Determination of velocity of fireballs from light curves

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L. Shrbený: measuring of fireballs and light curves, determination of LC velocities

P. Spurný: fireball data analysis, computations of atmospheric trajectories and velocities of fireballs

Outline

1. Introduction
2. Test fireballs
3. Comparison between LC velocity and RS velocity
4. Application of the method
5. Conclusions

Introduction

Motivation

- amateur and scientific digital observations
- long focus photographic observations
- no velocity data
  - fault of rotating shutter (RS)
  - bad weather conditions
  - unfavourable angular velocity
  - short duration fireballs

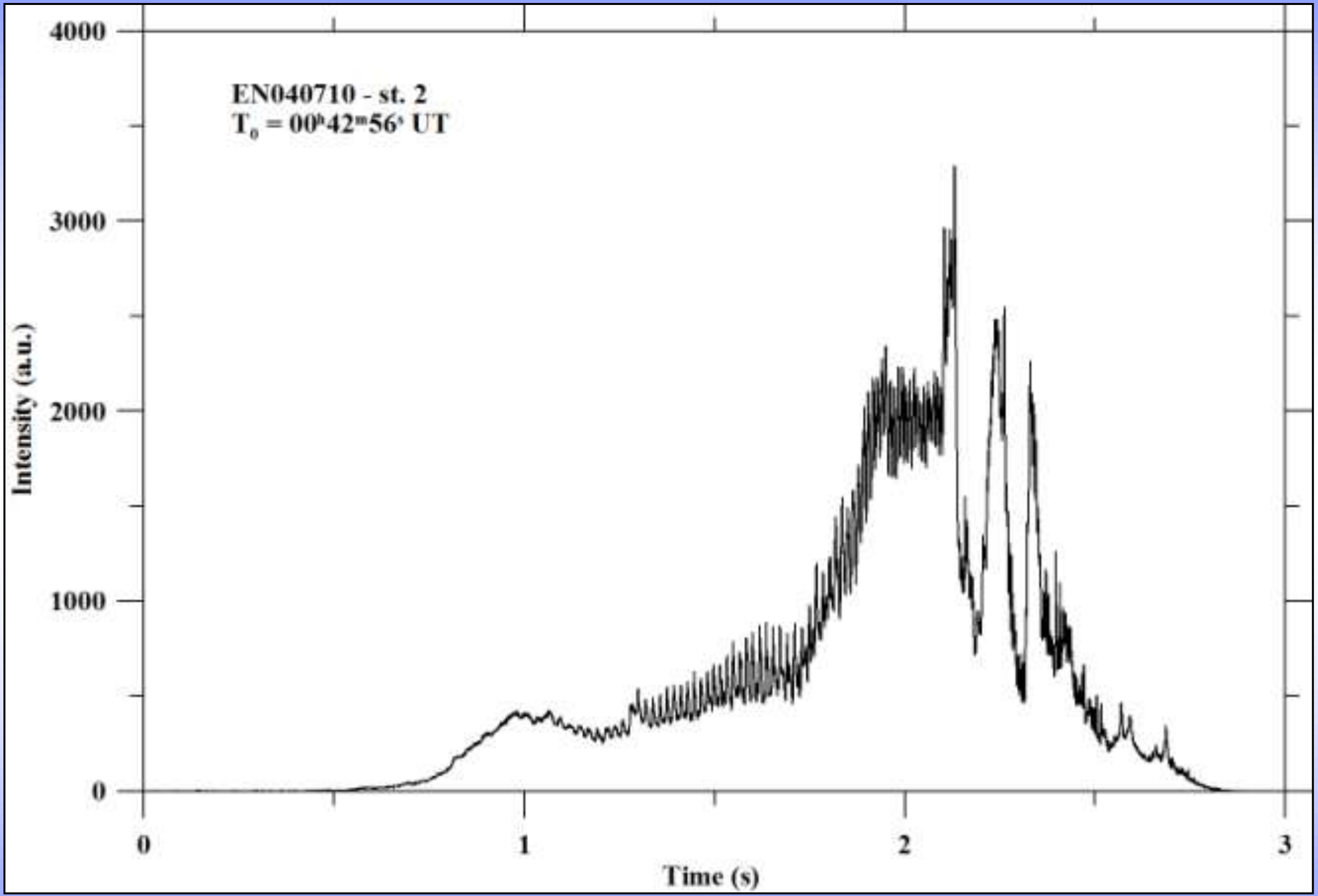
Method

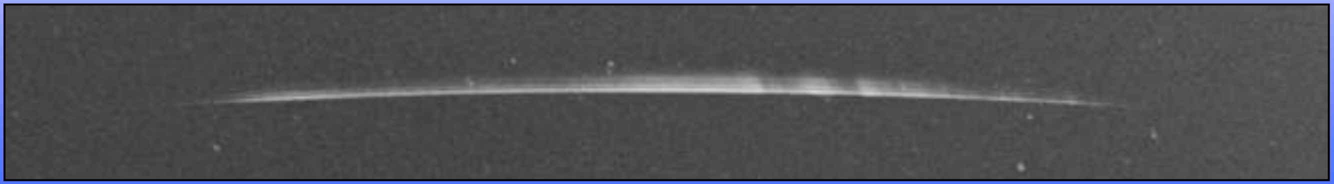
- light curves (LC) with high time resolution (AFO radiometers with 500 or 5000 samples/s)
- identification of flares on luminous trajectory
- lenght of atmospheric trajectory is empirical function of time

