

Taiwanese American Occultation Survey:

Products: dim KBO

& by-products: Gamma Ray
Bursts, Exo-planets, Flare stars

by Typhoon Lee (phys1970) of AsiaA
at Astrophysics Inst. NTHU on 4/9/2008



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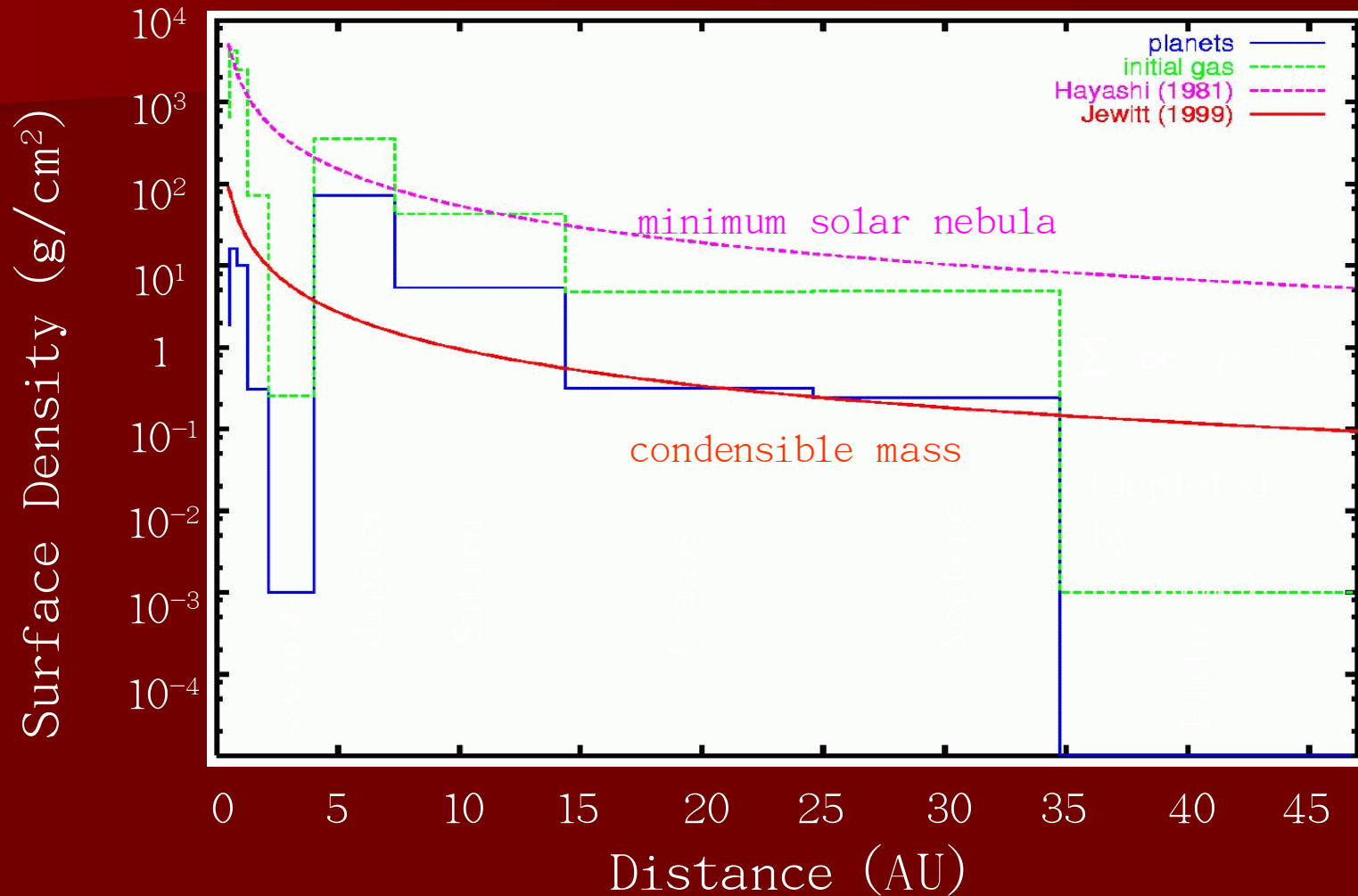
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University**

