The UKIRT Success Story

Richard Ellis (Caltech)

UKIRT 1979 – 2009

- For a modest financial investment, a pivotal role in world IR astronomy for 30 years
- An unrivalled reputation for technical innovation, cost-effective operations and reliability
- A dedicated staff who willingly work in a hostile environment (and can spin some interesting yarns!)
- Scientific accomplishments that have influenced all of astronomy (and made many careers)

UKIRT: Early history

- ~1967 Engineering concept proposed
- 1975 Funded by SRC as a light bucket (£2.5M then = £10M today)
- 1976-8 Construction
- 1978 July 31 - First light
- 1979 April 1 - Newsletter #1
- October 10 – Telescope dedication
- 1981 UKIRT Symposium: Edinburgh
- 1982-3 Remote operations
- 1983 New facilities at Hale Pohaku
- 1983 Dome extension complete
- 1985 Base Facility in Hilo

RAS meeting 1975

The President. Thank you very much, Professor Neugebauer. We now come to some techniques of infrared astronomy. The first of these papers is by Professor J. Ring on the progress of the UK 3·8-metre flux collector.

Professor J. Ring. May I begin by explaining my position *vis-à-vis* this project. The Director of the ROE is in overall charge of the execution of the project with Mr. G. Carpenter acting as Project Manager. I chair a Steering Committee of prospective users who are responsible for scientific control, that is making sure that the flux collector will meet our scientific needs.

There are many astronomical observations which do not require the high angular resolution of which a modern optical telescope at a good site is capable. I will give a few examples: at infrared wavelengths of ten microns and beyond, a good deal of photometry and spectrometry can be done with diaphragms or slits which are somewhat larger than the Airy disk (that is, about 2 arc seconds at ten microns to about 3 arc minutes at one millimetre); visual photoelectric photometers often incorporate diaphragms of about 5 arc seconds in size; échelle-grating and interference spectrometers can give resolving powers of 10^4 to 10^6 with 2-arc-second entrance slits.

There is thus a case for constructing a "flux collector" which has an image quality of about 2 arc seconds, if the consequent saving in cost over an optical telescope is significant—a given sum of money can be put into a larger diameter rather than accurate figuring and support systems. You will note that all the above examples require the observation of a single object "on-axis" and this, too, can simplify the design.

RAS meeting 1975

Contracts have been placed with Grubb Parsons for the optics and with Dunford-Hadfield for the structure. Mr. Carpenter is now busily designing the building and dome, and hopes to have the flux collector in operation in less than three years from now. We are all very grateful to Dr. John Jeffries of the University of Hawaii for his assistance in making the Mauna Kea site available to us.

The President. The only thing that concerns me about the rapid progress with this project is that Grubb Parsons have just started on the replacement mirror for the Isaac Newton Telescope. Clearly the two will be in conflict!

Does anyone want to make any comments about the instrument, the site or the auxiliary equipment? Will anyone volunteer to make an échelle?

Dr. J. R. Shakeshaft. Could Professor Ring tell us why échelles are coming back?

Professor Ring. Mainly because the manufacturers have learnt to make them bigger. Also, since the advent of the image tube, astronomers have favoured the compact format of the échelle spectrum.

A Fellow. Can I ask a question on behalf of the young astronomers present: how many staff will it need?

Professor Ring. We envisage a total staff of about ten at Mauna Kea, but only one or two of these will be astronomers. The instrument will mainly be used by groups from UK universities and establishments.

The President. Thank you, Professor Ring. I now ask Professor Neugebauer to return and talk about the plan for the United States' infrared telescope.

Professor Neugebauer. NASA plans building a 126-inch telescope to be located on the same site in Hawaii. Basically the telescope is in support of the planetary Mariner Jupiter–Saturn mission. We have emphasized the ability

SRC Astronomy II Committee

1 February 1977

Science Research Council

Astronomy, Space and Radio Board

ASTRONOMY II COMMITTEE

UKIRT: Refiguring of the Primary Mirror (Technical and Financial Considerations)

Note by the Director, ROE

1. One of the major reasons the UKIRT is such a low cost instrument is that it uses a thin mirror, 13:1 diameter to edge ratio rather than the conventional 6:1. Because of this and the lack of experience of figuring such a thin mirror, the optical specification was written so as to specify visual images of 90% of the light into 2 arc seconds, although the original specification did leave open the possibility of making improvements if it was considered that these could be achieved. However, at the time, this was as much as the contractor (Grubb Parsons) was prepared to guarantee and, indeed, it is adequate for the majority of infrared observations.

Money Well Spent

2. Now that experience has been gained in figuring the blank it is apparent that with comparatively little extra work, 1 arc second images can be obtained. Mr. D.S. Brown (Grubb Parsons) presented his findings at the meeting of the UKIRT Steering Committee which was held on 28 October, 1976. The Steering Committee agreed that:

a) on the basis of the strong case on scientific grounds which could be made to try and achieve an improvement of this kind in the performance of the telescope, it would be irresponsible not to seek the funds required for such work to be carried out;

b) the Project Scientist should be asked to prepare a case giving the scientific justification for the request for increased funds;

c) the Director, ROE, should be asked to make a submission for an increase in funds amo[illegible] to £12K plus variation of price adjustments.

3. It was pointed out by the Project Manager that the support system required re-evaluation to ensure that it was capable of properly supporting the improved mirror. He was instructed by the Steering Committee to continue his evaluation of the tests being carried out by Grubb Parsons in order to verify that there

April 1979

Editor: Peredur Williams

Officer-in-charge: Terry Lee

f/9 Cassegrain

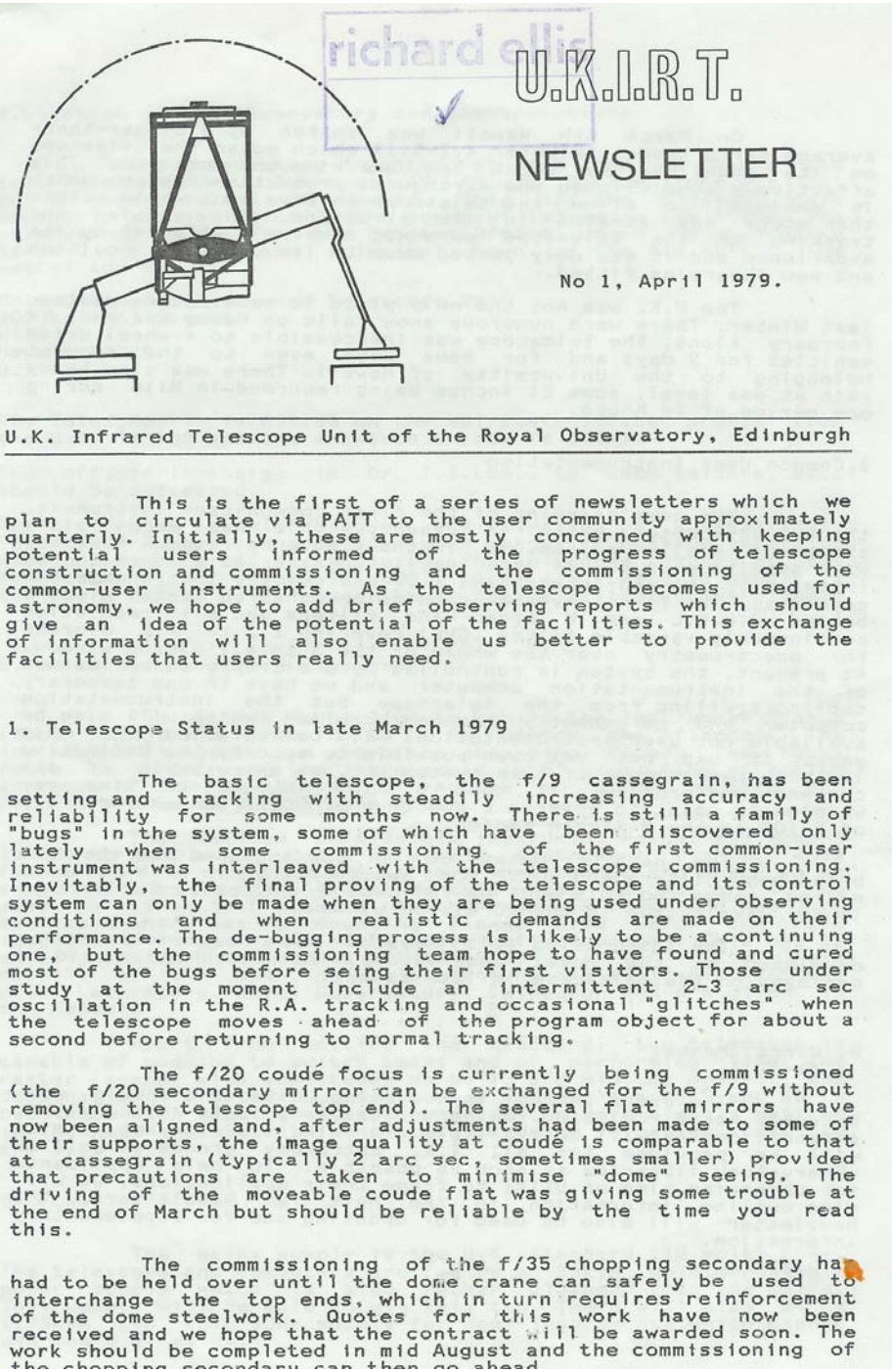
Image quality 2 arcsec

No integrating TV

Control computer 28k RAM

Users manual “soon” (actually 1981!)

