Testing stellar flares with fast photometry

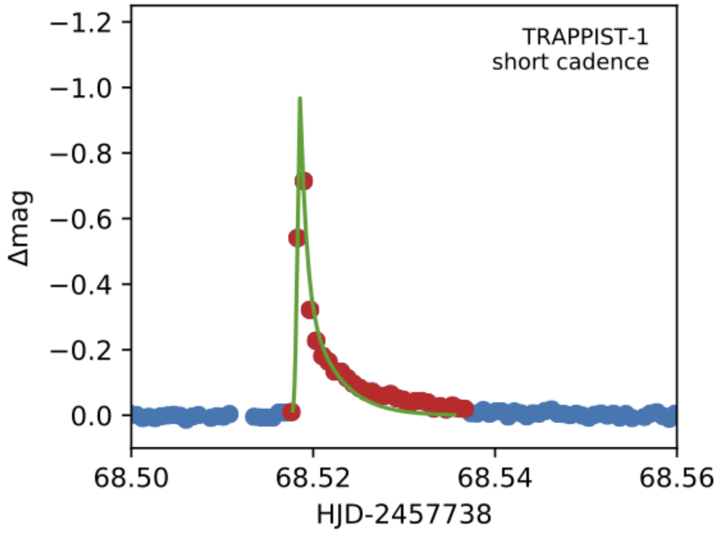
Krisztián Vida

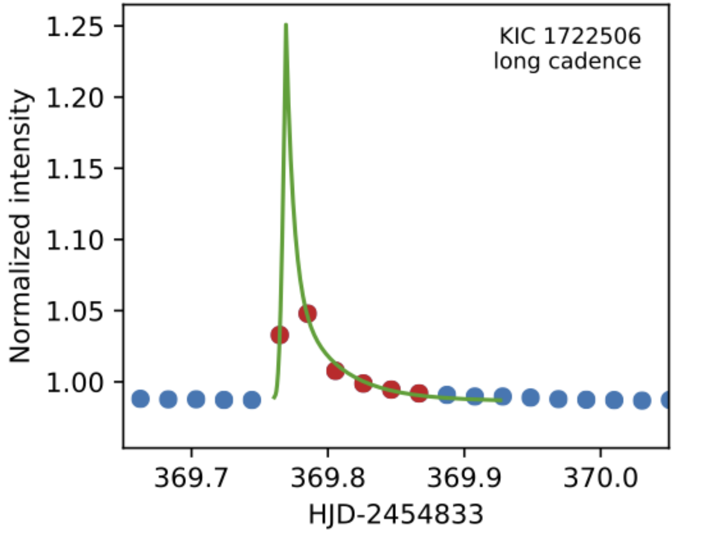
Konkoly Observatory,
Budapest, Hungary

Motivation

High resolution photometry can be crucial for fast transients – e.g. determining flare parameters: energy estimation depends heavily on sampling!

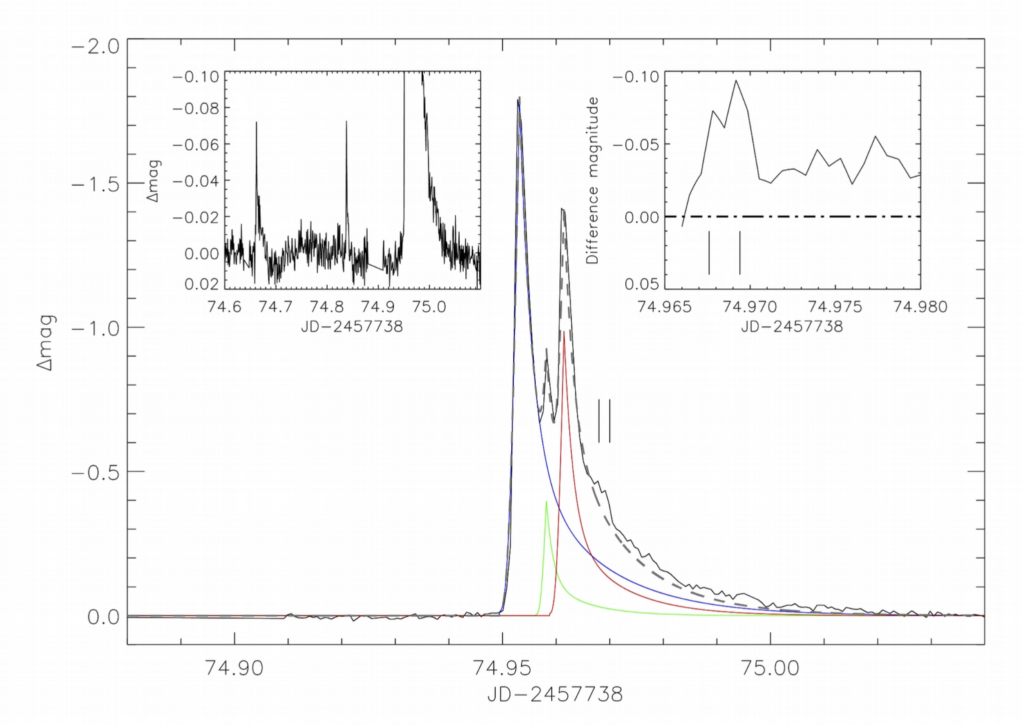
Flare analysis with machine learning on Kepler light curves: energy estimation of long cadence events can be nasty...





