A NEW TECHNIQUE FOR MEASURING LOW S/N EVENTS IN PYMOVIE / PYOTE

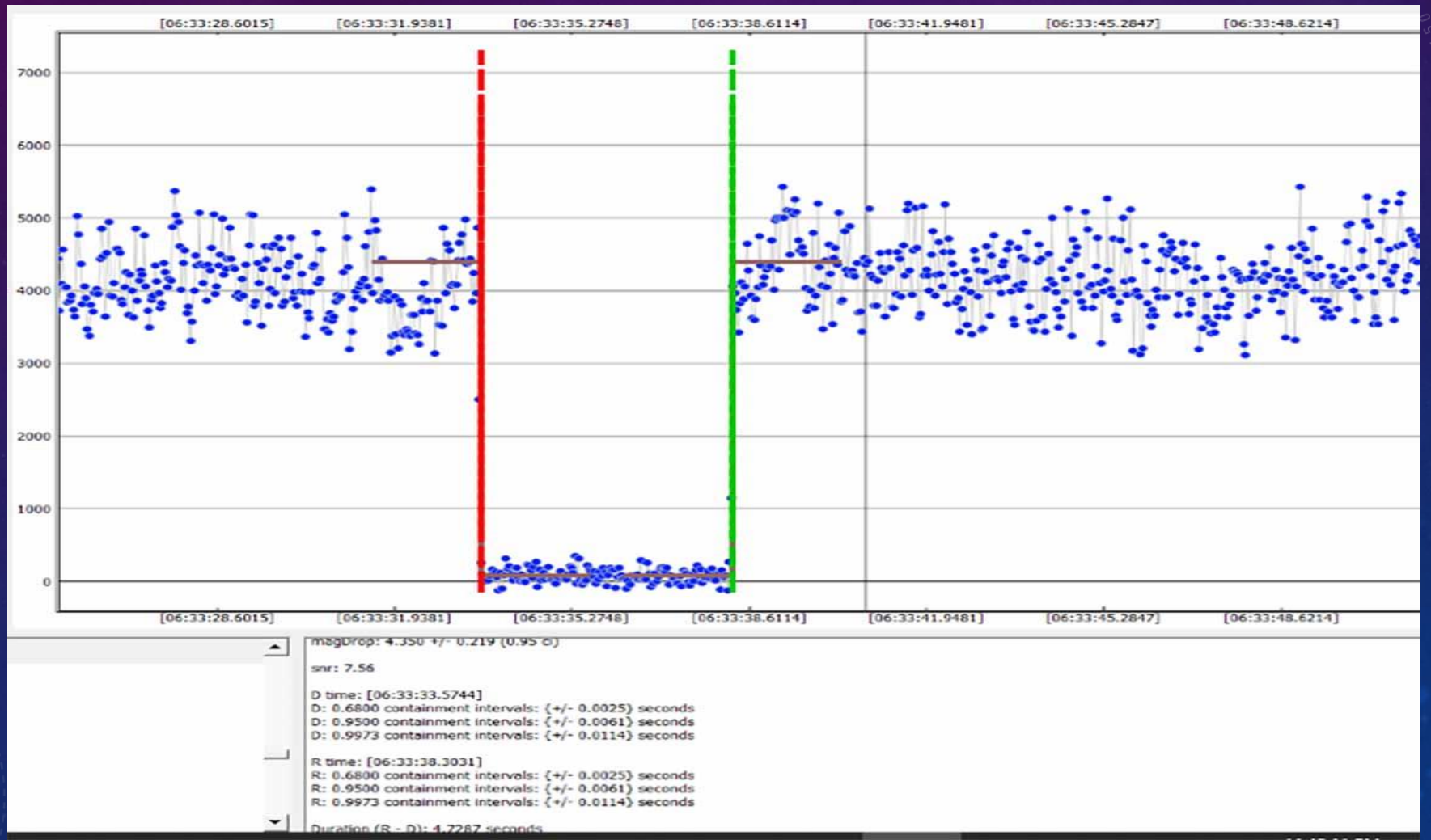
RICHARD NOLTHENIUS
CHAIR, ASTRONOMY DEPT
CABRILLO COLLEGE, CA.

A PRESENTATION AT THE 2022 SUMMER MEETING OF
THE INTERNATIONAL OCCULTATION TIMING ASSOCIATION
AUG 13, 2022

WITH THE RELEASE OF THE GAIA DATA DR3…

- Much higher accuracy in star positions and asteroids has meant…
- There’s a major increase in the number of events which satisfy most observers’ rank criteria
- Dealing with bright targets with deep events requires less delicate handling to preserve high accuracy timings …

MY ALKMENE EVENT OF JUNE ‘22, OF AN 8.3 MAGNITUDE STAR BY A 13TH MAGNITUDE ASTEROID, GAVE A 2-SIGMA TIMING ACCURACY OF 0.006 SECONDS. WE DON’T NEED THE NEW TECHNIQUE TO BE DESCRIBED HERE, FOR SUCH EVENTS!



BUT MUCH TOUGHER EVENTS ON MY OCCULTWATCHER LIST NOW OUTNUMBER EASY EVENTS BY 10:1 OR MORE

- Observers like me, with too much time spent either with climate change science or other stressful endeavors, find the lure of a little Astro Get-Away good for the psyche… to grab an asteroid occultation, and get under dark skies, to be with science and equipment... is a tonic for the soul!
- **I can be so tempted, I may over-reach. But then…**

A man's reach should exceed his grasp, else what's a Heaven for?

-Browning

THE IOTA OCCULTATION AUDITOR'S HAVE LEARNED TO SIGH, AT DEALING WITH MY FAINT TARGETS. AND SO… HERE'S MY THOUGHTS ON HOW TO IMPROVE DETECTION

- For some events, it may be enough to just confirm there really was an occultation, if the path uncertainty is high.
- Highly accurate times may be less important.
- This may be especially true for KBO's and Centaurs, where time accuracies to a second or two may still be quite valuable in improving the orbit and future occultation predictions.

THIS NEW TECHNIQUE I'LL DESCRIBE IS SUITED ESPECIALLY FOR THE FOLLOWING SITUATIONS:

- 1. Bright moon nearby, so sky brightness is high
- 2. Deep twilight instead of full darkness
- 3. City light pollution
- 4. Faint targets which otherwise are barely above "sky" background

LAST WEEK'S 8/9/22 OCCULTATION BY QUAOAR WILL PROVIDE A GOOD EXAMPLE… A 15.3 MAG STAR 12 DEGREES FROM THE NEAR FULL MOON… ON AN 8" CELESTRON 8SE TELESCOPE

PyMovie ALREADY HAS CODING FOR MAKING "FINDERS" TO BETTER POSITION TRACKING AND TARGET APERTURES

- Let's use this coding to produce a series of 'finders' in time
- Each 'finder' will be be as long as necessary to positively ID the target star
- Each 'finder' will already be saved as a CCDOPS FITS file and have the image of the VTI time on the first frame of the 'finder'

BUT WHY RESORT TO ‘FINDERS’? WHAT’S WRONG WITH JUST INCREASING THE INTEGRATION SETTING TO BRING OUT FAINT TARGETS?

- **For targets barely above the ‘sky’, increasing the integration time is not a good strategy**
- Why? Because upping the integration makes the sky brighten as well, and for an integration in which the star is bright enough to see, it’s still lost in the sky brightness.
- Otherwise, though, Dave Herald points out the value of using higher integrations: The noise in an image is composed of not only the Poisson noise (“shot noise”) of the pixel’s finite integration time and photon arrival times, but also the read-out noise and A/D conversion accuracy. It pays to minimize read-out noise, and integrating cameras do this. In the case of stars barely above “sky”, this is a problem however. Hence, my proposed new idea of ‘finders’.

BUT A ‘FINDER’, RATHER THAN ADDING TOGETHER FRAMES LIKE AN EXPOSURE INTEGRATION SETTING, IT AVERAGES TOGETHER FRAMES, THUS KEEPING PIXELS BELOW SATURATION.

- And, PyMovie further allows the observer to re-map the brightness range black-to-white to optimally show the target against a suitable sky brightness.
- The key, is that the star’s light is on every frame of the finder, while the sky pixel frame-to-frame brightnesses are random and usually lower, so that the star then pokes more easily above the background on a ‘finder’.
- To better preserve time resolution, ‘finders’ could be made so as to overlap each other.

