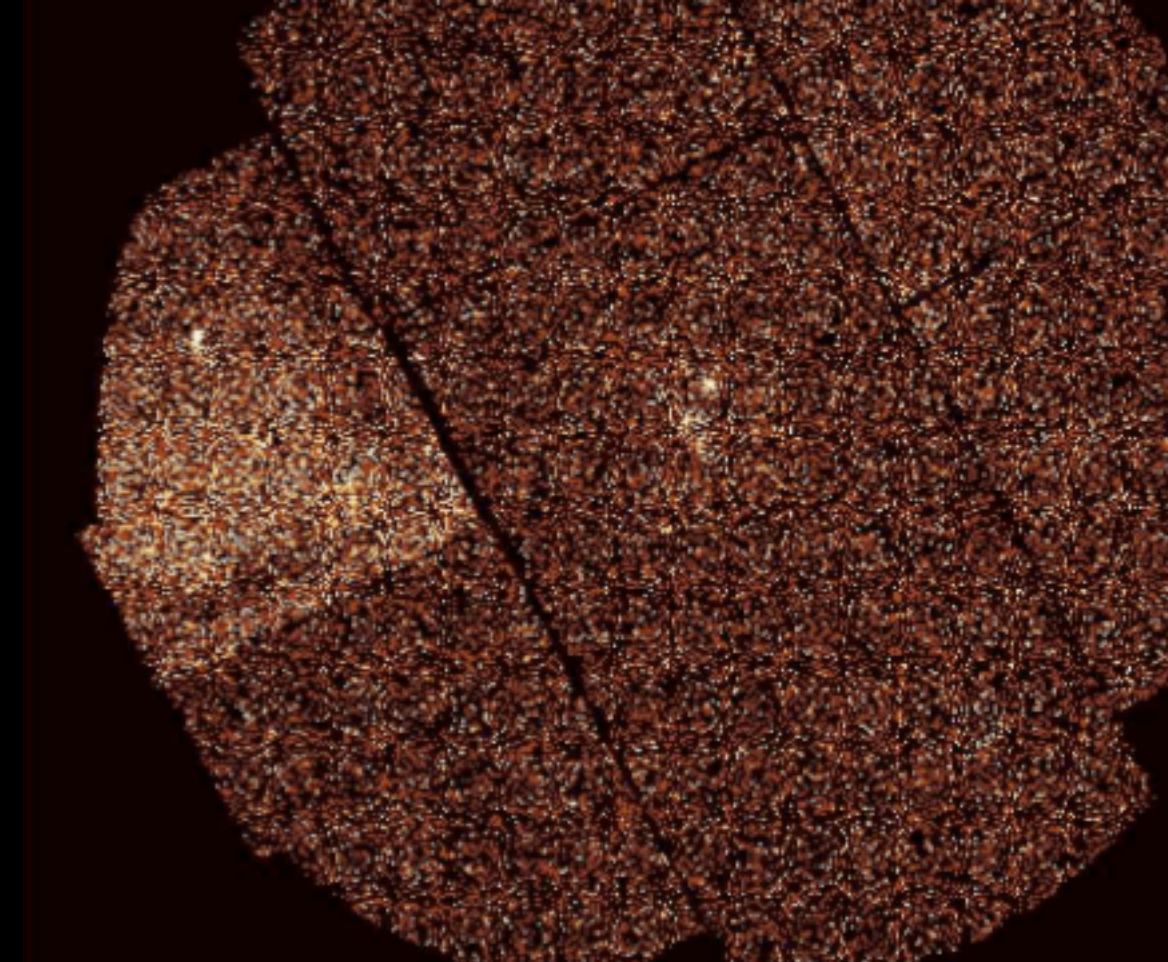
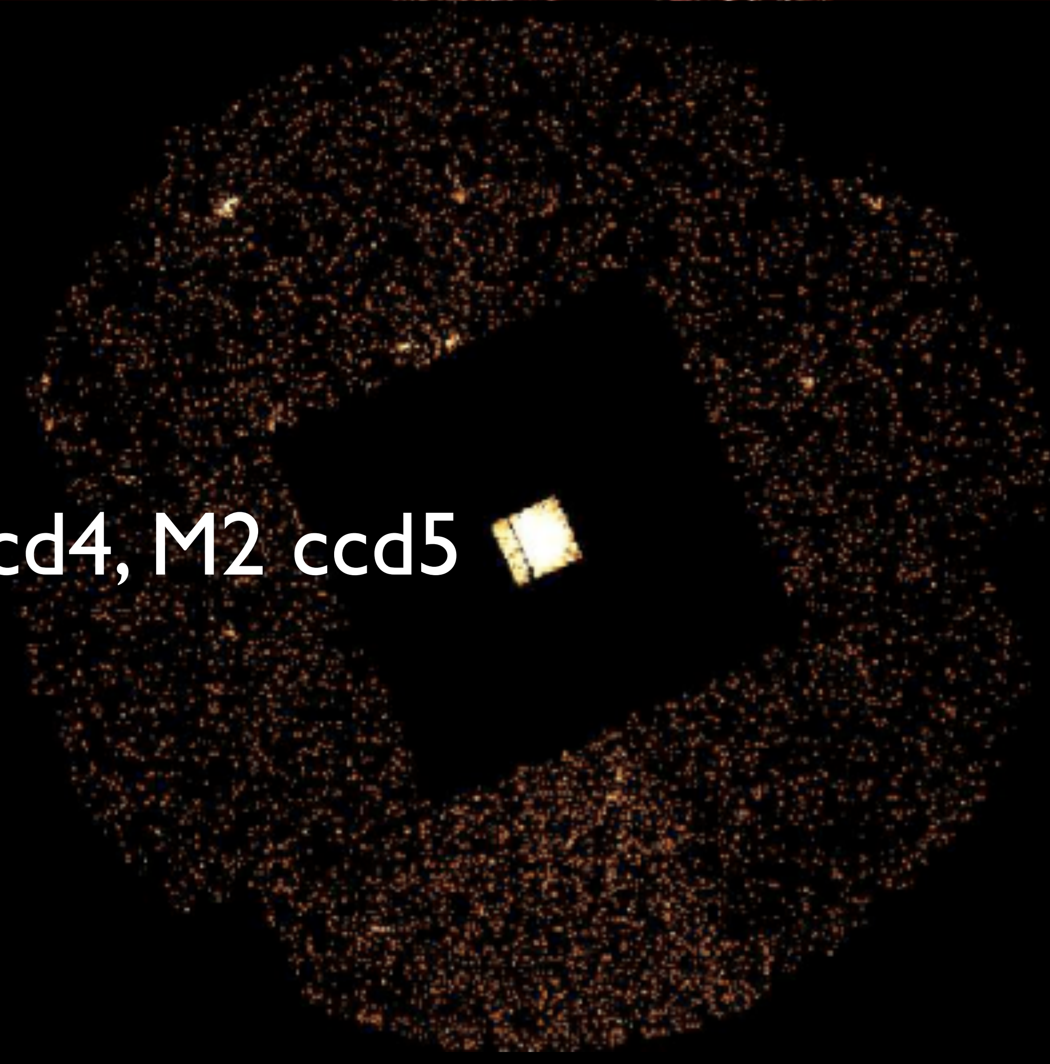
MOS CCD NOISE

Andy Read

Tao Song, Steve Sembay, Tony Abbey

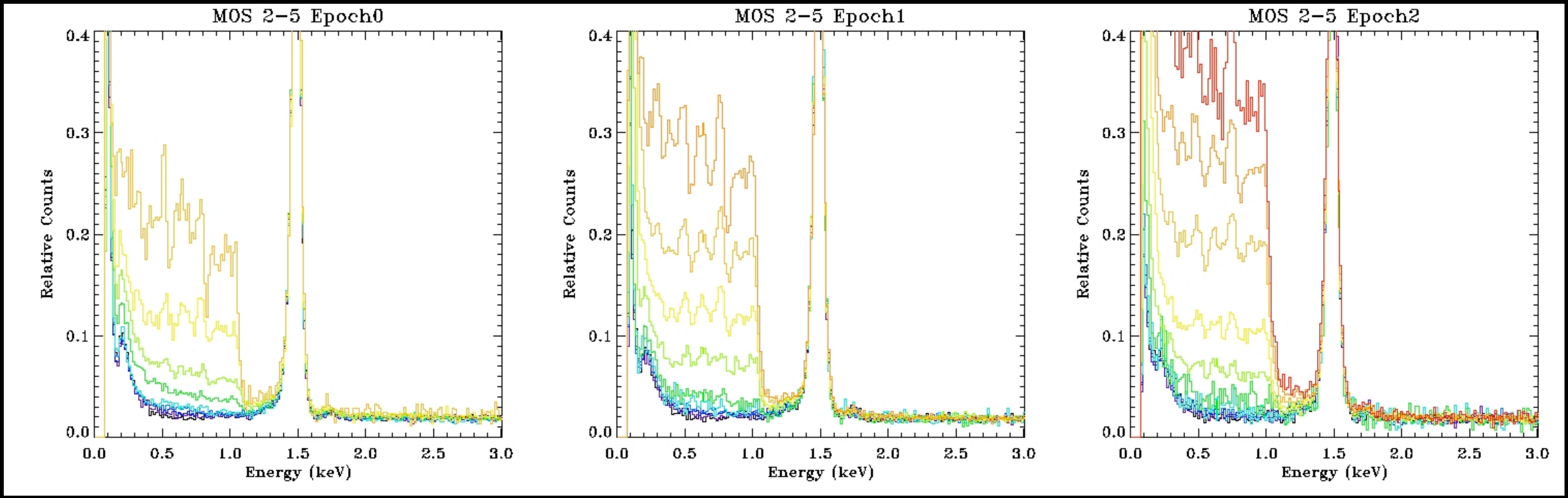






- Noise in MOS CCDs
- Low energy plateau (<1keV)
- Multiple CCDs, both MOS, notable M1 ccd4, M2 ccd5
- Varying intensities
- No on/off within an observation
- No correlation with any HK
- Excess of patterns 2 & 4

Previous studies by KK, MSt : MOS2 CCD5, Noise getting more intense, more frequent



Early Rev Mid Rev Late Rev

Hubert Chen, last calibration meet:

- Noise is correlated in P2 and P4 in Energy1-Energy2 (E1-E2) plane

- Problem in readout amplifier circuit, not in pixels

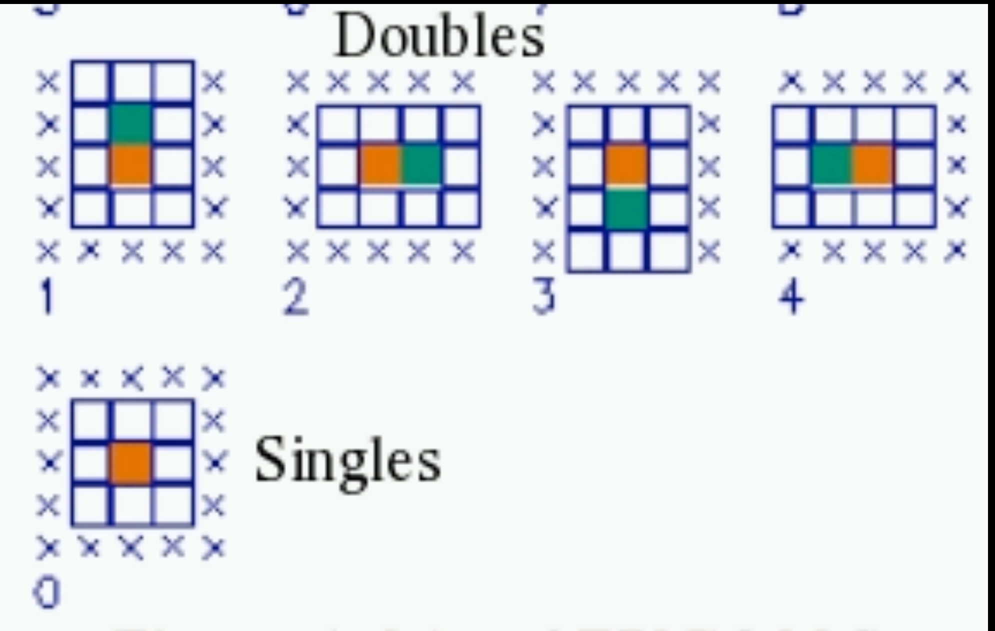
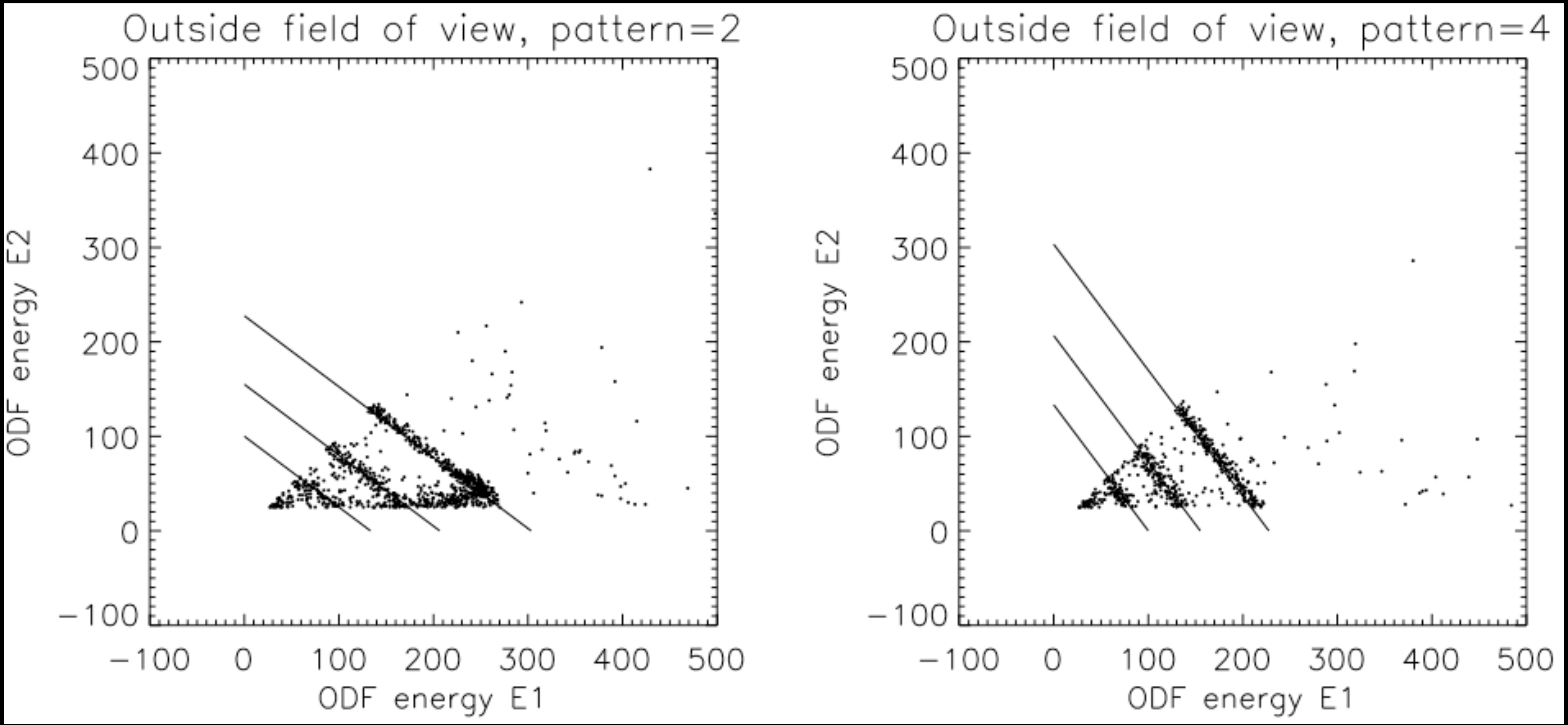


Figure 1: List of EPIC-MOS patterns (IMAGING mode)



The MOS Noise Test

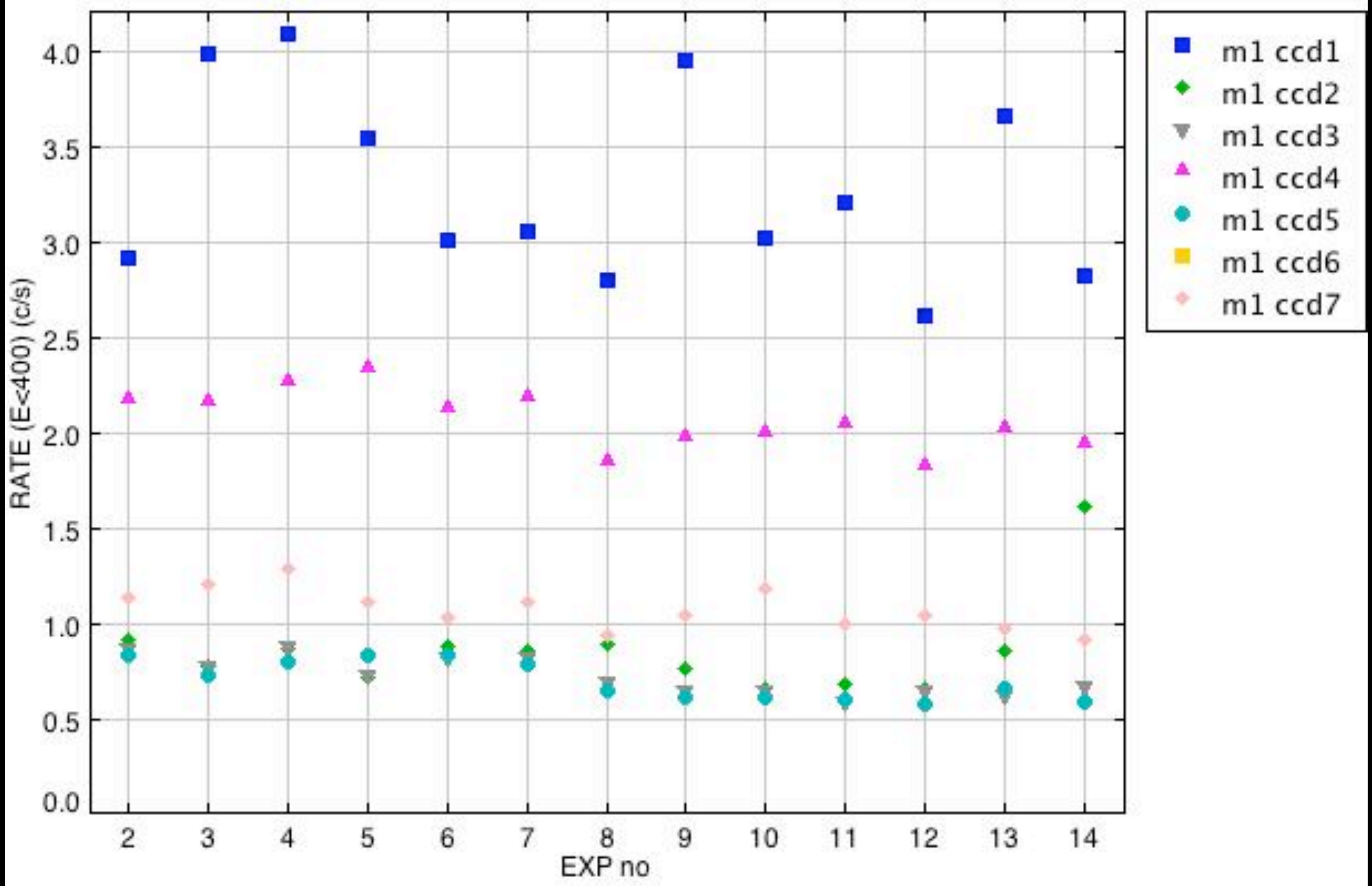
- Onset of noise could be related to the readout sequence
- Test, to restart the sequence in the middle of an observation - see whether the noise disappears
- The Results:

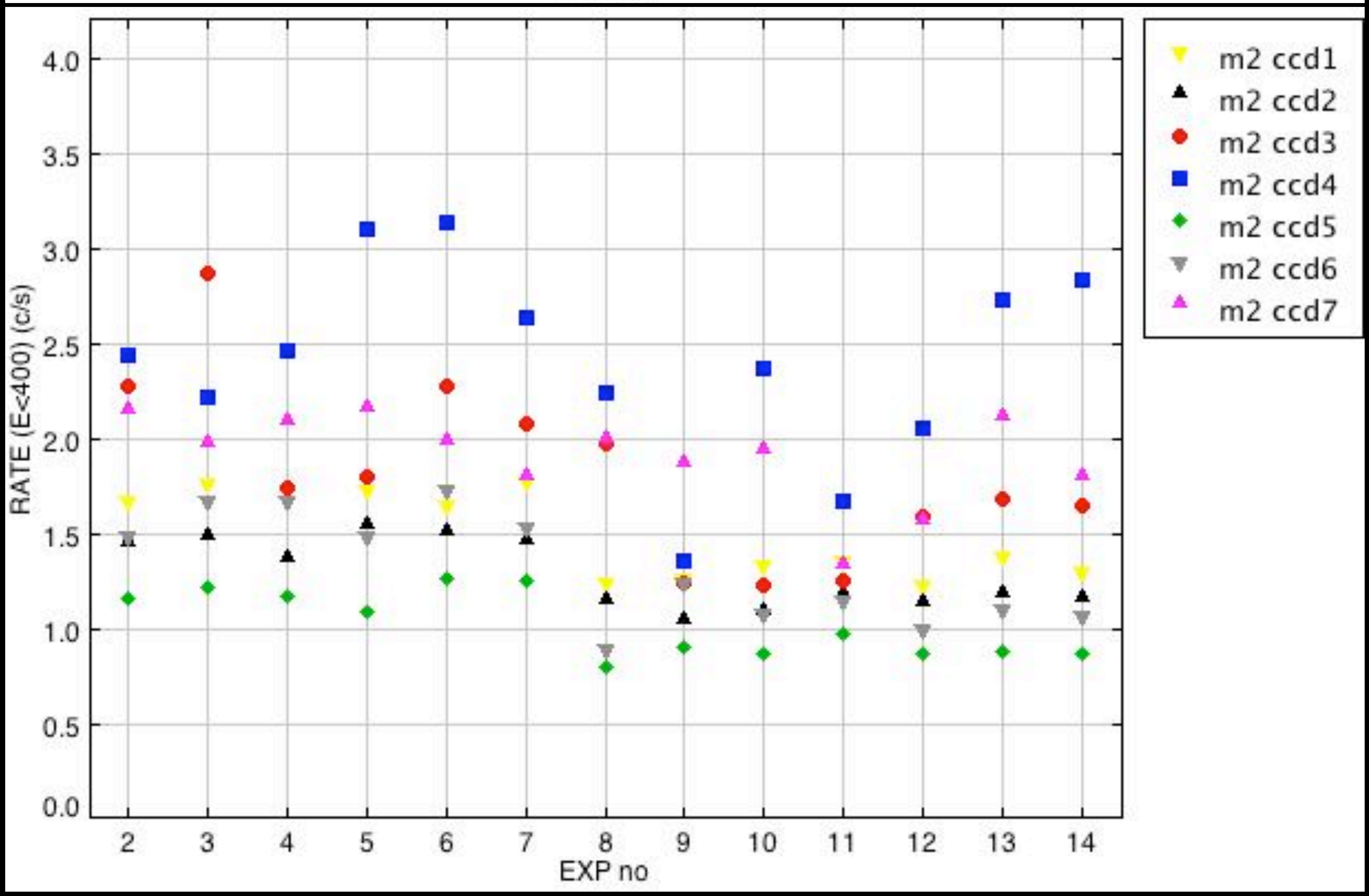
The MOS Noise Test

- Onset of noise could be related to the readout sequence
- Test, to restart the sequence in the middle of an observation - see whether the noise disappears
- The Results: It didn’t work

The MOS Noise Test

- Onset of noise could be related to the readout sequence
- Test, to restart the sequence in the middle of an observation - see whether the noise disappears
- The Results: It didn't work
    - MOS1 ccd4 appeared noisy throughout the whole test
    - MOS2 ccd5 appeared clean throughout the whole test
    - This behaviour remained ~constant despite 12 restarts





Rates (E<400)

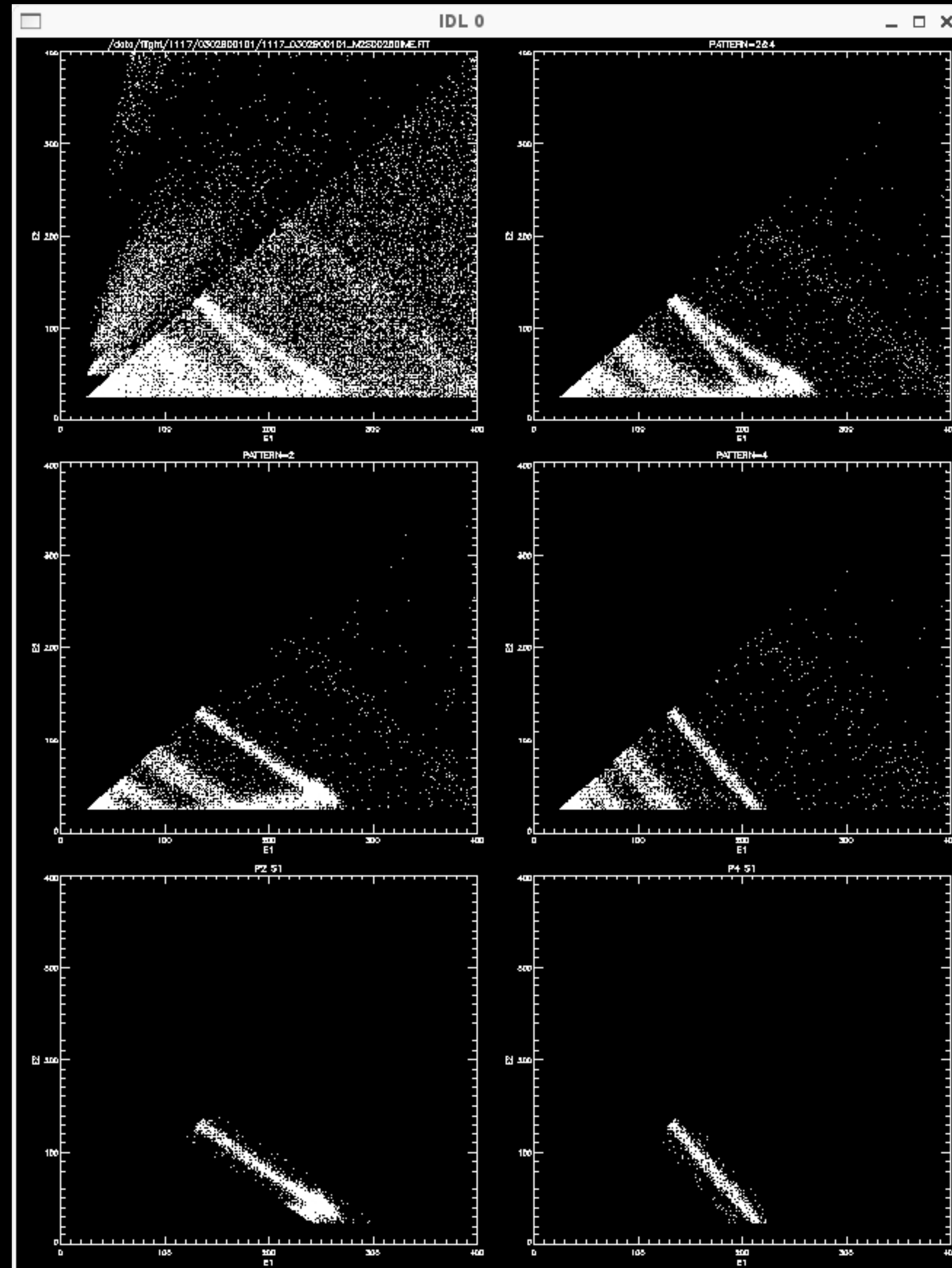
M1 ccd1 strong
M1 ccd4 strong
M1 rest weak
M2 all medium
M2 ccd5 medium/weak
No change exp to exp

