High-cadence photometry of bright Type Ia Supernovae with the 2.3m Aristarchos telescope

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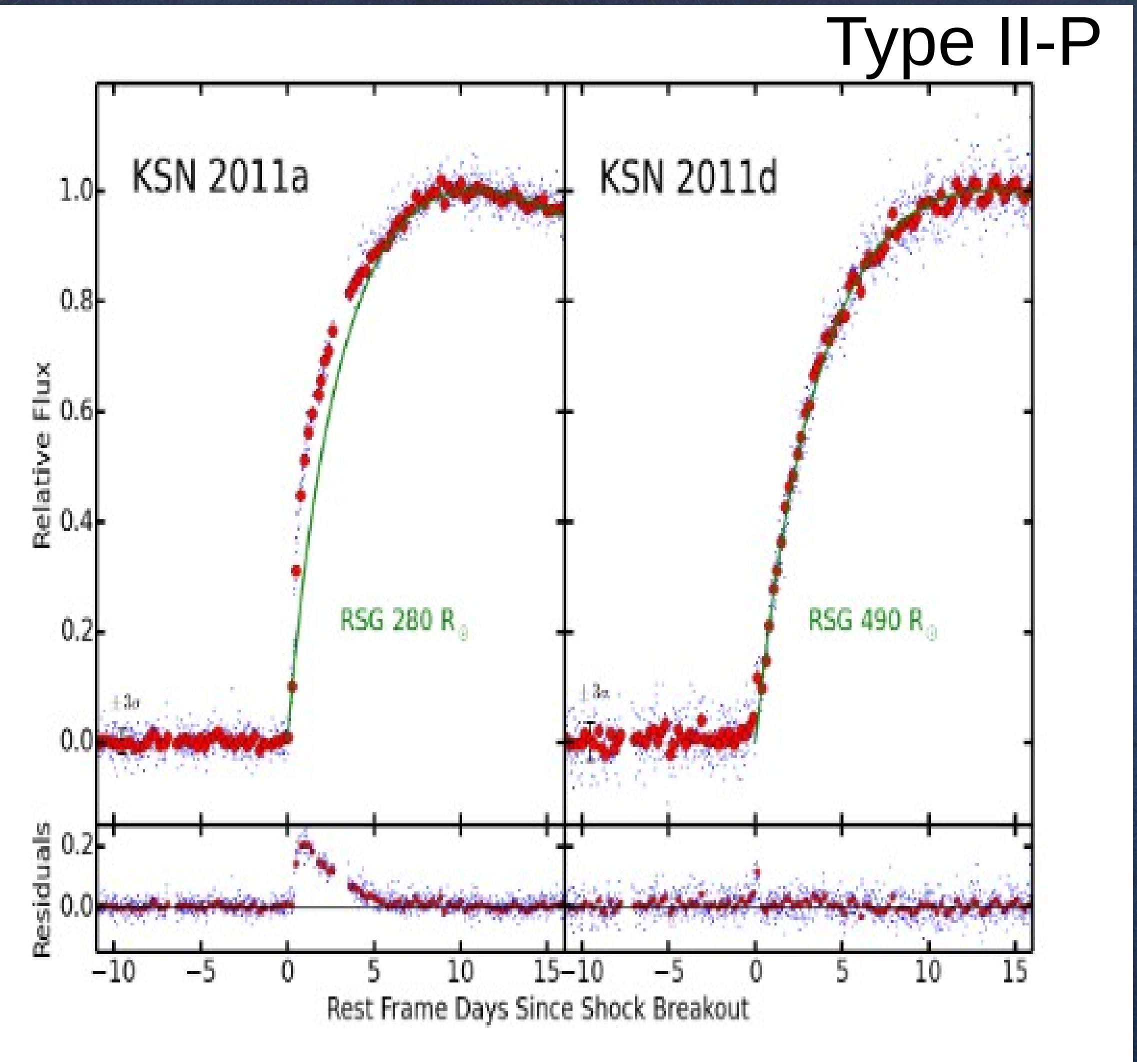
Outline

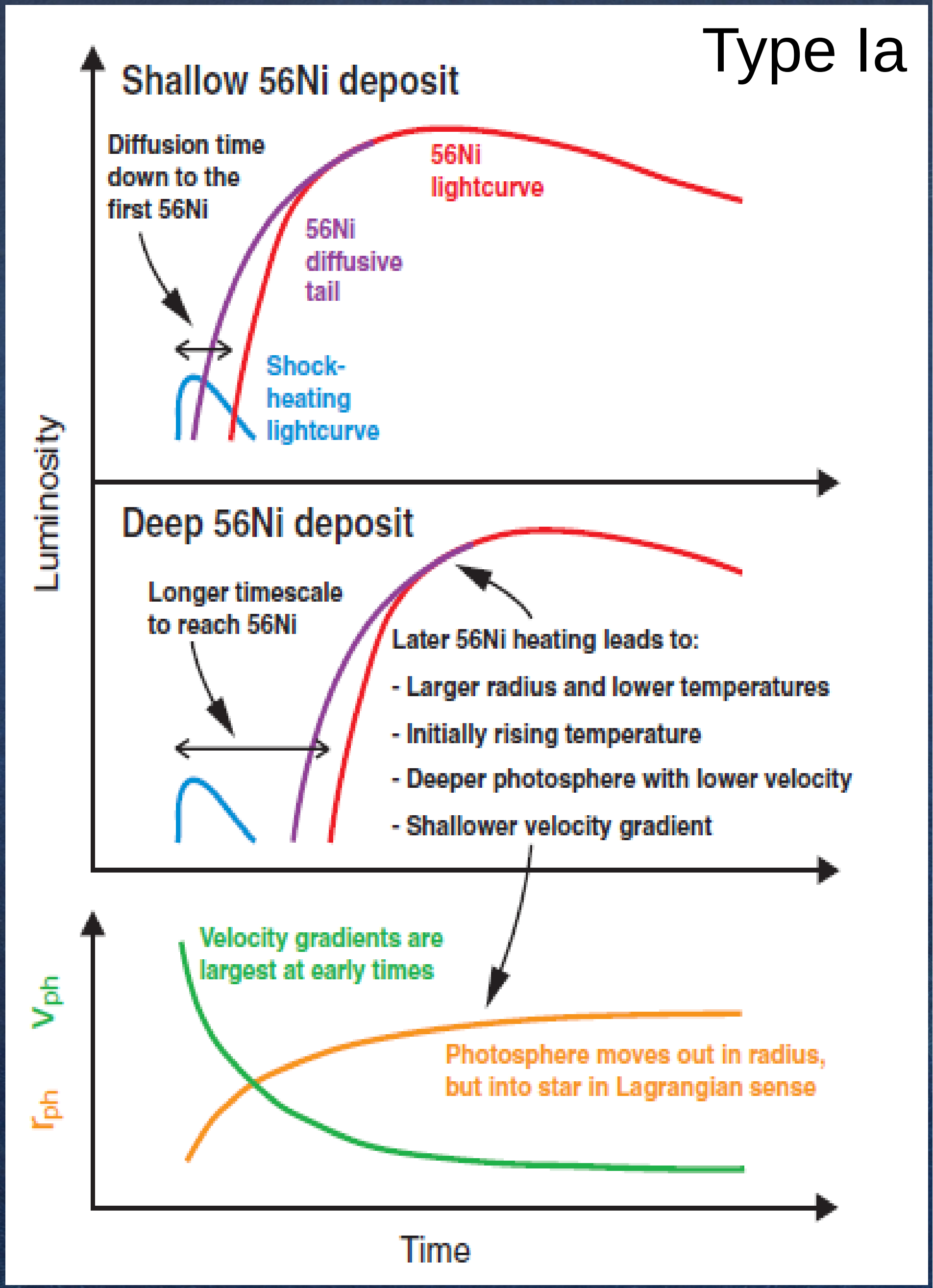
- Motivation
- Observations with 2.3m Aristarchos telescope
- Methods
- Results of high cadence monitoring of SN 2016gsn & 2016gsb
- Conclusions and future monitoring of bright supernovae

Open questions...