Motivation

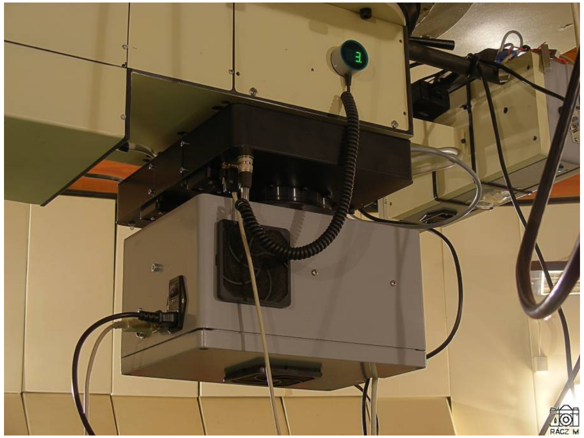
There could be several smaller events (microflares) that we are missing, that we see e.g. on the Sun



OCELOT EMCCD

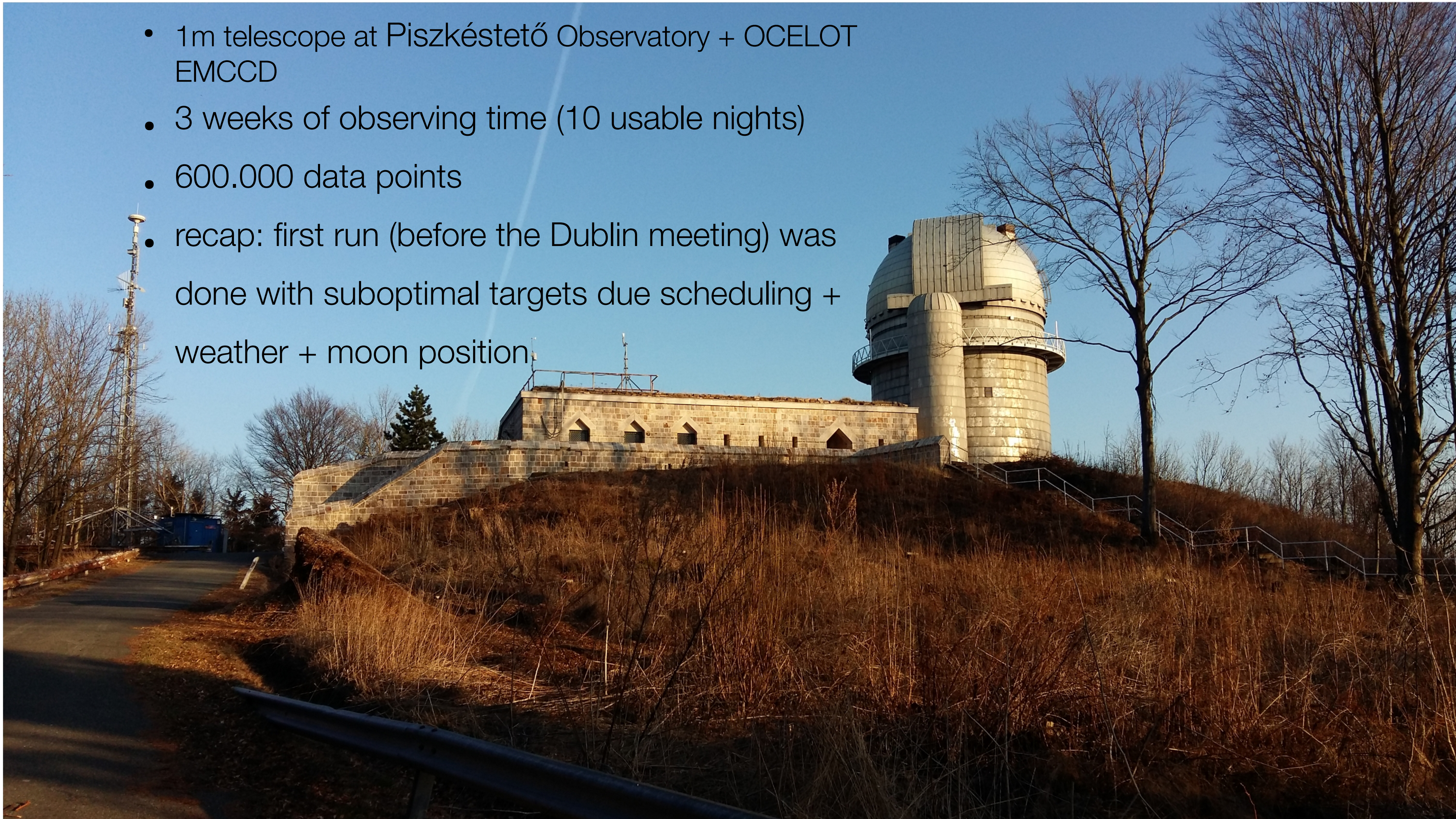
Specifications

- Sensor: e2V CCD201-20
- Sensor size: 1024*1024
- Pixel size: 13 µm * 13 µm
- Image area: 13.3 mm * 13.3 mm
- Active area pixel well depth: 80 000 electron (typ.)
- Gain regeister pixel well depth: 730 000 electron (typ.)
- Max readout rate: 10 MHz
- Frame rates (full frame): 8.9 frames per sec
- Read noise (10 MHz): 1 to 47 electron
- Peak quantum efficiency (575 nm, typ.): 92.5%