Example of noisy CCD
1117 0302900101
E1-E2 plot
MOS2 CCD5

All Events P2&P4

P2 P4

P2 in S1 P4 in S1

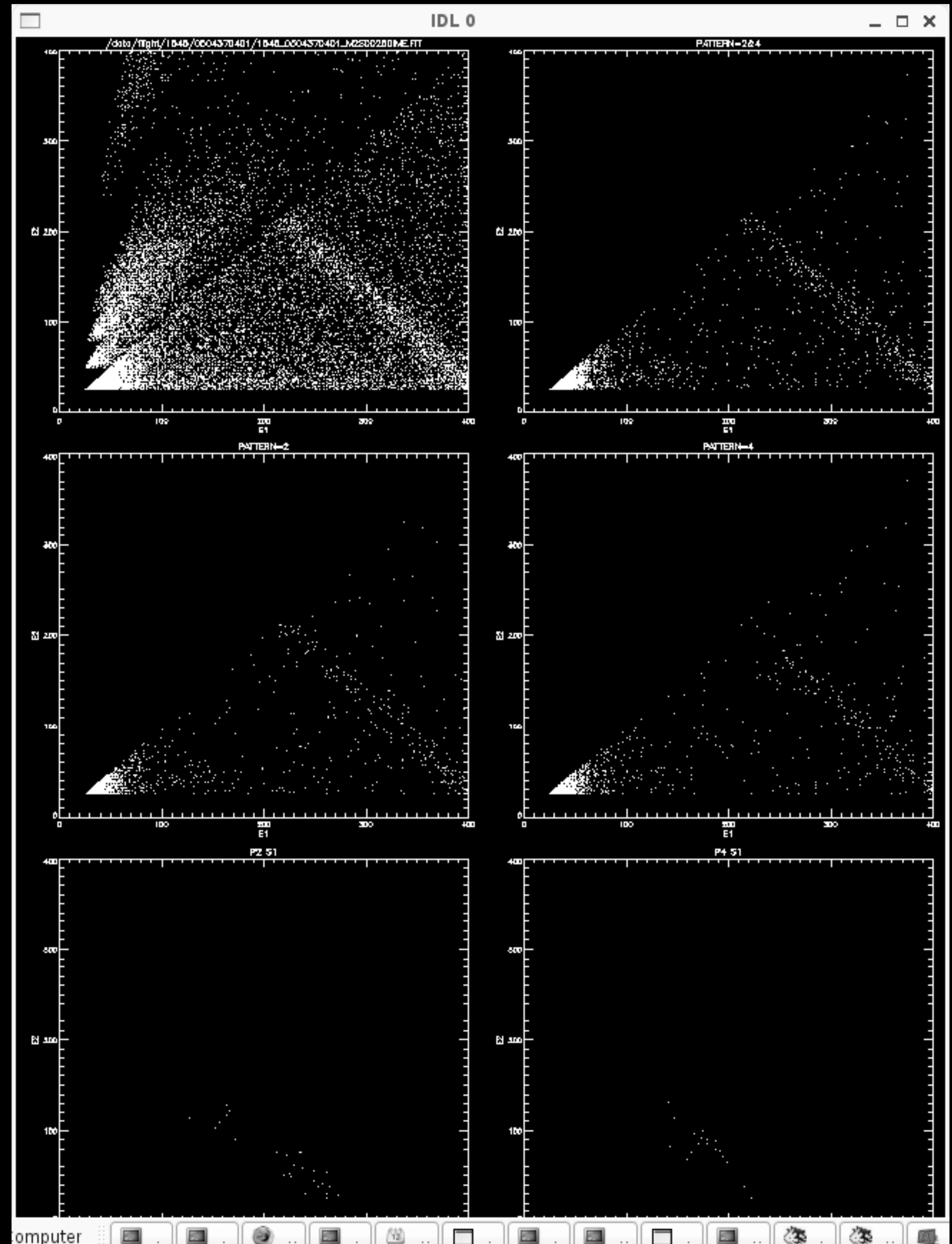


Example of quiet CCD
1545 0504370401
E1-E2 plot
MOS2 CCD5

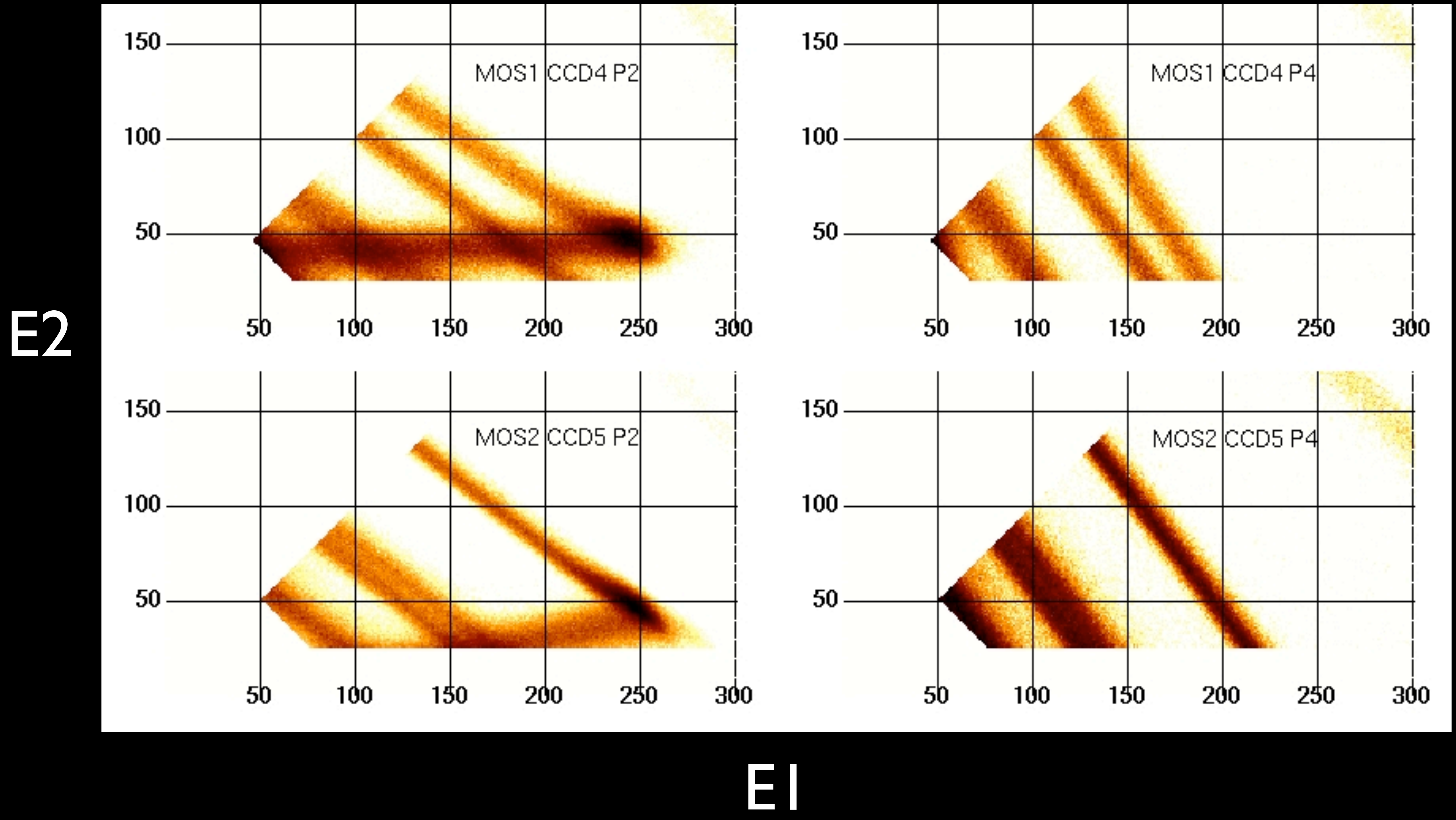
All Events   P2&P4

P2   P4

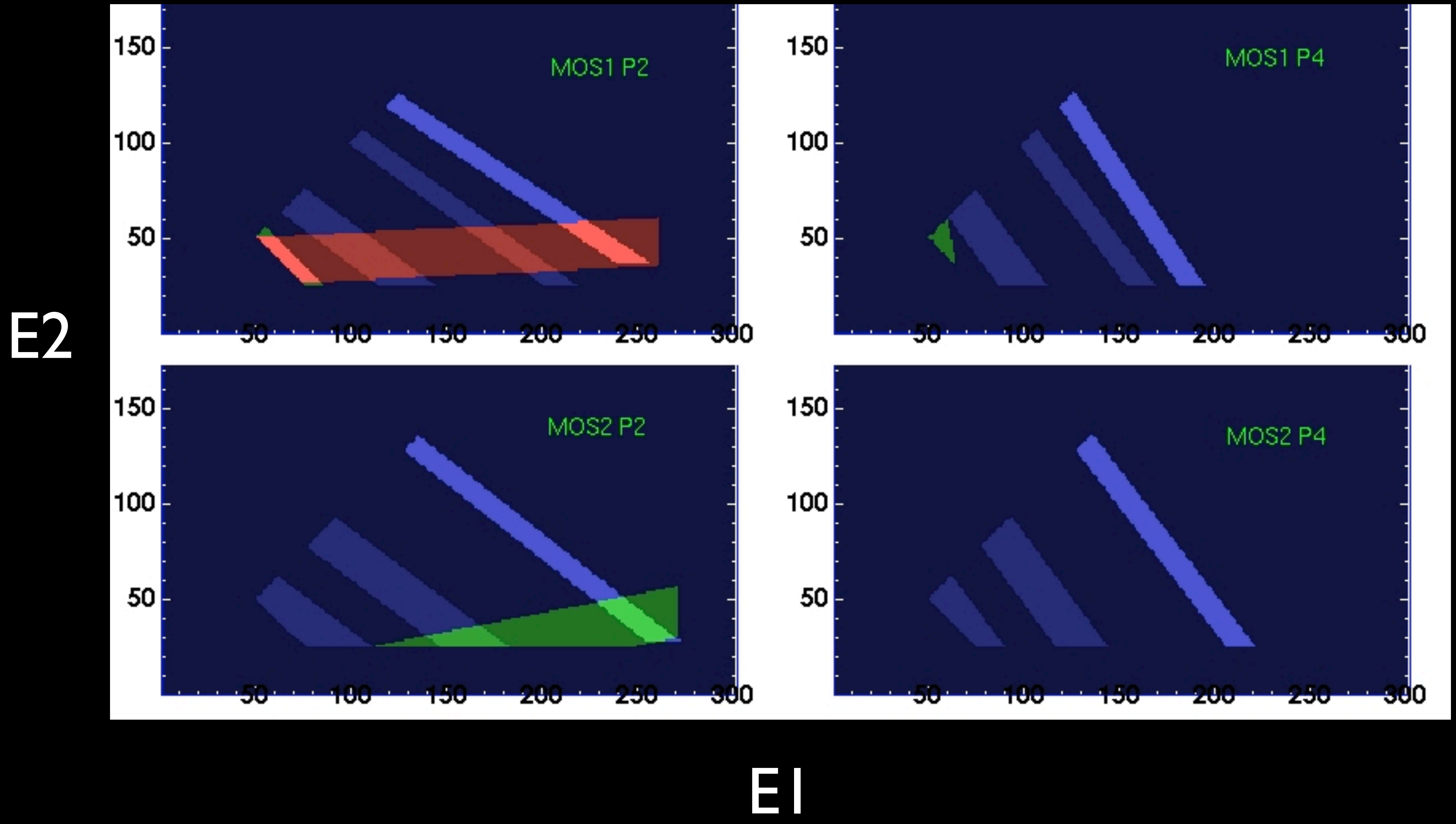
P2 in S1   P4 in S1



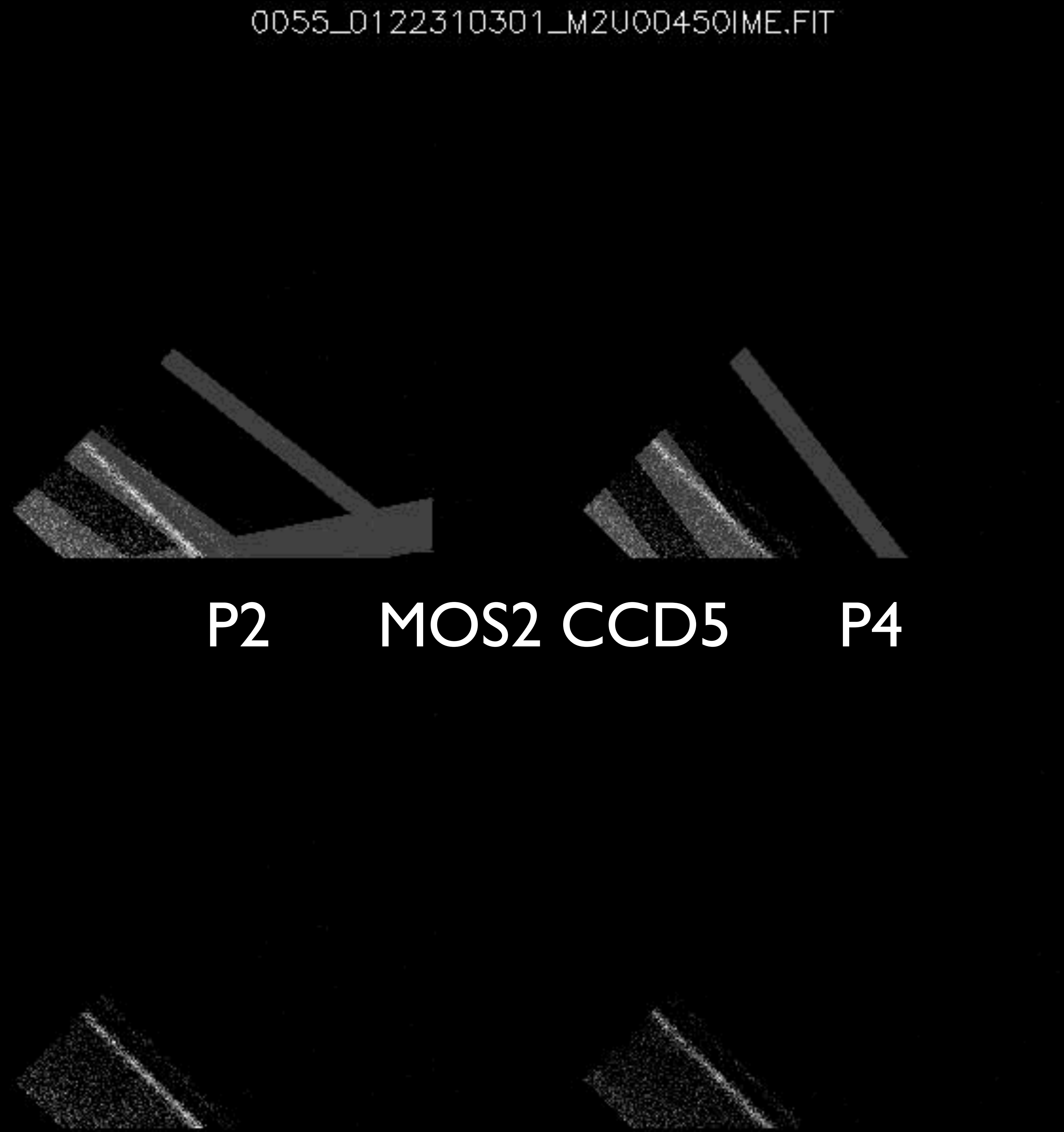
Bad cases: M1 ccd4 and M2 ccd5: Stacking many noisy datasets together - looking at P2 and P4 distributions in the E1-E2 plane



Bad cases: M1 ccd4 and M2 ccd5:
Use data stacks to define regions - ‘stripes’ and ‘floor’
- different for each detector and for each chip



0023_0115810301_M1S00940IME.FIT
P2
MOS1 CCD4
P4


0055_0122310301_M2U00450IME.FIT
P2
MOS2 CCD5
P4

fP2S1 (E<400) - fraction of P2s in main stripe S1 - as a function of revolution and CCD

MOS1 CCD4 and MOS2 CCD5 very evident

Also strengthening effect, but biased by 'moving target' effect...

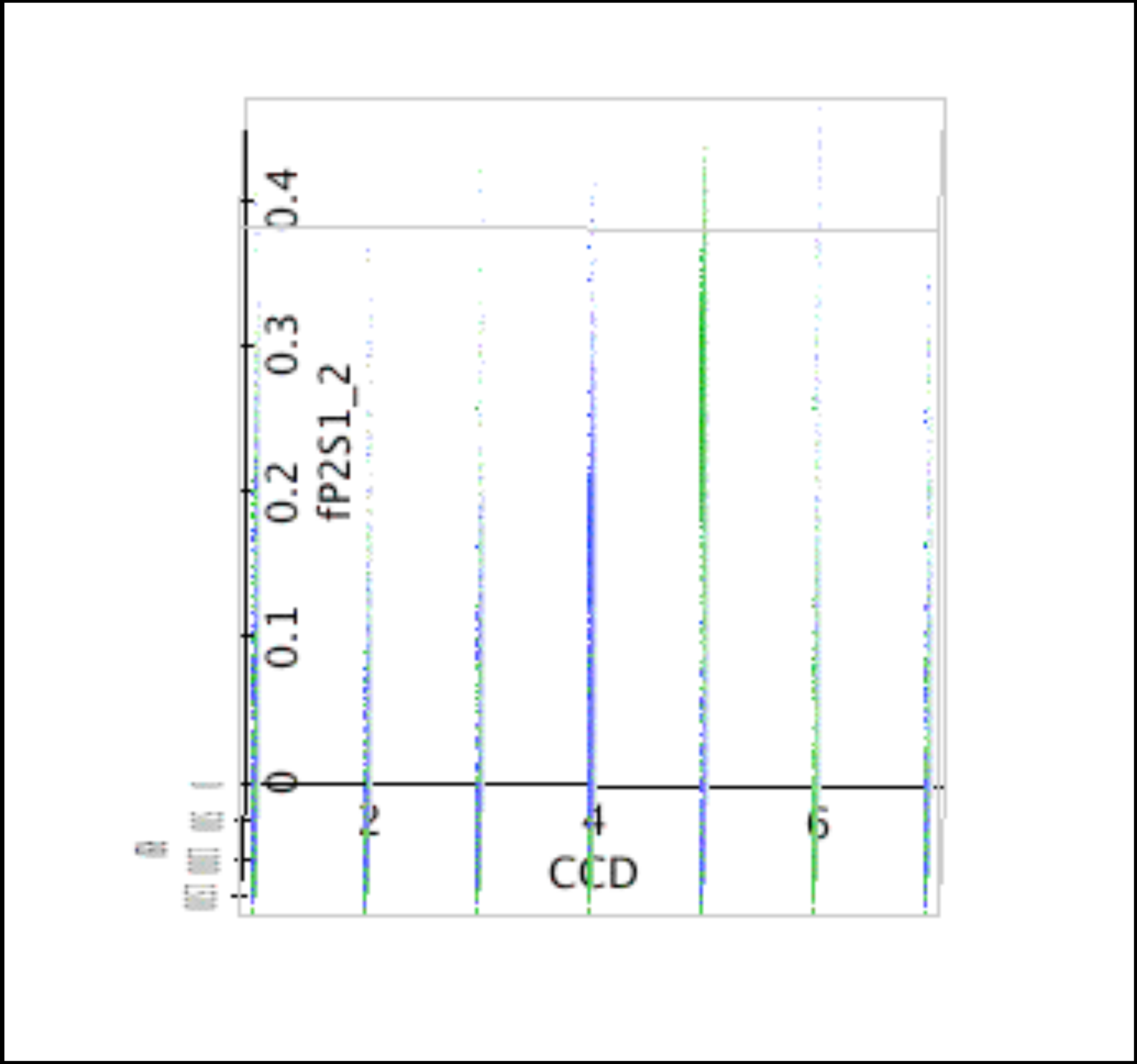
MOS1
MOS2

fP2S1 (E<400) - fraction of P2s in main stripe S1 - as a function of revolution and CCD

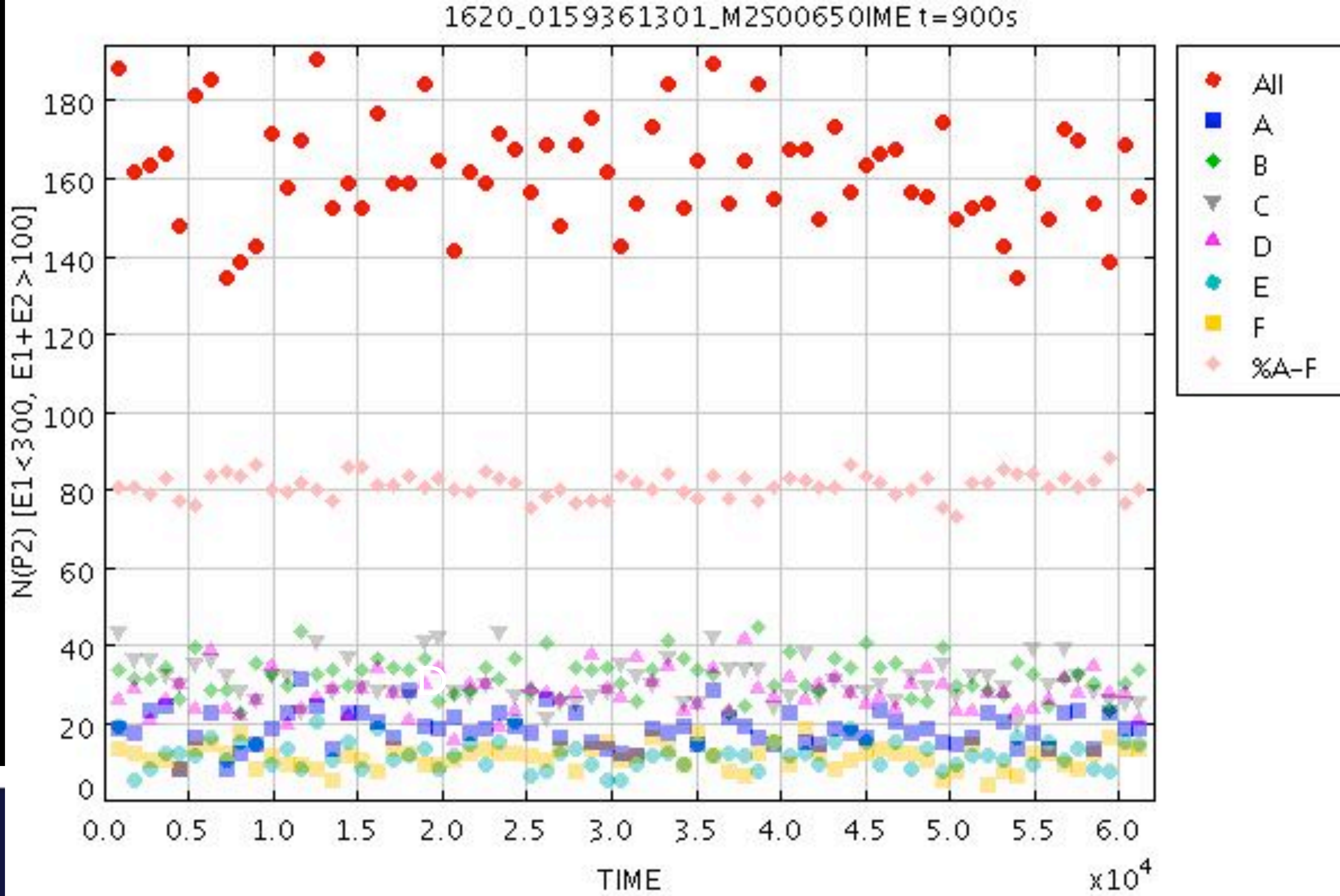
MOS1 CCD4 and MOS2 CCD5 very evident

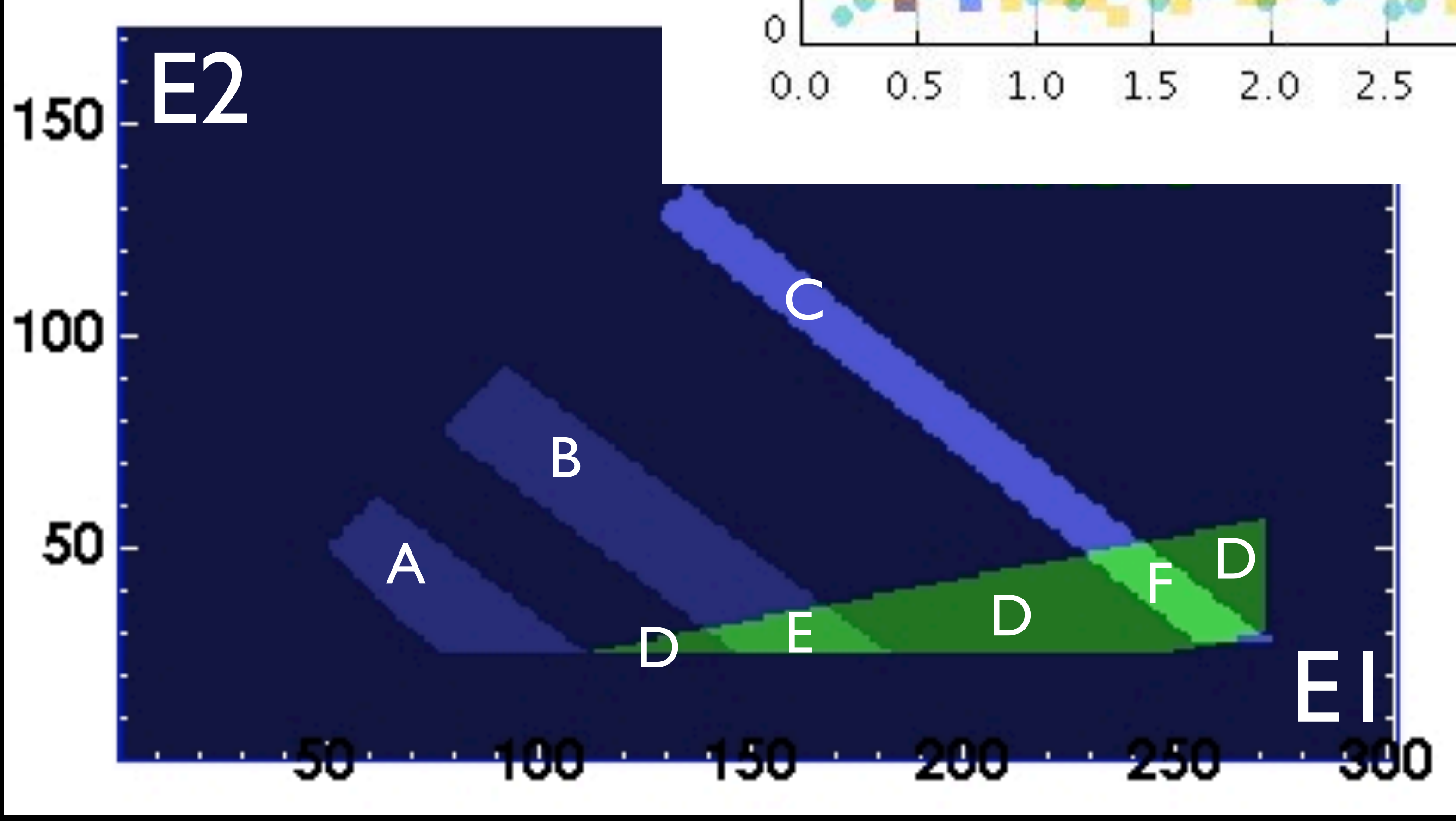
Also strengthening effect, but biased by 'moving target' effect...

MOS1
MOS2



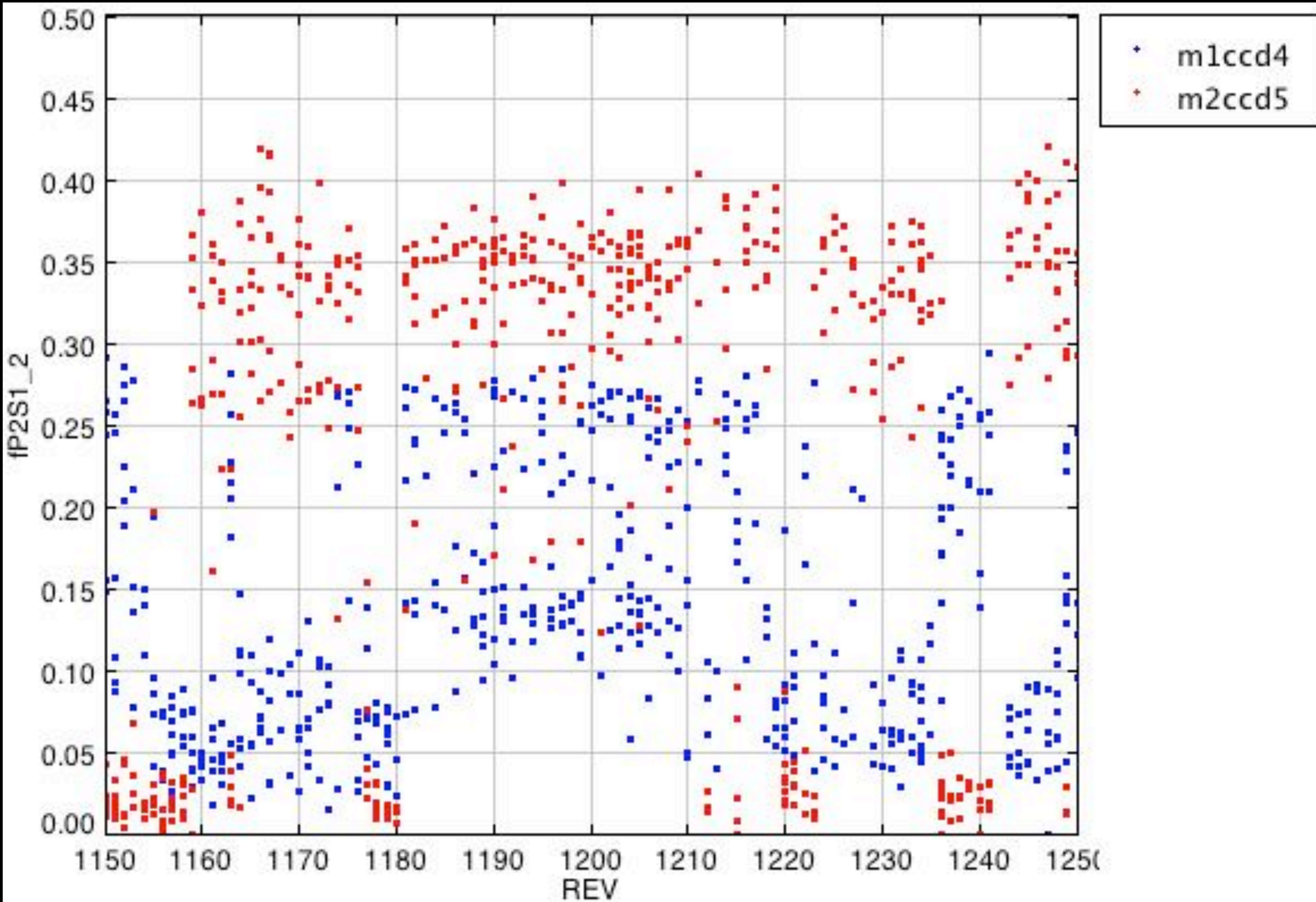
Noise rates in P2 regions
MOS2
CCD5 P2
1620
0159361301
900s time bins