Tim Axelrod

**Ames Research Center, National Aeronautics & Space Administration,
California**

Jack Lissauer

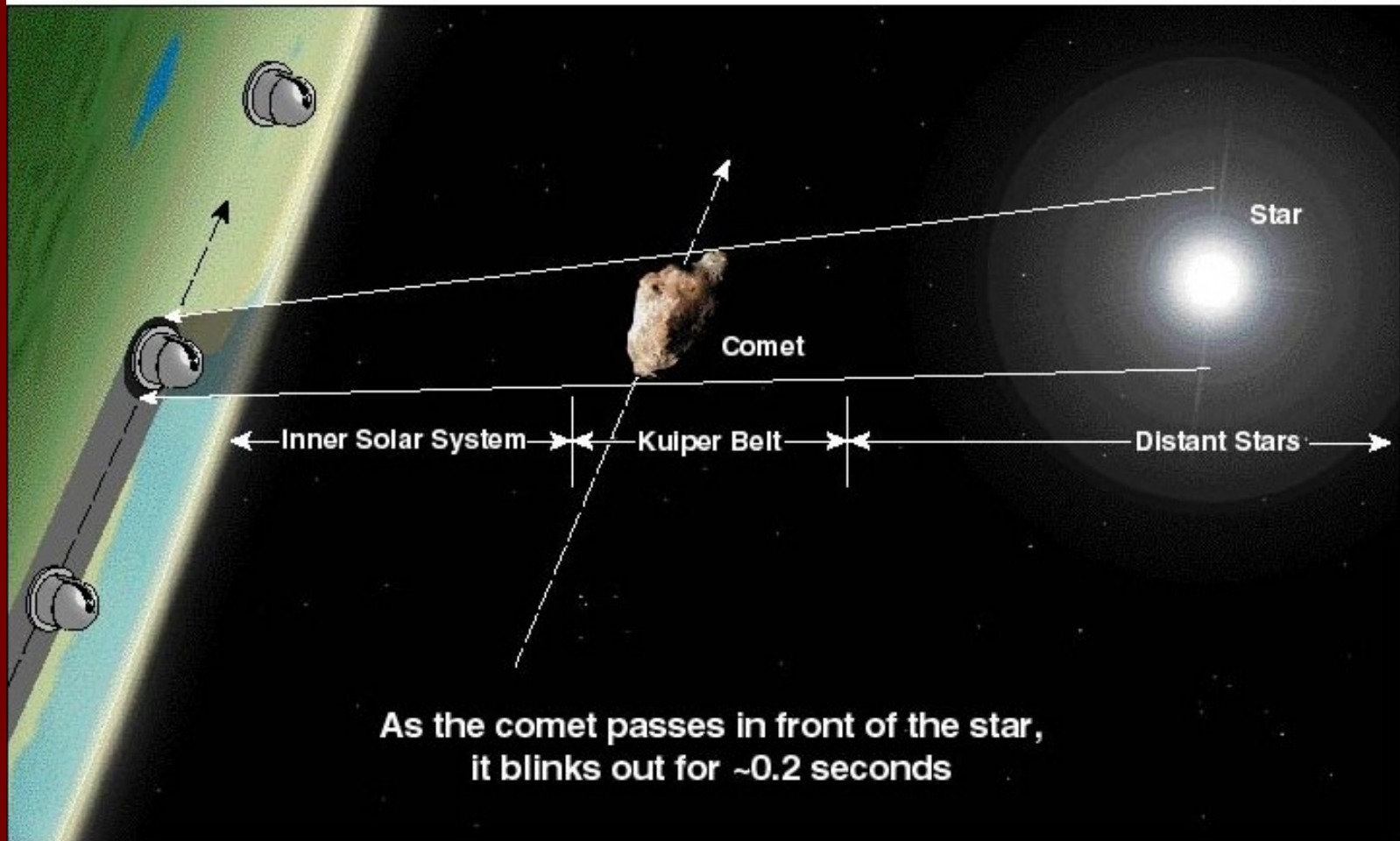
Surface Density of the Solar System



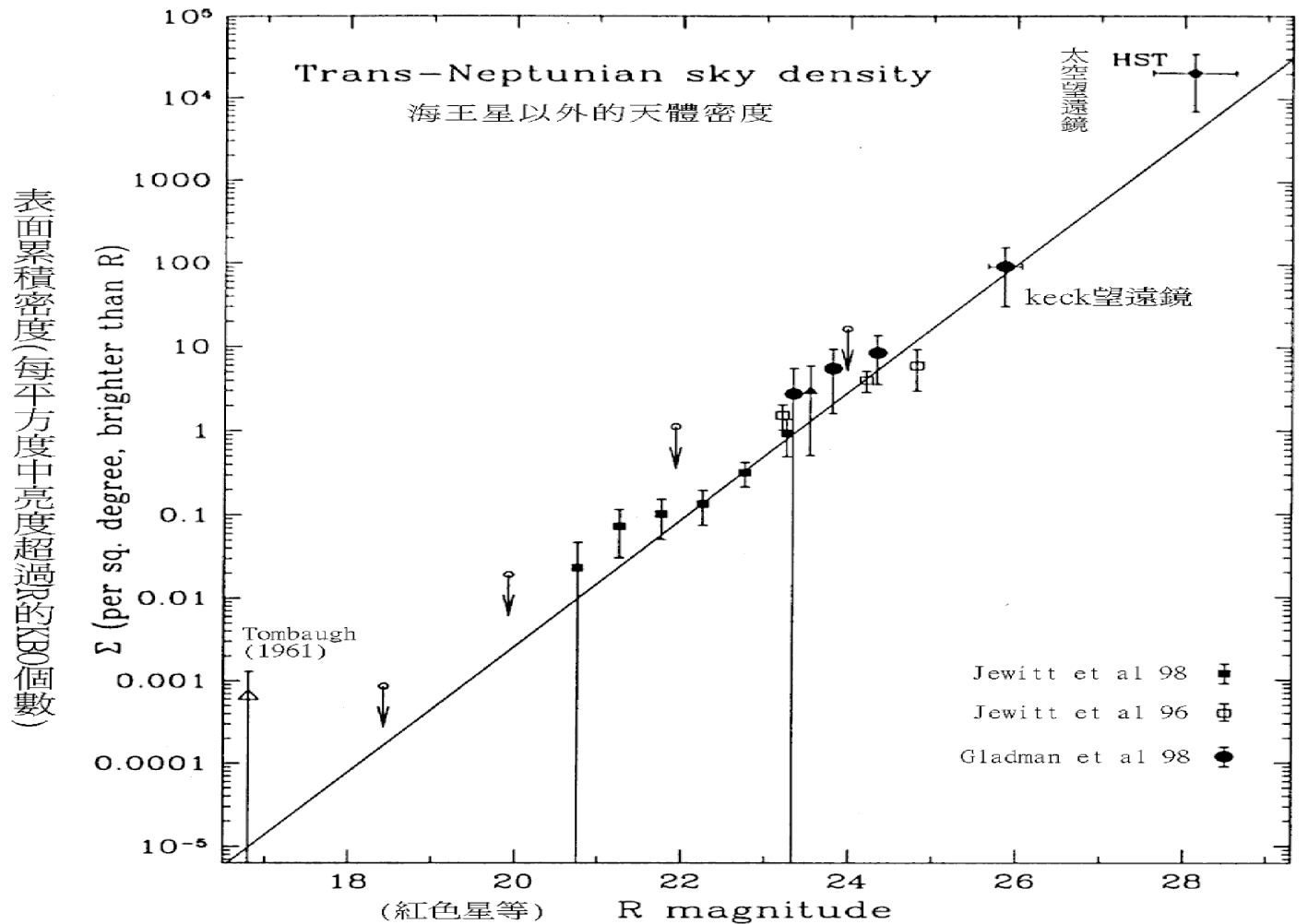
Q: What's the behavior beyond 50 AU ?

