1.5-m Danish Telescope, CCD Camera

Having acquired a set of IHW imaging quality filters which isolate the same molecular emissions and continuum windows as the photometric filters (with the exception of the OH filter), we wanted to take advantage of the favourable conditions near the perigee of P/Halley and obtain high spatial resolution pictures. Thus a total series of about forty frames were secured on 8 and 9 April, when the geocentric distance of the comet was ~0.42 A.U. The exposure times ranged from 1 minute with the red filters to 10–20 minutes near 400 nm.

Now, the nearness of the comet to the Earth also has a drawback in that it causes a troublesome very rapid apparent motion of the object. Indeed, at a rate of some 16"/min the autoguiding system had a hard time in trying to follow the comet perfectly. Therefore we decided to split the longest exposures into several shorter ones in order to preserve the excellent spatial resolution (a few 100 km), the more so that the image quality itself was quite good (seeing ~0."9). This will of course require delicate image processing. We hope to end up with valuable "monochromatic" bidimensional data, covering a field of about 45,000 × 70,000 km projected on the comet. The resulting spatial distributions of the various components may provide useful information bearing upon the enigmatic question of how they are produced in the inner coma.

Let us mention here that we were struck by the similitude between some of the pictures, especially the red ones, H_2O^+ and red continuum, suggesting that the solar radiation scattered by the dust may have a predominant contribution even in a filter centred on a molecular emission and that careful treatment will be necessary in order to derive significant results from images taken through such filters.

We all enjoyed living and working in a very hospitable and dynamic observatory and we appreciated very much the efficient help we received on many occasions in the course of our activities at ESO. Our heartiest thanks to all who contributed to make our respective stays in La Serena and in La Silla so pleasant and fruitful!

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The PHEMU 85 International Campaign

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1. Introduction

The mutual phenomena of the Galilean satellites of Jupiter take place every six years, when the Earth and the Sun cross the equatorial plane of Jupiter which coincides with the orbital planes of the satellites. At that time, mutual occultations and eclipses may occur. However, the only favourable situation for observing such phenomena is when the crossing of the equatorial plane occurs simultaneously with the opposition of Jupiter. These phenomena are often observable only once every twelve years. In 1985, during the latest opposition of Jupiter, its declination was between −19 and −15 degrees, which made La Silla one of the best places to observe them.

In order to improve the theory of the motion of the Galilean satellites, two kinds of observations have been made so far: photometric observations of the eclipses by Jupiter yielding a positional accuracy of 1,000 km and photographic astrometry giving an accuracy of 300 km. However, as the satellites have no atmosphere, an even higher accuracy can be achieved by observing mutual phenomena, that are eclipses and occultations of the satellites by themselves. These observations are the most precise that can be made of those bodies and lead to a precision of about 100 km, which explains why international campaigns have been organized to carry them out.

Is such a precision for a position of the Galilean satellites necessary? The answer is yes for several reasons. First, the exploration of Jupiter and its satellites by space probes requires a very accurate knowledge of the orbital motions of these bodies. This will especially be the case when the Galileo probe in a few years will be put in orbit around Jupiter. Secondly, the motion of the Galilean satellites around Jupiter, affected by several so far little understood perturbations, is one of the most complex problems of celestial mechanics. The system of moons is submitted to very fast changes and by studying these we may hope to detect non-gravitational effects. Io, for instance, is suspected to have a secular acceleration due to energy dissipation. It is a very inconspicuous effect which cannot be observed easily, but observations of mutual phenomena over a couple of Jupiter oppositions should allow us to explore it.

Therefore, an international campaign, PHEMU 85, has been organized by the Bureau des Longitudes (France), bringing together theoreticians working in celestial mechanics and observational astronomers (which does not happen so often!). As part of this campaign, ESO allocated a large amount of observing nights to the programme at the ESO 50-cm and 1-m telescopes. In total we were able to observe 46 mutual phenomena, during 32 nights (or half-nights).

