The Anglo-Australian Planet Search

Prof. Chris Tinney,
ARC Australian Professorial Fellow, ACA Deputy Director
University of New South Wales

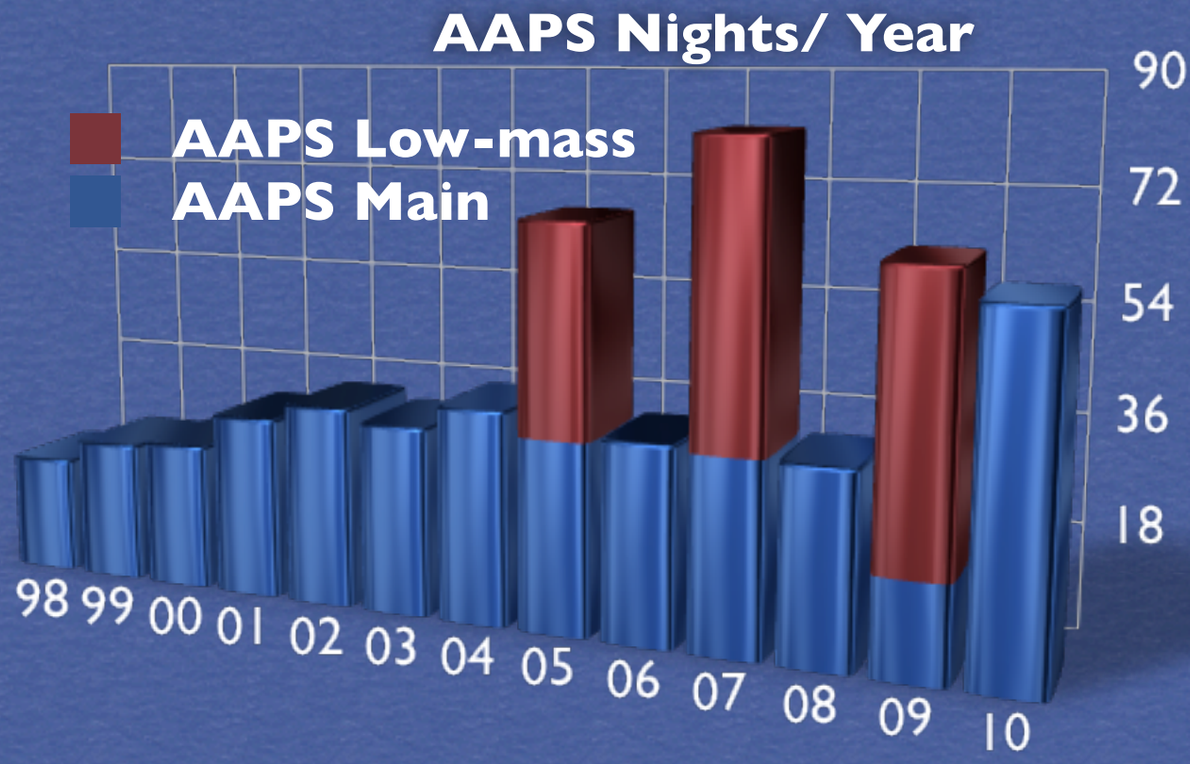
The AAPS Team

Paul Butler, Carnegie Institution
Hugh Jones, U.Hertfordshire
Brad Carter, U.Southern Queensland
Simon O'Toole, AAO
Rob Wittenmyer, Jeremy Bailey UNSW