- How many Type Ia supernovae arise from single degenerate vs. double degenerate vs. sub-Chandrasekhar progenitor systems?
- What is the role of the companion in Type Ia supernovae?
- Initial conditions for supernova modeling Ia

Motivation



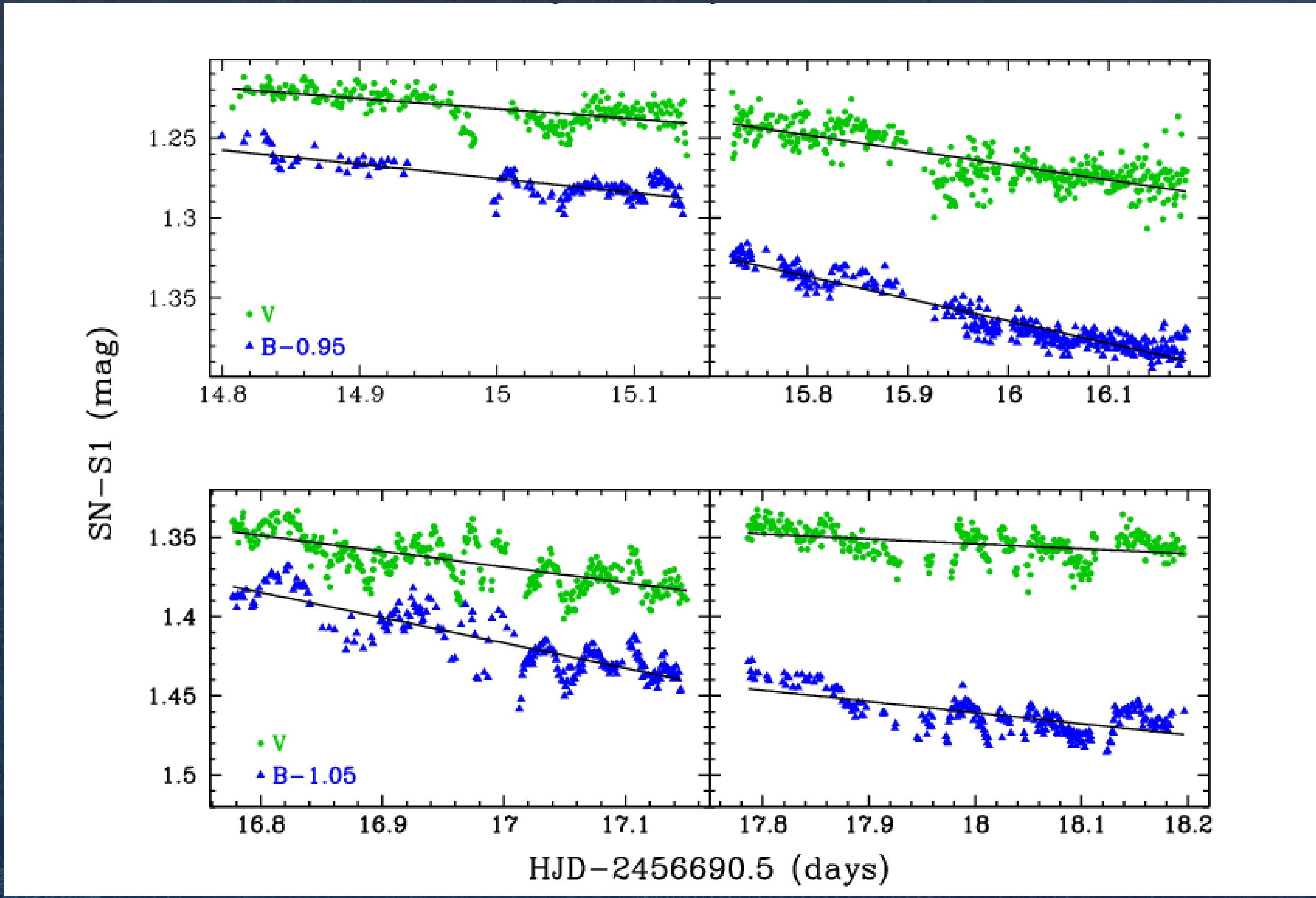


- Blue dots are flux measurements with a 30 minute cadence
- Red symbols are 6-hour medians

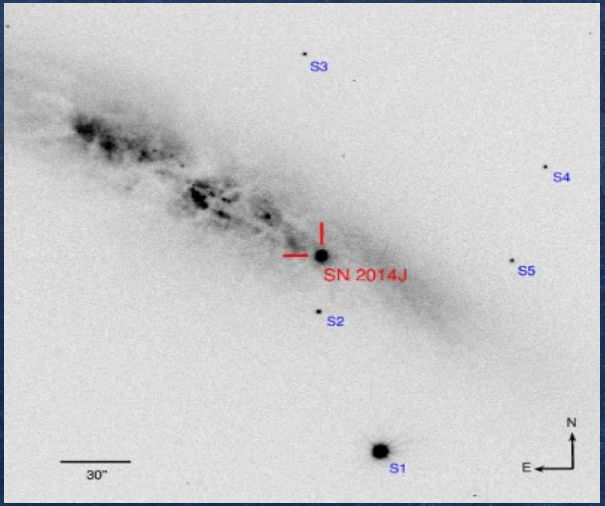
Garnavich et al. (2016, 2 Type IIp SNe)

Piro & Morojova (2016, Early Type Ia SNe)

Differential light curve of SN 2014J obtained with the 2.3m Aristarchos telescope over 4 nights



Evidence for rapid variability of 0.02-0.05 mag on a timescale of 15-60min on all nights, peaking on 3rd night

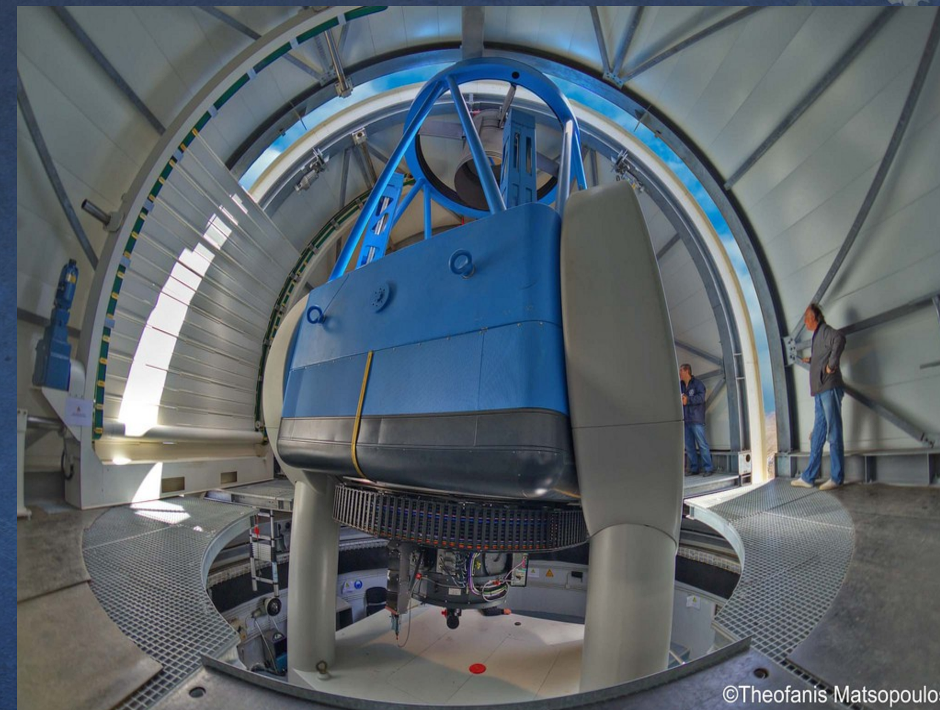


- High-cadence monitoring of the optical light curve of the nearby, Type Ia SN 2014J in M82
- 15-18 days after peak
- 2 min cadence

Bonanos & Boumis (2016, A&A, 585, 19)

Observations

- 4 nights with the 2.3m Aristarchos telescope in October 2016
- RISE2 camera (10'x10' FOV, broad-VR filter)
- High cadence (10-60s) photometry