2. The Observations

The observations were carried out in fast photometry mode, generally with a time resolution of 50 ms. This mode of observing is briefly described in the present issue of the *Messenger* and has been extensively used already in the

TABLE 1

Date	Phenomenon	Observing conditions (a)	Result (b)	Telescope	Filter	Diaphragm
26/27. V .85	3.occ.1	1 – 2	0	50 cm	V	15″
28/29. V .85	2.occ.4	3	0 – 1?	50 cm	V	10″
29/30. V .85	2.occ.4	3	3	50 cm	V	10″
02/03. VI .85	3.occ.2	3	3	50 cm	V	10″
	3.occ.1	3	–	50 cm	V	10″
09/10. VI .85	3.occ.2	3	3	50 cm	V	10″
15/16. VI .85	1.occ.4	1	–	50 cm	V	15″
09/10. VII .85	3.occ.1	2	–	50 cm	V	10″
	4.occ.1	2 – 1?	3	50 cm	V	10″
11/12. VII .85	4.occ.3	2 – 1	1	50 cm	B	15″
15/16. VII .85	3.ecl.2	1	–	50 cm	V	20″
	3.occ.2	1	2	50 cm	V	20″
18/19. VII .85	1.occ.4	3	3	50 cm	V	10″
19/20. VII .85	1.occ.3	1	–	50 cm	V	10″
26/27. VII .85	1.occ.3	2	–	50 cm	V	10″
02/03. VIII .85	1.occ.3	3	3	50 cm	B	10″
05/06. VIII .85	3.occ.4	1	–	50 cm	V	10″
	3.occ.2	1	–	50 cm	V	10″
	3.ecl.2	1	–	50 cm	V	10″
09/10. VIII .85	1.occ.3	2 – 1	–	50 cm	V	10″
28/29. VIII .85	3.ecl.2	3	3	1 m	V	7″
	4.occ.1	3	3	1 m	V	7″
03/04. IX .85	3.occ.2	1	–	50 cm	V	10″
	3.ecl.2	1	–	50 cm	V	10″
04/05. IX .85	3.occ.2	3	3	50 cm	B	10″
05/06. IX .85	1.occ.4	1	–	50 cm	V	10″
	1.occ.4	1	–	50 cm	V	10″
07/08. IX .85	1.ecl.3	3	3	50 cm	B	10″
13/14. IX .85	1.occ.2	3	3	50 cm	B	15″
	1.ecl.2	3	3	50 cm	B	15″
	4.occ.2	3	0	50 cm	B	15″
14/15. IX .85	1.occ.3	3	3	50 cm	V	10″
	1.ecl.3	3	0	50 cm	V	10″
20/21. IX .85	1.occ.2	3	3	50 cm	B	15″
	1.ecl.2	3	3	50 cm	B	15″
21/22. IX .85	1.occ.3	3	3	50 cm	V	10″
24/25. IX .85	3.ecl.4	3	3	50 cm	V	10″
25/26. IX .85	3.ecl.1	3	3	50 cm	V	10″
08/09. X .85	1.ecl.2	2	2	50 cm	V	15″
22/23. X .85	1.occ.2	1	0	50 cm	V	10″
	1.ecl.2	1	–	50 cm	V	10″
27/28. X .85	2.ecl.1	3	3	50 cm	B	10″
14/15. X .85	3.ecl.1	1	2	1 m	V	15″
21/22. X .85	3.occ.1	3	2	50 cm	B	10″
	3.ecl.1	2	–	50 cm	B	10″
08/09. IV .86	2.occ.1	3	0	50 cm	V	15″

Notes: (a): 3 = No problem; 2 = Technical problem; 1 = Bad weather
(b): 3 = Strong phenomenon; 2 = Visible; 1 = Faint; 0 = Not visible

infrared for Neptunian and Uranian occultations leading to the discovery and study of rings around these planets, as well as in the visible to search for flares and outbursts.

As the acquisition is made in pulse-counting mode, it is of course possible to gather or smooth the data afterwards, in order to obtain any time resolution higher than 50 ms.