Geoff Marcy, UC Berkeley
Alan Penny, NASA AMES

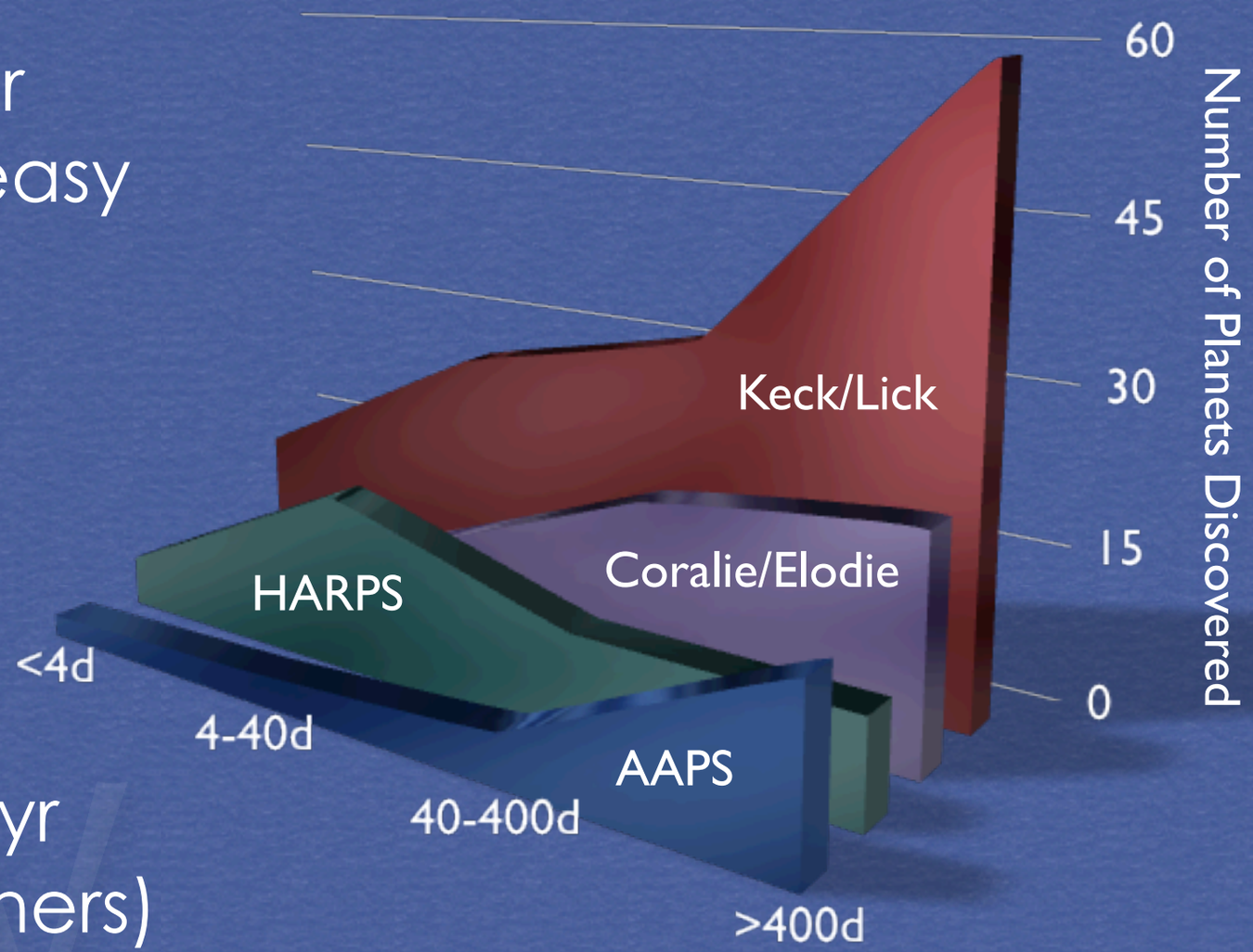
The AAPS

- Established in 1998
- First planet in 2001.
- ~32n/yr since 2001
- “Rocky Planet” campaigns in 05, 07 & 09
- 50n/yr from 09B-12B
- I_2 cell spectroscopy