- Cooling: thermoelectric + liquid, -90°C

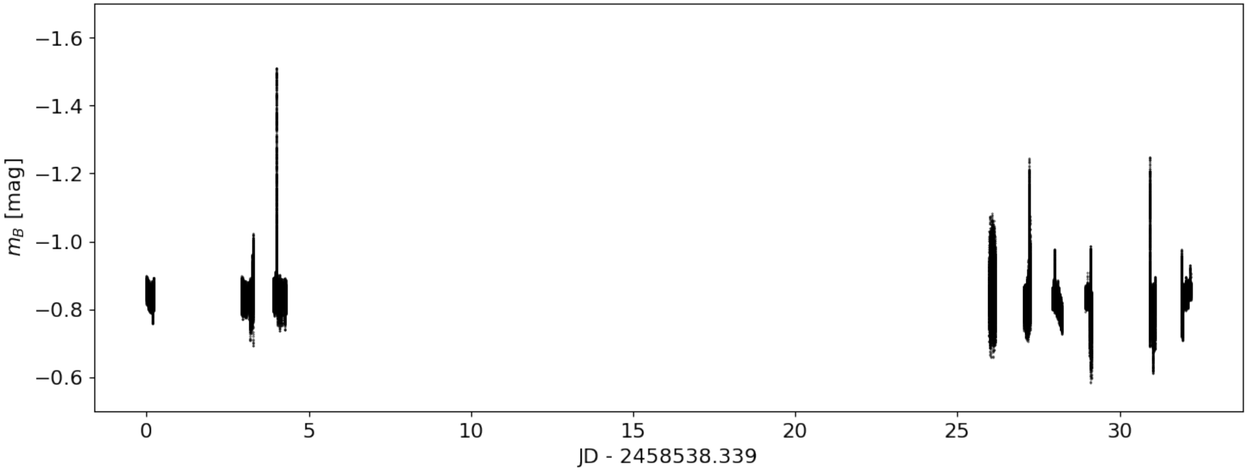


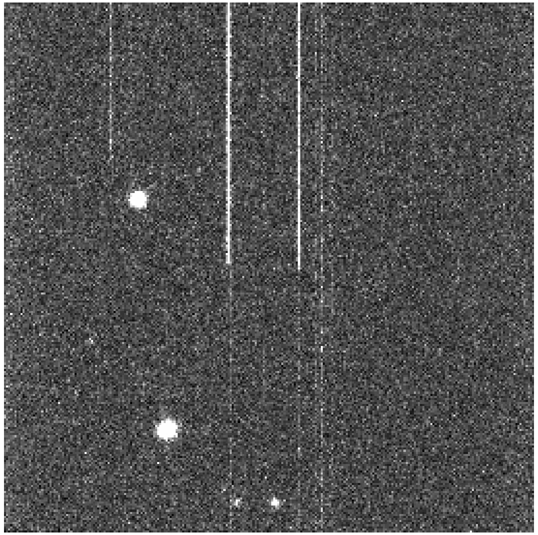
we could test what ARIEL would see...

- 1m telescope at Piszkéstető Observatory + OCELOT EMCCD
- 3 weeks of observing time (10 usable nights)
- 600.000 data points
- recap: first run (before the Dublin meeting) was done with suboptimal targets due scheduling + weather + moon position.



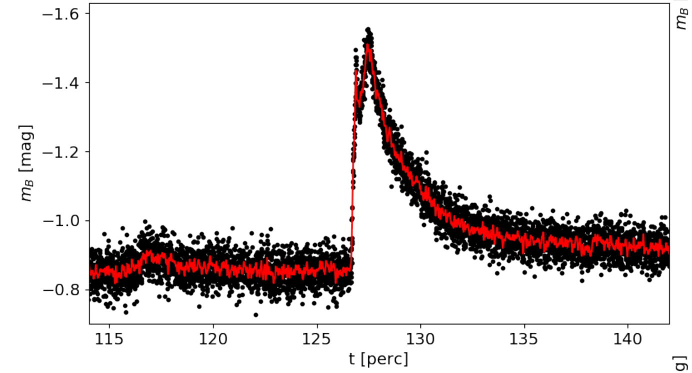
- AD Leo (B~10^m, M3V)
- B filter (target will be fainter, but larger flare amplitudes)
- 0.3s exposures - ~0 readout time