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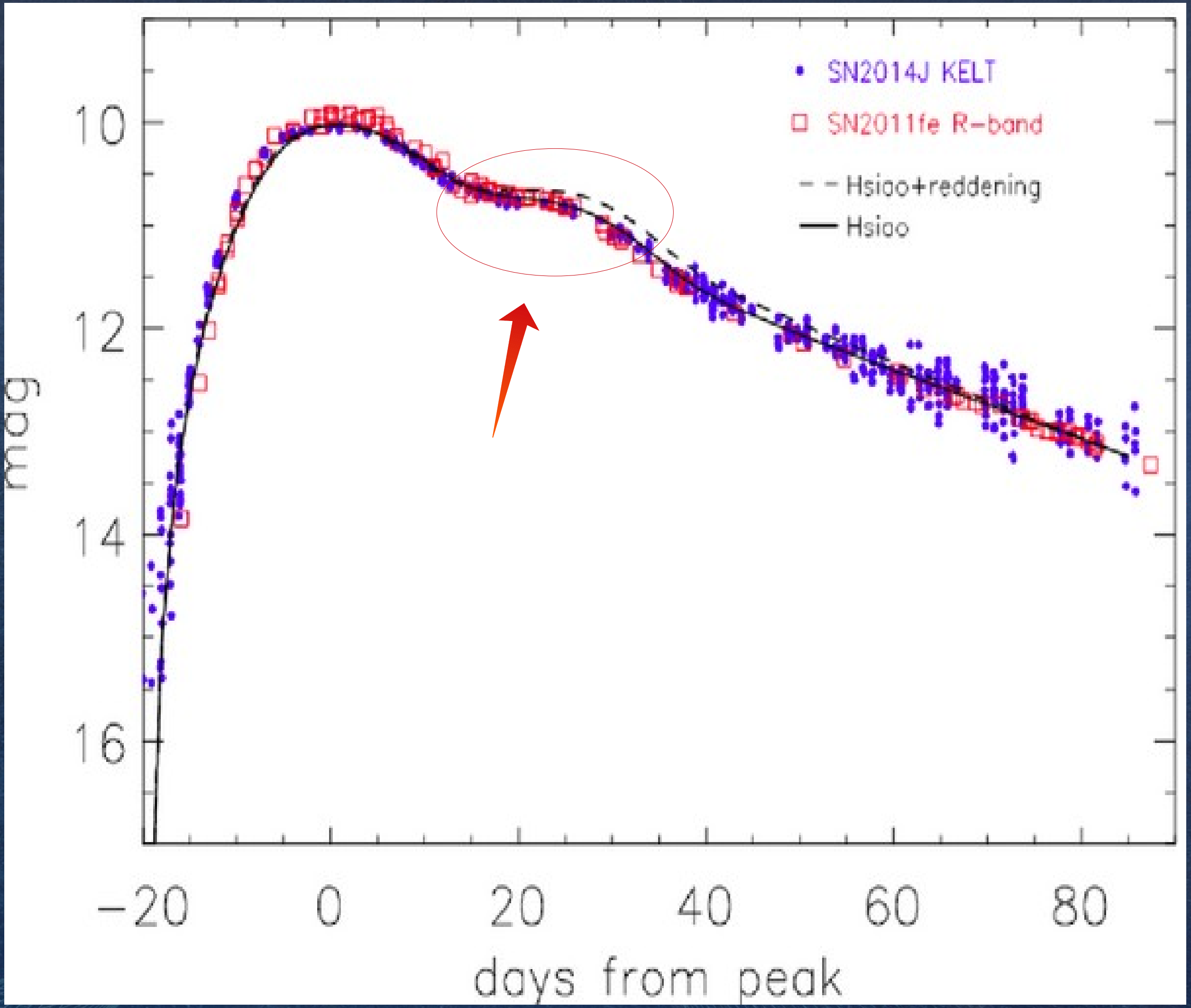
ARISTARCHOS TELESCOPE

HELMOS OBSERVATORY

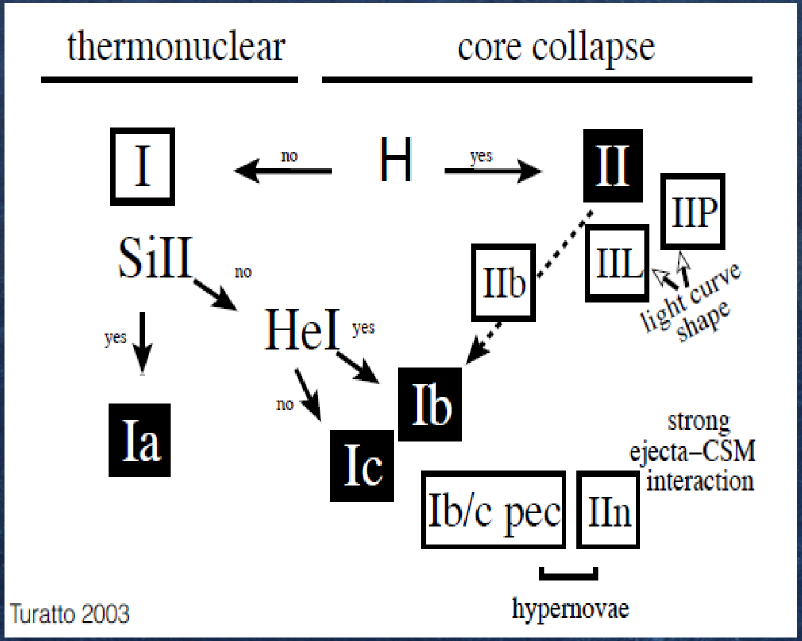
RISE2 camera

The typical light curve of a SN Type Ia



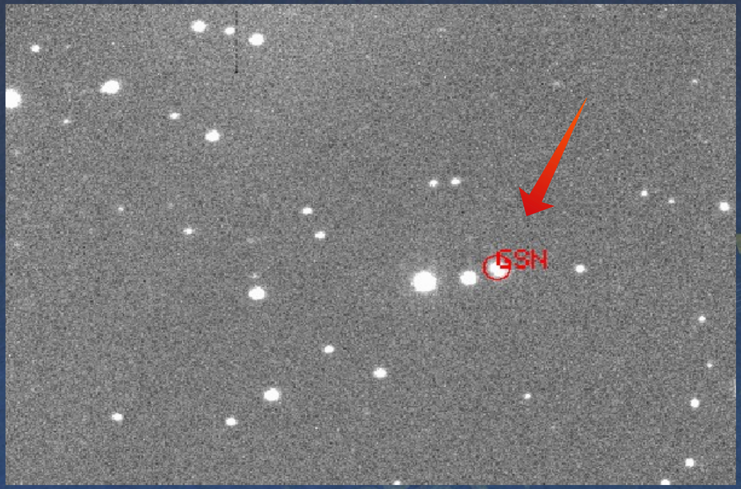
Siverd et al. (2015)

Supernovae Family



2016gsn ASAS-SN

- Type: SN Ia
- Redshift: 0.018
- 21-32 days after peak
- 4520 frames
- 10-20s exposure time & cadence
- Discovery mag: 16.3 mag