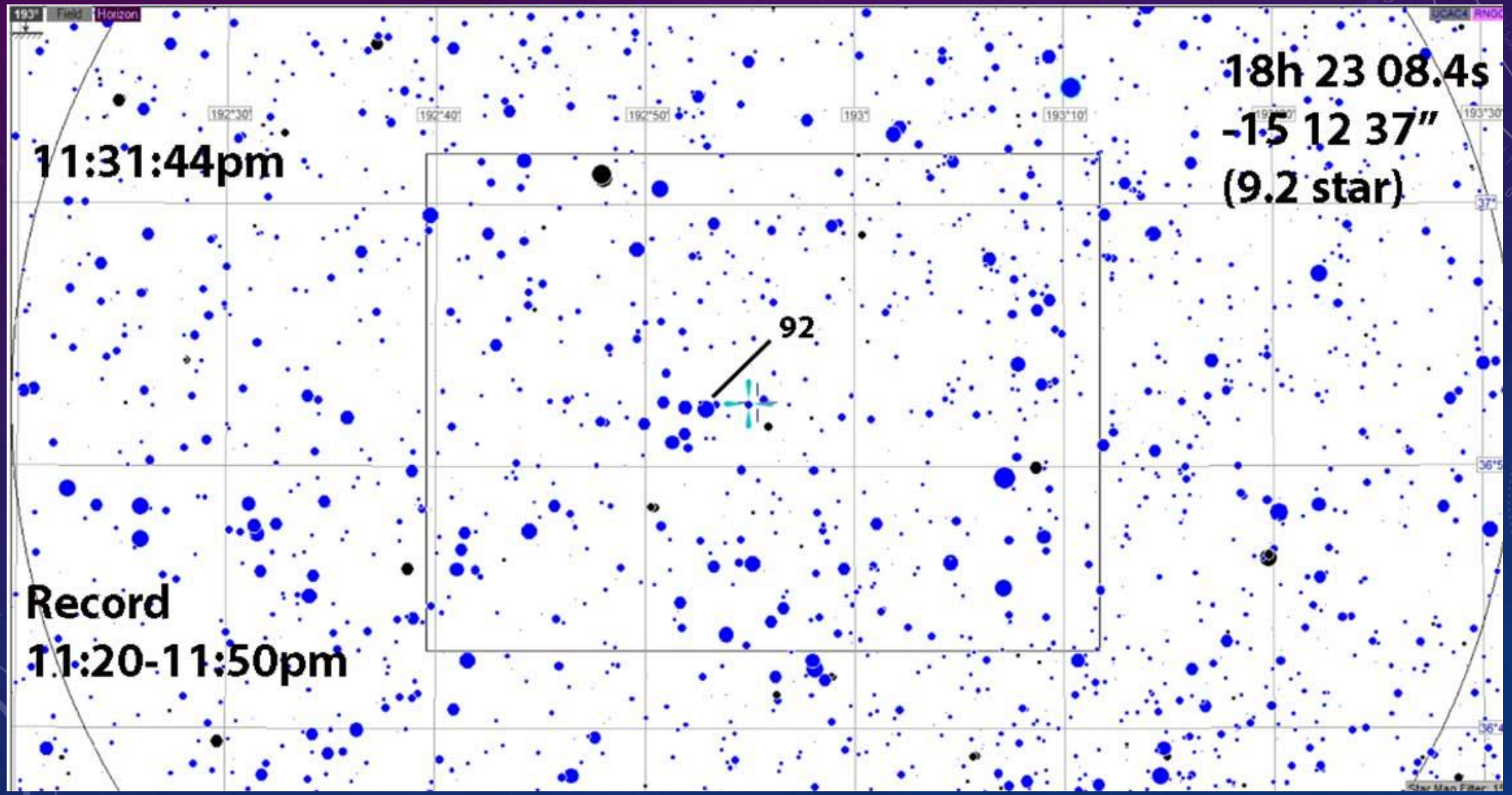
TO RECOVER TIMINGS OF EVENTS

- <u>PyMovie would need to add coding features:</u>
- Menu choices: Let observers make finders, as now, and settle on a cadence for making ‘finders’ and for a consistent brightness/contrast setting to be applied to all finders.
- PyMovie would then make a sequence of ‘finders’ from the observer’s choice of frames-per-finder, and brightness/contrast setting, and cadence in time to make the finder sequence…. and convert this sequence into an *.avi* video
- This video would then be analyzed by PyMovie with the knowledge given by the observer that this was a finder sequence with perhaps time-overlapped images. This would be a significant improvement over the competing TANGRA software, I believe.

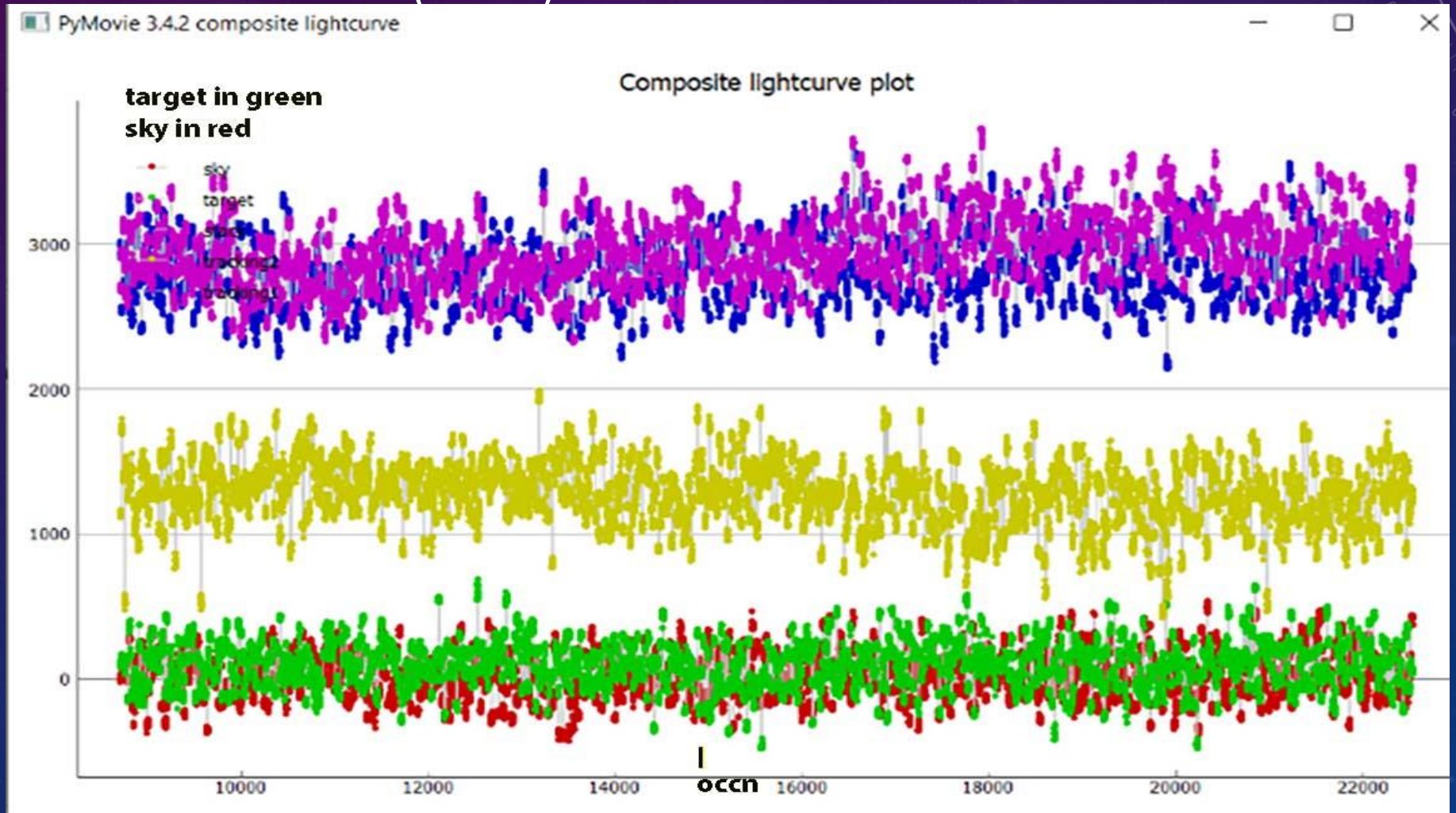
GETTING ACCURATE PHOTOMETRY WILL CLEARLY BE COMPROMISED BY THIS ‘FINDER’ TECHNIQUE

- So, this method would be best used only if main value is in identifying an occultation occurred and the D and R timings, not the accurate magnitudes during the event.
- And, if getting timings not possible with existing conventional procedures.

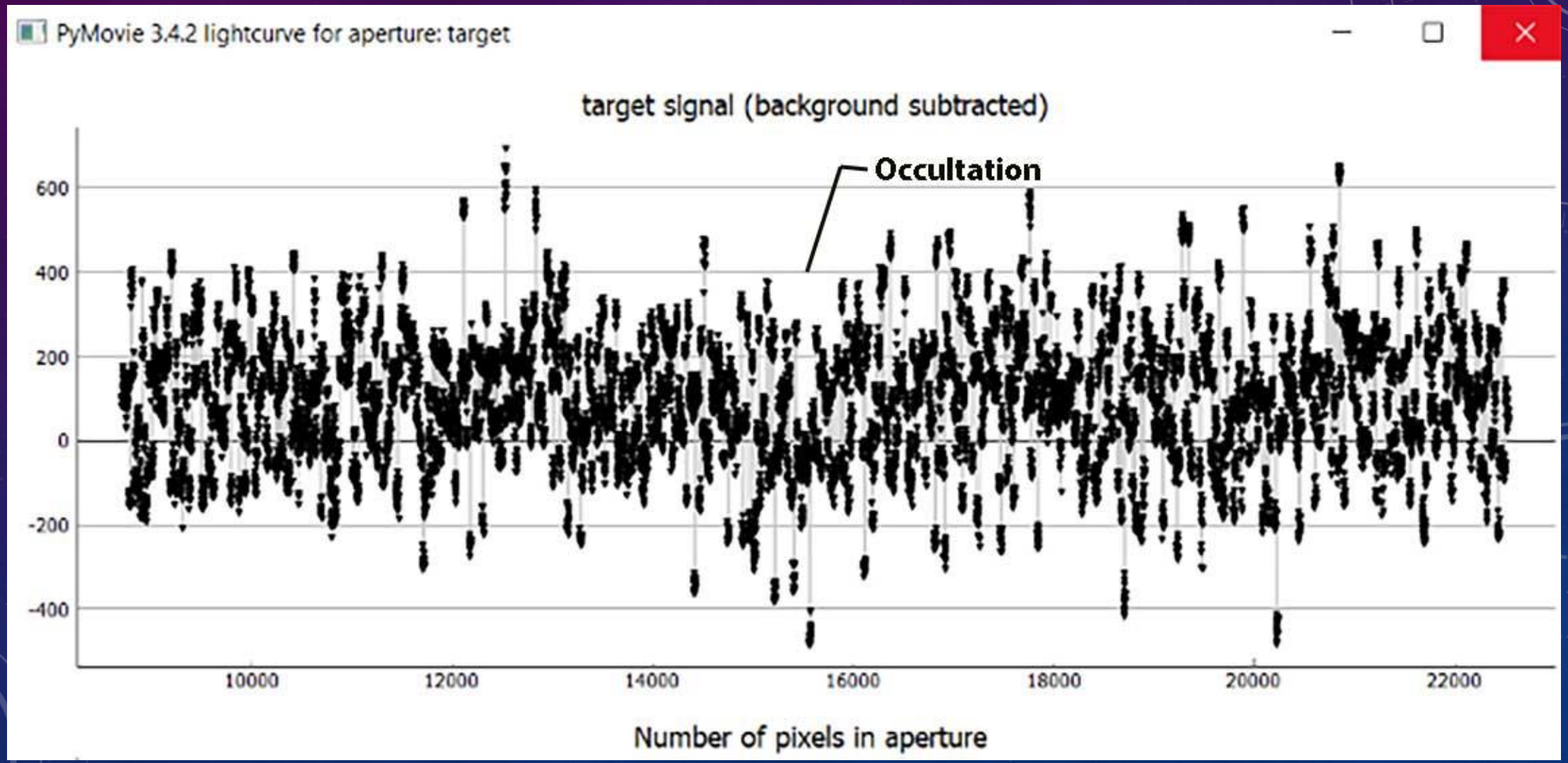
THE QUAOAR EVENT OF AUG 9, 2022 IS A GOOD EXAMPLE FOR THIS TECHNIQUE. THIS C2A MAP HAS A BLACK CROSS ON THE TARGET, INVISIBLE AT THIS MAGNITUDE PLOT LIMIT. A NEARBY STAR IS G=9.2