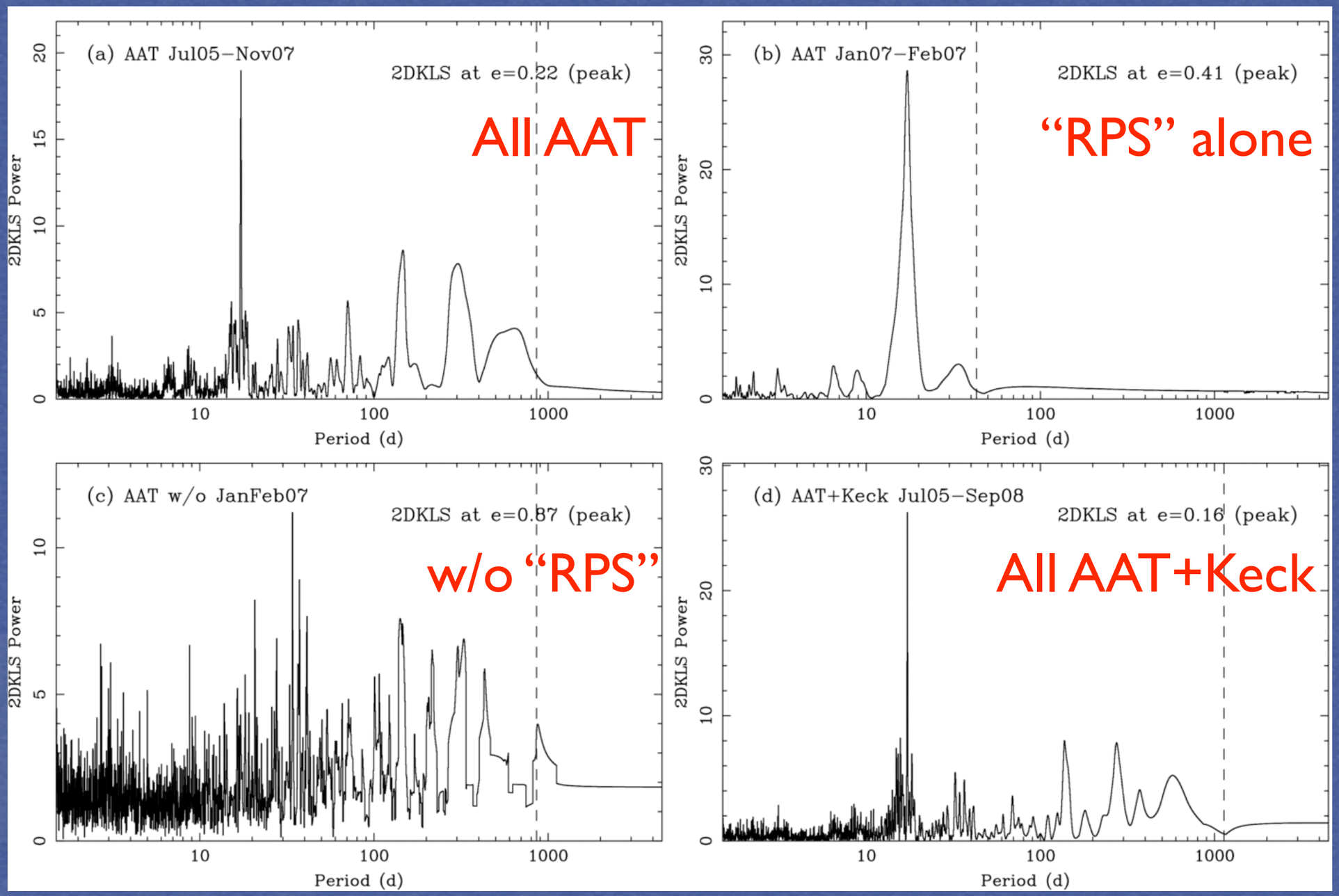
AAPS in the Global Planet Hunt

- Small number of scattered nights/ year => short-periods not easy
- Long-term precision => P>300d more detectable
- 66% of planets at P>1yr (cf. 45%,29,46% for others)



The "Rocky Planet Search" Strategy

Neptune-mass, P=17.2d
HD164177b

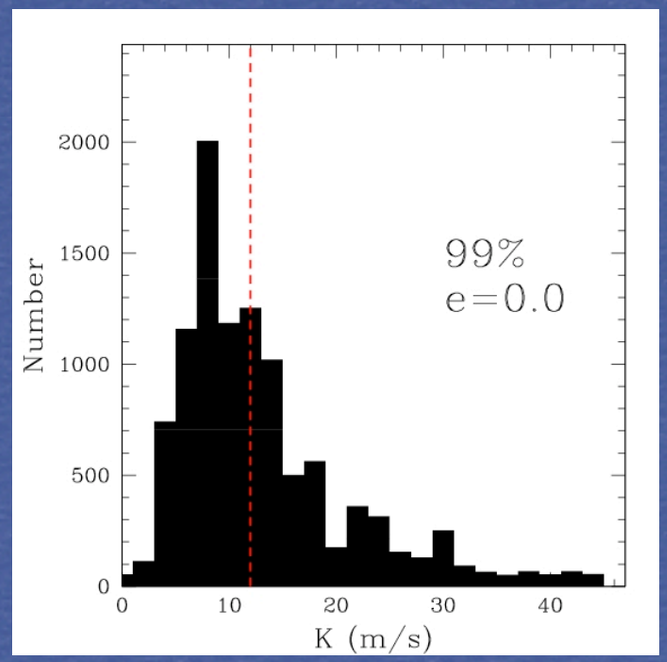


O'Toole et al. (2009) ApJ 697:1263

Simulate, Simulate, Simulate

- O'Toole et al (2010) - two low-mass planets in a 24 star "Rocky Planet Search" sample indicate the mass function at low masses is flat ($\alpha \sim -1$ for $dN/dM \propto M^{\alpha}$) and that between 15±10%(at $\alpha=-0.3$) and 48±34%(at $\alpha=-1.3$) of stars host planets with P<16d & Msini > 3M

- Wittenmyer et al (2010, in prep)
  - 3 Jupiter analogs from 123 stars with >8y data and >30 epochs, implies 3.6±1.4% at 3-6 AU.
  - 120 non-detections implies upper limit of 37.2% for planets with K > 10 m/s in 3-6 AU



Where to Next? - The Fundamental Problems

- S/N : "Collecting enough photons"
  - 50-100n on a 4m, or 10-25n on an 8m
- Solving the aperture problem
  - Slit + Iodine to calibrate the aperture
  - Fibres to scramble the aperture
- Stabilising the Spectrograph
