

Fireballs And How To Catch Them...

James Appleton & Alan Smith

OASI Astronomy Workshop 06 May 2019

Low-res presentation minus animation and videos!

Fireball 06 August 2018

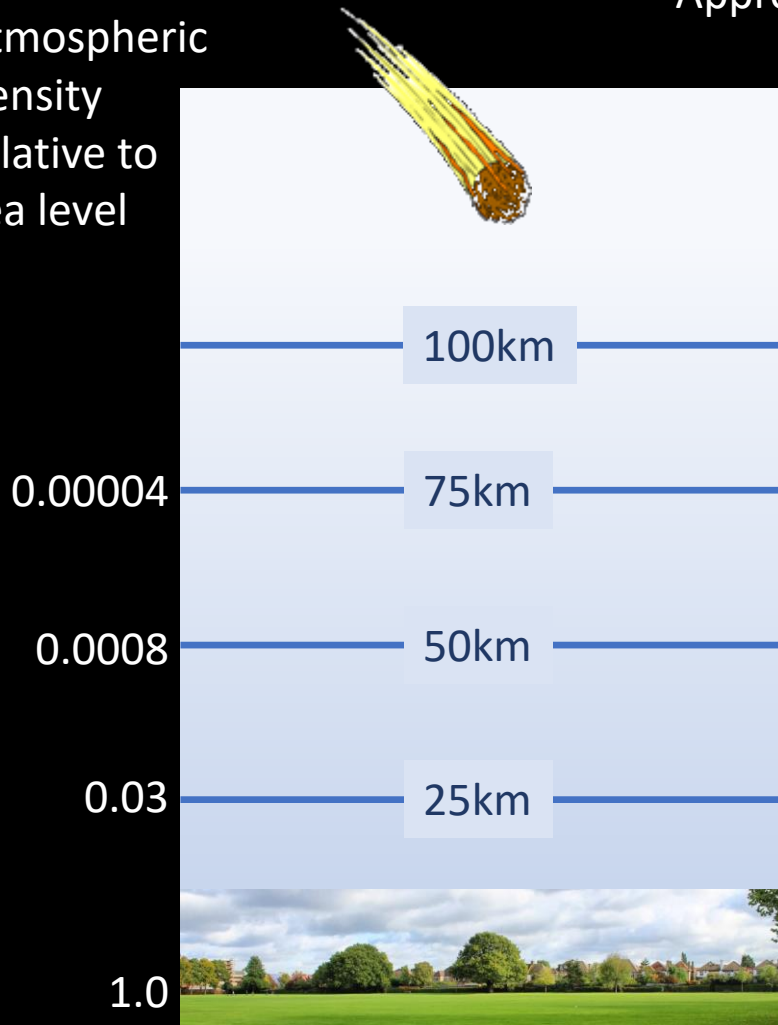
2

Image by Alan Smith, Canon 1100D, 06 Aug 2018, 01:07:20-01:12:26 UT

What is a meteor? What is a fireball?

Most naked-eye meteors are the size of a grain of sand.
Approach velocity to Earth typically several 10s of km/s.

Atmospheric
density
relative to
sea level



First encounter with significant traces of atmosphere.

Ablation, vaporisation and ionisation.
Most meteors destroyed by ~80 km altitude.

Few meteors reach 50 km.
Shock waves, sonic booms.

Typically “dark flight” for meteors reaching below 30 km altitude.

Typically <5% of an object reaches the ground as a meteorite.

Types of meteorite

Abundance	Composition	Origin
94%	Stony • Chondrites: mix of rocks in a matrix • Achondrites: once-molten	• Solar nebula • Asteroid, igneous
5%	Iron	Core of asteroid
1%	Stony-iron	Outer core of asteroid

Chondrite

5



Note: Chondrules

Achondrite



Iron



Widmanstätten pattern



Stony-iron



Mr Smith...

Beginnings! 1976...

11



Basic enclosure

12



Logging and reporting

The first log sheet!

18-19 September 1978.

Records details of 39 exposures over 17 nights (continues on two sides).

The film was sent to the BAA.

Meteor Section Fireball Programme All-Sky Camera Exposure Record

STATION _____ Sheet No. _____ of _____

Camera has : HEATER ☐ ROTATING SHUTTER ☐

I now have _____ films on hand.

I need fresh supplies of : FILM ☐ FORMS ☐

Received Log No. 1.

Film Sent to BAA.

Nights 17 17 TOT

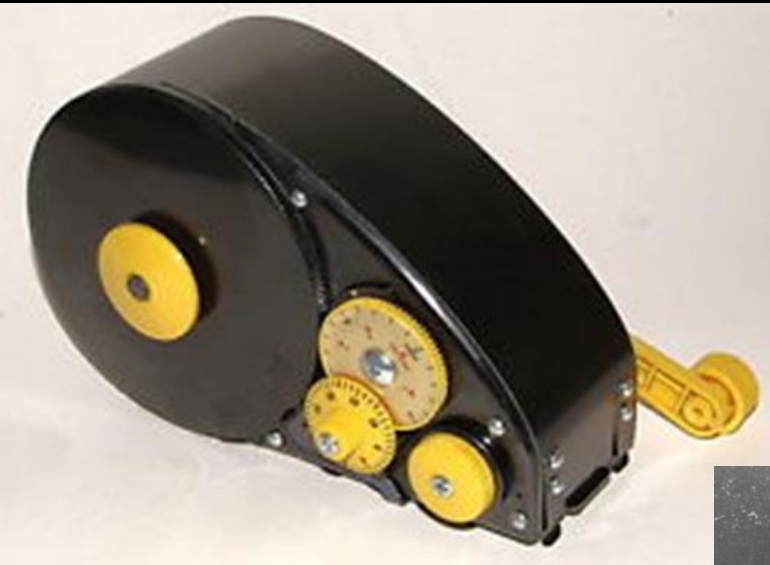
Exposures 39 39 TOT

Time 43hr 39mins 0secs

Frame No.	Year, Month, Date (Use double date)	F No.	Exposure Times (U.T.)			NOTES : sky conditions, cloud, aircraft, limiting magnitude overhead, dew.
			Start	End	Duration	
1	18-19 Sept 1978		2030	2150	80	3 $\frac{5}{10}$
2			2150	2230	40	4 $\frac{1}{10}$ moon
3	19-20 Sept 1978		2025	2125	60	3 $\frac{9}{10}$
4			2125	2210	45	5 $\frac{1}{10}$ moon
5	20-21 Sept 1978		2150	2215	25	4 0
6			2215	2315	60	4 0 - $\frac{10}{10}$
7	21-22 Sept 1978		2050	2210	80	3 $\frac{2}{10}$
8	23-24 Sept 1978		1959.15	2101.35	62.20	4 $\frac{1}{10}$
9			2102.10	2202.20	60.10	4 0
10			2203.00	2315.25	71.35	3-4 $\frac{3}{10}$ - 0
11	24-25 Sept 1978		1945.00	2050.10	65.10	3 0
12			2050.45	2150.15	59.30	5 0
13		1st	2150.50	2236.10	45.40	5 0
14	25-26 Sept 1978	2nd	2001.15	2133.15	92.00	5 0
15		Times 3rd	2134.00	2250.00	76.00	5 $\frac{1}{10}$
16		all	2250.30	0024.25	93.55	5 0
17	26-27 Sept 1978		213.15	2227.40	74.25	1-3 $\frac{9}{10}$ - $\frac{5}{10}$
18	27-28 Sept 1978		2138.17	2250.42	72.25	5 0
19	29-30 Sept 1978		2029.10	2115.00	45.50	3 $\frac{6}{10}$ - $\frac{10}{10}$

Film stars?

14



A close encounter. Almost...

26 December 1980, 03:00



S OF THE WORLD

Sunday

25p
BEST VALUE
FOR MONEY

STREET'S BIGGEST SUNDAY NEWSPAPER

No. 1,234

● Colonel's top
secret report
tells the facts

● Mystery craft
in exploding
wall of colour

● Animals flee
from strange
glowing object

UFO LANDS IN SUFFOLK

A UFO has landed in Britain - and that's the first time that sighting fact has been officially confirmed.

Despite a massive covering force of the World's most famous men, the sighting was not until the morning of 26th Dec. at 03:00, when a UFO was seen.

It happened in a town known as 'Suffolk' - and the sighting was not until the morning of 26th Dec. at 03:00, when a UFO was seen.

And that's OFFICIAL

**NEWS OF THE WORLD
INVESTIGATES**

By **KEITH BEADY**

The sighting was not until the morning of 26th Dec. at 03:00, when a UFO was seen. It happened in a town known as 'Suffolk' - and the sighting was not until the morning of 26th Dec. at 03:00, when a UFO was seen.

EVIDENCE - The sighting was not until the morning of 26th Dec. at 03:00, when a UFO was seen. It happened in a town known as 'Suffolk' - and the sighting was not until the morning of 26th Dec. at 03:00, when a UFO was seen.

NO HOAX

Automation



A servo motor fitted with cams and micro switches enabled the shutter-release cable to be operated from within the shed.

An electro-mechanical timer allowed exposures to be terminated before dawn.

A rain detector activated a servo-operated cover to protect the entire upper surface.

Rotating shutter

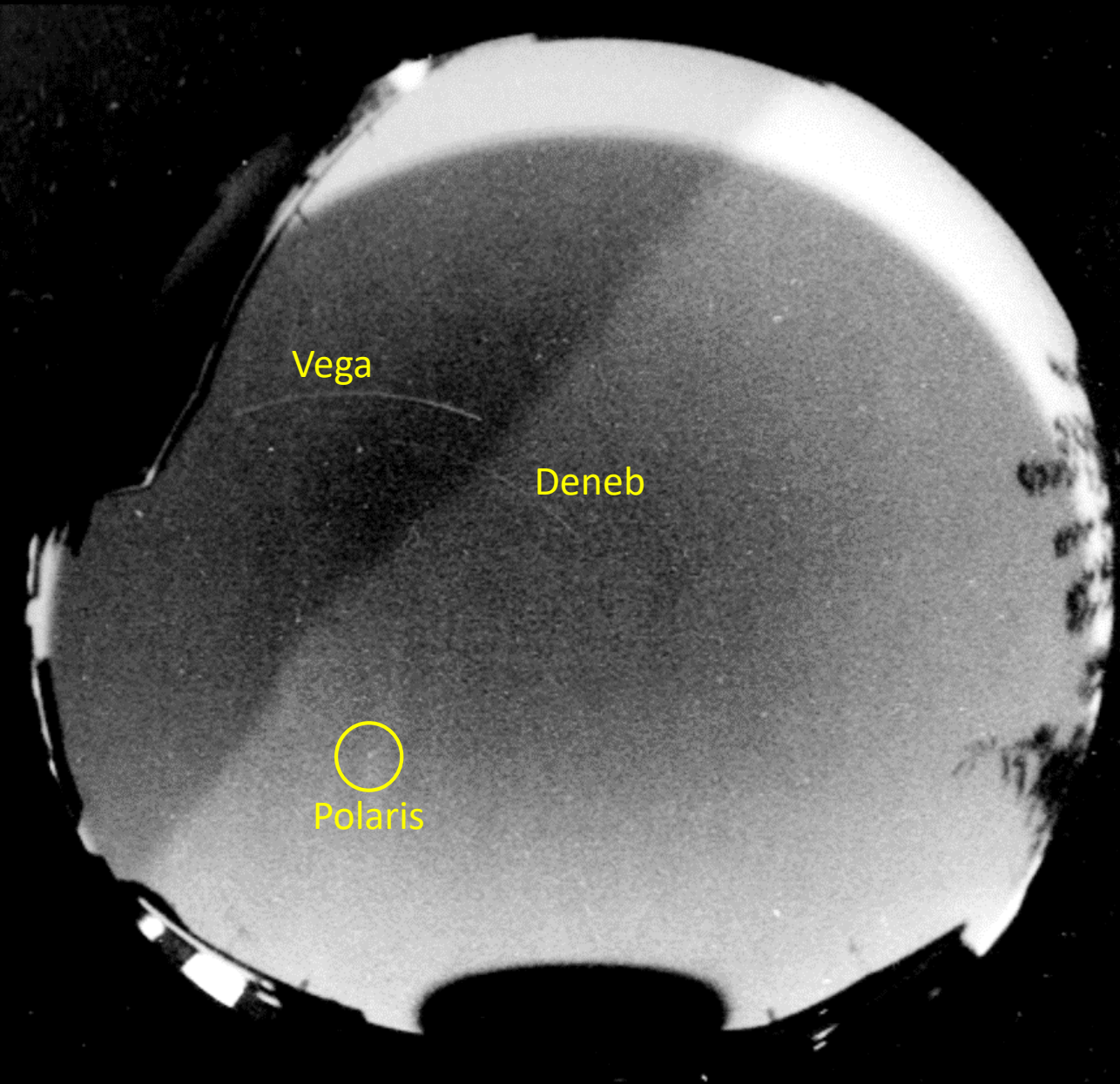


Rotating shutter.

Five revs per second, giving
10 breaks per second.

Operational from late
March, 1981.