The Idea of Occultation Survey

Counting Kuiper Belt objects
using occultations



Luminosity Function & Size Distribution of KBOs

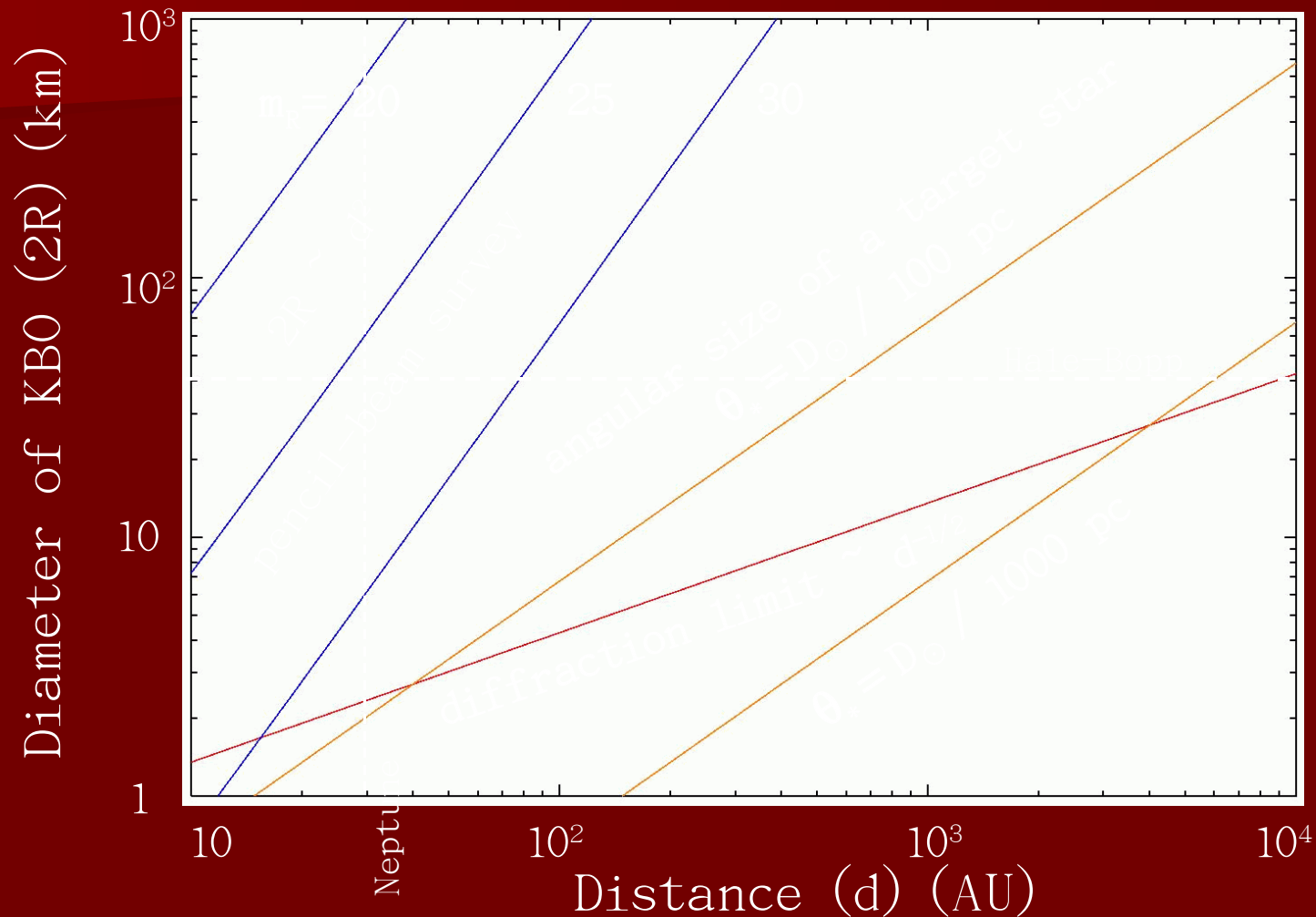


between
 $dN \propto s^{-4}$
 and
 $dN \propto s^{-3.5}$
 KBO diameter

圖三 古柏帶天體 (KBO) 表面密度與亮度的關係

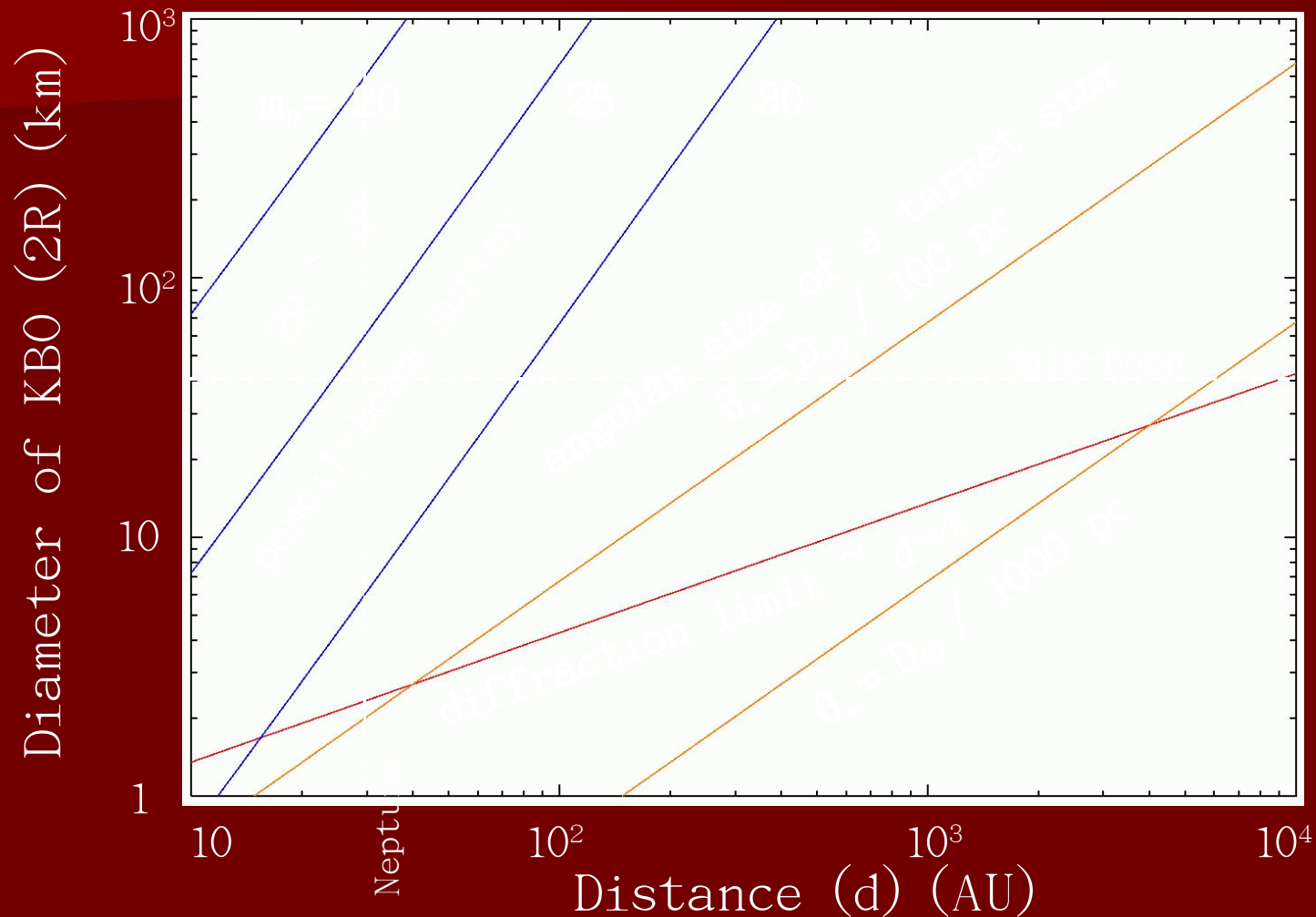
(圖三取自 Gladman et al 1998)

Minimum Detectable KBO Diameter



An occultation survey like TAOS can detect comet-size objects beyond a few hundred AU !