$L = A + Bt + C\exp(Kt)$, where A, B, C, K are constants to be determined

Test fireballs

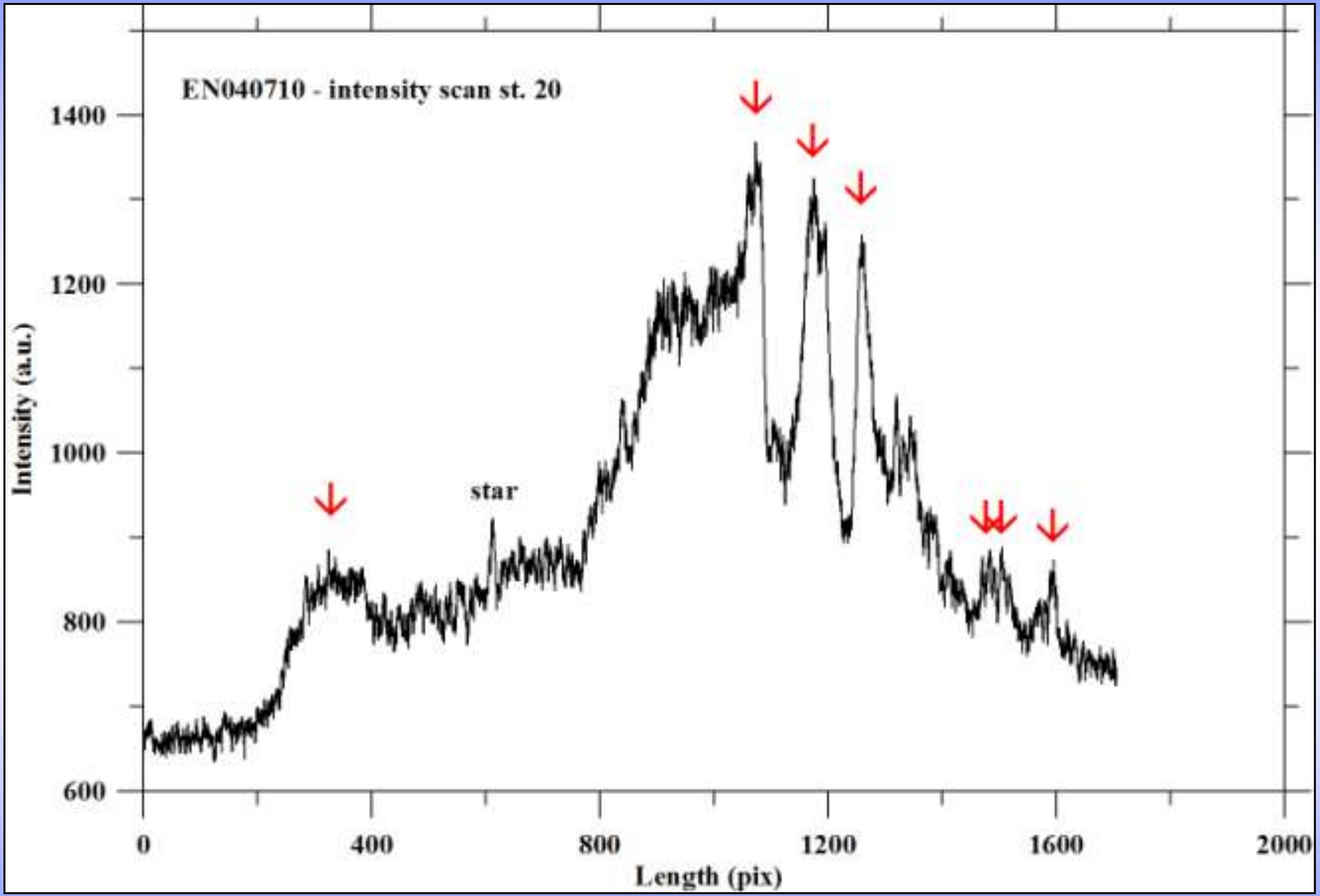
EN040710

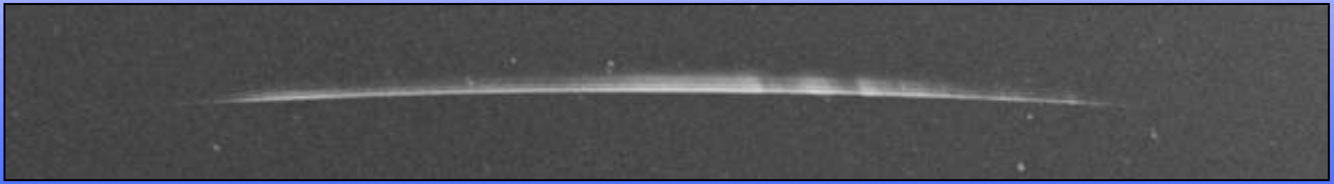




Test fireballs

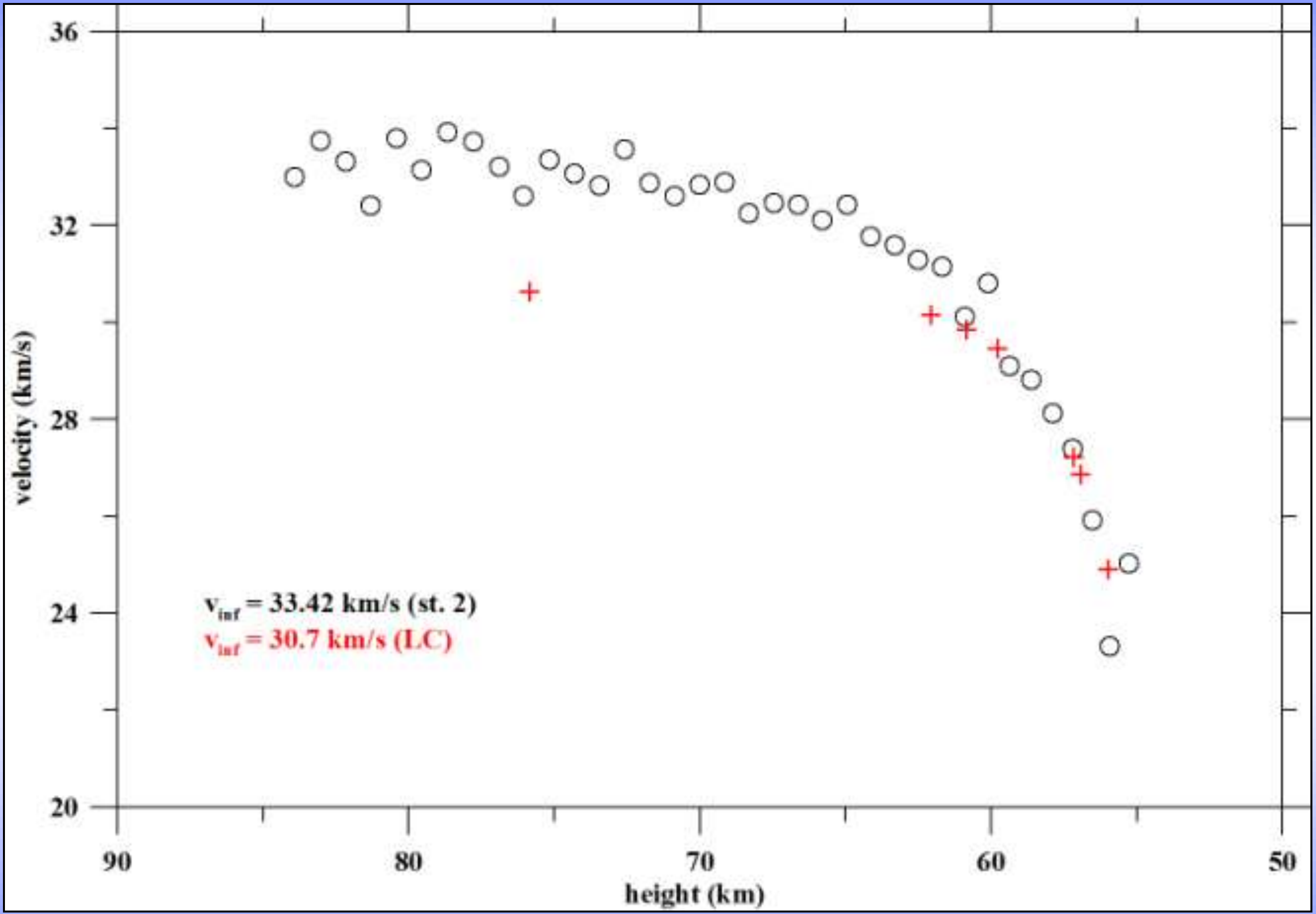
EN040710 (7 points)

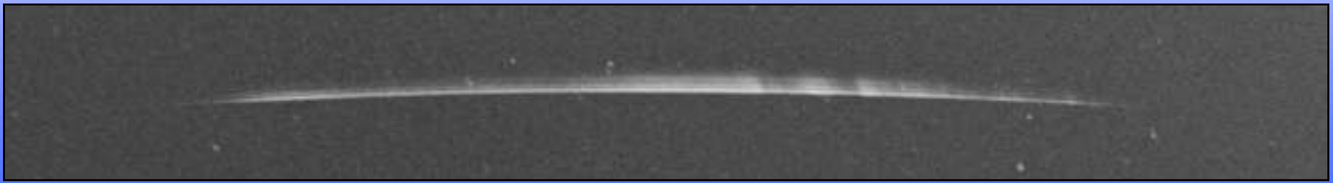




Test fireballs

EN040710





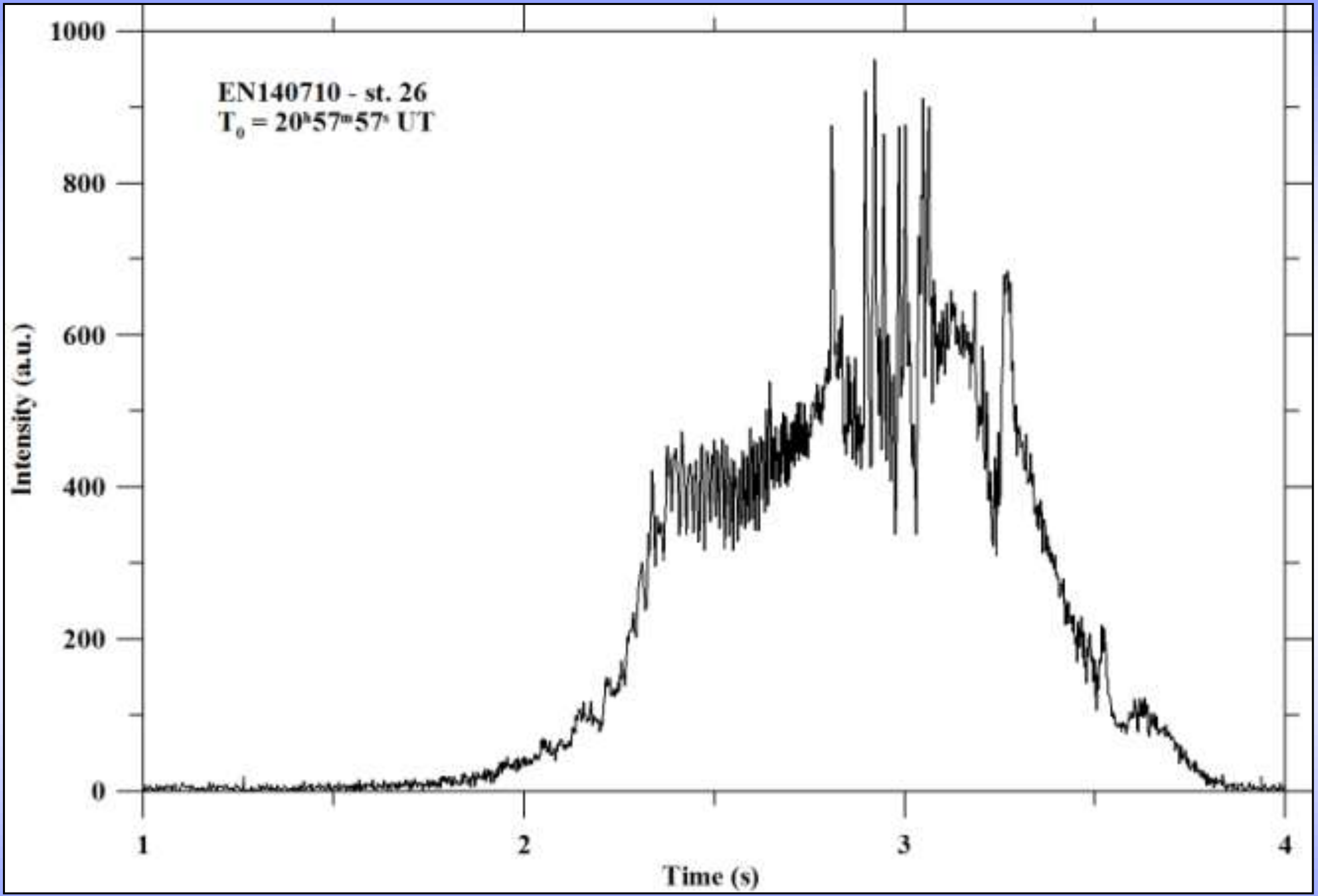
First point in not accurate

Initial velocity remains smaller than 32 km/s even if we do not take the first point into account

LC velocity is determined for trajectory after fragmentation with the same accuracy as using rotating shutter