Early results

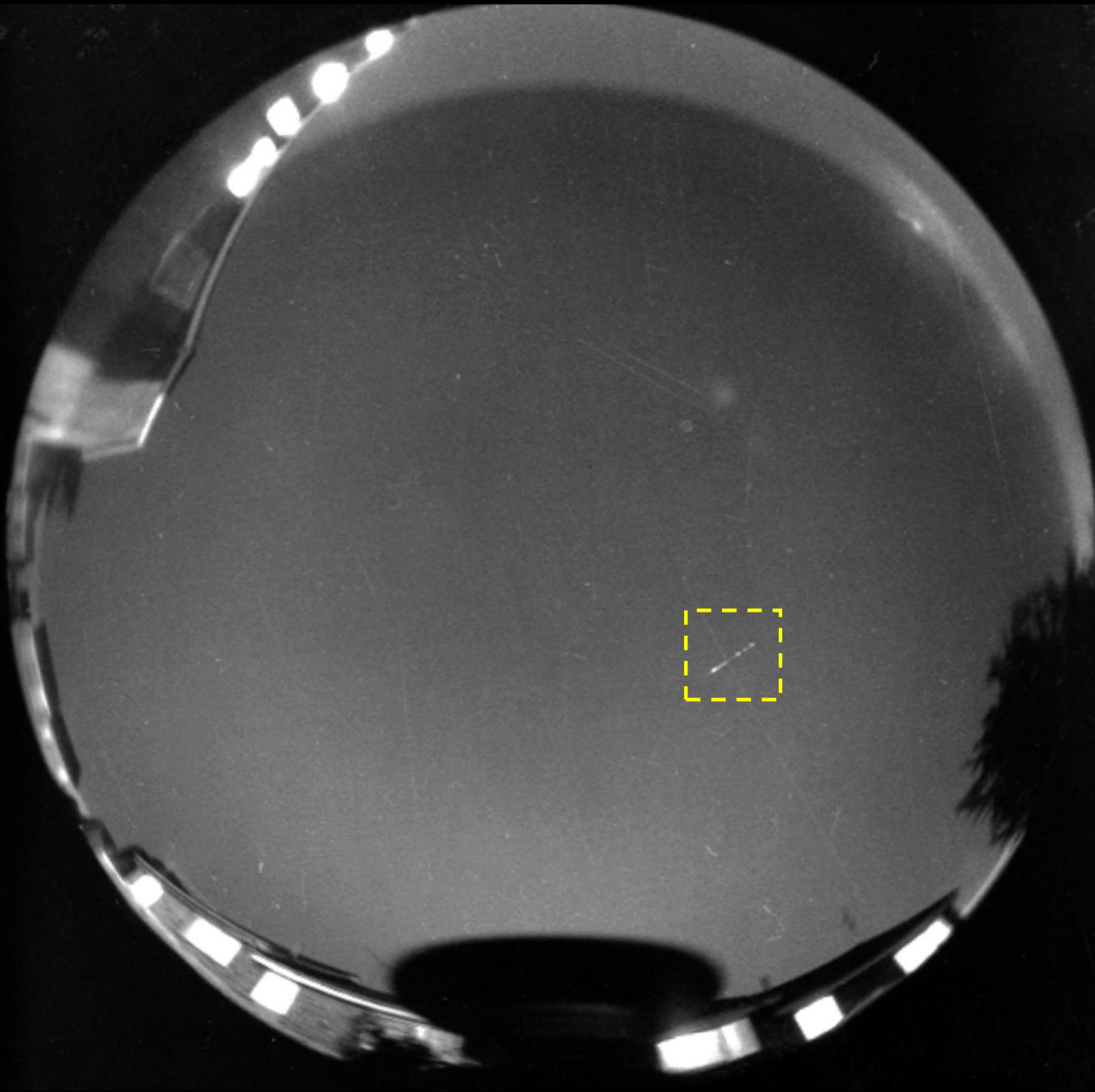


Typical image from early equipment.

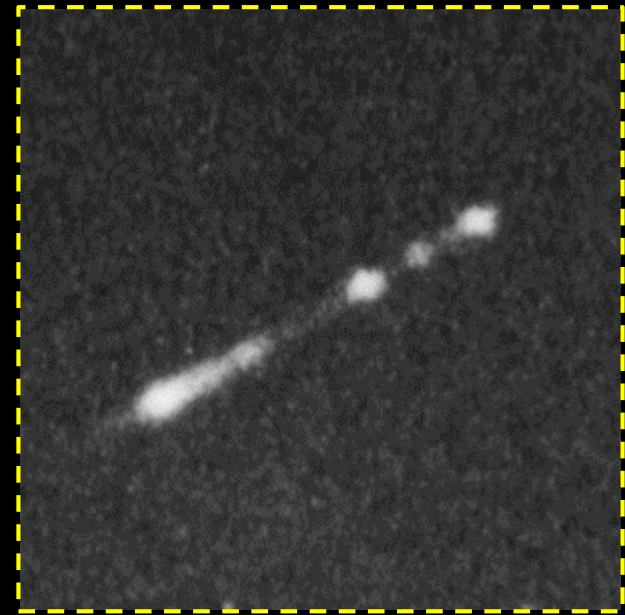
00:00:00 - 03:08:00 UT
(188 min exposure) on
02 August 1981.

Note Polaris, Vega and
Deneb.

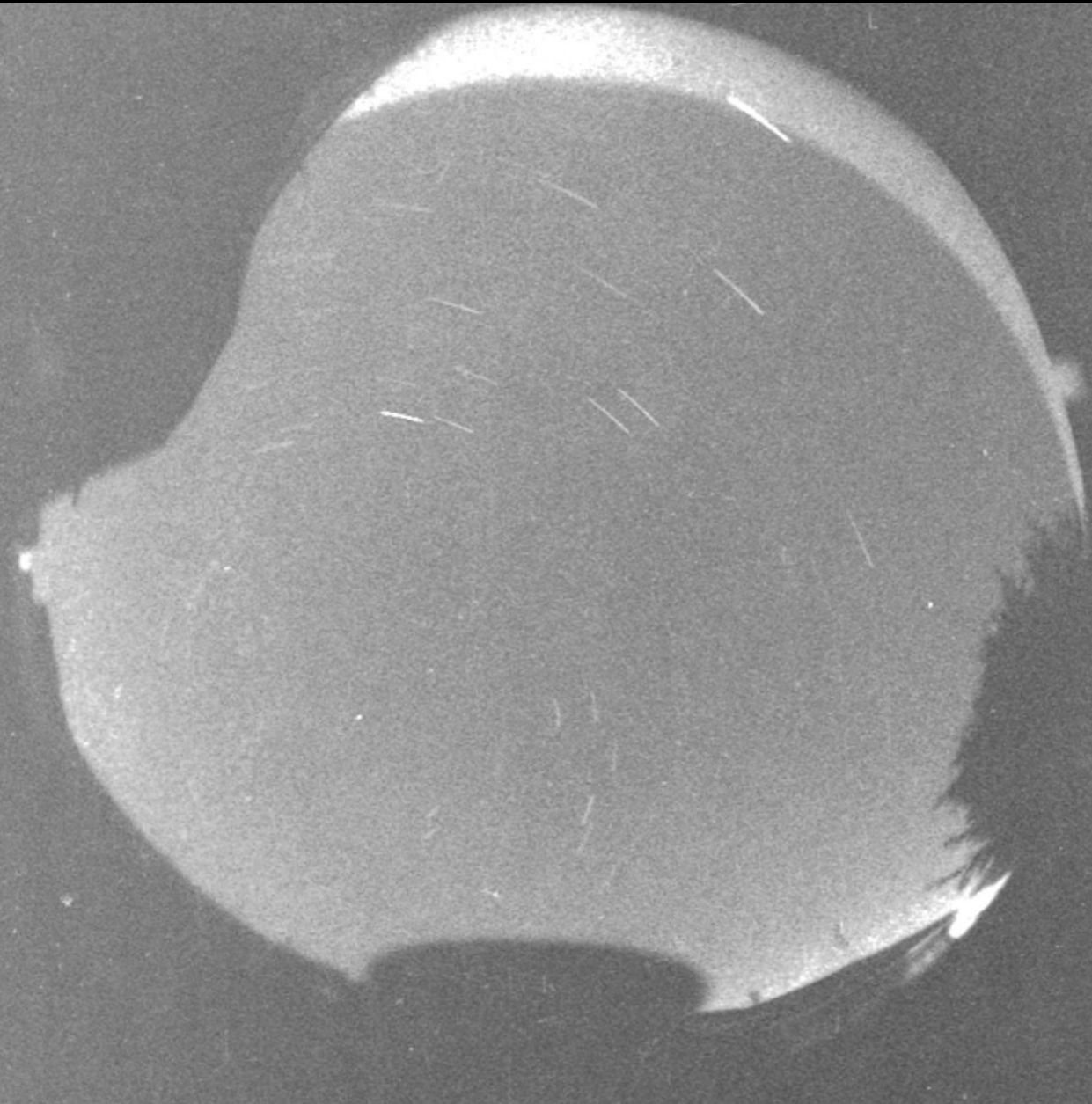
The first 'reasonable' fireball



15 March 1983, 22:36:30 -
05:00:00 UT (383 mins).



Maximum achievable quality

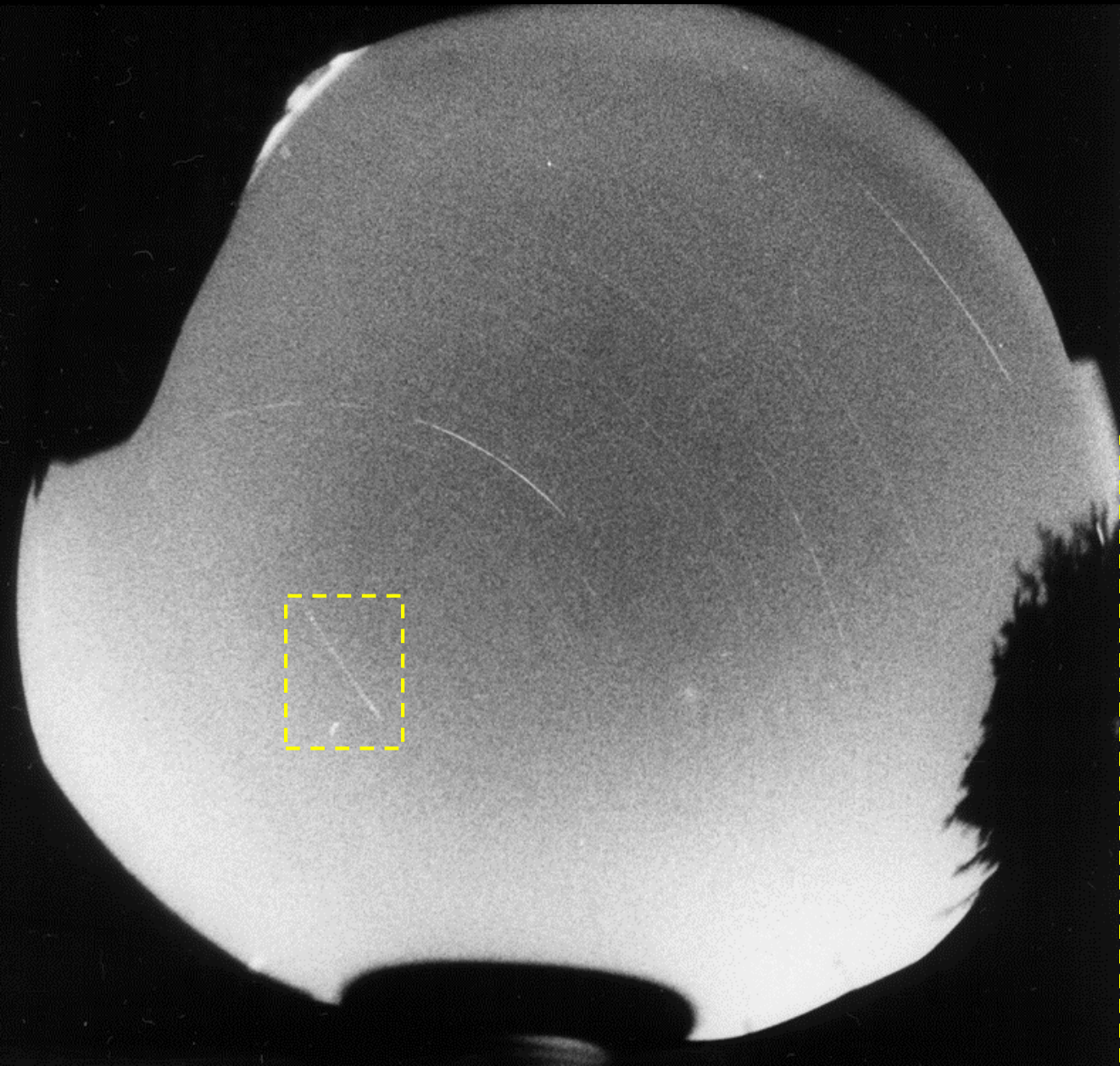


Zenit B camera, 58mm
Helios lens with x0.15
'Spiratone' fisheye afocal
attachment.

