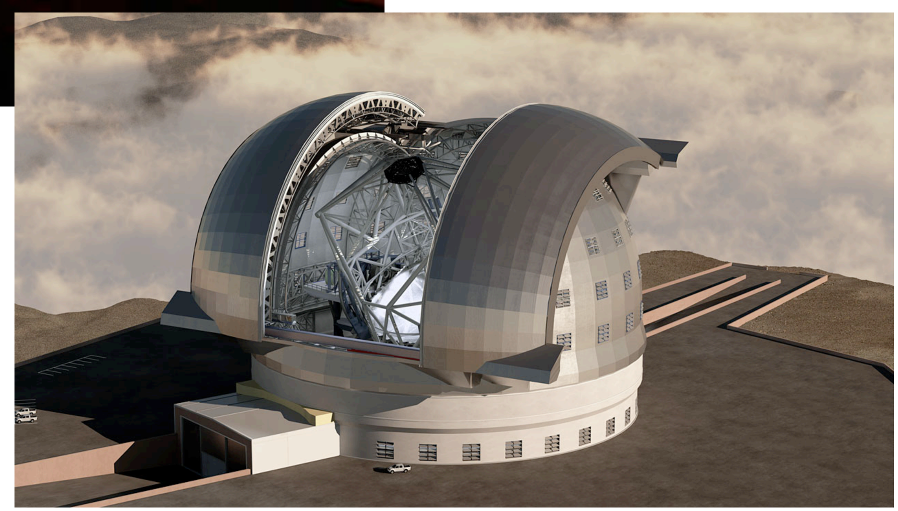
The Global Impact of ESO

Richard Ellis (Caltech)



ESO @ 50

Garching, September 5th 2012

The 50 Year Story

Caveats: Personal views from UK (1974-1999) and Caltech (2000-2012)
Focusing primarily on optical/IR and extragalactic achievements and activities
Material: Personal, ESO Messenger/Reports, Woltjer's "Europe's Quest for the Universe"

- **The Formative Years (1962 – 1986)**
  - modeling the organization on CERN
  - building the 3.6m - the first European large telescope
  - establishing a new scientific culture and focus
  - demonstrating ambition at an early stage (VLT)

- **The NTT Era (1986 – 1998)**
  - investing in new technologies
  - developing competitive instruments
  - paying attention to infrastructure
  - testing VLT concepts at La Silla while constructing at Paranal

- **The VLT Era (1998 – present)**
  - producing ambitious instruments and exploiting Guaranteed Time
  - expanding the organization and its scope (new members, ALMA)
  - producing world-class science and initiating the E-ELT

- **The Future (E-ELT and global science)**

ESO @ 15 (1977)


Hale 5m 1949


Lick 3.0m1959


ESO 3.6m 1976


AAT 3.9m 1974


KPNO 4.0m 1973
SCIENCEphotoLIBRARY

Challenges for European Astronomy in 1977

- ESO 3.6m and AAT 3.9m opened new opportunities to an optical community previously overshadowed by Californian astronomy (Hale 5m and Lick 3m)
- However, new facilities need to be matched by new ideas; these emerged slowly
- US astronomy continued to be resurgent as many Kitt Peak/CTIO observers had received their training in California
- Many astronomers were reluctant to branch beyond Local Group and variable stars
- Excepting photography, ESO was behind the curve in detector investment

AAT was lucky to have two pioneering detectors: Wampler's IDS and Boksenberg's IPCS
– this opened extragalactic horizons very quickly

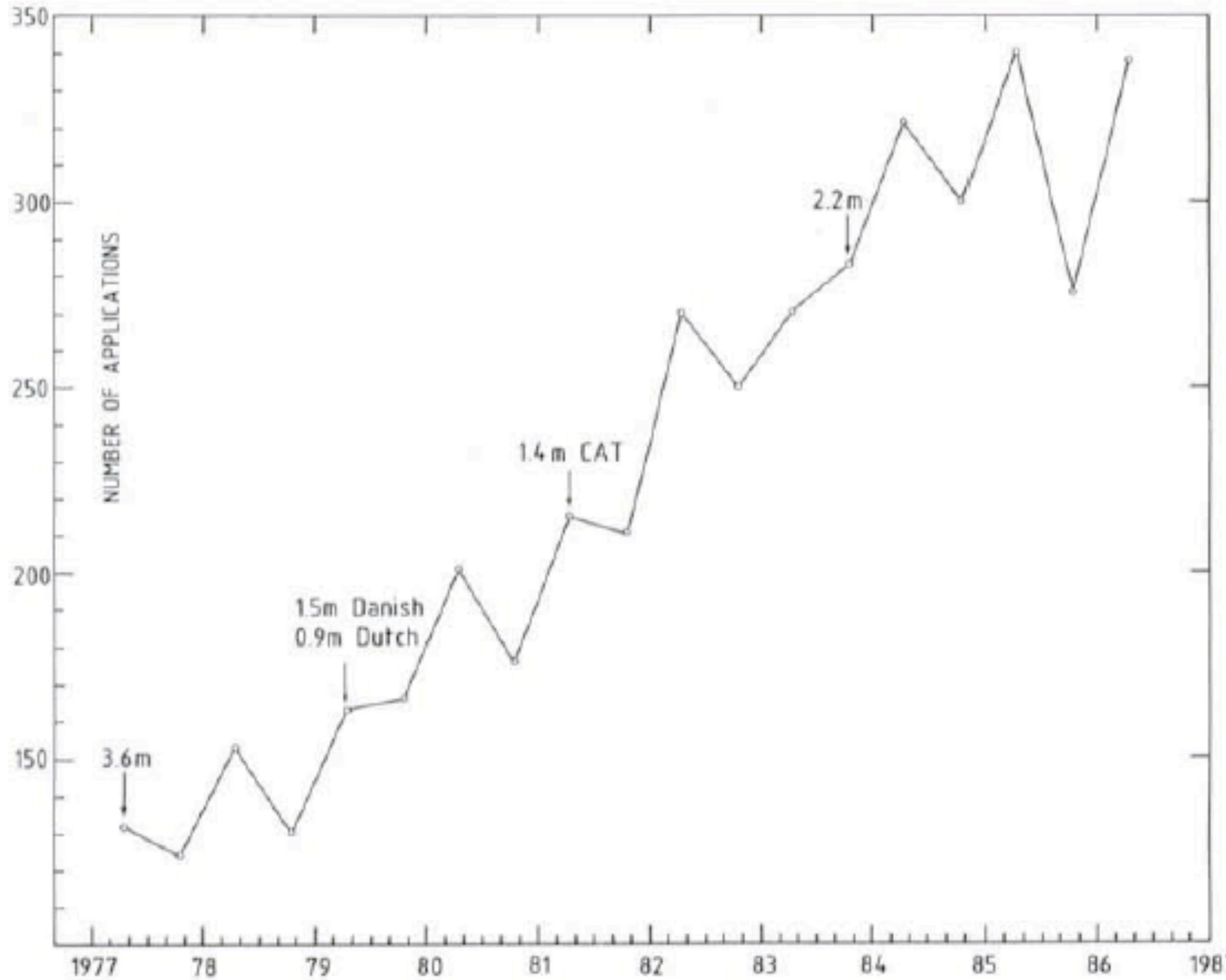
Strengths of ESO during that time:

3.6m advantages: wide field prime focus, IR top-end, CAT feed to CES
Danish 1.5m – excellent performance & very effective synergistically
Willingness to accept visitor instruments and detectors (IPCS, McMullen camera, speckle)
Strong in house instrument group (1981) & data processing system (IHAP, MIDAS)

Early strategic factors of great importance:
Prominence in radio astronomy lay groundwork for SEST and interferometry
Strong links to space programmes: Ariel, IUE..ultimately ST-ECF and now JWST
Alignment with CERN gave strong basis for future vision and central leadership

Formative Years: Growth in Proposals

No of received proposals per 6 month semester

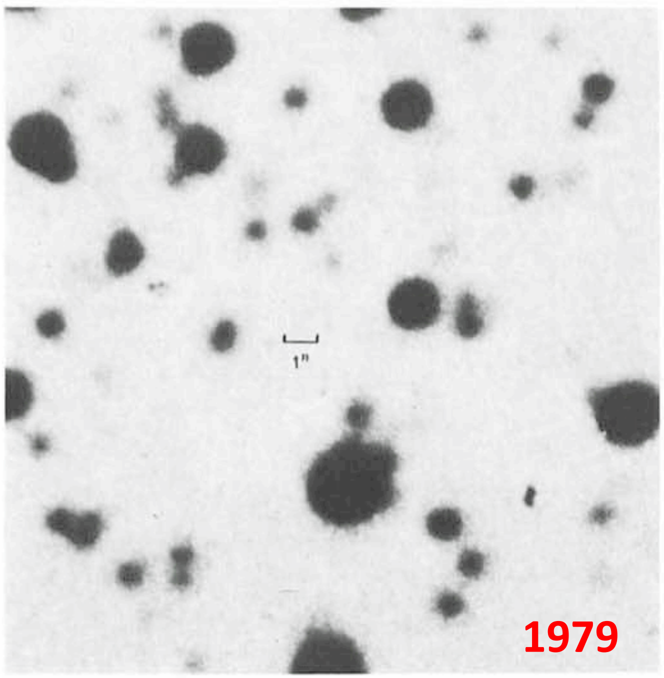


1977: 140 proposals overall, 54 for 3.6m (40% extragalactic) [Messenger #10]
1986: 350 proposals overall, oversubscription doubled [Messenger #45, 51]

1977-1986 Highlights: Danish 1.5m telescope

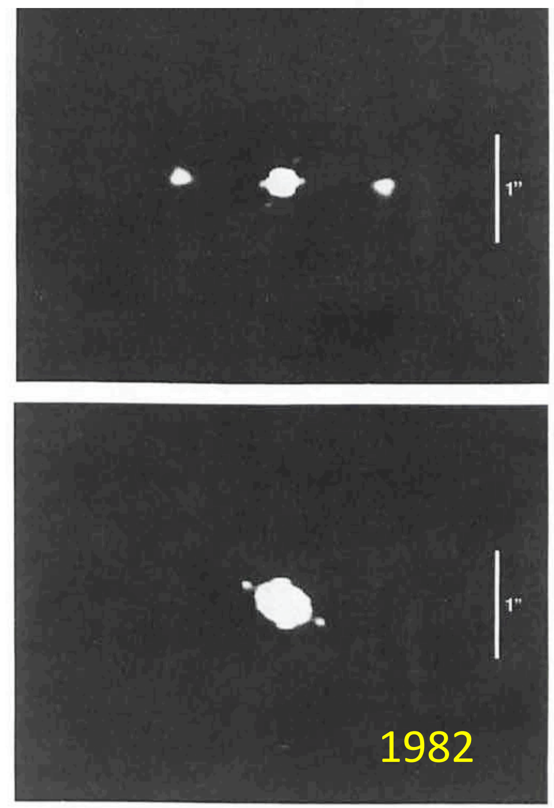
0.5 Arcsecond Images with the Danish 1.5 m Telescope on La Silla!

J. Andersen and B. Niss



Digital Speckle Interferometry of Juno, Amphitrite and Pluto's Moon Charon

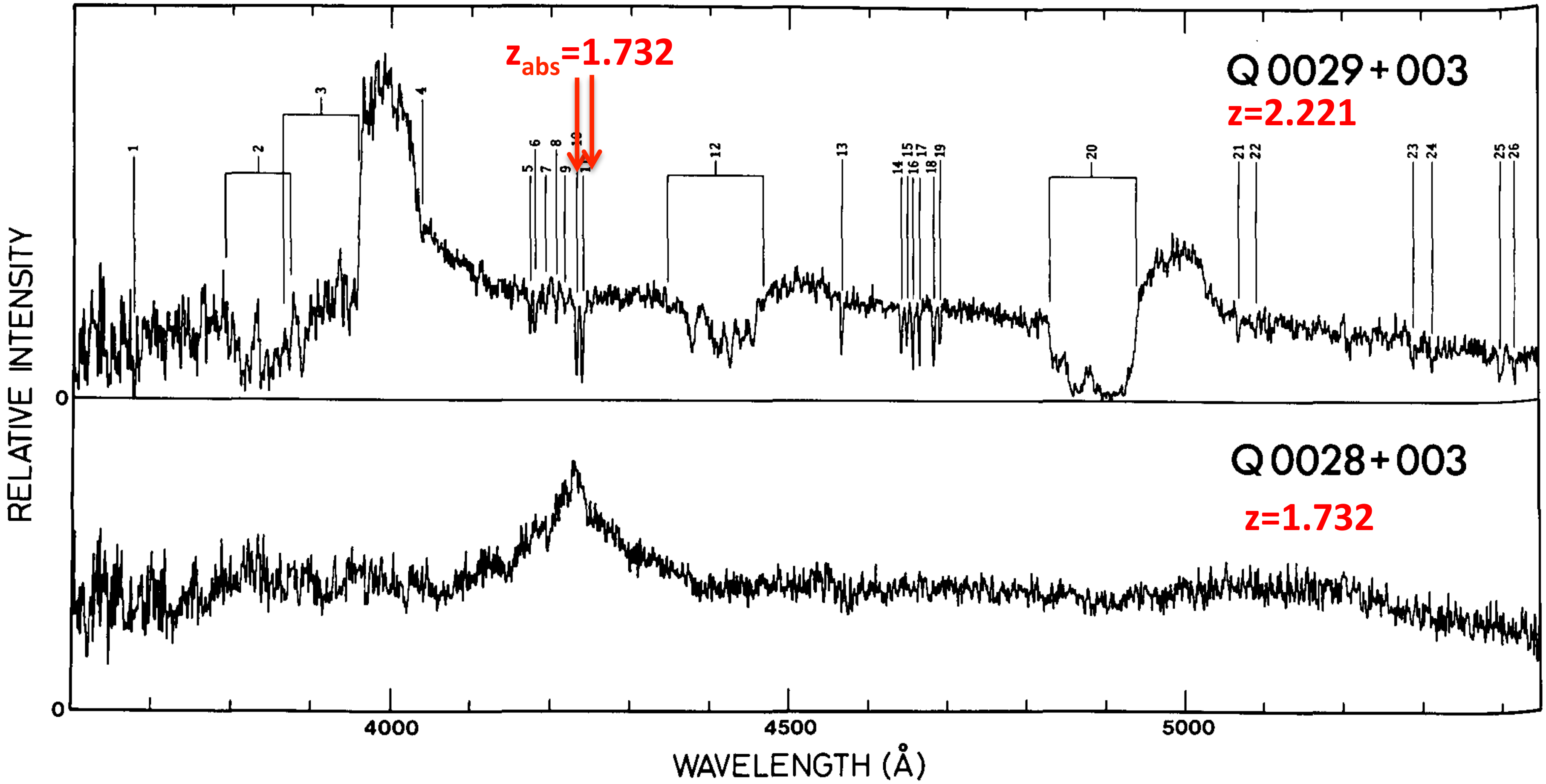
G. Baier, N. Hetterich and G. Weigelt, Physikalisches Institut der Universität Erlangen, Fed. Rep. of Germany



Danish 1.5m emerged quickly as a creative facility demonstrating ESO's commitment to excellent image quality, innovative techniques and programs

Messenger #17 (1979), #30 (1982)

