

# Gravitational Microlensing At Auckland Observatory

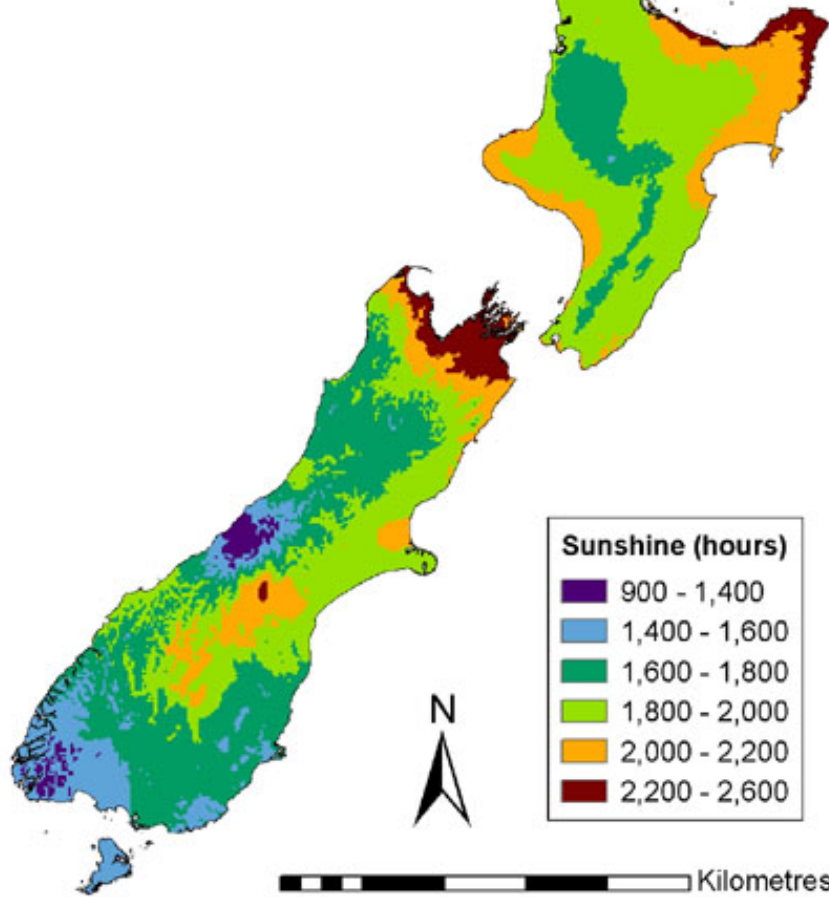
**Grant Christie**  
**Tim Natusch**

**Auckland Observatory**  
**New Zealand**

# Outline

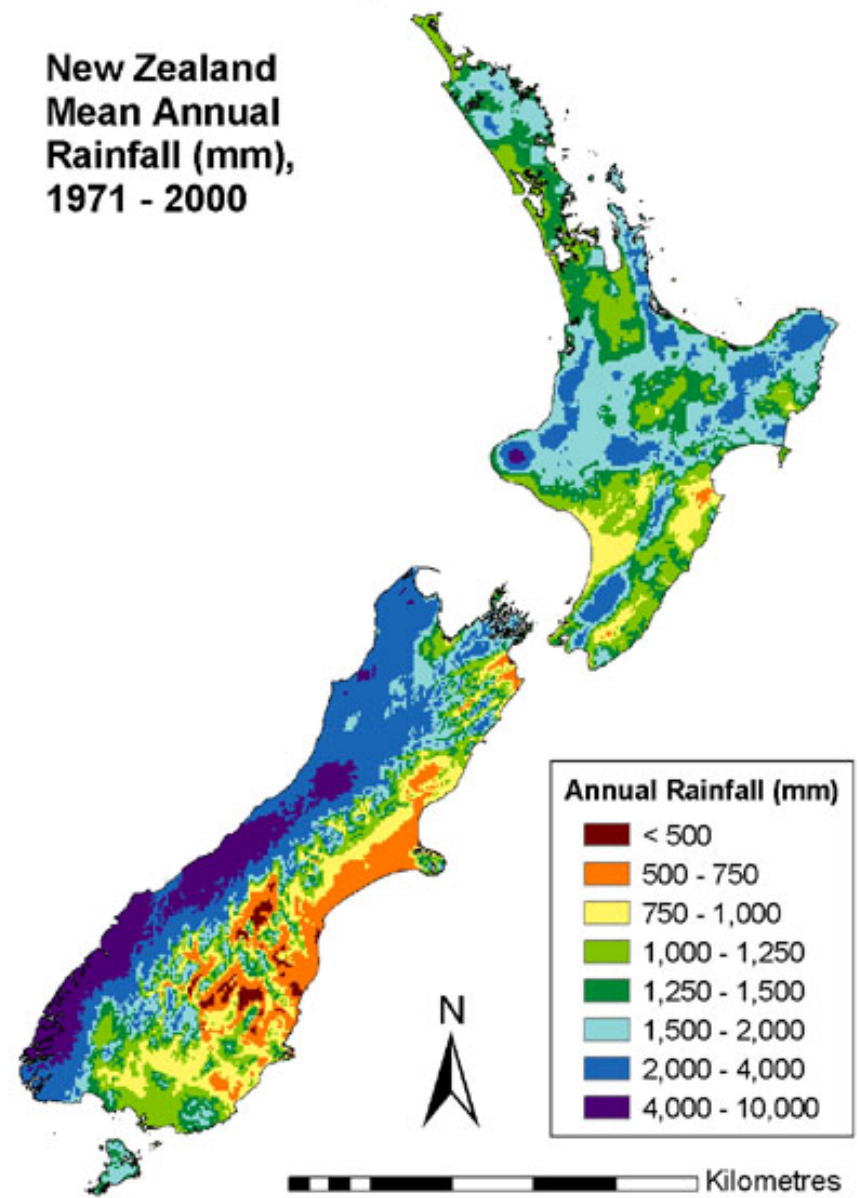
- **Auckland situation**
- **Equipment and software**
- **Image calibration and reduction**
- **Event follow-up**
- **Issues**