03 December 1983
03:15:20 – 03:49:55 UT (34
mins).

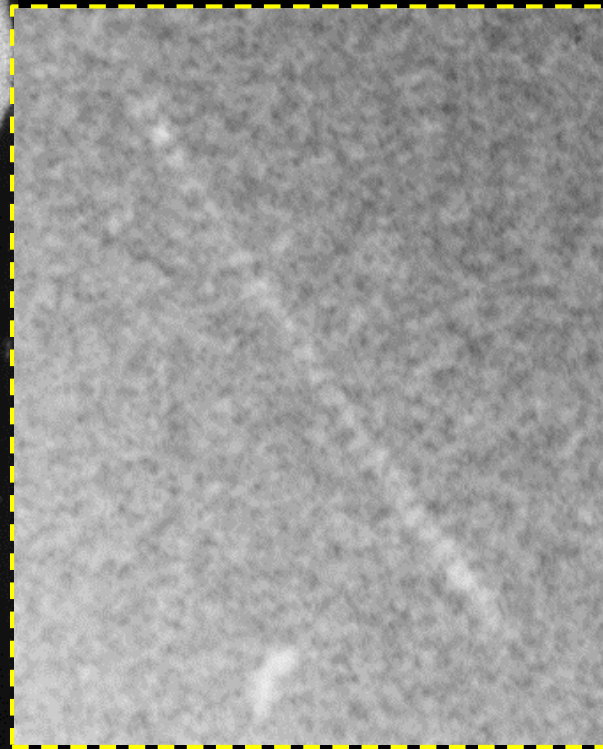
HP5 film, 400 ASA push-
processed to approx. 1250
ISO equivalent.

Long duration fireball



06 January 1984,
02:27:30 - 06:42:00 UT.

23 breaks in trail
represent about 2.5
seconds of visibility.



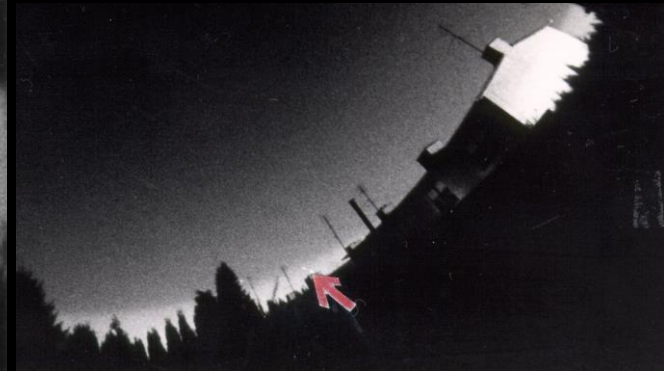
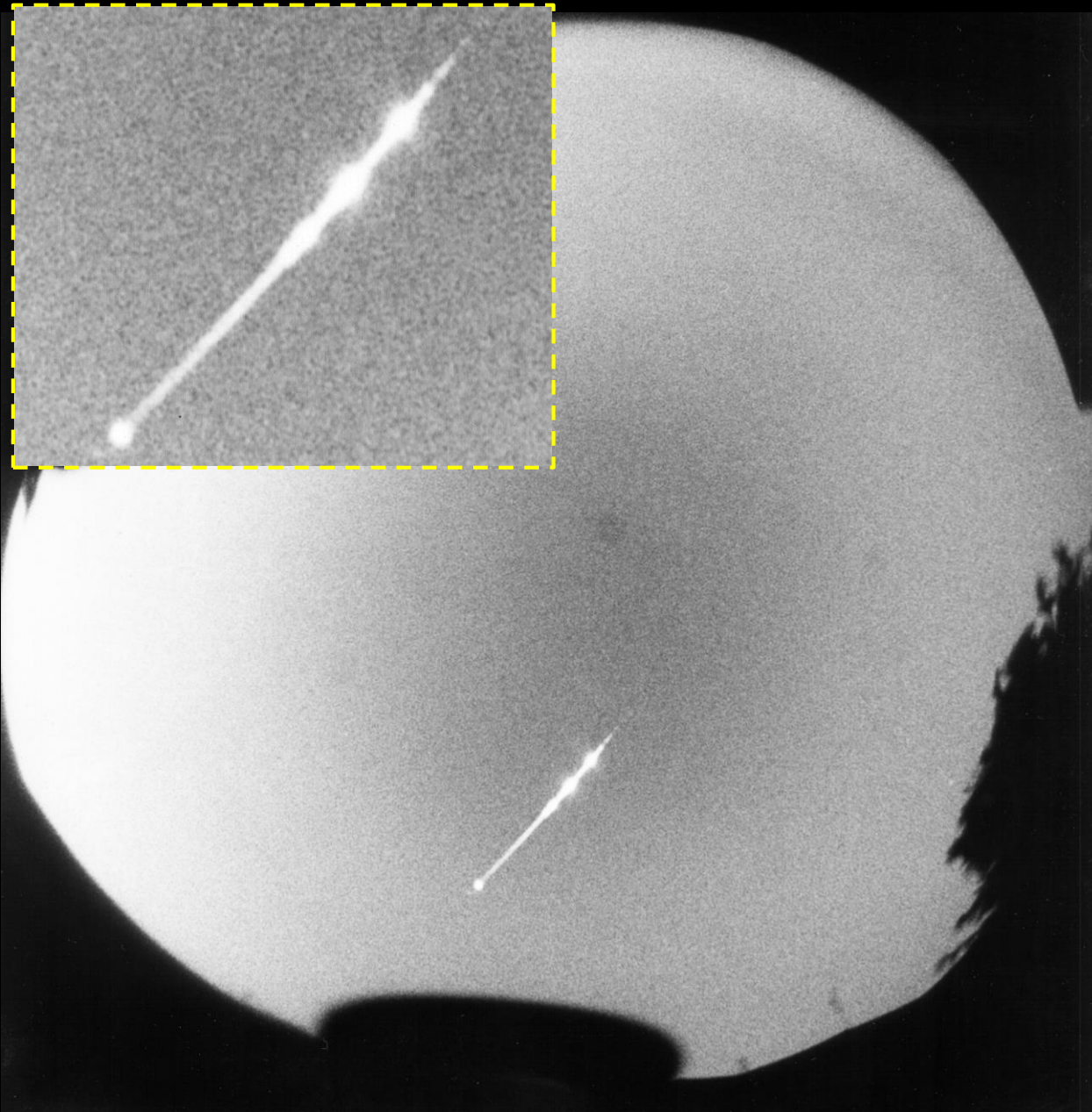
Collaboration

23 April 1984, 20:27 UT. 22

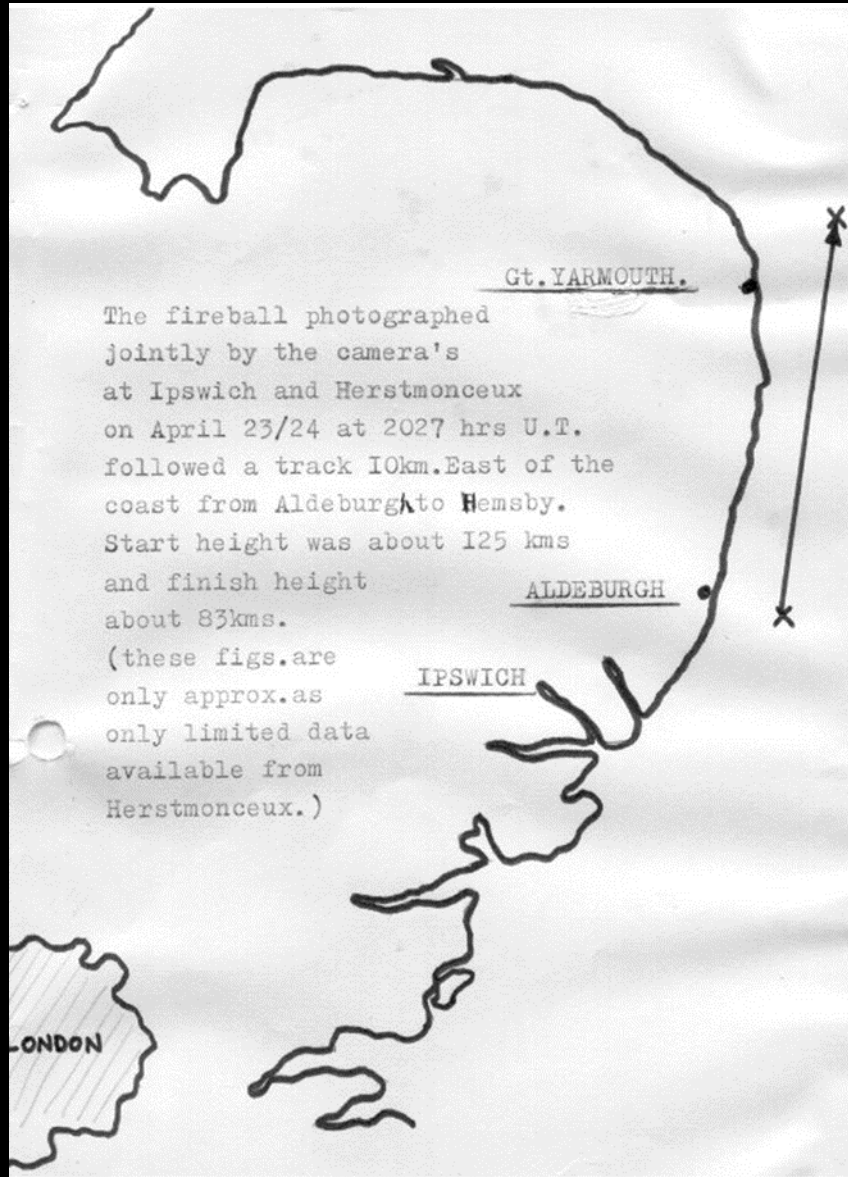
Fireball magnitude -14
(brighter than full moon).

Images to left by AJS.

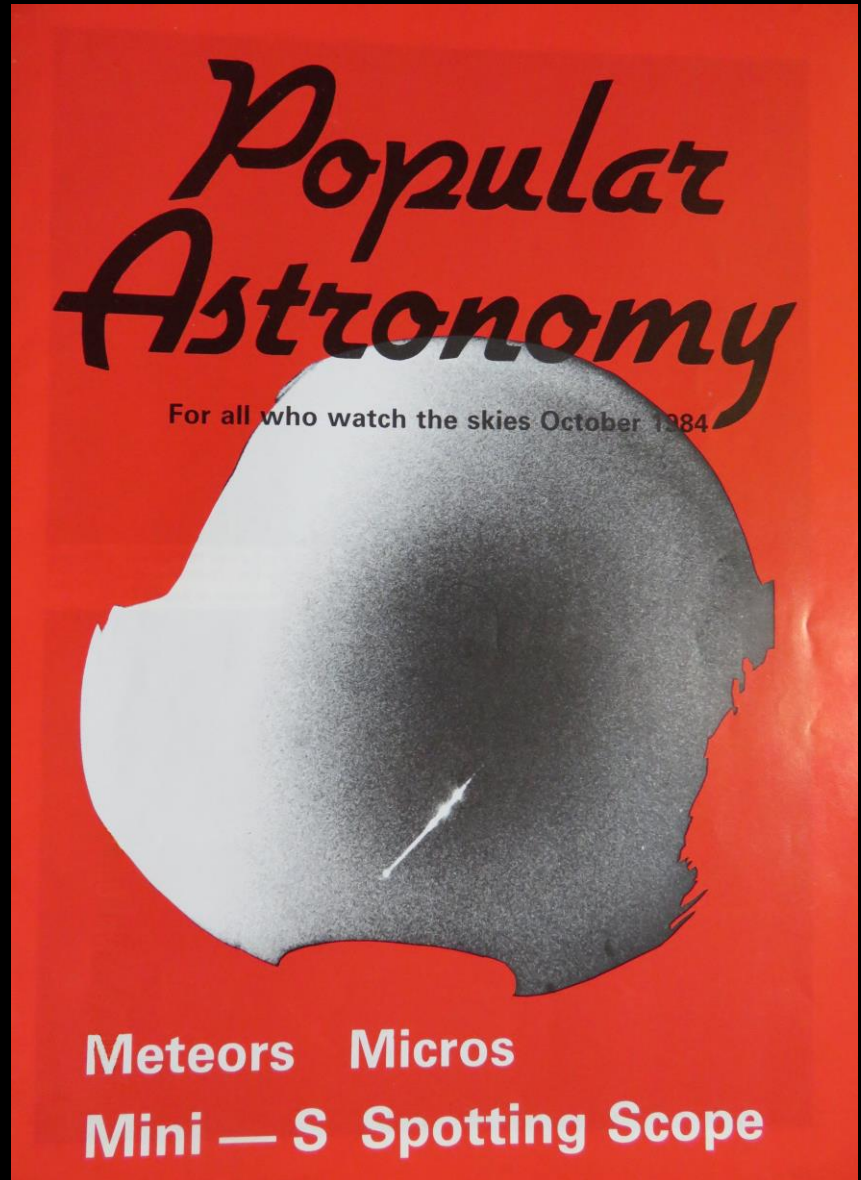
Images below by Hans
Betlem, Elsloo, Holland.



Publication!