1977-1986 Highlights: Quasar Absorption Lines



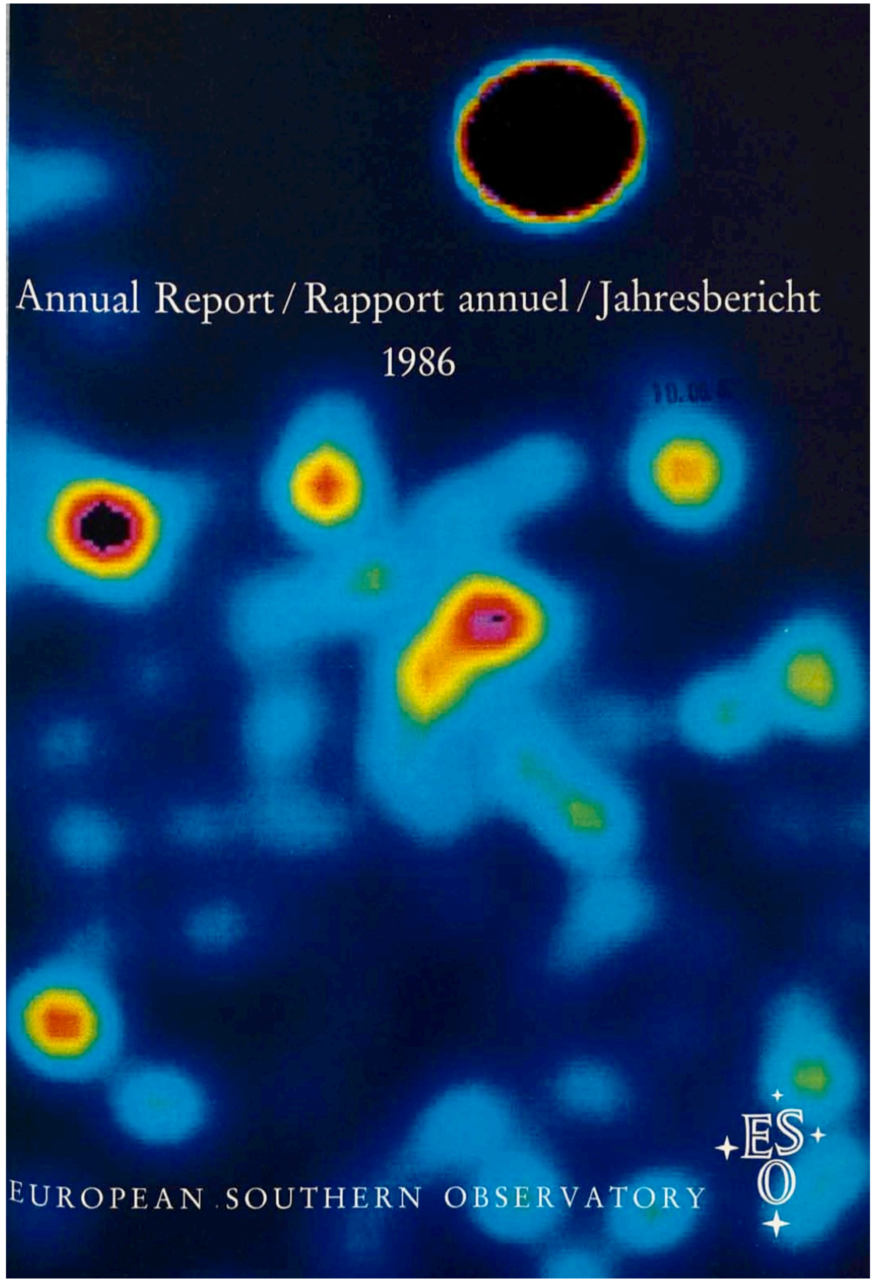
ESO 3.6m BC spectra with IPCS of a close pair of QSOs provided clear evidence for the `intervening' hypothesis for QSO absorption lines

Shaver et al Ap J 261, L7 (1982)

1977-1986 Highlights: NIR Imaging on 2.m

ESO realized the importance of a strong infrared program with a succession of ever more impressive instruments led by Alan Moorwood and colleagues (31 in ~ 30 years!)

This infrared image (2.2 μm) of the innermost region of the galactic centre was obtained with the 2.2-m telescope and an 8 × 8 array camera built at the Observatoire de Meudon. The image was processed with the CLEAN algorithm and has an angular resolution of 0.8 arcsec. The IRS 16 complex (centre) coincides within 1 arcsec with the strong radio source Sgr A. (Observer: F. Lacombe.)



The NTT Era: 1986 -1998

The NTT Era: 1986 -1998

A sound vision:

- By 1978, there was a vision for the VLT/I (science thoughts from senior figures)
- Addition of Italy and Switzerland enabled NTT as early demonstration facility
  - pioneering active control (R. Wilson)
  - low cost & mass, alt-az mount
  - focused goals c.f. "universal" 4m
  - testbed for VLT control software, adaptive optics etc
- Site testing campaign selects Paranal yet NTT is built at La Silla

Realized premier facilities & opportunities:

- SEST 15m, 3.6m + Optopus/AO, NTT + EMMI/EFOSC2/SUSI/SOFI, 2.2m + IRAC(2)
- Key projects initiated to improve competitiveness
- International prominence through initiatives (SN 1987a, Shoemaker-Levy9 encounter)

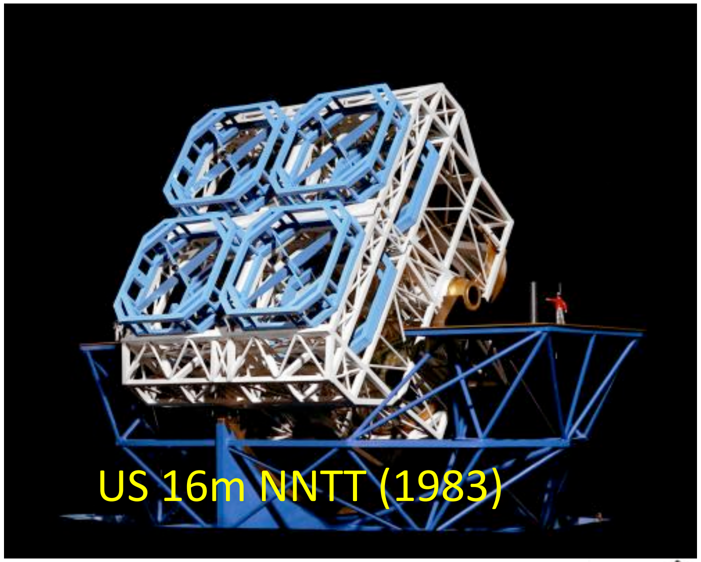
Attention to infrastructure:

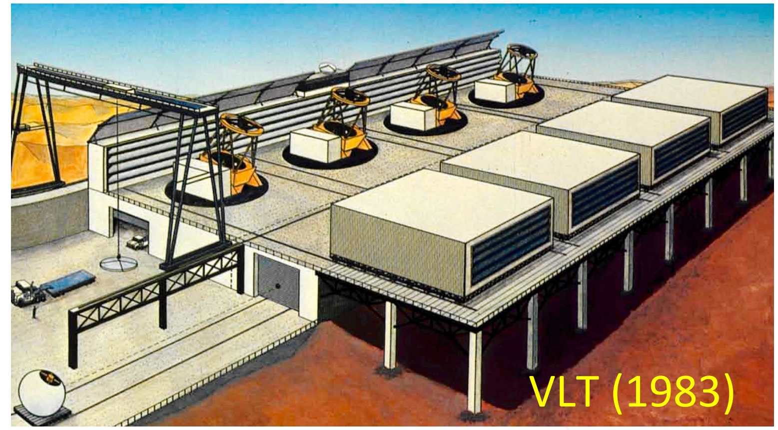
- New detectors, VPH gratings etc
- Major seeing and upgrade campaigns (Danish 1.5m, 3.6m, NTT..)
- MIDAS distributed to ~180 sites

Emerging broader role:

Scientific staff and technical center at Garching, ESO-CERN conferences, workshops on 8m science and instrumentation, interferometry, HST (leading to ST-ECF)

Early Discussions of the VLT (1978-83)





VLT was initially scoped as a 25 meter with much discussion on the optimum number of component mirrors (many small telescopes acting as interferometer, multiple mirrors on a common mount (MMT-like) or array of large 8ms)

Messenger #12

Key Programmes at ESO (1988 - 1994)

33 key programmes from 83 proposals

Most successful but some overlapped, were less fundamental

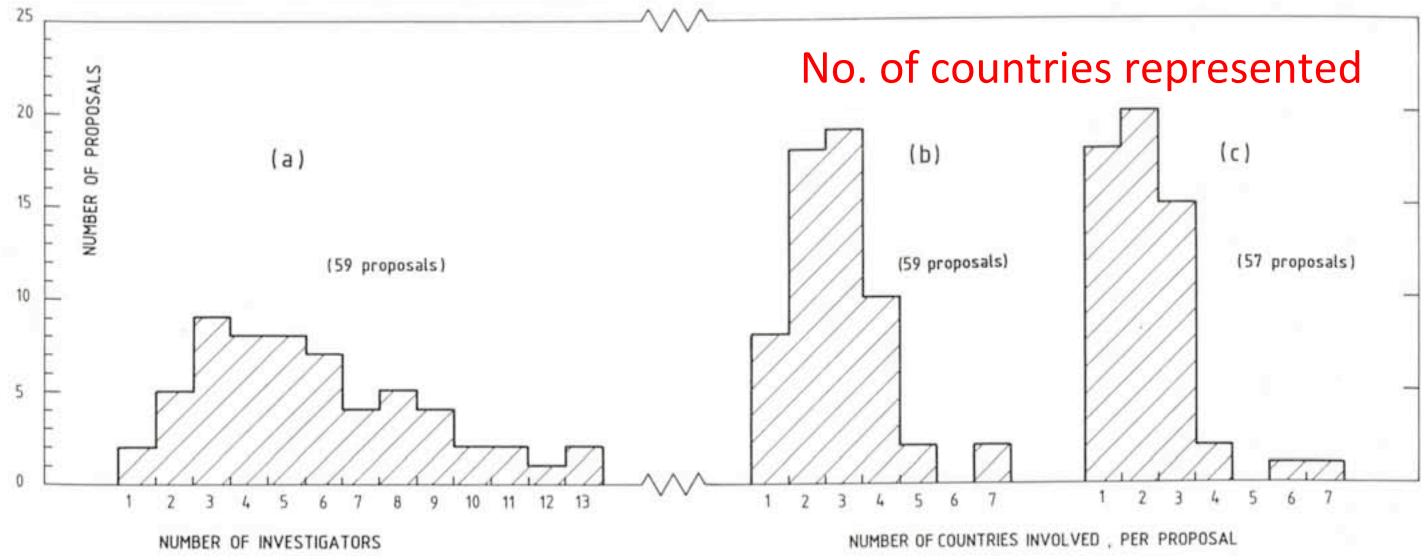


Figure 1: *Histograms showing the distribution of the proposals, (a) as a function of the number of investigators involved; (b) as a function of the number of institutional nationalities per proposal when ESO and ESA institutes are included, (c) when ESO and ESA institutes are excluded. The programme related to HST follow-up, which involves 32 investigators from 19 institutes, is not included.*

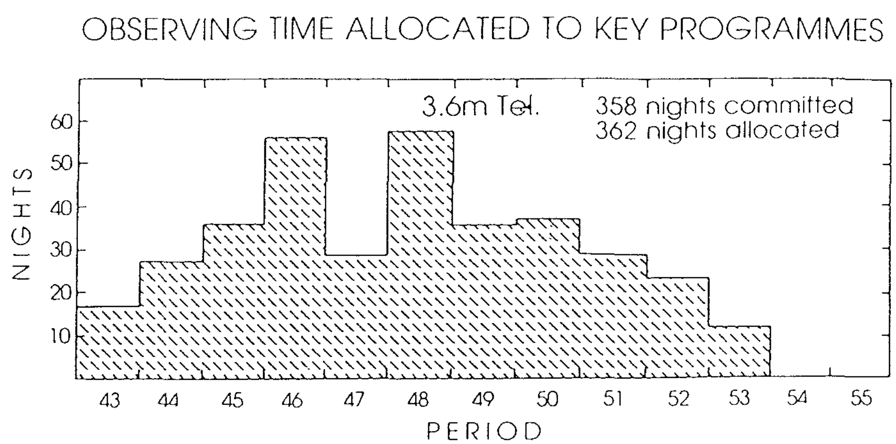


TABLE 1. *Distribution of the accepted key programmes*

OPC Categories	No. of KPs	
	accepted	completed*
1. Galaxies, Clusters of Galaxies	10	7
2. Quasars, Seyferts, Radio Galaxies	6	2
3. Magellanic Clouds	2	1
4. Interstellar Matter	2	1
5. Star Clusters, Galactic Structure	5	2
6. X-Ray Sources	2	1
7. Stars	3	2
8. Miscellaneous	3	1
Total	33	17

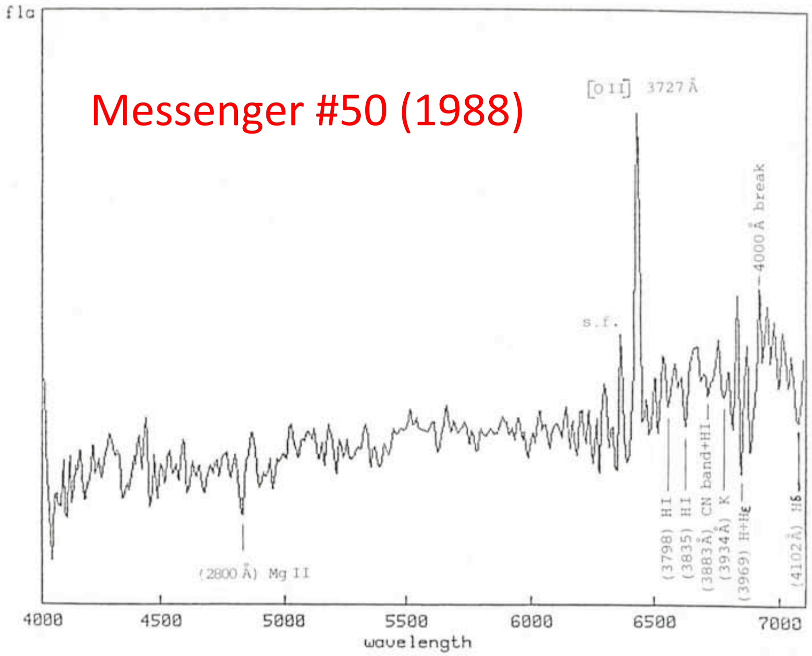
* at the end of Period 52

Messenger #52 (1988), #55 (1989), #75 (1994)

Highlights 1986-1998: Gravitational Lensing

Discovery of the First Gravitational Einstein Ring: the Luminous Arc in Abell 370

G. SOUCAIL, Y. MELLIER, B. FORT, G. MATHEZ, M. CAILLOUX
Observatoire de Toulouse, France



Messenger #50 (1988)

Figure 1: *Spectrum of the luminous arc in Abell 370. The lines mentioned in the text are indicated. ESO 3.6 m + EFOSC, 6 hours integration.*

PROFILE OF A KEY PROGRAMME

Arc Survey in Distant Clusters of Galaxies

B. FORT, J.F. LE BORGNE, G. MATHEZ, Y. MELLIER, J.P. PICAT
Midi-Pyrénées, Toulouse, France
R. PELLO-DESCAYRE, B. SANAHUJA, Dept. d'Astronomia i Mete
Barcelona, Spain

Cluster	z_{cl}	z_s	B	R	B-R	R-K	μB	γ	B_{int}	R_{int}
A370 (A0)[1]	0.374	0.725	21.1	19.4	1.7	4.1	24.6	12	23.8	22.1
A370 (A5)[2]	0.374	1.305?	22.7	22.3	0.4	~3.0	25.4	6	24.7	24.2
Cl2244-02[2]	0.336	2.237	21.2	20.4	0.8	3.0	25.3	20	24.5	23.7
A2390[3]	0.231	0.913	21.9	20.0	1.9	4.2	25.3	12	24.6	22.7
A2218 (# 359)[4]	0.176	0.702	24.3	21.4*	2.9	—	25.0	4	25.8	22.9
A2218 (# 289)[4]	0.176	1.034	22.5	21.7*	0.8	—	24.2	5	24.2	23.4
A963 N[5]	0.206	0.771	23.6	23.1	0.5	3.5	25.5	4	25.1	24.6
Cl0024+1654[2]	0.391	?	23.0	22.3	0.7	3.3	25	4	24.5	23.8
S506 (Cl0500-24)[6]	0.321	0.91?	21.0	19.8	1.2	<3.0	—	8	23.2	22.0
A2163 (A1)[7]	0.203	0.742	24.2	21.8	2.4	—	—	3	25.4	23.0
A2163 (A2)[7]	0.203	0.728	23.1	21.2	1.9	—	—	3	24.3	22.4

*Gunn r filter; [1]Soucail et al., 1987; [2]Mellier et al., 1991; [3]Pelló et al., 1991; [4]Pelló et al., 1992; [5] Ellis et al., 1991; [6]Giraud 1992, preprint; [7]Soucail G., Amaud M., Lachièze-Rey M., Mathez G., in preparation.