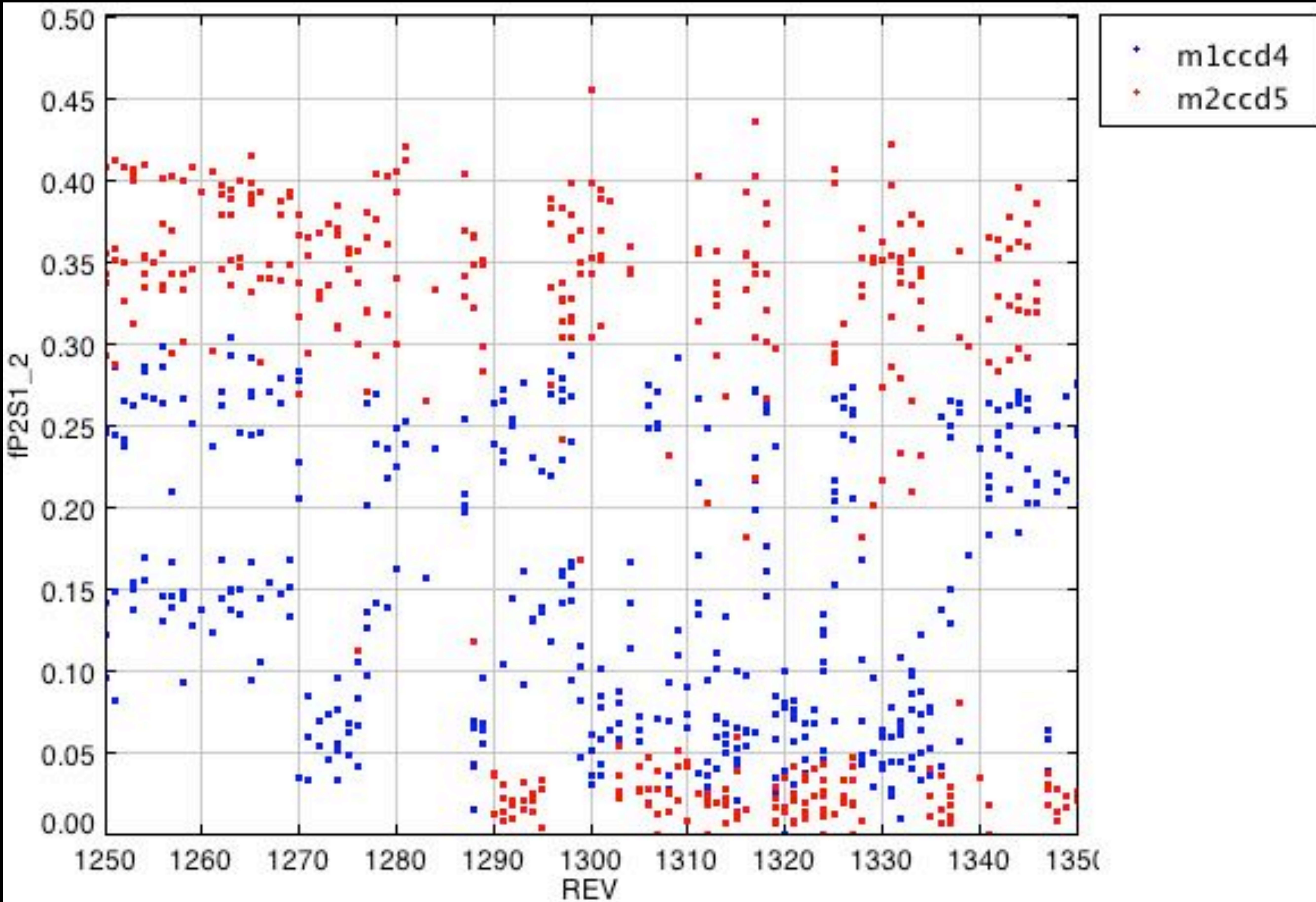


Rates in individual regions remain ~constant over an observation

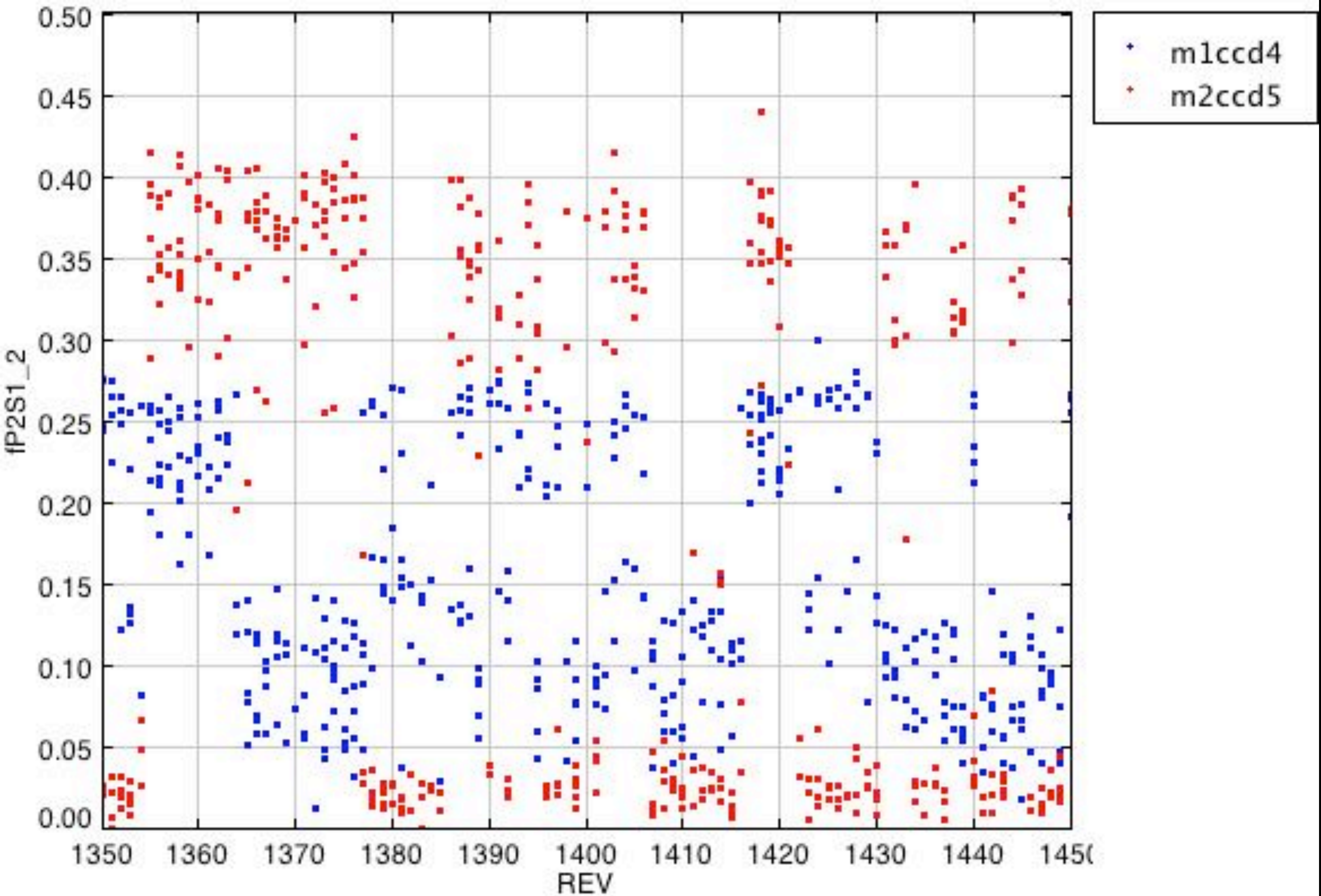
Longterm variations?



Longterm variations?

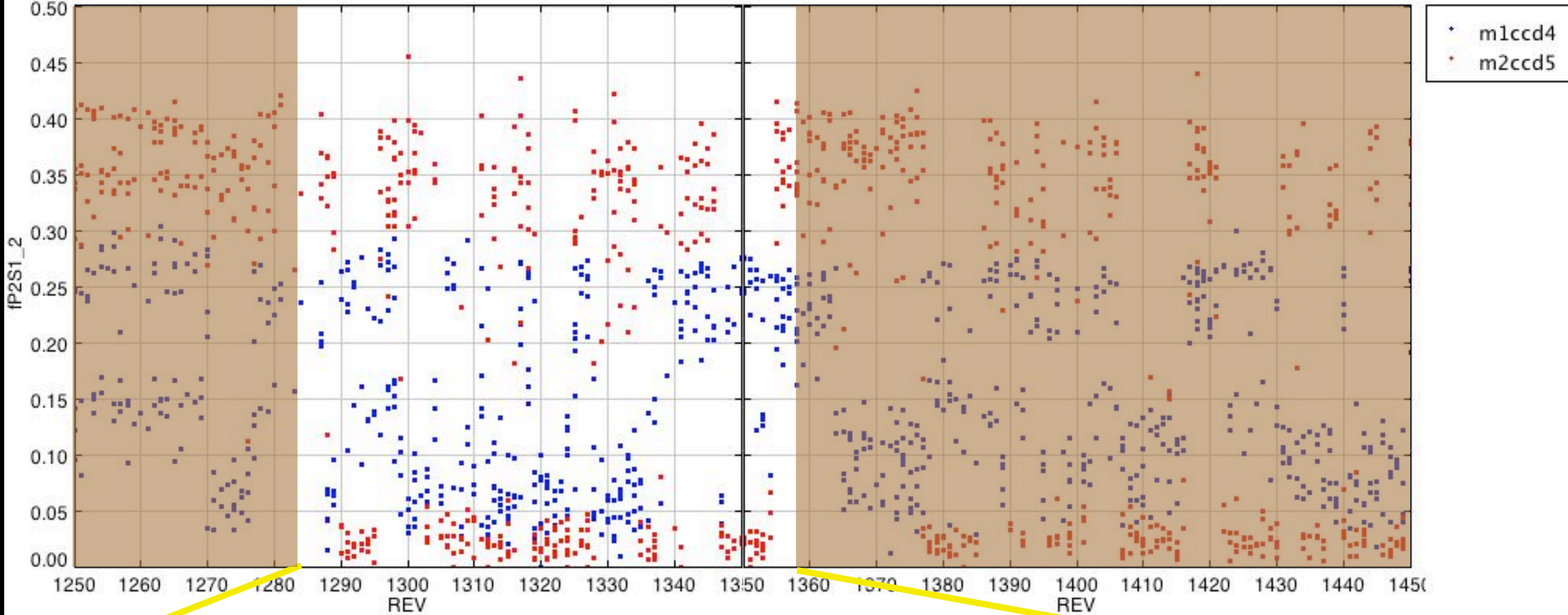


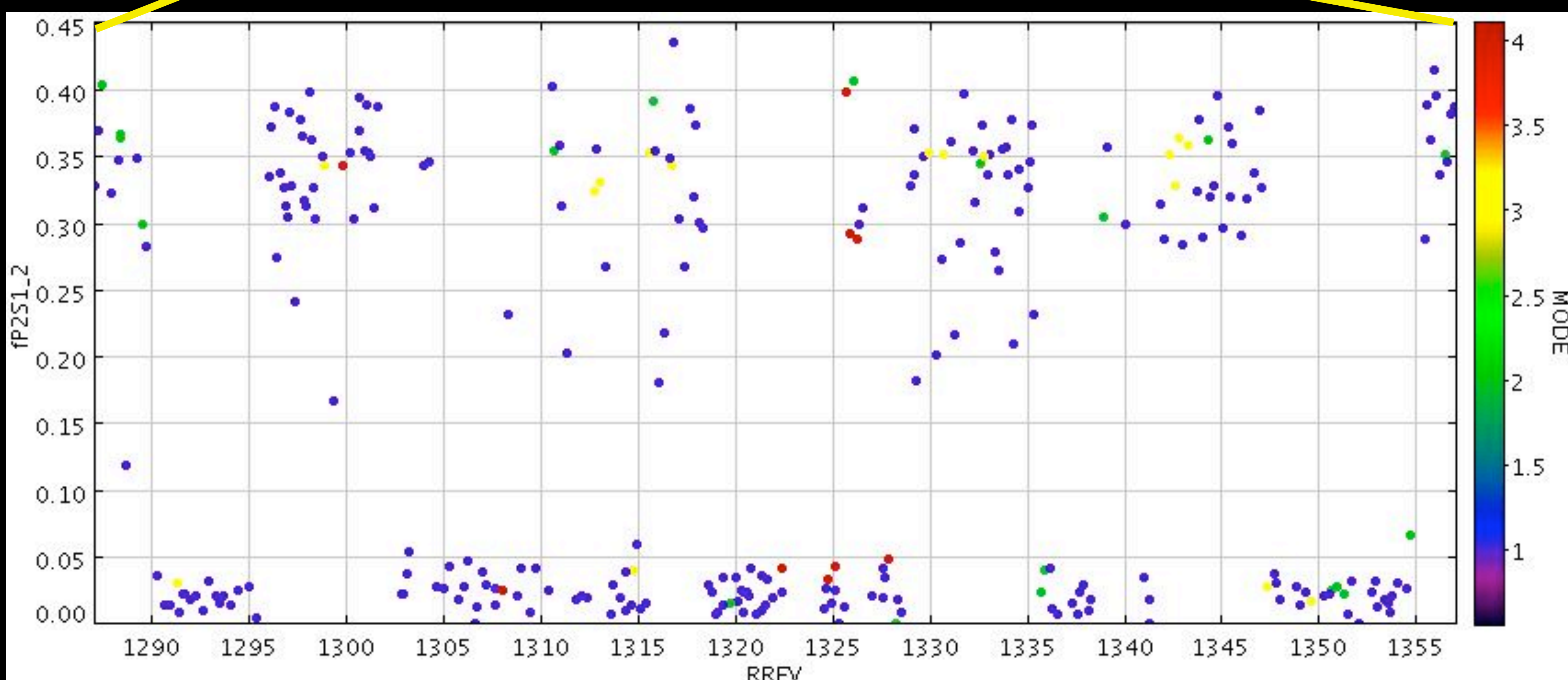
Longterm variations?



Situation at time of XMM-Newton 10th Birthday Meeting

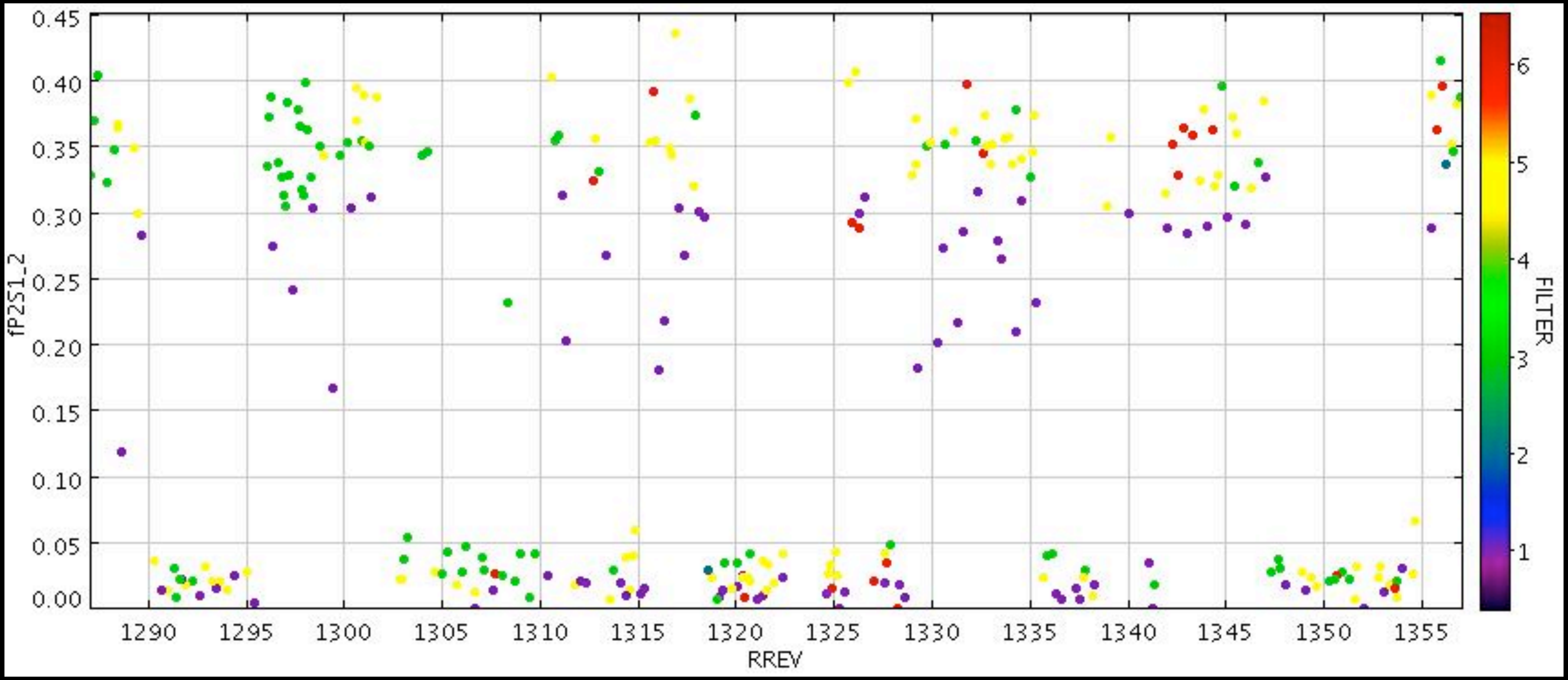
• Continue to look at correlations of high noise with other parameters
• Already believe that no correlations exist with HK parameters (HC/AMR/AA)
• Looking at other observational and spacecraft parameters...
• Zoom in on detailed look of interesting, clean, dynamic revolution range... MOS2 CCD5 (M2C5)





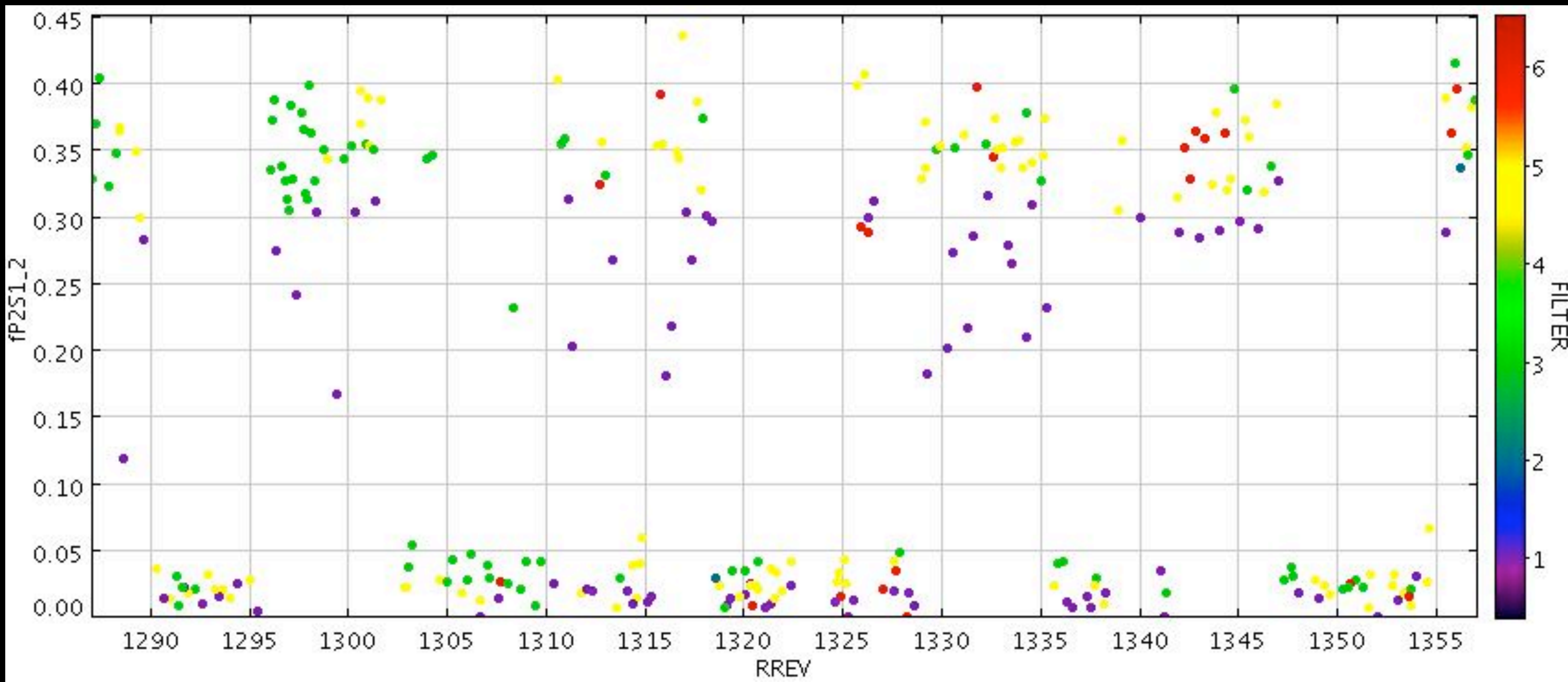
M2C5
Rev:
1287-1357

Instrument
Mode



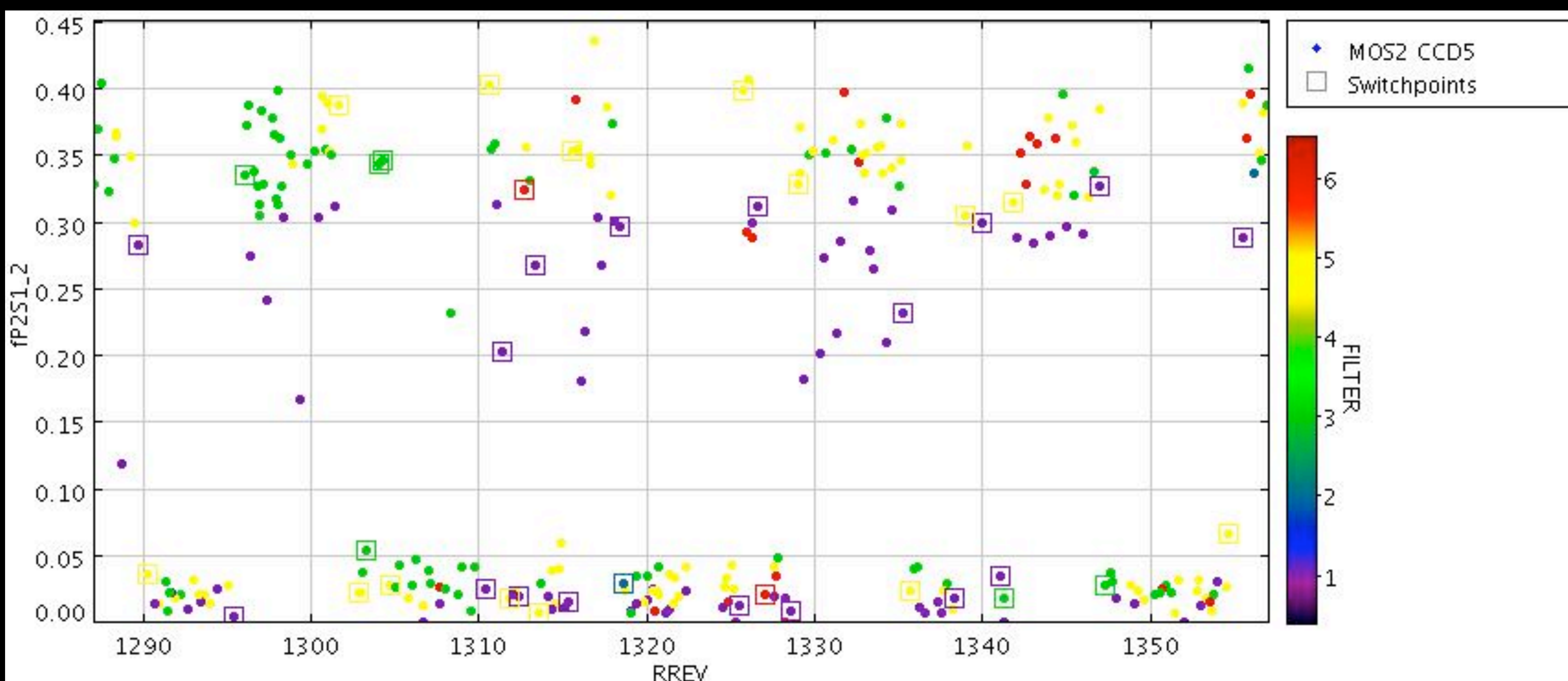
M2C5
Rev:
1287-1357

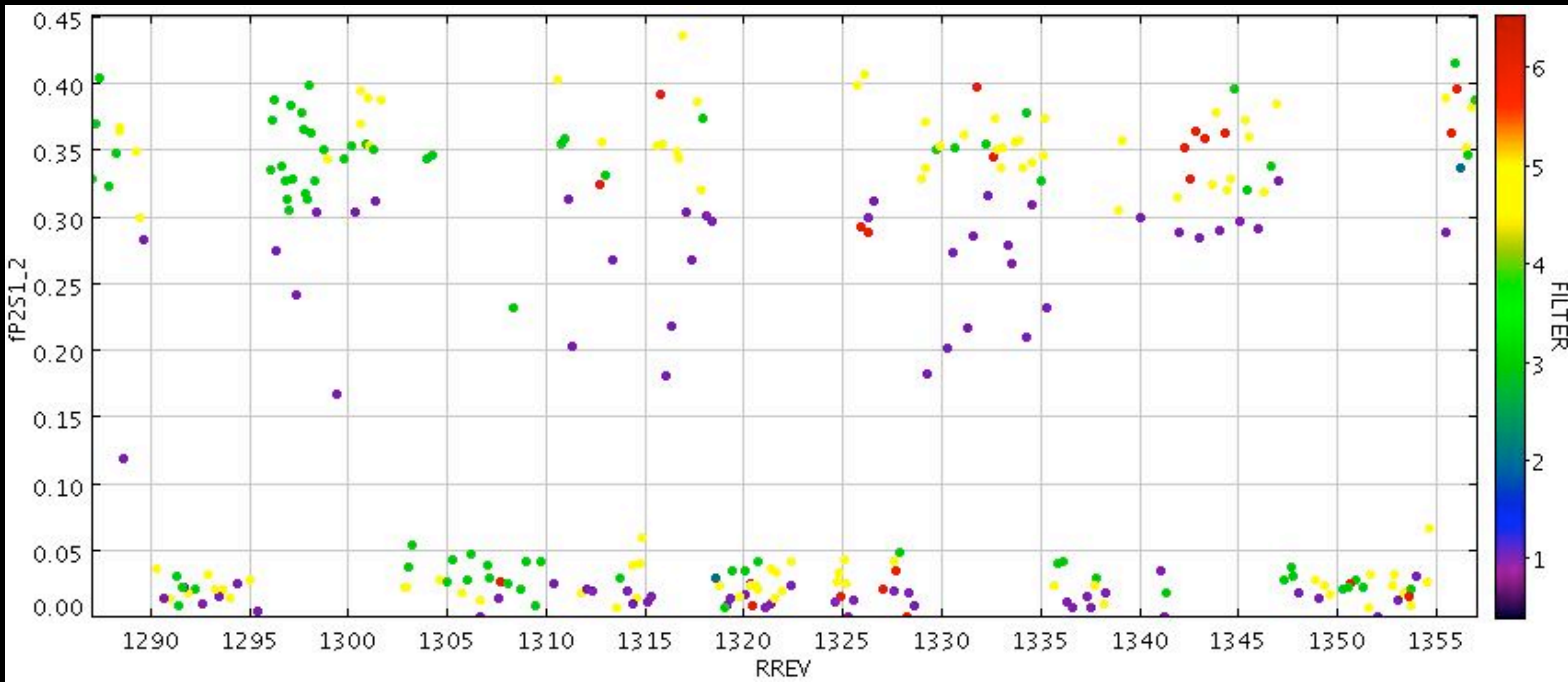
Filter



M2C5
Rev:
1287-1357

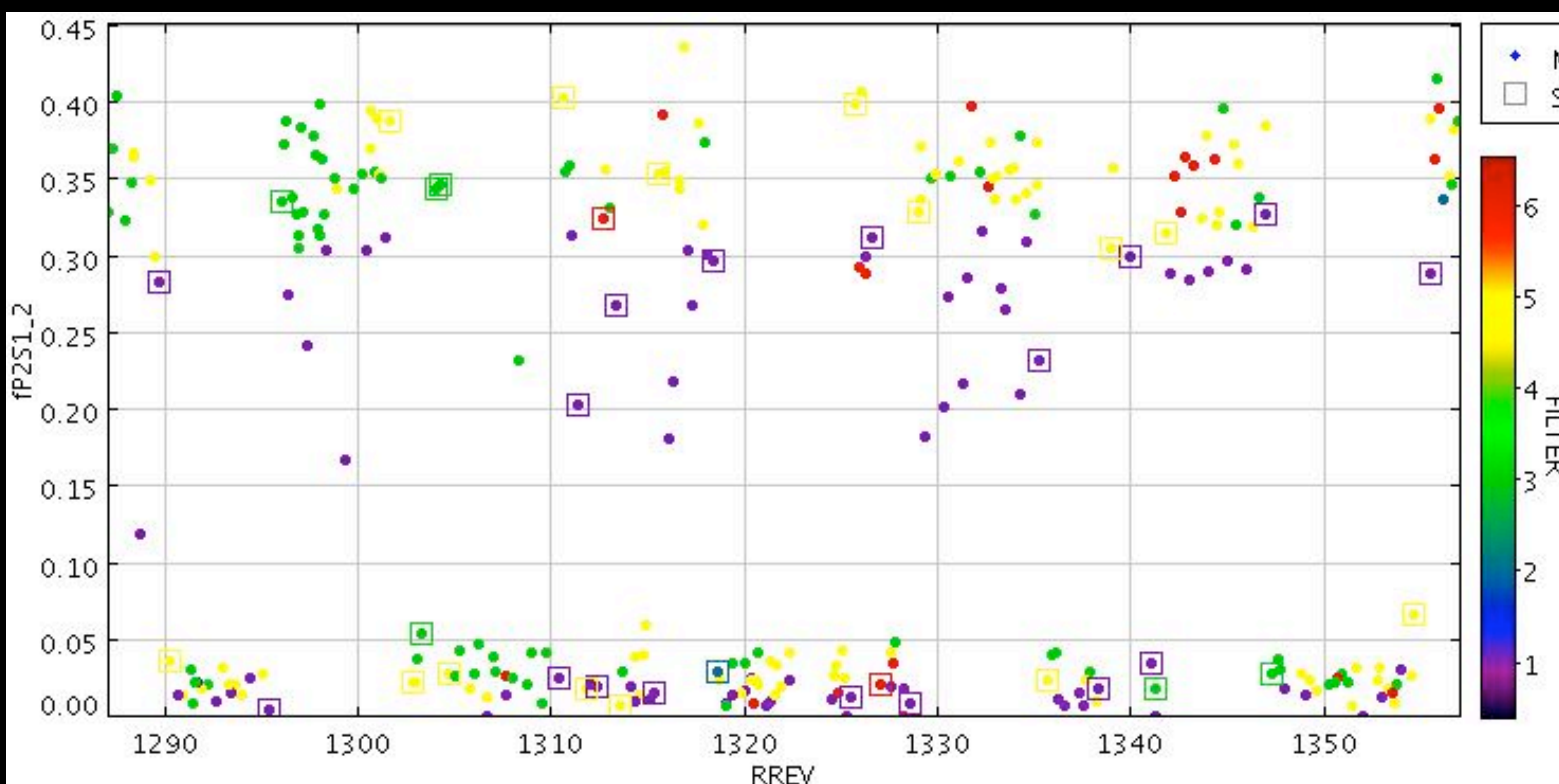
Filter





M2C5
Rev: 1287-1357

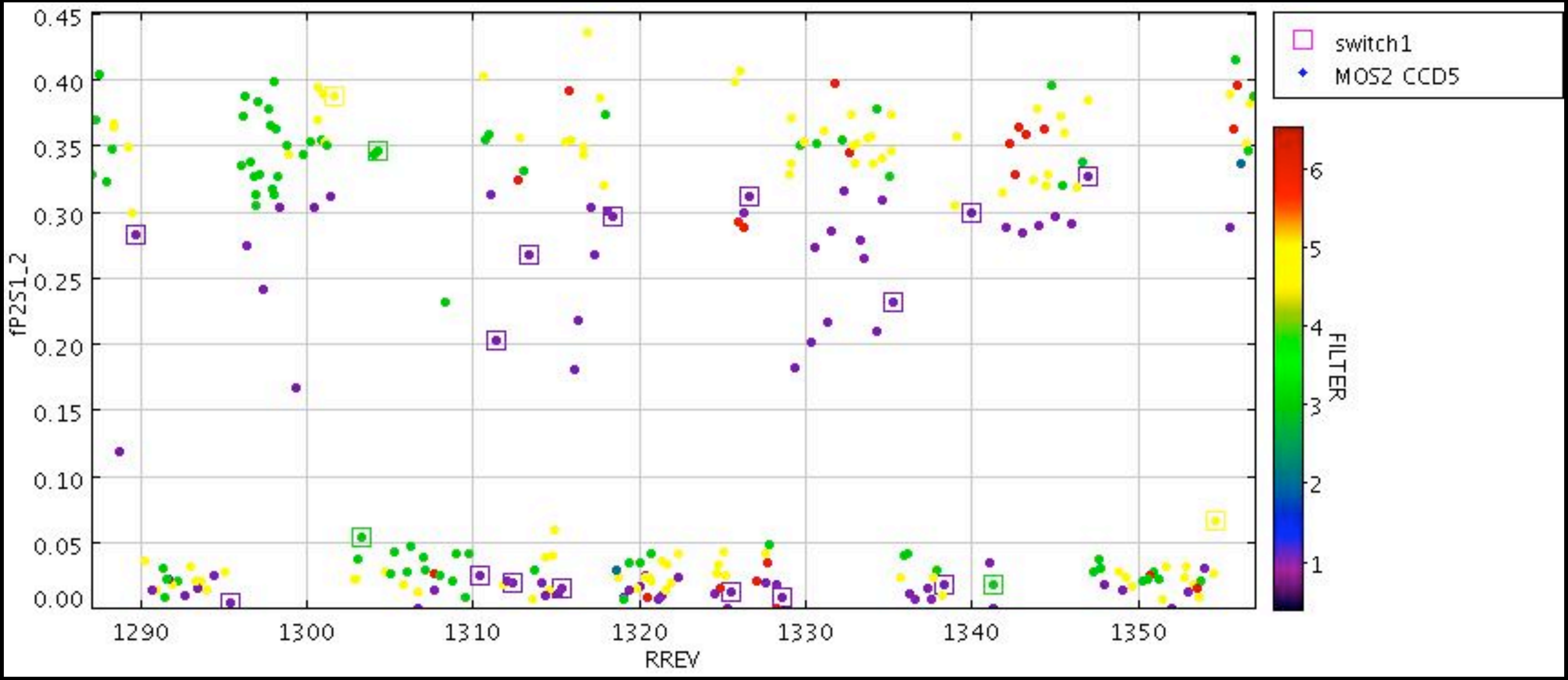
Filter



'Switchpoints' :

Observations directly before and directly after a large change in the BG.