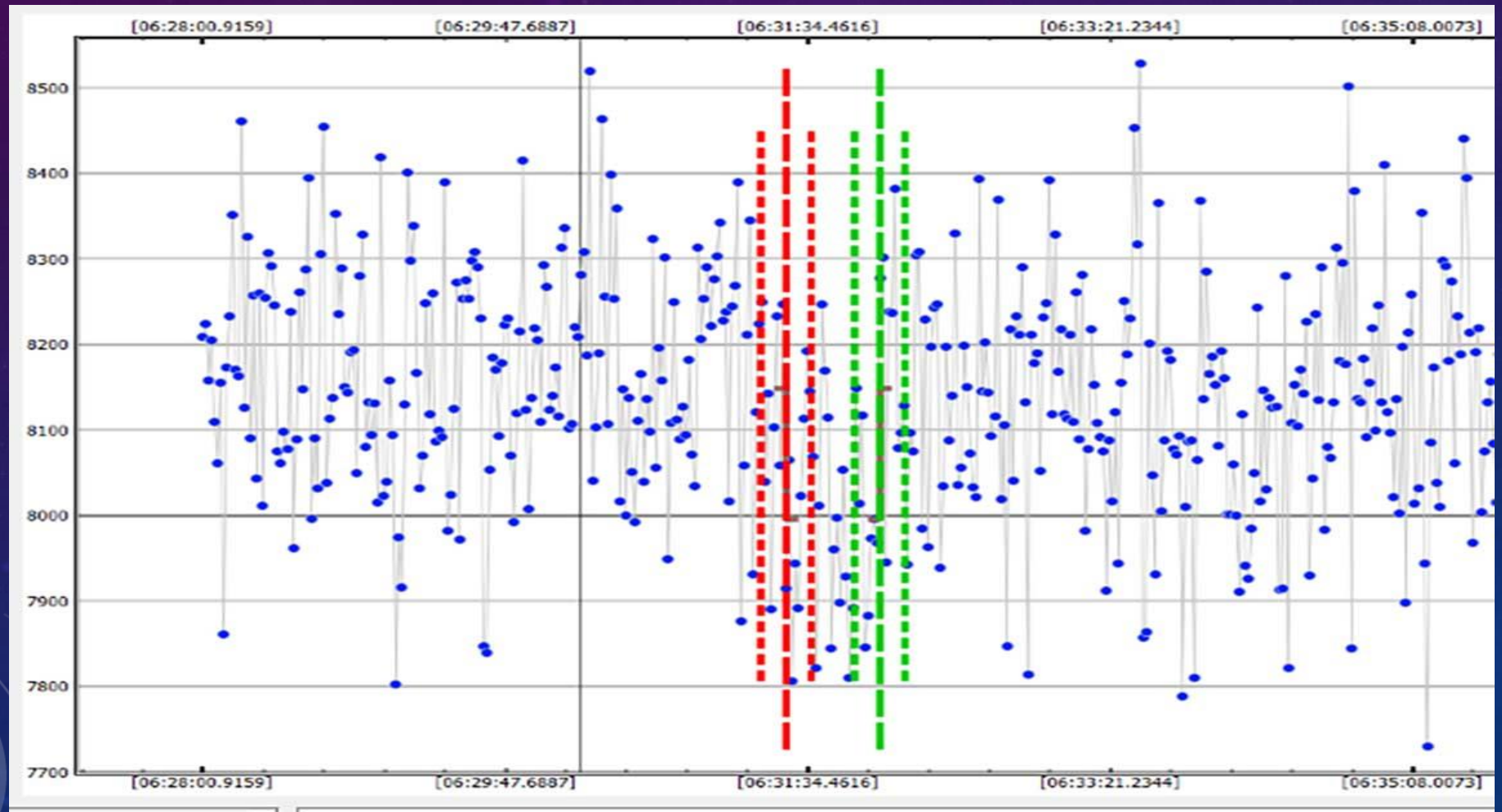
AN 89% MOON ONLY 12 DEGREES BELOW THE TARGET. TARGET AT 31 DEGREES ALTITUDE. BRIGHT SKY, AND 15.3 MAGNITUDE TARGET. AND, ONLY AN 8” F/10 TELESCOPE. QUAOAR (GREEN) IS BARELY ABOVE SKY (RED)



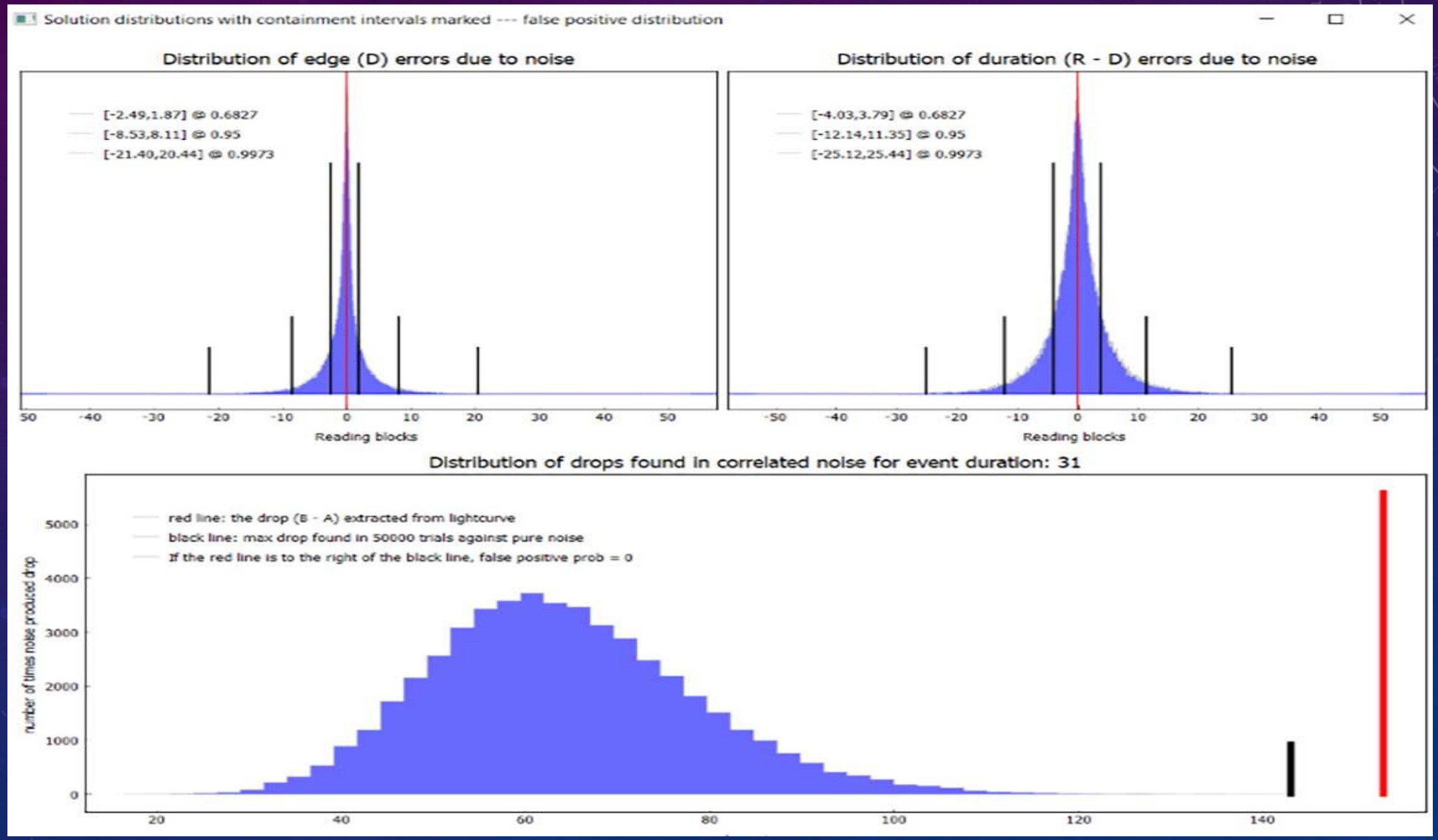
PYMOVIE, IN NORMAL MODE. OCCULTATION ON RAGGED EDGE OF DETECTION SIGNIFICANCE



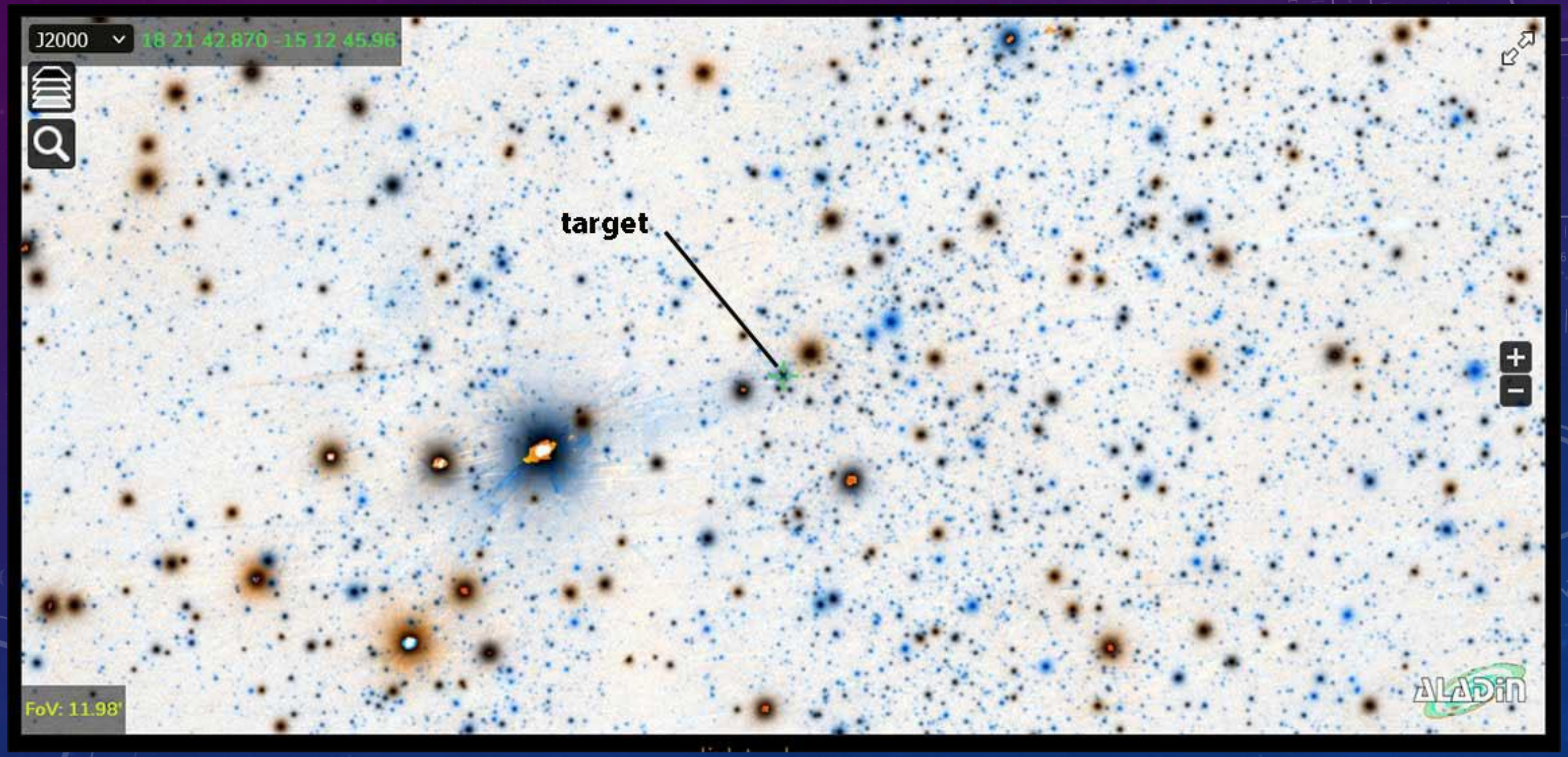
PYOTE DID FIND THE EVENT, PASSING THE FALSE POSITIVE TEST BUT ONLY WITH “APPSUM”; NO BACKGROUND SUBTRACTION DONE, AND MANUAL INTEGRATION OF 32 FRAMES (NOT THE 16 FRAMES THE WATEC SETTING USED)