Highlights 1986-1998: Galaxy Redshift Surveys

The ESO-Sculptor Faint Galaxy Survey: Large-Scale Structure and Galaxy Populations at 0.1 $\lesssim$ z $\lesssim$ 0.5*

V. DE LAPPARENT, G. GALAZ, S. ARNOUTS, CNRS, Institut d'Astrophysique de Paris
S. BARDELLI, M. RAMELLA, Osservatorio Astronomico di Trieste

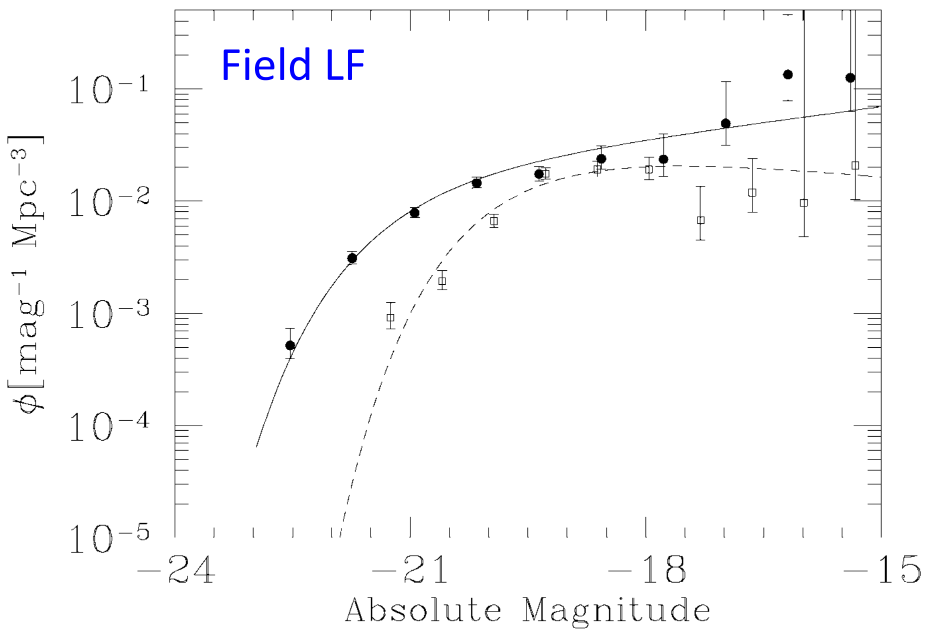
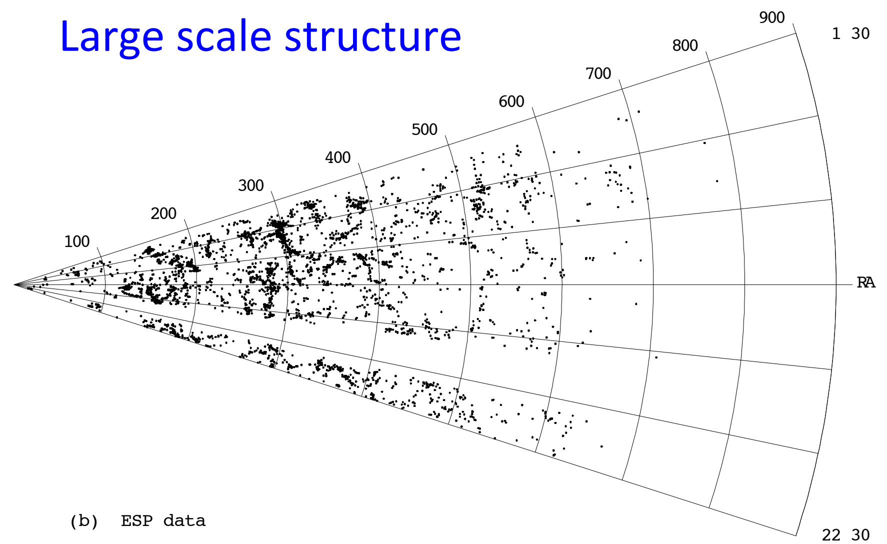


Figure 7: Luminosity functions in B (open squares) and R (filled circles) for 327 galaxies of the ESS. The best fit Schechter functions have M^*_B = −19.58 ± 0.17 α_B = −0.85 ± 0.17, and M^*_R = −21.15 ± 0.19 α_R = −1.23 ± 0.13 [32].

PROFILE OF A KEY PROGRAMME:

A Galaxy Redshift Survey in the South Galactic Pole Region

G. VETTOLANI[1], J.M. ALIMI[2], C. BALKOWSKI[2], A. BLANCHARD[2], A. CAPPI[6], V. CAYATTE[2], G. CHINCARINI[3,10], C. COLLINS[4], P. FELENBOK[2], L. GUZZO[3], D. MACCAGNI[5], H. MACGILLIVRAY[4], S. MAUROGORDATO[2], R. MERIGHI[6], M. MIGNOLI[7], D. PROUST[2], M. RAMELLA[8], R. SCARAMELLA[9], G.M. STIRPE[6], G. ZAMORANI[1], [6] and E. ZUCCA[1,7]



Various field redshift surveys were undertaken through the Key Project initiative but these had overlapping goals and were perhaps insufficiently ambitious c.f. initiatives e.g at the AAT/WHT and Las Campanas

de Lapparent et al Messenger #55 (1989) #89 (1997); Vettolani et al Messenger #67 (1992)

Highlights 1988-1996: Danish 1.5m detects first high z Type Ia SN

The discovery of a type Ia supernova at a redshift of 0.31

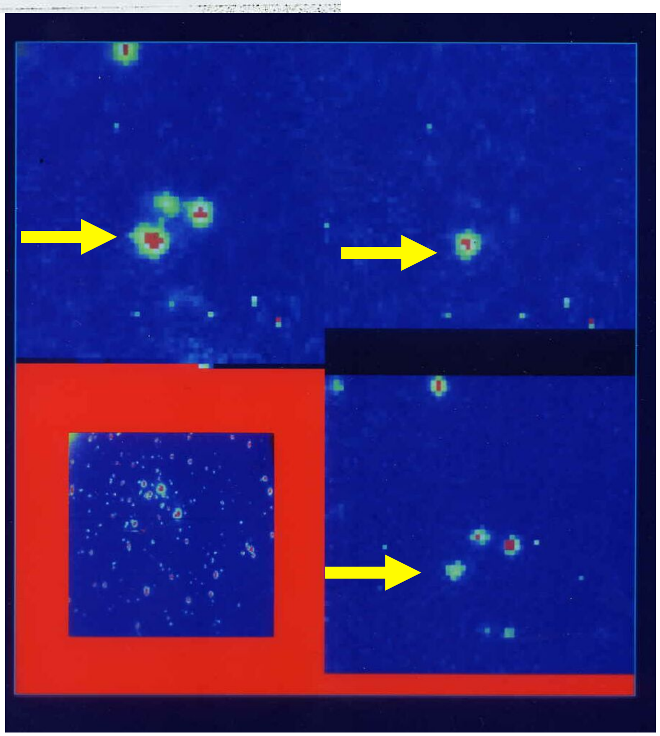
Hans U. Nørgaard-Nielsen*, Leif Hansen†, Henning E. Jørgensen†, Alfonso Aragón Salamanca‡, Richard S. Ellis‡ & Warrick J. Couch§

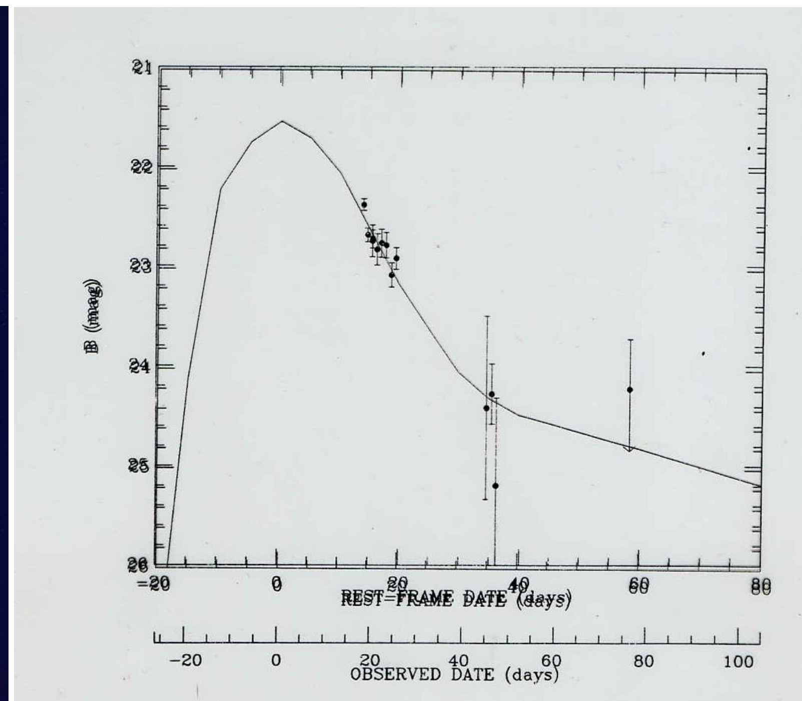
* Danish Space Research Institute, Lundtoftevej 7, DK-2800 Lyngby, Denmark
† Copenhagen University Observatory, Øster Voldgade 3, DK-1350 Copenhagen K, Denmark
‡ Physics Department, University of Durham, South Road, Durham DH1 3LE, UK
§ Anglo-Australian Observatory, Epping Laboratory, PO Box 296, Epping, New South Wales 2121, Australia

DANISH - DURHAM SN SEARCH (1986-1989)

Early recovery of z>0.3 Type Ia SN (light curve and spectrum) demonstrated feasibility of later SCP and HiZ SN campaigns with improved surveying cameras in the 1990's

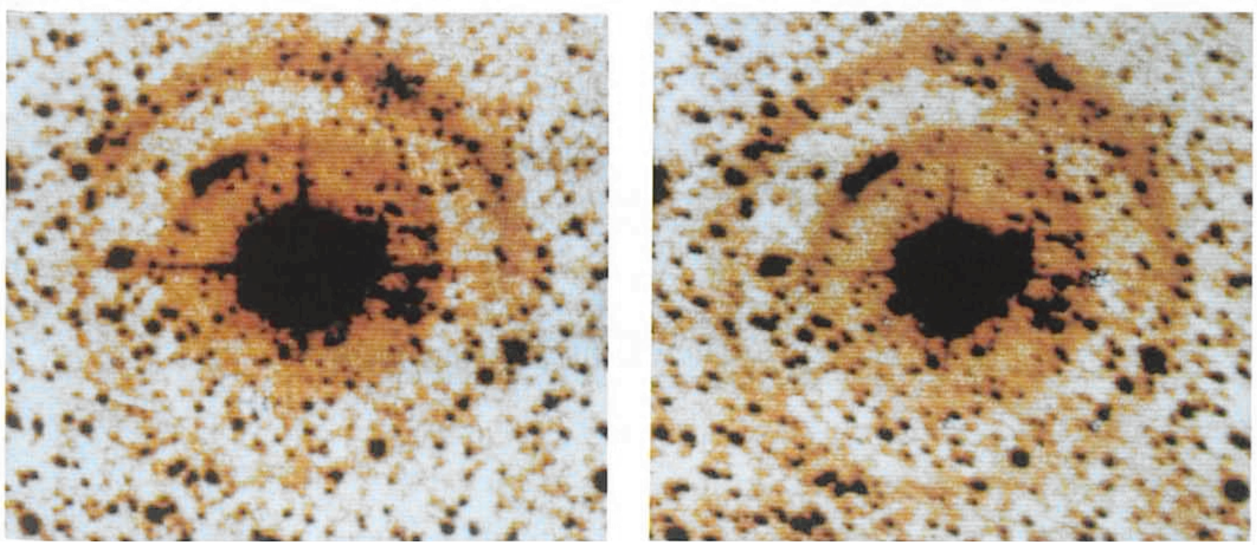
Norgaard-Nielsen et al
Nature 339, 523 (1989)



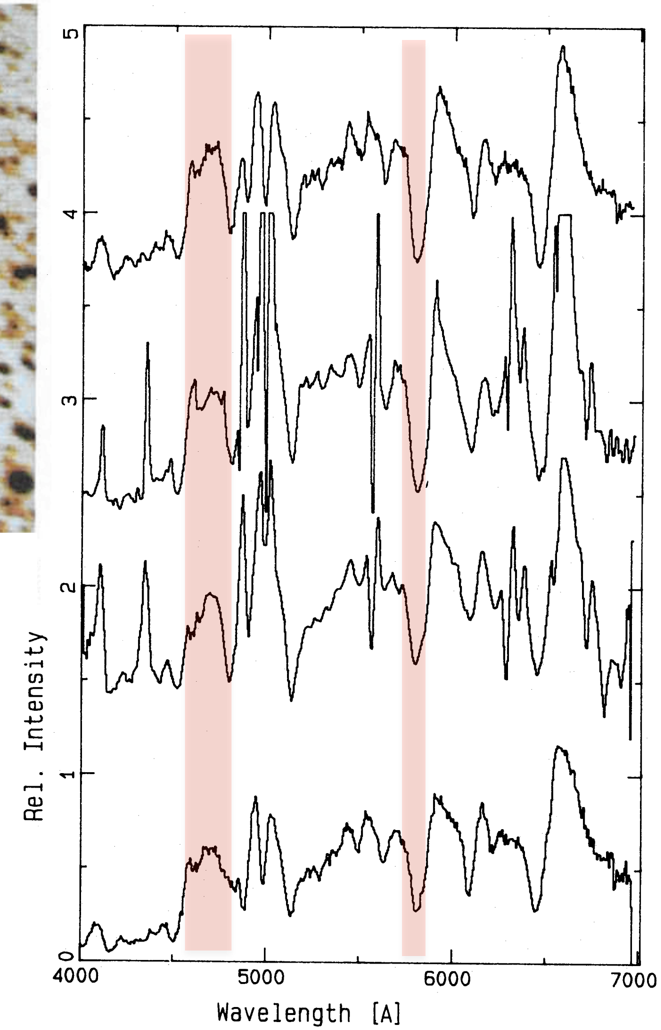


Highlights 1986-1998: Light Echos in SN 1987A

3.6m EFOSC + coronographic images



3.6m EFOSC spectra



Coronographic imaging with EFOSC reveals size and expansion rate of faint rings. The time delay from explosion plus angular scale provides distance to LMC (a method subsequently exploited with HST)