Minimum Detectable KBO Diameter

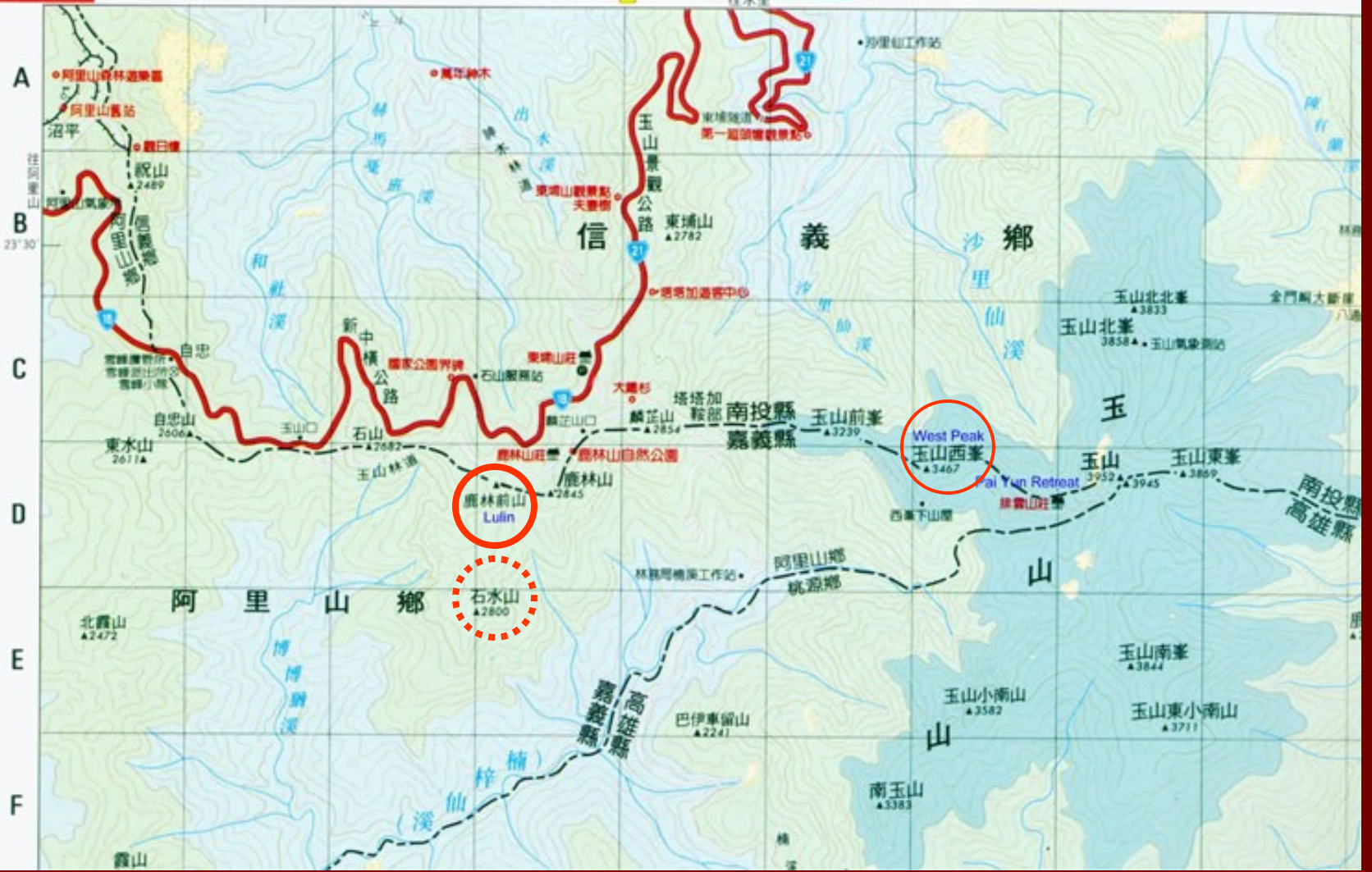


An occultation survey like TAOS can detect comet-size objects beyond a few hundred AU !

TAOS Sites: Map

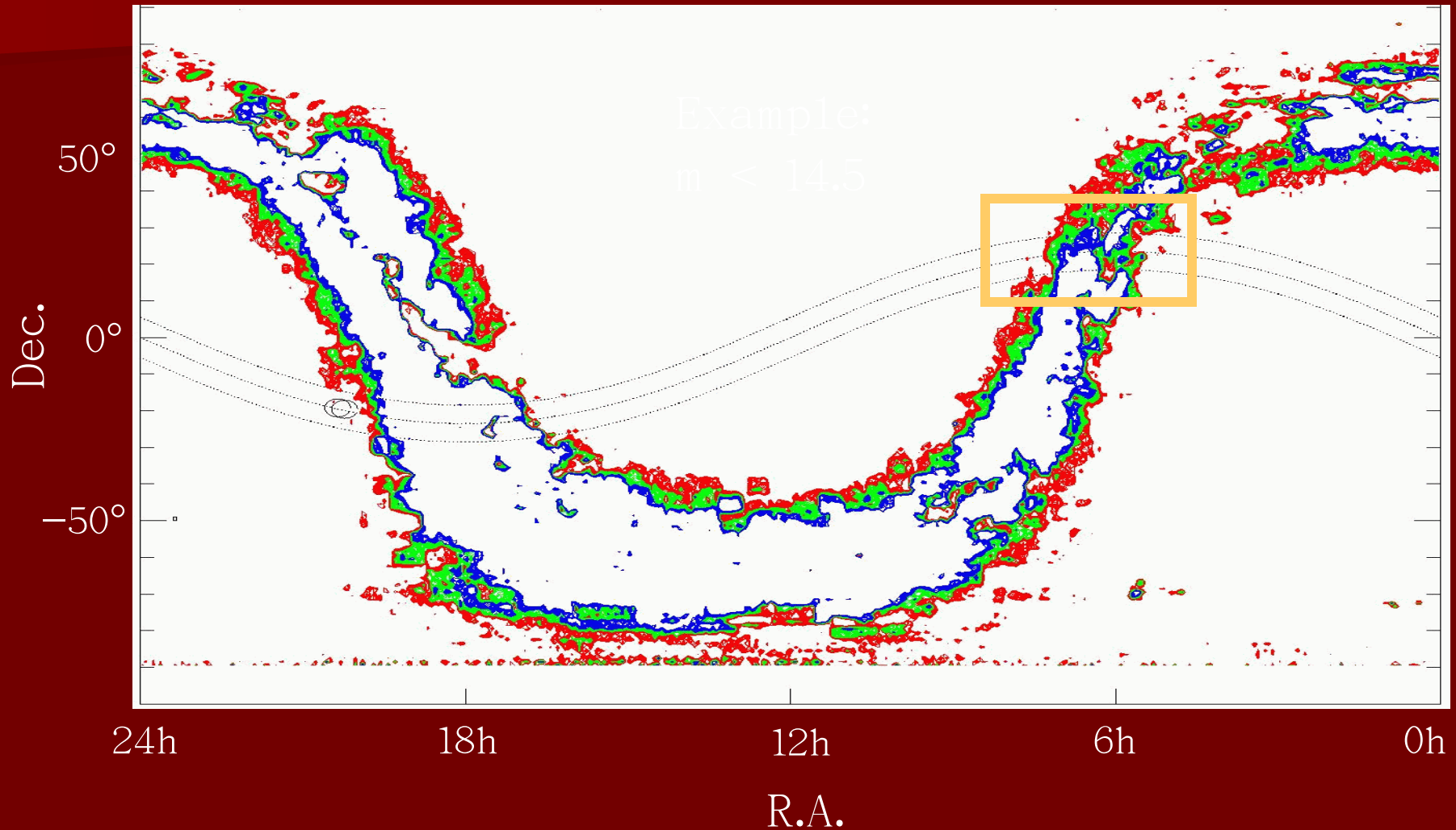
30

新中橫·玉山國家公園

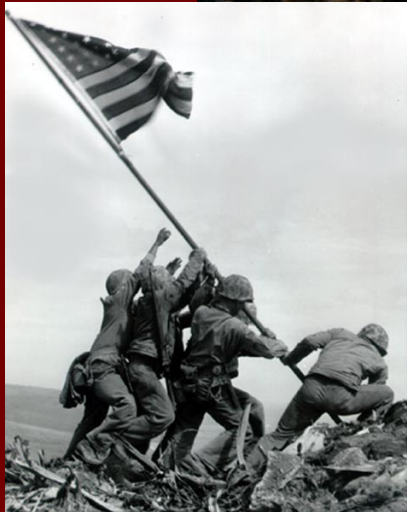


TAOS: Star Fields Selection

statistics of (normalized) star density based on USNO-A2.0 catalog



TAOS: Head for the Peak !