New Zealand  
Mean Annual  
Sunshine Hours,  
1971 - 2000



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New Zealand  
Mean Annual  
Rainfall (mm),  
1971 - 2000



Copyright NIWA, 2003©





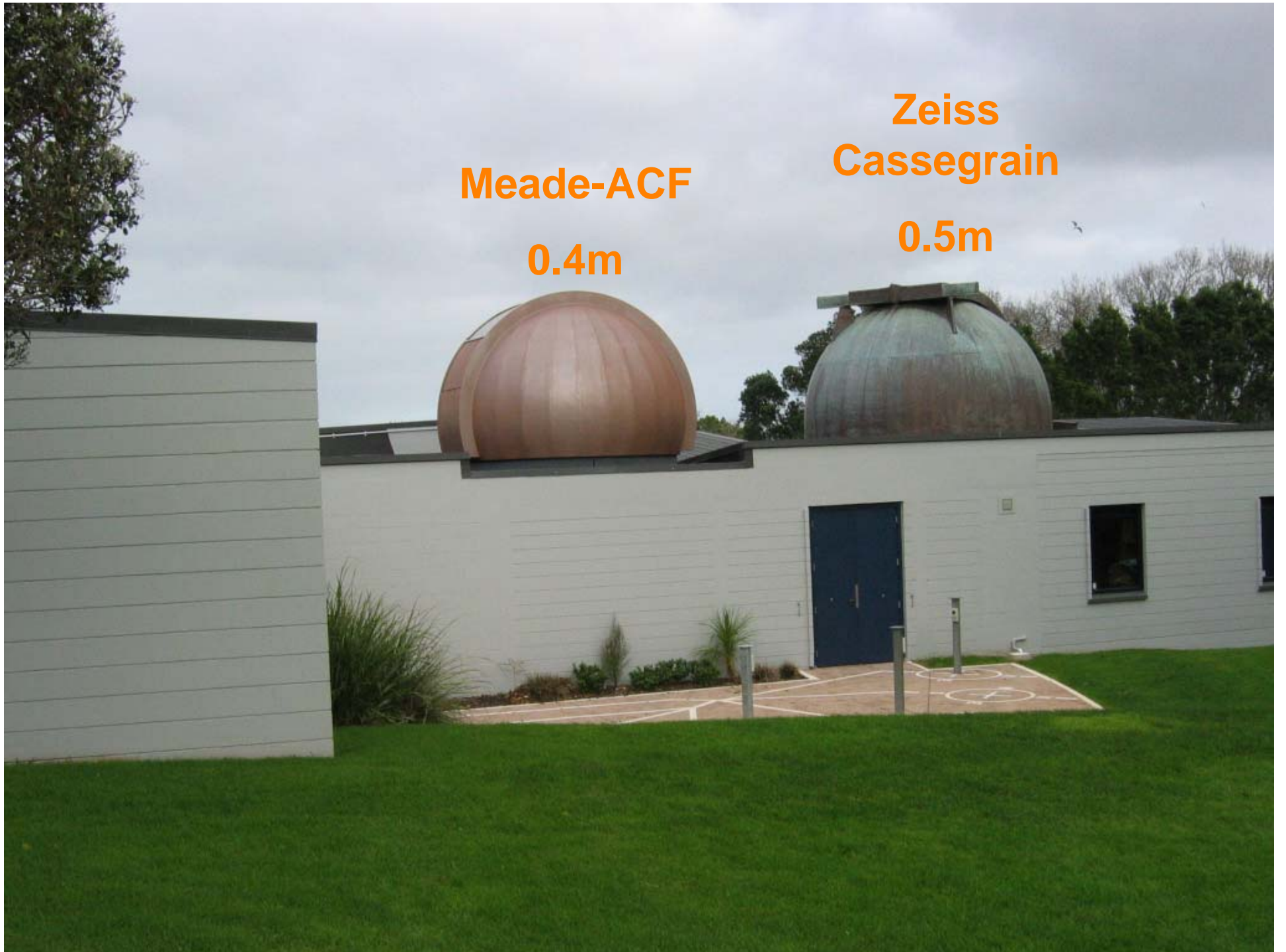
*First MicroFUN Workshop – Auckland 2008*