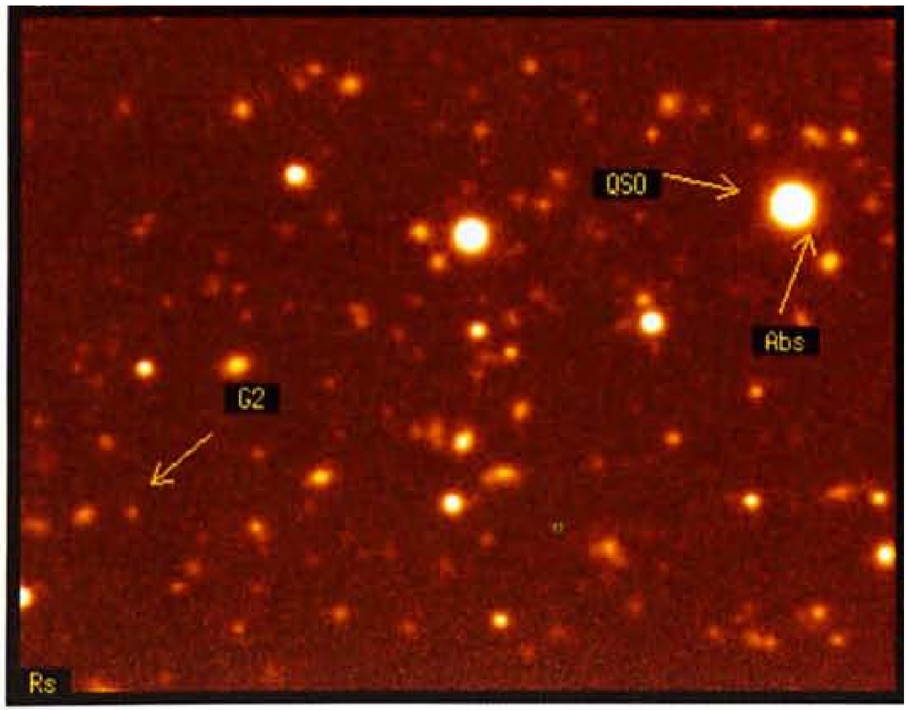
Faint spectra confirm features consistent with maximum light SNII (not scattered light from ageing SN)

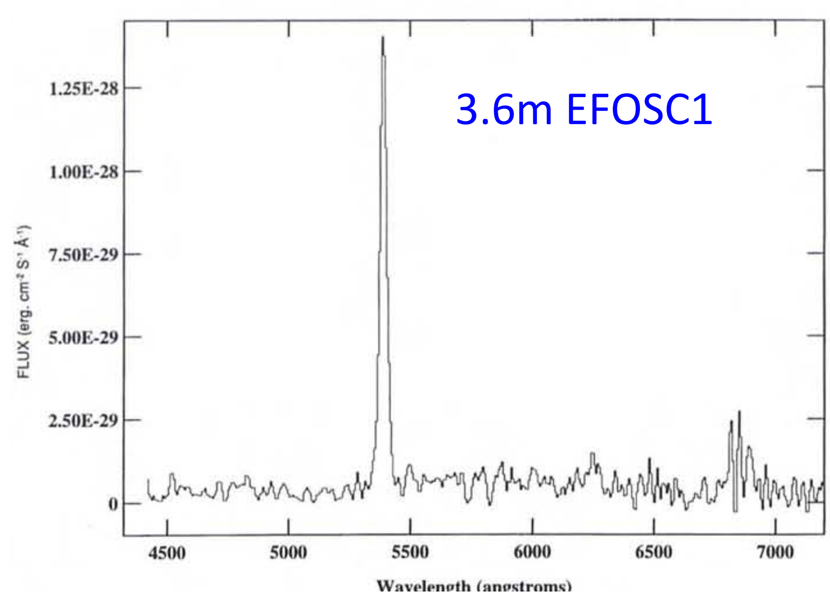
Gouiffes et al Astron. Astrophys 198, L9 (1988)

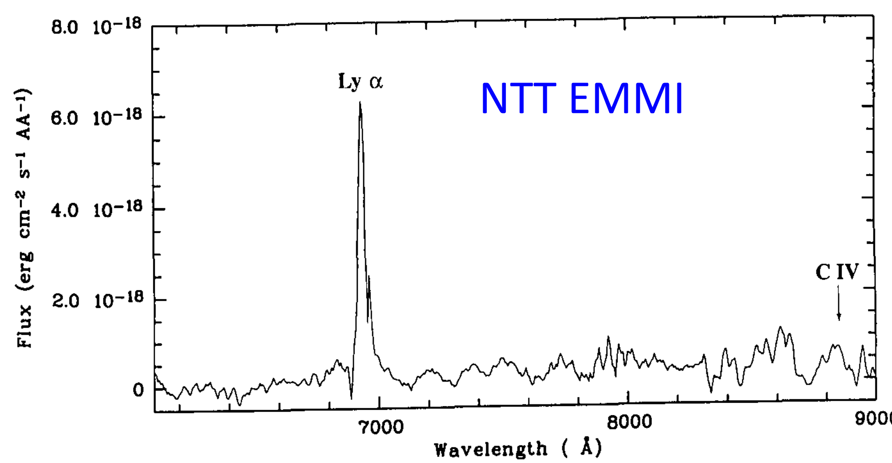
Highlights 1986-1998: Lyα galaxies at z=3.4 & 4.7

Have We Detected the Primeval Galaxies?

D. MACCHETTO[1] and M. GIAVALISCO[2], Space Telescope Science Institute



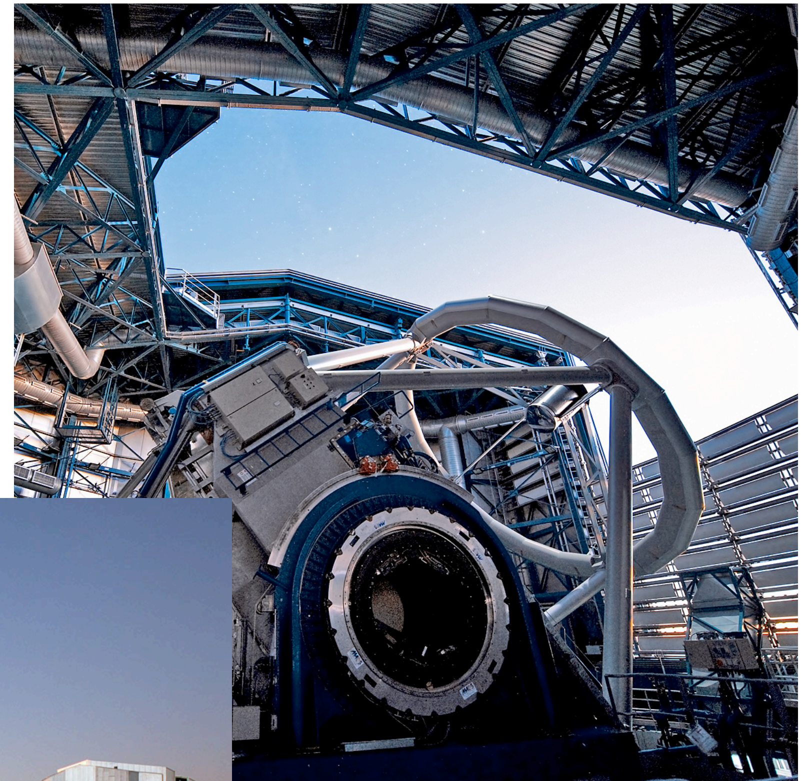




Spectra of 3<z<5 Lyα emitting galaxies close to high z QSOs demonstrated remarkable sensitivity of EFOSC and EMMI

Messenger #81 (1995), #84 (1996)

The VLT Era : 1998 - present



"10 nights on 25m VLT" (Messenger #15-18 1978-79)

Appenzeller: High resolution imaging: exoplanets, study of protoplanetary disks, resolved stellar populations in nearby galaxies

Oort: Large scale structure: which came first – galaxies or clusters? Radius of curvature of Universe, counts and colours of galaxies to V~25-26

Pecker: Chemical composition of galaxies, high time resolution studies of protostars, Galactic centre stellar motions, Galactic halo

Bertola: 2-D velocity fields of elliptical galaxies beyond Virgo, black holes and stellar content in galactic nuclei

Borgman: exploit diffraction limit in mid-IR to study Galactic centre, HII regions in nearby galaxies, consider daytime use

Housiaux: high time resolution studies of variable stars (novae etc), optimise use in partnership with space-based observatories

Mezger: use at sub-mm wavelengths to study pre-MS stars, giant molecular clouds, redshifted dust from primeval galaxies

VLT Science Case March 1997

- Evolution of galaxies from z = 0.6 to z = 4.3
- Testing the redshift evolution of potential wells and scaling relations of galaxies
- The evolution of cluster galaxies
- A search for binaries in globular cluster cores
- High redshift radio galaxies:
  - (a) Their stellar content and surrounding clusters
  - (b) Gas kinematics and jet/cloud interactions
  - (c) Imaging- and spectro-polarimetry to identify and separate the scattered component
  - (d) UV nebular diagnostics of the extended gas
  - (e) Absorption studies of Lyα and C IV as probes of the circumnuclear gas particularly the cold component
- Distant cluster of galaxies
- Measuring Ω with weak gravitational lensing
- Dark matter searches with weak gravitational lensing from a drift-scan image
- Measuring Ω_Λ from (weak and strong) lensing modelling of rich clusters
- The star formation history of ultra-low surface-brightness galaxies
- Extending extragalactic PN as probes of galaxies out to 50 Mpc
- Astronomy of isolated neutron stars
- Spectroscopy and photometry of very distant supernovae
- Chemical evolution and star formation history in nearby galaxies
- A complete sample of 1000 active galactic nuclei to $R = 23.5$
- Dynamics of the Carina dwarf spheroidal galaxy
- Properties of compact emission line galaxies up to $z = 1.2$: velocity dispersions and emission line ratios
- Chemical abundances of stars in globular clusters
- Physics of main-sequence and slightly evolved stars in young open clusters
- RR Lyrae stars in the LMC: tracers of the structure and the metallicity of the old population
- The galaxy population in the redshift interval $0.5 < z < 5$
- Redshift evolution of chemical abundances in damped Lyman-α system
- Dynamics of galaxies at the VLT with FUEGOS/ARGUS
- Optical identification of gamma-ray burst sources

Time and again, history shows large telescopes achieve far more than their original science cases!

[Same was true of Keck c.f. its original `Blue Book' (1985)]

Renzini & Leibundgut Messenger #87

The VLT Era : 1998 - present

Technical Success:

- Realization of an ambitious goal first considered in 1978
- Progress like clockwork:
  VLT approval 1988
  UT1 May 1998, UT2 Mar 1999, UT3 Sep 1999, UT4 Sep 2000, VLTI Mar 2001
- VLT contractual cost rose 15% from 1987 to 1998; total cost including VLTI unchanged (~1.0BDM to 2003)
- 4 × 8ms with aux telescopes offers remarkable flexibility plus VLTI capability

Strategic advantages:

- Engagement with industry established new *modus operandi*
- Successful instrument model involving ESO and partner countries
- Instruments on time: UT1 May 16 and FORS1 Sep 15, ISAAC Nov 16 (1998)

Science readiness:

- Project had strong in-house science focus
- Numerous planning workshops and meetings: technical and scientific
- Preparatory imaging surveys (EIS, WFI @ 2.2m, VST..VISTA)

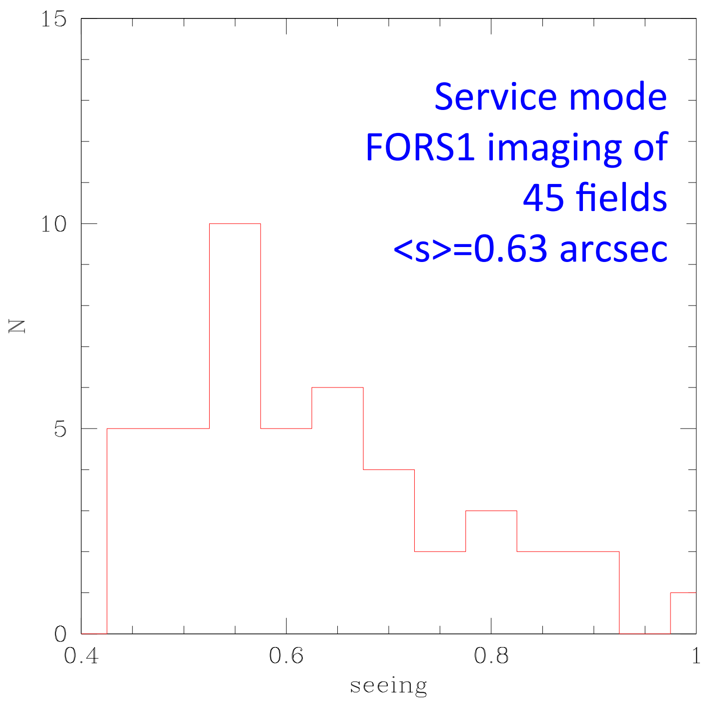
Science output:

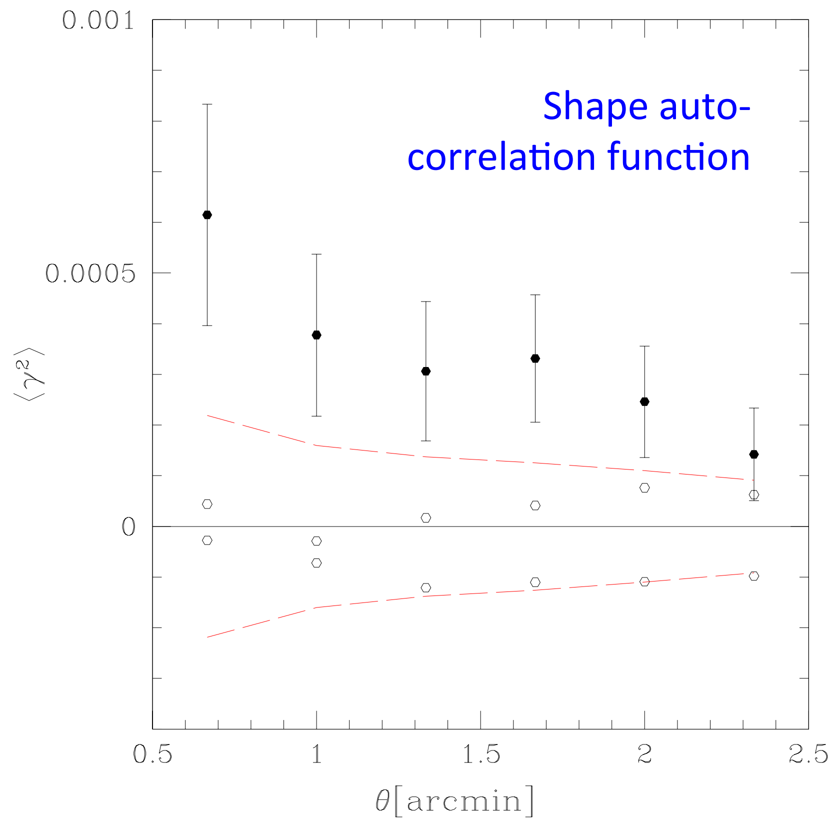
- Dramatic impact, particularly through generous Guaranteed Time awards
- Citations now confirm world-leading impact

VLT Highlights: Cosmic Shear

Cosmic Shear Analysis in 50 Uncorrelated VLT Fields. Implications for Ω_0, σ_8 *

R. Maoli[1,2,3] L. Van Waerbeke[1,4], Y. Mellier[1,2], P. Schneider[5], B. Jain[6], F. Bernardeau[7], T. Erben[8,1,2], B. Fort[1]





Convincing detection of weak lensing by large scale structure confirmed low DM density (independently of dynamics) and paved the way for a new method to study DE