  - Make it so stable it never changes (HARPS etc)
  - Calibrate it well enough (Iodine cell etc)
- Stars are just not stable enough
  - Observing strategies / Selecting the right stars

Super AAPS Observing System

File Observing Commands UCLES

Queue Actions

Stop | Pause | Hard Stop | Abort

Queue Status

Queue: RUNNING Doing: Exposing CCD: Exposing

Guider: Uninitialised ExpMeter: DISABLED T=-15.3 06:34:46.52 -31:16:09.5

Tel: Tracking Dome: Vignetted

Last Measured Seeing: 1.5 Time to queue empty: 9002 s Comment on Run Note on Night

This Run: 128 Object: Wideflat Time:46% 55 / 120

Stop Exp | Change Exp Last File: /data/aatobs/OptDet_data/071121/ccd_2/21nov20127.fits

Queue

Now Observing

ID	St	SNR	Time	N	M	Q?	RA(2000)	DEC(2000)	UTC	HA	Am	Slv	V	SpT	Fe/H	E
Wideflat	W		120	1	M		06 34 14.52	-31 16 09.9	16:36	-00:00	1.00	0				

Next Target

ID	St	SNR	Time	N	M	Q?	RA(2000)	DEC(2000)	UTC	HA	Am	Slv	V	SpT	Fe/H	E
Wideflat	W		120	19	M		06 34 14.52	-31 16 09.9	16:38	+00:01	1.00	0				

Rest of Queue

ID	St	SNR	Time	N	M	Q?	RA(2000)	DEC(2000)	UTC	HA	Am	Slv	V	SpT	Fe/H
Test06	X		30	1	M		06 05 24.428	-37 21 26.50	17:36	+01:28	1.06	55	2.5	M2V	
10180	h!	90	420	11	A		01 37 53.576	-60 30 41.50	17:38	+05:57	2.18	138	7.33	G2V	-