Papers

- System Paper: Recommended for publication, Pub. Ast. Soc. Pacific
- GRB paper: accepted ApJ Lett
- First two years of data, submitted to ApJ Lett
- Search for Sedna-like KBO: Near completion
- Photometry paper: in preparation
- Statistics paper: in preparation

Drastic measures were deemed
necessary...



First results paper!

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FIRST RESULTS FROM THE TAIWANESE-AMERICAN OCCULTATION SURVEY

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ABSTRACT

Results from the first two years of data from the Taiwanese-American Occultation Survey are presented. Stars have been monitored photometrically at 4 Hz or 5 Hz to search for occultations by small (~ 3 km) Kuiper Belt Objects (KBOs). No statistically significant events were found, allowing us to present an upper bound to the size distribution of KBOs with diameters $0.5 \text{ km} < D < 10 \text{ km}$.

Subject headings: Kuiper Belt, occultations, solar system: formation

1. INTRODUCTION

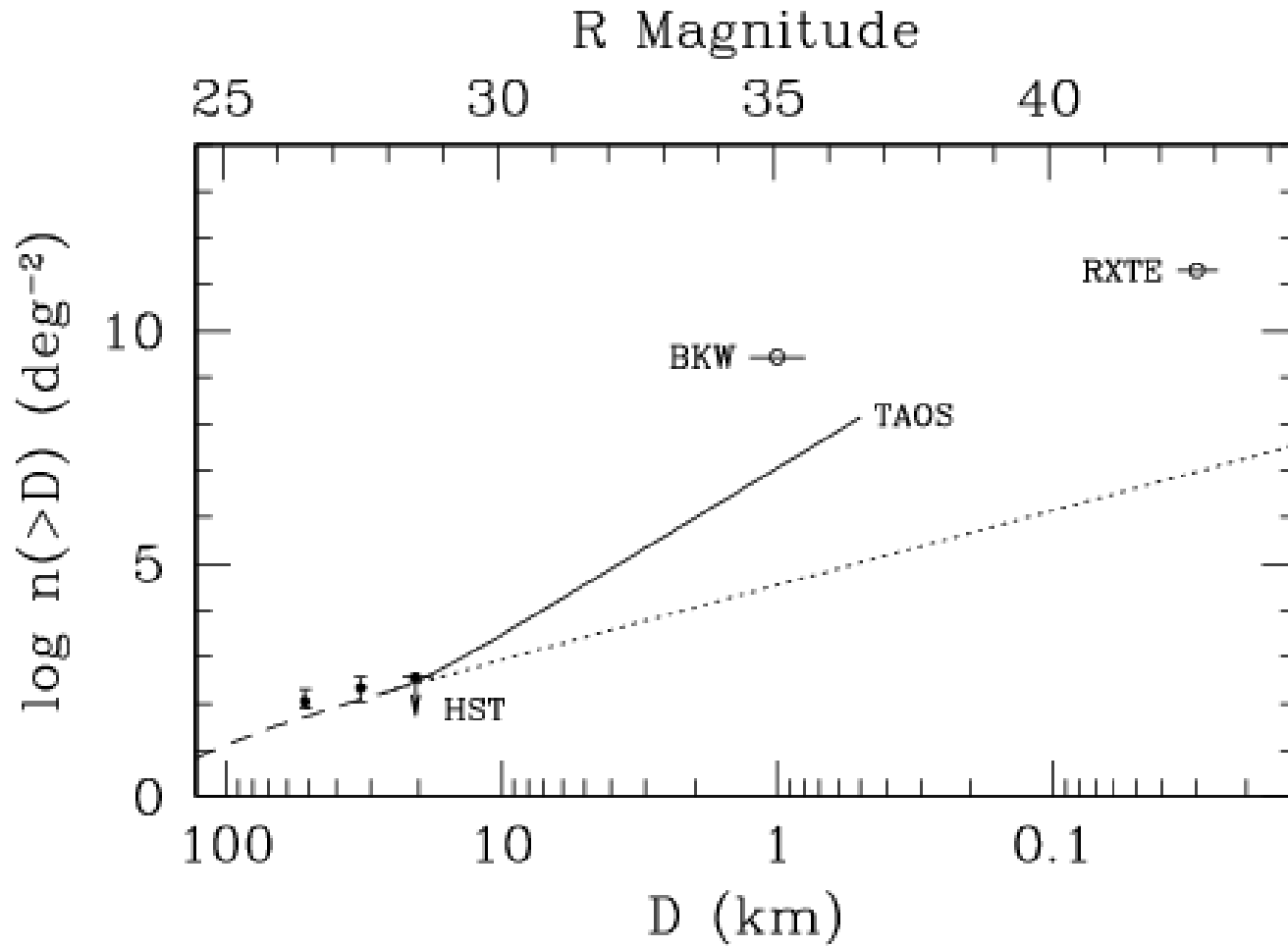
The study of the Kuiper Belt has exploded since the discovery of 1992 QB1 by Jewitt & Luu (1993). The brightness distribution of objects with R -magnitude brighter than ~ 26 is relatively well-established by many surveys, most recently by Fraser et al. (2008, and references therein). The brightness distribution is adequately described by a simple cumulative luminosity function $\Sigma(< R) = 10^{\alpha(R-R_0)}$, where $R_0 \sim 23$ and $\alpha \sim 0.6$, for objects with magnitude $R < 26$. There is clear evidence for a break to a shallower slope for fainter objects: the deepest survey, conducted using the Advanced Camera for Surveys on the *Hubble Space Telescope* (Bernstein et al. 2004) extended to $R = 28.5$, and found a factor of ~ 25 fewer objects than would be expected if the same distribution extended into this range.

TABLE 1
DATA SET PARAMETERS.

| | |
|------------------------------------|---------------------|
| Start Date | 2005 February 7 |
| End Date | 2006 December 31 |
| Number of Data Runs | 156 |
| Number of Lightcurve Sets | 110,895 |
| Total Exposure | 153,209 star-hours |
| Number of Photometric Measurements | 7.101×10^9 |