**Meade-ACF**

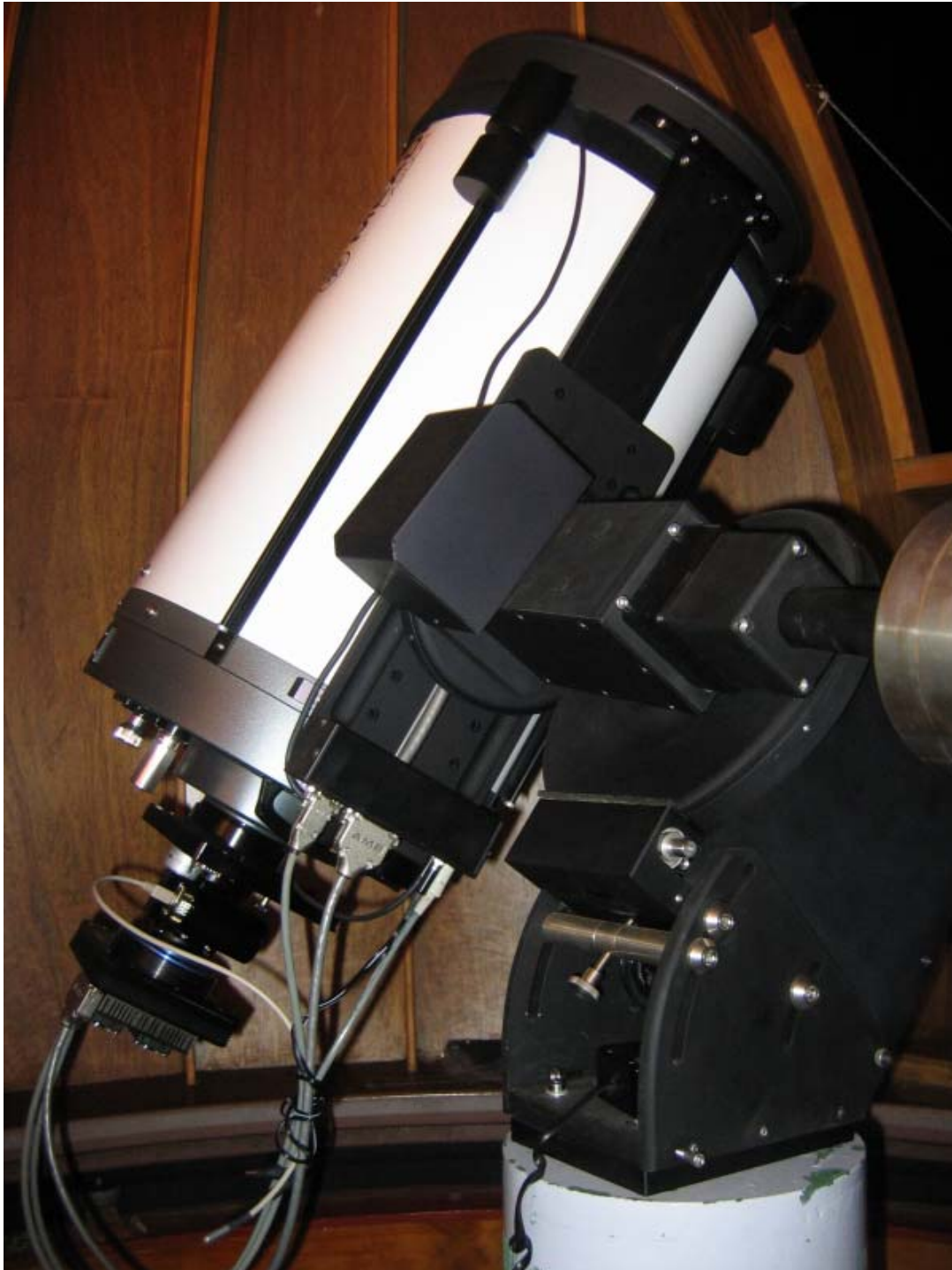
**0.4m**

**Zeiss  
Cassegrain**

**0.5m**







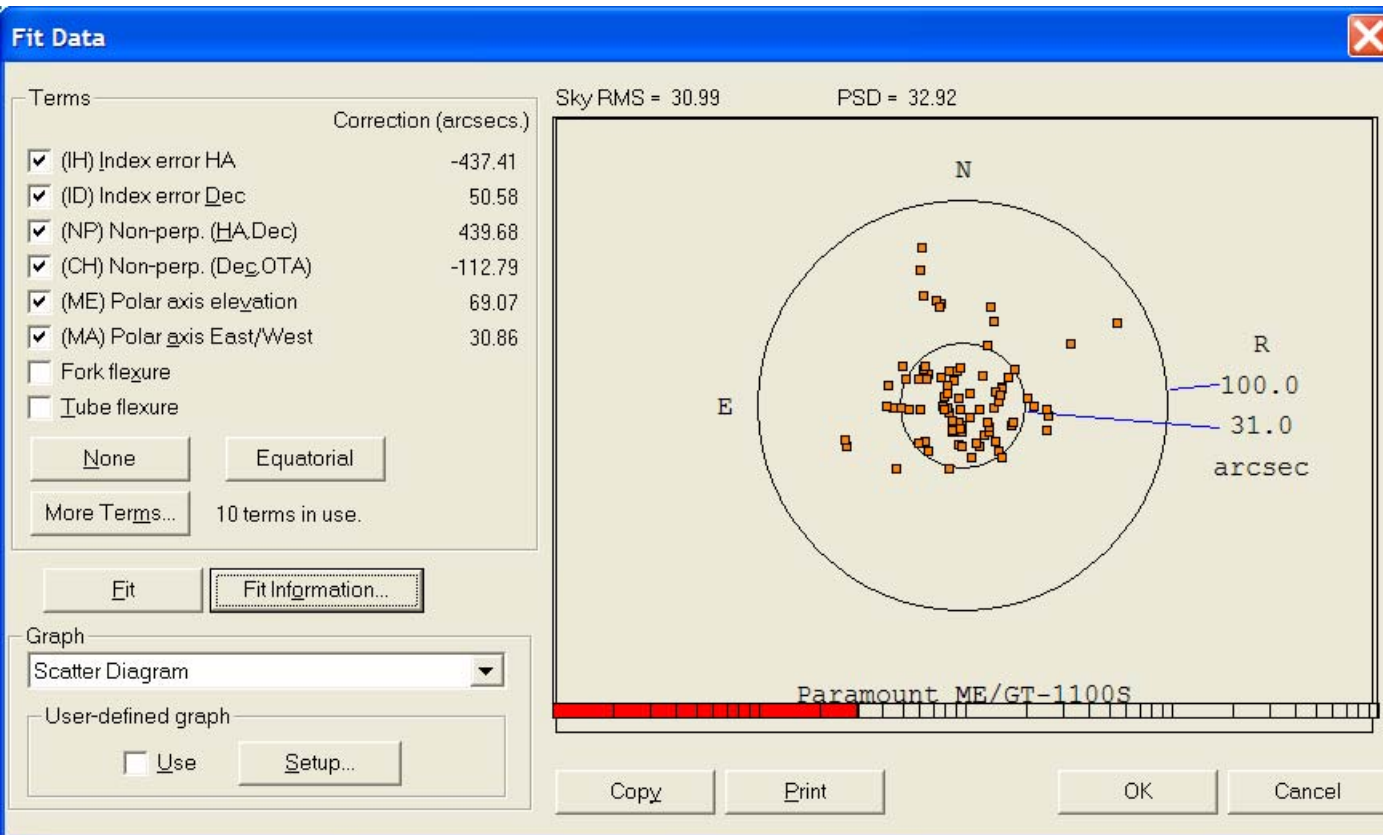
0.4m Meade-ACF

Dew heater

Paramount GT1100s

*Minimal periodic error  
( $<0.5\text{as}$ )*





## TPoint

Improves absolute pointing and tracking

**Fit Information**

```
* fit
```

	coeff	change	value	sigma
1	IH	-437.247	-437.25	14.993
2	ID	+49.348	+49.35	8.912
3	NP	+440.570	+440.57	15.296
4	CH	-112.904	-112.90	16.695
5	ME	+68.143	+68.14	8.910
6	MA	+31.579	+31.58	9.075
7	HCES	-70.028	-70.03	19.692
8	HCEC	-342.848	-342.85	19.496
9	DCEC	+92.497	+92.50	9.514
10	DCEC	-96.816	-96.82	9.094