Add | Remove | Clear | ↑ | ↓ | Make Next | Modify

Messages

```
[16:36:41] UCLES:QUARTZ lamp selected and turned on
[16:36:42] DETECTOR_2 exposure 120
[16:36:42] DETECTOR_2 object Wideflat
[16:36:42] DETECTOR_2 run FLAT -novait
[16:36:42] DETECTOR_2 wait exposure_end
```

Observing Log

Run	Object	I2	Midtime	Exp	SN/p	See	Comments
123	Wideflat	n	15:56:08	m 120	448		
124	Wideflat	n	15:59:14	m 120	448		
125	Wideflat	n	16:02:19	m 120	448		
126	Wideflat	n	16:05:25	m 120	448		
127	Wideflat	n	16:08:30	m 120	448		

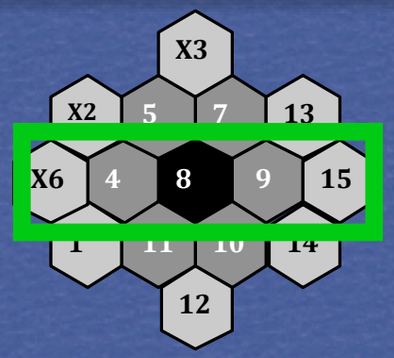
Observing Log Notes

```
13:30:27 Rain and thick cloud since sunset
15:21:36 Still thick cloud
```

Catalogue

ID	St	SNR	Q?	RA(2000)	DEC(2000)	UTC	HA	Am	V	SpT
Calibrate										
Wideflat	W	120		20 copies		16:36				
Wideflat	W	120		40 copies		16:36				
ThAr0.5px	As	30		1 copy		16:36				
ThAr1.0"	A	10		1 copy		16:36				
Narrowflt	N	120		1 copy		16:36				
Iodine	I	120		1 copy		16:36				
Test00	X	30		00 05 24.428	-37 21 26.50	16:36			2.5	M2V
Test06	X	30		06 05 24.428	-37 21 26.50	16:36	+00:28	1.01	2.5	M2V
Test09	X	30		09 05 24.428	-37 21 26.50	16:36	-02:31	1.17	2.5	M2V
Test12	X	30		12 05 24.428	-37 21 26.50	16:36			2.5	M2V
Test18	X	30		18 05 24.428	-37 21 26.50	16:36			2.5	M2V
AAPS Srvy										
225213		2		00 05 24.428	-37 21 26.50	16:36			8.56	M2V
240	K	4		00 06 10.176	-49 04 30.50	16:36			5.70	G1V
1581		4		00 20 04.260	-64 52 29.25	16:36	+06:13	2.22	4.23	G0V
2039	K	4		00 24 20.278	-56 39 00.17	16:36	+06:09	2.40	9.00	G4V
2071		2		00 24 42.548	-53 59 02.39	16:36			7.40	G8IV
2151		4		00 25 45.072	-77 15 15.28	16:36	+06:07	1.99	2.80	G2IV
2587		2		00 29 10.422	-50 36 42.86	16:36			8.46	G7V
3277		2		00 35 34.256	-39 44 46.65	16:36			7.45	G6V
3823		4		00 40 25.670	-59 27 16.58	16:36	+05:53	2.17	5.89	G1V
4308		4		00 44 39.268	-65 38 58.28	16:36	+05:48	2.03	6.55	G4V
5562		2		00 56 21.249	-63 57 30.18	16:36	+05:37	1.98	7.10	G8IV
6735		2		01 07 32.052	-41 44 48.12	16:36	+05:26	2.27	7.01	F9V
7199		2		01 10 47.223	-66 11 17.39	16:36	+05:22	1.88	8.06	K0V
7693		2		01 15 00.993	-68 49 08.08	16:36	+05:18	1.85	7.22	K2V
7570		2		01 15 11.121	-45 31 53.99	16:36	+05:18	2.08	4.97	G0V
9280		2		01 31 13.946	-10 53 47.55	16:36			8.03	G8V
9540		2		01 33 15.809	-24 10 40.66	16:36	+05:00	2.41	6.96	K0V
10180	h!	3		01 37 53.576	-60 30 41.50	16:36	+04:55	1.76	7.33	G2V
10360		4	No	01 39 47.7	-56 11 34.0	16:36	+04:53	1.76	5.87	K0V
10361		4	No	01 39 47.2	-56 11 44.0	16:36	+04:53	1.76	5.76	K5V
10647		2		01 42 29.316	-53 44 27.00	16:36	+04:51	1.76	5.52	F9V
10700	P!	4		01 44 04.083	-15 56 14.93	16:36			3.50	G8V
11112	h!	3		01 48 20.583	-41 29 42.23	16:36	+04:45	1.82	7.13	G3V
12387	H!	3		02 00 32.125	-40 43 52.49	16:36	+04:33	1.73	7.37	G4V
13445	K	4		02 10 25.934	-50 49 25.41	16:36	+04:23	1.60	6.12	K1V
14412		4		02 18 58.505	-25 56 44.47	16:36	+04:14	1.76	6.33	G8V
16417	H!	4		02 36 58.608	-34 34 40.72	16:36	+03:56	1.52	5.79	G5IV
17051	K	2		02 42 33.466	-50 48 01.06	16:36	+03:51	1.45	5.40	G3IV
18709		2		02 58 59.070	-43 44 53.98	16:36	+03:34	1.38	7.39	G1V
18907		2		03 01 37.637	-28 05 29.59	16:36	+03:32	1.43	5.89	G5IV
19632		2		03 08 52.445	-24 53 15.53	16:36	+03:24	1.42	7.29	G5V
20029		3		03 11 52.579	-39 01 23.58	16:36	+03:21	1.33	7.05	F9V
20201		3		03 12 54.379	-47 09 18.84	16:36	+03:20	1.33	7.27	G0V
20766	P!	3		03 17 46.163	-62 34 31.16	16:36	+03:16	1.39	5.53	G3V
20807		4		03 18 12.819	-62 30 22.91	16:36	+03:15	1.39	5.24	G1V
20794	P!	4		03 19 55.651	-43 04 11.22	16:36	+03:13	1.30	4.27	G8V
20782		2		03 20 03.578	-28 51 14.66	16:36	+03:13	1.34	7.36	G3V
22104		2		03 27 37.181	-73 26 22.44	16:36	+03:06	1.50	8.32	G5V
23127		2		03 39 23.639	-60 04 40.23	16:36	+02:54	1.32	8.58	G5V
23079	K	3		03 39 42.095	-52 54 57.08	16:36	+02:54	1.27	7.19	G0V