OASI Newsletter, August 1984



A faster camera and full automation



16mm, F2.8 fisheye lens, coupled to a motor-driven, Minolta 35 mm camera.



A calculator modified to print time and date onto a thermal paper 'till roll'.

Fast and furious!

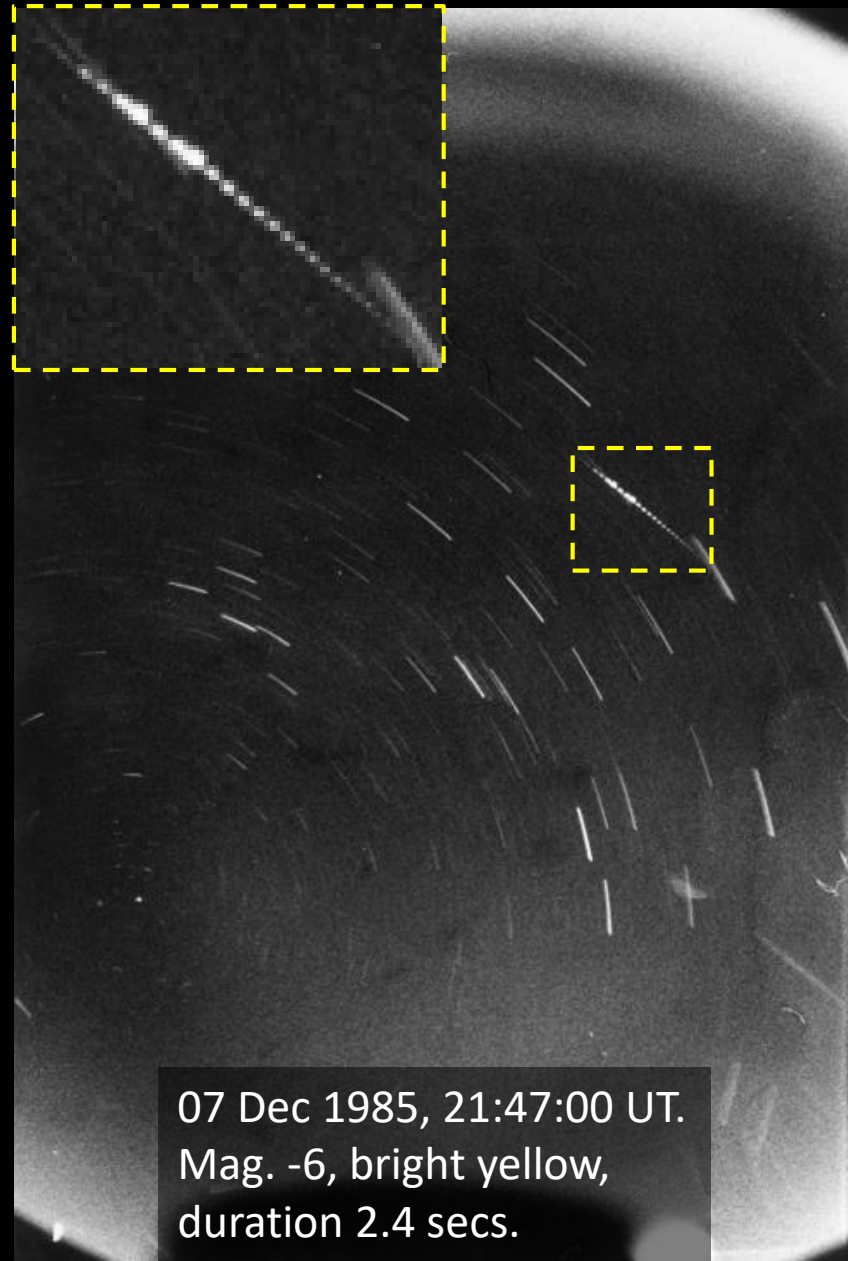
24 Jul 1985

00:18-00:48 UT,
duration <0.5 sec.

12 Aug 1985

01:43:23 UT,
duration 0.5 sec.
Mag -4 as observed.

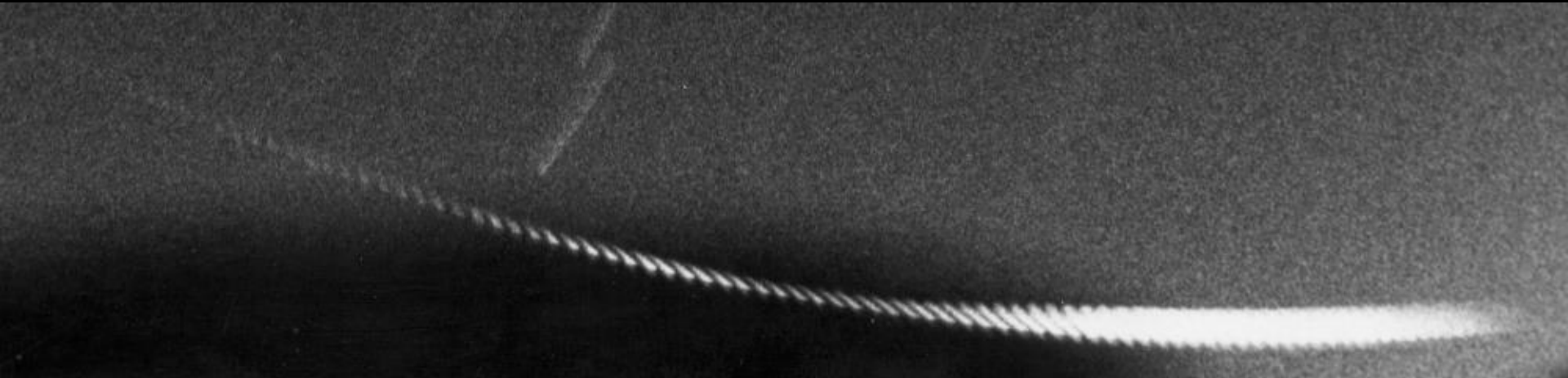
Slow and very bright!



Enlargement of fireball image

22 Jan 1986 04:24-04:54 UT.

Mag. -10, duration 8.4 secs.



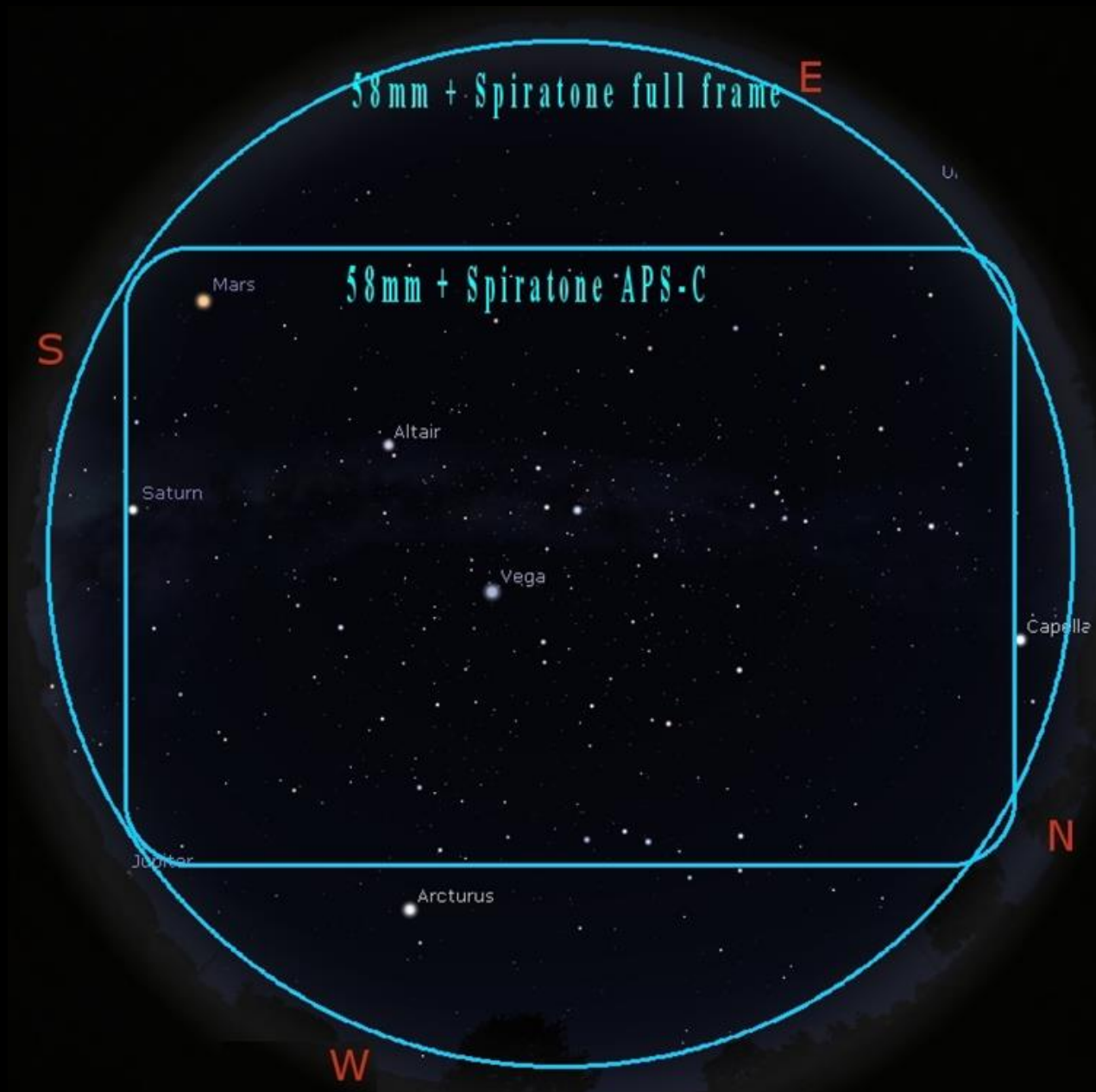
The modern era

- Canon 1100D DSLR, APS-C format (22.5×15 mm), 11 Mpixels (full frame 35mm is 36x24mm).
- Initially the original lens combination of 58 mm Helios + Spiratone fisheye adapter (EFL 8.7 mm). Later replaced by a Sigma 4.5 mm, F2.8, fisheye lens.
- Controlled by EOS Utility s/w running on a Windows XP laptop.
- Remote access using Google Chrome Remote Desktop.
- Wooden enclosure with dew heaters, fan and glass dome.