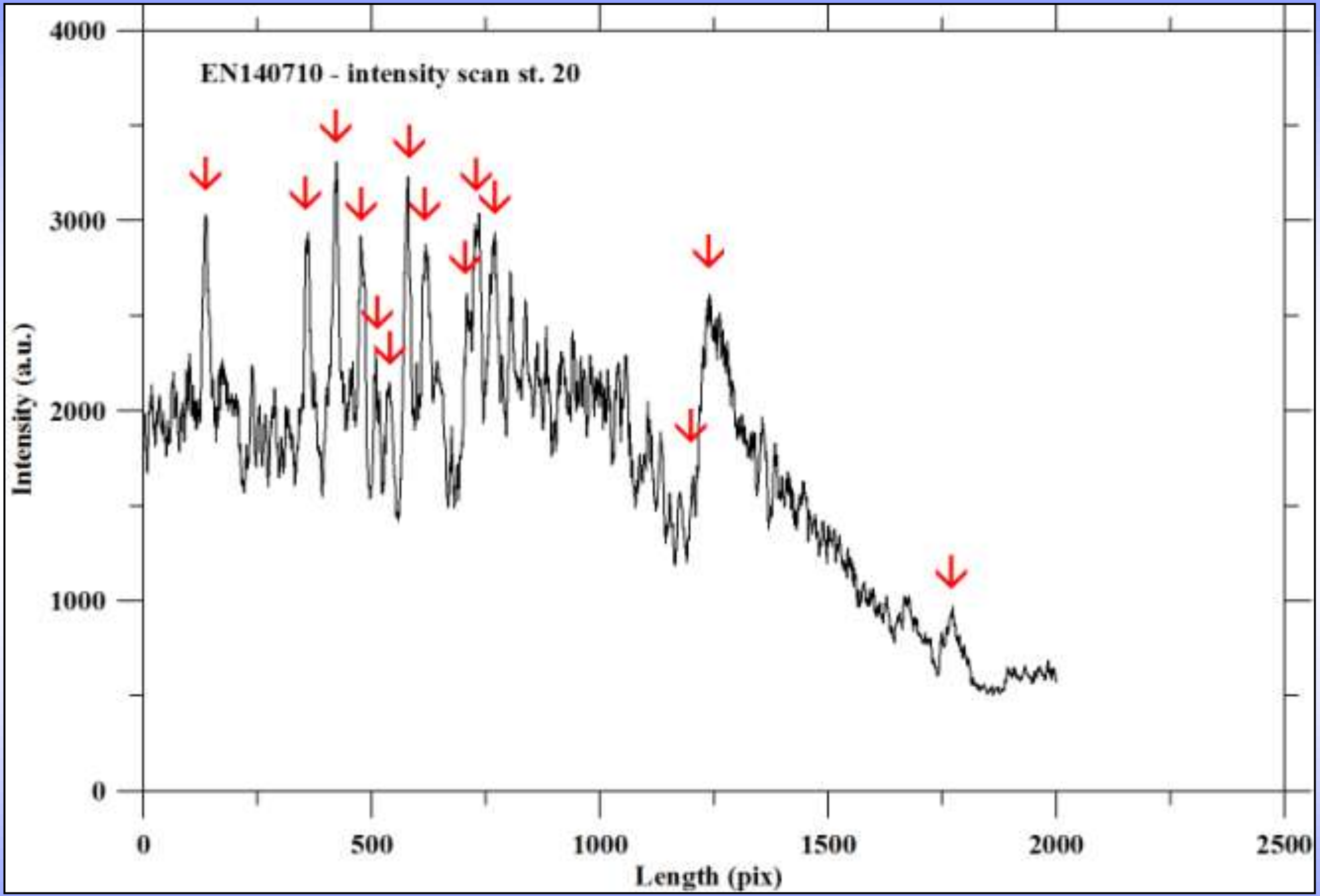
Test fireballs

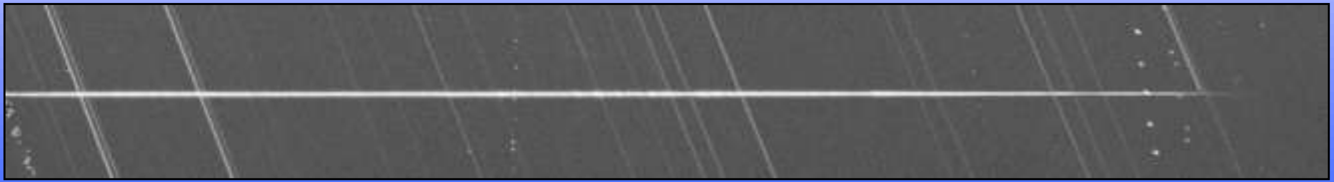
EN140710



Test fireballs

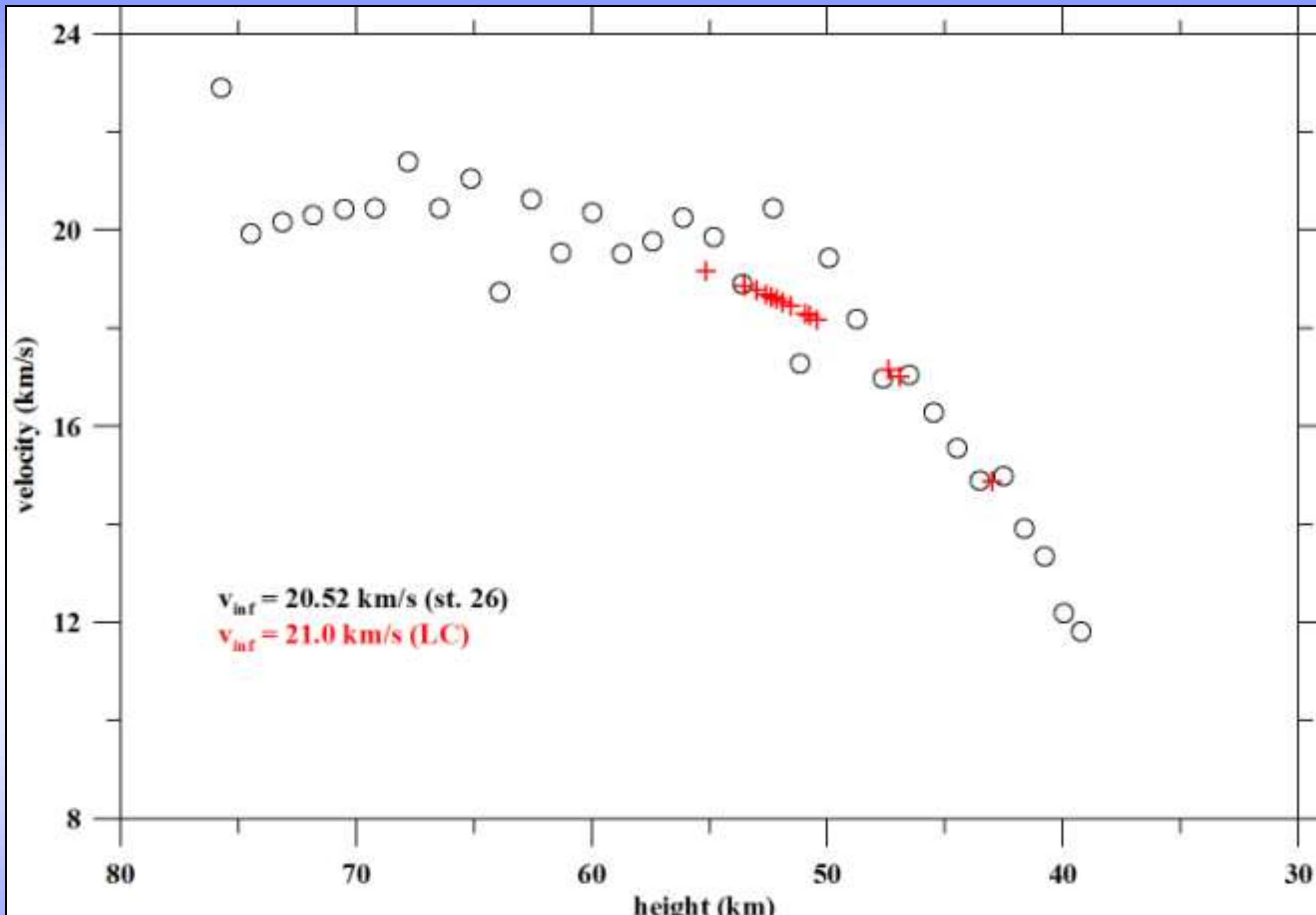
EN140710 (14 points)