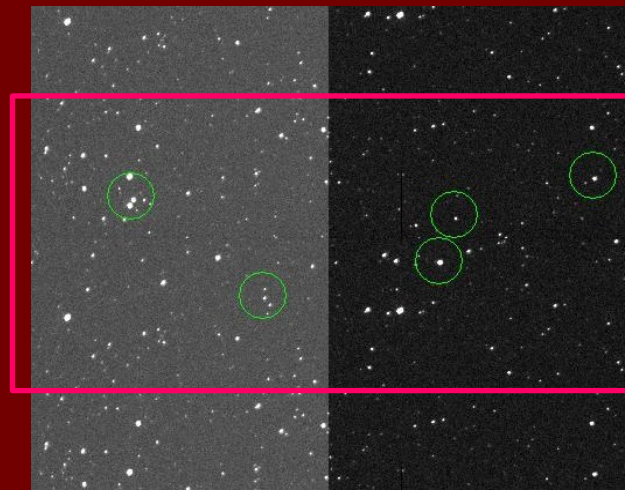
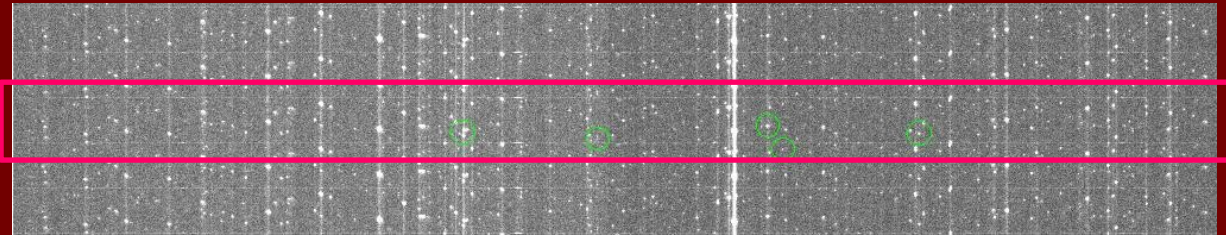
& Luu 1999a,b; Kenyon & Bromley 2004; Pan & Sari 2005). The slope of the distribution function for larger objects reflects the early phase of agglomeration, while the shallower distribution for smaller objects reflects a subsequent phase of destructive collisions. The location

First results paper!