In the case of the mutual phenomena, it soon turned out that the number of interruptions in the acquisition which were necessary to recentre the satellites in the diaphragm was a serious handicap. We therefore introduced a splitting mirror in the large field eye-piece. In this way, it was possible to guide the telescope during the phenomena without interruption.

Two types of photomultipliers have been used: either the EMI 6256 (S-13), or the QUANTACON RCA-31034 (Ga-As). Both are equally good for this purpose. So, the selection was simply based on the following observers needs, in order to avoid too many instrument changes. The filters used were the Johnson V with the EMI photomultiplier and B with the QUANTACON (the satellites of Jupiter are too bright to be observed in V with this photomultiplier without damaging the tube).

The diaphragm employed depended on the weather and was to some extent determined by the type of the phenomenon observed (for an eclipse, the smallest diaphragm is the best one, as you need to follow only one satellite).

3. The Results

Table 1 gives a summary of our observations. Figure 1 shows a group of observations made of an event. Some phenomena have been observed very clearly (Figs. 2, 3, 4) while some others were not seen. A preliminary analysis appears to show good agreement between theory and observations for the timing of the phenomena.

Mutual phenomena do not always occur at the most convenient time, and we have often had to deal with difficult observing conditions, either during twilight when the sky brightness changed rapidly, or at very high airmass. On such occasions, the events could sometimes be hardly observable. While some observations were lost for meteorological reasons, none were lost due to technical problems.

Finally, we note that the major challenge when analyzing the data will be to measure the duration of a phenomenon. Figures 5 and 6 represent the same observation, but the data have been binned to different time resolutions, 400 ms and 800 ms respectively. Using the same graphic method, however, we find that the two data representations give a difference of 26 seconds in duration (corresponding to 8 %). The timing of the minimum agrees within .8 second. We thus note that the determination of the intensity and maximum of a phenomenon is far more accurate than an estimate of its duration. Our observations should point out to observers using a conventional photometer how difficult it is to determine the beginning and end of such an event.

4. Conclusion

We could observe a large amount of mutual phenomena at La Silla, even though generally the July–September period is not especially good for photometric observations. The ESO contribution to the campaign is therefore quite substantial.

A workshop organized by the Bureau des Longitudes took place this April, in Bagnères-de-Bigorre (Pic-du-Midi Observatory) to discuss the first results of the PHEMU 85 campaign. Observations carried out in many places in France, Brasil, Spain and Italy were presented. Table 2 shows a summary of all observations made during this campaign. Theoreticians working in celestial mechanics will now have to interpret them, and start their computations to improve the present models. We should

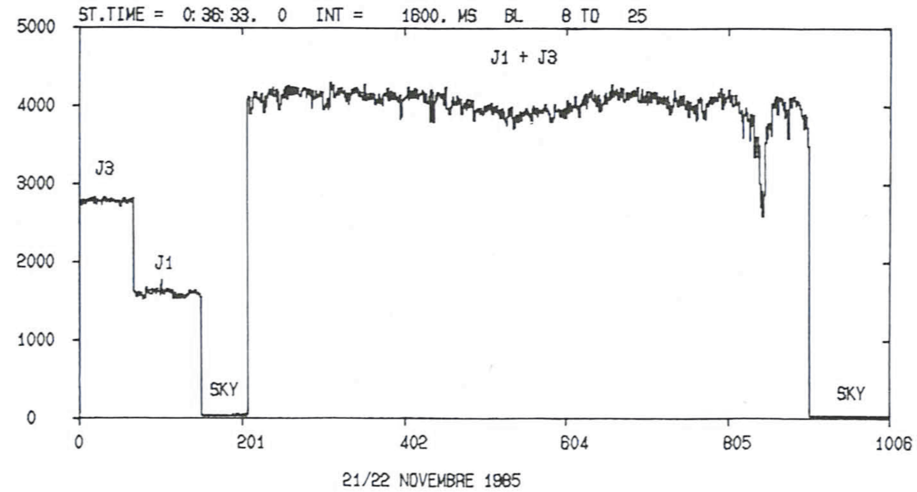

Figure 1: *Sequence of observations made for the occultation of IO (J1) by GANYMEDE (J3), on November 21, 1985, showing the relative intensities of each satellite, of the sky, and of the phenomenon. ST. TIME is the starting UT time, and one time unit is 1,600 ms. Blocks 8 to 25 were added on this picture.*