Earthquake protection system commissioned with a R5.1 event



U.K.I.R.T.

NEWSLETTER

No 1, April 1979.

U.K. Infrared Telescope Unit of the Royal Observatory, Edinburgh

This is the first of a series of newsletters which we plan to circulate via PATT to the user community approximately quarterly. Initially, these are mostly concerned with keeping potential users informed of the progress of telescope construction and commissioning and the commissioning of the common-user instruments. As the telescope becomes used for astronomy, we hope to add brief observing reports which should give an idea of the potential of the facilities. This exchange of information will also enable us better to provide the facilities that users really need.

1. Telescope Status in late March 1979

The basic telescope, the f/9 cassegrain, has been setting and tracking with steadily increasing accuracy and reliability for some months now. There is still a family of "bugs" in the system, some of which have been discovered only lately when some commissioning of the first common-user instrument was interleaved with the telescope commissioning. Inevitably, the final proving of the telescope and its control system can only be made when they are being used under observing conditions and when realistic demands are made on their performance. The de-bugging process is likely to be a continuing one, but the commissioning team hope to have found and cured most of the bugs before seing their first visitors. Those under study at the moment include an intermittent 2-3 arc sec oscillation in the R.A. tracking and occasional "glitches" when the telescope moves ahead of the program object for about a second before returning to normal tracking.

The f/20 coudé focus is currently being commissioned (the f/20 secondary mirror can be exchanged for the f/9 without removing the telescope top end). The several flat mirrors have now been aligned and, after adjustments had been made to some of their supports, the image quality at coudé is comparable to that at cassegrain (typically 2 arc sec, sometimes smaller) provided that precautions are taken to minimise "dome" seeing. The driving of the moveable coude flat was giving some trouble at the end of March but should be reliable by the time you read this.

The commissioning of the f/35 chopping secondary has had to be held over until the dome crane can safely be used to interchange the top ends, which in turn requires reinforcement of the dome steelwork. Quotes for this work have now been received and we hope that the contract will be awarded soon. The work should be completed in mid August and the commissioning of the chopping secondary can then go ahead.

Dedicated Staff on a hostile mountain..

Adversity even in the control room….

Technical Innovation

- Lightweight thin primary
- Remote operations (now WORF)
- Service observing
- Upgrades program
- Tip tilt secondary & hexapod
- Cooled primary
- ORAC acquisition & reduction
- Flexible scheduling
- Integral field unit
- WFCAM/UKIDSS

30 years of instrumentation

Jun 80 UKT8 10μm JAC

Oct 81 UKT6 1-5μm ROE

Oct 81 F-Perot QI

Jun 84 UKT9 1-5μm ROE

Sep 86 IRCAM 1-5μm ROE

Jan 87 IRPOL ROE

Apr 87 UKT16 10-30μm ROE/JAC

Sep 87 Visphot Leicester

Sep 88 IRCAM2 ROE

Dec 88 IRCAM3 ROE

Apr 90 CGS3 17-24μm UCL

Jan 91 CGS4 1-5μm ROE

Oct 98 UFTI 1-2.5μm Oxford/ATC

Aug 01 Michelle ATC

Aug 02 UIST 1-5μm ATC

Sep 04 WFCAM ATC

Ten Years of Operation

Newsletter #19

Editor: Peredur Williams

IRCAM: world's first common-user IR array 58 × 62 (McLean)

CGS2: K=14 1σ 1sec

Control computer 16Mb RAM

Image quality: 0.9 arcsec (90%)

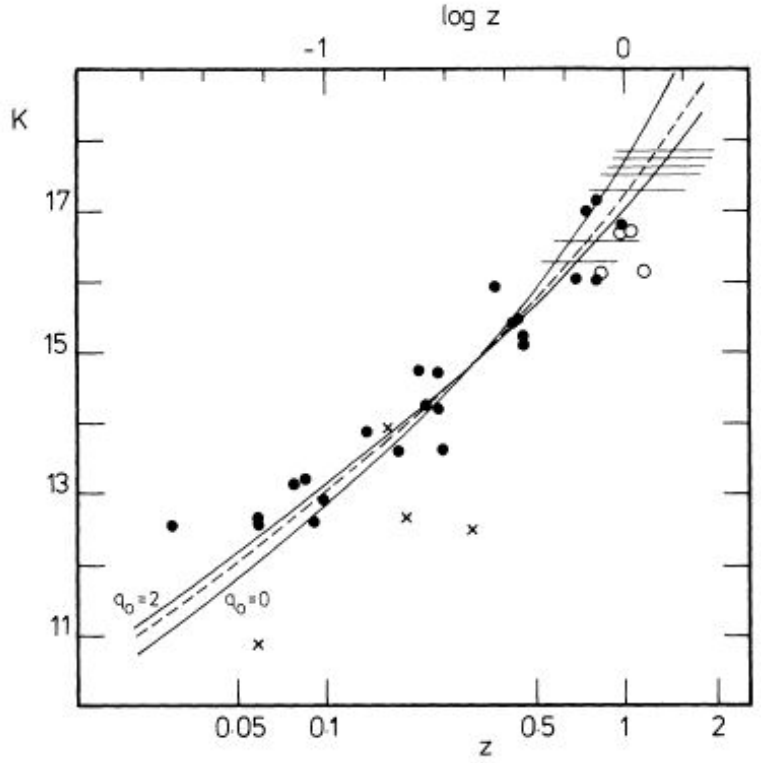
50 papers per year

Orion: 490 × 483 mosaic of 435 JHK images (McCaughrean)

Science highlights (personal choice): Pre-IRCAM

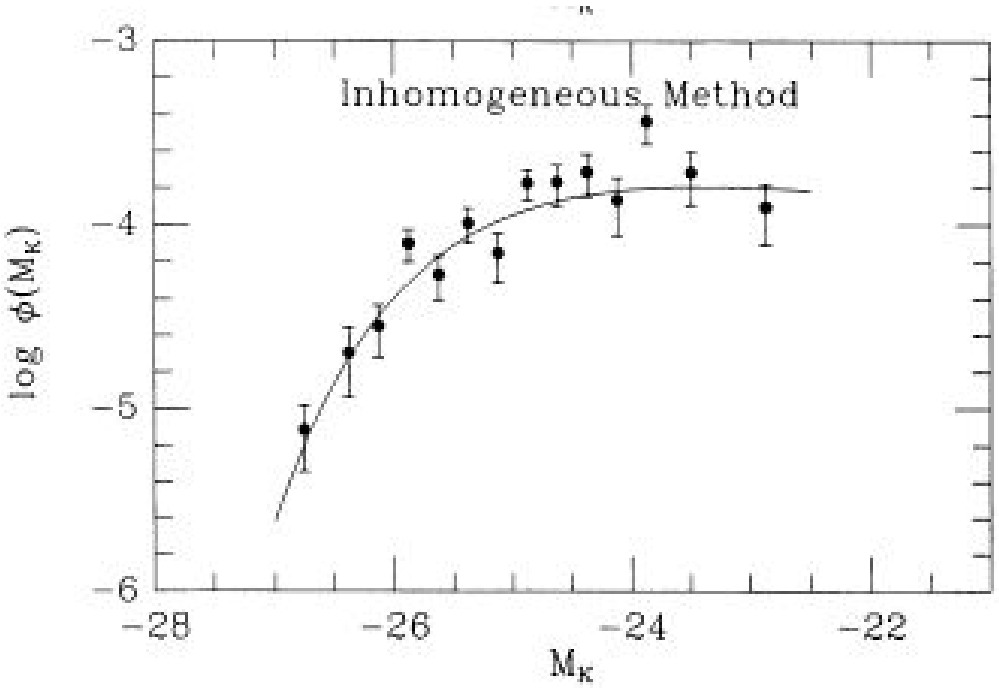
Lilly & Longair

Distant radio galaxies



Mobasher Ph.D.