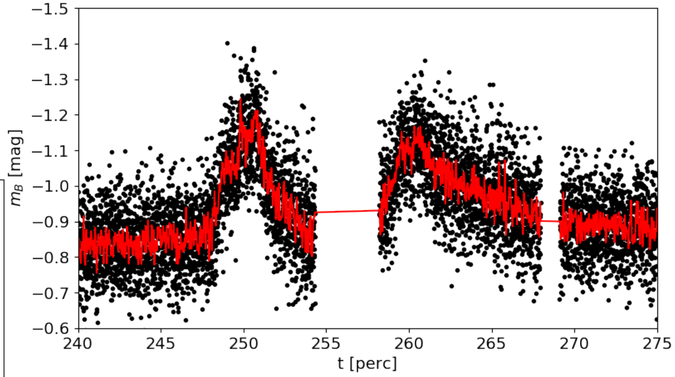


roughly real-time animation of data aquisition

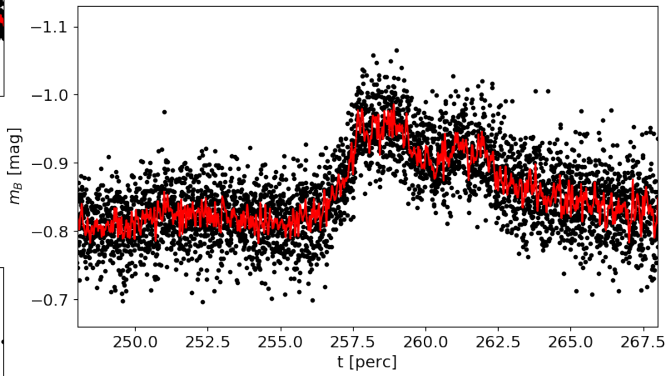
A flare “zoo”



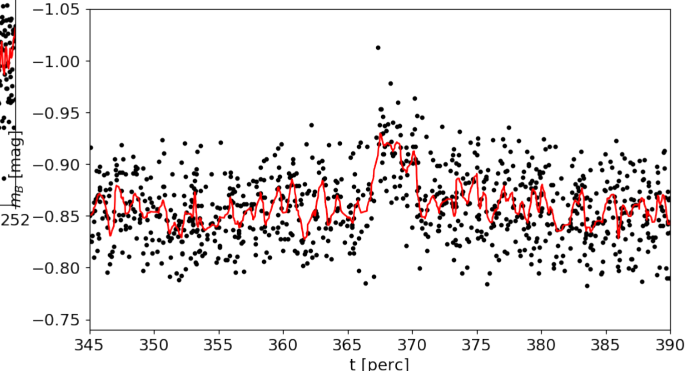
m_B [mag]
t [perc]
−1.6
−1.4
−1.2
−1.0
−0.8
115
120
125
130
135
140



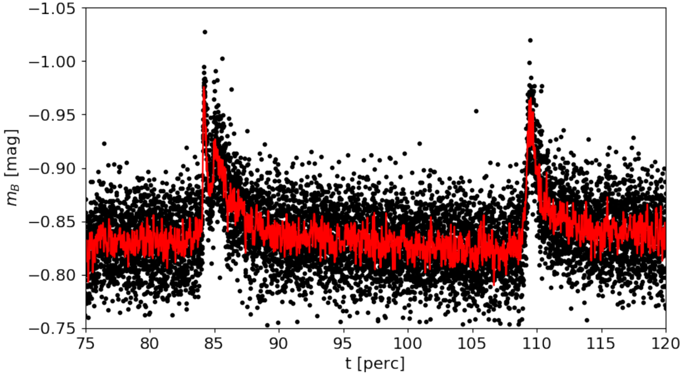
m_B [mag]
t [perc]
−1.5
−1.4
−1.3
−1.2
−1.1
−1.0
−0.9
−0.8
−0.7
−0.6
240
245
250
255
260
265
270
275



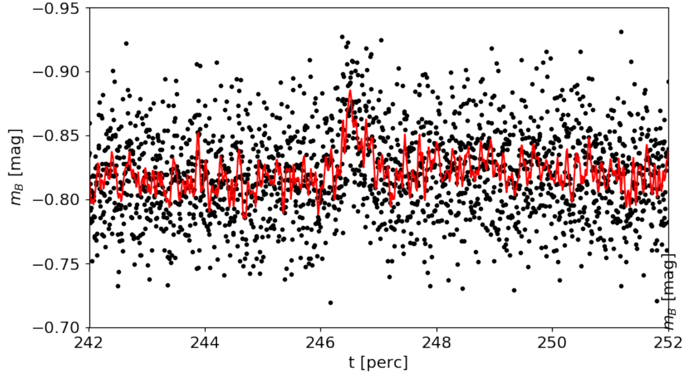
m_B [mag]
t [perc]
−1.1
−1.0
−0.9
−0.8
−0.7
250.0
252.5
255.0
257.5
260.0
262.5
265.0
267.5