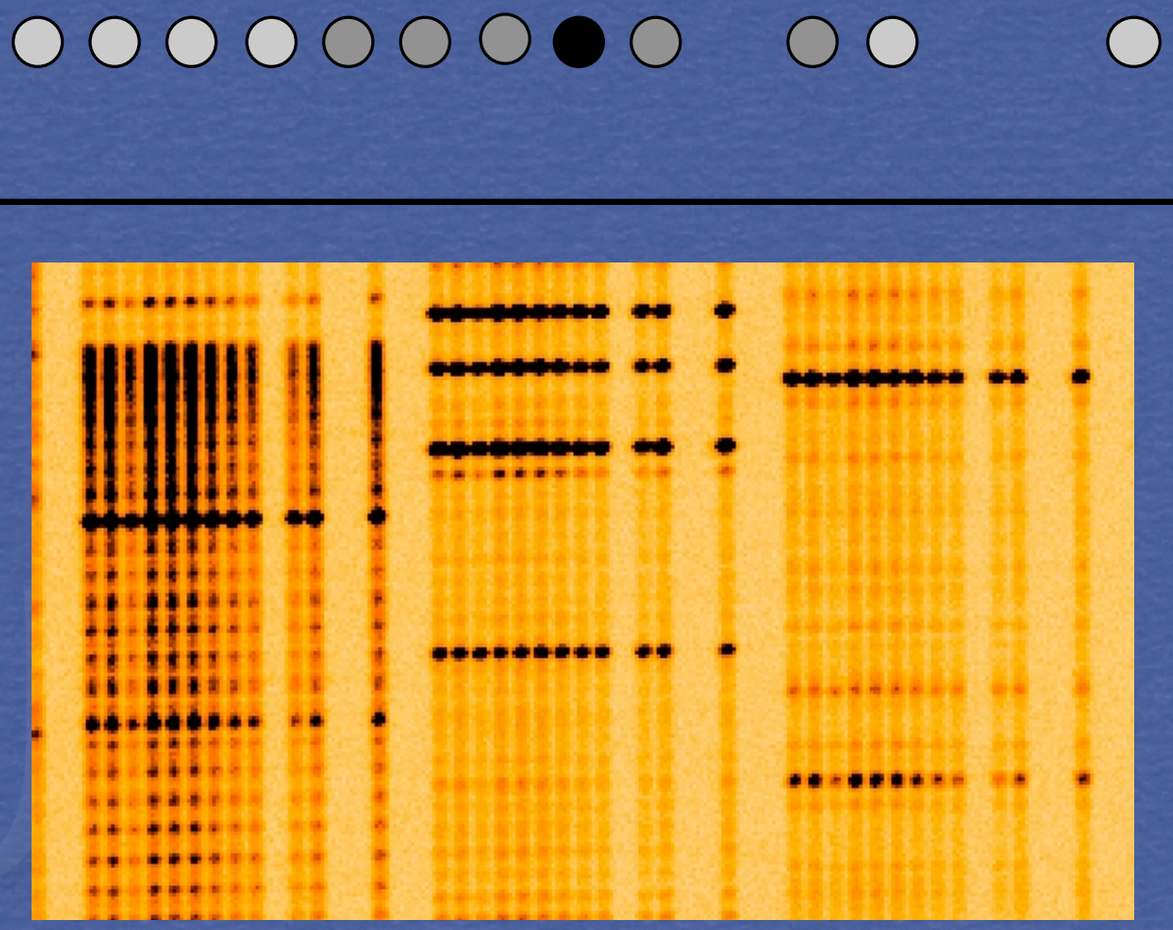
CYCLOPS



CYCLOPS Cass Feed Layout

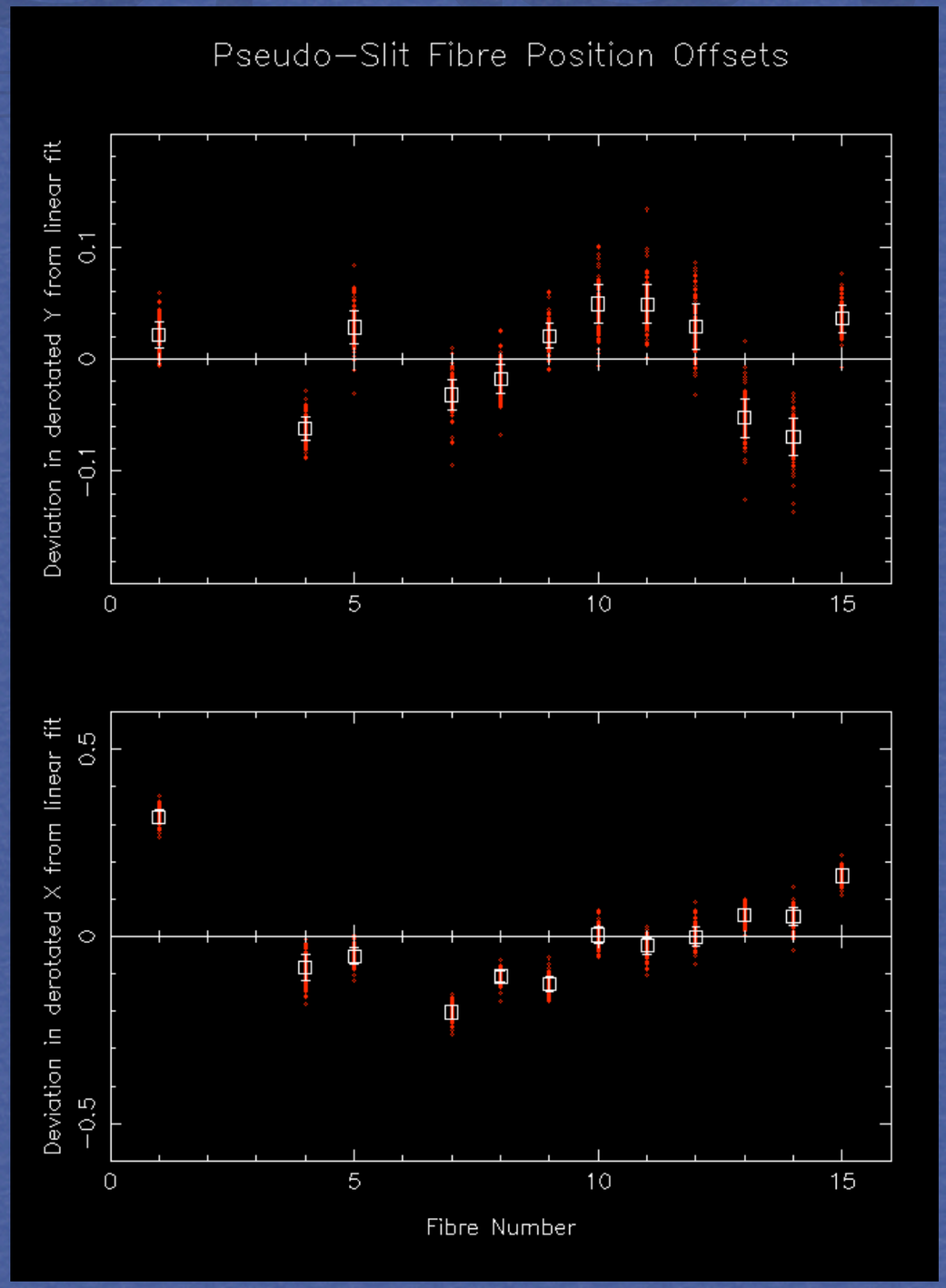
- orientation currently unknown
- three fibres dead (6,3 & 2)

CYCLOPS Pseudo-slit Layout.