First K-band luminosity function for field galaxies

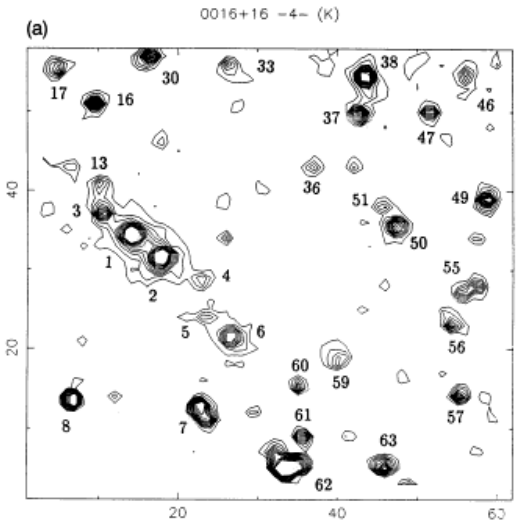


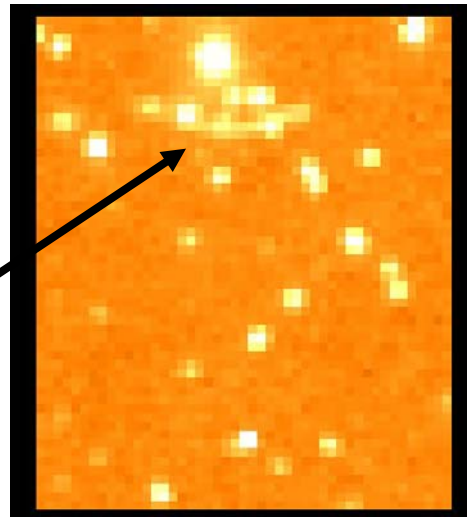
IRCAM – early years

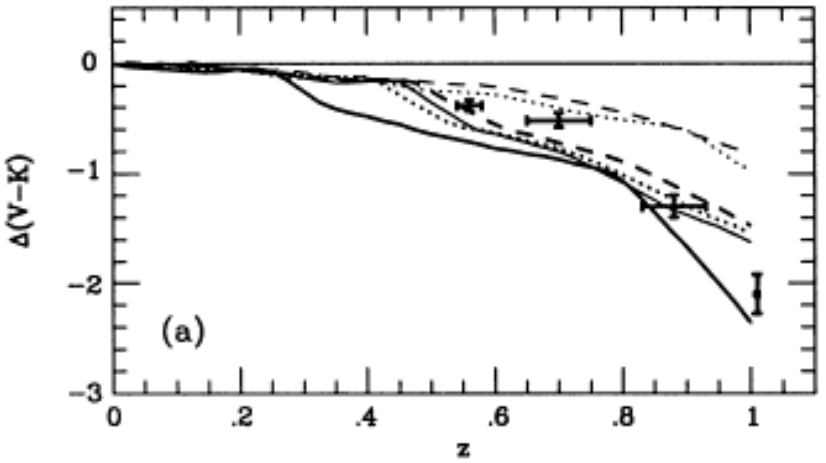
Aragon-Salamanca Ph.D.

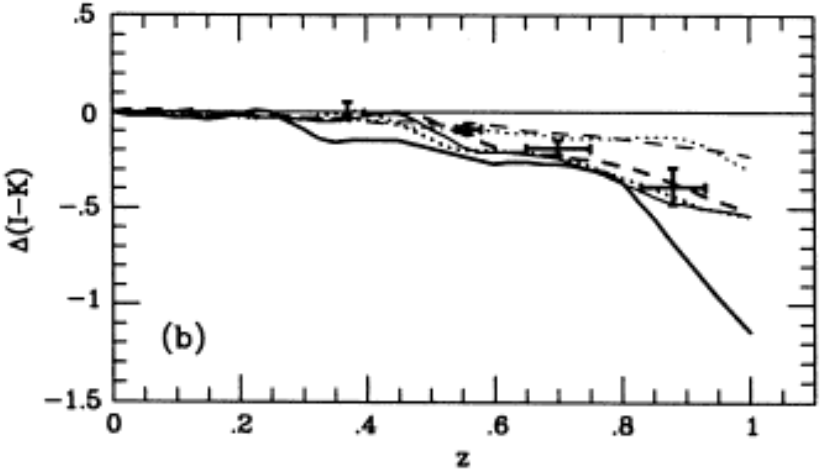
Colour evolution in cluster galaxies to z~1 consistent with early formation

Also first IR detection of a gravitationally-lensed arc (Smail)









IRCAM – early years

Glazebrook, Cowie and others: First deep K-band counts

LETTERS TO NATURE

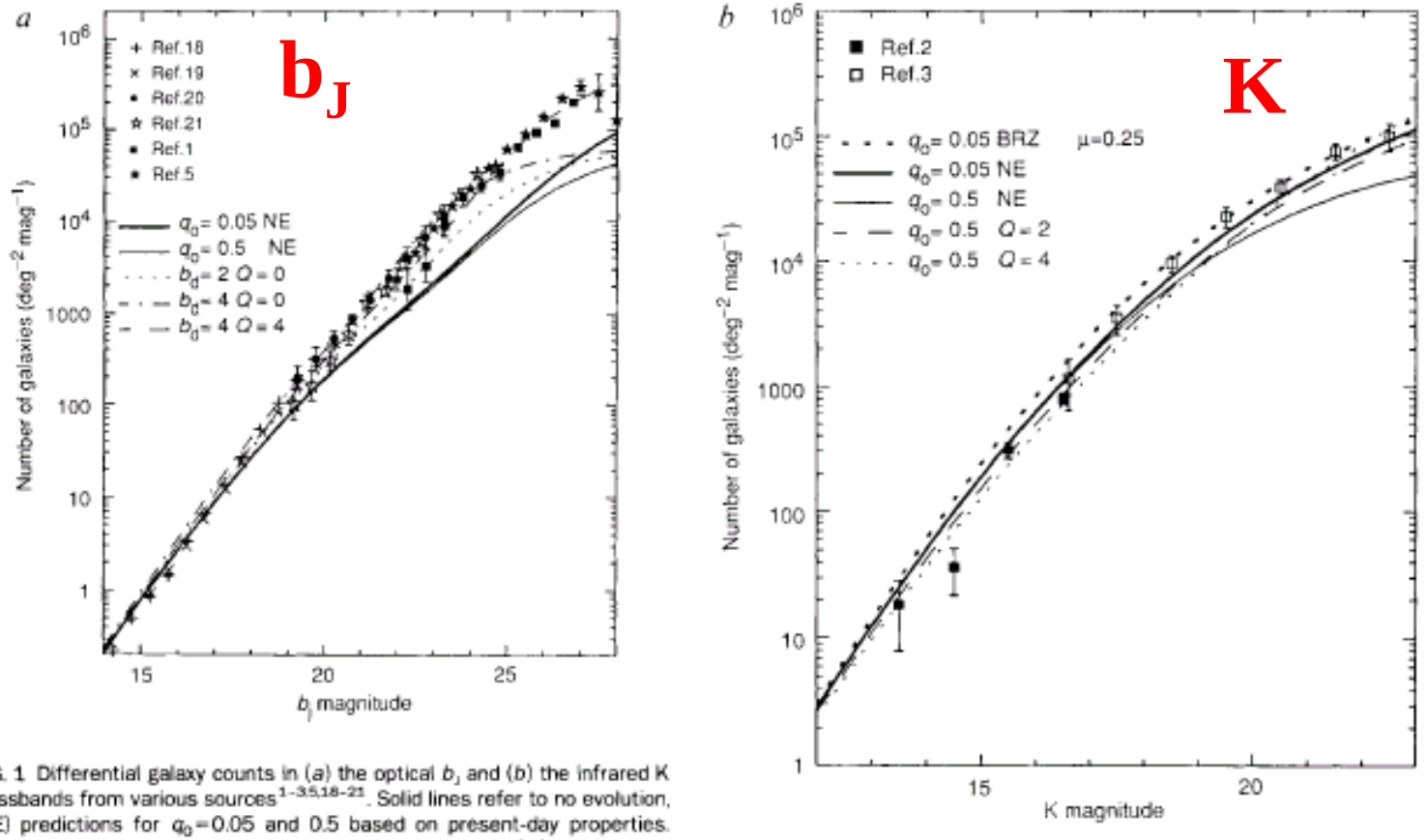
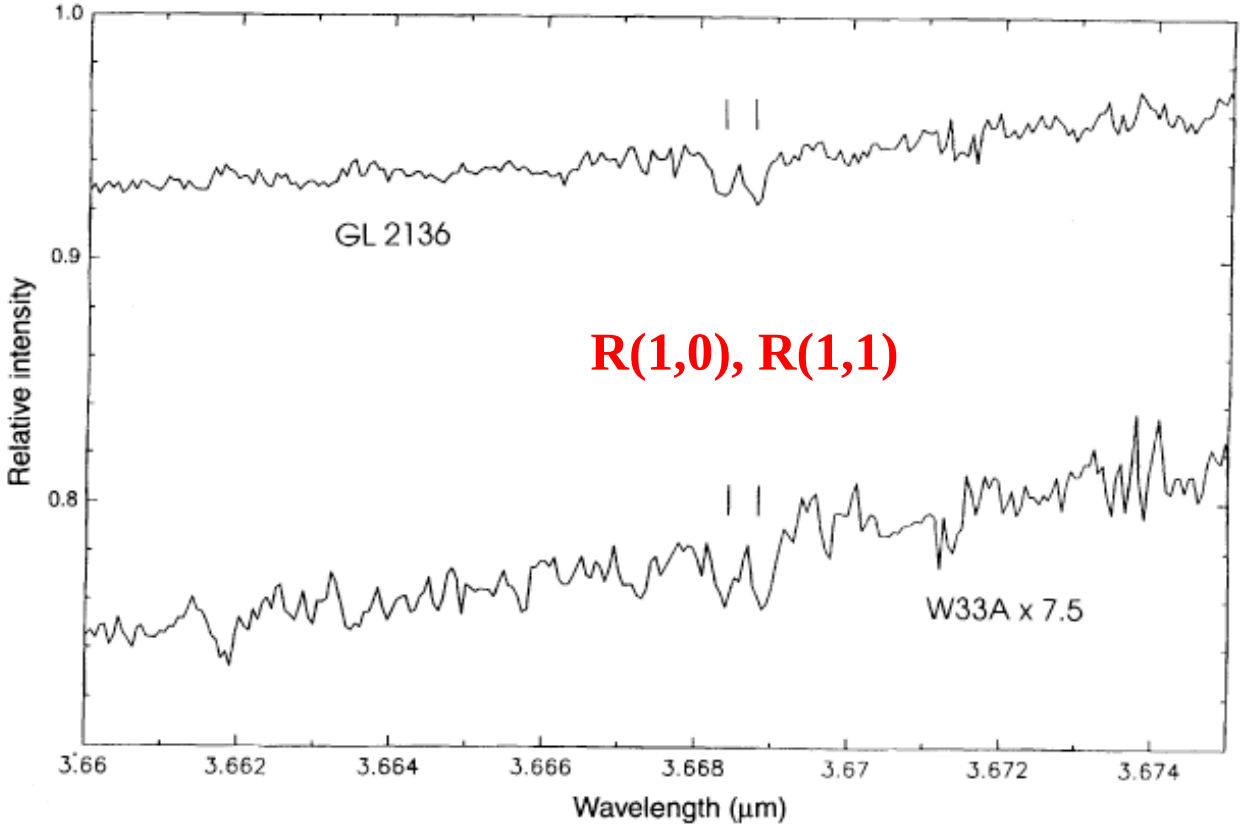