Frame Transfer Camera Test

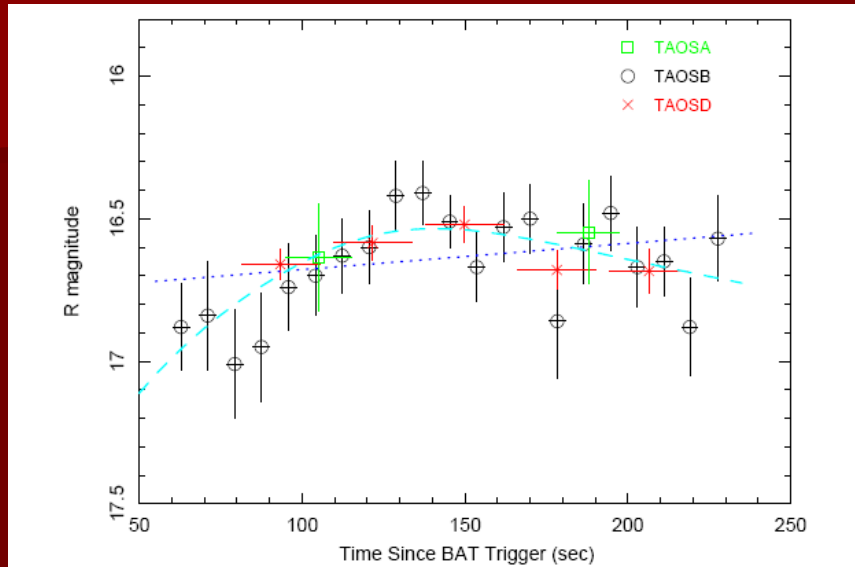
TAOS CCD, 5Hz several Row Blocks



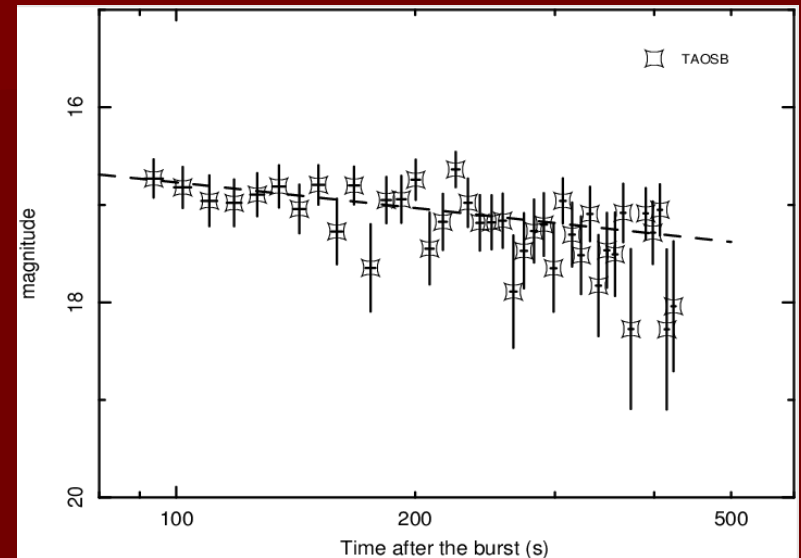
FTCCD,

5Hz with 2X2 binning, several Row Blocks

Other Science with TAOS



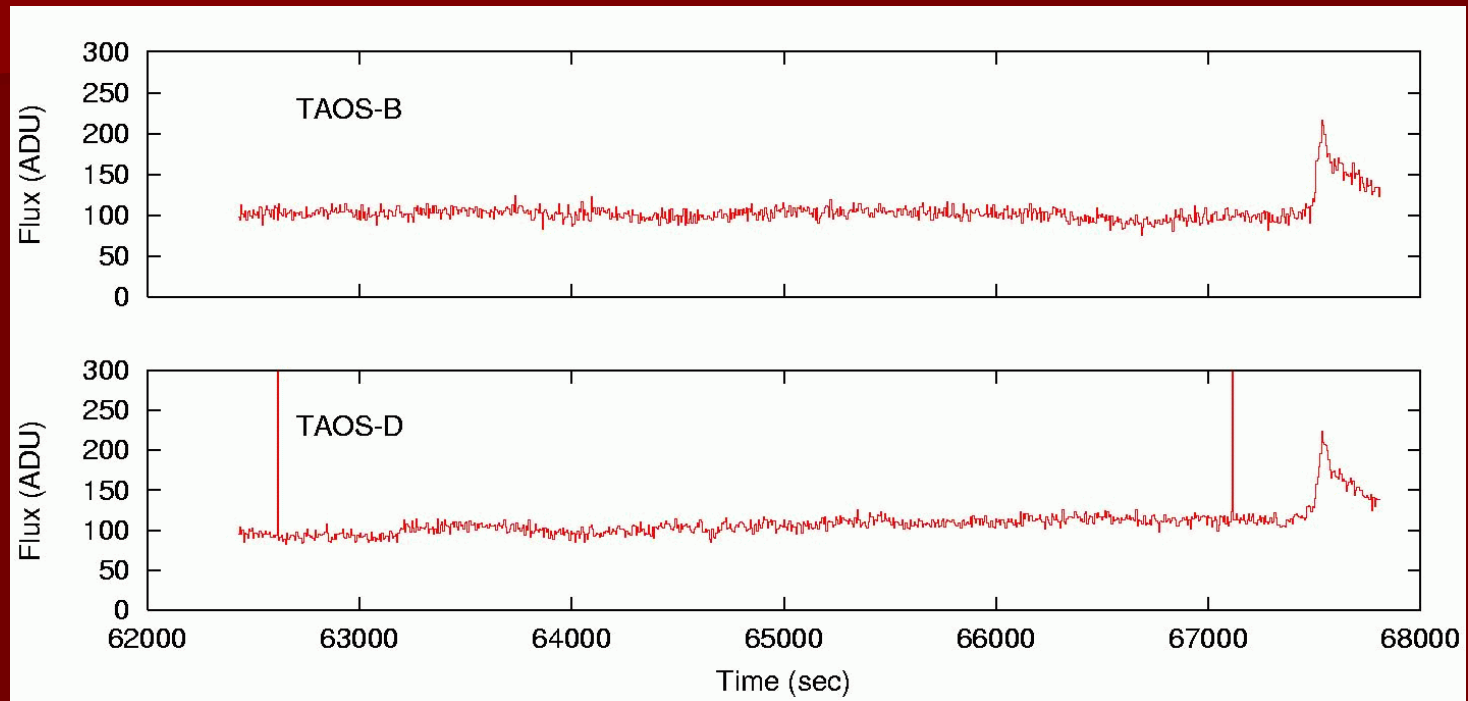
GRB 071010B



GRB 07112C

Two GRB Afterglows Detected

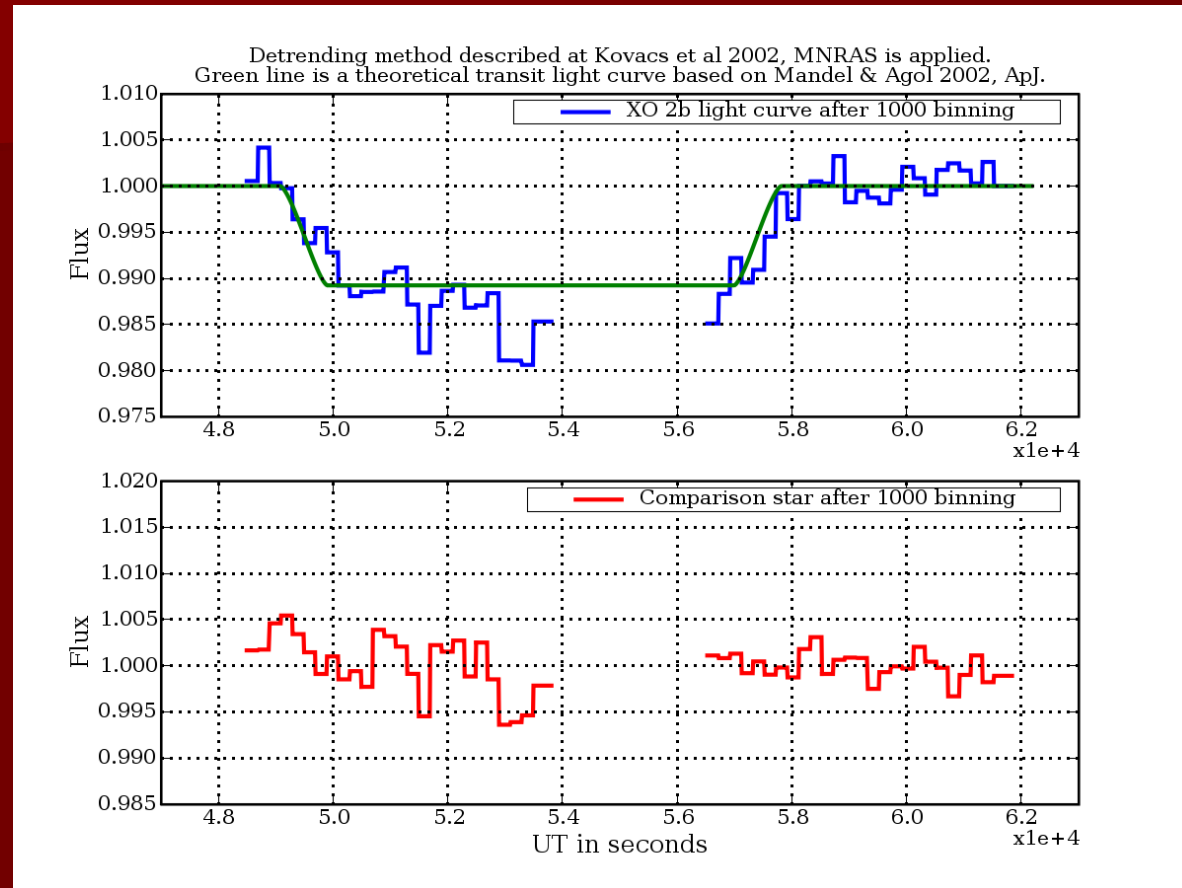
Other Science with TAOS



RXJ0447.2+2038, M3, RA:70.800998, DEC:+20.636367

Flare Star

Other Science with TAOS



Transiting Extra-Solar Planet!

TAOS II

- Next generation occultation survey
- Design Goal: 100 times the event rate of TAOS I
- Better site, better telescope, larger focal plane, 20 Hz sampling cadence
- Preliminary design work has begun!

Telescope

- DFM Engineering
- F/4 1.3 m
- 1.7° FOV
- Design review underway with engineers at SAO