Test fireballs

EN140710

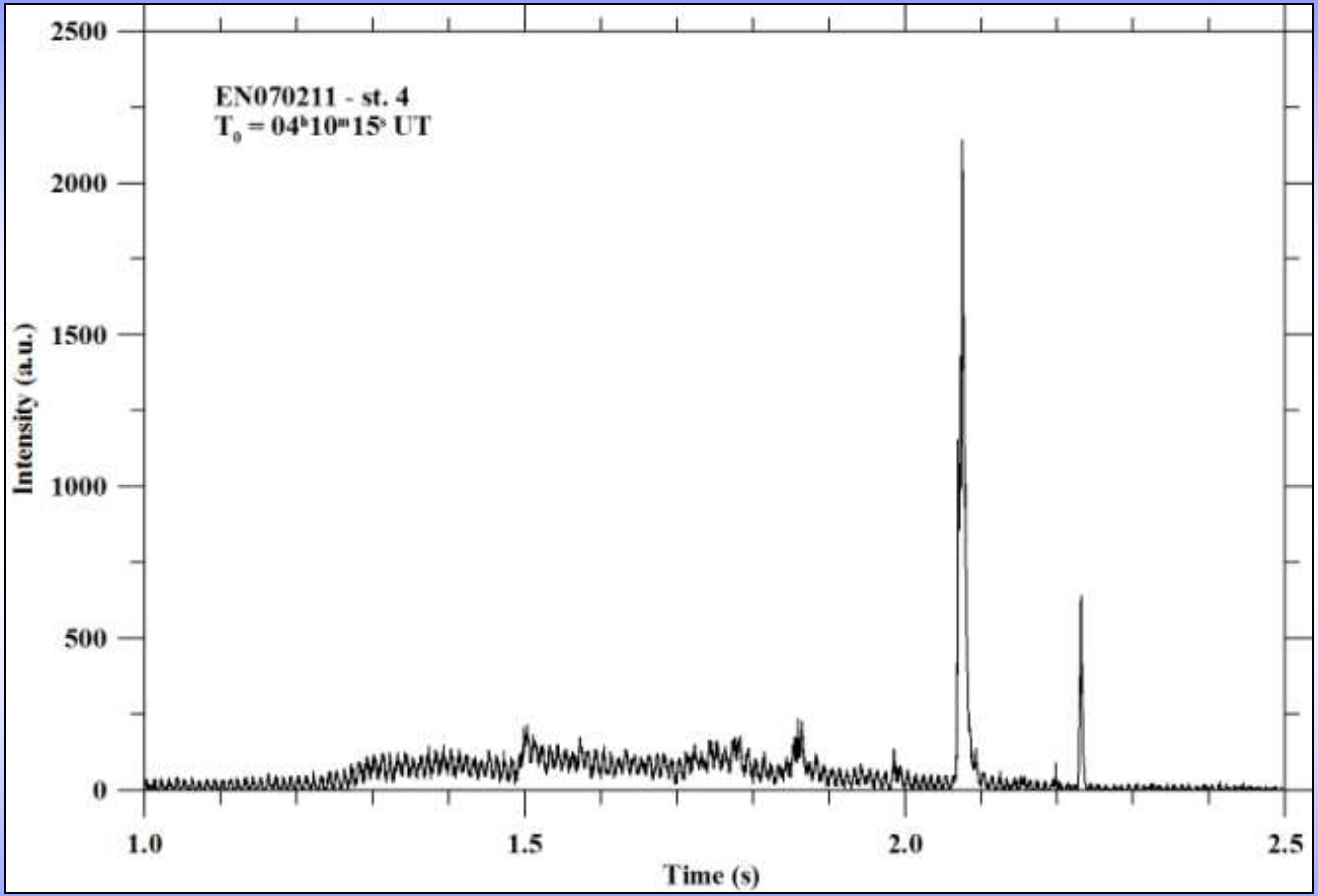


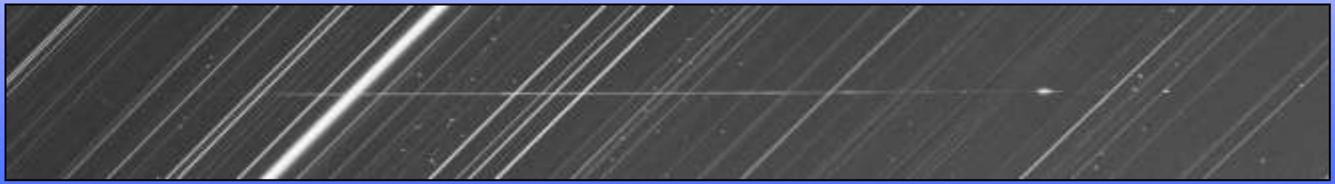
Even if the initial velocity is determined from the second part of the trajectory (after fragmentation point) it provides accurate value