FIG. 1 Differential galaxy counts in (*a*) the optical b_J and (*b*) the infrared K passbands from various sources[1-3,5,18-21]. Solid lines refer to no evolution, (NE) predictions for $q_0 = 0.05$ and 0.5 based on present-day properties. Other models incorporate various rates of galaxy merging (Q) and a rise in star formation rate (b_d). Star formation is modelled according to a standard initial mass function, and evolutionary corrections in the infrared are based on Bruzual's evolutionary code[1,D] (BRZ).

CGS4

H_3^+ ortho-para doublet in absorption in YSOs (Geballe & Oka 1996)

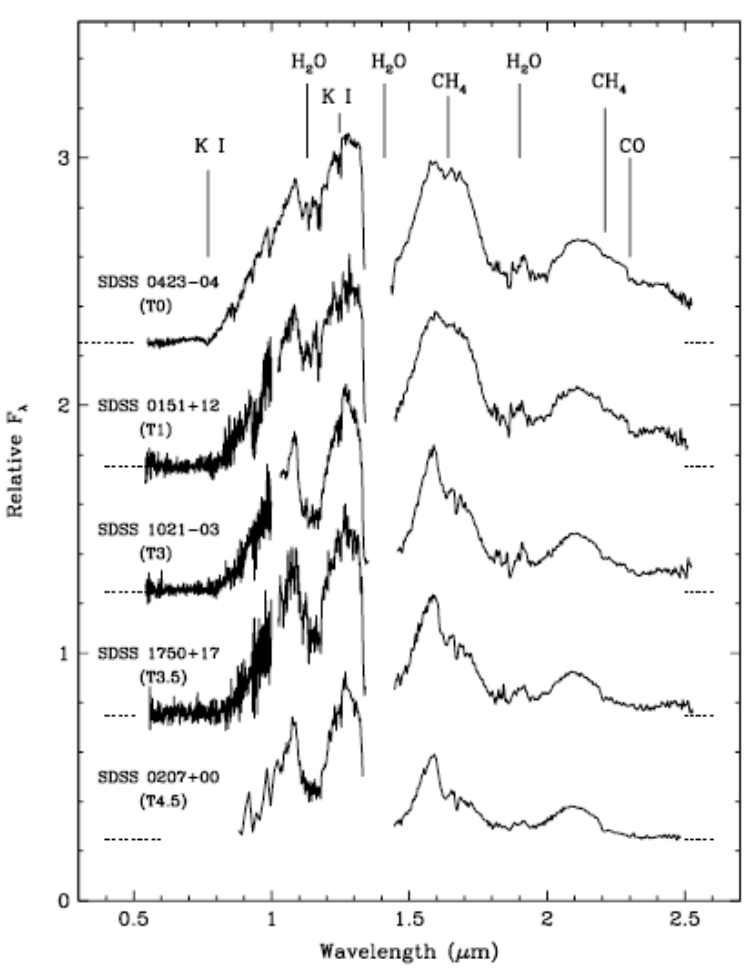
Challenging observation (2% dip) confirming key role of H_3^+ in production of complex molecules and ion-neutral interstellar chemistry

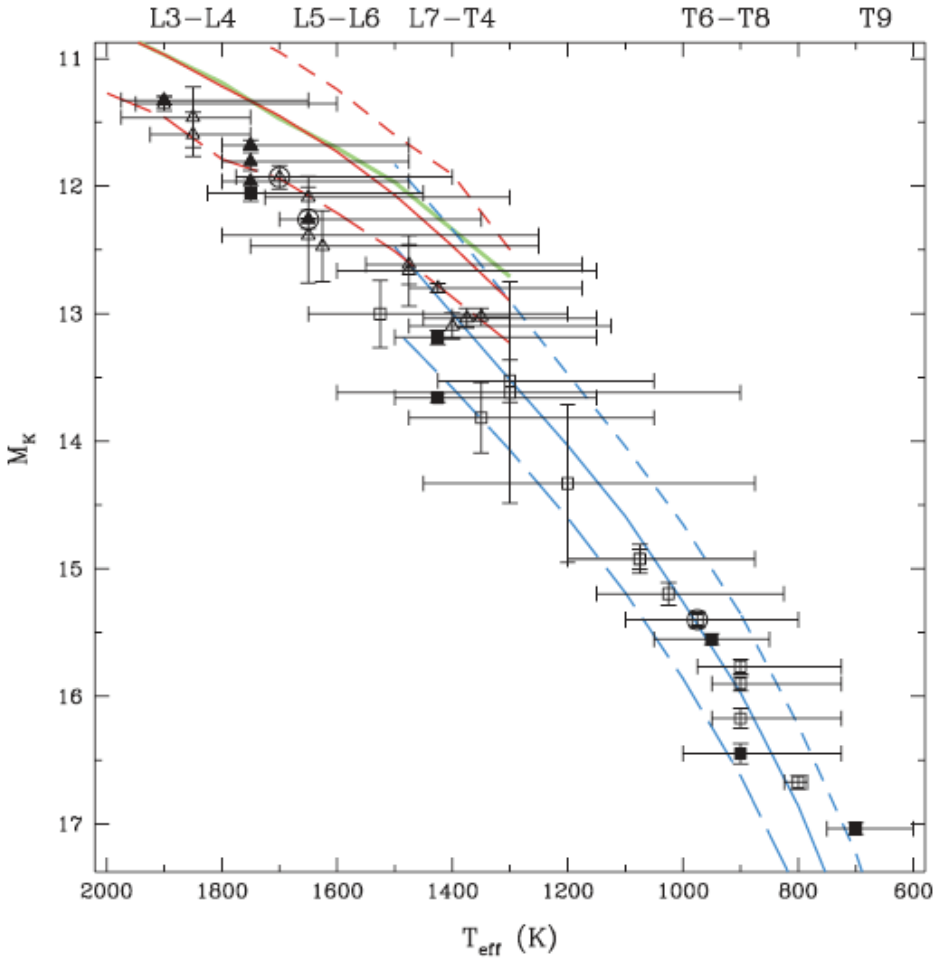


CGS4/IRCAM

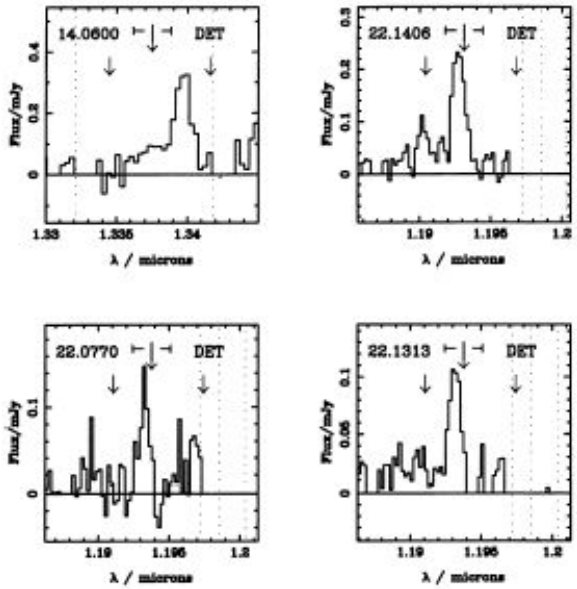
Physics of 2MASS/SDSS L/T dwarfs (Leggett, Geballe, Golimowski et al)

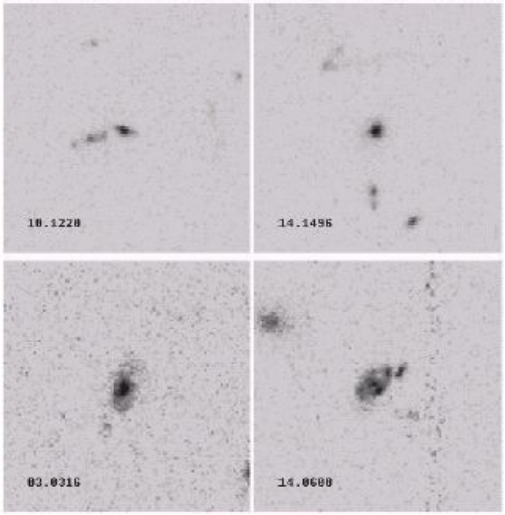
Established classification methods, T_{eff} and models into sub-stellar regime