Many appear to be blue (CalClosed)



Of the 'pre-switch' <u>Switchpoints 1</u>'s (SP1: observations directly <u>before</u> the switch), a very great many are CalClosed - 15/20: 75%

This compares with:

percentage of M2C5 CalClosed in all Revs: 17%

percentage of M2C5 CalClosed in Revs 1287-1357: 28%

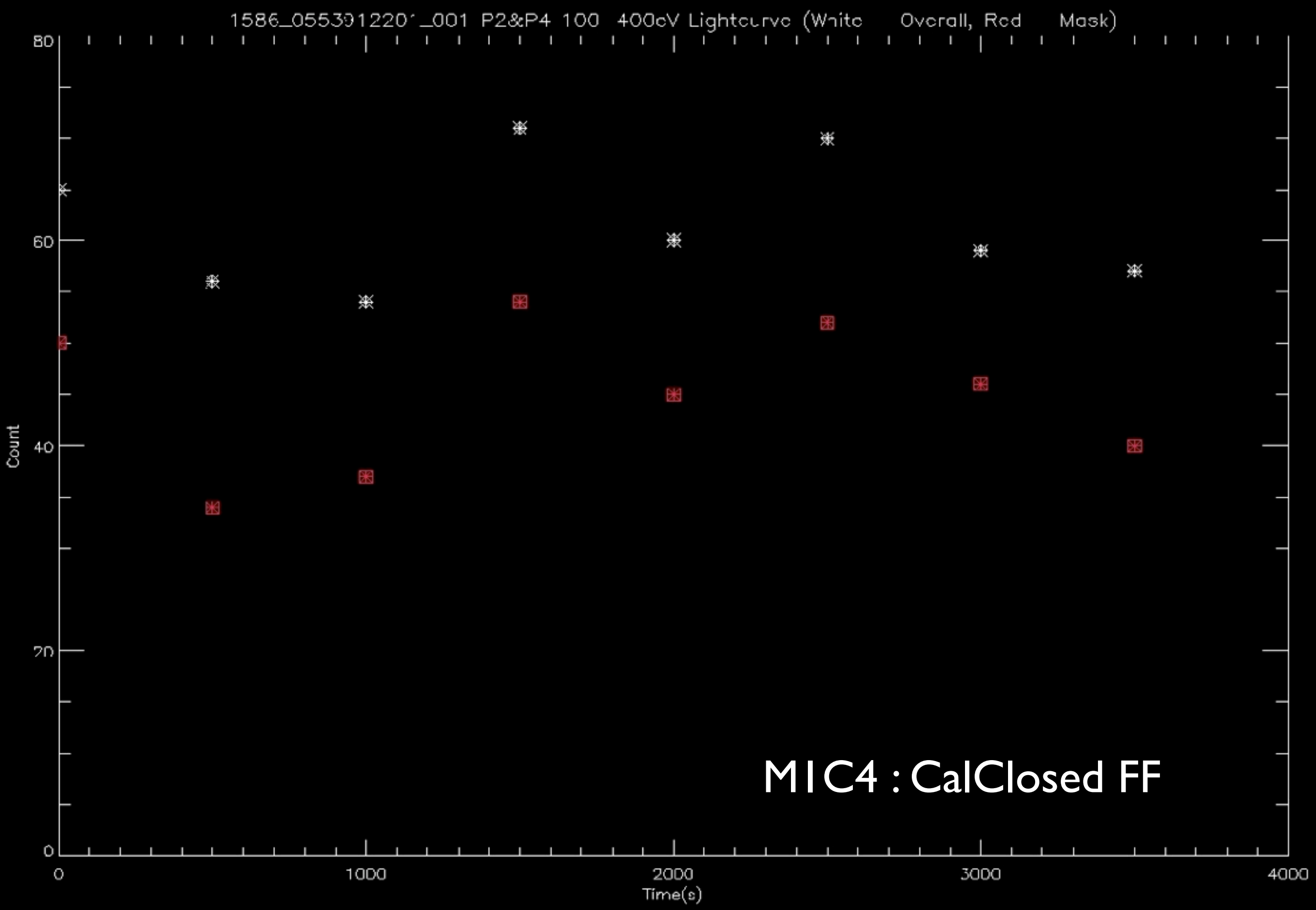
Further checks in archives and browsers etc., for lost, intermediate observations within the switch - some found and analysed - situation still remains: 15/20 (75%) of the SP1s are CalClosed

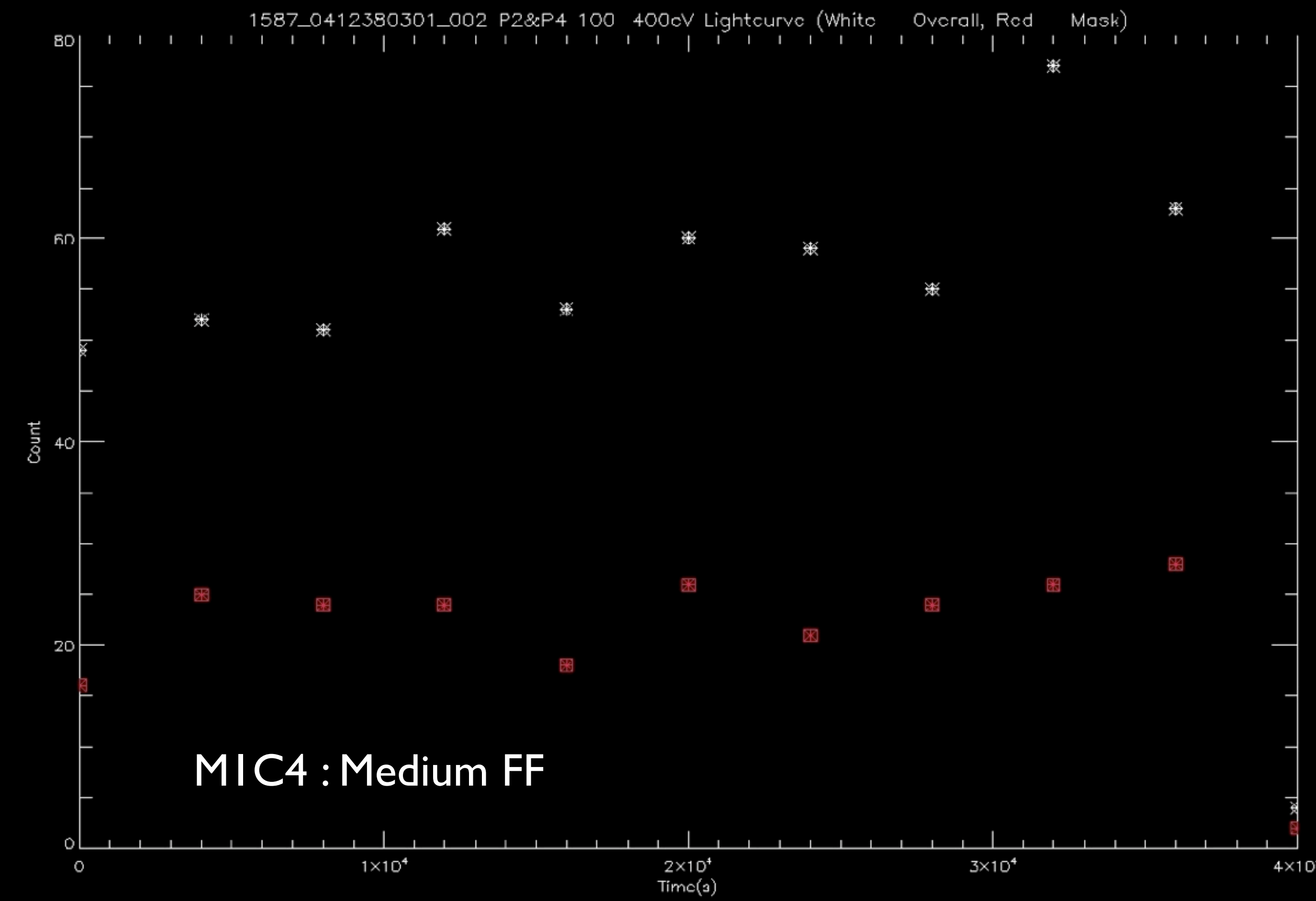
Note that only 1/20 (5%) of the SP2s (observations directly after the switch) are CalClosed

REV	OBSID	INSTR	EXPID	CCD	TIME	NEVENTS_1	RATE_1	fP2S1_2	TARGET	MODE	FILTER	TSCHED	TPERF_1
1289	0400200401	2	S004	5	8430.	103054	12.2247	0.281343	PG_1402+261	1	1	8472	8472
1290	0402560801	2	S002	5	65627.	183586	2.79742	0.034749	M_31_S2	1	5	65672	65672
1295	0402562001	2	S004	5	8027.	64095	7.98493	0.003257	M_31_NS3	1	1	8072	8072
1296	0404966601	2	S004	5	13627.	151823	11.1413	0.333333	XMM-LSS_52	1	3	13672	13672
1302	0406840301	2	S003	5	1.11017E 5	279201	2.51494	0.386273	SN_1987_A	1	5	111059	111059
1303	0402781001	2	S002	5	19506.	37267	1.91054	0.021459	J150754.38+01...	1	5	19553	19553
1303	0401520601	2	S002	5	16629.	87322	5.25119	0.052632	Abell_2052	1	3	23222	14903
1304	0401040101	2	S002	5	38828.	361042	9.2985	0.341419	RXCJ1504.1-0248	1	3	38872	38872
1304	0401521101	2	S002	5	16682.	175331	10.5102	0.344408	Abell_2052	1	3	20672	16593
1305	0400600101	2	S002	5	34496.	83656	2.42509	0.027523	G107.5-1.5	1	5	34539	34539
1311	0401521401	2	S004	5	2032.	16052	7.89961	0.024691	Abell_2052	1	1	2072	2072
1311	0405320901	2	S003	5	16625.	34389	2.06851	0.400634	M31	1	5	16672	16672
1312	0400490301	2	S004	5	4051.	32254	7.96198	0.202055	NGC_1600_Group	1	1	2572	4046
1312	0405950401	2	S004	5	37595.	88143	2.34454	0.017544	IRAS_F05024-19...	1	5	41672	38787
1313	0404790201	2	S004	5	12528.	99086	7.90916	0.018832	PSR_J1614-2230	1	1	2672	12524
1313	0202611401	2	S002	5	12415.	30815	2.48208	0.322222	ALPHA_CEN	3	6	12462	12462
1314	0402330701	2	S004	5	10581.	141440	13.3674	0.266845	X_1624-490	1	1	2742	10577
1314	0403070801	2	S002	5	13226.	22637	1.71155	0.005988	NGC_3059	1	5	13272	13272
1316	0403280301	2	S004	5	11341.	91666	8.08271	0.015119	HESS_J1626-491	1	1	3332	11336
1316	0402330601	2	S002	5	26617.	90133	3.38629	0.352262	X_1624-490	3	5	26662	26662
1319	0134722201	2	S004	5	10164.	120371	11.8429	0.295809	Capella	1	1	3872	10160
1319	0134722101	2	S019	5	29551.	49576	1.67764	0.028796	Capella	1	2	29594	29594
1325	0412590801	2	S004	5	4534.	33491	7.38663	0.011696	Crab	1	1	4572	4572
1325	0405510701	2	S002	5	27504.	66737	2.42645	0.397075	4U_1746-371	4	5	27547	26647
1326	0406800801	2	S004	5	8545.	74464	8.71434	0.310625	XTE_J1810-197	1	1	4472	8541
1326	0413780301	2	S002	5	26627.	51058	1.91753	0.019355	Jupiter	1	6	26672	26672
1328	0400230601	2	S004	5	9227.	69502	7.53246	0.008152	SAX_J1808.4-36...	1	1	4672	9222
1328	0400260301	2	S002	5	24175.	68774	2.84484	0.327037	Geminga	1	5	24222	24222
1334	0404050501	2	S004	5	7531.	65021	8.63378	0.230089	4C_73.08	1	1	7572	7572
1335	0401660101	2	S002	5	35296.	61655	1.7468	0.022624	V2487_Oph	2	5	35347	35347
1337	0403072701	2	S004	5	7432.	57025	7.6729	0.017668	NGC_1792	1	1	7472	7472
1338	0510010401	2	S003	5	11961.	162149	13.5565	0.303141	AX_J1749.1-2733	2	5	12005	12005
1339	0403072801	2	S004	5	6833.	96515	14.1248	0.297595	NGC_6744	1	1	6872	6872
1340	0403073001	2	S004	5	6829.	59655	8.73554	0.034375	NGC_6744	1	1	6872	6872
1341	0400010201	2	S005	5	77640.	242497	3.12335	0.017593	filament	1	3	77683	77683
1341	0404240701	2	S002	5	19320.	349219	18.0755	0.313482	ugc4713	1	5	21672	19225
1346	0403191101	2	S004	5	5130.	60511	11.7955	0.325472	SDSSJ0841+5455	1	1	5172	5172
1347	0506070201	2	S002	5	54557.	142071	2.60408	0.026918	HD_189733b	3	3	54602	54602
1354	0510390101	2	S004	5	48440.	170293	3.51554	0.065804	PSR_B0833-45	2	5	48502	48436
1355	0505110501	2	S004	5	2033.	16777	8.25234	0.287081	Cyg_OB2_8a	1	1	2072	2072

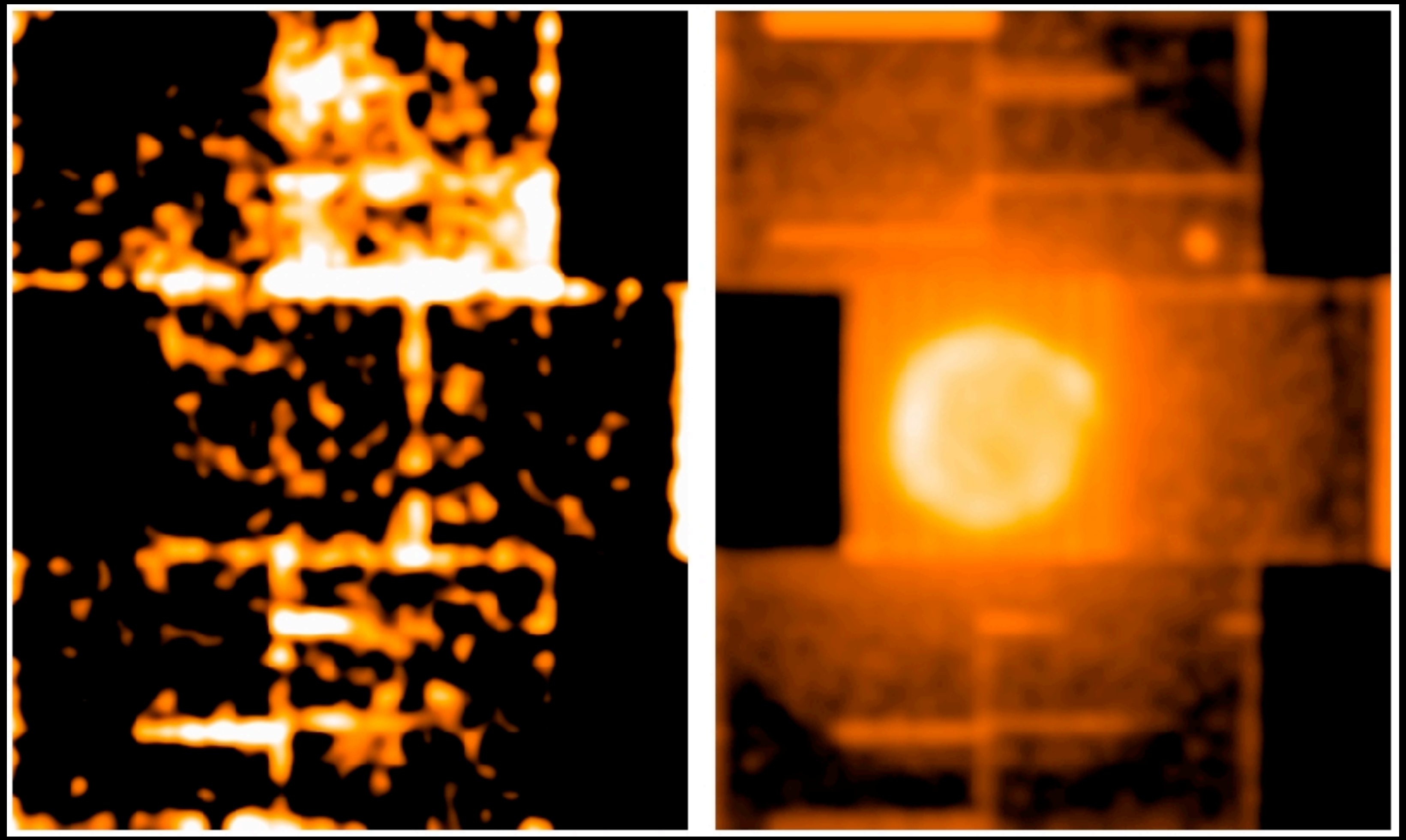
REV	OBSID	INSTR	EXPID	CCD	TIME	NEVENTS_1	RATE_1	fP2S1_2	TARGET	MODE	FILTER	TSCHED	TPERF_1
1289	0400200401	2	S004	5	8430.	103054	12.2247	0.281343	PG_1402+261	1	1	8472	8472
1290	0402560801	2	S002	5	65627.	183586	2.79742	0.034749	M_31_S2	1	5	65672	65672
1295	0402562001	2	S004	5	8027.	64095	7.98493	0.003257	M_31_NS3	1	1	8072	8072
1296	0404966601	2	S004	5	13627.	151823	11.1413	0.333333	XMM-LSS_52	1	3	13672	13672
1302	0406840301	2	S003	5	1.11017E 5	279201	2.51494	0.386273	SN_1987_A	1	5	111059	111059
1303	0402781001	2	S002	5	19506.	37267	1.91054	0.021459	J150754.38+01...	1	5	19553	19553
1303	0401520601	2	S002	5	16629.	87322	5.25119	0.052632	Abell_2052	1	3	23222	14903
1304	0401040101	2	S002	5	38828.	361042	9.2985	0.341419	RXCJ1504.1-0248	1	3	38872	38872
1304	0401521101	2	S002	5	16682.	175331	10.5102	0.344408	Abell_2052	1	3	20672	16593
1305	0400600101	2	S002	5	34496.	83656	2.42509	0.027523	G107.5-1.5	1	5	34539	34539
1311	0401521401	2	S004	5	2032.	16052	7.89961	0.024691	Abell_2052	1	1	2072	2072
1311	0405320901	2	S003	5	16625.	34389	2.06851	0.400634	M31	1	5	16672	16672
1312	0400490301	2	S004	5	4051.	32254	7.96198	0.202055	NGC_1600_Group	1	1	2572	4046
1312	0405950401	2	S004	5	37595.	88143	2.34454	0.017544	IRAS_F05024-19...	1	5	41672	38787
1313	0404790201	2	S004	5	12528.	99086	7.90916	0.018832	PSR_J1614-2230	1	1	2672	12524
1313	0202611401	2	S002	5	12415.	30815	2.48208	0.322222	ALPHA_CEN	3	6	12462	12462
1314	0402330701	2	S004	5	10581.	141440	13.3674	0.266845	X_1624-490	1	1	2742	10577
1314	0403070801	2	S002	5	13226.	22637	1.71155	0.005988	NGC_3059	1	5	13272	13272
1316	0403280301	2	S004	5	11341.	91666	8.08271	0.015119	HESS_J1626-491	1	1	3332	11336
1316	0402330601	2	S002	5	26617.	90133	3.38629	0.352262	X_1624-490	3	5	26662	26662
1319	0134722201	2	S004	5	10164.	120371	11.8429	0.295809	Capella	1	1	3872	10160
1319	0134722101	2	S019	5	29551.	49576	1.67764	0.028796	Capella	1	2	29594	29594
1325	0412590801	2	S004	5	4534.	33491	7.38663	0.011696	Crab	1	1	4572	4572
1325	0405510701	2	S002	5	27504.	66737	2.42645	0.397075	4U_1746-371	4	5	27547	26647
1326	0406800801	2	S004	5	8545.	74464	8.71434	0.310625	XTE_J1810-197	1	1	4472	8541
1326	0413780301	2	S002	5	26627.	51058	1.91753	0.019355	Jupiter	1	6	26672	26672
1328	0400230601	2	S004	5	9227.	69502	7.53246	0.008152	SAX_J1808.4-36...	1	1	4672	9222
1328	0400260301	2	S002	5	24175.	68774	2.84484	0.327037	Geminga	1	5	24222	24222
1334	0404050501	2	S004	5	7531.	65021	8.63378	0.230089	4C_73.08	1	1	7572	7572
1335	0401660101	2	S002	5	35296.	61655	1.7468	0.022624	V2487_Oph	2	5	35347	35347
1337	0403072701	2	S004	5	7432.	57025	7.6729	0.017668	NGC_1792	1	1	7472	7472
1338	0510010401	2	S003	5	11961.	162149	13.5565	0.303141	AX_J1749.1-2733	2	5	12005	12005
1339	0403072801	2	S004	5	6833.	96515	14.1248	0.297595	NGC_6744	1	1	6872	6872
1340	0403073001	2	S004	5	6829.	59655	8.73554	0.034375	NGC_6744	1	1	6872	6872
1341	0400010201	2	S005	5	77640.	242497	3.12335	0.017593	filament	1	3	77683	77683
1341	0404240701	2	S002	5	19320.	349219	18.0755	0.313482	ugc4713	1	5	21672	19225
1346	0403191101	2	S004	5	5130.	60511	11.7955	0.325472	SDSSJ0841+5455	1	1	5172	5172
1347	0506070201	2	S002	5	54557.	142071	2.60408	0.026918	HD_189733b	3	3	54602	54602
1354	0510390101	2	S004	5	48440.	170293	3.51554	0.065804	PSR_B0833-45	2	5	48502	48436
1355	0505110501	2	S004	5	2033.	16777	8.25234	0.287081	Cyg_OB2_8a	1	1	2072	2072

Does the Switch occur within an observation, or between?



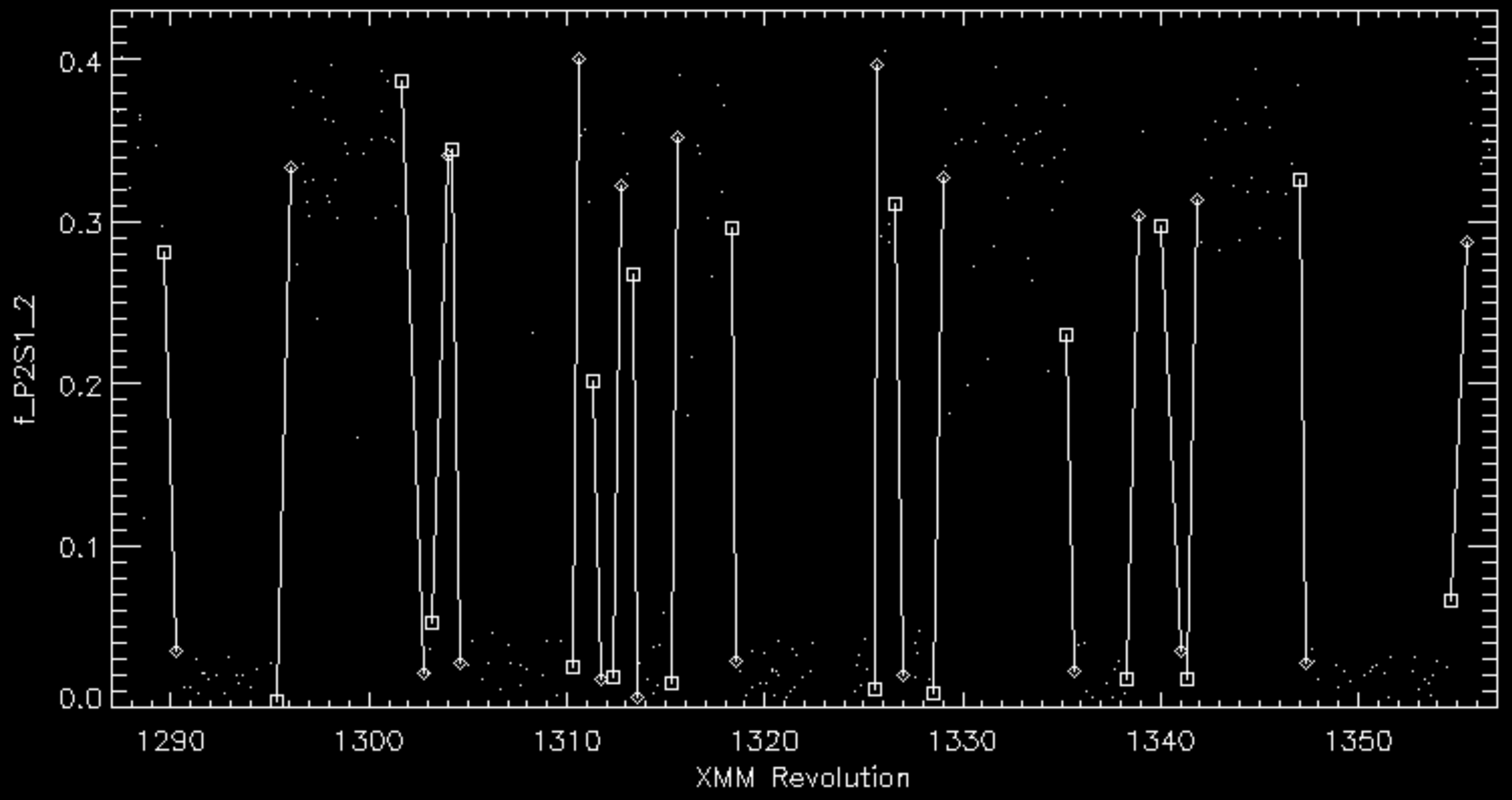


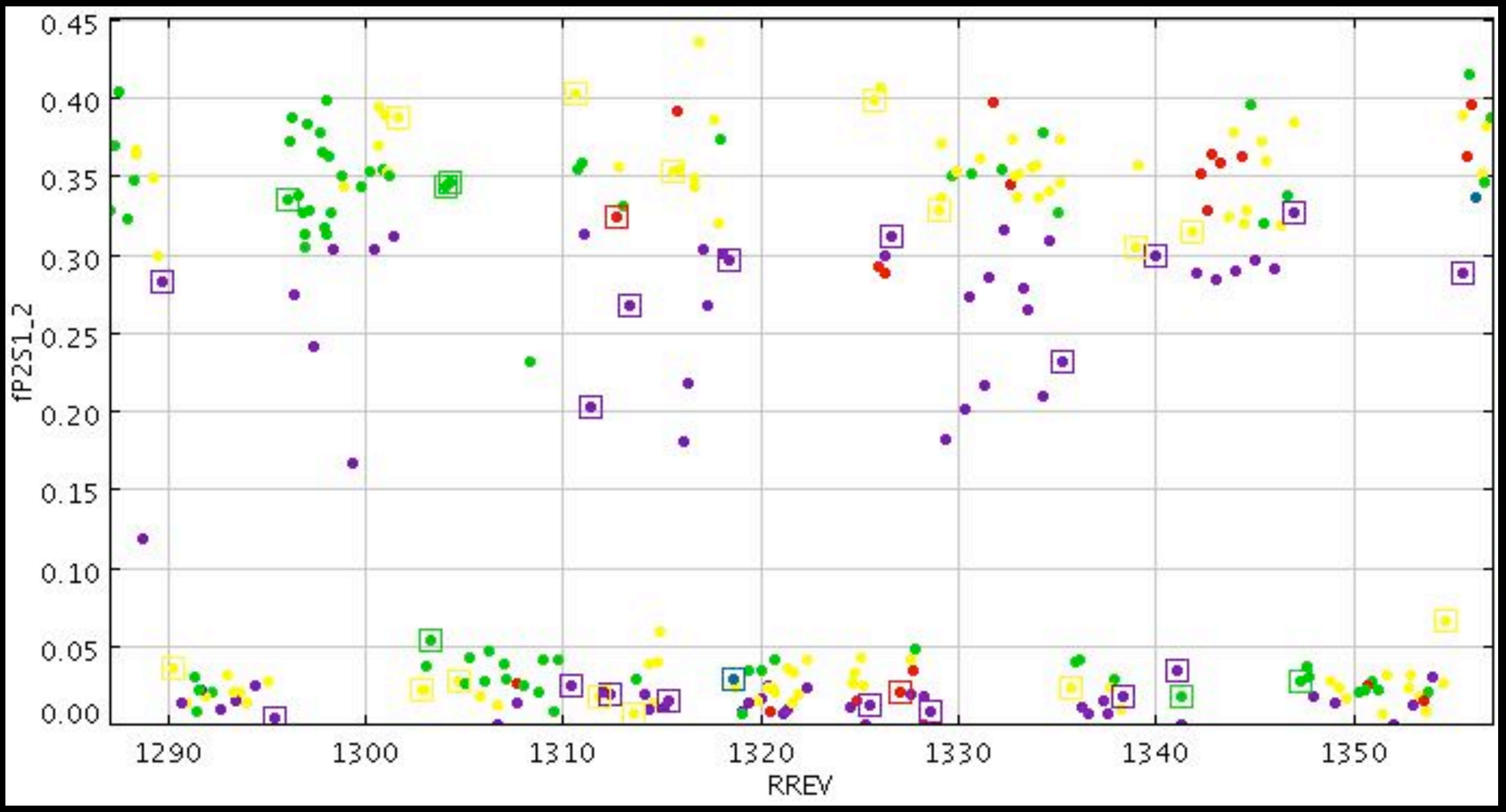
Lightcurves (100-400 adu, all P2+P4 & P2+P4 in stripes) within an SP1 and the next directly consecutive SP2 observation:



Switch does not occur within an observation

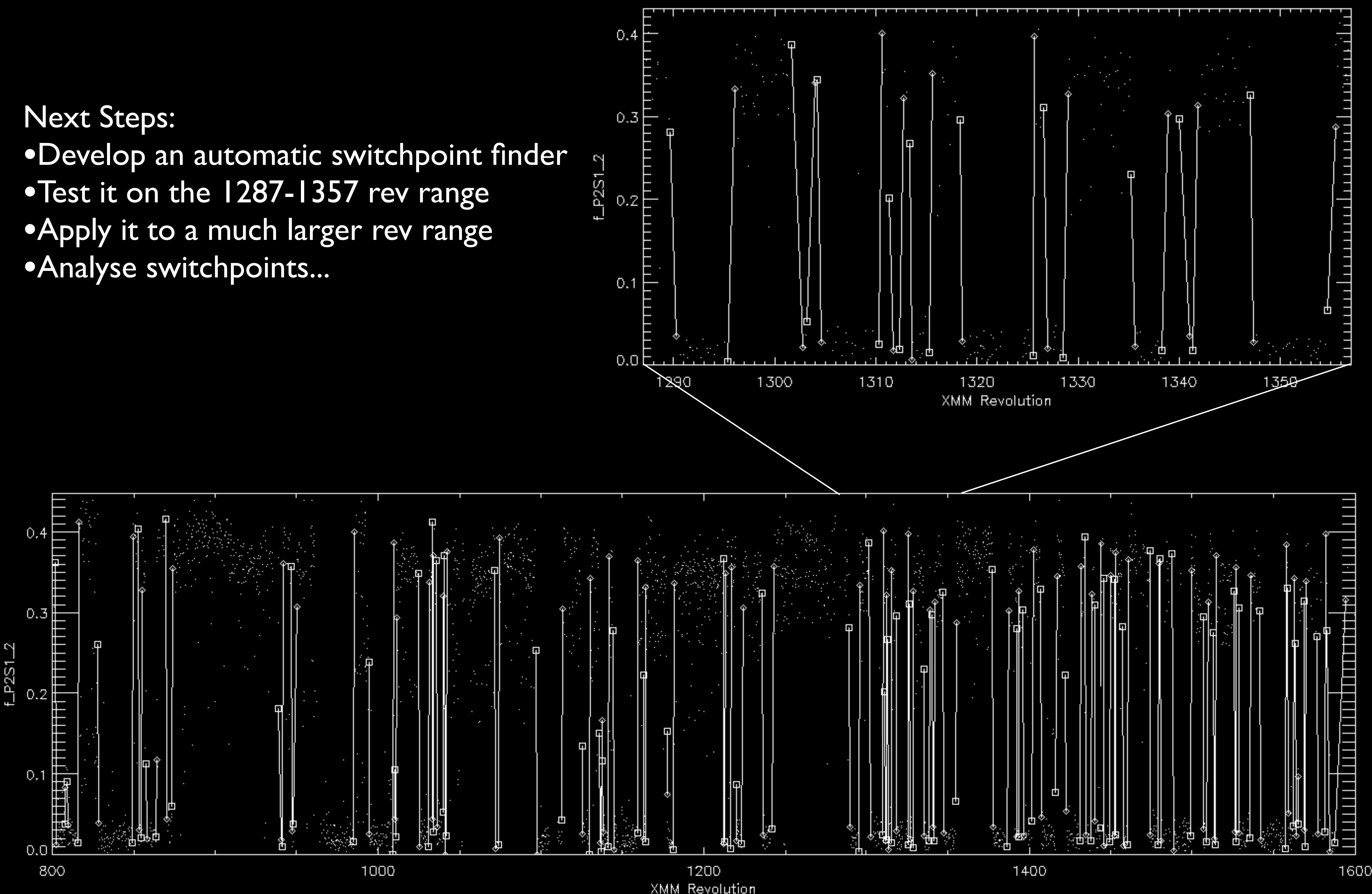
Next Steps:
- Develop an automatic switchpoint finder
- Test it on the 1287-1357 rev range





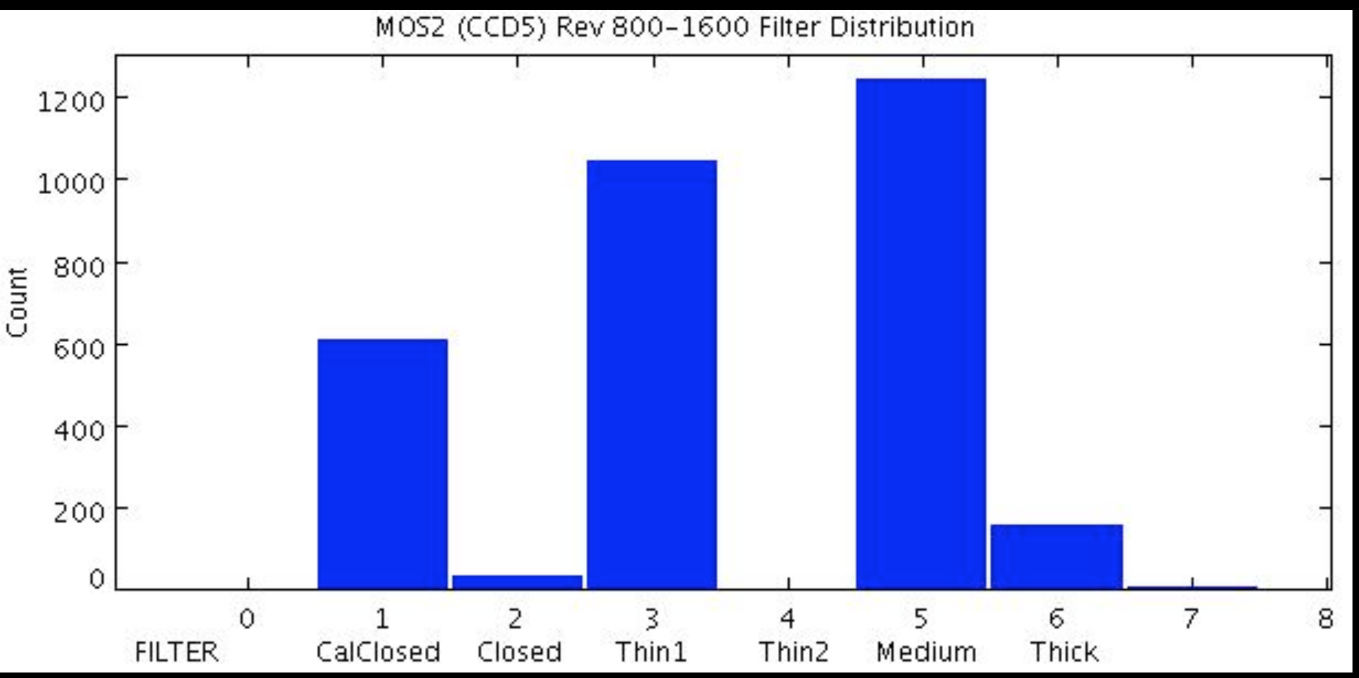
Next Steps:

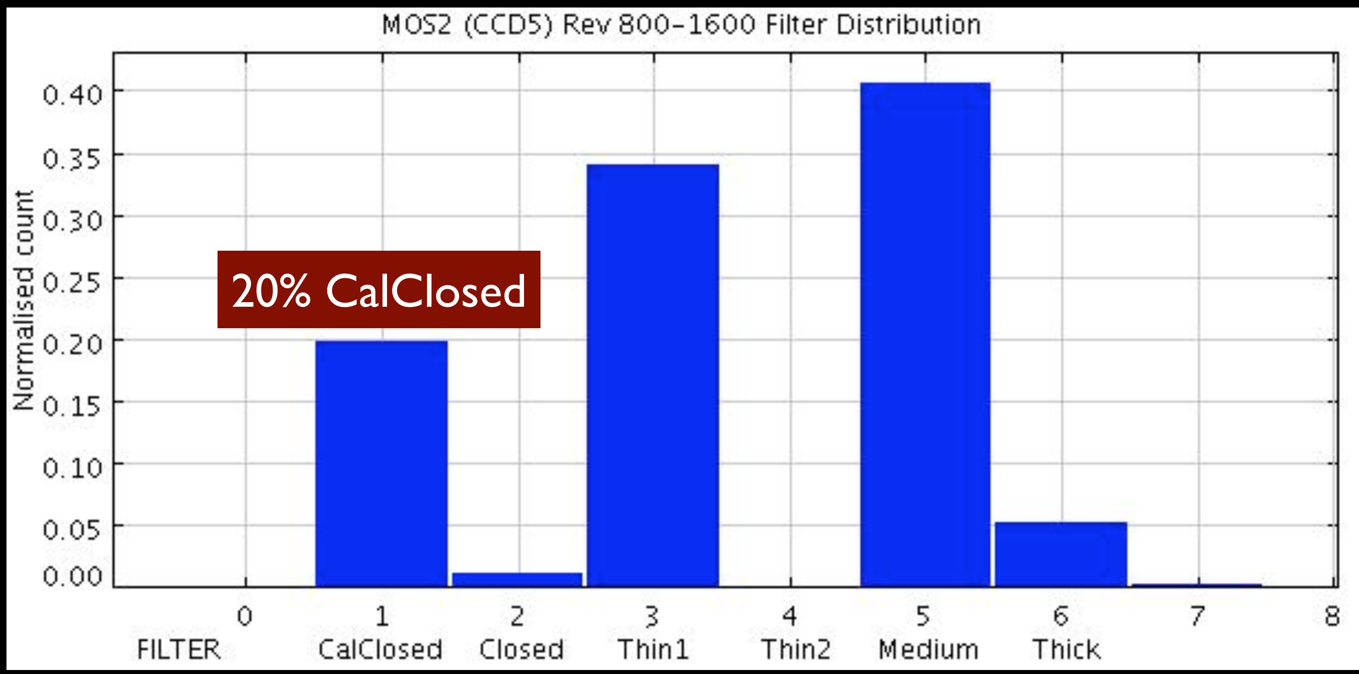
- Develop an automatic switchpoint finder
- Test it on the 1287-1357 rev range
- Apply it to a much larger rev range
- Analyse switchpoints...