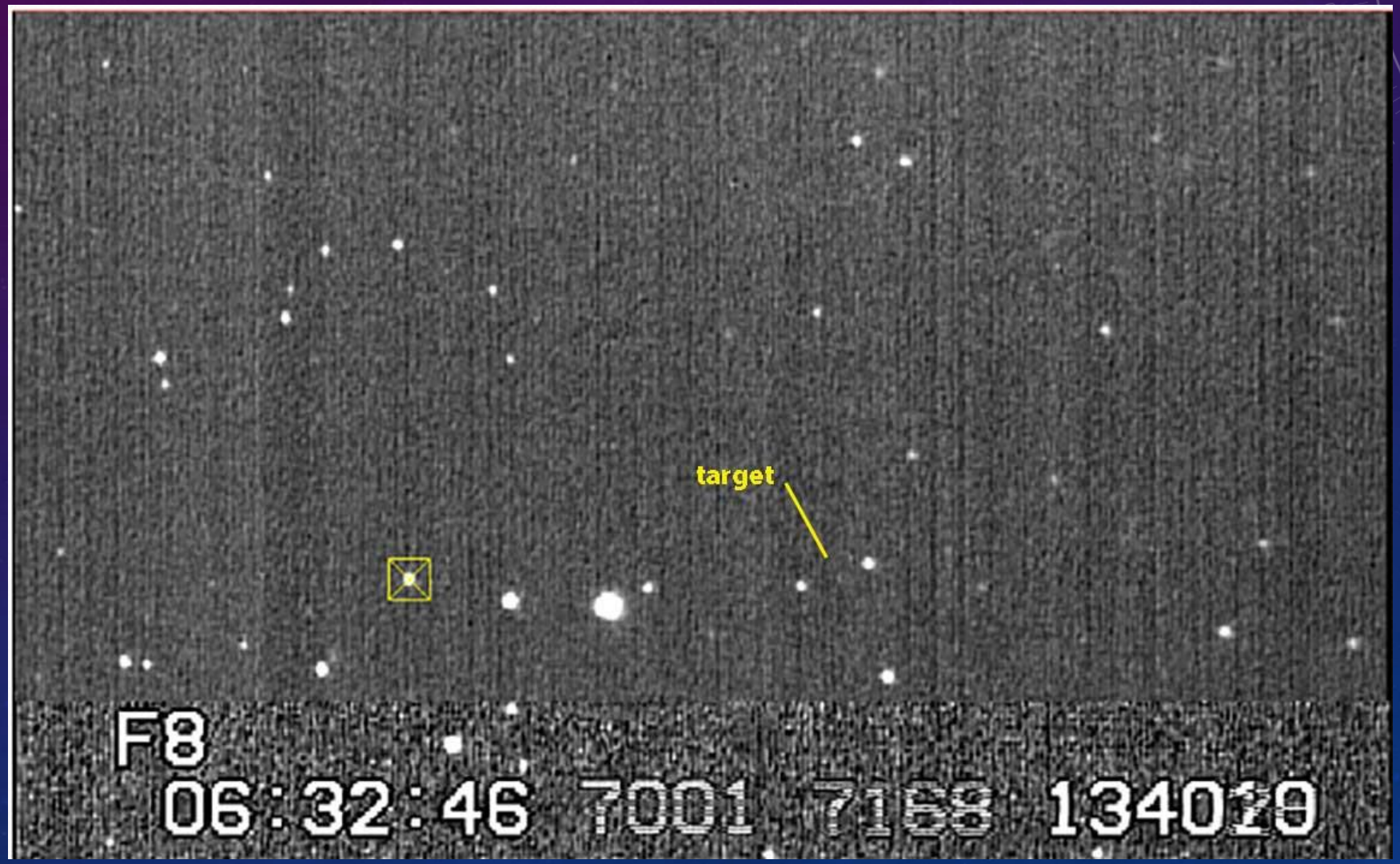
FALSE POSITIVE TEST PASSED. 33 SEC EVENT. BUT THE 2-SIGMA ERROR IN DURATION INTERVAL WAS 12 SECONDS!