LC velocity is determined with the same accuracy as using rotating shutter

Test fireballs

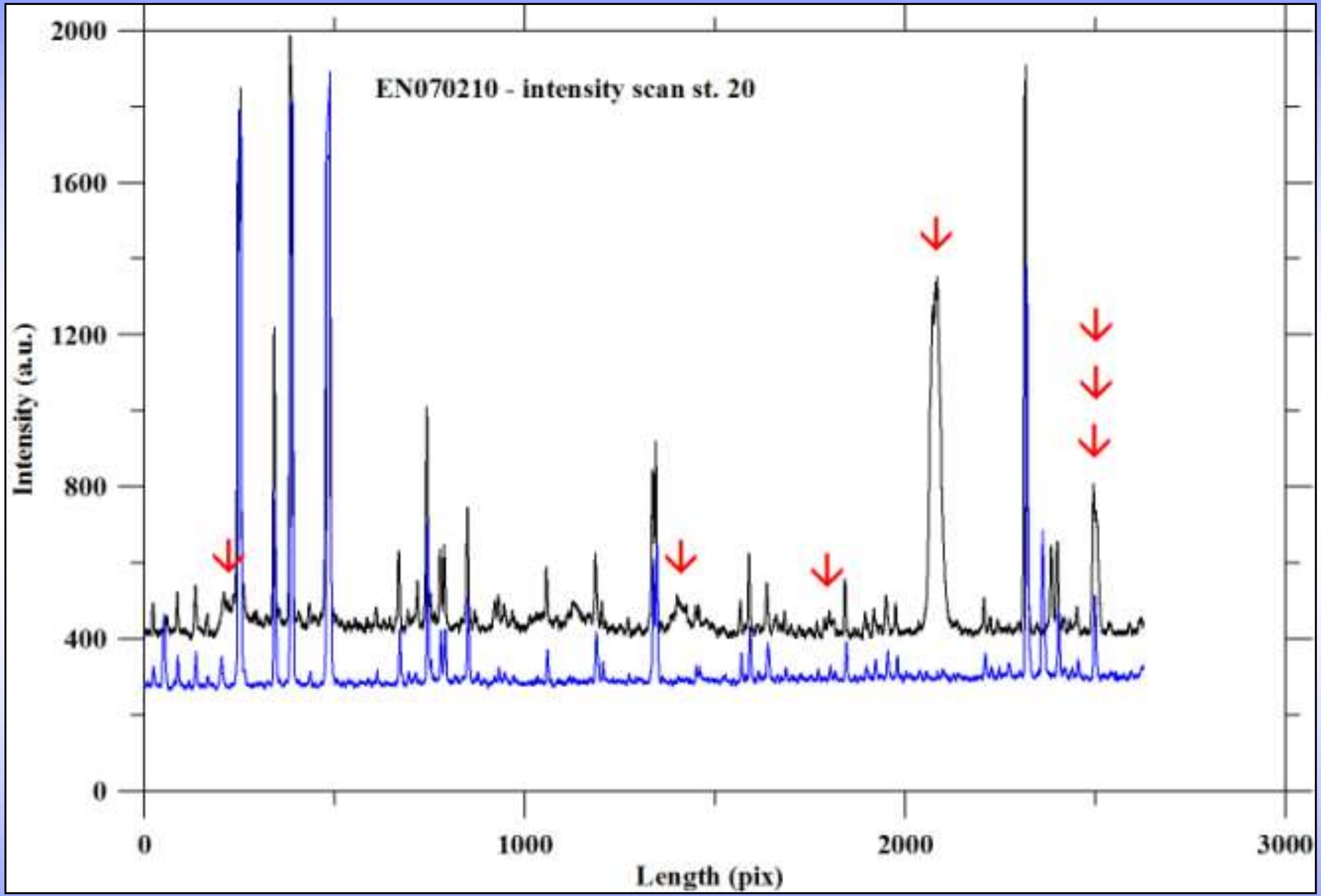
EN070211

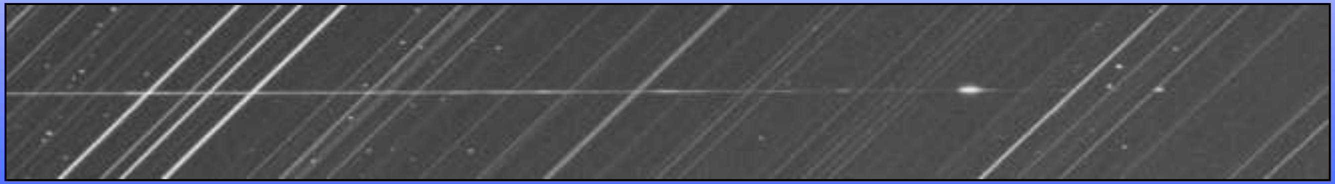




Test fireballs

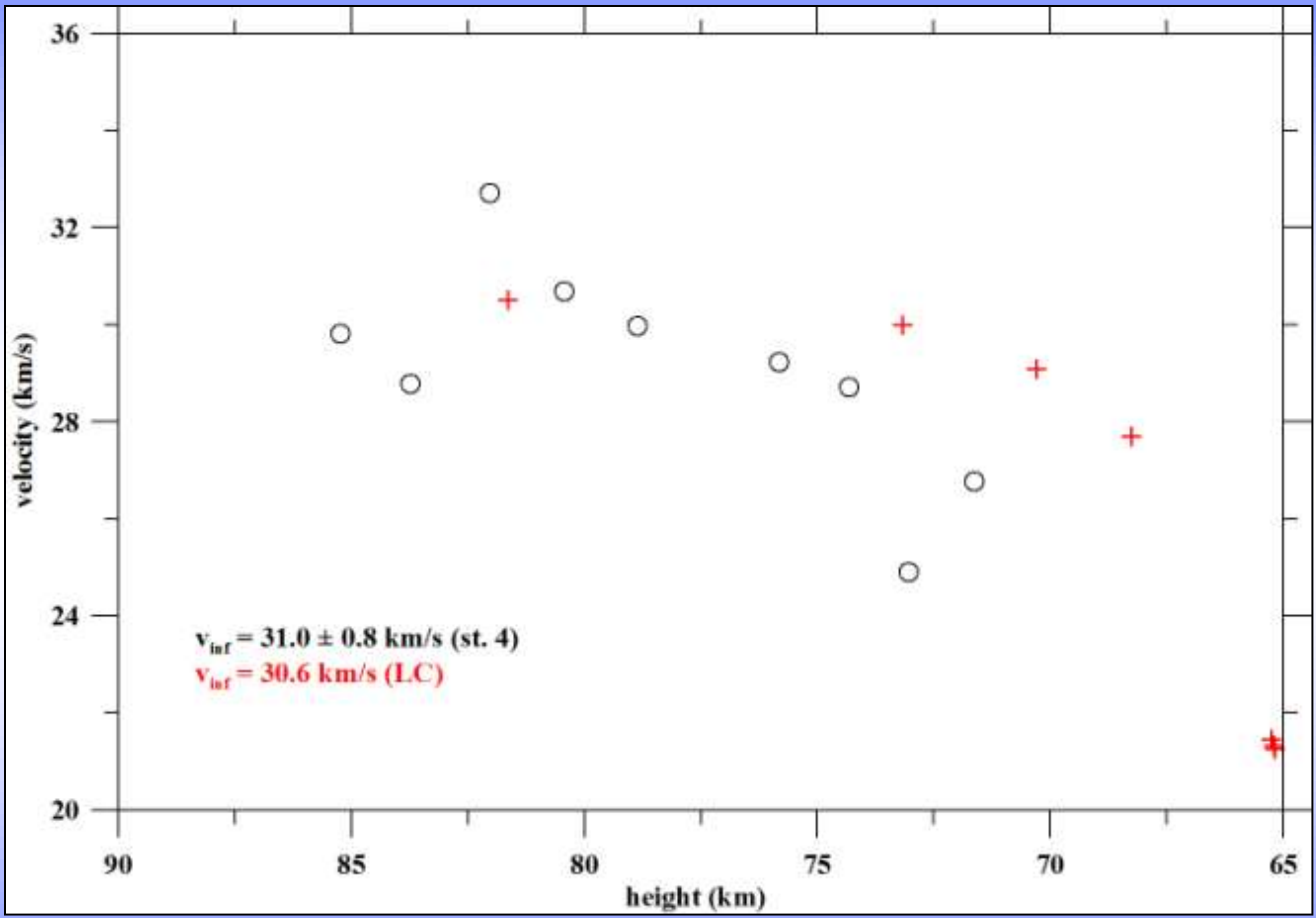
EN070211 (7 points)

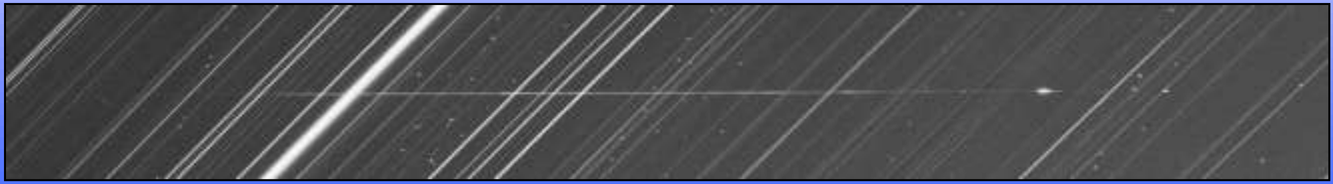




Test fireballs

EN070211





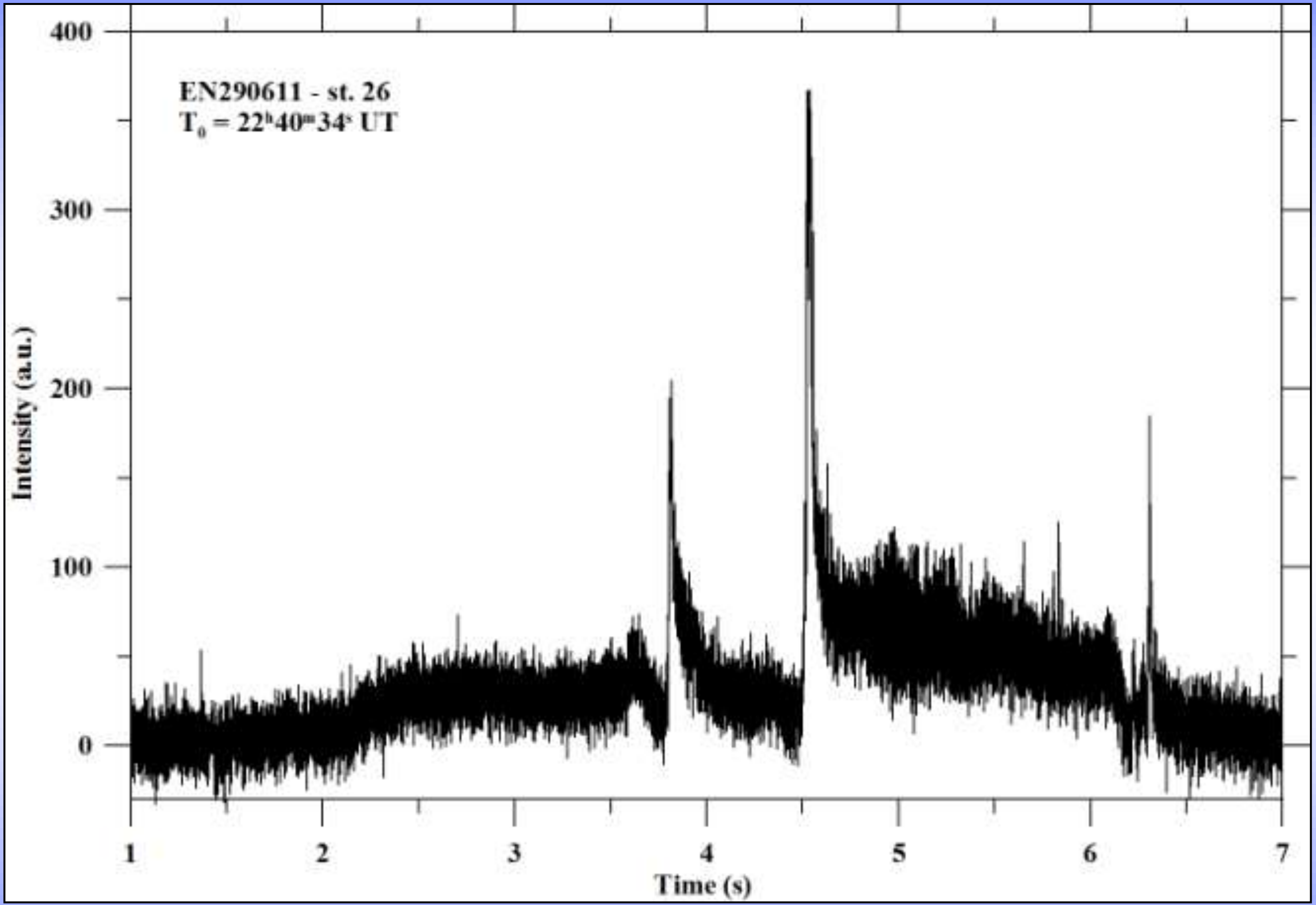
The first point is close to the beginning of the fireball, and thus the LC initial velocity is accurate

LC velocity is determined with higher accuracy than using RS (the fireball is short, faint and RS velocity is only from one station)