Filter Distributions

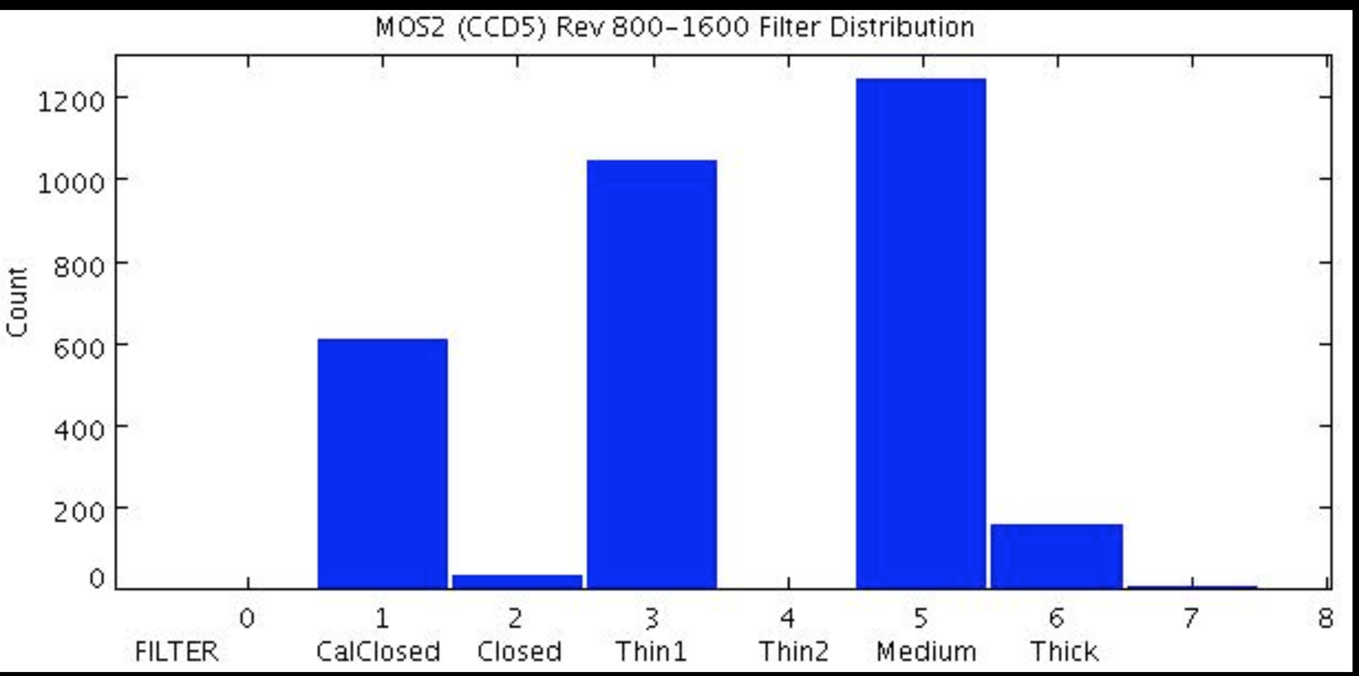
All Observations: Revs 800-1600

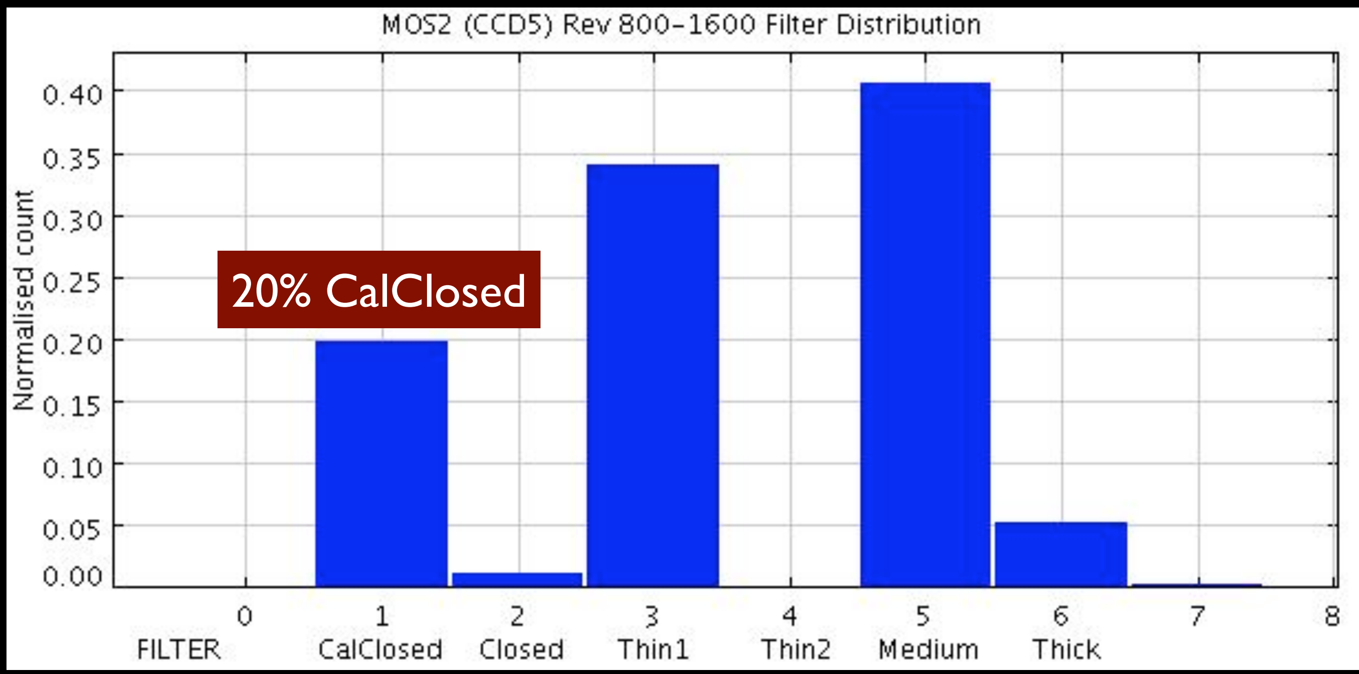




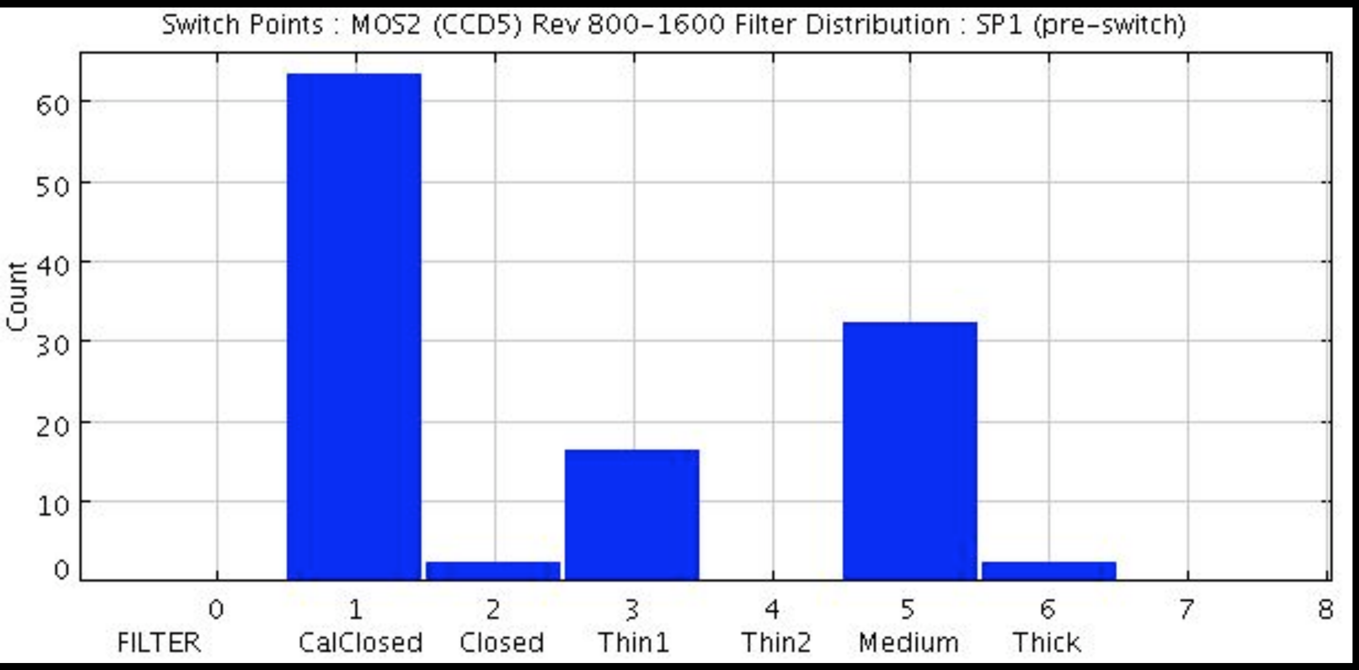
Filter Distributions

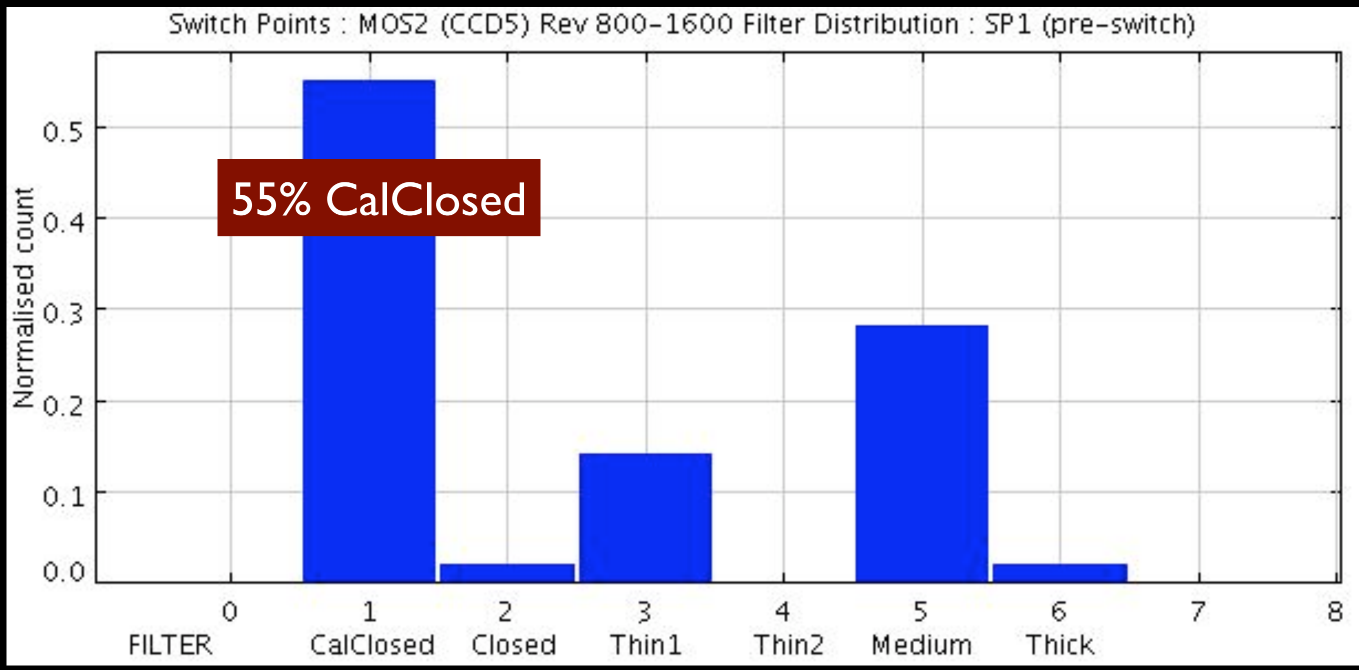
All Observations: Revs 800-1600





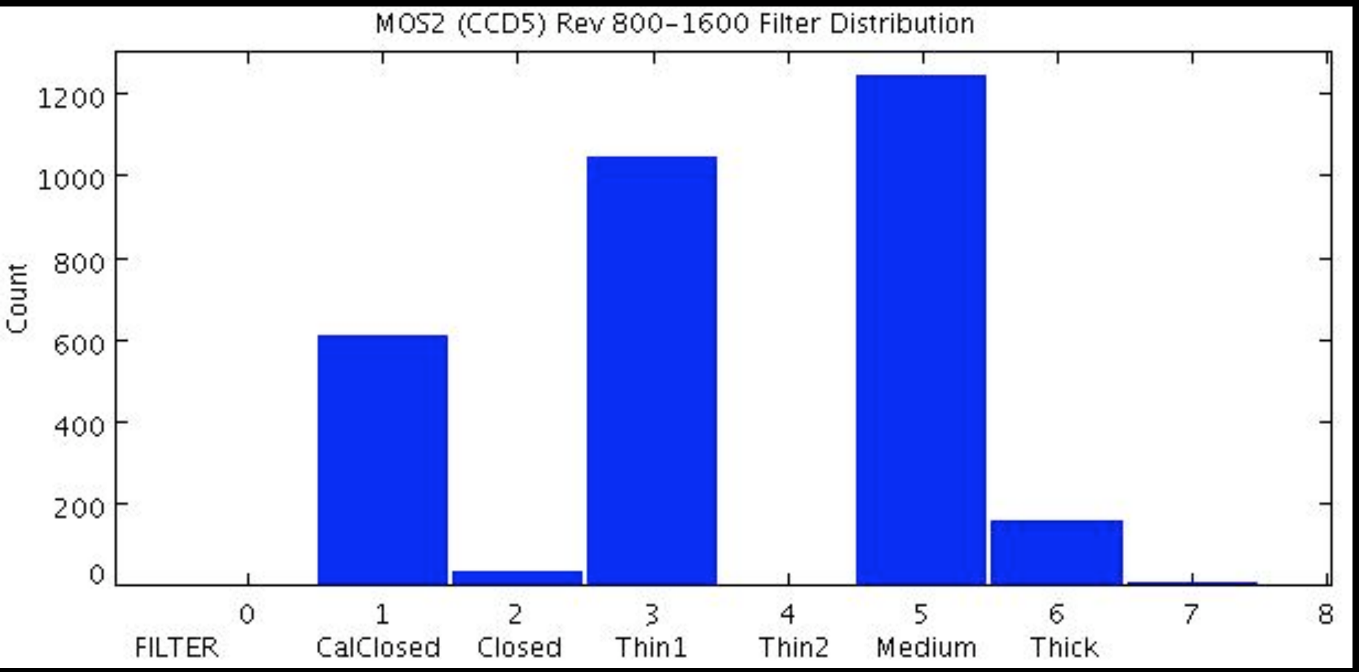
All SP1s: Revs 800-1600

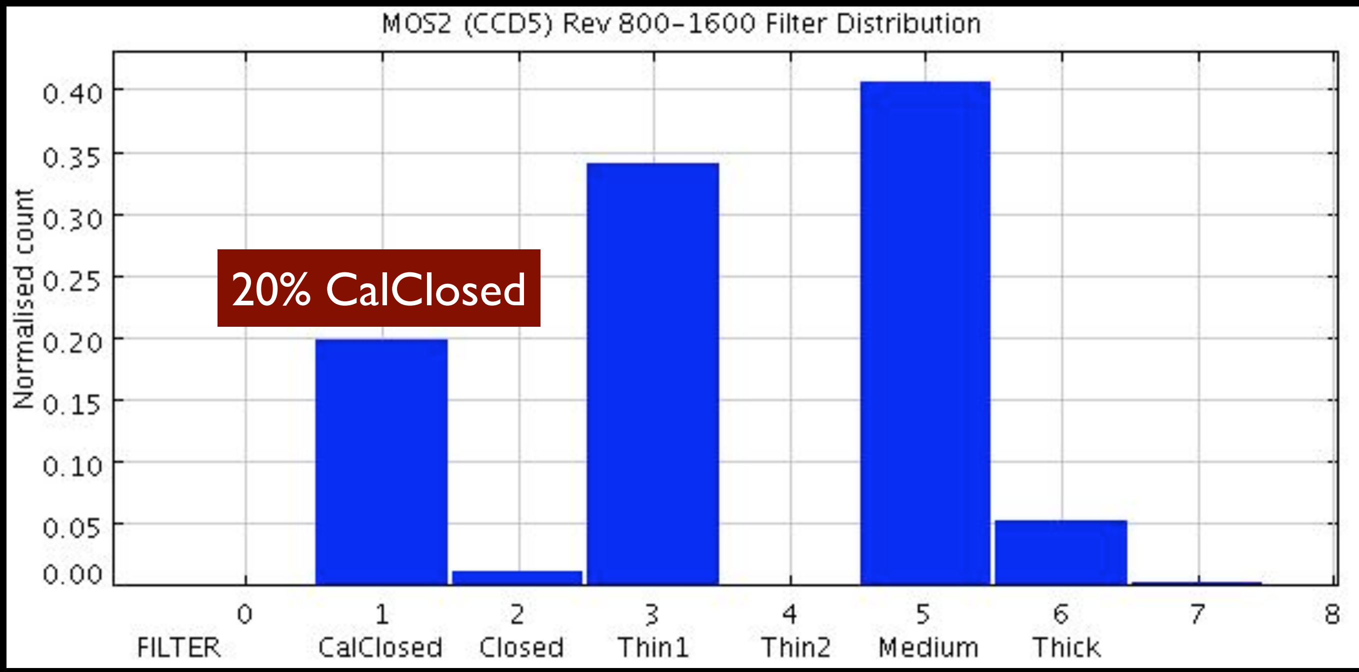




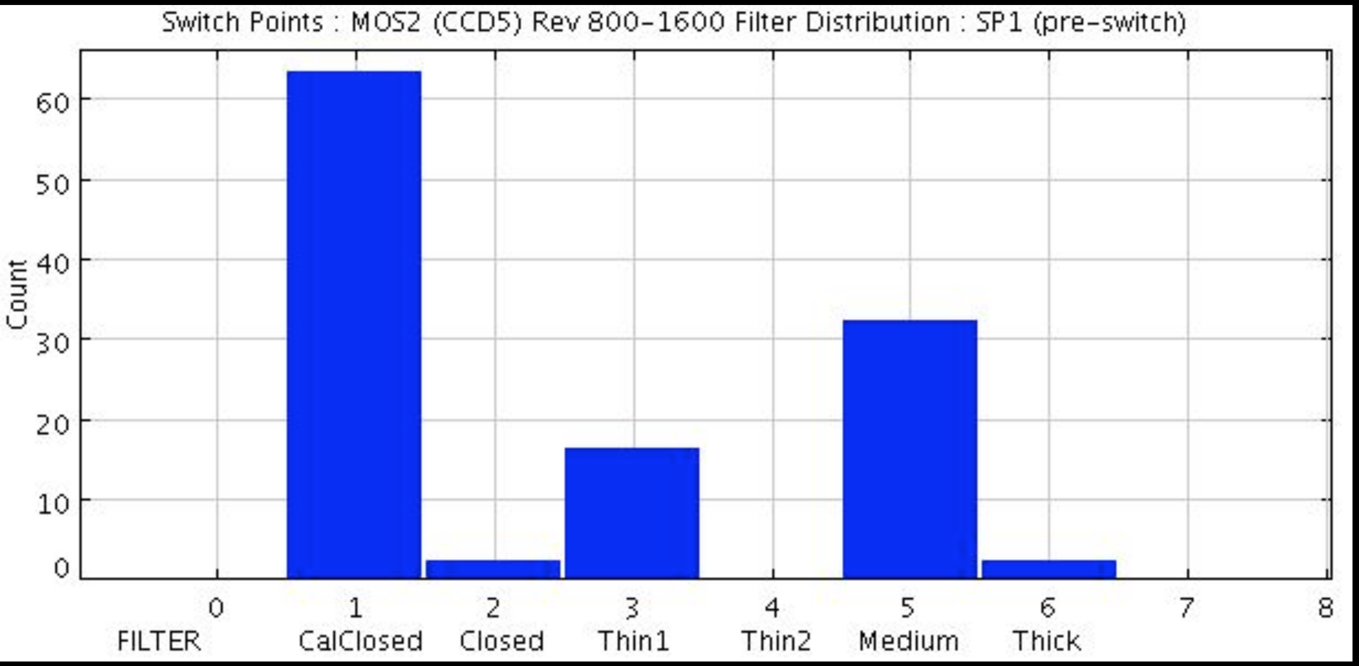
Filter Distributions

All Observations: Revs 800-1600

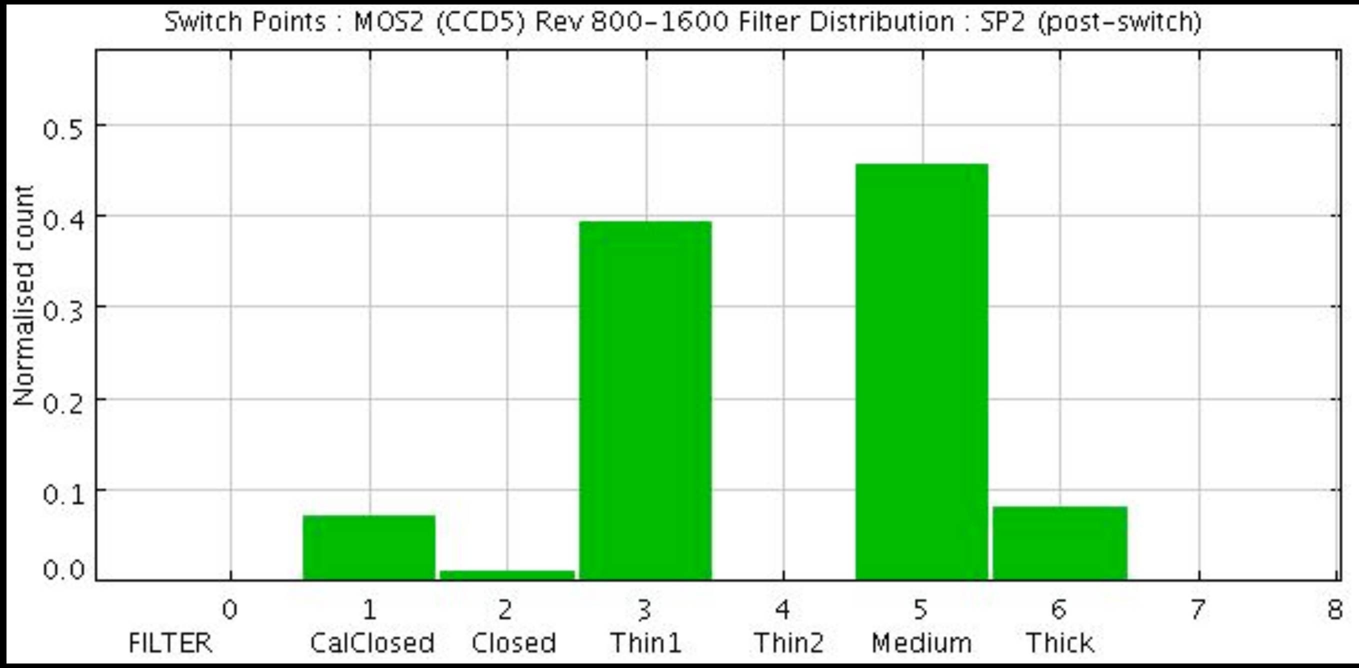




All SP1s: Revs 800-1600

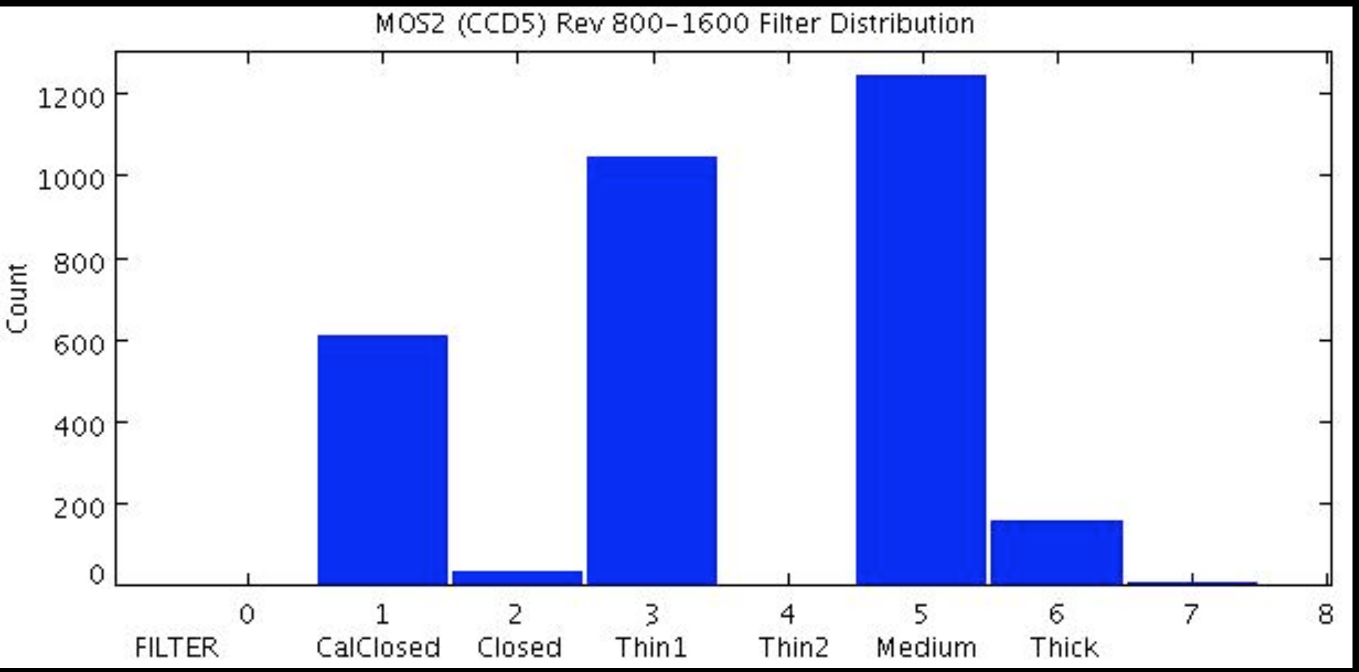


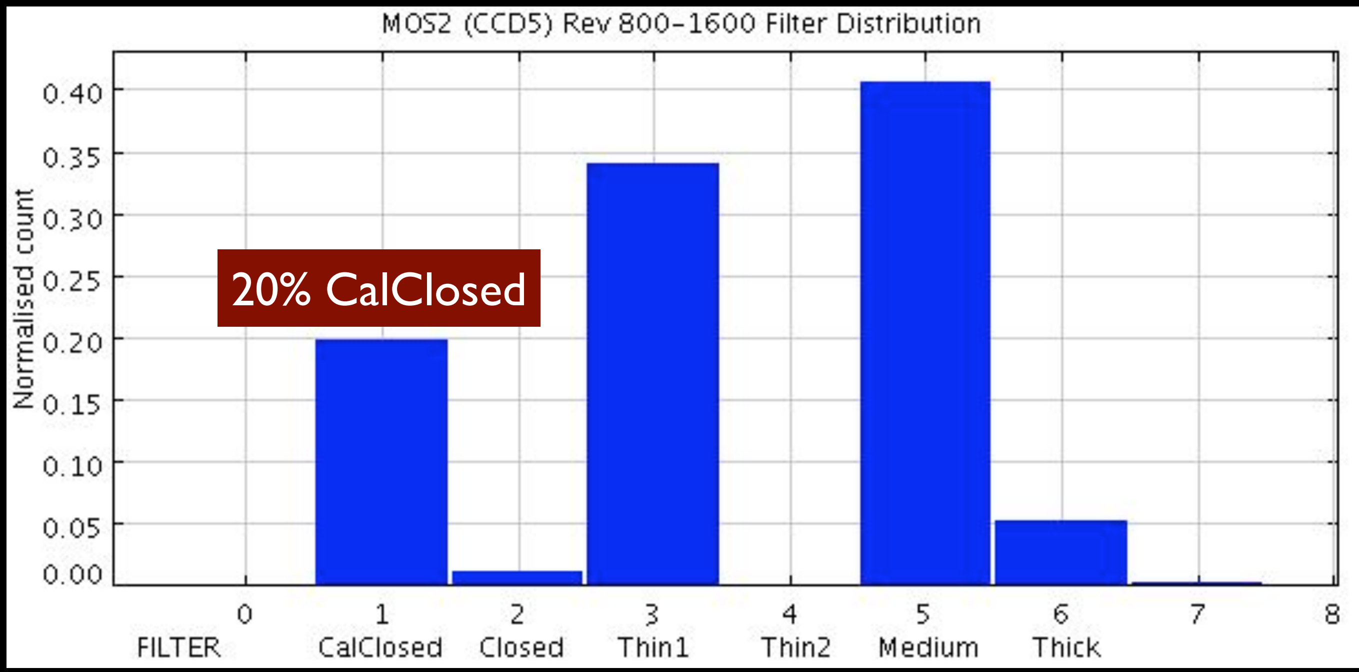
All SP2s: Revs 800-1600



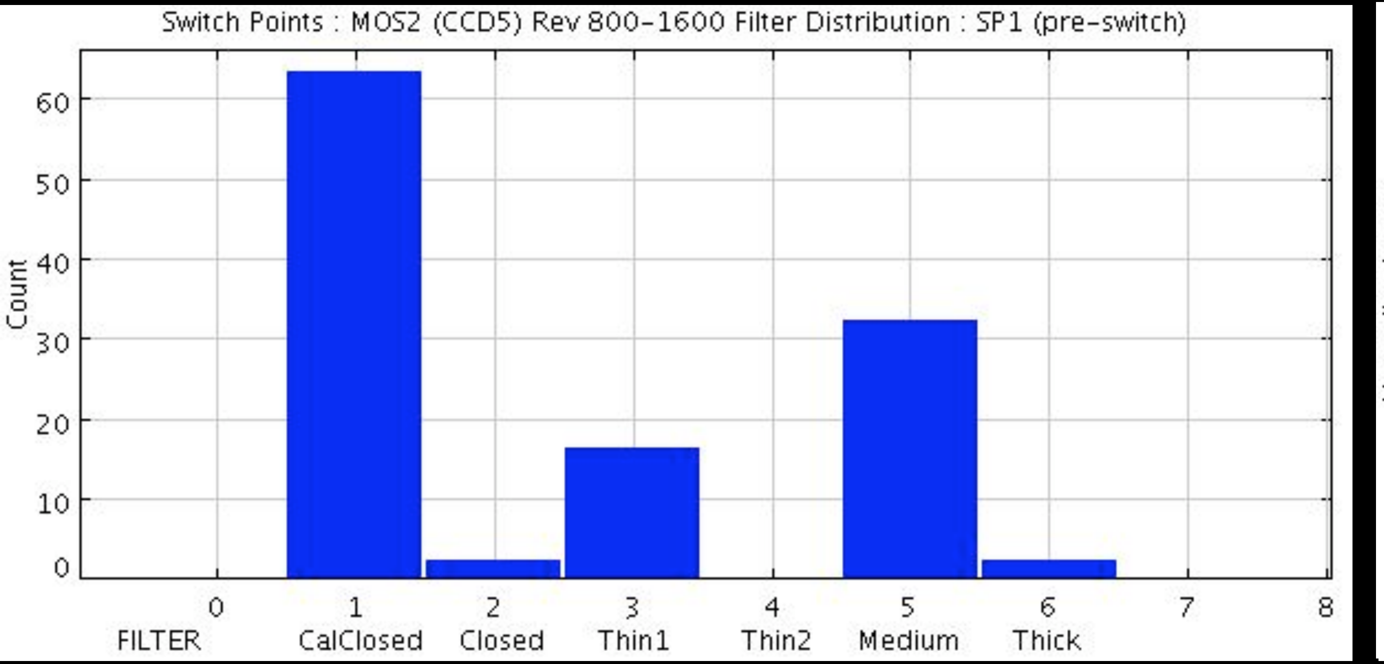
Filter Distributions

All Observations: Revs 800-1600

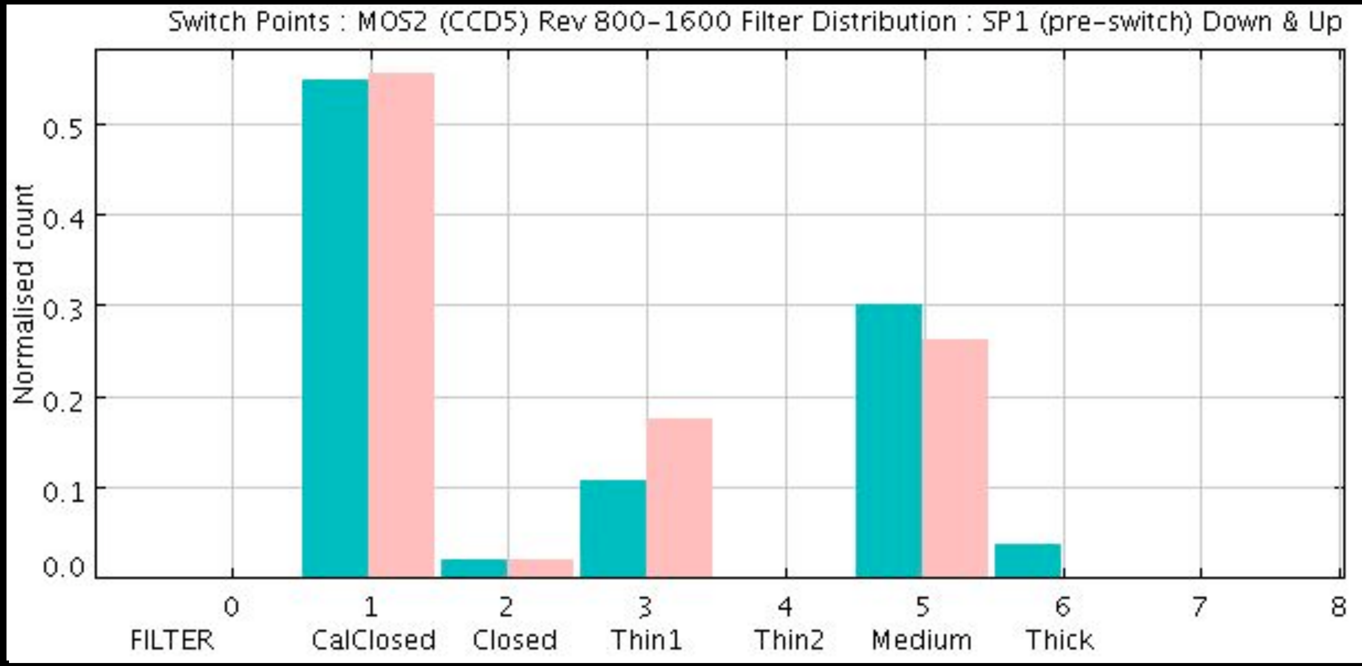




All SP1s: Revs 800-1600



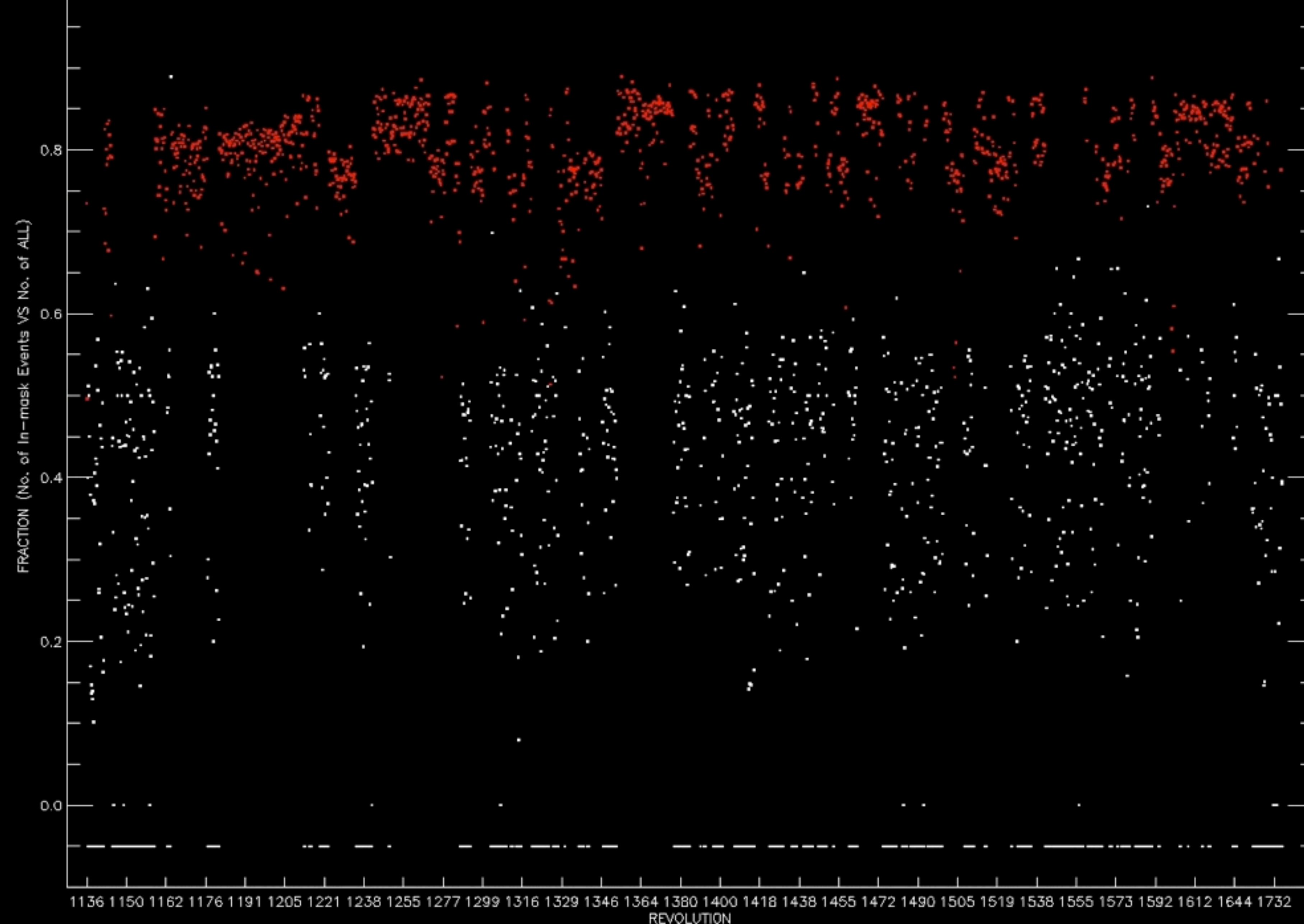
All SP1s: Revs 800-1600: Downs & Ups

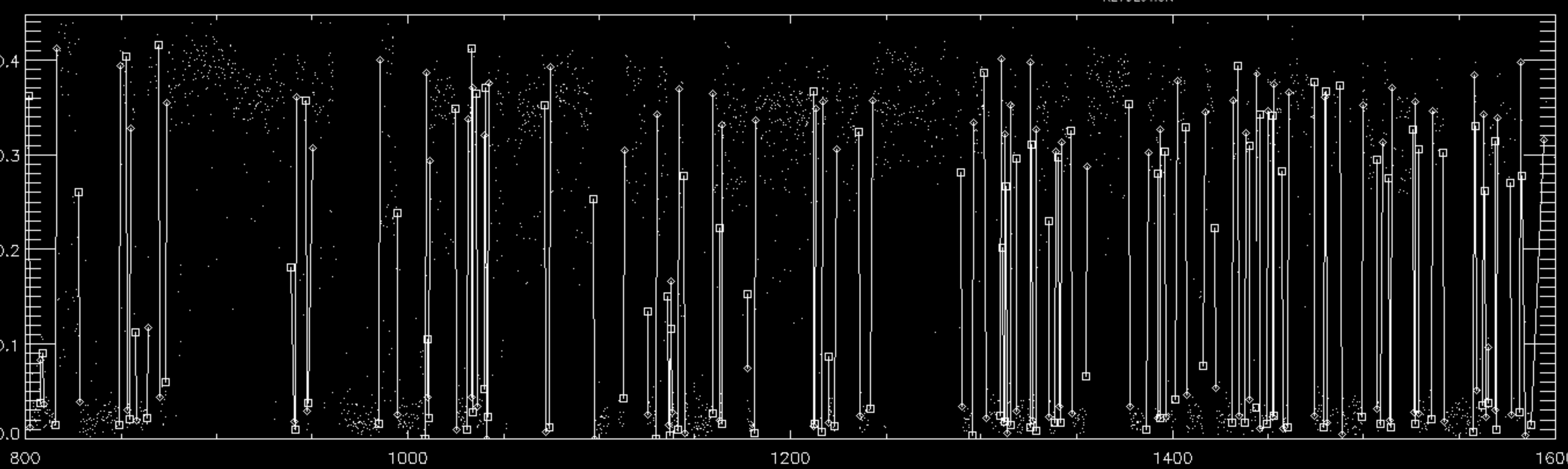


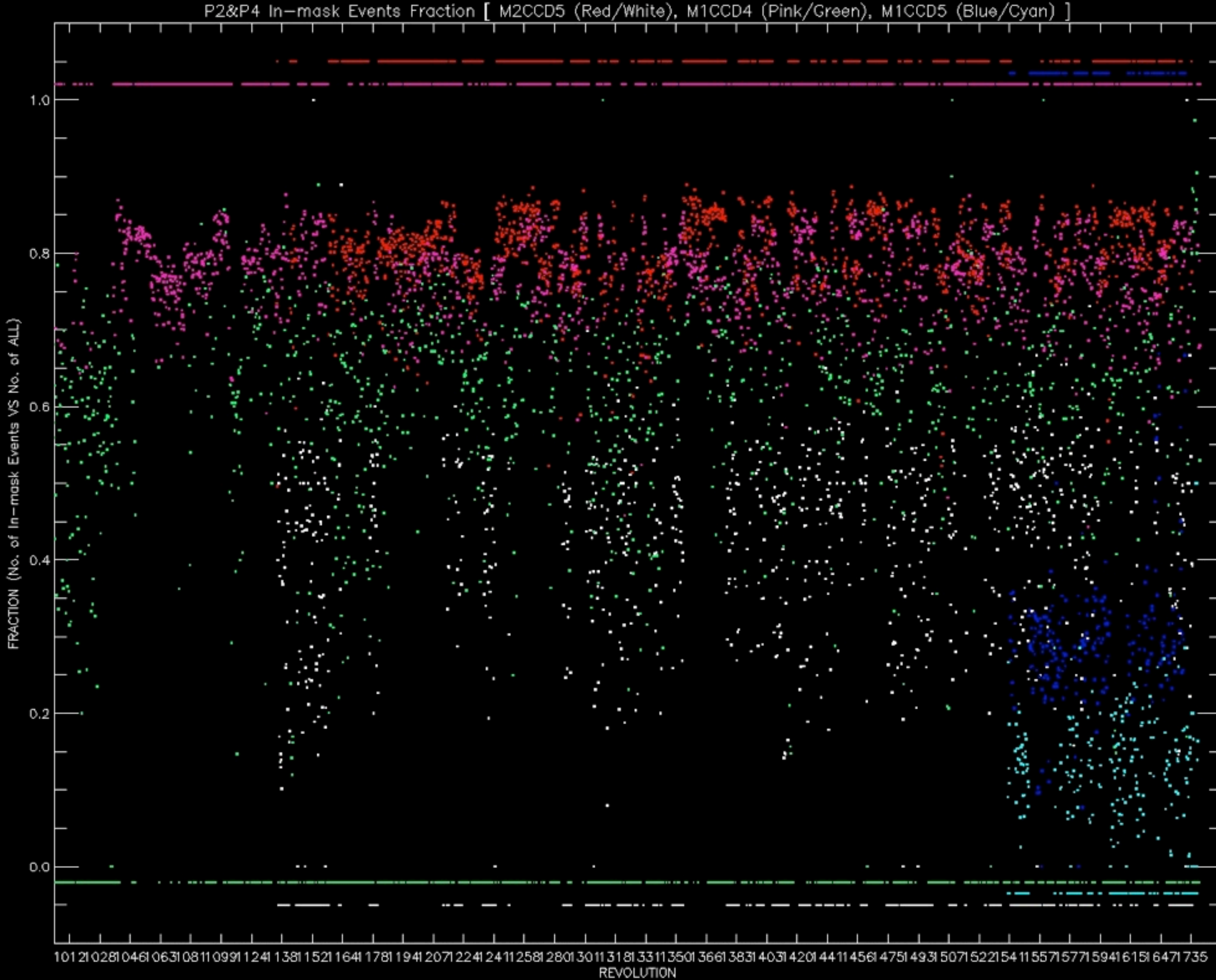
Separate complementary analysis (TS) involving ‘by eye’ noise determination and similar P2+P4 stripe fractions etc.