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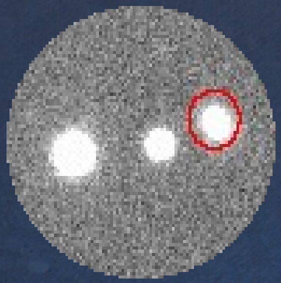
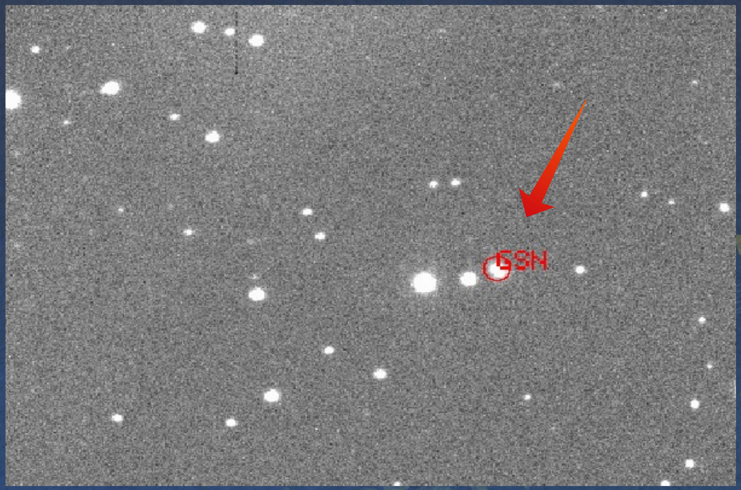
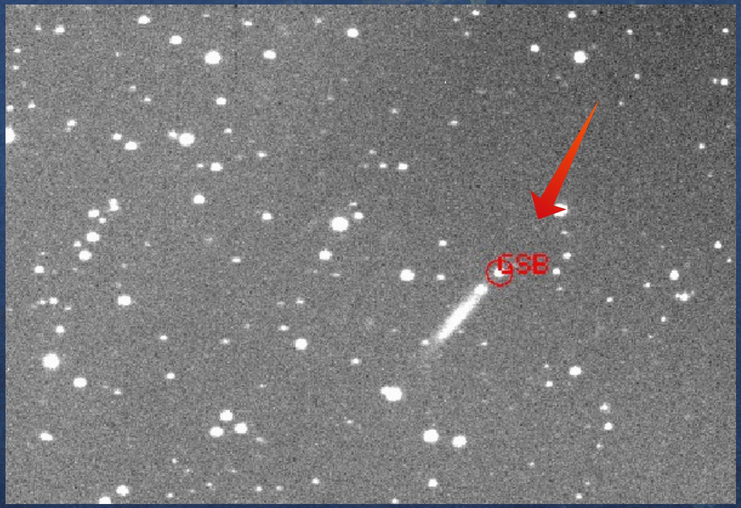




2016gsb

- Type: SN Ia
- Redshift: 0.0097
- 15-26 days after peak
- 1892 frames
- 15-20s exposure time & cadence
- Discovery mag: 15.9 mag



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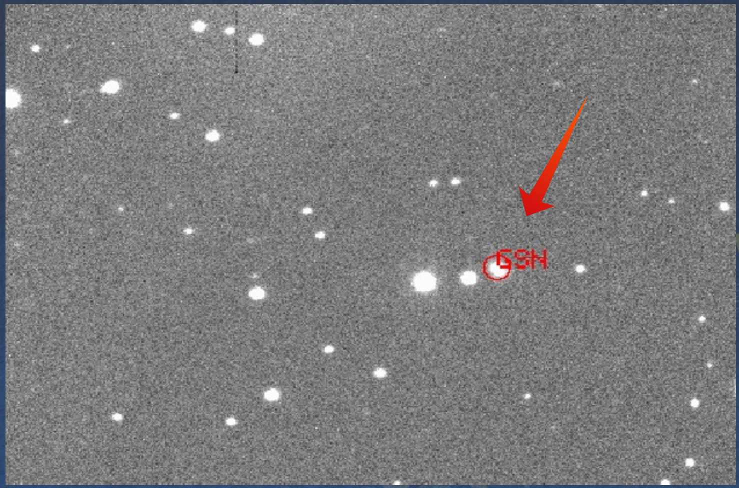

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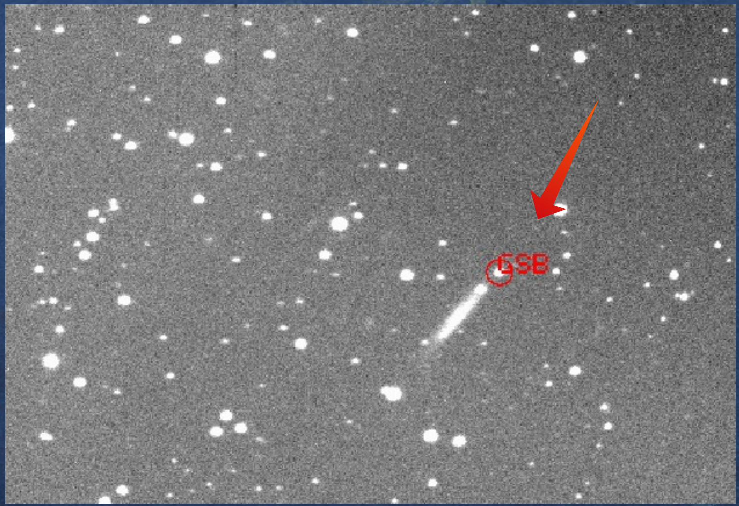
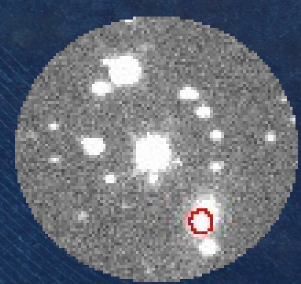
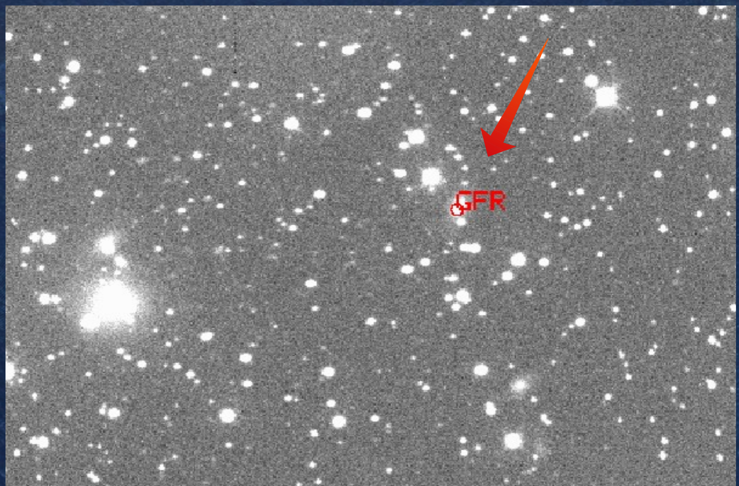


2016gfr

- Type: SN Ia
- Redshift: 0.014
- 32-42 days after peak
- 1085 frames
- 10-60s exposure time & cadence
- Discovery mag: 17.6 mag