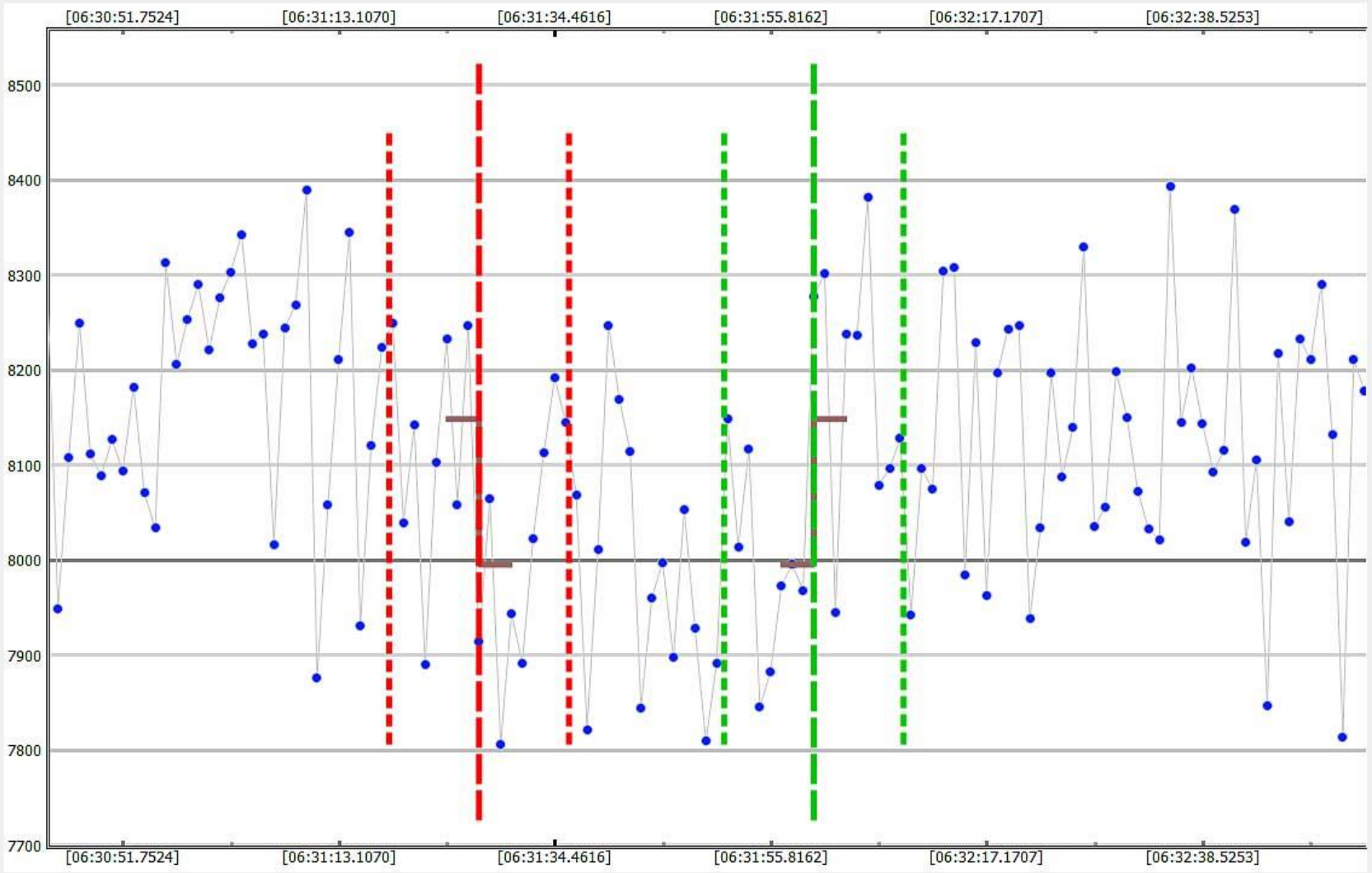


DSS IMAGE: TARGET IS DEAD CENTER, BETWEEN TWO 13TH MAGNITUDE STARS, AND ABOVE TWO OTHER ~17TH MAGNITUDE STARS



3-SECOND (96 FRAME) FINDER, A MINUTE AFTER THE OCCULTATION. BRIGHTNESS/CONTRAST SET TO 140/70

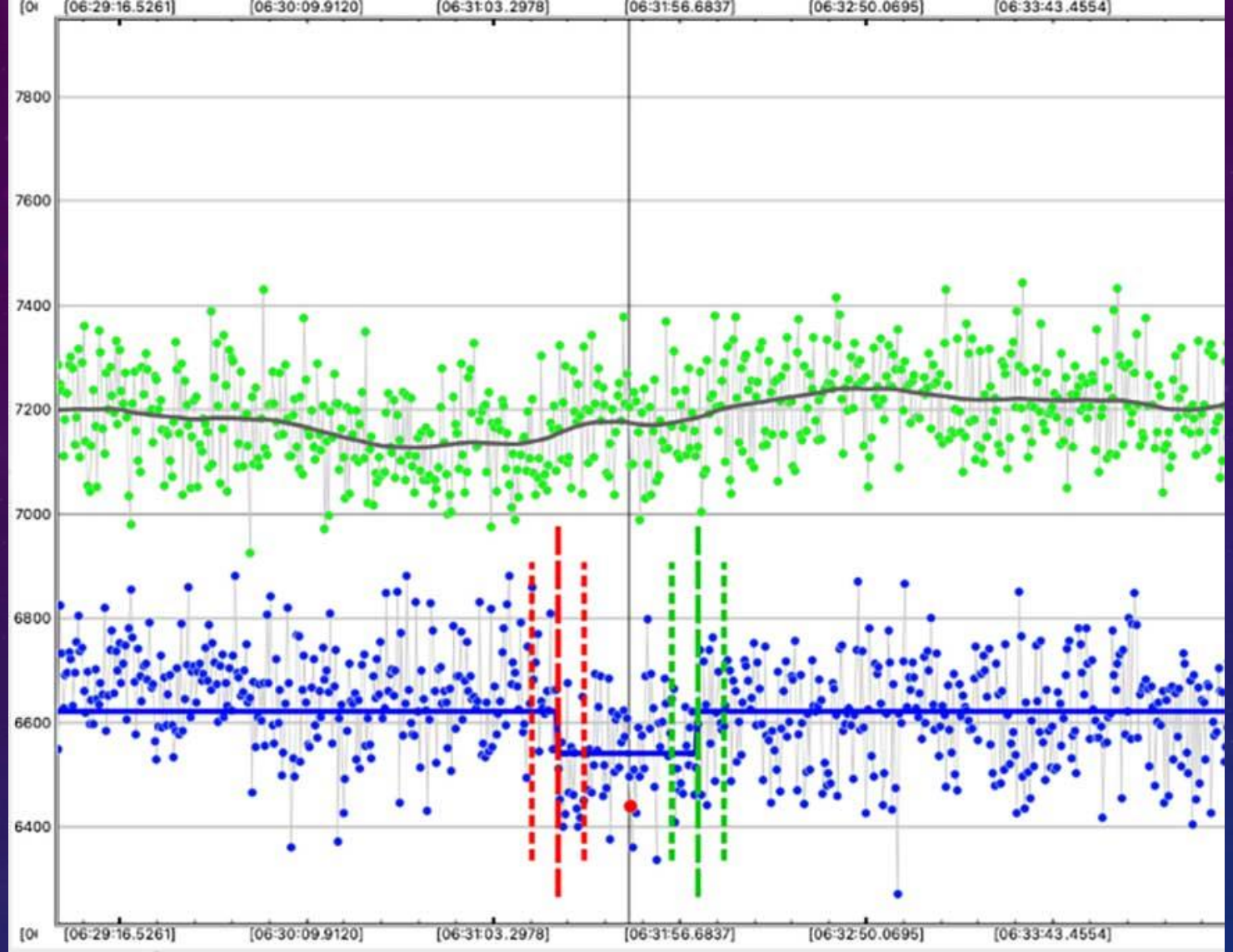





```
snr: 1.14

D time: [06:31:26.9875]
D: 0.6800 containment intervals: {+/- 2.3264} seconds
D: 0.9500 containment intervals: {+/- 8.8837} seconds
D: 0.9973 containment intervals: {+/- 22.3339} seconds

R time: [06:32:00.0871]
R: 0.6800 containment intervals: {+/- 2.3264} seconds
R: 0.9500 containment intervals: {+/- 8.8837} seconds
R: 0.9973 containment intervals: {+/- 22.3339} seconds

Duration (R - D): 33.0996 seconds
```

PYOTE'S D AND R DETERMINATION.

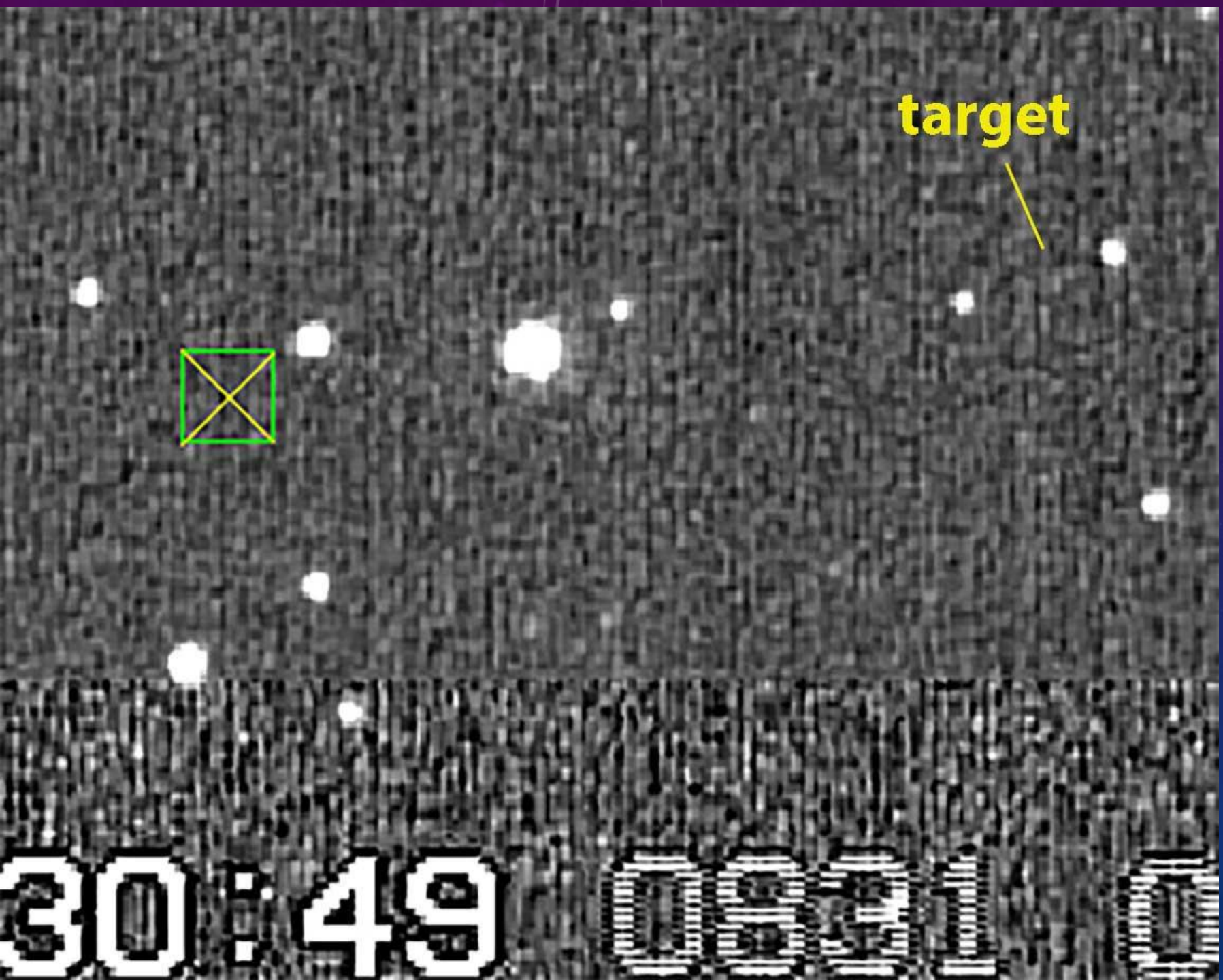
AGREED TO WITHIN ERRORS OF THE PREDICTED TIMES.




```
D time: [06:31:21.9829]
D: 0.6800 containment intervals: (+/- 2.0425) seconds
D: 0.9500 containment intervals: (+/- 7.4846) seconds
D: 0.9973 containment intervals: (+/- 18.6878) seconds

R time: [06:32:02.0223]
R: 0.6800 containment intervals: (+/- 2.0425) seconds
R: 0.9500 containment intervals: (+/- 7.4846) seconds
R: 0.9973 containment intervals: (+/- 18.6878) seconds

Duration (R - D): 40.0394 seconds
Duration: 0.6800 containment intervals: (+/- 3.6164) seconds
```

KIRK BENDER ALSO DETECTED THE OCCULTATION ON IDENTICAL EQUIPMENT.

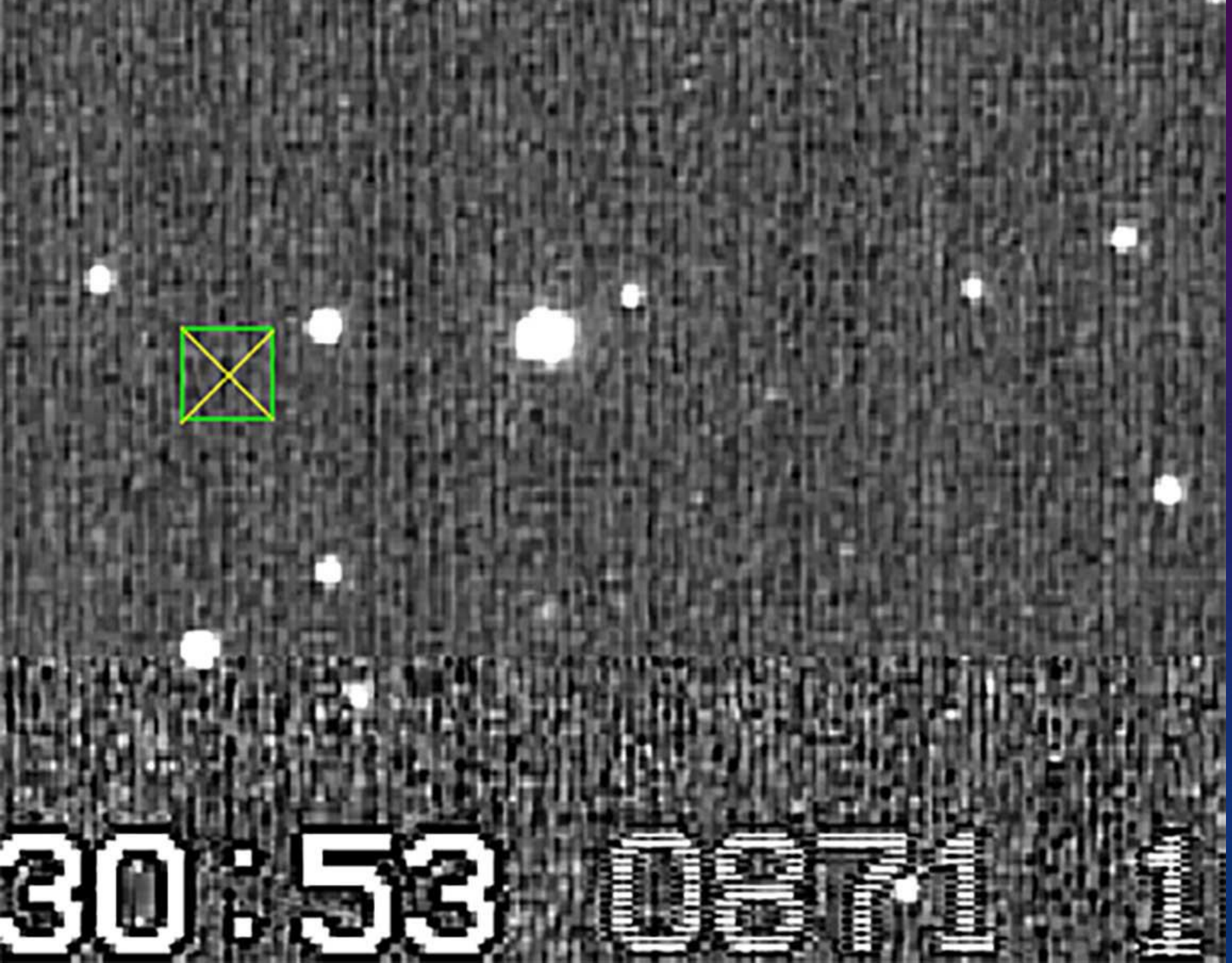
DURATION = 40 SEC, FROM A CROSS TRACK LOCATION ~3 MILES NORTH OF MY SITE



I'LL NOW DO 2-SECOND 'FINDERS' BACK TO BACK THROUGH THE OCCULTATION… TIMES AT BOTTOM ARE 6HR UT PLUS THE MIN AND SEC SHOWN. CENTRAL OCCULTATION PREDICTED AT 6:31:44 UT. NOMINAL PREDICTED OCCN IS FROM 6:31:22 – 6:32:06 UT.