Sky RMS = 31.01

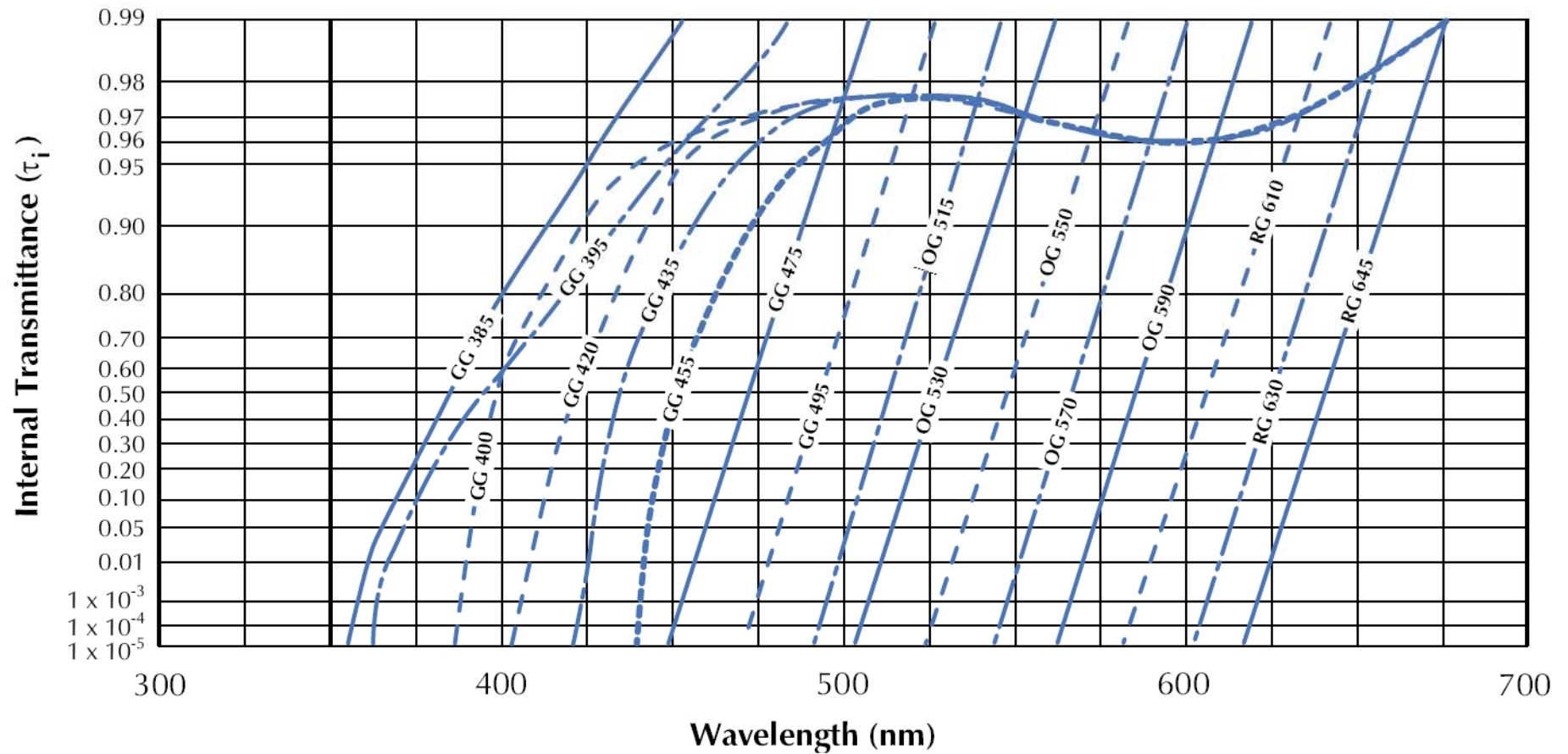
Close

## Major Hardware

- Paramount GT1100s mount (**ASB Trust**)
- Meade-ACF 0.40m f/10 (2006) (**Sth Auckland Trust**)
- Optec TCF-S focuser (**MicroFUN**)
- Optec filter wheel (Schott OG530 filter) (**MicroFUN**)
- Apogee AP8p CCD with 24  $\mu\text{m}$  pixels (1.2as) (**ASB Trust**)
- SBIG ST7XME with 9 $\mu\text{m}$  pixels (0.46as) (2007/08) (**MAGS**)
- Boltwood Cloud Sensor (**MicroFUN**)