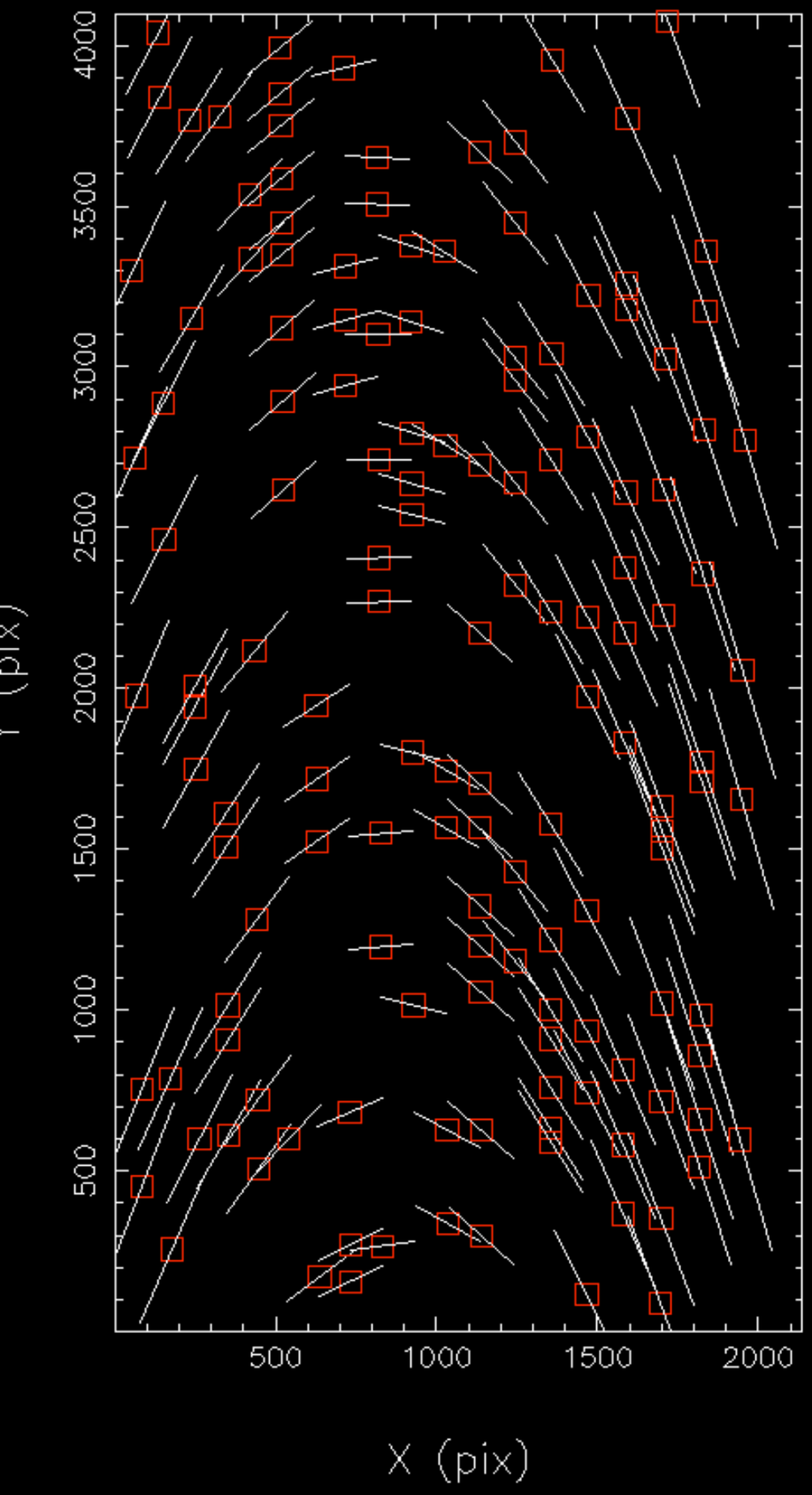


CYCLOPS Performance

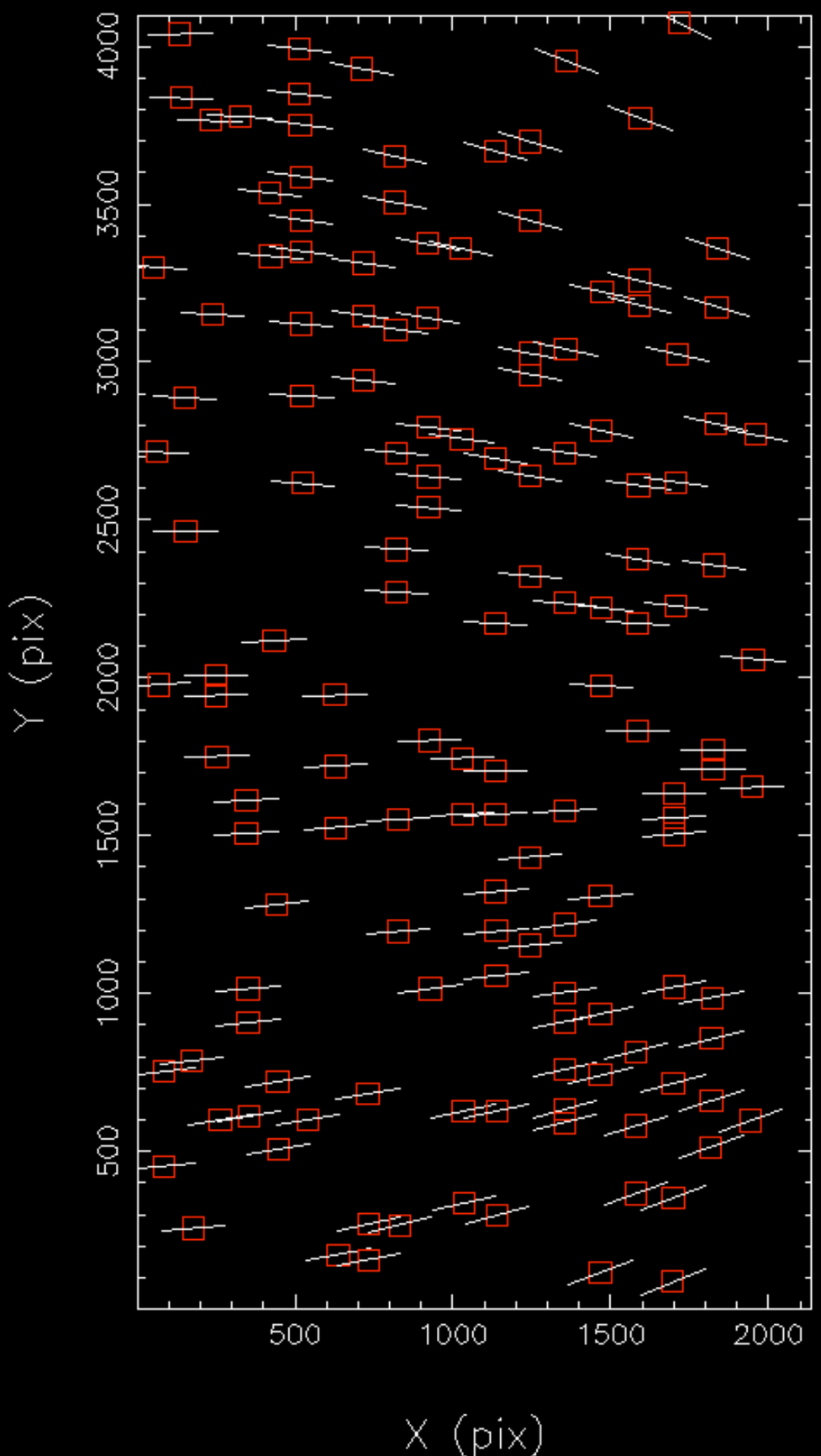
- Fibre images have 2.55 pixel FWHM ($\lambda/\Delta\lambda$~69,500)
- Fibre offsets 2.5µm p-p (or 1/200th of a spectral PSF) in the spectral direction.
- Total throughput (with sub-optimal bundle) is ~ 50% better than a 1" slit, and at 50% higher resolution