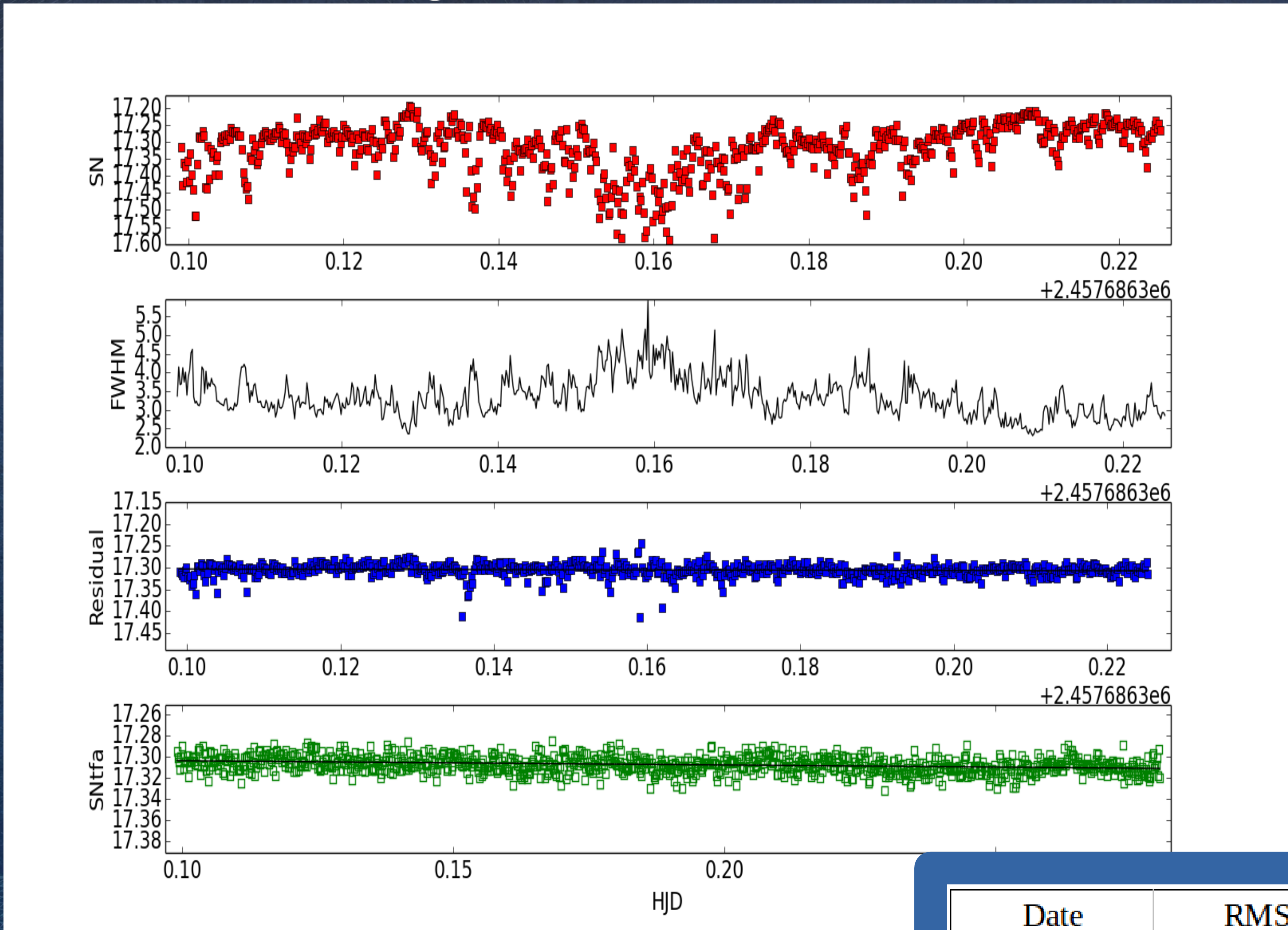




Methods

- CCD reduction
- Aperture photometry with VAPHOT (Deeg et al. 2013) (2016gsn, 2016gsb)
  - APCALC task finds the optimum aperture size for each star in a reference image
  - VAPHOT is similar to IRAF's "PHOT" task
- PSF photometry with DAOPHOT (2016gfr)
- ISIS image subtraction (2016gfr)
- For systematic errors:
  - Trend-Filtering Algorithm (TFA, Kovacs et al. 2005)
  - Fitting a quadratic polynomial to the shift as function of the measured FWHM of the stellar images (Irwin et al. 2007)

Results: 2016gsn



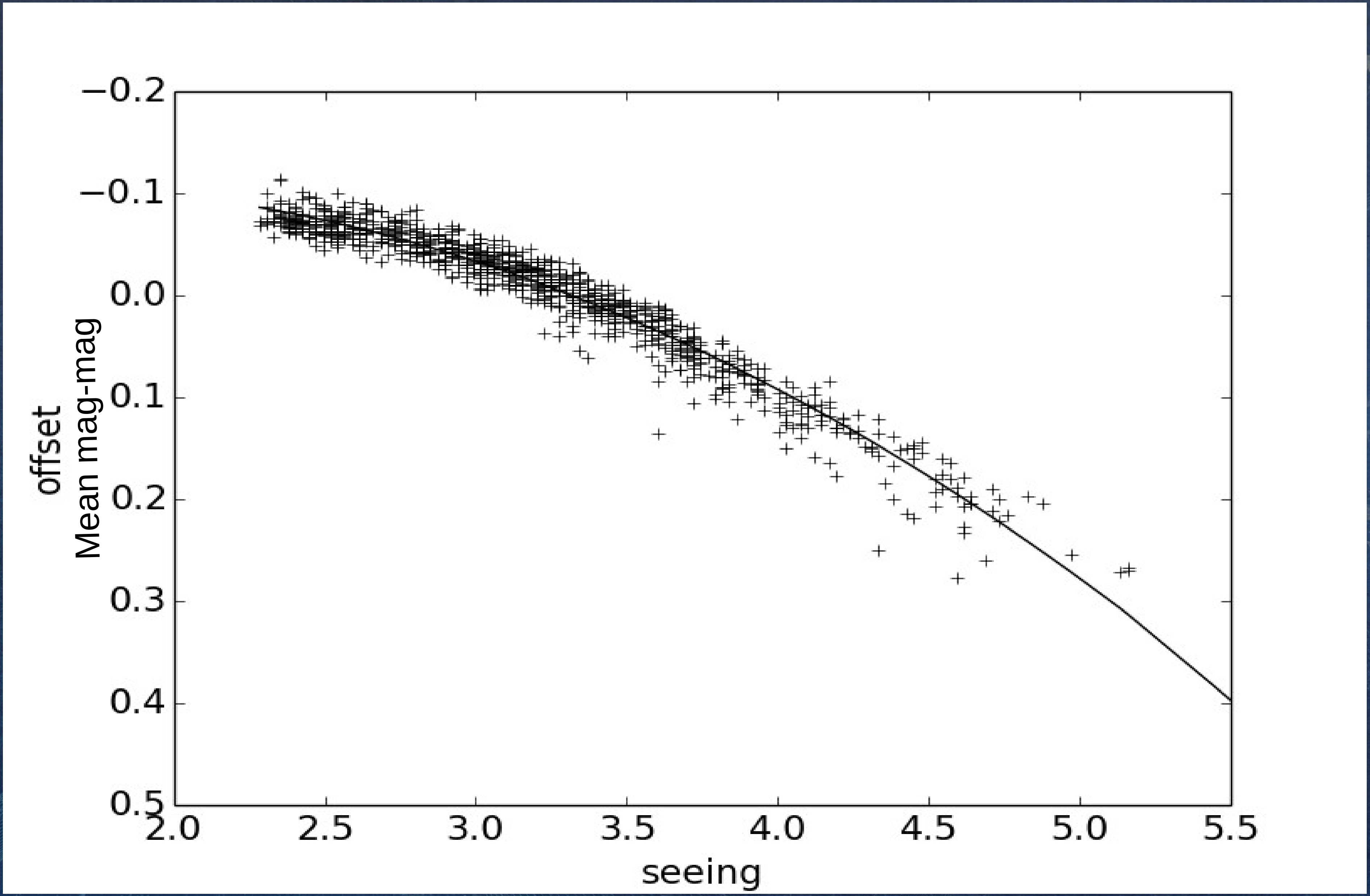
RMS 0.072 mag

The residual after subtracting the quadratic fit.