Good cross-comparison (M2C5)

Performed on other chips

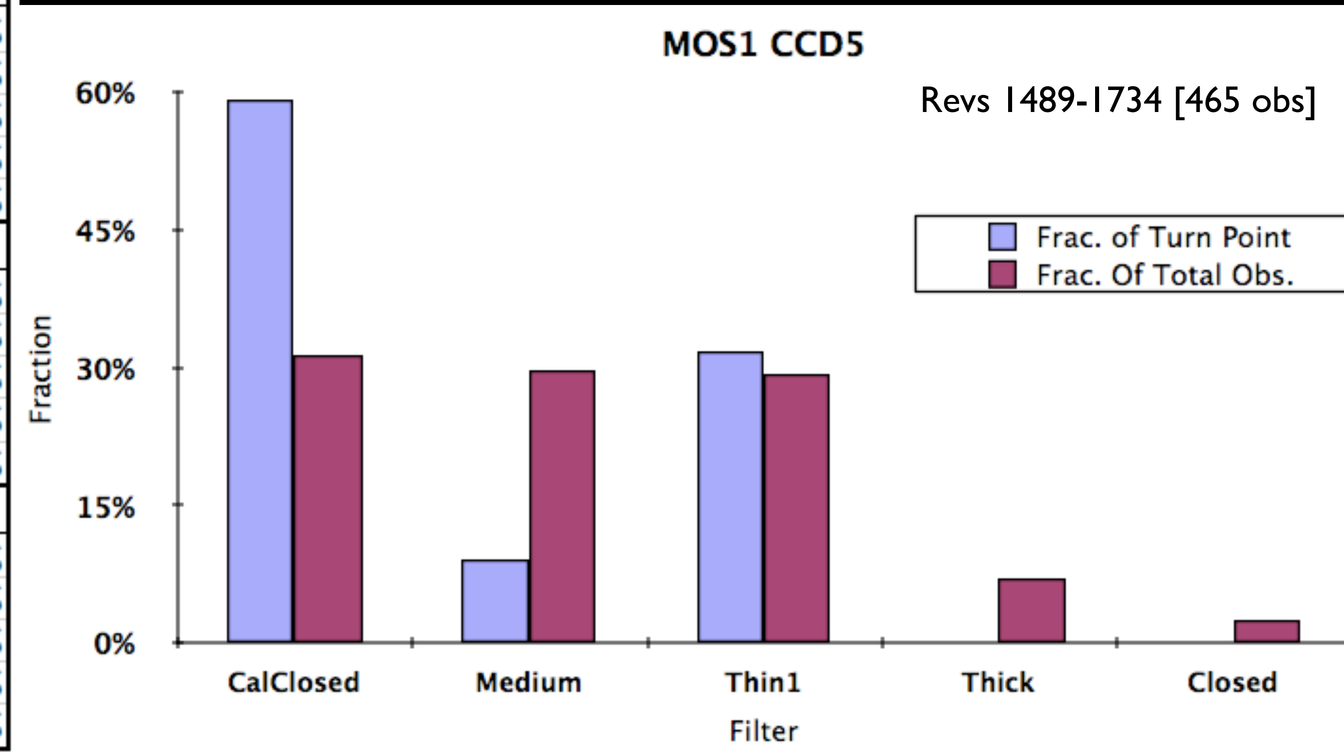


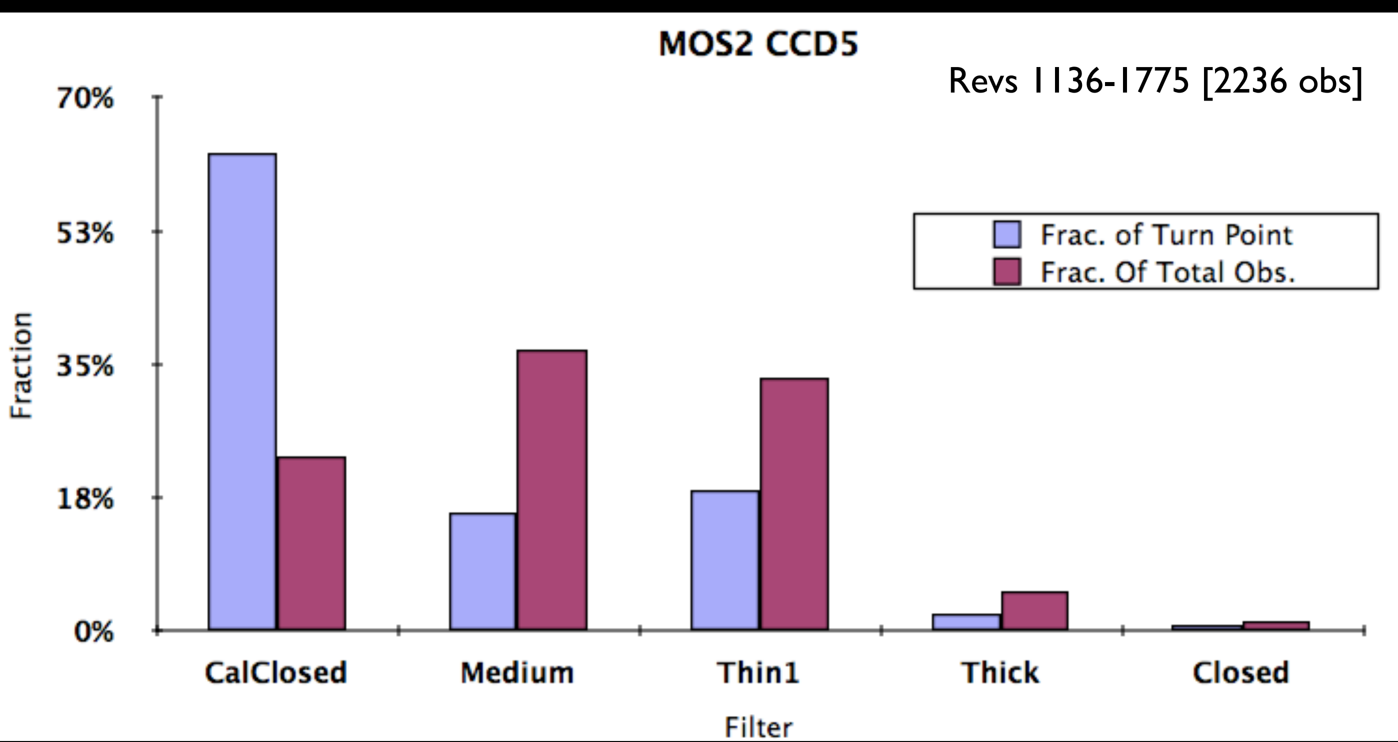


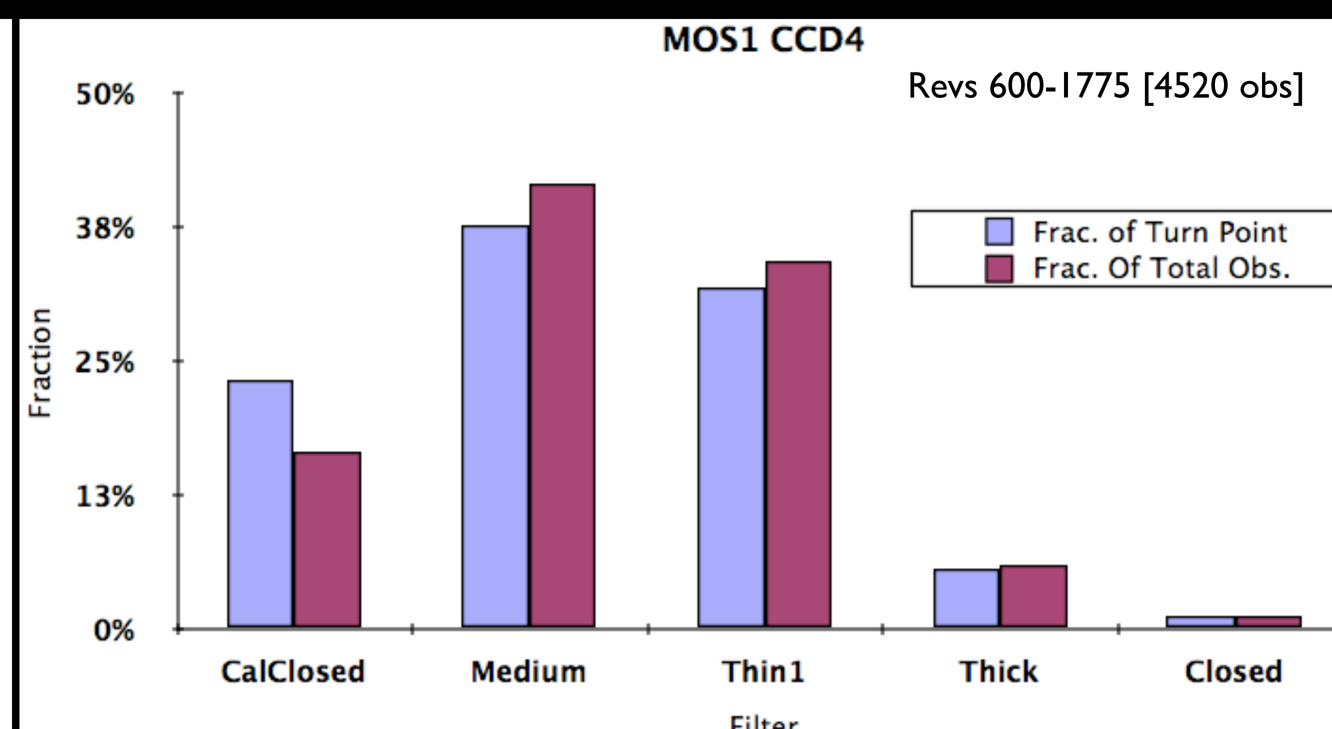

P2&P4 In-mask Events Fraction [M2CCD5 (Red/White), M1CCD4 (Pink/Green), M1CCD5 (Blue/Cyan)]
FRACTION (No. of In-mask Events VS No. of ALL)
1.0
0.8
0.6
0.4
0.2
0.0
REVOLUTION

Filter Distributions at Noise Switchpoints for other Chips

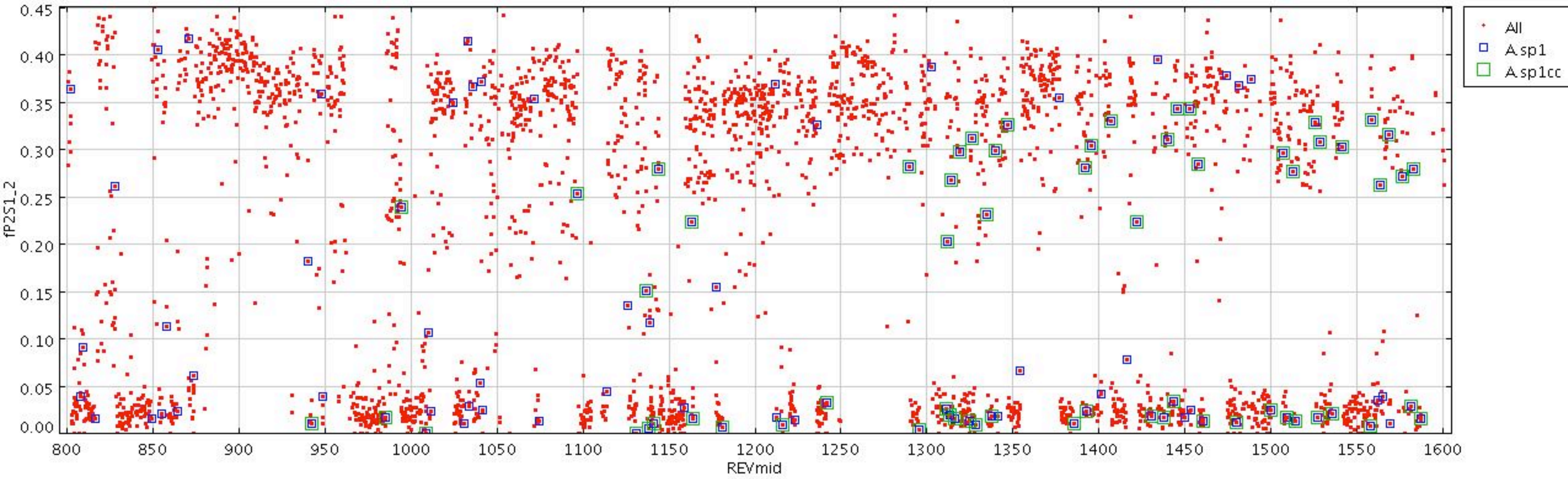
	Filter	Frac. of Turn Point	Frac. Of Total Obs.
M1 CCD5	CalClosed	59%	31%
	Medium	9%	30%
	Thin1	32%	29%
	Thick	0%	7%
	Closed	0%	3%
	Filter	Frac. of Turn Point	Frac. Of Total Obs.
M1 CCD4	CalClosed	23%	17%
	Medium	38%	42%
	Thin1	32%	34%
	Thick	6%	6%
	Closed	1%	1%
	Filter	Frac. of Turn Point	Frac. Of Total Obs.
M2 CCD5	CalClosed	63%	23%
	Medium	16%	37%
	Thin1	19%	33%
	Thick	2%	5%
	Closed	1%	1%



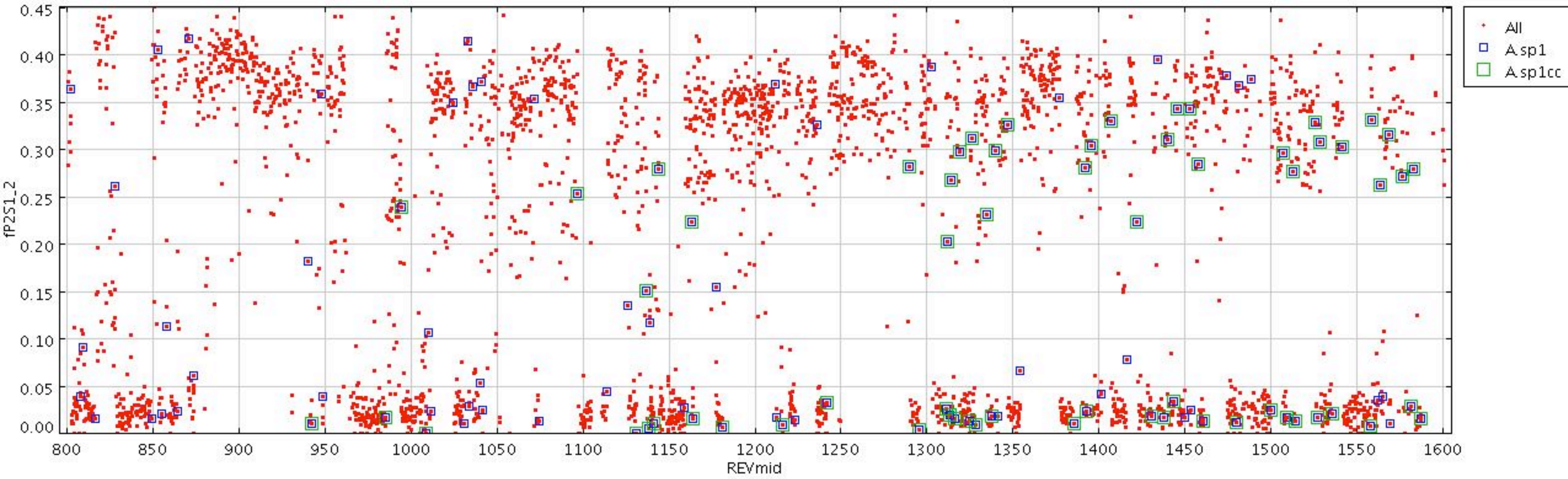


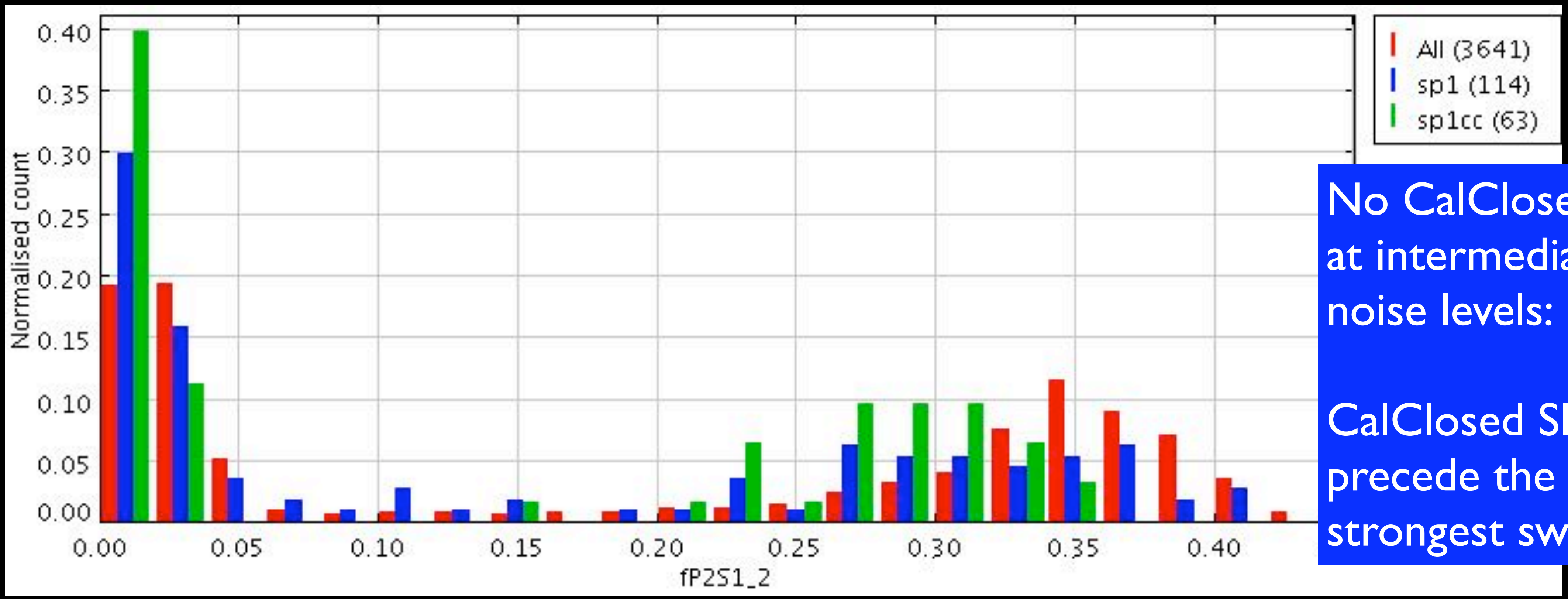


M2C5 : Are the CalClosed SP1s different from other SP1s?



M2C5 : Are the CalClosed SP1s different from other SP1s?

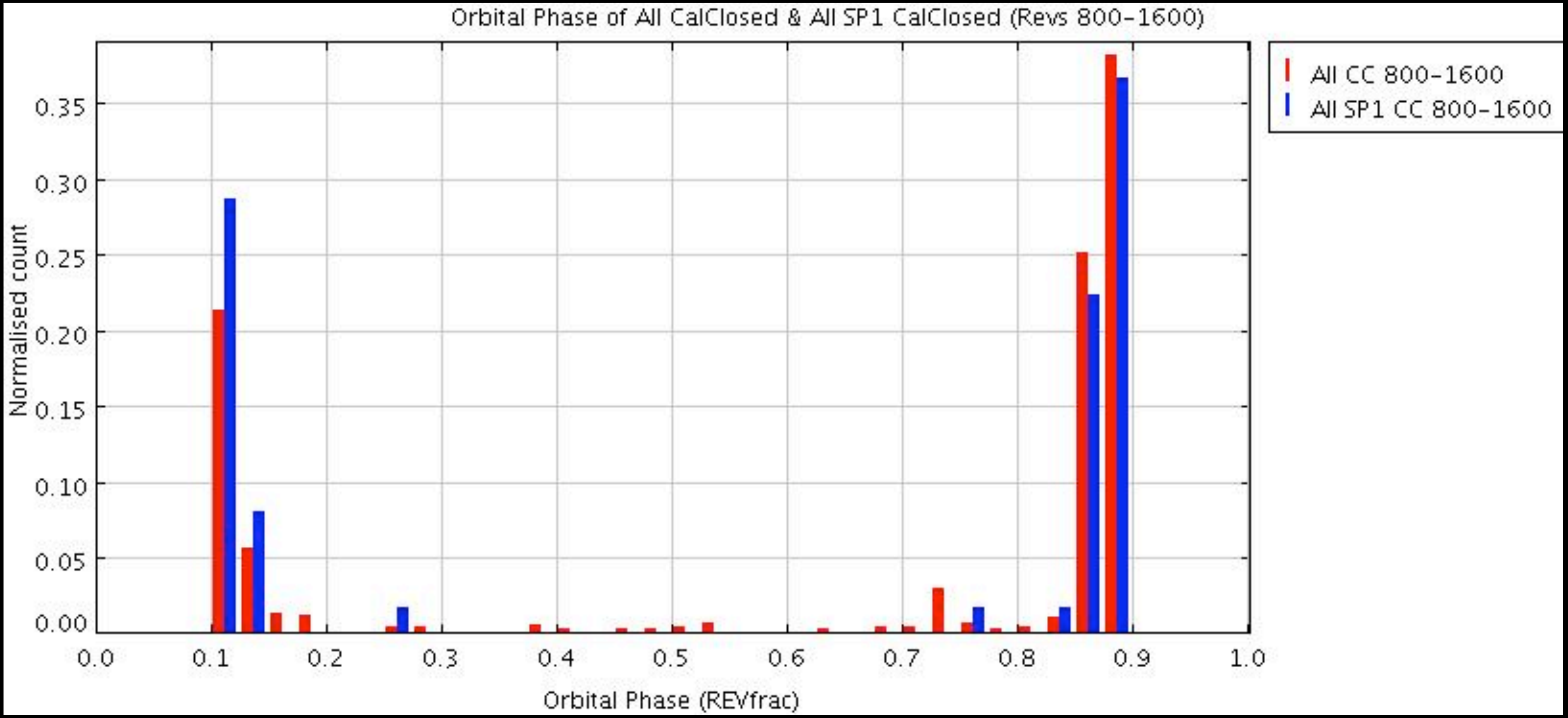




No CalClosed SP1s at intermediate noise levels:

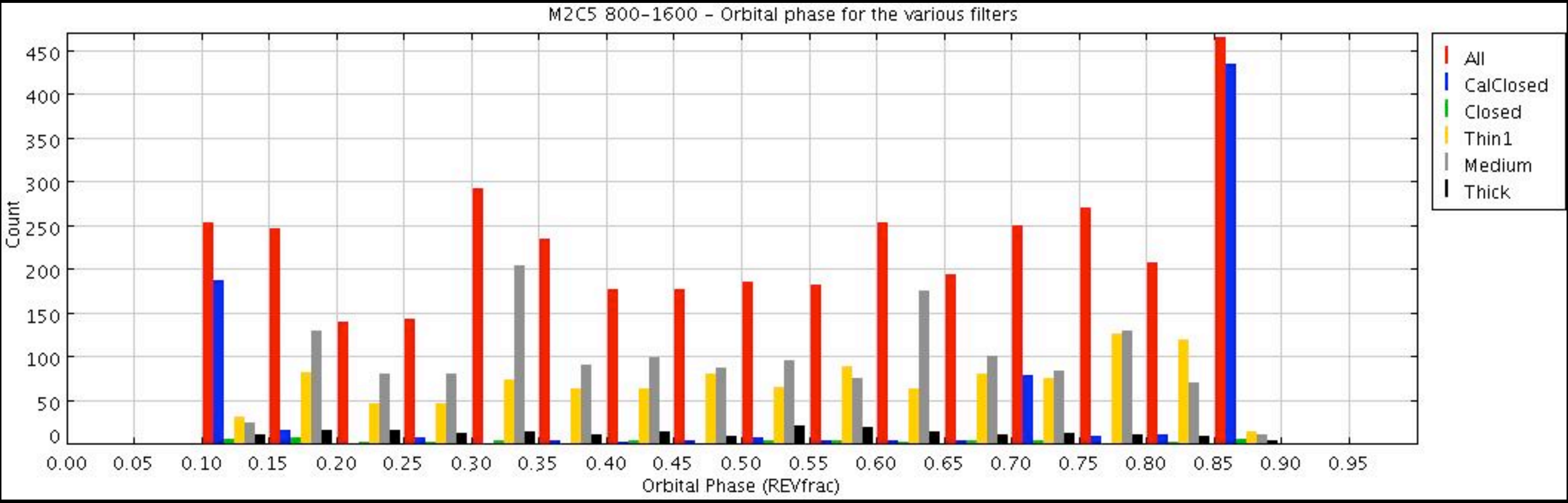
CalClosed SP1s precede the strongest switches

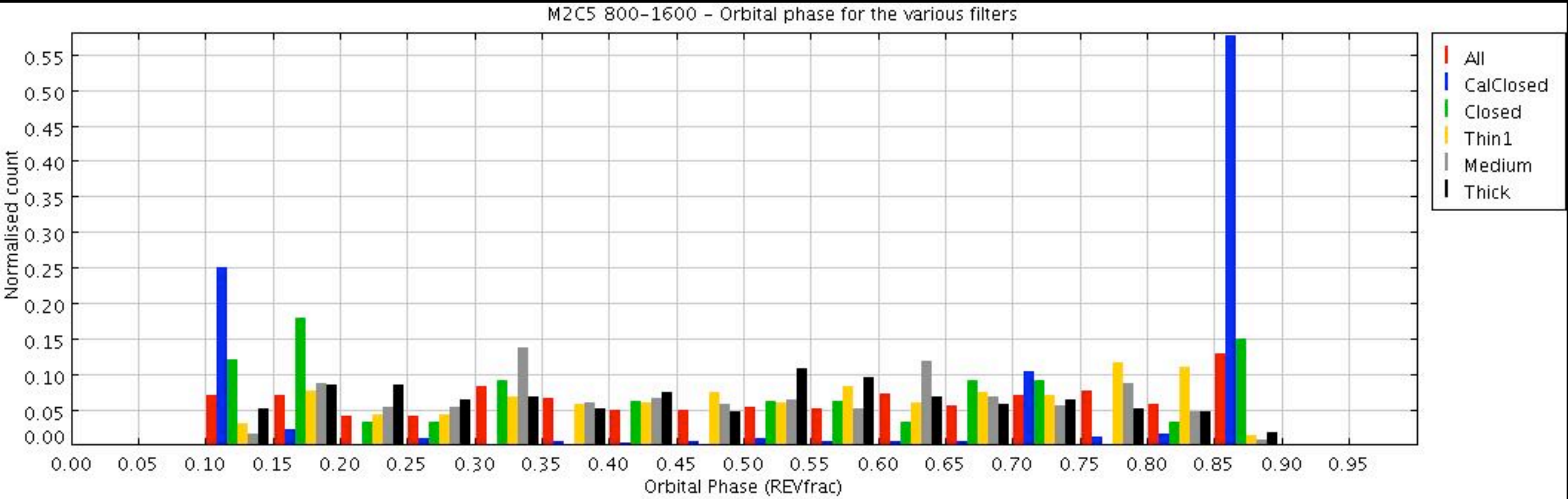
Are the SP1s different from normal CalClosed?



In terms of when in the orbit the SP1s occur, they appear the same as normal CalClosed

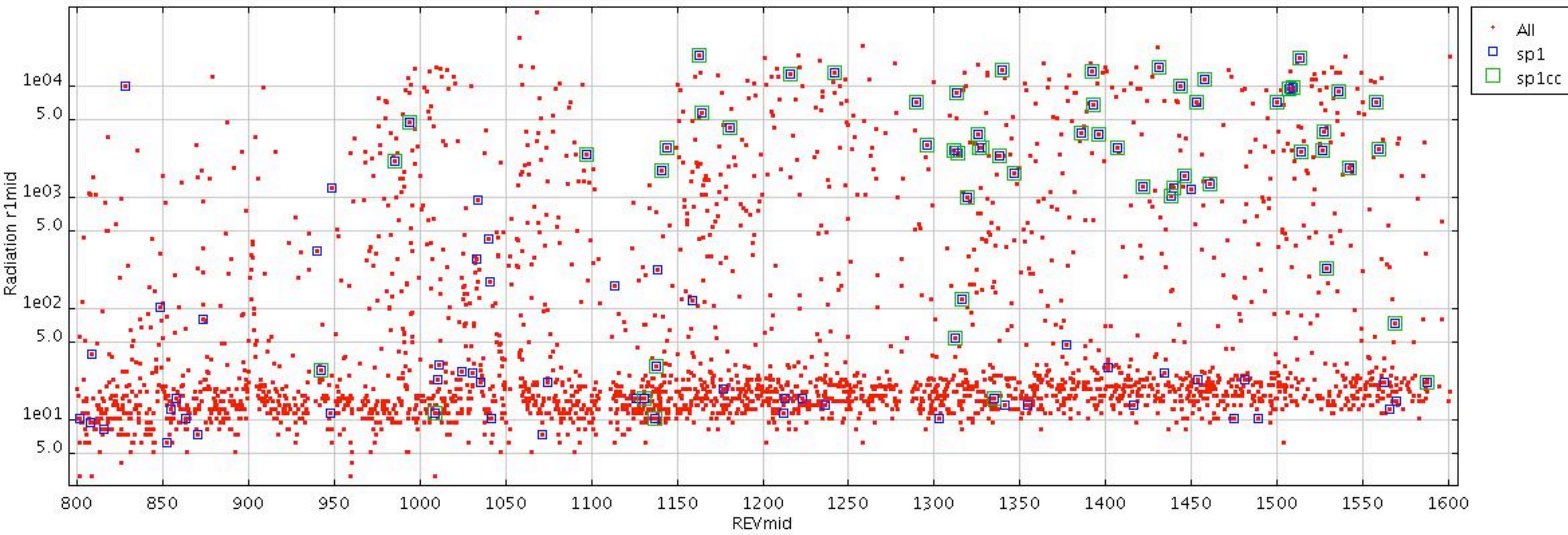
Distribution of Orbital Phase for the Various Filters



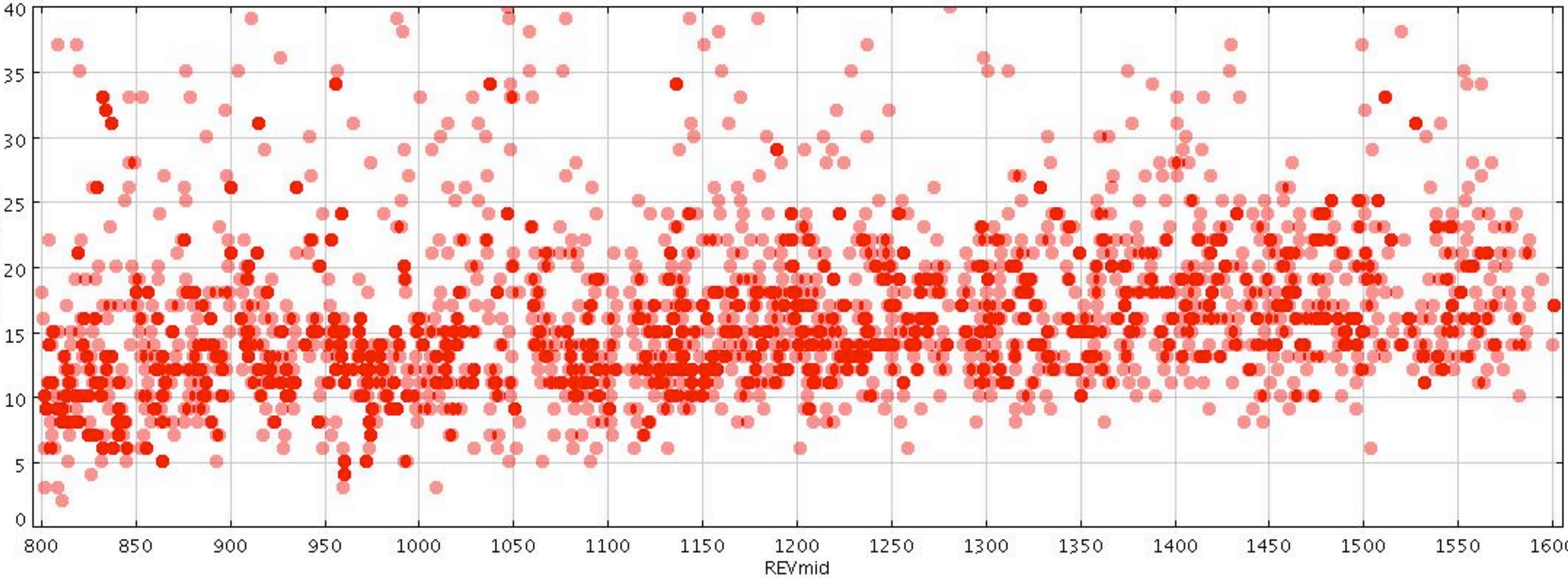


CalClosed predominately at start/end of orbit...

Radiation?