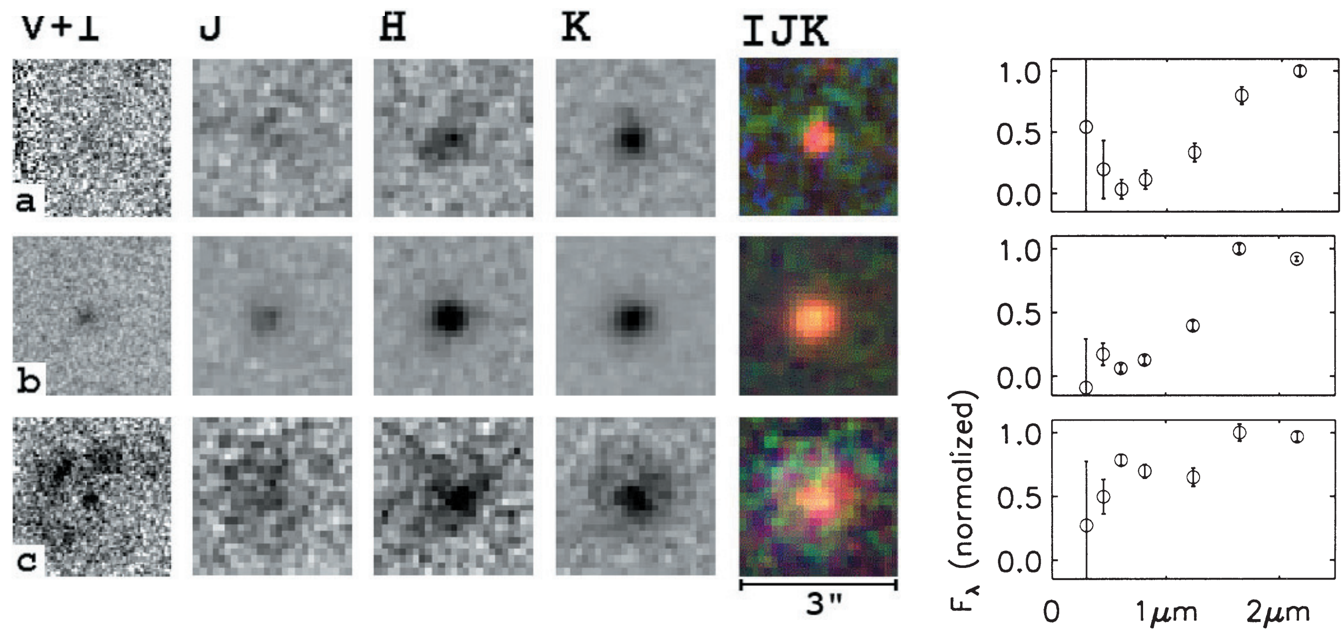
Maoli et al Astron. Astrophys. 368, 766 (2000)

VLT Highlights: Quiescent Galaxies at z~2

FIRES: Ultradeep Near-Infrared Imaging with ISAAC of the Hubble Deep Field South

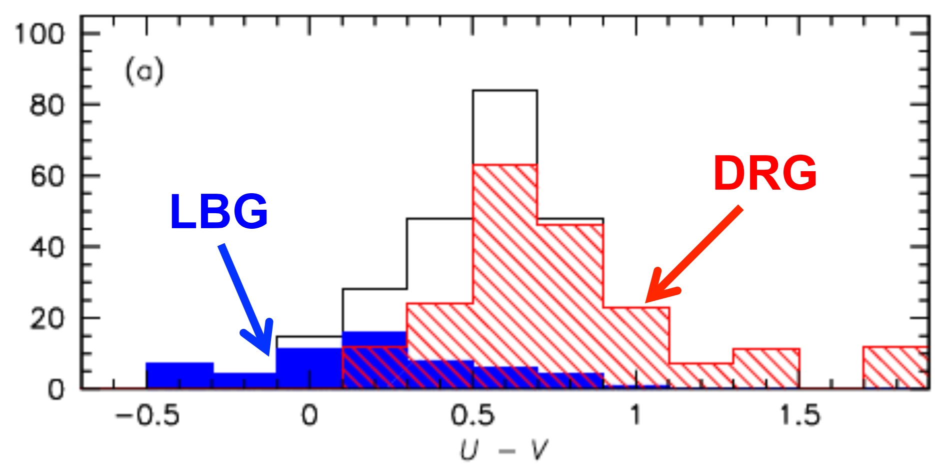
I. LABBÉ[1], M. FRANX[1], E. DADDI[3], G. RUDNICK[2], P.G. VAN DOKKUM[4], A. MOORWOOD[3], N.M. FÖRSTER SCHREIBER[1], H.-W. RIX[5], P. VAN DER WERF[1], H. RÖTTGERING[1], L. VAN STARKENBURG[1], A. VAN DE WEL[1], I. TRUJILLO[5], and K. KUIJKEN[1]

Ultradeep imaging with ISAAC located galaxies with J-K>2.3 undetected in deep HST imaging



A population of massive galaxies as important as Lyman break population

N~300g with M > $10^{11} M_\odot$ in 400 arcmin^2 ≳
DRGs comprise 77%, LBGs only 17%

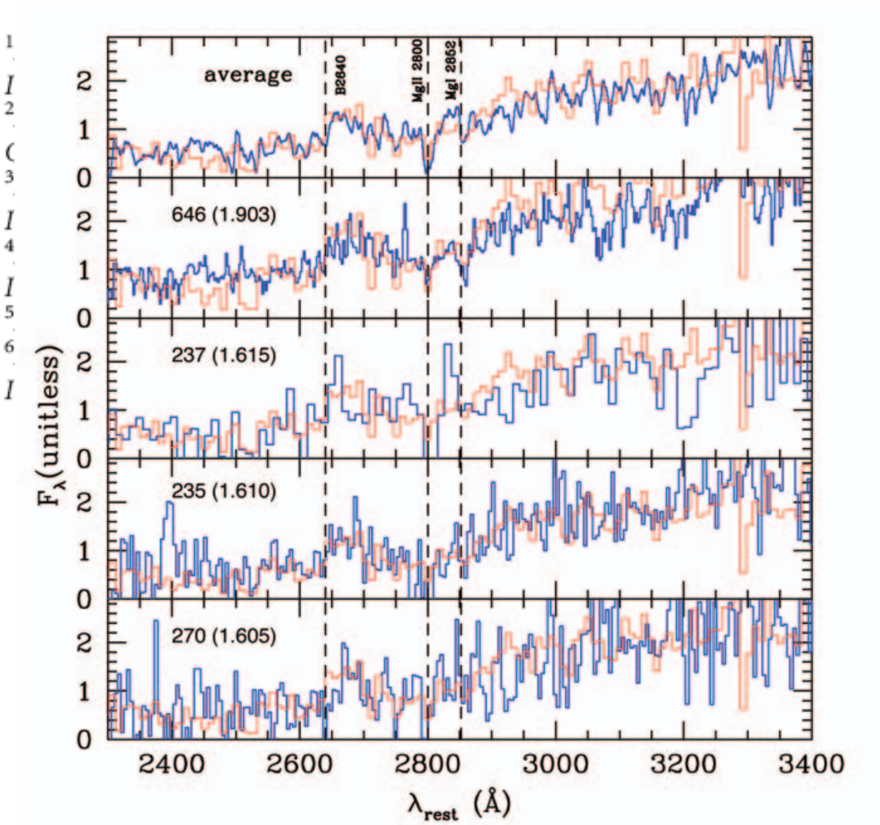


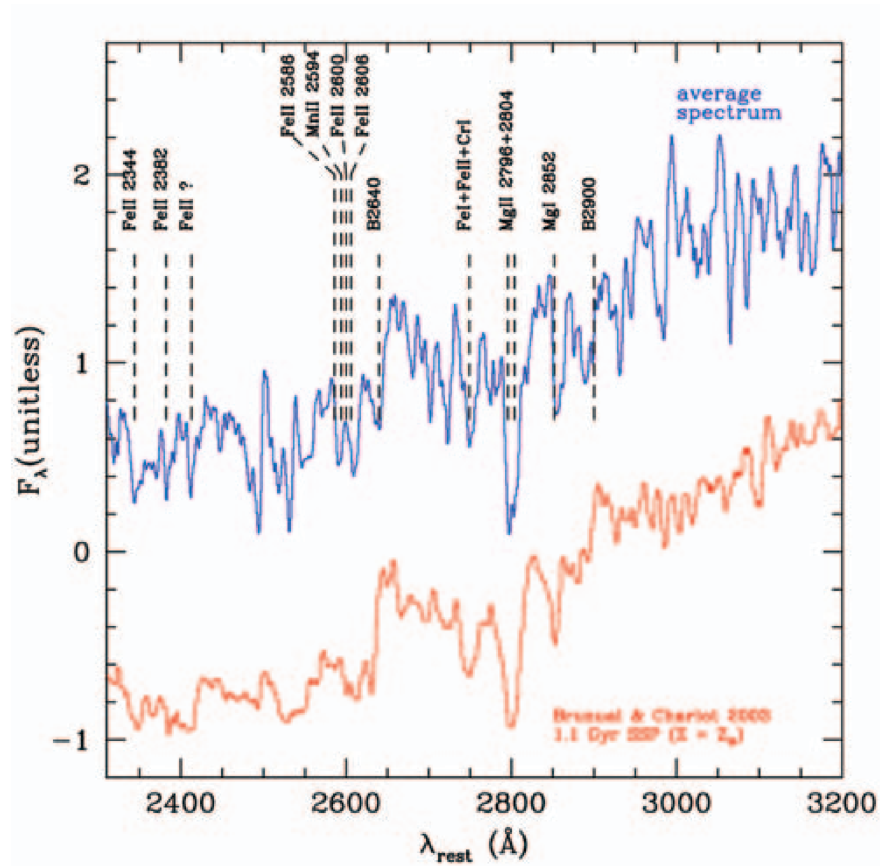
Franx et al Ap J 587, L79(2003)

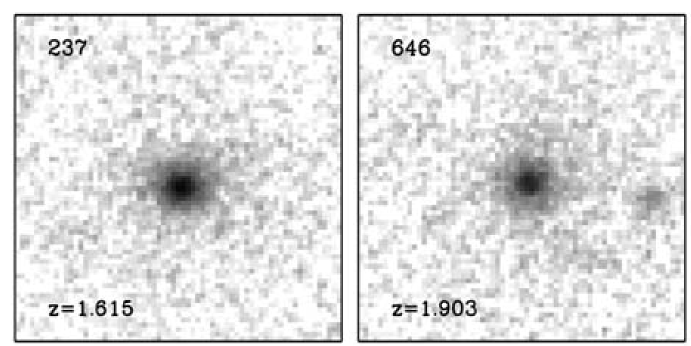
VLT Highlights: Quiescent Galaxies at z~2 cont.

Old galaxies in the young Universe

A. Cimatti[1], E. Daddi[2], A. Renzini[2], P. Cassata[3], E. Vanzella[3], L. Pozzetti[4], S. Cristiani[5], A. Fontana[6], G. Rodighiero[3], M. Mignoli[4] & G. Zamorani[4]





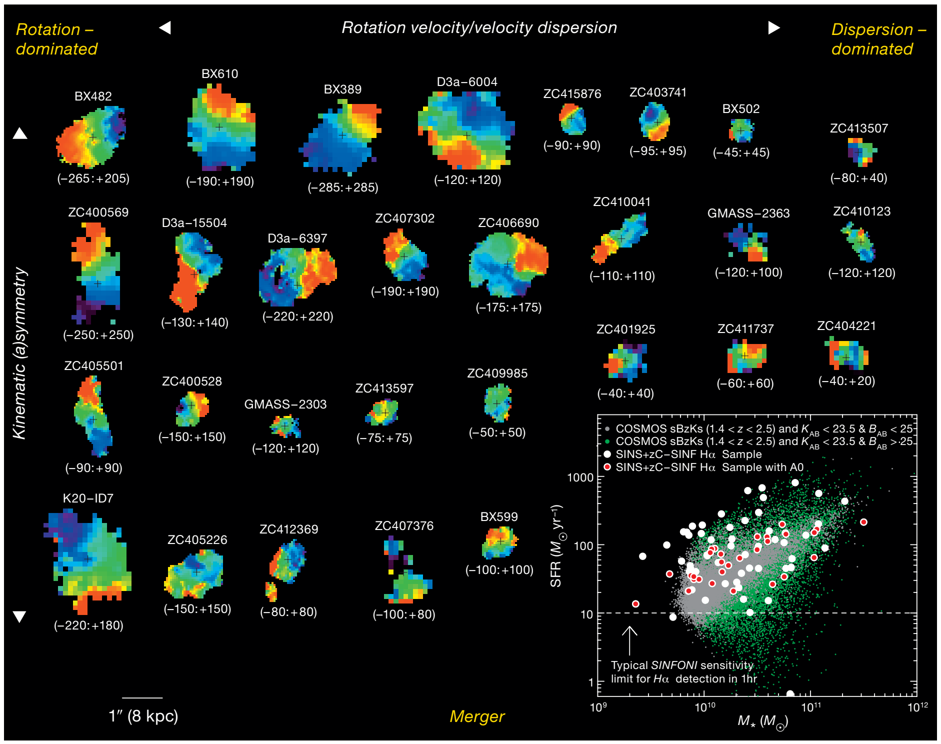


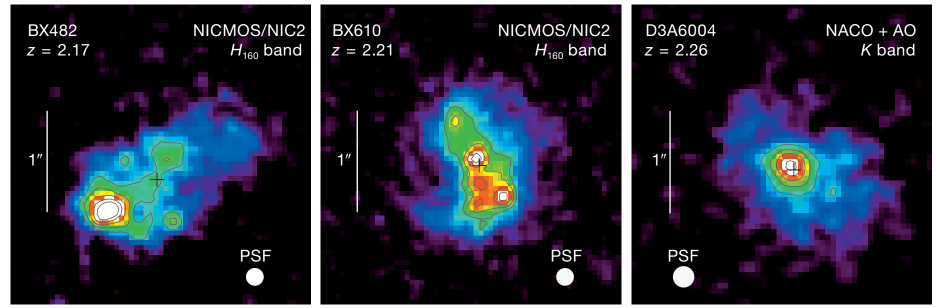
Detailed FORS1/2 spectra confirm established stellar populations in massive spheroidals at z~2

Cimatti et al Nature 430, 184 (2004)

VLT Highlights: Assembly History of Disk Galaxies

The SINS and zC-SINF Surveys: The Growth of Massive Galaxies at $z \sim 2$ through Detailed Kinematics and Star Formation with SINFONI





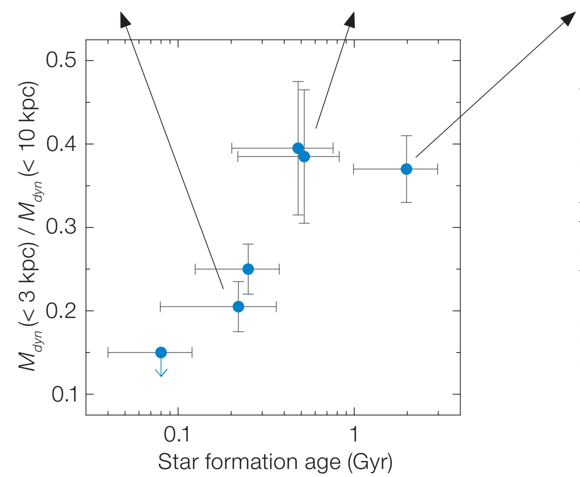
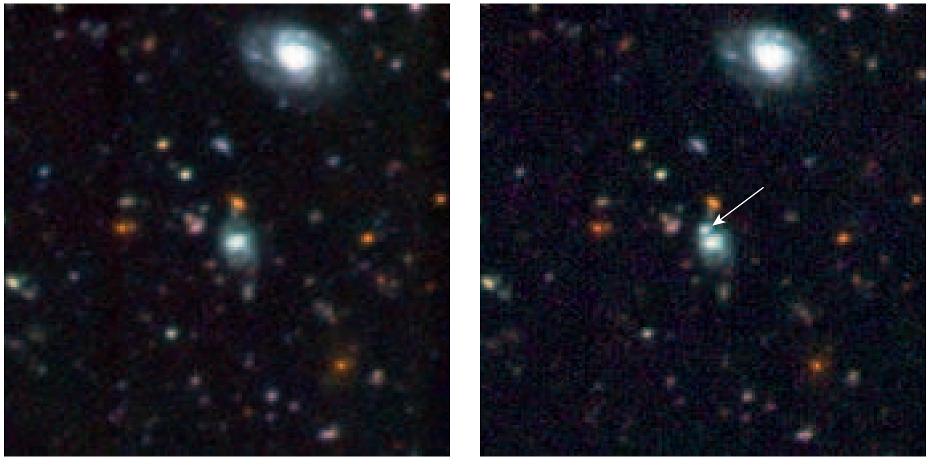


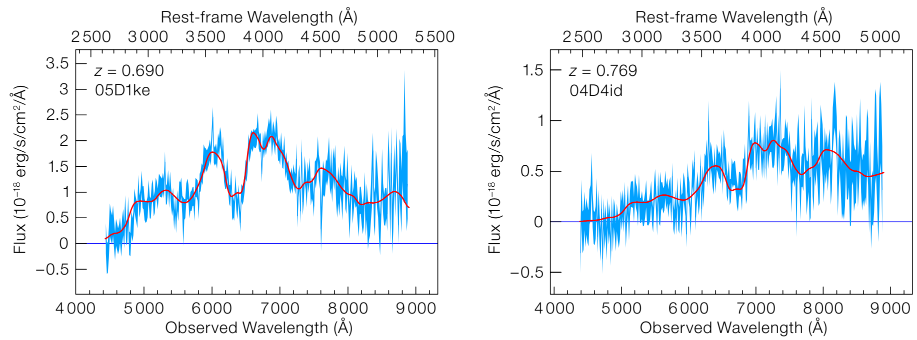
Figure 2. Trend of increasing central mass concentration (ratio of dynamical mass within a radius of 3 kpc and 10 kpc) with stellar age among six $z \sim 2$ gas-rich turbulent SINS discs (adapted from Genzel et al., 2008). The rest-optical morphologies at ~ 1.5 kpc resolution for three of the discs (upper) illustrate the evolutionary sequence: prominent clumps out to large radii at early stages and a progressively more concentrated distribution as clumps migrate inward and ultimately merge into a young bulge.