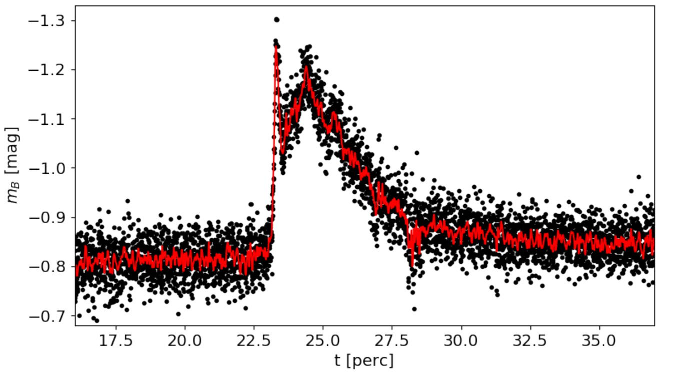
m_B [mag]
t [perc]
−1.05
−1.00
−0.95
−0.90
−0.85
−0.80
−0.75
345
350
355
360
365
370
375
380
385
390



m_B [mag]
t [perc]
−1.05
−1.00
−0.95
−0.90
−0.85
−0.80
−0.75
75
80
85
90
95
100
105
110
115
120

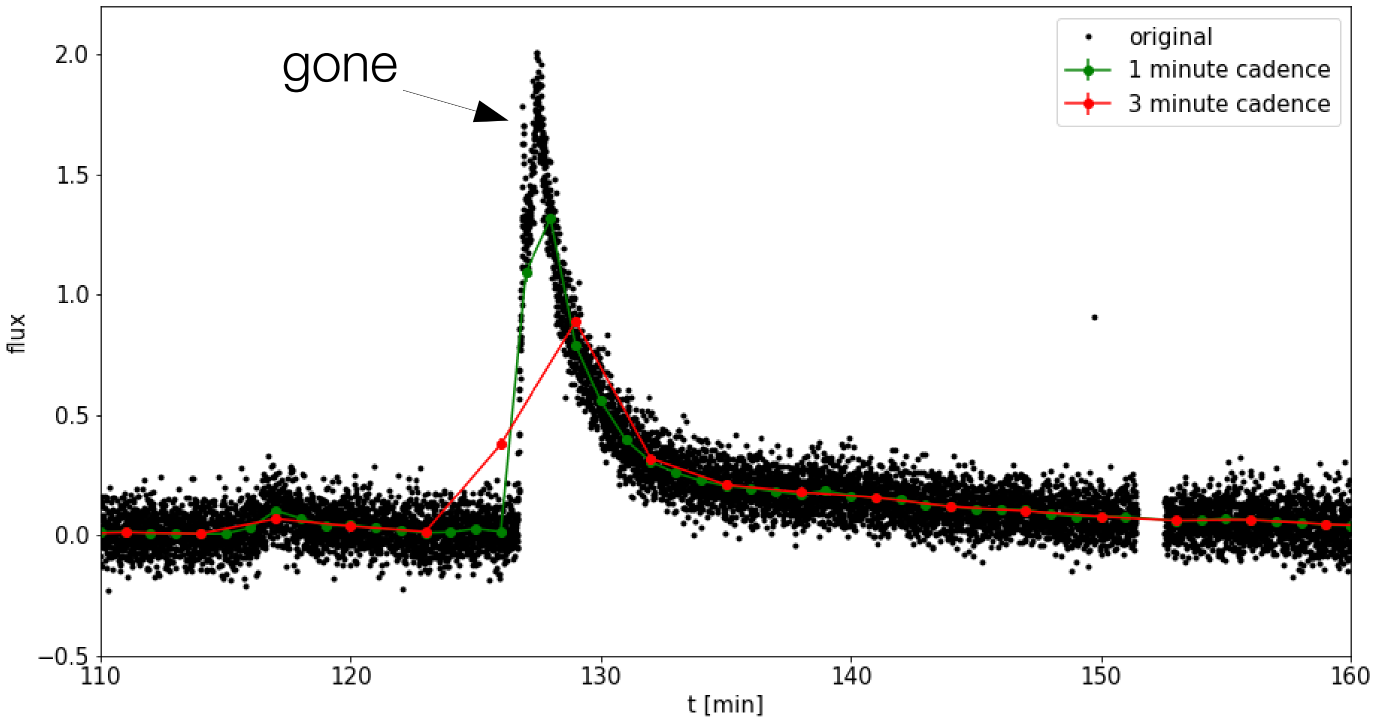


m_B [mag]
t [perc]
−0.95
−0.90
−0.85
−0.80
−0.75
−0.70
242
244
246
248
250
252

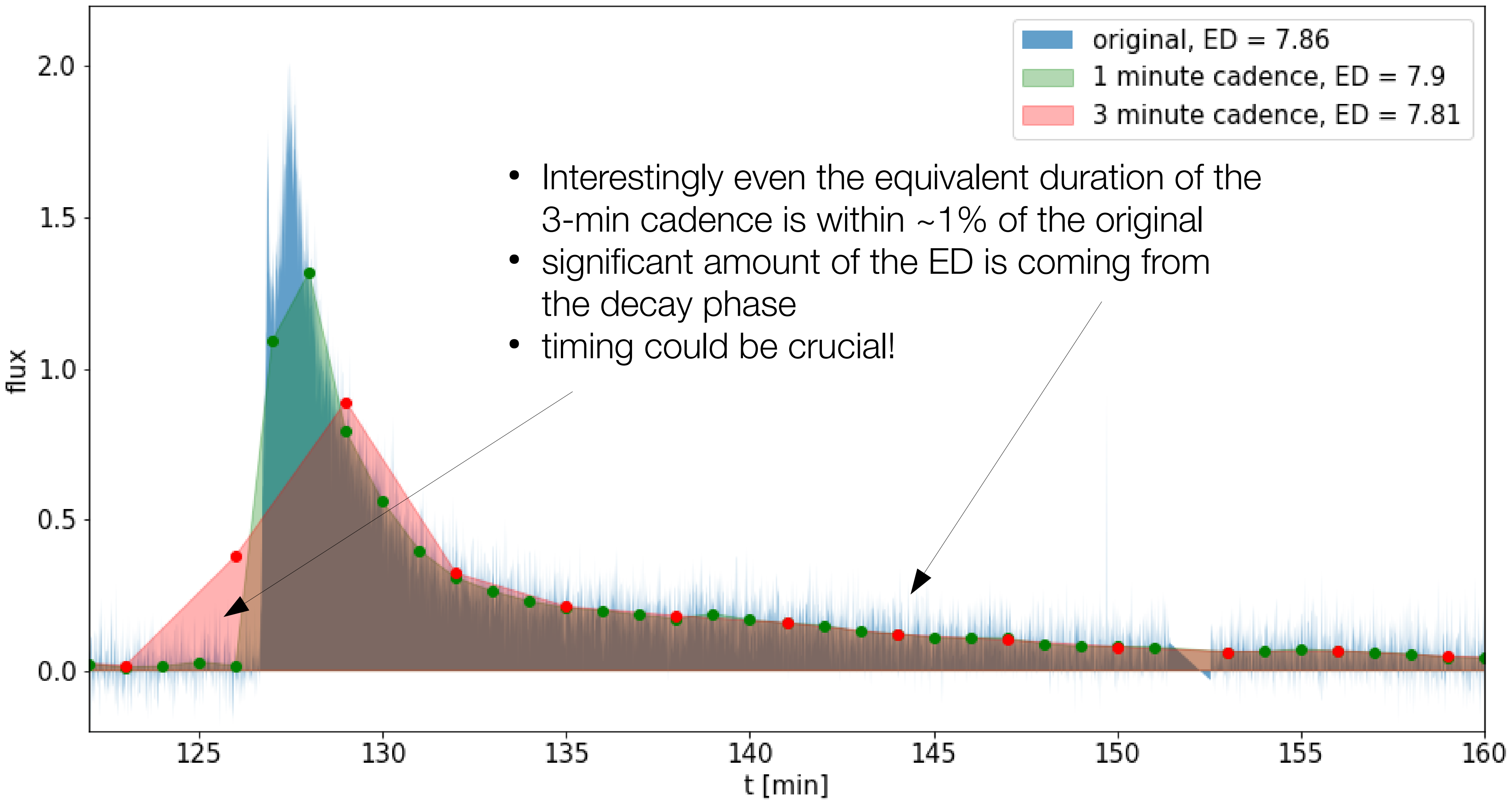


m_B [mag]
t [perc]
−1.3
−1.2
−1.1
−1.0
−0.9
−0.8
−0.7
17.5
20.0
22.5
25.0
27.5
30.0
32.5
35.0