Trial run



Comparative field of view

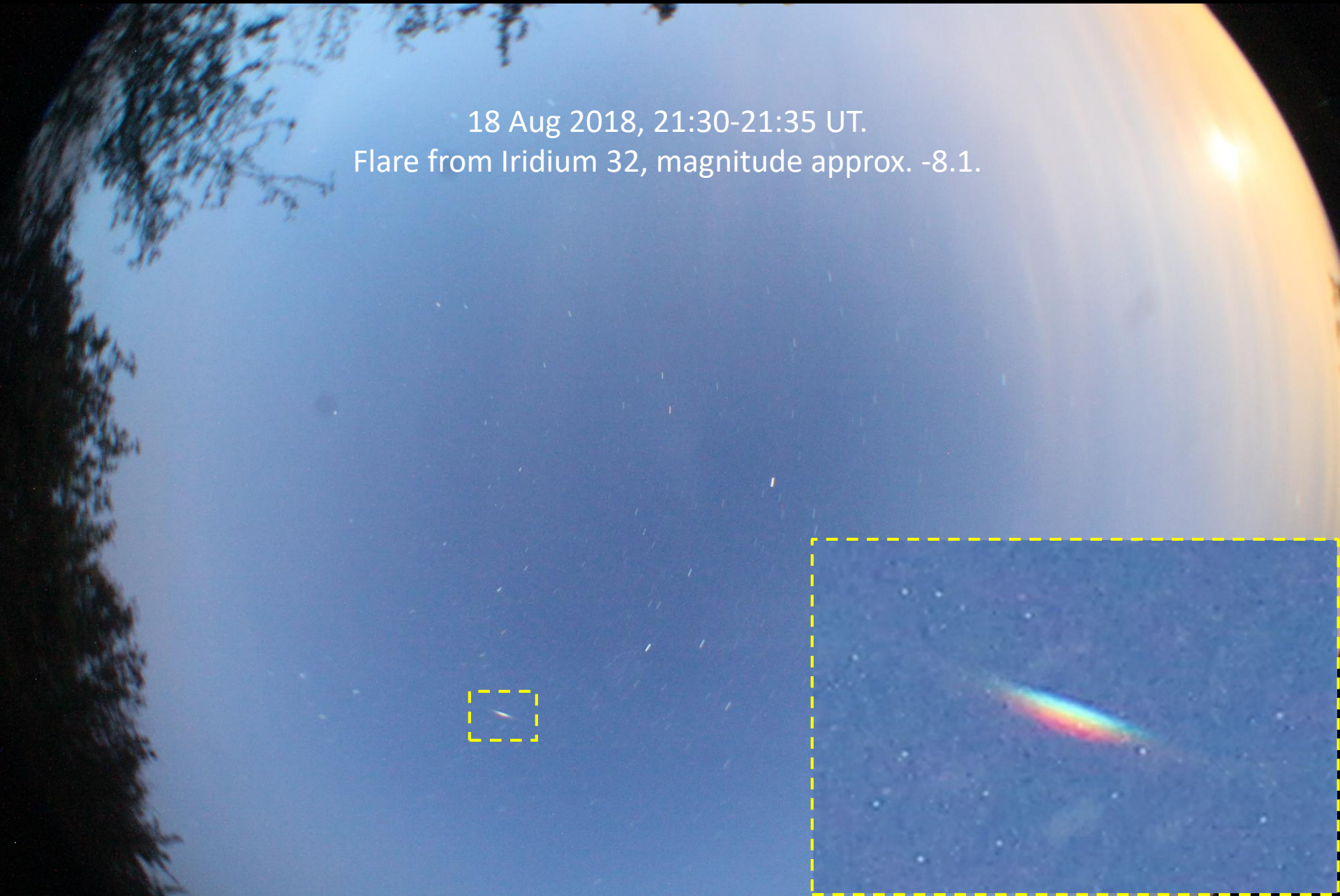


Typical Iridium flare

31

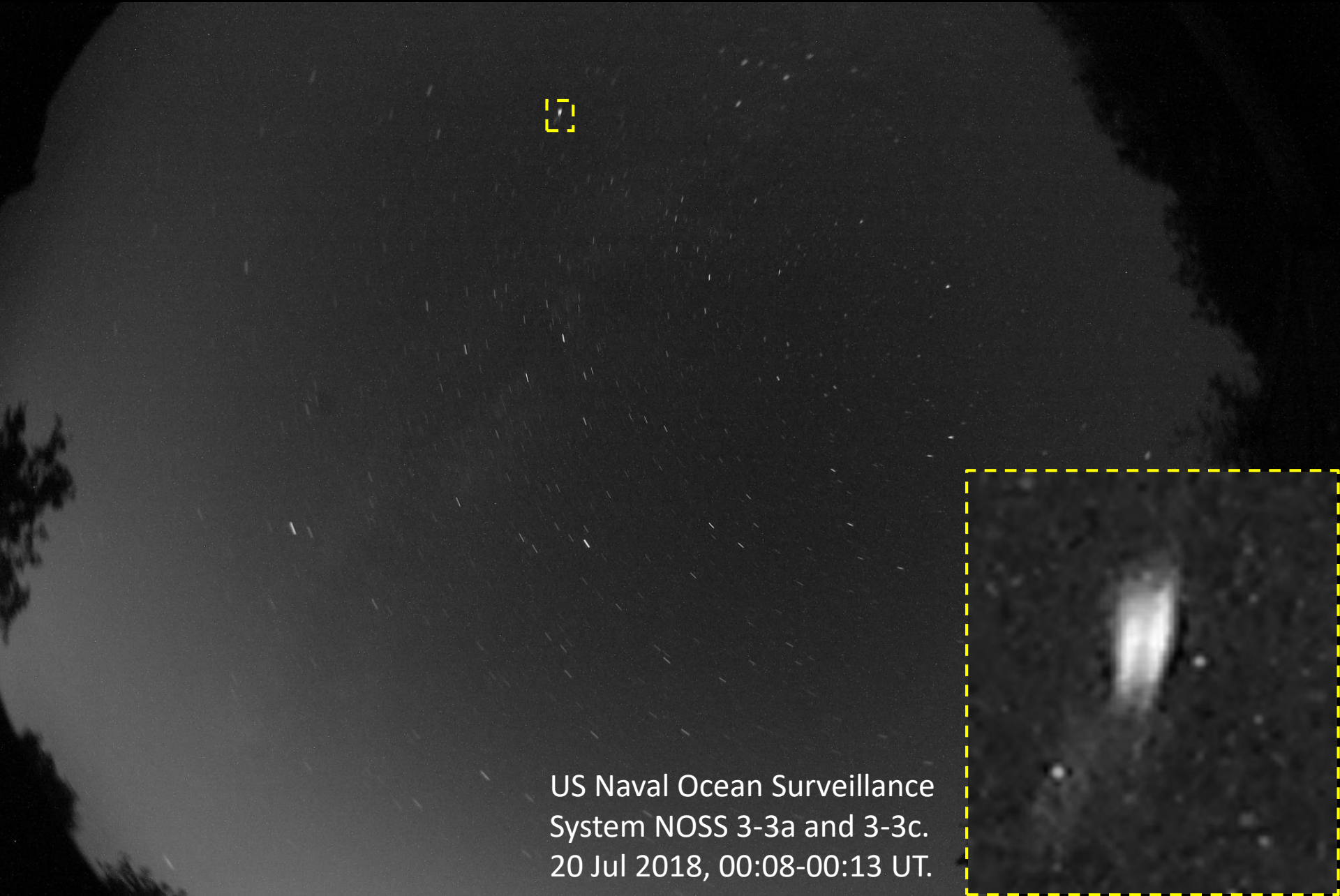
18 Aug 2018, 21:30-21:35 UT.

Flare from Iridium 32, magnitude approx. -8.1.



Spy satellite

32



US Naval Ocean Surveillance
System NOSS 3-3a and 3-3c.
20 Jul 2018, 00:08-00:13 UT.

Current configuration



Fireballs



08 Dec 2018, 21:10-21:12 UT



10 Dec 2018, 03:56-03:58 UT



12 Oct 2018, 05:38-05:40 UT



31 Jan 2019, 03:02-03:04 UT

Collaboration (again), 2019

15 Feb 2019 20:07 - 20:09 UT

Grundisburgh



Ermelo, the Netherlands

2019-02-15 20:09 UT: Sporadic fireball $M_v = -6$
LC Shutter: 10 br/s
EN-98 Ermelo NL
05°17'20"
52°36'44"



UK collaboration

36

30 Mar 2019
Grundisburgh,
03:51 – 03:53 UT



Wilcot, Wiltshire
03:52:09 UT

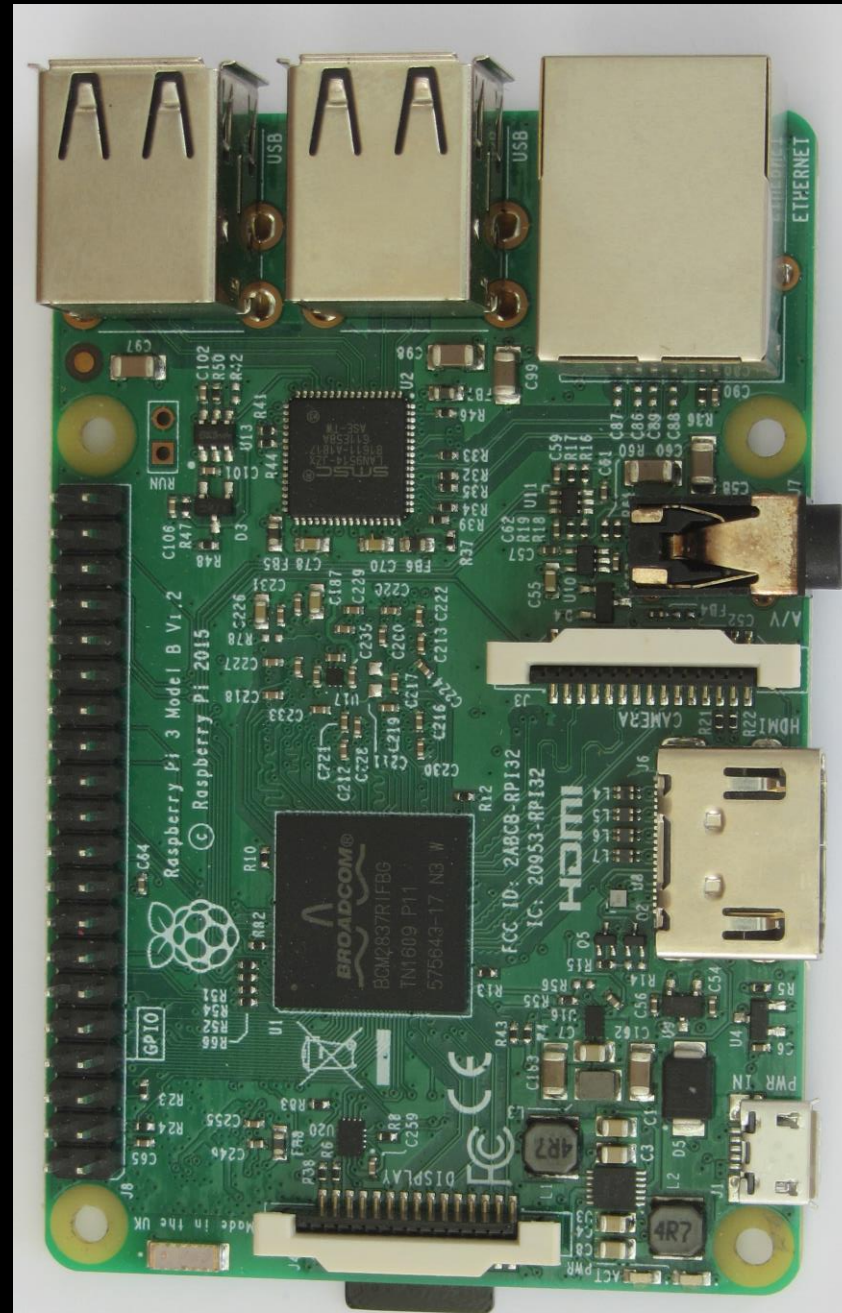


Dr Appleton...

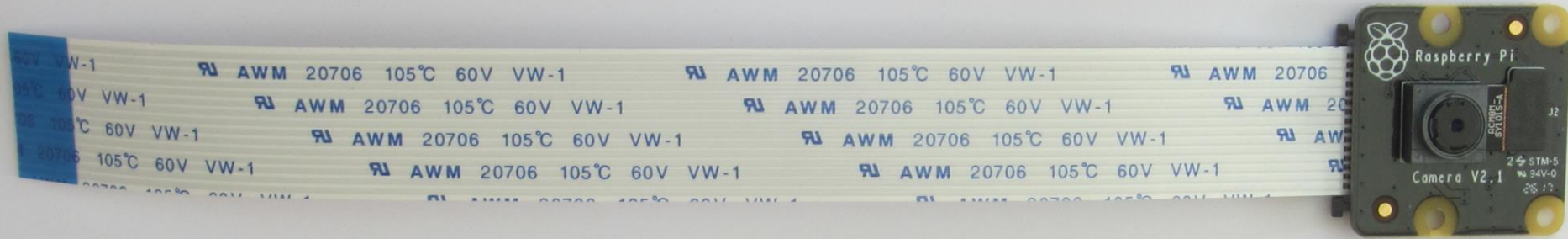
Raspberry Pi

Model 3B specification

- **SoC:** Broadcom BCM2837
- **CPU:** 4× ARM Cortex-A53, 1.2GHz
- **GPU:** Broadcom VideoCore IV
- **RAM:** 1GB LPDDR2 (900 MHz)
- **Networking:** 10/100 Ethernet, 2.4GHz 802.11n wi-fi
- **Bluetooth:** Bluetooth 4.1 Classic, Bluetooth Low Energy
- **Storage:** microSD
- **GPIO:** 40-pin header, populated
- **Ports:** HDMI, 3.5mm analogue audio-video jack, 4× USB 2.0, Ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI)
- **Cost:** £34



PiCamera



Camera v2 specifications

- Sensor: Sony IMX219, CMOS
- Size: 3.7 x 2.8 mm (4.6 mm diag)
- Resolution: 3280 x 2464 px, 8.1Mpx
- Output: 10 bits
- Sensitivity: up to ISO 800
- FL: 3.0 mm
- F-number: 2.0
- Frame rate: 0.1 - 15 fps (90 fps for sub-frames)
- FoV: 62.2° x 48.8°
- Shutter: rolling
- IR filter: removed
- Cost: £24

Inside the camera box



On the other side...

Dew heater
resistors

Camera
chip

DC
input
socket



03/11/2018 16:00

Ready for use...