TARGET IS JUDGED VISIBLE BUT FAINT, IN THE FOLLOWING SLIDES, IF “YES” IS SHOWN AT RIGHT.

YES.



YES?

YES, BLURRED

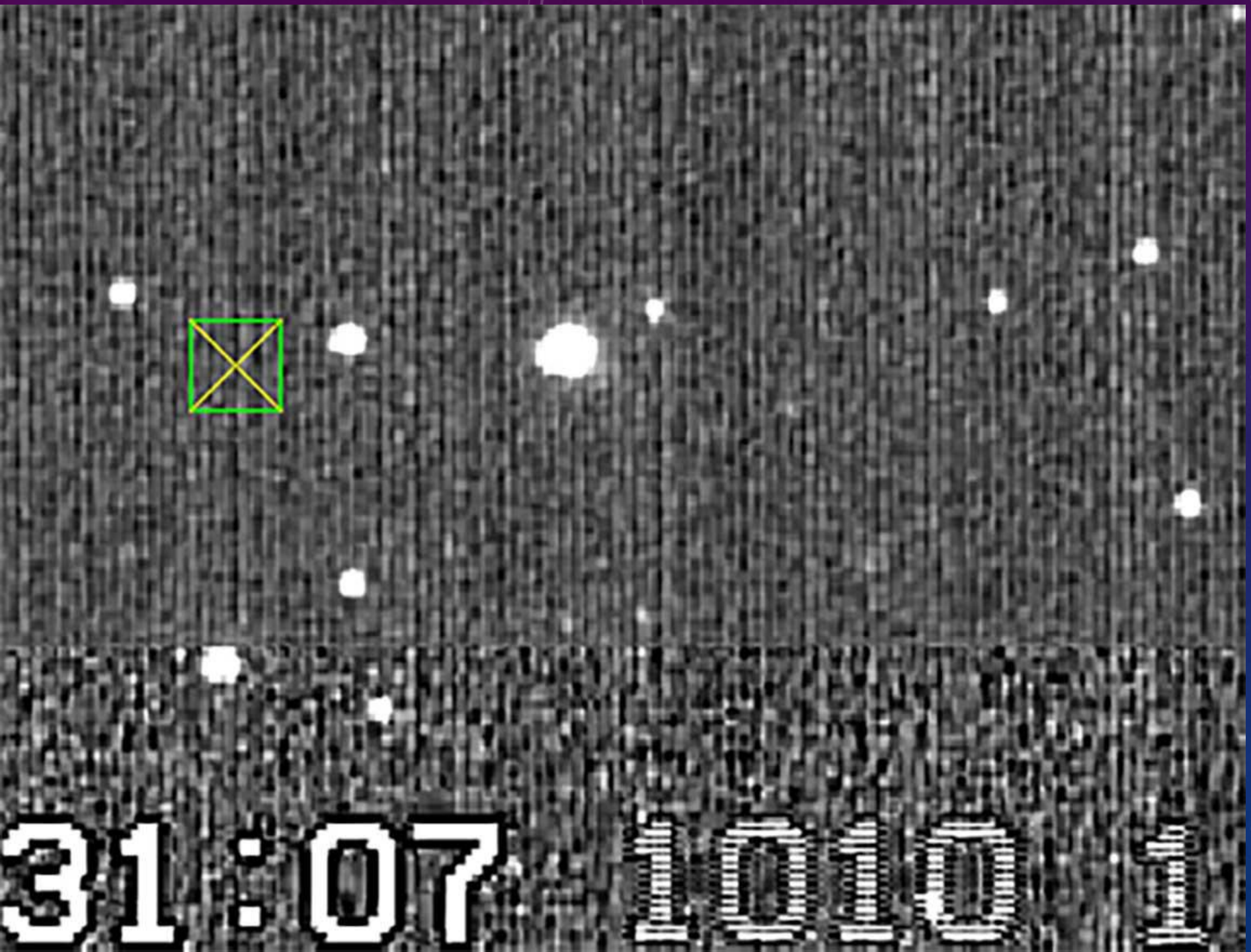
YES

YES

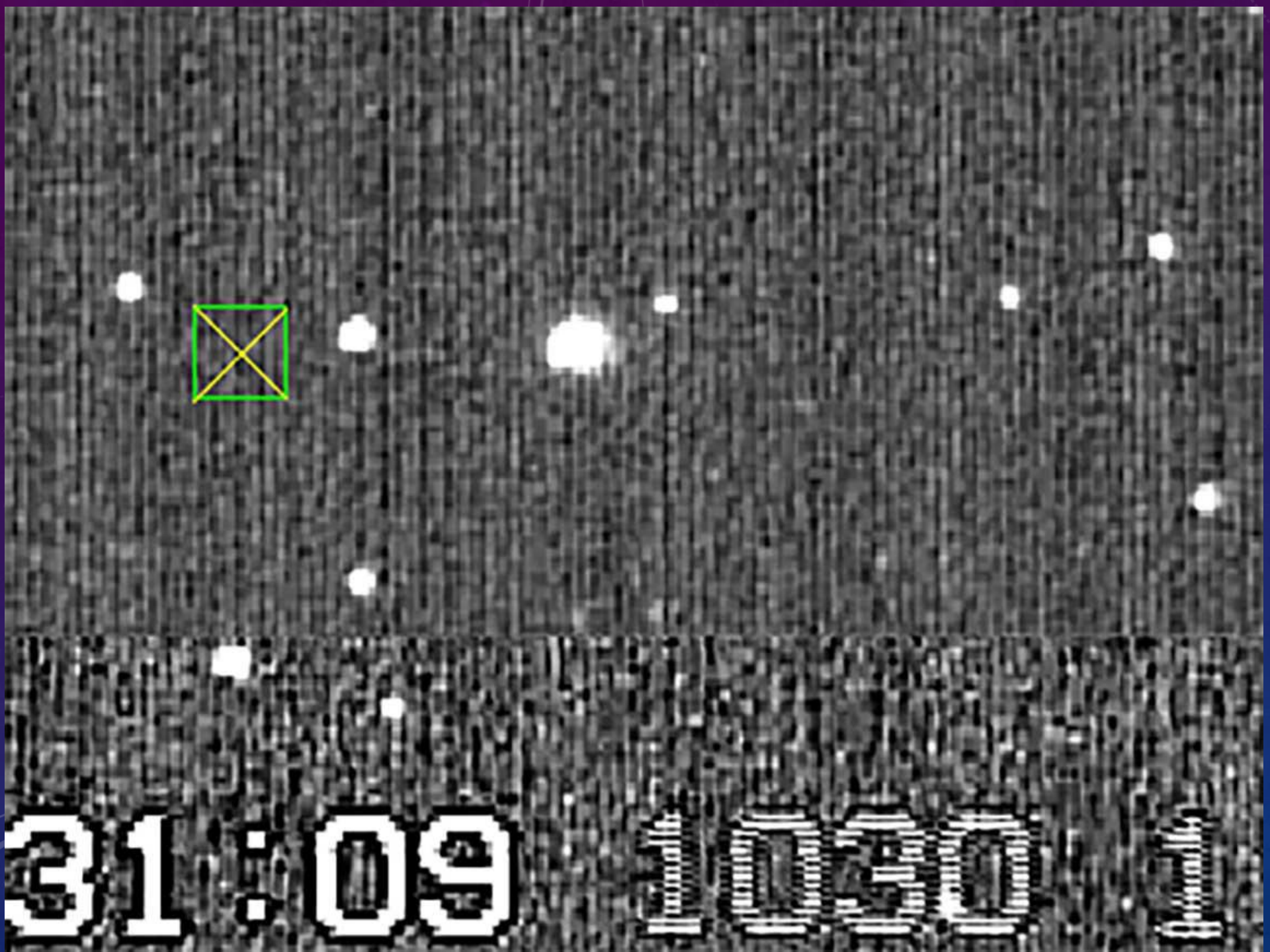
YES

YES

YES



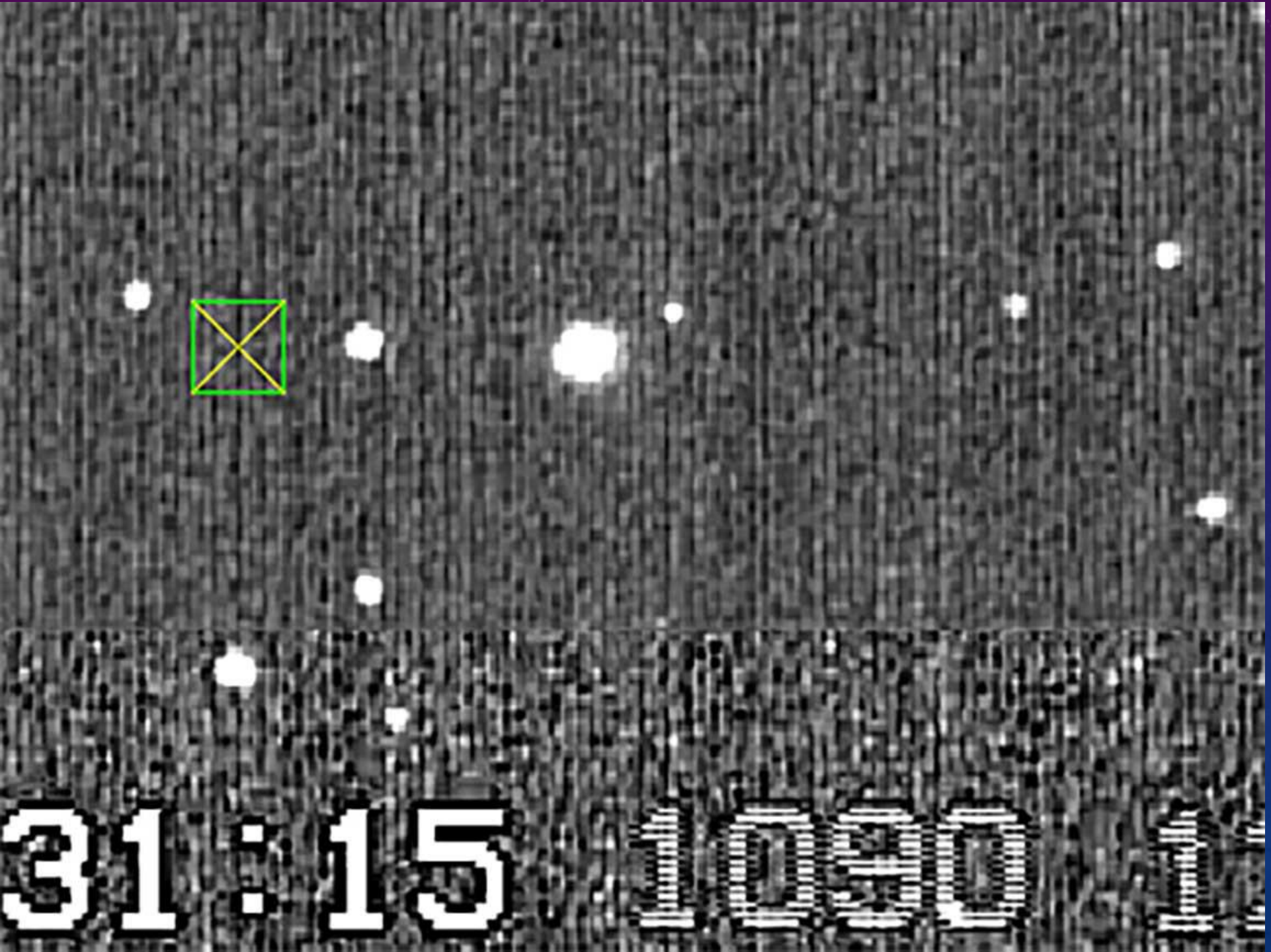