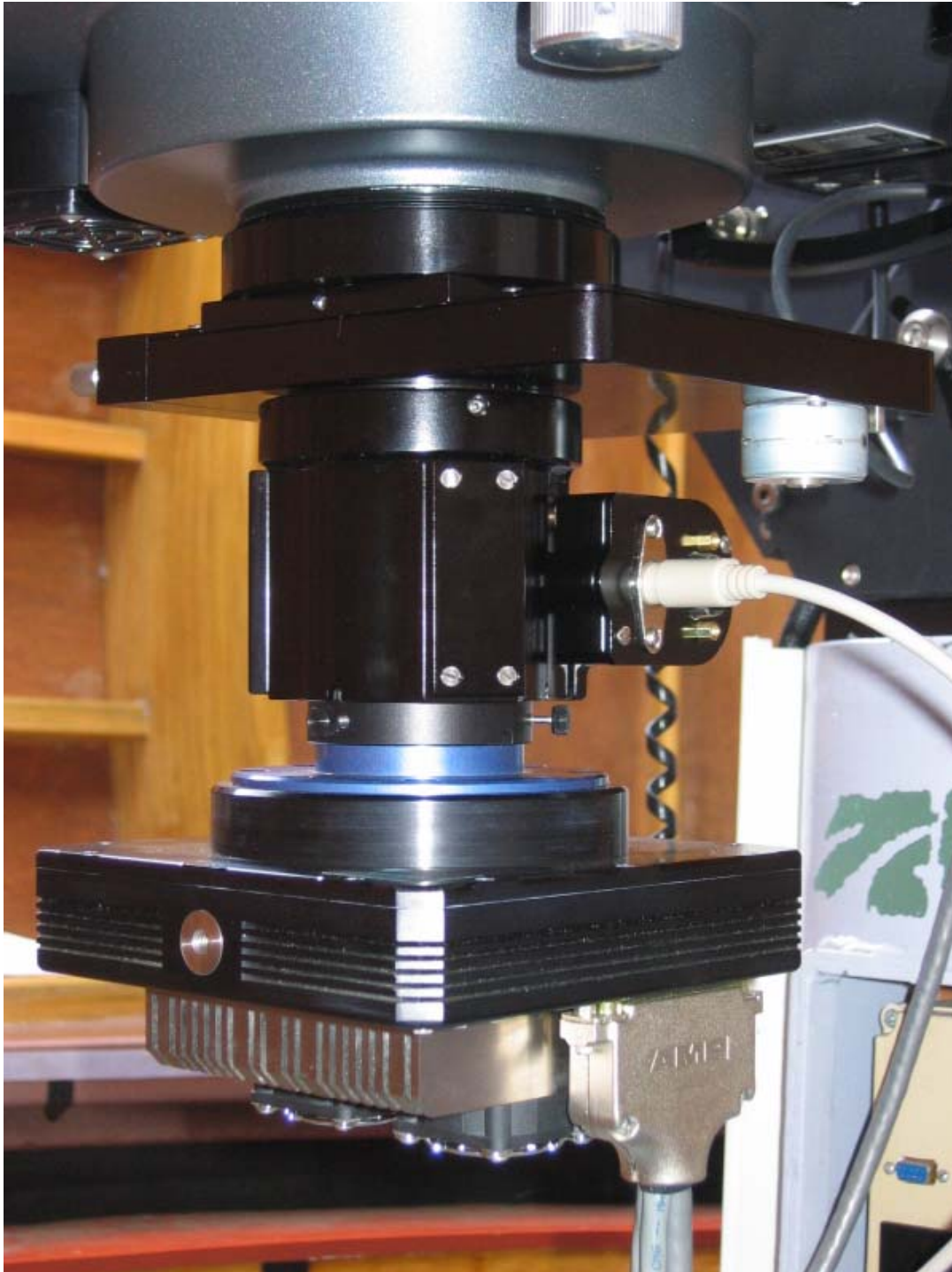
## Major Software

- The Sky v6 - with TPoint
- MaxIm DL/CCD v4



## Schott OG530 (#12 Kodak Wratten)

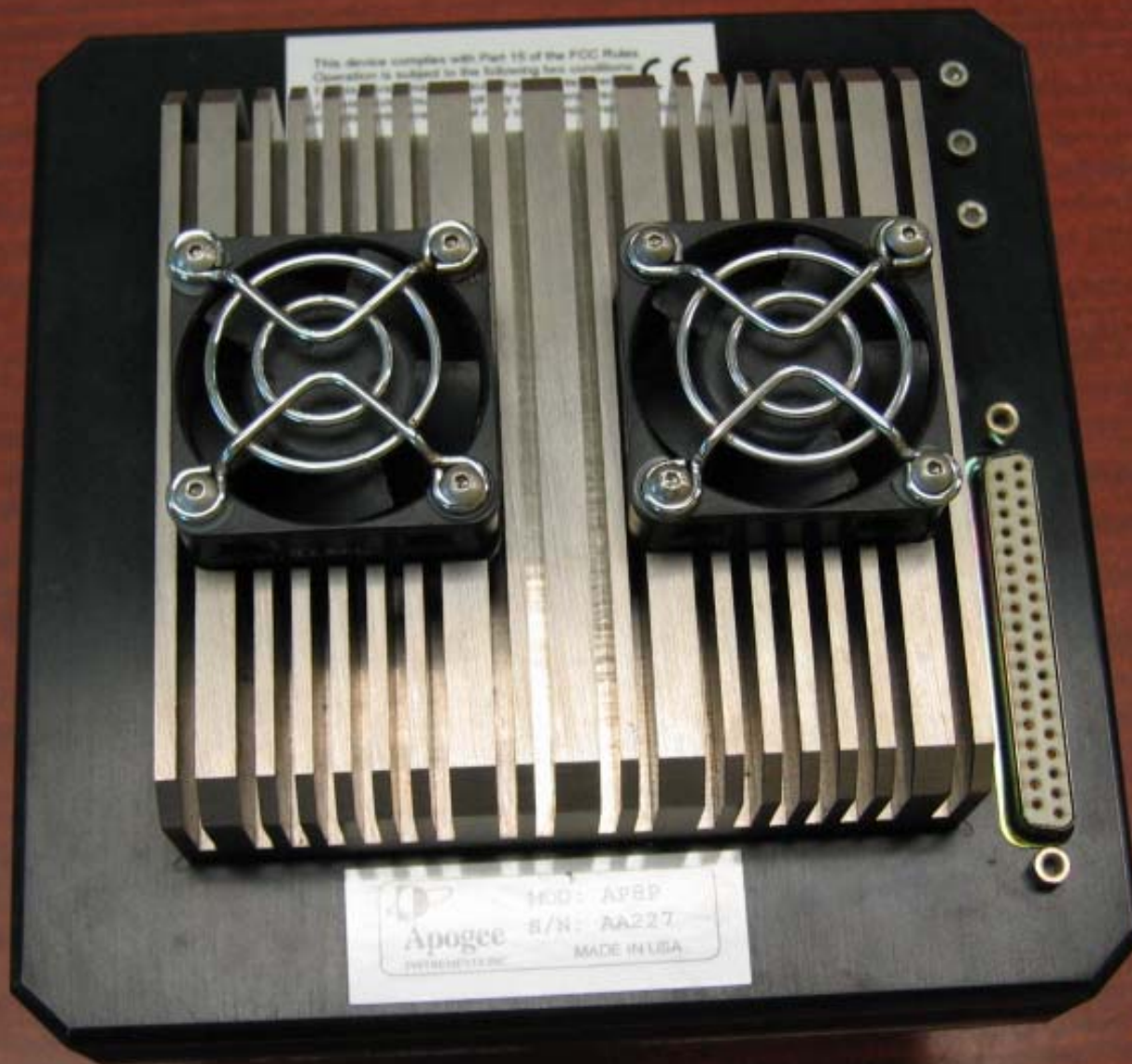


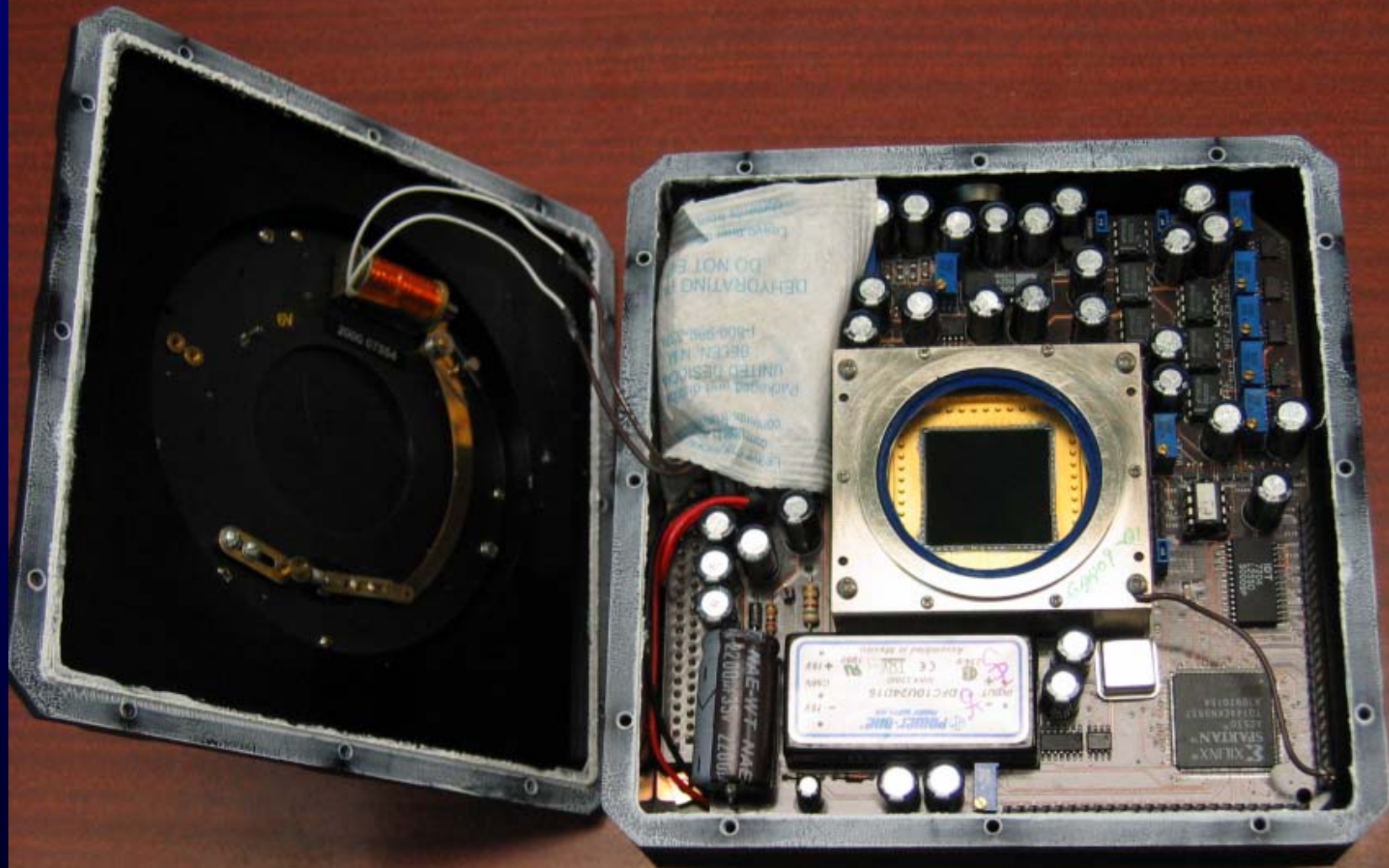


**Optec filter wheel:  
BVRI + Schott OG530**

**Optec TCF-S focuser  
Temperature compensating**

**Apogee AP8p CCD Camera  
1kx1k 24 $\mu$ m pixels  
Scale: 1.2as/pixel**









# Image Calibration

- Record bias at regular intervals (~1950ADU)
- Expose science frame (1-5mins)
- Subtract median bias (n=20) from image
- Subtract scaled dark (~20hr) from image
- Divide image by flat field frame
- **We only use twilight sky flats**