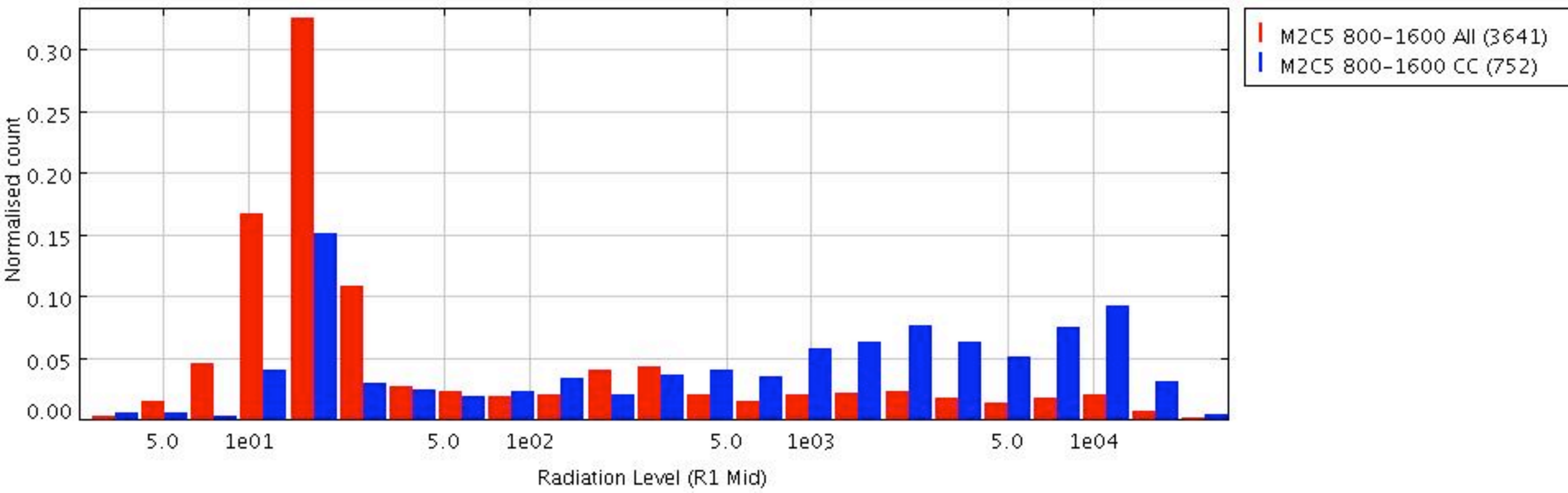


- Radiation Monitor R1 levels
- Values from low-energy NLE0 data in rrrr_SLOW_ECE.FIT files
- Note general rise in radiation level, both quiescent and noisy



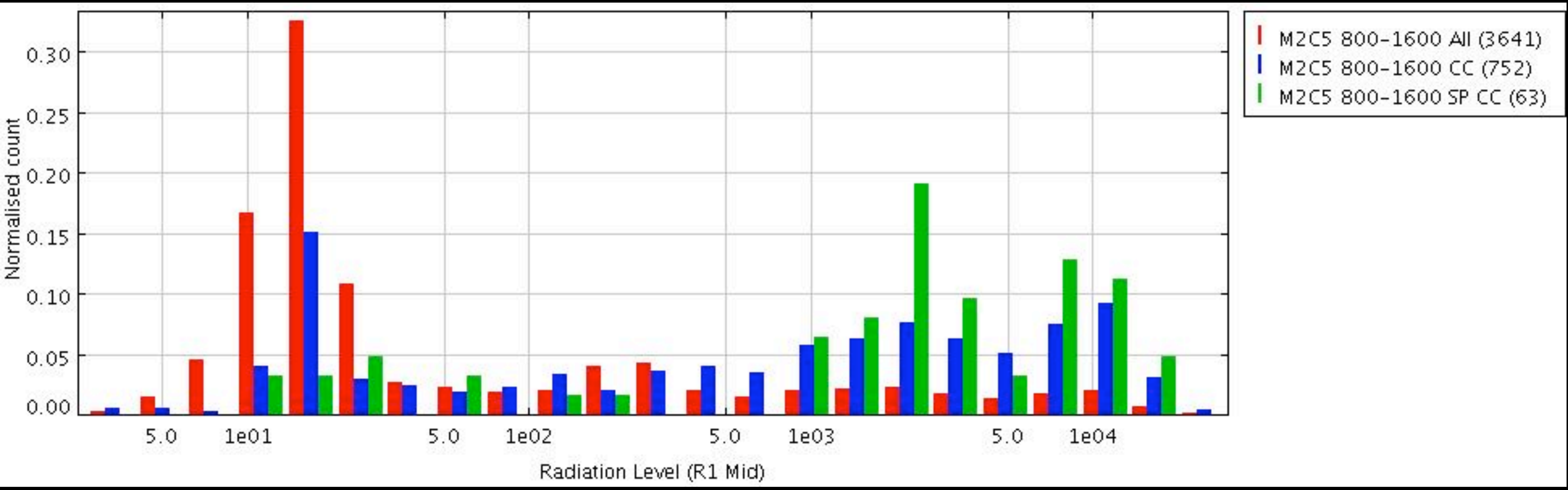
40
35
30
25
20
15
10
5
0
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500
1550
1600
REVmid

Radiation Monitor (RM) Level



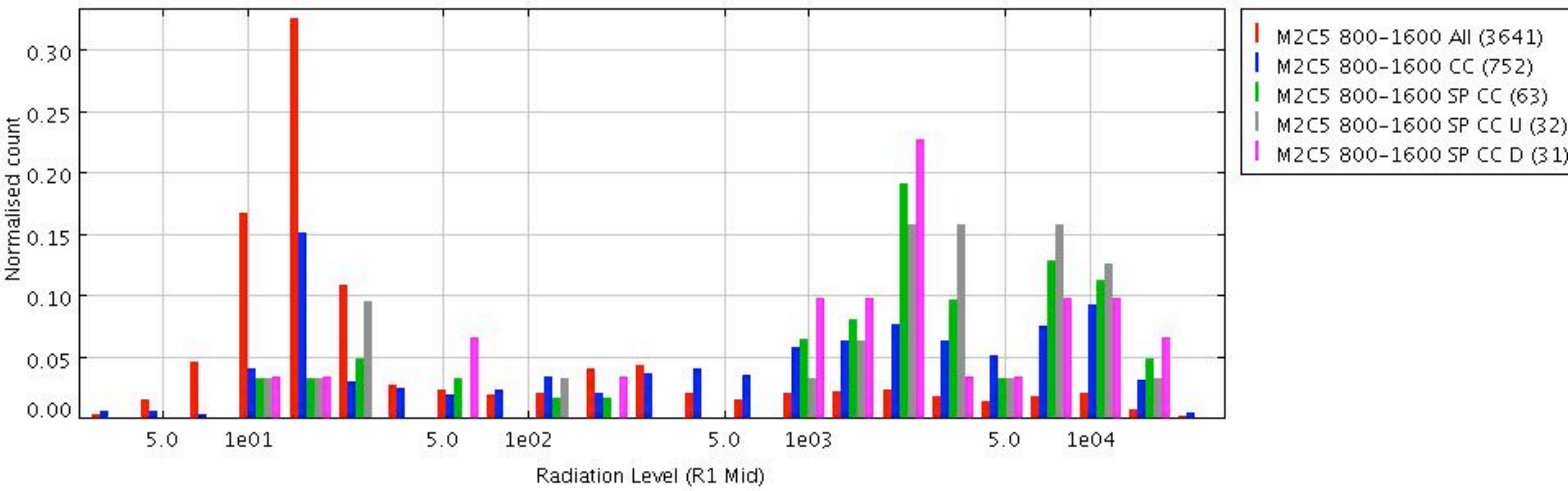
Radiation level for CalClosed is higher than for all observations (as expected)

Radiation Monitor (RM) Level



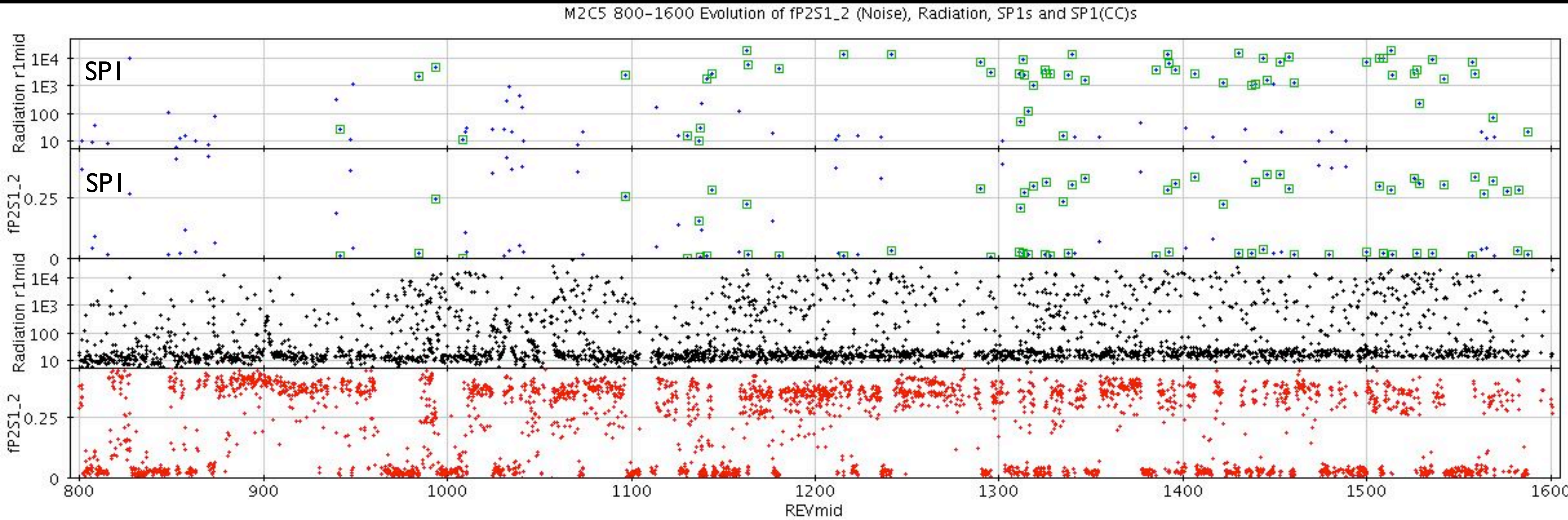
Radiation level for SP1s is even higher that for normal CalClosed!

Radiation Monitor (RM) Level



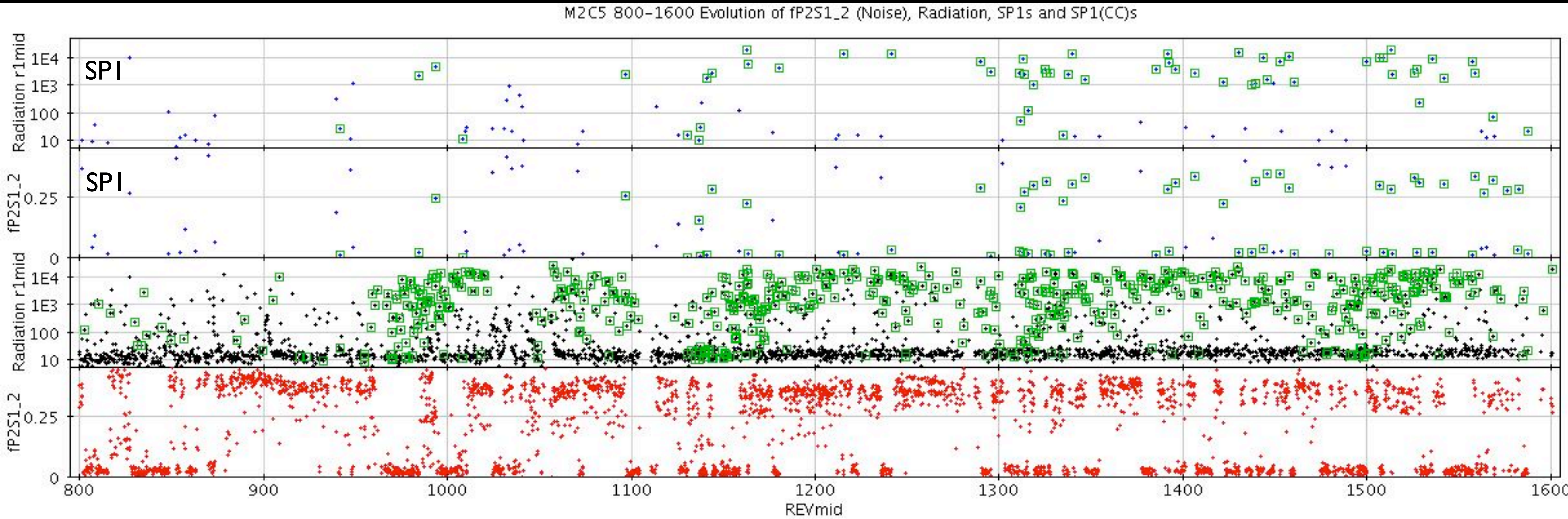
Radiation level for SP1s is equally high, whether Up or Down

Evolution of the CCD Noise and the Radiation



Squares: CalClosed

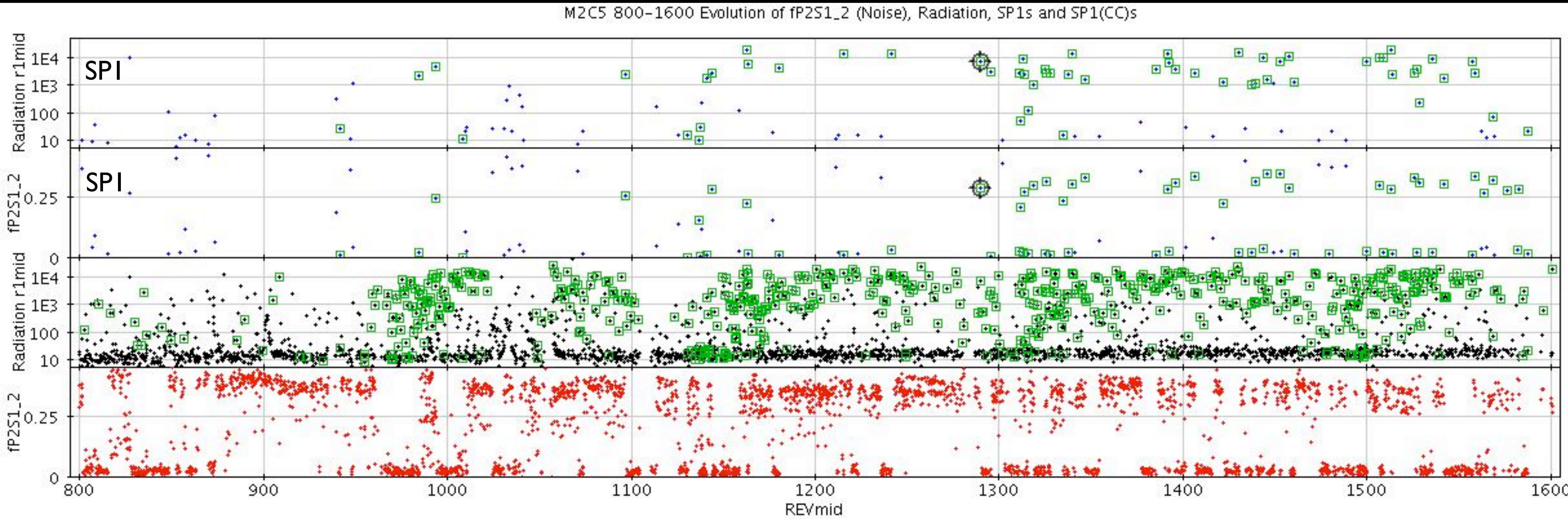
Evolution of the CCD Noise and the Radiation



Squares: CalClosed

Many examples of high-radiation (CalClosed) observations where a switch doesn't occur

Evolution of the CCD Noise and the Radiation



Squares: CalClosed

Many examples of high-radiation (CalClosed) observations where a switch doesn't occur - e.g.

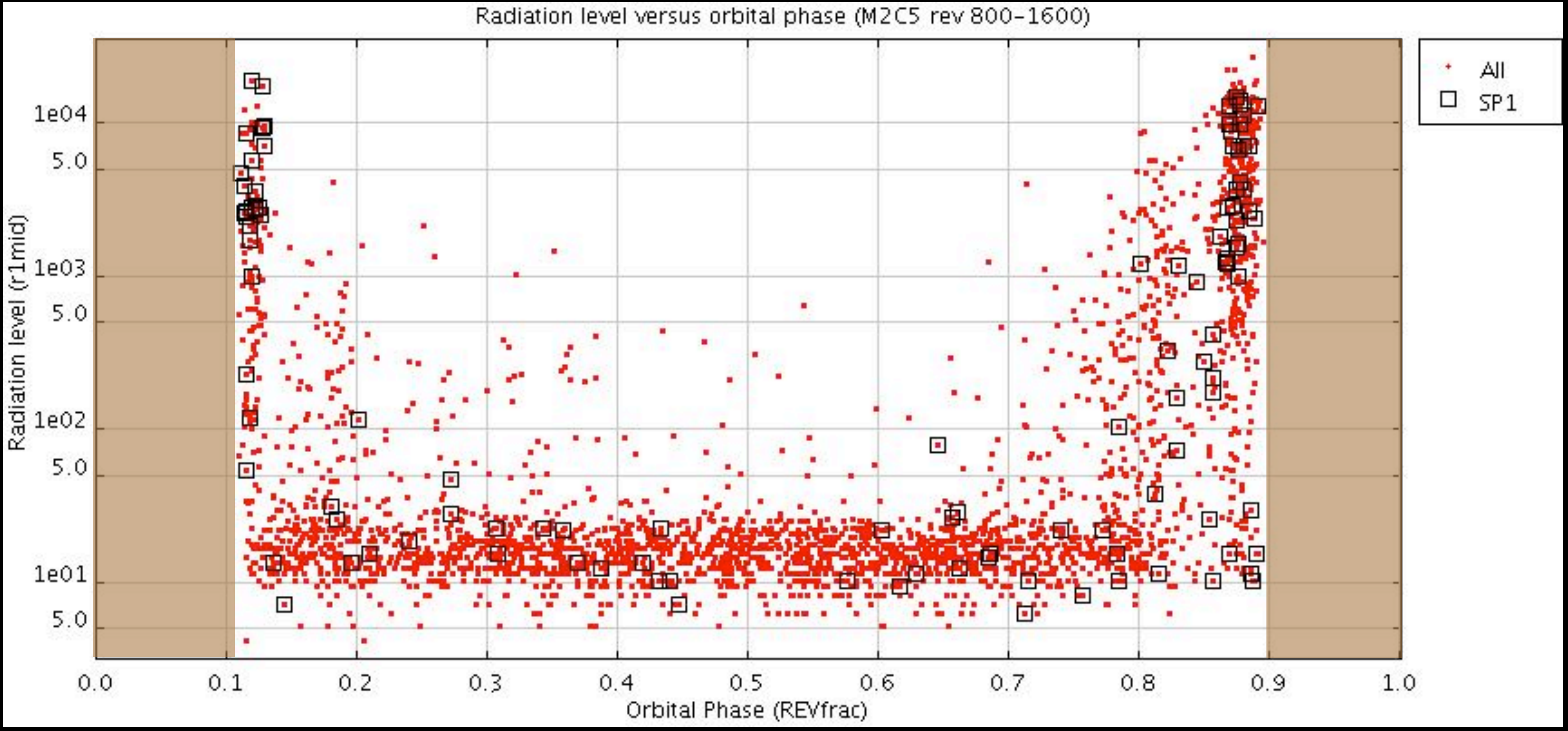
Why does it switch here, and not before?

Suggested Recommendations for Operations

- Separately for MOS1 and MOS2 we require a real-time status of the noise, i.e. whether MOS1 is noisy/clean and whether MOS2 is noisy/clean
- This may require some balance between the noise status of the bad chips (M1C4, M2C5), other candidate bad chips (M1C5, M2C2) and the rest of the chips - the chips do not switch noisy/clean at the same time, though there are some good overlaps

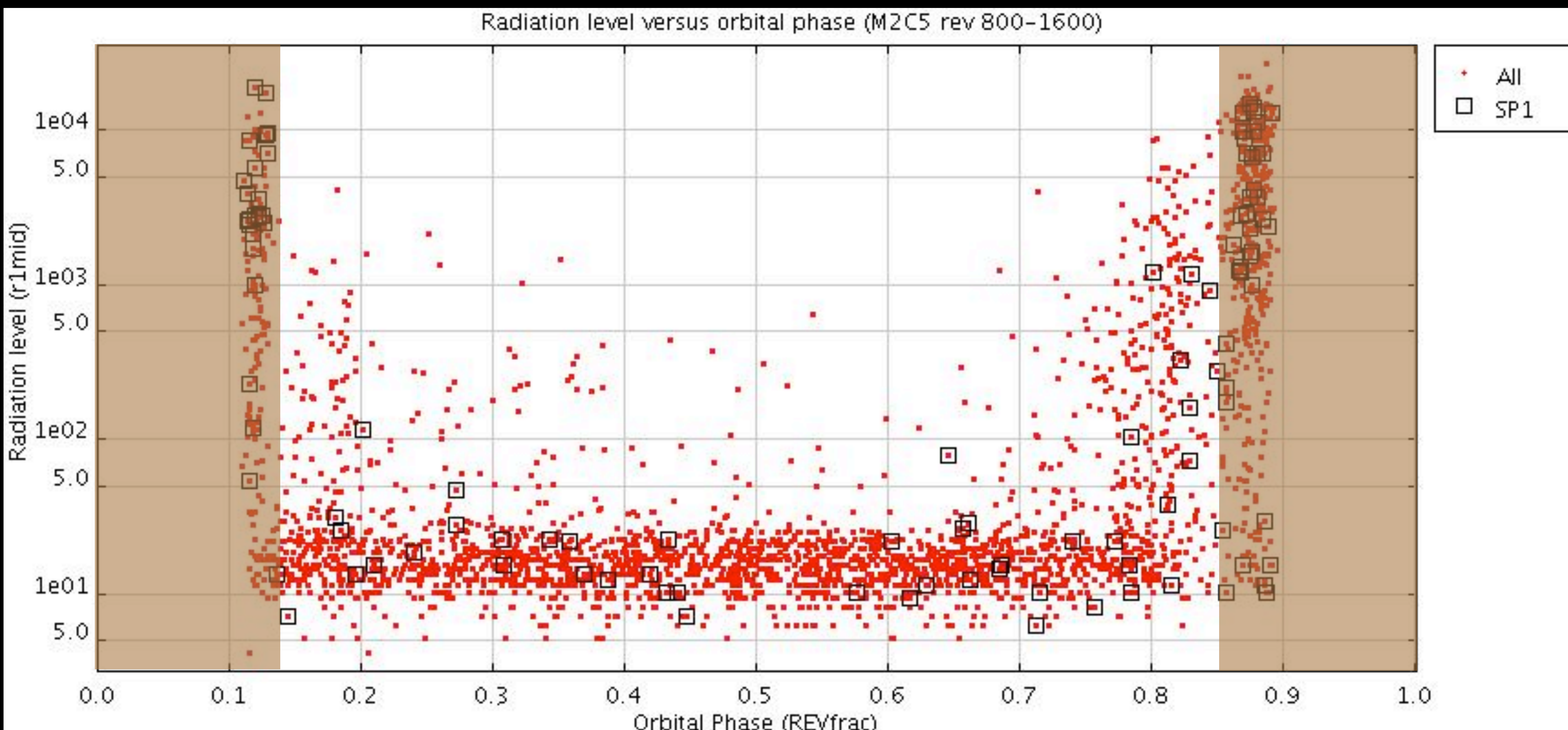
Suggested Recommendations for Operations

- If a MOS is noisy, we need to switch it to clean, so we widen the observation window for that MOS, exposing it to high radiation, until it switches to clean



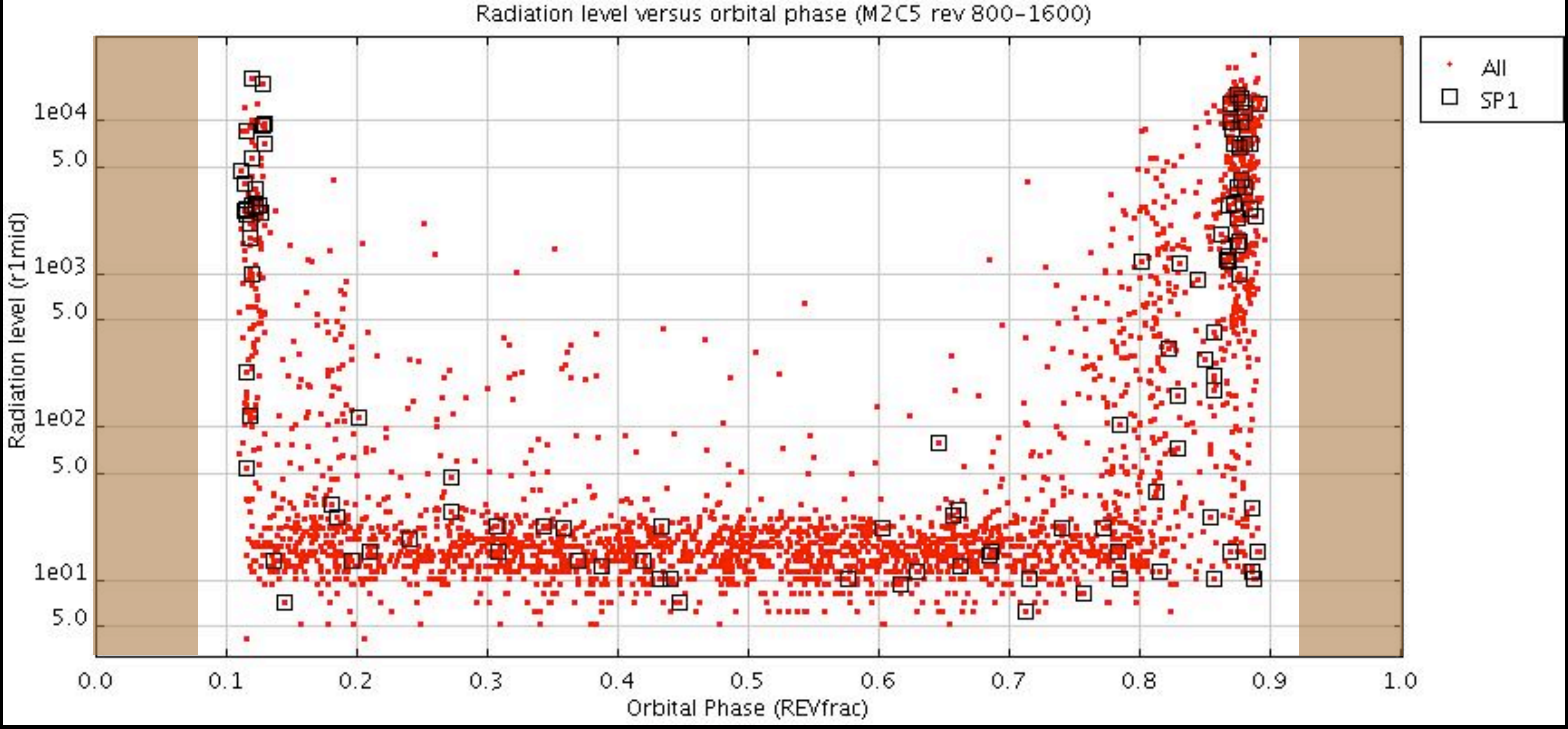
Suggested Recommendations for Operations

- Once that MOS becomes clean, we need to keep it clean, and so we narrow the observation window for that MOS, protecting it from high radiation



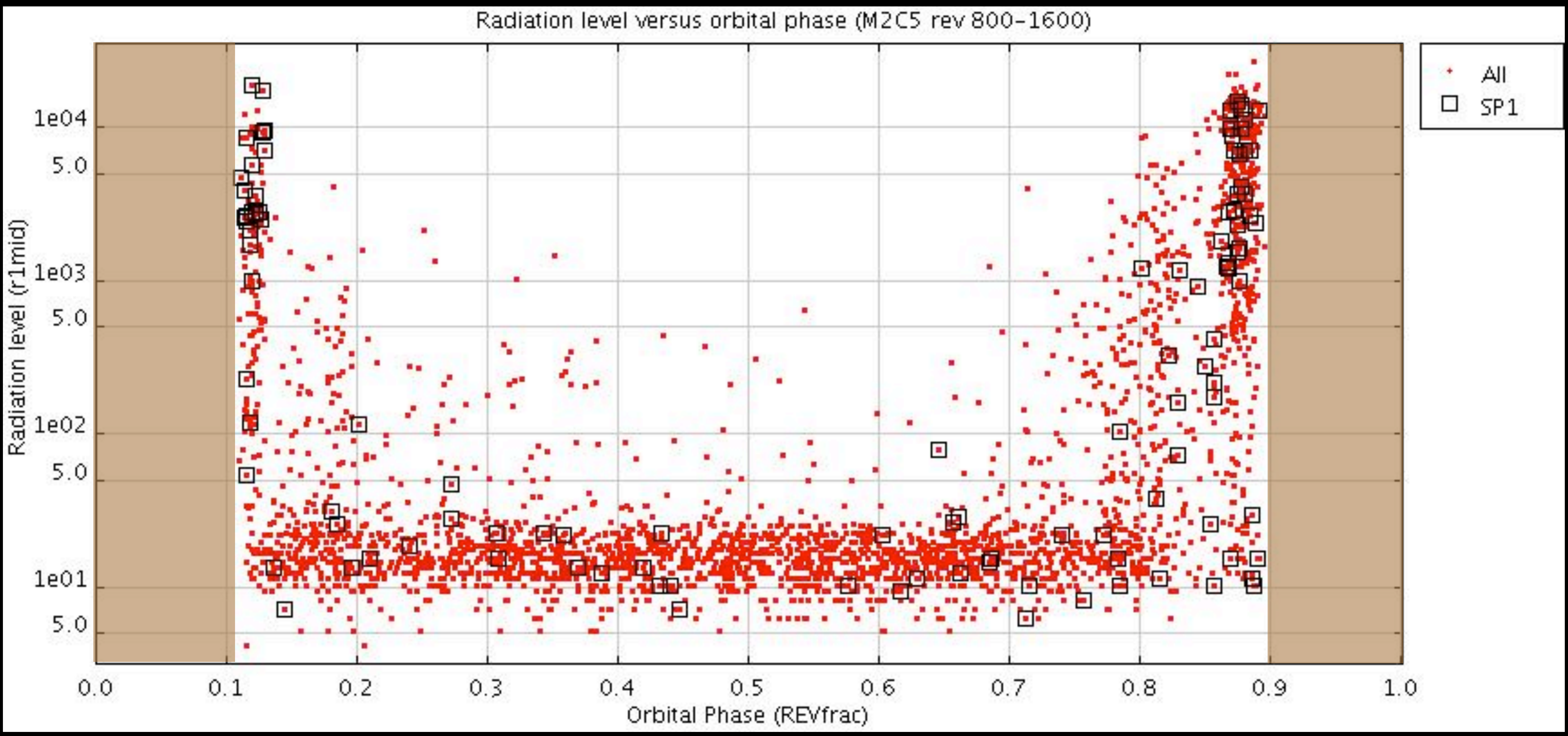
Suggested Recommendations for Operations

- If that MOS does become noisy again, we need to widen the observation window for that MOS again - perhaps we can widen further to increase the chances of a switch and to gain back exposure time



Suggested Recommendations for Operations

- This can be done separately for each MOS
- If we can turn individual chips off, then we may be able to prevent inadvertently switching clean chips to noisy when trying to switch a noisy MOS to a clean MOS



End