Aries

Cassiopeia

Andromeda

Triangulum

Double
Cluster



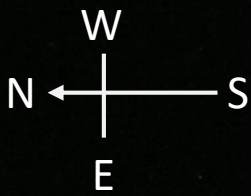
Pleiades

Camelopardalis

Perseus

Taurus

Auriga



Typical image

00:47:12 on 04 Nov 2018

Aircraft trails

44

31 Mar 2019



Satellites

26 Feb 2019

05:00:04 -

05:01:05

Unidentified

18 Mar 2019

04:34:52 -

04:35:33

Cosmos 2184
rocket

28 Mar 2019

19:59:48 -

20:00:40

ISS

18 Mar 2019, 03:13:48

45

Unidentified



28 Mar 2019

21:47:19

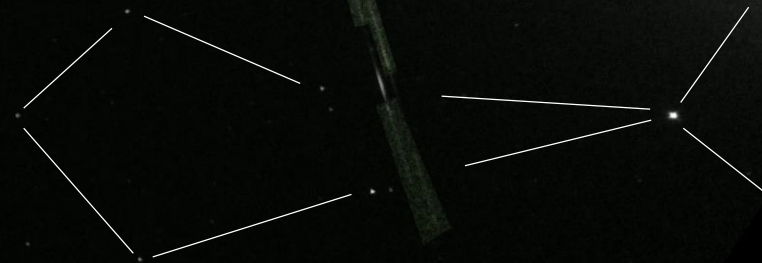
Unidentified



29 Mar 2019

03:20:36-03:20:57

USA 238

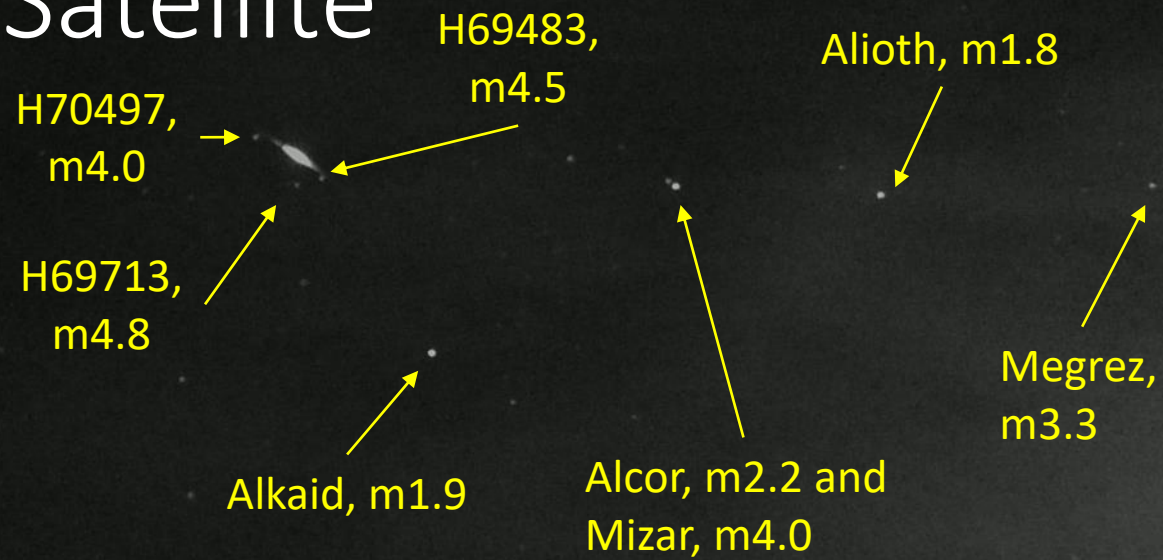


Satellite

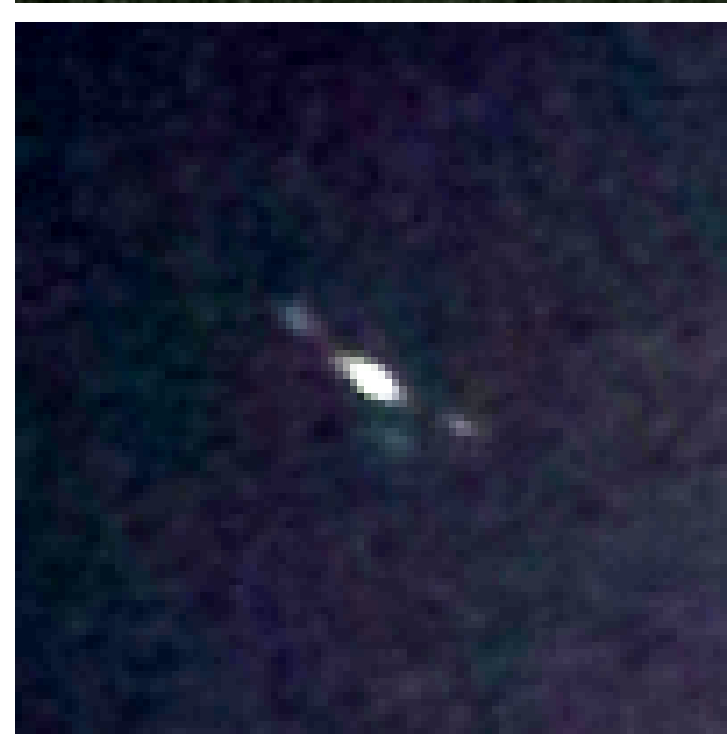
18 Mar 2019, 03:13:48

JMA

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AJS



Mystery object

28 Mar 2019, 21:47:19 – 21:47:29

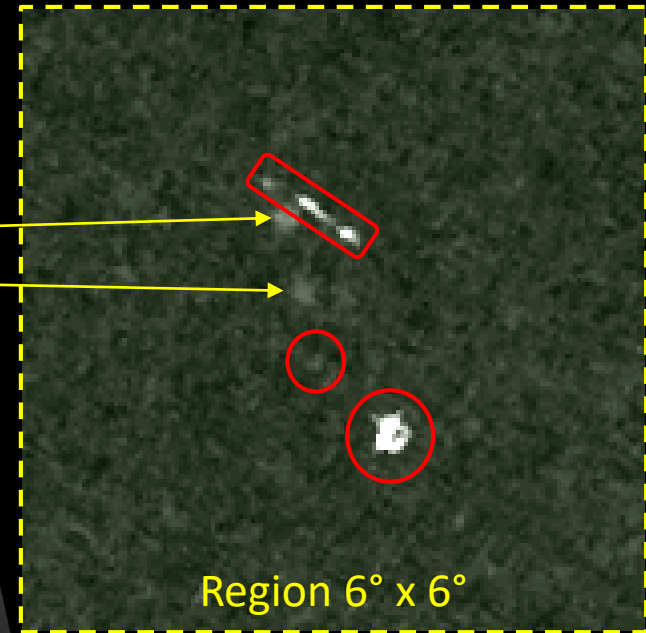


Stars:

m6.0

m6.5

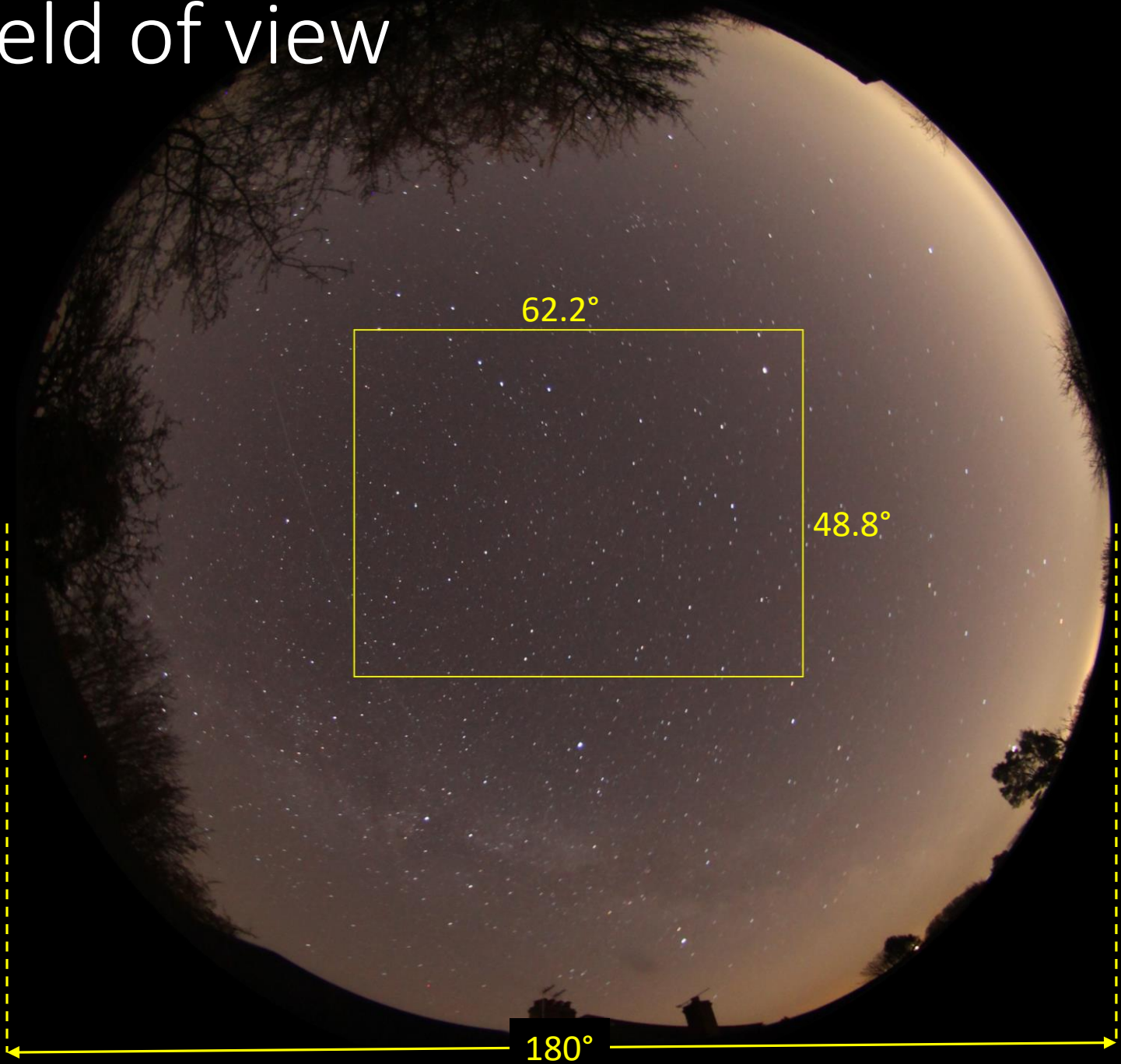
JMA



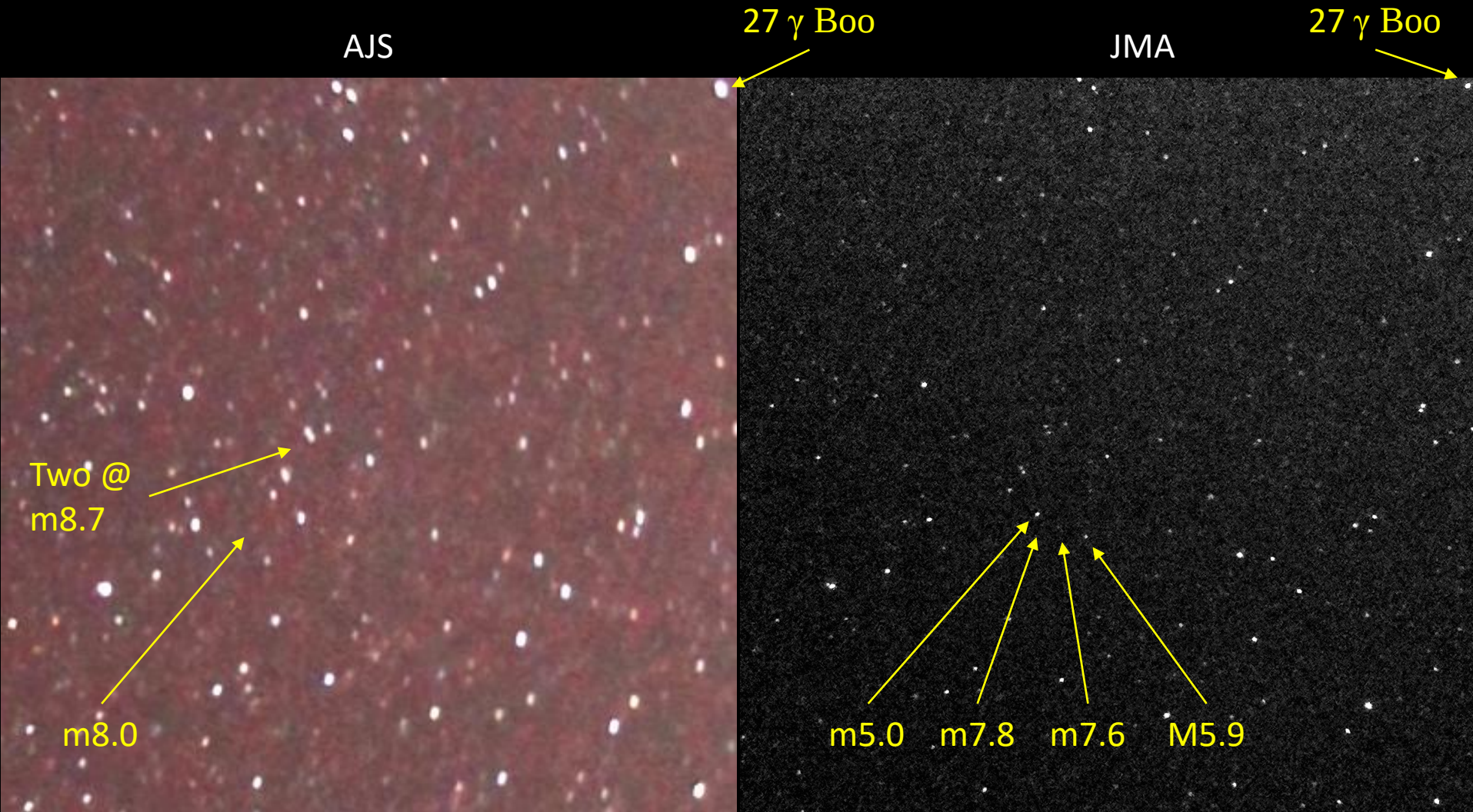
AJS



Field of view



Limiting magnitudes



Images approx 26.5° square.
Extreme contrast-stretch.
Magnitudes are Hipparcos visual.