# Photometric Reductions

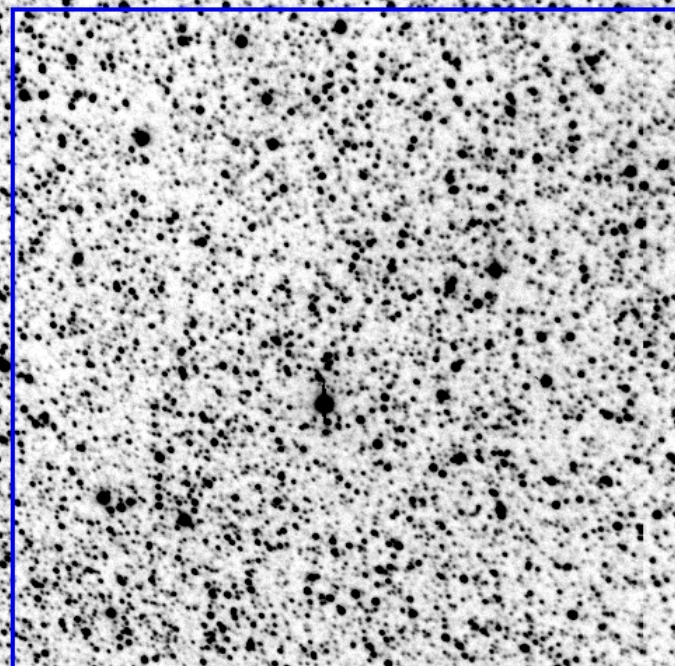
- Aperture photometry “at the telescope”
- OSU pipeline uses DoPhot (PSF fitting)
- OGLE & MOA pipelines use image subtraction (DIA) which is close to optimal for information extraction
- Inter-site calibration. Need to match to I-band for different detectors and filters

OGLE-2005-BLG-071

NGC 6453

N

E

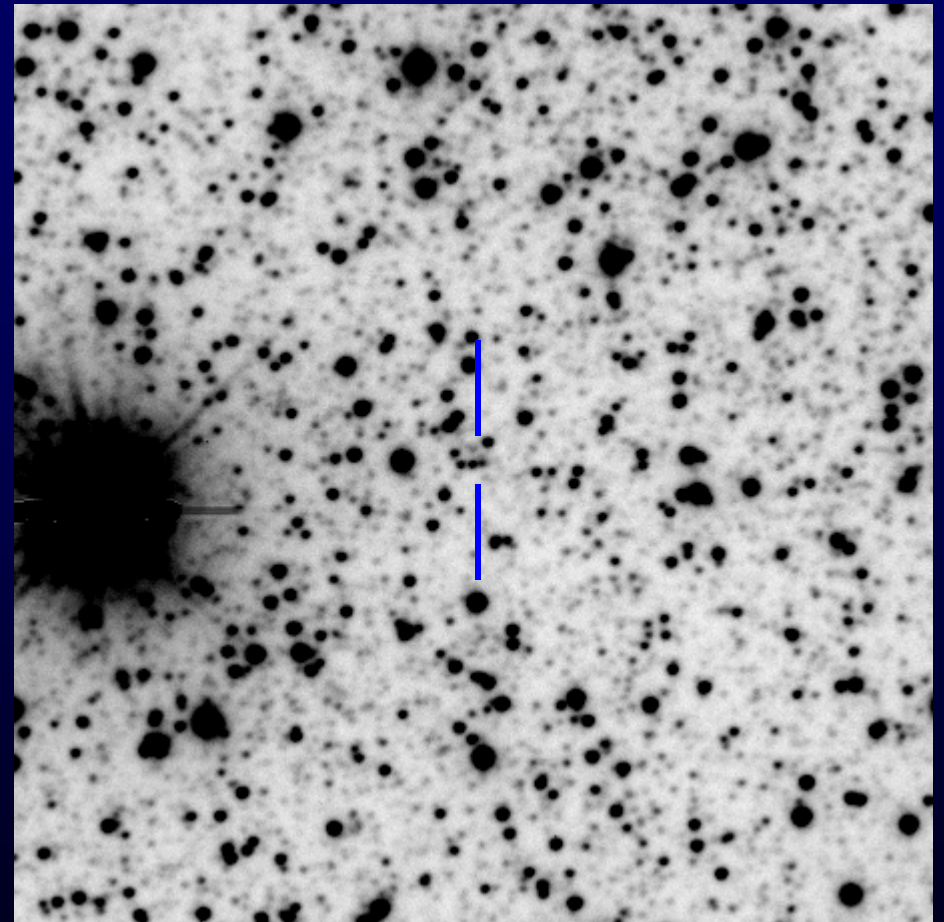
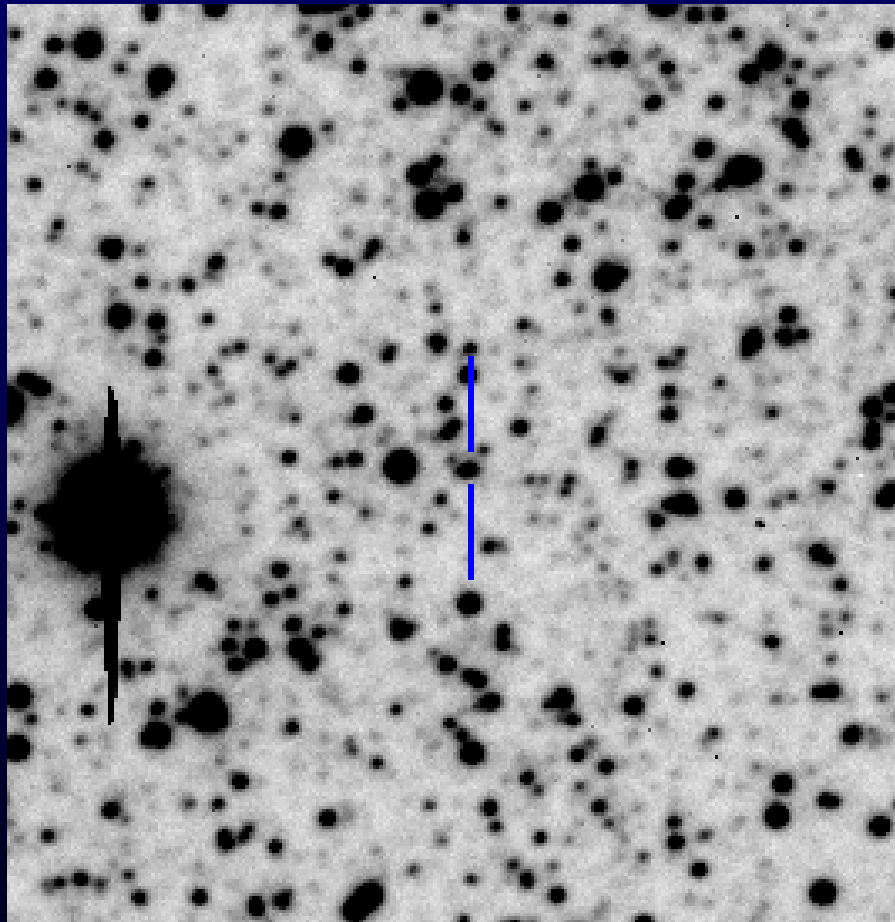