Deceleration after terminal flare can not be observed by RS

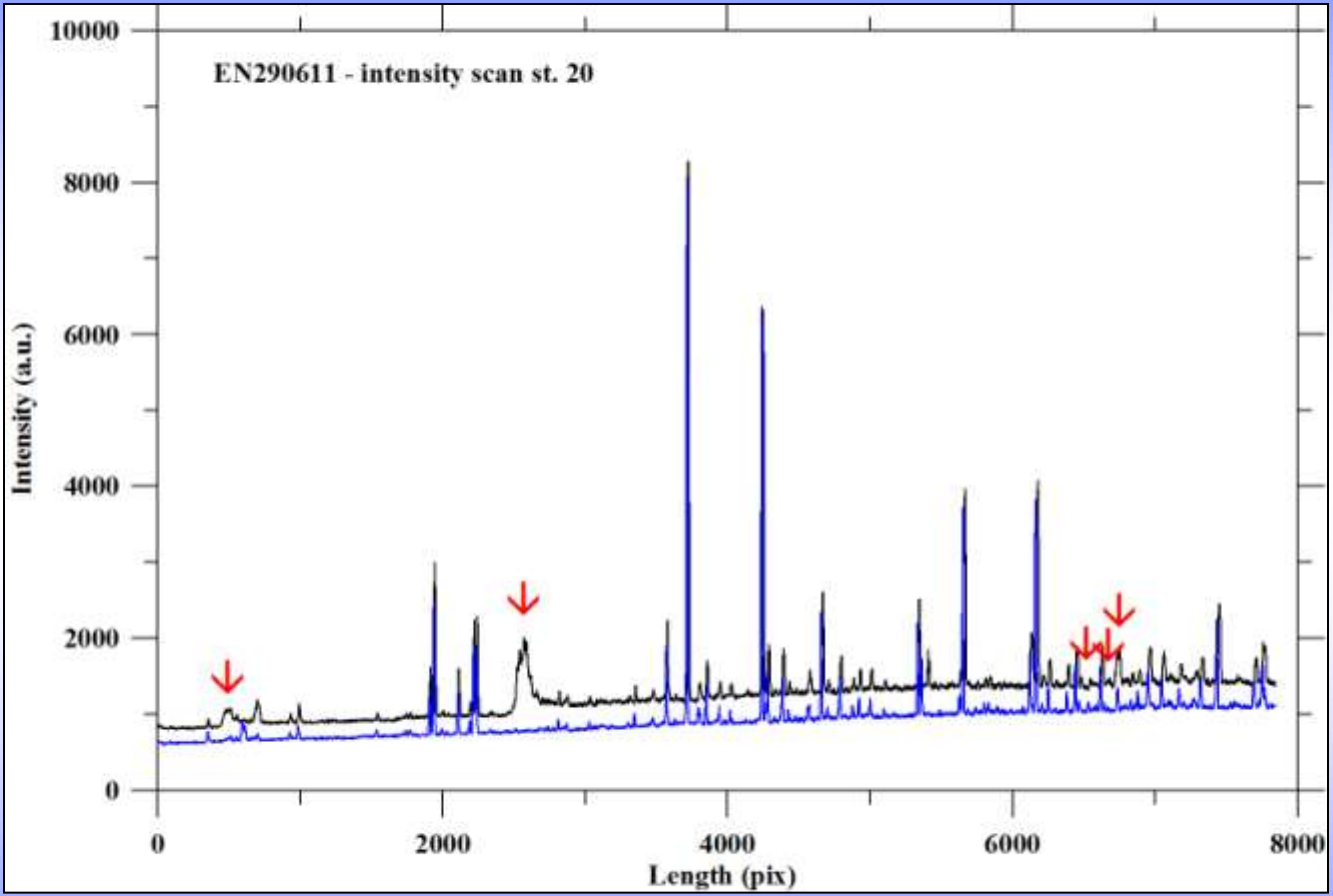
Test fireballs

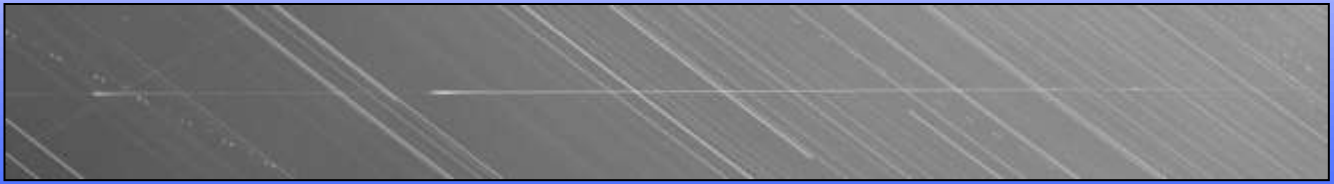
EN290611



Test fireballs

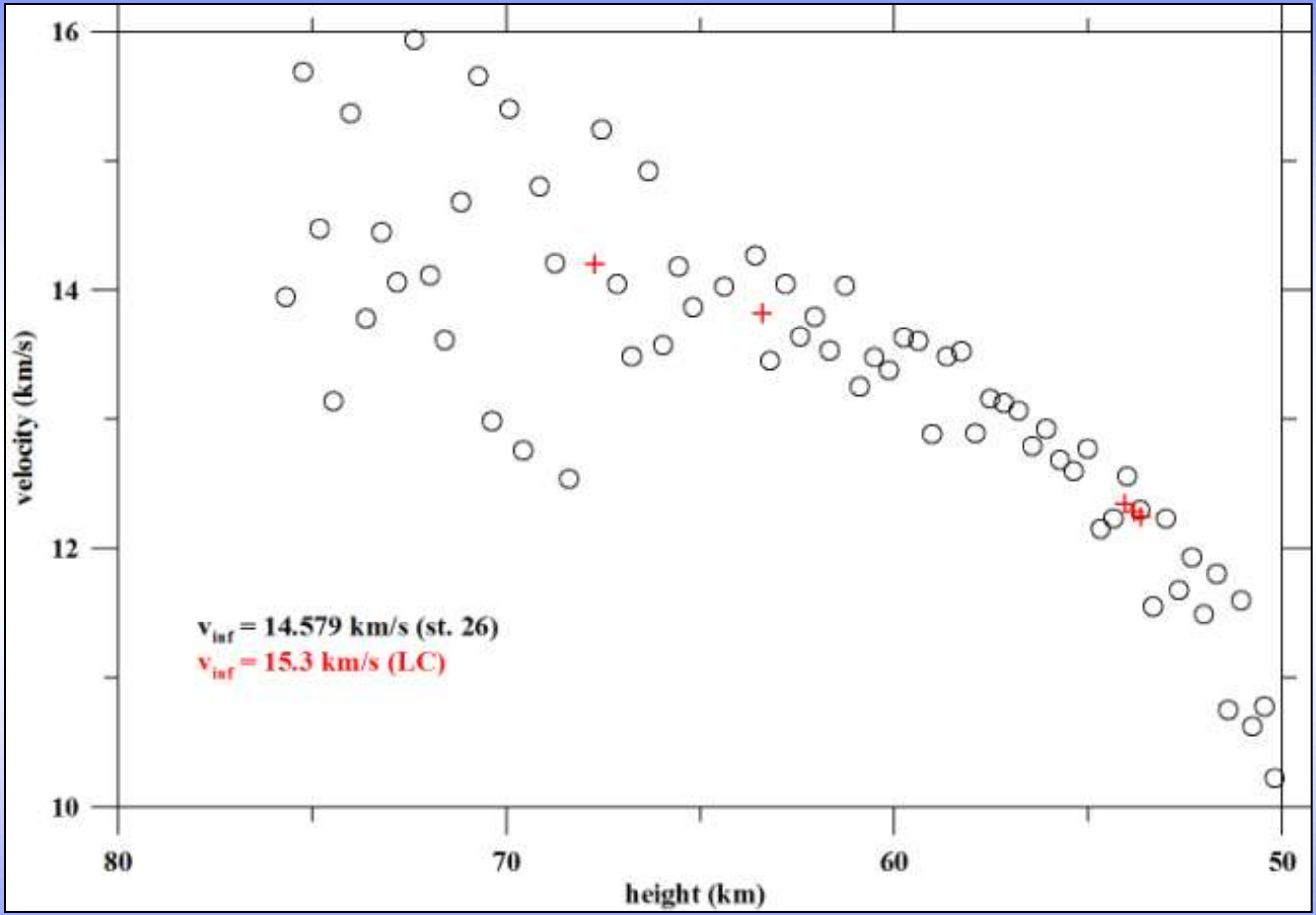
EN290611 (5 points)