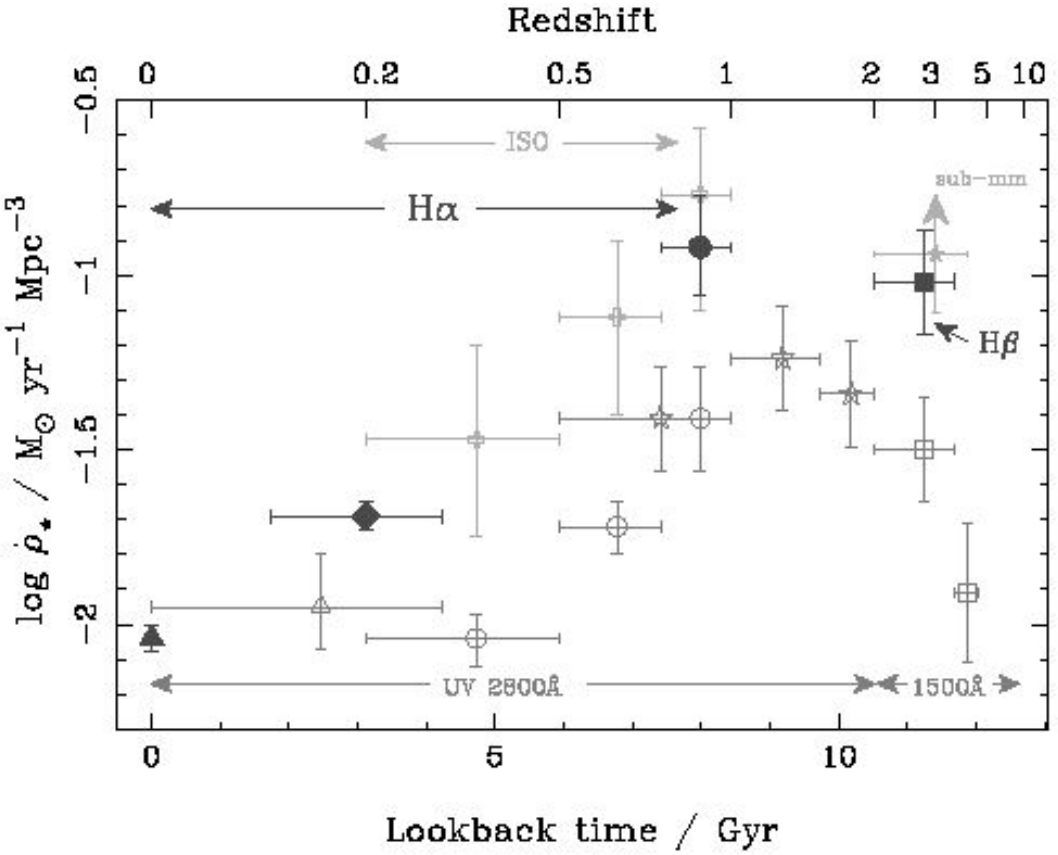
CGS4





Glazebrook et al: Hα survey at z ≈ 1

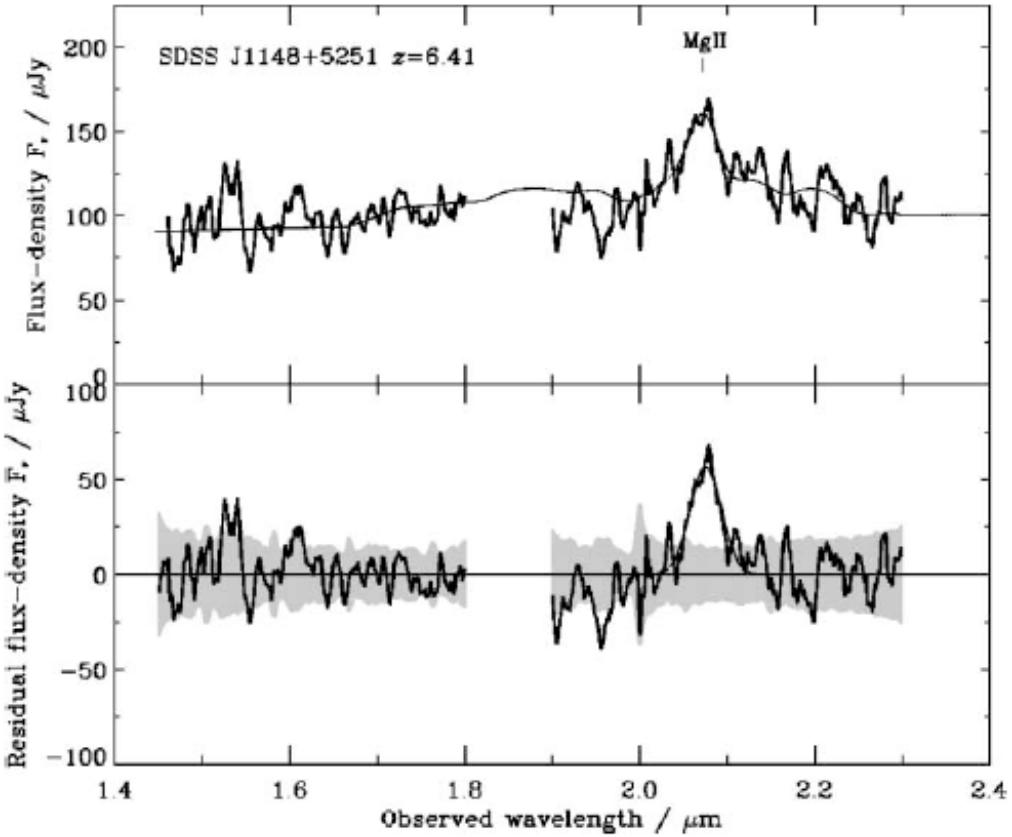
Early measure of star formation rate 7 billion years ago



UIST long slit

Black hole mass (3. 10^9 M_o) in a z=6.41 QSO (Willott et al 2003)

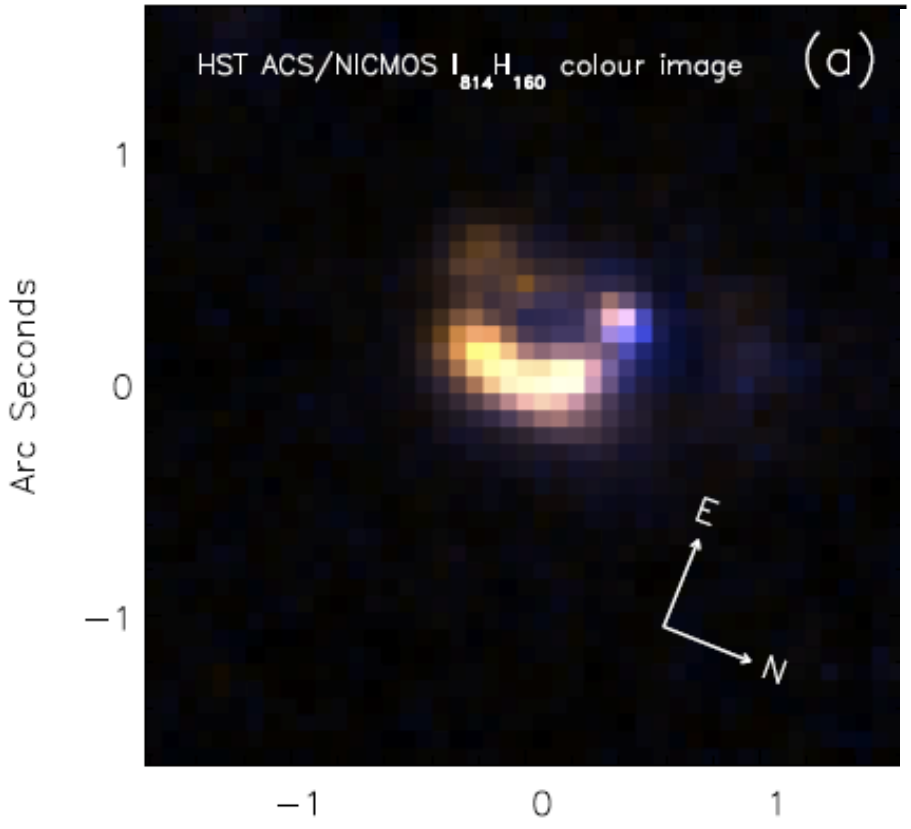
Unique role of UKIRT via access to redshifted Mg II