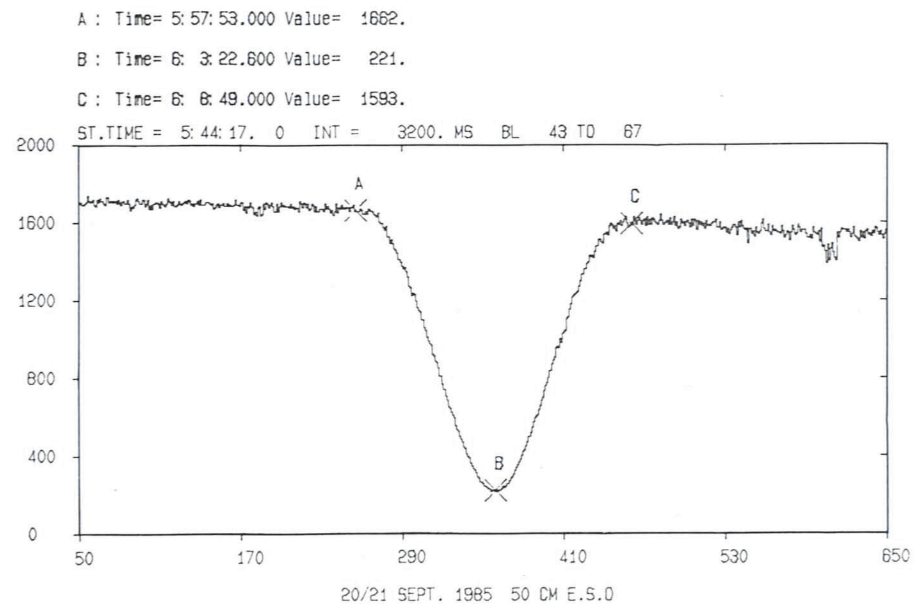

Figure 3: *IO occults EUROPA on September 20, 1985.*

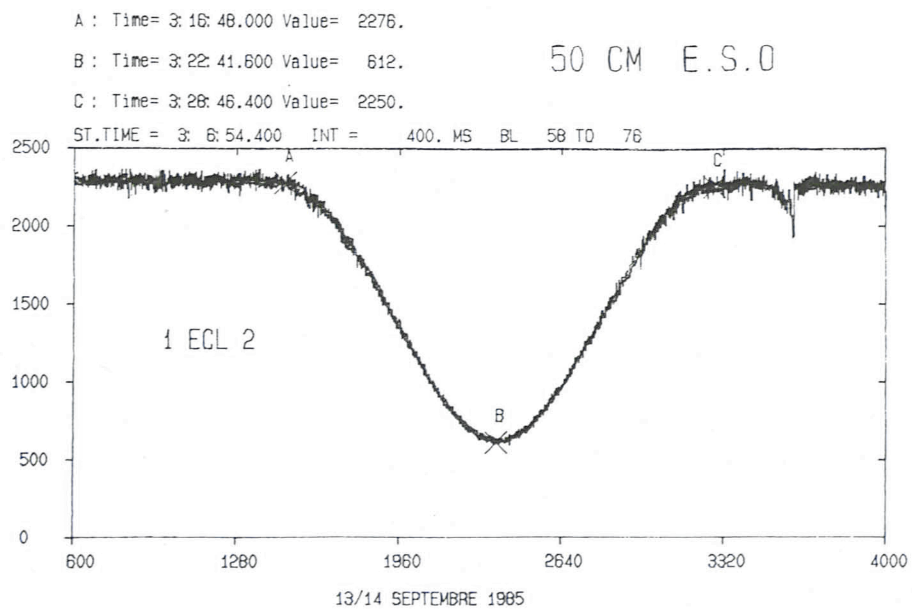

Figure 2: *IO (J1) eclipses EUROPA (J2) on September 13, 1985. The time unit on this picture is 400 ms, and 18 blocks have been added. The points A, B, C have been determined graphically through the reduction programme available at La Silla.*