Test fireballs

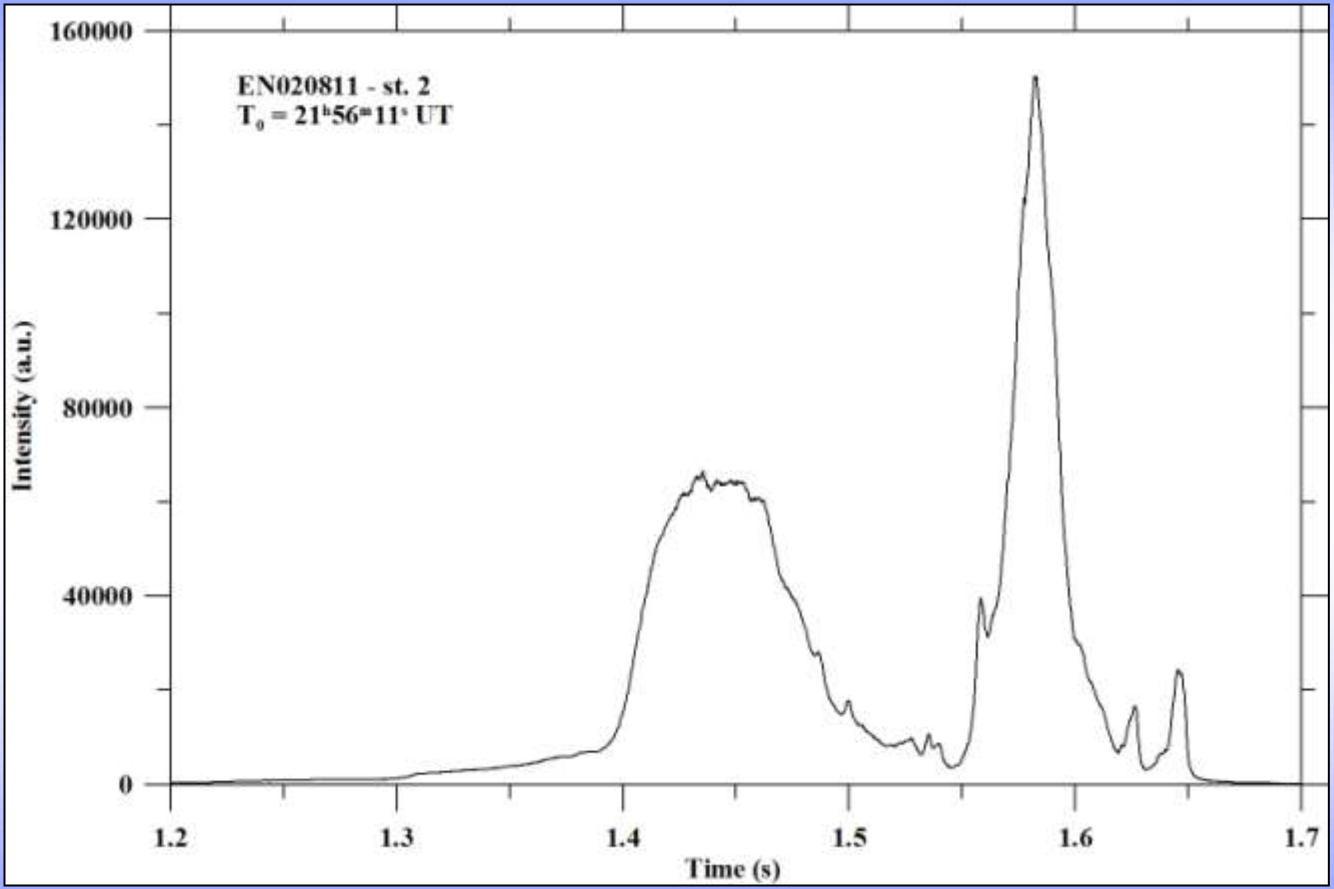
EN290611



LC velocity is determined with the same accuracy as using rotating shutter

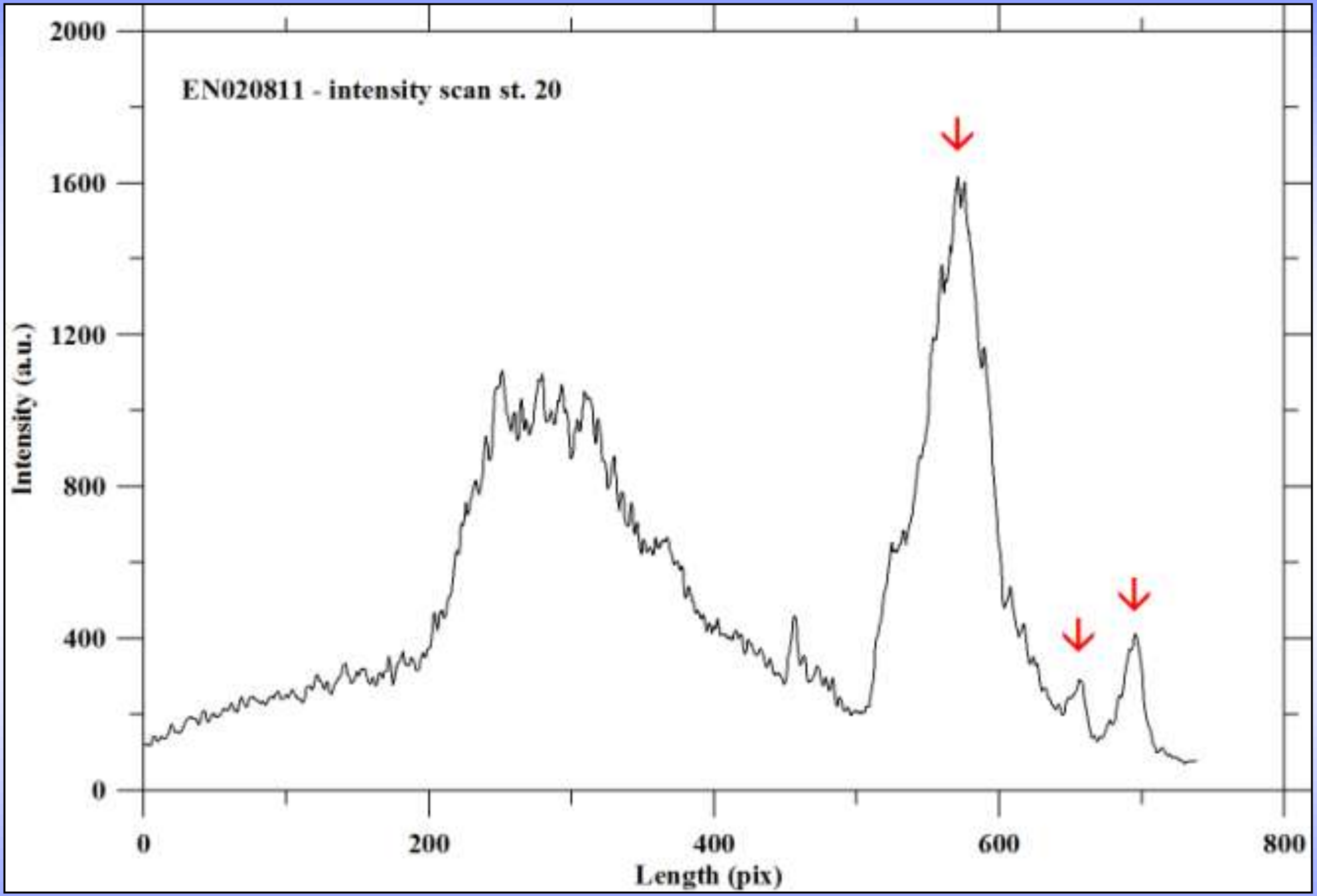
Test fireballs

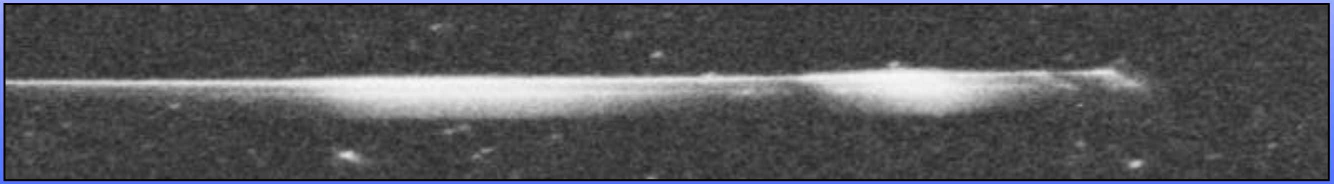
EN020811



Test fireballs

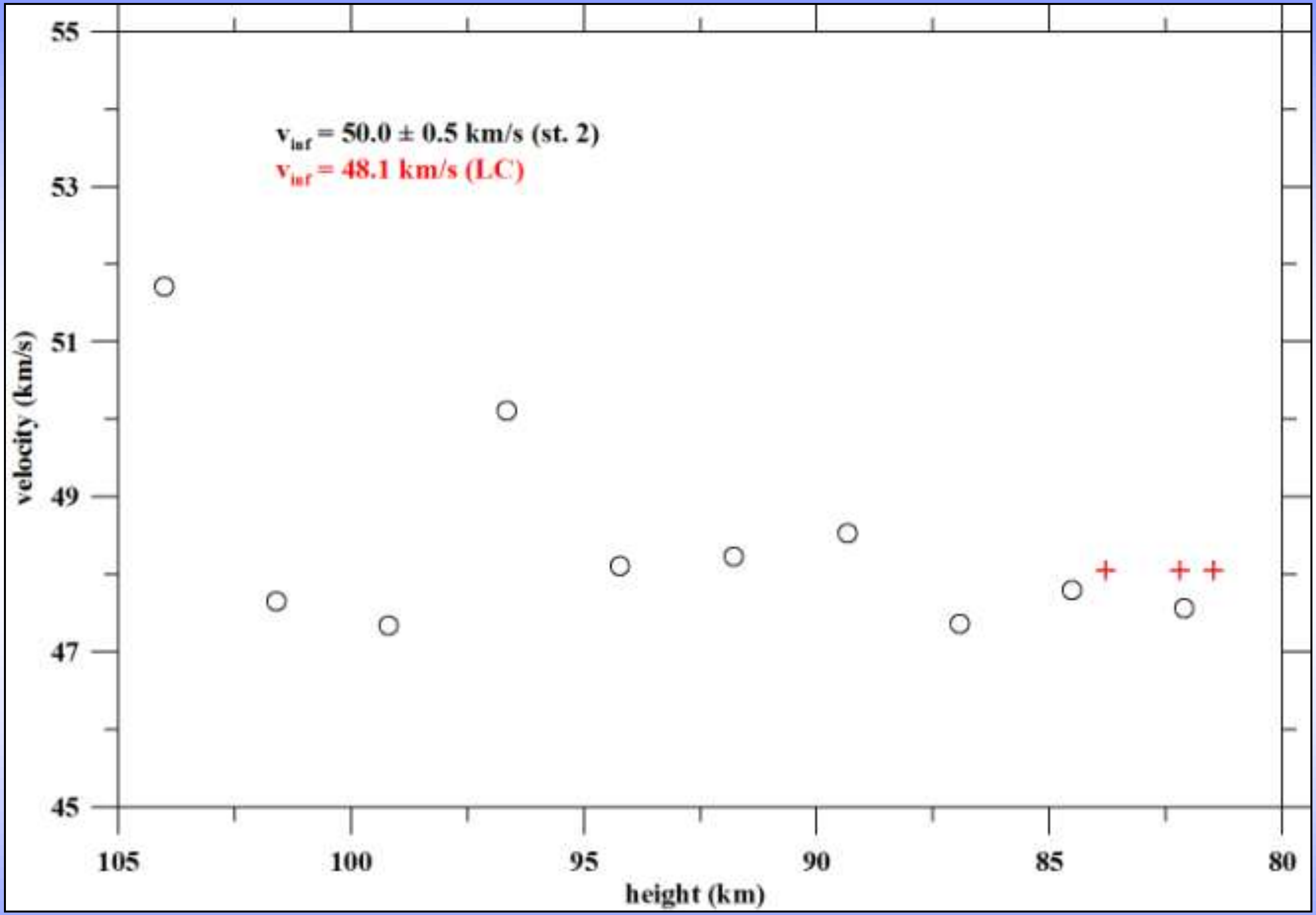
EN020811 (3 points)