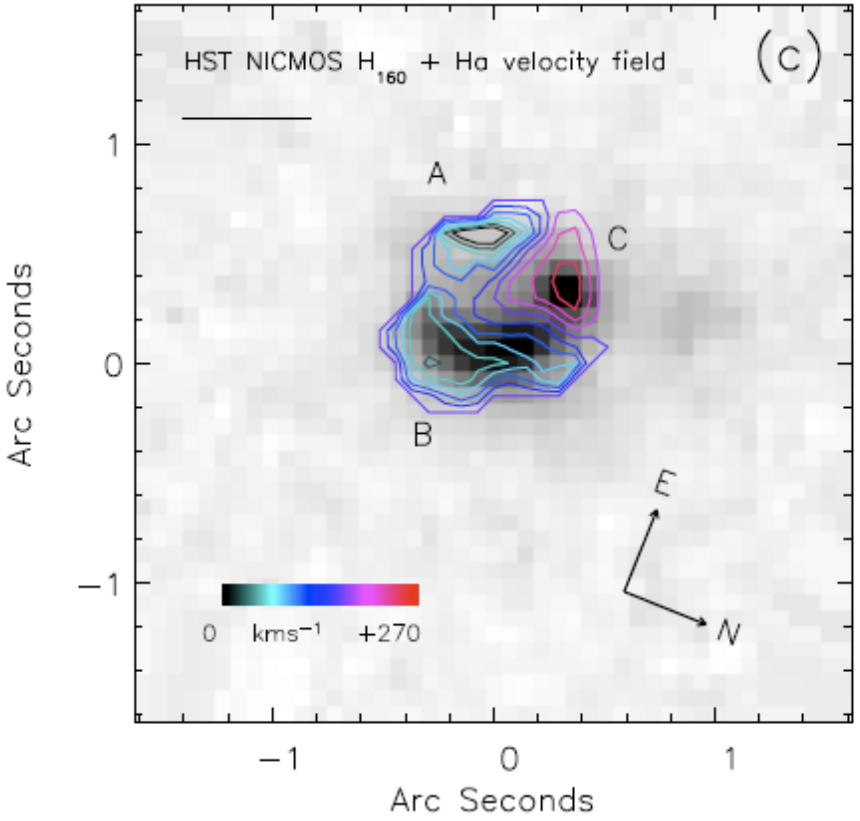


UIST + IFU

Resolved Hα dynamics of z=2.385 sub-mm galaxy (Swinbank et al 2005)

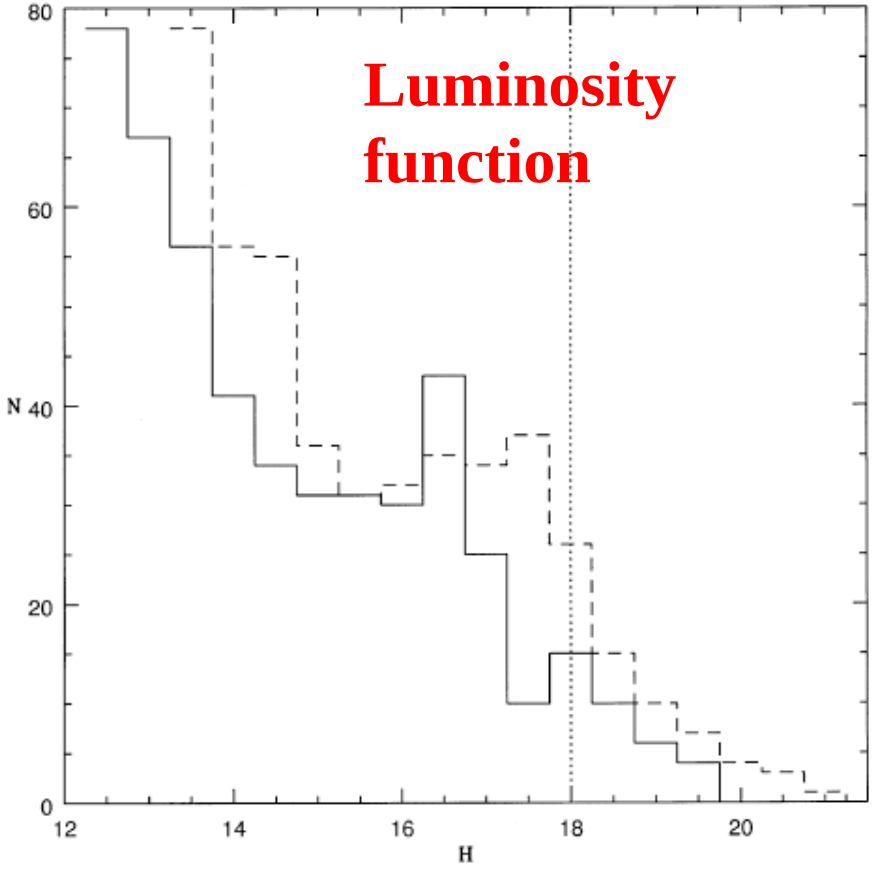
Combining with GMOS Lyα demonstrates role of galactic outflows

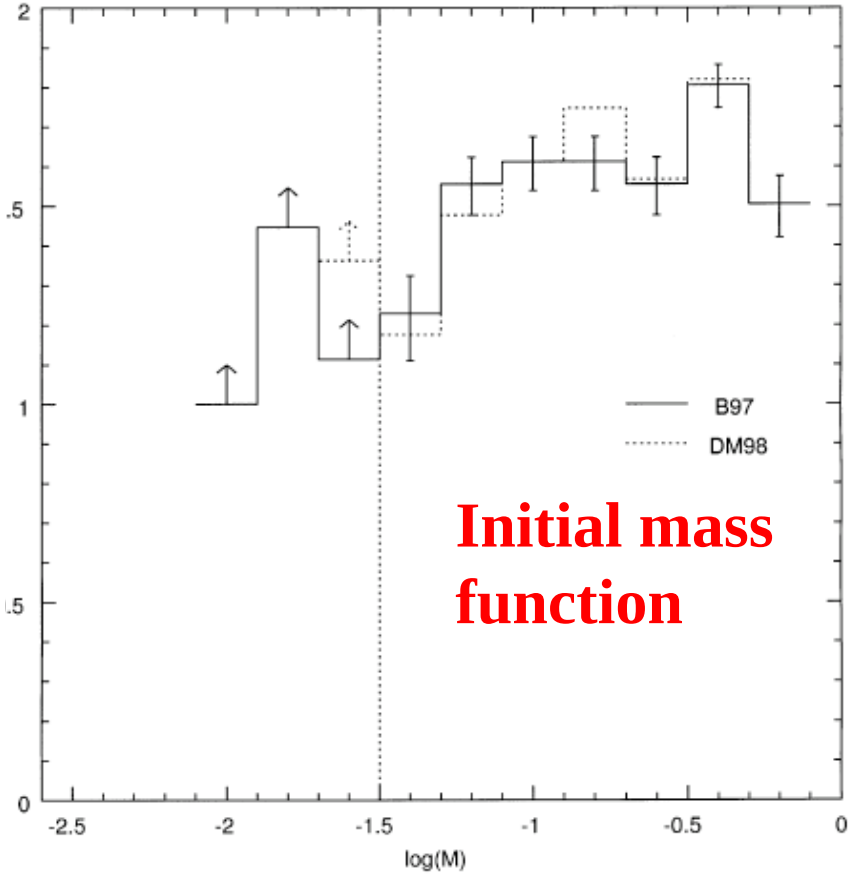




UFTI imaging

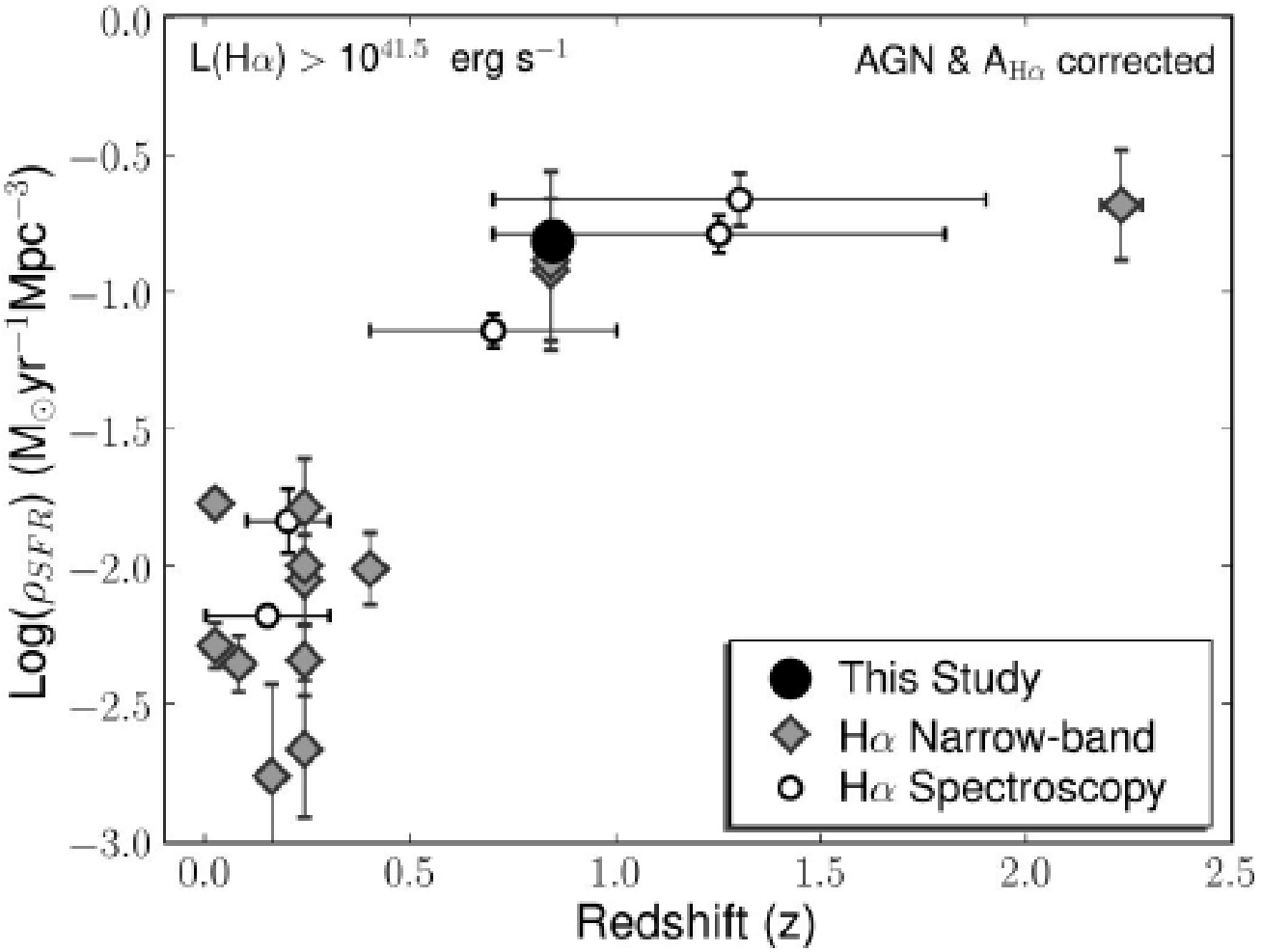
Young brown dwarfs and planets in Trapezium (Lucas & Roche 2000)
IJH photometry for 515 sources in 33 arcmin^2 survey
Abundance of sub-stellar objects in star-forming regions and IMF to ~20 M_{Jup}