Resolution

The Hyades

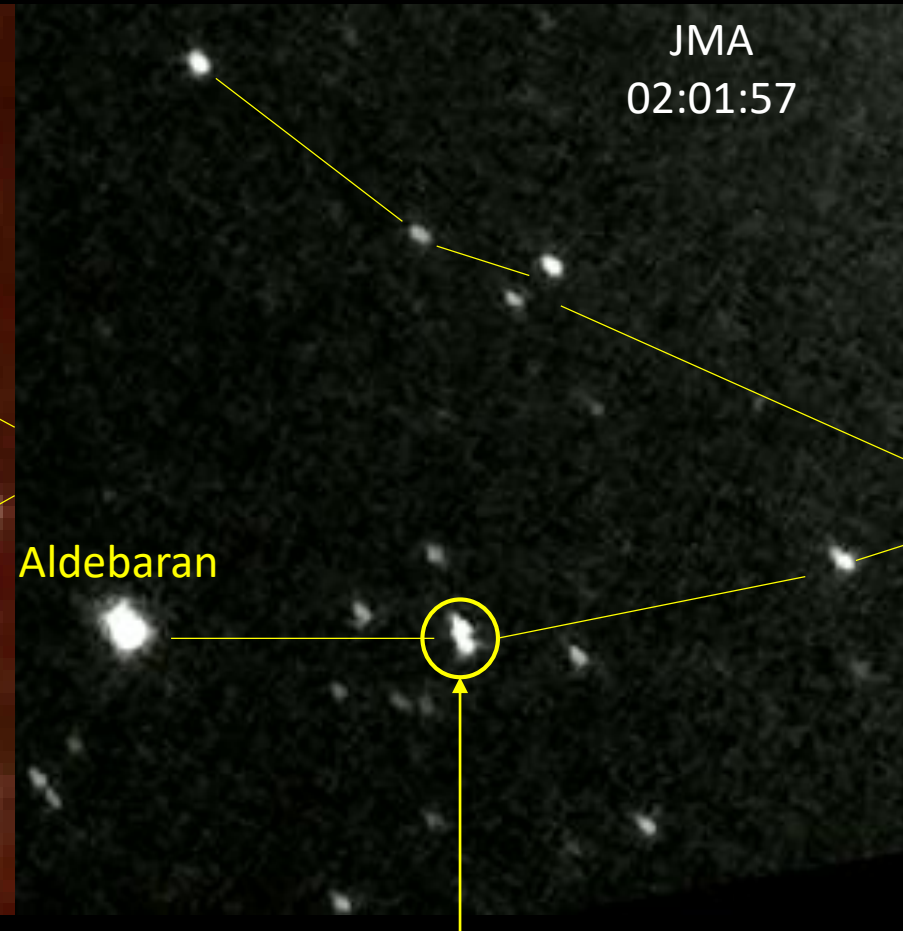
18 November 2018

FoV 180°, 2400px → 13 px/°

FoV 62.2°, 3280px → 53 px/°



Θ^1 and Θ^2 Tau, separation 0.1°



Θ^1 and Θ^2 Tau

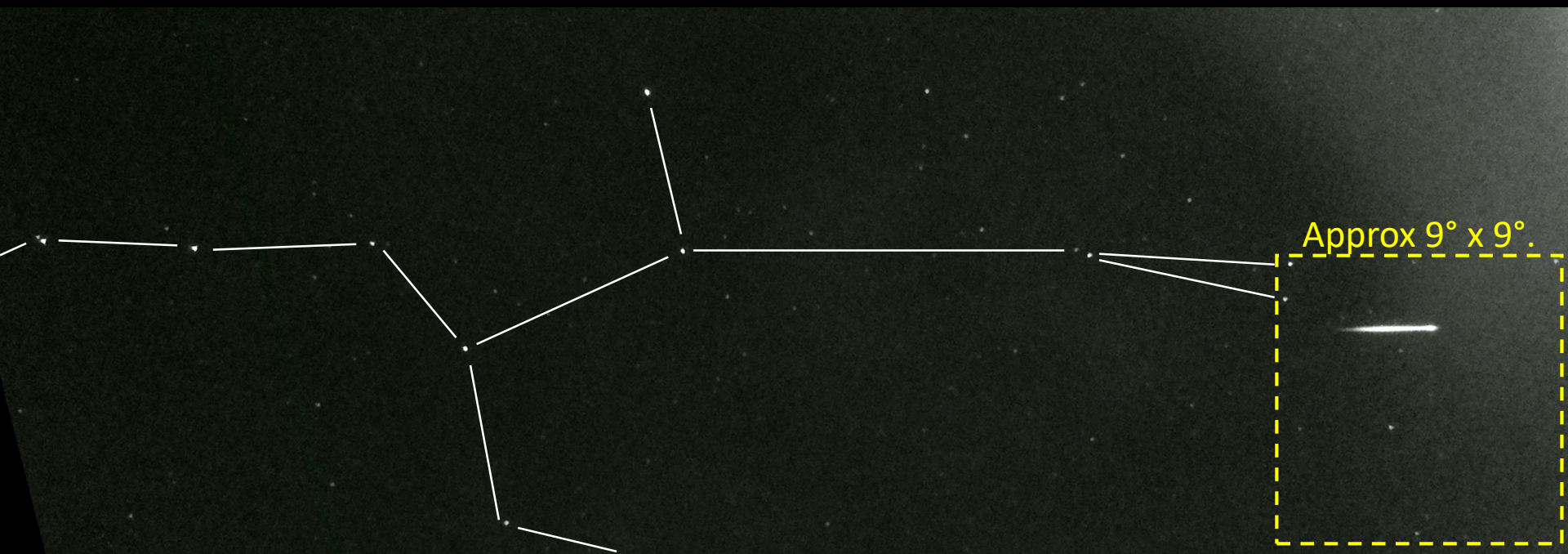
Meteor

10 Dec 2018 05:38:41

JMA

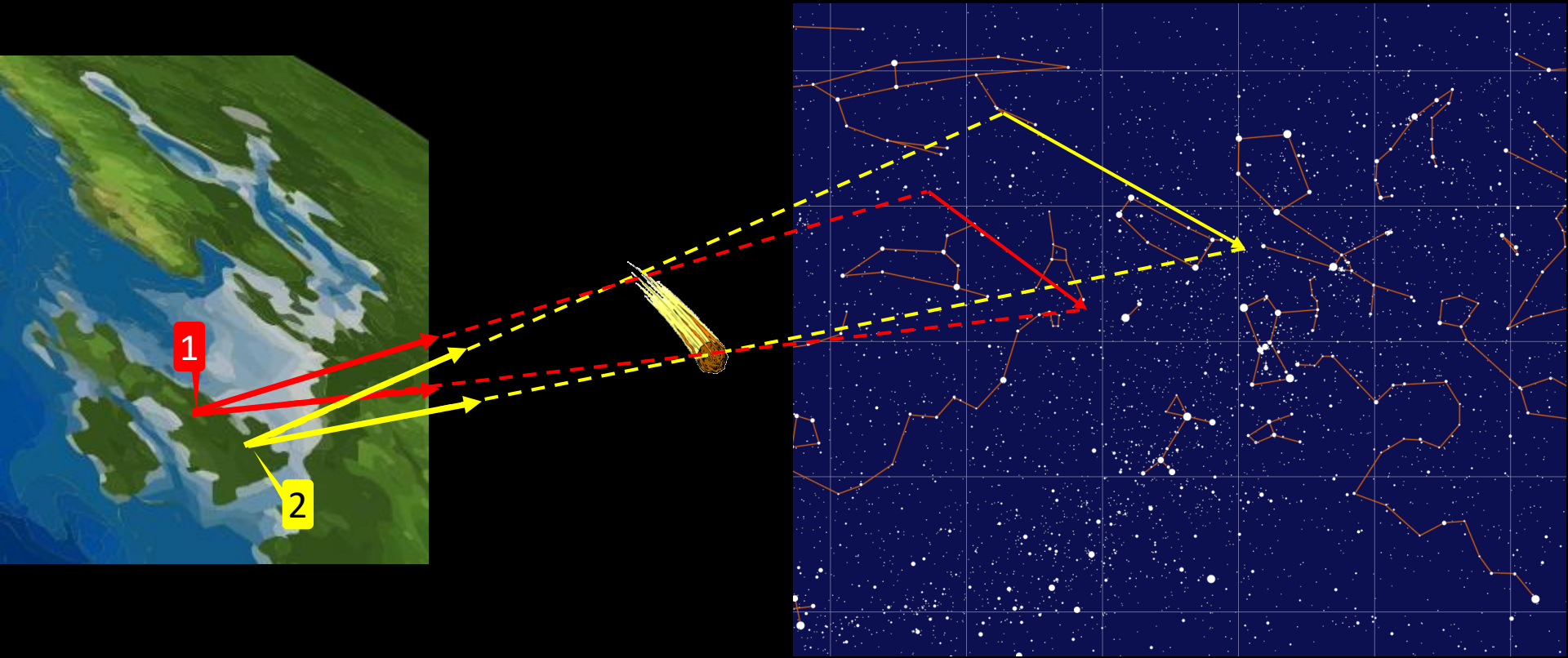
AJS

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Approx 9° x 9°.