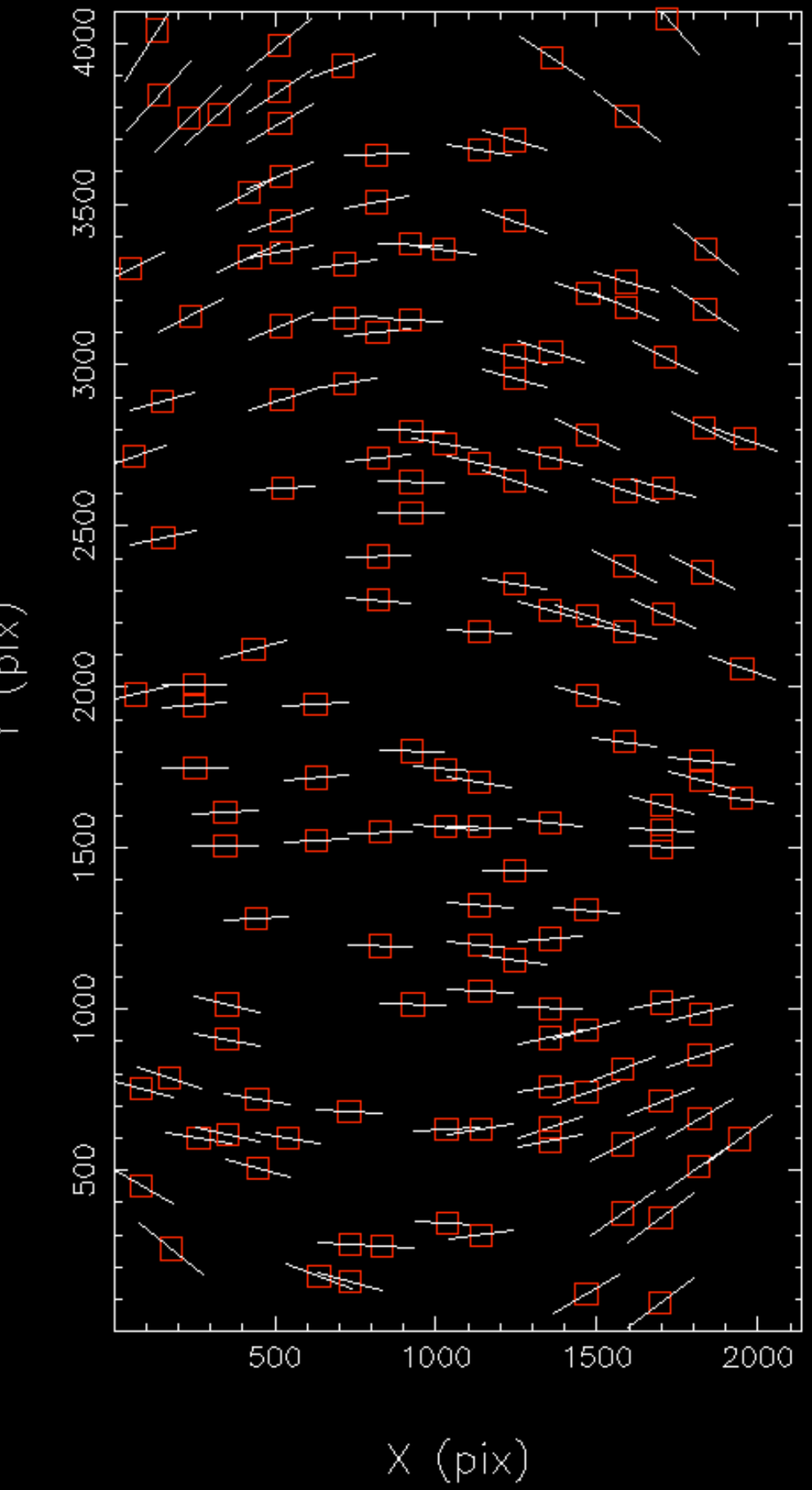
Pseudo−Slit Orientation (Slope exag. x50)



Pseudo−Slit Orientation (Slope exag. x100)



Pseudo–Slit Orientation (Slope exag. x500)



Pseudo–Slit Orientation (Slope exag. x500)