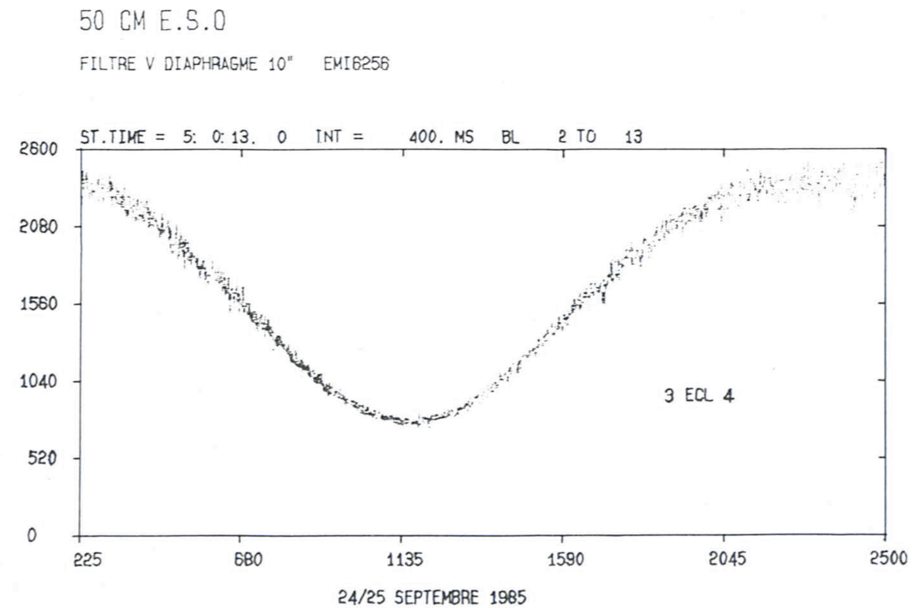

Figure 4: *CALLISTO (J4) is eclipsed by GANYMEDE (J3) on September 24, 1985.*

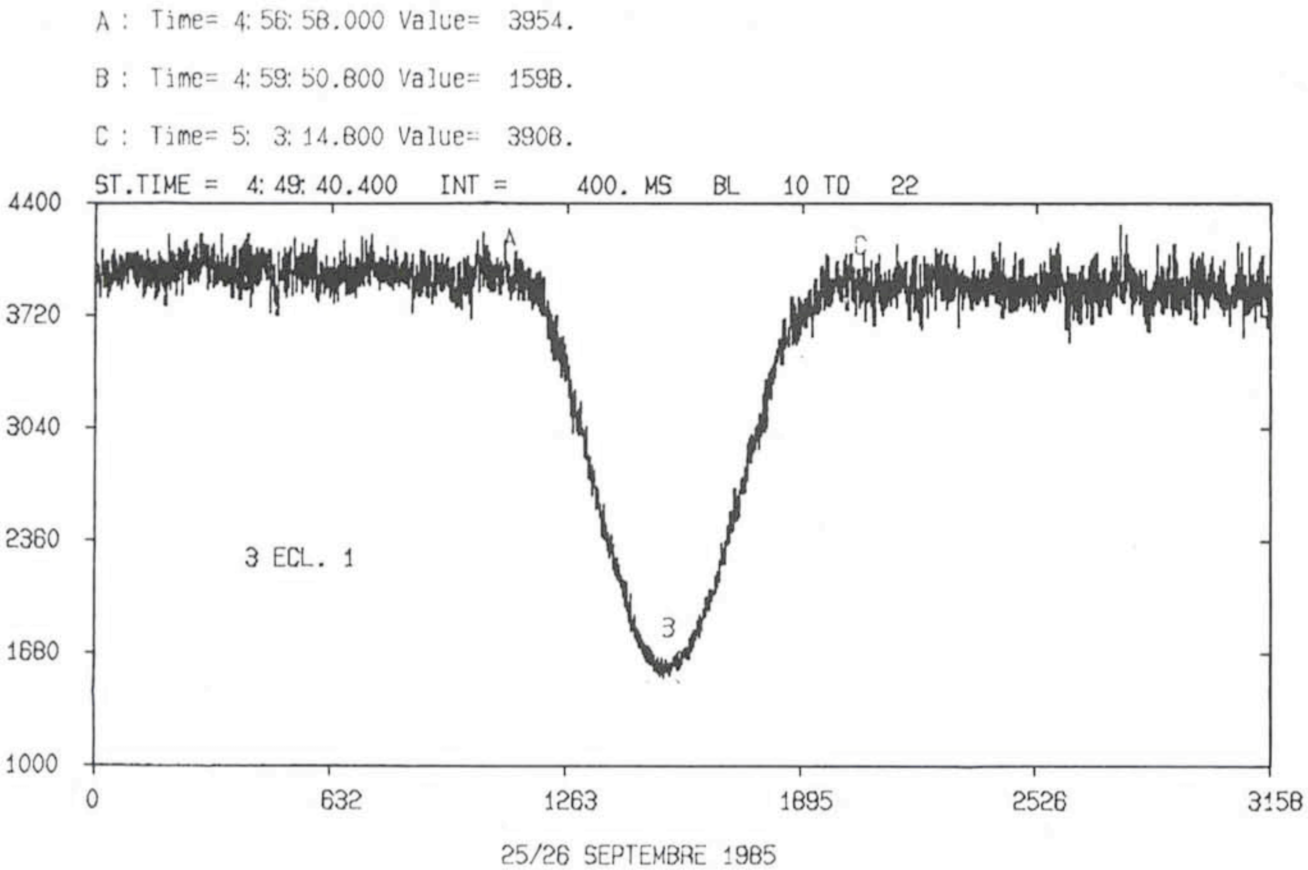

Figure 5: *GANYMEDE eclipses IO on September 25, 1985. The time resolution has been set to 400 ms, and the graphic determination gives a phenomenon duration of 6 mn 17 s.*