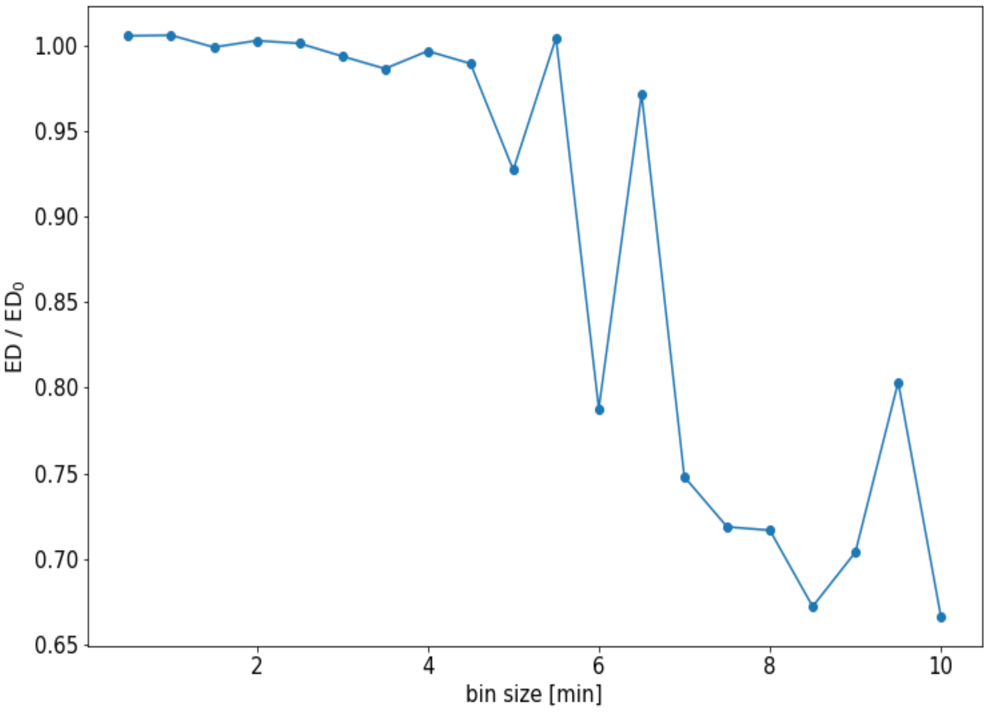
What do we gain/lose with longer exposures?