5 arc min

NGC 6444

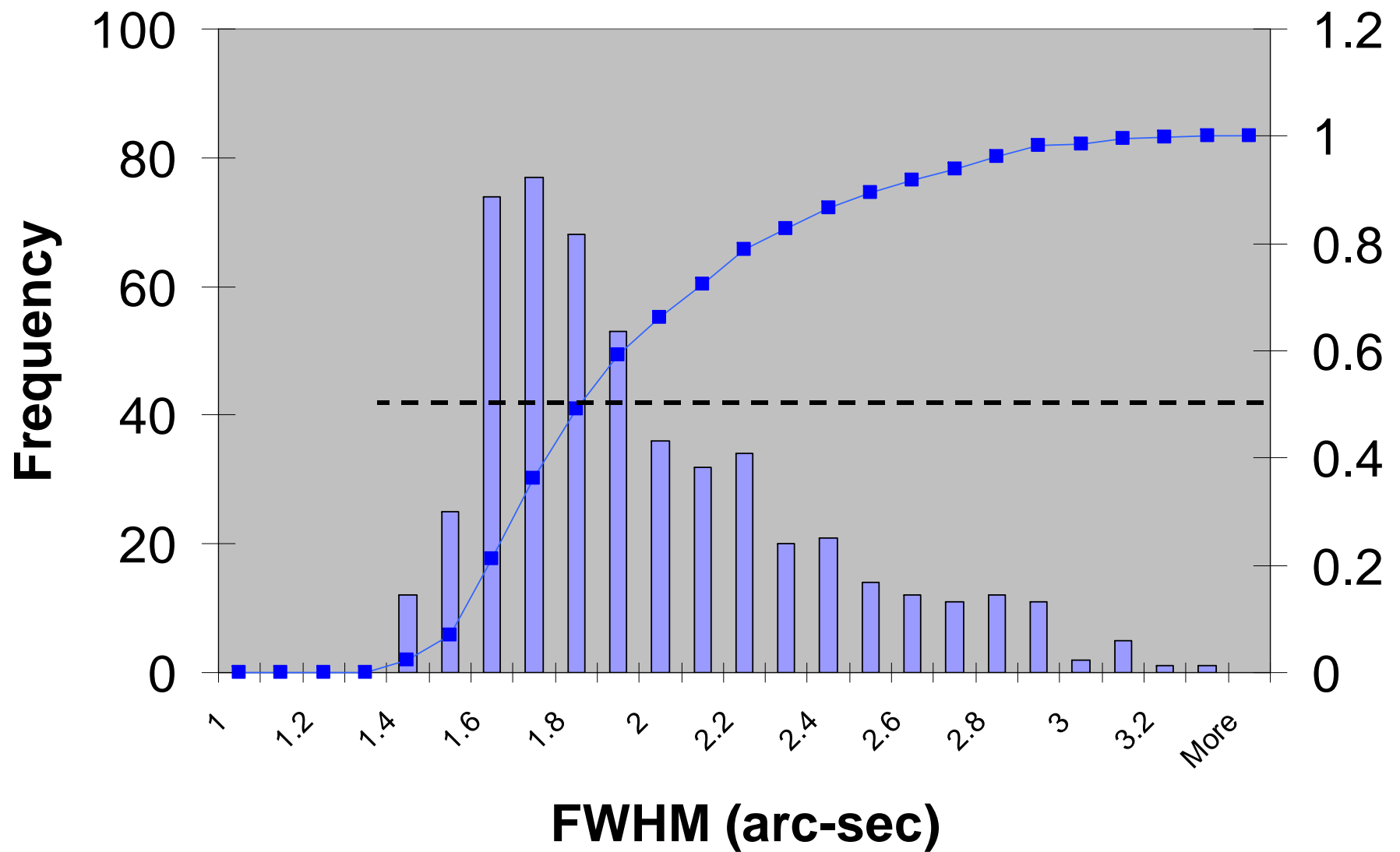
Auckland (seeing ~1.3as)

OGLE



**OGLE-2007-BLG-013**

# OSU Dophot reduction (n=521) 0.4m Meade-ACF/ST7XME



## Locating an object

- **Add coordinates to “The Sky”**
- **Slew to this object (~60as RMS)**
- **Expose a 10s image in MaximDL**
- **Copy/Paste image into “The Sky”**
- **Astrometrically align to field stars (Image Link)**
- **Object will now be marked on the image**
- **Re-centre on target**
- **Make a positive ID from OGLE image**

# Summary of Microlensing Events Observed

Year	Events	Observing Time (Hours)	Planets
2003	4	11	
2004	3	35	
2005	27	252	2
2006	17	158	2
2007	27	165	1
2008	20	142	
<b>TOTALS</b>	<b>98</b>	<b>763</b>	<b>5</b>

# Operational Requirements

- Southern latitude preferred

**Declination:  $-30^\circ$**

- Aperture  $>0.2\text{m}$
- Image scale with FWHM 2-3 pixels
- Good tracking for 2-5 mins
- Broadband Internet access



## Auckland Issues

- CCD camera – 9 $\mu$ m pixels
- Dome automation

## MicroFUN Issues

- Filters – help or hinderance?
- What to do about bad pixels
- Local photometry pipelines

# Summary

- **Small telescopes can be surprisingly effective**
- **They are common, can re-schedule targets at short notice and dedicate 100% of time**
- **Redundancy defeats weather and provides corroboration**
- **Good collimation, focus, tracking and calibration are needed**
- **MicroFUN is a textbook example of pro-am collaboration**