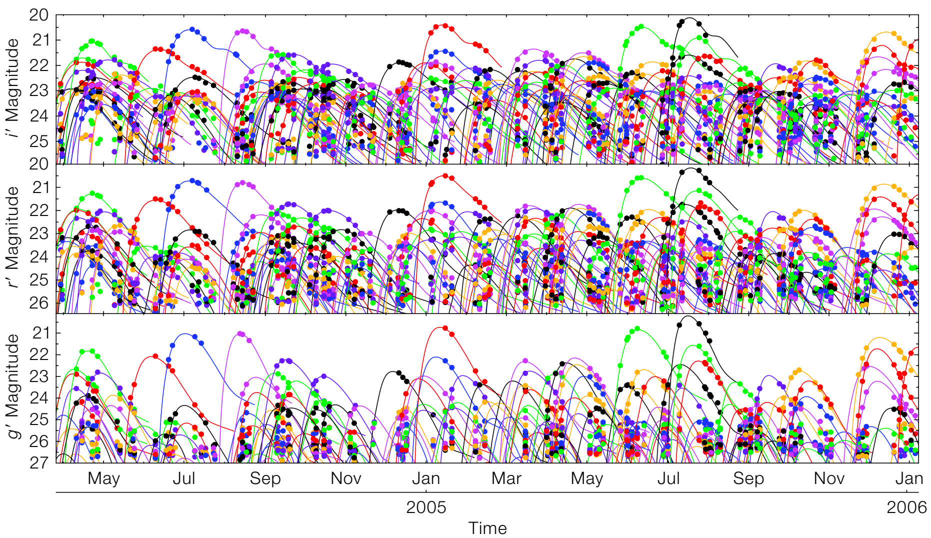
Resolved kinematics of > 100 z~2 galaxies demonstrates correlations between age of SF and central concentration implying fragmentation of primitive disks and bulge formation

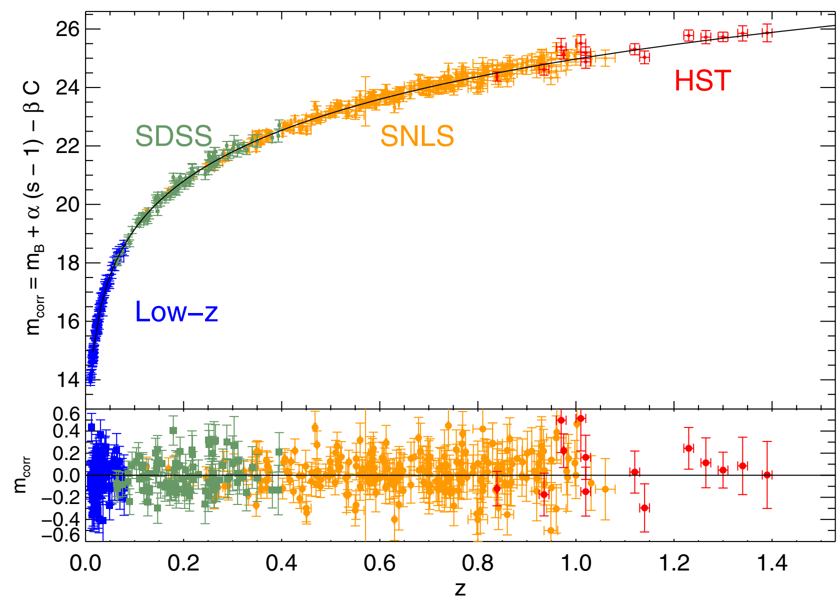
Förster-Schreiber et al Messenger #145 (2011)

VLT Highlights: Nature of Dark Energy









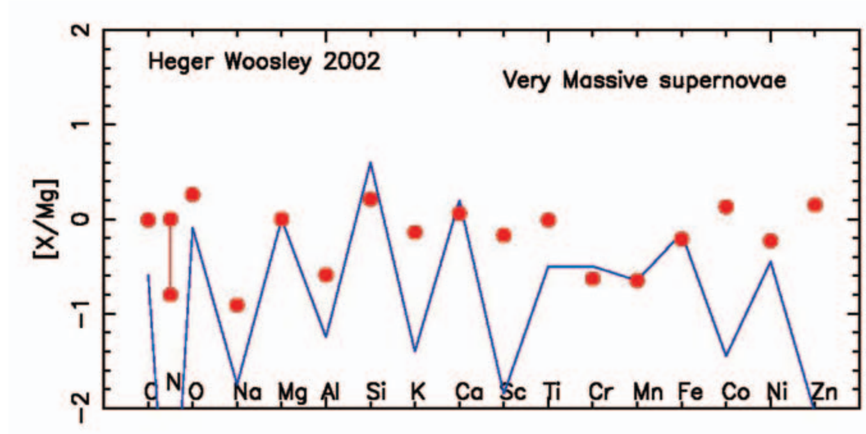
VLT ToO spectroscopy of CFHT SNe Ia provides most accurate measure of expansion history

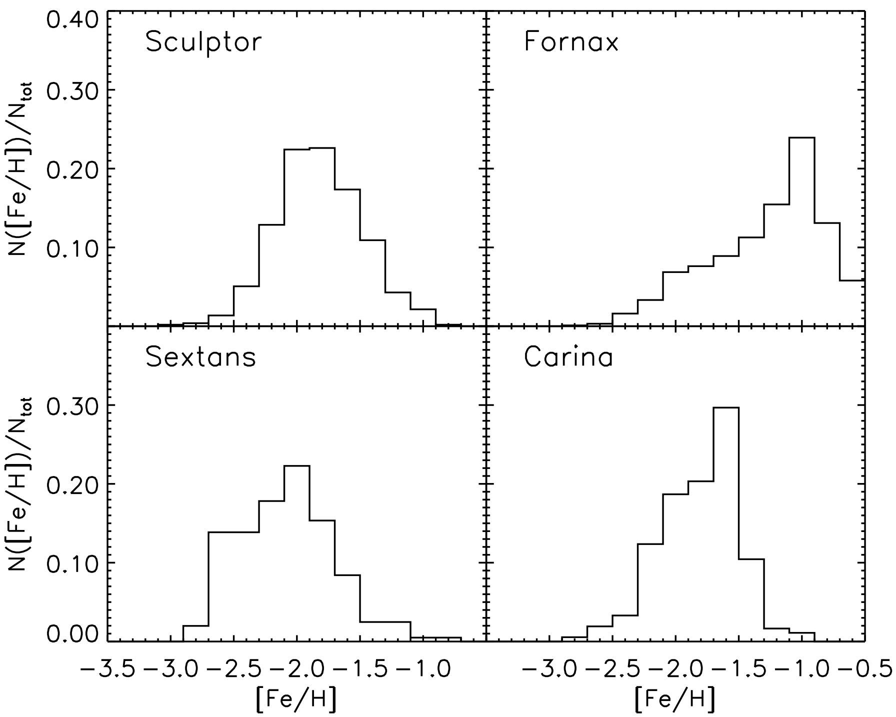
Conley et al Ap J Supp 192, 1 (2011); Sullivan et al Ap J 737, 102 (2011)

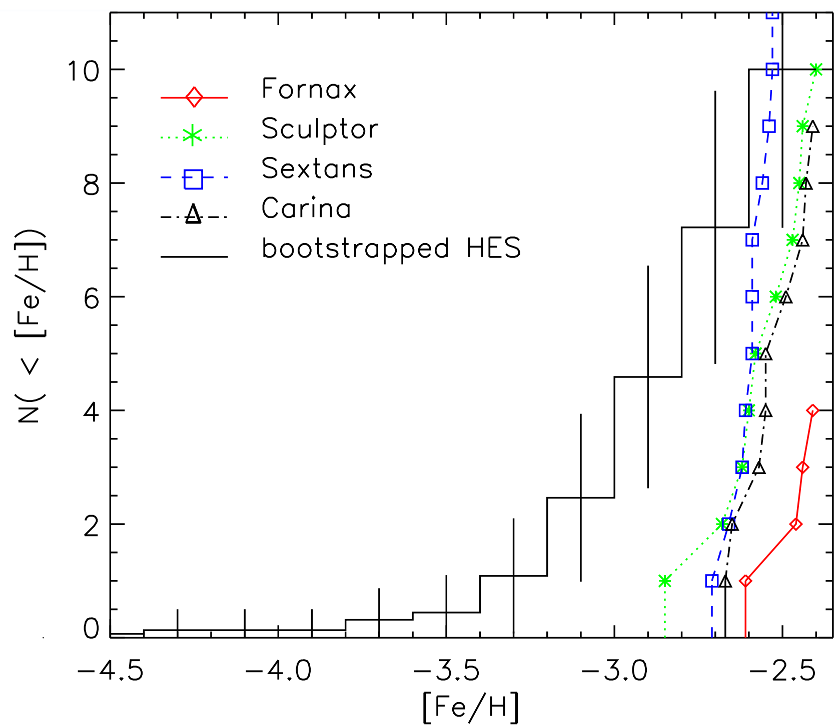
VLT Highlights: Metal Poor Stars in LG

UVES studies of XMP Galactic halo stars challenges idea of enrichment from pair-instability SNe.

FLAMES reveals <u>deficit of XMP</u> stars in LG dSphs suggesting they were enriched prior to mergers with the Galactic halo







Cayrel & Spite Messenger #118 (2004); Helmi et al (2006) Ap J651, L121

ESO and World Supremacy?

The dramatic progress in the successes of ESO has been recognised by all astronomers

The days of being `Keck'd' are long over!

However, across the Atlantic, we detect a tone of occasional superiority in many ESO articles:

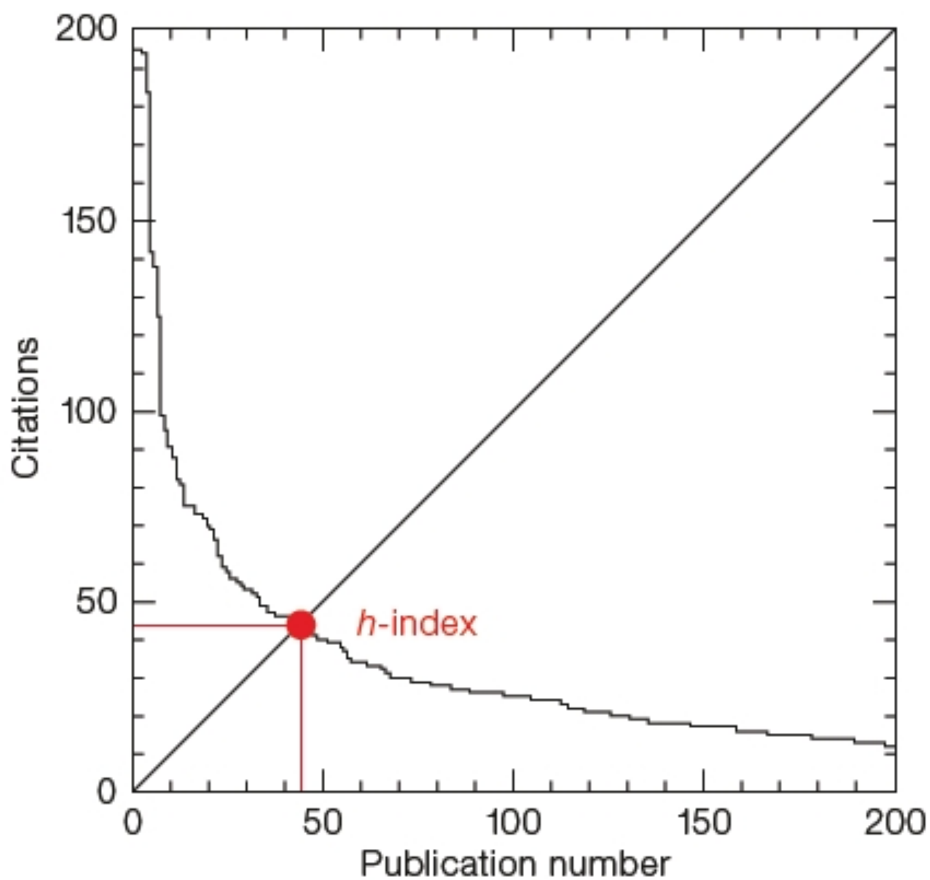
- "the most successful ground-based observatory" (Annual Report)
- "The Perfect Machine" (de Zeeuw, Messenger #132, 2008)
- "making Americans green with envy" (first light of an instrument)