Test fireballs

EN020811



LC velocity is determined for trajectory after fragmentation with the same accuracy as using RS

LC initial velocity is determined from 3 points in the very end part of the fireball without measurable deceleration

RS velocity points have spread about 1 km/s

Application of the method

EN080111

Picture taken by Hermann Koberger form Fornach, Austria

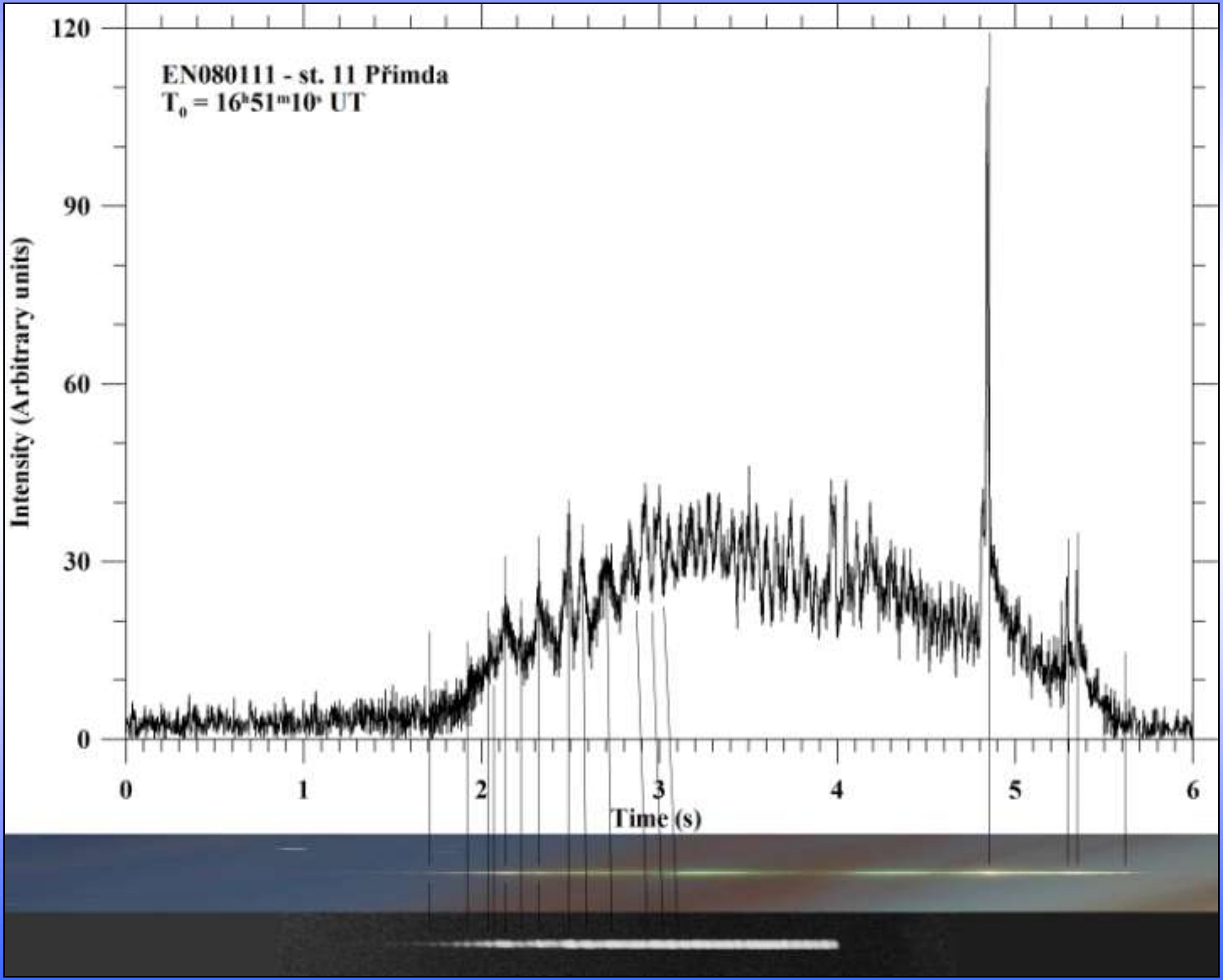
Application of the method

EN080111

Picture taken form Ondřejov observatory, Czech Rep.

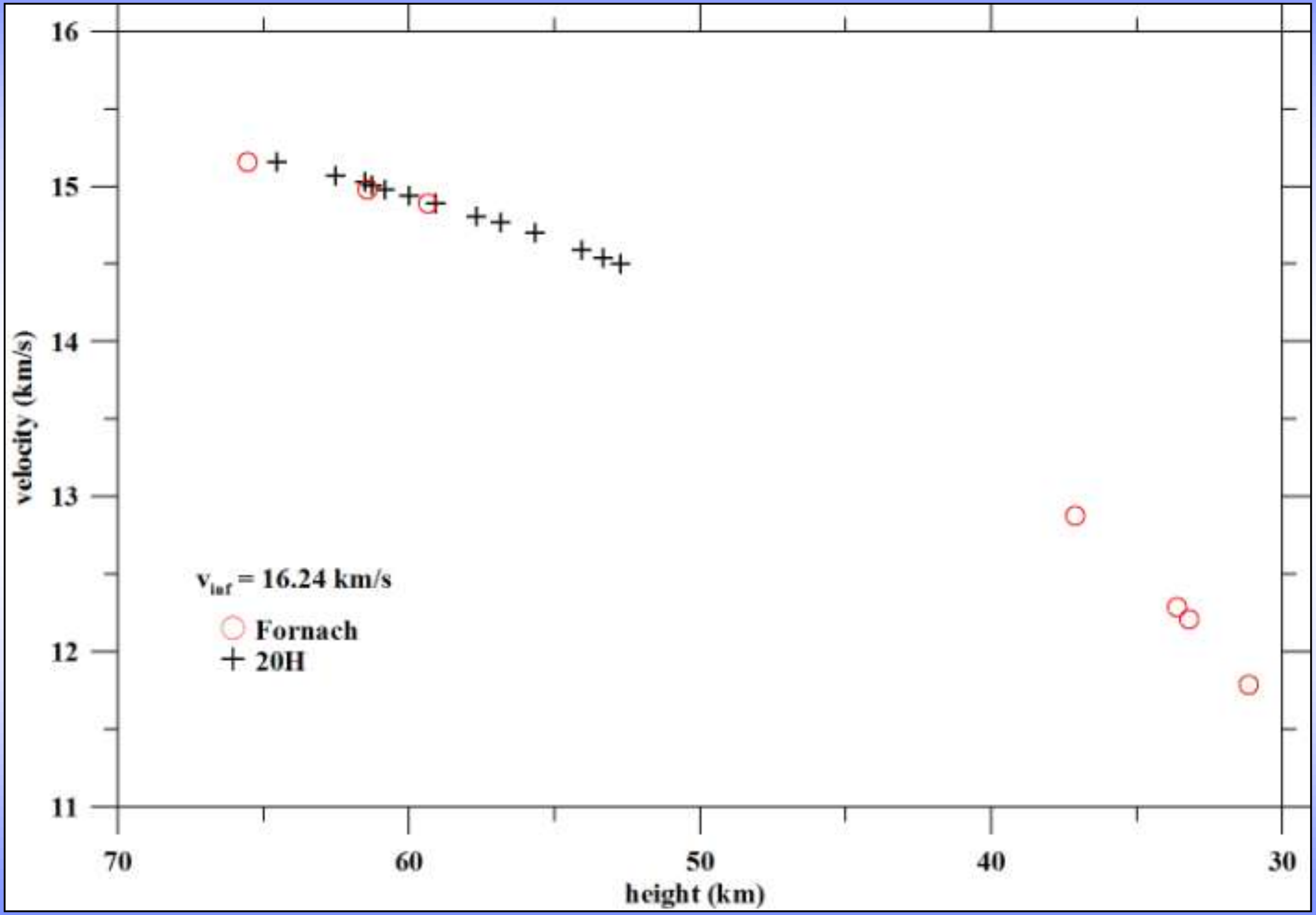
Application of the method

EN080111 (7 + 13 points)



Application of the method

EN080111



Three inaccurate RS velocity points measured on st. 26, RS initial velocity about 20 km/s

LC initial velocity determined from 2 stations and 20 points

Initial height of the fireball is 81 km

Conclusions

Advantages

- LC velocity provides acurate velocity of fireballs
  - with high time resolution light curve (500 samples/s is enough)
  - on parts of atmospheric trajectory with flares
  - within the range of possible velocities
- accuracy of LC velocity is compareable with rotating shutter velocity
- applicable on short fireballs

Disadvantages

- applicable only for fireballs with flares
- determination of intial velocity is not that acurate
- full Moon nights are unfavouable due to low value of S/N ratio