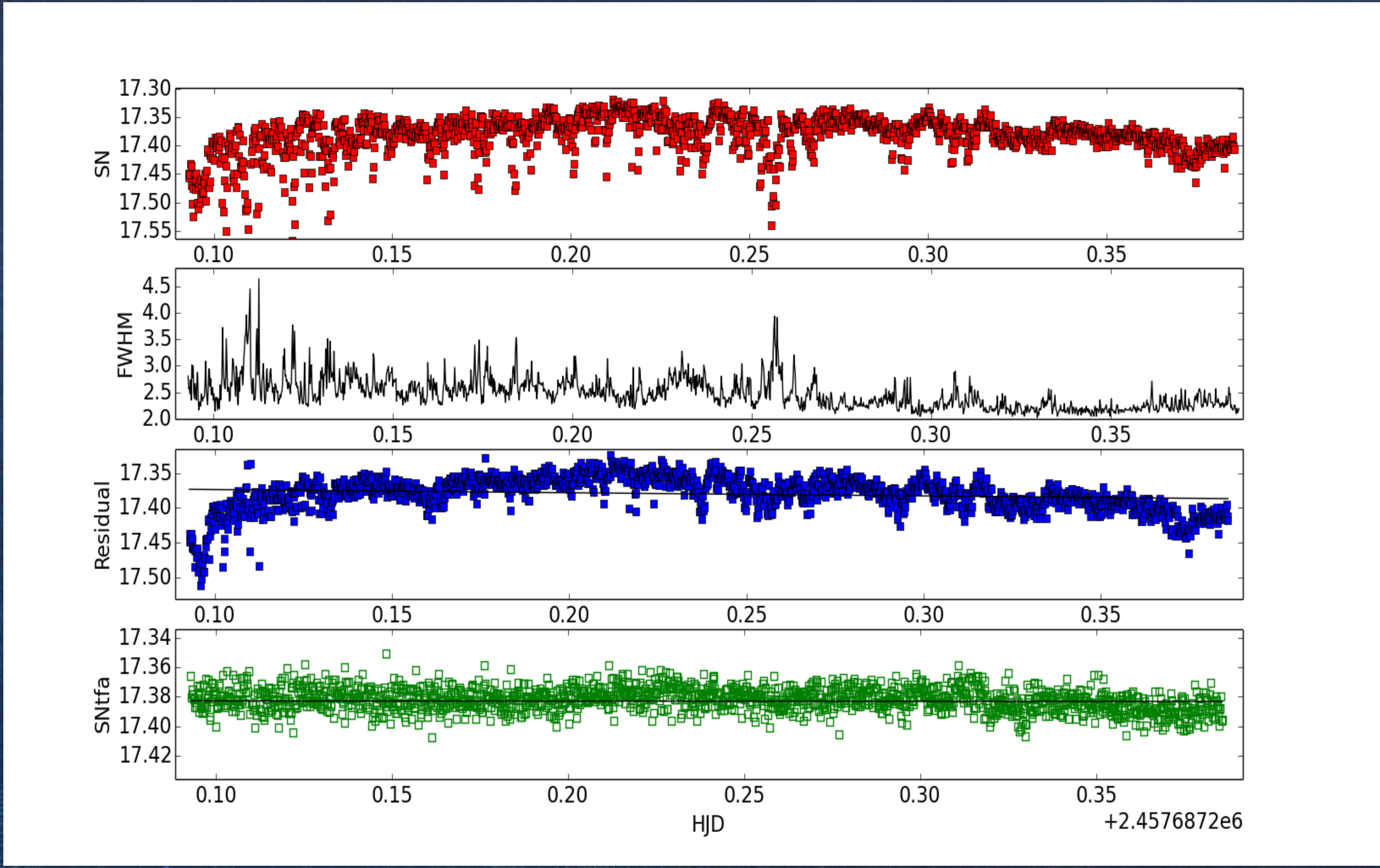
After Trend-Filtering Algorithm RMS 0.016 mag

Date	RMS	RMS -TFA
14/10/16	0.021	0.015
15/10/16	0.250	0.206
24/10/16	0.072	0.016
25/10/16	0.039	0.021