So let's take a (light hearted!) look at the situation…

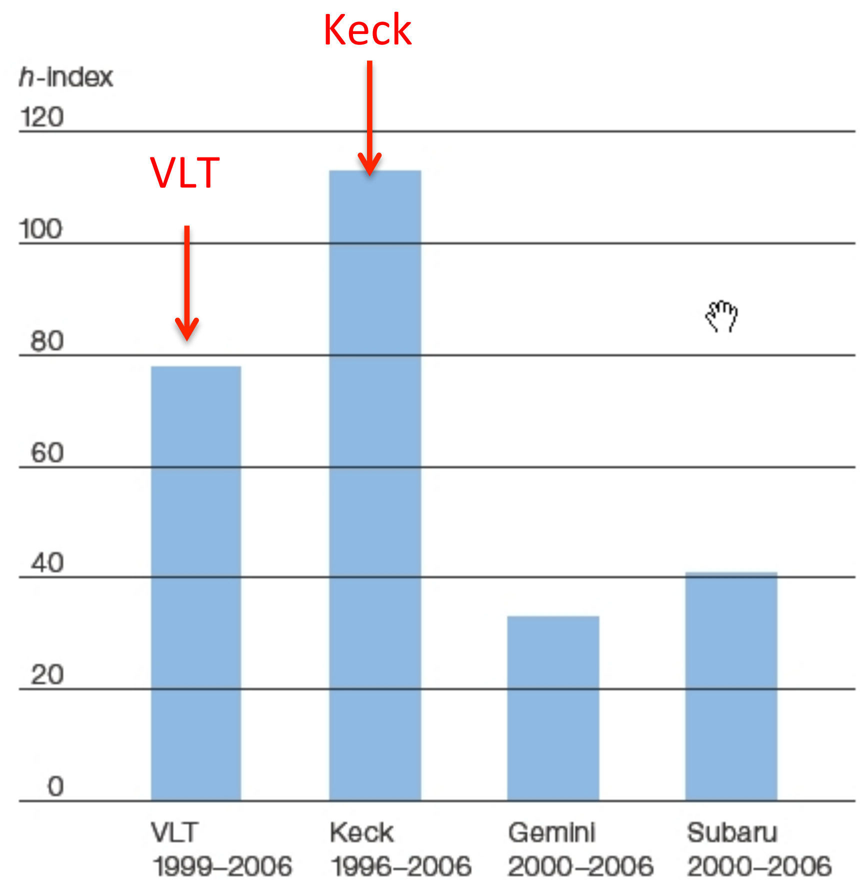
h - index of 8-10m Class Telescopes

The *h*-index is now a well-used statistic for individual researchers and so could be utilised to gauge the output of an observatory

h represents the number of publications with a citation rate ≥ *h*



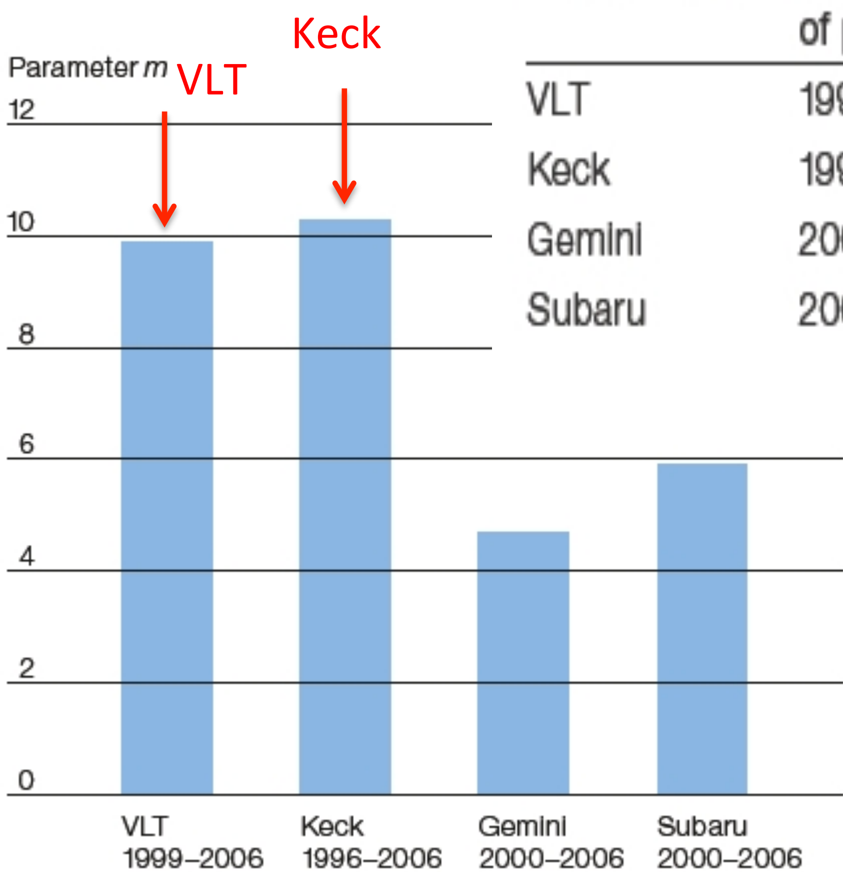
Hirsh Proc. NAS 102, 16569 (2005)



Grothkopf et al Messenger #128 (2007)

m - index:
(taking into account operational years)

Observatory	Range of years of publications	Years since first publication	*h*	*m*
VLT	1999–2006	8	79	9.9
Keck	1996–2005	11	113	10.3
Gemini	2000–2006	7	33	4.7
Subaru	2000–2006	7	41	5.9



Grothkopf et al. 2007

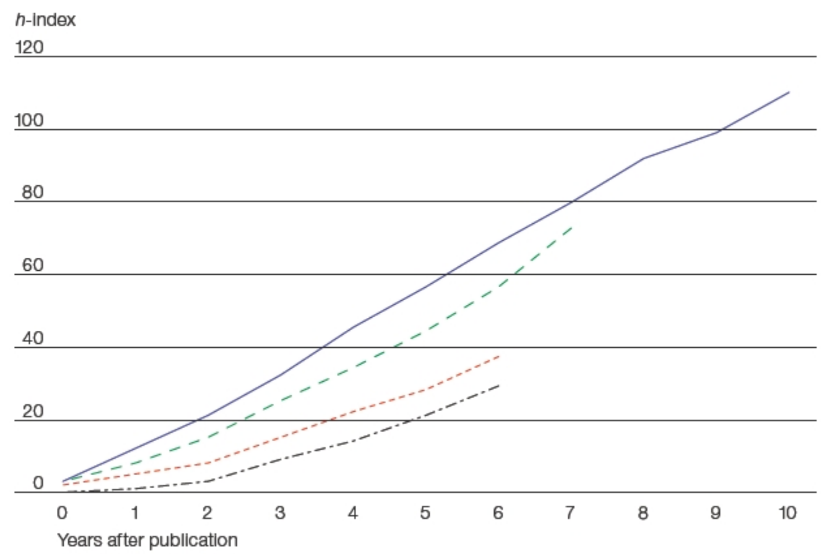
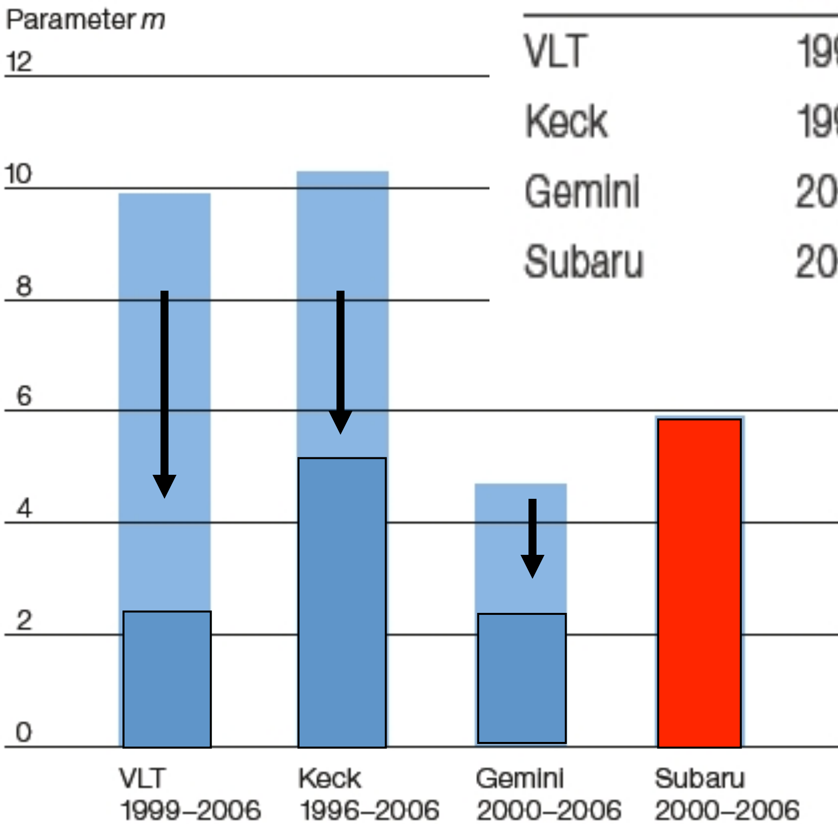


Figure 4: *h(t)* of Keck, VLT, Subaru and Gemini by years after first publication (as of April 2007).

i - index:
taking account of number of telescopes

Observatory	Range of years of publications	Years since first publication	*h*	*m*	*i*
VLT	1999–2006	8	79	9.9	2. 5
Keck	1996–2005	11	113	10.3	5. 2
Gemini	2000–2006	7	33	4.7	2. 4
Subaru	2000–2006	7	41	5.9	5. 9

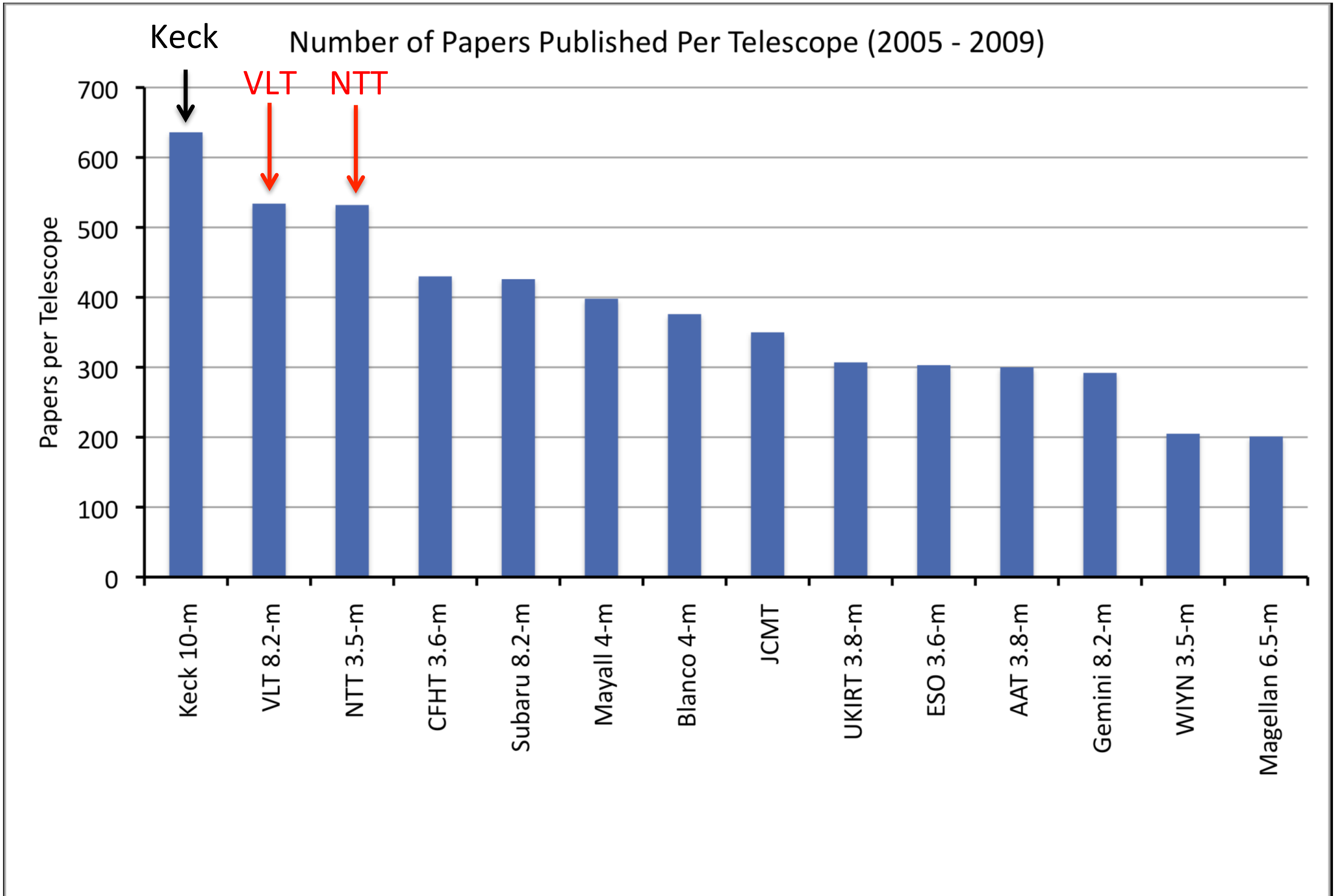


Simple division by the number of telescopes used (Iye 2007a)

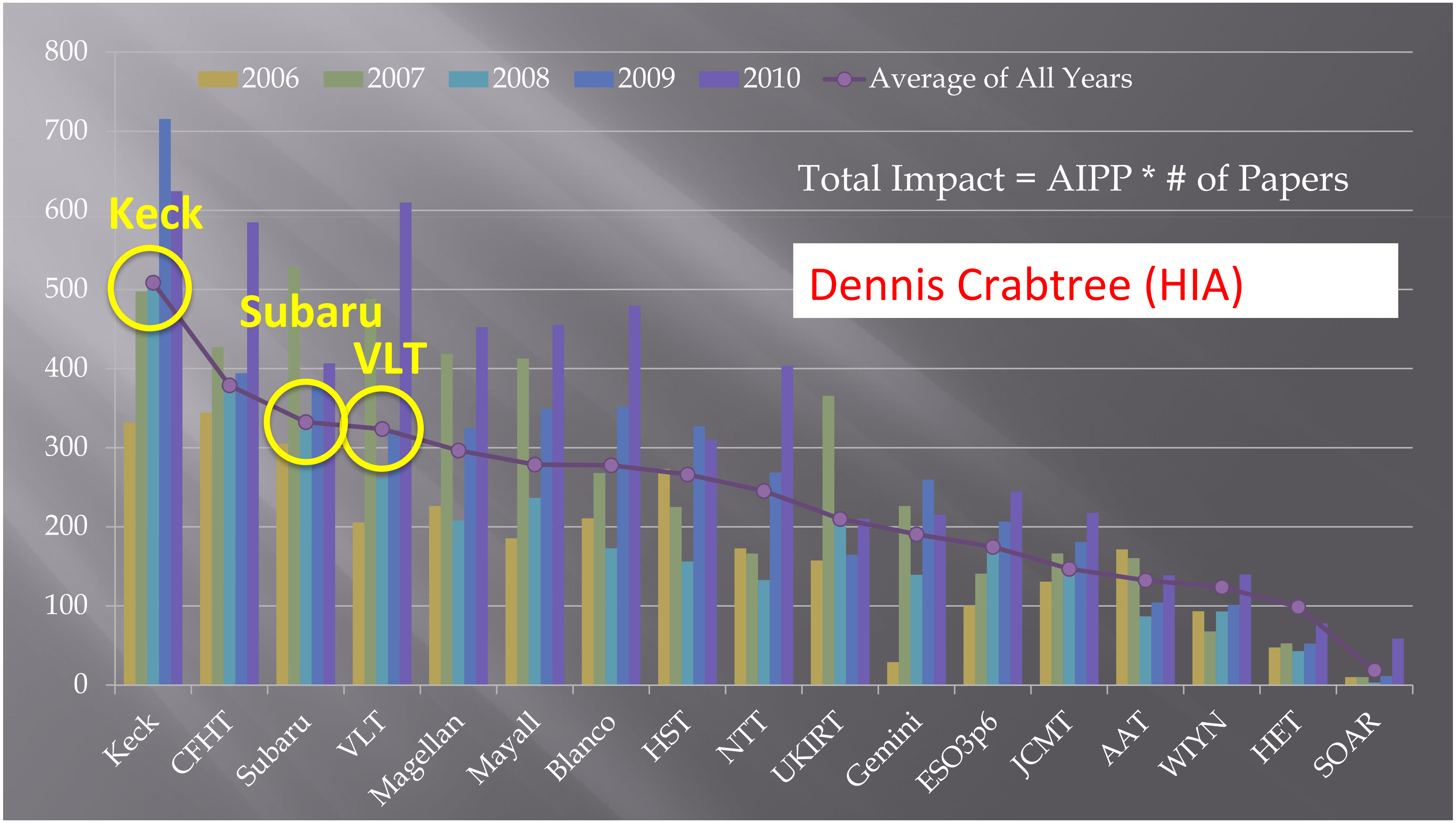
Subaru rules!