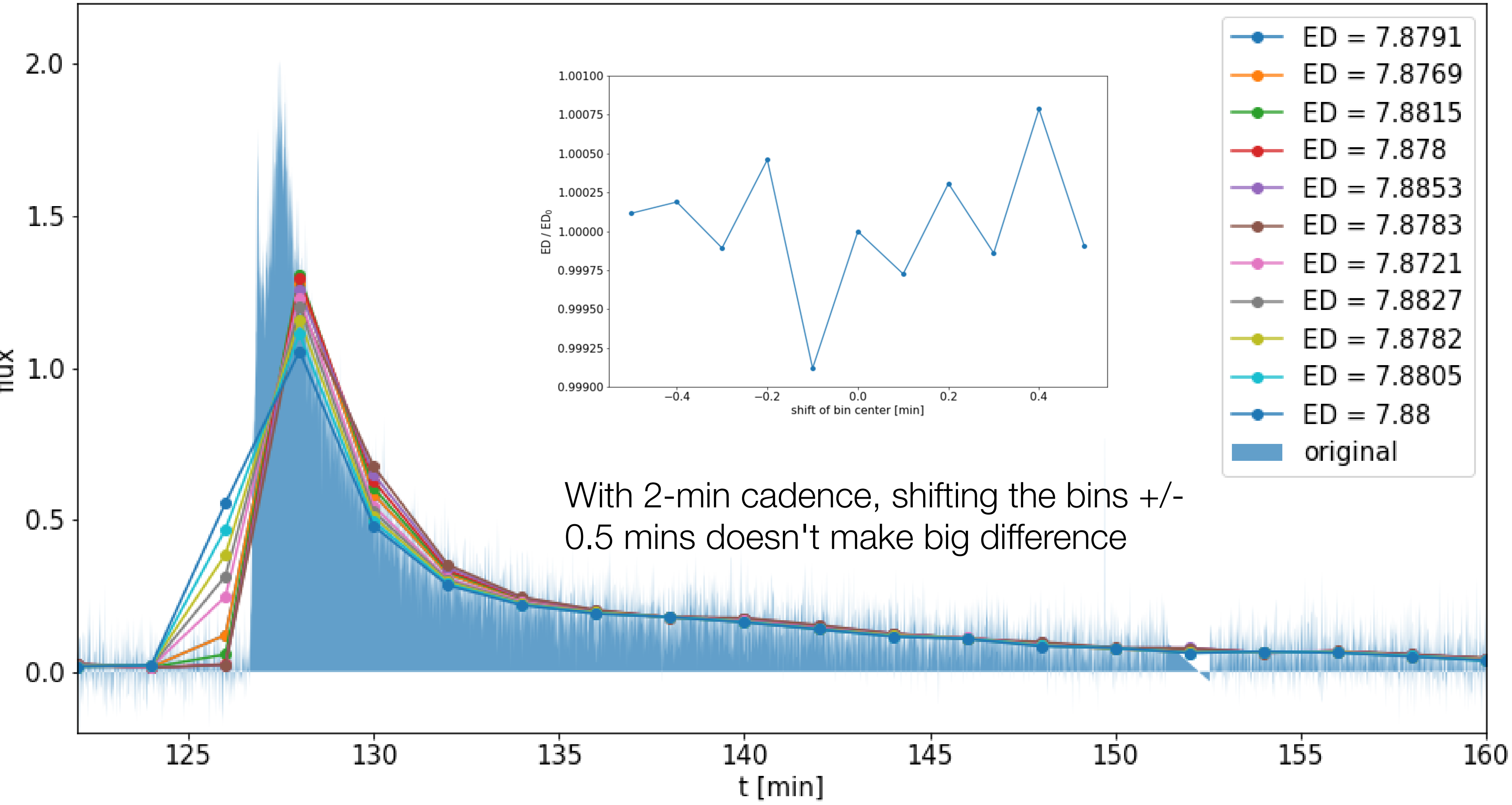
data rebinned to 1 and 3-minute cadence



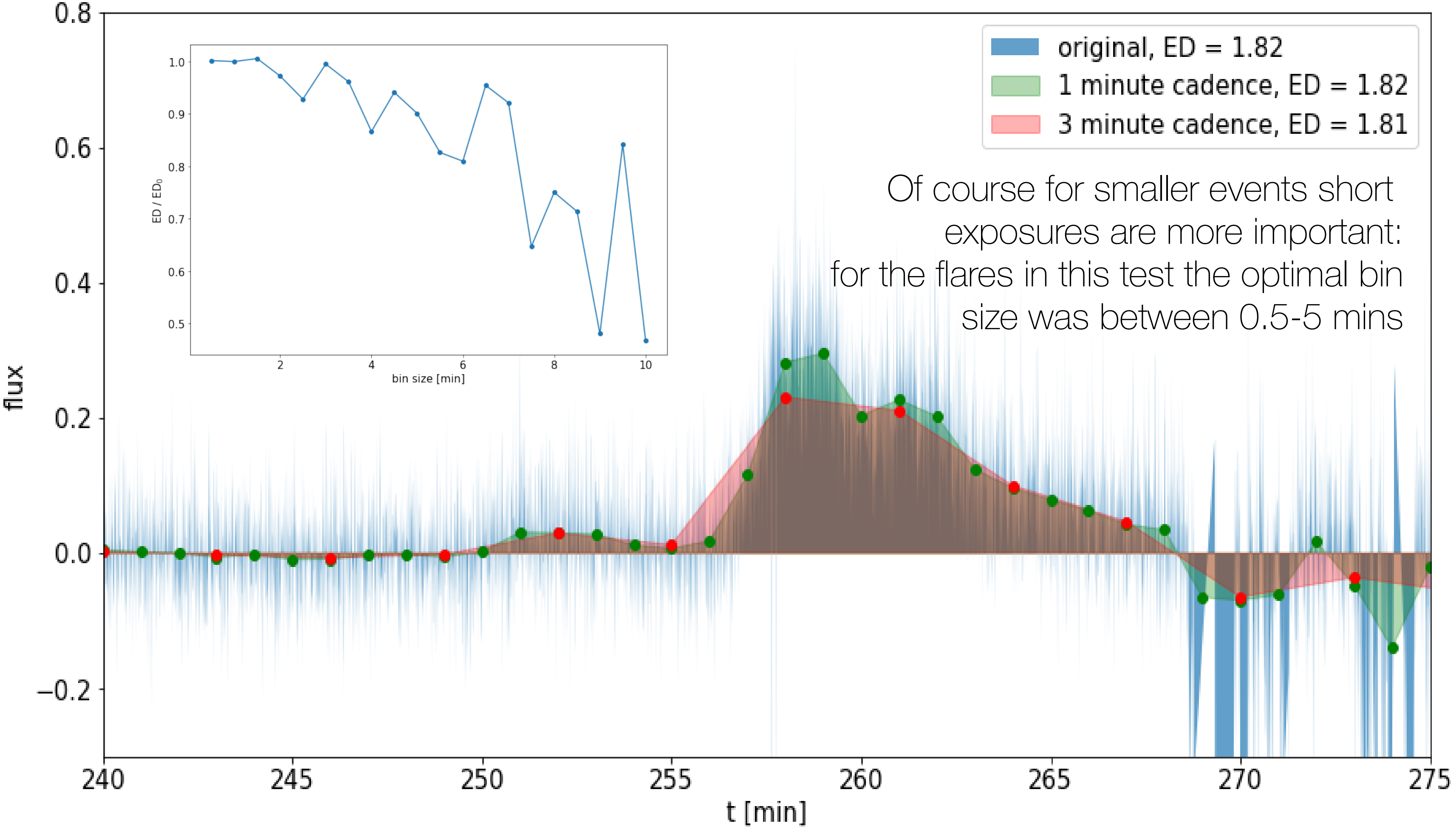
- Interestingly even the equivalent duration of the 3-min cadence is within ~1% of the original
- significant amount of the ED is coming from the decay phase
- timing could be crucial!



for this event we get the same energy (within few %) up to 4 min cadence!



With 2-min cadence, shifting the bins +/- 0.5 mins doesn't make big difference



Of course for smaller events short exposures are more important: for the flares in this test the optimal bin size was between 0.5-5 mins

What did we learn?

- For the few observed events 0.5-5 min cadence is enough
- Surprisingly the timing seemed not that crucial in energy determination

  BUT
- Small events were not detected due to higher noise level

  (telescope/atmosphere/camera limitations)