YES, BLURRED



YES, BLURRED

YES

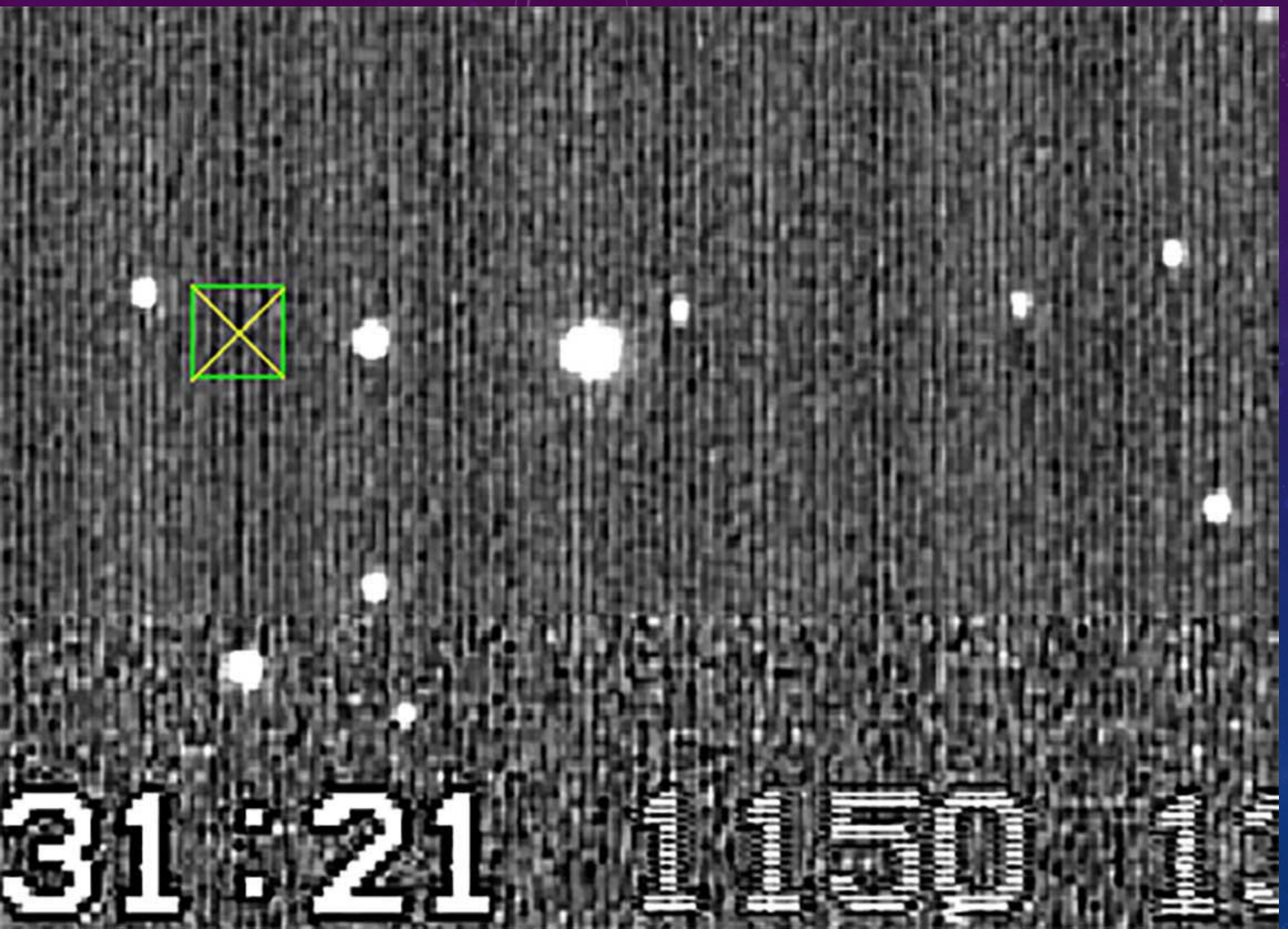
YES



YES

YES

YES



YES?

YES?
BLURRED.

NO

NO

NO

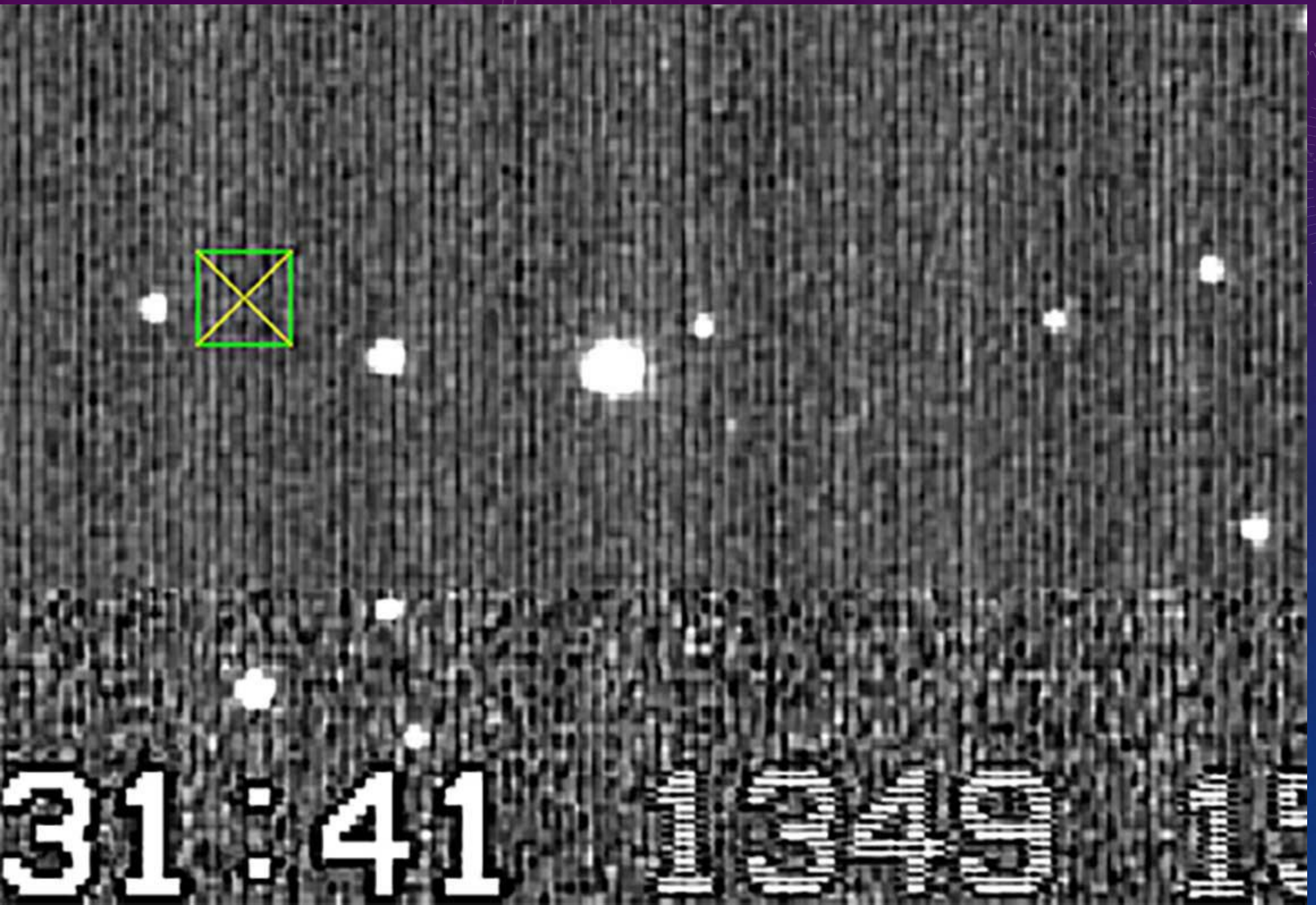
NO

NO?

YES?

NO,
BUT HARD TO BE SURE BECAUSE OF VERTICAL BRIGHT NOISE COLUMN

YES?



NO

NO

NO

NO?