Courtesy of Masanori Iye

Refereed Papers per Telescope (2005-2009)



Total Impact per Telescope (2006-July 2012)



Impact = citation count of a paper ÷ average citation of a AJ paper published the same year
AIPP = average impact per paper from the observatory

Global Astronomy – Some Observations

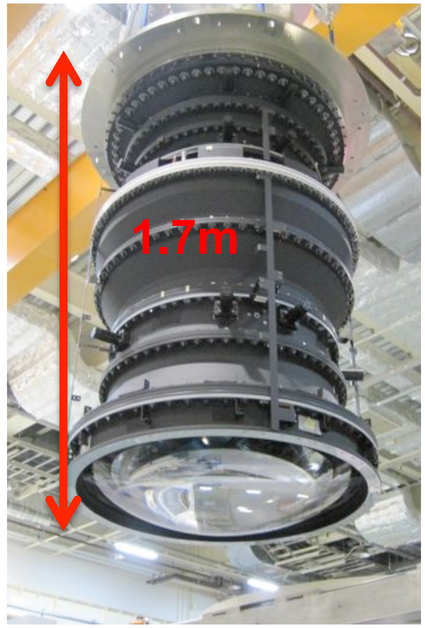
- VLT, Keck and Subaru are clearly each remarkably successful
- The growth in VLT's science output is the largest over the past decade
- VLT has the fullest complement of impressive instruments and is unrivalled in interferometric applications
- Large observing allocations (including Guaranteed Time for instrument builders) have played a key role in ESO's recent success

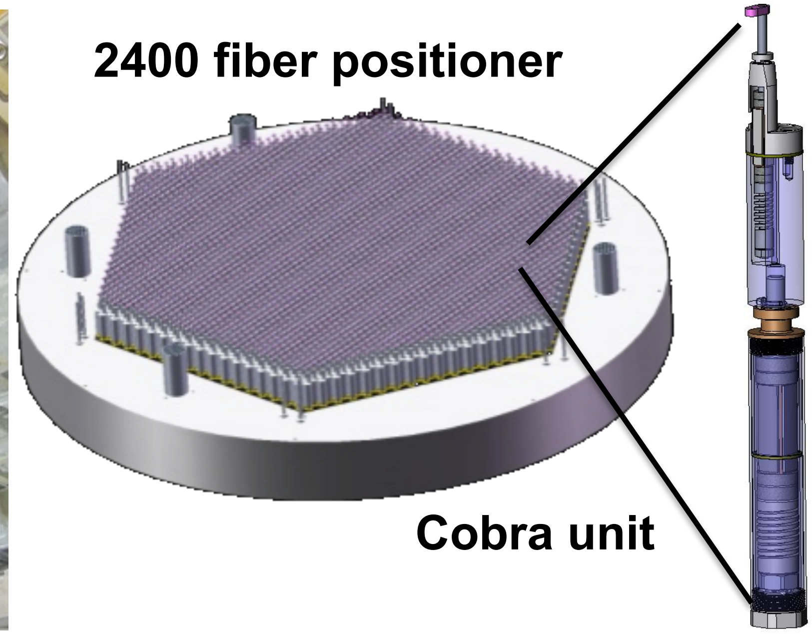
But there are complementary strengths elsewhere:

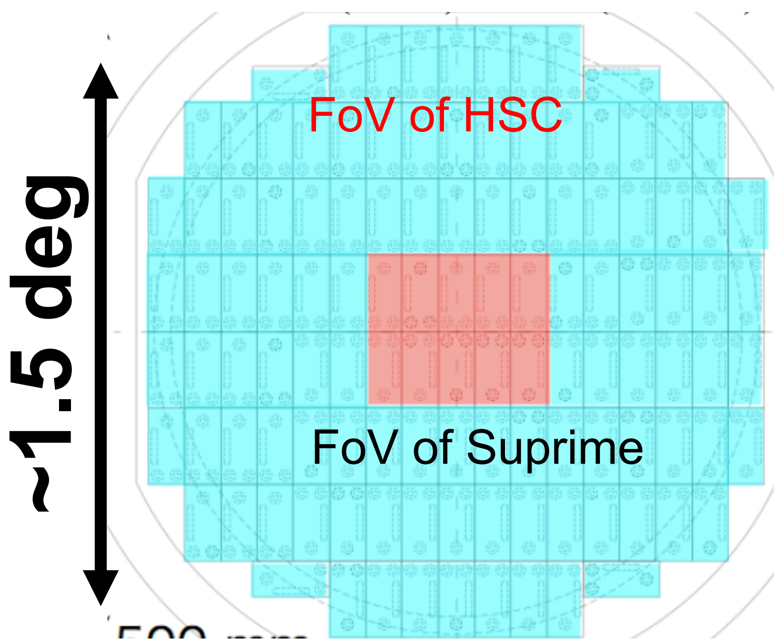
- Keck users have creatively exploited the flexibility they have with their observing time to undertake timely and ambitious science programs
- The Subaru community has been very effective in wide-field applications

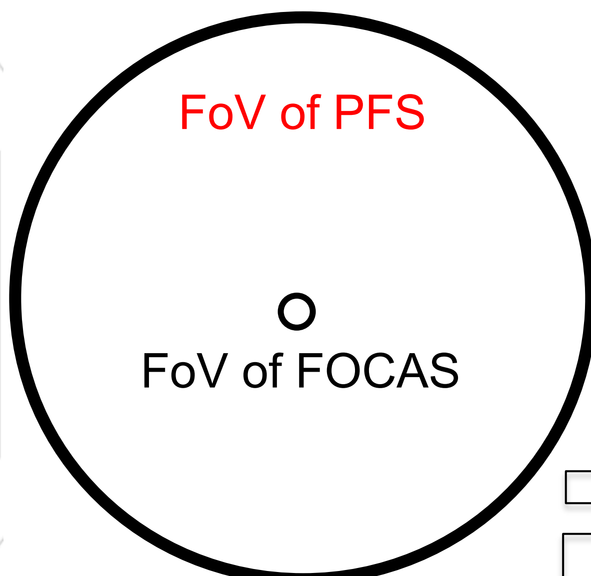
This complementarity will continue given the way in which these observatories are run and instrumented

Subaru Wide Field Instrumentation

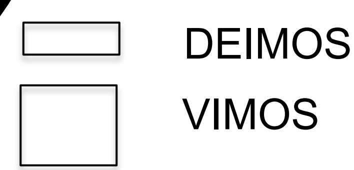






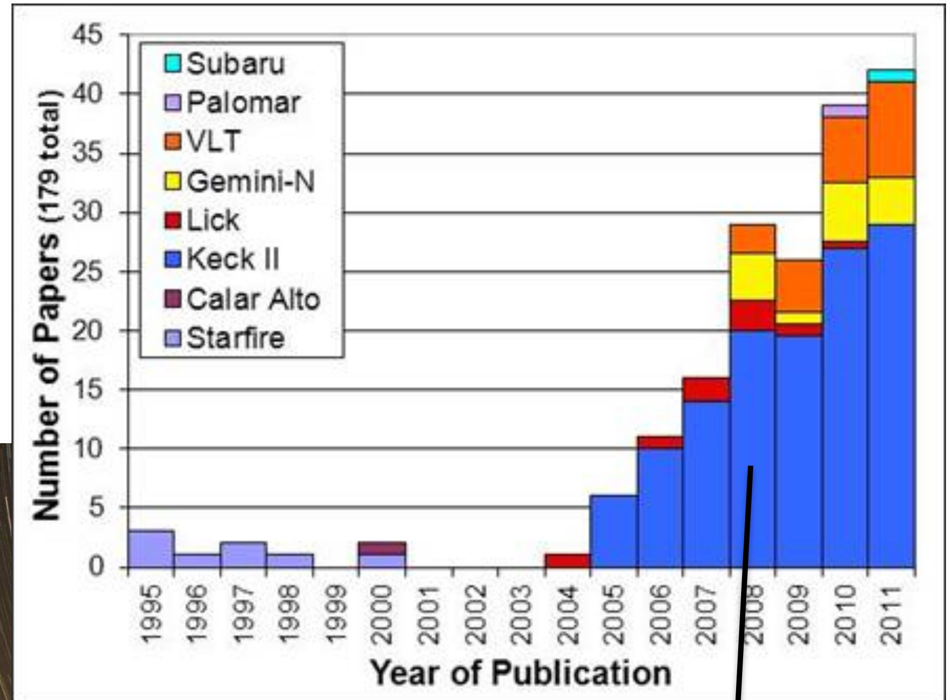


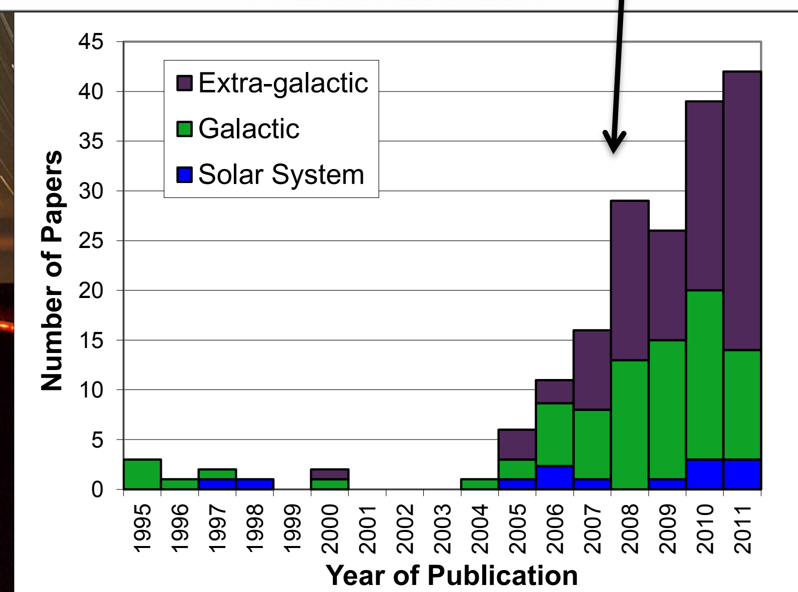
Subaru's HSC/PFS combination promises great progress in large scale structure, Lyα mapping and Local Group chemistry and kinematics



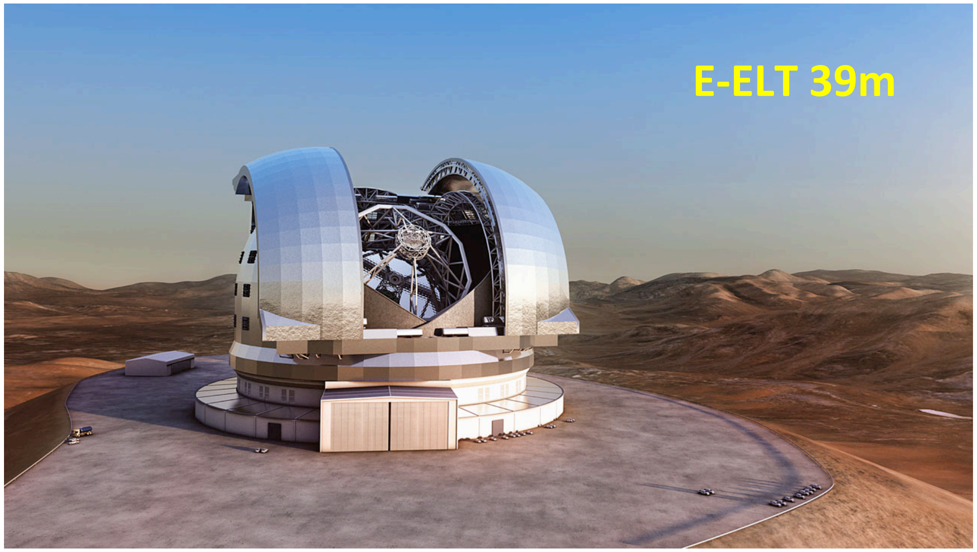
Laser Guide Star Adaptive Optics

Keck has invested heavily in a common-user Laser Guide Star system with OSIRIS (IFU s/g) and NIRC2 (imager) which has greatly accelerated interest from extragalactic users





The Future

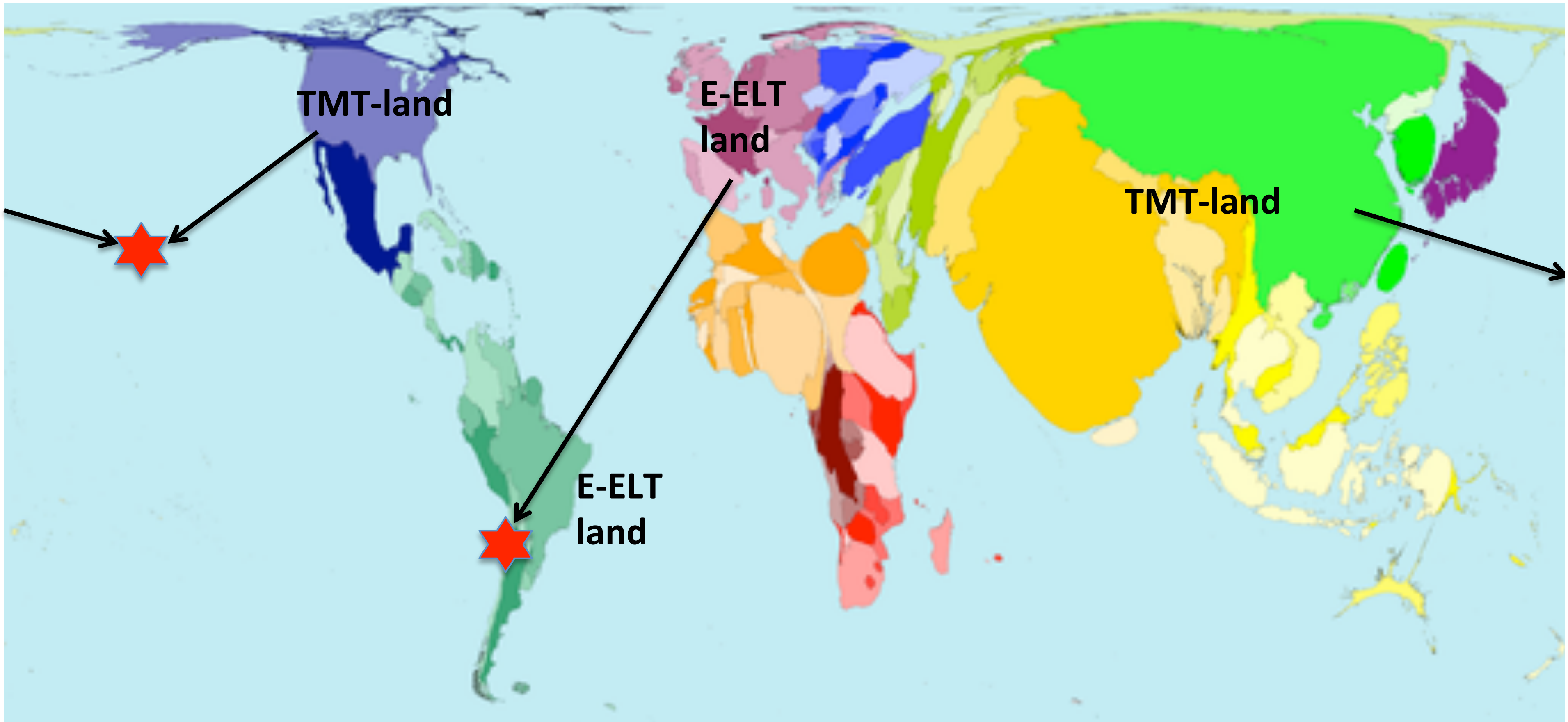


TMT and E-ELT have much in common:

- technically strong design efforts motivated by mature scientific communities
- finely segmented primaries with fast f/ratios
- emphasis on diffraction limited performance through adaptive optics
- well-characterised sites with nearby infrastructure

Both deserve to succeed and much can be learned by sharing technical solutions and cooperating scientifically ; fortunately there are good relations between both projects

The World in 2020



TMT has transformed in ten years from being the traditional "Caltech-UC competitor" to ESO into a new challenge – a global facility incorporating several emerging nations (China/India)

Although TMT and its Mauna Kea facilities will never be a "treaty organization" much can be learned from ESO's progress over the past 50 years

Happy Fiftieth Anniversary!