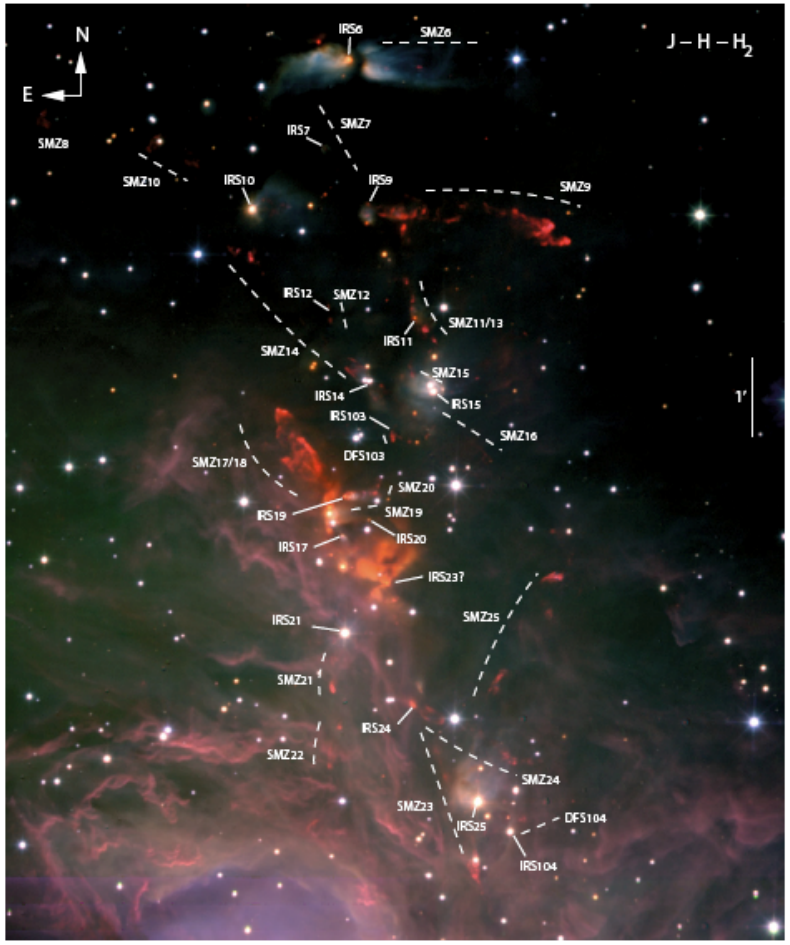
WFCAM nb - 1

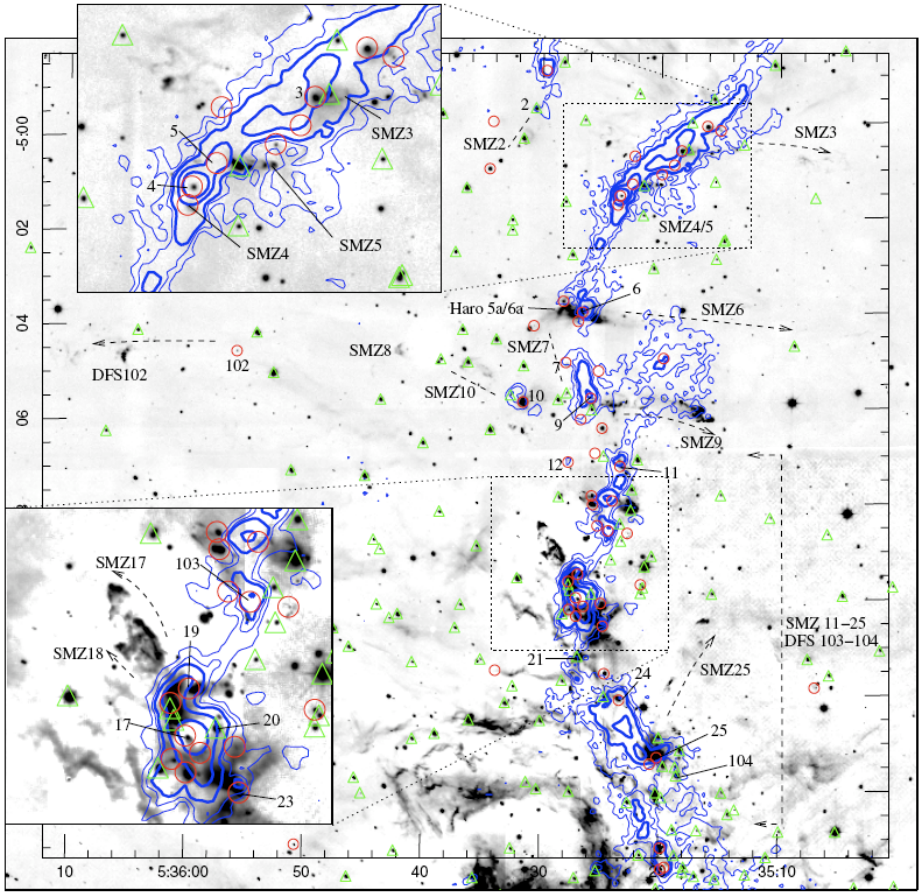
HiZELS – Hα imaging over COSMOS/UDF fields
Self-consistent SF history using single tracer (Sobral et al 2009)



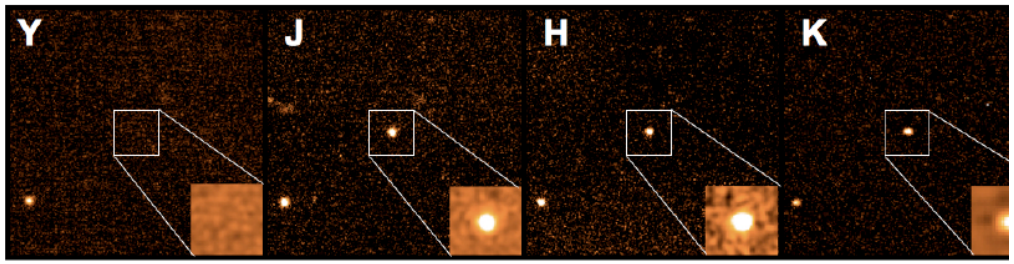
WFCAM nb-2

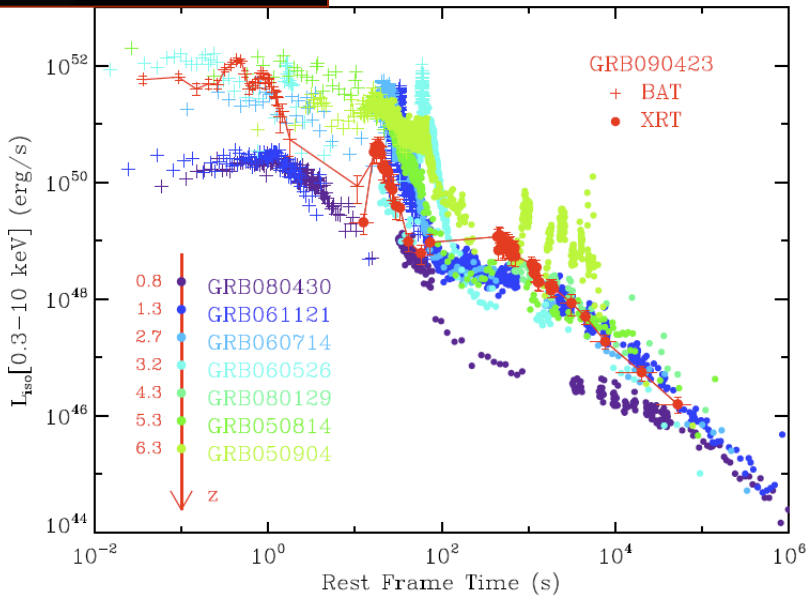
H_2 (2.122μm) mapping over 8 deg^2 in Orion (C. Davis et al 2009)
Association of ~100 jets with protostellar objects