October 25, 2016



The quadratic polynomial fit



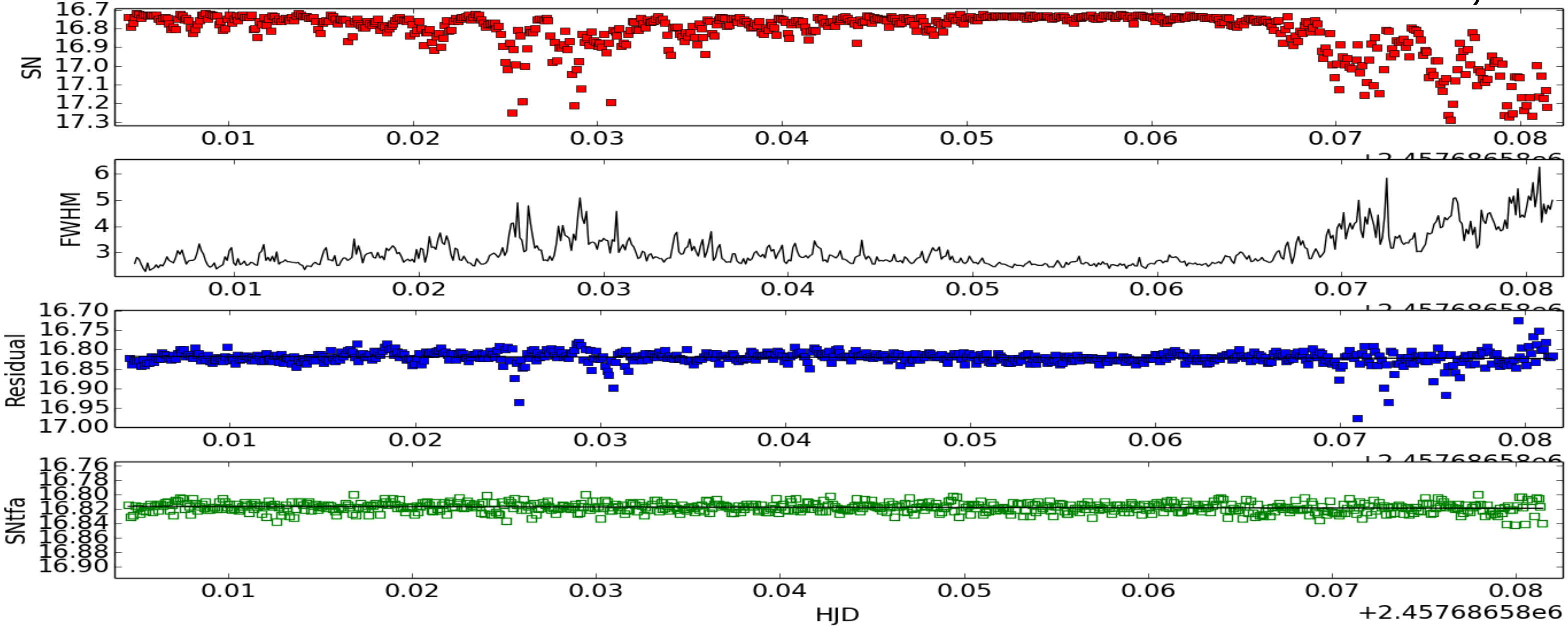
RMS
0.1235

TFA RMS
0.0381

October 26, 2016

Results: 2016gsb

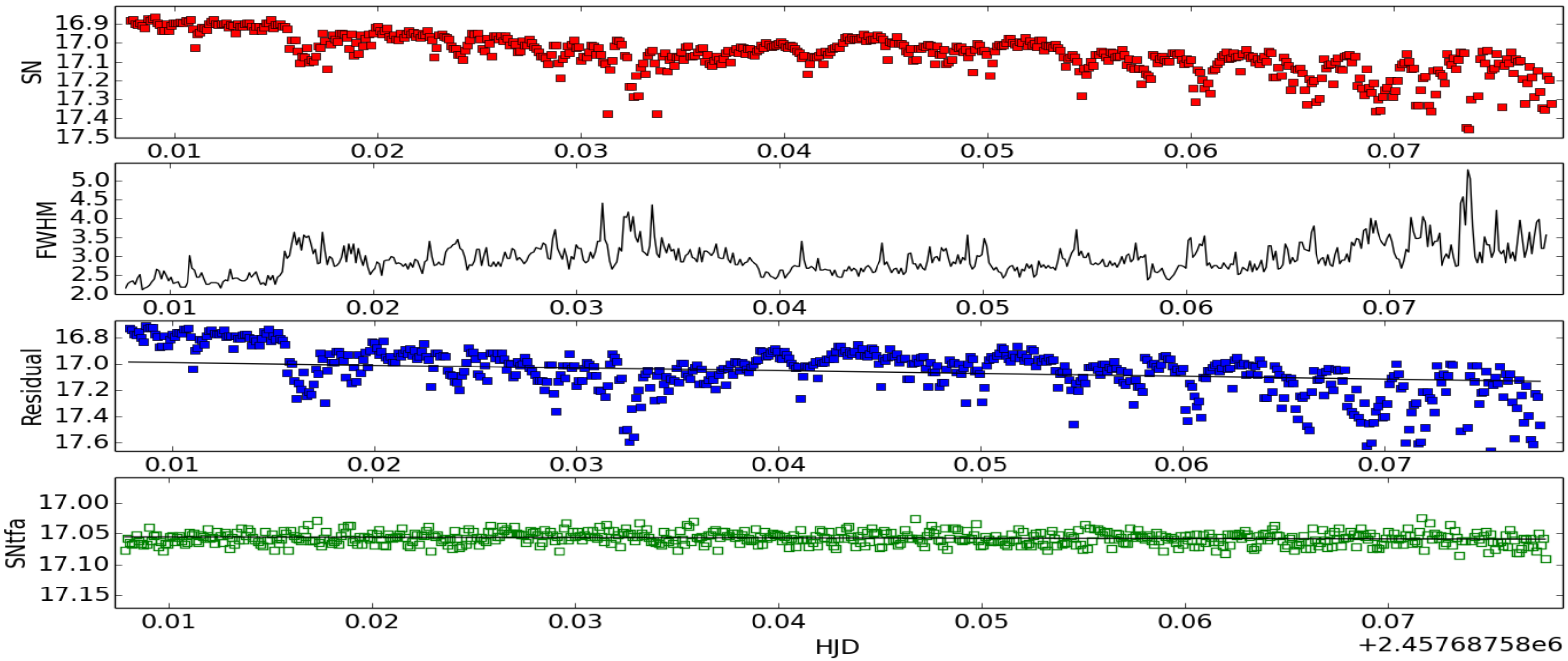
October 25, 2016



RMS 0.1235

TFA RMS 0.0381

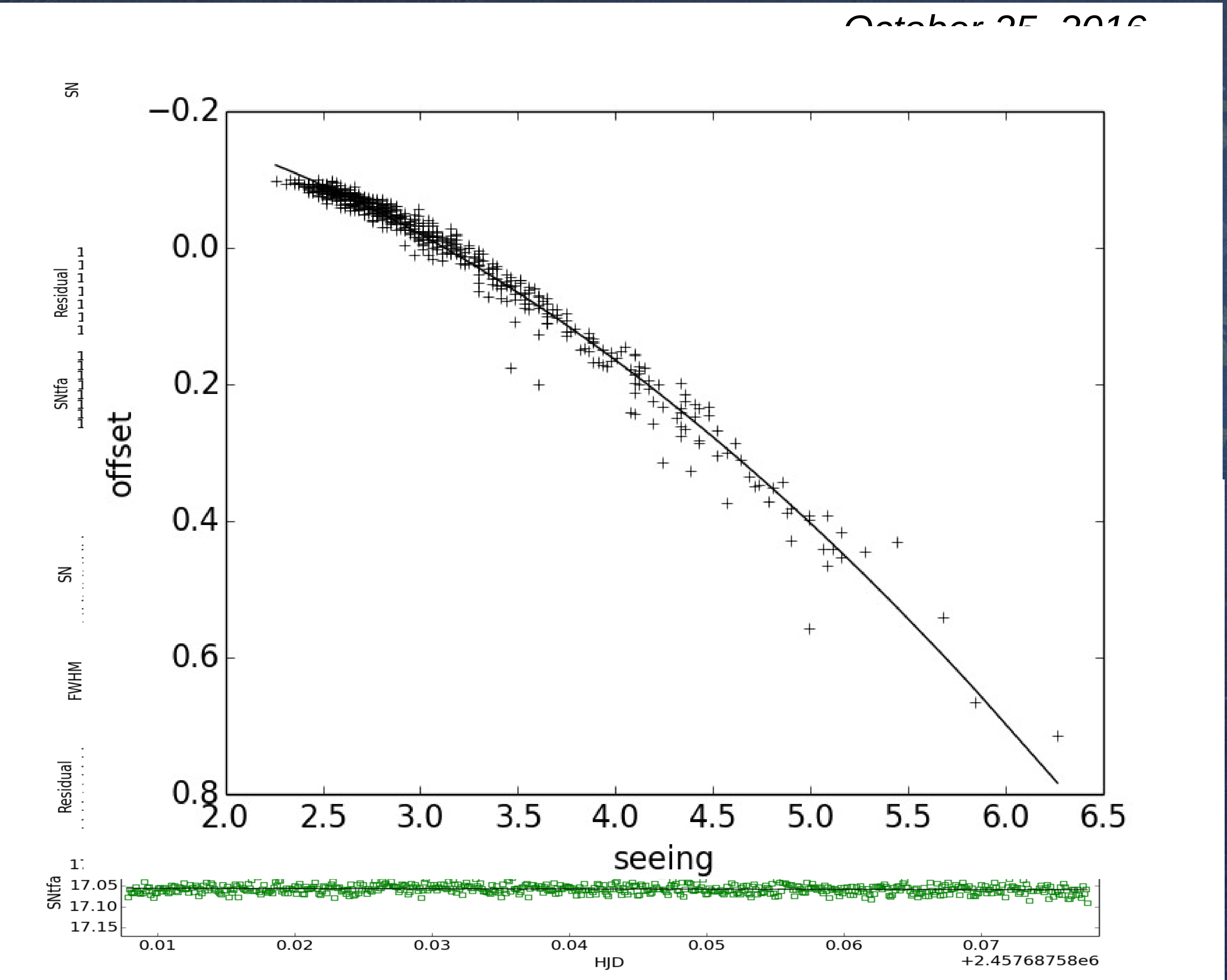
October 26, 2016



RMS 0.111

TFA RMS 0.04

Results: 2016gsb



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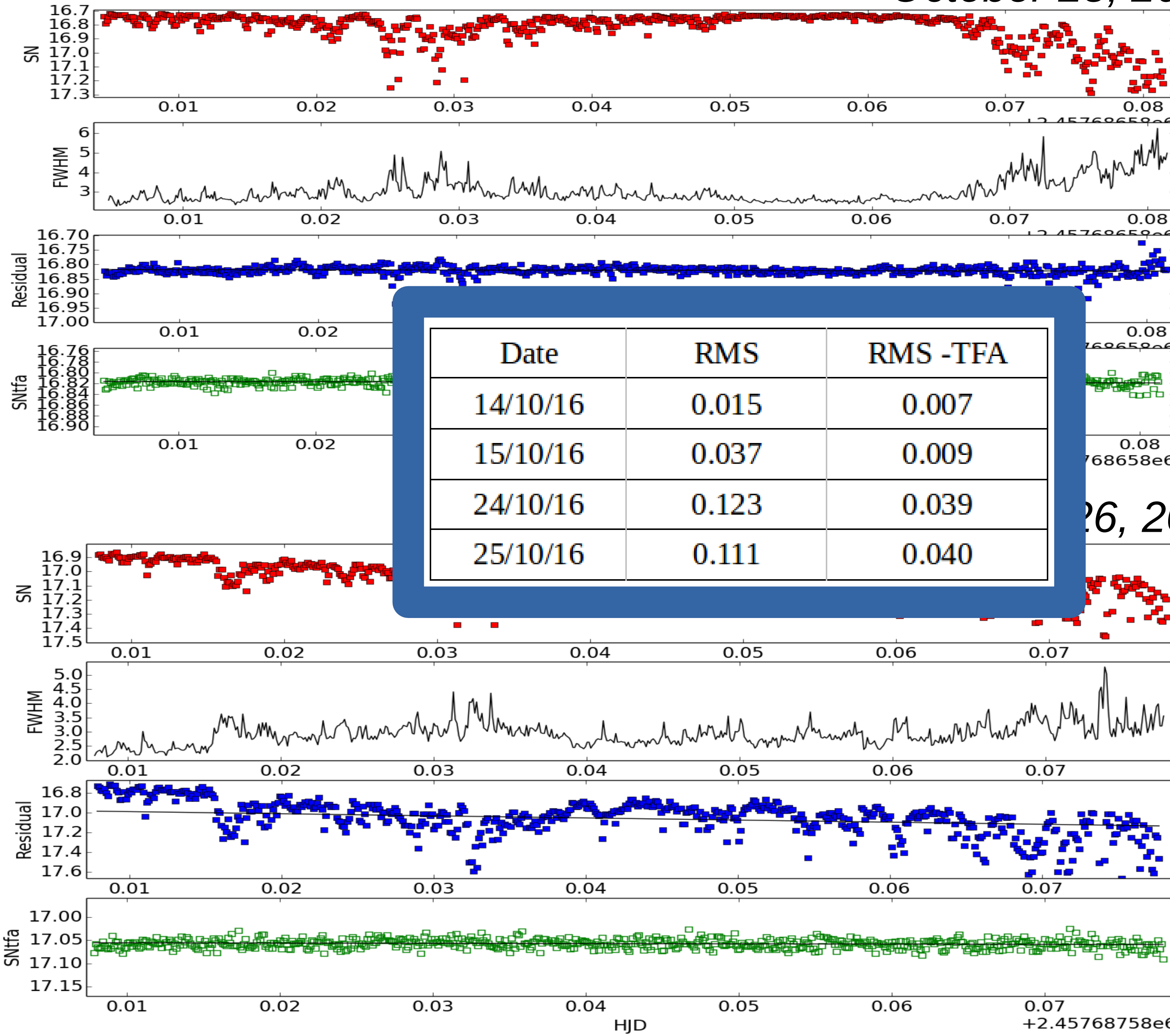