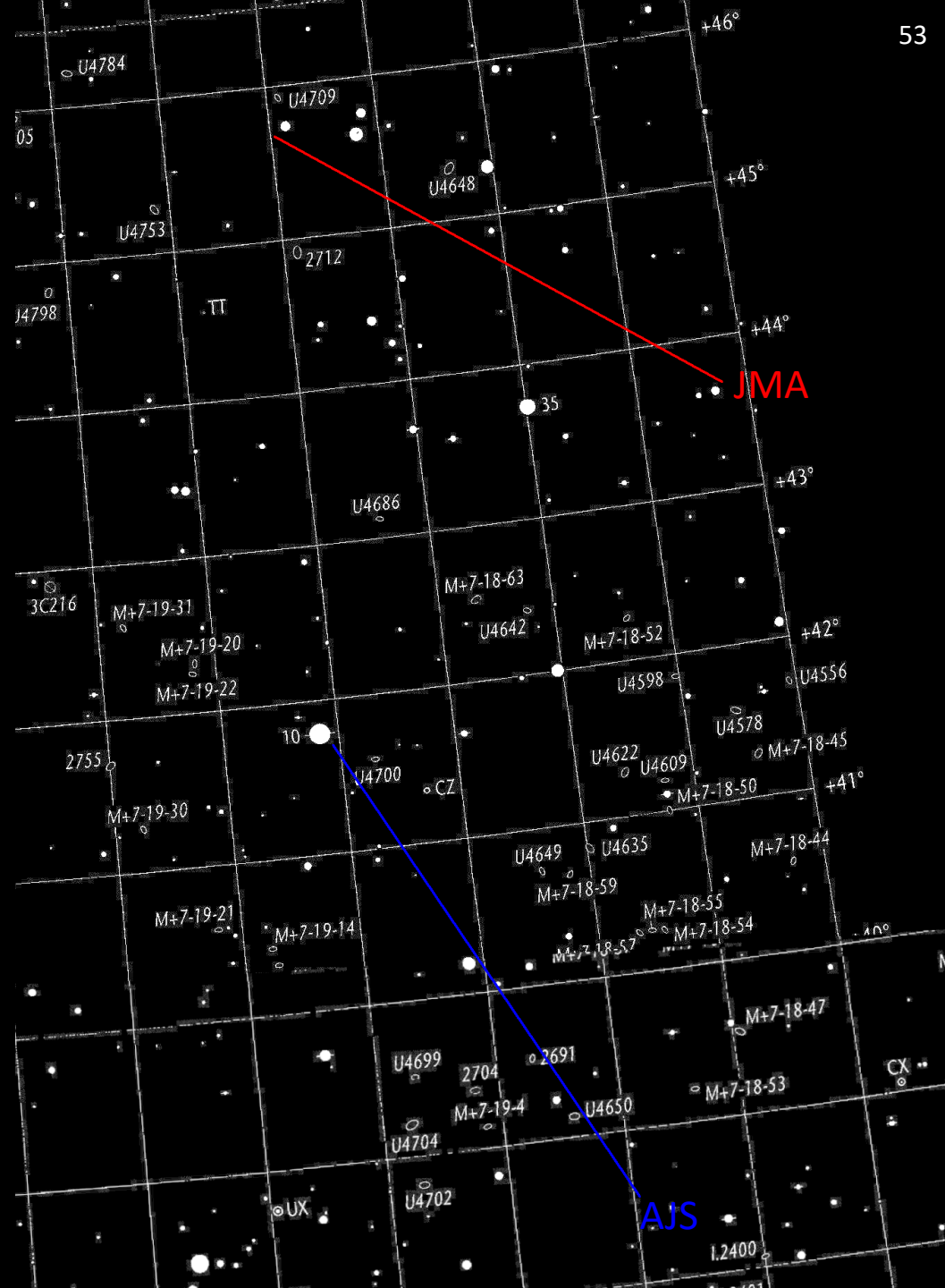
Triangulation



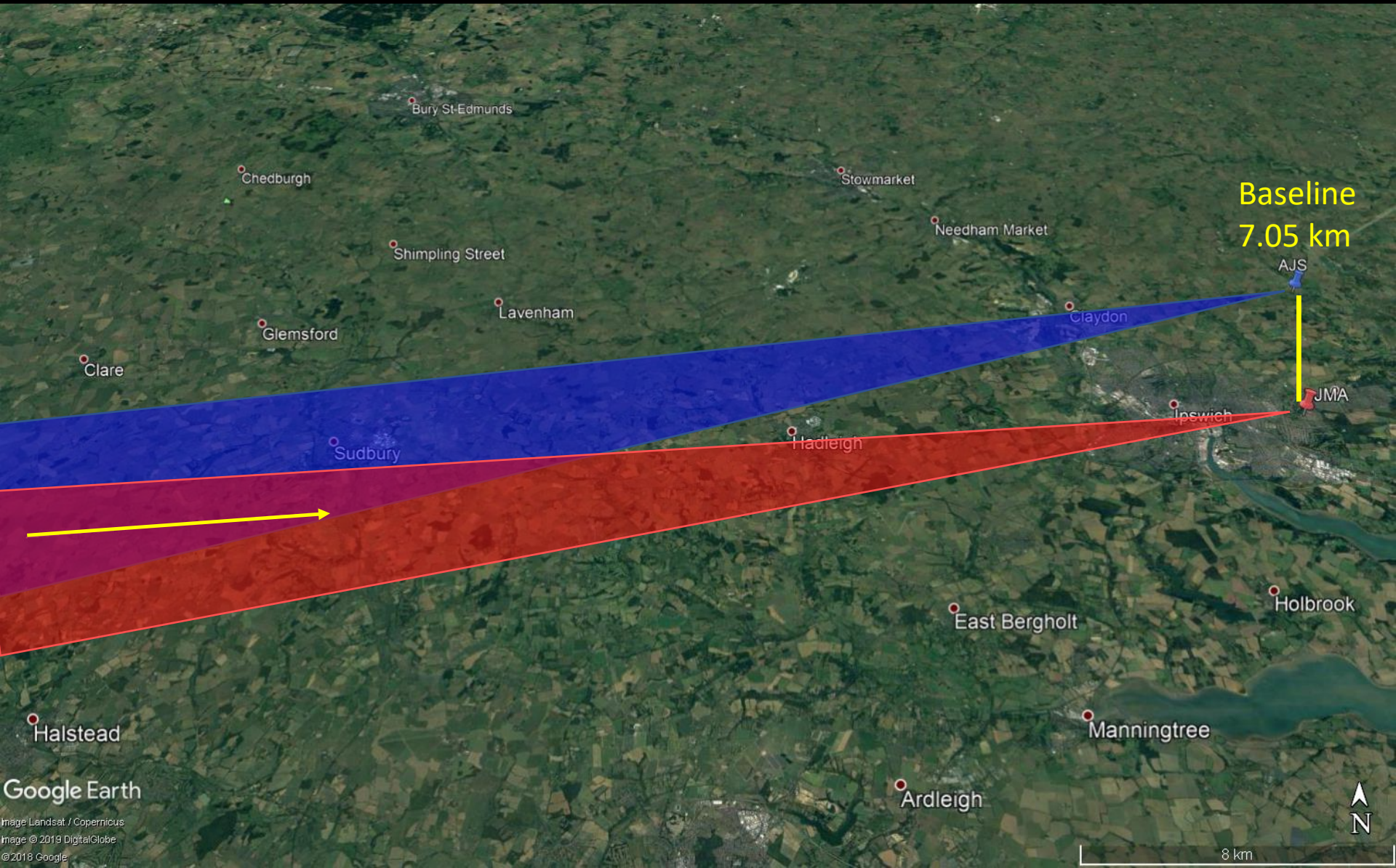
Algorithm:

1. For each observer, plot the meteor trail against the background stars.
2. Calculate, for each observer, the equation of the mean plane passing through the observer's location and containing the trail (use geocentric equatorial Cartesian coordinates).
3. Calculate the line of intersection of the two planes – this defines the trajectory of the meteor.
4. Transform to terrestrial coordinates.

Tracks 4° apart at closest point – enables reasonably accurate positional estimate.



Observer's planes



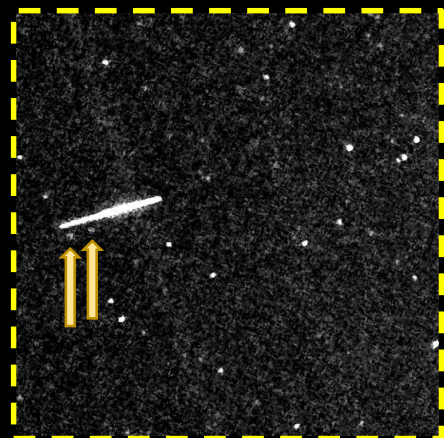
Result from triangulation



Satellite

15 Feb 2019, 03:49:25

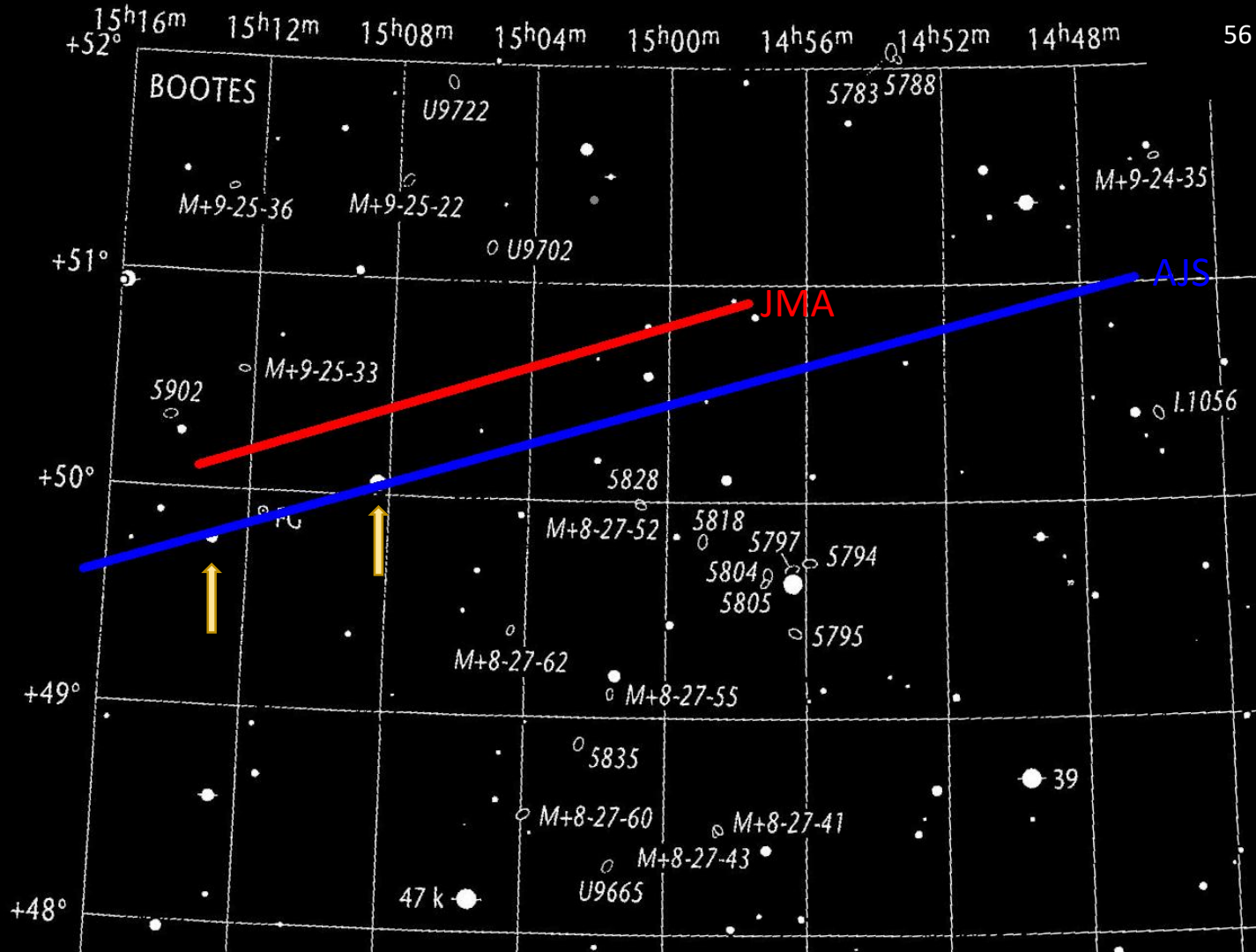
JMA



AJS



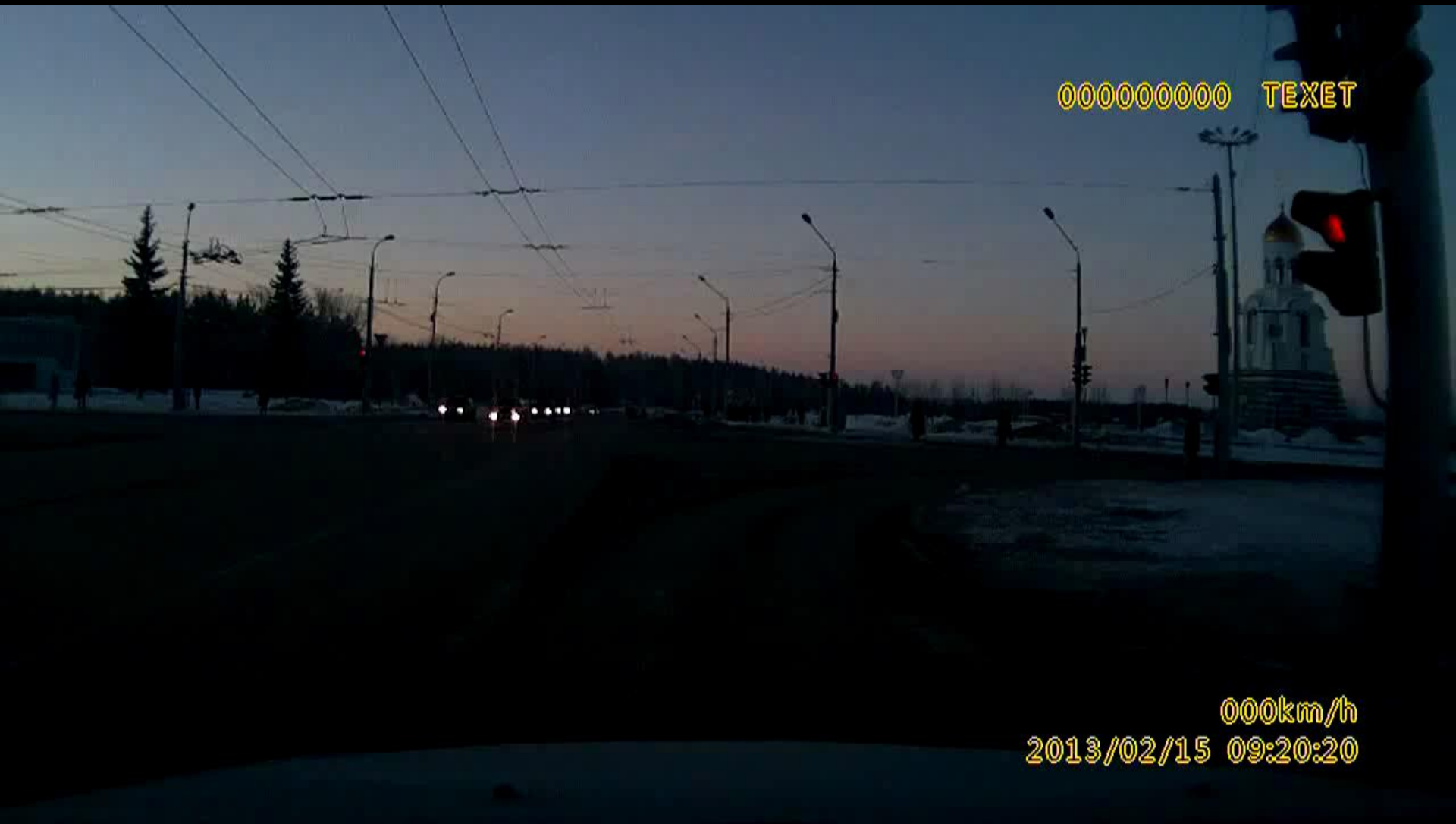
Images ~11° square.



Tracks are approx. 0.3° apart – too close for accurate estimate.
Altitude estimate ~1000 km.
Unidentified satellite.

Chelyabinsk meteor, 15 Feb 2013

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Time- lapse

28 Mar 2019, 19:13 to
29 Mar 2019, 04:44.
3350 frames @ 10 s.
Playback 25 fps.
Acceleration 250x.

Time-lapse



17 Nov 2018, 17:47 -
18 Nov 2018, 06:18.
299 frames @ 150 s.
Playback 5 fps.
Acceleration 750x.

*Thank you,
and any questions?*