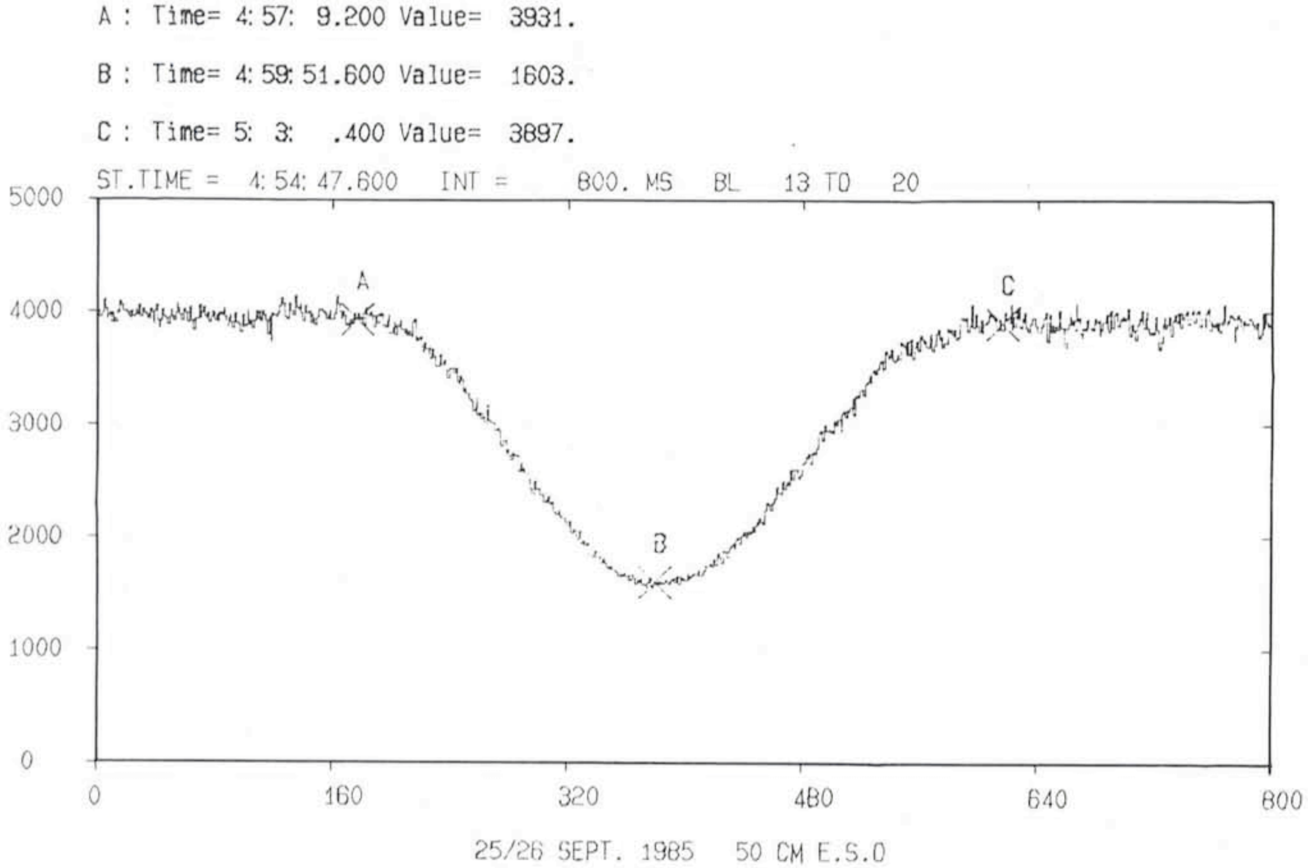

Figure 6: *Same observation as for Figure 5 but now the data are binned with a time resolution of 800 ms. The same graphics method gives a duration of 5 mn 51 s.*

TABLE 2

Observ.	Number of light-curves obtained (a)				Number of good non visual light-curves	Number of events	
	PP	VD	PH	VI		observable	observed
OHP	23	–	–	–	15		
CHIRAN	7	–	–	–	3		
OPMT	–	21	–	–	18		
NICE	19	4	–	–	10		
CERGA	7	–	–	–	6		
MEUDON	6	23	–	–	15		
PARIS	10	–	–	–	8	74	52
BORDEAUX	7	–	–	–	4		
TERAMO	19	–	–	–	16		
CATANIA	11	–	–	–	7		
GEOS	1	–	–	81	1		
GEA, Barcelona	10	–	–	9	9		
Miscel.	–	7	5	20	?		
ESO, CHILE	25	–	–	–	23	31	30
LNA, BRAZIL	9	–	–	–	8		
SUMS	154	55	5	90	143	105	82
	209		95				
	304						

Notes: (a): PP = Photoelectrical photometry; VD = Video recording;
PH = Photographic photometry; VI = Visual photometry

stress that it is the first time that such a campaign gives so many results and we can already see that although another one will certainly be necessary (in 12 years!), it might well be the last one, provided that the next harvest is as rich as the '85 one.

Acknowledgements

Our best thanks go to F. Gutierrez for his continuous help in managing the software during these observations, and to M. Maugis for his support in the electronics.