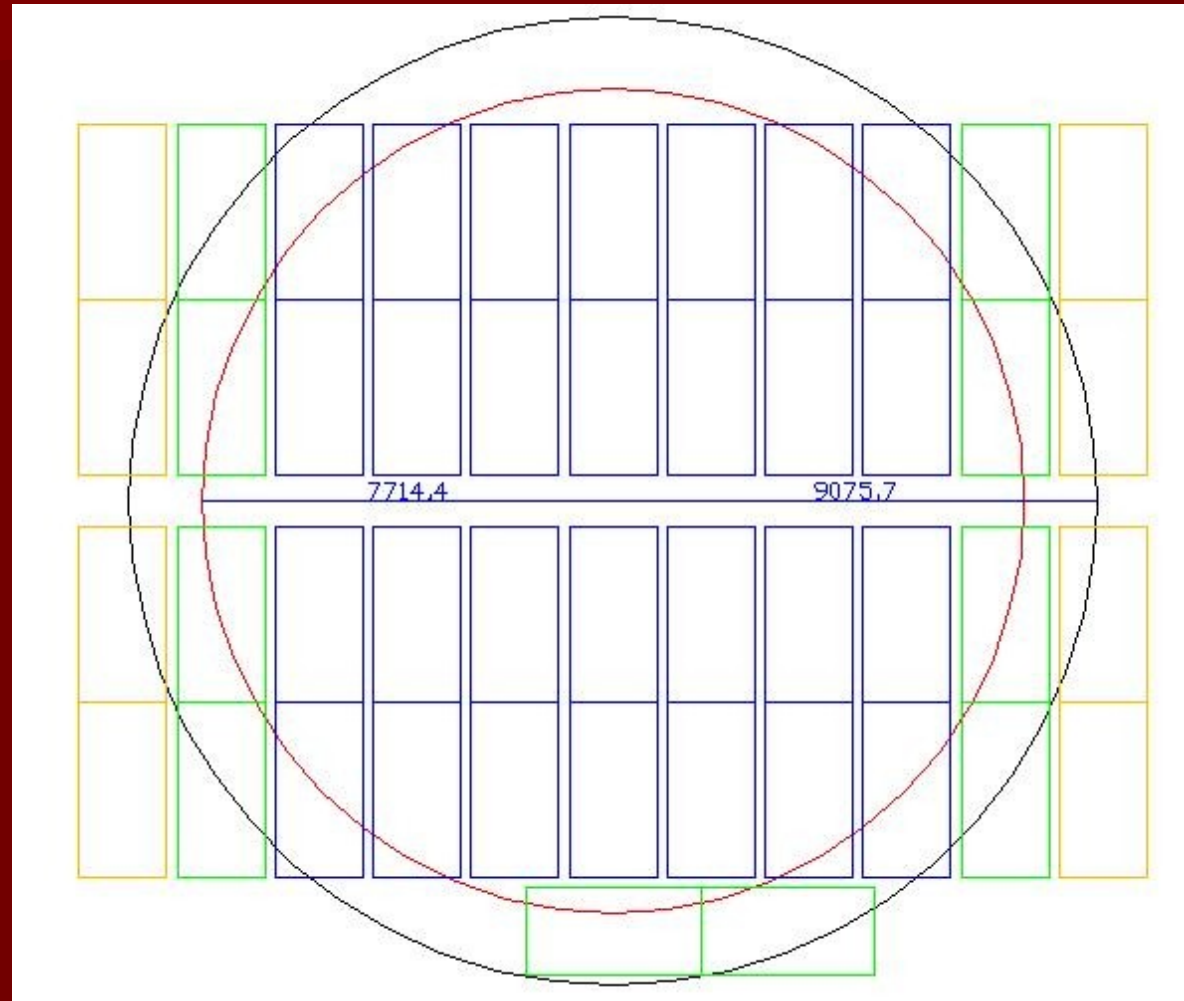
Focal Plane

Custom designed
Frame Transfer
EMCCD

14 4.5k × 2k
16 μm pixels

Effective FOV
1.0 sq. deg.
(1.4 sq. deg.)

£1.4M quoted



Site Survey

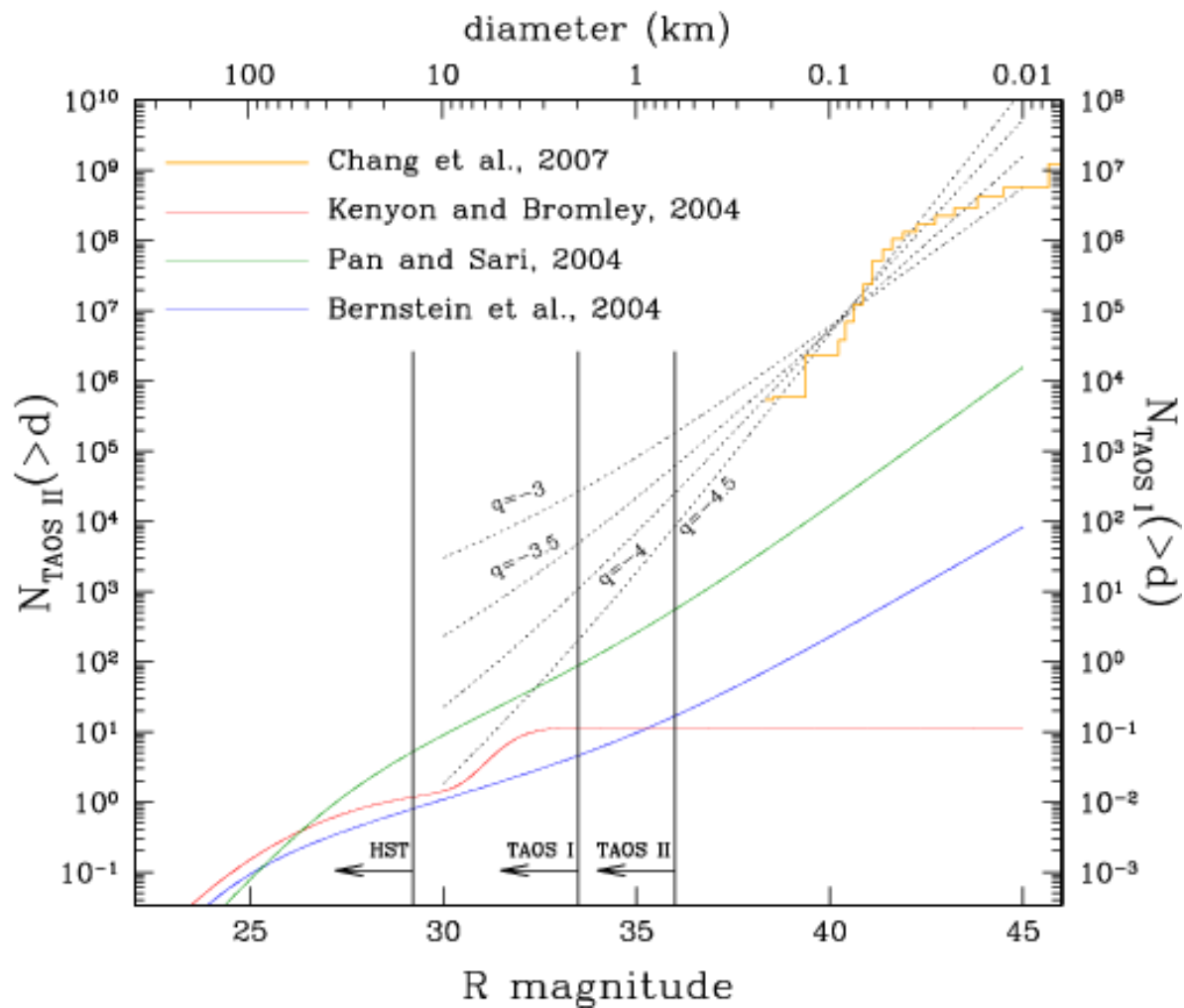
- VLA
 - Poor seeing
 - Speeding ticket
- Mt. Hopkins
 - Limited space available
- Mauna Loa
 - Currently our favorite option

Site Survey

- Land use application under preparation
- Weather, seeing monitoring will be set up this summer



Expected sensitivity



Report for 2007

| | |
|-------------------|---------------------------------------|
| 1-Telescope Data | 14.57 hours 262,240 row blocks |
| 2-Telescope Data | 248.22 hours 4,468,000 row blocks |
| 3-Telescope Data* | 309.97 hours 5,579,392 row blocks |
| 4-Telescope Data | 0 hours 0 row blocks |
| Total | 572.76 hours 10,309,632 row blocks |

* Limited by two separate camera failures

Recent Improvements

- Replaced focus modules, new, low temperature grease
- New, more accurate weather monitoring equipment now online
 - Better humidity sensitivity = more data
- Datalogger now running
- New software version, greater stability
- TAOS C nearly online
- Wavefront sensor for characterization of optics

Frame Transfer Camera Test

- 5 Hz full frame (no zipper mode!)
- Test shows 25% increase in number of stars
- 14-bit readout: factor of 3 improvement in speed?
 - Faster sampling rate: better sensitivity to smaller objects

Plans for Coming Year

- Continue operating TAOS -- with 4 telescopes!
- Frame transfer cameras:
 - Convert to 14-bit readout
 - Acquire 3 more???
 - Update control software
- Finish Papers!!!!
- Continue optical testing, optimize performance