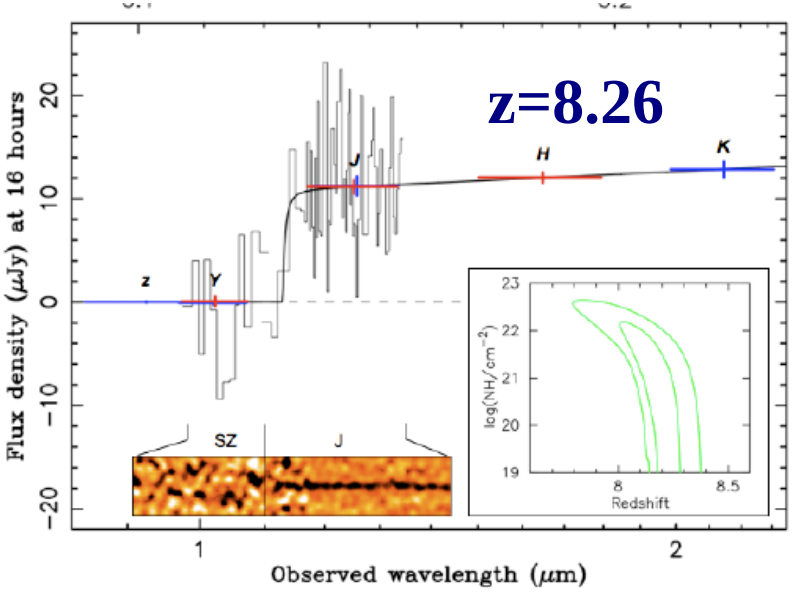


Rapid response: example GRB090423



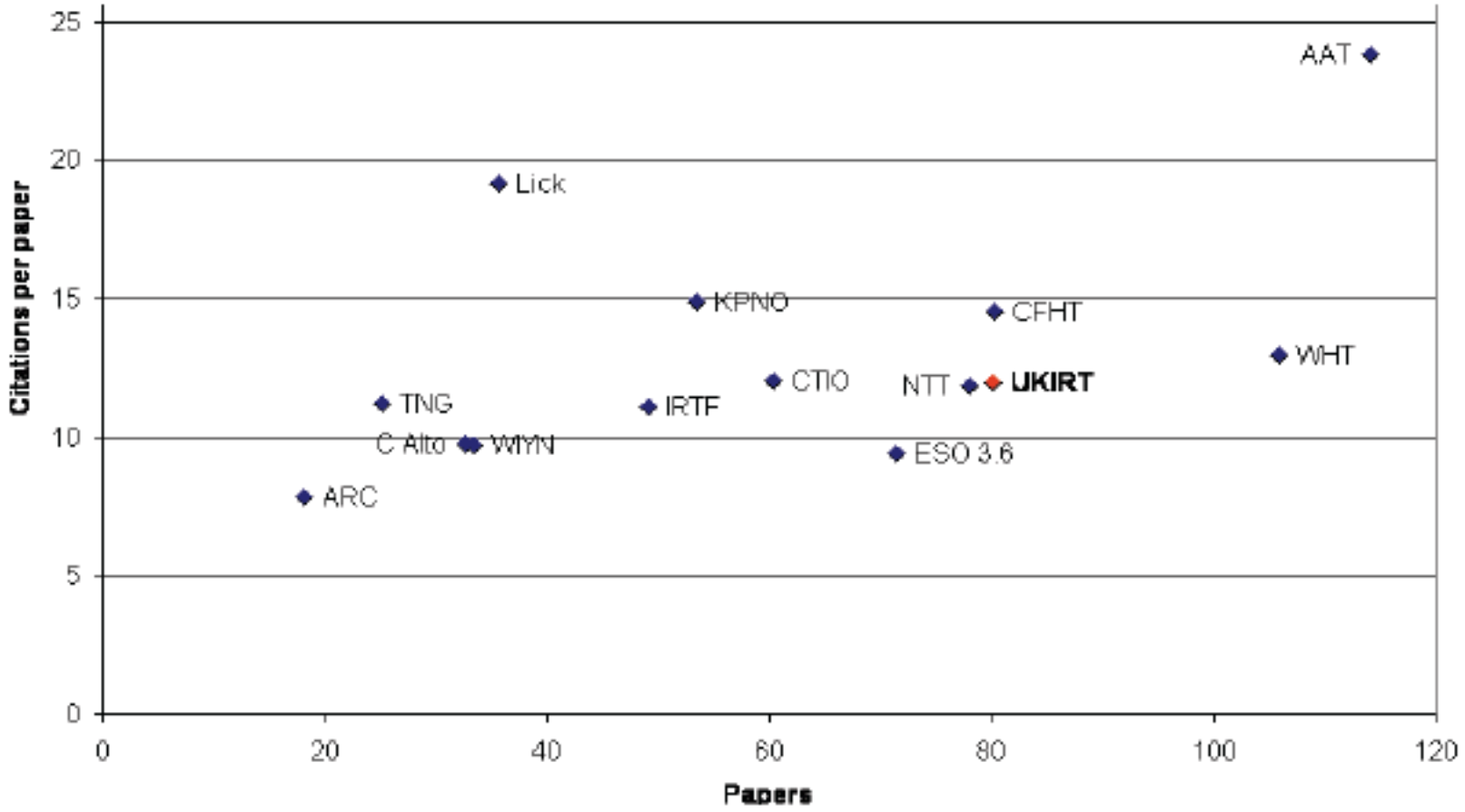


- UKIRT WFCAM images 30 min post-burst key to discovery (Tanvir et al 2009)
- Long burst typical of lower z examples, thus similar massive star progenitor
- VLT spectrum t=16hrs
- Low discovery rate mirrors LBG abundance (Kistler et al 2009)



UKIRT Productivity - 1

Trimble + Cepa (2007), Trimble et al (2005)



UKIRT Productivity - 2

	m	%
MMT	6.5	0.41
Bolshoi	6.0	0.00
Hale	5.1	0.71
WHT	4.2	0.83
CTIO	4.0	1.19
AAT	3.9	3.70
KPNO	3.8	0.64
UKIRT	3.8	0.74
CFHT	3.6	0.81
ESO	3.6	0.10
C Alto	3.5	0.12
NTT	3.5	0.46
TNG	3.5	0.00
ARC	3.5	0.40
WIYN	3.5	0.10
Lick	3.1	0.48
IRTF	3.0	0.36

Chris Benn (see http://www.ing.iac.es/~crb/cit/9903_prelim.html)

Fraction of *highly-cited* (top 2%) of world literature (1999-2003) identifiable with a specific telescope in the 3-6m range

- UKIRT equivalent to WHT
- UKIRT fares as well as it did in 1991-98
- UKIRT outpaces IRTF by ×2

UKIRT remarkably productive facility on global scale given it is a IR-only telescope

Why is UKIRT such a success?

- Mauna Kea site – excellent seeing, stable thermal environment
- Cost-effective operations – jointly operated from JAC
- Flexible suite of front-rank instruments
- Creative operations models – flexible scheduling, training opportunities
- Provision of online data processing
- Able to reinvent itself – WFCAM/UKIDSS
- Wholly UK owned – no complex treaty or major partner issues

The future should be bright…

The Future as viewed in 2004 (25 years)

UKIRT is remarkably well-placed to move forward in era of Gemini/Subaru/Keck and TMT

- innovative & unique instrumentation
- operationally effficient
- an integral part of the Mauna Kea network
- popular with astronomers!

2005 UKIRT Review

"Consider role and international context of UKIRT 2005-2015 and consider options for development of facility"

- Concluded UKIRT is a highly successful, well-run facility
- Recommended rebalancing UKIDSS/non-UKIDSS imaging
- Discussed several post-UKIDSS instrument developments
  - Further imaging: larger area/second epoch complementing WISE, SDSS and VISTA
  - Adaptive Optics: GLAO and/or mid-IR AO
  - Wide Field Spectroscopy (pending FMOS)
  - High dispersion spectra; low mass planets in habitable zone
  - Panoramic imaging in thermal bands (complement Herschel prior to JWST)
- Panel noted absence of any financial guidelines from PPARC!

Conclusions

- UKIRT has been a great success not only for UK science but also in promoting the growth of infrared astronomy worldwide
- It is one of the best examples of a telescope that has adapted to new technologies, far surpassing the original goals envisaged in the 1970's
- It remains cost-effective and innovative in its approach to operations and science delivery
- It remains strategically important for the UK – sited on the best northern site
- The UK community should push hard to retain access with new instruments and continued imaging surveys