List of ESO Preprints

June – August 1986

445. B. Reipurth and G. Gee: Star Formation in Bok Globules and Low-Mass Clouds. III. Barnard 62. *Astronomy and Astrophysics.* June 1986.
446. A. Tornambè and F. Matteucci: Type I SNe from Double Degenerate CO Dwarfs and their Rate in the Solar Neighbourhood. *Monthly Notices of the Royal Astronomical Society.* June 1986.
447. P. Crane, D.J. Hegyi, N. Mandolesi and A.C. Danks: Cosmic Background Radiation Temperature from CN Absorption. *Astrophysical Journal.* June 1986.
448. F. Murtagh: Clustering Techniques and their Applications. *Data Analysis and Astronomy,* Plenum Press. June 1986.
449. A. Terzan, Ch. Turati and Ch. Ounnas: A Photometric Study of the Bright Cloud B in Sagittarius: V. 185 New Proper Motion Stars. *Astronomy and Astrophysics.* June 1986.
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451. G. Contopoulos, H. Varvoglis and B. Barbanis: Large Degree Stochasticity in a Galactic Model. *Astronomy and Astrophysics.* July 1986.
452. E.I. Robson et al.: The Rise and Fall of the Quasar 3C273. *Nature.* July 1986.
453. E. Hummel et al.: The Central Region of NGC 613. Evidence for an Accelerated Collimated Outflow. *Astronomy and Astrophysics.* July 1986.
454. A. Llebaria, J.-L. Nieto and S. di Serego Alighieri: On the Non-Linearity of the ESA Photon Counting Detector. *Astronomy and Astrophysics.* July 1986.
455. M.W. Pakull and L.P. Angebault: Detection of an X-Ray Ionized Nebula Around the Black Hole Candidate Binary LMC X-1. *Nature.* July 1986.
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457. F. Matteucci: The Evolution of CNO Abundances in Galaxies. *P.A.S.P.* August 1986.
458. R. Gathier: Radio Observations of Young Planetary Nebulae. *The Late Stages of Stellar Evolution.* Reidel, Dordrecht. August 1986.
459. R.H. Sanders: Alternatives to Dark Matter. *Monthly Notices of the Royal Astronomical Society.* August 1986.
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461. L. Binette and A. Robinson: Fossil Nebulae in the Context of Active Galaxies. I. Time Evolution of a Single Cloud. *Astronomy and Astrophysics.* August 1986.
462. D. Baade: Ground-Based Observations of Intrinsic Variations in O, Of and Wolf-Rayet Stars. *NASA/CNRS Monograph Series on Nonthermal Phenomena in Stellar Atmospheres,* volume *O, Of and Wolf-Rayet Stars,* eds. P.S. Conti and A.B. Underhill. August 1986.
463. B.E.J. Pagel: Helium, Nitrogen and Oxygen Abundances in Blue Compact Galaxies and the Primordial Helium Abundance. Paper delivered to the Paris (IAP) Conference on Nucleosynthesis, 1986, July 7–11. August 1986.
464. J.M. Rodriguez Espinosa et al.: Star Formation in Seyfert Galaxies. *Astrophysical Journal.* August 1986.

VLT REPORTS

In connection with ESO's planned Very Large Telescope the following VLT Reports have recently been published:

No. 41: A First Evaluation of the Effects of Wind Loading on the Concept of the ESO Very Large Telescope. By L. Zago. June 1985.

No. 42: Aperture Synthesis (Spatial Interferometry) with the Very Large Telescope. An Interim Report by the ESO/VLT Working Group on Interferometry. October 1985.

No. 43: Site Testing at Cerro Paranal – Results from 1983. By A. Ardeberg, H. Lindgren and I. Lundström. December 1985.

No. 44: Very Large Telescope. An Interim Report by the ESO Study Group. January 1986.

No. 45: Site Testing at Cerro Paranal – Results from 1984. By A. Ardeberg, H. Lindgren and I. Lundström. March 1986.

No. 46: Enclosure and Buildings for the ESO Very Large Telescope. By L. Zago. May 1986.

No. 47: Adaptive Optics for ESO's Very Large Telescope (VLT) Project. By F. Merkle. May 1986.

No. 48: Comparison of Meteorological Conditions on Chilean Sites. Annual Summary 1985. By M. Sarazin. June 1986.

No. 49: Interferometric Imaging with the Very Large Telescope. Final Report. By the ESO/VLT Working Group on Interferometry. June 1986.

No. 50: VLT Working Group on High Resolution Spectroscopy. Final Report. June 1986.

No. 51: VLT Working Group on Infrared Aspects. Final Report. July 1986.

No. 52: Report to the ESO VLT Projekt of the Working Group on Imaging and Low Resolution Spectroscopy. July 1986.

VLT Reports No. 1–40 were mainly for internal purposes and are meanwhile out of print.