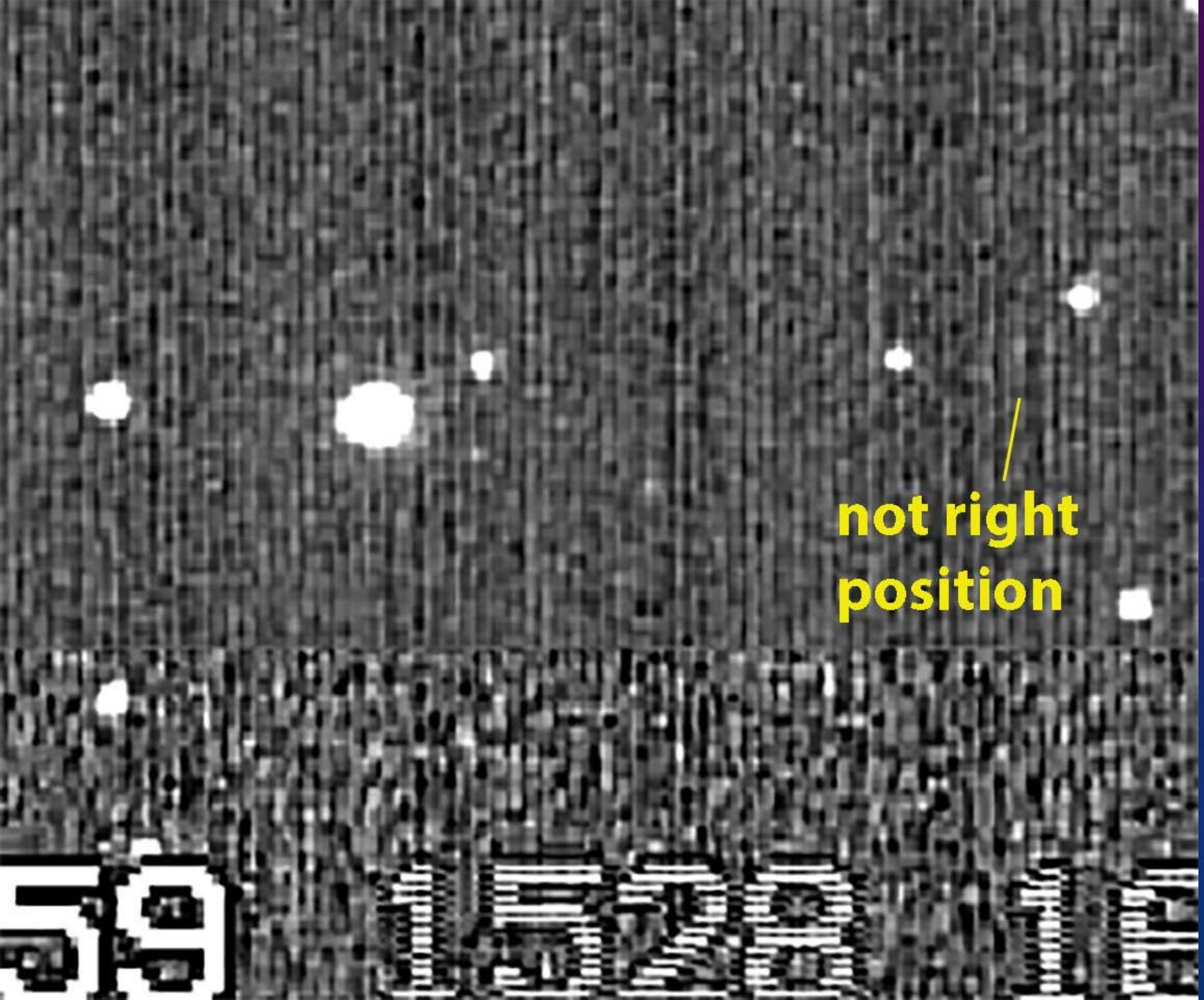
NO

YES?
BUT BRIGHT SPLOTCH IS CENTERED TOO FAR TO THE RIGHT

NO

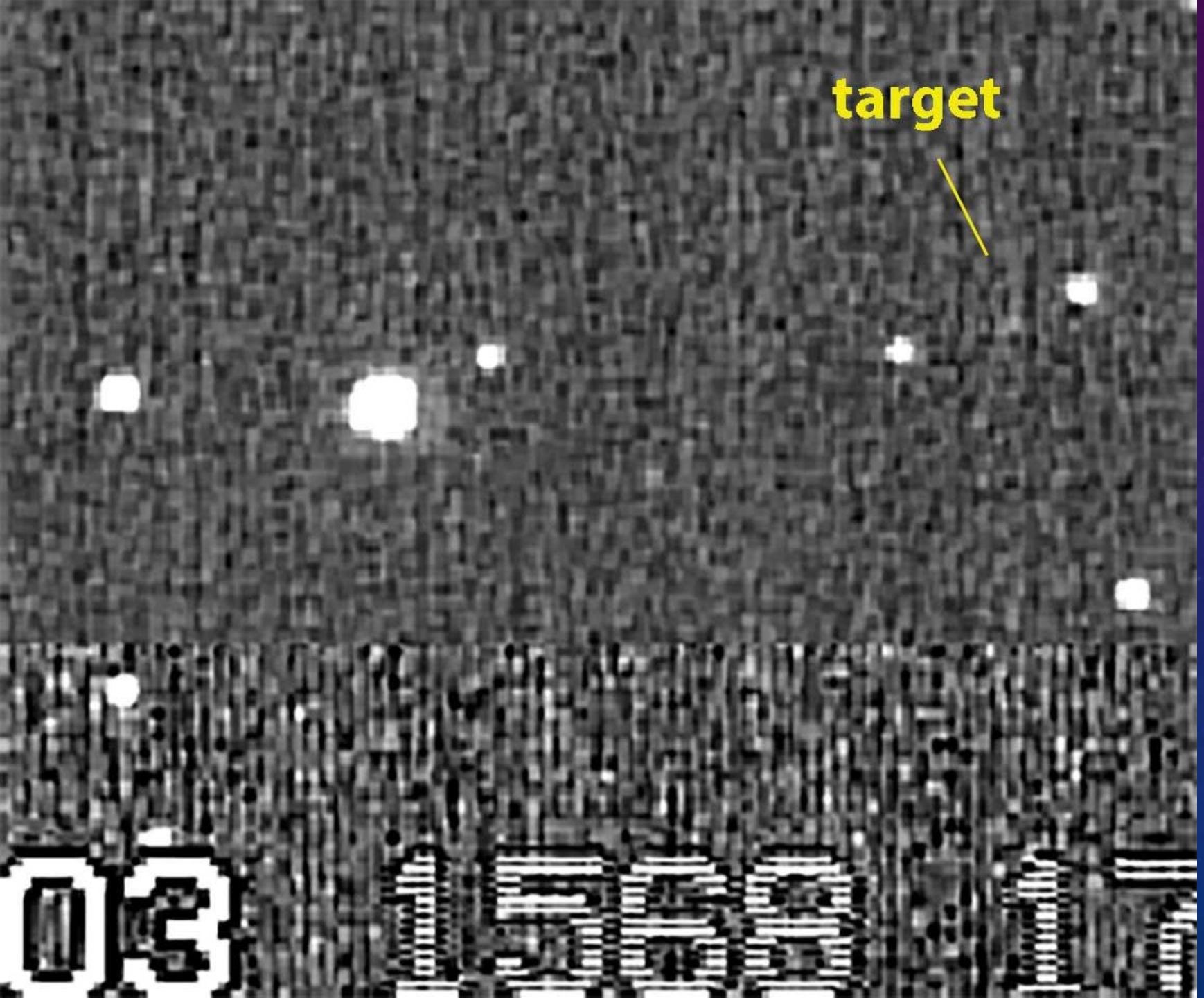
NO

NO



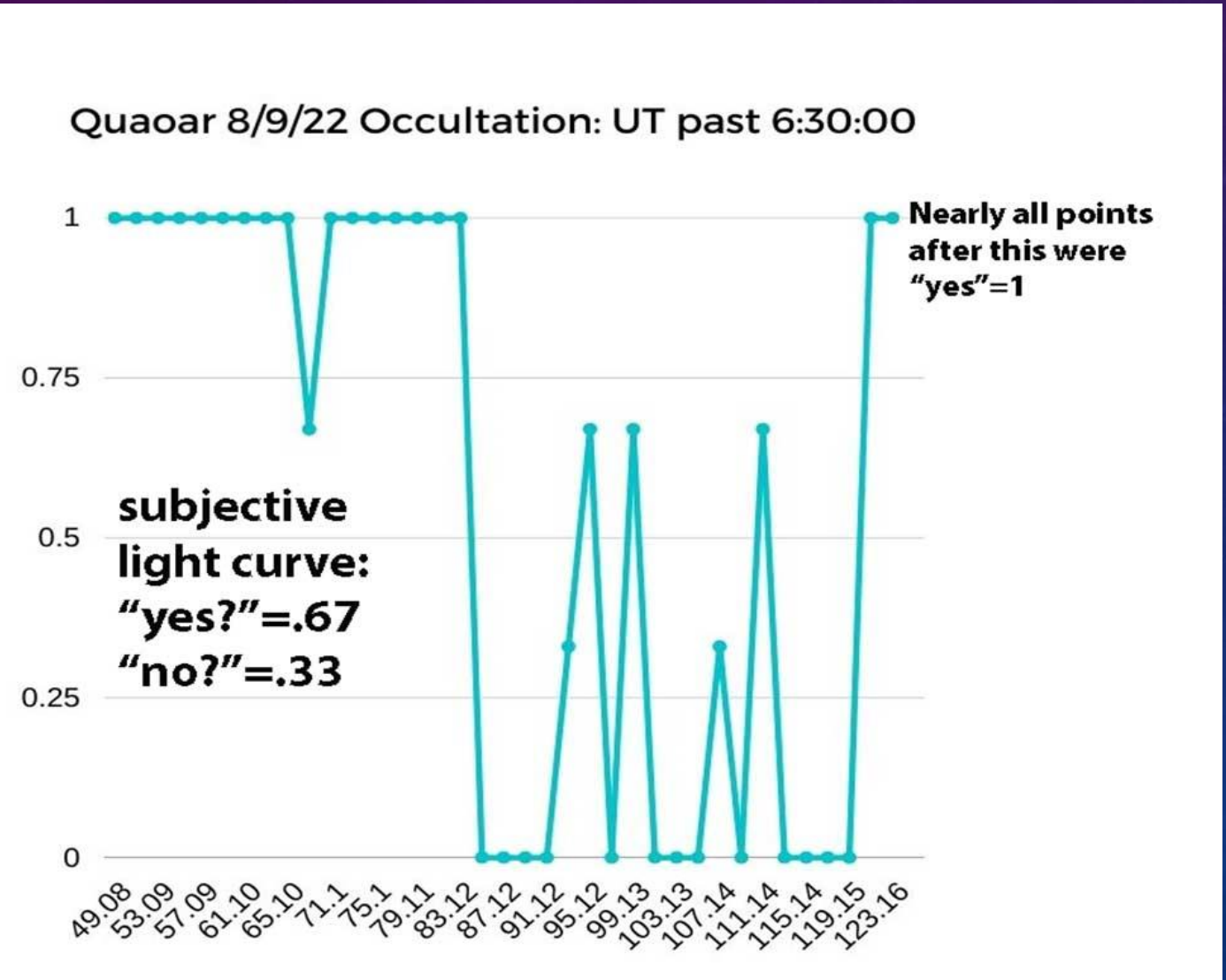
NO.
BRIGHT SPOT IS TOO FAR FROM STAR'S ACTUAL POSITION.

YES
THAT'S THE CORRECT EXACT POSITION OF THE TARGET STAR



YES

HERE'S A SUBJECTIVE LIGHT CURVE BASED ON PRIOR SLIDES. "YES"=1, "YES?"=0.67, "NO?"=0.33 AND NO=0. APOLOGIES FOR THE POOR ON-LINE PLOTTER CHOICE! I WAS IN A HURRY!



AGAIN – TO INCORPORATE THESE IDEAS IN A MUCH MORE AUTOMATED WAY…

- Seems like most of the work, the subroutines, have been done and are in PyMovie now
- But integrating them into making a new video output which could be analyzed seamlessly by PyOTE would take some more effort.
- I believe the advantage here is that one can look at a scene and the brain will look at the surrounding pixels and the patterns and make a “significant” or “noise” judgment with more ultimate accuracy than can be done strictly in a numerical simple way.
- **Best used for dim objects in bright skies, where the drop Is right down to “Sky”**

SUGGESTIONS FOR PYMOVE / PYOTE…

- Add capability to do flat fielding and dark subtraction
- Especially valuable for cameras with unusual noise or electronic interference patterns.
- The vertical and horizontal median filters in PyMovie are a great advance, but flat fielding would be perhaps do-able with simple added software