…26, 2016

Date	RMS	RMS -TFA
14/10/16	0.015	0.007
15/10/16	0.037	0.009
24/10/16	0.123	0.039
25/10/16	0.111	0.040

RMS 0.1235

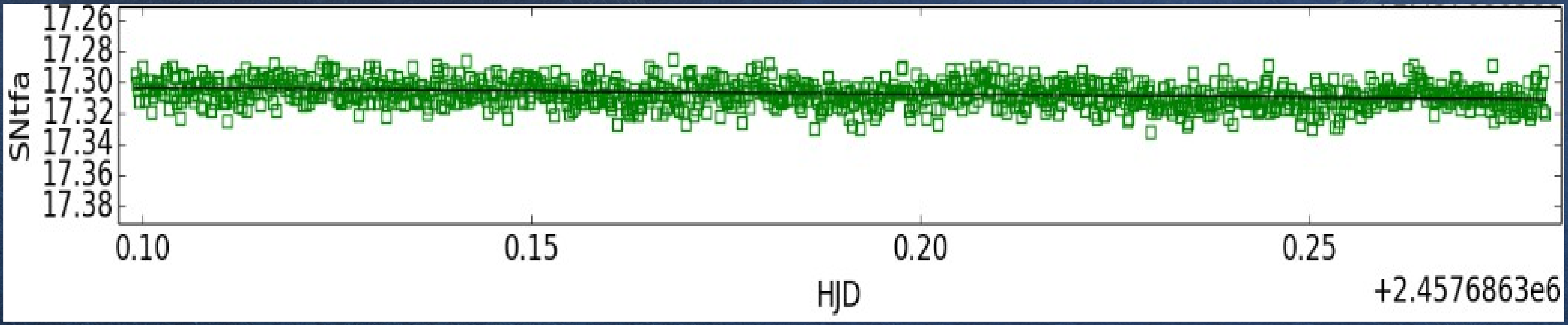
TFA RMS 0.0381

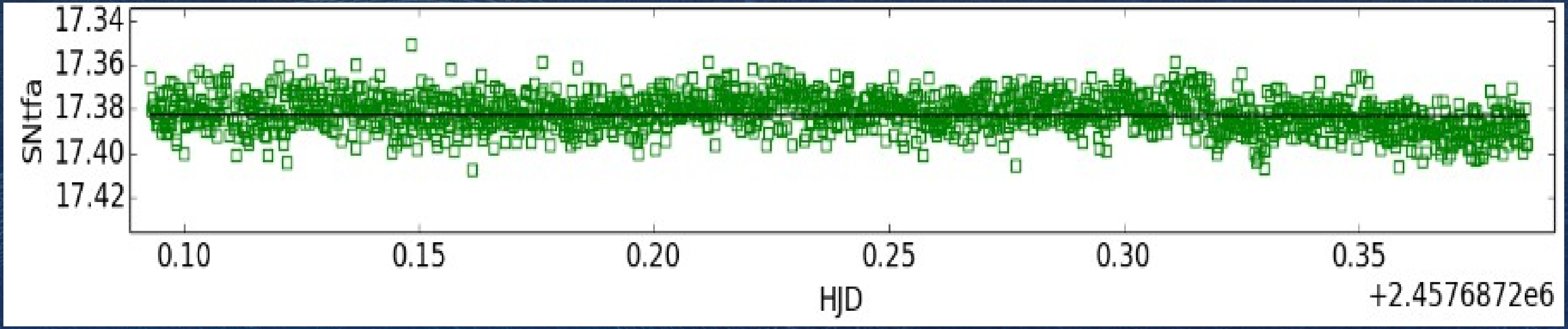
RMS 0.111

TFA RMS 0.04

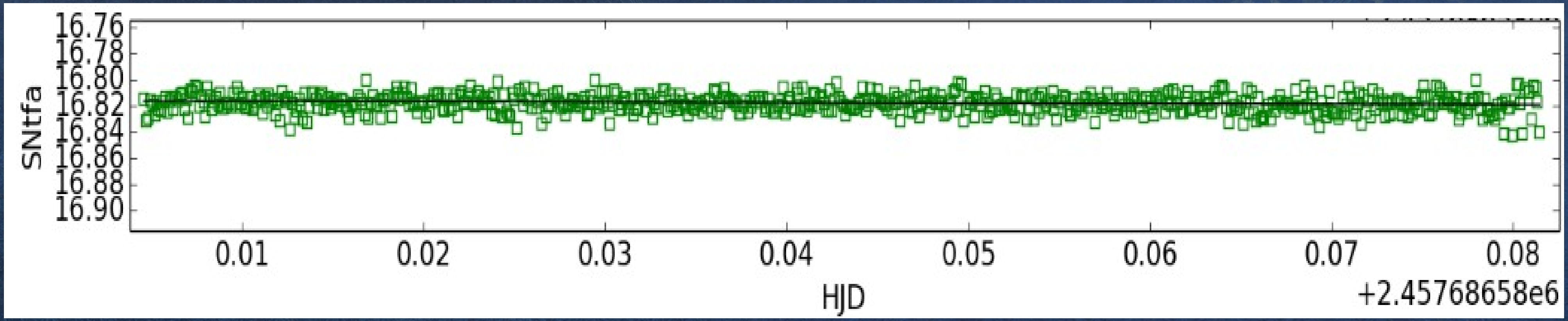
Decline Rate

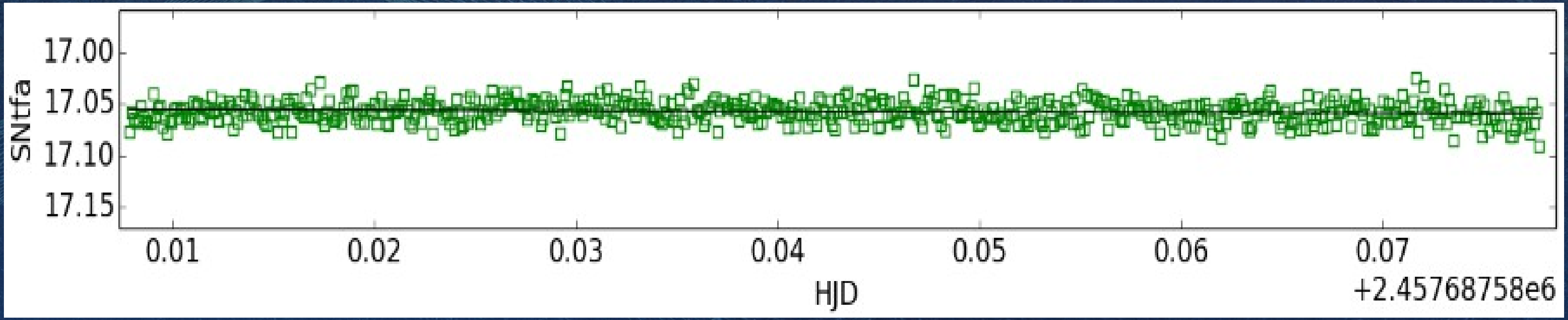
- Measured decline rates on October 25 & 26 for SN2016gsn: 0.036 & 0.001 mag/day





- Measured decline rates on October 25 & 26 for SN2016gsb: 0.035 & 0.053 mag/day





Conclusions

- Pilot study for high-cadence photometry which is a powerful tool for probing supernova physics
- 3 Type Ia SNe observed with Aristarchos telescope
- 10-60 sec cadence
- SN 2016gsb and SN 2016gsn not variable at level 0.02 mag over 2 nights
- Measured internight decline rate of 3 Type Ia SNe
- Future monitoring of bright supernovae with:
  - 1.2m Kryoneri (NELIOTA Lunar Imager) telescope
  - 2.3m Aristarchos (RISE2) telescope

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Thank you!